DY 11: Quantum Dynamics, Decoherence, and Quantum Information II

Time: Tuesday 14:00–16:15 Location: H38

Topical Talk DY 11.1 Tue 14:00 H38

AC-driven quantum systems: cold atom ratchets and beyond — •Sergey Denisov — Institut fur Physik, Universitat Augsburg, Univeritatsstr. 1, 86135 Augsburg

I will start with a short introduction by using a simple model of an ac-driven quantum particle in a pulsating periodic potential ("flashing quantum ratchet"), and discuss the main mechanisms of current rectification. I will then present results on the theoretical treatment of the problem [1, 2], specify quantum features, and review the recent experimental realization of the quantum flashing ratchet with ultracold atoms [3]. Finally I will discussed two important issues: (i) the ability of coherent ac-driven quantum motors to perform a work against a constant bias and (ii) the performance of quantum motors in the presence of decoherence.

[1] S. Denisov, L. Morales-Molina, S. Flach, and P. Hanggi, Phys. Rev. A 75, 240604 (2006).

[2] A. V. Ponomarev, S. Denisov, and P. Hanggi, Phys. Rev. Lett. 102, 230601 (2009).

[3] T. Salger et al., Science 326, 1241 (2009).

DY 11.2 Tue 14:30 H38

Signatures of nonclassicality in the non-linear dynamics of an optomechanical system — •Jiang Qian and Florian Marquardt — Arnold Sommerfeld Center for Theoretical Physics, LMU, Munich, Germany

We study the non-linear dynamics in the quantum mechanical time-evolution of an optomechanical system. We discuss the time-evolution of the mechanical Wigner density and discuss the parameter dependence of nonclassical signatures. We describe a long-term steady state that significantly deviates from the semiclassical coherent state picture.

DY 11.3 Tue 14:45 H38

Dynamical typicality of quantum expectation values — •Christian Bartsch and Jochen Gemmer — Fachbereich Physik, Universität Osnabrück, Barbarastrasse 7, D-49069 Osnabrück, Germany

We show that the vast majority of all pure states featuring a common expectation value of some generic observable at a given time will yield very similar expectation values of the same observable at any later time. This is meant to apply to Schrödinger type dynamics in high dimensional Hilbert spaces. As a consequence individual dynamics of expectation values are then typically well described by the ensemble average. Our approach is based on the Hilbert space average method. We support the analytical investigations with numerics obtained by exact diagonalization of the full time-dependent Schrödinger equation for some pertinent, abstract Hamiltonian model. Furthermore, we discuss the implications on the applicability of projection operator methods with respect to initial states, as well as on irreversibility in general.

DY 11.4 Tue 15:00 H38

Creation and destruction of entanglement by a nonequilibrium environment — •Max Ludwig[1], Klemens Hammerer[2], and Florian Marquardt[1] — [1]Department of Physics, Center for NanoScience, and Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians-Universität München, Munich, Germany — [2]Institute for Theoretical Physics, University of Innsbruck, and Institute for Quantum Optics and Quantum Communication, Austrian Academy of Sciences, Innsbruck, Austria

Recent experiments try to cool nanomechanical resonators to the ground state by coupling them to nonequilibrium environments that originate either from electrons or cooper pairs in single electron transistors, or from photons inside an optical cavity. The ultimate goal of these experiments is the observation of quantum effects on macroscopic objects such as entanglement between coupled oscillators. This raises the general question of how nonequilibrium environments affect entanglement.

Here we show that there is an optimal dissipation strength for which the entanglement between two coupled oscillators is maximized. Below this value the cooling mechanism is too weak to overcome the influence of the thermal environment. Above this value, the dissipation via the nonequilibrium bath destroys entanglement. Our results are established with the help of a general framework of exact quantum Langevin equations valid for arbitrary bath spectra, in and out of equilibrium. We point out why the commonly employed Lindblad approach fails to give even a qualitatively correct picture.

DY 11.5 Tue 15:15 H38

Mechanically driven coherent photon dynamics in optomechanical systems — •Georg Heinrich[1], Jack Harris[1,2] und Florian Marquardt[1] — [1]LMU, Department für Physik, ASC, CeNS, München, Germany — [2]Yale University, Department of Physics, Department of Applied Physics, New Haven, CT, USA

The motion of micro- and nanomechanical objects can be coupled to electromagnetic fields. Such optomechanical systems provide new means to manipulate both light as well as mechanical motion and allow to explore the interaction of light and matter in a new regime at the boundary between quantum and classical physics. Besides the objective to eventually explore the quantum regime of mechanical motion, there have been several studies of the complex nonlinear dynamics of these systems. A recent development has introduced setups with multiple coupled optical and vibrational modes pointing the way towards integrated circuits. Here we present non-equilibrium photon dynamics in multimode systems due to the application of external, mechanical driving. This mechanically driven coherent photon dynamics can introduce the whole domain of strongly driven two- and multilevel systems to the field of optomechanics. In particular we consider the recently introduced setup consisting of a movable membrane, placed in the middle between two high-finesse mirrors, that tunnel-couples two optical modes residing in the left and the right half of the cavity, respectively. For mechanical driving of the membrane we predict Autler-Townes splittings, Rabi processes and Landau-Zener-Stueckelberg dynamics, all observable in the transmission spectrum of the system.

DY 11.6 Tue 15:30 H38

Random variable approach to dissipative spin dynamics and Landau-Zener transitions — •Peter Philipp Orth[1], Adilet Imambekov[2], and Karyn Le Hur[1] — [1]Department of Physics, Yale University, New Haven, CT 06520, USA — [2]Department of Physics and Astronomy, Rice University, Houston TX 77251, USA

We present a random variable approach to solve for the dynamics of a dissipative two-state system. Based on an exact functional integral description, our method reformulates the problem as that of non-unitary time evolution of a quantum state vector under a Hamiltonian containing random noise fields. This non-perturbative formalism goes beyond the frequently used Non-Interacting Blip Approximation (NIBA) and is particularly well suited to treat an explicitly time-dependent Hamiltonian. As an example, we consider the renowned Landau-Zener problem in the presence of an Ohmic bath with a large bath cutoff frequency ω_c. We identify an intermediate time regime where the energy separation of the two spin states is much larger than their tunneling coupling Δ, but still smaller than ω_c such that bath mediated spin transitions still occur. Such a situation can for example be realized with a cold atomic quantum dot setup. We also derive an approximate analytical expression for the decay of the upper spin state population in this regime, which agrees well with our numerical results.

DY 11.7 Tue 15:45 H38

Weak to strong values crossover in many body systems — •Alessandro Romito[1], Yuval Gefen[2], and Yaroslav Blanter[3] — [1]Karlsruher Institut für Technologie (KIT), Institut für Theoretische Festkörperphysik, 76128 Karlsruhe, Germany — [2]Department of Condensed Matter Physics, Weizmann Institute of Science, 76100 Rehovot, Israel — [3]Kavli Institute of Nanoscience, Delft University of Technology, Lorentzweg 1, 2628 CJ Delft, The Netherlands

Weak quantum measurement, as opposed to (strong) projective ones described by the projection postulate, provide partial information about the state of the system, while weakly disturbing it. A remarkably effect in this context is the appearance of "weak values" [1] as a result of a two-step measurement procedure – weak measurement followed by a strong one, where the outcome of the first measurement is kept provided a second post-selected outcome occurs. They have proven to be a remarkable concept in addressing fundamental aspects of quantum mechanics and applications to metrology. We have recently addressed the measurement of weak values in solid state physics.

Here I review some of the ideas associated with weak values, including the first proposal to observe weak values in a solid state system. I will then discuss the generalization of weak values to many-body systems specifically considering an electronic Mach-Zehnder interferometer. Within the same setup I will discuss the crossover between weak and strong values.

[1] Y. Aharonov, D. Z. Albert, L. Vaidman, Phys. Rev. Lett. 60, 1351-1354 (1988).

DY 11.8 Tue 16:00 H38

Anderson Localization of Solitons — Krzysztof Sacha[1,2], •Cord A. Müller[2,3], Dominique Delande[2], and Jakub Zakrzewski[1,2] — [1]Uniwersytet Jagielloński, Kraków, Poland — [2]Laboratoire Kastler-Brossel, UPMC, ENS, CNRS, Paris, France — [3]Physikalisches Institut, Universität Bayreuth, Germany

At low temperature, a quasi-one-dimensional ensemble of atoms with an attractive interaction forms a bright soliton. When exposed to a weak and smooth external potential, the shape of the soliton is hardly modified, but its center-of-mass motion is affected. We show that in a spatially correlated disordered potential, the quantum motion of a bright soliton displays Anderson localization. The localization length can be much larger than the soliton size and could be observed experimentally.

[1] Phys. Rev. Lett. 103, 210402 (2009)