Magnetic soft X-ray spectromicroscopy: From nanoscale behavior to mesoscale phenomena

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Over the last decade magnetism research focused on a fundamental understanding and controlling spins on a nanoscale. Recently, it has been recognized, that the next step beyond the nanoscale will be governed by mesoscale phenomena [1], since those are supposed to add complexity and functionality, which are essential parameters to meet future challenges in terms of speed, size and energy efficiency of spin driven devices. The development and application of multidimensional visualization techniques, such as tomographic magnetic imaging and investigations of fast and ultrafast spin dynamics down to fundamental magnetic length and time scales with elemental sensitivity in emerging multi-component materials will be crucial to achieve mesoscience goals.

Magnetic soft X-ray spectromicroscopy is a unique analytical technique combining X-ray magnetic circular dichroism (X-MCD) as element specific magnetic contrast mechanism with a spatial (2D and 3D) resolution down to currently about 20nm. In addition, utilizing the inherent time structure of current synchrotron sources fast magnetization dynamics in ferromagnetic elements can be performed with a stroboscopic pump-probe scheme with 70ps time resolution [2,3].

To demonstrate the capabilities of magnetic soft x-ray spectromicroscopy I will review in this talk recent achievements with full-field magnetic soft x-ray transmission microscopy (MTXM). In studies of magnetic vortex structures we found a stochastic character in the nucleation process, which can be described within a symmetry breaking DM interaction [4]. With time resolved MTXM of dipolar coupled magnetic vortices an efficient energy transfer mechanism was identified, which can be used for novel magnetic logic elements [5]. Spectroscopic MTXM images allowed us to apply sum rules down to almost the current spatial resolution limit [6]. First attempts to image the 3dim magnetic domain structures in rolled-up Ni nanotubes are very promising [7].

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