Lensless Imaging of Magnetic Domains: From Switching Bits to Femtosecond Snapshots

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I will discuss the potential for magnetism research at soft x-ray FELs utilizing lensless imaging based on coherent scattering. The starting point is very favorable: magnetic phenomena span all lengthscales from the interatomic to the macroscopic realm, with many intriguing effects specifically on the nm scale. In the temporal domain, phenomena on the femtosecond and picosecond time scale are intrinsic to magnetic systems. Very adequately, FELs deliver sub-ps pulses with wavelengths and flux densities that will give access to the nm spatial regime with fs temporal resolution. Finally, the x-ray pulses are powerful probes of local magnetic properties via resonant scattering giving rise to XMCD and XMLD - especially if full polarization control is available as foreseen for FERMI@elettra.

Lensless imaging via holography and/or iterative phase retrieval exploits the coherence of FEL pulses to reconstruct an image of a magnetic specimen without sophisticated optical elements and directly benefits from the high brightness of the new x-ray sources. As a basis to discuss future research at FELs, I will present examples from magnetic imaging and scattering obtained today. Holographic imaging of the magnetization in bit patterned magnetic media allows observing switching processes in external magnetic fields in a quasistatic way. Domain dynamics with a few ps time resolution is in principle accessible (for repetitive processes) in such and similar experiments at ring-based SR sources today. As a first step towards the intrinsic fs-timescale of ultrafast demagnetization and all-optical switching, I will present first studies at FLASH on pump-probe magnetic scattering at the Co M and L edges of multilayer systems. Finally, recent FEL-specific method developments for ultrafast holographic imaging are presented.