Nanoscale Magnetic Imaging Using High-Harmonic Radiation

S Zayko¹, O Kfir¹, M Heigl², M Sivis¹, M Albrecht³, and C Ropers¹

¹IV. Physics Institute, University of Göttingen, Göttingen, Germany. Contact Phone: +49551395113
²University of Augsburg, Augsburg, Germany
³Institute of Physics, Augsburg University, Augsburg, Germany. Contact Phone: +49551395113
Contact Email: szayko@gwdg.de

High-harmonic generation (HHG) has opened up a possibility to obtain femtosecond pulses of coherent extreme-UV radiation on a table-top. The accessible spectral range and exceptional spatial coherence makes HHG a formidable source for lensless imaging with high spatial and temporal resolution as well as elemental specificity [1-4]. However, imaging of magnetic features remained challenging, mainly due to poor scattering efficiency and a requirement for a controllable circular polarization. Here, we use and a novel scheme for generation of circularly polarized harmonics [5] together with an advanced detection mechanism for enhancement of weakly scattering signals and demonstrate the first magnetic imaging using high-harmonic radiation [3]. We illuminate Co/Pd multilayer structures with circularly polarized harmonics, and record the far-field intensities on a CCD camera. Magnetic contrast is provided by recording the separate scatter patterns of left- and right-handed circularly polarized 38th harmonic order, near the cobalt M-edge (59 eV, 21 nm). Using a combination of Fourier transform holography and iterative methods for coherent diffractive imaging the complex waves exiting the sample are robustly reconstructed for the two illuminating polarizations. Thus, the magnetic signal (x-ray magnetic circular dichroism) can be isolated from non-magnetic contributions as well as from high-frequency modulations inevitably appearing at the exit surface due to propagation effects within the sample at the extreme-UV frequencies – waveguiding and edge-diffraction [2,6]. The high spatial and temporal coherence of our source, combined with the interferometric enhancement of weak scattering signals, allow us to perform diffraction limited imaging with spatial resolution at- and below the illuminating wavelength – down to 19 nm. This work enables in-house magneto-optical microscopy at the nanoscale and paves the way towards spatially-resolved and element-specific femtosecond movies of ultrafast spin dynamics.

References


