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Anisotropic x ray magnetic linear dichroism and its meaning for the interpretation of soft x ray dichroism spectra

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To be able to engineer magnetic nanostructures comprised of multiple layers with very different magnetic characteristics for device applications in information storage technology, requires the precise determination of the spin structure in heteromagnetic nanostructures. Soft x ray magnetic dichroism spectroscopies play an ever increasing role in improving our understanding of complex magnetic nanostructures since these techniques provide elemental and chemical site-specific magnetic information with high sensitivity and tunable probing depth. X ray spectromicroscopy techniques such as photoemission electron microscopy (PEEM) add spatial resolution down to a few nm. It is clear that using spectroscopic information for magnetometry and magnetic microscopy, i.e., to determine the alignment of magnetic moments relative to the crystal axes and to image domains, requires the detailed knowledge and theoretical understanding of spectral shape and magnitude of dichroism signals as well as their dependence on the relative orientation of polarization, external field, and crystallographic axes.

In this presentation we will discuss the first observation as well as accurate theoretical description of anisotropic x ray magnetic linear dichroism (XMLD) at the transition metal $L_{2,3}$ edges in Fe_3O_4, $CoFe_2O_4$, $NiFe_2O_4$, and NiO and the rare earth $M_{4,5}$ edges in EuO. We show unambiguously that − contrary to common belief − spectral shape and magnitude of the XMLD is not only determined by the relative orientation of magnetic moments and x ray polarization but that their orientation relative to the crystallographic axes has to be taken into account. The XMLD angular dependence reflects the symmetry of the crystal field and can be well reproduced using atomic multiplet theory.

The observed anisotropy of XMLD is indeed a general phenomenon and is expected in any magnetic system. Consequently, conclusions based on the interpretation of XMLD spectra without accounting for the XMLD anisotropy have to be reconsidered. We will revisit some of the previous experimental results and reinterpret the experimental data based on our findings.

References: E. Arenholz *et al.*, *Phys. Rev. B* **74**, 094407 (2006); *Phys. Rev. Lett*. **98**, 197201 (2007).
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