ESRF	**Experiment title: Angular dependent RIXS-MCD study of $CoFe_2O_4$ and $FeMn_2O_4$.**	**Experiment number**: HE-3363
Beamline: ID26	**Date of experiment**: from: 30 june 2010 to: 6 july 2010	**Date of report**: 20-02-13
Shifts: 18	**Local contact(s)**: Dr. Pieter Glatzel	*Received at ESRF:*

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Report:

The goal of the experiment was to perform 1s2p RIXS-MCD measurements on model magnetic compounds in order to improve our understanding of this spectroscopy. We wanted to address in particular three points, which concern the intensity of RIXS-MCD depending on (1) the orientation of the sample (2) the absorbing element (3) on its coordination (tetrahedral vs octahedral) and its valence. The measurements were performed at room temperature using a small permanent magnet of $Nd_2Fe_{14}B$ positioned along the beam.

We first measured the RIXS-MCD signal on a $CoFe_2O_4$ sample. At the Fe K pre-edge, the RIXS-MCD plane (Figure 1) shows only a double (positive + negative) intense MCD feature, which is due to tetrahedral Fe^{3+} . The weak MCD feature due to Fe^{2+} is absent from the RIXS-MCD plane (it would be visible at lower incident energy and lower energy transfer). Therefore the assignement that we previously did of the RIXS-MCD features visible in the spectrum of magnetite (based on theoretical considerations) is confirmed experimentally. A RIXS-MCD spectrum was also measured at the Co K pre-edge (Figure 1 right). The shape of the RIXS-MCD signal is similar to the one measured for Fe, but the MCD signal at the $K\alpha_2$ emission is significantly larger for Co than the one measured at the Fe K pre-edge. The detailed comparison of the data measured at both edges, using Ligand Field Multiplet calculations, is under progress.

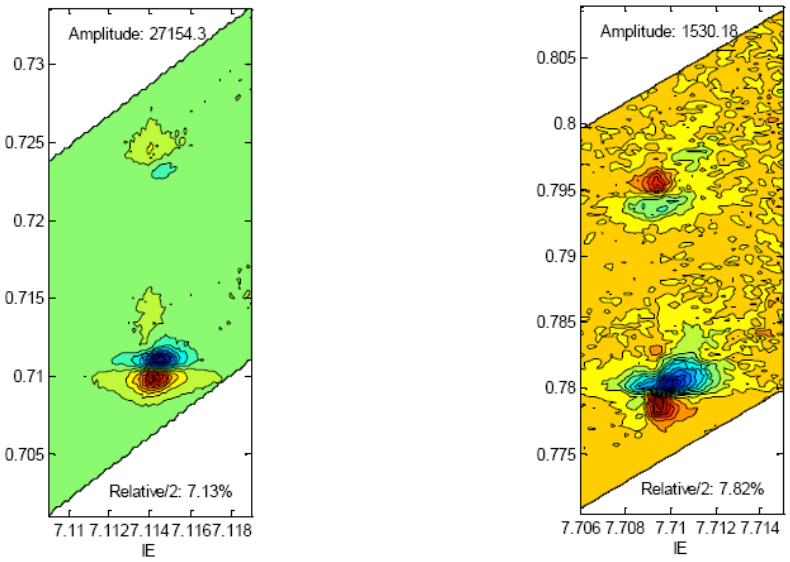

Figure 1. RIXS-MCD signal measured on a $CoFe_2O_4$ sample at the Fe K pre-edge (left) and the Co K pre-edge (right).

Then we investigated the angular dependence of RIXS-MCD using a single crystal of magnetite. Figure 2 shows that both the shape and intensity of the RIXS-MCD signal are significantly modified when the orientation of the single crystal is varied with respect to the direction of the beam and of the magnetic field. The intensity of the main MCD feature, which is due to tetrahedral Fe^{3+}, is changed by a factor of two between the different orientations chosen, which is very large. Additionnally, the MCD feature due to octahedral Fe^{2+} (at 707 eV energy transfer) changes from a single positive peak into a double (positive + negative) feature, depending on the configuration. The quantitative analysis and simulation of these angular effects is under process. A paper discussing the fundamental aspects of RIXS-MCD is currently under writing.

Finally, we used RIXS-MCD to analyse the composition and structure of bimagnetic core-shell nanoparticles. The RIXS-MCD results evidence the existence of a magnetic interdiffused inner shell of (Mn,Fe) spinel growing from the core γ-Fe_2O_3 and the shell Mn_3O_4. A paper based on these results is currently under revision in ACS Nano.

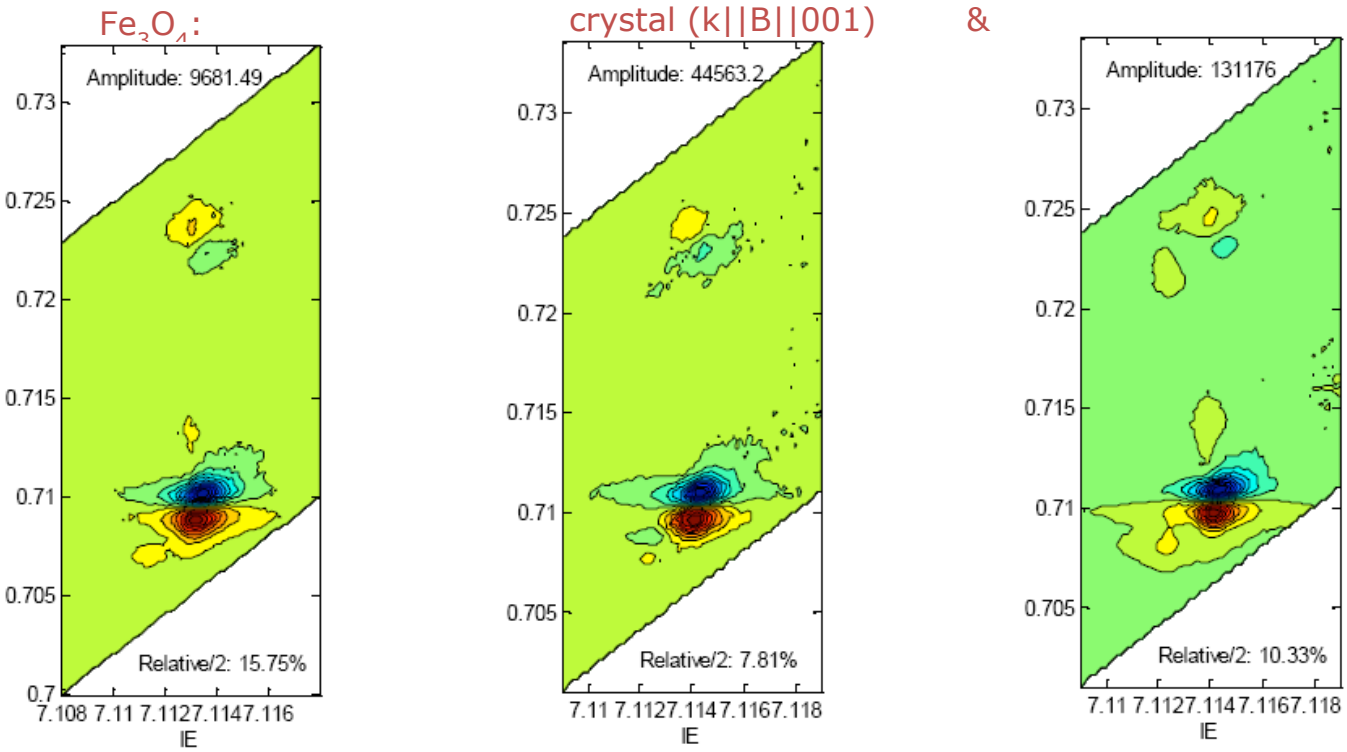

Figure 2. RIXS-MCD signal measured at the Fe K pre-edge on a magnetite sample. (left) powder, (centre) single crystal with k //B//001, (right) k //B//101.

All the results obtained during this beamtime were presented during several conferences listed below.

- M. Sikora. 56th conference on Magnetism and Magnetic Materials, Scottsdale, Arizona (USA), 30 October–3 November 2011.
- A.Juhin. Workshop on Fundamental Aspects of X-ray Spectroscopies: the role of the 2p core hole in XAS and RIXS. Utrecht (Netherlands), 20-21 february 2013.
- A.Juhin. CTM4XAS 2012 Winter School, Utrecht (Netherlands), 13-14 february 2012. Application of Ligand Field Multiplet Theory to the calculation of dichroisms.
- A.Juhin. The Electronic Structure of Transition Metal Systems, Utrecht (Netherlands), 21 october 2010. Strong K-edge Magnetic Circular Dichroism detected by Resonant Inelastic X-ray Scattering.