MA 38: Transport: Spintronics, Magnetotransport 1 (jointly with HL&MA)

Time: Thursday 9:30–13:00 Location: H18

MA 38.1 Thu 9:30 H18

A relativistic implementation of the non-equilibrium Green's function formalism for layered systems — •S Wimmer[1], M Ogura[2], H Akai[2], and H Ebert[1] — [1]Department Chemie, Ludwig-Maximilians-Univeristät München — [2]Department of Physics, Graduate School of Science, Osaka University

The non-equilibrium Green's function formalism has been implemented within the Korringa-Kohn-Rostoker (KKR) multiple scattering theory following previous work [1,2]. First results for the transport in layered systems are presented and compared to available results of other authors [1–3]. Using a fully relativistic approach within the Dirac-formalism allows us to investigate the influence of spin-orbit coupling. This will be discussed for various transport properties including the spin-transfer torque.

[1] C. Heiliger et al., J. Appl. Phys. **103**, 07A709 (2008)
[2] S. Achilles, Ph.D. thesis, Martin-Luther-Universität Halle-Wittenberg (2012)
[3] P. M. Haney et al., Phys. Rev. B **76**, 024404 (2007)

MA 38.2 Thu 9:45 H18

Persistent Spin Helix Conditions in Two-Dimensional Electron and Hole Gases — •Tobias Dollinger, Andreas Scholz, Paul Wenk, John Schliemann, and Klaus Richter — Institut für Theoretische Physik, Universität Regensburg

We discuss magnetotransport in systems with nonnegligable cubic in momentum Dresselhaus Spin Orbit Interaction (SOI). The latter has been found responsible for diminishing and shifting the parameter regime where weak localization signatures, attributed to the so called "Persistent Spin Helix"(PSH) symmetry [1,2], are detected in magnetoconductance traces [3]. Building on the electronic results, we present an effective model for the heavy hole band of a confined twodimensional hole gas, where typically SOI terms with cubic structure are relevant. We investigate numerically and analytically the magnetotransport propery of this model, in which we can identify an analogue to the PSH.

[1]J. Schliemann et al., PRL **90** 146801 (2003)
[2] Bernevig et al., PRL **97** 236601 (2006)
[3] Kohda et al., PRB **86** 081306 (2012)

MA 38.3 Thu 10:00 H18

Aharonov-Casher effect in quantum rings: geometric phase shift by in-plane magnetic field — Diego Frustaglia[1], •Henri Saarikoski[2], Klaus Richter[2], Fumiya Nagasawa[3], and Junsaku Nitta[3] — [1]Departamento de Física Aplicada II, Universidad de Sevilla, Sevilla, Spain — [2]Department of Theoretical Physics, Regensburg University, Germany — [3]Department of Materials Science, Tohoku University, Sendai, Japan

We study transport through Rashba spin-orbit coupled quantum rings where the spin-orbit field causes the Aharonov-Casher effect [1, 2]. The ring is subject to an in-plane magnetic field which gives rise to a shift in the geometric phase. We show that the in-plane field allows control of the geometric phase independently from the dynamic phase and without competing with Aharonov-Bohm phases. We use perturbation theory to calculate the resulting phase shift in quasi-1D rings for weak in-plane fields. The resulting phase shift is quadratic in the in-plane field. Numerical Recursive Green's function algorithm is used to study the effect in multi-mode quantum rings and in the case of large in-plane fields. We demonstrate the effect in InGaAs/InAlAs based quantum rings where the Rashba spin-orbit field is modulated by an external gate. As the in-plane magnetic field is increased we find a quadratic phase shift in the Aharonov-Casher effect towards lower spin-orbit fields in good agreement with calculations.

[1] F. Nagasawa, J. Takagi, Y. Kunihashi, M. Kohda, and J. Nitta, Phys. Rev. Lett. 108, 086801 (2012)
[2] K. Richter, Physics 5, 22 (2012).

MA 38.4 Thu 10:15 H18

Quantum Feedback in nuclear spin-assisted electronic transport — •Klemens Mosshamer and Tobias Brandes — Institut für theoretische Physik, Technische Universität Berlin, Hardenbergstrasse 36, 10623 Berlin

We investigate theoretically the electronic transport through quantum dot systems that interact with the nuclear environment via the hyperfine interaction. We show that the non-linear dynamics arising due to the hyperfine interaction can be controlled via closed-loop feedback operations, such as time-dependent modifications of the tunneling rate.

MA 38.5 Thu 10:30 H18

Projective Boltzmann approach to thermal drag in spin-1/2-ladder systems coupled to phonons — •Christian Bartsch and Wolfram Brenig — Institute for Theoretical Physics, Technical University Braunschweig, D-38106 Braunschweig

We quantitatively investigate the spin-phonon drag contributions to the thermal conductivity of a two-leg-spin-1/2-ladder coupled to lattice vibrations in a magnetoelastic way. By applying suitable transformations the system is mapped onto a weakly interacting quantum gas model of bosonic spin excitations (magnons) and phonons. We adequately construct a collision term of a linear(ized) Boltzmann equation from the underlying quantum dynamics by means of a pertinent projection operator technique. From the Boltzmann equation we obtain concrete numerical values for the drag conductivity and relate it to the individual thermal conductivities of magnons and phonons for parameter ranges which are typical for certain material classes.

MA 38.6 Thu 10:45 H18

Rashba spin-orbit-interaction-based quantum pump in graphene — •Dario Bercioux[1], Daniel F. Urban[2,3], Francesco Romeo[4], and Roberta Citro[4] — [1]Freiburg Institute for Advanced Studies, Albert-Ludwigs-Universität, 79104 Freiburg, Germany — [2]Physikalisches Institut, Albert-Ludwigs-Universität, 79104 Freiburg, Germany — [3]Fraunhofer Institute for Mechanics of Materials IWM, Wöhlerstraße 11, 79108 Freiburg, Germany — [4]Dipartimento di Fisica "E. R. Caianiello" and Spin-CNR, Università degli Studi di Salerno, I-84084 Fisciano (Sa), Italy

We present a proposal for an adiabatic quantum pump based on a graphene monolayer patterned by electrostatic gates and operated in the low-energy Dirac regime [1]. The setup under investigation works in the presence of inhomogeneous spin-orbit interactions of intrinsic- and Rashba-type and allows to generate spin polarized coherent current. A local spin polarized current is induced by the pumping mechanism assisted by the spin-double refraction phenomenon [2].

[1] Citro, Appl. Phys. Lett. **101**, 122445 (2012)
[2] D. Bercioux, A. de Martino, Phys. Rev. B **83**, 012106 (2011)

MA 38.7 Thu 11:00 H18

First-principles calculation of ballistic transport in single-atom contacts — •Fabian Otte[1], Björn Hardrat[1], Frank Freimuth[2], Yuriy Mokrousov[2] und Stefan Heinze[1] — [1]Institut für Theoretische Physik und Astrophysik, Christian-Albrechts-Universität zu Kiel, 24098 Kiel, Germany — [2]Peter-Grünberg-Institut, Forschungszentrum Jülich, 520425 Jülich, Germany

Recently, the spin-valve effect of single-atom contacts has been demonstrated using scanning tunneling microscopy [1]. In these measurements a magnetic tip approaches magnetic adatoms on a surface and the distance-dependent conductance and magnetoresistance is obtained. Here, we report first-principles calculations of ballistic transport in model systems of such single-atom contacts using our recently developed approach [2] which allows to include spin-orbit coupling and non-collinear spin structures. We present the conductance between two ferromagnetic Co monowires terminated by single Mn apex atoms while varying the distance between the two Mn atoms. Due to frustration of exchange interactions a non-collinear spin state is favorable in the contact regime. We show that it leaves a fingerprint in the distance-dependent conductance and magnetoresistance [3]. We also study the ballistic anisotropic magnetoresistance from the tunneling to the contact regime for leads whose structure is modeled with Fe monowires.

[1] M. Ziegler et al., New J. Phys. 13, 085011 (2011)
[2] B. Hardrat et al., Phys. Rev. B 85, 245412 (2012)
[3] B. Hardrat et al., Phys. Rev. B 86, 165449 (2012)

15 min. break

MA 38.8 Thu 11:30 H18

A carbon nanotube quantum dot in the intermediate coupling regime: Conductance and tunnel magnetoresistance — •Alois Dirnaichner, Johannes Kern, and Milena Grifoni — Universität Regensburg

We discuss transport through carbon nanotube quantum dots with intermediate coupling to ferromagnetic leads. In a density matrix approach we sum up infinite-order corrections due to charge fluctuations within the dressed second order approximation (DSO) [1], allowing us to go beyond the sequential tunneling regime. From the master equation we deduce conductance and tunnel magnetoresistance (TMR). The results are compared to experimental data with a pronounced gate modulation of the TMR and negative TMR features in particular.

[1] J. Kern and M. Grifoni, arXiv:1209.4995v1

MA 38.9 Thu 11:45 H18

Spin transport in carbon nanotubes in the Fabry-Perot regime — •Miriam del Valle and Milena Grifoni — Institute of Theoretical Physics, University of Regensburg

We investigate the spin-dependent transport through carbon nanotubes connected to two ferromagnetic leads in the ballistic regime. The effect and origin of the phases acquired by electrons upon scattering at the contact interfaces are analyzed. These phases greatly determine the Fabry-Perot patterns obtained in this transport regime. With stress on the nanotube fingerprints, the magneto-resistance is calculated with the inclusion of spin-orbit effects, which are not negligible due to the finite curvature of the nanotubes.

MA 38.10 Thu 12:00 H18

Investigation of spin transfer torques in $Mn_{1-x}Fe_xSi$ — •Christoph Schnarr, Robert Ritz, Andreas Bauer, Christian Franz, and Christian Pfleiderer — Technische Universität München, Physik-Department E21, D-85748 Garching, Germany

Small angle neutron scattering and Hall effect measurements recently revealed sizeable effects of spin transfer torques in the skyrmion lattice phase of MnSi [1,2]. The associated critical current densities of $\sim 10^6$ A/m^2, are exceptionally small and about 5 orders of magnitude smaller than the spin transfer torque observed in conventional systems. The low critical current density is due to a very efficient gyromagnetic coupling exhibited by a topological Hall contribution that arises in the topologically non-trivial magnetic structure of a skyrmion lattice. We report spin transfer torque experiments, measuring the Hall effect in $Mn_{1-x}Fe_xSi$ for a wide range of x, where the topological Hall effect increases by up to a factor of ten characteristic of a much more efficient coupling of the electric currents to the magnetic structure. The dependence of j_c on the doping concentration is discussed in view of the increased topological Hall effect as well as the increased pinning by disorder.

[1] F. Jonietz *et al.*, Science **330**, 1648-1651 (2010)
[2] T. Schulz *et al.*, Nat Phys **8**, 4, 301-304 (2012)

MA 38.11 Thu 12:15 H18

Magnetotransport along a boundary: From coherent electron focusing to edge channel transport — •Thomas Stegmann, Dietrich E. Wolf, and Axel Lorke — University of Duisburg-Essen, Department of Physics and CENIDE

In a two dimensional electron system with a boundary, electrons are injected at one point on the boundary and focussed by a perpendicular magnetic field B onto another voltage probe on the boundary. Using the nonequilibrium Green's function approach we study theoretically the 4-point Hall resistance R_{xy} as a function of B. For low fields, R_{xy} shows the characteristic equidistant peaks observed in the experiment, which can also be explained by simple classical trajectories: The electrons are guided on cyclotron orbits, are reflected speculary at the boundary, and end finally at the collector when a multiple of the cyclotron diameter equals the distance between injector and collector. In a strong magnetic field, the current is carried by edge channels parallel to the boundary and the typical fingerprint of the quantum Hall effect is observed. Here, we study the transition from the classical cyclotron motion to the edge channel transport and discuss its influence on the focussing spectrum. In intermediate fields, we find that R_{xy} shows sets of oscillations, which are neither periodic in B (such as the magnetic focussing peaks) nor in $1/B$ (quantum Hall effect). These oscillations can be understood as interference between adjacent edge states.

MA 38.12 Thu 12:30 H18

Entanglement detection in Cooper pair splitters based on carbon nanotubes in magnetic fields — •Pablo Burset[1,2], Bernd Braunecker[1], and Alfredo Levy Yeyati[1] — [1]Departamento de Fisica Teorica de la Materia Condensada, Universidad Autonoma de Madrid, E-28049 Madrid, Spain — [2]Institute for Theoretical Physics and Astrophysics, University of Wuerzburg, Am Hubland, 97074 Wuerzburg, Germany

The production of entangled electron pairs in a solid state device from the splitting of a Cooper pair is currently attracting much attention. Recent experiments have shown that Cooper pairs can be split in a controlled fashion in double quantum dot structures. In this talk I will describe how spin-orbit interaction in carbon nanotubes presents unique characteristics for the study of the entanglement of injected pairs of electrons.

I will briefly introduce the double dot Cooper pair splitter device based on carbon nanotubes. In this setup, I will review the form of spin-orbit interaction and demonstrate that it leads to a perfect spin filter with spin orientations tunable by external fields. Tunable spin-orbit induced spin-filtering allows to implement entanglement detectors, such as probing a Bell inequality. These detectors can rely on conductance measurements alone and do not require the precise knowledge of the spin orientations of the spin filter. Yet if in addition the spin orientations are known, the same setup can be used for full quantum state tomography.

MA 38.13 Thu 12:45 H18

Electronic correlations in magnetic heterostructures. — •Liviu Chioncel[1,2] and Junya Otsuki[2,3] — [1]Augsburg Center for Innovative Technologies, University of Augsburg, D-86135 Augsburg, Germany — [2]Theoretical Physics III, Center for Electronic Correlations and Magnetism, Institute of Physics, University of Augsburg, D-86135 Augsburg, Germany — [3]Department of Physics, Tohoku University, Sendai, Japan

Heterostructures that contain semiconducting and magnetic monolayers offer the possibility to adjust simultaneously band-gap and magnetic properties. Dynamical Mean Field Theory is a necessary theoretical tool to address physical properties of multilayer systems containing correlated electrons. Here we solve a simplified Hubbard model within DMFT using the recently developed CT-QMC solver, for several magnetic monolayers embedded into semiconducting/insulating host. Our approach is relevant for the Cr/Mn-doped semiconducting heterostructures. We discuss possible half-metallic properties in these systems in the presence of dynamic correlations at finite temperatures.