E1 and E2 contributions to the resonant line shapes of the rare-earths: the case of Ho and Er

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The identification of E1 (dipolar) and E2 (quadrupolar) features in energy line shapes measured across the rare-earths $L_{2,3}$ absorption edges in x-ray magnetic scattering (XRMS) [1-3], x-ray magnetic circular dichroism (XMCD) [4-7] and resonant ineslatic scattering (RIXS) [8,9] has been the subject of a long controversy. The observation of a pre-edge peak has generally been interpreted as arising purely from E2 processes, whereas the higher energy peak has been attributed to E1 excitations. A recent combined experiment and theory investigation of charge-magnetic x-ray resonant interference scattering (XRIS) [10,11] has challenged the general interpretation concerning the identification of E1 and E2 features in the heavy rare-earth metals. The study relied upon strongly reducing the E2 cross-section by scattering at a normal Bragg position around 90°, with the incident polarization in the scattering plane. In spite of this reduction, a strong peak lying at the L_3 pre-edge position was observed for each rare-earth. Thus, the authors concluded that the low and high energy resonant peaks arose from E1 transitions, implying a splitting of the *d*-band polarization caused by *f-d* spin hybridization just above the Fermi energy. The results were also consistent with first principles band structure calculations.
Having established the split E1 resonances across the heavy RE, it was natural to attempt to quantify the relative E1 and E2 contributions. I will demonstrate that a complete polarization analysis of the XRMS is a valuable technique which allows accurate identification of all the resonance processes and quantification of each scattering term that contributes. The recent work on Ho at the L_3 edge [12] will be presented as well as the primary results on Er. Using the imaginary part of the resonant scattering factors obtained with our phenomenological approach, I will show that we can reconstruct the XMCD spectrum across the Ho L_3 edge.

Figure: Scattering factor moduli of Ho across the L3 edge: $F_{E1}^{(1)}$ (solid line), $F_{E2}^{(1)}$ (crosses) and $F_{E2}^{(3)}$ (circles) .

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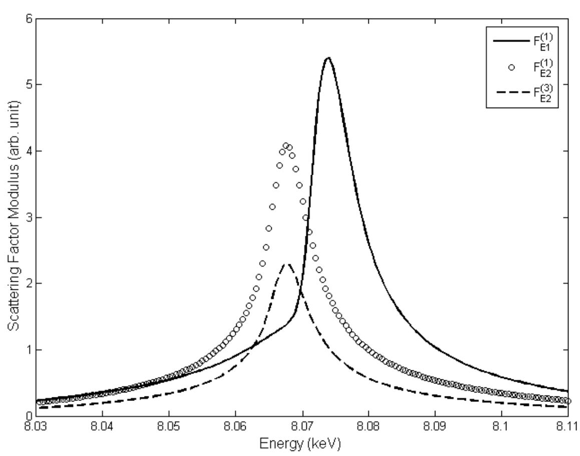

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