TT 19 Transport - Nanoelectronics I: Spintronics and Magnetotransport

Zeit: Montag 10:00–12:15 Raum: TU H3027

TT 19.1 Mo 10:00 TU H3027

Dielectric function of 2DEG with Rashba spin-orbit interaction — •Mikhail Pletyukhov[1] and Vladimir Gritsev[2] — [1]Institute for Theoretical Solid State Physics, University of Karlsruhe, Germany — [2]Department of Physics, University of Fribourg, Switzerland

We study how the dielectric function of two-dimensional electron gas is modified due to Rashba spin-orbit interaction. We present the results of our calculations for finite momenta and frequencies. We discuss the modification of plasmon spectrum due to spin-orbit coupling, and make estimates for quasiparticle lifetime for different values of Rashba coupling parameter.

TT 19.2 Mo 10:15 TU H3027

Andreev magnetotransport in low-dimensional semiconductors: Application to spin detection — •Grigory Tkachov and Klaus Richter — Institute for Theoretical Physics, Regensburg University, 93040 Regensburg, Germany

We investigate a possibility of using the superconducting proximity effect for detecting spin of transport carriers in two-dimensional electron systems (2DES), a problem closely related to the ongoing work on spin injection in semiconductors. The proximity effect is described within a ballistic approach taking into account the formation of an induced minigap in the excitation spectrum of a 2DES in planar superconductor/2DES contacts, which leads to enhanced Andreev reflection and the excess conductance at low bias voltages in agreement with experiments [1]. We show that in a 2DES subject to an in-plane magnetic field the Zeeman splitting of the proximity-modified states gives rise to spin-selective Andreev transport as opposed to conventional tunnel junctions where the spin splitting affects only the quasiparticle current [2]. Our model of spin-dependent Andreev reflection also accounts for a diamagnetic effect of the screening supercurrent induced by the magnetic field.

[1] C. Nguyen, H. Kroemer, and E.L. Hu, Phys. Rev. Lett. **69**, 2847 (1992); F. Rahman and T. J. Thornton, Superlat. Microstr., **25** 767 (1999); J. Eroms, M. Tolkiehn, D. Weiss, U. Rössler, J. DeBoeck, S. Borghs, Europhys. Lett. **58**, 569 (2002).
[2] R. Meservey, P. M. Tedrow, and P. Fulde, Phys. Rev. Lett. **25**, 1270 (1970); R. Meservey and P. M. Tedrow, Phys. Reports **238**, 173 (1994).

TT 19.3 Mo 10:30 TU H3027

Zero-bias anomaly in cotunneling transport through quantum-dot spin valves — Ireneusz Weymann[1], Józef Barnaś[1,2], •Jürgen König[3], Jan Martinek[2,4], and Gerd Schön[4] — [1]Department of Physics, Adam Mickiewicz University, 61-614 Poznań, Poland — [2]Institute of Molecular Physics, Polish Academy of Sciences, 60-179 Poznań, Poland — [3]Institut für Theoretische Physik III, Ruhr-Universität Bochum, 44780 Bochum, Germany — [4]Institut für Theoretische Festkörperphysik, Universität Karlsruhe, 76128 Karlsruhe, Germany

Quantum dots attached to ferromagnetic leads define quantum-dot spin valves. The interplay of spin-dependent transport due to finite spin polarization in the leads and strong Coulomb interaction gives rise to complex transport behavior. In the limit of weak dot-lead coupling, and deep in the Coulomb-blockade regime, sequential tunneling [1,2] is suppressed, and transport is dominated by cotunneling [3].

We analyze cotunneling transport through a quantum-dot spin valve with antiparallel alignment of the leads' magnetic moments. We find a zero-bias anomaly in the differential conductance for Coulomb-blockade valleys with an unpaired dot electron. It is a consequence of the interplay of single- and double-barrier cotunneling processes and their effect on the spin accumulation in the dot. The anomaly becomes significantly modified when an external magnetic field is applied.

[1] J. König and J. Martinek, Phys. Rev. Lett. **90**, 166602 (2003).
[2] M. Braun, J. König, and J. Martinek, cond-mat/0404455.
[3] I. Weymann, J. Barnaś, J. König, J. Martinek, and G. Schön, preprint.

TT 19.4 Mo 10:45 TU H3027

Investigation of a mesoscopic spin-ratchet — •Andreas Pfund and Klaus Richter — Institut für Theoretische Physik, Universität Regensburg, Germany

We consider the possibility to generalize the well known ratchet-mechanism to generate a spin-polarized current between electronic reservoirs. The effect of spin-orbit interaction is in particular considered. As a starting point, transport through a confined 2DEG in presence of a 'ratchet-potential', magnetic field and spin-orbit interaction is studied in a coherent and ballistic picture. The next step is to investigate the general non-equilibrium situation in contact with a heat-bath, introducing dissipation and thermal noise.

Hauptvortrag

TT 19.5 Mo 11:00 TU H3027

Spin Pumping in a Mesoscopic Spin Battery — •Bart van Wees — Department of Applied Physics and Materials Science Center, University of Groningen, The Netherlands

In the field of spintronics it has become possible to generate, study, and employ phenomena like spin currents and spin accumulation. A very new and exciting development is to use the fact that a spin current represents a flow of angular momentum. A new prediction [1] concerns a ferromagnetic island of which the magnetization direction is made to precess using ferromagnetic resonance, by driving it with a RF magnetic field with frequencies in the gigahertz range. It is predicted that as a result a spin current can be emitted into the non-magnetic metal or semiconductor which is attached to this ferromagnet. The ferromagnet will therefore act as a "spin battery", which can supply energy, not by an electronic charge current, but by a spin current. In this talk I will give a introduction into the relevant concepts for this phenomenon, including spin injection, spin mixing, spin transport and spin pumping. I will then discuss some of our recent experiments which show how spin accumulation can be created and studied in mesoscopic devices[2], and experiments [3] which show that spin currents are created by a "mesoscopic spin battery"by driving a micrometer sized ferromagnet with a strong RF field, generated by an "on-chip"microwave circuit close to the mesoscopic device structure. [1] Y. Tserkovnyak et al., Phys. Rev. Lett. 88, 117601 (2002) [2] M. Zaffalon, and B.J. van Wees, Phys. Rev. Lett. 91, 186601 (2003) [3] M. Costache et al., in preparation

Hauptvortrag

TT 19.6 Mo 11:30 TU H3027

Intrinsic Spin Hall Effect — •Shuichi Murakami — Department of Applied Physics, University of Tokyo, Tokyo 113-8656, Japan

We theoretically predict that the electric field can induce a substantial amount of spin current at room temperature, in p-type semiconductors such as GaAs [1,2]. This spin current is even under time reversal, and can flow without dissipation. It is caused by the topological Berry phase felt by a hole when it traverses the momentum space, and all the filled states below the Fermi level contribute to the spin current. On the other hand, in some band insulators such as PbTe, the charge conductivity vanishes, and the spin Hall current flows without any dissipation; we can call it a spin Hall insulator [3]. We discuss recent experimental observations of this effect. This effect leads to efficient spin injection into semiconductors without the need for metallic ferromagnets, opening up a new possibility for spintronic devices with low power consumption.

This work was done in collaboration with N. Nagaosa and S.-C. Zhang. References: S. Murakami, N. Nagaosa, and S.-C. Zhang, Science 301, 1348 (2003); Phys. Rev. B69, 235206 (2004); Phys. Rev. Lett. 93, 156804 (2004).

TT 19.7 Mo 12:00 TU H3027

Spin Hall conductivity of a two dimensional electron gas — •Peter Schwab[1] and Roberto Raimondi[2] — [1]Institut für Physik, Universität Augsburg, 86135 Augsburg — [2]Dipartimento di Fisica, Università di Roma Tre, 00146 Roma, Italy

In a two-dimensional electron gas with spin orbit couping an electric field applied in the x-direction in the plane induces a spin current in the y-direction with the spins polarized perpendicular to the plane. Over the last year this so-called spin Hall effect has attracted a lot of attention due to possible applications in spintronics.

We calculate the spin Hall conductivity $\sigma_{xy}(\omega)$ for a weakly disordered two-dimensional electron gas, varying both the strength and type of disorder. In the static limit, i.e. for frequencies that are below the elastic scattering rate, we find a vanishing spin Hall conductivity, independent of the type of disorder. The spin Hall conductivity vanishes due to a cancellation between a reactive contribution to the conductivity $\sigma_{\text{react}} = e/8\pi$ whose universal value is related to a Berry phase, and a dissipative contribution $\sigma_{\text{diss}} = -e/8\pi$.

[1] S. Murakami, N. Nagaosa, and S.-C. Zhang, Science **301**, 1348 (2003); J. Sinova, D. Culcer, Q. Niu, N. A. Sinitsy, T. Jungwirth, and A. H. MacDonald, Phys. Rev. Lett. **92**, 126603 (2004).
[2] R. Raimondi and P. Schwab, cond-mat/0408233.