EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

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 via the User Portal:
https://wwws.esrf.fr/misapps/SMISWebClient/protected/welcome.do

Deadlines for submission of Experimental Reports

Experimental reports must be submitted within the period of 3 months after the end of the experiment.

Experiment Report supporting a new proposal ("relevant report")

If you are submitting a proposal for a new project, or to continue a project for which you have previously been allocated beam time, you must submit a report on each of your previous measurement(s):

- even on those carried out close to the proposal submission deadline (it can be a *"preliminary report"),*
- even for experiments whose scientific area is different form the scientific area of the new proposal,
- carried out on CRG beamlines.

You must then register the report(s) as "relevant report(s)" in the new application form for beam time.

Deadlines for submitting a report supporting a new proposal

- 1st March Proposal Round - **5th March**
- 10th September Proposal Round - **13th September**

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.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report in English.
- include the experiment number 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:** Novel magnetic RE-i-MAX phases investigated by XMCD	**Experiment number**: HC-4112
Beamline: ID12	**Date of experiment**: from: 23 Sep 2020 to: 29 Sep 2020	**Date of report**: 01/09/2021
Shifts: 12	**Local contact(s)**: Fabrice Wilhelm	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

BARBIER Maxime* (ESRF + LMGP)

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Report:

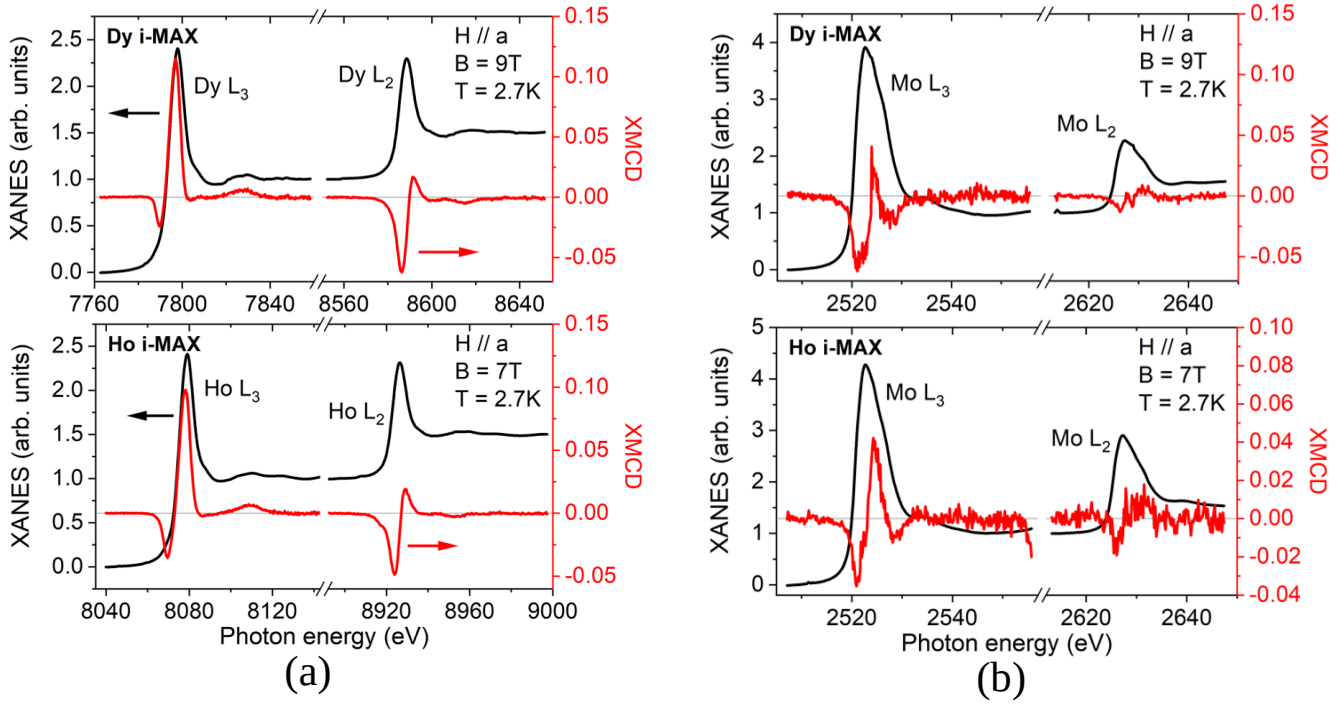

Figure 1: Normalized $L_{3,2}$-edges XANES (left axis) and XMCD (right axis, same scale as XANES) spectra measured at T = 2.7K on the RE (a) and Mo (b) elements of Ho and Dy i-MAX.

The goal of this beamtime was to make use of XANES and XMCD to study the magnetic and spectroscopic properties of single crystals of $(Mo_{2/3}RE_{1/3})_2AlC$ (also called "i-MAX phase"), where RE = Ho and Dy. Preliminary bulk magnetisation measurements had been conducted, and revealed complex behaviour, with multiple metamagnetic transitions along the easy magnetisation axis *a*, which called for a follow-up element specific study. Since Mo atoms lie within the RE planes, we wondered if they would be exchange coupled with the RE atoms. In the case of Ce4473, a parent nano-laminar system, no magnetic moments on Mo was observed.

In the first step, a magnetic field strong enough to saturate the magnetic moments was applied along the easy axis of the single crystals, and XANES and XMCD spectra were recorded at the $L_{3,2}$-edges of the RE (Fig. 1 (a)) and Mo (Fig. 1 (b)) on Dy and Ho i-MAX. On both compounds, there is an intense XMCD signal at the $L_{3,2}$-edges of Mo, which proves that there is indeed a magnetic moment on the Mo atoms. We then proceeded to set the energy at the energy position of an XMCD peak and swept the magnetic field, so as to obtain element-specific magnetisation curves on the RE and Mo (Figure 2). The RE magnetisation is following the behaviour of the bulk magnetisation, as could be expected. The magnetisation of the Mo atoms is in turn following the RE, which tells us that the moment on Mo is induced by its proximity with the RE, as opposed to being the result of a Mo magnetic sublattice that would be uncoupled with the RE. In the light of this, it is interesting to note that the magnitude of the XMCD peaks at Mo L_3 on Dy or Ho i-MAX is quite different (Figure 1 (b)), which hints at variations in the coupling with the Mo depending on the RE element.

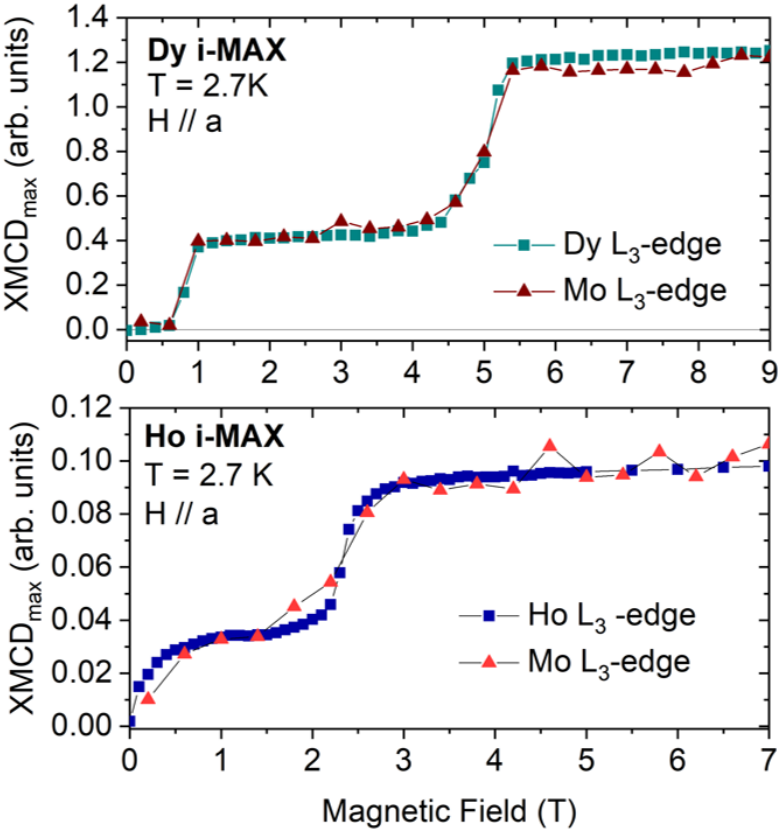

Figure 2: Element-specific XMCD intensity vs H measured at the L_3-edge of the RE and Mo on Dy and Ho i-MAX

We then made use of the magneto-optical sum rules to determine the orbital and spin magnetic moments of the Mo atoms, which gives us an opportunity to go a step further in the study of the couplings at play in these compounds. Indeed, the relative orientation of the orbital and spin moments on Mo and the RE hint at an unusual coupling scheme, where the 4*f* moments of the RE would interact directly with the 4*d* spin of Mo, instead of being mediated by the RE 5*d* orbital, as is usually believed to be the case. These results, along with bulk measurements, soft x-ray XAS and inelastic neutron scattering measurements were combined and analysed together, and led to the redaction of an article that will be submitted soon.