MA 48: Ultrafast Magnetization Effects II

Time: Friday 11:15–13:00 Location: H20

MA 48.1 Fri 11:15 H20

Measurement of time resolved magneto-optic Kerr effect on ruthenium dioxide — •Holger Grisk[1], Maik Gaerner[2], Jakob Walowski[1], Timo Kuschel[2], and Markus Münzenberg[1] — [1]Institute of Physics, Greifswald University, Germany — [2]Faculty of Physics, Bielefeld University, Germany

Altermagnetism is a novel fundamental phase of magnetism with exciting properties such as spin split bands.Ruthenium dioxide is one of the mostly investigated altermagnetic candidates. The antiparallel alignment of the Ru spins along with the anisotropic distribution of oxygen atoms leads to time reversal symmetry breaking and non-relativistic, anisotropic spin-splitting in the band structure. We used the time-resolved magneto-optic Kerr effect to measure the transient Kerr angle and reflectivity change after excitation with a femtosecond laser pulse to access the potential magnetic properties of ruthenium dioxide. The setup for the measurement exploits the pump-probe technique. A femtosecond laser pulse is split into a powerful pump and a low-power probe beam. The pump beam is used to photoexcite the electrons in the ruthenium dioxide. The probe beam is used to measure the shift in the Kerr rotation. Delaying the pump temporally and probing the evolution of the Kerr signal we can measure the ultrafast spin dynamics of ruthenium dioxide. The measurement shows Terahertz dynamics in the Kerr signal that is an order of magnitude faster than conventional ferromagnets. The studies were performed at room temperature and with small in plane magnetic field.

MA 48.2 Fri 11:30 H20

Dynamical renormalization of the magnetic excitation spectrum via high-momentum nonlinear magnonics — •Julian Bär[1], Lennart Feuerer[1], Alfred Leitenstorfer[1], Dominik Juraschek[2], and Davide Bossini[1] — [1]Department of Physics and Center for Applied Photonics, University of Konstanz, D-78464 Konstanz, Germany — [2]Department of Applied Physics and Science Education, Eindhoven University of Technology, Eindhoven, Netherlands

Manipulating the macroscopic properties of solids with light is a key challenge in condensed matter physics. While resonantly driving low-momentum collective excitations has led to nonlinear lattice and spin dynamics [1,2], controlling magnon spectra in terms of amplitude and frequency remains unexplored. In my talk I will discuss the resonant excitation of pairs of high-momentum magnons in Hematite (α-Fe2O3). By exciting hematite in its weak-ferromagnetic phase, our approach results in a direct coupling between high- and low-momentum magnons. In particular, the spectrum of the latter is modified. This astonishing effect is explained with a resonant light-scattering mechanism that couples high- and low-momentum eigenmodes across momentum space [3]. As hematite undergoes a phase transition at 260 K to a collinear antiferromagnetic state, we have developed a cryogenic pump-probe setup. Preliminary results reveal behaviour distinct from that observed in the weak ferromagnetic phase. [1] A. S. Disa et al., Nat Phys 17, 1087-1092 (2021). [2] Z. Zhang et al., Nat Phys., 1-6 (2024). [3] C. Schoenfeld et al., arXiv:2310.19667 (2024)

MA 48.3 Fri 11:45 H20

Bias field studies of all-optical helicity-dependent switching. — •Kevin Jäckel[1], Marcel Kohlmann[1], Jakob Walowski[1], Markus Münzenberg[1], Yuta Sasaki[2], and Karel Carva[3] — [1]University of Greifswald, Germany — [2]Research Center for Magnetic and Spintronic Materials, Japan — [3]Charles University, Czech Republic

The mechanisms underlying all-optical helicity-dependent switching AOHDS need a better understanding to improve the process towards single pulse switching. We apply external magnetic fields (anti-) parallel of up to $H_{\mathrm{ext}} = 72\,\mathrm{mT}$, (opposing) supporting the desired magnetization direction in FePt granular media to disentangle the contribution of the inverse Faraday effect IFE within the switching process. Those measurements, performed on samples with varying average grain size diameters of $d = 10\,\mathrm{nm}$, $d = 6\,\mathrm{nm}$ nm, and $d = 4\,\mathrm{nm}$, reveal a grain size dependent impact of the applied field strength. Using the helicity-dependent refractive index calculated from density functional theory (DFT) calculations, we calculate the absorbed laser fluence for each grain size using the transfer matrix method. The absorption data, combined with the inverse Faraday constant, allows us to quantify the optically induced magnetization ΔM by the IFE. From this data, we can estimate the contribution of the IFE to the switching process. The research is funded by DFG, Fundamental aspects of all-optical pulse switching in nanometer-sized magnetic storage media Project number: 439225584.

MA 48.4 Fri 12:00 H20

Terahertz study of antiferromagnetic resonance in α MnTe — •Michal Šindler[1], Roman Tesař[1], Karel Výborný[1], Stáňa Tazlerů[1], Christelle Kadlec[1], Peter Kubaščík[2], Lukáš Nádvorník[2], Marcin Bialek[3], Jan Dzian[2,4], and Milan Orlita[4] — [1]Institute of Physics of the Czech Academy of Sciences, Prague, Czech Republic — [2]Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic — [3]Institute of High Pressure Physics Polish Academy of Sciences, Warszawa, Poland — [4]Laboratoire National des Champs Magnétiques Intenses, Université Grenoble Alpes, CNRS-UPS-INSA-EMFL, Grenoble, France

Antiferromagnetic resonance in bulk α-MnTe crystal was studied in the terahertz (THz) range. First, we will describe the three experimental methods used: (i) infrared Fourier transform spectroscopy,(ii) time-domain THz spectroscopy, and (iii) frequency-domain terahertz spectroscopy with linearly and circularly polarized THz beams. Second, we will present experimental results featuring a magnon mode ($k = 0$) with the low-temperature energy of 3.5 meV and its temperature and magnetic field evolution. Finally, we will show how to extract the out-of-plane component of the single-ion magnetic anisotropy $D \approx 40\,\mu\mathrm{eV}$ using a simple spin model of antiferromagnetic resonance in an easy-plane antiferromagnet.

MA 48.5 Fri 12:15 H20

Indications of terahertz spin transport in the altermagnet candidate RuO2 — •Oliver Gueckstock[1], Clara Simons[1], Maik Gaerner[2], Zdenek Kaspar[3], Jiri Jechumtal[3], Tom S. Seifert[1], Lukas Nadvornik[3], Günter Reiss[2], and Tobias Kampfrath[1] — [1]FU Berlin — [2]U Bielefeld — [3]Charles University Prague

The recently emerging material class of altermagnets has large potential to offer properties like strong spin splitting, which are so far rather typical for classical ferromagnets [1]. RuO2 appears to be a promising metallic altermagnet candidate with huge spin splitting in the electronic band structure and for photoinduced spin and orbital transport with a Néel temperature above room temperature [1,2]. Here, we apply femtosecond laser pulses to RuO2(110)|HM stacks consisting of a twinned RuO2 layer and a heavy-metal layer HM of Pt or W. We observe THz emission signals with distinct pump-polarization dependence. The signals change sign when HM=Pt is replaced by W and exhibit a marked temperature dependence, thereby suggesting a magnetism-related signal origin. We discuss possible mechanisms of THz-signal generation, including an ultrafast photoinduced spin current from RuO2 to HM and its conversion into in-plane charge in HM, which gives rise to the emission of a THz electromagnetic pulse. References: [1] Smejkal et al., Phys Rev. X 12, 040501 (2022), [2] Adamantopoulos et al., npj spintronics 2, 46 (2024)

MA 48.6 Fri 12:30 H20

THz emission control in exchange-coupled spintronic emitters. — •Roman Adam[1], Derang Cao[1,2], Daniel Bürgler[1], Sarah Heidtfeld[1], Christian Greb[1], Fangzhou Wang[1], Debamitra Chakraborty[3], Jing Cheng[3], Ivan Komissarov[3], Markus Büscher[1], Martin Mikulics[4], Hilde Hardtdegen[4], Roman Sobolewski[3], and Claus Schneider[1] — [1]Research Centre Jülich, Peter Grünberg Institute (PGI-6), 52425 Jülich, Germany — [2]College of Physics, Qingdao University, 266071 Qingdao, China — [3]University of Rochester, Rochester, New York 14627-0231, USA — [4]Research Centre Jülich, Ernst Ruska Centre (ERC-2), 52425 Jülich, Germany

Optical laser pulses impinging at the ferromagnet/metal thin film stacks can generate a pico-second electro-magnetic transients with frequency content extending into THz frequency range. We fabricated Si/SiO2//Ta/Fe/Ru/Ni/Al2O3 and Si/SiO2//Pt/Fe/Cr/Fe/Pt spintronic THz emitters in which we varied interlayer exchange coupling between the ferromagnetic thin films by varying the thicknesses of either the Ru or Cr spacer layer. As a result, THz emission shows a dramatic variation of amplitude in weak external magnetic fields due to an interference of THz transiens generated at the individual Fe/Ru, Ru/Ni or Fe/Pt emitters. We explore the effect of the ambient temperature and the spacer layer thickness variations on the THz amplitude.

MA 48.7 Fri 12:45 H20

On-Chip Multilayer Spintronic THz Emitters — •Wolfgang Hoppe[1], Amine Wahada[2], Stuart Parkin[3], and Georg Woltersdorf[1] — [1]Institute of Physics, Martin-Luther-Universität Halle-Wittenberg, Von-Danckelmann-Platz 3, 06120 Halle, Germany — [2]Department of Physical Chemistry, Fritz Haber Institute, Faradayweg 4-6, 14195 Berlin, Germany — [3]Max Planck Institute for Microstructured Physics, Weinberg 2, 06120 Halle, Germany

Nanometer thin ferromagnet/heavy metal bilayers illuminated by intense short laser pulses have proven to be a realiable source for THz emission [1]. When integrated into a gold waveguide structure, the bilayer can be used as an on-chip source for ultrafast current pulses from the GHz to the THz regime [2]. Stacking severeral bilayers, each separated by a thin MgO interlayer enhances the charge current amplitude, as the MgO suppresses spin-currents in between the individual bilayers [3]. In this way we construct multilayers where all charge currents add up constructively, enhancing the signal up to a factor of three. As one possible application these ultrafast currents could be used to switch the magnetization of an adjacent ferromagnet, similar to previous experiments [4]. Electro-optic sampling is employed to characterize the charge current with sub-ps time resolution.

References:
[1] Seifert et al., Nat. Photonics 10 (2016) 438-488
[2] W. Hoppe et al., ACS. Appl. Nano Mater. 4,7 (2021) 7454-7460
[3] A. Wahada et al., ACS Nano Lett. 22, 9 (2022) 3539-3544
[4] Y. Yang et al., Sci. Adv. 3, 11 (2017) e1603117