TT 5 Transport: Nanoelectronics I - Quantum Dots, Wires, Point Contacts - Part 1

Time: Monday 09:30–13:00 Room: HSZ 304

Invited Talk

TT 5.1 Mon 09:30 HSZ 304

Correlation effects on electronic transport through dots and wires — •Volker Meden — Institut für Theoretische Physik, Universität Göttingen

We investigate how two-particle interactions affect the electronic transport trough several meso- and nanoscopic systems made of two building blocks: quasi one-dimensional quantum wires of interacting electrons and quantum dots with local Coulomb correlations. A recently developed functional renormalization group scheme is used that includes the essential aspects of Tomonaga-Luttinger liquid physics (one-dimensional wires) as well as of the physics of local correlations, with the Kondo effect being an important example. We describe the appearance of a variety of surprising correlation effects. (1) For a Y-junction of wires pierced by a magnetic flux we find a regime in which correlations restore time-reversal symmetry. (2) We investigate the interplay of Tomonaga-Luttinger physics and the Kondo effect in transport through a single site dot with interacting leads. Studied separately, the first leads to a sharp Lorentz-like resonance in the gate voltage dependence of the linear conductance while the latter implies a broad plateau-like resonance. (3) We find a pair of novel correlation induced resonances in the gate voltage dependence of the linear conductance through a parallel double-dot systems that results from the interplay of correlations and quantum interference. It should be observable in experiments on the basis of presently existing double-dot setups. An outlook on future application of the functional renormalization group scheme in mesoscopic physics is given.

TT 5.2 Mon 10:00 HSZ 304

Two-electron entanglement in double quantum dots with Coulomb and spin-orbit interaction — •S. Weiss, M. Thorwart, and R. Egger — Heinrich-Heine Universität Düsseldorf

We investigate the entanglement of two-particle electronic charge states in vertical double quantum dots in presence of the Coulomb and spin-orbit interaction. Upon using exact diagonalization, the spectrum and the eigenvectors of the Hamiltonian are obtained as a function of all the model parameters. The entanglement is quantified in terms of the Peres-Horodecki measure which follows immediately from the density operator of the system. Interestingly enough, we find a non-monotonous dependence of the entanglement on the Coulomb interaction strength. Depending on the tunneling amplitude between the two dots, we even find a suppression of the entanglement for large Coulomb interaction and for intermediate tunneling couplings. This counterintuitive behavior can be explained by the confinement of the electrons in the dots.

[1] S.Weiss, M. Thorwart and R. Egger, submitted.

TT 5.3 Mon 10:15 HSZ 304

Cotunneling and renormalization effects in the thermopower of a single-electron transistor — •Björn Kubala and Jürgen König — Institut für Theoretische Physik III, Ruhr-Universität Bochum, D-44780 Bochum, Germany

We study thermal conductance and thermopower of a metallic single-electron transistor (SET) within a perturbative real-time theory. Like the conductance, the thermal conductance of an SET is governed by Coulomb blockade physics at low temperatures. The (Coulomb-) oscillations of thermopower with varying gate voltage have been studied, considering sequential [1] and cotunneling [2] processes.

We investigate thermopower by performing a systematic perturbative calculation of the (thermal) conductance including sequential tunneling and cotunneling as well as terms capturing the renormalization of system parameters by quantum fluctuations. As thermopower constitutes a direct measure of the average energy of transported particles, we predict, that the logarithmic reduction of the Coulomb blockade gap due to a multi-channel Kondo-effect can be accessed in thermopower measurements.

[1] A. A. M. Staring, L. W. Molenkamp, B. W. Alphenhaar, H. van Houten, O. J. A. Buyk, M. A. A. Mabesoone, C. W. J. Beenakker, and C. T. Foxon, Europhys. Lett. 22, **57** (1993).
[2] M. Turek and K. A. Matveev, Phys. Rev. B **65**, 115332 (2002).

TT 5.4 Mon 10:30 HSZ 304

Aharonov-Bohm Interferometry with Quantum Dots — •Stefan Legel[1], Jürgen König[2], and Gerd Schön[1,3] — [1]Universität Karlsruhe — [2]Ruhr-Universität Bochum — [3]Forschungszentrum Karlsruhe, Institut für Nanotechnologie

We study electron transport through a closed Aharonov-Bohm interferometer containing two single-level quantum dots. We address the question how Coulomb interaction on the dots affects the coherence of the transport. The method of real-time transport theory enables us to treat these systems both in equilibrium as well as in non-equilibrium. A perturbation expansion in the coupling strength of the quantum dots to the leads allows us to make predictions for the signatures of quantum interference in the conductance of the considered systems in first and second order (so-called cotunneling) in the coupling strength.

TT 5.5 Mon 10:45 HSZ 304

Non-local effects in transport through coupled quantum dots — •Jasmin Aghassi[1,2], Axel Thielmann[1,2], Matthias Hettler[1], and Gerd Schön[1,2] — [1]Forschungszentrum Karlsruhe, INT, Postfach 3640, 76021 Karlsruhe — [2]Institut für Theoretische Festkörperphysik, Universität Karlsruhe, 76128 Karlsruhe

We study current and shot noise in sequential tunneling through nonlocal systems such as two and three coupled quantum dots ("artificial molecules"). The dots are fully coherent among each other and weakly coupled to the electrodes via the interfacial dots. In the case of two coupled quantum dots various sources of asymmetry, i.e. non-resonant dots or asymmetric couplings lead eventually to super-Poissonian noise and negative differential counductance above the sequential tunneling threshold. In contrast, the three dot system displays interesting super-Poissonian behavior even in fully symmetric situations due to a complex spin-related mechanism. Fano factors may thus be largely enhanced up to values of 100. Such strong enhancement should allow direct experimental detection of shot noise in lateral quantum dot experiments. Within our diagrammatic approach we further discuss the influence of cotunneling processes on the transport characteristics in these non-local systems.

[1] J. Aghassi, A. Thielmann, M.H. Hettler, and G. Schön, cond-mat/0505345

TT 5.6 Mon 11:00 HSZ 304

Electron pumping in periodic fields — •Stefan Kurth[1], Angel Rubio[2], and E.K.U. Gross[1] — [1]Institute for Theoretical Physics, Free University Berlin, Berlin, Germany — [2]Donostia International Physics Center, San Sebastian/Donostia, Spain

Using our recently developed algorithm for the time-dependent description of transport(Phys. Rev. B **72**,035308 (2005)) we study pumping of electrons between two reservoirs at the same chemical potential. Pumping is achieved by applying a spatially inhomogeneous perturbation which is periodic in time. The flexibility of the algorithm, which is based on the time evolution of the Schrödinger equation, allows us to study pumping in the linear and nonlinear, adiabatic and non-adiabatic regimes. For perturbations with the shape of a travelling wave, electrons are transferred in packets moving with the minima of the wave.

— 15 min. break —

TT 5.7 Mon 11:30 HSZ 304

Adiabatic Pumping through Interacting Quantum Dots — •Janine Splettstoesser[1,2], Michele Governale[1,2], Jürgen König[2], and Rosario Fazio[1] — [1]Scuola Normale Superiore, Piazza dei Cavalieri, I-56126 Pisa — [2]Institut für Theoretische Physik, Ruhr-Universität Bochum, D-44780 Bochum

By periodically changing in time some parameters of a conductor a DC current can be produced without applying a bias voltage. This effect is known as *pumping*. In case of non-interacting electrons Brouwer's formula provides a general framework for the computation of the pumped charge [1]. The situation is profoundly different for pumping through interacting systems. In fact, there are only few works that address this problem with methods suited to tackle specific systems/regimes. We present a general formalism to study adiabatic pumping through interacting quantum dots. We derive a formula that relates the pumped