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Time resolved Scanning X-ray Microcopy of Magnetic Nano Structures

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Pump and Probe dynamic imaging utilizing the stroboscopic nature of synchrotron light as probe is a powerful tool for investigation of magnetization dynamics. To utilize this method we have built, and since 2010 put in user operation, a soft x-ray transmission microscope at an APPLE II undulator beamline at BESSY II. It combines spatial resolutions of up to 15 nm (limited by zone plate optics) and time resolutions down to 40 ps (limited by synchrotron pulse lengths).

Sophisticated photon detection and sorting hardware and fast APD point detectors that can operate at 500MHz photon rates not only allow time-resolved measurements using the complete filling pattern of the synchrotron, but also make every synchrotron bucket contribute to each time channel equally and interleaved, yielding shot-noise limited fidelity for dynamic acquisitions.
The pump is performed using linear and rotating magnetic fields created by currents through striplines, where synchronization hardware can provide repetition rates from the 400KHz to 30GHz with both RF and patterned excitation shapes.

The unique combination of time and spatial resolution and high magnetic sensitivity of XMCD make this method perfectly suited to cover a wide range of magnetic phenomena, as we will present in examples. In particular we will demonstrate results of imaging intense and fast propagating spin-waves (vg > 1 km/sec) with sub 100 nm wavelength, which are expected play a key role for the realization of future magnonic nano devices.

Finally we will illustrate how time resolved STXM as a brilliance limited technique can profit from future high brilliance light sources compared to current 3rd generation storage rings.

Summary

We present the method of time resolved magnetic microscopy using a pump-and-probe setup at a scanning transmission x-ray microscope, and illustrate its capabilities with experiments investigating a variety of dynamic magnetic effects including domain wall movement, vortex core switching and direct imaging of spin-wave propagation. This is accompanied by an outlook of using this method at high brilliance sources for better imaging capabilities.

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