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Recent Work

Title
High-Resolution Imaging of Magnetization Dynamics Using X-PEEM

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Ultrafast x-ray pulses (p-sec to f-sec) promise to be an ideal tool to probe the dynamics of magnetic materials. X-rays are sensitive to both ferromagnetic and antiferromagnetic order. Sum rules allow us to quantify spin moment, orbital moment and magnetic anisotropy specific for each element in a sample. High spatial resolution on the order of nanometers can be obtained using x-ray microscopy techniques using zone-plates or electron microscopes.

As an example, a study of the precessional dynamics of magnetic vortices, 3-dimensional magnetic curls, will be presented [1]. The dynamics is probed at 100 nm spatial resolution and 70 ps temporal resolution using the PEEM-2 Photoemission Electron Microscope at the Advanced Light Source. It will be demonstrated that the vortex chirality or handedness, which is determined by the out-of-plane magnetization of the vortex core, governs the sub-ns dynamics of the structure, leading to a precessional motion of the vortex center. The dynamics is initiated by a sub-ns field pulse triggered by a laser, which is synchronized to the x-ray source. In contrast, on longer time scales it is known that damping dominates and the dynamics is governed by the in-plane domain structure. The measured vortex speed and the internal magnetic field at the core will be compared with the result of micromagnetic simulations and with the static susceptibility of the magnetic structure.

The potential of studying processes beyond the Landau-Lifshitz-Gilbert dynamics using currently developed ultrafast x-ray techniques will also be discussed.