MA 51: Spin Excitations/ Spin Torque

Time: Friday 9:30–11:45 Location: H 1012

MA 51.1 Fri 9:30 H 1012

Ab initio investigation of the influence of the magnetic material in magnetic tunnel junctions on the bias dependence of the spin-transfer torque — •Christian Franz, Michael Czerner, and Christian Heiliger — I. Physikalisches Institut, Justus-Liebig-Universität, Gießen, Deutschland

We perform an investigation of the material dependence of the bias dependent spin-transfer torque (STT) in magnetic tunnel junctions using *ab initio* methods. In particular, we investigate Fe, Co and FeCo alloys.

We calculate the STT using a non-equilibrium Green's function method based on the Keldysh formalism which was implemented in a KKR method. The FeCo alloy is described both by a stacking of Fe and Co layers (ordered alloy) and by the coherent potential approximation (CPA). In the CPA calculations we incorporate non-equilibrium vertex corrections.

Our results show that for an ordered alloy the material of the ferromagnetic layer closest to the barrier has a strong influence on the bias dependence of the STT. Although the size of the STT is nearly independent of the material the qualitative bias dependence changes substantially. When we use the CPA to describe the FeCo alloy different terminations at the interface are mixed. Consequently, the features of the bias dependence of the different pure materials or ordered alloys are washed out. We compare our results to recently presented experimental ones.

MA 51.2 Fri 9:45 H 1012

Electronic transport and magnetization dynamics in realistic devices: a multiscale approach — •Simone Borlenghi[1,2], Valentin Rychkov[2], Cyril Petitjean[3], Grégoire De Loubens[2], Olivier Klein[2], and Xavier Waintal[3] — [1]Department of Material Science and Engineering, KTH-Stockholm, Sweden — [2]Nanoelectronic group, SPEC, CEA-Saclay, France — [3]Theory group SPSMS, CEA-Grenoble, France

We report on a theoretical model, based on Continuous Random Matrix Theory (CRMT) [1] and non equilibrium Green functions, that describes on an equal footing transport and magnetic degrees of freedom in realistic devices. Our approach offers a systematic way to perform multiscale simulations of spin transport [2] in mesoscopic systems with arbitrary geometry, connected to an arbitrary number of electron reservoirs. The model can be parametrized both with experimentally accessible parameters and ab initio calculations, and it is suitable for a large variety of materials (normal metals, ferromagnets, superconductors, semiconductors).

As an application of our model, we have coupled CRMT to a micromagnetic simulation code, in order to model a spectroscopic experiment performed on a spin torque nano oscillator. Our simulations predict correctly the selection rules for spin wave modes excited by spin torque, and give a description of the complex dynamics of the magnetization in qualitative agreement with experiments.

[1] V. Rychkov et al., Phys. Rev. Lett. 103 (2009), 066602.
[2] S. Borlenghi et al., Phys. Rev. B 84 (2011), 035412.

MA 51.3 Fri 10:00 H 1012

Extrinsically controlled spin relaxation in NiFe thin films induced by a periodic scattering potential — •Michael Körner[1], Kilian Lenz[1], Anja Banholzer[1], Jochen Grebing[1], Igor Barsukov[2], Florian M. Römer[2], Jürgen Lindner[2], Michael Farle[2], and Jürgen Fassbender[1] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf (HZDR), P.O. Box 510119, 01314 Dresden, Germany — [2]Fakultät für Physik and Center for Nanointegration Duisburg-Essen (CeNIDE), Universität Duisburg-Essen, D-47048 Duisburg, Germany

The spin relaxation process of thin $Ni_{80}Fe_{20}$ (Py) films is influenced by introducing a periodic scattering potential using ion beam techniques. These potentials can be created in two ways: (i) by Cr^+ implantation into the surface of the Py film, using a lithographically defined mask. (ii) by using nanometer scale periodically modulated substrates (ripple) that change the morphology of the Py film grown on top [2]. The magnetic damping contributions are determined by frequency-dependent ferromagnetic resonance measurements using a vector network analyzer. For both sample systems we find several strongly enhanced linewidth peaks over a wide frequency range. By varying the scattering potential, the frequency positions of the damping peaks are preselectable.

This work is supported by DFG grant FA 314/6-1 and SFB 491.

[1] I. Barsukov et al., Phys. Rev. B 84, 140410(R) (2011).
[2] J. Fassbender et al., New Journal of Physics 11, 125002 (2009).

MA 51.4 Fri 10:15 H 1012

Domain Wall Torques from First Principles — •Frank Freimuth, Yuriy Mokrousov, and Stefan Blügel — Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

We present first-principles calculations of the adiabatic and non-adiabatic (NA) torques on domain-walls (DW) in bulk Fe, Co, Ni, FePd and FePt. Our calculations take into account both disorder and the spin-orbit interaction (SOI). The relation between the Gilbert damping and the NA torque is discussed. It has been shown experimentally [1] that additional SOI-mediated torques occur in asymetrically interfaced magnetic layers and suppress the Walker breakdown. The underlying mechanisms of these SOI-driven torques are investigated for Co/Pt slabs. It is shown that – in analogy to anomalous Hall and spin Hall effects – intrinsic [2,3] and extrinsic [4] contributions to the various torques can be distinguished and sometimes are of similar size. Additionally, we briefly describe our computational method [5,6], discussing particularly the use of the Wannier interpolation technique and the treatment of disorder. This work is supported by the HGF-YIG grant VH-NG-513.

[1] I. M. Miron et al., Nature Materials **10**, 419-423 (2011)
[2] H. Zhang et al., Phys. Rev. Lett. **106**, 117202 (2011)
[3] F. Freimuth et al., Phys. Rev. Lett. **105**, 246602 (2010)
[4] J. Weischenberg et al., Phys. Rev. Lett. **107**, 106601 (2011)
[5] F. Freimuth et al., Phys. Rev. B **78**, 035120 (2008)
[6] www.flapw.de

MA 51.5 Fri 10:30 H 1012

Determination of the nonadiabatic spin transfer torque parameter via SEMPA investigations — •Stefan Rössler[1], Sebastian Hankemeier[1], Robert Frömter[1], Hans Peter Oepen[1], and Benjamin Krüger[2] — [1]Institute of Applied Physics, Hamburg, Germany — [2]I. Institute of Theoretical Physics, Hamburg, Germany

The displacement of a magnetic vortex core in a permalloy rectangle due to an ultrahigh DC current density has been measured utilizing Scanning Electron Microscopy with Polarization Analysis (SEMPA).

A permalloy square of 6 μm x 6 μm x 10 nm size has been prepared on a single crystalline diamond substrate. The ground state for structures of this size is the Landau structure where the magnetization is curling around a sharp vortex core in the middle of the structure. In the center of the core the magnetizaion points out of plane to reduce exchange energy. Thus, each Landau state can be characterized by its sense of rotation c and the direction of the out of plane magnetization p allowing four different states of magnetization. The displacement of the vortex core for three of these different cp-states has been measured up to a DC current density of $7 \times 10^{11}\mathrm{A/m^2}$. As shown in [1] the measurement of three different cp-states allows to separate the effects caused by the oerstedt field, the nonadiabatic, and the adiabatic spin transfer torque. From these measurements the parameter of nonadiabaticity has been determined.

This work is supported by DFG via SFB 668.

References: [1] Krüger et al., Phys. Rev. Lett. **104**, 077201 (2010)

MA 51.6 Fri 10:45 H 1012

Life times and chirality of spin-waves in antiferromagnetic and ferromagnetic FeRh: time depedent density functional theory perspective — •Leonid Sandratskii and Pawel Buczek — Max-Planck-Institut für Mikrostrukturphysik, Halle

The first-principles study of the spin excitations in antiferromagnetic (AFM) and ferromagnetic (FM) phases of FeRh is reported. The study is based on the calculation of the transversal dynamic spin susceptibility. We demonstrate that although the Fe atomic moments are well defined there is a number of important phenomena absent in the Heisenberg description: Landau damping of spin waves, large Rh moments induced by the AFM magnons, the formation of the optical magnons terminated by Stoner excitations. We relate the properties of the spin-wave damping to the features of the Stoner continuum and compare the chirality of the spin excitations in AFM, FM and param agnetic systems.

MA 51.7 Fri 11:00 H 1012

Magnon Excitations in Epitaxial Fe Films on Ir(001) — •Tzu-Hung Chuang, Yu Zhang, Huajun Qin, Khalil Zakeri, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle, Germany

Fe(001) films with a thickness of up to 10 monolayers (ML) grow pseudomorphically on Ir(001) with a constant in-plane film strain [1]. The room temperature ferromagnetic hysteresis loop is observed only above 5 ML. The Fe films with a thickness of 6 ML show a very small magnetic anisotropy. Here we report the experimental results of high wavevector magnon excitations probed on a 6 ML Fe film by spin-polarized electron energy loss spectroscopy (SPEELS). The magnon dispersion relation is measured along the [100]- and [110]- directions of the Fe film. It is found that the magnon dispersion relation is anisotropic. The results cannot be explained by the classical Heisenberg spin Hamiltonian taking only the isotropic Heisenberg exchange interaction into account.

[1] V. Martin, W. Meyer, C. Giovanardi, L. Hammer, K. Heinz, Z. Tian, D. Sander, and J. Kirschner, Phys. Rev. B **76**, 205418 (2007).

MA 51.8 Fri 11:15 H 1012

Time-dependent spin-wave theory — •Andreas Rückriegel, Andreas Kreisel, and Peter Kopietz — Institut für Theoretische Physik, Universität Frankfurt

We generalize the spin-wave expansion in powers of the inverse spin to time-dependent quantum spin models describing rotating magnets or magnets in time-dependent external fields. We show that in these cases the spin operators should be projected onto properly defined rotating reference frames before the spin components are bosonized using the Holstein-Primakoff transformation. As a first application of our approach, we calculate the re-organization of the magnetic state due to Bose-Einstein condensation of magnons in the magnetic insulator yttrium-iron garnet; we predict a characteristic dip in the magnetization which should be measurable in experiments.

MA 51.9 Fri 11:30 H 1012

Charge ordering and charge accumulation in magnetic spin-ice lattices — •Elena Y. Vedmedenko — Institute of Applied Physics, University of Hamburg Jungiusstr. 11, 20355 Hamburg, Germany

Dipolar spin ice has attracted much attention because of their intriguing ground state ordering and elementary excitation properties. We present the theoretical investigation of magnetic dipolar spin ice on periodic and aperiodic lattices. Especial attention is paid to the evolution and the distribution of excitations with magnetic charges as a function of magnetic field and magnetic potential. It is demonstrated that depending on the micromagnetic reversal mechanism in individual particles charge ordered states or charge accumulation can be observed.