Complete Magneto-Optical Description of Fe Near Its $L_{2,3}$ Edges

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A complete optical description of the magneto-optical (MO) response of materials in the x-ray range requires knowledge of the spectral dependence of the full dielectric tensor, or equivalently of the complex refractive indices for circularly polarized components of opposite helicity, near core absorption edges. This complete description is important because basic optical properties such as reflectivity and penetration depth depend on both refractive and absorptive effects contained in this complete description. Knowledge of these basic MO properties is thus essential in the analysis of many magnetic measurements near core levels. Magnetic circular dichroism (MCD) directly measures the absorptive MO response, while Faraday magneto-optical rotation (MOR) directly measures the refractive MO response, and together these measures provide this complete description. Refractive and absorptive responses are related by Kramers-Kronig dispersion relations, so that measurement of only one is required, in principle, to obtain a complete description. We consider the utility of the dispersion relations to obtain the refractive from the absorptive response, and vice versa, for the case of polycrystalline Fe films near the Fe $L_{2,3}$ levels using only a limited energy range near the edges. We find that results are sensitive to the precise energy range of the dispersion integrals, and that close agreement can be obtained between the measured MCD(MOR) and the dispersion transformation of the measured MOR(MCD) with careful choice of energy range. Examples of numerical application of the dispersion relations are presented,and implications of the need for this complete MO description for Fe and Fe-containing films will also be discussed.