Domain-wall dynamics in functional magnetic multilayers

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Nanometer-scale spin configurations such as magnetic domains walls (DW) or skyrmions are attractive as information entities for spintronic applications as they can be generated and manipulated by electrical spin-polarized currents. Naturally, the function of such devices is crucially determined by the thermal stability of the magnetic configuration used for encoding the information. In our study, we have investigated thermally activated magnetic DW dynamics in equilibrium on timescales ranging from sub-seconds to hours in a thin-film magnetic multilayer that was already successfully used to demonstrate the basic operation of a skyrmion-based racetrack memory [1]. For our investigations, we developed a new experimental approach combining real-space imaging via Fourier-transform holography [2] and x-ray photon correlation spectroscopy [3]. Both methods rely on detecting coherent far-field diffraction from a disordered sample—a pattern of magnetic up and down domains in our case. Magnetic contrast is achieved by tuning the wavelength of circularly polarized x-rays to the Co L_3 absorption edge (1.6 nm). For slow timescales (> 3 min), the analysis is based on the difference of scattering patterns recorded with opposite x-ray helicity (Fig. 1a). On one hand, the Fourier inversion of this difference results in a real-space image of the domains in the field of view (FOV) defined by a circular optics mask on the sample (Fig. 1b). On the other hand, we use the difference as input for an adapted temporal correlation analysis. Already at slightly elevated temperatures (310 K), the resulting two-time correlation function of the magnetic configuration at times t_1 and t_2 (Fig. 1c) reveals time periods of high correlation, *i.e.*, high stability interrupted by sudden extensive domain rearrangements as witnessed by the related images. This kind of intermittent dynamics reflects the complex energy landscape of the system. We further achieved access to much shorter timescales by using data from single acquisitions recorded at 2.5 Hz repetition rate for one helicity only.

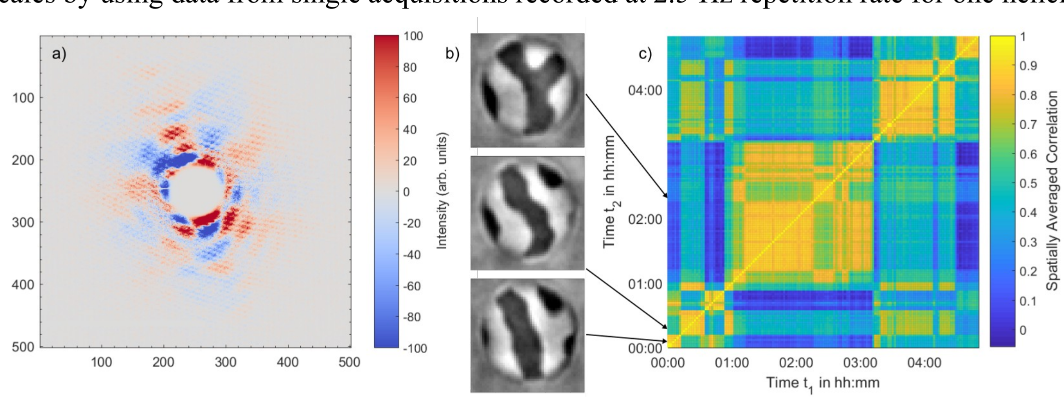

Fig. 1: a) Difference of diffraction patterns recorded with opposite helicity. b) Real-space images of the domain patterns taken with x-ray holography. FOV is 0.72 µm in diameter. Arrows indicate time of image acquisition. c) Two-time correlation function of the magnetic-domain configuration inside the FOV at 310 K.

References:

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