TT 47: TR: Nanoelectronics I - Quantum Dots, Wires, Point Contacts 1

Time: Thursday 10:30–13:00 Location: HSZ 304

TT 47.1 Thu 10:30 HSZ 304

Universal relaxation resistance in the interacting resonant level model — •Oleksiy Kashuba, Herbert Schoeller, and Janine Splettstoesser — Institute for Theory of Statistical Physics, RWTH Aachen, 52056 Aachen, Germany

We calculated relaxation resistance, capacitance and relaxation time for the quantum dot interacting with a single-channel spin-polarised contact using the interacting resonant level model[1]. Extending the real-time renormalisation group method[2] for the case of adiabatic time depending parameters we confirmed the prediction of the universal relaxation resistance which was made for the non-interacting system[3]. We also expanded our model allowing adiabatic time dependence in interaction strength as well as in the escape rate and the level position. We found the corrections to the transport coefficients and showed that the relaxation time is less sensitive to the adiabatic time dependence then the resistance and capacitance, and the calculation of the correction to the relaxation time cannot be made in the frame of perturbation expansion with renormalised parameters requiring renorm-group approach.

[1] S.Andergassen, M.Pletyukhov, D.Schuricht, H.Schoeller, and L.Borda, arXiv:1010.5666 (2010).
[2] H.Schoeller, Eur. Phys. J. Special Topics 168, 179 (2009).
[3] M.Buttiker, H.Thomas, and A.Pretre, Mesoscopic capacitors, Phys. Lett. A 180, 364 (1993).

TT 47.2 Thu 10:45 HSZ 304

Obtaining the Full Counting Statistics from Time Dependent Simulations for Strongly Correlated Systems — Dmitry Bagrets[1], Sam Carr[2], and •Peter Schmitteckert[1] — [1]Institute of Nanotechnology, Karlsruhe Institute of Technology — [2]Institut für Theorie der Kondensierten Materie, Karlsruhe Institute of Technology

Recent advances in the simulation of time evolution of correlated electron systems led to progress in understanding transport properties of nano scale systems attached to leads. Time dependent simulations enable the extraction of the IV characteristic [1,2] and noise correlations [3] from the transient evolution of a charge imbalanced quench. In this work we extend the idea of obtaining the Full Counting Statistics (FCS) from time dependent simulations [4] of the cumulant generating function and apply it to model systems such as the interacting resonant level model. The simulations are performed within the framework of the density matrix renormalization group approach.

[1] E. Boulat, H. Saleur, and P. Schmitteckert, Phys. Rev. Lett. 101, 140601 (2008).
[2] A. Branschädel, G. Schneider, and P. Schmitteckert; Ann. Phys. 522, 657 (2010).
[3] A. Branschädel, E. Boulat, H. Saleur, and P. Schmitteckert; Phys. Rev. B 82, 205414 (2010); Phys. Rev. Lett. 105, 146805 (2010).
[4] K. Schönhammer; Phys. Rev. B 75, 205329 (2007).

TT 47.3 Thu 11:00 HSZ 304

Full counting statistics of a molecular quantum dot with strong electron-phonon interaction — •Stefan Maier and Andreas Komnik — Institut für Theoretische Physik, Heidelberg, Germany

We investigate the non-equilibrium charge transfer properties of a single level quantum dot with a local bosonic degree of freedom (aka Holstein phonon) coupled to metallic reservoirs. Using the Lang-Firsov transformation we have derived a diagrammatic scheme for the calculation of the full counting statistics. Our approach is exact in the electron-phonon interaction and resums a certain diagram subset with respect to the tunneling amplitude. A comparison with Monte-Carlo simulation data shows that the formalism captures basic properties of the strong electron-phonon coupling regime. In addition to the nonlinear current-voltage relation we analyze noise properties and higher order cumulants of the system.

TT 47.4 Thu 11:15 HSZ 304

Full counting statistics for the Kondo dot coupled to normal as well as ferromagnetic electrodes — •Henning Soller and Andreas Komnik — Ruprecht-Karls-Universität Heidelberg, Philosophenweg 19, 69120 Heidelberg, Germany

We investigate the interplay of the Kondo effect, superconductivity and ferromagnetic correlations in a quantum dot coupled to metallic electrodes. We concentrate on the non-equilibrium transport properties and calculate the full counting statistics of the structure in the different parameter regimes. We take into account the full energy dependence of the superconductor DOS and use an effective model for the quantum dot in the Kondo regime. We achieve good agreement with the experimental data for the non-linear current-voltage relations in the case of a normal as well as a ferromagnetic electrode coupled to the Kondo dot. This allows us to make reliable predictions for the noise and higher order cumulants. All analyzed structures represent basic building blocks of devices for generation and detection of entanglement via crossed Andreev reflection.

TT 47.5 Thu 11:30 HSZ 304

Real time Effective-action approach to the Anderson quantum dot — •Denes Sexty, Thomas Gasenzer, and Jan Pawlowski — ITP Uni Heidelberg, Deutschland

The non-equilibrium time evolution of an Anderson quantum dot coupled between two leads forming a chemical-potential gradient for fermions is investigated. We use Kadanoff-Beym dynamic equations derived from the two-particle irreducible effective action with a non-perturbative resummation of the s-channel bubble chains. The effect of the resummation is shown to be equivalent to the introduction of a frequency dependent 4-point vertex. The tunneling to the leads is taken into account exactly, without further approximations. The method allows the determination of the transient as well as stationary transport through the quantum dot, and results are compared to different schemes (fRG, ISPI, tDMRG and QMC) for different values of the interactions between the fermions.

15 min. break

TT 47.6 Thu 12:00 HSZ 304

Anderson impurity model in nonequilibrium: analytical results versus quantum Monte Carlo data — Lothar Mühlbacher[1], •Daniel F. Urban[1], and Andreas Komnik[2] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, D-79104 Freiburg, Germany — [2]Institut für Theoretische Physik, Ruprecht-Karls-Universität Heidelberg, D-69120 Heidelberg, Germany

We analyze the spectral function of the single-impurity two-terminal Anderson model at finite voltage using the recently developed diagrammatic quantum Monte Carlo technique as well as perturbation theory. In the (particle-hole-)symmetric case we find an excellent agreement of the numerical data with the perturbative results of second order up to interaction strengths $U/\Gamma \approx 2$, where Γ is the transparency of the impurity-electrode interface. The analytical results are obtained in form of the nonequilibrium self-energy for which we present explicit formulas in the closed form at arbitrary bias voltage. We observe an increase of the spectral density around zero energy brought about by the Kondo effect. Our analysis suggests that a finite applied voltage V acts as an effective temperature of the system. We conclude that at voltages significantly larger than the equilibrium Kondo temperature there is a complete suppression of the Kondo effect and no resonance splitting can be observed. We confirm this scenario by comparison of the numerical data with the perturbative results.

[1] L. Mühlbacher, D. F. Urban, and A. Komnik, arXiv:1007.1793.

TT 47.7 Thu 12:15 HSZ 304

Correlated current- and spin dynamics in a quantum dot with magnetic impurity — •Daniel Becker, Stephan Weiss, Michael Thorwart, and Daniela Pfannkuche — I. Institut für Theoretische Physik, Universität Hamburg, 20355 Hamburg

Based on the numerically exact, non-perturbative scheme of iterative summation of path integrals (ISPI)[1,2], the fully correlated dynamics of a single-level quantum dot is studied, which contains a quantum spin-1/2 magnetic impurity, interacting with the dot-electron spins, and is in contact with unpolarized, metallic leads. The main focus lies on the charge current and electron-induced dynamics of the impurity spin. Their dependence on crucial model parameters, such as the on-dot interaction strengths (Coulomb, electron-impurity), the bias voltage, and the temperature is systematically investigated in the non-perturbative regime, where all appearing energy scales are of the same order of magnitude. Due to flip-flop processes between electron- and impurity spins and stochastic tunneling of electrons onto and off the dot, a polarization of the impurity spin decays exponentially, even for vanishing charge current. The current, in turn, is solely affected by the longitudinal part of the electron-impurity interaction, which acts as an effective magnetic field. From the dependence of the impurity relaxation time on the bias voltage, conclusions about the nontrivial energy level structure can be drawn, while the charge current shows a monotonic dependence on the bias voltage.

[1] S. Weiss et al., Phys. Rev. B 77, 195316 (2008)
[2] D. Becker et al., J. Phys.: Conf. Ser. 245 012021 (2010)

TT 47.8 Thu 12:30 HSZ 304

Transport through quantum-dot spin valves with a magnetic impurity — •Björn Sothmann and Jürgen König — Theoretische Physik, Universität Duisburg-Essen

Quantum-dot spin valves, i.e., quantum dots coupled to ferromagnetic electrodes with noncollinear magnetizations exhibit a number of interesting effects. On the one hand, spin accumulates on the dot and blocks further transport. On the other hand, an effective exchange field gives rise to a precession of the accumulated spin thereby lifting the spin blockade [1].

Here, we investigate transport through a quantum-dot spin valve with a side-coupled spin on the dot using a real-time diagrammatic approach. We find that for a large external magnetic field, the current is insensitive to the coherent dynamcis of the two spins on the dot. In contrast, the finite-frequency noise acquires a peak at the precession frequency of the spins. For a small magnetic field, the system exhibits a nontrivial spin dynamics due to the interplay between exchange coupling, external magnetic field and exchange field. We show how this spin dynamics can be studied in the finite-frequency noise.

[1] M. Braun, J. König, J. Martinek, Phys. Rev. B **70**, 195345 (2004).
[2] B. Sothmann, J. König, arXiv:1009.5901, Phys. Rev. B in press.

TT 47.9 Thu 12:45 HSZ 304

Nonequilibrium Zeeman-splitting in quantum transport through nanoscale junctions — •Sebastian Schmitt and Frithjof B. Anders — Theoretische Physik II, Technische Universität Dortmund

We study an interacting quantum dot –modeled by a single impurity Anderson model– coupled to two different leads where a finite bias voltage is applied. The quantum transport through such a device is governed by the charging energy U of the dot. We employ the scattering-states numerical renormalization-group approach to open quantum systems to study nonequilibrium Green functions and current-voltage characteristics of such a junction. At intermediate to large values of U considerable voltage-dependent redistribution of spectral weight occurs. In a finite magnetic field the Zeeman-split Kondo resonance is rapidly destroyed upon increasing the bias voltage. The nonlinear differential conductance of a particle-hole symmetric as well as particle-hole asymmetric quantum dot is studied for various coupling asymmetries. In contrast to maxima derived from charge-excitations of the quantum dot, the position of the Zeeman-split zero-bias anomaly is independent of these asymmetries. Additionally, at large magnetic fields its position can even exceed the value given by the Zeeman-energy. The results are discussed in connection with recent experiments where similar behavior was encountered.