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Imaging fast spin dynamics at the nanoscale with soft x-ray microscopy[1]

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Nanoscale and multicomponent magnetic systems are attracting both fundamental interest and are widely used in technological applications such as high density magnetic storage and sensor devices. The challenge to modern magnetic microscopies is to image magnetic microstructures in such specimens with high spatial and time resolution and elemental specificity. Magnetic soft X-ray microscopy is a novel technique combining a spatial resolution down to currently 15nm, elemental sensitivity due to X-ray magnetic circular dichroism used as huge magnetic contrast mechanism and a sub-ns time resolution limited by the current time structure of the synchrotron radiation used as source for circularly polarized soft X-rays. We report on recent results and achievements in magnetic soft X-ray microscopy obtained at the full-field soft X-ray microscopy beamline 6.1.2 (XM-1) located at the Advanced Light Source in Berkeley CA. Magnetization reversal processes at the grain level in a nanogranular CoCrPt system were studied with 15nm spatial resolution to obtain insight into spin fluctuations on a fundamental length scale. The inherent elemental sensitivity of XMCD contrast allows e.g. in (coupled) multilayered magnetic systems to explore their microscopic magnetization reversal process with layer resolution. Spin dynamics in magnetic nanostructures can be addressed by a stroboscopic pump and probe scheme utilizing the inherent time structure of synchrotron radiation, where the pump is a fast electronic pulse launched into a waveguide structure to excite the spin dynamics of a magnetic nanoelement. Varying the delay time between the pump and the probing x-ray flash one can follow the time development of e.g local spin and vortex dynamics and relaxation phenomena, but also spin-torque driven domain wall displacements with sub-ns time resolution. Current developments of X-ray optics aim to achieve better than 10nm spatial resolution. At upcoming high brillant ultrast X-ray sources snapshots of spin dynamics with fs time resolution recorded with magnetic soft X-ray microscopy can be foreseen. Many thanks to D.-H. Kim, B. Mesler, W. Chao, R. Oort, E. Anderson, G. Meier, R. Eiselt, M. Bolte, M.-Y. Im, S.-C. Shin, S. Mangin, E. Fullerton.

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