EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

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:** First detection of the U 6d magnetic polarisation using XMCD	**Experiment number**: HE-2865
Beamline: ID12	**Date of experiment**: from: 18/09/08 to: 24/09/08	**Date of report**: 01/04/11
Shifts: 18	**Local contact(s)**: Fabrice Wilhelm, Andrei Rogalev	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

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Prof. LANDER Gerard*, ILL, Grenoble, France

Report:

The premise of this proposal was to probe the *6d* conduction band polarisation of uranium, using XMCD at the U $L_{2,3}$ edges. This represents a new venture, both from a materials point of view; this would be the first detection of the uranium *6d* states, using XMCD, but also from a technique point of view; the high energies of the U L edges (17.195 keV and 21.000 keV, respectively) represent the upper limit for the reliable detection of XMCD.

In the initial proposal, a series of multilayer samples was suggested as the both a means for detecting the *6d* states and also to enhance our understanding of the mechanism of induced magnetism in such systems. However, we decided that it would be more prudent to accurately determine the origin of any observable dichroism at the U L edges, by investigating a very well-understood uranium ferromagnet. We mounted a $U_{0.9}La_{0.1}S$ single crystal (practically identical physics to the pure US compound) with its [001] axis oriented along the beam direction, parallel to the applied magnetic field. $U_{0.9}La_{0.1}S$ has a T_C of 160 K and a [111] easy axis of magnetisation.

Many other techniques have been used over the past thirty or so years to well-characterise the moment values for both the *5f* magnetic states and also those of the *6d* conduction band, which lie antiparallel to the *5f*. So, we set about probing both the *5f* and *6d* states, using the U $M_{4,5}$ edges (3.728 and 3.552 keV, respectively) and the U $L_{2,3}$ edges. Firstly, the sample was cooled, using the He flow cold finger system, mounted inside the 6T cryomagnet in hutch 1.

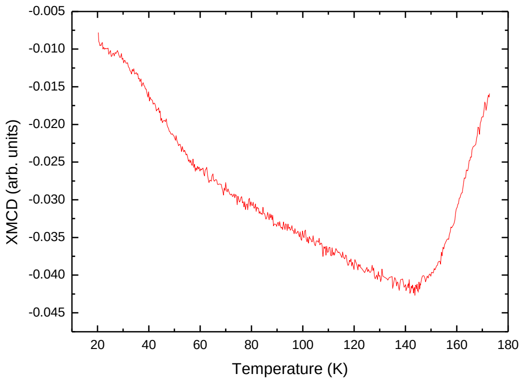

Figure 1 – XMCD at U M_4 edge in a field of 2 T, measured as a function of temperature.

The energy was tuned to the U M_4 edge and the XMCD signal was measured as a function of temperature (see fig. 1) in order to determine the maximum in the susceptibility (since the easy

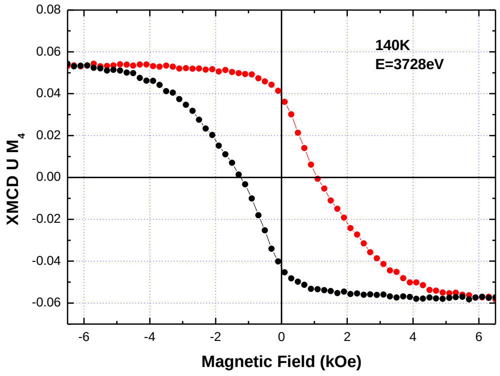

Figure 2 – Element specific hysteresis loop at U M_4 edge at 140 K.

axis was along [111] with the field applied along [001]). The maximum in this case was found at 140 K. An element specific hysteresis was then measured in order to determine the applied field required for magnetic saturation, shown in figure 2. The hysteresis loop shows that the saturation field is approx. 6 kOe. At this low field at was possible to flip the field at each measurement point in order to measure the XMCD and then reverse the helicity of the beam and repeat, detecting any artefacts not reversed in an applied field (linear dichroic effects/diffraction peaks etc.).The XANES and XMCD signals at the U $M_{4,5}$ edges are shown in figure 3, not corrected for self absorption or for polarisation rate.

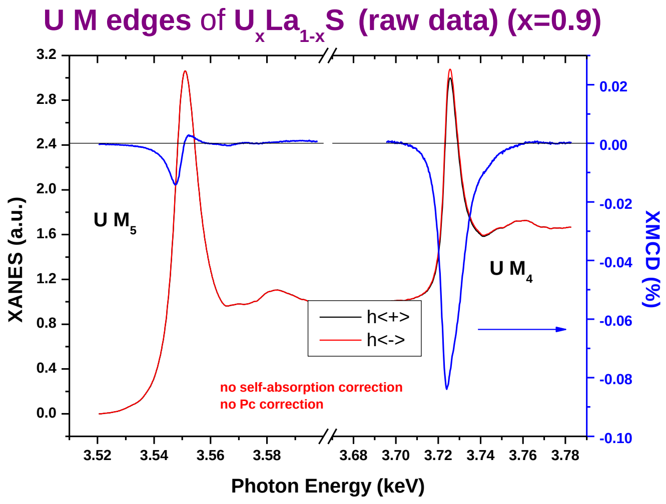

Figure 3 – XANES and XMCD signals, measured at the U $M_{4,5}$ edges in an applied field of 6 kOe at 140 K. No self-absorption or polarisation corrections have been included.

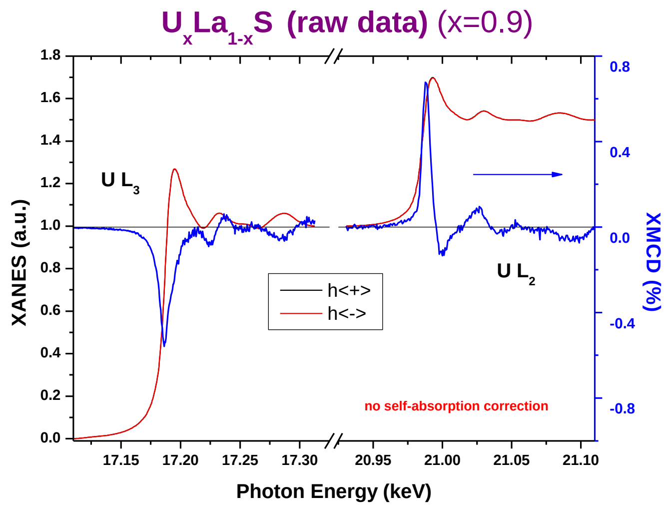

Figure 4 – XANES and XMCD spectra, measured at the U $L_{2,3}$ edges in an applied field of 6 kOe at 140 K. No self-absorption or polarisation corrections have been included.

The U M edges were measured having zero-field cooled (ZFC) the sample to 140 K, using the helios II undulator, using a Si photodiode in backscattering, through a Be window. We also attempted to measure the $M_{1,2,3}$ edges in order to probe the *6d* electrons, but the edges were not strong enough to be well-resolved above the background.

In order to probe the *6d* states, we moved to the U-32 undulator; we optimised the monochromator first at the at the 3rd harmonic for the U L_3 edge (17.195 keV) and then at the 4th harmonic for the L_2 (21.000 keV). The sample was held at 140 K and a field of 6 kOe was flipped as a function of energy over the absorption edges. Figure 4 shows the XANES and XMCD signals without self-absorption or polarisation (should be ~100% circular polarisation, CP) correction.

Initial analysis indicates that the observable signals at the U $L_{2,3}$ edges may not be entirely dipole in nature. In fact, a large contribution may come from the quadrupolar transitions. This can be seen by the maximum in the dichroic signal centred ~10eV below the peak in the white line. A more detailed, quantitative analysis will follow, outlining the first report of XMCD at the U L edges.