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Vortex Dynamics Imaged by Time-Resolved Scanning Transmission X-Ray Microscopy.

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Substantial progress in the understanding of magnetic vortex dynamics has been achieved by implementing 100 ps time-resolved magnetic imaging techniques into a Scanning Transmission X-Ray Microscope (ALS, Berkeley, BL 11.0.2) with a lateral resolution of 20-40 nm. Gyrotropic vortex motion excited by in-plane alternating magnetic fields was studied in micron-sized ferromagnetic vortex structures.

The vortex core, extending over a range of about 20 nanometers in the center of a vortex structure, plays a key role in vortex dynamics. We have been able to perform time-resolved imaging of the out-of-plane magnetization distribution of the excited vortex core. In addition, we have discovered new switching schemes to change the direction of the vortex core polarization in micron-sized ferromagnetic vortex structures, either (i) by altering the amplitude of an alternating magnetic field at a frequency close to the eigenfrequency of the gyrotropic vortex motion or (ii) by applying a short burst (e.g., one single period) of ac magnetic fields [1].

Magnetic vortex cores have already been discussed as candidates for magnetic data storage, but for the switching of their polarization large magnetic fields in the order of half a Tesla were required so far. The vortex core reversal schemes presented here need significantly lower magnetic fields (down to a few mT). The switching mechanism as reproduced by micromagnetic simulations [1] involves: (i) creation of a vortex–antivortex pair, both with opposite polarisation and (ii) annihilation of the antivortex with the original vortex. At the end a vortex with opposite polarization remains.

[1] B.Van Waeyenberge, A.Puzic, H.Stoll et al., *Magnetic vortex core reversal by excitation with short bursts of an alternating field*, Nature, Nov.23 (2006)