6th Workshop on Quantum Chaos and Localisation Phenomena

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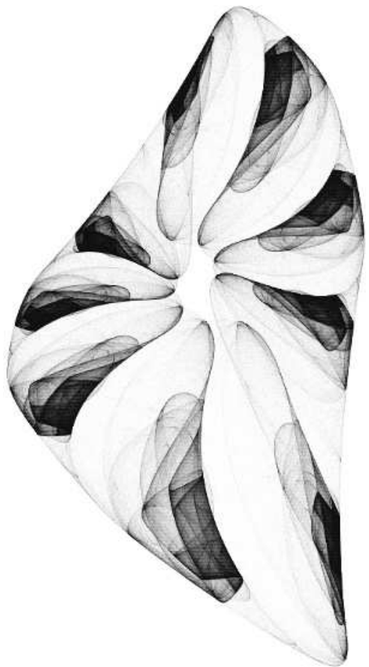

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Objectives

- 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

Nonlinear time-reversal in a wave chaotic system

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Exploiting the time-reversal invariance and reciprocal properties of the lossless wave equation enables elegantly simple solutions to complex wave-scattering problems and is embodied in the time-reversal mirror [1]. In previous work, we extended the concepts of Loschmidt Echo and Fidelity to classical waves, such as acoustic and electromagnetic waves, to realize a new sensor paradigm [2–4]. Here we demonstrate the implementation of an electromagnetic time-reversal mirror in a wave chaotic system containing a discrete nonlinearity [5]. We demonstrate that the time-reversed nonlinear excitations reconstruct exclusively upon the source of the nonlinearity. As an example of its utility, we demonstrate a new form of secure communication and point out other applications.

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[1] Steven M. Anlage, John Rodgers, Sameer Hemmady, James Hart, Thomas M. Antonsen, Edward Ott, *Acta Physica Polonica A* **112**, 569 (2007).
[2] B. T. Taddese, James Hart, Thomas M. Antonsen, Edward Ott, and Steven M. Anlage, *Appl. Phys. Lett.* **95**, 114103 (2009).
[3] B. T. Taddese, Thomas M. Antonsen, Edward Ott, and Steven M. Anlage, *J. Appl. Phys.* **108**, 114911 (2010).
[4] Biniyam T. Taddese, Gabriele Gradoni, Franco Moglie, Thomas M Antonsen, Edward Ott, Steven M. Anlage, *New J. Phys.* **15**, 023025 (2013).
[5] Matthew Frazier, Biniyam Taddese, Thomas Antonsen, Steven M. Anlage, *Phys. Rev. Lett.* **110**, 063902 (2013) – see “Alice and Bob Go Nonlinear”, Synopsis on Physics.APS.org.

Universality of the momentum band density of periodic graphs

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The momentum spectrum of a periodic network (quantum graph) has a band-gap structure. We investigate the relative density of the bands or, equivalently, the probability that a randomly chosen momentum belongs to the spectrum of the periodic network. We show that this probability exhibits universal properties. More precisely, the probability to be in the spectrum does not depend on the edge lengths (as long as they are generic) and is also invariant within some classes of graph topologies.

Based on a joint work with Gregory Berkolaiko.

Nonmonotonic quantum-to-classical transition in multiparticle interference

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Quantum-mechanical wave-particle duality implies that probability distributions for granular detection events exhibit wave-like interference. On the single-particle level, this leads to self-interference—e.g., on transit across a double slit—for photons as well as for large, massive particles, provided that no which-way information is available to any observer, even in principle. When more than one particle enters the game, their specific many-particle quantum features are manifested in correlation functions, provided the particles cannot be distinguished. We are used to believe that interference fades away monotonically with increasing distinguishability—in accord with available experimental evidence on the single- and on the many-particle level. We demonstrate experimentally and theoretically that such monotonicity of the quantum-to-classical transition is the exception rather than the rule whenever more than two particles interfere. As the distinguishability of the particles is continuously increased, different numbers of particles effectively interfere, which leads to interference signals that are, in general, nonmonotonic functions of the distinguishability of the particles.

Conservation laws and thermodynamic efficiencies

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The understanding of the microscopic mechanisms which determine the macroscopic laws of heat and particles transport is one of the main problems of statistical mechanics. On the other hand, thermoelectric phenomena, which involve the conversion between thermal and electrical energy, and provide a method for heating and cooling materials, are expected to play an increasingly important role in meeting the energy challenge of the future. Here we discuss a new approach to this problem, which is rooted in nonlinear dynamical systems. More precisely we will discuss idealized models of interacting particles in one and two dimensions.

Isoscattering quantum graphs and microwave networks

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Can one hear the shape of a graph from outside? This is a modification of the famous question of Mark Kac "Can one hear the shape of a drum?" which can be asked in the case of scattering systems such as quantum graphs and microwave networks. It addresses an important mathematical problem whether scattering properties of such systems are uniquely connected to their shapes? We present the first experimental approach to this problem in the case of microwave networks simulating quantum graphs. We discuss the scattering from a pair of isospectral microwave networks consisting of vertices connected by microwave coaxial cables. The networks are extended to scattering systems by connecting leads to infinity in a way preserving their symmetry to form isoscattering networks. We show that the concept of isoscattering graphs is not only a theoretical idea but it could be realized experimentally.

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Asymmetry induced localization transition

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We investigate a two-level system (TLS), which couples via non-commuting operators to two independent oscillator baths. In equilibrium the renormalized hopping matrix element is finite when the coupling is symmetric even for infinitely strong coupling strength. The two level system is in a delocalized phase. For finite coupling strength a localization transition occurs for a critical asymmetry angle, which separates the localized from the delocalized phase. Using the method of flow equations we are also able to monitor real time dynamics.

Random matrix theory approach to mesoscopic fluctuations of heat transport

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We consider an ensemble of fully connected networks of N oscillators coupled harmonically with random springs and show, using Random Matrix Theory considerations, that both the average phonon heat current and its variance are scale-invariant and take universal values in the large N-limit. These anomalous mesoscopic fluctuations are the hallmark of strong correlations between normal modes.

Spectral gap for quantum graphs and their connectivity

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Spectral gap for discrete graphs is sometimes called algebraic connectivity due to its close relation to vertex and edges connectivities. We study the spectral gap for quantum graphs in relation to graph's connectivity. First of all using Euler's theorem we prove, that among all graphs having the same total length the spectral gap is minimal for the graph formed by one edge. Moreover we show that in contrast to discrete graphs connection between the connectivity and the spectral gap is not one-to-one. The size of the spectral gap depends not only on the topology of the metric graph but on its geometric properties as well. It is shown that adding sufficiently large edges as well as cutting away sufficiently small edges leads to a decrease of the spectral gap. Corresponding explicit criteria are given.

This is a joint work with G. Malenova and S. Naboko.

Experimental studies in quasi 1D elastic rods

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A revision of recent experimental results on the vibrations of elastic systems is given. In locally periodic rods, which have approximate invariance under translations, constructed joining N unit cells, the spectrum shows bands and gaps whereas the wave amplitudes are extended. When defects are introduced the states are localised and different phenomena are observed. When the defects are chosen with certain rule the Wannier–Stark Ladders are obtained; when the defects are random, Anderson localisation is observed. All these effects were found for closed systems but the introduction of absorbers allows to mimic open scattering systems. In this case quasi-1D cavities can be constructed and the reflection amplitude, including its phase, can be measured. In all cases analyzed excellent agreement between theory and experiment is obtained.

Dirac-microwave billiards, photonic crystals and graphene

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In the Workshop on Quantum Chaos and Localization Phenomena, May 20–22, 2011 in Warsaw, Poland I have spoken about our first experiments and modeling grapheme with photonic crystals [1]. In my talk in the present 6th Workshop I will, after recapitulating the analogy between two-dimensional non-relativistic (Schrödinger) and relativistic (Dirac) quantum billiards and microwave billiards, discuss in detail e.g. the band structure, the local density of states at the Dirac point, its relation to the scattering matrix and its use for determining the experimental length spectrum of periodic orbits in the relativistic regime around the Dirac point and in the non-relativistic one away from it, and the effect of edge states on the behavior of the mean density of states as function of quasimomentum. Finally it is shown how the logarithmic divergency of states at the so called Van Hove singularities can be interpreted as a Lifshitz topological phase transition.

Supported by the DFG within the SFB 634.

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[2] B. Dietz, M. Miski-Oglu, N. Pietralla, A. Richter, L. von Smekal, J. Wambach, F. Iachello, to be published.

Shifts of resonance widths as a probe of eigenfunction nonorthogonality

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Resonances feature themselves in the energy-dependent S matrix as its poles in the complex energy plane. They can be analytically described as the complex eigenvalues of an effective non-Hermitian operator. Notably, the associated resonance wavefunctions are known to be non-orthogonal that has many important applications, ranging from nuclear physics, to quantum optics and solid state. In this talk, I will consider an open (scattering) quantum system under the action of a perturbation of its closed counterpart. It is demonstrated that the resulting shift of resonance widths is a sensitive indicator of the non-orthogonality of resonance wavefunctions, being zero only if those were orthogonal. Focusing further on chaotic systems, I will introduce a new type of parametric statistics in open systems, and derive (within random matrix theory) the distribution of the resonance width shifts in the regime of weakly open system.

Based on a joint work with Yan Fyodorov (QMUL).

N-particle quantum statistics on graphs

Adam Sawicki

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I will show how to develop a full characterization of abelian quantum statistics on graphs. We explain how the number of anyon phases is related to connectivity. I will show the independence of quantum statistics with respect to the number of particles for 2-connected graphs. For non-planar 3-connected graphs bosons and fermions will be identified as the only possible statistics, whereas for planar 3-connected graphs I will show that one anyon phase exists. The approach also yields an alternative proof of the structure theorem for the first homology group of n-particle graph configuration spaces.

This is a joint work with Jonathan Harrison, Jon Keating and Jonathan Robbins.

Local stable or unstable regions in 2-dimensional chaotic forms: Examples and simulations

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We analyze 2-dimensional chaotic forms resulting from very simple systems based on two chaotic characteristics that is rotation and parallel movement or translation in geometric terms. Reflection is another alternative, along with rotation, for several interesting chaotic formations.

Rotation and translation are very common types of movements in the world around us. It is worth noting to explore the chaotic or non-chaotic forms arising from these two main generators. The rotation-translation chaotic case presented is based on the theory analyzed in the book [3] and in the paper [5].

An overview of the chaotic flows in rotation-translation is given. It is observed the presence of chaos when discrete rotation-translation equation forms are introduced. Instead the continuous equations analogue of the discrete cases is useful to find the trajectories of chaotic flows. Characteristic cases and illustrations of chaotic attractors and forms are analyzed and simulated. The analysis of chaotic forms and attractors of the models presented is given along with an exploration of the characteristic or equilibrium points. Applications in the fields of Astronomy-Astrophysics (Galaxies [1,5]), Chaotic Advection (the sink problem [2]) and Von Karman streets [4] are presented.

[1] C. H. Skiadas, "Chaotic dynamics in simple rotation-reflection models", in: *Int. Workshop on Galaxies and Chaos: Theory and Observations*, Academy of Athens, Astronomy Research Center, Athens, Greece, September 16–19, 2002.

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[4] C. H. Skiadas, "Von Karman streets chaotic simulation", in: *Topics on Chaotic Systems* (World Scientific, Singapore 2009), pp. 309–313.

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Transmission through noisy graphs

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We study the transmission of waves through quantum graphs which are subject to time dependent random noise. This way we model e.g., graphs with fluctuating bond lengths. We obtain expressions for the noise averaged transmission coefficients, and in particular, study the effects of the noisy environment on resonance transmission.

Mesoscopic quantum transport in presence of a weakly disordered background: time delay, decoherence and energy absorption

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Effect of a disordered many-body environment is analyzed on the chaotic dynamics of a quantum particle in a mesoscopic ballistic structure. The decoherence and energy absorption phenomena are treated on the same footing within the framework of a microscopic model based on the general theory of the resonance scattering. The single-particle doorway resonance states excited in the structure via external channels are damped not only because of the escape onto such channels but also due to ulterior population of the long-lived background states. The latter broadens the delay time distribution thus strongly enhancing the time delay inside the system. As a result, transmission through the structure splits up into incoherent sum of the flow formed by the interfering damped doorway resonances and the retarded flow of the particles re-emitted by the environment back in the structure. The resulting internal energy absorption as well as the decoherence rate are uniquely expressed in terms of the spreading width that controls coupling to the background.

Microwave studies of complex scattering systems

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Most of the phenomena observed for waves are universal and can be found likewise in water, sound, and electromagnetic waves as well as in wave mechanics. Using microwave techniques it thus becomes possible to study e.g. questions by means of classical waves which originally had been conceived in the context of quantum mechanics. This will be illustrated by a number of examples such as the study of a microwave analogue of graphene, or the transport of microwaves through a potential landscape simulating the situation in the ocean.

Taming quantum chaos in the many-body Wannier–Stark system

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Modern quantum and atom-optical experiments allow for an unprecedented control of microscopic degrees of freedom, not just in the initialization but also in the dynamical evolution of quantum states. This talk focuses on the dynamics of ultra-cold bosons in optical lattice structures. Results are reported on the interband transport in a tilted lattice, i.e. a cold-atoms realization of the famous Wannier–Stark problem. Single-particle and mean-field experimental investigations motivate our many-body Bose–Hubbard model for the system.

Many-body Anderson localization in one dimensional systems

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The problem of Anderson localization of interacting particles is revisited. We demonstrate, using quasi-exact numerical simulations, that Anderson localization in a disordered one-dimensional potential survives in the presence of attractive interaction between particles. The localization length of the particles center of mass – computed analytically for weak disorder – is in good agreement with the quasi-exact numerical observations using the Time Evolving Block Decimation algorithm. Comparison with previously developed mean field description of the problem is made. Our approach allows for a simulation of the entire experiment including the final measurement of all atom positions [1].

[1] D. Delande, K. Sacha, M. Płodzień, S. Avazbaev, and J. Zakrzewski, *New. J. Phys.*, in press (2013).

Random quantum states and random unitary matrices associated with a graph

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For a class of graphs consisting of m vertices one defines an ensemble of random pure states on a composite system with m subsystems of the same dimension n. Each edge of the graph represents a random unitary matrix of size n^2 distributed according to the Haar measure, which describes an unknown interaction between the subsystems. For a given topology of the graph we analyze statistical properties of the corresponding ensemble of quantum pure states and the ensemble of structured random unitary matrices of size $N = n^m$.

This is a joint work with Paweł Kondratiuk.

Using semi-classics to create a time-reversed wave collapse at an arbitrary location in a ray-chaotic scattering environment

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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]. 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 (out to the Ehrenfest time) with the time-reversal mirror, we can make a waveform appear at an arbitrary location in a complex scattering environment. We will present experimental results on such a system implemented in a quasi-two-dimensional bow-tie billiard using an electromagnetic time-reversal mirror.

This work was funded by the ONR AppEl Center Task A2 (No. N000140911190), the AFOSR (No. FA95500710049), and the Maryland Center for Nanophysics and Advanced Materials.

[1] Steven M. Anlage, John Rodgers, Sameer Hemmady, James Hart, Thomas M. Antonsen, Edward Ott, *Acta Physica Polonica A* **112**, 569 (2007).
[2] Matthew Frazier, Biniyam Taddese, Thomas Antonsen, Steven M. Anlage, *Phys. Rev. Lett.* **110**, 063902 (2013) – see “Alice and Bob Go Nonlinear”, Synopsis on Physics.APS.org.
[3] James A. Hart, T. M. Antonsen, E. Ott, *Phys. Rev. E* **80**, 041109 (2009).
[4] Jen-Hao Yeh, James Hart, Elliott Bradshaw, Thomas Antonsen, Edward Ott, Steven M. Anlage, *Phys. Rev. E* **81**, 025201(R) (2010).
[5] Jen-Hao Yeh, James Hart, Elliott Bradshaw, Thomas Antonsen, Edward Ott, Steven M. Anlage, *Phys. Rev. E* **82**, 041114 (2010).
[6] Jen-Hao Yeh, Thomas M. Antonsen, Edward Ott, Steven M. Anlage, *Phys. Rev. E* **85**, 015202(R) (2012).

Level coupled but not probed in multilevel Λ-type system

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We present numerical simulations of a weak probe absorption profiles in the multilevel Λ-type system consisting of two ground and three excited levels under the presence of much stronger coupling. In calculations we assumed parameters relevant for the ^{85}Rb D2 transitions. The $5P_{3/2}$ state of ^{85}Rb with its closely spaced hfs structure supports simultaneous coupling of three excited levels ($F' = 1, 2, 3$ in our case) with the ground level ($F = 2$) by means of one laser field. Our aim was to study the impact of the $F' = 1$ level on probe absorption. In the adopted configuration while the coupling transition (starting from the $F = 2$ level) to this level is allowed, the probe transition (starting from the $F = 3$ level) to the same upper level is forbidden due to selection rules. We use optical Bloch equations in the dipole and RWA approximations and derive the stationary solutions. Motionless (cold) atoms are assumed. We assume that coherence decay is related either to natural decay and finite line widths of both pump and probe lasers or alternatively to natural decay only (with negligible laser line widths). Simulations are performed for a number of Rabi frequencies and detunings of the pump field. The probe is tuned across the manifold of the upper levels. Spectra obtained via the 5-level model calculations are compared with those of the 4-level model calculations (in the latter the coupled but not probed level $F' = 1$ is eliminated). Particular attention is paid to how the $F' = 1$ level affects the narrow resonances, such as these of EIT origin or a "distant wing" of the Autler–Townes splitting, because such resonances are of interest, e.g., for developing quantum memory protocols [A. S. Sheremet *et al.*, PRA 82, 033838 (2010)]. Our results indicate that even for weak pump with Rabi frequency comparable to the natural line width, spectra are significantly modified due to the presence of $F' = 1$ level. The effect is especially prominent for pump in the vicinity of the $F = 2 \rightarrow F' = 1$ resonance. In conclusion: a level which is not directly involved in probe absorption can still (due to multiphoton transitions) considerably shape probe spectra, and therefore its influence has to be carefully considered, even for pump Rabi frequency not exceeding the natural line width.

Wigner function for the orientation state

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The Wigner function has proven to be an extremely useful tool to describe quantum phenomena in the motion of point particles. But in many situations it is not desirable to neglect the extension of quantum objects, e.g. if one wants to describe a rotating molecule. The poster introduces a viable phase space description for the orientation state of extended objects. All essential features of the standard Wigner function are shown to be recovered, in particular the interpretability as a quasi-probability.

Elastic enhancement factor as a quantum chaos probe

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Recent development of the resonance scattering theory with a transient from the regular to chaotic internal dynamics inspires renewed interest to the problem of the elastic enhancement phenomenon. We reexamine the question what the experimentally observed value of the elastic enhancement factor can tell us about the character of dynamics of the intermediate system.

Noting first a remarkable connection of this factor with the time delays variance in the case of the standard Gaussian ensembles we then prove the universal nature of such a relation. This reduces our problem to that of calculation of the Dyson's binary form factor in the whole transition region.

By the example of systems with no time-reversal symmetry we then demonstrate that the enhancement can serve as a measure of the degree of internal chaos.

Conservation of energy in coherent backscattering of light

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We investigate the phenomenon of coherent backscattering of light, an interference effect that is observed when light propagates in disordered media in the presence of a boundary interface. Up to this day, it is not yet well-known, what are the processes that allow this effect to occur without violating the law of conservation of total energy [1].

We analyze in detail the processes at the origin of coherent backscattering as well as their relation to the mechanism that gives rise to the effect of weak localization. In the frame of a full description treating jointly these interference effects in random media, we are able to provide an explanation of the mechanism ensuring energy conservation.

[1] S. Fiebig et al., *Europhys. Lett.* **81**, 64004 (2008).

Resonance asymptotics in quantum graphs

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We summarize the known results on the high-energy asymptotics of the number of resonances in quantum graphs. We study resonance behaviour of a quantum graph which has both finite and infinite edges. We are interested in the number of resolvent resonances enclosed in the circle of a radius R in the complex momentum plane in the limit $R \to \infty$. It appears that for most of the graphs the asymptotics is Weyl – the first term of the asymptotics is same as the eigenvalue asymptotics of corresponding compact graph. On the other hand, there exist graphs for which the constant by the first term of the asymptotics is smaller than expected (e.g. an abscissa freely coupled to a halfline). We give criteria of non-weylness of the graph for both the standard and general coupling conditions.

Dynamical localization in kicked rotator as a paradigm of other systems: spectral statistics and the localization measure

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We study quantum kicked rotator in the classically fully chaotic regime, in the domain of the semiclassical behaviour. We use Izrailev's N-dimensional model for various $N \leq 4000$, which in the limit $N \to \infty$ tends to the quantized kicked rotator, not only for $K = 5$ as studied previously, but for many different values of the classical kick parameter $5 \leq K \leq 35$, and also of the quantum parameter k. We describe the dynamical localization of chaotic eigenstates as a paradigm for other both time-periodic and time-independent fully chaotic or/and mixed type Hamilton systems. We generalize the localization length L and the scaling variable (L/N) to the case of anomalous classical diffusion. We study the generalized classical diffusion also in the regime where the simple minded theory of the normal diffusion fails. We greatly improve the accuracy of the numerical calculations with the following conclusions: The level spacing distribution of the eigenphases is very well described by the Brody distribution, systematically better than by other proposals, for various Brody exponents. When $N \to \infty$ and L is fixed we have always Poisson, even in fully chaotic regime. We study the eigenfunctions of the Floquet operator and characterize their localization properties using the information entropy measure describing the degree of dynamical localization of the eigenfunction. The resulting localization parameter is found to be almost equal to the Brody parameter. We show the existence of a scaling law between the localization parameter and the scaling variable L/N, now including the regimes of anomalous diffusion. The above findings are important also in time-independent Hamilton systems, like in mixed type billiards, where the Brody distribution is confirmed to a very high degree of precision for dynamically localized chaotic eigenstates.

Recovering matching conditions for quantum graphs

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The Schrödinger operator on a metrized star graph, a graph consisting of a finite number of edges connected at one point, is considered. We investigate the general matching (boundary) conditions at the central vertex that lead to a self-adjoint operator. First we establish the relation between matching conditions and the vertex scattering matrix. Then, using boundary control method, we show that the potential on each of the edges can be reconstructed. Moreover we show that the vertex scattering matrix and therefore the boundary conditions can be reconstructed up to one real phase parameter.

These are the results of a joint work with S. Avdonin and P. Kurasov.

Statistical model of short wavelength transport through cavities with coexisting chaotic and regular ray trajectories

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We study the statistical properties of the impedance matrix (related to the scattering matrix) describing the input/ouput properties of waves in cavities in which ray trajectories that are regular and chaotic coexist (i.e., 'mixed' systems). The impedance can be written as a summation over eigenmodes where the eigenmodes can typically be classified as either regular or chaotic. By appropriate characterizations of regular and chaotic contributions, we obtain statistical predictions for the impedance. We then test these predictions by comparison with numerical calculations for a specific cavity shape, obtaining good agreement.

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Matter-waves analog of an optical random laser

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The accumulation of atoms in the lowest energy level of a trap and the subsequent out-coupling of these atoms is a realization of a matter-wave analog of a conventional optical laser. Optical random lasers require materials that provide optical gain but, contrary to conventional lasers, the modes are determined by multiple scattering and not a cavity. We show that a Bose–Einstein condensate can be loaded in a spatially correlated disorder potential prepared in such a way that the Anderson localization phenomenon operates as a band-pass filter. A multiple scattering process selects atoms with certain momenta and determines laser modes, which represents a matter-wave analog of an optical random laser.

Centro-symmetric Hamiltonians foster quantum transport

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Lossless and rapid transport of elementary excitations in complex materials is a crucial prerequisite for functional optimisation, from information transfer to energy conversion. With increasing complexity of the underlying structures, random perturbations become unavoidable, and rather be incorporated than fought when seeking robust optimisation strategies. We propose a general mechanism for highly efficient quantum transport through finite, disordered 3D networks, which relies on an appreciable statistical weight of rare events, is robust against reconformations, can be controlled by tuning coarse-grained quantities, and thus qualifies as a general design principle.

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PROGRAMME

Friday, May 24

19:00-22:00	Welcome party (Gromada hotel)

Saturday, May 25

9:00–9:10	**Leszek Sirko** (Warsaw, Poland) Opening
	INVITED TALKS
9:10–9:45	**Achim Richter** (Darmstadt, Germany) Dirac-microwave billiards, photonic crystals and graphene
9:45–10:20	**Hans-Jürgen Stöckmann** (Marburg, Germany) Microwave studies of complex scattering systems
10:20–10:55	**Steven M. Anlage** (College Park, USA) Nonlinear time-reversal in a wave chaotic system
10:55–11:30	**Rafael Mendez** (Cuernavaca, Mexico) Experimental studies in quasi 1D elastic rods
11:30–12:00	coffee break
12:00–12:35	**Giulio Casati** (Como, Italy) Conservation laws and thermodynamic efficiencies
12:35–13:10	**Tsampikos Kottos** (Middletown, CT, USA and Goettingen, Germany) Random matrix theory approach to mesoscopic fluctuations of heat transport
13:10–13:45	**Andreas Buchleitner** (Freiburg, Germany) Nonmonotonic quantum-to-classical transition in multiparticle interference
13:45–14:45	lunch break
14:45–16:00	POSTER SESSION
	INVITED TALKS
16:00–16:20	**Sandro Wimberger** (Heidelberg, Germany) Taming quantum chaos in the many-body Wannier–Stark system
16:20–16:40	**Oleh Hul** (Warsaw, Poland) Isoscattering quantum graphs and microwave networks
16:40	Warsaw tour and conference dinner

PROGRAMME

Sunday, May 26

	INVITED TALKS
9:00–9:35	**Uzy Smilansky** (Rehovot, Israel) Scattering properties of chaotic microwave resonators
9:35–10:10	**Pavel Kurasov** (Stockholm, Sweden) Spectral gap for quantum graphs and their connectivity
10:10–10:45	**Karol Życzkowski** (Warsaw and Cracow, Poland) Random quantum states and random unitary matrices associated with a graph
10:45–11:20	**Valentin V. Sokolov** (Novosibirsk, Russia) Mesoscopic quantum transport in presence of a weakly disordered background: time delay, decoherence and energy absorption
11:20–11:50	coffee break
11:50–12:25	**Christos H. Skiadas** (Chania, Crete, Greece) Local stable or unstable regions in 2-dimensional chaotic forms: Examples and simulations
12:25–13:00	**Dmitry Savin** (London, UK) Shifts of resonance widths as a probe of eigenfunction nonorthogonality
13:00–13:35	**Heinerich Kohler** (Madrid, Spain) Asymmetry induced localization transition
13:35–14:10	**Jakub Zakrzewski** (Cracow, Poland) Many-body Anderson localization in one dimensional systems
14:10–15:00	lunch break
	INVITED TALKS
15:00–15:20	**Rami Band** (Bristol, UK) Universality of the momentum band density of periodic graphs
15:20–15:40	**Adam Sawicki** (Warsaw, Poland and Bristol, UK) Investigation of graphs with absorption
15:40–15:50	Closing remarks

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