TT 57: Transport: Fluctuations and Noise (jointly with CPP, DY)

Time: Wednesday 11:30–12:45 Location: H 3005

TT 57.1 Wed 11:30 H 3005

Quantum transport, master equations, and exchange fluctuations — •Sigmund Kohler and Robert Hussein — Instituto de Ciencia de Materiales de Madrid, CSIC, 28049 Madrid, Spain

We investigate to which extent a many-body Bloch-Redfield master equation description of transport in coupled quantum dots is consistent with the exact generalized equilibrium conditions known as exchange fluctuation theorems. Thereby we identify a class of master equations for which this is the case. Beyond this class, we find deviations which exhibit characteristic scaling laws as functions of the dot-lead tunneling, the inter-dot tunneling, and the temperature. These deviations are accompanied by an increase of lead energy fluctuations inherent in the Bloch-Redfield equation beyond rotating-wave approximation. We illustrate our results with numerical data for a double and a quadruple quantum dot attached to four leads.

[1] R. Hussein and S. Kohler, Phys. Rev. B **89**, 205424 (2014).

TT 57.2 Wed 11:45 H 3005

Waiting time-distribution of a quantum-dot spin valve — •Björn Sothmann — Département de Physique Théorique, Université de Genève, Genève, Switzerland

Recently, the study of waiting-time distributions of electron transport has received a lot of interest [1]. It can provide information about transport processes that is complementary to average current and noise. Here, we discuss the waiting-time distribution of a a quantum-dot spin valve [2], i.e., a single-level quantum dot coupled to two ferromagnetic electrodes with magnetizations that can point in arbitrary directions [3]. We demonstrate that the rich transport physics of this setup, such as the dynamical channel blockade and spin precession in an interaction-driven exchange field, shows up in the waiting-time distribution, and we analyze the conditions necessary to observe the various effects.

[1] M. Albert, G. Haack, C. Flindt, M. Büttiker,
Phys. Rev. Lett. **108**, 186806 (2012).
[2] B. Sothmann, Phys. Rev. B **90**, 155315 (2014).
[3] M. Braun, J. König, J. Martinek,
Phys. Rev. B **70**, 195345 (2004).

TT 57.3 Wed 12:00 H 3005

Waiting-time distribution of light from superconducting resonators coupled to voltage-biased Josephson junctions — •Simon Dambach, Björn Kubala, Vera Gramich, and Joachim Ankerhold — Institute for Complex Quantum Systems, Ulm University, Ulm, Germany

The interplay of the tunneling transfer of charges and the emission and absorption of light can be investigated in a set-up, where a voltage-biased Josephson junction is placed in series to a microwave cavity. In such devices measurements of the emitted microwave radiation can yield information about the Cooper pair current and its fluctuations and vice versa.

Due to the inherent nonlinearity of the Josephson junction tunneling Cooper-pairs can create a variety of non-classical states of light already at weak driving. Depending on experimental parameters and tuning, the device can be described by effective Hamiltonians, indicating specific photon creation mechanisms which lead to strongly bunched or anti-bunched light emission [1].

We will use the waiting-time distribution [2] of emitted photons to highlight how charge quantization of the Cooper pair current drives a crossover from a coherent light source to a single-photon source. Analytical results for the weak driving regime, based on a quantum regression approach, are complemented by numerical results for the full nonlinear quantum case.

[1] B. Kubala, V. Gramich, and J. Ankerhold, arXiv:1404.6259.
[2] T. Brandes, Ann. Phys. (Berlin) **17**, 477 (2008).

TT 57.4 Wed 12:15 H 3005

Input-output description of microwave radiation in the dynamical Coulomb blockade — Juha Leppäkangas[1], Göran Johansson[1], •Michael Marthaler[2], and Mikael Fogelström[1] — [1]Microtechnology and Nanoscience, MC2, Chalmers Universit y of Technology, SE-412 96 Göteborg, Sweden — [2]Institut für Theoretische Festkörperphysik, Karlsruhe Institute of Technology, D-76128 Karlsruhe, Germany

We study microwave radiation emitted by a small voltage-biased Josephson junction connected to a superconducting transmission line. An input-output formalism for the radiation field is established, using a perturbation expansion in the junction's critical current. Using output field operators solved up to the second order, we estimate the spectral density and the second-order coherence of the emitted field. For typical transmission line impedances and at frequencies below the main emission peak at the Josephson frequency, radiation occurs predominantly due to two-photon emission. This emission is characterized by a high degree of photon bunching if detected symmetrically around half of the Josephson frequency. Strong phase fluctuations in the transmission line make related nonclassical phase-dependent amplitude correlations short lived, and there is no steady-state two-mode squeezing. However, the radiation is shown to violate the classical Cauchy-Schwarz inequality of intensity cross-correlations, demonstrating the nonclassicality of the photon pair production in this region.

TT 57.5 Wed 12:30 H 3005

Distribution of energy dissipated by a driven two-level system — •Philip Wollfarth[1,2], Alexander Shnirman[1,2], and Yasuhiro Utsumi[3] — [1]Institut für Theorie der Kondensierten Materie, Karlsruhe Institute of Technology, 76128 Karlsruhe, Germany — [2]DFG Center for Functional Nanostructures (CFN), Karlsruhe Institute of Technology, 76128 Karlsruhe, Germany — [3]Department of Physics Engineering, Faculty of Engineering, Mie University, Tsu, Mie, 514-8507, Japan

In the context of fluctuation relations, we study the distribution of energy dissipated by a driven two-level system. Incorporating an energy counting field into the well known spin-boson model enables us to calculate the distribution function of the amount of energy exchanged between the system and the bath. We also derive the conditional distribution functions of the energy exchanged with the bath for particular initial and/or final states of the two-level system. We confirm the symmetry of the conditional distribution function expected from the theory of fluctuation relations. We also find that the conditional distribution functions acquire considerable quantum corrections at times shorter or of the order of the dephasing time. Our findings can be tested using solid-state qubits.

[1] P. Wollfarth, A. Shnirman, Y. Utsumi,
Phys. Rev. B **90**, 165411 (2014).