EUROPEAN SYNCHROTRON RADIATION FACILITY

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ESRF

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:** Magnetic X-ray resonant study of [110] Europium	**Experiment number**: HE - 937
Beamline: BM28	**Date of experiment**: from: 07/02/01 to: 13/02/01	**Date of report**: 21/02/01
Shifts:	**Local contact(s)**: Simon BROWN	*Received at ESRF:*

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Report:

The Eu metal is an unusual rare earth, that crystallises in the bcc structure, exhibits a low melting point and a large atomic radius. All these particularities, different from the other rare earths, are commonly attributed to the stabilisation of a divalent state, since the 4f shell tends to be half-filled with 7 electrons. Thus, although europium and gadolinium exhibit the same number of 4f electrons, the ordering temperature is much lower in europium due to a lower density of state at the Fermi level and a smaller indirect exchange.

These various characteristics make europium a suitable element for fundamental investigation of related electronic and magnetic properties. Our aim is to combine the Molecular Beam Epitaxy technique, to get high purity and high quality europium films, with the powerful Resonant X-ray Magnetic Scattering tool. RXMS permits both to investigate magnetic configurations and to probe the vacant states near the Fermi level that contribute to the resonant process.

Since no RXMS experiments were previously performed on pure Eu metal, our investigation started with a quite simple system: a thick Eu film (9700Å). This film was deposited on a single crystal sapphire substrate, first covered with a niobium buffer layer. RHEED observations during the first stages of growth have shown an initial hexagonal surface structure that relaxes into the bcc structure: the growth direction is [110] and 3 structural domains rotated by 60° in the (110) plane coexist. The structural coherence length along the growth direction is close to 680 Å and the mosaïc spread is about 0.7°.

The experiment divided into two parts. First, using RXMS at the Eu L_3 edge, we confirmed the magnetic structure and investigated its thermal evolution. Second, using pure charge scattering at a higher energy ($\approx$14 keV) for improved resolution, we studied the related magnetostrictive effects. The RXMS measurements were performed in the σ-π polarization channel, using the (2 2 0) reflection from a Cu analyser crystal, to eliminate most of the charge background from the substrate and of the fluorescence.

At T=10K for E=6.971 keV, several magnetic satellites have been measured around the (110), (220) and (310) charge peaks, presented with small solid circles on the reciprocal lattice fig.1. They reveal a modulated magnetic structure whose propagation vector is parallel to the <100> directions of the cubic lattice, in agreement with the magnetic phase in bulk Eu. Let us however underline that no magnetic satellites could be measured along the c* direction. This could indicate the absence of this magnetic domain and will have to be related to magnetoelastic effects: since [001] is the only <100> in-plane direction, it is no longer equivalent to [100] and [010].

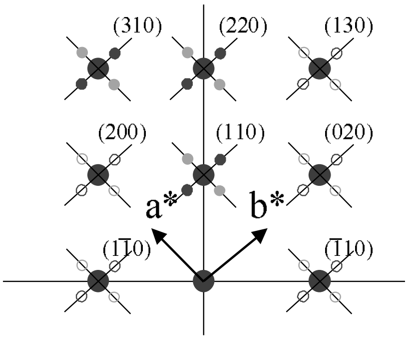

Fig.1: sketch of the Eu reciprocal lattice. Small circles correspond to magnetic contributions. The solid ones have been actually measured.

Figure 2a shows the (1 1 0) charge peak and the (1 1±τ 0) magnetic satellites, in the ordered phase and close to T_N .The thermal evolution on heating of the (1 1−τ 0) magnetic intensity and of the turn angle is given in figure 2b.

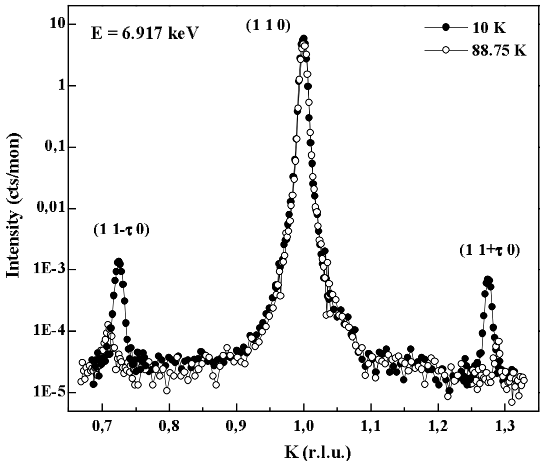

Fig.2a: K-scans measured around the (110) charge peak, at 10K and at 88.75K in the σ–π channel for E=6.971 keV.

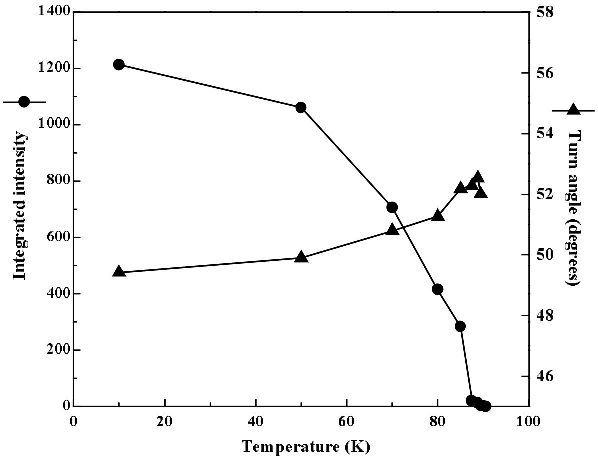

Fig.2b: Thermal evolution of the integrated intensity of the (1 1-τ 0) magnetic satellite and of the turn angle

The thermal evolution of the integrated intensity reveals an ordering temperature very close to 89K. The turn angle of the helical phase slightly increases with temperature, from 49° at 10K to 52° at the ordering temperature. Both the turn angle and the ordering temperature are similar to bulk values.

At 14 keV, we followed the thermal evolution on heating of the (6 6 0), (7 5 0) and the (5 0 –3) charge peaks. We observed a broadening in Q-space on approaching the transition, consistent with the tetragonal distortion that was reported for bulk Eu.

From the peak positions, we deduced an average (cubic) lattice constant (Fig.3). We attribute the discrepancies in the calculated parameters to the fact that (6 6 0) and (7 5 0) are both sensitive only to the out of plane (a* and b*) 4-fold axes, whereas (5 0 –3) is sensitive to a* and to the in-plane 4-fold axis c*. The parameters along **a** and **b**, and along **c** must evolve in different ways.

In conclusion, RXMS experiments permitted to analyse both magnetic configurations and magnetoelastic effects in a Eu film. Further analysis of the lattice constants and of the line-shape in Q-space will give us a good knowledge of the magnetoelastic effects, which we hope to relate to the apparent absence of the magnetic domain along c*.

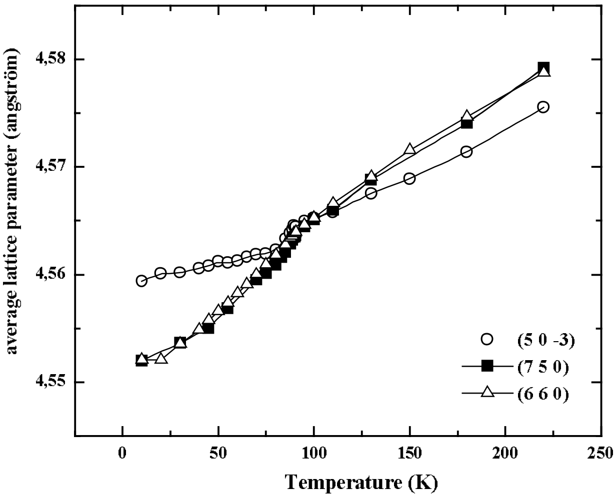

Fig.3: Thermal evolution of the average lattice parameter deduced from three charge peaks assuming a bcc structure