ESRF	**Experiment title:** Does non-magnetic ferromagnetism exist in Sm compounds?	**Experiment number**: HE867
Beamline:	**Date of experiment**: from: 20/09/00 to: 26/09/00 (ID12A) from: 04/10/00 to: 11/10/00 (ID12B)	**Date of report**: 20/2/01
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Report:

The ground state spin (**S**) and orbital (**L**) moments of Sm^{3+} are coupled antiparallel according to Hund's rule and are almost equal in magnitude. Furthermore, the energy difference between the ground and first excited state is relatively small (0.13eV) so that mixing between these multiplets can occur even without the effects of a crystal field or exchange interactions. The delicate balance between **S** and **L** in Sm^{3+} implies that under specific conditions a perfect compensation between the two components could lead to a ferromagnet with large spin polarization, but no net magnetisation. Recently, $Sm_{1-x}Gd_xAl_2$ (x~2.6%) alloys have been shown to exhibit ferrimagnetic behaviour using temperature dependent SQUID magnetometry [1]. The results were interpreted in terms of a spin-orbit compensation model with a compensation temperature of (T_{comp}) 64K. This unique system therefore offers the possibility of exploring temperature dependent spin and orbital magnetism using element-specific probes such as x-ray magnetic circular dichroism (XMCD).

The samples were prepared by argon-arc melting, characterized using SQUID magnetometry and x-ray diffraction and scarped *in situ* to remove surface contamination. The XMCD measurements were performed using the 7T superconducting magnets on ID12A and ID12B. The XMCD spectra were recorded by reversing both the helicity of the incoming radiation and the direction of the applied magnetic field. Fig. 1 shows the XMCD spectra recorded over the Sm $M_{4,5}$ edges from a $Sm_{1-x}Gd_xAl_2$ (x~2.6%) alloy at 10K and 120K; the spectra have been normalised to the leading peak. For these measurements, the dipole allowed $d \rightarrow f$ transitions probe the localized magnetic moments of the Sm 4*f* states. In Fig. 1, the reversal of the XMCD amplitude is an indication that total magnetic moment has reversed direction. It is also evident from the change in the ratio of the integrated intensity over the two edges that the spin and orbital moments are temperature dependent. The orbital to spin moment ratio (L/S) can be calculated for the $M_{4,5}$ edges of the rare earths according to the sum rule $L/S = 4 / (5(p/q) - 3)$ where p is the integrated intensity over the M_5 XMCD and q is the total integrated intensity of the XMCD [2,3]. Figure 2 shows the temperature dependence of Sm L/S ratio in $Sm_{1-x}Gd_xAl_2$ (x~2.6%), $Sm_{1-x}Nd_xAl_2$ (x~6%) and $SmAl_2$ determined using XMCD combined with the above sum rule. SQUID magnetometry shows that the latter two compounds do not exhibit ferrimagnetic behaviour and in Fig. 2 it is clear that they also show no variation in the Sm L/S ratio over the whole temperature range. The contrast for the ferrimagnetic like $Sm_{1-x}Gd_xAl_2$ (x~2.6%) is striking which shows a large anomaly in the L/S ratio at T_{comp}. The value of L/S at T_{comp} is close to 2 implying almost perfect compensation of the spin and orbital moments. From Fig. 1 it is also clear that the XMCD lineshape is temperature dependent with the relative intensities of the peaks changing with temperature; this is especially noticeable at the M_4 edge where the 2 dominant peaks reverse in relative intensity. The lineshape changes were not observed for $Sm_{1-x}Nd_xAl_2$ (x~6%) or $SmAl_2$ implying that these changes maybe the key to understanding the spin-orbit compensation in $Sm_{1-x}Gd_xAl_2$ (x~2.6%). The data are therefore being modeled using atomic multiplet calculations to further understand the driving mechanism behind the spin-orbit compensation at T_{comp}.

Further XMCD studies over the Sm $L_{2,3}$ edges show strong quadrupolar and dipolar transitions enabling the simultaneous study of the temperature dependent magnetism in the Sm 4*f* and conduction states. The temperature dependence of these features has also been used to understand the assignment of the pre-edge peaks in more detail [4].

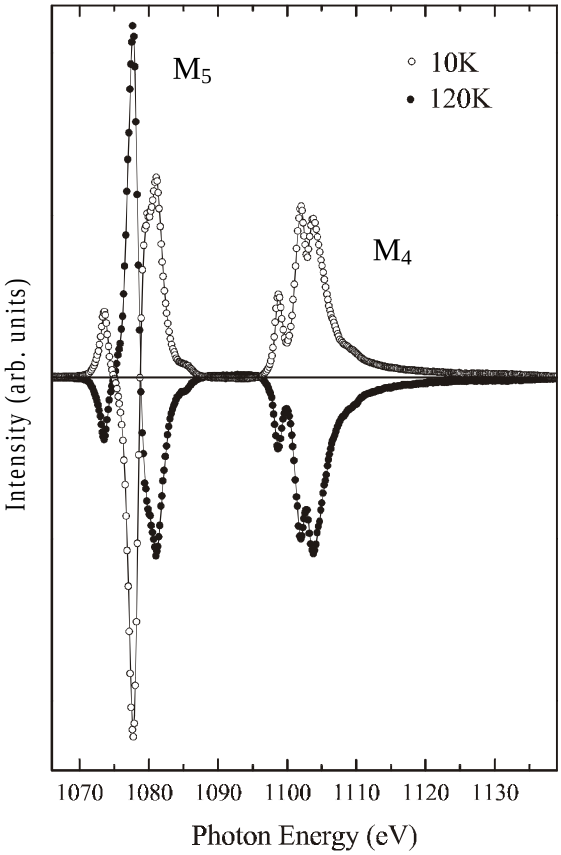

Fig.1 Temperature dependent XMCD spectra over the Sm $M_{4,5}$ edges for $Sm_{1-x}Gd_xAl_2$ (x~2.6%). The spectra were recorded in applied magnetic fields of ±5T.

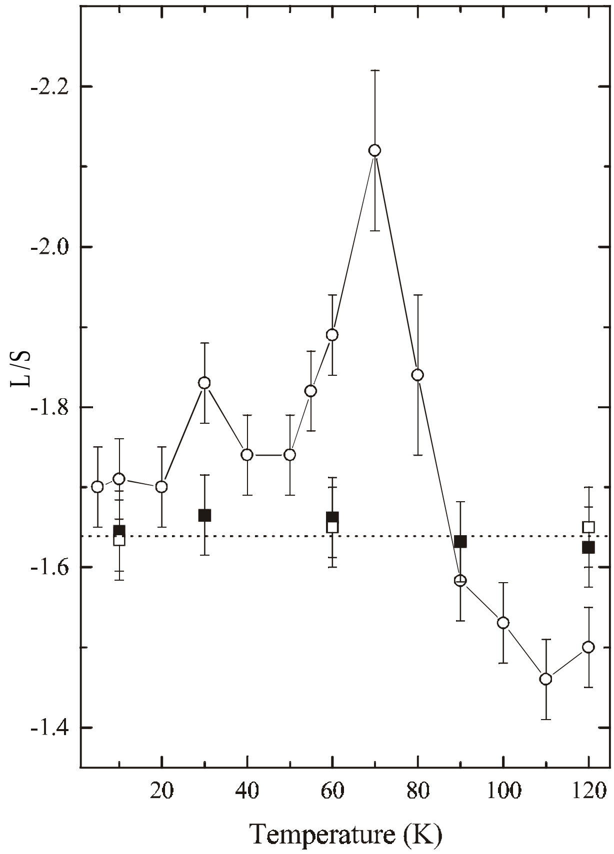

Fig. 2 L/S ratio for $Sm_{1-x}Gd_xAl_2$ (x~2.6%) (open circles), $Sm_{1-x}Nd_xAl_2$ (x~6%) (solid squares) and $SmAl_2$ (open squares) as a function of temperature. The dashed line is a guide to the eye for the constant value exhibited by $Sm_{1-x}Nd_xAl_2$ (x~6%) and $SmAl_2$.

References
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