ESRF	**Experiment title:** Temperature dependence of the structural distortions in magnetoelectric gallium thin films	**Experiment number**: 02-02-869
Beamline:	**Date of experiment**: from: 22 june 2021 to: 28 June 2021	**Date of report**: 29 June 2021
Shifts:	**Local contact(s)**: Stéphane GRENIER	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Main Proposer *Prof. Dr. VIART Nathalie Inst. de Physique et Chimie des Matériaux de Strasbourg STRASBOURG CEDEX 2

Co-Proposers *Dr. LEFEVRE Christophe Inst. de Physique et Chimie des Matériaux de Strasbourg STRASBOURG CEDEX 2

*Dr. MEUNIER Benjamin Inst. de Physique et Chimie des Matériaux de Strasbourg STRASBOURG CEDEX 2

*Dr. GRENIER Stéphane Inst. Néel GRENOBLE CEDEX 9

Report:

Objective and expected results

Gallium ferrite, $Ga_{0.6}Fe_{1.4}O_3$, is a room temperature multiferroic and magnetoelectric material which is the subject of an increasing interest for its potential applications in low power spintronics. Its magnetic properties result from the superimposition of four magnetic sublattices and are not completely understood on the atomic scale. We have performed temperature dependent XMCD experiments on thin films of this material which show a minimum at 120 K in the unexpected negative orbital moment of Fe^{3+}.
A possible explanation for these unusual variations in the orbital moment relies on lattice distortions and structural changes. We therefore want to study the temperature dependence of the atomic positions in our thin films in order to understand their influence on the atomic-scale magnetic properties.
These positions will be determined by resonant elastic X-ray diffraction (REXS) experiments.

Experimental

Resonant Elastic X-ray Scattering experiments were perfomed on the D2AM beamline equiped with a cryofurnace. The sample, a 64 nm thick GFO thin film deposited by pulsed laser deposition onto a $SrTiO_3$ (111) substrate, is mounted in a Be dome specimen holder evacuated down to 10^{-6} mbar (Fig. 1), and maintained to a fixed temperatures, between 300 and 20 K, by an ARS compressor.

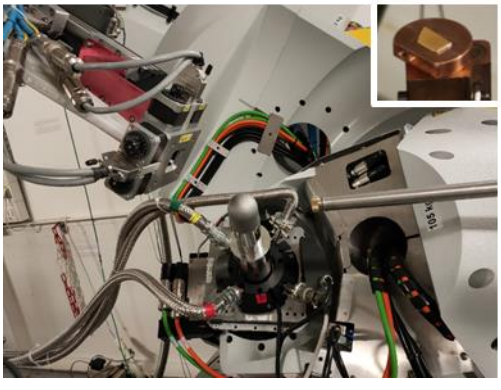
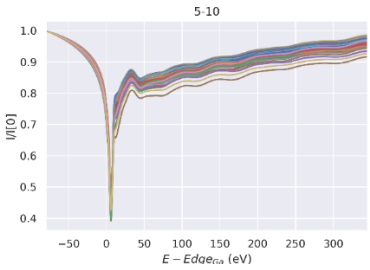
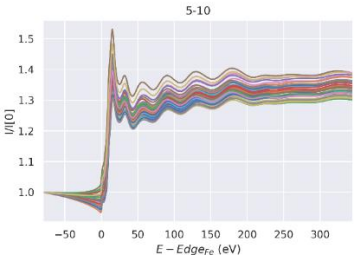
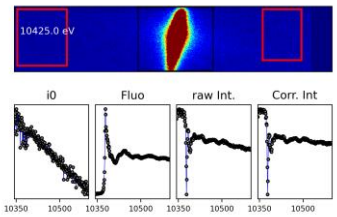
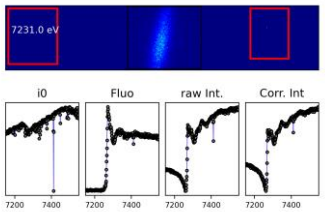
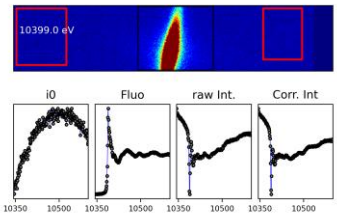
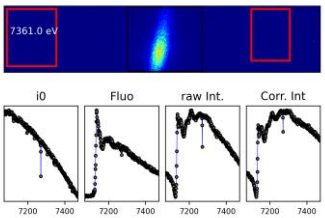
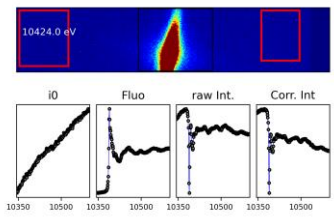
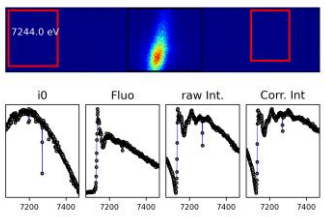
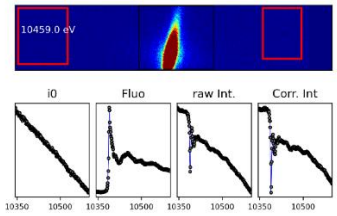
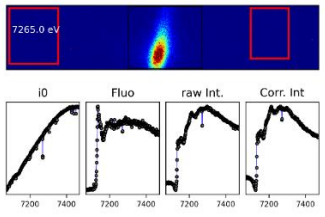


Fig. 1: Measurement configuration (the sample, in insert, is placed in an evacuated Be dome to allow the temperature dependent measurements)

Results and Conclusions

Some resonant diffraction spectra were acquired at both the Fe and Ga K-edges, over the 7.072-7.472 keV and 10.344-10.6 keV energy ranges, respectively, for about 10 different reflections chosen for their sensitivity to the positions of the oxygens in the cell, at 8 different temperatures (300, 250, 200, 160, 120, 80, 50, and 20 K).
Some of the experimental spectra acquired for various temperatures, at the Ga and Fe K-edges for the 051 reflection are shown in the table here below, as representative of the acquired data, together with the simulated curves for this reflection with various positions of the oxygen atoms. The signal is probably partly absorbed by the Be dome, with a higher impact at the Fe edge due to its lower energy. One can however clearly observe distinct features on the spectra.

Temperature	051 Ga	051 Fe
Simulations (for various positions of the oxygens within the cell)		
300 K		
120 K		
50 K		
20 K		

The spectra will be fitted with the FitREXS and FDMNES codes, in order to determine the orientation of the GFO cell, the cationic distribution within the four cationic sites, and the positions of both the cations and anions for each temperature. After a long analysis procedure, the large set of data should thus give conclusions on the positions of the atoms, and therefore on the possible temperature dependent lattice distortion.