MA 29: Spin dependent Transport Phenomena

Time: Tuesday 14:00–15:15 Location: HSZ 403

MA 29.1 Tue 14:00 HSZ 403

Ab initio calculations of bias voltage dependence of magneto crystalline anisotropy in magnetic tunnel junctions — •Christian Heiliger, Carsten Mahr, and Michael Czerner — Institute for Theoretical Physics, Justus Liebig University Giessen, Germany

Spin-orbit effects play an important role in current spintronics research. One effect due to spin-orbit coupling is the magneto crystalline anisotropy (MCA) and the control of this effect by a bias voltage. Using density functional theory in combination with non-equilibrium Green's function method we calculate the bias voltage dependence of MCA for the case of a V/Fe/MgO/V. We discuss the dependence of MCA and of the tunneling anisotropic magneto resistance (TAMR) on the Fe and MgO slab thicknesses. Further, we show the voltage dependence of spin-torque originated in these tunnel junctions and clarify the connection to the MCA. All our results are compared to recent experimental results in the same junctions.

MA 29.2 Tue 14:15 HSZ 403

Planar Hall effect in Au/Fe/MgO (001) heterostructures for spin-orbitronics — •Pika Gospodaric[1], Ewa Mlynczak[1], Daniel E. Bürgler[1], Frank Volmer[2], Bernd Beschoten[2], Lukasz Plucinski[1], and Claus M. Schneider[1] — [1]Peter Grünberg Institut PGI-6, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]2nd Institute of Physics and JARA-FIT, RWTH Aachen University, 52074 Aachen, Germany

The combined effects of the spin-orbit coupling (SOC) and the exchange interaction can generate torques acting on the magnetization of a ferromagnet. Strong SOC can be achieved in a ferromagnetic metal (FMM) by close proximity to a heavy metal (HM). Recently, it was shown that by applying a current in the plane of a FMM, sandwiched between a HM and an oxide layer, the magnetization of the FMM layer can be manipulated. This phenomenon is now known as the spin-orbit torque (SOT) and is explained either on the basis of the Rashba field present at the interface of the layers or a strong spin Hall effect in the HM layer. In this contribution we present the observation of changes of the magnetization direction of a prototypical FMM, namely an Fe (001) thin film in epitaxially grown Au/Fe/MgO (001) heterostructures. We identified a four-fold in-plane magnetic anisotropy of the Fe (001) layer with magneto-transport measurements and detected changes of the magnetization direction using the planar Hall effect. Above a critical current threshold of 2 x 10^7 A/cm^2 we measured an increase of the induced Hall voltage, which we attribute to a SOT-induced tilt of the magnetization direction of the Fe (001) layer.

MA 29.3 Tue 14:30 HSZ 403

Ab initio calculation of thermal dependent anomalous Hall effect — •David Wagenknecht, Karel Carva, and Ilja Turek — Department of Condensed Matter Physics, Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic

Anomalous Hall effect (AHE) is directly connected to nondiagonal elements of the electrical conductivity tensor. Therefore, it is an important phenomenon bringing fundamental information about solid materials. A large change in the AHE may be used, e.g., to define a binary information leading to a construction and switching of antiferromagnetic structures like memories [1]. Thus, the knowledge of the AHE is essential at the room temperatures, where the devices should operate.

We have calculated electrical transport properties including the AHE from the first principles and incorporated thermal disorder. Fully relativistic linear muffin-tin orbital (LMTO) approach with the coherent potential approximation (CPA) was used [2] and the effect of nonzero temperature was described by a frozen lattice displacements [3]. Nickel and simple nickel-based alloys (nonstochiometric $Cu_{1-x}Ni_x$ and $Co_{1-x}Ni_x$) were used to verify our approach that may now be applied to more complex materials (semi-Heusler NiMnSb, antiferromagnet CuMnAs, ...).

[1] N. Kiyohara et al. Phys. Rev. Applied 5, 064009 (2016)
[2] K. Carva et al. Phys. Rev. B 73, 144421 (2006)
[3] D. Wagenknecht et al. In Šafránková, Jana; Pavlů, Jiří. WDS'15 Proceedings of Contributed Papers - Physics. : Matfyzpress (2015). s. 42*47. ISBN 978-80-7378-311-2.

MA 29.4 Tue 14:45 HSZ 403

Nonlocal anomalous Hall effect in ternary alloys — •Franziska Töpler[1], Albert Hönemann[1], Katarina Tauber[1], Dmitry Fedorov[2,1], Martin Gradhand[3], Ingrid Mertig[1,2], and Albert Fert[4] — [1]Martin Luther University Halle-Wittenberg, Halle, Germany — [2]Max Planck Institute of Microstructure Physics, Halle, Germany — [3]University of Bristol, Bristol, United Kingdom — [4]Université Paris-Sud, Université Paris-Saclay, Paris, France

The spin Hall effect (SHE) [1] and the anomalous Hall effect (AHE) [2] are two promising phenomena for novel spintronic devices. Authors of Ref. [3] proposed to enhance the AHE in noble metal hosts with magnetic 3*d* impurities by codoping of heavy nonmagnetic impurities.

We present a detailed study [4] of the transverse charge transport in such ternary alloys related to the so-called *nonlocal* AHE, recently introduced [5]. The results of our *ab initio* calculations are underpinned and explained by theoretical investigations via Matthiessen's rule. Considering transport properties of the constituent binary alloys, we reveal optimal host-impurity combinations to enhance the AHE. This allows us to explain experimental findings [3] showing a strong effect in Cu-based alloys but a vanishing effect in the case of the Au host.

[1] Sinova *et al.*, Rev. Mod. Phys. **87**, 1213 (2015)
[2] Nagaosa *et al.*, Rev. Mod. Phys. **82**, 1539 (2010)
[3] Fert *et al.*, J. Magn. Magn. Mater. **24**, 231 (1981)
[4] Töpler *et al.*, Phys. Rev. B **94**, 140413(R) (2016)
[5] Zhang and Vignale, Phys. Rev. Lett. **116**, 136601 (2016)

MA 29.5 Tue 15:00 HSZ 403

Exchange and spin-orbit induced phenomena in diluted (Ga,Mn)As from first principles — •Josef Kudrnovsky[1], Vaclav Drchal[1], and Ilja Turek[2] — [1]Institute of Physics AS CR, Prague, Czech Republic — [2]Institute of Physics of Materials AS CR, Brno, Czech Republic

Physical properties induced by exchange interactions (Curie temperature and spin stiffness) and spin-orbit coupling (anomalous Hall effect, anisotropic magnetoresistance, and Gilbert damping) in the diluted (Ga,Mn)As ferromagnetic semiconductor are studied from first principles. Recently developed Kubo-Bastin transport theory and nonlocal torque operator formulation of the Gilbert damping as formulated in the tight-binding linear muffin-tin orbital method are used. The first-principles Liechtenstein mapping is employed to construct effective Heisenberg Hamiltonian and to estimate Curie temperature and spin stiffness in the real-space random-phase approximation which takes into account the effect of magnetic percolation. Good agreement of calculated physical quantities with experiments for well-annealed samples containing only a small amount of compensating defects is obtained. Their possible effect will be briefly discussed.