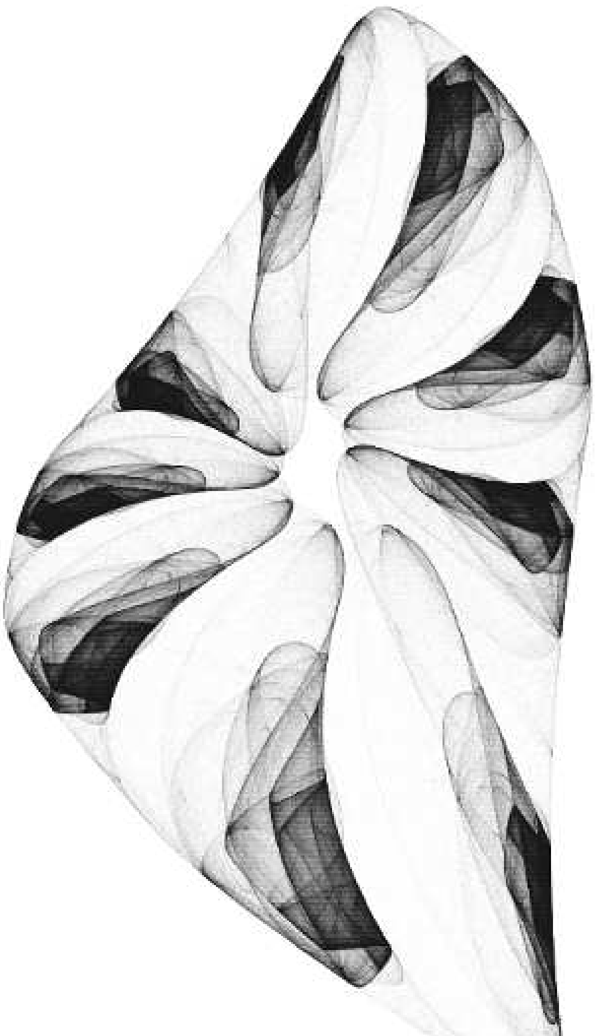
7th Workshop on Quantum Chaos and Localisation Phenomena

29–31 May 2015, Warsaw, Poland

organised by Institute of Physics of the Polish Academy of Sciences,
Center for Theoretical Physics of the Polish Academy of Sciences,
and Pro Physica Foundation



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Objectives

- To assess achievements and to formulate directions of new research on quantum chaos and localisation
- To bring together prominent experimental and theoretical physicists who share a common interest in quantum chaos and localisation phenomena

Scope

Presentations will focus on the following topics:

- Quantum chaos and nonlinear classical systems
- Quantum and microwave billiards
- Quantum and microwave graphs
- Atoms in strong electromagnetic fields – experiment and theory
- Chaos vs. coherent effects in multiple scattering
- Anderson localisation
- Random lasers
- Quantum chaos and quantum computing
- Entanglement and noise

Focusing waves at arbitrary locations in a ray-chaotic enclosure using semi-classical analysis

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Time-reversal invariance of the lossless wave equation allows reconstruction of collapsing waveforms in a ray-chaotic scattering environment utilizing a single-channel time-reversal mirror [1–2]. However, a typical time reversal experiment requires that a transmitter be initially present at the target focusing point, which limits the application of this technique. We have extended the Random Coupling Model (RCM) to include the effects of short orbits on the statistical properties of wave chaotic systems with non-universal features [3–6]. By combining the semi-classical description of short orbits with the time-reversal mirror, we can make a waveform appear at an arbitrary location in a complex scattering environment. Specifically, we use knowledge of the billiard geometry and a semi-classical ray algorithm to calculate the signal that would be received at a transceiver port resulting from the injection of a short pulse at the desired target location [7]. The time-reversed version of this signal is then injected into the transceiver port and an approximate reconstruction of the short pulse is created at the target. We experimentally demonstrate the method using a microwave billiard and quantify the reconstruction quality as a function of enclosure loss, port coupling and other considerations. The reconstruction quality is predicted by the statistics of the scattering-parameter $|S_{21}|^2$ between the transceiver and target points in the enclosure.

This work was funded by the Office of Naval Research (contracts No. N00014130474 and N000141512134), and the Center for Nanophysics and Advanced Materials (CNAM).

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A statistical benchmark for BosonSampling

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Computing the state of a quantum mechanical many-body system composed of indistinguishable particles distributed over a multitude of modes is one of the paradigmatic test cases of computational complexity theory: Beyond well-understood quantum statistical effects, the coherent superposition of many-particle amplitudes rapidly overburdens classical computing devices – essentially by creating extremely complicated interference patterns, which also challenge experimental resolution. With the advent of controlled many-particle interference experiments, optical set-ups that can efficiently probe many-boson wave functions – baptised BosonSamplers – have therefore been proposed as efficient quantum simulators which outperform any classical computing device, and thereby challenge the extended Church–Turing thesis, one of the fundamental dogmas of computer science. However, as in all experimental quantum simulations of truly complex systems, there remains one crucial problem: How to certify that a given experimental measurement record is an unambiguous result of sampling bosons rather than fermions or distinguishable particles, or of uncontrolled noise? We describe a statistical signature of many-body quantum interference, which can be used as an experimental (and classically computable) benchmark for BosonSampling.

Experiments with superconducting microwave resonators emulating artificial graphene and fullerene C_{60}

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We determined experimentally the eigenvalues of quantum billiards with the shapes of a rectangle and of Africa, respectively, that contain circular scatterers forming a triangular grid, so-called Dirac billiards. For this, high-precision measurements have been performed with superconducting microwave billiards. We investigated the particular features of the density of the eigenvalues (DOE), which resembles that of a graphene flake, and of their fluctuation properties. I will demonstrate in my talk that the van Hove singularities, that show up as sharp peaks in the DOE, divide the associated band into regions where the system is governed by the non-relativistic Schrödinger equation of the quantum billiard and the Dirac equation of the graphene billiard of corresponding shape, respectively. Furthermore, experiments have been performed using a spherical superconducting microwave resonator with the geometric structure of the C_{60} fullerene molecule in order to, firstly, study with very high resolution the exceptional spectral properties emerging from the symmetries of the icosahedral structure of the carbon lattice. Secondly, we determined the number of zero modes with eigenvalues at the Dirac point to test the predictions of the Atiyah–Singer index theorem, which relates it to the topology of the curved carbon lattice.

Supported by the DFG within the Collaborative Research Center CRC634.

Chaotic scattering: exact results and microwave experiments

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Chaotic scattering is relevant in many areas of physics, from nuclei and mesoscopic systems to telecommunication. While the whole scattering matrix is assumed to be random in the Mexico approach, only the Hamiltonian of the interaction zone is modelled by a random matrix in the Heidelberg approach. We solve a long-standing problem in the Heidelberg approach: we calculate the distribution of the off-diagonal scattering elements exactly. We also carry out a comparison with data from microwave experiments.

How to find the effective size of a non-Weyl graph

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We study the asymptotics of the number of resolvent resonances in a quantum graph with attached halflines. It has been proven that in some cases the constant by the leading term of the asymptotics (the effective size of the graph) is smaller than one expects by the Weyl law, since some resonances escape to infinity. We show how to find this effective size by the method of pseudo orbit expansion. Furthermore, we prove two theorems on the effective size of certain type of graphs with standard (Kirchhoff) coupling.

Study of the power spectra and the elastic enhancement factor for chaotic quantum systems

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We present the results of the experimental study of the power spectra $S(f)$ of discrete and finite series of eigenenergies for quantum and microwave graphs and billiards. Quantum graphs were simulated by microwave networks. It is possible because the one-dimensional Schrödinger equation, describing the wave functions on graph bonds, is analogical to the Telegraph equation describing the electric potentials on network bonds. The rectangular and chaotic microwave cavities simulate quantum regular and chaotic billiards, respectively. The analogy between quantum and microwave billiards is based upon the equivalency of the Schrödinger equation and the Helmholtz equation. Our results indicate that the power spectra can be used as an experimental measure of chaoticity of such systems.

We also present the results of a study of the elastic enhancement factor $W(S)$ for partially chaotic and chaotic quantum billiards simulated by rectangular and rough microwave cavities in the case of preserved time reversal symmetry.

This work was partially supported by the National Science Centre grant No. UMO-2013/09/D/ST2/03727.

Out of equilibrium measurements on a quantum dot: determination of the equilibrium free energy and an experimental test of the Jarzynski equality

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Equilibrium thermodynamics is a fundamental branch of physics providing tools to make predictions of macroscopic many-particle systems independent of detailed microscopic processes governing their properties. In the recent trend towards smaller systems, which deviate strongly from the thermodynamic limit, fluctuations departing from the equilibrium state often become prominent and non-equilibrium dynamics needs to be taken into account. We investigate a single discrete energy level, a fundamental building block in quantum mechanics, in a GaAs/AlGaAs quantum dot coupled to a single thermal and electron reservoir by using single-electron counting techniques [1]. The device we use is presented in Fig. 1 (a). By applying a voltage ramp to a plunger gate electrode, we change the chemical potential of the electrons in the dot and thus perform work and change the internal energy of the system. We demonstrate that with a fast drive, the system is driven out of equilibrium. By utilizing the so-called Jarzynski equality [2] we show that the result of our non-equilibrium measurement is predicted by an equilibrium property, the free energy. Since our system consists essentially of a single discrete electronic state and it is possible to realize controllably tens of thousands of repetitions of the drive protocol, our experiments provide a controllable and precise test of the free energy extraction based on the Jarzynski equality.

In a second set of experiments we employ feedback in the drive protocol as shown in Figs. 1 (b) and (c). If an excess electron resides in the quantum dot, we bring its chemical potential high so that it tunnels out quickly. When the excess electron is out of the dot, we drive the chemical potential down so that an electron is taken into the dot. Such a feedback protocol allows us to determine the tunnel dynamics of the system efficiently. With this technique we demonstrate, that the quantum dot we use, has doubly degenerate energy levels due to spin for the first eight electrons taken into the dot. We also probe the energy dependence of the tunnel coupling as well as perform exited state spectroscopy with the feedback technique.

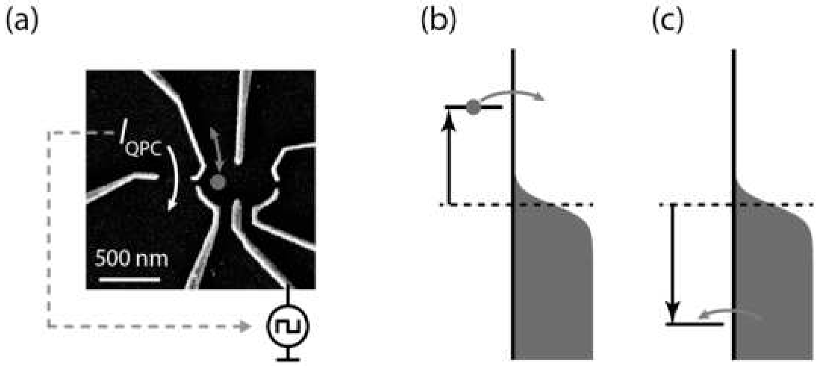

Fig. 1 (a) Scanning electron micrograph of the device. An electron tunnels back and forth between a quantum dot and a reservoir. A quantum point contact (QPC) current I_{QPC} is used for measuring if the electron is in or out of the quantum dot. A voltage source is connected to one of the gate electrodes to change the chemical potential of the quantum dot. In the second set of experiments, a feedback scheme shown in gray dashed line is used for controlling the voltage. (b) Density of states of the dot (in right) and reservoir (in left). The chemical potential of the electron is increased above the Fermi level shown by the dashed line when the electron resides in the quantum dot. (c) When the electron is not in the dot, the chemical potential is decreased to take an electron into the dot.

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Spectral statistics of chaotic many-body systems

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We investigate the spectral statistics of chaotic many-body systems, using a trace formula that expresses the level density of chaotic many-body systems as a smooth term plus a sum over contributions associated to solutions of the nonlinear Schrödinger equation. Our formula applies to bosonic systems with discrete sites, such as the Bose–Hubbard model, in the semiclassical limit as well as in the limit where the number of particles is taken to infinity. The focus of the talk will be to investigate the two point correlation function of the level density by studying interference between solutions of the nonlinear Schrödinger equation. We show that in the limits taken the statistics of fully chaotic many-particle systems becomes universal and agrees with predictions from the Wigner–Dyson ensembles of random matrix theory. We also discuss the effect of discrete geometric symmetries on this statistics for the example of the Bose–Hubbard model without disorder. The conditions for Wigner–Dyson statistics involve a gap in the spectrum of the Frobenius–Perron operator, leaving the possibility of different statistics for systems with weaker chaotic properties.

Level spacing distribution of the Bianchi IX model

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Our results concern quantum chaos of the vacuum Bianchi IX model. We apply the equilateral triangle potential well approximation to the potential of the Bianchi IX model to solve the eigenvalue problem for the physical Hamiltonian. Such approximation is well satisfied in vicinity of the cosmic singularity. Level spacing distribution of the eigenvalues is studied with and without applying the unfolding procedure. In both cases, the obtained distributions are qualitatively described by Brody's distribution, revealing some sort of the level repulsion. The observed repulsion may reflect chaotic nature of the classical dynamics of the Bianchi IX universe.

Dimensional reduction and localization of a Bose–Einstein condensate in a quasi-1D bichromatic optical lattice

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From the 3D Gross–Pitaevskii equation we derive an effective 1D Gross–Pitaevskii equation which is used to study different aspects of the localization of a Bose–Einstein condensate made of dilute and ultracold alkali-metal atoms and confined in a one-dimensional bichromatic quasiperiodic optical-lattice potential. Our numerical results suggest the breaking of localization induced by a sufficiently strong repulsion generated by a positive inter-atomic scattering length.

Resonance width distribution beyond Porter–Thomas

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This talk discusses the distribution of resonance widths in quantum chaotic systems weakly coupled to the continuum via a finite number M of open channels. In contrast to the standard perturbative treatment of random matrix theory (RMT), we do not a priori assume the resonance widths being small compared to the mean level spacing. We show that to the leading order in weak coupling the perturbative chi-square distribution of the resonance widths (in particular, the Porter–Thomas distribution at $M = 1$) should be corrected by a factor related to a certain average of the ratio of square roots of the characteristic polynomial (‘spectral determinant’) of the underlying RMT Hamiltonian. A simple single-channel expression is obtained that properly approximates the width distribution also at large resonance overlap, where the Porter–Thomas result is no longer applicable.

Based on a joint work with Yan V. Fyodorov, School of Mathematical Sciences, Queen Mary University of London, Mile End Road, London E1 4NS, UK.

Dyson's Brownian motion model for random matrix theory – revisited

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In his 1962 paper, F. Dyson introduced a then novel approach for studying random matrix ensembles in terms of Brownian dynamics in the space of matrices. He then proposed a Fokker–Planck evolution for the spectral distribution function, whose stationary solution provides the spectral joint probability distribution function $P(\lambda_1, \ldots, \lambda_N)$. Here, we reformulate the approach for the traces $t_n = \sum_{k=1}^{N} \lambda_k^n$, and derive the Fokker–Planck equations and the joint probability distribution $Q(t_1, \ldots, t_N)$. Advantages of this version of Dyson's theory will be discussed, and a few new identities between traces will be derived.

Elastic enhancement factor: mesoscopic systems versus macroscopic 2D electromagnetic analogous devices

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Excess of probabilities of the elastic processes over the inelastic ones is a common feature of the resonance scattering processes that are described with the aid of the random matrix theory (RMT). Quantitatively, this phenomenon is characterized by the elastic enhancement factor F that is a typical ratio of elastic and inelastic cross sections. Being measured experimentally, this quantity can supply us with important information about the character of the complicated states formed on the intermediate stage of a resonance reaction. Generally speaking, this factor depends on the number M of scattering channels as well as on the channel's transmission coefficients T. However, when the number of channels is very large, what is typical of the processes such as, for example, the resonance nuclear reactions, the enhancement factor is entirely controlled by the only parameter $\eta = MT$ that changes in very wide bounds (Verbaarschot's regime).

On the contrary, in the macroscopic analogous experiments with 2D irregularly shaped electromagnetic resonators, that are widely used to mimic the chaotic quantum dynamics, the number of channels is very restricted. In this case the enhancement factor depends on the number of channels and on transmission coefficients separately. We juxtapose the two specified regimes in detail. We demonstrate that complete analytical solution valid for any fixed number M of equivalent channels with arbitrary transmission coefficients $0 < T < 1$ is possible in the case of the systems without time-reversal symmetry. More than that, in the practically significant case of only two scattering channels, $M = 2$, influence of the absorption due to ohmic losses can also be described analytically.

Meanwhile, no explicit analytical results can be derived in the case of a T-invariant device. Therefore we have used numerical methods to be able to demonstrate the similarity as well as distinctions between these two cases.

Spectral properties of microwave graphs with local absorption

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The influence of absorption on the spectra of microwave graphs has been studied experimentally [1]. The microwave networks were made up of coaxial cables and T junctions. First, absorption was introduced by attaching a 50 Ohm load to an additional vertex for graphs with and without time-reversal symmetry. The resulting level-spacing distributions were compared with a generalization of the Wigner surmise in the presence of open channels proposed recently by Poli et al. [2]. A good agreement was found using an effective coupling parameter. Secondly, absorption was introduced along one individual bond via a variable microwave attenuator, and the influence of absorption on the length spectrum was studied. The peak heights in the length spectra corresponding to orbits avoiding the absorber were found to be independent of the attenuation, whereas the heights of peaks belonging to orbits passing the absorber once or twice showed the expected decrease with increasing attenuation.

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The semiclassical approximation in Fock space: interactions, interference, and quantum signatures of field chaos

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We will review recent developments in the rigorous construction of semiclassical approximations for interacting bosonic systems, in the spirit of Gutzwiller where the quantum mechanical time evolution operator is written as a coherent sum over the real solutions of some classical equations. After briefly presenting our derivation of the quantum-field analog of the van Vleck–Gutzwiller propagator, we show how it can be used to predict a new kind of many-body phenomena due to interference in many-body space which, contrary to wave interference, are not affected by the presence of interactions and their characteristic non-linear effect in the classical mean field equations. In a further development, a trace formula that associates long-wavelength oscillations in the smoothed many-body density of states with specific types of solutions of non-linear wave equations in the lattice will be derived, and possible applications will be discussed.

Cold atom motivated models with off-diagonal disorder

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A well known problem of one dimensional tight binding model in the presence of disorder leading to Anderson localization is reconsidered. A binary disorder is assumed to be created by immobile heavy particles for the motion of the lighter, mobile species in the limit of no interaction between mobile particles. Fast periodic modulations of interspecies interactions allow us to produce an effective model with small diagonal and large off-diagonal disorder unexplored in cold atoms experiments. We present an expression for an approximate Anderson localization length and verify the existence of the well known extended resonant mode. We also analyze the influence of nonzero next-nearest neighbor hopping terms. We point out that periodic modulation of interaction allow disorder to work as a tunable band-pass filter for momenta. We discuss also the impact of off-diagonal disorder on Bose glass formation for interacting particles.

Atomic nucleus as chaotic quantum many-body system

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Complex atomic nuclei are quantum many-body systems with strong interaction between the constituents. With growing excitation energy, the combinatorics of fermionic levels makes the density of states extremely high, so that corresponding many-body wave functions become exceedingly complicated. At this stage the nuclei reveal typical properties of quantum chaos similar to the Gaussian Orthogonal Ensemble of random matrices. Based on the exact large-scale diagonalization of Hamiltonian matrices, we see these properties gradually arising as a function of excitation energy. This can be interpreted as thermalization in an isolated system where the interactions play the role of a heat bath. It will be shown how chaotic properties can be used as a practical tool for experiments, theory and computations. Finally, the applications to open systems with and without disorder will be discussed.

Quantum chaos in composite systems and properties of generic mixed quantum states

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Unitary evolution operator of a quantum analogue of a classically chaotic system transforms a typical initial state into a delocalized random pure state. Analyzing such a unitary dynamics for a composite, bipartite system and performing partial trace over a selected subsystem one obtains a generic mixed state on the second subsystem. We investigate statistical properties of such generic mixed states and show that for a large dimension of the Hilbert space they become universal due to the effect of concentration of measure. In particular the trace distance between two random mixed states converges to $1/2 + 2/\pi$, which due to the Helstom bound determines their discrimination in an optimal measurement scheme.

Role of excitation spectrum during a quantum phase transition: semiclassical approach

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We develop a semiclassical method to reproduce spectral features of a family of spin chain models with variable range in a transverse magnetic field, which interpolates between the Lipkin–Meshkov–Glick model and the Ising model. The semiclassical spectrum is exact in the limit of very strong or vanishing external magnetic fields. Each of the semiclassical energy landscapes shows a bifurcation when the external magnetic field exceeds a threshold value. This reflects the quantum phase transition from the symmetric paramagnetic phase to the symmetry-breaking (anti-)ferromagnetic phase in the entire excitation spectrum – and not just in the ground state.

Effective dynamics of disordered quantum systems

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In order to obtain a generic understanding of the dynamics of disordered quantum systems, it is often neither useful nor sufficient to focus on single disorder realizations; rather, one studies the dynamical behavior of the system averaged over all its realizations. Usually, the time evolution of the ensemble average is traced by direct numerical simulation of many disorder realizations and subsequent averaging. This approach, however, can capture the resulting dynamics only on a phenomenological level. We seek instead to formulate an effective description of the dynamics of the ensemble average directly. As we argue and underline with paradigmatic examples, local-in-time Lindblad-type quantum master equations provide us with the appropriate framework to grasp the in general incoherent dynamics emerging on the ensemble average level. We show that the ensemble average dynamics of simple, isolated systems can already give rise to intricate non-Markovian behavior as, for example, coherence revivals. In general, our approach allows for an efficient description and the deduction of disorder-induced dynamical features from the perspective of quantum master equations, not only on asymptotic, but also on transient timescales. Ultimately, this may pave an alternative way for the engineering of disordered systems towards desired dynamical properties, such as the preservation of coherence or the optimization of transport.

GSE statistics without spin

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Energy levels statistics following the Gaussian Symplectic Ensemble (GSE) of Random Matrix Theory have been predicted theoretically and observed numerically in numerous quantum chaotic systems. However in all these systems there has been one unifying feature: the combination of half-integer spin and time-reversal invariance. Here we provide an alternative mechanism for obtaining GSE statistics that is based on geometric symmetries of a quantum system which alleviates the need for spin. As an example, we construct a quantum graph with a particular discrete symmetry given by the quaternion group Q_8. GSE statistics is then observed within one of its subspectra.

Dynamical localization of the wave packet in disordered environment: phase-space approach

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The phase-space approach based on the Wigner distribution function is applied to the description of dynamics of a Gaussian wave packet in finite one-dimensional systems with randomly distributed scattering centers. It is shown that the coherent multiple scattering of the wave packet in the disordered environment leads to the slowdown of the dynamics of the wave packet due to the weak localization. This quantum phenomenon can be treated as a source of the subdiffusion of the quantum particles.

Study of the elastic enhancement factor and nearest neighbor spacing distribution for partially chaotic and chaotic systems

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We present the results of experimental studies of the elastic enhancement factor W and the nearest neighbor spacing distribution $P(s)$ for microwave rectangular and rough cavities simulating two-dimensional quantum billiards in a transient region between regular and chaotic dynamics [1] and in a pure chaotic dynamics region, respectively. The analogy between microwave cavities and quantum billiards is based upon the equivalency of the Helmholtz equation describing 2D microwave cavities and the Schrödinger equation describing the quantum systems [2]. It holds for the excitation frequency below $\nu_{\max} = c/2d$, where c is the speed of light in the vacuum and d is the height of the cavity, when only the transverse magnetic TM_0 mode can be excited inside the cavity.

The elastic enhancement factor W is the ratio of variances of diagonal elements of the two-port scattering matrix S to off-diagonal elements of this matrix and is defined by the relationship [3,4]:

$$W_\beta = \frac{\sqrt{\mathrm{var}(S_{aa})\,\mathrm{var}(S_{bb})}}{\mathrm{var}(S_{ab})},$$

where $\mathrm{var}(S_{ab}) \equiv \langle |S_{ab}|^2 \rangle - |\langle S_{ab} \rangle|^2$ is the variance of the scattering matrix element S_{ab} of the two-port scattering matrix.

In order to measure scattering matrices of rectangular and rough cavities we used a vector network analyzer Agilent E8364B, which was connected to the antennas introduced inside a cavity through the flexible microwave cables HP 85133-616 and HP 85133-617. The measurements were done in the frequency range 16–18.5 GHz for a moderate absorption $\gamma = 5.2$–7.4.

The results obtained for the elastic enhancement factor W for the rectangular cavity are not in the agreement with the theoretical prediction for the integrable systems. On the other hand, they are significantly different than the results obtained for the microwave rough cavity, simulating chaotic billiard, which seem to lie between the results predicted by RMT and the ones predicted within a recently introduced model of the two-channel coupling [5,6]. The results for the rectangular cavity may be explained by taking into account a scattering on the antennas, which causes that the system becomes partially chaotic. We found that in our experiment a transient parameter describing the departure from the integrability equals $k = 2.8$. Our experimental results suggest that the enhancement factor can be used as a measure of internal chaos that can be especially useful for systems with significant absorption or openness.

This work was partially supported by grants of the Ministry of Science and Higher Education N N202 130239 and the National Science Centre UMO-2013/09/D/ST2/03727.

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NOTES

PROGRAMME

Friday, May 29

19:00-22:00	Welcome party (Airport Hotel Okęcie)

Saturday, May 30

9:00–9:10	**Leszek Sirko** (Warsaw, Poland) Opening
	INVITED TALKS
9:10–9:45	**Hans-Jürgen Stöckmann** (Marburg, Germany) Spectral properties of microwave graphs with local absorption
9:45–10:20	**Steven M. Anlage** (College Park, USA) Focusing waves at arbitrary locations in a ray-chaotic enclosure using time-reversed synthetic sonas
10:20–10:55	**Barbara Dietz-Pilatus** (Darmstadt, Germany) Experiments with superconducting microwave resonators emulating artificial graphene and fullerene C_{60}
10:55–11:30	**Ville Maisi** (Zurich, Switzerland) Out of equilibrium measurements on a quantum dot: determination of the equilibrium free energy and an experimental test of the Jarzynski equality
11:30–12:00	coffee break
12:00–12:35	**Jakub Zakrzewski** (Cracow, Poland) Cold atom motivated models with off-diagonal disorder
12:35–13:10	**Andreas Buchleitner** (Freiburg, Germany) A statistical benchmark for BosonSampling
13:10–13:45	**Luca Salasnich** (Padova, Italy) Dimensional reduction and localization of a Bose–Einstein condensate in a quasi-1D bichromatic optical lattice
13:45–14:45	lunch break
14:45–16:00	POSTER SESSION
	INVITED TALKS
16:00–16:20	**Włodzimierz Piechocki** (Warsaw, Poland) Level spacing distribution of the Bianchi IX model
16:20–16:40	**Juan Diego Urbina** (Regensburg, Germany) The semiclassical approximation in Fock space: interactions, interference, and quantum signatures of field chaos
16:40	Warsaw tour and conference dinner

PROGRAMME

Sunday, May 31

	INVITED TALKS
9:00–9:35	**Uzy Smilansky** (Rehovot, Israel) Dyson's Brownian motion model for random matrix theory – revisited
9:35–10:10	**Karol Życzkowski** (Warsaw and Cracow, Poland) Quantum chaos in composite systems and properties of generic mixed quantum states
10:10–10:45	**Dmitry Savin** (London, UK) Resonance width distribution beyond Porter–Thomas
10:45–11:20	**Valentin V. Sokolov** (Novosibirsk, Russia) Elastic enhancement factor: mesoscopic systems versus macroscopic 2D electromagnetic analogous devices
11:20–11:50	coffee break
11:50–12:25	**Thomas Ghur** (Duisburg, Germany) Chaotic scattering: exact results and microwave experiments
12:25–13:00	**Vladimir Zelevinsky** (East Lansing, USA) Atomic nucleus as chaotic quantum many-body system
13:00–13:35	**Sebastian Müller** (Bristol, UK) Spectral statistics of chaotic many-body systems
13:35–14:30	lunch break
	INVITED TALKS
14:30–14:50	**Michał Ławniczak** (Warsaw, Poland) Study of the power spectra and the elastic enhancement factor for chaotic quantum systems
14:50–15:10	**Jiří Lipovský** (Hradec Kralove, Czech Republic) How to find the effective size of a non-Weyl graph
15:10–15:20	Closing remarks

The workshop organizers acknowledge a financial support
from the Ministry of Science and Higher Education.