MA 14: Magnetization Dynamics II

Time: Monday 17:00–19:00 Location: HSZ 403

MA 14.1 Mon 17:00 HSZ 403

Femtosecond XUV Spectroscopy of Gadolinium and Terbium — •Robert Carley[1], Björn Frietsch[1], Kristian Döbrich[1], Martin Teichmann[1], Cornelius Gahl[1], Olaf Schwarzkopf[2], Philippe Wernet[2], Frank Noack[1], and Martin Weinelt[1,3] — [1]Max-Born-Institute, Berlin — [2]Helmholtz-Zentrum für Materialien und Energie (BESSY II), Berlin — [3]Fachbereich Physik, Freie Universität, Berlin

We present recent results of time-resolved IR-pump-XUV-probe experiments on the ultrafast demagnetization of thin films of Gadolium (0001) and Terbium (0001) on Tungsten (110). The experiments are the first to be done using a newly developed high-order harmonics (HHG) XUV beamline at the MBI. The beamline delivers monochromated XUV pulses of approximately 150 fs duration with a photon energy resolution of up to 150 meV. Following excitation by intense femtosecond infrared (IR) pulses, photoemission with 35 eV photons allows us to directly probe the 4f electrons and their interaction with the valence band, both in the bulk and at the surface, to follow the ultrafast magnetization dynamics in the Lanthanide metals. As signatures of ultrafast demagnetization of the metal by the IR pulse, we see for the first time, rapid strong reduction of the exchange splitting in the valence band. This is followed by a slower demagnetization due to the spin-lattice interaction.

MA 14.2 Mon 17:15 HSZ 403

Influence of equilibrium temperature on the femtosecond magnetization dynamics of Gd — •Muhammad Sultan[1,2], Alexey Melnikov[2], and Uwe Bovensiepen[1] — [1]Fakultät für Physik, Uni. Duisburg-Essen — [2]Fachbereich Physik, Freie Uni. Berlin

Understanding the demagnetization of solids after femtosecond laser excitation requires the knowledge of the involved processes and their time scales. Previously we found by fs time resolved X-ray magnetic circular dichroism that Gd exhibits at an equilibrium temperature T_o=120K a faster and a slower demagnetization with characteristic time scales τ_f=0.75 ps and τ_s=40 ps, respectively [1]. In this study we focus on the question how T_o affects laser induced demagnetization. We employed the magneto-optical Kerr effect to investigate the temperature dependence of both demagnetization time scales. We find that the demagnetization evolves slower in time with increasing T_o for both processes. However, in detail they show different temperature dependence. τ_f increases linearly with temperature and exhibits a larger $\frac{d\tau_f}{dT_o}$ for T_o >170K, τ_f enhanced to double between 50 and 280 K. Remarkably, τ_s increases by a factor of five in the same temperature interval and follows a continuous change that suggests a divergence at the Curie temperature T_c. These findings demonstrate that thermal spin fluctuations influence the laser induced demagnetization and tend to inhibit the demagnetization in line with an increase of spin fluctuation times if a ferromagnet reaches T_c under equilibrium conditions.

[1] Wietstruk et al, submitted arxiv.org/abs/1010.1374

MA 14.3 Mon 17:30 HSZ 403

Investigating the opto-magnetic switching in ferrimagnetic GdFeCo — •Stefan Gerlach[1], Denise Hinzke[1], Thomas Ostler[2], Roy W. Chantrell[2], and Ulrich Nowak[1] — [1]University of Konstanz, 78457 Konstanz, Germany — [2]University of York, York YO10 5DD, U. K.

It was recently demonstrated [1] that a 100 fs circularly polarized laser pulse is able to reverse the magnetization on a picosecond time scale as if the laser pulse acts as an equally short magnetic field pulse with a polarization dependent direction caused by the so-called inverse Faraday effect. However, so far this opto-magnetic switching has only been successfully demonstrated for a certain class of ferrimagnetic thin films and only for a narrow window of parameters [2].

To investigate the opto-magnetic magnetization reversal, we use Landau-Lifshitz-Bloch (LLB)-based simulations [3] combined with a two temperature model to describe the effect of a realistic femtosecond laser pulse. The ferrimagnetic properties of GdFeCo are included by a self-consistent mean-field approximation [4] to get the temperature dependent input parameters for the LLB equations. We will discuss the parameters under which opto-magnetic switching is possible and the influence of the ferrimagnetic compensation point on the switching process.

[1] C. D. Stanciu et al., Phys. Rev. Lett. 99, 047601 (2007) [2] K. Vahaplar et al., Phys. Rev. Lett. 103, 117201 (2009) [3] N. Kazantseva et al., Phys. Rev. B 77, 184428 (2008) [4] A. Gangulee, et al., J. Appl. Phys. 49, 4896 (1978)

MA 14.4 Mon 17:45 HSZ 403

Hot electron driven enhancement of spin-lattice coupling — •Marko Wietstruk[1,2], Christian Stamm[2], Niko Pontius[2], Torsten Kachel[2], Cornelius Gahl[1], Alexey Melnikov[3], Muhammad Sultan[3], Martin Weinelt[1,3], Hermann Dürr[2,4], and Uwe Bovensiepen[3,5] — [1]Max-Born-Institut Berlin — [2]Helmholtz-Zentrum Berlin — [3]Freie Universität Berlin, Fb. Physik — [4]SLAC, California, USA — [5]Universität Duisburg-Essen, Fak. für Physik

Laser induced demagnetization of elemental Gd is known to occur on the order of tens of picoseconds [1]. This slow time scale reflects the weak 4f spin-lattice coupling caused by the zero orbital momentum of the half-filled Gd 4f shell.

However, our fs time-resolved x-ray magnetic circular dichroism (TR-XMCD) measurements show that the spin-lattice coupling and thus the demagnetization rate is enhanced by excitation of the sample with an intense fs Laser pulse [2]. We conclude that the additional fast demagnetization process with $\tau < 1$ ps is driven by spin-flip scattering of hot electrons, i.e. the demagnetization time corresponds to the equilibration of excited electrons with the lattice.

These findings are supported by measurements on Tb that exhibits much stronger spin-lattice coupling, as well as on Ni, which shows a much shorter demagnetization time scale [3] but nevertheless a similar angular momentum transfer rate.

[1] A. Vaterlaus et al., Phys. Rev. Lett. **67**, 3314 (1991)
[2] M. Wietstruk et al., arXiv:1010.1374v1[cond-mat.mtrl-sci] (2010)
[3] C. Stamm et al., Phys Rev. B **81**, 104425 (2010)

MA 14.5 Mon 18:00 HSZ 403

Elastically driven ferromagnetic resonance in nickel thin films — Mathias Weiler[1], Lukas Dreher[2], Christian Heeg[1], Hans Huebl[1], Rudolf Gross[1], Martin S. Brandt[2], and •Sebastian T. B. Goennenwein[1] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Walter Schottky Institut, Technische Universität München, Garching, Germany

Because of magneto-elastic coupling, magnetic degrees of freedom are influenced by elastic deformation. We here demonstrate that the magneto-elastic interaction of a radio frequency (RF) surface acoustic wave (SAW) with a ferromagnetic thin film enables an all-elastic excitation and detection of ferromagnetic resonance (FMR) in nickel/lithium niobate hybrid devices. We have measured the SAW magneto-transmission in such samples at room temperature, as a function of microwave frequency, external magnetic field magnitude, and magnetic field orientation. Our data are consistently described by a modified Landau-Lifshitz-Gilbert approach [1], in which the magnetization precession is not driven by a conventional, external RF magnetic field, but rather by a purely virtual, internal tickle field stemming from RF magneto-elastic interactions. This causes a distinct magnetic field orientation dependence of elastically driven FMR, clearly observed in both simulation and experiment.

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[1] M. Weiler *et al.* arXiv:1009.5798

MA 14.6 Mon 18:15 HSZ 403

Structual and electronic dynamics across the Verwey transition in magnetite — •C. Trabant[1,2], N. Pontius[2], C.-F. Chang[1], T. Kachel[2], M. Beye[2,3], F. Sorgenfrei[4], W. Schlotter[3], S. de Jong[3], R. Kukreja[3], B. Bräuer[3], M. Döhler[1], S. Hossain[3], C. Back[3], A. Scherz[3], D. Zhu[3], J. Turner[3], W.-S. Lee[3], Y.-D. Chuang[3], O. Krupin[3], M. Buchholz[1], P. Vogt[1], W. Wurth[4], A. Föhlisch[2], C. Schüssler-Langeheine[2,1], and H. A. Dürr[3] — [1]II. Physikalisches Institut, Universität zu Köln — [2]Helmholtz-Zentrum Berlin — [3]SLAC RSXS collaboration, USA — [4]Universität Hamburg and CFEL

At 123K magnetite (Fe_3O_4) undergoes a metal-to-insulator transition, the Verwey transition. It is accompanied by a transition from a

charge/orbital ordered low temperature state with monoclinic symmetry to a cubic phase without electronic order. Until today the question how structual and electronic degrees contribute to this transition has remained unanswered.

Here we report on a time-resolved soft x-ray diffraction experiment performed at the LCLS. By tuning the photon energy to the oxygen 1s → 2p and Fe 2p→ 3d excitation and off resonance we studied the structural and electronic response when the insulator-to-metal transition is induced by a fs laser pulse. We observered fast and slow timescales for all energies from which we derive a picture of the IR laser pulse induced phase transition. Supported by the DFG through SFB 608 and by the BMBF project 05K10PK2.

MA 14.7 Mon 18:30 HSZ 403

Ultrafast lattice dynamics in FeRh during a laser-induced magnetic phase transition — •Florian Quirin, Michael Vattilana, Uladzimir Shymanovich, Abd-Elmonien El-Kamhawy, Matthieu Nicoul, Alexander Tarasevitch, Dietrich von der Linde, and Klaus Sokolowski-Tinten — Universität Duisburg-Essen, Duisburg, Germany

FeRh exhibits an anti-ferromagnetic to ferromagnetic phase transition upon heating to temperatures above 353 K, which is accompanied by an iso-structural increase in volume of about 1%. Recent results of time-resolved magneto-optical experiments gave indication that after intense optical excitation ferromagnetic order starts to build up on sub-ps time-scales [1,2]. We have used time-resolved X-ray diffraction with fs X-ray pulses from a laser-produced plasma to directly follow the lattice response of FeRh after optical excitation. From experimental data obtained at different starting temperatures below and above the phase transition temperature we have to conclude that the fast changes of the magnetic properties do not lead to the corresponding structural changes as under equilibrium conditions.

1 G. Ju, J. Hohlfeld, B. Bergman, R. J. M. van deVeerdonk, O. N. Mryasov, J.-Y. Kim, X. Wu, D. Weller, and B. Koopmans, Phys. Rev. Lett. 93, 197403 (2004).

2 J.-U. Thiele, M. Buess, and C. H. Back, Appl. Phys. Lett. 85, 2857 (2004).

MA 14.8 Mon 18:45 HSZ 403

Zero-field magnetization reversal of two-body Stoner particles with dipolar interaction — •Zhouzhou Sun, Alexander Lopez, and John Schliemann — Institute for Theoretical Physics, University of Regensburg, D-93040 Regensburg, Germany

In the framework of the Landau-Lifshitz-Gilbert equation, we investigate magnetization reversal in a system of two Stoner particles both subject to a static antiparallel magnetic field, and taking into account their mutual dipolar interaction. We identify an interesting regime of stable synchronized dynamics where the two particles are implementing a single information bit. Here a modified Stoner-Wohlfarth limit is obtained which shows a dramatically lower critical switching field (even including zero) and also a substantially shorter reversal time, by appropriately engineering the dipolar interaction strength between the two particles. Our analytical results are also verified by numerical simulations and thus offer new technological perspectives regarding devices for information storage and/or fast magnetic response.