X-ray magnetic circular dichroism as a tool to investigate magnetic nanostructures.

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Abstract

Chiral magnetic structures induced by Dzyaloshinskii-Moriya interaction (DMI) [1] have been proposed as the cornerstone of new technology applications such as high-density data storage devices or neuromorphic computing [2], due their room temperature stability and efficient current induced motion. Given the size and the in-depth complexity of these structures, techniques such as MFM or MOKE are often not enough to study and characterize them completely. In this sense, X-ray magnetic circular dichroism (XMCD) is a powerful tool to study chiral magnetic structures, with element specificity, nanometric resolution, and with access to the magnetism buried underneath the surface.

In this talk we present the use XMCD as a tool to investigate the properties of chiral magnetic structures by using two experimental setups: x-ray holography, HERALDO, in transmission mode and X-ray resonant magnetic scattering in reflection mode. In one hand, we use HERALDO to image and study the out-of-plane field dependence of a skyrmion array hosted in a ferromagnetic multilayer with perpendicular magnetic anisotropy (PMA) engineered to obtain skyrmion sizes down to 20 nm. In the other hand, we use small angle reflectivity XRMS to directly reveal the chiral properties of ferromagnetic (FM) and synthetic antiferromagnetic multilayers (SAF) with tailored magnetic chiralities driven by spin-orbit-related effects at interfaces [3,4]. We show that it can straightforwardly and unambiguously determine the main characteristics of chiral magnetic distributions in perpendicularly magnetized multilayers [3]: its chiral nature, the quantitative winding sense (clockwise or counterclockwise), and its type, i.e. Néel (cycloidal) or Bloch (helical). In the FM systems we prove that this approach combined with micromagnetic simulations reveals hybrid chiral spin texture in multilayers [4]. In the SAF systems, we can sense independently the spin spiral chirality in each magnetic layer coupled antiferromagnetically, where we studied the robustness of these magnetic configurations in temperature.

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