MA 49: Transport: Spintronics and Magnetotransport (Joint session of DS, HL, MA and TT organized by TT)

Time: Thursday 16:15–18:30 Location: H23

Invited Talk MA 49.1 Thu 16:15 H23

Non-Abelian gauge theory description of (dynamical) spin-orbit coupling effects in Fermi gases. — •Cosimo Gorini — Institut für Theoretische Physik, Universität Regensburg, Germany

Spin-orbit coupling heavily influences the dynamics of charge carriers in a solid, where its strength can be enhanced by orders of magnitude as compared to the vacuum. Remarkable consequences are phenomena such as the spin Hall and inverse spin galvanic (or Edelstein) effects, where spin currents and polarizations are generated by purely electrical means. The intricacies of such rich spin-charge coupled dynamics can be described within a non-Abelian gauge theory approach [1], based on Keldysh non-equilibrium formalism [2]. Thanks to a symmetric treatment of spin and charge degrees of freedom, and the removal of ambiguities related to spin non-conservation in the presence of (static or dynamical) spin-orbit coupling, a physically transparent picture is achieved [3]. Furthermore, the non-Abelian language, by virtue of its universal character, treats on the same footing standard spin-orbit interaction in solid state systems and exotic forms of (pseudo) spin-orbit coupling which arise, or can be engineered, in different contexts.

[1] H. Mathur and A. D. Stone, PRL **68**, 2964 (1991)
I. V. Tokatly, PRL **101**, 106601 (2008).
[2] C. Gorini et al., PRB **82**, 195316 (2010).
[3] C. Gorini et al., PRL **109**, 246604 (2012)
C. Gorini et al., PRL **115** , 076602 (2015).

MA 49.2 Thu 16:45 H23

Shot noise in magnetic tunnel junctions: effect of the geometric phase — •Tim Ludwig[1] and Alexander Shnirman[1,2] — [1]Institut für Theorie der Kondensierten Materie, Karlsruher Institut für Technologie, 76131 Karlsruhe, Germany — [2]L. D. Landau Institute for Theoretical Physics RAS, Kosygina street 2, 119334 Moscow, Russia

We analyze the current driven dynamics of magnetization and voltage in a magnetic tunnel junction. As predicted in [1, 2], the magnetization can be driven by spin currents. This effect can also be reversed, such that an externally driven magnetization generates a dc voltage [3]. Although both effects are intimately related, so far they have been treated separately. We generalize the approach of [4] to derive an action that contains both effects simultaneously. We employ the Keldysh formalism, which allows us to derive stochastic Landau-Lifshitz-Gilbert-Langevin equations describing the angular dynamics of the magnetization coupled with the voltage dynamics. We identify two low-temperature regimes. In one regime the voltage fluctuations are governed by the applied current only, as expected for the shot noise. In the other regime an excess noise arises, which is governed by the geometric phase of the precessing magnetization.

[1] L. Berger, PRB **54**, 9353 (1996)
[2] J. C. Slonczewski, J. Magn. Magn. Mater. **159**, L1 (1996)
[3] L. Berger, PRB **59**, 11465 (1998)
[4] A. Shnirman, Y. Gefen, A. Saha, I. S. Burmistrov, M. N. Kiselev, A. Altland, PRL **114**, 176806 (2015)

MA 49.3 Thu 17:00 H23

Electron transport through the helical molecules in the presence of spin-orbit coupling — •Volodymyr V. Maslyuk, Rafael Gutiérrez, and Gianaurelio Cuniberti — Institute for Material Science and Max Bergmann Center for Biomaterials, Dresden University of Technology, Hallwachstr. 3, 01069 Dresden, Germany

Recently it was shown [1] that electron transport through systems with helical symmetry shows spin selectivity. Here we present a theoretical investigation of the transport properties through helical molecules placed between magnetic and nonmagnetic leads by using the DFT and NEGF approach. The performed analysis of the data allow us to show that the systems show spin-polarization only because of spin-orbit interaction and the spin polarization is clearly related to the helical symmetry since a change in handedness of the helix changes the sign of the spin-polarization and a linear chain does not display any sizeable polarization.

[1] B. Göhler, V. Hamelbeck, T. Z. Markus, M.Kettner, G. F. Hanne, Z. Vager, R. Naaman, and H. Zacharias, Science **331**, 894 (2011).

15 min. break

MA 49.4 Thu 17:30 H23

Magnetic impurities on Bi thin films - conductivity and surface diffusion — •Philipp Kröger[1], Sergii Sologub[2], Andreas Lücke[3], Nora Vollmers[3], Uwe Gerstmann[3], Wolf Gero Schmidt[3], Herbert Pfnür[1], and Christoph Tegenkamp[1] — [1]Leibniz Universität Hannover, Inst. für FKP, Appelstr. 2, 30167 Hannover — [2]Inst. of Ph., Nat. Acad. of Sc., Nauky Av. 46, 03028 Kyiv, Ukraine — [3]Universität Paderborn, Theoretische Materialphysik, Pohlweg 55, 33098 Paderborn

The semimetal bismuth has attracted a lot of interest because of its unique electronic properties such as low carrier concentration and large mobility. The surface states reveal a pronounced Rashba splitting. The surface conductivity can well be discriminated from bulk contributions for ultra-thin films grown epitaxially on Si(111) substrates, so that surface related effects are accessible even in macroscopic conductance measurements.

In this context, the adsorption of Cr with its high magnetic moment on the Bi(111) surface will be discussed. Cr induces a transition from Weak Anti- to Weak Localization. This indicates strong impurity scattering that mixes spin and orbit momenta, with corresponding symmetry breaking on the Bi surface (TRS), in agreement with results from DFT calculations. Contrary to other impurities adsorbed at subsurface sites (Fe,Co,Cr, Sb), Cr shows signs of diffusion processes at low T ($T \approx 10$ K), as previously observed for Tb which adsorbes on the surface.

MA 49.5 Thu 17:45 H23

Spin-vibronics in interacting nonmagnetic molecular nanojunctions — •Stephan Weiss[1], Jochen Brüggemann[2], and Michael Thorwart[2] — [1]Theoretische Physik, Universität Duisburg-Essen & CENIDE — [2]1. Institut für Theoretische Physik, Universität Hamburg

We show that in the presence of ferromagnetic electronic reservoirs and spin-dependent tunnel couplings, molecular vibrations in nonmagnetic single molecular transistors induce an effective intramolecular exchange magnetic field[1]. It generates a finite spin-accumulation and -precession for the electrons confined on the molecular bridge and occurs under (non)equilibrium conditions. The effective exchange magnetic field is calculated here to lowest order in the tunnel coupling for a nonequilibrium transport setup. Coulomb interaction between electrons is taken into account as well as a finite electron-phonon coupling. For realistic physical parameters, an effective spin-phonon coupling emerges. It is induced by quantum many-body interactions, which are either electron-phonon or Coulomb-like.

[1] S. Weiss, J. Brüggemann and M. Thorwart,
PRB **92**, 045431 (2015).

MA 49.6 Thu 18:00 H23

Coherent Dynamics of Quantum Spins in Magnetic Environments — •Lars-Hendrik Frahm[1], Christoph Hübner[1], Benjamin Baxevanis[1,2], and Daniela Pfannkuche[1] — [1]1. Institut für Theoretische Physik, Universität Hamburg, 20355 Hamburg, Germany — [2]Instituut-Lorentz, Universiteit Leiden, P.O. Box 9506, 2300 RA Leiden, The Netherlands

We investigate equilibration and transport effects of a magnetic atom that is exchange coupled to two electron reservoirs. An effective crystal field, which arises from the substrate the atom is living on gives the spin of the atom an easy axis for alignment. Further, a spin-polarized electron reservoir breaks the rotation symmetry around the spin quantization axis. A proper description of the dynamics of the quantum spin requires to consider the complete density operator, where its knowledge allows to calculate magnetization dynamics and transport properties on an equal footing. We discuss the electron transport through the atomic system by especially focusing on the non-linear influence of the spin torque effect.

MA 49.7 Thu 18:15 H23

Colossal Magnetoresistance observed in Natural Graphite — •Jose Barzola-Quiquia[1], Mahsa Zoraghi[1], Markus Stiller[1], Christian Precker[1], Ana Champi[2], and Pablo Esquinazi[1] — [1]Institute for Experimental Physics II, University of Leipzig, 04103 Leipzig, Germany — [2]Centro de Ciencias Naturais e Humanas Universidade Federal do ABC, Sao Paulo- Brasil

In this work, the electrical transport properties of a bulk natural graphite flake extracted from a mine in Brazil were investigated. The sample showed metallic behavior and the changes in the magnetoresistance (MR) at 5 K and 7 T shows 1123600% change when the field was applied parallel to the *c*-axis. This value was not yet reported in any graphite sample in the literature. Applying constant magnetic field, resistance measurements as a function of the temperature show also a magnetic field induces metal-insulator transition (MIT), with a small critical field $B_0 \approx 10$ mT compared to literature. We observed also that at fields $B > 0.2$ T a metallic reentrance was observed that remains up to ≈ 50 K. STEM measurements reveal the presence of interfaces in the investigated material. Therefore, the observed transport properties are not an intrinsic behavior of the graphite sample but due to the presence of these interfaces. Interfaces in the sample are formed at the interfaces between two crystalline regions inside the sample where a two dimensional electron gas (2DEG) system appears. Raman measurements reveal that our samples are free from any other defects.