MA 42: Spin Transport and Orbitronics, Spin-Hall Effects II (joint session MA/TT)

Time: Thursday 15:00–16:00 Location: EB 107

MA 42.1 Thu 15:00 EB 107

Controlling the Interlayer Dzyaloshinskii-Moriya Interaction by Electrical Currents — •Fabian Kammerbauer[1], Won-Young Choi[1], Freimuth Frank[1,2], Robert Frömter[1], Yuriy Mokrousov[1,2], and Mathias Kläui[1] — [1]Institute of Physics, Johannes Gutenberg University, Staudingerweg 7, 55128 Mainz, Germany — [2]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

The recently discovered interlayer Dzyaloshinskii-Moriya interaction (IL-DMI) in multilayers exhibiting perpendicular magnetic anisotropy induces a canting of spins in the in-plane direction, potentially stabilizing intriguing spin textures like Hopfions [1]. Nucleation control becomes pivotal, prompting our exploration into the impact of electric currents on IL-DMI strength–a phenomenon previously established for DMI [2]. To quantify IL-DMI, we use out-of-plane hysteresis loops, applying a static in-plane magnetic field at varied azimuthal angles. A notable observation emerges: a shift in azimuthal dependence with increasing current. This shift is attributed to an additional in-plane symmetry breaking introduced by the electrical current. Detailed fitting substantiates the presence of an additive current-induced term [3]. This unveils a practical avenue for manipulating 3D spin textures on-the-fly via a readily accessible method.

[1] Han et al., Nat. Mater. 18, 703-708 (2019)
[2] Karnad et al., Phys. Rev. Lett. 121, 147203 (2018)
[3] Kammerbauer et al, Nano Lett. 2023, 23, 15, 7070-7075 (2023)

MA 42.2 Thu 15:15 EB 107

Local violation of the reciprocity between the direct and inverse orbital Hall effects — •Dongwook Go[1,2], Tom S. Seifert[3,4], Tobias Kampfrath[3,4], Stefan Blügel[1], Hyun-Woo Lee[5], and Yuriy Mokrousov[1,2] — [1]Peter Grünberg Institute and Institute for Advanced Simulation, Forschungszentrum Jülich, Jülich, Germany — [2]Institute of Physics, Johannes Gutenberg Universität Mainz, Mainz, Germany — [3]Department of Physics, Freie Universität Berlin, Berlin, Germany — [4]Department of Physical Chemistry, Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, Germany — [5]Department of Physics, Pohang University of Science and Technology, Pohang, Korea

We theoretically investigate the reciprocity between the direct and inverse orbital Hall effects [1]. We show that the reciprocal relation between charge and orbital transport can be rigorously established by adopting the definition of the *proper* current that takes nonconservation effects into account [2]. Importantly, we find that the local reciprocity of charge and orbital currents is violated in thin films, as we demonstrate for the case of W(110) from first principles. Our results explain a seemingly inconsistent behavior of direct and inverse orbital Hall effect observed in recent experiments, where the two phenomena are found to be dominant in bulk and at surfaces, respectively [3,4]. References: [1] Go *et al.* In Preparation; [2] Shi *et al.* Phys. Rev. Lett. **96**, 076604 (2007); [3] Hayashi *et al.* Commun. Phys. **6**, 32 (2023); [4] Seifert *et al.* Nat. Nanotechnol. **18**, 1132 (2023).

MA 42.3 Thu 15:30 EB 107

Spin-orbitronics in two dimensional systems: Orbital magnetization, orbital Hall effect and orbital Edelstein effect — •Börge Göbel[1], Oliver Busch[1], Annika Johansson[2], Manuel Bibes[3], and Ingrid Mertig[1] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg — [2]Max-Planck-Institut für Mikrostrukturphysik, Halle — [3]Unité Mixte de Physique, CNRS, Thales, Paris

The orbital contribution to the magnetization is often quenched by the crystal field which is why it is typically significantly smaller than the spin contribution, in equilibrium. In this talk, I will present the generation of a large orbital magnetization and orbital currents.

In non-collinear spin textures, crystal symmetries are broken and the quenching is lifted. In topologically non-trivial skyrmion crystals, for example, the emergent field forces electrons on orbital trajectories which leads to the generation of a considerable orbital magnetization [1]. Likewise, an orbital Hall effect with orbital edge states arises in non-magnetic Kagome nanoribbons [2]. In two-dimensional electron gases (2deg), e.g. at the interface of STO/AlO [3,4] or KTO/AlO [5], the inversion symmetry is broken so that an (inverse) Edelstein effect arises. The application of a charge current leads to the generation of spin and orbital magnetization densities and vice versa.

[1] BG et al. PRB 99, 060406 (2019)
[2] Busch, Mertig, BG, PRResearch 5, 043052 (2023)
[3] Vaz, BG et al. Nature Materials 18, 1187 (2019)
[4] Johansson, BG et al. PRResearch 3, 013275 (2021)
[5] Varotto, BG et al. Nature Communications 13, 6165 (2022)

MA 42.4 Thu 15:45 EB 107

Spin Fluctuation Enhancement of Spin Hall Effect in Low-resistive Antiferromagnet — •Chi Fang and Stuart S.P. Parkin — Max Planck Institute of Microstructure Physics, Halle (Saale) 06120, Germany

The spin Hall effect (SHE) generates a pure spin current by a charge current, which is promisingly adopted to electrically manipulate magnetization. To reduce power consumption of such control, a giant spin Hall angle (SHA) in the SHE is expected in low-resistive systems for practical applications. Low resistive antiferromagnet Chromium(Cr) is reported with remarkble SHA. Here, critical spin fluctuation near the antiferromagnetic (AFM) phase-transition in Cr is proved as an effective mechanism to further create an additional part of SHE. The SHA is significantly enhanced when temperature approaches the Néel temperature of Cr and has a peak value of -0.36 near the Néel temperature. This value is higher than the room-temperature value by 153% and leads to a low normalized power consumption among known spin-orbit torque (SOT) materials. This study demonstrates the critical spin fluctuation as a prospective way of increasing SHA and enriches the AFM material candidates for spin-orbitronic devices.