TT 21 Transport: Nanoelectronics II - Spintronics and Magnetotransport - Part 2

Time: Tuesday 16:15–19:00 Room: HSZ 105

TT 21.1 Tue 16:15 HSZ 105

Coherent Spin Ratchets — •Klaus Richter, Andreas Pfund, and Dario Bercioux — Fakultät für Physik, Universität Regensburg

We propose a new class of quantum ratchet devices, namely spin-orbit based ratchets which act as sources for pure spin currents. To this end we demonstrate that the combined effect of a spatially periodic electrostatic potential, lateral confinement and spin-orbit interaction in a two-dimensional coherent conductor gives rise to a quantum ratchet mechanism for spin-polarized currents. Upon external ac-driving, and in the absence of a static bias, the system generates a directed spin current, while the total charge current is zero. We analyze the underlying mechanism by employing symmetry properties of the scattering matrix, and we numerically verify the effect for different setups relevant for experiment. We further show that the spin current directions can be changed upon tuning the Fermi energy or the relative strength of Rashba and Dresselhaus spin orbit coupling.

TT 21.2 Tue 16:30 HSZ 105

Spin-dependent Transport through Quantum Dots connected to Three Ferromagnetic Leads — •Daniel Urban, Matthias Braun, and Jürgen König — Ruhr-Universität Bochum, 44780 Bochum, Germany

Transport through a non-magnetic, single-level quantum-dot with ferromagnetic leads is investigated in the sequential tunneling regime by a real-time diagrammatic technique. If a current is forced through the system, spin accumulates on the dot, which reduces transport (spin-valve effect). The interplay of Coulomb interaction and ferromagnetism gives rise to an exchange field [1], in which the spin precesses so that transport is enhanced.

We consider setups in which a current flows only between two of the leads. The third lead is kept current-free and enters only by its ferromagnetic properties.

The two systems analyzed are a quantum dot spin-flip transistor with coplanar magnetizations and a setup with pairwise orthogonal lead magnetizations. In both cases spin precession due to the third lead further enhances transport while in the latter we additionally observe asymmetries in the conductances under current reversal.

[1] M. Braun, J. König, and J. Martinek, Phys. Rev. B **70**, 195345 (2004)

TT 21.3 Tue 16:45 HSZ 105

Signature of spin-related phases in transport through regular polygones — •Dario Bercioux[1], Diego Frustaglia[2], and Michele Governale[3] — [1]Institut für Theoretische Physik, Universität Regensburg, Germany — [2]NEST-INFM & Scuola Normale Superiore, Pisa, Italy — [3]Institut für Theoretische Physik III, Ruhr-Universität Bochum, Germany

We address the subject of transport in one-dimensional ballistic polygon loops subject to spin-orbit interactions. The polygons are modeled in the framework of the spin quantum-network technique [1]. We identify the role played by the polygon vertices in the accumulation of spin-related phases by studying interference effects as a function of the spin-orbit interaction strength. We find that the vertices act as strong spin-scattering centers that hinder the developing of Aharovov-Casher and Berry phases. In particular, we show that the oscillation frequency of interference pattern can be doubled by modifying the shape of the loop from a square to a circle [2].

[1] D. Bercioux *et al.*, Phys. Rev. Lett. **93**, 56802 (2004).
[2] D. Bercioux, D. Frustaglia, and M. Governale, Phys. Rev. B **72**, 113310 (2005).

TT 21.4 Tue 17:00 HSZ 105

Tunneling current through Tomonaga-Luttinger liquid ring with spin-orbit coupling — •Mikhail Pletyukhov[1], Nicolas Pauget[1], and Vladimir Gritsev[2] — [1]Institut für Theoretische Festkörperphysik, Universität Karlsruhe, D-76128 Germany — [2]Department of Physics, Harvard University, Cambridge, MA 02138, USA

We calculate dc conductance of an interacting quantum ring with spin-orbit coupling which is attached to normal leads. We consider the linear response regime and assume a weak coupling to the leads. Electron-electron interaction in the ring is described non-perturbatively by means of the multicomponent Tomonaga-Luttinger liquid model. We study how the positions of the conductance peaks depend on the system parameters (magnetic flux, gate voltage, spin-orbit coupling strength) and observe the features arising due to electron correlations.

TT 21.5 Tue 17:15 HSZ 105

Sequential and Co-Tunneling Shot Noise in Quantum Dot Spin Valves — •Matthias Hettler[1], Axel Thielmann[1], Jürgen König[2], and Gerd Schön[1,3] — [1]Forschungszentrum Karlsruhe, Institut für Nanotechnologie — [2]Institut für Theoretische Physik III, Ruhr-Universität Bochum — [3]Institut für Theoretische Festkörperphysik, Universität Karlsruhe

For a single level quantum dot coupled to ferromagnetic electrodes transport is sensitively dependent on the magnetic orientation and degree of polarization of the electrodes. If in addition a magnetic field leads to Zeemann split states on the quantum dot, the additional energy scale of inelastic co-tunneling processes comes into play. Co-tunneling processes strongly influence the transport not only in the Coulomb-blockade regime, but also around the resonances and above the sequential tunneling threshold, even at quite small dot-electrode coupling. In particular, the shot noise displays rich behavior that can only be understood by dealing with sequential and co-tunneling processes on equal footing. We present a diagrammatic approach to this problem that is valid for for arbitrary Coulomb interaction and accounts for non-Markovian memory effects relevant to the shot noise [1]. We observe spin-accumulation and spin-inversion on the quantum dot and predict strongly non-monotonic behavior of the shot noise with peaks and peak-dip features as well as various regimes where the noise is anomalously enhanced (super-Poissonian noise).

[1] A. Thielmann, M. H. Hettler, J. König, and G. Schön, Phys. Rev. Lett. 95, 146806 (2005).

— 15 min. break —

TT 21.6 Tue 17:45 HSZ 105

Fingerprints of spin polaron states in quantum transport through mesoscopic wires — •Herbert Schoeller, Frank Reininghaus, and Thomas Korb — Institut für Theoretische Physik A, RWTH Aachen, 52056 Aachen

Using the Keldysh formalism in combination with a self-consistent diagrammatic approach, we investigate the possibility to find fingerprints of spinpolaron states in quantum transport trough a mesoscopic quantum wire coupled via local exchange to a ferromagnetic spin chain. The spin polaron state occurs due to a hybridization between electronic states and magnons. Due to its low decoherence rate we find coherent transport and a new peak in the differential conductance as function of bias voltage. In addition we find peaks from the usual scattering states and inelastic tunneling. We discuss the peak structure as function of an external magnetic field, polarization of the leads, and the level spacing on the quantum wire.

TT 21.7 Tue 18:00 HSZ 105

Effects of Disorder and Reduced Adiabaticity on the Topological Hall Effect — •Michael Wimmer, Tobias Breu, and Klaus Richter — Institut für Theoretische Physik, Universität Regensburg

In the Topological Hall Effect (THE), a non-vanishing Hall effect is introduced not by a magnetic field, but by the Berry phase of spins adiabatically following a magnetic texture. Based on theoretical considerations on a clean, perfectly adiabatic system, an experimental realization was proposed in [1]. However, a real system might not be perfectly adiabatic: For example, elastic scattering has shown to be impairing adiabaticity [2].

We have developed a recursive Green's function algorithm to calculate the conductance of a four-terminal structure and present numerical studies on the THE. Our main focus is on the effects of disorder and on parameters outside the perfectly adiabatic regime. First results indicate that the THE persists for scattering lengths in reach of experiment.

[1] P. Bruno, V. K. Dugaev, and M. Taillefumier, Phys. Rev. Lett **93**, 096806 (2004)
[2] M. Popp, D. Frustaglia, K. Richter, Phys. Rev. B **68**, 041303 (2003).

TT 21.8 Tue 18:15 HSZ 105

Magnetotransport along a barrier: multiple quantum interference of edge states — •Anatoli M. Kadigrobov, Mikhail V. Fistul, and Konstantin B. Efetov — Theoretische Physik III, Ruhr-Universität Bochum, D-44801 Bochum Germany

Transport in a two-dimensional electron gas subject to an external magnetic field is analyzed in the presence of a *longitudinal barrier.* Similar systems have been produced by using a split-gate technique or cleaved edge fabrication method. We show that *quantum interference of the edge states* bound by the longitudinal barrier results in a drastic change of the electron motion: the degenerate discrete Landau levels are transformed into an alternating sequence of energy bands and energy gaps. The spectrum $\epsilon_n(p_x)$ is characterized by a nearly periodic dependence on the momentum p_x along the barrier. The width of the bands and the gaps can be tuned by the magnetic field and the gate voltage. These features of the electron spectrum should result in a high sensitivity of thermodynamic and transport properties of the 2D electron gas to external fields. In particular, we predict giant oscillations of the ballistic conductance and discuss nonlinear current-voltage characteristics, coherent Bloch oscillations and effects of impurities.

TT 21.9 Tue 18:30 HSZ 105

Magnetic Switching of the Superconducting Transition Temperature Ferromagnetic/Superconducting Bi- and Tri-Layers — •Roland Steiner, Alfred Plettl, and Paul Ziemann — Abteilung Festkörperphysik, Universität Ulm, D-89069 Ulm

Superconductivity and ferromagnetism are two antagonistic phenomena. The interplay between these two phenomena in multilayer systems is currently under intensive research [1].

In the present contribution results are presented on the magnetoresistance R(H) of ferromagnet/superconductor double- and trilayer-systems in their superconducting state with a typically 30 nm thick Niobium film as superconductor in all cases. It is demonstrated that the R(H)-curve exhibits a non-monotonous behaviour in the range of the coercitive field H_{coe} of the involved ferromagnets close to the superconducting transition at T_c. The T_c(H)-curves show a local minimum at H_{coe}. In contrary to theoretical results based on the Proximity-effect in trilayer systems [2], in the present system, switching into a parallel oriented magnetization of the sandwiching FM-layers leads to a T_c increase ($\Delta T_c \approx 50$ mK) as compared to the corresponding antiparallel alignement.

Additional experiments on FM/SC double layers deliver clear indications that the observed behaviour can be attributed to stray fields acting on the superconducting Niobium layer. To underline this conclusion micromagnetic simulations (oommf-code) will be discussed.

[1] A. Buzdin, Nat. Mat. (3), 751 (2004)
[2] I. Baladié et al., Phys. Rev. B 63, 54518 (2001)

TT 21.10 Tue 18:45 HSZ 105

Transport through anisotropic magnetic molecules — •Florian Elste[1] and Carsten Timm[2,1] — [1]Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, D-14195 Berlin, Germany — [2]Department of Physics and Astronomy, University of Kansas, Lawrence, KS 66045, USA

We theoretically investigate inelastic transport through anisotropic magnetic molecules, weakly coupled to metallic leads. The differential conductance shows characteristic fine-structure splitting of the Coulomb blockade peaks originating from excitations involving nondegenerate spin multiplets. Magnetic anisotropy is found to be crucial for slow spin relaxation. In the presence of anisotropy we find giant spin amplification: If a bias voltage is applied to a molecule prepared in a spin-polarized state the spin accumulated in the leads can be made exponentially large. If the molecule is coupled to one ferromagnetic and one paramagnetic lead the molecular spin can be reversed by applying a bias voltage even in the absence of a magnetic field. For this case, the current-voltage characteristics reveal wide voltage ranges where the current is strongly suppressed due to selection rules for the spin. Spin blockade behavior is accompanied by negative differential conductance and super-Poissonian shot noise. Based on our findings, we propose schemes for reading and writing spin information in molecular memory devices.