X-Ray Studies of the Ultrafast Magnetic Nanoworld

Joachim Stöhr

Stanford Synchrotron Radiation Lightsource
Stanford University, Stanford, California, USA

Starting in the late 1980s the field of magnetism has undergone a revolution that is based on spin engineered nanostructures, which among other advances led to the discovery of the giant magneto-resistance effect, honored with the 2007 Nobel Prize in Physics. About the same time, x-ray based techniques were developed that through control of the polarization and photon energy offered large magnetic effects. Such resonant x-ray absorption and scattering techniques have since challenged the prominence of conventional magnetism tools like optical photons and neutrons. X-ray techniques offer large cross-sections, are element and chemical state specific, can be carried out in surface and bulk sensitive modes, and in conjunction with microscopy provide nanoscale magnetic maps. Most importantly, in the era of "smaller and faster", pulsed x-rays provide information of magnetization dynamics on the picosecond time scale with conventional synchrotron radiation sources, and the advent of the first x-ray laser at Stanford in 2009 will enable femtosecond snapshots of the ultrafast magnetic nanoworld.

This talk will review various x-ray imaging techniques for magnetism and present applications to modern problems in magnetism.* An example is the direct observation of the complex temporal evolution of spin torque switching in magnetic nanodevices. In the latter case, the picosecond evolution of the non-uniform magnetization triggered by an injected spin polarized current pulse is directly observed through an x-ray movie. Finally, a brief outline of future developments will be given.

*J. Stöhr and H. C. Siegmann, *Magnetism: From Fundamentals to Nanoscale Dynamics***,** Springer 2006