MA 27: Magnetic Thin Films II of 2

Time: Wednesday 15:00–17:45 Location: H3

MA 27.1 Wed 15:00 H3

Dynamics of a magnetic bubble in thin films with perpendicular anisotropy — •B. Krüger[1], F. Büttner[1,2], C. Moutafis[3], M. Schneider[2], C. Günther[2], J. Geilhufe[4], J. Mohanty[2], C. v. Korff Schmiesing[2], J. Franken[5], M. Foerster[1], T. Schulz[1], C. Vaz[3], H. Swagten[5], S. Eisebitt[2,4], and M. Kläui[1] — [1]Uni Mainz, Germany — [2]TU Berlin, Germany — [3]PSI, Villigen, Switzerland — [4]HZB, Berlin, Germany — [5]TU Eindhoven, Netherlands

Magnetic bubbles are circular bi-domain states in perpendicular magnetic thin films. The magnetization structure with the curling in-plane domain wall defines a topology, which determines the equation of motion. It was predicted that the lowest lying eigenmode motion is not circular [1], in contrast to observations on magnetic vortices, which are the in-plane analogous of bubbles. These differences can be explained by a recent analytical model[2], which describes the displacement of the bubble by two waves that travel along the domain wall at different speeds and in opposite directions. This results in an effective mass of the bubble, whereas the vortex is described as a massless particle.

Using X-ray holographic imaging, we image the gyration of a bubble and we present the experimental determination of the trajectory. We demonstrate the good agreement with our theoretical model, allowing us to determine the eigenfrequencies and the effective mass of the bubble domain.

[1] C. Moutafis et al., PRB 79, 224429 (2009).
[2] I. Makhfudz et al., PRL 109, 217201 (2012).

MA 27.2 Wed 15:15 H3

Magnetic domain walls and thermally-excited spin waves in single-chain magnets and ferromagnetic thin films — •Alessandro Vindigni[1], Thomas T. Micheals[1], Boris Sangiorgio[1], Orlando V. Billoni[2], Rodolphe Clérac[3], Hitoshi Miyasaka[4], Niculin Saratz[1], Urs Ramsperger[1], and Danilo Pescia[1] — [1]Laboratory for Solid State Physics, ETH Zurich, Switzerland — [2]Facultad de Matematica, Astronomia y Fisica, Universidad National de Cordoba (AR) — [3]CNRS, Centre de Recherche Paul Pascal (CRPP), Pessac, France — [4]Graduate School of Natural Science and Technology, Kanazawa University, Japan

Several properties of magnetic materials are determined by domain-walls (DWs) and their structure. In many fundamental and applicative contexts, modeling a DW with a (Walker) profile which solely depends on one spatial variable suffices to capture the essential physics. Though somewhat forgotten, it has been known since the eighties that spin waves propagating through such a DW are expected to acquire a phase shift. Besides those traveling waves, an additional eigenmode of the linearized Landau-Lifshitz equation is a "bound state", localized right at the DW center. These distinctive features make spin-wave renormalization act differently in the presence of DWs with respect to the standard case in which the magnetization is assumed to be spatially homogeneous. The two alternative treatments yield different predictions, which are discussed in relationship with experiments on molecular spin chains and ultra-thin magnetic films.

MA 27.3 Wed 15:30 H3

Longitudinal transport properties of Fe films on GaAs(001) — •S Wimmer[1], S Bornemann[1], D Ködderitzsch[1], J Minár[1], T Hupfauer[2], D Weiss[2], and H Ebert[1] — [1]Department Chemie, Ludwig-Maximilians-Universität München — [2]Department Physik, Universität Regensburg

We have applied the fully relativistic spin-polarized Korringa-Kohn-Rostoker method to investigate the longitudinal transport properties of Fe layers on GaAs(001) substrates. Our theoretical approach is based on the linear response Kubo formalism that allows to introduce a layer-resolved conductivity σ^{IJ} for two-dimensional systems [1] and that has been extended to the fully relativistic case. For the Fe_n/GaAs(001) metal/semiconductor surface system our results qualitatively reproduce the experimentally observed in-plane anisotropy (IPA) of the resistivity which is caused by the the low symmetry of the underlying surface. Our results demonstrate in particular that the anisotropic magnetoresistance (AMR) as well as the surface induced IPA are sensitive to the substrate termination and thickness of the Fe overlayer.

[1] W.H. Butler, et al. *Phys. Rev. B* **52**, 13399 (1995)

MA 27.4 Wed 15:45 H3

Magneto-crystalline anisotropy detected by X-ray magnetic linear dichroism at the 3p edge of Fe: First experiments and theory — •Marc Tesch[1], Markus Gilbert[1], Hans-Christoph Mertins[1], Andreas Gaupp[2], Dominik Legut[3], Peter Oppeneer[4], Daniel Bürgler[5], and Claus Schneider[5,6] — [1]FH Münster, Stegerwaldstr. 39, D-48565 Steinfurt — [2]HZB, Albert Einstein Str. 15, D-12489 Berlin — [3]Nanotechnology Centre, Ostrava, Czech Republic — [4]Depart. of Physics, Uppsala Uni., Box 530, S-751 21 Uppsala, Sweden — [5]FZ Jülich GmbH, PGI-6, D-52425 Jülich — [6]Fakultät f. Physik and CeNIDE, Uni Duisburg-Essen, D-47048 Duisburg

We present first experimental results of magneto-crystalline anisotropy detected on single crystalline bcc Fe films at the 3p edge by X-ray magnetic linear dichroism (XMLD) measurements using linearly polarized undulator radiation at BESSY. We found a strong dependence of the XMLD signal on the orientation of the crystal axes, i.e. the magnetic hard and easy axes, with respect to the polarization vector of the light. The extension of measurements of the magneto-crystalline anisotropy from the 2p to the 3p edge completes the understanding of underlying effects, in particular concerning the role of the exchange splitting. While it can often be neglected in calculations for the 2p edge with large spin-orbit splitting it must be considered at the 3p edge, where exchange splitting and spin-orbit splitting are of the same order of magnitude. The experimental results are compared with our ab initio calculations to distinguish between competing models of the electronic band structure.

MA 27.5 Wed 16:00 H3

Investigation of induced Pt magnetic polarization in Pt/$Y_3Fe_5O_{12}$ bilayers — •Sibylle Meyer[1], Stephan Geprägs[1], Matthias Opel[1], Stephan Altmannshofer[1], Fabrice Wilhelm[2], Andrei Rogalev[2], Rudolf Gross[1,3], and Sebastian T. B. Goennenwein[1] — [1]Walther Meißner Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]European Synchrotron Research Facility (ESRF), Grenoble, France — [3]Physik-Department, Technische Universität München, Garching, Germany

The detection of spin currents is often based on the interconversion of spin and charge currents in a metallic Pt layer, taking advantage of the inverse spin Hall effect. However, for an unambiguous interpretation the presence of a static magnetic proximity effect, as it is well established in ferromagnetic metal/Pt heterostructures, has to be taken into account. So far, no information on such a proximity effect is available for ferromagnetic insulator/Pt heterostructures. Using X-ray magnetic circular dichroism (XMCD) measurements, we explore the possible existence of induced magnetic moments in thin Pt films deposited onto the ferrimagnetic insulator $Y_3Fe_5O_{12}$. Our data shows that if present at all, the induced moment in Pt is small. Integrating the XMCD signal allows to estimate an upper limit for the induced Pt magnetic polarization of $(0.003 \pm 0.001)\,\mu_B$ per Pt atom [1]. This work was supported by the ESRF via HE-3784, by the DFG via SPP 1538, and the German Excellence Initiative via NIM.

[1] S. Geprägs *et al.*, Appl. Phys. Lett., submitted (2012); arXiv:1211.0916.

15 min. break

MA 27.6 Wed 16:30 H3

Magnetization profile across bcc Fe films as seen by x-ray resonant magnetic reflectivity — •Emmanuelle Jal[1], Jean-Marc Tonnerre[1], Maciej Dabrowski[2], Marek Przybylski[2,3], and Jürgen Kirschner[2,4] — [1]Institut Néel, CNRS and UJF, Grenoble, France — [2]Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany — [3]Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Kraków, Poland — [4]Naturwissenschaftliche Fakultät II, Martin-Luther-Universität Halle-Wittenberg, Halle, Germany

Any modification in electronic states occupation and lower atomic coordination at the surface/interface resulting in band narrowing changes the surface magnetic moment. Since the magnetometric methods are integral and feature no spatial resolution, they cannot be used for local investigations. However, the magnetic moment can be taken as a parameter influencing diffraction or reflectivity that can be either probed with neutrons or polarized x-ray at the absorption edge. Therefore, we investigate the Au/Fe(13.5 and 5.9ML)/Ag(1,1,6) as well as on Au/Fe(13ML)/Ag(001), by soft x-ray resonant magnetic reflectivity (SXRMR) at the Fe L3 edge. At T=20K we observe 30% enhancement of the Fe magnetic moment with respect to the bulk value, located within 2-3ML of Fe (the spatial resolution of our method) at both Au/Fe and Fe/Ag interfaces. This increase in the very interface region is in agreement with theoretical findings. The comparison of the calculated value averaged for the first three layers is in a good agreement with 2.7μB, observed in our experiment.

MA 27.7 Wed 16:45 H3

Straining epitaxial Fe-Co thin films to increase magnetocrystalline anisotropy — •Ludwig Reichel[1,2], Sandra Kauffmann-Weiss[1,2], Ludwig Schultz[1,2], and Sebastian Fähler[1] — [1]IFW Dresden, PF 270116, 01171 Dresden — [2]TU Dresden, 01062 Dresden

The demand on permanent magnets is strongly increasing and alternatives to the common rare-earth based alloys lack. Fe-Co alloy is a promising candidate as it provides already a very high magnetic moment. High magnetocrystalline anisotropy is expected when its equilibrium cubic unit cell is strained tetragonally with $(c/a)_{bct}$ around 1.2 [1,2].

In the present investigation, epitaxial Fe-Co films between 1 and 10 nm thickness were deposited at room temperature using pulsed laser or magnetron sputtering deposition. Different buffer layers were used to provide the required in-plane lattice parameter a. As the unit cell volume should remain constant, the out-of-plane lattice parameter c is expected to adapt accordingly. In situ diffraction of high energetic electrons (RHEED) during film growth allows us to monitor the epitaxial growth and the relaxation of strain which begins at a critical film thickness d_C. Out-of-plane magnetic hysteresis measurements exploiting the anomalous Hall effect are compared with the in situ results. Both methods show that the critical thickness does not exceed few nanometers for the described approach.

[1] Burkert et al. Phys. Rev. Let. 93 (2004) 027203

[2] Neise et al. Phys. Status Solidi B 248 (2011) 2398

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MA 27.8 Wed 17:00 H3

Symmetric magnetization reversal in polycrystalline exchange coupled systems — •Amitesh Paul[1], Neelima Paul[2], Arno Ehresmann[3], Stefan Mattauch[4], and Peter Böni[1] — [1]Technische Universität München, Physik Department E21,James-Franck-Strasse, D-85748 Garching b. München Germany — [2]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH,Hahn-Meitner-Platz 1, D-14109 Berlin, Germany — [3]Universität Kassel, Institut für Physik and CINSaT, Heinrich-Plett-Strasse 40, D-34132 Kassel, Germany — [4]Jülich Centre for Neutron Science JCNS, Forschungszentrum Jülich GmbH, Outstation at FRM II, Lichtenbergstraße 1, 85747, Garching, Germany

Training in exchange bias systems plays an essential role in understanding the very origin of the biasing effect. The nonequilibrium arrangement of antiferromagnetic (AF) spins at the antiferromagnetic-ferromagnetic interface, related to the AF uniaxial anisotropy, plays a crucial role during the initial training. Our system of choice,IrMn/CoFe, possesses softer uniaxial anisotropy compared to other AF systems (e.g., CoO), thereby reducing the energy penalty due to nonequilibrium spins. Different methods have been applied to initialize or modify the unidirectional anisotropy. Magnetization reversal mechanisms were investigated during the first two field cycles to identify the role of each method on the training. A detailed analysis of polarized neutron scattering using the distorted wave Born approximation reveals a simultaneous process of domain nucleation and coherent rotation for magnetization reversal.

MA 27.9 Wed 17:15 H3

Influence of keV-He ion bombardment on the magnetic properties of Co/Pd multilayers — •Nicolas Müglich[1], Olav Hellwig[2], Oliver Buhl[1], Tanja Weis[1], Dieter Engel[1], and Arno Ehresmann[1] — [1]Institute of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Strasse 40, Kassel 34132, Germany — [2]San Jose Research Center, HGST, A Western Digital Company, 3403 Yerba Buena Road, San Jose, California 95135, USA

Thin films of ferromagnetic Co separated by Pd films with thicknesses in the first ferromagnetic maximum of interlayer exchange coupling are magnetically dominated by perpendicular-to-plane anisotropy and labyrinth stripe domain patterns in remanence. During the magnetization reversal of such a multilayer system domain nucleation and domain wall movement can be observed for different external magnetic fields H. The influence of keV-He ion bombardment on the microstructure of the system and its resultant decrease of magnetic anisotropy has been investigated by vibrating sample magnetometry, polar magneto-optical Kerr effect and magnetic force microscopy. It is shown that areas of ferromagnetic in-plane anisotropy are created due to the ion bombardement and that the system shows an increasing quotient of superparamagnetism in the deeper layers of the multilayersystem.

MA 27.10 Wed 17:30 H3

Quantum well states in Cu and oscillatory magnetic anisotropy in Cu/Fe and Cu/Co bilayers — •Sujit Manna[1], Pedro L. Gastelois[1,2], Maciej Dabrowski[1], Piotr Kuświk[1], Marek Cinal[3], Marek Przybylski[1,4], and Jürgen Kirschner[1,5] — [1]Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany — [2]Centro de Desenvolvimento da Tecnologia Nuclear, Belo Horizonte, Brazil — [3]Institute of Physical Chemistry of the Polish Academy of Sciences, Warszawa, Poland — [4]Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Kraków, Poland — [5]Naturwissenschaftliche Fakultät II, Martin-Luther-Universität Halle-Wittenberg, Halle, Germany

From our previous experiments it is obvious that the strong effect of quantum well states (QWS) formed by d-electrons on magnetic anisotropy (MA) of Fe and Co films exists at low temperature only. In case of nonmagnetic/ferromagnetic bilayers one can expect changes of MA due to the QWS formed in the nonmagnetic cover layer. In an extension of the previously reported experiment [1], we were able to observe oscillatory magnetic anisotropy of large amplitude at T=5K for both Co and Fe films due to QWS formed in the Cu overlayer. We explain such quantum oscillation of MA as originating from d-QWS formed in Fe and/or Co, but hybridized to the sp-QWS formed in the Cu film and penetrating to the Fe and/or Co films. The period of MA oscillations for Cu/Fe is found to be independent of the Fe film thickness, in agreement with our theoretical predictions. [1] Ch. Würsch et al., Nature 389, 937 (1997).