LT28 ABSTRACTS

Wednesday, 9 August 2017
13.20-14.20
Congress Hall

001
Topological defects and phase transitions
Kosterlitz J.M.
Brown University, Physics, Providence, United States

This talk reviews some of the applications of topology and topological defects in phase transitions in two-dimensional systems for which Kosterlitz and Thouless split half the 2016 Physics Nobel Prize. The theoretical predictions and experimental verification in two dimensional superfluids, superconductors and crystals will be reviewed because they provide very convincing quantitative agreement with topological defect theories.

Wednesday, 9 August 2017
14.20-15.20
Congress Hall

002
Topological superfluids
Volovik G.[1,2]
[1]Aalto University, Espoo, Finland, [2]Landau Institute for Theoretical Physics, Moscow, Russian Federation

Phases of liquid 3He represent topological matter with exotic defects protected by topology in r-space and nodes in fermionic spectrum protected by p-space topology. Phases of 3He belong to 4 classes.
(i) Normal 3He and normal metals belong to class with Fermi surfaces. Extension of Fermi surface to flat band opens the route to room-T superconductivity.
(ii) 3He-A - chiral superfluid with topologically protected Weyl fermions - is analog of Standard Model (SM). Its bosonic modes include effective gauge bosons and gravitons. Analogs of chiral anomaly, chiral magnetic and vortical effects have been experimentally demonstrated. Above Landau critical velocity the type-II Weyl points are formed. Such points are also formed in Weyl semimetal and behind the black hole horizon, which allows us to simulate Hawking radiation in semimetals.
(iii) In fully gapped 3He-B the p-space topology is similar to r-space topology of skyrmions and protects Majorana fermions on surface. The Nambu rule connecting spectrum of Higgs and fermionic modes in 3He-B, suggests extra Higgs bosons in SM.
(iv) Polar phase of 3He has Dirac nodal lines and contains 2D flat band of surface Majorana fermions. In semimetals with Dirac lines, the surface flat band is possible source of high-T superconductivity.

Wednesday, 9 August 2017

15.50-16.50
Congress Hall

003

On the pairing mechanism of unconventional high temperature superconductivity

Xue Q.-K.
Tsinghua University, Beijing, China

The pairing mechanism of unconventional high Tc superconductivity in cuprates and iron-pnictides has remained as a major problem in condensed matter physics. Both cuprates and iron-pnictides have a layered crystalline structure where charge reservoir layers reside in both sides of superconducting layers that are difficult to be measured directly by most experimental techniques. By using state-of-the-art molecular beam epitaxy (MBE)-scanning tunneling microscopy (STM), we are able to study the gap structures of superconducting copper oxide and FeSe planes by low temperature STM [1, 2]. Our results reveal that the pairing symmetry in two systems is actually isotropic and can be explained in the framework of BCS theory. We propose a model for understanding the complicated phase diagram of unconventional high temperature superconductors.

References:

"[1] Q. Y. Wang et al., Chin. Phys. Lett. **29**, 037402 (2012)"
"[2] Y. Zhong et al., Sci. Bull. **61**, 1239 (2016)"

Friday, 11 August 2017
14.50-15.20
Congress Hall

004

2D crystalline superconductors with broken inversion symmetry

Saito Y.[1], *Wakatsuki R.*[1], *Hoshino S.*[2], *Itahashi Y.*[1], *Ideue T.*[1], *Ezawa M.*[1], *Nagaosa N.*[2], *Iwasa Y.*[1]
[1]University of Tokyo, Tokyo, Japan, [2]RIKEN, Wako, Japan

Recent advances have developed methods to produce ideal two-dimensional (2D) electron systems, which are highly-crystalline with minimal disorder [1]. Here, we introduce the recent developments of highly-crystalline 2D superconductors and a series of unprecedented physical properties discovered originating from inversion symmetry in these systems. First of all, we highlight the quantum phases, i.e., quantum metallic state [2] and the quantum Griffiths phase [3] in out-of-plane magnetic fields. In addition, we focus two novel phenomena owing to broken inversion symmetry originating from crystal structure in ion-gated MoS_2: one is the experimental observation of enhanced in-plane upper critical field up to 52 Tesla by spin-valley locking (Ising superconductivity) [4] and the other is the nonreciprocal superconducting transport, the latter of which is later expected to be universal phenomena in noncentrosymmetric superconductors [5]. This nonreciprocal transport can be regard as intrinsic ratchet effect originating from noncentrosymmetric structure. These series of unprecedented phenomena suggest that highly-crystalline 2D superconductors evidently offer tremendous opportunities to unveil the intrinsic exotic nature of superconductors, leading to a new era of 2D superconductivity.

References:

[1] **Y. Saito**, T. Nojima and Y. Iwasa *Nature Reviews Materials* **2**, 16094 (2016).
[2] **Y. Saito** *et al. Science* **350**, 409 (2015). A. W. Tsen *et al. Nature Physics* **12**, 208 (2016).
[3] **Y. Saito** *et al.* submitted. Y. Xing *et al. Science* **350**, 6260 (2015).
[4] **Y Saito** *et al. Nature Physics* **12**, 144 (2016).
[5] R. Wakatsuki* and **Y. Saito*** *et al. Science Advances* in press. (*equal contribution)

Thursday, 10 August 2017
11.30-11.50
G1

005

Critical velocity in the presence of surface bound states in superfluid ^{3}He-B

Zheng P.[1], Jiang W.G.[2], Barquist C.S.[2], Lee Y.[2], Chan H.B.[3]
[1]University of Waterloo, Physics and Astronomy, West Waterloo, Canada, [2]University of Florida, Physics, Gainesville, United States, [3]Hong Kong University of Science and Technology, Physics, Hong Kong, China

A microelectromechanical oscillator with a gap of 1.25µm was immersed in superfluid 3He-B and cooled below 250µK at various pressures. Mechanical resonances of its shear motion were measured at various levels of driving force. The oscillator enters into a nonlinear regime above a certain threshold velocity. The damping increases rapidly in the nonlinear region and eventually prevents the velocity of the oscillator from increasing beyond the critical velocity which is much lower than the Landau critical velocity. We propose that this peculiar nonlinear behavior stems from the escape of quasiparticles from the surface bound states into the bulk fluid.

References:

[1] P. Zheng, W. G. Jiang, C. S. Barquist, Y. Lee, and H. B. Chan, Phys. Rev. Lett. **117**, 195301 (2016).
[2] P. Zheng, W. G. Jiang, C. S. Barquist, Y. Lee, and H. B. Chan, J. Low Temp. Phys. **183**, 313 (2016).
[3] Y. Nagato, M. Yamamoto, and K. Nagai, J. Low Temp. Phys. **110**, 1135 (1998).
[4] S. Murakawa, Y. Tamura, Y. Wada, M. Wasai, M. Saitoh, Y. Aoki, R. Nomura, Y. Nagato, M. Yamamoto, S. Higashitani, and K. Nagai, Phys. Rev. Lett. **103**, 115301 (2009).

Thursday, 10 August 2017
11.30-11.50
G3

006

Imaging Andreev reflection under magnetic field in graphene†

Bhandari S., Lee G.-H., Kim P., Westervelt R.
Harvard University, Department of Physics and School of Engineering and Applied Sciences, Cambridge, United States

Graphene (G) channels with superconducting (S) contacts combine the long mean free path of Dirac fermions with the coherence of Cooper pairs [1,2]. An Andreev reflection allows a normal electron in graphene to bounce off S as a hole (Figs.1a,b), while it transmits a Cooper pair [3]. We use a cooled scanning probe microscope (SPM) to image Andreev reflection in a hBN-G-hBN device (Fig 1c) at 4.2 K with normal (N) and superconducting (S) contacts in a perpendicular magnetic field *B*. Using our SPM, we have previously imaged magnetic focusing of electrons in graphene [4]. Fig 1a illustrates the cyclotron orbit for an electron passing from contact N1 to S, and a hole passing from S to N3; a Cooper pair passes into S. Orbits of electrons and holes are imaged by deflecting their paths with the SPM tip, and displaying the voltage V_m between N3 and N4 as SPM tip is raster scanned above the sample. Fig 1d shows an SPM image of Andreev reflection in the magnetic focusing regime, where the cyclotron diameter equals N1 to S and S to N3 - the blue region shows the cyclotron orbits of electron

from N1 and the holes reflected from S. Using ray tracing simulations, we model the electron and hole orbits associated with Andreev reflection (Fig.1e), which matches well with the experimental result.

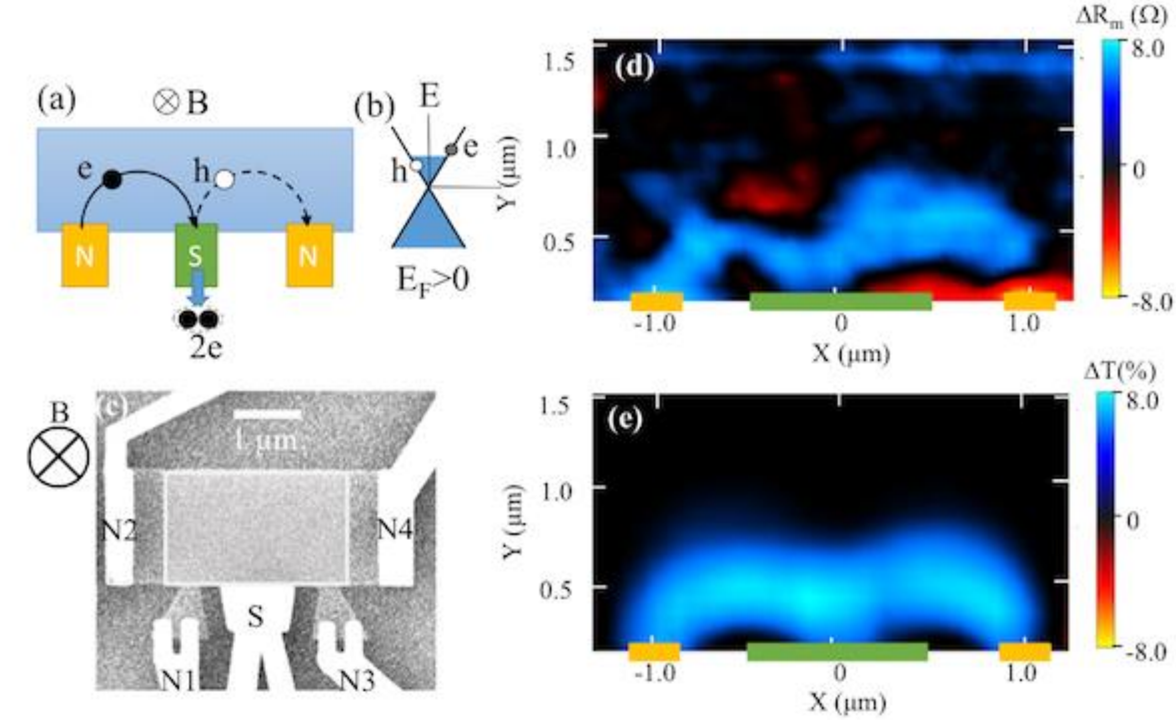


Figure 1: (a,b) Schematic showing Andreev reflection at the graphene/superconducting interface. In a perpendicular magnetic field B, an electron entering the graphene from the normal (orange) contact on the follows a cyclotron orbit. When it hits the superconducting contact in the center (green), a hole is emitted owing to Andreev reflection. (c) SEM image of the hBN-graphene-hBN device patterned with four normal (N) gold contacts and a superconducting (S) niobium contact. A current I is passed between from N1 to the superconducting contact S, contacts S and N2 are grounded. The voltage V_m is measured between N3 and N4. (d) SPM image of Andreev reflection under magnetic field in the magnetic focusing regime at 4.2 K – the blue region shows the cyclotron orbit of electrons traveling to the superconducting contact and the holes reflected. (e) Image of Andreev reflection obtained using ray tracing simulations. Both images at $B = 0.31$T and electron density $n = 1.29 \times 10^{12}$ cm^{-2}.

[picture]

*S.B. and G-H.L. contributed equally to this work.

†Supported by DOE grant DE-FG02-07ER46422

References:

[1] C.W.J. Beenakker, Phys. Rev. Lett. **97**, 067007 (2006)
[2] C.W.J. Beenakker, Rev. Mod. Phys. **80**, 1337-1354 (2008)
[3] D.K. Efetov et al, Nature Phys. **12,** 328-332 (2016)
[4] S. Bhandari et al, Nano Lett. **16(3),** 1690-1694 (2016)

11.30-11.50
Congress Hall

007

Engineering the coupling of Yu-Shiba-Rusinov states in a chain of magnetic adatoms

Kamlapure A.[1], *Cornils L.*[1], *Pradhan S.*[2], *Fransson J.*[2], *Wiebe J.*[1], *Wiesendanger R.*[1]
[1]University of Hamburg, Department of Physics, Hamburg, Germany, [2]Uppsala University, Department of Physics and Astronomy, Uppsala, Sweden

Recently, it has been proposed that a chain of magnetic adatoms (MA) hosting a spin-spiral on an *s-wave* superconductor (SC) may give rise to spinless *p-wave* pairing in this chain and the emergence of Majorana modes at the ends of the chain [1]. The subsequent investigation of self-assembled ferromagnetic Fe chains on superconducting Pb, featuring strong spin-orbit coupling, triggered enhanced interest in the possible realization of Majorana end modes [2]. However, Yu-Shiba-Rusinov (YSR) states close to the Fermi energy can hinder a doubtless assignment of those modes [3]. Moreover, for realizing quantum circuits for applications, one needs to artificially construct such chains and control the coupling between the MA.
Here, we will present our investigation towards the engineering of the coupling between MA and an underlying SC as well as amongst the MA. The tip of a scanning tunneling microscope has been used as a tool to construct dimers, trimers and chains of Fe atoms on an oxygen reconstructed Ta(001) surface, and the YSR states have been studied by scanning tunneling spectroscopy. Our work demonstrates the possibility of tuning the coupling within the artificially constructed Fe-atom chain and adds an important step towards the controlled realization of Majorana end states.

References:

[1] S. Nadj-Perge, I. K. Drozdov, B. A. Bernevig, and A. Yazdani, Phys. Rev. B **88**, 020407(R) (2013).
[2] S. Nadj-Perge, I. K. Drozdov, J. Li, H. Chen, S. Jeon, J. Seo, A. H. MacDonald, B. A. Bernevig, and A. Yazdani, Science **346**, 602 (2014).
[3] M. Ruby, F. Pientka, Y. Peng, F. von Oppen, B. W. Heinrich, and K. J. Franke, Phys. Rev. Lett. **115**, 197204 (2015)

Thursday, 10 August 2017
11.50-12.10
G1

008

Vortex non-dynamics and exceeding the Landau speed limit in the polar phase of superfluid ^{3}He

Mäkinen J.T.[1], *Autti S.*[1], *Eltsov V.B.*[1], *Rysti J.*[1], *Volovik G.E.*[1,2]
[1]Aalto University, Low Temperature Laboratory, Espoo, Finland, [2]Landau Institute for Theoretical Physics, Chernogolovka, Russian Federation

The Fermi surface emerges in superfluids and superconductors in the presence of supercurrent, when the velocity of the superflow exceeds Landau critical velocity.[1] The fermionic quasiparticles then occupy the negative energy levels, giving rise to non-zero normal component density even at zero temperature.[2] The superflow above the Landau critical velocity remains stable until the density of the non-thermal normal component reaches the total density, or the critical velocity for vortex formation is exceeded.
Here we report observation of the super-Landau supercurrent in the polar phase of superfluid 3He. The Landau critical velocity in the polar phase is zero, like in the A phase,[3] since the polar phase is gapless: it contains the Dirac nodal line in the equatorial plane in momentum space.[4,5]

Using BEC of magnon quasiparticles as a probe we have found that superflow in the polar phase remains stable for velocities up to 0.3 cm/s. Above this velocity vortex lines are formed. The vortices in the polar phase are pinned so strongly that they remain in place for days after the rotation has stopped. We also report an attempt to determine non-thermal part of the normal density from high-accuracy measurements of the Leggett frequency in the NMR experiments.

References:

[1] D. I. Bradley *et al.*, Nature Physics **12**, 1017 (2016)
[2] G.E. Volovik, Sov. Phys. Uspekhi **27**, 363 (1984)
[3] V. M. H. Ruutu *et al.*, Phys. Rev. Lett. **79**, 5058 (1997)
[4] V. V. Dmitriev *et al.*, Phys. Rev. Lett. **115**, 165304 (2015)
[5] S. Autti *et al.*, Phys. Rev. Lett. **117**, 255301 (2016)

Thursday, 10 August 2017
11.50-12.10
G3

009

Electron transport in a bilayer graphene/layered superconductor $NbSe_2$ junction

Yarimizu K.[1]*, Tomori H.*[1,2]*, Watanabe K.*[3]*, Taniguchi T.*[3]*, Kanda A.*[1]
[1]Univeristy of Tsukuba, Division of Physics, Faculty of Pure and Applied Sciences, Tsukuba, Japan, [2]PRESTO, Japan Science and Technology Agency, Kawaguchi, Japan, [3]National Institute for Materials Science (NIMS), Tsukuba, Japan

We have experimentally studied electron transport in a bilayer graphene (BLG)/layered superconductor $NbSe_2$ junction encapsulated with hexagonal boron nitride (hBN). We fabricate the junctions with the so-called van der Waals dry transfer method [1] in a glove box filled with Ar gas to prevent the degradation of $NbSe_2$. In the transport measurement, we observe that the charge neutrality point at the interface is shifted from that at the BLG portion far from the interface, indicating that the difference in work function between $NbSe_2$ and BLG plays an important role in the transport characteristics, which was not taken into account in the analysis of a previous report.[2] The variation of the differential conductance as a function of the gate voltage and the bias voltage agrees qualitatively with the theory of specular Andreev reflection taking into account the difference in work function, strongly indicating the existence of the specular Andreev reflection in this system.

References:

[1] L. Wang et al. Science **342**, 614 (2013).
[2] D. K. Efetov et al., Nat. Phys. **12**, 328 (2016).
[3] D. K. Efetov and K. B. Efetov, Phys. Rev. B **94**, 075403 (2016).

Saturday, 12 August 2017
14.30-14.50
G2

010

Magnetic field dependence of spin excitations in CeB6

Inosov D.
TU Dresden, Dresden, Germany

We employ inelastic neutron scattering (INS) to study the field dependence of spin fluctuations in CeB_6. The exciton shows no field splitting in marked contrast to CeCoIn5. Instead, we observe a second field-induced magnon whose energy increases with field. At the ferromagnetic zone center, however, we find only a single mode with a nonmonotonic field dependence. At low fields, it is initially suppressed to zero together with the antiferromagnetic order parameter, but then reappears at higher fields inside the hidden-order phase, following the energy of an electron spin resonance (ESR). This is a unique example of a ferromagnetic resonance in a heavy-fermion metal seen by both ESR and INS consistently over a broad range of magnetic fields.

Thursday, 10 August 2017
11.50-12.10
Congress Hall

011

Flat Andreev bound states at a dirty surface of a nodal superconductor and odd-frequency Cooper pairs

Asano Y., Ikegaya S.
Hokkaido University, Applied Physics, Sapporo, Japan

The quantization of an observable value in physics is closely related some of the time to an invariant in mathematics. We focus on the minimum value of the zero-bias differential conductance G_{min} in a junction consisting of a dirty normal metal and a nodal superconductor preserving time-reversal symmetry. Our analytical results based on the quasiclassical Green function method show that G_{min} is quantized at $(4e^2/h)N_{ZES}$ in the limit of strong impurity scatterings in the normal metal at zero temperature [1,2]. The integer N_{ZES} represents the number of Andreev bound states at zero energy which assist the perfect transmission through the dirty normal metal. An analysis of the chiral symmetry of the Hamiltonian indicates that N_{ZES} corresponds to the Atiyah-Singer index in mathematics [3]. The perfect transmission of a Cooper pairs is responsible for the fractional Josephson effect in a dirty Josephson junction [4,5] which has been a central issue in Majorana physics.
We have discussed that odd-frequency Cooper pairs play an essential role in such unusual proximity effect. In the presentation, we will demonstrate the stable paramagnetic superconducting states due to odd-frequency pairs in a small nodal superconductor.[6]

References:

[1] Y. Tanaka and S. Kashiwaya, Phys. Rev. B **70**, 012507 (2004).
[2] S. Ikegaya, Y. Asano, and Y. Tanaka, Phys. Rev. B **91**,174511 (2015).
[3] S. Ikegaya, S.-I. Suzuki, Y. Tanaka, and Y. Asano, Phys. Rev. B **94**, 054512 (2016).
[4] Y. Asano, Y. Tanaka, and S. Kashiwaya, Phys. Rev. Lett. **96**, 097007 (2006).
[5] S. Ikegaya and Y. Asano, J. Phys.: Condens. Matter **28**, 375702 (2016).
[6] S.-I. Suzuki and Y. Asano, Phys. Rev. B **89**, 184508 (2014); ibid **91**, 214510 (2015).

Thursday, 10 August 2017
11.50-12.10
H1

012

The anomalous metallic phase in an atomically thin van der Waals superconductor

de la Barrera S.[1]*, Sinko M.*[1]*, Lanes O.*[2]*, Liu G.*[2]*, Hatridge M.*[2]*, Hunt B.*[1]
[1]Carnegie Mellon University, Pittsburgh, United States, [2]University of Pittsburgh, Pittsburgh, United States

The zero-temperature limit of a two-dimensional electron system is thought to support only insulating and superconducting states. Experimental studies of thin-film superconductors have verified that a direct transition between the two states is possible by varying disorder or an external magnetic field. Surprisingly, an intermediate metallic phase with finite, saturating resistivity in the presence of a small perpendicular magnetic field has also been observed in a variety of ultrathin superconducting materials. Here, we report the observation of such an anomalous metallic ground state in atomically thin 2H-TaS_2, a crystalline superconductor which also exhibits Ising symmetry-protection and an unusual trend in its critical temperature. We investigate the low-temperature magnetotransport signatures of this metallic state and discuss a few of the possible underlying mechanisms.

Thursday, 10 August 2017
12.10-12.30
G3

013

Specific heat and entropy in the second Landau level

Schmidt B.[1]*, Bennaceur K.*[1]*, Gervais G.*[1]*, Pfeiffer L.*[2]*, West K.*[2]
[1]McGill University, Montreal, Canada, [2]Princeton University, Princeton, United States

The difficulty of edge-based measurements has led to interest in alternative means of testing whether fractional quantum Hall states, such as ν=5/2, are non-Abelian. In principle, there should be a non-Abelian contribution to the entropy, which would be detectable by measuring thermodynamic quantities such as specific heat [1]. In this talk, we will introduce our technique to measure the specific heat of a 2DEG in absolute units with no contribution of the phonons or other addenda. Working in the Corbino geometry, we measure both the DC thermal conductance to the environment and the thermal relaxation time. Our measured thermal relaxation times are around 1 microsecond at 100 mK, and the magnitude and temperature dependence of the power dissipation suggest cooling via phonon emission. We use a simple thermal RC-circuit model to determine the heat capacity of the electronic system, which is found to follow Arrhenius-like activation behavior. Integration of our results to obtain the entropy at filling factors 5/2 and 7/3 yields good quantitative agreement with previous measurements of entropy via the thermopower [2]. By extending our technique to lower temperatures and exploring the flank of ν=5/2, it may be possible to detect the entropic signature of bulk non-Abelian anyons.

References:

[1] N. R. Cooper and A. Stern, Phys. Rev. Lett. **102**, 176807 (2009).
[2] W. E. Chickering, J. P. Eisenstein, L. N. Pfeiffer, and K. W. West, Phys. Rev. B **87**, 075302 (2013).
[3] B. A. Schmidt, K. Bennaceur, S. Gaucher, G. Gervais, L. N. Pfeiffer, K. W. West, arxiv:1605.02344

Thursday, 10 August 2017
11.30-11.50
H1

014
Effect of carbon coating on the superconducting properties of Sn nano-spheres
Shani L.[1], *Kumar V.B.*[2], *Gedanken A.*[2], *Shapiro I.*[1], *Shapiro B.Y.*[1], *Shaulov A.*[1], *Yeshurun Y.*[1]
[1]Bar Ilan University, Physics and Institute of Nanotechnology and Advanced Materials, Ramat Gan, Israel, [2]Bar Ilan University, Chemistry and Institute of Nanotechnology and Advanced Materials, Ramat Gan, Israel

Carbon coating is commonly used to protect superconducting nano-particles. In this paper we show that the coating process may cause doping of the superconducting material and thus may affect drastically its properties. Tin spheres of radius ~60 nm and ~700 nm coated with sub-nanometer carbon layers were fabricated, using a sonochemical technique. Samples of both spheres reveal a type-I superconductivity characterized by super-critical fields and an intermediate state manifested by a gradual increase of the magnetization to zero. However, the small and large tin spheres exhibit similar critical fields, H_c, contrary to the expected increase in H_c in spheres with size smaller than the coherence length (~230 nm). Analysis of the data shows that the relative high degree of carbon doping in the small tin spheres eliminates the expected size-effect on H_c. Simulations, based on the time dependent Ginzburg-Landau equations, imply that the intermediate state in both measured samples consists of only one superconducting domain surrounded by a normal domain, whereas a rich multi-domain structure is predicted for larger Sn spheres.

Thursday, 10 August 2017
12.10-12.30
Congress Hall

015
Momentum space imaging of chiral unconventioal superconductors UPt_3 and URu_2Si_2
Thalmeier P.[1], *Lambert F.*[2], *Akbari A.*[3], *Eremin I.*[2]
[1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany, [2]Institute for Theoretical Physics III, Ruhr University, Bochum, Germany, [3]Asia Pacific Center for Theoretical Physics and Dept.of Physics, POSTECH, Pohang, Korea, Republic of

Surface tunneling quasiparticle interference (QPI) investigation is able to specify the symmetry of superconducting (SC) gap functions, in particular in heavy fermion compounds where the size of the gap is quite small. This has been successfully demonstrated in $CeCoIn_5$.
UPt_3 is the only known 2-component unconventional SC belonging to a two-dimensional hexagonal E-representation. Existing experiments cannot distinguish between the chiral E_{1g}, E_{2u} and E_{1u} models. Using a finite-slab calculation we show that the QPI images of those gap functions have characteristic differences. In particular for zero bias they show signature of different Weyl arc structure of surface states stemming from the different topological charges of the nodes. This provides a powerful criterion to decide between gap models [1].
In URu_2Si_2 presumably a chiral d-wave singlet SC state exists inside a hidden order (HO) phase.. We show that the QPI pattern contains clues on the HO reconstructed quasiparticle bands and the essential HO property of in-plane rotational symmetry breaking. We also demonstrate that the chiral d-wave SC gap leads to a crossover to a quasi-2D QPI spectrum below T_c which sharpens the HO features. We give a comparison with existing STM experiments in the HO phase.
References:
[1] F. Lambert, A. Akbari, P. Thalmeier and I. Eremin, Phys. Rev. Lett. **118**, 087004 (2017)

Thursday, 10 August 2017
11.50-12.10
G2

016
Dynamical magnetism in the iron-based ladder compound BaFe2Se3 through multi-probe techniques
Nambu Y.[1], Suzuki K.[1], Imaizumi S.[2], Hashizume K.[2], Aoyama T.[2], Imai Y.[2], Ohgushi K.[2]
[1]Tohoku University, Institute for Materials Research, Sendai, Japan, [2]Tohoku University, Department of Physics, Sendai, Japan

Since the discovery, Fe-based superconductivity (SC) has attracted much attention. To gain further insight into the mechanism of SC, investigation of Fe-based compounds over distinct spatial dimensions is important. We have examined magnetism of ladder compounds AFe2X3 (A = Rb, Cs, Ba; X = S, Se) [1,2], and recently found the first SC in BaFe2S3 [3]. As for other parent compounds, this family shows 3D magnetic ordering. However, anomaly at the magnetic transition is not detectable by bulk properties.
For BaFe2Se3, Block-type magnetic structure below TN = 255 K was elucidated by neutron diffraction [1]. However, Moessbauer experiment reports no anomaly at TN, instead hyperfine splitting appears at 235 K. There is a gradual formation of the magnetic ordering on further cooling, and it finally falls into the ordered state at 10 K, consistent with hindered entropy release evidenced by the specific heat [1]. This behavior can be originating from the difference in timescale of the techniques (neutron: 1e-13 sec, Moessbauer: 1e-7 sec). Here we report on magnetic dynamics of BaFe2Se3 through multi-probe techniques including neutrons and muons. Observed magnetic fluctuations over a wide regime of temperatures are inherent to low-dimensionality of the material.
References:
[1] Y. Nambu et al., Phys. Rev. B 85, 064413 (2012).
[2] F. Du et al., Phys. Rev. B 85, 214436 (2012).
[3] H. Takahashi et al., Nat. Mat. 14, 1008 (2015).

Thursday, 10 August 2017
12.10-12.30
G1

017
Motion beyond Landau critical velocity in a Fermi superfluid
Kuorelahti J.A., Laine S.M., Thuneberg E.V.
University of Oulu, Nano and Molecular Systems Research Unit, Oulu, Finland

We study drag forces on objects that move in a p-wave Fermi superfluid at velocities on the order of the Landau critical velocity v_L. We concentrate on low temperatures where quasiparticle collisions can be neglected. For a point-like impurity we calculate analytically the force, which vanishes at T=0 for $v< v_L$ and starts to increase toward its normal state value for $v>v_L$. The situation is more complicated for an object larger than the coherence length scale. Firstly, the superfluid flow around the object causes part of the incident ground state quasiparticles to be Andreev reflected, giving only a weak force on the object. Secondly, the flow field is modified by local pair breaking already at object velocities less than v_L. We calculate self-consistently the velocity field using different approximations, and calculate the resulting force on the object. As a technical tool we propose a "macroscopic" diffuse-scattering boundary condition in the superfluid state, where quasiparticles are scattered equally in all allowed directions, consistently with conservation of mass and excitation number.

Thursday, 10 August 2017
14.30-14.50
Congress Hall

018
Unconventional superconductivity and quantum criticality in heavy fermions $CeIrSi_3$ and $CeRhSi_3$

Landaeta J.F.[1], *Subero D.*[1], *Catalá D.*[1], *Taylor S.V.*[1], *Kimura N.*[2], *Settai R.*[3], *Onuki Y.*[4], *Sigrist M.*[5], *Bonalde I.*[1]
[1]Instituto Venezolano de Investigaciones Científicas, Centro de Física, Caracas, Venezuela, [2]Tohoku University, Graduate School of Science, Sendai, Japan, [3]Niigata University, Department of Physics, Niigata, Japan, [4]University of the Ryukyus, Faculty of Science, Okinawa, Japan, [5]ETH Zürich, Institute for Theoretical Physics, Zürich, Switzerland

Superconductivity and magnetism are mutually exclusive in most alloys and elements, so it is striking that superconductivity emerges around a magnetic quantum critical point (QCP) in many strongly correlated electron systems (SCES). In the latter case superconductivity is believed to be unconventional and directly influenced by the QCP. However, experimentally unconventional superconductivity has neither been established nor directly been linked to any mechanism of the QCP. To gain insight into these open questions, we developed a measuring system, to study the superconducting order parameter symmetry under pressure using a high-resolution magnetic penetration-depth λ(T) probe. Here we report measurements of λ(T) in heavy fermions CeIrSi3 and CeRhSi3 up to 3 GPa and 200 mK. Superconductivity in $CeIrSi_3$ shows a change from a line-nodal to an isotropic gap structure when pressure is close but not yet at the QCP. In contrast, $CeRhSi_3$ does not possess an obvious pressure-tuned QCP and the superconducting phase remains for all accessible pressures with a nodal gap. Combining both results suggests that unconventional behaviours may be connected with the coexisting antiferromagnetic order. This study provides a new viewpoint on the interplay of superconductivity and magnetism in SCES.

Thursday, 10 August 2017
14.30-14.50
G2

019
Emergence of a fermionic finite-temperature critical point in a Kondo lattice

Chung C.-H.[1], *Chou P.-H.*[2], *Zhai L.-J.*[2], *Mou C.-Y.*[2], *Lee T.-K.*[3]
[1]National Chiao Tung University, Department of Electrophysics, Hsinchu, Taiwan, Republic of China,
[2]National Tsing-Hua University, Department of Physics, HsinChu, Taiwan, Republic of China,
[3]Academia Sinica, Institute of Physics, Taipei, Taiwan, Republic of China

Topological insulators can exhibit low-dimensional Dirac Fermions at surfaces due to the nontrivial topology in bulk electronic structures [1]. Recently, 3D Dirac semi-metallic phases were found [2,3] where the mass vanishes at the Dirac point, known as fermionic quantum critical point between the hole and the electron Fermi liquid. The quantum criticality extends effects of the Dirac point to a finite

critical regime and results in nontrivial scaling in Dirac semimetals. However, it is often difficult to drive a system with Dirac points across the massless fermionic critical point. Here, by exploiting screening of local moments under spin-orbit interactions in a Kondo lattice, we show that the Kondo lattice undergoes a topological transition from a strong topological insulator to a weak topological insulator at a finite temperature $T_{D.}$ At T_D, massless Dirac points emerge and the Kondo lattice becomes a Dirac semimetal [4]. Our analysis based on a slave-boson approach indicates that the emergent relativistic symmetry dictates nontrivial thermal responses over large parameter and temperature regimes. In particular, it yields critical scaling behaviors both in magnetic and transport responses near T_D. Our results are relevant for the topological Kondo insulator SmB_6 [5].

References:

[1] M. A. Hasan and C. L. Kane, Rev. Mod. Phys. **82**, 3045 (2010); X. L. Qi and S.-C. Zhang, Rev. Mod. Phys. **83**, 1057 (2011).
[2] Z. K. Liu et al., Science **343**, 864 (2014).
[3] S. Borisenko, Q. Gibson, D. Evtushinsky, V. Zabolotnyy, B. Buchner, and R. J. Cava, Phys. Rev. Lett. **113**, 027603 (2014).
[4] Po-Hao Chou, Liang-Jun Zhai, Chung-Hou Chung, Chung-Yu Mou, and Ting-Kuo Lee, Phys. Rev. Lett. **116**, 177002 (2016).
[5] D. J. Kim, J. Xia, and Z. Fisk, Nat. Mater. **13**, 466 (2014).

Thursday, 10 August 2017
14.30-14.50
H1

020

Time quasicrystals in superfluid ^{3}He

Autti S.[1], *Mäkinen J.T.*[1], *Rysti J.*[1], *Volovik G.E.*[1,2], *Eltsov V.B.*[1]
[1]Aalto University, Low Temperature Laboratory, Espoo, Finland, [2]Landau Institute for Theoretical Physics, Chernogolovka, Russian Federation

The concept of time crystals, spontaneous reduction of continuous time translation symmetry to a discrete one, has recently attracted a lot of discussions [1,2]. It has been established that time crystals can be realized only in periodically driven systems, where response develops at a longer period, commensurate with the drive [3,4]. Here we report that in superfluid ^{3}He-B, periodically driven with NMR excitation, a new type of response has been observed: part of the response has a longer, incommensurate period as compared with the drive, and the combined response is therefore quasiperiodic. This system can be called a time quasicrystal, realised as Bose-Einstein condensates of magnon quasiparticles. The appearance of the response at a longer period is not just a curious property but also has an important practical consequence. Frequency separation of the drive and the detection allows using those magnon condensates as sensitive and fast probes of various properties of the topological superfluid for instance in in-situ thermometry, in probing topological defects and their dynamics, and probing other spinwave modes [5-7].

References:

[1] F Wilczek, PRL **109**, 160401 (2012)
[2] H Watanabe et al, PRL **114**, 251603 (2015)
[3] D V Else et al, PRL **11**7, 090402 (2016)
[4] N. Y. Yao et al, PRL **118**, 030401 (2017)
[5] P.J. Heikkinen, JLTP **175**, 681-705 (2014).
[6] J.J. Hosio et al, Nat. Comms. **4**, 1614 (2013)
[7] V.V. Zavjalov, Nat. Comms. **7**, 10294(1-6) (2016).

Thursday, 10 August 2017
14.30-14.50
G1

021

The symplectic Fermi liquid and its realization in cold atomic systems

Ramires A.
ETH, Institute for Theoretical Studies, Zurich, Switzerland

We study the behaviour of fermions with large spin and SP(N) symmetry. We contrast their behaviour with the case of SU(N) symmetry by analysing the conserved quantities and dynamics in each case. We also develop the Fermi liquid theory for fermions with SP(N) symmetry. We find that the effective mass and compressibility are always enhanced in the presence of interactions, and that the N-dependence of the enhancement can be qualitative different in distinct parameter regimes of the interactions strengths. The magnetic susceptibility can be either enhanced or suppressed, with the larger effects present for small values of N. We conclude discussing what are the routes to realize SP(N) symmetry within cold atoms.

Thursday, 10 August 2017
14.30-14.50
G3

022

Quantum microwaves with a strong coupling QED open circuit

Mukharsky Y.[1], *Rolland ,.C.*[1], *Westig M.*[1], *Peugeot A.*[1], *Parlavecchio O.*[1], *Kubala B.*[1], *Altimiras C.*[1], *Joyez P.*[1], *Vion D.*[1], *Roche P.*[1], *Simon P.*[2], *Hofheinz M.*[1], *Trif M.*[2], *Ankerhold J.A.*[3], *Esteve D.*[1], *Portier F.*[1]
[1]CEA-CNRS, Université Paris-Saclay, Service de Physique de l'Etat Condensé, Gif sur Yvette, Cedex, France, [2]Université Paris-Saclay, Laboratoire de Physique des Solides, Orsay, France, [3]University of Ulm, Institute for Complex Quantum Systems, Ulm, Germany

Transport of elementary charge carriers across a circuit usually does not couple to the electromagnetic modes embedded in the circuit. We consider here a dc voltage biased Josephson junction in series with a microwave resonator. In this system, the effective coupling constant is the ratio between the resonator characteristic impedance , which can be engineered, and the relevant resistance quantum R_Q= h/4e^2 ~6.5 kOhms. At large coupling constant, the transfer of a single Cooper pair across the Josephson junction strongly couples to the circuit mode.
We show that, in the strong coupling regime, the transfer of a single Cooper pair only occurs when its energy *2eV* can be transformed in *1,2,..n* photons. We also identify a recently predicted regime for which the presence of a single photon blocks the creation of a second one, which prevents new excitation by Cooper pair tunneling until the resonator empties itself. Cooper pair transfer and photon emission are locked.
Using a two-mode resonator circuit with different frequencies, we demonstrate a regime in which the transfer of a single Cooper pair simultaneously excites a single photonic excitation in each mode. We demonstrate entanglement of these photons. [1].

References:

[1] Westig *et al*., arXiv 1703.05009.

Thursday, 10 August 2017
15.20-15.40
G1

023

Scattering of phonons by atomic nano-bubbles in superfluid helium doped with dysprosium

Moroshkin P., *Kono K.*
RIKEN, Center for Emergent Matter Science, Wako, Japan

Foreign atoms injected in superfluid helium and resonantly excited by laser radiation can be used as sensitive probes for the elementary excitations in the quantum fluid and as tracers for the turbulent fluid flow. The dopants reside in nanometer-sized cavities, also known as atomic bubbles [1], whose vibration modes provide the coupling between the electronic transitions of the dopant and the excitations of the liquid (phonons) [2].
We present an experimental study of Dy atoms injected in superfluid He by means of laser ablation. The atoms are excited by a cw frequency-doubled Ti:Sapphire laser tuned to one of the transitions between the electronic configurations $4f^{10}6s^2$ and $4f^9 5d6s^2$ (λ = 458.9 nm), and the spectrally-resolved fluorescence is observed at several transitions originating from the lower lying excited states. The excitation spectrum obtained by scanning the laser wavelength displays a pronounced sharp zero-phonon line (ZPL) and a blue-shifted phonon wing (PW). The PW spectrum reflects the structure of the phonon wavepacket excited by the laser-induced atomic bubble vibrations and the spectral width of ZPL provides the measure for the rate of the phonon scattering by a non-vibrating atomic bubble.

References:

[1] P. Moroshkin, A. Hofer, A. Weis, Phys. Rep., **469**, 1 (2008)
[2] P. Moroshkin, V. Lebedev, A. Weis, Europhys. Lett., **96**, 26002 (2011)

Thursday, 10 August 2017
15.20-15.40
H1

024

Anomalous asymmetry in melting and growth relaxations of ^{4}He crystals after manipulation by acoustic radiation pressure

Nomura R.[1], *Abe H.*[2], *Okuda Y.*[3]
[1]Tokyo Institute of Technology, Tokyo, Japan, [2]National Metrology Institute of Japan, AIST, Tsukuba, Japan, [3]RIKEN, Wako, Japan

We succeeded in manipulating the crystal-superfluid interface of ^{4}He in desired orientations by acoustic radiation pressure and discovered that the relaxation times to the equilibrium state after the manipulation were very different between in melting and growth [1]. The melting relaxation was much slower than the growth relaxation. This asymmetry was apparent only on anisotropic surfaces like facets and vicinal surfaces, but did not show up on the isotropic rough surface. Furthermore, the melting relaxation exhibited a complicated behavior in multiple stages showing the anomalous shapes, such as needle or irregular shapes, depending on temperature, while growth relaxation was a simple one back to the initial flat surface in a single stage. These phenomena will be understood by taking into account the important role of superflow induced by anisotropic interface motion in the relaxation processes.

References:

[1] R. Nomura, H. Abe, and Y. Okuda, New J. Phys. **19**, 023049 (2017).

Thursday, 10 August 2017
15.20-15.40
G2

025
Massive anyons in the Kitaev spin-liquid candidate *α*-$RuCl_3$ under a magnetic field
Klanjsek M., Jansa N.
Jozef Stefan Institute, Condensed Matter Physics Department, Ljubljana, Slovenia

Quantum spin liquid is a theoretical concept describing a disordered magnetic state with fractional spin excitations [1]. Its clearest realization is found in an exactly solved Kitaev honeycomb model where the spin fractionalizes into two types of anyonic - neither fermionic nor bosonic - excitations: gauge fluxes and Majorana fermions [2]. Using ^{35}Cl nuclear magnetic resonance, we show that the candidate material *α*-$RuCl_3$ [3] exhibits the key features of the ferromagnetic Kitaev model. Above and beyond the antiferromagnetically ordered phase at low temperatures and low magnetic fields, in the so called Kitaev paramagnetic phase [4], we observe a gapped spin-excitation continuum accompanied by the contrasting, monotonic negative temperature dependence of the magnetic susceptibility, together revealing the presence of fractional spin excitations [5]. Moreover, the excitation gap, observed to increase as a theoretically predicted third power of the applied magnetic field [2,6] with nonzero initial value, reveals the gauge flux mass and the field-induced mass of an otherwise massless Majorana fermion [5]. This is the first demonstration of the massive character of these two anyonic excitations, a crucial property for their potential application in topological quantum operations [2].
References:
[1] L. Savary and L. Balents, Rep. Prog. Phys. **80**, 016502 (2017).
[2] A. Kitaev, Ann. Phys. **321**, 2 (2006).
[3] K. W. Plumb *et al.*, Phys. Rev. B **90**, 041112(R) (2014).
[4] S.-H. Do *et al.*, arXiv:1703.01081 (2017).
[5] N. Jansa and M. Klanjsek, unpublished.
[6] H.-C. Jiang *et al.*, Phys. Rev. B **83**, 245104 (2011).

Thursday, 10 August 2017
15.20-15.40
Congress Hall

026
Observation of the Flux Line Lattice in $CeCu_2Si_2$: implications for its pairing state
Forgan T.[1], Blackburn E.[1], Stockert O.[2], Holmes A.[3], Cubitt R.[4], Riyat R.[1]
[1]University of Birmingham, Physics & Astronomy, Birmingham, United Kingdom, [2]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany, [3]European Spallation Source ERIC, Scientific Activities Division, Lund, Sweden, [4]Institut Laue Langevin, Grenoble, France

Using small-angle neutron scattering, we have observed the flux line lattice (FLL) in the archetypical heavy fermion superconductor $CeCu_2Si_2$. For magnetic field parallel to the c-axis, we observe an almost undistorted hexagonal FLL, and the intensity of the signal *rises*, as the field is increased towards H_{c2}. The strengthening of the field contrast of the FLL as the field is raised is a clear indication of Pauli paramagnetic flux line cores, similar to those observed in the *d*-wave heavy fermion

superconductor $CeCoIn_5$ [1]. This is an indication of Pauli limiting, which indicates even-parity pairing (*s*, *d* etc). However, unlike $CeCoIn_5$, the FLL is hardly distorted at any field or temperature, and certainly never develops a square structure. We therefore conclude that this material is not a *d*-wave superconductor, despite being tetragonal and having magnetically mediated superconductivity.

References:

[1] J.S. White *et al.* New J. Phys. **12**, 023026 (2010)

Thursday, 10 August 2017
15.20-15.40
G3

027

Correlations and entanglement of microwave photons emitted in a cascade decay

Gasparinetti S., Pechal M., Besse J.-C., Mondal M., Eichler C., Wallraff A.
ETH Zurich, Zurich, Switzerland

We use a three-level artificial atom in the ladder configuration as a source of microwave photons of different frequency. Our artificial atom is a transmon-type superconducting circuit, driven at the two-photon transition between ground and second-excited state. The transmon is embedded into a single-pole, double-throw switch [1] that selectively routes different-frequency photons into different spatial modes. We characterize the decay process for both continuous-wave and pulsed excitation. When the source is driven continuously, power cross-correlations between the two modes exhibit a crossover between strong antibunching and superbunching, typical of cascade decay, and an oscillatory pattern as the drive strength becomes comparable to the radiative decay rate. Using pulsed excitation, we prepare an arbitrary superposition of the ground and second-excited state and monitor the spontaneous emission of the source in real time. This scheme allows us to deterministically produce entangled photon pairs, as demonstrated by nonvanishing phase correlations and more generally by joint state tomography of the two itinerant photonic modes. [2]

References:

[1] M. Pechal, J.-C. Besse, M. Mondal, M. Oppliger, S. Gasparinetti, and A. Wallraff, Phys. Rev. Appl. **6**, 024009 (2016).
[2] S. Gasparinetti, M. Pechal, J.-C. Besse, M. Mondal, C. Eichler, and A. Wallraff, submitted.

Thursday, 10 August 2017
15.40-16.00
G1

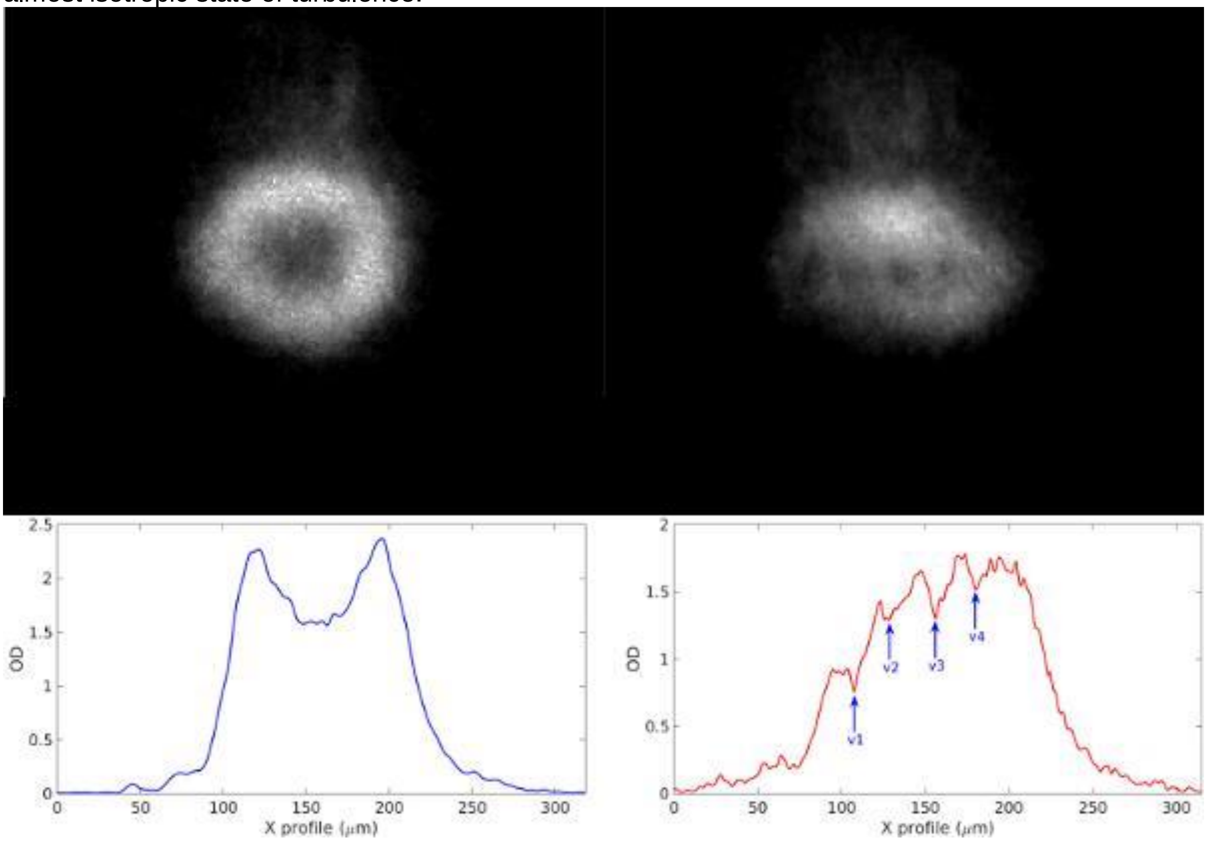
028

Decay dynamics of quadruply quantized vortices in a BEC

Telles G.[1], Fritsch A.[1], Vivanco F.[1], Tavares P.[1], Cidrim A.[1], Barenghi C.[2], Bagnato V.[1]
[1]University of Sao Paulo, Physics Institute of Sao Carlos, Sao Carlos, Brazil, [2]Newcastle University, JQC Durham-Newcastle, Newcastle upon Tyne, United Kingdom

Quantized vortices, topologically imprinted to dilute Bose-Einstein condensates (BECs), have been intensively studied in the last decade [1], contributing to the early studies carried out in standard superfluids and superconductors [2]. In this work, we present results from quadruply quantized vortices, which were topologically imprinted in ^{87}Rb Bose-Einstein condensates [1], produced and held in a QUIC trap. We investigated the vortex complex split decay process using 2-axis absorption

imaging, and observed the spontaneous decay into four single charged vortices, shown in Fig.1. Moreover, we report the experimental observation of the twisted split decay of the quadruply charged vortices magnetically imprinted in the BEC. The observations were supported by numerical simulations showing that the process takes place in the shape of helical waves, finally splitting into separate singly-charged vortices as expected. We believe that the effect may be exploited to generate an almost isotropic state of turbulence.



[Fig.1: OD images (top); 1D profiles (bottom)]

References:
[1] T. Isoshima *et al.*, Phys. Rev. A **61**, 063610 (2000); A. Leanhardt *et al.*, Phys. Rev. Lett. **89**, 190403 (2002); Y. Shin *et al.*, Phys. Rev. Lett. **93**, 160406 (2004); A. Mateo *et al.*, Phys. Rev. Lett. **97**, 180409 (2006); T. Isoshima *et al.*, Phys. Rev. Lett. **99**, 200403 (2007); T. Kuwamoto *et al.*, J. Phys. Soc. Jpn. **79**, 034004 (2010)
[2] R.J. Donnelly, *Quantized Vortices in Helium II*, Cambridge, Oxford (2003); M. Tinkham, *Introduction to Superconductivity*, McGraw-Hill, New York (1996)

Thursday, 10 August 2017
15.40-16.00
G3

029
Device characteristics of high-T_c superconducting intrinsic Josephson junction terahertz emitters

Kashiwagi T.[1], *Yuasa T.*[1], *Tanabe Y.*[1], *Tanaka T.*[1], *Komori Y.*[1], *Ota R.*[1], *Kuwano G.*[1], *Nakamura K.*[1], *Watanabe C.*[1], *Tsujimoto M.*[1], *Yamamoto T.*[2], *Yoshizaki R.*[1], *Minami H.*[1], *Klemm R.*[3], *Kadowaki K.*[1]

[1]Univ. of Tsukuba, Ibaraki, Japan, [2]Hasselt University, Diepenbeek, Belgium, [3]Univ. of Central Florida, Florida, United States

Electromagnetic waves in the terahertz (THz) frequency range (0.1~10 THz) have been recognized to be a fascinating area of research for the practical applications [1]. Lacking of compact THz emitters, so far, THz emitters based on the semiconductor technologies such as resonant tunneling diodes and THz quantum cascade lasers have rapidly been developed [2,3]. On the contrary, we have succeeded in generating THz waves (IJJ-THz emitter) using the stack of intrinsic Josephson junctions (IJJs) [4] existing in the single crystal of high-T_c superconductor $Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi2212) [5,6,7]. The IJJ-THz emitter is made of the mesa structure of Bi2212 single crystals. The radiation frequency of this device is determined by the applied bias voltage to the IJJs according to the ac-Josephson effect and the radiation intensity is enhanced at characteristic cavity modes determined by the shape and the size of the Bi2212 mesa structures. Recently, in order to improve the device characteristics of the IJJ-THz emitters, we have developed a high heat exhausting structure from the mesa structures. We have obtained radiation frequencies from 0.3 to 2.4 THz and a few tens of microwatt level of output power by adjusting bias voltage conditions and sample temperatures [8].

References:

[1] M. Tonouchi, Nat. Photon. **1**, 97 (2007)
[2] T. Maekawa *et al.*, APEX **9**, 024101 (2016)
[3] Q. Lu *et al.*, Scientific Rep. **6**, 23595 (2016)
[4] R. Kleiner *et al.*, Phys. Rev. Lett. **68**, 2394 (1992)
[5] L. Ozyuzer *et al.*, Science **318**, 1291 (2007)
[6] U. Welp, K. Kadowaki, and R. Kleiner, Nat. Photon. **7**, 702 (2013)
[7] I. Kakeya, and H. Wang, Supercond. Sci. Technol. **29**, 073001 (2016)
[8] T. Kashiwagi *et al*., Appl. Phys. Lett. **107**, 082601 (2015)

Thursday, 10 August 2017
15.40-16.00
Congress Hall

030

Direct evidence for an internal degree of freedom and broken time reversal symmetry in the B-phase of UPt_3

Eskildsen M.[1], *Avers K.*[2], *Gannon W.J.*[3], *Kuhn S.J.*[1], *Halperin W.P.*[2]
[1]University of Notre Dame, Department of Physics, Notre Dame, United States, [2]Northwestern University, Evanston, United States, [3]Texas A&M University, College Station, United States

With three different mixed (vortex) phases UPt_3 is a paradigm for unconventional superconductivity, and a definitive understanding of the superconducting state in this material has remained elusive. The order parameter structure consistent with a number of experiments is an odd-parity, *f*-wave orbital state of E_{2u} symmetry. This order parameter is chiral and breaks time reversal symmetry in the low-temperature B-phase.

We have performed small-angle neutron scattering studies of the vortex lattice (VL) in UPt_3 in the B- and C-phases with ***H*** // ***c***, finding a previously unknown field-induced VL rotation. The magnitude of the rotation show a subtle magnetic field history dependence; VLs prepared with the field parallel or anti-parallel with respect to initial direction for entry into the B-phase are rotated by different amounts. This suggests an internal degree of freedom associated with the vortex cores, and provides direct evidence for broken time reversal symmetry in the B-phase in non-zero fields by a bulk measurement. This corresponds to an order parameter chirality that is respectively in the same or opposite sense as the VL supercurrent circulation.

Supported by the USDOE Awards DE-FG02-10ER46783 (neutron scattering) and DE-FG02-05ER46248 (crystal growth and characterization).

Thursday, 10 August 2017
15.40-16.00
H1

031

Metallurgy of a quantum solid: plastic deformation of hcp ^{4}He

<u>Cheng Z.G</u>, Beamish J
University of Alberta, Physics, Edmonton, Canada

In the elastic regime of solids, stress is proportional to strain and independent of strain rate. For larger strains the relationship becomes nonlinear, reflecting plastic deformations involving creep, yield, slip and work hardening. Most of these phenomena involve glide or climb of dislocations and, at large strains, their multiplication and entanglement. Here we report our observations of creep, slip, and yield in hcp ^{4}He - a quantum solid with elastic moduli orders of magnitude lower than conventional solids and in which some dislocations are extraordinarily mobile. Above 0.6 K, the crystals deformed via thermally activated creep, with flow stresses that decreased when the temperature or strain rate was raised. At lower temperatures, sudden drops in stress appeared when the strain exceeded a threshold. These slip events reflect dislocation avalanches and were less frequent after repeated strain cycling, which suggests that dislocations multiply and entangle, effectively strengthening the solid (work hardening). Annealing the samples above 0.6 K, where creep is observed, restores the original behavior. We are studying the slip at temperatures as low as 20 mK, where the deformation is nonthermal and may reveal new quantum behavior involving dislocations.

Thursday, 10 August 2017
15.40-16.00
G2

032

Elementary excitations of fluctuating-stripe state in quantum spin chain

Pregelj M.[1], Zorko A.[1], <u>Gomilšek M.</u>[1], Zaharko O.[2], Coomer F.[3], Ivek T.[4], Berger H.[5], Arčon D.[1,6]
[1]Jozef Stefan Institute, Ljubljana, Slovenia, [2]Paul Scherrer Institute, Villigen, Switzerland, [3]ISIS Facility, Rutherford Appleton Laboratory, Didcot, United Kingdom, [4]Institute of Physics, Zagreb, Croatia, [5]Ecole Polytcchnique Federal de Lausanne, Lausane, Switzerland, [6]Faculty of Mathematics and Physics, University of Ljubljana, Ljubljana, Slovenia

Elementary excitations are a basic concept used to describe dynamical processes in condensed matter and are essential for explaining fundamental physical phenomena. Their variety is vast; ranging from established phonons and magnons to exotic magnetic monopoles [1] and Majorna fermions [2]. Yet, when order parameters intertwine, identification of elementary excitations is extremely difficult. For instance, the elusive excitations in high-temperature superconductors that propel enigmatic fluctuating-charge-stripe, i.e., electronic nematic, phases [3] are still unidentified.

Here we report on a new type of elementary excitations in a spin-stripe state, which occur as two perpendicular amplitude-modulated magnetic components with different modulation periods slide through each other. Exploring the frustrated zigzag spin-1/2 chain compound b-$TeVO_4$ [4,5] by muon-spin relaxation and dielectric spectroscopy, we find that the spin-orbit coupling introduces sizable anisotropic- and biquadratic-exchange interactions, which stabilize the spin-stripe phase and set the energy scale of underlying excitations. b-$TeVO_4$ thus offers a unique perspective on the stripe physics that avoids the problem of intertwining degrees of freedom, which hinders the research in high-temperature superconductors.

References:

[1] C. Castelnovo et al., Nature **451**, 42 (2008).
[2] A. Banerjee et al., Nat. Mater. **15**, 733 (2016).
[3] R. M. Fernandes et al., Nature Phys. **10**, 97 (2014).
[4] M. Pregelj et al., Nature Commun. **6**, 7255 (2015).
[5] M. Pregelj et al., Phys. Rev. B **94**, 081114 (2016).

Thursday, 10 August 2017
09.00-09.45
Congress Hall

033

Topological superconductors derived from topological insulators

Ando Y.
University of Cologne, Physics Institute II, Cologne, Germany

After the discovery of topological insulators (TIs), it was recognized that similar topological concepts can be applied to superconductors, which have an energy gap as is the case of insulators. Such a recognition led to the interest in topological superconductors as a new class of topological materials [1]. In this talk, I will discuss why the normal-state band structures of TIs provide particularly promising grounds for topological superconductivity. Both the 3D bulk band structure of a certain TI materials and the 2D surface band structure of TIs can be responsible for topological superconductivity. The superconductor $Cu_xBi_2Se_3$ is an example of the former, and I will present accumulating evidence that this material realizes a peculiar topological superconducting state characterized by a “nematic” order parameter [2,3]. I will also discuss that the proximity-induced superconductivity on the surface of TIs provides a promising platform for realizing localized Majorana zero modes, which allow for encoding quantum information and could be used for topological quantum computation.

This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant No 741121) and from DFG (CRC1238 Project A04).

References:

[1] M. Sato and Y. Ando, Topological superconductors: a review, **Rep. Prog. Phys. 80**, 076501 (2017).
[2] K. Matano, M. Kriener, K. Segawa, Y. Ando, and G.-Q. Zheng, Spin-rotation symmetry breaking in the superconducting state of $Cu_xBi_2Se_3$, **Nature Phys. 12**, 852 (2016).
[3] S. Yonezawa, K. Tajiri, S. Nakata, Y. Nagai, Z. Wang, K. Segawa, Y. Ando, and Y. Maeno, Thermodynamic evidence for nematic superconductivity in $Cu_xBi_2Se_3$, **Nature Phys. 13**, 123 (2017).

Thursday, 10 August 2017

09.00-09.45
H1

034

From roton to quantum droplets: dipolar quantum gases echo He superfluid phenomena

Ferlaino F.
University of Innsbruck, Innsbruck, Austria

With the tremendous advances in cooling and manipulation techniques, ultracold atomic gases have consolidated themselves as an ideal system to address fundamental questions in quantum fluid physics. Recently, we have produced Bose and Fermi quantum gases of dipolar character with ultra-cold Erbium atoms, which possess an unusually large magnetic moment.
In the quantum regime, Er Bose-Einstein condensates feature two sources of interactions of genuinely different nature. The ordinary short-range van-der-Waals interaction combines with the long-range and anisotropic magnetic dipole-dipole interaction. The mere existence and competition between these two sources of interactions dictate the physics at play, disclosing a variety of intriguing phenomena in close connection to superfluid He.
This talk will provide an overview of some fascinating dipolar phenomena from the Innsbruck prospective, including the first observation of roton in the gas and quasi-self-bound quantum droplets.

Thursday, 10 August 2017
09.45-10.30
Congress Hall

035

Fermi surface instabilities and field induced phenomena in ferromagnetic superconductors

Aoki D.
Tohoku University, IMR, Oarai, Japan

The coexistence of ferromagnetism and superconductivity is one of the most interesting topics in the correlated electron systems[1]. The microscopic coexistence is established in three uranium ferromagnets, UGe2, URhGe and UCoGe. The large internal field due to the ferromagnetism is not compatible with the superconductivity based on the spin-singlet state. Therefore the spin-triplet state is believed to be realized. Surprisingly the field-reentrant (reinforced) superconductivity is observed with the extremely large upper critical field. The unusual superconducting behavior is due to the ferromagnetic fluctuations and Fermi surface instabilities under magnetic field. The microscopic evidence for the ferromagnetic fluctuations is given by the NMR experiments. The Fermi surface instabilities at high fields are clearly observed in the quantum oscillations and thermopower measurements. We review our recent studies on URhGe and UCoGe with fine tuning field angle and pressure, focusing on the Fermi surface instabilities and field induced phenomena[2,3,4]. This work was done in collaboration with G. Bastien, A. Gourgout, B. Wu, G. Knebel, A. Pourret, D. Braithwaite, J. P. Brison, A. Nakamura, S. Araki, Y. Tokunaga, A. Nikitin, A. de Visser and J. Flouquet.

References:

[1] D. Aoki and J. Flouquet: J. Phys. Soc. Jpn. 81, 011003 (2012)
[2] B. Wu, G. Bastien, M. Taupin, C. Paulsen, L. Howald, D. Aoki, J. P. Brison: Nature Com. 8, 14480 (2017).
[3] G. Bastien, A. Gourgout, D. Aoki, A. Pourret, I. Sheikin, G. Seyfarth, J. Flouquet and G. Knebel: Phys. Rev. Lett. 117, 206401 (2016).

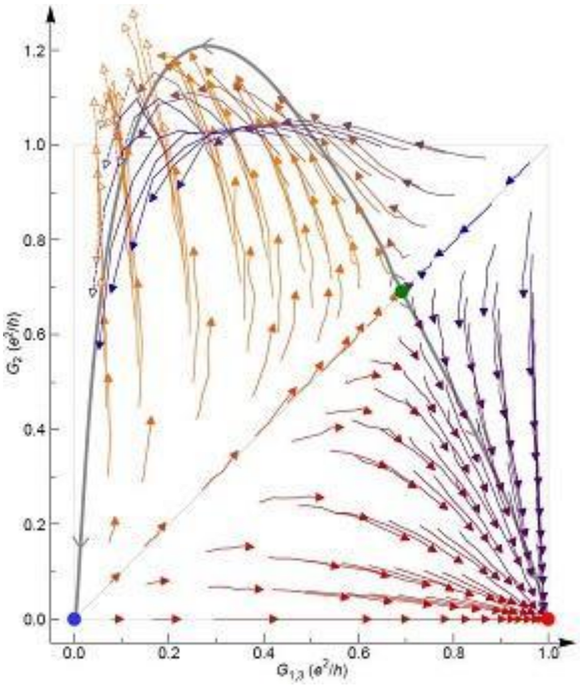
[4] A. Gourgout, A. Pourret, G. Knebel, D. Aoki, G. Seyfarth and J. Flouquet: Phys. Rev. Lett. 117, 046401 (2016).

Thursday, 10 August 2017
09.45-10.30
G3

036
Tunable quantum criticality and super-ballistic transport in a circuit

Pierre F.[1], *Iftikhar Z.*[1], *Anthore A.*[1,2], *Mitchell A.*[3], *Parmentier F.*[1], *Gennser U.*[1], *Ouerghi A.*[1], *Cavanna A.*[1], *Mora C.*[4], *Simon P.*[5]
[1]CNRS, Université Paris Sud-Université Paris-Saclay, C2N, Marcoussis, France, [2]Université Paris-Diderot-Sorbonne Paris Cité, Marcoussis, France, [3]University College Dublin, Dublin, Ireland, [4]Ecole Normale Supérieure-PSL Research University, CNRS, Univ Paris Diderot-Sorbonne Paris Cité, UPMC-Sorbonne Universités, LPA, Paris, France, [5]Université Paris Sud-Université Paris-Saclay, CNRS, LPS, Orsay, France

The exotic 'quantum critical' physics that develops in the vicinity of quantum phase transitions is believed to underpin the fascinating behaviors of many strongly correlated electronic systems, such as heavy fermions and high temperature superconductors. However, the microscopic complexity impedes their quantitative understanding.
Tunable circuits could circumvent this obstacle. With a device implementing a quantum simulator for the three-channel 'charge' Kondo model [1], we explore the rich strongly correlated physics in two profoundly dissimilar regimes of quantum criticality [2]. The universal scalings, both toward different low-temperature fixed points and along the multiple crossovers from quantum criticality, are observed. Notably, we demonstrate an unanticipated violation of the maximum conductance for ballistic free electrons, in agreement with novel numerical renormalization group calculations.



[Three-channel Kondo renormalization flow.]

References:

[1] K. Matveev, Sov. Phys. JETP **72**, 892 (1991); K. Matveev, Phys. Rev. B **51**, 1743 (1995).
[2] Z. Iftikhar *et al.*, Nature **526**, 233 (2015); Z. Iftikhar *et al.*, submitted.

Thursday, 10 August 2017
09.45-10.30
H1

037
Experiments on quantum turbulence in superfluid ^{4}He in the zero-temperature limit
Golov A.
The University of Manchester, School of Physics and Astronomy, Manchester, United Kingdom

Manchester experiments on the generation and detection of tangles of vortex line in superfluid ^{4}He at temperatures T < 0.2K, when the viscous normal component is virtually absent, are reviewed. In most of them, negative ions (electron bubbles), trapped by vortex lines and rings, are used to force and detect turbulence. Free decay of Vinen (unstructured) [1] and Kolmogorov (quasiclassical) [2] turbulence, as well as of their controlled mix [3], is observed and analyzed. The decay rate, its dependence on the polarization of vortex tangles, and mechanisms of energy cascade and dissipation at quantum length scales are discussed. Evidence for the change, below T ~ 0.8K, of the boundary conditions at solid walls from no-slip to free-slip is presented [2]. A finite critical amplitude of forcing for the transition to turbulence in steady rotation, i.e. from arrays to tangles of vortex line, is observed [4]. Attempts to investigate processes at quantum length scales and preparations for the visualization of vortex lines at T < 0.2K are outlined.
References:
[1] P. M. Walmsley and A. I. Golov, Phys. Rev. Lett. **100**, 245301 (2008).
[2] D. E. Zmeev, P. M. Walmsley, A. I. Golov, P. V. E. McClintock, S. N. Fisher, and W. F. Vinen Phys. Rev. Lett. **115**, 155303 (2015).
[3] P. M. Walmsley and A. I. Golov, Phys. Rev. Lett. **118**, 134501 (2017).
[4] P. M. Walmsley and A. I. Golov. Phys. Rev. B **86**, 060518(RC) (2012).

Thursday, 10 August 2017
11.00-11.30
H1

038
Superconductivity at extremely low carrier density: ultra pure Bismuth crystal
Ramakrishnan S., Prakash O., Thamizhavel A., Kumar A.
Tata Institute of Fundamental Research, Condensed Matter Physics and Materials Science, Mumbai, India

Bismuth (Bi) has played a very important role in uncovering many interesting physical properties in condensed matter research [1] and continues to draw enormous scientific interests due to its anomalous electronic properties. Unlike metals where there is roughly one mobile electron per atom, in a semi-metal like Bi, the concentration of mobile electrons is extremely low (100,000 atoms share a single mobile electron). Hence, the superconductivity (SC) in bulk Bi is thought to be very unlikely at a currently achievable temperature (~0.04 mK). In this talk, I will describe the first-ever observation of bulk SC in Bi single crystals (99.9999%) below **0.53 mK** under ambient pressure with an estimated critical magnetic field of **0.0052 mT (one eighth of earth's magnetic field)** at absolute zero [2]. The

standard models (superconductivity) cannot explain this phenomenon because the characteristic thermal energy is comparable to the Fermi energy in Bi and a new theory is necessary.

References:
[1]. V.S. Edel'man, Advances in Physics, 25, 555 (1976) and references cited therein.
[2]. Om Prakash, Anil Kumar, A. Thamizhavel and S. Ramakrishnan, Science Vol. 355, Issue 6320, pp. 52-55 (2017).

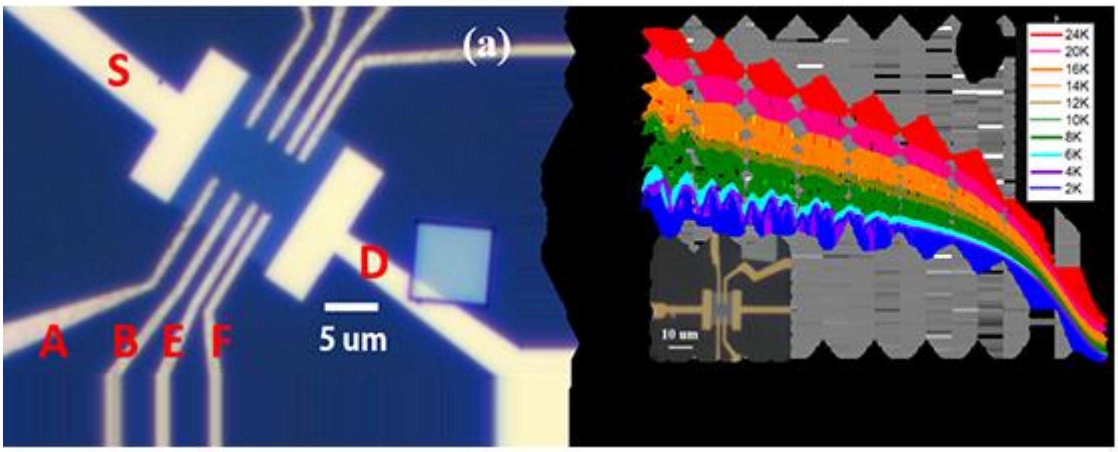
Thursday, 10 August 2017
11.00-11.30
G3

039

Quantum coherent transport characteristics of two-dimensional semiconducting Bi_2O_2Se nanoplates

<u>Meng M.</u>[1], Huang S.[1], Wu J.[2], Jing Y.[1], Peng H.[2], Xu H.Q.[1,3]
[1]Peking University, Beijing Key Laboratory of Quantum Devices, Key Laboratory for the Physics and Chemistry of Nanodevices and Department of Electronics, Beijing, China, [2]Peking University, Center for Nanochemistry, Beijing National Laboratory for Molecular Sciences (BNLMS), College of Chemistry and Molecular Engineering, Beijing, China, [3]Lund University, Division of Solid State Physics, Lund, Sweden

Recently, the inventionof 2D semiconducting Bi_2O_2Se nanoplates has attracted a lot of interest[1]. CVD grown Bi_2O_2Se nanoplates possess not only a band energy gap ~0.8 eV for logical circuits, but also is air-stable. The top-gate field effect transistors of Bi_2O_2Se nanoplates display excellent performance at room temperature, see Ref 1.
In this report, we systematically investigate the transport characteristics of a Bi_2O_2Se nanoplate. In a typical high mobility sample, ~20000 cm^2/V×s at 2 K, we observe the Shubnikov-de Haas (SdH) oscillations, indicating great advantages as a host material for the exploration of novel quantum condensed states. On the other hand, the presence of weak disorders, introduced during material growth and device fabrications, may degrade the mobility. We study the coherent transport on Bi_2O_2Se nanoplates in terms of weak localization (WL) effect and universal conductance fluctuations (UCFs) in a weak disordered sample. The extracted phase-coherence length (L_j) reaches at ~60 nm at 2 K, larger than the nanoplate thickness ~ 9 nm and is proportion to $T^{-0.5}$, indicating the 2D transport nature. We also find that UCFs can survive in a length scale as far as 4.6 um. Our result may offer guide to help to design quantum device in Bi_2O_2Se nanoplates in the future.



[Figure. (a) OM (b)SdH oscillations]

References:
1. J. Wu, H. Yuan, M. Meng, C. Chen, Y. Sun, Z. Chen, W. Dang, C. Tan, Y. Liu, J. Yin, Y. Zhou, S. Huang, H. Q. Xu, Y. Cui, H. Y. Hwang, Z. Liu, Y. Chen, B. Yan and H. Peng, Nature nanotechnology (2017). DOI: 10.1038/NNANO.2017.43.
2. H. Boller, Monatshefte Fur Chemie **104** (4), 916-919 (1973).

Thursday, 10 August 2017
11.00-11.30
G2

040

Frustrated magnetism in strongly correlated oxides with large spin-orbit coupling

Gegenwart P.
Augsburg University, Institute of Physics, Augsburg, Germany

Frustrated magnets with competing interactions and anisotropies can host topologically non-trivial quantum ground states and spin excitations. We focus on model materials in the class of strongly correlated oxides with large spin-orbit coupling that will serve as experimental realizations of this intriguing physics. Magnetic properties of two- and three-dimensional honeycomb iridates [1,2] and rhodates [3], as well as the triangular mixed valence iridate Ba3InIr2O9 [4] will be discussed. We also focus on the rare-earth based triangular quantum magnet YbMgGaO4 [5,6].

Work in collaboration with A.A. Tsirlin, F. Freund, A. Jesche, R. Manna, S. Manni, I. Pietsch, Yuesheng Li, S. Choi, S. Williams, R. Coldea, P. Khuntia, M. Baenitz.

References:
1. S. C. Williams et al., PRB **93**, 195158 (2016).
2. F. Freund et al., Sci. Rep. 6 (2016) 35362.
3. P. Khuntia et al., arXiv:1512.04904
4. T. Dey et al., arXiv:1702.08305
5. Y. Li et al., PRL 117, 097201 (2016)
6. Y. Li et al., PRL 118, 107202 (2017)

Thursday, 10 August 2017
11.00-11.30
Congress Hall

041

Color code quantum computation with Majorana bound states[*]

von Oppen F.
Freie Universität Berlin, Berlin, Germany

Semiconductor quantum wires proximity coupled to superconductors have become the material of choice to realize Majorana bound states. Recent experimental as well as material-science progress has intensified the search for implementations of topological quantum computation. In this talk, I will sketch recent ideas to realize quantum error correction on the basis of wire networks. Specifically, I will argue that color codes provide a natural setting in which advantages offered by topological hardware can be combined with those arising from topological error-correcting software [*]. Most importantly, color codes have a set of transversal gates which coincides with the set of topologically protected gates in Majorana-based systems, namely the Clifford gates. We illustrate the scheme by providing a complete description of a possible architecture.

References:

[*] D. Litinski, M. S. Kesselring, J. Eisert, F. von Oppen, *Combining Topological Hardware and Topological Software: Color Code Quantum Computing with Topological Superconductor Networks,* arXiv:1704.01589 (2017).

Thursday, 10 August 2017
11.00-11.30
G1

042

The quasiparticles in superfluid ^{3}He near T=0 behave well for imaging, but where are they at supercritical velocities?

Pickett G.
Lancaster University, Department of Physics, Lancaster, United Kingdom

We have been studying the dynamics of the almost negligible gas of quasiparticles in superfluid ^{3}He in the zero temperature limit ($T \sim 0.1T_c$). Of course the very low density implies ballistic collisionless transport for the quasiparticles, which coupled with the relative ease of detecting them, has allowed us to make increasingly sophisticated imaging experiments using a multi-pixel quasiparticle “retina”. For example we can “watch” pair breaking by a moving object as imaged on the retina. In that context the quasiparticle gas does what we want. However, surprisingly, at these low temperatures, the quasiparticle gas is too tenuous to provide a proper continuous “normal fluid” and thus the communication of movement in the quasiparticle gas is very poor. Moving surfaces go “undetected” by the superfluid, which very counter-intuitively allows dissipationless motion of moving objects in the superfluid well beyond the Landau critical velocity.

Thursday, 10 August 2017
14.00-14.30
Congress Hall

043

Intertwined orders in superconducting heavy-fermion $CeCoIn_5$

Kim D.Y.[1], Weickert F.[1], Kenzelmann M.[2], Bauer E.D.[1], Ronning F.[1], Thompson J.D.[1], Movshovich R.[1]
[1]Los Alamos National Laboratory, MPA-CMMS, Los Alamos, United States, [2]Paul Scherrer Institute, Laboratory for Scientific Developments & Novel Materials, Villigen, Switzerland

We present measurements of the thermal conductivity of heavy-fermion superconductor $CeCoIn_5$ in rotating magnetic field, that provide a clear evidence for intertwined orders in its high field superconducting (HFSC) phase [1]. Experiments were performed in a dilution refrigerator coupled with a superconducting magnet, allowing investigations down to 20mK and fields up to 14T. The sample, polished with a long axis in the [110] direction of tetragonal $CeCoIn_5$, nodal for its $d_{x^2-y^2}$ order parameter, was mounted with c-axis parallel to the horizontal axis of rotation of a piezo-electric rotator. Recent neutron scattering measurements [2] indicated that the SDW order in the HFSC phase is

single-domain. The ordering wave-vector ***Q*** switches abruptly when magnetic field is rotated through the anti-nodal [100] direction, with ***Q*** choosing the direction (node) more perpendicular to the magnetic field. The direction of ***Q*** in our experiment, therefore, switches from being parallel to perpendicular to the heat current. The observed anisotropy of the heat current calls for a presence of a third order intertwined with the *d*-wave and SDW. A *p*-wave pair-density-wave, proposed to exist on theoretical grounds, can explain our results. An FFLO scenario[3], slightly modified, may also explain our results.

References:

[1] Duk Y. Kim, Shi-Zeng Lin, Franziska Weickert, Michel Kenzelmann, Eric D. Bauer, Filip Ronning, J. D. Thompson, and Roman Movshovich, Phys. Rev. X, **6**, 041059 (2016).
[2]. S. Gerber, M. Bartkowiak, J. L. Gavilano, E. Ressouche, N. Egetenmeyer, C. Niedermayer, A. D. Bianchi, R. Movshovich, E. D. Bauer, J. D. Thompson, and M. Kenzelmann, Nat. Phys. **10**, 126 (2014).
[3] Y. Hatakeyama and R. Ikeda, Phys. Rev. B **91**, 94504 (2015).

Thursday, 10 August 2017
14.00-14.30
G2

044

Topological honeycomb materials

Kee H.Y.
University of Toronto, Department of Physics, Toronto, Canada

Interplay between spin-orbit coupling and electronic correlation plays an important role in determining a variety of novel phases in quantum materials.[1] In particular layered honeycomb materials are candidates for topological phases ranging from Haldane model to Kitaev spin liquid. Among several intriguing materials, I will focus on α-$RuCl_3$, quasi-two dimensional honeycomb lattice.[2] Theoretical studies on bond-dependent spin exchange interactions including Kitaev spin term and phase transitions will be presented.[3] Possible magnetic orderings, topological edge states [4], and route to spin liquids will be also discussed.

References:

[1] J. G. Rau et al, Annual Review of Condensed Matter Physics 7:195-221 (2016).
[2] K. W. Plumb et al, Phys. Rev. B 90, 041112 (2014).
[3] J. G. Rau et al, Phys. Rev. Lett. 112, 077204 (2014).
[4] A. Catuneanu et al, Phys. Rev. B 94, 121118 (2016).

Thursday, 10 August 2017
14.00-14.30
G3

045

Quantum microwave generated by electronic shot noise in a normal conductor

Reulet B., Simoneau J.-O., Virally S., Forgues J.-C.
Université de Sherbrooke, Département de Physique, Sherbrooke, Canada

A classical current in a conductor radiates a classical electromagnetic field. We explore some properties of the field radiated by a conductor when electron transport must be described by quantum mechanics, i.e. when the electron current becomes quantum itself. Using a tunnel junction between normal metal contacts placed at ultra-low temperature as a quantum conductor, we demonstrate the existence of squeezing as well as entanglement in the microwave radiation, thus proving that the electron shot noise generates a quantum electromagnetic field. We measure the photon statistics of that field, i.e., photon shot noise, that directly shows that the quantum conductor emits photons by pairs.

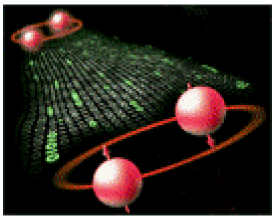
Thursday, 10 August 2017
14.00-14.30
G1

046

Condensed matter, quantum fluids and quantum simulation

Le Hur K.
Centre de Physique Theorique, Ecole Polytechnique, Palaiseau, France

Quantum materials exhibit emergent collective behaviors giving rise to exotic quantum phases and quantum phase transitions. The recent progress in « quantum control » in ultra-cold atoms, nanotechnology and quantum electrodynamics circuits also allows to engineer many-body Hamiltonians and quantum fluids of matter and light, with modern applications in quantum information, Feynman simulation and quantum computation.



[Logo]

We will discuss at a general level a few relations between

- Emergent phases and quantum phase transitions
- Topological phases and gauge theories, Anderson Resonating Valence Bond States and topological superconductivity, Mott physics and Magnetism
- Applications in « protected » quantum transport and quantum computing
- Sensing (dynamics, transport, light-matter phenomena, Floquet engineering)
- Quantum information perspectives, entanglement measures

The presentation will be based on reviews we wrote on related subjects. Co-authors will be introduced in the presentation.

Thursday, 10 August 2017
14.00-14.30
H1

047

Visualizing chiral domain structure in a sheet of superfluid ^{3}He-A by magnetic resonance imaging

Sasaki Y.[1,2]

[1]Kyoto University, Department of Physics, Kyoto, Japan, [2]Kyoto University, Research Center for Low Temperature and Materials Sciences, Kyoto, Japan

The stable texture in a sheet of superfluid ^{3}He-A under in-plane magnetic field is believed to be a uniform dipole-locked texture of parallel spin anisotropic vector ***d*** and orbital anisotropic vector ***l*** except for a slight distortion near the edge of the sheet. However, the real space images of the texture obtained by specialized magnetic resonance imaging revealed that they are easy to hold planar textural defects, which have no significant footprint such as visible satellite peak in the NMR spectrum. We have shown that they are the chiral domain walls in between domains with opposite chirality. Main part of the wall consists of dipole-locked soliton, in which the ***l=d*** vectors rotate from a direction perpendicular to the sheet to the opposite direction over a distance comparable to a thickness of the sheet. The domain structure is rather stable at temperatures far below the superfluid transition temperature T_C. However, we find that at temperatures near T_C the domain walls move spontaneously or under the influence of external flow. Thus we could marginally manipulate the chiral domain structure with flow, although we have never observed a texture without chiral domain walls.

Thursday, 10 August 2017
14.50-15.20
Congress Hall

048

NMR study of rotational and superconducting symmetry in URu_2Si_2

Kambe S.[1], Hattori T.[1], Sakai H.[1], Tokunaga Y.[1], Matsuda T.D.[2], Haga Y.[1], Walstedt R.E.[3]

[1]Japan Atomic Energy Agency, Advanced Science Research Center, Tokai-mura, Japan, [2]Tokyo Metropolitan University, Department of Physics, Hachioji, Japan, [3]University of Michigan, Physics Department, Ann Arbor, United States

In strongly correlated 5f-electrons systems, exotic electronic states appear due to the competition between itinerant and localized nature of the 5f electrons. The appearance of unconventional superconductivity within the hidden ordered state in URu_2Si_2 is a typical example of it. In this study, the rotational symmetry of the hidden ordered state and the superconducting gap symmetry are investigated by means of ^{29}Si NMR. As previously reported [1-3], a rather weak breakdown of 2-fold rotational order is distributed in the basal plane of the hidden ordered state. The local 4-fold symmetry is consistently supported via the Ruderman-Kittel interaction between nearest-neighbor Si sites determined by the NMR spin echo decay in the present study. The origin of a muted 2-fold symmetry reported earlier will be discussed. Concerning the superconducting gap symmetry, the T-dependence of the Knight shift along the *a* [4] and *c* [5] axes indicates that singlet pairing (*i.e.* d-wave) is likely for the superconducting state of URu_2Si_2. This result also indicates the strongly anisotropic spin susceptibility ($\chi_c >> \chi_a$), consistent with the previous quantum oscillation measurements [6], which may also be characteristic of the hidden ordered state.

References:

[1] S. Kambe et al, PRL 110, 246406 (2013).
[2] S. Kambe et al, PRB 91, 035111 (2015).
[3] R.E. Walstedt et al, PRB 93, 045122 (2016).
[4] T. Hattori et al, JPSJ 85, 073711 (2016).
[5] T. Hattori et al, in preparation.

[6] M.M. Altarawneh et al PRL 108, 066407 (2012).

Thursday, 10 August 2017
14.50-15.20
H1

049

Magnetic waves on ^{3}He surfaces

Todoshchenko I., Savin A., Haataja M., Hakonen P.J.
Aalto University, Low Temperature Laboratory, Deptartment of Applied Physics, Espoo, Finland

Interfaces between different ^{3}He phases are extremely rich physical systems. At low enough temperatures ^{3}He interfaces support phase waves, like crystallization waves [1] or massless phase waves on the A-B interface [2].
The phase waves in ^{3}He are very unusual due to a significant magnetic contribution from spin supercurrents to the inertia. These waves present unique, directly observable objects which violate the Equivalence principle postulating the identity between gravitational and inertial masses [3].
In our experiments on crystallization waves a quartz tuning fork placed in liquid helium near the liquid-solid interface was used as a displacement sensing element [4]. High quality factor of the fork made it possible to detect amplitude of surface oscillations down to 1 Å by measuring the detuning of the fork. Such sensitive detection allowed us to apply relatively low AC voltage to the capacitor used for excitation of the surface waves. This experimental configuration resulted in a record low, of the order of 20 pW, heat dissipation to the helium sample and allowed us to cool the ^{3}He below 0.4 mK and to obtain the first evidence of the crystallization waves. We report also the results of preliminary measurements in a magnetic field.

References:

1. A.F. Andreev and A.Ya. Parshin, *Sov. Phys. JETP* **48**, 763 (1978).
2. I. Todoshchenko, *Phys. Rev. B* **93**, 134509 (2016).
3. A. Einstein, *Jahrbuch der Radioaktivität und Elektronik* **4**, 411 (1907).
4. I. Todoshchenko, A. Savin, M. Haataja, J.-P. Kaikkonen, and P.J. Hakonen,
Appl. Phys. Lett. **110**, 071601 (2017).

Thursday, 10 August 2017
14.50-15.20
G3

050

Finite frequency admittance of a phase biased NS ring with large spin-orbit interactions

Bouchiat H.[1], Murani A.[2], Dassonneville B.[1], Guéron S.[1], Chepelianskii A.[1]
[1]LPS Université Paris Sud, Orsay, France, [2]Université Paris Sud, Orsay, France

We discuss the finite frequency admittance (susceptibility) of a phase biased hybrid NS ring whose normal part is constituted by a quantum wire with large spin-orbit interactions. At finite temperature this quantity is very sensitive to Andreev level crossings and the lifting of their degeneracy by a small Zeeman field. We focus on the case where the wire is made of 2D topological insulator with 1D helical edges protected against disorder.. The finite frequency admittance carries then a very specific signature at low temperature of a protected Andreev level crossing at pi and zero energy in the form of

a sharp peak at phase pi. We present recent experiments obtained on Bi nanowires inserted in a multimode superconducting resonator which can be interpreted along these lines.

References:
A.Murani et al. arXiv:1609.04848 to appear in Nature Communicatons.
A. Murani et al. arXiv:1611.03526

Thursday, 10 August 2017
14.50-15.20
G1

051
Creation of vortex solitons due to the motion of trapped electrons along quantized vortices
<u>Walmsley P.</u>[1], Villois A.[2], Salman H.[2], Golov A.[1]
[1]University of Manchester, School of Physics and Astronomy, Manchester, United Kingdom,
[2]University of East Anglia, School of Mathematics, Norwich, United Kingdom

We have measured the mobility and limiting terminal velocity of electron bubbles (negative ions) sliding along vortex lines in superfluid ^{4}He for a broad range of temperatures (0.1 - 1 K). This allows dissipative processes at small length scales to be probed, which can include drag exerted by an excess density of excitations in the vicinity of the vortex core; the scattering and generation of vortex waves and solitons; condensation of ^{3}He impurity atoms onto vortex cores.
Using a Gross-Pitaevskii model, we simulate the dynamics of an ion trapped on a quantized vortex line. The fully 3D simulations reproduce the complex spatio-temporal dynamics and reveal that a soliton-ion complex forms on the vortex and this characterises the behaviour of the ion in the zero temperature limit. We interpret the experimental measurements below 0.7 K in terms of these novel excitations.

Thursday, 10 August 2017
14.50-15.20
G2

052
Observation of magnetic fragmentation in pyrochlore spin ices
<u>Lhotel E.</u>
Institut Néel CNRS, Grenoble, France

Magnetic fragmentation is a new state of matter in which the magnetic moment fragments, leading to the superposition of a magnetically ordered phase and a persistently fluctuating one, which is a Coulomb phase [1]. This fragmentation can occur in spin ice, a correlated but disordered ground state governed by a local constraint, the ice-rule, when the density of magnetic excitations that locally violate the ice-rule, is large enough. These excitations, the magnetic monopoles, can then organise as a crystal of alternating magnetic charges resulting in the fragmentation of the magnetic moment.
I will present two examples of realization of this fragmentation mechanism in pyrochlore oxide materials. Firstly, I will focus on $Nd_2Zr_2O_7$, where we have observed fragmentation in neutron scattering experiments through the superposition of an all in-all out ordered state, with a reduced

magnetic moment, and a pinch point pattern, characteristic of the Coulomb phase [2]. The finite energy of the pinch point pattern points out the quantum origin of the fragmentation in this system [3]. Secondly, I will present our results on $Ho_2Ir_2O_7$, where we have shown that fragmentation of the Ho magnetic moment can be produced by the injection of magnetic charges through the iridium molecular field [4].

References:

[1] M.E. Brooks-Bartlett et al., Phys. Rev. X **4**, 011007 (2014).
[2] S. Petit et al., Nature Phys. **12**, 746 (2016).
[3] O. Benton, Phys. Rev. B **94**, 104430 (2016).
[4] E. Lefrançois et al. To appear in Nature Commun.

Friday, 11 August 2017
11.30-11.50
G2

053

Importance of virtual singlets in RVB theory of quantum spin liquids

Ralko A.[1], *Mila F.*[2], *Rousochatzakis I.*[3]
[1]Institut Néel, CNRS and University Grenoble Alpes, Grenoble, France, [2]Ecole Polytcchnique Federal de Lausanne, Lausanne, Switzerland, [3]School of Physics and Astronomy, University of Minnesota, Minneapolis, United States

It is well known that the low-energy sector of quantum spin liquids and other magnetically disordered systems is governed by short-ranged resonating-valence bonds. Here, we will show that the standard minimal truncation to the nearest neighbor valence-bond basis fails completely even for systems where it should work the most, according to received wisdom. This paradigm shift is demonstrated for both the quantum spin-1/2 square-kagome [1] and kagome [2] lattices, where the strong geometric frustration prevents magnetic ordering down to zero temperature. In the former, the shortest tunneling events bear the strongest longer-range fluctuations, leading to amplitudes that do not drop exponentially with the length of the loop, and to an unexpected loop-six valence-bond crystal, which is otherwise very high in energy at the minimal truncation level. In the latter, we will show from preliminary results [3] how the virtual singlets help in understanding the complex structure of the spin liquid of the RVB description of spin-1/2 kagome antiferromagnets by evidencing the proximity of a diamond-like crystal and making comparison with DMRG data.

References:

[1] A. Ralko and I. Rousochatzakis, Phys. Rev. Lett. 115 167202 (2015)
[2] I. Rousochatzakis, Y. Wan, O. Tchernyshyov and F. Mila, Phys. Rev. B 90 100406(R) (2014)
[3] A. Ralko, F. Mila and I. Rousochatzakis, in preparation (2017)

Friday, 11 August 2017
11.30-11.50
G1

054

Dynamics of surface Andreev-bound states and superfluidity beyond the Landau velocity in ^{3}He-B

Bradley D.I., Fisher S.N., Guénault A.M., Haley R.P., Pickett G.R., Schanen R., Tsepelin V., Vonka J., Zmeev D.E.
Lancaster University, Lancaster, United Kingdom

Recently, it has been shown that superfluidity in ^{3}He-B can survive in flows past objects at velocities far exceeding the critical Landau value [1]. The model supporting this phenomenon suggests that the Andreev-bound states on the surface of the moving object are emitted into bulk, causing dissipation only during acceleration. Meanwhile, the mechanism for breaking bulk Cooper pairs does not appear to exist for arbitrarily fast uniform motion in our experimental configuration.
We have developed a set of experimental techniques to measure the lifetime of the surface Andreev-bound states (SABS) responsible for the dissipation. Our experimental results imply that we can empty certain SABS into bulk in a controllable manner and then observe as they are replenished. We were surprised to find the typical lifetime of SABS to be on the order of 10 milliseconds.
The experiments are performed in the temperature range of 150-220 microkelvin, where the bulk quasiparticle excitations are ballistic. Our measurements provide insight into the dynamics of interaction between the gas of Bogoliubov excitations in a 3D topological superfluid and the corresponding gas of 2D edge states.

References:
[1] D. I. Bradley, S. N. Fisher, A. M. Guénault, R. P. Haley, C. R. Lawson, G. R. Pickett, R. Schanen, M. Skyba, V. Tsepelin & D. E. Zmeev, **Breaking the superfluid speed limit in a fermionic condensate**, Nat. Phys. **12**, 1017 (2016)

Friday, 11 August 2017
11.30-11.50
Congress Hall

055
Effects of reduction annealing on the electron-doped cuprates revealed by ARPES and core-level spectroscopy
Fujimori A.[1], Horio M.[1], Takahashi A.[2], Mori Y.[2], Konno T.[2], Ohgi T.[2], Sato H.[2], Yoshida T.[3], Okazaki K.[4], Suzuki H.[1], Koshiishi K.[1], Ootsuki D.[4], Mizokawa T.[5], Ono K.[6], Kobayashi M.[6], Minohara M.[6], Horiba K.[6], Kumigashira H.[6], Anzai T.[7], Arita M.[7], Namatame H.[7], Taniguchi M.[7], Ideta S.[8], Tanaka K.[8], Yokoyama Y.[4], Takubo K.[4], Hirata Y.[4], Shin S.[4], Wadati H.[4], Yasui A.[9], Ikenaga E.[9], Krockenberger Y.[10], Yamamoto H.[10], Adachi T.[11], Koike Y.[2]
[1]University of Tokyo, Tokyo, Japan, [2]Tohoku University, Sendai, Japan, [3]Kyoto University, Kyoto, Japan, [4]University of Tokyo, Kashiwa, Japan, [5]Waseda University, Tokyo, Japan, [6]KEK Photon Factory, Tsukuba, Japan, [7]Hiroshima University, Higashi-Hiroshima, Japan, [8]Institute for Molecular Science, Okazaki, Japan, [9]SPring-8, Mikazuki-cho, Japan, [10]NTT Basic Research Laboratories, Atsugi, Japan, [11]Sophia University, Tokyo, Japan

In the electron-doped cuprates with the *T*'-type structure such as $Nd_{2-x}Ce_xCuO_4$, superconductivity appears only after appropriate reduction annealing, but strong antiferromagnetic (AFM) correlation is known to persist even in the superconducting phase [1]. Recently, bulk crystals of $(Pr,La)_{2-x}Ce_xCuO_4$ with Ce doping concentrations as low as x ~ 0.05 [2] and thin films of R_2CuO_4 (R = Nd, Pr) without Ce doping [3] have shown superconductivity by improved annealing methods.
We have performed systematic studies of the effects of the improved annealing methods on the *T*'-type cuprates in bulk [4] and thin film forms by ARPES and core-level spectroscopic methods. By reduction annealing, the signature of AFM correlation was suppressed, the electron carrier concentration significantly increased, and the T_c increased over a much wider electron concentration range than the previous reports. Our results indicated that, in addition to the removal of a small amount of apical oxygen atoms which suppress the superconductivity, a significant amount of oxygen

atoms should be removed from “regular” sites (in the block layer and/or the CuO_2 plane), thereby doping the system with a sufficient amount of electron carriers.

References:

[1] E. M. Motoyama *et al.*, Nature **445**, 186 (2007).
[2] T. Adachi *et al*., J. Phys. Soc. Jpn. **82**, 063713 (2013).
[3] Y. Krockenberger *et al*., Sci. Rep. **13**, 2235 (2013).
[4] M. Horio *et al.*, Nat. Commun. **7**, 10567 (2016).

Friday, 11 August 2017
11.30-11.50
H1

056

Possibility of Cooper-pair formation controlled by multi-terminal spin injection

Ohnishi K.[1,2], *Sakamoto M.*[1], *Ishitaki M.*[1], *Kimura T.*[1,2]
[1]Kyushu University, Fukuoka, Japan, [2]Research Center for Quantum Nano-Spin Sciences, Fukuoka, Japan

Recently the ferromagnet (F) / superconductor (S) hybrid structure has been studied intensively since the interplay between superconductivity and ferromagnetism produces various intriguing phenomena[1]. However, in general, the magnetic proximity effect destroys the superconducting properties in the vicinity of F/S junction, resulting in the difficulty of the coexistence of the spin-polarized electrons and Cooper-pairs. In this work, by measuring the spin transport of a normal metal / superconductor bilayer film under the spin injection, we investigate the formation and de-formation processes of the Cooper pairs.
We fabricated three ferromagnetic Ni-Fe nanopillars, which are the dual spin injectors and the spin detector, on a Cu/Nb bilayer film. In this structure, because of the small volume of the nanopillars, the large spin current can be generated by minimizing the Joule heating. In addition, the magnitude of the spin current can be controlled by the magnetic configuration of the injectors.
By analyzing carefully the bias current and magnetic configuration dependences of the spin transports, we find that superconducting property can be suppressed by the spin current. This indicates that the formation process of the Cooper-pair can be affected by the spin current injected.

References:

[1] A. I. Buzdin, Rev. Mod. Phys. **77**, 935 (2005).

Friday, 11 August 2017
11.30-11.50
G3

057

Tying quantum knots

Hall D.S.[1], *Ray M.W.*[2], *Tiurev K.*[3], *Ruokokoski E.*[3], *Gheorghe A.H.*[4], *Möttönen M.*[3,5]
[1]Amherst College, MA, United States, [2]California State University, CA, United States, [3]Aalto University, Espoo, Finland, [4]Harvard University, MA, United States, [5]University of Jyväskylä, Jyväskylä, Finland

The theory of knots has a long history in mathematics and physics since Lord Kelvin proposed knots in ether as a model of atoms [1]. Although this proposal did not work in physical reality, it gave a birth to mathematical study of knots [2]. Recent experiments have observed knots in a variety of classical contexts, including nematic liquid crystals, DNA, optical beams and water. However, no experimental observations of knots have yet been reported in quantum matter. We demonstrate the controlled creation and detection of knot solitons in the order parameter of a spinor Bose-Einstein condensate [3]. The observed texture corresponds to a topologically nontrivial element of the third homotopy group and exhibits the celebrated Hopf fibration, which unites many seemingly unrelated physical phenomena. The very good agreement between the experiments and theory provides conclusive evidence for the existence of the knot soliton. Our observations establish an experimental foundation for future studies of stability and dynamics of three-dimensional topological solitons within quantum systems.

References:

[1] W. Thomson. Proc. R. Soc. Edinburgh VI, 197-206 (1867)
[2] C. C. Adams. The Knot Book (W. H. Freeman, 1994)
[3] D. S. Hall, M. W. Ray, K. Tiurev, E. Ruokokoski, A. H. Gheorghe and M. Möttönen. Nature Physics 12, 478-483 (2016)

Friday, 11 August 2017
11.50-12.10
G1

058
Visualizing quantum turbulence in superfluid ^{3}He-B using quasiparticles

Ahlstrom S.L., Bradley D.I., Guenault A.M., Guise E.A., Haley R.P., Pickett G.R., Poole M., Tsepelin V., Woods A.J.
Lancaster University, Lancaster, United Kingdom

We present experimental studies of quantum turbulence in superfluid ^{3}He-B, the coldest fermionic liquid available. While the flow of bulk superfluid must be irrotational, it can mimic classical turbulence by supporting singly quantised vortices. Measurements were carried out at low temperatures where the thermal excitations in the superfluid comprise ballistic quasiparticles. In addition to normal scattering fermionic excitations can undergo Andreev reflection, which underpins non-invasive imaging of structures present in the superfluid such as quantum vortices or textures. The topological structures in superfluid could be produced via analogues of cosmological processes, for example the Kibble mechanism, or by exceeding the Landau critical velocity and breaking the condensate. We created a 5x5 pixel quasiparticle camera operating at 150 microkelvin and show two-dimensional ´images´ of a quasiparticle beam and of a tangle of quantised vortices (quantum turbulence), that we produced mechanically. Quasiparticle imaging techniques could be used to observe other defects and to investigate pair-breaking processes in ^{3}He.

Friday, 11 August 2017
11.50-12.10
G2

059
Magnetism in a strongly interacting topological Kondo insulator

Peters R., Yoshida T., Kawakami N.
Kyoto University, Kyoto, Japan

Topological Kondo insulators are strongly correlated systems which form a topologically nontrivial hybridization gap at the Fermi energy [1]. Strong correlations have significant impact on the surface states which are protected by the topology. It has been shown that correlations are strongly enhanced at the surface, which can lead to a coexistence of light and heavy surface states or a Kondo break down at the surface [2,3].
However, as commonly observed in heavy fermion materials and Kondo insulators, strong correlations can also lead to a magnetic ground state by tuning parameters such as pressure or doping. Thus, it is natural to ask: What is the impact of a magnetic state on the topology and the topologically protected surface states.
We theoretically analyze a three-dimensional cubic Kondo insulator with nontrivial topology using real-space dynamical mean field theory. Depending on the model parameter, we are able to stabilize different magnetic states in this model. Although the time-reversal symmetry is broken by the magnetic state, we demonstrate that topological surface states can exist in this model, which are protected by the reflection symmetry.

References:
[1] Maxim Dzero et al, Phys. Rev. Lett. 104, 106408 (2010)
[2] Victor Alexandrov et al. Phys. Rev. Lett. 114, 177202 (2015)
[3] Robert Peters et al. Phys. Rev. B 93, 235159 (2016)

Friday, 11 August 2017
11.50-12.10
G3

060
Majorana bound states vs. Shiba states in artificially constructed magnetic Fe atom-chains on superconducting Re(0001)

Kim H., Palacio-Morales A., Posske T., Wiesendanger R.
University of Hamburg, Department of Physics, Hamburg, Germany

A magnetic nanowire with non-collinear spin texture (NCST) on a s-wave superconducting (SC) substrate is a fascinating platform, which has been proposed for observing Majorana bound states (MBS). Recently, evidences for topologically non-trivial end-states were experimentally found for Fe chains on Pb(110) [1-4]. However, such self-assembled nanowires have unavoidable limitations, such as uncontrolled length and orientation, and intermixing of atomic species of the nanowire and the substrate during the annealing process. Here, we demonstrate the fully-controlled formation of atomic chains from individual magnetic Fe adatoms on the SC Re(0001) by atom-manipulation techniques at T=350 mK. Spin-polarized STM results indicate the presence of a NCST, stabilized by interfacial DM interactions similar to Fe chains on Ir(001) [5]. Tunneling spectra measured spatially resolved on the Fe-atom chain reveal the evolution of the local density of states inside the SC gap as well as the development of edge states at the ends of chain, which are distinguishable from trivial ones by increasing the number of atoms within the chain. The experimental results will be compared with model-type calculations supporting the interpretation of the spectroscopic signatures at the ends of the chains as MBS.

References:
[1] S. Nadj-Perge *et al.*, Science **346,** 602 (2014).
[2] M. Ruby *et al.*, Phys. Rev. Lett. **115**, 197204 (2015).
[3] R. Pawlak *et al.*, NPJ Quantum Information **2**, 16035 (2016).
[4] B. E. Feldman *et al.*, Nature Phys. **13**, 286 (2017).
[5] M. Menzel *et al.*, Phys. Rev. Lett. **108**, 197204 (2012).

Friday, 11 August 2017
11.50-12.10
H1

061
The theory of long-range spin-singlet proximity effect for Josephson system with single-crystal ferromagnet nanowire
Avdeev M., *Proshin Y.*
Kazan Federal University, Kazan, Russian Federation

The spin-triplet long-range superconducting proximity effect may arise in superconductor - ferromagnet (SF) structures if there are magnetic inhomogeneities. So, the first observation of the spin-singlet long-range proximity effect for clean SFS system (weak-link through the single-domain monocrystalline ferromagnetic Co nanowire) [1] became surprising. The theoretical model [2] explained this effect by the spin-orbit interaction.
We propose another theoretical model of the long-range Josephson transport. We take into account the Fermi surface anisotropy and the mismatch between the electron effective masses of majority and minority spin bands. The effective renormalized exchange interaction becomes dependent on the quasiparticle momentum direction in nanowire and must be completely compensated under certain conditions; thereby it leads to long-range spatial extent of the supercurrent. With the Eilenberger-like equations, we calculate the critical Josephson current flow through nanowire. The long-range proximity effect [2] can be quantitatively explained within the proposed theoretical framework.
The work is supported by the subsidy allocated to KFU for performing the state assignment in the area of scientific activities. YP is partially supported by the RFBR (16-02-01016).
References:
[1] J. Wang, M. Singh, M. Tian, *et al*., *Nature Physics* **6**, 389 (2010)
[2] A.S. Mel'nikov, A.V. Samokhvalov, S.M. Kuznetsova, *et al*. *Phys. Rev. Lett*. **109**, 237006 (2012)

Friday, 11 August 2017
11.50-12.10
Congress Hall

062
Nanoscale ordering in $YBa_2Cu_3O_{7-\delta}$ nanowires
Arpaia R., *Bauch T.*, *Lombardi F.*
Chalmers University of Technology, Göteborg, Sweden

It has been recently demonstrated that nanoscale Charge Density Wave (CDW) order is ubiquitous in the High-T_C Superconductors (HTS) cuprate families, both electron and hole doped [1-2]. This local order is intertwined to pair density waves (PDWs), theoretically predicted in cuprates more than 20 years ago [3], which give a local modulation of the Cooper pair density. As a consequence of PDW, the absolute value of the critical current density may vary in different directions of the a-b planes.
We have grown untwinned $YBa_2Cu_3O_{7-\delta}$ (YBCO) thin films at different dopings and fabricated nanowires with lateral dimensions down to 65 nm, not far from the CDW coherence length. The nanowires are patterned at different angles γ with respect to a reference in-plane direction of the substrate. We have used the measurement of the critical current density J_C of the nanowires at various γ (in the interval 0°- 180°) to reveal the possible existence of a PDW. The measurements have shown a clear cosinusoidal modulation of the J_c for the narrowest wires which smears out for wider nanowire

dimensions. This experiment represents one of the first evidence of the existence of a pair density wave in HTS [4], the first one in YBCO.

References:
[1] G. Ghiringhelli et al, Science **337**, 821 (2012).
[2] R. Comin et al, Science **343**, 390 (2014).
[3] C. Castellani et al, Phys. Rev. Lett. **75**, 4650 (1995).
[4] M. H. Hamidian et al, Nature **532**, 343 (2016).

Friday, 11 August 2017
11.00-11.30
G3

063
Emulating Majorana fermions and their braiding by Ising spin chains
<u>Schön G.</u>[1], Backens S.[1], Shnirman A.[1], Makhlin Y.[2], Gefen Y.[3], Mooij J.E.[4]
[1]Karlsruhe Institute of Technology, Karlsruhe, Germany, [2]National Research University Higher School of Economics, Moscow, Russian Federation, [3]Weizmann Institute of Science, Rehovot, Israel, [4]Delft University of Technology, Delft, Netherlands

We analyse the control of Majorana zero-energy states by mapping the fermionic system onto a chain of Ising spins. Although the topological protection is lost for the Ising chain, the properties of this system provide added insight into the nature of the quantum states. By controlling the local magnetic field, the Ising chain can be separated into topological and non-topological parts. We propose (topologically non-protected) schemes which allow performing the braiding operation, and in fact also more general rotations. We consider a T-junction geometry, but we also propose a protocol for a strictly one-dimensional setup. Both setups rely on an extra spin-1/2 coupler included either in the T-junction, or as part of the chain such that it controls one of the Ising links. Depending on the quantum state of the coupler, this link can be either ferromagnetic or antiferromagnetic. The coupler can be manipulated once the topological parts of the chain hosting the Majorana fermions are moved far away. Our scheme overcomes limitations which are a consequence of the 1D character of the Jordan-Wigner transformation. We also propose an experimental implementation of our scheme based on a chain of flux qubits with a design providing the needed control fields.

Friday, 11 August 2017
12.10-12.30
G1

064
Fermi liquid theory applied to a film on an oscillating substrate
<u>Kuorelahti J.A.</u>, Thuneberg E.V.
University of Oulu, Nano and Molecular Systems Research Unit, Oulu, Finland

We have studied the motion of a thin film of liquid helium-3 on a transversely oscillating planar substrate. The linear response of the fluid film to the oscillations of the substrate is calculated by means of Landau´s fermi liquid theory. The response consists of a collective transverse zero sound mode, as well as incoherent quasiparticle excitations of the degenerate fermions. We calculate

numerically the acoustic impedance of the film under a wide range of conditions relevant to normal state helium-3 at millikelvin temperatures [1]. Some cases of known experiments are studied but most of the parameter range has not yet been tested experimentally. The theory is formulated for an arbitrary bidirectional reflectance distribution function (BRDF) of quasiparticles from the surfaces. In order to test more general boundary condition than the combination of diffuse and specular scattering, we have used the lowest order correction in the spherical harmonic expansion of the BRDF. No spectacular deviation from the combination of diffuse and specular scattering is found.

References:

[1] J. A. Kuorelahti, J. A. Tuorila and E. V. Thuneberg, Phys. Rev. B **94**, 184103 (2016)

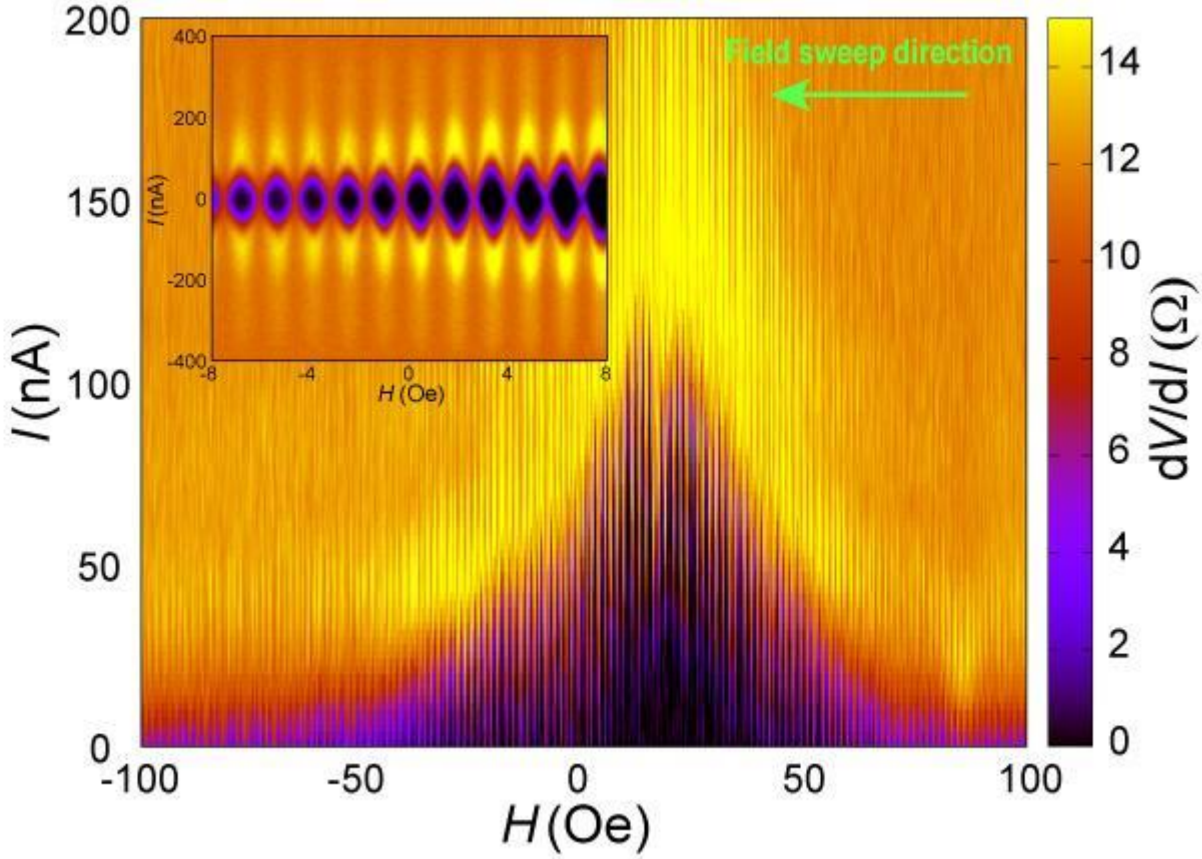
Friday, 11 August 2017
12.10-12.30
H1

065

Proximity-induced superconductivity in a ferromagnetic semiconductor (In,Fe)As

<u>Nakamura T.</u>[1], Le D.A.[2], Hashimoto Y.[1], Ohya S.[2,3], Tanaka M.[2,3], Katsumoto S.[1,3]
[1]University of Tokyo, Institute for Solid State Physics, Kashiwa, Japan, [2]University of Tokyo, Department of Electrical Engineering and Information Systems, Bunkyo-ku, Japan, [3]University of Tokyo, Center for Spintronics Research Network, Bunkyo-ku, Japan

Coexistence of superconductivity and magnetism gives rise to unconventional phases such as FFLO or spin-triplet states
[1, 2] not only in native superconductors but also in proximity effects. In ferromagnetic semiconductors (FMSs), the magnetism is mediated by charge carriers and the half-metallic nature is often found. Hence the interplay between the superconductivity and the magnetism is of great interest in them. Here we report proximity-induced superconductivity in an *n*-type FMS (In,Fe)As [3].
An (In,Fe)As (Fe 6%) film with Curie temperature of 120 K was grown by MBE. Nb electrodes with gaps from 0.6 to 1.5 µm along [-110] or [110] were deposited on the film. In all the junctions, differential resistance exhibits zero-bias dips. In the junction with the gap of 0.6 µm, the dip reaches zero and the critical current I_c oscillates against the magnetic field H as shown in the figure. I_c takes maximum at H = +20 Oe, where the magnetization M is positive and hence the flux in the junction area is much larger than the flux quantum at the maximum. Though the behavior is against common knowledge on conventional Josephson effect, it can consistently be explained by spin-triplet pairing in the FMS.



[Differential resistance of a junction.]

References:
[1] T. Kontos et al., Phys. Rev. Lett. 89, 137007 (2002)
[2] F. S. Bergeret et al. Phys. Rev. Lett. 86, 4096 (2001)
[3] P. N. Hai, et al., Appl. Phys. Lett. 101, 182403 (2012)

Friday, 11 August 2017
12.10-12.30
G2

066
Theory of electron spin resonance for detecting spin nematic orders

Furuya S., Momoi T.
RIKEN, Wako, Japan

Spin nematic phase is an intriguing phase of quantum magnets where the bound magnon pair condenses. One of the most important issues around the spin nematic phase is how to detect the spin nematic order. It was recently pointed out theoretically that the inelastic neutron scattering (INS) cross section shows the excitation spectrum of the bound magnon pair [1]. However, the intensity of the INS cross section related to the bound magnon pair is reduced with increase of the field while the spin nematic phase often manifests itself under high fields close to the saturation field.Therefore, a detecting method of the spin nematic order effective at high fields is still strongly called for.
In this presentation, we discuss that the electron spin resonance (ESR) spectrum is a direct probe to the spin nematic order effective under high magnetic fields [2]. In contrast to INS, the ESR absorption

peak related to the bound magnon pair has larger intensity at higher fields. It was recently reported that the bound magnon pair was observed in an ESR experiment in the fully polarized phase [3]. Our result is not only consistent with the experiment [3] but also will open a further way for experimentally observing the condensation and dynamics of the bound magnon pair in the spin nematic phase.

References:

[1] A. Smerald, H. T. Ueda, and N. Shannon, Phys. Rev. B **91**, 174402 (2015).
[2] S. C. Furuya and T. Momoi, in preparation.
[3] M. Akaki D. Yoshizawa, A. Okutani, T. Kida, J. Romhányi, K. Penc, and M. Hagiwara, arXiv:1702.04158 (2017).

Friday, 11 August 2017
12.10-12.30
Congress Hall

067

Experimental detection of the anomalous dimension of the current in the strange metal of the cuprates

Phillips P., *Limtragool K.*
University of Illinois at Urbana Champaign, Physics, Urbana, United States

The strange metal in the cuprates remains an unsolved problem because no knock-down experiment has revealed unambiguously the nature of the charge carriers in the normal state. Recent theoretical scaling analyses of the DC and AC transport properties indicate that a consistent theory is possible only if the current has an anomalous dimension that is fairly large. Indeed this is striking because a textbook problem in field theory is to show that conserved quantities cannot have anomalous dimensions. I will first show how a conserved current can have an anomalous dimension. I will then show that if the current in the normal state of the cuprates has an anomalous dimension, then the Aharonov-Bohm flux through a ring does not have the standard $eBA/\hbar$ form, where A is the area and B the external magnetic field, but instead is modified by a geometrical factor that depends directly on the anomalous dimension of the current. We calculate the signal in square and disk geometries. In both cases, the deviation from the standard result is striking and offers a fingerprint about what precisely is strange about the strange metal.

Friday, 11 August 2017
14.30-14.50
G3

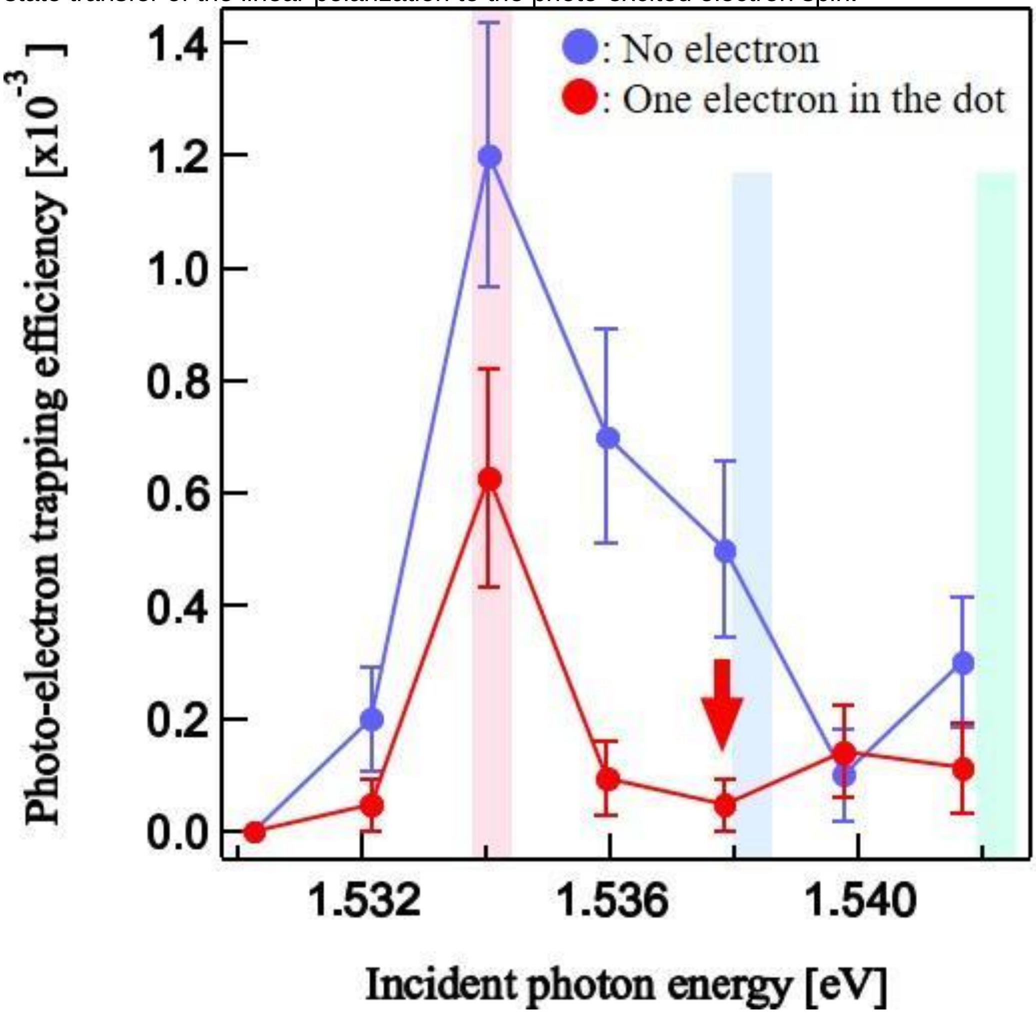
068

Observation of quantum state transfer from polarized photons to electron spins using optical Pauli blockade effect

Kuroyama K.[1], *Larsson M.*[1], *Matuso S.*[1], *Fujita T.*[1], *Valentin S.*[2], *Ludwig A.*[2], *Wieck A.*[2], *Oiwa A.*[3], *Tarucha S.*[1,4]
[1]University of Tokyo, Tokyo, Japan, [2]Ruhr-Universität, Bochum, Germany, [3]Osaka University, Osaka, Japan, [4]RIKEN Center for Emergent Matter Science (CEMS), Saitama, Japan

Photo-generation of electron-hole pairs is a fundamental optical process that preserves the quantum number, and the concept can apply for quantum repeater with single photons and spins as qubits. The

photon-to-spin quantum state transfer has been demonstrated for numerous photons and electrons with light-hole excitation of a GaAs quantum well, but not yet for single photons and electrons [1]. Here we use a GaAs quantum dot to verify the quantum state transfer from single photon polarization to single electron spin by optical Pauli spin blockade [2]. We observe significant reduction of the quantum efficiency for the one-electron dot compared to the empty dot in photo-electron generation by single photons [3-5] of linear polarization parallel to the magnetic field (Fig.1), to the half in the heavy-hole excitation (highlighted by red) and to zero in the light hole excitation (highlighted by blue). The reduced efficiency is assigned to the Pauli effect for the one-electron dot, and the latter is assigned to resonant excitation of the lower-energy Zeeman sub-state of the light hole exciton from detailed spectroscopy measurement of photo-trapping quantum efficiency. The results indicate that coherent state transfer of the linear polarization to the photo-excited electron spin.



[Photo-electron trapping efficiency]

References:
[1] H. Kosaka *et al.*, PRL **100**, 096602 (2008).
[2] A. Högele *et al.*, APL **86**, 221905 (2005).
[3] A. Pioda, *et al.*, PRL **106**, 146804 (2011).
[4] T. Fujita *et al.*, PRL **110**, 266803 (2013).
[5] K. Morimoto *et al.,* PRB **90**, 085306 (2014).

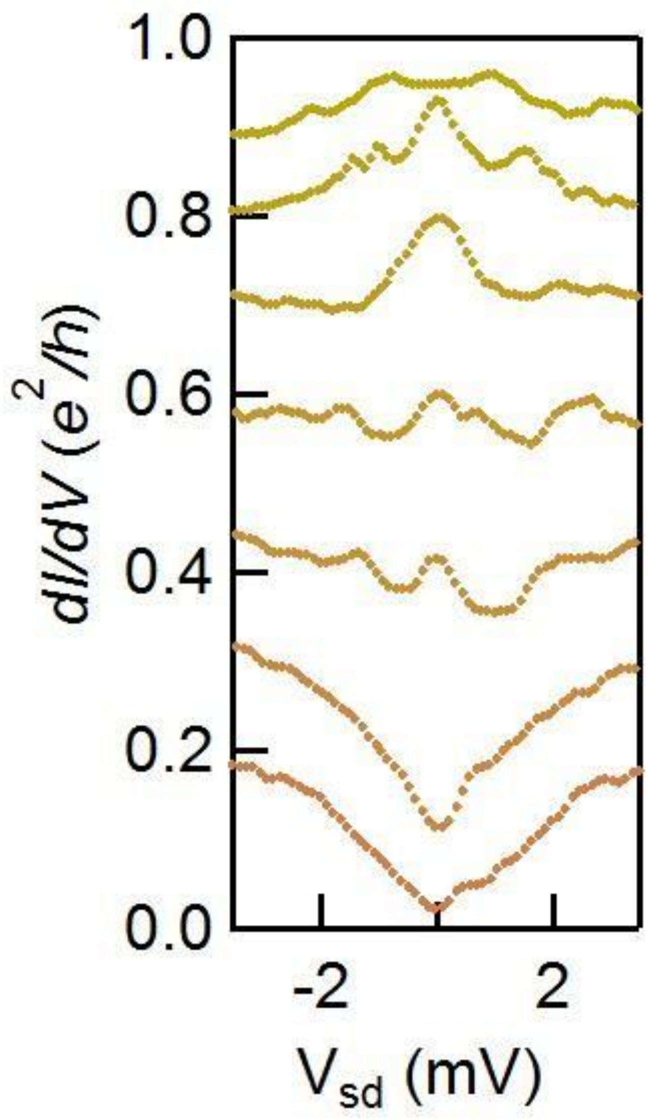
Friday, 11 August 2017
14.30-14.50
H1

069

Andreev reflection in junctions of spin-resolved InAs quantum Hall bulk state and superconductor NbTi

Matsuo S.[1], *Ueda K.*[1], *Baba S.*[1], *Kamata H.*[2], *Tateno M.*[1], *Shabani J.*[3], *Palmstrøm C.*[3], *Tarucha S.*[1,2]
[1]University of Tokyo, Tokyo, Japan, [2]RIKEN Center for Emergent Matter Science (CEMS), Saitama, Japan, [3]University of California, California, United States

Andreev reflection intermediated by spin-flip process is a necessary ingredient to induce superconductivity (SC) in spin-polarized states, which is known as the spin-triplet SC proximity effect [1,2]. This proximity has been studied in SC-ferromagnetic metal junctions to date but not in junctions of superconductor and spin-polarized states in semiconductors like spin-resolved QH states.
Here we report an experimental study of Andreev reflection in junctions of spin-resolved QH bulk states in an InAs quantum well and NbTi superconductor. At 0 T we observe conductance enhancement in the SC bulk due to Andreev reflection. At 4 T the spin-resolved QH states emerge and we observe specific sub-gap features in the differential conductance, dI/dV versus. bias voltage, V_{sd} in the plateau-transition regime. Figure 1 shows dI/dV versus. V_{sd} at different gate voltages. As the filling increases in the transition regime, the sub-gap feature changes from a dip, to a peak, and to a dip. We use a two-channel model to reproduce the observed sub-gap feature and finally assign the emerging peak in the middle of the transition regime to Andreev reflection intermediated by the spin-flip process [3]. These results mean that the spin-triplet SC proximity can be induced in the spin-resolved QH state.



[Figure 1]

References:
[1] R.S.Keizer, *et al.*, Nature **439**, 825 (2006).
[2] J.W.Robinson, *et al.*, Science **329**, 59 (2010)
[3] S. Matsuo, *et al.*, arXiv:1703.03189 (2017)

Friday, 11 August 2017
14.30-14.50
G1

070
Topological quantum criticality in confined superfluid ^{3}He-B
Mizushima T.

Osaka University, Department of Materials Engineering Science, Toyonaka, Japan

We here study the topological aspect of the quantum critical point (QCP) in confined superfluid ^{3}He-B. It has recently been demonstrated that the hidden discrete symmetry can protect the topological phase even in the presence of a magnetic field [1] and the hidden symmetry breaking occurs at the QCP. From the fermionic viewpoint, the symmetry breaking triggers off the topological transition and the Majorana fermion acquires the mass gap. From the bosonic viewpoint, the Ising order emerges at the QCP. To discuss the physics behind the QCP, we utilize the effective action comprised of surface Majorana Fermions and Ising order fluctuations. Using the effective field theory, we clarify that the fluctuation of the Ising order develops at the QCP, which simultaneously triggers off the fluctuation of the topological order. In the topological phase, the Ising order behaves as the pseudo Nambu-Goldstone boson. The softening of this bosonic mode occurs at the QCP, which is a manifestation of the dynamical instability of the ground state towards the Ising-ordered non-topological state. Here, we discuss the interplay between fluctuations of topological order and Ising order and clarify the connection to *supersymmetry* which is expected to emerge at the QCP [2].

References:

[1] T. Mizushima, M. Sato, and K. Machida, Phys. Rev. Lett. **109**, 165301 (2012).
[2] T. Grover, D. N. Sheng, and A. Vishwanath, Science **344**, 280 (2014).

Friday, 11 August 2017
14.50-15.20
G2

071

U(1) quantum spin liquid and valence bond solid ground states of quantum spin ice under a [111] magnetic field

Bojesen T.A.[1], *Onoda S.*[1,2]
[1]RIKEN Center for Emergent Matter Science (CEMS), Quantum Matter Theory Research Team, Wako, Japan, [2]RIKEN, Condensed Matter Theory Laboratory, Wako, Japan

Quantum spin ice, modeled for magnetic rare-earth pyrochlores [1,2], has attracted current great interest as a promising candidate to host a U (1) quantum spin liquid [3], which accommodates gapped deconfined spinon and gapless analogous photon excitations with and without spin-ice monopole charges, respectively. Recent finite-temperature Monte-Carlo simulations on a minimal model have revealed a thermal crossover on cooling from a classical spin ice regime to a U (1) quantum spin liquid regime [4], as well as a monopole supersolid phase intervening the kagome spin ice and a fully polarized ionic monopole insulator under a [111] magnetic field [5]. Now, critical numerical tests of an emergence of the gapless charge-0 and gapped charge-1 excitation spectra as a compelling evidence of the U (1) quantum spin liquid strictly at the ground state are called for. Here, we report evidence of these excitations by means of quantum Monte-Carlo simulations strictly at the ground state [6]. The nature of a valence bond solid ground state at the 2/3 magnetization plateau associated with quantum kagome spin ice [5] is also clarified on the same pyrochlore model. Possible relevance to experiments is discussed.

References:

[1] H. R. Molavian, M. J. P. Gingras, B. Canals, Phys. Rev. Lett. **98**, 157204 (2007).
[2] S. Onoda, Y. Tanaka, Phys. Rev. B **83**, 094411 (2011).
[3] M. Hermele, M. P. A. Fisher, L. Balents, Phys. Rev. B **69**, 064404 (2004).
[4] Y. Kato, S. Onoda, Phys. Rev. Lett. **115**, 077202 (2015).
[5] T. A. Bojesen, S. Onoda, arXiv:1702.07455.
[6] T. A. Bojesen, S. Onoda, unpublished.

Friday, 11 August 2017
14.30-14.50
Congress Hall

072

Robust odd-parity superconductivity in the doped topological insulator NbxBi2Se3

Welp U.[1], *Smylie M.P.*[2], *Willa K.*[2], *Claus H.*[2], *Snezhko A.*[2], *Martin I.*[2], *Kwok W.K.*[2], *Qiu Y.*[3], *Hor Y.S.*[3], *Bokari E.*[4], *Niraula P.*[4], *Kayani A.*[4], *Mishra V.*[5]
[1]Argonne National Laboratory, Materials Science Division, Argonne, United States, [2]Argonne National Laboratory, Materials Science Divison, Argonne, United States, [3]Missouri University of Sciene and Technology, Department of Physics, Rolla, United States, [4]Western Michigan University, Department of Physics, Kalamazoo, United States, [5]Oak Ridge National Laboratory, Computer Science and Mathematics Division, Oak Ridge, United States

We present resistivity and magnetization measurements on pristine [1] and proton-irradiated [2] crystals demonstrating that the superconducting state in the doped topological superconductor $Nb_xBi_2Se_3$
(x = 0.25) is surprisingly robust against disorder-induced electron scattering. The superconducting transition temperature T_c decreases without indication of saturation with increasing defect concentration, and the corresponding scattering rates far surpass expectations based on conventional theory. The low temperature variation of the London penetration depth $\Delta\lambda(T)$ of pristine as well as irradiated crystals follows a power law $\Delta\lambda(T) \sim T^2$. Together, these results suggest the presence of symmetry-protected point nodes in $Nb_xBi_2Se_3$, and support the proposed odd-parity nematic E_u pairing state [3]. Owing to strong spin-orbit locking, these results are the first demonstration of an unconventional superconductor that is robust against nonmagnetic disorder suggesting that topological superconductivity can be realized in rather dirty materials.
This work was supported by the U.S. Department of Energy, Office of Science, Basic Energy Sciences, Materials Sciences and Engineering Division. YSH acknowledges support from the National Science Foundation grant number DMR-1255607.

References:

[1] M. P. Smylie, H. Claus, U. Welp, W.-K. Kwok, Y. Qiu, Y. S. Hor, and A. Snezhko, Phys. Rev. B 94, 180510(R) (2016).
[2] M. P. Smylie, K. Willa, H. Claus, A. Snezhko, I. Martin, W.-K. Kwok, Y. Qiu, Y. S. Hor, E. Bokari, P. Niraula, A. Kayani, V. Mishra, and U. Welp, arXiv:1704.01225.
[3] L. Fu, Phys. Rev. B 90, 100509(R) (2014).

Friday, 11 August 2017
15.20-15.40
H1

073

Supercurrent induced nonequilibrium effects in mesoscopic superconductors with Zeeman splitting

Aikebaier F., *Silaev M.*, *Heikkilä T.T.*
University of Jyväskylä, Jyväskylä, Finland

Thermoelectric effects in ferromagnetic-superconducting hybrid structures have attracted a lot of interest in the last few years, due to the interesting physics revealed by the interplay between superconductivity and magnetism. Huge thermoelectric effects were theoretically predicted[1] and experimentally observed[2] in such structures. Recently, a long-range spin accumulation in a ferromagnetic-superconducting hybrid structure with a strong Zeeman splitting was observed[3]. This unusual phenomena has been explained via the thermoelectric effect for Bogolubov quasiparticles in a spin-polarized superconductor[4]. However, the effect of the supercurrent was not discussed in these studies. Since the supercurrent induces a charge imbalance in the presence of a temperature gradient [5, 6], including the supercurrent in this structure causes some interesting thermoelectric effects, such as the spin Seebeck effect. We use the theoretical framework developed in Ref.[4] based on the quasiclassical Usadel-Keldysh formalism, include the supercurrent and spin supercurrent in the superconducting wire, and investigate the nonequilibrium effects in a mesoscopic superconductor with Zeeman splitting.

References:

[1] A. Ozaeta, et al, Phys. Rev. Lett. 112, 057001(2014).
[2] S. Kolenda, et al, Phys. Rev. Lett. 116, 097001 (2016).
[3] F. Hübler, et al, Phys. Rev. Lett. 109,
207001 (2012).
[4] M. Silaev, et al, Phys. Rev. Lett. 114, 167002(2015).
[5] C.J. Pethick, et al, Phys. Rev. Lett. 43, 640 (1979).
[6] J. Clarke, et al, Phys. Rev. Lett. 43, 642 (1979).

Friday, 11 August 2017
15.20-15.40
G1

074

Scattering theory on surface Majorana fermions by an impurity in ^{3}He-B

Tsutsumi Y.
University of Tokyo, Department of Basic Science, Meguro, Japan

The superfluid ^{3}He is a topological superfluid with the surface bound state. In ^{3}He-B, the surface bound state consists of Majorana fermions with linear dispersion. Detection of the surface Majorana fermions was attempted in RIKEN via mobility of ions, trapped below a free surface, driven by electric field parallel to a free surface [1]. It is expected that the drag force owing to scattering by the surface Majorana fermions works on the mobility of the driven ions. The observed mobility is, however, independent of the trapped depth in spite of the spatial dependence of the density of states for the surface bound state, which is damped with the coherence length. The depth independent mobility is quantitatively reproduced by considering intermediate states in the scattering process [2]. Therefore, we conclude that the experiment succeeded in detection of the surface Majorana fermions. In this presentation, I will also show the mobility of ions perpendicular to a free surface which is strongly suppressed in low temperatures owing to scattering by the low energy Majorana fermions.

References:

[1] H. Ikegami, S. B. Chung, and K. Kono, J. Phys. Soc. Jpn. **82**, 124607 (2013).
[2] Y. Tsutsumi, Phys. Rev. Lett. **118**, 145301 (2017).

Friday, 11 August 2017
15.20-15.40
Congress Hall

075

Topological surface superconductivity induced by geometry in thin topological insulators

Mou C.-Y.[1,2], Chou P.-H.[1], Ou M.-N.[3], Chen Y.-Y.[3]
[1]National Tsing Hua University, Department of Physics, Hsinchu, Taiwan, Republic of China, [2]National Center for Theoretical Sciences, Physics Division, Hsinchu, Taiwan, Republic of China, [3]Academia Sinica, Institute of Physics, Nankang, Taiwan, Republic of China

We report the experimental evidence and theoretical finding of a new class of topological superconductors formed by pairing of strongly correlated surface electrons in thin topological insulators. Measurements on transport properties of the topological insulator single crystal Sb2Te3 nanoflakes are performed for sample thickness ranging in from 5 to 27 nm[1]. Steep drops of resistance are observed for a number of nanoflakes below 2 K, manifesting superconducting transitions. Experimental results show that without structural changes, superconductivity emerges only when the thickness of nanoflakes is less than 9nm. Furthermore, normal state conductivity and upper critical fields exhibit strong increase as the thickness decreases below 9nm. Theoretical analyses show that the strong thickness dependences origin from the hybridization of two surface Dirac fermions of nanoflakes. It is found that the superconducting transition temperature reaches the maximum when the thickness is around 6nm and the hybridization gap starts to form. Our results indicate that the pairing symmetry of the emergent superconductivity is dominated by p-wave and forms a new class of topological superconductors.

References:

"[1] Wei-Han et al, arXiv 1608.05337"

Friday, 11 August 2017
15.20-15.40
G2

076

Quantum phases of triangular-lattice spin-*S XXZ* antiferromagnets near saturation

Yamamoto D.[1], Ueda H.[2], Danshita I.[3], Marmorini G.[4], Momoi T.[5,6], Shimokawa T.[7]
[1]Aoyama-Gakuin University, Sagamihara, Japan, [2]RIKEN Advanced Institute for Computational Science (AICS), Kobe, Japan, [3]Yukawa Institute for Theoretical Physics, Kyoto University, Kyoto, Japan, [4]Keio University, Yokohama, Japan, [5]RIKEN Center for Emergent Matter Science (CEMS), Wako, Japan, [6]RIKEN Condensed Matter Theory Laboratory, Wako, Japan, [7]Okinawa Institute of Science and Technology Graduate University, Onna, Japan

We study the quantum phases near the saturation of triangular-lattice antiferromagnets with XXZ anisotropy (generic J/J_z). The renewed interest for this system comes from the suggestion that a nontrivial coplanar phase, called π-coplanar or Ψ phase, could be stabilized by quantum effects besides the well-known 0-coplanar (or V) and umbrella phases. For S=1/2, our previous cluster mean-field analysis [1] predicted that theπ-coplanar state emerges for $1.6 \lesssim J/J_z \lesssim 2.2$. However, a recent exact-diagonalization study in Ref. [2] claimed that theπ-coplanar state is absent. Here we first offer a counterargument to Ref. [2] by reconsidering the exact-diagonalization analysis with much larger system sizes and a careful identification of the low-lying eigenstates. We conclude that the distinction between 0-coplanar andπ-coplanar is fundamentally impossible in the symmetry-preserving finite-size calculations at fixed magnon number. We also perform a cluster mean-field+scaling analysis for $S \leq$ 3/2. The results are smoothly connected to the large-S expansion results [3], and the quantum-classical crossover of the phase diagram shows that theπ-coplanar phase exists for any S except for the classical limit ($S = \infty$). The most quantum case of S=1/2 has the largest existence range in terms of J/J_z.

References:

[1] D. Yamamoto, G. Marmorini, and I. Danshita, Phys. Rev. Lett. **112**, 127203 (2014); *ibid*, **112**, 259901 (2014)

[2] D. Sellmann, X.-F. Zhang, and S. Eggert, Phys. Rev. B **91**, 081104(R) (2015)
[3] O. A. Starykh, W. Jin, and A. V. Chubukov, Phys. Rev. Lett. **113**, 087204 (2014)

Friday, 11 August 2017
15.20-15.40
G3

077
Subharmonic oscillations in a driven superconducting resonator
<u>Svensson I.M.</u>, Bengtsson A., Krantz P., Simoen M., Bylander J., Shumeiko V., Delsing P.
Chalmers University of Technology, Göteborg, Sweden

We have observed subharmonic oscillations in a microwave resonator. Our device is a superconducting coplanar waveguide resonator terminated by a SQUID, which provides a nonlinear inductance that can be controlled by an external magnetic flux or by an alternating current (AC) drive. We detect the output field quadratures at frequencies near the fundamental mode of the resonator. We show that when the SQUID is AC-driven at a frequency 3f, with amplitude exceeding an instability threshold, this results in three subharmonic states at frequency f (~5 GHz), which are red-detuned from the fundamental mode of the resonator. These three states have the same amplitude but different phases evenly spread out on a circle. Theory has been developed to explain this process, and it agrees well with the data. Downconversion occurs due to interaction between two modes of the resonator, via the SQUID nonlinearity, when the driving frequency is nearly resonant with a higher mode.

Friday, 11 August 2017
15.40-16.00
H1

078
Thermal Hall conductivity of a nodal chiral superconductor
<u>Yip S.</u>
Academia Sinica, Institute of Physics, Taipei, Taiwan, Republic of China

Motivated by the suggestion that Sr_2RuO_4 is a chiral p-wave superconductor and the experimental observation of universal thermal conductivity at low temperatures indicating line nodes or nearly line nodes in the gap for this system, we evaluate the zero field thermal Hall conductivity of a chiral nodal p-wave superconductor. We show that this thermal Hall conductivity (in contrast to the diagonal component) is not universal in the low temperature limit but depends on impurity concentration and phase shift characterizing the impurities. This zero-field Hall thermal conductivity vanishes when the phase shifts are multiple of pi/2. However, under general circumstances, it is smaller than the universal diagonal thermal conductivity only by the factor $\ln(2\Delta/\gamma)$, where Δ is the maximum superconducting gap and γ is the impurity band width. Numerically this is roughly 0.1-0.2 for available samples. Hence this value of the thermal Hall conductivity is quite large. In particular it is much larger than the expected edge state contributions. Measurement of this zero-field thermal Hall conductivity would be an unambiguous indication that Sr_2RuO_4 is a chiral superconductor.

Friday, 11 August 2017
15.40-16.00
Congress Hall

079
Nonreciprocal fluctuation current in noncentrosymmetric superconductors
Wakatsuki R.[1], *Saito Y.*[1], *Hoshino S.*[2], *Itahashi Y.M.*[1], *Ideue T.*[1], *Ezawa M.*[1], *Iwasa Y.*[1,2], *Nagaosa N.*[1,2]
[1]University of Tokyo, Applied Physics, Tokyo, Japan, [2]RIKEN Center for Emergent Matter Science (CEMS), Wako, Japan

In systems without the inversion symmetry, the I-V characteristics can show asymmetric behavior between positive and negative directions. It is called nonreciprocal current, and the most famous example is the p-n junction, where the inversion symmetry is broken by its structure. Even in bulk crystals, the nonreciprocal transport occurs, however, the amplitude is usually very small [1-5]. In this talk, we focus on the resistive regime of noncentrosymmetric superconductors, where the superconducting fluctuation conductivity is dominant [6]. As an example, we study the monolayer transition metal dichalcogenides MoS2 [7-9] theoretically, and show that the nonreciprocal current is dramatically enhanced compared to the normal regime, which is consistent with the experiment. This dramatic enhancement of the nonreciprocal current comes from the scale difference between the Fermi energy and the superconducting gap. Therefore, we expect that this enhancement occurs in any other noncentrosymmetric superconductors.
References:
[1] G. L. J. A. Rikken et al., Nature 390, 493 (1997)
[2] G. L. J. A. Rikken et al., PRL 87, 236602 (2001)
[3] F. Pop et al., Nat. Commun. 5, 3757 (2014)
[4] G. L. J. A. Rikken and P. Wyder, PRL 94, 016601 (2015)
[5] V. Krstic et al., J. Chem. Phys. 117, 11315 (2002)
[6] W. J. Skocpol and M. Tinkham, Rep. Prog. Phys. 38, 1049 (1975)
[7] Q. H. Wang et al., Nat. Nanotechnol. 7, 699 (2012)
[8] X. Xu et al., Nat. Phys. 10, 343 (2014)
[9] K. F. Mak et al., Nat. Photon. 10, 216 (2016)

Friday, 11 August 2017
15.40-16.00
G1

080
Anomalous enhancement of mobility of a Wigner crystal on a free surface of dilute ^{3}He-^{4}He mixtures
Ikegami H.[1], *Kim K.*[2], *Choi H.*[2], *Sato D.*[1], *Kono K.*[1], *Monarkha Y.*[3]
[1]RIKEN, CEMS, Wako, Japan, [2]KAIST, Department of Physics, Daejeon, Korea, Republic of, [3]Institute for Low Temperature Physics and Engineering, Kharkov, Ukraine

The free surface of a dilute ^{3}He-^{4}He liquid mixture offers a unique system where two Fermi liquids with distinct dimensions coexist: A three-dimensional (3D) Fermi liquid composed of ^{3}He atoms in the bulk mixture and a two-dimensional (2D) Fermi liquid formed of ^{3}He atoms bounded to the surface [1]. Interplay of the two Fermi systems is expected to generate novel phenomena which are not seen only in either system. Here we present our experimental results of mobility of a Wigner crystal (WC) on the free surface of the mixture. We found that, in the ballistic regime at low temperatures, the mobility is enhanced compared to the case of the specular reflection of ^{3}He quasiparticles at the surface. This anomalous enhancement of the WC mobility indicates that the momentum transfer at the reflection is smaller than that of the specular reflection, and can be attributable to an unusual reflection associated with accommodation process of a 3He quasiparticle into the 2D ^{3}He surface layer [2].

References:
[1] A. F. Andreev, *Sov. Phys. JETP* **23** 939 (1966).
[2] Yu. P. Monarkha and K. Kono, *J. Phys. Soc. Jpn.* **75** 044601 (2006).

Friday, 11 August 2017
15.40-16.00
G3

081

Reducing 1/f noise in superconducting resonators by surface spin desorption

de Graaf S.[1], *Faoro L.*[2], *Burnett J.*[3], *Adamyan A.*[3], *Tzalenchuk A.*[1,4], *Kubatkin S.*[3], *Lindström T.*[1], *Danilov A.*[3]
[1]National Physical Laboratory, Quantum Science, Teddington, United Kingdom, [2]CNRS, Laboratoire de Physique Theorique et Hautes Energies, Paris, France, [3]Chalmers University of Technology, Microtechnology & Nanoscience, Gothenburg, Sweden, [4]Royal Holloway University of London, Department of Physics, Egham, United Kingdom

Reducing noise and decoherence in solid state quantum devices will enable enhanced performance of a wide range of sensors and circuits. However, such efforts have been largely inhibited by the lack of knowledge about the origin of this noise and decoherence. We correlate measurements of frequency (dielectric) noise and loss in superconducting resonators made from NbN on Al2O3 with ultrasensitive in-situ electron spin resonance (ESR) measurements on the same devices [1]. We find that after removing a large fraction of surface spins by a simple heat treatment, the magnitude of the dielectric noise is reduced by almost 10 times. Our data is in excellent agreement with a model for strongly interacting two-level systems [2,3], allowing us to attribute the origin of the dielectric noise to ESR-active slow two-level charge fluctuators on the surface of our devices. Here we show that surface spins directly affect the performance of high-Q superconducting resonators, and the chemical fingerprint of the ESR spectrum together with noise and loss data enables a whole new route to identifying the origin of noise in quantum circuits.

References:
[1] S.E. de Graaf et al., Phys. Rev. Lett. **118**, 057703 (2017)
[2] L. Faoro et al., Phys. Rev. B **91**, 014201 (2015)
[3] J. Burnett et al., Nature Communications **5**, 4119 (2014)

Friday, 11 August 2017
15.40-16.00
G2

082

Numerical study of the Kitaev-Heisenberg chain

Agrapidis C.E.[1], *van den Brink J.*[1,2], *Nishimoto S.*[1,2]

[1]IFW Dresden, Institute for Theoretical Solid State Physics, Dresden, Germany, [2]Technische Universität Dresden, Department of Physics, Dresden, Germany

In recent years, because of the emergence of candidate materials and the interest in the spin liquid state realization, there has been a growing number of studies on the Kitaev model, at first, and on the Kitaev-Heisenberg (KH) after. Adding the Heisenberg type interaction to the initial, exactly integrable, model is necessary and inevitable for any realistic description, but leads to spin frustration. Nevertheless, the vast majority of these studies is focused on 2-dimensional lattices, while research on the KH chain is lacking.
Motivated by this, we study the KH chain using the exact diagonalization and the density matrix renormalization group techniques. We present the phase diagram as a function of an angle parameter φ, setting the Heisenberg interaction to cosφ and the Kitaev one to sinφ. We identify six different possible phases; namely, Heisenberg, XY-spiral, S_z-ferromagnetic, ferromagnetic, XY and Néel phases, by calculating total spin, spin-spin correlations, correlation length, central charge, static structure factor, and the Néel, S_z-ferromagnetic and XY order parameters. Moreover, we investigate specific features of the dynamical structure factor in each phase. In addition, we present how the phase diagram changes under the application of a magnetic field.

Friday, 11 August 2017
09.00-09.45
H1

083
Superconductive electronics for voltage metrology
Benz S.
NIST, Superconductive Electronics Group, Boulder, United States

Josephson's discovery in 1962 of the quantum behavior of superconducting junctions enabled a revolution in precision voltage measurement that replaced electrochemical cells, which are artifact standards whose behavior depends on environmental conditions, with quantum-based standards that are intrinsically accurate. Many technological advances in junction fabrication, superconducting integrated circuit technology, bias techniques, and instrumentation were required to achieve the present generation of practical dc and ac voltage standard systems. Quantum-based 10 V programmable Josephson voltage standards and 1 V rms Josephson arbitrary waveform synthesizers are now used in a wide range of metrology applications, calibration laboratories and precision measurement experiments. For metrology and precision measurements, these two NIST systems, and others like them, are used for measuring dc and ac voltage, ac power, and impedance. They are also key instruments in precision measurement experiments of mass and temperature to determine more accurate values of the Planck and Boltzmann constants. I will review major technological advances with a focus on the superconducting devices and circuits and describe the current state-of-the-art in applications.
References:
S P Benz, “Synthesizing accurate…”, *IEEE Instr. Meas. Magazine*, June 2010, p. 8.
N E Flowers-Jacobs et al., "2 volt pulse-driven Josephson arbitrary waveform synthesizer," DOI: 10.1109/CPEM.2016.7540601.
A Rüfenacht et al., "10 volt automated direct comparison of two cryocooled programmable Josephson voltage standards," DOI: 10.1109/CPEM.2016.7540474.
F Overney et al., "Josephson-based full digital bridge for high-accuracy impedance comparisons," *Metrologia*. doi:10.1088/0026-1394/53/4/1045.

Friday, 11 August 2017
17.15-18.00
Congress Hall

084

Ion transport on the surface of superfluid ^{3}He

Ikegami H.[1], *Kono K.*[1,2,3]
[1]RIKEN Center for Emergent Matter Science (CEMS), Wako-shi, Japan, [2]National Chiao Tung University, Hsinchu, Taiwan, Republic of China, [3]Kazan Federal University, Kazan, Russian Federation

Superfluid ^{3}He is a BCS type p-wave superfluid. Ions moving in the superfluid ^{3}He scatter thermally excited quasiparticles and the transport properties are determined by the quasiparticle scattering. The ^{3}He-A phase is characterized by the psuedovector field of Cooper pair orbital-angular-momentum, which aligns perpendicularly to the surface. This chiral symmetry breaking results in a skew scattering of quasiparticles from the moving ions. And hence, the anomalous Hall effect (AHE) of ion current occurs[1]. Our observation of this AHE[2] is quantitatively explained by the recent theory[3]. Near the surface of ^{3}He-B phase, on the other hand, low-energy quasiparticle subgap bound states form Andreev surface bound states (ASBS), which possess Majorana nature. We observed an excess scattering from the ASBS in the surface ion mobility, and the absence of depth dependence[4]. Although the excess scattering did not accord with the naive Majorana picture of ASBS by contraries, Tsutsumi theoretically worked out this puzzle, recently[5]. We now obtain a clear evidence for the surface Majorana fermions in the superfluid ^{3}He-B phase.

References:

[1] R. H. Salmelin, M. M. Salomaa, and V. P. Mineev, Phys. Rev. Lett. **63**, 868 (1989).
[2] H. Ikegami, Y. Tsutsumi, and K. Kono, Science **341**, 59 (2013).
[3] O. Shevtsov and J. A. Sauls, Phys. Rev. B **94**, 064511 (2016).
[4] H. Ikegami, S. B. Chung, and K. Kono, J. Phys. Soc. Jpn. **82**, 124607 (2013).
[5] Y. Tsutsumi, Phys. Rev. Lett. **118**, 145301 (2017).

Friday, 11 August 2017
09.00-09.45
G3

085

Gate-induced two-dimensional superconductivity

Iwasa Y.[1,2]
[1]University of Tokyo, Department of Applied Physics and QPEC, Tokyo, Japan, [2]RIKEN, CEMS, Wako, Japan

Recent technological advances of materials fabrication have led to discoveries of a variety of 2D superconductors at heterogeneous interfaces and in ultrathin films [1]; examples include superconductivity at oxide interfaces, electric-double-layer interfaces, and mechanically exfoliated, molecular-beam-epitaxy grown, or chemical vapor deposited atomically thin layers. All these 2D superconductors have very high crystallinity in marked contrast with the conventional 2D superconductors with amorphous or granular structures, and thus provide opportunities for investigating the intrinsic nature of 2D superconductors, in terms of extremely weak pinning coupled with enhanced thermal/quantum fluctuations, and also of the broken spatial inversion symmetry.

Here we discuss a variety of peculiar properties of gate-induced superconductivity using electric double layer transistor (EDLT) devices. Vortex phase diagram in highly crystalline superconductors is very much distinct from the conventional ones due to the strong quantum fluctuation. Also, we succeeded in observation of magnetochiral anisotropy in superconducting transport owing to the broken inversion symmetry [2, 3]. Finally, tunneling spectroscopy revealed new aspects of gate induced superconductivity.

References:

[1] For a review, Y. Saito, T. Nojima, and Y. Iwasa, *Nat. Rev. Mater.* **2**, 16094 (2016).
[2] R. Wakatsuki, Y. Saito, S. Hoshino, Y. M. Itahashi, T. Ideue, M. Ezawa, Y. Iwasa, and N. Nagaosa, *Sci. Adv.* **3**, e1602390 (2017).
[3] F. Qin, W. Shi, T. Ideue, M. Yoshida, A. Zak, R. Tenne, T. Kikitsu, D. Inoue, D. Hashizume and Y. Iwasa, *Nat. Comm.* **8**, 14465 (2017).

Friday, 11 August 2017
09.45-10.30
Congress Hall

086
Topological matter in the ultra-low-temperature laboratory
Eltsov V.
Aalto University, Department of Applied Physics, Espoo, Finland

The talk presents an overview of recent advances in the experimental studies of topological quantum matter realized by superfluid phases of ^{3}He. A new window to the fascinating world of fermionic Majorana, Weyl and Dirac modes, of various bosonic modes, including analogues of the Higgs boson, and of topological structures of superfluid vacuum is opened by the progress in experimental techniques. One example is new superfluid phases engineered with nanostructured confinement, like the polar phase, which possesses Dirac node line in bulk and fermionic flat band at the surfaces. In the polar phase long-sought half-quantum vortices (HQVs) have been discovered. It turns out that HQVs survive transition to the A phase, where they may serve in future as a platform to study core-bound Majorana modes. Moreover, HQVs can be transferred to the B phase, where their pairs form structures similar to cosmic Kibble walls. Another development is ultra-sensitive probes based on Bose-Einstein condensates of magnon quasiparticles. In ^{3}He-B they e.g. reveal production of light Higgs modes in vicinity of vortex cores and by topological surface spin currents. Magnon condensates are expected to bring new results also in the polar phase, where they have been recently successfully created.

Friday, 11 August 2017
11.00-11.30
Congress Hall

087
Superconductivity in the antiperovskite oxide $Sr_{3-x}SnO$
Maeno Y.[1], *Oudah M.*[1], *Ikeda A.*[1], *Hausmann J.N.*[1,2], *Yonezawa S.*[1], *Fukumoto T.*[3], *Kobayashi S.*[3], *Sato M.*[1]

[1]Kyoto University, Kyoto, Japan, [2]Humboldt-Universität zu Berlin, Berlin, Germany, [3]Nagoya University, Nagoya, Japan

Recently, we discovered the first superconducting "antiperovskite oxide" $Sr_{3-x}SnO$ with the transition temperature of around 5 K [1]. Oxides with perovskite-based structures have been known as essential materials for fascinating phenomena such as high-temperature and spin-triplet superconductivity. The cubic perovskite oxides, ABO_3, also exhibit superconductivity as in $SrTiO_{3-x}$ and $Ba_{0.6}K_{0.4}BiO_3$. Perovskite oxides have their counterparts, antiperovskite oxides A_3BO (orBOA_3), in which the position of metal and oxygen ions are reversed and therefore metallic B ions take unusual negative valence states. The parent compound (with x = 0) of the new superconductor, Sr_3SnO, possesses Dirac points in its electronic structure and is a candidate of a topological crystalline insulator. Furthermore, a possibility of a topological odd-parity superconductivity has beed proposed upon hole doping [1]. In this presentation, we will report the properties of $Sr_{3-x}SnO$ with improved superconducting chracteristics. We envision that this discovery of the new class of oxide superconductors will lead an important progress in physics and chemistry of antiperovskite oxides consisting of unusual metallic anions.

This work was suppoerted by the JSPS KAKENHI Nos. JP15H05852 and JP15K21717.

References:

[1] "Superconductivity in the antiperovskite Dirac-metal oxide $Sr_{3-x}SnO$"
Mohamed Oudah, Atsutoshi Ikeda, Jan Niklas Hausmann, Shingo Yonezawa, Toshiyuki Fukumoto, Shingo Kobayashi, Masatoshi Sato, Yoshiteru Maeno,
Nature Communications **7**, 13617-1-6 (Dec. 2016). DOI: 10.1038/ncomms13617

Friday, 11 August 2017
11.00-11.30
G2

088

Fermi surface instabilities in ferromagnetic superconductors

Pourret A.[1,2]*, Knebel G.*[2]*, Gourgout A.*[2]*, Bastien G.*[2]*, Aoki D.*[3]*, Flouquet J.*[2]
[1]University Grenoble Alpes, INAC-PHELIQS, Grenoble, France, [2]CEA, INAC-PHELIQS, Grenoble, France, [3]Tohoku University, IMR, Oarai, Japan

In highly correlated electron systems, one of the main issue is to understand the interplay of Fermi surface instabilities, magnetic fluctuations and quantum criticality through competing orders. Among them, two compounds are particularly interesting, UCoGe and URhGe, because they show the coexistence of two “antagonist” states of matter, ferromagnetism and superconductivity. The most fascinating aspect in UCoGe is the peculiar dependence of the upper critical field with an “S-shape”, for URhGe, it is the apparition of a reentrant superconducting phase around 12T. Recently, we put emphasis on the important role of the Fermi surface on the transport properties in these systems. Indeed, in UCoGe, several successive anomalies were observed under magnetic field (along the easy magnetization c-axis) in resistivity, Hall effect and thermoelectric power. The direct observation of quantum oscillations showed that these anomalies are related to topological changes of the Fermi surface, also known as Lifshitz transitions [1]. In URhGe with the field applied along the hard magnetization *b*-axis, a drastic change in the Fermi surface at the spin reorientation field (HR = 11.75 T) has been observed through thermoelectric power measurements [2].

References:

[1] G. Bastien, A. Gourgout, D. Aoki, A. Pourret et al., "Lifshitz Transitions in the Ferromagnetic Superconductor UCoGe ", Phys. Rev. Lett. 117, 206401 (2016)
[2] A. Gourgout, A. Pourret, et al., "Collapse of Ferromagnetism and Fermi Surface Instability near Reentrant Superconductivity of URhGe", Phys. Rev. Lett. 117, 046401 (2016)

Friday, 11 August 2017
11.00-11.30
H1

089
Triplet spin-valves with half-metal manganites
Robinson J.
University of Cambridge, Materials Science, Cambridge, United Kingdom

Superconducting spintronics represents a new paradigm for information processing involving the coexistence of spin-polarization and superconducting phase coherence [1-3]. The pairing state and critical temperature (Tc) of a thin s-wave superconductor (S) on two or more ferromagnets (F) are controllable through the magnetization-alignment of the F layers. Magnetization misalignment leads to spin-polarized triplet pair creation, and since such triplets are compatible with spin-polarized materials they are able to pass deeply into the F layers and so, cause a decrease in Tc. Routine transfer of spin-polarized triplets to HMFs is a major goal for superconducting spintronics so as to maximize triplet-state spin-polarization. In my talk I discuss our recent results on magnetization-tuneable pair conversion and transfer of spin-polarized triplet pairs to the chemically stable mixed valence manganite La2/3Ca1/3MnO3 in a pseudo spin-valve device using in-plane magnetic fields [4].
References:
[1] J.W.A. Robinson and J. Linder, Nature Phys. **11**, 307-315 (2015).
[2] M. Eschrig, Rep. Prog. Phys. **78** (10), 104501 (2015).
[3] Singh *et al.*, Phys. Rev. X **5**, 021019 (2015).
[4] A. Srivastava et al., arXiv:1706.00332 (2017).

Friday, 11 August 2017
14.00-14.30
G2

090
CORE results for the Kagome antiferromagnet: spin liquid with p6 chirality
Auerbach A.
Technion – Israel Institute of Technology, Physics, Haifa, Israel

The spin 1/2 Kagome Heisenberg antiferromagnet is the most studied model of highly frustrated quantum magnetism. It found experimental realization in herbertsmithite,
and both theoretical and experimental indications of describing a true two dimensional spin liquid. However, its correlations have not been yet resolved by the conflicting proposals of variational wavefunctions. Therefore, a systematic approach provided by Contractor Renormalization, (CORE) offers an alternative insight into the low energy excitations. We compute [1] the CORE interactions up to range 3 on the 12 site stars superlattice using exact diagonalizations of up to 36 spins. Errors due to longe rrange interactions are determined by comparison of ground state energy to DMRG. We confirm a singlet ground state with no broken translational symmetry (spin liquid). However, we discover the onset of p6 - two dimensional chirality symmetry breaking. This prediction is currently being tested by careful DMRG studies on large cylinders. Experimentally, the p6 chirality order parameter should split the optical phonons degeneracy near the zone center. Signatures of this effect may have been observed by recent infrared measurements [2]. p6 symmetry breaking may explain difficulties in DMRG convergence on wide cylinders.

References:
1. Sylvain Capponi, V. Ravi Chandra, Assa Auerbach, and Marvin Weinstein, Phys. Rev. B 87, 161118(R), (2013).
2. A B Sushkov, G S Jenkins, Tian-Heng Han, Young S Lee and H D Drew, Infrared phonons as a probe of spin-liquid states in herbertsmithite $ZnCu_3(OH)_6Cl_2$, Journal of Physics 29, 095802, (2017).

Friday, 11 August 2017
14.00-14.30
H1

091
Ballistic edge states in Bismuth nanowires revealed by SQUID interferometry
Murani A.[1]*, Kasumov A.*[1]*, Sengupta S.*[1]*, Delagrange R.*[1]*, Deblock R.*[1]*, Chepelianskii A.*[1]*, Bouchiat H.*[1]*, Guéron S.*[2]
[1]Laboratoire de Physique des Solides Unversité Paris Sud, Orsay, France, [2]Laboratoire de Physique des Solides Unversité Paris Sud Université Paris Saclay, Orsay, France

Reducing the size of a conductor usually decreases its conductivity because of the enhanced effect of disorder in low dimensions, leading to diffusive transport and to weak, or even strong localization. Notable exceptions occur when topology provides protection against disorder. For instance in the recently discovered two-dimensional Topological Insulators, perfect spin-momentum locking should forbid backscattering along the edge states, and lead to ballistic conduction. In this talk, I will present a direct signature of ballistic 1D transport along the topological surfaces of a single crystal bismuth nanowire connected to superconducting electrodes. This signature was obtained by exploiting the extreme sensitivity of the supercurrent-versus-phase relation (CPR). The sharp sawtooth-shaped CPR we find demonstrates that transport occurs ballistically along two edges of the nanowire, and confirms the predicted nearly perfect transmission of Cooper pairs through Quantum Spin Hall edge states. In addition, we show that a magnetic field can induce 0-pi transitions and phi_0-junction behavior, providing a way to manipulate the phase of the supercurrent-carrying edge states and generate spin supercurrents.
References:
[1]: Murani et al, arXiv:1609.04848, to appear in Nature Communications

Friday, 11 August 2017
14.00-14.30
G1

094
Signatures of Majorana-Weyl Fermions in superfluid ^{3}He-A
Sauls J.
Northwestern University, Physics, Evanston, United States

I discuss the relationship between broken symmetries and topology of the chiral ground state of superfluid ^{3}He-A and the Fermionic states confined near surfaces, domain walls and mesoscopic defects. The low-energy Fermionic spectrum of thin films of ^{3}He-A contains a branch of chiral edge states (Majorana-Weyl Fermions). The chiral vacuum hosts a mass current confined near the edge boundaries. For translationally invariant confining boundaries the vacuum edge current is given by $J = n_3\, \hbar/4$, where n_3 is particle density of bulk ^{3}He. I will highlight several results:
(i) the connection between the Majorana-Weyl spectrum on the edge and the chiral vacuum,

(ii) the absence of topological protection of the vacuum edge current to symmetry breaking perturbations,
(iii) the effects of hybridization of spatially separated Majorana-Weyl Fermions under lateral confinement, and (iv) their experimental signatures in heat and mass transport, as well as ion mobility experiment.

References:

Research Supported by U.S. National Science Foundation Grant DMR-1508730.

Friday, 11 August 2017
14.50-15.20
G1

095

Majorana quasiparticles in topological insulator, superfluid ^{3}He-B

Bunkov Y.
Kazan Federal University, Kazan, Russian Federation

Majorana quasiparticles were predicted as the edge state in topological isolators, and particularly in superfluid ^{3}He-B. The heat capacity of bulk superfluid ^{3}He-B decrees at cooling by exponential law, while the Majorana heat capacity should decrease by a power law. Consequently, the Majorana heat capacity should play a major role at very low temperatures. We have measured the heat capacity of superfluid 3He in two bolometers with different surface to volume ratio. We have found that the heat capacity of both bolometers deviates from the exponential law at cooling down to temperature of 100 µK. The additional heat capacity is proportional to the surface of bolometers and corresponds quantitatively to a prediction for Majorana heat capacity. We succeed to get the conditions, when the Majorana heat capacity is even bigger than the bulk heat capacity in 3 times. The results of our experiments strongly support the theory of Magorana quasiparticles formations as an edge states in topological isolator superfluid ^{3}He.

References:

Yu.M. Bunkov, R.R. Gazizulin, arXiv:1605.05203. (2016)

Friday, 11 August 2017
14.50-15.20
H1

096

Heat transport through a Josephson junction

Golubev D., Faivre T., Pekola J.
Aalto University, Espoo, Finland

We discuss heat transport through a Josephson tunnel junction under various bias conditions. We first derive the formula for the cooling power of the junction valid for arbitrary time dependence of the Josephson phase. Combining it with the classical equation of motion for the phase, we find the time-averaged cooling power as a function of bias current or bias voltage. We also find the noise of the heat current and, more generally, the full counting statistics of the heat transport through the junction. We separately consider the metastable superconducting branch of the current-voltage characteristics allowing quantum fluctuations of the phase in this case. This regime is experimentally attractive since

the junction has low power dissipation, low impedance, and therefore may be used as a sensitive detector.

References:
[1] Dmitry Golubev, Timothe Faivre, and Jukka P. Pekola, Phys. Rev. B **87**, 094522 (2013)

Friday, 11 August 2017
14.30-14.50
G2

097

Mott semimetal state emerging under DC current in Ca_2RuO_4

Maeno Y.[1], *Sow C.*[1], *Yonezawa S.*[1], *Nakamura F.*[2], *Kitamura S.*[3,4], *Oka T.*[4,5], *Kuroki K.*[6]
[1]Kyoto University, Kyoto, Japan, [2]Kurume Institute of Technology, Kurume, Japan, [3]University of Tokyo, Tokyo, Japan, [4]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany, [5]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany, [6]Osaka University, Osaka, Japan

The Mott insulator is considered as an electron “solid” frozen due to strong electron correlations. It has a potential to become a good metal if the electron solid melts by tuning of suitable stimuli. Chemical substitutions as well as pressure have been used extensively as such "tuning parameters" to induce novel electronic states of correlated electron liquids from Mott insulators.
In this talk, we will describe novel phenomena we found in the layered ruthenium oxide Ca_2RuO_4, for which non-equilibrium conditions introduced by DC electric field and current trigger and maintain the charge “liquid” state down to low temperatures [1].
When the electric current is not very strong, the Mott-gap can be tuned to disappear gradually. In such a condition, Ca_2RuO_4 exhibits a semi-metallic conduction and giant diamagnetism [2]. We will discuss how the partial Mott-gap closing leads to the emergence of a "Mott semimetal" state exhibiting such diamagnetic behavior.
The important implication of this study is that simple DC current may be used as a useful control parameter to induce entirely novel states from some Mott insulators.
This work was supported by the JSPS KAKENHI Nos. JP 26247060, JP15H05852 and JP15K21717.

References:
[1] “Electric-field-induced metal maintained by current of the Mott insulator Ca_2RuO_4”, F. Nakamura, M. Sakaki, Y. Yamanaka, S. Tamaru, T. Suzuki, and Y. Maeno, Sci. Rep. 3, 2536 (2013).
[2] “Current-induced giant diamagnetism in the Mott insulator Ca_2RuO_4”,
C. Sow, S. Yonezawa, S. Kitamura, T. Oka, K. Kuroki, F. Nakamura, and Y. Maeno, arXiv. 1610.02222.

Saturday, 12 August 2017
09.45-10.30
Congress Hall

098

Nodeless and nodal topological crystalline supercondutors

Sato M.
Yukawa Institute for Theoretical Physics, Kyoto University, Kyoto, Japan

After almost ten years since the discovery of topological insulators, the idea of topological phases has been widely accepted in a variety of condensed matter systems. Not only gapped materials but also gapless ones have been explored under the spell of topological phase. In particular, much efforts have been paid recently for searching topological crystalline phases, which acquire topological stability with the aid of crystalline symmetries. In this talk, I report our works on topological crystalline superconductors. First, I discuss possible topological superconductivity in Dirac semimetals [1-3]. Recent experiments have reported that doped Dirac semimetals show superconductivity in low temperature [3,4]. We show that doped Dirac semimetals naturally may host topological (crystalline) superconductivity due to the orbital mixing of Dirac points. Another topic is novel gapless topological phases in nonsymmorphic crystalline materials [5,6]. A nonsymmorphic crystalline symmetry is a symmetry obtained as a combination of point group operation and non-primitive lattice translation. I discuss that nonsymmorphic symmetry gives novel nodal superconductivity [5,6]. Furthermore, I present a systematic framework to explore topological crystalline phases in terms of K theory [6].

References:

[1] S. Kobayashi, M. Sato, Phys. Rev. Lett. 115, 187001 (2015).
[2] T. Hashimoto, S. Kobayashi, Y. Tanaka, M. Sato, Phys. Rev. B94, 014510 (2016).
[3] M. Oudah et al, Nat. Commu. 7, 13617 (2016)
[4] L. Aggarwal et al, Nat. Mater. 15, 32 (2015); H. Wang et al, Nat. Mater. 15, 38 (2015).
[5] S. Kobayashi, Y. Yanase, M. Sato, Phys. Rev. B94, 134512 (2016).
[6] K. Shiozaki, M. Sato, K. Gomi, Phys. Rev. B91, 174305 (2015); Phys. Rev. B93, 195413 (2016); arXiv:1701.08725.

Friday, 11 August 2017
16.30-17.15
Congress Hall

099

BCS-BEC crossover and exotic pairing in FeSe

Matsuda Y.
Kyoto University, Department of Physics, Kyoto, Japan

There is growing evidence that superconducting semimetal FeSe (Tc=8 K) is deep in the crossover regime between weak coupling BCS and strong-coupling BEC limits [1]. Therefore FeSe offers a unique and fascinating platform to study the crossover physics. Here we discuss several unique features which may provide new insights into fundamental aspects of the crossover. First is the observation of giant superconducting fluctuations by far exceeding the standard Gaussian theory and a possible pseugogap formation above Tc [2]. Second is the electronic structure. FeSe is a compensated semimetal, and hence it is essentially multiband superconductor, which makes the crossover physics in FeSe distinguished from that in ultracold atomic gases. Third concerns the fate of the superfluid when the spin populations are strongly imbalanced [3]. We show the emergence of a distinct field induced superconducting phase with unprecedentedly large spin-imbalance. We also show that the superconducting gap is significantly anisotropic in both the nematic and tetragonal regimes of Fe(Se1-xSx), indicating exotic pairing interaction [4][5].

References:

[1] S. Kasahara et al. Proc. Natl. Acad. Sci. USA 111, 16309 (2014).
[2] S. Kasahara et al. Nature Commun. 7, 12843 (2016).
[3] T. Watashige et al. J. Phys. Soc. Jpn. 86, 014707 (2017).
[4] T. Watashige et al. Phys. Rev. X 5, 031022 (2015).
[5] Y. Sato et al. arXiv:1705.09074.

Friday, 11 August 2017
16.30-17.15
H1

100

Cascade electronic refrigerator using superconducting junctions in the sub kelvin regime

Nguyen H.[1], *Meschke M.*[2], *Courtois H.*[3], *Pekola J.*[2]
[1]Center for Quantum Devices, Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark, [2]Department of Applied Physics, Aalto University, Helsinki, Finland, [3]Institut Neel, Universite Grenoble Alpes, CNRS, Grenoble, France

Micro-refrigerators that operate in the subkelvin regime are key devices in quantum technology. A well-studied candidate, an electronic cooler using normal-metal-insulator-superconductor (N-I-S) tunnel junctions, offers substantial performance and power. Operation of such electronic cooler is limited by the accumulation of hot quasiparticles in its superconducting leads, due to the low relaxation rate and thermal conductivity of the superconductor. We employ a second N-I-S cooling stage to thermalize the hot superconductor at the backside of the main N-I-S cooler. Not only providing a lower bath temperature, the second-stage cooler actively evacuates quasiparticles out of the hot superconductor, especially in the low-temperature limit. It results in a three fold temperature drop at bath temperature 300 mK on the normal metal at 1 nW power. We integrate this device with a dielectric silicon nitride membrane and transform it into a robust and versatile cooling platform for multiple practical purposes.

Saturday, 12 August 2017
09.00-09.45
G3

101

Quantum simulation with cold atoms

Zoller P.[1,2]
[1]University of Innsbruck, Institute for Theoretical Physics, Innsbruck, Austria, [2]Austrian Academy of Sciences, IQOQI, Innsbruck, Austria

In this talk we give an overview, and describe recent advances in realizing engineered quantum many-body systems with cold atoms. Topics of interest include analog quantum simulation with atoms in optical lattices: as an illustrative example we will focus on artificial magnetic fields for topological phases [1], and we describe in some detail protocols and experiments allowing direct measurement of entanglement entropies and entanglement spectra [2]. We illustrate the design of spin models with arrays of Rydberg atoms [3]. As an example, we describe the realization of quantum spin glasses with all-to-all connectivity in a novel architecture [4], which points towards building a coherent quantum annealer, or adiabatic quantum computer, to solve optimization problems with techniques developed in atomic quantum simulation. We conclude with a brief discussion of digital quantum simulation, which we illustrate with the recent experiment simulating Schwinger pair production as a 1+1 QED on an ion trap quantum computer [5].

References:

[1] N. Goldman, J. C. Budich, and P. Zoller, Nature Physics 12.7, 639 (2016)

[2] M. Dalmonte, B. Vermersch and P. Zoller, unpublished
[3] A.W. Glaetzle, R.M.W. van Bijnen, P. Zoller, and W. Lechner, arXiv:1611.02594
[4] W. Lechner, P. Hauke, and P. Zoller, Science Advances 1.9, e1500838 (2015)
[5] E.A. Martinez, C.A. Muschik, P. Schindler, D. Nigg, A. Erhard, M. Heyl, P. Hauke, M. Dalmonte, T. Monz, P. Zoller, and R. Blatt, Nature 534, 516 (2016)

Friday, 11 August 2017
09.00-09.45
Congress Hall

102

Emerging phenomena at the magnetic field-tuned superconductor to insulator transition

Kapitulnik A.
Stanford University, Physics and Applied Physics Departments, Stanford, United States

The magnetic-field tuned superconductor-to-insulator transition (H-SIT), along with the quantum-Hall liquid-to-insulator transitions (QHIT) are paradigmatic quantum phase transitions and among the best experimentally studied. While evidence continue to mount to the fact that these two phenomena are in the same universality class, key results in the QHIT were not previously identified in the case of H-SIT. Tuning the disorder of two-dimensional superconducting films, and studying the full resistivity tensor, our results show a stark difference between films exhibiting weak vs. strong disorder. In weakly disordered films, the superconducting state gives way to an "anomalous metallic phase" with a resistivity that extrapolates to a non-zero value, but with a vanishing Hall resistance. In the strong disorder limit a "true" H-SIT is observed, characterized by an emerging self-duality at the H-SIT, and the proximate insulating phase is fundamentally distinct from a conventional "Anderson insulator" in that the Hall resistance, rather than diverging, tends to a finite value as the temperature approaches zero [1]. These features are analogous to behaviors previously documented near QHIT, thus support the correspondence between the two problems as implied by the composite boson theory.

References:

[1] N.P. Breznay, M.A. Steiner, S.A. Kivelson, A. Kapitulnik, Proceedings of the National Academy of Sciences 113, 280 (2016).

Saturday, 12 August 2017
11.30-11.50
G1

104

Application of SQUIDs to ultra-low noise torque magnetometry in high magnetic fields

Arnold F.[1], *Naumann M.*[1], *Lühmann T.*[1], *Hassinger E.*[1,2]
[1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany, [2]Technische Universität München, Physik-Department, Garching, Germany

Torque magnetometry is a key method to measure the magnetic anisotropy and quantum oscillations in metals [1,2]. Ultra pure materials are often present only in very small sample sizes. Therefore, in the case of strongly correlated metals with large Fermi surfaces and high cyclotron masses, high magnetic torque sensitivities are required at temperatures well below 100 mK and magnetic fields beyond 10 T. Here, we present a new broadband read-out scheme for piezo-electric micro-cantilevers and Wheatstone type resistance measurements in magnetic fields up to 15 T and temperatures down to 50 mK. By using a two-stage SQUID as null detector of a cold Wheatstone bridge, we were able to

achieve a magnetic moment resolution of Δm = 2*10^{-14} J/T, outperforming conventional magnetometers by at least one order of magnitude in this temperature and magnetic field range.

References:

[1] C. Rossel *et al.* J. Appl. Phys. **79**, 8166 (1996).
[2] A. McCollam *et al.* Rev. Sci. Instr. **82**, 053909 (2011)

Saturday, 12 August 2017
11.30-11.50
H1

105

Superfluid ^{3}He confined in nanoscale pores

Zimmerman A.M., Nguyen M.D., Halperin W.P.
Northwestern University, Evanston, United States

Theoretical investigations of the phase diagram of superfluid ^{3}He confined in long nanoscale pores of ~200nm diameter have predicted a rich phase diagram, vastly altered from that of the bulk superfluid. Predictions show many new stabilized phases, including distorted A-like and B-like phases as well as the polar phase and a translational symmetry breaking spiral phase.[1] We report NMR measurements on superfluid ^{3}He performed in 200nm co-aligned pores with lengths of 100µm in order to test these predictions.

This work was supported by the National Science Foundation, DMR-1602542.

References:

[1] J. J. Wiman *et al*., Phys. Rev. B **92**, 144515 (2015).

Saturday, 12 August 2017
11.30-11.50
G2

106

Toward Mott transition in quantum spin liquid

Shimizu Y.[1], Hiramatsu T.[2], Maesato M.[3], Otsuka A.[3], Yamochi H.[3], Ono A.[1], Itoh M.[1], Yoshida M.[4], Takigawa M.[4], Yoshida Y.[2], Saito G.[2]
[1]Nagoya University, Nagoya, Japan, [2]Meijo University, Nagoya, Japan, [3]Kyoto University, Kyoto, Japan, [4]University of Tokyo, Kashiwa, Japan

The effects of pressure on a quantum spin liquid are investigated in an organic Mott insulator κ-$(ET)_2Ag_2(CN)_3$ with a spin-1/2 triangular lattice [1]. The application of negative chemical pressure to κ-$(ET)_2Cu_2(CN)_3$ [2], which is a well-known sister Mott insulator, allows for extensive tuning of antiferromagnetic exchange coupling, with J/k_B = 175 - 310 K, under hydrostatic pressure. Based on ^{13}C nuclear magnetic resonance measurements under pressure, we uncover universal scaling in the static and dynamic spin susceptibilities down to low temperatures < $0.1k_BT/J$. The persistent fluctuations and residual specific heat coefficient are consistent with the presence of gapless low-lying excitations, in contrast to the gapped spin-dimer system κ-$(ET)_2B(CN)_4$ [3]. Our results thus demonstrate fundamental finite-temperature properties of quantum spin liquid in a wide parameter range.

References:

[1] Y. Shimizu *et al*. Phys. Rev. Lett. **117**, 107203 (2016).

[2] Y. Shimizu *et al*. Phys. Rev. Lett. **91**, 107001 (2003).
[3] Y. Yoshida *et al.* Nat. Phys. **11**, 679 (2015).

Saturday, 12 August 2017
11.30-11.50
G3

107

Superadiabatic population transfer realized with a three-level transmon qubit

Vepsäläinen A., Danilin S., Paraoanu S.
Aalto University, Department of Applied Physics, Espoo, Finland

Quantum control by adiabatic pulses presents the advantage of robustness under errors in the control parameters, yet it is inherently slow. Here we present an implementation of the superadiabatic protocol [1] in a three-level system realized with a transmon superconducting circuit, where an additional control pulse is used to cancel the non-adiabatic evolution of the system. This enables the transfer of population from the ground state to the second excited state by stimulated adiabatic Raman passage [2] in only a few tens of nanoseconds, approaching the quantum speed limit. As a bridge between adiabatic and direct methods, superadiabatic concept allows a continuous interpolation between the speed and robustness of the population transfer. As a result, it is possible to choose an optimal protocol speed that meets the given robustness criteria. This is particularly important in the field of circuit quantum electrodynamics, where the acceptable duration of the protocol is limited by the coherence time.

References:

[1] M. Demirplak and S. Rice, The Journal of Physical Chemistry A 107, 9937-9945 (2003)
[2] K. Kumar, A. Vepsäläinen, S. Danilin, and S. Paraoanu, Nat. Comm. 7, 10628 (2016)

Saturday, 12 August 2017
11.30-11.50
Congress Hall

108

Superconducting vortex cores in tilted magnetic fields

Suderow H.
Universidad Autonoma de Madrid, Departamento de Fisica de la Materia Condensada, Instituto N. Cabrera, Condensed Matter Physics Center (IFIMAC), Madrid, Spain

Very low temperature Scanning Tunneling Microscopy STM probes the superconducting density of states at the surface as a function of the position. Vortex lattices and vortex cores have been largely studied using magnetic fields perpendicular to the surface[1]. Since the seminal experiments by Hess et al in Bell labs during the late eighties, STM has given considerable understanding of the properties of vortices in many superconductors[1,2,3]. But Hess also provided measurements of vortex cores in tilted magnetic fields[4]. The properties of vortex cores in tilted fields have remained largely un-understood.
I will discuss new and extensive STM measurements of vortex cores in tilted fields in two different materials. In the simple isotropic s-wave superconductor β-Bi$_2$Pd it has been shown that vortices bend to exit perpendicular to the surface[5]. Also, under some circumstances, the intervortex

interaction in tilted fields is dominated by the stray magnetic field and not by bulk pinning[5]. In the anisotropic system 2H-NbSe$_2$ we present a systematic study of vortex cores in tilted fields and find oval shaped vortices[6]. I will compare these two situations with the well-studied case of crossing Abrikosov/Josephson vortex lattices of extremely anisotropic superconductors.

References:

[1] H. Suderow et al, Superc. Sci. Technol. **27** (2014) 063001.
[2] H. F. Hess et al Phys. Rev. Lett. **62** 214 (1989).
[3] I. Guillamón, et al Phys. Rev. Lett. **101** 166407 (2008)
[4] H. F. Hess et al, Phys. Rev. B **50** 16528 (1994)
[5] E. Herrera et al arXiv:1703.06493.
[6] J.A. Galvis et al, in preparation.

Saturday, 12 August 2017
11.50-12.10
G1

109

Tunable sub-gap radiation detection with superconducting resonators

Dupré O.[1], Benoît A.[1], Calvo M.[1], Catalano A.[2], Goupy J.[1], Hoarau C.[1], Klein T.[1], Le Calvez K.[1], Sacépé B.[1], Monfardini A.[1], Levy-Bertrand F.[1]
[1]CNRS, Néel Institute, Grenoble, France, [2]CNRS, LPSC, Grenoble, France

Superconducting microwaves resonators are the building blocks of various technologies ranging from sensitive photon detectors for astrophysics to superconducting quantum devices. Kinetic Inductance Detectors (KIDs) are a particular implementation of superconducting resonators. They are state-of-the-art detectors for millimeter wave observations in astrophysics. The critical superconducting temperature Tc imposes a working temperature T< < Tc and the superconducting gap Δ sets in the photon detector cutoff frequency to hv>2Δ. Within the BCS-superconducting theory Δ=1.76 KBTc. Thus, for classic KIDs lowering the cutoff frequency requires to lower accordingly the operating temperature.
We published a proof-of-concept of a disruptive technology for millimetric down to centimetric detection that we have called Sub-gap Kinetic Inductance Detectors (SKIDs) [1]. These detectors are sensitive to photons with an energy hv laying well below twice the superconducting gap 2Δ. We show that the detected frequency can be adjusted by modulating the total length of the superconducting resonator. These devices are to be distinguished from the standard kinetic inductance detectors in which quasiparticles are generated when incident light breaks down Cooper pairs.

References:

[1] O. Dupré and al, Supercond. Sci. Technol 30, 045007 (2017)

Saturday, 12 August 2017
11.50-12.10
H1

110

Tuneable surface scattering and T_c suppression in superfluid ^{3}He confined in a 200 nm nanofabricated slab geometry

Heikkinen P.J.[1], Casey A.[1], Levitin L.V.[1], Rojas X.[1], Vorontsov A.[2], Zhelev N.[3], Parpia J.M.[3], Saunders J.[1]

[1]Royal Holloway, University of London, Department of Physics, Egham, United Kingdom, [2]Montana State University, Department of Physics, Bozeman, United States, [3]Cornell University, Department of Physics, Ithaca, United States

In unconventional p-wave superfluid ^{3}He, Cooper pairs are subject to anisotropic pair breaking in the vicinity of surfaces and interfaces. This effect dominates when the superfluid is confined in a cavity of height comparable to the coherence length. This can be tuned from 80 nm to 15 nm by pressure. The surface pair-breaking depends on the boundary condition for surface scattering of quasiparticles. Here we provide a direct experimental demonstration of the ability to tune the surface scattering *in situ*. We study superfluid ^{3}He confined in a single nanofabricated 200 nm high cavity, using SQUID-NMR as a probe of superfluid order parameter. We make an accurate determination of the suppression of the superfluid transition temperature, T_c. We start from atomically rough solid ^{3}He layers on the surfaces, which show the largest suppression resulting from diffuse (random) scattering with evidence of magnetic surface scattering. Pre-plating the surfaces with a solid ^{4}He film shows diffuse scattering, in good agreement with the predictions of quasiclassical theory. Finally we coat the surface with a superfluid ^{4}He film and demonstrate close to perfect specular scattering, with the almost complete elimination of T_c suppression. Measurements of the gap suppression will also be discussed.

References:

[1] L. V. Levitin *et al.*, Science **340**, 841 (2013)
[2] L. H. Kjäldman *et al.*, J. Low Temp. Phys. **33**, 577 (1978)
[3] Y. Nagato *et al.*, J. Low Temp. Phys. **110**, 1135 (1998)
[4] A. B. Vorontsov and J. A. Sauls, Phys. Rev. B **68**, 064508 (2003)

Saturday, 12 August 2017
11.50-12.10
Congress Hall

111

Equilibrium properties of the mixed state in a transverse magnetic field. Experiment and theoretical model

Kozhevnikov V.[1]*, Valente-Feliciano A.-M.*[2]*, Curran P.J.*[3]*, Richter G.*[4]*, Volodin A.*[5]*, Suter A.*[6]*, Bending S.J.*[3]*, Van Haesendonck C.*[5]
[1]Tulsa Community College, Tulsa, United States, [2]Thomas Jefferson National Lab, Newport News, United States, [3]University of Bath, Bath, United Kingdom, [4]Max-Planck-Institut for Intelligent Systems, Stuttgart, Germany, [5]KU Leuven, Leuven, Belgium, [6]Paul Scherrer Institute, Villigen, Switzerland

Equilibrium magnetic properties of the mixed state in type-II superconductors were studied on niobium high purity film and single-crystal samples in perpendicular and parallel magnetic fields, using dc magnetometry and scanning Hall-probe microscopy. The reversible magnetization curve for plane samples in perpendicular field was obtained for the first time. It was found that none of the existing theories is consistent with these new data. To address this problem, a theoretical model is developed and comprehensively validated. The new model describes the mixed state in an averaged limit, i.e. without detailing the samples´ magnetic structure and therefore ignoring interactions between the structural units (vortices). At low values of the Ginzburg-Landau parameter it converts to the model of Peierls and London for the intermediate state in type-I superconductors. The model is quantitatively consistent with experimental data for the perpendicular geometry and provides new insights in properties of the mixed state, including properties of individual vortices, in the fields of all orientations.

Saturday, 12 August 2017
11.50-12.10
G2

112

Magnetic Structure of Coupled Spin Tube with Kagome-Triangular Geometry in $CsCrF_4$

Hagihala M.[1,2], Hayashida S.[1], Avdeev M.[3], Manaka H.[4], Masuda T.[1]
[1]University of Tokyo, Institute for Solid State Physics, Kashiwa, Japan, [2]KEK, Tokai, Japan, [3]Australian Nuclear Science and Technology Organization, Lucas Heights, Australia, [4]Kagoshima University, Korimoto, Japan

When a theoretical model is realized in nature, small additional terms play important roles particularly in geometrically frustrated magnets. In case of a triangular spin tube, the two-dimensional network of the inter-tube interaction forms characteristic lattices. Among them Kagome-Triangular (KT) lattice is known to exhibit an enriched phase diagram. $CsCrF_4$ is a rare experimental realization of such a system, and we investigate the magnetic state in the compound by using neutron diffraction technique. The diffraction profile exhibited a quasi-120 structure with $\boldsymbol{k}$ = (1/2, 0, 1/2) at the base temperature. The calculation of the ground state phase diagram reveals that a single-ion anisotropy and Dzyaloshinskii-Moriya interaction suppress the cuboc structure, leading to the appearance of the quasi-120 structure. A successive phase transition having an intermediate state represented by $\boldsymbol{k}$ = (1/3, 1/3, 1/2) was observed. Discussion on the phase diagram suggested that partially ordered 120 structure is induced by thermal fluctuation.

Saturday, 12 August 2017
11.50-12.10
G3

113

Mesoscopic fluctuations in the interferometry of driven flux qubits

Sánchez M.J.[1], Ferrón A.[2], Dominguez D.[1]
[1]Centro Atómico Bariloche and Instituto Balseiro, San Carlos de Bariloche, Argentina, [2]Instituto de Modelado e Innovación Tecnológica (CONICET-UNNE) and Facultad de Ciencias Exactas, Naturales y Agrimensura, Universidad Nacional del Nordeste, Corrientes, Argentina

We investigate flux qubits driven by a biharmonic magnetic signal, with a phase lag that acts as an effective time reversal broken parameter. The driving induced transition rate can be thought as an effective transmitance, profiting from a direct analogy between interference effects at avoided level crossings and scattering events in disordered electronic systems. For time scales prior to full relaxation, but large compared to the decoherence time, this characteristic rate has been accessed experimentally and signatures of Universal Conductance Fluctuations-like effects have been analized and compared with predictions from a model that only accounts for decoherence, as a classical noise.[1] We here go beyond the classical noise model and solve the full dynamics of the driven flux qubit in contact with a quantum bath employing the Floquet- Born- Markov Master equation. [2] Within this formalism, the computed relaxation and decoherence rates turn out to be strongly dependent on both the phase lag and the dc flux detuning. In particular we demonstrate the Weak Localization-like effect in the averages values of the relaxation rate. [3]
Our predictions can be tested for accessible, but longer time scales than the current experimental times.

References:
[1] S. Gustavsson , J. Bylander and W. D. Oliver, Phys. Rev. Lett. **110**, 016603 (2013).
[2] A. Ferron A, D. Domınguez, and M. J. Sanchez, Phys. Rev.B **93**, 064521 (2016).
[3] A. Ferron A, D. Domınguez, and M. J. Sanchez, Phys. Rev.B **95**, 045412 (2017).

Saturday, 12 August 2017
12.10-12.30
H1

114
The A-B transition for 3He confined in a 1 micrometer geometry
Parpia J.[1], *Zhelev N.*[1], *Abhilash T.S.*[1], *Smith E.*[1], *Bennett R.*[1], *Rojas X.*[2], *Levitin L.*[2], *Saunders J.*[2]
[1]Cornell University, Department of Physics, Ithaca, United States, [2]Royal Holloway University of London, Department of Physics, Egham, United Kingdom

We use the torsional pendulum method to study the A B transition between 0.1 and 5.6 bar in an annular nanofluidic flow channel with height of 1.08 micrometers. We focus on the phase transition between the chiral A-phase and the time-reversal-invariant B-phase, motivated by the prediction of a spatially-modulated (stripe) phase at the A-B phase boundary[1,2]. We map the phase diagram and observe only small supercooling of the A-phase, in comparison to bulk or when confined in aerogel, with evidence for a non-monotonic pressure dependence. This suggests that a new intrinsic B-phase nucleation mechanism operates under confinement, mediated by the putative stripe phase. We discuss new insights this brings to the mystery of B-phase nucleation. Both the phase diagram and the relative superfluid fraction of the A and B phases, show that strong coupling is present at all pressures because the superfluid fraction of the A phase is greater than that of the B phase at all pressures.[3] Strong coupling at all pressures has implications for the stability of the stripe phase.
Research at Cornell supported by the NSF under DMR 1202991 and at Royal Holloway by the EPSRC under EP/J022004/1.
References:
1. J.A. Sauls and A. Vorontsov, Phys. Rev. Lett., **98** 045301 (2007).
2. J.J. Wiman and J.A. Sauls, J. Low Temp. Phys., **184** 1054 (2016).
3. Y. Kuroda and A.D.S. Nagi, J. Low Temp. Phys., **23** 751 (1976).

Saturday, 12 August 2017
12.10-12.30
G3

115
Deterministic quantum nonlinear optics with single atoms and virtual photons
Frisk Kockum A.[1], *Miranowicz A.*[1,2], *Macrì V.*[3], *Savasta S.*[1,3], *Nori F.*[1,4]
[1]RIKEN, Center for Emergent Matter Science, Wako, Japan, [2]Adam Mickiewicz University, Faculty of Physics, Poznan, Poland, [3]Università di Messina, Dipartimento di Scienze Matematiche e Informatiche, Scienze Fisiche e Scienze della Terra, Messina, Italy, [4]University of Michigan, Department of Physics, Ann Arbor, United States

We show how ultrastrong coupling between light and matter allows us to realize analogues of many nonlinear-optics phenomena in simple setups with one or more two-level atoms coupled to one or more resonator modes. The quantum Rabi model describing the light-matter interaction allows for processes that do not conserve the number of excitations in the system. This makes possible

interesting phenomena such as multiphoton Rabi oscillations [1] and a single photon exciting two or more atoms [2]. Here, we show that single- and multiphoton frequency-conversion can be realized with two resonator modes coupled ultrastrongly to a single two-level atom [3,4]. Indeed, with this and similar setups we can make a complete table with translations between three- and four-wave-mixing processes in nonlinear optics and analogous deterministic realizations with single photons in USC systems [3]. Furthermore, we show that these setups also provide analogues for higher-harmonic and -subharmonic generation, multiphoton absorption, parametric amplification, and the Kerr and cross-Kerr effects [3]. We present a unified picture of how all these effects are realized via higher-order processes and calculate the relevant transition rates. All the proposed setups can be experimentally realized in circuit QED.

References:

[1] L. Garziano, R. Stassi, V. Macrì, A. F. Kockum, S. Savasta, and F. Nori, Phys. Rev. A **92**, 063830 (2015)

[2] L. Garziano, R. Stassi, V. Macrì, O. Di Stefano, S. Savasta, and F. Nori, Phys. Rev. Lett. **117**, 043601 (2016)

[3] A. F. Kockum, A. Miranowicz, V. Macrì, S. Savasta, and F. Nori, arXiv: 1701.05038 (2017).

[4] A. F. Kockum, V. Macrì, L. Garziano, S. Savasta, and F. Nori, arXiv:1701.07973 (2017).

Saturday, 12 August 2017
12.10-12.30
G1

116

Current sensing noise thermometer for milli-Kelvin temperatures with optimized dc-SQUIDs for cross correlated readout

Fleischmann A., Mücke F., Hempel M., Richter D., Reifenberger A., Kempf S., Reiser A., Enss C.
Heidelberg University, Kirchhoff Institute for Physics, Heidelberg, Germany

Within our search for easy-to-use reliable thermometers for milli-Kelvin and micro-Kelvin temperatures we recently developed a noise thermometer, where the Johnson current noise of a massive cylinder of high purity silver is monitored simultaniously by two current sensing dc-SQUIDs. The Si-Chip carrying the two SQUIDS is glued directly onto the noise source. Operating both SQUIDS in voltage biased mode in 2-stage SQUID configurations allows to reduce the power dissipation as well as the noise of the SQUIDS to a minimum. By computing the cross-correlation of the two SQUID signals the noise contribution of the read-out is suppressed to a level which is marginal even at micro-Kelvin temperatures. To further increase the suppression we fabricated a new SQUID design with minimal mutual inductance of input and feedback coil. We compare the thermometer to a previously developed magnetic field fluctuation thermometer in the temperature range from 2.5 K down to 9 mK. Statistical uncertainties below 0.5 % are achieved within 10 s of measurement time. Within this uncertainty no self heating was observable at base temperature. This agrees with predictions from the thermal model of the thermometer, which suggests that self heating should be marginal even at temperatures well below 1 mK.

Saturday, 12 August 2017
12.10-12.30

G2

117

Photovolatic chiral magnetic effect in a Weyl semimetal

Taguchi K.[1]*, Imaeda T.*[1]*, Sato M.*[2]*, Tanaka Y.*[1]
[1]Nagoya University, Department of Materials, Physics and Energy Engineering, Graduate School of Engineering, Nagoya, Japan, [2]Kyoto University, Kyoto, Japan

Dirac and Weyl semimetals, which host bulk gapless excitations obeying quasi-relativistic fermion equations, have attracted much attention recently in condensed matter physics, since the anomaly-induced currents are dissipationless; thus, they have potential applications to unique electronics. Among the anomaly-related effects, one of the most interesting phenomena is the chiral magnetic effect [1-4], which is magnetic field-induced electric current. We theoretically predict the photovoltaic chiral magnetic effect, which is induced by the effective magnetic field due to circularly polarized light [5]. In the low-light-frequency regime, we find that the effective magnetic field triggers a finite spin polarization and drives the finite charge current. On the basis of the Keldysh-Greens function, we show that a net current is obtained by applying circularly polarized light. The current is proportional to the effective magnetic field, in the form of the chiral magnetic effect. On the other hand, unlike other chiral magnetic effects [2-4], it is dissipative and extrinsic. For Ta compound Weyl semimetals, the current reaches a huge value of $O(10^6) A/m^2$. In contrast, higher-frequency light realizes a quasi-static Floquet state with no induced electric current.

References:

[1] D. E. Kharzeev, Prog. Part. Nucl. Phys. 75, 133 (2014).
[2] M. M. Vazifeh and M. Franz, Phys. Rev. Lett. 111, 027201 (2013).
[3] D. T. Son and N. Yamamoto, Phys. Rev. Lett.109.181602 (2012)
[4] Y. Chen, S. Wu, and A. A. Burkov, Phys. Rev. B 88, 125105 (2013).
[5] K. Taguchi, T. Imaeda, M. Sato, and Y. Tanaka, Phys. Rev. B 93, 201202 (2016)

Saturday, 12 August 2017
12.10-12.30
Congress Hall

118

Anomalous magnetic moments as evidence of chiral superconductivity in Bi/Ni bilayer

Wang J.[1]*, Gong X.*[2]*, Yang G.*[1]*, Lyu Z.*[1]*, Pang Y.*[1]*, Liu G.*[1]*, Ji Z.*[1]*, Fan J.*[1]*, Jing X.*[1]*, Yang C.*[1]*, Qu F.*[1]*, Jin X.*[2]*, Lu L.*[1]
[1]Institute of Physics, Chinese Academy of Sciences, Beijing, China, [2]Fudan University, State Key Laboratory of Surface Physics and Department of Physics, Shanghai, China

There have been continuous efforts in searching for unconventional superconductivity over the past five decades. But there still lack of a common agreement on the existence of chiral superconductivity with broken time reversal symmetry (TRS) and spontaneous magnetization. Bi/Ni epitaxial bilayer is a potential unconventional superconductor with broken TRS, for that it demonstrates superconductivity and ferromagnetism simultaneously at low temperatures. We employ a specially designed superconducting quantum interference device (SQUID) constructed in situ on the Bi/Ni bilayer, to detect the orbital magnetic moment which is expected if the TRS is broken. An anomalous hysteretic magnetic response has been observed in the superconducting state, providing the evidence for the existence of chiral superconducting domains in the material.

References:

J. Wang et al., arXiv:1611.02946v1 .

Saturday, 12 August 2017
14.30-14.50
G2

119
Ising-type magnetic anisotropy in $CePd_2As_2$
Ajeesh M.O.[1], *Shang T.*[2], *Jiang W.B.*[2], *Xie W.*[2], *dos Reis R.D.*[1], *Smidman M.*[2], *Geibel C.*[1], *Yuan H.Q.*[2], *Nicklas M.*[1]
[1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany, [2]Zhejiang University, Center for Correlated Matter and Department of Physics, Hangzhou, China

We investigated the anisotropic magnetic properties of $CePd_2As_2$ by magnetic, thermal, and electrical transport studies. X-ray diffraction studies confirmed the tetragonal $ThCr_2Si_2$-type structure and the high-quality of the $CePd_2As_2$ single crystals. Magnetization and magnetic susceptibility data taken along the different crystallographic directions evidence a huge crystalline electric field (CEF) induced Ising-type magneto-crystalline anisotropy with a large *c*-axis moment and a small in-plane moment at low temperature. A detailed CEF analysis based on the magnetic-susceptibility data indicates an almost pure |±5/2> CEF ground state doublet with the dominantly |±3/2> and the |±1/2> doublets at 290 K and 330 K, respectively. At low temperature, we observe a uniaxial antiferromagnetic (AFM) ordering at temperature T_N = 14.7 K with the crystallographic *c*-direction being the magnetic easy axis. The magnetic entropy gain up to T_N reaches almost *R*ln2 indicating localized 4*f*-electron magnetism without significant Kondo-type interactions. Below T_N, the application of a magnetic field along the *c*-axis induces a metamagnetic transition from the AFM to a field-polarized phase at $\mu_0 H_c$ = 0.95 T, exhibiting a text-book example of a spin-flip transition as anticipated for an Ising-type AFM.

Saturday, 12 August 2017
14.30-14.50
H1

120
Probing a new time-reversal symmetry breaking phase in high-Tc superconductors
Holmvall P., *Löfwander T.*, *Fogelström M.*
Chalmers University of Technology, Microtechnology and Nanoscience, Gothenburg, Sweden

Theory has long suggested that *d*-wave superconductors host low-temperature phases with spontaneously broken translational and time-reversal symmetries. Experimental verification of the associated spontaneous magnetic fields of such phases remains controversial, however. In a previous study [1], we showed that this could be due to finite-size effects tied to mid-gap states, with a symmetry-breaking phase manifested as a staggered vortex-antivortex structure. In this presentation, we look at the stability of this phase against an external magnetic field. We use the quasiclassical theory of superconductivity to study mesoscopic-sized superconducting grains with a *d*-wave order parameter. We find that under an external magnetic field [2], the vortex-antivortex phase competes with an intrinsic paramagnetic Meissner response. As the temperature is lowered, the strength of the vortices grows highly non-linearly, and the paramagnetic response is suppressed, making the phase robust against the external field. The competition gives rise to several macroscopic observables, and the phase transition is associated with a large jump in the heat capacity, serving as a hallmark for the phase to be observed experimentally.

References:
[1] M. Håkansson, T. Löfwander, and M. Fogelström, Nat. Phys. 11, 755 (2015).
[2] P. Holmvall, T. Löfwander, and M. Fogelström (manuscript in preparation)

Saturday, 12 August 2017
14.30-14.50
G1

121
Coherent modification of low-temperature thermal properties using phononic crystals
Maasilta I., Puurtinen T., Tian Y., Geng Z.
University of Jyväskylä, Department of Physics, Jyväskylä, Finland

Controlling thermal properties has become relevant in recent years, in light of the strong push to develop dissipation management and detection techniques [1]. Typically, phonon thermal conductivity is controlled by scattering, but much less attention has been given to *coherent control* by engineering the dispersion relations. Here, we discuss our recent experimental and computational advances for controlling thermal conduction [2,3] and heat capacity [4], using two-dimensional hole array phononic crystals (PnCs) at sub-Kelvin temperatures.
In our initial study [2], we observed a strong reduction of thermal conductance by a factor 30, with micron-scale periodicity. Further calculations [3] indicate that it can be reduced further with larger period arrays, or can even be *increased* by a factor ~3 with small period arrays. We have confirmed the further reduction experimentally in larger 4- 8 µm period arrays, demonstrating the strange prediction [3] that larger dimensions lead to smaller thermal conductance. However, by increasing the period to 16 µm, no further reduction was seen, indicating that the coherent picture starts to be destroyed. We also demonstrate an analytic Debye-like metamaterial theory for the heat capacity of the PnCs in the low temperature limit.
References:
[1] I. J. Maasilta and A. Minnich, Phys. Today **67**, 285-290 (2014)
[2] N. Zen, T. A. Puurtinen, T. J. Isotalo, S. Chaudhuri, and I. J. Maasilta, Nat. Comm. **5**, 3435 (2014)
[3] T. A. Puurtinen and I. J. Maasilta, Crystals **6**, 72 (2016)
[4] T. A. Puurtinen and I. J. Maasilta, AIP Advances **6**, 121902 (2016)

Saturday, 12 August 2017
14.30-14.50
Congress Hall

122
Single-gap superconductivity in doped $SrTiO_3$: results of optical spectroscopy at GHz frequencies and mK temperatures
Scheffler M.[1], Thiemann M.[1], Beutel M.H.[1], Dressel M.[1], Lee-Hone N.R.[2], Broun D.M.[2,3], Fillis-Tsirakis E.[4], Boschker H.[4], Mannhart J.[4]
[1]Universität Stuttgart, 1. Physikalisches Institut, Stuttgart, Germany, [2]Simon Fraser University, Burnaby, Canada, [3]CIFAR, Toronto, Canada, [4]Max Planck Institute for Solid State Research, Stuttgart, Germany

Superconducting $SrTiO_3$ features an extremely low charge carrier density and is ideal candidate for multiband superconductivity: with increasing doping, three electronic bands are successively filled, causing a superconducting dome in the phase diagram with critical temperature up to 0.4 K. Spectroscopic studies on superconducting $SrTiO_3$ are highly desired, but so far were limited to tunnelling, which is challenging due to the low carrier density.
Here we present a new spectroscopic approach, namely optics at microwave frequencies (2 to 23 GHz) and mK temperatures using superconducting stripline resonators [1]. We obtain the complete electrodynamic response of superconducting $SrTiO_3$ and access both the quasiparticles and the superconducting condensate, and we determine the temperature dependence of the superfluid density and the superconducting energy gap for five samples throughout the superconducting dome. Surprisingly we find that only a single superconducting gap acts in $SrTiO_3$ [2], although at least two bands contribute (as we confirm by measurements in magnetic field). We can explain this finding with scattering that averages the superconducting gap structure, and this is consistent with an estimate for the transport relaxation rate based on our microwave data.

References:
[1] D. Hafner, M. Dressel, M. Scheffler, Rev. Sci. Instrum. **85**, 014702 (2014)
[2] M. Thiemann *et al*., arXiv:1703.04716 [cond-mat.supr-con]

Saturday, 12 August 2017
14.30-14.50
G3

123
Electronic Fabry-Perot interference and the chiral angle: carbon nanotube structure determination from transport data

Dirnaichner A.[1,2], del Valle M.[2], Götz K.J.G.[1], Schupp F.J.[1], Paradiso N.[1], Grifoni M.[2], Strunk C.[1], Hüttel A.K.[1]
[1]University of Regensburg, Institute for Experimental and Applied Physics, Regensburg, Germany,
[2]University of Regensburg, Institute for Theoretical Physics, Regensburg, Germany

Connecting low-temperature transport spectroscopy features with a specific microscopic nanotube structure has been an elusive goal so far. While in Coulomb blockade many aspects of the discrete level spectrum are well-understood, a closer look leads to a fascinating (and puzzling) world of hard questions.
Here, we apply a complementary approach [1] and analyze the Fabry-Perot interference pattern of a carbon nanotube strongly coupled to metallic leads [2]. By tuning a gate voltage over a large range, the trigonal warping of the Dirac cones at large energies can be probed. This, in combination with the valley degree of freedom, leads to a superstructure in the interference pattern, i.e., a secondary interference.
Measurements on an ultraclean, long and suspended carbon nanotube device at millikelvin temperatures are complemented with tight binding calculations of the transmission for specific chiralities and analytic modelling. Taking symmetry classes of nanotubes [3,4], but also effects of symmetry breaking at the contacts into account, we show that the crucial parameter for the robust secondary interference pattern is the chiral angle. Consequently, the pattern provides valuable information for determining the structure of a carbon nanotube device.

References:
[1] A. Dirnaichner et al., Phys. Rev. Lett. **117**, 166804 (2016)
[2] W. Liang et al., Nature **411**, 665 (2001)
[3] A. M. Lunde et al., Phys. Rev. B **71**, 125408 (2005)
[4] M. Marganska et al., Phys. Rev. B **92**, 075433 (2015)

Saturday, 12 August 2017
15.20-15.40
G1

124
Microwave attenuator for reducing photon dephasing in superconducting qubits below 100 mK
Yeh J.-H.[1,2], *LeFebvre J.*[3], *Zhang R.*[1,2], *Premaratne S.*[1,2], *Wellstood F.C.*[1,4], *Palmer B.S.*[1,2]
[1]University of Maryland, Department of Physics, College Park, United States, [2]Laboratory for Physical Sciences, College Park, United States, [3]University of California, Riverside, Department of Physics and Astronomy, Riverside, United States, [4]University of Maryland, Joint Quantum Institute, College Park, United States

With recent improvements in the energy relaxation times of superconducting qubits, effects from dephasing have become more noticeable. To improve the thermalization of microwave input signals propagating to circuit-QED devices and reduce dephasing from the fluctuation of a non-equilibrium photon in and out of the read-out cavity [1], we have developed cryogenic broadband (1-10 GHz) microwave attenuators [2]. Our attenuators are fabricated in a coplanar waveguide geometry and formed from a thin film of dissipative nichrome and a thick film of silver acting as a heat sink for hot electrons. The attenuators have been quantified at millikelvin temperatures by measuring the dephasing rate of a 3D $Al/AlO_x/Al$ transmon qubit which acts as a thermometer for non-equilibrium microwave photons. With a 20 dB attenuator strongly coupled to a 3D 8 GHz cavity at a temperature of 20 mK, the qubit dephasing rate is found to be $\Gamma_\phi < 7000\ s^{-1}$ corresponding to an average number of cavity photons smaller than 10^{-3} or an attenuator noise temperature $T_n \leq 50$ mK. In the limit of large dissipated power ($P_d > 1$ nW), the cooling power of the attenuator is proportional to T_n^5 ($T_n \cong 120$ mK at $P_d = 30$ nW), suggesting that the cooling power is limited by the decoupling of hot electrons from the cold phonon bath.

References:
[1] A. P. Sears, A. Petrenko, G. Catelani, L. Sun, H. Paik, G. Kirchmair, L. Frunzio, L. I. Glazman, S. M. Girvin, and R. J. Schoelkopf, Phys. Rev. B **86**, 180504(R) (2012).
[2] J.-H. Yeh, J. LeFebvre, S. Premaratne, F. C. Wellstood, and B. S. Palmer, arXiv:1703.01285.

Saturday, 12 August 2017
15.20-15.40
H1

125
Ensemble of electrons on the surface of liquid helium in a microwave cavity
Konstantinov D., *Abdurakhimov L.*, *Yamashiro R.*, *Badrutdinov A.*
Okinawa Institute of Science and Technology (OIST) Graduate University, Onna, Japan

Collective coupling of an ensemble of quantum particles to electro-magnetic modes in a resonator has been of great interest to general studies of light-matter interaction, as well as design of hybrid quantum systems. We report on our experimental studies of a collection of electrons on the surface of liquid helium placed in a perpendicular magnetic field and coupled to a single mode Fabry-Perot resonator. When the cyclotron frequency of electrons is close to the resonance frequency of the cavity we observe a high-cooperativity strong-coupling regime manifested by the normal-mode splitting in both the cavity resonant spectrum and cyclotron motion of the electrons, the latter measured as an electron

photo-conductivity response [1]. We show that due to the linearity of the coupled quantum systems such “quantum” features of the strong coupling regime, such as “avoided energy crossing”, the “vacuum” Rabi oscillations, suppression of “superradiance”, etc., can be accounted by a model based entirely on classical mechanics and electrodynamics. In addition, we observe strong photo-conductivity response of electrons at the harmonics of the cyclotron resonance, which arises from the scattering of the microwave-driven electrons from the ripplons on the surface of liquid helium [2].

References:

[1] L. V. Abdurakhimov, R. Yamashiro, A. O. Badrutdinov, and D. Konstantinov, Phys. Rev. Lett. **117**, 056803 (2016)
[2] R. Yamashiro, L. V. Abdurakhimov, A. O. Badrutdinov, Yu. P. Monarkha, and D. Konstantinov, Phys. Rev. Lett. **115**, 256802 (2015)

Saturday, 12 August 2017
15.20-15.40
G2

126

Electrical creation and control of spin current in 2D materials heterostructures

Dankert A., Kamalakar M.V., Dash S.P.
Chalmers University of Technology, Gothenburg, Sweden

Exploiting the spin degrees of freedom of electrons in solid state devices is considered as one of the alternative state variables for information storage and processing beyond the charge based technology. However, one of the primary challenges in this field is the efficient creation, transport and control of spin polarization. For this purpose, two-dimensional (2D) atomic crystals and their heterostructures provide an ideal platform for spintronics. Recently, we demonstrated a long distance spin transport over 16 µm and spin lifetimes up to 1.2 ns in large area CVD graphene [1]. In order to achieve an efficient spin injection into graphene, we further used h-BN tunnel barriers with large tunnel spin polarization up to 65 % [2]. More recently, we demonstrated gate control of spin polarization by employing graphene/MoS2 heterostructures [3]. Our findings demonstrate all-electrical spintronic device with the creation, transport and control of the spin current in 2D materials heterostructures, which can be key building blocks in future device architectures.

References:

[1] M.V. Kamalakar, G. Chris, A. Dankert, S.P. Dash; Nature Communication, 6, 6766 (2015).
[2] M.V. Kamalakar, A. Dankert, P. Kelly, S.P. Dash; Scientific Reports, 6, 21168 (2016).
[3] A. Dankert, S.P. Dash; arXiv:1610.06326. Under review in Nature Communication.

Saturday, 12 August 2017
15.20-15.40
Congress Hall

127

Superconductivity in the $LaAlO_3/SrTiO_3$ nanostructures

Kalaboukhov A.[1], Aurino P.P.[1], Galletti L.[2], Bauch T.[1], Lombardi F.[1], Winkler D.[1], Claeson T.[1]
[1]Chalmers University of Technology, Microtechnology and Nanoscience - MC2, Göteborg, Sweden,
[2]University of California Santa Barbara, Materials Research Laboratory, MC 5121, Santa Barbara, United States

The discovery of a two-dimensional electron gas that exhibits superconductivity, ferromagnetism and large spin-orbit coupling in the interface between two wide band-gap insulators, $LaAlO_3$ and $SrTiO_3$ (LAO/STO), has stimulated increasing interest in both experimental and theoretical studies of this system [1]. There are indications that the conducting interface is strongly inhomogeneous on nanoscale [2]. In order to understand possible effect of the inhomogeneity on the superconducting state, we performed a systematic characterization of the LAO/STO nanostructures fabricated using our novel patterning method based on low-energy Ar+ ion irradiation [3]. We realized nano-rings and nano-wires with a lateral width of 100 - 300 nm. Analysis of current-voltage characteristics suggests that our nanostructures behave like clean superconducting filaments without formation of weak links. Moreover, we observed a SQUID-like periodic modulation of the critical current in nano-rings corresponding to the Little-Parks fluxoid quantization [4]. A most remarkable observation is enhancement of the critical current by a small perpendicular magnetic field. This effect may be explained by the suppression of spin flip scattering on magnetic domains by external magnetic field [5].

References:

[1] S. Gariglio, M. Gabay, and J.-M. Triscone, *APL Materials* **4**, 060701 (2016).
[2] S. Caprara, D. Bucheli, N. Scopigno, N. Bergeal, J. Biscaras, S. Hurand, J. Lesueur, and M. Grilli, *Supercond. Sci. Technol.* **28** 014002 (2015).
[3] P.P. Aurino *et al.*, *Appl. Phys. Lett.* **102** 201610 (2013).
[4] R. D. Parks and W. A. Little, *Phys. Rev.* **133** A97 (1964).
[5] T.-C. Wei, D. Pekker, A. Rogachev, A. Bezryadin, and P.M. Goldbart, *Europhys. Lett.*, **75**, 943 (2015).

Saturday, 12 August 2017
15.20-15.40
G3

128

Strong coupling between an electron in a carbon nanotube quantum dot circuit and a photon in a cavity

Bruhat L.E.[1], Cubaynes T.[2], Viennot J.J.[3], Dartiailh M.C.[2], Desjardins M.M.[2], Cottet A.[2], Kontos T.[2]
[1]Chalmers University of Technology, Microtechnogy and Nanoscience, Göteborg, Sweden, [2]Ecole Normale Supérieure-PSL Research University, CNRS, Université Pierre et Marie Curie-Sorbonne Universités, Université Paris Diderot-Sorbonne Paris Cité, Laboratoire Pierre Aigrain, Paris, France, [3]University of Colorado, JILA and Department of Physics, Boulder, United States

Circuit quantum electrodynamics allows one to probe, manipulate and couple superconducting quantum bits using cavity photons at an exquisite level. One of its cornerstones is the possibility to achieve the strong coupling which allows one to hybridize coherently light and matter. Its transposition to quantum dot circuits could offer the opportunity to use new degrees of freedom such as individual charge or spin. Recently, independent efforts to reach the strong coupling of quantum dot circuits to cavity photons have come to fruition with Si [1] and GaAs [2] double quantum dots, in parallel with our experiment using carbon nanotubes [3]. Specifically, we demonstrate a hybrid superconductor-quantum dot circuit which realizes the strong coupling of an individual electronic excitation to microwave photons. We observe a vacuum Rabi splitting 2g~10 MHz which exceeds by a factor of 3 the linewidth of the hybridized light-matter states. Our findings open the path to ultra-long distance entanglement of quantum dot based qubits. They could be adapted to many other circuit designs, shedding new light on the roadmap for scalability of quantum dot setups.

References:

[1] X. Mi, Science **355**, 156-158 (2016)
[2] A. Stockklauser, Phys. Rev. X **7**, 011030 (2017)

[3] L. E. Bruhat, arXiv:1612.05214 (2016)

Saturday, 12 August 2017
15.40-16.00
H1

129

Rotation speed dependent NMR frequency in superfluid ^{3}He-A between parallel plates

Kimura Y.[1,2], *Obara K.*[1], *Yano H.*[1], *Takagi T.*[3], *Yamashita M.*[2], *Ishikawa O.*[1]
[1]Osaka City University, Osaka, Japan, [2]ISSP, Kashiwa, Japan, [3]Fukui University, Fukui, Japan

In superfluid ^{3}He-A, it has been theoretically predicted that the halfquantum vortices (HQVs), whose winding number is 1/2, is stable in the order parameter configuration where the order parameters, l-vector and d-vector are perpendicular to each other [1]. The HQVs have not yet been observed in experiments with the parallel-plates sample cell in superfluid ^{3}He-A [2, 3]. Recently a theoretical calculation has suggested that the HQVs become stable under the specific cooling conditions through T_c of a high magnetic field, a high angular velocity, and a temperature near T_c [4].
We performed continuous-wave nuclear magnetic resonance (cw-NMR) measurements at 0.96 T_c under a magnetic field of 27 mT by using the parallel-plates sample cell with 12.5 µm spacing at ISSP [5].
We observed that the negatively shifted resonance frequency depends on the angular velocity and found that the amount of negative shift becomes smaller with increasing angular velocity under some cooling conditions through T_c. Our numerical calculation also showed that the NMR frequency with HQVs depends on the angular velocity of rotation and the amount of negative shift becomes smaller with increasing angular velocity. Our experimental result is qualitatively similar to our calculation with HQVs.

References:

[1] M. M. Salomaa and G. E. Volovik, *Phys. Rev. Lett.* **55**, 1184 (1985).
[2] P. J. Hakonen *et al.*, *Phys. Rev. Lett.* **58**, 678 (1987).
[3] M. Yamashita *et al.*, *Phys. Rev. Lett.* **101**, 025302 (2008).
[4] K. Kondo *et al.*, *J. Phys. Soc. Jpn.* **81**, 104603 (2012).
[5] Y. Kimura *et al, J. Phys.: Conf. Ser.* **568**, 012006 (2014).

Saturday, 12 August 2017
15.40-16.00
Congress Hall

130

Magnetic-field-induced first order transition to FFLO state at H_{Pauli} in 2D superconductors: heat capacity measurements

Fortune N.[1], *Agosta C.*[2], *Hannahs S.*[3], *Schleuter J.*[4]
[1]Smith College, Physics, Northampton, United States, [2]Clark University, Physics, Worcester, United States, [3]National High Magnetic Field Laboratory, DC Field Facility, Tallahassee, United States, [4]Argonne National Laboratory, Materials Science Division, Argonne, United States

We report new calorimetric observations of a magnetic-field-induced first order phase transition between two different superconducting states in the highly 2D organic superconductors κ-(BEDT-

TTF)$_2$Cu(NCS)$_2$ and β´´-(BEDT-TTF)$_2$SF$_5$CH$_2$CF$_2$SO$_3$. The existence of the phase transition is highly magnetic-field-orientation dependent, existing only for magnetic fields applied parallel to the 2D superconducting planes. In strong disagreement with previous calorimetric reports [1,2] but in good agreement with recent penetration depth [3,4] and NMR [5-7] measurements, we observe these phase transitions to occur at the Clogston-Chanrashekar paramagnetic limit H_{Pauli} for each material. The location of the phase boundary, the order of the transition, and the extreme field-angle dependence are consistent with theoretical predictions [8,9] for a field-induced phase transition at H_{Pauli} into an "FFLO" inhomogeneous superconducting state (in the absence of magnetic vortices within the superconducting planes).

References:

[1] R. Lortz, Phys. Rev. Lett. **99**, 187002 (2007)
[2] R. Beyer, Phys. Rev. Lett. **109**, 027003 (2012)
[3] K. Chol, Phys. Rev. B, **79**, 220507 (2009)
[4] C. Agosta, Phys. Rev. B, **85**, 214514 (2012)
[5] J. Wright, Phys. Rev. Lett. **107**, 087002 (2011)
[6] H. Mayaffre, Nature Physics, **10**, 928 (2014)
[7] G. Koutroulakis, Phys. Rev. Lett. **116**, 067003 (2016)
[8] P. Fulde and R. Ferrell, Phys. Rev. **135**, A550 (1964)
[9] A. Larkin and Y. Ovchinnikov, Sov. Phys. JETP **20**, 762 (1965)

Saturday, 12 August 2017
15.40-16.00
G1

131

Low-noise correlation measurements based on real time processing and cooled microwave amplifiers

Tan Z., Nieminen T., Lähteenmäki P., Cox D., Hakonen P.
Aalto University, Department of Applied Physics, Espoo, Finland

Shot noise is an important measurement quantity in various experiments in mesoscopic physics, providing information of the transport properties and internal energy scales of the sample [1]. Furthermore, shot noise correlations can be used to detect coherence phenomena, including Hanbury-Brown and Twiss effects and Cooper pair splitting [2-6]. We developed a microwave correlation measurement system based on real time processing [7]. To achieve low noise, we introduce an easy low-noise solution for cryogenic amplification at 600-900 MHz based on single discrete HEMT with 21 dB gain and 7 K noise temperature. In addition, we study the quantization effects in a digital correlation measurement and determination of optimal integration time by applying Allan deviation analysis. Finally, the low noise correlation measurement system is used to study the noise correlation of a graphene cross sample.

References:

[1] Y. M. Blanter and M. Büttiker, Phys. Rep. **336**, 1 (2000).
[2] M. Henny et al. Science **284**, 296 (1999).
[3] W. D. Oliver et al. Science **284**, 299 (1999).
[4] A. Das et al. Nat. Commun. **3**, 1165 (2012).
[5] J. Wei and V. Chandrasekhar, Nat. Phys. **6**, 494 (2010).
[6] Z. B. Tan et al. Phys. Rev. Lett. **114**, 090662 (2015).
[7] T. Nieminen, P. Lähteenmäki, Z. B. Tan, D. Cox, and P. J. Hakonen, Rev. Sci. Intr. **87**, 114706 (2016)

Saturday, 12 August 2017
15.40-16.00
G3

132
Longitudinal qubit-resonator interaction in circuit QED
Krantz P.[1], *Gustavsson S.*[1], *Yan F.*[1], *Campbell D.L.*[1], *Kjaergaard M.*[1], *Kim D.*[2], *Yoder J.*[2], *Grimsmo A.*[3], *Bourassa J.*[3], *Blais A.*[3], *Kerman A.J.*[2], *Orlando T.P.*[1], *Oliver W.D.*[1,2]
[1]Massachusetts Institute of Technology, Cambridge, United States, [2]MIT Lincoln Laboratory, Lexington, United States, [3]Université de Sherbrooke, Sherbrooke, Canada

We investigate an experimental implementation of a longitudinal interaction between a superconducting qubit and a half-wavelength coplanar microwave resonator. As opposed to the transverse coupling, commonly used when dispersively reading out qubits in circuit QED, the longitudinal coupling has several potential advantages, including reduced read-out times, absence of the Purcell effect, and increased signal-to-noise ratio (SNR). Instead of detecting a dispersive frequency shift of the resonator, the readout mechanism for our system is based on a parametric modulation of the qubit-resonator coupling that is on resonance with the resonator. This resonant modulation gives rise to a difference in amplitude between the two qubit states. To enhance this interaction and thus improve the state discrimination, we inductively couple the qubit to the resonator using an array of Josephson junctions placed in the center of the half-wavelength microwave resonator, which increases the participation ratio of inductance at the coupling point. I will present our latest experimental progress.

Friday, 11 August 2017
16.30-17.15
G3

134
Protecting quantum information in superconducting circuits
Devoret M.
Yale University, Applied Physics, New Haven, United States

Can we prolong the coherence of a two-state manifold in a complex quantum system beyond the coherence of its longest-lived component? This question is the starting point in the construction of a scalable quantum computer. It translates in the search for processes that operate as some sort of Maxwell's demon, reliably correcting the errors resulting from the coupling between qubits and their environment. The presentation will review recent experiments that tested the dynamical protection, by Josephson circuits, of a logical qubit memory based on superpositions of particular coherent states of a superconducting resonator.

Saturday, 12 August 2017

09.00-09.45
H1

135
Topological order in magnetic materials
Pfleiderer C.
Technical University of Munich, Physik-Department, Garching, Germany

A long history of intense research based on the notions of symmetry breaking and generalized rigidities have resulted in a remarkably comprehensive account of complex forms of magnetic order in condensed matter systems. In recent years a new facet of magnetism research receives increasing attention that concerns the topological character of magnetically ordered systems, notably those properties that remain unchanged under elastic deformations. Important examples include skyrmions, vortices and monopoles in chiral or frustrated magnets. These topological aspects of magnetic order are not only appealing from an esthetical and conceptual point of view, but offer strikingly simple explanations for materials properties that may seem to be surprising and hideously complicated at first sight. Several examples of topological order in magnetic materials will be presented, focusing on multi-k structures in chiral magnets and systems with centro-symmetric crystal structures.

Saturday, 12 August 2017
09.00-09.45
Congress Hall

136
From single magnetic adatoms on superconductors to coupled spin chains
Ruby M.[1], Heinrich B.W.[1], Peng Y.[1,2], Pientka F.[1,2], von Oppen F.[1,2], Franke K.J.[1]
[1]Freie Universität Berlin, Fachbereich Physik, Berlin, Germany, [2]Dahlem Center for Complex Quantum Systems, Berlin, Germany

Magnetic adsorbates on conventional s-wave superconductors lead to exchange interactions that can induce bound states inside the superconducting energy gap. These states are known as Yu-Shiba-Rusinov (YSR) states and can be resolved by scanning tunneling spectroscopy as a pair of resonances at positive and negative bias voltages in the superconducting gap.
Here, we employ tunneling spectroscopy at 1.1 K to investigate magnetic atoms and chains on superconducting Pb surfaces. We show that individual Manganese (Mn) atoms give rise to a distinct number of YSR-states, depending on the crystal field imposed by the adsorption site. The spatial extension of these states directly reflects their origin as the singly occupied d-states [1].
When the atoms are brought into sufficiently close distance, the Shiba states hybridize, thus giving rise to states with bonding and anti-bonding character. It has been shown that the Pb(110) surface supports the self-assembly of Fe chains, which exhibit fingerprints of Majorana bound states [2]. Here, we test, if Co chains on Pb(110) exhibit similar characteristics of ferromagnetic coupling and zero-energy states.
References:
[1] M. Ruby, et al., Phys. Rev. Lett. **117**, 186801 (2016).
[2] S. Nadj-Perge, et al., Science **346**, 602 (2014).

Saturday, 12 August 2017

09.45-10.30
H1

137

Quantum liquid state of J_{eff}=1/2 isospins in complex Ir oxides

Takagi H.[1,2], *Takyama T.*[1], *Kitagawa K.*[2], *Matsumoto Y.*[1]
[1]Max Planck Institute for Solid State Research, Stuttgart, Germany, [2]University of Tokyo, Department of Physics, Tokyo, Japan

In 5d Ir^{4+} oxides, the spin-orbit coupling for 5d electrons is as large as ~0.5 eV and not small as compared with on-site Coulomb U. This often gives rise to a novel spin-orbital Mott state with J_{eff}=1/2 isospins, which was first identified in the layered perovskite Sr_2IrO_4 [1]. When J_{eff}=1/2 iso-spins interact with each other through 90° Ir-O_2-Ir bonds, an Ising ferromagnetic coupling is expected [2]. In a-, b-, g-Li_2IrO_3 with honeycomb based structure, J_{eff}=1/2 iso-spin are connected by the three competing 90° Ir-O_2-Ir bonds. These compounds were pointed out theoretically to be a materialization of Kiatev model [3], where S=1/2 spins on honeycomb lattice is connected by a bond dependent ferromagnetic interaction and a topological spin liquid with Majorana excitations is realized as the ground state. A long range magnetic ordering, however, was observed in a-, b-, g-Li_2IrO_3, which is likely due to the presence of additional magnetic couplings not included in the original Kitaev model [3]. The exploration of Kitaev spin liquid state was recently extended. We found that a quantum spin liquid state is realized in “hydrogenated” a-Li_2IrO_3 and b-Li_2IrO_3 under a high pressure [4]. The search for possible fractionalized excitations, expected for Kitaev spin liquid, is now underway.

References:

[1] B. J. Kim *et al.*, *Phys. Rev. Lett.* **101**, 076402 (2008), *Science* **323**, 1329 (2009).
[2] G. Jackeli and G. Khaliullin, *Phys. Rev. Lett.* **102**, 017205 (2009).
[3] S. Fujiyama *et al.*, *Phys. Rev. Lett.* **108**, 247212 (2012).
[4] A.Kitaev, Annals of Physics **312** 2 (2006).
[5] T.Takayama, *et al*., *Phys. Rev. Lett.*114, 077202 (2015).

Saturday, 12 August 2017
11.00-11.30
G1

138

MMC based cryogenic micro-calorimeters a new key technology for particle detection

Fleischmann A., Kempf S., Gastaldo L., Enss C.
Heidelberg University / Kirchhoff Institute of Physics, Heidelberg, Germany

Over the past 25 years cryogenic micro-calorimeters based on metallic paramagnetic temperature sensors operated at temperatures below 100 mK have been developed and optimized for different applications. Today metallic magnetic calorimeters (MMCs) are fully micro-fabricated densely packed 2d detector arrays with up to 4000 pixels that are applied in many fields of physics like atomic physics, nuclear physics, astro-particle physics, metrology and neutrino physics. For the readout of large arrays novel SQUID based microwave multiplexing schemes exist and their functionality in connection with MMCs has been successfully demonstrated recently. Single pixel capability of such detectors has reached cutting edge performance with an energy resolving power of close to 4000, signal rise-times below 100 ns and excellent spectral linearity. This unique combination of attributes makes MMCs an emerging key technology for many new applications. We will discuss the principle of operation and the status of development of MMCs detectors. Particular attention will be given to new readout schemes for large arrays. In addition, we will present results from a number of novel applications.

Saturday, 12 August 2017
11.00-11.30
H1

139
Helium films: from strongly correlated atomically layered films to topological mesoscopic superfluidity
Saunders J.[1], *Casey A.*[1], *Cowan B.*[1], *Heikkinen P.*[1], *Levitin L.*[1], *Nyeki J.*[1], *Parpia J.*[2], *Rojas X.*[1], *Waterworth A.*[1], *Zhelev N.*[2]
[1]Royal Holloway University of London, Physics, Egham, United Kingdom, [2]Cornell University, Ithaca, United States

Helium films provide model systems for strongly correlated quantum matter and topological superfluidity. The top-down approach involves the confinement of topological superfluid ^{3}He in engineered nanoscale geometries, with in situ tuneability of the surface scattering of ^{3}He quasiparticles, which we have recently demonstrated. Specular surfaces enable us to approach the quasi-two-dimensional limit in slab-like cavities of sub-coherence length height. This opens up the study of topological superfluid ^{3}He in height modulated structures, in which surfaces, edges and interfaces and their excitations, arising from bulk-edge correspondence, play a central role: topological mesoscopic superfluidity. The bottom-up approach is the investigation of helium films on the surface of graphite. We have recently identified a novel quasi-condensate in a ^{4}He monolayer with intertwined superfluid and density wave order. The study of two dimensional ^{3}He grown on superfluid ^{4}He films allows the study of the potential instabilities of a 2D Fermi fluid, and we discuss recent results. Here the key features are the atomic layering of the films, and the ability to cool into the microkelvin regime. In this coupled fermion-boson system, interfacial excitations potentially play an important role.

Saturday, 12 August 2017
11.00-11.30
G3

140
Physics of ultra-pure delafossite metals
Mackenzie A.[1,2]
[1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany, [2]University of St Andrews, St Andrews, United Kingdom

I will describe my group's research on a relatively little-studied but intriguing family of metals, the delafossite series of layered oxides. For reasons that are not perfectly understood, these materials have amazingly high electrical conductivity, with mean free paths of hundreds of angstroms (longer than even elemental copper or silver) at room temperature, growing to tens of microns at low temperatures. We are interested in them as possible hosts for hydrodynamic electronic transport, and investigate this by fabricating size-restricted microstructures using focused ion beam techniques. As layered materials that can be cleaved at low temperatures, they are also well suited to study by angle resolved photoemission spectroscopy, and host a variety of interesting surface states in addition to a simple single-band bulk electronic structure. If time permits I will discuss our findings on non-magnetic PdCoO2, PtCoO2 and PdRhO2 and magnetic PdCrO2.

Saturday, 12 August 2017
11.00-11.30
G2

141

Chiral liquid phase near a quantum critical point

Wang Z.[1]*, Starykh O.*[2]*, Chubukov A.*[3]*, Feiguin A.*[4]*, Zhu W.*[5]*, Batista C.D.*[1]

[1]University of Tennessee, Physics and Astronomy, Knoxville, United States, [2]University of Utah, Physics, Salt Lake City, United States, [3]University of Minnesota, Physics, Minneapolis, United States, [4]Northeastern University, Physics, Boston, United States, [5]Los Alamos National Laboratory, Theoretical Division, Los Alamos, United States

Highly frustrated magnetic materials provide a natural test bed for exploring new phases. Although elusive for many years, exotic quantum states of matter are slowly appearing in several frustrated spin Hamiltonians. Different types of phases, including topological states, such as the time-reversal invariant Z_2 spin liquid, double-semion spin liquids, Dirac spin liquids, and chiral spin liquids, have been proposed to exist in frustrated quantum magnets. Although the number keeps increasing , in most cases these models are somewhat artificial and it remains unclear how to find experimental realizations. The purpose of this presentation is to show that quantum spin liquids, which only break discrete symmetries, such as chiral or nematic liquids, could appear under quite general conditions near a quantum phase transition between a quantum paramagnet and a magnetically ordered state. A necessary condition is that the magnetic ordering must break both continuous and discrete symmetries of the underlying model. This phenomenon can be exploited as a guiding principle in the ongoing experimental search for quantum spin liquid phases.

Saturday, 12 August 2017
11.00-11.30
Congress Hall

142

Observation of topological superconductivity and Majorana fermions in superconducting-ferromagnetic hybrid systems

Ménard G.[1]*, Guissart S.*[2]*, Brun C.*[1]*, Leriche R.*[1]*, Debontridder F.*[1]*, Triff M.*[3]*, Roditchev D.*[4]*, Simon P.*[2]*, Cren T.*[5]

[1]CNRS & Sorbonne University, Paris, France, [2]Université Paris-Saclay, Orsay, France, [3]Université Paris-Saclay, Orday, France, [4]ESPCI, Paris, France, [5]CNRS & Sorbonne University, Institut des NanoSciences de Paris, Paris, France

Majorana fermions are very peculiar quasiparticles that are their own antiparticle. They obey non-abelian statistics: upon exchange, they behave differently from fermions (antisymmetric) and bosons (symmetric). Their unique properties could be used to develop new kind of quantum computing schemes. Majorana states are predicted to appear as edge states of topological superconductors. In

2D systems one expects to get some propagative Majorana edge states around the topological domains since the edges have a 1D character. The edge states in 2D topological superconductors are analogous to the edge states in Quantum Spin Hall systems. However, there is a very fundamental difference here as the superconducting topological edge states have the specificity of being Majorana excitations.
We will show that using sizeable magnetic disks made of Cobalt buried under a superconducting monolayer of Pb/Si(111), allows to generate topological superconductivity in 2D. We observe dispersive edge states crossing the gap all around the magnetic domains [1]. These spectroscopic features as signatures of a locally induced topological superconductivity in 2D Pb/Co/Si(111). We will show that a vortex generated in a topological domain support a localized Majorana bound state in its core.

References:

[1] G. C. Ménard, S. Guissart, C. Brun, M. Trif, F. Debontridder, R. T. Leriche, D. Demaille, D. Roditchev, P. Simon, T. Cren, arXiv:1607.06353 (2016)

Saturday, 12 August 2017
14.00-14.30
H1

143

Fermi liquid theory of vortex excitations and moving macroscopic objects in superfluid ^{3}He-B

Thuneberg E.V.
University of Oulu, Nano and Molecular Systems Research Unit, Oulu, Finland

We consider several recent advances in the application of Fermi liquid theory to the normal and superfluid phases of liquid ^{3}He. The stable vortex type in low temperature ^{3}He-B has a structure where the core is split into two half cores. Numerical calculation of the structure reveals a Lifshitz transition in bound fermionic excitations circling the half cores [1]. In NMR the precessing magnetization induces oscillation of the vortex structure. The core excitations set a strong damping force on the oscillation of the core, allowing only slow rotation of the core. Instead, we find strong oscillation of the asymptotic structure of the vortex far from the core. This leads to radiation of spin waves and relaxation of the magnetization. The calculation of the relaxation based on spin wave radiation is in good agreement with measurements. In the normal state the Fermi liquid theory has been applied to calculate the forces on oscillating wires and surfaces [2]. These are now extended to the superfluid state to study motion at velocities exceeding the Landau critical velocity.

References:

[1] M.A. Silaev, E. Thuneberg, and M. Fogelström, Phys. Rev. Lett. **115**, 235301 (2015).
[2] J.A. Kuorelahti, J.A. Tuorila, and E.V. Thuneberg, Phys. Rev. B **94**, 184103 (2016).

Saturday, 12 August 2017
14.00-14.30
G2

144

Exploring quantum spin-frustrated compound $YbMgGaO_4$

Zhang Q.
Renmin University of China, Beijing, China

The exploring of quantum spin-frustrated materials has attracted tremendous research interests and always been one of the frontiers in condensed matter physics for quite a long time, as quantum spin liquid (QSL) and many other exotic quantum spin states may be realized in this kind of materials. In this talk, I will introduce the exploring of a new spin-frustrated compound $YbMgGaO_4$, which possesses a perfect triangular spin lattice and strong spin-orbit coupling. By combining careful thermodynamics measurements and microscopic magnetic probes like muSR and neutron scattering, we demonstrate that the new compound is promising QSL candidates and favors a picture of U(1) gapless QSL.

References:

Yuesheng Li et al., Scientific Reports 5, 16419 (2015)
Yuesheng Li et al., Phys. Rev. Lett. 115, 167203 (2015)
Yuesheng Li et al., Phys. Rev. Lett. 117, 097201 (2016)
Y. Xu et al., Phys. Rev. Lett. 117, 267202 (2016)
Yuesheng Li et al., Phys. Rev. Leb. 118, 107202 (2017)
Yao Shen at al., Nature 540, 559-562 (2016)

Saturday, 12 August 2017
14.00-14.30
Congress Hall

145

Superconductivity and ferroelectricity in strontium titanate

Rischau C.W.[1], Lin X.[2], Grams C.P.[2], Finck D.[2], Harms S.[2], Engelmayer J.[2], Lorenz T.[2], Galais Y.[3], Fauqué B.[1], Hemberger J.[2], Behnia K.[1]
[1]ESPCI, Paris, France, [2]University of Cologne, Cologne, Germany, [3]Université Paris-Diderot, Paris, France

The large-gap semiconductor strontium titanate ($SrTiO_3$) becomes a metal upon removal of a tiny fraction of its oxygen atoms. The dilute metal has a sharp Fermi surface and is subject to a superconducting instability. Discovered half-a-century ago, the superconducting dome of strontium titanate remains doubly mysterious: How can superconductivity persist when there is only one carrier for 10^5 atoms and the Fermi energy an order of magnitude smaller then than the Debye energy [1]? What destroys this cooperative order as soon as carrier density exceeds 0.02 electrons per formula unit?

On the other hand, substituting strontium with calcium stabilizes a long-range ferroelectric order in $Sr_{1-x}Ca_xTiO_3$. We find that in $Sr_{1-x}Ca_xTiO_{3-d}$ ferroelectricity coexists with metallicity and its superconducting instability in a narrow window of doping. As the carrier concentration is increased, the ferroelectric order is eventually destroyed by a quantum phase transition [2]. This happens at a critical doping level at which the Friedel oscillations generated by neighboring dipoles interfere destructively. In the vicinity of this quantum phase transition, the superconducting critical temperature is enhanced. We will discuss a possible link to ferroelectric quantum criticality [3,4].

References:

1. X. Lin, Z. Zhu, B. Fauqué, and K. Behnia, Phys. Rev. X **3**, 021002 (2013)
2. Rischau *et al.* Nature Phys. (2017), DOI:10.1038/nphys4085
3. S. E. Rowley et al., Nature Phys. **10**, 367 (2014).
4. J. M. Edge *et al.* Phys. Rev. Lett. **115**, 247002 (2015).

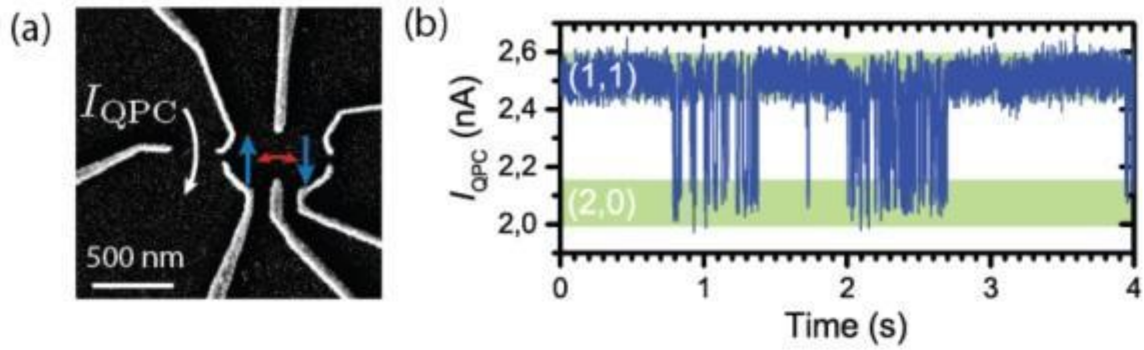
Saturday, 12 August 2017

14.00-14.30
G3

146
Probing degeneracy, spin configuration and hybridization of gallium-arsenide based quantum dots

Maisi V.[1,2], *Hofmann A.*[2], *Stockklauser A.*[2], *Basset J.*[2], *Gold C.*[2], *Röösli M.*[2], *Reichl C.*[2], *Wegscheider W.*[2], *Wallraff A.*[2], *Ihn T.*[2], *Ensslin K.*[2]
[1]Aalto University, Aalto, Finland, [2]Solid State Physics Laboratory, ETH Zurich, Zurich, Switzerland

Degeneracies play an important role in quantum statistics and operation of any physical system. The degeneracy is typically determined by spatial symmetries and the spin degree of freedom. Moreover, hybridization of different quantum states influence on the energy level configuration and changes the degeneracy.
I present our experimental work where we have utilized single-electron electrometry to probe directly the degeneracy [1] and spin states [2, 3] of the discrete energy levels in GaAs quantum dots. Figure 1 represents a typical device that we study and the charge detector signal that reveals the electron tunneling evens in the system. The tunnel events are strongly bunched because of spin blockade [2, 3]. I show furthermore how we achieved to probe the hybridization of two coupled quantum dots by measuring photon emission to a superconducting resonator [4]. Our results allow us to draw conclusions about the symmetries of our system and the mechanisms which cause spin-flipping such as the anisotropy of the spin-orbit interaction [3].



[Figure 1: Real-time detection of spin blockade.]

References:
[1] A. Hofmann et al. Phys. Rev. Lett. 117, 206803 (2016).
[2] V. F. Maisi et al. Phys. Rev. Lett. 116, 136803 (2016).
[3] A. Hofmann et al. arXiv:1612.06199 (2016).
[4] A. Stockklauser et al. Phys. Rev. Lett. 115, 046802 (2015).

Friday, 11 August 2017
17.15-18.00
H1

147
A closed cycle dilution refrigerator for space applications

Haziot A., *Triqueneaux S.*, *Vermeulen G.*

Institut Néel - CNRS, MCBT, Grenoble, France

The Planck mission sub-K cooler was the so called open cycle dilution refrigerator (OCDR): incoming streams of liquid ^{3}He and ^{4}He mix in a Y-junction to produce cooling. Since the isotopes mixture was ejected into space, the amount of helium stored on the satellite set the limit of the cooling power (0.1 µW at 100 mK) and the lifetime (30 months). Future space missions (X-IFU, PIXIE) require an order of magnitude more cooling power, lower temperatures and longer lifetime. We are developing a closed cycle dilution refrigerator (CCDR) with a lifetime around 5 years and a cooling power up to 1 µW at 50 mK or 3 µW at 100 mK.
The CCDR design extends the one of the OCDR with an isotope separator (still) working at 1 K that allows to re-use the ^{3}He and the ^{4}He. Liquid ^{4}He is extracted by a thermo-mechanical pump that uses the fountain effect of its superfluid phase, while almost pure vapor ^{3}He is pumped thanks to the large difference in vapor pressure between ^{3}He and ^{4}He in the still conditions. The mixture in the still is confined in a porous material where capillarity forces replace gravity forces to form a liquid/vapor interface.
The results of the prototypes will be presented as well as the perspective demonstration model integrating a structure more suitable for space missions.

Saturday, 12 August 2017
14.50-15.20
G2

148
Real-space observation of surface-assisted orbital order in the heavy fermion compound $CeCoIn_5$

<u>Yoshida Y.</u>[1], Kim H.[1,2], Lee C.-C.[1,3], Chang T.-R.[4], Jeng H.-T.[4,5], Lin H.[3], Haga Y.[6], Fisk Z.[6,7], Hasegawa Y.[1]
[1]University of Tokyo, Institute for Solid State Physics, Kashiwa, Japan, [2]University of Hamburg, Hamburg, Germany, [3]National University of Singapore, Singapore, Singapore, [4]National Tsing Hua University, Hsinchu, Taiwan, Republic of China, [5]Academia Sinica, Taipei, Taiwan, Republic of China, [6]Japan Atomic Energy Agency, Tokai, Japan, [7]University of California, Irvine, United States

Orbital-related physics attracts growing interest in condensed matter research, but direct access to the orbital degree of freedom is challenging. Here we report the visualization of a surface-assisted orbital ordered structure on a cobalt-terminated surface of the heavy fermion compound $CeCoIn_5$. With small tip-sample distance in our scanning tunneling microscopy, cobalt atoms are found to be dumbbell-shaped alternatingly in the [100] and [010] directions. A domain boundary of this ordered structure, which is localized within a terrace, denotes two-dimensionality of the ordered structure. First-principles calculations reveal that this structure is a consequence of the staggered d_{xz}-d_{yz} orbital order assisted by enhanced on-site Coulomb interaction at the surface. This novel surface-assisted orbital ordering seems to be ubiquitous in transition metal oxides, heavy fermion superconductors and other materials, but has been overlooked until now.

Saturday, 12 August 2017
14.50-15.20

H1

149

Properties and fate of multielectron bubbles in liquid helium

Yadav N.[1], Vadakkumbatt V.[1], Joseph E.[1], Maris H.[2], Ghosh A.[1]
[1]Indian Institute of Science, Bangalore, India, [2]Brown University, Providence, United States

Multielectron bubbles (MEBs) are cavities in liquid helium containing more than one electron. These objects provide a rich platform to study the properties of a two-dimensional electron system over a wide range of densities, as well as to investigate the effects of curvature. Although they have been predicted to show many interesting properties, the experimental progress has been relatively limited with most studies confined to their observation and measurement of charge. In a recent development, we have been able to trap [1] the MEBs in a Paul trap and subsequently measure their properties in a non-destructive manner. Our studies reveal the bubbles to be stable and long-lived under the presence of vapor inside the bubbles, which allowed us to study the effect of electric field [2] on the shape and dynamics of these objects. A question that naturally arises is what happens to the bubbles as the vapor condenses, and whether the MEBs are stable against shape perturbations. From the experiments carried out below the Lambda point, we conclude the MEBs to spontaneously break into smaller objects till they cannot be imaged any more. The final stable configuration appears to be bubbles containing very small (12) number of electrons, in accordance with recent theoretical [3] predictions.

References:

[1] V. Vadakkumbatt, E. Joseph, A. Pal, and A. Ghosh, Nat. Commun. **5**, (2014).
[2] V. Vadakkumbatt and A. Ghosh, J. Low Temp. Phys. 1 (2016).
[3] W. Wei, Z. Xie, and H. J. Maris, Phys. Rev. B **89**, 64504 (2014).

Saturday, 12 August 2017
14.50-15.20
Congress Hall

150

Tunable superconductivity and spin polarization in an oxide two-dimensional electron system

Stornaiuolo D.[1,2], Cantoni C.[3], De Luca G.M.[1,2], Di Capua R.[1,2], Di Gennaro E.[1,2], Ghiringhelli G.[4,5], Jouault B.[6,7], Marrè D.[8,9], Massarotti D.[1,2], Miletto Granozio F.[2], Pallecchi I.[8,9], Piamonteze C.[10], Rusponi S.[11], Tafuri F.[2,12]
[1]Università degli Studi di Napoli 'Federico II', Napoli, Italy, [2]CNR-SPIN UO Napoli, Napoli, Italy, [3]Oak Ridge National Laboratory, Oak Ridge, United States, [4]Politecnico di Milano, Milano, Italy, [5]CNR-SPIN, Milano, Italy, [6]Université de Montpellier, Montpellier, France, [7]CNRS, Montpellier, France, [8]Università di Genova, Genova, Italy, [9]CNR-SPIN UO Genova, Genova, Italy, [10]Paul Scherrer Institute, Villigen, Switzerland, [11]Ecole Polytcchnique Federal de Lausanne, Lausanne, Switzerland, [12]Seconda Università degli Studi di Napoli, Caserta, Italy

The control of individual atomic layers, now available also for oxide materials, paves the way to the creation of new heterostructures where diverse oxide functionalities are integrated and their interplay can drive the emergence of novel quantum phenomena in solid state physics.
Following this idea, we engineered an oxide heterostructure based on $LaAlO_3$ and $EuTiO_3$ thin films deposited on an $SrTiO_3$ substrate. Similarly to the LAO/STO interface [1], the LAO/ETO/STO system exhibits a two-dimensional electron gas (2DEG) with Rashba spin-orbit coupling and a superconductive transition. In addition, the LAO/STO/STO 2DEG shows also robust ferromagnetism, fully tunable using electric field effect [2].

The coexistence of superconductivity and spin-polarization in the same system, showing also spin-orbit coupling, is of great interest for the emergence of novel quantum states in oxide 2DES.

References:
[1] A. Ohtomo et al., Nature **427**, 423 (2004)
[2] D. Stornaiuolo et al. Nature Materials **15**, 278-283 (2016)

Monday, 14 August 2017
14.30-14.50
G2

151
Doped Kondo chain - a heavy Luttinger liquid
Khait I.[1], *Azaria P.*[1,2], *Berg E.*[3], *Auerbach A.*[1]
[1]Technion - Israel Institute of Technology, Physics Department, Haifa, Israel, [2]Université Pierre et Marie Curie, Laboratoire de Physique Théorique des Liquides, Paris, France, [3]Weizmann Institute of Science, Rehovot, Israel

We study the Kondo Lattice Model (KLM) in the paramagnetic metallic phase away from half-filling using Density Matrix Renormalization Group. It is commonly accepted that for a weak enough interaction between the conduction electrons and the localized spins a Tomonaga-Luttinger Liquid (TLL) is formed [1,2]. The TLL is characterized by a large Fermi Surface (FS) [3,4] consisting of the original conduction electrons and the localized spins. Previously, Friedel oscillations were used to determine the size of the FS, however contradictions between wave vectors of spin and charge oscillations did not resolve the nature of the large FS [5]. In the present work, we directly compute the density and spin susceptibilities which unambiguously reveal a large FS, and hence establish the TLL description of the KLM. We also find a hybridization gap at the small FS location and compare it to the large N (slave-boson) theory of the KLM.

References:
[1] N. Shibata, A. Tsvelik, K. Ueda, Phys. Rev. B, **56**, 330 (1997).
[2] A. Sikkema, I. Affleck, S. White, Phys. Rev. Lett., **79**, 929 (1997).
[3] M. Yamanaka, M. Oshikawa, I. Affleck, Phys. Rev. Lett., **79**, 1110 (1997).
[4] M. Oshikawa, Phys. Rev. Lett., **84**, 3370 (2000).
[5] N. Shibata, K. Ueda, T. Nishino, Phys. Rev. B, **54**, 13495 (1996).

Monday, 14 August 2017
14.30-14.50
G1

152
Vortex reconnections and decay of quantum turbulence in superfluid ^{4}He: possible role of rotons and how to detect them
Galli D.E., Amelio I., Reatto L.
Università degli Studi di Milano, Dipartimento di Fisica, Milano, Italy

Reconnections of vortices have a fundamental role in the decay of quantum turbulence in superfluid ^{4}He. At low temperatures, emission of phonons and of small vortex rings generated by reconnections

and Kelvin wave cascades are commonly considered the channels for the dissipation of the turbulent energy but, at present, there is no direct experimental evidence for such processes. The theoretical evidence is based on phenomenological models and on the Gross-Pitaevskii equation (GPE). A microscopic study of a vortex reconnection requires to know the local structure of the vortex core, a region where GPE gives a poor representation of ^{4}He. Recent ab initio many-body computations of a vortex line in superfluid ^{4}He at T=0K have been performed [1]. For the Onsager-Feynman phase (equivalent to that of GPE) the *exact* energy and density profile are now known. Improved variational results have been obtained by assuming a more general form for the phase that accounts for backflow effects. Building upon these results we argue that a vortex reconnection leads not to a rarefaction wave as given by GPE but to emission of rotons. We estimate the number of rotons emitted in quantum turbulence and we propose a way to detect such non-thermal rotons based on the peculiar properties of superfluid ^{4}He.

References:

[1] D.E. Galli, L. Reatto, M. Rossi, Phys Rev B **89**, 224516 (2014).

Monday, 14 August 2017
14.30-14.50
G3

153

Quasiparticle poisoning in Majorana island devices

<u>van Veen J.</u>[1], Watson J.D.[1], Proutski A.[1], de Jong D.[1], Sartori N.[1], Binci L.[1], Singh A.[1], Karzig T.[2], Pikulin D.I.[2], Lutchyn R.[2], Nygard J.[3], Krogstrup P.[3], Geresdi A.[1], Kouwenhoven L.P.[4]
[1]QuTech and Kavli Institute of NanoScience, Delft University of Technology, Delft, Netherlands, [2]Station Q, Microsoft Research, Santa Barbara, California, United States, [3]Center for Quantum Devices and Station-Q Copenhagen, Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark, [4]Microsoft Station-Q at Delft University of Technology, Delft, Netherlands

Over the past years numerous studies have reported on signatures of Majorana zero modes (MZMs) via zero-bias peaks, however, to date there have been no experiments demonstrating non-Abelian statistics. While a definitive proof of non-Abelian statistics would require a topological T-junction, it has recently been proposed that the fusion channels of MZMs, intimately related to the non-Abelian statistics, could be probed in a single-wire geometry [1]. An outstanding issue for a fusion experiment, however, is quasiparticle poisoning.
In our work we study quasiparticle poisoning using the gate modulation of the switching current in gate-tunable single Cooper pair transistors fabricated from InAs nanowires half-covered with an epitaxial Al shell. We find a 2e periodic modulation of the switching current in a wide range of gate voltages, nicely fitting the Joyez model [2]. Moreover, there was no sign of switching to the normal conducting state over a remarkably long timescale of 45 minutes. These results indicate the lack of deep quasiparticle traps on the island which is highly promising for the readout of the fusion experiment.

References:

[1] D. Aasen et al., PRX **6**, 031016 (2016)
[2] P. Joyez et al., PRL **72**, 2458 (1994)

Monday, 14 August 2017
14.30-14.50

Congress Hall

154

Fluctuations of nematicity and the spin subsystem in FeSe and FeSeS

Lin J.-Y.
National Chiao Tung University, Institute of Physics, Hsinchu City, Taiwan, Republic of China

The nematic order (nematicity) is considered one of the essential ingredients to understand the mechanism of Fe-based superconductivity. In most Fe-based superconductors (pnictides), nematic order is reasonably close to the antiferromagnetic order. In FeSe and FeSeS, in contrast, a nematic order emerges below the structure phase transition at T_s = 90 K (70 K for FeSeS) with no magnetic order. The case of FeSe is of paramount importance to a universal picture of Fe-based superconductors. The polarized ultrafast spectroscopy provides a tool to probe simultaneously the electronic structure and the magnetic interactions through quasiparticle dynamics. Here we show that this novel approach reveals both the electronic and magnetic nematicity below and, surprisingly, far above T_s to at least 200 K. The quantitative pump-probe data clearly identify a correlation between the topology of the Fermi surface (FS) and the magnetism in all temperature regimes, thus providing profound insight into the driving factors of nematicity in both FeSe and FeSeS and the origin of its uniqueness.
Support from MOST of Taiwan is acknowledged.

Monday, 14 August 2017
14.30-14.50
H1

155

Interplay of the inverse proximity effect and magnetic field in out-of-equilibrium single-electron devices

Nakamura S.[1], *Pashkin Y.*[2], *Taupin M.*[3], *Maisi V.*[4], *Khaymovich I.*[5], *Mel'nikov A.*[6], *Peltonen J.*[4], *Pekola J.*[4], *Okazaki Y.*[1], *Kashiwaya S.*[1], *Kawabata S.*[1], *Vasenko A.*[7], *Tsai J.-S.*[8], *Kaneko N.-H.*[1]
[1]National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan, [2]Lancaster University, Department of Physics, Lancaster LA YB, United Kingdom, [3]Institute of Solid State Physics, Vienna University of Technology, Wiedner Hauptstrasse, Austria, [4]Aalto University, Low Temperature Laboratory, Department of Applied Physics, Aalto, Finland, [5]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany, [6]Institute for Physics of Microstructures, Russian Academy of Sciences, Nizhny Novgorod, Russian Federation, [7]National Research University Higher School of Economics, Moscow, Russian Federation, [8]RIKEN Center for Emergent Matter Science, Wako, Japan

The proximity effect, which is the induction of the superconducting order into a normal conductor at the interface, plays an important role in the physics of solid-state devices [1,2]. In addition to this, the normal metal also affects the order parameter in the superconducting side via the inverse proximity effect.
Here we demonstrate the effect of an external magnetic field on non-equilibrium quasiparticle (QP) distribution in a single-electron hybrid device, under the conditions of the inverse proximity effect. Hot QPs that get trapped at zero field in the vicinity of the junctions, become released in a weak magnetic field, which creates additional QP traps in the leads. As a clear experimental evidence of the interplay of the inverse proximity effect and magnetic field, we observe an enhancement of the superconducting gap and significant improvement of the turnstile characteristics related to efficient QP relaxation in magnetic field. Theoretical calculations using the heat diffusion equation support this scenario

quantitatively [3]. This mechanism of gap enhancement and efficient QP relaxation is important for understanding phenomena in various superconducting and hybrid devices and can be used for applications in quantum computation, photon detection and quantum metrology.

References:

[1] V. Mourik, K. Zuo, S. M. Frolov, S. R. Plissard, E. P.A. M. Bakker and L. P. Kouwenhoven, Science 336, 1003 (2012)
[2] F. Giazotto, J. T. Peltonen, M. Meschke and J. P. Pekola, Nature Physics 6, 254 (2010)
[3] S. Nakamura, Y. A. Pashkin, M. Taupin, V. F. Maisi, I. M. Khaymovich, A. S. Mel'nikov, J. T. Peltonen, J. P. Pekola, Y. Okazaki, S. Kashiwaya, S. Kawabata, A. S. Vasenko, J. Tsai, and N.-H. Kaneko, arxiv:1612.04116

Monday, 14 August 2017
15.20-15.40
G2

156

Magnetic excitations with series expansion methods for Kitaev-Heisenberg models on honeycomb lattices

Yamada T., Suzuki T., Suga S.-I.
University of Hyogo, Himeji, Japan

Recently, honeycomb-lattice magnets such as α-$RuCl_3$ and Na_2IrO_3 have attracted much attention because of their novel properties. Although these materials undergo phase transitions to the zigzag antiferromagnetic states, their ground states are considered to be located close to the Kitaev spin liquid (KSL) state. We have revealed from the studies on dynamical structure factors of the Kitaev-Heisenberg (KH) model [1,2] that the linear spin-wave approximation fails in explaining low-lying excitations, when the magnetically ordered state is located close to the phase boundary to the KSL phase [3,4]. In this study, we investigate the ground-state phase diagram and low-lying excitations of the KH model using a cluster expansion method [5]. This method enables us to include effectively the interaction between magnon excitations. We calculate the ground state energies and the dispersion relations of low-lying excitations by changing the parameters from the region deep inside the magnetically ordered phase to the phase boundary of the KSL phase. We compare the dispersion relations obtained by this method with those obtained by a numerical diagonalization method, and discuss the characteristics of low-lying excitations close to the phase boundary.

References:

[1] J. Chaloupka, *et al*., Phys. Rev. Lett. **105**, 027204 (2010); *ibid*. **110**, 097204 (2013).
[2] K. W. Plumb, *et al*., Phys. Rev. B **90**, 041112(R) (2014).
[3] T. Suzuki, *et al*., Phys. Rev. B **92**, 184411 (2015).
[4] Y. Yamaji, *et al*., Phys. Rev. B **93**, 174425 (2016).
[5] J. Oitmaa, *et al*., Series Expansion Methods for Strongly Interacting Lattice Models, Cambridge University Press, Cambridge (2006).

Monday, 14 August 2017
15.20-15.40
G3

157

Catch and release of microwave phonons

Ekström M.K.[1], *Aref T.*[1], *Sanada H.*[1,2], *Suri B.*[1], *Andersson G.*[1], *Delsing P.*[1]
[1]Chalmers University of Technology, Microtechnology and nanoscience, Göteborg, Sweden, [2]NTT Corporation, NTT Basic Research Laboratories, Kanagawa, Japan

It has recently been shown that surface acoustic waves (SAWs) can interact with artificial atoms (transmon qubits) at the quantum level [1]. This has opened up for new possibilities utilizing SAWs (phonons) instead of electromagnetic waves (photons) [2-4] in quantum physics experiments. Here we explore one of these experiments; time-control of phonons. The time-control of propagating phonons benefits from the five orders of magnitude slower speed of SAWs than the speed of photons in vacuum. It takes the phonons about 200 ns to traverse from one transmon to a second transmon in our device. The transmons' coupling to the phonons can be tuned separately by applied magnetic flux and hence serve as tunable mirrors for individual phonons. The ample time it takes the phonons to traverse between the two transmons makes it possible to capture phonons and to on-demand release them in one desired direction. Since the phonons can traverse long distances, it should also be possible store them between the two transmons during a substantial time.

References:

[1] M.V. Gustafsson, T. Aref, A. Frisk Kockum, M.K. Ekström, G. Johansson and P. Delsing, Science **346**, 207-211 (2014).
[2] Y. Yin *et al.*, Phys. Rev. Lett. **110**, 107001 (2013).
[3] M. Pierre, I.-M. Svensson, S. Raman Sathyamoorthy, G. Johansson, and P. Delsing, **104**, 232604 (2014).
[4] E. Flurin, N. Roch, J.D. Pillet, F. Mallet, and B. Huard, Phys. Rev. Lett. **114**, 090503 (2015).

Monday, 14 August 2017
15.20-15.40
G1

158

Instabilities of ^{3}He on atomically layered ^{4}He films

Waterworth A., Nyeki J., Cowan B., Saunders J.
Royal Holloway, University of London, Egham, United Kingdom

We report SQUID NMR measurements of the nuclear magnetic susceptibility of ^{3}He on atomically layered ^{4}He films on graphite at ^{3}He coverages $n_3 < 1$ nm^{-2}, in the temperature range 200 µK to 500 mK. One motivation is to seek a regime, at low ^{3}He densities, in which the ^{3}He-^{3}He interactions are attractive, with a contribution from indirect interactions mediated by the ^{4}He film [1,2]. The temperature independent Pauli susceptibility at sufficiently low temperatures provides a powerful way to characterize the ground state of the film. In practice we find this to be influenced by a rich interplay of competing surface states, condensation of ^{3}He and phase separation into distinct and coexisting Fermi systems, with a clear dependence on the number of ^{4}He layers and ^{3}He coverage. Of particular interest is the possibility of ^{3}He dimer formation [2,3,4]. On a three layer ^{4}He film we observe a thermally activated temperature dependence of the susceptibility over a narrow range of ^{3}He coverage, giving rise to a distinct maximum in susceptibility. Potential interpretations of this anomalous behaviour will be discussed.

References:

[1] S. Kurihara, JPS **52**, 1311 (1983)
[2] M. Kagan, Physics-Uspekhi **37**, 69 (1994)
[3] K. Miyake, Prog. Theor. Phys. **69**, 1794 (1983)
[4] E. Krotscheck, J. Paaso, M. Saarela and K. Schorkhuber, Phys. Rev. Lett. **85**, 2344 (2000)

Monday, 14 August 2017
15.20-15.40
H1

159

Insulating Josephson-junction chains as pinned Luttinger liquids

Cedergren K.[1,2], Ackroyd R.[1,2], Kafanov S.[1,2], Vogt N.[3], Shnirman A.[4], Duty T.[1,2]
[1]University of New South Wales, Physics, Sydney, Australia, [2]ARC Centre for Engineered Quantum Systems - EQuS, University of New South Wales, Sydney, Australia, [3]RMIT University, Chemical and Quantum Physics, Melbourne, Australia, [4]Karlsruhe Institute of Technology, Institut für Theorie der Kondensierten Materie, Karlsruhe, Germany

Quantum physics in one spatial dimension is remarkably rich, yet even with strong interactions and disorder, surprisingly tractable. This is due to the fact that the low-energy physics of one-dimensional systems can be cast in terms of the Luttinger liquid. We have measured critical voltages for a large number of simple chains of sub-micron Josephson junctions with significantly varying energy scales. We observe universal scaling of critical voltage with single-junction Bloch bandwidth [1], strongly validating the quantum many-body theory of one-dimensional disordered systems [2,3]. In contrast to the presumed Mott insulator, this establishes the ground state of insulating Josephson junctions chains as a Luttinger liquid pinned by random offset charges, thereby providing a one-dimensional implementation of the Bose glass. The ubiquity of such an electronic glass in Josephson-junction chains has important implications for their proposed use as a fundamental current standard, which is based on synchronisation of coherent tunnelling of flux quanta (quantum phase slips)[4,5]. We have recently extended our measurements to SQUID chains and ladders, finding unexpected and tantalising behaviour.

References:

[1] K. Cedergren, R. Ackroyd, S. Kafanov, N. Vogt, A. Shnirman, and T. Duty, submitted to Phys. Rev. Lett. (under review, 2017)
[2] T. Giamarchi and H. J. Schulz, Phys. Rev. B 37, 325 (1988)
[3] Thierry Giamarchi, Quantum Physics in One Dimension, Clarendon Press, Oxford (2003)
[4] D. Haviland, "Superconducting circuits: Quantum phase slips", Nat. Phys. 6, 565-566 (2010)
[5] I. M. Pop, I. Protopopov, F. Lecocq, Z. Peng, B. Pannetier, O. Buisson, and W. Guichard, Nat. Phys. 6, 589-592 (2010)

Monday, 14 August 2017
15.20-15.40
Congress Hall

160

Spin space anisotropy in underdoped Ba$(Fe_{1-x}Co_x)_2As_2$ with coexistence of superconductivity and antiferromagnetism

Waßer F.[1], Lee C.-H.[2], Kihou K.[2], Steffens P.[3], Schmalzl K.[4], Qureshi N.[1,3], Braden M.[1]
[1]Universität zu Köln, II. Physikalisches Institut, Köln, Germany, [2]National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan, [3]Institut Laue Langevin, Grenoble, France, [4]Jülich Centre for Neutron Science, Forschungszentrum Jülich GmbH, Outstation at Institut Laue-Langevin, Grenoble, France

The emergence of a spin-resonance mode in the superconducting (SC) state provides strong support for a pairing mechanism based on spin fluctuations. For optimal and overdoped $BaFe_2As_2$ there are two resonance contributions: an isotropic mode at larger energy and an anisotropic mode at low energy. Several reports on Ni-, K-, and Co-doped samples suggest a rather general behaviour. On the other side the question of how static AFM influences the resonance mode has not been explored so far in any unconventional superconductor. $Ba(Fe_{0.955}Co_{0.045})_2As_2$ is well suited for such study due to the well-established microscopic phase coexistence of AFM order and SC. We performed polarised inelastic neutron scattering experiments on $Ba(Fe_{0.955}Co_{0.045})_2As_2$ [1], and with respect to the three orthorhombic directions, we observe three spin gaps in the AFM phase resembling those in $BaFe_2As_2$ [2]. Particularly, the longitudinal gap is large, and no spectral weight persists below the SC 2Δ gap value. Consequently, in the SC state two fully anisotropic resonance modes without longitudinal contributions emerge in stark contrast to the optimal and over doping [3]. Band-selective properties in the AFM state must be taken into account to describe SC in materials with coexistence of SC and magnetic order.

References:

[1] F. Waßer et al. arxiv: 1609.02027 (2016)
[2] N. Qureshi et al. PRB 86, 060410(R) (2012)
[3] P. Steffens et al. PRL 110, 137001 (2013)

Monday, 14 August 2017
15.40-16.00
Congress Hall

161

X-ray fluorescence holography of Pr-doped $CaFe_2As_2$

Kudo K.[1], *Ioka S.*[1], *Happo N.*[2], *Ota H.*[3], *Ebisu Y.*[4], *Kimura K.*[5], *Hada T.*[2], *Kimura T.*[1], *Tajiri H.*[6], *Hosokawa S.*[7], *Hayashi K.*[5], *Nohara M.*[1]

[1]Okayama University, Research Institute for Interdisciplinary Science, Okayama, Japan, [2]Hiroshima City University, Graduate School of Information Sciences, Hiroshima, Japan, [3]Okayama University, Advanced Science Research Center, Okayama, Japan, [4]Hiroshima Instituite of Technology, Graduate School of Science and Technology, Hiroshima, Japan, [5]Nagoya Institute of Technology, Department of Physical Science and Engineering, Nagoya, Japan, [6]Japan Synchrotron Radiation Research Institute, Hyogo, Japan, [7]Kumamoto University, Department of Physics, Kumamoto, Japan

The state-of-the-art technique, x-ray fluorescence holography experiment [1], was performed in order to visualize the local 3D atomic configurations and positional fluctuations [2] of iron-based superconductor $Ca_{1-x}Pr_xFe_2As_2$. $Ca_{1-x}Pr_xFe_2As_2$ has been reported to exhibit high superconducting transition temperature T_c = 49 K with a very small superconducting volume fraction of several percent [3,4]. STM/STS observed a large superconducting gap around the doped Pr atoms, but no superconducting gap was observed around Ca [5]. In order to investigate the reason why the high T_c superconductivity emerges around Pr, we performed x-ray fluorescence holography experiments using synchrotron radiation at BL13XU, SPring-8, Japan.

The atomic images of As revealed that As positions fluctuated significantly even in the parent $CaFe_2As_2$ compound without Pr doping. For Pr-doped $Ca_{0.9}Pr_{0.1}Fe_2As_2$, we found that the positional fluctuations of As were almost unchanged around Pr atoms compared with $CaFe_2As_2$, but the positional fluctuations of As were significantly increased around Ca atoms, which were located far from doped Pr. These observations were consistent with the local superconductivity at T_c = 49 K around the doped Pr.

References:

[1] K. Hayashi *et al*., J. Phys.: Condens. Matter **24**, 093201 (2012).
[2] J. J. Barton, Phys. Rev. Lett. **67**, 3106 (1991).

[3] B. Lv *et al*., PNAS **108**, 15705 (2011).
[4] S. R. Saha *et al*., Phys. Rev. B **85**, 024525 (2012).
[5] K. Gofryk *et al*., Phys. Rev. Lett. **112**, 047005 (2014).

Monday, 14 August 2017
15.40-16.00
G1

162
Superfluid boundary layer
Barenghi C.F., Stagg G.W., Parker N.G.
Newcastle University, School of Mathematics, Statistics and Theoretical Physics, Newcastle upon Tyne, United Kingdom

We model the superfluid flow of liquid helium over a real surface, rough at the microscopic scale, derived from a wire used to experimentally generate turbulence and profiled by Atomic Force Microscopy. Our numerical simulations [1] of the Gross-Pitaevskii equation reveal that the sharpest features in the surface induce vortex nucleation both intrinsically (due to the raised local fluid velocity) and extrinsically (due to their role as pinning sites of vortex lines). Vortex interactions and reconnections contribute to form a well-defined, dense, turbulent layer of vortices with a non-classical average velocity profile and which continually sheds small vortex rings into the bulk. We characterise this behaviour for various imposed flows. As boundary layers conventionally arise from viscous forces, this result is surprising and opens up new insight into the nature of superflows at real boundaries.
References:
[1] G.W. Stagg, N.P. Parker and C.F. Barenghi, Phys. Rev. Lett. 118, 135301 (2017).

Monday, 14 August 2017
15.40-16.00
G2

163
Chiral spin liquids and anomalous Hall effect on the kagome lattice
Essafi K.[1], Benton O.[1,2], Jaubert L.D.C.[1,3], Udagawa M.[4]
[1]Okinawa Institute of Science and Technology, Onna-son, Japan, [2]RIKEN, Condensed Matter Theory Laboratory, Wako, Japan, [3]University of Bordeaux, Laboratoire Ondes et Matieres d'Aquitaine, Bordeaux, France, [4]Gakushuin University, Department of Physics, Tokyo, Japan

Competing interactions in frustrated magnets prevent ordering down to very low temperatures and stabilize exotic highly degenerate phases where strong correlations coexist with fluctuations. We study the fully anisotropic nearest-neighbour model on kagome, whose ground state is described by a variety of exotic (chiral) phases, including classical spin liquids. When restricted to the XXZ model with Dzyaloshinskii-Moriya, our theory shows a three-fold mapping [1] which transforms the well-known Heisenberg antiferromagnet (HAF) and XXZ model onto two lines of time-reversal Hamiltonians.
The mapping is exact for both classical and quantum spins, i.e. preserves the energy spectrums of the HAF and XXZ model. Therefore, our three-fold mapping gives rise to a connected network of quantum spin liquids centered around the Ising antiferromagnet. We show that this quantum disorder spreads

over an extended region of the phase diagram at linear order in spin wave theory, which overlaps with the parameter region of Herbertsmithite ZnCu3(OH)6Cl2. At the classical level, some of the phases unveiled here support a spontaneous scalar chirality which was absent in the original HAF and XXZ models.
The consequence of this scalar chirality on finite-temperature conductivity will be discussed [2].

References:
[1] Essafi, Benton, Jaubert, Nature Comm. 2016
[2] Jaubert, Udagawa, Essafi & Benton, in preparation

Monday, 14 August 2017
15.40-16.00
H1

164
Quantum coherently-driven charge transport across two SQUIPTs coupled by a Coulomb island

Enrico E.[1], *Croin L.*[1], *Strambini E.*[2], *Giazotto F.*[2]
[1]INRIM, Istituto Nazionale di Ricerca Metrologica, Torino, Italy, [2]NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, Pisa, Italy

Actual research on the manipulation of quantum phenomena at the level of artificial atoms and qubits mainly focuses on nanostructured superconducting circuitry.
We will present a device concept based on the exploitation of quantum interference in short phase-biased superconducting nanowires implementing a superconducting quantum interference proximity transistor (SQUIPT) that leads to a tunable gap in the wire density of states (DOSs). A quantum-enhanced turnstile for single electrons based on SQUIPTs has been recently demonstrated exploiting analogous phenomena [2].
We will show how the flux dependence of the proximity gap induced in the weak link of a SQUIPT can be exploited as a phase-tunable energy barrier which enables quantum charge configurations with enhanced functionalities. Coupling two SQUIPTs with a metallic or superconducting Coulomb island we will present a novel single-electron superconducting transistor (called SQUISET) in which the charging landscape is coherently driven by an external magnetic field.
Resuming, this device adds new perspectives to quantum electronics being an alternative building block in fields such as quantum metrology, coherent caloritronics, or quantum information technology.

References:
[1] Y. Nakamura, Y. A. Pashkin, J. S. Tsai, Nature 398 , (1999)
[2] E. Enrico and F. Giazotto, Phys. Rev. Appl., Vol. 5, Issue 6, 064020, (2016).

Monday, 14 August 2017
15.40-16.00
G3

165
Giant acoustic atom: a single quantum system with a deterministic time delay

Guo L.[1,2], *Grimsmo A.*[3], *Frisk Kockum A.*[2,4], *Pletyukhov M.*[5], *Johansson G.*[2]
[1]Karlsruher Institut für Technologie (KIT), Karlsruhe, Germany, [2]Chalmers University of Technology, Department of Microtechnology and Nanoscience (MC2), Gothenburg, Sweden, [3]Université de Sherbrooke, Institut Quantique and Département de Physique, Sherbrooke, Canada, [4]Center for

Emergent Matter Science, RIKEN, Saitama, Japan, [5]RWTH Aachen University, Institute for Theory of Statistical Physics, Aachen, Germany

We investigate the quantum dynamics of a single transmon qubit coupled to surface acoustic waves (SAWs) via two distant connection points. Since the acoustic speed is five orders of magnitude slower than the speed of light, the travelling time between the two connection points needs to be taken into account. Therefore, we treat the transmon qubit as a giant atom with a deterministic time delay. We find that the spontaneous emission of the system, formed by the giant atom and the SAWs between its connection points, initially decays polynomially in the form of pulses instead of a continuous exponential decay behaviour, as would be the case for a small atom. We obtain exact analytical results for the scattering properties of the giant atom up to two-phonon processes by using a diagrammatic approach. We find that two peaks appear in the inelastic (incoherent) power spectrum of the giant atom, a phenomenon which does not exist for a small atom. The time delay also gives rise to novel features in the reflectance, transmittance, and second-order correlation functions of the system. Furthermore, we find the short-time dynamics of the giant atom for arbitrary drive strength by a numerically exact method for open quantum systems with a finite-time-delay feedback loop.

Monday, 14 August 2017
10.10-10.40
Congress Hall

166
Electronic transport in semiconductor nanowires and 2D topological insulators

Pribiag V.
University of Minnesota, Minneapolis, United States

Semiconductors with strong spin-orbit coupling and topological insulators (TIs) have emerged as promising platforms for spintronics and quantum information processing. In the first part of this talk, I will present experiments that rely on the strong spin-orbit interaction in InSb nanowires to achieve all-electrical control of individual electron and hole spins in quantum dots [1, 2].
In the second part of the talk I will present our experimental efforts to demonstrate topological superconductivity in a 2D TI [3]. In proximity to a superconductor, 2D TIs are predicted to host topological superconductivity, which supports non-Abelian excitations known as Majorana zero-modes. We demonstrate that supercurrents can flow through the edge modes of Type-II InAs/GaSb quantum wells, a 2D TI. By gating the devices we observe superconducting transport in all three regimes of the 2D TI: bulk electrons, edge modes and bulk holes. From superconducting quantum interference measurements, we extract the spatial distribution of the supercurrent in all three regimes. A clear transition to edge-dominated supercurrent is observed under conditions of high bulk resistivity. These experiments establish InAs/GaSb as a promising platform for realizing topological superconductivity.

References:

[1] S. Nadj-Perge *et al.*, *Phys. Rev. Lett.***108** 166801 (2012).
[2] V. S. Pribiag *et al.*, *Nature Nanotechnology* **8**, 170 (2013).
[3] V. S. Pribiag *et al.*, *Nature Nanotechnology* **10**, 593 (2015).

Monday, 14 August 2017

10.40-11.10
Congress Hall

167
Correlated electron materials under uniaxial stress
Hicks C.W.[1], *Steppke A.*[1], *Barber M.E.*[1,2], *Park J.*[1], *Mackenzie A.P.*[1,2]
[1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany, [2]University of St Andrews, St Andrews, United Kingdom

Over the past few years we have developed piezoelectric-based apparatus to apply continuously-tunable uniaxial stress to materials, especially at cryogenic temperatures. By preparing samples to have high length-to-width and length-to-thickness aspect ratios, and securing them in place with epoxy, high-elastic-modulus materials such as Sr_2RuO_4 can be compressed by, so far, at least 1%. Such large strains can induce substantial changes in electronic structure. The superconducting transition temperature of Sr_2RuO_4 passes through a pronounced peak - it more than doubles - with compression by ~0.6%, consistent with driving one of the Fermi surfaces through a topological transition. Compression by ~0.3% splits the Néel transition of the heavy-fermion antiferromagnet $CeAuSb_2$ into two transitions, and further compression suppresses the lower one to zero temperature. In this presentation I will discuss the present state-of-the-art of this technique, and present results of measurements, focusing on the unconventional superconductor Sr_2RuO_4.

Monday, 14 August 2017
11.45-12.30
Congress Hall

168
Currents and phases in quantum rings
Moler K.A.
Stanford University, Stanford, United States

The current that flows in a ring can be a signature of fundamental and topological properties of quantum states of charge-carrying particles. Applying a magnetic flux through a ring creates a phase gradient, in response to which a current flows, creating magnetic fields that we measure with a scanning SQUID microscope. I will take you on a tour of currents and phases in common and exotic quantum materials. Gold rings are normal metals with finite resistance, but remarkably, they carry persistent currents whose sign and magnitude confirm the quantum behavior of disordered metals. Aluminum rings superconduct at low temperatures, and are an ideal model system to study superconducting fluctuations. The strong agreement of theory and experiment in conventional metals and superconductors sets the stage to study superconducting rings interrupted by a single Josephson junction. This geometry allows us to measure a fundamental and informative property of the junction, called the current-phase relation. In junctions made of topological materials, the current could theoretically be 4pi-periodic rather than 2pi-periodic as a function of the phase winding in the ring. I will report on progress towards this smoking-gun signature for Majorana modes.

Monday, 14 August 2017

14.00-14.30
Congress Hall

169
On the superconductivity of FeSe/STO interface
Feng D.
Fudan University, State Key Laboratory of Surface Physics, Department of Physics, Shanghai, China

Recently, interfacial superconductivity up to 75K has been discovered in FeSe/STO and FeSe/BTO interfaces [1,2]. We combine angle resolved photoemission spectroscopy (ARPES), scanning tunneling microscopy (STM) and molecular beam epitaxy (MBE) to study the superconductivity at interfaces and surfaces. Based on the impurity effects and quasiparticle interference behaviors revealed in our STM data, we found that the pairing symmetry of FeSe/STO is the plain *s*-wave type [3]. Moreover, with surface electron doping, the FeSe thick film exhibits an anomalous phase diagram with a correlated insulating phase and a superconducting phase with Tc up to ~46K [4]. By placing such a heavily electron doped FeSe superconducting layer closer to the FeSe/STO interface, its superconducting gap increases exponentially to the single layer FeSe/STO value [5], which resembles the behavior of the STO phonon strength measured by EELS [6]. Our results demonstrate the critical role of interfacial electron-phonon interactions in the high Tc of FeSe/STO interface.
I will also briefly introduce our recent STM study of the nematic superconductivity in $Cu_xBi_2Se_3$.
References:
[1] Q.Y. Wang *et al.*, Chin. Phys. Lett. **29**, 037402 (2012)
[2] R. Peng *et al.*, Nature Commun. **5**, 5044 (2014).
[3] Q. Fan *et al.*, Nature Physics **11**, 946-952 (2015).
[4] C.-H.-P. Wen *et al.*, Nature Commun. **7**, 10840 (2016).
[5] W. H. Zhang *et al.*, Nano Lett. **16**, 1969 (2016).
[6] S. Zhang *et al.*, arXiv:1605.06941 (2016).

Monday, 14 August 2017
14.00-14.30
G1

170
Investigation of grid turbulence decay in He II in a large square channel
Yang J., Ihas G.G.
University of Florida, Physics, Gainesville, United States

Temporal decay of grid turbulence is experimentally studied in superfluid ^{4}He in a square channel. The second sound attenuation method [1] is used to measure the turbulent vortex line density (*L*) with a novel signal processing technique (phase locked tracking system) to minimize frequency shift effects induced by temperature fluctuations. Grids are pulled at different speeds to generate turbulence at temperatures from 1.5 to 2.1 K. Different power laws for decaying behavior are predicted by theory [2]. According to this theory, *L* should decay as $t^{-11/10}$ when the length scale of energy containing eddies grows from the grid mesh size to the size of the channel. At later time, after the energy containing eddy size becomes comparable to the channel, *L* should follow $t^{-3/2}$. Our recent experimental data exhibit evidence for $t^{-11/10}$ during the early time and t^{-2} instead of $t^{-3/2}$ for later time. Moreover, a consistent bump/plateau feature in between the two decay regimes is prominent and will be discussed.
References:
[1] H. E. Hall and W. F. Vinen, Proc. R. Soc. Lond. A 238, 215 (1956).
[2] S. R. Stalp, L. Skrbek, and R. J. Donnelly, Phys. Rev. Lett. 82, 4831 (1999).

Monday, 14 August 2017
14.00-14.30
G3

171

Dynamics of quasiparticles in Andreev quantum dots

Pothier H., Tosi L., Goffman M., Urbina C.
CEA-Saclay, Quantronics Group, SPEC, Gif-sur-Yvette Cedex, France

In contrast with a bulk superconductor, a single-channel phase-biased superconducting weak link hosts a discrete subgap quasiparticle state, called “Andreev state”. As such, it can be seen as a sort of quantum dot in quasiparticles can be trapped, not due to electrostatic barriers, but to the phase drop. I will present vey recent experiments in which, by coupling Andreev quantum dots obtained at one-atom contacts between aluminum electrodes to a microwave resonator (circuit-QED setup) [1], we probe the transitions between states with 0, 1 and 2 quasiparticles.

References:

[1] C. Janvier et al., Science **349**, 1199 (2015)

Monday, 14 August 2017
14.00-14.30
G2

172

Field-induced quantum phase transition within a superconducting condensate

Kenzelmann M.
Paul Scherrer Institut, Villigen-PSI, Switzerland

The application of magnetic fields, chemical or hydrostatic pressure to strongly-correlated electron materials can stabilize electronic phases with different organizational principles. We studied Ce0.95Nd0.05CoIn5 where a spin-density wave exists within the superconducting state [1]. We find evidence for a field-induced quantum phase transition that separates two antiferromagnetic phases with identical magnetic symmetry. The zero-field spin-density wave is suppressed at the critical field Hstar=8T, but reemerges at higher fields. The high-field phase shares many properties with the Q phase in CeCoIn5 [2]. Our results suggest that this magnetic instability is not magnetically driven. We propose that it is instead driven by a modification of superconducting condensate at Hstar [3].

References:

[1] S. Raymond et al., J. Phys. Soc. Jpn. 83, 013707 (2014).
[2] M. Kenzelmann et al., Science 321, 1652 (2008).
[3] D.G. Mazzone et al., Science Advances 3, e1602055 (2017).

Monday, 14 August 2017
14.50-15.20
G2

173

Quantum spin fluid behaviors of the kagome- and triangular-lattice antiferromagnets

Sakai T.[1,2], *Nakano H.*[1]
[1]University of Hyogo, Graduate School of Material Science, Kamigori, Japan, [2]QST SPring-8, Sayo, Japan

The S=1/2 kagome-lattice antiferromagnet is one of interesting frustrated quantum spin systems. The systems exhibit the quantum spin fluid behavior, which was proposed as an origin of the high-Tc superconductivity. The spin gap is an important physical quantity to characterize the spin fluid behavior. Whether the S=1/2 kagome-lattice antiferromagnet is gapless or has a finite spin gap, is still unsolved issue. Because any recently developped numerical calculation methods are not enough to determine it in the thermodynamic limit. Our large-scale numerical diazonalization up to 42-spin clusters and a finite-size scaling analysis indicated that the S=1/2 kagome-lattice antiferromagnet is gapless in the thremodynamic limit[1-3]. It is consistent with the U(1) Dirac spin liquid theory of the kagome-lattice antiferromagnet[4,5]. On the other hand, the density matrix renormalization group calculations supported the gapped Z2 topological spin liquid theory[6,7]. We propose one of better methods to determine whether the spin excitation is gapless or gapped, based on the finite-size scaling analysis of the spin susceptibility calculated by the numerical diagonalization. The present work indicates that the kagome-lattice antiferromagnet is gapless, as well as the triangular-lattice one.

References:

[1]H. Nakano and T. Sakai, J. Phys. Soc. Jpn. 80, 053704 (2011)
[2]H. Nakano and T. Sakai, J. Phys. Soc. Jpn. 84, 063705 (2015)
[3]T. Sakai and H. Nakano, Phys. Rev. B 83, 100405(R) (2011)
[4]Y. Ran et al., Phys. Rev. Lett. 98, 117205 (2007) 2007
[5]Y. Iqbal et al., Phys. Rev. B 87, 060405(R) (2013)2013
[6]S. Yan et al., Science 332, 1173 (2011)2011
[7]S. Nishimoto et al., Nature Commun. 4, 2287 (2013)

Monday, 14 August 2017
14.50-15.20
G3

174

Non-adiabatic geometric phase and decoherence in an open quantum system

Svetogorov A.[1,2], *Makhlin Y.*[3,4]
[1]Université Grenoble Alpes, Grenoble, France, [2]Moscow Institute of Physics and Technology, Moscow, Russian Federation, [3]National Research University Higher School of Economics, Condensed-Matter Physics Laboratory, Moscow, Russian Federation, [4]Landau Institute for Theoretical Physics, Chernogolovka, Russian Federation

Generalizing the work of Berry, Aharonov and Anandan showed that certain quantum states acquire geometric phases even during non-adiabatic modification of paramaters. We analyze how these phases are modified under the influenece of dissipative environment. We find dissipative contributions to the acquired phase and modification of dephasing. Analysis is performed for the limiting cases of weak short-correlated noise as well as of slow quasi-stationary noise. Motivated by recent experiments with superconducting quantum bits [1], we find the leading non-adiabatic corrections to the results, known for the adiabatic limit [3].

References:

[1] S. Berger et al., Nature Comm. 6, 8757 (2015)
[2] A.E.Svetogorov and Yu.Makhlin, JETP Lett. 103(8), 535-538 (2016)
[3] R.S. Whitney, Yu. Makhlin, A. Shnirman, and Y. Gefen, Phys. Rev. Lett. 94, 070407 (2005)

Monday, 14 August 2017
14.50-15.20
G1

175

The elementary excitations of liquid ^{3}He: the complete picture unveiled

Beauvois K.[1,2,3], *Fåk B.*[1], *Godfrin H.*[2,3], *Krotscheck E.*[4,5], *Lichtenegger T.*[4,5], *Ollivier J.*[1]
[1]Institut Laue-Langevin, Grenoble, France, [2]CNRS, Inst NEEL, Grenoble, France, [3]University Grenoble Alpes, Inst NEEL, Grenoble, France, [4]University at Buffalo, Buffalo, United States, [5]Johannes Kepler University, Linz, Austria

We present new results on the dynamics of bulk liquid ^{3}He, obtained at very low temperatures using modern inelastic neutron scattering techniques. The data, which cover a very large range in energy and momentum transfer, provide an interesting perspective on the dynamics of this canonical Fermi Liquid. The experimental data confirm the predictions of the Dynamic Many-Body Theory. Furthermore, the comparison to our similar measurements and calculations [1] performed on ^{4}He, a Bose Liquid, provides a spectacular illustration of the effects of statistics on the dynamics of many-body quantum systems.

References:

[1] K. Beauvois, C. E. Campbell, J. Dawidowski, B. Fåk, H. Godfrin, E. Krotscheck, H.-J. Lauter, T. Lichtenegger, J. Ollivier, A. Sultan, Phys. Rev. B **94**, 024504 (2016), and to be published.

Monday, 14 August 2017
14.50-15.20
Congress Hall

176

Direct observation of coexisting nematic and superconducting domains in the Ca122 pnictide superconductor under strain

Guillamon I.
Universidad Autonoma de Madrid, Departamento Física de la Materia Condensada, Instituto N. Cabrera, Condensed Matter Physics Center (IFIMAC), Madrid, Spain

The Ca122 pnictide is extremely sensitive to strain. Co doping induces superconductivity in this compound at the same point of the phase diagram where antiferromagnetic and orthorhombic order are simultaneously suppressed through a first order phase transition. It has been recently shown that biaxial strain induces a magnetostructural transition and superconductivity in the same sample [1]. Here we make Scanning Tunneling in a sample under biaxial strain and image nanometer sized nematic-orthorhombic and superconducting domains in the same sample [2]. Using atomic size measurements, we characterize electronic properties and spatial distribution of both phases. In the superconducting tetragonal domains we measure the superconducting gap and the vortex lattice and in the orthorhombic domains we observe the nematic band structure through quasiparticle interference measurements. Our work provides first microscopic measurements directly imaging the two different phases at both sides of a quantum critical phase transition.
Finally, I will also present recent advances in the superconductor CaKFe4As4 that shows the highest Tc among stoichiometric pnictide materials (35 K) [3]. I will discuss evidence for two gap superconductivity and show large scale images of the vortex lattice.

References:
* Work supported by Spanish MINECO, ERC Starting Grant and CIG Marie Curie program.
[1] A. Böhmer, et al., Phys. Rev. Lett. 118, 107002 (2017)
[2] Direct observation of coexisting nematic and superconducting domains in the Ca122 pnictide superconductor under biaxial strain. A. Fente et al, in preparation.
[3] Fente el al., arXiv:1608.00605

Monday, 14 August 2017
14.50-15.20
H1

178
Coherent manipulation of single atomic-scale two-level defects in amorphous oxides
Lisenfeld J., Bilmes A., Weiss G., <u>Ustinov A.</u>
Karlsruhe Institute of Technology, Physikalisches Institut, Karlsruhe, Germany

In structurally disordered solids, some atoms or small groups of atoms are able to quantum mechanically tunnel between two nearly equivalent sites. These atomic tunneling systems have been previously identified as the cause of various low-temperature anomalies of bulk glasses and as a source of decoherence of superconducting quantum circuits where they are sparsely present in the disordered oxide barriers. A tiny mechanical deformation of the oxide barrier changes the energies of the atomic tunneling systems. We have measured these changes by tracing changes in the microwave spectra of superconducting qubits induced by coherent interactions with microscopic two-level tunneling systems. The observed hyperbolic dependence of the energy splitting of individual atomic tunneling states on external strain [1], for the first time, confirmed the central hypothesis of the two-level tunneling model for disordered solids [2]. Tuning the properties of individual defects by applying mechanical strain allowed us to detect their mutual interactions [3] and study their spectral properties [4]. Recently, we also probed the interaction between individual two-level defects and quasiparticles in a superconductor and observed an increase of defect decoherence rates with quasiparticle density.
References:
[1] G. J. Grabovskij, T. Peichel, J. Lisenfeld, G. Weiss, A. V. Ustinov, Science **338**, 232 (2012).
[2] P. W. Anderson, B. I. Halperin, C. Varma, Phil. Mag. **25**, 1 (1972); W. A. Phillips, J. Low Temp. Phys. **7**, 351 (1972).
[3] J. Lisenfeld, G. J. Grabovskij, C. Mueller, J. H. Cole, G. Weiss, A. V. Ustinov, Nature Commun. **6**, 6182 (2015)
[4] J. Lisenfeld, A. Bilmes, S. Matityahu, S. Zanker, M. Marthaler, M. Schechter, G. Schön, A. Shnirman, G. Weiss, A. V. Ustinov, Sci. Rep. **6**, 23786 (2016).

Tuesday, 15 August 2017
14.30-14.50
Congress Hall

179
Fermi surface topology and chirality in Weyl semimetals
<u>Arnold F.</u>[1], Naumann M.[1], Wu S.-C.[1], Sun Y.[1], Ajeesh M.O.[1], dos Reis R.D.[1], Shekhar C.[1], Kumar N.[1], Süß V.[1], Schmidt M.[1], Nicklas M.[1], Felser C.[1], Yan B.[1], Hassinger E.[1,2]

[1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany, [2]Technische Universität München, Physik-Department, Garching, Germany

The non-centrosymmetric monopnioctides are a new class of materials, which are putative Weyl semimetals [1]. In these semimetals three-dimensional chiral massless quasiparticles, the so-called Weyl fermions [2], arise at symmetry protected linear band crossings and are predicted to induce novel quantum mechanical phenomena such as the chiral anomaly and topological surface states [3-5].
Here we present an overview over the Fermi surface topologies of two members of this family, TaP [6] and TaAs [7]. Based on quantum oscillation measurements and ab-initio bandstructure calculation, we will show that TaAs contains chiral Weyl Fermi surface pockets, which coexist with topologically trivial electron and hole pockets. Its sister compound TaP, however, only contains topologically trivial Fermi surface pockets. Thus the observed negative magnetoresistances in TaP, which was initially interpreted as a sign for the chiral anomaly is reevaluated in terms of inhomogeniouse current distributions in the samples [8].

References:

[1] H. Weng *et al.*, Phys. Rev. X **5**, 011029 (2015)
[2] H. Weyl, Z. Phys. **56**, 330 (1929)
[3] S.L. Adler, Phys. Rev. **177**, 2426 (1969)
[4] J. Bell and R. Jackiw, Nuovo Cimento A **60**, 47 (1969)
[5] S.-M. Huang *et al.*, Nat. Commun. **6**, 7373 (2015)
[6] F. Arnold *et al.*, Phys. Rev. Lett. **117**,146401 (2016)
[7] F. Arnold *et al.*, Nat. Commun. **7**,11615 (2016)
[8] R.D. dos Reis *et al.*, New J. Phys. **18**, 085006 (2016)

Tuesday, 15 August 2017
14.30-14.50
G3

180

Observation of flux-tuneable heat transport across superconducting circuits, towards a quantum heat engine

Senior J.[1], *Ronzani A.*[1], *Chang Y.-C.*[1,2,3], *Karimi B.*[1], *Meschke M.*[1], *Peltonen J.T.*[1], *Chen C.D.*[1,3], *Pekola J.P.*[1]
[1]Aalto University, Low Temperature Laboratory, Department of Applied Physics, Espoo, Finland, [2]National Taiwan University, Department of Physics, Taipei, Taiwan, Republic of China, [3]Academia Sinica, Institute of Physics, Taipei, Taiwan, Republic of China

The field of heat transport across mesoscopic systems has generated much interest in recent years, with particular interest to facilitating quantum devices, such as quantum heat engines [1,2]
Here we present the experimental demonstration of flux tuneable, frequency selective heat transport between mesoscopic thermal reservoirs using superconducting circuits.
This is mediated by a superconducting qubit implementation, capacitively coupled to two seven gigahertz co-planar waveguide resonators, that can each be thermally populated by Joule heating of micrometre scale metallic resistor elements acting as dissipative terminations. Tunnel probe transport spectroscopy on these resistive elements provides information on the thermal occupation of electrons in each reservoir.
In this system, we achieve flux controllable transport corresponding to a heating power of order 0.1 fW. This experiment contributes a key milestone on the way to experimentally realising a quantum Otto refrigerator [3].

References:
[1] M. Partanen et al, Nature Physics **12**, 460-464 (2016)
[2] M. Campisi & R. Fazio, Nature Communications **7**, 11895 (2016)
[3] B. Karimi & J. P. Pekola, Phys. Rev. B **94**, 184503 (2016)

Tuesday, 15 August 2017
14.30-14.50
G2

181
Small-angle and inelastic neutron scattering studies of ferromagnetic superconductor URhGe

Sokolov D.[1,2], *O'Neill C.*[2], *Entwisle O.*[2], *Boehm M.*[3], *Cubitt R.*[4], *Huxley A.*[2]
[1]MPI CPfS, Dresden, Germany, [2]University of Edinburgh, Physics, Edinburgh, United Kingdom, [3]Institut Laue-Langevin, Grenoble, France, [4]Institut Laue Langevin, Grenoble, France

The unconventional superconductivity in URhGe, which develops within the ferromagnetic state is considered to be of the spin-triplet type mediated by the longitudinal spin fluctuations [1]. This notion is further supported by the observation of the re-entrant superconductivity in the magnetic field of 12T [2]. Here we present the first direct microscopic measurements of the magnetic fluctuations in URhGe, which establish the energy scale and the wavevector dependence of the magnetic fluctuations, which tests the predictions of the theory [3]. Our cold inelastic neutron scattering in high magnetic fields probed the critical fluctuations associated with the Curie temperature, which is gradually suppressed by the magnetic field. The inelastic measurements showed a suppression of the transverse fluctuations at fields up to 11T, close to the onset of the re-entrant superconductivity. The small-angle neutron scattering (SANS) measured both the transverse and longitudinal magnetic fluctuations. SANS showed a quick suppression of the fluctuations already in small fields around 1T and showed no longitudinal fluctuations, seemingly at odds with the recent NMR observation of the longitudinal fluctuations in Co doped URhGe[4].

References:
[1] D. Aoki, et al., Nature, **413**, 613 (2001)
[2] F. Levy, et al., Science, **309**, 1343 (2005)
[3] V. P. Mineev, et al., Phys. Rev. B, **91**, 014506 (2015)
[4] Y. Tokunaga, et al., Phys. Rev. Lett., **114**, 216401 (2015)

Tuesday, 15 August 2017
14.30-14.50
G1

182
Calorimetry based on hysteretic superconductor-normal metal-superconductor Josephson junctions

Wang L.[1], *Saira O.P.*[1], *Proutski A.*[2,3], *Maisi V.*[1], *Geresdi A.*[2,3], *Krogstrup P.*[4], *Nygard J.*[4], *Pekola J.*[1]
[1]Low Temperature Laboratory, Department of Applied Physics, Aalto University, Espoo, Finland, [2]QuTech, Delft University of Technology, Delft, Netherlands, [3]Kavli Institute of Nanoscience, Delft University of Technology, Delft, Netherlands, [4]Center for Quantum Devices and Station-Q Copenhagen, Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark

Calorimetry is an important tool in investigating thermodynamics. Especially for a small system in mesoscopic level, fast and sensitive calorimeters which are able to measure energy transferred within the system is in great request. Recently it has been proposed that one could also couple the calorimeter to a quantum system, for instance, to a superconducting qubit. The calorimeter can then be used to observe the exchange of microwave photons [1]. Works have been done before on fast and sensitive calorimeter [2-4]. To enhance the energy resolution of calorimeter, heat conductance and heat capacity of the absorber of calorimeter are needed to be low [5]. Here we show the measurement results of the heat conductance and heat capacity of normal metal with hysteretic Josephson junctions. We found anomalously high heat capacity of Au, Ag and Cu at low temperature, and the value measured for the three metals are about one order of magnitude higher than that calculated from the standard free electron model. We have replaced the normal metal with InAs semiconductor nanowires. Compared with metal, the heat conductance and heat capacity of semiconductor nanowire are expected to be low due to low electron density, so higher energy resolution is expected for the an InAs based calorimeter.

References:

[1] J. P. Pekola et al, New J. Phys. **15**, 115006 (2013)
[2] D.R. Schmidt et al, App. Phys. Lett. **86**, 053505 (2005)
[3] S. Gasparinetti et al, Phys. Rev. A. **3**, 014007 (2015)
[4] J. Govenius et al, Phys. Rev. Lett. **117**, 030802 (2016)
[5] K. L. Viisanen et al, arXiv: 1606.02985.z

Tuesday, 15 August 2017
14.30-14.50
H1

183

Superfluid phases for a model of ^{3}He confined in nematic aerogels[1]

Wiman J., Sauls J.A.
Northwestern University, Physics & Astronomy, Evanston, United States

Superfluid ^{3}He has recently been observed in disordered ``nematic aerogel´´ (N-aerogel) materials.[2] The N-aerogels consist of 9 nm diameter strands that are predominantly oriented along one axis, producing far more anisotropy in confinement than could be achieved in previous experiments using anisotropic silica aerogels. In one class of N-aerogels, Dmitriev et al. reported the first observation of the superfluid Polar phase, a phase which is stabilized by uniaxial anisotropy and not present in pure bulk ^{3}He. The strong nematic order and small radius of the strands suggest that they may be modeled as arrays of parallel line impurities. We show that the experimentally determined phase diagram, including Polar, polar-distorted A, and polar-distorted B phases, for this class of N-aerogels is well accounted for by strong-coupling Ginzburg-Landau theory with a regular array of such line impurities. We also find that the locations of these phase transitions are insensitive to positional disorder of the impurities.

References:

[1] Supported by NSF grants DMR-1106315 and DMR-1508730.
[2] V. V. Dmitriev, A. A. Senin, A. A. Soldatov, and A. N. Yudin, Phys. Rev. Lett. 115, 165304 (2015).

Tuesday, 15 August 2017

15.20-15.40
G2

184

Gapless Fermi-surface spin liquid on the kagome lattice and its instabilities

Gomilsek M.[1], *Klanjšek M.*[1], *Pregelj M.*[1], *Coomer F.C.*[2], *Luetkens H.*[3], *Zaharko O.*[4], *Fennell T.*[4], *Li Y.*[5], *Zhang Q.*[5], *Zorko A.*[1]
[1]Jožef Stefan Institute, Ljubljana, Slovenia, [2]Rutherford Appleton Laboratory, ISIS Facility, Didcot, United Kingdom, [3]Paul Scherrer Institute, Laboratory for Muon Spin Spectroscopy, Villigen PSI, Switzerland, [4]Paul Scherrer Institute, Laboratory for Neutron Scattering and Imaging, Villigen PSI, Switzerland, [5]Renmin University of China, Department of Physics, Beijing, China

Quantum kagome antiferromagnets (QKA's) are spin systems in which strong frustration coupled with quantum fluctuations suppresses any long-range order. In its stead a new state of matter, a quantum spin liquid with long-range entanglement but no long-range order, arises. The properties of this state are hotly debated with several competing theoretical proposals [1].
One of the few experimental realization of a QKA is Zn-brochantite, $ZnCu_3(OH)_6SO_4$ [2]. In this compound we observe two distinct spin-liquid regimes, a high-temperature one, preceded by quantum-critical behavior at even higher temperatures, and a low-temperature one with an enhanced density of states [3].
We show that site-mixing impurities, unavoidable in most QKA candidates, are strongly coupled to the low-temperature spin liquid state in Zn-brochantite [4]. Their behavior identifies the low-temperature state of Zn-brochantite as a gapless spinon Fermi-surface spin liquid [4,5].
We also observe a field-induced instability of this spin liquid, most likely due to spinon pairing, where a (possibly nodal) gap opens up [6]. We thus obtain a comprehensive understanding of the spin-liquid state and its instabilities in the QKA Zn-brochantite, which can serve as a benchmark against which to compare theoretical proposals.

References:

[1] M. R. Norman, Rev. Mod. Phys., **88**, 041002 (2016).
[2] Y. Li *et al.*, New J. Phys., **16**, 093011 (2014).
[3] M. Gomilšek *et al.*, Phys. Rev. B, **93**, 060405(R) (2016).
[4] M. Gomilšek *et al.*, Phys. Rev. B, **94**, 024438 (2016).
[5] M. Gomilšek *et al.*, in preparation (2017).
[6] M. Gomilšek *et al.*, in preparation (2017).

Tuesday, 15 August 2017
15.20-15.40
G1

185

Investigating nonlinear decoherence in a nanomechanical resonator

Maillet O., Ngoma A., Zhou X., Gazizulin R., Fefferman A., Bourgeois O., Collin E.
CNRS, Institut Néel, Grenoble, France

While they appear as a practical limitation to the performance in stability for sensing applications [1,2], frequency fluctuations in nanomechanical resonators can also be appreciated as a versatile playground for the study of complex nonlinear and stochastic dynamics [3,4].
We addressed the interplay between the driven motion of a nanomechanical beam cooled down to helium temperatures and a noisy source dispersively coupled to its motion, hence modulating randomly its eigenfrequency. Through coupling to voltage fluctuations of a gate electrode, we first

realized a model experiment of "classical decoherence", on which we quantitatively separated mechanical damping and dephasing processes [5]. It was found that the latter depends non-trivially on the magnitude of frequency fluctuations. These results were extended to the situation encountered when one nanomechanical mode far from equilibrium is coupled dispersively through geometric nonlinearities to another mode driven by a force field [6]. Pushing the study a step forward, we developed a sensitive frequency tracking technique relying on nanomechanical bifurcation to unravel a motion-dependent frequency noise, which origin remains controversial [7].

References:

[1] M. Sansa et al., Nat. Nano., **11**, 552-558, (2016)
[2] M. S. Hanay et al., Nat. Nano. **7**, 602-608 (2012)
[3] Y. Zhang et al, Phys. Rev. Lett. **113**, 255502 (2014)
[4] J. Gieseler et al., Nat. Phys. **9**, 806-810, (2013)
[5] O. Maillet et al., New. J. Phys., **18**, 073022 (2016)
[6] O. Maillet et al., ArXiv, (2017)
[7] B. Schneider et al., Nat. Commun., **5**, 5819 (2014)

Tuesday, 15 August 2017
15.20-15.40
Congress Hall

186

Identifying detrimental effects for multiband superconductivity - application to Sr_2RuO_4

Ramires A.[1], *Sigrist M.*[2]
[1]ETH, Institute for Theoretical Studies, Zurich, Switzerland, [2]ETH, Institute for Theoretical Physics, Zurich, Switzerland

We propose a general scheme to probe the compatibility of arbitrary pairing states with a given normal state Hamiltonian by the introduction of a concept called *superconducting fitness*. This quantity gives a direct measure of the suppression of the superconducting critical temperature in the presence of key symmetry-breaking fields. A merit of the superconducting fitness is that it can be used as a tool to identify nontrivial mechanisms to suppress superconductivity under various external influences, in particular, magnetic fields or distortions, even in complex multiorbital systems. In the light of this concept we analyze the multiband superconductor Sr_2RuO_4 and propose a new mechanism for the suppression of superconductivity in multiorbital systems, which we call interorbital effect, as a possible explanation for the unusual limiting feature observed in the upper critical field of this material.

References:

[1] Aline Ramires and Manfred Sigrist, Physical Review B **94**, 104501 (2016).
[2] Aline Ramires and Manfred Sigrist, arXiv:1606.08709 (to appear in J. of Phys.: Conf. Series)

Tuesday, 15 August 2017
15.20-15.40
H1

187

Pure ^3He in nematic aerogel

Dmitriev V.[1], *Soldatov A.*[1,2], *Yudin A.*[1]

[1]P.L. Kapitza Institute for Physical Problems of RAS, Moscow, Russian Federation, [2]Moscow Institute of Physics and Technology, Dolgoprudnyi, Russian Federation

A new superfluid phase of ^{3}He - the polar phase - is realized in high-density nematic aerogel (nafen) [1]. Nafen consists of strands which are nearly parallel to one another. It leads to an anisotropic scattering of ^{3}He quasiparticles that makes the polar phase favorable [2]. In experiments [1] the strands of nafen were covered by ≈2.5 atomic layers of ^{4}He. In presence of such a coverage the scattering conserves spin and should be specular at low pressures and diffusive above ~25 bar [3,4]. Here we report results of NMR studies of pure ^{3}He in nafen. In this case the strands are covered by ~2 atomic layers of paramagnetic solid ^{3}He and the scattering should be diffusive at all pressures. In addition, due to a fast exchange between liquid and solid ^{3}He atoms a magnetic scattering channel appears. The experiments were done in a wide range of pressures with samples of different porosities. It was found that the polar phase is no longer observed at all pressures and ^{3}He superfluid transition temperatures are significantly suppressed in comparison with the case of ^{4}He coverage. Our results show that the magnetic scattering plays a decisive role in the observed changes of the superfluid phase diagram. Additional experiments with smaller ^{4}He coverages confirm this assumption.

References:

[1] V.V. Dmitriev, A.A. Senin, A.A. Soldatov, and A.N. Yudin, Phys. Rev. Lett. **115**, 165304 (2015)
[2] K. Aoyama and R. Ikeda, Phys. Rev. B **73**, 060504 (2006)
[3] D. Kim, M. Nakagawa, O. Ishikawa, T. Hata, T. Kodama, and H. Kojima, Phys. Rev. Lett. **71**, 1581 (1993)
[4] S.M. Tholen and J.M. Parpia, Phys. Rev. B **47**, 319 (1993)

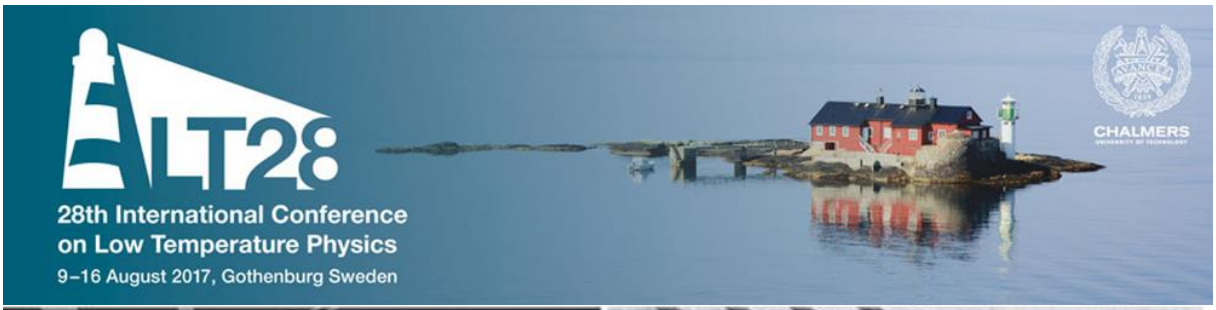
Tuesday, 15 August 2017
15.20-15.40
G3

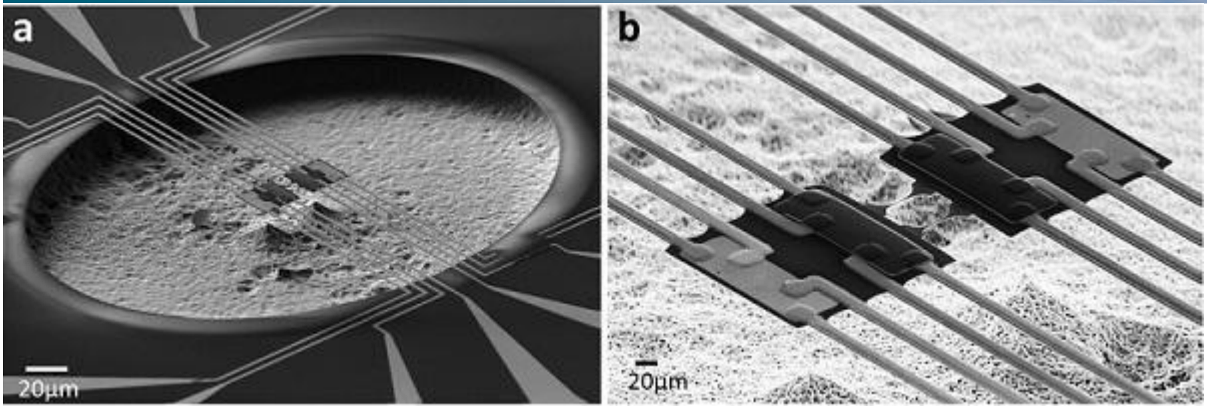
188

Ballistic phonon heat transport a 1D quantum channel

Tavakoli A., Lulla K., Crozes T., Collin E., Bourgeois O.
Institut Néel, CNRS and University Grenoble Alpes, MCBT, Grenoble, France

The investigation of low temperature thermal conductance of 1D phonon waveguide unveils a new understanding of limited heat transport in the ballistic regime.
In the two extreme limits of having (i) highly confined structures, and (ii) subKelvin temperatures which gives rise the phonon mean free path far above the lateral dimensions, Then the phonon transport is expected to be in the quantum regime (fully ballistic transport). In a 1D quantum channel connecting two reservoirs, the heat current can be expressed through the probability of a phonon to be transmitted from one heat reservoir to the other. This is well described by the Landauer formalism viewing thermal conductance as transmission through the transmission coefficient of phonon plane waves in parallel to the direction of nanowire length.
We have elaborated a new generation of suspended membrane based nano-calorimeter (see Figure nanocalorimeter). This sensor is adapted to very low temperature measurements with an unprecedented power sensitivity of ~5 Attowatt. It is demonstrated that the transfer of phonons inside the nanowire is ballistic and 1D. However, we show that the thermal transport is dominated by the transmission coefficient and not by the universal value of quantum of thermal conductance.





[nanocalorimeter]

References:
[1] D. Cahill, et al, Appl. Phys. Rev. **1**, 011305 (2014).
[2] J.S. Heron, C. Bera, T. Fournier, N. Mingo, and O. Bourgeois , Phys. Rev. B, **82**, 155458 (2010).
[3] L.G. C. Rego and G. Kirczenow, Phys. Rev. Lett. **81**, 232 (1998).
[4] K. Schwab, E. Henriksen, J. Worlock, M. L. Roukes, Nature. **74**, 4 (2000).
[5] R.O. Pohl, X. Liu, and E. Thompson, Rev. Mod. Phys. **74**, 4 (2002).

Tuesday, 15 August 2017
15.40-16.00
Congress Hall

189
Type-1.5 superconductivity in Sr2RuO4
<u>Babaev E.</u>
KTH, Stockholm, Sweden

In general a superconducting state breaks multiple symmetries and, therefore, is characterized by several different coherence lengths ξi , i=1,…,N. Moreover in multiband material even superconducting states that break only a single symmetry are nonetheless described, under certain conditions by multi-component theories with multiple coherence lengths. As a result of that there can appear a "type-1.5" state where some coherence lengths are smaller and some are larger than the magnetic field penetration length λ. One of the properties of this regime is that vortices can attract one another at long range but repel at shorter ranges. Such a system can form vortex clusters in low magnetic fields. I will discuss the recent experimental evidence that this regime is realized in Sr2RuO4, providing evidence for a multicomponent order parameter. Also I will discuss that it is consistent with other previously observed effects in this material such as "zero-creep" in the absence of dramatic increase of critical current.

References:
Muon-spin rotation measurements of the vortex state in Sr2RuO4: type-1.5 superconductivity, vortex clustering and a crossover from a triangular to a square vortex latticeS.J. Ray, A.S. Gibbs, S.J. Bending, P.J. Curran, E. Babaev, C. Baines, A.P. Mackenzie, S.L. Lee Phys. Rev. B 89, 094504 (2014)
Type-1.5 superconductivity in multicomponent systems
E Babaev, J Carlström, M Silaev, JM SpeightPhysica C: Superconductivity and its Applications 533, 20-35

Tuesday, 15 August 2017
15.40-16.00
G3

190

Spin-dependent thermoelectric effects in superconductor-ferromagnet tunnel junctions

Kolenda S.[1], Wolf M.J.[1], Fischer G.[2], Sürgers C.[2], Beckmann D.[1]
[1]Karlsruhe Institute of Technology, Institute of Nanotechnology, Karlsruhe, Germany, [2]Karlsruhe Institute of Technology, Physikalisches Institut, Karlsruhe, Germany

We report on the experimental observation of spin-dependent thermoelectric effects in superconductor-ferromagnet tunnel junctions in high magnetic fields. The thermoelectric signals are due to a spin-dependent lifting of particle-hole symmetry on the energy scale of the superconducting gap. Our results directly prove the coupling of spin and heat transport in superconductors with spin splitting of the density of states. A Seebeck coefficient of about -100 µV/K is obtained from our data. The thermoelectric effects can be further increased by an exchange field induced via the proximity effect with the ferromagnetic insulator europium sulfide.

References:

S. Kolenda et al., Phys. Rev. Lett. **116**, 097001 (2016); Beilstein J. Nanotechnol. **7**, 1579 (2016).

Tuesday, 15 August 2017
15.40-16.00
G2

191

Quantum oscillations from a bulk Fermi surface in Kondo insulating SmB_6

Hartstein M.[1], Hsu Y.-T.[1], Zeng B.[2], Ciomaga Hatnean M.[3], Zhang Q.H.[2], Rodway-Gant G.[1,4], Berk J.[1], Kingston M.K.[1], Zhang G.H.[1,5], Chan M.K.[6], Park J.-H.[2], Balicas L.[2], Harrison N.[6], Shitsevalova N.[7], Balakrishnan G.[3], Lonzarich G.G.[1], Sebastian S.E.[1]
[1]University of Cambridge, Cambridge, United Kingdom, [2]National High Magnetic Field Laboratory, Tallahassee, United States, [3]University of Warwick, Coventry, United Kingdom, [4]University of Oxford, Oxford, United Kingdom, [5]Massachusetts Institute of Technology, Cambridge, United States, [6]National High Magnetic Field Laboratory, Los Alamos, United Kingdom, [7]National Academy of Sciences of Ukraine, Kiev, Ukraine

Our recent observation of quantum oscillations in the Kondo insulator SmB_6 has revealed a bulk Fermi surface consisting of large ellipsoidal spheres characteristic of metallic hexaborides [1]. I will discuss new magnetic torque measurements of the angular dependence of the quantum oscillations, and their absolute size that provide further support for the picture of a bulk three-dimensional Fermi surface of neutral low energy excitations.

References:

[1] B. S. Tan et al., Science **349**, 287-290 (2015).

Tuesday, 15 August 2017
15.40-16.00
H1

192

Odd-frequency cooper pairing in normal liquid ^{3}He at aerogel interface

Mizuhata H.[1], Nomura N.[1], Kimura Y.[1,2], Obara K.[1], Yano H.[1], Ishikawa O.[1]
[1]Osaka City University, Graduate School of Science, Osaka, Japan, [2]University of Tokyo, Institute for Solid State Physics, Tokyo, Japan

A novel feature of condensate state in liquid ^{3}He is predicted theoretically, which consists of odd-frequency spin triplet s-wave Cooper pairs as a proximity effect[1]. Such an s-wave state will appear inside aerogel near the interface contacting with superfluid ^{3}He-B. The aerogel plays a role of impurity in quasiparticles scattering for the appearance of odd frequency Cooper pairings. It is expected that this novel state will cause an enhancement of magnetization at lower temperatures[2,3]. We actually observed such an enhancement of magnetization near the edge of aerogel, where we coated aerogel strands with 2.5 layers of ^{4}He films in advance[4]. However, we also observed an enhancement of magnetization inside aerogel. This indicates that the observed enhancement near the edge of aerogel may partly include the enhancement of magnetization caused by surface solid ^{3}He on aerogel.
Now we have coated aerogel with 3.0 layers of ^{4}He films to kill solid ^{3}He. We have measured magnetization as a function of temperature. We discuss whether there still exists the surface solid ^{3}He on aerogel by coating ^{4}He or not. Also, we discuss whether this novel state shows an enhancement of magnetization at lower temperatures.

References:

[1] S. Higashitani et al., *JLTP* **155**, 83 (2009)
[2] Y. Nagato et al., *J. Phys. Soc. Jpn.* **78**, 123603 (2009)
[3] S. Higashitani et al., *Phys. Rev. Lett*. **110**, 175301 (2013)
[4] A. Fukui et al., *JLTP* **171**, 245 (2012)

Saturday, 12 August 2017
14.50-15.20
G1

193

On-chip nuclear demagnetisation cooling of electrons in a nanoelectronic device

Jones A.T.[1], Bradley D.I.[1], Guénault A.M.[1], Gunnarsson D.[2,3], Haley R.P.[1], Holt S.[1], Pashkin Y.A.[1], Penttilä J.[4], Prance J.R.[1], Prunnila M.[2], Roschier L.[3,4]
[1]Lancaster University, Department of Physics, Lancaster, United Kingdom, [2]VTT Technical Research Centre of Finland Ltd, Espoo, Finland, [3]Bluefors Cryogenics Oy, Helsinki, Finland, [4]Aivon Oy, Helsinki, Finland

We describe a new technique [1] for the cooling of electrons in a nanostructure: nuclear demagnetisation of on-chip, thin-film copper refrigerant. We are motivated by the potential improvement in the operation of nanoelectronic devices below 10 mK. At these temperatures, weak electron-phonon coupling provides a bottleneck to traditional cooling, yet here gives the advantage of thermal isolation between the environment and the on-chip electrons, enabling cooling significantly below the base temperature of the host lattice. To demonstrate this we electroplate copper on to the metallic islands of a Coulomb blockade thermometer (CBT), and hence provide a direct thermal link between the cooled copper nuclei and the device electrons. The CBT can provide primary thermometry of its low internal electron temperature [2], and we use this to monitor the cooling process. Using an optimised demagnetisation profile we observe the electrons being cooled from 9 mK to 4.5 mK, and remaining below 5 mK for an experimentally useful time of 1200 seconds. We anticipate that applying this technique with higher initial magnetic fields and lower initial temperatures will yield sub-1mK electron temperatures.

References:

[1] D. I. Bradley et al, Sci. Rep. 7, 45566 (2017)
[2] D. I. Bradley et al, Nat. Commun.7, 10455 (2016)

Tuesday, 15 August 2017
09.15-10.00
Congress Hall

194
^{3}He in aerogel - discovery and some historic experiments

Parpia J.
Cornell University, Department of Physics, Ithaca, United States

I will provide a brief overview of experimental investigations of ^{3}He in aerogel starting from the first observations at Cornell and Northwestern through experiments in the many laboratories that conducted investigations worldwide on this system. The talk will focus on historic context from the use of aerogel to introduce isotropic disorder through a brief discussion of the use of anisotropic aerogel to demonstrate control over new phases of ^{3}He.

Tuesday, 15 August 2017
10.00-10.45
Congress Hall

195
Superfluid phases of liquid ^{3}He in random media and confined space

Sauls J.
Northwestern University, Physics, Evanston, United States

The quantum liquid phases of ^{3}He confined in random solids and sub-micron structures provide a unique system for studying the struggle between spontaneous symmetry breaking by a BCS condensate, and disorder originating from atomic-scale impurities to bulk and surface random potentials. This competition leads to a remarkable spectrum of phases exhibiting broken spin- and orbital rotation symmetries, as well as discrete space-time symmetries, that are not realized in pure liquid ^{3}He. I will highlight theoretical ideas and understanding of the effects of disorder on unconventional BCS condensates that have emerged from studies of the superfluid phases of liquid ^{3}He in random media and confined geometries.

References:

Supported by U.S. National Science Foundation Grant DMR-150873.

Tuesday, 15 August 2017
10.45-11.00
Congress Hall

196

Superfluid ^{3}He with globally anisotropic quenched disorder

Halperin W.
Northwestern University, Evanston, United States

In 1995 disordered phases of superfluid 3He in highly porous silica aerogel were discovered by Porto and Parpia at Cornell University using torsional oscillator techniques, and from NMR observations by Sprague, Haard, Kycia, Rand, Lee, and Halperin at Northwestern University. Also at Northwestern University, Thuneberg, Yip, Fogelström and Sauls developed a theoretical framework that guided both the experiment and theory that followed in 30 different research groups and institutions world-wide. The interplay of length scales, those intrinsic to the pure superfluid on the one hand, and from the silica aerogel structure on the other, are responsible for the existence of new quantum states of matter with sharply-defined thermodynamic transitions. The order parameter symmetry of these superfluid phases is controlled by engineering globally-uniform anisotropy in the aerogel.

Tuesday, 15 August 2017
14.00-14.30
Congress Hall

197

Topologically protected Bogoliubov Fermi surfaces

Agterberg D.F.[1], *Brydon P.M.R.*[2], *Timm C.*[3]
[1]University of Wisconsin, Milwaukee, United States, [2]University of Otago, Dunedin, New Zealand, [3]Technische Universität Dresden, Dresden, Germany

It is commonly believed that, in the absence of disorder or an external magnetic field, there are three possible types of superconducting excitation gaps: The gap is nodeless, it has point nodes, or it has line nodes. Here, we show that, for an even-parity nodal superconducting state which spontaneously breaks time-reversal symmetry, the low-energy excitation spectrum generally does not belong to any of these categories; instead, it has extended Bogoliubov Fermi surfaces [1]. These Fermi surfaces are topologically protected from being gapped by a Z_2 invariant. We also show that superconducting states possessing these Fermi surfaces are energetically stable. A crucial ingredient in our theory is that more than one band is involved in the pairing; since all candidate materials for even-parity superconductivity with broken time-reversal symmetry are multiband systems, we expect these Z_2-protected Fermi surfaces to be ubiquitous.

References:

[1] D.F. Agterberg, P.M.R. Brydon, and C. Timm, Phys. Rev. Lett. **118**, 127001 (2017)

Tuesday, 15 August 2017
14.00-14.30
H1

198

Mesoscopic transport experiments with cold atoms

Brantut J.-P.
EPFL, Institute of Physics, Lausanne, Switzerland

Over the last decade, the level of control over cold atomic gases has improved to the point that atoms can now be used to simulate the behavior of electrons in realistic materials. I will present the progresses that we accomplished in the last years in measuring the transport properties of cold atomic gases using the Landauer two-terminals setup. I will present the first observation of quantized conductance for neutral particles [1]. Its evolution as attractive interactions between particles is increased up to unitarity will be presented as pairing and superfluidity emerge [2,3]. I will then describe the most recent technical developments, namely the transposition of scanning gate microscopy in the cold atoms context, and the observation of quantum interferences in transport.

References:

[1] S. Krinner, D. Stadler, D.Husmann, J.P. Brantut and T. Esslinger, Nature **517**, 65 (2015)
[2] D. Husmann, S. Uchino, S. Krinner, M. Lebrat, T. Giamarchi, T. Esslinger and J.P. Brantut, Science **350**, 1498 (2015)
[3] S. Krinner, M. Lebrat, D. Husmann, C. Grenier, J.P. Brantut and T. Esslinger, Proceedings of the National Academy of Science, **113** 8144 (2016)

Tuesday, 15 August 2017
14.00-14.30
G3

199

Coherent caloritronics with superconductors: from heat interferometers to 0-π controllable thermal Josephson junctions

Giazotto F.
NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, Physics, Pisa, Italy

In this talk I will initially report the first experimental realization of a thermal interferometer [1-3]. We investigate heat exchange between two normal metal electrodes kept at different temperatures and tunnel-coupled to each other through a thermal device in the form of a DC-SQUID. Heat transport in the system is found to be phase dependent, in agreement with the original prediction. After this initial demonstration, we have extended the concept of heat interferometry to various other devices, implementing the first quantum `*diffractor'* for thermal flux [4, 5], realizing the first *balanced* Josephson heat modulator [6], and an ultra-efficient low-temperature hybrid `*heat current rectifier*' [7], thermal counterpart of the well-known electric diode. The latter structure offers a remarkable heat rectification ratio up to about 140 which allows its implementation in solid-state thermal nanocircuits and general-purpose electronic applications requiring energy harvesting and isolation at the nanoscale. Finally, I will conclude by showing the realization of a fully superconducting heat modulator based on the first tunable „0-π“ *thermal* Josephson junction [8].

References:

[1] B. D. Josephson, Phys. Lett. **1**, 251 (1962).
[2] K. Maki et al., Phys. Rev. Lett. **15**, 921 (1965).
[3] F. Giazotto et al., Nature 492, 401 (2012).
[4] F. Giazotto et al., Phys. Rev B **88**, 094506 (2013).
[5] M. J. Martínez-Pérez et al., Nat. Commun. 5, 3579 (2014).
[6] A. Fornier et al., Nat. Nanotechnol. **11**, 258 (2016).
[7] M. J. Martínez-Pérez et al., Nat. Nanotechnol. **10**, 303 (2015).
[8] A. Fornieri et al., Nat. Nanotechnol. **12**, 425 (2017).

Tuesday, 15 August 2017

14.00-14.30
G2

200
Observation of high pressure phase in Shastry-Sutherland Model Substance $SrCu_2(BO_3)_2$ by high pressure THz ESR

Ohta H.[1], *Sakurai T.*[2], *Hijii K.*[1], *Okubo S.*[1], *Uwatoko Y.*[3], *Kudo K.*[4], *Koike Y.*[5]
[1]Kobe University, Molecular Photoscience Research Center, Kobe, Japan, [2]Kobe University, Research Facility Center for Science and Technology, Kobe, Japan, [3]University of Tokyo, Institute for Solid State Physics, Kashiwa, Japan, [4]Okayama University, Department of Physics, Okayama, Japan, [5]Tohoku University, Department of Applied Physics, Sendai, Japan

$SrCu_2(BO_3)_2$, which shows multi-step magnetization plateaus at low temperature, has attracted much attention since the discovery by Kageyama *et al*. [1]. It is a unique 2 dimensional orthogonal dimer antiferromagnet with the singlet ground state and a spin gap, and Miyahara *et al*. suggested that it is equivalent to the Shastry-Sutherland Model [2]. Moreover, as the ratio $\alpha=J'/J$, where J' and J are inter-dimer and intra-dimer exchange interactions, respectively, is 0.64 for $SrCu_2(BO_3)_2$ and it is close to the critical ratio α_{c1}=0.677 between the dimer and the plaquette phases suggested by the theory [3], various pressure measurements have been performed to find the pressure induced phase transition [4-6]. However, the experimental results are still controversial. Therefore, we have developed a new hybrid-type pressure cell for our high pressure THz ESR and extended our pressure from 1 GPa [6] to 2.5 GPa [7] and applied to $SrCu_2(BO_3)_2$ single crystal. As THz ESR at 2 K can observe the spin gap directly, we have clearly shown that the spin gap still exists at 2 GPa. This is in contrary to the previous suggestion that the spin gap disappears at 2GPa by the X-ray measurement under high pressure [4]. Moreover, our results suggest the pressure induced phase transition at 1.85 GPa.

References:
[1] H. Kageyama et al., Phys. Rev. Lett. 82, 3168 (1999).
[2] S. Miyahara and K. Ueda, Phys. Rev. Lett. 82, 3701 (1999).
[3] A. Koga and N. Kawakami, Phys. Rev. Lett. 84, 4461 (2000).
[4] S. Haravifarda et al., Porc. Natl. Acad. Sci. USA 109, 2286 (2012).
[5] T. Waki et al., J. Phys. Soc. Jpn. 76, 073710 (2007).
[6] T. Sakruai et al., J. Phys.: Conf. Ser. 150, 042171 (2009).
[7] H. Ohta et al., J. Phys. Chem. B 119 13755 (2015).

Tuesday, 15 August 2017
14.00-14.30
G1

201
Quantum dynamics in superconductor - quantum dot junctions

van Zanten D.M.T.[1], *Basko D.*[2], *Khaymovich I.*[2], *Pekola J.*[3], *Courtois H.*[1], *Winkelmann C.B.*[1]
[1]Université Grenoble Alpes, Institut Néel, Grenoble, France, [2]Université Grenoble Alpes, LPMMC, Grenoble, France, [3]Aalto University, Helsinki, Finland

We report on the realization of a single-electron source, where current is transported through a single-level quantum dot tunnel coupled to two superconducting leads (S) [1,2]. The quantum dot is provided by a colloidal gold nanoparticle, about 5 nm in diameter. When driven with an ac gate voltage at frequency f, the experiment demonstrates electron turnstile operation, delivering a current $I = e f$. Compared to the more conventional superconductor-normal-metal-superconductor turnstile [3], our superconductor-quantum-dot- superconductor device presents a number of novel properties, including higher immunity to the unavoidable presence of nonequilibrium quasiparticles in superconducting

leads. Further, we demonstrate its ability to deliver electrons with a very narrow energy distribution. Finally, we discuss signatures of an intriguing effect going beyond the semi-classical picture, associated to the quantum dynamics at the anti-crossing between the quantum dot level and the superconducting gap edge [4].

References:
[1] D.M.T. van Zanten, F. Balestro, H. Courtois, and C.B. Winkelmann, Phys. Rev. B **92**, 184501 (2015).
[2] D.M.T. van Zanten, D.M. Basko, I.M. Khaymovich, J.P. Pekola, H. Courtois, and C.B. Winkelmann, Phys. Rev. Lett. **116**, 166801 (2016).
[3] J. P. Pekola, J. Vartiainen, M. Möttönen, O.-P. Saira, M. Meschke, and D. V. Averin, Nat. Phys. **4**, 120 (2008).
[4] Yu. N. Demkov and V. I. Osherov, Sov. Phys. JETP **26**, 916 (1968).

Tuesday, 15 August 2017
14.50-15.20
G1

202
Non-linear frequency transduction of nanomechanical Brownian motion

<u>Collin E.</u>, Maillet O., Zhou X., Gazizulin R., Maldonado Cid A., Defoort M., Fefferman A., Bourgeois O.
Université Grenoble Alpes - CNRS, Grenoble, France

Fluctuations in nanomechanical systems are of primary interest since they address both applied and fundamental issues. On one hand, a device implementing an electromechanical function (for instance transducing force into voltage) will have its characteristics impacted if amplitude and/or phase noise are present.
On the other hand, a nanomechanical system can be studied as a *model (slightly) anharmonic resonator dissipatively coupled to a thermal bath*. The latter ensures through fluctuation-dissipation theorem that the resonator experiences a stochastic Langevin force, i.e. *thermal fluctuations in position*. Meanwhile, geometric nonlinearities enable to dispersively couple two distinct modes of the same device while allowing a good implementation of the Duffing model for a single mode. For weakly nonlinear resonances, the position fluctuations of a given mechanical mode are thus converted into *frequency fluctuations* [1].
In this talk, we will discuss *model experiments* realized with simple beam-based NEMS devices where a *controlled injected force noise* mimics the thermal bath. The resonators are very well characterized, and results are fit to theory with *essentially no free parameters [2]*.

References:
[1] Yaxing Zhang and M. I. Dykman, Phys. Rev. B 92, 165419 (2015)
[2] Olivier Maillet et al. on ArXiv.

Tuesday, 15 August 2017
14.50-15.20
G3

203
Thermal conductance of a single-electron transistor

Courtois H.[1], _Dutta B._[1], _Peltonen J.T._[2], _Antonenko D.S._[3], _Meschke M._[2], _Skvortsov M.A._[3], _Kubala B._[4], _König J._[5], _Winkelmann C.B._[1], _Pekola J.P._[2]
[1]Institut Néel, CNRS and University Grenoble Alpes, Grenoble, France, [2]Low Temperature Laboratory, Department of Applied Physics, Aalto University School of Science, Aalto, Finland, [3]L. D. Landau Institute for Theoretical Physics, Chernogolovka, Russian Federation, [4]Institute for Complex Quantum Systems and IQST, University of Ulm, Ulm, Germany, [5]Theoretische Physik and CENIDE, Universitat Duisburg-Essen, Duisberg, Germany

We report on combined measurements of heat and charge transport through a single-electron transistor [1]. The device acts as a heat switch actuated by the voltage applied on the gate. The Wiedemann-Franz law for the ratio of heat and charge conductances is found to be systematically violated away from the charge degeneracy points. The observed deviation agrees well with the theoretical expectation [2]. With large temperature drop between the source and drain, the heat current away from degeneracy deviates from the standard quadratic dependence in the two temperatures.

References:

[1] B. Dutta, J. T. Peltonen, D. S. Antonenko, M. Meschke, M. A. Skvortsov, B. Kubala, J. König, C. B. Winkelmann, H. Courtois, J. P. Pekola, Thermal Conductance of a Single-Electron Transistor, submitted to Phys. Rev. Lett., arXiv:1704 (2017).
[2] B. Kubala, J. König, and J. Pekola, Violation of the Wiedemann-Franz Law in a Single-Electron Transistor, Phys. Rev. Lett. **100**, 066801 (2008).

Tuesday, 15 August 2017
14.50-15.20
H1

204

New phases of superfluid ^{3}He in nematic aerogel

Dmitriev V.[1], _Soldatov A._[1,2], _Yudin A._[1]
[1]P.L. Kapitza Insitute for Physical Problems of RAS, Moscow, Russian Federation, [2]Moscow Institute of Physics and Technology, Dolgoprudny, Russian Federation

Superfluid phase diagram of ^{3}He confined in nematic aerogel (which strands are nearly parallel to one another) qualitatively differs from the diagrams of bulk ^{3}He or ^{3}He in nearly isotropic silica aerogel. A strong global anisotropy of nematic aerogel suppresses various possible superfluid phases of ^{3}He differently, and instead of A and B phases 3 new phases become favorable: the polar phase, the polar-distorted A phase, and the polar-distorted B phase. NMR experiments which have allowed to identify these phases and investigate their properties will be discribed in the talk. Possible future experiments will be also discussed.

Tuesday, 15 August 2017
14.50-15.20
Congress Hall

205

High-spin superconductivity in topological half-Heusler semimetal YPtBi

Paglione J.

University of Maryland, College Park, United States

In all known fermionic superfluids, Cooper pairs are composed of spin-1/2 quasi-particles that pair to form either spin-singlet or spin-triplet bound states. The "spin" of a Bloch electron, however, is fixed by the symmetries of the crystal and the atomic orbitals from which it is derived, and in some cases can behave as if it were a spin-3/2 particle. The superconducting state of such a system allows pairing states to form "beyond triplet", with higher spin quasi-particles combining to form quintet or even septet pairs. After reviewing the general properties of Pt- and Pd-based half-Heusler systems, I will present evidence for the first experimentally realized case of a high-spin fermionic superfluid in the exotic superconducting state of the half-Heusler compound YPtBi, as well as the rich landscape of ground states and intertwining orders found in the X-Y-Z family of materials.

Tuesday, 15 August 2017
14.50-15.20
G2

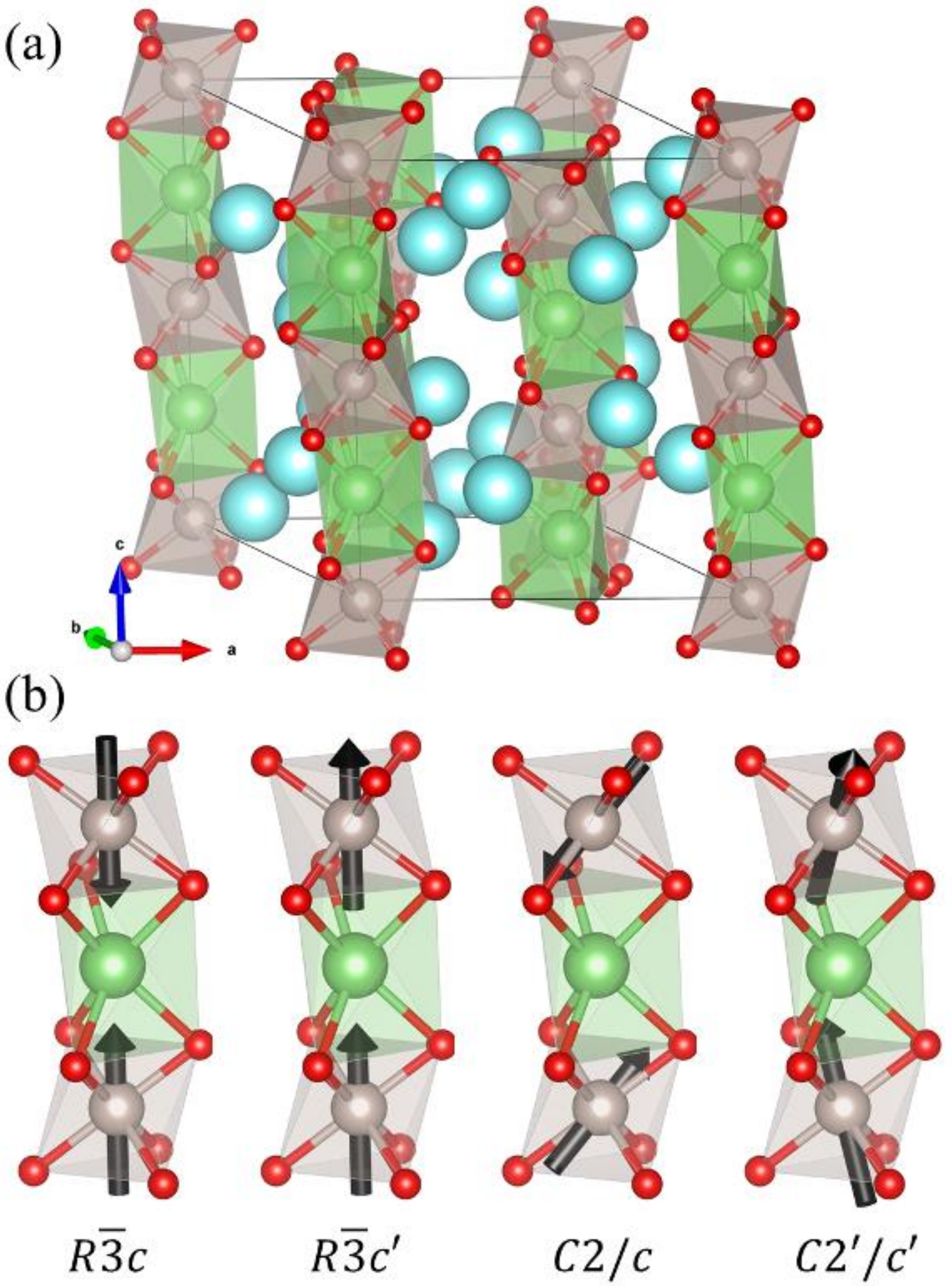
206

Magnetostriction-driven ground-state in hexagonal perovskites

<u>Porter D.G.</u>[1], Senn M.S.[2], Khalyavin D.D.[3], Cortese A.[4], Waterfield Price N.[5], Radaelli P.G.[5], Manuel P.[3], zur-Loye H.-C.[4], Mazzoli C.[6], Bombardi A.[1]

[1]Diamond Light Source Ltd, Physical Sciences, Didcot, United Kingdom, [2]University of Oxford, Inorganic Chemistry Laboratory, Oxford, United Kingdom, [3]ISIS Facility, Rutherford Appleton Laboratory, Didcot, United Kingdom, [4]University of South Carolina, Department of Chemistry & Biochemistry, Columbia, United States, [5]Oxford University, Department of Physics, Oxford, United Kingdom, [6]Politecnico di Milano, CNISM, Milano, Italy

The magnetic ground state of Sr_3ARuO_6, with *A* = (Li,Na), is studied using neutron diffraction, resonant x-ray scattering, and laboratory characterisation measurements of high-quality crystals. Combining these results allows us to observe the onset of long-range magnetic order and distinguish the symmetrically allowed magnetic models, identifying in-plane antiferromagnetic moments and a small ferromagnetic component along the *c*-axis. While the existence of magnetic domains masks the particular in-plane direction of the moments, it has been possible to elucidate the ground state using symmetry considerations. We find that due to the lack of local anisotropy, antisymmetric exchange interactions control the magnetic order, first through structural distortions that couple to in-plane antiferromagnetic moments and second through a high-order magnetoelastic coupling that lifts the degeneracy of the in-plane moments. The symmetry considerations used to rationalise the magnetic ground state are very general and will apply to many systems in this family, such as Ca_3ARuO_6, with *A* = (Li,Na), and Ca_3LiOsO_6 whose magnetic ground states are still not completely understood.



[Sr3LiRuO6 Structure]

References:
[1] D. G. Porter, Phys. Rev. B, **94**, 134404 (2016)

Wednesday, 16 August 2017
10.00-11.00
Congress Hall

207
Quantum spin liquids
Balents L.
University of California Santa Barbara, Kavli Institute of Theoretical Physics, Santa Barbara, United States

Quantum spin liquids[1,2] may be considered “quantum disordered” ground states of spin systems, in which zero point fluctuations are so strong that they prevent conventional magnetic long range order. More interestingly, quantum spin liquids are prototypical examples of ground states with massive many-body entanglement, of a degree sufficient to render these states distinct phases of matter. Their highly entangled nature imbues quantum spin liquids with unique physical aspects, such as non-local excitations, topological properties, and more. I will discuss the different types of quantum spin liquids, the models and theories used to describe them, and describe the current status of experiments.
References:
[1] L. Balents, Nature **464**, 199-208 (2010).
[2] L. Savary, and L. Balents, Reports on Progress in Physics, **80,** 016502 (2016).

Wednesday, 16 August 2017
11.30-12.30
Congress Hall

208
Order parameter symmetry in ^{3}He and UPt_3
Halperin W.
Northwestern University, Evanston, United States

New anisotropic states of superfluid ^{3}He have been studied at Northwestern University similar to those in a number of superconducting compounds, like UPt_3 and Sr_2RuO_4. I will discuss and compare three unconventional superconducting materials for which measurements of physical properties indicate unusual order parameter symmetry including chiral symmetry and broken time reversal symmetry, most clearly in evidence in high quality single crystals of UPt_3, pure superfluid ^{3}He, and superfluid ^{3}He in highly porous silica aerogel. These systems have multiple thermodynamic phases, with different order parameter structure. Theoretical predictions indicate that anisotropic quasiparticle scattering favors the stability of anisotropic quantum states. In particular we have shown this is the case for chiral states of superfluid ^{3}He confined to uniformly anisotropic silica aerogel. This also appears to be the case for superconducting UPt_3 and can be attributed to an inhomogeneous impurity phase associated with prism plane stacking faults.

Wednesday, 9 August 2017

16.50-17.50
Congress Hall

209
Superconducting detectors and sub-Kelvin instrumentation for astronomy
Monfardini A.
CNRS, Inst NEEL, Grenoble, France

Astronomy is historically the main driver for developing new detectors. The ultimate search of sensitivity, strict requirement for most astronomical applications, ends up inexorably in lowering the temperature of the sensing part until reaching almost the absolute zero. In fact the thermal noise "hides" the tiny amounts of energy that we try to resolve. Moreover, these small amounts of energy can only be measured adopting even smaller "units" like individual excitations in superconductors (quasi-particles) or ultra-low temperature phonons.
It is also thanks to the efforts deployed by the low temperature physics community if the state-of-the-art today shows multi-thousands pixels, i.e. large field-of-view, cameras operating at IR-to-radio frequencies and unveiling the details of the cold and primordial Universe.
After a general introduction, I will mainly focus, as a case study, on our own NIKA2 (New IRAM KID Arrays 2) millimetre-wave imager/polarimeter operating at the 30-meters radiotelescope at Pico Veleta. NIKA2, based on Kinetic Inductance Detectors (KID), is today the biggest mm-wave camera available to the astronomers for general purpose observations, ranging from the local Universe to cosmological distances. General context will be given.
References:
M. Calvo et al., "The NIKA2 Instrument, A Dual-Band Kilopixel KID Array for Millimetric Astronomy", Journal of Low Temperature Physics 184, Issue 3-4, 816 (2016)

Thursday, 10 August 2017
09.00-09.45
G3

210
Multi-terminal Josephson junctions as topological matter
Meyer J.S.
Universite Grenoble Alpes, INAC/PHELIQS, Grenoble, France

Topological phases of matter have attracted much interest in recent years. Starting with gapped phases such as topological insulators and superconductors, more recently gapless topological phases possessing topologically protected band crossings have been discovered.
Here we show that n-terminal Josephson junctions with conventional superconductors may provide a straightforward realization of tunable topological materials in n−1 dimensions [1], the independent superconducting phases playing the role of quasi-momenta.
In particular, we find zero-energy Weyl points in the Andreev bound state spectrum of 4-terminal junctions. The topological properties of the junction may be probed experimentally by measuring the transconductance between two voltage-biased leads [2], which we predict to be quantized.
Further, the analogy between the spectrum of Andreev bound states in an n-terminal Jospehson junction and the bandstructure of an n-1-dimensional material opens the possibility of realizing topological phases in higher dimensions, not accessible in real materials.
References:
[1] R.-P. Riwar, M. Houzet, J.S. Meyer, and Y.V. Nazarov, Nature Communications **7**, 11167 (2016).
[2] E. Eriksson, R.-P. Riwar, M. Houzet, J.S. Meyer, and Y.V. Nazarov, Phys. Rev. B **95**, 075417 (2017).

Friday, 11 August 2017
09.45-10.30
H1

211
Transition edge sensors: precision measurements of photons for cosmology and biospectroscopy
Cho H.-M.
SLAC National Accelerator Laboratory, Menlo Park, United States

Transition Edge Sensors (TES) are a powerful tool for the detection of electromagnetic radiation from microwaves through gamma rays. TES arrays have been used in a wide range of applications such as astronomy, particle astrophysics, nuclear security, and materials analysis in the laboratory and at light source facilities. These measurements have been enabled by the sensitivity provided by superconducting detectors and by the readout of multi-kilopixel detector arrays by superconducting multiplexer technology. At this talk, I will focus on two applications: probing cosmology using superconducting polarimeters and probing biology, chemistry and materials with a new soft x-ray TES spectrometer at Stanford Synchrotron Radiation Lightsource (SSRL).

Saturday, 12 August 2017
09.45-10.30
G3

212
The second quantum revolution
Siddiqi I.
UC Berkeley, Physics, Berkeley, United States

Quantum mechanics continues to stretch the limits of human thought by asserting that objects can exist simultaneously in multiple states until they are projected into a familiar classical outcome by a measurement - hence a cat in a sealed box can be dead and alive until the lid is opened. Moreover, two objects can be entangled such that a probe of one automatically yields information about the other, even if they are at opposite ends of the universe. Generating entanglement in bulk at the macroscopic scale is the engine behind the second quantum revolution, promising ultra-secure communications systems and unparalleled computing power. At a yet larger cosmic scale, this same entanglement which once troubled the architect of the theory of general relativity, Einstein, is now postulated to be the thread that stitches the fabric of the universe. Cryogenic superconducting resonant circuits and detectors, originally developed in the 1970s and 80s, form the basis of contemporary quantum information processing hardware when operated at the level of single excitation quanta in a well-controlled electromagnetic environment. In this talk, I will illustrate the essential features of quantum measurement and entanglement as observed with superconducting qubits.

Saturday, 12 August 2017
14.00-14.30
G1

213

Superconductivity and cryogenics for future circular colliders

Benedikt M.
CERN, Geneva, Switzerland

The global Future Circular Collider (FCC) study is designing a 100-TeV hadron collider (FCC-hh) in a new 100 km long tunnel, i.e. about four times larger than the operating Large Hadron Collider (LHC). The FCC study also includes the design of a high-luminosity electron-positron collider (FCC-ee), which could be installed in the same tunnel as a potential first step as well as an energy upgrade of the LHC using the FCC-hh technology (HE-LHC). The scope of the FCC study comprises accelerators, technology, infrastructure, detectors, physics, international governance models, and implementation scenarios.
Key technologies for FCC are beyond-state-of- the-art 16 T dipole magnets, based on some 6000 tons of advanced Nb_3Sn superconductor, as well as highly efficient superconducting radiofrequency systems for all collider scenarios. Use of HTS and MgB_2 cables is also considered for special magnets, SC links and other applications. All these technologies and applications also require large cryogenic plants and distribution systems. The presentation will summarize how a large-scale future research infrastructure like a high-energy circular collider makes use of advances in superconductivity and cryogenics.

Saturday, 12 August 2017
14.50-15.20
G3

214

Chiral 1D transport in magnetic topological insulators: precise quantization and manipulation

Goldhaber-Gordon D.[1,2], Fox E.[1,2], Rosen I.[2,3], Yang Y.[4], Jones G.[4], Elmquist R.[4], Kou X.[5], Pan L.[6], Wang K.[6]
[1]Stanford University, Physics, Stanford, United States, [2]SLAC National Accelerator Laboratory, Menlo Park, United States, [3]Stanford University, Applied Physics, Stanford, United States, [4]National Institute of Standards and Technology, Gaithersburg, United States, [5]Shanghai Tech University, Shanghai, China, [6]UCLA, Los Angeles, United States

Chiral (one-way) one-dimensional conduction is important for metrology, and could be interesting technologically. Such conduction occurs at the edge of a 2D electron system in high magnetic field, giving rise to dissipationless longitudinal transport and Hall conductance well-quantized in multiples of the von Klitzing constant: the quantum Hall effect. The recent prediction and discovery of the quantum anomalous Hall (QAH) effect in thin films of the three-dimensional ferromagnetic topological insulator $Cr_yBi_xSb_{1-x-y})_2Te_3$ has opened new possibilities for chiral edge state-based devices in zero external magnetic field. Like the nu=1 quantum Hall system, the QAH system is predicted to have a single chiral edge mode encircling the boundary of the film, with a chirality determined by the TI's out-of-plane magnetization. Backscattering of the chiral edge mode should be suppressed, and this is supported by earlier measurements. We will report on new observations of well-quantized Hall

resistivities along with very low longitudinal resistivities. We will also demonstrate 1D conduction not only at film edges but also along engineered magnetic domain walls within the plane.

Friday, 11 August 2017
17.15-18.00
G3

215

Levitons: a unique single charge quantum excitation for electron quantum optics and flying qubits

Glattli D.C., *Roulleau P.*
CEA - Saclay, SPEC, Gif-sur-Yvette, France

Single electron sources have made possible a real Electron Quantum Optics and have enable the use of single charges propagating in ballistic channels as flying charge qubits.
The ideal electron source is provided by levitons [1,2]. They are minimal excitation states carrying integer charge and produced by voltage pulses on a contact. Observations of Hong Ou Mandel interference of single or doubly charged indistinguishable levitons show 100% HOM dip resulting from the Fermi statistics [1] and an exceptional robustness of HOM correlations versus temperature is observed. Using quantum noise measurements the quantum state tomography of leviton wavepackets have been performed [3], an important step for electron quantum optics.
Beyond periodic leviton injection we will consider the pseudo-random binary sequence of levitons showing new features in the HOM correlation [4]. Finally, the possibility to generate levitons in the Quantum Hall regime, where chirality can be exploited for electron quantum optics, and the generation of on-demand anyon with fractional charge [5] will be discussed.

References:

[1] J. Dubois et al, Nature 502, 659-663 (2013)
[2] Levitov et al., J. Math. Phys. 37, 4845-4856 (1996)
[3] T. Jullien et al., Nature 514, 603-607 (2014)
[4] D.C. Glattli and P. Roulleau, arXiv:1702.00499
[5] L. Saminadayar, D. C. Glattli, Y. Jin, and B. Etienne, Phys. Rev. Lett. 79, 2526-2529 (1997)

Friday, 11 August 2017
11.00-11.30
G1

216

Influence of surface bound states on damping of MEMS oscillator in superfluid ^{3}He-B

Lee Y.[1], *Zheng P.*[1], *Jiang W.G.*[1], *Barquist C.S.*[1], *Chan H.B.*[2]
[1]University of Florida, Department of Physics, Gainesville, United States, [2]The Hong Kong University of Science and Technology, Department of Physics, Clear Water Bay, Kowloon, Hong Kong

The mechanical properties of a micro-electro-mechanical oscillator with a gap of 1.25 μm was studied in superfluid ^{3}He-B at various pressures. The damping of the shear mode of the oscillator was measured in the linear and nonlinear damping regimes. The quality factor of the oscillator remains low ($Q \approx 80$) down to $0.1T_c$, many orders of magnitude less than the intrinsic quality factor, exhibiting a dominant linear temperature dependence in the low temperature limit [1]. The oscillator enters into a nonlinear regime above a certain threshold velocity. The damping increases rapidly in the nonlinear region and eventually prevents the velocity of the oscillator from increasing beyond the critical velocity which is much lower than the Landau critical velocity [2]. We propose a multiple scattering mechanism of the surface Andreev bound states to be a possible cause for the anomalous behavior.

References:
[1] P. Zheng *et al*., Phys. Rev. Lett. **111**, 195301 (2016).
[2] P. Zheng *et al.*, Phys. Rev. Lett. **118**, 065301 (2017).

Monday, 14 August 2017
14.00-14.30
H1

217
Quantum engineering of superconducting qubits
Oliver W.[1,2]
[1]Massachusetts Institute of Technology, Cambridge, United States, [2]MIT Lincoln Laboratory, Lexington, United States

Superconducting qubits are coherent artificial atoms assembled from electrical circuit elements and microwave optical components. Their lithographic scalability, compatibility with microwave control, and operability at nanosecond time scales all converge to make the superconducting qubit a highly attractive candidate for the constituent logical elements of a quantum information processor.
In this talk, we revisit the design, fabrication, and control of the superconducting flux qubit. By adding a high-Q capacitor, we dramatically improve its reproducibility, anharmonicity, and coherence, achieving T_1 = 55 us and T_2 = 90 us. We identify quasiparticles as a leading cause of temporal variability in the T_1. We introduce and demonstrate a stochastic control technique that effectively pumps away these quasiparticles and thereby stabilizes and improves T_1.

References:
[1] J. Bylander, et al., Nature Physics 7, 565 (2011)
[2] W.D. Oliver & P.B. Welander, MRS Bulletin 38, 816 (2013)
[3] F. Yan et al., Nature Communications 7, 12964 (2016)
[4] S. Gustavsson et al., Science 354, 1573 (2016)

Friday, 11 August 2017
09.45-10.30
G3

218
Quantum oscillations and superconductivity in the cuprate high Tc's
Sebastien S.

I will discuss measurements of quantum oscillations and electrical transport in the cuprate high temperature superconductors to explore the high magnetic field state in these materials.

Saturday, 12 August 2017
09.45-10.30

Congress Hall

TBA

Monday, 14 August 2017
09.05-10.05
Congress Hall

220

The quantum critical point of cuprate superconductors

Taillefer L.[1,2]

[1]University of Sherbrooke, Institut Quantique, Sherbrooke, Canada, [2]Canadian Institute for Advanced Research, Toronto, Canada

Cuprates exhibit exceptionally strong superconductivity, with critical temperatures and magnetic fields that can exceed 100 K and 100 T, respectively. However, the nature of the electron interactions responsible for the strong pairing is still not clear.

I will present recent experimental studies performed using high magnetic fields to suppress superconductivity and access the non-superconducting ground state of cuprates in the $T = 0$ limit. These reveal the presence of a quantum critical point in the phase diagram of cuprates [1,2], where the enigmatic pseudogap phase ends, around which the superconducting phase forms a dome, and at which the resistivity exhibits an anomalous linear dependence on temperature [3,4].

Strong similarities with the quantum critical point at which antiferromagnetic order ends in organic [5], iron-based [6] and heavy-fermion [7] superconductors suggest that antiferromagnetic spin correlations also play a fundamental role in cuprates, in particular as the mechanism for *d*-wave pairing. The outstanding questions are: Does antiferromagnetic order extend up to the critical point in cuprates? Is long-range order necessary to open a (pseudo)gap and generate anomalous, non-Fermi-liquid scattering and mass renormalization down to $T \sim 0$?

References:

[1] S. Badoux *et al*., Nature **531**, 210 (2016).
[2] C. Collignon *et al*., Phys. Rev. B (in press); arXiv:1607.05693.
[3] R. Daou *et al*., Nat. Phys. **5**, 31 (2009).
[4] L. Taillefer, Annu. Rev. Condens. Matter Phys. **1**, 51 (2010); arXiv:1003.2972.
[5] N. Doiron-Leyraud *et al*., Phys. Rev. B **80**, 214531 (2009).
[6] T. Shibauchi, A. Carrington, Y. Matsuda, Annu. Rev. Condens. Matter Phys. **5**, 113 (2014).
[7] P. Monthoux, D. Pines, G. G. Lonzarich, Nature **450**, 1177 (2007).

Friday, 11 August 2017
14.00-14.30
G3

221

QND spin measurement and CPHASE with exchange-coupled two qubits of different kinds

Tarucha S.

The University of Tokyo, Applied Physics, Tokyo, Japan

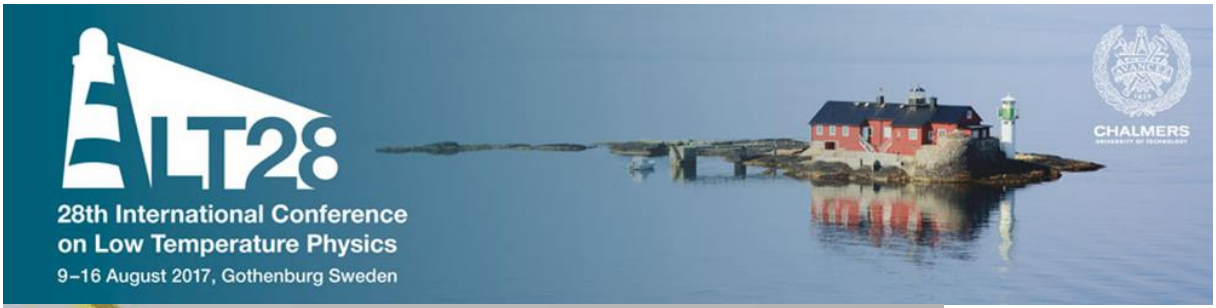
Various kinds of spin qubits, spin-1/2, singlet-triplet and exchange-only, have been developed to date. Coupling of them can provide efficient quantum gates and more variations of quantum operations. We

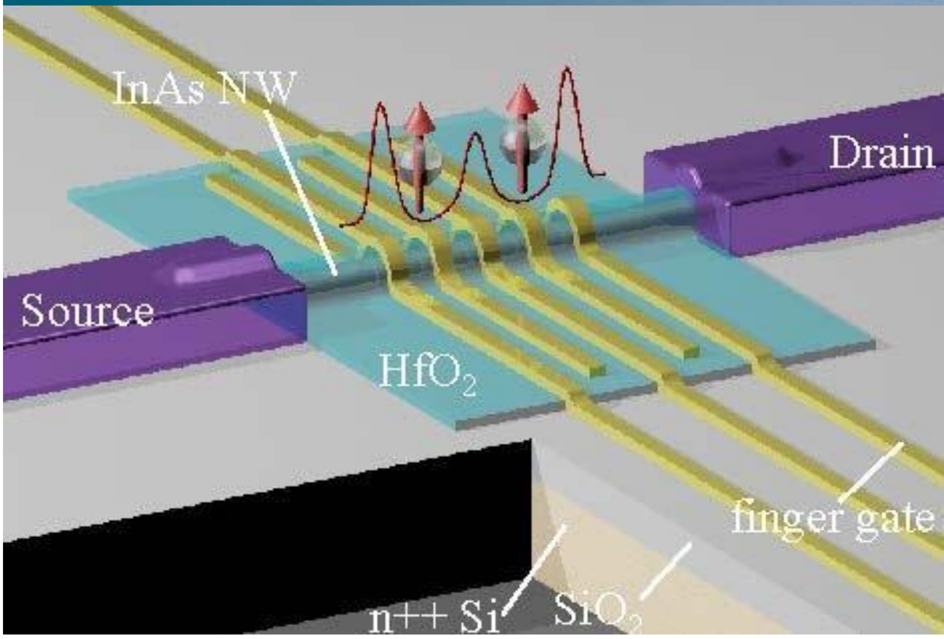
use a triple GaAs quantum dot to manipulate exchange coupling between a spin-1/2 qubit and a singlet-triplet qubit and apply it for QND readout of the spin-1/2 state as well as CPHASE operation. We prepare phase-controlled singlet-triplet entanglement in two of the three dots and show the singlet-triplet phase evolution frequency is modulated depending on the orientation of the spin-1/2 in the third dot. This frequency modulation can be used for QND measurement of the spin-1/2 qubit and also for CPHASE operation of the singlet-triplet qubit. Finally, I will discuss quantum dephasing in either qubit due to the nuclear spin environment. I show that the dephasing is significantly reduced by decreasing the data acquisition time in the non-ergodic condition of the magnetic noise and also that the qubit gate fidelity is largely improved by adaptive feedback control to compensate for the magnetic noise in real time.

Friday, 11 August 2017
12.10-12.30
G3

222
Anisotropic Pauli spin-blockade effects in double quantum dots made from InAs nanowire
Wang J.-Y.[1], *Huang S.*[1], *Huang G.-Y.*[1], *Pan D.*[2], *Zhao J.*[2], *Xu H.Q.*[1,3]
[1]Peking University, Key Laboratory for the Physics and Chemistry of Nanodevices, and Department of Electronics, Beijing, China, [2]Institute of Semiconductors, Chinese Academy of Sciences, Beijing, China, [3]Lund University, Division of Solid State Physics, Lund, Sweden

Semiconductor quantum dots (QDs) are one of the most promising building blocks for the physical implementation of electron-spin based quantum computers.[1,2] The electron spin relaxation time in the QD is essential for robust and functional computations but limited by two dominating mechanisms: nuclear hyperfine[3] and spin-orbit interactions[4]. The former is usually random, while the latter is anisotropic. Experimentally, the magnitude of leakage current through double quantum dot (DQD) in spin-blockade regime reflects the strength of spin mixing.
In this work, we investigate the spin mixing effects caused by hyperfine interaction and spin-orbit interaction in a top-finger-gate defined DQD in InAs nanowire, as shown in Fig. 1. In spin-blockade regime, by detuning the energy levels of each dot and applying an external magnetic field, we systematically study the roles of two spin-mixing mechanisms and identify each mechanism.Spin mixing arising from hyperfine interaction can be suppressed completely by a magnetic field of several mili-Tesla. By applying the external magnetic field in different directions with regard to the nanowire axis, the anisotropic lifting of the Pauli spin blockade is observed and attributed to the anisotropic spin-orbit interaction.





[Fig.1 Schematics of the DQD]

References:

[1] D. Loss, D. P. DiVincenzo, Phys. Rev. A 57, 120 (1998).
[2] J. Y. Wang, S. Y. Huang, Z. Lei, D. Pan, J. Zhao, H. Q. Xu, Appl. Phys. Lett. 109, 053106 (2016),.
[3] Oleg N. Jouravlev, Y. V. Nazarov, Phys. Rev. Lett 96, 176804 (2006).
[4] J. Danon, Y. V. Nazarov, Phys. Rev. B 80, 041301 (2009).

Friday, 11 August 2017
14.50-15.20
G3

223

Quantum simulation of a Fermi-Hubbard model using a semiconductor quantum dot array

<u>Hensgens T.</u>[1], Fujita T.[1], Janssen L.[1], Li X.[2], Van Diepen S.[3], Reichl C.[4], Wegscheider W.[4], Das Sarma S.[2], Vandersypen L.M.K.[1]
[1]Delft University of Technology, QuTech & Kavli Institute of Nanoscience, Delft, Netherlands, [2]University of Maryland, Condensed Matter Theory Center & Joint Quantum Institute, College Park, United States, [3]Netherlands Organization for Applied Scientific Research (TNO), Delft, Netherlands, [4]ETH Zürich, Zürich, Switzerland

Seminal efforts are underway to study novel emergent magnetic and electronic properties of strongly-correlated electronic phases of low-dimensional condensed matter physics using dedicated quantum simulators. Experimentally realized correlations, however, are typically limited by the residual entropy of the initialized systems, and scaling to similarly homogeneous but larger system sizes is not always straightforward.

We show that quantum dot arrays in semiconductors constitute a promising platform in these regards. Not only do tunnel-coupled dots readily adhere to the Fermi-Hubbard model in the effective low temperature limit necessary for seeing strong correlations, but one can also directly leverage developments for using quantum dots as spin qubits. By describing an experimental toolbox for Hamiltonian engineering, validated by direct numerical simulations, we negate the combination of disorder inherent to the solid state and the inefficiency of calibration routines which has previously

limited the scaling of quantum dot experiments in scope and size. As we map out the experimental phase space of a triple quantum dot device [1], we show the onset of collective Coulomb blockade [2], the finite-size analogue of the interaction-driven Mott transition.

References:
[1] T. Hensgens *et al.*, ArXiv1202.07511 (2017).
[2] C. A. Stafford and S. Das Sarma, Phys. Rev. Lett. **72**, 3590-3593 (1994).

Tuesday, 15 August 2017
11.30-12.30
Congress Hall

224
Majorana wires and next steps toward topological quantum devices
Marcus C.
Station Q Copenhagen and Center for Quantum Devices, Niels Bohr Institute, University of Copenhagen DK

This talk will briefly review the experimental status and evidence for Majorana modes in semiconductor-superconductor nanowire systems, then discuss extensions to future topological devices, and how we are assembling components for topological information processing. Along the way, new materials challenges arise, including moving from as-grown hybrid nanowires to top-down processed 1D systems fabricated from two-dimensional heterostructures. Many new problems, from fundamentals of how to identify Majorana zero modes, to how to process and store quantum information with topological protection, to how to design and extended hybrid superconductor-semiconductor materials will be touched on, though the most exciting developments are for the future.
Research supported by the Danish National Research Foundation and Microsoft Corporation.

Tuesday, 15 August 2017
15.40-16.00
G1

225
Fully coupled dynamics of two-fluid model in thermal counterflow: deformation of the Poiseuille normal fluid profile
Tsubota M.[1], *Yui S.*[1], *Kobayashi H.*[2]
[1]Osaka City University, Department of Physics, Osaka, Japan, [2]Keio University, Department of Physics, Hiyoshi Campus, Yokohama, Japan

Since the proposal of the two-fluid model in 1941 by Tisza and Landau, the model has succeeded in revealing many kinds of physics on superfluidity. Since the rotation of superfluid is sustained only by quantized vortices, the vortex filament model (VFM) has been used for superfluid 4He and worked very much. Most previous numerical studies of the VFM in thermal counterflow were performed for the periodic boundary condition under the prescribed normal fluid profile [1]. However, the recent visualization experiments observed the deformation of the normal fluid profile in a square channel [2], which invites us to study the fully coupled dynamics of two-fluid in a channel. This motivation is closely related to the old problem on the two-stage transition toward turbulence too [3]. Thus we study numerically the fully coupled dynamics of two-fluid model in thermal counterflow in a square channel. The superfluid and the normal fluid are treated by the VFM and the Navier-Stokes equation

respectively, and they are coupled by mutual friction. We found the profile of the normal fluid can change from the Poiseuille flow to the tail-flattened flow[2]. We discuss the mechanism of the deformation.

References:

[1] K. W. Schwarz, Phys. Rev. B 38, 2398 (1988): H. Adachi et al., Phys. Rev. B 81, 104511 (2010)
[2] A. Marakov et al., Phys. Rev. B 91, 094503 (2015)"" [3] J. T. Tough, in Prog. Low Temp. Phys. , ed. C. J. Gorter (North-Holland, Amsterdam, 1982) Vol. VIII, p. 133

Wednesday, 16 August 2017
09.00-10.00
Congress Hall

226

High temperature conventional superconductivity

Eremets M.
Max-Planck-Institut fur Chemie, Mainz, Germany

Progress in conventional phonon-mediated superconductivity will be discussed, in particular, the record 203 K critical temperature T_c in sulfur hydride at high pressures [1]. This superconductivity has been proved by observation of zero resistance, Meissner effect [2], isotope effect, X-ray diffraction studies [3], in infrared [4] and Raman studies. Other hydrides also revealed superconductivity with T_c >100 K [5]. The mechanism of this apparently conventional superconductivity was elucidated in numerous theoretical works. In particular, it turned out that hydrogen atoms give the major input (~90%) into the superconductivity, and in this respect, sulfur hydride can be considered as atomic metallic hydrogen. Recent results on pure hydrogen at pressures up to 480 GPa also will be presented. Prospects for achieving high critical temperatures of superconducting transition at ambient pressure will be discussed too.

References:

[1] Drozdov, A. P., et al. (2015). Nature **525**, 73-77.
[2] Troyan, I., et al. Science, **351,** 1303 (2016).
[3] Einaga, M., et al. Nature Physics. 12 835 (2016).
[4] Capitani, F., et al, Nature Physics, doi:10.1038/nphys4156 (2017).
[5] Drozdov, A. P., et al. arXiv:1508.06224, (2015).

Thursday, 10 August 2017
11.30-11.50
G2

227

Defects in low dimensional quantum magnets

Povarov K.[1], Simutis G.[1], Schmidiger D.[1], Galeski S.[1], Gvasaliya S.[1], Mansson M.[1], Chernyshev A.[2], Mohan A.[3], Singh S.[3], Hess C.[3], Buchner B.[3,4], Savici A.[5], Kolesnikov A.[5], Ollivier J.[6], Piovano A.[6], Perring T.[7], Bewley R.[7], Guidi T.[7], Zaliznyak I.[8], Zheludev A.[1]
[1]ETH Zürich, Neutron Scattering and Magnetism, Laboratory for Solid State Physics, Zürich, Switzerland, [2]University of California, Department of Physics and Astronomy, Irvine, United States, [3]Leibniz Institute for Solid State and Materials Research IFW Dresden, Dresden, Germany, [4]TU Dresden, Department of Physics, Dresden, Germany, [5]NScD, Oak Ridge National Laboratory, Oak Ridge, United States, [6]Institut Laue-Langevin, Grenoble, France, [7]ISIS Facility, Rutherford Appleton

Laboratory, Chilton, Didcot, United Kingdom, [8]Brookhaven National Laboratory, Upton, New York, United States

One-dimensional quantum systems are known to be extremely susceptible to defects. Here I will demonstrate the dramatic effect that a depletion with nonmagnetic impurities has on several spin chain and spin ladder compounds. Due to fundamentally different low-energy degrees of freedom, impurities in spin chains and ladders play very different roles. In spin chains, scattering by defects leads to a confinement of low energy quasiparticles already present in the unperturbed system. As a result, a magnetic excitation spectrum acquires a concentration-dependent "pseudogap" which bears a universal description[1]. In contrast, the unperturbed spin ladder has no low-energy excitations of its own. Instead, new local degrees of freedom are released upon the introduction of defects. Strong antiferromagnetic correlations shape them as spatially extended "spin islands". Although these spin islands are localized, they strongly interact and thereby give rise to unusual thermodynamic properties and novel collective modes[2]. In both cases, inelastic neutron scattering observes the corresponding defect-induced transformations of the spin excitation spectra *directly*, and the effective theories allow to describe the metamorphoses of gapped and gapless behavior *quantitatively*.

References:

[1] G. Simutis, S. Gvasaliya *et al.*; Phys. Rev. Lett. **111**, 067204 (2013)
[2] D. Schmidiger, K. Yu. Povarov *et al.*; Phys. Rev. Lett. **116**, 257203 (2016)

LT28 POSTER SESSION 1

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.302

Magnetization measurements of Sr_2RuO_4-Ru eutectic microplates using dc-SQUIDs

Nago Y.[1,2,3]*, Sakuma D.*[2,3]*, Ishiguro R.*[3,4]*, Kashiwaya S.*[5]*, Nomura S.*[6]*, Kono K.*[3]*, Maeno Y.*[7]*, Takayanagi H.*[2]

[1]Keio University, Yokohama, Japan, [2]Tokyo University of Science, Tokyo, Japan, [3]RIKEN Center for Emergent Matter Science (CEMS), Wako, Japan, [4]Japan Women's University, Tokyo, Japan, [5]AIST, Tsukuba, Japan, [6]University of Tsukuba, Tsukuba, Japan, [7]Kyoto University, Kyoto, Japan

The layered perovskite Sr_2RuO_4 is a strong candidate of chiral p-wave superconductor [1]. The Sr_2RuO_4-Ru eutectic crystal is very effective to study topological frustration because, below a superconducting transition temperature of Ru (~ 0.5 K), Sr_2RuO_4/Ru interfaces become unstable due to phase competition between a chiral p-wave state of Sr_2RuO_4 and a s-wave state of Ru. It is expected that a quantized vortex state spontaneously nucleates at the center of the Ru inclusion to compensate the frustration [2]. However, no unambiguous experimental observation of it has been reported so far [3]. In this study, we invetigated vortex states in Sr_2RuO_4-Ru eutectic microplates using micro-dc-SQUIDs. The eutectic was milled into a micron-sized square plate using a focused Ga ion beam so that a cylindrical-shaped Ru inclusion was located at the center of the plate. The microplate was directly mounted on the SQUID based on our technique in a previous study [4]. Magnetization measurements were performed down to below the transition temperature of the Ru with zero-field-cooling and field-cooling methods. We discussed the transition of the vortex states and influence of proximity-induced superconductivity at the Sr_2RuO_4/Ru interface.

References:

[1] A.P. Mackenzie and Y. Maeno, Rev. Mod. Phys. 75, 657(2003); Y. Maeno et al., J. Phys. Soc. Jpn. 81, 011009(2012).
[2] H. Kaneyasu and M. Sigrist, J. Phys. Soc. Jpn. 79, 053706(2010).
[3] Y. Nago et al., Phys. Rev. B 94, 054501(2016).
[4] Y. Nago et al., J. Low Temp. Phys. 183, 292 (2016).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.303

Transport Properties of the layered transition metal cxypnictide $Sr_2ScCo_{1-x}Fe_xPO_3$ with Fe-doped $Co_{1-x}Fe_xP$ layers

Okada S.[1]*, Kamihara Y.*[2]*, Ohkubo N.*[1]*, Ban S.*[1]*, Matoba M.*[2]

[1]Nihon University, Laboratory of Physics, College of Science and Technology, Funabashi, Japan, [2]Keio University, Department of Applied Physics and Physico-Informatics, Faculty of Science and Technology, Yokohama, Japan

We have successfully synthesized Fe-doped cobalt oxypnictides, $Sr_2ScCo_{1-x}Fe_xPO_3$ with $Co_{1-x}Fe_xP$ layer. This material, Sr2Sc$Co_{1-x}Fe_xPO_3$, crystallizes in a layered structure which represents an

alternative stack of $ThCr_2Si_2$ type $Co_{1-x}Fe_xP$ layer and K_2NiF_4 type Sr_2ScO_3 layer. This material has a similar structure to $Sr_2ScFePO_3$ which exhibits superconductivity below 17 K [1].
In the case of x = 0 ($Sr_2ScCoPO_3$), synthesis procedures and measured transport properties are reported in our previous paper [2]. The resistivity (ρ) is 4.5 mΩcm at room temperature, and decreases with decreasing temperature. The Seebeck coefficient (S) is -12 µV/K at room temperature, and it decreases with decreasing temperature, and rapidly increases below 50 K [2]. In the case of x = 0.5 ($Sr_2ScCo_{0.5}Fe_{0.5}PO_3$), the S increases with decreasing temperature, and attains to a positive value below 270 K [3].
In this study, we report that the transport properties of $Sr_2ScCo_{1-x}Fe_xPO_3$ ($0.04 \le x \le 0.8$). The ρ of $Sr_2ScCo_{1-x}Fe_xPO_3$ decrease with decreasing temperature like a metal. The S of these materials are negative value at room temperature, and these sign inversion are obtained for $0.04 \le x \le 0.7$.

References:

[1] H. Ogino *et al.*, Supercond. Sci. Technol. **22**, 075008 (2009).
[2] S. Okada *et al.*, J. Phys.: Conf. Ser. **400**, 022091 (2012).
[3] S. Okada *et al.*, J. Phys.: Conf. Ser. **568**, 022034 (2014).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.304

Vortex states in three-dimensional superconductors under a helical magnetic field from a chiral helimagnet

Fukui S.[1], *Kato M.*[1], *Togawa Y.*[2], *Sato O.*[3]
[1]Osaka Prefecture University, Department of Mathematical Sciences, Sakai, Japan, [2]Osaka Prefecture University, Department of Physics and Electronics, Sakai, Japan, [3]Osaka Prefecture University College of Technology, Neyagawa, Japan

It is known that a vortex state in a superconductor can be generated by a magnet. For example, in a ferromagnet / superconductor bilayer system, vortices appear in the superconductor spontaneously [1]. However, we focus on a chiral helimagnet, whose magnetic structure of the chiral helimagnet forms a helical rotation along one direction and is transformed into an incommensurate magnetic structure by an uniform applied magnetic field [2, 3]. Because of this characteristic magnetic structure, we expect that the chiral helimagnet affects vortex states in the superconducting state strongly.
In order to investigate effects of the chiral helimagnet on superocnductors, we consider a chiral helimagnet / superconductor bilayer system. An effect of magnetic structure of the chiral helimagnet is treated as an external magnetic field on the superconductor. So, we consider a superconductor under the helical magnetic field. In order to investigate vortex states, we solve the Ginzburg-Landau equations using the three-dimensional finite element method and obtain distributions of the order parameter [4].
In this presentation, we show how distributions of the order parameter and vortex states in the superconductor change when the helical magnetic field from the chiral helimagnet is changed.

References:

[1] I. F. Lyuksyutov, V. L. Pokrovsky, Adv. Phys. **54**, 1 (2005)
[2] Y. Togawa, et al., Phys. Rev. Lett. **108**, 107202 (2012)
[3] J. Kishine, et al., Prog. Theor. Phys. Suppl., **159**, 82 (2005)
[4] S. Fukui, M. Kato, and Y. Togawa, Supercond. Sci. Technol., **29**, 125008 (2016)

Postersession 1
Thursday, 10 August 2017
16.30-18.30

G Foyer

P.305

Quantum-circuit refrigerator

Tan K.Y.[1], Masuda S.[1], Partanen M.[1], Lake R.[1,2], Govenius J.[1], Silveri M.[1,3], Grabert H.[4], Goetz J.[1], Hazra D.[1], Vesterinen V.[1,5], Möttönen M.[1]

[1]Aalto University, QCD Labs, Department of Applied Physics, AALTO, Finland, [2]National Institute of Standards and Technology, Boulder, United States, [3]University of Oulu, Research Unit of Theoretical Physics, Oulu, Finland, [4]University of Freiburg, Department of Physics, Freiburg, Germany, [5]VTT Technical Research Centre of Finland Ltd, VTT, Finland

Quantum technology holds great potential in providing revolutionizing practical applications. However, fast and precise cooling of the functional quantum degrees of freedom on demand remains a major challenge in many solid-state implementations, such as superconducting circuits. We demonstrate direct cooling of a superconducting resonator mode using voltage-controllable quantum tunneling of electrons in a nanoscale refrigerator. In our first experiments on this type of a quantum-circuit refrigerator [1], we measure the drop in the mode temperature by electron thermometry at a resistor which is coupled to the resonator mode through ohmic losses. To eliminate unwanted dissipation, we remove the probe resistor and directly observe the power spectrum of the resonator output in agreement with the so-called P(E) theory [2]. We also demonstrate in microwave reflection experiments that the internal quality factor of the resonator can be tuned by orders of magnitude. In the future, our refrigerator can be integrated with different quantum electric devices, potentially enhancing their performance. For example, it may prove useful in the initialization of superconducting quantum bits and in dissipation-assisted quantum annealing.

References:

[1] K. Y. Tan, M. Partanen, R. E. Lake, J. Govenius, S. Masuda, and M. Möttönen, Nature Commun. **8**, 15189 (2017); ibid. arXiv:1606.04728 (2016).

[2] S. Masuda, K. Y. Tan, M. Partanen, R. E. Lake, J. Govenius, M. Silveri, H. Grabert, and M. Möttönen, arXiv:1612.06822 (2016).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.306

Electron energy relaxation in thin superconducting NBN films

Sidorova M.[1], Zhang X.[2], Charaev I.[3], Kaurova N.[4], Goltsman G.[4], Schilling A.[2], Semenov A.[5], Hübers H.-W.[5], Siegel M.[3]

[1]DLR Institut für Optische Sensorsysteme, Berlin, Germany, [2]Physics Institute, University of Zurich, Zurich, Switzerland, [3]Karlsruhe Institute of Technology, Karlsruhe, Germany, [4]Moscow State Pedagogical University, Moscow, Russian Federation, [5]DLR Institut of Optical Systems, Berlin, Germany

Essential part of physics of superconducting detectors is the model of energy outflow from electrons first absorbing electromagnetic radiation. For many detector technologies, it includes escape of phonons from metal film to dielectric substrate. Recently there have been indications that for very thin films this interface is noticeably less transparent for acoustic phonons than the isotropic Debye model predicts. The inconsistency was related to the modification of both the electron-phonon interaction and the phonon spectrum in the film. To revise the problem we studied energy relaxation in a series of ultrathin NbN films with different thicknesses by means of time-resolving and steady state techniques which also included measurements of magnetoconductance. Using the approach of effective electron and phonon temperatures, we extracted the ratio between heat capacities of electrons and phonons,

the effective phonon escape time and the electron-phonon interaction time. In particular, we found that the temperature dependence of the latter time differs from the dependence obtained earlier for thicker films and that this time depends on the thickness. The results are important for understanding the evolution of the electron hot-spot in superconducting nanowire single-photon detectors.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.307

Weak-link formation in Nb nanoconstrictions by electro-annealing

Lombardo J.[1], *Baumans X.D.A.*[1], *Jelić Ž.L.*[1,2], *Scheerder J.*[3], *Moshchalkov V.V.*[3], *Van de Vondel J.*[3], *Milosevíc M.V.*[2], *Kramer R.B.G.*[4], *Silhanek A.V.*[1]
[1]University of Liège, Department of Physics, Liège, Belgium, [2]Universiteit Antwerp, Departement Fysica, Antwerp, Belgium, [3]Katholieke Universiteit Leuven, Institute for Nanoscale Physics and Chemistry, Leuven, Belgium, [4]Université Grenoble Alpes, Institut Néel, Grenoble, France

In this work we report the possibility to create weak links in nanostructured Nb thin films using electro-annealing. By using electron-assisted atom diffusion in Nb nanconstrictions, we were able to locally change the material properties (superconducting critical temperature and normal resistance). When the critical temperature of the nanoconstriction is sufficiently decreased, the field dependence of the critical current exhibits a Fraunhofer-like pattern, confirming the formation of the weak link. Scanning electron microscopy images clearly reveals the structural change underwent by the constriction resulting from the effect of the high current density. Numerical simulations within the Ginzburg-Landau formalism are also presented. These findings represent the first evidence of weak link formation by electro-annealing and provide an easy method for the fabrication of Josephson junctions with tunable resistance and critical temperature in Nb thin films.

References:

[1] B. D. Josephson, Phys. Lett. **1**, 251 (1962)
[2] T. Aref and A. Bezryadin, Nanotechnology **22**, 395302 (2011)
[3] X. D. A. Baumans *et al.*, Nat. Comm. **7**, 10560 (2016)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.308

Intrinsic conduction mechanism in polymer nanofibers

Park Y.W.[1], *Kim K.H.*[2], *Lara-Avila S.*[2], *Kubatkin S.*[3]
[1]Seoul National University, Seoul, Korea, Republic of, [2]Chalmers University, Gothenburg, Sweden, [3]Chalmers University, Gothenberg, Sweden

We studied the I-V characteristics on pristine polymer nanofibers and carbonized polymer nanofibers. Both types of materials give apparent power law dependence of current with voltage and temperature and scaling of all measurements into a single universal curve despite the structural differences: the former quasi one-dimensional and the latter quasi-amorphous carbon networks of two- or three-dimensional. We have interpreted the power law scaling in both materials as the manifestation of the

Efros-Shklovskii variable range hopping (ES-VRH) in wide range of T and V parameters. The magneto resistance (MR), however, shows distinct behaviors between the two materials. The pristine polyacetylene nanofibers show zero magneto resistance (ZMR) in high electric field, E = 3 x 10^4 V/cm. But the MR of carbonized polyacetylene nanofibers remains positive which is typical for the VRH conduction. The ZMR observed in polyacetylene nanofibers in high electric field is explained with the de-confined conduction of spinless charged soliton which is a 1-D topological insulator. A possibility to investigate the Majorana state in the polyacetylene nanofibers will be discussed.

References:

[1] K. H. Kim, S. Lara-Avila, H. Kang, H. He, J. Eklof, S. J. Hong, M. Park, K. Moth-Poulsen, S. Matsushita, K. Akagi, S. Kubatkin and Y. W. Park, Sci. Rep. 6, 37783 (2016)
[2] Y. W. Park, Chem. Soc. Rev. 39, 2428 (2010)
[3] A. Choi, K. H. Kim, S. J. Hong, M. Goh, K. Akagi, R. B. Kaner, N. N. Kirova, S. A. Brazovskii, A. T. Johnson, D. A. Bonnell, E. J. Mele, and Y. W. Park, Phys. Rev. B 86, 155423 (2012).

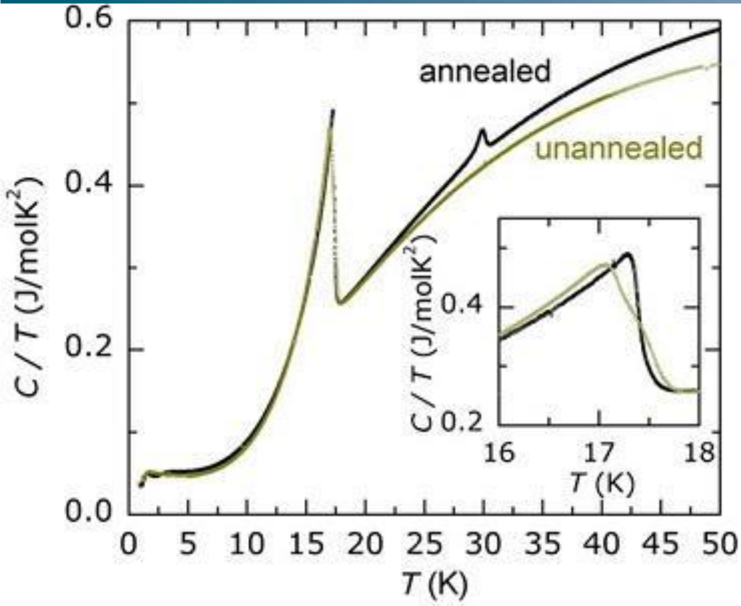
Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.309

Observation and origin of specific heat peak at 29.5 K in annealed URu_2Si_2

Campanini D.[1], Diao Z.[1], Rydh A.[1], Balatsky A.V.[2], Kanchanavatee N.[3], Maple B.[3]
[1]Stockholm University, Department of Physics, Stockholm, Sweden, [2]NORDITA, Stockholm, Sweden, [3]University of California, Department of Physics, San Diego, United States

The heavy fermion URu_2Si_2 has attracted great attention in the scientific community during the last three decades (See [1] for a review) because of a mysterious phase transition at 17.5 K. In this work, we investigate small (≈ µg size) URu_2Si_2 single crystals through a custom-built nanocalorimeter [2]. We measure the specific heat around and above the hidden-order transition temperature on annealed and unannealed crystals. Annealed samples display a sharper and more pronounced peak at 17.5 K, showing that the hidden-order transition is enhanced by a higher crystal quality. However, a second transition peak with lower intensity is observed at 29.5 K in the very same annealed crystals. Its transition temperature, together with its first-order character, leads us to associate it with the presence of a thin (20-100 nm) surface layer of UO_2. This layer corresponds to only ≈ 0.1 - 0.5 % of the total sample, making it hard to detect with conventional x-rays methods. However, its effect is well detectable in the specific heat data and should be taken into consideration in the interpretation of surface-sensitive measurements on annealed URu_2Si_2. No other signs of precursors of the hidden-order phase at temperatures above 17.5 K are detected from our specific heat measurements.



[Low temperature molar specific heat of URu2Si2]

References:
[1] J. A. Mydosh and P. M. Oppeneer, Rev. Mod. Phys. **83,** 1301 (2011)
[2] S. Tagliati, V. M. Krasnov, and A. Rydh, Rev. Sci. Instrum. **83**, 055107 (2012)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.310

Transport properties in high-quality two-dimensional ultrathin Mo_2C superconducting crystals

Kang N.[1], *Wang L.*[1], *Xu C.*[2], *Song S.*[1], *Cheng H.*[2], *Ren W.*[2]
[1]Peking University, Key Laboratory for the Physics and Chemistry of Nanodevices and Department of Electronics, Beijing, China, [2]Shenyang National Laboratory for Materials Science, Institute of Metal Research, Chinese Academy of Sciences, Shenyang, China

There is particularly interesting in the studies on a cleaner superconducting crystal samples for the understanding the nature of superconductivity in the 2D limit. Very recently, we have obtained high-quality 2D ultrathin Mo_2C superconducting crystals [1]. Here, we report on low-temperature transport measurements on high-quality ultrathin Mo_2C crystals. They show 2D characteristics of superconducting transitions that are consistent with Berezinskii-Kosterlitz-Thouless behaviour and show strong anisotropy with magnetic field orientation, as shown in Fig 1(a). We observe reproducible magnetoresistance (MR) oscillations and a negative MR behavior at low magnetic fields for temperature far below superconducting transition temperature of the crystals, as shown in Fig 1(b). We discuss that these anomalous MR behaviors can be understood quantitatively by including the effects of inhomogeneous superconducting phase and quantum fluctuations of the phase order parameter in the vicinity of the superconductor-insulator transition regime [2,3]. Our results demonstrate that such stable high-quality clean 2D superconducting crystals provide a new material platform to investigate novel phenomena in 2D superconductor.

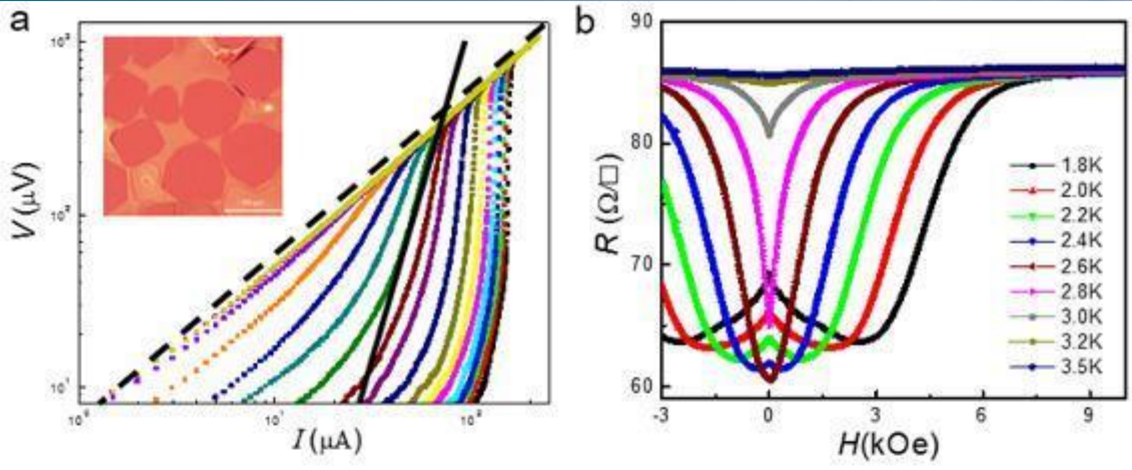


Fig. 1: (a) BKT transition of 2D ultrathin α-Mo2C crystals. *V–I* characteristic at different temperatures on a logarithmic scale [1]. The inset shows typical optical image of ultrathin crystals. (b) Negative magneto-resistance below T_C within the superconducting transition region [2].

[mo2c]

References:

[1] C. Xu, L. B. Wang, Z. B. Liu, L. Chen, J. K. Guo, N. Kang*, X, L. Ma, H. M. Cheng, and W. C. Ren*, Nature Mater, **14**, 1135 (2015).
[2] L. B. Wang, C. Xu, Z. B. Liu, L. Chen, X, L. Ma, H. M. Cheng, W. C. Ren*, and N. Kang*, ACS NANO. **10**, 4504 (2016).
[3] Z. B. Liu†, C. Xu†, N. Kang†, L. B. Wang, Y. Jiang, J. Du, Y. Liu, X, L. Ma*, H. M. Cheng, and W. C. Ren*, Nano Letters. **16**, 4243 (2016).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.311

Effect of the type I to type II Weyl semimetal topological transition on superconductivity

<u>Shapiro B.</u>[1], Li D.P.[2], Rosenstein B.[3], Shapiro I.[1]
[1]Bar Ilan University, Physics, Givat Shemuel, Israel, [2]Peking University, Physics, Beijing, China, [3]National Chiao Tung University, Electrophysics, Hsinchu, Taiwan, Republic of China

The influence of recently discovered topological transition between type I and type II Weyl semi-metals on superconductivity is considered. A set of Gorkov equations for week superconductivity in Weyl semi-metal under topological phase transition is derived and solved. The critical temperature and superconducting gap both have spike in the point the transition point as function of the tilt parameter of the Dirac cone determined in turn by the material parameters like pressure. The spectrum of superconducting quasi-particles is different in two phases: the sharp cone pinnacle is characteristic for a type I, while two parallel almost flat bands, are formed in type II. Spectral density is calculated on both sides of transition demonstrate different weight of the bands. The superconductivity thus can be used as a clear indicator for the topological transformation. Results are discussed in the light of recent experiments.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.312

Quantum phase transitions in heavily hydrogen-doped LaFeAsO under pressure

Fujiwara N.[1]*, Kawaguchi N.*[1]*, Iimura S.*[2,3]*, Matsuishi S.*[2,3]*, Hosono H.*[2,3]

[1]Graduate School of Human & Environmental Studies, Kyoto University, Kyoto, Japan, [2]Material and Structures Laboratory (MSL), Tokyo Institute of Technology, Yokohama, Japan, [3]Frontier Research Center (FRC), Tokyo Institute of Technology, Yokohama, Japan

A prototypical iron-based pnictide $LaFeAsO_{1-x}H_x$ experiences an antiferromagnetic (AF) phase, a superconducting (SC) phase with double domes, and another AF phase upon H doping [1]. The double domes transform to a single dome with an optimal T_c of 48 K at 3.0 GPa [2, 3]; T_c goes up to 48 K without the influence of low-energy AF fluctuations [3] as well as the case of $LaFeAsO_{1-x}F_x$ (x=0.14) [4].

To investigate how the SC and second AF phases evolve by tuning pressure and the doping level, we performed NMR measurements at 3.0 GPa in a heavily H-doped regime (x~0.5-0.6).

The second AF phase, which is adjacent to the SC phase at ambient pressure [5], is very much suppressed at 3.0 GPa, and two phases are well separated in the phase diagram. The quantum critical point (QCP) emerges in-between two phases and Curie-Weiss behavior covers a paramagnetic region around the QCP. Contrary to the AF phase, the SC phase is almost unchanged except for the expansion to the AF-phase boundary. The expansion is limmited to a narrow doping range. The behavior is anomalous on the basis of AF-fluctuations mediated superconductivity.

In the conference, we will discuss possible superconducting mechanisms with s^{++}- or S^{+-}-wave symmetry in relation to low-energy AF fluctuations.

References:

[1]N. Fujiwara, *et al*., Phys. Rev. Lett. **111**, 097002 (2013)
[2]S. Iimura, *et al*., Nature Commun. **3**, 943 (2012)
[3]N. Kawaguchi, *et al*., Phys. Rev. B **94**, 161104(R) (2016)
[4]T. Nakano, *et al*., Phys. Rev. B **81**, 100510(R) (2010)
[5]R.Sakurai, et al., Phys. Rev. B **91**, 064509 (2015)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

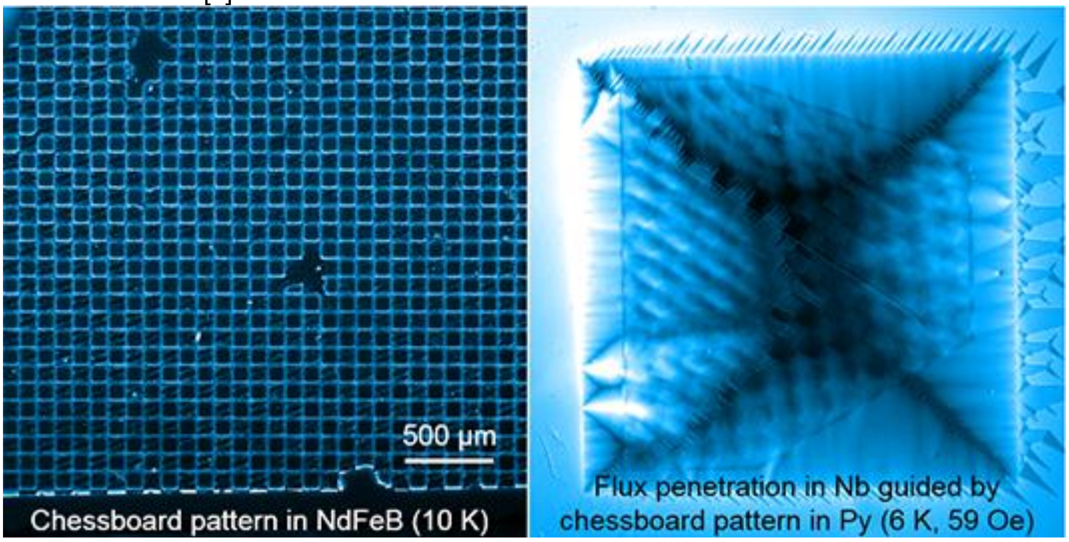
P.313

A novel approach towards manipulation of vortex matter in a superconductor with micromagnetic structures

Shaw G.[1]*, Brisbois J.*[1]*, Pinheiro L.B.G.L.*[2]*, Devillers T.*[3,4]*, Dempsey N.M.*[3,4]*, Motta M.*[2]*, Ortiz W.A.*[2]*, Hasselbach K.*[3,4]*, Kramer R.B.G.*[3,4]*, Silhanek A.V.*[1]

[1]Université de Liège, Experimental Physics of Nanostructured Materials, Q-MAT, CESAM, Liège (Sart-Tilman), Belgium, [2]Universidade Federal de São Carlos, Departamento de Física, São Carlos, Brazil, [3]Université Grenoble Alpes, Institut Néel, Grenoble, France, [4]CNRS, Institut Néel, Grenoble, France

Hard permanent magnetic materials offer a number of advantages over softer magnetic materials as sources of vortex pinning in a superconductor, like greater stability and larger magnetic field amplitudes. Permanent micromagnet structures prepared using thermomagnetic patterning (TMP) [1] present an interesting and so far unexplored option for controlled artificial pinning.
We have investigated the vortex matter in superconductor/TMP micromagnet heterostructures (Nb-NdFeB) using quantitative Magneto-Optical Imaging (MOI). Comprehensive protocols have been developed for calibrating and converting Faraday rotation data acquired by MOI to magnetic field maps. These protocols reveal the comparatively weaker magnetic response of the superconductor from the background of larger fields associated with the magnetic layer in its vicinity. Further, TMP micromagnet structures have been imprinted in a Permalloy (Py) layer [2] to obtain flexible magnetic landscapes for flux guidance in a Nb layer below it. Both smooth flux penetration and vortex avalanches in Nb are observed to be strongly influenced by the micromagnetic patterns. Our study offers new insights into the peculiarities of the vortex state in these superconductor-micromagnet heterostructures [3].



[MO Images]

References:

[1] F. Dumas-Bouchiat et al, Appl. Phys. Lett. **96**, 102511 (2010).
[2] J. Brisbois et al, Sci. Rep. **6**, 27159 (2016).
[3] G. Shaw et al, unpublished.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

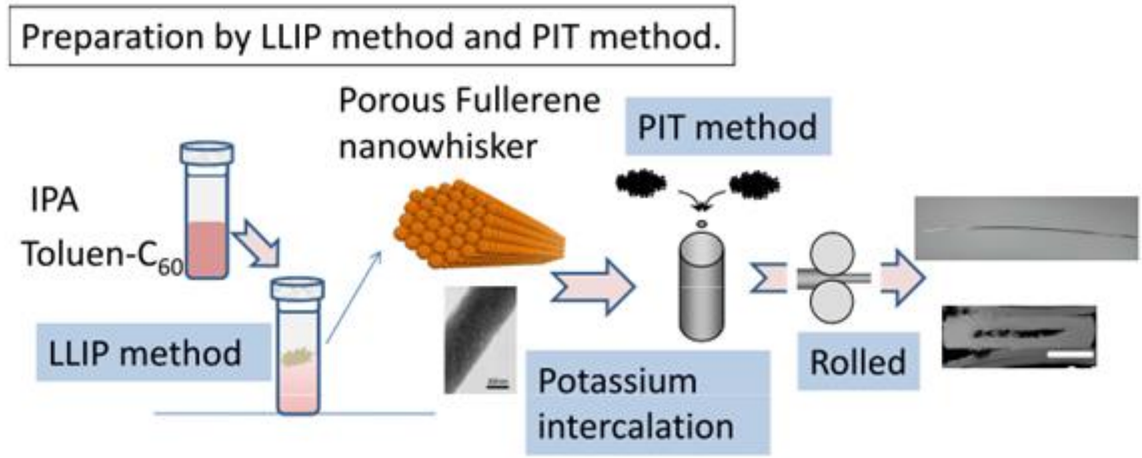
P.314

Fullerene-based superconducting fibers and wires

<u>*Takeya H.*</u>*[1], Tanaka M.[1], Konnno T.[1], Wakahara T.[1], Hirata C.[1], Yamaguchi T.[1], Miyazawa K.[2], Takano Y.[1]*
[1]National Institute for Materials Science (NIMS), MANA, Tsukuba, Japan, [2]Tokyo University of Science, Tokyo, Japan

Superconductivity of alkali-metal(A)-doped fullerenes was found in 1991. A-doped fullerides A_xC_{60} [0< x< 6] are particularly interesting since their structures and electronic properties are strongly related to the doping carrier concentration. The compound, A_3C_{60}, shows superconducting transition at 19K

(A=K), 29K (A=Rb) or 33K (A=Cs_2Rb). Various types of fullerene-based supramolecular materials have been developed by Miyazawa et al. using a liquid-liquid-interfacial-precipitation (LLIP) technique[1], so far, such as nanowhiskers (C_{60}NWs), nanosheets, nanowires, and nanotubes. If such a form of C_{60}NWs turns out to be a superconductor, it will be a promising material for superconductive fibers or wires. We have tried to dope alkali metals (K, Rb, Cs_2Rb) into the C_{60}NWs for future application to superconducting light fibers. The superconductivity was observed at 17 K in the K-doped C_{60}NWs heated at 200^{o}C and their superconducting volume fraction reached 80 % in 24 hours. The critical current density (J_c) of K_3C_{60}NWs is estimated over 10^5A/cm^2 up to 5 T using the Bean model in *M-H* curves[2]. The superconducting wires were prepared using LLIP and the wires using metal sheath were done by PIT (powder in tube) methods as shown in the following figure. We will show their properties.



[Fig1]

References:
[1] K. Miyazawa et al.., J. Mater. Res. 17(2002) 83.
[2] H. Takeya et al., Mat. Res. Bull. 48(2013) 343.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.317

Granulation in Bose-Einstein condensates as manifestation of quantum fluctuations

Tsatsos M.C.
University of Sao Paulo, Sao Carlos, Brazil

Quantum fluctuations are inherent to any microscopic system and manifest the very probabilistic nature of quantum matter. In Bose-Einstein condensates (BECs) however, where typically 10^4 atoms are trapped, fluctuations are washed out due to the large particle number together with long-range coherence and, hence, lack of quantum correlations. Hence conventional mean-field theories are considered apt for the description of dynamics of BECs. Nevertheless, the recently seen granulated states in elongated condensates of lithium-7 atoms cannot be explained via mean-field; one arrives at the emergence and proliferation of grains only through a many-body description, that takes correlations and fragmentation into account. Here the main characteristics of the observed granulated states are presented as well as results that go beyond the Gross-Pitaevskii theory, obtained by solving the MCTDHB equations. While the density alone shows no traces of granulation, an accurate

simulation of single shots indeed shows grains, i.e. spatially separated regions of atoms. Therefore, granulation consists a case study where higher-order correlations of zero-temperature gases are paramount and the accurate description of the experiment cannot rely on GP or other mean-field theories.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.320

Application of metamaterial nano-engineering for increasing the superconducting critical temperature

Osofsky M.[1], *Smolyaninova V.*[2], *Zander K.*[2], *Gresock T.*[2], *Saha S.*[2], *Yost B.*[2], *Jensen C.*[2], *Prestigiacomo J.*[1], *Kim H.*[1], *Bassim N.*[3], *Greene R.*[4], *Smolyaninov I.*[5]
[1]Naval Research Laboratory, Materials Science and Technology Division, Washington, United States, [2]Towson University, Department of Physics Astronomy and Geosciences, Towson, United States, [3]McMaster University, Materials Science and Engineering Department, Hamilton, Canada, [4]University of Maryland, Department of Physics, Center for Nanophysics and Advanced Materials, College Park, United States, [5]University of Maryland, Department of Electrical and Computer Engineering, College Park, United States

We have demonstrated that the metamaterial approach to dielectric response engineering increases the critical temperature of a composite superconductor-dielectric system in the epsilon near zero (ENZ) and hyperbolic regimes. To create such metamaterial superconductors three approaches were implemented. In the first approach, mixtures of tin and barium titanate nanoparticles of varying composition were used [1]. An increase of the critical temperature of the order of 5% compared to bulk tin has been observed for a 40% volume fraction of barium titanate nanoparticles. Similar results were also obtained with compressed mixtures of tin and strontium titanate nanoparticles. In the second approach, we demonstrate the use of Al_2O_3-coated aluminium nanoparticles to form an ENZ core-shell metamaterial superconductor with a T_c that is three times that of pure aluminium [2]. In the third approach, we demonstrate a similar T_c enhancement in thin Al/Al_2O_3 heterostructures that form a hyperbolic metamaterial superconductor [3]. IR reflectivity measurements confirm the predicted metamaterial modification of the dielectric. These results open up numerous new possibilities of considerable Tc increase in other superconductors. This work was supported in part by NSF grant DMR-1104676.

References:

[1] V. N. Smolyaninova, B. Yost, K. Zander, M. S. Osofsky, H. Kim, S. Saha, R. L.Greene, and I. I. Smolyaninov, Scientific Reports 4, 7321 (2014).
[2] V. N. Smolyaninova, K. Zander, T. Gresock, C. Jensen, J. C. Prestigiacomo, M. S. Osofsky, and I. I. Smolyaninov, *Sci. Rep.* **5**, 15777 (2015).
[3] V. N. Smolyaninova, C. Jensen, W. Zimmerman, J. C. Prestigiacomo, M. S. Osofsky, H. Kim, N. Bassim, Z. Xing, M. M. Qazilbash, I. I. Smolyaninov' *Sci. Rep.* **6**, 34140 (2016).

Postersession 1
Thursday, 10 August 2017
16.30-18.30

G Foyer

P.321
Magnetoresistance of single-electron transistors comprising a superconducting island with ferromagnetic leads
Mizugaki Y., Takiguchi M., Tamura N., Shimada H.
University of Electro-Communications, Department of Engineering Science, Chofu, Japan

We report electric and magnetic field responses of single-electron transistors (SETs) comprising ferromagnetic lead electrodes with a superconducting island.
We fabricated two SETs, one of which had relatively high resistance and the other had relatively low resistance. Measurements were executed at approximately 0.1 K in a compact dilution refrigerator. The SETs had two states for the gate charge: SET-ON or SET-OFF. It also had two states for the FM lead magnetization: parallel (P) or anti-parallel (AP) configuration. I-V characteristics of four SET states ("P & SET-ON," "P & SET-OFF," "AP & SET-ON," and "AP & SET-OFF") were measured for both SETs. Magnetoresistance ratios (MRR) were then obtained for the SET-ON and SET-OFF states. The high-resistance SET1 exhibited positive MRR values for all bias voltages. The enhancement of MRR was confirmed for the SET-OFF state, which agreed well with the co-tunneling model. The low-resistance SET2 exhibited negative and positive MRR values for high and low bias voltage conditions, respectively. The bias voltages for the polarity switching were changed by the gate charge.

References:
[1] K. Ono, H. Shimada, and Y. Ootuka, J. Phys. Soc. Jpn. **87**, 606 (1999).
[2] H. Yang, et. al, Nature Mat. **9**, 586 (2010).
[3] S. Takahashi, H. Imamura, and S. Maekawa, Phys. Rev. Lett. **82**, 6237 (1999).
[4] M. Takiguchi, T. Sato, H. Shimada, and Y. Mizugaki, JPS Conf. Proc. **1**, 012004 (2014).
[5] M. Takiguchi, H. Shimada, and Y. Mizugaki, Jpn. J. Appl. Phys. **53**, 043101 (2014).
[6] Y. Mizugaki, N. Tamura, and H. Shimada, J. Appl. Phys. **113**, 156101 (2013).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.322
GeTe-based additions to MgB_2
Batalu D.[1], Bane M.[1], Bunescu A.[1], Svoboda R.[2], Aldica G.[3], Burdusel M.[3], Popa S.[3], Enculescu M.[3], Mihalache V.[3], Badica P.[3]
[1]University Politehnica of Bucharest, Metallic Materials Science, Physical Metallurgy, Bucharest, Romania, [2]University of Pardubice, Department of Physical Chemistry, Pardubice, Czech Republic, [3]National Institute of Materials Physics, Magurele, Romania

Searching for new additions to improve the superconducting properties of MgB_2, and for a better understanding of the vortex pinning mechanism are of great practical interest. Additives such as Te and Ge were tested and reported in literature. Te improves density, does not affect the critical temperature (T_c) and marginally improves critical current density (J_c) of MgB_2 obtained by *in-situ* route [1, 2]. In ref. [3] was shown that Te addition to MgB_2, obtained by *ex-situ* Spark Plasma Sintered (SPS) technique, lead to significant enhancement of J_c and of the irreversibility magnetic field (H_{irr}). For samples obtained by the same technology, Ge addition [4] was also shown to promote a higher J_c. The improvement was explained based on formation of MgTe and Mg_2Ge nanophases. Formation of the secondary phases due to the reaction between the additive and MgB_2 decreases the MgB_2 grain size and, hence, increases the density of grain boundaries considered pinning centers in MgB_2.

In our work, we prepared by *ex-situ* SPS samples of MgB_2 added with crystalline GeTe and amorphous Ge20Te80. Structural, microstructural and superconducting properties were measured. Results are presented and discussed.

References:

[1] J.H. Ahn, J. Park, *Phys. C* **471**, 721-724 (2011)

[2] J.C. Grivel, N.H. Andersen, P.G.A.P. Pallewatta, Y. Zhao, M. von Zimmermann, *Supercond. Sci. Technol*. **25**, 015010 (2012)

[3] G. Aldica, S. Popa, M. Enculescu, P. Badica, *Scripta Mater.* **66**, 570-573 (2012)

[4] D. Batalu, G. Aldica, M. Burdusel, S. Popa, M. Enculescu, I. Pasuk, D. Miu, P. Badica, J. Supercond. Nov. Mag. **28**, 531-534 (2015)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.323

Development of birefringence imaging techniques under high electric fields

Manaka H.[1], *Nozaki H.*[1], *Miura Y.*[2]

[1]Kagoshima University, Graduate School of Science and Engineering, Kagoshima, Japan, [2]National Institute of Technology, Suzuka College, Suzuka, Japan

Optical birefringence imaging systems demonstrate a high potential for comprehensively investigating various phase transitions[1, 2]. In this study, we developed birefringence imaging techniques under high electric fields and low temperatures. To demonstrate such abilities, the temperature dependence of the birefringence was measured under high electric fields in quantum paraelectric material $SrTiO_3$. In zero electric field, the retardation gradually increases below 105 K because the second order structural phase transition occurs from cubic to tetragonal[1]. On the other hand, the electric field was applied to be 5.2 kV/cm at 300 K, and then temperature decreased from 300 K to 20 K. As a result, the retardation begins to increase at 105 K and the domains having large retardation appeared below 50 K. Because the values of retardation under high electric fields become larger than those in $SrTi(^{16}O_{1-x}{}^{18}O_x)_3$
(ferroelectric state)[3], we found the electric field-induced ferroelectric domains below 50 K.

References:

[1] H. Manaka, G. Yagi, and Y. Miura, Rev. Sci. Instrum. **87**, 073704 (2016).

[2] H. Manaka, T. Fukuda, and Y. Miura, J. Phys. Soc. Jpn. **85**, 124701 (2016).

[3] K. Yamanaka, R. Wang, M. Itoh, and K. Iio, J. Phys. Soc. Jpn. **70**, 3213 (2001).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.324

Recombination of radiation defects in solid methane: neutron sources and cryo-volcanism on celestial bodies

Kirichek O.[1], *Savchenko E.*[2], *Lawson C.*[1], *Khyzhniy I.*[2], *Jenkins D.*[1], *Uyutnov S.*[2], *Bludov M.*[2], *Haynes D.*[1]

[1]ISIS Neutron and Muon Source, Science and Technology Facilities Council, Didcot, United Kingdom, [2]Institute for Low Temperature Physics & Engineering, NASU, Kharkiv, Ukraine

Dramatic change in mechanical properties of solid methane at 60K has attracted significant interest in recent years [1]. Not long ago it was suggested that this change is caused by quantum effects of rotational degrees of freedom and their collectivization [2]. We present our experimental results which demonstrate the change in thermo-mechanical properties of solid methane in temperature range from 10 K to 90 K, particularly focusing on radiation defects recombination in this temperature range. We also discuss the role of the recombination mechanism in “burp” phenomenon discovered by John Carpenter in late 1980s [3]. An understanding of this mechanism is vital for the designing of solid methane moderators used in advanced neutron sources (such as European Spallation Source in Sweden or ISIS pulsed spallation source in UK) and for explaining driving forces behind cryo-volcanism on celestial bodies like Pluto or comets.

References:

1. O. Kirichek, A.J. Church, M.G. Thomas, D. Cowdery, S.D. Higgins, M.P. Dudman, Z.A. Bowden *Cryogenics* **52**, 325 (2012)
2. A.Yu. Zakharov, A.V. Leont'eva, A.Yu. Prokhorov, A.I. Erenburg *J. of Low Temp. Phys.* **187**, 1/2 (2017)
3. J. M. Carpenter *Nature* **330**, 358 (1987)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.325

Emergent phenomena in the magnetic-superconducting hybrid system Fe on Re(0001) analyzed by STM/S measurements

<u>Palacio Morales A.</u>, Kim H., Wiesendanger R.
Hamburg University, Dept. of Physics, Hamburg, Germany

Superconductivity and magnetism have been seen as antagonist until recent progress shows that their coupling leads to new phenomena. Specially, Majorana Fermions (MF) have attracted widespread interest for their promising potential for future applications in topological quantum computation. Advances in nano-fabrication techniques combined with local probe microscopies have paved the way to build up such hybrid systems (HybS) and to analyse them at the nanoscale.
Recently, results on ferromagnetic chains [1] and nanoislands [2] on superconductors (SC) revealing YSR bands were reported. These YSR bands are the precursors to observe MF modes at the edge of these HybS at low dimensionality. However, the observation of these MF modes is still under debate and has raised questions about experimental considerations that must be accounted. Lack of well-defined structures, MF spatial distribution and evolution inside the HybS are among the reasons of these concerns. Hence, other combinations of SC and magnetic systems with well-defined structures should be investigated in order to deeply understand their physics.
Here, we present emergent phenomena appearing on the non-collinear magnetic spin textures of the Fe monolayer on Re(0001) [3] in the superconducting regime analyzed by SP-STM/S.

References:

[1] S. Nadj-Perge et al., Science **346**, 602 (2014)
[2] G. C. Ménard et al., arXiv. 1607.06353 (2016)
[3] A. Palacio Morales et al., Nano Lett. **16**, 6252-6256 (2016)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.327
Manipulating the electronic structure and magnetism of spin-orbit Mott insulator by tailoring superlattices
Liu Z., *Shen D.*
Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, Shanghai, China

In this talk, we will introduce how to fabricate and study the artificial 5d iridate superlattices by the combo of oxide molecular beam epitaxy (OMBE), in situ angle-resolved photoemission spectroscopy (ARPES) and X-ray magnetic circular dichroism (XMCD) techniques. We successfully fabricated a series of high-quality $[(SrIrO_3)_m/(SrTiO_3)]_n/SrTiO_3(100)$ superlattices using the state-of-the-art layer-by-layer OMBE growth method, and consequently realized the emergent interfacial magnetism and metal-insulator transition (MIT) by artificial dimensionality control of iridates. The mechanism of this MIT and the elemental specificity of magnetism were then investigated by the in-situ ARPES system and the XMCD, respectively. Our results could provide a comprehensive understanding of the phase transition in this spin-orbit Mott insulator.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.328
Incommensurate spiral magnetic order in the Hubbard model on anisotropic triangular lattice
Goto S.[1], *Kurihara S.*[2], *Yamamoto D.*[3]
[1]Yukawa Institute for Theoretical Physics, Kyoto University, Kyoto, Japan, [2]Waseda University, Department of Physics, Tokyo, Japan, [3]Aoyama Gakuin University, Department of Physics and Mathematics, Kanagawa, Japan

We study the magnetism of the half-filled Hubbard model on the anisotropic triangular lattice at zero temperature. We assume that one bond in a unit triangle has a different hopping integral (t') from the others (t). The previous analyses of this system in the strong coupling limit have shown that spin spiral states whose periodicity is incommensurate to that of the lattice are stabilized besides the commensurate Néel ($t' << t$) and 120º ($t'=t$) states [1,2]. However, for finite values of the on-site interaction U, few studies have properly dealt with the incommensurability of the spiral states since most numerical analyses have been performed in a finite system or with cluster tiling in real space [3,4]. In this work, we employ the dynamical mean-field theory with a technique of local spin-axis rotation to represent incommensurate magnetic orders. With this method, we determine the magnetic phase diagram including incommensurate orders as a function of the on-site interaction U and the hopping t'/t. For finite but strong U, we find three magnetic insulating phases: the Néel state for small t'/t, the 120º state at $t'=t$, and the incommensurate spiral state for any other t'/t region. We also discuss insulator-to-metal transitions of these states when decreasing the interaction U.
References:

[1] J. Merino, R. H. McKenzie, J. B. Marston, and C. H. Chung, J. Phys.: Condens. Matter 11, 2965 (1999)
[2] R. F. Bishop, P. H. Y. Li, D. J. J. Farnell, and C. E. Campbell, Phys. Rev. B 79, 174405 (2009)
[3] L. F. Tocchio, H. Feldner, F. Becca, R. Valentí, and C. Gros, Phys. Rev. B 87, 035143 (2013)
[4] M. Laubach, R. Thomale, C. Platt, W. Hanke, and G. Li, Phys. Rev. B 91, 245125 (2015)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.329
Time-dependent charge transport in interacting mesoscopic systems with Time-Dependent Density-Functional Theory

Dittmann N.[1,2], *Helbig N.*[3]
[1]RWTH Aachen University, Institute for Theory of Statistical Physics, Aachen, Germany, [2]Chalmers University of Technology, Department of Microtechnology and Nanoscience MC2, Gothenburg, Sweden, [3]Research Center Juelich, Peter Gruenberg Institute 1, Juelich, Germany

We push forward density-functional calculations of time-resolved charge transport in mesoscopic solid-state structures. Our approach combines a real-time perturbative method with Time-Dependent Density Functional Theory (TDDFT) beyond linear response. In TDDFT, a central challenge is the approximation of the Hartree-Exchange-Correlation (Hxc) potential. Commonly applied approximations are almost only adiabatic functionals of the charge density and thereby local in time. Our new analytic approach, however, provides access to non-adiabatic properties of the Hxc potential in a quantum-transport setup. We present a new non-adiabatic Hxc-potential and apply it to study charge pumping in quantum dots with strong on-site interaction and applied time-dependent gate-voltage driving. Beyond the adiabatic driving regime, we find a dynamically shifted derivative discontinuity in the Hxc-potential as a central non-adiabatic feature and we show how the magnitude of this shift is related to the time scale of charge relaxation. In general, our study advances TDDFT simulations of real-time charge transport in time-dependently driven mesoscopic systems.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.330
Flux-tunable dissipation for superconducting quantum circuits

Partanen M.[1], *Tan K.Y.*[1], *Masuda S.*[1], *Govenius J.*[1], *Lake R.E.*[1], *Grönberg L.*[2], *Hassel J.*[2], *Simbierowicz S.*[2], *Vesterinen V.*[1,2], *Tuorila J.*[1,3], *Ala-Nissilä T.*[1,4], *Möttönen M.*[1]
[1]Aalto University, Department of Applied Physics, Espoo, Finland, [2]VTT Technical Research Centre of Finland, Espoo, Finland, [3]University of Oulu, Theoretical Physics Research Unit, Oulu, Finland, [4]Brown University, Department of Physics, Providence, United States

Circuit quantum electrodynamics (cQED) is one of the most promising approaches for building a large-scale quantum computer [1-3]. However, further development steps are needed to obtain this goal. Especially, fast initialization of qubits is beneficial for various error correction codes. In the framework

of cQED, we experimentally investigate a tunable environment for a qubit utilizing a normal-metal resistor. Our system can be used for qubit initialization as theoretically studied in Ref. [4]. Here, we demonstrate tuning of the loaded quality factor of the system from above 10^5 down to a few thousand. Essentially, our system consists of two coupled resonators: one with a high quality factor, and the other with a low quality factor and a tunable resonance frequency achieved with a superconducting quantum interference device. An on-chip resistor determines the low quality factor. Potentially, the tunability can be further increased by optimizing the design and fabrication.

References:

[1] A. Blais, R.-S. Huang, A. Wallraff, S. M. Girvin, and R. J. Schoelkopf, Phys. Rev. A 69, 062320 (2004).
[2] T. D. Ladd, F. Jelezko, R. Laflamme, Y. Nakamura, C. Monroe, and J. L. O'Brien. Nature 464, 45 (2010).
[3] M. H. Devoret, and R. J. Schoelkopf, Science 339, 1169 (2013).
[4] J. Tuorila, M. Partanen, T. Ala-Nissilä, and M. Möttönen, arXiv:1612.04160 (2016).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.332

Observation of ferroelastic domains in layered magnetic compounds using birefringence imaging system

Miura Y.[1], *Okumura K.*[2], *Fukuda T.*[2], *Manaka H.*[2]
[1]National Institute of Technology, Suzuka College, Suzuka, Mie, Japan, [2]Kagoshima University, Kagoshima, Japan

Birefringence imaging microscopy is well suited for comprehensively investigating various structural and magnetic phase transitions[1,2]. In ferroelastic systems, the temperature dependence of birefringence is directly proportional to the order parameter.
The layered magnetic compounds $(C_nH_{2n+1}NH_3)_2CuCl_4$ with n = 1 and 2 are known as representative two-dimensional Heisenberg magnets[3]. Each compound basically consist of $CuCl_4$ layers, well separated from one another by a bilayer of $C_nH_{2n+1}NH_3$. In these compounds, the intralayer exchange interaction is ferromagnetic because of the antiferrodistortive arrangement of the Jahn-Teller distorted $CuCl_6$ octahedra. However the growth of ferroelastic domains in the layer is difficult to evaluate the magnetic anisotropy. In the present study, to confirm the ferroelastic domains, the birefringence imaging measurements were performed on these compounds. As a result, we found that the 90 deg. domains appeared at 300 K, and switched at low temperature region although no structural phase transition occurs. These results are useful to understanding the structural properties of the ferroelastic systems.

References:

[1] H. Manaka, G. Yagi, and Y. Miura, Rev. Sci. Instrum. **87**, 073704 (2016).
[2] H. Manaka, T. Fukuda, and Y. Miura, J. Phys. Soc. Jpn. **85**, 124701 (2016).
[3] L. J. de Jongh: Physica **82B**, 247 (1976).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.333

Evaluation of temperature-rise due to Joule heating in NiCrAl-DAC in pulsed high magnetic fields

Tahara T.[1], *Kida T.*[1], *Kohama Y.*[2], *Miyake A.*[2], *Tokunaga M.*[2], *Kindo K.*[2], *Hagiwara M.*[1]
[1]Osaka University, Center for Advanced High Magnetic Field Science, Grad. Sch. of Sci., Toyonaka, Japan, [2]Univ. of Tokyo, Institute for Solid State Physics, Kashiwa, Japan

We have developed an apparatus for electrical conductivity measurements under high pressure and high magnetic fields using a Diamond anvil cell (DAC) made of NiCrAl alloy and a nondestructive pulse magnet [1]. Recently, we developed a small DAC (18 * 18 * 30 mm^3) to suppress Joule heating caused by eddy current in the metal part of DAC in pulsed magnetic fields. We utilized a RuO_2 thermometer to evaluate the temperature during field duration (~ 40 msec) at various places of the DAC. At temperatures below 4.2 K (immersed in liquid Helium), the measured temperatures did not change much even in pulsed high magnetic fields of up to 40 T. We demonstrate the current status of development of the present apparatus.

References:

[1] M. Hagiwara *et al*., J. Low Temp. Phys. **170**, 531 (2013).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.334

Andreev reflection in a proximity junction of graphene: influence of a naturally formed *pn* junction

Takane Y.[1], *Kanda A.*[2]
[1]Hiroshima University, Higashi-Hiroshima, Japan, [2]University of Tsukuba, Tsukuba, Japan

A normal conductor-superconductor (NS) junction of graphene can be made by partially covering a graphene sheet with a bulk superconductor [1,2]. In such a graphene junction, the charge neutrality point (CNP) shifts near the NS interface as a result of the penetration of carriers from a deposited superconductor. We theoretically study the electron transport in the proximity junctions of monolayer and bilayer graphene. Owing to the spatial variation of the CNP, a *pn* junction is naturally formed near the NS interface. It is shown that this *pn* junction induces quasi-bound states near the NS interface, which resonantly enhance the probability of Andreev reflection and hence give rise to resonant peaks in the differential conductance.

References:

[1] H. B. Heersche, P. Jarillo-Herrero, J. B. Oostinga, L. M. K. Vandersypen, and A. F. Morpurgo, Nature 446, 56 (2007).
[2] F. Miao, S. Wijeratne, Y. Zhang, U. C. Coskun, W. Bao, and C. N. Lau, Science 317, 1530 (2007).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.335

Thermoelectric Kondo effect in quantum dots beyond linear response

Sierra M.A., *Lopez R.*, *Sanchez D.*
Instituto de Física Interdisciplinar y Sistemas Complejos (UIB-CSIC), Palma de Mallorca, Spain

At low temperatures, a quantum dot acting as an artificial quantum impurity develops a many-body singlet with strongly coupled electronic reservoirs. This is the celebrated Kondo effect, which manifests itself as a sharp peak in the differential conductance when temperature falls below the characteristic Kondo temperature of the system. Here [1] we consider the influence of a thermal gradient applied across the leads on the Kondo physics of a quantum dot. This is genuinely a nonequilibrium problem that leads to thermoelectric effects. Based on perturbation theory and a slave-boson mean-field approach, we find that the Kondo effect becomes quenched as the thermal bias increases. Interestingly, the quench is monotonic unlike a dc voltage shift, which causes a splitting of the Kondo resonance. Furthermore, we apply the equation-of-motion method to evaluate the dot nonequilibrium Keldysh Green's function for finite charging energies. This allows us to determine the thermocurrent for a wide range of energies. Importantly, the thermocurrent vanishes at finite values of the thermal gradient due to asymmetric DOS peaks (Kondo and single-particle resonances). Our results are thus relevant for a deep understanding of strong electron-electron correlations in thermally driven nanostructures.

References:

[1] Miguel A. Sierra, Rosa Lopez and David Sanchez, arXiv:1702.07550 (2017).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.336

Dielectric anomaly and magnetoelectric effect in the charge-ordered manganite $Ca_{1-x}Sr_xMn_{0.85}Sb_{0.15}O_3$

<u>Taniguchi H.</u>[1], Takahashi H.[1], Terui A.[1], Kobayashi S.[1], Matsukawa M.[1], Suryanarayanan R.[2]
[1]Iwate University, Morioka, Japan, [2]Université Paris-Sud, Orsay, France

Multiferroics is a big research topic because it includes interesting physics and is expected to be applied to various devices. Recently, a new origin of multiferroicity was theoretically proposed [1]: the mixed state of bond-centered (BC) charge order (CO) and site-centered (SC) CO exhibits macroscopic electric polarization, and the polarization is expected to couple with the double exchange interaction which acts in dimers formed by BC CO. Experimentally, signs of multiferroicity are reported in hole-doped CO systems [2]. In this study, in order to shed light on electron-doped system as a new candidate for CO-originated multiferroics, we measured dielectric constant of polycrystalline $Ca_{1-x}Sr_xMn_{0.85}Sb_{0.15}O_3$ in magnetic field.
We have revealed that the dielectric constant exhibits a broad peak, which suggests ferroelectricity. Importantly, the peak temperature coincides with the CO transition temperature. Moreover, we have revealed that the dielectric constant is suppressed by magnetic field. These tendencies, which were commonly observed among all the CO samples studied here, indicate that the mixed CO state (BC and SC) is realized in this system and induces electric polarization, which is stabilized by magnetic field.

References:

[1] D. V. Efremov et al., Nature Materials **3**, 853 (2004); D. V. Efremov et al., Physica B **359**, 1433 (2005); J. Brink and D. I. Khomskii, J. Phys.: Condens. Matter **20**, 434217 (2008).
[2] C. R. Serrao et al., J. Phys.: Condens. Matter **19**, 496217 (2007); J. R. Sahu *et al*., Solid State Commun. **149**, 4951 (2009).

Postersession 1
Thursday, 10 August 2017

16.30-18.30
G Foyer

P.338
NMR study of the layered cobalt oxyphosphide $Sr_2Sc(Co_{1-x}Fe_x)PO_3$
Magishi K.-I.[1], *Watanabe R.*[1], *Hisada A.*[1], *Saito T.*[1], *Koyama K.*[1], *Okada S.*[2], *Kamihara Y.*[3], *Ohkubo N.*[2], *Ban S.*[2], *Matoba M.*[3]
[1]Tokushima University, Tokushima, Japan, [2]Nihon University, Funabashi, Japan, [3]Keio University, Yokohama, Japan

Since the discovery of iron-based superconductior LaFeAs(O,F), many researchers focus on physical properties on oxypnictides. Recently, we have successfully synthesized and evaluated the transport properties of a novel cobalt oxypnictide $Sr_2ScCoPO_3$ [1,2], which has the same structure as iron-based superconductor $Sr_2ScFePO_3$ with T_c = 17 K [3]. The resistivity of $Sr_2ScCoPO_3$ decreases on cooling like a metal, and the resistivity of $Sr_2Sc(Co_{0.5}Fe_{0.5})PO_3$ is larger than that of $Sr_2ScCoPO_3$. In the presentation, we will report on the ^{31}P-NMR results of $Sr_2Sc(Co_{1-x}Fe_x)PO_3$, and discuss the microscopic electronic states. It is quite helpful to make use of the NMR method for a study of local electronic properties. The ^{31}P-NMR spectrum shows a typical powder pattern with the axial Knight shift component. The component parallel to the principal axis shifts markedly on cooling, and the spectrum becomes broader at low temperatures. Also, the nuclear spin-lattice relaxation rate $1/T_1$ is almost proportional to the temperature at low temperatures. The value of $1/T_1T$ decreases with increasing the Fe content, which suggests the decrease of the density of states around the Fermi level. More detailed experiments are now in progress and their results and analyses will be presented at the conference.
References:
[1] S. Okada *et al*., J. Phys.: Conf. Ser. **400**, 022091 (2012).
[2] S. Okada *et al*., J. Phys.: Conf. Ser. **568**, 022034 (2014).
[3] H. Ogino *et al*., Supercond. Sci. Technol. **22**, 075008 (2009).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.339
Magnetic properties of the antiferromagnetic spin-1/2 tetramer compound $CuInVO_5$
Hase M.[1], *Matsumoto M.*[2], *Matsuo A.*[3], *Kindo K.*[3]
[1]National Institute for Materials Science (NIMS), Tsukuba, Japan, [2]Shizuoka University, Shizuoka, Japan, [3]University of Tokyo, Institute for Solid State Physics (ISSP), Kashiwa, Japan

We measured the temperature dependence of the magnetic susceptibility and specific heat and the magnetic-field dependence of the magnetization of $CuInVO_5$ [1]. An antiferromagnetically ordered state appears below T_N = 2.7 K [2]. We observed a 1/2 quantum magnetization plateau above 30 T at 1.3 K. An isolated antiferromagnetic spin-1/2 tetramer model with J_1 = 240 and J_2 = -142 K can closely reproduce the magnetic susceptibility above 30 K. We were able to explain the magnetization curves using the interacting spin tetramer model with the effective intertetramer interaction J_{eff} = 30 K. We consider that the probable spin model for $CuInVO_5$ is an interacting spin-1/2 tetramer model. The value of the spin gap (singlet-triplet gap) is 17 K (1.5 meV) in the isolated spin tetramer. Detectable low-energy (on the order of 1 meV) longitudinal-mode magnetic excitations may exist in $CuInVO_5$ [3].
References:
[1] P. Moser, V. Cirpus, and W. Jung, Z. Anorg. Allg. Chem. **625**, 714 (1999).
[2] M. Hase et al., Phys. Rev. B **94**, 174421 (2016).

[3] M. Matsumoto et al., J. Phys. Soc. Jpn. **79**, 084703 (2010).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.341
Co-addition of Te and Ho_2O_3 to MgB_2 superconductor

<u>Badica P.</u>[1], Aldica G.[1], Burdusel M.[1], Grigoroscuta M.A.[1], Ionescu A.M.[1], Sandu V.[1], Enculescu M.[1], Batalu D.[2], Popa S.[1], Mihalache V.[1]
[1]National Institute of Materials Physics, Magurele, Romania, [2]University Politehnica of Bucharest, Bucharest, Romania

Pinning engineering in MgB_2 superconductor is of much interest. Different additives and technological approaches have been used to fabricate MgB_2 with effective pinning centers and a higher critical current density, J_c.
We fabricate high density MgB_2 samples by using Spark Plasma Sintering (SPS). We have shown that introduction of nano Ho_2O_3 increases J_c at low and intermediate magnetic fields [1]. We also found that Te addition promotes enhancement of J_c at high magnetic fields [2]. The next step would be to use both additions in a pinning-engineering-attempt to enhance J_c in the entire magnetic field. We present results on fabrication and characterization of samples with starting compositions $(MgB_2)_{0.99}(Te_2(Ho_2O_3)_y)_{0.01}$, y=0.5, 1, 2, 3, 4. Te and Ho_2O_3 react with MgB_2 to form MgTe and HoB_4. The total amount of the co-additive corresponds to the optimum one when additives are introduced individually. The best results are for sample with y=2. It shows similar J_c-values at low and intermediate fields as for the sample added with Ho_2O_3 and at high fields as for the sample added with Te. The pinning-force-related parameters are discussed. Remarkable is that the curve of pinning force vs. magnetic field has an unusual shape when y≥2 that infers occurrence of two overlapped maximums.

References:
[1] G Aldica, S. Popa, M. Enculescu, D. Batalu, L. Miu, M. Ferbinteanu, Badica P, Mater. Chem. Phys. **146** 313-323 (2014)
[2] G. Aldica, S. Popa, M. Enculescu, P. Badica, Scripta Mater. **66** 570-573 (2012)

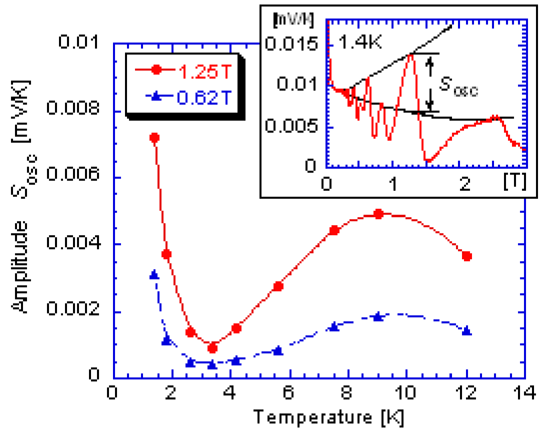
Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.342
Anomalous amplitude of the quantum oscillations in the longitudinal magneto-thermoelectric power

<u>Satoh N.</u>
Iwaki Meisei University, Department of Electronics and Computer Science, Iwaki, Japan

Unique properties of bismuth are still attracting new attention. The oscillatory longitudinal magneto-thermoelectric power (MTP) for single-crystal bismuth has been measured in the magnetic fields *B* up to 9T at several fixed temperatures beween 1.4K and 15K. In our experimental configuration, both the temperature gradient and the *B* were parallel to the bisecrtix axis of bismuth. Since the oscillatory part of MTP is directly related to the transverse magnetoresistivity, we can justly expect that oscillation

patterns similar to the longitudinal Shubnikov-de Haas (SdH) effect should also appear in the longitudinal MTP. Nevertheless, as shown in Fig.1, the observed amplitudes S_{osc} that arise only from a piece of electron pockets along the bisectrix axis show curious temperature dependence. Namely, at a range of temperature $T \geq 4.2$K, for instance, the S_{osc} (1.25T) is explained well by using the formula for MTP [1], in which we need to add a proportional factor for excited phonons. The cyclotron mass m^* obtained by a curve fitting at $T \geq 4.2$K is to be $0.035m_0$. But on the other hand, at $T < 4.2$K the S_{osc} is enhanced markedly in spite of the fact that the longitudinal SdH oscillation patterns become less pronounced by lowering temperature [2,3]. This discrepancy is not clear so far.



[Fig. 1. Amplitude as a function of temperature]

References:
[1] R. Fletcher, J. Low Temp. Phys. **43**, 363 (1981)
[2] S. Tanuma, R. Inada, Phys. Cond. Matter **19**, 95 (1975)
[3] N. Satoh, Y. Kitamura, H. Takenaka, Physica B **391**, 244 (2007)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.343

High-frequency resonances in coplanar waveguides embedded into Josephson oscillator - single charge transistor circuit

<u>Lotkhov S.</u>, Jalali Jafari B., Zorin A.
Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

Resonant properties of Aluminum-based coplanar waveguides (CPW) are studied at frequencies as high as $f \sim 100$ GHz with the photon energy within reach of the quasiparticle excitation gap $2\Delta_{AL} \sim 400$ µeV. This experiment is generally challenging, since the weak high-frequency response has to be transmitted between $T = 15$ mK and 300 K at minor loss. Our approach is based on integrating the CPW as a resonant coupler into the microwave generator - quantum detector *device on-chip* fully controlled and read out via dc signals [1]. As a microwave generator, we use a resistively-shunted Josephson junction with the voltage-tunable frequency $f_J = 2eV_J/h$, $V_J < 2\Delta_{AL}/e$ being an average junction voltage. The microwave signal is fed to the CPW and detected at its output owing to photon absorption in a superconducting single charge transistor exhibiting a microwave-sensitive Cooper pair - Quasiparticle cotunneling current at low bias voltages [2]. A few modifications of the resistive shunt were compared in respect to the *external* quality factor of the CPW resonator. The *internal* quality factor was found dependent on the magnetic field applied to Al film. Application of the observed effects in single microwave photon spectrometry is envisaged.

References:

[1] B. Jalali-Jafari, S. Lotkhov, and A.B. Zorin, Appl. Sci. **6**, 35 (2016)
[2] P. Hadley *et al*., Phys. Rev. B **58**, 15317 (1998)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.344
Anomalies in thermal properties of 1-fluoroadamantane

Szewczyk D., *Jeżowski A.*
Institute of Low Temperature and Structure Research PAS, Low Temperature and Superconductivity, Wrocław, Poland

The polymorphic nature of 1-fluoroadamantane (1FADM) has been studied by the means of thermal transport. The heat capacity of crystalline 1FADM was measured by thermal relaxation calorimetry between 1.8 and 250 K. Two anomalies in the heat capacity temperature dependency were detected. First sharp peak around 227 K was attributed to a phase transition to the low temperature disordered phase[1]. A new result, not seen in any other experiments, was a noticeable bulge in vicinity of 186 K. The authors recognize the observed change as an evidence of a possible glass transition. Complementary results of the thermal conductivity have been carried out by stationary heat flow method in 4.5 and 275 K range. 1FADM, which at room temperature forms an orientationally disordered phase, exhibits crystalline features in thermal transport results by single slowly cooling till helium temperatures. However going back to high temperatures influences the observed temperature dependencies of thermal conductivity, indicating the introduction of the new type of disorder, eventually causing an irreversible transition. Every other cooling procedure results in a metastable but an entirely amorphous state. The analysis of our investigation will be presented based on the thermal transport mechanisms.

References:

[1] N. T. Kawai, D. F. R. Gilson, I. S. Butler, Canadian J. of Chem. **69**(11), 1758 (1991)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.345
Orientational tunneling of trapped CH_3 sensors the rotational motion of the matrix molecules

Dmitriev Y.[1], *Zelenetckii I.*[2], *Benetis N.*[3]
[1]Ioffe Institute, St. Petersburg, Russian Federation, [2]'Peter the Great' St. Petersburg Polytechnic University, Department of System Analysis and Control, Institute of Computer Science and Technology, St. Petersburg, Russian Federation, [3]Technological Educational Institute of Western Macedonia, Department of Environmental Engineering and Antipollution Control, Kozani, Greece

In the present study, experimental EPR data and their theoretical analysis on the quantum rotational motion of matrix-isolated methyl radicals is reported. For the first time, values of the molecule rotation rate about the two-fold symmetry axes, C_2, of methyl radical trapped in different matrices were compared. A new low-temperature matrix effect, “libration trap”, was suggested which accounts for transition of the trapped radical reorientational motion from the excited rotation about the C_3-symmetry axes to excited librations. Our present findings on the CH_3 EPR line shape isolated in CO_2 and N_2O testify a new model of orientational dynamics of CO_2 matrix molecules in solid state - “hopping precession", applicable possibly to N_2O and CO matrices. The theoretical study confirms fast methyl radical orientational motion at low temperatures by sufficiently rapid tunneling about the C_3 and the C_2 symmetry axes. It suggests temperature dependence of the tunneling and allows estimation of the potential barriers from the tunneling rotation rate. The present study also reveals large-amplitude librations even at liquid-helium temperatures. An effect of non-monotonic temperature dependence of the C_2 jump rate is predicted which is expected to be more pronounced for the smaller barriers.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.346

Noise, coherence, and relaxation of tunneling two level systems within the standard tunneling and the two-TLS models

Schechter M.
Ben Gurion University of the Negev, Physics, Beer Sheva, Israel

The coupling of tunneling two-level systems (TLSs) to devices such as superconducting microwave resonators, single electron transistors, nanomechanical resonators, and superconducting qubits is deleterious from the point of view of coherent operation. At the same time, it opens up novel possibilities to study individual and ensembles of TLSs against various models describing their characteristics. In this talk I will discuss recent studies of individual TLS dynamics as function of varying bias energy as studied by their coupling to a phase qubit, as well as the noise and nonlinear response of an ensemble of TLSs coupled to superconducting microresonators. Theoretical analysis within the standard tunneling model and within a recently proposed two-TLS model will be described. The latter model suggests the generic existence of two types of TLSs, differing by their extent of deviation from symmetry under local inversion and consequently by their coupling strength to the strain. It provides an explanation for the universality of the acoustic properties in strongly disordered solids at low temperatures, as well as an explanation to recent experimental data on TLS dynamics and nonlinear response, some of which can not be satisfactorily explained by the standard tunneling model.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.347

^{133}Cs-NMR study on the ground state of the equilateral triangular spin tube $CsCrF_4$

Matsui K.[1], *Goto T.*[1], *Manaka H.*[2], *Miura Y.*[3]
[1]Sophia University, Physics Division, Tokyo, Japan, [2]Kagoshima University, Graduate School of Science and Engineering, Kagoshima, Japan, [3]Suzuka National College of Technology, Mie, Japan

$CsCrF_4$ is S = 3/2 three-leg Heisenberg spin tube system, in which magnetic Cr^{3+} ions form equilateral triangles stacked along the leg direction without rotation and connected via an F atom. Due to low dimensionality and to the geometrical frustration within an equilateral triangle, the system is expected

to have an exotic ground state. Although the system has been believed to have the ground state of the spin liquid [1], the existence of a magnetic phase transition has been suggested by quite recent NMR, µSR and neutron scattering measurement [2, 3]. In order to investigate the magnetic structure at the low-temperatures, it is essential to determine the hyperfine coupling tensor. We have already reported the hyperfine coupling tensor for inequivalent three ^{19}F-sites [4].
To improve reliability of analysis, we have measured the temperature dependences of ^{133}Cs-NMR spectra in paramagnetic state above 20 K and determine the hyperfine coupling tensor for ^{133}Cs-site. The components of the hyperfine coupling tensor, A_{dip} (dipole-dipole interaction), A_{iso} and A_{an} (isotropic and anisotropic contribution of transferred hyperfine coupling), were separated by the dipole sum calculation (see Table).
We have also measured the spin-lattice relaxation rate T_1^{-1} and Knight shift on ^{133}Cs-NMR.

site	A_{dip} (T/μ$_B$)	A_{an} (T/μ$_B$)	A_{iso} (T/μ$_B$)
Cs(3*g*)	+0.0412	-0.0345	+0.100

[Hyperfine coupling parameters for ^{133}Cs]

References:
[1] H. Manaka *et al.*, JPSJ80,084714.
[2] T. Masuda *et al.*, SCES2013, 6P-196 A_392.
[3] K. Matsui *et al.*, Physics Procedia, 75 (2015)726.
[4] K. Matsui *et al.,* Hyperfine Interaction (2016) 237:123.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.349
Supermagnonics
<u>*Bunkov Y.*</u>
Kazan Federal University, Kazan, Russian Federation

The coherent transport of magnetization (magnonics) has been observed in many magnetically ordered materials. In particular a great interest arises for the transfer of the magnetic moment at a large magnons concentration, when their density corresponds to the conditions of Bose - Einstein condensation. This phenomenon was observed in a first time in antiferromagnetic superfluid ^{3}He-B [1]. Later it was observed in other antiferromagnetic states of superfluid ^{3}He, in solid antiferromagnets and in YIG film. In this talk we will consider the stability of spin current in conditions, when magnons chemical potential is higher than the local Larmore frequency. In this case an energy gap appears, as was measured experimentally. This gap has a similarity with the gap in superfluidity and determines the coherent length of spin supercurrent. In a difference from usual magnonics, the transport of magnetization in these conditions we can name supermagnonics. The different applications of supermagnonics will be discussed. In particularly we will consider the magnetic SQUID, the filed transistor and the units of quantum memory.
References:
[1] Yu. M. Bunkov, G. E. Volovik, "Spin superfluidity and magnon BEC" Chapter IV of the book "Novel Superfluids", eds. K. H. Bennemann and J. B. Ketterson, Oxford University press, (2013) arXiv:1003.4889v3

Postersession 1

Thursday, 10 August 2017
16.30-18.30
G Foyer

P.350
Variational Monte Carlo analysis on the potential for high T_c superconductivity in the 2-leg Hubbard ladder model
Kato D., *Kuroki K.*
Osaka University, Toyonaka, Japan

In the single band Hubbard model on a square lattice, the pairing interaction becomes the largest at half-filling, but superconductivity does not take place due to the occurrence of the Mott transition. Maier and Scalapino showed that in the bilayer Hubbard model, Mottness is reduced by the inter-layer coupling, while the pairing interaction remains to be strong, thereby resulting in a possibility of extremely high T_c superconductivity near half-filling(1). Then, it is an intriguing question to ask whether a similar tendency is seen in the 2-leg Hubbard model(2,3), which is a one dimensional analogue of the bilayer model.
In the present study, we apply the multi-variable Variational Monte-Carlo method(6), which can deal with the correlation effect more accurately, to the 2-leg Hubbard ladder model, and show that the superconducting correlation is indeed enhanced in the large inter-chain-hopping regime, which is consistent with the previous FLEX study (4,5). Furthermore, it is found that the inter-chain coupling enhances the electron mobility in spite of the large D_F , which is expected to enhance the electron correlation and hence the effective mass. The relation between this finding in the ladder model and a similar tendency in the bilayer model(1) will be discussed.
References:
(1) T. A. Maier and D. J. Scalapino, *Phys. Rev*. *B* **84** (2011) 180513(R).
(2) E. Dagotto and T. M. Rice, *Science* **271** (1996) 618.
(3) M. Uehara *et al., J. Phys. Soc. Jpn.* **65** (1996) 2764.
(4) K. Kuroki and R. Arita, *Phys. Rev*. *B* **64** (2001) 024501.
(5) K. Kuroki, T. Higashida, and R. Arita, *Phys. Rev*. *B* **72** (2005) 212509.
(6) D. Tahara and M. Imada, *J.Phys. Soc. Jpn.* **77** (2008) 114701.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.351
Tunneling and direct relaxation between orthogonal configurations in the ZnSe:Cr crystal induced by magnetic fields
Averkiev N.S.[1], *Bersuker I.B.*[2], *Gudkov V.V.*[3], *Zhevstovskikh I.V.*[3,4], *Baryshnikov K.A.*[1], *Sarychev M.N.*[3], *Zherlitsyn S.*[5], *Yasin S.*[5,6], *Korostelin Y.V.*[7]
[1]Ioffe Institute, St. Petersburg, Russian Federation, [2]University of Texas at Austin, Institute for Theoretical Chemistry, Austin, United States, [3]Ural Federal University, Institute of Physics and Technology, Ekaterinburg, Russian Federation, [4]M.N. Miheev Institute of Metal Physics, Ural Branch RAS, Ekaterinburg, Russian Federation, [5]Dresden High Magnetic Field Laboratory, Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany, [6]American University in Middle East, College of Engineering &Technology, Egaila, Kuwait, [7]P.N. Lebedev Physical Institute RAS, Moscow, Russian Federation

Tunneling and relaxation transitions between equivalent configurations of Jahn-Teller (JT) centers in crystals can be observed by means of ultrasonic experiments that allow to measure relaxation time

and to evaluate the parameters of the adiabatic potential energy surface of JT centers [1-3]. In case of any system in a threefold degenerate electronic T state subject to tetragonal distortions of the environment in a JT T×e problem, the three distorted configurations have orthogonal electronic wavefunctions due to which tunneling between them and direct relaxation transitions are forbidden, and at low temperatures the ultrasound relaxation is only due to phonon-assisted processes. Unexpectedly, we observed a sharp peak of ultrasound attenuation by Cr^{2+} centers in the cubic ZnSe:Cr^{2+} crystal at the field of B=0.15T and the temperature of 1.3K, its position being independent of the ultrasound frequency. A detailed microscopic theory of this effect shows that the magnetic field of appropriate orientation mixes the electronic wavefunctions and opens a new channel for tunneling and direct relaxations between the tetragonal distortions which, however, decreases in larger fields due to the induced decoherence between the minima states.

References:

[1]. M.D. Sturge, The Jahn-Teller effect in solids, in *Solid State Physics: Advances in Research and Applications*, Eds: F. Seitz, D. Turnbull, H. Ehrenreich, Vol.20, p.92-211 (Academic Press, New York, London) 1967.
[2] V.V. Gudkov, I.B. Bersuker, I.V. Zhevstovskikh, *et al*, J. Phys.: Condens. Matter **23**, 115401 (2011).
[3] I.V. Zhevstovskikh, I.B. Bersuker, V.V. Gudkov*, et al*, J. Appl. Phys.**119**, 225108 (2016).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

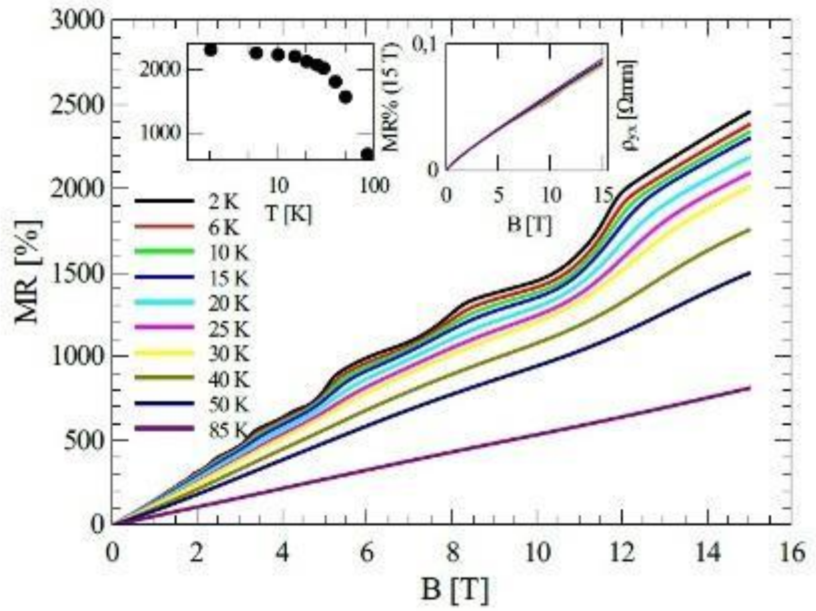
P.352

Quantum magnetotransport and de Haas-van Alphen measurements in the three-dimensional Dirac semimetal $Pb_{0.83}Sn_{0.17}Se$

Orbanić F.[1]*, Novak M.*[1]*, Pleslić S.*[2]*, Kokanović I.*[1]
[1]University of Zagreb, Faculty of Science, Department of Physics, Zagreb, Croatia, [2]University of Zagreb, Faculty of Electrical Engineering and Computing, Department of Applied Physics, Zagreb, Croatia

Magnetoresistance, Hall resistance and magnetization of the $Pb_{0.83}Sn_{0.17}Se$ crystals have been measured in magnetic field up to 15 T and 5 T, respectively, and temperatures from 1.7 K up to 85 K. A large linear and temperature dependent magnetoresistance is observed in magnetic field up to 15 T, figure.

The de Haas-van Alphen (dHvA) and Shubnikov de Haas effects (SdH) of $Pb_{0.83}Sn_{0.17}Se$ crystals have been clearly seen in the temperature range from 30 K down to 1.7 K and magnetic field as low as 2 T. The dHvA and SdH oscillations reveal single frequency of around 8 T which confirms the existence of a single Fermi surface cross section. Influence of isothermal annealing of $Pb_{0.83}Sn_{0.17}Se$ crystals in Se vapors on the dHvA and SdH effects has been investigated. By increasing the annealing temperature from 433 ^{o}C up to 438 ^{o}C, only a suppression of the amplitude of the quantum oscillations has been observed. The Fermi surface parameters, calculated from both the experimental measured data, are close to each other and match well with earlier report [1]. The dHvA and SdH effects clearly reflects the existence of a nontrivial Berry's phase owing to the linear band dispersion which is the signature of a three-dimensional Dirac fermion in the $Pb_{0.83}Sn_{0.17}Se$ crystals.



[Fig]

References:

[1] F. Orbanić, M. Novak, M. Baćani, I. Kokanović, Phys. Rev. B **95,** 035208 (2017)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.353

Magnetic phase diagram and the electronic phase separation in the systems with imperfect nesting of the Fermi surface

Kugel K.[1,2], Sboychakov A.[1], Rakhmanov A.[1,3,4], Rozhkov A.[1,4], Nori F.[5]
[1]Institute for Theoretical and Applied Electrodynamics, Russian Academy of Sciences, Moscow, Russian Federation, [2]National Research University Higher School of Economics, Moscow, Russian Federation, [3]Dukhov Research Institute of Automatics, Moscow, Russian Federation, [4]Moscow Institute for Physics and Technology (State University), Dolgoprudny, Russian Federation, [5]RIKEN, Center for Emergent Matter Science, Wako-shi, Japan

We analyze the effects of an applied magnetic field on the phase diagram of a weakly correlated electron system with imperfect nesting of the Fermi surface. The Hamiltonian under study describes two bands: electron and hole ones. Both bands have spherical Fermi surfaces, whose radii are slightly mismatched due to doping. These types of models are often used in the analysis of magnetic states in chromium and its alloys, superconducting iron pnictides, AA-type bilayer graphene, borides, etc. At zero magnetic field, the uniform ground state of the system turns out to be unstable against electronic phase separation [1]. The applied magnetic field affects the phase diagram in several ways. In particular, the Zeeman term stabilizes new antiferromagnetic phases. It also significantly shifts the boundaries of inhomogeneous (phase-separated) states [2]. At sufficiently high fields, the Landau quantization gives rise to oscillations of the order parameters and of the Néel temperature as a function of the applied magnetic field.

References:

[1] A.L. Rakhmanov, A.V. Rozhkov, A.O. Sboychakov, and F. Nori, Phys. Rev. B **87**, 075128 (2013).
[2] A.O. Sboychakov, A.L. Rakhmanov, K.I. Kugel, A.V. Rozhkov, and F. Nori, Phys. Rev. B **95**, 014203 (2017).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.355
Superconductivity in lithium- and diamines-intercalated $TiSe_2$ and $MoSe_2$

Sato K., Noji T., Hatakeda T., Kawamata T., Kato M., Koike Y.
Tohoku University, Department of Applied Physics, Graduate School of Engineering, Sendai, Japan

Recently, transition metal dichalcogenides have attracted interest owing to the appearance of superconductivity via intercalation or the application of pressure or electric field [1-5].
We have succeeded in synthesizing new superconductors $Li_x(C_2H_8N_2)_yTiSe_2$ and $Li_x(C_6H_{16}N_2)_yTiSe_2$ with T_c = 4.2 K via the co-intercalation of Li and ethylenediamine (EDA) $C_2H_8N_2$ and hexamethylenediamine (HMDA) $C_6H_{16}N_2$ into semimetallic 1T-$TiSe_2$ exhibiting a CDW transition. Moreover, it has been found that both Li_xTiSe_2 and $(C_2H_8N_2)_yTiSe_2$ also show superconductivity with T_c = 2.4 K and 2.8 K, respectively. These results indicate that the electron doping due to the Li intercalation and the expansion of the interlayer spacing between $TiSe_2$ layers due to the intercalation of diamines suppress the CDW transition, leading to the appearance of superconductivity.
We have also succeeded in synthesizing new superconductors $Li_x(C_2H_8N_2)_yMoSe_2$ and $Li_x(C_6H_{16}N_2)_yMoSe_2$ with T_c = 4.2 K and 3.2 - 6.0 K, respectively, via the co-intercalation of Li and EDA and HMDA into semiconducting 2H-$MoSe_2$. It has been found that the T_c values are related not to the interlayer spacing but to the carrier density increased by the electron doping due to the Li intercalation.

References:

[1] E. Morosan *et al*., Nat. Phys. **2**, 544 (2006).
[2] E. Morosan *et al*., Phys. Rev. B **81**, 094524 (2010).
[3] A. F. Kusmartseva *et al*., Phys. Rev. Lett. **103**, 236401 (2009).
[4] W. Shi *et al*., Sci. Rep. **5**, 12534 (2015).
[5] X. Miao *et al*., Sci. Rep. **6**, 29292 (2016).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.356
Single-electron pumps based on GaAs/AlGaAs heterostructures - systematic investigation of design parameters

Gerster T., Ubbelohde N., Müller A., Freise L., Maradan D., Stein F., Weimann T., Pesel E., Pierz K., Schumacher H.W., Hohls F.
Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany

A possible realization of a new definition of the SI unit ampere are tunable barrier single-electron pumps (SEP) [1,2]. The clocked transfer of single electrons generates a current $I = n\, e\, f$, only depending on the number of electrons n transferred per cycle, the repetition frequency f and the

elementary charge *e*. Recently, the quantization of the current of a single-electron pump was verified with a total relative uncertainty of 0.2 ppm [3,4]. Beside metrological applications, these SEPs are a useful building block as an on-chip source of deterministic single electrons, i.e. in electron quantum optics. Therefore, it is important to improve reliability, robustness and performance of these devices. In our GaAs/AlGaAs heterostructure based SEPs, tunable barriers and a shallow-etched mesa structure define the dynamical quantum dot. To improve the charge capture probability, we systematically investigated the fabrication process and studied the influence of mesa etch and barrier design on the confinement potential. A reliable and robust design was established and allows us to investigate error mechanisms and frequency dependencies of electron transfer.

References:

[1] I. M. Mills et al., Phil. Trans. R. Soc. A **369**, 3907-3924 (2011).
[2] B. Kaestner, V. Kashcheyevs, Rep. Prog. Phys. **78,** 103901 (2015).
[3] F. Stein et al., Appl. Phys. Lett. **107**, 103501 (2015).
[4] F. Stein et al., Metrologia **54,** S1-S8 (2017)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.357

Doping-induced giant phonon softening and superconductivity enhancement of $BaNi_2As_2$

<u>Nohara M.</u>, Takasuga M., Kudo K.
Okayama University, Research Institute for Interdisciplinary Science, Okayama, Japan

The effects of chemical doping on the structural and superconducting phase transitions of $BaNi_2As_2$ were studied. We found an abrupt increase in the superconducting transition temperature T_c from 0.6 K in the triclinic phase with less doping to 2.5-3.3 K in the tetragonal phase with more doping at x = 0.067 for $BaNi_2(As_{1-x}P_x)_2$ [1] and at x = 0.16 for $Ba(Ni_{1-x}Cu_x)_2As_2$ [2]. Specific-heat data suggested that doping-induced phonon softening was responsible for the enhanced superconductivity in the tetragonal phase. The triclinic phase was not suppressed by the doping of Co, Pd, Ag, Ir, and Pt because of the low solubility limit of these elements.

References:

[1] K. Kudo, M. Takasuga, Y. Okamoto, Z. Hiroi, and M. Nohara, Phys. Rev. Lett. **109**, 097002 (2012).
[2] K. Kudo, M. Takasuga, and M. Nohara, to be submitted.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.358

Effect of dynamic strain in magnetic superlattice of monoaxial chiral magnet

<u>Tsuruta K.</u>[1], Mito M.[1,2], Togawa Y.[2,3], Kousaka Y.[2,4], Akimitsu J.[2,4], Inoue K.[2,5,6]
[1]Kyushu Institute of Technology, Graduate School of Engineering, Kitakyushu, Japan, [2]Hiroshima University, Center for Chiral Science, Higashihiroshima, Japan, [3]Osaka Prefecture University, Graduate School of Engineering, Sakai, Japan, [4]Okayama University, Department of Physics Faculty of Science, Okayama, Japan, [5]Hiroshima University, Graduate School of Science, Higashihiroshima, Japan, [6]Hiroshima University, Department of Chemistry Faculty of Science, Higashihiroshima, Japan

Magnetic properties of chiral materials are characterized by the competition between symmetric and antisymmetric Dzyaloshinskii-Moriya exchange interactions, resulting in a chiral helimagnetic structure.[1,2] When a magnetic field is applied perpendicular to the chiral axis, a type of superlattice structure called the chiral soliton lattice (CSL) becomes stabilized.[3] It has been experimentally found that the magnetoresistance (MR) is scaled by the soliton density.[4] Conduction electrons couples magnetic structure. Structural modification would change magnetic structure, resulting in the change in MR.

In semiconductor silicon and cuprate superconductor, we have succeeded in manipulations of physical properties by the dynamic (i.e. time-dependent) strain (DS).[5,6] In the present study, we applied the DS to the monoaxial chiral magnet $CrNb_3S_6$ in order to change the CSL artificially.

In stationary DS, we observed that the hysteresis area of MR against the field scanning at around 100 K increased with increasing magnitude of the DS. We consider the DS modulates the crystalline structure and influence formation process of the CSL. On the other hand, in a pulse-like DS, we have enhanced the change from the forced-ferromagnetic to CSL states in the process of decreasing field.

References:

[1] I. Dzyaloshinsky, J. Phys. Chem. Solids **4**, 241 (1958).
[2] T. Moriya, Phys. Rev. Lett. **4**, 228 (1960).
[3] J. Kishine *et al*., Prog. Theor. Phys. Suppl. **159**, 82 (2005).
[4] Y. Togawa *et al*., Phys. Rev. Lett. **111**, 197204 (2013).
[5] K. Tsuruta *et al*., Jpn. J. Appl. Phys. **53**, 07KC07 (2014).
[6] K. Irie *et al*., Jpn. J. Appl. Phys. **53**, 07KC05 (2014).

*Current address of Tsuruta K.: Japan Synchrotron Radiation Research Institute, Sayo, Hyogo, Japan.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.359

quantum phases and excitation in Bose-Fermi mixtures in a three-dimensional optical lattice

<u>*Hatsuda R.*</u>
Tokyo Metropolitan University, Hatiouzi, Japan

Superfluid of a cold mixture of bosonic atoms and fermionic atoms has been experimentally realized by ENS group[1], which renewed interest in the Bose-Fermi mixture. Attentions have therefore been attracted to study on quantum phases in the Bose-Fermi mixture.The Bose-Fermi mixtureconfined in a three-dimensional optical lattice can be described by Bose-Fermi Hubbard model, which includes various parameters such as Bose-Fermi interactions, total filling factor, and number ratio between the bosons and the fermions. The model with these experimentally-tunable parameters is expected to have rich quantum phases.

In a preceding study[2], the Bose-Fermi Hubbard model in a three-dimensional optical lattice was analyzed within a single-particle approximation for a particular set of the parameters to reveal a rich phase diagram.In the present study, we analyzed the model for a variety of sets of the parameters in two approaches, analytical and numerical ones, after applying Gutzwiller's approximation[3,4]. We derived phase diagrams consisting of various quantum phases for different parameter sets and found no mixed Mott state in either approach, unlike in the preceding study. We also calculated excitation energies of the quantum phases.

References:

[1] I. Ferrier-Barbut , M. Delehaye, S. Laurent, A.T. Grier, M. Pierce, B.S. Rem, F. Chevy, C. Salomon, Science 345.6200(2014).
[2] Q.-M. Liu, X. Dai, Z. Fang, J.-N. Zhuang, Y. Zhao, Appl. Phys. B 99,639-650(2010).
[3] J. Bunemann, W. Weber, Phys. Rev. B 57,6896(1998).

[4] Takuya. saito, Ippei. Danshita, Takeshi. Ozaki, and Tetsuro. Nikuni, Phys. Rev. A 86,023623(2012).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.361
Enhanced current-induced spin polarisation in topological surface states in bulk semiconducting $Bi_{1.5}Sb_{0.5}Te_{1.7}Se_{1.3}$

Dankert A., Bhaskar P., Khokhriakov D., Charpentier S., Dash S.P.
Chalmers University of Technology, Gothenburg, Sweden

In topological insulators´ (TI) two distinct tranport channels, their surface states are heavily studied due to their interesting spin-momentum locking (SML), whereas the influence of a highly doped bulk background has not yet been investigated. Here we report the electrical detection of SML up to room temperature on the surface of $Bi_{1.5}Sb_{0.5}Te_{1.7}Se_{1.3}$ (BSTS). A semiconducting behaviour in the temperature dependence combined with weak anti-localization measurements in different geometries and the observation of Shubnikov-de Haas oscillations proves a pure surface transport in BSTS at cryogenic temperatures. The current-induced SML in BSTS yields a spin resistance up to 1.5Ohm, increases linearly with current bias, reverses sign with current direction and increases strongly with decreasing temperature below 100K. We correlate this strong increase in the signal with the vanishing of the bulk-background contribution. Our results prove for the first time that the detected surface spin polarization dominates even a large bulk background and reinforce the electrical accessibility of SML in TIs up to room temperature, making them more interesting for fundamental research and applications in dissipationless quantum devices.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.362
Dirac materials heterostructure: graphene and topological insulator

Khokhriakov D., Dankert A., Dash S.
Chalmers, Microtechnology and Nanoscience, Göteborg, Sweden

Topological insulators (TIs) represent a new class of materials, consisting of an insulating bulk and spin-polarized metallic surface states that represent a quantum spin Hall (QSH) regime. Graphene has been thought of as a model system for such a 2D QSH insulator, however, due to its small intrinsic spin-orbit (SO) coupling these states were not observed experimentally. Heterostructures between the two materials are emerging systems that are expected to have interesting interaction effects, including the transfer of novel spin textures and the appearance of a giant SO gap in graphene due to the TI proximity effect.
We study the 3D TI $Bi_{1.5}Sb_{0.5}Te_{1.7}Se_{1.3}$ both individually and in heterostructures with graphene employing electrical and quantum transport techniques. Combining exfoliated TIs with chemical vapor

deposited graphene, we fabricate vertical heterostructures that exhibit low-resistive tunneling behavior on their interface and represent a suitable system for exploring interaction effects. Our findings provide a route for further explorations of proximity effects between graphene and topological insulators, and understanding the basic phenomena that control their behavior.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.363

Vortex penetration into a sub-micron stack of intrinsic Josephson junctions of $Bi_2Sr_2CaCu_2O_{8+y}$

Ooi S., Tachiki M., Mochiku T., Wang H., Hirata K., Komori K., Arisawa S.
National Institute for Materials Science (NIMS), Tsukuba, Japan

It has been known that vortex matter in bulk single crystals of $Bi_2Sr_2CaCu_2O_{8+y}$ (Bi2212) in a field perpendicular to the CuO_2 planes shows a rich variety of vortex phases and transitions between them, i.e., vortex liquid, Bragg glass, first-order melting of vortex lattice, etc, in relatively low fields. However, the influence of sample-size reduction on the vortex phases and transitions was not investigated well; there are a few studies by magnetical methods using micro-Hall-sensors or magneto-optical techniques. To explore the vortex states confined in a micron-sized Bi2212, we have employed a stack of intrinsic Josephson junctions (IJJs) of Bi2212 as a detector of vortices, and found the oscillating behavior in the melting transition line reflecting a geometrical matching of vortex crystals within a square shape of samples [1]. This vortex-detection method by IJJs is applicable for further smaller samples. In this presentation, we will show results about vortex states in a sub-micron stack of IJJs. Clear vorticity transitions and hysteretic behavior of vortex penetrations below a certain temperature are observed.

References:

[1] S. Ooi, T. Mochiku, M. Tachiki, K. Hirata, Phys. Rev. Lett. **114**, 087001 (2015).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.364

High temperature superconductivity in a two dimensional Ca_2RuO_4

Nobukane H.[1,2], Yanagihara K.[1], Kunisada Y.[3], Ogasawara Y.[1], Nomura K.[1], Asano Y.[2,4], Tanda S.[2,4]
[1]Hokkaido University, Department of Physics, Sapporo, Japan, [2]Hokkaido University, Center of Education and Research for Topological Science and Technology, Sapporo, Japan, [3]Hokkaido University, Center for Advanced Research of Energy and Materials, Sapporo, Japan, [4]Hokkaido University, Department of Applied Physics, Sapporo, Japan

We report the observation of high-T_c superconductivity at 96 K with onset in a Ca_2RuO_4 nanofilm single crystal [1]. The film of Ca_2RuO_4 shows the Kosterlitz-Thouless transition behavior around 30 K. We also found the bias current applied to the film causes a superconductor-insulator transition. The critical value of the sheet resistance 16.5 k ohm is very close to the universal resistance predicted by the superconductor to Mott-insulator transition. The samples show the non-linear current-voltage characteristics with supercurrent. Our results imply the presence of two-dimensional high-T_c superconductivity. The fabrication of nanofilms made of layered material enable us to discuss rich superconducting phenomena in ruthenates.

References:
[1] H. Nobukane, K. Yanagihara, Y. Kunisada, Y. Ogasawara, K. Nomura, Y. Asano and S. Tanda, arXiv:1703.09459

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.365
The superconducting pairing mechanism and the gap structure in BiS2-based layered superconductors

Suzuki K.[1], *Usui H.*[2], *Kuroki K.*[2], *Nomoto T.*[3], *Hattori K.*[4], *Ikeda H.*[1]
[1]Ritsumeikan University, Department of physics, Kusatsu, Japan, [2]Osaka University, Department of physics, Toyonaka, Japan, [3]RIKEN Center for Emergent Matter Science (CEMS), Wako, Japan, [4]Tokyo Metropolitan University, Department of Physics, Hachioji, Japan

The pairing state in the BiS_2-based layered superconductors [1] has attracted a great interest due to the large spin-orbit coupling and the non-symmorphic crystal structure, where the inversion symmetry is locally broken at the Bi site. Recently, some experiments [2,3] have implied the presence of remarkable gap anisotropy, especially, an angle-resolved photoemission spectroscopy indicated a sign change of the gap function on the small Fermi pocket around X point. These observations imply a possibility of an unconventional pairing state. In this work, we have studied unconventional superconductivity in an extended repulsive/attractive Hubbard model with inter-site interactions between Bi and S atoms and the band structure from the first-principles downfolding. We find that the inter-site interaction between Bi and S can lead to sizable gap anisotropy on the Fermi surface. We stress that the presence of degenerate p_x/p_y orbitals can yield the anisotropic gap without competitive multiple pairing interactions. These findings give us an important clue to understand the pairing mechanism of the BiS_2-based superconductors.

References:
[1] Y. Mizuguchi et al., J. Phys. Soc. Jpn. 81 114725 (2012)
[2] Y. Ota et al., arXiv:1703.08379
[3] M. Aslam et al., arXiv:1604.06325

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.366
New ethylenediamine-intercalated superconductor $(C_2H_8N_2)_yTa_2PdSe_6$ with T_c = 4.5 K

Nakamura S., *Noji T., Hatakeda T., Sato K., Kawamata T., Kato M., Koike Y.*
Tohoku University, Department of Applied Physics, Graduate School of Engineering, Sendai, Japan

Layered compounds $T_2Pd_xCh_5$ (T = Nb, Ta ; Ch = S, Se) with the strong spin-orbit interaction have attracted attention owing to their extremely high upper critical fields exceeding their Pauli paramagnetic fields [1-4]. We have succeeded in synthesizing a new superconductor $(C_2H_8N_2)_yTa_2PdSe_6$ with T_c = 4.5 K via the intercalation of ethylenediamine (EDA) $C_2H_8N_2$ into semimetallic Ta_2PdSe_6. On the other hand, it has been found that the co-intercalation of lithium and EDA into Ta_2PdSe_6 suppresses the superconductivity, indicating that the electron doping is harmful to the superconductivity in $(C_2H_8N_2)_yTa_2PdSe_6$. Accordingly, it has been concluded that the superconductivity in $(C_2H_8N_2)_yTa_2PdSe_6$ is induced not only by the enhancement of the two-dimensional nature of the electronic structure due to the expansion of the interlayer spacing but also by the enhancement of the electron-phonon interaction and/or the possible pairing interaction mediated by the electronic polarization of EDA.

References:

[1] Q. Zhang *et al*., Sci. Rep. **3**, 1446 (2013).
[2] S. Khim *et al*., New J. Phys. **15**, 123031 (2013).
[3] Y. Lu *et al*., J. Phys. Soc. Jpn. **83**, 023702 (2014).
[4] J. Zhang *et al*., Supercond. Sci. Technol. **28**, 115015 (2015).

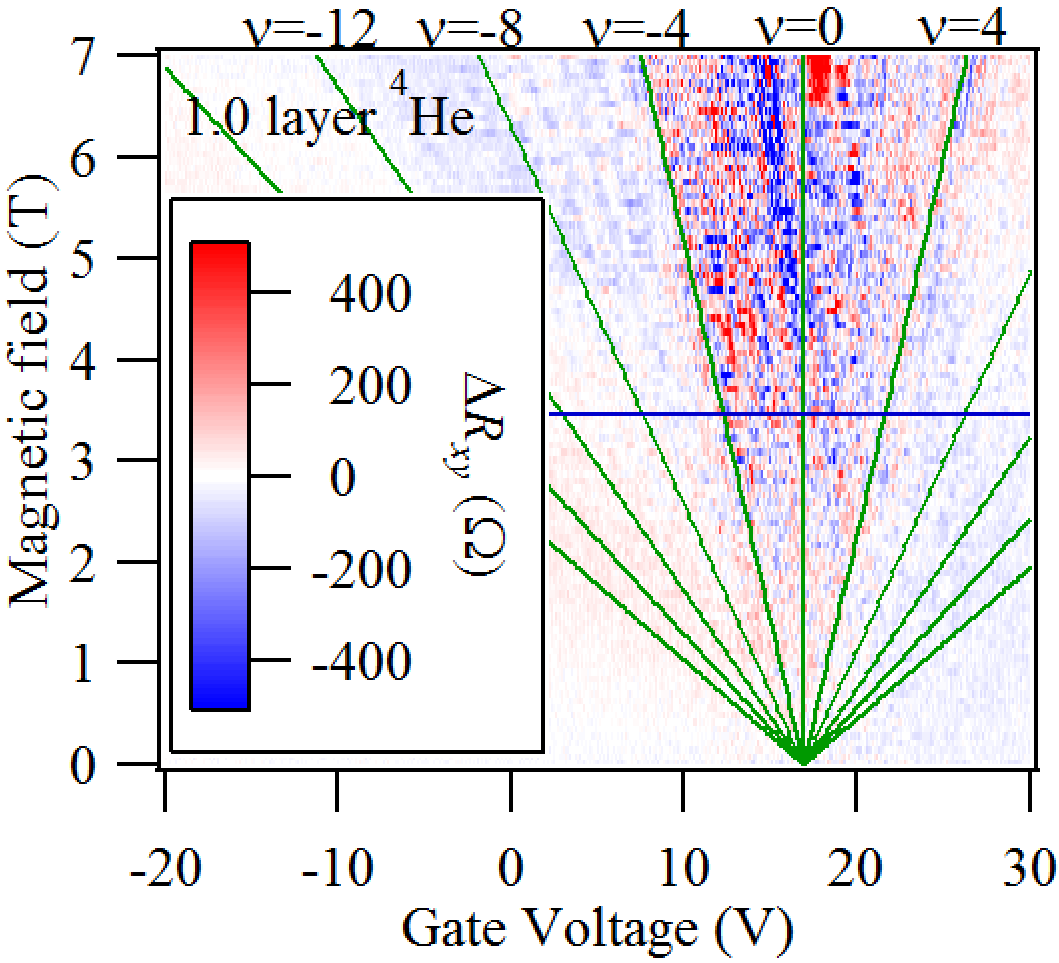
Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.367

Magnetotransport of the monolayer graphene adsorbed by the inert gas in the quantum Hall regime

<u>Fukuda A.</u>[1], Terasawa D.[1], Fujimoto A.[2], Kanai Y.[3], Matsumoto K.[3]
[1]Hyogo College of Medicine, Physics Department, Nishinomiya, Japan, [2]Osaka Institute of Technology, Applied Physics, Osaka, Japan, [3]Osaka University, Institute of Scientific and Industrial Research, Ibaraki, Japan

Graphene is easily accessible from outside, whose transport is sensitively affected by the adsorption of various kinds of molecules. Thus it is challenging to investigate the effects of the adsorption of an inert gas on graphene, which may be least effective. Previously we reported the magnetotransport of ^{4}He-adsorbed bilayer graphene [1]. In this study we carry out the magnetotransport measurements of inert-gas-adsorbed monolayer graphene at the temperature of 4 K and the magnetic field ranging from 0 to 7 T. The monolayer graphene is prepared by the exfoliation method mounted on SiO_2. We measure the 4-terminal magnetoresistance R_{xx} and Hall resistance R_{xy} where we clearly find the qhantum Hall plateaus. We introduced ^{4}He or Ar gas as an inert gas at low temperature to the graphene inside a sample cell. The R_{xx} change ΔR_{xx}, and R_{xy} change ΔR_{xy} from the pristine graphene(Fig) is measured as a function of gate voltage and magnetic field for various layers of adsorbates. Amplitudes of ΔR_{xx} and ΔR_{xy} are relatively large around the charge neutral point and both quantities have oscillating structures, almost along the constant filling factor lines in the Landau-fan diagram. In the conference, we discuss origins of these phenomena and their dependence on a layer number of adsorbates.



[Fig]

References:
[1] A. Fukuda *et al*., J. Phys.: Conf. Ser. **568**, 052009 (2014).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.368
Defects in low dimensional quantum magnets

Povarov K.[1], *Simutis G.*[1], *Schmidiger D.*[1], *Galeski S.*[1], *Gvasaliya S.*[1], *Mansson M.*[1], *Chernyshev A.*[2], *Mohan A.*[3], *Singh S.*[3], *Hess C.*[3], *Buchner B.*[3,4], *Savici A.*[5], *Kolesnikov A.*[5], *Ollivier J.*[6], *Piovano A.*[6], *Perring T.*[7], *Bewley R.*[7], *Guidi T.*[7], *Zaliznyak I.*[8], *Zheludev A.*[1]
[1]ETH Zürich, Neutron Scattering and Magnetism, Laboratory for Solid State Physics, Zürich, Switzerland, [2]University of California, Department of Physics and Astronomy, Irvine, United States, [3]Leibniz Institute for Solid State and Materials Research IFW Dresden, Dresden, Germany, [4]TU Dresden, Department of Physics, Dresden, Germany, [5]NScD, Oak Ridge National Laboratory, Oak Ridge, United States, [6]Institut Laue-Langevin, Grenoble, France, [7]ISIS Facility, Rutherford Appleton Laboratory, Chilton, Didcot, United Kingdom, [8]Brookhaven National Laboratory, Upton, New York, United States

One-dimensional quantum systems are known to be extremely susceptible to defects. Here I will demonstrate the dramatic effect that a depletion with nonmagnetic impurities has on several spin chain and spin ladder compounds. Due to fundamentally different low-energy degrees of freedom, impurities in spin chains and ladders play very different roles. In spin chains, scattering by defects leads to a confinement of low energy quasiparticles already present in the unperturbed system. As a result, a magnetic excitation spectrum acquires a concentration-dependent "pseudogap" which bears a universal description[1]. In contrast, the unperturbed spin ladder has no low-energy excitations of its own. Instead, new local degrees of freedom are released upon the introduction of defects. Strong antiferromagnetic correlations shape them as spatially extended "spin islands". Although these spin islands are localized, they strongly interact and thereby give rise to unusual thermodynamic properties and novel collective modes[2]. In both cases, inelastic neutron scattering observes the corresponding defect-induced transformations of the spin excitation spectra *directly*, and the effective theories allow to describe the metamorphoses of gapped and gapless behavior *quantitatively*.

References:

[1] G. Simutis, S. Gvasaliya *et al.*; Phys. Rev. Lett. **111**, 067204 (2013)
[2] D. Schmidiger, K. Yu. Povarov *et al.*; Phys. Rev. Lett. **116**, 257203 (2016)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.369

Spin current of fermions induced in spin-orbit coupled Bose-Fermi mixture

Sakamoto R., Ono Y., Hatsuda R., Arahata E., Mori H.
Tokyo Metropolitan University, Department of Physics, Tokyo, Japan

A neutral atomic Bose-Einstein condensate (BEC) with a synthetic spin-orbit (SO) coupling was engineered by dressing two atomic spin states with a pair of lasers[1]. Since the SO coupling is known to induce various phenomena such as topological insulator or spin-Hall effect, a number of theoretical and experimental studies of SO coupled BEC have been reported. In particular, a spiral spin structure that has experimentally-controllable periodicity can be induced in the BEC[2]. On the other hand, a spin current of spin-1/2 particles can be induced in a spiral magnetic field. Based on these studies, it is expected that a spin current of fermions could be induced in a mixture of an SO coupled BEC and spin-1/2 fermions. However, little has been reported so far on the study of the SO coupled Bose-Fermi mixture.

We studied a spin current of fermions in the SO coupled Bose-Fermi mixture. First of all, we investigated an effect of the spin-1/2 fermions on the SO coupled BEC to check the persistence of the spiral spin structure in the BEC. Next, we calculated the spin current of the fermions induced by the spiral spin structure in the BEC and clarified the controllability of the spin current by controlling the applied lasers to modify the periodicity of the spiral spin structure.

References:

[1] Y.-J. Lin, K. Jiménez-García, and I. B. Spielman, Nature **471**, 83 (2011)
[2] Y. Li, L. P. Pitaevskii, and S. Stringari, Phys. Rev. Lett. **108**, 225301 (2012)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.370
Magnetic anisotropy from Kitaev interactions
Ishizuka H.
University of Tokyo, Applied Physics, Bunkyo, Japan

We theoretically discuss that the Kitaev interactions induce a temperature-dependent magnetic anisotropy in the high-temperature paramagnetic phase which is potentially useful for experimentally evaluating the anisotropic interactions. Electrons in 4d/5d transition metal compounds are subject to strong spin-orbit interactions. In Mott insulators, the spin-orbit interactions generate anisotropic exchange interactions, e.g., Kitaev interactions; these interactions give rise to rich magnetic behaviors in the ground state, such as the order from disorder and spin liquids. In contrast, the effect of the anisotropic interactions in finite temperature is less studied.
In this work, we theoretically study how the anisotropic interactions affect magnetism in a finite temperature. We show that the Kitaev interactions give rise to a temperature-dependent magnetic anisotropy even in the high-temperature paramagnetic phase. We discuss that the anisotropy can be observed by using the magnetic torque measurements. As the magnetic torque depends on the anisotropic interactions, it is potentially used to experimentally evaluate the strength of the interactions. We also discuss that, in a certain setup, the magnetic anisotropy changes its direction between the paramagnetic and ordered phases.
References:
[1] H. Ishizuka, preprint (arXiv:1612.00057).
[2] H. Ishizuka and L. Balents, Phys. Rev. B **92**, 020411 (2015).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.372
Sound propagation and density response in a Bose-Fermi mixture superfluid at finite temperatures
Ono Y., Sakamoto R., Hatsuda R., Arahata E., Mori H.
Tokyo Metropolitan University, Department of Physics, Tokyo, Japan

Recently, a Bose-Fermi mixture (BFM) superfluid in which both Bose and Fermi gases are superfluid was realized [1]. The experiment has renewed interest in a BFM superfluid. Moreover, there has been renewed interest in the second-sound mode in superfluid Fermi gases [2], which are described by Landau´s two-fluid hydrodynamics equations [3].
Here we report on sound propagation in a BFM superfluid at finite temperatures in the collisional hydrodynamic regime. We extend Landau´s hydrodynamic theory to deal with a BFM superfluid assuming a Bose gas is nearly degenerate in the lowest energy state.
First, we have found that three sound modes exist and the three-sound-modes hybrid in a BMF superfluid [4]. The first mode of three sound modes is that normal fluid, Bose superfluid and Fermi superfluid move together. The second is a mode that Bose and Fermi superfluids move against a normal fluid, and the third is a mode that Bose superfluid and a normal fluid move against Fermi superfluid.
Second, we have found that the three-sound-modes can be observed by a sudden modification of the external potential generating pulse propagation. The density response of the first and second mode is positive but the third mode is negative.
References:

[1] I. Ferrier-Barbut, *et al*., Science **345**, 1035 (2014); T. Ikemachi, *et al*., J. Phys. B: At. Mol. Opt. Phys. **50**, 01LT01 (2017).
[2] L. A. Sidorenkov, *et al*., Nature **498**, 78 (2013).
[3] L. D. Landau, J. Phys. (USSR) **5**, 71 (1941).
[4] Y. Ono, R. Sakamoto, H. Mori, and E. Arahata, J. Phys. Soc. Jpn. **85**, 065004 (2016).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.373
Multigap nodeless superconductivity in FeSe single crystals
Rößler S.[1], *Huang C.-L.*[1,2], *Jiao L.*[1], *Koz C.*[1,3], *Schwarz U.*[1], *Wirth S.*[1]
[1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany, [2]Rice University, Houston Texas, United States, [3]University of Liverpool, Liverpool, United Kingdom

We present superconducting properties of FeSe single crystals [1-3] grown by chemical vapor transport (CVT) using very small quantities of $AlCl_3$ as transport reagent. The electronic part of the specific heat can be described by a phenomenological two-gap model [3]. Our data analysis suggests that the superconducting gap value on one of the Fermi pocket is about $1/6^{th}$ of the larger one. Moreover, the larger gap displays a strong anisotropy, but remains nodeless [3]. We further show that, in FeSe single crystals grown by CVT in presence of KCl flux, the smaller gap was found to be not as prominently manifested in the specific heat measurements as in those grown by CVT using only $AlCl_3$. This suggest that the superconducting gap structure is sensitive to different crystal growth environments.

References:
[1] C. Koz *et al.,* Z. Anorg. Allg. Chem. 640, 1600 (2014).
[2] S. Rößler *et al*., Phys. Rev. B **92**, 060505(R) (2015).
[3] S. Rößler *et al*., Phys. Status Solidi B 254, 1600149 (2017).
[4] L. Jiao *et al*., Sci. Rep. 7, 44024 (2017).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.374
STM/STS studies on electronic superstructures in the superconducting state of high-T_c cuprate $Bi_2Sr_2CaCu_2O_{8+\delta}$
Mizuta S.[1], *Kurosawa T.*[1], *Takeyama K.*[2], *Momono N.*[3], *Yoshida H.*[1], *Oda M.*[1], *Ido M.*[1]
[1]Hokkaido University, Department of Physics, Sapporo, Japan, [2]Asahikawa Medical University, Department of Physics, Asahikawa, Japan, [3]Muroran Institute of Technology, Department of Applied Sciences, Muroran, Japan

In this study, we performed STM/STS experiments at 8 K in underdoped (UD) $Bi_2Sr_2CaCu_2O_{8+\delta}$ with T_c=76 K and examined electronic superstructures such as checkerboard modulation (CBM) [1,2] and Cu-O-Cu bond-centered modulation (BCM) [3]. In the UD crystals, the STS spectrum exhibits a two-gap structure consisting of a d-wave superconducting gap (SCG) and a spatially inhomogeneous

pseudogap (PG) whose energy size Δ_{PG} varies over a wide range from the SCG amplitude Δ_0 to several times larger one [4]. We confirmed that CBM and BCM are observed with the mapping of spectral weights around Δ_0 and Δ_{PG}, respectively. It has been suggested in previous studies that the low-energy CBM may result from the so-called “set-point effect” in the conventional method of STS, in which the tip height is set every measurement position so as to give a constant set-current under a high bias voltage [5,6]. In this study, however, CBM was also observed with the mapping of differential conductance measured while taking a current-image in constant height mode for an applied bias of ~Δ_0/e, which will be free from the set-point effect. These results suggest that the coexistence of two electronic superstructures with different characteristic energies (~Δ_0 and ~Δ_{PG}) will be an intrinsic property of the Cu-O plane.

References:

[1] T. Kurosawa *et al.*, J. Phys. Soc. Jpn. **85**, 044709 (2016).
[2] C. V. Parker *et al.*, Nature **468**, 677 (2010).
[3] Y. Kohsaka *et al.*, Nature **454**, 1072 (2008).
[4] T. Kurosawa *et al.*, Phys. Rev. B **81**, 094519 (2010).
[5] Y. Kohsaka *et al.*, Science **315**, 1380 (2007).
[6] T. Hanaguri *et al.*, Nat. Phys. **3**, 865 (2007).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.375

High-magnetic field magnetization in alkali-metal superoxide, CsO_2

Miyajima M.[1], Astuti F.[2,3], Matsuo A.[4], Kakuto T.[1], Sari D.P.[2,5], Asih R.[2,5], Nakano T.[5], Nozue Y.[5], Kindo K.[4], Watanabe I.[2,3,5], Kambe T.[1]

[1]Okayama University, Physics, Okayama, Japan, [2]RIKEN Nishina Center, Advanced Meson Science Laboratory, Wako, Japan, [3]Hokkaido University, Physics, Sapporo, Japan, [4]University of Tokyo, Institute for Solid State Physics, Kashiwa, Japan, [5]Osaka University, Physics, Osaka, Japan

Magnetism of alkali-metal superoxide, AO_2 (A = Na, K, Rb and Cs), originates in unpaired π-electron on the O_2 molecule. Among them, CsO_2 can be considered as the spin-1/2 one-dimensional (1D) Heisenberg antiferromagnet. It is proposed that, due to the orbital-ordering of O_2 molecule below T_S ~ 70 K [1], the magnetic exchange interaction path between O_2 molecules elongates along the *b*-axis, which should correspond to the 1D axis. Below 9.6 K (= the Néel ordering temperature, T_N), the long-ranged antiferromagnetic ordering was observed. Moreover, NMR experiments suggested a Tomonaga-Luttinger liquid (TLL) state below ~30 K [2]. Here, we have carried out high-magnetic field magnetization measurements in CsO_2 in pulsed-magnetic fields of up to 60 Tesla to investigate the direct evidence for the 1D character. Remarkable up-turn curvature in the magnetization around a saturation field of ~ 60 T is found, indicating the 1D nature of this spin system. The saturated magnetization is also estimated to be ~1 μ_B, which corresponds to the spin-1/2. We will present the full temperature dependence of high-magnetic field magnetization from T_S to T_N, and compare with the theoretical calculation.

References:

[1] S. Riyadi, et al., Phys. Rev. Lett., **108**, 217206 (2012).
[2] M. Klanjsek, et al., Phys. Rev. Lett., **115**, 057205 (2015).

Postersession 1
Thursday, 10 August 2017

16.30-18.30
G Foyer

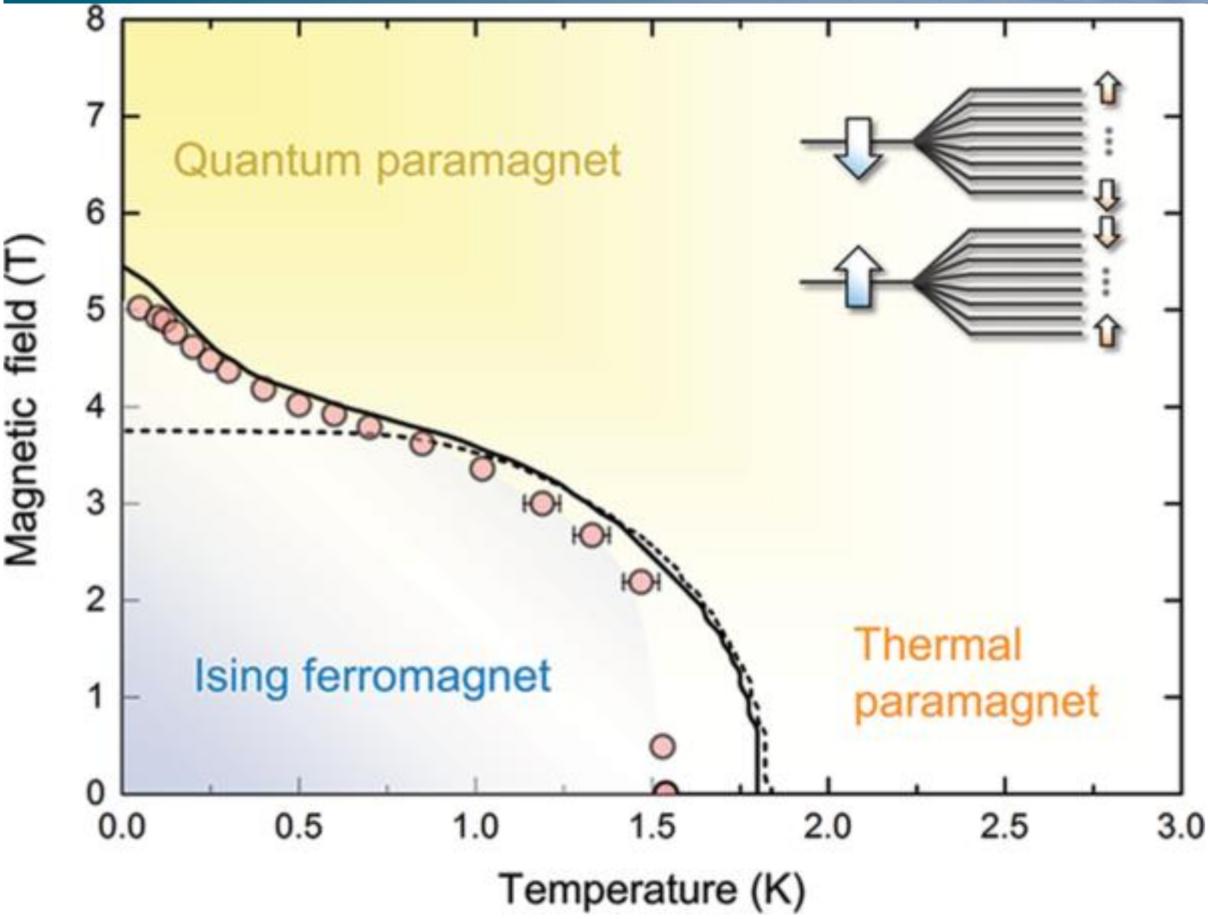
P.376
Intermediate representation between Matsubara and retarded Green functions: analytical continuation and compression
Otsuki J.[1], *Ohzeki M.*[2], *Shinaoka H.*[3], *Yoshimi K.*[4]
[1]Tohoku University, Department of Physics, Sendai, Japan, [2]Tohoku University, Graduate School of Information Sciences, Sendai, Japan, [3]Saitama University, Department of Physics, Saitama, Japan, [4]Institute for Solid State Physics, University of Tokyo, Kashiwa, Japan

Quantum Monte Carlo (QMC) methods are important tools of wide applicability in studies of quantum many-body systems. In practical computations, however, one frequently faces two problems:
(1) ill-conditioned analytical continuation of imaginary-time data to real-frequency spectra and
(2) massive high-dimensional data for multiple-time correlation functions.
The former reduces reliability of even highly accurate QMC data regarding dynamical properties, and the latter limits applications of sophisticated QMC simulations to realistic material calculations.
We propose a unified solution to the two apparently different problems based on an ``intermediate representation´´ (IR) between imaginary-time and real-frequency representations. By transforming QMC data to the IR basis, we can easily remove influences of statistical errors, leaving only relevant information unaffected by the errors. A stable analytical continuation is thus achieved [solution to (1)]. Furthermore, the IR provides a significantly compact representation of dynamical quantities including multiple-time correlation functions [solution to (2)]. The IR, therefore, provides general ways to boost the power of cutting-edge QMC computations in quantum many-body systems.
References:
[1] J. Otsuki, M. Ohzeki, H. Shinaoka, K. Yoshimi: arXiv:1702.03056 (2017)
[2] H. Shinaoka, J. Otsuki, M. Ohzeki, K. Yoshimi: arXiv:1702.03054 (2017)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.377
Probing strongly hybridized nuclear-electronic states in a model quantum ferromagnet
Dutta Mazumdar N., *M.Ronnow H., Chung M., Babkevich P., Kovacevic I.*
EPFL, Physics, Lausanne, Switzerland

$LiReF_4$ (Re- rare earth) are model materials for dipolar coupled quantum magnets. $LiHoF_4$ is an Ising ferromagnet. Its ground state in zero field is ferromagnetically ordered, but on applying a transverse magnetic field at zero temperature, a quantum phase transition to a quantum paramagnet occurs at 4.95 T, as shown in figure 1. Also, the hyperfine coupling strength of Ho^{3+} ion is exceptionally large, resulting in strong hybridization between the electronic and nuclear magnetic moments.This leads to two dramatic effects near to quantum critical point; firstly, significant modification of the low-temperature phase boundary and secondly, incomplete mode softening of the low-energy electronic excitations at the critical point. Thus, this system provides a rare opportunity to explore quantum phase transition of a magnet coupled to a nuclear spin bath. But till now, there has been no microscopic realization of this unique nuclear-electronic Ising model.



[Figure 1]

In our lab we have been able to demonstrate experimentally the nuclear-electronic magnetic resonance in $LiHoF_4$ using coplanar resonators and a vector network analyzer. Our results are remarkably well reproduced by mean-field calculations with parameters set by independent spectroscopic measurements.

References:
[1] I.Kovacevic, PHYSICAL REVIEW B 94, 214433 (2016).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.378

Thermal expansion and magnetostriction measurements of perovskite-type Co oxides $Sr_{1-x}Y_xCoO_{3-\delta}$ in high magnetic fields

Imura S.[1], *Kimura S.*[1], *Awaji S.*[1], *Terasaki I.*[2]
[1]Institute for Materials Research (IMR), Tohoku University, High Field Laboratory for Superconducting Materials, Sendai, Japan, [2]Nagoya University, Department of Physics, Nagoya, Japan

The perovskite-type Co oxides, of which magnetism is characterized by Co^{3+} ion with $3d^6$ electronic configuration, show very rich physical behaviors associated with spin crossover. $Sr_{1-x}Y_xCoO_{3-\delta}$ undergoes a ferromagnetic transition in a narrow compositional range of 0.2 *x* 0.25 at about 350 K, which is the highest Currie temperature (T_C) among the perovskite-type Co oxides[1]. Magnetic properties of $Sr_{1-x}Y_xCoO_{3-\delta}$ are greatly changed by temperature, pressure or chemical composition of the sample. As shown in Figure 1, the magnetization of the x = 0.25 sample shows a curious behavior as follows. The magnetization increases upon cooling below T_C as usual ferromagnetic materials, while an abrupt decrease of magnetization is seen below 250 K. We consider that this decrease of the magnetization is due to the spin crossover from the high-spin to low-spin state. In general, a crystal lattice is largely changed by the spin crossover[2]. In this study, we have measured the thermal expansion and magnetostriction in high magnetic fields, in order to examine the relationship between the magnetism and the crystal lattice of $Sr_{1-x}Y_xCoO_{3-\delta}$ (x = 0.25).

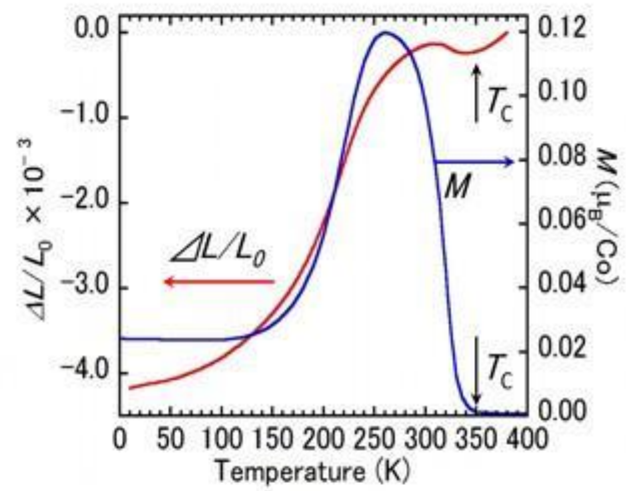


Figure 1 : Temperature dependences of the thermal expansion at 0 T and the magnetization at 0.1 T for $Sr_{1-x}Y_xCoO_{3-\delta}$ ($x = 0.25$)

[Figure]

References:
[1] W. Kobayashi *et al.*, Phys. Rev. B **72**, 104408 (2005)
[2] P. Gutlich *et al*., Angrew. Chem. Int. Ed. Engl. **33**, 2024 (1994)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.379
Magneto-transport measurements on multilayered graphene on SiC(000-1)
Tahar M.Z.
State University University of New York, College at Brockport, Physics, Brockport, United States

This report is on transport measurements for a multilayer graphene on the carbon face of a SiC sample. Both the magnetoresistance (MR) and Hall Effect were carried out at ten constant temperatures (2 K - 300 K) and magnetic field scans up to 9 T. The MR signal shows negative MR and sign reversal at low field (< 0.4 T) and temperatures above 50 K, and no sign reversal below that, up to 2 T. Additionally, for low temperatures (< 20 K) and high field (>2 T), the MR signal exhibits S.d.H. oscillations

of the same frequency f =64 T. The Hall Effect signal shows a linear increase with magnetic field (H < 0.3 T) and a leveling off at higher fields. Using the two signals and the metallic resistance with residual resistance ratio (RRR=1.7), one deduces the carrier concentration, 3.3 - 1.0 X10^{13} cm^{-2}, and mobility 3,700 - 21,000 cm^2/V-s at 300 K and below 20 K, respectively.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.381

Theory of two-photon absorption and amplitude mode in conventional superconductors with paramagnetic impurities

Jujo T.
Nara Institute of Science and Technology, Graduate School of Materials Science, Ikoma,Nara, Japan

The two-photon absorption (TPA) spectrum of BCS superconductors is theoretically investigated. We discuss possibility of observing the amplitude mode (one of collective modes in superconductors) in this spectrum. Though this collective mode is possibly observed in the TPA spectrum of superconductors with time reversal symmetry, the absorption edge by this mode appears at the same frequency as that by quasiparticle excitations. [1] Then it will be difficult to distinguish the amplitude mode from quasiparticle excitations. This property originates from the fact that the magnitude of superconducting order parameter is equal to one half of the energy gap in the linear absorption spectrum. In contrast to this the energy gap is smaller than twice the magnitude of order parameter in superconductors with paramagnetic impurities. Though the amplitude mode is not well-defined owing to the broken time reversal symmetry, a numerical calculation shows that the peak by this mode persists in the TPA spectrum. This peak appears at the frequency different from that of the absorption edge by quasiparticle excitations. Then it is possible to specify the amplitude mode in the TPA spectrum.

References:

[1] T. Jujo, J. Phys. Soc. Jpn. **84**, 114711 (2015).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.383

Thermal conductivity and magnetic phase diagram in the quasi-one-dimensional frustrated spin system $Na_3Fe_5Si_8O_{22}(OH)_2$

Kawamata T.[1], *Endo T.*[1], *Ohno M.*[1], *Sasaki T.*[2], *Koike Y.*[1]
[1]Tohoku University, Department of Applied Physics, Sendai, Japan, [2]Tohoku University, Institute for Materials Research, Sendai, Japan

We have measured the thermal conductivity, magnetic susceptibility and specific heat of single crystals of the quasi-one-dimensional frustrated spin system $Na_3Fe_5Si_8O_{22}(OH)_2$, in order to investigate the thermal conductivity due to spins,κ_{spin}, and the magnetic phase diagram. $Na_3Fe_5Si_8O_{22}(OH)_2$ has quasi-one-dimensional spin chains consisted of edge-sharing FeO_6 octahedra running along the *c*-axis. In the spin chain, Fe spins are connected to form a triangular lattice, so that a geometric frustration exists between Fe spins. It has been found that both thermal conductivities parallel to and perpendicular to the *c*-axis, $\kappa_{//c}$ and $\kappa_{\perp c}$, respectively, decrease with decreasing temperature, indicating that little κ_{spin} exists owing to the strong spin fluctuation due to the spin frustration. From the temperature and magnetic-field dependences of $\kappa_{//c}$, the magnetic susceptibility and specific heat in magnetic fields parallel to the *c*-axis, furthermore, antiferromagnetic and spin-slop transitions [1] have been observed. Accordingly, the magnetic phase diagram of $Na_3Fe_5Si_8O_{22}(OH)_2$ has been determined.

References:

[1] R. J. Borg *et al*., AIP Conf. Proc. **24**, 365 (1975).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.384

Dynamical spin structure factors of α-$RuCl_3$

Suzuki T., Suga S.-I.
University of Hyogo, Himeji, Japan

Honeycomb-lattice magnet α-$RuCl_3$ has attracted much attention as a potential candidate of realizing Kitaev spin liquid. Several effective models by *ab-initio* calculations have been proposed. Although the features of the effective models are qualitatively different with each other, they have succeeded in explaining observed thermodynamic quantities. The adequate effective model is thus controversial. Dynamical properties may offer key roles in considering the adequate effective model, which is helpful to search Majorana fermions in α-$RuCl_3$. Quite recently, inelastic neutron-scattering experiments using single crystals have unveiled characteristic dynamical properties of excited states [1,2]. The results have been analyzed with a phenomenological method [1] and using the pure Kitaev model [2], leading to the different conclusions on the dominant interaction. In this study, we calculate dynamical spin structure factors of three effective models [3-5] with an exact numerical diagonalization method. We also calculate the temperature dependences of the specific heat and the entropy by employing thermal pure quantum states [6,7]. We compare our numerical results with experiments and discuss characteristics obtained by using three effective models.

References:

[1] A. Banerjee, *et al*., arXiv:1609.00103.
[2] S.-H. Do, *et al*., arXiv:1703.01081.
[3] H.-S. Kim *et al*., Phys. Rev. B **93**, 155143 (2016).
[4] S. M. Winter, *et al*., Phys. Rev. B **93**, 214431 (2016).
[5] R. Yadav, *et al*., Sci. Rep. **6**, 37925 (2016).
[6] A. Hans and H. D. Readt, Phys. Rev. E **64**, 4365 (2000).
[7] Shimizu and Sugiura, Phys. Rev. Lett. **108**, 240401 (2012); *ibid*. **111**, 010401 (2013).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.386

Reduction annealing effects on Cu *K*-edge XAFS in electron-doped cuprate superconductors

Asano S.[1], Suzuki K.[2], Matsumura D.[3], Ishii K.[4], Ina T.[5], Fujita M.[2]

[1]Tohoku University, Sendai, Japan, [2]Institute for Materials Research (IMR), Tohoku University, Sendai, Japan, [3]Japan Atomic Energy Agency, Hyogo, Japan, [4]National institutes for Quantum and Radiological Scince and Technology, Hyogo, Japan, [5]Japan Synchrotron Radiation Research Institute, Hyogo, Japan

In electron-doped cuprate superconductors $R_{2\text{-}x}Ce_xCuO_{4\text{-}\delta}$ (*R* : rear earth), reduction annealing and carrier doping by Ce substitution are necessary for the emergence of superconductivity. It is recognized that a small amount of oxygen can be removed by reduction annealing, resulting into a drastic change of physical property. However, the microscopic mechanism of annealing has not been fully understood yet.
To investigate annealing effects on the electronic states at the Cu sites, we performed Cu *K*-edge transmission XAFS measurements for as-sintered and annealed $R_{2\text{-}x}Ce_xCuO_{4\text{-}\delta}$ (*R* : Pr and Nd) (x = 0, 0.15).
For both systems (x = 0, 0.15), X-ray absorption near-edge structure (XANES) is modified by reduction annealing, and the change in structure is similar to the case of Ce doping [1]. This similarity suggests an increase of electron density at the Cu sites, indicating the electron doping by annealing. Furthermore, we found that in the all reduction annealed samples the XANES are reverted to that in the as-sintered one by additional oxygenate annealing. Since the superconductivity disappears by oxidation, these results suggest that a sufficient number of electron density induced by reduction annealing would be an important role for the emergence of superconductivity.

References:

[1] H. Oyanagi et al., Phys. Rev. B **42**, 10136 (1990).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.387

The radio-frequency response of linear arrays of mesoscopic Josephson junctions and its detector application

Kanyolo G.M., Nishigaki H., Mizugaki Y., Shimada H.
University of Electro-Communications, Department of Engineering Science, Tokyo, Japan

The interaction of radio-frequency (RF) electromagnetic fields with linear arrays of mesoscopic Josephson junctions was studied. The dc characteristic of a linear array of Al tunnel junctions was measured while a RF voltage was applied through the transmission line at 40 mK. In the range of frequency f, 1 MHz < f < 1 GHz, the Coulomb blockade (CB) was lifted gradually with increase in applied alternating voltage of the RF field irrespective of frequency. This lifting is quantitatively understood in terms of the multi-photon absorption and photon-assisted tunneling of a Cooper-pair into the array. This indicates a possibility of using linear arrays for on-chip detection of RF fields. Subsequently, we succeeded in detecting the RF field emitted by a superconducting single electron transistor (SSET) by using an array of junctions. The array was fabricated adjacent to the SSET at a distance 2-30 µm without any coupling structure. Both devices were also made of Al. The CB voltage range of the array rapidly decreased with increase in applied SSET voltage $0 < V < V_{JQP} = 0.37$ mV where the RF emission was by the ac Josephson effect [1] and further diminished with increase in V, with characteristic structures which corresponded to specific tunneling processes in SSET.

References:

[1] P.-M. Billangeon,F. Pierre,H. Bouchiat,and R. Deblock, Phys. Rev. Lett. **98**, 216802 (2007).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.388
Cooper-pair excitons and quasiparticle excitons in capacitively coupled chains of small Josephson junctions
Shimada H., Matsudo K., Ishida C., Mizugaki Y.
University of Electro-Communications, Department of Engineering Science, Tokyo, Japan

We demonstrate the transport of Cooper-pair excitons and quasiparticle excitons in capacitively coupled two chains of mesoscopic Al/AlO_x/Al Josephson junctions. In the device, each opposite electrodes of the two chains were mutually coupled via capacitance C_c (1-6 fF) that was greater than the capacitance C
(~ 1 fF) of the junction. Here, “exciton” means the bound state of each entity (a Cooper pair or a quasiparticle) and its positive hole due to the Coulomb interaction via C_c. The transport of these excitons manifested itself as current induction in the opposite direction when one of the chains was biased to pass a current in one direction and the other unbiased. The Cooper-pair excitons appeared when the bias voltage V was small, while the quasiparticle excitons appeared when V was above the superconducting-gap voltage. In both cases, the current induction characteristics were more prominent when the coupling strength C_c/C was larger and the temperature T lower, corresponding to a larger probability of forming the excitons. From the temperature dependence of the current-induction coefficient in the rage 80 mK < T < 1 K, we obtained the binding energies of these excitons, the magnitudes of which are consistent with those deduced from the equivalent capacitance model.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.391
Theory of superconductivity in a 2D Weyl Fermi gas at high magnetic fields applied to surface states of the TI Sb_2Te_3
Zhuravlev V.[1], Duan W.[2], Maniv T.[1]
[1]Technion - Israel Institute of Technology, Schulich Faculty of Chemistry, Haifa, Israel, [2]Peking University, School of Physics, Beijing, China

We apply the Nambu-Gorkov Green´s function approach to strongly type-II superconductivity in a 2D spin-momentum locked (Weyl) Fermi gas model at high perpendicular magnetic fields, in a study of novel magneto-quantum oscillations effects, which are strongly enhanced when the chemical potential is close to the Dirac point and the cyclotron effective mass, $m^*=E_F/v^2$ [1], is very small. For the Landau-level filling factor close to, or smaller than 1, it is found that the effective pair interaction constant increases with increasing magnetic field. For larger filling factor values the resulting self-consistent BdG equations in the vortex lattice state [2] reveal a novel quantum mixed state, characterized by a well-defined Landau-Bloch band structure in the quasi-particle spectrum and suppressed order-parameter amplitude, which sharply crossovers into the semi-classical result upon decreasing magnetic field. Application to the 2D superconducting state, observed recently on the surface of the topological insulator Sb_2Te_3 [3], accounts reasonably well for the experimental dHvA oscillations data,

revealing a strongly type-II superconducting system, with unusually small cyclotron mass, which can be realized only in the strong coupling superconductor limit.

References:
[1] M. I. Katsnelson, Graphene, Carbon in two Dimensions (Cambridge University Press, Cambridge, 2012).
[2] V. Zhuravlev, W. Duan and T. Maniv, Phys. Rev. B **95**, 024502 (2017).
[3] L. Zhao, H. Deng, I. Korzhovska, M. Begliarbekov, Z. Chen, E. Andrade, E. Rosenthal, A. Pasupathy, V. Oganesyan, and L. Krusin-Elbaum, "Emergent surface superconductivity in the topological insulator Sb_2Te_3", Nat. Commun. **6**, 8279 (2015).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.392
Fully coupled dynamics of two-fluid model in thermal counterflow: deformation of the Poiseuille normal fluid profile

Tsubota M.[1], *Yui S.*[1], *Kobayashi H.*[2]
[1]Osaka City University, Department of Physics, Osaka, Japan, [2]Keio University, Department of Physics, Hiyoshi Campus, Yokohama, Japan

Since the proposal of the two-fluid model in 1941 by Tisza and Landau, the model has succeeded in revealing many kinds of physics on superfluidity. Since the rotation of superfluid is sustained only by quantized vortices, the vortex filament model (VFM) has been used for superfluid 4He and worked very much. Most previous numerical studies of the VFM in thermal counterflow were performed for the periodic boundary condition under the prescribed normal fluid profile [1]. However, the recent visualization experiments observed the deformation of the normal fluid profile in a square channel [2], which invites us to study the fully coupled dynamics of two-fluid in a channel. This motivation is closely related to the old problem on the two-stage transition toward turbulence too [3]. Thus we study numerically the fully coupled dynamics of two-fluid model in thermal counterflow in a square channel. The superfluid and the normal fluid are treated by the VFM and the Navier-Stokes equation respectively, and they are coupled by mutual friction. We found the profile of the normal fluid can change from the Poiseuille flow to the tail-flattened flow[2]. We discuss the mechanism of the deformation.

References:
[1] K. W. Schwarz, Phys. Rev. B 38, 2398 (1988): H. Adachi et al., Phys. Rev. B 81, 104511 (2010)
[2] A. Marakov et al., Phys. Rev. B 91, 094503 (2015)"" [3] J. T. Tough, in Prog. Low Temp. Phys. , ed. C. J. Gorter (North-Holland, Amsterdam, 1982) Vol. VIII, p. 133

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.393
Decay of counterflow quantum turbulence in superfluid ^{4}He in a channel

Yui S.[1], *Tsubota M.*[1], *Gao J.*[2], *Guo W.*[2], *Vinen W.F.*[3]
[1]Osaka City University, Osaka, Japan, [2]Florida State University, Tallahassee, United States, [3]University of Birmingham, Birmingham, United Kingdom

We study numerically the decay of counterflow turbulence of superfluid ^4He in a channel by the vortex filament model. Quantum turbulence of thermal counterflow was discovered in 1950's, and lots of experimental and numerical studies have confirmed the picture that the statistically steady states are self-sustained by the competition between the excitation due to the injected heat and the dissipation of the mutual friction. However, there still remain many mysteries, and one of them is decay, namely how the vortex tangle decays after turning off the heat. Recent experiments observe that the line length density L of quantized vortices decays as t^{-1} at very short times , then as $t^{-3/2}$ at later times [1,2]. The previous numerical work addressed the decay of counterflow in a spatially homogeneous system [3], but we should study the decay of inhomogeneous counterflow in a channel [4]. We study numerically the decay of inhomogeneous counterflow
(i) between two parallel plates and
(ii) in a square channel. In both cases the normal fluid is prescribed to take the Poiseuille profile.
We obtain the decay coefficients of Vinen's equation as a function of temperature.

References:

[1] L. Skrbek, A. V. Gordeev, and F. Soukup, Phys. Rev. E 67, 047302 (2003)
[2] J. Gao at al., JETP Letters 103, 648 (2016)
[3] Y. Mineda, M. Tsubota, W. F. Vinen, J. Low Temp. Phys. 171, 511 (2013)
[4] S. Yui and M. Tsubota, Phys. Rev. B 91, 184504 (2015)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.394

Charge transport in Josephson junctions using atomistic models: beyond the cartoon picture of barrier tunnelling

Cyster M.J., Smith J.S., Vogt N., Vaitkus J.A., Russo S.P., Cole J.H.
Chemical and Quantum Physics, School of Science, RMIT University, Melbourne, Australia

In order to improve the noise performance of a Josephson junction, it is essential to link the details of the amorphous nature of the metal-oxide directly to the electrical characteristics of the junction. Starting from purely atomistic models of metal-oxide barriers, we have developed a numerical non-equilibrium Greens function (NEGF) model of charge transport through tunnel barriers in 1-, 2- and 3-dimensions. Using this model we can link structural disorder, density, stoichiometry, defect location and other materials characteristics directly to the electrical response of the junction. This provides a full computational model with which to benchmark new structures, as well as improve fabrication techniques to increase reproducibility and decrease noise sources.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.395

Charge order driven by Fermi-arc instability in electron-doped cuprate superconductors

Feng S., Mou Y.

Beijing Normal University, Department of Physics, Beijing, China

The recently discovered charge order is a generic electronic property of both the hole- and electron-doped cuprate superconductors [1,2], where a central issues is what mechanism causes the charge-order formation. Within the framework of the t-J model in the fermion-spin representation [3,4], the doping dependence of charge order in the electron-doped cuprate superconductors is studied by taking into account the electron self-energy effect (then the strong electron correlation effect) [5]. It is shown that as in the hole-doped cuprate superconductors [6], the charge-order state in the electron-doped cuprate superconductors is also driven by the Fermi-arc instability, with a characteristic wave vector corresponding to the hot spots of the Fermi arcs, therefore there is a common physical origin for the charge-order correlation in both the hole- and electron-doped cuprate superconductors. However, in a striking contrast to the hole-doped case [6], the magnitude of the charge-order wave vector in the electron-doped side increases almost linearity with the increase of doping. The theory also indicates that the Fermi-arc instability generated charge-order state in cuprate superconductors is intimately related to the strong electron correlation induced electron self-energy.

References:
[1] R. Comin and A. Damascelli, Annu. Rev. Condens. Matter Phys. **7**, 369 (2016).
[2] E. H. da Silva Neto *et al*., Sci. Adv. **2**, e1600782 (2016); E. H. da Silva Neto *et al*., Science **347**, 281 (2015).
[3] S. Feng *et al*., J. Phys.: Condens. Matter **16**, 343 (2004); S. Feng *et al*., Phys. Rev. B **49**, 2368 (1994).
[4] See, *e.g*., S. Feng *et al*., Int. J. Mod. Phys. B **29**, 1530009 (2015).
[5] Y. Mou *et al*., unpblished.
[6] S. Feng *et al*., Phil. Mag. **96**, 1245 (2016); H. Zhao *et al*., Physica C **534**, 1 (2017).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.397

Interference of?13×?13 and 3×3 supermodulations in TaS2 probed by scanning tunneling microscopy

<u>Fujisawa Y.</u>, Iwasaki T., Iwashita J., Kishimoto K., Nakada M., Fujita T., Demura S., Sakata H.
Tokyo University of Science, Shinjuku-ku, Japan

Charge density wave (CDW), spontaneous reconstruction of electron distribution and lattice in solid, has attracted many interests because of its relationship to exotic phenomena, such as high temperature superconductivity. One of the transition metal dichalcogenide TaS_2 exhibits various CDW formation in accordance with polytypes, such as 1*T*, 2*H*, and $4H_b$. For example, 1*T* (2*H*) - TaS_2 show commensurate CDW with $\sqrt{13}a_0\times\sqrt{13}a_0$ ($3a_0\times3a_0$) supermodulation (SM) at 4.2 K (a_0 is lattice constant at normal state) [1, 2]. We have studied 2*H*-TaS_2 by scanning tunneling microscopy at 4.2 K and discovered interference of $13a_0\times\sqrt{13}a_0$ and $3a_0\times3a_0$ SM. This is caused by the existence of 1*T* layer under top-most 2*H* layer: Similar stacking to $4H_b$ polytype may exist. However, the observed interference pattern is different from the surface structure observed in pure $4H_b$ polytype [3]. We will discuss the origin of the interference pattern in the conference.

References:
[1] J. J. Kim *et al.*, Phys. Rev. Lett. **73**, 2103 (1994).
[2] J. Dai *et al*., Phys. Rev. B **89**, 165140 (2014).
[3] W. Han *et al.*, Phys. Rev. B (R) **50**, 14746 (1994).

Postersession 1

Thursday, 10 August 2017
16.30-18.30
G Foyer

P.398

Motion of electrically charged metallic microparticles in superfluid helium

Moroshkin P.[1], *Leiderer P.*[2], *Kono K.*[1,3,4]
[1]RIKEN, Center for Emergent Matter Science, Wako, Japan, [2]University of Konstanz, Department of Physics, Konstanz, Germany, [3]National Chiao Tung University, Institute of Physics, Hsinchu, Taiwan, Republic of China, [4]Kazan Federal University, Institute of Physics, Kazan, Russian Federation

We present an experimental study of the motion of metallic nano- and microparticles injected into superfluid helium in the presence of a vertical static electric field. The particles are produced by laser ablation and their dynamics is controlled by electric charges attached to the particles and distributed in the sample volume. If no charge carriers are injected into the liquid, the particles charge once in the contact with a submerged electrode, rise up, and become trapped under the free surface of the liquid due to the combined action of the electrostatic force and the surface tension. We investigate their dynamics in the trap driven by the variations of the external electric field, surface waves, and thermal counterflow. Injection of free electrons or positive ions into the liquid from above leads to a recharging of the trapped microparticles and their motion in the vertical direction [1, 2]. Our results contribute to the understanding of the recently discovered phenomenon of nanowire and network formation at the free surface of superfluid helium [1].

References:

[1] P. Moroshkin *et al*., Phys. Chem. Chem. Phys. **18**, 26444 (2016)
[2] P. Moroshkin, P. Leiderer, K. Kono, Phys. Fluids, accepted (2017)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.399

Anisotropy of the Seebeck and Nernst effect in $BaFe_2As_2$ and $CaFe_2As_2$ parent compounds

Matusiak M.[1], *Wolf T.*[2], *Babij M.*[1]
[1]Institute of Low Temperature and Structure Research PAS, Wroclaw, Poland, [2]Karlsruhe Institute of Technology, Institute of Solid State Physics (IFP), Karlsruhe, Germany

Phases with spontaneously broken symmetries driven by electronic correlations rather than the anisotropy of the underlying crystal lattice have recently attracted a considerable attention. Despite of clear experimental evidence for the existence of the nematic order in iron based superconductors, its origin remains debatable. Here we report studies of the Seebeck and Nernst effects that turned out to be highly sensitive to the existence of either long- or short-range nematic order. Measurements were carried out on detwinned by uniaxial stress (controlled in situ) $BaFe_2As_2$ and $CaFe_2As_2$ single crystals.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.400
Helical gaps in interacting Rashba wires
Schmidt T.
University of Luxembourg, Luxembourg, Luxembourg

A partially gapped spectrum due to the application of a magnetic field is one of the main probes of Rashba spin-orbit coupling in the nanowires used in the quest for Majorana fermions. I will present results about the helical gap with a particular focus on the interplay between Rashba spin-orbit coupling and electron-electron interactions.
In a quasi-one-dimensional wire, interactions can open a helical gap even without magnetic field [2,4,5], and indeed this prediction was recently verified experimentally [6]. To show how the two types of helical gaps, caused by magnetic fields or interactions, can be distinguished in experiments, we calculated dynamic response functions such as the spectral function, density of states and the structure factor [4]. Moreover, we showed that if a wire with such an interaction-induced helical gap is proximity-coupled to a superconductor it can host Z4-parafermions [2].
The helical gap typically occurs at low electron densities where the Coulomb energy dominates over the kinetic energy. To address this strongly correlated limit, we have also investigated Rashba wires using Wigner crystal theory [3,5].
References:
[1] T. L. Schmidt, Phys. Rev. B, 88, 235429 (2013)
[2] C. J. Pedder, T. Meng, R. P. Tiwari, and T. L. Schmidt, arxiv/1507.08881 (2015)
[3] T. L. Schmidt and C. J. Pedder, Phys. Rev. B 94, 125420 (2016)
[4] C. J. Pedder, T. Meng, R. P. Tiwari, and T. L. Schmidt, Phys. Rev. B 94, 245414 (2016)
[5] V. Kornich, C. J. Pedder, T. L. Schmidt, Phys. Rev. B 95, 045413 (2017)
[6] S. Heedt et al., Nat. Phys. (2017), doi:10.1038/nphys4070

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.401
String-valence bond solid phase of frustrated $J_1 - J_2$ transverse field Ising model on the square lattice
Langari A., _Sadrzadeh M., Haghshenas R., S. Jahromi S.S._
Sharif University of Technology, Physics Dept., Tehran, Iran, Islamic Republic of

We investigate the ground-state nature of the transverse field Ising model on the J1-J2 square lattice at the highly frustrated point J2/J1 = 0.5. We consider two types of quantum fluctuations, harmonic ones by using linear spin-wave theory (LSWT) [1] with single-spin-flip excitations above a long-range magnetically ordered background and anharmonic fluctuations, by employing a cluster-operator approach (COA) with multispin cluster-type fluctuations above a nonmagnetic cluster-ordered background. Our findings reveal that the harmonic fluctuations of LSWT fail to lift the extensive degeneracy as well as signaling a violation of the Hellmann-Feynman theorem. However, the string-type anharmonic fluctuations of COA are able to lift the degeneracy toward a string valence-bond-solid (VBS) state, which is obtained from an effective theory consistent with the Hellmann-Feynman theorem as well. Our results are further confirmed by implementing numerical tree tensor network simulation [2]. The emergent nonmagnetic string VBS phase is gapped and breaks lattice rotational symmetry with only twofold degeneracy. The critical behavior is characterized by $\nu \sim = 1.0$ and $\gamma \sim = 0.33$ exponents.
References:
[1]- L.-P. Henry, P. C. W. Holdsworth, F. Mila, and T. Roscilde, Phys. Rev. B 85, 134427 (2012).

[2]- M. Sadrzadeh, R. Haghshenas, S. S. Jahromi, and A. Langari, Phys. Rev. B 94, 214419 (2016).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.402

Resonant x-ray scattering study on electronic hybridization in unconventional ordered phase of $PrRu_4P_{12}$

Nakao H.[1], *Tabata C.*[1], *Iwasa K.*[2]

[1]High Energy Accelerator Research Organization, Institute of Materials Structure Science, Tsukuba, Japan, [2]Ibaraki University, Frontier Research Center for Applied Atomic Sciences & Institute of Quantum Beam Science, Naka, Japan

Filled skutterudite $PrRu_4P_{12}$ exhibits a metal-insulator (MI) transition at T_{MI} = 63 K [1,2], and has attracted much attention about an origin of the transition, i.e. charge density wave [3], antiferro-hexadecapole order [4, 5], and so on. Neutron scattering study elucidated the presence of strong orbital hybridization between Pr *4f* and P *3p* (*p-f* hybridization), which causes the formation of staggered *f*-electron order below T_{MI} [6]. Hence the *p-f* hybridization is expected to be essential for the MI transition. On the other hand, photoemission study indicated that there is no notable change in the *p-f* hybridization strength across the MI transition [7]. Therefore, the effect of *p-f* hybridization on the electronic ordering is still a controversial problem in $PrRu_4P_{12}$.
In order to clarify the hybridized state in the unconventional ordered phase, resonant x-ray scattering has been performed at the Pr L_3-edge, the P *K*-edge, and the Ru L_3-edge. Resonating energy spectra at the 111 forbidden reflection were found at the Pr L_3-edge and P *K*-edge, while it was not observed at the Rh L_3-edge. This is the first observation of quite large resonant signal at the P *K*-edge. This result is considered as a direct evidence for the strong *p-f* hybridization effect on the staggered order phase.

References:

[1] C. Sekine et al., Phys. Rev. Lett. **79**, 3218 (1997).
[2] C. H. Lee et al., Phys. Rev. B **70**, 153105 (2004).
[3] H. Harima et al., Physica B **312-313**, 843 (2002).
[4] Y. Kuramoto et al., Prog. Theo. Phys. Suppl. **160**, 134 (2005).
[5] T. Takimoto, J. Phys. Soc. Jpn. **75**, 034714 (2006).
[6] K. Iwasa et al., Phys. Rev. B **72** (2005) 024414; J. Phys. Soc. Jpn. **74**, 1930 (2005).
[7] A. Yamasaki et al., Phys. Rev. B **77**, 165125 (2008).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.403

Fulde-Ferrell-Larkin-Ovchinnikov phase in layered organic superconductor β´´-(BEDT-TTF)$_4$[(H_3O)X(C_2O4)$_3$]Y

Uji S.[1,2], *Iida Y.*[1,2], *Sugiura S.*[1,2], *Sugii K.*[3], *Isono T.*[4], *Yasuzuka S.*[5], *Kikugawa N.*[1], *Terashima T.*[1], *Akutsu H.*[6], *Nakazawa Y.*[6], *Day P.*[7]

[1]National Institute for Materials Science, Tsukuba, Japan, [2]University of Tsukuba, Graduate School of Pure and Applied Sciences, Tsukuba, Japan, [3]University of Tokyo, ISSP, Kashiwa, Japan, [4]RIKEN,

Wako, Japan, [5]Hiroshima Institute of Technology, Research Center for Condensed Matter Physics, Hiroshima, Japan, [6]Osaka University, Graduate School of Science, Toyonaka, Japan, [7]University College London, Department of Chemistry, London, United Kingdom

In conventional superconductors, the superconducting order parameter is spatially homogeneous. However, when the superconductivity is in the clean limit, and the orbital effect is strongly quenched, so-called Fulde and Ferrell [1], and Larkin and Ovchinnikov (FFLO) phase [2] can be stabilized in fields above the Pauli limit H_{Pauli}. Layered organic superconductors are best candidates for the FFLO phase studies[3-5]. In the FFLO phase, the order parameter oscillates in real space, leading to periodic nodal planes. To investigate the nature of the FFLO phase, we have performed systematic measurements of resistance and magnetic torque in organic superconductors,β´´-(BEDT-TTF)$_4$[(H$_3$O)X(C$_2$O$_4$)$_3$]Y, X=Ga,Fe, Y=Nitrobenzene. The large counter-anion [(H$_3$O)X(C$_2$O4)$_3$]Y makes the electronic state highly two dimensional (2D). The H_{c2} value is strongly anisotropic, showing a highly 2D superconductivity. The obtained phase diagram in parallel fields clearly shows that H_{c2} significantly exceeds H_{Pauli}, which strongly suggests the presence of FFLO phase above H_{Pauli},. The observation of the quantum oscillations shows the presence of the small 2D Fermi surface and high quality of the samples as well. The results are compared with other FFLO phases.[3-5]

References:

[1] P. Fulde and R. A. Ferrell, Phys. Rev. 135, A550 (1964).
[2] A. I. Larkin and Y. N. Ovchinnikov, Sov. Phys. JETP 20, 762 (1965).
[3] S. Uji, et al., Phys. Rev. B 85, 174530 (2012).
[4] S. Uji, et al., J. Phys. Soc. Jpn. 82, 034715 (2013).
[5] S. Uji, et al., J. Phys. Soc. Jpn. 84, 104709 (2015).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.404

Spontaneous magnetization of the spin-1/2 Heisenberg antiferromagnet on the triangular lattice with a distortion

Shimada A.[1], Sakai T.[2,3], Nakano H.[2], Yoshimura K.[1]
[1]Kyoto University, Graduate School of Science, Kyoto, Japan, [2]University of Hyogo, Graduate School of Material Science, Kamigori, Japan, [3]QST SPring-8, Sayo, Japan

The triangular-lattice antiferromagnet is a typical system that has attracted much attention from its behavior owing to frustrations. It is widely believed that the so-called 120-degree structure is realized as a spin structure of its ground state. Some experiments reported that antiferromagnets have the triangular-lattice structure.[1,2,3] Some of them however include a distortion in the triangular lattice.[2,3] The purpose of this study is to clarify effects of such a distortion in the spin-1/2 triangular-lattice Heisenberg antiferromagnet by means of a numerical-diagonalization method of the Lanczos algorithm. We examine the model between the two cases, one is the undistorted triangular lattice and the other is the model on the honeycomb lattice with isolated spins. Our numerical results suggest that the ground states for the two limiting cases do not show a spontaneous magnetization; however, there appear nonzero spontaneous magnetizations in an intermediate region. The spontaneous magnetization is smaller than one third of the saturated magnetization and increases gradually as the distortion is larger. The spin structure of the state with spontaneous magnetization is different from other states with spontaneous magnetization observed in different cases.[4,5]

References:

[1]Y. Shirata, H. Tanaka, A. Matsuo, K. Kindo, Phys. Rev. Lett. 108, 057205 (2012).

[2]H. Tanaka and K. Kakurai, J. Phys. Soc. Jpn. 63, 3412 (1994).
[3]Y. Nishiwaki, A. Osawa, K. Kakurai, K. Kaneko, M. Tokunaga, and T. Kato, J. Phys. Soc. Jpn. 80, 084711 (2011).
[4]H. Nakano, T. Shimokawa, and T. Sakai, J. Phys. Soc. Jpn. 80, 033709 (2011).
[5]H. Nakano and T. Sakai, to be published in J. Phys. Soc. Jpn.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.405

Electronic state in the undoped superconductor T´-$La_{1.8}Eu_{0.2}CuO_4$ studied from impurity effects

Kawamata T.[1], *Ohashi K.*[1], *Takamatsu T.*[1], *Adachi T.*[2], *Watanabe I.*[3], *Kato M.*[1], *Koike Y.*[1]
[1]Tohoku University, Department of Applied Physics, Sendai, Japan, [2]Sophia University, Department of Engineering and Applied Sciences, Tokyo, Japan, [3]RIKEN Nishina Center, Advanced Meson Science Laboratory, Wako, Japan

In order to investigate the electronic state in the undoped superconductor T´-$La_{1.8}Eu_{0.2}CuO_4$ (T´-LECO), we performed muon spin relaxation (µSR) measurements using superconducting (SC) reduced samples of T´-$La_{1.8}Eu_{0.2}Cu_{1-y}M_yO_4$ (M = Ni, Zn; x = 0, 0.005, 0.01) and a non-SC as-grown sample of T´-LECO. Our recent studies on undoped superconductors have suggested a new electronic-structure model based on the strong electron correlation, where a finite density of states at the Fermi level is induced owing to the collapse of the charge-transfer (CT) gap [1-5]. From the analysis of µSR spectra, it has been found that phase separation into SC regions and magnetically ordered regions takes place and that no magnetic order appears around *M* in the SC regions of the *M*-substituted reduced samples. Furthermore, it has also been found that the electronic state in the SC regions of T´-LECO is understood as a strongly correlated itinerant electron system, while that in the magnetically ordered regions formed around excess oxygen is understood as an insulating localized-spin system induced by the carrier localization and/or the local opening of the CT gap. The present results strongly support that the electronic-structure model based on the strong electron correlation holds good in T´-LECO.

References:

[1] T. Takamatsu *et al*., Appl. Phys. Express **5** (2012) 073101.
[2] T. Adachi *et al*., J. Phys. Soc. Jpn. **82** (2013) 063713.
[3] T. Takamatsu *et al*., Phys. Procedia **58** (2014) 46.
[4] K. Ohashi *et al*., J. Phys. Soc. Jpn. **85** (2016) 093703.
[5] T. Adachi *et al*., J. Phys. Soc. Jpn. **85** (2016) 114716.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.406

Developing MEMS gyroscope with signal sensitivity to detect angular momentum of ^{3}He-A

Jeong J.[1], *Byun H.*[1], *Kim K.*[1], *Kim S.G.*[2], *Shim S.-B.*[2], *Suh J.*[2], *Choi H.*[1]
[1]KAIST, Physics, Daejeon, Korea, Republic of, [2]KRISS, Daejeon, Korea, Republic of

One of the hallmarks of topological materials is presence of topologically protected states at their boundaries. Topological superconductor (TSC) also should have edge states and it is expected to include Majorana Fermions which is a promising candidate of topological quantum computing. Superfluid ^{3}He-A, a well-established p_x+ip_y superfluid, confined in a 2D slab has 1D chiral edge states on its boundary much like the integer quantum Hall systems. This chiral flow in 1 µm thick ^{3}He-A slab produces angular momentum on the order of 10^{14} ħ. Our analysis reveals that a carefully designed cryogenic micro-electro-mehcanical systems (MEMS) gyroscopic device should have good enough signal sensitivity to measure such a signal.[1] We report the experimental design and our progress in fabricating the planar MEMS gyroscope for this purpose.

References:

[1] arXiv:1609.07641v2 [cond-mat.supr-con]

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.407

Electronic structure of electron-doped cuprate superconductors in pseudogap phase

<u>Mou Y.</u>, Feng S.
Beijing Normal University, Department of Physics, Beijing, China

The understanding the pseudogap regime in cuprate superconductors is thought to be key to understanding the high-T_c phenomenon in general, where an important component will be the determination of the particular characteristics of the electronic structure [1,2]. Based on the kinetic energy driven superconducting mechanism [3,4], we study the electronic structure of the electron-doped cuprate superconductors in the pseudogap phase. It is shown that the amplitude of the electron self-energy (then the pseudogap) around the nodes is smaller than that around the antinodes, in qualitative agreement with the experimental results [2]. In particular, this special structure of the self-energy therefore generates a coexistence of the Fermi arcs and Fermi pockets in the electron-doped cuprate superconductors. Moreover, in corresponding to the large values of the electron self-energy around the antinodal region, the dispersion of the electron excitations around the antinodal point has an anomalously small changes of electron energy as a function of momentum, leading to appearance of the unusual flat band around the antinodal point. In analogy to the hole-doped case [5], the theory also indicates that the peak-dip-hump structure in the electron spectrum is absent from the hot-spot directions.

References:

[1] See, e.g., the review, A. Damascelli *et al*., Rev. Mod. Phys. **75**, 473 (2003).
[2] M. Horio *et al*., Nat. Commun. **7**, 10567 (2016); D. Song *et al*., Phys. Rev. Lett. **118**, 137001 (2017).
[3] S. Feng, Phys. Rev. B **68**, 184501 (2003); S. Feng *et al*., Phys. Rev. B **85**, 054509 (2012).
[4] See, *e.g*., the review, S. Feng *et al*., Int. J. Mod. Phys. B **29**, 1530009 (2015).
[5] H. Zhao *et al*., Physica C **534**, 1 (2017).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.408

Transfer of light´s orbital angular momentum onto exciton-polariton condensates

Oh B.Y.[1], *Kwon M.*[1,2], *Gong S.-H.*[1,2], *Kim J.-H.*[1,2], *Kang H.K.*[3], *Kang S.*[3], *Song J.D.*[3], *Cho Y.-H.*[1,2], *Choi H.*[1]
[1]Korea Advanced Institute of Science and Technology (KAIST), Physics, Daejeon, Korea, Republic of, [2]Korea Advanced Institute of Science and Technology (KAIST), KI for the Nanocentury, Daejeon, Korea, Republic of, [3]Korea Institute of Science and Technology (KIST), Seoul, Korea, Republic of

Exciton polariton condensates are a unique system manifesting superfluidity through Bose-Einstein condensate-like transition in semiconductors. The system has a great potential for quantum fluid dynamics research by controlling quantized vortices in a driven-dissipative superfluid by optical manipulation and detection. In this study, we observed quantized vortices generated by the transfer of non-resonant pump beam´s angular momentum onto the polariton. A large energy difference between pumped electron-hole state and the final polariton condensate requires relaxation of the hot carriers through phonon scattering. It has been widely believed to destroy the original quantum states of incident light such as momentum and angular momentum. Our finding suggests otherwise and some of the information, i.e., angular momentum, is conserved within polaritons through the relaxation process. We measured not only the creation but also the chirality and stability of these vortices, confirming that these are generated by orbital angular momentum transfer. This study will open further discussion on the relaxation mechanism by using nonresonant pump in exciton polariton.
Equally contributing authors : B.Y. Oh & M. Kwon

References:

[1] J. Kasprzak *et al.* Nature **443**, 409-414 (2006)
[2] K. Lagoudakis et al. Nat. Phys. **4**, 706-710 (2008)
[3] H. Deng et al. Rev. Mod. Phys. **82**, 1489-1537 (2010)
[4] I. Carusotto et al. Rev. Mod. Phys **85**, 299-396 (2013)
[5] D. Sanvitto et al. Nat. Phys. **6**, 527-533 (2010)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.409

Pseudogap-induced anisotropic suppression of electronic Raman response in cuprate superconductors

Liu Y.[1], *Jing P.*[1], *Zhao H.*[2], *Kuang L.*[3], *Feng S.*[1]
[1]Beijing Normal University, Department of Physics, Beijing, China, [2]Qingdao University, College of Physics, Qingdao University, Qingdao, China, [3]Sugon National Research Center for High-Performance Computing Engineering Technology, Beijing, China

It has become clear that the anomalous properties of cuprate superconductors are intimately related to the formation of a pseudogap [1]. Within the framework of the kinetic-energy-driven superconducting mechanism [2,3], the effect of the pseudogap on the electronic Raman response of cuprate superconductors in the superconducting-state [4] is studied by taking into account the interplay between the superconducting gap and pseudogap. It is shown that the low-energy spectra almost rise as the cube of energy in the B_{1g} channel and linearly with energy in the B_{2g} channel [5]. It is also shown that the pseudogap is strongly anisotropic in momentum space, where the magnitude of the pseudogap around the nodes is smaller than that around the antinodes, which leads to that the low-energy spectral weight of the B_{1g} spectrum is suppressed heavily by the pseudogap, while the pseudogap has a more modest effect on the electronic Raman response in the B_{2g} orientation [5].

References:

[1] See, *e.g.*, T. P. Devereaux *et al*., Rev. Mod. Phys. **79**, 175 (2007).
[2] S. Feng, Phys. Rev. B**68**, 184501 (2003); S. Feng *et al*., Phys. Rev. B**85**, 054509 (2012).

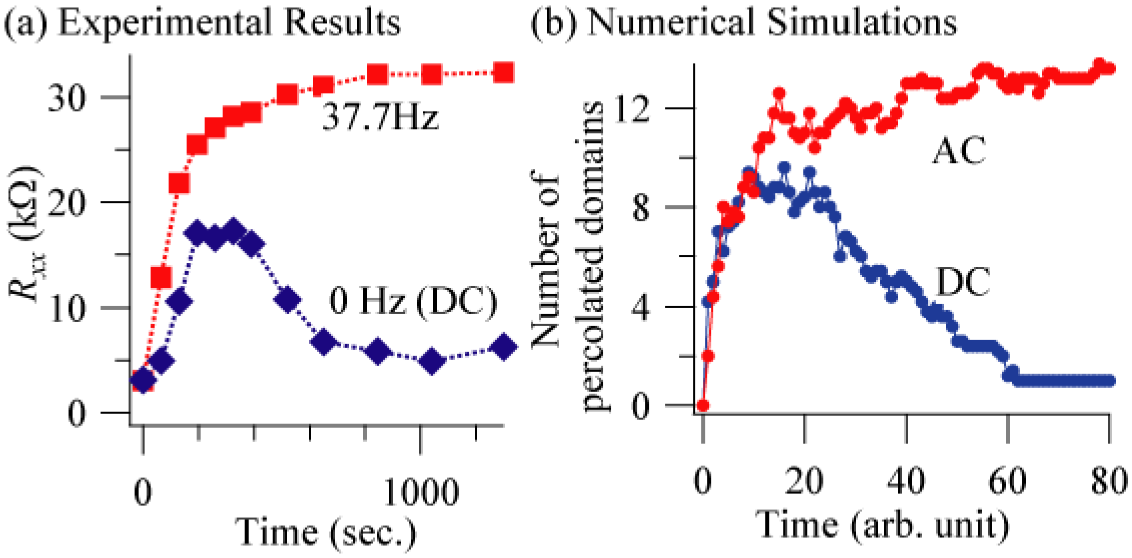
[3] See, *e.g.*, the review, S. Feng *et al*., Int. J. Mod. Phys. B **29**, 1530009 (2015).
[4] R. Nemetschek *et al*., Phys. Rev. Lett. **78**, 4837 (1997); J. G. Naeini *et al*., Can. J. Phys. **78**, 483 (2000); S. Sakai *et al*., Phys. Rev. Lett. **111**, 107001 (2013).
[5] P. Jing *et al*., Phil. Mag. Lett., in the press (2017), arXiv:1701.00693.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.410
Electron spin domain dynamics and the numerical simulations in the v=2/3 fractional quantum Hall state

Fukuda A.[1], *Tsuda S.*[2], *Terasawa D.*[1], *Sawada A.*[3]
[1]Hyogo College of Medicine, Physics Department, Nishinomiya, Japan, [2]Kyoto University, Department of Physics, Graduate School of Science, Kyoto, Japan, [3]Kyoto University, Research Center for Low Temperature and Materials Sciences, Kyoto, Japan

In the fractional quantum Hall states (QHSs) at the Landau level filling factor v = 2/3, magnetoresistance enhanced states (MESs) emerge by the current-induced dynamic nuclear spin polarization (DNP) owing to the electron-nuclear spin flip flops when the electric current passes through the domain walls between two different spin states. Recent intensive study of the transient MESs after DNP reveals that the magnetoresistance R_{xx} of the MESs has an insulator-like temperature dependence [1]. However detailed mechanisms of the MESs induced by the domain dynamics are still unclear and should be investigated. In this study, we carry out the current-induced DNP with large amplitude of 60 nA in the v = 2/3 QHSs and measure the time-dependent R_{xx} by changing the current frequency from 37.7 Hz down to the DC limit[Fig.(a)]. When we use the high frequency current, R_{xx} initially increases and saturates, which is a usual behavior. In contrast, when the DNP frequency approaches to 0, an unusual decrement followed by an increment of the R_{xx} is observed, and the MESs vanish finally. To explain these novel phenomena, we run a time-dependent numerical simulation of the percolation theory with two-spin Ising model[Fig.(b)], considering the recent optically imaged striped domain structures [2].



[Fig]

References:

[1] S. Tsuda *et al*., Phys. Rev. B **93**, 125426 (2016).
[2] J. N. Moore *et al*., Phys. Rev. Lett. **118**, 076802 (2017).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.411
Interference in magnetic focusing with strong spin orbit interactions
Bladwell S., *Sushkov O.*
University of New South Wales, School of Physics, Kensington, Australia

Transverse magnetic focusing (TMF), where a charge carrier is focused from a source to a detector by a weak magnetic field, has a long and impressive experimental history in solid-state physics. Recently, TMF has been employed in two dimensional hole systems characterized by extremely large spin-orbit interactions. In these systems, the spin orbit interaction leads to a real space splitting between the spin-states, and a resulting ´double´ focusing peak. This double peak allows for the exploration of polarization in the injector and detector, along with studies of the spin split Fermi surfaces. Two features of this system make it particularly interesting both experimentally and theoretically: a Fermi momentum comparable to the feature size [1, 2], and a secondary, tunable spin-orbit interaction that can be induced via an in-plane magnetic field [3]. In this theoretical work we examine the topic of interference in TMF in hole systems, focusing on the first magnetic focusing peak. We find that the small changes in the Fermi surface due to an in-plane magnetic field can significantly alter the magnetic focusing spectrum, leading to interference induced pseudo-polarization, among other effects. From our analysis we present detailed experimental predictions.
References:
[1] H. Van Houten, C. W. J. Beenakker, J. G. Williamson, M. E I Broekaart,
P. H. M. Van Loosdrecht, B. J. Van Wees, J. E. Mooij, C. T. Foxon, and J. J. Harris, Phys. Rev. B. **39**, 8556 (1989).
[2] S. Bladwell, O.P. Sushkov, arxiv:1702.04425, (2017)
[3] S. Bladwell, O.P. Sushkov, Phys. Rev. B. Phys. Rev. B **92**, 235416 (2015)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.412
Multipole interactions of Γ_3 non-Kramers doublet systems on cubic lattices
Kubo K.[1], *Hotta T.*[2]
[1]Japan Atomic Energy Agency, Advanced Science Research Center, Tokai, Japan, [2]Tokyo Metropolitan University, Department of Physics, Hachioji, Japan

In *f*-electron systems, multipole physics has been studied, in particular, on the Γ_8 systems. The Γ_8 quartet has sufficient degrees of freedom to possess higher-order multipoles such as octupoles and it is regarded as an ideal system for the multipole physics. However, such large degeneracy is not a necessary condition to possess higher-order multipoles. If the crystalline electric field (CEF) ground state does not have the dipole but is not a singlet, this state inevitably has higher-order multipoles.

Indeed, the Γ_3 non-Kramers doublet does not have the dipole but has quadrupole and octupole moments.
In this study, we investigate the multipole interactions between f^2 ions with the Γ_3 CEF ground state [1]. We construct the Γ_3 doublet state of the electrons with the total angular momentum j = 5/2. To derive the multipole interactions, we apply the second-order perturbation theory with respect to the intersite hopping. We obtain a quadrupole interaction for a simple cubic lattice, an octupole interaction for a bcc lattice, and both quadrupole and octupole interactions for an fcc lattice. To discuss general tendencies of the multipole interactions, we compare the present results with those for the Γ_8 quartet systems of f^1 ions [2,3].

References:
[1] K. Kubo and T. Hotta, Phys. Rev. B **95**, 054425 (2017).
[2] K. Kubo and T. Hotta, Phys. Rev. B **71**, 140404(R) (2005).
[3] K. Kubo and T. Hotta, Phys. Rev. B **72**, 144401 (2005).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.413
Superconductivity in alkali-metal- and organic-molecule-intercalated FeSe: comparison with single-layer FeSe films

Koike Y., Hatakeda T., Hosono S., Noji T., Sato K., Kawamata T., Kato M.
Tohoku University, Department of Applied Physics, Sendai, Japan

The simple layered compound FeSe has attracted great interest, because the superconducting transition temperature, T_c, dramatically increases from 8 K to ~45 K through the co-intercalation of alkali or alkali-earth metal and ammonia or organic molecules such as ethylenediamine ($C_2H_8N_2$) [1-3] and hexamethylenediamine ($C_6H_{16}N_2$) [4-6] between FeSe layers. Recently, we have succeeded in the synthesis of alkali-metal- and 2-phenethylamine-interclated $A_x(C_8H_{11}N_2)Fe_{1-z}Se$ (A = Li, Na) with T_c = 39 - 44 K and the largest interlayer spacing d of 19 Å among those of the FeSe-based intercalation superconductors [7]. It has been concluded that the relationship between T_c and d in the FeSe-based intercalation superconductors is not domic but T_c is saturated at ~45 K for d > 9Å. This saturated value of T_c is comparable to not onset T_c values due to the superconducting fluctuation but mean T_c values of single-layer FeSe films obtained from resistive measurements [8]. This is reasonable, because the single-layer FeSe films may be regarded as a kind of FeSe-based intercalation compound with infinite d values. Accordingly, it is concluded that the electronic structure of the single-layer FeSe films is very similar to that of the FeSe-based intercalation superconductors with large d values.

References:
[1] T. Hatakeda et al., J. Phys. Soc. Jpn. **82**, 123705 (2013).
[2] T. Noji et al., Physica C **504**, 8 (2014).
[3] T. Hatakeda et al., J. Phys.: Conf. Ser. **568**, 022032 (2014).
[4] S. Hosono et al., J. Phys. Soc. Jpn. **83**, 113704 (2014).
[5] S. Hosono et al., J. Phys. Soc. Jpn. **85**, 013702 (2016).
[6] S. Hosono et al., J. Phys. Soc. Jpn. **85**, 104701 (2016).
[7] T. Hatakeda et al., J. Phys. Soc. Jpn. **85**, 103702 (2016).
[8] J. Shiogai et al., Nat. Phys. **12**, 42 (2016).

Postersession 1

Thursday, 10 August 2017
16.30-18.30
G Foyer

P.415
Thermal conductivity due to spins in the two-dimensional quantum spin system $Ba_2Cu_3O_4Cl_2$ with the Cu_3O_4 plane
Kawamata T.[1], *Ohno M.*[1], *Akoshima M.*[2], *Koike Y.*[1]
[1]Tohoku University, Department of Applied Physics, Sendai, Japan, [2]National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan

We have measured the thermal conductivity of single crystals of $Ba_2Cu_{3-x}M_xO_4Cl_2$ (M = Co, Ni, Pd; x = 0, 0.03) with the Cu_3O_4 plane, in order to investigate the thermal conductivity due to spins, k_{spin}. In the Cu_3O_4 plane, there are two kinds of Cu, namely, Cu_A forming the CuO_2 plane and Cu_B being located at a space in the CuO_2 plane, and a geometric frustration exists between Cu_A and Cu_B spins. For x = 0, it has been found that the temperature dependence of the thermal conductivity along the ab-plane, k_{ab}, parallel to the Cu_3O_4 plane shows a peak at ~ 30 K, while the temperature dependence of the thermal conductivity along the c-axis perpendicular to the Cu_3O_4 plane shows only one peak at ~ 30 K and a broad peak at ~ 300 K. The broad peak at ~300 K in k_{ab} has been found to be suppressed through the substitution of M for Cu, so that the broad peak has been concluded to be due to the contribution of k_{spin}. The maximum value of k_{spin} has been estimated to be nearly equal to that observed in Ln_2CuO_4 (Ln: lanthanide element) with the CuO_2 plane [1-3]. Accordingly, it has been concluded that the CuO_2 plane contained in the Cu_3O_4 plane induces large k_{spin} and that the frustration between Cu_A and Cu_B spins in the Cu_3O_4 plane does not affect the presence of k_{spin}.
References:
[1] Y. Nakamura et al., Physica C **185-189**, 1409 (1991).
[2] C. Hess et al., Phys. Rev. Lett. **90**, 197002 (2003) .
[3] K. Berggold et al., Phys. Rev. B **73**, 104430 (2006).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.416
Electronic and transport properties in the BCS-BEC crossover regime: DMFT+CTQMC analysis of the attractive Hubbard model
Shimazu K.[1], *Nomoto T.*[2], *Hoshino S.*[2], *Nagai Y.*[3], *Ikeda H.*[1]
[1]Ritsumeikan University, Department of Physics, Kusatsu, Shiga, Japan, [2]RIKEN Center for Emergent Matter Science, Wako,Saitama, Japan, [3]CCSE, Japan Atomic Energy Agency, Wakashiba, Kashiwa, Chiba, Japan

In the research field of superfluidity/superconductivity, the crossover from a weak-coupling Bardeen-Cooper-Schrieffer (BCS) pairing state to a Bose-Einstein condensate (BEC) of the preformed boson has long been of interest. The crossover as a function of the attractive interaction between fermions has been well studied in an ultracold Fermi gas [1]. However, since it is difficult to be realized with electrons in solids, electronic and transport properties are not so clear yet. Recently, the superconducting semimetal FeSe has attracted a great deal of attention due to an expectation that it may be in the BCS-BEC crossover regime [2]. Here we have investigated the electronic and transport properties in the attractive Hubbard model using the dynamical mean field theory (DMFT) [3] and the hybridization expansion continuous-time quantum Monte Carlo method (CTQMC) [4]. We have evaluated the NMR relaxation rate $1/T_1$, the Knight shift and the electric resistivity under several magnetic field. We found that the temperature dependence of the NMR $1/T_1$ remarkably changes through the crossover regime. Our findings may be a clue to understanding the superconducting state in FeSe.

References:

[1] Q. Chen, J. Stajic, S. Tan, K. Levin, Physics Reports **412**, 1 (2005).
[2] S. Kasahara, Y. Yamashita, *et al.,* Nature Commun. **7**, 12843 (2016).
[3] A. Georges, G. Kotliar, W. Krauth, M. J. Rozenberg, Rev. Mod. Phys. **68** 13 (1996).
[4] E. Gull, A. J. Millis, et al., Rev. Mod. Phys. **83**, 349 (2011).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.417

Chern invariant in a Sr_2RuO_4 thin film

Nobukane H.[1,2], *Matsuyama T.*[2,3], *Tanda S.*[2,4]
[1]Hokkaido University, Department of Physics, Sapporo, Japan, [2]Hokkaido University, Center of Education and Research for Topological Science and Technology, Sapporo, Japan, [3]Nara University of Education, Department of Physics, Nara, Japan, [4]Hokkaido University, Department of Applied Physics, Sapporo, Japan

We report the observation of the Chern invariant in the Bose-insulating phase of a two dimensional Sr_2RuO_4 single crystal. We observed the superconductor-insulator transition in two dimensions by reducing the thickness of Sr_2RuO_4 single crystals. The presence of a gap structure in the insulating phase implies localized superconductivity. In a zero magnetic field, a quantized fractional Hall resistance was observed. We found the anomalous induced voltage and the switching behavior of the voltage for an applied magnetic field parallel to *c* axis. The results suggest the presence of the fractional topological magneto-electric effect in the Bose insulating phase of Sr_2RuO_4 thin films. We determined the fractional axion angle theta=pi/6 in the topological theta-term.

References:

[1] H. Nobukane, T. Matsuyama and S. Tanda, Sci. Rep. 7, 41291 (2017).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.418

Development of mechanical sensors for probing quantum fluids

Bradley I., Guthrie A., Jennings A., Haley R., Kafanov S., Pashkin Y., Pickett G., Poole M., Schanen R., Tsepelin V., Zmeev D.
Lancaster University, Lancaster, United Kingdom

Nanoelectromechanical systems (NEMS) have a great potential for sensing applications due to their strong temperature dependence, high mass sensitivity and extremely low power dissipation. Our work demonstrates the potential for NEMS to probe the properties of quantum fluids -- superfluid ^4He and ^3He at the lowest temperatures. We present our experiments with doubly clamped aluminium nano-beams operating in superfluid ^4He at mK temperatures. Experiments show a significant increase in the

quality factors of nanomechanical beams operated in superfluid when compared with vacuum measurements. Thus, the superfluid ^{4}He at mK temperatures behaves as a mechanical vacuum as well as providing good thermalization for nano-beams in the normal state. The measured power dependence of the quality factor in the superconducting state supports the idea that dissipation in the nanomechanical system is associated with the saturation of an ensemble of two--level fluctuators.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.419
Quantum phase slips in superconducting silicide nanowires
Lehtinen J., Mykkänen E., Kemppinen A., Manninen A.J.
VTT Technical Research Centre of Finland Ltd, Centre for Metrology MIKES, Espoo, Finland

A completely new class of quantum electronic devices based on quantum phase slips (QPS) is emerging [1-6]. Coherent QPS is the magnetic counterpart for charge tunneling in a Josephson junction (JJ): instead of charge tunneling through electrically insulating layer, magnetic vortices tunnel through a narrow superconducting nanowire (magnetic insulator). The effect is as fundamental as the Josephson effect. From the application point of view, nanowires may have major benefits compared to JJs: less fabrication process steps, robustness to larger electric currents, wide parameter range, and the lack of undesired two-level fluctuators present in the insulating contacts of JJs.
Highly disordered compound superconductors are promising materials for QPS based devices [2]. We have developed a fabrication process for high-resistivity ultra-narrow superconducting silicide nanowires. The process is suitable for controllable wafer scale fabrication of QPS components. We have measured transport properties of these nanowires as a function of cross section. The largest wires exhibit sharp superconducting transition, but as the cross section gets smaller, the QPS is observed.
References:
[1] J. Mooij and Y. V. Nazarov, Nature Phys. 2, 169 (2006)
[2] O. V. Astafiev et al., Nature 484, 355 (2012)
[3] J. S. Lehtinen et al., Phys. Rev. Lett. 109, 187001 (2012)
[4] T. T. Hongisto and A. B. Zorin, Phys. Rev. Lett. 108, 097001 (2012)
[5] J. T. Peltonen et al., Phys. Rev. B 88, 220506 (2013)
[6] S. Kafanov and N. M. Chtchelkatchev, J. Appl. Phys. 114, 073907 (2013)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.422
Strong bilayer coupling induced by the symmetry breaking in the monoclinic phase of BiS_2-based superconductors
Ochi M.[1], Akashi R.[2], Kuroki K.[1]
[1]Osaka University, Department of Physics, Osaka, Japan, [2]University of Tokyo, Department of Physics, Tokyo, Japan

BiS_2-based superconductors [1,2] have attracted much attention owing to their strong similarity to the layered superconductors such as the cuprates and the iron pnictides. Recent experimental studies have revealed that an abrupt increase (more than doubling) of the critical temperature in BiS_2-based superconductors [3-5] coincides with the structural phase transition from a P4/nmn tetragonal structure to a $P2_1/m$ monoclinic structure by applying the pressure [5,6]. This experimental observation strongly emphasizes the importance of the structural dependence of the electronic structure in the BiS_2-based superconductors. However, many theoretical studies so far have focused only on the tetragonal structure.
In this study [7], we perform first-principles calculations on the electronic structure of the tetragonal and monoclinic structures of $LaO_{0.5}F_{0.5}BiS_2$. We find that the symmetry breaking in the monoclinic structure triggers a strong enhancement of the bilayer coupling, which induces a sizable band splitting. We also show that the Fermi surface becomes significantly anisotropic with respect to the *x* and *y* directions through the structural phase transition. The present observations should be important knowledge to understand the superconductivity in these compounds.

References:

[1] Y. Mizuguchi *et al*., Phys. Rev. B **86**, 220510(R) (2012).
[2] Y. Mizuguchi *et al*., J. Phys. Soc. Jpn. **81**, 114725 (2012).
[3] C. T. Wolowiec *et al*., Phys. Rev. B **88** ,064503 (2013).
[4] C. T. Wolowiec *et al*., J. Phys.: Condens. Matter **25**, 422201 (2013).
[5] T. Tomita *et al*., J. Phys. Soc. Jpn. **83**, 063704 (2014).
[6] C. Y. Guo *et al.*, Phys. Rev. B **91**, 214512 (2015).
[7] MO, R. Akashi, and K. Kuroki, J. Phys. Soc. Jpn. **85**, 094705 (2016).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.423

Shear viscosity and effects of pairing fluctuations in a strongly-interacting ultracold Fermi gas

Kagamihara D., Inotani D., Ohashi Y.
Keio University, Department of Physics, Yokohama, Japan

We theoretically investigate the shear viscosity η, as well as the entropy density s, in the normal state of an ultracold Fermi gas. Including paring fluctuations within the framework of a strong-coupling theory, we calculate these in the BCS-BEC crossover region. To properly examine η in whole BCS-BEC crossover regime, we point out that, not only Fermi atom contribution, but also effects of composite molecular bosons, are important, especially in the strong-coupling BEC regime. We also compare the calculated ratio η/s with the so-called KSS conjecture, stating the existence of the lower bound, $\eta/s \geq \hbar/4\pi k_B$[1]. The recent experiment shows that the minimal value of η/s in a unitary Fermi gas is still about six times larger than the KSS bound[2]. It has also been reported that the shear viscosity η takes a minimal value slightly in the BEC side away from the unitarity limit[3]. These results imply that the lower bound of η/s may be obtained in the BEC side. Thus, our analyses would be useful for the assessment of the KSS conjecture using an ultracold Fermi gas in the BCS-BEC crossover region.

References:

[1] P.K. Kovtun, D.T. Son, A.O. Starinets, Phys. Rev. Lett. 94, 111601(2005)
[2] J.A. Joseph, E. Elliott, J.E. Thomas, Phys. Rev. Lett. 115, 020401(2015)
[3] E. Elliott, J.A. Joseph, J.E. Thomas, Phys. Rev. Lett. 113, 020406(2014)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.424
Flux-flow instability in cleaved thin films of 2H-$NbSe_2$ single crystals
Ando H., Yoshida J.-I., Kokubo N.
University of Electro-Communications, Department of Engineering Science, Tokyo, Japan

The flux-flow instability proposed by Larkin and Ovhinnikov (LO) causes an abrupt voltage jump in current-voltage characteristics at high vortex velocity [1]. While the mechanism behind the nonlinear behavior is based on the low viscous friction of driven vortices due to the shrinkage of vortex core at high velocity, many other contributions, including Joule heating and heat removal through substrate, must be taken into account. Bezuglyj and Shklovskij extended LO model by considering unavoidable heating effect and proposed that the instability depends on the vortex density and occurs below a crossover field above which Joule heating dominates [2]. In this study, we investigated the flux-flow instability in micro-bridges of a clean superconductor of 2H-$NbSe_2$ thin single crystals. We found the crossover behavior of the critical power as function of magnetic field which is qualitatively consistent with the modified LO model. We estimated heat transfer coefficient and the inelastic scattering time of quasi-particles governing the instability based on the model.

References:
[1] A. I. Larkin, and Yu. N. Ovchinnikov, Zh. Eksp. Teor. Fiz. 68, 1915 (1975)[Sov. Phys. JETP 41, 960(1975)].
[2] A.I. Bezuglyj and V.A. Shklovskij, Physica C 202, 234 (1992).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.425
Observation of flux states and interstitial vortices in perforated mesoscopic squares of amorphous superconducting films
Mitsuishi M.[1], Kitano K.[1], Kokubo N.[1], Okayasu S.[2], Nojima T.[3], Sasaki T.[3]
[1]University of Electro-Communications, Department of Engineering Science, Tokyo, Japan, [2]Japan Atomic Energy Research Institute, Advanced Science Research Center, Tokai-mura, Naka-gun, Ibaraki, Japan, [3]Tohoku University, Institute for Materials Research, Sendai, Japan

In mesoscopic superconductors, arrangements of quantized magnetic flux (vortices) are determined by the interplay between the confinement and mutual repulsive interaction. While many mesoscopic flux states have been proposed theoretically [1] and observed experimentally [2-5], direct observation of some of unique flux states, including the multiply quantized flux (giant vortex) and anti-flux (antivortex), remains an experimental challenge [6]. In this study, we report magnetic visualizations of fluxoid states in mesoscopic squares of amorphous superconducting thin films with four/five antidots by the scanning SQUID microscope. The observed magnetic images clearly reveal how the magnetic flux are distributed and trapped in the antidots at different magnetic fields. For low filling of flux in the antidots, fluxoid arrangements with different symmetries appear with the same flux number and frequency of the arrangements varies with the spacing between the antidots. For high flux filling, we observed the multiply quantized fluxoid arrangements and/or interstitial vortices between antidots. The

results reveal that proper arrangement of antidots is necessary for observing multiply quantized magnetic fluxoid states.

References:
[1] B.J. Baelus, et al., Phys. Rev. B 69, 064506 (2004).
[2] N. Kokubo, et al., Phys. Rev. B 82, 014501 (2010).
[3] N. Kokubo, et al., J. Phys. Soc. Jpn 83, 083704 (2014).
[4] N. Kokubo, et al., J. Phys.Soc. Jpn. 84, 043704 (2015).
[5] N. Kokubo, et al., in Multi-Vortex States in Mesoscopic Superconductors, The Oxford Handbook of Small Superconductors, edited by A. V. Narlikar, (Oxford University Press, United Kindam), 81-107 (2017).
[6] L.F. Chibotaru, et al., Nature 408, 833 (2000).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.426

Magnetic phase diagram of the frustrated *S*=1/2 triangular-lattice magnet $Cu_2(NO_3)(OH)_3$

Kikuchi H.[1], *Kasamatsu N.*[1], *Ishikawa Y.*[1], *Fujii Y.*[2], *Koizumi Y.*[1], *Matsuo A.*[3], *Kindo K.*[3]
[1]University of Fukui, Department of Applied Physics, Fukui, Japan, [2]University of Fukui, Research Center for Development of Far-Infrared Region, Fukui, Japan, [3]Institute for Solid State Physics, University of Tokyo, Kashiwa, Japan

$Cu_2(NO_3)(OH)_3$ (rouaite) is a frustrated triangular lattice magnet. Although some theoretical and experimental works have been reported so far[1], the magnetic ordering behavior of $Cu_2(NO_3)(OH)_3$ is not clear yet. We measured the magnetic susceptibility, specific heat, ^{1}H-NMR spectra and high field magnetization of powder sample of $Cu_2(NO_3)(OH)_3$ and found clear evidence of an occurrence of the long range magnetic order at about 8 K in zero field. The transition temperature is found to decrease as increasing the magnetic field *B* and *B-T* phase diagram of $Cu_2(NO_3)(OH)_3$ is determined. The high field magnetization curve up to about 60 T is analyzed based on possible spin structure.

References:
[1] S. Pillet *et al.* Phys. Rev. **73,** 115116 (2006) and references therein.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.427

Diffusive real-time dynamics of a particle with Berry curvatures

Misaki K.[1], *Miyashita S.*[2], *Nagaosa N.*[1,3]
[1]University of Tokyo, Department of Applied Physics, Tokyo, Japan, [2]University of Tokyo, Department of Physics, Tokyo, Japan, [3]RIKEN Center for Emergent Matter Science (CEMS), Saitama, Japan

The importance of Berry phase in condensed matter physics cannot be overemphasized [1,2]. Berry curvature appears in the semiclassical equation for the dynamics of the Bloch electrons in a single band in solids; there has been much study on the effect of Berry curvature on the transport in the nonequilibrium steady state [3], but the effect on the real-time diffusive dynamics of the particle [4] has been less studied. We clarified the role of Berry curvature in phase space in the diffusive dynamics by

studying the Langevin equation with Berry curvature in phase space. From the analytic solution, we can see,
(1) the effect of Berry curvature in momentum space — the fast spread of the position distribution at short time and the slow relaxation of the momentum distribution toward the equilibrium — appears only in the short time region before the equilibration of the momentum distribution;
(2) in some parameter range, the dynamics of position and momentum decouples, and we get the dynamics of the Brownian particle for all the time scale;
(3) the coexistence of berry curvature in momentum and real space leads to the resonant behavior of the characteristic time scale; etc.. These results offer yet another method to disentangle Berry curvatures in terms of time-resolved experiments.

References:

[1] F. Wilczek, and S. Alfred, *Geometric phases in physics*. Vol. 5. World Scientific, (1989).
[2] A. Böhm, et al., *The geometric phase in quantum systems*. Springer (2003)
[3] D. Xiao, et al., Rev. of Mod. Phys. 82(3), 1959 (2010)
[4] J. C. Olson and P. Ao, Phys. Rev. B 75(3), 035114 (2007)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.428

How to harness molecular vibrations to improve magnetic bistability of a device based on a single magnetic molecule?

Kenawy A.[1], *Splettstoesser J.*[1], *Misiorny M.*[1,2]
[1]Chalmers University of Technology, Department of Microtechnology and Nanoscience — MC2, Gothenburg, Sweden, [2]Adam Mickiewicz University, Faculty of Physics, Poznan, Poland

In high-spin single-molecule devices, the key property of interest for operational stability of such devices is the energy barrier for spin reversal. This barrier stems from uniaxial magnetic anisotropy of a molecule, and many efforts have been undertaken to develop means of controlling this quantity, e.g., by electrical gating [1], mechanical straining [2] or a quadrupolar spintronic exchange field [3]. Here, we explore a yet different control mechanism that exploits the interplay between the charge, magnetic and vibrational degrees of freedom [4,5]. Specifically, we show that the combination of spin-vibron and charge-vibron couplings leads to a renormalization of magnetic anisotropy when electronic transport through an individual molecule occurs.
To illustrate this mechanism, we consider a stretchable junction that allows for in situ modification of vibrations of a single magnetic molecule captured in it. Using the perturbative approach for a weak coupling between a molecule and terminals, we demonstrate how the spin-vibron coupling in a magnetic molecule manifests on its transport characteristics. Importantly, we show that not only does it lead to a shift of spectroscopic features, but also can result in a transport blockade depending on an applied gate voltage.

References:

Work supported by the Polish Ministry of Science and Education as Iuventus Plus project (IP2014 030973) in years 2015-2017.
[1] A. Zyazin et al., Nano Lett. 10, 3307 (2010)
[2] J. Parks et al., Science 328, 1370 (2010)
[3] M. Misiorny et al., Nat. Phys. 9, 801 (2013)
[4] A. Kenawy et al., in prepartation
[5] A. Kenawy et al., AIP Advances 7, 055708 (2017)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.429

Low temperature characterization of MEMS gyroscope for studying topological superfluidity

Byun H.[1], *Jeong J.*[1,2], *Kim K.*[1], *Kim S.G.*[2,3], *Shim S.-B.*[2], *Suh J.*[2], *Choi H.*[1]
[1]KAIST, Daejeon, Korea, Republic of, [2]Korea Research Institute of Standards and Science, Daejeon, Korea, Republic of, [3]Chungnam National University, Daejeon, Korea, Republic of

Detection of angular momentum in a thin film of superfluid 3He-A is considered one of the more direct ways to probe the topological chiral edge states [1]. However, the signal is expected to be very small for gyroscopes used for quantum fluid research in the past. Developing micro-electro-mechanical systems (MEMS) gyroscopic devices can overcome this limitation [2] but no MEMS gyroscope has ever been fabricated and tested at low temperatures. Here we report mechanical performance of a MEMS gyroscope specifically designed for detection of chiral edge states in 3He-A at milliKelvin temperature range.

References:

[1] J. A. Sauls, Phys. Rev. B 84, 214509 (2011).
[2] HeeSu Byunet al.,arXiv:1609.07641

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.431

Variations of superconducting transition temperature in $YbBa_2Cu_3O_{7-\delta}$ ceramics by Gd substitution

Matsushima K., Taka C., Nishida A.
Fukuoka University, Department of Applied Physics, Fukuoka, Japan

So-called RE-123 superconductors are said to all superconduct at the transition temperature T_c around 90K with RE (rare-earth) ions from Nd to Lu. However there is some tendency that T_c decreases with decrease in RE ion radius. Especially for Yb-123, T_c often becomes below 90K.
We find that the smaller the ion radius is, the lower the melting temperature becomes for RE-123 ceramics. In fact, Yb-123 ceramics often melt above 910°C, while Gd-123 ceramics can be sintered above 950°C without melting. From this tendency we suppose that such T_c lowering is due to insufficient sintering temperature, resulting in insufficient solid state reaction.
In this work, we try to raise T_c in Yb-123 ceramics by increasing the sintering temperature through Gd substitution. We find that the optimum sintering temperature is 930°C in $Yb_{0.7}Gd_{0.3}Ba_2Cu_3O_{7-\delta}$ ceramics with highest T_c of 91.8K (zero resistivity).

Postersession 1
Thursday, 10 August 2017
16.30-18.30

G Foyer

P.434
Effect of silica and palladium nanoinclusions on low-temperature thermal transport of N_2 and CO crystals
Nikonkov R.[1]*, Stachowiak P.*[1]*, Jezowski A.*[2]
[1]Institute of Low Temperatures and Structure Research PAS, Low Temperatures and Superconductivity, Wroclaw, Poland, [2]Institute of Low Temperatures and Structure Research PAS, Wroclaw, Poland

The composites consisted of nanoparticles embedded in a structure of a simple dielectric crystalline matrix seem to be very interesting objects of investigations. Applying the thermal conductivity experimental technique to investigate such composites allows one to get answers to numerous questions regarding the influence of properties and parameters of the components of the nanocomposite on phononic phenomena inside its structure. To obtain samples of the nanocomposites we used nitrogen and carbon monoxide as the crystalline matrixes and nanopowders of silica and palladium as the includings. The key goal of the thermal transport investigations was to obtain and understand the basic information about phonon interactions in such nanocomposites. In our experiment we determined how the nanoparticles of different sizes affect the total thermal conductivity of the investigated objects. The role of the parameters of the crystalline matrix, such as the interaction strength between its constituents or the presence of molecular dipole moment in case of carbon monoxide for the thermal conductivity was also specified. To see the most pronounced effects the measurements were carried out at low-temperature region from 2K to 35K.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.435
Dielectric measurements of the dynamics of atomic tunneling systems in thin-film AlO_x
Meißner S., *Seiler A., Weiss G.*
Physikalisches Institut, Karlsruher Institut für Technologie, Karlsruhe, Germany

From the study of glasses atomic tunneling systems (TS) are well known to dominate the low temperature properties of disordered materials. They also appear in thin-film dielectrics of superconducting circuits, where AlO_x is a common material for the fabrication of Josephson Junctions. We present a broadband study of the dynamics of TS contained in thin-film disordered AlO_x ranging from kHz to GHz frequencies.
The TS´ density of states is probed at kHz frequencies by capacitance measurements as well as in the GHz range by tracking the resonance frequencies of superconducting microstrip resonators with embedded plate capacitors. Due to the homogeneous electric field concentrated in the dielectric AlO_x the influence of native oxide on top of the Al structures is negligible.
The large bandwidth of the excitation frequencies allows us to verify the standard tunneling model [1,2] as proposed by Leggett et al [3]. Contrary to this prediction the measured data is more consistent with an increasing density of TS with increasing energy. Moreover, our observations reveal that the relaxation rates of TS are not only caused by their interaction with phonons and other TS as expected in dielectrics but also by quasiparticles penetrating the AlO_x from the superconducting Al plates.
References:
[1] P. W. Anderson, B. I. Halperin, and C. M. Varma. Phil. Mag., **25**(1):1-9, 1972.
[2] W. A. Phillips. J. Low Temp. Phys., **7**, Nov 1972.

[3] A. J. Leggett and D. C. Vural. J. of Phys. Chem. B, **117**(42):12966-12971, 2013.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.436

Superconductivity, magnetoresistance and magnetic anomaly in new phases of topological insulators Sb_2Te_3 and Bi_2Se_3

Kulbachinskii V.[1,2], *Kytin V.*[1], *Buga S.*[3,4], *Pahomov I.*[3,4], *Perov N.*[1], *Serebryanaya N.*[3,4], *Tarelkin S.*[3,4], *Blank V.*[3,4]
[1]M.V. Lomonosov Moscow State University, Department of Low Temperature Physics and Superconductivity, Moscow, Russian Federation, [2]Moscow Engineering Physics Institute (MEPhI), National Nuclear Research University, Moscow, Russian Federation, [3]Technological Institute for Superhard and Novel Carbon Materials, Moscow, Russian Federation, [4]Moscow Institute of Physics and Technology, Moscow region, Russian Federation

Surface superconductivity in topological insulators (TI) attracts much attention as far as it may have the unconventional p-wave type. Mostly the superconductivity in TI´s was observed "in situ" under high-pressure or, as in the case of Bi_2Se_3, due to intercalation of copper atoms [1,2]. We synthesized bulk polycrystalline samples of metastable at ambient conditions monoclinic phase of Sb_2Te_3 by rapid quenching after a high-pressure-high-temperature treatment at P = 3.7-7.7 GPa; T = 873 K and found superconductivity with Tc=2 K. A zero-field magnetic susceptibility cusp and linear positive magnetoresistance indicate a topological insulator state. Also we synthesized two new metastable phases of Bi_2Se_3 topological insulator by a rapid quenching after a high-pressure-high-temperature treatment at P about 7.7 GPa; T about 1400 K. The structure of metastable phases is monoclinic C2m type and tetragonal (or cubic) similarly to known ones observed earlier “in situ” under pressure. We observed the zero-field magnetic susceptibility cusp and linear positive magnetoresistance indicating the topological insulator state. The annealing at 673 K during 2 hours resulted in complete reversible transformation into the initial crystalline rhombohedral structure.

References:

[1] K. Kirshenbaum, P.S. Syers, A.P. Hope, et al., Phys. Rev. Lett., **111**, 87001 (2013)
[2] Y. S. Hor, A. J. Williams, J. G. Checkelsky, et al., Phys. Rev. Lett.**104,** 057001 (2010)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.437

An exact transmission coefficient with an applied electrical field in graphene

Hernández Fuentevilla C., *Lejarreta González J.D.*, *Diez E.*
University of Salamanca, Salamanca, Spain

In this work, we find the exact transmission coefficient across one and two potential barriers in graphene with an applied electric field within the Dirac formalism. This coefficient is essential in order to characterize the conductance in several electronic devices based on graphene. We extend our previous result without electric field [1] by using both a mean-field [2] and a linear potential [3] approximation to calculate the wave functions in our system. We will show this is possible by using

Hermite and hypergeometric functions, and imposing these wave functions to be continuous in the potential barriers boundaries.

References:

[1] J.D. Lejarreta, C.H. Fuentevilla, E. Diez, J.M. Cerveró, J. Phys. A : Math. Theor. **46** (15), 155304 (2013).

[2] D. Dragoman, M. Dragoman, Appl. Phys. Lett. **90**, 143111 (2007).

[3] M.L. Glasser, N. Shawagfeh, J. Math. Phys. **25** (8), 2533 (1984).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.438

Magnetotransport of half-metallic ferromagnetic Heusler alloys Co_2YZ (Y=Ti, V, Cr, Mn, Fe, Ni; Z=Al, Ge, In, Si, Sn, Sb)

Marchenkov V.V.[1,2,3], Perevozchikova Y.A.[1], Kourov N.I.[1], Marchenkova E.B.[1], Irkhin V.Y.[1], Eisterer M.[4], Gao T.[5]

[1]M.N. Mikheev Institute of Metal Physics, Ekaterinburg, Russian Federation, [2]Ural Federal University, Ekaterinburg, Russian Federation, [3]International Laboratory of High Magnetic Fields and Low Temperatures, Wroclaw, Poland, [4]TU Wien Atominstitut, Vienna, Austria, [5]Shanghai University of Electric Power, Shanghai, China

Some of the Heusler alloys were predicted to be half-metallic ferromagnets (HMF), which are characterized by the presence of an energy gap at the Fermi level in one spin sub-band and a metallic character of the density of states in the other. This can lead to 100% spin polarization of the charge carriers, which can be used for spintronic devices. We studied the electric resistivity and galvanomagnetic properties of HMF Co_2YZ Heusler alloys at varying *Y*- and *Z*-elements in the temperature range from 4.2 to 800 K and in magnetic fields of up to 10 T. It was found that the variation of *Y* strongly affects the change in number of current carriers and alters the electronic band structure near the Fermi level E_F, and, hence, the magnetotransport of Co_2YAl. In case of Co_2FeZ, varying *Z* does not change the electronic transport properties significantly.

This work was partly supported by the state assignment of FASO of Russia (theme “Spin” No. 01201463330), by the Scientific Program of UB RAS (No. 15-17-2-12), by the RFBR (Nos. 15-02-06686 and 16-32-00072), by the Government of the Russian Federation (No.02.A03.21.0006), by the National Natural Science Foundation of China (No.11204171), by the Shanghai Municipal Natural Science Foundation (No.16ZR1413600).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.439

^{133}Cs-NMR study on aligned power of competing spin chain $Cs_2Cu_2Mo_3O_{12}$

Yagi A.[1], Matsui K.[1], Goto T.[1], Hase M.[2], Sasaki T.[3]

[1]Sophia University, Physics Division, Tokyo, Japan, [2]National Institute for Materials Science (NIMS), Tsukuba, Japan, [3]Institute for Material Science (IMR), Tohoku University, Sendai, Japan

S = 1/2 competing spin chain $Cs_2Cu_2Mo_3O_{12}$ has two dominant exchange interactions of the nearest-neighboring ferromagnetic J1= -93 K and the second nearest-neighboring antiferromagnetic J2= +33 K, and is expected to show the nematic Tomonaga-Luttinger liquid (TLL) phase under high magnetic fields near the saturation field H_S = 9.15T [1]. In order to investigate its existence, we have performed ^{133}Cs-NMR experiments on the aligned power sample under the wide range of magnetic field. We followed the theoretical idea by Sato *et. al* [2] to search the nematic TLL phase, that is, within the phase, the longitudinal component of spatial spin correlation is strongly suppressed, so that one expects that $1/T_1$ should decrease at low temperatures.
Before examining it, we first determined the isotropic and anisotropic parts of hyperfine coupling tensor, to found that they have comparable magnitude. This assures that both the longitudinal and transverse component of spin fluctuation contribute to $1/T_1$, validating the above argument.
The observed temperature dependence of $1/T_1$ at low temperatures changed its gradient from negative to positive at around 7 T with increasing field, suggesting the existence of spin nematic TLL state at high fields.

References:
[1] M. Hase et al., J. Appl. Phys. 97 (2005) 10B303.
[2] M. Sato et al. Phys. Rev. B83 (2011) 064405.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.440
Magnetic properties of the $UNiX_2$ ternary compounds (X=C, Si, Ge, Sn) at low temperature
Ohashi K.[1], <u>Ohashi M.</u>[1], Maeta K.[1], Yamamura T.[2]
[1]Kanazawa University, Kanazawa, Japan, [2]Tohoku University, Institute for Materials Research, Sendai, Japan

There are few reports about $UNiX_2$ ternary compounds. Previously, we have grown single crystals of $UNiSi_2$, which has a crystal structure of orthorhombic $CeNiGe_2$ type [Cmcm, 63] [1]. We found that $UNiSi_2$ is a ferromagnet of T_C = 95 K and shows high magnetic anisotropy. Gerss *et al*. reported $UNiC_2$ has a tetragonal $UCoC_2$ type structure [P4/nmm, 129] [2], but magnetic property of $UNiC_2$ has not been reported yet. Moreover, there is no creation report on $UNiGe_2$ and $UNiSn_2$. In the present study, polycrystalline samples of $UNiC_2$, $UNiGe_2$ and $UNiSn_2$ were synthesized by arc melting in an Ar gas atmosphere. These arc-melted samples were sealed in evacuated quartz tubes for subsequent annealing. The samples were chacterized by X-ray powder diffraction (XRD) experiments. The dc magnetization was measured by using a Quantum Design MPMS. The unit cell volume of $UNiX_2$ tends to increase as increasing the atomic nunber of X(C,Si,Ge,Sn). While no trace of any impurity phase was obtained in the XRD pattern of $UNiGe_2$, some impurity phase was observed in those of $UNiC_2$ and $UNiSn_2$.

References:
[1] M. Ohashi, G. Oomi, K. Ishida, I. Satoh, J. Phys. Soc. Jpn., **75**, 124-126 (2006)
[2] M.H. Gerss, W. Jeitschko, Mat. Res. Bull., **21**, 209-216 (1986)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.441

Circuit QED investigations of Josephson junction arrays

Ikegami H.[1], Cosmic R.[1,2], Lin Z.[1], Inomata K.[1,3], Taylor J.[2,4,5], Nakamura Y.[1,2]
[1]RIKEN, CEMS, Wako, Japan, [2]University of Tokyo, RCAST, Tokyo, Japan, [3]AIST, Tsukuba, Japan, [4]University of Maryland, College Park, United States, [5]NIST, Gaithersburg, United States

Josephson junction arrays (JJAs), periodic arrays of superconducting islands connected by small Josephson junctions, offer a unique platform for realizing an artificial quantum many-body system with well-controlled parameters. Depending on parameters of JJAs, various kinds of classical and quantum Hamiltonians can be implemented, and interesting quantum many-body phenomena such as the quantum phase transitions between superconducting and insulating states and the Mott-insulator transition of vortices have been studied by transport measurements. Here we present the first experimental study of JJAs using the circuit quantum electrodynamics (cQED) architecture, where a JJA is coupled to a three-dimensional microwave cavity strongly. We observe that the spectrum of the cavity in a magnetic field shows some features at commensurate values of magnetic flux. The spectrum also shows a broadening as a function of magnetic field and temperature. We discuss these observed features in connection with melting of vortex lattices in the JJA.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.442

Unusual magnetic response of an *S* = 1 antiferromagetic linear-chain material

Meisel M.W.[1], Xia J.-S.[1], Ozarowski A.[2], Spurgeon P.M.[3], Baldwin A.G.[3], Manson J.L.[3]
[1]University of Florida, Department of Physics and NHMFL, Gainesville, United States, [2]National High Magnetic Field Laboratory, Floridia State University, Tallahassee, United States, [3]Eastern Washington University, Department of Chemistry and Biochemistry, Cheney, United States

An S = 1 antiferromagnetic polymeric chain, $[Ni(HF_2)(3\text{-}Clpy)_4]BF_4$ (py = pyridine), hereafter referred to as NBCT, has previously been identified to have intrachain, nearest-neighbor antiferromagnetic interaction strength J/k_B = 4.86 K and single-ion anisotropy (zero-field splitting) D/k_B = 4.3 K [1]. Furthermore, muon-SR (spin relaxation) data indicate the system is not long-range ordered down to 25 mK [1]. The ratio D/J = 0.88 suggests this system close to the $D/J \approx 1$ gapless critical point between the topologically distinct Haldane and Large-D phases. The magnetization was studied over a range of temperatures, 50 mK ≤ T ≤ 1 K, and magnetic fields, B ≤ 10 T, in an attempt to identify a critical field, B_c, associated with the closing of the Haldane gap, and the present work places an upper bound of Bc ≤ (35 ± 10) mT. At higher fields, the observed magnetic response is qualitatively similar to the "excess" signal observed by other workers at 0.5 K and below 3 T [1]. The high-field (up to 14.5 T), multi-frequency (nominally 200 GHz to 425 GHz) ESR spectra at 3 K reveal several broad features considered to be associated with the linear-chain sample.
This work was supported by the National Science Foundation (NSF) through DMR-1202033 (MWM), DMR-1306158 (JLM), and DMR-1157490 (NHMFL).

References:

[1] J. L. Manson, A. G. Baldwin, B. L. Scott, J. Bendix, R. E. Del Sesto, P. A. Goddard, Y. Kohama, H. E. Tran, S. Ghannadzadeh, J. Singleton, T. Lancaster, J. S. Möller, S. J. Blundell, F. L. Pratt, V. S. Zapf, J. Kang, C. Lee, M.-H. Whangbo, and C. Baines, Inorganic Chemistry **51**, 7520 (2012).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.443

Anomalous spin-lattice relaxation time of ^{13}C in graphite at ultralow temperatures

<u>Nyeki J.</u>[1], Waterworth A.[1], Arnold F.[1,2], Yager B.[1,3], Cowan B.[1], Saunders J.[1]
[1]Royal Holloway, University of London, Physics, Egham, United Kingdom, [2]Max-Planck-Institute for Chemical Physics of Solids, Dresden, Germany, [3]University of Waterloo, Waterloo, Canada

Exfoliated forms of graphite have been extensively used as substrates to study helium films into the microkelvin temperature range. Spin-½ ^{13}C nuclei are present in graphitic substrates at a natural abundance of 1.1%. The nuclear magnetism of ^{13}C follows Curie's Law well below 1mK and can be measured simultaneously with the ^{3}He properties using broadband SQUID NMR spectrometers [1]. This provides an opportunity to use an ensemble of ^{13}C atoms as a thermometer directly embedded in the substrate.
Using a SQUID NMR technique we have measured the longitudinal relaxation time T_1 of ^{13}C in Grafoil at temperatures in the range 250 µK to 80 mK. The recovery of the longitudinal magnetisation following an 180^o excitation pulse was found to be best described by a stretched exponential with exponent $\alpha \cong 2/3$. For temperatures below 20 mK we observed power law behaviour $T_1 \sim 1/T^{1/2}$. We will discuss the potential origin of these effects in the semi-metal exfoliated graphite.
We will also discuss influence of ^{3}He adsorbed onto the substrate and potential consequences to the nuclear magnetic relaxation, thermometry, and thermal equilibrium at ultralow temperatures.

References:

[1] F.Arnold et al., J Phys: Conference Series **568**, 032020 (2014)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.444

Strange metal state near a heavy-fermion quantum critical point

<u>Chung C.-H.</u>[1], Chang Y.-Y.[1], Paschen S.[2]
[1]National Chiao Tung University, Department of Electrophysics, Hsinchu, Taiwan, Republic of China, [2]TU Vienna, Institute of Solid State Physics, Vienna, Austria

Recent experiments [1][2] on quantum criticality in the Ge-substituted heavy-electron material YbRh2Si2 under magnetic fields have revealed a possible non-Fermi-Liquid (NFL) strange metal (SM) state [2] over a finite range of fields at low temperatures, which still remains a puzzle. In the SM region, the zero-field antiferromagnetism is suppressed. Above a critical field, it gives way to a heavy Fermi liquid with Kondo correlation. The T (temperature)-linear resistivity and the T-logarithmic followed by a power-law singularity in the specific heat coefficient at low T, salient NFL behaviours in the SM region, are un-explained. Here, we offer a mechanism to address these open issues theoretically based on the competition between a quasi-2d fluctuating short-ranged resonant- valence-bonds (RVB) spin-liquid and the Kondo correlation near criticality. Via a field-theoretical renormalization group analysis on an effective field theory beyond a large-N (Sp(N)) approach to an anti-ferromagnetic Kondo-Heisenberg lattice model, we identify the critical point, and explain remarkably well both the crossovers and the SM behaviour [3]. The strange metal state can be interpreted as the extended quantum critical region to T -->0 due to its proximity to Kondo breakdown at criticality.

References:
[1] J. Custers, P. Gegenwart, H. Wilhelm, K. Neumaier, Y. Tokiwa, O. Trovarelli, C. Geibel, F. Steglich, C. Ppin, and P. Coleman, Nature (London) 424, 524527 (2003).
[2] J. Custers, P. Gegenwart, C. Geibel, F. Steglich, P. Coleman, and S. Paschen, Phys. Rev. Lett. 104, 186402 (2010).
[3] Yung-Yeh Chang, Silke Paschen, Chung-Hou Chung*, Strange metal state near a heavy-fermion quantum critical point, arXiv:1701.04599.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.445

Landau level structure of Bernal-stacked tetra-layer graphene device with single gate electrode

<u>Hirahara T.</u>[1], Ebisuoka R.[1], Watanabe K.[2], Taniguchi T.[2], Yagi R.[1]
[1]Hiroshima University, AdSM, Higashi-Hiroshima, Japan, [2]National Institute for Material Science, Tsukuba, Japan

Although there are a few experimental studies reporting low energy band structure in tetra-layer graphene, [1, 2] details of the band structure has not been fully understood. In this work, we studied magneto-transport of tetra-layer graphene using high-quality graphene/h-BN devices with single gate electrode. Layer number and stacking were determined by Raman spectroscopy and AFM measurements, to verify Bernal-stacked tetra-layer graphene. Low temperature magnetoresistance showed Shubnikov-de Haas effect. Two sets of bilayer-like bands with complicated crossings, predicted for Bernal-stacked tetra-layer, were clearly observed in a Landau fan diagram, the mapping of resistance against carrier density and magnetic fields. We found that a N=0 Landau level for a light mass bilayer band exhibited clear splitting in high magnetic fields. Because Bernal-stacked tetra-layer graphene is predicted to be valley-degenerated by space-reversal symmetry in the crystal structure, the splitting was caused by some broken symmetry. Origin of the broken symmetry would be asymmetric electronic potential applied by a single gate.

References:
[1] A. L. Grushina *et al.*, Nature Commun. 6, 6419 (2015)
[2] Zefei Wu *et al.*, Phys. Rev. B 92, 075408 (2015)

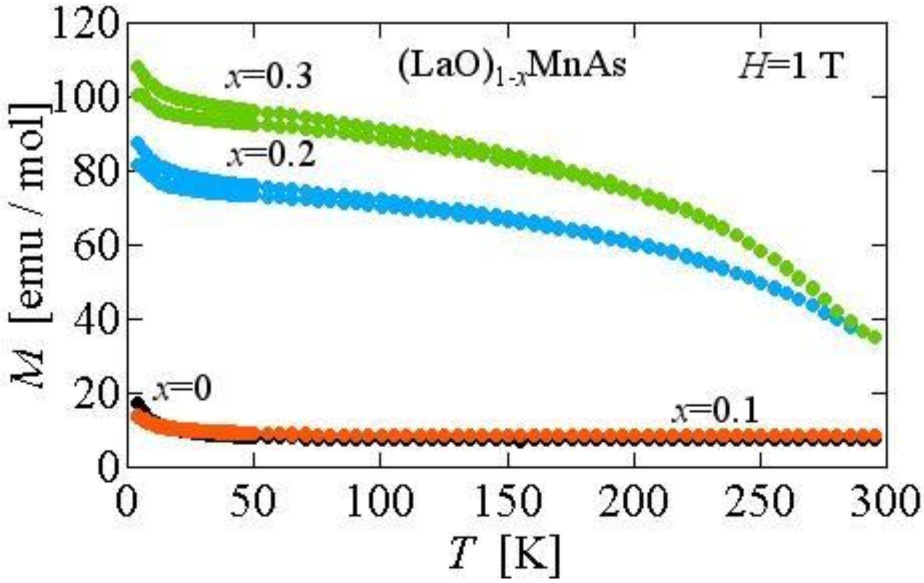
Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.446

Magnetism of the carrier doped oxypnictide (LaO)MnAs

<u>Takase K.</u>[1], Ishiwata S.[1], Kawamoto K.[1], Moriyoshi C.[2], Kuroiwa Y.[2]
[1]Nihon University, Tokyo, Japan, [2]Hiroshima University, Higashi-Hiroshima, Japan

The layered oxypnictide (LaO)MnAs which consists of the LaO and the MnSb layers stacked along *c* axis alternatively, is a room temperature antiferromagnetic insulator with half-filed Mn 3*d* band. In our previous study, carrier doping effect to (LaO)MnAs was investigated and then ferromagnetic behaviors were found in hole doped (LaO)MnAs as shown in fig.1.



[Magnetization of hole doped (LaO)MnAs]

There are two scenarios to explain found ferromagnetism; one is intrinsic feature of these materials, the other is a ferromagnetic impurity. In these cases, MnAs is a candidate as a ferromagnetic impurity. However, we couldn't find any peaks from MnAs in the x-ray diffraction profiles using Cu *K*α line.
In this study, we have examined synchrotron X-ray diffraction (SXRD) measurement with strong X-ray intensity for hole doped (LaO)MnAs to evaluate ferromagnetic impurity effects at SPring8 BL02B2 beam line. The MnAs peaks don't coincide with hole doped (LaO)MnAs at all. So, the ferromagnetic behavior found in hole doped (LaO)MnAs is definitely due to the intrinsic feature of this material.
The origin of the ferromagnetism will be discussed in this report.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.447
Strong coupling effects on specific heat of a p-wave superfluid Fermi gas
Inotani D., van Wyk P., Ohashi Y.
Keio University, Department of Physics, Yokohama, Japan

We investigate strong coupling effects on the thermodynamic properties of a *p*-wave superfluid Fermi gas. Including *p*-wave pairing fluctuations within a strong-coupling theory developed by Nozières and Schmitt-Rink [1], we calculate specific heat C_v in this system below the superfluid transition temperature T_c. We find that low temperature behavior of the specific heat is sensitive to the interaction strength. In a p_x-wave superfluid state, while in the weak-coupling regime C_v is proportional to T^2 as predicted within the BCS theory, as increasing the interaction strength, the exponent α ($C_v \propto T^\alpha$) continuously decreases and eventually approaches 3/2 in the strong coupling limit as an ideal superfluid Bose gas. Since this result indicates that the main contribution to C_v is gradually changes from fermionic excitations near the node structure of the superfluid order parameter in the weak-coupling regime to bosonic molecular excitations in the strong-coupling regime, the low temperature behavior of C_v is useful for studies of strong coupling effects in the *p*-wave superfluid Fermi gas.
References:

[1] P. Nozières and S. Schmitt-Rink, J. Low. Temp. Phys. **59** 195 (1985).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.449

Visualization of streaming flow due to quartz tuning fork oscillating in normal and superfluid He4

Duda D., La Mantia M., Skrbek L.
Charles University, Mathematics and Physics, Prague, Czech Republic

Using the particle-tracking-velocimetry (PTV) technique based on recording trajectories of small solid deuterium particles, we present visualization of streaming flow occurring outside the Stokes boundary layer in the surrounding bulk liquid due to a fast oscillating quartz tuning fork, in both normal He I and, for the first time, in superfluid He II. In normal liquid He I, the observed flow patterns closely resemble those due to oscillating square cylinder observed and theoretically analyzed as outer solutions of streaming flow in a viscous incompressible fluid by Kim and Troesch [1]. In He II, over the investigated temperature range, 1.25 K < T < 2.2 K, at the experimentally probed length scales, the streaming patterns appear identical as in He I, displaying 12 stronger and 4 weaker outer streaming cells. Our direct observations based on recorded particle trajectories is backed up by employing the concept of PTV-based pseudovorticity [2].
The work is supported by the Czech Science Foundation # GACR 16-00580S.

References:

[1] S. K. Kim, A. W. Troesch, Phys. Fluids A **1**, 975 (1989)
[2] D. Duda, P. Svancara, M. La Mantia, M. Rotter, and L. Skrbek, Phys. Rev. B **92**, 064519 (2015)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.450

Strong coupling effects in an ultracold Fermi gas with an orbital Feshbach resonance

Mondal S., Inotani D., Ohashi Y.
Keio University, Department of Physics, Yokohama, Japan

We theoretically investigate an ultracold Fermi gas with an orbital Feshbach resonance. Including fluctuations in both the interband and intraband Cooper channels within the framework of a strong-coupling T-matrix approximation, we self-consistently determine superfluid transition temperature T_c , as well as the Fermi chemical potential, as functions of the strength of an effective s-wave interaction in the open channel. Using these, we examine how strong-coupling effects appear in physical properties of the open channel, as well as those of the closed channel, in the normal state above T_c. We also compare our results with the conventional case with a magnetic Feshbach resonance, realized in ^{6}Li and ^{40}K Fermi gases. In the current stage of cold Fermi gas physics, using an orbital Feshbach resonance is a promising scenario to achieve the superfluid phase transition in a ^{173}Yb Fermi gas. Thus, our results would be useful for the studies toward the realization of this non-alkali metal Fermi gas superfluid.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.451
DMFT study on the electron-hole asymmetry of the electron correlation strength in the high Tc cuprates

Mizuno R., Ochi M., Kuroki K.
Osaka University, Osaka, Japan

It has been believed that the mother compounds of the cuprates are Mott insulators due to their strong electron correlation, and doping carriers induces superconductivity. However, recent study shows that, in the electron doped systems, the electron correlation strength is not so strong that even their mother compounds might exhibit superconductivity[1-4]. It was also reported that the pseudo gap disappears[5,6]. By contrast, in the hole doped systems, the pseudo gap exists in a wide doping range. In this way, the cuprates exhibit striking electron-hole asymmetry in their phase diagram. It is reasonable to suppose that the origin of this asymmetry is the difference in the interaction strengths between the hole- and the electron-doped systems. However, a recent first principles estimation has shown that the interaction strengths are comparable in these systems[7].
Given this background, we analyze the one-particle spectrum near the Fermi level using DMFT with two kinds of impurity solvers: IPT and CT-QMC methods. As a result, we find the difference in the “visibility" of the strong correlation effect between the hole and the electron doped systems, which explains the electron-hole asymmetry of the correlation strength without introducing difference in the interaction strength.

References:

[1] A.Tsukada *et al.*, Solid State Commun.**133**, 427 (2005).
[2] Y.Krockenberger *et al.*, Sci. Rep. **3**, 2235 (2013).
[3] C. Weber, K. Haule, and G. Kotliar, Phys. Rev. B **82**, 125107 (2010).
[4] H.Yokoayama, *et al,*J. Phys. Soc. Jpn.**82**, 014707(2013).
[5] M. Horio *et al*, Nat. Commun. **7** (2016) 10567.
[6] M.M.Zemljic, P.Prelovsec, and T.Tohyama, Phys. Rev. B **76**, 012502 (2007).
[7] S.W. Jang *et al*, Sci. Rep. **6**, 33397 (2016)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.452
Superfluidity of ^{4}He in dense aerogel studied using quartz tuning fork

Matsumoto K., Okamoto R., Nakajima A., Abe S.
Kanazawa University, Kanazawa, Japan

Superfluid ^{4}He in aerogel is of interest because it has a normal component that plays the role of viscous fluid and simultaneously a superfluid component with zero viscosity. There are two sound modes, a slow critical mode and a fast one[1,2]. We have reported acoustic properties of liquid ^{4}He in aerogel using longitudinal ultrasound and the different behavior from rigid porous material[3, 4]. In this study, quartz tuning fork was used in order to study the acoustic properties of liquid ^{4}He in porous materials around several ten kHz because coupling between aerogel and ^{4}He could be changed by varying the viscous penetration depth. Two pieces of aerogel with 90% porosity were glued on the both prongs of quartz tuning fork that had a resonance frequency of 33 kHz in vacuum. The tuning fork was immersed in liquid ^{4}He at 10 and 20 bar. The resonance frequency increased in the superfluid phase due to decrease in loaded mass. The onset of the frequency change at superfluid transition with aerogel shifted 2 mK lower than that without gel. This temperature change was consistent with other experiments. Temperature variation of resonance frequency was explained from that of normal density. Additional dissipation was observed in the temperature range between 1 K and transition temperature.

References:

[1] M. J. McKenna, T. Slawecki and J. D. Maynard Phys. Rev. Lett. 66 1878 (1991)

[2] P. Brusov, J. M. Parpia, P. Brusov and G. Lawes Phys. Rev. B 63 140507 (2001)

[3] M. Nishikawa, K. Yoshino, S. Abe, H. Suzuki, K. Matsumoto, D. Tayurskii and K. Tajiri J. Phys. Chem. Solids 66 1506 (2005)

[4] K. Matsumoto, H. Tsboya, K. Yoshino, S. Abe, H. Suzuki and D. Tayurskii J. Low Temp. Phys. 148 615 (2007)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.453

A compact, fast turn-around, cryogen-free platform operating at 1 K or 50 mK

Matthews A., Patton M., Marsh T.

Oxford Instruments NanoScience, Abingdon, United Kingdom

We present the design and performance characteristics of a compact cryogen-free platform.
The cold environment is provided by a pulse tube refrigerator with a typical cooling power of 0.9 W at 4.2 K. From this, a continuous 1 K pot is operated using a small (10 m^3 / h) room temperature circulation pump. The pot cools an experimental plate ~ 160 mm in diameter to a base temperature ~ 1.2 K, and a cooling capacity of 100 mW is available at a temperature ~ 1.9 K. Cooling the pot from room temperature to < 2 K takes just over 12 hours.
The temperature range of the platform can be lowered to < 50 mK with the addition of a compact dilution refrigerator, using the 1 K pot as a pre-cooling stage for the circulating ^{3}He. The dilution stage has a typical (continuous) cooling capacity of 30 µW at 100 mK and 300 µW at 300 mK available on the ~ 150 mm diameter experimental plate. The dilution unit is designed to operate with just 3 litres of (NTP) ^{3}He.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.454

Liquid ^{3}He on clean and preplated graphite

Gordillo M.C.[1], Boronat J.[2]

[1]Unviersidad Pablo de Olavide, Departamento de Sistemas Fïsicos Químicos y Naturales, Seville, Spain, [2]Universitat Politecnica de Catalunya, Departament de Física, Barcelona, Spain

Using diffusion Monte Carlo calculations, we calculated the phase diagram of normal ^{3}He adsorbed on clean and ^{4}He-preplated graphite. Our results are, for the first time, fully compatible with recent heat-capacity experiments [1], that indicated the existence of a liquid at low ^{3}He densities. We showed that to reconcile the results of the experiments with the theoretical description, we needed to introduce the substrate corrugation in the context of a fully three-dimensional description of both systems. On clean graphite, we found that when the density is lower that 0.006 A^{-2}, the ^{3}He is a dilute gas. At that density, the system is in equilibrium with a 0.014 A^{-2} liquid [2]. On the other hand, for the preplated setup, the ^{3}He ground state is a self-bound liquid of density 0.007 +- 0.001 A^{-2} [3}, in good agreement with previous experimental data.

References:

1. D. Sato, K. Naruse, T. Matsui, and H. Fukuyama, Phys. Rev. Lett. **109,** 235306 (2012)
2. M.C. Gordillo and J. Boronat, Phys. Rev. Lett. **116**, 145301 (2016)
3. M.C. Gordillo and J. Boronat, Phys. Rev. B. **94**, 165421 (2016)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.455

Competition of dynamic and structural disorder in a doped "triangular" antiferromagnet $RbFe(MoO_4)_2$

Smirnov A.I.[1], Soldatov T.A.[1], Petrenko O.A.[2], Kida T.[3], Takata A.[3], Hagiwara M.[3], Shapiro A.Y.[4], Zhitomirsky M.E.[5]
[1]P. L. Kapitza Institute for Physical Problems, Moscow, Russian Federation, [2]University of Warwick, Department of Physics, Coventry, United Kingdom, [3]Osaka University, AHMF Center, Osaka, Japan, [4]A. V. Shubnikov Institute for Crystallography RAS, Moscow, Russian Federation, [5]CEA-INAC/UJF, PHELIQS, Grenoble, France

The low-temperature spin configuration of a two-dimensional antiferromagnet on a triangular lattice is known to be stabilized from a degenerate manifold of classical ground states by the "order-by-disorder" mechanism: thermal and quantum fluctuations lift the degeneracy (see, e.g.,[1]). In particular, the remarkable "up-up-down" phase is stabilized in this way and is marked by a magnetization plateau at 1/3 of saturation magnetization [1,2]. We observe a disappearance of this plateau and a striking change of the spin structure (proved by ESR) under a moderate nonmagnetic doping (Rb/K) of the model triangular antiferromagnet $RbFe(MoO_4)_2$. At the same time, the Néel transition near T=4 K remains sharp. The reason of the observed effects is an effective lifting of degeneracy by a random potential of impurities, which compensates the fluctuation contribution to free energy [3]. These results provide an experimental confirmation of the fluctuation origin of the ground state in a real frustrated system. The change of the ground state to a least collinear configuration reveals an effective positive biquadratic exchange provided by the structural disorder. On heating, doped samples regain the structure of a pure compound demonstrating a competition between thermal and structural disorder.

References:

[1] A. V. Chubukov, D. I. Golosov, Journal of Physics: Condensed Matter, **3**, 69 (1991).
[2] A. I. Smirnov, H. Yashiro, S. Kimura, M. Hagiwara, Y. Narumi, K. Kindo, A. Kikkawa, K. Katsumata, A. Ya. Shapiro, and L. N. Demianets, Phys. Rev. B, **75**, 134412 (2007).
[3] V. S. Maryasin and M. E. Zhitomirsky, Phys. Rev. Lett., **111**, 247201 (2013).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.456
First principles study on the impurity effect on the band structure of the FeSe systems
Usui H., Kuroki K.
Osaka University, Department of Physics, Toyonaka, Japan

The discovery of the iron-based superconductors[1] has given great impact to the field of condensed-matter physics. In most of the iron-based superconductors, the amount of carriers can be controlled by substituting an atom in the blocking layer (e.g. $LaFeAsO_{1-x}F_x$), while in the FeSe system, excess Fe atoms and/or deficiency of Fe and Se atoms control the number of carriers (e.g. $Fe_{1+y}Se$ and $K_{1-x}Fe_{1-y}Se$). The excess Fe atoms play an important role in determining the superconducting properties not only through controlling the amount of carriers but also through impurity effect on the electronic structure[2]. In fact, an ARPES observation on FeSe suggests that the experimental Fermi surface is strongly different from that obtained from the first principles calculation[3] In this study, we investigate for the FeSe systems the impurity effect of excess Fe and deficiency of Fe on the band structure within the first principles band calculation. It is found that excess Fe of about y=0.1 drastically deforms the band structure and the Fermi surface. In this presentation, we will also discuss the effect of other impurities on the band structure such as the deficiency of Fe.

References:
[1] Y. Kamihara et al., J. Am. Chem. Soc. **130**, 3296 (2008).
[2] Y. Mizuguchi and Y. Takano, J. Phys. Soc. Jpn. **79**, 102001 (2010).
[3] T. Shimojima et al., Phys. Rev. B **90**, 121111(R) (2014).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.457
The role of cluster interaction in quantum chaos in 1D spin-1/2 XXZ model
Vahedi J.[1], Moshfegh S.[2], Ashouri A.[2], Mahdavifar S.[2]
[1]Sari Branch, Islamic Azad University (IAU), Physics, Sari, Iran, Islamic Republic of, [2]Guilan University, Physics, Rasht, Iran, Islamic Republic of

Historically the magnetic behavior of quantum magnet insulators is studied using the Heisenberg Hamiltonian. Recent progress in the field of quantum magnets has shown that a wide variety of novel spin-1/2 Hamiltonians can be generated in the different configurations of optical lattices. Among them, cluster interaction is taken into consideration. The cluster interaction is defined as a multispin interaction. Here, we focus on the role of the cluster interaction in appearance of the quantum chaotic dynamics. Specially, we consider 1D spin-1/2 XXZ Heisenberg model with added cluster interaction. Previews studies had shown that a dynamical phase transition into the chaotic phase happens with the addition of a single defect in the spin-1/2 XXZ Heisenberg model except when the strength of the Ising interaction is much larger than the in-plane Heisenberg interaction. Using the numerical full diagonalization method, we show that in presence of a cluster interaction, the chaotic phase exist in the dynamical phase diagram even for strong Ising interaction region. In addition, the effect of the cluster size on the dynamical phase transition is also investigated.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.458
The characteristics of 35 kJ HTc-SMES direct cooling Low-temperature system
Wang H.L.[1], *Li J.D.*[2], *Wu G.*[1], *Shi L.*[1], *Liu M.Y.*[1]
[1]Huazhong University of Scinece and Technology, Laboratory of Cryogenics, Wuhan, China,
[2]Huazhong University of Scinece and Technology, School of Electrical and Electronic Engineering, Wuhan, China

The HTc magnet of the 35 kJ SMES is wound by Bi-2223 superconducting tape with an outer diameter of 320 mm and about 200 kg in weight. The magnet was cooled from room temperature to below 20 K by an American-made Cryomech G-M cryocooler. The mid-point of the binary current lead and the thermal shielding was cooled by a British-made SHI G-M cryocooler. The magnet reached its working temperature 20 K required by the superconducting magnet 24 h after start of the cryogenic system. At this temperature the SMES worked for full 480 h (20 days) continuously. Temperature distribution during cooling and the loading way dynamic characteristics of temperature in operation were recorded. The results indicate that the cryogenic system has a high cooling efficiency and the magnet has good thermal stability. Further analysis shows that control of the heat leak to the interior of the magnet, optimization of the heat conducting components, and practical reduction of the heat conduction resistance between the heat conduction parts are all the key problems for application of the conduction cooled HTc magnet.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.459
Dynamics of vortex line density in counterflow quantum turbulence - experimental investigation.
Varga E., *Skrbek L.*
Charles University, Faculty of Mathematics and Physics, Prague, Czech Republic

The vortex tangle in quantum turbulence is commonly characterised by its vortex line density (VLD) - the total line length per unit volume. For the case of thermal counterflow, a dynamical equation for the VLD has been written down by Vinen [1] which correctly predicts the dependence of the VLD on the counterflow velocity in steady-state thermal or mechanical counterflow [2] and in limited range in the decay [3]. However, this equation has been determined largely through dimensional reasoning with certain ambiguity in its exact form. Recently, a theoretical treatment [4] has suggested that the generally accepted form may need to be revised and the issue is yet to be satisfactorily resolved [5,6]. In the present work, we examine large statistical sets of VLD data measured using second-sound attenuation in unsteady counterflow with the aim to discern minute differences between the proposed forms of the Vinen equation. Based on preliminary data, we present evidence that the identification of the exact form of the Vinen equation is plausible and that neither of the currently favoured forms

provide the best fit of the data over the entire investigated parameter range. The work is supported by the Czech Science Foundation under # GACR 17-03572S.

References:

[1] W. F. Vinen, Proc. R. Soc. Lond. A **242** 493-515 (1957)
[2] S. Babuin et al., Phys. Rev. B **86**, 134515 (2012)
[3] S. Babuin et al., Phys. Rev. B **92**, 184503 (2015)
[4] D. Khomenko et al., Phys. Rev. B **91**, 180504(R) (2015)
[5] S. K. Nemirovskii, Phys. Rev. B **94**, 146501 (2016)
[6] D. Khomenko et al., Phys. Rev. B **94**, 146502 (2016)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.460

The magnetic properties of Cu-phthalocyanine in a mechanically controllable device - a DFT based insight

Wawrzyniak-Adamczewska M.[1], *Misiorny M.*[1,2]
[1]Adam Mickiewicz University, Faculty of Physics, Poznan, Poland, [2]Chalmers University of Technology, Gothenburg, Sweden

The control of the charge and spin in the molecular devices is currently a challenge for theoretical analysis and experiment. Within this work we focus on how the distortion and charge state of the single molecule, Cu-phthalocyanine (Cu-Pc), influences the magnetic properties of the device.
We performed a DFT-based analysis which takes into account the spin-orbit interaction that leads to corresponding degeneration of the molecular energy alignment, especially pronounced for the d-states of Cu ion. The energy level alignment is strongly modified by the distortion of the molecule as well as by the modification of its charge state.
The analysis shows that the spin of the molecule is localized not only on the metal ion, but also it spreads on the neighboring atoms. Importantly, the spin state of the device strongly depends on its charge state. While the neutral Cu-Pc is paramagnetic, the anion and cation forms of Cu-Pc display different spin states: whereas the former supports the triplet spin state, the latter is diamagnetic.
Finally, the magnetic anisotropy energy for charge-neutral and charged Cu-Pc is calculated. The influence of the electron-vibron interaction on the density of states is also discussed.

References:

This work has been supported by the Polish Ministry of Science and Higher Education as the Iuventus Plus project (IP2014 030973) in years 2015--2017. Calculations have been performed in the Cyfronet Computer Centre using Prometheus computer which is a part of the PL-Grid Infrastrucure.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.461

Enhancing the absorption and energy transfer process via quantum entanglement

Zong X.-L.[1,2,3], *Wei S.*[1], *Yang M.*[2], *Cao Z.-L.*[1]

[1]School of Electronic and Information Engineering, Hefei Normal University, Hefei, China, [2]School of Physics and Material Science, Anhui University, Hefei, China, [3]University of Michigan, Department of Physics, Michigan, United States

The quantum network model is widely used to describe the dynamics of excitation energy transfer in photosynthesis complexes. We utilize the continuous external driving fields to simulate the energy absorption process and define a rescaled measure to reflect the energy absorption efficiency from external driving to the sink. We mainly investigate the effect of the initial entanglement and multiple pathways on the transfer efficiency and energy absorption process. To study the role of initial state in the light-harvesting and energy transfer process, we assume the initial state of the donors to be two-qubit and three-qubit entangled states, respectively. In the two-qubit initial state case, we find that the initial entanglement between the donors can help to improve the energy absorption process and the absorption efficiency of sink for both the near-resonant and large detuning cases. For the case of three-qubit initial state, we can see that the absorption efficiency will reach a larger value more quickly in the three-partite entangled states compared to the two-partite entangled states. Furthermore, we introduce a symmetric complex quantum network with N pathways to investigate the effect of multiple-pathway on energy absorption efficiency under the external driving fields.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.462

Mean field theory of fully-gapped triplet superconductors

Whittlesea P.[1], Quintanilla J.[1], Annett J.F.[2], Smidman M.[3], Yuan H.[3,4], Steglich F.[5]
[1]University of Kent, Canterbury, United Kingdom, [2]University of Bristol, Bristol, United Kingdom, [3]Zhejiang University, Hangzhou, China, [4]Collaborative Innovation Center of Advanced Microstructures, Nanjing, China, [5]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany

Muon spin rotation measurements in the superconductors LaNiC2 [1] and LaNiGa2 [2] indicate that time-reversal symmetry is broken in their superconducting states. Symmetry analyses [1,2,3] imply non-unitary triplet pairing and predict [2] a small, bulk magnetisation which may have recently been observed in LaNiC2 [4]. On the other hand, the same symmetry arguments imply a nodal gap, while there is experimental evidence in both materials of two-gap, nodeless superconductivity [5,6]. This seems at odds with the broken time-reversal symmetry [1,2] leading to the proposal [6] of a novel triplet superconducting state where pairing occurs between electrons on different orbitals of the same site with the same spin. Here we present a numerical study of the self-consistency equations of the model and discuss the phase diagram in connection with the phenomenology of LaNiC2 and LaNiGa2. We find that, depending on the model´s parameters, the theory can lead to both two-gap superconductivity and gapless superconductivity, as well as a coexistence of both phenomena on different Fermi surface sheets.

References:

[1] AD Hillier, et al. PRL 102, 117007 (2009)
[2] AD Hillier, et al. PRL 109, 097001 (2012).
[3] J Quintanilla, et al. PRB 82, 174511 (2010)
[4] A Sumiyama, et al. JPSJ 84, 013702 (2015).
[5] J Chen, et al. NJP 15, 053005 (2013).
[6] ZF Weng, et al. PRL 117, 027001 (2016).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.463
Nature of exchange-bias effect in $ErFeO_3$, La-doped $BaFeO_3$, and $LaCr_{0.5}Fe_{0.5}O_3$ orthoferrites
Wisniewski A.[1], _Fita I._[1], _Puzniak R._[1], _Markovich V._[2]
[1]Institute of Physics, Polish Academy of Sciences, Warszawa, Poland, [2]Department of Physics, Ben-Gurion University of the Negev, Beer Sheva, Israel

Exchange bias (EB) effect in single crystal of $ErFeO_3$ emerges in the vicinity of the compensation point T_{comp} = 45 K, at which the oppositely directed magnetic moments of the antiferromagnetically (AFM) coupled Er and Fe sublattices are equal. The novel feature observed is the change of EB sign achieved by varying the field-cooling protocol, depending if T_{comp} is crossed with decreasing or increasing temperature. The origin of EB effect is related to the intrinsic exchange coupling within the unit cell. The negative EB effect occurs in polycrystalline $La_xBa_{1-x}FeO_3$ (x = 0.125, 0.25, 0.33). In low doped samples $x \leq 0.25$, the EB field H_{EB} was found to increase in absolute value rapidly at small cooling field H_{cool} but it falls abruptly at higher H_{cool}, due to the field-induced ferromagnetism (FM). In contrast, the x = 0.33 sample, with strong AFM constituent, shows no field-induced FM and the H_{EB} vs. H_{cool} dependence is reminiscent of that observed commonly for system of isolated FM clusters embedded in an AFM matrix. The positive EB observed in $LuCr_{0.5}Fe_{0.5}O_3$ is due to the magnetic moment reversal which results from an interplay of various Dzyaloshinskii-Moriya interactions between Fe^{3+} and Cr^{3+} ions.
Part of presented results was published in [1,2].

References:
[1] I. Fita, A. Wisniewski, R. Puzniak, V. Markovich, G. Gorodetsky, Phys. Rev. B **93**, 184432 (2016).
[2] I. Fita, A. Wisniewski, R. Puzniak, P. Iwanowski, V. Markovich, S. Kolesnik, B. Dabrowski, Phys. Rev. B (2017), accepted.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.464
Low temperature scanning tunneling microscopy characterization of Sr_2FeMoO_6 thin films
Angervo I., _Saloaro M., Huhtinen H., Paturi P._
University of Turku, Turku, Finland

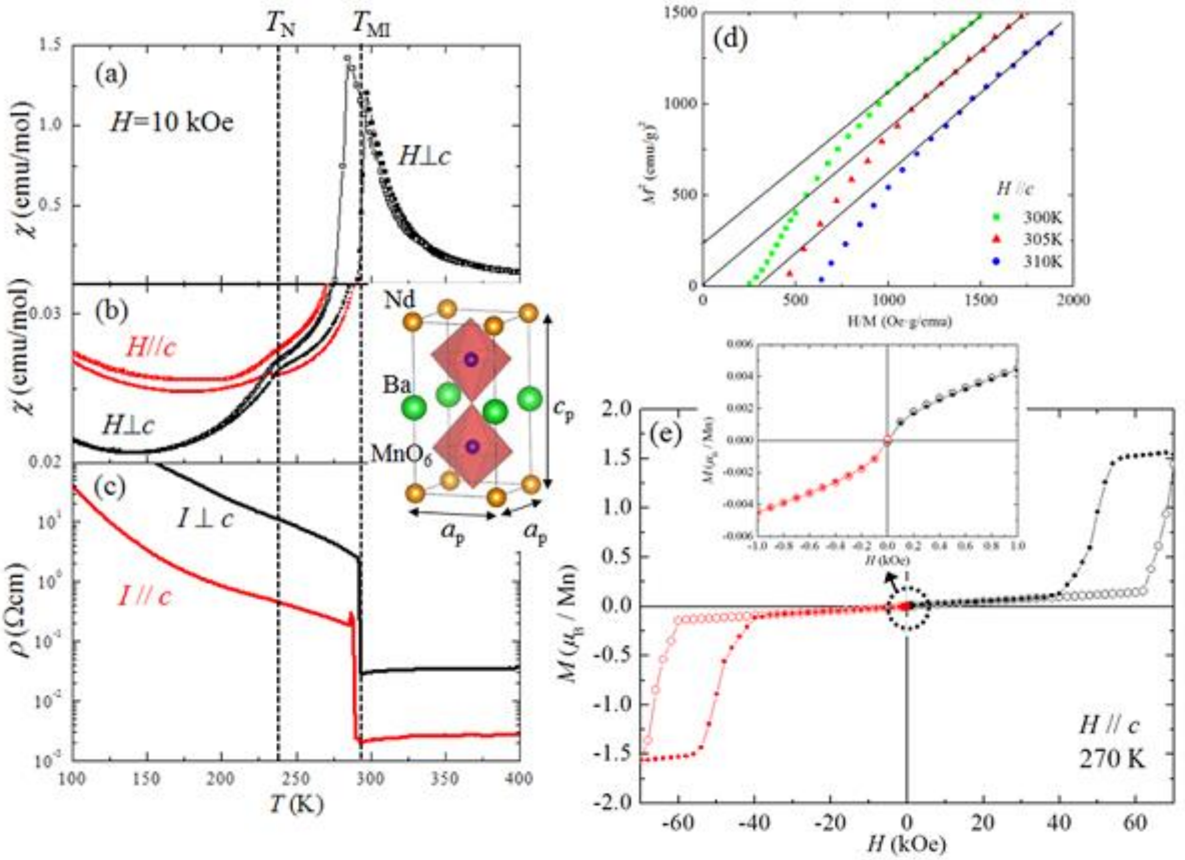
A high Curie temperature (T_C), around 410 K, and a 100% spin polarization highlight Sr_2FeMoO_6 (SFMO) as a valuable candidate for future spintronic applications. The attributes of the films must be studied as functions of temperature, because even below T_C, at room temperature, the properties are different when compared with lower temperatures.
The low temperature scanning tunneling microscopy (STM) and scanning tunneling spectroscopy (STS) measurements are conducted alongside room temperature measurements. Atomic scale thin film growth is confirmed by the STM. The STS measurements are conducted to obtain a detailed surface electronic structure. Compared with X-ray and magnetometric measurements, which provide information averaged over the entire sample, the STS accompanied by the STM gives detailed correlated information between physical and electronic surface structure. The detailed analysis of room temperature and low temperature STS measurements is conducted to study the evolution of electronic properties from a low temperature to room temperature.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.466
Successive phase transitions and phase separations in a double-perovskite $NdBaMn_2O_6$ single crystal

<u>Yamada S.</u>[1], Sagayama H.[2], Sugimoto K.[3], Arima T.[4]
[1]Yokohama-City University, Depertment of Materials System Science, Yokohama, Japan, [2]High Energy Accelerator Research Organization (KEK), Tsukuba, Japan, [3]Japan Synchrotron Radiation Research Institute, Hyogo, Japan, [4]University of Tokyo, Department of Advanced Materials Science, Kashiwa, Japan

We have succeeded in growing large and high quality single crystals of double-perovskite $NdBaMn_2O_6$ with c-axis aligned.[1] Curie-Weiss paramagnetism and metallic conduction are observed above 290K (T_{MI}). The magnetic susceptibility sudden drops at T_{MI} accompanied by a metal-insulator transition. Some pervious studies[2,3] using the poly-crystals proposed that this material have a ferromagnetic(FM) phase transition near 300K, and that the magnetic anomaly at T_{MI} should be ascribed to layered antiferromagnetic(AFM) phase transition. However we do not observe any anomaly indicating the FM phase transition above T_{MI}. The onset of a magnetic anisotropy $T_N \cong 235$ K. Though Arrott-plots above T_{MI} suggest FM phase transition near 305 K, the magnetization does not saturate under 70kOe at 300K. These results imply a growth of FM clusters just above $T_{MI.}$ The application of a relatively low magnetic field (< 1kOe) can induce the ferromagnetic correlation in the temperature range of $T_{MI}>T>T_N$. Additionally, a metamagnetic transition is observed at a higher magnetic field. These results strongly suggest a keen competition between FM and AFM phases.



Temperature dependence of (a) magnetic susceptibility, (b) magnetic anisotropy, and (c) resistivity. (d) Arrott-plot above T_{MI}. (e) Magnetic field dependence of magnetization at 270K.

[Fig_1]

References:

[1] S.Yamada. H.Sagayama, K. Higuchi, T. Sasaki, K. Sugimoto, and T. Arima, Phys. Rev. B **95**, 035101 (2017).
[2] T. Nakajima, H. Kageyama, H. Yoshizawa, K. Ohoyama and Y. Ueda, J. Phys. Soc. Jpn. 72, 3237 (2003).
[3] D. Akahoshi, M. Uchida, Y. Tomioka, T. Arima, Y. Matsui, and Y. Tokura, Phys. Rev. Lett. 90, 177203 (2003).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.467
Magnetic field induced multiferroic behavior in Kagome $Cu_3Bi(SeO_3)_2O_2Cl$

Wu H.C.[1], Chandrasekhar K.D.[1], Yuan J.K.[1], Huang J.R.[2], Lin J.Y.[2], Berger H.[3], Yang H.D.[1]
[1]National Sun Yat-Sen University, Physics, Kaohsiung, Taiwan, Republic of China, [2]National Chiao Tung University, Physics, Hsinchu, Taiwan, Republic of China, [3]Ecole Polytcchnique Federal de Lausanne, Lausanne, Swaziland

Temperature and magnetic field dependent magnetization, specific heat, dielectric, magneto-dielectric, and ferroelectric properties were investigated on Kagome single crystal $Cu_3Bi(SeO_3)_2O_2Cl$. Without magnetic field, an antiferromagnetic transition is clearly established at T_N ~ 25 K. Above the critical field H_C ~ 0.8 T, a metamagnetic spin-flip transition from antiferromagnetic to ferrimagnetic order at T ~ T_N is induced anisotropically only for H // c. Simultaneously, a ferroelectric behavior is observed below T ~ T_N, then a corresponding type-II multiferroics emerges above H_C. The key mechanism of the anisotropic spin-flip induced multiferroicity in $Cu_3Bi(SeO_3)_2O_2Cl$ can be ascribed to the breaking of magnetic two-fold symmetry in the bc plane above H_C. Furthermore, pressure and doping effects on the related properties were also presented and discussed to explore more this novel phenomenon.

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.468

Growth and formation of vortex tangle by vibrating wire in superfluid ^{4}He

Yano H., Mushiake R., Ogawa K., Obara K., Ishikawa O.
Osaka City University, Graduate School of Science, Osaka, Japan

To investigate the growth and formation of quantum turbulence in superfluid ^{4}He, we have studied the time of flights of vortex rings emitted from a vortex tangle generated by a vibrating wire, using a set of two vibrating wires as a generator of turbulence and a detector of vortex rings. The emission rate of vortex rings remains low until the beginning of high-rate emissions, suggesting that some of the vortex lines produced by the wire combine to form a vortex tangle, until an equilibrium is established between the rate of vortex line combination with the tangle and dissociation. Vortex rings emit more frequently in the direction parallel to the vibrating direction of the generator than that for the perpendicular direction, in agreement with numerical simulation results [1]. At diameters larger than a wire diameter of 2.5 µm, however, the emission rate of the rings becomes lower for the parallel direction. These results suggest that the generation mechanism of vortex rings depends on their sizes. Small rings may be produced in a cascade process from a large scale to a smaller scale in the vortex tangle, while large rings may be produced directly by stretching vortex lines to a size of the vibrating amplitude of the generator.

References:

[1] A. Nakatsuji, M. Tsubota, H. Yano, Phys. Rev. B **89**, 174520 (2014)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.469

SQUID behavior of superconducting Nb nano-rings without Josephson junctions

Sharon O.[1], Shaulov A.[1], Sharoni A.[2], Berger J.[3], Yeshurun Y.[4]
[1]Bar Ilan University, Department of Physics, Institute of Superconductivity and Institute of Nanotechnology, Ramat-Gan, Israel, [2]Bar Ilan University, Department of Physics, Institute of Nanotechnology, Ramat-Gan, Israel, [3]Ort Braude College, Physics, Karmiel, Israel, [4]Bar-Ilan

University, Department of Physics, Institute of Superconductivity and Institute of Nanotechnology, Ramat-Gan, Israel

Homogeneous Nb nano-rings connected serially by Nb nano-wires exhibit magneto-resistance oscillations of markedly different character at different bias-currents. At low bias current the classical Little-Parks parabolic oscillations are observed. As the bias current increases, these oscillations become sinusoidal and, at a certain threshold current, they transform into oscillations of a superconducting interference device (SQUID) [1]. Interpretation of these results is based on the non-uniformity of the order parameter along each nano-ring, caused by the Nb wires attached to it. Current enhanced phase slips rate at the two antipodal locations with minimal order parameter create Josephson junctions in the ring, transforming the ring into a SQUID.

References:

[1] Omri J. Sharon *et al., Scientific Reports **6**,* 28320 (2016).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.470

Low-temperature scanning tunneling microscopy and spectroscopy of the heavy fermion compound CeB_6

Yoshida Y.[1], Kim H.[1,2], Haze M.[1,3], Miyata Y.[1], Suzuki H.[1,4], Iga F.[5,6], Hasegawa Y.[1]
[1]University of Tokyo, Institute for Solid State Physics, Kashiwa, Japan, [2]University of Hamburg, Hamburg, Germany, [3]Kyoto University, Kyoto, Japan, [4]National Institute for Material Science, Tsukuba, Japan, [5]University of Ibaraki, Graduate School of Engineering and Science, Ibaraki, Japan, [6]University of Ibaraki, Collage of Science, Ibaraki, Japan

We conducted scanning tunneling microscopy and spectroscopy measurements at low temperatures and in magnetic fields to investigate the (001) surface of the heavy fermion compound CeB_6. By cleaving the sample in ultrahigh vacuum and at room temperatures, we obtained flat and wide terraces separated by an atomic size step. We observed various types of reconstructed and non-reconstructed surfaces, which are similar to ones observed on cleaved surfaces of SmB_6 [1, 2]. The reconstructed surfaces have strong bias-voltage dependence indicating the semiconducting characters of the surfaces. We also observed a Fano-like peak structure in the tunnel spectra of the non-reconstructed Ce-terminated surface as expected for Kondo systems. We will report the details of the experimental results in the presentation.

References:

[1] S. Rossler *et al*., Proc. Natl. Acad. Sci. USA **111**, 4798 (2014).
[2] W. Ruan *et al*., Phys. Rev. Lett. **112**, 136401 (2014).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.471

The structure of impurity hydrogen and Ti^{3+} ions in rutile TiO_2

Yoshizawa K.[1], Iwazaki Y.[2], Gohda Y.[3], Tsuneyuki S.[4]

[1]Research Organization for Information Science & Technology, Kobe, Japan, [2]TAIYO YUDEN CO., LTD., Gunma, Japan, [3]Tokyo Tech, Dept. Mater. Sci. Eng., Yokohama, Japan, [4]University of Tokyo, Dept. of Physics, Tokyo, Japan

Titanium dioxide (TiO_2) is a widely used photocatalytic material with many potential application in electronics, optoelectronics, and photovoltaics. The change of the crystal structure by impurity hydrogen (H) and oxygen vacancy (V_O) affects the electronic properties and the activation performance of TiO_2. Therefore, we pay attention to the effect of H doping of TiO_2, and there are excess electrons accompanying H or V_O. It is known that the electrons can localize at Ti 3d orbitals, forming Ti^{3+} ions [1, 2]. The trapped electrons form small polarons that consist of the electrons coupled to the distortion of the lattice around the Ti^{3+} ions. We examine the structure of H in rutile TiO_2 by using density functional theory (DFT) calculation. The spin density for a localized electron in Ti site exists and it is verified that the excess electrons are described as localized small polarons by DFT calculation. We also understand H behavior by calculating the isotropic and anisotropic hyperfine coupling constants. Because muonium in crystals behaves similarly to H, muon spin rotation (µSR) has played an important role in identification of hydrogen-like states in TiO_2. We evaluate the accuracy of DFT calculation for H in TiO_2 by the comparison with hyperfine parameters of µSR [3].

References:
[1] A. Janotti, C. Franchini, J. B. Varley, G. Kresse, and C. G. Van de Walle, Phys. Status Solidi RRL **7**, 199 (2013).
[2] F. Filippone, G. Mattioli, P. Alippi, and A. Amore Bonapasta, Phys. Rev. B **80**, 245203 (2009).
[3] K. Shimomura, R. Kadono, A. Koda, K. Nishiyama, and M. Mihara, Phys. Rev. B **92**, 075203 (2015).

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

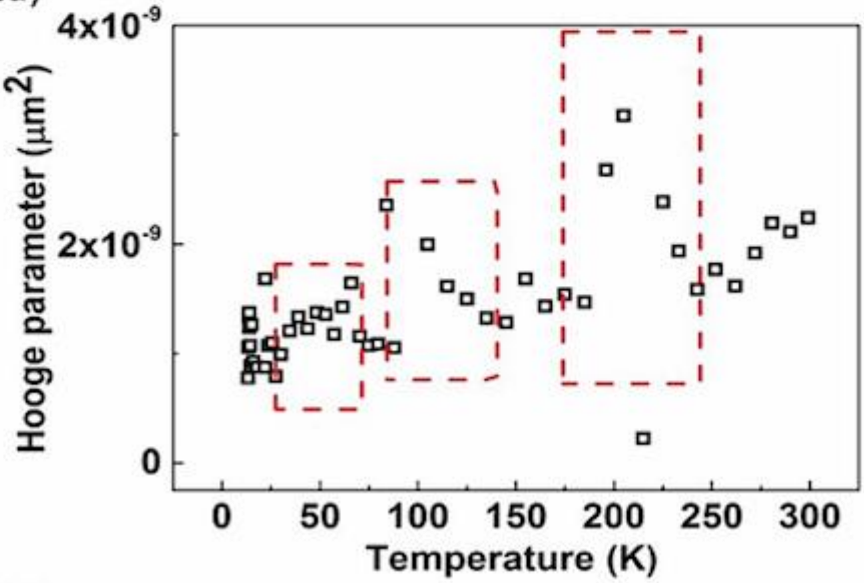
P.472

Enhancement of 1/*f* noise due to thermally-activated trapping-detrapping processes in Magnetic Tunnel Junctions (MTJs)

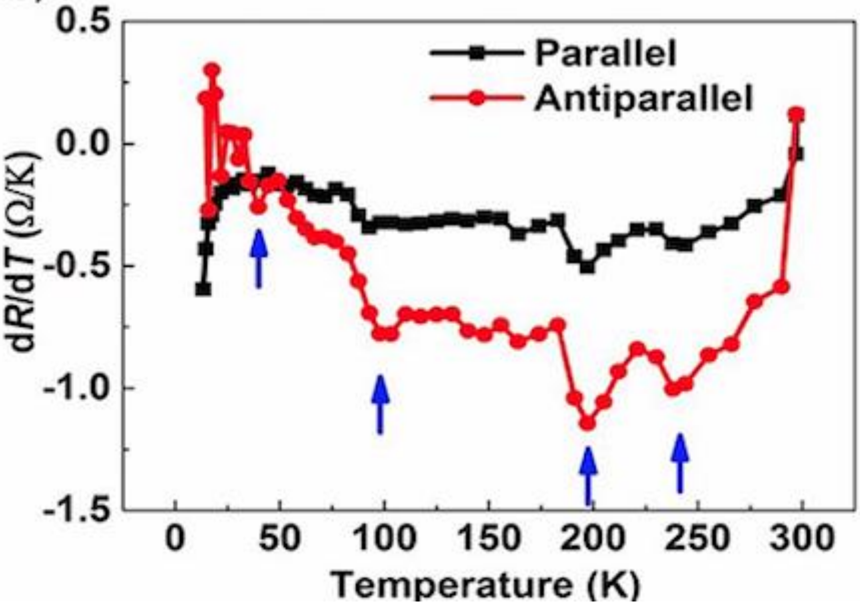
Zheng C.[1], *Shull R.*[2], *Chen P.J.*[2], *Pong P.*[1]
[1]University of Hong Kong, Hong Kong, Hong Kong, [2]National Institute of Standards and Technology, Gaithersburg, United States

In MTJs, the electronic 1/*f* noise is attributed to the resistance fluctuation that originates from the trapping-detrapping (TD) events during tunneling process [1]. Previous studies have focused on the impact of temperature (*T*),[2] bias voltage,[3] and magnetization configuration[2] on the electronic 1/*f* noise. However, a more elaborated description of TD mechanism is still lacking. Herein we investigated the *T* dependence of the electronic 1/*f* noise and several abnormal noise peaks were observed (Fig.1a). These peaks should not arise from the random telegraph noise because no Lorentzian feature was observed.[4] They presumably derive from the activation of extra TD events during the tunneling process, which is evidenced by the observation of the dips in the d*R*(*T*)/d*T* curve (Fig.1b). These TD processes impede the tunneling of electrons and locally increase the resistance (*R*). As a result, the *R* fluctuation in MTJs is promoted, enhancing the electronic 1/*f* noise. Since the manifestation of the electronic 1/*f* noise is closely related to the activation energies of TD processes, the observed phenomenon indicates that the distribution of activation energies of the thermally-activated TD processes could be dramatically altered at certain *T*, leading to the abnormally boosted electronic 1/*f* noise.

(1a)



(1b)



[Temperature dependence of electronic 1/f noise]

References:
1. Z.H. Yuan *et al.*, *J. Magn. Magn. Mater.* **398**, 215-219, (2016)
2. L. Jiang *et al*., *Phys. Rev. B* **69**(5), 054407 (2004)
3. F.G. Aliev *et al*., *Phys. Rev. Lett.* **112**(21) 216801 (2014)
4. T. Arakawa *et al*., *Phys. Rev. B* **86**(22) 224423 (2012)

Postersession 1
Thursday, 10 August 2017
16.30-18.30
G Foyer

P.473

Liquid helium^4 surface as a mirror for ultra-cold neutrons

Grigoriev P.[1]*, Zimmer O.*[2]*, Grigoriev A.*[3]*, Ziman T.*[2,4]

[1]Landau Institute for Theoretical Physics, Chernogolovka, Moscow Region, Russian Federation,
[2]Institut Laue Langevin, Grenoble, France, [3]Samara State University, Samara, Russian Federation,
[4]LPMMC, CNRS, Universite Grenoble-Alpes, Grenoble, France

We investigate the possibility of ultra-cold neutron storage in quantum states defined by the combined potentials of the Earth´s gravity and the neutron optical repulsion by a horizontal surface of liquid helium.[1] We analyse the stability of the lowest quantum state, which is most susceptible to perturbations due to surface excitations, against scattering by helium atoms in the vapor and by excitations of the liquid, comprised of ripplons, phonons and surfons. This is an unusual scattering problem since the kinetic energy of the neutron parallel to the surface may be much greater than the binding energies perpendicular. The total scattering time of these UCNs at 0.7 K is found to exceed one hour, and rapidly increases with decreasing temperature. Such low scattering rates should enable high-precision measurements of the sequence of discrete energy levels, thus providing improved tests of short-range gravity or for experiments of neutron beta - decay.

References:

[1] P. D. Grigoriev, O. Zimmer, A. D. Grigoriev, and T. Ziman, Phys. Rev. C **94**, 025504(2016)

LT28 POSTER SESSION 2

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.475

Electrical transports between MoS_2 based electric double layer transistor and normal and superconducting Al

Aikawa Y.[1]*, Tsumura K.*[2]*, Narita T.*[1]*, Takayanagi H.*[3]*, Ishiguro R.*[1]
[1]Japan Women's University, Tokyo, Japan, [2]AIST, Tsukuba, Japan, [3]Tokyo University of Science, Tokyo, Japan

The electric double layer transistor (EDLT) is a kind of a field effect transistor with an ionic liquid gate, and enable high density carrier accumulation in the surface of channel material. Electric-field-induced superconductivity with the ultrahigh upper critical field in transition-metal di-chalcogenide molybdenum disulfide (MoS_2), which is a two-dimensional layered crystal, was demonstrated by using the EDLT [1] [2].
With the aim of test of pairing symmetry in the electrically induced two-dimensional superconductivity in MoS_2, we fabricated a junction between the MoS_2 based EDLT configuration and a normal metal or conventional superconductor Aluminum.
We measured electrical transports of the junction in a temperature range of 20mK to 10K, and will discuss the results from the point of view of tunneling spectroscopy and phase sensitive test of superconductor.

References:

[1] J. T. Ye et al., Science 338, 1193 (2012).
[2] Y. Saito et al., Nat. Phys. 12, 144 (2016).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.476

The onset of nanoscale dissipation in superfluid He-4 at T=0: the role of vortex shedding and cavitation bubbles

Ancilotto F.[1]*, Barranco M.*[2]*, Pi M.*[2]*, Eloranta J.*[3]
[1]University of Padova, Physics and Astronomy, Padova, Italy, [2]Universitat de Barcelona, Facultat de Fisica, Barcelona, Spain, [3]California State University at Northridge, Chemistry and Biochemistry, Northridge, United States

Two-dimensional flow past an infinitely long cylinder of nanoscopic radius in superfluid He-4 at zero temperature is studied by time-dependent density functional theory. The calculations reveal two distinct critical phenomena for the onset of dissipation:
1) vortex-antivortex pair shedding from the periphery of the moving cylinder and
2) the creation of cavitation bubbles in the wake.
The bubble formation behind the cylinder is accompanied by a sudden jump in the drag exerted by the fluid. Vortex line pairs with the same circulation are occasionally emitted in the form of "dimers", which

constitute the building blocks for the Benard-von Karman vortex street structure observed in classical turbulent fluids and in Bose-Einsten condensates.
We compare our findings with recent experimental observations for fast moving micrometer-scale spherical objects in superfluid He-4.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.478
Normal metal - insulator - superconductor refrigerators with titanium-gold as normal metal lead
Räisänen I., *Geng Z., Kinnunen K.M., Maasilta I.J.*
University of Jyväskylä, Jyväskylä, Finland

Normal metal - insulator - superconductor (NIS) tunnel junctions are versatile and useful devices for thermometry, cooling, and metrological applications for the definition of ampere. Usually, copper has been used as the normal metal. We have observed how the Cu electrode degrades strongly with heating, and in contact with some solvents. Thus, it is desirable to find other alternatives for the normal metal.
We have fabricated superconductor - insulator - normal metal - insulator - superconductor (SINIS) junctions in which Al acts as superconductor, AlOx is the insulator, and the normal metal consists of a thin Ti layer (5 nm) covered with a much thicker Au layer (40 nm). We characterized the junctions by measuring their current-voltage curves and current biased temperature response (thermometry) between 60 mK and 750 mK, and found near ideal response. We also measured dynamic conductance with respect to voltage and temperature above 4.2 K, and determined the thickness and height of the tunneling barrier in the junction. With the Ti-Au bilayer the junction seems to have a lower and thinner tunneling barrier and thus lower tunneling resistance than with Cu. This means our novel junctions can be used as effective electron refrigerators, which we already have observed experimentally.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.479
Non-integer-spin magnonic excitations in untextured magnets
Kamra A.[1], *Agrawal U.*[2], *Belzig W.*[1]
[1]University of Konstanz, Konstanz, Germany, [2]Indian Institute of Technology, Mumbai, India

Interactions are responsible for intriguing physics, e.g. emergence of exotic ground states and excitations, in a wide range of systems. Here we theoretically demonstrate that dipole-dipole interaction leads to bosonic eigen-excitations with spin ranging from zero to above $\hbar$ in magnets with uniformly magnetized ground states. These exotic excitations can be interpreted as quantum coherent conglomerates of magnons, the eigen-excitations when the dipolar interactions are disregarded. We further find that the eigenmodes in an easy-axis antiferromagnet are spin-zero quasiparticles instead of the widely believed spin $\pm\hbar$ magnons. The latter re-emerge when the symmetry is broken by a

sufficiently large applied magnetic field. The spin greater than $\hbar$ is accompanied by vacuum fluctuations and may be considered a weak form of frustration.

References:

[1] A. Kamra and W. Belzig, Super-Poissonian shot noise of squeezed-magnon mediated spin transport, Phys. Rev. Lett. **116**, 146601 (2016).
[2] A. Kamra, U. Agrawal, and W Belzig, Non-integer-spin bosonic excitations in untextured magnets, arxiv:1612.04163 (2016).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.480

From chiral p+ip superfluid to super Efimov effect

Moroz S.[1], *Hoyos C.*[2], *Son D.T.*[3], *Nishida Y.*[4], *Radzihovsky L.*[5]
[1]TU Munich, Garching bei München, Germany, [2]Oviedo, Oviedo, Spain, [3]UChicago, Chicago, United States, [4]Tokyo Institute of Technology, Tokyo, Japan, [5]CU Boulder, Boulder, United States

Two-dimensional fermionic chiral superfluidity and superconductivity is an active area of experimental and theoretical research in condensed matter physics. It is of interest in diverse fields such as the physics of 3He, quantum Hall physics, unconventional superconductivity and topological quantum computing. In this poster I will summarize our hydrodynamic effective theory of a chiral p+ip superfluid at zero temperature. It naturally incorporates the parity and time reversal violating effects such as the Hall viscosity and the edge current. I will also show how a chiral p+ip superfluid can be put on a sphere. In addition, I will also describe the few-body aspects of this problem and introduce the super Efimov effect- a new type of three-body quantum universality manifesting itself in a tower of three-body bound states with a double-exponential scaling. These universal few-body states may be observed in ultracold atom experiments and should be taken into account in future many-body studies of p+ip paired states.

References:

[1] Carlos Hoyos, Sergej Moroz, Dam Thanh Son Phys. Rev. B 89, 174507 (2014),
[2] Yusuke Nishida, Sergej Moroz, Dam Thanh Son, Phys. Rev. Lett. 110, 235301 (2013),
[3] Sergej Moroz, Yusuke Nishida, Phys. Rev. A 90, 063631 (2014),
[4] Sergej Moroz, Carlos Hoyos, Phys. Rev. B 91, 064508 (2015),
[5] Sergej Moroz, Carlos Hoyos, Leo Radzihovsky Phys. Rev. B 93, 024521 (2016).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.481

Electronic phase diagram of superconductor $BaTi_2(Sb_{1-x}Bi_x)_2O$

Ishii W., *Yajima T.*, *Hiroi Z.*
University of Tokyo, Institute for Solid State Physics, Kashiwa, Japan

$BaTi_2Sb_2O$ and $BaTi_2Bi_2O$ exhibit superconductivity (SC) at 1.2 and 4.6 K, respectively [1,2]. In the solid solutions of $BaTi_2(Sb_{1-x}Bi_x)_2O$, SC has not been observed down to 1.85 K for $0.35 \leq x \leq 0.55$ (region B), resulting in two SC domes at $0 \leq x \leq 0.3$ (region A) and $0.6 \leq x \leq 1$ (region C) in the

electronic phase diagram [3]. This observation has attracted much attention in relation to the similar electronic phase diagrams of cuprate and iron pnictide superconductors [4,5]. However, the origin of the two SC domes has not been clarified yet partly because of the lack of low-temperature data in the previous work. Here we performed heat capacity measurements down to 0.5 K and found SC transitions at around 1 K in region B. Interestingly, the Sommerfeld coefficients γ in region B are almost the same as those in region A, while the T_c is significantly lower than that in region A (T_c^{max} = 2.5 K). Moreover, at the boundary between regions B and C, γ suddenly drops from 17.6 mJ K^{-2} mol^{-1} (x = 0.55) to 7.1 mJ K^{-2} mol^{-1}

(x = 0.60) in spite that T_c drastically increases from 1 to 3.6 K, suggesting a substantial change in the electronic state at the boundary. These results would provide a hint for understanding the mechanism of the SC of this system.

References:
[1] T. Yajima et al., J. Phys. Soc. Jpn. **81,** 103706 (2012).
[2] T. Yajima et al., J. Phys. Soc. Jpn. **82,** 013703 (2013).
[3] T. Yajima et al., J. Phys. Soc. Jpn. **82,** 033705 (2013).
[4] C. C. Homes et al., Phys. Rev. B **85,** 134510 (2012).
[5] N. Fujiwara et al., Phys. Rev. Lett. **111,** 097002 (2013).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.482
Magnetostriction of the frustrated pyrochlores $Dy_2Sn_2O_7$ and $Ho_2Sn_2O_7$ – a comparison to the titanates

Doerr M.[1], Stöter T.[1], Nomura T.[2], Zherlitsyn S.[2], Wosnitza J.[1,2], Prabhakaran D.[3]
[1]Technische Universität Dresden, Dresden, Germany, [2]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany, [3]University of Oxford, Clarendon Laboratory, Oxford, United Kingdom

The collective behaviour of interacting magnetic moments can be strongly influenced by lattice variations. In geometrically frustrated spin systems, interesting correlations may develop that are related to the composition and stoichiometry of the compounds. The current interest is focused especially on the question whether an increase of the lattice parameters stabilize the spin-ice character or rather enhances the antiferromagnetic correlations. We report a magnetoelastic study by use of magnetostriction measurements in magnetic fields up to 5 T applied along the [111] direction on single-crystalline $Dy_2Sn_2O_7$ and $Ho_2Sn_2O_7$, which are characterized by a roughly 3% larger cubic lattice constant compared to the well-known spin-ice materials $Dy_2Ti_2O_7$ and $Ho_2Ti_2O_7$. At low temperatures, the magnetic field induces transitions between states with different non-trivial spin textures. The relative length changes in field are smaller and the anomalies less pronounced as compared to the titanates. Summarizing, our data indicate frustration effects and spin-ice-like behaviour, increased due to negative chemical pressure, in good agreement with results reported in [1].

References:
[1] H.D. Zhou *et. al.*, Phys. Rev. Letters **108**, 207206 (2012)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.483
Spin-caloritronic transport in superconductor-ferromagnet tunnel structures
Rezaei A., Kamra A., Machon P., Belzig W.
Universität Konstanz, Department of Physics, Konstanz, Germany

We investigate the effect of an exchange field and spin-flip scattering on the pair potential and the spin Seebeck coefficient of superconductor (S) - ferromagnet (F) hybrid structures using the Green's functions method. Such structures have been predicted to show giant charge Seebeck coefficient [1,2]. In the absence of spin-flip scattering, the pair potential of the S has been studied for different values of the exchange field. We show that the normal to S phase transition with decreasing temperature changes character from second to first order above a certain value of exchange field. The density of states in energy, and spin Seebeck coefficient as a function of temperature have been computed for several values of spin-flip scattering time. We show that spin-flip scattering limits the enhancement in the spin Seebeck coefficient in realistic settings.
References:
[1] P. Machon, M. Eschrig, and W. Belzig, Phys. Rev. Lett. **110**, 047002 (2013)
[2] A. Ozaeta, P. Virtanen, F. S. Bergeret, and T. T. Heikkilä, Phys. Rev. Lett. **112**, 057001 (2014)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.485
Correlation of microstructure and TLS density of Al/AlO$_x$/Al-layer systems for superconducting qubits
Fritz S.[1], Seiler A.[2], Schneider R.[1], Radtke L.[2], Weides M.[2], Weiß G.[2], Gerthsen D.[1]
[1]Karlsruher Institut für Technologie, Laboratorium für Elektronenmikroskopie, Karlsruhe, Germany,
[2]Karlsruher Institut für Technologie, Physikalisches Institut, Karlsruhe, Germany

The realization of scalable circuits for quantum information technology is a major goal in information science. Superconducting quantum bits (qubits), which are typically fabricated on the basis of Al/AlO$_x$/Al-Josephson junctions (JJs) are considered among the most promising approaches.
Much progress has been achieved with respect to coherence times [1], but a remaining roadblock towards scalability are two-level tunneling systems (TLS) [2], which are associated with structural anomalies of the disordered AlO$_x$-tunnel barrier [3]. The identification of the microscopic nature of TLS was not possible up to now and prevented the deterministic reduction of TLS density. Analytical transmission electron microscopy (TEM) yields structural and chemical properties on an atomic scale and recent work has shown the potential of these techniques [4,5] for analyzing JJs.
In this work we study different Al/AlO$_x$/Al-layer systems, which were fabricated under well-controlled oxidation conditions. We strive to understand whether the TLS density can be reduced by optimizing the structural and chemical properties of the AlO$_x$-tunnel barrier. For this purpose, we correlate structural and chemical properties obtained by analytical TEM with data on the TLS density from low-temperature capacity measurements.
References:
[1] M. H. Devoret, R. J. Schoelkopf, *Science* **339**, 1169 (2013)
[2] J.M. Martinis *et al.*, *Phys. Rev. Lett.* **95***,* 210503 (2005)
[3] T.C. DuBois *et al.*, *New J. Phys.* **17**, 023017 (2015)
[4] V. V. Roddatis *et al.*, *J. Appl. Phys.* ***110****,* 123903 (2011)
[5] L. J. Zeng *et al.*, *Scientific Rep**. 6,*** 29679 (2016)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.486

Probing the dynamics of ^{3}He atoms adsorbed on MCM-41with pulsed NMR

Huan C., Masuhara N., Sullivan N.S.
University of Florida, Department of Physics, Gainesville, United States

The mesoporous material MCM-41 provides a framework that allows the study of quantum liquids or solids in confined states. The typical pore is about 1-2 nm in diameter and 300 nm in length. By properly plating the pores, one can achieve effective 1D quantum wells for the adsorbed atoms. Previous research has observed the crossover from 2D motion to 1D motion for adsorbed ^{3}He atoms [1][2]. However to observe the predicted 1D Luttinger liquid behavior, much lower temperatures are necessary [3]. At the Microkelvin laboratory of the University of Florida, we have the capability of cooling ^{3}He samples down to sub-mK regime with our nuclear demagnetization and dilution refrigerator system. In this experimental study, we carried out preliminary NMR measurements on an adsorbed ^{3}He sample of multiple layers on MCM-41, which showed that the nuclear susceptibility deviates from the prediction of the Fermi liquid theory and both T_1 and T_2 decrease with temperature down to 80 mK. The results were compared with a simple hydrodynamic model.

References:

[1] B. Yager *et.al*., Phys. Rev. Letts., **111**, 215303 (2013)
[2] T. Matsushita *et.al.*, Journal of Low Temp. Phys., **183**, 251 (2016)
[3] G. E. Astrakharchik and J. Boronat, Phys.Rev. B, **90**, 235439 (2014)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.487

The resistive transition to superconductivity in $YbRh_2Si_2$

Levitin L.[1], van der Vliet H.[1], Nyeki J.[1], Casey A.[1], Hamann S.[2], Steppke A.[2], Koenig M.[2], Kliemt K.[3], Krellner C.[3], Brando M.[2], Saunders J.[1]
[1]Royal Holloway University of London, Physics, Egham, United Kingdom, [2]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany, [3]Physics Institut, Goethe University, Frankfurt, Germany

We report electrical transport measurements on the putative heavy fermion superconductor $YbRh_2Si_2$. Measurements of the Nyquist noise were made on a high quality single crystal sample, over the temperature range 1K to 0.6 mK. In the Earth's magnetic field we find the sample to be superconducting below 4.1 mK, with an upper bound of the sample resistance of 1 nΩ (sample resistance at 20 mK is 0.75 mΩ). In addition on cooling below 12 mK there is a clear transition from normal metal to a new intermediate state in which the resistance decreases with decreasing temperature, initially approximately linearly, towards zero. We propose this to be a dissipative superconducting state. These features correspond to the A and B features identified [1] from measurements of magnetization and magnetic susceptibility, below 0.1 mT. The Nyquist noise was then studied in magnetic fields up to 9 mT, applied in plane, perpendicular to the c-axis. The zero resistance state was observed to be quenched above approximately 5 mT. At 9 mT we observe "re-

entrance” of the normal state resistance at the lowest temperature. In the light of this critical field behavior, we discuss the nature of the superconductivity in the system, and the interplay with both electronic and nuclear magnetism.

References:
[1] E. Schuberth et al., Science, **351**, 495 (2016).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.488
Formation of vortex lattices in superfluid bose gases at finite temperatures

Arahata E.[1], *Nikuni T.*[2]
[1]Tokyo Metropolitan University, Tokyo, Japan, [2]Tokyo University of Science, Tokyo, Japan

The mechanism of vortex nucleation in a rotating Bose Einstein condensate (BEC) is an important subject in ultracold quantum gases. The important role of the thermal cloud has been experimentally investigated by the JILA group, who created vortex lattices by first spinning a normal cloud and then cooling the rotating gas through the BEC transition[1]. This experiment indicated that vortex nucleation can arise from the transfer of angular momentum between the thermal cloud and the condensate. In order to clarify the effect of a thermal cloud theoretically, it is necessary to simulate both a BEC and the thermal cloud dynamically.
Here we report on the dynamics of a rotating trapped BEC at finite temperatures. Using the Zaremba-Nikuni-Griffin (ZNG) formalism[2], based on a generalized Gross-Pitaevskii equation for the condensate coupled to a semiclassical kinetic equation for a thermal cloud, we numerically simulate vortex lattice formation in the presence of a time-dependent rotating trap potential under the experimental situation. Our simulations show that the thermal cloud triggers vortex lattice formation in the rotating BEC. We shall also discuss how the angular momentum transfers from the thermal cloud to the condensate.

References:
[1] P. C. Haljan, I. Coddington, P. Engels, and E. A. Cornell, Phys. Rev. Lett 87, 210403 (2001).
[2] E. Zaremba, T. Nikuni, and A. Griffin, J. Low Temp. Phys. 116, 277 (2009).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.489
Symmetry-protected line nodes in non-symmorphic magnetic space groups

Nomoto T.[1], *Ikeda H.*[2]
[1]RIKEN, Center for Emergent Matter Science, Wako, Japan, [2]Ritsumeikan University, Department of Physics, Kusatsu, Japan

Coexisting phases between superconductivity and magnetism have often been discovered in the U-based heavy fermion superconductors. They have many fascinating properties including exotic pairing glues such as magnetic excitons in UPd_2Al_3 [1] and Ising ferromagnetic fluctuations in UCoGe [2]. However, the nodal structure of such coexisting phases is less well understood systematically [3].

Here, we present the group theoretical classification of gap functions in the coexisting phases, especially which belong to non-symmorphic magnetic space groups [4]. Based on the general space group approach [5, 6], we show that UCoGe-type ferromagnetic superconductors must have horizontal line nodes on either the k_z=0 or π plane. Moreover, it is likely that additional Weyl point nodes exist at the axial point. In UPd_2Al_3-type antiferromagnetic superconductors, gap functions with A_g symmetry possess horizontal line nodes in the antiferromagnetic Brillouin zone boundary. In other words, the conventional fully gapped s-wave superconductivity is forbidden, regardless of the pairing mechanism. We conclude that these two are candidate unconventional superconductors possessing hidden symmetry-protected line nodes, peculiar to non-symmorphic magnetic space groups.

References:

[1] C. Geibel *et al*., Z. Phys. B **84**, 1 (1991).
[2] N. T. Huy *et al*., Phys. Rev. Lett. **99**, 067006 (2007).
[3] V. P. Mineev, Phys. Rev. B **66**, 134504 (2002).
[4] T. Nomoto and H. Ikeda, J. Phys. Soc. Jpn. **86**, 023703 (2017).
[5] V. G. Yarzhemsky, Phys. Status Solidi B **209**, 101 (1998).
[6] T. Micklitz and M. R. Norman, Phys. Rev. B **80**, 100506(R) (2009).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.490

Thermal expansion and magnetostriction of clathrate compound $Pr_3Pd_{20}Ge_6$

Matsumoto K.[1], *Sekiguchi Y.*[1], *Iwakami O.*[1], *Ono T.*[1], *Abe S.*[1], *Ano G.*[2], *Akatsu M.*[2], *Mitsumoto K.*[2], *Nemoto Y.*[2], *Goto T.*[2], *Takeda N.*[2], *Kitazawa H.*[3]
[1]Kanazawa University, Kanazawa, Japan, [2]Niigata University, Niigata, Japan, [3]National Institute for Materials Science (NIMS), Tsukuba, Japan

The clathrate compounds $R_3Pd_{20}X_6$ where *R*=rare earth and *X*=Si or Ge are interesting compounds showing either rattling motions of *R* atoms, quadrupole order of 4*f* electrons, or both [1]. In $Pr_3Pd_{20}Ge_6$, the Pr ions are located at two different crystallographic sites, 4a and 8c site. Antiferro-quadrupole ordering (AFQ) of the 8c site occurs at 250 mK. The ac-susceptibility measurements indicated that antiferro-magnetic ordering (AFM) of the 4a site occurs at 77 mK. Furthermore, Hyperfine-enhanced Pr-nuclear magnetic ordering of the 8c site was observed at 9 mK [2].
To clarify the magnetic and quadrupole properties of $Pr_3Pd_{20}Ge_6$, we studied thermal expansion and magnetostriction using capacitive dilatometers constructed in similar way to our previous studies. Thermal expansion and magnetostriction measurements on single crystal samples were carried out along the [001] and [110] directions in applied external fields up to 9 T and down to 10 mK.
In zero magnetic field, the temperature dependence of the relative length change ΔL/L in [001] direction had a dip at AFQ and abrupt decrease at AFM. ΔL/L in [110] direction showed abrupt increase at AFM. From thermal expansion and isothermal magnetostriction measurements, magnetic phase diagram was obtained.

References:

1. G. Ano et al., J. Phys. Soc. Jpn. **81**(3):034710 (2012)
2. O. Iwakami et al., Phys. Rev. B **90**:100402 (2014)

Postersession 2
Saturday, 12 August 2017

16.30-18.30
G Foyer

P.491
Superconducting-fluctuation effects in strong-coupling regime
Adachi K., Ikeda R.
Kyoto University, Department of Physics, Kyoto, Japan

FeSe has multi-band structure with small Fermi energies. Interestingly, in one of these bands, the magnitude of the superconducting gap is comparable to the Fermi energy. This suggests an exciting possibility that the attractive interaction among the electrons in FeSe is in the strong-coupling, or the BCS-BEC-crossover, regime [1]. To consider this possibility, we focus on the superconducting-fluctuation (SCF) phenomena [2]. Regarding SCF effects, it has been observed in FeSe that the diamagnetic responses are much larger than those in the Gaussian-fluctuation approximation (GFA) [3].
We study an electron system with a strong attractive interaction [4]. The short coherence length characteristic of the strong-coupling regime makes the interaction between SCFs significant. We find that this feature can lead to the large diamagnetic responses compared to those in the GFA, which are qualitatively consistent with the observation in FeSe. Our results show that the SCF-induced specific heat will be also larger than that in the GFA. In addition, we find that the lowest-Landau-level scaling of thermodynamic quantities in high magnetic fields, which has been observed experimentally in cuprates [5] and theoretically in the weak-coupling regime, can break down in the strong-coupling regime.
References:
[1] S. Kasahara et al., Proc. Natl. Acad. Sci. U.S.A. **111**, 16309 (2014).
[2] A. Larkin and A. Varlamov, "Theory of Fluctuations in Superconductors" (Clarendon Press, Oxford, 2005).
[3] S. Kasahara et al., Nat. Commun. **7**, 12843 (2016).
[4] K. Adachi and R. Ikeda (in preparation).
[5] U. Welp et al., Phys. Rev. Lett. **67**, 3180 (1991).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.492
Performance evaluation of cooled resonator coils for wireless high power charging system in electric vehicle
Chung Y.D.[1], Lee C.Y.[2], Kim D.W.[3]
[1]Suwon Science College, Hwasung-si, Korea, Republic of, [2]Korea Railroad Institute, Uiwang-si, Korea, Republic of, [3]Yonsei University, Seoul, Korea, Republic of

The wireless power transfer (WPT) technology based on strongly resonance coupled method realizes large power charging without any wires through the air. Recently, the WPT systems have started to be applied to the wireless charging for electrical vehicles (EVs) because of their advantages compared with the wired counterparts, such as convenient, safety, and fearless transmission of power [1]. However, there are challenges in its commercialization, such as delivery distance and efficiency. To solve the problems, we proposed the technical fusion using high-temperature superconducting (HTS) resonance coil in the WPT system, which is called superconducting wireless power transfer for electric vehicle (SUWPT4EV) system [2]. Since the superconducting wire has merits, i.e., a larger current density and a higher Q value than normal conducting wire, the HTS antenna coil enables to deliver a mass amount of electric energy in spite of a small-scale antenna. In this study, we proposed the

advanced SUWPT4EV system with inserted various resonators using non-cooled copper, cooled copper, and HTS resonators, respectively, in order to expand the transfer distance and improve the transfer ratio within 40-cm distance under radio frequency power of 370 kHz below 600 W.

References:

[1] A. Kurs et al., Science. vol. 317, no. 5834, pp. 83-86, 2007.
[2] Y. D. Chung et al. Physica C. vol. 504, pp. 115-119, 2014.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.493

Onsager vortex formation in two-component Bose-Einstein condensates in two-dimensional traps

Han J.[1], *Tsubota M.*[2]
[1]Osaka City University, Department of Physics, Osaka, Japan, [2]Osaka City University, Osaka, Japan

Three-dimensional classical turbulence shows the energy cascade from large to small spatial scales. Three-dimensional quantum turbulence also shows the similar energy cascade [1]. On the other hand, Kraichnan predicted that two-dimensional classical turbulence shows the inverse energy cascade from small to large spatial scales [2]. Onsager predicted the emergence of large-scale vortex structures for two-dimensional system by using a statistical model of point vortices [3]. In two-dimensional quantum turbulence, like-sign vortices are expected to cluster and form a large-scale Onsager vortex. Groszek et al. studied numerically the dynamics of quantized vortices in two-dimensional one-component Bose-Einstein condensate (BEC) by the Gross-Pitaevskii equation (GPE), thus showing numerically formation of a Onsager vortex [4]. Multicomponent BECs are related to superfluid ^{3}He, unconventional superconductors, and so on, and show some different dynamics from one-component BEC [5]. Thus we study numerically the dynamics of quantized vortices in two-dimensional two-component BEC trapped by a harmonic and box traps. We discuss the formation of Onsager vortex and configuration.

References:

[1] M. Kobayashi and M. Tsubota, Pays. Rev. Lett. **94**, 065302 (2005)
[2] R. H. Kraichnan, Phys. Fluids **10**, 1417 (1967)
[3] L. Onsager, Nuovo Cimento **6**, 279 (1949)
[4] A. J. Groszek et al., Phys. Rev. A **93**, 043614 (2016)
[5] K. Kasamatsu and M. Tsubota and M. Ueda, Int. J . Mod. Phys. B, **19**, 1835 (2005)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.494

Quantum phase slip and enhancement of superconductivity by magnetic field in NbN nano wires

Shinozaki B.[1], *Makise K.*[2], *Asano T.*[3]
[1]Kyushu University, Physics, Fukuoka, Japan, [2]National Institute of Advanced Industrial Science and Technology, Tukuba, Japan, [3]Fukui University, Fukui, Japan

Transport properties were investigated for quasi-one dimensional superconducting NbN nano-wires with width w=20nm and thickness d=20nm on 3C-SiC substrate. It has been found that
1) the resistance R shows the broad superconducting transition and the $R(T)$ characteristic at temperatures bellow T_c~13.5K can be well explained by the sum of the thermal activated phase slip and the quantum phase slip(QPS) of the superconducting order parameter.
2) The $R(T)$ due to the QPS contribution is suppressed to enhance the superconductivity by the external magnetic field H. With decreasing temperature, the $R(T)$ of short specimen with length 600nm shows nearly zero resistance in the restricted temperature region depending on the magnitude of H and recovers the QPS resistive state.
3) The critical magnetic field $H_{c2}(T)$ is fit to the theoretical expression $H_{c2,theo}(T)=\Phi_0/[2\xi_{GL}(T)\times w]\propto(1-T/T_c)^{1/2}$, where the $\xi_{GL}(T)$ is the Gintzburg-Landau superconducting coherence length determined from the data of $H_{c2}(T)$ for the two dimensional film with the same d=20nm in the perpendicular magnetic field to the film surface. Although the relation $H_{c2,exp}(T)\propto(1-T/T_c)^{1/2}$ is satisfied, the magnitude of $H_{c2,exp}(T)$ is about 5 times larger than that of the theoretical one.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.495

Effects of sulfur doping on the superconducting properties of $(Tl_{0.5}Pb_{0.5})Sr_2CuO_z$

<u>Lee H.K.</u>[1], Kim Y.-I.[2]
[1]Kangwon National University, Physics, Chuncheon, Korea, Republic of, [2]Korea Research Institute of Standards and Science, Daejeon, Korea, Republic of

Polycrystalline samples with nominal compositions of $(Tl_{0.5}Pb_{0.5})Sr_2CuO_zS_x$ (PbS-doped samples) and $(Tl_{0.5}Pb_{0.5})Sr_2CuO_z(SO_4)_x$ ($PbSO_4$-doped samples) where x = 0 , 0.05 and 0.075 have been synthesized and characterized by X-ray diffraction, electrical resistivity and thermoelectric power measurements. The sulfur-free pristine sample (x = 0) showed no superconductivity down to about 10 K. In contrast, superconductivity could be induced by the sulfur doping for both series of samples, but better superconducting transition behavior was observed for the PbS-doped samples at the same doping content. Superconductivity with an onset T_c of 61 K and a zero-resistivity of 52 K was observed for the PbS-doped sample with x = 0.05. The room temperature measurements indicated that the sulfur doping caused a decrease in the hole concentration of the sample. The superconducting behavior of the sulfur-doped samples is discussed in conjunction with the changes in the hole concentration and the structure.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.496

Thermal and quantum fluctuation effects on the ordering of the *S*=1/2 kagome Heisenberg antiferromagnet

<u>Shimokawa T.</u>[1,2], Kawamura H.[2]

[1]Okinawa Institute of Science and Technology Graduate University, Onna, Japan, [2]Osaka University, Toyonaka, Japan

Kagome antiferromagnets have attracted much interest in the field of magnetism as a typical geometrically frustrated magnet. Especially, the *S*=1/2 nearest-neighbor antiferromagnetic Heisenberg model on the kagome lattice has received special attention in achieving a quantum spin liquid (QSL) state having no magnetic long-range order. In spite of the tremendous theoretical and experimental efforts, true properties of the model still remain unclear.
In this study, we investigate the thermal and quantum fluctuation effects on the ordering of the *S*=1/2 kagome antiferromagnet by means of the Hams-de Raedt method [1-3]. This numerical method allows us to compute exact finite-temperature physical quantities for larger lattice sizes than those treated by the conventional exact diagonalization method. We identify the additional 3rd and 4th peaks in the low-temperature specific heat and find a finite-temperature crossover phenomenon occurring between the QSL states with distinct magnetic short-range orders (SROs) around the 3rd peak temperature. Static spin structure factors show that the low-temperature state is associated with the so-called *q*=0 SRO, while the high-temperature one with the so-called √3×√3 SRO [4].

References:

[1] M. Imada and M. Takahashi, J. Phys. Soc. Jpn. **55**, 3354 (1986).
[2] A. Hams and H. De Raedt, Phys. Rev. E **62**, 4365 (2000).
[3] S. Sugiura and A. Shimizu, Phys. Rev. Lett. **111**, 010401 (2013).
[4] T. Shimokawa and H. Kawamura, J. Phys. Soc. Jpn. **85**, 113702 (2016).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.497

Irreversibility and critical current density of $FeSr_2ErCu_2O_{6+y}$ superconductor

<u>Hata Y.</u>[1], Iida I.[1], Mochiku T.[2], Yasuoka H.[1]
[1]National Defense Academy, Applied Physics, Yokosuka, Kanagawa, Japan, [2]National Institute for Materials Science, Research Center for Advanced Measurement and Characterization, Tsukuba, Ibaraki, Japan

$FeSr_2ErCu_2O_{6+y}$ (ErFe1212) exhibits superconductivity only when it is annealed in N_2 atmoshpere and subsequently in an O_2 atmosphere. Annealing in N_2 atmosphere prevents the distribution of Fe ions at CuO_2 plane and that in O_2 atmosphere supplies adequate carriers to CuO_2 planes. Large irreversibility was observed in the magnetization measurement [1] and the origin of this irreversibility was unclear.
To reveal the origin of the irreversibility and superconducting properties, polycrystalline samples of ErFe1212 and non-superconducting $FeSr_2ErCu_{1.9}Zn_{0.1}O_{6+y}$ were synthesized and their magnetic property and resistivity were studied.
Zero resistivity of ErFe1212 was observed below 43 K. The magnetism of Er ion kept Curie-Weiss type paramagnetism more than 2 K. Since a similar irreversibility was observed for non-superconducting $FeSr_2ErCu_{1.9}Zn_{0.1}O_{6+y}$, the irreversibility of ErFe1212 may originate from the magnetism of the Fe ion.
The J_c of ErFe1212 in individual grains at 10 K under 0.1 T was estimated at J_c^{intra}=2.6 x 10^9 A/m^2 from the magnetization measurement and that in inter-grain boundaries at 10 K was estimated at J_c^{inter} =5.7 x 10^4 A/m^2 from *V-I* measurement. In ErFe1212, large difference between J_c^{inter} and J_c^{intra} was observed like $FeSr_2YCu_2O_{6+y}$.[2]

References:

[1] Y. Hata, K. Yamaguchi, K. Kinoshita, E. Kita, T. Mochiku and H. Yasuoka, Physica C **507** 85 (2014).
[2] K. Yamaguchi, Y. Hata, T. Mochiku and H. Yasuoka, Physica C **487** 56 (2013).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.498
Superconducting properties of epitaxial aluminum thin films on InGaAs/InAs quantum wells
Fuchs L., Brunner M.C.P., Huber T., Gronwald I., Schuh D., Bougeard D., Strunk C.
University of Regensburg, Institute for Experimental and Applied Physics, Regensburg, Germany

Thin films of aluminum have been grown epitaxially on InAs based quantum wells few nanometers below the crystal surface. Superconducting properties of these films down to a few nm thickness are studied by means of electric transport and two-coil mutual inductance techniques. The resistive transition with critical temperatures of >2.2K can be described by superconducting fluctuations above T_c [1], and BKT-physics below. T_{BKT} is determined from the analysis of non-linear current-voltage characteristics $V \propto I^{\alpha(T)}$. Magnetic penetration depth measurements allow for a direct determination of superfluid density $n_s(T)$ and show jumps at T_{BKT} and conventional BCS-behavior at lower temperatures [2]. Strong magnetoresistance of the order of unity and Shubnikov-de-Haas oscillations are observed in perpendicular magnetic fields.

References:
[1] A. Glatz, A. A. Varlamov and V. M. Vinokur, Phys. Rev. B **84**, 104510 (2011)
[2] John R. Clem and Mark W. Coffey, Phys. Rev. B **46**, 14662 (1992)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.499
Low-temperature electronic state in the titanium-oxypnictide $BaTi_2As_2O$
Kobayashi Y., Inadomi K., Itoh M.
Nagoya University, Department of Physics, Nagoya, Japan

In titanium oxypnictides $BaTi_2(Bi_{1-x}M_x)_2O$ (M = As or Bi) with two-dimensional structural features, the superconducting phase was reported to appear adjacent to some kind of ordered phase in the temperature (T)-x phase diagram [1, 2]. Although several models such as orbital, charge or spin order are discussed for the origin of the ordered phase, it is not still clarified.
To investigate the local electronic state of the ordered phase, we have performed ^{75}As NMR measurements on a single crystal of $BaTi_2As_2O$ which undergoes structure transition from tetragonal to orthorhombic at ~186 K with decreasing T.
The T dependence of the ^{75}As NMR spectrum indicates that $BaTi_2As_2O$ has one As site above T_s and two or more sites below T_s. This appearance of the multi-site can not be explained by the crystal structure reported for the low-T phase [3]. We consider superlattice structure (or phase separation) emerges in the low-T phase. We discuss the local structures below T_s based on the results of ^{75}As NMR and neutron diffraction measurements on $BaTi_2As_2O$.

References:
[1] T. Yajima et al., J. Phys. Soc. Jpn. 81 (2012) 103706.
[2] T. Yajima et al., J. Phys. Soc. Jpn. 82 (2013) 033705.

[3] B. A. Frandsen et al., Nat. Commun. 5:5761 doi: 10.1038/ncomms6761 (2014).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.500
The stiffnessometer: a magnetic-field-free superconducting stiffness meter and its application to the cuprates

Kapon I., *Keren A.*
Technion - Israel Institute of Technology, Physics, Haifa, Israel

We developed a new method to measure superconducting stiffness ρ_s and critical current density $\mathbf{J}_c$ without subjecting the sample to a magnetic field. The method is based on the London equation $\mathbf{J}=-\rho_s\mathbf{A}$, where **J** is the current density and **A** is the vector potential. Using a rotor free **A** and measuring **J** via the magnetic moment of a superconducting ring, we determine ρ_s. By increasing **A** until the London equation breaks, we determine $\mathbf{J}_c$. The technique is sensitive to very small stiffness, equivalent to penetration depth λ larger than 1 mm. Naturally, it does not suffer from demagnetization factor complications or the presence of vortices. Therefore, the absolute value of the stiffness can be determined. We apply this method to $La_{2-x}Sr_xCuO_4$ and compare with Low Energy µSR (LEM) on the same sample. We show that the Stiffnessometer can measure stiffness where LEM and, in fact, all other techniques fail. This leads to new conclusions on the cuprates phase transition.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.501
Yanson and Andreev-reflection point-contact spectroscopy of iron-based superconductors

Naidyuk Y.
B.Verkin Institute for Low Temperature Physics and Engineering NAS of Ukraine, Kharkiv, Ukraine

Point-contact spectroscopy (PCS) is widely used, versatile tool for the investigation of modern superconductors. In the normal state, Yanson`s PCS is a powerful method to study the fundamental processes of conduction electron scattering and their interaction with other quasiparticles and excitations in solids. On the other hand, in the superconducting (SC) state, PCS exploits a phenomenon of Andreev reflection (AR) to obtain information about the SC order parameter(s). There are expectations that PCS investigations can vastly contribute to understanding the nature of superconductivity in iron-based superconductors. Here, I will report about the main results that we received in recent years in the study of single crystals and films of several type [1111], [122] and [11] iron-based superconductors [1-6]. Along with the results of measurements in the SC state by AR spectroscopy, I will also present data on the study of some iron-based compounds in the normal state by Yanson`s PCS, looking for characteristic bosonic excitations.

References:

[1] Yu. G. Naidyuk et al., Supercond. Sci. Technol. **24**, 065010 (2011).
[2] Yu. G. Naidyuk et al., Phys. Rev. B **89,** 104512 (2014).
[3] Yu.G. Naidyuk et al., Phys. Rev. B **90,** 094505 (2014).

[4] V.V. Fisun et al., Fiz. Nizk. Temp. **40**, 1175 (2014) [Low Temp. Phys. **40**, 919 (2014)].
[5] Yu.G. Naidyuk et al., Fiz. Nizk. Temp., **42**, 42 (2016) [Low Temp. Phys. **42**, 31 (2016)].
[6] [Yu.G. Naidyuk, G. Fuchs, D.A. Chareev, A.N. Vasiliev, Phys. Rev. B **93,** 144515 (2016).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.502
Superconducting gap in FeSe single crystal studied by soft point-contact Andreev-reflection spectroscopy

Kvitnytska O.E.[1], *Naidyuk Y.G.*[1], *Gamayunova N.V.*[1], *Bashlakov D.L.*[1], *Fuchs G.*[2], *Chareev D.A.*[3], *Vasiliev A.N.*[4,5,6]
[1]Verkin Institute for Low Temperature Physics and Engineering, NAS of Ukraine, Kharkiv, Ukraine, [2]Leibniz Institute for Solid State and Material Research, Dresden, Germany, [3]Institute of Experimental Mineralogy, RAS, Chernogolovka, Russian Federation, [4]Lomonosov Moscow State University, Low Temperature Physics and Superconductivity Dep, Moscow, Russian Federation, [5]Ural Federal University, Theoretical Physics and Applied Mathematics Dep, Ekaterinburg, Russian Federation, [6]National University of Science and Technology 'MISiS', Moscow, Russian Federation

Soft point-contact Andreev-reflection (PCAR) spectroscopy study of FeSe single crystals has been carried out. *dV/dI(V)* with superconducting (SC) features like a double-minimum structure, characteristic for PCAR, vs temperature and magnetic field along the c-axis and in the basal plane have been measured. Furthermore, we have not observed a noticeable anisotropy. Analysis of *dV/dI(V)* within the extended two-gap BTK model allows us to extract the temperature and magnetic field dependence of the SC gaps. The gap values concentrate around Δ_L=1.6 and Δ_S =0.8 meV for the large (L) and small (S) gaps, respectively. Remarkably, the small gap contribution to the spectra is mainly within 10-20% at low temperatures of 3K and it vanishes above 6K or in the magnetic field above 6T.

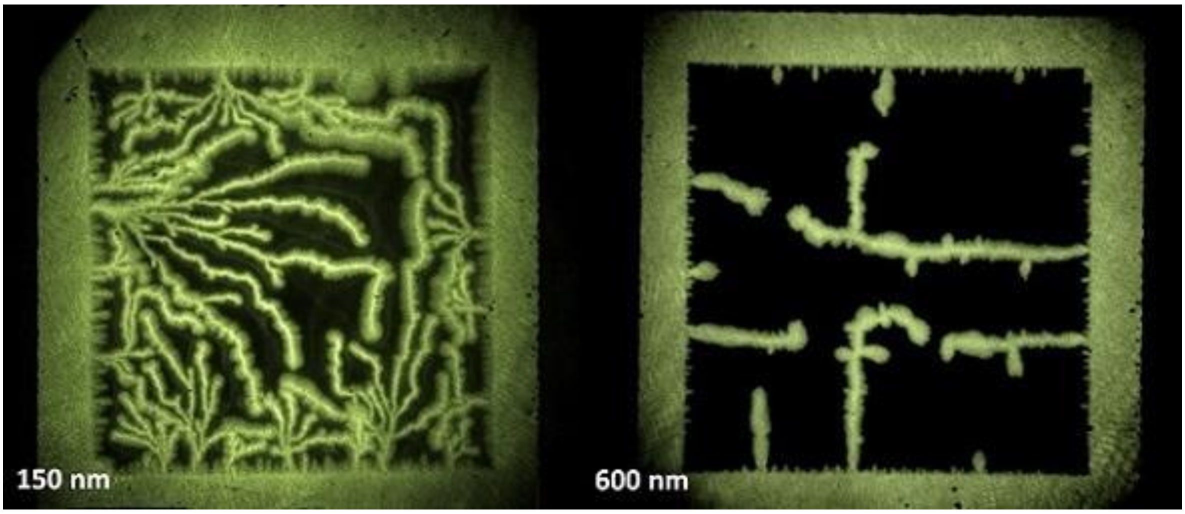
Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.503
Thickness dependence of dendritic flux instability in thin $YBa_2Cu_3O_{7-x}$ films

Baruch-El E.[1], *Baziljevich M.*[2], *Johansen T.H.*[2], *Shaulov A.*[1], *Yeshurun Y.*[1]
[1]Bar Ilan University, Department of Physics, Institute of Superconductivity and Institute of Nanotechnology and Advanced Materials, Ramat Gan, Israel, [2]University of Oslo, Department of Physics, Oslo, Norway

By implementing a unique magneto-optical system and its ultrafast magnetic-field ramping-rate (up to 3 kT/s), we have been able to routinely generate and image dendritic flux instabilities in $YBa_2Cu_3O_{7-x}$ (YBCO) films. In the present work we study the effect of film thickness (50-600 nm) on the dendritic instability. The images below show typical dendritic avalanches in 150 and 600 nm thick films exposed at 7 K to magnetic field ramped up from zero to 60 mT at a rate of 3 kT/s. Evidently, each avalanche in

the thinner film contains much more branches. The dendritic morphology in the thicker sample displays some favored directions, parallel to the film´s edges. Fractal analysis of the different dendritic morphologies reveals that the fractal dimension decreases as the film thickness increases. We attribute the above results to the thickness dependence of both the thermal and magnetic diffusion in the films.



[Figure]

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.504

Annealing effect on effective mass of two-dimensional electrons in InGaAsN/GaAsSb type II Quantum well

Kawamata S., *Tanaka S., Hibino A., Kawamura Y.*
Osaka Prefecture University, Graduate School of Engineering, Sakai, Japan

The InP-based InGaAs/GaAsSb type II multiple quantum well is the system for developing optical devices for 2 - 3 µm wavelength regions [1]. By doping nitrogen into InGaAs layers, the system becomes effective to fabricate the optical devices with longer wavelength [2]. The epitaxial layers of InGaAsN/GaAsSb on InP substrates are grown by the molecular beam epitaxy. The electrical resistance has been measured as a function of the magnetic field up to 9 Tesla at several temperatures between 2 and 8 K. The effective mass is obtained from the temperature dependence of the amplitude of the Shubnikov-de Haas oscillations. We have reported the nitrogen concentration dependence of the effective mass on the InGaAsN/GaAsSb type II system [3]. The effective mass increases as the nitrogen concentration increases from 0.0 to 1.5 %. In this report, the annealing effect on the effective mass is investigated. The effective mass decreases by the annealing. This result suggests that some amount of nitrogen atoms of the InGaAsN layers are considered to diffuse to the GaAsSb layers by the annealing.

References:

[1] Y. Yonezawa, R. Hiraike, K. Miura, Y. Iguchi and Y. Kawamura, Physica E 42 (2010) 2781.

[2] Y. Kawamura and T. Sahashi, Jpn. J. Appl. Phys., 53 (2014) 028004.
[3] S. Kawamata, A. Hibino, S. Tanaka and Y. Kawamura, J. Appl. Phys. 120 (2016) 142109_1-3.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.505
Spin-spirals in bottom-up fabricated Fe chains induced by Dzyaloshinskii-Moriya interaction
Steinbrecher M.[1], Ton That K.[1], Hermenau J.[1], Khajetoorians A.A.[2], Wiebe J.[1], Wiesendanger R.[1]
[1]Uni Hamburg, Department of Physics, Hamburg, Germany, [2]Radboud University, IMM, Nijmegen, Netherlands

Magnetic atoms adsorbed on the surface of strong spin-orbit coupling materials experience indirect Dzyaloshinskii-Moriya interaction (DMI) [1]. DMI is an exchange interaction responsible for the stabilization of spin-spirals or Skyrmions by favoring perpendicular orientation of neighboring spins. By depositing single magnetic atoms on a surface and using the tip of a scanning tunneling microscope as a tool, those atoms can be moved to build bottom-up fabricated nanostructures [2]. Spin-sensitive measurements of such bottom-up fabricated chains enable the observation of the spin-state of each atom within the chain. So far, only collinear ferromagnetic [3] or antiferromagnetic [4] ground states have been observed.
Here, we were able to measure DMI induced non-collinear ground states on chains of Fe atoms on Pt(111) of different lengths. By fixing the magnetization of the outermost atom in a 16 atoms long chain, we were able to stabilize a spin-spiral and investigate its properties by spin-polarized tunneling spectroscopy.
References:
[1] Khajetoorians et al., Nat. Commun. 7, 10620 (2016)
[2] Khajetoorians et al., Nat. Phys. 8, 497 (2012)
[3] A. Spinelli et al., Nat. Mat.13, 782 (2014)
[4] Khajetoorians et al. Science 332, 1062 (2011)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.506
Nanoscale quantum calorimetry with electronic temperature fluctuations
Brange F.[1], Samuelsson P.[1], Pekola J.[2]
[1]Lund University, Lund, Sweden, [2]Aalto University, Helsinki, Finland

In small metallic islands, at low temperatures, electron-electron relaxation is typically much faster than the timescale at which energy is exchanged with the environment. Such systems have a well-defined effective temperature, whose fluctuations caused by energy absorption can be used for calorimetry. Here we consider a quantum calorimeter, with the aim of detecting single quantas of energy, by investigating the temperature fluctuations induced by electrons tunneling between a superconducting lead and a normal metallic dot. In addition to the tunneling mechanism, we also investigate the effect of fluctuations in the electron-phonon relaxation on the temperature fluctuations. Using full counting statistics, we fully characterize the temperature fluctuations for both single event and long-time

measurements. Our results constitute an important step towards detecting single microwave photons in nanoscale systems.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.507

Identification of surface spins on Al_2O_3 with electron spin resonance technique: implications for noise and decoherence

Danilov A.[1]*, de Graaf S.*[2]*, Adamyan A.*[1]*, Lindström T.*[2]*, Erts D.*[3]*, Tzalenchuk A.*[2,4]*, Kubatkin S.*[1]
[1]Chalmers University of Technology, Microtechnology and Nanoscience, MC2, Gothenburg, Sweden, [2]National Physical Laboratory, Teddington, United Kingdom, [3]University of Lativa, Institute of Chemical Physics, Riga, Latvia, [4]Royal Holloway, University of London, Egham, United Kingdom

It is universally accepted that the flux noise affecting the performance of superconducting quantum circuits is consistent with the presence of spurious environmental spins on the surface of dielectric substrates. Despite a wide range of experimental efforts, the nature and the origin of these surface spins still remain largely unknown, making further mitigation of associated decoherence extremely challenging. Recently we developed on-chip electron spin resonance (ESR) technique that allows to detect spins with a very low surface coverage. We combine this technique with various surface treatments specifically to reveal the nature of native surface spins on Al_2O_3 - the mainstay of almost all solid state quantum devices. On a large number of samples we resolve three ESR peaks with the measured total paramagnetic spin density $n=2.2\times10^{17}$ m^{-2} which matches the density inferred from the flux noise in SQUIDs. We show that two of these peaks originate from physisorbed atomic hydrogen which appears on the surface as a by-product of water dissociation. We argue that the third peak is due to molecular oxygen on the Al_2O_3 surface captured at strong electron donor cites, producing charged O_2^-.

References:

[1] S. de Graaf, A. Adamyan, T. Lindström, D. Erts, S. Kubatkin, A. Tzalenchuk, A. Danilov, Phys. Rev. Lett. **118**, 057703 (2017)
[2] S. de Graaf, A. Danilov, A. Adamyan, T. Bauch, S. Kubatkin, Journ. of Appl. Phys. **112**, 123905 (2012)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.508

Theoretical analysis of optical conductivity in Ta_2NiSe_5

Sugimoto K.[1]*, Nishimoto S.*[2,3]*, Kaneko T.*[4]*, Ohta Y.*[5]
[1]Chiba University, Center for Frontier Science, Chiba, Japan, [2]Technische Universität Dresden, Department of Physics, Dresden, Germany, [3]IFW Dresden, Dresden, Germany, [4]RIKEN,

Computational Condensed Matter Physics Laboratory, Wako, Japan, [5]Chiba University, Department of Physics, Chiba, Japan

In small band-overlap semimetals or narrow band-gap semiconductors, the phase where electrons in the conduction bands and holes in the valence bands spontaneously form pairs and condense in the ground state is called the excitonic insulator [1]. Ta_2NiSe_5 is one of the candidate materials of this phase [2].
To elucidate the electronic state of this material, we carry out the first-principles band calculations using the TB-mBJ exchange potential [3]. The isostructural material Ta_2NiS_5, which has a larger band gap and shows no excitonic ordering, is also studied for comparison. We then calculate the optical conductivity and compare with experiment [4]. We thus find that the experimental spectra of Ta_2NiS_5 is in good agreement with those of the band calculations but that of Ta_2NiSe_5 cannot be explained, in particular, in the low-energy region where a large peak is present. These results imply that the effects of strong electron correlations emerge in Ta_2NiSe_5. To consider the effects explicitly, we calculate the optical conductivity using the dynamical density-matrix renormalization group method for the models of Ta_2NiSe_5 and show that the observed low-energy peak can be explained by the strong intersite Coulomb interaction leading to the instability towards the excitonic ordering.

References:
[1] D. Jerome, T. M. Rice, and W. Kohn, Phys. Rev. **158**, 462 (1967)
[2] Y. Wakisaka et al., Phys. Rev. Lett. **103**, 26402 (2009)
[3] F. Tran and P. Blaha, Phys. Rev. Lett. **102**, 226401 (2009)
[4] T. I. Larkin et al., arXiv:1702.05953

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.510
Improving the charge pumping accuracy of SINIS-type turnstiles

Haley R.P.[1], Jones A.T.[1], Kafanov S.[1], Meschke M.[2], Pashkin Y.A.[1], Peasey A.[1], Pekola J.P.[2], Prance J.R.[1], Senior J.[2]
[1]Lancaster University, Physics Department, Lancaster, United Kingdom, [2]Aalto University, Low Temperature Laboratory, Helsinki, Finland

Coulomb blockade provides the means to control electric current in nanoelectronic devices down to the level of individual charges, single electrons or Cooper pairs [1]. A lot of research activity is aimed at building a stable DC current source based on the controlled transfer of elementary charges, which may find applications in metrology [2]. One of the promising implementations of an accurate current source is the SINIS-type single-electron transistor operated in the turnstile regime. Here S, I and N stand for a superconductor, insulator and normal metal, respectively [3]. If this device is biased by a constant voltage, and a periodic gate voltage shifts the island potential in a cyclic manner, then, ideally, exactly one electron is transferred per cycle, producing a net current proportional to the control frequency. Progress towards the creation of a stable current source depends on the elimination of unwanted errors in tunnelling events occurring in ultrasmall tunnel junctions. One of the ways to suppress the higher-order tunnelling processes is to modulate the bias voltage at twice the gate frequency. In this case the bias voltage vanishes when the transistor is in the gate-open state. We will present data from the experiments that are currently underway.

References:
[1] D.V. Averin and K.K. Likharev, in *Mesoscopic Phenomena in Solids*, edited by B. L. Altshuler, P. A. Lee, and R. A. Webb, (Elsevier, Amsterdam, 1991), p. 173
[2] J.P. Pekola et al., Rev. Mod. Phys. **85**, 1421 (2013)
[3] J.P. Pekola et al., Nature Phys. **4**, 120 (2008)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.511
High frequency magnetization dynamics of individual atomic-scale magnets
Krause S., Sonntag A., Hermenau J., Friedlein J., Wiesendanger R.
University of Hamburg, Hamburg, Germany

Nucleation, annihilation and domain wall propagation are the most fundamental microscopic processes of magnetization reversal [1, 2]. Understanding and controlling these mechanisms is crucial for the development of future high-speed spintronic applications. In previous time-resolved spin-polarized scanning tunneling microscopy (SP-STM) studies it was shown that the thermally activated magnetization reversal of Fe/W(110) nanomagnets consisting of less than 100 atoms is realized by nucleation and propagation instead of a coherent rotation of all magnetic moments [3].
Within the present study we use SP-STM to investigate the magnetic ground state dynamics of individual nanomagnets with uniaxial magnetic anisotropy over a very wide temperature (30 K..70 K) and switching rate (100 mHz..10 MHz) regime, combining telegraphic noise analysis and pump-probe schemes. With increasing temperature a transition between two Arrhenius regimes is observed, resulting in switching rates that are by orders of magnitude lower than expected from an extrapolation from the low temperature regime. The time-resolved SP-STM experiments will be presented and interpreted in terms of an analytical model that accounts for the interplay of temperature-dependent nucleation, annihilation and propagation rates [4].

References:
[1] W. Wernsdorfer *et al.*, Phys. Rev. Lett. **77**, 1873 (1996).
[2] S. S. Parkin *et al.*, Science **320**, 190 (2008).
[3] S. Krause *et al.*, Phys. Rev. Lett. **103**, 127202 (2009).
[4] S. Krause *et al.*, Phys. Rev. B **93**, 064407 (2016).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.512
Turbulent transition in He II due to a torsionally oscillating disc
Schmoranzer D.[1], Jackson M.J.[1], Skyba M.[2], Skokankova T.[1], Dolezal L.[1], Skrbek L.[1]
[1]Charles University, Mathematics and Physics, Prague, Czech Republic, [2]Institute of Physics ASCR, Prague, Czech Republic

We discuss recent studies on the transition to turbulence in the flow of superfluid ^{4}He around a torsionally oscillating disc. Utilizing modern experimental techniques and digital image processing to revisit the pioneering work of Donnelly and Hollis-Hallett [1,2], we have studied the damping and the period of oscillation of a single disc in superfluid ^{4}He for 1.37 < T< 2.16 K. Apart from determining critical amplitudes we newly examine the interplay between the normal and superfluid components of He-II based on classical fluid mechanical scaling arguments. Moreover, the experiment reveals new

features such as a continuing drift of the period of oscillation after the drag has settled, and the obtained temperature dependences suggest that except near the lambda transition, the non-linear forces measured close above the critical amplitude originate from the superfluid component alone. We interpret the drag measurements in terms of an effective density and viscosity and relate the frequency shifts to the coupling of the superfluid component to the disc via quantized vortices. A model describing the mechanisms of the transition to turbulence in a flow of He-II due to a torsionally oscillating disc is proposed.

The work is supported by the Czech Science Foundation # GACR 17-03572S.

References:

[1] A. C. Hollis-Hallett, Proc. Roy. Soc. London. Series A, Mathematical and Physical Sciences **210**, 404 (1952)
[2] R. J. Donnelly, A.C. Hollis-Hallett, Annals of Physics **3**, 320-345 (1958)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.513

High-Q micromechanical resonator as a probe of superfluid ^{4}He in the ballistic regime

Kamppinen T., Eltsov V.B., Mäkinen J.T.
Aalto University, Department of Applied Physics, Low Temperature Laboratory, Espoo, Finland

Immersed oscillating objects have proven to be useful and multifunctional probes in studies of superfluid ^{4}He and ^{3}He. Smaller devices are required for higher sensitivity. Thus, we have fabricated suspended aluminium micromechanical resonators with beam cross-section 0.15×1 µm^2 and dimensions ~10 µm. Magnetomotive drive and detection is used and Q-values up to $2x10^4$ and force resolution ~4 fN have been achieved.
We have measured response of these devices at temperatures from 15 mK to 1 K in vacuum and superfluid ^{4}He. In this temperature range the intrinsic damping has dependence $\Delta f \propto T^{0.3}$. In ^{4}He-II, the resonance linewidth increases as $\Delta f_{ph} \propto T^4$ and $\Delta f_{rot} \propto \exp(-\Delta/T)$ due to scattering of phonons and rotons, respectively. The temperature dependent intrinsic width and ballistic drag make these devices sensitive thermometers in the milliKelvin/sub-Kelvin temperature range.
At high oscillation amplitudes the resonance response becomes nonlinear and shows Duffing-like behaviour. In ^{4}He at T=18 mK we observe a collapse of the oscillations when velocity reaches v_c=0.17 m/s independently of the driving force. We interpret this as a sudden increase of the drag when critical velocity for emission of vortex rings is exceeded. We discuss the possibility to study single vortices with such devices.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.514

Electron polaron effect and inhomogeneous states of spin and charge in strongly-correlated electron systems

Kagan M.Y.[1,2]

[1]P.L. Kapitza Institute for Physical Problems RAS, Moscow, Russian Federation, [2]National Research University Higher School of Economics, Moscow, Russian Federation

The present talk deals with the advances in the subject of electronic phase separation and formation of different types of nanoscale FM metallic droplets (FM polarons or ferrons) in antiferromagnetically ordered (AFM), charged ordered (CO) or orbital ordered (OO) insulating matrices as well as the CMR effect and tunneling electron transport in nonmetallic phase-separated state of the complex magnetic oxides. It considers also the formation of the heavy-particle state and electron polaron effect (EPE), as well as anomalous resistivity characteristics and inhomogeneous phase-separated state in strongly correlated multiband systems as well as in the systems with the imperfect nesting such as stacked AA graphene bilayers, chromium alloys or iron-based pnictides. We briefly discuss also the formation of spin polarons in the inhomogeneous Griffits phase in MnSi as well as the manifestation of EPE in the tunneling density of states in the reduced geometry of the microcontact which contains deep and shallow traps.

References:

[1] M. Yu. Kagan and K. I. Kugel, Inhomogeneous charge distributions and phase separation in manganites, Sov. Phys. Uspekhi **171,** 577 (2001).
[2] M. Yu. Kagan, V.V. Val'kov, Anomalous resistivity and the Electron-polaron effect in the two-band Hubbard model with one narrow band. Int. Jour. Supercond. Nov. Magn., **25,** 1379 (2012).
[3] M. Yu. Kagan, K.I. Kugel, A.L. Rakhmanov, Electronic phase separation: recent progress in the old problem, Physics Reports (2017) in preparation.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.516

Vortex matter in clean $NbSe_2$ in combined *ac* susceptibility and neutron scattering experiments

<u>Bekeris V.</u>[1,2], Marziali Bermúdez M.[1,2], Louden E.R.[3], Eskildsen M.R.[3], Dewhurst C.D.[4], Pasquini G.[1,2]
[1]Universidad de Buenos Aires, Facultad de Ciencias Exactas y Naturales, Departamento de Física, Buenos Aires, Argentina, [2]CONICET-Universidad de Buenos Aires, Instituto de Física de Buenos Aires (IFIBA), Buenos Aires, Argentina, [3]University of Notre Dame, Deptartment of Physics, Notre Dame, Indiana, United States, [4]Institut Laue-Langevin, Grenoble, France

Plasticity, glassy behavior and metastable configurations in the vicinity of an order-disorder transition (ODT) are common features in a variety of systems, among which vortex matter is a model system. We present results, combining small angle neutron scattering (SANS) and non-invasive *ac* susceptibility measurements, that reveal qualitative differences between thermal and dynamic history effects near the ODT in the vortex lattice (VL) in clean NbSe2 [1]. We carried out a systematic study of the effective pinning and structural characterization of the VL and explored the neighboring intermediate region recently identified [2], between the ordered Bragg Glass at low temperature and magnetic field and the strongly disordered and pinned configurations close to the superconducting transition. The structural bulk VL correlation length, determined by the average distance between VL dislocations, is not trivially related to the effective pinning potential, and metastable superheated and supercooled configurations coexist with a hysteretic effective pinning response due to thermal cycling of the system. The reported results suggest a novel scenario to describe the ODT and the peak effect (PE) anomaly, where high plastic barriers and low elastic barriers are basic ingredients.

References:

[1] M. Marziali Bermúdez, E. R. Louden, M. R. Eskildsen C. D. Dewhurst, V. Bekeris and G. Pasquini, Phys. Rev. B **95** 104505 (2017)
[2] M. Marziali Bermúdez, M. R. Eskildsen, M. Bartkowiak, G. Nagy, V. Bekeris and G. Pasquini; Phys. Rev. Lett. **115**, 067001 (2015)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.517

Thermal boundary resistance between liquid helium and solids at ultra low temperatures

van der Vliet H., Levitin L., Nyéki J., Casey A., Saunders J.
Royal Holloway, University of London, Physics Department, Egham, United Kingdom

The thermal contact between liquid helium and solids at ultra low temperatures is a long-standing puzzle. The acoustic mismatch theory of heat transfer via phonons generally predicts higher thermal boundary resistance than observed, suggestive of additional channels [1], such as magnetic coupling in case of ^{3}He and ^{3}He/^{4}He mixtures. Most previous experiments required large surface areas of order m^2 and were conducted on sintered metal powders, with a number of drawbacks, including contributions from poor thermal conductance of helium within sinter pores. Using a compact SQUID-based noise thermometer we measured the thermal boundary resistance R_K between ^{3}He and a single 2 cm^2 sheet of 7 µm Au foil at 0.6-20 mK. This thickness is comparable to the wavelength of thermal phonons in Au at few mK. We observe a cross-over at T=5 mK from R_K~$1/T^3$ at high T, characteristic to phonons, to a nearly constant R_K at low T, indicative of a parallel channel. To test for finite-size and magnetic effects, we plan to vary the foil thickness and material, as well as adjust the helium-solid interface by preplating with ^{4}He. This setup lends itself to precise characterisation of thermal boundary resistance between a range of materials and helium with potential impact on future heat exchanger designs.

References:

[1] F. Pobell, "Matter and Methods at Low Temperatures", Springer (2006), chapter 4.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.518

Spatially dispersive surface impedance in the electrodynamics of conductors without dc dissipation

Volchkov N.A.[1], Karuzskii A.L.[1], Kulbachinskii V.A.[2], Mityagin Y.A.[1], Perestoronin A.V.[1], Chernyaev A.P.[3]
[1]P. N. Lebedev Physical Institute of RAS, Moscow, Russian Federation, [2]M.V. Lomonosov Moscow State University, Moscow, Russian Federation, [3]Moscow Institute of Physics and Technolgy (State University), Dolgoprudny, Moscow Region, Russian Federation

Previous formulations [1] are applied here to derive general frequency (ω) dependences of moduli of spatially dispersive eigenvalues (ε_a) of the permittivity operator and of the surface impedance (Z) for conductors without the dc dissipation, i. e. superconductors or perfect conductors. The spatial field nonhomogeneity in the form of a wave number is considered at first similarly to [1], assuming the problem is stationary. Taking into account an absence of the dc dissipation the dependencies Z~ω and ε_a~$1/\omega^2$ are found for both superconductors and perfect conductors. That follows from the behaviour of the ponderomotive interaction. An Abraham force achieves the highest magnitude when the spatial nonhomogeneity gets the largest value corresponding to the London penetration depth.

The zero spatial nonhomogeneity corresponds to the zero Abraham force and to the absolutely unstable spatially homogeneous configuration. So the conclusions obtained here in the surface impedance approximation show that the spatial dispersion leads to the appearance of Meissner effect in perfect conductors in the same manner as in superconductors contrary to the earlier considerations [2], which do not incorporate the spatial dispersion effects. A driving force of its appearance is the Abraham force.

References:

[1] M. A. Dresvyannikov, A. P. Chernyaev, A. L. Karuzskii, Yu. A. Mityagin, A. V. Perestoronin, N. A. Volchkov, "Spatial-dispersion eigenvalues for permittivity operator of conductors and superconductors in a microwave field", *Journal of Low Temperature Physics*, **185,** 495 (2016).

[2] F. London, "Superfluids, Vol. I: Macroscopic Theory of Superconductivity", Dover Publications, New York (1961).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.519

Opening the microkelvin regime to low-dimensional electron systems in semiconductor heterostructures

Levitin L.[1], *van der Vliet H.*[1], *Dimitriadis S.*[1], *Corcoles A.*[1,2], *Quilter J.H.*[1], *Creeth G.*[3,4], *Farrer I.*[3,5], *Ritchie D.*[3], *Nyéki J.*[1], *Nicholls J.*[1], *Casey A.*[1], *Saunders J.*[1]

[1]Royal Holloway, University of London, Physics Department, Egham, United Kingdom, [2]IBM Thomas J. Watson Research Center, Yorktown Heights, United States, [3]University of Cambridge, Department of Physics, Cambridge, United Kingdom, [4]London Centre for Nanotechnology, London, United Kingdom, [5]University of Sheffield, Department of Electronic and Electrical Engineering, Sheffield, United Kingdom

Motivated by the theoretical predictions of magnetic and crystalline order in 1D electron systems and of exotic Fractional Quantum Hall states in 2D, we have developed a platform for cooling low-dimensional electrons in semiconductor heterostructures to ultra-low temperatures. We investigate the thermalisation of a 2D electron gas (2DEG) in a GaAs/AlGaAS heterostructure via low-resistance AuGeNi Ohmic contacts cooled in a ^{3}He immersion cell mounted on a nuclear demagnetisation cryostat. The temperature of the sample is measured with a SQUID-based noise thermometer attached to the 2DEG via an additional contact. By carefully shielding the sample and filtering the electrical connections we achieve an estimated electron temperature of 1.4 mK under a heat leak of 3 fW, inferred from the noise thermometer base temperature of 1.3 mK and measured thermal conductances of the 2DEG and contacts, that are found to be consistent with Wiedemann-Franz law with reduced Lorenz numbers. With further filtering we expect to cool the 2DEG below 1 mK. The investigation of the electrical transport in 1D quantum wires in a gated 2DEG in this ultra-low temperature environment is underway.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.520
The giant atom regime of quantum acoustics
Andersson G.[1]*, Suri B.*[1]*, Guo L.*[2]*, Aref T.*[1]*, Ekström M.K.*[1]*, Ask A.*[1]*, Johansson G.*[1]*, Delsing P.*[1]
[1]Chalmers University of Technology, Department of Microtechnology and Nanoscience (MC2), Gothenburg, Sweden, [2]Karlsruhe Institute of Technology, Karlsruhe, Germany

We study the interaction of superconducting artificial atoms with surface acoustic wave (SAW) phonons. Piezoelectric substrates and interdigital transducers provide a “quantum acoustic” platform for experiments analogous to quantum optics. Here, however, the artificial atom has characteristic dimensions much larger than the wavelength of the coupled acoustic field. By exploiting the slow propagation velocity of SAW, artificial atoms can be designed that couple to a propagating field at two distant points such that the SAW travel time between them has to be taken into account. Phonons emitted into the acoustic channel by such a “giant atom” may interact with the atom again leading to revivals in the excited state population. We observe the resulting non-exponential energy relaxation as well as the phonon scattering properties of giant atoms with a resonance frequency in the 2 - 2.5 GHz range.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.521
Operating nanobeams in quantum fluids: probing the condensate and cooling the beam.
Bradley I., George R., Guénault A., Guthrie A., Jennings A., Haley R., Kafanov S., Noble T., Pashkin Y., Pickett G., Poole M., Prance J., Sarsby M., Schanen R., Tsepelin V., Wilcox T., Zmeev D.
Lancaster University, Physics Department, Lancaster, United Kingdom

Microelectromechanical and nanoelectromechanical systems are ideal candidates for exploring quantum fluids since they can be manufactured reproducibly, cover the frequency range from hundreds of kHz up to GHz and have very low dissipation. Their small size offers the possibility of probing the superfluid on scales comparable to, and below, the coherence length.
Here we summarise our experiments on aluminium nanomechanical resonators in superfluid ^{4}He from temperatures spanning the superfluid transition down to 10mK. Such devices are shown to be very sensitive detectors of the superfluid density and the normal fluid damping. We demonstrate the operation of nanobeams both in the superconducting and normal state. Experiments show a significant increase in the quality factors for nanomechanical beams operated in superfluid compared with vacuum measurements, which confirms the idea that superfluid helium at mK temperatures behaves as a mechanical vacuum. In addition, we discuss the possibility of incorporating the nanobeams into quantum circuits (qubits) to probe superfluid ^{3}He, which can be routinely cooled to below 100µK. This brings us into the regime where nanomechanical devices operating at a few MHz may enter their mechanical quantum ground state.

Postersession 2
Saturday, 12 August 2017
16.30-18.30

G Foyer

P.522

Superfluid ^{3}He under extreme confinement in a 100 nm nanofabricated slab geometry: chiral or time-reversal invariant?

Heikkinen P.J.[1], *Casey A.*[1], *Levitin L.V.*[1], *Rojas X.*[1], *Abhilash T.S.*[2], *Parpia J.M.*[2], *Saunders J.*[1]
[1]Royal Holloway, University of London, Department of Physics, Egham, United Kingdom, [2]Cornell University, Department of Physics, Ithaca, United States

The experimental SQUID-NMR study of topological superfluidity of ^{3}He in nanofabricated cavities of height comparable to the coherence length, ξ_0, has demonstrated the influence of confinement on the superfluid order parameter [1,2,3,4]. Here we describe progress on experiments with a cavity height D ~ 100 nm as a first step towards studies in the quasi-two-dimensional limit $D < \xi_0$. In order to eliminate suppression of both the superfluid transition temperature and the order parameter, we require specular boundary conditions [5]. This may be achieved by plating the surfaces with a superfluid ^{4}He film, as described elsewhere in these proceedings. In a cavity of height 200 nm we find the chiral A-phase to be stable at all pressures investigated, including zero pressure. However, previous work on thinner films grown on metal substrates [6,7] has shown anomalous features which may indicate a new phase. The current challenge is to fingerprint the superfluid phase in the 100 nm cavity, under well-controlled effective confinement D/ξ_0, using NMR and pressure tuning. At issue is the topology of the superfluid as the film becomes more two-dimensional; whether the chiral A-phase remains stable, or whether the planar phase (which is time-reversal invariant) emerges.

References:

[1] L. V. Levitin *et al.*, Science **340**, 841 (2013)
[2] L. V. Levitin *et al.*, Phys. Rev. Lett **111**, 235304 (2013)
[3] L. V. Levitin *et al.*, J. Low Temp. Phys. **175**, 667 (2014)
[4] L. V. Levitin *et al.*, App. Phys. Lett. **91**, 262507 (2007)
[5] A. B. Vorontsov and J. A. Sauls, Phys. Rev. B **68**, 064508 (2003)
[6] J. Xu and B. C. Crooker, Phys. Rev. Lett. **65**, 3005 (1990)
[7] A. M. R. Schechter *et al.*, Nature **396**, 554 (1998)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.523

Electron spin resonance study of atomic hydrogen stabilized in solid neon below 1K

Sheludiakov S.[1], *Ahokas J.*[1], *Järvinen J.*[1], *Vasiliev S.*[1], *Lee D.M.*[2], *Khmelenko V.V.*[2], *Dmitriev Y.A.*[3]
[1]University of Turku, Department of Physics and Astronomy, Turku, Finland, [2]Texas A&M University, Institute for Quantum Science and Engineering, Department of Physics and Astronomy, College Station, United States, [3]Ioffe Institute, St. Petersburg, Russian Federation

We report on the first electron spin resonance study of atomic hydrogen stabilized in solid Ne carried out in a high magnetic field of 4.6T and temperatures below 1K. Unpaired H atoms inside solid Ne films were produced by *in situ* dissociation of H_2 molecules by electrons released in the β-decay of tritium trapped in the metallic walls of the sample cell and studied by a 128GHz ESR spectrometer. We observed two doublets of H atoms assigned to two distinct sites of H atoms in the Ne matrix with both positive and negative changes of their hyperfine constants compared to free atoms. We suggest that the ESR line with the reduced hyperfine constant corresponds to H atoms in the regular substitutional positions of the neon lattice [1], while the spectra with increased hyperfine constant may be related to H atoms initially trapped in octahedral interstices and then residing in somewhat

intermediate sites with 12 nearest neighbors but more cramped than unperturbed substitutional sites [2]. The amplitudes of both lines changed significantly in the temperature range of 500-900mK. We suggest that this behavior may be related to the re-distribution of atoms between the sites when the system relaxes to thermal equilibrium or to a *fcc-hcp* transformation observed in H_2-Ne solid mixtures [3].

References:
[1] Yu. A. Dmitriev, R. A. Zhitnikov, and M. E. Kaimakov, Fiz. Nizk. Temp. **15**, 495 (1989).
[2] T. Kiljunen, J. Eloranta, and H. Kunttu, J. Chem. Phys. **110**, 11814 (1999).
[3] N. N. Gal'tsov, A. I. Prokhvatilov, and M. A. Strzhemechny, Low Temp. Phys. **30**, 984 (2004)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.524
Momentum-space electromagnetic induction and adiabatic charge pumping in Weyl semimetals
Ishizuka H.[1], *Hayata T.*[2], *Ueda M.*[3,4], *Nagaosa N.*[1,4]
[1]University of Tokyo, Applied Physics, Bunkyo, Japan, [2]Chuo University, Bunkyo, Japan, [3]University of Tokyo, Bunkyo, Japan, [4]RIKEN Center for Emergent Matter Science (CEMS), Wako, Japan

We discuss that the dynamics of Weyl nodes in momentum space induces a charge-pumping phenomenon similar to Thouless' adiabatic pump owing to the fact that the node is a magnetic monopole of the Berry curvature. The Berry phase is one of the fundamental properties of quantum mechanics. Theoretical studies in the last several decades have revealed that the Berry phase leads to various nontrivial transport phenomena such as Thouless' adiabatic pump. In the adiabatic charge pump, the Berry "electric" field (the Berry curvature with the time differential of Bloch wave functions) takes a key role; the amount of charge transported from one side to the other is proportional to the "electric" field.
Though this effect is often negligible in solids, in this work, we show that the "electric" field is enhanced in Weyl semimetals inducing a dc "electric" field [1]. We also argue that this phenomenon can be understood as an emergent electromagnetic induction in momentum space; the dynamics of a Weyl node under external time-dependent perturbations induces the dc "electric" field [1,2]. By considering light as an external perturbation, we find that the momentum-space electromagnetic induction can be observed as a photocurrent that arises only with circularly polarized light.

References:
[1] H. Ishizuka, T. Hayata, M. Ueda, and N. Nagaosa, Phys. Rev. Lett. **117**, 216601 (2016).
[2] H. Ishizuka, T. Hayata, M. Ueda, and N. Nagaosa, preprint (arXiv:1702.01450) (2017).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.525
Dynamics of vortex lattice formation in rotating two-component Bose-Einstein condensates
Kanai T.[1], *Tsubota M.*[1,2]

[1]Osaka City University, Department of Physics, Osaka-Shi, Japan, [2]Osaka City University, OCU Advanced Research Institute for Natural Science and Technology (OCARINA), Osaka-Shi, Japan

Quantized vortices appear in Bose-Einstein condensate(BEC) as topological defects. In various systems, it is important to study the nucleation mechanism, the dynamics, and the equilibrium states of topological defects. In single-component BECs, quantized vortices have been studied experimentally, numerically, and theoretically[1]. By rotating an asymmetric potential, the condensate is distorted to an elliptic shape and oscillates. Then the surface of the condensate becomes unstable, leading to the excitation of the surface wave. From the depression of the surface, the quantized vortices enter the condensate, and form a triangular lattice. Rotating two-component BECs are known to have many kind of equilibrium states of vortices[2]. However, the dynamics toward the equilibrium states has been studied hardly. Thus, we study the dynamics numerically. We confine ourselves the case of miscible condensates. The dynamics is qualitatively similar to that of single-component BEC in many respects, but has some differences. We found that the characteristic time toward the surface wave excitation and the vortices entering the condensate depends strongly on the intercomponent interaction.

References:

[1] K. Kasamatsu and M. Tsubota, Prog. Low Temp. Phys., ed. W. P. Halperin and M. Tsubota(Elsevier, Amsterdam, 2008) Vol. 16, pp. 349 - 401(2008)
[2] K. Kasamatsu, M. Tsubota, and M. Ueda, Phys. Rev. Lett. 91, 15 (2003)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.526

Spin excitations of hole-overdoped Fe-based superconductors

Lee C.H.[1], Horigane K.[2], Kihou K.[1], Park J.T.[3], Waßer F.[4], Qureshi N.[5], Sidis Y.[6], Kajimoto R.[7], Ikeuchi K.[8], Ji S.[8], Akimitsu J.[2], Braden M.[4]
[1]AIST, Tsukuba, Japan, [2]Okayama University, Okayama, Japan, [3]MLZ, München, Germany, [4]Universität zu Köln, Köln, Germany, [5]ILL, Grenoble, France, [6]LLB, Gif-sur-Yvette, France, [7]J-PARC Center, Tokai, Japan, [8]CROSS, Tokai, Japan

The relationship between magnetism and superconductivity is an essential issue in iron-based superconductors. In this study, we examined the overall features of spin fluctuation in hole-doped Ba1-xKxFe2As2 by inelastic neutron scattering.
We have found that spin spectra in entire energy range consist of spin-wave and chimney-like dispersions [1]. The chimney-like dispersion can be originated from particle-hole excitations, defining the itinerant character of magnetism. Band width of spin-wave like dispersion is almost constant from non-doped to optimum doped region, followed by large reduction in overdoped region. Smaller band width leads to weaker effective magnetic exchange couplings J. The results suggest that superconductivity is suppressed by the reduction of J in overdoped region.
In addition, the behavior of the spin resonance dramatically changes in overdoped region [2]. Strong resonance peaks are observed clearly below superconducting gap (2Δs) in the optimum doping region, while they are absent in the overdoped region. Instead, there is a transfer of spectral weight from energies below 2Δs to higher energies, peaking at values of 3Δs for x = 0.84. These results indicate a reduced impact of magnetism on Cooper pair formation in the overdoped region.

References:

[1] K. Horigane et al., Sci. Rep. 6, 33303 (2016).
[2] C. H. Lee et al., Sci. Rep. 6, 23424 (2016).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.527
Magnetic properties in the Penrose-Hubbard model
Koga A.[1], Tsunetsugu H.[2]
[1]Tokyo Institute of Technology, Tokyo, Japan, [2]Institute for Solid State Physics, University of Tokyo, Tokyo, Japan

Recently, electron correlations on quasiperiodic systems have attracted much interest since the observation of quantum critical behavior in the quasicrystal $Au_{51}Al_{34}Yb_{15}$ [1]. One fundamental and important question is the effect of the quasiperiodicity on electronic and magnetic properties. To examine this issue, we study the half-filled Hubbard model on the Penrose lattice, and discuss its magnetic properties in the ground state. The noninteracting case has been examined in detail [2-4], and it is known that there exist confined states with thermodynamic degeneracy. Therefore, when switching the Coulomb repulsion induces an antiferromagnetic order, the confined states lead to an exotic spatial pattern and unique distribution of staggered moments in the weak coupling region, whereas the strong coupling limit was studied in Ref.[5]. In this study, we employ the Hartree-Fock approximation and some exact results are also addressed.
References:
[1] K. Deguchi et al., Nat. Mat. **11**, 1013 (2012).
[2] M. Kohmoto and B. Sutherland, Phys. Rev. B **34**, 3849 (1986).
[3] H. Tsunetsugu et al., J. Phys. Soc. Jpn. **55**, 1420 (1986).
[4] M. Arai et al., Phys. Rev. B **38**, 1621 (1988).
[5] A. Jagannathan et al., Phys. Rev. B **75**, 212407 (2007).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.528
Magnetic excitations in antiferromagnetic alternating spin-3/2 chain compounds *R*CrGeO$_5$
Hase M.[1], Asai S.[2], Soda M.[2], Masuda T.[2], Kawana D.[2], Yokoo T.[3], Itoh S.[3], Kohno M.[1]
[1]National Institute for Materials Science (NIMS), Tsukuba, Japan, [2]University of Tokyo, Institute for Solid State Physics (ISSP), Kashiwa, Japan, [3]High Energy Accelerator Research Organization (KEK), Tsukuba, Japan

We confirmed that the spin system of Cr^{3+} in *R*CrGeO$_5$ (*R* = Y or ^{154}Sm) [1] was an antiferromagnetic alternating spin-3/2 chain [2]. We evaluated two exchange interactions in the chain to be 16.0 and 2.3 meV (20.9 and 1.1 meV) for $YCrGeO_5$ ($^{154}SmCrGeO_5$) in inelastic neutron scattering (INS) measurements. The values of the exchange interactions must be determined mainly by the Cr-Cr distance. To investigate the distance dependence on magnetism, we performed INS measurements on *R*CrGeO$_5$ (*R* = Ho, ^{166}Er or Nd) powder using the High Resolution Chopper (HRC) spectrometer at BL 12 in J-PARC. Strong excitations exist between 10 and 15 meV (9 and 15 meV) in $HoCrGeO_5$ ($^{166}ErCrGeO_5$) and include both magnetic excitations of Cr and crystal-field excitations of Ho and Er. Weak excitations were seen up to 24 and 25 meV in $HoCrGeO_5$ and $^{166}ErCrGeO_5$, respectively. In $YCrGeO_5$, magnetic excitations exist between 8 and 23 meV. The nearest neighbor Cr-Cr distances in the chain are almost the same in the three compounds. Magnetic excitations of Cr exist in almost the

same energy range in the three compounds. Magnetic excitations of Cr exist between 20 and 25 meV (18 and 23 meV) in $NdCrGeO_5$ ($^{154}SmCrGeO_5$). The nearest neighbor Cr-Cr distances are almost the same in the two compounds.

References:

[1] R. V. Shpanchenko et. al., J. Solid State Chem. 181, 2433 (2008).
[2] M. Hase, et. al., Phys. Rev. B 90, 024416 (2014).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.529

Magnetoelectric properties of $Ca_2CoSi_2O_7$ studied by high-field electron spin resonance

Akaki M., Kanaida K., Hagiwara M.
Osaka University, Center for Advanced High Magnetic Field Science, Graduate School of Science, Toyonaka, Japan

Since magnetic-field-induced electric polarizations were observed below the magnetically ordered temperature in åkermanite materials $Ca_2CoSi_2O_7$ [1,2] and $Ba_2CoGe_2O_7$ [3,4], their multiferroicities have attracted much attention. The electric polarizations depend on the field and spin directions, which is explained by the transition-metal-ligand (*p-d*) hybridization mechanism. In addition, $Ca_2CoSi_2O_7$ shows the following anomalous magnetic behavior [2]. The magnetization along the [110] direction shows a magnetization jump at 11 T, and the electric polarization parallel to the *c*-axis flips simultaneously. The magnetization along the *c*-axis increases linearly up to 18 T and shows a magnetization plateau, the magnitude of which is slightly smaller than the saturation magnetization up to 50 T, and a step-like increase to the saturation value at ~60 T. To clarify the origins of these anomalous magnetization curves from the microscopic viewpoint, we have performed electron spin resonance (ESR) experiments of single crystals of $Ca_2CoSi_2O_7$ in high magnetic fields. We found many ESR straight branches (magnon and electromagnon excitations) for the *c*-axis in the plateau region. We discuss the magnetoelectric properties from these branches and the others in different field regions.

References:

[1] M. Akaki *et al*., Appl. Phys. Lett. 94, 212904 (2009).
[2] M. Akaki *et al*., J. Phys. Soc. Jpn. 83, 093704 (2014).
[3] H. T. Yi *et al*., Appl. Phys. Lett. 92, 212904 (2008).
[4] H. Murakawa *et al*., Phys. Rev. Lett. 105, 137202 (2010).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.530

Sol-gel processing of precursor for synthesis of Tl-1223 superconductors

Lobzhanidze T.[1], Metskhvarishvili I.[2], Dgebuadze G.[2], Metskhvarishvili M.[3], Bendeliani B.[2], Gabunia V.[4], Farulava G.[1]
[1]Ivane Javakhishvili Tbilisi State University, Faculty of Exact and Natural Sciences, Department of Chemistry, Tbilisi, Georgia, [2]Ilia Vekua Sukhumi Institute of Physics and Technology, Department of

Cryogenic Technique and Technologies, Tbilisi, Georgia, [3]Georgian Technical University, Department of Engineering Physics, Tbilisi, Georgia, [4]Petre Melikishvili Institute of Physical and Organic Chemistry of the Iv. Javakhishvili Tbilisi State University, Tbilisi, Georgia

The influence of $Ba_2Ca_2Cu_3O_x$ precursor on the synthesis and properties of Tl-based superconductors has been examined. $TlBa_2Ca_2Cu_3O_y$ superconducting samples were prepared by a two-step method. In the first step, was prepared Ba:Ca:Cu=2:2:3 multiphase ceramic precursors, for comparisons two methods we synthesized precursors by sol-gel method (SG) using poly (vinyl alcohol)/poly (vinyl acetate) (PVA/ PVAc) and as well as ordinary solid-state reaction method (SSR). In second step on both samples Tl_2O_3 was added and finale synthesis of $TlBa_2Ca_2Cu_3O_y$ was carried out in a sealed quartz tube.
We note that for both methods, starting materials was used powders materials of BaO, $CaCO_3$ and CuO. The synthesis of a precursor by the sol-gel method was used acetic and nitric acid for dissolved oxide and PVA/ PVAc as a complexing agent.
The prepared patterns were characterized by X-ray diffraction with CuKa radiation. Ac susceptibility and high harmonic response of samples are measured in weak *ac* and *dc* magnetic fields. As a result, we could conclude that, in comparison with SSR in SG sample we found highest value of the transport critical current densities J_c.
Acknowledgements: This work is supported by the Georgian Shota Rustaveli National Science Foundation. Project Number: FR/261/6-260/14.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.531
Phase diagram in high magnetic fields for layered organic superconductor β ”-$(ET)_2SF_5CH_2CF_2SO_3$

<u>Sugiura S.</u>[1,2], Isono T.[3], Terashima T.[1], Yasuzuka S.[4], Schlueter J.[5], Uji S.[1,2]
[1]National Institute for Materials Science, Quantum Transport Properties Group, Tsukuba, Japan, [2]University of Tsukuba, Graduate School of Pure and Applied Sciences, Tsukuba, Japan, [3]RIKEN, Wako, Japan, [4]Hiroshima Institute of Technology, Research Center for Condensed Matter Physics, Hiroshima, Japan, [5]Argonne National Laboratory, Chemistry and Materials Science Divisions, Argonne, United States

Layered superconductors have attracted particular interest because of fascinating superconducting phenomena in high magnetic fields. When the superconductivity is in the clean limit and the orbital effect is strongly quenched, a novel superconducting phase, Fulde-Ferrell-Larkin-Ovchinnikov (FFLO) phase[1,2], can be stabilized above the Pauli limit (H_P). Because of high two dimensionality (2D) of the electronic state, a layered organic superconductor β”-$(ET)_2SF_5CH_2CF_2SO_3$ (β”-SF_5)[3] is one of the best candidates for the FFLO phase studies. We have performed systematic measurements of the magnetic torque and magnetocaloric (MC) effect to reveal the FFLO phase for β”-SF_5. We find a steep decrease of the diamagnetic susceptibility and a small peak associated with hysteresis in the MC effect above H_P. Since this peak is observed only when the field is nearly parallel to the conducting layer, it can be assigned to the FFLO phase transition. In addition, we find two distinct peaks in the MC effect, which are observable in wider field angle regions. The peak fields rapidly decrease as the field is tilted from the parallel direction. These peaks are likely ascribed to quantum melting transitions of the pancake and Josephson vortices.
References:
[1] P. Fulde and R. A. Ferrell, Phys. Rev. 135 A550 (1964)

[2] A. I. Larkin and Yu. N. Ovchinnikov, Sov. Phys. JETP 20, 762 (1965)
[3] U. Geiser et al. J. Am. Chem. Soc. 118, 9996 (1996)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.532

Characterization of topological phases by the Weyl points of the entanglement Hamiltonian

Araki H.[1], *Fukui T.*[2], *Hatsugai Y.*[3]
[1]University of Tsukuba, Graduate School of Pure and Applied Sciences, Tsukuba, Japan, [2]Ibaraki University, Department of Physics, Mito, Japan, [3]University of Tsukuba, Division of Physics, Tsukuba, Japan

Topological insulators have been extensively studied that potentially exhibits novel phenomena in low temperature. Quantum spin Hall phases in two dimensions such as the Kane-Mele model are well described by the entanglement Chern number (ECN)[1-2], which is defined as the Chern number for the entanglement Hamiltonian (EH)[1-3]. It is also well defined with particle-particle interaction.
The ECN for the three dimensional topological insulator is focused using the section Chern number, that is defined for two dimensional periodic sections in three dimensional Brillouin zone. The Weyl point of the EH is specified by the topological change of the section ECN. Then the parity of the number of the Weyl points is useful topological quantity which distinguishes the strong topological insulator (STI) from the weak one (WTI)[2]. Its consistency with the Z2 characterization is also discussed [2].

References:

[1] T.Fukui and Y.Hatsugai, JPSJ, 83, 113705 (2014)
[2] H. Araki, T. Kariyado, T. Fukui and Y. Hatsugai, JPSJ, 85, 043706 (2016)
[3] T.Fukui and Y.Hatsugai, JPSJ, 84, 043703 (2015)
[4] H. Araki, T. Fukui and Y. Hatsugai, in preparation.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.533

High-pressure studies for hydrogen doped *R*FeAsO$_{1-x}$H$_x$ (*R*=Sm,Tb)

Shinzato T.[1], *Kikuchi R.*[1], *Kawashima C.*[2], *Iimura S.*[3], *Matsuishi S.*[4], *Hosono H.*[3,4], *Takahashi H.*[2]
[1]Nihon University, Graduate School of Integrated Basic Sciences, Tokyo, Japan, [2]Nihon University, Department of Physics, College of Humanities and Sciences, Tokyo, Japan, [3]Tokyo Institute of Technology, Laboratory for Materials and Structures, Yokohama, Japan, [4]Tokyo Institute of Technology, Materials Research Center for Element Strategy, Yokohama, Japan

Iron-based superconductors have attracted much attention because of showing high T_c and wide variety of materials based on the magnetic element iron. Recently, hydrogen can be successfully doped to the 1111-type compound up to the over-doped region. The phase diagrams of 1111-type *Ln*FeAsO$_{1-x}$H$_x$
(*Ln* = La,Ce,Sm,Gd,) show antiferromagnetic ordering phase (AFM1) and dome-shape $T_c(x)$ successively with hydrogen doping[1]. Recent experiments revealed that the phase diagram of

LaFeAs$O_{1-x}H_x$ tends to be similar to the one of SmFeAs$O_{1-x}H_x$ under high pressure [2]. Such results indicate that physical pressure effect has chemical pressure-like effect, that is, the $T_c(x)$ dome shifts to the lightly-doped side with applying pressure.
The second antiferromagnetic phase (AFM2) was observed for *Ln*FeAs$O_{1-x}H_x$(*Ln*=Sm,Tb) in the over-doped region. However, it has not been clear that the interplay between the magnetic phase and the superconducting one. Applying pressure to the over-doped region is expected to provide the important information to study the highly doped region beyond the AFM2 phase.
In this study, electrical resistivity measurements under high pressure were carried out for *Ln*FeAs$O_{1-x}H_x$(*Ln*=Sm,Tb) in the over-doped region and the phase diagram of these materials will be presented.

References:

[1] S. Iimura, *et al., Nature Commun.* **3** (2012) 943.
[2] H. Takahashi, *et al., Sci. Rep.* **5** (2015) 7829.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.534
Leapfrogging Kelvin waves

Hietala N.[1], *Hänninen R.*[1], *Salman H.*[2], *Barenghi C.F.*[3]
[1]Aalto University, Helsinki, Finland, [2]University of East Anglia, Norwich, United Kingdom, [3]Newcastle University, Newcastle upon Tyne, United Kingdom

Local induction approximation (LIA) is a convenient tool for solving the dynamics of a single quantized vortex. It allows soliton and breather solutions. Since LIA neglects all nonlocal interactions and specifically interactions between different vortices, it is not adequate for describing the dynamics of complex vortex configurations in superfluids. Klein *et al.* [1] derived a model for the interactions of nearly parallel vortex filaments. This model combines LIA with a point vortex model. Interactions between vortices are described in a layered fashion: the points of the filaments lying in at the same height interact as they were point vortices lying in a plane.
We have used the model for nearly parallel vortex filaments to study the motion of two interlaced helical vortices with the same wavelength in the absence of the mutual friction [2]. We find a solution for a recurrence phenomenon that is similar to the leapfrogging of two vortex rings. For small-amplitude Kelvin waves we demonstrate that our full Biot-Savart simulations closely follow predictions obtained from the simplified model. The recurrence phenomenon generalises to cases with noncoaxial vortices, vortices with a Hasimoto soliton, or more than two vortices.

References:

[1] R. Klein, A. J. Majda, and K. Damodara, J. Fluid Mech. **288**, 201-248 (1995)
[2] N. Hietala, R. Hänninen, H. Salman, and C. F. Barenghi, Phys. Rev. Fluids **1**, 084501 (2016)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.535
Gauge-invariance argument for the quantization of the thermal Hall conductivity

Nakai R.[1], *Ryu S.*[2], *Nomura K.*[3]

[1]RIKEN, Wako, Japan, [2]University of Chicago, Chicago, United States, [3]Tohoku University, Sendai, Japan

We study the quantization of the thermal Hall conductivity in quantum Hall systems from the perspective of the gauge invariance and noninvariance. By extending the Laughlin´s magnetic-flux-threading argument [1] that accounts for the quantization of the electric Hall conductivity, the thermal counterpart of the magnetic-flux-threading process is introduced in terms of the gravitational field. The quantization of the thermal Hall conductivity is shown to be resulting from the breakdown of the modular invariance of the chiral boundary modes [2].

References:

[1] R. B. Laughlin, Phys. Rev. B **23**, 5632 (1981).
[2] R. Nakai, S. Ryu, K. Nomura, Phys. Rev. B **95**, 165405 (2017).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.536

Kosterlitz-Thouless transitions of incommensurate orders in frustrated Heisenberg models

Tabata M., *Yamamoto D., Furukawa N.*
Aoyama-Gakuin University, Graduate School of Science and Engineering, Sagamihara, Japan

The triangular-lattice antiferromagnetic Heisenberg model under magnetic fields is a prototypical system to study the lifting of classical ground-state degeneracy by (thermal or quantum) fluctuations or some sort of perturbations. We study the magnetic phases of the classical Heisenberg model on a spatially anisotropic triangular lattice as a function of temperature T and magnetic field H. It has been known that, within the degenerate ground-state manifold, systems with thermal fluctuations select collinear (so-called “up-up-down”) or coplanar (“Y” or “V”) ordered states, while those with spatial anisotropies prefer non-coplanar incommensurate (“cone”) orders. Therefore, the competition of the two different effects gives rise to various magnetic states and non-trivial phase transition phenomena [1]. In this work, we determine the magnetic phase diagram of T versus H as a function of the magnitude of the spatial anisotropies in detail, using Monte Carlo simulations. We have performed careful size-scaling analyses with various boundary conditions, since those suffer from strong finite-size effects in incommensurate systems. In particular, we discuss the Kosterlitz-Thouless transition of incommensurate magnetic orders in detail.

References:

[1] L. Seabra *et al.*, Phys. Rev. B **84**, 214418 (2011).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.537

Limitations on coherent work extraction in open quantum systems

Menczel P., *Flindt C., Brandner K.*
Aalto University, Department of Applied Physics, Aalto, Finland

As the miniaturization of thermal machines advances towards ever-smaller scales [2], the question arises how quantum effects such as coherence will influence their performance, see for example [3]. Here, we investigate this problem for heat engines operating periodically and under weak-coupling conditions.
To assess the role of quantum effects, the total energy content of the working substance is divided into a passive part and one which can be extracted through coherent operations [4]. Using this scheme, we obtain a refined version of the first law, which allows us to derive a general criterion necessary for coherent work extraction. Specializing to Lindblad dynamics, we identify different universality classes of systems in which quantum effects can only decrease the total power.
In the limit of small driving amplitudes, we recover previously obtained bounds for the linear-response regime [5]. Our new bounds are, however, valid also arbitrarily far from equilibrium, that is, for strong and fast driving. Thus, our results are a step towards a systematic understanding of the role of coherence for power generation in open quantum systems.

References:

[1] P. Menczel, C. Flindt and K. Brandner, in preparation (2017).
[2] J. Roßnagel, S. T. Dawkins, K. N. Tolazzi, O. Abah, E. Lutz, F. Schmidt-Kaler, and K. Singer, Science **352**, 325 (2016).
[3] J. P. Pekola, Nat. Phys. **11**, 118 (2015).
[4] A. E. Allahverdyan, R. Balian, and T. M. Nieuwenhuizen, EPL **67**, 565 (2004).
[5] K. Brandner, M. Bauer and U. Seifert, arXiv:1703.02464

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.538

Luttinger parameter of quasi-one-dimensional para-H_2

Boronat J.[1], *Ferré G.*[1], *Gordillo M.C.*[2]
[1]Universitat Politecnica de Catalunya, Barcelona, Spain, [2]Universidad Pablo de Olavide, Sevilla, Spain

We have studied the ground-state properties of para-hydrogen in one dimension and in quasi-one-dimensional configurations using the path integral ground state Monte Carlo method [1]. This method produces zero-temperature exact results for a given interaction and geometry. The quasi-one-dimensional setup has been implemented in two forms: the inner channel inside a carbon nanotube coated with H_2 and a harmonic confinement of variable strength. Our main result is the dependence of the Luttinger parameter on the density within the stable regime. Going from one dimension to quasi-one dimension, keeping the linear density constant, produces a systematic increase of the Luttinger parameter. This increase is however not enough to reach the superfluid regime and the system always remain in the quasi-crystal regime, according to Luttinger liquid theory.

References:

[1] G. Ferré, M. C. Gordillo, and J. Boronat, Phys. Rev. B **95,** 064502 (2017)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

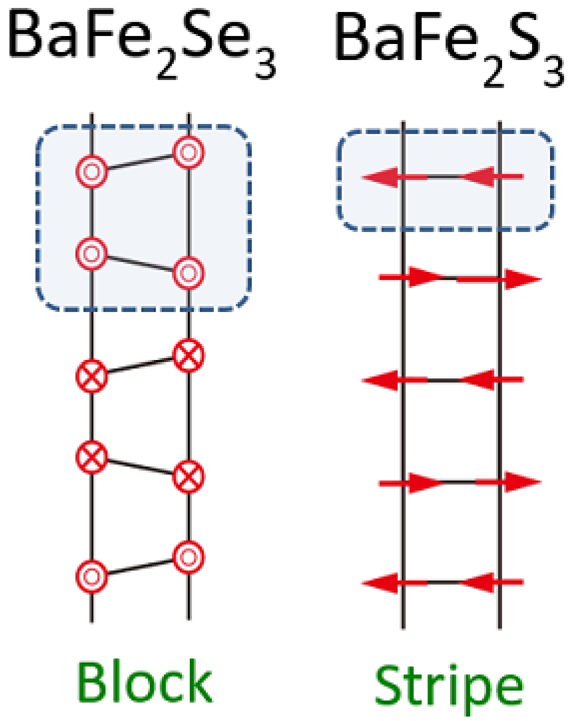
P.539

Pressure effect for iron-based spin-ladder compound $Ba_{1-x}Cs_xFe_2X_3$ (X=Se, S)

Kawashima C.[1], *Takahashi H.*[1], *Hawai T.*[2], *Nambu Y.*[3], *Sato J.T.*[3], *Ohgushi K.*[3]

[1]Nihon University, Setagaya-ku, Japan, [2]KEK, Tokai-mura, Japan, [3]Tohoku University, Sendai, Japan

Crystal structures of AFe_2X_3 (A = Ba, Cs; X = Se, S) consist of edge-shared FeX_4 tetrahedra and channels occupied by A atoms, in which Fe atoms form a ladder structure [1], [2]. The magnetic structure of $BaFe_2Se_3$ is block-type, in which the magnetic moments form Fe_4 ferromagnetic units, which stack antiferromagnetically along the leg direction of the ladder. In contrast, the magnetic structures of the $BaFe_2S_3$ are of the stripe-type, in which the magnetic moments couple ferromagnetically along the rung, and antiferromagnetically along the leg direction[3].



[Magnetic structure in the ladder]

These magnetic structures remind the iron-based superconductors such as the 245 or 1111 systems. And the ladder material, for example, $Sr_{14-x}Ca_xCu_{24}O_{41}$ exhibits superconductivity under high pressures above 4 GPa [4]. In previous study, we found that $BaFe_2S_3$ exhibits superconductivity at about 11 GPa below T_C =14 K [3].
We performed the electrical resistance measurements under high pressure for $(Ba,Cs)Fe_2S_3$ and $(Ba,Cs)Fe_2Se_3$ using a diamond anvil cell (DAC).

References:
[1] Y. Nambu, *et al. Phys. Rev.* B **85**, 064413 (2012).
[2] F. Du, *et al. Phys. Rev.* B **85**, 214436 (2012).
[3] H. Takahashi, *et al. Nature Mater.* **14**, 1008 (2015).
[4] M. Uehara, *et al. J. Phys. Soc. Jpn.* **65**, 2764 (1996).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.540
Electron waiting times of a periodically driven single-electron turnstile

Potanina E., *Flindt C.*
Aalto University, Department of Applied Physics, Espoo, Finland

The distribution of waiting times between tunneling events is a useful statistical tool to characterize quantum transport. Waiting time distributions (WTD) complement zero-frequency observables such as the mean current and the shot noise, for example by revealing the regularity of single electrons emitted from dynamically driven devices.
In recent years, WTDs have been investigated for a variety of quantum transport setups, including quantum dots [1], dynamic single-electron emitters [2], mesoscopic conductors [3,4] as well as superconducting devices [5]. In this contribution, we present a general theory for calculating the WTD of a periodically driven single-electron device [6]. Our approach is applicable for any periodic driving protocol and leads to analytic expressions for the WTDs. Our results can be directly compared with future measurements of WTDs based on a charge detector that couples capacitively to a dynamic single-electron turnstile.

References:
[1] T. Brandes, Ann. Phys.**17**, 477(2008)
[2] M. Albert, C. Flindt, and M. Büttiker, Phys. Rev. Lett.**107**, 086805 (2011)
[3] M. Albert, C. Flindt, G. Haack, and M. Büttiker, Phys. Rev. Lett.**108**, 186806 (2012)
[4] D. Dasenbrook, C. Flindt, and M. Büttiker, Phys. Rev. Lett.**112**, 146801 (2014)
[5] L. Rajabi, C. Pöltl, and M. Governale, Phys. Rev. Lett.**111**, 067002 (2013)
[6] E. Potanina and C. Flindt, submitted to Phys. Rev. B (2017)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.541

Fe-impurity-induced magnetic excitations in heavily over-doped $La_{0.7}Sr_{0.3}Cu_{0.95}Fe_{0.05}O_4$

Ikeuchi K.[1], *Kikuchi T.*[2], *Nakajima K.*[2], *Kajimoto R.*[2], *Wakimoto S.*[3], *Fujita M.*[4]
[1]CROSS, Neutron Science and Technology Center, Tokai, Japan, [2]J-PARC Center, Materials and Life Science Division (MLF), Tokai, Japan, [3]Japan Atomic Energy Agency, Quantum Beam Science Center, Tokai, Japan, [4]Tohoku University, Institute for Materials Research, Sendai, Japan

Dilute doping of Fe impurities into a metallic phase of La214 type cuprate induces a static magnetic order[1]. The fact means that the Fe has some role to play in enhancing spin correlations between Cu spins. Also, the fact can be a key to understand how the strong spin correlations give the system an inter-electron coupling behind the high-T_c superconductivity, where incommensurate structure of the induced magnetic order resembles that of the Fe-free system.
In order to study the upgrowth of the spin correlation, we performed inelastic neutron scattering experiments to observe magnetic excitations of Fe-substituted $La_{1.7}Sr_{0.3}Cu_{0.95}Fe_{0.05}O_4$. The experiments were carried out with the Cold chopper spectrometer BL14 AMR installed at J-PARC. We observed incommensurate paramagnetic spin-fluctuation induced by the Fe-substitution, which is in contrast to the Fe-free $La_{1.7}Sr_{0.3}CuO_4$ showing no magnetic excitations in the low-energy region. In addition to the incommensurate spin-fluctuation, we observed a magnetic excitation with a ring-like shape around the magnetic G point $\boldsymbol{Q}$ = (0.5, 0.5).
In this presentation, we will discuss the Fe-induced spin correlation and its class structure from a dynamical point of view.

References:
[1] R.-H. He *et al.*, Phys. Rev. Lett. **107**, 127002 (2011).

Postersession 2

Saturday, 12 August 2017
16.30-18.30
G Foyer

P.542
Using graphene Josephson junctions to make tunable DC SQUIDs
Thompson M.[1], *Prance J.*[1], *Haley R.*[1], *Pashkin Y.*[1], *Ben Shalom M.*[2], *Falko V.*[2], *Geim A.*[2], *Matthews A.*[3], *White J.*[3], *Melhem Z.*[3]
[1]Lancaster University, Department of Physics, Lancaster, United Kingdom, [2]University of Manchester, School of Physics & Astronomy, Manchester, United Kingdom, [3]Oxford Instruments NanoScience, Oxford, United Kingdom

The superconducting proximity effect in graphene can be used to build Josephson junctions whose critical current can be controlled by field-effect gates. These junctions combine the tunability of semiconductor Josephson junctions with the high critical currents and low contact resistances of metal SNS junctions. We present measurements of graphene Josephson junctions which exhibit low contact resistance and ballistic transport[1] and demonstrate how these can be used to create tunable DC SQUIDs[2]. Using local gates, the SQUID junction critical currents can be modified individually, allowing the sensitivity and symmetry of the SQUID to be controlled in-situ. We compare the critical current of the SQUID with simulations using a non-sinusoidal current phase relation which is expected for ballistic junctions. We have also investigated the transfer function of the device in both symmetric and asymmetric configurations and find a highest transfer function of 300 uV/Phi_0. Graphene Josephson junctions have the potential to add functionality to existing technologies; for example, to make SQUID magnetometers with tunable sensitivity or superconducting qubits with fast electrical control.
References:
[1] Ben Shalom et al., Nature Physics 2015, 12, 318-322
[2] Thompson et al., Appl. Phys. Lett. (in press)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.543
Unconventional superconductivity in low density electron systems
Kagan M.Y.[1,2]
[1]P.L. Kapitza Institute for Physical Problems RAS, Moscow, Russian Federation, [2]National Research University Higher School of Economics, Moscow, Russian Federation

In this talk I first discuss the results on nonphonon superconductivity in fermion systems at low electron densities. In the context of repulsive-U Hubbard model and Shubin-Vonsovsky model we consider briefly the superconducting phase diagrams and the symmetries of the order parameter in novel strongly correlated electron systems including idealized monolayer and bilayer graphene. We stress that purely repulsive fermion systems are mainly the subject of unconventional low-temperature superconductivity. To get the high temperature superconductivity in cuprates (with T_C of the order of 100 K) we should proceed to the t-J model with the van der Waals interaction potential and the competition between short-range repulsion and long-range attraction. Finally we note that to describe superconductivity in metallic hydrogen alloys under pressure (with record high T_C of the order of 200 K) it is reasonable to reexamine more conventional mechanisms connected with electron-phonon interaction. These mechanisms arise in attactive-U Hubbard model with static onsite or intersite

attractive potential or in more realistic theories (which include retardation effects) such as Migdal-Eliashberg strong coupling theory or even Femi-Bose mixture theory of Ranninger et al and its generalizations.

References:
[1] M.Yu. Kagan, Modern Trends in Superconductivity and Superfluidity, Lecture Notes in Physics, v.874, Springer, Dordrecht (2013).
[2] M.Yu Kagan, M.M. Korovushkin, V.A. Mitskan, Anomalous superconductivity and superfluidity in fermionic systems with repulsion, Sov. Phys. Uspekhi **58**, 733 (2015).
[3] M.Yu. Kagan, Unconventional superconductivity in low density electron systems and conventional superconductivity in hydrogen metallic alloys, JETP Lett., **103**, 822 (2016).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.544
5d transition-metal superconductor $SrIr_2$
Horie R.[1], Nishiyama S.[1], Akimitsu M.[1], Horigane K.[1], Kobayashi K.[1,2], Kambe T.[2], Kubozono Y.[1], Akimitsu J.[1]
[1]Okayama University, Research Institute for Interdisciplinary Science, Okayama, Japan, [2]Okayama University, Department of Physics, Okayama, Japan

Compounds based on 5d transition metals are attracting interests recent years because novel physical properties are expected due to their strong spin-orbit coupling [1]. $SrIr_2$ is a superconductor containing 5d transition metal iridium and was discovered by Matthias *et al*. in 1957 [2]. Because there is no detailed report since then, the purpose of this research is to study the physical properties of $SrIr_2$ in detail.
We succeeded in synthesizing nearly single-phase $SrIr_2$. It was found that $SrIr_2$ is a superconductor with T_c of 5.9 K, which is slightly higher than the previously reported value of 5.7 K. We carried out the specific heat measurement and calculated superconducting parameters. It is suggested that $SrIr_2$ is a strongly coupled superconductor from the value of $2\Delta(0)/k_B T_c$ ~4.26 (>3.53(BCS)). In this presentation, we report the results of X-ray structure analysis and also the superconducting parameters such as H_{c1} and H_{c2} determined from resistivity, specific heat and magnetization measurements.

References:
[1] B. J. Kim *et al*., Phys. Rev. Lett. **101**, 076402 (2008).
[2] B. T. Matthias and E. Corenzwit, Phys. Rev. **107**, 1558 (1957).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.545
Pre-cooling of ton-scale particle detectors in low radioactivity environments
Cappelli L.[1], Pagliarone C.E.[1,2], Marignetti F.[1,3], D'Aguanno D.[1,3], Erme G.[1,2], Kartal S.[4]
[1]Istituto Nazionale di Fisica Nucleare (INFN) - Laboratori Nazionali del Gran Sasso, Assergi, Italy, [2]Università di Cassino e del Lazio Meridionale, Dipartimento di Ingegneria Civile e Meccanica (DICEM), Cassino, Italy, [3]Università di Cassino e del Lazio Meridionale, Dipartimento di Ingegneria

Elettrica e dell'Informazione (DIEI), Cassino, Italy, [4]Istanbul University, Physics Department, High Energy Physics Division, Istanbul, Turkey

Low radioactivity sites are mandatory to make searches for rare processes that cannot be studied with particle accelerators and requires low environmental backgrounds. Neutrino-less double b decay or Dark Matter searches must be performed in underground low radioactivity observatories. Large detectors are needed to increase the acceptances and proper cryogenic systems to run dedicated detectors. To reach the working temperatures, refrigerators as Pulse Tubes, Dilution Units are used inside complex cryostats. CUORE, Cryogenic Underground Observatory for Rare Events is an experiment located at LNGS under the Gran Sasso mountain. So far, it's the coldest m^3 and the largest cold mass ever realized. Its 998 TeO_2 bolometers need to be kept at temperatures T< 10 mK. Using only PTs, CUORE needs several weeks to reach the baseline T. Then a Fast Cooling System, FCS has been designed and constructed for a faster precooling of the whole CUORE cold volume. The FCS consists of a cryostat with heat exchangers that use 3 Gifford-McMahon refrigerators, a He blower, a filtering module and several sensors that allow to monitor and control the system during CUORE cooldown. The present work will describe the FCS and will summarize the FCS performances during the first full CUORE cooldown
(Run I).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.546
Relationship between spin fluctuations and superconductivity in the d-p model: Two-particle Self-Consistent analysis

<u>Ogura D.</u>, Kuroki K.
Osaka University, Department of Physics, Osaka, Japan

In the study of the high-T_c cuprate superconductors, usually a single-band model that considers the Cu $3d_{x2-y2}$ orbital is adopted. However, Ref. [1] has pointed out the importance of the orbital hybridization of the Cu $3d_{z2}$ orbital to understand the material dependence of the superconducting transition temperature T_c. In Ref. [2], it has been suggested that the hybridized Cu3*d*-O2*p* electronic state plays an essential role in understanding the doping dependence of T_c. These studies suggest the importance of the multi-orbital nature in the cuprate superconductors.
Given this background, we study the three-band *d-p* model, which explicitly considers the O2*p* orbitals in addition to the Cu $3d_{x2-y2}$ orbital. To consider the electron correlation effect, we apply the Two-Particle Self-Consistent method [3-5], in which the vertex corrections are considered in a non-perturbative manner. In the presentation, we will focus on the *d-p* level offset, which is one of the parameters that controls the *d-p* hybridization, and discuss the relationship between antiferromagnetic spin fluctuations and superconductivity.

References:
[1] H. Sakakibara and H. Usui, K. Kuroki, R. Arita, and H. Aoki, Phys. Rev. Lett. **105**, 057003 (2010**)**.
[2] D. Ogura and K. Kuroki, Phys. Rev. B **92**, 144511 (2015**)**.
[3] Y. Vilk and A.-M. Tremblay, J. Phys. I (France) **7**, 1309 (1997).
[4] H. Miyahara, R. Arita, and H. Ikeda, Phys Rev B **92**, 045113 (2013).
[5] S. Arya, P. Sriluckshmy, S. Hassan, and A.-M Tremblay, Phys Rev B **92**, 045111 (2015).

Postersession 2

Saturday, 12 August 2017
16.30-18.30
G Foyer

P.547

Multiferroic phases of a frustrated quantum spin chain compound linarite

Feng Y., Yu. Povarov K., Zheludev A.
Neutron Scattering and Magnetism, Laboratory for Solid State Physics, ETH Zurich, Zürich, Switzerland

We present our studies of the frustrated S=1/2 spin chain compound $PbCuSO_4(OH)_2$, also known as linarite. Dielectric measurements were performed across its strongly anisotropic phase diagram down to 200mK. In particular, electric polarization was measured on single crystals of the titled material in 6 different geometric configurations. At least 2 of the magnetic phases for H||b-axis were revealed to be also ferroelectric [1]. The observed orientation of dielectric polarization confirmes the spin structure in the thermodynamic ground state of the material, but also suggests that one of the previously proposed phase-coexistence regions is actually a proper thermodynamic phase, possibly with a multi-q magnetic structure.

References:

[1] K. Yu. Povarov, Y. Feng, A. Zheludev, Multiferroic phases of the frustrated quantum spin chain compound linarite, Phys. Rev. B **94**, 214409

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.548

Charge transport in ferromagnet / spin-singlet superconductor junctions with interfacial Rashba spin-orbit coupling

Fukumoto T.[1], Tanaka Y.[1,2]
[1]Nagoya University, Department of Applied Physics, Nagoya, Japan, [2]Moscow Institute of Physics and Technology, Dolgoprudny, Russian Federation

Investigating magnetic properties of materials has much importance in spintronics for the application. As an example, observing the charge transport of ferromagnet (FM) / *s*-wave superconductor (SC) junctions is known as a significant method to estimate the spin polarization of FMs [1,2]. Recently, however, it was found that the tunneling conductance of FM / *s*-wave SC junctions can be enhanced by the Rashba spin-orbit coupling (RSOC) at the interface [3]. This behavior of the charge transport is already discussed from spin-triplet Cooper pairs induced by the RSOC in the *s*-wave SC [3,4]. In contrast, it has not been studied in light of the RSOC near the surface of the FM, so far.
In the presentation, we would like to report obtained the tunneling conductance of FM / spin-singlet SC junctions. The results are calculated using lattice models. Here, *s*-wave and d_{xy}-wave pairing symmetries are chosen for the spin-singlet SC, and the RSOC is introduced near the surface of the FM. We show that the tunneling conductance can increase also due to this RSOC. Particularly, owing to the RSOC, a zero-bias tunneling conductance can appear even in half-metallic FM / d_{xy}-wave SC junctions at finite temperature [5]. Besides, we discuss the relevance between this result and experiments [6].

References:

[1] R. J. Soulen *et. al.*, Science **282**, 85 (1998)
[2] M. J. M. de Jong *et. al.*, Phys. Rev. Lett. **74**, 1657 (1995)
[3] P. Högl *et. al.*, Phys. Rev. Lett. **115**, 116601 (2015)

[4] M. Duckheim *et. al.*, Phys. Rev. B **83**, 054513 (2011)
[5] S. Kashiwaya *et. al.*, Phys. Rev. B **60**, 3572 (1999)
[6] H. Kashiwaya *et. al.*, Phys. Rev. B **70**, 094501 (2004)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.549
Probing the magnitude of variable-range hopping length in carbonized polymer nanofibers by magnetotransport measurement

Kim K.H.[1]*, Lara-Avila S.*[1]*, Kubatkin S.*[1]*, Eklof J.*[1]*, Moth-Poulsen K.*[1]*, Kang H.*[2]*, Hong S.J.*[2]*, Park M.*[2]*, Park Y.W.*[2]*, Matsushita S.*[3]*, Akagi K.*[3]
[1]Chalmers University of Technology, Gothenburg, Sweden, [2]Seoul National University, Seoul, Korea, Republic of, [3]Kyoto University, Kyoto, Japan

We report magnetotransport on carbonized conductive polymer nanofibers, which have undergone profound structural changes during pyrolysis, to become essentially amorphous carbons. Pristine polymer nanofibers consist of quasi one-dimensional hydrocarbon chains where charge transport is predicted to be mediated by non-linear local excitations such as soliton, polaron, or bipolarons [1]. Despite the profound structural difference before and after carbonization, we find that both systems display power law dependence of current with voltage and temperature that can be scaled into a single universal curve. We argue that the variable range hopping of normal electrons and the VRH of soliton, polaron or bipolaron is the transport mechanism that dominates in carbonized and pristine nanofibers, respectively [2]. We then employ magneto transport measurements to quantify hopping lengths under different experimental conditions. We find that, in the non-linear transport regime, the hopping length decreases for both increasing electric field and temperature, due to the transition from the thermally-activated to electric- field driven transport.

References:

[1] A. Choi *et al*., Phys. Rev. B **86**, 155423 (2012)
[2] K. H. Kim *et al*., Sci. Rep. **6**, 37783 (2016)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.551
Optical, electrical and galvanomagnetic properties of $PtSn_4$ single crystals

Marchenkov V.V.[1,2,3]*, Naumov S.V.*[1]*, Makhnev A.A.*[1]*, Chistyakov V.V.*[1]*, Marchenkova E.B.*[1]*, Huang J.C.A.*[4]*, Eisterer M.*[5]
[1]M.N. Mikheev Institute of Metal Physics, Ekaterinburg, Russian Federation, [2]International Laboratory of High Magnetic Fields and Low Temperatures, Wroclaw, Poland, [3]Ural Federal University, Ekaterinburg, Russian Federation, [4]National Cheng Kung University, Tainan, Taiwan, Republic of China, [5]TU Wien, Atominstitut, Vienna, Austria

Recently, topological Weyl semimetals (TWSM), which are new quantum materials with a topologically nontrivial band structure arising due to strong spin-orbit interaction, were discovered. TWSM have a nontrivial current transport both in the volume and on the surface. The quasiparticles in TWSM are

"massless" Weyl fermions with "zero" effective mass, which are protected topologically. This means that such quasiparticles can be controlled much faster than conventional charge carriers, and the probability of their scattering is sufficiently small. Therefore, TWSM can be used in ultra-fast electronics and spintronics. We studied the optical, electrical and galvanomagnetic properties of $PtSn_4$ single crystals, a promising TWSM, in the temperature range from 4.2 to 300 K and in magnetic fields of up to 10 T. Anomalies of the optical properties as well as in the electronic transport were observed, which can be explained by light current carriers of high mobility and apparently are a manifestation of the TWSM nature.

This work was partly supported by the state assignment of FASO of Russia (theme “Spin” No. 01201463330), by the RFBR (project No. 17-52-52008), by the Government of the Russian Federation (state contract No. 02.A03.21.0006).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.552

Nuclear quadrupole driven relaxation of atomic tunneling systems in glasses at very low temperatures

Luck A., Frey B., Hauff N., Homann G., Scholz W., Schrodin M., Wesp P., Zeissner A., Fleischmann A., Reiser A., Enss C.

Kirchhoff-Institute for Physics, Heidelberg University, Heidelberg, Germany

The universal behavior of amorphous solids at low temperatures, governed by atomic tunneling systems as described by the standard tunneling model (STM), has long been a generally accepted fact.

In order to investigate whether nuclear moments are not only responsible for the characteristic magnetic field dependence of polarization echo amplitudes but also for the surprising magnetic field dependence of the low frequency dielectric and elastic susceptibility, we have measured the temperature dependence of the dielectric function over eight orders of magnitude in frequency on two glasses containing ^{181}Ta and ^{165}Ho respectively. Both isotopes carry large nuclear quadrupole moments, and thus should be ideal candidates to determine the influence of nuclear moments.

Even at zero magnetic field both glasses show a behavior that cannot be explained by the STM but rather by a fundamentally new nuclear quadrupole based relaxation for tunneling systems, dominating over the one phonon relaxation at very low temperatures. We show experimental evidence and discuss the results in a first simple model, which also explains why in most glasses this new relaxation mechanism only shows up via a magnetic field dependence but is masked in the temperature dependence of the dielectric susceptibility.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.553

Charge and energy noise from on-demand electron sources

Dashti N.[1], Samuelsson P.[2], Misiorny M.[3], Splettstoesser J.[3]
[1]Chalmers University of Technology, Microtechnology and Nanoscience, Gothenburg, Sweden, [2]Lund University, Physics and NanoLund, Lund, Sweden, [3]Chalmers University of Technology, Microtechnology and Nanoscience (MC2), Gothenburg, Sweden

On-demand single electron sources (SES) are of key importance for future electronic appli- cations, as they allow for achieving a controlled and noiseless flow of particles in a coherent mesoscopic conductor. The precision and spectrum of the injected single-particle state can be charactrized by the correlations of the charge- and energy-current fluctuations. We analyze two prominent examples:
(1) the emission of single electrons from a driven mesoscopic capacitor in the quantum Hall regime and
(2) the application of a Lorentzian-shaped time-dependent poten- tial to a coherent conductor.
By employing a Floquet scattering matrix approach, we compare the features in charge- and energy-current noise. While the charge-current noise is identical, the energy-current noise is sensitive to possible chirality and properties of driving potential.
In contrast to charge currents, energy currents and their fluctuations are difficult to access experimentally. Employing the Boltzmann-Langevin approach, we show that the measurement of the frequency-dependent chemical potential and temperature fluctuations gives access to the low-frequency charge-, energy- and mixed-current noises. We investigate to what extent back- action of the probe reduce access to the pure noise of the source.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.554
Quantitative force microscopy measurements of quantum turbulence

Noble M.T.[1], Bradley D.I.[1], Forchheimer D.[2], Haley R.P.[1], Haviland D.B.[2], Kafanov S.[1], Pickett G.R.[1], Tsepelin V.[1], Wilcox T.[1]
[1]Lancaster University, Physics Department, Lancaster, United Kingdom, [2]KTH Royal Institute of Technology, Nanostructure Physics, Stockholm, Sweden

Quartz tuning forks have been used extensively to study the onset of quantum turbulence in superfluids at temperatures where normal fluid dissipation is negligible. At low excitation in the absence of turbulence a tuning fork can be modelled as a simple harmonic oscillator. In this regime driving a tuning fork at multiple frequencies simultaneously yields a response only at these frequencies, and is simply a superposition of the solutions for single frequencies [1]. However, at larger excitations when the fork motion exceeds the critical threshold and the onset of turbulence creation begins, non-linear forces acting on the fork create additional responses at frequencies different to those of the drive. These responses, the so-called intermodulation, or mixing products, contain information about the non-linear turbulence force. The measurement of these mixing products is an established technique in intermodulation atomic force microscopy [2]. In this work, we adapt these techniques to the study of quantum turbulence.

References:
[1] D.I. Bradley, R.P. Haley, S. Kafanov, M.T. Noble, G.R. Pickett, V. Tsepelin, J. Vonka and T. Wilcox, J. Low Temp. Phys. **184,** 1080 (2016)
[2] D. Platz, D. Forchheimer, E.A. Tholén and D.B. Haviland, Nanotechnology **23**, 265705 (2012)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.556
Epitaxial growth of rare-earth hexaboride thin films prepared by the molecular beam epitaxy
Shishido H.[1,2]*, Kozuka Y.*[1]*, Nakagami T.*[1]*, Ishida T.*[1,2]
[1]Osaka Prefecture University, Department of Physics and Electronics, Graduate School of Engineering, Sakai, Japan, [2]Osaka Prefecture University, NanoSquare Research Institut, Sakai, Japan

The rare-earth hexaboride compounds have been studied extensively for elucidating their various interesting properties. CeB_6 shows the antiferro-quadrupole (AFQ) ordering below T_Q = 3.2 K [1]. It has been attracted much attention as a prototypical AFQ system. SmB_6 is known as a typical Kondo insulator [2]. Furthermore, it has recently been proposed as a candidate for a topological insulator [3]. Fabricating epitaxial thin films of rare-earth hexaboride compounds allow us to tune the electronic state by changing a film thickness. In fact, magnetic and superconducting properties were successfully controlled by the dimensional tuning in heavy fermion artificial superlattices [4]. We have succeeded in growing epitaxial thin films of hexaboride compounds, CeB_6 and SmB_6 by molecular beam epitaxy. X-ray diffraction (XRD) and reflection high energy electron diffraction (RHEED) results indicate successful epitaxial growth of CeB_6 and SmB_6.
References:
[1] J.M. Effantin, *et al*., J. Magn. Magn. Matter. **47-48**, 145 (1985).
[2] A. Menth, *et al*., Phys. Rev.Lett. **22**, 295 (1969).
[3] M. Dzero *et al*., Phys. Rev. Lett. **104**, 106408 (2010).
[4] M. Shimozawa *et al*., Rep. Prog. Phys., **79**, 074503 (2016).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.557
Autler-Townes splitting probed by two-photon absorption in superconducting artificial atoms
Chien W.-C.[1]*, Hsieh Y.-L.*[1]*, Chen C.-H.*[2]*, Wu C.-S.*[2]*, Kuo W.*[1]
[1]National Chung Hsing University, Physics, Taichung, Taiwan, Republic of China, [2]National Changhua University of Education, Physics, Changhua, Taiwan, Republic of China

We experimentally study interactions between two microwave fields mediated by transmon-type 3-level artificial atom. The transmon has good selection rule, preventing one-photon transition, but allowing two-photon transition from ground state(0) to 2nd excited state(2). By pumping a control tone in resonance to the transition between 1st(1) and 2nd excited state(2), we control the one-photon transparency for 0 to 1 transition and two-photon transparency for 0 to 2 transition. The results are explained by the Autler-Townes splitting induced by the control microwave.

Postersession 2
Saturday, 12 August 2017

16.30-18.30
G Foyer

P.558
Strongly interacting multi-component fermions: from ultracold Fermi atomic gas to neutron star interior
Tajima H.[1]*, Hatsuda T.*[1,2]*, Ohashi Y.*[3]
[1]RIKEN Nishina Center, Wako, Japan, [2]RIKEN iTHES Research Group and iTHEMS Program, Wako, Japan, [3]Keio University, Department of Physics, Yokohama, Japan

We theoretically discuss connections between a strongly interacting two-component Fermi atomic gas and the low density region of a neutron star interior where majority two-component neutrons (↑,↓) and minority two-component protons (↑,↓) interact one another, via s-wave interactions. Recently, two of the authors have showed that the precisely observed equation of state in the unitary regime of a ^{6}Li superfluid Fermi gas far below T_c [1] can theoretically be well explained, once strong-coupling effects are correctly taken into account [2]. In this talk, using this strong-coupling theory, we try to approach the low-density region of the neutron star interior, by gradually adding protons to a pure neutron matter. We clarify how pairing fluctuations associated with a strong proton-neutron interaction modify the system properties, as one moves from the ``Fermi gas case (pure neutron matter)" to the "neutron star case (neutron-proton mixture)," with gradually increasing the proton fraction. Our results would contribute to the unified understanding of many-body phenomena in condensed matter physics and nuclear physics.
References:
[1] M. Horikoshi, M. Koashi, H. Tajima, Y. Ohashi, and M. Kuwata-Gonokami, arXiv:1612.04026.
[2] H. Tajima, P. van Wyk, R. Hanai, D. Kagamihara, D. Inotani, M. Horikoshi, and Y. Ohashi, Phys. Rev. A (in press).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.559
Enhancement of macroscopic quantum tunneling in the higher-order phase switches of Bi2212 intrinsic Josephson junctions
Kitano H., Yamaguchi A., Takahashi Y., Umegai S., Watabe Y., Ohnuma H., Hosaka K., Kakehi D.
Aoyama Gakuin University, Department of Physics and Mathematics, Sagamihara, Japan

The macroscopic quantum tunneling (MQT) in the current-biased intrinsic Josephson junctions (IJJs) of cuprates has attracted much attention for decades due to its potentiality for the future application to quantum information technology. Although early studies were concentrated on the phase switches from the zero to the first voltage state (1st SW), the recent experimental studies on the higher order switches [1-5], such as the second switch (2nd SW) from the 1st to the 2nd voltage state, clearly show that the MQT in IJJs survives up to a much higher temperature (roughly ~10 K) than a temperature predicted by the conventional MQT theory. This strongly suggests that the MQT occurring in the higher order switches involves a novel mechanism of the enhancement of MQT rate. Here, we present a study on the phase switches of small IJJs fabricated from $Bi_2Sr_2(Ca,Y)Cu_2O_y$ single crystals. Interestingly, our results indicate that a crossover temperature to the MQT state for the 2nd SWs is more strongly enhanced for the IJJs with a depressed 1st switching current than those without it. These results strongly suggest that the MQT for the higher-order phase switch is largely affected by an oscillatory current occurring in the phase running state of the phase-switched junction.
References:

[1] D. Kakehi *et al*, IEEE TASC **26** 1800204 (2016).
[2] H. Kitano *et al*, JPSJ **85**, 054703 (2016).
[3] Y. Takahashi *et al*, JPSJ **85**, 073702 (2016).
[4] Y. Kakizaki *et al*, JJAP **56**, 043101 (2017).
[5] H. Kitano *et al*., Journal of Physics: Conference Series (accepted for publication).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.560
Superconductivity mediated by excitonic fluctuations: variational cluster approach

Fujiuchi R.[1]*, Sugimoto K.*[2]*, Ohta Y.*[1]
[1]Chiba University, Department of Physics, Chiba, Japan, [2]Chiba University, Center for Frontier Science, Chiba, Japan

The Bose-Einstein condensation of electron-hole pairs (excitons) can occur in the ground state of some materials, the phase of which is called the excitonic insulator. 1*T*-$TiSe_2$ and Ta_2NiSe_5 are promising candidates for the realization of the spin-singlet excitonic phase. Intriguingly, in the phase diagrams of these materials, the superconducting phase is adjacent to the excitonic insulator phase [2,3]. This behavior resembles that of cuprates and iron pnictides, where the superconducting phase is adjacent to the antiferromagnetic phase [4]. In particular, the superconductivity in iron pnictides, where the electron-pocket and hole-pocket Fermi surfaces are present, was sometimes discussed in relation to the excitonic fluctuations [5].
Motivated by such developments in the field, we investigate the two-orbital Hubbard model defined on the two-dimensional square lattice using the variational cluster approach based on the self-functional theory, whereby we consider the mechanism of the exciton-mediated superconductivity. We show that actually there occurs the instability towards superconductivity in this model, which is mediated by the excitonic fluctuations, and that the suppression of the excitonic ordering by any means leads to the superconducting ground state.

References:
[1] D. Jerome, T.M. Rice, and W. Kohn, Phys. Rev. **158**, 462 (1967).
[2] A. F. Kusmartseva, B. Sipos, H. Berger, L. Forro, and E. Tutis, Phys. Rev. Lett. **103**, 236401 (2009).
[3] K. Matsubayashi, available at http://ci.nii.ac.jp/naid/110009990261/en (2015).
[4] D. N. Basov and A. V. Chubukov, Nat. Phys. **7**, 272 (2011).
[5] K. Sano and Y. Ono, J. Phys. Soc. Jpn. **78**, 124706 (2009).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.562
Contact angles of ^{4}He crystals on a rough wall

Nomura R.[1]*, Okuda Y.*[2]
[1]Tokyo Institute of Technology, Tokyo, Japan, [2]RIKEN, Wako, Japan

To investigate whether wetting properties of a ^{4}He crystal in superfluid is possibly controlled or not, contact angles of ^{4}He crystals were measured on rough and smooth walls. A rough surface was formed by coating the surface of a glass plate with a commercially available super-hydrophobic coating agent. Contact angles of ^{4}He crystals were found to increase by about 10 degrees on the rough wall coated with the agent. The repellency of ^{4}He crystals in superfluid was thus enhanced by the roughness of the surface. From the comparison of the contact angles and SEM image of the rough surface, the Cassie-Baxter state was likely to be realized on the rough surface; the ^{4}He crystal had a contact with the protruding parts of the rough surface but superfluid was entrapped between the crystal and the hollow parts of the wall [1].

References:

[1] T. Takahashi, H. Minezaki, A. Suzuki, K. Obara, K. Itaka, R. Nomura, and Y. Okuda, Phys. Rev. E **93**, 052806 (2016).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.563

Symmetry change of the pseudogap state revealed by underdoped ultrathin $YBa_2Cu_3O_{7-\delta}$ nanowires

<u>Andersson E.</u>, Arpaia R., Bauch T., Lombardi F.
Chalmers University of Technology, Department of Microtechnology and Nanoscience, MC2, Göteborg, Sweden

The microscopic origin of the properties of High T_c Superconductors (HTS) remains elusive 30 years after their discovery. Various symmetry breaking electronic ordering, such as charge density waves and nematicity, have been revealed in the underdoped region of the phase diagram, where the pseudogap dominates the normal state properties[1-2]. The correlation lengths of these phenomena are in the nm-range; the study of HTS nanodevices can be instrumental for understanding the intertwining of the various orders and the superconducting state.

We have developed a fabrication method to realize nanowires from untwinned YBCO films, which allows one to study the YBCO transport properties as a function of hole doping and device dimensions. With this approach heavily underdoped nanowires retain the physical properties of the as-grown films[3].

Transport measurements on underdoped devices have revealed a remarkable in plane anisotropy of the pseudogap. As the thickness is reduced to 10nm, the pseudogap features completely disappear at 90° (*b*-axis) which does not correlate with the expected d-wave symmetry. This “unconventional” behavior of the pseudogap is most prominent at the 1/8 hole doping which points towards a common critical doping for the various nanoscale electronic orders in HTS.

References:

[1] G. Ghiringhelli et al., *Science* **337**, 821 (2012)
[2] O. Cyr-Choiniére et al., *Phys. Rev. B* **92**, 224502 (2015)
[3] R. Arpaia et al., *IEEE Trans. Appl. Supercond.*, **23**, 1101505 (2013)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.565

Magnetization and magnetic phase diagram of Heusler compounds $Fe_{3-y}(Mn_{1-x}V_x)_ySi$ (*y* =1 and 1.5)

Hiroi M.[1], *Ishikuma S.*[1], *Shigeta I.*[1], *Koyama K.*[1], *Kondo A.*[2], *Kindo K.*[2], *Manaka H.*[3], *Terada N.*[3]
[1]Kagoshima University, Department of Physics and Astronomy, Kagoshima, Japan, [2]University of Tokyo, Institute for Solid State Physics, Kashiwa, Japan, [3]Kagoshima University, Department of Electrical and Electronics Engineering, Kagoshima, Japan

Heusler compound Fe_2MnSi exhibits a ferromagnetic transition at $T_C \sim 230$ K and another transition to a phase with antiferromagnetic components at $T_A \sim 60$ K. [1]. By substituting V for Mn, so as to obtain $Fe_2Mn_{1-x}V_xSi$, T_A decreases with x and then vanishes around $x \sim 0.2$ [2]. In this study the magnetization of $Fe_2(Mn_{1-x}V_x)Si$ (y = 1) is studied up to a high field of ~70 T and the magnetic phase diagram is revealed [3]. In addition, the magnetic properties of $Fe_{1.5}(Mn_{1-x}V_x)_{1.5}Si$ (y = 1.5) is investigated up to 5 T. T_A for y = 1 does not change much in low magnetic fields. The critical field of this transition of Fe_2MnSi is larger than 70 T, and, with increasing x, the critical field decreases corresponding to the decrease of T_A. For y = 1.5, with increasing the content of V, x, T_A decreases but the rate of the decrease is smaller than for y = 1. Also in this case T_A is found to be almost unchanged by magnetic fields up to 5 T.

References:

[1] S. Yoon and J. Booth, J. Phys. F: Metal. Phys. **8**, 1079 (1977).
[2] M. Kawakami, Physica B: Condens.Matter **186-188**, 1037 (1993).
[3] M. Hiroi et al., Phys. Rev. B**95**, 014410 (2017).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.566

Magnetocaloric effect in Heusler alloys based on Ni-Mn-Sn

Marchenkov V.V.[1,2,3], *Emelyanova S.M.*[1], *Marchenkova E.B.*[1], *Koshkid'ko Y.S.*[3], *Ćwik J.*[3], *Dilmieva E.T.*[3], *Wang R.L.*[4], *Yang C.P.*[4], *Sauerzopf F.*[5], *Frischauf K.*[5], *Gao T.*[6]
[1]M.N. Mikheev Institute of Metal Physics, Ekaterinburg, Russian Federation, [2]Ural Federal University, Ekaterinburg, Russian Federation, [3]International Laboratory of High Magnetic Fields and Low Temperatures, Wroclaw, Poland, [4]Hubei University, Wuhan, China, [5]TU Wien, Atominstitut, Vienna, Austria, [6]Shanghai University of Electric Power, Shanghai, China

Heusler alloys based on Ni-Mn-X (X=Ga, In, Sn) are promising candidates for applications in magnetic refrigerators because they exhibit a maximal magnetocaloric effect (MCE) during their first order phase transition. We studied the effect of Al and Si doping on the magnetization and the MCE in the Heusler compounds $Ni_{43}Mn_{46}Sn_{11-x}Z_x$ (Z = Ge, Si; x = 0, 1, 2), in the temperature range between 4.2 and 360 K and in magnetic fields of up to 7 T. It was demonstrated that the substitution of Sn atoms by Ge changes the MCE and shifts its maximum to higher temperatures. On the contrary, if Sn atoms are replaced by Si, the temperature maximum is shifted to lower temperatures. The results are discussed within frameworks of existing models.
This work was partly supported by the state assignment of FASO of Russia (theme “Spin” No. 01201463330), by the Scientific Program of UB RAS (project No. 15-17-2-12), by the RFBR (grant Nos. 15-02-06686 and 16-32-00072), by the Government of the Russian Federation (state contract No. 02.A03.21.0006), by the NCBR (Poland) within the project “ERA.Net RUS Plus: No. 146-MAGNES” financed by the EU 7th FP, grant No. 609556, by the National Natural Science Foundation of China (No.11204171), by the Shanghai Municipal Natural Science Foundation (No.16ZR1413600).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.567
Global spin current and spin texture in the excitonic phase of the triangular-lattice Hubbard model
Nishida H., Miyakoshi S., Ohta Y.
Chiba University, Department of Physics, Chiba, Japan

The Bose-Einstein condensation of fermion pairs is one of the most intriguing phenomena in condensed matter physics. The excitonic phase is representative of such a pair condensation, where holes in valence bands and electrons in conduction bands spontaneously form pairs owing to attractive Coulomb interaction [1-3].
Kuneš and Geffroy [4] recently pointed out that, in such a system of spin-triplet excitonic condensation, the spin texture in reciprocal space and the global spin current in real space can spontaneously appear, where the 'cross hopping' of electrons (i.e., electron hopping between different orbitals on the neighboring sites) plays an essential role.
Motivated by such developments in the field, we study the anomalous features of the excitonic phase in the triangular-lattice Hubbard model with the cross hopping parameters (either even or odd) using the mean-field and variational-cluster approximation calculations. In particular, we study the fixation of the phase of the order parameter, the stability of the spin-current-density-wave state, the coexistence of the excitonic spin-density-wave state and antiferromagnetism, the k-space spin texture with f-wave symmetry, and the emergence of the global spin current in real space when the lattice is deformed.
References:
[1] Y. Ohta, T. Kaneko, and K. Sugimoto, Solid State Physics 52, 119 (2017) [in Japanese].
[2] T. Kaneko, K. Seki, and Y. Ohta, Phys. Rev. B 85, 165135 (2012).
[3] T. Kaneko, B. Zenker, H. Fehske, and Y. Ohta, Phys. Rev. B 92, 115106 (2015), and references therein.
[4] J. Kuneš and D. Geffroy, Phys. Rev. Lett. 116, 256403 (2016).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.568
Measurement of vortex line density generated by quartz tuning fork in superfluid ^{4}He
Jackson M.[1], Schmoranzer D.[1], Skrbek L.[1], Tsepelin V.[2], Woods A.[3], Bahyl J.[4]
[1]Charles University, Faculty of Mathematics and Physics, Prague, Czech Republic, [2]Lancaster University, Department of Physics, Lancaster, United Kingdom, [3]National High Magnetic Field Laboratory, Gainesville, United States, [4]Comenius University, Faculty of Mathematics, Physics and Informatics, Bratislava, Slovakia

We report on our recent investigations of vortex line densities produced by vibrating structures in superfluid ^{4}He. We measured the force-velocity response of a custom-made quartz tuning fork with a

6.5 kHz fundamental and a 40 kHz flexural resonant mode in a cylindrical experimental volume, whilst simultaneously monitoring a second-sound resonance at various temperatures in the range 1.35 K to 2.15 K, extending our preliminary study [1]. We compare and contrast the onset of non-linear damping of the tuning fork and the attenuation of the second sound signal. At all temperatures, except near the lambda point, the onset of non-linear drag is accompanied by an attenuation of the second sound resonance, indicating the production of quantized vortices as the dominant damping mechanism. We present the vortex line densities inferred from second sound attenuation and discuss their relationship to the excess damping. We hope that this study will serve as the foundation for the construction of a phase diagram for oscillatory quantum flows.
This work is supported by the Czech Science Foundation #GACR 17-03572S.

References:
[1] M.J. Jackson, O. Kolosov, D. Schmoranzer, L. Skrbek, V. Tsepelin & A. J. Woods, J. Low Temp. Phys. **183**, 208 (2016)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.569
High temperature superconductivity originating from coexisting wide- and narrow-bands: study on 1D lattices

Matsumoto K., Ogura D., Kuroki K.
Osaka University, Department of Physics, Osaka, Japan

In the single-band Hubbard model on a square lattice, a simplest model for the high-T_c cuprates, the strong antiferromagnetic spin fluctuation not only gives rise to the strong d-wave pairing interaction, but also suppresses superconductivity due to the strong quasiparticle renormalization. In order to circumvent this latter problem, systems with coexisting narrow and wide bands have been proposed [1, 2]. Namely, when the Fermi level within the wide band lies close to, but not within the narrow band, high-T_c superconductivity may occur due to the large number of interband pair scattering channels and the small renormalization of the quasiparticles.
In order to test the general validity of the above picture, here we study the one dimensional Hubbard model on two- and three-leg ladder lattices with diagonal hoppings, as well as on the diamond chain lattice [2], all of which have coexisting wide and flat bands under certain conditions. We evaluate the superconducting transition temperature within the fluctuation exchange approximation, and discuss the relationship between superconductivity and the coexisting wide- and narrow-bands.

References:
[1] K. Kuroki, T. Higashida, and R. Arita, Phys. Rev. B **72**, 212509 (2005).
[2] K. Kobayashi, M. Okumura, S. Yamada, M. Machida, and H. Aoki, Phys. Rev. B **94**, 214501 (2016).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.570
Multiple critical velocities in oscillatory flow of superfluid ^{4}He due to quartz tuning forks

Jackson M.[1], Schmoranzer D.[1], Skrbek L.[1], Tsepelin V.[2], Poole M.[2], Človečko M.[3], Woods A.[4]

[1]Charles University, Faculty of Mathematics and Physics, Prague, Czech Republic, [2]Lancaster University, Department of Physics, Lancaster, United Kingdom, [3]Slovak Academy of Sciences, Institute of Experimental Physics, Košice, Slovakia, [4]National High Magnetic Field Laboratory, Gainesville, United States

We discuss recent investigations [1] into the transition to turbulence in superfluid ^{4}He. We have studied the turbulent transition by measuring the in-line forces acting on a quartz tuning fork with a 6.5 kHz fundamental and a 40 kHz flexural resonant mode in the temperature range 10 mK to 1100 mK. Extending the range of available velocities with respect to previous studies, we have been able to observe three distinct hydrodynamic critical velocities. We discuss their significance in relation to the nucleation of quantized vortex loops and the evolution of the vortex tangle. We associate the newly observed third critical velocity with the emergence of polarized, classical-like vortex structures. We also report on non-linearities observed in the oscillators' resonant response, and discuss their physical significance and their effect on drag force measurements.
This work is supported by the Czech Science Foundation #GACR 17-03572S.
References:
[1] D. Schmoranzer, M. J. Jackson, V. Tsepelin, M. Poole, A. J. Woods, M. Clovecko, L. Skrbek, Phys. Rev. B **94**, 214503 (2016)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.571
Formation of Aharonov-Bohm states and coherent quantum dot states in InP-InAs core-shell nanowires

Göransson D.J.O.[1], Abay S.[1], Heurlin M.[1], Dalelkhan B.[1], Yu C.L.[1], Hessman D.[1], Samuelsson P.[2], Borgström M.T.[1], Xu H.Q.[1,3]
[1]Lund University, Division of Solid State Physics/NanoLund, Lund, Sweden, [2]Lund University, Division of Mathematical Physics/NanoLund, Lund, Sweden, [3]Peking University, Beijing Key Laboratory of Quantum Devices, Key Laboratory for the Physics and Chemistry of Nanodevices, and Department of Electronics, Beijing, China

InAs nanowires (NWs) are currently of interest in studies of low temperature electron transport [1] and Majorana bound states [2-3]. Here we present electron transport studies of wurtzite InP-InAs core-shell NWs. The NWs, each with an InAs shell and an InP core, were grown by metal-organic vapor phase epitaxy and the electrical contacts were fabricated on the NW side facets. Two types of the fabricated devices were measured in a dilution refrigerator. In a device with highly transparent contacts, conductance oscillations with increasing magnetic field applied along the NW axis were observed. These oscillations are well described by model simulation and can be attributed to the Aharonov-Bohm effect. In a device with weak tunnel coupling contacts, Coulomb current oscillations and Coulomb diamond structures were observed. These results show that a single quantum dot is formed in the entire InAs shell of the NW. In addition, the conductance lines corresponding to excited states were observed, showing that coherent states are formed in the InAs shell and the system could be used to construct hybrid superconducting devices in which Majorana bound states can be formed.
References:
[1] F. Haas, P. Zellekens, M. Lepsa, T. Rieger, D. Grützmacher, H. Lüth, T. Schäpers, Nano Lett. **17**, 128 (2017)
[2] A. Das, Y. Ronen, Y. Most, Y. Oreg, M. Heiblum, H. Shtrikman, Nat. Phys. **8**, 887 (2012)
[3] S. M. Albrecht, A. P. Higginbotham, M. Madsen, F. Kuemmeth, T. S. Jespersen, J. Nygård, P. Krogstrup, C. M. Marcus, Nature **531**, 206 (2016)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.572
Superconducting TiN NIS tunnel junctions
Torgovkin A.[1], Chaudhuri S.[1], Sajavaara T.[1], Lahtinen M.[2], Maasilta I.[1]
[1]University of Jyväskylä, Department of Physics, Jyväskylä, Finland, [2]University of Jyväskylä, Department of Chemistry, Jyväskylä, Finland

Recently, titanium nitride (TiN_x) has attracted attention as a high quality superconductor for various applications. We present here characterizations of TiN_x films deposited using atomic layer deposition (ALD) [1] and pulsed laser deposition (PLD) techniques on a variety of substrates. We discuss results on lattice structure, elemental composition, resistivity and charge density in addition to the superconducting properties. In the best cases, Tcs close to 4 K were obtained for PLD films. We also successfully fabricated NIS tunnel junction devices from these films and measured their characteristics down to temperatures below 0.1 K.
The observed tunnel junction conductance characteristics show a fairly low zero-bias current, indicating a reasonably small DOS broadening due to quasiparticle lilfetime effects. This is significant to minimize losses and non-idealities in detectors, qubits and tunnel junction refrigerators. In addition, many interesting details can be seen, typically not found in junctions made from other superconducting materials such as Nb [2,3], NbN [4] or TaN [5]. These include number of extra quasiparticle peaks and non-linearities above Tc. We discuss possible interpretations for these observations.

References:
[1] A. Torgovkin, S. Chaudhuri, J. Malm, T. Sajavaara, and I. J. Maasilta, IEEE Trans. Appl. Supercond. 25, 1101604 (2015)
[2] J. K. Julin and I. J. Maasilta, Supercond. Sci. Technol. 29, 105003 (2016)
[3] M. R. Nevala, S. Chaudhuri, J. Halkosaari, J. T. Karvonen, and I. J. Maasilta, Appl. Phys. Lett. 101, 112601 (2012)
[4] S. Chaudhuri, M. R. Nevala, and I. J. Maasilta, Appl. Phys. Lett. 102, 132601 (2013)
[5] S. Chaudhuri and I. J. Maasilta, Appl. Phys. Lett. 104, 122601 (2014)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.573
Magnetic properties of Heusler compound $Fe_{1.3}Mn_{1.7}Si$
Hiroi M.[1], Nonoyama T.[1], Adachi G.[1], Shigeta I.[1], Manaka H.[2], Terada N.[2]
[1]Kagoshima University, Department of Physics and Astronomy, Kagoshima, Japan, [2]Kagoshima University, Department of Electrical and Electronics Engineering, Kagoshima, Japan

The magnetic properties of Heusler compounds $Fe_{1.3}Mn_{1.7}Si$ and, for comparison, $Fe_{1.4}Mn_{1.6}Si$ are investigated. Fe_2MnSi exhibits a ferromagnetic transition at $T_C \sim 230$ K and another transition to a phase with antiferromagnetic components at $T_A \sim 60$ K. For $Fe_{3-x}Mn_xSi$, with increasing x, T_C decreases but T_A keeps almost constant, and they meet around $x \sim 1.7$ [1].

The careful measurements of magnetization at various magnetic fields reveal that in $Fe_{1.3}Mn_{1.7}Si$ T_C and T_A are 95 K and 67 K, respectively, and, furthermore, another transition occurs, at 77 K when the magnetic field is 0.01T. This transition is characterized by a rapid decrease in magnetization with decreasing temperature and strong magnetic field dependence, in contrast to the transition with respect to T_A that does not depend much on magnetic field; the critical field is found to be $\sim$2.5 T. Although the existence of this transition was suggested in earlier studies [1-3], the complex magnetic phase diagram in this materials was not clarified. Whereas, in $Fe_{1.4}Mn_{1.6}Si$ we do not recognize another transition that was found for x = 1.7, although we find the transition at T_A.

References:
[1] S. Yoon and J. Booth, J. Phys. F: Metal. Phys. **7**,1079 (1977).
[2] H. Al-Kanani, J. Booth, and S. Yoon, J.Appl. Phys. **73**, 5671 (1993).
[3] H. Al-Kanani et al., J.Appl. Phys. **76**, 6359 (1994).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.574
Development of a novel calorimetry setup based on metallic paramagnetic temperature sensors

Reifenberger A., Kempf S., Fleischmann A., Klingeler R., Enss C.
Kirchhoff-Institute for Physics, Heidelberg University, Heidelberg, Germany

For the measurement of the specific heat of superconducting mg-sized metallic glass samples in the temperature range down to 10 mK we have developed a new micro-fabricated platform based on a metallic paramagnetic temperature sensor. Our novel setup is based on the well-known relaxation method, where the thermal relaxation following a heat pulse is monitored to extract the specific heat. The temperature of the platform is measured by a paramagnetic Ag:Er sensor, which is sputtered on one wing of a micro-structured gradiometric Nb meander type coil. It forms a superconducting flux transformer together with the input coil of a dc-SQUID (Superconducting Quantum Interference Device). In this way, a relative temperature precision of 0.5 μK can be reached. Heating is provided by a AuPd thin film resistor that is also deposited by sputtering on the sapphire substrate of the platform. A gold-coated mounting area (4.4 mm× 3 mm) is included to improve the thermal contact between sample and platform. It allows for attaching metallic samples via diffusion welding. We will discuss design and performance of this new platform.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.575
Efficiency of cooling by adiabatic melting of solid ^4He to superfluid ^3He

Riekki T.S.[1], Sebedash A.P.[1,2], Tuoriniemi J.T.[1]
[1]Aalto University, Department of Applied Physics - Low temperature laboratory, Espoo, Finland, [2]P.L. Kapitza Institute for Physical Problems RAS, Moscow, Russian Federation

Adiabatic melting of solid ^{4}He to superfluid ^{3}He is a novel method aiming to cool ^{3}He-^{4}He mixtures to below 0.1 mK. The cooling power of this method applies directly to the liquid so thermal boundary resistance will not limit the cooling process. The phase separation at low temperature is achieved by solidifying the ^{4}He component by increasing the pressure in the experimental cell, precooled by nuclear demagnetization, while mixing is initiated by melting the ^{4}He crystal. Both are achieved by moving superfluid ^{4}He to and from the cell via a superleak line in which ^{4}He would solidify at higher pressure than in the bulk. The superleak is operated either by pressurizing it directly from room temperature, or by a low temperature bellows system in order to decrease heat leak to the cell [1]. The process is monitored by two quarz tuning fork oscillators, one in the pure ^{3}He phase, and the other in the dilute phase. As long as ^{3}He is normal Fermi liquid, the cooling factor (ratio of initial and final temperature) in adiabatic mixing stays constant, but when ^{3}He is precooled to below the superfluid transition temperature T_c, it increases rapidly as the entropy of ^{3}He starts to decrease exponentially. The cooling factor can be used to evaluate the adiabaticity of the process.

References:

[1] A. Sebedash, S. Boldarev, T. Riekki, J. Tuoriniemi, J. Low Temp. Phys. (2017) doi:10.1007/s10909-017-1755-5

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.576

Band structure calculations and transport properties of CrAs

<u>Cuono G.</u>[1], Autieri C.[2], Forte F.[1,3], Noce C.[1,3]

[1]Università degli Studi di Salerno, Dipartimento di Fisica 'E. R. Caianiello', Fisciano, Italy, [2]CNR-SPIN UO L'Aquila, L'Aquila, Italy, [3]CNR-SPIN UO Salerno, Fisciano, Italy

We present the electronic structure and the transport/magnetic properties of the newly discovered pressure-induced superconductor CrAs.[1] We apply an approach that combines the tight-binding approximation and the Löwdin down-folding technique in order to set up an effective Hamiltonian projected on the Cr electronic degrees of freedom and to obtain analytical expressions for the low energy bands, which are ready to be used to evaluate relevant physical quantities. In particular, we have been able to calculate the electronic band structure, the corresponding density of states and the Fermi surface of CrAs, together with transport and magnetic properties of this compound. Our results are consistent with local-density approximation calculations and show good agreement with available experimental data for resistivity and Cr magnetic moment. [2]

References:

[1] W. Wu, J. Cheng, K. Matsubayashi, P. Kong, F. Lin, C. Jin, N. Wang, Y. Uwatoko, and J. Luo, Nature Commun. **5**, 5508 (2014).

[2] C. Autieri, G. Cuono, F. Forte and C. Noce (in press), Low energy bands and transport properties of chromium arsenide, *Journal of Physics: Condensed Matter*.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.578

Discontinous transition and tricritical wings in $UCo_{1-x}Ru_xAl$

Opletal P.[1], *Prokleška J.*[1], *Valenta J.*[1], *Proschek P.*[1], *Tkáč V.*[1], *Tarasenko R.*[1], *Matoušková Š.*[2], *Abd-Elmeguid M.M.*[1,3], *Sechovský V.*[1]
[1]Faculty of Mathematics and Physics, Charles University, Department od Condensed Matter Physics, Prague, Czech Republic, [2]Institute of Geology, Czech Academy of Science v.v.i., Prague, Czech Republic, [3]II. Physikalisches Institut, Universität zu Köln, Köln, Germany

Suppression of thermodynamic phase transitions leads to quantum critical behavior as described in detail in antiferromagnets. In recent years this behavior is under investigation (theoretical and experimental) for weak metallic ferromagnets. Four classes of phase diagrams (PD) were described [1]. We investigate the experimental observation of discontinuous transition near tricritical point (TCP). Only few compounds were found to exhibit (presumed to have) PD with discontinuous transition (e.g. $ZrZn_2$ [2], URhAl [3], UCoGa [4]). One of the candidates is UCoAl. UCoAl is 5f itinerant paramagnet with first order metamagnetic transition (MT) at low temperatures [5]. By applying hydrostatic pressure MT is suppressed and completely disappears at 2.9 GPa and 13.0 T. Resulting PD agrees with proposed PD. Ferromagnetism, and subsequently TCP can be induced by doping.
We have prepared two single crystals of UCoAl doped by Ru: $UCo_{0.990}Ru_{0.010}Al$ and $UCo_{0.995}Ru_{0.005}Al$. Both single crystals show ferromagnetic ground state, $UCo_{0.995}Ru_{0.005}Al$ being presumably close to TCP. We present results of magnetic, electric transport and thermal expansion measurements obtained in ambient and hydrostatic pressures. We show discontinuous transition PD based on varying doping and hydrostatic pressure (T-B-x-p).

References:

[1] M. Brando, et al., Reviews of Modern Physics, **88**(2), 025006 (2016).
[2] M. Uhlarz, et. al., Physical Review Letters, **93**(25), 256404 (2004).
[3] Y. Shimizu, et al., Physical Review B, **91**(12) 125115 (2015).
[4] M. Míšek, et al., AIP Advances, **7**(5) 055712 (2017).
[5] V. Sechovsky, et al., Physica B+C, **142**(3) 283 (1986).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.579

Preparation of experiment for direct observation of Majorana cone at surface of superfluid helium three B phase

Murakawa S.[1,2], *Yoshida K.*[2]
[1]University of Tokyo, Cryogenic Research Center, Tokyo, Japan, [2]University of Tokyo, Department of Physics, Tokyo, Japan

Recently, one of most interesting topic in low temperature physics is “topological materials”. Superfluid ^{3}He is one of them and it is known that Superfluid ^{3}He B phase is 3D topological superfluid. At its surface, there appears a gapless cone-like surface state in the bulk gap of a surface density of states (SDOS). We call such dispersion of surface state Majorana cone. Recent transverse acoustic impedance measurements of superfluid ^{3}He B-phase revealed the SDOS [1-5].
However, because all incidents were summed up in those measurements, they only suggested a shape of the total SDOS that is calculated by integration of all momentum. In this work, we plan to detect Majorana cone directly by quantum Andreev reflection which should depend on the energy of SDOS at an angle of incident.
In previous experiment, the quantum Andreev reflection was detected quantitatively at only one angle [6]. We will expand that experiment to various angle. To study the reflection, the quasiparticle beam emitted from black body radiator is driven into the surface. In our radiator, we prepare two semisphere,

one has many holes and another has a slit. And the hole is chosen by moving the slit at low temperature. Now we are testing a stepping motor and tuning forks which is used for thermometer and heater.

References:

[1] Y. Aoki *et al*., Phys. Rev. Lett. **95**, 075301 (2005).
[2] M. Saitoh *et al*., Phys. Rev. B **74**, 220505(R) (2006).
[3] Y. Wada *et al*., Phys. Rev. B **78**, 214516 (2008).
[4] S. Murakawa *et al*., Phys. Rev. Lett. **103**, 155301 (2009).
[5] S. Murakawa *et al*., J. Phys. Soc. Jpn. **80**, 013602 (2011).
[6] T. Okuda *et al*., Phys. Rev. Lett. **80**, 2857 (1998).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.581

Improved critical current and pinning potential in YBa2Cu3Ox superconducting films with nanoengineered pinning centres

Crisan A., Ivan I., Miu L.
National Institute of Materials Physics Bucharest-Magurele, Magurele, Romania

We have grown by PLD YBCO films with naoengineered pinning centres using various approaches: substrate decoration [1], quasi-multilayers [2], targets with secondary phase nanoinclusions [3], and combinations of the above mentioned, involving various architectures and nanoinclusions (Ag, BZO, PrBCO, $LaNiO_3$, etc.).
From DC magnetization loops and AC multiharmonic susceptibility measurements we have studied the critical current densities and pinning potentials, and correlated the results with TEM images. We have found that both J_c and U_p depend strongly on the types of material(s) used for the nanoengineered pinning centres and on the architectures used in the nanostructures.

Acknowledgement: Financial support from Romanian Ministry of Research and Innovation through POC (European Regional Development Fund) Project P-37_697 nr. 28/01.09.2016 is gratefully acknowledged.

References:

[1] A. Crisan, S. Fujiwara, J.C. Nie, A. Sundaresan, H. Ihara, Appl. Phys. Lett. 79, 4547 (2001)
[2] T. Haugan, P.N. Barnes, R. Wheeler, F. Meisenkothen, M. Sumption, Nature 430, 867 (2004)
[3] J.L. MacManus-Driscoll, S.R. Foltyn, Q.X. Jia, H. Wang, A. Serquis, L. Civale, B. Maiorov, M.E. Hawley, M.P. Maley, D.E. Peterson, Nat. Mater. 3, 439 (2004)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.582

Flexural and torsional vibrations of the same quartz tuning fork in superfluid helium

Efimov V., Guthrie A., Jennings A., Haley R., Kafanov S., Kolosov O., Mucientes M., Tsepelin V.
Lancaster University, Lancaster, United Kingdom

Quartz tuning forks have become the main mechanical tool for probing quantum fluids ^{3}He and ^{4}He. The hydrodynamics of flexural oscillations in superfluid helium are well known. However up to now torsional oscillations have not been investigated. Here we present a series of experimental works focused on the investigation of torsional oscillations of quartz tuning forks in superfluid ^{4}He. We have demonstrated that the critical velocity for vortex nucleation in superfluid ^{4}He is almost two orders of magnitude smaller than that for flexural oscillations. This allows us to realise an experiment where we create and detect quantum turbulence in superfluid helium using the same tuning fork.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.583

Capacitance spectroscopy of large quantum dot arrays for simulating Fermi-Hubbard physics

Mukhopadhyay U.[1], *Hensgens T.*[1], *Barthelemy P.*[1], *Fallahi S.*[2], *Gardner G.C.*[2], *Reichl C.*[3], *Wegscheider W.*[3], *Manfra M.J.*[2], *Vandersypen L.M.K.*[1]
[1]Delft University of Technology, QuTech & Kavli Institute of Nanoscience, Delft, Netherlands, [2]Purdue University, Purdue, United States, [3]ETH Zürich, Zurich, Switzerland

In the last few years, quantum simulation experiments have started to probe problems in many-body physics that are not accessible to classical platforms, due to the exponential growth in complexity for highly-entangled systems. Here we report our progress on simulating fermionic Mott-Hubbard physics using two-dimensional arrays of quantum dots, which readily adhere to the same Hamiltonian. Such arrays would allow for emulations of the Mott insulator transition as well as band and Hofstadter physics. By providing a voltage difference between two nanofabricated top gate layers on the sample surface, a periodic potential difference is created in the 2D electron gas (2DEG) underneath. Adding a doped back gate region and using capacitance spectroscopy, the global density of states in the 2DEG is measured as a function of Fermi energy. Although disorder levels are found to be sufficient for witnessing this transition, setting a sufficiently strong periodic potential proves difficult. A variety of different wafers and sample designs are tested to both lower disorder further and increase the periodic potential strength, which is needed to hit the ideal parameter regime.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

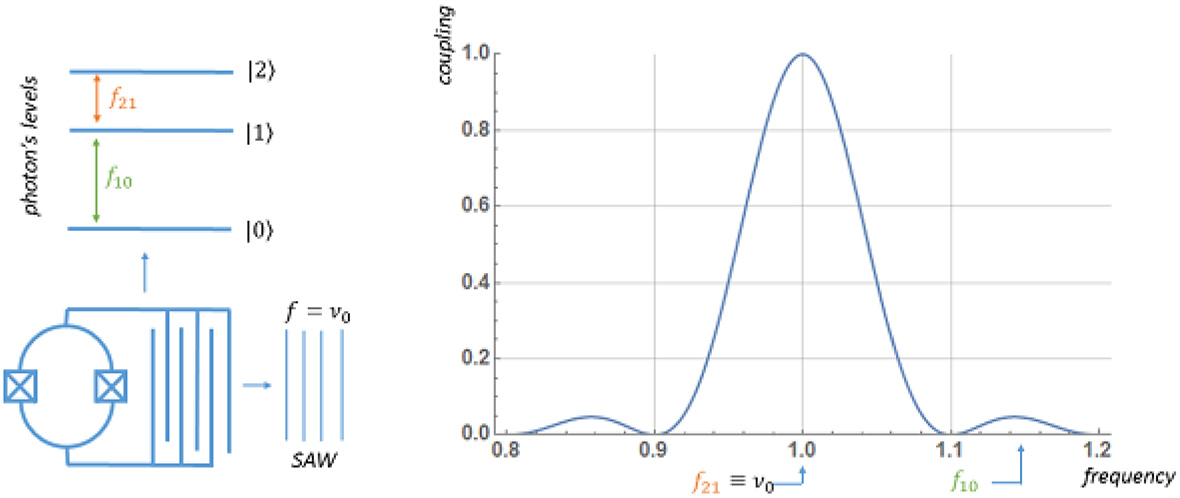
P.584

Population inversion and stimulated emission of phonons in a transmon qubit coupled to phonons

Scigliuzzo M., *Suri B.*, *Andersson G.*, *Aref T.*, *Ekström M.*, *Bruhat L.*, *Delsing P.*
Chalmers University of Technology, Microtechnology and Nanoscience, MC2, Göteborg, Sweden

The interaction between qubits and mechanical waves on a piezoelectric substrate has been demonstrated for different geometries and material [1,2]. In particular for superconducting qubits, the

coupling between qubit and phonons strongly depends on frequency since it is provided by an interdigital transducer (IDT). The coupling between surface acoustic waves (SAWs) and the resonant excitation in the qubit is shown in Fig.1.



[Figure1]

Figure 1: Left: highlight of three different frequencies for a transmon qubit fabricated on a piezoelectric substrate: the IDT resonance frequency and the transition frequencies and respectively between the two levels 1 and 0, and 2 and 1. Right: coupling between the resonants photons in the qubit and the phonons on the substrate.

Choosing the transmon transition in resonance with the IDT frequency (by sweeping the magnetic flux), and designing the transmon anharmonicity such that is located at the maximum of the first side lobe, the transition rate between level 2 and 1 is much higher than between levels 1 and 0. Driving the 0-2 transition then results in population inversion. Sending additional phonons to the qubit, it should be possible to stimulate the emission of the phonon, increasing the decay rate from level 1.

References:

[1] M.V. Gustafsson et al., Science 346, 207 (2014)
[2] Y. Chu et al., arXiv:1703.00342 (2017)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.585

In-gap features in superconducting $LaAlO_3$-$SrTiO_3$ interfaces observed by tunneling spectroscopy

Kuerten L.[1], *Richter C.*[2], *Mohanta N.*[2], *Kopp T.*[2], *Kampf A.*[2], *Mannhart J.*[1], *Boschker H.*[1]
[1]Max-Planck-Institute for Solid State Research, Stuttgart, Germany, [2]Institute of Physics, University of Augsburg, Center for Electronic Correlations and Magnetism, Theoretical Physics III and Experimental Physics VI, Augsburg, Germany

The $LaAlO_3$-$SrTiO_3$ interface electron system is a model 2-dimensional superconductor with a dome-shaped phase diagram which can be tuned by the application of a back-gate voltage. In tunneling spectra of this electron system, we identified quasiparticle states at well-defined energies inside the superconducting gap. The states consist of a peak at zero energy and other peaks at finite energies, symmetrically placed around zero energy. These peaks disappear, together with the superconducting gap, with increasing temperature and magnetic field. We discuss the likelihood of various physical mechanisms that are known to cause in-gap states in superconductors and conclude that none of these mechanisms can easily explain the results. The conceivable scenarios are the formation of Majorana bound states, Andreev bound states, or the presence of an odd-frequency spin triplet component in the superconducting order parameter.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.586

Is magnetism relevant to cuprate superconductivity: lanthanides versus charge compensated 123?

Keren A.
Technion-Israel Institute of Technology, Physics, Haifa, Israel

Many theories suggest that the mechanism for cuprate superconductivity is based on super-exchange interaction between electrons. The most obvious test of these theories is a measurement of the correlation between T_c and the super-exchange parameter J. Alteration of J is achieved by chemical modifications or external pressure. Measurements of J are done with: Neutron scattering, muon spin rotation, two magnon Raman scattering or resonant inelastic x-ray scattering. However, the experimental data is confusing. A recent Raman study showed an anticorrelation between T_c and J in the set of $LnBa_2Cu_3Oy$ compounds with Ln=(La,..Lu,Y) [1]. On the other hand, experimental measurements on the charge compensated 123 material $(Ca_xLa_{1-x})(Ba_{1.75-x}La_{0.25+x})Cu_3O_y$ (CLBLCO) inferred an overall positive correlation between T_c and J. Thus, the effect of J on T_c is not established experimentally. I will review the experimental situation, and shed light on this controversy.

References:

[1] B.P.P. Mallet *et al.*, Phys. Rev. Lett. 111, 237001 (2013)
[2] D.S. Ellis et al., Phys. Rev. B 92, 104507 (2015)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.587

Fluxoids arrangements in 1D superconducting networks

Sharon O.J., Haham N., Shaulov A., Yeshurun Y.
Bar-Ilan University, Department of Physics, Institute of Superconductivity and Institute of Nano Technology and Advanced Materials, Ramat Gan, Israel

Analysis of superconducting 1D networks (´ladders´), based on the ´J^2 model´, yields an Ising like expression for the total energy of the network as a function of the loops' vorticities and the external magnetic field. This expression includes interaction terms between fluxoids and between them and the external magnetic field. Competition between these two terms elucidates the mechanism governing the fluxoid arrangement in the network as a function of the field. In particular, it explains why the first fluxoid always appears in the loop at the network's center, or next to it, in ladders with an odd or even

number of loops, respectively. The repulsive interaction between fluxoids depends on the ratio l between the loops length and the common width of adjacent loops. A 'short range' and a 'long range' interactions obtained for $l \gtrsim 1$ and $l \ll 1$, respectively, give rise to remarkably different fluxoid configurations. The different configurations of fluxoids in different types of ladders are illustrated.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.588
Extreme sample environments at the ISIS spallation neutron source
Lawson C.
Rutherford Appleton Laboratory, Didcot, United Kingdom

The ISIS pulsed neutron and muon source at the Rutherford Appleton Laboratory completes approximately 800 experiments per year, with more than 2/3rd of these requiring a low temperature or high pressure sample environment.
The popularity of neutron scattering experiments in combination with very low temperatures is rapidly growing, due to high profile investigations into effects such as quantum criticality, low temperature magnetism and quantum fluids and solids.
Here I am going to describe briefly the neutron scattering method, and explain the increased demand for ultra-low temperatures within the neutron scattering community. I am also going to present some examples of the extreme sample environments used in ISIS neutron scattering experiments including: high magnetic fields, high pressures and ultra-low temperatures.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.589
Composition and annealing effects on superconductivity in sintered and arc-melted $Fe_{1+\varepsilon}Te_{0.5}Se_{0.5}$
Foreman M.M., Ponti G., Mozaffari S., Markert J.T.
University of Texas at Austin, Department of Physics, Austin, United States

We present the results of x-ray diffraction, electrical resistivity, and ac magnetic susceptibility measurements on various specimens of the "11"-structure, mixed-chalcogenide superconductor $Fe_{1+\varepsilon}Te_{0.5}Se_{0.5}$ ($0 \le \varepsilon \le 0.15$). Samples were initially either sintered in sealed quartz tubes or melted in a zirconium-gettered arc furnace. Sintered samples were fired two to three times at temperatures of 425°C, 600°C, or 675°C, while arc-melted samples were studied both as-melted and after annealing at 600°C and 675°C. X-ray diffraction data for all samples show a predominant PbO-type tetragonal phase as reported [1] previously for $\varepsilon = 0.10$, with a secondary hexagonal NiAs-type phase gradually disappearing with increasing ε over the range $0 \le \varepsilon \le 0.10$; also, higher annealing temperatures promoted tetragonal phase-purity, with optimal superconducting behavior for the composition $Fe_{1.05}Te_{0.5}Se_{0.5}$. Magnetic data show similar trends in superconducting volume fraction, with broad

transitions. Resistive transition onsets above 14 K were observed, with midpoint temperatures as high as $T_{50\%}$ = 13.6 K and 10%-90% transition widths as narrow as ΔT_c = 1.4 K.

References:
[1] J. Liu, C. Li, S, Zhang, J. Feng, and P. Zhang, Physica C **527**, 68 (2016).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.591
Quantum dot attached to superconducting leads: the relation between symmetric and asymmetric coupling

Kadlecová A., Žonda M., Novotný T.
Charles University, Faculty of Mathematics and Physics, Department of Condensed Matter Physics, Prague, Czech Republic

We study the Anderson single-level quantum dot attached to two BCS superconducting leads with the same gap size. We reveal that a system with asymmetric tunnel coupling to the leads ($\Gamma_L \neq \Gamma_R$) can be related to the symmetric system with the same net coupling strength $\Gamma = \Gamma_L + \Gamma_R$. Surprisingly, it is the symmetric case which is the most general, meaning that all physical quantities in case of asymmetric coupling are fully determined by the symmetric ones. We give ready-to-use conversion formulas for the phase transition boundary, on-dot quantities, and the Josephson current, and illustrate them on the NRG results of reference [1]. We apply our theory to the recent 0-π transition measurement [2] and determine the asymmetry of the experimental setup from the measured transition widths. We point out that the widely assumed “universal dependence” of physical quantities on the ratio of the Kondo temperature and the superconducting gap T_K / Δ cannot hold for asymmetric junctions.

References:
[1] A. Oguri, Y. Tanaka, and J. Bauer, Phys. Rev. B **87**, 075432 (2013)
[2] R. Delagrange *et al.*, Phys. Rev. B **93**, 196437 (2016)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.592
The orbitropic effect in superfluid helium-3

Arrayás M.[1], *Haley R.P.*[2], *Zmeev D.*[2]
[1]Universidad Rey Juan Carlos, Área de Electromagnetismo, Mostoles, Spain, [2]Lancaster University, Physics Department, Lancaster, United Kingdom

We are studying the influence of orbital viscosity on the dynamics of the order parameter texture in the superfluid B phase of helium-3 near a moving boundary. We have found that the redistribution of thermal quasiparticles within the texture has both a dissipative component which can be related to orbital viscosity, and a reactive one which can be characterized as an effective mass. We use this new mechanism to resolve unexpectedly large measurements of the friction on a moving A-B interface whose motion was controlled using magnetic field. Further, we make predictions for other experimental configurations where this "orbitropic effect" should also be observed owing to texture rearrangement as the B-phase boundary moves.

References:
[1] Orbital damping of the oscillating superfluid He A-B interface at low temperatures. M. Arrayás, S. N. Fisher et al. JLTP 151, 5-6, 706 (2014).
[2] In preparation for PRL.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.593

Quantum vortex induced thermoluminescence of nitrogen nanoclusters immersed in superfluid ^{4}He

Khmelenko V.V.[1], *Meraki A.*[1], *McColgan P.T.*[1], *Rentzepis P.M.*[2], *Li R.Z.*[2], *Lee D.M.*[1]
[1]Texas A&M University, Department of Physics and Astronomy, College Station, United States, [2]Texas A&M University, Department of Electrical and Computer Engineering, College Station, United States

We studied thermoluminescence of nitrogen and nitrogen-inert gas nanoclusters containing stabilized nitrogen atoms which were immersed in superfluid helium-4. Thermoluminescence was observed during warming from 1.2 to 2.16 K with a maximum at T=1.9K. The intensity of thermoluminescence was proportional to the concentration of nitrogen atoms stabilized on the surfaces of the nanoclusters. We measured the gradient of temperature in the vertical direction in the cryostat and obtained the temperature dependence of the vortex density in bulk superfluid helium for the conditions of our experiments. We found that the vortex density also has a maximum at T=1.9K. These facts lead us to the conclusion that we have observed quantum vortex induced chemical reactions on the surfaces of nanoclusters, leading to thermoluminescence of nanoclusters immersed in superfluid helium.[1]

References:
[1] A. Meraki, P.T. McColgan, P.M. Rentzepis, R.Z. Li, D. M. Lee, and V. V. Khmelenko, Phys. Rev. B 95, 104502 (2017).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.594

Not just a quantum box: tuning the shape of an electron in a nanotube with a magnetic field

Marganska M.[1], *Schmid D.R.*[2], *Stiller P.L.*[2], *Dirnaichner A.*[1,2], *Strunk C.*[2], *Grifoni M.*[1], *Hüttel A.K.*[2]
[1]University of Regensburg, Institute for Theoretical Physics, Regensburg, Germany, [2]University of Regensburg, Institute for Experimental and Applied Physics, Regensburg, Germany

Transport measurements on single wall carbon nanotubes allow fascinating insights into the interplay of molecular structure and electronic wave functions. Here, we analyze the magnetic field behaviour of quantum states in the limit of a single electron strongly confined to a quantum dot. An axial magnetic field (in the experiment up to 17T) exposes a very distinct behaviour of the two valleys. K´ valley states experience an increase of the tunnel coupling at low field, followed by subsequent decoupling. In contrast, K valley states decouple from the leads monotonically.
This phenomenon stems from the unique combination of cylindrical topology and honeycomb atomic lattice. Longitudinal and transversal momentum are coupled, allowing manipulation of the longitudinal electronic wave function via the Aharonov-Bohm phase. At zero field, the nanotube acts similar to a

"λ/4 resonator", where a wave function amplitude is finite near one of the contacts. A large magnetic field restores quantum box behaviour comparable to a "λ/2 resonator", where the amplitude vanishes on both sides. This is directly reflected in the tunnel rates.
In addition, the magnetic field induces a Franck-Condon vibrational coupling; different electronic states show different behaviour of the vibrational side bands.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.595
Observation of high-field vortex lattice structural transition in $HgBa_2CuO_{4+\delta}$ with nuclear magnetic resonance
Lee J.A.[1], Stolt I.[1], Xin Y.[1], Halperin W.P.[1], Reyes A.P.[2], Chan M.K.[3]
[1]Northwestern University, Physics and Astronomy, Evanston, United States, [2]National High Magnetic Field Laboratory, Tallahassee, United States, [3]Los Alamos National Laboratory, Los Alamos, United States

Vortex dynamics in the tetragonal, single-layer, cuprate superconductor $HgBa_2CuO_{4+\delta}$ (Hg1201) transition from a high temperature "liquid" phase, characterized by high vortex mobility, to a low temperature "solid" phase, characterized by low vortex mobility and the formation of a vortex lattice (VL), at a temperature T_v. The local magnetic field distribution, produced by vortex supercurrents, depends on the superconducting penetration depth, coherence length, and the symmetry of the VL. We determined this distribution from ^{17}O nuclear magnetic resonance (NMR) spectral lineshape measurements, for magnetic fields from 6.4 to 30 T, at the apical oxygen site where the hyperfine field is negligible. We find a structural evolution of the VL near 15 T from orthorhombic to triangular symmetry with increasing field by fitting the NMR lineshape to the field distribution of an idealized VL given by Ginzburg-Landau theory.[1] The T_v was determined for several single crystal samples, underdoped and overdoped, from NMR transverse relaxation.
References:
[1] Jeongseop A. Lee, Yizhou Xin, I. Stolt, W. P. Halperin, A. P. Reyes, P. L. Kuhns, and M. K. Chan, Phys. Rev. B **95**, 024512 (2017).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.596
Superconductivity, magnetism, anisotropy and memory: the remarkable properties of the (111) $LaAlO_3/SrTiO_3$ interface
Davis S.[1], Huang Z.[2], Han K.[2], Ariando A.[2], Venkatesan T.[2], Chandrasekhar V.[1]
[1]Northwestern University, Physics, Evanston, United States, [2]National University of Singapore, Singapore, Singapore

The 2D conducting gas that forms at the interface between the two insulators $LaAlO_3$ (LAO) and $SrTiO_3$ (STO) has garnered a lot of attention due to wide variety of physical phenomena that it

exhibits, including strong spin-orbit coupling, superconductivity, magnetism, and localization effects, among others. Most of the experimental and theoretical work so far has been on LAO/STO interfaces grown in the (001) crystal orientation, in which the system has rectangular symmetry at the interface. More recently, interest has focused on LAO/STO interface grown in the (111) crystal orientation, in which the interface has hexagonal symmetry, raising the possibility of topological effects. As with the (001) interface structures, we find that the system exhibits both superconductivity and magnetism coexisting at the same interface. Unlike the (001) interface, the (111) interface is highly anisotropic, showing varying characteristics along different crystal directions in all its properties, including longitudinal resistivity, Hall effect, quantum capacitance, superconductivity and magnetism. In addition, we observe an unusual memory effect near the superconducting transition: the system remembers the gate voltage at which it is cooled through the superconducting transition.

References:

[1]. S. Davis et al., arXiv:1704.01203 [cond-mat.str-el] (2017).
[2]. S. Davis et al., Phys. Rev. B, 95 (3), pp. 035127, 2017.
[3]. S. Davis et al., Advanced Materials Interfaces, pp. 1600830, 2016, ISSN: 21967350 (2016).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.597

The persistence of Hubbard model in $La_{2-x}Sr_xCuO_4$

Chen Y.-J.[1,2], *Hu C.C.*[3], *Wu K.H.*[4], *Luo C.W.*[4], *Juang J.Y.*[4], *Lee J.M.*[5], *Chen J.M.*[5], *Lin J.-Y.*[3], *Cheng C.-L.*[1], *Wu M.K.*[2]
[1]National Dong Hwa University, Department of Physics, Hualien, Taiwan, Republic of China, [2]Institute of Physics, Academia Sinica, Nankang, Taipei, Taiwan, Republic of China, [3]National Chiao Tung University, Institute of Physics, Hsinchu, Taiwan, Republic of China, [4]National Chiao Tung University, Department of Electrophysics, Hsinchu, Taiwan, Republic of China, [5]National Synchrotron Radiation Research Center, Hsinchu, Taiwan, Republic of China

According to the recent controversial issue of the Hubbard model used in high-T_c cuprate systems, we have systemically measured the $La_{2-x}Sr_xCuO_4$ (LSCO) thin films with a wide doping range of $0 \le x \le 0.4$ using linear-polarized X-ray absorption spectroscopy (XAS). A rapid increase of the spectral-weight ratio of *E* // *ab* to *E* // *c* O *K*-edge XAS observed near optimal doping, the effect of the distribution of the apical and planar holes was considered in our analysis. From the obtained value of the planar holes concentration in LSCO using two proposed empirical formulas, our experimental XAS results show that the two-dimensional theoretical Hubbard model is still applicable used in high-T_c cuprates within the measured doping regime and without any signs of collapse until p_{pl} ~0.3.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

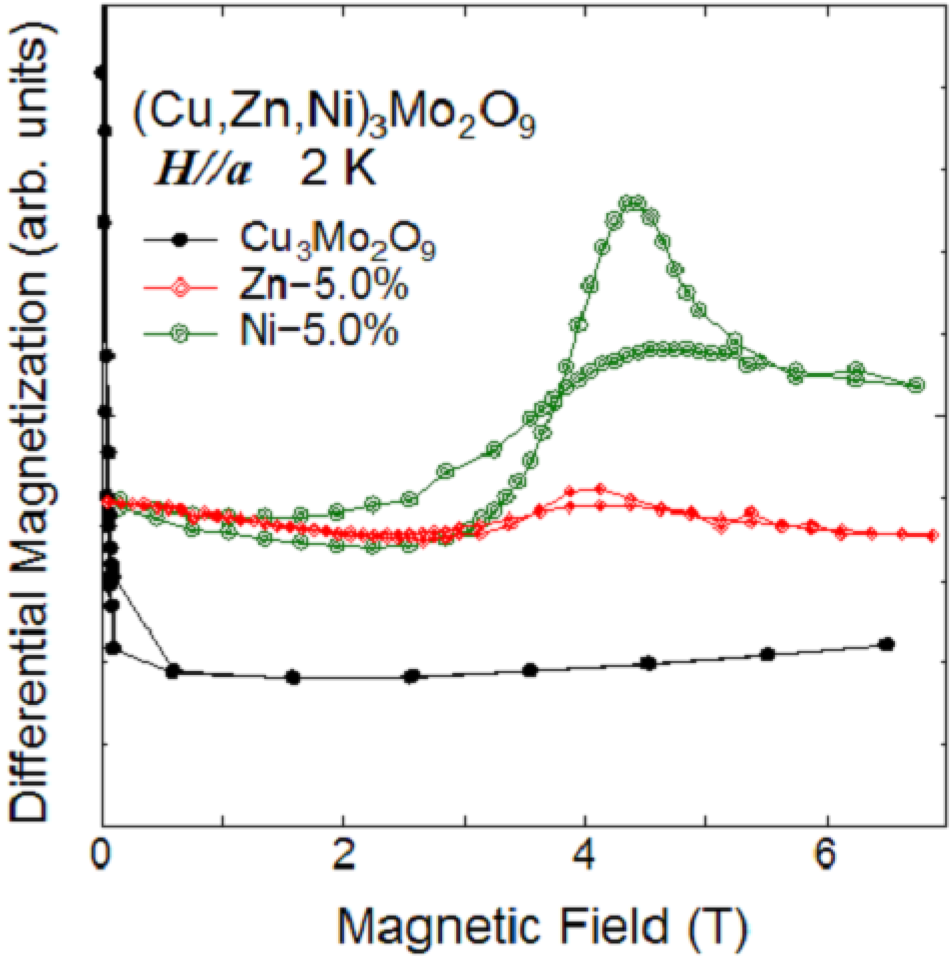
P.598

Magnetic and nonmagnetic impurity substitution effects on $Cu_3Mo_2O_9$

Ebukuro Y.[1], *Noda M.*[1], *Kuwahara H.*[1], *Kuroe H.*[1], *Hase M.*[2], *Oka K.*[3], *Ito T.*[3], *Eisaki H.*[3]

[1]Sophia University, Tokyo, Japan, [2]National Institute for Materials Science (NIMS), Ibaraki, Japan, [3]National Institute of Advanced Industrial Science and Technology (AIST), Ibaraki, Japan

We discuss the magnetic and nonmagnetic impurity substitution effects on $Cu_3Mo_2O_9$ which has a distorted tetrahedral quasi-one-dimensional spin structure made from the S = 1/2 Cu^{2+} ions. We have found that $Cu_3Mo_2O_9$ is a multiferroic material, where the weak ferromagnetic component of the spin moments and the ferroelectricity coexist below T_N = 7.9 K [1,2]. In $(Cu,Zn)_3Mo_2O_9$, we have found a decrease of T_N [3] and impurity-induced phases [4]. In $(Cu,Ni)_3Mo_2O_9$, S = 1 Ni^{2+} ions directly substituted for Cu^{2+} ones work as the additional spin moments, which introduces disorder effects.



[dM/dH vs. H]

Figure 1: Magnetic-field dependences of differential magnetizations in $(Cu,Zn,Ni)_3Mo_2O_9$ systems.

Figure 1 shows the comparison among the differential magnetization along the *a* axis of the crystal taken at 2 K in $Cu_3Mo_2O_9$, that in $(Cu,Zn)_3Mo_2O_9$, and that in $(Cu,Ni)_3Mo_2O_9$. One can see two peaks around 4.5 T with a hysteresis effect in impurity-substituted samples. As we did in $(Cu,Zn)_3Mo_2O_9$ [4], we consider that the peaks indicate the magnetization jump due to the impurity-induced phase transition. The rapid increase of magnetization in $(Cu,Ni)_3Mo_2O_9$ is larger than that in $(Cu,Zn)_3Mo_2O_9$. We consider that the phase induced by Ni substitution is different from that induced by Zn substitution.

References:

[1] T. Hamasaki *et al.*, Phys. Rev. B **77** (2008) 134419.
[2] H. Kuroe *et al.*, J. Phys. Soc. Jpn. **80** (2011) 083705.
[3] M. Hase *et al.*, J. Phys. Soc. Jpn. **77** (2008) 034706.
[4] H. Kuroe *et al.*, J. Kor. Phys. Soc. **63** (2013) 542.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.599
Superconducting-state in $EuAFe_4As_4$ (A = Rb, Cs) with 1144-type structure
Kawashima K.[1,2], *Iyo A.*[2], *Kinjo T.*[2,3], *Nishio T.*[2,3], *Ishida S.*[2], *Kito H.*[2], *Takeshita N.*[2], *Oka K.*[2], *Fujihisa H.*[2], *Gotoh Y.*[2], *Kihou K.*[2], *Eisaki H.*[2], *Yoshida Y.*[2]
[1]IMRA Material R&D Co., Ltd., Kariya, Japan, [2]National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan, [3]Tokyo University of Science, Department of Physics, Shinjuku, Japan

Fe-based superconductor $EuAFe_4As_4$ (A = Rb, Cs) has an 1144-type structure, which is a derived 122-type crystal feature (tetragonal, space group: P4/mmm (No. 123))[1)]. The Eu ion and the A ion occupy different atomic positions in its crystal structure, and the Eu and A layers are inserted alternately between the Fe_2As_2 layers in the *c*-axis direction in $EuAFe_4As_4$.
$EuAFe_4As_4$ exhibits superconductivity and an anomalous magnetic transition at approximately 35 and 15 K, respectively[2)]. $EuAFe_4As_4$ has similar superconducting transition temperature as 122-type $Eu_{1-x}A_xFe_2As_2$ (A = Na, K)[3)]. The magnetic transition is observed only in the magnetic susceptibility data. This behavior suggests that the Eu^{2+} ions induce a magnetic ordered state below the superconducting transition temperature. The calculated upper critical magnetic field is large H_{c2} ~ 900 kOe. We compared the determined physical properties of $EuAFe_4As_4$ with one of other 1144-type superconductors to reveal the superconducting state of $EuAFe_4As_4$.

References:
[1] A. Iyo, K. Kawashima, T. Kinjo, T. Nishio, S. Ishida, H. Fujihisa, Y. Gotoh, K. Kihou, H. Eisaki, and Y. Yoshida, J. Am. Chem. Soc. **138** 3410 (2016).
[2] K. Kawashima, T. Kinjo, T. Nishio, S. Ishida, H. Fujihisa, Y. Gotoh, K. Kihou, H. Eisaki, Y. Yoshida, and A. Iyo, J. Phys. Soc. Jpn. **85** 064710 (2016).
[3]Y. Qi, L. Wang, Z. Gao, X. Zhang, D. Wang, C. Yao, C. Wang, C. Wang, and Y. Ma, New J. Phys. **14** 033011 (2012).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.600
Theory of anomalous features of multiferroics nanoparticle
Miyahara S.
Fukuoka University, Fukuoka, Japan

Recently, nanoparticles of the multiferroic materials are synthesized and show different behaviors from the bulk crystal [1-3]. However, the origin of them is not clarified, yet. We try to clarify the anomalous behaviors of the nanoparticle in the theoretical point of views.
We discuss magnetoelectric behaviors of the multiferroics DyMn2O5 for both bulk and nanoparticles by introducing the coupling between electric polarization and spin-pair due to exchange striction mechanism. We perform Monte Carlo calculation for the Heisenberg model for DyMn2O5 [4]. We

show that, in the nanoparticle, spins at surface show anomalous behaviors due to the frustration: some of spins behaves as quasi-free spin. Such behaviors are qualitatively consistent with the recent experimental observation. In addition, we can predict the magentoelectric behaviors of the nanoparticle. Reflecting the highly frustrated model, spin structures of the nanoparticle can be tuned even by the external electric fields.

References:

[1] T. Tajiri *et al*, Journal of the Physical Society of Japan **75**, 113704 (2006).
[2] T. Tajiri *et al*, Journal of the Physical Society of Japan **77**, 074715 (2008).
[3] T. Tajiri *et al*, The Journal of Physical Chemistry C **119**, 1194 (2015).
[4] G. R. Blake *et al*, Physical Review B **71**, 214402 (2005).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.601

Development of a pressure cell using a beta-titanium alloy for a Differential Scanning Calorimeter

<u>Eto T.</u>[1], Akagi K.[1], Takashima E.[1], Noguchi A.[1], Sakami T.[1], Noda T.[1], Maeno Y.[2], Nakamura F.[1]
[1]Kurume Institute of Technology, Faculty of Engneering, Kurume, Fukuoka, Japan, [2]Kyoto University, Department of Physics, Kyoto, Japan

We have precisely measured a specific heat under pressure for a commercial Differential Scanning Calorimeter (SHIMADZU, DSC-60 plus). We have achieved downsizing a piston-cylinder clamp-cell by using a high-yield-strength alloy of beta-titanium (KOBELCO, KS15-5-3)[1] and reducing the number of the components. The dimensions of our cell are less than a diameter of 6.0 mm and a height of 5.0 mm. The number of the components is reduced from eleven to four. We evaluate the maximum achievable pressure to be 0.7 GPa at room temperature.
As a demonstration of the cell, we have measured the pressure dependence of the specific heat anomaly due to the Mott transition in Ca_2RuO_4[2]. From the pressure variation of metal-insulator transition temperature, our cell allows us to achieve pressure of ~0.3 GPa so far.
This work was supported by the JSPS KAKENHI Nos. JP 26247060.

References:

[1] K.Kamishima, *et al*., Rev. Sci. Instrum. **72**, 1472(2001)
[2] F.Nakamura *et al.*, Phys. Rev. **B65**, 220402(2002)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.602

Superconductivity on quasiperiodic lattice

<u>Sakai S.</u>
RIKEN, Center for Emergent Matter Science, Wako, Japan

Motivated by a recent experimental search for superconducting quasicrystals [1], we theoretically study a possible superconductivity on a quasiperiodic lattice. The fundamental questions include whether the superconductivity can occur in a system without translational symmetry (i.e., without a

well-defined momentum space), and if it occurs, what property differs from that of periodic superconductors. We portray the issue within an attractive Hubbard model on a two-dimensional Penrose lattice. Applying a real-space dynamical mean-field theory to the model consisting of 4181 sites, we indeed find a superconducting phase at low temperatures.
Reflecting the aperiodicity, the superconducting phase exhibits a spatial inhomogeneity. In the phase diagram of the average electron density and the attraction, we find three regions showing different types of inhomogeneity. The difference originates from different spatial extensions of the Cooper pairs, and the three states cross over each other. Among them, the one appearing in a weak-coupling region exhibits the most nontrivial property - it shows spatially extended Cooper pairs, which are nevertheless distinct from the conventional BCS-type pairing of two electrons with opposite momenta [2].

References:

[1] K. Deguchi *et al.*, J. Phys. Soc. Jpn. **84**, 023705 (2015).
[2] S. Sakai, N. Takemori, A. Koga, and R. Arita, Phys. Rev. B **95**, 024509 (2017).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.603

Experimental evidence the structural transformation in ultrathin $SrCuO_2$ films

Chiang P.-C.[1], *Chu Y.-H.*[2], *Yang J.-C.*[3], *Lin J.-Y.*[4]
[1]National Chiao Tung University, Hsinchu, Taiwan, Republic of China, [2]National Chiao Tung University, Department of Materials Science and Engineering, Hsinchu, Taiwan, Republic of China, [3]Institute of Physics, National Cheng Kung University, Tainan, Taiwan, Republic of China, [4]Institute of Physics, National Chiao Tung University, Hsinchu, Taiwan, Republic of China

Tetragonal phase $SrCuO_2$ is an example of a polar infinite-layer system and is widely known to be a parent structure for high-T_c cuprate superconductors. A recent theoretical study predicted a transition from the bulk planar to a chain-type structure for a $SrCuO_2$ film with fewer than five unit cells (uc), driven by the associated electrostatic instability [1]. In this study, the ultrathin (1 - 10 uc) $SrCuO_2$ films were successfully grown on TiO_2-terminated $SrTiO_3$ substrates using pulsed laser deposition. The thickness-dependent structural transformation of the $SrCuO_2$ films was studied by polarization dependent x-ray absorption spectra. Importantly, a two-dimensional (2D) monolayer CuO_2 which is the basis for studying high-T_c superconducting cuprates was successfully grown between a TiO_2-terminated $SrTiO_3$ substrate and a 3uc-thick $SrTiO_3$ top-layer.

References:

[1] Z. Zhong, G. Koster, and P. J. Kelly, Phys. Rev. B - Condens. Matter Mater. Phys. **85**, 1 (2012).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.604

High-field ESR study of S=1/2 frustrated J_1-J_2 chain $NaCuMoO_4(OH)$ as candidate substance for spin nematic

Okubo S.[1,2], *Kubota S.*[2], *Kitahara Y.*[2], *Hara S.*[3], *Sakurai T.*[3], *Ohta H.*[1,2], *Yoshizawa D.*[4], *Hagiwara M.*[4], *Kimura F.*[5], *Kimura T.*[5], *Nawa K.*[6], *Okamoto Y.*[7], *Hiroi Z.*[8]

[1]Kobe University, Molecular Photoscience Research Center, Kobe, Japan, [2]Kobe University, Graduate School of Science, Kobe, Japan, [3]Kobe University, Center for Support to Research and Education Activities, Kobe, Japan, [4]Osaka University, Center for Advanced High Magnetic Field Science, Graduate School of Science, Osaka, Japan, [5]Kyoto University, Devision of Forest and Biomaterials Science, Kyoto, Japan, [6]Tohoku University, Institute of Multidisciplinary Research for Advanced Materials, Sendai, Japan, [7]Nagoya University, Department of Applied Physics, Nagoya, Japan, [8]Univerisity of Tokyo, Institute for Solid State Physics, Kashiwa, Japan

Recently, low-dimensional frustrated spin system have attracted much attention to have novel ground states. The existence of a spin nematic phases, analogous to nematic liquid crystal, is expected theoretically in S=1/2 ferromagnetic and antiferromagnetic frustrated chain at slightly below the saturation field [1]. New candidate substance $NaCuMoO_4(OH)$ shows relatively low saturation field of 25 T and no random substitution [2]. Superexchange interactions are estimated to be J_1=-51 K and J_2=36 K from the magnetic susceptibility measurements [2]. The specific heat does not show long range order down to 0.6 K. Furthermore, relaxation time from NMR measurements behave a spin density wave (SDW), which is expected blow the spin nematic phase. Previously, feature of a spin nematic phase could not observe due to powder samples. In this work, we treat a three-dimensional magnetically aligned powder sample as quasi large single crystal [3]. High-frequency ESR measurements of $NaCuMoO_4(OH)$ for parallel and perpendicular fields to chain have been performed at 1.8 K using the pulsed magnetic fields[4]. The linewidth for H⊥chain is wider than that for H//chain. Field dependence of resonance field and linewidth at spin nematic phase will be discussed.

References:

[1] T. Hikihara, L. Kecke, T. Momoi, A. Furusaki, Phys. Rev. B, 2008, **78** , 144404-19.
[2] K. Nawa, Y. Okamoto, A. Matsuo, K. Kindo, Y. Kitahara, S. Yoshida, S. Ikeda, S. Hara, T. Sakurai, S. Okubo, H. Ohta, Z. Hiroi, J. Phys. Soc. Jpn., 2014, **83**, 103702-5.
[3] F. Kimura, C. Chang, F. Kimura, M. Maeyama, Appl. Crystallogr., 2009, **42**, 535-537.
[4] S. Okubo, H. Ohta, Y. Inagaki, T. Sakurai, Physica B, 2004, **246-247**, 627-632.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.605
Pairing fluctuations in a strongly interacting two-dimensional Fermi gas

Matsumoto M.[1], *Hanai R.*[2], *Inotani D.*[1], *Ohashi Y.*[1]
[1]Keio University, Faculty of Science and Technology, Department of Physics, Yokohama, Japan, [2]Osaka University, Department of Physics, Toyonaka, Japan

We theoretically investigate strong-coupling properties of a two-dimensional Fermi gas near the observed BKT (Berezinskii-Kosterlitz-Thouless) transition temperature T_{BKT} [1,2]. Including pairing fluctuations within the framework of a self-consistent T-matrix approximation, we calculate the single-particle density of states (DOS) in the normal state. We show that pairing fluctuations (that are enhanced by the low-dimensionality of the system) give a pseudogap structure in DOS near T_{BKT}. However, except deep inside the strong-coupling regime, we find that their strengths are still not enough to open a BCS-like full gap. That is, non-vanishing DOS still remains at the Fermi level, implying that the amplitude of the superfluid order parameter is fluctuating. In theoretically evaluating T_{BKT} in an ultracold Fermi gas, it is frequently assumed that, while phase fluctuations exist, the amplitude of the superfluid order parameter is fixed. However, our results indicate the necessity of both including amplitude and phase fluctuations of the order parameter in evaluating T_{BKT} , especially in the weak-coupling side. Since the BKT phase transition has recently attracted much attention in cold Fermi gas physics, our results would be useful for the study of this novel Fermi superfluid.

References:

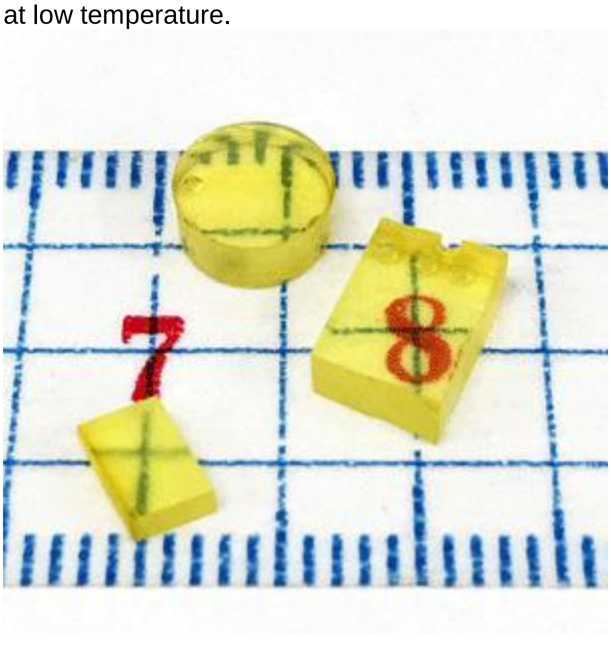
[1] M. G. Ries, A. N. Wenz, G. Zürn, L. Bayha, I. Boettcher, D. Kedar, P. A. Murthy, M. Neidig, T. Lompe, and S. Jochim, Phys. Rev. Lett. 114, 230401 (2015).
[2] P. A. Murthy, I. Boettcher, L. Bayha, M. Holzmann, D. Kedar, M. Neidig, M. G. Ries, A. N. Wenz, G. Zürn, and S. Jochim, Phys. Rev. Lett. 115, 010401 (2015).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.606
Low temperature properties of cyanate ester resins - an alternative to commonly used epoxy resins

Nakamura S.[1], *Fujii T.*[1], *Matsukawa S.*[2], *Katagiri M.*[2], *Fukuyama H.*[1,3]
[1]University of Tokyo, Cryogenic Research Center, Tokyo, Japan, [2]Mitsubishi Gas Chemical Company, Inc., Tokyo, Japan, [3]University of Tokyo, Department of Physics, Tokyo, Japan

To seal, glue, and cast parts of experimental apparatus used at low T, Stycast 1266 and 2850FT epoxy resins (EPs) [1,2] are the most commonly used materials. Since their glass transition temperatures (T_g) are below 115°C, EPs are unusable for some applications which require baking at T>100°C to obtain higher vacuum before cooling down. Cyanate ester resins (CEs) [3] are a high-T compatible and low outgassing thermoset with much higher T_g (=300°C). They have comparable thermal expansion coefficients and mechanical properties to those of EPs, and have been used in electronic and aerospace industries. However, they have never been used as a cryogenic resin below 4 K because of the lack of characterization of their low-T properties. Here we report results of measurements of specific heat c (≥0.5 K), thermal conductivity κ (≥2 K), magnetic susceptibility χ (≥2 K), and permeability p of ^{4}He (≥77 K) up to room temperature (RT) for different kinds of CEs. Compared to Stycast 1266, c is larger by a factor of 3 (≤30 K), κ is lower by a factor of 4 (≤10 K), and χ is in the same range. p is higher by a factor of 6−12 at RT but is negligibly small at T < 130 K. Thus cyanate esters are excellent alternatives to epoxy resins especially for surface sensitive experiments at low temperature.



[CE thermosets]

References:
[1] Henkel LOCTITE (former Emerson & Cuming).
[2] Frank Pobell, Matter and Methods at Low Temperatures (Springer-Verlag Berlin Heidelberg, 2007, 3rd ed.).
[3] I. Hamerton (Ed.), Chemistry and Technology of Cyanate Ester Resins (Springer Netherlands, 1994, 1st ed.).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.607

Applicability of spin fluctuation theory to actinide 5f electron systems

Tateiwa N.[1]*, Pospisil J.*[2]*, Haga Y.*[1]*, Sakai H.*[1]*, Matsuda T.*[3]*, Yamamoto E.*[1]
[1]Japan Atomic Energy Agency, Tokai, Japan, [2]Charles University in Prague, Prague, Czech Republic, [3]Tokyo Metropolitan University, Tokyo, Japan

We have carried out analyses of magnetic data in 67 uranium, 7 neptunium and 4 plutonium ferromagnets with spin fluctuation theory developed by Takahashi[1,2]. We have determined the basic and spin fluctuation parameters of the actinide ferromagnets using experimental data obtained in our experiment as well as those from literatures. The applicability of the spin fluctuation theory to actinide 5*f* system has been discussed. Itinerant ferromagnets of the 3*d* transition metals and their intermetallics follow generalized Rhodes-Wohlfarth relation between p_{eff}/p_s and T_C/T_0 viz., $p_{eff}/p_s \propto (T_C/T_0)^{-2/3}$. Here, p_s, p_{eff}, T_C and T_0 are the spontaneous and effective magnetic moments, the Curie temperature and the width of spin fluctuation spectrum in energy space, respectively. The same relation is satisfied for $T_C/T_0 < 1.0$ in the actinide ferromagnets This suggests the itinerant nature of the 5*f* electrons in most of the actinide ferromagnets. Meanwhile, the relation is not satisfied in a few ferromagnets with $T_C/T_0 \sim 1.0$ that corresponds to local moment system in the spin fluctuation theory. The deviation from the theoretical relation may be due to several other effects not included in the spin fluctuation theory.

References:
[1] Y. Takahashi, J. Phys. Soc. Jpn. **55**, 3553 (1986).
[2] Y. Takahashi, Spin Fluctuations Theory of Itinerant Electron Magnetism (Springer, New York, 2012).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.608

Vortex states in three-dimensional superconductors under a helical magnetic field from a chiral helimagnet

Fukui S.[1]*, Kato M.*[1]*, Togawa Y.*[2]*, Sato O.*[3]
[1]Osaka Prefecture University, Department of Mathematical Sciences, Sakai, Japan, [2]Osaka Prefecture University, Department of Physics and Electronics, Sakai, Japan, [3]Osaka Prefecture University College of Technology, Neyagawa, Japan

It is known that a vortex state in a superconductor can be generated by a magnet. For example, in a ferromagnet / superconductor bilayer system, vortices appear in the superconductor spontaneously [1]. However, we focus on a chiral helimagnet, whose magnetic structure of the chiral helimagnet forms a helical rotation along one direction and is transformed into an incommensurate magnetic structure by an uniform applied magnetic field [2, 3]. Because of this characteristic magnetic structure, we expect that the chiral helimagnet affects vortex states in the superconducting state strongly.
In order to investigate effects of the chiral helimagnet on superocnductors, we consider a chiral helimagnet / superconductor bilayer system. An effect of magnetic structure of the chiral helimagnet is treated as an external magnetic field on the superconductor. So, we consider a superconductor under the helical magnetic field. In order to investigate vortex states, we solve the Ginzburg-Landau equations using the three-dimensional finite element method and obtain distributions of the order parameter [4].
In this presentation, we show how distributions of the order parameter and vortex states in the superconductor change when the helical magnetic field from the chiral helimagnet is changed.

References:

[1] I. F. Lyuksyutov, V. L. Pokrovsky, Adv. Phys. **54**, 1 (2005)
[2] Y. Togawa, et al., Phys. Rev. Lett. **108**, 107202 (2012)
[3] J. Kishine, et al., Prog. Theor. Phys. Suppl., **159**, 82 (2005)
[4] S. Fukui, M. Kato, and Y. Togawa, Supercond. Sci. Technol., **29**, 125008 (2016)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.609

Local electronic structure around nonmagnetic impurity in $CeCoIn_5$ studied by scanning tunneling microscopy

<u>Haze M.</u>[1], Torii Y.[1], Peters R.[1], Kasahara S.[1], Kasahara Y.[1], Hanaguri T.[2], Shibauchi T.[3], Terashima T.[1], Matsuda Y.[1]
[1]Kyoto University, Department of Physics, Kyotoshi-Sakyoku, Japan, [2]RIKEN Center for Emergent Matter Science (CEMS), Wakoshi, Japan, [3]University of Tokyo, Department of Advanced Materials Science, Kashiwashi, Japan

Since $CeCoIn_5$ is in the vicinity of quantum critical point at ambient pressure, it is an ideal system to explore the interplay between antiferromagnetism and superconductivity. It has been reported that enhancement of long range antiferromagnetic order and suppression of superconductivity are induced by nonmagnetic impurities, such as cadmium, mercury and zinc. However, the roles of nonmagnetic impurities have been unclear, because of the lack of local measurements.
Here, in order to investigate the local electronic structure around a nonmagnetic impurity, we performed measurements of scanning tunneling microscopy (STM), which has high energy and spatial resolution. Although it is difficult to obtain atomically flat surfaces in bulk crystals, we have successfully prepared atomically flat thin films of $CeCoIn_5$ which contains nonmagnetic impurities by molecular beam epitaxy and performed *in situ* STM measurements. We clearly resolved the spatial modulation of local density of states around the nonmagnetic impurity caused by the suppression of the hybridization. We also discuss the effect on superconductivity.

Postersession 2

Saturday, 12 August 2017
16.30-18.30
G Foyer

P.610
Superconductivity of strongly correlated electrons in cubic $Yb_3Pd_4Sn_{13}$
Strydom A.[1], *Djoumessi R.*[1], *Gastaldo F.*[2], *Giovannini M.*[2,3], *Solokha P.*[2], *Saccone A.*[2], *Curlik I.*[4], *Reiffers M.*[4], *Roberts J.*[2]
[1]University of Johannesburg, Physics Department, Auckland Park, South Africa, [2]University of Genova, Department of Chemistry, Genova, Italy, [3]CNR-SPIN UO Genova, Genova, Italy, [4]University of Presov, Faculty of Humanities and Natural Sciences, Presov, Slovakia

The intermetallic compound $Yb_3Pd_4Sn_{13}$ is a recently discovered member [1,2] of the large series of cubic space group *Pm*-3*n.* The unit cell contains two formula units but only a single site for occupation by the rare-earth ion. The structure of this material type has attributes of an atomic cage-like environment with important salient consequences for thermal transport [3], and the large separation between the rare-earth ions (~4.8 Å, or more than 5 times the ionic radius of Yb^{3+}) means that in Ce-based examples magnetic order is avoided despite the rare-earth magnetic moment in favor of Kondo lattice formation in the ground state [4]. In the title compound $Yb_3Pd_4Sn_{13}$ our exploratory studies have found signatures of superconductivity but the involvement of elemental Sn, a type I superconductor that accidentally co-precipitated in trace amounts in our sample material unfortunately obscured the intrinsic behaviour of the Yb compound. In this study we report our results of having isolated the trace impurity role and our suite of physical properties including specific heat, magnetic susceptibility, and electrical resistivity consistently show intrinsic and bulk superconductivity of $Yb_3Pd_4Sn_{13}$ below T_c= 2.3 K. The upper critical field is estimated at H_{c2}= 1 T.
References:
[1] F. Gastaldo *et al*., J. Alloys Comp. **694** 185 (2017)
[2] F. Gastaldo *et al*., to appear in Acta Phys. Polon A, proceedings of the 16th Czech and Slovak Conference on Magnetism, 2016, Košice, Slovakia
[3] A. M. Strydom, J. Phys. Condens. Matter **19** 386205 (2007)
[4] U. Köhler *et al*., J. Phys. Condens. Matter **19** 386207 (2007)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.611
Physical properties of new iron-based superconductors *AeA*Fe_4As_4 (*Ae* = Ca, Sr, *A* = K, Rb, Cs) and (Ba,Cs)Fe_2As_2
Iyo A.[1], *Kawashima K.*[1,2], *Kinjo T.*[3], *Nishio T.*[3], *Ishida S.*[1], *Fujihisa H.*[1], *Gotoh Y.*[1], *Kihou K.*[1], *Takeshita N.*[1], *Kito H.*[1], *Eisaki H.*[1], *Yoshida Y.*[1]
[1]National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan, [2]IMRA Material R&D Co., Ltd., Kariya, Japan, [3]Tokyo University of Science, Shinjuku, Japan

Fe-based superconductors attract research interest because of their rich structural variety, which is due to their layered crystal structures. Here, we report physical properties of new Fe-based superconductors *AeA*Fe_4As_4 (*Ae* = Ca, Sr, *A* = K, Rb, Cs) [1,2]. The *AeA*Fe_4As_4 can be regarded as hybrid phases between *Ae*Fe_2As_2 and *A*Fe_2As_2. Unlike solid solutions such as $(Ba_{1-x}K_x)Fe_2As_2$ and $(Sr_{1-x}Na_x)Fe_2As_2$, the *Ae* and *A* do not occupy crystallographically equivalent sites, owing to large differences between their ionic radii. Rather, the *Ae* and *A* layers are inserted alternately between the Fe_2As_2 layers in the *c*-axis direction in *AeA*Fe_4As_4 (*AeA*1144). The ordering of the *Ae* and *A* layers causes a change in space group from *I4/mmm* to *P4/mmm*, which is clearly apparent in powder X-ray diffraction patterns. Because the *AeA*1144 is formed as a stoichiometric compound. Each *AeA*1144 has its own superconducting transition temperature of approximately 31−36 K. In addition, the *AeA*Fe_4As_4 superconductors have high upper critical fields H_{c2} like as the 122-type compound of (Ba,K)Fe_2As_2. Therefore, they are promising candidates for wire application. We also show synthesis and properties of a new 122-type superconductor (Ba,Cs)Fe_2As_2.

References:
[1] A. Iyo *et al*. J. Am. Chem. Soc. **138** (2016) 3410.
[2] K. Kawashima *et al*. J. Phys. Soc. Jpn. **85** (2016) 064710.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.612
Rotational senses and types of chiral spin spiral structure studied by spin-polarized scanning tunneling microscopy

Haze M.[1,2], *Yoshida Y.*[2], *Hasegawa Y.*[2]
[1]Kyoto University, Department of Physics, Kyotoshi-Sakyoku, Japan, [2]University of Tokyo, Institute for Solid State Physics, Kashiwa, Japan

In magnetic systems whose inversion symmetry is broken, the Dzyaloshinskii-Moriya interaction (DMI) plays a key role in the formation of chiral spin structures, e.g. skyrmion lattices, domain walls, and homogeneous spin spiral structures. Since the inversion symmetry is naturally broken at interfaces, 3d magnetic ultrathin films formed on 5d non-magnetic heavy-elemental substrates, which have strong spin-orbit coupling, often exhibit non-collinear chiral spin structures driven by DMI . These chiral spin structures may show various types of rotation, such as Bloch- or Neel-type rotations. They may also have different rotational senses, either left-handed or right-handed. However, it is difficult to reveal rotational sense of chiral spin structure which has short periodicity such as a homogeneous spin spiral structure.
Here, we focus on Mn thin films on W(110) substrate because both Mn monolayer (ML) and DL show homogeneous spin spiral structures, which propagate different directions. In this work, we performed spin-polarized scanning tunneling microscopy with a tip magnetized in various directions in the rotational plane, and we determined the rotational senses and types of Mn this films.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.613
Thermodynamics of a Bose-Fermi mixture with a hetero-nuclear Feshbach resonance

Kharga D.[1], *Tajima H.*[2], *Hanai R.*[3], *Inotani D.*[1], *Ohashi Y.*[1]
[1]Keio University, Yokohama, Japan, [2]RIKEN Nishina Center, Wako, Japan, [3]Osaka University, Osaka, Japan

We theoretically investigate normal-state properties of a strongly-interacting Bose-Fermi mixture with a hetero-nuclear Feshbach resonance. We use a diagrammatic Green's function technique wherein we adequately incorporate strong-coupling effects by improving the ordinary T-matrix approximation (TMA), so as be consistent with the so-called Hugenholtz-Pines' relation for Bose Green's function appearing in the TMA self-energy at the Bose-Einstein condensation temperature (T_{BEC}). Using this strong-coupling formalism, we discuss how Bose-Fermi pairing fluctuations adjusted by a hetero-nuclear Feshbach resonance affect thermodynamic properties of this system near T_{BEC}. We will also compare our results with the case of a two-component Fermi gas in the BCS-BEC crossover region. Since hetero-nuclear Feshbach resonances, as well as the formation of Bose-Fermi pairs, have been realized in cold atom physics, our results would contribute to the research toward to the understanding of strong-coupling properties of this novel quantum system.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.614

Electronic states around a vortex core in chiral and herical p-wave superconducting states

Asaoka R.[1], *Tsuchiura H.*[1], *Sigrist M.*[2]
[1]Tohoku University, Applied Physics, Sendai, Japan, [2]ETH Zürich, Zurich, Switzerland

P-wave superconductors, in which triplet Cooper pairs have non-zero orbital angular momenta, exhibit the distinct bound states around a surface or a vortex core not to be seen in conventional superconductors. Chiral and helical symmetries of Cooper pairs are suggested to be realized in Sr_2RuO_4[1], which has been studied as a strong candidate for p-wave superconductor, and these symmetries lead to the surface current[2] and the charging effect around a vortex core[3] reflecting its characteristic quasi-particle excitation modes. The electronic states around a vortex core should, in particular, strongly depend on whether the symmetry is chiral or helical ones because they depend on the combination of orientation of chirality and vorticity[4]. To argue these electronic states in realistic experiments appropriately, microscopic features of materials should be considered.
In this contribution, we investigate the electronic state around a vortex core in chiral and helical p-wave superconducting states in a square lattice three band tight-binding model with the spin-orbit coupling reproducing the three Fermi surfaces of Sr_2RuO_4[5]. We also study the distribution of the charge current around a vortex accompanied by its characteristic quasi-particle excitation modes.

References:

[1] A. P. Mackenzie and Y. Maeno, Rev. Mod. Phys. **75**, 657-712 (2003)
[2] M. Matsumoto and M. Sigrist, J. Phys. Soc. Jpn **68**, 994-1007 (1999)
[3] M. Takigawa, M. Ichioka, K. Machida, and M. Sigrist, Phys. Rev. B **65**, 014508 (2001)
[4] M. Matsumoto and R. Heeb, Phys. Rev. B **65**, 014504 (2001)
[5] Y. Imai, K. Wakabayashi, and M. Sigrist, Phys. Rev. B, **88**, 144503 (2013)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.615

Dynamic nuclear polarization of doped silicon at low temperatures

Järvinen J.[1], *Zvezdov D.*[2], *Ahokas J.*[1], *Sheludiakov S.*[3], *Lehtonen L.*[4], *Vlasenko L.*[5], *Vasiliev S.*[1]

[1]University of Turku, Physics and Astronomy, Wihuri Physical Laboratory, Turku, Finland, [2]Institute of Physics, Kazan Federal University, Kazan, Russian Federation, [3]Texas A&M University, Physics and Astronomy, Institute for Quantum Science and Engineering, College Station, United States, [4]University of Turku, Physics and Astronomy, Laboratory of Optics, Turku, Finland, [5]A. F. Ioffe Physico-Technical Institute, Russian Academy of Sciences, St. Petersburg, Russian Federation

Nuclear spins coupled to electrons is interesting system for future quantum architectures. Shallow donors in Si coupled to 29Si nuclei is one such system. The coherence of 29Si nuclei in the "frozen core" near the donor is protected by the donor electron leading to very long coherence times [1]. Here, we report on dynamic nuclear polarization (DNP) experiments of donor and 29Si nuclear spins in silicon. The Overhauser and solid effect methods of DNP provide almost full control of spin polarization of the donor and the nearby 29Si nuclei [2]. In magnetic field of 4.6 T and below 1 K temperatures the donor electron spins are fully polarized. The DNP of nuclear spins is achieved by exciting electron spin resonance (ESR) transitions. Spin polarization is observed directly from the ESR spectrum and the polarization is not disturbed during the measurement.

References:

[1] Gary Wolfowicz et al., New J. Phys. **18**, 023021 (2016)
[2] J. Järvinen, et al., Phys. Rev. B, **92**, 121202 (2015)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.616

Turbulence scaling laws across the superfluid to supersolid transition

Hsueh C.-H.[1], *Tsai Y.-C.*[2], *Horng T.-L.*[3], *Tsubota M.*[4], *Wu W.C.*[1]
[1]National Taiwan Normal University, Taipei, Taiwan, Republic of China, [2]National Changhua University of Education, Changhua, Taiwan, Republic of China, [3]Feng Chia University, Taichung, Taiwan, Republic of China, [4]Osaka City University, Osaka, Japan

We investigate quantum turbulence in a two-dimensional trapped supersolid and show that both the wave and vortex turbulence possess triple rather than dual cascades as in a superfluid. Owing to a second gapless mode in association with the translation symmetry breaking, it is predicted that a new $k^{-13/3}$ scaling law occurs in the wave turbulence. Simultaneously a fast vortex-antivortex creation and annihilation cycle in the interior of the oscillating supersoild can result in a k^{-1} scaling law in the vortex turbulence. Numerical simulations based on the GPE approach confirmed the predictions.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.617

Parity mixing transition realized in a pyrochlore compound $Cd_2Re_2O_7$

Harima H.
Kobe University, Physics, Kobe, Japan

A metallic pyrochlore oxide $Cd_2Re_2O_7$ undergoes a structural phase transition at 200K, followed by another phase transition at 120K and a superconducting transition at 1.0K. Although the atomic positions below 200K has not yet determined precisely, the space group is I4m2 (#119, D_{2d}^{9}) below 200K, and $I4_122$ (#98, D_4^{10}) [2] below 120K. Then, the space inversion symmetry is lost at 200K from the space group Fd3m (#227, O_h^{7}). Below 200K, due to the lack of the space inversion symmetry, each the electronic state lifts the degeneracy corresponding to the spin degree of freedom. The degeneracy is not left completely, so the $Cd_2Re_2O_7$ remains metallic below 200K [3]. The phase transition at 200K is investigated by using the bandstructure calculations. $Cd_2Re_2O_7$ in high temperature phase is a compensated metal, so there are a hole pocket at the K points and two electron pockets around point. One the space inversion symmetry is lost; the electron pockets are split to four and the hole pocket becomes split to two. However, the splitting around the K points is so large that one hole become below the Fermi level, then disappears. Such the large splitting around the K point is understood by considering the parity mixing effect and the precise treatment of the spin-orbit coupling.

References:
[1] Z. Hiroi *et al.*, J. Phys. Soc. Jpn., **71**, 1634 (2001).
[2] J. Yamaura *et al.*, J. Phys. Soc. Jpn., **71**, 2598 (2002).
[3] Z. Hiroi *et al.*, J. Phys. Soc. Jpn., **72**, 21 (2003).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.618
Surface acoustic wave unidirectional transducers for quantum applications

Ekström M.K., *Aref T., Runeson J., Björck J., Boström I., Andersson G., Suri B., Delsing P.*
Chalmers University of Technology, Microtechnology and Nanoscience, Göteborg, Sweden

The demonstration of artificial atoms interacting with surface acoustic waves (SAWs) [1] has opened up for new possibilities utilizing SAWs (phonons) instead of electromagnetic waves (phonons) in quantum physics experiments. When SAWs are used to carry quantum information, it is important to have low loss, motivating the need for good conversion between photons and phonons. In quantum SAW experiments, the signal is converted using interdigital transducers (IDTs). However, their symmetric bidirectional nature results in a theoretical minimum insertion loss of 3 dB. Unlike the IDTs, unidirectional transducers (UDTs) [2] can be optimized to release most of their SAW energy in one preferred direction and can, in this way, exceed the 3 dB loss. Therefore, we compare delay lines containing UDTs and IDTs at microwave frequencies and low temperature with the aim to use them as photon to phonon converters at the quantum level. We found an improved insertion loss of 4.7 dB using UDTs and a directivity of 22 dB per UDT, indicating that 99.4 % of the acoustic power goes in the desired direction. The power lost in the undesired direction accounts for more than 90 % of the total loss in IDT delay lines, but only 3 % of the total loss in the UDT delay lines [3].

References:
[1] M.V. Gustafsson, T. Aref, A. Frisk Kockum, M.K. Ekström, G. Johansson and P. Delsing, Science **346**, 207-211 (2014).
[2] K. Yamanouchi and H. Furuyashiki, Electron. Lett. **20**, 989 (1984).
[3] M.K. Ekström, T. Aref, J. Runeson, J. Björck, I. Boström and P. Delsing, Appl. Phys. Lett. **110**, 073105 (2017).

Postersession 2
Saturday, 12 August 2017

16.30-18.30
G Foyer

P.619
Magnetocaloric effect in Haldane - gap *S* = 1 spin chain $[Ni(C_2H_8N_2)_2NO_2](BF_4)$
Orendáč M.[1], *Tarasenko R.*[1], *Tkáč V.*[1], *Orendáčová A.*[1], *Zvyagin S.*[2], *Sechovský V.*[3]
[1]Institute of Physics, P. J. Šafárik University, Košice, Slovakia, [2]Dresden High Magnetic Field Laboratory (HLD), Helmholtz-Zentrum Dresden-Rossendorf and TU Dresden, Dresden, Germany, [3]Faculty of Mathematics and Physics, Department of Condensed Matter Physics, Charles University, Prague, Czech Republic

Magnetocaloric effect in Haldane - gap S = 1 spin chain $[Ni(C_2H_8N_2)_2NO_2](BF_4)$ was investigated at low temperatures ($T << J$) and magnetic fields up to nominally $0.1B_{sat}$, where J and B_{sat} denote an exchange interaction and saturation magnetic field, respectively. Magnetic entropy was found to scale as $exp(\Delta/k_BT)$ in zero magnetic field for and $T^{0.67}$ for $B = B_c$, in which Haldane gap should be closed, in reasonable agreement with the theoretical predictions. The existence of the inverse magnetocaloric effect for $B < B_c$ was confirmed. The occurrence of normal magnetocaloric response at lowest temperatures and magnetic fields was attributed to S = 1/2 degrees of freedom arising from the ends of chain segments.
The work was supported by project APVV - 14 - 0073 and VEGA 1/0296/17.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.620
Electric(magnetic)-field control of magnetization(electric polarization) in $CaBaM_4O_7$ (M=Co, Fe) single crystals
Kuwahara H.[1], *Oda R.*[1], *Noda M.*[1], *Ebukuro Y.*[1], *Akaki M.*[2], *Kuroe H.*[1]
[1]Sophia University, Tokyo, Japan, [2]Center for Advanced High Magnetic Field Science, Graduate School of Science, Osaka University, Osaka, Japan

The present compounds, $CaBaM_4O_7$ (M=Co, Fe), have been attracting attention for their nontrivial magnetism because of the geometrically frustrated crystal structure consisting of triangular and Kagome layers. From the viewpoints of the studies of multiferroics, we have expected that the magnetic ordering would couple with the spontaneous electric polarization (P) due to the crystal structure with a polar point-group of *mm*2. Indeed, we have observed the change of P_c induced by the weak ferromagnetic ordering in $CaBaCo_4O_7$ [1]. Then the magnetic-field (H_b)-induced giant variation in P_c was reported and the magnetostriction mechanism was proposed [2]. Also in the case of $CaBaFe_4O_7$, the magnetoelectric coefficient α_{cc} with a maximum value of 39 ps/m defined as $\Delta P_c=\alpha_{cc}H_c$ was reported for the measurements of H_c-induced change of P_c at 80 K below the ferrimagnetic transition temperature of 275 K [3]. In this work, we have systematically investigated magnetic, dielectric, and lattice structural properties of $CaBaM_4O_7$ (M=Co, Fe) single crystals. Especially, we focused on the electric-field (E_c)-induced magnetization (M_c) in $CaBaFe_4O_7$, which had not yet been performed. We will present a comparative study of magnetoelectric properties of $CaBaCo_4O_7$ and $CaBaFe_4O_7$ single crystals in E and/or H.

References:
[1] H. Iwamoto *et al.*, J. Phys: Conf. Ser. **400**, 032031 (2012).
[2] V. Caignaert *et al.*, Phys. Rev. **B 88**, 174403 (2013).

[3] V. Kocsis *et al.*, Phys. Rev. **B 93**, 014444 (2016).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.621
Interplay of spin and spatial anisotropy in a quasi-two -dimensional quantum magnet $Cu(en)SO_4(H_2O)_2$

Orendáčová A.[1], *Lederová L.*[1], *Chovan J.*[2], *Strečka J.*[1], *Tarasenko R.*[1], *Legut D.*[3], *Čižmár E.*[1], *Orendáč M.*[1], *Feher A.*[1]
[1]P. J. Šafárik University, Košice, Slovakia, [2]M. Bel University, B. Bystrica, Slovakia, [3]Technical University of Ostrava, Ostrava, Czech Republic

First-principle calculations of exchange interactions in the quantum Heisenberg antiferromagnet (HAF) $Cu(en)SO_4(H_2O)_2$ (CUEN) revealed a presence of a two-dimensional (2D) array of zig-zag chains forming a zig-zag square lattice. Using quantum Monte Carlo simulations, the analysis of experimental specific heat, susceptibility and magnetization confirmed that 2D correlations in CUEN approximate spin 1/2 HAF zig-zag square lattice with the in-plane spatial anisotropy $J_{interchain}/J_{chain}$ = 0.35 and J_{chain} = 3.5 K. Symmetry constraints within the magnetic layer result in the symmetric exchange anisotropy with the easy-axis breaking symmetry within the easy plane. While the spin anisotropy of the order 10^{-3} J_{chain} has a negligible effect on the finite-temperature properties of the 2D lattice, it has significant influence in the ordered phase below T_N= 0.93 K, manifesting in the spin flop transition within the easy plane observed in the field 200 mT applied along the easy axis. It was found that sufficiently strong magnetic field can overcome the intrinsic spin anisotropy and magnetic phase transitions in the applied field show universal behavior independent of the field orientation, mimicking the scenario of the field-induced Berezinskii-Kosterlitz-Thouless phase transition.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.622
Elastic properties of amorphous Si films at mK temperatures

Fefferman A.[1], *Gazizulin R.*[1], *Maillet O.*[1], *Zhou X.*[1], *Collin E.*[1], *Liu X.*[2], *Metcalf T.*[2], *Jernigan G.*[2]
[1]Institut Néel, CNRS and University Grenoble Alpes, Grenoble, France, [2]Naval Research Laboratory, Washington, DC, United States

The low temperature properties of glass are distinct from those of crystals due to the presence of poorly understood low-energy excitations. These are usually thought to be atoms tunneling between nearby equilibria, forming tunneling two level systems (TLSs). Elastic measurements on amorphous silicon films deposited with e-beam evaporation showed that this material contains a variable density of TLSs that decreases as the growth temperature increases from room temperature to 400 °C [1]. We present measurements of the elastic properties of these films down to 10 mK and an analysis in the framework of the standard tunneling model.

References:

[1] X. Liu, D. R. Queen, T. Metcalf, J. Karel and F. Hellman, Phys. Rev. Lett., **113**, 025503 (2014)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.623
Elastic properties of YbSbPt at extreme low temperatures probed by ultrasound measurements

Nakanishi Y.[1], *Takahashi S.*[1], *Hasegawa J.*[1], *Ohyama Y.*[1], *Nakamura M.*[1], *Yoshizawa M.*[1], *Suzuki H.*[2]
[1]Iwate University, Graduate School of Engineering, Morioka, Japan, [2]National Institute for Materials Science (NIMS), Tsukuba, Japan

The compound YbPtSb crystallizes in a MgAgAs cubic structure (space group $F43m$), being referred to as the half-Heusler structure. The study of this structure has attracted considerable attention due to the discovery that the family YbPtX (X = Sb, Bi) shows the exceptionally large specific heat coefficient g = 8 and 9 J/mol K^2 for X = Bi and Sb, respectively, i.e., super heavy fermion behavior even though a low-carrier concentration. [1-3] This value is approximately three orders of magnitude larger than that of conventional metals. Interestingly, YbPtSb undergoes magnetic order at T_c = 0.34 K with a very tiny ordered moment of 0.1 m_B/Yb ion, and shows anisotropic resistivity below T_c. These findings suggest that a spin-density-wave transition would occur at T_c, and that this transition gaps partially the Fermi surface. Of central importance in these Yb-based systems is whether the large g can be associated with the existence of very heavy renormalized quasi-particles. We performed ultrasound measurements on YbPtSb in the extremely low temperature ranges crossing the T_c. The nature of the low temperature elastic properties and electronic states involving a topological insulator phase will be discussed.

References:
[1] Z. Fisk *et al*, Phys. Rev. Lett. **67** (1991) 3310.
[2] K. Matsubayashi *et al*, J. Ohys.: Conf. Ser. **391** (2012) 012040.
[3] Y. Nakanishi *et al*, Phys. Status Solidi B **247** (2010) 754.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.624
Probing the phase diagram in $YBa_2Cu_3O_{7-x}$ nanostructures through resistance noise measurements

Trabaldo E., *Andersson E.*, *Arpaia R.*, *Lombardi F.*, *Bauch T.*
Chalmers University of Technology, Microtechnology and Nanoscience, Gothenburg, Sweden

The microscopic origin of superconductivity and the related phase diagram of High critical Temperature Superconductors (HTS) is far from being fully understood. During the last few years Charge Density Wave (CDW) order has been ubiquitously observed in these materials unifying the behavior of the various HTS compound families [1-3]. In this respect resistance noise measurements can be a powerful tool to understand the properties of these materials in the phase under study and to detect symmetry breaking orders [4,5]. Here we present resistance noise measurements performed on $YBa_2Cu_3O_{7-x}$ (YBCO) nano-structures, as a function of temperature and hole doping. Our measurements reveal a clear indication that oxygen dynamics is the dominant mechanism responsible for the 1/f flicker noise [6]. The noise also shows strong two level fluctuators (TLFs) at characteristic temperatures, which depend on the doping of the nanostructures. These TLFs can be associated with phase transitions [7], which opens the possibility of using noise measurements to map the phase diagram. Finally, we performed cross-correlation noise measurements on YBCO nano-crosses, which are instrumental to detect fluctuations in a nematic ordered phase (CDW).

References:

[1] Ghiringhelli, G. et al., Science **337**, 821 (2012)
[2] Chang, J. et al., Nature Phys. **8**, 871 (2012)
[3] Comin, R. et al., Science **347**, 1335-1339 (2015)
[4] Bonetti, J. A. et al., Phys. Rev. Lett. **93**, 087002 (2004)
[5] Caplan, D. S. et al., Phys. Rev. Lett. **104**, 177001 (2010)
[6] Trabaldo, E. et al., *IEEE TAS* **27**, 7500904 (2017)
[7] Chen, Z. et al., Phys. Rev. Lett. **98**, 057204 (2007)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.625
Fast charge detectors for single electron experiments

Reifert D., Ubbelohde N., Dolata R., Weimann T., Zorin A.
Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

We utilize rf-driven semiconductor-based dynamic quantum dots as single electron pumps (SEP). These SEPs can transport a controlled number of n electrons per pump cycle and therefore create a precise quantized current **I**=n·e·f, where f is the pumping frequency.
Since this current has a high accuracy of 0.2ppm [1], these SEPs are a good candidate for a new primary standard for the unit ampere.
To validate their precision, we are implementing an error counting scheme [2,3] where we operate several SEPs in series, creating isolated charge nodes between them. By coupling highly sensitive charge detectors to these nodes we can count the errors of the pumps by monitoring the charge and therefore determine the precision of the pumps. We examine the suitability of several types of detectors, including semiconductor based quantum dots, quantum point contacts and superconducting single electron transistors (SETs). Theses detectors are tested in the rf-regime [4], by performing fast charge measurement in integrated SEP devices. The results of their comparison will be reported.

References:

[1] F. Stein et al., Appl. Phys. Lett. 107, 103501 (2015)
[2] M. Wulf, Phys. Rev. B 87, 035312 (2013)
[3] L. Fricke et al., Phys. Rev. Lett 112, 226803 (2014)
[4] R. J. Schoelkopf et al., Science 280, 1238-1242 (1998)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.628
Electrical autonomous Brownian gyrator

Chen Y.-F., *Chiang K.-H., Lee C.-L., Lai P.-Y.*
National Central University, Department of Physics, Taoyuan, Taiwan, Republic of China

Heat engines based on microscopic working substances with few degrees of freedom are of great interests for both demand of energy harvesting and development of microscopic (stochastic) thermodynamics. The Feynman ratchet, a thought autonomous perpetual machine to rectify Brownian motions to work, has never been demonstrated near room temperature scale for the challenge of coupling a microscopic object to more than one heat bath. Here we report an experimental investigation of an electrical version of an autonomous Brownian ratchet truly relied on real heat baths. The ratchet is manifested via two resistor-capacitor circuits subject to two different thermal baths and coupled through a third capacitor. The collective dynamics of the fluctuating voltages across the two resistors exhibits an average gyrating motion owing to the lack of detailed balance caused by the unequal temperatures of the two baths. Our experiment and analysis affirm the general principle and the possibility of a Brownian ratchet working near room temperature scale.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.629
Time-domain characterisation and coherent acoustic manipulation of a SAW qubit
Suri B., *Andersson G., Ekström M., Scigliuzzo M., Bruhat L., Aref T., Delsing P.*
Chalmers University of Technology, Department of Microtechnology and Nanoscience, Göteborg, Sweden

Surface Acoustic Wave (SAW) phonons on a piezoelectric (GaAs) substrate interacting with a superconducting transmon qubit provide a “quantum acoustic” platform for experiments analogous to quantum optics. However, the slow propagation velocity of sound (~ 3000 m/s) compared to that of light leads to the superconducting artificial atoms being several orders of magnitude larger than the wavelength of sound, allowing us to probe a new regime of quantum optics. We use a dispersively coupled coplanar waveguide $\lambda/4$ microwave resonator to read out the excited state population of the qubit and perform its time-domain characterisation. We report on the time-domain excited state decay of such ´giant atoms´ with transition frequency in the 2 - 2.5 GHz range. We also discuss coherent manipulation of the qubit using SAW applied using an interdigital transducer (IDT), while reading out the state of the qubit using the microwave resonator.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.630
Surface scattering effects on spontaneous edge current and relevant physical phenomena in d-wave superconductors
Miyawaki N., *Higashitani S.*
Hiroshima University, Higashi-Hiroshima, Japan

We present a theoretical study on surface states in unconventional superconductors in which a spontaneous edge current arises due to the formation of surface Andreev bound states. The quasiclassical theory of superconductivity is applied to d-wave superconductors with surface Andreev bound states. The Maxwell equation is self-consistently solved to obtain the spatial distribution of spontaneous magnetization. We discuss how diffuse surface scattering affects the transition between superconducting states with and without the spontaneous edge current.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.631

Decoherence of superconducting qubits in large in-plane magnetic fields

Schneider A.[1], *Braumüller J.*[1], *Pfirrmann M.*[1], *Ustinov A.V.*[1,2], *Weides M.*[1,3]
[1]Karlsruhe Institute of Technology, Physikalisches Institut, Karlsruhe, Germany, [2]National Institute of Science and Technology MISIS, Moscow, Russian Federation, [3]Johannes Gutenberg University, Institute of Physics, Mainz, Germany

We intend to directly interface thin film ferromagnets with planar superconducting qubits to study the quantum dynamics within the magnet. To achieve this, superconducting qubits have to be placed in or close to the static magnetic field (10-250 mT) applied to the ferromagnet.
As a first step, we experimentally study the coherence properties of superconducting qubits under the influence of an external magnetic field which is oriented in parallel to the plane of the chip. The qubit is a superconducting concentric transmon having a microstrip geometry [1,2] showing up to 20 µs coherence times T_1 and T_2 at zero magnetic field. Qubit properties such as relaxation and dephasing times, as well as the shift of the qubit and resonator frequency, are measured in an external field up to 50 mT at temperature ranges below 50 mK.

References:

[1] M. Sandberg, M.R. Vissers, T.A. Ohki, J. Gao J. Aumentado, M Weides, and D.P. Pappas, Appl. Phys. Lett. **102**, 72601 (2013)
[2] J. Braumüller, M. Sandberg, M.R. Vissers, A. Schneider, S. Schlör, L. Grünhaupt, H. Rotzinger, M. Marthaler, A. Lukashenko, A. Dieter, A.V. Ustinov, M. Weides, and D.P. Pappas, Appl. Phys. Lett. **108**, 32601 (2016).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.632

Low-temperature physical properties of the *S*=1/2 frustrated square lattice

Tamekuni Y., Yamaguchi H., Iwasaki Y., Ono T., Hosokoshi Y.
Osaka Prefecture University, Department of Physical Science, Sakai, Japan

We have demonstrated the tuning of exchange interactions in spin-ladder systems [1,2] and the formation of a variety of unconventional lattice systems [3,4] by using verdazyl radicals. Recently, we have succeeded in synthesizing a new charge-transfer complex $[p\text{-MePyV}]^+[\text{TCNQ}]^- \cdot(CH_3)_2CO$ derived from verdazyl radicals. The column structure composed of the TCNQ anions forms an *S*=1/2 antiferromagnetic (AF) chain with strong exchange interaction more than 1000 K. Therefore, in the low-temperature region below room temperature, such AF chain shows a nearly nonmagnetic state. Then, the magnetic properties in the low-temperature region originate from the verdazyl radical cations with *S*=1/2. *Ab initio* molecular orbital calculations associated with the verdazyl radical cations indicate that the three AF and one ferromagnetic interactions form an *S*=1/2 fully-frustrated square lattice. The experimental result of the magnetic susceptibility indicates the gapped behavior. Furthermore, the electric conductivity shows the property as semiconductor with activation energy of 0.2 eV.

References:

[1] H. Yamaguchi *et al*., Phys. Rev. Lett. **110** 157205 (2013)
[2] H. Yamaguchi *et al*., J. Phys. Soc. Jpn. **83** 033707 (2014)
[3] H. Yamaguchi *et al*., Phys. Rev. B **88** 174410 (2013)
[4] H. Yamaguchi *et al*., Sci. Rep. **5**15327 (2015)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.633
Cross-channel electron waiting times of a multi-channel multi-terminal scatterer

Mi S., Burset P., Flindt C.
Aalto University, Department of Applied Physics, Espoo, Finland

We investigate the cross-channel electron waiting time distribution (WTD) of systems with multiple transport channels and terminals. Extending previous work [1-5], using scattering matrix formalism, we obtain generalised forms for the WTD as functions of the detector positions and multiple measurement times in each channel.

We first apply our theory to an electron beam splitter based on a quantum point contact, where the incident electrons can be either reflected or transmitted into output channels with finite probability. We evaluate the distribution of WTDs between detections in each output channel. We show that the zero-point of the cross-channel WTD is shifted with respect to the relative position of the detectors. This suppression is a direct consequence of Pauli principle, where a electron can only occupy one transport state in either reflection or transmission channel at a given time.

We further investigate WTDs in normal-superconducting hybrid junctions. We consider topologically trivial and non-trivial superconductors. The study of WTDs of Andreev reflections between electron and hole channels allows us to identify the signature of Majorana zero-modes. Our study provides evidence that the WTDs can be used as a promising tool to study quantum transport processes [6].

References:

[1] G. Haack, M. Albert, and C. Flindt, Phys.Rev. B **90**, 205429 (2014).
[2] D. Dasenbrook, P. P. Hofer, and C. Flindt, Phys. Rev. B **91**, 195420 (2015).
[3] L. Rajabi, C. Pöltl, and M. Governale, Phys. Rev. Lett. **111**, 067002 (2013).
[4] T. Brandes, Ann. Phys.**17**, 477 (2008).
[5] D. Chevallier, M. Albert and P. Devillard, Europhys. Lett. **116**, 27005 (2016).
[6] S. Mi, P. Burset, and C. Flindt, in preparation (2017)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.635

Bound states in the continuum in interacting double quantum dots: thermoelectric effects

Sierra M.A.[1], *Saiz-Bretín M.*[2,3], *Domínguez-Adame F.*[2,3], *Sánchez D.*[1]
[1]Instituto de Física Interdisciplinar y Sistemas Complejos (UIB-CSIC), Palma de Mallorca, Spain,
[2]Universidad Complutense de Madrid, Departamento de Física de Materiales, Madrid, Spain,
[3]University of Warwick, Department of Physics, Coventry, United Kingdom

Parallel-coupled quantum dots (PCQD) are excellent systems to study the combined action of interference effects and electron-electron interactions. Interference between different paths in the system can cause the emergence of Fano antiresonances, which in some cases result in bounds states in the continuum (BIC): discrete states in the continuous energy spectrum. Here, we explore the electric and thermoelectric properties of PCQD supporting BIC. We consider dots with intradot Coulomb interactions and attached to two fermionic reservoirs. Using the nonequilibrium Green's-function formalism, we find that the BIC produced by the Fano antiresonance is not destroyed in the presence of Coulomb repulsion. We discuss the possibility of using the conductance as a tool for the experimental detection of BIC. We find that the differential conductance as a function of both the applied voltage and the dot energy level gives crossing points of minima conductance generated from transmission antiresonances. Further, the linear thermoelectric response shows sharp asymmetric peaks around the BIC energies. Remarkably, the nonlinearities in the current for large thermal biases applied in the reservoirs lead to nontrivial zeros in the thermocurrent.

References:

[1] Miguel A. Sierra, M. Saiz-Bretín, F. Domínguez-Adame and David Sánchez, Physical Review B, **93**, 235452 (2016).

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.636

ESR study of Y_2SiO_5:Nd^{143} isotopically pure impurity crystals for quantum memory

Eremina R.[1,2], *Tarasov V.*[1], *Yatsyk I.*[1,2], *Sukhanov A.*[1], *Kutovoi S.*[3], *Zavartsev Y.*[3], *Zagumennyi A.*[3]
[1]Kazan E. K. Zavoisky Physical -Technical Institute, Kazan, Russian Federation, [2]Kazan Federal University, Kazan, Russian Federation, [3]Prokhorov General Physics Institute of RAS, Moscow, Russian Federation

Two Y_2SiO_5 (YSO) single crystals doped with 0.001% of the $^{143}Nd^{3+}$ ion (sample I contains only the ^{28}Si isotope, while sample II has the natural abundance of silicon isotopes) have been studied using magnetic resonance methods. The spin-spin and spin-lattice relaxation times were measured at 9.7 GHz in the temperature range between 4 and 10 K. It is established that for both crystals the spin-lattice relaxation is described by three relaxation processes: the direct one-phonon spin-phonon interaction, Raman two-phonon interaction and two-phonon Orbach - Aminov relaxation. It is established that the character of the temperature dependences of spin-spin relaxation times for different hyperfine components of the Nd^{3+} EPR spectrum depends on the value of the applied magnetic field and on the neodymium isotope
(^{143}Nd or ^{145}Nd) [1]. The electron spin echo envelope modulation (ESEEM) spectrum was obtained for Nd^{3+} ions.

This work was supported by the Russian Science Foundation (project no. 16-12-00041).

References:

[1] G.Wolfowicz, H. Maier-Flaig,R.Marino, A. Ferrier, H.Vezin, J.J.L. Morton, P.Goldner, Phys.Rev.Lett.**114**, 170503 (2015)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.637
Phase transitions in a molecular zipper: lee-yang zeros and large deviation statistics
Deger A., Brandner K., Flindt C.
Aalto University, Department of Applied Physics, Aalto, Finland

Originally introduced to explain the behavior of a condensing gas, Lee-Yang zeros have nowadays become a universal and powerful tool for the unified description of phase transitions.Here, we use Lee-Yang zeros to analyze a paradigmatic model for thermal phase transitions in molecular systems.For the most simple version of this model, we explicitly calculate the Lee-Yang zeros with respect to inverse temperature.Extrapolation then allows us to infer a phase transition in the macroscopic limit, from the analysis of systems containing only a few molecular units.In a second step, we increase the complexity of the model.The Lee-Yang zeros can still be obtained using a recently established relation involving high-order cumulants of the energy.Finally, we show that, even when the system does not undergo a phase-transition, the Lee-Yang zeros still encode valuable physical information; they crucially determine the large deviation statistics of energy fluctuations.Specifically we show that the large deviation function generically has the form of an ellipse, whose tilt and width can be inferred from the complex Lee-Yang zeros.Our analysis reveals an interesting duality between the energy fluctuations of small-size systems in equilibrium and their phase-behavior in the thermodynamic limit.
References:
[1] C. Flindt, and J. P. Garrahan, Phys. Rev. Lett. **110**, 050601 (2013)
[2] K. Brandner, V. F. Maisi, J. P. Pekola, J. P. Garrahan, and C. Flindt, arXiv:1610.08669 (2016)
[3] A. Deger, K. Brandner, and C. Flindt (2017 - In preparation)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.639
One- and three-dimensional transitions of ^{4}He superfluid films formed in nanopores
Wada N.[1], Matushita T.[1], Suzuki T.[1], Urano S.[1], Muraki T.[1], Toda R.[2], Hieda M.[3]
[1]Nagoya University, Department of Physics, Nagoya, Japan, [2]University of Tokyo, Cryogenic Research Center, Tokyo, Japan, [3]Tokyo Medical and Dental University, College of Liberal Arts and Sciences, Ichikawa, Japan

A ^{4}He film formed on a flat solid surface is known to show the most typical 2D Kosterlitz-Thouless transition [1]. Here, we studied transitions of ^{4}He films formed on the pore walls of 1D and 3D nanopores, by measuring the superfluid frequency shift of a torsional oscillator and the heat capacity. In the case of the ^{4}He nanotubes formed in the 1D nanopores, we observed the superfluid shift in the 1 D state[2]. The observed superfluid shows the dependences on the nanotube diameter *d'* and the tube length *L* [3]. The system size dependence for *d'* and *L* can be understood as a finite 1D length dependence of the Tomonaga-Luttinger Boson liquid[4]. In the 3D nanopores, the ^{4}He films are connected in 3D with a period, typically 5.5 or 3nm, than which the thermal de Broglie wave length becomes longer at sufficiently low temperatures. Obviously different from the KT transition of the 2D film, this 3D-connected film shows a 3D transition with a sharp heat capacity peak[5]. The peak height becomes large with decreasing the 3D period.

References:
[1] M. Hieda, *et al.,* J. Phys. Soc. Jpn. **78**, 033604 (2009)
[2] H. Ikegami, *et al.,* Phys. Rev. B **76**, 144503 (2007)
[3] T. Matsushita, *et al.,* J. Low Temp. Phys. **183**, 273 (2016)
[4] D. Maestro, *et al.,* Phys. Rev. Lett. **106**,105303 (2011)
[5] R. Toda, *et al.,* Phys. Rev. Lett. **99**,255301 (2007)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.640
Spin liquid heat capacities at ultra-low temperatures

Wada N.[1], Hara Y.[1], Matushita T.[1], Mizuno A.[2], Shuku Y.[3], Awaga K.[2]
[1]Nagoya University, Department of Physics, Graduate School of Science, Nagoya, Japan, [2]Nagoya University, Department of Chemistry & IRCCS, Nagoya, Japan, [3]Nagoya University, VBL, Nagoya, Japan

Different from the Néel state and the quantum singlet dimers, a spin liquid ground state have been recently proposed for some antiferromagnets. Possibility of the liquid state has been proved by measuring a small but non-zero magnetic susceptibility and a finite heat capacity of C/T at the lowest temperature measured. Here, we measured the heat capacity in a wide temperature range down to 67mK for the possible spin liquid of an organic hyper-Kagomé lattice Mott-dimer magnet. Above about 1.8K, the phonon heat capacity ($C=\beta T^3$, β= 3.2×10^{-5}J K^{-4} g^{-1}) steeply increases to be dominant compared with the spin liquid heat capacity. While, below 1 to 0.2K, 90-100% of the observed heat capacity is that of the spin liquid. Below 0.2K to 67mK, upturn as $C=a/T^2$, where a=1.34×10^{-7}J K g^{-1}, is likely to be of the nuclear spins and/or magnetic impurities with very small interactions of the order of 1mK. The observed spin liquid heat capacity can be fitted with a power law of $C=bT^{0.62}$, where b=0.15mJ K$^{-1.62}$ g^{-1}, in the wide temperature range between 0.07 and 4.5K.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.641
Controllable frequency comb generation in a tunable superconducting coplanar waveguide resonator

Wang S.-P.[1], Li T.-F.[2], Wang Y.-P.[1], Zhang D.[1], Luo X.-Q.[1], Chen Z.[1], You J.Q.[1]
[1]Beijing Computational Science Research Center, Quantum Physics and Quantum Information Division, Beijing, China, [2]Tsinghua University, Tsinghua National Laboratory of Information Science and Technology, Institute of Microelectronics, Beijing, China

Frequency combs have attracted considerable interest because they are extremely useful in a wide range of applications, such as optical metrology and high precision spectroscopy. Here we report the design and characterization of a controllable frequency comb generated in a tunable superconducting coplanar waveguide resonator in the microwave regime. Two-tone pump is applied at one of the resonance modes, comb generation is observed just nearby the resonance frequency. Both the center frequency and teeth density of the comb are precisely controllable. The teeth spacing can be adjusted from Hz to MHz. The experimental results can be well explained via theoretical analysis.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.642

High density atomic hydrogen and tritium stabilized in solid molecular films at temperatures below 1K.

Vasiliev S.[1], *Sheludiakov S.*[1], *Ahokas J.*[1], *Järvinen J.*[1], *Lee D.M.*[2], *Khmelenko V.V.*[2]
[1]University of Turku, Physics and Astronomy, Turku, Finland, [2]Texas A&M University, College Station, United States

We report on the experimental study of atomic hydrogen and tritium trapped in thin films of solid T_2:H_2 mixtures at temperatures below 1 K. Dissociation of atoms occur in situ in the films due to the 5.7 keV electrons resulting from the decay of tritium. This method provides highest densities of atomic hydrogen isotopes in molecular solids: 10^{20} cm^{-3} for H and $2*10^{20}$ cm^{-3} for T [1]. At film thickness exceeding 100 nm we observed spontaneous explosive recombination of atoms with partial evaporation of the film. The atoms are studied by means of Electron Spin Resonance at 130 GHz. In addition to the ESR lines of trapped atoms, we observed signals from the electrons trapped in the films and on their surface [2]. A broad singlet ESR line was observed in the center of the spectrum, which remained after evaporation of the T_2:H_2 film and warming up the sample cell to temperatures about 150 K. We attribute this line to the clusters of T atoms trapped in the metallic mirors of the ESR cavity.

References:

[1] S. Sheludiakov *et. al*,.Phys. Chem. Chem. Phys, **19**, 2834 (2017)
[2] S. Sheludiakov *et. al*., JLow Temp Phys, **183**, 120 (2016)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.643

Multiferroics in spin frustrated system Cu_2OCl_2

Wu H.C.[1], *Yuan J.K.*[1], *Chandrasekhar K.D.*[1], *Wang C.W.*[2], *Chen J.M.*[2], *Lin J.-Y.*[3], *Yang H.D.*[1]
[1]National Sun Yat-Sen University, Department of Physics, Kaohsiung, Taiwan, Republic of China, [2]National Synchrotron Radiation Research Center, Hsinchu, Taiwan, Republic of China, [3]National Chiao Tung University, Hsinchu, Taiwan, Republic of China

The Cu_2OCl_2 polycrystalline sample was synthesized by solid-state reaction method and characterized using X-Ray diffraction (XRD). The DC magnetization, specific heat and neutron diffraction confirm antiferromagnetic ordering (T_N) near 70 K. Ferroelectricity close to 75 K is determined from dielectric constant and pyroelectric current measurements. In ferroelectric region at 40 K, the magnetodielectric (MD) shows a linear behavior with a significant change of 0.03% at 5 T indicates that the MD effect is associated to the magnetic structure of Cu_2OCl_2. The evolution of the (2 6 2) and (2 2 6) Bragg reflections based on orthorhombic structure at 148 K tends to merge into a single peak near and below T_N The structural transformation observed from a plot of volume vs. temperature is considered to be the key origin to induce ferroelectricity. The mechanism of multiferroic behavior is related to the inverse Dzyaloshinskii-Moriya (DM) interaction. Our novel findings will stimulate the theoretical and experimental researchers to explore high T_C multiferroic.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.644

Superconducting gap stabilized by artificial quasiparticle dissipation above the transition temperature

Yamada Y., *Ogawa T.*
Osaka University, Department of Physics, Osaka, Japan

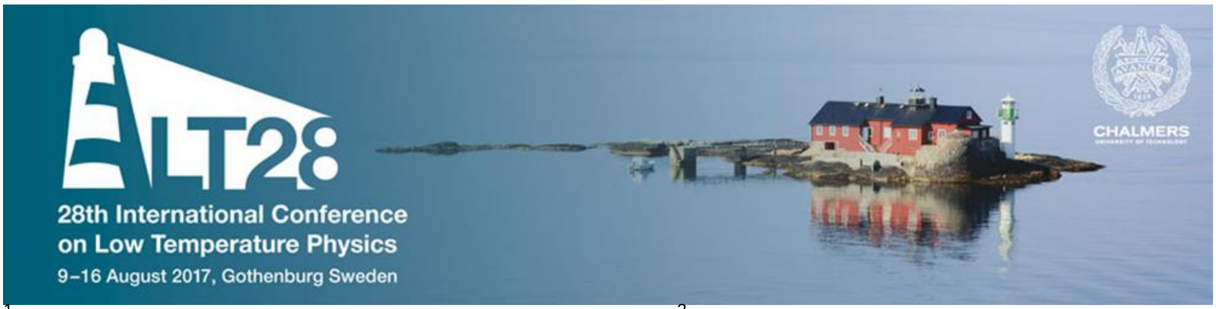
Establishing the stable superconductivity at higher temperature is the one of the most fascinating challenges in science and technology. The superconductivity per se appears typically near the zero temperature. The considerable difficulty in stabilizing superconductivity arises from the thermal excitation of the quasiparticles, which leads to the closing of the superconducting gap.
To enhance the stability of superconductivity in the thermal environment, here, we theoretically propose a useful dissipation that gets rid of the harmful quasiparticles and prevents the gap closing. Solving the quantum master equation and the superconducting gap equation simultaneously, we investigate the steady state of the s-wave superconductor in thermal bath with the artificial quasiparticle dissipation. From the analytical calculation, we find that the superconducting state is always stable in the presence of dissipation even above the original transition temperature, Tc. When the bath temperature T is larger than Tc, the superconducting gap shows a power-law decay of T with the exponent given by the inverse of the dimensionless strength of dissipation. We also propose a feasible system where the dissipation can be induced: mesoscopic semiconductor-superconductor junction.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.645

Excitonic fluctuation and collective excitations in cobalt oxides

Yamaguchi T.[1], *Sugimoto K.*[2], *Ohta Y.*[1]



[1]Chiba University, Depertment of Physics, Chiba, Japan, [2]Chiba University, Center for Frontier Science, Chiba, Japan

The excitonic phase (EP) is representative of a fermion pair condensation, where holes in valence bands and electrons in conduction bands spontaneously form pairs owing to attractive Coulomb interaction [1]. $Pr_{0.5}Ca_{0.5}CoO_3$ (PCCO) is one of the candidate materials of the EP [2]. Kuneš and Augustinský suggested the anomalous features of PCCO can be attributed to the EP transition, using the dynamical mean-field theory on the two-orbital Hubbard model as well as the first-principles band calculation [2]. The excitonic condensation and its collective excitations in the spin-pseudospin model were also studied [3].
Motivated by such developments in the field, we study the EP of PCCO using a realistic five-orbital Hubbard model [4]. Using the noninteracting tight-binding bands determined from first principles, we examine the spin susceptibility in the normal state in the random phase approximation (RPA) and show the instability toward the EP. We then show by the mean-field calculations that the ground state of this model is the EP with the magnetic multipole order. We also calculate the dynamical susceptibility of the spin-transverse and spin-longitudinal modes in the EP using the RPA and clarify the presence of the gapless Goldstone and gapful Higgs modes in the excitation spectra.

References:

[1] Y. Ohta, T. Kaneko, and K. Sugimoto, Solid State Physics **52**, 119 (2017) [in Japanese].
[2] J. Kuneš and P. Augustinský, Phys. Rev. B **90**, 235112 (2014).
[3] J. Nasu, T. Watanabe, M. Naka, and S. Ishihara, Phys. Rev. B **93**, 205136 (2016).
[4] T.Yamaguchi, K. Sgimoto, and Y. Ohta, J. Phys. Soc. Jpn. **86**, 043701 (2017)

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.646

Magnetic properties of quasi-two-dimensional *S* = 1/2 Heisenberg antiferromagnet with distorted square lattice

<u>Yamaguchi H.</u>[1], Iwasaki Y.[1], Hosokoshi Y.[1], Kida T.[2], Hagiwara M.[2]
[1]Osaka Prefecture University, Sakai, Japan, [2]Osaka University, Toyonaka, Japan

Many model compounds for the S = 1/2 square lattice Heisenberg antiferromagnet (SLHAF) have been reported to date, the majority of which are based on copper oxide. Although experimental studies have revealed the fundamental properties on such compounds, the large exchange interactions of the copper oxides have rendered complete examination of the field dependence of the magnetic behavior difficult. We report a new model compound of the S = 1/2 SLHAF. We successfully synthesize single crystals of the verdazyl radical α-2,3,5-Cl_3-V. The two dominant antiferromagnetic interactions form an S = 1/2 distorted square lattice. We explain the magnetic properties based on the S = 1/2 SLHAF using the quantum Monte Carlo method and examine the effects of the lattice distortion. In the low-temperature regions, we observe anisotropic magnetic behavior accompanied by a phase transition to an ordered state. In addition, we explain the frequency dependence of the electron spin resonance fields in the ordered phase using a mean-field approximation with out-of-plane easy-axis anisotropy.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.647

Observation of spiral flow and vortex induced by suction pump in superfluid ^{4}He

Ohyama K., Yano H., Obara K., Ishikawa O.
Osaka City University, Graduate School of Science, Osaka, Japan

We report a spiral flow and a vortex induced by a suction pump in superfluid ^{4}He. We mounted a cryogenic motor in a cylindrical box with a small hole at the center of the top and a narrow channel at the side, to produce a suction superfluid flow through the small hole. In this setup, we have successfully produced a vortex with a funnel-shape core in superfluid ^{4}He. The circulation of the vortex is estimated to be 4,000~10,000 mm^2/s from the shape of the core, being equal to (4~10)x10^4 κ, where κ is the circulation of the single quantized vortex of superfluid ^{4}He. These results suggest that a suction flow centralizes quantized vortices to the axis of the suction hole, increasing a circulation flow and sucking a free surface down through the hole.

Postersession 2
Saturday, 12 August 2017
16.30-18.30
G Foyer

P.649

First partial cool down of the SPIRAL 2 LINAC

Ghribi A., Bernaudin P.-E., Berthe C., Duteil G., Ferdinand R., Lescalié G., Philippe L., Thivel Y., Trudel A., Vassal A., Rozé J.-F., Touchard D.
GANIL, Accelerator Division, Caen, France

Spiral2 is a rare isotope accelerator dedicated to the production of some of the highest intensity beams on earth. Its driver is a superconducting linear accelerator that takes advantages of 26 bulk niobium quater wave accelerating cavities. It takes up to 1000W@4K, 95 cryo-valves and 22 automations systems to cryogenically operate the LINAC. The talk will present the achievement of years of hardwork to make the first trials of the LINAC partial cool down with its successes and challenges.

References:

[1] A Ghribi, P-E Bernaudin et A Vassal. « Status of the Spiral 2 Cryogenic System (Accepted for publication) ». In: Cryogenics (2017).
[2] A Ghribi et al. « Spiral 2 Cryogenic System for The Superconducting LINAC ». In: IOP Conference Series: Materials Science and Engineering 171.1 (2017), p. 012115. url: http://stacks.iop.org/1757-899X/ 171/i=1/a=012115.

LT28 POSTER SESSION 3

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.650
Low-temperature physical behavior in a novel compound $CePtIn_4$

Bławat J., Gnida D., Daszkiewicz M., Romanova T., Hackemer A., Wiśniewski P., Kaczorowski D.
Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Wrocław, Poland

In the course of our systematic investigation of the heavy-fermion superconductors forming in the Ce-*T*-In (*T* = Pd, Pt) ternary systems, high-quality single crystals of a novel intermetallic phase with high content of indium, viz. $CePtIn_4$, were grown and their low-temperature physical properties were determined.
The compound was found to crystallize with an orthorhombic unit cell of the $YNiAl_4$-type (space group *Cmcm*), reported before for $CeNiIn_4$ [1] and $CePdIn_4$ [2]. It exhibits good metallic conductivity and a Curie-Weiss behavior of rather well localized cerium 4*f* electrons. At T_N = 1.65 K, $CePtIn_4$ orders antiferromagnetically, as indicated by characteristic anomalies in the temperature variations of the magnetic susceptibility, heat capacity and electrical resistivity. Reduced jump in the specific heat at T_N and extended short-range ordering above the Néel temperature signal complex antiferromagnetic structure. The electronic contribution to the specific heat, extracted from the data taken just above T_N, is very small, and the magnetic entropy released in the ordered state is close to *R*ln2. Together with the lack of any hint at appreciable Kondo effect in the electrical resistivity, these features concomitantly suggest that the electronic correlations in $CePtIn_4$ are fairly weak.

References:
[1] H. Shishido, N. Nakamura, T. Ueda, R. Asai, A. Galatanu, E. Yamamoto, Y. Haga, T. Takeuchi, Y. Narumi, T. C. Kobayashi, K. Kindo, K. Sugiyama, T. Namiki, Y. Aoki, H. Sato, and Y. Onuki, J. Phys. Soc. Jpn. **73**, 664 (2004)
[2] S. N. Nesterenko, A. I. Tursina, D. V. Shtepa, H. Noël, and Y. D. Seropegin, J. Alloys Compd. **442**, 93 (2007)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.651
Scandium tunnel junctions and devices

Guthrie A., Kafanov S., Pashkin Y.
Lancaster University, Physics Department, Lancaster, United Kingdom

Aluminium is a commonly used material for the fabrication of high-quality tunnel junctions that find applications in superconducting and hybrid nanoelectronic devices. However, there is often a need for a normal metal that can replace aluminium in electronic applications. The requirements for such a metal are that it must be compatible with the fabrication process used for Al devices and form a high-quality insulating oxide that can be used as a tunnel barrier. Here, we present tunnel-junction devices including a single-electron transistor and Coulomb blockade thermometer made of scandium, a non-superconducting metal that has a valence of three. It forms a stable oxide which is

crystallographically similar to the well--known aluminium oxide, and the oxidation conditions for scandium are similar to those used for aluminium. Using a single scandium--scandium oxide--scandium tunnel junction, we have measured tunnel barrier parameters, which demonstrate the applicability of scandium for mesoscopic devices.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.652

Electron spectra of graphene with local and extended defects

__Sirenko V.__[1], Eremenko V.[1], Gospodarev I.[1], Syrkin E.[1], Feodosyev S.[1], Bondar I.[1], Minakova K.[2]
[1]B. Verkin ILTPE of NASU - B. Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine, Kharkov, Ukraine, [2]National Technical University 'Kharkiv Polytechnic Institute', Kharkov, Ukraine

Distortions of graphene honeycomb structure lift degeneracy of energy spectra of carbon atoms. Green function of graphene suggests a formation of quasi-local states near Fermi energy level ε_F due to defects. Local densities of states (LDOS) near ε_F are studied for graphene with vacancies and edges of different chiralities. “Arm-chair” edge produces gap in LDOS of width up to 50 meV. Energy bands and gap are described here by a function of one-dimensional quasi-wave vector along the edge boundary. A “zig-zag” edge, similar to vacancies, produces sharp resonances in LDOS. Analysis in terms of surface-projected spectral densities [1] explains it by detachment of the wave from the conductance band, propagated along “zig-zag” and attenuated apart from it. Independence of wave energy on quasi-local vector is yielded for nearest-neighbor interactions, in line with appearance of quasi-local level (sharp resonance). For unsaturated dangling bonds on zig-zag atoms, their interactions yield a dispersion relation, a detached wave shift to conductance band, resonance broadening and enhanced charge mobility. Vacancy groups complicate LDOS pattern but near ε_F they still grow. Developed approach is succesfully applied to carbon nano-films. Comparison of calculations and measurements is analyzed.

References:

- A. Maradudin, Surface waves In: Modern Problems of Surface Physics, ISCMP, 11 (1980)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.653

ISRE Spin waves in Spin-polarized atomic hydrogen

__Lehtonen L.__[1], Vainio O.[1], Vasiliev S.[1], Ahokas J.[1], Suominen K.-A.[1], Khmelenko V.V.[2], Lee D.M.[2]
[1]University of Turku, Department of Physics and Astronomy, Turku, Finland, [2]Texas A&M University, Department of Physics and Astronomy and Institute for Quantum Science and Engineering, College Station, United States

Spin state plays a crucial role in the scattering of bosons and fermions. Notably identical fermions in the same spin state do not scatter through the s-wave channel, contrary to those in orthogonal spin

states. Under certain circumstances this kind of behaviour leads to the Identical Spin Rotation Effect (ISRE)[1], which has been used to explain anomalous spin-state segregation in Rb [2] and also affects the coherence properties of atomic clocks [3]. Generally, the transport properties of a gas are modified by ISRE, and under suitable circumstances spin currents may form relatively long-lived precessing structures, spin waves.
We have already reported on trapping electron spin waves[4] and BEC of magnons[5]; in this work we focus on modeling some of the observed electron spin resonance spectra in spin-polarized atomic hydrogen. Analytic solutions are found for the ISRE spin diffusion equation under experimentally relevant circumstances, yielding the spin wave profiles and their lifetimes. These are then used to calculate the ESR absorption spectra.

References:

[1] C. Lhuillier, F. Laloë, J. Phys. France 43, 197-224 (1982)
[2] J. Fuchs et al., PRL 88, 230404 (2002)
[3] C. Deutsch et al., PRL 105, 020401 (2010)
[4] O. Vainio et al., PRL 108, 185304 (2012)
[5] O. Vainio et al., PRL 114, 125304 (2015)

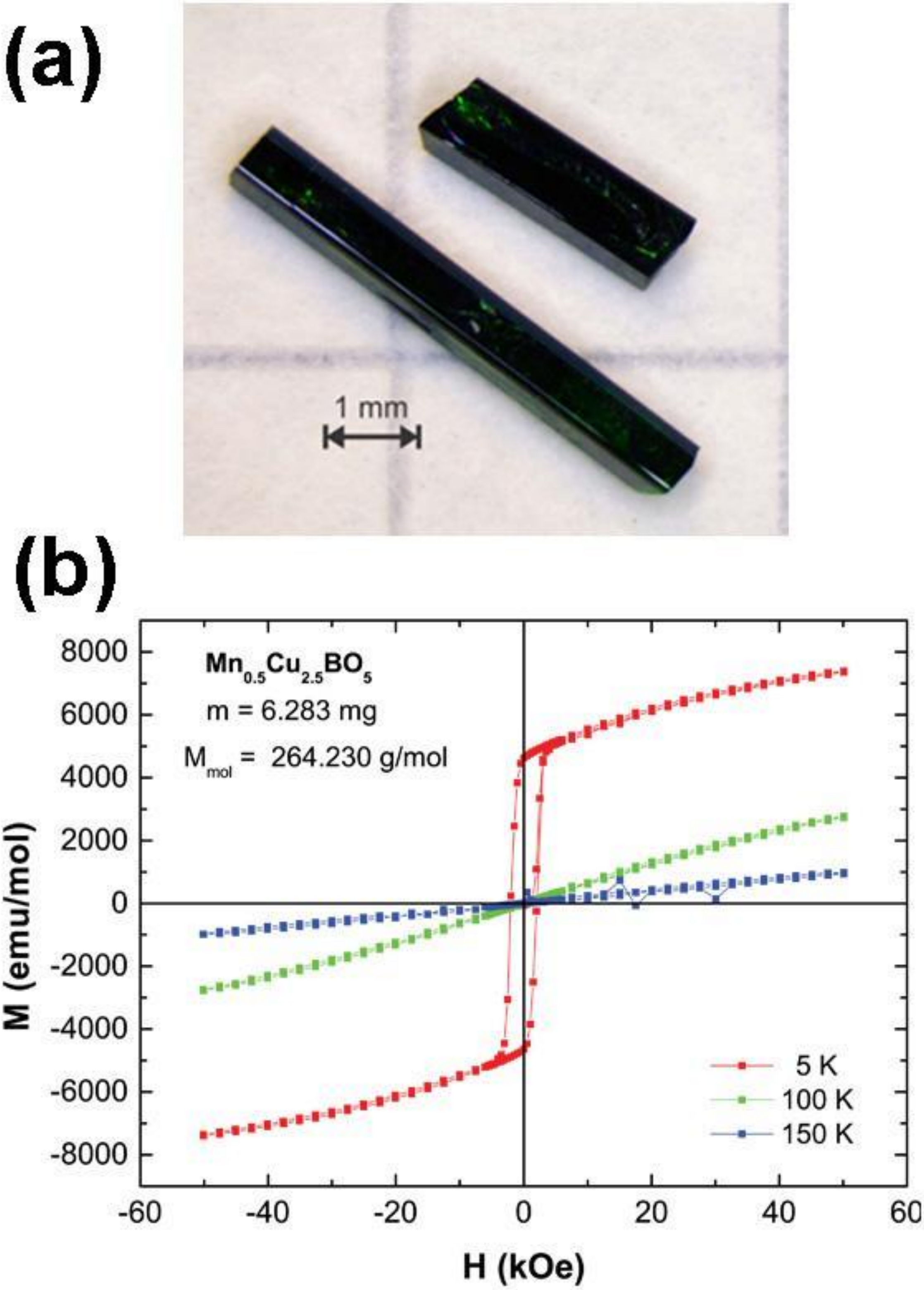
Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.654

Magnetic properties of ludwigites

Eremina R.[1,2], *Gavrilova T.*[1,2], *Krug von Nidda H.-A.*[3], *Moshkina E.*[4], *Bezmaternykh L.*[4]
[1]Kazan E. K. Zavoisky Physical -Technical Institute, Kazan, Russian Federation, [2]Kazan Federal University, Kazan, Russian Federation, [3]Augsburg University, Augsburg, Germany, [4]Kirensky Institute of Physics, Krasnoyarsk, Russian Federation

Here we present the investigations of structural and magnetic properties of Cu-based compounds of the ludwigite family: Cu_2GaBO_5 and $Cu_{2.5}Mn_{0.5}BO_5$. The results of the first studies of the structural and magnetic properties of ludwigite are very interesting [1]. The important peculiarity of the presenting here type of ludwigite is the presence of two Jahn-Teller cations in the structure. Because of the strong distortions of the nearest surroundings of Mn and Cu ions the original magnetic structure is expected. The Cu_2GaBO_5 and $Cu_{2.5}Mn_{0.5}BO_5$ single crystals (the max. size: 4x10x3 mm^3) were synthesized by the flux method in the form of orthogonal prisms (Fig. 1a). The synthesized samples have a monoclinic symmetry and belong to the $P2_1/c$ space group. Field-thermal dependencies of the magnetization measurements revealed the paramagnetic-ferrimagnetic phase transition at Tc≈80 K. Field dependencies of magnetization are presented in Fig.1b at 5, 100 and 150K. The behavior of magnetization is paramagnetic at 100 and 150K. The narrow hysteresis loop is observed at 5K.


(a)
1 mm
(b)
$Mn_{0.5}Cu_{2.5}BO_5$
m = 6.283 mg
M_{mol} = 264.230 g/mol
M (emu/mol)
H (kOe)
5 K
100 K
150 K
8000
6000
4000
2000
0
-2000
-4000
-6000
-8000
-60
-40
-20
0
20
40
60

[Fig.1]

a) Temperature dependencies of magnetic susceptibility of Cu_2GaBO_5 monocrystal; b) Field dependence of the magnetization of the $Cu_{2.5}Mn_{0.5}BO_5$ ludwigite.

This work was supported by the RFBR no 17-02-00953.

References:

[1] L.Bezmaternykh et.al. *SSP*, **233-234**, 133 (2015)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

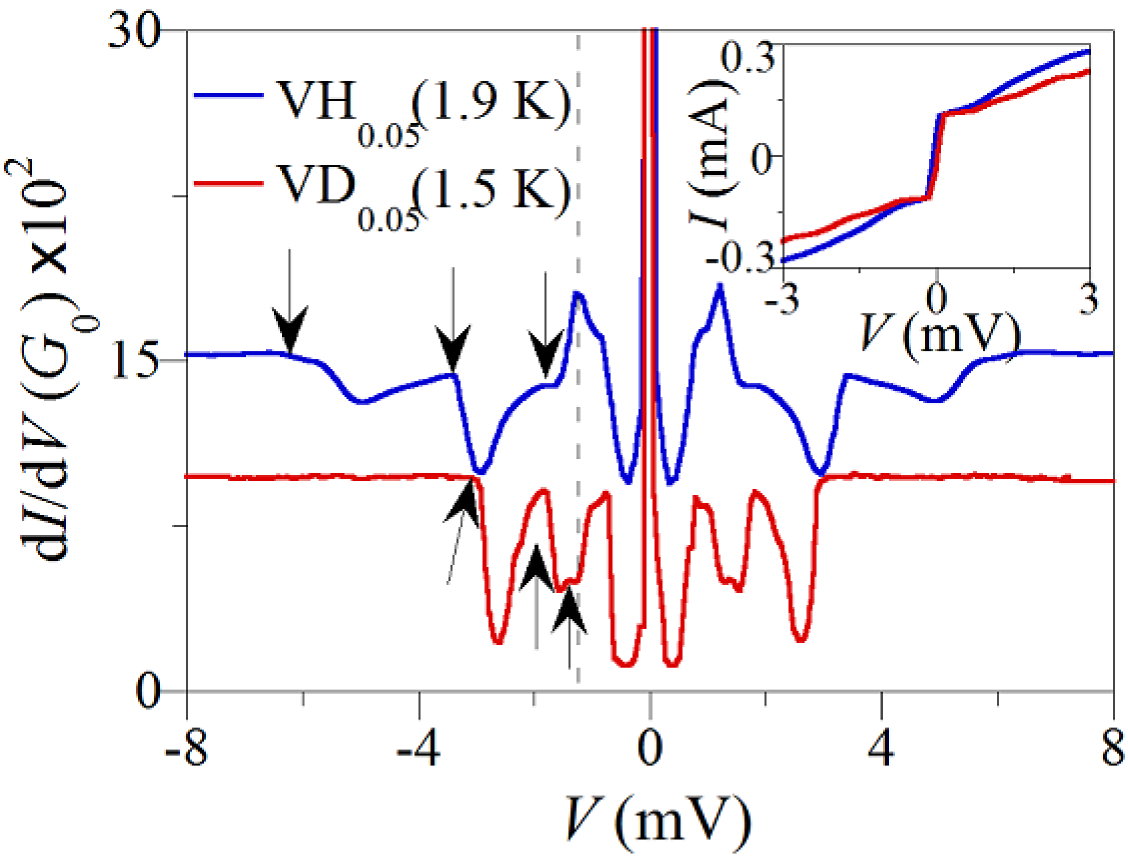
P.655

Impurity effects of hydrogen and deuterium in vanadium constrictions

Islam M.S., Ueno Y., Takata H., Inagaki Y., Hashizume K., Kawae T.
Kyushu University, Fukuoka, Japan

To study non-magnetic and magnetic impurity effects at the superconductor-normal metal (SN) interfaces, we have measured the differential conductance d*I*/d*V* spectra for Josephson contacts made by vanadium (V) nanoconstrictions with a small amount of hydrogen (H) and deuterium (D) impurities. H atoms are generally absorbed to be almost neutral condition in metals, act as a composite boson. On the other hand, D as an isotope of H, shows half-integer spin like fermion due to its constituent particles of neutron (I = 1/2). Josephson contacts are prepared by a mechanically controllable break junction technique.

The spectra of d*I*/d*V* for V nanocontacts consisting 5% of H and D is shown in Fig. 1. Below the superconducting transition temperature T_c, the contact exhibits a series of conductance enhancements outside the superconducting energy gap, referred as an over-the-gap structure (OGS) indicated by the black arrows. The appearance of sub-gap structures within the energy gap Δ is comparatively blurred due to the suppression of multiple Andreev reflections [1]. Similar findings are experimentally mentioned in both the symmetric and asymmetric Nb dimer contacts [2]. The corresponding Josephson currents are shown in the inset. The dashed line indicates the 2Δ gap of vanadium.



[Fig. 1. The observed spectra of dI/dV for VH0.05.]

References:
[1] M. Octavio, *et al*., Phys. Rev. B **27**, 6739 (1983)
[2] A. Marchenkov, *et al*., Nature Nanotech. **2**, 481 (2007)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.657
Multiplying microwave photons by inelastic Cooper-pair tunneling
Leppäkangas J.[1], *Marthaler M.*[1], *Hazra D.*[2], *Jebari S.*[2], *Johansson G.*[3], *Hofheinz M.*[2]
[1]Karlsruhe Institute of Technology, Karlsruhe, Germany, [2]Université Grenoble Alpes - INAC-SPSMS, Grenoble, France, [3]Chalmers University of Technology, Gothenburg, Sweden

The interaction between propagating microwave fields and Cooper-pair tunneling across a DC voltage-biased Josephson junction can be highly nonlinear. We show theoretically that this nonlinearity can be used to convert an incoming single microwave photon into an outgoing n-photon Fock state in a different mode. In this process the Coulomb energy released by Cooper-pair tunneling is transferred to the outgoing Fock state, providing energy gain. The conversion can be made reflectionless

(impedance-matched) so that all incoming photons are converted to n-photon states. With realistic parameters multiplication ratios n > 2 can be reached. By cascading two to three multiplications, the outgoing Fock-state number can get sufficiently large to accurately discriminate it from vacuum with linear post-amplification and power measurement. Our scheme can therefore be used as single-photon detector without dead time.

References:

[1] J. Leppäkangas, M. Marthaler, D. Hazra, S. Jebari, G. Johansson, and M. Hofheinz, arXiv:1612.07098

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

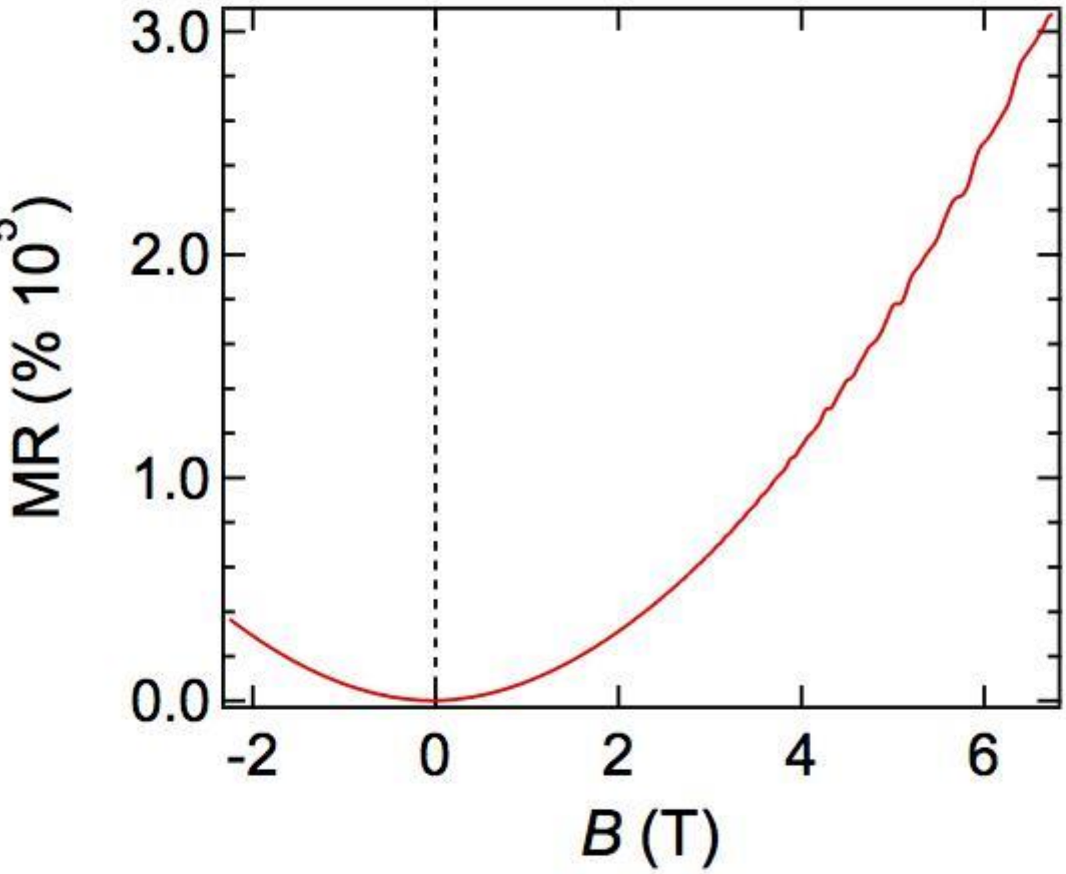
P.658

Extremely large magnetoresistance in a high-quality WTe_2 grown by flux method

Tsumura K.[1], *Yano R.*[1], *Kashiwaya H.*[1], *Koyanagi M.*[1], *Masubuchi S.*[2], *Machida T.*[2], *Namiki H.*[3], *Sasagawa T.*[3], *Kashiwaya S.*[1]

[1]National Institute of Advanced Industrial Science and Technology (AIST), Electronics and Photonics Research Institute, Tsukuba, Japan, [2]University of Tokyo, Institute of Industrial Science, Meguro, Japan, [3]Tokyo Institute of Technology, Laboratory for Materials and Structures, Yokohama, Japan

Layered transition metal dichalcogenide WTe_2 has attracted much attention; a bulk WTe_2 is considered as a type-II Weyl semimetal and a monolayer is expected to be a two-dimensional topological insulator. Recently, Ali *et al*. reported an extremely large magnetoresistance (XMR) with no saturation in a bulk WTe_2 [1]. Here, we report an improvement of XMR in a WTe_2 grown by a flux method. The measurements were carried out using a thin WTe_2 film prepared by mechanical exfoliation on a degenerately doped Si substrate covered with a thermally oxidized SiO_2 layer. Electrical contacts were directly connected to WTe2 using silver paste right after the exfoliation. Figure 1 shows the magnetoresistance as a function of a magnetic field applied parallel to the *c* axis at 1.7K. The XMR as large as 307,800% is achieved in an applied magnetic field of 6.75T. We discuss the correlation between the crystal quality and the magnitude of XMR in WTe_2.



[Fig. 1]

References:

[1] M. N. Ali *et al*., Nature **514**, 205 (2014).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.659

Materials´ specific theory expounding high-temperature superconductivity in monolayer FeSe/SrTiO$_3$

Aperis A., *Oppeneer P.M.*
Uppsala University, Physics & Astronomy, Uppsala, Sweden

Superconductivity in monolayer FeSe on SrTiO$_3$ reaches mysteriously high transition temperatures of typically 50-70 K [1,2] and up to 100 K [3], much higher than the T_c=8 K of bulk FeSe. At the FeSe/SrTiO$_3$ interface, a coupling between SrTiO$_3$ phonons and FeSe electrons that manifests as

electron replica bands [2], is commonly believed to enhance T_c moderately but not enough to fully explain it.
Here, we present anisotropic, full bandwidth multiband Eliashberg calculations to examine the impact of these phonons on the superconducting state of $FeSe/SrTiO_3$ [4]. We find that the interfacial electron-phonon interaction which is hidden behind the seemingly weak coupling constant, λ=0.4 [2,5], fully accounts for the high-T_c while also solving puzzling experimental facts like the s-wave symmetry [6] and replica bands.
Our calculations indicate that replica band formation has a T_c-decreasing effect which is nevertheless overcompensated by T_c-enhancing Cooper pairing at bands away from the Fermi level. We predict this mechanism to produce a strong coupling dip-hump signature in the tunneling spectra.

References:

[1] W. Qing-Yan et al., Chin. Phys. Lett., **29**, 037402 (2012).
[2] J. J. Lee et al., Nature, **515**, 245 (2014).
[3] J.F. Ge et al., Nature Materials, **14**, 285 (2015).
[4] A. Aperis and P.M. Oppeneer, arXiv:1701.08136 (2017).
[5] Y. C. Tian et al., Phys. Rev. Lett., **116**, 107001 (2016).
[6] Q. Fan et al., Nature Physics, **11**, 946 (2015).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.660

Optimal quantum interference thermoelectric heat engine with edge states

Samuelsson P.[1], *Kheradsoud S.*[1], *Sothmann B.*[2]
[1]Lund University, Physics Department, Lund, Sweden, [2]Universität Duisburg-Essen, Faculty of Physics, Duisburg, Germany

We show theoretically that a thermoelectric heat engine, operating exclusively due to quantum-mechanical interference, can reach optimal linear-response performance [1]. A chiral edge state implementation of a close-to-optimal heat engine is proposed in an electronic Mach-Zehnder interferometer with a mesoscopic capacitor coupled to one arm. We demonstrate that the maximum power and corresponding efficiency can reach 90% and 83%, respectively, of the theoretical maximum. The proposed heat engine can be realized with existing experimental techniques and has a performance robust against moderate dephasing.

References:

[1] P. Samuelsson, S. Kheradsoud, B. Sothman, arXiv:1611.02997

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.661

Resistivity plateau and extreme magnetoresistance in LuAs

Rudenko A.[1], *Juraszek J.*[1], *Bochenek L.*[1], *Samsel-Czekala M.*[1], *Wang Z.*[2], *Wosnitza J.*[2], *Henkie Z.*[1], *Cichorek T.*[1]
[1]Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Wroclaw, Poland, [2]Hochfeld Magnetlabor, Helmholtz-Zentrum, Dresden-Rossendorf, Germany

Results of various transport experiments in transverse and longitudinal fields show that a cubic semimetal LuAs has similar magnetotransport characteristics as those of nearly compensated semimetals hosting Weyl fermions. This holds especially true for an extremely large magnetoresistance (XMR close to 400 000 % at 60 T and 5 K) without any sign of saturation and a field-induced up-turn in the resistivity followed by a plateau upon cooling below about 20 K. However, the results of first principles calculations indicate that a band inversion necessary for topological nontriviality is absent in LuAs. Therefore, a negative longitudinal magnetoresistance below 50 K is truly unexpected result for a regular semimetal such as LuAs. These observations together with a weak sample dependence of our LuAs single crystals indicate that this first heavy rare-earth-based material with XMR is highly suited for further experimental studies and theoretical calculations. Finally, tentative results of Nernst effect measurements will be presented.
Acknowledgments: This work was supported by the Polish National Science Centre within Grant No. 2016/21/B/ST3/02361.

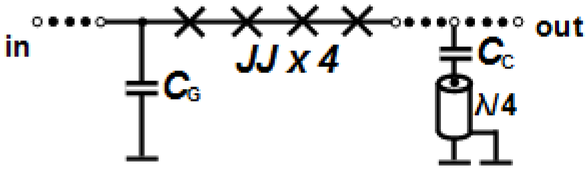
Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.662

Broadband Josephson parametric amplifiers using CLIP junctions

Elo T.[1], *Vesterinen V.*[2], *Simbierowicz S.*[2], *Lähteenmäki P.*[1], *Hassel J.*[2], *Hakonen P.*[1]
[1]Aalto University, Low Temperature Laboratory, Department of Applied Physics, Espoo, Finland, [2]VTT Technical Research Centre of Finland, Espoo, Finland

Low-noise amplification of microwave signals is a key requirement in numerous nanoelectronics experiments, including qubit readout, optomechanics and shot noise spectrometry. Lower system noise temperatures can be reached with superconductive parametric amplifiers which, however, have suffered from limited bandwidth and/or modest gain. Recently, a promising solution utilizing Josephson junctions has been introduced, namely the Josephson traveling wave parametric amplifier (JTWPA) [1] which is a nonlinear lumped-element transmission line formed by series inductance of Josephson junctions and shunt capacitors to ground as shown in Fig. 1. The nonlinearity of the device causes nonlinear dispersion at the pump frequency which is compensated with coupled resonators placed along the line.



[Figure 1]

Our JTWPA has been fabricated using Niobium CLIP junction process developed at VTT. In addition to JTWPA, we have realized simple Josephson LC resonator amplifiers where bandwidth is improved with impedance matching [2]. We present experimental results on these amplifiers, showing both high gain and noise performance approaching the standard quantum limit.

References:

[1] C. Macklin, *et al.,* Science **350**, 307 (2015).
[2] T. Roy, *et al.*, Appl. Phys. Lett. **107**, 262601 (2015).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.663
Anisotropy-induced transitions in superfluid ^{3}He
Nguyen M., Zimmerman A., Halperin W.
Northwestern University, Physics and Astronomy, Evanston, United States

Superfluid ^{3}He in the presence of silica aerogel is a model system to study the effects of disorder in condensed matter physics. Using NMR spectroscopy, we have uncovered strikingly different phase diagrams of superfluid ^{3}He in the presence of isotropic versus anisotropically distributed impurities. Anisotropy, introduced through either negative or positive strain on the aerogel, provides experimental control of the order parameter symmetry. Here we report observations of a strain-driven transition in the preferred direction of the order parameter of the B-like superfluid phase of ^{3}He in negatively strained aerogel. The interplay between strain and other control parameters such as pressure and magnetic field will also be discussed. Our NMR results show that strain introduces a new length scale to the system that affects the stability of phases and textures. This work was supported by the National Science Foundation, DMR- 1602542.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.664
Superconducting quantum interference through trivial edge states in InAs
de Vries F.K.[1], Timmerman T.[1], Ostroukh V.P.[2], van Veen J.[1], Beukman A.J.A.[1], Qu F.[1], Nguyen B.-M.[3], Yi W.[3], Sokolich M.[3], Manfra M.J.[4], Marcus C.M.[5], Kouwenhoven L.P.[1,6]
[1]QuTech and Kavli Institute of Nanoscience, Delft University of Technology, Delft, Netherlands, [2]Instituut-Lorentz Universiteit Leiden, Leiden, Netherlands, [3]HRL Laboratories, Malibu, California, United States, [4]Purdue University, West Lafayette, Indiana, United States, [5]Center for Quantum Devices, University of Copenhagen, Copenhagen, Denmark, [6]Microsoft Station Q at Delft University of Technology, Delft, Netherlands

Josephson junctions of strong spin orbit semiconductors are a highly interesting system for the search for topological states of matter. However, next to the predicted topological edge states in these systems, trivial edge conduction could also emerge[1]. Here we study these trivial edge states by performing superconducting quantum interference measurements on ballistic and gate tunable InAs Josephson junctions, which are known to be non-topological. In the open regime, a Fraunhofer interference pattern is observed as expected, originating from a uniform current density profile[2]. When we almost pinch off the supercurrent with the gate, a SQUID interference pattern is measured. This pattern is clear evidence of supercurrent through trivial edge states. In an intermediate gate regime, a highly unusual even-odd SQUID interference pattern is found, having a Φ_0 and $2\Phi_0$ contribution at the same time. Based on a tight binding model we show that this $2\Phi_0$ contribution could be due to single electron interference arising from non-local Andreev reflection processes. Together, these observations demonstrate and give insight in superconducting transport through trivial edge states, which is important for future studies of two-dimensional topological systems.

References:
[1] Nichele et al. New J. Phys. 18 083005 (2016)
[2] R. C. Dynes and T. A. Fulton, Phys. Rev. B 3, 3015 (1971)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.666
Thermal conductivity of 3He confined in micron sized channels

Parpia J., Eyal A., Zhelev N., Abhilash T.S., Pawakapan P., Smith E.
Cornell University, Department of Physics, Ithaca, United States

We describe the design and (hopefully) results of experiments on the thermal conductivity of 3He confined to nanofabricated channels of ~1 um height, fabricated in silicon that is anodically bonded to glass. Two channels have been mounted, one with a fixed 1.1 um separation and a second having modulated height with separations of 1.1 and 1.3 um. The channels separate a 3He filled chamber of small volume containing a fork thermometer/heater from a silver heat exchanger filled with 3He, which contains an identical fork thermometer. There are two different regimes which are expected to present different behaviors. The first is the normal state of 3He, in which a crossover from Fermi-liquid (inelastic scattering length varying as T^{-2}) to mean free-path-limited behavior (scattering length dominated by boundaries) is anticipated. The second is in the superfluid, where, even at low pressures, interfaces between the different superfluid phases are expected for these geometries.
Research at Cornell supported by the NSF under DMR 1202991

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.667
Thermoelectric transport properties in graphene connected molecular junctions

Rodriguez S.[1], Grosu I.[2], Crisan M.[2], Tifrea I.[1]
[1]California State University Fullerton, Fullerton, United States, [2]'Babes-Bolyai' University, Cluj, Romania

We study the main thermoelectric properties of a molecular junction consisting of a single quantum dot coupled to graphene external leads. The system electrical conductivity (G), Seebeck coefficient (S), and the thermal conductivity (κ), are numerically calculated based on a Green´s function formalism that includes contributions up to the Hartree-Fock level. We consider the system leads to be made either of pure or gapped-graphene. To describe the free electrons in the gapped-graphene electrodes we used two possible scenarios, the massive gap scenario, and the massless gap scenario, respectively. In all cases, the Fano effect is responsible for a strong violation of the Wiedemann-Franz law and we found a substantial increase of the system figure of merit ZT due to a drastic reduction of the system thermal coefficient. In the case of gapped-graphene electrodes, the system figure of merit presents a maximum at an optimal value of the energy gap of the order of

$\Delta/D\sim$ 0.002 (massive gap scenario) and $\Delta/D\sim$ 0.0026 (massless gap scenario). Additionally, for all cases, the system figure of merit is temperature dependent.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.669

Thermoluminescence during the destruction of molecular nitrogen nanoclusters containing stabilized N, O and H or D atoms

Khmelenko V.V.[1], *McColgan P.T.*[1], *Meraki A.*[1], *Boltnev R.E.*[2], *Lee D.M.*[1]
[1]Texas A&M University, Department of Physics and Astronomy, College Station, United States,
[2]Branch of Talroze Institute for Energy Problems of Chemical Physics, Russian Academy of Sciences, Chernogolovka, Russian Federation

We studied thermoluminescence of ensembles of molecular nitrogen nanoclusters containing high concentrations of stabilized nitrogen atoms as well as small quantities of oxygen and hydrogen or deuterium atoms. Ensembles of molecular nitrogen nanoclusters were formed in bulk superfluid helium at T=1.5 K by injection of a molecular nitrogen-helium gas jet containing small admixtures of O_2 and H_2 or D_2 molecules after passing through a radio-frequency discharge zone.[1] Warming of these ensembles of nanoclusters initiated fast recombination of stabilized nitrogen atoms resulting in explosive destruction of nanoclusters accompanied by bright flashes. The spectra of these flashes contain the Vegard-Kaplan bands of N_2 molecules, the M- bands of NO molecules, the alpha-group of N atoms, the beta-group of O atoms and the gamma-line of N^- anions.[2] In addition, a broad band at 360 nm and a line at 472 nm were present in the spectra. The origin of these latter spectral features will be discussed.

References:

[1] A. Meraki, S. Mao, P. T. McColgan, R. E. Boltnev, D.M. Lee, V. V. Khmelenko, Thermoluminescence Dynamics During Destruction of Porous Structures Formed by Nitrogen Nanoclusters in Bulk Superfluid Helium, J. Low Temp. Phys. **185**, 269-286 (2016).
[2] R.E. Boltnev, I.B. Bykhalo, I.N. Krushinskaya, A.A. Pelmenev, S. Mao, A. Meraki, P.T. McColgan, D.M. Lee, and V.V. Khmelenko, Spectroscopic observation of nitrogen anions N^- in solid matrices, Phys. Chem. Chem. Phys. **18**, 16013-16020 (2016).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

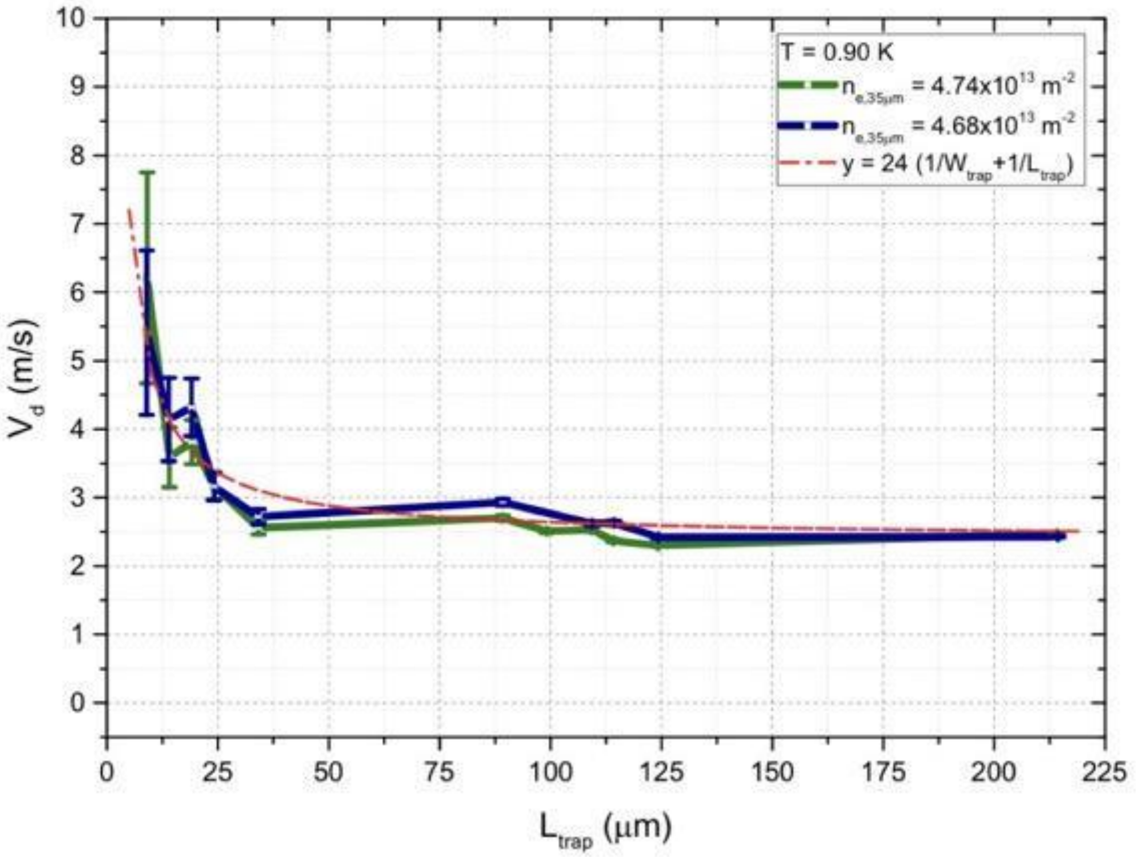
P.670

Finite-size effects on sliding of Wigner solid on the surface of liquid helium

Lin J.-Y., *Smorodin A.*, *Badrutdinov A.*, *Konstantinov D.*
Okinawa Institute of Science and Technology (OIST) Graduate University, Okinawa, Japan

Mechanism of friction is of general interest. However, its comprehensive theory is missing. A moving Wigner Solid (WS) of surface-state electrons on liquid helium offers unique opportunity to study the friction between a rigid periodic structure and a soft substrate. For small driving forces, WS is strongly coupled to the surface deformations due to resonant scattering of ripplons. At higher driving forces, the decoupling of WS from the surface deformations leads to its sliding along the surface. The mechanism

of this stick-slip transition is not sufficiently understood. According to one model, the depth of surface deformations, therefore the sliding transition, depends on the damping of ripplons [1]. The latter can be accounted for by introducing a phenomenological damping factor v_d which is expected to depend on the size of WS. Here, we report on the experimental investigation of the effect of WS size on the sliding transition. The numerical values of the damping factor v_d are obtained, and a clear size dependence of v_d is observed when the linear size of WS is as small as about 40 electrons. We show that the observed dependence is consistent with the damping of ripplons generated by moving WS due to their radiative loss through the WS boundary.



[Fig. 1]

References:
[1] W. F. Vinen, J. of Phys.: Cond. Matt. **11**, 9709 (1999)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.671
Granulated states of Bose-Einstein condensates
Tsatsos M.C.
University of Sao Paulo, Sao Carlos Institute of Physics, Sao Carlos, Brazil

Quantum fluctuations are inherent to any microscopic system and manifest the very probabilistic nature of quantum matter. In Bose-Einstein condensates (BECs) however, where typically 10^4 atoms

are trapped, fluctuations are washed out due to the large particle number together with long-range coherence and, hence, lack of quantum correlations. Hence conventional mean-field theories are considered apt for the description of dynamics of BECs. Nevertheless, the recently seen granulated states in elongated condensates of lithium-7 atoms cannot be explained via mean-field; one arrives at the emergence and proliferation of grains only through a many-body description, that takes correlations and fragmentation into account. Here the main characteristics of the observed granulated states are presented as well as results that go beyond the Gross-Pitaevskii theory, obtained by solving the MCTDHB equations. While the density alone shows no traces of granulation, an accurate simulation of single shots indeed shows grains, i.e. spatially separated regions of atoms. Therefore, granulation consists a case study where higher-order correlations of zero-temperature gases are paramount and the accurate description of the experiment cannot rely on GP or other mean-field theories.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.672

Superconducting planar microwave resonators at frequencies up to 50 GHz for mK spectroscopy applications

Scheffler M.[1], *Thiemann M.*[1], *Beutel M.H.*[1], *Rausch D.*[1], *Wollandt T.*[1], *Dressel M.*[1], *Bothner D.*[2], *Ferdinand B.*[2], *Koelle D.*[2], *Kleiner R.*[2]

[1]Universität Stuttgart, 1. Physikalisches Institut, Stuttgart, Germany, [2]Universität Tübingen, Physikalisches Institut and Center for Quantum Science in LISA+, Tübingen, Germany

Planar superconducting microwave resonators for frequencies between 2 and 15 GHz are well-known in quantum information science. Another application is microwave spectroscopy to study the dynamics of charges and spins in solids [1, 2]. In this context a wider spectral range is desired, but driving such resonators at higher frequencies is challenging due to enhanced losses and reduced wavelength. Here we present superconducting coplanar and stripline resonators operating at multiple frequencies as high as 50 GHz.

Coplanar resonators can be very compact in size and convenient in fabrication, and we use Nb resonators for ESR spectroscopy at frequencies and temperatures that are inaccessible with conventional techniques [1]. But for the study of charge dynamics in metals and superconductors, stripline resonators are more appropriate [2, 3] though more demanding in fabrication. We demonstrate superconducting Pb stripline resonators at frequencies up to 50 GHz, and we apply them to study superconductors such as Nb-doped $SrTiO_3$ or $CeCu_2Si_2$ at mK temperatures. In particular, we observe their microwave response both below and above the superconducting gap [4]. Our extended frequency range thus enables the first observation of the complete superconducting charge dynamics using microwaves.

References:

[1] M. Scheffler *et al*., Phys. Status Solidi B **250**, 439 (2013)
[2] M. Scheffler *et al*., Acta IMEKO **4**, 47 (2015)
[3] D. Hafner, M. Dressel, M. Scheffler, Rev. Sci. Instrum. **85**, 014702 (2014)
[4] M. Thiemann *et al*., arXiv:1703.04716 [cond-mat.supr-con]

Postersession 3
Monday, 14 August 2017

16.30-18.30
G Foyer

P.673
Correlated vs. uncorrelated noise acting on a quantum heat switch and refrigerator
Karimi B., Pekola J.
Aalto University, Low Temperature Laboratory, Department of Applied Physics, Helsinki, Finland

We investigate two qubits forming a quantum four-level system [1]. The transition rates between the states are determined by the coupling of the qubits to noise sources. Depending on whether the noise acting on the two qubits is correlated or not, these transitions are governed by different selection rules. For fully correlated or anticorrelated noise, there is a protected state, and the dynamics of the system depends on its initialization. For nearly (anti)correlated noise, there is a long time scale determining the temporal evolution of the qubits. We apply our results to a quantum Otto refrigerator based on two qubits coupled to hot and cold baths [2,3], a system that we are currently investigating experimentally. Even in the case when the two qubits do not interact with each other, the cooling power of the refrigerator does not scale with the number (=2 here) of the qubits when there is strong correlation of noise acting on them.
References:
[1] Bayan Karimi and Jukka P. Pekola, arXiv:1703.10507
[2] A. O. Niskanen, Y. Nakamura, and J. P. Pekola, Phys. Rev. B **76**, 174523 (2007).
[3] B. Karimi, and J. P. Pekola, Phys. Rev. B **94**, 184503 (2016).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.674
Self-condensed liquid phase of helium-3 adsorbed on hydrogen preplated graphite
Kamada M.[1], Nakamura R.[1], Ogawa K.[1], Matsui T.[1], Fukuyama H.[1,2]
[1]University of Tokyo, Department of Physics, Tokyo, Japan, [2]University of Tokyo, Cryogenic Reserach Center, Tokyo, Japan

Recently, Sato *et al*. [1] found that ^{3}He atoms confined in two-dimensional (2D) space on graphite are self-bound into a 2D liquid with the critical density (ρ_c) of 0.6−0.9 nm^{-2} below 80 mK. Although this experimental result contradicts to the previous belief that 2D ^{3}He system does not liquefy even at absolute zero, recent quantum MC calculations [2,3] showed that the gas-liquid phase separation emerges in a *finite* density range in the submonolayer of ^{3}He, if they take account of effects of the potential corrugation (ΔU_{cor}) by graphite surface properly (band mass effect). This is not perfectly consistent with the result of Ref. [1] but close. For the second layer of ^{3}He, however, the calculations gave different results, i.e., one agrees with the experiment and the other not. Thus we have made new heat capacity (C) measurements of ^{3}He monolayers on graphite preplated with a bilayer of HD. The periodicity of ΔU_{cor} of HD is longer and the amplitude is probably larger compared to those of bare graphite surface or He monolayers. Nevertheless, we found almost the same linear density dependence of γ at $\rho_c \leq 1$ nm^{-2} as that in Ref. [1], where γ is the coefficient of the T-linear term of C for a degenerated 2D Fermi liquid, suggesting less importance of ΔU_{cor}. The mystery still continues.
References:
[1] D. Sato, K. Naruse, T. Matsui, and H. Fukuyama, Phys. Rev. Lett. **109**, 235306 (2012).
[2] M. Ruggeri et al., Phys. Rev. B **93**, 104102 (2016).
[3] M. C. Gordillo and J. Boronat, Phys. Rev. Lett. **116**, 145301 (2016); Phys. Rev. B **94**, 165421 (2016).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.675
Quantum Hall transport across graphene monolayer-bilayer junction
Rui D.[1], *Sun L.*[2], *Kang N.*[1], *Peng H.*[2], *Liu Z.*[2], *Xu H.Q.*[1]
[1]Key Laboratory for the Physics and Chemistry of Nanodevices and Department of Electronics, Peking University, Beijing, China, [2]Center for Nanochemistry, Beijing Science and Engineering Center for Nanocarbons, Beijing National Laboratory for Molecular Sciences, College of Chemistry and Molecular Engineering, Peking University, Beijing, China

The manipulation of the edge states in graphene is of particular interest. In this work, we report on quantum Hall transport through a monolayer-bilayer junction in an epitaxial graphene sheet grown by chemical vapor deposition. The graphene samples are etched into a multiple Hall bar geometry and the domain stretches across the middle of a Hall bar device. At low temperatures, magnetoresistance measurements of R_{xx} across the junction exhibit quantized Hall plateaus for several ranges of gate voltage, which is a signal for edge states scattering at the interface of monolayer-bilayer junction. The observed resistance quantization can be explained by a Landauer-Buttiker formula over a wide range of filling factors [1-2]. Quantum Hall measurements of bilayer graphene show that the v=12 platform develops earlier than the v=8 with increasing magnetic field, a signature of twisted bilayer graphene [3]. The weak localization in magnetoresistance of junction is only noticeable near the Dirac point. Our results show the evident influence of monolayer-bilayer junction to the charge transport in graphene, and offers an interesting hybrid structure to study the quantum Hall transport in graphene.
References:
[1] Haug, R. J., et al. Phys. Rev. Lett. **61**, 24 (1988)
[2] Williams, J. R., L. DiCarlo, and C. M. Marcus. Science **317**, 5838 (2007)
[3] Sanchezyamagishi, Javier D, et al. Phys. Rev. Lett. **108**, 7 (2012)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.676
The role of the intersite Coulomb interaction in the implementation of the superconducting d-wave pairing in cuprates
Val'kov V.V.[1], *Dzebisashvili D.M.*[1], *Korovushkin M.M.*[1], *Barabanov A.F.*[2]
[1]Kirensky Institute of Physics, Krasnoyarsk, Russian Federation, [2]Vereshchagin Institute for High Pressure Physics, Moscow, Russian Federation

In the spin-fermion model [1,2] for cuprate superconductors, the influence of the Coulomb interaction of holes located at the nearest oxygen ions of CuO_2-plane on the implementation of the s- and $d_{x^2-y^2}$-wave pairings is studied. It is shown that an account for the space separatedness of the two-orbital subsystem of oxygen holes and the subsystem of the localized spins of copper ions lead to the stability of the d-wave pairing towards the strong Coulomb repulsion between holes. This is due to the fact that the Fourier-transform of the intersite Coulomb interaction slips out of the equation for the Cooper pairing in the $d_{x^2-y^2}$-wave channel owing to the properties of symmetry. At the same time, the

intersite Coulomb interaction between holes supresses the superconducting s-wave pairing at the optimal doping and, as a result, leads to the implementation of the $d_{x^2-y^2}$-wave pairing in cuprates.The work was supported by the Russian Foundation for Basic Research (RFBR) and partly by the Government of Krasnoyarsk Region and the Krasnoyarsk Region Science and Technology Support Fund (proj. 16-42-240435, 16-42 243057). The work of A.F.B. was funded by RFBR (proj. 16-02-00304). The work of M.M.K. was supported by the Council of the President of the Russian Federation (proj. MK-1398.2017.2).

References:

[1] A.F. Barabanov, L.A. Maksimov and G.V. Uimin, JETP Lett. **47**, 622 (1988)
[2] J. Zaanen and A.M. Oles, Phys. Rev. B **37**, 9423 (1988)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.677

Electronic state of domain structure in transition metal dichalcogenide 1*T*-$TaS_{2-x}Se_x$ observed by STM/STS

__Fujii D.__, Iwasaki T., Akiyama K., Fujisawa Y., Demura S., Sakata H.
Tokyo University of Science, Shinjuku-ku, Japan

The layered transition metal dichalcogenide (TMD) has been studied for a long time because of its plentiful physical properties. Among many TMDs, 1*T*-TaS_2 has attracted much attention due to the coexistence of Mott insulating and commensurate charge density wave (CCDW) state below 180 K [1]. Above 180 K, the Mott state melts into the metallic state accompanied with the periodic domain structure (NCCDW state) [2]. The Mott insulating CCDW state also melts by Se substitution; 1*T*-$TaS_{2-x}Se_x$. For $0.0 \le x \le 0.8$, the NCCDW-CCDW transition temperature decreases gradually. For $0.8 < x \le 1.6$, the NCCDW state remains at low temperature and superconductivity emerges at about 3 K [3]. The NCCDW state and its electronic states at this Se concentration have not been clarified yet. To investigate the nature of this state, we have performed systematic scanning tunneling microscopy and spectroscopy study on 1*T*-$TaS_{2-x}Se_x$ ($0.0 \le x \le 1.0$) at 4.2 K. From STM observations, we found an anomalous domain structure at x=1.0 that is different from the NCCDW domain structure at x=0.0. We also examined spatial evolution of the electronic state across the domain wall. From these results, we will discuss the relation between superconductivity at this Se concentration and the novel domain structure.

References:

[1] P. Fazekas, E. Tosatti, Physica B+C, **99**, 183 (1980)
[2] X.L. Wu, C.M. Lieber, Science **243,** 1703 (1989)
[3] Y. Liu, R. Ang, W. J. Lu, W. H. Song, L. J. Li, and Y. P. Sun, Applied Physics Letters **102**, 192602 (2013)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.678

Low temperature THz spectroscopy and transport in nanostructures

__Braun J.__, Pietsch T.
University of Konstanz, Physics, Konstanz, Germany

We constructed a novel, compact cw-THz spectrometer based on photomixing, which operates in a frequency range from 50 GHz to 2000 GHz in magnetic fields up to 9 T and at temperatures down to 4K. Using a rotatable sample stage, reference-based THz transmission-spectroscopy can be performed *in-situ*. Moreover, the sample stage is optimized for DC low-noise transport measurements. Therefore, this novel setup allows to correlate DC magnetotransport measurements with the THz spectroscopic analysis of thin films and solid-state devices, such as hybrid nanostructures of ferromagnets, semiconductors and superconductors.
Recently direct microwave-induced spin-flip transitions could be demonstrated in Zeeman-split Pd/Co heterocontacts [1]. The new experiment is suited to investigate similar transitions in dilute ferromagnets with exchange energies in the range of a few THz. Additionally the emission of THz radiation based on a spin relaxation in such system has been predicted theoretically [2] and will be observable in the combination of transport and spectroscopic features.

References:
[1] Pietsch, T., et al., Microwave-induced direct spin-flip transitions in mesoscopic Pd/Co heterojunctions. New Journal of Physics 18, 2016.
[2] Shekhter, R.I., et al., Subwavelength terahertz spin-flip laser based on a magnetic point-contact array. Optics Letters 36(12), 2011: p. 2381-2383

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.679
Dangling spin-triplet order in high field superconducting phase induced by strong paramagnetic pair-breaking
Hosoya K.-I., Ikeda R.
Kyoto University, Physics, Kyoto, Japan

The nature of the high field superconducting (SC) phase, the so-called *Q*-phase, of the d_{x2-y2} -wave superconductor CeCoIn5 is still a matter under much debate. This phase is believed to be a novel superconducting phase induced by a strong paramagnetic pair-breaking (PPB) effect: The presence of a long ranged spin density wave (SDW) order [1], its fragile nature against the impurity scattering [2], and the discontinuous switching of the SDW ***Q***-vector upon rotating the magnetic field through [100]-direction [3] have been commonly explained within the picture [4] based on the strong PPB and thus, by invoking the FFLO spatial modulation parallel to the field. There [4], a putative π-triplet pairing order to be induced by the d-wave pairing and the SDW orders did not have to be incorporated. However, the recent thermal conductivity measurement [5] suggests the presence of a π-triplet pairing order in the *Q*-phase of CeCoIn5. Here, we report on our investigation of a possible π-triplet SC order and its roles in the *Q*-phase of CeCoIn5 within the PPB-based approach [4]. We point out that the only possible π-triplet order unaffects the previous PPB-based results [4] on the *Q*-phase constructed previously and is consistent with the thermal conductivity result [5].

References:
[1] M. Kenzelmann et al., Science 321, 1652 (2008).
[2] Y. Tokiwa et al., Phys. Rev. B 82, 220502 (2010).
[3] S. Gerber et al., Nature Physics 10, 126 (2014).
[4] R.Ikeda, Y. Hatakeyama, and K. Aoyama, Phys. Rev. B 82, 060510(R) (2010); R. Ikeda, Phys. Rev. B 81, 060510(R) (2010); Y. Hatakeyama and R. Ikeda, Phys. Rev. B 91, 094504 (2015).
[5] D. Y. Kim, S-Z. Lin, F. Weickert, M. Kenzelmann, E. D. Bauer, F. Ronning, J. D. Thompson, and R. Movshovich, Phys.Rev. X 6, 041059 (2016).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.680
Low-temperature magnetic properties of verdazyl-based complexes
Okabe T., Yamaguchi H., Ono T., Hosokoshi Y.
Osaka Prefecture University, Department of Physical Science, Sakai, Japan

By using verdazyl radicals, which can exhibit a delocalized π-electron spin density even in nonplanar molecular structures, we have demonstrated the tuning of exchange interactions in spin-ladder systems and the formation of a variety of unconventional lattice systems [1,2]. Very recently, we succeeded in combining our verdazyl radicals with 3*d* transition metals [3,4]. The strong intramolecular couplings in such molecular-based complexes produced a metal-radical hybrid spin in low-temperature regions. We report the low-temperature magnetic properties of new verdazyl-based complexes $[M(hfac)_2]\cdot$
(o-Py-V-p-F_2) (M=Zn, Mn). For $[Zn(hfac)_2]\cdot$(o-Py-V-p-F_2) with non-magnetic Zn^{2+}, *ab* initio molecular orbital calculations associated with the verdazyl radicals indicate that the two antiferromagnetic and one ferromagnetic interactions form an S=1/2 distorted honeycomb lattice. Therefore, $[Mn(hfac)_2]\cdot$(o-Py-V-p-F_2) is expected to form an S=2 distorted honeycomb lattice through the strong intramolecular couplings. We discuss the qualitative difference between two compounds.

References:
[1] H. Yamaguchi *et al*., J. Phys. Soc. Jpn. **83**,033707 (2014).
[2] H. Yamaguchi *et al*., Sci. Rep. **5**,15327 (2015).
[3] H. Yamaguchi et al., Phys. Rev. B **91**, 085117 (2015).
[4] H. Yamaguchi et al., Phys. Rev. B **93**, 115145 (2016)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.681
Torsional oscillator measurements of liquid ^{4}He confined in 2.5-nm channel of FSM
Taniguchi K., Taniguchi J., Suzuki M.
University of Electro-Communications, Department of Engineering Science, Tokyo, Japan

It is of great interest how the superfluid response of liquid ^{4}He confined in a one-dimensional (1D) channel is changed as the channel diameter decreases. Up to the present, we examined the superfluid response in three kinds of 1D channels, whose diameters are 4.7, 2.8 and 2.2 nm, and found that it is drastically changed between 2.8-nm and 2.2-nm channels.[1] In the 2.8-nm channel, the superfluid fraction shows a second-stage growth; under 0.13 MPa, a sharp rise of the superfluid fraction occurs at 0.9 K accompanied by a large dissipation peak after it increases gradually below 1.8 K. In contrast, in the 2.2-nm channel, no second rise is observed although the superfluid fraction appears. To clarify how the second rise disappears between 2.8-nm and 2.2-nm channels, we recently started torsional oscillator measurements of ^{4}He confined in a 2.5-nm channel. It was found that under 0.05 MPa, the second rise occurs at 0.13 K after the superfluid appears at around 1.5 K. It was made clear that by decreasing diameter the second rise temperature is supressed much faster than that of the superfluid appearance.

References:

[1] J. Taniguchi, Y. Aoki, and M. Suzuki, Phys. Rev. B **82**, 104509 (2010).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.682

Exploring the period-doubling bifurcation in current-biased Josephson junctions

Porsch K.E.[1], *Khabipov M.*[2], *Long G.*[1], *Dunstan J.*[1], *Dolata R.*[2], *Dietel J.*[2], *Zorin A.B.*[2], *Meeson P.J.*[1]
[1]Royal Holloway, University of London, Department of Physics, Egham, United Kingdom,
[2]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

Josephson junctions may be used to introduce non-linearity in a controlled and non-dissipative way to superconducting resonant cavities, providing a model system for the study of dynamical bifurcations. In unbiased Josephson weak-links the naturally introduced cubic non-linearity leads to the well-known Josephson (amplitude) Bifurcation Amplifier (JBA) [1,2] or a period-doubling bifurcation (PDB) under periodic variation of its inductance [3]. Here we present recent experimental results exploring a new regime in which current-biased weak-links induce a quadratic non-linearity [4], leading the system to display period doubling bifurcations. The PDB signal is large, rises suddenly from zero to finite value and is well-separated from the drive frequency, it is hysteretic in both drive-power and drive-frequency. All these features indicate that the PDB may be more suitable as a qubit state detector than the JBA. We explore the effect in a Nb trilayer device to milliKelvin temperatures and fit theory to the measurements.

References:

[1] I. Siddiqi, R. Vijay, F. Pierre, C. M. Wilson, M. Metcalfe, C. Rigetti, L. Frunzio, and M. H. Devoret; Phys. Rev. Lett. 93, 207002 (2004)
[2] N. Boulant, G. Ithier, P. Meeson, F. Nguyen, D. Vion, D. Esteve, I. Siddiqi, R. Vijay, C. Rigetti, F. Pierre, and M. Devoret; Phys. Rev. B 76, 014525 (2007)
[3] C. M. Wilson, T. Duty, M. Sandberg, F. Persson, V. Shumeiko, and P. Delsing; Phys. Rev. Lett. 105, 233907 (2010)
[4] A. B. Zorin and Yu. Makhlin; Phys. Rev. B 83, 224506 (2011)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.684

Formation of the S=1 paramagnetic centres in the bond-diluted spin-gap magnet $(C_4H_{12}N_2)(Cu_2Cl_6)$

Glazkov V.[1,2], *Krasnikova Y.*[1,2], *Huvonen D.*[3], *Zheludev A.*[4]
[1]P. L. Kapitza Institute for Physical Problems, Moscow, Russian Federation, [2]National Research University Higher School of Economics, Moscow, Russian Federation, [3]National Institute of Chemical Physics and Biophysics, Tallinn, Estonia, [4]ETH Zürich, Zurich, Switzerland

The recently found quasi-two dimensional magnet $(C_4H_{12}N_2)(Cu_2Cl_6)$ is an example of the spin-gap magnet [1]. Its ground state is non-magnetic singlet and triplet excitations have a final excitation energy Δ=11K. This compound allows substitution of Cl by Br up to 12% [2]. This bond-doping does not directly deplete magnetic system, but results in the modulation of some exchange bonds.
We have found [3] that, surprisingly, bromine doping leads to the formation of S=1 gapless paramagnetic centres. The existence of these centres is revealed by electron spin resonance (ESR): below 3K ESR absorption contains split components, as is typical for the S=1 centre, and intensity of these components increases with cooling down to 450 mK, demonstrating their gapless spectrum. Analysis of the ESR absorption intensity leads to a conjecture that S=1 centres are formed on double substitution of Cl by Br in a Cu_2Cl_6 dimer, which is a building block of $(C_4H_{12}N_2)(Cu_2Cl_6)$ magnetic structure. Such a double substitution results in the effective attracting potential, which traps one of the triplet excitations.

References:
[1] Stone M. B. et al., New J. Phys. **9**, 31 (2007)
[2] Hüvonen D. et al., Phys. Rev. B **85,** 100410 (2012); Phys. Rev. B **86** 214408 (2012); Phys. Rev. B **88** 094402 (2013)
[3] Glazkov V. N. et al., Journ. Phys.:Cond. Matter **28**, 206003 (2016); Journ. Phys.:Cond. Matter **26**, 486002 (2014)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.685

Fractional quantum Hall effect and Wigner crystallization in suspended Corbino graphene disk

Kumar M., Laitinen A., Hakonen P.
Aalto University, Department of Applied Physics, Low Temperature Laboratory, Espoo, Finland

Competition between kinetic and Coulomb energy in two-dimensional electron system leads to a multitude of different ordered phases. At high magnetic fields, kinetic energy of electrons is suppressed, which favors crystallization of electrons *i.e.* Wigner crystal. However, electrons commonly favor an incompressible liquid state, the fractional quantum Hall (FQH) liquid, instead of the Wigner crystal solid phase.
We have investigated competing Wigner crystal and FQH liquid phases in monolayer suspended graphene devices in Corbino geometry [1]. Magneto- and transconductance measurements along with IV characteristics and mechanical resonances all indicate unconventional sequence of FQH phases with lowering electron density n, where the conventional sequence of FQH states [2] is interrupted by Wigner crystal order. At small n, with the filling factor $\nu \sim 0.15 - 0.16$, the electron crystallizes into ordered Wigner solid, while incompressible liquid state is reemerged with lowering density down to $\nu \sim 1/7$. The Wigner crystal state was experimentally confirmed by a microwave absorption resonance near 3 GHz which agrees with pinned, submicron-sized crystallites. Evidence of Dirac nature of composite fermions in graphene at high B at half filling is also obtained in our sample [3].

References:
[1] M. Kumar, A. Laitinen, and P. J. Hakonen, *Fractional quantum Hall effect and Wigner crystallization in suspended Corbino graphene disk*, arXiv:1611.02742.
[2] Jainendra K. Jain, *Composite Fermions* (Cambridge University Press, 2007)
[3] A. Laitinen, M. Kumar, and P. J. Hakonen, *Composite fermions in graphene fractional quantum Hall state at half filling: evidence for Dirac composite fermions*, arXiv:1612.03414

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.687
Demonstration of a micro-electromechanical oscillator as a sensitive probe for the study of quantum turbulence

Barquist C.S.[1], *Jiang W.G.*[1], *Zheng P.*[1], *Lee Y.*[1], *Chan H.B.*[2]
[1]University of Florida, Department of Physics, Gainesville, United States, [2]Hong Kong University of Science and Technology, Department of Physics, Clear Water Bay, Hong Kong

A micro-electromechanical plate resonator suspended 2 µm above a substrate was immersed in He II at temperatures below 100 mK. The resonance of the shear mode is at around 20 kHz. In the linear regime at low excitation, the resonator exhibits higher damping and resonance frequency in the presence of trapped remnant vortices. The oscillator can be annealed to remove the trapped vortices through consecutive frequency sweeps at a higher excitation. The behavior of the device is studied in the presence of turbulence generated by a quartz turning fork. When driven in the non-linear regime, fluctuations in the phase of the oscillator are observed in the presence of turbulence. The phase noise spectrum in turbulence has a distinct peak at 0.7 Hz below which a $1/f$ dependence persists, while in the absence of turbulence the spectrum is almost flat.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.688
Anisotropic superconducting gaps in optimally doped $Ba_{1-x}K_xFe_2As_2$ and $BaFe_{2-x}Ni_xAs_2$

Kuzmicheva T.[1], *Kuzmichev S.*[1,2], *Muratov A.*[1], *Pervakov K.*[1], *Sadakov A.*[1], *Pudalov V.*[1]
[1]P.N. Lebedev Physical Institute RAS, Moscow, Russian Federation, [2]M.V. Lomonosov Moscow State University, Moscow, Russian Federation

We studied nearly optimal single crystals of Ba-122 family by intrinsic multiple Andreev reflections effect (IMARE) spectroscopy (“break-junction” technique [1]). The current-voltage characteristics of SnS-Andreev contacts (S - superconductor, n - a ballistic layer of normal metal) showed a pronounced excess current at low bias, and two subharmonic gap structures (SGS) — series of dynamic conductance dips at positions $V_{n,i} = 2\Delta_i/en$ (n is a natural number) corresponding to the large and the small superconducting gaps [2,3]. The doublet-like shape of the SGS dips demonstrated the gap anisotropy in a k-space (extended s-wave symmetry) [4,5].
For nearly optimal potassium-doped $Ba_{0.65}K_{0.35}Fe_2As_2$ with $T_C \approx$ 34-36 K [6] we determined the large gap Δ_L = 6-8 meV (~30 % anisotropy in k-space) and the small gap $\Delta_S \approx$ 1.7 meV.
In nickel-doped single crystals $BaFe_{1.9}Ni_{0.1}As_2$ with $T_C \approx$ 19 K, we observed two gaps with moderate anisotropy: Δ_L = 3.2-4.4 meV (~33 % anisotropy in k-space, similarly to $Ba(K)Fe_2As_2$), and $\Delta_S \approx$ 1.6 meV (~25 % anisotropy).
The gap temperature dependences $\Delta_{L,S}(T)$ agree well with two-band system of equations by Moskalenko and Suhl [7]. We thank H.-H. Wen, M. Abdel-Hafiez, A.A. Kordyuk, Y.C. Chen for the providing samples and useful discussions.

References:

[1] J. Moreland and J. W. Ekin, J. Appl. Phys. **58**, 3888 (1985).

[2] M. Octavio et al., Phys. Rev. B **27**, 6739 (1983).
[3] R. Kuemmel et al., Phys. Rev. B **42**, 3992 (1990).
[4] T. P. Devereaux and P. Fulde, Phys. Rev. B **47**, 14638(R) (1993).
[5] A. Poenicke et al., Phys. Rev. B **65**, 220510(R) (2002).
[6] M. Abdel-Hafiez et al., Phys. Rev. B **90**, 054524 (2014).
[7] V.A. Moskalenko, Fiz. Met. Metall. **8**, 503 (1959); H. Suhl et al., Phys. Rev. Lett. **3**, 552 (1959).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.689

Decoupling of solid ^{4}He layers under the superfluid overlayer

<u>Ishibashi K.</u>, Hiraide J., Taniguchi J., Suzuki M.
University of Electro-Communications, Department of Engineering Science, Tokyo, Japan

We have carried out quartz crystal microbalance experiments for three- and four-atom thick ^{4}He films adsorbed on graphite. At present, it is known that in a large oscillation amplitude, the solid layers of ^{4}He film undergo decoupling from the oscillating substrate, and suddenly stick to the substrate at a certain temperature when the overlayer is superfluid.[1] It is of great interest to clarify the difference of the solid layers between the decoupling and the sticking states. Thus motivated, we measured the decoupling of ^{4}He film after switching from a large to a small amplitudes in the decoupling and the sticking states. In both cases, a metastable decoupling appears and depends on temperature history although it is quantitatively different. This suggests that there is no qualitative difference of the solid layers between the decoupling and the sticking states.

References:

[1] N. Hosomi, M. Suzuki and T. Minoguchi, Phys. Rev. B **79**, 172503 (2009).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.690

Origin of large amplitude oscillations of critical temperature for the (FeCrFe)-V-Fe trilayer

Tumanov V.[1], Goryunov Y.[2], <u>Proshin Y.</u>[1]
[1]Kazan Federal University, Kazan, Russian Federation, [2]Kazan Physical Technical Institute, Kazan, Russian Federation

Recently the superconducting multilayers (FeCrFe)-V-Fe were proposed as third type of superconducting spin valve [1]. Here the (FeCrFe) is effective magnetic layer containing several monolayers of iron and chromium. The large amplitude oscillations of the critical temperature were observed under changes of the Cr interlayer thickness [1,2].

In this work, we calculate the critical temperature using the model proposed earlier [3]. We suppose that the ferromagnet has periodic domain structure with planar domain walls induced by antiferromagnetic Cr interlayer.

We obtain that the superconducting correlations near domain walls in the ferromagnetic layer are more intensive in accordance with previous theories [4,5]. To find the system characteristics, which are optimal for spintronic applications, the critical temperature dependence as function of multilayer

geometry and domain structure parameters (domain size, domain wall thickness) is also discussed. Obtained results qualitatively agree with experimental data [1,2].

The work is supported by the subsidy allocated to Kazan Federal University for performing the project part of the state assignment in the area of scientific activities. Yu.P. thanks to the RFBR (16-02-01016) for partial support.

References:

[1] Yu. Goryunov, 11th Internat. Workshop on Low Temp. Electronics (WOLTE 2014), 45 (2014)
[2] Yu.V. Goryunov, arXiv:cond-mat/0305428 (2003)
[3] V.A. Tumanov, Yu.N. Proshin, *J. Low Temp. Phys.* **185**, 460 (2016)
[4] M. Houzet, A.I. Buzdin, *Phys. Rev. B* **74**, 214507 (2006)
[5] Ya.V. Fominov, A.F. Volkov, K.B. Efetov, *Phys. Rev. B* **75**, 104509 (2007)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.691

Neutron-scattering study of spin correlations in the T´-structured $Pr_{2-x}Ca_xCuO_4$

Fujita M., Tsutsumi K., MIura T.
Institute for Material Science (IMR), Tohoku University, Sendai, Japan

Superconductivity in cuprate oxide emerges when sufficient carriers are doped in Mott insulator. Magnetic and superconducting properties have been intensively studied and discussed the common relation between them. However, due to the difference in the crystal structure of available hole- and electron-doped systems, the universal nature of spin correlation irrespective of crystal structure is still under debate. In order to clarify the electron-hole symmetry of intrinsic spin correlation, we performed the first elastic neutron scattering measurement on the single crystal of hole-doped $Pr_{1.90}Ca_{0.10}CuO_4$ with T´-structure. A sharp magnetic Bragg peak was observed at (0.5, 0.5) reciprocal position at low-temperature, while no evidence of incommensurate spin correlation was detected. The magnetic ordering temperature (T_N) was determined to be ~290K, which is consistent with T_N in the mother compound of Pr_2CuO_4. These results suggest a negligible Ca-doping effect on the static magnetic correlation in T´-phase, contraction to the drastic doping evolution of magnetism in T-$La_{2-x}Sr_xCuO_4$. The doping asymmetry of spin correlation in T'-structured system will be discussed with showing the magnetic phase diagram as well as the low energy spin fluctuations.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.692

T_c depression and superconductor-insulator transition in molybdenum nitride thin films

Ichikawa F.[1], Makise K.[2], Tsuneoka T.[1], Maeda S.[1], Shinozaki B.[3]
[1]Kumamoto University, Department of Physics, Kumamoto, Japan, [2]National Institute of Advanced Industrial Science and Technology, Nanoelectronics Research Institute, Tukuba, Japan, [3]Kyushu University, Department of Physics, Fukuoka, Japan

We have studied that the T_c depression and the superconductor-insulator transition (SIT) in molybdenum nitride (MoN) thin films. Thin films were fabricated by reactive DC magnetron sputtering method onto (100) MgO substrates in the mixture of Ar and N_2 gases. Several dozen MoN thin films were prepared in the range of 3 nm < thickness d < 60 nm. The resistance was measured by a DC four-probe technique. It is found that T_c decreases from 6.6 K for thick films with increase of the normal state sheet resistance R_{sq}^N and experimental data were fitted to the Finkel'stein formula [2] using the bulk superconducting transition temperature T_{c0} =6.45 K and the elastic scattering time of electron $\tau = 1.6 \times 10^{-16}$ s. From this analysis the critical sheet resistance R_c is found about 2 kΩ, which is smaller than the quantum sheet resistance R_Q. This value of R_c is almost the same as those for 2D NbN films [3]. The value of τ for MoN films is also the similar value for NbN films 1.0×10^{-16} s, while T_{c0} is different from that for NbN films 14.85 K. It is indicated that the mechanism of SIT for MoN films is similar to that of NbN films.

References:

[1] T. Tsuneoka, K. Makise, S. Maeda, B. Shinozaki, F. Ichikawa, J. Phys.: Condens. Matter, **29**, 015701 (2017).
[2] A. M. Finkel'stein, JETP Lett., **45**, 46 (1987).
[3] S. Ezaki, K. Makise, B. Shinozaki, T. Odo, T. Asano, H. Terai, T. Yamashita, S. Miki, Z. Wang, J. Phys.:Condens. Matter., **24**, 475702 (2012).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.693

Andreev reflection in time-reversal symmetric Weyl semimetals

Schulenborg J.[1], *Zülicke U.[2], Governale M.[2]*
[1]Chalmers University of Technology, Department of Microtechnology and Nanoscience, Göteborg, Sweden, [2]Victoria University of Wellington, School of Physical and Chemical Sciences, Wellington, New Zealand

The prediction[1,2] and eventual discovery[3] of Weyl semimetals (WSM), hosting the long sought Weyl fermions as low-energy quasiparticle excitations, has attracted enormous attention during the last decade. Most recent reports on the so-called WSM „hydrogen atom"[4,5] - with the minimum number of Weyl nodes required by symmetry - suggest that future WSM-based devices might be simple enough to exploit the fixed *spin-momentum locking* of Weyl fermions directly in bulk transport. This can be useful for spectroscopy and for applications in, e.g., spin control.
To further explore this perspective, we study elastic Andreev reflection in such a minimal model of a time-reversal symmetric WSM, at an interface between a normal and superconducting region with induced s-wave pairing. We show that without Fermi velocity mismatch or interface-related spin-mixing, the subgap reflection processes at the four Weyl cones completely decouple. This arguably simplest form of Andreev scattering in a time-reversal symmetric WSM can be described by a 3D analogue of graphene, with the key difference that the pseudospin becomes an effective, yet accessible spin. To assess how this is affected by perturbations of the Fermi surface, we also discuss intervalley scattering due to Fermi velocity mismatch.

References:

[1] G. Volovik, „Quantum phase transitions from topology in momentum space“ (2007)
[2] X. Wan et al., Phys. Rev. B. **83**, 205101 (2011)
[3] S.-Y. Xu et al., Science **349**, 613 (2015)
[4] K. Koepernik et al., Phys. Rev. B **93**, 201101 (2016)
[5] I. Belopolski et al., arXiv:1610.02013 (2016)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.694
Correlation of Hall and Shubnikov-de Hass oscillations and impurity states in Sn and I doped single crystals *p*-Bi_2Te_3
Tahar M.Z.[1], _Popov D.I._[2], _Nemov S.A._[3]
[1]State University University of New York, College at Brockport, Physics, Brockport, United States, [2]Papula-Nevinpat per Pirogova 7, St. Petersburg, Russian Federation, [3]State Polytechnical University, St. Petersburg, Russian Federation

Oscillations of the Hall coefficient and Shubnikov-de Haas (SdH) were observed in *p*-Bi_2Te_3 crystals doped with *Sn* (acceptor) and with *I* (donor) in magnetic fields up to 9 T parallel to the C_3 trigonal axis at low temperatures (2 K< T < 20K), which is an evidence of the spatial homogeneity of carriers in complex solid solutions. This supports the existence of a narrow band of Sn states (partially filled) against the background of the valence band acting as a reservoir with high density of states partially filled with electrons. Previously, in these systems in which the Fermi level was in the light-hole valence band, both large Hall and SdH oscillations were observed, with ~π phase shift between them, whereas when the Fermi level was in the heavy-hole valence band (larger acceptor content), no quantum oscillations were observed. It was concluded that the observed low amplitude quantum oscillations may be attributed to the shifting of the reservoir from the light-hole band to the heavy-hole, and the observed phase shift in the range 0 - π/2 between Hall and SdH oscillations may be attributed to filling factor of the reservoir with electrons, which varies with *I* content. Experimental results along with theoretical explanation of these correlations is presented.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.695
Enhanced Josephson effect in hybrid nano-junctions
Montemurro D., _Bauch T., Lombardi F._
Chalmers University of Technology, Quantum Device Physics Laboratory, Microtechnology and Nanoscience, Göteborg, Sweden

During the recent years there has been an increased interest in superconductor-normal conductor-superconductor (SNS) hybrid Josephson junctions. The implementation of strong spin-orbit semiconducting nanowires [1] or topological insulators [2] in such devices is expected to reveal the existence of Majorana fermions [3]. Due to their non-Abelian statistic they offer possible application in quantum computation architectures [4]. At the same time such structures have a broad potential in other areas such as the superconducting field effect transistor [5]. In order to increase the operational temperature and magnetic field range of these junctions, superconducting materials, such as NbN or YBCO, with large critical temperatures (Tc) and magnetic fields are desirable.
Here we present the fabrication and characterization of NbN/Au nanogaps key element for building up hybrid SNS Josephson junctions. We address the importance of interface transparencies between

NbN, Au and bonding material as Ti/Al in such SNS junctions. We have realized a NbN/Au-Ti/Al-NbN/Au superconducting junction exhibiting Josephson coupling above the transition temperature of the Al link [6]. Our results pave the way for the realization of hybrid devices implementing superconductors with high-Tc [7].

References:

[1] C.Fasth et al., Phys. Rev. Lett. **98**, 266801 (2007)
[2] M.Z. Hasan and Kane, Rev. Mod. Phys. **82**, 3045(2010)
[3] V.Mourik et al., Science **336**, 1003(2012)
[4] Y.Kitaev, Ann. Phys., **303**, 2-30(2003); L.Casparis et al., Phys. Rev. Lett **116,** 150505(2016)
[5] Y.J.Doh et al., Science **309**, 272(2005)"
[6] V.Cherkez et al., Phys. Rev. X **4**, 011033(2014)
[7] D.Montemurro et al., Jour. of Super. and Nov. Mag. **28**, 3429 (2015)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.697

Fluxoid-periodicity crossover from *h/2e* to *h/e* in Al nano-loops

Sharon O.[1]*, Garreis R.*[2]*, Braun J.*[2]*, Espy C.*[2]*, Strigl F.*[2]*, Shaulov A.*[1]*, Scheer E.*[2]*, Yeshurun Y.*[1]

[1]Bar Ilan University, Department of Physics, Institute of Superconductivity and Institute of Nano Technology and Advanced Materials, Ramat Gan, Israel, [2]University of Konstanz, Department of Physics, Konstanz, Germany

In a multiply connected superconductor, the fluxoid is quantized in units of $\Phi_0=h/2e$, where the *2e* is a hallmark of electron pairing in the superconductor. Theoretical studies [1] have predicted that in superconducting nano-loops with length-scale $a < \xi_0$ the dominant periodicity is $2\Phi_0$ rather than Φ_0. Aluminum is a natural choice of material for experimental verification of this prediction because of its relatively large coherence length (ξ_0 = 1.6 µ*m*). We prepared aluminum networks with loop size of ~230 nm and measured their differential magnetoresistance at temperatures between 300 and 1400 mK. At low temperatures the usual Little-Parks flux periodicity of Φ_0, is observed. At temperatures above 1300 mK the Φ_0 periodicity clearly disappears, and the waveform of the first period is consistent with that predicted theoretically for loops with $a < \xi_0$, indicating a crossover to $2\Phi_0$ periodicity. A full experimental verification of the theory requires measurements of more than one period. However, the relatively low critical field of aluminum, in particular close to the transition temperature, and the large period of small loops, impede achieving this condition.

References:

[1] F. Loder, A. P. Kampf, T. Kopp, J. Mannhart, C. W. Schneider, Y. S. Barash, Nature Phys. **4**, 112 (2008)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.698

Polaron-plasmon superconductivity in strontium titanate

Edelman A.[1]*, Littlewood P.*[1,2]

[1]University of Chicago, James Franck Institute and Department of Physics, Chicago, United States, [2]Argonne National Laboratory, Lemont, United States

Strontium titanate is a bulk insulator that becomes superconducting at remarkably low carrier densities. Even more enigmatic properties become apparent at the strontium titanate/lanthanum aluminate (STO/LAO) interface and it is important to disentangle the effects of reduced dimensionality from the poorly-understood pairing mechanism. Recent experiments measuring the surface photoemission spectrum[1] and bulk tunneling spectrum[2] have found a cross-over, as a function of carrier density, from a polaronic regime with substantial spectral weight associated with strongly coupled phonons, to a more conventional weakly coupled Fermi liquid. Interestingly, it is only the polaronic state that becomes superconducting at low temperatures, although the properties of the superconducting phase itself appear entirely conventional. We interpret these results in a simple analytical model that extends an Engelsberg-Schrieffer theory of electrons coupled to a single longitudinal optic phonon mode to include the response of the electron liquid, and in particular phonon-plasmon hybridization. We perform a Migdal-Eliashberg calculation within our model to obtain this material´s unusual superconducting phase diagram.

References:

[1] Z. Wang et al, Nat. Mater. (2016)
[2] G. Swartz et al, arXiv:1608.05621

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.699

Possible existence of a filamentary state in type-II superconductors

<u>Kozhevnikov V.</u>[1], Valente-Feliciano A.-M.[2], Curran P.J.[3], Suter A.[4], Liu H.[5], Richter G.[6], Morenzoni E.[4], Bending S.J.[3], Van Haesendonck C.[5]
[1]Tulsa Community College, Tulsa, United States, [2]Thomas Jefferson National Lab, Newport News, United States, [3]University of Bath, Bath, United Kingdom, [4]Paul Scherrer Institute, Villigen, Switzerland, [5]KU Leuven, Leuven, Belgium, [6]Max Plank Institut for Intelligent Systems, Stuttgart, Germany

The standard interpretation of the phase diagram of type-II superconductors was developed in 1960s and has since been considered a well-established part of classical superconductivity. However, upon closer examination a number of fundamental issues arise that leads one to question this standard picture. To address these issues we studied equilibrium properties of niobium samples near and above the upper critical field Hc2 in parallel and perpendicular magnetic fields. The samples investigated were niobium high quality films and single crystal discs with the Ginzburg-Landau parameters 0.8 and 1.3, respectively. A range of complementary measurements have been performed, which include dc magnetometry, electrical transport, muSR spectroscopy and scanning Hall-probe microscopy. Contrarily to the standard scenario, we observed that a superconducting phase is present in the sample bulk above Hc2 and the field Hc3 is the same in both parallel and perpendicular fields. Our findings suggest that above Hc2 the superconducting phase forms filaments parallel to the field regardless on the field orientation. Near Hc2 the filaments preserve the hexagonal structure of the preceding vortex lattice of the mixed state and the filament density continuously falls to zero at Hc3.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.700

From Floquet topological insulators to Floquet isolators: Harnessing non-perturbative light-matter interaction effects

Foa Torres L.E.F.[1], *Usaj G.*[2], *Perez-Piskunow P.M.*[3], *Dal Lago V.*[4], *Calvo H.L.*[4], *Suárez Morell E.*[5], *Balseiro C.A.*[2]

[1]Universidad de Chile, Department of Physics, FCFM, Santiago, Chile, [2]Centro Atómico Bariloche and Instituto Balseiro, CNEA, Bariloche, Argentina, [3]Delft University of Technology, Delft, Netherlands, [4]Universidad Nacional de Córdoba, IFEG, FaMAF, Cordoba, Argentina, [5]Universidad Técnica Federico Santa María, Department of Physics, Valparaíso, Chile

Light-matter interaction is at the heart of intriguing phenomena and has led to many practical applications like, for instance, Raman spectroscopy. But beyond characterization, several studies have gone deeper into actually using light to modify the electrical properties of a material. This can be done, for example, by using light to switch off the conduction in graphene [1], thereby allowing to tune the material´s response with optical means, or even inducing tunable topological states in materials that would otherwise lack them [1,2,4,5,6,7] (i.e. a *Floquet topological insulator* [2]). The recent experimental realization of laser-induced bandgaps at the surface of a topological insulator [3] has added much interest to this area.

In this talk I will provide an overview of our recent works in this field with a focus on the generation of Floquet chiral edge states in graphene [4,6], and other materials including topological insulators [5]. I will also show how light-matter interaction could be used to realize a *Floquet isolator* [7], a system where transmission can occur only between say lead L and R and not viceversa while keeping a vanishing reflection at lead R. The emergence of a Hall response without Landau levels [8] will also be highlighted.

References:

[1] T. Oka and H. Aoki, Phys. Rev. B **79**, 081406 (2009).
[2] N. H. Lindner et al., Nat. Phys. **7**, 490 (2011).
[3] Y. H. Wang et al., Science **342**, 453 (2013).
[4] P. M. Perez-Piskunow et al., Phys. Rev. B **89**, 121401(R) (2014); Phys. Rev. A **91**, 043625 (2015).
[5] H. L. Calvo et al., Phys. Rev. B **91**, 241404(R) (2015).
[6] D. A. Lovey, et al., Phys. Rev. B **93**, 245434 (2016).
[7] V. Dal Lago et al. , to be published.
[8] L. E. F. Foa Torres et al., Phys. Rev. Lett. **113**, 266801 (2014).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.701

Augmented quasiclassical theory for single vortex in chiral p-wave superconductor

Masaki Y.[1], *Kato Y.*[2]

[1]University of Tokyo, Department of Physics, Tokyo, Japan, [2]University of Tokyo, Department of Basic Science, Tokyo, Japan

The Hall effect of the superconducting vortices is still a standing issue of importance. Particularly the chiral p-wave superconductor with the vorticity antiparallel to the chirality differs drastically from the conventional s-wave one; The charging effect is crucially suppressed [1] and the core states are rather robust against the Born-type disorder [2,3]. As a result, we expect that the vortices do not flow even in the presence of the transport current, or we could say there is a kind of ubiquitous pinning. Therefore the flux flow state of the chiral p-wave superconductor is non trivial.
The transport phenomena in the clean superconductor can be treated using the augmented Eilenberger equation, where particle-hole asymmetry important to the Hall effect is taken into account [4,5].
In this presentation, as a first step to address the above issues, we investigate the chirality effect on the charge modulation in the vortex core using the augmented Eilenberger equation and force balance description of the vortex. The force balance in the static regime explains an important role of the chirality. We also discuss the relation between the force from chirality studied here and the internal Magnus force studied before [6] and recently found in experiment [7].

References:

[1] M. Matsumoto and R. Heeb, Phys. Rev. B **65**, 14504 (2001).
[2] Y. Kato, J. Phys. Soc. Jpn. **69**, 3378 (2000).
[3] Y. Masaki and Y. Kato, J. Phys. Soc. Japan **85**, 14705 (2016).
[4] N. B. Kopnin, J. Low Temp. Phys. **97**, 157 (1994).
[5] T. Kita, Phys. Rev. B **64**, 54503 (2001).
[6] R. H. Salmelin, M. M. Salomaa, and V. P. Mineev, Phys. Rev. Lett. **63**, 868 (1989).
[7] H. Ikegami, Y. Tsutsumi, and K. Kono, Science **341**, 59 (2013).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.702

Superconducting fluctuations above T_c and pair breaking parameters of two dimensional niobium nitride films

<u>Shinozaki B.</u>[1], Ezaki S.[2], Makise K.[3], Asano T.[4], Odo T.[1]
[1]Kyushu University, Fukuoka, Japan, [2]National Astronomical Observatory of Japan, Tokyo, Japan, [3]National Institute of Advanced Industrial Science and Technology, Tukuba, Japan, [4]Fukui University, Fukui, Japan

Transport properties have been investigated for the epitaxial superconducting NbN thin films. We analyzed the excess conductance $\sigma'(T)=\sigma(T)-\sigma^N$ above T_c by the sum of the Aslamazov-Larkin and Maki-Thompson (MT) terms for thermal fluctuations, where the $\sigma^N=1/R_{sq}^N$ is the normal state sheet conductance. We have found
1) the theoretical expression $\sigma'_{theo}(T)=\sigma'_{AL}(T)+\sigma'_{MT}(T,\delta)$ can be well fit to $\sigma'_{exp}(T)$ with use of the suitable value of the pair breaking parameter δ in the MT term relating to the inelastic scattering rate $1/\tau_{in}(T)$ as $\delta=h/16k_BT\tau_{in}(T)$. The rate $1/\tau_{in}(T)$ is theoretically given by the sum of $1/\tau_{fluc}(T)$, $1/\tau_{e\text{-}e}(T)$ and $1/\tau_{e\text{-}ph}(T)$, where the first, second and third terms correspond to the rate due to the superconducting fluctuation effect, electron-electron and electron-phonon interactions, respectively.
2) The R_{sq}^N dependence of δ is expressed by $\delta_{exp}=\delta_0+\alpha R_{sq}^N$, where the first term relates to $1/\tau_{e\text{-}ph}(T)$ depending on the materials and the second term is due to the sum of $1/\tau_{fluc}(T)$ and $1/\tau_{e\text{-}e}(T)$. Although we obtained the reasonable value of Debye temperature from the δ_0 as for thin NbN films, the magnitude of the α is about 5 times larger than that of the theoretical one.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.703
Electrical transport between superconducting niobium and a zinc oxide based electric double layer transistor

Narita T.[1], *Takayanagi H.*[2], *Ishiguro R.*[1]
[1]Japan Women's University, Department of Mathematical and Physical Sciences, Tokyo, Japan,
[2]Tokyo University of Science, Research Institute of Science and Technology, Tokyo, Japan

Recently, electric double layer transistors (EDLTs) have attracted attention as a new method to control the property of solid state[1,2,3]. The EDLT is a kind of electric field-effect transistors (FETs) using an ionic liquid, which is a salt in liquid state without any additional solvents, as gate insulating layer of conventional FETs.The upper limit of the sheet carrier density in conventional FETs is restricted by dielectric breakdown field. By contrast, the upper limit of the sheet carrier density in EDLTs increases to approximately 10^{14}~ 10^{15}/cm^2. Since high-density carrier accumulation at the surface is induced by EDLTs, which is ten times more than that in FETs, it is reported that the insulating channel of EDLTs changes to metal and, moreover, superconductor. On the other hand, there are not many studies focusing on junction between a channel of EDLTs and superconductor.
In this study, we fabricated the junction between Zinc Oxide (ZnO), which is wide gap semiconductor and has demonstrated metallization at the surface due to high density carrier accumulation by EDLT[3], and Niobium (Nb), which is a type- ii superconductor with a superconducting transition temperature,T_c=9.2K.
We present the electrical transports property of the junction in a range of 20mK to 10K.

References:
[1] K. Ueno, S. Nakamura, H. Shimotani, A. Ohtomo, N. Kimura, T. Nojima, H. Aoki, Y. Iwasa, and M. Kawasaki, Nat Mater **7**, 855 (2008).
[2] Y. Yamada, K. Ueno, T. Fukumura, H. T. Yuan, H. Shimotani, Y. Iwasa, L. Gu, S. Tsukimoto, Y. Ikuhara, and M. Kawasaki, Science **332**, 1065 (2011).
[3] K. Hanzawa, H. Sato, H. Hiramatsu, T. Kamiya, and H. Hosono, P Natl Acad Sci USA **113**, 3986 (2016).
[4] H. Yuan, H. Shimotani, A. Tsukazaki, A. Ohtomo, M. Kawasaki, and Y. Iwasa, Adv Funct Mater 19, 1046 (2009).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.704
Supercurrent through MoS_2 based electric double layer transistor sandwiched between conventional superconductors

Aikawa Y.[1], *Tsumura K.*[2], *Narita T.*[1], *Takayanagi H.*[3], *Ishiguro R.*[1]
[1]Japan Women's University, Tokyo, Japan, [2]AIST, Tsukuba, Japan, [3]Tokyo University of Science, Tokyo, Japan

Transition-metal di-chalcogenide molybdenum disulfide (MoS_2) is a two-dimensional layered crystal with great potential as a flexible semiconductor device in the future. Recently, an appearance of electrically induced superconductivity at the surface of the MoS_2 based electric double layer transistor (MoS_2-EDLT) was reported [1]. The superconducting properties, such as the ultrahigh upper critical field, give a sign of unconventional spin locking superconducting state [2]. In this study, we aimed at realization of coherence between conventional superconductors Aluminum (Al) and the MoS_2-EDLT. Therefore, we firstly fabricated and evaluated the properties of Al/ MoS_2-EDLT configuration/Al junction.
The bulk MoS_2 was cleaved into single or triple layered flake by using the Scotch-tape method. The flake was transferred onto Si/SiO_2 substrate. Al electrodes as source-drain electrodes were formed by electron beam lithography. A droplet of ionic liquid (DEME-TFSI) was applied onto the surface of the channel and the gate electrodes.
We observed that the supercurrent (I_c=30pA) flows in the Al/MoS_2-EDLT configuration/Al junction at 18mK. We discussed the magnetic field response of this supercurrent.

References:

[1] J. T. Ye et al., Science **338**, 1193 (2012)
[2] Y. Saito et al., Nat. Phys. **12**, 144 (2016)

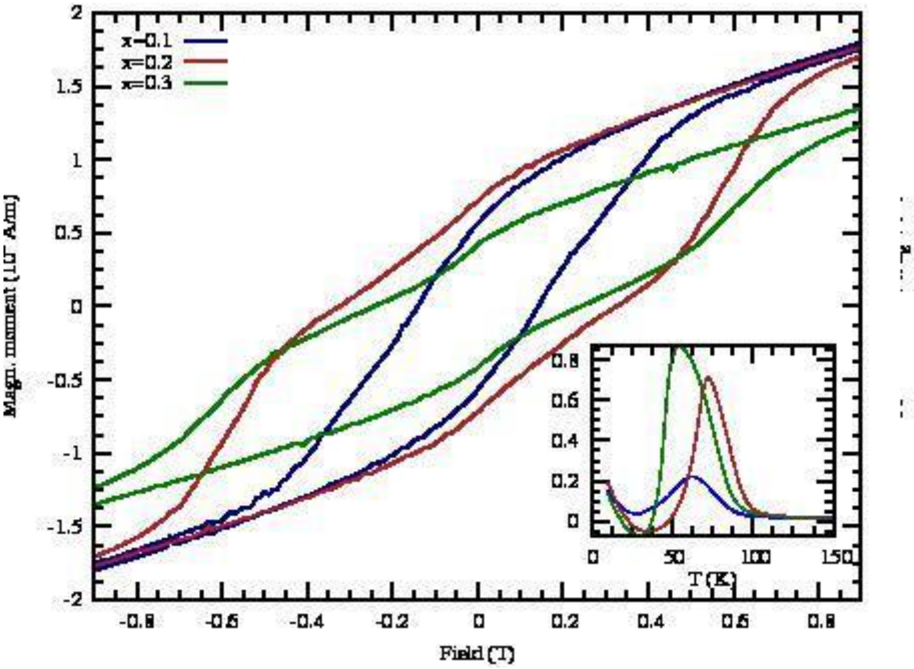
Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.705

Investigation of magnetic properties of epitaxial $Gd_{1-x}Ca_xMnO_3$ (0.1≤ x ≤ 0.3) thin films

<u>Beiranvand A.</u>, Huhtinen H., Paturi P.
University of Turku, Turku, Finland

Epitaxial $Gd_{1-x}Ca_xMnO_3$ (0.1≤ x ≤ 0.3) thin films have been deposited onto $SrTiO_3$ substrates by pulsed - laser deposition. The magnetic properties of the thin films are compared to those of bulk samples. The magnetic ordering temperature (T_C) is higher than the corresponding bulk values. All films exhibit magnetic reversal magnetization below T_C under small applied magnetic field. The reversal mechanism can be explained as a negative f-d interaction and polarization of Gd spins in the direction of the applied field at low temperature [1]. Most interestingly, hysteresis loop measurements show metmagnetic transition in 10 K that have never been seen in bulk samples. Also, coercive force values is much higher in films than in bulk samples and the maximum H_c at 0.35 T is observed for x=0.2. These properties can be associated with magnetic anisotropy and strain effects induced by the lattice mismatch between the films and the substrate [2].



[pic_01]

Figure 1 M-H curves of the thin films at 10 K.The inset shows temperature dependence of magnetization at 50 mT applied magnetic field.

References:

[1] Y. Ma, M. Guilloux-Viry, P. Barahona, and O. Peña, J. Applied Physics Letters **86**, 062506 (2005).
[2] P. Negi, H. M. Agrawal, J. P. Singh, H. Kumar, R. C. Srivastava, K. Asokan, K. H. Chae, J. Supercond Nov. Magn. **29**, 2705 (2016)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.706
Electrical transport properties of epitaxial titanium nitride nanowire

Makise K.[1], *Shinozaki B.*[2]
[1]National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan, [2]Kyushu University, Fukuoka, Japan

The application of nano-structured materials in electronic and opto-electronic devices are one of the major focuses in resent nano-science researches. Especially, nanowires and nano-tubes are important materials for the application to devises, because of nano-size function. We investigated epitaxial titanium nitride on MgO substrates for superconducting applications such as superconducting photon detector and qubits. The critical temperature (T_C) of TiN film is relatively low at around 5 K, but its lattice constant is about 0.424 nm, which is close to the lattice constant of MgO of 0.421 nm. TiN films were prepared by DC magnetron sputtering in a load-lock sputtering system with an ultra-high vacuum chamber. In XRD analysis, (200) peaks were observed in the TiN film. No other XRD peaks were observed in the films. The lattice constant of TiN was determined to be 0.4242 nm from XRD analysis, close to the value of 0.4212 nm for MgO. The 150 nm-thick TiN film on the MgO substrate showed a

T_C of 5.3 K and a resistivity of 3.5 µΩcm at 10 K. Based on these epitaxial TiN films and nanowire, we measured their temperature dependence of resistance.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.707

Superconductor-insulator transitions in sputtered amorphous MoRu and MoRuN thin films

Makise K.[1], *Shinozaki B.*[2], *Ichikawa F.*[3]
[1]National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan, [2]Kyushu University, Fukuoka, Japan, [3]Kumamoto University, Kumamoto, Japan

This work shows the experimental results of the superconductor-insulator (S-I) transition for amorphous molybdenum ruthenium (MoRu) and molybdenum ruthenium nitride (MoRuN) films in magnetic fields. These amorphous films onto c-plane sapphire substrates have been interpreted to be homogeneous by XRD and AFM measurements. Electrical and superconducting properties measurements were carried out on MoRu and MoRuN thin film deposited by reactive sputtering technique. We have analyzed the data on R_{sq} (T) as follows. Excess conductivity of superconducting films by the AL and MT term and weak localization and electron-electron interaction for the conductance at a high magnetic field. MoRu films which offer the most homogeneous film morphology, showed a critical sheet resistance of transition, Rc, of ~ 2 kΩ. These values are smaller than those previously our reported for quench-condensed MoRu films on SiO underlayer held at liquid He temperature.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.708

Theoretical analysis for spin-polarized local density of states in the vortex state of helical p-wave superconductors

Tanaka K.[1], *Ichioka M.*[1,2], *Onari S.*[1,2]
[1]Okayama University, Department of Physics, Okayama-shi, Japan, [2]Okayama University, Research Institute for Interdisciplinary Science, Okayama-shi, Japan

The spin-triplet superconductor (SC) has attracted much attention as a topological SC. A lot of studies support that the ruthenate SC is a spin-triplet chiral p-wave SC. However, the helical p-wave state has also been discussed as another possible pairing state [1]. Therefore, it is necessary that we study the property of physical quantity in the chiral or helical p-wave states.
In the previous study for the vortex state of chiral p-wave SC [2], we found that the local NMR relaxation rate depends on whether the chirality of Cooper pair is parallel or anti-parallel to the vorticity. On the other hand, in the vortex state of helical p-wave SC, we expect that the spin-polarized excitations appear, reflecting the interaction between vorticity and chirality of up- or down-spin pairs.

We study the properties of the vortex state in the helical p-wave SC by the self-consistent calculation of the Eilenberger equation in the vortex lattice state [3]. We confirm the instability of the helical p-wave state at high fields and that the spin-polarized local density of states (LDOS) appears. The site and energy dependences of spin-polarized LDOS are especially investigated. These results may be examined by the spin-polarized scanning tunneling microscopy and spectroscopy measurements.

References:

[1] M. Tsuchiizu *et al.*, Phys. Rev. B **91**, 155103 (2015)
[2] K. K Tanaka *et al.*, Phys. Rev. B **93**, 094507 (2016)
[3] K. K Tanaka *et al.*, Phys. Rev. B **95**, 134502 (2017)

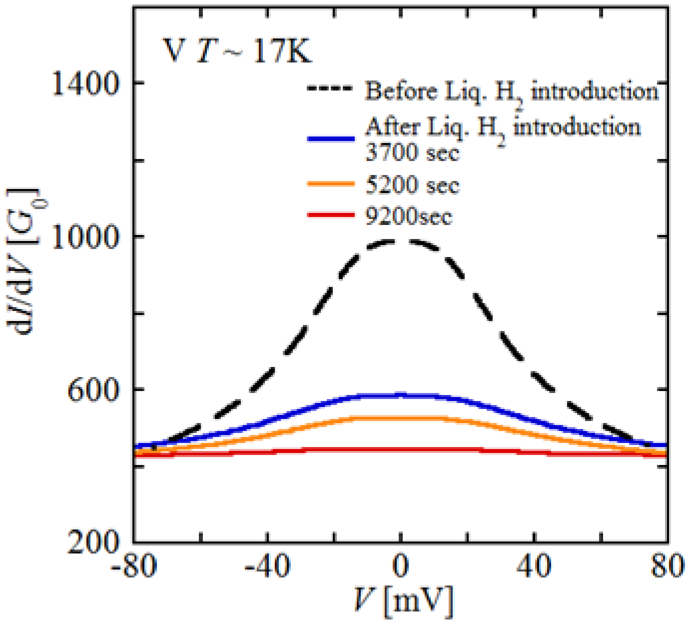
Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.709

Low-temperature hydrogen absorption into V and Nb metals from liquid hydrogen

Takata H.[1], *Ienaga K.*[2], *Shiga M.*[1], *Islam M.S.*[1], *Inagaki Y.*[1], *Tsujii H.*[3], *Hashizume K.*[4], *Kawae T.*[1]
[1]Kyushu University, Faculty of Engineering, Fukuoka, Japan, [2]Tokyo Institute of Technology, Tokyo, Japan, [3]Kanazawa University, Kanazawa, Japan, [4]Kyushu University, Fukuoka, Japan

Hydrogen (H) in metals shows quantum mechanical properties, because it is the lightest of all atoms. H diffusion inside metals is governed by thermal activation process at room temperature, while the diffusion due to tunneling process becomes dominant below liquid nitrogen temperature. Therefore, H absorption and diffusion is believed not to occur at low temperature, because thermal activation process is strongly suppressed and the diffusion rate due to tunneling is quite small. However, we found that H atoms are absorbed into palladium (Pd) nano-contacts when a small bias voltage is applied to the nano-contacts immersed in liquid H_2 [1].
In the present study, we report low-temperature H absorption experiments in nano-contacts made of bcc metals such as vanadium (V) and niobium (Nb). The figure shows the time revolution of differential conductance spectra in V nano-contact immersed in liquid H_2. A large amount of H absorption has been observed through the change of differential conductance spectra. Moreover, H absorption into V and Nb nano-contacts progresses more rapidly than that into Pd (fcc). The results suggest that the low-temperature H absorption experiments enable real-time study on H kinetics due to tunneling.



[Time revolution of differential conductance]

References:
"[1] K. Ienaga, H. Takata, Y. Onishi, *et al*, Appl. Phys. Lett. **106**, 021605 (2015)"

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.710
Introducing uniaxial local strain to graphene encapsulated with hBN

Tomori H.[1,2], *Hayashi M.*[3], *Yoshioka H.*[4], *Watanabe K.*[5], *Taniguchi T.*[5], *Ootuka Y.*[1], *Kanda A.*[1]
[1]University of Tsukuba, Tsukuba, Japan, [2]PRESTO-JST, Saitama, Japan, [3]Akita University, Akita, Japan, [4]Nara Women's University, Nara, Japan, [5]National Institute for Materials Science, Tsukuba, Japan

Due to high mobility, graphene is a promising candidate for electronic materials. However, for successful application of graphene to switching devices, gap formation is indispensable. In this study, we explore the gap formation in graphene based on strain engineering.[1]
We induced uniaxial local strain in graphene encapsulated with hBN. We inserted a graphene film between patterned hBN films by using the van der Waals assembly method. [2] The current path with uniaxial local strain was defined by reactive ion etching after the encapsulation. The spatial variation of strain was confirmed by micro-Raman spectroscopy.
In transport measurement, we compare electron transport in graphene with strain with that in graphene without strain. In graphene without strain, a symmetric V-shaped conductance-gate voltage curve is seen, which is conventional in graphene. On the other hand, in graphene with strain, the V-shaped curve is deformed and the conductance decreases with decreasing temperature within the whole gate voltage range. The minimum conductance exhibits the thermal activation behavior at high temperatures

(100 K - RT), indicating the existence of a transport gap.

References:
[1] V. M. Pereira and A. H. Castro Neto, Phys. Rev. Lett. 103, 046801 (2009).
[2] L. Wang et al. Science 342, 614 (2013).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.711
Magnus force on a vortex in a superfluid in a periodic potential
Sonin E.
Hebrew University, Racah Institute of Physics, Jerusalem, Israel

The analysis addresses the Magnus force on vortices in superfluids put into periodic potentials at T=0. The case of weak potential and the tight-binding limit described by the Bose-Hubbard model were considered. The analysis was based on the balance of true momentum and quasimomentum. A special attention was paid to the superfluid close to the superfluid-insulator transition observed in BEC of cold atoms in an optical lattice. In this area of the phase diagram the theory predicts the particle-hole symmetry line where the Magnus force changes sign with respect to that expected from the sign of velocity circulation. Our analysis has shown that the magnitude of the Magnus force is a continuous function at crossing the particle-hole symmetry line. This challenges the theory connecting the magnitude of the Magnus force with topological Chern numbers and predicting a jump at crossing this line. Disagreement is explained by the role of intrinsic pinning and guided vortex motion ignored in the topological approach.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.714
Spin superfluidity in YIG magnetic films
Sonin E.
Hebrew University, Racah Institute of Physics, Jerusalem, Israel

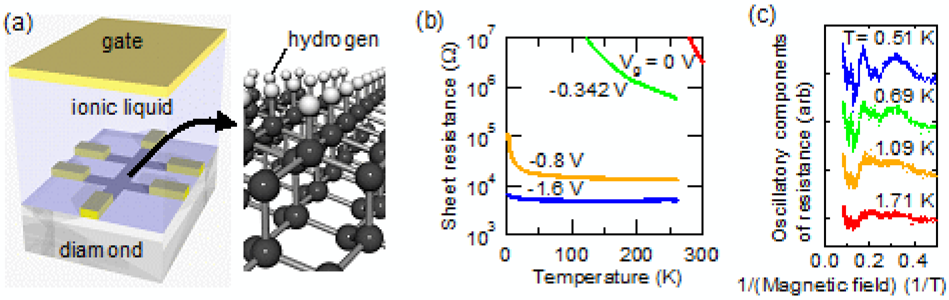
Recently it was suggested that spin supercurrents analogous to supercurrents in superfluids are possible in the magnon BEC observed in yttrium-iron-garnet (YIG) magnetic films under strong external pumping. Bozhko et al. [1] declared experimental detection of a spin supercurrent in a decay of the magnon condensate in YIG. Here we analyze possibility of spin superfluidity in YIG films. From topology of the equilibrium order parameter in YIG one must not expect energetic barriers making spin supercurrents metastable. However, some small barriers of dynamical origin are possible nevertheless. The critical phase gradient (analog of the Landau critical velocity in superfluids) is proportional to intensity of the coherent spin wave (number of condensed magnons). The conclusion is that although spin superfluidity in YIG films is possible in principle, the published claim of its observation is not justified because of rather small phase difference realized in the experiment.

References:
[1] D. A. Bozhko *et al*., Nat. Phys. 12, 1057 (2016)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.715
Quantum transport of electric field-induced carriers at the surface of diamond
Takahide Y.[1,2], *Sasama Y.*[1,2], *Tanaka M.*[1], *Takeya H.*[1], *Takano Y.*[1,2], *Kageura T.*[3], *Kawarada H.*[3]
[1]National Institute for Materials Science, Tsukuba, Japan, [2]University of Tsukuba, Tsukuba, Japan, [3]Waseda University, Tokyo, Japan

We report novel magnetoresistance phenomena of electric field-induced carriers at the surface of diamond.
Heavy boron doping into diamond introduces charge carriers, which show a metallic state and even a superconducting state at low temperature. However, carrier scattering due to the high-density dopants leads to a very low mobility. It is also predicted that the superconducting transition temperature is suppressed by the electronic disorder due to the heavy doping.
In this study, we introduced charge carriers at the hydrogen-terminated surface of diamond by an electric field effect using an ionic liquid (Fig. 1a). This method can accumulate high density carriers at the surface of diamond without inducing lattice disorder. Using this method, we successfully induced a metallic state with high mobility (Fig. 1b) and observed Shubnikov-de Haas oscillations of diamond for the first time
(Fig. 1c). [1,2] We also observed a spin-related anomalous positive magnetoresistance effect at the (001) surface of hydrogen-terminated diamond; the magnetoresistance ratio, $[\rho(B) - \rho(0)]/\rho(0)$, follows a universal function of (magnetic field B)/(temperature T) [3]. These results will open up the possibility of using diamond as a unique material in the field of quantum transport and spintronics.



[Figure 1]

References:
[1] Yamaguchi Takahide, et al., J. Phys. Soc. Jpn. **82**, 074718 (2013).
[2] Yamaguchi Takahide, et al., Phys. Rev. B **89**, 235304 (2014).
[3] Yamaguchi Takahide, et al., Phys. Rev. B **94**, 161301(R) (2016).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.716
Electric and magnetic tunability of Andreev levels via spin-orbit coupling in spin-split Josephson junctions
Hashimoto T.[1,2], *Golubov A.A.*[1,3], *Tanaka Y.*[2], *Linder J.*[4]
[1]University of Twente, Faculty of Science and Technology and MESA+ Institute of Nanotechnology, Enschede, Netherlands, [2]Nagoya University, Department of Applied Physics, Nagoya, Japan, [3]Moscow Institute of Physics and Technology, Moscow, Russian Federation, [4]Norwegian University of Science and Technology, Department of Physics, Trondheim, Norway

We theoretically study the Andreev level in the Zeeman splitting superconductor/Rashba metal/ Zeeman splitting superconductor (ZS/RM/ZS) junction by solving the Bogoliubov de-Gennes equation. Here, we consider short ballistic junctions. We find that the Andreev levels can be controlled by the strength of the RSOI, thickness of normal region, and the direction of the Zeeman field and RSOI. It is found that the magnitude of the energy band splitting of the Andreev level oscillates as a function of the strength of RSOI and the length of the Rashba metal with certain period. We also find that the Andreev level can be dramatically changed by changing the direction of the Zeeman field. In particular, if the Zeeman field has a component along the junction, the Andreev level become asymmetric as a function of the phase difference.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.717
Anomalous spatial variations of superfluid ^{3}He in aerogels at low temperatures
Nagamura N.[1], *Ikeda R.*[2]
[1]Kyoto University, Kyoto, Japan, [2]Kyoto University, Physics, Kyoto, Japan

Previous theoretical studies on superfluid 3He in aerogels have focused on possible pairing states at finite temperatures comparable with the transition temperature of the bulk liquid, and the polar pairing state [1] predicted for the 1D-like anisotropic aerogel has been discovered experimentally [2,3]. In aerogels with strong impurity scattering effects, the transition temperature *Tc* can vanish at a nonvanishing pressure, and it is valuable to study possible events occurring near the resulting quantum critical point (QCP).
We study the gradient terms of the Ginzburg-Landau free energy near the disorder-induced QCP, and its effects on the phase diagram are considered. In the globally isotropic aerogel, the longitudinal spatial variation of the orbital component of the order parameter is suppressed. It is found that, consequently, the so-called o-vortex in the B-phase at low enough temperatures cannot appear even as a metastable structure. In the presence of a globally stretched anisotropy, any spatial variation of the order parameter of the resulting polar phase in aerogels is found to be suppressed with vanishing *Tc* for a relatively large anisotropy. Its consequence implying divergence of the lower critical rotation velocity for vortex-creation is discussed.
References:
[1] K. Aoyama and R. Ikeda, Phys. Rev. B 73, 060504 (2006); R. Ikeda, Phys. Rev. B 91, 174515 (2015).
[2] V. V. Dmitriev et al., Phys. Rev. Lett. 115, 165304 (2015); N. Zhelev et al., Nature Comm. 7, 12975 (2016).
[3] S. Autti et al., Phys. Rev. Lett. 117, 255301 (2016)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.718

Cu-spin correlation and novel electronic state in the electron-doped high-T_c cuprates

Adachi T.[1], *Sumura T.*[1], *Baqiya M.A.*[2], *Takahashi A.*[2], *Konno T.*[2], *Ohgi T.*[2], *Kurashima K.*[2], *Kawamata T.*[2], *Ishimoto T.*[1], *Kuwahara H.*[1], *Watanabe I.*[3], *Koda A.*[4], *Miyazaki M.*[5], *Kadono R.*[4], *Awaji S.*[6], *Koike Y.*[2]
[1]Sophia University, Department of Engineering and Applied Sciences, Tokyo, Japan, [2]Tohoku University, Department of Applied Physics, Sendai, Japan, [3]RIKEN Nishina Center, Advanced Meson Science Laboratory, Wako, Japan, [4]KEK, Institute of Materials Structure Science, Tsukuba, Japan, [5]Muroran Institute of Technology, Muroran, Japan, [6]Tohoku University, Institute for Materials Research, Sendai, Japan

In order to investigate the electronic state relating to the undoped superconductivity in the parent compounds of electron-doped high-T_c cuprates [1,2], we have performed the Hall resistivity and muon-spin-relaxation (muSR) measurements of $Pr_{1.3-x}La_{0.7}Ce_xCuO_{4+d}$ (PLCCO) single crystals [3]. The Hall resistivity of the reduced superconducting (SC) crystals of PLCCO with x = 0.10 and 0.15 has been found to be nonlinear in magnetic field, suggesting the existence of multiple carriers. The muSR spectra of PLCCO with x = 0.10 have revealed that, through the moderate reduction annealing, an antiferromagnetic long-range order in the non-SC as-grown crystal changes to a short-range one in the SC moderately reduced crystal. It has been found that the further reduction brings about the destruction of the magnetic order and develops the Cu-spin correlation. Moreover, the development of the Cu-spin correlation has been found to weaken with increasing x and almost disappears at the end point of the SC region in the phase diagram. These results suggest that the developed Cu-spin correlation is crucial to appear the superconductivity in undoped and electron-doped cuprates. The novel electronic-structure model based on the strong electron correlation is proposed to explain these results [3,4].

References:

[1] A. Tsukada *et al*., Solid State Commun. **133**, 427 (2005).
[2] T. Takamatsu *et al*., Appl. Phys. Express **5**, 073101 (2012).
[3] T. Adachi *et al*., J. Phys. Soc. Jpn. **85**, 114716 (2016).
[4] T. Adachi *et al*., J. Phys. Soc. Jpn. **82**, 063713 (2013).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.719

Dimensional crossover as the origin of reentrant resistive behavior in superconducting films

Postolova S.[1,2], *Mironov A.*[1], *Vinokur V.*[3], *Baturina T.*[1,4]
[1]Institute of Semiconductor Physics, Siberian Branch of Russian Academy of Sciences, Novosibirsk, Russian Federation, [2]Novosibirsk State University, Novosibirsk, Russian Federation, [3]Argonne National Laboratory, Materials Science Divisio, Lemont, United States, [4]Universidad Autonoma de Madrid, Instituto de Ciencia de Materiales Nicolas Cabrera and Condensed Matter Physics Center (IFIMAC), Departamento de Fisica de la Materia Condensada, Madrid, Spain

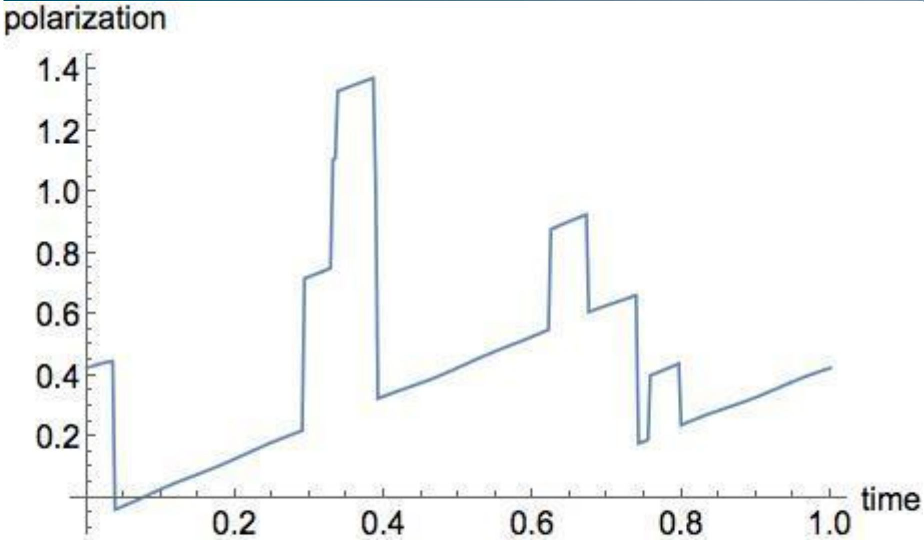
A reentrant temperature dependence of the normal state resistance often referred to as the *N*-shaped temperature dependence, is omnipresent in disordered superconductors - ranging from high-temperature cuprates to ultrathin superconducting films - that experience superconductor-to-insulator transition. We investigate strongly disordered superconducting TiN films and demonstrate universality of the reentrant behavior. We offer a quantitative description of the *N*-shaped resistance. We show that upon cooling down the resistance first decreases linearly with temperature and then passes through the minimum that marks the 3D-2D crossover in the system. We show that the shift from the downturn to upturn of the resistance occurs once the thermal coherence length L_T matches the thickness of the film d. In the 2D temperature range the resistance first grows with decreasing temperature due to quantum contributions and eventually drops to zero as the system falls into a superconducting state. Our findings demonstrate the prime importance of disorder in dimensional crossover effects [1].
T.I.B. acknowledges support from the Consejería de Educación, Cultura y Deporte (Comunidad de Madrid) through the program, Ref.2016-T3/IND-1839.
The experimental work was supported by RSCF(Grant No.14-22-00143).

References:
S.V. Postolova, A.Yu.Mironov, M.R. Baklanov, V.M. Vinokur, and T.I. Baturina, Scientific Reports, accepted to publication (2017).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.721
Bulk-edge correspondence in topological transport and pumping
Imura K.-I.[1], *Yoshimura Y.*[2], *Fukui T.*[3], *Hatsugai Y.*[4]
[1]Hiroshima University / AdSM, Department of Quantum Matter, Higashi-Hiroshima, Japan, [2]Tohoku University, Sendai, Japan, [3]Ibaraki University, Department of Physics, Mito, Japan, [4]Tsukuba University, Institute of Physics, Tsukuba, Japan

Topologically nontrivial phases show protected surface or edge states. The existence of such surface states and the way how they appear is uniquely determined by the bulk topological numbers. The bulk-edge correspondence (BEC) [1] refers to this one-to-one relation. Depending on the system in question, BEC manifests in different forms and govern the spectral and transport properties of topological insulators and semimetals. We have previously focused on the stability of surface states against lattice imperfections [2], cases of weak topological phases [3], and of Weyl semimetal thin films [4].
Quantization of pumped charge and spin is another manifestation of the nontrivial topological properties in the bulk. To quantify topological pumping, time evolution of the initial ground state is to be considered in the adiabatic limit [5,6]. Here, using the prescription of Ref. [6], we study the robustness of topological pumping against static disorder. FIG. 1 shows a typical time dependence of the system´s polarization, indicating that the pumped charge is unchanged in spite of the irregularities due to disorder. This “snapshot picture” (an approach from the adiabatic limit) reveals the role of edge states in topological pumping, providing also an interesting twist on the BEC picture.



[Time dependence of polarization]

References:

[1] Y. Hatsugai, Phys. Rev. Lett. **71**, 3697 (1993)
[2] K.-I. Imura and Y. Takane, Phys. Rev. B **87**, 205409 (2013)
[3] Y. Yoshimura, K.-I. Imura, T. Fukui and Y. Hatsugai, Phys. Rev. B **90**, 155443 (2014)
[4] Y. Yoshimura, W. Onishi, K. Kobayashi, T. Ohtsuki and K.-I. Imura, Phys. Rev. B. **94**, 235414 (2016)
[5] D. J. Thouless, Phys. Rev. B **27**, 6083 (1983)
[6] Y. Hatsugai and T. Fukui, Phys. Rev. B **94**, (R) 041102 (2016)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.722

Topology in single-wall carbon nanotube of zigzag and armchair type

Okuyama R.[1]*, Izumida W.*[2]*, Eto M.*[1]
[1]Keio University, Faculty of Science and Technology, Yokohama, Japan, [2]Tohoku University, Department of Physics, Sendai, Japan

The single-wall carbon nanotube (SWNT) is a unique one-dimensional (1D) system made by rolling up a graphene sheet. Even for a metallic SWNT, a narrow energy gap opens between conduction and valence bands due to the mixing of σ and π orbitals by the finite curvature of tube surface and spin-orbit interaction. It can be regarded as a 1D topological insulator owing to the sublattice symmetry for A and B lattice sites [1]. The electronic states are characterized by a Z topological invariant, winding number, in both the absence (class BDI) and presence (AIII) of magnetic field.
We theoretically examine the topological properties in a metallic SWNT, using a 1D lattice model to effectively describe curvature effects and spin-orbit interaction [2]. The winding number can be observed as the number of edge states in the SWNT via the bulk-edge correspondence. We find that zigzag and armchair tubes are non-trivial and trivial topological insulators, respectively: The number of

edge states is finite for the former and zero for the latter. We also find a topological phase transition in the zigzag tube by applying a magnetic field along the tube [3].

References:

[1] W. Izumida, R. Okuyama, A. Yamakage, and R. Saito, Phys. Rev. B **93**, 195442 (2016).
[2] W. Izumida, K. Sato, and R. Saito, J. Phys. Soc. Jpn **78**, 074707 (2009).
[3] R. Okuyama, W. Izumida, and M. Eto, J. Phys. Soc. Jpn **86**, 013702 (2017).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.723

SINIS bolometer with a suspended absorber

Tarasov M.[1,2], *Edelman V.*[3], *Mahashabde S.*[4], *Fominsky M.*[1], *Lemzyakov S.*[3,5], *Chekushkin A.*[1,5], *Yusupov R.*[1,5], *Yurgens A.*[2]
[1]V. Kotelnikov Institute of Radio Engineering and Electronics, Moscow, Russian Federation, [2]Chalmers University of Technology, Microtechnology and Nanoscience, Göteborg, Sweden, [3]P. Kapitza Institute for Physical Problems, Moscow, Russian Federation, [4]Oxford University, Astrophysics, Oxford, United Kingdom, [5]Moscow Institute for Physics and Technology (State University), Moscow, Russian Federation

We have developed a Superconductor-Insulator-Normal Metal-Insulator-Superconductor (SINIS) bolometer with a suspended normal metal bridge. The suspended bridge acts as a bolometric absorber with reduced heat losses to the substrate. Such bolometers were measured at 100-350 mK bath temperatures and electrical responsivity of over 10^9 V/W was measured by dc heating the absorber through additional contacts. Suspended bolometers were also integrated in planar twin-slot and log-periodic antennas for operation in the submillimetre-band of radiation. The measured voltage response to radiation at 300 GHz and at 100 mK bath temperature is $3*10^8$ V/W and a current response is $1.1*10^4$ A/W which corresponds to a quantum efficiency of ~15 electrons per photon. We investigate the performance of direct SN traps and NIS traps with tunnel barrier between superconductor and normal metal trap. Increasing the volume of superconducting electrode helps to reduce overheating of superconductor. Influence of Andreev reflection and Kapitza resistance, as well as electron-phonon heat conductivity and thermal conductivity of N-wiring are estimated for such SINIS devices.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.725

Film thickness dependence of CDW states in transition metal dichalcogenide 1*T*-TaS_2 observed by STM/STS

Ohta S., *Fujisawa Y.*, *Simabukuro T.*, *Demura S.*, *Sakata H.*
Tokyo University of Science, Shinjuku-ku, Japan

In layered transition metal dichalcogenide 1*T*-TaS_2, several CDW states emerge as a function of temperature. Bulk 1*T*-TaS_2 undergoes successive CDW transitions from metallic incommensurate

CDW (ICCDW) to metallic nearly commensurate CDW (NCCDW) at 350 K, to insulating commensurate CDW (CCDW) state at 190 K [1]. Furthermore, CDW states show thickness dependence. In thin samples whose thickness is less than a few nm, insulating ICCDW state was reported, which is different from that in bulk samples [2-3]. The reason for the insulating behavior has not been clarified yet.
In order to investigate the nature of this insulating ICCDW state, we have performed scanning tunneling microscopy and spectroscopy (STM/STS) measurements. STM image and tunneling spectra of thin 1*T*-TaS_2 samples will be presented. We will discuss the relation between the film thickness and the electronic structure in 1*T*-TaS_2.

References:

[1] B. Sipos *et al.*, Nature Materials **7**, 960 (2008)
[2] Y. Yu *et al.*, Nature Nanotechnology **10**, 270 (2015)
[3] W. Fu *et al.*, Chem. Mater. **28**, 7613 (2016)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.726

Otto refrigerator based on a superconducting qubit

Karimi B., *Pekola J.*
Aalto University, Low Temperature Laboratory, Department of Applied Physics, Espoo, Finland

The Otto cycle consists of adiabatic expansion, rejection of heat at constant volume, adiabatic compression, and heat extraction at constant volume. Here, we analyze a quantum Otto refrigerator based on a superconducting qubit coupled to two LC resonators, each including a resistor acting as a reservoir [1,2]. We find various operation regimes: nearly adiabatic (low driving frequency), ideal Otto cycle (intermediate frequency), and nonadiabatic coherent regime (high frequency). In the nearly adiabatic regime, the cooling power is quadratic in frequency, and we find a substantially enhanced coefficient of performance, as compared to that of an ideal Otto cycle. Quantum coherent effects lead invariably to a decrease in both cooling power and efficiency as compared to purely classical dynamics. In the nonadiabatic regime we observe strong coherent oscillations of the cooling power as a function of frequency. We investigate various driving wave forms: Compared to the standard sinusoidal drive, a truncated trapezoidal drive with optimized rise and dwell times yields higher cooling power and efficiency. With this set-up we predict an experimentally observable cooling power of few fW at the operation frequency of about 100 MHz.

References:

[1] A. O. Niskanen, Y. Nakamura, and J. P. Pekola, Phys. Rev. B 76, 174523 (2007).
[2] B. Karimi, and J. P. Pekola, Phys. Rev. B 94, 184503 (2016).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.727

Studies of SINIS detector response time at signal frequency of 350 GHz

Edelman V.[1], *Lemzyakov S.*[1,2], *Tarasov M.*[3,4]

[1]P. Kapitza Institute for Physical Problems, Moscow, Russian Federation, [2]Moscow Institute for Physics and Technology (State University), Moscow, Russian Federation, [3]Chalmers University of Technology, Microtechnology and Nanoscience, Göteborg, Sweden, [4]V. Kotelnikov Institute of Radio Engineering and Electronics, Moscow, Russian Federation

Response time constant of SINIS bolometer integrated with log-periodic antenna was measured at bath temperature of 100 mK. Samples comprising aluminium electrodes and suspended Cu strip connected to electrodes via tunnel junctions were fabricated on Si substrate using selective chemical etching of Cu in weak acid and Al in weak base. Bolometer was illuminated by fast black-body radiation source through a band-pass filter with central frequency 350 GHz and passband of 7 GHz. Radiation source is a thin NiCr film on silicon substrate with square resistance of 150 W. Source was equipped with RuO_2 thermometer. For rectangular 20-30 µs current pulse the radiation pulse front edge was rather sharp due to low thermal capacitance of NiCr film and low thermal conductivity of substrate at temperatures in the range 1-4 K. The time of response increase at the front edge was below 3-5 µs. This time presumably is limited by technical reasons: time of increase for radiation source, bandwidth of a readout amplifier and capacitance of rather long twisted pair wiring from SINIS bolometer to a room-temperature amplifier. According to such estimations we can expect the actual time constant of SINIS bolometer to be below 1 ms.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.729
Transport properties as a tool to study universal features of quench-induced dynamics in 1D systems

Calzona A.[1,2], Gambetta F.M.[2], Carrega M.[3], Cavaliere F.[2], Sassetti M.[2]
[1]University of Luxembourg, Luxembourg, Luxembourg, [2]University of Genova and CNR-SPIN, Genova, Italy, [3]CNR-Nano Pisa, Pisa, Italy

The study of the relaxation process that follows a quantum quench in 1D systems still represents an open research field. Here we consider a sudden change of the interparticle interaction and we identify a peculiar correlator of the system whose behavior is directly and deeply affected by the quench-induced dynamics. Interestingly, it features a universal power-law decay in time, a distinctive characteristic that should simplify the identification of this correlator´s effects on the system´s observables. Unfortunately, such a universal decay, although present, turns out to be subleading in intrinsic properties of the system such as the non-equilibrium spectral function. We thus consider a tunnel coupling of the system with a biased tip in order to be able to study also transport properties, namely the charge and energy current flowing from the tip to the system after the quench. In these quantities the universal power-law emerges clearly, especially if one focuses on energy current and its fractionalization into a right- and left- moving components. In particular, we show that the presence of a transient in the energy fractionalization ratio is a direct hallmark of the quench-induced relaxation and represent a new and useful tool to study out-of-equilibrium 1D systems.

References:
[1] F. M. Gambetta, F. Cavaliere, R. Citro, and M. Sassetti, Phys. Rev. B 94, 045104 (2016)
[2] A. Calzona, F. M. Gambetta, M. Carrega, F. Cavaliere, and M. Sassetti, Phys. Rev. B 95, 085101 (2017)
[3] A. Calzona, F. M. Gambetta, M. Carrega, F. Cavaliere, and M. Sassetti, in preparation.

Postersession 3

Monday, 14 August 2017
16.30-18.30
G Foyer

P.730
Kinematic and structural studies of metastable vortex lattice phases in MgB_2
Louden E.R., Eskildsen M.R., Rastovski C., Leishman A., Kuhn S.J.
University of Notre Dame, Department of Physics, Notre Dame, United States

The vortex lattice (VL) in MgB_2 exhibits an unprecedented degree of metastability in connection with a second order (continuous) VL rotation transition. This represents a novel kind of collective vortex behavior, and cannot be understood from the single VL domain free energy or from vortex pinning [1,2].
We have studied kinematic and structural properties of the metastable VL phases in MgB_2 using small-angle neutron scattering using a stop-motion technique. We find a dichotomy in the behavior for the superheated and supercooled metastable configurations. In the first case the VL returns to the ground state through a continuous domain rotation, while in the second case the transition takes on a first order nature. In the supercooled case where VL ground state domains nucleate and grow at their final orientation, the metastable volume fraction follow a power law with an exponent that increases with increasing AC field amplitude. Both metastable and ground state configurations show correlations along the field (vortex) direction that are comparable to the sample thickness. Finally, spatially resolved measurements show a spatial variation in the VL domain population on length scales of the order 100 µm.
Supported by the USDOE Awards DE-FG02-10ER46783.
References:
[1] P. Das. et al., Phys. Rev. Lett. **108**, 167001 (2012).
[2] C. Rastovski et al., Phys. Rev. Lett. **111**, 107002 (2013).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.731
The stripe phase as the dynamical instability of the Higgs field in confined superfluid ^{3}He
Mizushima T.[1], Sauls J.A.[2]
[1]Osaka University, Department of Materials Engineering Science, Toyonaka, Japan, [2]Northwestern University, Department of Physics and Astronomy, Evanston, United States

Superfluid ^{3}He exhibits a variety of topological and broken symmetry phases. In a thin film, a "stripe" phase that spontaneously breaks translational symmetry has been predicted on the basis of weak-coupling quasiclassical theory [1] and within strong-coupling Ginzburg-Landau (GL) theory [2]. Starting from a Lagrangian formulation for the dynamics of the order parameter for ^{3}He, we show that a superfluid film with translational symmetry is dynamically unstable for a range of film thicknesses of order several coherence lengths. The time-dependent GL Lagrangian describes the space-time Bosonic fluctuations around a stationary state of the GL functional. The formalism incorporates strong-coupling corrections via the GL material parameters, (β_1, ..., β_5). For a translationally invariant B-phase film the amplitude of the Bosonic mode dispersing from the $J=2^+$, $m_J=0$ Higgs mode softens at a finite wavevector, $Q = 0.3\xi$ (ξ is the superfluid coherence length), then develops a pole in the upper half of the complex frequency plane signaling a dynamical instability with exponential growth towards a new ground state with spontaneously broken translation symmetry. We discuss the dynamical instability and its relation to the predicted stripe phase of thin films of superfluid ^{3}He.

References:
[1] A. B. Vorontsov and J. A. Sauls, Phys. Rev. Lett. **98**, 045301 (2007).
[2] J. J. Wiman and J. A. Sauls, J. Low Temp. Phys. **184**, 1054 (2016).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.732

The mobility of ^{3}He absorbed on MCM-41: NMR studies

Birchenko O., Fysun Y., Mikhin N., Rybalko A., Rudavskii E.
B. Verkin Institute for Low Temperature Physics and Engineering, Kharkov, Ukraine

At low temperatures (T < 10 K) the powder MCM-41 is effective adsorbent of noble gases with good absorbency (specific surface area ~ 1000 m^2/g). Moreover, 99% of the adsorbing surface is the inner surface of the tubes [1]. It has known that roughly first 1.8 monolayers of adsorbed helium have the structure of disordered solid [2]. Next additional portions of ^{3}He have the properties of a “rarefied" liquid. This quasi-one-dimensional object is supposed to have properties of Tomonaga-Luttinger liquid, low-dimensional structure of the ^{3}He fermions [3]. We have investigated 3He adsorbed in 2.5 nm 1D channels 300 nm length by pulse NMR method ($\omega_0/2\pi$=9.15 MHz). Spin-lattice T_1 and spin-spin T_2 relaxation times, as well as D spin-diffusion coefficient were measured in the temperature range 1.3-8 K. It was found at least two different contributions to the NMR signal, which can be associated with “disordered solid” and “rarefied liquid” phases of ^{3}He mentioned above. The temperature dependence of the relative magnetization of ^{3}He was also obtained for different coverage. The results obtained in the experiments are discussed.

References:
[1] C. Kresge, M.E. Leonowicz, W.J. Roth, J.C. Vartuli, J.S. Beck, Nature **359**, 710 (1992)
[2] N. Wada,·T. Matsushita,·M. Hieda,·R. Toda, J. Low Temp Phys **157**, 324 (2009)
[3] B. Yager, J. Nye´ki, A. Casey, B. P. Cowan, C. P. Lusher, J. Saunders, PRL **111**, 215303 (2013)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.733

Fluctuation spectroscopy as a probe of granular superconducting diamond films

Klemencic G.M.[1], Fellows J.M.[2], Werrell J.M.[1], Mandal S.[1], Giblin S.R.[1], Smith R.A.[3], Williams O.A.[1]
[1]Cardiff University, School of Physics and Astronomy, Cardiff, United Kingdom, [2]University of Bristol, School of Physics and Astronomy, Bristol, United Kingdom, [3]University of Birmingham, Birmingham, United Kingdom

Here I present resistance versus temperature data for a series of superconducting boron-doped nanocrystalline diamond films whose grain size is varied by changing the film thickness. For this series, we have extracted the fluctuation conductivity in the vicinity of the superconducting transition and have studied the scaling behaviour with temperature. We have found that there are three distinct scaling regions - 3D intragrain, quasi-0D, and 3D intergrain - in confirmation of the prediction of Lerner, Varlamov and Vinokur [1]. I will describe how this result can be used as a probe of material

characteristics in granular superconductors. In particular, I will show how the diffusion constant can be inferred from the location of these dimensional crossovers.

References:

[1] Lerner, I. V., A. A. Varlamov, and V. M. Vinokur, Phys. Rev. Lett., **100**, 117003 (2008)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.734

Random field Ising versus Bose Glass physics in a disordered quantum magnet

Perren G.[1], *Lorenz W.*[1], *Ressouche E.*[2], *Zheludev A.*[1]
[1]Neutron Scattering and Magnetism, Laboratory for Solid State Physics, ETH Zurich, Zurich, Switzerland, [2]SPSMS, UMR-E CEA/UJF-Grenoble 1, INAC, Grenoble, France

IPA-$CuCl_3$ is a well-known S = 1/2 gapped quantum paramagnet which exhibits a field-induced BEC-like quantum phase transition to a magnetically ordered phase [1]. The corresponding transition in the random-bond Br-substituted derivative IPA-$Cu(Cl_{1-x}Br_x)$ has been interpreted as that from a magnetic Bose Glass (BG) phase to what appeared to be a short range ordered state [2]. The underlying mechanism remained unclear. In the present work we report new neutron diffraction and calorimetric measurements on the x=5% compound. We show that Ising-type anisotropy is a key factor, and that critical behavior and short range order at high field are strongly dependent on the applied field direction. The field-induced transition in the disordered system is actually of the Ising model-in-random-field universality class, rather than a BG to BEC transition.

References:

[1] T. Masuda, PRL **96**, 047210 (2005)
[2] T. Hong, PRB **81**, 060410 (2010)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.735

Observation of boson resonance in oxypnictide superconductors by means of IMARE spectroscopy

Kuzmichev S.[1,2], *Kuzmicheva T.*[2]
[1]M.V. Lomonosov Moscow State University, Low Temperature Physics and Superconductivity, Moscow, Russian Federation, [2]P.N. Lebedev Physical Institute RAS, Laboratory of Strongly Correlated Systems, Moscow, Russian Federation

We studied polycrystalline samples of various 1111-family superconductors: $GdO_{1-x}F_xFeAs$ ($x \approx 0.1$, T_c = 46-53 K), $CeO_{0.9}F_{0.1}FeAs$ ($T_c \approx 41$ K) [1], $Sm_{1-x}Th_xOFeAs$ (x = 0.08-0.3, T_c = 26-54 K) [2], and $LaO_{1-x}F_xFeAs$ ($x \approx 0.1$, $T_c \approx 26$ K) [3].
We used intrinsic multiple Andreev reflection effect (IMARE) spectroscopy realized by a break-junction technique [4]. In natural SnSn-…-S (S — superconductor, n — normal metal) arrays, IMARE causes a subharmonic gap structure (SGS) — a set of dI/dV dips at $eV_n = 2\Delta \cdot m/n$ (m — number of SnS junctions in the array, n = 1, 2, …). In 1111, we observed two gaps with $2\Delta_L/kT_c$ = 5.2-5.7, and $2\Delta_S/kT_c$ = 1.2-1.6 [5].

During IMARE, electron could emit a boson with energy ε_0, causing satellite dI/dV dips offset the Δ_L SGS at $eV_n = (2\Delta + k\varepsilon_0)\cdot m/n$ (k = 1, 2,… — number of emitted bosons) [6]. We observed a reproducible fine structure of up to k = 4 dips which (a) is caused by the bulk rather than surface, (b) holds its position regardless to contact resistance and m, (c) is not caused by a 3rd gap, or k-space Δ_L anisotropy, (d) has a particular T-dependence, proving its electron-boson origin. The directly determined ε_0 scales with T_c together with both gaps within T_c = 26-54 K, with $2\varepsilon_0/kT_c \approx 3.3$ staying close to the expected magnetic resonance energy $\Delta_L \pm \Delta_S$ [7].

References:

[1] E.P. Khlybov, *et al*., JETP Lett. **90**, 387 (2009)
[2] N.D. Zhigadlo, *et al*., Phys. Rev. B **82**, 064517 (2010)
[3] A. Kondrat, *et al*., Eur. Phys. J. B **70**, 461 (2009)
[4] S.A. Kuzmichev, T.E. Kuzmicheva, Low Temp. Phys. **42**, 1008 (2016)
[5] T.E. Kuzmicheva, *et al*., Physics-Uspekhi **57**, 819 (2014)
[6] U. Zimmermann, K. Keck, Z. Phys. B **101**, 555 (1996)
[7] M.M. Korshunov, *et al*., Phys. Rev. B **94**, 094517 (2016)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.736

Toward superfluid optomechanics with micro-fabricated Helmholtz resonators

Souris F.[1], *Rojas X.*[2], *Kim P.H.*[1], *Hauer B.D.*[1], *Davis J.P.*[1]
[1]University of Alberta, Physics, Edmonton, Canada, [2]Royal Holloway University of London, Department of Physics, Egham, United Kingdom

Superfluid mechanical resonators represent attractive tools to perform cavity optomechanics. They can reach very high quality factors, possess ultra-low dielectric loss in both the optical and microwave range, and exhibit a large thermal conductivity at low temperature. In this work, we study through numerical simulations the optomechanical properties of a system formed by a superconducting 3D microwave cavity, coupled to an on-chip superfluid Helmholtz resonator with a micron-scale confinement. Compared to other microwave superfluid optomechanical systems, we show that this system should present an optomechanical coupling rate g_0 enhanced by the very small effective volume of the mechanical resonator.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.737

Defect motion in quantum solids with spins - solid ^{3}He

Cheng Z.G., *Beamish J.*
University of Alberta, Physics, Edmonton, Canada

Defects have uniquely quantum properties in solid helium due to the large zero-point motion of atoms. The shear modulus and dissipation have proven to be sensitive probes of the motion of dislocations in solid ^{4}He. ^{3}He atoms have even larger zero-point motion than ^{4}He but also have nuclear spins which

may affect defect motion in solid ^{3}He. We have made shear modulus measurements for both bcc and hcp solid ^{3}He, in order to explore their dislocation motion. We observed quite different behavior in the two phases. In bcc ^{3}He, dislocation behavior is similar to that in hcp ^{4}He - isotopic impurities (^{4}He atoms) are bound to dislocations but move with them at low speeds. In hcp ^{3}He,however, ^{4}He impurities act as static pinning sites, immobilizing dislocations at the lowest temperatures. At higher temperatures, where impurity pinning can be neglected, the ^{3}He nuclear spins themselves introduce a new dissipation mechanism which strongly damps dislocation motion at low frequencies.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.738

Unconventional electrical resistance of chromium thin films at low temperature

Ohashi M.[1], *Sawabu M.*[1], *Maeta K.*[1], *Kubota T.*[2], *Takanashi K.*[2]
[1]Kanazawa University, Kanazawa, Japan, [2]Tohoku University, Institute for Materials Research, Sendai, Japan

Schmidt et al. reported that thin films of chromium (Cr) metal suppress the antiferromagnetic ordering and become superconductive at T_C ~1.5 K [1]. Taking account that the bulk Cr is an antiferromagnet below T_N = 311 K and does not show superconductivity [2], the relationship between film thickness and existence of superconductivity of Cr is opposite to the other examples of superconducting thin films.
Assuming that the magnetic correlation interaction is suppressed by controlling the film thickness, Cr may show a magnetic order-disorder transition tuned by the film thickness, and unconventional superconductivity may occur at the quantum critical point of T ~ 0, where an electron pair appears due to quantum fluctuation. Generally, the three-dimensional electron system such as bulk compounds and two-dimensional one such as thin films are described by completely different Hamiltonian. That is, film thickness is an effective parameter that can directly control dimensionality, and it is interested in whether Cr is the first case of the new quantum phase transition tuned by film thickness [3]. In the present study, we perform precise electrical resistance measurements of chromium thin films to clarify the electronic state in a wide temperature range.

References:

[1] P. H. Schmidt, R. N. Castellano, H. Barz, B. T. Matthias, Physics Letters, **41A**, 367 (1972).
[2] M. Ohashi, G. Oomi, Jpn. J. Appl. Phys., **48**, 070221 (2009).
[3] M. Ohashi, K. Ohashi, M. Sawabu, M. Miyagawa, T. Kubota, K. Takanashi, Physics Letters A, **380**, 3133 (2016).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.739

Superconductor-ferromagnet heterostructures for basic research and applications

Rogacki K.[1], *Matusiak M.*[1], *Lochmajer H.*[1], *Przysłupski P.*[2], *Omelchenko L.*[3], *Soloviov A.*[3]
[1]Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Wroclaw, Poland, [2]Institute of Physics, Polish Academy of Sciences, Warsaw, Poland, [3]B.I. Verkin Institute for

Low Temperature Physics and Engineering, National Academy of Science of Ukraine, Kharkov, Ukraine

Recent progress in growing of high quality superconductor (SC)/ferromagnet (FM) heterostructures (HS) has attracted considerable attention to these materials as an interesting subject for both fundamental research and applications. In the present work we have studied a series of high quality nanometer-sized $La_{0.67}Sr_{0.33}MnO_3$ (LSMO)/$YBa_2Cu_3O_{7+d}$ (YBCO) bi- and multilayers, where the manganite was FM with a Curie temperature of 350 K and the cuprate was SC with T_c ~ 90 K. Transport (resistivity and Nernst effect) and magnetic properties of a large set of HS were investigated in a wide temperature range 2-400 K and in fields up to 14 T. Pseudogap (PG, [1-4]) properties of the HS have been studied by the analysis of the excess conductivity, σ', and discussed within the local pair (LP) model. This model is based on the assumption that in high-T_c superconductors, paired fermions are formed below the characteristic temperature $T^* >> T_c$, resulting in the PG opening. Around T_c the temperature dependence of σ' was found to be described by the Aslamasov-Larkin fluctuation theories, suggesting the presence of superconducting fluctuations in a large (up to 15 K) temperature range above T_c.

Supported by NCBR within the project "ERA.Net RUS Plus: No146” financed by the EU 7th FP, grant no 609556.

References:

[1] V. J. Emery and S. A. Kivelson, Nature (London) **374**, 434 (1995).
[2] M. Randeria, Nat. Phys. **6**, 561 (2010).
[3] V. Mishra, U. Chatterjee, J. C. Campusano, and M. R. Norman, Nat. Phys. Lett. **1**, 1 (2014).
[4] R. Peters and J. Bauer, Phys. Rev. B **92**, 014511 (2015).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.740

Phase transitions in nanostructured ethanol samples

Efimov V., Izotov A., Mezhov-Deglin L., Rybchenko O.
Institute of Solid State Physics RAS, Chernogolovka, Russian Federation

Ethanol is a very convenient object for study phase transition at low temperatures. Ethanol easy formats an amorphous structure at quick cooling of the liquid below 156 K down to liquid nitrogen temperatures in bulk samples. A nanosize clusters with sizes ~30-60 nm, prepared through the “impurity-helium gel” process, have the same amorphous structure. In the work we studied the influence of size factor of the samples ("bulk" or "nano sizes") from absolutated ethanol as well as for the samples with remanent concentration of water (~4%) on the mechanisms and dynamics of phase transformations in solid ethanol.

Subsequent heating of the samples from absolutized ethanol above 100 K leads to crystallization amorphous into cubic phase (CP), the rate of which depends on size of the samples and the temperature of the annealing. After heating above 110 K CP phase began transform into monoclinic phase. The crystallization of amorphous sample from ethanol with small concentration of water never came through CP phase, we observed direct transition from amorphous phase into monoclinic structure.

Postersession 3
Monday, 14 August 2017

16.30-18.30
G Foyer

P.741
Possibility of spin-triplet supercurrent generated at the magnetic domain wall in the lateral structure
Ishitaki M.[1], *Ohnishi K.*[1,2], *Kimura T.*[1,2]
[1]Kyushu University, Fukuoka, Japan, [2]Reserch Center for Quantum Nano-Spin Sciences, Fukuoka, Japan

A spin-triplet superconductivity is an exciting subject because the triplet Cooper pair carries the spin current without any energy dissipation. The triplet Cooper pair can be expected to be realized in ferromagnet/superconductor hybrid structures with the inhomogeneous exchange interaction, where the singlet Cooper pair can be transformed into the triplet Cooper pair. Here, we investigated the transport properties of the supercurrent through a magnetic domain wall, which induces the inhomogeneous exchange interaction.
Our prepared device consists of superconducting Nb strips and a ferromagnetic Ni-Fe wire with a kink. When the magnetic domain wall is located in the vicinity of the Nb/Ni-Fe junction, the injected singlet Cooper pairs may be converted to the triplet one because of the spatially modulated magnetic field. We measured the temperature dependence of the resistance of the Ni-Fe wire under the Cooper-pair injection. The negative resistance due to the formation of the domain wall was clearly observed. Although this can be mainly understood by a conventional anisotropic magnetoresistance, an additional reduction of the resistance was observed below T_C. The additional reduction increases with decreasing the temperature, implying the formation of the triplet Cooper pairs.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.743
Symmetry breaking of quasi-spin inversion in magnetization-plateau phase diagram of frustrated spin ladder
Sugimoto T.[1], *Mori M.*[2], *Tohyama T.*[1], *Maekawa S.*[2]
[1]Tokyo University of Science, Applied Physics, Tokyo, Japan, [2]Japan Atomic Energy Agency, Advanced Science Research Center, Ibaraki, Japan

Magnetization plateau (MP) in frustrated quantum spin systems has attracted much attention due to spontaneously breaking of translational symmetry at low temperatures.
This phenomenon can be understood by an effect of marginally-relevant commensurability energy in sine-Gordon Hamiltonian, which is a low-energy effective model derived by bosonization of Jordan--Wigner fermion fields [1,2].
In this model, there is a gapless-to-gapful transition, so that a gapless spin-liquid phase appears next to a possible MP phase.
Though this phase boundary is basically determined by a competition between kinetic energy and potential energy with a help of the commensurability energy, it is not so trivial because of quantum fluctuation and additional effects due to higher-order corrections.
In present study, we numerically determine phase boundaries of MP phases in a frustrated spin ladder, which is reported to exhibit several MPs with finite magnetization by our preceding study [3]. Moreover, we find a symmetry breaking of quasi-spin inversion by comparing one-third and two-third MP phases, although the one-third MP state corresponds to the two-third MP state by quasi-spin

inversion in the strong rung limit, where the quasi-spin is constructed by singlet and triplet states on a rung.

References:
[1] E. H. Lieb, T. Schultz, and D. J. Mattis, Ann. Phys. (N.Y.) **16**, 407 (1961).
[2] M. Oshikawa, M. Yamanaka, and I.Affleck, Phys. Rev. Lett. **78**, 1984 (1997).
[3] T. Sugimoto, M. Mori, T. Tohyama, and S. Maekawa, Phys. Rev. B **92**, 125114 (2015); Physics Procedia **75**, 861 (2015).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.744
Novel quantum states and magnetic excitations in one-dimensional diamond chain and kagome strip chain

Morita K.[1]*, Sugimoto T.*[1]*, Sota S.*[2]*, Tohyama T.*[1]
[1]Tokyo University of Science, Department of Applied Physics, katsushika, Japan, [2]RIKEN, Advanced Institute for Computational Science (AICS), kobe, Japan

The realization of novel quantum states is one of hot topics in one-dimensional (1D) frustrated quantum spin systems. We focus on two types of the 1D systems, a diamond chain and a kagome strip chain. For diamond chain compounds, A3Cu3AlO2(SO4) (A=K,Rb, and Cs), we analyze the temperature dependence of the magnetic susceptibility and determine the magnetic exchange interactions [1]. In contrast to the azurite, a dimer is formed on one of the sides of the diamond. From density-matrix renormalization group (DMRG) calculations, we find that the dimer together with a nearly isolated 1D Heisenberg chain characterizes magnetic properties including magnetization curve and magnetic excitations. This implies that a dimer-monomer composite chain is a good starting point for describing these compounds. For a kagome-strip chain, we consider a model with three independent exchange interactions and study the magnetization plateaus by DMRG [2]. We find eight kinds of magnetization plateaus whose magnetic structures break either translational or reflection symmetry spontaneously. The structures are classified by a sequence of a five-site unit cell and novel magnetic structures with three and five unit cells are realized.

References:
[1] K. Morita et al., arXiv1701.02198, to be published in Phys. Rev. B.
[2] K. Morita, T. Sugimoto, S. Sota, and T. Tohyama, in preparation.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.745
Quantum water ice

Shannon N.[1]*, Benton O.*[2]*, Penc K.*[3]*, Sikora O.*[4]
[1]Okinawa Institute of Science and Technology Graduate University, Theory of Quantum Matter Unit, Onna son, Japan, [2]RIKEN, Theory of Condensed Matter Group, Wako-shi, Japan, [3]Wigner Research Centre for Physics, Budapest, Hungary, [4]Jagiellonian University, Krakow, Poland

Water is one of the most ubiquitous substances on earth, but also one of the strangest. For example, common, hexagonal water-ice is not really a crystal by any conventional definition, but rather an ordered lattice of oxygen ions, held together by a disordered network of hydrogren bonds.
There is now a growing body of evidence, from both experiment [1] and simulation [2], that the protons in hexagonal water ice are not merely disordered, but mobile, collectively tunneling from one configuration obeying the Bernal--Fowler ``ice rules´´ to another. However, despite enormous progress in understanding related quantum effects in magnets, very little is known about what effect such collective quantum tunnelling might have on the protons in water ice.
In this talk we revisit the theory of proton correlations in hexagonal water ice, showing how the disordered state selected by the ice rules changes, once collective quantum tunneling is taken into account. We find that quantum tunnelling can give rise to a novel quantum liquid state, involving the superposition of an extensive number of different proton configurations, with entanglement over macroscopic length scales [3]. This state shares many of the same properties as the quantum spin liquids sought in frustrated magnets.
References:
[1] L, Bove et al., Phys. Rev. Lett. 103, 165901 (2009)
[2] C. Drechsel-Grau and D. Marx, Phys. Rev. Lett. 112, 148302 (2014)
[3] O. Benton et al., Phys. Rev. B 93, 125143 (2016)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.746
Microfabrication of multi-slit structures for studies of topological properties of quasi-2 dimensional superfluid ^{3}He
Tani T.[1], Murakawa S.[2], Wada R.[1], Kaiya K.[1], Yamada K.[3], Itoh K.[3], Mita Y.[4], Shirahama K.[1]
[1]Keio University, Department of Physics, Yokohama, Japan, [2]University of Tokyo, Cryogenics Research Center, Tokyo, Japan, [3]Keio University, Department of Applied Physics and Physico-Informatics, Yokohama, Japan, [4]University of Tokyo, Department of Electrical Engineering and Information Systems, Tokyo, Japan

Confinement of Superfluid ^{3}He in micro-structures has been attracting much interest to realize a topological superfluidity and actually, many studies in micro-slab geometries have been performed. Nowadays, the development of techniques of semiconductor processing enables us to fabricate deep multi-slit structures with micro through-holes. Confinement of ^{3}He into well-defined slit geometries enables us to perform ultrasound experiments of topological properties, such as edge-related surface collective (Higgs) modes[1][2], and flow experiments, such as phase slippage by half-quantum vortices[3]. We will report fabrication of multiple micro-slit structures through a thin Si layer of SOI chips, where the target dimensions of slits are 1µm×100µm×50µm, by microfabrication techniques including EB lithography and Deep Reactive Ion Etchings. The methods and results of our microfabrication and prospective experiments will be discussed.
References:
[1] Takeshi Mizushima, presented at Grand Challenges in Quantum Fluids and Solids Workshop August 7 - 9, 2015, UNY at Buffalo
[2] Takeshi Mizushima, Masatoshi Sato, and Kazushige Machida, Phys. Rev. Lett. **109**, 165301
[3] S. Backhaus, S. Pereverzev, R. W. Simmonds, A. Loshak, J. C. Davis & R. E. Packard, Nature **392** 687 (1998)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.747
EPR and spin relaxation measurements of Er:YSO at millitesla magnetic fields and cryogenic temperatures using a JBA
Budoyo R.P., Kakuyanagi K., Toida H., Matsuzaki Y., Mahboob I., Munro W.J., Yamaguchi H., Saito S.
NTT Basic Research Laboratories, Atsugi, Japan

We used an electron paramagnetic resonance (EPR) spectrometer based on a tunable Josephson bifurcation amplifier to measure EPR spectra and electron spin relaxation time T_1 of Er^{3+} dopants in a Y_2SiO_5 crystal. We studied the relaxation behavior at different cryogenic temperatures T, millitesla magnetic fields B, and microwave excitation pulse power P. For T < 100 mK and high P corresponding to saturation, the initial relaxation behavior was non-exponential. The observed long-time T_1 showed approximately T^{-2} dependence within the range of measurement and no significant B and P dependences. We discuss possible processes limiting spin relaxation within the measurement range, including direct phonon process, phonon-bottleneck process, and the presence of impurities and disorders.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.748
Electric dipole spin resonance in the quantum spin dimer system $KCuCl_3$
Kimura S.[1], Akaki M.[2], Hagiwara M.[2], Matsumoto M.[3], Tanaka H.[4]
[1]Tohoku University, Institute for Materials Research, Sendai, Japan, [2]Osaka University, Center for Advanced High Magnetic Field Science, Toyonaka, Japan, [3]Shizuoka University, Department of Physics, Shizuoka, Japan, [4]Tokyo Institute of Technology, Department of Physics, Tokyo, Japan

In several quantum spin gap systems, the observations of optical transitions between the spin singlet and triplet states by high frequency ESR measurements have been reported. Magnetic dipole transition between such quantum states is, however, forbidden in principle because the total spin angular momentum must be conserved. In this study, we show that the singlet-triplet transition can occur due to electric dipole transition. Recent studies of magnetoelectric multiferroic materials indicated a generation of an electric polarization by a vector spin chirality [1,2]. An important property of a quantum spin gap system is that the vector spin chirality has a finite matrix element between the spin singlet and triplet states. This fact suggests a finite probability for the electric dipole transition between the singlet and triplet states due to spin dependent electric polarization mechanism. We have succeeded in confirming this electric dipole spin resonance in the spin gap system by high frequency ESR measurements of the quantum spin dimer system $KCuCl_3$ in illuminating polarized electromagnetic wave.
References:
[1] H. Katsura, N. Nagaosa and A. V. Balatsky, Phys. Rev. Lett. **95**, 057205 (2005)
[2] T. A. Kaplan and S. D. Mahanti, Phys. Rev. B **83**, 174432 (2011)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.749
Magneto-photoconductivity of 3D topological insulator bismuth telluride

Eginligil M.[1], *Cao B.*[2], *Yu T.*[2]
[1]Nanjing Tech University, Institute of Advanced Materials, Nanjing, China, [2]Nanyang Technological University, Singapore, Singapore

Topological insulator (TI) is an exotic phase of quantum matter with an insulating bulk state as well as time-reversal symmetry-protected Dirac-like surface state. Very well-known examples of TI materials are bismuth based 3D TIs such as bismuth selenide and bismuth telluride. The surface states in these TIs have been directly observed by angle resolved photoemission spectroscopy and scanning tunneling microscopy. Recently it has been shown that a photocurrent component upon circularly polarized light excitation can be due to the topological surface states as result of circular photogalvanic effect and control over TI surface state conduction is possible. Here, we report on low temperature magneto-photoconductivity (MPC) of bismuth telluride 3D TI excited by elliptically polarized light along the magnetic field perpendicular to the sample plane. At 4K, as the magnetic field increases the measured photocurrent at zero degree angle of photon polarization exhibits a positive MPC for < 4 Tesla. For magnetic fields > 4 Tesla, it exhibits a negative MPC. This behavior of MPC can be attributed to two different conduction mechanisms at play: one due to the bulk states and the other due to the surface states.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.750
Strain induced chiral d-wave superconductivity in doped graphene

Mou C.-Y.[1,2], *Xu F.*[1,3], *Chou P.-H.*[1]
[1]National Tsing Hua University, Department of Physics, Hsinchu, Taiwan, Republic of China, [2]National Center for Theoretical Sciences, Physics Division, Hsinchu, Taiwan, Republic of China, [3]Shaanxi University of Technology, School of Physics and Telecommunication Engineering, Hanzhong, China

We consider a highly unconventional superconducting state with chiral d-wave symmetry in doped graphene under strain. It is shown that a flat band emerges in the normal state for reasonably large strain. As a result, we find that the chiral d-wave superconductivity can be stablized under strain even for slightly doped graphene. The superconducting critical temperature is found to be linearly proportional to the strength of the attractive interraction. Furthermore, depending on the strength of strain, the chiral d-wave superconducting state may coexists with the charge density wave (CDW) and the pair density wave (PDW). In particular, a superconducting phase with only the presence of CDW and PDW is found in the small strain limit.

Postersession 3
Monday, 14 August 2017

16.30-18.30
G Foyer

P.752

Flow properties of superfluid ^{4}He in nanoporous media probed by Helmholtz resonator

Tani T.[1], *Murakawa S.*[2], *Shirahama K.*[1]
[1]Keio University, Department of Physics, Yokohama, Japan, [2]University of Tokyo, Cryogenics Research Center, Tokyo, Japan

Superfluidity of ^{4}He confined in a nanoporous Gelsil glass is drastically suppressed by pressure and the system exhibits a quantum phase transition (QPT) at zero temperature [1]. The nature of QPT has been understood by a 4-D XY model without disorder [2]. A series of torsional oscillator measurements suggest that the quantum critical pressure depends strongly on some unknown properties such as disorder in porous media [3]. In order to understand more deeply the mechanism of QPT and to utilize the suppression of superfluidity towards a novel superfluid Josephson junction, we have developed a Helmholtz resonator apparatus. In a preliminary run using porous Vycor glass we have succeeded to observe 8 Helmholtz resonances at frequencies from 30 to 450 Hz. We are preparing to install Gelsil glasses with different pore sizes, and a one-dimensional nanoporous material [4], in which frequency dependence of superfluid response has been expected as a manifestation of bosonic Luttinger liquid [5].

References:

[1] K. Yamamoto et al., Phys. Rev. Lett. **93**,075302 (2004) ; *ibid*. **100**, 195301 (2008).
[2] Th. Eggel et al., Phys. Rev. B. **84**, 020515(R) (2011)
[3] K. Mikami et al., J. Phys.: Conf. Ser. **400**, 012048 (2012)
[4] J. Taniguchi et al., Phys. Rev. B **88**, 014502 (2013)
[5] Th. Eggel et al., Phys. Rev. Lett. **107**, 275302 (2011)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.753

Possible phase transition induced by element substation in La(O,F)BiS_2

Demura S., *Otuki S., Shoubu S., Fujisawa Y., Sakata H.*
Tokyo University of Science, Tokyo, Japan

Layered BiS_2-based superconductors LnOBiS_2 (Ln = La, Pr, Ce, Nd, Yb, Bi) are attractive materials because of their novel superconducting properties. One is high sensitivity of superconducting properties to physical pressure. In particular, although La(O,F)BiS_2 shows superconductivity at around 3 K under ambient pressure, the superconducting temperature (T_c) increases up to 10 K by applying high pressure, which is the highest T_c among these materials. Another is high sensitivity to lattice strain. When Ln or Bi ion is substituted for an ion with different ionic radius, higher T_c is realized [1]. Recently, we found that partial Pb substitution for Bi ion in Nd(O,F)BiS_2 increases T_c [2].
In this study, we performed the Pb substitution in La(O,F)BiS_2 single crystal because the highest T_c is realized in La(O,F)BiS_2. The lattice constant along the *c* axis shows steep decrease in narrow Pb concentration of around 8 %. At this concentration, T_c and superconducting volume fraction increase. Furthermore, resistivity shows discontinuous drop at around 130 K. This is indicative of a transition of the crystal structure or an appearance of charge density wave. In this presentation, we will report the detail of these results.

References:

[1] S. Demura, Nov. Supercond. Mater. **2**, 1 (2016)

[2] S. Demura, Y. Fujisawa, S. Otuski, R. Ishio, Y. Takano and H. Sakata, Solid State Commun. **223**, 40 (2015)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.754
Quantum gates for propagating microwave photons

Kokkoniemi R.[1]*, Ollikainen T.*[1]*, Lake R.E.*[1,2]*, Saarenpää S.*[1]*, Tan K.Y.*[1]*, Kokkala J.I.*[1]*, Dağ C.B.*[1,3]*, Govenius J.*[1]*, Möttönen M.*[1]
[1]Aalto University, QCD Labs, Department of Applied Physics, Espoo, Finland, [2]National Institute of Standards and Technology, Boulder, United States, [3]University of Michigan, Physics Department, Ann Arbor, United States

We report a generic scheme to implement transmission-type quantum gates for propagating microwave photons, based on a sequence of lumped-element components on transmission lines [1]. By choosing three equidistant superconducting quantum interference devices (SQUIDs) as the components on a single transmission line, we experimentally implement a magnetic-flux-tunable phase shifter and demonstrate that it produces a broad range of phase shifts and full transmission within the experimental uncertainty. Together with previously demonstrated beam splitters, these phase shifters can be utilized to implement arbitrary single-qubit gates. Furthermore, we theoretically show that replacing the SQUIDs by superconducting qubits, the phase shifter can be made strongly nonlinear, thus introducing deterministic photon--photon interactions. These results critically complement the previous demonstrations of on-demand single-photon sources and detectors, and hence pave the way for an all-microwave quantum computer based on propagating photons.

References:

[1] R. Kokkoniemi, T. Ollikainen, R. E. Lake, S. Saarenpää, K. Y. Tan, J. I. Kokkala, C. B. Dağ, J. Govenius and M. Möttönen, arXiv preprint, arXiv:1703.02241 (2017)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.755
Superconductivity of *J*=3/2 fermions in half-Heusler semimetals

Brydon P.[1,2]*, Wang L.*[3]*, Weinert M.*[4]*, Agterberg D.*[4]
[1]University of Otago, Department of Physics, Dunedin, New Zealand, [2]University of Maryland, Condensed Matter Theory Center and Joint Quantum Institute, College Park, United States, [3]University of Maryland, Center for Nanophysics and Advanced Materials, Department of Physics, College Park, United States, [4]University of Wisconsin, Department of Physics, Milwaukee, United States

Inspired by recent experiments [1,2], we theoretically consider the superconductivity of the topological half-Heusler semimetals YPtBi and LuPtBi [3]. We show that pairing occurs between j = 3/2 fermion states in these compounds [4], which leads to qualitative differences from the conventional theory of pairing between j = 1/2 states. In particular, this permits Cooper pairs with quintet or septet total angular momentum, in addition to the usual singlet and triplet states. Purely on-site interactions can

generate unconventional (quintet) time-reversal symmetry-breaking states with topologically nontrivial point nodes. These local *s*-wave quintet pairs reveal themselves as *d*-wave states in momentum space. Furthermore, due to the broken inversion symmetry in these materials, the *s*-wave singlet state can mix with a *p*-wave septet state, with topologically-stable line nodes consistent with penetration-depth measurements. Our analysis lays the foundation for understanding the unconventional superconductivity [2] of the half-Heuslers in particular, and "high-spin" superconductivity in general.

References:

[1] N. P. Butch *et al.*, Phys. Rev. B **84**, 220504(R) (2011); F. F. Tafti *et al*., Phys. Rev. B **87**, 184504 (2013); Y. Pan *et al.*, Europhys. Lett. **104**, 27001 (2013).
[2] H. Kim et al., arXiv:1603.03375.
[3] P. M. R. Brydon, L. M. Wang, M. Weinert, and D. F. Agterberg, Phys. Rev. Lett. **116**, 177001 (2016).
[4] S. Chadov et al., Nature Mat. **9**, 541 (2010); H. Lin et al., Nature Mat. **9**, 546 (2010).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.756

Two-particle self-consistent analysis for the magnetism and superconductivity in the honeycomb lattice Hubbard model

Aizawa H.
Kanagawa University, Yokohama, Japan

The anisotropic superconductivity is related to the carrier doping to the insulating phase with the Mott, magnetic order, charge order and so on. In the honeycomb lattice which has the hexagonal Brillouin zone, a possibility of the spin liquid [1] or antiferromagnetism [2, 3] has been discussed for the ground state in the 1/2-filled Hubbard model. In the triangular lattice which also has the hexagonal Brillouin zone, a possibility of the *d*+i*d*-wave in the spin-singlet pairing has been suggested [4-6]. Also, it has been suggested that the odd-frequency triplet *s*-wave can be dominant over the even-frequency singlet *d*-wave [7].

To study the carrier-doping effect on the magnetism and superconductivity, we perform the two-particle self-consistent (TPSC) analysis [8] for the Hubbard model on the honeycomb lattice. In the system with the 1/2-filling, the critical temperature of the magnetism obtained from the temperature dependence of the Stoner factor is good agreement with the value shown in the previous studies. Applying the same analysis, we estimate the magnetic temperature around the van Hove singularity with the 3/8-filling. We show the pairing competition between the four pairing states, namely, the singlet and triplet channels with the both even- and odd- frequencies.

References:

[1] Z. Meng *et al*., Nature. **464**, 847 (2010)
[2] S. Sorella *et al*., Sci. Rep. **2**, 992 (2012)
[3] S. Arya *et al*., Phys. Rev. B **92**, 045111 (2015)
[4] G. Baskaran, Phys. Rev. Lett. **91**, 097003 (2003)
[5] B. Kumar and B. S. Shastry, Phys. Rev. B **68**, 104508 (2003)
[6] M. Ogata, J. Phys. Soc. Jpn. **72**, 1839 (2003)
[7] K. Yada *et al*., arXiv:0806.4241.
[8] Y. M. Vilk and A.-M. S. Tremblay, J. Phys. I (France) **7**, 1309 (1997)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.758
Phase-locked oscillations in a multimode Josephson parametric oscillator
Bengtsson A.[1], Wustmann W.[2], Schneider B.[1], Svensson I.-M.[1], Simoen M.[1], Krantz P.[3], Shumeiko V.[1], Delsing P.[1], Bylander J.[1]
[1]Chalmers University of Technology, MC2, Göteborg, Sweden, [2]Laboratory for Physical Sciences, College Park, United States, [3]Massachusetts Institute of Technology, Research Laboratory for Electronics, Cambridge, United States

We report the observation of nondegenerate parametric oscillations in a nonlinear superconducting microwave multimode resonator. We realize three-wave mixing by modulating a boundary condition at the sum of two eigenmode frequencies, via magnetic-flux pumping of a SQUID. We detect simultaneously the output quadrature voltages of both modes. For high pump amplitude, exceeding a parametric instability threshold, self-sustained oscillations appear in both modes. The phase dynamics of the oscillations is directly measured, and the phase sum is found to be fixed. The individual phases have continuous degeneracy, but the symmetry can be broken by the presence of a coherent injection signal, thus phase locking the oscillations.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.759
Single-electron emission from time-dependent gate modulation of chiral edge states
Misiorny M.[1,2], Fève G.[3], Splettstoesser J.[1]
[1]Chalmers University of Technology, MC 2, Göteborg, Sweden, [2]Adam Mickiewicz University, Poznan, Poland, [3]École Normale Superieure, Laboratoire Pierre Aigrain, Paris, France

In recent years, single-particle quantum optics experiments have been performed in electronic conductors, enabled by the development of coherent single-electron sources. Prominent examples for these sources use the time-dependent driving of discrete energy levels of a mesoscopic capacitor in combination with chiral edge states [1] or a time-dependent Lorentzian-shaped bias voltage in the absence of confinement, also named Levitons [2].
Here, we combine the advantages of both approaches and theoretically investigate the local creation of charge excitations by the gate-modulation of a chiral edge state [3]. Importantly, the internal potential build-up due to interactions is treated self-consistently in our approach [4].
The resulting charge current is intrinsically linear [3,5], as long as no backscattering is induced by the created potential landscape. We show how different setups allow for the generation of electron-hole pulses in one or oppositely propagating edge channels.
To examine how electron-hole pairs are “shaped” by a specific driving potential, we investigate the noise. For these sources, current noise only arises in the presence of a partitioner. The influence of the partitioner on the injected signal can be minimised by choosing an appropriate device geometry.
References:
[1] G. Fève et al., Science 316, 1169 (2007)

[2] J. Dubois et al., Nature 502, 659 (2013)
[3] M. Misiorny et al., work in progress
[4] M. Büttiker et al., Phys. Rev. Lett. 70, 4114 (1993)
[5] D. Litinski et al., arXiv 1612.04822 (2016)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.760

On low field magneto-resistance oscillations in moiré superlattices of bilayer graphene/h-BN heterostructure

Ebisuoka R.[1]*, Hirahara T.*[1]*, Watanabe K.*[2]*, Taniguchi T.*[2]*, Yagi R.*[1]
[1]Hiroshima University / AdSM, Higashi-Hiroshima, Japan, [2]National Institute for Materials Science (NIMS), Tsukuba, Japan

We have studied magneto-transport of moiré superlattice consisting of BN/Graphene heterostructure with carrier mobility exceeding 150,000 cm^2/Vs. We focused on relatively low field regime where Landau levels are densely populated for which it is still uncultivated as compared with where Hofstadter´s butterfly in high field regime.[1][2][3] High field magneto-resistance exhibited the Zak oscillations and complicated Landau structures, that should appear obeying the Wannier diagram. We clearly observed Landau levels arising from the second and the third Brillouin zones. FFT analysis of low field magneto-resistance oscillations less than B=2T showed carrier density dependence which should be those for semi-classical orbits of mini-bands at sufficiently low magnetic fields. Model calculations of Fermi surface cross-sections, including appropriate superlattice potential, explained some of its basic features if magnetic breakdown was taken into account.

References:

[1] L. A. Ponomarenko *et al*. Nature Phys. **497**, 101038 (2013)
[2] B. Hunt *et al*. Science. **340**, 101126 (2013)
[3] C. R. Dean *et al*. Nature Phys. 101038 (2013)
[4] P. Moon and M. Koshino, Phys. Rev. B **90**, 101103 (2014)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.761

***z* = 2 quantum criticality in Heisenberg spin chains near saturation**

Blosser D.[1]*, Povarov K.*[1]*, Kestin N.*[2]*, Bewley R.*[3]*, Giamarchi T.*[2]*, Zheludev A.*[1]
[1]ETH Zürich, Zürich, Switzerland, [2]Université de Genève, Geneva, Switzerland, [3]Rutherford Appleton Laboratory, Didcot, United Kingdom

We study quantum critical dynamics in Heisenberg spin chains near saturation. Using inelastic neutron scattering we investigate the prototypical Heisenberg spin chain compound $K_2CuSO_4Cl_2$. The full excitation spectra are measured at different temperatures near the critical point. This data we compare to finite temperature density matrix renormalization group calculations (T-DMRG). In addition, specific

heat and magnetization data show remarkable universal scaling behaviour near the quantum critical point.

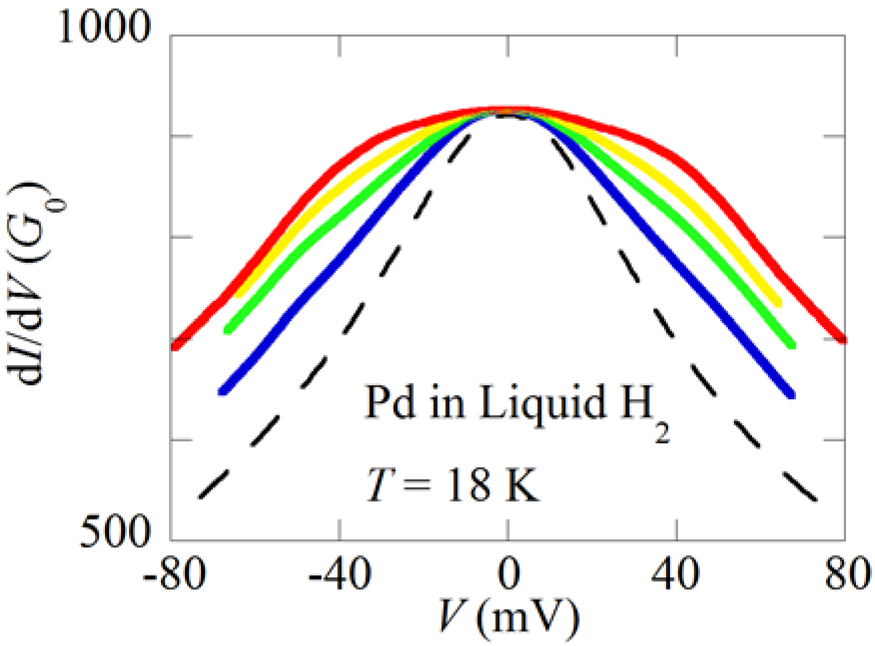
Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.762

Quantum properties of hydrogen atom in metal studied by point-contact spectroscopy

Takata H.[1], Islam S.[1], Ienaga K.[2], Inagaki Y.[1], Hashizume K.[1], Kawae T.[3]
[1]Kyushu University, Fukuoka, Japan, [2]Tokyo Institute of Technology, Tokyo, Japan, [3]Kyushu University, Department of Applied Quantum Physics, Fukuoka, Japan

Hydrogen (H) shows remarkable quantum mechanical properties, because it is the lightest of all atoms. In metal hydrides, therefore, H atom trapped at an interstitial site acts as a quantum mechanical particle. On the other hand, studying the kinetic behavior is unclear because of difficulty of the detection for H atom.
We focus on point-contact spectroscopy to investigate quantum properties of H atoms in metals. When the system size is smaller than the mean free path of conduction electrons, the electrons are transferred without energy dissipation in the system, and then lose their energy through the inelastic scattering with phonon vibrations or H atoms. Therefore, absorption of H atoms brings about considerable change of the differential conductance spectra [1].
Figure 1 shows the time evolution of the differential conductance d*I*/d*V* spectra of Pd nanocontacts, after covering the Pd nanocontacst with liquid H_2. The dashed line represents the spectra of pure Pd nanocontacts. Blue, green, yellow and red lines from the bottom to top are recorded at the spectra 500s, 2500sec, 4500s, 8000s after immersion in LH_2, respectively. The spectra change from the pure Pd to the Pd hydride, indicating that H atoms are absorbed in Pd nanocontacts below T = 20 K.



[Figure 1]

References:
[1] K. Ienaga, *et al*, Appl. Phys. Lett. **106**, 021605 (2015).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.763
Magnetic and optical properties of Sb-substituted Ba_2PrBiO_6 double perovskite oxides
Onodera K.[1], Kogawa T.[1], Matsukawa M.[1], Taniguchi H.[1], Matsushita A.[2]
[1]Iwate University, Morioka, Japan, [2]National Institute for Materials Science (NIMS), Tsukuba, Japan

We demonstrate crystal structures, magnetic, optical, and thermal properties of the B-site substituted perovskite oxides $Ba_2Pr(Bi_{1-x},Sb_x)\ O_6$ (x=0, 0.1 and 0.2). Polycrystalline samples of Sb-substituted Ba_2PrBiO_6 were prepared with the conventional solid-state reaction technique. The X-ray diffraction data revealed that the polycrystalline samples are an almost single phase with a monoclinic structure (C 2/m). Substitution of smaller Sb ion at Bi site causes a monotonic decrease in both the lattice parameters and volume. Magnetization measurements at high temperatures above 200K show that the effective magnetic moment is estimated to be around 3.15 m_B, which is close to that for Pr^{3+}ion. The X-ray photoemission spectroscopy analysis revealed that a prominent peak of Pr^{3+} is dominant with a smaller shoulder structure of Pr^{4+}. Optical spectra were measured using a diffuse-reflectance method. The band gaps were estimated from the optical data to be 0.97 eV and 1.05 eV, at *x*=0 and 0.2, respectively. A schottky-like anomaly observed in the low-temperature specific heat measurement is explained by low-lying splitting of Pr^{3+} ions under the crystal field effect. The band gap and the valence state of Pr ion are discussed on the basis of electronic band calculation.
References:
Z. Zou, J. Ye, K. Sayama, H. Arakawa, Nature 414, 625 (2001)
A. Matsushita et al., Jpn. J. Appl. Phys. 51,121802 (2012)
Sami Vasala, Maarit Karppinen, Progress in Solid State Chemistry 43,1 (2015)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.765
Construction of a high Q-factor superconducting aluminum cavity
Noh S., Choi J., Jang S., Choi J., Kim E.
Korea Advanced Institute of Science and Technology, Physics, Daejeon, Korea, Republic of

A hybrid system with strong coupling between a transmon qubit and a superconducting microwave cavity is successfully demonstrated [1]. The measurement and control of the coupled qubit are strongly linked to the Q-factor of a superconducting microwave cavity. We studied a TE011 mode of an aluminum cylindrical cavity with various surface treatments. Chemically etched high purity aluminum showed 50 times enhanced Q-factor by reducing conductive losses of the surface resistance and dielectric loss of an oxide layer[2]. Here, we conducted the electro-polishing on the surface of an Al cavity with various conditions. We will present the optimized electro-polishing conditions to enhance the Q-factor of the cavity.
References:

[1] H. Paik et. Al, Phys. Rev. Lett. 107, 240501(2011)
[2] Matthew Reagor, et al. Appl. Phys. Lett. 102, 192604 (2013);

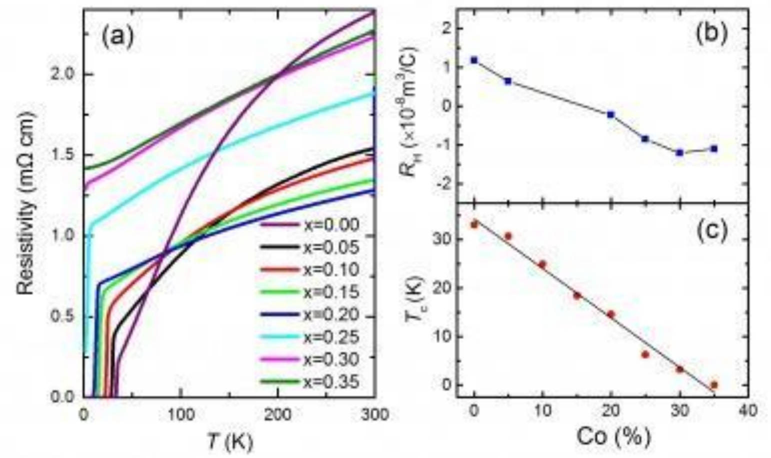
Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.766

Effects of Co substitution on the intrinsic hole-doped superconductor $KCa_2Fe_4As_4F_2$

Ishida J.[1], *Iimura S.*[1], *Hosono H.*[1,2]
[1]Tokyo Institute of Technology, Laboratory for Materials and Structures, Yokohama, Japan, [2]Tokyo Institute of Technology, Materials Research Center for Element Strategy, Yokohama, Japan

Carrier doping is a critical parameter that governs the electronic correlations and ground states in iron-based superconductors (FeBS). Recently Wang *et al.* reported a new FeBS, $KCa_2Fe_4As_4F_2$ abbreviated as 12442.[1] This material has the superstructure of KFe_2As_2 and CaFeAsF. According to the chemical composition, the valence state of Fe is +2.25 and thus can be regarded as an intrinsically hole doped compound. Given that the phase diagram of FeBS and cuprates strongly depends on the types of blocking layers and polarity of carrier, *i*. *e*., electrons or holes, it is imperative to construct the phase diagram of 12442 compounds and investigate the doping dependence of ground states. Figure 1a shows the resistivity curves of Co-substituted $KCa_2(Fe_{1-x}Co_x)_4As_4F_2$. The residual resistivity monotonically decreases with Co doping, and the temperature dependency above their T_c changes from a concaved- to convex-function. The Hall coefficient at 200K clearly shows a sign-change at $x \sim 0.1$ (Fig.1b), while the T_c linearly decreases with x (Fig.1c). In this talk, the doping dependence of effective mass as well as the results of other doping modes on the 12442-type compounds will be discussed.



[Fig.1a,b,c:a,resistivity b, Hall coefficient c,Tc]

References:

[1] Z.-C. Wang, C.-Y. He, S.-Q. Wu, Z.-T. Tang, Y. Liu, A. Ablimit, C.-M. Feng, and G.-H. Cao, J. Am. Chem. Soc. **138**, 7856 (2016).

Postersession 3
Monday, 14 August 2017

16.30-18.30
G Foyer

P.767
Application of machine learning to the quantum phase transitions in topological matters
<u>Ohtsuki T.</u>[1], Ohtsuki T.[2]
[1]Sophia University, Physics Division, Tokyo, Japan, [2]NTT Data Mathematical Systems, Tokyo, Japan

Random electron systems undergo quantum phase transitions and show rich phase diagrams. Examples of the phases are the band gap insulator, Anderson insulator, Chern insulator, strong and weak topological insulators, Weyl semimetal, and diffusive metal. We use an image recognition algorithm based on a multilayered convolutional neural network to identify which phase the eigenfunction belongs to. The Wilson-Dirac model for topological insulators, and the layered Chern insulator model for Weyl semimetal are studied. The situation where the standard transfer matrix approach is not applicable is also treated by this method.
References:
[1] Tomoki Ohtsuki, Tomi Ohtsuki: Journal of the Physical Society of Japan {¥bf 85}, 123706 (2016)
[2] Tomi Ohtsuki and Tomoki Ohtsuki: Journal of the Physical Society of Japan {¥bf 86}, 044708 (2017)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.768
On-chip charge counting for hybrid single-electron turnstiles
<u>Peltonen J.T.</u>, Maisi V.F., Singh S., Mannila E., Pekola J.P.
Aalto University, Low Temperature Laboratory, Department of Applied Physics, Espoo, Finland

The SI base unit for electric current, the ampere, awaits redefinition in terms of the quantized current produced by a solid-state single-electron pump [1].
We present our ongoing experiments on in-situ detection of individual electrons pumped through a single-electron turnstile based on ultrasmall normal metal - insulator - superconductor tunnel junctions [2]. In our setup, limited by the detector bandwidth, at low repetition rates we observe error-less sequential transfer of up to several hundred electrons through the system. At faster pumping speeds up to 100 kHz, we show relative error rates down to 10-3, comparable to typical values obtained from measurements of average pumped current in non-optimized individual turnstiles.
We compare the deviation from the expected current I=ef, observed both by direct counting at low duty cycle, and by measuring the average current under continuous drive.
The work constitutes an initial step towards a self-referenced quantum current standard realized with metallic single-electron turnstiles, complementing approaches based on semiconductor quantum dot pumps [3].
References:
[1] J. P. Pekola *et al*., Rev. Mod. Phys. **85**, 1421 (2013).
[2] J. T. Peltonen, V. F. Maisi, S. Singh, E. Mannila, and J. P. Pekola, arXiv:1512.00374.
[3] L. Fricke *et al*., Phys. Rev. Lett. **112**, 226803 (2014).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.770
Relaxation of resistive state in superconducting boron-doped diamond films
Kardakova A.[1], *Titova N.*[1], *Tovpeko N.*[1], *Ryabchun S.*[1], *Mandal S.*[2], *Morozov D.*[2], *Klemencic G.*[2], *Giblin S.*[2], *Williams O.*[2], *Bousquet J.*[3], *Eon D.*[3], *Sacepe B.*[3], *Klein T.*[3], *Bustarret E.*[3], *Goltsman G.*[1], *Klapwijk T.*[4]
[1]Moscow State Pedagogical University, Physics Department, Moscow, Russian Federation, [2]Cardiff University, School of Physics and Astronomy, Cardiff, United Kingdom, [3]Institut Neel, Grenoble, France, [4]Delft University of Technology, Delft, Netherlands

Superconducting films with the high normal state resistivity have demonstrated advantageous properties for superconducting quantum computing and astrophysics applications. In all these applications, the essential characteristics of the device such as noise in detectors and decoherence time in qubits are strongly dependent on the energy relaxation process in the material. An accurate knowledge of the relaxation rate is needed for the successful development of the device.
Recently, we have been studying superconducting diamond films as a potential materials for radiation detection. Our study of the energy relaxation in single-crystalline boron-doped diamond films epitaxially grown on a diamond shows a remarkably slow energy relaxation at low temperatures. The electron-phonon time varies from 400 ns to 700 ns over the temperature range 2.2 K to 1.7 K [1]. The same values of τ_{eph} have been also observed for nanocrystalline diamond films grown on silicon substrates [2]. Such slow electron-phonon relaxation in boron-doped diamond, in combination with a high normal-state resistivity (~1500 μΩ·cm), confirms that these films are prospective for superconducting resonators and superconducting detectors.
References:
[1] A. Kardakova, et al, Phys. Rev. B 93, 064506 (2016).
[2] N. Titova et al, IEEE Transactions on Applied Superconductivity, 27, 4 (2017).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.771
Interaction of electrons with atomic tunneling systems in a Zr-based superconducting metallic glass
Seiler A., *Meißner S.*, *Weiss G.*
Physikalisches Institut, Karlsruher Institut für Technologie, Karlsruhe, Germany

The low temperature properties of amorphous materials are known to be dominated by tunneling systems (TS) formed by atoms or groups of atoms that can tunnel between different configurations. Despite the success of the standard tunneling model in describing the properties of disordered dielectrics, its predictions for metallic glasses still appear incomplete.
In this work we investigate a Zr-based metallic glass where the interaction of TS with quasiparticles or conduction electrons can be switched on and off by suppressing the superconductivity by a magnetic field. Measurements on the same material ranging from kHz to GHz frequencies allows to investigate extensions of the standard tunneling model to describe the electron-TS interaction. The onset of the

relaxation process gives a clear indication of the relaxation rate of TS and allows to separate the underlying interactions. Contrary to the expectation of a frequency-independent, logarithmic increase of the sound velocity with temperature [1], we found a frequency dependence of the temperature variation in the normal conducting state when changing the frequency of ultrasonic excitation from 1 GHz to 2 GHz.

References:

[1] E. Bezuglyi, A. Gaiduk, V. Fil, S. Zherlitsyn, W. Johnson, G. Bruls, B. Lüthi, B. Wolf, Phys. Rev. B **62** (10):6656-6664 (2000)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.772

Thermodynamic properties of Zr- and Au-based superconducting bulk metallic glasses at low temperatures

Reifenberger A., Rothfuß D., Fleischmann A., Reiser A., Enss C.
Heidelberg University / Kirchhoff Institute of Physics, Heidelberg, Germany

The low temperature properties of metallic glasses are dominated by atomic tunneling systems interacting with thermal phonons and conduction electrons. The development of bulk metallic glasses has established a new class of amorphous metals. Despite the fact that these kinds of materials have been produced since over 15 years very little is known about their low temperature properties. Here we present measurements of the specific heat and thermal conductivity of superconducting bulk metallic glasses (based on Zr and Au, respectively) in the temperature range from 6 mK to 300 K. At lowest temperatures, we discuss these measurements in the framework of both the BCS-theory of superconductivity and the standard tunneling model. In the superconducting state, close to T_c, where interactions with quasi-particles need to be taken into account, both measurements agree well with BCS-theory predictions. Far below Tc we find good agreement between our data and the standard tunneling model predictions. For temperatures T > 2 K, we find pronounced low temperature anomalies in the phononic specific heat C_{ph}, which are attributed to localized harmonic vibration modes. These Einstein modes act as additional scattering centers.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.773

Soliton collisions in superfluid Fermi gases

Van Alphen W., Lombardi G., Klimin S., Tempere J.
Universiteit Antwerpen, Fysica, Antwerpen, Belgium

Superfluid systems can be described by a macroscopic wavefunction whose modulus squared represents the density and whose phase gradients represent the velocity field of superflow. For atomic Bose gases, this macroscopic wavefunction has to obey the well-known Gross-Pitaevskii equation. We derive an effective field theory for superfluid Fermi gases, such that the solution of the field equations corresponds to the appropriate macroscopic wavefunction to describe superfluid properties. This is applied to investigate collective modes and excitations such as vortices. We report on our latest results using the effective field theory to describe the soliton snake instability and soliton collisions. The soliton collisions are studied from the BEC limit - where the results are similar as for Bose gases - crossing over into the BCS limit. We discuss the changes that occur when going away from the BEC limit. We find sound emitted by the collision, and from the spectral analysis of this sound we retrieve the collective mode dispersion and in particular the coefficient of nonlinearity.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.774

Theory for analogous Josephson effects in quantum spin ice

Nakosai S., Onoda S.
RIKEN, Condensed Matter Theory Laboratory, Saitama, Japan

We propose novel magnetic interference phenomena based on an analogous quantum electrodynamics in quantum spin ice. This system can host a U(1) quantum spin liquid[1] or a Higgs ferromagnet, which behaves as an ``insulator´´ of deconfined bosonic spinons or a ``superfluid´´ of Bose-condensed confined spinons with a macroscopic phase coherence[2], respectively. Thereby, it is in principle possible to detect or control an interference between the macroscopic phases of Bose-condensed spionns in two Higgs ferromagnets in analogous Josephson junction devices of quantum spin ice systems. Here, we show theoretically that supercurrent of spinons through the Josephson junction can be controlled by tuning a configuration of the device. Our proposal also provides a unique way to provide a compelling evidence that spinons or so-called quantum spin ice monopoles are well-defined quasiparticles.

References:

[1] M. Hermele, M.P. Fisher and L. Balents, Phys. Rev. B **69,** 064404 (2004).
[2] L.J. Chang, S. Onoda, Y. Su *et al.,* Nat. Commun. **3,** 992 (2012).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.776

Superconductor-quantum dot based thermoelectric heat engine and Seebeck diode

Hwang S.-Y.[1,2], Lopez R.[2], Sanchez D.[2]
[1]Universität Duisburg-Essen, Theoretische Physik, Duisburg, Germany, [2]Institut de Fisica Interdisciplinaria i Sistemes Complexos IFISC (CSIC-UIB), Palma de Mallorca, Spain

Superconductors are perfect electric conductors but poor thermal conductors. This could be an excellent merit for creating thermoelectric power since this property may be able to break the conventional Wiedemann-Franz law. Nevertheless, the superconducting density of states exhibits particle-hole symmetry suppressing the thermopower generation. Thus, ways to break this symmetry should be devised for thermoelectric applications [1]. We propose that superconductor-quantum dot hybrid systems can pave the way for versatile thermoelectric devices with high efficiencies. This hybrid system, when attached to a ferromagnet, can act as a thermoelectric heat engine with a large figure-

of-merit ZT [2]. Moreover, nonlinear thermocurrents of this device show strong Seebeck and spin Seebeck diode effects with high rectification efficiencies [3]. Finally, in the subgap Andreev transport, interesting cross thermoelectric coupling effects appear uniquely in the nonlinear regime [4]. Importantly, transport properties of this device are easily adjustable by a gate potential or a magnetic field applied to the quantum dot.

References:

[1] P. Machon et al., Phys. Rev. Lett. **110**, 047002 (2013); A. Ozaeta et al., ibid. **112**, 057001 (2014); S. Kolenda et al., ibid. **116**, 097001 (2016).
[2] S.-Y. Hwang, R. Lopez, and D. Sanchez, Phys. Rev. B **94**, 054506 (2016).
[3] S.-Y. Hwang, D. Sanchez, and R. Lopez, New J. Phys. **18**, 093024 (2016).
[4] S.-Y. Hwang, R. Lopez, and D. Sanchez, Phys. Rev. B **91**, 104518 (2015).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.778

Fingerprint of topological Andreev bound states in phase-dependent heat transport

Sothmann B.[1], *Hankiewicz E.M.*[2]
[1]University Duisburg-Essen, Duisburg, Germany, [2]University Würzburg, Würzburg, Germany

We demonstrate that phase-dependent heat currents through superconductor-topological insulator Josephson junctions provide a useful tool to probe the existence of topological Andreev bound states, even for multi-channel surface states. We predict that in the tunneling regime topological Andreev bound states lead to a minimum of the thermal conductance for a phase difference $\phi=\pi$, in clear contrast to a maximum of the thermal conductance at $\phi=\pi$ that occurs for trivial Andreev bound states in superconductor-normal metal tunnel junctions. This opens up the possibility that phase-dependent heat transport can distinguish between topologically trivial and nontrivial 4π modes. Furthermore, we propose a superconducting quantum interference device geometry where phase-dependent heat currents can be measured using available experimental technology.

References:

[1] B. Sothmann and E. M. Hankiewicz, Phys. Rev. B **94**, 081407 (2016)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.779

Non-equilibrium Andreev states population in short conventional and topological superconducting junctions

Klees R.[1], *Rastelli G.*[1,2], *Belzig W.*[1]
[1]Universität Konstanz, Fachbereich Physik, Konstanz, Germany, [2]Zukunftskolleg, Fachbereich Physik, Konstanz, Germany

Recent experiments reported the observation of the non-equilibrium dynamics of the Andreev bound states (ABS) in superconducting atomic contacts [1] and in proximized semiconductor nanowires [2]. Motivated by these investigations, we study a short superconducting junction of length $L \ll \xi$ (coherence length) inserted in a dc-SQUID and coupled to an LC-resonator [2]. We calculate the non-

equilibrium occupation of the ABS by taking into account the phase fluctuations in the dc-SQUID and by assuming that the junction is irradiated with photons. We analyze the role of the distribution of the quasiparticles in the continuum in different regimes assuming that these quasiparticles have an effective temperature which differs from the one of the dc-SQUID, i.e. the LC-resonator. We systematically compare the occupations of the ABS of a short conventional and a short topological junction [3] in order to point out the peculiar features of the latter. In some regimes, we obtain that the ABS occupation behaves in a similar way and we argue that such results are also independent of the exact non-equilibrium distribution in the continuum. Finally, we discuss how to obtain information about the continuum quasiparticle temperature in experiments similar to [1].

References:

[1] C. Janvier *et al.*, Science **349**, 1199 (2015); L. Bretheau *et al.*, Nature **499**, 312 (2013).
[2] A. P. Higginbotham *et al.*, Nat. Phys. **11**, 1017 (2015).
[3] J. I. Väyrynen *et al.*, Phys. Rev. B **92**, 134508 (2015).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.780

Spin wave radiation from vortices of ^{3}He-B

Laine S.M., Thuneberg E.V.
University of Oulu, Nano and Molecular Systems Research Unit, Oulu, Finland

We have studied how an isolated vortex line affects uniformly rotating magnetisation of the Brinkman-Smith mode in the B-phase of superfluid ^{3}He. Using the analytically known order parameter of a static vortex outside of the core region as a boundary condition, we have solved the linearised Leggett equations of spin dynamics. The solution consists of spin waves propagating away from the vortex core. These waves carry energy away from the system, causing dissipation which can be observed as magnetic relaxation in NMR experiments. Comparison to Leggett-Takagi relaxation [1] shows that the spin wave radiation is the dominant dissipation mechanism at temperatures below $0.5T_c$. The results are in good agreement with experiments made both at small and large tipping angles. We calculate that twisting of the vortex core leads to reduced spin wave radiation, which is in good agreement with reduced dissipation seen in the measurements by Kondo et. al. [2].

References:

[1] S. M. Laine and E. V. Thuneberg, J. Low Temp. Phys. **183**, 222 (2016).
[2] Y. Kondo, J. S. Korhonen, M. Krusius, V. V. Dmitriev, Y. M. Mukharsky, E. B. Sonin and G. E. Volovik, Phys. Rev. Lett. **67**, 81 (1991).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.781

Design and expected performance of a compact and continuous nuclear demagnetization refrigerator for sub-mK applications

Toda R.[1], Murakawa S.[1], Fukuyama H.[1,2]
[1]University of Tokyo, Cryogenic Research Center, Tokyo, Japan, [2]University of Tokyo, Department of Physics, Tokyo, Japan

Sub-mK temperatures are achievable by a copper nuclear demagnetization refrigerator (NDR) [1]. Recently, research demands for such an ultra-low temperature environment are increasing not only in condensed matter physics but also in astrophysics using satellite. A standard NDR requires a specially designed room, a high-field superconducting magnet, and a high-power dilution refrigerator (DR). It is also a one-shot cooling apparatus. To reduce these requirements, we are developing a compact and continuous NDR with two $PrNi_5$ nuclear stages. It is installable even onto satellite since it occupies only a small space next to an appropriate pre-cooling stage such as DR. $PrNi_5$ has a large magnetic-field enhancement on Pr nuclei due to strong hyperfine coupling [1]. This enables us to enclose each stage in a miniature superconducting magnet (1.2 T, 40 mm bore) and to locate two such sets in close proximity by surrounding them with high-permeability magnetic shields. The two stages are thermally connected in series to the pre-cooling stage, by two Zn superconducting heat switches. A numerical analysis taking account of thermal resistances of all parts and eddy current heating shows that the lowest sample temperature of 0.8 mK can be maintained continuously under a 10 nW ambient heat leak.

References:

[1] F. Pobell: Matter and Method at Low Temperatures (Springer-Verlag Berlin Heidelberg 2007, 3rd ed.)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.782

Atomic-scale picture on impurity states in superconducting and charge density wave systems

Shawulienu K.[1]*, Dvorak M.*[2]*, Ojanen T.*[1]*, Liljeroth P.*[1]

[1]Aalto University, Department of Applied Physics, Aalto University School of Science, Aalto, Finland, [2]Aalto University, Centre of Excellence in Computational Nanoscience (COMP) and Department of Applied Physics, Aalto, Finland

Superconductivity and charge density waves (CDWs) are typical examples of symmetry breaking in materials .Impurities can result in formation of in-gap states and their properties can be used to probe the underlying ground state. For example, the exchange coupling between magnetic impurities and a superconducting substrate leads to Yu-Shiba-Rusinov (YSR) states. As the spatial extent of YSR states depends crucially on the dimensionality, it can be greatly enhanced in 2D systems providing a platform to study the formation of coupled states. I will show scanning tunneling microscopy (STM) and spectroscopy (STS) study of YSR states on single and dimer cobalt phthalocyanine molecules on a 2D superconductor $NbSe_2$. The spatially extended nature of these states has allowed us to observe coupled YSR states in molecular dimers which can be explained with simple tight binding model. Further, I will show the experimental detection of impurity induced states inside the CDW gap, which have been theoretically predicted but have been elusive. These impurity states also show coupling similar to YSR states. Our results provide insight into the formation of coupled impurity states which may help to realize exotic quantum states such as topological superconductivity in 2D magnetic lattices.

Postersession 3
Monday, 14 August 2017
16.30-18.30

G Foyer

P.786

Charge Berezinskii-Kosterlitz-Thouless transition in superconducting NbTiN films

<u>Baturina T.</u>[1,2,3], Mironov A.[2,3], Silevitch D.[4], Proslier T.[5], Postolova S.[2,3], Burdastyh M.[2,3], Gutakovskii A.[2,3], Rosenbaum T.[4], Vinokur V.[6,7]

[1]Universidad Autónoma de Madrid, Departamento de Física de la Materia Condensada, Madrid, Spain, [2]A. V. Rzhanov Institute of Semiconductor Physics SB RAS, Novosibirsk, Russian Federation, [3]Novosibirsk State University, Novosibirsk, Russian Federation, [4]California Institute of Technology, Division of Physics, Mathematics, and Astronomy, Pasadena, United States, [5]Institut de Recherches sur les Lois Fundamentales de l'Univers, Gif-sur-Yvette, France, [6]Argonne National Laboratory, Materials Science Division, Lemont, United States, [7]Computation Institute, University of Chicago, Chicago, United States

The superconductor-insulator transition (SIT) is a quantum phase transition in disordered superconducting films that occurs at the point where two inherently two-dimensional topological phase transitions - charge and vortex Berezinskii-Kosterlitz-Thouless (BKT) transitions [1,2] - terminate each other. Applied magnetic fields can tune the SIT with high resolution, offering a window into relatively unexplored electronic functionalities. While the superconducting side of the SIT is well understood, the nature of the highly resistive superinsulating state that terminates two-dimensional superconductivity at the quantum critical point remains an open question [3-8]. We report the magnetic field driven SIT in NbTiN films and demonstrate that the highly resistive state is an ordered charge BKT state. We observe nonmonotonic behaviour of the charge BKT transition temperature with magnetic field and resolve a long-standing question of the origin of a giant magnetoresistance peak in the insulating state. Our findings establish that BKT physics is a universal platform for the dual superconducting and superinsulating states.

T.I.B. acknowledges support from the Consejería de Educación, Cultura y Deporte (Comunidad de Madrid) through the talent attraction program, Ref. 2016-T3/IND-1839.

References:

[1]. Berezinskii, V. L. JETP 32, 493 (1970).
[2]. Kosterlitz, J.M. & Thouless, D. J. J. Phys. C: Solid State Phys. 5, L124 (1972).
[3]. Kowal, D & Ovadyahu, Z. Solid State Comm. 90, 783 (1994).
[4]. Sambandamurthy, G. et al. Phys. Rev. Lett. 94, 017003 (2005).
[5]. Baturina, T. I. et al. Phys. Rev. Lett. 99, 257003 (2007).
[6]. Vinokur, V. M. et al. Nature 452, 613 (2008).
[7]. Baturina, T. I. et al. C. JETP Lett. 88, 752 (2008).
[8]. Ovadia, M. et al. Scientific Reports 5,13503 (2015).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.787

Superconductivity in $LaPd_2Al_{2-x}Ga_x$ compounds

<u>Doležal P.</u>, Klicpera M., Kriegner D., Prchal J., Javorský P.

Charles University, Faculty of Mathematics and Physics, Department of Condensed Matter Physics, Prague, Czech Republic

$LaPd_2Al_{(2-x)}Ga_x$ compounds crystallize in tetragonal ordered $CaBe_2Ge_2$-type structure (*P*4/*nmm*) and undergo a structural phase transition to lower a symmetrical structure (orthorhombic *Cmma*) at low temperatures. Both structures are centrosymmetric but the centre of inversion is out of any atomic

position. Polycrystalline samples studied previously exhibit superconducting properties which do not follow the predictions of the BCS theory [1], i.e. non-exponential temperature dependence of the electronic contribution to specific heat below the critical temperature T_c, unusual curvature of the field dependence of the critical temperature $T_c(H)$ and significantly lower value of the ratio $\Delta c_{el}/\gamma T_c$ than is predicted in the weak-coupling BCS limit. The critical temperatures of investigated Al-Ga substitutions vary between 1.6 and 2.7 K. The presented study is focused on investigation of single crystalline $LaPd_2Al_2$, which is an incongruently melting phase, at low temperatures. The superconducting properties are studied by means of specific heat, electrical resistivity and electrical resistivity under hydrostatic pressure which decreases the T_c. The applied magnetic field lower than 1 T suppress the superconductivity in $LaPd_2Al_2$.

References:

[1] M. Klicpera, Superconductor Science and Technology **27**, 085001 (2014)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.788

Low temperature reduced self-diffusion of helium-3 gas in nematically ordered aerogel

Kuzmin V.[1], *Safiullin K.*[1,2], *Stanislavovas A.*[1], *Tagirov M.*[1,2]

[1]Kazan Federal University, Institute of Physics, Kazan, Russian Federation, [2]Academy of Sciences of the Republic of Tatarstan, Institute of Perspective Research, Kazan, Russian Federation

Aerogels with open-space pores present the unique model systems for studies of the impurities in superfluid ^3He. Recently the interest to study of superfluids in aerogels has been renewed due to observation of polar superfluid phase in nematically ordered aerogels [1,2]. We report on ^3He gas diffusion measurements in highly porous ordered Al_2O_3 aerogel samples carried out for the first time at low temperatures (1.5-4.2 K) by nuclear magnetic resonance field gradient technique. A strong influence of adsorbed ^3He layers on self-diffusion is observed. Anisotropic properties of aerogel are not reflected in the observed gas diffusion even at low gas densities where anisotropic Knudsen regime of diffusion is expected. Combination of empirical two phase diffusion and the Knudsen gas diffusion models fails to explain strongly reduced diffusion. The observed gas compression indicates on the influence of the aerogel attractive potential on the molecular dynamics that probably explains reduced diffusion. The mechanisms of gas diffusion in porous media at low temperatures must be understood to characterize the porous media structure in such experiments for studies of ^3He superfluidity.

This work was supported by the Russian Science Foundation (project no. 16-12- 10359).

References:

[1] N. Zhelev, M. Reichl, T. S. Abhilash, E. N. Smith, K. Nguyen, E. Mueller, and J. M. Parpia, Nature Communications **7**, 12975 (2016).

[2] V. V. Dmitriev, A. A. Senin, A. A. Soldatov, and A. N. Yudin, Phys. Rev. Lett. **115**, 165304 (2015).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.789

The inverse energy flux in a system of nonlinear surface waves on the surface He-II

Remizov I.A., *Levchenko A. A.*, *Mezhov-Deglin P. L.*

Institute of Solid State Physics Russian Academy of Sciences, Chernogolovka, Russian Federation

The results of studies of turbulent spectra in the system of surface waves in superfluid He-II filling the rectangular experimental cell are presented. The spectrum of surface excitations in the cell is discrete. The standing waves in frequency range 10-20 Hz were excited by an outer electric field applied perpendicular to the surface. It was found that with increasing the pump amplitude one could observe the development of modulation instability of the surface waves and generation of the low frequency waves in the non-decay frequency range of the spectrum gravity-capillary waves, that corresponded to the formation of a flux of wave action directed to the low-frequency domain of the spectrum. The work was supported by the Russian Science Foundation, Grant No. 17-12-01525.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.790

Gap formation by periodic strain in graphene field effect devices

Tomori H.[1,2]*, Hiraide R.*[1]*, Ootuka Y.*[1]*, Kanda A.*[1]

[1]University of Tsukuba, Tsukuba, Japan, [2]PRESTO-JST, Saitama, Japan

Due to high mobility, graphene is a promising candidate for electronic materials. However, for successful application of graphene to switching devices, gap formation is indispensable. In this study, we explore the gap formation in graphene based on periodic strain engineering.[1, 2]
For the periodic strain, a band gap has been observed only in scanning tunnel spectroscopy, while it has not been confirmed in actual field effect devices.[3] This missing gap is presumably due to the relaxation of strain in device fabrication processes. Here, we develop a novel device fabrication method which makes graphene largely strained even after the formation of electrical contacts. In this method, a graphene film is placed on a periodic array of resist HSQ bars. The introduction of strain was confirmed with micro-Raman spectroscopy.
The back gate voltage dependence of the conductance in the strained graphene exhibited remarkable difference from the conventional V-shaped curve observed in graphene placed on SiO2. The minimum conductance showed thermal activation behavior at high temperatures (> 50 K). From the Arrhenius plot, the band gap was estimated to be 2.4 meV. This value agreed well with the band gap estimated from the current-voltage characteristics.

References:

[1] F. Guinea et al, Nat. Phys. 6, 30 (2010)
[2] V. M. Pereira and A. H. Castro Neto, Phys. Rev. Lett. 103, 046801 (2009).
[3] J. K. Lee et al., Nano Lett. 13, 3494 (2013).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.791

Tailoring supercurrent confinement in graphene bilayer weak links

Kraft R.[1], Mohrmann J.[1], Du R.[1], Selvasundaram P.[1,2], Irfan M.[3], Kanilmaz U.[1,4], Wu F.[1,5], Beckmann D.[1], von Löhneysen H.[1,6], Krupke R.[1,2], Akhmerov A.[3], Gornyi I.[1,4,7], Danneau R.[1]
[1]Karlsruhe Institute of Technology, Institute of Nanotechnology, Karlsruhe, Germany, [2]Technical University Darmstadt, Department of Materials and Earth Sciences, Darmstadt, Germany, [3]Delft University of Technology, Kavli Institute of Nanoscience, Delft, Netherlands, [4]Karlsruhe Institute of Technology, Institute for Condensed Matter Theory, Karlsruhe, Germany, [5]National University of Defense Technology, College of Optoelectronic Science and Engineering, Changsha, China, [6]Karlsruhe Institute of Technology, Institute for Solid State Physics and Institute of Physics, Karlsruhe, Germany, [7]A.F. Ioffe Physico-Technical Institute, St. Petersburg, Russian Federation

Graphene appears to be an ideal candidate for superconducting weak link [1-3] thanks to its low contact resistance, large mean free path and its two-dimensionality which allows device geometry flexibility. Designing nanostructures based on electrostatic gating has been at the heart of the research in mesoscopic physics for the last thirty years. While graphene undergoes Klein tunneling making it inappropriate for charge carrier confinement, it is possible to create nanostructures based on band gap engineering in bilayer graphene (BLG). By inducing a displacement field between an overall back-gate and a local split-gate, we have confine the electrons and holes within a 1D constriction in an edge connected hBN-BLG-hBN heterostructures. We have studied the confinement of the supercurrent by probing its magnitude and the variations of the magneto-interference patterns while the constriction is formed. We demonstrate that it is possible to fully gate-control both amplitude and density profile a supercurrent, making BLG a highly tunable superconducting weak link. Both analytical and numerical model support our findings. Our work opens up possibilities to create more complex circuits such as superconducting electronic interferometers or transition-edge sensors [3].

References:

[1] V.E. Calado, *et al.,* Nat. Nanotech. 10, 761-764 (2015).
[2] M. Ben Shalom, *et al.,* Nat. Phys. 12, 318-322 (2016).
[3] R. Kraft, *et al.,* arXiv: 1702.08773 (2017).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.792

Low-temperature physical properties of the *S* = 1/2 four-leg ladder lattice consisting of a new organic biradical

Otsuka R.[1], Kikuchi K.[1], Okuda K.[1], Amaya N.[1], Yamaguchi H.[1], Ono T.[1], Nojiri H.[2], Hosokoshi Y.[1]
[1]Osaka Prefecture University, Physical Science, Sakai, Japan, [2]Tohoku University, IMR, Sendai, Japan

We have succeeded in synthesizing and crystallizing a new organic biradical 1,3-bis(nitronyl nitroxide-2-yl)-2-bromobenzene. This biradical contains two nitronyl nitroxide radical (NN) units, each of which carries an $S = 1/2$. X-ray structural analysis shows that the space group is $P2_1/n$ and each radical unit (NN1, NN2) is crystallographically independent. The intramolecular interaction J_0 is expected to be ferromagnetic by the molecular orbital calculation using the crystal structure. There are three kinds of intermolecular short contacts between NN units. The intermolecular interaction J_1 is assigned to the shortest contact between NN2 units related by inversion symmetry. Between the molecules related by *a*-translation symmetry, the contacts are seen between the NN2 units and between the NN1 units, which give the intermolecular interactions J_2 and J_3, respectively. As a result, the $S = 1/2$ four-leg ladder lattice is formed by the uniform stacking of two biradical molecules along the *a*-axis. The magnetic susceptibility shows the antiferromagnetic phase transition at $T_N = 0.57$ K due to weak interladder interactions. The magnetization curve at 0.5 K shows a spin flop behavior at B_{sp} = 0.25 T and two-step saturation with a 1/2-magnetization plateau in the field range of 5−14 T.

References:

[1] H. C. Longuet-Higgins: J. Chem. Phys. **18** 265 (1950)
[2] K. Itoh, Chem. Phys. Lett. **1** 235 (1967)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.793

The ac Josephson effect as a thermal probe of nanobridge weak links

Shelly C., *See P., Ireland J., Williams J.*
National Physical Laboratory, Teddington, United Kingdom

We present experimental work demonstrating the response of superconducting nanobridge Josephson junctions to microwave irradiation. Our nanobridge devices exhibit hysteretic current-voltage characteristics (IVC) below 7 K. In this regime the devices enter a resistive state when the applied current is increased to a value greater than the junction critical current I_c. When the applied current is then reduced, the nanobridge remains in the resistive state until the re-trapping current I_r is reached, where $I_r < I_c$. Unlike traditional tunnel junctions it is widely considered that the origin of this hysteresis is thermal with the device remaining in a non-superconducting state such that $T>T_c$ on the re-trapping branch of the IVC [1-3]. We present a possible use of the ac Josephson effect as a thermal probe of the device temperature in both hysteretic and non-hysteretic regimes.

References:

[1] W. J. Skocpol, M. R. Beasley, and M. Tinkham, J. Appl. Phys. **45**, 4054, (1974).
[2] D. Hazra, L. M. A. Pascal, H. Courtois, and A. K. Gupta, Phys. Rev. B **82**, 184530 (2010).
[3] A. Blois, S. Rozhko, L. Hao, J. C. Gallop and E. J. Romans, Supercond. Sci. Technol., 30, 014003 (2017).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.794

A proposal for investigating superfludity using SiN NEMS resonator

Choi J., *Choi J., Jang S., Noh S., Kim E.*
KAIST, Deajeon, Korea, Republic of

Recent advance in micro-fabrication technique leads to the development of various MEMS devices including mechanical resonators that exhibit multiple functionalities [1]. In particular, Silicon and Silicon Nitride were found to be suitable for making a MEMS resonator with high mechanical Q-factor and durability [2]. In this study, we fabricate a miniaturized paddle-type torsional resonator to investigate superfluidity by using micro-fabrication and MEMS technique. A large-size few layer graphene will be attached on top of the paddle of a resonator. Helium atoms are expected to be adsorbed on the graphene substrate in layer-by-layer fashion [3]. Our sub-micron-sized mechanical resonator is designed to be operated at two different frequencies, which enables us to distinguish the microscopic origin of various phase transitions. The resonant frequencies of the MEMS resonator were simulated

by using the Finite Element Method simulation. The in-phase (1^{st}) and out-of-phase (2^{nd}) modes of the resonator are expected to be 27.9 MHz and 85.9 MHz, respectively.

References:

[1] P. Mohanty *et al*., Phys. Rev. B 66, 085416 (2002)
[2] J. Rieger, T. Faust, M. J. Seitner, J. P. Kotthaus, and E. M. Weiga, Appl. Phys. Lett. 101, 103110 (2012)
[3] P. A. Crowell and J. D. Reppy. Phys. Rev. Lett. 70, 3291 (1993)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.795

Magnetic properties of α-Sr_2VO_4 with degenerated orbitals studied by single-crystal ^{51}V NMR

Kato Y.[1], *Shimizu Y.*[1], *Kobayashi Y.*[1], *Itoh M.*[1], *Jin-no T.*[1], *Sakurai H.*[2], *Kao T.-H.*[3], *Yang H.-D.*[3]
[1]Nagoya University, Nagoya, Japan, [2]National Institute for Materials Science (NIMS), Tsukuba, Japan, [3]National Sun Yat-Sen University, Kaohsiung, Taiwan, Republic of China

The layered-perovskite vanadium oxide α-Sr_2VO_4 has attracted much attention as a $3d^1$ system with the degenerated d_{xz}/d_{yz} orbital. The spin-orbital coupled J_{eff}=1/2 ground state is expected. This undergoes structural transitions, where magnetic susceptibility shows a sharp drop at T_1=101 K and a kink at T_2=127 K, and furthermore the antiferromagnetic transition at T_N=10 K [1]. From a theoretical point of view, the orbital-spin order model on the basis of the first principles calculation [2] and the magnetic octupole model [3] were proposed. Up to now, the magnetic properties and the phase transitions have not been well uncovered. We have made ^{51}V NMR measurement on a single crystal to reveal the magnetic properties of α-Sr_2VO_4. Above T_2, we observed the ^{51}V Knight shift with a temperature-dependent negative isotropic shift and an axially anisotropy, whereas the Knight shift shows a temperature-independent isotropic value of about +0.01 % and an anisotropic shift below T_1 much smaller than that above T_2. These Knight shifts cannot be reproduced by a single-ion model with Kramers doublets split by the crystal field and the spin-orbit interaction. This indicates that the interaction between the V ions may play an important role for the magnetic properties.

References:

[1] H. Sakurai, Physics Procedia. **75**, Pages 829-836 (2015). [2] Y. Imai et al., Phys. Rev. Lett. **95**, 176405 (2005). [3] G. Jackeli *et al*., Phys. Rev. Lett. **103**, 067205 (2009).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.796

Nanoelectromechanical beams immersed in quantum fluids

Mellor R.[1], *Casey A.*[1], *Cowan B.*[1], *Saunders J.*[1], *Parpia J.*[2], *De Alba R.*[2], *Sebastian A.*[2,3]
[1]Royal Holloway, University of London, Physics Department, Egham, United Kingdom, [2]Cornell University, Ithaca, United States, [3]Aalto University, Helsinki, Finland

We present work on high Q Nanoelectromechanical systems (NEMS) fabricated as doubly clamped SiN-Nb nanowires. The nanowires have dimensions less than the coherence length for a superfluid helium-3 Cooper pair, with a 50 x 50 nm cross-section that includes a 20 nm thick Nb film. The wires discussed in this work were 50 microns long, but can be fabricated from 1-100 microns in length, resulting in fundamental mode frequencies in the MHz range. Prior room temperature characterisation of these beams demonstrated that laser induced self-oscillation modes could be generated [1]. In this work the motion of the nanowire is detected by creating a circuit comprising of the beam and an input coil inductively coupled to a SQUID. The bandwidth of the SQUID allows us to detect motion up to a frequency of 6 MHz. The beam has been mounted in a cell in which the wire bonds are connected to sintered pads immersed in liquid helium, providing the means to cool the NEMs device. Johnson noise thermometry allows us to determine the electron temperature of the contact pads. Characterisation of the response with the beam in both vacuum and superfluid will be used to investigate the suitability of such beams as probes for the properties of quantum fluids and test the limits of brute force cooling.

References:

[1] Roberto De Alba, T. S. Abhilash, Richard Rand, Harold G. Craighead, Jeevak M. Parpia, Low-power photothermal self-oscillation of bimetallic nanowires, arXiv:1610.07591

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.797

The Majorana STM as a perfect detector of odd-frequency superconductivity

Kashuba O.[1], Sothmann B.[2], Burset P.[1,3], Trauzettel B.[1]
[1]Wuerzburg University, Institute for Theoretical Physics and Astrophysics, Wuerzburg, Germany, [2]University of Duisburg-Essen, Theoretische Physik, Duisburg, Germany, [3]Aalto University, Department of Applied Physics, Aalto, Finland

We propose a novel scanning tunneling microscope (STM) device in which the tunneling tip is formed by a Majorana bound state (MBS) [1]. This peculiar bound state exists at the boundary of a one-dimensional topological superconductor. Since the MBS has to be effectively spinless and local, we argue that it is the smallest unit that exhibits odd-frequency superconducting pairing.
Odd-frequency superconductivity is characterized by an anomalous Green function which is an odd function of the time arguments of the two electrons forming the Cooper pair. As such, our Majorana STM can be used as the perfect detector of odd-frequency superconductivity. This is because a supercurrent between the Majorana STM and any other superconductor can only flow if the latter system exhibits odd-frequency pairing.
To illustrate our concept, we consider the tunneling problem between the Majorana STM and a quantum dot in the vicinity of a conventional superconductor. In the (superconducting) quantum dot, the effective pairing can be tuned from even- to odd-frequency behavior by applying an external magnetic field. As expected, a supercurrent may only flow through the junction when an odd-frequency triplet pairing is induced in the dot.

References:

[1] O. Kashuba, B. Sothmann, P. Burset, and B. Trauzettel. arXiv:1612.03356.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.798

Pressure - temperature phase diagram of superconducting FeSe single crystals studied by complementary probes

Toulemonde P.[1], Raba M.[1], Rodière P.[1], Svitlyk V.[2], Dmitriev V.[2], Chernyshov D.[2], Mezouar M.[2], Lebert B.[3,4], Klotz S.[3], Balédent V.[5], Rueff J.-P.[3,4], Hansen T.[6]
[1]Institut NEEL, CNRS & UGA, Grenoble cedex, France, [2]European Synchrotron Radiation Facility (ESRF), Grenoble, France, [3]IMPMC, CNRS UMR 7590, Université P&M Curie, Paris, France, [4]Synchrotron SOLEIL, Gif-sur-Yvette Cedex, France, [5]Laboratoire de Physique des Solides, Orsay, France, [6]Institut Laue-Langevin, Grenoble, France

In addition to its low pressure nematic state [1,2,3], FeSe shows a pressure-induced magnetic (AFM) order [4] simultaneously where T_c increases strongly, from 9K up to 35K at 6-7GPa.
We confirm, thanks to XRD under high pressure (HP), that its low T orthorhombic distortion is retained in the region of SC/AFM coexistence [5]. Moreover, at P>7GPa, the decrease of T_c is found concomitant with the formation of a new polymorph, with an orthorhombic Pnma structure, characterized by a 3D network of face sharing $FeSe_6$ octahedra [6]. This 3D phase coexists with the low pressure 2D form up to the highest pressure studied.
We have also studied the magnetism of FeSe by performing RIXS at K-edge of iron. The EXAFS spectra measured at 10K/HP are strongly modified at 7GPa, corresponding to the change from the tetrahedral to the octahedral coordination of Fe in the Pnma structure. More interestingly the XES spectra measured at the K β' line shows a significant increase related to the enhancement of the local Fe magnetic moment occurring in the FeSe 3D form.
Finally, our neutron diffraction experiments under HP-lowT have not revealed any detectable long range magnetic order associated to the intermediate pressure-induced AFM phase or to the 3D HP polymorph despite its higher iron magnetic moment.

References:

[1] S. Karlsson, P. Toulemonde *et al.*, Supercond. Sci. Technol. **28**, 105009 (2015).
[2] P. Massat, P. Toulemonde, Y. Gallais *et al.,* PNAS USA **113**, 9177 (2016).
[3] L. Fanfarillo, J. Mansart, P. Toulemonde, H. Cercellier, V. Brouet, *et al.*, Phys. Rev. B **94**, 155138 (2016).
[4] M. Bendele *et al.,* Phys. Rev. B **85**, 064517 (2012).
[5] K. Kothapalli *et al.,* Nat. Comm. **7**, 12728 (2016).
[6] V. Svitlyk, M. Raba, V. Dmitriev, P. Rodière, P. Toulemonde *et al.*, submitted to Sc. Reports (2017).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.799

Superfluid 2 K cooling device with a distributed JT (Joule-Thomson) effect heat exchanger

Jeong S.
KAIST, Daejeon, Korea, Republic of

A cryogenic JT expansion refrigerator is used for various applications to obtain low temperature because of its simple configuration and manufacturing easiness. Superfluid at 2 K or below is readily obtained from liquid helium at 4.2 K by reducing its vapor pressure. For better cooling performance, however, the cold energy of vaporized helium at 2 K chamber is to be effectively utilized in a recuperator which is specially installed for accomplishing so-called distributed Joule-Thomson (JT) expansion effect. This paper describes the design methodology of distributed JT effect heat exchanger for 2 K JT cooling device. The newly developed distributed JT effect heat exchanger utilizes continuous pressure drop at high-pressure part of the recuperative heat exchanger by using a capillary tube. Being different from conventional recuperative heat exchangers, the efficient distributed JT effect HX must consider the pressure drop effect as well as heat transfer characteristic. The newly tested 2 K cooling device is more suitable for large measurement system that handles multiple cryogenic samples at the same time. This paper discusses the cooling performance of the proposed efficient cryogenic cooling device and the thermohydraulic characteristic of the distributed JT heat exchanger.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.800

Behavior of $U_4Ru_7Ge_6$ in the vicinity of thermal and quantum transitions

Vališka M., Valenta J., Proschek P., Prokleška J., Sechovský V.
Charles University, Faculty of Mathematics and Physics, Department of Condensed Matter Physics, Praha, Czech Republic

Uranium intermetallic compounds usually exhibit large magnetocrystalline anisotropy. It is born in strong spin-orbit coupling in U ions together with participation of 5*f* orbitals in anisotropic covalent bonding. High quality single crystals of cubic compound $U_4Ru_7Ge_6$, grown by Czochralski method, were studeid by XRPD, magnetization, AC susceptibility, thermal expansion, specific heat and electrical resistivity measurements in various conditions. It is ferromagnet below T_C= 10.7 K with the easy magnetization axis along the [111] at the ground state. This easy magnetization direction is changed to [100] at T_r = 5.9 K. The anisotropy fields for the [110] and [100] directions are very low and close to ~0.2 T [1]. This makes $U_4Ru_7Ge_6$ very rare exception among U intermetallics. We propose rhombohedral distortion, creating two different U sites, according to our thermal expansion measurements and ab-initio calculations. Application of hydrostatic pressure leads to the suppression of T_C down to zero temperature at pressure ~2.5 GPa, whereas the T_r remains almost unchanged up to 1 GPa where the transition line is finished by critical point at ~5 K.

References:

[1] M. Vališka et al., Phys. Rev. B 95, 085142 (2017)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.801

Electron waiting times of a Cooper pair splitter

Walldorf N.[1], Flindt C.[2], Padurariu C.[2], Jauho A.-P.[1]
[1]Technical University of Denmark, Kongens Lyngby, Denmark, [2]Aalto University, Aalto, Finland

Generation of non-local entangled states is of fundamental interest and is key in quantum information systems. In solid state systems, a promising route to generate non-local entangled electron pairs is through splitting of Cooper pairs.
We study and characterize non-locality and entanglement in Cooper pair splitters by waiting time distributions, i.e. the distribution of waiting times between subsequent jump events to external leads. In particular, we consider sub-gap transport from a superconducting source to two normal drains via a double quantum dot structure in order to split Cooper pairs into separate leads. The non-locality is characterized by means of a large cross waiting time distribution at times shorter than the average time needed to split a single Cooper pair. We show that this signature only survives for electrons with opposite spins, thus providing evidence that the pairs originate from spin-entangled Cooper pairs.

Furthermore, we study correlations and the statistical ordering of transport processes which are revealed by the joint waiting time distribution.
The results have guided our work towards time-dependent phenomena. The statistical ordering of transport can be exploited in the course of time-dependent manipulation of transport.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.802

Specific heat and effects of superfluid fluctuations in a superfluid Fermi atomic gas

van Wyk P., Inotani D., Ohashi Y.
Keio University, Faculty of Science and Technology, Yokohama, Japan

We investigate the specific heat C_V at constant volume in the BCS (Bardeen-Cooper-Schrieffer)-BEC (Bose-Einstein condensation) crossover regime of a superfluid Fermi gas. Including superfluid fluctuations within the Gaussian fluctuation theory developed by Nozières and Schmitt-Rink, we calculate C_V as a function of temperature below the superfluid phase transition temperature T_c. We clarify how effects of superfluid fluctuations on this thermodynamic quantity is gradually suppressed by the superfluid order, with decreasing the temperature below T_c. From this, we determine the superfluid region where fluctuations in the Cooper channel still play important roles, in the BCS-BEC crossover region. We also compare our results with the recent experiment on a unitary Fermi gas. Since pairing fluctuations is a crucial key in understanding physical properties of an ultracold Fermi gas, together with our previous results above T_c [1], our results would contribute to the further development of cold atom physics.

References:

[1] P. van Wyk, H. Tajima, R. Hanai, and Yoji Ohashi, Phys. Rev. A **93**, 013621

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

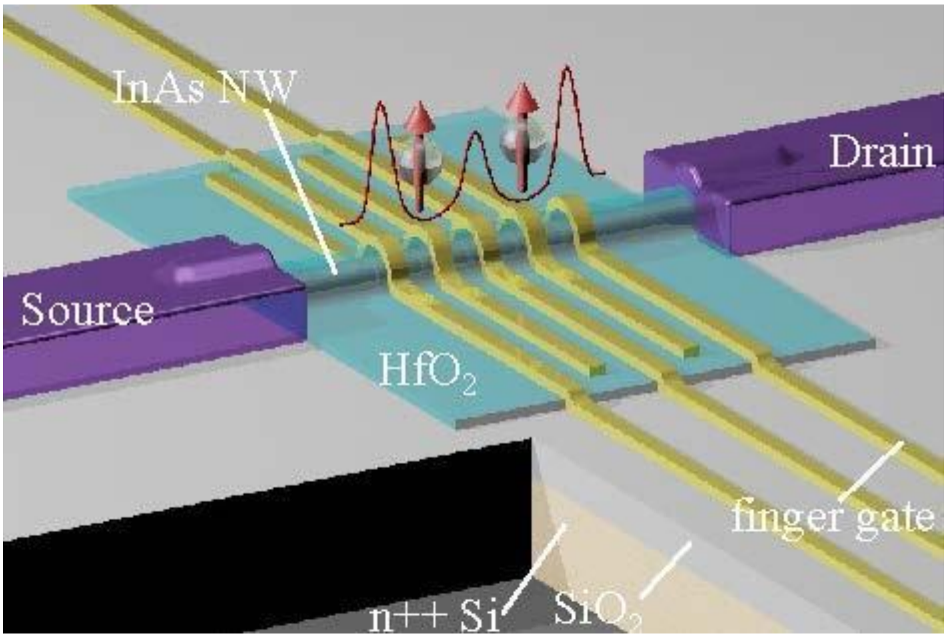
P.803

Anisotropic Pauli spin-blockade effects in double quantum dots made from InAs nanowire

Wang J.-Y.[1], Huang S.[1], Huang G.-Y.[1], Pan D.[2], Zhao J.[2], Xu H.Q.[1,3]
[1]Peking University, Key Laboratory for the Physics and Chemistry of Nanodevices, and Department of Electronics, Beijing, China, [2]Institute of Semiconductors, Chinese Academy of Sciences, Beijing, China, [3]Lund University, Division of Solid State Physics, Lund, Sweden

Semiconductor quantum dots (QDs) are one of the most promising building blocks for the physical implementation of electron-spin based quantum computers.[1,2] The electron spin relaxation time in the QD is essential for robust and functional computations but limited by two dominating mechanisms: nuclear hyperfine[3] and spin-orbit interactions[4]. The former is usually random, while the latter is anisotropic. Experimentally, the magnitude of leakage current through double quantum dot (DQD) in spin-blockade regime reflects the strength of spin mixing.

In this work, we investigate the spin mixing effects caused by hyperfine interaction and spin-orbit interaction in a top-finger-gate defined DQD in InAs nanowire, as shown in Fig. 1. In spin-blockade regime, by detuning the energy levels of each dot and applying an external magnetic field, we systematically study the roles of two spin-mixing mechanisms and identify each mechanism.Spin mixing arising from hyperfine interaction can be suppressed completely by a magnetic field of several mili-Tesla. By applying the external magnetic field in different directions with regard to the nanowire axis, the anisotropic lifting of the Pauli spin blockade is observed and attributed to the anisotropic spin-orbit interaction.



[Fig.1 Schematics of the DQD]

References:

1. D. Loss, D. P. DiVincenzo, Phys. Rev. A 57, 120 (1998).
2. J. Y. Wang, S. Y. Huang, Z. Lei, D. Pan, J. Zhao, H. Q. Xu, Appl. Phys. Lett. 109, 053106 (2016),.
3. Oleg N. Jouravlev, Y. V. Nazarov, Phys. Rev. Lett 96, 176804 (2006).
4. J. Danon, Y. V. Nazarov, Phys. Rev. B 80, 041301 (2009).

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.804

Influence of the interaction between iron impurities on the thermo-emf of dilute magnetic Cu-Fe alloy thermocouple

Wang H.L.[1], *Huang L.B.*[2], *Liu M.Y.*[1], *Zhang Y.S.*[1]
[1]Huazhong University of Scinece and Technology, Laboratory of Cryogenics, Wuhan, China, [2]National Institute of Metrology, Beijing, China

Dilute magnetic Cu-Fe alloy thermocouple is a new type of thermocouple which can be used for measurements in 4-273K since the famous Au-Fe alloy low temperature thermocouple. Cu has the same Femi structure as Au, which will be changed by magnetic impurity in the alloy, and this effect has more significant impact on the Cu-Fe alloy. This paper proposes the interaction between iron

impurities should be considered in theoretical analysis on the low temperature thermo-emf of dilute magnetic Cu-Fe alloy thermocouple and the analysis has been verified well by experimental results. It can be found from the calibration experiment on Cu-Fe thermocouple that, at a temperature below 20 K, the sensitivity of NiCr-CuFe thermocouple is close to that of NiCr-AuFe thermocouple; in the wide temperature region from 20 K to 90 K which is used for the high-temperature superconducting applications, the sensitivity of the NiCr-CuFe thermocouple is 25% higher than that of the NiCr-AuFe thermocouple. Along with the enormous advantages in economy and mechanical strength make the Cu-Fe alloy thermocouple capable of replacing the precious Au-Fe alloy thermocouple and having potentially broad applications. The calibration reference table of NiCr-Cu + 0.13 at% Fe thermocouple is given for reference.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.805

Levitons in the fractional quantum Hall regime

Vannucci L.[1], *Ronetti F.*[1,2], *Rech J.*[2], *Jonckheere T.*[2], *Ferraro D.*[2], *Martin T.*[2], *Sassetti M.*[1]
[1]University of Genova and CNR-SPIN, Genova, Italy, [2]Centre de Physique Théorique (CPT), Marseille, France

A minimal excitation state in quantum conductors corresponds to a single electron excited above the Fermi surface without any additional particle-hole pair. It has been shown, both theoretically and in experiments, that a quantum state with such a striking property can be realized by applying carefully-engineered voltage pulses to the conductor, following the recipe provided by L. Levitov and collaborators in the ´90s (hence the name "levitons" for such excitations). However, questions can be raised about the robustness of levitons against electron-electron interactions. Here we study levitons in the edge states of the fractional quantum Hall effect, where interactions give rise to exotic quasi-particles with fractional charge and statistic. It is shown that results by Levitov and coworkers are not affected by interactions, since integer levitons still represent minimal excitation states despite the typical nonlinear physics of the fractional regime. We use charge shot noise as well as heat and mixed fluctuations to shed light on the fascinating properties of Levitov´s excitations. In addition, we probe them through Hong-Ou-Mandel interferometry. The universal Pauli dip generated by Hong-Ou-Mandel collisions of levitons further demonstrates the uniqueness of such a quantum state.

References:

[1] L. S. Levitov, H. Lee, and G. B. Lesovik, J. Math. Phys. 37, 4845 (1996).
[2] J. Keeling, I. Klich, and L. S. Levitov, Phys. Rev. Lett. 97, 116403 (2006).
[3] J. Dubois et al., Nature (London) 502, 659 (2013).
[4] J. Rech, D. Ferraro, T. Jonckheere, L. Vannucci, M. Sassetti, and T. Martin, Phys. Rev. Lett. 118, 076801 (2017).
[5] L. Vannucci, F. Ronetti, J. Rech, D. Ferraro, T. Jonckheere, T. Martin, and M. Sassetti, arXiv:1704.01812.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.806

Surface states and correlations in two dimensional ^{3}He on atomically layered ^{4}He films

Waterworth A., Nyeki J., Cowan B., Saunders J.
Royal Holloway, University of London, Egham, United Kingdom

^{3}He adsorbed on an atomically layered ^{4}He film on the surface of graphite provides a model experimental realization of a correlated two dimensional fermionic system. In principle the ^{3}He surface density can be varied over a wide range, to explore direct ^{3}He-^{3}He interactions and those mediated by ^{4}He film excitations. Using a sensitive SQUID NMR technique we have measured the ^{3}He nuclear magnetic susceptibility over a range of ^{3}He coverages, n_3, from 0.1 to 7 nm^{-2}, at temperatures in the range 200 µK to 500 mK. For $n_3 > 1$ nm^{-2}, comparison to our previous heat capacity measurements enables the determination of both Landau parameters F_0^a and F_1^s, the interdependence of which fingerprints the ^{3}He-^{3}He interactions, which are repulsive. Our precision studies on well-characterized ^{4}He films of three and four layers help resolve long-standing controversies over “helium-mixture films” on the heterogeneous substrate nuclepore [1,2,3]. On three layers of ^{4}He we also report the population of the first excited surface Andreev bound state around 5 nm^{-2}, leading to two 2D Fermi systems. Our torsional oscillator measurements show the progressive suppression of ^{4}He superfluidity as n_3 is increased, with two regimes above and below around 1 nm^{-2}.

References:

[1] R. Hallock, Prog. Low Temp. Phys. **14**, 321 (1995)
[2] B. K. Bhattacharyya, M. J. DiPirro, F. Gasparini, Phys. Rev. B **30**, 5029 (1984)
[3] B. K. Bhattacharyya, F. Gasparini, Phys. Rev. B **31**, 2719 (1985)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.807

Microwave bolometer with low noise-equivalent power

Vesterinen V., Govenius J., Lake R.E., Kokkoniemi R., Gunyho M.A., Tan K.Y., Goetz J., Möttönen M.
Aalto University, QCD Labs, Department of Applied Physics, Espoo, Finland

We recently introduced a microwave bolometer based on superconductor—normal-metal—superconductor junctions[1] and showed that it can detect weak microwave pulses down to the zeptojoule level in a time-gated mode[2]. Here we use a similar device in the continuous mode. Its central component is a metallic nanowire which absorbs the incoming radiation and transduces the temperature change into a radio-frequency signal. We reach a noise-equivalent power (NEP) of the order of 10^{-20} W/Hz$^{1/2}$ with a time constant of 7 ms. We can also tune the time constant, in situ, down to 300 µs at the expense of increasing the NEP by an order of magnitude, which is nevertheless still on par with the best previously reported bolometer NEPs[3],[4]. For the ease of input power calibration, we couple the detector to an 8.4 GHz microwave source. However, we emphasize that there are no fundamental hurdles to adapting the design to the higher frequencies and antenna coupling required for THz detection.

References:

[1] J. Govenius et al., Phys. Rev. B **90**, 064505 (2014)
[2] J. Govenius et al., Phys. Rev. Lett. **117**, 030802 (2016)
[3] B. S. Karasik and R. Cantor, Appl. Phys. Lett. **98**, 193503 (2011)
[4] T. Suzuki et al., IEEE Trans. THz Sci. Technol. **4**, 171 (2014)

Postersession 3

Monday, 14 August 2017
16.30-18.30
G Foyer

P.808
Frequency dependence of Andreev reflection in superfluid ^{3}He-B
Wilcox T., Ahlstrom S.L., Bradley D.I., Guenault A.M., Guise E.A., Haley R.P., Kafanov S., Pickett G.R., Poole M., Tsepelin V., Woods A.J.
Lancaster University, Department of Physics, Lancaster, United Kingdom

We present a study of damping experienced by an oscillating object in superfluid ^{3}He-B. The damping force on an oscillating object can be split into three components: the intrinsic (vacuum) dissipation, the thermal contribution governed by quasiparticle scattering and a pair-breaking component that dominates above a certain critical velocity [1, 2]. Here we focus on the thermal component which arises due to the Andreev scattering of quasiparticles from the flow around the device. Using several vibrating wire resonators and quartz tuning forks we have measured the damping for temperatures from 100µK to 300µK and frequencies from 350Hz to 160kHz. Our measurements show that the influence of Andreev reflection reduces with frequency, which broadly agrees with theoretical predictions across the range tested.

References:
[1] S.N. Fisher, A.M. Guénault, C.J. Kennedy and G.R. Pickett, Phys. Rev. Lett. **63**, 2566 (1989)
[2] D.I. Bradley et al., J. Low Temp. Phys. **157**, 476 (2009)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.809
Anomalous KT onset slope from third sound measurements with layered helium films adsorbed on carbon nanotubes
Williams G., Menachekanian E., Iaia V., Fan M., Hu C., Wen F.
UCLA, Department of Physics & Astronomy, Los Angeles, United States

Third sound measurements of thin ^{4}He films adsorbed on multiwall carbon nanotubes 10 nm in diameter show layer-completion effects at 3, 4, and 5 atomic layers. Temperature sweeps at fixed film thickness show Kosteritz-Thouless (KT) onset behavior (a sudden rise in dissipation), but a puzzle is that the slope of the onset temperature with film thickness is only about 1/3 of the KT universal vaue. We speculate on the possibility of corrugation effects due to the non-uniform pull of the carbon atoms, forming "dimples" at the center of the carbon rings. Such 3D structures would invalidate the 2D KT theory, and the nonuniform potential for vortex formation could delay the onset of the superfluid transition. In the third sound measurements we also find an oscillation of the film expansion coefficient, correlated with the compressibility oscillation seen in the third sound velocity.

Postersession 3
Monday, 14 August 2017
16.30-18.30

G Foyer

P.810

Dynamics of free decay in the forward cascade of 2D quantum turbulence

Williams G., Chu H.-C., Forrester A.
UCLA, Department of Physics & Astronomy, Los Angeles, United States

The forward cascade in 2D quantum turbulence has previously been studied for the case of constant forcing, where vortex pairs of large separation are injected into the plane at a constant rate [1,2]. The pairs evolve under time-dependent renormalization equations to a steady-state cascade with a k^{-3} energy-entropy spectrum. Here we study the case of the free decay of an initial distribution sharply peaked at at a given small wavenumber (large separation). The distribution spreads rapidly toward larger wavenumbers, and after 3-4 eddy turnover times the peak in the distribution is gone and the k^{-3} spectrum is established. The behavior of the cascade in this positive-temperature state appears to be identical to that seen in recent numerical simulations starting from a negative-temperature state [3]. We note that the decay of temperature-quenched 2D superfluids [4] is also an example of the cascade decay process, in that case changing from the initial Boltzmann spectrum to a k^{-3} spectrum over several eddy turnover times.

References:

[1] H-C. Chu and G. A. Williams, in Proceedings of the Cambridge Workshop on Quantized Vortex Dynamics and Superfluid Turbulence, C.F. Barenghi, R.J. Donnelly, and W.F. Vinen (Eds., (Springer-Verlag, Berlin, New York, 2001), p. 226-232
[2] A. Forrester and G.A. Williams, J. of Phys.: Conf. Series **568**, 012031 (2014)
[3] M. Reeves, T. Billam, X. Yu, and A. Bradley, arxiv:1702.04445
[4] A. Forrester, H. Chu, and G. A. Williams, Phys. Rev. Lett. **110**, 165303 (2013)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.811

Kondo effect in transport through quantum dot based Cooper pair splitters

Wrześniewski K., Weymann I.
Adam Mickiewicz University, Faculty of Physics, Poznań, Poland

We study the Andreev transport properties of a Kondo-correlated double quantum dot attached to a common s-wave superconductor and two normal electrodes. The emphasis is put on the low bias voltage regime, where transport between the superconductor and normal leads takes place due to direct and crossed Andreev reflection processes. In the former type of processes, Cooper pair electrons are transferred through the same arm of the device, while in the latter type of processes, Cooper pairs become split and two entangled electrons leave the superconductor through separate arms of the system. We determine the splitting efficiency for various parameters of the system and, by analyzing the relevant spectral functions and Andreev transmission coefficients, we show that transport properties are generally conditioned by the interplay of superconducting correlations and those leading to the Kondo effect. Moreover, the influence of the proximity-induced on-dot pairing on both the SU(2) and SU(4) Kondo effects is thoroughly discussed. All calculations are performed with the aid of non-perturbative density-matrix numerical renormalization group method.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.812
Quantum heat transport in a spin-boson nanojunction
Wu C.
Fudan University, Department of Physics, Shanghai, China

Quantum heat transport in a spin-boson system under nonequilibrium steady state (NESS) is investigated by the nonequilibrium Green's function (NEGF) method.[1] Spin-spin correlators are calculated via the Majorana fermion representation of spin operators, which allows us to make use of Wick's theorem through standard diagrammatic techniques. An analytic formula of heat current is obtained, and numerical results are presented in comparison with those obtained by other methods. Two types of transport mechanisms are identified in high- and low-temperature regions, respectively, which shows a transition from incoherent to coherent transport process with the baths' temperatures decreased. By combining a polaron transformation, we are able to treat the system-bath coupling nonperturbatively [2] and then work out the transport in both the weak and strong coupling regimes.
References:
[1] Y. Yang and C. Q. Wu, EPL **107**, 30003 (2014)
[2] J. Liu, H. Xu, and C.Q. Wu, **481**, 42 (2016)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.813
Superconductivity in halogen-doped misfit compounds $(PbSe)_{1.12}(TaSe_2)$
Xu Z.-A.[1], *Yang X.*[1], *Bai H.*[1], *Wang M.*[1], *Dong C.*[2], *Zheng Y.*[1]
[1]Zhejiang University, Hangzhou, China, [2]Chinese Academy of Sciences, Beijing, China

Single crystals of new misfit structural compounds (PbSe)1.12(TaSe2) were synthesized using I2 or Cl/Br-containing transporting gas agents. Superconductivity can be induced by halogen doing on the Se site in the PbSe layer. Tc is 0.6 K for I doping. The Hall coefficient is positive, indicating that the hole-type charge carrier is dominant. The temperature dependence of Hall coefficient implies that these halogen doped misfit compounds are muilt-band systems. Possible coexistence or competition of charge-density wave order with superconductivity is discussed.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.814
Studies on antiferromagnetic Kondo lattice compound $CePt_3P$
Xu Z.-A.[1], *Chen J.*[1], *Lv B.*[1], *Wang Z.*[1], *Dai J.*[2]

[1]Zhejiang University, Hangzhou, China, [2]Hangzhou Normal University, Hangzhou, China

A new ternary platinum phosphide $CePt_3P$ with an antiperovskite tetragonal structure has been synthesized and characterized by means of magnetic, thermodynamic and transport property measurements. No superconductivity is observed in $CeP_{t3}P$ down to 0.5 K. Instead $CePt_3P$ is a moderately correlated antiferromagnetic Kondo lattice compound with T_N of 3 K. The Sommerfeld coefficient of electronic specific heat is 86 mJ/mol.K^2 and the Kondo temperature is of similar magnitude as T_N. We further investigate the evolution of properties with applying magnetic field and a monotonic depression of T_N with magnetic field is observed. Sr doping on the Ce site is also performed and possible quantum criticality is discussed.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.815

2D Mott VRH transport behaviors in exfoliated MoS_2 nanoflakes

<u>Xue J.H.</u>[1], Huang S.Y.[1], Wang J.-Y.[1], Xu H.Q.[1,2]
[1]Peking University, Key Laboratory for the Physics and Chemistry of Nanodevices and Department of Electronics, Beijing, China, [2]Lund University, Division of Solid State Physics, Lund, Sweden

Recent studies have shown that disorders strongly affect the performance of layered MoS_2 based electronic devices[1,2]. It was shown[3] that thermally activated transport is an acceptable mechanism at high temperatures, whereas the Efros-Shklovskii (ES) and Mott VRH models cannot be distinguished clearly at low temperatures. Thus, detailed investigation by magnetotransport measurements is desired to identify the transport mechanisms at low temperatures.
In this work, we report on an experimental study of MoS_2 nanoflakes by electrical and magnetotransport measurements. Metal-insulator transition[4] is observed at gate voltages $V_g > -30$ V and temperatures $T > 90$ K. In the insulating regime, the thermally activated transport dominates at relatively high temperatures, while 2D Mott VRH rather than ES VRH transport prevails at relatively low temperatures. A positive quadratic and a negative linear temperature dependence are observed in the measured magnetoconductance and well described by the Mott VRH mechanism based on the wave-function shrinkage[5] and forward interference models[6]. Our results provide first solid evidence that the Mott VRH transport is a dominant mechanism in the insulating regime of MoS_2 nanoflakes at low temperatures.

References:

[1] A. Ayari, E. Cobas, O. Ogundadegbe, and M. S. Fuhrer, J. Appl. Phys. **101**, 014507 (2007).
[2] S. Ghatak, A. N. Pal, and A. Ghosh, ACS Nano **5**, 7707 (2011).
[3] S. T. Lo, O. Klochan, C. H. Liu, W. H. Wang, A. R. Hamilton, and C. T. Liang, Nanotechnology **25**, 375201 (2014).
[4] B. Radisavljevic and A. Kis, Nat Mater **12**, 815 (2013).
[5] T.-I. Su, C.-R. Wang, S.-T. Lin, and R. Rosenbaum, Phys. Rev. B **66**, (2002).
[6] Y. Zhang, H. Ning, Y. Li, Y. Liu, and J. Wang, Appl. Phys. Lett. **108**, 153114 (2016).

Postersession 3
Monday, 14 August 2017
16.30-18.30

G Foyer

P.816

Theoretical study for the excitonic fluctuations and superconductivity in the three-chain Hubbard model for Ta_2NiSe_5

Yamada T.[1], Domon K.[2], Ono Y.[2]
[1]Tokyo University of Science, Noda, Chiba, Japan, [2]Niigata University, Niigata, Japan

Excitonic condensation has been a central issue in the condensed matter physics where conduction electrons and valence holes form the bound states, and they spontaneously condense the system into the ground state, called excitonic insulator[1,2]. Recently, Ta_2NiSe_5 has attracted much attention as a strong candidate for the excitonic insulator with two conduction bands and a single valence band[3,4]. Furthermore by applying pressure, the system shows a semimetallic behavior and finally exhibits a superconductivity around 8GPa[5]. Here we have studied the pairing mechanism mediated by the excitonic fluctuation in the three-chain Hubbard model[3,6,7] for Ta_2NiSe_5 within the random phase approximation for the intersite Coulomb interaction. In the high-pressued semimetallic situation, the two types of the Fulde-Ferrell-Larkin-Ovchinnikov (FFLO) excitonic fluctuations are highly enhanced depending on the size of the band-overlap. Such the FFLO excitonic fluctuations increase the T_c of FFLO excitonic superconductivity where the Cooper-pairs are formed by conduction and valence band electrons with a finite center-of-mass momentum due to the conduction-valence density imbalance. Such the mechanisms can be relevant for the high-pressured regime and its realization will be discussed.

References:

[1] D. Jerome, T. M. Rice, and W. Kohn, Phys. Rev **158**, 462 (1967)
[2] B. I. Halperin and T. M. Rice, Rev. Mod. Phys **40**, 755 (1968)
[3] Y. Wakisaka et al., Phys. Rev. Lett **103**, 026402 (2009)
[4] T. Kaneko et al., Phys.Rev. B **87**, 035121 (2013)
[5] K. Matsubayashi et al., JPS 70-th Annual Meeting (2015)
[6] T. Yamada, K. Domon, and Y. Ono, J. Phys. Soc. Jpn **85**, 053703 (2016)
[7] K. Domon, T. Yamada, and Y. Ono, J. Phys. Soc. Jpn **85**, 065005 (2016)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.817

From meta-magnetic transition to spin-flip behavior in Ce 122 system of (Ce-Gd)Ru_2S_{i2}

Yano K.[1], Amakai Y.[2], Hara Y.[3], Sato K.[3], Kita E.[3], Takano H.[2], Ohta T.[4], Murayama S.[2]
[1]Nihon University, Funabashi, Japan, [2]Muroran Institute of Technology, Muroran, Japan, [3]Ibaraki CT, Katsuta, Japan, [4]Quantum Design Japan Inc., Toshima-ku, Japan

One of the representative materials of Ce 122 system is the $CeRu_2Si_2$ and this compound retains two peculiarities [1]; one is the meta-magnetic transition around μ_0H=7.7 T and the other is the surprisingly smaller magnetic moment (< 1/10) of Ce in the direction of hard axis (H⊥c axis), in comparison with the value of easy axis (H//c axis). In this study, we tried to obtain some clues to understand the mechanism of meta-magnetic transition in $CeRu_2Si_2$ and the extremely small Ce magnetic moment in hard axis.
The *M*-*H* curves for $CeRu_2Si_2$ in the magnetic field of 9 T were measured at various temperatures and the magnetization at 2 K revealed a symptom to saturate by comparing the previous study [2]. Employing the 1/*H* plot, the Ce magnetic moment at 2 K becomes nearly identical to that at 4.2 K around 15 T and this suggests that the Ce 4*f* electronic states at 2 K coincide with those at 4.2 K,

which coincides with the XMCD study [3]. The $GdRu_2Si_2$ (Ce=0) showed a spin-flip behavior of 2-stages of Gd magnetic moment. The spin-flip behavior of Gd magnetic moment is an extremely rare case and the structure of Ce 122 system tends to support the spin-flip behavior. Furthermore, in $(Ce_{0.2}Gd_{0.8})Ru_2Si_2$, the second peculiarity of small magnetic moment of Ce in $H \perp c$ axis does disappear perfectly.

References:

1. P. Haen, J. Flouqu. Lapierre and P. Lejay, J. Low Temp. Phys., 67 (1987), 391.
2. T. Sakakibara, T. Tayama, K. Matsuhira, H. Mitamura and H. Amitsuka, Phys. Rev. B51 (1995), 12030.
3. T. Okane, Y. Takeda, H. Yamagami, A. Fujimori, Y. Matsumoto, N. Kimura, T. Komatsubara and H. Aoki, Phys. Rev. B 86 (2012), 125138.

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.818

Classical and quantum magnetic fluctuations in 1-dimensional Haldane chain Nd_2BaNiO_5

Yokoo T.[1], *Hawai T.*[2], *Itoh S.*[2], *Yoshizawa H.*[3]
[1]High Energy Accelerator Research Organization (KEK), Institute of Materials Structure Science, Tsukuba, Japan, [2]High Energy Accelerator Research Organization (KEK), Tsukuba, Japan, [3]University of Tokyo, Kashiwa, Japan

Linear-chain rare earth nickelates with the general formula R2BaNiO5 were recognized as unique model compounds for the realization of Haldane gap system of quantum spin chains [1]. In Nd2BaNiO5, 1D Haldane chains formed by S=1 Ni2+ and O2- ions show a singlet ground state and finite energy gap in the spin excitation spectrum [2]. At lower temperature, it was found that 3D antiferromagnetic ordering appears at T_N = 48 K, and the magnetic structure for both of Nd and Ni ions were determined [3]. Thus, the crossover (and coexistence) from quantum spin to classical spin system present a unique opportunity to investigate the phase transitions in marginal quantum effects on spins. We present here the entire spin excitations in Brillouin zone measured by means of pulsed neutron inelastic scattering. It is clearly observed the entire one-magnon band with 13 meV spin gap (Haldane gap) at MZC. The energy at zone boundary reaches 60 meV that is less comparing to R=Y system. On the other hand, the gap slightly increases in its energy. Also, at low temperature, the new excitation at E=4 meV and showing almost no momentum dependence has been observed. It is possibly originated from the crystal electric field of Nd^{3+} ions. We discuss the temperature evolution of the dynamics in Nd2BaNiO5.

References:

[1] A. Zheludev *et al*., Phys. Rev. Lett. **80**, 3630 (1998)
[2] T. Yokoo *et al*., Phys. Rev. B **55**, 11516 (1997)
[3] V. Sachan *et al*., Phys. Rev. B **49**, 9658 (1994)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

P.819

Magnetic field induced superconductor - insulator transition in $A^{IV}B^{VI}$ semiconductor heterostructures

Yuzephovich O.[1,2], Bengus S.[1,2]
[1]Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine, Department of Superconducting and Mesoscopic Structures, Kharkov, Ukraine, [2]International Laboratory of High Magnetic Fields and Low Temperatures, Wroclaw, Poland

A comprehensive study and comparison of the features of the magnetic field induced superconductor-insulator transition (SIT) in heterostructures PbTe/PbS and PbTe/YbS with different topologies superconducting interface [1, 2]. The superconductivity ($Tc \leq 6.5$ K) of PbTe/PbS and PbTe/YbS heterostructures are related to the band inversion in narrow-gap semiconductors due to the elastic stress field formed by misfit dislocation networks arising at the interface between the semiconductor layers of sufficient thickness ($d > 80$ nm). If d decreases the continuity of the superconducting interface is broken, Tc decreases and the metallic type conductivity changes to a semiconductive type. It is found that the discontinuity superconducting interface is a necessary condition for the observation of the magnetic field induced SIT in heterostructures PbTe/PbS and PbTe/YbS, and significantly affects its features: a fan-like set of curves $R(T)$, intersection of curves $R(B)$, a maxima value of $R(B)$ curves and negative magnetoresistance). In heterostructures with "perfect", defect-free interface features not found SIT. Thus, the mechanism of SIT in this case is associated with percolation phenomena inherent in granular superconductors.

References:

[1] N.Ya. Fogel et.al., Phys. Rev. B **73,** 161306(R) (2006)
[2] S. V. Bengus, A. Yu. Sipatov, and S. I. Yuzephovich, Low Temp. Phys. 39, 695 (2013)

Postersession 3
Monday, 14 August 2017
16.30-18.30
G Foyer

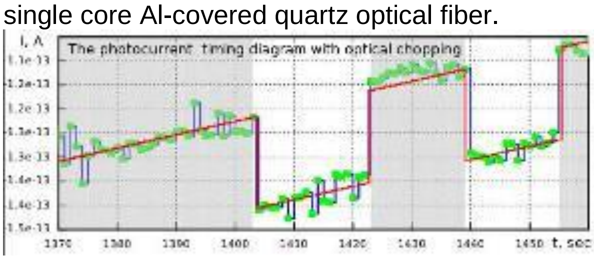
P.820

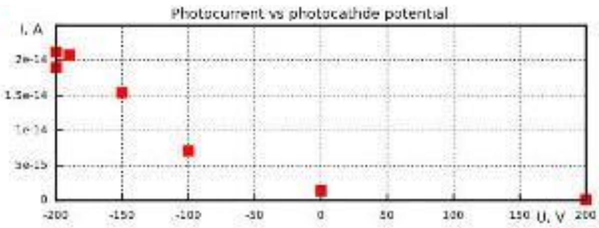
Photo-electron emission directly in superfluid helium

Zavyalov V.[1,2], Pyurbeeva E.[1,2], Khaldeev S.[1,2]
[1]Kapitza Institute for Physical Problems, RAS, Moscow, Russian Federation, [2]Moscow Institute of Physics and Technology (State University), Department of General and Applied Physics, Moscow, Russian Federation

Despite the fact that the electrons in bulk helium were studied for over half a century [1], observations of new intriguing effects still appear [2]. Alas, the traditional methods of injecting electrons into bulk helium (α-sources, W-thermoemitters, discharge or field emission) lead to the generation of a large number of excitations (ions, dimers, rotons, etc.). As a result, the interpretation of experiments are not simple and sometimes may be questionable. In this respect, the photoelectron emitters [3] are more preferable and have been used, for example, for emission of electrons to the helium surface. However, the photocurrent vanishes if the photoemitter´s surface is covered with a helium film thicker than 1.5 nm [4].

We managed to achieve the electron currents (~20 fA) with photocathode immersed directly in condensed superfluid helium. The UV light ($\lambda = 254$ nm) was guided to the photocathode through a single core Al-covered quartz optical fiber.





[eff]

Using more complex MOM structure as emitter, which we are studying at the moment, we hope to significantly improve this result.

References:

1. K.O. Keshishev, Yu. Kovdrya, L.P. Mezhdov-Deglin, A.I. Shal´Nikov, Sov. J. Exp. & Theor.l Phys. **29**, 53 (1969)
2. W. Wei, Z. Xie, L.N. Cooper,H.J. Maris, JLTP **185**, 313 (2016)
3. S,Shankar, G. Sabouret, S. A. Lyon JLTP, **161**, 410 (2010)
4. M. Zech, H.Bromberger, J. Klier, P. Leiderer, A.F.G. Wyatt, Phys. Rev. **B78**, 115113 (2008)
5. D.G. Onn, P. Smejtek, M. Silver, Journal of Applied Physics **45**, 119 (1974)

LT28 POSTER SESSION 4

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.822
Semiconductor-superconductor chip coolers
Mykkänen E., Lehtinen J., Shchepetov A., Grönberg L., Manninen A., Kemppinen A., Prunnila M.
VTT Technical Research Centre of Finland Ltd, Espoo, Finland

The single particle density of states of superconductor provides an energy filtering effect that can be utilized in tunnel junction refrigerators and thermal sensors [1]. The tunnel junction can be either normal metal-insulator-superconductor (NIS) or semiconductor-superconductor (Sm-S) junction, where insulating layer (I) is replaced by a Schottky barrier. It has been shown recently that by careful engineering of the junction fabrication the performance of Sm-S devices can reach that of NIS [2] and, here, we adapt the new Sm-S (Si-Al) junctions in cooling of a Si chip for the first time. In addition of sub-1 K cooler performance we will also discuss higher temperature operation (e.g. with Si-Nb junctions) and fundamental limits of superconductor based refrigerators. Concerning the latter, we note that the junction coolers typically work against electron-phonon coupling of metallic films on a substrate and we demonstrate a novel alternative method, not relying on such coupling, for engineering the coupling to the thermal phonon bath. This is one of our main results and it provides new insights on how to control electron and phonon heat/energy flux in solid-state devices.

References:
[1] J. Muhonen, M. Meschke, J. Pekola, Rep. Progr. Phys. 75, 046501 (2012).
[2] D. Gunnarsson, J. S. Richardson-Bullock, M. J. Prest, H. Q. Nguyen, A. V. Timofeev, V. A. Shah, T. E. Whall, E. H. C. Parker, D. R. Leadley, M. Myronov and M. Prunnila, Sci. Rep. 5, 17398 (2015).

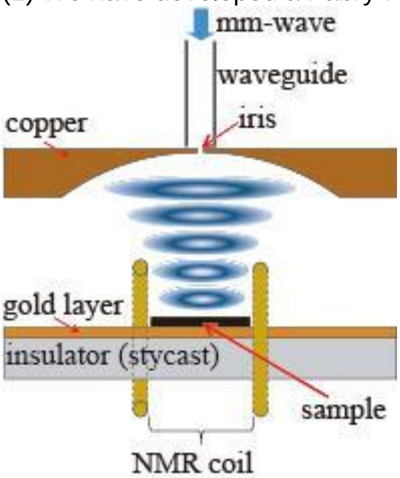
Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.823
Development of mm-wave ESR/NMR double magnetic resonance system for measurements at very low temperatures
Ishikawa Y.[1], Ohya K.[2], Miura S.[1], Fujii Y.[2], Mitsudo S.[2], Mizusaki T.[2], Fukuda A.[3], Matsubara A.[4], Kikuchi H.[1], Asano T.[1], Yamamori H.[5], Lee S.[6], Vasiliev S.[7]
[1]University of Fukui, Department of Applied Physics, Fukui, Japan, [2]University of Fukui, Research Center for Development of Far-Infrared Region, Fukui, Japan, [3]Hyogo College of Medicine, Department of Physics, Nishinomiya, Japan, [4]Kyoto University, Kyoto, Japan, [5]University of Fukui, Technical Division, School of Eng., Fukui, Japan, [6]Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Korea, Republic of, [7]University of Turku, Department of Physics and Astronomy, Turku, Finland

ESR/NMR double magnetic resonance (DoMR) techniques such as ENDOR and dynamic nuclear polarization (DNP)-NMR have been powerful methods to study electron-nuclear coupled spin systems. The DoMR measurement system is required to satisfy resonance conditions for spins with different gyromagnetic ratios by orders.

One of the fascinating systems to study by DoMR is lightly phosphorous-doped silicon (Si:P) since a quantum computer design using Si:P proposed by B. Kane [1] has been attracting much interest. We have been studying on Si:P by mm-wave ESR and DoMR in the temperature range down to 1.5 K [2,3] In this paper, we will report about development of DoMR system using a $^{3}He/^{4}He$ dilution refrigerator to reach below 1 K:

(1) We have developed a Fabry-Pérot type resonator for DoMR with flat mirror made of thin gold layer.



[A resonator for double magnetic resonance]

NMR test measurement was successful.

(2) Test measurements of ESR around 127 GHz using $Mn_xMg_{1-x}O$ ($x = 10^{-4}$) and organic radical DPPH have been performed down to 50 mK.

(3) By ESR on Si:P at 0.2 K, we have observed ^{31}P nuclear polarization up to approximately 50% enhanced by DNP effect.

(4) We have performed ESR measurements of a quasi-one dimensional spin system $Cu(C_4H_4N_2)(NO_3)_2$ [4] as a possible temperature standard of ESR.

References:

[1] B. E. Kane, Nature **133**, 393 (1998).
[2] M. Song *et al*., J. Phys.: Condens. Matter **22**, 206001 (2010).
[3] Y. Fujii *et al*., J. Phys.: Conf. Ser. **568**, 042005 (2014).
[4] A. A. Validov *et al*.: J. Phys.: Condens. Matter **26**, 026003 (2014).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.824

^{31}P NMR study of a quantum spin system CuP_2O_6 with two-dimensional planes and one-dimensional chains

Yamada H.[1], *Kobayashi Y.*[1], *Shimizu Y.*[1], *Itoh M.*[1], *Ranjith K.M.*[2], *Nath R.*[2]
[1]Nagoya University, Nagoya, Japan, [2]Indian Institute of Science Education and Research, Thiruvananthapuram, India

A low-dimensional quantum spin system CuP_2O_6 which undergoes an antiferromagnetic (AFM) transition at T_N= 8 K has two-dimensional (2D) spin square planes composed of $Cu(1)O_4$ plaquettes and on-dimensional (1D) spin chains composed of $Cu(2)O_4$ plaquettes. The 2D planes and the 1D chains are alternately stacked via the $P(1)O_4$ and $P(2)O_4$ tetrahedron along the a-axis direction. From

the analysis of magnetic susceptibility, the AFM exchange couplings are estimated as J_{2D}~40 K and J_{1D}~3 K much larger than the couplings between Cu(1) and Cu(2) [1]. However, local magnetic properties of CuP_2O_6 have not been clarified, although no magnetic order is proposed to take place in the 1D chain. In this study, we have made ^{31}P NMR experiments on a polycrystalline sample to investigate local magnetic properties of CuP_2O_6. We measured the ^{31}P Knight shift and the nuclear spin-lattice relaxation rate $1/T_1$ for the P(1) and P(2) sites located near the Cu(1) and Cu(2) sites, respectively. We found that both P sites monitor the magnetic properties of Cu(1) in the 2D square planer. Based on the analysis of the ^{31}P Knight shifts with a broad peak due to the short-range AFM order, we discuss local magnetic properties of the Cu spins on the 2D and 1D lattices.

References:

[1] R. Nath et al., Phys. Rev. B **89**, 014407 (2014).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.825

Noise, coherence, and relaxation of tunneling two level systems within the standard tunneling and the two-TLS models

Schechter M.
Ben Gurion University of the Negev, Physics, Beer Sheva, Israel

The coupling of tunneling two-level systems (TLSs) to devices such as superconducting microwave resonators, single electron transistors, nanomechanical resonators, and superconducting qubits is deleterious from the point of view of coherent operation. At the same time, it opens up novel possibilities to study individual and ensembles of TLSs against various models describing their characteristics. In this talk I will discuss recent studies of individual TLS dynamics as function of varying bias energy as studied by their coupling to a phase qubit, as well as the noise and nonlinear response of an ensemble of TLSs coupled to superconducting microresonators. Theoretical analysis within the standard tunneling model and within a recently proposed two-TLS model will be described. The latter model suggests the generic existence of two types of TLSs, differing by their extent of deviation from symmetry under local inversion and consequently by their coupling strength to the strain. It provides an explanation for the universality of the acoustic properties in strongly disordered solids at low temperatures, as well as an explanation to recent experimental data on TLS dynamics and nonlinear response, some of which can not be satisfactorily explained by the standard tunneling model.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.826

Splitting of energy gap in superfluid neutron matter with anisotropic spin-triplet pairing in strong magnetic field

Tarasov A.N.
Institute for Theoretical Physics, NSC 'Kharkov Institute of Physics and Technology', Kharkov, Ukraine

The previously derived (in the framework of generalized non-relativistic Fermi-liquid approach) nonlinear integral equations for the components of the order parameter (OP) of dense superfluid neutron matter (SNM) with anisotropic spin-triplet p-wave pairing (similar to ^{3}He-A) and with taking into account the effects of magnetic field and finite temperatures are reduced to the equations for the two components of OP in the limit of zero temperature. Here these equations are specified and solved numerically for the generalized BSk21 parametrization of the effective Skyrme interaction (with additional terms dependent on density *n*) in neutron matter. As the main result the splitting (slightly nonlinear due to the effect of strong magnetic field *H*) of the energy gap (in the energy spectrum of neutrons in SNM) is calculated as nonlinear function of density *n* in the limiting case of zero temperature. A small asymmetry (nonlinearly growing with magnetic field) of the energy gap splitting is also obtained in the range of strong magnetic fields 10^{16}G < *H* < 10^{17}G. Phase transitions in neutron matter to superfluid states of such type and so strong magnetic fields might occur at subnuclear and supranuclear densities in liquid outer core of magnetars (strongly magnetized neutron stars).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.827

Evolution of the field-induced superconductor-insulator transition in critically disordered titanium nitride films

Kronfeldner K.[1]*, Baturina T.*[2]*, Strunk C.*[1]

[1]University of Regensburg, Institute for Experimental and Applied Physics, Regensburg, Germany, [2]A. V. Rzhanov Institute of Semiconductor Physics SB RAS, Novosibirsk, Russian Federation

We measured magnetoresistance isotherms $R(T,B)$ of TiN-films in the vicinity of the disorder-tuned superconductor-insulator transition (D-SIT) for different degrees of disorder.
While the films are superconducting at zero magnetic field, at finite fields a field-induced SIT occurs. We find that the separatrix $B^*(T)$ between regions with $\partial R/\partial T > 0$ (superconducting) and $\partial R/\partial T < 0$ (insulating) behaves strongly non-monotonic, and identify three local extrema in $B^*(T)$, each corresponding to a crossing point $R_c(B_c)$ of magnetoresistance isotherms in a certain temperature regime.
We follow the variation of the critical parameters B_c, R_c and the critical exponent $z\nu$ [1] as a function of disorder. For the crossing point at medium temperatures we find $B_c \rightarrow 0$ at the D-SIT, while $R_c \approx h/4e^2$ and $z\nu \approx 1.2$ with z =1 are universal and independent of the level of disorder. For the crossing points at high and low temperatures, non-universal values for R_c and $z\nu$ are found.
We conclude that the crossing point at medium temperatures can be associated with a SIT in a disordered 2D system with long-ranged Coulomb interactions [1], while the crossing points at high and low temperatures are not related to a quantum phase transition.

References:

[1] M. Fisher, Phys. Rev. Lett. **65,** 923-926 (1990)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.828

Quantum oscillations from Andreev bound states: a toy model

Sharma P.[1], *Ramakrishnan T.V.*[1,2]
[1]Indian Institute of Science, Physics, Bangalore, India, [2]Banaras Hindu University, Varanasi, India

There is a wide range of views on the origin of quantum oscillations in the magnetic-field induced resistive state of high temperature superconductors, that range from the quantization of electronic orbits in the presence of a magnetic field to the segmented development of the Fermi surface in this state. In this work, we present a new mechanism for quantum oscillations that involves the formation of Andreev bound states (ABS) at order parameter(OP) discontinuities that coincide with truncation points of the Fermi surface. We present a toy model for the Fermi surface and OP structure and calculate the ABS spectrum that arises at such discontinuities from the magnetic-field induced modification of quasiclassical quasiparticle trajectories that cross these points. The well-known $\propto\sqrt{H}$ dependence of the DOS is recovered in the quasiclassical limit. This mechanism proposes to explain quantum oscillations via an extremely simple picture involving only ABS and a quasiparticle condensate with non-zero circulation, in a way not considered before. The formation of ABS in this case is unconventionally unique as there is no physical discontinuity (surface or interface) in real space and these are formed merely by discontinuities in momentum space introduced by OP structure.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.830

Quadratic characteristics of environment induced voltage shot noise in Josephson junctions

Wang J.-Y., Chung T.-H., Lee T.-H., Chen C.-D.
Academia Sinica, Institute of Physics, Taipei, Taiwan, Republic of China

The shot noise is originated from the granularity of the particles. However, in tunneling devices with negligible level spacing, the noise in tunneling current induced by particle-environment interaction is classified as thermal rather than shot noise. We argue that for systems with the level spacing much greater than the thermal energy, the particle interacting with environment can induce a new class of shot noise.
Here, we consider phase particle tunneling induced shot noise in Josephson junctions. Specifically, these phase particles tunnel between neighboring washboard potential valleys in which the energy level separation is defined by the Josephson plasma frequency, and the shot noise would reveal in the measured voltage noise.
We investigate theoretically and experimentally the environment-induced voltage shot noise in current biased Josephson junctions. A universal form of the zero-frequency noise spectrum is obtained, which exhibits a quadratic dependence on the mean voltage in small bias region. The quadratic dependence is verified experimentally on junctions covering a wide range of parameters, and is found also in junction arrays of various array sizes.

References:

1. Schön, G. Quantum shot noise in tunnel junctions. *Phys. Rev.* B **32**, 4469 (1985).
2. Koch, R. H., Van Harlingen, D. J. & Clarke, J. Measurements of quantum noise in resistively shunted Josephson junctions. Phys. Rev. B 26, 74 (1982).
3. Žonda, M., Belzig, W. & Novotný, T. Voltage noise, multiple phase-slips, and switching rates in moderately damped Josephson junctions. *Phys. Rev. B* **91**, 134305 (2015).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.831
Scattering of phonons in argon-palladium and methane-palladium nanocomposites
Nikonkov R., Stachowiak P., Jeżowski A.
Institute of Low Temperatures and Structure Research, Polish Academy of Sciences, Wrocław, Poland

The thermal conductivity coefficient *κ* dependence on temperature *T* of argon-palladium and methane-palladium nanocomposites has been determined experimentally in the temperature range 2 - 35K. The investigated samples were on-site prepared of simple van der Waals crystalline matrix (argon or methane) in structure of which the particles of palladium nanopowders were embedded. The used nanopowders consisted of palladium spheres of nanometer size featuring low dispersion of their dimensions. In the experiment the nanoparticles of diameter from the range 6 - 24nm were utilized and the volume fraction of palladium did not depend on the particle diameter amounting to 15% of the sample volume. For both crystalline matrices all the investigated nanocomposites showed the thermal conductivity lower than the pure crystals themselves. The difference of the thermal conductivities is best seen at the lowest investigated temperatures and in the vicinity of the maximum of the *κ*(*T*) dependence. While in the lowest temperature region the additional (when comparing to the matrix) scattering has a Reighley-type character, at higher temperatures the scattering shows more complex nature. For the analysis of the data obtained in the experiment the relaxation time approximation has been used.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.832
Normal and superconducting phase diagram of oxygen-implanted aluminum thin films
ElMassalami M., Sant'Anna M., Sinnecker E.
Institute of Physics, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil

Based on analysis of thermal events occurring in the magnetoresistivity of oxygen-implanted Al thin film, we constructed a normal-state and superconducting *T*-*x* phase diagram (*x* is a control parameter) [1]. In remarkable similarity with Al granular films [2], this phase diagram exhibits an enhancement of superconducting transition T_c(x), a negative curvature resistivity with a maximum at T_{NCR}(x), and a Kondo behavior with a minimum at T_K^{min}(x) [3]. Analysis of thermal and temporal evolution of kinetics of defects allows us to relate the enhancement of T_c(x) to an induced lattice softening, T_K^{min}(x) to an induced color-centre-type magnetic moment, and T_{NCR}(x) to kinetics of impurity-stabilized electric charges and defects. Applying the same analysis to other ion-irradiated films, one obtains similar phase diagrams [2-4]. In all these diagrams, one identifies two relaxation processes, depending on whether the projectiles are chemically inert or active: a fast process involving conventional recovery stages and a slower Cabrera-Mott-type multi-step process involving charges transfer and creation of stabilized vacancies and charged defects. The latter dictates the boundaries of the phase diagrams and is behind the slow (in weeks) thermally-activated relaxation processes.
References:

[1] E. Sinnecker, M. Sant´Anna, and M. ElMassalami, PRB 95, 054515 (2017).
[2] B. Abeles et al., Adv. Phys. 24, 407 (1975); G. Deutscher, in Superconductivity, (Springer, Berlin, 2008).
[3] N. Bachar, *et al.*, PRB 91, 041123 (2015); N. Bachar, *et al*., PRB 87, 214512 (2013); U. S. Pracht, *et al.*, PRB 93, 100503 (2016).
[4] A. Lamoise *et al*., J. Phys. Lett. 36, 271 (1975); A. Lamoise, *et al.*, ibid. 37, 287 (1976); F. Meunier, *et al.*, ibid. 38, 435 (1977).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.833
In-plane anisotropies of electronic and magnetic properties in nematic ordered phase of iron-based superconductors

Toyoda M., Kobayashi Y., Itho M.
Nagoya University, Physics, Nagoya, Japan

To investigate the orbital contribution to electronic and magnetic properties of iron-based superconductors, we have measured the ^{75}As NMR spectra for Ba($Fe_{1-x}Co_x$)$_2$As$_2$, NaFeAs, and LiFeAs. The in-plane anisotropy of the electric field gradient (EFG) observed in the NMR spectra demonstrate the appearance of the local orbital (nematic) order even above the orbital ordering temperature T_s. Moreover, we have measured the in-plane anisotropies of the ^{75}As nuclear spin-lattice relaxation rate $1/T_1$ for NaFeAs which shows the orbital (nematic) order at T_s~53K and the antiferromagnetic (AFM) order at T_N~42 K. We found that the in-plane anisotropy of $1/T_1$, $|(1/T_1)_a-(1/T_1)_b|$, appears just below T_s and gradually increases with decreasing T in the T range from T_s to T^*~48 K, where the in-plane anisotropy of the EFG also grows, in the orbital (nematic) ordered phase ($T_N< T< T_s$). Below T^*, the in-plane anisotropy of $1/T_1$ becomes T-independent, whereas the average value of the in-plane $1/T_1$'s increases toward T_N, showing that the antiferromagnetic fluctuation develops toward T_N. The in-plane anisotropy of the magnetic fluctuations seems to correlate with the in-plane anisotropy of the local crystal structure via the difference in orbital occupation.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.834
Stiffening of the gapped helium insulator

Makiuchi T., Tagai M., Nago Y., Shirahama K.
Keio University, Department of Physics, Yokohama, Japan

Quantum ground states with disorder are of great interests in both bosonic and fermionic systems. ^{4}He film adsorbed in porous Vycor glass exhibits a gapped Bose “insulating” phase below the critical coverage for the onset of superfluidity [1]. It is contrary to the theoretical prediction of a gapless Bose glass [2]. Our previous torsional oscillator (TO) studies implied a coverage-dependent stiffening phenomenon in the insulating state in porous Gelsil glass [3]. Here we report a new direct measurement of elastic property of ^{4}He and ^{3}He films. Our new TO consists of a torsion rod containing

a Gelsil and a dummy bob. This TO enables to directly measure the stiffness of the adsorbed films. We have observed that the shear moduli of both ^{4}He and ^{3}He films stiffen as temperature is lowered. By fitting the TO frequency and dissipation assuming Debye like relaxation with a distribution in energy gap, we obtain a coverage-dependent energy gap with much better reliability than previous heat capacity studies [1]. Our results indicate that the existence of gapped insulating phase and its stiffening behavior are universal characteristics of helium film on disordered substrate. We will discuss intriguing possibility that the gapped helium “insulator” is a sort of Mott glass [4].

References:
[1] R. H. Tait, and J. D. Reppy, PRB **20**, 997 (1979); P. A. Crowell, F. W. Van Keuls, and J. D. Reppy, PRB **55**, 12620 (1997)
[2] M. P. A. Fisher *et al.*, PRB **40**, 546 (1989)
[3] K. Shirahama *et al.*, O1.3, QFS2016 (not published)
[4] T. Giamarchi, P. Le Doussal, and E. Orignac, PRB **64**, 245119 (2001)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.835
Acoustic cavitation in liquid ^{4}He: density measurement and bubble liftime

Grucker J., Jacquier P., Qu A., Trimeche A.
Laboratoire Kastler Brossel, ENS-PSL Research University, CNRS, UPMC-Sorbonne-Universités, Collège de France, Paris, France

Because liquid helium is a model system to study phase transitions, acoustic cavitation in liquid ^{4}He has been intensively studied both experimentally and theoretically in the late 90´s [1]. In 2010, our group introduced a quantitative multiphase interferometric imaging technique[2] for measuring the density of a medium inside a sound wave with cylindrical symmetry. We have used this technique to measure the cavitation density of liquid ^{4}He around 1 K aiming at verifying the results of cavitation pressure measurements[3] using the well theoretically established equation of state of liquid ^{4}He at negative pressure (see for instance [4]). To our surprise, our density result [5] converted to pressure gives a cavitation pressure of about -5 bar which does not agree with previous estimations of about -9 bar [3]. The cause of this discrepancy may lie in the presence of quantized vortices which may affect either the equation of state or the validity of the pressure measurement. On the side of this metastability density measurement, we have measured that the lifetime of the collapsing bubble undergoes a dramatic transition while the liquid crosses the lambda transition[6]. This is due to different heat transport mechanisms in the normal and superfluid state.

References:
[1] F. Caupin et al., Physica B 329-333, **356** (2003)
[2] F. Souris, et al,, Europhys. Lett. **95**, 66001 (2011)
[3] F. Caupin et al., Phys. Rev. B **64**, 064507 (2001)
[4] G. H. Bauer et al., Phys. Rev. B **61**, 9055 (2000)
[5] A. Qu et al., Phys. Rev. B **91**, 214115 (2015)
[6] A. Qu et al., Phys. Rev. B **93**, 174521 (2016)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.836

Computation of magnetic losses in *REBCO* Coated Conductors

Gambardella U.[1,2], *Iannone G.*[2], *De Marzi G.*[3]
[1]CNR-SPIN UO Salerno, Fisciano, Italy, [2]INFN - Napoli, Fisciano, Italy, [3]ENEA Frascati, Frascati, Italy

We have investigated the magnetic losses of different 2G commercial REBCO Coated-Conductor (CCs) tapes as a function of ramp rate, in the low frequency range ~1-10 mHz, at 5 K and 77 K. The study is performed in perpendicular magnetic field orientation and well above the penetration field. A FEM model with H-formulation has also been implemented, in which the frequency dependence of the hysteresis loss is taken into account by the power-law E(J) characteristic for the electric field and a J_c(B) for the measured critical current dependence on the applied field. The frequency dependent magnetic loss has been analyzed by means of a power law: Q_{loss} is proportional to dB/dt, reduced to a characteristic ramp rate dB_0/dt, raised to a power *v,* which is a parameter related to the *n*-index measured in I-V transport measurements. We found that the in-field hysteresis losses increase with increasing frequencies in all the investigated HTS tapes, with a similar behavior. The numerical findings are in excellent agreement with experimental data in the frequency range considered. These results can provide a useful tool for the assessment of the hysteresis losses, also at higher ramp rate values, in fusion and accelerator HTS based magnets.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.837

Metal-insulator transition in a transition metal dichalcogenide: dependence on metal contacts

Shimazu Y., *Arai K.*, *Iwabuchi T.*
Yokohama National University, Yokohama, Japan

Transition metal dichalcogenides are promising layered materials for realizing novel nanoelectronic and nano-optoelectronic devices. Molybdenum disulfide (MoS_2), a typical transition metal dichalcogenide, has been extensively investigated due to the presence of a sizable band gap, which enables the use of MoS_2 as a channel material in field-effect transistors (FET). Using MoS_2, gate-voltage-tunable metal-insulator transition and superconductivity have been demonstrated previously. These interesting phenomena can be viewed as quantum phase transitions in two-dimensional systems. In this study, we observed that transport properties of thin MoS_2 flakes in a FET geometry significantly depend on metal contacts. Comparing between Ti/Au and Al contacts, the threshold voltages for FET switching and metal-insulator transition were considerably lower for the Al-contacted device. The possible origins of these observations will be discussed.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.838

Proposal for superfluid optomechanics within the nanofluidic environment

Rojas X.
Royal Holloway, University of London, Physics, Egham, United Kingdom

Important progress in optomechanics has enabled the development of extremely sensitive nano-electro-mechanical systems, which have recently reached the ultimate limits imposed by quantum mechanics theory. These quantum-limited sensors offer new opportunities for quantum information processing (e.g. quantum memory). The aim of this proposal is to exploit the unique properties of superfluid 4He at low mK temperature and the recent advances in quantum nanofluidics, to undertake a versatile programme of quantum optomechanics experiments. We will couple high quality factor superfluid acoustic resonators to high finesse superconducting microwave cavity within the nanofluidic environment. This platform offers a great flexibility in design over a wide range of parameters. Unlike classical materials, superfluid 4He is an exotic state of quantum matter showing exceptionally low dissipation at mK temperature. We expect these optomechanical systems to show extremely high sensitivity and long phonon lifetime. We will investigate the effects of an electrostrictive optomechanical coupling and the acoustic nonlinearities in superfluid 4He to explore phonon-photon interactions in a new regime. Many-body quantum effects will be studied using arrays of superfluid acoustic resonators.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.839

Zn-site substitution effect on non-Fermi liquid behavior in $PrIr_2Zn_{20}$

Onimaru T., Yamada R.J., Uenishi K., Yamane Y., Matsumoto K.T., Umeo K., Takabatake T.
Hiroshima University, Graduate School of Advanced Sciences of Matter, Higashi-Hiroshima, Japan

A family of PrT_2X_{20} (X = Al and Zn) with Pr^{3+} of $4f^2$ configuration attract much attention because they show interesting phenomena arising from the non-Kramers doublet with quadrupolar degrees of freedom [1-4]. Notably, $PrIr_2Zn_{20}$ undergoes an antiferroquadrupolar (AFQ) order at T_Q = 0.11 K and a superconducting transition at T_C = 0.05 K [1]. On cooling from 2 K to T_Q, the electrical resistivity decreases with an upward curvature. This non-Fermi liquid (NFL) behavior suggests formation of a quadrupole Kondo lattice [2,5].
In the present work, we have studied effects of Ga and Cd substitution for Zn on the NFL behavior. We observed that on cooling below 2 K, the electrical resistivity of the Ga and Cd substituted systems both decrease with upward curvatures. The temperature range of the upward curvature in the Ga substituted system shifts to higher temperatures compared with that of the pure system. On the other hand, that of the Cd substituted system shifts to lower temperatures. The results indicate that the characteristic temperature of the NFL state is increased by the Ga substitution, although it is decreased by the Cd substitution. Thereby, this NFL behavior depends on the strength of the c-f hybridization, supporting the formation of the quadrupole Kondo lattice.

References:

[1] T. Onimaru *et al*., Phys. Rev. Lett. **106**, 177001 (2011).
[2] T. Onimaru *et al*., Phys. Rev. B. **94**, 075134 (2016).
[3] A. Sakai *et al*., J. Phys. Soc. Jpn. **80**, 063701 (2011).
[4] K. Matsubayashi *et al*., Phys. Rev. Lett. **109**, 187004 (2012).
[5] A. Tsuruta and K. Miyake, J. Phys. Soc. Jpn. **84**, 114714 (2015).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.842
Field-induced multiple slow magnetic relaxation in [Co(dcnm)(H_2O)($phen)_2$](dcnm) complex with easy-plane anisotropy

Čižmár E.[1], *Ráczová K.*[1], *Potočňák I.*[2], *Váhovská L.*[2,3], *Bukrynov O.*[4], *Vitushkina S.*[4], *Findoráková L.*[5]
[1]P.J. Šafárik University, Institute of Physics, Košice, Slovakia, [2]P.J. Šafárik University, Institute of Chemistry, Košice, Slovakia, [3]University of Veterinary Medicine and Pharmacy, Košice, Slovakia, [4]V.N. Karazin Kharkiv National University, Faculty of Chemistry, Department of Applied Chemistry, Kharkhiv, Ukraine, [5]Slovak Academy of Sciences, Institute of Geotechnics, Košice, Slovakia

Magnetic relaxation in ionic cobalt(II) complex [Co(dcnm)(H_2O)($phen)_2$](dcnm) (dcnm = dicyanonitrosomethanide, phen = 1,10-phenantroline) was studied. The Co atom is six-coordinated in the form of a distorted octahedron by two chelate phen molecules, one O-coordinated dcnm ligand and one water molecule which is *cis*-coordinated to O atom of dcnm ligand yielding a rhombic type of anisotropy. Magnetic properties of title compound are dominated by a strong easy-plane anisotropy with energy difference between the two lowest Kramers doublets of 150 cm^{-1}. Two field-induced relaxation channels with distinct dependence on the applied field were observed by ac susceptibility study at low temperatures. Applying Arrhenius law to the temperature dependence of relaxation times yields much smaller energy barrier than expected for Orbach process in single-ion magnets. It is suggested that a direct spin-phonon relaxation is realized within the ground Kramers doublet and one of the relaxation channels is identified to be mediated by the electron-nuclear interaction [1]. The presence of the electron-nuclear interaction is evidenced from X-band EPR experiments.
(*This work was supported by APVV-14-0078 and ITMS26220120005.*)

References:
[1] S. Gómez-Coca, A. Urtizberea, E. Cremades, P.J. Alonso, A. Camón, E. Ruiz, F. Luis, Nature Commun. **5**, 4300 (2014)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.843
Kelvin-Helmholtz instability on the surface of superfluid He-II

Remizov I.A.[1,2], *Mezhov-Deglin L.P.*[1,2], *Levchenko A.A.*[1,2]
[1]Institute of Solid State Physics Russian Academy of Sciences, Chernogolovka, Russian Federation, [2]Landau Institute for Theoretical Physics of Russian Academy of Sciences, Chernogolovka, Russian Federation

We present the results of our experimental study of dynamic instability on the surface of superfluid He-II, induced by the relative motion (counterflow) of the normal and superfluid components, which arises under the action of a stationary heat flux in the volume of liquid. This instability is similar to the well-known Kelvin-Helmholtz instability, which takes place at the boundary of two ordinary immiscible liquids or dense gases moving with different velocities. The theory of the KH instability on the surface of He-II was first considered in detail by S.E.Korshunov. The results of our mesurements are

qualitatively consistent with the theoretical predictions. The work was supported by the Russian Science Foundation, Grant No. 14-22-00259.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.844

Bose-Einstein condensation of magnons in Dirac superfluid

Rysti J.[1]*, Autti S.*[1]*, Dmitriev V.*[2]*, Eltsov V.*[1]*, Mäkinen J.*[1]*, Soldatov A.*[2,3]*, Volovik G.*[1,4]*, Yudin A.*[2]
[1]Low Temperature Laboratory, Department of Applied Physics, Aalto University, Espoo, Finland, [2]P. L. Kapitza Institute for Physical Problems of RAS, Moscow, Russian Federation, [3]Moscow Institute of Physics and Technology, Dolgoprudny, Russian Federation, [4]Landau Institute for Theoretical Physics, Chernogolovka, Russian Federation

The polar phase of superfluid 3He [1] possesses a Dirac node line and belongs to the same class of topological matter as recently discovered Dirac nodal-line semimetals. In NMR experiments in the polar phase we have observed a coherently precessing spin state, which is a manifestation of BEC in the gas of magnon quasiparticles. We have previously demonstrated [2] that magnon BEC is a sensitive probe of the fermionic-quasiparticle-driven relaxation and it can be further used in the polar phase to study the Dirac fermions or various topological structures, like vortices and solitons.
In the magnon BEC, in our case a homogeneously precessing domain (HPD), we have observed phonon-like excitations, which are oscillations of magnetization on the background of coherent precession. When the magnon BEC is supported by continuous NMR pumping, the symmetry-breaking RF excitation gives rise to a gap in the phonon spectrum and thus a mass for the Goldstone mode. The phonon spectrum is controlled by the RF excitation amplitude, the orientation of the static magnetic field, and the magnon density. Spatial variation of these parameters forms an effective metric, which can be used in the future to simulate a black hole horizon.

References:

[1] V. V. Dmitriev, A. A. Senin, A. A. Soldatov, and A. N. Yudin, Phys. Rev. Lett. **115**, 165304 (2015).
[2] P. J. Heikkinen, S. Autti, V. B. Eltsov, R. P. Haley, and V. V. Zavjalov, J. Low Temp. Phys. **175**, 681 (2014).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.845

Quantum acoustics and Matrix Product States

Ask A.[1]*, L. Grimsmo A.*[2]*, Johansson G.*[1]
[1]Chalmers University of Technology, Gothenburg, Sweden, [2]Université de Sherbrooke, Sherbrooke, Canada

By forming the shunting capacitance of a Transmon qubit into an interdigitated transducer, Surface Acoustic Waves (SAW) in an open 1D SAW-waveguide has been made couple strongly to a Transmon [1]. The interdigitated nature of the coupling makes SAW coupled to a transmon an excellent candidate to study scattering in all coupling regimes: strong, ultra strong and deep strong.

However, scattering in the ultra strong coupling regime and beyond are hard to treat analytically where the rotating wave approximation no longer applies.
In this work we use Matrix Product States (MPS), based on the methods in [2], to study, numerically, the interaction of a propagating phonon with a Transmon qubit in the ultra strong coupling regime. We compare to master equation calculations where the counter rotating terms has been neglected and explore what new physics to expect. We also motivate why this regime should be in reach for current experimental efforts.
In addition, we implement a recently proposed MPS scheme [3], to simulate quantum feedback in SAW-transmon related systems, such as a giant acoustic atom [4], which allow for simulating non-Markovian systems with a wide range of propagation time delays.

References:
[1] M. Gustafsson, et. al. Science, 1245993 (2014)
[2] E. Sanchez-Brillo, et. al. Phys. Rev. Lett. 113, 263604 (2014)
[3] Hannes Pichler and Peter Zoller, Phys. Rev. Lett. 116, 093601 (2016)
[4] L. Guo, et. al. arXiv:1612.00865

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.846
Possible Tomonaga-Luttinger liquid state of ^{3}He adsorbed in 1D nanochannels
Matsushita T.[1], *Shibatsuji R.*[1], *Kurebayashi K.*[1], *Hieda M.*[2], *Wada N.*[1]
[1]Nagoya University, Department of Physics, Nagoya, Japan, [2]Tokyo Medical and Dental University, College of Liberal Arts and Sciences, Ichikawa, Japan

We have investigated the fluid state of ^{3}He adsorbed in ^{4}He-preplated nanochannels of FSM a few nm in diameter, by heat capacities and NMR. At dilute ^{3}He densities (on the order of 0.01 layers) where the ^{3}He motional states with azimuthal motion in 1D channels are not occupied at their ground states, the actual 1D fluid of ^{3}He adatoms is realized at low temperatures. The experimental 1D condition for the temperature and ^{3}He density was determined by a characteristic maximum of the heat capacity or density-independent decrease of the susceptibility. In this 1D state, density dependences of the spin relaxation times for ^{3}He were observed to be enhanced, suggesting the increase of correlation between ^{3}He atoms in the 1D state. Especially, we have observed a characteristic increase of the spin-spin relaxation time with decreasing temperature below 0.12K. Such increase was observed to be appear only in the 1D state of dilute ^{3}He, and has not been observed in the other ^{3}He system adsorbed in nanopores so far. The increase of the spin-spin relaxation time appeared to be proportional to the inverse of the temperature, which agrees with that expected for possible Tomonaga-Luttinger liquid state.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.847
Robustness of symmetry-protected topological states against time-periodic perturbations
Balabanov O.

University of Gothenburg, Department of Physics, Gothenburg, Sweden

The main feature of any topological insulator is the presence of gapless boundary states protected by relevant symmetries. In the talk I am going to discuss how the symmetry-protection extends to states subject to time-periodic perturbations. The focus will be placed on 1D chiral-symmetric topological insulators. Both types of systems, conventional time-independent and periodically-driven (Floquet), will be considered. Notably, it will be shown that boundary states in a time-independent topological insulator exhibit an enhanced robustness against time-periodic perturbations in comparison to static ones. I will argue that this is a generic property of the class of systems under consideration. A comment on the feasibility to test the results using cold atoms will also be given.

References:

[1] O. Balabanov, H. Johannesson, arXiv:1704.00782v2 (2017).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.848

^{3}He fluid states adsorbed in ^{4}He-preplated nanopores with 3D connection

Matsushita T.[1]*, Amaike K.*[1]*, Yoshimura T.*[1]*, Kuno M.*[1]*, Hieda M.*[2]*, Wada N.*[1]
[1]Nagoya University, Department of Physics, Nagoya, Japan, [2]Tokyo Medical and Dental University, College of Liberal Arts and Sciences, Ichikawa, Japan

In ^{4}He-preplated nanopores, dimensionality of adsorbed ^{3}He fluid can be changed by the pore structure in the thermal de Broglie wavelength scale, even though they remain film on the pore wall. And their interaction also can be controlled by the preplated ^{4}He film thickness. We have shown that ^{3}He adatoms in nanopores of HMM-2 with 3D connection have a variety of novel fluid states, which were investigated by heat capacities and NMR. When preplated ^{4}He is thicker than 1.8 layers, ^{3}He film shows three dimensionality, the heat capacity of 3D Boltzmann gas, and 3D density dependence of the Fermi temperature. On the other hand, when preplated ^{4}He is below 1.8 layers, dilute ^{3}He show exponentially-decreasing heat capacities at low temperatures, which suggests existence of a bound state even if underlying ^{4}He film is superfluid. Towards the bound state, decrease of the ^{3}He susceptibility from Curie´s law and characteristic decrease of the spin-spin relaxation time were also observed, which suggests that the bound state is caused by formation of quantum singlet dimers of ^{3}He pairs. When ^{3}He density increased until the energy gap is closed, heat capacities show non-Fermi liquid behavior proportional to log T, indicating the strong correlation among ^{3}He atoms in this condition.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.849

Error counting in quantum current metrology

Jenei M.[1]*, Tan K.Y.*[1]*, Tuomo T.*[2]*, Rossi A.*[3]*, Sun Y.*[2]*, Dzurak A.S.*[2]*, Möttönen M.*[1]

[1]Aalto University, QCD Labs, Department of Applied Physics, Espoo, Finland, [2]The University of New South Wales, School of Electrical Engineering and Telecommunications, Sydney, Australia, [3]University of Cambridge, Cavendish Laboratory, Cambridge, United Kingdom

Present silicon nanofabrication technology is capable of building devices that can be utilized to produce highly accurate quantized current of 160 pA with relative uncertainty below 1 ppm, specifically for applications in quantum metrology [1]. The reported pumping precisions are determined by the experimental apparatus resulting from inconveniently long averaging times of the output electric current [2]. To resolve this issue, two possibilities are identified: (I) increasing the pump frequency (thus increasing the output current) and reduce the averaging time (II) develop an integrated charge sensing system to detect errors in charge pumping scheme.
We will show our most recent progress of a novel twin Al-Al_2O_x-Al single-electron transistor charge sensor capacitively coupled to a Si MOSFET quantum dot pump. This constitute an improvement in detection sensitivity that was the limiting factor of our first generation design [3]. This new twin electrometer design is anticipated to not only improve the sensitivity of the charge detection scheme, but also eliminate correlated noise sources during sensing operation.

References:
[1] G. Yamahata, S. P. Giblin, M. Kataoka, T. Karasawa, and A. Fujiwara, Appl. Phys. Lett. **109,** 013101 (2016)
[2] B. Kaestner, and V. Kashcheyevs, Rep. Prog. Phys. **78**, 103901 (2015)
[3] T. Tanttu, A. Rossi, K. Y. Tan, K.-E. Huhtinen, K. W. Chan, M. Möttönen, and A. S. Dzurak, New J. Phys. **17**, 103030 (2015)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.851
Dynamics of half-quantized vortices in two-component Bose-Einstein condensates
Kasamatsu K.
Kindai University, Higashi-Osaka, Japan

We study dynamics of a pair of half-quantized vortices in two-component Bose-Einstein condensates. Through numerical simulations of the two-dimensional Gross-Pitaevskii equations, we study nontrivial dynamical trajectories of the vortices depending on the combinations of signs of circulations and the intercomponent density coupling. Under the adiabatic limit, we derive the equations of motion for the vortex coordinates, in which the motion is caused by the balance between Magnus force and the intervortex forces. The initial velocity of the vortex motion can be explained quantitatively by this point vortex approximation, but understanding the long-time behavior of the dynamics needs more consideration beyond the simple adiabatic model. To explain this long-time behavior, we consider the dynamics of a single half-quantized vortex when the non-vortex component has a uniform superflow.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.852

On the instability of the flux configuration in SQUID arrays

Dunstan J.W.[1], *Alfaleh I.*[1], *Khabipov M.*[2], *Porsch K.E.*[1], *Long G.*[1], *Dolata R.*[2], *Dietel J.*[2], *Zorin A.B.*[2], *Meeson P.J.*[1]
[1]Royal Holloway, University of London, Department of Physics, Egham, United Kingdom, [2]Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany

Superconducting metamaterials have possible applications in photon detection and manipulation, quantum simulation and elsewhere, but the field is in its early stages and basic developments in understanding the behaviour of even quite simple structures are still missing. In this work we experimentally probe the collective behaviour of arrays of Nb one-junction SQUIDs embedded in a superconducting coplanar waveguide resonator using the resonant frequency as a high resolution probe of the flux configuration of the array. The flux modulation curves of the array exhibit repeatable hysteretic 'jumps'. We report results of numerical modelling which show that the observed jumps are due to the SQUID-arrays assuming metastable flux (or persistent current) configurations arising from constraints due to the common phase difference in the sections of SQUID-loop shared between neighbouring SQUIDs. While individual SQUIDs can be non-hysteretic the flux configuration changes of the array can be hysteretic and are controlled through nearest-neighbour coupling, the array boundary conditions and the applied flux.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.853

Electron tunneling from multielectron bubbles

Tempere J.[1], *Klimin S.*[1], *Silvera I.*[2]
[1]Universiteit Antwerpen, Fysica, Antwerpen, Belgium, [2]Harvard University, Lyman Laboratory of Physics, Cambridge, United States

Multielectron bubbles are cavities in liquid helium, held open by the Coulomb repulsion of the electrons trapped in the cavity, which is in turn balanced by the surface tension. The electrons inside the bubble form a 2D electron liquid anchored to the inner surface of the bubble. These objects have been first observed forty years ago by Volodin, Khaikin and Edelman but their study has been hampered by stability issues. Apart from the most recent attempts using ion traps [1] or filament extraction [2], in most experiments the MEB is rapidly annihilated by nearby electrodes that drain away the charge in the bubble. In this contribution, we analyze in more detail the tunneling of electrons out of a bubble into an electrode, and derive the charge drainage rate as a function of the film thickness between the bubble and the electrode. The film thickness between a sessile bubble and an electrode is estimated from balancing the attraction of the electrons to their image charges with the Van der Waals forces between helium and the electrode. In combination, these results lead to an estimate of the lifetime of a multielectron bubble near an electrode.

References:

[1] V.Vadakkumbatt, E. Joseph, A. Pal, and A. Ghosh, Nat. Comm. 5, 4571 (2014).
[2] J. Fang, J. Tempere, I.F. Silvera, J. Low Temp. Phys. 187, 54 (2017).

Postersession 4
Tuesday, 15 August 2017

16.30-18.30
G Foyer

P.854
Emergence of a pseudo-Goldstone mode in the excitation spectrum of the helimagnetic spinel compound $ZnCr_2Se_4$

Cameron A.[1]*, Tymoshenko Y.*[1]*, Onykiienko Y.*[1]*, Portnichenko P.*[1]*, Abernathy D.*[2]*, Olliver J.*[3]*, Schneidewind A.*[4]*, Tsurkan V.*[5]*, Inosov D.*[1]
[1]Institut fuer Festkoerperphysik, Technische Universitaet Dresden, Dresden, Germany, [2]Oak Ridge National Laboratory, Oak Ridge, United States, [3]Institut Laue Langevin, Grenoble, France, [4]JCNS, Garching, Germany, [5]Augsburg University, Augsburg, Germany

$ZnCr_2Se_4$ is a magnetoelectric compound with a cubic spinel structure [1, 2]. Spinels present a strong opportunity to study the interplay between spin, charge and orbital degrees of freedom in a topologically frustrated environment. Particularly, those exhibiting magnetoelectric effects, such as $ZnCr_2Se_4$ [3], are of particular interest owing to the possibility for construction of devices with mutual magnetic and electric control, and the coupling between M and P in these materials remains a highly non-trivial issue. We present inelastic neutron scattering measurements of the magnetic excitations of $ZnCr_2Se_4$, probing a wide range of energy transfer across the whole Brillouin zone. Through comparison with spin-dynamical calculations, we find good agreement with the isotropic Heisenberg model when including interactions up to the forth nearest neighbour. Through low-energy investigation of the magnetic single-domain state, we are able to identify two separate excitations in the system: a Goldstone mode emanating from the magnetic Bragg peaks, and a soft pseudo-Goldstone mode emanating from the orthogonal wave-vectors and centred at the position of the forbidden magnetic Bragg peaks.

References:
[1] Tokura Y. et al., Adv. Mater., 22 1554 (2010).
[2] Kimura T., Ann. Rev. of Condens. Matter Phys., 3 93 (2012).
[3] Siratori K. et al., J. Phys. Soc. Jpn., 48 1111 (1980).

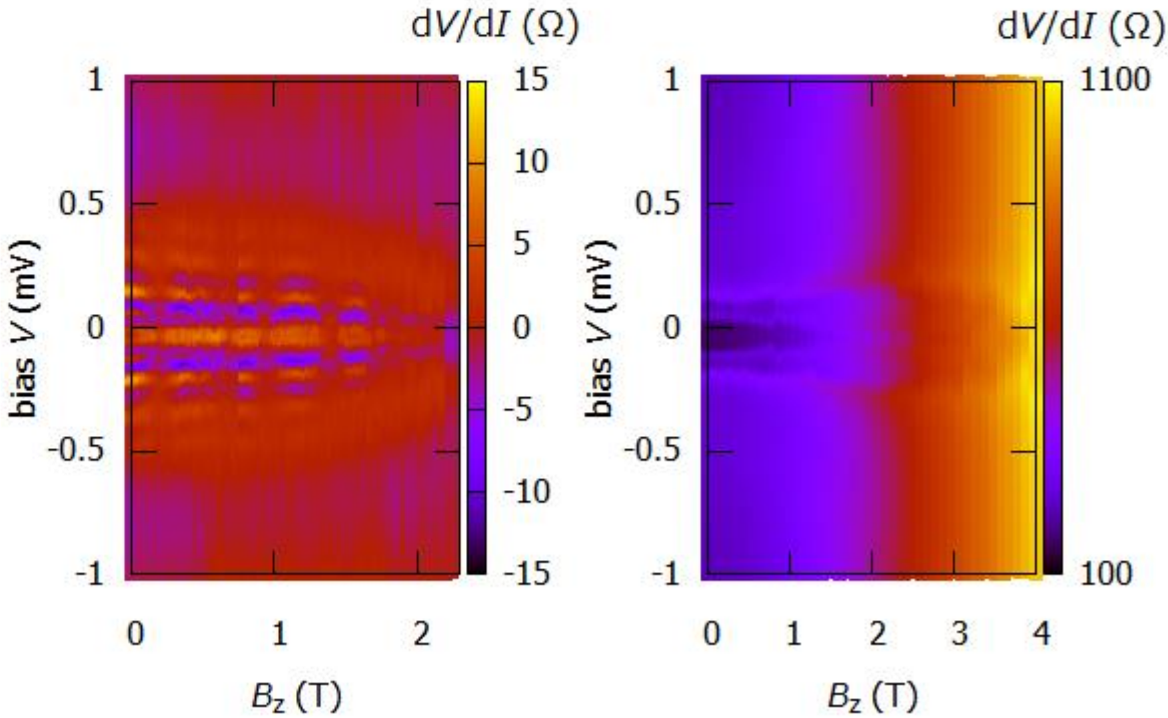
Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.855
Magnetic field dependence of Andreev reflection in two types of superconductor/2DEG/superconductor junctions

Onizaki M., Nakamura T., Hashimoto Y., Katsumoto S.
Institute for Solid State Physics, University of Tokyo, Kashiwa, Japan

The experiments on superconductor (S) - two dimensional electron gas (2DEG) - junctions under magnetic field have been facing technical difficulties of contacts or field-suppression of superconductivity. We report an experiment on 2 types of S-2DEG junctions, in which NbTi electrodes moderated magnetic field suppression of superconductivity.
We fabricated NbTi/2DEG/NbTi junction from an InAs 2DEG with inverted modulation doping (mobility and concentration of $1.03\times10^4 cm^2/Vs$ and 1.95×10^{12} cm^{-2}, respectively). The 2DEG was cut into 2 types of mesas, one was a 4×7 μm^2 rectangle and the other was a Hall bar. NbTi electrodes were deposited with 1 µm overlapping on the mesas. The samples were cooled down to 100 mK and the resistance-voltage characteristics showed multi-peak structures typical in multiple Andreev reflection. In the left panel of the Figure, the resistance peaks are emphasized with subtracting background and displayed as a color plot against the magnetic field B_z and the bias voltage V_{dc}. Aperiodic oscillation in

peak strength and positions versus Bz is observed. On the other hand, peak positions change almost monotonically in the Hall bar sample (the right panel). We infer vortex superlattice in the 2DEG forms electron energy gaps which cause repetitive peak suppression.



[peak emphasized color plot of dV/dI]

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.856

Coexistence of topological charge density waves and superconductivity in a two-dimensional topological superconductor

<u>Tanaka K.</u>[1], Nagai Y.[2], Goertzen S.L.[1], Smith E.D.B.[1]
[1]University of Saskatchewan, Department of Physics and Engineering Physics, Saskatoon, Canada,
[2]Japan Atomic Energy Agency, CCSE, Kashiwa, Japan

We perform microscopic mean-field studies of topological order in a two-dimensional *s*-wave topological superconductor with Rashba spin-orbit coupling and Zeeman field by solving the Bogoliubov-de Gennes equations. By solving for the spin-dependent Hartree potential self-consistently along with the superconducting order parameter, we show that topological charge density waves

(TCDW) can coexist with topological superconductivity (TSC) at half filling just as in a conventional *s*-wave superconductor. Furthermore, we examine the effects of nonmagnetic impurities -- which tend to create spin-polarised midgap excitations and pin the phase of charge density modulations -- on possible interplay of TCDW and TSC.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.857

Recent results from SHREK collaborations

Mukharsky Y.[1], *Collaboration S.*[2]
[1]CEA/Universite Paris-Saclay, SPEC, Gif sur Yvette, Cedex, France, [2]SHREK Collaboration, Grenoble, France

We will present recent results from SHREK collaboration. Different sensors were used to characterize the turbulence: hot wire anemometer, Pitot tubes, flexible cantilever anemometer and second-sound absorption.
Previously, hot wire anemometer data has shown a broad peak in the spectrum of flow energies, which has been interpreted as a possible sign of a bottleneck, stabilized by the tangle polarization, between Kolmogorov and Kelvin cascades [1]. Data from Pitot tube and cantilever does not support existence of this peak.
We will also present analysis of Pitot tube's data in terms of description by a Fokker-Plank equation along the lines suggested in [2,3]

References:

[1] V. S. L'vov, S. V. Nazarenko, and O. Rudenko, Phys. Rev. B **76**, 024520 (2007).
[2] R. Friedrich, J. Peinke, PRL, 78, 863 (1997).
[3] D. Nickelsen, A. Engel, PRL, 110, 214501 (2013).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.858

Resonant coupling of a multi-mode surface acoustic wave cavity to a tunable transmon qubit

Sletten L.R., Moores B.A., Viennot J.J., Lehnert K.W.
JILA, University of Colorado and NIST, Physics, Boulder, United States

A scheme coupling qubits to multiple cavity modes has been proposed as a means of creating distance-dependent qubit-qubit interactions. Despite the success of the circuit QED architecture, the dimensions required to implement an electromagnetic cavity with a narrow free spectral range are awkwardly large. In contrast, the slow propagation velocity of surface acoustic waves (several km/s) allow resonators with MHz mode spacing to be fabricated on chip, thus making them a promising means to achieve distance-dependent qubit coupling. We present results from a tunable transmon qubit coupled to a multi-mode surface acoustic resonator on GaAs. Tuning the qubit frequency through the 10 high-Q acoustic modes shows rich avoided crossing behavior where the qubit-cavity coupling exceeds the acoustic mode spacing.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.860
Apparent reversal of molecular orbitals reveals entanglement
Donarini A.[1], *Yu P.*[2,3], *Kocic N.*[2], *Repp J.*[2], *Siegert B.*[1]
[1]University of Regensburg, Institute of Theoretical Physics, Regensburg, Germany, [2]University of Regensburg, Institute of Experimental and Applied Physics, Regensburg, Germany, [3]ShanghaiTech University, School of Physical Science and Technology, Shanghai, China

The electronic structure and the transport characteristics of single molecule junctions are strongly influenced by many-body correlations. Some of their fingerprints have been theoretically predicted [1-3] others clearly observed in STM experiments [4,5] both at the spectral and topographical level.
We studied the frontier orbital sequence of individual dicyanovinyl-substituted oligothiophene molecules by means of scanning tunneling microscopy [6]. On NaCl/Cu(111) the molecules are neutral and the two lowest unoccupied molecular states are observed in the expected order of increasing energy. On NaCl/Cu(311), where the molecules are negatively charged, the sequence of two observed molecular orbitals is reversed, such that the one with one more nodal plane appears lower in energy. These experimental results, in open contradiction with a single-particle interpretation, are explained by a many-body theory predicting a strongly entangled doubly charged ground state.
References:
[1] A. Donarini, G. Begemann, and M. Grifoni Nano Lett. 9, 2897 (2009)
[2] D. Toroz, M. Rontani and S. Corni, Phys. Rev. Lett. 110, 018305 (2013)
[3] B. Siegert, A. Donarini, and M. Grifoni, Phys.Rev. B 93, 121406(R) (2016)
[4] F. Schulz, et al. Nat. Phys. 11, 229 (2015)
[5] B. W. Heinrich, L. Braun, J. I. Pascual, and K. J. Franke, Nat. Phys. 9, 765 (2013)
[6] P. Yu, N. Kocic, J. Repp, B. Siegert and A. Donarini, arXiv:1704.02282

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.862
x-T **normal and superconducting phase diagram of $Fe(Te_{1-x}X_x)_{1-y}$ (X=Se,S): influence of Fe excess and annealing condition**
S. L. Lima M., *ElMassalami M.*
Universidade Federal do Rio de Janeiro, Instituto de Física, Rio de Janeiro, Brazil

Normal and superconducting phase diagrams of titled chalcogenides depend on doping *x*, excess Fe y and annealing condition.[1-3] An increase in *x* induces a reduction in magnetism, an increase in T_c and an enhanced normal-state conductivity. However, an evolution of these *x*-dependent trends can be tuned by an optimization of both *y* and the annealing process:[2] for x>0.05, optimized annealing within a suitable gas or $y\rightarrow 0$ induce bulk SC and a crossover from a *log-in-T* into a metallic conductivity.[3]These features were usually interpreted in terms of a removal of interstitial Fe^{+} with $\sim$2.5μB.[3,4] However, ^{57}Fe Mössbauer spectroscopy on x>0 at 300K revealed only one equivalent nonmagnetic Fe^{+2} site with a textured-asymmetric doublet.[5] As an alternative interpretation, we propose that excess Fe does not occupy an interstitial site; rather chalcogens vacancies are created in the nonmagnetic $Fe_1(Te_{1-x}X_x)_{1-y}$. These together with trapped odd electrons (constituting paramagnetic color-centre-type pair breakers) leads to paramagnetism, localization and quench of SC. Optimized annealing (soaking) in specific vapor (liquid) causes a removal of vacancies by atomic diffusion and as such removal of magnetic pair-breaking centres as well as charge localization and recovers bulk SC.

References:

[1] Y. Mizuguchi and Y. Takano, JPSJ 79, 102001 (2010); K. Deguchi *et al*., STAM 13, 054303 (2012)
[2] Y. Mizuguchi *et al*., EPL 90, 57002 (2010);Y. Sun *et a*l., Sci. Rep. 6, 32290 (2016); T. Yamada *et al.*, JPSJ 85, 024712 (2016).
[3] T. J. Liu *et al*., PRB 80, 174509 (2009); S. Rossler *et al*., PRB 82, 144523 (2010);
[4] W. Bao *et al*., PRL 102, 247001 (2009); L. Zhang *et al*., PRB 79, 012506 (2009).
[5] K. Szymanski *et al.*, SST 24, 105010 (2011); T. McQueen *et al*., PRB 79, 014522 (2009).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.863

Quantum transport in nanolayers of Weyl-semimetal candidates

Karpiak B., Andersson L., Dankert A., Dash S.
Chalmers University of Technology, Microtechnology and Nanoscience, Gothenburg, Sweden

Two-dimensional (2D) transition metal dichalcogenides (TMDCs) with semimetallic characteristics such as WTe_2 and $MoTe_2$ has revived interest owing to their proposed rich physical properties[1,2], such as giant magnetoresistance, quantum spin Hall effect and Weyl states. Here we will present the temperature dependence of resistivity and magnetotransport properties of such TMDC single crystals. Our TMDC samples show metallic T_d phases by cooling the 1T' phase to lower temperatures. We measured the magnetotransport properties on devices with the nanolayers of TMDC single crystal flakes. Magnetotransport measurements at variable temperatures and angles show weak anti-localization at small magnetic field range, an evidence of strong spin−orbit coupling. Our results have important implications for further investigation of new physical phenomena for next-generation of nanoelectronic devices.

References:

[1] Mazhar N. Ali, Jun Xiong, Steven Flynn, Jing Tao, Quinn D. Gibson, Leslie M. Schoop, Tian Liang, Neel Haldolaarachchige, Max Hirschberger, N. P. Ong & R. J. Cava, Nature **514**, 205 (2014);
[2] A. A. Soluyanov, D. Gresch, Z. Wang, Q. Wu, M. Troyer, X. Dai & B. A. Bernevig, Nature **527**, 495 (2015).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.864

The ^3He NMR in detonation nanodiamonds

Alakshin E.[1], Dolgorukov G.[1], Klochkov A.[1], Kuzmin V.[1], Safiullin K.[1], Stanislavovas A.[1], Tagirov M.[1,2]
[1]Kazan Federal University, Institute of Physics, Kazan, Russian Federation, [2]Academy of Sciences of the Republic of Tatarstan, Institute of Perspective Research, Kazan, Russian Federation

In recent years nanodiamonds have become a widely investigated material for quantum engineering, biological and electronic applications. Nanodiamonds have extremely large surface area and appear to be a good model system for ^3He nuclear spin kinetics study in its restricted geometry. The spin-lattice (T_1) and spin-spin (T_2) relaxation times of ^3He were measured in adsorbed, gas and liquid phases in a detonation nanodiamond sample at the frequency range of 5 - 18 MHz and at T=1.6 K temperature. The observed T_1 values (few milliseconds) and T_2 (~0.5 ms) are much shorter in comparison with ^3He in similar experiments for samples with restricted geometry, thus we assume a strong impact of paramagnetic centers on nuclear magnetic relaxation. The T_1 is linearly dependent on the amount of ^3He in the gas phase and we observe a linear frequency dependence. The EPR studies of detonation nanodiamonds demonstrates a high paramagnetic centers concentration which are located near the nanodiamonds surface. Experiments with nanodiamond surface preplated with N_2 or ^4He layers will be presented. The model of ^3He relaxation in contact with detonation nanodiamonds that describes our experimental results will be proposed. The work was supported by the Russian Science Foundation (project 16-12-10359).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.866

Magnetic-field-induced superconducting coherence in $YBa_2Cu_3O_7/Pr_{0.5}La_{0.2}Ca_{0.3}MnO_3$ multilayers

Bernhard C.
Fribourg University, Department of Physics, Fribourg, Switzerland

We have recently observed an intriguing, magnetic-filed-induced insulator-to-metal transition in $YBa_2Cu_3O_7/Pr_{0.5}La_{0.2}Ca_{0.3}MnO_3$ (YBCO/PCMO) multilayers [1]. At low magnetic fields, the electronic response of these multilayers is highly resistive and resemables the one of a granular superconductor or a frustrated Josephson-junction network. Notably, a macroscopically coherent superconducting response is restored if a large magnetic field is applied that is also known to suppresses the charge/orbital order of the PCMO layers. This coincidence suggests that the granular superconducting state of YBCO arises from an interface effect that involves the charge/orbital order of PCMO. We discuss the evidence that the interfacial coupling induces (or strongly enhances) a static Cu-CDW order in YBCO that competes with superconductivity.

References:

[1] B.P.P. Mallett *et al.*, Phys. Rev. **B 94**, 180503(R) (2016).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.867

Coalescence of Multielectron bubbles in liquid helium

Vadakkumbatt V., Ghosh A.
Indian Institute of Science, Bangalore, India

In 1979, Volodin et al observed that the electro-hydro dynamic instability on the charged helium surface leads to the loss of the electrons from the surface in the form of bubbles. These objects which contain electrons pinned on their inner surfaces are known as Multielectron Bubbles (MEBs). The MEBs form a model system for studying electrons on curved surfaces, which are predicted to have many interesting properties. Recent experiments showed that the MEBs could be trapped using a Paul-trap and their sizes are mainly determined by the amount of the vapour present inside them. Here we report the experimental observation of the coalescence of two MEBs which were moving upward in the bulk liquid. The charge and radii of MEBs were determined before and after the coalescence. The merging of two similar charged MEBs is surprising, and this could provide a new way for tuning the number of electrons inside the MEBs.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.868

Time-reversal symmetry breaking phase and gapped surface states in d-wave nano superconductors

Nagai Y.[1,2]*, Ota Y.*[3]*, Tanaka K.*[4]

[1]Japan Atomic Energy Agency, CCSE, Kashiwa, Japan, [2]Massachusetts Institute of Technology, Department of Physics, Cambridge, United States, [3]Research Organization for Information Science and Technology (RIST), Kobe, Japan, [4]University of Saskatchewan, Department of Physics and Engineering Physics, Saskatoon, Canada

Sato et al. have shown the bulk-edge correspondence between the zero-energy Andreev bound states on [110] surfaces of a high-Tc cuprate superconductor and a topological invariant protected by time-reversal symmetry (TRS) [1]. We show that spontaneous disappearance of topological protection occurs with an alternative superconducting order parameter appearing on a surface [2]. We self-consistently solve the Bogoliubov-de Gennes equations and the d-wave gap equation in d-wave nanoislands and nanoribbons. Time-reversal symmetry is spontaneously broken at a lower temperature than the superconducting transition temperature. We find that this phase transition is of second order. This order parameter has extended s-wave symmetry and it characterizes the energy gap of the split Andreev bound states on the surfaces.

References:

[1] M. Sato, Y. Tanaka, K. Yada, and T. Yokoyama, Phys. Rev. B **83**, 224511 (2011).
[2] Y. Nagai, Y. Ota, and K. Tanaka, arXiv:1610.05501

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.870

Search for Majorana zero modes in rf-SQUIDs constructed on Bi_2Te_3 surface

Pang Y.[1]*, Shen J.*[1]*, Qu F.*[1]*, Lyu Z.*[1]*, Wang J.*[1]*, Feng J.*[1]*, Fan J.*[1]*, Liu G.*[1]*, Ji Z.*[1]*, Jing X.*[1]*, Yang C.*[1]*, Sun Q.*[2]*, Xie X.C.*[2]*, Fu L.*[3]*, Lu L.*[1]

[1]Institute of Physics, Chinese Academy of Sciences, Beijing, China, [2]International Center for Quantum Materials, Peking University, Beijing, China, [3]Massachusetts Institute of Technology, Department of Physics, Cambridge, United States

Recently, much attention has been paid to search for Majorana zero modes in solid-state systems. Among various searching proposals there is one category of experiments based on proximity-effect-induced Josephson devices and phase-sensitive detections, in which a 4π-perioded current-phase relation is expected to occur if Majorana zero modes exist. In this talk I will report the observations of fully gap-closing and the appearance of 4π-period-like but truncated current-phase relations in radio-frequency superconducting quantum interference devices (rf-SQUIDs) constructed on the surface of three-dimensional topological insulator Bi_2Te_3. The results reveal the existence of a fractional mode on the rf-SQUIDs, supporting the occurence of Majorana zero modes in these devices.

References:

1. Y. Pang, et al., arXiv:1503.00838v2.
2. Y. Pang, et al., arXiv:1603.04540v1

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.871
Real superelasticity in low temperature solid state physics

Fischer E.
GSI, Darmstadt, Germany

The well-known low temperatures anomalies of disordered materials - i.e. their significant deviations of their thermal, electrical and mechanical properties from the predictions of Debye's theory - are typically described introducing additional excitation spectra. The physical origin of these excitations and the related entirety of the various anomalies can be understood as characteristic critical effects of a topological phase transition, similar to the ideas of Kosterlitz-Thouless. Below the critical temperature of this transition (usually between 4...10 K), the material becomes superelastic. In this state any elastic deformation of the solid cannot relax via phonon emission and the deformation energy will be stored infinitely. This concept allows explaining and analysing various anomalies in thermal conductivity, specific heat, ultrasonic and dielectric properties consistently using one universal approach valid for a large range of different solids.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.872
Optical study of the anomalous phonon behavior in superconducting CaKFe4As4

Qiu X., Yang R., Qiu Z., Sui Q.
Institute of Physics, Chinese Academy of Sciences, Beijing, China

The temperature dependence of ab-plane optical conductivity of CaKFe4As4 has been measured below and above its superconducting transition temperature T c of 35.5 K. In the normal state,

analysis with the two-Drude model reveals a T-linear scattering rate for the coherent response, which suggests strong spin-fluctuation scattering. Below the superconducting transition, the optical conductivity below 120 cm −1 vanishes, indicating nodeless gap(s). The Mattis-Bardeen fitting in the superconducting state gives two gaps of 9 meV and 14 meV, in good agreement with recent angle-resolved photoemission spectroscopy (ARPES) results. In addition, around 255 cm−1, we observe two different infrared-active Fe-As modes with obvious asymmetric lineshape, originating from strong coupling between lattice vibrations and spin or charge excitations. Considering amoderate Hund's rule coupling determined from spectral weight analysis, we propose that the strong fluctuations induced by the coupling between itinerant carriers and local moments may affect the phonon mode, and the electron-phonon coupling through the spin channel is likely to play an important role in the unconventional pairing in iron-based superconductors.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.873
Domain growth dynamics in a population imbalanced binary BEC
Haneda K.[1], *Kudo K.*[2], *Kawaguchi Y.*[1]
[1]Nagoya University, Department of Applied Physics, Nagoya, Japan, [2]Ochanomizu University, Department of Information Sciences, Bunkyo-ku, Japan

When a symmetry-braking phase transition occurs, a local order appears randomly from a disordered state, and then long-range correlation develops with time. In this study, we investigate the phase separation and subsequent domain coarsening dynamics in a binary Bose-Einstein condensate (BEC) of cold atomic gases. Here, we consider a pseudo two dimensional system, in which the thickness of the system is small enough so that domain structure is uniform in the thickness direction. In the previous works [1, 2], it was shown that when populations in two components are equal, the domain size l grows in proportion to $t^{2/3}$. This growth law agrees with that of a classical binary fluid with zero viscosity [3]. In this study, we focus on the population balance dependence of the domain growth law. We prepare a two-component BEC uniformly mixed with a certain population balance, and numerically investigate the time evolution by solving the Gross-Pitaevskii equation. We find that as the population imbalance increases the exponent of the growth law changes from 2/3 to 1/3, suggesting that the atomic transport in domain structures changes from superfluid-like to diffusive. In the presentation we will also discuss the effect of the energy dissipation on the scaling law.
References:
[1] K. Kudo, and Y. Kawaguchi, Phys. Rev. A 88, 013630 (2013).
[2] J. Hofmann, S. S. Natu, and S. D. Sarma, Phys. Rev. Lett. 113, 095702 (2014).
[3] A. J. Bray, Advances in Physics, 43, 357-459 (1994).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.874
Onset of critical velocity in superfluid ^{3}He for various mechanical oscillators

Ahlstrom S.L., Bradley D.I., Guenault A.M., Guise E.A., Haley R.P., Pickett G.R., Poole M., Tsepelin V., Woods A.J., Wilcox T.
Lancaster University, Department of Physics, Lancaster, United Kingdom

We present a study of the onset of critical velocity in superfluid ^{3}He-B over a broad range of frequencies from 0.3 to 200 kHz. Below the Landau critical velocity, we expect the flow of superfluid to be dissipationless in the zero temperature limit. Previous studies using vibrating objects have shown that in superfluid ^{3}He the velocity for the onset of dissipation is about one third of the Landau critical velocity due to the flow enhancement around a moving object. We used a variety of mechanical oscillators: superconducting vibrating wires, MEMS and quartz tuning forks to measure the onset velocity at zero bar pressure and in temperatures low enough to be in the ballistic limit. We have found that some of the objects exhibit a much lower critical velocity. We contrast the measured frequency dependence of the onset of critical velocity with theoretical expectations and discuss similarities and differences.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.875

Peak effect and order-disorder transition in a conventional type-II superconductor

Toft-Petersen R.[1], Abrahamsen A.[2], Laver M.[3]
[1]Technical University of Denmark (DTU), Kongens Lyngby, Denmark, [2]Technical University of Denmark (DTU), Department of Wind Energy, Roskilde, Denmark, [3]University of Birmingham, School of Metallurgy & Materials, Birmingham, United Kingdom

In Type-II superconductors, disorder generally works to pin vortices, giving zero resistivity below a critical current j_c. However, peaks have been observed in the temperature and field dependences of j_c. This “peak effect” is difficult to explain in terms of an ordered Abrikosov lattice of vortices. We explore the widespread paradigm that an order-disorder transition of the vortex ensemble drives the peak effect. Using neutron scattering to directly probe the vortex order in superconducting vanadium, we uncover an order-disorder transition from a quasi-long-range-ordered phase (the so-called "Bragg glass") to a vortex glass. The peak effect, however, is found to lie at much higher fields and temperatures, in a region where thermal fluctuations of individual vortices are more significant.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.876

Correlation of T_c and coefficient of *quadratic-in-T* resistivity in Fe-based pnictides and chalcogenides superconductors

ElMassalami M., Castro P.
Federal University of Rio de Janeiro, Department of Solid State Physics, Institute of Physics, Rio de Janeiro, Brazil

It is empirically established that the normal-state of vast number of Fe-based pnictides [1] and chalcogenides [2] superconductors manifest a low-temperature *quadratic-in-T* resistivity, ρ_{tot}-ρ_o=AT^2, over wide ranges of temperature and pressure. It is remarkable that the *A* coefficient of most of these Fe-based systems is linearly related to ρ_o in accordance with Koshino-Taylor [3] relation. Considering the manifestation of such a Koshino-Taylor-type *quadratic-in-T* character, then it is not a trivial finding that $\ln(T_c) \propto A^{-½}$ even when a control parameter such as pressure is widely varied. Furthermore, it is not a coincidence that these systems manifest a related correlation $(1/T_c)(-\partial H_{c2}/\partial \mathrm{T})_{Tc} \propto A/n$ (*n* is charge density, H_{c2} is the upper critical field) [4]. Each of these relations establishes a common scenario for both the superconductivity and the normal-state *quadratic-in-T* contribution. We discuss possible driving mechanisms behinds such a common scenario.

References:
[1] S. J. Zhang et al., PRB 80, 014506 (2009); K. Mydeen et al., PRB 82, 014514(2010); H. Kotegawa et al., JPSJ 78, 123707 (2009); F. Rullier-Albenque et al., PRL 109, 187005 (2012); S. Kasahara et al., PRB 85, 060503 (2012).
[2] L. Sun et al., Nature 483, 67 (2012); J. J. Ying et al., NJP 13, 033008 (2011).
[3] G. D. Mahan and Z. Wang, PRB 39, 4926 (1989).
[4] V. Taufour et al., PRB 89, 220509 (2014).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.877
Steady-state generation of non-classical states of light in one-dimensional resonance fluorescence

Quijandria Diaz I.F., Strandberg I., Johansson G.
Chalmers University of Technology, Gothenburg, Sweden

Quasi-probability distributions, such as the Glauber-Sudarshan P function or the Wigner function, are a common resource to establish if a given state can be understood in terms of a classical counterpart. In this sense, we can talk about P or Wigner non-classicality. Recently, the Wigner function has been identified as a computational resource as it allows to discern which processes can be simulated efficiently with classical resources. Thus, it paves the way towards the long sought "quantum advantage". In this work, we study if the strong interaction between light and matter in an artificial one-dimensional architecture, suffices to generate the kind of states suitable for performing quantum information tasks beyond classical capabilities.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.878
Vortex lattice dynamics in high purity niobium studied with time-resolved small-angle neutron scattering

Larsen C.B.[1], Tekin E.[1], Keiderling U.[2], Toft-Petersen R.[3], Laver M.[1]

[1]University of Birmingham, School of Metallurgy and Materials, Birmingham, United Kingdom, [2]Helmholtz-Zentrum Berlin, Berlin, Germany, [3]Technical University of Denmark, Department of Physics, Lyngby, Denmark

Flux creep and other dissipative processes have a vital impact on possible technical applications of type-II superconductors. These processes are inherently dependent on the elastic properties of the vortex lattice, which presently only have been probed experimentally to a limited degree.
With the use of a time-resolved stroboscopic small-angle neutron scattering technique, we have characterized the evolution of the elastic constants of high purity niobium as a function of field, temperature and time. By applying an AC field perpendicular to the beam, we have been able to observe how the vortices are pulled away from their equilibrium positions and how they subsequently relax back into them. Despite being a conventional type-II superconductor, high purity niobium displays a rich phase diagram containing several structural transitions between square and triangular phases. Our results depict how the vortex lattice dynamics changes as the structural transitions are crossed.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.879
Density of states in a slab of ^{3}He-B

Egorov E.[1]*, Eschrig M.*[1]*, Vorontsov A.*[2]*, Sharma P.*[3]
[1]Royal Holloway University of London, Egham, United Kingdom, [2]Montana State University, Bozeman, United States, [3]Indian Institute of Science, Physics, Bangalore, India

We present calculations of the density of states(DOS) of ^{3}He quasiparticles in the B-phase confined to a slab a few tens of coherence lengths thick. There are bound states below the gap and oscillations in the DOS above the gap as expected in this geometry. The DOS is a function of the orientation of the quasiparticle trajectory with respect to the surface and we analyse the evolution of the DOS as the trajectory orientation changes. We consider nonmagnetic and spin active scattering channels within a quasiclassical framework, and present analytical as well as numerical results. These calculations probe in detail the exciation spectrum in the B-phase of confined ^{3}He and supplement earlier predictions of a nontrivial phase diagram under confinement. The results promise to be a useful reference point for recent experiments that investigate ^{3}He in a slab geometry.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.880
Elemental chalcogens as a minimal model for chiral charge and orbital order

Silva A.
University of Amsterdam, Institute for Theoretical Physics, Amsterdan, Netherlands

Helices of increased electron density can spontaneously form in materials containing multiple, interacting charge density waves. Although a macroscopic order parameter theory describing this behaviour has been proposed and experimentally tested, a detailed microscopic understanding of spiral electronic order in any particular material is still lacking. The elemental chalcogens Selenium and Tellurium are here presented as model materials for the development of chiral charge and orbital order. We formulate minimal models capturing the formation of spiral structures in terms of a macroscopic Landau theory and by constructing a microscopic Hamiltonian. The combination of microscopic and macroscopic frameworks allows us to extract key ingredients in the emergence of helical charge order, and may serve as a guide to understanding spontaneous chirality both in other specific materials and throughout materials classes.

References:

[1] Ana Silva, Jans Henke, Jasper van Wezel, arXiv:1704.00075 [cond-mat] (2017), 1704.00075
[2] J. van Wezel, EPL 96, 67011 (2011).
[3] J. Ishioka, Y. H. Liu, K. Shimatake, T. Kurosawa, K. Ichimura, Y. Toda, M. Oda, and S. Tanda, Phys. Rev. Lett. 105, 176401 (2010).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.881

Metal Insulator Transition on MoS_2 FETs

Sharma C.H., *Thalakulam M.*
IISER Thiruvananthapuram, School of Physics, Thiruvananthapuram, India

Metal Insulator Transition (MIT), an intriguing phenomena involving the interplay of electron-electron interaction and disorder, is one of the well-studied but less understood topics in condensed matter physics. Unlike on the bulk semiconductor materials, the reported MIT studies on two-dimensional layered systems focus on the variation of conductivity as a function of gate voltage and temperature whereas a complete study need to take into account electron-electron interaction and localization mechanisms in the system. Apart from this, the conductivity of 2D layered system is strongly influenced by the source and drain contacts which also depends on the gate voltage. In this work we study MIT on few-layer micro-mechanically exfoliated MoS_2 FET devices. We study the influence of gate voltage, temperature and the contact barrier on the conductance in a temperature range of 4K to 300 K. We find that the observation of MIT in these systems strongly depends on the behaviour of contacts apart from the gate voltage and the temperature. We also study the localization effects in these systems as a function temperature and carrier concentration.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.883

Josephson effect in bulk free topological insulator nanoribbons

Kunakova G.[1,2], *Galletti L.*[1], *Andzane J.*[2], *Erts D.*[2], *Bauch T.*[1], *Lombardi F.*[1]
[1]Chalmers University of Technology, Department of Microtechnology and Nanoscience, Gothenburg, Sweden, [2]University of Latvia, Institute of Chemical Physics, Riga, Latvia

Bismuth Selenide (Bi_2Se_3) is one of the most promising material in the recently discovered family of 3D chalcogenide Topological Insulators (TI). The induced superconductivity in the surface state has a topological nature and Majorana Bound State (MBS) can be formed at the interface between a superconductor and a TI. MBS can be probed in Josephson junctions with few conduction modes. Signature of the topological surface states in the transport measurement of currently existing materials is limited by the unwanted conduction of the bulk. The study of TIs at the nanoscale is a promising route to eliminate the bulk contribution and to reduce the number of conduction modes in Josephson devices. Here we present state-of-the art transport properties of TI nanoribbons of Bi_2Se_3, that within a certain range of thicknesses are *bulk-free* [1]. We have realized highly transparent interfaces between Al and thin Bi_3Se_3 nanoribbons. Josephson effect has been detected through Al nanogaps patterned on top of the nanoribbons, with high values of the Josephson current density and a clear Fraunhofer-like modulation in magnetic field. The induced superconducting gap in the nanoribbons is comparable with the Al gap signifying highly transparent interfaces.

References:

[1] J. Andzane, G. Kunakova, S. Charpentier, V. Hrkac, L. Kienle, M. Baitimirova, T. Bauch, F. Lombardi, and D. Erts, Nanoscale, **38**, 15935 (2015)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.884

Influence of shunting environment on coherent quantum phase-slips in superconducting nanowires

Fenton J.
UCL, London Centre for Nanotechnology, London, United Kingdom

In superconducting nanowires of sufficiently small-cross-section, quantum fluctuations lead to the phenomenon of coherent quantum phase-slip (CQPS) [1], in which phase coherence is replaced by coherent flux tunnelling. While several interesting consequences of the effect have been proposed [2] and/or demonstrated [3-4], close control of the CQPS properties of nanowire devices has not yet been achieved. The dimensions and resistivity of the nanowire material are known to be critical parameters for obtaining CQPS [5], but the environment in which the nanowire is situated also plays a key role [6-7], with both shunting inductive and resistive elements influencing the device properties. We report the results of measurements on niobium nitride nanowires with cross-sections as small as ~150 nm^2 in a variety of shunting environments.

References:

[1] J. Mooij, Y. Nazarov, Nature Phys. **2** 169 (2006)
[2] A. Hriscu, Y. Nazarov, Phys. Rev. B **83** 174511 (2011)
[3] T. Hongisto, A. Zorin, Phys. Rev. Lett. **108** 097001 (2012)
[4] O. Astafiev et al., Nature **484** 355 (2012)
[5] J. Fenton et al., J. Phys.: Conf. Ser. **286** 012024 (2011)
[6] J. Mooij et al., New J. Phys. **17** 033006 (2015)
[7] C. Webster et al., Phys. Rev. B **87** 144510 (2013)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.885

A novel multi-frequency lock-in technique to probe superfluid helium with quartz tuning forks

Noble M.T., Bradley D.I., Haley R.H., Kafanov S., Pickett G.R., Tsepelin V., Vonka J., Wilcox T.
Lancaster University, Physics Department, Lancaster, United Kingdom

We report on a novel new technique to measure the resonance of linear oscillators by measuring and exciting over multiple frequencies simultaneously. By using a multifrequency lock-in anlayser we can measure the resonance curve much quicker then by using a conventional single frequency lock-in amplifier technique. We use a multi-frequency lock-in amplifier and a Stanford Research Systems SR830 to measure the frequency response of two 25 µm wide tuning forks, and show that both instruments yield identical results. We further confirm this by measuring the resonant frequency and width of the forks in helium-4 from temperatures over 4.2 K to 1.5 K.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.886

Strong-coupling corrections to collective-mode frequencies in superfluid ^{3}He-B

Serene J.W., Paliotta J.A.
Georgetown University, Physics, Washington, United States

The frequencies of collective modes of the order parameter in superfluid ^{3}He-B are influenced by both molecular-field self-energies (Landau-parameter corrections) and non-trivial strong-coupling corrections (those not subsumed in the magnitude of the order parameter). The theory of the former is relatively straightforward and has been worked-out completely, but the latter, although known in principle, are technically daunting and have never been evaluated. We will report perturbative calculations of strong-coupling corrections to collective-mode frequencies in the framework of the weak-coupling-plus model of Rainer and Serene. [1]

References:

[1] J.W. Serene and D. Rainer, Phys. Rep. **101**, 221 (1983)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.888

Temperature dependent damping and frequency shift of multiple modes of a micro-electromechanical oscillator in ^{4}He

Barquist C.S.[1], Jiang W.G.[1], Zheng P.[1], Lee Y.[1], Chan H.B.[2]
[1]University of Florida, Department of Physics, Gainesville, United States, [2]Hong Kong University of Science and Technology, Department of Physics, Clear Water Bay, Hong Kong

A micro-electromechanical plate resonator suspended 2 µm above a substrate was immersed in ^{4}He at saturated vapor pressure. The temperature dependences of the damping and frequency shift of the shear mode are measured from 3.5 K to 14 mK. From these data, coefficients characterizing mass

loading and drag on the device in the laminar regime are extracted. The inertial coefficient is consistent with measurements made in superfluid ^{3}He-B [1]. Below 0.8 K two extra modes are observed and are identified as a trampoline mode and a pivot mode. In the ballistic regime, the damping arising from thermal excitations exhibits a T^4 dependence for all modes.

References:

[1] P. Zheng, P., Jiang, W.G., Barquist, C.S. et al. J. Low Temp. Phys. **187**, 309 (2017)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.889

Anomalous resonance frequency shift of a microelectromechanical oscillator in superfluid ^{3}He-B

Zheng P.[1], Jiang W.G.[2], Barquist C.S.[2], Lee Y.[2], Chan H.B.[3]
[1]University of Waterloo, West Waterloo, Canada, [2]University of Florida, Physics, Gainesville, United States, [3]Hong Kong University of Science and Technology, Physics, Hong Kong, China

A microelectromechanical oscialltor (MEMS) was immersed in superfluid ^{3}He, forming a 1.25µm-thick film. The oscillator was driven in the linear damping regime where the damping coefficient is independent of the velocity of the oscillator. The temperature and the pressure dependences of both the full-width-half-maximum (FWHM) and the resonance frequency shift are examined against those of two tuning forks. The inertial coefficient of the MEMS was measured to be ≈0.1, and was shown to be independent of pressure, which is consistent with a similar measurement in superfluid ^{4}He. For the resonance frequency shift, a peculiar onset of the hardening of the effective spring constant was observed under 9.2bar at 0.2T/Tc, and 18.2bar at 0.3T/Tc, which augments the resonance frequency beyond its intrinsic value when the temperature increases.

References:

[1] P. Zheng, W. G. Jiang, C. S. Barquist, Y. Lee, H. B. Chan, Phys. Rev. Lett. **117**, 195301 (2016).
[2] P. Zheng, W. G. Jiang, C. S. Barquist, Y. Lee, H. B. Chan, Phys. Rev. Lett. **118**, 065301 (2017).
[3] P. Zheng, W. G. Jiang, C. S. Barquist, Y. Lee, H. B. Chan, J. Low Temp. Phys. **183**, 313 (2016).
[4] A. B. Vorontsov, J. A. Sauls, Phys. Rev. Lett. **98**, 045301 (2007).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.890

Critical fields, superfluid and critical current densities of underdoped $YBa_2Cu_3O_{6+x}$ cuprates

Salas P., Solís M.A., Fortes M.
Instituto de Fisica, Universidad Nacional Autonoma de Mexico, Física Teórica, Ciudad de México, Mexico

We apply the Layered Boson-Fermion Model of Superconductivity [1] to underdoped cuprate superconductors $YBa_2Cu_3O_{6+x}$, with $x \in [0.55,0.9]$ ranging from underdoped to optimally doped, for which thermodynamic properties were previously reported [2].

Here we obtain the upper and lower critical fields of the cuprates as functions of temperature for different doping values, and present the phase diagram H_{c2} vs x for T=0, where, by comparison with

experimental results, we are able to determine the doping region where other quantum effects predominate over the influence of the layered structure.
Moreover, the coherence and penetration lengths are calculated from zero temperature to T_c, where their values at T=0 are free of extrapolations or adjusted parameters.
We also show the behavior of the critical current density J_c, the normalized superfluid density ρ_s and dB_{c1}/dT and dB_{c2}/dT for every temperature, for all the doping values of the $YBa_2Cu_3O_{6+x}$ cuprates, which we compare with available data.
We acknowledge partial support from grants PAPIIT IN107616 and CONACyT 221030, MEXICO.
References:
[1] P. Salas, M. Fortes, M. A. Sol\´is and F. J. Sevilla, Physica C {\bf 534}, 37 (2016).
[2] P. Salas, M. A. Sol\´is, M. Fortes and F. J. Sevilla, Int. J. Mod. Phys. B {\bf 30}, 1750100 (2016).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.891
Towards an on-demond tunable wideband single photon source in the microwave domain
<u>Lu Y.</u>, Bengtsson A., Suri B., Raman Sathyamoorthy S., Bylander J., Johansson G., Delsing P.
Chalmers University of Technology, MC2, Gothenburg, Sweden

A single-photon source is a key element in a rapid growing toolbox for quantum optics, quantum technolgies and applications, whcih is non-classical, can be taken as a flying qubit. In previous experiments [1,2], to obtain on-demond single photons,a resonator was required which limited the bandwidth of this photon source largely. Recently, An tunable photon source is generated [3],where a tuneable artificial atom coupled asymmetrically to two open-ended transmission lines,the control line and emission line, in which the bandwidth and photon-genration efficiency are still limited by the leakage from these two transmission lines. Here, we would like to realize the scheme proposed by Sankar[4]. In this scheme, A transmon qubit is put in front of a mirror. A single photon can be emitted after exciting the qubit by a short pulse from one port of a directional coupler. The remaining part of this coherent signal pulse reflected by the mirror can destructively interfere with another coherent pulse through a different port of the directional coupler. The numerical result [4] shows photon generation efficiency ∼ 99% is straightforward to achieve. And the bandwith of this kind of single-photon source has no limitation in principle.
References:
[1] A. A. Houck, Nature 449, 328-331 (2007)
[2]William F. Kindel,et al Phys. Rev. A 93, 033817
[3]Z.H. Peng, et al Nature Communications 7,12588 (2016)
[4]Sankar Raman Sathyamoorthy,Phys. Rev. A 93, 063823(2016)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.893
Specific heat of bosons within a periodic array of multi-cubes
<u>Solis M.A.</u>, Rodriguez-Rosenblueth C.D.

Instituto de Fisica, Universidad Nacional Autonoma de Mexico, Fisica Teorica, Ciudad de Mexico, Mexico

We report the Bose-Einstein condensation (BEC) critical temperature and the specific heat as a function of temperature, of an ideal Bose gas within a periodic array of interconnected cubes built with the sum of three mutually perpendicular Dirac comb potentials. In every cube unit, the separation between two parallel walls and their impenetrability are directly related to the distance between contiguous deltas and their strength, respectively. After finding the particle energy spectrum we calculate the Bose-Einstein critical temperature and the specific heat as a function of the temperature, for several values of impenetrability and separation of the walls. Some relevant results are: a) The BEC critical temperature continuously decreases as we increase the impenetrability of the walls; however the critical temperature curve as a function of the cube size, starting at the free ideal Bose gas critical temperature, decreases to a minimum and then returns to the initial value. b) We observe a crossover dimensional from 3D to 0D for large enough impenetrability c) A progressive nesting of the specific heat curves of the finite systems towards the infinite case has similar behavior like that observed by Pajkowski & Pathria [1] for only one cuboidal enclosure.

References:

[1] H.R. Pajkowski and R. K. Pathria, J. Phys. **A:** Math. Gen., Vol. 10, No. **4, (**1977).

We acknowledge partial support from grants PAPIIT IN107616 and CONACyT 221030.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.894

Boosting the BEC critical temperature of Bose gases within imperfect periodic structures

Martinez-Herrera J.G.[1], Garcia-Nila J.[1], Fortes M.[2], Salas P.[2], Rodriguez-Lopez O.A.[1], Solis M.A.[2]
[1]Posgrado en Ciencias Fisicas, Universidad Nacional Aut, Fisica Teorica, Instituto de Fisica, Ciudad de Mexico, Mexico, [2]Instituto de Física, Universidad Nacional Autonoma de México, Física Teorica, Ciudad de Mexico, Mexico

An Ideal Bose gas confined within a infinite box with periodic permeable structure (multilayers, multitubes or multicubes) [1], always shows a BEC critical temperature lower than that of an infinite homogeneous free ideal Bose gas. Here we show that when we introduce a plane vacancy in each of the above mentioned periodic structures, a finite gap emerges between the ground and first excited states in the particle energy spectrum, boosting the BEC critical temperature and inducing a jump in the isochoric specific heat, of the confined Bose gas.
Our expectation is that imperfections, like vacancies, could lead to an increase of the critical temperature of superfluids within imperfect periodic structures.

We acknowledge partial support from grants PAPIIT IN107616 and CONACyT 221030.

References:

[1] P. Salas, et al., PRA **82**, 033632 (2010); O.A. Rodriguez, et al., J. Low Temp. Phys. **183**, 144 (2016); V.E. Barragan, et al., Int. J. Mod. Phys. B **30,** 1650099 (2016).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.896

Electric field effect and thermally activated transport in misfit layer compound $(LaS)_{1.20}CrS_2$

Shimazu Y.[1], *Takanashi M.*[2], *Kurihara D.*[2], *Fujisawa Y.*[2], *Arai K.*[1], *Iwabuchi T.*[1], *Suzuki K.*[2]
[1]Yokohama National University, Department of Physics, Yokohama, Japan, [2]Yokohama National University, Department of Advanced Materials Chemistry, Yokohama, Japan

Misfit layer compounds are layered materials typically described as $(MX)_nTX_2$ (M= Sn, Pb, Bi, rare earth metals; T=Nb, Ta, Ti, V, Cr; X=S, Se), in which MX and TX_2 (transition-metal dichalcogenide) layered sublattices are incommensurately modulated.[1,2] Various transport properties have been observed in a wide variety of misfit layer compounds. By mechanical exfoliation, novel two-dimensional systems can be obtained from these materials. In this work, we studied a semiconducting misfit layer compound $(LaS)_{1.20}CrS_2$. In absence of intervening LaS layers, a CrS_2 layer does not exist in a stable state. Single crystals of $(LaS)_{1.20}CrS_2$ were synthesized by chemical vapor transport. Subsequently, we fabricated back-gated FET devices using thin (~10 nm) flakes obtained with mechanical exfoliation. The devices exhibited n-type transfer characteristics with an on-off ratio of ~3000 (at 120 K). The temperature dependence of the conductance showed thermally activated behavior for all the values of gate voltage V_g that were used. The activation energy decreased nearly linearly with increasing V_g. This result is analyzed in terms of the trap capacitance and the density of trap states, and compared with that for MoS_2 thin flakes.

References:

[1] G. A. Wiegers et al, J. Alloy. and Compd. **178**, 351-368 (1992).
[2] J. Rouxel et al, J. Alloy. and Compd. **229**, 144-157 (1995).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.897

Higgs mode in a trapped superfluid Fermi gas

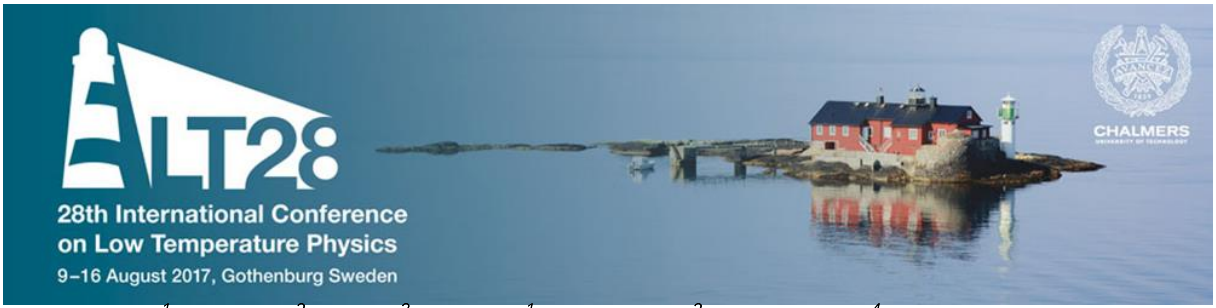
Tokimoto J.[1], *Tsuchiya S.*[2], *Nikuni T.*[1]
[1]Tokyo University of Science, Tokyo, Japan, [2]Chuo University, Tokyo, Japan

In quantum many-body systems with spontaneous breaking of a contin- uous symmetry, Higgs modes emerge as collective amplitude oscillations of order parameters. Recently, Higgs modes have been observed in superconductors and in Bose gases in optical lattices. However, it has yet to be observed in Fermi gases. In this study, we use the time-dependent Bogoliubov-de Gennes equations to investigate Higgs amplitude oscillations of the superfluid order parameter in a trapped Fermi gas induced by a sudden changes of the s-wave scattering length. In particular, we investigate the Higgs mode with different values of the initial scattering length and discuss how the frequency and damping of the Higgs mode changes around the unitarity regime.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.898

A continuous dry 300 mK cooler: design, construction and performance



Klemencic G.[1], Chase S.[2], Ade P.[3], Giblin S.[1], Sudiwala R.[3], Woodcraft A.[4]
[1]Cardiff, Physics and Astronomy, Cardiff, United Kingdom, [2]Chase Cryogenic Research, Sheffield, United Kingdom, [3]Cardiff University, Cardiff, United Kingdom, [4]QMC Instruments, Cardiff, United Kingdom

We describe and demonstrate the automated operation of a novel cryostat design that is capable of maintaining an unloaded base temperature of less than 300 mK continuously[1], without the need to recycle the gases within the final cold head as is the case for conventional sorb pumped 3He cooling systems. This closed, automated, dry system uses only 5 litres of 3He gas, making this an economical alternative to traditional systems where a long hold time is required. During testing, a temperature of 365 mK was maintained with a constant 20 W load, simulating the cooling requirement of a far infrared camera.

References:

[1] Review of Scientific Instruments 87, 045107 (2016); doi: 10.1063/1.4945691

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.899

Low temperature ESR measurements of copper pyrazine dinitrate: a possible temperature sensor from ESR spectrum

Fujii Y.[1], Ishikawa Y.[2], Asano T.[2], Miura S.[2], Ohya K.[1], Koizumi Y.[1], Mitsudo S.[1], Kikuchi H.[2], Fukuda A.[3], Matsubara A.[4]
[1]University of Fukui, Research Center for Development of Far-Infrared Region, Fukui, Japan, [2]University of Fukui, Department of Applied Physics, Fukui, Japan, [3]Hyogo College of Medicine, Department of Physics, Nishinomiya, Japan, [4]Kyoto University, Graduate School of Science, Kyoto, Japan

Copper pyrazine dinitrate, $Cu(C_4H_4N_2)(NO_3)_2$ (CuPzN for short), has been studied intensively because of its nature of a typical one-dimensional (1D) Heisenberg quantum spin system [1-4]. The main exchange coupling along the chain has been estimated to be 10.3 K. Muon-spin-relaxation experiment detected 3D ordering at 0.107 K [3]. From X-band ESR measurements of a single crystal of CuPzN, a rapid increase of a split of the ESR spectrum was predicted below 5 K down to 1.5 K [4].
We have investigated a single crystal of CuPzN by ESR at 128.9 GHz in the temperature range from 6.6 K down to 0.1 K with a ^{3}He-^{4}He dilution refrigerator [5] under the field applied along the direction between *b* and *c* axes. We observed the split of ESR spectrum in the whole temperature region, in agreement with ref. 4 which reported spectra measured at 1.4 K. Further, we found that the split width increased continuously with decreasing temperature down to approximately 1 K and became nearly constant below 1 K.
In general, the irradiation of microwave for ESR causes heating of the sample at very low temperatures. Therefore, it must be useful to know the real temperature from ESR spectrum. Our results suggest that ESR spectrum of CuPzN can work as a temperature sensor down to 1 K.

References:

[1] M. Koyama *et al*.: J. Phys. Soc. Jpn. **40**, 1564 (1976)
[2] M. Jeong and H. M. Rønnow: Phys. Rev. B **92**, 180409 (2015) and references therein.
[3] T. Lancaster *et al*.: Phys. Rev. B **73**, 020410 (2006)
[4] A. A. Validov *et al*.: J. Phys.: Condens. Matter **26**, 026003 (2014)
[5] Y. Ishikawa, K. Ohya *et al*.: Poster presentation of this conference (Development of mm-wave ESR/NMR double magnetic resonance system for measurements at very low temperatures)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.900
Low temperature properties and quantum criticality of $CrAs_{1-x}P_x$ single crystal

Luo J.
Institute of Physics, Chinese Academy of Sciences, Beijing, China

The discovery of superconductivity in CrAs and MnP has attracted considerable attention in studying the Cr- and Mn-based pnictides. Here, we report a systematically study of resistivity and specific heat on phosphorus doped $CrAs_{1-x}P_x$ single crystals with x=0 to 0.2. With the increasing of phosphorus doping concentration x, the magnetic and structural transition temperature T_N is suppressed. Non-fermi liquid behavior and quantum criticality phenomenon are observed from low temperature resistivity around critical doping with x_c ~ 0.05 where the long-range antiferromagnetic ordering is completely suppressed. The low temperature specific heat of $CrAs_{1-x}P_x$ is contributed by the thermal excitation of phonons and electrons. The electronic specific heat coefficient γ, which reflects the effective mass of quasi-particles, shows maximum around x_c ~ 0.05, also indicating the existence of quantum critical phenomenon around the critical doping. The value of Kadowaki-Woods ratio of $CrAs_{1-x}P_x$ shows no significant different from that of CrAs.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.901
Study of the pseudogap critical point in cuprate superconductors by specific heat

Michon B.[1,2]*, Marcenat C.*[3]*, Girod C.*[1]*, Zhou J.-S.*[4]*, Taillefer L.*[5]*, <u>Klein T.</u>*[1]
[1]Institut Néel - CNRS & Université Grenoble Alpes, Grenoble, France, [2]Université de Genève Sherbrooke, Département de Physique & RQMP, Sherbrooke, Canada, [3]INAC-Pheliqs - CEA & Université Grenoble-Alpes, Grenoble, France, [4]Texas Materials Institute, University of Texas - Austin, Austin, United States, [5]Université de Sherbrooke, Département de Physique & RQMP, Sherbrooke, Canada

Recent high-field transport measurements in cuprate superconductors have revealed that the carrier density n in the normal state at T = 0 drops abruptly upon entering the pseudogap phase below a critical doping p^*, from $n = 1 + p$ above p^* to $n = p$ below p^* [1,2,3].
To help elucidate the mechanism responsible for this sharp signature, we have performed high-sensitivity AC measurements of the specific heat in the normal state at several dopings, on the cuprates $La_{1.6-x}Nd_{0.4}Sr_xCuO_4$ and $La_{1.8-x}Eu_{0.2}Sr_xCuO_4$.
We report the detailed temperature dependence of the electronic contribution to the specific heat and discuss the doping dependence of the residual term, $\gamma = C/T$ at $T \to 0$, across p^*, and compare it with the evolution of the carrier density.

References:

[1] S. Badoux *et al*, Nature **531**, 210 (2016).
[2] F. Laliberté *et al*, arXiv:1606.04491 (2016).
[3] C. Collignon *et al*, arXiv:1607.05693 (2016).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.903
$BaBiO_3$ single crystal X-ray photoemission experiment and exact diagonalization analysis
Balandeh S., Green R., Sawatzky G.
University of British Columbia, Vancouver, Canada

Hole doped $BaBiO_3$ is one of the rare examples of a three dimensional high transition temperature superconductor (Tc = 34K) without a transition metal cation, which also has closely interlinked electronic and structural phase transitions. The parent $BaBiO_3$ is also an interesting semi-conducting material with an in-direct gap of about 0.5 eV which is usually believed to originate from a *charge-disproportionation* mechanism with Bi^{3+} and Bi^{5+} cations[1]; however recent band structure studies[2] show no significant charge transfer among bismuths and find instead one hole per three oxygens suggesting a *bond-disproportionation* insulating mechanism instead.
In this study we investigate this picture theoretically with Exact Diagonalization Single Cluster analysis and experimentally using oxygen 1s X-ray Photoemission Spectroscopy (XPS) on $BaBiO_3$ single crystals performed at Canadian Light Source (CLS) facilities.
References:
1. D.E. Cox, A.W. Sleight, Structural Studies of the $BaPb_{(1-x)}Bi_xO_3$ System, Proceedings of the Conference on Neutron Scattering 45-54 (1976)
2. Kateryna Foyevtsova *et al*, Hybridization effects and bond-disproportionation in the bismuth perovskites, PHYSICAL REVIEW B 91, 121114(R) (2015)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.904
Nanowire superinductors for novel quantum devices
Niepce D., Burnett J., Bylander J.
Chalmers University of Technology, Microtechnology and Nanoscience, Göteborg, Sweden

Josephson junction-based qubits constitute a promising platform for QIP but decoherence of the quantum states due to noise is still a major problem. However, by embedding a Josephson junction in a high impedance environment, we can effectively suppress charge fluctuations. In order to reduce the charge fluctuations across the Josephson junction below 2e, the impedance must be larger than the superconducting resistance quantum $R_Q = h/4e^2 \approx 6.5$ kΩ. A purely electromagnetic inductance is incompatible with such a requirement as it is in practice always bounded by the vacuum impedance $\sqrt{\mu_0/\varepsilon_0} \approx 377\ \Omega < R_Q$.
This limitation can be beaten by taking advantage of superconducting circuits. We have shown that the high kinetic inductance of disordered niobium nitride (NbN) thin films can be used to fabricate superinductors that exhibit an inductance two to three orders of magnitude larger than an ordinary geometric inductance of the same size. We have demonstrated inductances as large as Z = 7.5 kΩ for NbN nanowires.

Moreover, study of highly disordered superconductors is at the forefront of modern low temperature physics and offers a promising platform to deepen our understanding of many exciting physics phenomena such as quantum phase slips and the superconductor-to-insulator transition.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.905

FFLO excitonic state in the two-dimensional Hubbard model for Ta_2NiSe_5

Domon K.[1], *Yamada T.*[2], *Ono Y.*[1]
[1]Niigata University, Niigata, Japan, [2]Tokyo University of Science, Noda, Chiba, Japan

Transition metal chalcogenide Ta_2NiSe_5 known as a candidate material for excitonic insulator shows a structural phase transition from orthorhombic (semiconductor) to monoclinic (semiconductor) at T_s=328K under ambient pressure.Flattening of the top of the valence band below Ts was observed by angle-resolved photoemission spectroscopy (ARPES) and the possibility of excitonic order was proposed as the origin of the structural transition[1,2].Theoretically, the experimental results were well accounted for by the BCS type mean-field analysis of the excitonic order based on the three-chain Hubbard model for Ta_2Ni chain which reproduces the first principles calculation for Ta_2NiSe_5 at ambient pressure[3].We investigate the three-chain Hubbard model in the semimetallic case under pressure and find that the FFLO excitonic state characterized by the condensation of excitons with finite center-of-mass momentum corresponding to the nesting vector between the electron-hole Fermi surfaces is stabilized by the imbalance between electrons and holes due to the difference in degeneracy between the two-fold degenerate conduction bands and the non-degenerate valence band[4,5].We also report the results of the FFLO states in a more realistic two-dimensional Hubbard model[6].

References:

[1] Y. Wakisaka et al., Phys. Rev. Lett. **103**, 026402 (2009)
[2] T. Mizokawa et al., J. Supercond. Nov. Magn. **22**, 67 (2009)
[3] T. Kaneko, T. Toriyama, T. Konishi and Y. Ohta, Phys. Rev. B **87**, 035121 (2013)
[4] T. Yamada, K. Domon and Y. Ono, J. Phys. Soc. Jpn **85**, 053703 (2016)
[5] K. Domon, T. Yamada and Y. Ono, J. Phys. Soc. Jpn **85**, 065005 (2016)
[6] K. Sugimoto et al., Phys. Rev. B **94**, 085111 (2016)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.906

Torque magnetometry using a membrane-type surface-stress sensor

Takahashi H.[1], *Ishimura K.*[2], *Okamoto T.*[2], *Ohmichi E.*[2], *Ohta H.*[3]
[1]Kobe University, Organization for Advanced and Integrated Research, Kobe, Japan, [2]Kobe University, Graduate School of Science, Kobe, Japan, [3]Kobe University, Molecular Photoscience Research Center, Kobe, Japan

Torque magnetometry using a piezoresistive microcantilever is a powerful method for material research. Due to its great force/torque-sensitivity, this method has been applied to measure the magnetic susceptibility of small samples, to accurately map Fermi surfaces and to detect the magnetic resonance signal [1,2].
However, the most popular commercial piezoresistive cantilever (PRC-series, Hitach Hitech. Corp.) was discontinued from its production about three years ago. After that, many researchers gave up the torque magnetometry while its importance has been growing. Due to such circumstances, the development of the alternative method has been a serious and urgent issue.
We propose a new method for torque magnetometry using a commercial membrane-type surface-stress sensor (MSS) instead of microcantilever [3,4]. Although this device was originally developed as a gas sensor, we found that it can be used as a torque sensor. We sucessfully measured the magnetization of a superconductor and de-Haas-van-Alphen oscillation at low temperature [5]. It is possible to use the same experimental setup that we used in the measurement using a piezoresistive microcantilever [1]. We believe that MSS can be an alternative tool of self-sensitive microcantilevers.

References:

[1] E. Ohmichi and T. Osada, Rev. Sci. Instrum. **73**, 3022 (2002).
[2] H. Takahashi, E. Ohmichi and H. Ohta, Appl. Phys. Lett. **107**, 182405 (2015).
[3] G. Yoshikawa, T. Akiyama, S. Gautsch, P. Vettiger, and H. Rohrer, Nano Lett. **11**, 1044 (2011).
[4] SD-MSS-1K, NANOSENSORS Inc.
[5] H. Takahashi, K. Ishimura, T. Okamoto, E. Ohmichi and H. Ohta, arXiv:1703.07935.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.907

Phase dependent heat currents in superconducting nanostructures

Hajiloo F.[1], *Splettstoesser J.*[1], *Hassler F.*[2]
[1]Chalmers University of Technology, Department of Microtechnology and Nanoscience - MC2, Göteborg, Sweden, [2]RWTH Aachen University, Institute for Quantum Information, Aachen, Germany

The sensitivity of the operation of nanoscale devices at low temperatures on heating effects makes it important to do research on controlling heat currents. In this context it is particularly interesting to study superconducting devices due to their application in quantum refrigerators on one hand and superconducting qubits on the other hand.
Heat currents in superconducting junctions depends on the phase difference between superconducting condensates. Our project deals with those thermal effects in superconducting junctions as well as normal(N)/superconductor(S) hybrid structures. Our aim is to understand how we can use the geometrical properties of multi-terminal junctions to reach a control over the phase dependent heat currents. In addition we want to investigate how sensitive the device properties are to unavoidable disorder scatterings.
As a first example, we study an SNS junction with additional generic barriers in the normal region. We use scattering matrix theory to calculate heat currents. For this purpose, we construct the scattering matrix of the SNS junction which allows for arbitrary distribution of multiple scatterers in the normal region.
To complement our understanding of thermal properties of hybrid junctions we also study heat current noise in SNS junction.

Postersession 4

Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.908
Order-disorder transition in 2D quantum systems and Its doping effects
Nakamura S.[1], *Fukuyama H.*[1,2]
[1]University of Tokyo, Cryogenic Research Center, Tokyo, Japan, [2]University of Tokyo, Department of Physics, Tokyo, Japan

The order-disorder transition of the √3×√3 commensurate phase in He monolayers adsorbed on graphite is accompanied by a sharp specific heat anomaly. It is known as a nearly ideal realization of the 3-state Potts model. The anomaly should become largest in peak height (C_p) and highest in peak temperature (T_p) at the critical density (ρ_c) where atoms occupy one third of all hollow sites of graphite honeycomb lattice. We have reexamined isotope effects on this transition from new C measurements using a ZYX substrate with 10 times larger platelet size than previously used Grafoil [1,2]. We confirmed the result with Grafoil [3] that T_p of ^{3}He is 3% higher than ^{4}He. This is consistent with the theoretical calculation [4] and the known isotope effect on melting temperatures of 2D and 3D quantum solids [5]. Also, we observed that C_p becomes largest with the same values at $\rho = \rho_c$ for both ^{3}He and ^{4}He (no isotope effect). Although this is inconsistent with the previous data [3], it is more natural since C_p should be determined by the finite size effect of substrate. By comparing these results with those on hydrogen systems [6], we argue intriguing quantum (mass) effects and doping effects on the order-disorder transition for helium.

References:
[1] S. Nakamura et al., J. Low Temp. Phys. **171**, 711 (2013).
[2] S. Nakamura and H. Fukuyama, to be published.
[3] M. Bretz et al., Phys. Rev. A **8**, 1589 (1973); M. Bretz, Phys. Rev. Lett. **38**, 501 (1977).
[4] D. S. Hirashima, T. Momoi, and T. Takagi, J. Phys. Soc. Jpn. **72**, 1446 (2003).
[5] S. Nakamura et al., Phys. Rev. **94**, 180501(R) (2016).
[6] H. Freimuth and H. Wiechert, Surface Science **178**, 716 (1986).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.909
Gate-based read-out of the Rydberg states of electrons on helium
Kawakami E., *Konstantinov D.*
Okinawa Institute of Science and Technology, Okinawa, Japan

Electrons on the surface of helium have a high potential for serving as quantum bits. The vertical motion of electrons exhibits hydrogen-like quantized states (Rydberg states) and can be used as qubit states [1].
Electrons can be excited from the ground to an excited Rydberg state by applying a resonant microwave. Previously, this excitation of many electrons was detected by measuring the microwave absorption signal and the Stark shift was observed by applying a voltage to the electrode situated below the electrons [2].
Here we propose to use rf gate-based sensing [3] to detect the excitation of electrons. The electrodes above and below the electrons are capacitively coupled. We connect an inductor to the electrodes to form an LC-circuit. The ground and 1st excited Rydberg states are ~30nm apart. When an electron is

excited, an additional image charge is introduced on the electrodes due to the electron's position shift. This additional image charge introduces an additional capacitance, which can be detected by the resonance frequency shift of the LC-circuit.
This read-out technique is sensitive enough to detect the excitation of a single electron, which paves the way to realize a quantum computer using electrons on helium.

References:

[1] P.M. Platzman, Science 284, 1967 (1999).
[2] C.C. Grimes, Phys. Rev. B 13, 140 (1976). E. Collin, Phys. Rev. Lett. 89, 245301 (2002).
[3] F. Persson, Nano Lett. 10, 953 (2010). M.F. Gonzalez-Zalba, Nat. comm. 6, 6084 (2015).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.911

The role of phonon and electronic confinement in the enhanced superconducting properties of Sn nanowires

Perez D.[1], Couet S.[1], Petermann C.[1], Hamoir G.[1], Jochum J.[1], Picot T.[1], Menéndez E.[1], Houben K.[1], Joly V.[1], Antohe V.[2], Hu M.[3], Leu B.[3], Piraux L.[2], Vantomme A.[1], Temst K.[1], Van Bael M.[1]
[1]KU Leuven, Leuven, Belgium, [2]Université Catholique de Louvain, Louvain la Neuve, Belgium, [3]Argonne National Laboratory, Lemont, United States

Nanostructuring superconductors leads to substantial changes in their properties compared to their bulk counterparts due to the modification of the electron-phonon coupling. These changes appear once the size of the superconductor is smaller than the Ginzburg-Landau coherence length ξ(T), resulting in a modification of the critical magnetic field H_c [1] as well as the critical temperature T_c [2] and the superconducting gap Δ_0[3].
Using magneto-transport experiments we found an enhancement of about 10-20% in the T_c of Sn nanowires ranging from 18 to 100 nm. In order to elucidate the role of phonon confinement, we have determined the phonon density of states F(E) in these nanowires using nuclear resonant inelastic X-ray scattering, NRIXS [4]. For all nanowire diameters, a decrease in the average phonon frequency $<\omega^2>$ is observed, indicating an overall phonon softening. Using the measured F(E) [5], T_c was calculated and it was found to be in excellent agreement with the results from magneto-transport (Fig.1).
Moreover, the superconducting phase boundary indicates that H_c is up to 100 times higher than that of bulk Sn and shows a dimensional cross-over from a 2D to a 3D behavior, which is related to the coupling between the nanowires and the Sn electrodes.

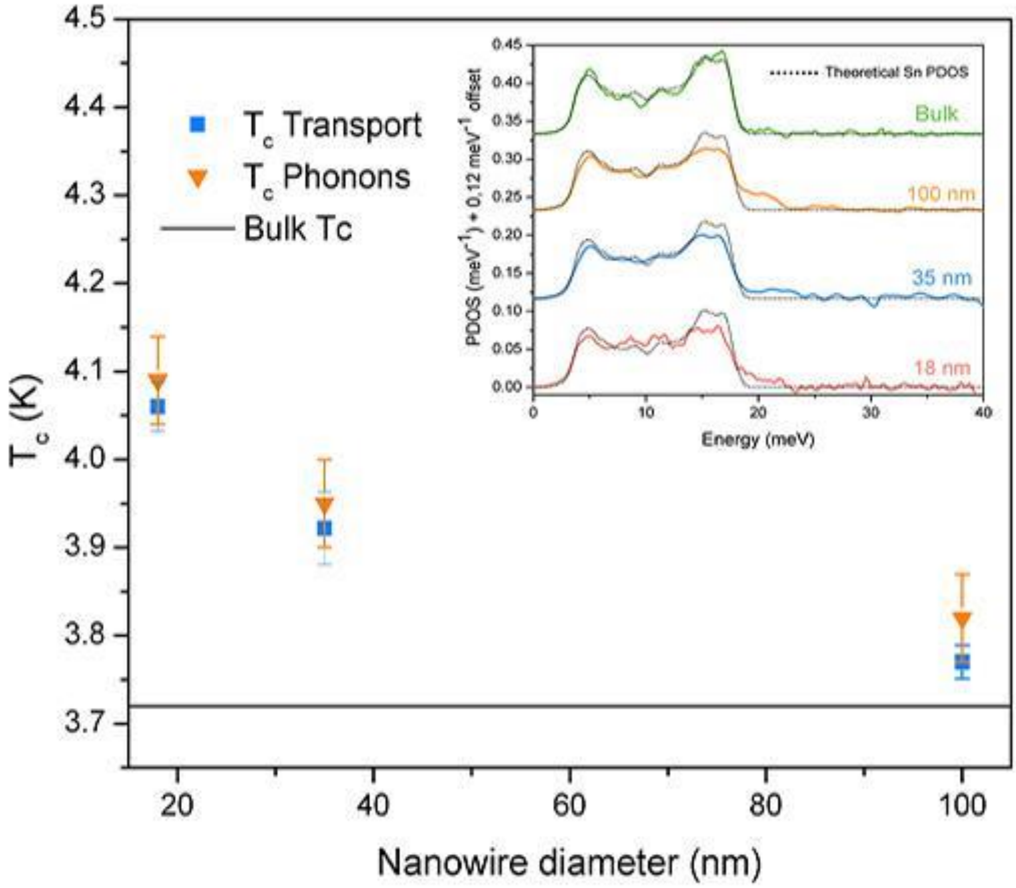


Figure 1. Critical temperatures as a function of the diameters. The blue squares represent the critical temperatures determined using transport measurements. The orange triangles are the critical temperatures calculated using the phonon density of states. The inset shows the phonon density of states of the different samples.

[Figure 1]

References:

[1] S. Dubois, A. Michel, J. P. Eymery, J. L. Duvail, L. Piraux, Journal of Materials Research, 14(3), pp. 665671 (1999).
[2] M. Strongin, O. F. Kammerer, J. E. Crow, R. D. Parks, D. H. Douglass, Jr., and M. A. Jensen, Physical Review Letters 21 (18), 13201323 (1968).v
[3] S. Bose *et al.*, Nature Materials 9, 550554 (2010).
[4] W. Sturhahn, J. Phys. Condens. Matter 16 S497S530 (2004).
[5] V. Z. Kresin, Phys Lett A, 122, 434 - 438 (1987).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.912
Strong electron self-cooling in the cold-electron bolometers designed for CMB measurements
Kuzmin L.[1,2], Pankratov A.[2], Gordeeva A.[2], Zbrozhek V.[2], Revin L.[2], Shamporov V.[1,2], Gunbina A.[1,2], Masi S.[3], de Bernardis P.[3]
[1]Chalmers University of Technology, Gothenburg, Sweden, [2]Nizhny Novgorod State Technical University, Nizhny Novgorod, Russian Federation, [3]Sapienza University of Rome, Rome, Italy

We have realized photon-noise-limited cold-electron bolometers (CEB) [1] for OLIMPO Balloon Telescope [2]. The ultimate performance is fully based on the strong direct electron self-cooling of the nanoabsorber by SIN tunnel junctions. The high efficiency of electron self-cooling is achieved by
- a very small volume of the nanoabsorber (0.02 um^3) and a large relative area of the SIN tunnel junctions,
- effective removing of hot quasiparticles by arranging double stock at both sides of the junctions and close position of the normal metal traps,
- self-protection of the 2D array of CEBs against interferences in by dividing them between N series CEBs (for voltage interferences) and M parallel CEBs (for current interferences). For this array N=48 and M=4.

As a result, the CEB array demonstrates very effective electron cooling from 310 mK to 100 mK without optical power load, Po, and from 310 mK to 160 mK with Po= 40 pW at 350 GHz. Due to this effective electron cooling, the photon-noise-limited operation is realized in the range of Po from 8 pW to 30 pW at Tph=310 mK. That means that even under high power load the CEBs are working at Te less than Tph.
To our knowledge, there is no analog in the world for bolometers working at electron temperature less than phonon temperature.
References:
[1] L. Kuzmin, “Ultimate Cold-Electron Bolometer with Strong Electrothermal Feedback”, Proc. of the SPIE conference “Millimeters and Submillimeter Detectors”, **5498**, pp 349-36 (2004).
[2] S. Masi, E. Battistelli, D. Brienza et al., "OLIMPO", Mem. S. It., **79**, p.887 (2008).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.913
Influence of defects on quantum transport in quantum Hall graphene
Myoung N., Park H.C.
Institute for Basic Science, Ceneter for Theoretical Physics of Complex Systems, Daejeon, Korea, Republic of

Graphene in quantum Hall regime is a good playground for studying the topological edge states owing to its capability of tuning Chern number by controlling gate voltages. Both from fundamental and application points of view, it is very interesting to understand how the topological states are affected by defects. In this study, we investigate that the quantum Hall conductance in graphene can be influenced by the presence of defects, such as edge roughness and strains. It is shown that the presence of edge roughness gives rise to the crossover from the ballistic to Ohmic regime of transport, via the interplay between topological states. Also, the strain-induced localized states also can affect drastically the transport phenomena throughout the quantum Hall graphene.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.914
Theory of enhanced interlayer tunneling in optically driven high-T_c superconductors
Okamoto J.[1,2], *Cavalleri A.*[3,4], *Mathey L.*[1,2]
[1]University of Hamburg, Center for Optical Quantum Technologies, Institute for Laser Physics, Hamburg, Germany, [2]The Hamburg Centre for Ultrafast Imaging, Hamburg, Germany, [3]Max Planck Institute for the Structure and Dynamics of Matter, Hamburg, Germany, [4]University of Oxford, Department of Physics, Clarendon Laboratory, Oxford, United Kingdom

Recent pump-probe experiments indicating enhanced coherent c-axis transport in underdoped YBCO [1] have triggered a number of theoretical attempts to explain the observation. Here we propose a mechanism for this observation by demonstrating that a parametrically driven Josephson junction shows an effectively enhanced Josephson coupling (extracted from the imaginary part of conductivity) when the driving frequency is just above the plasma frequency [2]. It is also found that the transient enhancement of the Josephson coupling can be even larger than the steady state. Finally, we show that our simulation of bilayer Josephson junctions qualitatively agrees with experimental data.
References:
[1] W. Hu *et al*., Nat. Mater. **13**, 705 (2014).
[2] J. Okamoto, A. Cavalleri, L. Mathey, Phys. Rev. Lett. **117**, 227001 (2016).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.915
Strong anisotropy effect and magnetic field induced metal-insulator quantum phase transition in CaFeAsF system
Mu G., *Ma Y., Li W., Hu T.*
Shanghai Institute of Microsystem and Information Technology, CAS, Shanghai, China

The anisotropy of the Fe-based superconductors is much smaller than that of the cuprates and the theoretical calculations. A credible understanding for this experimental fact is still lacking up to now. Here we experimentally study the magnetic-field-angle dependence of electronic resistivity in the superconducting phase of iron-based superconductor CaFe_0.882Co_0.118AsF, and find the strongest anisotropy effect of the upper critical field among the iron-based superconductors based on the framework of Ginzburg-Landau theory. The evidences of energy band structure and charge density distribution from electronic structure calculations demonstrate that the observed strong anisotropic effect mainly comes from the strong ionic bonding in between the ions of Ca^2+ and F^-, which weakens the interlayer coupling between the FeAs and CaF layers. In addition, we find a metal-insulator quantum phase transition tuned by the magnetic field.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.916
Design versions of HTS three-phase cables with the minimized value of AC losses
Altov V.[1], Balashov N.[1], Degtyarenko P.[1,2], Ivanov S.[1], Kopylov S.[1], Zheltov V.[1], Lipa D.[3], Sytnikov V.[4]
[1]Joint Institute for High Temperatures of Russian Academy of Sciences, Moscow, Russian Federation, [2]JSC SuperOx, Moscow, Russian Federation, [3]FSBEI HE RGAZU, Moscow, Russian Federation, [4]JSC R&D Center, FGC UES, Moscow, Russian Federation

Design versions of HTS three-phase cables consisting of 2G HTS tapes have been investigated by the numerical simulation method with the aim of AC losses minimization. Two design versions of cables with the coaxial and extended rectangular cross-section shape are considered - the non-sectioned and sectioned one. In the latter instance each cable phase consists of sections connected in parallel. The optimal dimensions of sections and order of their alteration are chosen by appropriate calculations. The model used takes into account the current distribution between the sections and its non-uniformity within each single HTS tape as well. The following characteristics are varied: design version, dimension, positioning of extra copper layer in a cable, design of HTS tapes themselves and their mutual position. The dependence of AC losses on the latter two characteristics is considered in details. Additionally, are given the examples of cable designs optimized by the total set of characteristics for the medium class of voltages (10 - 60 kV). At the critical current J_C = 5,1 кА per phase and current amplitudes lower than 0,85 J_C, the level of total AC losses does not exceed the natural cryostat heat losses. The work was supported by RFBR, Project Nr. 16-08-00304a.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.917
Quantum correlations in microwave frequency combs
Jolin S.W., Weissl T., Haviland D.B.
Kungliga Tekniska Högskolan KTH, Department of Applied Physics, Stockholm, Sweden

Non-linear superconducting resonators are used as parametric amplifiers in circuit quantum electrodynamics experiments [1]. When a strong pump is applied to a non-linear microwave oscillator, it correlates vacuum fluctuations at signal and idler frequencies symmetrically located around the pump, resulting in two-mode squeezed vacuum. When the non-linear oscillator is pumped with a frequency comb, complex multipartite entangled states can be created as demonstrated with experiments in the optical domain [2, 3]. Such cluster states are considered to be a universal resource for one-way quantum computing. With our microwave measurement setup it is possible to pump and measure response at as many as 42 frequencies in parallel, with independent control over all pump amplitudes and phases. We show results of two-mode squeezing for pairs of tones in a microwave frequency comb. The squeezing is created by four-wave mixing of a pump tone applied to a non-linear coplanar-waveguide resonator.

References:
[1] E. Tholén et al., Appl. Phys. Lett. **90**, 253509 (2007)

[2] M. Chen et al., PRL **112**, 120505 (2014)
[3] J. Roslund et al., Nat. Phot. 2013.340 (2013)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.918
Fractional electric charge and anomalous solitons on the domain wall between He3-a phase and spin ice compounds

Kanazawa I., Maeda R.
Tokyo Gakugei University, Physics, Tokyo, Japan

The most prominent examples of emergent quasiparticles are magnetic monopoles emerge in a class of exotic magnets known collectively as spin ices [1]. Spin ices are found to have a residual entropy at low temperature, which is well-approximated by the Pauling entropy for water ice. Another interesting material is superfluid He3 in A-phase which belongs to that special universulity class of Fermi liquids, where the effective gravity, gauge fields and chiral fermions appear in the low-energy corner together with Lorentz and gauge invariant [2]. The present author(I.K) has reported the importance of the hole-induced domain-wall and the hedgehog-like magnetic soliton in magnetoresistance in diluted magnetic semiconductors [3,4], and doped manganites [5].
In this study, we will argue anomalous solitons on the domain wall between He3-A phase and spin ice compounds, using the previous theory [6,7].

References:
[1] C.Castelnovo, R.Moessner,S.L.Sondhi, Nature 452,42(2008)
[2] G.E.Volovik, Proc.Natl.Acod.Sci.USA 96,6042(1999)
[3]I. Kanazawa. Phys.Lett.A355,460(2006)
[4]I.Kanazawa, Physica E40,277(2007)
[5]I.Kanazawa, J.Low Temp.Phys.172,177(2013)
[6]T.Sasaki,E.Imai,I.Kanazawa, J.Phys.Conf.Ser.568,052029(2014)
[7]I.Kanazawa,T.Sasaki, Physics Procedia 75,967(2015)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.919
Different electronic states at crystallographically inequivalent CuO_2 planes on four-layered cuprates $HgBa_2Ca_3Cu_4O_{10+\delta}$

Sekine R.[1,2], Nakayama S.[1], Tsukada A.[2], Denholme S.[2], Miyakawa N.[2], Tokiwa K.[1]
[1]Tokyo University of Science, Department of Applied Electronics, Tokyo, Japan, [2]Tokyo University of Science, Department of Applied Physics, Tokyo, Japan

Spectroscopic studies on multi-layered cuprates (MLC) with three or more CuO_2 planes per unit cell have not been sufficient, despite those on mono- or bi-layered cuprates have been extensively done. The MLCs exhibit two kinds of crystallographically inequivalent CuO_2 planes i.e., the inner plane (IP) with four-fold oxygen coordination and the outer plane (OP) with five-fold oxygen coordination. It has become clear that the local doping level at the OP is larger than that at the IP from NMR studies [1].

Moreover, the different electronic states at the IP and OP provides two kinds of superconducting gap from tunneling studies [2].
In this study, we will present tunneling results on four-layered cuprate superconductor $Hg_{0.95}Ba_2Ca_3Cu_4O_{10.05}$ (Hg1234) with T_C ~ 127 K [3]. As shown in figure (a), the sample exhibits two kinds of the superconducting gap originating from the OP and IP. Figure (b) shows the histogram of the gap magnitudes at the OP and IP [$V_{p(OP)}$ and $V_{p(IP)}$]. The $V_{p(OP)}$ and $V_{p(IP)}$ correspond to 36 ± 2 mV and 55 ± 2 mV, respectively. Furthermore, the tunneling conductance for both the IP and OP exhibits the dip feature which has been discussed as a strong coupling structure for Cooper-pair formation [4].

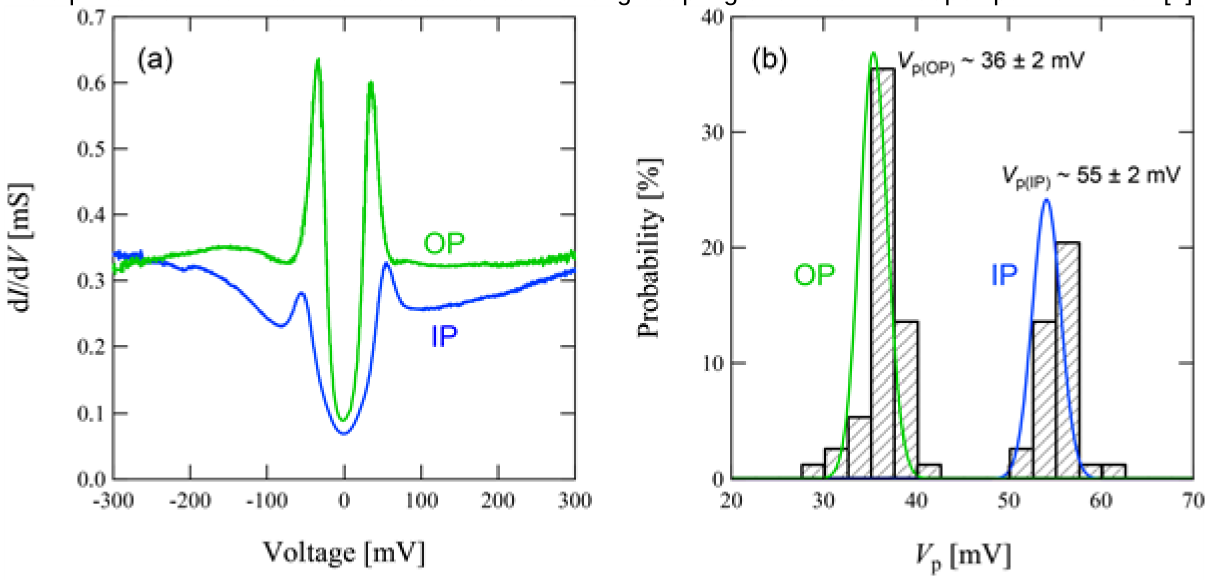


Figure: (a) The two kinds of typ ical tunneling spectra at the OP (green) and IP (blue) for Hg1234 measured at 4.2 K. (b) Histogram of the magnitudes of the gap for Hg1234. Hg1234 exhibits two distinct distributions originating from the OP and IP. The $V_{p(OP)}$ and $V_{p(IP)}$ on Hg 1234 correspond to 36 ± 2 mV and 55 ± 2 mV, respectively.

[fig]

References:

[1] H. Kotegawa et al. Phys. Rev. B **64**, 064515 (2001).
[2] R. Sekine et al. Phys. Procedia **65**, 45 (2015).
[3] Hg1234 polycrystalline sample was synthesized under high pressure of 4.5 GPa at 850 °C for 1 h. The average doping level between IP and OP was estimated as *p* ~ 0.13 (under-doped region) by iodometry method.
[4] R. Sekine et al. J. Phys. Soc. Jpn. **85**, 024702 (2016).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.920

Extremely anisotropic suppression of huge enhancement of electrical resistivity by magnetic field in α-R_2S_3 (*R* = Sm, Dy)

<u>Ebisu S.</u>, Era T., Guo Q., Miyazaki M.
Muroran Institute of Technology, Division of Applied Sciences, Muroran, Japan

Rare earth sesquisulfides α-R_2S_3 (R = Sm, Dy) have an orthorhombic crystal structure with two crystallographically inequivalent *R* sites. There exist complex exchange interactions between magnetic atoms on these *R* sites and they bring about novel physical properties in low temperature. The most attractive phenomena in these compounds are huge enhancements of the electrical resistivity in narrow temperature range. It had been found that the enhancement was rapidly suppressed by applying magnetic field perpendicular to the *b*-axis. In the present work, we have found the suppression effect is extremely anisotropic for the orientation of the applied magnetic field in the ac-plane. The suppression effect under the magnetic field along the easy-magnetization axis is more than 500 times larger in some cases than that under the magnetic field perpendicular to the easy-magnetization axis.

References:

[1] S. Ebisu, T. Iijima, T. Iwasa and S. Nagata, J. Phys. Chem. Solids **65**, 1113 (2004)
[2] S. Ebisu, M. Narumi and S. Nagata, J. Phys. Soc. Jpn. **75**, 085002 (2006)
[3] S. Ebisu, H. Omote and S. Nagata, J. Phys.: Conf. Ser. **200**, 092005 (2010)

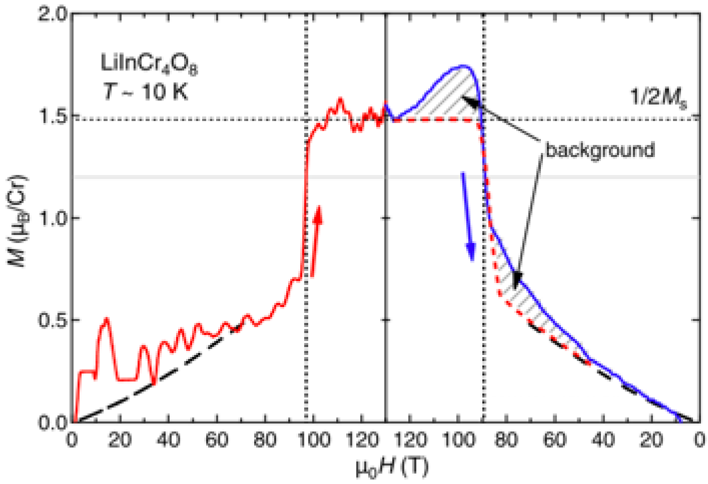
Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.921

1/2 magnetization plateau of breathing pyrochlore antiferromagnet Li*M*Cr_4O_8 (*M*=Ga, In) in magnetic fields up to 130 T

Gen M.[1]*, Nakamura D.*[1]*, Okamoto Y.*[2]*, Takeyama S.*[1]
[1]Institute for Solid State Physics, University of Tokyo, Kashiwa, Japan, [2]Nagoya University, Nagoya, Japan

Geometrically frustrated spin systems have attracted considerable attention for decades as they present a playground for exotic ground states such as spin liquid. Cr spinel oxides ACr_2O_4 (A=Hg, Cd, Zn, Mg) where Cr^{3+} ions form a pyrochlore lattice have been extensively studied as good model materials. One of the most distinctive features of ACr_2O_4 is its field-induced magnetic phase transitions, represented by a 1/2 plateau phase [1-4].
We focus on breathing pyrochlore antiferromagnets, LiMCr_4O_8 (M=Ga, In), in which Cr_4 tetrahedra with small and large size are alternately arranged, causing two different exchange interactions, J and J'. The value of $B_f \equiv J'/J$ is estimated to be about 0.6 for $LiGaCr_4O_8$ and 0.1 for $LiInCr_4O_8$ [5]. Breathing pyrochlore spin systems with various values of B_f provide the opportunity to understand the frustration and the possibility of discovering novel quantum phases. We conducted magnetization measurements in ultra-high magnetic fields up to 130 T at very low temperature. Figure 1 shows a magnetization curve obtained for $LiInCr_4O_8$. It exhibits a sharp jump to a 1/2 plateau at around 90 T, which continues at least up to 130 T, suggesting the presence of strong spin-lattice coupling [6]. We attempt to clarify the B_f dependence of the plateau widths.



[Figure 1]

References:

[1] S. Kimura, et al., Phys. Rev. B **83**, 214401 (2011)
[2] A. Miyata, et al., Phys. Rev. B **87**, 214424 (2013)
[3] A. Miyata, et al., J. Phys. Soc. Jpn. **81**, 114701 (2012)
[4] K. Penc, et al., Phys. Rev. Lett. **93**, 197203 (2004)
[5] Y. Okamoto, et al., Phys. Rev. Lett. **110**, 097203 (2013)
[6] Y. Okamoto, et al., Phys. Rev. B **95**, 134438 (2017)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.923

Localization of chiral-like spin solitons with carriers in the layered organic k-(ET)2Cu2(CN)3

<u>Kanazawa I.</u>, Nakajima M.
Tokyo Gakugei University, Tokyo, Japan

In the frustrated layered organic k-(ET)2X salts dimers of ET = bis [ethylenedithio]- tetrathiafulvalence molecules are arranged in an anisotropic traiangular lattice, with a charge state of one hole per dimer site, so that the on-site Coulomb repulsion inhibits the hole transfer. The similarities between the layered organics and high-Tc cuprates superconductors have been suggested strongly [1,2]. The NMR spectra of k-(ET)2 Cu2(CN)3 show neither distinct broadening nor splitting down to 32 mK, which indicates the absence of long-range magnetic ordering at least down to 32 mK [3]. The result might suggest the realization of a quantum spin liquid in k-(ET)2Cu2(CN)3. The present author has discussed freezing mechanism of hole-induced chiral-like spin solitons in the spin glass phase in underdoped high-Tc cuprates using the gauge-invariantly theoretical formula [4]. In this study, we will argue the localization and the pressure dependence of the effective mass of hole-induced chiral-like spin solitons in k-(ET)2Cu2(CN)3, using the previous theories [4,5].

References:

[1] K. Kanoda, J.Phys. Soc. Jpn. 75,051007(2006)
[2] R.H.MaKenzie, Science 278, 820(1997)
[3] Y.Shimiza et.al. Phys. Rev. Lett. 91,107001(2003)
[4] I. Kanazawa, R. Maeda, J.Super.Nov. Magn.30,49(2007)
[5] I. Kanazawa,T.Sasaki, Phys. Scr. T165,014038(2016)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.925
Spinor polariton condensates: steady state phases and elementary excitations
Liang Z.
Zhejiang Normal University, Department of Physics, Jinhua, China

Semiconductor microcavities can host spinor polariton condensates with inherent spin multistabilities and fast spin dynamics, promising novel solid-state optoelectronic spin-logic architectures. Here we present a detailed theoretical study on the steady state phases and elementary excitations of a spinor polariton condensate, motivated by ongoing experimental efforts in realizing such systems. We show that a steady homogeneous spinor condensate can exhibit a unpolarized phase and a polarised phase. In each phase, we investigate the elementary excitations using the Bogoliubov de-Gennes approach. We find the spin mode is non-decaying in the unpolarized phase while weakly damped in the polarized phase, along with a gapped energy spectrum which characteristics are indifferent to the reservoir effect. By contrast, the density mode displays rich behavior depending on reservoir parameters. Interestingly, we demonstrate that the negative energy ghost branch of the spin mode can be visualized in the photoluminescence emission, distinguishable from that of the density mode and thus allowing for experimental observation, when the spinor polariton condensate is polarized.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.926
Transport through domain-wall in disordered magnetic Weyl semimetals
Kobayashi K., Ominato Y., Nomura K.
IMR, Tohoku University, Sendai, Japan

We study transport properties in magnetic junction of Weyl semimetals. The Weyl semimetal is a kind of topological quantum matter and can be realized by breaking time-reversal or inversion symmetry of Dirac semimetal. In magnetic Weyl semimetals, the Weyl nodes (Fermi surface) move in accordance with the magnetization and it is expected to show novel anisotropic transport properties.
We show that the transport through a junction of Weyl semimetals with different magnetizations can be strongly suppressed, due to (1) dis-overlapping of Fermi surface and (2) mismatch of the chirality of Dirac electrons.
We calculate two-terminal conductance using the Landauer formula and find that the system exhibits extraordinarily large anisotropic magnetoresistance when the overlapping area of Fermi surface vanishes [1]. Even if the Fermi surfaces are overlapping, the transport is strongly suppressed when the Weyl nodes have opposite chirality: in the junction of Weyl semimetals with anti-parallel magnetizations.

We also calculate the conductance numerically by using transfer matrix method on the lattice model. We show that these novel transport phenomena are robust against disorder and discuss the effect of the type and length of the domain-wall at the junction.

References:

[1] Y. Ominato, K. Kobayashi, K. Nomura, Phys. Rev. B **95**, 085308 (2017)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.927

Vortex physics in a strongly anisotropic superfluid: ^{4}He on fluorographene

Reatto L.

Università degli Studi di Milano, Dipartimento di Fisica, Milano, Italy

Graphite (Gf) is a favorite substrate for adsorption studies of ^{4}He. The He-Gf potential is highly corrugated such that ^{4}He atoms are localized and no superfluidity is present in a monolayer. A similar phase diagram is expected for ^{4}He on graphene [1]. A derivative of graphene, fluorographene (GF), appears to be very attractive. Compared with Gf the adsorption potential ^{4}He-GF has a much stronger corrugation with a reduced distance between adsorption sites and this is unfavorable to localization. Advanced quantum Monte Carlo computations [2] have shown that ^{4}He atoms on GF are delocalized forming a strongly anisotropic superfluid: for instance, the roton energy [3] changes by more than a factor two as function of direction of the q-vector. Here we explore how such anisotropy affects the vortex physics. Vortices are important because the unbinding of vortex pairs is expected to be at the basis of destruction of superfluidity. A vortex in ^{4}He on GF differs in two ways from the case of a uniform superfluid: i) a reduced vortex core energy ε_c when the core position is in regions of very low density due to unfavorable adsorption potential, ii) ε_c has the periodicity of GF and an energy barrier is present between minima. Consequences on the superfluid transition will be discussed.

References:

[1] L. Reatto et al., J. Phys. CM **25**, 443001 (2013)
[2] M. Nava et al., Phys. Rev. B **86**, 174509 (2012)
[3] M. Nava et al., J. Low Temp. Phys. **171**, 699 (2013)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

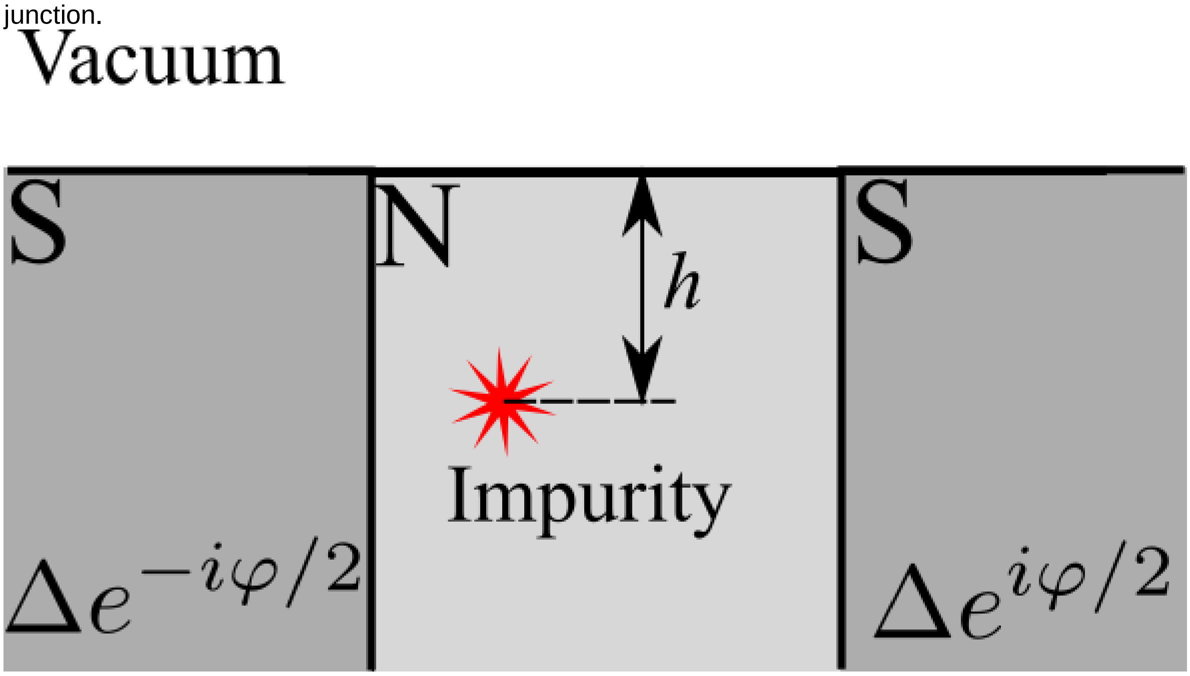
P.929

Impurity states in a mesoscopic SNS junction with a point defect

Bespalov A., _Mel'nikov A._

Institute for Physics of Microstructures RAS - Branch of Federal State Budgetary Scientific Institution 'Federal Research Center The Institute of Applied Physics of the Russian Academy of Sciences' (IAP RAS), Nizhny Novgorod, Russian Federation

Josephson superconductor-normal metal-superconductor (SNS) junctions are used in a variety of electronic devices ranging from voltage standards to SQUIDs. Over the last few years several scientific groups succeeded in fabrication and characterization of SNS junction with nanoscale-sized dimensions [1,2]. In such systems mesoscopic effects become significant: the characteristics of samples may noticeably depend on the realization of disorder in them. In this work, we study theoretically mesoscopic effects in a short 3D SNS junction with a point defect (ordinary or magnetic impurity) located in the normal layer. We find that such defect reduces the transparencies of two conducting channels in the junction, giving rise to two quasibound impurity states (resonances), which are similar to Shiba states in bulk superconductors [3]. In a semi-infinite system (see figure) the energies of the impurity states exhibit strong mesoscopic fluctuation with changing distance *h* between the defect and the free boundary of the junction. Finally, we show that in a junction with two ordinary point impurities there are generally two quasibound states for each spin direction. The obtained theoretical results may be checked experimentally by measuring the local density of states in the junction.



[Semi-infinite SNS junction]

References:

[1] F. Chiodi, M. Ferrier, S. Gueron, J. C. Cuevas, G. Montambaux, F. Fortuna, A. Kasumov, and H. Bouchiat, Phys. Rev. B **86**, 064510 (2012).

[2] E. M. Levenson-Falk, F. Kos, R. Vijay, L. Glazman, and I. Siddiqi, Phys. Rev. Lett. **112**, 047002 (2014).

[3] H. Shiba, Prog. Theor. Phys. **40**, 435 (1968).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.930

Effect on human of generated strong magnetic field by superconducting wireless power transfer for electric vehicle

<u>Chung Y.D.</u>[1], Park E.Y.[2], Kim D.W.[3]

[1]Suwon Science College, Dept. Electrical Engineering, Seoul, Korea, Republic of, [2]Korea Christian University, Seoul, Korea, Republic of, [3]Yonsei University, Dept. Electrical & Electronics Eng., Seoul, Korea, Republic of

Our research team have been developed wireless power charging (WPC) system for electric vehicle using superconducting resonance coils in order to improve the transfer efficiency and stability [1]. As the human safety with respect to electromagnetic fields (EMFs) is an important measure, it is required to identify the condition under which human exposure complies with the safety regulations. Since the WPC system based on the resonance coupling method provides basic restrictions for EMFs in terms of internal electric field and specific absorption rate (SAR) to prevent effects on nervous system functions and excessive localized tissue heating, the effect of human body for EMFs should be investigated [2-3]. The enzyme is one of food elements, which is to being found in all living things, can be reacted by thermal energy. Those affect healing, growth, cancer-fighting and anti-aging in human body[4]. In this paper, as a fundamental approach, authors investigate the EMFs influence for food element (enzyme) using apple, banana, pear and potato since it is difficult to make clinical trial for human. Thus, in this study, the authors focus on effect by EMFs for Human body using various food between antenna and receiver in the WPC system for EV.

References:

[1]Chung Y D Lee C Y Jo H C and Yim S W, Physica C vol 504 p 115 (2014)
[2] Amiot M J Tacchini M Aubert S Y and Oleszek W, J. Agric. Food Chem. vol 43 no 5 p 1132 (1995)
[3] Sun T Xie X and Wang Z, Wireless Power Transfer for Medical Microsystems, (New York: Springer) p 34 (2103)
[4]Kuster N and Balzano Q, IEEE Trans. Veh. Technol. vol 41 no 1 p 17 (1992)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.931

Observation of broadband entanglement in radiation from the dynamical Casimir effect

Schneider B.H., Bengtsson A., Svensson I.M., Aref T., Johansson G., Bylander J., Delsing P.
Chalmers University of Technology, Microtechnology and Nanoscience (MC2), Gothenburg, Sweden

We demonstrate entanglement in photon pairs generated in a wideband superconducting circuit by using the dynamical Casimir effect. We use a SQUID at the end of an open transmission line to generate photons with the dynamical Casimir effect at 10 mK. The circuits are calibrated by using the same SQUID also as a shot noise tunnel junction. After calibration we measure and calculate the covariance matrix for photons generated by the dynamical Casimir effect. We calculate the logarithmic negativity, two-mode squeezing and quadrature fluctuations for different photon rates. All three indicate entanglement with a potentially usable rate of 254 mega entangled bits per second (Mebit).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.932

Localization phenomena enhanced by disorder and lattice geometry effects in two dimensions

Gonzalez L.A.[1], *Paredes R.*[2]
[1]Univirsidad Nacional Autonoma de Mexico, Fisica Teorica, San Mateo Atenco, Mexico, [2]Universidad Nacional Autonoma de Mexico, Fisica Teorica, Mexico, Mexico

We investigate the effects of disorder and lattice geometry in generating localization in ultracold weakly interacting Bose atoms confined in two dimensional optical lattices. For our study we employ the Gross-Pitaevskii mean field theory to analyze the stationary states for finite lattices. In particular, we determine the localization length and investigate the energy spectrum as a function of the disorder strength. An scaling analysis allow us to demonstrate that localization phenomena occurs from a certain threshold value for large lattices. This result is reminiscent of the original Anderson localization in three dimensions where localization occur for arbitrary values of disorder in infinite lattices. The structure of the energy spectrum reveals that discrete energy levels acquire a finite width that is always smaller than the distance among energy levels.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.933

Novel proton-electron coupled state in an organic molecular solid κ-X_3(Cat-EDT-TTF)$_2$

Naka M.[1], *Ishihara S.*[2]
[1]Waseda University, Waseda Institute for Advanced Study, Shinjuku, Japan, [2]Tohoku University, Department of Physics, Sendai, Japan

A new molecular compound κ-X_3(Cat-EDT-TTF)$_2$ [X = H, D] (abbreviated as κ-X) has a unique structure, in which the conducting layers are connected by the hydrogen bonds [1]. The κ-H does not exhibit any magnetic orders and is regarded as a quantum spin liquid material [2]. Substituting the protons by deuterons, a CDW state accompanied by cooperative proton-displacements emerges [3]. Behind these electronic states and isotope effects, the electron-proton interaction and quantum fluctuation of protons are expected to play important roles. In this study, we clarify the electronic state and optical response in the κ-X system. We construct an effective model for κ-X, which treats electronic and proton degrees of freedom on equal footing, and analyze this model by using the mean-field approximation and exact diagonalization method. Increasing the electron-proton coupling, a successive phase transition occurs as antiferromagnetic (AFM) Mott insulating phase → polar charge-ordered phase → CDW phase. In the vicinity of the CDW phase, the AFM correlation is strongly suppressed. Charge excitation peaks in the optical conductivity spectra show frequency shifts with increasing proton-electron coupling, which enables us to estimate the magnitude of the proton-electron coupling in the κ-X.

References:

[1] T. Isono et al., Nat. Comm. **4**, 1344 (2013)
[2] T. Isono et al., Phys. Rev. Letters **112**, 177201 (2014)
[3] A. Ueda et al., J. Am. Chem. Soc **136,** 12184 (2014)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30

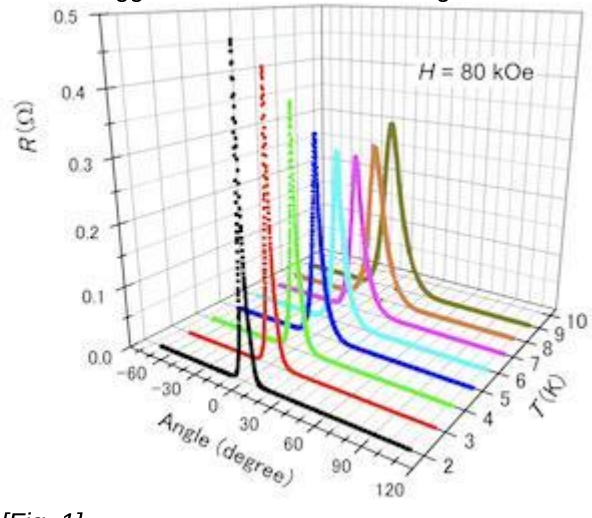
G Foyer

P.934

The possibility of forming intrinsic Josephson junctions in iron-based superconductor $FeSe_{1-x}Te_x$

Ayukawa S.[1], *Hirata K.*[2], *Kakehi D.*[3], *Okada K.*[3], *Ooi S.*[2], *Noji T.*[4], *Koike Y.*[4], *Kitano H.*[3]
[1]Okayama University, Research Institute for Interdisciplinary Science, Okayama, Japan, [2]National Institute for Materials Science (NIMS), Tsukuba, Japan, [3]Aoyama Gakuin University, Department of Physics and Mathematics, Kanagawa, Japan, [4]Tohoku University, Department of Applied Physics, Sendai, Japan

Recently, Intrinsic Josephson effects have reported in iron-based superconductors *Ln*FeAs(O,F) (*Ln*=La, Pr, Sm) and $(V_2Sr_4O_6)Fe_2As$, and mixed Abrikosov vortices with Josephson cores were observed in SmFeAs(O,F) [1-4]. We have focused on $FeSe_{1-x}Te_x$ that has a structure of simply stacking iron-chalcogenide layers with a small distance between iron layers. It is interesting whether intrinsic Josephson junctions (IJJs) are formed in $FeSe_{1-x}Te_x$ or not. In this work, we studied the angular dependence of the interlayer resistance at various temperatures for small microbridges of $FeSe_{1-x}Te_x$ single crystal. In order to fabricate a microbridge with small stack of the superconducting iron layers, the standard focused ion beam (FIB) technique was used. Figure 1 shows the temperature and angular dependence of the interlayer resistance in $FeSe_{0.4}Te_{0.6}$ At the zero angle of the magnetic field which is parallel to layers, the resistance has a peak, and vortex flow occurred. With decreasing temperatures, the peak height is decreased down to T ~ 7 K and is increased with decreasing T below ~ 7 K. Moreover, the peak width are found to be decreased with decreasing temperature. These results suggest that vortex core changes from Abrikosov to Josephson core.



[Fig. 1]

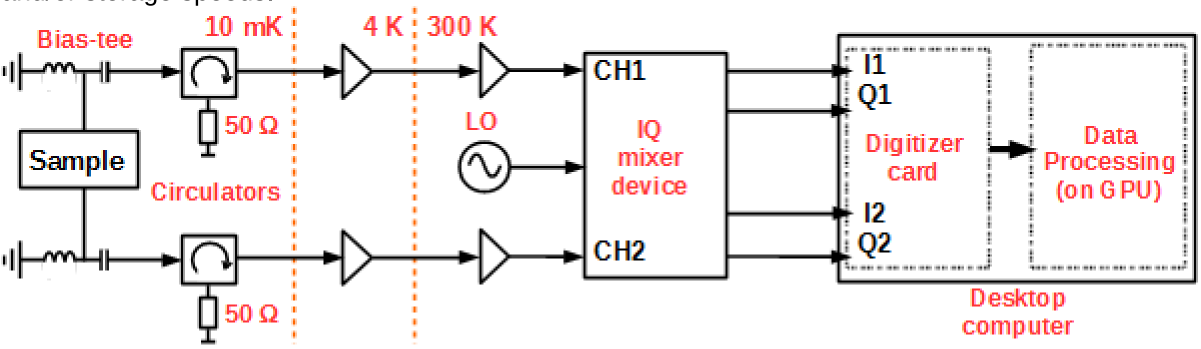
References:

[1] H. Kashiwaya *et al.,* Appl. Phys. Lett. **96**, 202504 (2010).
[2] P. J. W. Moll *et al.,* Nat. Mat. **12**, 134 (2013).
[3] P. J. W. Moll *et al.,* Nat. Phys. **10**, 644 (2014).
[4] P. J. W. Moll *et al.,* Phys. Rev. Lett. **113**, 186402 (2014).

Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.937
High-sensitivity microwave correlation spectrometer
Elo T., Lähteenmäki P., Hakonen P.
Aalto University, Low Temperature Laboratory, Department of Applied Physics, Espoo, Finland

Shot noise measurement is an important characterization method in nanophysics research, although shot noise correlation measurement setups have gained little attention in the literature. Most of the previous setups either utilize low frequencies around 1 MHz [1] or rely on solely analog circuitry [2]. A digital system provides versatility since several quantities can be computed from the same captured data. The high data capture rates required for good sensitivity set high demand for data processing and/or storage speeds.



[Figure 1]

We present a novel correlation spectrometer for low-temperature quantum transport measurements at 0.7 - 6 GHz, utilizing a four-channel PCI-E digitizer card and data processing on a graphics processing unit (GPU) of a desktop computer. Schematic of the system is presented in Fig. 1. The microwave signals in two amplifier chains are mixed down and separated to quadratures in the IQ mixer, after which the signals are digitized at 125 MS/s at 14-bit resolution. Cross- and autocorrelation values are calculated in real time on the GPU. The sensitivity of our system (630 µK in 1 s) follows the theoretical values for the given sample rate and keeps improving with increasing integration time, as we have determined using Allan deviation analysis [3].

References:
[1] L. DiCarlo, Y. Zhang, D.T. McClure, C.M. Marcus, L.N. Pfeiffer, and K.W. West, Rev. Sci. Instrum. **77**, 73906 (2006).
[2] F.D. Parmentier, A. Mahé, A. Denis, J.-M. Berroir, D.C. Glattli, B. Plaçais, and G. Fève, Rev. Sci. Instrum. **82**, 13904 (2011).
[3] T. Nieminen, P. Lähteenmäki, Z. Tan, D. Cox, and P.J. Hakonen, Rev. Sci. Instrum. **87**, 114706 (2016).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.938
Strong coupling condition for quantum plasmonics with single emitters
Rousseaux B.[1,2], Baranov D.[1], Shegai T.[1], Johansson G.[2], Käll M.[1]

[1]Chalmers University of Technology, Department of Physics, Göteborg, Sweden, [2]Chalmers University of Technology, Department of Microtechnology and Nanoscience - MC2, Göteborg, Sweden

Strong light-matter coupling, manifested in the Rabi splitting of the eigenenergies of the coupled system, is one of the key effects of quantum interaction between photons and quantum emitters (QEs). In the context of quantum optical effects such as single photon blockade, realization of the strong coupling regime with a single QE is of crucial importance. While Rabi splitting of single emitters coupled to high-Q diffraction limited cavities have been reported in numerous configurations, attaining single emitter Rabi splitting with a plasmonic nanostructure is still elusive. Here, we establish the analytical condition for strong coupling of between a single QE and a plasmonic nanocavity and apply it to study various plasmonic arrangements that were shown to enable Rabi splitting. We investigate numerically optical response and the resulting Rabi splitting in metallic nanostructures such as bow-tie nanoantennas, nanosphere dimers and nanoshapes on a surface and find the optimal geometries for emergence of the strong coupling regime with single QEs.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.939

Cross-correlation limit of a SQUID-based noise thermometer of the pMFFT type

Kirste A., Engert J.
Physikalisch-Technische Bundesanstalt (PTB), Berlin, Germany

The primary magnetic field fluctuation thermometer (pMFFT) is a SQUID-based noise thermometer for temperatures below 1 K, which complies with metrological requirements [1]. It combines two signal channels in order to apply the cross-correlation technique, which requires statistically independent noise signals for proper operation [2]. So far, the limit of the cross-correlation readout was checked in a zero measurement without temperature sensor only at 4.2 K, using a special setup [3].
Now we have performed, for the first time, zero measurements in the millikelvin range in a setup that is identical to the pMFFT, except for the removed temperature sensor (copper body) located directly beneath the detection coils. We have examined the influence of different parameters such as SQUID working point or flux-lock loop parameters on the minimum cross-correlation signal down to 24 mK and below 100 kHz. In some configurations we observed typical minimum SQUID-referred cross-power spectral densities of $1.5\times10^{-15}\ \Phi_0^2$/Hz, and in others, even much smaller values. For the pMFFT, considering its thermal noise spectrum, these flux densities correspond to a noise temperature of ≤2.5 µK, enabling a reasonably small uncertainty contribution at the lower end of the PLTS-2000 (0.9 mK).

References:

[1] A. Kirste, J. Engert, A SQUID-based primary noise thermometer for low temperature metrology. Phil. Trans. R. Soc. A **374**, 20150050 (2016)
[2] E. Rubiola and F. Vernotte, The cross-spectrum experimental method. http://arxiv.org/pdf/1003.0113v1.pdf (2010)
[3] A. Kirste, M. Regin, J. Engert, D. Drung, Th. Schurig, A calculable and correlation-based magnetic field fluctuation thermometer. J. Phys.: Conf. Ser. **568**, 032012 (2014)

Postersession 4
Tuesday, 15 August 2017

16.30-18.30
G Foyer

P.940
Ultracold atoms in stroboscopic 1D optical lattices: topology and long-range interactions in phase space crystals
Liang P., Marthaler M., Guo L.
Karlsruher Institut für Technologie (KIT), Karlsruhe, Germany

We propose to investigate topology and many-body physics using ultracold atoms in stroboscopic one-dimensional lattices. In this way, it is possible to create two-dimensional lattices in phase space, which we call phase space crystals[1,2]. Effective Hamiltonians which are otherwise difficult to realize (such as quasicrystals) can be created, and they can be varied by tuning the driving parameters. Phase space crystals also provide a new way to study topological phenomena in physics. They differ from lattices in real space since their coordinate system, i.e., the phase space, has a non-commutative geometry, which naturally produces phases like those arising from magnetic fields. The famous Hofstadter-butterfly structure in the energy spectrum thus can be realized in one-dimensional systems. Furthermore, we find that, in quasi-1D, the point-like contact interaction between ultracold atoms becomes an effective Coulomb-like interaction in phase space. In pure-1D, the hard-core interaction even becomes a quark-like confinement interaction in phase space[3]. Our proposal may bring a new way to simulate many-body dynamics with long-range interactions in ultracold atomic systems.
References:
[1] L. Guo, M. Marthaler and G. Schön, Phys. Rev. Lett. **111**, 205303 (2013)
[2] L. Guo and M. Marthaler, New J. Phys. **18**, 023006 (2016)
[3] L. Guo, M. Liu and M. Marthaler, Phys. Rev. A **93**, 053616 (2016)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.941
Experimental investigation on cryogenic chilldown of helical transfer lines of varying helix angles
Mohammed J.[1], Shameer M.[1], Sasikumar S.[1], Rahman M.[1], Abdul Mohizin A.M.[2], Roy R.[1], Bindu S.S.[1]
[1]TKM College of Engineering, Mechanical Engineering, Kollam, India, [2]Kookmin University, Mechanical Engineering, Seongbuk-gu, Korea, Republic of

Chilldown of transfer lines is an important phenomenon associated with cryogenic liquid transfer from the storage facility to the location of its intended application. As helical transfer lines are widely used as meissner traps in cryopumps, the present study is concentrated on the chilldown time analysis of helical coils.
Liquid nitrogen was used as the cryogen and was transmitted through copper helical test sections with 7.94mm outer diameter, 0.81mm wall thickness and having helix angles 4^0, 6^0, 8^0, 10^0, 12^0, 16^0 and 32^0, with horizontal axes, at three mass fluxes of 66 kg/m^{2}s, 86 kg/m^{2}s and 102 kg/m^{2}s under terrestrial gravity conditions. The sections were instrumented with temperature sensors, the readings of which were tracked in real-time using a Data Acquisition System. Temperature-time relationships were obtained and the results were compared with that of straight channels.
The results of the experiment indicated that the chilldown time is the least for helical coil having helix angle 8^0 for all mass fluxes. The optimum helix angle found would hence serve in minimising the chilldown time, thereby reducing the cryogenic liquid consumption. Finding correlations connecting heat transfer parameters in helical coils would enhance the scope of this study.

References:
[1] J.C. Burke, W.R. Byrnes, A.H. Post, F.E. Ruccia, Pressure cooldown of cryogenic transfer lines, Adv. Cryogenic Eng. 4 (1960) 378-394
[2] R. Shaeffer et al. / International Journal of Heat and Mass Transfer 67 (2013) 955-966
[3] D.G. Prabhanjan, G.S.V. Raghavan, T.J. Rennie, Comparison of heat transfer rates between a straight tube heat exchanger and a helically coiled heat exchanger

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.942

Frequency dependent ac transport of films of close-packed carbon nanotube array

Endo A.[1], Katsumoto S.[1], Matsuda K.[2], Norimatsu W.[2], Kusunoki M.[3]
[1]Univerisity of Tokyo, Institute for Solid State Physics, Chiba, Japan, [2]Nagoya University, Graduate School of Engineering, Nagoya, Japan, [3]Nagoya University, Institute of Materials and Systems for Sustainability, Nagoya, Japan

Films of closely-packed, highly-aligned carbon nanotubes can be prepared by thermal decomposition of silicon carbide wafers [1]. We have measured the low-temperature ac resistance of such films with the thickness (the length of the nanotubes) ranging from 6.5 to 65 nm. We found that the resistance rapidly decrease with the frequency. This can be interpreted as resulting from the electric transport via capacitive coupling between adjacent nanotubes. We also found numbers of sharp spikes superposed on frequency vs. resistance curve, which presumably represent resonant frequencies seen in the calculated conductivity of random capacitance networks [2,3]. Coupling between the nanotubes were reduced by the magnetic field parallel to the nanotubes.

References:
[1] K. Kusunoki, T. Suzuki, T. Hirayama, and N. Shibata, Appl. Phys. Lett. **77**, 531 (2000).
[2] N. A. Olekhno, Y. M. Beltukov, and D. A. Parshin, J. Phys: Conference Series **661**, 012042 (2015).
[3] P. Karki and Y. L. Loh, J. Phys: Condens. Matter **28**, 435701 (2016).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.944

Magnetic properties of NiO/(Bi,Pb)-2223 composite

Isber S.[1], Rahal H.T.[2], Awad R.[3], Abdel-Gaber A.M.[2,4]
[1]American University of Beirut, Physics Department, Beirut, Lebanon, [2]Beirut Arab University, Chemistry Department, Beirut, Lebanon, [3]Beirut Arab University, Physics Department, Beirut, Lebanon, [4]Alexandria University, Chemistry Department, Alexandria, Egypt

Composite superconducting samples of type $(NiO)_x(Bi_{1.6}\,Pb_{0.4})Sr_2Ca_2Cu_3O_{10}\text{-}_d$, wt.%, were synthesized by the conventional solid-state reaction technique. The nano-sized NiO particles were prepared by the Co-participation method by using EDTA as capping; their average crystalline size was about 30 nm. The temperature dependence of AC-magnetic susceptibility at various oscillatory magnetic field amplitudes (3-15 Oe) were investigated by using the Bean critical state model. The values of the critical current density J_c at $T > T_p$ (T_p is the inter-granular loss peak temperature) as a function of both the amplitude of the magnetic field and the nanosized NiO- content were estimated. It was found that the addition of low concentration (*x*) of nano-sized NiO increases J_c in (Bi,Pb)-1223 superconducting phase. Moreover, the observed variation of J_c with temperature indicates that the weak links between the superconducting grains changes from superconductor-normal metal-superconductor (SNS) to superconductor-insulator-superconductor (SIS) junctions as x is increased. We also discuss the experimental results in the framework of the critical state model to estimate the effective volume fraction of the grains g_f using Cole-Cole plots.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.945

Scanning tunneling spectroscopy at very low temperatures in URu_2Si_2

Herrera Vasco E.[1], *Barrena V.*[1], *Guillamón I.*[1,2], *Levy A.*[1], *Suderow H.*[1,2], *Aoki D.*[3], *Flouquet J.*[3]
[1]Universidad Autónoma de Madrid, Madrid, Spain, [2]Unidad Asociada de Bajas Temperaturas y Altos Campos Magnéticos, UAM, CSIC, Madrid, Spain, [3]Institut Nanosciences et Cryogénie, SPSMS, CEA-Grenoble, Grenoble, France

The rich physics behind the Kondo lattice in URu_2Si_2 has been revealed thanks to surface interference experiments using Scanning Tunneling Microscopy [1,2]. These experiments have shown the formation of heavy quasiparticles and characterized the hidden order phase with a gap, giving tunneling conductance curves that remain wavy down to surprisingly low energies. Here we have studied the superconducting phase of URu_2Si_2 with detail [3]. We show how the superconducting gap opens in the extremely energy dependent background and propose a new multiple channel tunneling scheme that accounts for the observed superconducting tunneling conductance. Our quasiparticle interference experiments show the low temperature reconstructed Fermi surface and the superconducting gap opening. Furthermore, we observe a strong feature at the same energy as the peak in the dynamical spin susceptibility and discuss its relation to superconductivity. Finally, we present amazing modulations of the surface topography and discuss their origin.

References:

[1] P. Aynajian, et. al., PNAS **107**, 10383 (2010)
[2] A. R. Schmidt, et. al., Nature, **465**, 570 (2010)
[3] E. Herrera, In preparation.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.946

Probing the superconducting state of $SrTiO_3/LaAlO_3$ by using superconducting coplanar waveguide resonators

Saglam Y., *Manca N.*, *Bothner D.*, *Caviglia A.*, *Steele G.*

Delft University of Technology, Quantum Nanoscience, Kavli Institue of Nanoscience, Delft, Netherlands

Discovery of two dimensional electron gas at the interface between bulk $SrTiO_3$ (STO)and $LaAlO_3$ (LAO) thin film have led to a strong interest owing to their electronic and structural properties.This 2DES exhibit electrical conductivity, low-temperature superconductivity and ferromagnetism. Coplanar waveguide resonators are accomplished tools for probing wide variety of excitations in circuit and materials. They can have a very high quality factors owing to their low intrinsic losses. This makes CPW's interesting candidate as sensitive probes of electronic properties of materials.
In this study, we are probing the superconducting state of (100) STO/LAO interfaces by using superconducting coplanar waveguides. By measuring the characteristics of a CPW made of a STO/LAO superconducting 2DES we can directly probe the characteristics of the superfluid.
Here, we fabricated a waveguide resonator out of a STO/LAO thin film within a line width S is 40um, the gap to the ground plane W is 10um and the line length l is 2.5mm. Later, we probe the CPW with a Vector Network Analyser by sending a signal out of one port and measuring its amplitude in another one.
We measure the CPW spectral response as a function of temperature, back-gate voltage and power of the RF field.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.947

Superconducting resonators with single photon quality factors approaching 1 Million

Burnett J., Bengtsson A., Niepce D., Bylander J.
Chalmers, University of Technology, MC2, Gothenburg, Sweden

Superconducting resonators are sensitive probes of the loss and noise mechanisms that cause decoherence in superconducting qubits. We are optimising the single photon quality factor of superconducting $\lambda/4$ resonators fabricated from aluminium on silicon. Here, we examine the dependence of microwave losses on the magnetic environment, microwave circuitry, cryogenic filtering and material interfaces. We obtain quality factors that are equivalent to those found in state of the art superconducting qubits.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.948

High magnetic field scanning tunneling microscopy and spectroscopy in the type-II Weyl semimetal WTe_2

Martín Vega F.[1], Guillamón I.[1], Suderow H.[1], Jo N.H.[2], Bud'ko S.L.[2], Canfield P.C.[2]

[1]Universidad Autonoma de Madrid, Instituto de Ciencia de Materiales Nicolas Cabrera and Condensed Matter Physics Center (IFIMAC), Madrid, Spain, [2]Ames Laboratory, U.S. DOE, Iowa State University, Department of Physics and Astronomy, Ames, United States

The material WTe_2 crystallizes in a layered structure without inversion symmetry. The crystals are of extremely high quality. In particular, at zero field, the residual resistance is nearly three orders of magnitude smaller than the room temperature resistance [1]. Interestingly, when applying a magnetic field, the magnetoresistance increases by more than five orders of magnitude [1]. The dependence on the magnetic field is linear and the origin for this linear magnetoresistance is highly debated. The Fermi surface has been studied using ARPES and quantum oscillations [2]. This material is conjectured to be a type-II Weyl semimetal. Here we use Scanning Tunneling Spectroscopy at high magnetic fields to investigate the electronic structure at the surface down to atomic scale. We observe atomic scale images showing the crystalline structure without inversion symmetry. We make quasiparticle interference imaging and find topologically non-trivial features in the bandstructure. Finally, we also discuss a new shapal-made, very small-sized, high magnetic field STM (which is a modified design of [3]) that will be capable to perform measurements down to 10 mK and up to 17 T.

References:

[1] Y. Wu et al., *Phys. Rev. Lett*. **115**, 166602 (2015)
[2] Y. Wu et al., *Phys. Rev. B.*, **94**, 121113 (2016)
[3] H. Suderow et al. *Review of Scientific Instruments* **82**, 033711 (2011)

Work supported by Spanish MINECO, ERC Starting Grant and CIG Marie Curie program.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.949

Indirect exchange interaction between magnetic impurities in CdTe/HgTe/CdTe quantum wells

Kurilovich P.[1,2]*, Kurilovich V.*[1,2]*, Burmistrov I.*[1,3]
[1]Moscow Institute of Physics and Technology, Dolgoprudny, Russian Federation, [2]Skolkovo Institute of Science and Technology, Moscow, Russian Federation, [3]L.D. Landau Institute for Theoretical Physics, Moscow, Russian Federation

We study indirect exchange interaction between magnetic impurities in the (001) CdTe/HgTe/CdTe symmetric quantum well. We consider low temperatures and the case of the chemical potential placed in the energy gap of the two-dimensional quasiparticle spectrum. We find that the indirect exchange interaction is suppressed exponentially with the distance between magnetic impurities. The presence of inversion asymmetry results in oscillations of the indirect exchange interaction with the distance and generates additional terms which are noninvariant under rotations in the (001) plane. The indirect exchange interaction matrix has complicated structure with some terms proportional to the sign of the energy gap.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.950

Indirect exchange interaction between magnetic impurities near the helical edge

Kurilovich V.[1,2], Kurilovich P.[1,2], Burmistrov I.[1,3]
[1]Moscow Institute for Physics and Technology, Dolgoprudny, Russian Federation, [2]Skolkovo Institute of Science and Technology, Moscow, Russian Federation, [3]Landau Institute for Theoretical Physics, Chernogolovka, Russian Federation

The indirect exchange interaction between magnetic impurities located in the bulk of a two-dimensional topological insulator decays exponentially with the distance. The indirect exchange interaction for magnetic impurities mediated by the helical states at the edge of the topological insulator demonstrates behavior which is typical for the Ruderman-Kittel-Kasuya-Yosida interaction in a one-dimensional metal. We have shown that interference between the bulk and the edge states in the two-dimensional topological insulator results in existence of an unusual contribution to the indirect exchange interaction which, on the one hand, decays exponentially with a distance at the length scale controlled by the Fermi energy of the edge states and, on the other hand, oscillates with distance along the helical edge with the period determined by the Fermi wavelength. We found that this interference contribution to the indirect exchange interaction becomes dominant for such configurations of two magnetic impurities that one of them is situated close to the helical edge whereas the other one is located far away in the bulk.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.951

Cooling metallic samples to microkelvin temperatures for electrical transport measurements

Nguyen H.D.[1], Sidorenko A.[1], Haenel J.[1], Geiger D.[1], Krellner C.[2,3], Steglich F.[3], Paschen S.[1]
[1]Vienna University of Technology, Institute of Solid State Physics, Vienna, Austria, [2]Goethe University Frankfurt, Frankfurt am Main, Germany, [3]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany

In general, a sample can be cooled down to µK temperatures by direct coupling to a nuclear demagnetization refrigerator (NDR). However, in the case of transport properties measurements on metallic samples with an extremely low resistance at ultra-low temperatures (ULT) this method cannot be used due to high noise level. In order to avoid direct electrical contacts between metallic samples and the NDR we have constructed a liquid ^{3}He cell and succeeded in cooling a high quality single crystal of $YbRh_2Si_2$ down to µK temperatures. Each device measurement lead was attached to an individual sintered silver heat exchanger, which was immersed in liquid ^{3}He, allowing efficient thermal contact to the µK bath. The cell was thermally coupled with the NDR of the Vienna Microkelvin Laboratory [1]. A quartz tuning fork integrated into the cell was served as a thermometer at the ULT. A calibration of the thermometer was performed by using ^{195}Pt pulsed NMR and CMN thermometers. The ^{3}He cell was enclosed in magnetic shielding consisting of high permeability material called Cryoperm-10 and superconducting lead (Pb) shields. We found that this design with heat exchanger cooling is applicable to study the field-induced quantum critical behaviour of heavy fermion compounds at µK temperatures regime.
We acknowledge financial support from the Austrian Science Fund (FWF project P29296-N27) and the European Research Council (ERC Advanced Grant 227378).

References:

[1] D. H. Nguyen et al., J. Phys.: Conf. Series 400, 052024 (2012).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.953
Binary energy spectrum of counter-propagating Tomonaga-Luttinger liquid
Tokura Y.
University of Tsukuba, Physics, Tsukuba, Japan

Non-equilibrium steady states beyond the linear response regime are the actively researched field in many physical systems. In condensed matters, quantum Hall edge states provide the system of topologically protected and well-defined effect of interaction. Recently, a long-lived binary energy distribution spectrum had been observed in the electro-statically coupled two v=2 quantum Hall edge channels, when one of the channels is fed with electrons via a quantum point contact (QPC) with higher energies compared with that of the other channels [1]. The spectra of the counter-propagating channels were observed by weakly-coupled single-level quantum dot. The results were theoretically analyzed with the model that one of the channels is maintained to a higher temperature. The observed stability of the energy distribution spectra implies the manifestation of the integrable characteristics of the chiral Tomonaga-Luttinger liquid [2]. In this contribution, we extend the analysis by considering the finite transmission probability of the QPC from the biased reservoir, instead of considering higher temperature reservoir. We also quantitatively studied the effect of various decoherence/dissipation mechanisms for the longer edge propagation length [3]. Supported by JSPS KAKENHI (26247051).

References:
[1] K. Washio, R. Nakazawa, M. Hashisaka, K. Muraki, Y. Tokura, and T. Fujisawa, Phys. Rev. B 93, 075304 (2016).
[2] M. Hashisaka, N. Hiyama, T. Akiho, K. Muraki and T. Fujisawa, Nat. Phys. (2017) doi:10.1038/nphys4062.
[3] K. Sasaki, S. Murakami, Y. Tokura, and H. Yamamoto, Phys. Rev B 93, 125402 (2016).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.954
Generation and non-destructive detection of single microwave photons
Sathyamoorthy S.R., _Johansson G._
Chalmers University of Technology, Gothenburg, Sweden

Microwave quantum optics using superconducting circuits has been a fast growing field in the past few years. In this field known as circuit-QED, microwaves guided through 1-D transmission lines interact with superconducting artificial atoms. Fundamental tools in these systems are the single photon sources and detectors in microwave frequencies. Such sources and detectors are useful for studying the foundations of quantum mechanics, for several applications in quantum communications, quantum computing and in metrology.
In this presentation, we show how to generate and detect microwave photons using superconducting qubits at the end of a semi-infinite transmission line. Such a setup is analogous to having an atom in front of a mirror, and along with either a beam splitter or tunable coupling, can be used to generate single photons on demand with high efficiency. We also present a scheme to non-destructively detect

a propagating microwave photon by cascading atoms in front of a mirror. To do this, we take advantage of the strong photon-photon interaction mediated by a three level superconducting atom. We show that with few atoms, it is possible to achieve signal to noise ratio (SNR) for photon detection above 1.

References:

[1] S. R. Sathyamoorthy, A. Bengtsson, S. Bens, M. Simoen, P. Delsing, and G. Johansson, Phys. Rev. A **93**, 063823 (2016).
[2] S. R. Sathyamoorthy, L. Tornberg, A. F. Kockum, B. Q. Baragiola, J. Combes, C. M. Wilson, T. M. Stace, and G.Johansson, Phys. Rev. Lett. 112, 093601 (2014).
[3] S. R. Sathyamoorthy, T. M. Stace, and G. Johansson, Comptes Rendus Phys. 17, 756 (2016).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.955

Triplet superconducting correlations and spin imbalance in magnet-superconductor hybrid structures

Seja K.M.[1], *Löfwander T.*[1], *Shevtsov O.*[2]
[1]Chalmers University of Technology, Göteborg, Sweden, [2]Northwestern University, Evanston, United States

We examine a superconductor that is in contact with a normal metal via a spin-active interface. Using quasiclassical theory of superconductivity, we study the system in equilibrium as well as in non-equilibrium induced by a voltage bias. Earlier investigations have shown that in equilibrium the interface gives rise to Andreev bound states that induces a spin magnetization in the superconductor. It was found that this equilibrium magnetization is related to non-trivial triplet superconducting correlations, a key feature of unconventional superconductivity. Out of equilibrium there is an additional contribution to spin imbalance related to spin-filtering and spin-mixing mechanisms. [1,2] However, in non-equilibrium the possible connection between magnetization and superconducting triplet correlations is not yet understood. The aim of this work is to examine this relation as well as the change in distribution and the spatial behavior of these correlations in non-equilibrium configurations.

References:

[1] O. Shevtsov and T. L\"ofwander, J. Phys Conf. Ser. \textbf{568}, 2 (2014)
[2] O. Shevtsov and T. L\"ofwander, Phys. Rev. B. \textbf{90}, 085432 (2014)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.956

Dynamic scaling law and phase ordering percolation in multi-component superfluids

Takeuchi H.
Osaka City University, Department of Physics, Osaka, Japan

There has been growing interest in the phase ordering kinetics of atomic Bose-Einstein condensates (BECs), and the dynamic-scaling law in superfluid systems has been investigated theoretically in different situations.

Recently, percolation theory has been applied to the segregation of binary BECs in quasi-two-dimensions, and the dynamic finite-size-scaling analysis revealed that the domain structures preserve the percolation criticality during Z_2 symmetry breaking with the percolation threshold p_c=0.5 [1].
In this work, the domain-area distribution in the phase transition dynamics of Z_2 symmetry breaking is studied for quasi-two-dimensional multi-component superfluids [2,3]. The distribution is divided into microscopic and macroscopic regimes with distinct power-law exponents. The macroscopic regime universally exhibits Fischer´s law in percolation theory, while the microscopic regime depends on the microscopic dynamics of the system. Numerical experiments of segregating binary BECs reveal that the exponent in the microscopic regime reaches its theoretical upper limit in the presence of the circular vortex sheet described by quantum hydrodynamics. An analogy to quantum turbulence and the applicability to superfluid ^{3}He-A in a slab are also discussed.

References:

1. H. Takeuchi, Y. Mizuno, and K. Dehara, Phys. Rev. A **92**, 043608 (2015).
2. Hiromitsu Takeuchi, J. Low Temp. Phys. **183**, 169 (2016).
3. Hiromitsu Takeuchi, arXiv:1703.10581 (2017)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.957

Anomalous dispersion relations in the coexisting state of the staggered flux state and d-wave superconductivity

Tsuchiura H.[1], *Ogata M.*[2], *Yamazaki K.*[1], *Asaoka R.*[1]
[1]Tohoku University, Department of Applied Physics, Sendai, Japan, [2]University of Tokyo, Department of Physics, Bunkyo-ku, Japan

Recent experimental studies have indicated that the pseudogap phase in underdoped high-Tc cuprates is accompanied by some phase transitions with the breaking of time-reversal, rotational, or translational symmetry. These symmetry breakings imply that there can be nematic order, charge order, or other instabilities in the pseudogap phase. It has also been suggested that the pseudogap order and d-wave superconductivity (dSC) can coexist within the superconducting dome of the cuprates at p< 0.19, where p is the hole concentration, resulting in a gap to open with broken particle-hole symmetry found in the recent ARPES data [1].
Motivated by these experimental evidences, we here focus on a staggered flux (SF) state, which is a *normal* (or non-superconducting) state with broken symmetries. In particular, we study the quasiparticle dispersions in the coexisting states of the SF and dSC by using the t-J model within the Bogoliubov-de Gennes theory based on an extended version of the Gutzwiller approximation. We find the gap structure without particle-hole symmetry in the dispersion relations consistent with the ARPES data mentioned above. We will also discuss the temperature dependences of this gap structures.

References:

[1] M. Hashimoto *et al*., Nat. Phys. **10**, 483 (2014)
[2] M. Ogata and A. Himeda, J. Phys. Soc. Jpn. **72**, 374 (2003)
[3] H. Tsuchiura et al, Phys. Rev. B **64**, 140501(R) (2001), *ibid*. **68**, 012509 (2003)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30

G Foyer

P.964

Magnetic flux sensor based on a superconducting circuit

Danilin S.[1], Lebedev A.[2], Vepsäläinen A.[1], Lesovik G.[3], Blatter G.[2]
[1]Aalto University, Department of applied physics, Espoo, Finland, [2]ETH Zürich, Zürich, Switzerland, [3]Landau Institute for Theoretical Physics, Moscow, Russian Federation

Many important quantum algorithms, like Shor's factorization algorithm [1] and Lloyd's algorithm [2] for solving a system of linear equations, employ phase estimation algorithms. Besides its applicability in quantum computing and quantum information processing, phase estimation is at the core of quantum metrological measurements. In this kind of measurement one estimates an unknown parameter, which commonly determines the energy states of the system. The energy states can be measured through an estimation of a phase accumulated by the system during its time evolution. Fast estimation of the phase can be realized in a coherent quantum system, where the phase precision is limited by the Heisenberg relation, whereas in a standard classical measurement the precision is restricted by a shot noise limit. Nowadays the Heisenberg limit can be reached with the use of two major classes of phase estimation algorithms: first one suggested by Kitaev [3] and another one originated from the quantum Fourier transform. Here we show how to implement suitably modified Kitaev- and Fourier algorithms on a superconducting transmon qubit, and use it as a Heisenberg limited sensor of magnetic flux. Our experiment paves the way for the use of superconducting qubits as metrological devices.

References:

[1] P.W. Shor, ”Algorithms for quantum computation: discrete logarithms and factorizing“, Proceedings of the 35th Annual Symposium on Foundations of Computer Science (IEEE Computer Science Press, 1994), pp. 124-134
[2] A.W. Harrow, A. Hassidim, and S. Lloyd, ”Quantum algorithm for solving linear systems of equations“, Phys.Rev.Lett. 15, 150502 (2009)
[3] A.Yu. Kitaev, ”Quantum measurements and the Abelian stabilizer problem“, arXiv:quant-ph/9511026 (1995)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.966

Superfluid ^{3}He beyond weak-coupling[1]

Wiman J., Sauls J.A.
Northwestern University, Physics & Astronomy, Evanston, United States

Although it has been the subject over 40 years study and observation, superfluid ^{3}He still lacks a precise theoretical model for the phase diagram and thermodynamics beyond BCS weak-coupling theory. One of the most striking features of the superfluid ^{3}He is the appearance of the A phase above the polycritical pressure of 21 bar, separated from the B phase by a pressure and temperature dependent first-order transition. The stability of the A phase over the B phase can only be achieved by including higher-order corrections to the superfluid free energy beyond that of weak-coupling BCS theory. We use the formulation of Rainer & Serene[2] for the free-energy functional of ^{3}He, and construct a theoretical model for superfluid ^{3}He that accurately describes the bulk A and B phases at and below T_c, for all pressures,

0 to 34 bar. The key input to this theory is the normal-state quasiparticle scattering amplitude. Once this amplitude is fixed it may be used to make precise theoretical predictions of not only the bulk phases but also inhomogeneous superfluid ^{3}He under confinement. In particular, recent experiments in thin film geometries[3] cannot be interpreted theoretically without a strong-coupling model even at low pressures.

References:
[1] Supported by NSF grants DMR-1106315 and DMR-1508730.
[2] D. Rainer & J. W. Serene. Phys. Rev. B 13.11 (1976)
[3] L. V. Levitin et al. Science 340.6134 (2013)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.967

Anomalous Hall effect and magnetic orderings in nano-thick V_5S_8

Niu J.[1], Ji Q.[2], Yan B.[1], Li M.[1], Gao P.[1], Liu Z.[2], Zhang Y.Z.[2], Yu D.[1], Wu X.[1]
[1]Peking University, Physics, Beijing, China, [2]Peking University, Chemistry, Beijing, China

The rise of graphene marks the advent of two-dimensional atomic crystals, which have exhibited a cornucopia of intriguing properties, such as the integer and fractional quantum Hall effects, valley Hall effect, charge density waves and superconductivity, to name a few. Yet, magnetism, a property of extreme importance in both science and technology, remains elusive. There is a paramount need for magnetic two-dimensional crystals. With the availability of many magnetic materials consisting of Van der Waals coupled two-dimensional layers, it thus boils down to the question of how the magnetic order will evolve with reducing thickness. Here we investigate the effect of thickness on the magnetic ordering in nano-thick V_5S_8. We uncover an anomalous Hall effect, by which the magnetic ordering in V_5S_8 down to 3.2 nm is probed. With decreasing thickness, a breakdown of antiferromagnetism is evident, followed by a spin-glass-like state. For thinnest samples, a weak ferromagnetic ordering emerges. The results not only show an interesting effect of reducing thickness on the magnetic ordering in a potential candidate for magnetic two-dimensional crystals, but demonstrate the anomalous Hall effect as a useful characterization tool for magnetic orderings in two-dimensional systems.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.968

Superconductivity in the underdoped region of the T'-structure cuprates based on an effective two-band model

Yamazaki K.[1], Tsuchiura H.[1], Yoshioka T.[1], Ogata M.[2]
[1]Tohoku University, Department of Applied Physics, Sendai, Japan, [2]University of Tokyo, Department of Physics, Bunkyo, Tokyo, Japan

Recently, growing attention has been paid to the reconstruction of the phase diagram of the T'-structure cuprates, that is, the so-called electron-doped cuprates. Several experimental studies have shown that the T'-type cuprates exhibit superconductivity with very low or without chemical carrier doping, only when excess oxygen which inevitably exists in as-grown samples are properly removed [1-3].
Theoretically, we have studied the superconducting transition around the underdoped region of these cuprates based on an effective two-band model for the CuO_2 plane, which can be derived from the d-p model essentially along with the idea of Zhang and Rice [4], but explicitly consists of Cu d-orbitals and symmetrically hybridized O 2p orbitals. By applying the fluctuation-exchange approximation (FLEX), we found that the d-wave superconductivity appears around the underdoped region and even at the half-filling when the charge transfer gap Δ = Ud - Δp is small enough (less than about 1.8 eV), where Ud is the on-site Coulomb repulsion on Cu site and Δp is the energy difference between the O 2p and Cu 3d levels. We also found the deformation of the Fermi surface induced only by changing the charge transfer gap, which is consistent with the recent ARPES observation for PLCCO[5].

References:
[1] A. Tsukada *et al*., Solid State Commun.**133**, 427 (2005).
[2] O. Matsumoto *et al*., Physica C **469**, 924 (2009).
[3] S. Asai et al., Physica C 471, **682** (2011).
[4] F. C. Zhang and T. M. Rice, Phys. Rev. B 37, 3759 (1988).
[5] M. Horio *et al*., Nature Commun. **7**, 10567 (2016).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.970
BCS pairing state of a dilute Bose gas with spin-orbit coupling
Yin L.
Peking University, Physics, Beijing, China

We study a two-component Bose gas with a symmetric spin-orbit coupling, and find that two atoms can form a bound state with any intra- or inter-species scattering length. Consequently, in the dilute limit, the Bardeen-Cooper-Shrie
er (BCS) pairing state of bosons can be formed with weakly-attractive inter-species and repulsive intra-species interactions. The quasiparticle excitation energies are anisotropic due to spin-orbit coupling. This BCS paring state is energetically favored over Bose-Einstein condensation (BEC) of atoms at low densities. As the density increases, there is first-order transition from the BCS to BEC states.

References:
[1] D. Luo and L. Yin, arXiv:1609.09691 (2016)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.971
Self-energy in the superconducting states of the high-T_c cuprates revealed by angle-resolved photoemission spectroscopy

Yoshida T.[1], Ootsuki D.[1], Yamawaki K.[1], Shimonaka D.[1], Shibata D.[1], Eisaki H.[2], Sasagawa T.[3], Fujimori A.[4], Kumigashira H.[5], Ono K.[5], Arita M.[6], Namatame H.[6], Taniguchi M.[6], Ideta S.[7], Tanaka K.[7]
[1]Kyoto University, Kyoto, Japan, [2]National Institute of Advanced Industrial Scienceand Technology, Tsukuba, Japan, [3]Tokyo Institute of Technology, Yokohama, Japan, [4]University of Tokyo, Tokyo, Japan, [5]KEK Photon Factory, Tsukuba, Japan, [6]Hiroshima University, Higashi-Hiroshima, Japan, [7]Institute for Molecular Science, Okazaki, Japan

In previous angle-resolved photoemission (ARPES) studies of the high-T_c cuprate superconductors, self-energy analyses have been done mostly in the nodal direction where the superconducting gap closes. However, in order to investigate the paring mechanism, the self-energy in the anti-nodal direction in the superconducting state is important. Several ARPES studies have reported the self-energy for the spectra with superconducting gap [1,2] and pointed out that there is bosonic structure in the self-energy. However, the origin of the bosonic mode has not been clarified yet.
In the present study, we have performed ARPES study of the high-T_c cuprates $Bi_2Sr_2CaCu_2O_{8+d}$ (Bi2212) and have extracted the self-energy from the ARPES spectra. Particularly, we have separated the normal and anomalous self-energy in the superconducting anti-nodal spectra. The both self-energies have a characteristic energy scale corresponding to the pole of the functions, while the energy scale of the pole does not appear in the ARPES spectra. This result is consistent with the theoretical prediction by the cellular dynamical mean-field theory calculation and the composite fermion model [3,4].

References:
[1] M. R. Norman *et al*. Phys. Rev. B **60**, 7585 (1999).
[2] J. M. Bok *et al*., Sci. Adv. **2**, e1501329 (2016).
[3] S. Sakai, M. Civelli, and M. Imada, Phys. Rev. Lett. **116**, 057003 (2016).
[4] S. Sakai, M. Civelli, and M. Imada, Phys. Rev. B **94**, 115130 (2016).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.972
Ginzburg-Landau analysis of slow dynamics near charge ordering transition
Yoshimi K., Kato T., Konishi Y.
ISSP, Univerisity of Tokyo, Chiba, Japan

Theta-type BEDT-TTF salts is one of typical quasi-two-dimensional organic conductors which induce charge ordering (CO) transition at low temperatures. Recently, glass-like slow dynamics has been observed in these salts near the CO transition temperature [1]. The origin of this slow dynamics has been discussed in several theoretical works. In Ref. [2], one of the authors has shown by the fluctuation-exchange approximation that a charge compressibility becomes negative in the vicinity of CO transition, indicating a tendency of phase separation. Furthermore, it has been also found that a glassy behavior can be reproduced by a competition between the phase separation and long-range Coulomb interaction by analytic calculation of the Ginzburg-Landau (GL)theory [3]. However, an estimate of a relaxation time is difficult by this analysis. In this study, we estimate a relaxation time, a charge domain size and, a correlation length as a function of the system parameters by solving the Ginzburg-Landau equation numerically, and discuss a relation between phase separation and glassy behavior. We also compare our result with a recent Monte Calro study in which the importance of the geometric charge frustration on the long-range Coulomb interaction has been stressed [4].

References:
[1] F. Kagawa *et al.*, Nat. Phys. **9**, 419 (2013).
[2] K. Yoshimi and H. Maebashi, J. Phys. Soc. Jpn. **81**, 063003 (2012) .

[3] J. Schmalian and P. G. Wolynes, Phys. Rev. Lett. **85**, 836 (2000) .
[4] S. Mahmoudian *et al.*, Phys. Rev. Lett. **115**, 025701(2015).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.973
Frist-principle study on spin reorientation transitions in $R_2Fe_{14}B$ systems
Yoshioka T.[1], *Tsuchiura H.*[1], *Novak P.*[2]
[1]Tohoku University, Sendai, Japan, [2]Institute of Physics ASCR, Prague, Czech Republic

$Nd_2Fe_{14}B$, the main phase of strong permanent magnet Nd-Fe-B, exhibits non-trivial magnetic behavior at the low-temperatures. That is the so-called spin-reorientation (SR) transition where the ferromagnetic easy-axis rotates about 30 degrees gradually from the c-axis direction below T~135K. Among the $R_2Fe_{14}B$ compounds (*R*: rare-earth), such transition appears in *R*=Nd, Ho, Er, Tm, and Yb with several transition temperatures T_{SR} and maximum angles θ_{max} for each *R* [1]. A multi-parameter analysis of the magnetization curves of these systems have been successfully carried out within the crystal field theory based on a conventional single ion model [2], which is followed by the study on the first-principles-based crystal field theory [3,4]. These studies, however, assumed a completely localized 4f electronic picture that may not be plausible for $R_2Fe_{14}B$ systems with lighter *R*-ions such as Nd. Thus, theoretical examination of this SR transitions based on fully first-principles method is needed not only to obtain a satisfactory understanding of the magnetic properties of $R_2Fe_{14}B$ but also to establish a way to predict the properties of newly found or newly emerging magnetic materials. In this contribution, we deeply understand the magnetic properties of $R_2Fe_{14}B$ systems.
References:
[1] J. F. Herbst, Rev. Mod. Phys. **63**, 819 (1991).
[2] M. Yamada, H. Kato, H. Yamamoto, and Y. Nakagawa, Phys. Rev. B **38**, 620 (1988).
[3] K. Hummler and M. Fähnle, Phys. Rev. B **53**, 3290 (1996).
[4] T. Yoshioka, H. Tsuchiura, P. Novák MATER RES INNOV **19**, S34-S38 (2015).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.974
Multistage RF filtering system for ultralow temperature nanoelectronic experiments
Zavyalov V.[1], *Chernyaev S.*[2], *Shein K.*[2], *Shukaleva A.*[2], *Arutyunov K.*[1,2]
[1]Kapitza Institute for Physical Problems, RAS, Moscow, Russian Federation, [2]National Research University Higher School of Economics, Moscow Institute of Electronics and Mathematics, Moscow, Russian Federation

At ultralow temperatures (T< 100 mK) rather small external disturbance might lead to a noticeable overheating. While electron transport measurements the inevitable external EM noise, picked-up and transmitted through electric wires, results in a mismatch between the electron Te and the phonon Tph temperatures P~W(Te^5-Tph^5), where P is the power dissipated at the sample with volume W. Hence, for sufficiently small nanoelectronic systems the effect might be clearly pronounced. Multiple methods have been suggested to reduce the undesired electron heating. Typically various RF filters are used to cut the impact of noisy EM environment. Often the supporting amplitude vs. frequency data are obtained only at room temperatures analyzing the impact of 'isolated' elements without taking into consideration the wires. Here we describe the custom made multistage RLC filtering system for ultralow temperature nanoelectronic experiments. The amplitude vs. frequency characteristics were measured down to very low temperatures. Distributed elements theory analysis supports experimental data.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.975

Puzzling thermal counterflow turbulence in superfluid helium-4

Gao J.[1]*, Varga E.*[1,2]*, Guo W.*[1]*, Vinen W.*[3]

[1]Florida State University, National High Magnetic Field Lab, Mechanical Engineering Department, Tallahassee, United States, [2]Charles University, Department of Physics, Prague, Czech Republic, [3]University of Birmingham, School of Physics and Astronomy, Birmingham, United Kingdom

Thermal counterflow turbulence in superfluid helium-4 is the first type of quantum turbulence to be identified and studied [1]. The generation of turbulence in the superfluid as a random tangle of vortices, assuming a spatially uniform laminar flow of the normal fluid, has been understood for years [2]. However, our recent flow visualization studies, based on imaging thin lines of He_2 molecular tracers, have revealed that this small-scale turbulence can be accompanied by large-scale turbulence in both fluids with a novel energy spectrum [3,4]. Recent theoretical work suggests that this spectrum arises from a balance between two processes: the counterflow that tends to pull eddies in the two fluids apart, and mutual friction that tends to keep them coincident [5]. The latter process ought to win at high heat fluxes, leading to a spectrum more of the classical Kolmogorov form. Here we report our latest studies showing that the energy spectrum of the large-scale turbulence deviates more strongly from the classical form as the heat flux is increased, in apparent disagreement with the theory. This result shows that our current understanding of the large-scale turbulence in counterflow remains seriously incomplete, which calls for more studies of this interesting form of turbulence.

References:

[1] W. F. Vinen, Proc. R. Soc. London. Ser. **A 242**, 493 (1957).
[2] K.W. Schwarz, Phys. Rev. **B 18**, 245-262 (1978).
[3] A. Marakov, J. Gao, W. Guo, S.W. Van Sciver, G.G. Ihas, D.N. McKinsey, and W.F. Vinen, Phys. Rev. **B 91**, 094503 (2015).
[4] J. Gao, W. Guo, V.S. L´Vov, A. Pomyalov, L. Skrbek, E. Varga, and W.F. Vinen, JETP Letters, **103**, 732 (2016).
[5] S. Babuin, V. S. L´vov, A. Pomyalov, L. Skrbek, and E. Varga, Phys. Rev. **B 94**, 174504 (2016).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.977
Observation of doubly dressed states in a transmon qubit
Luo X.-Q.[1], *Li T.-F.*[2,3], *Zhang D.-K.*[1], *Wang Y.-P.*[1], *Wang S.-P.*[1], *Tsai J.-S.*[3,4], *You J.Q.*[1]
[1]Beijing Computational Science Research Center, Quantum Physics and Quantum Information Division, Beijing, China, [2]Tsinghua University, Institute of Microelectronics, Tsinghua National Laboratory of Information Science and Technology, Beijing, China, [3]RIKEN Center for Emergent Matter Science (CEMS), Saitama, Japan, [4]Tokyo University of Science, Department of Physics, Tokyo, Japan

We have experimentally studied a system composed of a transmon qubit coupled to the electromagnetic field in a three-dimensional cooper microwave cavity. Due to the weak anharmonicity of the transmon qubit, it is possible to generate the doubly dressed states, which involve more than two bare states, by using only one strong microwave pump tone. It is shown that amplification or attenuation of a probe field has been observed by measuring its transmission coefficient through the cavity. Moreover, we demonstrate that the suppression of the transmission peaks of both the Rabi sidebands and Autler-Towers doublet can be modulated by varying the detuning of the pump field. Finally, our theory provides good agreement with the experimental results in the dressed-state model. Our results may facilitate the study of the coherent quantum dynamics of the microwave photons in a dressed-state basis and stimulate research on constructing scalable quantum networks.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.978
A doping dependent study of interplay between magnetic and superconducting properties in $BaFe_{2-x}Co_xAs_2$ single crystals
Bag B.[1], *Vinod K.*[2], *Bharathi A.*[2], *Banerjee S.S.*[1]
[1]Indian Institute of Technology, Physics, Kanpur, India, [2]Indira Gandhi Centre for Atomic Research, Condensed Matter Physics Division, Materials Science Group, Kalpakkam, India

In iron pnictide superconductors the effect of doping on the interplay between magnetism and superconductivity is an ongoing topic of investigation [1,2]. We have recently shown [3] the presence of short range magnetic order or magnetic fluctuation (MF) along with superconductivity in $BaFe_{2-x}Co_xAs_2$ samples. Here using bulk and local magnetization (M) measurements, we explore the interplay between magnetic and superconducting (SC) properties and how it evolves with applied field (H) for three $BaFe_{2-x}Co_xAs_2$ single crystals with different Co doping concentration. The bulk $M(H)$ data suggests that the strength of the MF and bulk pinning are the strongest for the optimally doped sample (in which T_c is maximum) and weakest for the overdoped sample. Our local $M(H)$ data suggests that application of H in our samples suppresses the MF response and enhances the SC response. Further, we image the presence of unusual superconducting fluctuations (SF) coexisting with MF above T_c. We find the volume fraction of SF (V_{sf}) decreases with suppression of MF and with increasing H. The above analysis reveals that the strength of SF above T_c strongly depends on the strength of the MF. We believe that our data suggest the MF plays an important role in generating SC correlations above T_c in pnictides.

References:
[1] A. V. Chubukov, *Annu. Rev. Condens. Matter Phys.* **3**, 57-92 (2012); C. L. Song, *et. al.*, *Science* **332**, 1410 (2011)

[2] T. Shimojima, *et. al.*, *Phys. Rev. B* **89**, 045101 (2014); S. Kasahara, *et. al.*, *Proc. Natl. Acad. Sci.* USA, **111**, 16309 (2014)
[3] Biplab Bag, *et. al.*, *New J. Phys.* **18**, 063025 (2016)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.979
Negative vortex-velocity fluctuations in the driven vortex state of 2H-NbS_2 superconductors

Bag B.[1], Banerjee S.S.[1], Sood A.K.[2], Grover A.K.[3]
[1]Indian Institute of Technology, Physics, Kanpur, India, [2]Indian Institute of Science, Physics, Bengaluru, India, [3]Tata Institute of Fundamental Research, Department of Condensed Matter Physics and Materials Science, Mumbai, India

Depinning of vortices in a type II superconductor is a nonequilibrium (NE) process which strongly depends on the underlying pinning strength in a superconductor [1]. Recently, a new NE driven transition in 2H-NbS_2 superconductor (Tc = 5.8 K) has been reported [2] wherein it is found that driven vortices transform from a free flow state into an immobile state with a negative differential resistance (NDR) [3] regime in the *I-V* characteristics. Using four-probe magneto-transport measurements in 2H-NbS_2 compound, we identify two distinct depinning regimes [4], (i) depinning from the static pinned state (having lower critical current), and (ii) depinning from a vortex state achieved by NDR transition at higher critical currents. The depinning threshold (ii) is unique as it is independent of the pinning properties of the samples and further, depinning in this regime exhibits large fluctuations in the vortex velocity with unusual negative velocity events associated with vortices drifting opposite to drive. We analyze these velocity fluctuations via Gallavotti-Cohen nonequilibrium fluctuation relations [5]. We show regimes of validity of these relations and determine a high effective energy scale to describe the behavior of the vortex state achieved via the sharp NDR transition [4].

References:

[1] G. Blatter, *et. al.*, *Rev. Mod. Phys.* 66, 1125 (1994)
[2] G. Shaw, *et. al.*, *Phys. Rev. B* **85**, 174517 (2012)
[3] M. N. Kunchur, *et. al.*, *Phys. Rev. Lett* **84**, 5204 (2000); M. N. Kunchur, *et. al. Phys. Rev. Lett* **87**, 177001 (2001); C. Reichhardt, *et. al.*, *Phys. Rev. Lett.* **78**, 2648 (1997)
[4] Biplab Bag et al. (submitted 2017)
[5] G. Gallavotti, *et. al.*, *Phys. Rev. Lett.*, **74**, 2694 (1995); ibid *J. of Stat. Phys.* **80**, 931-970 (1995)

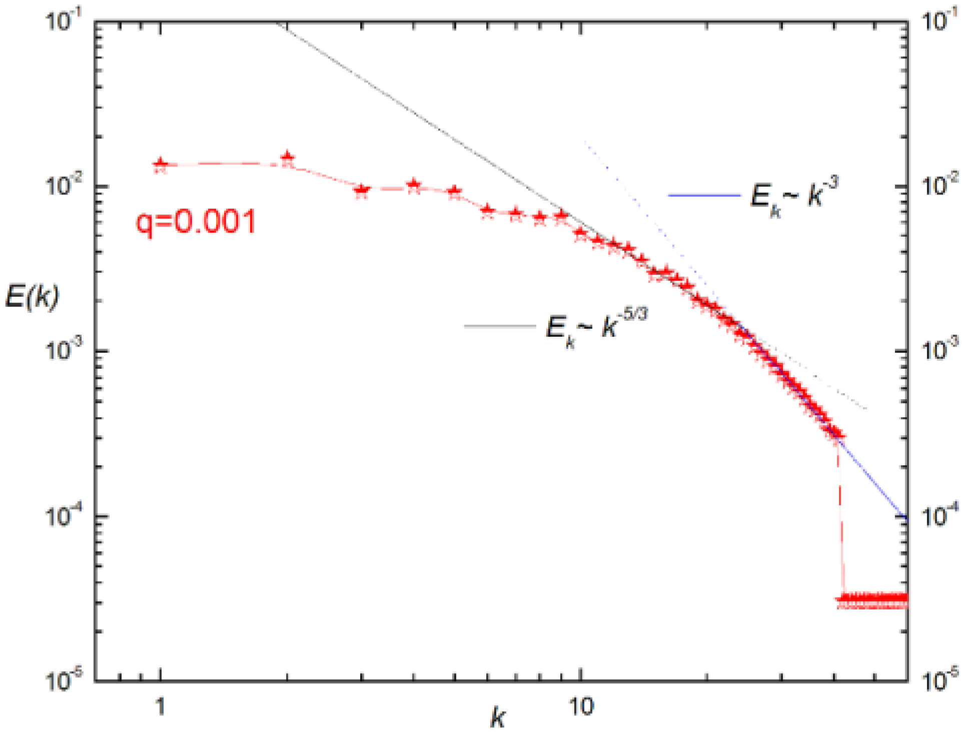
Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.980
Large eddy simulations analysis in superfluid turbulence: coarse-grained equations

Bakhtaoui M., Merahi L.
University of Science and Technology of Oran, Mechanical Engineering, Oran, Algeria

In superfluids, we argue and confirm that the developed turbulence occurs at q< < 1. As a starting point we utilize a coarse-grained hydrodynamic equation, using a large eddy simulations (LES). In the

LES, these are represented using a convolution filter, while the scale separation is performed; a general closure based on differential approximations of unknown non-linear terms is used. Our simulation for the cascade spectrum is in an excellent agreement with the predictions of analytic theory. This state displays both the Kolmogorov 5/3-scaling law $\sim k^{-5/3}$ and the 3~scaling law $\sim k^{-3}$, as shown in Figure 1. The LES has also displayed, that even at q< < 1, a crossover between Kolmogorov cascade and the Kelvin wave cascade. As a result, the energy dissipation in the hydrodynamic equation is produced by the non-linear mutual friction term. In the problem of superfluid turbulence decay at length scales greater than the interline spacing, the non-local interactions of vortex lines result in Kolmogorov cascade of eddies mimicking the behavior of the classical turbulence even without the normal component.



[Figure 1]

References:
1. L'VOV. V.S., JETP Letters, 80 (2004) 479.
2. SONIN E.B., J. Rev. Mod. Phys., 59 (1987) 87.
3. VOLOVIK G.E., J. Low Temp. Phys., 136 (2003) 309.
4. MERAHI L., SAGAUT P., and ABIDAT M., J. Europhys. Lett., 75 (2006) 757.
5. ROGALLO R. S., NASA Technical Report, TM-73, 203(1977).
6. CHOLLET J. P. and LESIEUR M., J. Atmos. Sci., 38 (1981) 2747.
7. VINEN W. F., J. Phys. Chem. Solids, 66 (2005) 1493.
8. VINEN W.F., J. Physc: Condens. Matter, 17 (2005) S3231.

Postersession 4
Tuesday, 15 August 2017

16.30-18.30
G Foyer

P.981
Non local triplet correlation in superconducting graphen in the presence of spin-orbit interaction

Beiranvand R., Hamzehpour H.
Khaje Nasir University of Technology, Science, Tehran, Iran, Islamic Republic of

In recent years, the generation and manipulation of quantum entanglements have attracted considerable attention both theoretically and experimentally and are expected to be employed in novel ultra-fast technologies such as secure quantum computing and low dissipative spintronics devices [1, 2].
Using a wavefunction Dirac Bogoliubov-de Gennes method, we demonstrate that the tunable Fermi level of a graphene layer in the presence of Rashba spin orbit coupling (RSOC) allows for producing an anomalous nonlocal Andreev reflection and equal spin superconducting triplet pairing. We consider a graphene junction of a ferromagnet-RSOC-superconductor-ferromagnet configuration and study scattering processes, the appearance of spin triplet correlations, and charge conductance in this structure. We show that the anomalous crossed Andreev reflection is linked to the equal spin triplet pairing. Moreover, by calculating current cross-correlations, our results reveal that this phenomenon causes negative charge conductance at weak voltages and can be revealed in a spectroscopy experiment, may providing a tool for detecting the entanglement of the equal spin superconducting pair correlations in hybrid structures[3].

References:

[1] C. Nayak, S. H. Simon, A. Stern, M. Freedman, and S. Das Sarma, Rev. Mod. Phys. 80, 1083 (2008).
[2] A. Steane, Quantum computing, Rep. Prog. Phys. 61, 117 (1998).
[3]I. Žutić, J. Fabian, and S. Das Sarma, Reviews of Modern Physics 76, 323 (2004).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.982
Magnetoplasma excitations of two-dimensional anisotropic heavy fermions in AlAs quantum wells

Khisameeva A.[1,2], Muravev V.[1], Gubarev S.[1], Kukushkin I.[1]
[1]Institute of Solid State Physics, Chernogolovka, Russian Federation, [2]Moscow Institute of Physics and Technolgy (State University), Dolgoprudny, Russian Federation

The spectra of plasma and magnetoplasma excitations in a 2D system of anisotropic fermions are investigated for the first time[1].The spectrum of microwave absorption by disklike samples of AlAs quantum wells at low electron densities shows two plasma resonances separated by a frequency gap.These two plasma resonances correspond to electron mass principle values of (1.10 ± 0.05)m_0 and (0.20 ± 0.01)m_0 which are consistent with previous results [2].The observed results correspond to the case of a single valley strongly anisotropic Fermi surface.It is established that an increase in electron density results in the population of the second valley, manifesting itself as a drastic modification of the spectrum. The plasma excitations could be considered using a two-component anisotropic plasma model.We determine the electron densities in each valley and the intervalley splitting energy.Amazing feature is that cyclotron mode shows anomalously large retardation effects: reduction of the resonant plasma frequency and its flat magnetic field dependence.Most remarkable is that the fundamental and multiple modes intersect the cyclotron resonance line.Experimental results

demonstrate that coupling between light and 2D plasma can be radically increased in the case of anisotropic solids.

References:
[1] V. M. Muravev, A. R. Khisameeva et al., Phys.Rev. B 92, 041303(R) (2015)
[2] M.Shayegan, E.P. De Poortere, O.Gunawan, Y.P. Shkolnikov, E.Tutue, K.Vakili Phys.stat.sol.(b) 243, No. 14, 3629-3642(2006)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.983
Low temperature ESR in spin ladder $(C_7H_{10}N_2)_2Cu_{(1-x)}Zn_xBr_4$

<u>Krasnikova Y.</u>[1,2], Glazkov V.[1,2], Fayzullin M.[3], Schmidiger D.[4], Zheludev A.[4], Povarov K.[4]
[1]P. L. Kapitza Institute for Physical Problems RAS, Moscow, Russian Federation, [2]National Research University Higher School of Economics, Moscow, Russian Federation, [3]Institute for Physics, Kazan Federal University, Kazan, Russian Federation, [4]Neutron Scattering and Magnetism, Laboratory for Solid State Physics, ETH Zurich, Zurich, Switzerland

"Spin ladder" is a model low-dimensional spin system. It consists of two coupled chains and can be described by two exchange coupling constants. The spectrum of excitations in such system has a gap and its ground state is a non magnetic singlet state.
The compound $(C_7H_{10}N_2)_2Cu_{(1-x)}Zn_xBr_4$, DIMPY for short, is an example of the spin ladder. The gap and exchange coupling constants for DIMPY are Δ=0.33 meV, $J_{\parallel}$=1.42 meV, $J_{\perp}$=0.82 meV [1]. DIMPY symmetry allows presence of a Dzyaloshinskii-Moriya (DM) interaction, which should be uniform along the ladder. High energy resolution of ESR method gave opportunity to detect this interaction and to prove by analysis of orientation and temperature dependencies of ESR linewidth that uniform Dzyaloshinskii-Moriya interaction (D~0.3 K) is the main anisotropic spin-spin interaction in DIMPY [2].
Substitution of Cu by Zn results in the formation of multi-spin defects ("spin islands") around the impurity [3]. At x=0.02…0.06 these defects dominate magnetic response below approx. 4 K, while above 5 K magnetic susceptibility of doped DIMPY is mostly due to copper ions. We have found that ESR linewidth above 5 K systematically decreases with doping. I. e., introduction of random defects suppress spin relaxation mechanisms related to DM interaction.

References:
[1] D. Schmidiger et al. PRL **111**, 107202 (2013)
[2] V. N. Glazkov et al. Phys. Rev. B **92**, 184403 (2015)
[3] D. Schmidiger et al. Pys. Rev. Lett. **116**, 257203 (2016)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.984
Superfluid to Mott insulator phase transition in a Bose gas within multi-rods

<u>Rodríguez-López O.A.</u>, Solís M.A.
Universidad Nacional Autonoma de Mexico, Mexico City, Mexico

We analyze the ground state physical properties of a 1D, interacting Bose gas at zero temperature confined by a periodic permeable multi-rods structure. The periodic structure is modeled by means of a 1D Kronig-Penney potential. Variational Monte Carlo (VMC) technique is used to calculate the one-body density matrix (OBDM). The quantum phase transition from superfluidity to a Mott insulator appears when the OBDM shows a change in the decay rate as a function of the distance and the potential magnitude is large enough, passing from a power-law decay to an exponential one while keeping constant the value of the interaction strength. Similar behavior is manifested when the potential barriers are wide enough while keeping constant the value of the potential magnitude.
On the other hand, we compare the ground state energy obtained by three ways: solving analytically the Gross-Pitaevskii equation [1], and those numerically obtained using Variational Monte Carlo and Diffusion Monte Carlo methods.

References:

[1] Omar A. Rodríguez-López and M. A. Solís, "Ground state of a Lieb-Liniger gas within multi-rods solving analytically the Gross-Pitaevskii equation", work in process.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.985

Fractional Josephson current and resonance peak of Majorana fermions in the presence of pseudo-scalar order parameter

Salehi M., Jafari S.A.
Sharif University of Technology, Physics, Tehran, Iran, Islamic Republic of

We find that singlet superconducting pairing can lead to Majorana fermions in three dimensional Dirac superconductors (3DDS) if the pairing order parameter is a pseudo-scalar, i.e. it changes sign under mirror reflection. The pseudo-scalar superconducting order parameter, Δ5 can close and reopen the spectral gap caused by the scalar Dirac mass (m) in a three-dimensional Dirac material (3DDM), giving rise to a two-dimensional Majorana sea (2DMS) at the plane of the gap kink. By bringing the Hamiltonian into a canonical form which then gives the winding number, we show that this system belongs to the DIII class of topological superconductors. We calculate the transport signature of 2DMS, namely a perfect Andreev-Klein transmission that manifests in a robust peak in the differential conductance. Further, we find the 4π periodicity in the Δ5jmjΔ5 Josephson junctions. Gauge transformed version of the present scenario implies that the interface of a conventional s-wave superconductor with a peculiar 3DDM whose mass is a pseudo-scalar, m5 also hosts a 2DMS[1].

References:

[1] M. Salehi and S. A. Jafari, arXiv:1611.03122 (2016).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.986

ESR uncovers doping-induced change of spin structure in a “triangular” antiferromagnet $RbFe(MoO_4)_2$

Soldatov T.[1,2], Smirnov A.[1], Kida T.[3], Takata A.[3], Hagiwara M.[3], Petrenko O.[4], Zhitomirsky M.[5], Shapiro A.[6]

[1]P.L. Kapitza Institute for Physical Problems RAS, Moscow, Russian Federation, [2]Moscow Institute for Physics and Technology, Dolgoprudny, Russian Federation, [3]Osaka University, Center for Advanced High Magnetic Field Science, Osaka, Japan, [4]Warwick University, Coventry, United Kingdom, [5]CEA-INAC/UJF, Grenoble, France, [6]A.V. Shubnikov Institute for Crystallography RAS, Moscow, Russian Federation

The selection of the ground state of the two-dimensional Heisenberg antiferromagnet on a triangular lattice (AFMTL) is performed by the order-by-disorder mechanism, implying thermal and quantum spin fluctuations, lifting a degeneracy of classical ground states [1]. It was theoretically shown that weak chaotic modulation of exchange bonds competes with fluctuation effects and, thus, may be a reason of a striking change of the spin structure of AFMTL [2]. We have checked these theoretical principles in ESR experiments with S = 5/2 AFMTL $Rb_{1-x}K_xFe(MoO_4)_2$ doped up to 15 % K.
The results of the ESR study in a range 25 - 150 GHz reveal a strong change of the antiferromagnetic resonance spectrum caused by doping - the descending branch observed in pure samples completely disappears in a 15 % doped samples, indicating a change of the ground state. These doping-induced changes of ESR spectra uncover a transformation of the low-field spin structure from “Y-type” to inverted “Y-type” structure as well as a transition from the collinear up-up-down structure, stabilized by fluctuations, to a fan-structure, caused by weak static disorder. These observations directly demonstrate a competition of structural disorder and fluctuations in formation of the ground state.
References:
[1] A.V. Chubukov, D.I. Golosov, J. Phys.: Condens. Matter **3**, 69 (1991)
[2] V.S. Maryasin, M.E. Zhitomirsky, Phys. Rev. Lett. **111**, 247201 (2013)

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.987

Effect of diffusion annealing regimes on the structure of Nb_3Sn Layers in ITER-type bronze-processed wires

Valova-Zaharevskaya E.[1], *Popova E.*[1], *Deryagina I.*[1], *Abdyukhanov I.*[2]
[1]M.N. Miheev Institute of Metal Physics of Ural Branch of Russian Academy of Sciences, Department of Precision Metallurgy and Pressure Processing Technologies, Laboratory of Precision Alloys and Intermetallic Compounds, Ekaterinburg, Russian Federation, [2]A.A. Bochvar High-Technology Research Institute of Inorganic Materials, Moscow, Russian Federation

The goal of the present study is to characterize the growth kinetics and structural parameters of the Nb_3Sn layers formed under various regimes of the diffusion annealing. The structure of the superconducting layers is characterized by their thickness, average size of equiaxed grains and by the ratio of fractions of columnar and equiaxed grains. Fine equiaxed grains of the Nb_3Sn phase with composition close to stoichiometry are desirable to ensure the higher current-carrying capacity of the wires. On the contrary, columnar grains with high deviation from stoichiometry and coarse grains of irregular shape result in lower critical current densities of the composites both in intermediate and high magnetic fields. It was found that at higher diffusion annealing temperatures (above 650°C) thicker superconducting layers are obtained, but the average sizes of equiaxed Nb_3Sn grains even under short exposures (10 h) are much larger than after the long low-temperature annealing. It is demonstrated that to ensure the best current-carrying capacity of the Nb_3Sn-based wires in high magnetic fields it is necessary to obtain maximum amount of stoichiometric fine-grained Nb_3Sn phase and to avoid the undesirable growth of grains and the columnar grains formation.

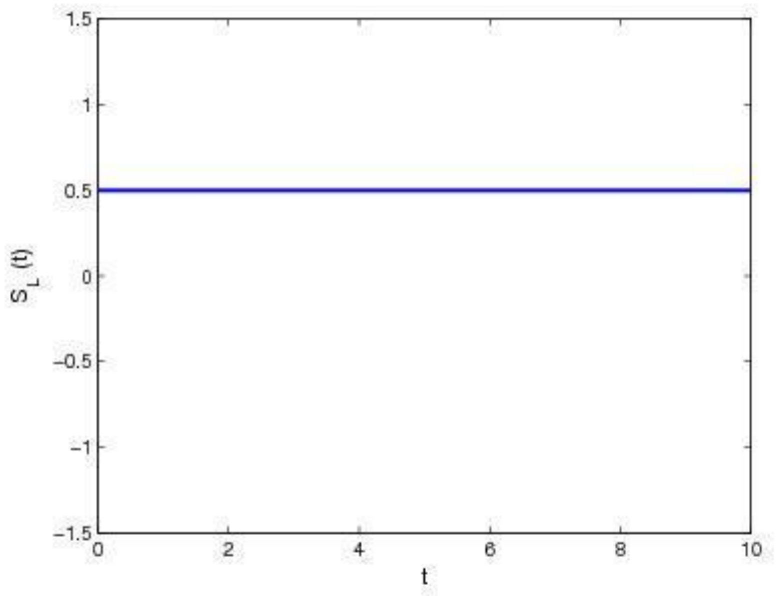
Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.988

Entanglement preservation in an ultracold Bose gas coupled to a reservoir of excitations

Villegas V., Caballar R.C.
University of the Philippines, Quezon City, Philippines

We study a system composed of particles of a Bose gas trapped in an optical lattice, which is interacting with a bath of excitations in the form of another Bose gas. In general, the particle number of each lattice site remains constant through time due to dissipative effects of the coupling with the bath. Moreover, if the system is initially in an entangled state, the dissipative effects help preserve the entanglement of the particles in the lattice through time and help facilitate the transport of entanglement from one lattice site to another.



[bb50emp50fullsl]

References:

[1] E. Cornell and C. Wiemann, *Rev. Mod. Phys.* **74**, 875 (2002).
[2] D. Jaksch et al., *Phys. Rev. Lett.* **81**, 3108 (1998).
[3] D. Jaksch and P. Zoller, *Ann. Phys.* **315**, 52 (2005).
[4] R. Caballar, S. Diehl, H. Mäkelä, M. Oberhaller, and G. Watanabe, *Phys. Rev. A* **89**, 013620 (2014).
[5] C. J. Pethick and H. Smith, Cambridge University Press, Cambridge, UK, 2008.
[6] G. Kordes et al., *Eur. J. Phys.* **224**, 2127 (2015).
[7] H.-P. Breuer and F. Petruccione, Oxford University Press, Oxfordshire, UK, 2002.

Postersession 4
Tuesday, 15 August 2017
16.30-18.30

G Foyer

P.989

Entanglement preservation in an ultracold Fermi gas coupled to a reservoir of excitations

Villegas V., Caballar R.C.
University of the Philippines, National institute of Physics, Quezon City, Philippines

We study a system of particles composed of a Fermi gas trapped in an optical lattice, which is interacting with a bath of excitations in the form of another Fermi gas. In general, the particle number of each lattice site and the spin of each particle in the lattice remain constant through time due to the dissipative effects of the coupling with the bath. Moreover, if the system is started in an entangled state, the dissipative effects help preserve the entanglement of the particles in the lattice through time and help facilitate the transport of entanglement from one lattice site to another.

References:

[1] I. Bloch, J. Dallibard, and W. Zweger, *Rev. Mod. Phys.* **80**, 885 (2008).
[2] D. Wecker et al., *Phys. Rev. A* 92, 062318 (2015).
[3] D. Jaksch and P. Zoller, *Ann. Phys.* 315, 52 (2005).
[4] C. J. Pethick and H. Smith, (Cambridge University Press, Cambridge, UK, 2008).
[5] H.-P. Breuer and F. Petruccione, (Oxford University Press, Oxfordshire, UK, 2002).

Postersession 4
Tuesday, 15 August 2017
16.30-18.30
G Foyer

P.990

Arcing time analysis of liquid nitrogen with respect to electrode materials

Junaid M., Yang K., Ge H., Wang J.
State Key Laboratory of Electrical Insulation and Power Equipment, School of Electrical Engineering, Xi'an Jiaotong University, Xi'an, China

Unlike Sulphur hexafluoride (SF_6), Liquid Nitrogen (LN_2) is cost effective, environment friendly and cryogenic dielectric. It has astounding insulating properties with the potential to decrease the power loss in switchgear applications due to its remarkably low temperature. The basic research is however a necessity to observe the performance of LN_2 subjected to high luminance arcs. So far, there´re no findings to refer on the arcing time inside the LN_2 environment. The objective of this work was to investigate the arcing time of LN_2 and compare the results with open air conditions using different electrode materials.

Experiments were conducted on different DC voltages and their arcing times were measured. Three different kinds of electrode materials, namely: Pure Copper, Stainless Used Steel (SUS) and Aluminum alloy (Al 6061) were tested under 1 atmospheric pressure of LN_2.

The results revealed that LN_2 extinguishes arc in almost half of the time required by the open air insulation with Al 6061 having the shortest arcing time while Pure Copper, the second best choice and SUS standing last in the evaluation. It was encapsulated from the findings that LN_2 is a better choice than air insulation in terms of arc quenching and a better alternative to SF_6 when environment is the priority.

References:

[1] J. Wang, Y. Tan, L. Zhang, Y. Geng, Z. Liu, and S. Wang, "Conceptual Design of a Liquid-Nitrogen-Insulated Metal-Enclosed Switchgear," IEEE Transactions on Applied Superconductivity, vol. 26, pp. 1-5, 2016.

[2] K. Golde, V. Hinrichsen, D. Gentsch, A. Lawall and E. D. Taylor, "Short-circuit current interruption in liquid nitrogen environment," *2016 27th International Symposium on Discharges and Electrical Insulation in Vacuum (ISDEIV)*, Suzhou, 2016, pp. 1-4.