Experimental report

11/11/2022

Proposal:	**DIR-248**	**Council:**	4/2021
Title:	MAGNETIC EXCITATIONS IN THEQUANTUM SPIN-LIQUID CANDIDATE S=1 KAGOME ANTIFERROMAGNETND4NI2.5V2O7(OD)2.D2O		
Research area:	Physics		

This proposal is a continuation of 4-05-827

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Samples: $ND_4Ni_{2.5}V_2O_7(OD)_2.D_2O$

Instrument	Requested days	Allocated days	From	To
IN5	2	2	12/07/2021	14/07/2021

Abstract:

Experimental report: Magnetic excitations in the quantum spin-liquid candidate S = 1 kagome antiferromagnet, $ND_4Ni_{2.5}V_2O_7(OD)_2D_2O$

The aim of this experiment was to probe the magnetic excitations in $ND_4Ni_{2.5}V_2O_7(OD)_2.D_2O$, using inelastic neutron scattering (INS) on IN5. $ND_4Ni_{2.5}V_2O_7(OD)_2.D_2O$ is a novel S = 1 kagome material consisting of isotropic Kagome layers of S = 1 Ni^{2+} ions. These are well separated by diamagnetic bivanadate pillars, interstitial ND_4^+ ions and D_2O molecules, in a structural framework similar to the S = 1/2 kagome antiferromagnet (KAFM) volborthite. Bulk magnetometry showed an absence of magnetic order down to 5 K, despite an antiferromagnetic field of θ_W = -32 K and curvature in the inverse susceptibility at $T < 150$ K. This absence of magnetic order was further confirmed down to 280 mK through µSR measurements. The disordered-dynamic ground state of $ND_4Ni_{2.5}V_2O_7(OD)_2.D_2O$ suggests it may represent a rare example of a quantum spin-liquid (QSL) state in a S=1 kagome system.

Our recent inelastic neutron scattering experiment on PANTHER (4-05-807) evidenced low-*E* low-*Q* magnetic excitations. An incoming energy of E_i = 19.03 meV at T = 10 K showed magnetic scattering cantered at Q ~ 1.5 Å^{-1}. The magnetic origin of the scattering is confirmed by the extracted imaginary magnetic susceptibility against energy at Q = 1.50 ± 0.5 Å^{-1}. The scattering observed at E < 4 meV disappears at $T > 50$ K and indicates the onset of magnetic scattering. The observed magnetic scattering formed in the tail of the Bragg peaks making detailed characterisation of the magnetic excitations difficult. For E_i < 19.03 meV similar problems were observed, where the reduced flux of PANTHER at low energies was detrimental to more detailed characterisation. In order to complete the characterisation of the low $E - Q$ region directorial discretionary time was awarded for further analysis on the IN5 spectrometer.

For the experiment on IN5, 3.5 g of sample was loaded into a 15 mm diameter aluminium can and cooled to 1.5 K. We collected data with energy E_i = 3.55 meV for 2 hours, followed by a further collecting for 2 hours at 50 and 100 K. Magnetic scattering was observed at $T < 50$ K and further scans at 20, 10 and 5 K were completed to track the evolution of the scattering with temperature. The magnetic scattering was isolated by subtraction of the T = 50 K data from the T = 1.5 K data (Figure1a). The temperature subtracted data shows a magnetic excitation with a broad a Q-range of Q ~ 0.25 - 2.75 Å . Cuts through the dynamic susceptibility at Q = 1.2 Å show the build-up of the excitation at $T < 50$ K with intensity maximum at E_{max} = 1.20 meV (Figure 1b).

The energy was changed to E_i = 2.27 meV to explore a potential gapless magnetic excitation at low-Q and low-E. This excitation is not present in temperature subtracted data and is believed to be a temperature-independent spurion. Scans were also completed at E_i = 10.43 and 5.11 meV for temperatures between 150 – 1.5 K to increase the kinematic window and explore the Q dependency of the E_{max} = 1.25 meV magnetic excitation. Further analysis of the Q-dependence and potential gap for this magnetic excitation is ongoing. The combined PANTHER and IN5 data will allow determination of the low-energy profile of the magnetic scattering in $ND_4Ni_{2.5}V_2O_7(OD)_2.D_2O$.

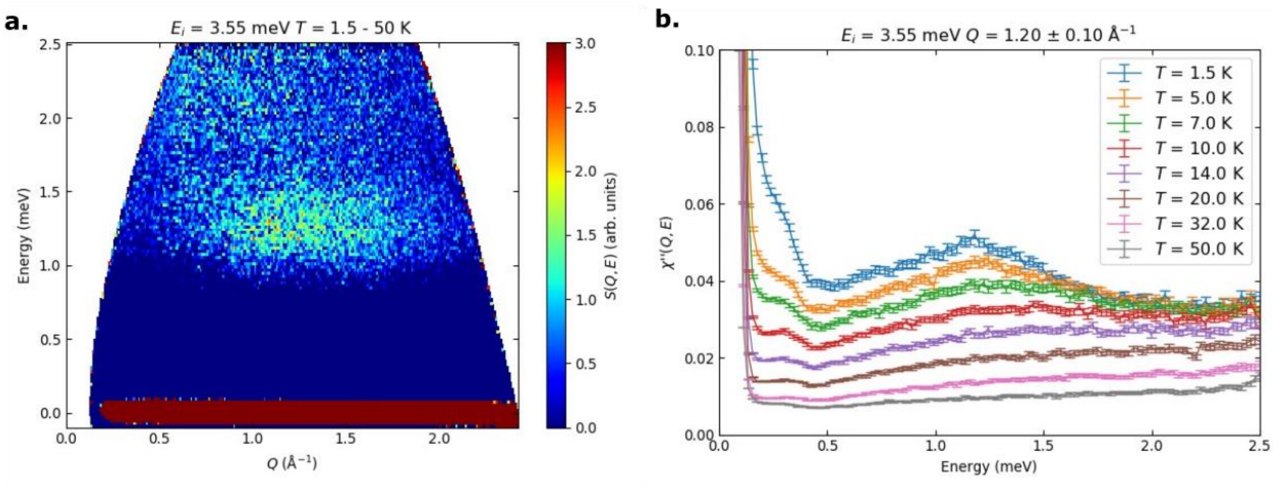

Figure 1 **a.** Temperature subtracted (T = 1.5 – 50 K) *S(Q,E)* map using E_i = 3.55 meV data. A gapped magnetic excitation from Q ~ 0.25 - 2.75 Å is observed **b.** Temperature dependant Q-cuts of $\chi''(Q,E)$ showing the build-up of the magnetic excitation with a peak in intensity at E_{max} = 1.25 meV.