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**IT-5-P-1826 Orientational dependence of EMCD signals of hcp Co with strong magnetocrsytalline anisotropy**

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Electron magnetic circular dichroism (EMCD) is an electron spin-related property of ferromagnetic samples revealed as the difference of the EELS inner shell spectra measured at two specific positions on the diffraction plane [1]. EMCD at transmission geometry can be advantageous to the X-ray counterpart, XMCD, in spatial resolution and probing bulk properties since the $L_{2,3}/M_{4,5}$ white-lines of transition metals/rare earth elements, to which the sum rule is applicable, are located in the soft X-ray energy region. For these advantages, a number of experimental schemes have been proposed for better quantitative measurement and higher spatial resolution [2].
In the intrinsic EMCD experimental scheme, with magnetization of a crystalline sample aligned along the strong magnetic field of the objective lens, the symmetric two- or three-beam condition is required [1]. The dichroic signal, Δσ, is acquired as the difference between the two ELNES spectra measured at the two positions, A and B (Fig.1-(a) and (b)). According to the inversion sum-rule [3], the dichroic signal intensity is approximately proportional to $(\boldsymbol{q}\times\boldsymbol{q}')\cdot\boldsymbol{M}$ , where $\boldsymbol{q}$ and $\boldsymbol{q}'$ are the inelastic scattering vectors respectively pointing from **O** and **G** to the two detector positions lying on the Thale circle (cf., Fig. 1), and $\boldsymbol{M}$ is the magnetization of the sample. The measured signal intensity is proportional to $\boldsymbol{M}\cdot\boldsymbol{H}$ ($\boldsymbol{H}$: external magnetic field, parallel to the optic axis) if the direction of $\boldsymbol{M}$ is not fully saturated in the direction of the external magnetic field, which has not yet been experimentally exploited.
We measured EMCD signals of $L_{2,3}$ in hcp Co, a hard magnet, exhibiting relatively larger magnetocrystalline anisotropy. A thin sample was prepared by electrochemical polishing. In Fig.2-(a) and (b) are shown spectra collected at the two different geometries of Fig.1-(a) and (b), where the optical axis is nearly parallel and perpendicular to the [001] easy magnetization direction of hcp Co with the low-order systematic row excitation conditions. The spectral intensities are normalized by the $L_3$ peak collected at the detector position A. The magnetic dichroism is clearly enhanced in the geometry (a), compared to (b), confirming the unsaturated magnetization along the external magnetic field.
Moreover, a theoretical simulation [3] predicts that with the specific EELS detector positions on the three-beam condition the spin moment in the plane normal to the optical axis can be probed, the trial of which is also presented.
References
[1] P. Schattschneider *et al. Nature* **441**, 486 (2006)
[2] S. Muto *et al., Nature Commun.*, **5**, 3138 (2014): doi:10.1038/ncomms4138
[3] J. Rusz *et al., Phys. Rev. B* **84**, 064444 (2011)

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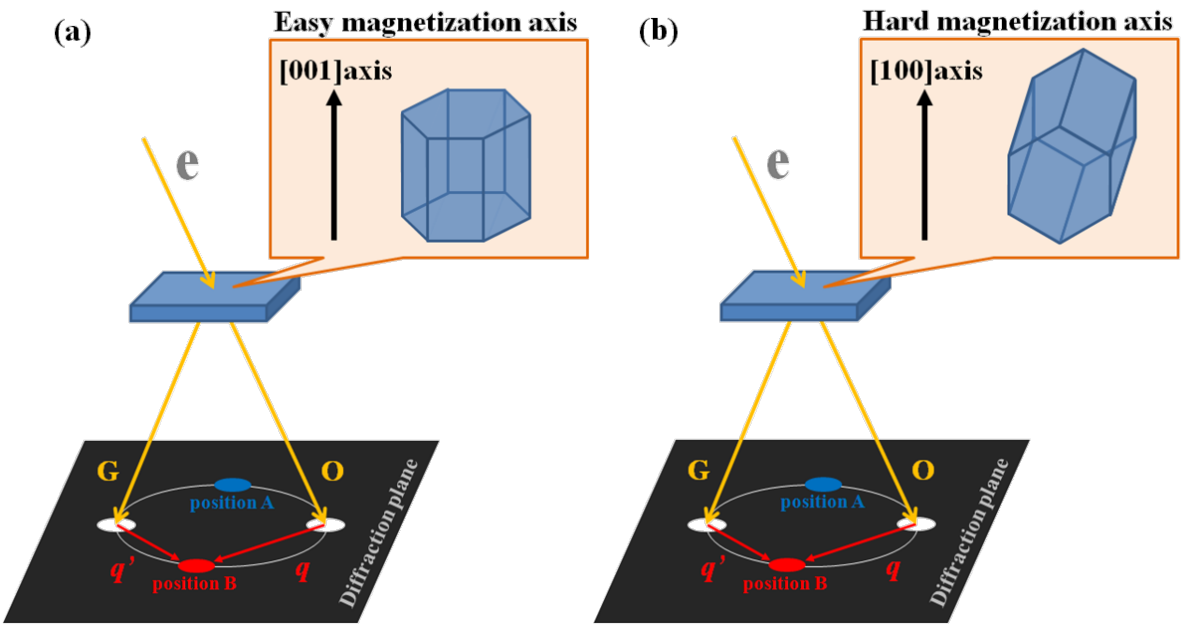


Fig. 1: Schematics of two experimental geometries in the present study. Optical axis is nearly parallel (a) and perpendicular (b) to easy magnetization axis, respectively.

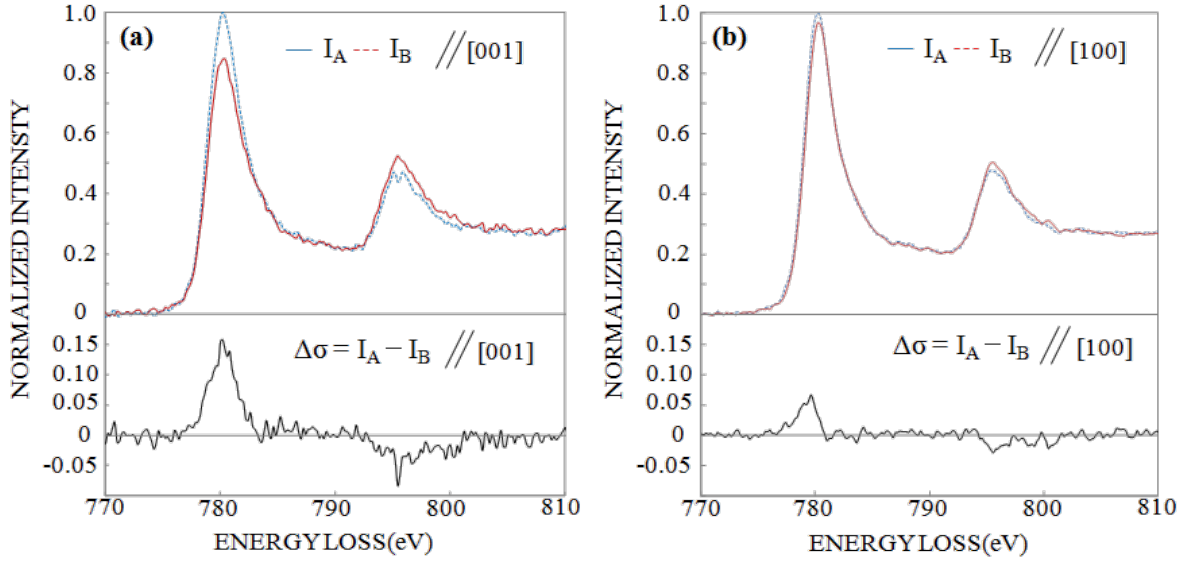


Fig. 2: Experimental Co-$L_{2,3}$ ELNES and difference spectra respectively corresponding to geometries (a) and (b) in Fig. 1.