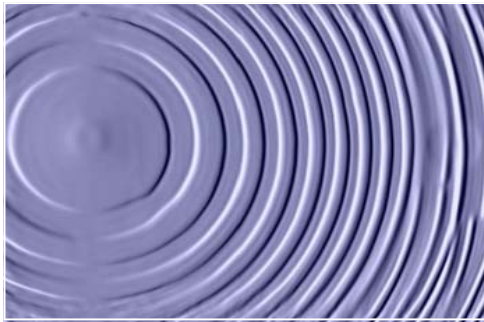




Imaging of magnetization dynamics Using x-ray microscopy

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The dynamics of nanoscale magnetic structures are of both fundamental interest and primary importance for devices that incorporate nanomagnets into high-speed electronics. One of the principal questions is the behavior of magnetic vortices. A magnetic vortex is a flux-closure state arising in micron- and submicron-sized ferromagnetic disks that consists of a circulating in-plane magnetization and an out-of-plane vortex core. Vortices have polarity, and therefore are potential memory devices. They also exist in magnetic domain walls, and thus govern magnetization reversal, and offer insight into magnetization dynamics on a fundamental level. Recently, time-resolved x-ray microscopy techniques have become available at synchrotron light sources that allow unprecedented insight into the dynamics of these nanoscale magnets. We use time resolved x-ray photoemission electron microscopy to image the response of micron-scale patterned $\text{Ni}_{80}\text{Fe}_{20}$ disks to fast magnetic field pulses. We have imaged the undriven relaxation of a displaced magnetic vortex core in 6 nm disks after a field pulse. We find a strong dependence of the core relaxation behavior on the excitation amplitude, and a link to reversals of the core polarity. Below a critical field amplitude of ~ 2.5 mT, the core follows the expected spiral motion towards the center of the disk with an oscillation frequency in agreement with theoretical predictions of the lowest frequency eigenmodes. However, above the critical field the trajectory of the core is dependent on the excitation amplitude, with elliptical trajectories appearing as the field is increased. The observed elliptical trajectories turn out to be associated with transient magnetic domain states that appear in the first 300ps of the core relaxation. These arise as a result of non-linear effects that become significant when the core is displaced more than 20% of the disk radius. These states are associated with distortions of the core and vortex anti-vortex pairs that promote multiple core polarity reversals, and profoundly influence the core motion.

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