DY 35: Quantum Chaos and Coherent Dynamics

Time: Wednesday 15:30–18:00 Location: H20

DY 35.1 Wed 15:30 H20

THz-induced high-order harmonic generation and nonlinear transport in graphene — •Wenwen Mao[1], Angel Rubio[1,2], and Shunsuke A. Sato[3,1] — [1]Max Planck Institute for the Structure and Dynamics of Matter, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]Center for Computational Quantum Physics (CCQ), Flatiron Institute, 162 Fifth Avenue, New York, NY 10010, USA — [3]Center for Computational Sciences, University of Tsukuba, Tsukuba 305-8577, Japan

Employing the quantum master equation with phenomenological relaxation, we theoretically study the nonequilibrium dynamics of THz-induced high-order harmonic generation in graphene. We first performed fully dynamical simulation to investiget the high-order harmonic generation in graphene induced by THz laser fields. We found that the emitted harmonics is enhanced with the increase in the chemical potential, and this observation is consistent with the recent experiments. Then we introduce a quasi-static picture to develop the microscopic understanding of the THz-induced currents and the population distribution of conduction band in graphene from the viewpoint of a nonequilibrium picture of electron dynamics. The nonlinear electric conductivity of graphene is also investigated under static electric fields for various field strength and chemical potential shifts. The impact of electron temperature change is also investigated to compare with the thermodynamic model in the previous work.

DY 35.2 Wed 15:45 H20

Explicit expressions for stationary states of the Lindblad equation for a finite state space — •Bernd Michael Fernengel — Technische Universität Darmstadt, Darmstadt, Germany

The Gorini-Kossakowski-Sudarshan-Lindblad Equation describes the time evolution of the probabilities of and the coherences between the quantum mechanical states. It is often used to model open quantum systems. We give explicit expressions of stationary solutions of the Lindblad equation in the case of a finite state space, using the concept of state transition networks of Markov chains. Our treatment is based on the so-called quantum-jump unravelling, which is an ensembles of stochastic quantum trajectories, compatible with the Lindblad equation. A single such trajectory shows a continuous time evolution, which is interrupted by stochastic jumps. We discuss differences to the classical case and conditions, under which the Lindblad equation is asymptotically stable (also called 'relaxing').

DY 35.3 Wed 16:00 H20

Eigenstate entanglement in coupled kicked spin chains with chaotic dynamics — •Tabea Herrmann, Maximilian F. I. Kieler, and Arnd Bäcker — TU Dresden, Institut für Theoretische Physik, Dresden, Germany

We study the behaviour of the eigenstate entanglement in two coupled quantum chaotic kicked spin chains in dependence on the coupling strength. It is demonstrated that a random matrix transition ensemble explains the transition from the uncoupled case to strong coupling. Remarkably, the numerical results can be described by an extended perturbation theory which was introduced for the case of two coupled chaotic one-body-systems.

DY 35.4 Wed 16:15 H20

Quantum chaos in microwave cavities with mixed dynamics — •Lennart Anderson and Andreas Wieck — Angewandte Festkörperphysik, Ruhr-Universität Bochum

Based on the analogy of the Schrödinger equation with Dirichlet boundary conditions and the Helmholtz equation for a flat resonator, it is possible to study the dynamical and statistical properties of quantum billiards experimentally in the quasi-classical limit. Billiards, i.e. dynamical systems in which a particle moves ballistically and gets reflected by hard walls, provide a very simple model system, since the entire dynamics only depends on the geometry of the boundary. We investigate Hamiltonian systems with divided phase space, i.e. systems enabling a continuous transition from completely regular to completely chaotic dynamics, like the mushroom billiard, introduced by L. Bunimovich, in the quantum regime. Generalizations of the mushroom billiard and further geometries, i.e. those ranging from convex to non-convex domains, are considered. We further discuss the experimental setup and the impact of parameters like the conductivity of the resonator.

15 min. break

DY 35.5 Wed 16:45 H20

NQCDynamics.jl: Nonadiabatic quantum classical dynamics in the Julia language — •James Gardner[1], Oscar A. Douglas-Gallardo[1], Wojciech G. Stark[1], Julia Westermayr[1], Svenja M. Janke[1,2], Scott Habershon[1], and Reinhard J. Maurer[1] — [1]Department of Chemistry, University of Warwick, United Kingdom — [2]Institute of Advanced Study, University of Warwick, United Kingdom

Accurate and efficient methods to simulate nonadiabatic and quantum nuclear effects in high-dimensional and dissipative systems are crucial for the prediction of chemical dynamics in the condensed phase. To facilitate effective development, code sharing, and uptake of newly developed dynamics methods, it is important that software implementations can be easily accessed and built upon. In this talk, I will present the NQCDynamics.jl package, which provides a Julia language framework for established and emerging methods for performing semiclassical and mixed quantum-classical dynamics in the condensed phase. The code provides several interfaces to existing atomistic simulation frameworks, electronic structure codes, and machine learning representations. In addition to the existing methods, the package enables the development and deployment of new dynamics methods for condensed phase quantum dynamics, which I will show using examples based on model Hamiltonians and full-dimensional ab-initio systems.

DY 35.6 Wed 17:00 H20

Metastability and quantum coherence-assisted sensing in interacting parallel quantum dots — •Stephanie Matern[1], Katarzyna Macieszczak[2], Simon Wozny[1], and Martin Leijnse[1] — [1]NanoLund and Solid State Physics, Lund University, Box 118, 22100 Lund, Sweden — [2]TCM Group, Cavendish Laboratory, University of Cambridge, J. J. Thomson Ave., Cambridge CB3 0HE, United Kingdom

We study the transient dynamics of two interacting parallel quantum dots weakly coupled to macroscopic leads to gain access to the non-equilibrium transport properties. The stationary state current of this quantum system is known to be sensitive to perturbations much smaller than any other energy scale in the system, specifically compared to the system-lead coupling and the temperature. We show that this is due to a bistable point which leads to a regime in the dynamics where the system exhibits metastability and the dynamics is described as classical dynamics between two metastable phases. The competition of those two metastable phases explain the sensitive behaviour of the stationary current towards small perturbations. We show that this behaviour bears the potential of utilizing the parallel dot as charge sensor which makes use of the quantum coherence effects to achieve a high sensitivity that is not limited by temperature. We analyse the sensitivity in terms of the current signal to noise ratio and find that the parallel dots outperform an analogous single dot setup for a wide range of parameters.

DY 35.7 Wed 17:15 H20

Classical and Quantum Dynamics in Resonance Channels — •Jan Robert Schmidt, Arnd Bäcker, and Roland Ketzmerick — TU Dresden, Institut für Theoretische Physik, Dresden, Germany

In higher-dimensional Hamiltonian systems resonance channels play a prominent role for chaotic transport. It is typically slow due to Arnold diffusion, leading quantum mechanically to dynamical localization. Resonance channels widen as they approach the chaotic sea. We show that this geometry induces classically a drift. Quantum mechanically this leads to a transition from localization to delocalization if the drift is strong enough. This is quantified using a transition parameter depending on classical quantities only. Numerically this is confirmed for a 4D symplectic map.

DY 35.8 Wed 17:30 H20

Coupling in Optical Microcavity-Arrays — •Tom Rodemund and Martina Hentschel — Department of Physics, Technische Universität Chemnitz, Chemnitz, Germany

Optical microcavities capture light by total internal reflection in so-called whispering-gallery modes. Deformed disk-shaped microcavities, for example of Limaçon shape, allow one to keep high Q-factors while manipulating the far-field emission via the resonator geometry, thereby allowing for a wide range of applications from microlasers to sensors.

Coupling of several microdisk resonators enhances the possibilities to tame light considerably [1]. Depending on the number and distance of the coupled cavities, the far-field characteristics vary tremendously and can even be reversed [1]. Here, we investigate the underlying mechanisms. To this end we use phase-space methods and analyze the resonance wave functions in real space as well as the corresponding Husimi functions to characterize the coupling behavior. We employ ideas from ray-wave correspondence to deepen our insight by establishing a relation to the nonlinear light ray dynamics and its fingerprint in the Poincaré surface of section.

[1] J. Kreismann et al., Phys. Rev. Res. 1, 033171 (2019).

DY 35.9 Wed 17:45 H20

Time-dependent Redfield and Lindblad equations with effective time-dependent temperature — •Nikodem Szpak, Lukas Litzba, Eric Kleinherbers, and Jürgen König — Theoretische Physik, Universität Duisburg-Essen, Lotharstr. 1, 47048 Duisburg

For a quantum system coupled to environment we apply the first Markov approximation and write the Redfield equation at the first order in the system-environment coupling. Then, we evaluate the remaining time-dependent integral and approximate it uniformly for all times, temperatures and energies by one simple analytical function which corresponds to the Fermi-Dirac distribution with time-dependent effective temperature T(t). Thus, we obtain a new Redfield equation with time-dependent effective temperature. A consecutive approximation brings it to the Lindblad equation with time-dependent Lindblad operators whose time-dependence enters solely via T(t). The variation of the effective temperature T(t) reflects the sudden switch-on of the system-environment interaction at the beginning and becomes high at early times to eventually fall to the true environment temperature T. We discuss possible physical effects and their measurability in some simple examples.