

TT 22 Transport - Nanoelectronics II: Quantum Dots and Wires, Point Contacts

Zeit: Montag 14:00–17:30

Raum: TU H2053

TT 22.1 Mo 14:00 TU H2053

Elektron-Elektron Wechselwirkung in nanostrukturierten, ferromagnetischen Leiterbahnen unterschiedlicher Dimension — ●MARIO BRANDS, AXEL CARL und GÜNTER DUMPICH — Fachbereich Physik, Experimentalphysik, AG Farle, Universität Duisburg-Essen (Campus Duisburg), Lotharstr. 1, 47048 Duisburg

Es wurden Magnetowiderstandsmessungen an einzelnen, nanostrukturierten Kobalt-Leiterbahnen bei tiefen Temperaturen durchgeführt. Die Leiterbahnen wurden zum Schutz vor Oxidation in-situ mit isolierendem Kohlenstoff abgedeckt. Die Kontaktierung erfolgt über nicht-magnetische Gold- bzw. Platinkontaktpads unter Zuhilfenahme eines aufwendigen Drei-Schritt-Elektronenstrahlithografie-Prozesses. Der Magnetowiderstand der Leiterbahnen kann, für beliebig orientierte Magnetfelder, mit Hilfe des AMR-Effektes erklärt werden. Hingegen zeigt sich in der Temperaturabhängigkeit des Widerstandes ein logarithmischer Beitrag aufgrund von erhöhter Elektron-Elektron-Wechselwirkung. Durch Reduzierung der Leiterbahnbreite kann ein Übergang von zweidimensionalem zu eindimensionalem Verhalten beobachtet werden. Beiträge aufgrund von schwacher Lokalisierung werden nicht beobachtet. Die Arbeit wird gefördert von der DFG im Rahmen des SFB 491.

TT 22.2 Mo 14:15 TU H2053

Giant super-poissonian Fano factors in shuttle devices — ●ANDREA DONARINI^{1,2}, TOMAŠ NOVOTNÝ², CHRISTIAN FLINDT², and ANTTI-PEKKA JAUHO² — ¹Institut für Theoretische Physik, Universität Regensburg, D-93040 Regensburg, Germany — ²MIC - Department of Micro and Nanotechnology, Technical University of Denmark

Shuttle devices are a particular kind of NEMS characterized by a nanometer scale oscillating quantum dot that transfers electrons one-by-one from the source to the drain lead. We study the dynamics of an archetypal model device in the density matrix formalism and represent the numerical results by means of phase space distribution (Wigner function), current and current noise (Fano factor). The device presents tunnelling and shuttling as limiting operating regimes for respectively high and low mechanical damping conditions. In the transition region between the tunnelling and shuttling regime the system is characterized by a giant super-poissonian Fano factor ($F \approx 100$).

This feature is the signature of a coexistence regime: i.e. a slow switching dichotomous process between the tunnelling and the shuttling current modes. For this regime we propose a simplified description in terms of a bistable effective potential. This description captures the main features of the coexistence regime (confirmed by the quantitative agreement with the numerical results) and gives also a more transparent physical insight of the device dynamics.

TT 22.3 Mo 14:30 TU H2053

Quantized Conductance in Atomic-Scale Point Contacts Formed by Local Electrochemical Deposition of Silver — ●STEFAN BRENDELBERGER¹, CHRISTIAN OBERMAIR¹, ROBERT KNIESE¹, FANGQING XIE¹, and THOMAS SCHIMMEL^{1,2} — ¹Institute for Applied Physics, University of Karlsruhe, D-76128 Karlsruhe, Germany — ²Institute of Nanotechnology, Forschungszentrum Karlsruhe, D-76021 Karlsruhe, Germany

We report on conductance quantization at room temperature in atomic-scale silver point contacts electrochemically fabricated within a nanoscale gap between two gold electrodes on a glass substrate. The formation of stable contacts exhibiting quantized conductance at integer multiples of the conductance quantum $G_0 = 2e^2/h$ ($\approx 1/12.9k\Omega$) was observed. While transient contacts with other conductance values were also found, a clear preference for values close to integer multiples of G_0 was observed for contacts stable for up to several hours. When applying electrochemical deposition or dissolution potentials, sharp transitions were induced between different quantized conductance levels while between these transitions, horizontal plateaus of constant conductance were found.

[1] Ch. Obermair et al. In: A. S. Alexandrov et al. (eds.) *Molecular Nanowires and Other Quantum Objects*, NATO Science Series II, Kluwer, Dordrecht, The Netherlands, 233-242, 2004.

[2] F.-Q. Xie, L. Nittler, Ch. Obermair and Th. Schimmel, *Phys. Rev. Lett.* 93, 128303 (2004).

TT 22.4 Mo 14:45 TU H2053

Conduction Channels of One-Atom Zinc Contacts — ●MICHAEL HÄFNER¹, PATRICK KONRAD², FABIAN PAULY¹, JUAN-CARLOS CUEVAS^{1,3}, and ELKE SCHEER² — ¹Institut für Theoretische Festkörperphysik, Universität Karlsruhe, 76128 Karlsruhe, Germany — ²Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany — ³Departamento de Física Teórica de la Materia Condensada C-V, Universidad Autónoma de Madrid, 28049 Madrid, Spain

We have determined the transmission coefficients of atomic-sized Zn contacts using a new type of breakjunction which contains a whisker as a central bridge. We find that in the last conductance plateau the transport is unexpectedly dominated by a well-transmitting single conduction channel. We explain the experimental findings with the help of a tight-binding model which shows that in an one-atom Zn contact the current proceeds through the 4s and 4p orbitals of the central atom.

TT 22.5 Mo 15:00 TU H2053

Transport properties of single channel quantum wires with an impurity: Influence of finite length and temperature on average current and noise — ●FABRIZIO DOLCINI¹, BJÖRN TRAUZZETTEL², INÈS SAFI³, and HERMANN GRABERT¹ — ¹Albert-Ludwigs-Universität, Freiburg — ²Leiden University, The Netherlands — ³Université Paris-Sud, France

The inhomogeneous Tomonaga Luttinger liquid model describing an interacting quantum wire adiabatically coupled to non-interacting leads is analyzed in the presence of a weak impurity within the wire. Due to strong electronic correlations in the wire, the effects of impurity backscattering, finite bias, finite temperature, and finite length lead to characteristic non-monotonic parameter dependencies of the average current [1]. We discuss oscillations of the non-linear current voltage characteristics that arise due to reflections of plasmon modes at the impurity and quasi Andreev reflections at the contacts. The finite frequency current noise is also investigated in detail. We find that the effective charge extracted in the shot noise regime in the weak backscattering limit depends on the noise frequency ω relative to v_F/gL , where v_F is the Fermi velocity, g the Tomonaga Luttinger interaction parameter, and L the length of the wire [2]. The excess noise is finite even for frequencies larger than the applied voltage, which is a signature of correlation effects.

[1] F. Dolcini, H. Grabert, I. Safi, and B. Trauzettel, *Phys. Rev. Lett.* 91, 266402 (2003).

[2] B. Trauzettel, I. Safi, F. Dolcini, and H. Grabert, *Phys. Rev. Lett.* 92, 226405 (2004).

TT 22.6 Mo 15:15 TU H2053

Co-tunneling current and shot noise in quantum dots and molecules — ●AXEL THIELMANN¹, MATTHIAS H. HETTLER¹, JÜRGEN KÖNIG² und GERD SCHÖN^{1,3} — ¹Forschungszentrum Karlsruhe, Institut für Nanotechnologie, 76021 Karlsruhe, Germany — ²Institut für Theoretische Physik III, Ruhr-Universität Bochum, 44780 Bochum, Germany — ³Institut für Theoretische Festkörperphysik, Universität Karlsruhe, 76128 Karlsruhe, Germany

We study current and shot noise up to second-order perturbation theory in the coupling of a mesoscopic object (e.g. quantum dot or molecule) to metallic electrodes. In particular, we discuss the influence of co-tunneling processes for the Anderson-impurity model with finite spin splitting. We show that spin-flip co-tunneling leads to a super-Poissonian Fano factor at a different energy scale than expected from first-order calculations. Furthermore, we find the Fano factor in the Coulomb-blockade regime to be very sensitive to the tunnel-coupling strength, which may serve as a spectroscopic tool for the latter.

TT 22.7 Mo 15:30 TU H2053

Anomalous conductance of a spin-1 quantum dot — ●ANNA POSAZHENNIKOVA¹ and PIERS COLEMAN² — ¹TKM, Universität Karlsruhe, 76128, Germany — ²Center for Materials Theory, Rutgers University, Piscataway, NJ 08855, USA

We interpret the recent observation of a zero-bias anomaly in spin-1 quantum dots in terms of an underscreened Kondo effect. Although a spin-1 quantum dots are expected to undergo a two-stage quenching effect, in practice the log normal distribution of Kondo temperatures leads to a broad temperature region dominated by underscreened Kondo

physics. General arguments, based on the asymptotic decoupling between the partially screened moment and the leads, predict a singular temperature and voltage dependence of the conductance and differential conductance. Using a Schwinger boson approach, we show how these qualitative expectations are borne out in a detailed many body calculation.

Pause

TT 22.8 Mo 16:00 TU H2053

Nonequilibrium Kondo physics in double quantum dots — •YIFENG YANG and KARSTEN HELD — MPI for solid state research, Stuttgart

We study the multi-orbital Kondo effect at a finite bias, generalizing the nonequilibrium scaling approach suggested recently by Rosch et al. [Phys. Rev. Lett. 90, 076804 (2003)]. The finite current through the quantum dots gives rise to a cutoff of the scaling equations, which is calculated from the spin susceptibility. We study in detail the strong orbital Kondo effect in a parallel double quantum dot. The results are consistent with recent experiments. Moreover, we also report on genuine nonequilibrium effects like a negative differential conductance at finite bias voltage.

TT 22.9 Mo 16:15 TU H2053

Electron transport through strongly correlated nanostructures: Frequency vs. real-time approach within DMRG — •PETER SCHMITTECKERT — Institut für Theorie der Kondensierten Materie, Universität Karlsruhe, 76128 Karlsruhe, Germany

We provide an overview over various strategies to study the problem of electron transport through onedimensional, strongly correlated quantum systems within the framework of density matrix renormalization group calculations. Specifically we compare the Kubo formalism approach in frequency space, in which we calculate the linear dc conductance, with real time simulations, where we extract the conductance from the real-time evolution of suitably chosen initial states.

TT 22.10 Mo 16:30 TU H2053

Full Counting Statistics in Non-Markovian Interacting Electron Systems — •ALESSANDRO BRAGGIO^{1,2}, JÜRGEN KÖNIG¹, and ROSARIO FAZIO³ — ¹Institut für Theoretische Physik III, Ruhr-Universität Bochum, 44780 Bochum, Germany — ²LAMIA-INFN, Dipartimento di Fisica, Università di Genova, Via Dodecaneso 33, 16133 Genova, Italy — ³NEST-INFN & Scuola Normale Superiore, Piazza dei Cavalieri 7, 56126 Pisa, Italy

Full counting statistics for electron transport is generalized to interacting electron systems with non-Markovian dynamics. In deriving a general expression for the cumulant generating function, we develop a method to properly account for the non-Markovian nature of the system. We compare with both the limits of Markovian dynamics and with transport through non-interacting systems, and discuss under which circumstances non-Markovian effects appear in the transport properties. As specific examples, we consider transport through a single-level quantum dot in second order of the tunnel coupling strength.

TT 22.11 Mo 16:45 TU H2053

Adiabatic pumping and Berry's phase in a mesoscopic ring — •ANGELIKA BENDER^{1,2}, FRANK W. J. HEKING², ALEXANDER SHNIRMAN¹, and YUVAL GEFEN³ — ¹Institut für Theoretische Festkörperphysik, Universität Karlsruhe, D-76128 Karlsruhe, Germany — ²Laboratoire de Physique et Modélisation des Milieux Condensés, CNRS, BP 166, F-38042 Grenoble, France — ³Department of Condensed Matter Physics, The Weizmann Institut of Science, Rehovot 76100, Israel

We study parametric pumping of charge in a mesoscopic system, induced by adiabatic and periodic changes of system parameters. Adiabatic changes of a Hamiltonian lead to phases in the wavefunction. We study the physical meaning of these phases for a loop with an impurity. The loop is threaded by a magnetic flux that induces persistent currents. We compute the total charge that passes the system upon a periodic change of flux and impurity strength and show that it is directly related to the phases of the wavefunction. We find in particular the link between pumped charge and Berry's phase. Further calculations include noise and decoherence due to the coupling of the system to its environment.

TT 22.12 Mo 17:00 TU H2053

Spin and Charge Channels in Zero Dimensional Systems — •MIKHAIL KISELEV¹ and YUVAL GEFEN² — ¹Institut für Theoretische Physik, Universität Würzburg, D-97074 Würzburg, Germany — ²Department of Condensed Matter Physics, The Weizmann Institute of Science, Rehovot 76100, Israel

We consider the effects of the charge and spin zero-mode interactions in quantum dots. The non-perturbative effects of zero-mode interaction are described in terms of the propagation of gauge bosons associated with U(1) charge and SU(2) spin fluctuations in the dot. The Coulomb and longitudinal spin components are accounted for "exactly", while transverse spin fluctuations are analyzed perturbatively (with the easy-axis anisotropy). These fluctuations become important as one approaches the Stoner instability. We study the influence of spin on the differential conductance as well as the dynamic spin susceptibility.

TT 22.13 Mo 17:15 TU H2053

On the visibility of electron-electron interaction effects in field emission spectra of single-wall carbon nanotubes — •THOMAS SCHMIDT and ANDREI KOMNIK — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, 79104 Freiburg, Germany

The electron-electron interaction effects turn out to alter considerably the energy-resolved current measured in field emission experiments. The most prominent feature is the so-called secondary current, which is related to the energy spectrum of the emitted electrons above the Fermi edge and which is brought about by processes of second order in tunnelling. The latter can be calculated exactly for a wide variety of emitters and turns out to be divergent towards E_F . We perform an analysis of tunnelling processes of higher orders and show that they are divergent as well and overcome the leading order contributions sufficiently close to E_F . Another effect which complicates the measurement of the secondary current is the thermal broadening of the Fermi edge. We discuss this aspect as well and make estimations for the energy and temperature windows for the secondary current to be reliably observable during field emission experiments from single-walled carbon nanotubes.