ESRF	**Experiment title:** Interlayer exchange coupling in rare earth - yttrium trilayers studied by x-ray absorption and resonant scattering	**Experiment number:** HE-753
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Report:

The goal of HE-753 at ID12-A was to measure, via XMCD, the Y 4d magnetic moment in exchange coupled layered rare-earth (RE) metal systems, with yttrium (Y) spacer layers between ferromagnetic Gd (Tb) layers. As prototype samples, Y/Gd doublelayers, Gd/Y/Gd trilayers and [Gd/Y] multilayers have been prepared with atomically flat interfaces in situ — an UHV chamber was installed at ID12-A by us — on a single-crystal W(110) substrate. The Y layer thickness was varied between 5 and 15 atomic layers, since in this thickness range the exchange coupling across Y spacers is theoretically expected to change sign.

The first Y $L_{2,3}$ x-ray absorption (XA) spectra were recorded using fluorescence yield, which is the standard XA detection method for bulk samples in the hard x-ray regime. It became clear immediately that no sufficiently large signal can be obtained via fluorescence yield from only a few atomic layers of yttrium (compared to the high background from the thick tungsten substrate). We thus had to change the XA detection method to electron yield (which benefits from the substantial Auger-decay rate af Y 2p hole and, in addition, gives a much shorter information depth matching the few atomic layers of Y in the sample). Unfortunately, the sample holder/cryostat unit of our UHV system did not allow a sample-current measurement, which constitutes the most reliable way of electron yield detection. We thus decided to collect secondary electrons by using a channeltron. The detection unit included a 3kV battery between channeltron anode and current amplifier; the system was optimized in terms of electromagnetic shielding but could not be made a truely triaxial ciruit, commonly used for low-noise current detection. As another drawback, we found that the channeltron needed several minutes of constant x-ray illumination of the sample, before a stable absorption signal was obtained. In addition, channeltron detection is not compatible with an application of external magnetic fields (above a few ten Gauss) so that no element-specific hysteresis loops could be recorded.

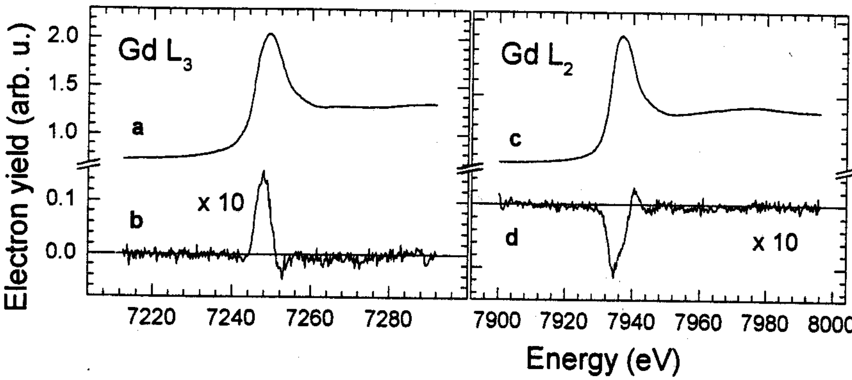

Figure 1. (a,c) Gd $L_{2,3}$ absorption and (b,d) XMCD spectra from a remanently magnetized Gd(0001)/W(110) film.

The detection system was first checked by recording XMCD spectra at the Gd $L_{2,3}$ edge (7.2 ... 8 keV) using a 15 nm "thick" Gd film (~50 atomic layers). Figure 1 shows absorption spectra (a,c) along with difference (XMCD) spectra (b,d), obtained at fixed remanent magnetization using light of opposite helicity from the HELIOS undulator. Note that reversal of the sample magnetization resulted in virtually identical XMCD spectra of opposite sign. To our knowledge, these are the first XMCD spectra of the Gd L edge obtained from a clean Gd metal film of nanometer range thickness.

For XMCD at the low-energy Y $L_{2,3}$ edge, the recently commissioned electromagnetic undulator was utilized, which allows to change the light helicity (in ~0.1 s) at each energy point of a spectrum; hence a pair of XMCD spectra can be recorded quasi-simultaneously which would give high accuracy (differential method). However, we found that this method could not be applied here since the x-ray intensity briefly becomes zero during the helicity flip, which resulted in considerable drifts of the channeltron signal. We could flip the helicity (or reverse the sample magnetization) only after a complete scan.

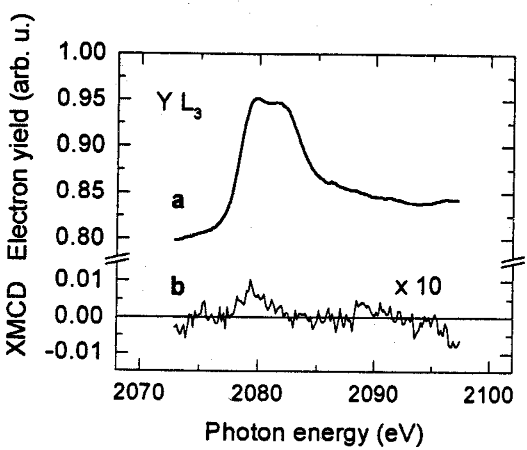

Figure 2. (a) Y L_3 absorption and (b) XMCD spectra from a remanently magnetized [Gd/Y] multilayer.

Despite these difficulties we were able to obtain the first XMCD spectra of the yttrium L_3 edge from a [Gd/Y] multilayer system (7 periods with 5 Gd and 5 Y atomic layers per period), presented in Figure 2. The difference spectrum (b) gives evidence of an induced magnetic moment in the Y spacer layers, yet so far with insufficient signal-to noise ratio. Note that the positive XMCD signal near the leading absorption edge changes sign upon magnetization reversal. The associated Y L_2 spectra suffer from absorption features in the "I-zero" signal used for normalization. This makes it necessary to replace the polyimid foil used here with some other material which does not absorb in the Y $L_{2,3}$ energy range.