DY 32: Quantum Chaos

Time: Wednesday 10:00–13:00 Location: HÜL 186

DY 32.1 Wed 10:00 HÜL 186

Spectral two-point correlation functions in microwave graphs with symplectic symmetry — •Aimaiti Rehemanjiang[1], Ulrich Kuhl[2,1], and Hans-Jürgen Stöckmann[1] — [1]Fachbereich Physik der Philipps-Universität Marburg, D-35032 Marburg, Germany — [2]Université Côte d'Azur, CNRS, LPMC, France

In a recent experiment we succeeded in a microwave realization of the Gaussian symplectic ensemble (GSE) in a microwave graph [1,2] obeying an antiunitary symmetry T with $T^2 = -1$. The Kramers doublets, expected in such a system, were clearly observed and showed a level spacing distribution in full agreement with the Wigner GSE prediction. In the present talk results on the two-point correlation function, the spectral form factor, the number variance and the spectral rigidity are presented. Furthermore we discuss the transition from GSE to GOE statistics by continuously changing T from $T^2 = -1$ to $T^2 = 1$.

[1] A. Rehemanjiang, M. Allgaier, C. H. Joyner, S. Müller, M. Sieber, U. Kuhl, and H.-J. Stöckmann. Phys. Rev. Lett. 117, 064101 (2001).
[2] C. H. Joyner, S. Müller, and M. Sieber. Europhys. Lett. 107, 50004 (2014).

DY 32.2 Wed 10:15 HÜL 186

Phase-space dynamics of van der Waals dissociation — •Tom Schilling[1] and Arnd Bäcker[1,2] — [1]TU Dresden, Institut für Theoretische Physik, Dresden — [2]MPI für Physik komplexer Systeme, Dresden

An effective description of the dissociation of van der Waals complexes, such as He−I_2, can be obtained in terms of 4D symplectic maps. The escape dynamics is governed by a mixed phase space where invariant manifolds are attached to a family of fixed points at infinity. We use frequency space plots, escape time plots, and 3D phase-space slices to visualize the dynamics. Together with an analysis of the escape time statistics this allows for an understanding of the higher-dimensional chaotic transport leading to dissociation.

DY 32.3 Wed 10:30 HÜL 186

Exceptional points in the elliptical three-disk scatterer using semiclassical periodic orbit quantization — •Niklas Liebermann, Jörg Main, and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart, Germany

The three-disk scatterer has served as a paradigm for semiclassical periodic orbit quantization of classical chaotic systems using Gutzwiller's trace formula. It represents an open quantum system, thus leading to spectra of complex eigenenergies. An interesting general feature of open quantum systems described by non-Hermitian operators is the possible existence of exceptional points where not only the complex eigenvalues but also their respective eigenvectors coincide.

Using Gutzwiller's periodic orbit theory we show that exceptional points exist in a three-disk scatterer as well if the system's geometry is modified by extending the system from circular to elliptical disks. The extension is implemented in such a way that the system's characteristic C_{3v} symmetry is conserved. The two-dimensional parameter plane of the system is then spanned by the distance and the excentricity of the elliptical disks. As characteristic features of exceptional points we observe the permutation of two resonances when an exceptional point is encircled in parameter space and the non-exponential decay of the periodic orbit signal. This non-exponential behaviour is related to a non-Lorentzian shape of resonances in the density of states.

DY 32.4 Wed 10:45 HÜL 186

Complex-Path Prediction of Resonance-Assisted Tunneling in MixedSystems — •Felix Fritzsch[1,2], Arnd Bäcker[1,2], Roland Ketzmerick[1,2], and Normann Mertig[1,2,3] — [1]TU Dresden, Institut für Theoretische Physik, Dresden — [2]MPI für Physik komplexer Systeme, Dresden — [3]Department of Physics, Tokyo Metropolitan University, Tokyo

Dynamical tunneling occurs between regular and chaotic regions of a system with a mixed phase space. We present a semiclassical theory for regular-to-chaotic tunneling, which also describes the resonance-assisted enhancement due to a nonlinear resonance chain in the classical phase space. Based on an integrable approximation with one nonlinear resonance chain we derive a complex-path prediction based on just a few phase-space properties [1]. We illustrate our approach with the paradigmatic model of the standard map where excellent agreement with numerically determined tunneling rates is observed.

[1] arXiv:1609.09276 [nlin.CD] (2016)

DY 32.5 Wed 11:00 HÜL 186

Ballistic Transport in graphene antidot lattices — •George Datseris, Ragnar Fleischmann, and Theo Geisel — Max Planck Institute for Dynamics and Self-Organization, Am Fassberg 17, 37077 Goettingen, Germany

Recent experiments have demonstrated ballistic transport effects in graphene antidot super-lattices. In the two-dimensional electron gas of semiconductor heterostructures, antidot systems have long been established as a prime example of ballistic transport, showing fingerprints of nonlinear resonances and chaos in magneto-transport measurements. We study quasi-classical electron dynamics in graphene using different models of the antidot lattice and calculate their magneto-transport properties, in overall very good agreement with the experiments. In particular, we study the effects of imperfections in lithographically fabricated antidots and show that even significant perturbations of the potential landscape have little effect on most resonances, leaving the structure of resistance curves surprisingly robust to this disorder.

15 min. break

Invited Talk DY 32.6 Wed 11:30 HÜL 186

Semiclassical Classification of Periodic Orbits in Quantum Many-Body Systems — •Daniel Waltner, Maram Akila, Boris Gutkin, Petr Braun, and Thomas Guhr — Fakultät für Physik, Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg

Classical periodic orbits on the one side and the quantum energy spectrum on the other are related in semiclassical theories by trace formulae. In the past, there has been huge interest in obtaining periodic orbit spectra for one-particle quantum systems (for example for the hydrogen atom in a strong magnetic field [1]). Here, the Fourier transformation of the trace formula was compared with the periodic orbits calculated by the classical equations of motion. In this talk, I demonstrate how to generalize this comparison to a many-particle system considering a kicked spin chain with nearest neighbor Ising coupling and on-site kicked magnetic field. Here, we face the problem that the dimension of the quantum Hilbert space and the number of periodic orbits is too large to apply the conventional methods used in [1]. We show how to overcome the problem arising from the large Hilbert space dimension by a duality relation and identify dominant contributions to the quantum spectrum arising from collective classical motion of the spins.

[1] D. Wintgen, Phys. Rev. Lett. **58**, 1589 (1987).
[2] M. Akila, D. Waltner, B. Gutkin, P. Braun, T. Guhr, `arXiv1611.05749`.

DY 32.7 Wed 12:00 HÜL 186

Berry-Tabor Trace Formula for the Lieb-Liniger Model — •Christian Scharf, Juan-Diego Urbina, and Klaus Richter — Universität Regensburg

We report our progress in constructing a trace formula for the semiclassical density of states of the Lieb-Liniger model, describing a gas of one-dimensional bosons interacting via a repulsive δ-potential.

We combine the methods of Berry and Tabor used in [1] for any integrable Hamiltonian and apply them to this system by making use of the Bethe-Ansatz equations expressing the quantization of the momenta. Further, using Poisson summation and applying a stationary phase approximation we get perfect agreement between semiclassical and numerical calculation for the oscillatory part of the density of states for the two-particle case while extending the results to arbitrary number of particles is work in progress. We show how this method can be used to obtain a trace formula for other systems like the Fermi- or the Bose-Hubbard models.

[1] Berry, M. V.,Tabor, M., Proc. R. Soc. Lond. A. 349, 101-123 (1976)

DY 32.8 Wed 12:15 HÜL 186

Polarization evolution in 3D micro-cavities — •Jakob Kreismann and Martina Hentschel — TU Ilmenau, Institut für Physik, Theoretische Physik II / Computational Physics, Weimarer Straße 25, 98693 Ilmenau

We investigate electromagnetic propagation in three-dimensional cone-shaped microtube cavities. In such a geometry, the polarization state of resonant whispering gallery modes may differ strongly from the reference case of homogeneous cylinders. In particular, we study how breaking of symmetries influences the morphology of resonances that can be associated with inclined trajectories. This is accompanied by the transition from linear to elliptical polarization. Eventually, we discuss the results from the point of view of spin-orbit interaction of light and its interpretation in terms of Berry phases.

DY 32.9 Wed 12:30 HÜL 186

Stationary waves on nonlinear quantum graphs: Canonical perturbation theory — •Daniel Waltner[1] and Sven Gnutzmann[2] — [1]Fakultät für Physik, Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg — [2]School of Mathematical Sciences, University of Nottingham, Nottingham NG7 2RD, UK

We present a general framework for solving the stationary nonlinear Schrödinger equation on a network of one-dimensional wires modelled by a metric graph with suitable matching conditions at the vertices. For sufficiently small intensities we use canonical perturbation theory that allows to reproduce characteristic effects of nonlinear equations like bifurcations and multistabilities. Simple closed and scattering graphs serve as examples.

DY 32.10 Wed 12:45 HÜL 186

Angular deflection on transmission: From planar to curved dielectric interfaces — •Daniel Kotik — Technische Universität Dresden

Optical beams of finite spatial extent show deviations from the classical laws of reflection and refraction when incident upon a dielectric interface. The resulting spatial and angular beam shifts are well understood on reflection (Goos-Hänchen shift and Fresnel filtering effect) and are typically small compared to the width and divergence of the incident beam. In this respect the angular deflection on transmission is different: even in the short wavelength limit this effect is in its most pronounced form on the order of several degrees.

Our objective is to clarify the deflection mechanism and to reveal the different contributing parts. We identify two partly opposing processes—a refraction induced weighting as well as an accompanying deformation of the incident angular spectrum and show that the angular shift at critical incidence is primarily determined by a displacement of the whole spectrum due to its weighting, and that the deflection caused by Fresnel's transmission coefficients is comparably small and actually *weakens* the effect.

An extended theory for curved interfaces is presented and compared with independent numerical studies. We conclude with a discussion of the prediction capability of our amended ray optics theory concerning the emission properties of *ultrasmall* optical microcavities.