MA 32: Spin Transport and Orbitronics, Spin-Hall Effects II (joint session MA/TT)

Time: Wednesday 17:30–19:00 Location: H19

MA 32.1 Wed 17:30 H19

Orbital torques and orbital pumping in two-dimensional rare-earth dichalcogenides — •Mahmoud Zeer[1,2,3], Dongwook Go[3], Mathias Kläui[3,4], Wulf Wulfhekel[5], Stefan Blügel[1], and Yuriy Yuriy Mokrousov[1,3] — [1]Peter Gr *unberg Institute, Forschungszentrum J *ulich, 52425 J *ulich, Germany — [2]Department of Physics, RWTH Aachen University, 52056 Aachen, German — [3]Institute of Physics, Johannes Gutenberg-University Mainz, 55099 Mainz, Germany — [4]Centre for Quantum Spintronics, Department of Physics, Norwegian University of Science and Technology, 7491 Trondheim, Norway — [5]5Physikalisches Institut, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany

The design of spin-orbit torque (SOT) properties in two-dimensional (2D) materials represents a key challenge in modern spintronics. We now explore ferromagnetic Janus H-phase monolayers of 4f-Eu rare-earth dichalcogenides EuSP, EuSSe, and EuSCl using first-principles calculations. Our findings reveal that these compounds exhibit substantial SOT, primarily driven by the colossal current-induced orbital response of Eu f-electrons. Additionally, the resulting orbital torques can generate strong in-plane currents of orbital angular momentum with non-trivial orbital polarization directions. These results establish f-based 2D materials as a highly promising platform for in-plane orbital pumping and SOT applications, positioning f-based 2D materials as a promising platform for next-generation orbitronic and spintronic technologies with 2D materials.

MA 32.2 Wed 17:45 H19

Orbital Topology of Chiral Crystals for Orbitronics — •Ying-Jiun Chen[1], Kenta Hagiwara[1,2], Dongwook Go[3], Xin Liang Tan[1,2], Sergii Grytsiuk[1], Kui-Hon Ou Yang[4], Guo-Jiun Shu[5], Jing Chien[4], Yi-Hsin Shen[4], Xiang-Lin Huang[5], Iulia Cojocariu[1], Vitaliy Feyer[1,2], Minn-Tsong Lin[4,6], Stefan Blügel[1], Claus Michael Schneider[1,2], Yuriy Mokrousov[1,3], and Christian Tusche[1,2] — [1]Forschungszentrum Jülich — [2]University of Duisburg-Essen — [3]Johannes Gutenberg University Mainz — [4]National Taiwan University, Taiwan — [5]National Taipei University of Technology, Taiwan — [6]Academia Sinica, Taiwan

Chirality is ubiquitous in nature and manifests in a wide range of phenomena including chemical reactions, biological processes, and quantum transport of electrons. In quantum materials, the chirality of fermions, given by the relative directions between the electron spin and momentum, is connected to the band topology of electronic states. Here, we show that in structurally chiral materials like CoSi, the orbital angular momentum (OAM) serves as the main driver of a nontrivial band topology in this new class of unconventional topological semimetals, even when spin-orbit coupling is negligible. A nontrivial orbital-momentum locking of multifold chiral fermions in the bulk leads to a pronounced OAM texture of the helicoid Fermi arcs at the surface. Our findings highlight the pivotal role of the orbital degree of freedom for the chirality and topology of electron states, in general, and pave the way towards the application of topological chiral semimetals in orbitronic devices.

MA 32.3 Wed 18:00 H19

Vectorial flow of the Berry curvature and its relation to the transport and band structure — •Jaroslav Hamrle[1,2], Ondřej Stejskal[1], Milan Vrána[2,1], and Martin Veis[2] — [1]Czech Technical University, Prague, Czechia — [2]Charles University, Prague, Czechia

Berry curvature expresses the curvature of the reciprocal space, in a similar manner as magnetic field express curvature of the real space, resulting in a curved transport of electrons in solids. Therefore, Berry curvature is a base of various lossless transport phenomena such as anomalous Hall effect, anomalous Nerst effect, orbital magnetization or electric polarization. Here, in model materials bcc Fe and Fe_3Ga, we demonstrate details of the vectorial flow of the Berry curvature (monopole source, 1-dimensional flow, 2-dimensional flow), and its relations to the band structure, orbital magnetization as well as anomalous Hall and Nerst effects.

[1] O. Stejskal, M. Veis, J. Hamrle, Sci Rep **12**, 97 (2022) [doi: 10.1038/s41598-021-04076-z]

[2] O. Stejskal, M. Veis, J. Hamrle, Phys. Rev. Materials **7**, 084403 (2023) [doi:10.1103/PhysRevMaterials.7.084403]

MA 32.4 Wed 18:15 H19

Finite-temperature transport properties of magnetic/non-magnetic alloys: trends in the longitudinal and in the transverse charge and spin currents — •Alberto Marmodoro[1], Yang Wang[2], Yuqing Lin[3], and Ilja Turek[4] — [1]Institute of Physics (FZU), Czech Academy of Sciences, Prague, Czech Republic — [2]Pittsburgh Supercomputer Center (PSC), Carnegie Mellon University, Pittsburgh, USA — [3]Mellon College of Science, Carnegie Mellon University, Pittsburgh, USA — [4]Institute of Physics of Materials, Czech Academy of Sciences, Brno, Czech Republic

Alloys composed of magnetic and non-magnetic metals exhibit non-trivial transport trends as a function of composition and temperature. The stoichiometry controls not only the Curie point, but also the slope of resistivity vs. temperature. Beside affecting longitudinal currents, this has further implications also for transverse charge and spin currents, i.e. on anomalous Hall effects [1]. We report first-principles results based on density functional theory (DFT), relativistic linear response and Green function methods based on the multiple scattering Korringa-Kohn-Rostoker (KKR) or linear muffin tin orbitals (LMTO) frameworks.

[1] "Large anomalous Hall angle in the Fe(60),Al(40) alloy induced by substitutional atomic disorder" by J.Kudrnovsky et al. PRB 101, 054437 (2020); "Exploiting Spin Fluctuations for Enhanced Pure Spin Current" by P.Wu et al. PRL 128, 227203 (2022); "Critical enhancement of the spin Hall effect by spin fluctuations" by S.Okamoto et al. Quantum Materials 29, 9 (2024).

MA 32.5 Wed 18:30 H19

Impact of the substrate on angular momentum transport between separated ferromagnets — •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] by converting a DC current at one of the electrodes to a non-equilibrium magnon accumulation. Due to dipolar and potentially phononic coupling, angular momentum is transferred to the magnonic system of the second FM electrode and measured by the inverse processes. In this work, we investigate the substrate influence on the angular momentum transport by comparing our results for SiOx and SiN layers on Si substrates. As a next step, we investigate substrate-supported strips versus freestanding strings to separate phononic contributions from dipolar coupling.
[1] R. Schlitz et al., Phys. Rev. Lett. 132, 256701 (2024)

MA 32.6 Wed 18:45 H19

Orbital Edelstein contribution to the spin-charge conversion in Germanium Telluride — •Sergio Leiva-Montecinos[1], Libor Vojáek[2], Jing Li[2], Mairbeck Chshiev[2], Ingrid Mertig[1], and Annika Johansson[3] — [1]Martin Luther University Halle-Wittenberg, Halle (Saale), Germany — [2]Université. Grenoble Alpes, CEA, CNRS, SPINTEC, Grenoble, France — [3]Max Planck Institute of Microstructure Physics, Halle (Saale), Germany

The Edelstein effect (EE) 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 reversible spin-charge interconversion [1, 2].

In this work, we investigate current-induced spin and orbital magnetization in bulk GeTe using Wannier-based tight-binding models derived from DFT calculations and semiclassical Boltzmann theory.

Employing the modern theory of orbital magnetization (MTOM), we demonstrate that the orbital Edelstein effect (OEE) entirely dominates its spin counterpart (SEE). This difference is visualized through the spin and orbital textures at the Fermi surfaces, where the orbital moment surpasses the spin moment by one order of magnitude. Moreover, the OEE remains largely unaffected when we suppress the spin-orbit coupling, highlighting its distinct physical origin compared to the SEE.

[1] D. Di Sante *et al.*, Adv. Mater. **25**, 509 (2012).
[2] C. Rinaldi *et al.*, Nano Lett. **18**, 2751 (2018).