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Unrevealing the 3D magnetic configuration of nanostructures via x-ray microscopy

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Nanomagnetism is nowadays expanding into three dimensions, triggered by the discovery of new magnetic phenomena and their potential use in applications. This shift towards 3D structures should be accompanied by strategies and methodologies to map the tridimensional spin textures associated. Different lab-microscopy techniques like magnetic force microscopy can be used to explore the magnetic configuration of these nanoobjects. However, these techniques normally do not provide us with information about the 3D configuration of the magnetic moments, which could be crucial in many cases. In this work we combine the use of XMCD-PEEM, X-ray transmission microscopy and micromagnetic simulation to obtain 3D information of the magnetic configuration of in-situ grown single crystal nanometer-thick magnetite islands [1,2] and of magnetic nanowires [3,4].
The experiments have been performed at the CIRCE and MISTRAL beamline of the Alba synchrotron. CIRCE beamline is equipped with a photoemission microscope in which, by taking XMCD images, is possible to acquire nanometer resolution maps of the magnetization of nanosystems. Combining measurements at different azimuthal angles, the full magnetization vector can be determined. MISTRAL beamline is equipped with a transmission X ray microscope operating in the soft X ray range that utilizes photons extracted from a bending magnet source. The angle of the X ray beam with respect to the normal direction to the membrane could be varied by rotating the sample around a vertical axis, typically from +55◦ to−55◦ which allow the acquisition of multiple projections of the magnetization to reconstruct the 3D magnetization. Combining the experimental magnetization maps with micromagnetic simulations, the magnetic configuration of the systems can be completely determined. We will show how the combination of XMCD-PEEM, TXM with imaging and data analysis is a very powerful tool for the study of magnetic configurations of nanometer sized objects.

[1] S. Ruiz-Gómez et al. Nanoscale, 10 (2018) 5566.
[2] A. Mandziak et al. Sci. Rep. 8 (2018) 17980.
[3] S. Ruiz-Gómez et al. Nanoscale, 12 (2020) 17880.
[4] S. Ruiz-Gómez et al. Sci. Rep. (2018) 16695.

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