MA 33: Magnetization Dynamics I of 3

Time: Thursday 9:30–12:00 Location: H22

MA 33.1 Thu 9:30 H22

Ultrafast transiently inversed magnetization in TbCo alloys — •Sabine Alebrand[1], Ute Bierbrauer[1], Michel Hehn[2], Matthias Gottwald[2,3], Oliver Schmitt[1], Daniel Steil[1], Eric E. Fullerton[3], Stéphane Mangin[2], Mirko Cinchetti[1], and Martin Aeschlimann[1] — [1]Dep. of Physics and Research Center OPTIMAS, University of Kaiserslautern, Germany — [2]IJL, Université de Lorraine, Nancy, France — [3]University of California, San Diego, USA

Since the discovery of all-optical magnetization switching in 2007 [1], the rare earth (RE) -transition metal (TM) alloy GdFeCo gained special attention. In 2011 Radu et al. [2] performed an XMCD experiment on GdFeCo, which allows to detect the magnetization dynamics of both the Gd- and FeCo-sublattice seperately. They found that the two sublattices not only demagnetize after laser exciation but they can even transiently be switched on a subpicosecond timescale.

We focus on the RE-TM alloy TbCo which combines all-optical switching with high perpendicular anisotropy [3]. We performed time-resolved magneto-optical Kerr measurements, investigating the fluence and composition dependent ultrafast demagnetization behavior. We find that for equal excitation conditions the demagnetization strength of the Co sublattice strongly depends on the Tb concentration. Moreover for $Tb_{32}Co_{68}$ we observe a transient magnetization switching of the Co sublattice on a timescale similar the one in GdFeCo. The magnetization switched state can last for several picoseconds.

[1] Stanciu et al. PRL 99, 047601 (2007) [2] Radu et al. Nature 472, 205-208 (2011) [3] Alebrand et al. APL 101, 162408 (2012)

MA 33.2 Thu 9:45 H22

Thermally assisted all-optical helicity dependent magnetic switching in $Fe_{100-x}Tb_x$ films — Alexander Hassdenteufel[1], Birgit Hebler[1], Christian Schubert[1], •Andreas Liebig[1], Martin Teich[2,3], Manfred Helm[2,3], Martin Aeschlimann[4], Manfred Albrecht[1], and Rudolf Bratschitsch[1] — [1]Institute of Physics, Chemnitz University of Technology, D-09107 Chemnitz (Germany) — [2]Helmholtz Zentrum Dresden Rossendorf, P. O. Box 510119, D-01314 Dresden (Germany) — [3]Technische Universität Dresden, D-01062 Dresden (Germany) — [4]Department of Physics and Research Center Optimas, University of Kaiserslautern, D-67663 Kaiserslautern (Germany)

Magnetization switching is at the heart of both modern information storage technology and fundamental science. Ultrafast laser pulses are promising to explore and finally reach the ultimate speed limit of this process. We present all-optical switching (AOS) in amorphous ferrimagnetic $Fe_{100-x}Tb_x$ alloy films with circularly polarized laser pulses. A Tb content of 22 to 34 at.% is necessary for AOS to occur. Outside this composition range pure thermal demagnetization is observed. AOS occurs not only below and above the magnetic compensation temperataure (T_{comp}), but also in samples without T_{comp}. We find that AOS is associated with laser heating up to the Curie temperature. AOS is intimately linked to a low remanent sample magnetization M_R. Above a threshold magnetization of 220 emu/cc helicity dependent AOS is replaced by pure thermal demagnetization.

MA 33.3 Thu 10:00 H22

Tuning the timescale of ultrafast demagnetization in GdTb alloys through spin-lattice coupling — •Andrea Eschenlohr[1,2], Muhammad Sultan[1], Nicolas Bergeard[1], Alexey Melnikov[3], Jens Wieczorek[1], Torsten Kachel[2], Christian Stamm[2], and Uwe Bovensiepen[1] — [1]Fakultät für Physik and Center for Nanointegration (CeNIDE), Universität Duisburg-Essen — [2]Institut für Methoden und Instrumentierung der Forschung mit Synchrotronstrahlung, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH — [3]Fritz-Haber-Institut der MPG, Berlin

Pure Gd and Tb show femtosecond laser-induced demagnetization in two steps, with the time constant of the second, slower step depending on the strength of coupling of the $4f$ magnetic moments to the lattice [Wietstruk et al., PRL **106**, 127401 (2011)]. In time-resolved magneto-optical Kerr effect measurements on GdTb alloys, we see a decrease of this time constant from 33 ps to 9 ps with Tb content increasing from 0 to 70 %, due to the strong spin-lattice coupling of Tb. In time- and element-resolved x-ray magnetic circular dichroism measurements at the BESSY II Femtoslicing source concomitant dynamics of the Gd and Tb magnetization components is observed, revealing an increased coupling of the Gd $4f$ magnetic moments to the lattice via indirect exchange coupling to the neighboring Tb $4f$ moments, so that demagnetization of Gd in the alloy is accelerated compared to the pure material.

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MA 33.4 Thu 10:15 H22

Ultrafast magnetic dynamics in the metallic 4f antiferromagnet Holmium — •Christoph Trabant[1,2,3], Niko Pontius[2], Hartmut Zabel[4], Alexander Föhlisch[2,3], and Christian Schüssler-Langeheine[2] — [1]II. Physikalisches Institut, Universität zu Köln — [2]Institut für Methoden und Instrumentierung der Synchrotronstrahlung, Helmholtz-Zentrum Berlin — [3]Institut für Physik und Astronomie, Universität Potsdam — [4]Institut für Experimentalphysik / Festkörperphysik, Ruhr Universität Bochum

We studied the laser induced fs magnetic dynamics of a metallic 4f antiferromagentic Holmium thin film. The dynamics was mapped using the strong resonant x-ray scattering signal of the helical magnetic (00τ) superstructure reflection. We found a fast quenching of the magnetic order on a $\sim$ 200 fs timescale which is essentially independent of the applied laser fluence. Comparing this demagnetization time and those of the the 4f ferromagnets Terbium and Gadolinium (750 fs each) [1] to their respective atomic magnetic moment (Gd: $7.55\mu_B$, Tb: $9.3\mu_B$, and Ho: $10.6\mu_B$) leads to the conclusion that the time constant does not scale with the size of the magnetic moment as proposed for ferromagnets. The optical pump xray probe measurements have been performed at the FEMTOSPEX facility at BESSY II. Supported by the BMBF through contract 05K10PK2.

[1] M. Wietstruk, et al.: PRL 106, 127401 (2011).

MA 33.5 Thu 10:30 H22

On the role of the transient ferromagnetic-like state and of the magnetization compensation temperature in all-optical magnetization switching in GdFe ferrimagnetic alloys — •Loïc Le Guyader[1,2], Ilie Radu[2], Souliman El Moussaoui[1], Michele Buzzi[1], Ilya Razdolski[3], Rajasekhar Medapalli[3], Matteo Savoini[3], Christian Stamm[2], Rolf Mitzner[2], Karsten Holldack[2], Torsten Kachel[2], Arata Tsukamoto[4], Akiyoshi Itoh[4], Frithjof Nolting[1], Andrei Kirilyuk[3], Theo Rasing[3], and Alexey Kimel[3] — [1]Swiss Light Source, Paul Scherrer Institut, Villigen, Switzerland — [2]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany — [3]Institute for Molecules and Materials, Radboud University, Nijmegen, The Netherlands — [4]College of Science and Technology, Nihon University, Chiba, Japan

Understanding the ultrafast all optical magnetization reversal is a challenging issue which could have tremendous impact for the magnetic recording industry. Combining femtosecond X-ray transmission measurements with picosecond time-resolved photo-emission electron microscopy, both using X-ray magnetic circular dichroism, we report on new insights into the ultrafast magnetization switching in GdFe ferrimagnetic alloys. In particular, we demonstrate that a prerequisite for all optical magnetization switching is the existence of a transient ferromagnetic-like state. Indeed, for sample temperature far from the magnetization compensation temperature, such transient state is not observed, leading to no switching behaviour.

MA 33.6 Thu 10:45 H22

Ultrafast Magnetization Dynamics in Co-Based Heusler Compounds with Tuned Structural Order — •Daniel Steil[1], Takahide Kubota[2], Mikihiko Oogane[2], Yasuo Ando[2], Christian G.F. Blum[3], Sabine Wurmehl[3], Anna Suszka[4], Olatz Idigoras[4], Andreas Berger[4], Martin Aeschlimann[1], and Mirko Cinchetti[1] — [1]Dept. of Physics and Res. Center OPTIMAS, TU Kaiserslautern, Germany — [2]Tohoku University, Sendai, Japan — [3]IFW Dresden, Germany — [4]CIC nanoGUNE, San Sebastian, Spain

Several Heusler compounds are predicted to be half-metallic ferromagnets (FM), making them interesting sources of spin-polarized currents. Time-resolved Kerr magnetometry (TR-MOKE) was suggested as a probe for half-metallicity, as a minority band gap should slow down magnetization dynamics compared to the $3d$-FM [1]. However, Heusler

compounds typically show magnetization dynamics similar to the 3*d*-FM [1-3], which has been partly attributed to defect states destroying the half-metallicity [1]. We studied thin films of Co_2MnSi (CMS) and Co_2FeSi (CFS) with different defect concentrations, as well as bulk single crystals with TR-MOKE to elucidate the influence of defects on magnetization dynamics. Surprisingly, we find no influence of defects on ultrafast dynamics in both systems, but a second demagnetization step in CMS for high defect concentrations. Single crystals of CFS and CMS show similar dynamics as the thin films. We discuss our results considering the DOS of the systems using the model from Ref. [2].

[1] G.M. Müller et al.; NMat **8**, 56 **(2009)** [2] D. Steil et al., PRL **105**, 217202 **(2010)** [3] J.-P. Wüstenberg et al., PSS B **248**, 2330 **(2011)**

MA 33.7 Thu 11:00 H22

Ultrafast spin dynamics in epitaxial Co/Cu(001) analyzed by femtosecond time-resolved linear and non-linear magneto optics — •Jens Wieczorek, Nicolas Bergeard, Alexander Tarasevitch, and Uwe Bovensiepen — Universität Duisburg-Essen, Fakultät für Physik, 47057 Germany

In order to investigate the microscopic processes in laser-induced demagnetisation, we performed pump probe measurements at Co/Cu(001)films at thicknesses 5 ML< d < 30 ML. We used simultaneously time resolved magneto-optical Kerr effect(MOKE)and magneto induced second harmonic generation (MSHG) in a transversal geometry. The transient nonlinear MSHG signal is essentially independent on thickness, whereas the linear MOKE signal shows an increasing pump induced demagnetisation ΔM and an increase in the demagnetization time for larger d. Since MSHG is generated at the films interfaces and MOKE probes the film as a whole we conclude from the observed thickness dependence that different mechanisms contribute to the laser- induced change of the magnetization. At smallest d transport contributions might represent the dominant channel[1,2], while for larger d also slower, local processes like angular momentum transfer to phonons[3] become relevant.

We acknowledge support by the DFG through SFB616. [1] M. Battiato et al., PRL **105**, 027203 (2010) [2] A. Melnikov et al., PRL **107**, 076601 (2011) [3] Koopmans et al., Nat Mat 9, **259** (2010)

MA 33.8 Thu 11:15 H22

Tuning the Ultrafast Spin Dynamics in Magnetic Alloys — •Ilie Radu[1], Christian Stamm[1], Andrea Eschenlohr[1], Kadir Vahaplar[2], Torsten Kachel[1], Niko Pontius[1], Rolf Mitzner[1], Karsten Holldack[1], Alexander Föhlisch[1], Florin Radu[1], Richard Evans[3], Thomas Ostler[3], Johan Mentink[2], Roy Chantrell[3], Arata Tsukamoto[4], Akiyoshi Itoh[4], Andrei Kirilyuk[2], Alexey Kimel[2], and Theo Rasing[2] — [1]Helmholtz-Zentrum Berlin, BESSY II, Germany — [2]Radboud University Nijmegen, The Netherlands — [3]University of York, United Kingdom — [4]Nihon University, Chiba, Japan

The microscopic mechanisms behind the ultrafast, laser-driven demagnetization remain an intriguing and actively debated issue of ultrafast magnetism. Here we report on laser-driven dynamics of multi-sublattice magnetic materials, with both ferromagnetic and antiferromagnetic coupling between sublattices, investigated using element-specific, femtosecond time-resolved XMCD. These measurements [1], fully supported by phenomenological modeling and atomistic spin simulations, provide evidence for a demagnetization time that scales with the elemental magnetic moment and varies with the sign of the exchange interaction. As such, one can tune the speed of magnetization processes in multi-sublattices alloys, being either switching or demagnetization, by properly choosing the magnitude of the constituent magnetic moments and the sign of the exchange interaction that couples them, as exemplified for the case of a synthetic ferrimagnet. [1] I. Radu et al., submitted (2012)

MA 33.9 Thu 11:30 H22

Ultrafast loss of the classical magnetization — •Andreas Fognini[1], Gerard Salvatella[1], Florian Sorgenfrei[2], Martina Dell'Angela[3], Martin Beye[2], Florian Hieke[3], Dima Kutnyakhov[4], Pavel Lushchyk[4], Andrea Eschenlohr[2], Sanne de Jong[5], Roopali Kukreja[5], Natalia Gerasimova[6], Harald Redlin[6], Joerg Raabe[7], Andreas Oelsner[8], Christian Stamm[2], Urs Ramsperger[1], Joachim Stöhr[5], Hermann Dürr[5], Alexander Föhlisch[2], Wilfried Wurth[3], Gerd Schönhense[4], Andreas Vaterlaus[1], Thomas Michlmayr[1], and Yves Acremann[1] — [1]ETH Zürich, Schweiz — [2]HZB Berlin, Deutschland — [3]Uni. Hamburg, Deutschland — [4]Uni. Mainz, Deutschland — [5]SLAC, Stanford, USA — [6]DESY, Hamburg, Deutschland — [7]PSI, Villigen, Schweiz — [8]Surface Concept GmbH, Mainz, Deutschland

If a ferromagnet is exposed to an ultrafast laser pulse its magnetization can be reduced within less than a picosecond. Most detection schemes for the magnetization focus on electrons close to the Fermi energy or the density of empty states. The *classical* magnetization (the average spin polarization of the whole valence band) is difficult to detect. Here we present a method based on spin and time resolved photoemission using free electron laser radiation. A femtosecond 800nm laser pulse excites an Iron film. Vacuum ultraviolet pulses from the free electron laser FLASH in Hamburg extract polarized photoelectrons. Their spin polarization is detected by a Mott polarimeter as well as a novel spin analyzer based on specular reflection of an Ir crystal. We can confirm a loss of the *classical* magnetization on a sub-picosecond time scale.

MA 33.10 Thu 11:45 H22

Optically induced ultrafast spin dynamics in Au/Fe/MgO(001) structures: the role of hot carrier transport — •Alexandr Alekhin[1], Damian Bürstel[2], Tim O. Wehling[3], Detlef Diesing[2], Alexander I. Lichtenstein[4], Uwe Bovensiepen[5], and Alexey Melnikov[1] — [1]Fritz-Haber-Institut der MPG, Dep. of Phys. Chem., Berlin, Germany — [2]University of Duisburg-Essen, Insitute of Phys. Chem., Essen, Germany — [3]University of Bremen, Institute of Theor. Phys., Bremen, Germany — [4]University of Hamburg, Institute of Theor. Phys., Hamburg, Germany — [5]University of Duisburg-Essen, Dep. of Physics, Essen, Germany

Spin dynamics (SD) induced by ultrashort laser pulses is of great importance in light of recent advance in spintronics and attempts to control magnetization on femtosecond (fs) time scales. To understand the origin of ultrafast demagnetization, pump-probe experiments have been performed on epitaxial Au/Fe/MgO(001) structures. Using 14 fs laser pulses to probe the Fe side of the samples, we monitor bulk SD by the magneto-optical Kerr effect (MOKE) and SD at interfaces by the magneto-induced second harmonic generation (mSHG). To disentangle interfering mSHG contributions from different interfaces, we have analyzed the dependence of mSHG response on the thickness of Fe film. This approach gives us an access to spatially non-uniform transient magnetization. Comparison of transient mSHG response of Fe to direct optical excitation with that to excitation by hot carriers (HC) generated in Au reveals a significant contribution of spin polarized HC transport to ultrafast demagnetization.