TT 3: Transport: Fluctuations and Noise

Time: Monday 9:30–13:00 Location: H 2053

TT 3.1 Mon 9:30 H 2053

Joint counting statistics of voltage and current — •HEIDI FÖRSTER[1], PETER SAMUELSSON[2], and MARKUS BÜTTIKER[1] — [1]University of Geneva, Switzerland — [2]Lund University, Sweden

Current through a conductor can be characterized by the statistics of transferred charge. Of importance are also internal properties like fluctuations of charge inside the coherent conductor, these quantities can be investigated using voltage and dephasing probes. We determine the joint distribution of charge transferred into contacts and voltage at a voltage probe and compare it with the joint distribution of transferred charge and average occupation number at a dephasing probe. Of particular interest is the manifestation of which path information in the current-voltage correlations in interferometers.

[1] H. Förster, P. Samuelsson, and M. Büttiker, New J. Phys. **9**, 117 (2007).
[2] H. Förster, P. Samuelsson, S. Pilgram, and M. Büttiker, Phys. Rev. B **75**, 035340 (2007).
[3] S. Pilgram, P. Samuelsson, H. Förster, and M. Büttiker, Phys. Rev. Lett. **97**, 066801 (2006).

TT 3.2 Mon 9:45 H 2053

Counting statistics of transport through non-Markovian systems — •CHRISTIAN FLINDT[1,2], ALESSANDRO BRAGGIO[3], ANTTI-PEKKA JAUHO[1,2], and TOMÁŠ NOVOTNÝ[4] — [1]Laboratory of Physics, Helsinki University of Technology, Finland — [2]MIC – Department of Micro and Nanotechnology, Technical University of Denmark, Denmark — [3]Dipartimento di Fisica, Università di Genova, Italy — [4]Department of Condensed Matter Physics, Charles University, Czech Republic

Current fluctuations have been promoted as a useful tool to probe the quantum dynamics of nanoscopic transport systems. In this contribution we describe a method for calculating the current cumulants of transport through systems described by non-Markovian generalized master equations. As an illustrative example, we consider transport through a Coulomb-blockade double quantum dot coupled to a dissipative heat bath [1]. We show how the cumulant generating function in the long time limit is determined by a single dominating pole of the memory kernel [2] and describe how the zero-frequency cumulants of the current can be extracted from this pole in a recursive manner. For the evaluation of the finite-frequency noise we show that not only the full set of poles is important, but also initial system-bath correlations play a crucial role [3].

[1] R. Aguado and T. Brandes, PRL **92**, 206601 (2004)
[2] A. Braggio, J. König, and R. Fazio, PRL **96**, 026805 (2006)
[3] C. Flindt, A. Braggio, A.-P. Jauho, and T. Novotný, in preparation (2007)

TT 3.3 Mon 10:00 H 2053

Full Counting Statistics of a Quantum-Dot Aharonov-Bohm Interferometer — •DANIEL URBAN[1,2], ROSARIO FAZIO[2,3], and JÜRGEN KÖNIG[1] — [1]Ruhr-Universität Bochum — [2]Scuola Normale Superiore, Pisa — [3]International School for Advanced Studies, Trieste

The visibility of the interference signal in Aharonov-Bohm (AB) interferometers provides information about the coherence of transport channels. For instance, spin-flip processes in embedded quantum dots lead to partial destruction of the coherence [1] and thus reduction of the AB-oscillation amplitude. The occurrence of this effect depends on the dot occupation.

We perform a perturbation expansion of the Cumulant Generating Function [2] of an AB-Interferometer with embedded quantum dots in the regime of weak tunnel coupling. Different statistics are found for vanishing and infinite charging energy: Without interaction the interfering part of the statistics consists of non-resonant Poissonian processes with an even dependence on the AB-flux.

In the presence of strong interaction on the dot interaction gives rise to additional resonant processes with an odd flux dependence in non-equilibrium situations. In the regime where one dot-lead coupling is close to pinch-off, these processes consist of both single- and double-charge transfers.

[1] J. König and Y. Gefen, PRL **86**, 3855 (2001).
[2] A. Braggio, J. König, and R. Fazio, PRL **96**, 026805 (2006).

TT 3.4 Mon 10:15 H 2053

Full counting statistics of electronic transport through quantum-dot spin valves — •STEPHAN LINDEBAUM, DANIEL URBAN, and JÜRGEN KÖNIG — Institut für Theoretische Physik III, Ruhr-Universität Bochum

We study the full counting statistics of electronic transport through a quantum dot weakly coupled to two ferromagnetic leads with non-collinear polarization directions. It is possible to generate a nonequilibrium spin accumulation on the dot which affects the spin valve characteristics of transport[1].
To investigate the system we perform a perturbative analysis of the transport properties to first order in the tunnel-coupling strength. A diagrammatic real-time transport theory enables us to calculate the cumulant generating function starting from a generalized master equation[2].
A comparision of the cumulants' dependence on the angle enclosed by the magnetizations reveals notable differences between the interacting and non-interacting case.

[1] M. Braun, J. König, and J. Martinek, Phys. Rev. B **70**, 195345 (2004).
[2] A. Braggio, J. König, and R. Fazio, Phys. Rev. Lett. **96**, 026805 (2006).

Invited Talk TT 3.5 Mon 10:30 H 2053

Noise and current cross-correlations in nano-electromechanical systems — •CHRISTOPH BRUDER — Department of Physics, University of Basel, Klingelbergstr. 82, CH-4056 Basel, Switzerland

After some general remarks about current cross-correlations in electronic (fermionic) three-terminal devices, I would like to focus on position measurements using the cross-correlated output of two tunnel junction position detectors. The bound on the peak-to-background ratio in a position measurement using a single detector can be overcome using detector cross-correlations. Furthermore, the double-detector setup can be exploited to drastically reduce the added displacement noise of the oscillator [C.B. Doiron, B. Trauzettel, C. Bruder, Phys. Rev. B **76**, 195312 (2007)].

I would also like to show that the momentum $\hat{p}$ of a nanomechanical oscillator can be measured [C.B. Doiron, B. Trauzettel, C. Bruder, arXiv: 0707.2709; accepted in PRL] by two tunnel junctions in an Aharonov-Bohm-type setup. The tunneling amplitude of one of the junctions depends linearly on the position $\hat{x}$ of the oscillator $t(\hat{x}) = t_0 + t_1\hat{x}$. The presence of two junctions can, under certain conditions, lead to an effective imaginary coupling $t(\hat{x}) = t_0 + it_1\hat{x}$. By calculating the equation-of-motion for the density matrix of the coupled (oscillator+tunnel junction) system, we show that in this case the finite-frequency current noise of the detector is proportional to the momentum spectrum of the oscillator.

Work done in collaboration with W. Belzig, C.B. Doiron, and B. Trauzettel.

Invited Talk TT 3.6 Mon 11:00 H 2053

Nonlinear dynamics and cooling in optomechanical systems — •FLORIAN MARQUARDT — Arnold-Sommerfeld Center for Theoretical Physics, Center for NanoScience, und Department für Physik, Ludwig-Maximilians Universität München, Theresienstr. 37, 80333 München

This talk will provide an overview of ongoing developments and basic theoretical ideas concerning the manipulation of a mechanical cantilever using light-induced forces. During recent years, a series of experiments by various groups has exploited the resonant enhancement of light-induced forces in optical cavities to demonstrate both the emergence of nonlinear classical dynamics, with multiple attractors, as well as impressive progress in cooling. Ultimately, this line of research may lead to the quantum-mechanical ground state of the center-of-mass motion of objects composed of many billions of atoms. A recently developed theory of optomechanical cooling yields a quantum-limit for the reachable phonon number that can be made arbitrarily small, provided a high-finesse cavity is combined with a high-frequency cantilever. I will conclude with an outlook regarding the opportunities for quantum-coherent experiments that will open up once the ground state has been reached.

I thank J. Harris, K. Karrai, S. Girvin, A. A. Clerk, J. P. Chen,

M. Ludwig, C. Neuenhahn, A. Ortlieb, C. Metzger, and I. Favero for collaboration on this topic.

15 min. break

TT 3.7 Mon 11:45 H 2053

Current correlations under AC-bias - quantum noise vs. photon-assisted transport — •Jan C. Hammer and Wolfgang Belzig — University of Konstanz, Department of Physics, Universitätsstr. 10, D-78464 Konstanz, Germany

We study coherent charge transport through a double barrier quantum dot coupled to metallic leads and driven by an AC-bias voltage. Such a voltage is produced e.g. by a laser irradiating a mesoscopic structure. For a resonant level this gives rise to photon-assisted tunneling events of electrons trough the system. The scattering formalism allows us to understand the conductance and the spectral properties of the non-symmetrized current-current correlators as an interplay between correlation induced antibunching and photon-assisted transport events. We discuss how these measurable quantities depend on the coupling to the leads, the applied bias voltage, the driving frequency and the structure of the energy levels inside the scattering region.

TT 3.8 Mon 12:00 H 2053

Noise spectra in mesoscopic transport - an exact result — •Philipp Zedler and Tobias Brandes — Sekr. EW 7-1, TU Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

The resonant level model, which is exactly solvable, provides us with the opportunity to check approaches to quantum noise in mesoscopic transport. We evaluate current cumulants using the exact Keldysh Green Functions. In this approach we can easily assume non-flat tunneling density of states and observe all quantum effects. We compare our results to those obtained with Master equations and scattering theory.

TT 3.9 Mon 12:15 H 2053

Vibrational coherences in tunneling through nanoscale oscillators — Hannes Hübener[1] and •Tobias Brandes[2] — [1]Laboratoire des Solides Irradiés, Ecole Polytechnique, 91128 Palaiseau, France — [2]Institut für Theoretische Physik, Technische Universität Berlin, D-10623 Berlin, Germany

Charging a nano-scale oscillator by single electron tunneling leads to an effective double-well potential due to image charges. We combine exact numerical diagonalizations with generalized Master equations and show [1] that the resulting quantum tunneling of the mechanical degree of freedom can be visualized in the electronic current noise spectrum.

[1] H. Hübener, T. Brandes; Phys. Rev. Lett. xxx (2007).

TT 3.10 Mon 12:30 H 2053

Decoherence by Quantum Telegraph Noise — •Benjamin Abel and Florian Marquardt — Arnold-Sommerfeld Center for Theoretical Physics, Center for NanoScience and Department of Physics, Ludwig-Maximilians Universität München, Munich, Germany

We investigate the time-evolution of the density matrix of a charge qubit subject to quantum telegraph noise, produced by a single electronic defect level. We obtain strikingly different results for the time-evolution of the coherence from the case of Gaussian noise. Depending on the coupling strength of the qubit to the heat-bath and temperature we observe a qualitatively different behavior of the coherence. We simulated spin-echo sequences and discuss the time-evolution of the echo signal. Our analysis relies on a numerical evaluation of the exact solution for the density matrix of the qubit.

TT 3.11 Mon 12:45 H 2053

Non-Markovian dephasing in a structured environment — •Clive Emary — TU Berlin, Sekr. PN 7-1, Institut für Theoretische Physik, Hardenbergstr. 36, D-10623 BERLIN, Deutschland

We describe a theory of the non-Markovian behaviour of a quantum system coupled to an environment whose dynamics are governed by a generalised master equation. Such an environment can be, in general, far from equilibrium and exhibit strongly non-Gaussian fluctuations. We calculate the influence of such fluctuations on the system from a Dyson-like equation for the full system-environment propagator in Liouvillian space. We consider particular application to mesoscopic systems, such as a double quantum dot charge qubit, coupled to an environment of fluctuating charges. In the limit of classical environment with a “pure dephasing” coupling to a qubit, we obtain a relation between the long-time qubit dephasing rate, and a generalised full-counting statistics of the environment.