Combining high time and spatial resolution of magnetic microscopy with X-ray ptychography

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Transmission X-ray Microscopy (TXM) and its scanning counterpart, STXM, are widely used to perform magnetic microscopy of nanomagnetic systems when combined with X-ray Magnetic Circular Dichroism, XMCD [1]. Their main assets are good spatial resolution (≈25 nm), versatility of sample environment incl. absence of perturbation from applied magnetic fields, easiness of sample preparation and electrical connection to conduct spintronic experiments. STXM is easily combined with time resolution, owing to the existence of fast detectors [2]. More recently, ptychography has been increasingly implemented at STXM end stations, making use of a reconstruction algorithm to process a 2D set of 2D scattering patterns and deliver a real-space image with spatial resolution below 10 nm [3]. However, it cannot be combined with time resolution as easily as STXM, as cameras cannot be blanked and read at sub-GHz frequency.

Here, we report the implementation of time-resolved XMCD ptychography imaging at the HERMES beamline of SOLEIL synchrotron. We phase-locked an electric excitation sent to a sample with the RF clock of the synchrotron ring, using an arbitrary wave generator, so that the sample is expected to be in the same state for every bunch. A 5D series of data is acquired, consisting of a phase (time)-series of the usual 2D set of 2D scattering patterns, from which a movie of magnetic images is reconstructed. We have been able to follow several important dynamical phenomena at a sub-100 ps time and sub-10 nm length scale, such as coherent reversal, domain-wall motion, ferromagnetic resonance and spin waves emitted from wiggling domain walls. This has been demonstrated on electrically-contacted electroplated permalloy nanowires with diameter 200 nm, whose Œrsted field arising from the charge current flowing in the wires is the source of excitation, taking the form of a radio-frequency sine waveform.

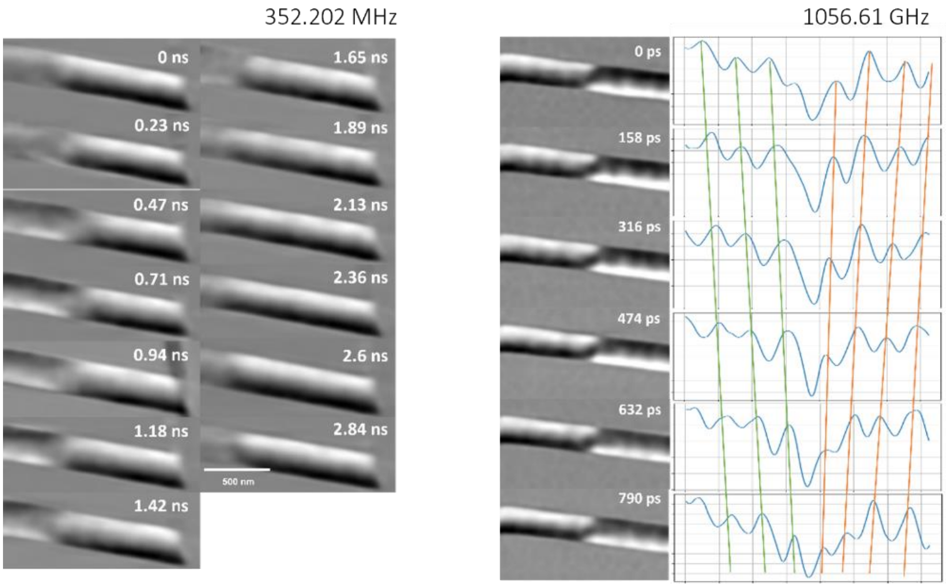

Figure 1. Time-resolved domain-wall motion (left) and spin-wave emission (right) in a 200 nm-diameter permalloy nanowire.

References

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