ESRF	**Experiment title:** Interfacial magnetism of Eu/Gd(0001) studied by magnetic circular dichroism in x-ray absorption	**Experiment number**: HE-149
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Report:

Although rare-earth (RE) superlattices [1] have been prepared since the mid-80ies, it was not until recently that interdiffusion-free RE interfaces could be fabricated [2-4].
In the present experiment HE-149, using magnetic circular dichroism in x-ray absorption (XMCD) at the *Eu*- and Gd-$M_{4,5}$ edges, we investigated 1-monolayer (ML) *Eu*/*Gd*(0001) which constitutes a Heisenberg (spin only) heteromagnetic RE interface.

Samples were prepared *in situ* by UHV metal-vapor deposition, at pressures below $2 \cdot 10^{-10}$ mbar, on a W(110) single crystal. Starting with 10-nm thick *Gd* films, deposited at low rates of ~0.5 nm / minute, *Eu* was adsorbed on the annealed *Gd*(0001) surface at room temperature. Post-deposition annealing resulted in an *Eu*(6×6) superstructure with good lateral near-surface order [2], as monitored by LEED.

XMCD spectra were calculated from pairs of absorption spectra for (*i*) a fixed x-ray helicity and opposite sample magnetizations and (*ii*) a fixed magnetization and opposite x-ray helicities. By comparison of both sets we could exclude significant apparatus asymmetries. All spectra were recorded in total-electron yield mode by a channeltron for remanent sample magnetization; remanence was obtained by an *in vacuo* 0.2-T electromagnet.

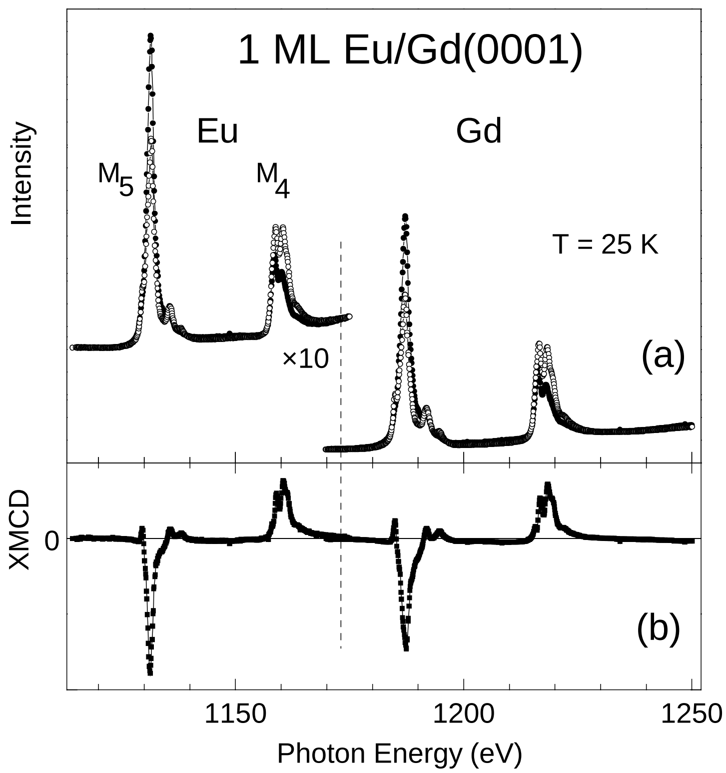

Fig. 1 (a) shows *Eu*- and *Gd*-$M_{4,5}$ x-ray absorption spectra for opposite sample magnetizations of 1 ML *Eu*(6×6)/*Gd*(0001), together with associate XMCD spectra in (b). The large *Eu* XMCD signal corresponds to ~70 % of saturation and confirms the existence of *ferrimagnetic order* in this 2-dimensional *Eu* 4*f*-spin lattice [2]. Absence of a perpendicular *Eu*-magnetization component (spectra not shown) corroborates the postulate of a *coplanar* non-collinear arrangement of the *Eu* 4*f*-spins at low temperatures.

Based on their common $3d^9\,4f^8$ multiplet structure, a comparison of the high-resolution *Eu* and *Gd* XMCD spectra in Fig. 1(b) is of practical use. While the *Gd* XMCD spectrum is subject to saturation - typical for 'thick' films and strong absorption lines [5] - the XMCD spectrum of the *Eu*-monolayer is approximately *unsaturated*. The multiplet intensities of both spectra match perfectly assuming a total-yield information depth of d_e = 2.0 nm, together with the theoretical $3d\rightarrow4f$ linestrength [6]. The knowledge of d_e is crucial for a reliable saturation correction of XMCD signals at RE M_5 edges.

In addition, we measured the ac-susceptibility (χ_{ac}) of 1 ML *Eu*(6×6)/*Gd*(0001) in an element specific way, employing ac-XMCD [7] at the M_5 peaks of *Eu*- and *Gd*. No χ_{ac}-peak was discernible for *Eu*, indicating that magnetic coupling between *Eu*- and *Gd*-spin sublattices is substantial. - By contrast, pronounced χ_{ac}-peaks, with excellent signal-to-noise ratios (~100) were observed, even for very thin *Gd* films (< 5 ML) on *W*(110). This opens the door to element specific ac-susceptibility studies of 'buried' layers near the surface of RE superlattices.

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