DY 4: Quantum Dynamics, Decoherence, and Quantum Information

Time: Monday 15:00–18:15 Location: MA 001

DY 4.1 Mon 15:00 MA 001

Langevin trajectories deriving from quantum histories — •Hendrik Niemeyer and Jochen Gemmer — Universität Osnabrück, Barbarastraße 7, D-49069 Osnabrück

Our point of departure is the Pauli master equation and its conceptual framework. According to the latter a "property" of a system such as a particle being in a certain region in space or two macroscopic objects featuring a certain temperature difference, etc. corresponds to a (projective) subspace of full Hilbert space. The Pauli master equation suggests transitions between these quantitiative properties (which we choose to call "mesostates") with rates given by Fermis Golden Rule. We show that assuming such rates as well as Gaussian scaling of the dimension of the above subspace with the mesostate and an exponential relaxation of the average mesostate neccessarily yields Langevin-type stochastic dynamics for the mesostate. From a purely quantum perspective the Langevin trajectories then correspond to quantum consistent and markovian histories.

DY 4.2 Mon 15:15 MA 001

Survival probabilities of energy transfer in random networks — •Anastasiia Anishchenko, Alexander Blumen, and Oliver Mülken — Universität Freiburg, Physikalisches Institut, Hermann-Herder-str. 3, Freiburg im Breisgau, Germany

Recently, the dynamics of excitations in, e.g., ultra-cold Rydberg gases or in light-harvesting complexes, both of which can be modelled by networks, have been of particular interest. Here, the initial excitation (a Frenkel exciton) is created by absorbing a laser excitation or by capturing solar photons. The exciton is transported over the network until it encounters sites where it can get absorbed (the reaction center in the light-harvesting complexes). This process can be modelled by non-hermitian Hamiltonians having complex eigenvalues [1]. In the following, we study (ensemble-averaged) random networks in which the excitation can vanish only at certain (trap) nodes and investigate the survival probability that the exciton does not get trapped during the (quantum) walk over the network. We further show how this is related to the distribution of the imaginary parts of the eigenvalues of the Hamiltonian [2].

[1] O. Mülken, A. Blumen, Phys. Rep. 502, 37 (2011).
[2] A. Anishchenko, A. Blumen, O. Mülken, in preparation.

DY 4.3 Mon 15:30 MA 001

Counting statistics of collective photon transmissions — •Malte Vogl, Gernot Schaller, and Tobias Brandes — Institut für Theoretische Physik, Technische Universität Berlin,Berlin

We theoretically study cooperative effects in the steady-state transmission of photons through a medium of N radiators. Using methods from quantum transport, we find a cross-over in scaling from N to N^2 in the current and to even higher powers of N in the higher cumulants of the photon counting statistics as a function of the tunable source occupation. The effect should be observable for atoms confined within a nano-cell with a pumped optical cavity as photon source.

Ref.: Annals of Physics 326 (2011) 2827

DY 4.4 Mon 15:45 MA 001

Entanglement properties of conditional states — •Juan-Diego Urbina[1] and Carlos Viviescas[2] — [1]University of Regensburg, Germany — [2]National University, Colombia

We present a rigorous mathematical result for the amount of multipartite entanglement in conditional states of open quantum systems just after the state of their bosonic environment is measured.

Our main result is a closed formula providing a scaling relation between the probability distribution of experimental outcomes and the amount of entanglement in the state of the central system.

We use this connection to study the distribution of entanglement over the physical ensemble of experimental outcomes, and briefly discuss other consequences of the scaling formula.

DY 4.5 Mon 16:00 MA 001

Dynamics in open systems - from assisted to impeded transport — Petrus Schijven, Alexander Blumen, and •Oliver Mülken — Institute of Physics, University of Freiburg, Germany

We study the dynamics of excitons in molecular aggregates, such as, e.g., photosynthetic complexes or J-aggregates. The dynamics will be modeled by the so-called quantum stochastic walk (QSW) which allows - on a phenomenological level - to interpolate between purely coherent (quantal) transport and purely incoherent (diffusive) transport. Here, the quantum system with a given Hamiltonian is coupled to an environment which we assume to induce diffusive behavior (derived from Fermis golden rule). By introducing excition sources and drains (traps) for the exciton, we show the importance of the initial preparation for, say, transport efficiency measures such as the expected survival time of the exciton [1]. For a given system, a suitable choice of the initial preparation allows to enhance or impede the transport.

[1] P. Schijven, A. Blumen, and O. Mülken, in preparation (2012)

15 min. break

DY 4.6 Mon 16:30 MA 001

Universal Quantum Computing with Spin and Valley Qubits — •Niklas Rohling and Guido Burkard — Department of Physics, University of Konstanz, D-78457 Konstanz, Germany

We study theoretically how to perform state preparation (a), universal quantum gates (b), and read-out (c) in a two-electron double quantum dot with spin and valley degrees of freedom as they are present in graphene or carbon nanotubes. In the spin-only case, task (b) can be implemented via Heisenberg-exchange coupling and local gates [1] and the tasks (a) and (c) by adiabatic transitions between (0,2)- and (1,1)-charge configurations [2]. If valley degeneracy is present, we can consider all states with symmetric charge distribution as a 16-dimensional logic space consisting of two spin and two valley qubits. We show that, although the exchange interaction couples spins as well as valleys, this exchange coupling together with local gates is sufficient to generate a unitary operation which is a universal two-qubit gate in spin space and does not change the valley qubits, or vice versa. State preparation and projective measurements on a specific state are possible by obtaining control of the spin and the valley Zeeman term in each dot.

[1] D. Loss and D. P. DiVincenzo, Phys. Rev. A **57**, 120 (1998)
[2] J. R. Petta et al., Science **309**, 2180 (2005)

DY 4.7 Mon 16:45 MA 001

Non-equilibrium Quantum Phase Transitions in the Dicke Model — •Victor Manuel Bastidas Valencia, Clive Emary, Benjamin Regler, and Tobias Brandes — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

We establish a set of non-equilibrium quantum phase transitions in the Dicke model by considering a monochromatic non-adiabatic modulation of the atom-field coupling. For weak driving the system exhibits a set of side-bands which allow the circumvention of the no-go theorem which otherwise forbids the occurence of superradiant phase transitions. At strong driving we show that the system exhibits a rich multistable structure and exhibits both first- and second-order non-equilibrium quantum phase transitions.

DY 4.8 Mon 17:00 MA 001

Noise-induced Förster Resonant Energy Transfer between orthogonal dipoles — •Peter Nalbach[1], Igor Pugliesi[2], and Michael Thorwart[1] — [1]I. Institut für Theoretische Physik, Universität Hamburg, Jungiusstraße 9, 20355 Hamburg, Germany — [2]II. Lehrstuhl für BioMolekulare Optik, Ludwig-Maximilians-Universität München, Oettingenstraße 67, 80538 Munich, Germany

We show that Förster resonance energy transfer (FRET) in an orthogonally arranged donor-acceptor pair can be induced by environmental noise although direct transfer is prohibited. Environmental fluctuations break the strict orthogonal arrangement of the dipoles and cause effective fluctuating excitonic interactions. Using a scaling argument, we show that interaction fluctuations are coupled to those of the energy levels and are strong enough to induce large FRET rates. This mechanism also explains their temperature dependence observed in a recent experiment on a perylene bisimide dyad and predicts a modified distance dependence as compared to standard Förster theory.

DY 4.9 Mon 17:15 MA 001

Exciton transfer dynamics and quantumness of energy

transfer in the Fenna-Matthews-Olson complex — •Peter Nalbach[1], Daniel Braun[2], and Michael Thorwart[1] — [1]I. Institut für Theoretische Physik, Universität Hamburg, Jungiusstraße 9, 20355 Hamburg, Germany — [2]Laboratoire de Physique Théorique, Université Paul Sabatier, 118, route de Narbonne, 31062 Toulouse, France

We present numerically exact results for the quantum coherent energy transfer in the Fenna-Matthews-Olson molecular aggregate under realistic physiological conditions, including vibrational fluctuations of the protein and the pigments for an experimentally determined fluctuation spectrum. We find coherence times shorter than observed experimentally. Furthermore we determine the energy transfer current and quantify its "quantumness" as the distance of the density matrix to the classical pointer states for the energy current operator. Most importantly, we find that the energy transfer happens through a "Schrödinger-cat" like superposition of energy current pointer states.

DY 4.10 Mon 17:30 MA 001

Phase transitions and dark-state physics in two-color superradiance — •Mathias Hayn, Clive Emary, and Tobias Brandes — Institut für Theoretische Physik, Technische Universität Berlin, 10623 Berlin

We theoretically study an extension of the Dicke model, where the single-particle Hamiltonian has three energy levels in Lambda configuration (i.e., the excited state is coupled to two nondegenerate ground states via two independent quantized light fields). The corresponding many-body Hamiltonian can be diagonalized in the thermodynamic limit with the help of a generalized Holstein-Primakoff transformation. Analyzing the ground-state energy and the excitation energies, we identify one normal and two superradiant phases, separated by phase transitions of both first and second oder. A phase with both superradiant states coexisting is not stable. In addition, in the limit of two degenerate ground states a dark state emerges, which seems to be analogous to the dark state appearing in the well-known stimulated Raman adiabatic passage scheme.

[1] M. Hayn, C. Emary, and T. Brandes, Phys. Rev. A 84, 053856 (2011)

Invited Talk DY 4.11 Mon 17:45 MA 001

Environment-induced heating in composite quantum systems — •Almut Beige — The School of Physics and Astronomy, University of Leeds, Leeds, LS2 9JT, United Kingdom

It is emphasized that repeated energy-absorbing measurements on a single component of a composite quantum system can result in a significant amount of heating. In quantum optical systems, this heating might manifest itself for example as a non-zero stationary state photon emission rate – even in the absence of external driving. The underlying energy concentrating mechanism might not be present, when a two-level atom interacts with a free radiation field and a photon-absorbing environment [1]. Nevertheless, it might play a crucial role in sonoluminescence experiments [2].

[1] Extending the validity range of quantum optical master equations, A. Stokes, A. Kurcz, T. P. Spiller, and A. Beige, arXiv:1111.7206 (2012).

[2] Sonoluminescence and quantum optical heating, A. Kurcz, A. Capolupo, and A. Beige, New J. Phys. 11, 053001 (2009).