	Experiment title: X-Ray Resonant Scattering Study of Strain Effects in Sr2IrO4 Thin Films	**Experiment number**: 28-01-1135
Beamline: XMaS		**Date of report**: *Received at ESRF:*
Shifts: 18		

Names and affiliations of applicants (* indicates experimentalists):

MANNIX Danny Email danny.mannix@sljus.lu.
GEPRÄGS Stephan Email stephan.gepraegs@wmi.badw.de
WERMEILLE DidierPhone 29-24 Email wermeille@esrf.f

Report:

Aims: The aim of the experiment was to investigate the strain effects on the exotic magnetic properties of the large spin orbit driven Mott Insulator Sr_2IrO_4, with J_{eff}=1/2 ground state. The experiment was undertaken at the XMAS CRG beamline, using X-ray Resonant Scattering (XRS) with photon tuned to the Ir L_3 absorption edge. The experiment focussed on investigations, the correlation lengths, temperature dependence and azimuthal dependence of the thin films in the thickness range of 20nm to 120nm. The first part of the experiment were performed in zero field and the second part in applied magnetic field. The Ir L_3 absorption edge, is know. to produce very large XRS magnetic signal in Sr_2IrO_4, which we exploited to investiged the magnetic structure of our thin films down to 20nm thickness, even using the moderate flux of a bending magnetic beamline of the ESRF.

Results: Part I - Zero Field Studies.

The main results found in the films in zero field it that we found a dramatic tuning of the c-axis magnetic correlation length out of plan of the films, by varying the thin film thickness. The magnetic scattering because very sharp and strong above a critical thin thickness of around 60nm as shown in figure 1a&b. Surprisingly, we find that this growth in the magnetic correlation length is independent of the film strain state, but only the film thickness. As shown in figure 1b, the magnetic correlation length grows irrespective of the film strain state (tensile or compressive strain) and follows an easy to model power law function.

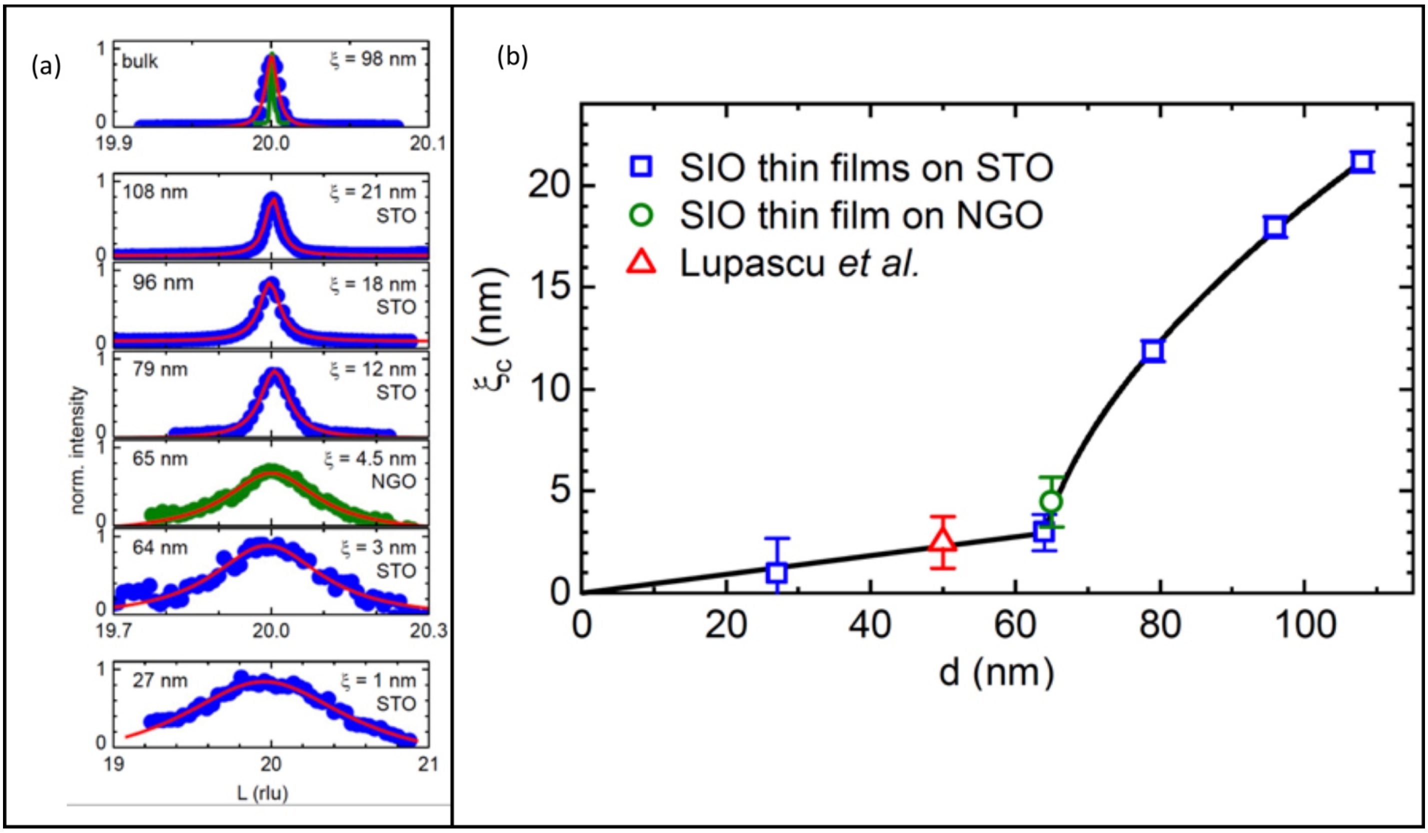

Figure 1(a) (left). L-scans of the magnetic Bragg reflection (1 0 4n), vs thin film thickness. The magnetic correlation length is always shorter than the film thickness, but grown with thickness, reaching. close to bulk value at around 100nm thickness. (b) (right).The magnetic correlation length vs films thickness (b) A critical thickness is reached at about 60nm above which the correlation length grows as a power-law fit. The thickness grows regardness of strain state (tensile or compressive strain) and depends only on thr thickness.

Results: Part II - Applied Magnetic Field Studies.

Bulk Sr_2IrO_4 is known to undergo a metamagnetic phase transition at about B=0.2T, with a change of magnetic structure. The nominal magnetic reflections defined at (1 0 4n) and (0 1 4n+2) change to become (1 0 2n+1) and (0 1 2n+1) type reflections. We have discovered a dramatic switching of the c-axis magnetic correlation length from long range order to short range order under applied magnetic field, which is not observed in the bulk material (figure 2). This effect is not reported in the bulk material and further enriches the results of the tuning of the magnetic correlation length with. thickness described above.

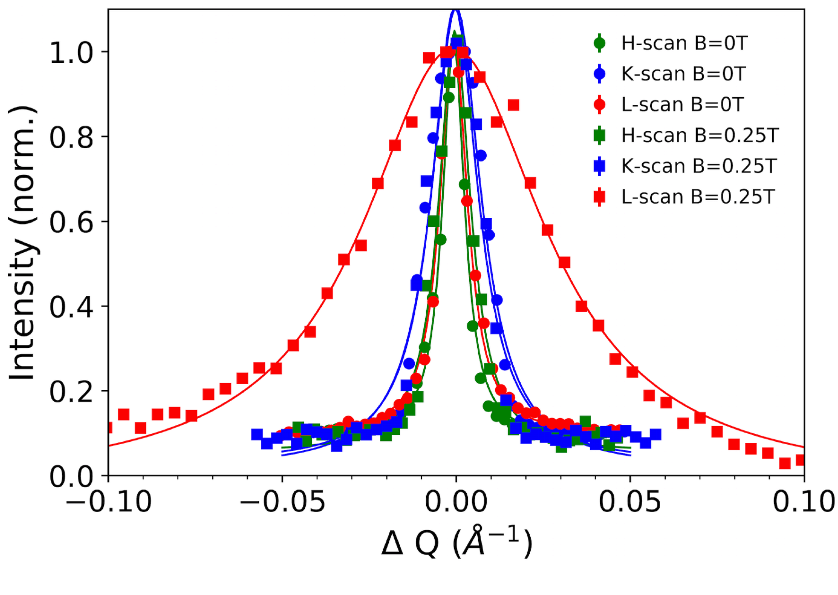

Figure 2. H,K and L scans in zero applied magnetic field (circles) and 0.25T magnetic field (squares). A dramatic change in the L-scans is observed in applied field, reflecting the switching from long range magnetic order to short range order. Similar effects are not observed in the in-plane H and K scans. The effect is not reported in the bulk compound.

Further work and publications:

This work has recently been submitted as part of two publications to Physical review B and Physical Review letters [1,2]. We plan to continue the investigations under applied magnetic field to further explore the phase diagram.

References

[1] Precise control of the J_{eff}=1/2 ground state magnetic properties of Sr_2IrO_4 epitaxial films by variation of thickness and strain.
S. Gepraegs, D.Mannix et al. Submotted to Physical Review B 2020.

[2] Ultrafine tuning of the J_{eff}=1/2 ground state magnetic correlations in Sr_2IrO_4 epitaxial films by applied magnetic fields.
S. Gepraegs, D.Mannix et al. Submitted to Physical Review Letters 2020