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Correlating Magnetic Anisotropy and Electronic Structure in Complex Oxides Thin Films.

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Tailoring magnetic anisotropies is of critical importance for the optimization of novel memory and sensor devices for future use in information storage and processing technology. Since engineered magnetic nanostructures typically consist of several layers with distinct magnetic characteristics access to element-specific information about the magnetocrystalline anisotropy energy (MAE) is essential. MAEs can be determined quantitatively employing a theoretically derived sum rule for x ray magnetic linear dichroism (XMLD) [1] connecting the integrated intensity of the XMLD signal with the spin-orbit anisotropy and hence the MAE. Moreover, integration and proper normalization of x ray magnetic circular dichroism (XMCD) spectra allow quantifying the anisotropy of the orbital moment, *L*, which determines the easy-magnetization direction [2]. While the values derived for the MAE using the XMCD and XMLD sum rules agree rather well with each other, the analysis gives energy values larger by a factor of 10 to 50 compared to macroscopic measurements such as magneto-optical Kerr effect and ferromagnetic resonance [3]. This suggests that the approach of using soft x ray dichroism techniques for the element-specific study of the MAE requires further refinement. We aim to evaluate the influence of the crystal electric field and the orbital moment, *L*, on the spectral shape and angular dependence of the XMCD signal in order to elucidate the origin of the magnetocrystalline anisotropy.

We have measured the angular dependence of the Mn $L_{3,2}$ XMCD signal from $MnCr_2O_4$ and $MnFe_2O_4$. The XMCD signal was determined for a fixed angle of x ray incidence while varying the angle φ of the magnetic field relative to the x ray beam. A very strong variation of the XMCD spectral shape with angle φ is observed. For $MnCr2O_4$, in transverse geometry, i.e. φ = 90°, the XMCD spectral shape resembles the derivative of the XMCD signal observed for φ = 0°. Applying the sum rule suggests a vanishing orbital moment, *L*, for φ = 90°. However, in a comparable data set obtained on $MnFe_2O_4$ exhibiting an in-plane easy axis the angular dependence is distinctly different. For φ = 70° the XMCD signal resembles the derivative of the XMCD spectrum observed for φ = 0°. This indicates that a careful study of the angular dependence of the XMCD signal can provide the means to determine the angle of *L* = 0° and ultimately the anisotropy of the orbital magnetic moment with great precision.

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