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Hybrid Spintronics: From Field-Free Control of the Néel Vector to Spin Selectivity in Hybrid Chiral Perovskites

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Current demands on energy consumption generated by the IT industry pose significant challenges for energy-efficient data storage technologies. Spintronics aims to address this issue by searching for efficient ways to control and read out magnetic/spin states in various systems. While traditional ferromagnetic spintronic materials already form a well-established field with industrial-scale implementations such as GMR, TMR, and HDD, the manipulation of spin states in magnetic materials with antiparallel spin alignment(antiferromagnets) poses significant challenges due to the lack of net magnetization. Despite these challenges, antiferromagnets offer a unique set of properties, such as THz spin dynamics, as well as stability of information encoded in their spin state.

In my talk, I will show that the spin states (Néel vector) in antiferromagnetic compounds Mn_2Au can be controlled via the injection of current pulses, and that their spin-state configuration upon switching can be detected by various means such as optical response, magnetotransport measurements, and advanced X-ray microscopy methods (X-PEEM) [1,2].

As an alternative to magnetically ordered materials for data storage applications, we can use a novel class of hybrid perovskites in combination with different tailoring approaches. The first approach is to dope this class of semiconductors with magnetic ions or to use hybrid perovskites in combination with magnetically ordered systems such as ferromagnetic quantum dots. In the case of 3D hybrid perovskites ($MAPbBr_3$), this leads to extended light-induced spin dynamics, as well as modification of scattering processes [3]. At the same time, spin selectivity can be enabled in hybrid perovskites by using chiral molecules in combination with a 2D architecture. Such intrinsic structural spin selectivity is also imprinted in the optical response of chiral perovskites, manifesting in effects such as strong circular dichroism, circularly polarized photoluminescence under non-polarized excitation, as well as transient absorption response [4].

[1] S. Bodnar et al., *Nature Communication* **9**, 348 (2018)
[2] S. Bodnar et al., *Phys. Rev. B* **99**, 140409I (2019)
[3] J. Zerhoch, S. Bodnar et al., *J. Phys. Chem. Lett.***15** (2024)
[4] S. Liu et al., *Sci. Adv.* **9**, 5083 (2023).