Experimental report

15/09/2016

Proposal: **5-53-244** **Council:** 4/2014

Title: Er magnetism in the Iridate Pyrochlore Er2Ir2O7

Research area: Physics

This proposal is a new proposal

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Samples: Er2Ir2O7

Instrument	Requested days	Allocated days	From	To
D7	5	4	17/12/2014	21/12/2014

Abstract:

The Ir-5d electrons in most iridate pyrochlores R2Ir2O7 (R = Y, Rare Earth), except Pr2Ir2O7, exhibit a metal-insulator transition accompanied with a magnetic freezing at temperature ranging from 35 K in Nd2Ir2O7 to 155 K in Y2Ir2O7. This magnetic freezing induces an "all-in all-out" magnetic order of the R moments around 15 K in Nd2Ir2O7 and 20 K in Tb2Ir2O7 through the f-d exchange. In contrast, no Er magnetic order is detected by neutron diffraction in Er2Ir2O7 down to 2K. We understand this by modelling the Nd or Tb magnetism with multi-axial Ising spins (aligned along the <111> directions) and the Er magnetism with multi-planar XY spins (perpendicular to these directions). We however observed additional hysteresis features in recent thermomagnetic measurements at around 0.6 K. We shall therefore request 5 days beam time on D7 with a dilution fridge to check whether the low temperature magnetization processes accounts for Er magnetic freezing or has still to do with the Ir magnetism.

EXPERIMENTAL REPORT

EXPERIMENT N° 5-53-244 INSTRUMENT: D7

DATES OF EXPERIMENT : 17/12/2014 → 21/12/2014

TITLE: **Er magnetism in the iridate pyrochlore $Er_2Ir_2O_7$**

EXPERIMENTAL TEAM: (names and affiliation)

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Attention of the community of condensed matter was recently attracted by the iridate pyrochlores $R^{3+}{}_2Ir^{4+}{}_2O_7$, where, owing to the competition between spin-orbit, crystal field and electron-electron interactions, the Ir-5d electrons might stabilize unprecedented electronic phases [1, 2] and, inherently to the geometric frustration combined with the 4*f*-5*d* exchange interactions, the R-4*f* electrons might display novel magnetic phases. Almost all the members of the series exhibit a metal–insulator transition accompanied by a magnetic transition, with an increase of the transition temperature when one scans the R species from the lightest to heaviest. The high temperature phase is a metal for the lighter R. It is a semi-metal then a semiconductor for increasingly heavy R [3]. It was argued from powder neutron diffraction experiments that its magnetic order might be the so-called "all-in / all out" [4]. The magnetic arrangement of the Ir moments was actually inferred indirectly and this was questioned from muon spin relaxation/rotation experiments [5]. The magnetic moment of Ir itself is very difficult to observe, but possible ordering configurations can be indirectly determined by the type of magnetic order of the rare-earth sublattice using symmetry arguments [6].

We considered $Er_2Ir_2O_7$, which we have investigated by magnetization measurements at the Institut Néel and by neutron diffraction at ISIS [6]. It is expected that the local magnetocrystalline anisotropies associated with the Tb^{3+} and Er^{3+} ions will be of opposite signs, in agreement with the corresponding signs of the reduced matrix element in the ground multiplet of the quadrupole contribution to the crystal field (αJ Steven's factors). Thermomagnetic measurements performed according to the ZFC-FC protocol on $Y_2Ir_2O_7$ and on $Er_2Ir_2O_7$, show a magnetic freezing evidenced at 140 K in $Er_2Ir_2O_7$. However, no magnetic signal is detected by powder neutron diffraction down to 2K, suggesting that this freezing is not associated to Er magnetic order. This is in sharp contrast with $Nd_2Ir_2O_7$ or $Tb_2Ir_2O_7$, where we found out that an 'all-in/all-out' magnetic ordering of the Tb moments is induced at 40K.

Additional hysteresis was found out at very low temperature in recent thermomagnetic measurements performed on $Er_2Ir_2O_7$using a dilution fridge. The new irreversible processes come out below 0.6 K and suggests a possible ordering or freezing of the Er magnetism, but might as well account for a magnetization process inherent to the Ir magnetism seen through the Er magnetism coupled by the Ir-Er exchange.

The aim of the proposed experiment was to determine whether the magnetization processes observed below 0.6K are associated to a magnetic ordering of Er moments, either in a long range or a short range configuration.

The measurements performed on D7 allowed us to established the absence of long range order down to 0.05K. However, the existence of short range correlations, evidenced by the presence of a large bump around Q = 1.2 Å^{-1}, is observed as the temperature is lowered (see Fig 1). These correlations are most likely related to Er-Er interactions.
Monte Carlo calculations are under way in order to better understand the magnetic behavior of $Er_2Ir_2O_7$.

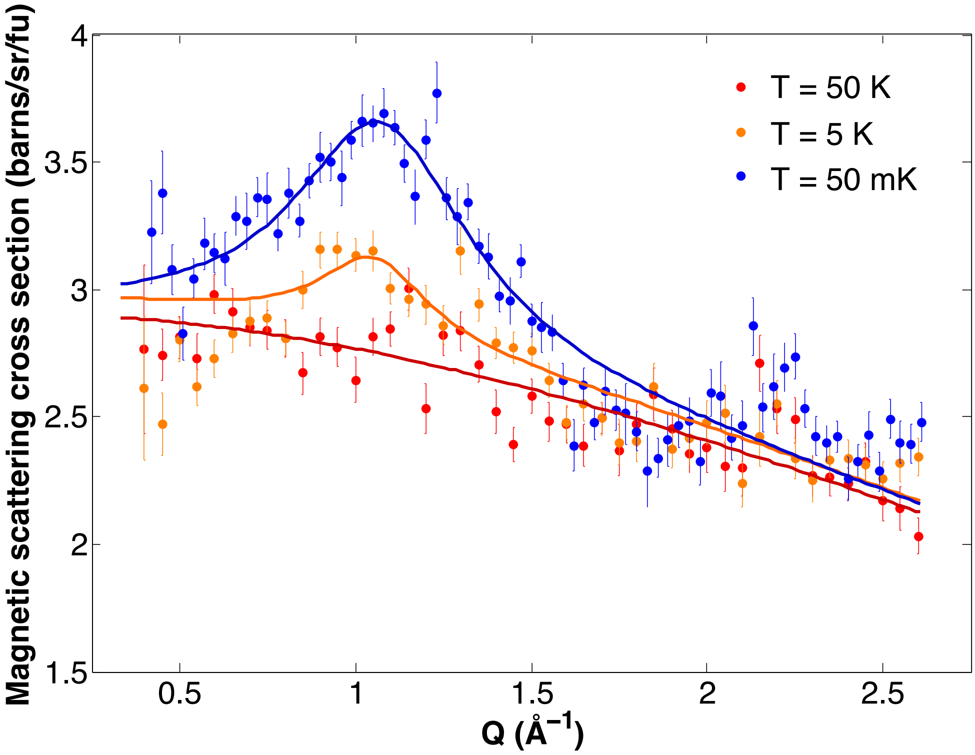

Figure 1: Diffuse magnetic scattering cross section for Er2Ir2O7 measured between 0.05 K and 50 K on D7 using XYZ polarization analysis. The lines are guide to the eye.

References:

[1] D. Pesin and L. Balents, Nature Physics 6 (2010) 376
[2] X. Wan *et al*, Phys. Rev. B 83 (2011) 205101
[3] K. Matsushira *et al*, J. Phys. Soc. Jpn 80 (2011) 094701
[4] K. Tomiyasu *et al*, J. Phys. Soc. Jpn 81 (2012) 034709
[5] S. M. Disseler *et al*, Phys. Rev. B 85 (2012) 174441
[6] E. Lefrançois *et al*, PRL 114 (2015) 247202