Experimental report

17/07/2021

Proposal: 5-31-2794 **Council:** 4/2020

Title: The Detailed Magnetic Structure ofMnSb2O6 – Helix or Ellipse?

Research area: Physics

This proposal is a new proposal

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Samples: MnSb2O6

Instrument	Requested days	Allocated days	From	To
D20	1	1	04/03/2021	05/03/2021
D1B	0	0		

Abstract:

MnSb2O6 has both chiral magnetic and crystal structures. We wish to characterize the magnetic structure near Tn given previous BT1 results that have been suggestive of an elliptical structure near Tn. We propose to use D20 for 1 day to measure the magnetic structure near Tn with high statistics to verify this and also to connect with structural results we have obtained on D2B.

Proposal 5-31-2784, 1 day on D20 (2021/03/04) The Detailed Magnetic Structure of $MnSb_2O_6$ – Helix or Ellipse?

Introduction

A transition to a "spin-density wave" (SDW) phase was reported in several compounds before a cycloidal magnetic phase at low temperature. In $Cu_3Nb_2O_8$, this phase was explained by the symmetry allowed decoupling of the different components of the magnetic order parameter [1]. We want to investigate in details the ellipticity of the cycloidal magnetic structure in $MnSb_2O_6$ near $T_N = 12\,K$ to see if a SDW phase appears in this compound, as suggested in previous results from BT1 (NIST).

Experimental details

20 g of powder was measured between 2.5 and 89.5 K, with fine steps until 15 K and coarse steps after. The data was sequentially refined using Fullprof.

Results

Magnetic structure

Powder diffraction is not sensitive to the direction of the magnetic moments in the *ab*-plane, but only to their magnitude. The magnetic structure can be described by a real magnetic moment along *a*-axis, and an imaginary one along *c*-axis. The refined values as a function of the temperature are shown in Fig. 1a) were the dashed line represents $T_N = 11.87(2)\,K$ obtained with a power law fit to the real magnetic moment. The critical exponent $\beta = 0.298(5)$ is comparable with previous $\beta = 0.30(2)$, but far from $\beta = 0.367$ expected for the 3D Heisenberg model [2]. The non-zero values of the magnetic moments above T_N are due to short-range order which is also proved by the presence of broad magnetic peaks in the paramagnetic phase.

The ratio between the two magnitudes is shown in Fig. 1b). The last point shown is at 11.85 K where the magnetic transition could have already happened. Excluding this point, the last points indicate a tendency to ellipticity, within the error bars, near the transition temperature. However, there is no evidence of a "spin-density wave" (SDW) phase which would need the imaginary part (thus the ellipticity) to go to zero near the transition temperature. The behavior is thus different from some other compounds such as $CaCr_2O_4$ [3] and $Cu_3Nb_2O_8$ [1], where a SDW phase was observed before the low temperature cycloidal phase.

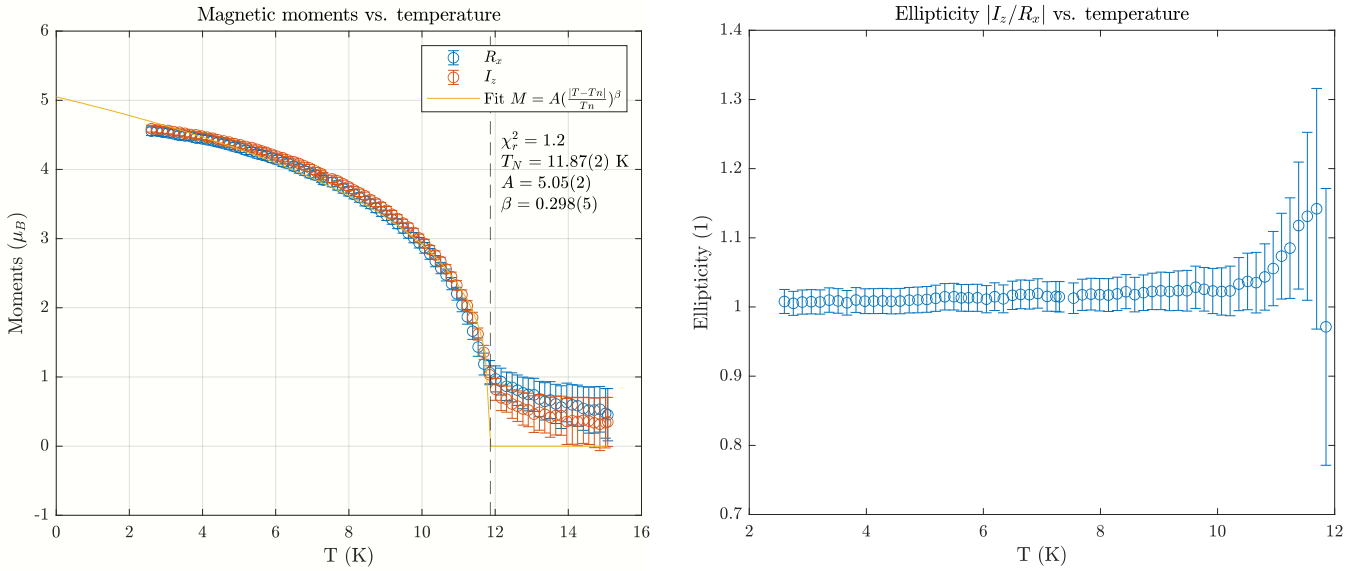

Fig. 1: a) Refined magnetic moments, and fit of the real moment to a powel law. b) Near the transition temperature, a small tendency to ellipticity can be observed.

Structural parameters

The variation of the lattice parameters are sharper below T_N than above as pictured in Fig 2.a). The scale of this variation is comparable to previous data from BT1, shown in Fig 2.b).

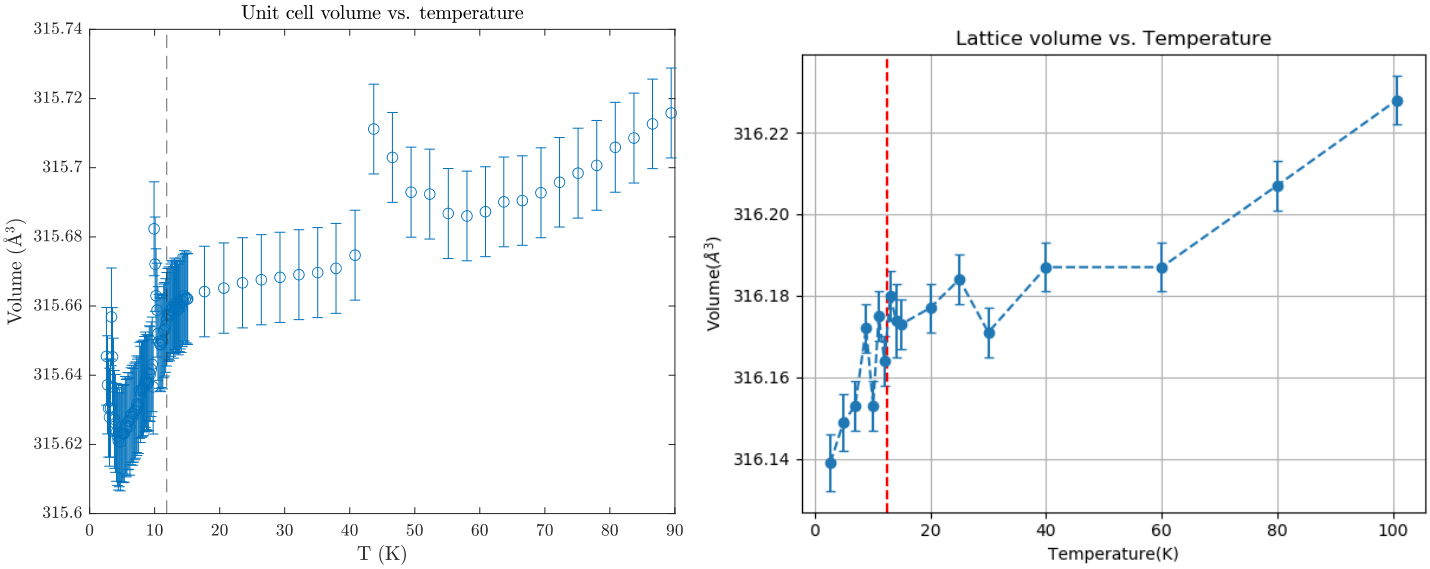

Fig. 2: Unit cell volume as a function of temperature, from a) D20 data, b) BT1 data.

We can also point out the sharp variations of some atomic positions below T_N, especially for the O atoms, as shown in Fig. 3. Even if a symmetry reduction from the P321 space-group was not observed in our previous D9 single-crystal experiment, these variations, in addition to the lattice volume, evidence structural changes at low temperature.

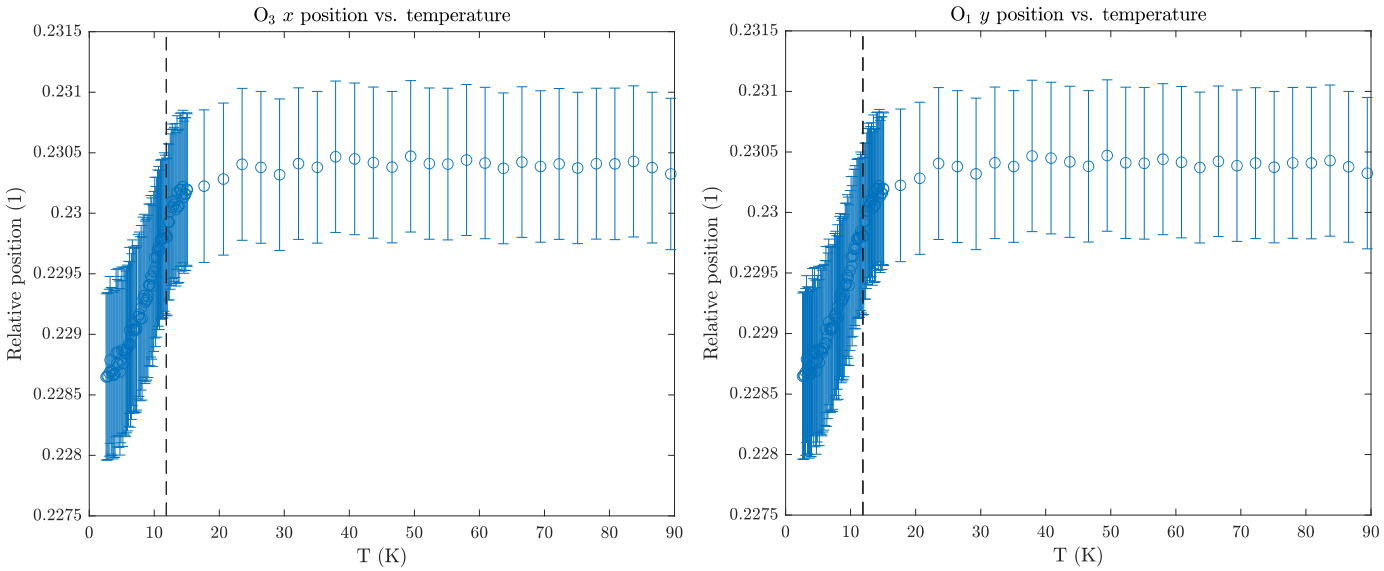

Fig. 3: Temperature dependence of the relative positions of O atoms in the compound.

[1] N. Giles-Donovan, N. Qureshi, R. D. Johnson, L. Y. Zhang, S.-W. Cheong, S. Cochran, and C. Stock, Phys. Rev. B **102**, 024414 (2020).
[2] J. N. Reimers and J. E. Greedan, Journal of Solid State Chemistry 263 (1989).

[3] F. Damay, C. Martin, V. Hardy, A. Maignan, G. André, K. Knight, S. R. Giblin, and L. C. Chapon, Phys. Rev. B **81**, 214405 (2010).