TT 11: Transport: Nanoelectronics I - Quantum Dots and Wires, Point Contacts 2

Time: Monday 14:00–16:45 Location: HSZ 301

TT 11.1 Mon 14:00 HSZ 301

Pair tunneling resonance in the single-electron transport regime — •Martin Leijnse[1,3], Maarten Wegewijs[1,2,3], and Herbert Schoeller[1,3] — [1]Institut für Theoretische Physik A, RWTH Aachen, 52056 Aachen, Germany — [2]Institut für Festkörper-Forschung - Theorie 3, Forschungszentrum Jülich, 52425 Jülich, Germany — [3]JARA-Fundementals of Future Information Technology

We predict a new resonance in non-linear transport through strongly interacting quantum dots, originating from the coherent tunneling of electron pairs (PT). The PT resonance shows up as a peak in the derivative of the differential conductance, d^2I/dV^2, in the *single-electron* transport (SET) regime. The position is determined by the electrochemical potential of one electrode matching the average of two subsequent charge addition energies. Using 4th order perturbation theory in the tunneling coupling[1] for a single level quantum dot (Anderson model), we present an analytic expression for the peak shape, which reveals the bosonic nature of the charge transfer. Awareness of the PT resonance can be crucial for interpretation of experimental low-temperature transport spectroscopy data of semi-conducting, carbon nanotube, or single molecule quantum dots, since it can easily be mistaken for a weak SET resonance judging only by the voltage dependence of its position. We show that the PT resonance can be distinguished from SET by its anomalous temperature- and magnetic field dependence, peak shape and shot-noise signature.

[1] M. Leijnse, M. R. Wegewijs, PRB (in print), arXiv:0807.4027.

TT 11.2 Mon 14:15 HSZ 301

Electron tunneling into a quantum wire in the Fabry-Pérot regime — •Dario Bercioux[1], Stefano Pugnetti[2], Fabrizio Dolcini[2], and Hermann Grabert[1] — [1]Physikalisches Institut and Freiburg Institute for Advanced Studies, Universität Freiburg, D-79104 Freiburg, Germany — [2]Scuola Normale Superiore and NEST CNR-INFM, I-56126, Pisa Italy

We study a gated quantum wire contacted to source and drain electrodes in the Fabry-Pérot regime. The wire is also coupled to a third terminal (tip) at an arbitrary position along its length. We allow for an asymmetry of the tunneling amplitudes between right/left moving electrons and the tip. Electron-electron interaction in the wire is taken into account by means of the inhomogeneous Luttinger liquid model. The current-voltage characteristics of this three-terminal set-up is shown to exhibit very rich physical effects. We analyze configurations where the tip acts as an electron injector or as a voltage probe. When the tip is in the electron-injection configuration we find that electron-electron coupling does not affect the ratio of the currents flowing to the source and drain electrodes [1]. Contrary to the result by Steinberg *et al.*[2], this ratio depends only on the asymmetry in tunneling.

[1] S. Pugnetti, F. Dolcini, D. Bercioux, and H. Grabert, arXiv:0810.2962v1 [cond-mat.str-el].
[2] H. Steinberg, G. Barak, A. Yacoby, L. N. Pfeiffer, K. W. West, B. I Halperin, and K. Le Hur, Nature Phys. **4**, 116 (2008).

TT 11.3 Mon 14:30 HSZ 301

Charge and spin pumping through quantum dots beyond the adiabatic regime — •Fabio Cavaliere[1], Michele Governale[2], and Jürgen König[2] — [1]Dipartimento di Fisica, Università di Genova, LAMIA CNR-INFM, Via Dodecaneso 33, 16146 Genova, Italy — [2]Theoretische Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany

We study charge and spin pumping in an interacting quantum dot connected to normal or ferromagnetic leads, beyond the adiabatic regime. We employ a systematic expansion of the pumped currents in both frequency and tunneling strength. Going beyond the adiabatic regime has important consequences on the pumping characteristics. In the case of normal leads, the pumped current exhibits a sub-linear increase for increasing pumping frequency and its dependence on the phase-difference between the pumping field deviates from that of the adiabatic regime. In the ferromagnetic case, spin and charge currents behave differently as a function of the phase difference, allowing to obtain pure spin pumping without net charge transfer, in sharp contrast to the adiabatic regime [1].

[1] J. Splettstoesser, M. Governale, and J. König, Phys. Rev. B **77**, 195320 (2008).

TT 11.4 Mon 14:45 HSZ 301

Resonant spin pumping with spin-orbit coupling — Markus Jerger[1], •Valentina Brosco[1], Pablo San José[2,1], Gergely Zarand[3], Alexander Shnirman[4], and Gerd Schön[1] — [1]Institut für Theoretische Festkörperphysik , Universität Karlsruhe, Karlsruhe, Germany — [2]Department of Physics, Lancaster University, Lancaster, United Kingdom — [3]Theoretical Physics Department, Budapest University of Technology and Economy, Budapest, Hungary — [4]Institut der Theorie der Kondersierten Materie, Universität Karlsruhe, Karlsruhe, Germany

Adiabatic particle transport in a periodic potential cyclically modulated in time was first proposed by Thouless [1]. Since then, due to to its fundamental interest in relation with the theory of geometric phases and to possible applications in metrology, charge pumping has been studied in a variety of mesoscopic devices. More recently, various authors considered pumping of spin in semiconductor nanostructures.

In the present work we discuss spin pumping in a quantum dot with spin-orbit coupling using a scattering matrix approach [2]. First, we present a general analysis of spin and charge pumping based on the symmetries of the scattering matrix. Then, we focus on spin pumping in the resonant transport regime, we calculate explicitly the pumped spin and charge for some specific pumping cycles and we analyze the conditions to have pure spin currents.

[1] D. J. Thouless, Phys. Rev. B **27**, 6083 (1983).
[2] M. Büttiker, H. Thomas and A. Prêtre Z. Phys. B **94**, 133 (1994); P. W. Brouwer, Phys. Rev. B **58**, R10135 (1998).

TT 11.5 Mon 15:00 HSZ 301

A time dependent approach to obtain transmission coefficients of multi-terminal devices — •Christoph Kreisbeck[1], Viktor Krückl[1], and Tobias Kramer[1,2] — [1]Institute for Theoretical Physics, University of Regensburg, 93040 Regensburg, Germany — [2]Department of Physics, Harvard University, Cambridge, MA 02138, USA

We are interested in the transport behavior of semiconductor nanostructures, where we particularly focus on multi-terminal devices. The conductivity through these devices can be described theoretically within the Landauer-Büttiker formalism, which connects conductance-voltage characteristics with scattering matrices. To obtain the latter we introduce a time dependent approach, which proves to be a very efficient way to calculate transmission coefficients numerically. Moreover this method can go beyond Landauer-Büttiker. This means that we do not have to restrict ourself to asymptotic channels anymore, but we can study localised electron sources as well.

15 min. break

TT 11.6 Mon 15:30 HSZ 301

Dephasing due to phonons in a double dot Aharonov-Bohm interferometer — •Björn Kubala[1], David Roosen[2], Florian Marquardt[1], and Walter Hofstetter[2] — [1]Physics Department, ASC, and CeNS, Ludwig-Maximilians-Universität, 80333 Munich, Germany — [2]Institut für Theoretische Physik, Goethe-Universität, 60438 Frankfurt/Main, Germany

We investigate an Aharonov-Bohm interferometer consisting of two quantum dots coupled in parallel to two lead electrodes and to a common Einstein phonon mode. Without coupling to phonons transport of noninteracting electrons is fully coherent and the interferometer can be tuned to complete destructive interference even for finite applied bias. If phonons couple differently to the electrons on the two dots, which-path infomation is transferred to the phononic bath and the electronic coherence is diminished. It is only this dephasing due to phonons which enables transport, making the device ideal for studying decoherence issues. In this talk, we focus on results from Keldysh diagrammatic perturbation theory, which are complemented by studies using the numerical renormalization group.

TT 11.7 Mon 15:45 HSZ 301

1D to 0D crossover of decoherence time in small mesoscopic rings — •Maximilian Treiber[1], Oleg Yevtushenko[1], Florian Marquardt[1], Igor V. Lerner[2], and Jan von Delft[1] — [1]Physics

Department, ASC, and CeNS, LMU, Theresienstrasse 37, 80333 Munich, Germany — [2]School of Physics and Astronomy, University of Birmingham, Birmingham B15 2TT, United Kingdom

We study the decoherence time $\tau_\phi(T)$ in a disordered quasi 1D ring weakly coupled to leads, in the low temperature regime where decoherence is governed by electron interactions. We employ a path integral approach which is free of IR singularities and reproduces the known power-law dependence $\tau_\phi \sim T^{-a}$, where $a = 2/3$ or 1 for the diffusive ($\tau_\phi E_c \lesssim 1$, where E_c is the Thouless energy) [1] or ergodic ($\tau_\phi E_c \geq 1$) [2] regimes, respectively. By incorporating the Pauli principle into the Nyquist noise correlation function, thus excluding large energy transfers ($\omega \gtrsim T$), we are able to also describe the dimensional crossover of τ_ϕ from 1D to 0D as T is lowered below E_c, causing the exponent to change to $a = 2$. The $\sim T^{-2}$ dependence has been predicted before [3], but has so far eluded direct observation. We point out that in the ring geometry it is possible to measure it not only via the smooth part of the magnetoresistance but also via the amplitude of the Altshuler-Aronov-Spivak oscillations.

[1] B. L. Altshuler et al., J. Phys. C, **15**, 7367 (1982).
[2] C. Texier and G. Montambaux, Phys. Rev. B **72**, 115327 (2005); T. Ludwig and A. D. Mirlin, Phys. Rev. B **69**, 193306 (2005).
[3] U. Sivan et al., Europhys. Lett. **28**, 115 (1994).

TT 11.8 Mon 16:00 HSZ 301

Electron-Spin-Resonance (ESR) in Triple Quantum Dots — •Maria Busl[1], Rafael Sánchez[1,2], and Gloria Platero[1] — [1]ICMM, CSIC, Cantoblanco, E-28049 Madrid — [2]Département de Physique Théorique, Université de Genève, CH-1211 Genève 4

In the last years a big effort has been devoted to measure ESR in single and double quantum dots [1]. There, crossed DC and AC magnetic fields with a frequency resonant to the Zeeman splitting in the dots drive electrons to perform spin coherent rotations.

We analyze coherent spin rotations induced by an AC magnetic field in a DC biased triple quantum dot (TQD), both in linear and triangular configuration, filled with one and two extra electrons. We analyze the case where the DC magnetic field is homogeneous and the case where an inhomogeneous DC magnetic field yields to different Zeeman splittings within each dot.

We will discuss how coherent population trapping, which occurs in a TQD filled with one electron[2], is affected by the AC field. There, the electron can be forced to perform single spin rotations induced by the field. Those are stable against decoherence coming from the leads, once the electron drops in the so-called dark state. In the case of two extra electrons, we analyze spin blockade in the presence of the AC magnetic field.

[1] F. H. L. Koppens et al., Nature 442, 766 (2006)
[2] C. Emary, PRB 76, 245319 (2007)

TT 11.9 Mon 16:15 HSZ 301

Understanding energy-resolved spectroscopy of nonequilibrium Luttinger liquids — •So Takei, Mirco Milletari, and Bernd Rosenow — Max-Planck-Institute for Solid State Research

We theoretically analyze a system in which a measurement of an energy-resolved nonequilibrium electronic distribution can be used to gain an understanding on the relaxational properties of a Luttinger liquid (LL). The setup consists of a LL tunnel-coupled to two resonant levels, denoted source and probe, at two points separated by a distance L. The source, whose resonant level is tuned above the chemical potential of the LL, injects high energy electrons into the system. An energy-resolved measurement of the LL distribution is then achieved downstream with the probe by tuning its resonant level. An experimental realization of the setup can be achieved in the context of an edge state in the fractional quantum Hall regime for both the Laughlin sequence of filling fractions $\nu = 1/m$ and the hierarchical edge states with multiple edge excitations.

TT 11.10 Mon 16:30 HSZ 301

Magnetic field dependence of 0.7 Anomaly in Quantum Point Contacts: A Study Using the Functional Renormalization Group — •Florian Bauer and Jan von Delft — Arnold Sommerfeld Center for Theoretical Physics, Munich

We study the magnetic field dependence of the 0.7 anomaly of the conductance through a quantum point contact at zero temperature, using the functional renormalization group (fRG). We model a 1-D quantum wire using a tight-binding chain with short-ranged Coulomb interactions and a prescribed onsite potential to mimick the potential barrier caused by the 2-D constriction. Our fRG results qualitatively reproduce the experimentally observed magnetic field dependence of the conductance anomaly (splitting of the first conductance step into two substeps) and the shot noise. The resulting effective g-factor is strongly enhanced by interactions, in agreement with the experimental observation of anomalously large g factors.