MA 38: Ultrafast Magnetization Effects III

Time: Thursday 11:15–12:45 Location: EB 202

MA 38.1 Thu 11:15 EB 202

Ultrafast changes in the M_5/M_4 branching ratio in Terbium — •Tim Amrhein[1], Beyza Salantur[1], Niko Pontius[2], Christian Schuessler-Langeheine[2], Martin Weinelt[1], and Nele Thielemann-Kühn[1] — [1]Freie Universität Berlin, Fachbereich Physik, Arnimallee 14, 14195 Berlin, Germany — [2]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Albert-Einstein-Str. 15, 12489 Berlin, Germany

As reported recently, inelastic $5d$-$4f$ electronic scattering in $4f$ rare earth metals transiently alters the $4f$ orbital state and therewith the total angular momentum J [1]. These transitions change the electronic and magnetic properties in $4f$ metals on ultrafast time scales. Within an X-ray absorption study performed at the FemtoSpeX slicing facility at BESSY II we show, that the observed changes of J also affect the M_5/M_4 branching ratio on ultrafast timescales in Terbium, proving the 3rd rule of Thole and Van der Laan [2] to be applicable in non-equilibrium. The change of the branching ratio can be used, to calculate the percentage of $4f$-excited atoms.

[1] N. Thielemann-Kühn et al., *Optical control of $4f$ orbital state in rare-earth metals.* https://doi.org/10.48550/arXiv.2106.09999 (Science Advances, in revision)

[2] B. T. Thole and G. van der Laan., *Branching ratio in x-ray absorption spectroscopy.* Phys. Rev. B, 38:3158-3171, Aug 1988.

MA 38.2 Thu 11:30 EB 202

Picosecond X-ray magnetic circular dichroism with a laser-driven plasma source — •Konstanze Korell, Martin Borchert, Leonid Lunin, Daniel Schick, and Stefan Eisebitt — Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie, Max-Born-Straße 2A, 12489 Berlin

X-ray magnetic circular dichroism (XMCD) combines large magnetic contrast with element-selectivity, and access to buried layers. In the soft-X-ray range at the 3d transition metal L and rare earth M edge (500-1500 eV), so-called sum-rules even allow to disentangle the spin and orbital angular momentum. However, XMCD spectroscopy requires soft X-rays with circular polarization, limiting this powerful technique to accelerator-based large-scale facilities such as synchrotrons and free-electron lasers. Recently, we have demonstrated the first laboratory-based XMCD experiment at the Fe L-edges outside of large-scale facilities using laser-driven plasma X-ray source (PXS) in combination with a ferrimagnetic polarizer to generate partially circular polarization. In this contribution, I will present the design and specifications of our new beamline dedicated for time-resolved XMCD spectroscopy. The setup features an extremely broad spectral range from 50-1500 eV with a 40 μm (FWHM) X-ray focus and sub-10 ps temporal resolution. Further, I will present and discuss first results towards time-resolved XMCD spectroscopy on a FeGd multilayer sample after photoexcitation.

MA 38.3 Thu 11:45 EB 202

Magneto-thermal engineering of the fast magnetic response to ultrashort laser excitation of 2D-van der Waals heterostructures — •Theodor Griepe[1], Sumit Haldar[2], Unai Atxitia[1], and Elton Santos[2] — [1]CSIC Insituto de Ciencia de Materiales de Madrid — [2]University of Edinburgh

Two-dimensional van der Waals ferromagnets, such as Cr2Ge2Te6 and Fe3GeTe2, have gathered an increasing interest over the past years. As for example, their ultrafast magnetic response to femtosecond optical excitation. For practical applications, full control of magnetization dynamics time scales up to several nanoseconds is an paramount for the design of magnetic devices with high high access rate. In this work, we conduct a numerical investigation of both thermal and magnetic response of 2D van der Waals heterostructures, composed of a ferromagnetic layers sandwiched between two insulating cap and substrate layers. Our model shows that the picosecond magnetic response is governed by strong out-of-equilibrium interactions between the subsystems of electrons, phonons and spins. We use an enhanced microscopic three temperature model to show how the picosecond magnetic response is governed by strong out-of-equilibrium interactions between the subsystems of electrons, phonons and spins. For longer time scales, the magnetic response can be controlled by the thermodynamic properties of the heterostructure owing to the distinct heat transport and interfacial conductivity of the constituents.

MA 38.4 Thu 12:00 EB 202

Nonlinearities in ultrafast transverse magneto-optical Kerr effect spectroscopy — •Johanna Richter, Somnath Jana, Ole Zülich, Daniel Schick, Clemens von Korff-Schmising, and Stefan Eisebitt — Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy

Ultrafast magneto-optical Kerr effect spectroscopy (T-MOKE) in the extreme ultraviolet spectral range provides detailed insight into element-specific magnetization dynamics and has become a powerful experimental technique for unravelling the fundamental microscopic processes occurring in laser-excited magnetic materials.

In this work, we investigate the relationship between the T-MOKE observable (magnetic asymmetry) and the element-specific magnetization by calculating the exact response based on a wave propagation algorithm. We present detailed simulations for realistic magnetic multilayers as a function of incident angle and photon energies between 40 eV and 72 eV and find pronounced deviations in the proportionality between magnetization and asymmetry. These findings reproduce time-resolved measurements exhibiting strong nonlinearities, including situations where the asymmetry increases despite of a decreasing magnetization. We introduce a metric to quantify these nonlinearities and identify sample structures and T-MOKE geometries where a direct proportionality between T-MOKE measurements and magnetization remains a good approximation, and show how our data methodology allows a correct interpretation of T-MOKE experiments.

MA 38.5 Thu 12:15 EB 202

Coherent control of nuclear excitons in FeRh — •Sakshath Sadashivaiah[1,2], Kai Schlage[3], Anjali Panchwanee[3], Christina Bömer[3], Dietrich Krebs[3], Berit Marx-Glowna[1,2], Robert Lötzsch[4], Lars Bocklage[3], Olaf Leupold[3], Ilya Sergueev[3], and Ralf Röhlsberger[1,2,3,4] — [1]Helmholtz-Institut Jena, Fröbelstieg 3, 07743 Jena, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstraße 1, 64291 Darmstadt, Germany — [3]Deutsches Elektronen Synchrotron, Notkestraße 85, 22607 Hamburg, Germany — [4]Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany

The narrow linewidth of Mössbauer resonances (4.5 neV in ^{57}Fe) enables the preparation of well-defined nuclear quantum states, whose energies are addressed by accelerator-driven light sources [1,2]. Laser-induced phase transitions can modify these nuclear excitonic states via the hyperfine interactions [3]. In ^{57}FeRh thin films femtosecond laser pulses cause an isostructural antiferromagnet (AFM) - ferromagnet (FM) phase transition. Simultaneously, the coherence of the nuclear resonant forward scattered photons is changed within 500 ps. By characterizing the (002) diffraction peak of ^{57}FeRh, we demonstrate that the laser pulses can coherently steer the resonant photons from along the AFM phase to the direction corresponding to the FM phase. Thus, we strive to open new pathways for the coherent control of nuclear excitonic states. [1] R. Röhlsberger et al., Science 328, (2010) 1248. [2] K. P. Heeg et al., Nature 590, (2021) 401. [3] S. Sadashivaiah et al., J. Phys. Chem. Lett. 12, (2021) 3240.

MA 38.6 Thu 12:30 EB 202

Ultrafast Magnetization Dynamics of Nanoscale Domains in Ferrimagnetic DyCo Films Studied at European XFEL — •Simon Marotzke[1,2], André Philippi-Kobs[1], Dieter Lott[3], Matthias Riepp[4], Leonard Müller[1], Robert Frömter[5], Loic Le Guyader[6], Andreas Scherz[6], Florin Radu[7], Gerhard Grübel[1,6], Martin Beye[1,8], and Kai Rossnagel[1,2] — [1]DESY, Hamburg, Germany — [2]CAU Kiel, Germany — [3]Helmholtz-Zentrum Hereon, Geesthacht, Germany — [4]Université de Strasbourg, France — [5]JGU Mainz, Germany — [6]European XFEL, Schenefeld, Germany — [7]HZB, Berlin, Germany — [8]Stockholm University, Sweden

Ferrimagnetic $DyCo_x$ is a fascinating magnetic composition for both fundamental as well as applied studies on magnetism due to the easy tunability of its magnetic state by temperature and composition. While the global behavior of its magnetization dynamics upon ultrashort laser excitation has been studied, the response of its nanoscale magnetic domain state is completely unknown. Here, in particular, it

is of high interest if super-diffusive currents of highly excited electrons lead to modifications of the domain structure that may be different for both Dy and Co sublattices, resulting in the creation of a transient non-collinear state within the domain walls. We addressed the ultrafast response of the nanoscale domain state by performing magnetic small-angle X-ray scattering experiments on ultrathin $DyCo_3$ films at the Spectroscopy and Coherent Scattering (SCS) instrument of the European XFEL. We report on first results indicating the existence of a transient non-colinear magnetic state.