

Magnetic circular dichroism of hard x-ray non-resonant Raman Scattering at transition metal L-edges

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Recently, Hiraoka et al. have successfully observed the magnetic circular dichroism (MCD) of hard X-ray Raman scattering (XRS) spectra at iron L-edge from pure ferromagnetic iron[1]. The MCD-XRS technique is expected to become one of the useful spectroscopic tools as well as MCD-XAS, particularly, in the extreme conditions. Following the derivation of the formula for elastic x-ray magnetic scattering[2] and paying attention to the energy loss in the inelastic scattering, we have derived the scattering formula for MCD-XRS. Within the dipolar and spherical approximation, we compare the calculated and observed spectra at iron L-edge. The formula consists of the terms corresponding to the charge (Thomson) (C1), electric (E1), orbital magnetic (OM1) spin magnetic (SM1) scattering processes. We note that the E1 process is absent in the elastic magnetic scattering. The C1 scattering mostly gives the total XRS intensity. The MCD appears due to the interference between C1 scattering amplitude and the others. The C1-E1, C1-OM1 and C1-SM1 cross terms contribute to the MCD signal depending differently on angle α_M between the incident wave vector and the magnetization vector. At $\alpha_M = 0^\circ$, the SM1 scattering is suppressed, and E1 scattering plays central roles, so that the MCD spectrum becomes similar to the MCD-XAS spectra. At $\alpha_M = 135^\circ$, the E1 and OM1 scatterings are suppressed, and the SM1 scattering plays crucial roles. As a result, the magnitude of the MCD signal turns out to be proportional to the spin density of states projected onto the 3d states at the scattering site in the unoccupied state. Consequently, the value of the integrated MCD signal simply over the L2 and L3 region is proportional to the local 3d spin moment.

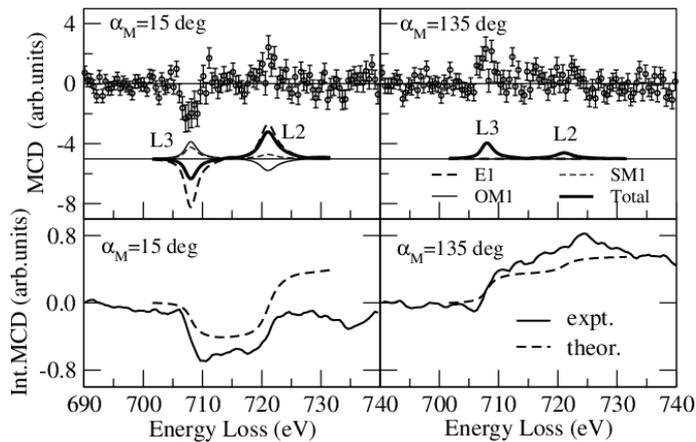


Figure 1: Upper and lower panels show the MCD spectra and the integrated MCD spectra at $\alpha_M=15^\circ$ (left) and 135° (right). In the upper panels, the circles with error bar indicate the observed MCD signal. The lines, which are shifted downwards for easy comparison, are calculated scattering intensities within the spherical approximation.

References

- [1] N. Hiraoka, et al., PRB91, 24112(2015)
- [2] M. Blume and D. Gibbs, PRB37, 1779(1988)

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