A soft X-ray view on ultrafast magnetization dynamics

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Abstracts: *Soft X-rays femtosecond sources are a powerful tool enabling the application of spectroscopy techniques to the study of ultrafast phenomena. Here, I will show how these sources can be applied to the study of ultrafast demagnetization to provide valuable new insights on the microscopic mechanisms governing this phenomenon.*

Since its discovery by Beaurepaire and coworkers in 1996, the phenomenon of laser induced ultrafast demagnetization has attracted world-wide attention and created an entirely new research field in magnetism. Despite nearly 20 years of ongoing experimental and theoretical research activities, the underlying mechanism of the rapid decrease of the magnetization of a ferromagnetic film on the femtosecond time scale after a femtosecond optical excitation remains debated intensively. The heart of this research is to explain this magnetization dynamics with its associated energy and angular momentum transfer between the electron/spin system and the crystalline lattice occurring on a sub-picosecond time scale. Further interest derives from the fact that this phenomenon paves the way to applications of magnetization control on the femtosecond time scale as shown by the demonstration of the all-optical magnetization reversal. This discovery could enable the realization of ultrafast magneto-electronic devices.

Typically, experiments exploring ultrafast magnetization dynamics are performed as a stroboscopic pump-probe measurement, in which the system is pushed out of equilibrium using a pulsed excitation (pump) and the subsequent relaxation dynamics is followed by applying a second pulse to determine the status of a particular property of the sample after a given delay (probe). Pump and probe are typically realized by near infrared (IR) laser pulses. However, with the advent of suitable femtosecond pulsed X-ray sources (X-ray free electrons lasers (XFELs), high order harmonic generation (HHG) or femto-slicing sources at synchrotron radiation storage rings), the application of X-ray pulses have attracted increasing attention as a probe. X-rays offer a rich variety of resonantly enhanced magnetic contrast mechanisms and thus provide an element-specific probe with remarkably higher sensitivity when compared to visible light or near IR radiation. X-rays furthermore enable experiments with sub-100 nm spatial resolution due to their short wavelength.

I will present an overview of the results we obtained on ultrafast magnetization dynamics with those sources in the past few years.