DY 29: Quantum Chaos I

Time: Thursday 10:15–12:30 Location: ZEU 255

DY 29.1 Thu 10:15 ZEU 255

Planar anharmonic two-electron quantum dots — •Sebastian Schröter, Johannes Eiglsperger, Moritz Schönwetter, and Javier Madroñero — TU München, Physik Department

As a first attempt to understand from first principles an unusual behaviour of the coherence of many-body systems [1,2,3] we propose an *ab initio* quantum approach for planar two-electron quantum dots. In our approach the quantum dot is approximated by an harmonic potential with an additional quartic perturbation. An appropriate coordinate transformation leads to a finite exact representation of the eigenvalue problem in creation and annihilation operators. In order to investigate the dynamics of the system a novel explicit time propagation method [4,5] is utilised to solve the time dependent Schrödinger equation.

Within this approach we focus on the study of the complex dynamics of the system. In particular we address the quantum fidelity of wave packets to investigate the loss of coherence of the system.

[1] G. Manfredi, P.-A. Hervieux, New J. Phys. **11**(2009), 013050.
[2] G. Manfredi, P.-A. Hervieux, Phys. Rev. Lett. **100**(2008), 050405.
[3] G. Manfredi, P.-A. Hervieux, Phys. Rev. Lett. **97**(2006), 190404.
[4] S. O. Fatunla, Math. Comput. **34**(1980), 373.
[5] J. Madroñero, B. Piraux, Phys. Rev. A **80**(2009), 033409.

DY 29.2 Thu 10:30 ZEU 255

Phase-Space Properties of a Classical Non-Harmonic Two-Electron Quantum Dot — •Moritz Schönwetter, Javier Madroñero, Sebastian Schröter, and Johannes Eiglsperger — Physik Department, Technische Universität München, James-Franck-Str. 1, D-85748 Garching

Recent investigations of the fidelity in many body systems – which include trapped BEC [1], many electrons in nonparabolic quantum wells [2], and electron gases [3] – have shown an unusual behaviour of the quantum fidelity: it stays equal to unity until a critical time, then drops suddenly to much lower values. In order to understand the origin of this phenomenom the dynamics of a non-harmonic two-electron quantum dot is investigated. We present our first results in an attempt to characterize the coherence of this system in terms of the underlying mixed regular-chaotic classical dynamics.

[1] G. Manfredi, P.-A. Hervieux, Phys. Rev. Lett. **100** (2008), 050405.
[2] G. Manfredi, P.-A. Hervieux, New J. Phys. **11** (2009), 013050.
[3] G. Manfredi, P.-A. Hervieux, Phys. Rev. Lett. **97** (2006), 190404.

DY 29.3 Thu 10:45 ZEU 255

Collective versus Single-Particle Motion in Quantum Many-Body Systems from the Perspective of an Integrable Model — •Jens Haemmerling, Boris Gutkin, and Thomas Guhr — Theoretische Physik Universität Duisburg-Essen

We study the emergence of collective dynamics in the integrable Hamiltonian system of two finite ensembles of coupled harmonic oscillators. After identification of a collective degree of freedom, the Hamiltonian is mapped onto a model of Caldeira-Leggett type, where the collective coordinate is coupled to an internal bath of phonons. In contrast to the usual Caldeira-Leggett model, the bath in the present case is part of the system. We derive an equation of motion for the collective coordinate which takes the form of a damped harmonic oscillator. We show that the distribution of quantum transition strengths induced by the collective mode is determined by its classical dynamics.

DY 29.4 Thu 11:00 ZEU 255

Transport moments beyond the leading order — Gregory Berkolaiko[1] and •Jack Kuipers[2] — [1]epartment of Mathematics, Texas A&M University, College Station, TX 77843-3368, USA — [2]Institut für Theoretische Physik, Universität Regensburg, D-93040 Regensburg, Germany

For chaotic cavities with scattering leads attached, transport properties can be approximated in terms of the classical trajectories which enter and exit the system. With a semiclassical treatment involving fine correlations between such trajectories we show by using graphical recursions how we can obtain the moments of various transport quantities. In particular we give the moment generating function of the transmission and reflection eigenvalues at the first two subleading orders in the inverse channel number for systems with and without time reversal symmetry. These results suggest patterns which could hold for higher order corrections and which would match the low order moments derived from random matrix results. The techniques can also incorporate an energy dependence which allows us to show that the gap in the density of states of chaotic Andreev billiards is robust against the subleading corrections and to obtain the next orders of the moment generating function of the Wigner delay times. Furthermore, the graphical representation provides an intuitive picture for non-linear statistics and we conclude with some generating functions for the correlation between transport moments.

DY 29.5 Thu 11:15 ZEU 255

Whispering Gallery Modes by Partial Barriers in Deformed Microcavities — •Jeong-Bo Shim[1], Jan Wiersig[1], and Hui Cao[2] — [1]Institut für Theoretische Physik, Otto-von-Guericke-Universität Magdeburg, D-39106, Magdeburg, Germany — [2]Department of Applied Physics, Yale University, New Haven, Connecticut 06520-8482, USA

The idea of deformed optical micorcavities was first suggested to induce a directional light emission from the whispering gallery modes. However, it is still not easy to control the optical properties of the whispering gallery modes such as the emission directionality or the quality factor due to the chaotic internal ray dynamics.

In this work, we introduce the possibility that the remnant of a dynamical invariant structure in the phase space of the deformed microcavity, the so-called partial barrier play a role of an unbroken tori due to the openness of the system. Using the semiclassical approach, the spectrum of the microcavity is qualtitatively analyzed in the short wavelength regime. As a result, we are able to predict the spectral and emissional properties of the microcavity along with a good agreement between the theoretical analysis and the numerically obtained spectrum.

DY 29.6 Thu 11:30 ZEU 255

A spectrum and the eigenfunctions of a rectangular microwave Dirac billard — Stefan Bittner[1], Barbara Dietz[1], •Maksym Miski-Oglu[1], and Achim Richter[1,2] — [1]Institut für Kernphysik, Technische Universität Darmstadt, D-64289 Darmstadt, Germany — [2]ECT*, Villa Tambosi, I-38100 Villazzano (Trento), Italy

A spectrum and the eigenfunctions of a rectangular microwave Dirac billard have been measured. The microwave Dirac billiard is a rectangular microwave billiard filled with a photonic crystal consisting of a triangular lattice of metallic cylinders. In the frequency range around the Dirac point two bands approach each other as a pair of cones, i.e. the dispersion relation of the photonic crystal resembles the spectrum of relativistic massless fermions. Microwave power is coupled into (out of) the microwave billiard via dipole antennas and the transmitted power is measured. The eigenvalues of a Dirac billiard correspond to resonances in the transmission spectra. The eigenfunctions are measured by a so-called perturbation body method. Arround the Dirac frequency the eigenfunctions show a clear localization along the ΓK direction of the photonic crystal which corresponds to the zigzag edge in graphene. The observed states are analogous to edge states in graphene nanoribbons.

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DY 29.7 Thu 11:45 ZEU 255

Random caustics and the branching of two-dimensional flows — •Jakob J. Metzger, Ragnar Fleischmann, and Theo Geisel — Max-Planck-Institut für Dynamik und Selbstorganisation

When particles or waves emitted from a source travel through a weak, correlated disorder potential, strong density fluctuations in the form of branches appear on scales much smaller than the mean free path. This branching of the flow has been observed on length scales ranging from a few micrometres, affecting the transport properties of semiconductor devices [1], up to several thousand kilometres, influencing sound propagation through the ocean [2]. It is also responsible for the appearance of large and hazardous freak waves and tsunamis [3].

We present recent results on the statistics of branches which are universal for many types of disorder [4] and their implication on the

statistics of the flow density.

[1] e.g. M. A. Topinka et al., Nature **410**, 183 (2001), M. P. Jura et al., Nature Physics **3**, 841 (2007)

[2] M. Wolfson & S. J. Tomsovic, Acous. Soc. Am., **109**, 2693 (2001)

[3] M. V. Berry , New J. Phys. **7**, 129 (2005); M. V. Berry, Proc. R. Soc. A **463**, 3055 (2007); E. J. Heller, L. Kaplan & A. Dahlen, J. Geophys. Res., **113**, C09023 (2008)

[4] J. J. Metzger, R. Fleischmann and T. Geisel, Phys. Rev. Lett. **105**, 020601 (2010)

DY 29.8 Thu 12:00 ZEU 255

Flooding Signatures in Spectral Statistics — Arnd Bäcker[1,2], Steffen Löck[1], Normann Mertig[1], and •Torsten Rudolf[1] — [1]Technische Universität Dresden, Institut für Theoretische Physik, 01062 Dresden — [2]MPI für Physik komplexer Systeme, 01187 Dresden

We investigate the consequences of flooding on spectral statistics in systems with a mixed phase space, where regions of regular and chaotic motion coexist. Quantum mechanically, eigenstates are typically concentrated on regular tori or in the chaotic sea. However, when increasing the coupling between the regular and the chaotic region, the chaotic states flood the regular island and simultaneously the regular states disappear. We demonstrate that flooding has a significant impact on the level-spacing distribution, which shows a transition from Berry-Robnik statistics in the semiclassical regime to Wigner statistics in the flooding regime.

DY 29.9 Thu 12:15 ZEU 255

How long is the chaotic boundary of a billiard? — Arnd Bäcker[1,3], Roland Ketzmerick[1,3], •Steffen Löck[1], and Holger Schanz[2,3] — [1]Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden — [2]Institut für Maschinenbau, Hochschule Magdeburg-Stendal, 39114 Magdeburg — [3]MPI für Physik komplexer Systeme, 01187 Dresden

For two-dimensional quantum billiards we derive a partial Weyl law, i.e. the average density of states for a subset of eigenstates concentrating on an invariant region Γ of phase space. The leading term is proportional to the area of the billiard times the phase-space fraction of Γ. The boundary term is proportional to the fraction of the boundary where *parallel* trajectories belong to Γ. Agreement with numerical data will be presented for the mushroom and the cosine billiard, where we determine the boundary lengths associated with chaotic and regular states, and for the elliptical billiard, where we consider rotating and oscillating states.