	Experiment title:	**Experiment number**:
	Ferrimagnetic order in thin-film Fe_3O_4 studied by resonant inelastic x-ray scattering	MI405
Beamline:	**Date of experiment**:	**Date of report**:
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Shifts:	**Local contact(s)**:	*Received at ESRF:*
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Report:

We have set out to use the ID21 microfocusing beamline to perform resonant inelastic x-ray scattering (RIXS) experiments on magnetic materials. For the first tests and experiments we start off with Fe oxide thin films of potential interest in new technical applications. Of main interest are thin films of Fe_3O_4 epitaxially grown on alumina. Note that RIXS is particularly well adapted to experiments involving samples on insulating substrates (no charging effects) prepared *ex-situ* (bulk sensitivity) which can be magnetized (all-photons experiment). Our intention was to progress in three phases.

- Ascertain that RIXS signals of sufficient intensity and resolution were obtainable even with the incident photon beam focused to a very small spot (~ 1μm diameter).
- Single domains would be identified using x-ray absorption MCD (i.e., using circularly polarized photons).
- Finally, RIXS would be used to characterize the sample as the magnetic field intensity is varied.

We are presently in the first phase. Following some initial tests performed November 4-8, 1999 (the low-energy monochromator on ID21 had not been commissioned in time for proposal HE720), we modified the configuration of our bent crystal x-ray spectrometer so that it could be bolted directly to the ID21 optical bench for maximum stability. It was then possible to align in succession a beam-stop, a high quality zone-plate (supplied by Jean Susini), a pin-hole, and the Rowland circle of our spectrometer at the focal point of the zone-plate. The positioning of each element has to be performed to better than 1μm.

The precision of our sample holder prevented us from measuring the exact vertical dimension of the spot but we ascertained that it was < 5μm. A more precise sample-holder is being designed for future experiments. It was also noted that the thickness of the beam-stop was insufficient to absorb all the intensity (~5-10% transmission) thus effectively broadening the beam at the sample. This will be modified for future experiments.

Using the focused beam we obtained the RIXS data presented in figures 1 and 2. In Fig. 1 the curves represent the scattered photon intensity as a function of energy for single crystals of α–Fe_2O_3 and Fe_3O_4 (continuous line and dots respectively). The bottom curves were excited with an incident photon energy 14 eV below the Fe 1*s*→4*p* white line in the absorption spectrum. This is 7116 eV on our energy scale. Spectra obtained at four other energies are also shown. Similar measurements for a 270 Å thick Fe_3O_4 (111) film grown on an α–Al_2O_3 (0001) single crystal using atomic oxygen-assisted MBE are shown in figure 2. 1*s*2*p* RIXS spectra have previously been calculated by Caliebe *et al*. (1998) which show that the curves are the sum of quadrupole and dipole contributions which vary in intensity as a function of the incident photon energy. Thus structure corresponds to mainly quadrupole transitions (1*s*→3*d*) except towards lower emitted-photon energies where a strong dipole (1*s*→*p*-like) component is apparent in Fe_2O_3 (arrow A). The Fe_3O_4 film is very similar to the single crystal with a more marked high emitted-photon energy quadrupole peak (arrow B). In these experiments the x-ray spectrometer used a Si(333) crystal but resolution was limited by the monochromator fitted with Si(111) crystals. We anticipate much high resolving power using Si(220) crystals for the monochromator. This will make it possible to better resolve the weaker structure at low energies (arrow B) and thus distinguish the role of the *d*-orbitals in this more complex Fe^{2+} and Fe^{3+} ferrimagnetic compound.

Reference

W. A. Caliebe *et al*., Phys. Rev. B 58, 13452 (1998).

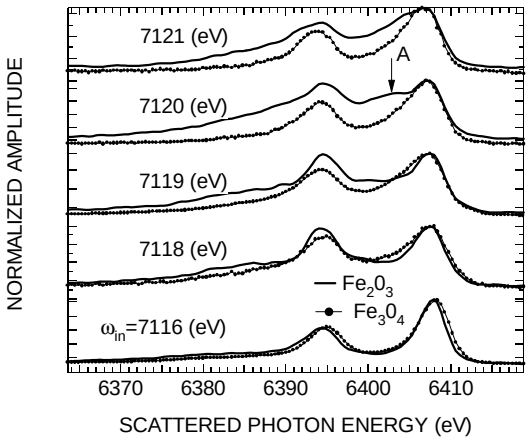

Fig. 1

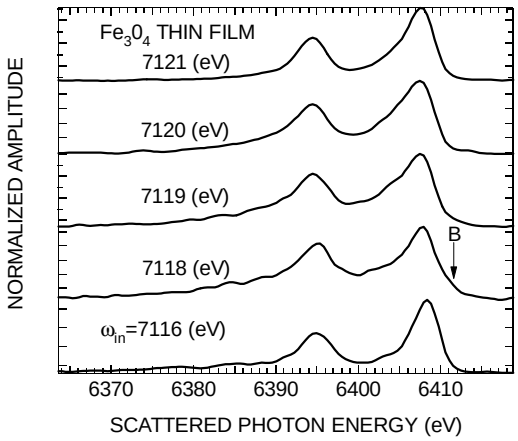

Fig. 2