MA 12: Terahertz Spintronics

Time: Monday 15:00–16:30 Location: POT/0351

MA 12.1 Mon 15:00 POT/0351

Interface Modification of Spintronic THz emitters — •David Stein[1], Krishna Rani Sahoo[2], Alexander Heise[1], Stephan Glamsch[1], Jannis Bensmann[2], Robert Schmidt[2], Steffen Michaelis de Vasconcellos[2], Rudolf Bratschitsch[2], and Manfred Albrecht[1] — [1]Universität Augsburg, Augsburg, Germany — [2]Universität Münster, Münster, Germany

The spintronic Terahertz (THz) emission of thin magnetic/heavy metal bilayers with fs laser excitation is an excellent alternative to the well-known bulk nonlinear crystals. Many works have been published about different material combinations of spintronic emitters, but the properties of the bilayer interface and its influence on the THz emission is not well understood. We study Fe/Pt interfaces, which were modified by implantation with foreign atoms to investigate the influence of the interface on the THz emission. THz-Time Domain Spectroscopy and SQUID-VSM Magnetometry, as well as high-resolution Scanning Transmission Electron Microscopy (STEM) with Energy Dispersive X-Ray Spectroscopy (EDS) were performed to understand the effects of the modifications.

MA 12.2 Mon 15:15 POT/0351

Lightwave-driven spintronics by coherent breaking of time-reversal symmetry — •Philipp Weissenberger[1], Josef Riepl[1], Adrian Seith[1], Michael Aschenbrenner[1], Josef Freudenstein[1], Omer Kneller[1], Daniel Riese[1], Manuel Meierhofer[1], Konstantin Kokh[2], Oleg Tereshchenko[2], Jörg Wunderlich[1], Ulrich Höfer[1], Ferdinand Evers[1], Jan Wilhelm[1], and Rupert Huber[1] — [1]University of Regensburg, Germany — [2]Novosibirsk, Russia

Lightwave electronics has the potential to revolutionize high-speed information technology by using the carrier field of light to steer electrons at optical clock rates. Yet, expanding this subcycle control scheme to the spin, one of the most important quantum attributes, has remained a challenge. Additionally, time-reversal symmetry (TRS) prohibits a net spin polarization in non-magnetic solids, limiting ultrafast spintronics to magnetic systems with intrinsically broken TRS. Here, we transcend these boundaries by leveraging intense, phase-stable terahertz (THz) pulses to accelerate Dirac fermions in the topological state of Bi2Te3. Due to spin-momentum locking, the THz field drives ballistic, spin-polarized currents. The nonequilibrium occupation coherently breaks TRS and leads to a net surface magnetization. Our all-optical measurements show that these dynamics follow the driving vector potential, proving their dissipationless nature and our magnetic switching abilities. Astonishingly, the data reveals an anisotropic coupling to higher-lying topological states. Our scheme could be transferred to a host of non-magnetic systems and boost ultrafast magnetic metrology.

MA 12.3 Mon 15:30 POT/0351

Spin Inertia as a Source of Topological Magnons — •Subhadip Ghosh[1], Mikhail Cherkasskii[2], Ritwik Mondal[1], Alexander Mook[3], and Levente Rozsa[4] — [1]IIT (ISM) Dhanbad, India. — [2]RWTH Aachen University, Germany. — [3]University of Munster, Germany — [4]BME, Budapest, Hungary

Ferromagnets exhibit not only the familiar precessional magnon bands, but also high-frequency nutational modes originating from spin inertia [1]. In this work, we show that the hybridization between these nutational and precessional branches opens a magnonic gap whose topology can become nontrivial. In a honeycomb ferromagnet, this topological phase is caused by the pseudodipolar coupling, which not only gaps out the well-known precessional Dirac cones [2,3] but also causes precessional and nutational modes to anticross. By computing the Chern numbers of the full magnon spectrum, we demonstrate that the nutational-precessional gap can host chiral, topologically protected edge states. We highlight the role of spin inertia as a source of topological magnonic phenomena.

[1] R. Mondal *et al.*, Phys. Rev. B 106, 134422 (2022). [2] A. Mook *et al.*, Phys. Rev. B. 90, 024412 (2014). [3] X. S. Wang *et al.*, Phys. Rev. Appl. 9, 024029 (2018).

MA 12.4 Mon 15:45 POT/0351

THz light field driven unidirectional spin Hall magnetoresistance in magnetic heterostructures — •Sergey Kovalev[1], Ruslan Salikhov[2], Igor Ilyakov[2], Anneke Reinold[1], Jan Deinert[2], Thales Oliveira[2], Alexey Ponomaryov[2], Gulloo Prajapati[2], Patrick Pilch[1], Ahmed Ghalgaoui[1], Steffen Kober[1], Jürgen Fassbender[2], Jürgen Lindner[2], and Zhe Wang[1] — [1]Technische Universität Dortmund, Dortmund, Germany — [2]Helmholtz Zentrum Dresden Rossendorf, Dresden, Germany

We demonstrate unidirectional spin Hall magnetoresistance (USMR) in magnetic heterostructures driven by terahertz (THz) light electric fields [1]. To isolate USMR from other spin transport phenomena, we performed anisotropy characterization of spintronic THz second-harmonic generation as a function of sample magnetization and THz pump polarization states. By investigating the temperature dependence of THz-driven USMR, we reveal distinct contributions to USMR dynamics on picosecond time scales. Our approach enables the characterization of ultrafast, field-driven spin-related magnetoresistance in free-standing heterostructures without the need for lithographic processing.

[1] R. Salikhov et al., "Ultrafast unidirectional spin Hall magnetoresistance driven by terahertz light field." Nat Commun 16, 2249 (2025)

MA 12.5 Mon 16:00 POT/0351

Orbital-torque driven excitation of Terahertz perpendicular standing spin wave (PSSW) modes — •Harshita Devda[1], Peter M. Oppeneer[2], and Ulrich Nowak[1] — [1]Fachbereich Physik, Universität Konstanz, Konstanz, Germany — [2]Department of Physics and Astronomy, Uppsala University, Uppsala, Sweden

Layered ferromagnets support interface-sensitive THz spin dynamics, making the controlled excitation of such THz magnon modes relevant for spintronics applications. Recent experiments show that asymmetric NM/FM/NM trilayers couple efficiently to THz fields via interfacial spin-orbit torques (SOTs)[1], emphasizing the importance of interface effects in THz spin dynamics.

Here, we employ atomistic spin-dynamics simulations using ab-initio exchange parameters in thin NM/Co/NM trilayers to investigate ultrafast magnon excitation in presence of asymmetric and symmetric SOT interfaces. SOTs are implemented using the induced spin and orbital moments from first principles calculations. Our simulations show that nanometer thick Co-layers host exchange-dominated PSSWs in 1-3 THz range. Crucially, the efficient excitation of these THz modes is governed by interfacial field-like orbital torques, which follow directly from our recent study on layer-resolved SOTs[2]. This work establishes orbital torques as a robust route to ultrafast magnon generation.

[1]Salikhov et al., Nat. Phys. 19, 529-535 (2023)
[2]Devda et al.,Phys. Rev. B 112, 144438 (2025)

MA 12.6 Mon 16:15 POT/0351

Tuning terahertz emission from spintronic devices via interface engineering — Rahul Gupta[1,2], •Francesco Foggetti[3], Francesco Cosco[3], Venkatesh Mottamchetty[4], Martin Pavelka[3], Kasturie Jatkar[5], Anders Rydberg[3], Rimantas Brucas[3], Peter M. Oppeneer[3], and Peter Svedlindh[3] — [1]University of South Florida, Tampa, Florida, USA — [2]University of Gothenburg, Gothenburg, Sweden — [3]Uppsala University, Uppsala, Sweden — [4]Aarhus University, Aarhus, Denmark — [5]Stockholm University, Stockholm, Sweden

Spintronic terahertz (THz) emitters are emerging as compact and broadband sources. While common optimization approaches consist in the exploration of different materials and stacking geometries, the effects of the external interfaces have been poorly understood. Here we show that THz radiation amplitude from Pt/Fe grown on MgO and MgAl2O4 depends significantly on the interface reflection of spin currents, which is controlled by lattice mismatch and strain of the Fe/substrate interface, providing a powerful lever to tune THz emission. We use the superdiffusive transport theory to simulate the Pt/Fe bilayer, modeling the different interfaces via tunable interface reflection or via simulated substrate layer, resulting in very good agreement with the experimental data. Our results establish interface reflection governed by strain and lattice mismatch as a general design knob for optimizing spintronic THz emitters, opening new routes to engineer material platforms for next-generation THz technologies.