Experimental report

04/04/2016

Proposal: 5-53-241 **Council:** 4/2014

Title: Pinch points and diffuse scattering in the spin liquid Pr2Zr2O7

Research area: Physics

This proposal is a new proposal

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Samples: Pr2Zr2O7

Instrument	Requested days	Allocated days	From	To
D7	8	8	25/11/2014	03/12/2014

Abstract:

Pr2Zr2O7 is a candidate for quantum spin ice behavior, which can be studied in details since large single crystals are now available. Recent neutron data show a broadening of the "pinch points" and a signal dominated by the inelastic contribution. We propose to measure the diffuse scattering maps using polarized neutrons on D7, at 3 temperatures, 15K, 1.7K and 0.1K. With respect to the classical spin ice Ho2Ti2O7,we expect the SF and NSF contributions to be quite similar due to the influence of quantum fluctuations. Simulations of the maps will allow to check the crystal field and energy terms derived from inelastic neutron scattering studies, currently in process.

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$Pr_2Zr_2O_7$ is considered by theoreticians as a potential "quantum spin ice" [1], namely a compound where transverse components of the exchange tensor induce quantum tunneling between different spin ice configurations. Such state could have non-vanishing entropy at zero temperature, keeping the characteristics of a Coulomb phase, such as algebraic correlations and fractional excitations associated with the degeneracy of the spin ice state. Such excitations, called emergent photons, are eagerly searched as the signature of a long-sought quantum spin liquid [2]. The only published neutron study of $Pr_2Zr_2O_7$ indeed shows the presence of low energy excitations, together with broadened pinch points [3].

Our study of $Pr_2Zr_2O_7$ on D7 initially intended to check the results of ref. [3] using polarized neutrons. While no signal could be evidenced in the spin flip channed (with Pz polarization), they pointed out, however, a new feature in the **non-spin flip** channel (Fig 1a). Indeed, we observed a temperature independent (in the range 50 mK- 10K at least) anisotropic broadening of the nuclear Bragg peaks.

We tentatively attribute it to the Huang scattering [4], namely to elastic deformations of the crystal induced by a small quantity of defects (such as Pr/Zr inversion). Recent simulations carried out by Nicolas Martin (Post-Doc at LLB) of the scattering assuming cubic defects and taking typical values of the elastic constants for pyrochlores [5] indeed show that this assumption is realistic (Fig1b). Such defects induce a distribution of stresses and distortions in the sample. As discussed in [5,6] distortions provide an efficient channel to stabilize low energy excitations in pyrochlores with non Kramers ions, such as Tb or Pr, by splitting the ground state crystal field doublet.

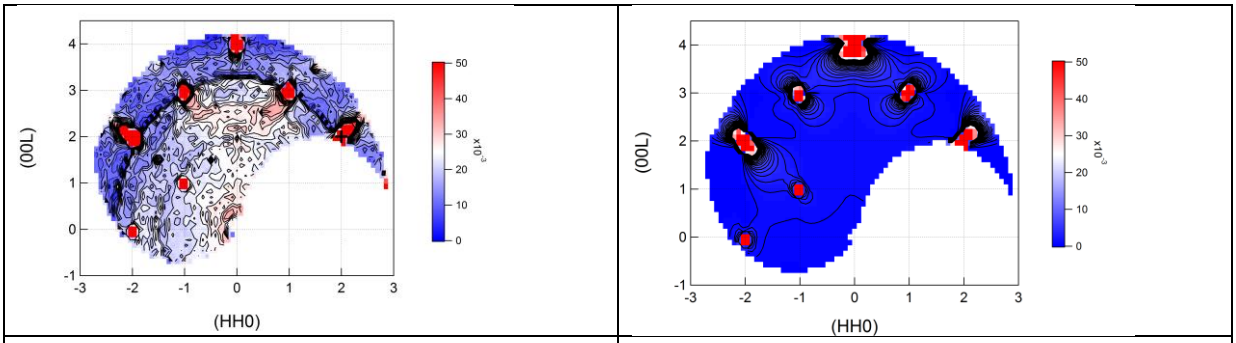

Fig. 1 – ***Left:*** Elastic scattering map measured at T = 50 mK on D7 (Pz, NSF)

Right: simulated scattering intensity in the case of Huang scattering.

[1] MJP Gingras and PA Mc Clarthy Rep. Prog. Phys. **77**, 056501, (2014); L. Savary and L. Balents arxiv 1601.03742 (2016).
[2] O. Benton *et al* PRB **86**, 075154, (2012).
[3] K. Kimura *et al* Nat. Comm **4**, 1934 (2013).
[4] Larson and Schmatz Phys. Rev **10**, 2307, (1974).
[5] BZ Malkin *et al* PRB **86**, 134110 (2012)
[6] P. Bonville *et al* PRB **84**, 184409, (2011).