

Experimental report

19/06/2026

Proposal: 4-05-917 **Council:** 10/2024

Title: Excitations of the highly-frustrated centred-pyrochlore lattice magnet Mn(ta)2

Research area: Physics

This proposal is a new proposal

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Samples: Mn(ta)2

Instrument	Requested days	Allocated days	From	To
IN5	2	2	04/07/2025	06/07/2025

Abstract:

The centred pyrochlore lattice is extremely highly frustrated lattice, and we have recently shown that it has a spin liquid phase even more degenerate than the canonical pyrochlore and kagome lattices when considering nearest and next nearest neighbour Heisenberg interactions . It also is described by an emergent Coulomb gauge field theory coupled to gauge charges, that can be seen as a "three-dimensional slab" of a four-dimensional structure.

We have recently uncovered the first example of a material that realises this model: the metal-organic framework Mn(II) triazolate (Mn(ta)2). Mn(ta)2 is highly frustrated ($T_{CW}/T_c \sim 50$, $T_c = 430$ mK) and bulk property measurements suggest this material will have a spin liquid phase around 1-2K before ordering into its ground state. We therefore propose to carry out the first neutron spectroscopy study of this lattice: determining the spin Hamiltonian parameters from the ground state spin waves and measuring the spin liquid excitations to compare with our extensive theory.

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The experiment was successfully completed on IN5 using a 2 g deuterated powder sample of Mn(ta)2. The primary objective was to investigate the magnetic excitation spectrum of this highly frustrated centred-pyrochlore lattice magnet and to determine the microscopic magnetic Hamiltonian governing its low-temperature behaviour. Measurements were designed to probe both the magnetically ordered state below $T_N \approx 0.43$ K and the cooperative paramagnetic regime above the ordering transition.

Inelastic neutron scattering data were collected using incident neutron wavelengths of 6 Å and 8 Å. Measurements were performed at temperatures between approximately 50 mK and 20 K using a dilution refrigerator. Long counting measurements were obtained at base temperature together with a detailed temperature series through the ordered and paramagnetic regimes, allowing the evolution of the magnetic excitations to be followed as a function of temperature.

The experiment successfully achieved its primary objective of collecting inelastic neutron scattering data on Mn(ta)2 across the ordered and paramagnetic temperature regimes. High-quality datasets were obtained at multiple temperatures, providing a comprehensive basis for investigating the low-energy magnetic excitations and spin dynamics of this highly frustrated centred-pyrochlore lattice magnet.

The data are currently being reduced and analysed using complementary theoretical modelling and simulations to identify and characterise the magnetic excitations and determine the microscopic magnetic Hamiltonian of Mn(ta)2. The results will also be compared with complementary neutron diffraction measurements performed on D20 in order to establish a complete picture of both the static and dynamic magnetic properties of the material.

Data analysis is ongoing. The combined neutron scattering datasets are expected to provide important insights into the nature of magnetic correlations and excitations in Mn(ta)2 and will form part of a manuscript currently in preparation in collaboration with experimental and theoretical partners.



