MA 51: Spin Transport and Orbitronics, Spin-Hall Effects II (joint session MA/TT)

Time: Thursday 15:00–17:00 Location: POT/0361

MA 51.1 Thu 15:00 POT/0361

Spin-pumping and induced magnetic polarization in permalloy/platinum heterostructures — •Verena Ney[1], Kilian Lenz[2], Fabrice Wilhelm[3], René Hübner[2], Fabian Ganss[2], Andrei Rogalev[3], Jürgen Lindner[2], and Andreas Ney[1] — [1]Johannes Kepler Universität Linz, Österreich — [2]Helmholtz Zentrum Dresden-Rossendorf, Deutschland — [3]ESRF, Grenoble, Frankreich

Spin pumping is the transfer of angular momentum across interfaces into a non-ferromagnetic material driven by the precessing magnetization of an adjacent ferromagnet. Using ferromagnetic resonance (FMR) the presence of spin pumping can be evidenced by an increase of the Gilbert damping parameter α [1]. Here we study platinum-permalloy (Pt/Py) heterostructures using temperature-dependent broadband FMR. A clear increase of α is seen in a temperature range from 10 to 300 K when Pt and Py are in direct contact. The temperature dependence of the spin-pumping contribution can be derived by comparing with an Al-sandwiched Py reference film from [2]. Surprisingly, upon insertion of a thin Al spacer layer between Pt and Py the increase in α is suppressed. X-ray magnetic circular dichroism at the Pt L_3-edge reveals a clear magnetic polarization in Pt/Py whereas it is absent when a spacer layer of only 2 nm of Al is inserted. The induced polarization of Pt can thus be associated with spin pumping, while non-polarized Pt in proximity to Py shows an almost identical $\alpha(T)$ behavior as the Py reference sample in [2].

[1] Y. Tserkovnyak Phys. Rev. Lett. **88**, 117601 (2002)
[2] V. Ney et al. Phys. Rev. Materials **7**, 124403 (2023)

MA 51.2 Thu 15:15 POT/0361

Single and double spin Hall anomalous Hall and Hanle effects in Pt/YIG and Ta/YIG bilayers — •Akashdeep Akashdeep, Duc Minh Tran, Mathias Kläui, Gerhard Jakob, and Timo Kuschel — Johannes Gutenberg University Mainz, Germany

Anomalous Hall effect data of heavy metal / magnetic insulator bilayers, such as Pt/$Y_3Fe_5O_{12}$ (YIG), are commonly explained by magnetoresistance effects that are quadratically depending on the spin Hall angle (SHA) [1-4]. This is because they usually consist of two spin Hall processes as for example valid for spin Hall magnetoresistance [1,2]. In addition, S. Zhang et al. predicted theoretically a single spin Hall process combined with interfacial spin-dependent scattering which results in a linear SHA dependence [5] not reported experimentally so far.
In this contribution, we present anomalous Hall effect results for Pt/YIG and Ta/YIG with opposite sign in SHA of Pt and Ta. Thus, we can probe even and odd SHA dependencies. For thin Pt and Ta thicknesses, we observe results that are even in the SHA which is consistent with experimental literature. However, we found an odd SHA dependence for thicker heavy metal layers which is only partially mentioned in theory. We will present the separation of the effects and discuss the impact of the SHA on the individual effect contributions.

[1] H. Nakayama et al., Phys. Rev. Lett. 110, 206601 (2013)
[2] S. Meyer et al., Appl. Phys. Lett. 106, 132402 (2015)
[3] S. Vélez et al., Phys. Rev. Lett. 116, 016603 (2016)
[4] J. Li et al., Phys. Rev. B 106, 184420 (2022)
[5] S. S.-L. Zhang, G. Vignale, Phys. Rev. Lett. 116, 136601 (2016)

MA 51.3 Thu 15:30 POT/0361

Current-induced spin and orbital polarization in the ferroelectric Rashba semiconductor GeTe — •Sergio Leiva-Montecinos[1], Libor Vojácek[2], Jing Li[2], Mairbek Chshiev[2], Laurent Vila[2], Ingrid Mertig[1], and Annika Johansson[3] — [1]Martin-Luther-Universität Halle-Wittenberg, Germany — [2]Univ. Grenoble Alpes, CEA, CNRS, Grenoble, France — [3]Max Planck Institute of Microstructure Physics, Halle (Saale), Germany

The Edelstein effect is a promising mechanism for generating spin and orbital polarization from charge currents in systems without inversion symmetry. In ferroelectric materials, such as Germanium Telluride (GeTe), the combination of bulk Rashba splitting and voltage-controlled ferroelectric polarization provides a pathway for electrical control of the sign of the charge-spin conversion [1, 2].

In this work [3], we investigate current-induced spin and orbital magnetization in bulk GeTe using Wannier-based tight-binding models derived from *ab initio* calculations and semiclassical Boltzmann theory. Employing the modern theory of orbital magnetization, we demonstrate that the orbital Edelstein effect surpases its spin counterpart by one order of magnitude. Moreover, the orbital Edelstein effect remains largely unaffected in the absence of spin-orbit coupling, highlighting its distinct physical origin compared to the spin Edelstein effect.

[1] D. Di Sante *et al.*, Adv. Mater. **25**, 509 (2012).
[2] C. Rinaldi *et al.*, Nano Lett. **18**, 2751 (2018).
[3] S. Leiva-Montecinos *et al.*, arXiv:2505.21340 (2025).

MA 51.4 Thu 15:45 POT/0361

Orbital contribution to g-tensor from first-principles modern theory — •Garima Ahuja[1], Mirco Sastges[2,3], Dongwook Go[4], Shobhana Narasimhan[1], Yuriy Mokrousov[2,3], and Stefan Blügel[2,5] — [1]Theoretical Sciences Unit, Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru, India — [2]Peter Grünberg Institut, Forschungszentrum Jülich and JARA, Jülich, Germany — [3]Institute of Physics, Johannes Gutenberg University Mainz, Mainz, Germany — [4]Department of Physics, Korea University, Seoul, South Korea — [5]Institute for Theoretical Physics, RWTH Aachen University, Aachen, Germany

The electronic g-factor, which measures how angular momentum couples to magnetic fields, is a key descriptor of magnetic behavior in solids. In crystalline materials, the orbital contribution to the g-factor can significantly modify its value. In this talk, we present a first-principles framework for computing g-factors, based on multiband perturbation theory with the DFT-Wannier approach, to reveal microscopic origins of the orbital contribution, highlighting the roles of local and non-local orbital currents. We resolve both orbital and spin responses, determine the full g-tensor, and show how interband couplings and band geometry shape the g-tensor across the Brillouin zone. g-tensor plays a key role in quantum technologies, where qubit coherence and control depend on accurate knowledge of magnetic response. We present our findings for some interesting bulk and 2D systems, offering a predictive route for engineering magnetic responses in materials relevant to quantum computing, spin-orbitronics, and spectroscopy.

MA 51.5 Thu 16:00 POT/0361

Inherent Electro-Optic Kerr Rotation — •Erlend Syljuåsen[1], Alireza Qaiumzadeh[1], Rembert Duine[2,3], and Arne Brataas[1] — [1]Center for Quantum Spintronics,Trondheim, Norway — [2]Institute for Theoretical Physics, Utrecht University, The Netherlands — [3]Department of Applied Physics, Eindhoven University of Technology, The Netherlands

Static electric-field–induced Kerr rotation of reflected light is used to probe symmetry breaking, electronic properties, and transport phenomena as the spin and orbital Hall effects. In this talk, we uncover a previously overlooked contribution to the electric-field–induced Kerr rotation, arising from the interplay of matter, the static electric field, and the magnetic component of light. This contribution remains nonzero even in isotropic nonmagnetic homogeneous materials, making this effect inherent to any such Kerr measurement. We present analytical expressions for both two-dimensional layers and semi-infinite bulk metals, and find within the relaxation-time approximation signal magnitudes directly relevant for experiments.

MA 51.6 Thu 16:15 POT/0361

Thermally Activated Spin Transport in a Multiferroic $LiCu_2O_2$/Pt Heterostructure — •Mathew James, Ankita Nayak, István Kézsmárki, and Aisha Aqeel — University of Augsburg, 86159 Augsburg, Germany

Multiferroics, in which electric and magnetic orders are coupled, are potential materials for low-power spintronic devices. $LiCu_2O_2$ is a Type II multiferroic material known to exhibit spiral (non-collinear) spin ordering below its antiferromagnetic transition temperature, $T_N \approx 23$ K [1]. In this material, the magnetic Cu^{2+} ions form double chains along the crystallographic b-axis, resulting in a double-leg spin-ladder configuration.

In this study, we use the Spin Seebeck Effect (SSE) as an electric probe to investigate the thermally activated magnetic response of $LiCu_2O_2$ across different magnetic configurations. In the SSE, a temperature gradient across a magnetic insulator generates non-equilibrium magnons that carry a spin current. This spin current is converted into a measurable voltage in a heavy-metal layer deposited on top of the insulator, via the Inverse Spin Hall Effect [2]. Our preliminary results indicate that the SSE voltage is sensitive to the spiral ordering in $LiCu_2O_2$. References: [1]S. Park, et al., Phys. Rev. Lett., 98, 5 (2007). [2]K. Uchida et al., Nature, vol. 455, no. 7214, (2008).

MA 51.7 Thu 16:30 POT/0361

Current-induced orbital dynamics in magnetic oxides — •Mahmoud Zeer[1], Marjana Ležaic[1], Dongwook Go[1,2], Leonid Pourovskii[3], Stefan Blügel[1,4], Mathias Kläui[2], Olena Gomonay[2], and Yuriy Mokrousov[1,2] — [1]Peter Grünberg Institute, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Institute of Physics, Johannes Gutenberg-University Mainz, 55099 Mainz, Germany — [3]CPHT, CNRS, École polytechnique, Institut Polytechnique de Paris, 91120 Palaiseau, France — [4]Institute of Theoretical Physics, RWTH Aachen University, 52074 Aachen, Germany

Magnetic oxides provide an ideal platform for exploring orbital degrees of freedom emerging from strong orbital angular momentum and spin-orbit coupling. The resulting unquenched orbital moments enable rich orbital-transport phenomena, particularly in antiferromagnetic systems. In this work, we investigate current-induced orbital dynamics in representative transition-metal oxides using first-principles calculations in both bulk and thin-film geometries. We identify sizable orbital response and highly efficient orbital-to-spin conversion mechanisms, which give rise to substantial torque components on the magnetic sublattices [1]. In addition, we analyze the contributions of dipole, quadrupole, and octupole magnetic moments to the overall orbital response. Our findings establish magnetic oxides as a promising and realistic platform for harnessing orbital degrees of freedom for next-generation spin-orbital technologies. [1] S. Krishnia, C. Schmitt, M. Zeer et al., under review.

MA 51.8 Thu 16:45 POT/0361

Disentangling angular momentum transport in ferromagnet-diamagnet structures via suspended systems — •Fiona Sosa Barth[1,2], Matthias Grammer[1,2], Richard Schlitz[3], Tobias Wimmer[1,2], Janine Gückelhorn[1,2], Luis Flacke[1,2], Sebastian T.B. Goennenwein[3], Rudolf Gross[1,2,4], Hans Huebl[1,2,4], Akashdeep Kamra[5], and Matthias Althammer[1,2] — [1]Walther-Meißner-Institut, BAdW, Garching, Germany — [2]School of Natural Sciences, TUM, Garching, Germany — [3]Department of Physics, University of Konstanz, Konstanz, Germany — [4]Munich Center for Quantum Science and Technology, München, Germany — [5]RPTU Kaiserslautern-Landau, Kaiserslautern, Germany

Spintronics relies on the transfer of angular momentum between electrons and solid state excitations such as magnons and phonons. In our recent work, we demonstrate angular momentum transfer between two ferromagnetic strips on diamagnetic substrates [1]. A DC current on one of the strips is converted into a non-equilibrium magnon accumulation, which transfers angular momentum to the magnonic system of the second FM strip, detected electrically by the inverse processes. In this work, we investigate how the nature of this angular momentum transport is affected by the substrate. We first examine how SiOx, SiN and SiN/SiOx layers on Si substrates impact the transport response, and then study the effect in freestanding ferromagnetic strips fully decoupled from the substrate. This allows us to separate potential dipolar from phononic contributions to the coupling between the FM strips. [1] R. Schlitz et al., Phys. Rev. Lett. 132, 256701 (2024)