	Experiment title: Resonant Magnetic X-ray Scattering from Co/Gd Multilayers	**Experiment number**: 28-01-604
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Names and affiliations of applicants (* indicates experimentalists):

T.P.A. Hase*, S.B. Wilkins*, B.K. Tanner*
Department of Physics, University of Durham, Durham, DH1 3LE, U.K.

J. P. Andrés*, J. A. González*, M. A. López de la Torre, J. M. Riveiro
Dto. Física Aplicada, Facultad de Químicas. 13071 Ciudad Real, Spain

L. Bouchenoire*, S. Brown*
XMaS CRG, European Synchrotron Radiation Facility, Grenoble, France

Report:

Gd/Co multilayers show interesting magnetic properties and below the Curie temperature of the Gd, the sample behaves as a ferrimagnet with the Gd aligning itself in an anti-parallel configuration along the easy axis defined by the direction of the ordered Co layer at all temperatures. As the temperature is lowered, and the Gd moment increases, there exists a compensation temperature when the magnitudes of the Co and Gd moments are equal and the net magnetisation a minimum. Interdiffusion effects that result in the formation of amorphous Co_xGd_{1-x} alloy interface layers dominate the growth of Co on Gd. We have previously conducted an extensive investigation into this phenomenon using both structural and magnetic probes.

This experiment is a continuation of our previous feasibility study 28-01-103 on the use of the diamond phase plate on XMaS to extract magnetic information from Gd/Co multilayers. In particular, the aim of this experiment was to enhance our understanding of the magnetic arrangement at temperatures close to the compensation temperature. Our goal was to measure the magnetic signal as a function of flipping field, and to measure successfully the magnetic scatter as a function of scattering vector. In this experiment the magnetic signal was extracted by measuring the so called flipping ratio, $(I^+ - I^-)/(I^+ + I^-)$ where I^+ and I^- correspond to the intensity when measured with positive and negative applied fields in the scattering plane. Figure 1 shows the energy scans recorded at a fixed momentum transfer corresponding to the second structural Bragg peak. Measuring the sum $(I^+ + I^-)/2$ signal records the charge signal only and is independent of helicity. On the other hand, the magnetic signal is equal and opposite when measured with positive and negative helicity. We can therefore be sure that peak in the flipping ratio seen in figure 1 is associated with the magnetic structure. In figure 2 we show the flipping ratio and sum recorded as a function of scattering vector over the same Bragg peak. A magnetic signal is only observed in the vicinity of the Bragg peak. The width of the charge and magnetic peak is similar, showing that the out-of-plane coherence of the two structures is similar.

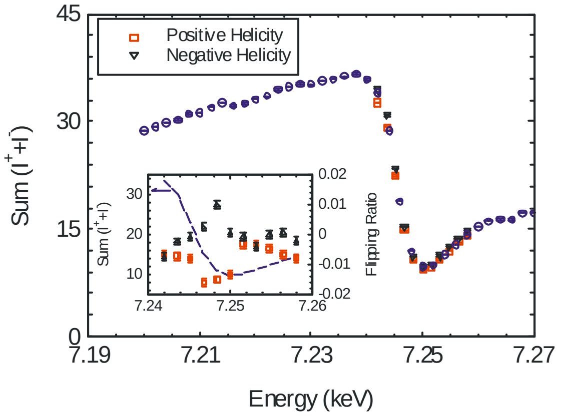

Fig 1: Energy scans, at fixed q, for linear, negative and positive helicities at the second Bragg peak through the Gd L_3 edge

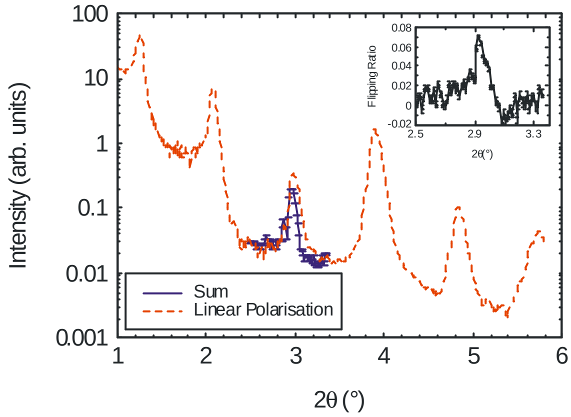

Fig 2: Scattered intensity at the third Bragg. Inset shows flipping ratio with negative helicity. Sum data is superimposed with data recorded using linear polarisation

We have followed the flipping ratio as a function of flipping field (fig. 3). At temperatures away from compensation (T=130K), there is little evidence for any systematic field dependence. Close to the compensation temperature, the flipping ratio reduces, and tends towards zero at high flipping fields. Applying the magnetic field at 90° shows an increase in the flipping ratio at these high fields (fig. 4). This is strong evidence that around this temperature the magnetic structure is characterised by a spin-flop which occurs for fields above 400mT. The reversal in sign of the flipping ratio above and below the compensation temperature is consistent with a reversal of the Gd layer moments.

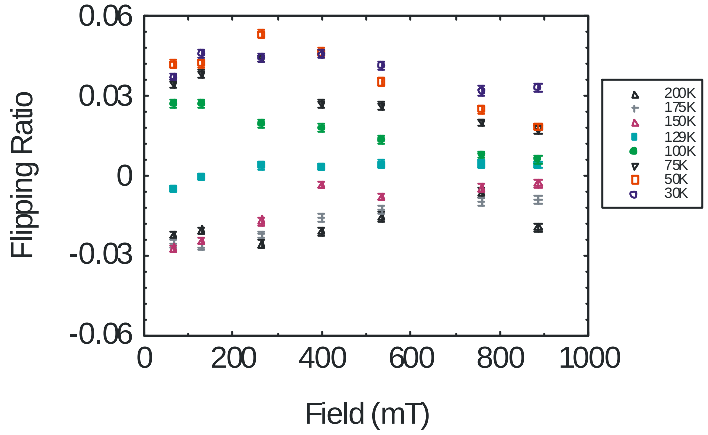

Fig 3: The variation of the flipping ratio with applied field as a function of temperature.

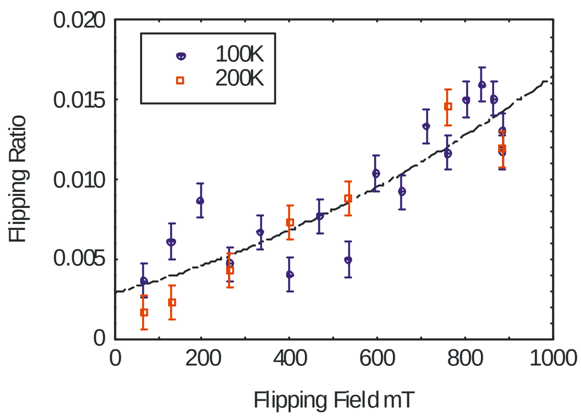

Fig 4: The variation of the flipping ratio with applied transverse at 100 and 200K.

We have successfully extended the technique of resonant magnetic scattering using the phase plate to measure a magnetic signal as a function of field, temperature and scattering vector. Unlike our previous experiment we did not observe a difference in sign between odd and even numbered Bragg peaks. We tentatively attribute this to the different layer thickness in the samples studied here, and the corresponding greater effect of interdiffusion on the magnetic interface profile.