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Experiment title:

Experiment number:

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Shifts: **Local contact(s):** Dr. Simon Brown

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Names and affiliations of applicants (* indicates experimentalists):

Dr Michael Thomas Department of Physics, University of Liverpool, L69 7ZE UK

MSc Laurence Bouchenoire Department of Physics, University of Warwick, Coventry CV4 7AL UK

MSc Angela Beesley, Department of Physics, University of Liverpool, L69 7ZE, UK.

Report:

The aim of this experiment was to investigate the magnetic moment distribution of the uranium atom on a set of U/Fe multilayers deposited by DC magnetron sputtering. This is potentially important due to the large orbital moment provided by the 5f electrons of the Uranium that, coupled with the lattice creates one of the largest known values of magnetic anisotropy [1]. The experiment was carried out on a [UAs(30A)/Fe(40A)]30 multilayer through resonant magnetic reflectivity using circularly polarized radiation. This technique was proved to be valid by a previous experiment on a [UAs(80A)/Co(20A)] [2][3]. Specular reflectivity data were taken using linear polarization at a photon energy of 7 keV. Circular polarization of the incident photon beam was used in order to investigate the magnetic response on the U site. A 0.3 mm thick diamond (111) was used as phase plate, that by offsetting it 300 arcseconds from the Bragg condition a degree of circular polarization of 98.2% was obtained. The sample was mounted on a cryostat with base temperature of 10K and the measurement was carried out by reversing the magnetic field at different values of energy around the UM1v edge at different scattering angles (constant wavevector), and at different wavevector positions at a fixed energy 3.728 keV.

From each case the asymmetry ratio was calculated as (I - I)/(I + I) where I (I) is the normalized intensity obtained with circular polarization and the applied field parallel (antiparallel) to the beam direction. Finally, the asymmetry ratio was measured as a function of temperature up to 290K. Figure 1 shows the asymmetry ratio as a function of energy around the U *M1v* edge, for a series of wavevectors along [00L] direction. The clear peaks confirm the presence of a magnetic moment on the uranium site non-uniformly distributed along the multiplayer. This is confirmed by measuring the asymmetry ratio at different positions in reciprocal space along [0 0 L] at 3.728 keV shown in Figure 2. This lack of uniformity in the distribution of magnetic moment at the U site, could be associated to polarization of the U at the U/Fe interfaces, with non-magnetic U in the regions away from the Fe interfaces.

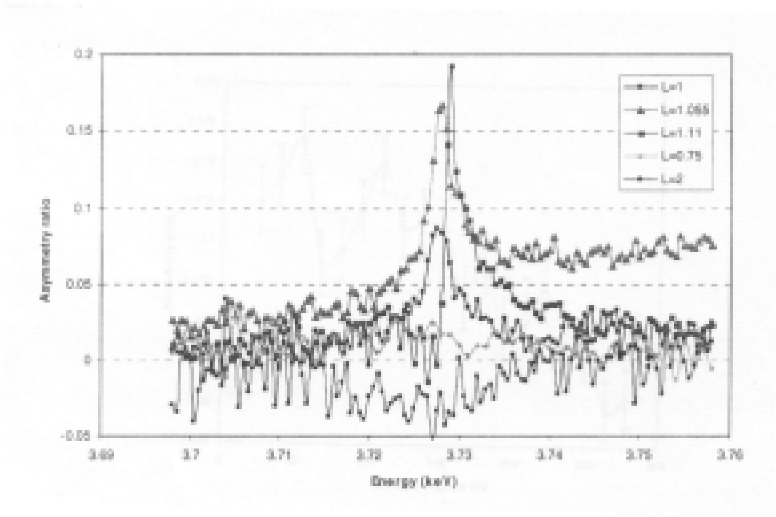

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Figure 1. Assymetry ratio as function of energy around the UM1v edge, at different constant wavevectors transfer along [0 0 L].

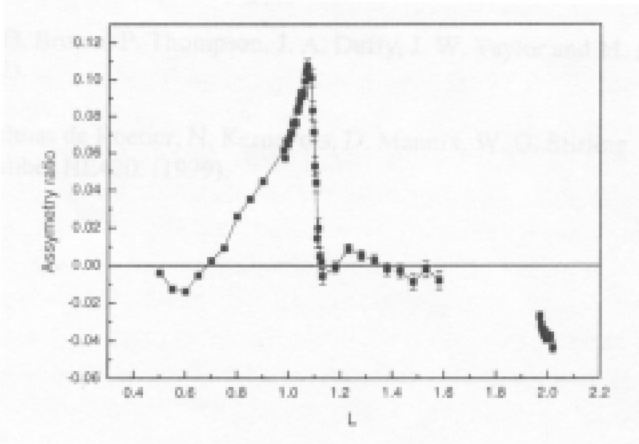

Figure 2. Asymmetry ratio along [0 0 L] at the UM1v edge 3.728 keV.

The temperature dependence of the asymmetry ratio obtained in this experiment is shown in Figure 3. The small fluctuations can be associated to the experimental set up but it is clear that the magnetic response is smaller as the temperature increases but still appreciable at room temperature.

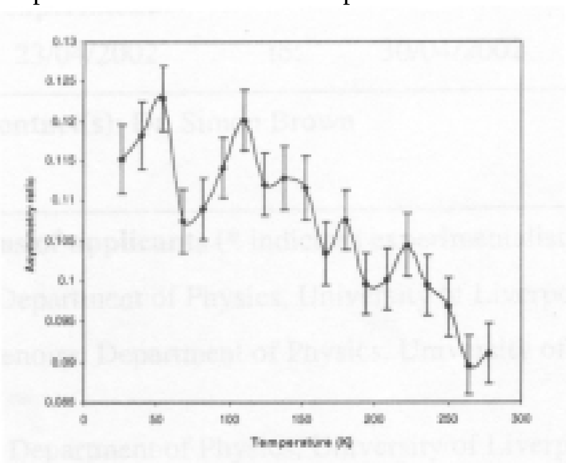

Figure 3. Asymmetry ratio as function of temperature taken at the U M1v edge (3.728 ke V) in (001.07).

Based on these results, further experiments will be carried out to measure the magnitude of this magnetic moment on the U site for several multilayers, through X-ray Magnetic Circular Dichroism and to determine its spatial distribution through the multilayers.

[1] M. S. S. Brooks and B. Johanson, Handbook of Magnetic Materials. North Holland, 7 (1993) 139-230.

[2] Bouchenoire, S. D. Brown, P. Thompson, J. A. Duffy, J. W. Taylor and M. J. Cooper, submitted to J. Synchrotron Rad. (2002).

[3] J. P. Sanchez, P. Dalmas de Roetier, N. Kernavois, D. Mannix, W. G. Stirling, A. Yaouane, ESRF Experimental report number HE420. (1999).