On-line SPICE-SPIN+X Seminars

Wednesday, 30th March 2022, 15:00 (CET)

The seminar will be via Zoom (Meeting ID: 833 4178 9351**) and live streamed in the SPICE YouTube Channel.**

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Ultrafast optical excitation and probing of coherent antiferromagnetic spin dynamics

Antiferromagnetic spintronics present a promising approach to overcome limitations of current information technology. Owing to the vanishing net magnetization, antiferromagnetic materials exhibit spin dynamics on sub-picosecond timescales potentially allowing for not only data storage and logic circuit applications that are orders of magnitude faster than their established ferromagnetic counterparts, but also the development of new paradigms for device architectures with greater functionality. The tremendous interest in the realization of antiferromagnet-based devices has triggered an ongoing exploration of tools for controlling and manipulating antiferromagnets.

In this talk, I will present recent advances in the ultrafast optical excitation and probing of antiferromagnetic spin precessions. Based on the inverse magneto-optical effects [1,2], laser pulses can act like ultrafast magnetic field pulses, thereby enabling efficient non-thermal optical excitation of coherent spin precessions in fully compensated antiferromagnets. We show that the initial phase of the spin precession contains valuable information about the excitation, which allows us not only to distinguish between different excitation mechanisms [3], but also to reveal an ultrafast damping torque which can even become the dominant excitation mechanism in antiferromagnets [4]. The ensuing coherent spin precession leads to a transient symmetry reduction. Using symmetry-sensitive nonlinear optical probes, we track the antiferromagnetic order parameter quantitatively in three dimensions [5]. We observe a strongly elliptical precession – typical for antiferromagnetic dynamics. I will conclude with an outlook on how these results can contribute to emerging topics in ultrafast magnetization dynamics [6].

[1] A.V. Kimel, A. Kirilyuk, P.A. Usachev, R.V. Pisarev, A.M. Balbashov, and Th. Rasing, “Ultrafast non-thermal control of magnetization by instantaneous photomagnetic pulses”, Nature 435, 655 (2005).

[2] A.M. Kalashnikova, A.V. Kimel, R.V. Pisarev, V.N. Gridnev, A. Kirilyuk, and Th. Rasing, “Impulsive generation of coherent magnons by linearly polarized light in the easy-plane antiferromagnet FeBO3”, Phys. Rev. Lett. 99, 167205 (2007).

[3] C. Tzschaschel, K. Otano, R. Iida, T. Shimura, H. Ueda, S. Günther, M. Fiebig, and T. Satoh, “Ultrafast optical excitation of coherent magnons in antiferromagnetic NiO”, Phys. Rev. B 95, 174407 (2017).

[4] C. Tzschaschel, T. Satoh, and M. Fiebig, “Efficient spin excitation via ultrafast damping-like torques in antiferromagnets”, Nat. Commun. 11, 6142 (2020).

[5] C. Tzschaschel, T. Satoh, and M. Fiebig, “Tracking the ultrafast motion of an antiferromagnetic order parameter”, Nat. Commun. 10, 3995 (2019).

[6] J. Li, C.-J. Yang, R. Mondal, C. Tzschaschel, and S. Pal, “A perspective on nonlinearities in coherent magnetization dynamics”, Appl. Phys. Lett. 120, 050501 (2022)