

## DY 13 Quantum Chaos

Zeit: Freitag 14:00–18:30

Raum: TU H2032

**Hauptvortrag**

DY 13.1 Fr 14:00 TU H2032

**Directed chaos in a mixed phase space** — ●HOLGER SCHANZ — Max-Planck-Institut für Strömungsforschung und Institut für Nichtlineare Dynamik der Universität Göttingen, Bunsenstr. 10, 37073 Göttingen

In generic Hamiltonian systems regular and chaotic dynamics coexist in phase space. What happens when such systems are used to transport particles over a long distance? While global chaos leads to diffusion, chaotic transport may be directed and ballistic in a mixed phase space. This can be applied to rectify oscillating forces in a periodic potential without any dissipation, i.e., as a Hamiltonian ratchet. However, we address directed chaos also for undriven and for scattering systems.

Classical and quantum transport are in correspondence for a finite time only. After that tunneling and localization dominate. In the case of directed chaos localization can occur either in phase space or in configuration space, with different consequences for the long-time dynamics. We elucidate how in either case quantum transport is encoded in phase-space structures of the eigenstates.

DY 13.2 Fr 14:30 TU H2032

**Flooding of regular islands by chaotic states** — ●ARNOLD BÄCKER, ROLAND KETZMERICK, and ALEJANDRO G. MONASTRA — Institut für Theoretische Physik, TU Dresden, 01062 Dresden

We introduce a criterion for the existence of regular states in systems with a mixed phase space. If this condition is not fulfilled chaotic eigenstates substantially extend into a regular island. Wave packets started in the chaotic sea progressively flood the island. The extent of flooding by eigenstates and wave packets increases logarithmically with the size of the chaotic sea and the time, respectively. This new effect can be observed for island chains with just 10 islands.

Reference: A. Bäcker, R. Ketzmerick, and A. G. Monastra, *nlin.CD/0409029*, <http://arxiv.org/abs/nlin.CD/0409029>

DY 13.3 Fr 14:45 TU H2032

**Resonance- and chaos-assisted tunneling in mixed regular-chaotic systems** — ●CHRISTOPHER ELTSCHKA and PETER SCHLAGHECK — Institut f. Theoretische Physik, Universität Regensburg

Despite its genuine quantal character, dynamical tunneling is strongly sensitive to details of the underlying classical phase space. A particularly prominent scenario in this context is “chaos-assisted” tunneling which takes place between quantum states that are localized on two symmetry-related islands in a mixed regular-chaotic phase space. We present evidence that nonlinear resonances govern this tunneling process. In a similar way as for near-integrable tunneling, such resonances induce couplings between regular states within the island and states that are supported by the chaotic sea. On the basis of this mechanism, we derive a semiclassical expression for the average tunneling rate, which yields good agreement in comparison with the exact quantum tunneling rates calculated for the kicked rotor and the kicked Harper.

DY 13.4 Fr 15:00 TU H2032

**A super-Ohmic energy absorption in driven quantum chaotic systems** — ●ALEXANDER OSSIPOV<sup>1</sup>, DENIS BASKO<sup>2</sup>, and VLADIMIR KRAVTSOV<sup>1,3</sup> — <sup>1</sup>The Abdus Salam International Centre for Theoretical Physics, Strada Costiera 11, 34014 Trieste, Italy — <sup>2</sup>Physics Department, Princeton University, NJ 08450, USA — <sup>3</sup>Landau Institute for Theoretical Physics, 2 Kosygina Street, 117940 Moscow, Russia

We consider energy absorption by driven chaotic systems of the symplectic symmetry class. According to our analytical perturbative calculation, at the initial stage of evolution the energy growth with time can be faster than linear. This appears to be an analog of weak anti-localization in disordered systems with spin-orbit interaction. Our analytical result is also confirmed by numerical calculations for the symplectic quantum kicked rotor.

DY 13.5 Fr 15:15 TU H2032

**A universal ionization threshold for strongly driven Rydberg states** — ●ANDREAS BUCHLEITNER and ANDREAS KRUG — Max-Planck-Institut für Physik komplexer Systeme, D-01187 Dresden

We observe a universal ionization threshold for microwave driven one-electron Rydberg states of H, Li, Na, and Rb, in an *ab initio* numerical

treatment without adjustable parameters. This sheds new light on old experimental data, and widens the scene for Anderson localization in light matter interaction. Recent experimental observations [1] confirm our predictions [2]. [1] H. Maeda and T.F. Gallagher, *Phys. Rev. Lett.* 93, 193002 (2004) [2] A. Krug and A. Buchleitner, *quant-physics/0404117*

DY 13.6 Fr 15:30 TU H2032

**First experimental evidence for quantum echoes in scattering systems** — ●T. FRIEDRICH<sup>1</sup>, B. DIETZ<sup>1</sup>, H.-D. GRÄF<sup>1</sup>, A. HEINE<sup>1</sup>, C. MEJIA-MONASTERIO<sup>2</sup>, M. MISKI-ÖGLÜ<sup>1</sup>, A. RICHTER<sup>1</sup> und T. H. SELIGMAN<sup>3</sup> — <sup>1</sup>TU-Darmstadt, Institut für Kernphysik, Schlossgartenstr. 9, 64289 Darmstadt — <sup>2</sup>Center for Nonlinear and Complex Systems, Como, Italy — <sup>3</sup>Centro Internacional de Ciencias, Cuernavaca, Mexico

We investigated a scattering system with mixed dynamics and a large stable island in phase space. In those systems the dynamics in the interface between the stable island and the surrounding chaotic sea is described by a Smale horseshoe and a periodic response to an incoming pulse has been predicted theoretically. We observed for the first time this self-pulsing effect, termed quantum echoes, experimentally in an open superconducting microwave billiard [*Phys. Rev. Lett.* 93, 134102 (2004)]. The periods of the echoes can be related to the development stage of the horseshoe and therefore the quantum measurement provides information about the classical scattering process. This work has been supported by DFG within SFB 634.

DY 13.7 Fr 15:45 TU H2032

**Goos-Hänchen effect at curved interfaces** — ●MARTINA HENTSCHEL<sup>1</sup> and HENNING SCHOMERUS<sup>2,3</sup> — <sup>1</sup>Universität Regensburg, 93040 Regensburg — <sup>2</sup>MPIPKS Dresden, Nöthnitzer Str. 38, 01187 Dresden — <sup>3</sup>University of Lancaster, Lancaster LA1 4YW

The Goos-Hänchen effect describes that under the conditions for total reflection the reflected beam is displaced along the dielectric interface from the point of incidence of the incoming beam. This effect leads to corrections to the ray picture, and at curved interfaces also implies corrections to Fresnel’s laws, which become sizable when the wavelength becomes comparable to the system size. Here, we use Husimi functions generalized to dielectric interfaces in order to study the Goos-Hänchen effect at curved interfaces, for which we consider a focussed beam that hits a circular resonator. We show that the Husimi functions allow to read-off the Goos-Hänchen shift directly in phase space. We study the dependence on the angle of incidence, the index of refraction and the curvature of the resonator, as well as on the wavelength and the beam width. This allows us to distinguish between beam and curvature effects. We also determine the effective scattering radius of the cavity and discuss near and far field radiation characteristics.

DY 13.8 Fr 16:00 TU H2032

**Langzeitasymptotik der Fidelity für kohärente Anfangszustände** — ●JENS BOLTE und TOBIAS SCHWAIBOLD — Abteilung Theoretische Physik, Universität Ulm

Die *Fidelity* ist ein von A. Peres eingeführtes Maß für die Empfindlichkeit einer Quantendynamik auf Störungen des Hamiltonoperators. Für Systeme, die in Wechselwirkung mit ihrer Umgebung stehen, mißt sie auch die von der Ankopplung an die Umwelt induzierte Dekohärenz.

Wir untersuchen die Fidelity für kohärente Anfangszustände mit semiklassischen Methoden, insbesondere in Systemen mit chaotischer klassischer Dynamik. Dies geschieht ohne Verwendung von Störungstheorie. Hierbei nutzen wir aus, daß für Zeiten unterhalb der Ehrenfestzeit die Zeitentwicklung kohärenter Zustände rigoros bis auf  $O(\sqrt{\hbar})$  kontrolliert werden kann. Für große Zeiten zerfällt die Fidelity in zwei Beiträge: Ein Faktor beschreibt das mit bzw. ohne Störung unterschiedliche Zerfließen des Wellenpakets, während der zweite Faktor vom Auseinanderlaufen klassischer Bahnen bestimmt wird. Bei einer instabilen klassischen Dynamik zerfällt die Fidelity daher typischerweise schneller als exponentiell.

DY 13.9 Fr 16:15 TU H2032

**A new experimental setup for measuring wave functions in a microwave billiard** — ●M. MISKI-ÖGLÜ, B. DIETZ, T. FRIEDRICH, H.-D. GRÄF, A. HEINE, A. RICHTER, and F. SCHÄFER — TU Darmstadt, Institut für Kernphysik, Schlossgartenstr. 9, 64289 Darmstadt

A new method for the measurement of field distributions in microwave

billiards has been developed. It is based on a well-known perturbation body technique. From the experimentally determined electric field intensity distribution the wave function can be reconstructed. The reconstruction only uses the properties of the Fourier expansion of the wave function. The procedure is equally effective for low lying and highly excited wave functions. The whole set of wave functions up to the 1000th state can be obtained. This allows us to study properties of the nodal lines and nodal domains of a wave function in microwave billiards. This work has been supported by DFG within SFB 634.

DY 13.10 Fr 16:30 TU H2032

**Signatures of Dynamical Tunneling in the Wave function of a Soft-Walled Open Microwave Billiard** — •ULRICH KUHLE<sup>1</sup>, YOUNG-HEE KIM<sup>1</sup>, HANS-JÜRGEN STÖCKMANN<sup>1</sup>, and JON BIRD<sup>2</sup> — <sup>1</sup>Fachbereich Physik der Philipps-Universität Marburg, Renthof 5, D-35032 Marburg — <sup>2</sup>Department of Electrical Engineering, the University at Buffalo, Buffalo, NY 14260-1920, USA

Evidence for dynamical tunneling is observed in studies of the transmission, and wave functions, of a soft-walled microwave cavity resonator. In contrast to previous work, we identify the conditions for dynamical tunneling by monitoring the evolution of the wave function phase as a function of energy, which allows us to detect the tunneling process even under conditions where its expected level splitting remains irresolvable.

DY 13.11 Fr 16:45 TU H2032

**Wavefunction analysis of coupled Bose-Einstein condensates: A non-perturbative approach** — •MORITZ HILLER, TSAMPIKOS KOTTOS, and THEO GEISEL — Max-Planck-Institut für Strömungsforschung und Fakultät Physik der Universität Göttingen, Bunsenstr. 10, 37073 Göttingen, Germany

We study a BEC in a double well trap. As we turn on the coupling between the two wells, the wavefunctions undergo a crossover from a perturbative to a non-perturbative structure. The latter is analyzed by employing semiclassical methods which allows us to identify traces of the underlying phase-space structure. The limitations of perturbation theory are exposed and analytical expressions for the wavefunction shape in all regimes are given.

DY 13.12 Fr 17:00 TU H2032

**Bose-Einstein Condensation in Canonical Ensembles** — •KONSTANTIN GLAUM<sup>1</sup> and AXEL PELSTER<sup>2</sup> — <sup>1</sup>Institut für Theoretische Physik, Freie Universität Berlin, Berlin, Germany — <sup>2</sup>Fachbereich Physik, Universität Duisburg-Essen, Essen, Germany

We set up a recursion relation for the partition function of a finite number of bosons in different trap configurations. This leads to explicit formulas for the specific heat and the number of particles in the ground state defining the condensate. All curves have the correct small  $T$ -behavior and approach their thermodynamic limits uniformly for all temperatures. This is in contrast to an earlier version of the theory in Feynman's textbook on Statistical Mechanics, which ignored the special role of the ground state.

DY 13.13 Fr 17:15 TU H2032

**Quantendynamik von Wellenpaketen auf gekoppelten adiabatischen Potentialen** — •MONIKA HEJJAS und BERND ESSER — Institut fuer Physik, Humboldt-Universitaet, Berlin, Newtonstr. 15, 12489 Berlin, Germany

Die Dynamik von Wellenpaketen auf gekoppelten Potentialen wird mittels des Spin - Boson Modells untersucht. Die Spin Abhaengigkeit in den numerisch bestimmten Eigenzuständen wird benutzt um die Wellenpakete bestimmten klassischen Phasenraumtrajektorien zuzuordnen. Anhand numerisch propagierter Zustandsvektoren des Spin - Boson Systems wird das Aufspaltungsverhalten der Wellenpakete in den Kreuzungspunkten der klassischen Trajektorien untersucht. Es wird die Ausbreitung verallgemeinerter kohärenter Zustände mittels numerischer und analytischer Methoden betrachtet. Die Ergebnisse werden durch Husimi Projektionen als zeitabhängige Phasenraumdichten veranschaulicht.

DY 13.14 Fr 17:30 TU H2032

**Local Equilibrium Aspects of Small Quantum Systems: Kubo Formula in Liouville Space** — •MATHIAS MICHEL<sup>1</sup>, JOCHEN GEMMER<sup>2</sup>, and GÜNTER MAHLER<sup>1</sup> — <sup>1</sup>Institute of Theoretical Physics I, University of Stuttgart — <sup>2</sup>Department of Physics, University of Osnabrueck

We consider chains consisting of several identical subsystems weakly coupled by various types of next neighbor interactions. At both ends the chain is coupled to a respective heat bath with different temperature modeled by a Lindblad formalism [1]. The temperature gradient introduced by this environment is then treated as an external perturbation. We propose a method to evaluate the heat current and the local temperature profile of the resulting stationary state as well as the heat conductivity in such systems [2]. This method is similar to Kubo techniques used e.g. for electrical transport but extended here to the Liouville space.

[1] J. Gemmer, M. Michel and G. Mahler, Quantum Thermodynamics, Springer LNP657 (2005)

[2] M. Michel, J. Gemmer and G. Mahler, Eur. Phys. J. B, submitted (2004)

DY 13.15 Fr 17:45 TU H2032

**Autonomous Quantum Thermodynamic Machines** — •FRIEDEMANN TONNER and GÜNTER MAHLER — Institut für Theoretische Physik 1, Universität Stuttgart, Pfaffenwaldring 57, D-70550 Stuttgart, Universität Stuttgart

How far can a thermodynamic machine be down-scaled? We show, how each functional part of a thermodynamic machine (gas system, piston, control of bath coupling, work reservoir) can be modeled quantum mechanically. Our approach is unique in constructing an autonomous model consisting of a spin (acting as gas system) and a harmonic oscillator (acting as piston, bath-control and work variable) using autonomous Hamiltonians and incoherent Lindblad operators (bath coupling is Markovian). We present explicit results for Carnot-like cyclic processes (heat engine and heat pump). Thermodynamic machines prove to be ideal testbeds for exploring quantum control in open systems.

DY 13.16 Fr 18:00 TU H2032

**Spacetime structures of continuous time quantum walks** — •OLIVER MÜLKEN and ALEXANDER BLUMEN — Institut für Physik, Universität Freiburg

The propagation by continuous time quantum walks (CTQW) on one-dimensional (1d) lattices shows structures in the transition probabilities between different sites reminiscent of quantum carpets. For a system with periodic and reflecting boundary conditions, we calculate the transition probabilities for a CTQW by diagonalizing the Hamiltonian and by Bloch function ansatz. Both results coincide.

DY 13.17 Fr 18:15 TU H2032

**Dynamics of systems coupled to finite markovian environments: Deviations from standard quantum master equation results** — •JOCHEN GEMMER<sup>1</sup> and MATHIAS MICHEL<sup>2</sup> — <sup>1</sup>Universität Osnabrück, Barbarastr. 7, 49069 Osnabrück — <sup>2</sup>Universität Stuttgart, Institut für Theoretische Physik I, Pfaffenwaldring 57, 70550 Stuttgart

We investigate few level quantum systems coupled to environments which are specified only by their energy spectra. For environments featuring a finite but large enough number of eigenstates to represent markovian systems, we find local system dynamics that deviate from what Nakajima-Zwanzig type quantum master equations produce. We compare results from the Nakajima-Zwanzig method, the Hilbertspace average method and present exact numerical solutions for the corresponding Schrödinger equations.