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:** **Interface magneto-crystalline anisotropy of Fe/CeH_2 probed by x-ray resonant magnetic scattering**	**Experiment number**: HE-768
Beamline: ID12B	**Date of experiment**: from: 18/2/2000 to: 22/2/2000	**Date of report**: 16/8/2000 *Received at ESRF:*
Shifts: 12	**Local contact(s)**: S.S. Dhesi	

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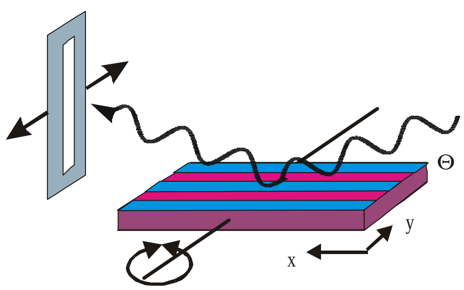
Report:

The interfaces between magnetic and non-magnetic layers are of high importance for many magnetic properties such as the magneto-crystalline anisotropy (MCA). It is well established that electronic hybridization at the interfaces of 3*d* and 5*d* transition metals (TM) can lead to a spin orientation perpendicular to the layers which is preferred for magneto-optical recording applications. The strong 5*d* spin-orbit coupling and an induced magnetic moment at the interface layer have been identified as the main driving force for the perpendicular spin arrangement. A similar phenomenon is observed at 3*d* TM / rare earth (RE) interfaces. There, however, it is expected that a different mechanism dominates especially at low temperatures when the indirect exchange coupling between TM 3*d* and RE 4*f* shell mediated by the RE 5*d* electrons induces a significant 4*f* magnetic moment. In this single-ion anisotropy picture the strong crystalline field of the TM interface atoms acting on the large orbital quadrupole moment of the RE 4*f* shell pulls the spins out-of-plane.

The magnetization of Fe/CeH_2 is oriented perpendicular to the layer planes in a multidomain configuration at low temperatures [1]. This is expected as a consequence of a strong interface MCA that promotes a spin orientation perpendicular to the layers and the magneto-static interaction between spins. The latter tries to force the spins in-plane and usually dominates at high temperatures. The perpendicular magnetization configuration is considerably stabilized when the multilayer magnetization splits up into adjacent spin-up and down domains of regular size (stripe domains) which can be readily detected with x-ray resonant magnetic scattering (XRMS) in the geometry shown in Fig. 1 [2]. XRMS in the soft x-ray region is sensitive to the magnetic domain structure of Fe 3*d* and Ce 4*f* electrons. The corresponding spectra are displayed in Fig. 2. We find a different domain structure of the Fe 3*d* and Ce 4*f* subsystems. While at the Fe L_3 edge the XRMS scans show pronounced side peaks characteristic of stripe-like domains [2] the magnetic domain pattern at the Ce M_5 edge is clearly more disordered. The magnetic scattering contribution of the Ce 4*f* electrons can be identified by forcing the sample into a single domain state by applying a strong magnetic field (dotted curve in Fig. 2). This different domain structure rules out crystal-field induced single-ion anisotropy as the microscopic driving force of the perpendicular spin orientation. The magnetic stripe-domain configuration also leads to a straightforward separation of first- and second-order magnetic scattering contributions as magnetic superstructure Bragg peaks. The first-order contribution probes mainly the magnetic moment. The second-order contribution is a measure of the spin-orbit quadrupole moment that describes the difference in the expectation value of the spin-orbit interaction with the spins aligned along the easy and hard magnetic axis of the system. This quantity is directly related to the MCA [3].



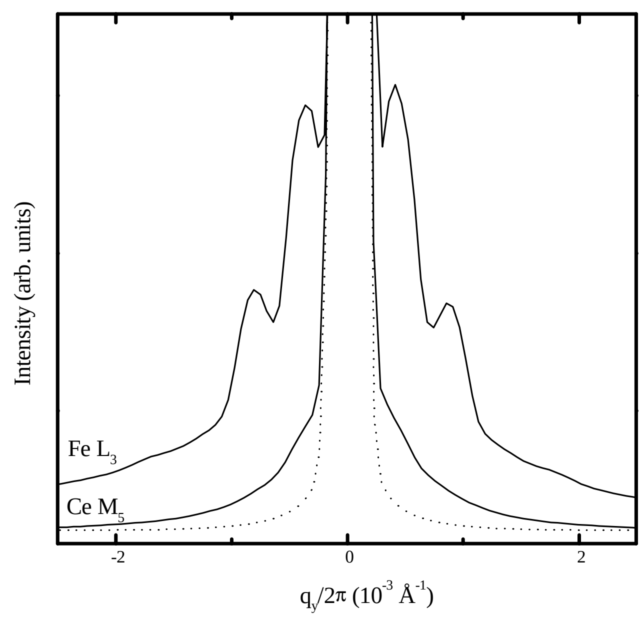


Fig.1. Schematic layout of the experimental setup.

Fig. 2. XRMS spectra taken at the Fe L3 and Ce M5 absorption edges (solid lines). A magnetic field of 1 T was appied to quench the magnetic domains (dotted line).

References

[1] M. Arend, et al. Phys. Rev. B **59**, 3707 (1999).

[2] H.A. Dürr et al., Science **284**, 2166 (1999).

[3] G. van der Laan, Phys. Rev. Lett. **82**, 640 (1999).