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Ultrafast Magnetization Dynamics in the light of fs short X-ray pulses

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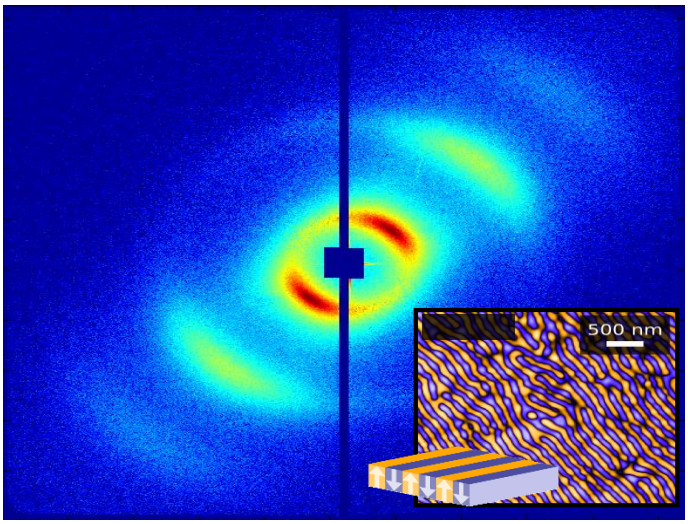
Since the discovery of the ultrafast demagnetization phenomenon by E. Beaurepaire and colleagues in 1996 [1], the field of femtomagnetism has developed to a world-wide active research area. Initial experiments relied mostly on all-optical pump-probe techniques, which raised concerns about optical artifacts hampering the data interpretation. Since these limitations can be overcome by X-ray based techniques, the advent of sources providing femtosecond short X-ray pulses was waited for by the interested community. In addition to giving access to the entire electronic structure of the valence band, X-ray techniques offer additional key advantages. First of all, this is their shorter wavelength, which matches naturally the nanometer length scales expected to be of relevance in ultrafast magnetization dynamics. Furthermore, X-ray techniques provide via the accessible core electron absorption resonances element sensitivity and offer a wide variety of magnetic dichroism effects that can be exploited as contrast mechanism, for example, in scattering experiments. This allows probing of the magnetization dynamics of individual components of complex, heterogeneous materials on the nanometer length scale.

In this talk I will review how we [2-4] (but certainly also others, e.g., Ref. [6]) have exploited the high intensity, the femtosecond short duration and the high degree of coherence of X-ray Free Electron Lasers (XFELs) to obtain novel insight into the mechanisms underlying ultrafast magnetization dynamics. In particular, I will show how the combined nanometer spatial and femtosecond temporal resolution enabled us to obtain clear evidence for the occurrence of spin transport by the hot, polarized valence electrons, a phenomenon predicted theoretically in 2010 by Battiatio and co-workers [6]. An outlook to future experimental possibilities due to the advent of more refined XFEL sources (seeding, few fs and multi-color probe pulses) will conclude the presentation.



References:
[1] E. Beaurepaire et al., Phys. Rev. Lett. 76, 4250 (1996).
[2] B. Pfau et al., Nature Communications 3, 1100 (2012).
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[6] M. Battiato et al., Phys. Rev. Lett. 105, 027203 (2010).