Element-selective pump-probe studies of fast magnetization dynamics using soft x-rays

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Fast magnetic switching processes are at the heart of magnetic data storage and spintronics and determine the functionality and frequency characteristics of devices. In order to push the speed of magnetization reversal to its physical limits, micromagnetic processes on the nano- and picosecond time scales need to be explored in detail. It is generally accepted now that even in confined systems the macrospin picture is often not adequate to describe the dynamic response. This is due to nonuniform magnetization distributions in the transient states or already in the ground state. In order to map the behavior of the nonuniform magnetization spatially resolved techniques are needed.

Synchrotron radiation – particularly in the soft x-ray regime – has become a very important and versatile tool in the study of static and dynamic phenomena in magnetism. Through the x-ray magnetic dichroism effects it combines high magnetic contrast, element selectivity, and intrinsic time-resolution in the picosecond regime. Employing magnetic dichroism in a photoemission microscope (PEEM) provides access to magnetization dynamics with high lateral resolution [1].

In my contribution I will discuss recent experiments on magnetization dynamics performed with the PEEM technique on different material systems. The time resolution of this imaging approach reaches down to about 10 picoseconds. The systems studied comprise polycrystalline Permalloy films, epitaxial single-crystalline Iron films, and several trilayer systems with interlayer exchange coupling. For soft magnetic films we observe a wide variety of dynamic phenomena on different length and time scales, including incoherent and coherent rotation processes [2], resonance-driven domain wall shifts [3], or the formation of precessional modes [4]. In epitaxial Fe films the magnetocrystalline anisotropy reduces the precessional motion, resulting in a stronger response of the domain walls. In interlayer-coupled trilayers, the dynamic response is quite complex and depends sensitively on the strength and character of the coupling (ferromagnetic, antiferromagnetic, or biquadratic) and may even differ for the bottom and top magnetic layer in the stack.

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