



Experiment title: Resonant local-spin-resolved and symmetry-selective inelastic x-ray scattering from Europium

Experiment number:

HC-408

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Shifts: 6 **Local contact (s):** M. Krisch

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Report:

We have measured the shape of the europium $4d \rightarrow 2p$ fluorescence line while varying the exciting energy around the Eu- L_{III} -edge for Eu metal and Eu_2O_3 . The positions of the L_{III} absorption edges for Eu metal and Eu_2O_3 were found to be at $E = 6977 \text{ eV}$ and $E = 6985.7 \text{ eV}$, respectively. Fig. 2 shows some representative examples of the obtained spectra. The Eu metal fluorescence line shows the well-known resonant-Raman-behaviour, that is, it shifts towards higher energies, while $E < E_{edge}$ when E is increased, then narrows and undergoes a resonance when $E \approx E_{edge}$, and then settles as normal fluorescence line. The fluorescence line of Eu_2O_3 in general shows a double peak structure (two leftmost peaks) that can be understood as follows:

A level scheme of Eu, that may explain this feature, is shown in Fig. 1. The $4f$ -shell is occupied by seven electrons, all having the same spin orientation. $5d$ -levels are situated just above the Fermi level. The fact, that all $4f$ -electrons have the same spin orientation, causes a strong exchange interaction with other electron levels. This exchange interaction makes the energy position spin orientation dependent, e. g. the $2p^6 4f^7 4d^9 5d^1$ state, the final state, when filling up a core hole in a resonant scattering process, yielding two different fluorescence energies to be emitted /1/ (Experimental proof of the exchange splitting of the N_V level by measurements of the $4d \rightarrow 2p$ emission in a ferromagnetically ordered Eu compound is in progress). If the density of those unoccupied states, that are reached by exciting the core electron, have sharp features in their DOS (as is the case for $5d$ of Eu_2O_3), the $4d$ -fluorescence line will be split into two energetically separated contributions, each one belonging to one spin orientation of the electron filling up the core hole (which has the same spin orientation as that electron, that was excited above the Fermi level in the first place). By measuring the relative strength of both contributions to the fluorescence line while varying the exciting energy around the Eu L_{III} -edge, it is therefore possible to probe the $5d$ -density-of-states spin selectively with respect to the $4f$ -majority spin, that acts as an internal spin reference /2/. Extraction of this kind of information from the obtained spectra is in progress.

This splitting is not resolved in the Eu metal spectra, because there the $5d$ -DOS is smeared out. The remaining signature of the splitting is the asymmetrically broadened fluorescence line, being the envelope of both contributions. The rightmost peak in the Eu_2O_3 -spectra for $E < 6983 \text{ eV}$ is due to some metallic remains within the oxide-sample and not, as was suggested, by quadrupolar excitation /3/. Note, that the so-called correlation satellite (leftmost broad peak in the Eu metal spectra) is not seen for Eu_2O_3 .

/1/ Kowalczyk et al., Chem. Phys. Lett 29,491 (1974)

/2/ Hämäläinen et al., Phys. Rev. **B** 46, 14274 (1992), Phys. Rev. **B** 51, 1045 (1995)

/3/ Schülke et al., HASYLAB annual report **1995**, p. II-149

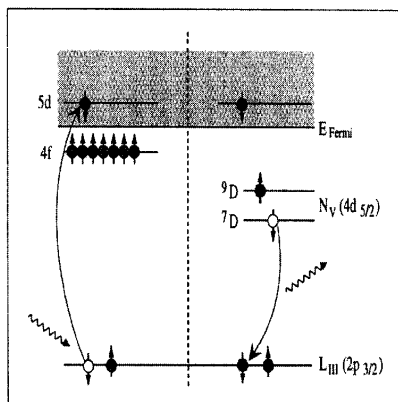


Fig. 1: Electronic level scheme of Eu

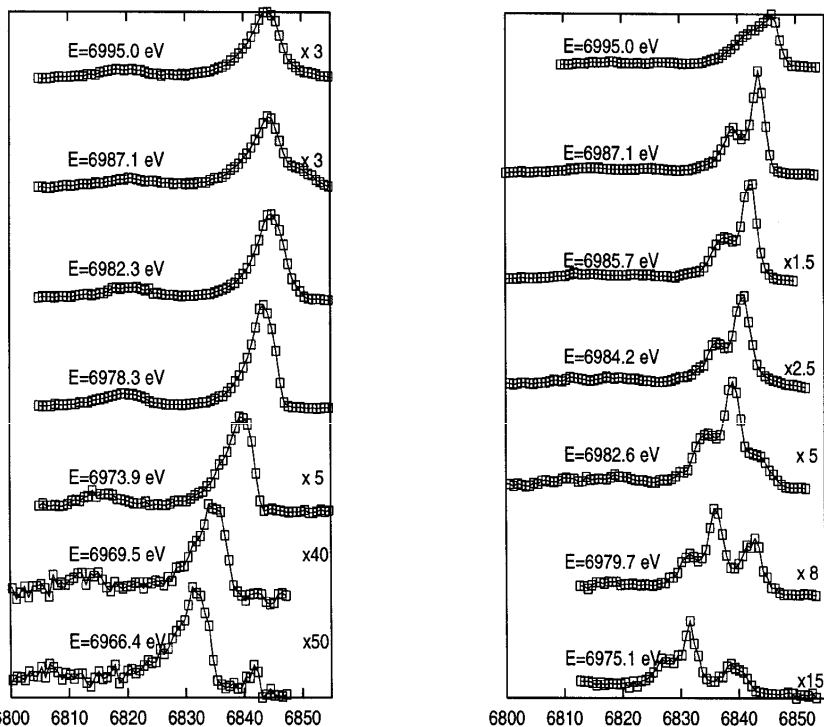


Fig. 2: $4d \rightarrow 2p$ fluorescence of Eu metal (left) and Eu_2O_3 (right) for $E \approx E_{L_{\text{III}}}$