MA 25: Ultrafast Magnetization Effects 2

Time: Wednesday 15:00–17:00 Location: H43

MA 25.1 Wed 15:00 H43

Light-induced magnetization dynamics in a ferromagnetic semiconductor — •Jingwen Li[1], Masakazu Matsubara[2], Kristin Kliemt[3], Nazia Kaya[3], Isabel Reiser[3], Cornelius Krellner[3], Johann Kroha[4], Shovon Pal[5], and Manfred Fiebig[1] — [1]ETH Zurich, Switzerland — [2]Tohoku University, Japan — [3]Goethe University Frankfurt, Germany — [4]Bonn University, Germany — [5]NISER Bhubaneshwar, India

Ferromagnetic semiconductors are a rare class of materials that can provide a new platform with spin degrees of freedom in electronic and optical devices. All-optical control of the magnetic order is a demanding task, however. As one prototype example, EuO is intriguing for its high Curie Temperature ($T_c = 69\,K$) induced by the indirect exchange interactions between the Eu atoms. The interactions can be enhanced by photo-doping in an ultrafast non-thermal way, strengthing the ferromagnetic order. This was verified in the ferromagnetic phase of the material [1], but evidence for an enhancement of the magnetic order around or above T_c is still lacking. In this contribution, we show the photo-induced presence of magnetic ordering even at temperatures higher than T_c by making use of the temperature-dependent spectral shift accompanying the magnetically ordered states using optical pump-probe spectroscopy. In optical reflection experiments, we observe two distinct types of ultrafast processes related to the optically driven magnetic order that show different relaxation rates. Our results provide clear evidence of short-range magnetic order above T_c, originating from the so-called exciton magnetic polarons.

MA 25.2 Wed 15:15 H43

Non-thermal optical generation of non-collinear magnetic phase in insulating ferrimagnetic iron garnet — •Sergii Parchenko[1], Antoni Frej[2], Hiroki Ueda[1], Robert Carley[1], Laurent Mercadier[1], Natalia Gerasimova[1], Giuseppe Mercurio[1], Justine Schlappa[1], Alexander Yaroslavtsev[1], Naman Agarwal[1], Andreas Scherz[1], Andrzej Stupakiewicz[2], and Urs Sergii[3] — [1]European Free Electron Laser, Schenefeld, Germany — [2]University of Bialystok, Bialystok, Poland — [3]Paul Scherrer Institute, Villigen, Switzerland

For a long time, nearly all experimental examples of magnetic switching by femtosecond pulses were demonstrated on metals and relied on mechanisms directly related to laser-induced heating close to the Curie temperature. The discovery of all-optical magnetization switching in Co: doped iron garnets via photomagnetic effect opened a new approach for magnetization control and raised a question about the microscopic nature of photo-magnetic spin dynamics. In order to reveal the magnetization dynamic of individual sublattices after excitation with NIR ultrashort laser pulses, we implement time-resolved XMCD techniques in a soft x-ray regime. We found that the dynamics of two antiferromagnetically coupled magnetic moments are drastically different during the first picosecond after the NIR excitation. The dynamics of Fe in tetrahedral oxygen surroundings showed a fast component lasting for about a picosecond. We state that the observed photoinduced noncolinear magnetic phase might be crucial for the all-optical magnetization switching in this material.

MA 25.3 Wed 15:30 H43

Spin-dependent carrier dynamics in antiferromagnetic model systems — •Marius Weber[1], Kai Leckron[1], Benjamin Stadtmüller[1,2], Baerbel Rethfeld[1], and Hans Christian Schneider[1] — [1]Department of Physics and Research Center OPTIMAS, TU Kaiserslautern — [2]Institute of Physics, Johannes Gutenberg University Mainz

The Elliot-Yafet mechanism for the relaxation of an electronic spin polarization was originally derived for the electron-phonon scattering in degenerate bands in semiconductors [1]. Recently, we investigated how the concept of Elliott-Yafet spin-flip scattering can be applied to a microscopic treatment of carrier scattering in ferromagnetic metals including a ferromagnetic splitting and spin-orbit coupling [2].

Here we use the microscopic approach of [2], which utilizes the equation of motion formalism for the k-resolved reduced spin density matrix, to calculate the electronic dynamics in antiferromagnets such as the minimal model system discussed in [3]. The band structure of this model is anisotropic with two twofold degenerate bands and pronounced spin mixing. We investigate the spin-resolved electronic dynamics for different scenarios of spin-polarized anisotropic excitation, such as spin injection and k-selective spin flips.

[1] R. J. Elliott; Physical Review 96, 266, (1954).
[2] K. Leckron et al.; Phys. Rev. B 96, 140408 (2017).
[3] L. Smejkal et al.; Phys. Status Solidi RRL, 11 (2017).

MA 25.4 Wed 15:45 H43

Spectroscopic Analysis of the Ultrafast Non-Equilibrium Dynamics in Nickel at the European X-Ray Free-Electron Laser — •T. Lojewski[1], M. F. Elhanoty[2], N. Rothenbach[1], Y. Kvashnin[2], L. Le Guyader[3], B. Van Kuiken[3], R. Carley[3], J. Schlappa[3], R. Gort[3], G. Mercurio[3], A. Yaroslavtsev[2,3], N. Gerasimova[3], M. Teichmann[3], L. Mercadier[3], R. Y. Engel[4], P. Miedema[4], L. Spieker[1], F. Döring[5], B. Rösner[5], F. De Groot[6], P. Thunström[2], O. Gråsäs[2], J. Jönsson[2], C. Lambert[7], I. Pronin[8], J. Rezvani[9], M. Pace[10], C. Boeglin[10], C. Stamm[7,11], M. Beye[4], C. David[5], O. Eriksson[2], A. Scherz[3], U. Bovensiepen[1], H. Wende[1], K. Ollefs[1], and A. Eschenlohr[1] — [1]Univ. Duisburg-Essen — [2]Uppsala Univ. — [3]European XFEL — [4]DESY — [5]PSI — [6]Utrecht Univ. — [7]ETH Zürich — [8]ITMO Univ. — [9]INFN — [10]Univ. of Strasbourg — [11]FHNW

X-ray absorption spectroscopy is a powerful technique to investigate non-equilibrium dynamics combining a sensitivity to electron and lattice dynamics with element specificity. We report the time-resolved, spectroscopic analysis of Nickel-metal $L_{2,3}$-edge X-ray absorption spectra and their pump-induced changes measured at the SCS instrument of the European XFEL with unprecedented energy resolution and dynamic range. In addition, *ab initio* DFT and TD-DFT calculations connect the pump-induced changes to modifications of the electronic DOS. We find pump-induced redshifts and reduced absorption at the $L_{2,3}$-edges, which we explain by a loss of magnetic moment, changes in the electronic correlations and redistribution of electron population.

MA 25.5 Wed 16:00 H43

Indirect optical manipulation of the antiferromagnetic order of insulating NiO by ultrafast interfacial energy transfer — •Stephan Wust[1], Christopher Seibel[1], Hendrik Meer[2], Paul Herrgen[1], Christin Schmitt[2], Lorenzo Baldrati[2], Rafael Ramos[3], Takashi Kikkawa[4], Eiji Saitoh[4], Olena Gomonay[2], Jairo Sinova[2], Yuriy Mokrousov[2], Hans Christian Schneider[1], Mathias Kläui[2], Baerbel Rethfeld[1], Benjamin Stadtmüller[1,2], and Martin Aeschlimann[1] — [1]Department of Physics and Research Center OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Institute of Physics, Johannes Gutenberg-University Mainz, 55128 Mainz, Germany — [3]CIQUS, Departamento de Química-Física, Universidade de Santiago de Compostela, Santiago de Compostela, Spain — [4]Department of Applied Physics, The University of Tokyo, Tokyo 113-8656, Japan

Antiferromagnets are promising candidates for improved future spintronic devices in terms of robustness and speed. Here, we report the ultrafast, (sub)picosecond reduction of the antiferromagnetic order of the insulating NiO thin film in a Pt/NiO bilayer. This reduction of the antiferromagnetic order is not present in pure NiO thin films after a strong optical excitation. This ultrafast phenomenon is attributed to an ultrafast and highly efficient energy transfer from the optically excited electron system of the Pt layer into the NiO spin system. We propose that this energy transfer is mediated by a stochastic exchange scattering of hot Pt electrons at the Pt/NiO interface.

MA 25.6 Wed 16:15 H43

Heat-conserving three-temperature model for ultrafast demagnetisation simulations of nickel and iron — •Maryna Pankratova[1], Ivan Miranda[1], Danny Thonig[2,1], Manuel Pereiro[1], Erik Sjöqvist[1], Anna Delin[3], Olle Eriksson[1,2], and Anders Bergman[1] — [1]Department of Physics and Astronomy, Uppsala University, Box 516, SE-75120 Uppsala, Sweden — [2]School of Science and Technology, Örebro University, SE-701 82, Örebro, Sweden — [3]Department of Applied Physics, School of Engineering Sciences, KTH Royal Institute of Technology, AlbaNova University Center, SE-10691 Stockholm, Sweden

In this work, we introduce a new heat-conserving three temperature model (HC3TM) for calculations of spin, electron, and lattice temperatures during ultrafast magnetisation dynamics simulations.

The proposed HC3TM has several advantages in comparison with the three-temperature model (3TM), proposed by Beurepaire. It reduces the reliance on heat transfer parameters, such as electron-spin, electron-lattice, and spin-lattice. These parameters are often hard to estimate which impedes the comparison with experimental data.

We apply HC3TM for the simulations of ultrafast demagnetisation of nickel and iron and compare the results with 3TM. HC3TM gives a demagnetisation rate during the first picoseconds after the absorption of a laser pulse which is in line with experiments. Overall, the proposed HC3TM reproduces experimental observations for nickel and iron better than most existing 3TM while it reduces the number of required parameters.

MA 25.7 Wed 16:30 H43

X-ray absorption spectroscopy on spin-crossover molecules — •Lea Spieker[1], Tobias Lojewski[1], Carolin Schmitz-Antoniak[2], Florin Radu[3], Torsten Kachel[3], Laurent Mercadier[4], Andreas Scherz[4], Loïc le Guyader[4], Martin Teichmann[4], Robert Carley[4], Giuseppe Mercurio[4], Natalia Gerasimova[4], Benjamin van Kuiken[4], Cammille Carinan[4], David Hickin[4], Damian Günzing[1], Soma Salamon[1], Gérald Kämmerer[1], Peter Kratzer[1], Klaus Sokolowski-Tinten[1], Manuel Gruber[1], Andrea Eschenlohr[1], Katharina Ollefs[1], Senthil Kumar Kuppusamy[5], Mario Ruben[5,6], Uwe Bovensiepen[1], and Heiko Wende[1] — [1]University of Duisburg-Essen and CENIDE — [2]University of Applied Science Wildau — [3]Helmholtz Center Berlin — [4]European XFEL — [5]Karlsruhe Institute of Technology — [6]CNRS-University of Strasbourg

Spin-crossover molecules with abrupt spin-state switching in the room temperature regime are of great interest for future device applications. With X-ray absorption spectroscopy (XAS), it is possible to investigate their temperature-, visible light-, or X-ray induced spin-state switching. Recently, we performed static, temperature-dependent XAS measurements to study X-ray induced switching behavior as well as ultrafast time-resolved XAS measurements to analyze light-induced spin-state switching. We acknowledge European XFEL in Schenefeld, Germany, for the provision of X-ray free-electron laser beamtime at the SCS instrument. The financial support by CRC 1242 Projects A05, A07, B02, and C01 (Project-ID 278162697) is gratefully acknowledged.

MA 25.8 Wed 16:45 H43

Ultrafast magnetization dynamics in heterogeneous material compositions — •Sebastian T. Weber[1], Christopher Seibel[1], Marius Weber[1], Martin Stiehl[1], Sanjay Ashok[1], Simon Häuser[1], Martin Aeschlimann[1], Hans Christian Schneider[1], Benjamin Stadtmüller[1,2], and Baerbel Rethfeld[1] — [1]Department of Physics and Research Center OPTIMAS, TU Kaiserslautern — [2]Institute of Physics, Johannes Gutenberg University Mainz

Ultrafast magnetization dynamics plays a key role in the development of spintronic devices. The dynamics are influenced by the composition of material systems as well as the wavelength of the optical excitation. The latter can create spatially inhomogeneous excitation profiles in thick nickel films [1,2] or Ni|Au heterostructures [3].

In this contribution, we compare results of the thermodynamic μT-model with kinetic Boltzmann calculations and MOKE-measurements to investigate the influence of the wavelength on magnetization dynamics in different compositions. Our results show that laser and material parameters can enhance or hinder the interplay of relaxation processes, leading to different laser-induced magnetization dynamics.

[1] U. Bierbrauer *et al.*, JOP: Cond. Mat. 29, 244002 (2017)
[2] S. Ashok *et al.*, Appl. Phys. Lett. 120, 142402 (2022)
[3] C. Seibel *et al.*, arXiv:2112.04780 (2021)