

# Allgemeines Physikalisches Kolloquium

Donnerstag, 06.07.2023 um 16 Uhr c.t.

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### Dynamical spin-injection at spinorbitronic interfaces probed by THz-TDS spectroscopy

Terahertz (THz) spintronics has emerged as a prominent field at the frontier between magnetism, spintronics, and photonics. Spin-to-charge conversion (SCC) in femtosecond laser excited magnetic heterostructures may generate high efficiency and wide-bandwidth terahertz emission with a magnetically controllable polarization state<sup>1</sup>. The origin of this THz emission has been assigned to the generation of a spin-polarized current and subsequent conversion of the spin current to a transverse charge current<sup>2</sup>. Two main SCC mechanisms are generally involved: the Inverse Spin Hall Effect (ISHE) and the Inverse Rashba-Edelstein Effect (IREE).

The discovery of metallic quantum states at the surface of 3D topological insulators (TIs) has opened exciting new functionalities owing to their time-reversal symmetry property and their spin-momentum locking (SML) properties. The resulting SCC combining strong spin-orbit coupling (SOC) and SML is expected to be enhanced compared to the spin Hall effect (SHE) of heavy metals. SCC has been demonstrated in a range of Bi-based TI compounds, including bismuth selenide  $\text{Bi}_2\text{Se}_3$ , bismuth telluride  $\text{Bi}_2\text{Te}_3$ ,  $\text{Bi}_2(\text{Se},\text{Te})_3$  or  $\text{Bi}_{1-x}\text{Sb}_x$  (BiSb). To benefit fully from IREE, the charge currents should be confined in the surface states and any current flowing through the bulk states should be avoided.

In this seminar, I will report particularly on our detailed investigation of the surface state SML properties of ultrathin (111)-oriented  $\text{Bi}_{1-x}\text{Sb}_x$  epitaxial films. They exhibit a topological phase as recently confirmed by angular-resolved photo-emission spectroscopy (ARPES)<sup>3</sup> and mainly in-plane spin texture as shown by SARPES. SCC mediated by the BiSb surface states is probed at the sub-picosecond timescale. Unprecedentedly large SCC is measured with efficiencies beyond the level of carefully optimized Co/Pt systems.

## References

- [1]. Seifert T. et al., “*Efficient metallic spintronic emitters of ultrabroadband terahertz radiation*”, Nature Photon 10, 483–488, 2016.
- [2]. Dang T. H. et al., “*Ultrafast spin-currents and charge conversion at 3d-5d interfaces probed by time-domain terahertz spectroscopy*”, Appl. Phys. Rev. 7, 2020
- [3]. L. Baringthon et al “*Topological surface states in ultrathin  $\text{Bi}_{1-x}\text{Sb}_x$  layers*” Physical Review Materials 6, 074204, 2022
- [4] E. Rongione et al., “*Spin-Momentum Locking and Ultrafast Spin-Charge Conversion in Ultrathin Epitaxial  $\text{Bi}_{1-x}\text{Sb}_x$  Topological Insulator*”, Adv. Sci. **2023**, 2301124