Experimental report

08/09/2022

Proposal: 5-42-504 **Council:** 4/2019

Title: Study of the magnetic diffuse scattering in Sr3Ir2O7

Research area: Materials

This proposal is a new proposal

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Samples: Sr3Ir2O7

Instrument	Requested days	Allocated days	From	To
D7	10	6	10/01/2020	16/01/2020

Abstract:

Layered perovskite iridates realize a rare class of Mott insulators, which are predicted to be the strongly spin orbit coupled analogues of the parent state of cuprate high temperature superconductors. The ground state of Sr3Ir2O7 (Sr327) is an antiferromagnetic insulator with a gap of 100meV and the electronic structure of this compound seems to be intimately coupled to its magnetic structure. Indeed, transport and angle resolved photoemission spectroscopy studies show that the electronic density of states near the Fermi level changes in the vicinity of the AF ordering temperature (TN=280 K). Additionally, the in-plane resistivity shows a strong enhancement below T*=70K in this material, which corresponds to a glassy-like transition according to magnetization data. A possible explanation of this glassy behaviour would be the freezing of an orbital or charge phase into an inhomogeneous textured electronic ground state. Our recent polarized neutron diffraction data evidence the presence of a low temperature diffuse magnetic scattering at 8K that vanishes at 150K, possibly associated with this freezing. We ask for 10 days on D7 to study this diffuse scattering.

Proposal 5-42-504 details

Scientific council	2019-4
Proposal number	5-42-504
Title	Study of the magnetic diffuse scattering in Sr3Ir2O7
Main proposer	Dalila BOUNOUA, Marine VERSEILS, LLB SACLAY
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Local contact	Lucile MANGIN-THRO

The bi-layer Iridate $Sr_3Ir_2O_7$ (Sr237): Layered perovskite iridates realize a rare class of Mott insulators, which are predicted to be the strongly spin–orbit coupled analogues of the parent state of cuprate high temperature superconductors. Recent discoveries of pseudogap, magnetic multipolar order and possible d-wave superconducting phases in doped Sr_2IrO_4 have reinforced this analogy among the single layer variants. A starting point for understanding this state is the spin-orbit Mott insulator model in which the low-energy electronic structure is approximated by half-filled pseudospin J_{eff}=1/2 and filled J_{eff}=3/2 bands that are derived from spin-orbit split Ir^{4+} t_{2g} orbitals. In the presence of on-site Coulomb repulsion, a Mott gap is driven in the J_{eff} =1/2 band without requiring antiferromagnetic ordering of the J_{eff} =1/2 moments. However, experimental evidence suggests that $Sr_3Ir_2O_7$ does not adhere to this strong Mott insulator description. Notably, there is evidence from transport, optical conductivity and angle resolved photoemission spectroscopy studies that the electronic density of states near the Fermi level changes in the vicinity of the antiferromagnetic ordering temperature (T_N=280 K).

Prime measurements of the AF phase were performed on 15 co-aligned single crystals of composition Sr237 with a size of $\sim 2 * 1 * 0.5\ mm^3$ each, on the cold TAS 4F2 at LLB. The temperature dependence of the AF Bragg peak at Q (1,0,2) was measured by performing H and L-scans around (1 0 2). Above T_N=280K, the magnetic signal collapses. The wavevector of the magnetic scattering corresponds to a parallel stack of the AF ordered moments between the Ir bilayers as deduced from the corresponding magnetic structure factor [6]. The measured peaks are resolution limited and the corresponding correlation lengths are at least $\xi_a \sim 75$ Å and $\xi_c \sim 95$ Å.

Similar measurements have been attempted on D7 at λ=3.1 Å during the 5-42-504 proposal beam time. The measurement was performed on an assembly of 15 single crystals, with a total co-aligned mass ~7mg. We perform a full XYZ-polarization analysis to determine the Q-dependence of the magnetic scattering. To save time, only a 30° ω-map was performed at 5K. Flipping ratios, vanadium and empty cells corrections have been all applied to the raw data.

Unfortunately, the deduced magnetic intensity is much weaker than the measurement on triple axis 4F2 at LLB with a larger background. To remove the background, we have to make the difference between the spin-flip intensity for different polarization. The figure is showing at 5K the difference of the intensity between SF_Y and SF_X. On D7, the channel Y is typically where the magnetic signal is maximum for the scattering angle around 2θ ~ 40-80 deg where the magnetic peaks (such as (1,0,L)

with L integer) should appear as the polarization is along the wavevector, **Q**. For the X channel, the magnetic intensity is reduced as the polarization is typically perpendicular to the **Q**. By doing the difference SF_Y-SF_X one get rid of the large background. The scan is integrating the map over a limited range around H=1 covering many Q=(1,0,L) AF peaks. As shown in Fig. 1, where the spin-flip intensity is shown versus L for H~1, AF peaks are visible for L=-1,-2,-3, -4 and -5. However, the peaks are too small to be able to study them in details.

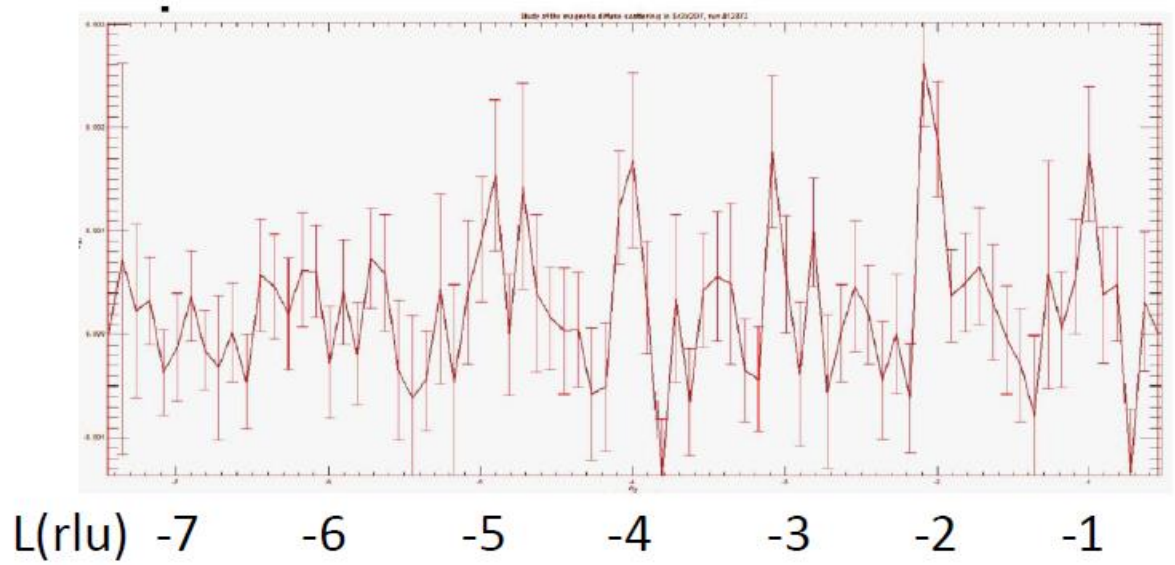

Figure: (1,0,L)-Scan along c* obtained from the map around H=1 of the difference of the spin-flip intensities measured in channels SF_Y and SF_X.

We also attempted to look diffuse scattering of the spin-flip intensity. Here, again, the experiment could not confirm the 4F1 LLB experiment due to a lack of statistics. There is limited indication that a part of the spin-flip background is magnetic in origin it increases at low scattering angles.