Time-Resolved Transmission X-Ray Microscopy

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Fast magnetization dynamics of ferromagnetic elements on short length scales is currently attracting substantial scientific interests for both technological and fundamental reasons. Measurements with a time resolution of 70-100 ps combined with a lateral resolution of 20-40 nm were performed using two different sample geometries (magnetic 'in-plane' excitation by a microcoil and 'out-of-plane' excitation by a stripline) at two different microscopes: a full-field soft X-ray microscope (XM-1, ALS beamline 6.1.2) and a scanning transmission X-ray microscope (STXM, ALS beamline 11.0.2). The scanning microscope equipped with a fast avalanche photo diode (APD) detector allowed us to speed up time-dependent measurements by about a factor of 10.

Complementary to the time-domain 'pump-and-probe' measurements [1] a frequency-domain 'sine excitation' technique [2] was implemented into X-ray microscopy. Spin precession [1] and gyrotropic vortex motion [2] in micron-sized ferromagnetic patterns have been studied. Magnetic vortices show low frequency modes, appearing as translational gyrotropic motions of the vortex when the system is excited with an in-plane sine magnetic field. This gyrotropic motion was imaged not only in Permalloy (Py), but also in Py Cu Co trilayers [3]. By tuning the photon energy to the absorption edges of Ni or Co, we could study separately the vortex dynamics in the Permalloy and in the Co layer as well as the magnetic interaction between them. The vortex structures in the Permalloy and the Co layer show the same sense of in plane flux closure and the same polarisation of the out-of–plane vortex core and thus the same handedness. But remarkable is a 180 degrees phase shift between the vortex motions of the Permalloy and the Co layers caused by the magnetic coupling between them.

[1] H. Stoll et al., *High-Resolution Imaging of Fast Magnetization Dynamics in Magnetic Nanostructures,* Appl. Phys. Lett., **84**, 3328 (2004)

[2] A. Puzic et al., *Spatially Resolved FerromagneticRresonance: Imaging of Ferromagnetic Eigenmodes,* J. Appl. Phys. **97**, 10E704 (2005).

[3] K.W. Chou et al., *Vortex Dynamics in Coupled Ferromagnetic Multilayer Structures* accepted for publication in J. Appl. Phys.