Max-Planck-Institut für Struktur und Dynamik der Materie

Max Planck Institute for the Structure and Dynamics of Matter

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CFEL Seminar Room IV, O1.111 (Bldg. 99)

Ilie Radu

Institute for Optics and Atomic Physics, Technical University Berlin and
Helmholtz-Zentrum Berlin, BESSY II, Berlin, Germany

Exploring Ultrafast Magnetism with X-rays and THz Excitations

Controlling magnetic order on ultrashort timescales is crucial for engineering the next-generation magnetic devices that combine ultrafast data processing with ultrahigh-density data storage [1]. An appealing prospect in this context is the use of femtosecond laser pulses as an ultrafast, external stimulus to fully set the orientation and the magnetization magnitude of a spin ensemble. Achieving such control on ultrashort timescales, e.g. comparable to the excitation event itself, remains however a formidable challenge. This is mainly due to the lack of understanding the non-equilibrium behavior of the key parameters and interactions governing magnetism: the elemental magnetic moments and the exchange interaction.

Here, I report on the latest developments in our studies on ultrafast magnetism, which reveal highly unexpected and sometime counterintuitive results [2,3] by employing a novel experimental approach combining the femtosecond laser excitation with an ultrafast, element-specific X-ray probing of spins. In particular, by investigating the laser-driven magnetization dynamics in ferromagnetic and ferrimagnetic alloys and heterostructures, we demonstrate a simple but powerful way of controlling the ultrafast spin dynamics in a large class of magnetic materials.

In order to identify and disentangle the various quasiparticles (e.g. phonons, magnons) that are driving the ultrafast magnetization dynamics on ultrashort timescales, we follow a research line aiming at a resonant and selective excitation of quasiparticles using THz/mid-IR radiation and X-ray probing. Here I will present our ongoing activities along these lines showing our first results on THz-driven dynamics of magnetic oxides.

[1] A. Kirilyuk, A.V. Kimel, and Th. Rasing, Rev. Mod. Phys. **82**, 2731 (2010)
[2] I. Radu et al., Nature **472**, 205–208 (2011); C. Graves et al., Nature Materials **12**, 293 (2013)
[3] I. Radu et al. (submitted)

Host: Andrea Cavalleri

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