Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

http://193.49.43.2:8080/smis/servlet/UserUtils?start

Reports supporting requests for additional beam time

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** Soft x-ray resonant magnetic scattering from Co/Cu multilayers	**Experiment number:** HE 755
Beamline: ID12B	**Date of experiment:** from: 6.6.00 to: 13.6.00	**Date of report:** 21.8.00
Shifts: 15	**Local contact(s):** Alberto Tagliaferri, Philippe Ohresser	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

B K Tanner* Department of Physics, University of Durham, Durham, U.K.

T P A Hase*
B D Fulthorpe*
S B Wilkins*
M D Roper* Daresbury Laboratory, Warrington, Cheshire, U.K.

Report:

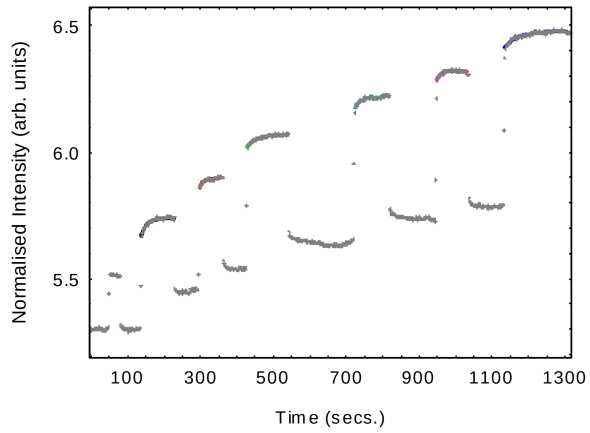
Soft resonant magnetic x-ray scattering experiments were undertaken to study the rotational magnetization processes in transition metal multilayers. The primary objective was to determine whether circularly polarised soft x-ray could be used to determine the relative fractions of ferromagnetically and antiferromagnetically coupled material in Co/Cu multilayers. The secondary objective was to study the magnetic viscosity observed in the bilinear antiferromagnetically coupled systems and determine its temperature dependence.

The Co/Cu samples with Cu thickness correponding to the 1st antiferromagnetic coupling peak showed a mixture of bilinear and biquadratic antiferromagnetic coupling and negligible ferromagnetic coupling. The biquadratic coupling was seen both by the behaviour of the intensity of the antiferromagnetic Bragg peak in reverse fields and also in the helicity dependence of the antiferromagnetic Bragg peak. The fractional change in the height of this peak on flipping the helicity of the incoming beam provides a measure of the fraction of material coupled in the two configurations.

No time dependence was observed in biquadratically coupled material or in samples with Cu thickness correponding to the 2nd a.f. peak. In the bilinearly coupled samples, viscosity was observed in the intensity of the (pure magnetic) a.f. Bragg during a step magnetising sequence in which the field was applied parallel to the easy direction. (Prior to all experiments, a high magnetic field was applied perpendicular to this easy direction, defined by the original growth field direction). As a function of the magnetising field, which was chosen to be perpendicular to the scattering plane, the antiferromagnetic magnetic Bragg peak showed significant and hysteretic changes in amplitude. On application of the magnetizing field, the viscosity was greatest at low fields (Figs 1 and 2). A satisfactory fit to a single exponential was obtained. Very little viscosity was observed in the magnetisation decay at low fields, this becoming more pronounced at higher fields. Equally good fits could be obtained to a single exponential or a logarithmic decay. No systematic trend could be found in the rise or decay rates, the behaviour being irreproducible from one run to the next. No significant temperature dependence was found over the range available.

The results support our suggestion that the viscosity arises from thermal activation over a collective energy barrier formed in the antiferromagnetically coupled layer system. Lorentz microscopy results have shown that there exists a small canting of the antiferromagnetically coupled moments on adjacent layers leading to a weak ferromagnetic behaviour.

The energy surface associated with the moment distribution is not reproducible from one magnetisation sequence to the next and thus there is no systematic trend in the time dependence rates [1].



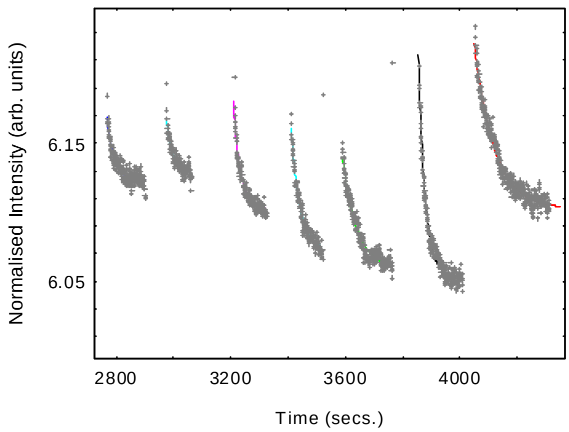
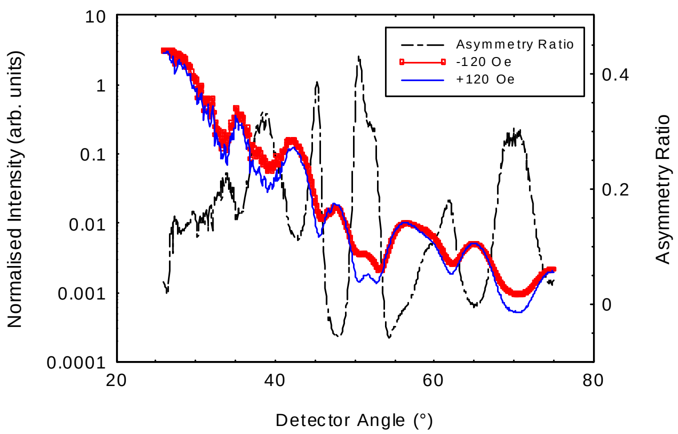


Fig 1. Low field viscosity in Co/Cu

Fig 2. High field viscosity in Co/Cu

The rotational magnetisation process in the Co layer of Ta/NiFe/Cu/Co/IrMn/Ta spin valves was studied. From the asymmetry ratio (Fig 3) between the intensities of the specular scatter with right-handed and left-handed circularly polarised x-rays tuned to the Co L_3 edge, we were able to reconstruct the magnetisation curve for the Co layer.



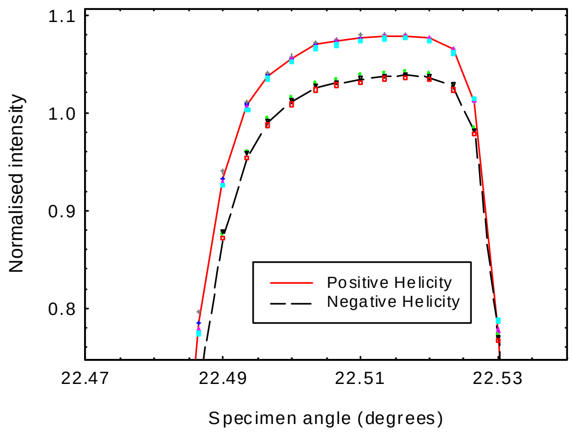


Fig 3 Specular scatter (at the Co L_3 edge) from a spin valve.

Fig 4 Specimen scan across the specular ridge with the x-ray energy tuned to the Mn L_3 edge

On tuning the x-ray energy to the Mn L_3 edge, a small change in the specular intensity was detected on reversal of the helicity (fig 4). The magnitude of the change fell on detuning from the Mn edge. The data show that a small ferromagnetic moment is associated with the antiferromagnetic IrMn layer which is grown to pin the ferromagnetic Co layer in the spin valve structure. The origin of this exchange field is in dispute but the most strongly favoured mechanism is that of a layer of uncompensated spins at the antiferromagnet/ferromagnet interface providing the pinning via exchange coupling. Our data provide evidence for the existence of such a layer of uncompensated spins.

References

[1] Soft x-ray magnetic scattering study of rotational magnetisation processes in cobalt/copper multilayers, T.P.A.Hase, B.D.Fulthorpe, S.B.Wilkins, B.K.Tanner, C.H.Marrows, B.J.Hickey and M D Roper, J. Magn. Mag. Mater. (in press)