3D magnetic reconstruction of non-trivial spin textures from simulated dichroic soft X-ray transmission tomography

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Traditionally, magnetism has been linked to the imaging and study of magnetic domains within ferromagnets as their behavior is critical to understand the magnetic properties of the systems under investigation [1]. Nowadays, with the increased complexity of the magnetic textures to be used in Spintronics [2] and at the beginning of the novel field of 3D Nanomagnetism [3], magnetic imaging techniques face the challenge of moving from the characterization of magnetization textures in planar systems to the study of complex 3D magnetic configurations within heterostructures and 3D nanomagnets. In this framework, magnetic X-ray transmission tomography is an excellent tool which allows the user to reconstruct the full magnetization configuration within the volume of the sample with high spatial resolution [4,5].

In this work we have reconstructed the complex magnetization configuration of a Ni₈₀Fe₂₀/NdCo₅/Ni₈₀Fe₂₀ heterostructure by micromagnetically solving its magnetic state and simulating dichroic soft X-ray transmission tomograms of the system. Several interesting magnetic singularities appear as a result of the weak perpendicular magnetic anisotropy character of the NdCo₅ magnetic layer [6]. First, a stable 3D magnetic configuration at the beginning of the in-plane reversal of the multilayer is simulated using the Mumax3 code [7]. Then, soft X-ray transmission microscopy tomograms at the Fe L₃ edge are calculated from the micromagnetic simulations to get access to the vortex-antivortex pairs present in top and bottom magnetic layers. Finally, the magnetization configuration is reconstructed using the method reported in ref. [5] and compared with the original simulated textures.

The reconstructed configuration shows good agreement with the simulated micromagnetic ground truth proving the capability of reconstructing complex 3D non-trivial spin textures with in-thickness resolution. The results show the potential of the technique as a unique tool for the magnetic 3D characterization of arbitrary systems and heterostructures which is of great interest for Spintronics and 3D Nanomagnetism.
Figure 1. a) Scheme of the magnetic heterostructure. Top and bottom layers indicate where the magnetization slices for the Simulation/Reconstruction comparison were taken. b) 3D representation of the overall magnetization configuration in the heterostructure. c) Simulated and Reconstructed magnetization components for top and bottom layers of the heterostructure.

References:


