MA 36: Terahertz Spintronics II

Time: Thursday 9:30–10:45 Location: EB 202

MA 36.1 Thu 9:30 EB 202

Simulating the THz response of Mn_2Au — •Tobias Dannegger, Fynn Renner, and Ulrich Nowak — Fachbereich Physik, Universität Konstanz

The antiferromagnet Mn_2Au is one of very few materials whose symmetry allows for Néel spin orbit torques, which can be used to excite its magnetic order on ultrafast timescales with the electric field of a THz pulse, as has recently been demonstrated [1]. Its perfectly uncompensated coupling to ferromagnetic permalloy is a promising option for detecting its magnetic state [2], while still allowing for ultrafast switching dynamics [3]. Here, we use atomistic spin dynamics simulations with ab initio calculated parameters [4] to understand the THz response of Mn_2Au on a microscopic level and predict the conditions that allow for ultrafast THz-induced switching both in pure Mn_2Au and in bilayers coupled to permalloy.

[1] Y. Behovits et al., *Nat. Commun.* **14**, 6038 (2023).
[2] S. P. Bommanaboyena et al., *Nat. Commun.* **12**, 6539 (2021).
[3] J. Hirst et al., *Sci. Rep.* **13**, 12270 (2023).
[4] S. Selzer et al., *Phys. Rev. B* **105**, 174416 (2022).

MA 36.2 Thu 9:45 EB 202

Advancing the Efficiency of Spintronic Terahertz Frequency Conversion — •Hatice Nur Koyun[1], Ruslan Salikhov[1], Ciaran Fowley[1], Jürgen Lindner[1], Stephan Winnerl[1], Artur Erbe[1,2], Jürgen Fassbender[1,2], Manfred Helm[1,2], and Sergey Kovalev[1,3] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Germany — [2]Technische Universität Dresden, 01062 Dresden, Germany — [3]Technische Universität Dortmund, 44227, Dortmund, Germany

Terahertz (THz) spintronics, operating on picosecond timescales, involves the generation and control of non equilibrium electron spin states within the THz frequency regime. Recent studies have shown that THz light can efficiently drive coherent spin currents in nanometer-thick ferromagnet (FM)/heavy-metal (HM) heterostructures, primarily due to demagnetization process of FM and the ultrafast spin Seebeck effect. Owing to the fact that the electron-phonon relaxation time is comparable (or smaller) to the period of a THz wave, the induced spin current from each half cycle of the THz wave results in THz second harmonic generation (TSHG) and THz optical rectification. In this study, we explore the potential of utilizing subwavelength-sized gold periodic arrays with a grating period smaller than the THz wavelength to enhance local spin currents, thereby improving the efficiency of THz frequency conversion.

MA 36.3 Thu 10:00 EB 202

Modeling superdiffusive spin current-induced terahertz emission from layered heterostructures — •Francesco Foggeti and Peter M. Oppeneer — Uppsala University, Uppsala, Sweden

In ultrafast spintronic teraherts emitters, THz radiation is generated by exciting an ultrafast spin current through femtosecond laser pulse in ferromagnetic-non magnetic heterostructures. Here, due to inverse spin Hall effect, the excited spin current results in an electromagnetic signal in the THz frequency range. Although an extensive phenomenological knowledge has been built through the last decade, a solid theoretical modeling that connects the generated signal to the laser induced-spin current is still incomplete. In this work, starting from general solutions to Maxwell equations, we model the electric field generated by a superdiffusive spin current in spintronic emitters. Additionally, effects due to the detector presence are also studied and taken into account, resulting in a good agreement between the predicted THz signal and the experimental measurements.

MA 36.4 Thu 10:15 EB 202

Light field-driven spin current generation for spintronic terahertz frequency multiplication — •Sergey Kovalev[1,2], Igor Ilyakov[2], Arne Brataas[3], Thales Oliveira[2], Alexej Ponomaryov[2], Jan Deinert[2], Olav Hellwig[2], Jürgen Fassbender[2], Jürgen Lindner[2], and Ruslan Salikhov[2] — [1]Fakultät Physik, Technische Universität Dortmund, Dortmund, Germany — [2]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [3]Center for Quantum Spintronics, Department of Physics, Norwegian University of Science and Technology, Trondheim, Norway

Efficient generation and control of spin currents launched by terahertz (THz) radiation with subsequent ultrafast spin-to-charge conversion is the current challenge for the next generation of high-speed communication and data processing units. In this talk, we demonstrate that THz light can efficiently drive coherent angular momentum transfer in nanometer-thick ferromagnet/heavy-metal heterostructures. The coherently driven spin currents originate from the ultrafast spin Seebeck effect, caused by a THz-induced temperature imbalance in electronic and magnonic temperatures and fast relaxation of the electron-phonon system. Owing to the fact that the electron-phonon relaxation time is comparable with the period of a THz wave, the induced spin current results in THz second harmonic generation and THz optical rectification [1], providing a spintronic basis for THz frequency mixing and rectifying components.

[1] I. Ilyakov et al., Nature Communications 14, 7010 (2023)

MA 36.5 Thu 10:30 EB 202

Voltage-Controlled High-Bandwidth Terahertz Oscillators Based On Antiferromagnets — Mike Lund[1], Davi Rodrigues[2], Karin Everschor-Sitte[3], and •Kjetil Hals[1] — [1]Department of Engineering Sciences, University of Agder, 4879 Grimstad, Norway — [2]Department of Electrical and Information Engineering, Polytechnic University of Bari, 70125 Bari, Italy — [3]Faculty of Physics and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen, 47057 Duisburg, Germany

The terahertz (THz) technology gap refers to a frequency range of electromagnetic radiation in the THz regime where current technologies are inefficient for generating and detecting radiation. Here, we show that noncollinear antiferromagnets (NCAFM) with kagome structure host gapless self-oscillations whose frequencies are tunable from 0 Hz to the THz regime via electrically induced spin-orbit torques (SOTs) [1]. The auto-oscillations' initiation, bandwidth, and amplitude are investigated by deriving an effective theory, which captures the reactive and dissipative SOTs. We find that the dynamics strongly depends on the ground state's chirality, with one chirality having gapped excitations, whereas the opposite chirality provides gapless self-oscillations. Our results demonstrate that NCAFMs offer unique THz functional components, which could play a significant role in bridging the gap between technologies operating in the microwave and infrared regions.

[1] M. A. Lund, D. R. Rodrigues, K. Everschor-Sitte, and K. M. D. Hals, Phys. Rev. Lett. 131, 156704 (2023).