Experimental report

26/02/2018

Proposal: 4-01-1533 **Council:** 10/2016

Title: Investigation of possible magneticfragmentation of a new rare earth pyrochlore Nd2Hf2O7

Research area: Physics

This proposal is a new proposal

Main proposer: Alexandros SAMARTZIS

Experimental team: Alexandros SAMARTZIS
Jianhui XU

Local contacts: Jacques OLLIVIER

Samples: Nd2Hf2O7

Instrument	Requested days	Allocated days	From	To
IN5	6	6	02/03/2017	08/03/2017

Abstract:

We plan to perform diffuse scattering measurements on the large single crystal Nd2Hf2O7 by using the direct geometry Time of Flight spectrometer IN5. The magnetic moment is highly anisotropic with a value that reflects strong quantum fluctuations in the ground state, while magnetization measurements suggest weak FM coupling of Nd spins, in spite of an AFM transition at T=0.55K. The inelastic neutron scattering at base temperature will provide information about the allegations that it is a system with magnetic moment fragmentation. We wish also to determine the Hamiltonian by fitting the expected spin wave excitations to extract the couplings that will provide us with a better understanding of Nd2Hf2O7 ground state. Furthermore we plan to measure the neutron scattering at a temperature above TN in order to shed light onto the possible formation of a Coulomb phase which may make Nd2Hf2O7 a candidate for the observation of a Higgs transition.

Title: Investigation of possible magnetic fragmentation of a new rare earth pyrochlore $Nd_2Hf_2O_7$.

Unopolarized inelastic neutron scattering on IN5 Spectometer of ILL.
02.03.2017 until 08.03.2017.

Introduction:

Magnetic frustration can be understood simply as the inability of a spin system to find the appropriate spin configuration to minimise its energy resulting into highly degenerate ground states. Pyrochlores are excellent structures for realizating frustration. The magnetic ions are located at the egges of corner sharing tetrahedral, which combined with the strong oxygen environment forces into competing interactions resulting into new and exciting ground states. Here we investigate a pyrochlore system, $RE_2Hf_2O_7$, with Nd^{3+} a RE- magnetic Kramers ion, with small magnetic moment. Previews results have shown high anisotropy along [1,1,1] direction, a doublet ground state well separated from the first excited state and an AFM transition at T=480mK.

Experimental setup:

IN5 is a direct geometry Time of Flight spectrometer, ideal for measuring low energy excitations with high Energy resolution and low background. A single crystal of $Nd_2Hf_2O_7$ was mounted on a Cu, oxygen free, sample holder. For better thermal conductivity Cu foil covered the sample before it touches the sample holder while fastened on it by a Cu wire. The sample was oriented in a way that it gives access along (H, H, L) plane and then was screwed onto the dilution stick. The sample was rotated ~155°, scanning a Q-area which include the high symmetry directions (H, H, 0), (H, H, H) and (0, 0, L) and measured for three temperatures, T=40mK, T=600mK and T=25K. The high temperature data were used in order to Normalise the data and as a background. During the main experiment a wavelength of λ=6Å was used for chopper configuration that gives an optimum time- resolution combination. Finally we switched to λ=6.5A with best possible resolution, measuring rocking scans along the positions of the magnetic Bragg peak (1, 1, 1) just above and below the transition temperature.

Results:

The measurement confirms the ordering of the system with extra intensity on the magnetic Bragg positions on the top of the nuclear Bragg peaks, bellow ~580mK. At 40mK, a clear pinch point pattern is revealed which is gapped at averaged energy transfer E~0.1meV while increasing the energy the pattern evolves following the symmetry of the plane and reaching maxima at E~0.3meV on the magnetic Bragg positions. The pinch-point pattern is the signature of the 2-in 2-out spin configuration on the tetrahedra while the ordered state is known from literature that is formed by an all-in all-out spin configuration. Such a confusing spin configuration can be explained by the spin fragmentation theory. Energy slices along high symmetry directions show a clear gap with the pinch point pattern following as a flat band (Figure1). Above it dispersive and sharp magnetic excitations filling the magnetic excitation features of the system at the ordered state.

Just above the transition temperature, the clear and sharp modes becomes broad blurry diffuse scattering with the pinch point to become drastically lower in intensity and much broader. Energy slices confirm the exchange of the sharp modes of the ordered state, into a spinon continuum- like dispersion. The data below ~0.9meV are not to be trusted due to over subtraction. Further analysis

techniques will be used to provide an insight into this area, since we are interested to see the evolution of the pinch point pattern and the gap as well.

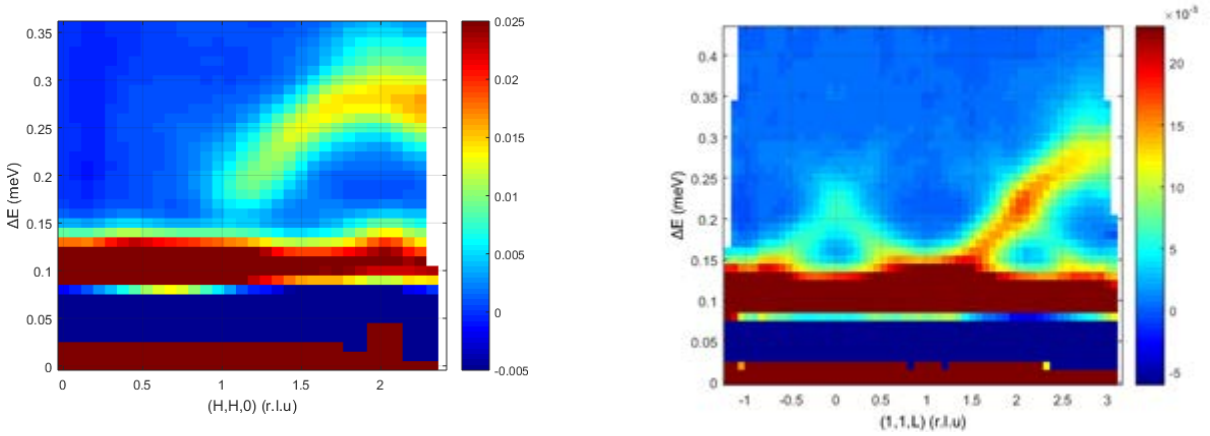

Figure 1: Inelastic Neutron scattering along two different high symmetry directions of the pyrochlore $Nd_2Hf_2O_7$ measured at T=40mK (ordered state). The T=25K data were subtracted and used to Normalise the data as well. Sharp spin wave with a gapped flat band followed by dispersive modes.