Q 17: Quantum Effects: Entanglement and Decoherence II

Time: Tuesday 11:00–13:00 Location: B/gHS

Q 17.1 Tue 11:00 B/gHS

Quantum-to-classical transition in disordered media — •Clemens Gneiting[1], Felix Anger[1], and Andreas Buchleitner[1,2] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Straße 3, 79104 Freiburg — [2]Freiburg Institute for Advanced Studies, Albert-Ludwigs-Universität Freiburg, Albertstr. 19, 79104 Freiburg

The problem of single- and many-particle transport through disordered media lies at the heart of a multitude of physical processes. A prominent consequence of disorder is that the propagation of particles exhibits interference-induced phenomena such as Anderson localization. We investigate how this transition into localized asymptotic states takes place. In particular, we focus on single- and many-particle coherence properties and their evolution in the ensemble average. We find that, upon averaging over the disorder realization, the effective time evolution of arbitrary initial states exhibits a dephasing process towards their Anderson-localized asymptotic limit, for instance indicated by the decreasing visibility of an interference pattern. We characterize this dephasing process for the case of a single and two particles in a discrete lattice with disorder and different initial states.

Q 17.2 Tue 11:15 B/gHS

Effective dynamics of disordered quantum systems — •Chahan M. Kropf[1], Clemens Gneiting[1], and Andreas Buchleitner[1,2] — [1]Institute of Physics, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3, D-79104 Freiburg — [2]Freiburg Institute for Advanced Studies, Albert-Ludwigs-Universität Freiburg, Albertstr. 19, D-79104 Freiburg

In order to reach a generic understanding of the dynamics of disordered quantum systems, it is not sufficient to focus on single disorder realizations; rather, one studies the dynamical behavior of the system upon average over different realizations. Usually, the time evolution of the ensemble average is derived from direct numerical simulation of many disorder realizations and subsequent averaging. Such approach, however, does not provide any physical insight in the characteristic dynamical manifestations of different types of disorder.

Instead, we seek an effective description of the dynamics of the ensemble average within the framework of quantum master equations. We show that the average dynamics of simple, isolated systems can already give rise to intricate non-Markovian behaviour, manifest, for example, in coherence revivals. Ultimately, this approach may pave an alternative way for the engineering of disordered systems towards desired dynamical properties, such as the preservation of coherence or the optimization of transport.

Q 17.3 Tue 11:30 B/gHS

Extended quantum delocalization in photosynthetic complexes — •Christopher Schroeder[1,3], Caycedo-Soler Felipe[1], Autenrieth Caroline[2], Ghosh Robin[2], Huelga Susana[1], and Plenio Martin[1] — [1]Institute for Theoretical Physics, Ulm University, Ulm, Germany — [2]Department of Bioenergetics, Institute of Biomaterials and Biomolecular Systems, University of Stuttgart, Stuttgart, Germany — [3]Joint Quantum Institute, University of Maryland, College Park, USA

Light absorption in photosynthetic complexes occurs predominantly at light-harvesting (LH) antenna complexes, composed of many pigments, followed by excitation energy transfer (EET) between antenna complexes and the reaction centre (RC), containing far fewer pigments. Photon absorption is completed on timescales (~10fs) much shorter than both the coherence time (~100fs) and EET (~1-10ps), which means quantum mechanical delocalization across extended domains must be accounted for in an accurate description of the absorption process, regardless of the nature of transport. We develop a theory to characterize delocalization over extended domains in photosynthetic membranes of purple bacteria and show that the excitonic coupling among different units effects experimentally measurable redistributions of absorption intensity. Coupling between LH complexes leads to a polarized optical response which depends on the geometry of the array, the measurement of which would allow the experimental determination of the inter-complex Förster rate, and delocalization across LH1 and RC leads to an 80 % increase in RC absorption.

Q 17.4 Tue 11:45 B/gHS

Pointer state dynamics of quantum Brownian motion — •Lutz Sörgel and Klaus Hornberger — Fakultät für Physik, Universität Duisburg-Essen

To explore the emergence of classical Langevin equations of motion within the quantum framework, we consider the master equation of quantum Brownian motion. By identifying the pointer states of this equation with the help of a particular stochastic unraveling, we derive a set of classical stochastic differential equations describing their quantum phase space dynamics. This allows us to discuss when and how the limit comes about where the particle trajectories exhibit classical diffusion.

Q 17.5 Tue 12:00 B/gHS

Dynamics of the quantum kicked oscillator in a heat bath — •Pablo Carlos Lopez[1] and Thomas Gorin[2] — [1]Max-Planck-Institut für Physik komplexer Systeme, D-01187 Dresden, Germany — [2]Departamento de Física, Universidad de Guadalajara, 44840, Guadalajara, Jalisco, México.

We discuss the dynamics of a quantum harmonic oscillator under the influence of two different external forces. The first are kicks which are periodically applied to the oscillator and the second one is a surrounding heat bath to which the oscillator is in contact with. It is known that the kicks alone can drive the system into a diffusive regime if the period of the kicks is chosen to be commensurable with the period of the oscillator and localization phenomena can occur if the kicks are done with a incommensurable manner with respect to that of the oscillator. On the other hand the effect of being in contact with the heat bath alone will produce a relaxation process to a thermal equilibrium state. The different regimes of the dynamics of the oscillator under the influence of these two mechanisms is what we present here.

Q 17.6 Tue 12:15 B/gHS

Completely positive hierarchy equations of motion — •Björn Witt[1,3], Łukasz Rudnicki[2,3], and Florian Mintert[1,3] — [1]Imperial College London, London SW7 2AZ, United Kingdom — [2]Institute for Physics, Albert-Ludwigs-Universität Freiburg, Rheinstrasse 10, 79104 Freiburg, Germany — [3]Freiburg Institute for Advanced Studies (FRIAS), Albert-Ludwigs-Universität Freiburg, Albertstr. 19, 79104 Freiburg, Germany

A hierarchical expansion of equations of motion permit to approximate non-Markovian dynamics of open quantum systems very efficiently. Often, however, the inevitable truncation of such hierarchy equations of motion (HEOM) result in a violation of complete positivity and only well chosen hierarchies induce genuine quantum channels. We propose strategies in order to derive sufficient conditions for HEOM to preserve complete positivity. Such hierarchies extend the Lindblad formalism and give rise to a broadened range of dynamics as we demonstrate by applying them to low-dimensional quantum mechanical systems.

Q 17.7 Tue 12:30 B/gHS

Hierarchy of stochastic pure states for open quantum system dynamics — Daniel Suess[1], Walter T. Strunz[1], and •Alexander Eisfeld[2] — [1]TU Dresden — [2]MPIPKS Dresden

We derive a hierarchy of stochastic evolution equations for pure states (quantum trajectories) for open quantum system dynamics with non-Markovian structured environments [1]. This hierarchy of pure states (HOPS) is generally applicable and provides the exact reduced density operator as an ensemble average over normalized states. The corresponding nonlinear equations are presented. We demonstrate that HOPS provides an efficient theoretical tool and apply it to the spin-boson model, the calculation of absorption spectra of molecular aggregates, and energy transfer in a photosynthetic pigment-protein complex.

[1] Phys. Rev. Lett. 113, 150403

Q 17.8 Tue 12:45 B/gHS

Quantum Memristors — •Paul Pfeiffer[1], Mikel Sanz[2], Iñigo Egusquiza[2], and Enrique Solano[2] — [1]Dep. of Physics, LMU Munich — [2]QUTIS, University of the Basque Country

We introduce the concept of Quantum Memristors, decoherence of a quantum system controlled by the history of the quantum state. Classical memristors are powerful circuit elements that promise new information processing platforms and appear in circuit models of neurons. We derive a phenomenological quantum memristor master equation based on coupling the quantum system to a structured environment of a bath and a measurement device which feeds back the measurement output on the system-bath coupling Hamiltonian. As memristive elements are well-known in classical electrical circuits, especially the famous flux-charge memristor, and have been demonstrated experimentally, we study Quantum Memristance in superconducting circuits and demonstrate memory effects in the evolution of Gaussian states in a quantum LC circuit coupled to a memristive environment. Finally, we discuss controlled engineering of memristive environments and applications like learning circuits.