# Experimental report

08/02/2019


**Proposal:** **5-32-864** **Council:** 4/2018


**Title:** Diffuse magnetic scattering in thefrustrated kagomé lattice compoundFe4Si2Sn7O16

**Research area:** Physics

**This proposal is a new proposal**


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**Samples:** Fe4Si2Sn7O16

| Instrument | Requested days | Allocated days | From | To |
|---|---|---|---|---|
| D7 | 5 | 5 | 27/09/2018 | 02/10/2018 |


**Abstract:**

We recently reported long-range Néel ordering in Fe4Si2Sn7O16. The only magnetic ions are layers of high-spin Fe(II) (d6, S = 2) arranged on perfect kagomé lattices. Below TN = 3.5 K, 2/3 of these Fe(II) ions order into canted AFM chains, separated by the remaining 1/3 which are geometrically frustrated and show no long-range order down to at least 0.1 K according to conventional neutron powder diffraction. Moessbauer spectroscopy shows that there is no static order on the latter 1/3 of the Fe(II) ions - i.e., they are in a liquid-like rather than a frozen state - down to at least 1.65 K. Although the propagation vector k = (0, 1/2, 1/2) breaks hexagonal symmetry, we see no evidence for a lattice distortion within the resolution of our data. To the best of our knowledge, this type of magnetic order on a kagomé lattice has no precedent experimentally and has not been explicitly predicted theoretically. In the experiment proposed here, we wish to probe this liquid-like state in more detail, by using polarised neutrons on D7 to search for magnetic diffuse scattering associated with possible short-range ordering of the 1/3 of HS Fe(II) ions that resist long-range order down to 0.1 K.

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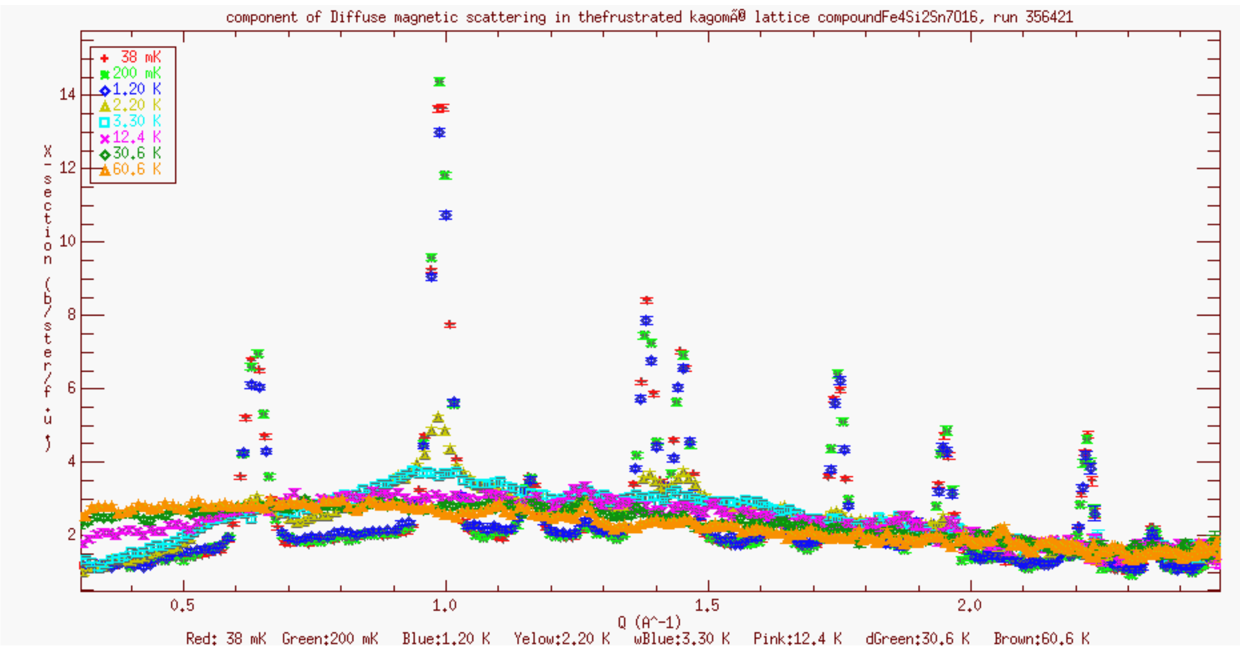
The sample was placed in an annular Cu can (3 mm; OD 15 mm, insert 12 mm). The sample height was 35 mm. The sample mass was 7.368 g.

Data were collected using 4.75 Å neutrons at the following temperatures (sample thermocouple reading):

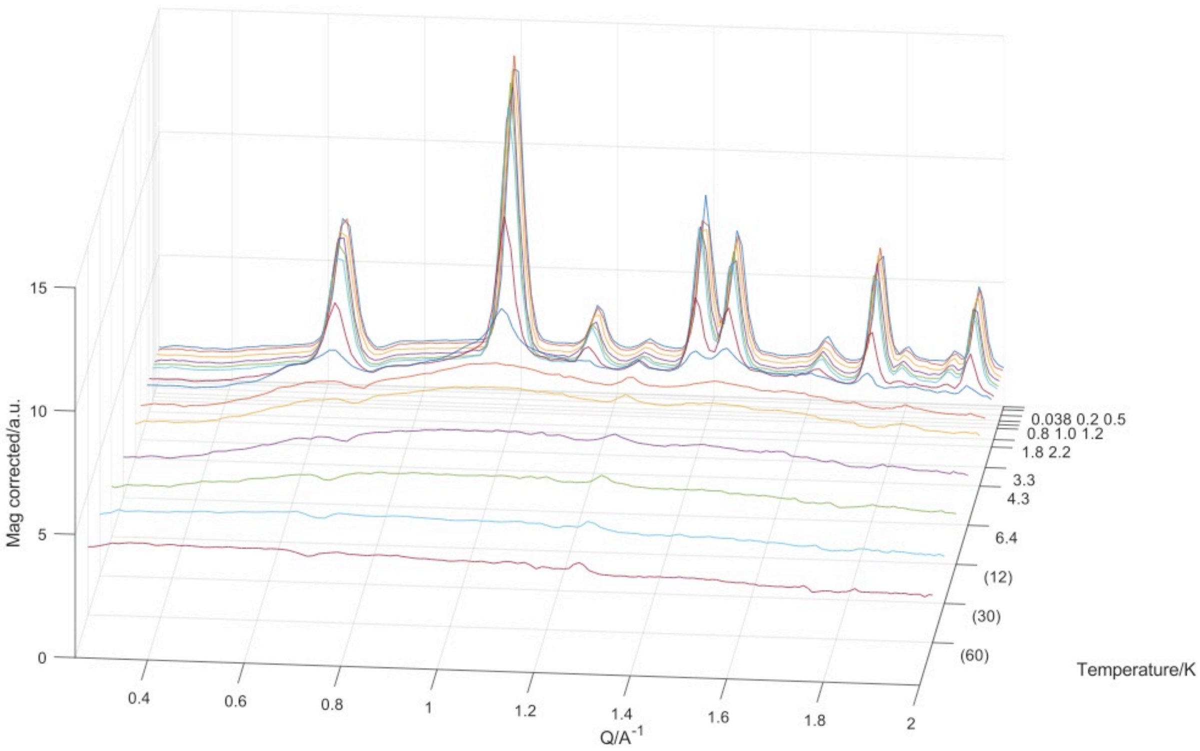
0.038 K
0.200 K
0.500 K
0.800 K
1.000 K
1.200 K
1.79 K
2.19 K
3.26 K
4.29 K
6.42 K
12.38 K
30.58 K
60.56 K

Selected data sets in the purely magnetic channel are shown below, to illustrate the observed trend in diffuse magnetic scattering.




Discussion

The magnetic (M) channel decreases at low Q, even at 60 K; i.e., the sample appears not to be purely paramagnetic. This contradicts other data for this compound. However, we also note that the nuclear incoherent (NI) channel increases, which it should not do; and that these two channels add up to the raw experimental data. It therefore appears that there was a deficiency in the M/NI separation during initial data processing. It should be possible to correct for this by taking the anomalous additional NI scattering at low Q, and adding it back to the M scattering. To do this, we fit a straight horizontal line to the NI across all temperature where it is well behaved (≥6.4 K data sets) for $1 \leq Q \leq 2$ Å$^{-1}$. This line sits at 1.1800 barns.sterad$^{-1}$.fu$^{-1}$. The corrected data are shown below.




Note that the magnetic data corrected in this manner represent half the total spin-flip signal minus a constant – i.e., we have essentially just assumed that the NI scattering is a constant. We also assume that all corrections have been done perfectly: background; polarisation correction (quartz); detector efficiency (V); self-attenuation; and multiple-scattering. The presence of some small features indicates that they were not. Most of the features correspond to strong Bragg peaks, so are probably due to an imperfect polarisation correction. (The polarisation correction uses diffuse scattering from quartz, but Bragg peaks don't scatter in quite the same way; this is a known experimental issue.) The feature at 1.25 Å is a magnetic Bragg peaks from a small fayelite impurity.

The corrected magnetic data at the highest temperature have the appearance of a magnetic form factor, i.e., paramagnetic scattering. Note that the Q = 0 intercept in the paramagnetic regime (remembering that there are 3 Fe per fu) should be $3.g^2.S(S+1) = 3.53$, which these data are consistent with, providing additional confidence in the correction used to obtain them.

These D7 data indicate that the "idle" 1/3 of magnetic HS $Fe^{2+}$ cations slow down but nevertheless continue to fluctuate to at least 0.038 K. This is consistent with our other data for $Fe_4Si_2Sn_7O_{16}$ and lend further support to it being a unique type of partial spin-liquid.