Experimental report

30/03/2017

Proposal: 5-42-452 **Council:** 10/2016

Title: Ground states in Ho, Gd and Yb iridate pyrochlores: influence of the single-ion anisotropy and of rare-earth interactions

Research area: Physics

This proposal is a new proposal

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Samples: Yb2Ir2O7
Ho2Ir2O7
Gd2Ir2O7

Instrument	Requested days	Allocated days	From	To
D7	10	8	31/01/2017	08/02/2017

Abstract:

The Ir-5d electrons in most iridate pyrochlores R2Ir2O7 (R = Y, Rare Earth) exhibit a metal-insulator transition accompanied by an ordering of the Ir sublattice. This induces an "all-in all-out" magnetic field on the R moments through the f-d exchange. This well-controlled staggered molecular field is a new parameter allowing to explore the rich physics of rare-earth pyrochlores. It is expected to strongly depend on the single-ion magnetocrystalline anisotropy of the rare-earth and on the interactions between the rare-earth playing a role at a much lower temperature than the Ir ordering. The aim of this proposal is to measure at very low temperature the magnetic diffuse scattering on the D7 spectrometer in order to unveil the ground states of three compounds: (i) Ho2Ir2O7, with an easy-axis anisotropy and ferromagnetic interactions competing with the "all-in all-out" magnetic field, (ii) Yb2Ir2O7, with an easy-plane anisotropy where no signature of any ordered moment was detected, (iii) Gd2Ir2O7, with an isotropic moment which shows the peculiar coexistence of long-range and short-range order at 2 K.

EXPERIMENTAL REPORT

EXPERIMENT N° 5-42-452 INSTRUMENT: D7

DATES OF EXPERIMENT : 31/01/2017 → 08/02/2017

TITLE: Ground states in Ho, Gd and Yb iridate pyrochlores: influence of the single-ion anisotropy and of rare-earth interactions

EXPERIMENTAL TEAM: (names and affiliation)

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Pyrochlore iridates of formula $R_2Ir_2O_7$, feature a new family of magnetic materials with fascinating properties as concerns the role of the spin-orbit coupling in the stabilization of novel electronic phases [1], but also from the point of view of magnetic frustration. Indeed, in these materials, both the rare-earth and the iridium ions occupy a pyrochlore lattice, made of corner-sharing tetrahedra and prone to frustration. Moreover, as demonstrated by our previous study on the Tb and Er compounds [2], as well as by other research teams, the Ir^{4+} magnetic moments order at rather high temperature (above 120 K for all rare-earths smaller than Nd) in the all-in all-out configuration, that is to say with all spins pointing inward or outward of each tetrahedron. This magnetic arrangement produces on the rare-earth sublattice site a local magnetic field oriented locally along the <111> directions that also follows an all-in all-out configuration. This staggered field can go along with the single-ion anisotropy of the rare-earth and with the magnetic correlations promoted by the interactions between the rare-earths. This is the case of the Tb compound, which displays an easy-axis of anisotropy along the <111> local directions and presents Tb-Tb antiferromagnetic interactions [2]. The local field can however rather compete with the single-ion anisotropy (case of the Er with an easy-plane of anisotropy [2]) and/or with the R-R interactions. This is the case of the Ho where, due to the R-R ferromagnetic interactions, the presence of the local field leads to a spectacular fragmentation of the Ising-like magnetic moment into a persistently fluctuating part (Coulomb phase) and an ordered part (magnetic charge crystal) [3,4].

During our experiment performed on D7 using the XYZ polarizarion analysis and a wavelength λ=3.1435 Å, we measured the magnetic signal of two other compounds with Gd and with Yb using a dilution insert. In the Gd case, the magnetic moment is isotropic in first approximation and therefore was naively expected to follow the all-in all-out local field of the Ir. However, we have evidenced a more complex and unexpected behavior: the magnetic moment again separates into two parts, the easy-axis component ordering in the all-in all-out arrangement, thus giving rise to the two Bragg reflections at 1.7 and 2.1 $Å^{-1}$ (see figure 1), while the easy-plane component of the moment shows a tendency towards ordering but at a much lower temperature, possibly in the so called Palmer-Chalker arrangement (broad feature at 1.1 $Å^{-1}$ with two rising peaks on top).

In the Yb compound, the magnetic moment is much weaker and the magnetic signal is difficult to extract. A ferromagnetic-like signal, increasing at low Q, was however evidenced on D7 using polarized neutrons (see Fig. 2). These results show that both compounds start to present a tendency towards peculiar magnetic orderings due to the interactions between the rare-earths competing with the molecular field of the Ir, that has still to be fully analyzed.

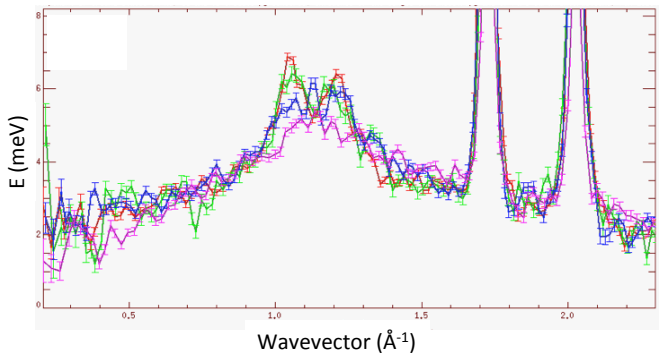

Figure 1: magnetic scattering recorded on D7 on the Gd isotopic powder sample using the XYZ polarization analysis, at various temperatures: 50 mK (red), 300 mK (green), 1.2 K (blue) and 5 K (pink).

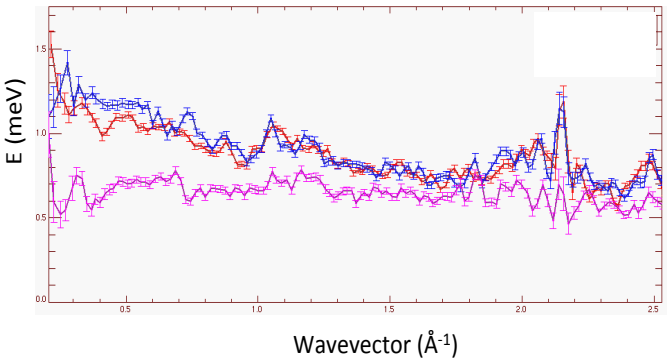

Figure 2: magnetic scattering recorded on D7 on the Yb powder sample using the XYZ polarization analysis, at various temperatures: 50 mK (blue), 1 K (red), and 10 K (pink).

References:

[1] Wan *et al.*, Phys. Rev. B 83, 205101 (2011).

[2] Lefrançois *et al.* Phys. Rev. Lett. 114, 247202 (2015).

[3] Lefrançois *et al.* arXiv:1702.02864.

[4] Brooks-Bartlett *et al.*, Phys. Rev. X 4, 011007 (2014).