Experimental Report

Proposal: **4-01-1397** **Council:** 4/2014

Title: Temperature dependence of the magnetic excitations in the quasi-perfect S = 1/2 kagome antiferromagnet vesignieite, BaCu3V2O8(OD)2

This proposal is a new proposal

Researh Area: Physics

Main proposer: **FAK Bjorn**

Experimental Team: BOLDRIN David
FAK Bjorn
CANEVET Emmanuel

Local Contact: OLLIVIER Jacques

Samples: BaCu3V2O10D2

Instrument	Req. Days	All. Days	From	To
IN5	4	4	29/08/2014	02/09/2014

Abstract:

Quantum spin liquids (QSL) are novel states of matter that display exotic ground states and fractionalized excitations. In two dimensions, the most promising model system is the S = 1/2 kagome Heisenberg antiferromagnet (KHA), where quantum spins form a geometrically frustrated network of corner-sharing triangles. The mineral vesignieite, BaCu3V2O8(OD)2, which consists of a 0.07% distorted kagome lattice, develops a partially frozen spin state at low temperatures. This static spin structure sets vesignieite apart from other S=1/2 KHAs such as herbertsmithite, whose spins remain dynamic, and is thought to be a consequence of a significant Dzyaloshinskii- Moriya interaction. Our very recent measurements on the thermal time-of-flight spectrometer MERLIN revealed that the energy scale is much lower than anticipated, and we therefore propose to use cold neutrons on IN5 to investigate the dispersion of the 4-meV excitation observed on MERLIN and to search for magnetic scattering at lower energies salient to the QSL ground state.

Temperature dependence of the magnetic excitations in the quasi-perfect $S = \frac{1}{2}$ kagome antiferromagnet vesignieite, $BaCu_3V_2O_8(OD)_2$

The aim of the experiment was to measure the magnetic excitations in the magnetically ordered regime of a new, high-quality sample of the $S = \frac{1}{2}$ kagome magnet vesignieite. A previous attempt at a similar experiment on the MERLIN spectrometer at ISIS was unsatisfactory due to poor flux at the lower than expected E_i that were required, therefore IN5 was thought to be the ideal instrument for this experiment. From the magnetic excitation spectra, the main goal was to extract the magnetic exchange values but also to potentially determine several other properties, such as an excitation gap from a Dzyaloshinskii-Moriya interaction or any diffuse scattering related to a quantum spin liquid response.

A ~ 8 g mass of deuterated vesignieite was loaded into a 15 mm outside diameter aluminium can with no insert and measurements were performed in a standard 'orange' cryostat. Data were collected at $\lambda = 1.8, 3.2, 4.8$ and 6.5 Å at temperatures between $2 < T < 50$ K. Data reduction involved removing bad spectra, subtracting empty can runs and normalising to vanadium.

The first measurements were taken at $\lambda = 1.8$ Å to measure the previously observed 4 meV magnetic excitation at MERLIN and data at $T = 1.6$ K clearly show strong scattering at $E \sim 4$ meV. To confirm that this scattering is magnetic in origin, data were collected at $T = 25$ K, well above $T_N \sim 9$ K, and the temperature subtracted data is shown in Figure 1a. Both the temperature and Q-dependence of this flat mode at 4 meV strongly suggests it is magnetic in origin.

To determine if any additional magnetic excitations are present at lower energy data were also collected at longer wavelengths. At $\lambda = 3.2$ and 4.8 Å weak spin-wave-like features are observed below T_N, however this scattering remains well above the transition temperature, as shown in Figure 1b, and is reminiscent of a spin-liquid like response due to magnetic correlations that persist up to high temperature.

Data were collected at $\lambda = 6.5$ Å to probe yet lower excitations. This data was used to perform high-precision searches for a gap in the excitation spectrum as well as to observe in any changes in the scattering at the elastic line. Interestingly, Bragg peaks were observed that disappeared above T_N that must arise from the magnetic structure. Magnetic Bragg peaks had not previously been observed for vesignieite, even during a dedicated high-resolution neutron diffraction experiment performed on this same sample. Observation of magnetic Bragg peaks in related $S = \frac{1}{2}$ kagome magnets has previously been possible on IN5, but not in diffraction experiments, highlighting the utility of this instrument.

In conclusion, the experiment provided data that are a vast improvement over that collected during previous experiments. Future analysis of the excitation spectra may allow extraction of the magnetic exchange values, whilst the observation of magnetic Bragg peaks has spurred on further experiments at high intensity neutron diffraction beamlines in an attempt to determine the magnetic structure.

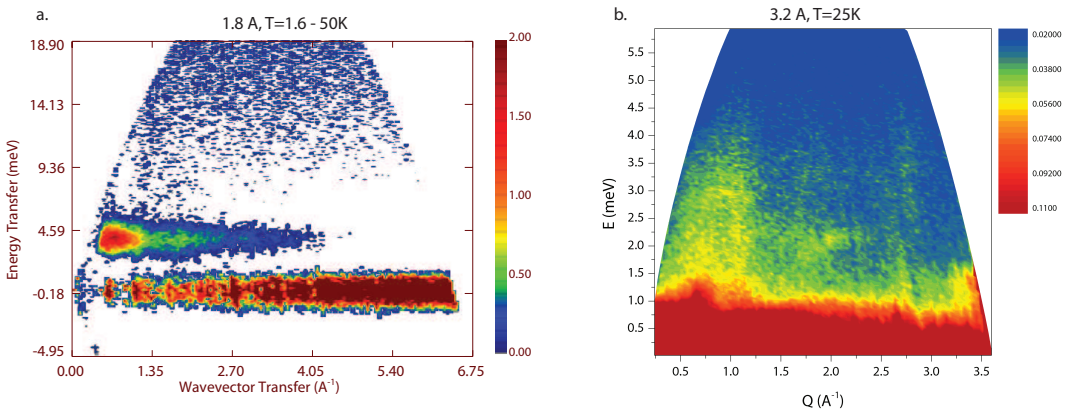

Figure 1: Data collected at IN5 on vesignieite with **a.** $T = 1.6 - 50\,\mathrm{K}$, $\lambda = 1.8\,\text{Å}$ and **b.** $T = 25\,\mathrm{K}$, $\lambda = 3.2\,\text{Å}$.