TT 31: TR: Nanoelectronics II - Spintronics and Magnetotransport 1 (jointly with HL and MA)

Time: Wednesday 10:30–13:00 Location: HSZ 301

Invited Talk TT 31.1 Wed 10:30 HSZ 301

New insights into the spin Hall effect — •Peter Schwab — Institut für Physik, Universität Augsburg, 86135 Augsburg, Germany

The spin Hall effect allows to generate spin polarized currents without the need of magnetic materials or magnetic fields. Despite intensive theoretical and experimental efforts over the last years the microscopic mechanism that is responsible for the effect is in many cases not clear. Within a kinetic euqations approach we studied in detail the coupled dynamics of spin and charge currents in the two-dimensional electron gas and found that, surprisingly, the spin Hall effect and the inverse spin Hall effect are of different microscopic origin [1,2]. Recent experiments aim for an all-electrical measurement of the spin Hall effect. We will comment on an attempt to detect the spin Hall effect through the non-local voltage in H-shaped nanostructures, where an unexpected sign-change of the non-local voltage was observed when lowering the temperature.
[1] R. Raimondi, P. Schwab, EPL **87**, 37008 (2009)
[2] P. Schwab, R. Raimondi, C. Gorini, EPL **90**, 67004 (2010).

TT 31.2 Wed 11:00 HSZ 301

Geometric Correlations and Breakdown of Mesoscopic Universality in Spin Transport — •Klaus Richter[1], Inanc Adagideli[2], Philippe Jacquod[3], Matthias Scheid[1], Mathias Duckheim[4], and Daniel Loss[5] — [1]Institut für Theoretische Physik, Universität Regensburg, D-93040 Regensburg, Germany — [2]Faculty of Engineering and Natural Sciences, Sabanci University, 34956 Istanbul, Turkey — [3]Physics Department, University of Arizona, Tucson, USA — [4]Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, 14195 Berlin, Germany — [5]Department of Physics, University of Basel, CH-4056 Basel, Switzerland

We construct a unified semiclassical theory of charge and spin transport in chaotic ballistic and disordered diffusive mesoscopic systems with spin-orbit interaction [1]. Neglecting dynamic effects of spin-orbit interaction, we reproduce the random matrix theory results that the spin conductance fluctuates universally around zero average. Incorporating these effects in the theory we show that geometric correlations generate finite average spin conductances, but that they do not affect the charge conductance to leading order. The theory, which is confirmed by numerical transport calculations, allows us to investigate the entire range from the weak to the previously unexplored strong spin-orbit regime, where the spin rotation time is shorter than the momentum relaxation time.
[1] I. Adagideli et al., Phys. Rev. Lett., in print (2010); arXiv:1008.4656

TT 31.3 Wed 11:15 HSZ 301

Direct observation of band-gap closure for a semiconducting carbon nanotube in a large parallel magnetic field — •Sungho Jhang[1], Magdalena Margańska[1], Yurii Skourski[2], Milena Grifoni[1], Joachim Wosnitza[2], and Christoph Strunk[1] — [1]University of Regensburg, Germany — [2]Dresden High Magnetic Field Laboratory, Germany

We have investigated the magnetoconductance of semiconducting carbon nanotubes (CNTs) in pulsed, parallel magnetic fields up to 60 T, and report the direct observation of the predicted band-gap closure and the reopening of the gap under variation of the applied magnetic field. We also highlight the important influence of mechanical strain on the magnetoconductance of the CNTs.

TT 31.4 Wed 11:30 HSZ 301

Spin and charge transport in magnetically modulated 2DEGs — •Tobias Dollinger[1], Henri Saarikoski[1], Michael Wimmer[2], and Klaus Richter[1] — [1]Institut für Theoretische Physik, Universität Regensburg, Germany — [2]Instituut-Lorentz, Universiteit Leiden, The Netherlands

We investigate transport properties of disordered mesoscopic conductors in the presence of periodically modulated magnetic field textures. The focus of the work lies on examining the effects due to the resulting spin superstructure which is of relevance in transport experiments on magnetic semiconductor systems with giant Zeeman interaction. Observables like transmission and local spin densities have been calculated by means of a Recursive Greens Function Technique. The numerical results are interpreted within a semiclassical picture. Furthermore, the influence of adiabaticity on the observed transport features such as an anomalous peak in the magnetoconductance, is discussed.

15 min. break

TT 31.5 Wed 12:00 HSZ 301

Transport of Dirac fermions in HgTe quantum wells: Mobility anomaly and weak antilocalization — •G. Tkachov and E. M. Hankiewicz — Würzburg University, Germany

Recent studies of the quantum Hall effect and the minimal conductivity in HgTe quantum wells [1] have shown that this electronic system exhibits a single-valley Dirac fermion spectrum. In this work, we investigate further manifestations of the Dirac fermion transport in HgTe quantum wells: nonmonotonic carrier-density-dependent mobility and weak antilocalization effects. We demonstrate both theoretically and experimentally [2] that the carrier mobility has a maximum due to the competition of two disorder scattering mechanisms, viz. scattering by charged impurities and by quantum-well-width fluctuations which induce a fluctuating band gap, or, equivalently, fluctuating Dirac mass. Using the cooperon description of quantum interference effects, we also analyze how the symmetry breaking due to the finite band gap (Dirac mass) influences the weak antilocalization correction to the Drude conductivity.
[1] B. Büttner, C.X. Liu, G. Tkachov, E.G. Novik, C. Brüne, H. Buhmann, E.M. Hankiewicz, P. Recher, B. Trauzettel, S.C. Zhang and L. W. Molenkamp, *Single-valley Dirac fermions in zero-gap HgTe quantum wells*, to appear in Nature Physics; arXiv:1009.2248.
[2] G. Tkachov, C. Thienel, V. Pinneker, B. Büttner, C. Brüne, H. Buhmann, L. W. Molenkamp, and E. M. Hankiewicz, *Backscattering of Dirac fermions in finite gap HgTe quantum wells*, submitted to Physical Review Letters (2010)

TT 31.6 Wed 12:15 HSZ 301

Magnetotransport measurements of Bi(111) thin films on Si(111) — •Daniel Lükermann[1], Sergii Sologub[2], Christoph Tegenkamp[1], and Herbert Pfnür[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, D-30167 Hannover — [2]Academy of Science, Ukraine, 54 Volodymyrska St., Kiev, Ukraine

The semimetal bismuth has attracted a lot of interest because of its unique electronic properties such as the low carrier concentration and a large mobility of the carriers. Furthermore, the surface states reveal a pronounced Rashba splitting and the conductivity can be well discriminated from bulk contributions if thin films are grown on Si(111) substrates.
In this talk the magnetotransport properties of epitaxially grown Bi(111) thin films in the range of 10 to 40 bilayers (BL) on Si(111) will be presented. The films show positive magnetoresistance, i.e. decreasing conductance with magnetic field. The amplitude of the effect depends on the film thickness. We could observe different contributions from the surface state and the bulk in the magnetotransport measurements. A sharp peak in the magnetoconductance in the low B-field regime can be attributed to bulk holes and electrons with high mobility. For higher B-fields a nearly linear decrease of the conductance was found, stemming from carriers within the surface states. Measurements of the Hall-resistance show that mainly electrons contribute to the conductance of the surface state. The hole density is around two orders of magnitude smaller. As it turns out, even Bi films as thick as 40 BL are not fully charge compensated.

TT 31.7 Wed 12:30 HSZ 301

Spin and density response of interacting particles with spin-orbit coupling — •Klaus Morawetz[1,2], Janik Kailasvuori[3], and Ozgur Bozat[2] — [1]University of Applied Science Münster, Stegerwaldstrasse 39, 48565 Steinfurt, Germany — [2]International Institute of Physics (IIP), Universidade Federal do Rio grande do Norte - UFRN, Brazil — [3]Max-Planck-Institute for the Physics of Complex Systems, Noethnitzer Str. 38, 01187 Dresden, Germany

Linearizing the appropriate kinetic equation, the density and spin response functions of an interacting particle system coupled to an external magnetic field is derived. Special attention is paid to the spin-orbit coupling. Different known cases are contained in the obtained expression, among them magnetized plasmas in high magnetic fields, quasi two-dimensional graphene with interband coupling and spin-polarized electrons interacting with impurities. The interplay between collective spin and charge phenomena dependent on the interaction and the magnetic field is presented and the resulting transport coefficients are calculated.

TT 31.8 Wed 12:45 HSZ 301

Spin transfer torques in chiral magnetic structures — •Karin Everschor[1], Markus Garst[1], Rembert Duine[2], Achim Rosch[1], Florian Jonietz[3], Sebastian Mühlbauer[3,4], Christian Pfleiderer[3], Andreas Neubauer[3], Wolfgang Münzer[3], Andreas Bauer[3], Tim Adams[3], Robert Georgii[3,4], Peter Böni[3], Michael Wagner[3], and Tomek Schulz[3] — [1]Inst. für Theoretische Physik, Universität zu Köln — [2]Inst. for Theoretical Physics, Utrecht University, Netherlands — [3]Physik-Department E21, Technische Universität München — [4]FRM II, Technische Universität München

We investigate the influence of electric currents on magnetic structures in bulk materials. In magnets without inversion symmetry, weak spin-orbit coupling leads to the formation of magnetic helices with a long pitch. These helices pin only weakly to disorder and the underlying crystalline lattice. Another weakly pinned, non inversion symmetric phase is the 2d Skyrmion lattice which appears for example in MnSi. Electrons traversing the topolocially stable knots pick up a Berry phase, which leads to an effective Lorentz force acting on the electrons. Via a "topological" contribution to the Hall effect this Lorentz force can be observed. The counter force, which is a Magnus force, acts together with additional drag forces on the Skyrmion lattice. A gradient in these forces (induced by a small temperature gradient) results in a net torque that can be observed with neutron scattering.

The coupling of the Skyrmion lattice to inhomogeneous spin currents is very efficient, leading to an ultra-low electrical threshold current of $j = 10^6 A/m^2$ to observe spin transfer torques.