MAGNETIZATION DYNAMICS WITH X-RAYS

H.C. Siegmann

Stanford Linear Accelerator Center, Stanford University

Changing the direction of magnetization is the basic process in key technologies such as magnetic recording or electric transformers. Today's most advanced technologies for magnetization switching are limited to about 1 nanosecond (ns). Scientific experiments on ferromagnets have been carried out on the femtosecond (fs) time scale by use of lasers but the results are controversial. Experiments to determine the motion of the magnetization vector **M** on the fs time scale are therefore one of the most challenging issues in modern magnetism. They are expected to open a new field of research with significant technological impact in the areas of magnetic recording and spin electronics.
The pathway of the endpoint of the vector **M** on the sphere of Poincaré is determined by the precessional torque and the damping torque according to the Landau-Lifshitz (L-L) equation. We discuss the basic processes leading to relaxation of the spin polarization in ferromagnetic metals together with the existing experimental techniques from which the existing knowledge has been obtained. The damping torque is not well understood at the atomic level in nanomagnetic structures. It has been suggested that it depends on the nature of the paramagnetic/ferromagnetic interface, and that even its sign may be varied by injecting spin polarized electrons opening innovative approaches to magnetization reversal and faster as well as smaller bits in magnetic recording.
We present recent experimental results on magnetization switching in high density magnetic recording materials using the ultrafast magnetic field pulses at amplitudes in the Tesla-range produced by the relativistic electron bunches from the SLAC-Final Focus Test Beam Facility. We discuss the prospects of measuring the pathway of **M** at a time resolution of 100 fs by coherent scattering of pulsed polarized x-rays near the 2p-3d resonance of the ferromagnetic transition metals (near 800 eV). The ultrafast magnetic field pulses of a strength sufficient to set **M** in motion in realistic materials may be produced by current pulses passing through a strip line at variable time intervals prior to the arrival of the x-ray pulse. Simulations with the L-L-Gilbert equation demonstrate the wealth of new knowledge expected from this type of experiment.