

# Experimental report

28/06/2023

**Proposal:** DIR-276

**Council:** 10/2022

**Title:** What is the high-field magnetic structure of Mn<sub>3</sub>Sn?

**Research area:** Physics

**This proposal is a new proposal**

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**Local contacts:** Eric RESSOUCHE

**Samples:** Mn<sub>3</sub>Sn

Instrument	Requested days	Allocated days	From	To
D23	4	4	11/05/2023	15/05/2023

## Abstract:

Hexagonal Mn<sub>3</sub>Sn displays a large Anomalous Hall Effect (AHE) at room temperature, which can easily be controlled by a magnetic field in the ab plane, and is therefore an excellent candidate material for spintronic applications. The AHE is closely linked to the magnetic structure.

It was recently discovered that applying a magnetic field out of the ab plane induces an exceptionally large Hall effect, much larger than the ordinary Hall effect. It is speculated that this effect is caused by canting of the spins in the direction of the field. The precise magnetic structure in applied magnetic fields is not known, and there is a discrepancy between the calculated canting-induced Hall effect based on magnetization measurements, and the measured Hall effect. To resolve this, a more accurate model of the magnetic structure in high fields is needed. We here propose to use neutron diffraction to determine the induced canting of the spins in large magnetic fields for multiple temperatures to resolve this discrepancy.

# What is the high-field magnetic structure of $\text{Mn}_3\text{Sn}$

## 1 Introduction

This is a report of the experiment on  $\text{Mn}_3\text{Sn}$  taking place at D23 11/5-15/5 2023. Present for the experiment were Henrik Jacobsen, Jeppe Jon Cederholm, and Plamen Stanislavov Stamenov. Instrument responsible was Eric Ressouche. The proposalID is DIR-276.

The sample was a  $3 \times 2 \times 1 \text{ mm}^3$  single crystal of  $\text{Mn}_3\text{Sn}$ . It was aligned with (100) and (010) in the scattering plane, in a 15 T vertical cryomagnet. To limit He consumption, we only reached fields up to 13.5 T. The incoming wavelength was 1.2830 Å, selected using the (200) reflection of the Cu monochromator.

The goal of the experiment was to observe the temperature dependence of the canting angle of the magnetic moments when a magnetic field was applied along the  $c$  axis.

## 2 Results

We carried out two types of measurements: the first were sets of all peaks that could be reached in the  $ab$  plane in zero field and 13.5 T at various temperatures. The second type was hysteresis loops of selected Bragg peaks at various temperatures. We here present preliminary analysis of our data.

We show the measured Bragg peaks in Fig 1. The first column shows data in zero field, the second column shows data in 13.5 T, and the third column shows the difference between the two data sets. The first row shows data at 100 K, while the second row shows data at 300 K. A clear effect of the magnetic field can be seen in the difference plot. However, the effect of the canting is still much smaller than expected, and hence a thorough analysis of the data is required.

Fig 2 shows hysteresis loops measured on the (1 1 0) Bragg peak at three different temperatures. A small hysteresis is seen, with an unclear temperature dependence of the effect. With a careful analysis, we hope to be able to subtract the nuclear contribution to the peaks and isolate the magnetic signal.

In summary, the impact of the canting on the magnetic signal is smaller than anticipated. A careful analysis of the background and the nuclear signal is required to accurately extract the magnetic signal.

The sample will be shipped to Plamen Stamenov.

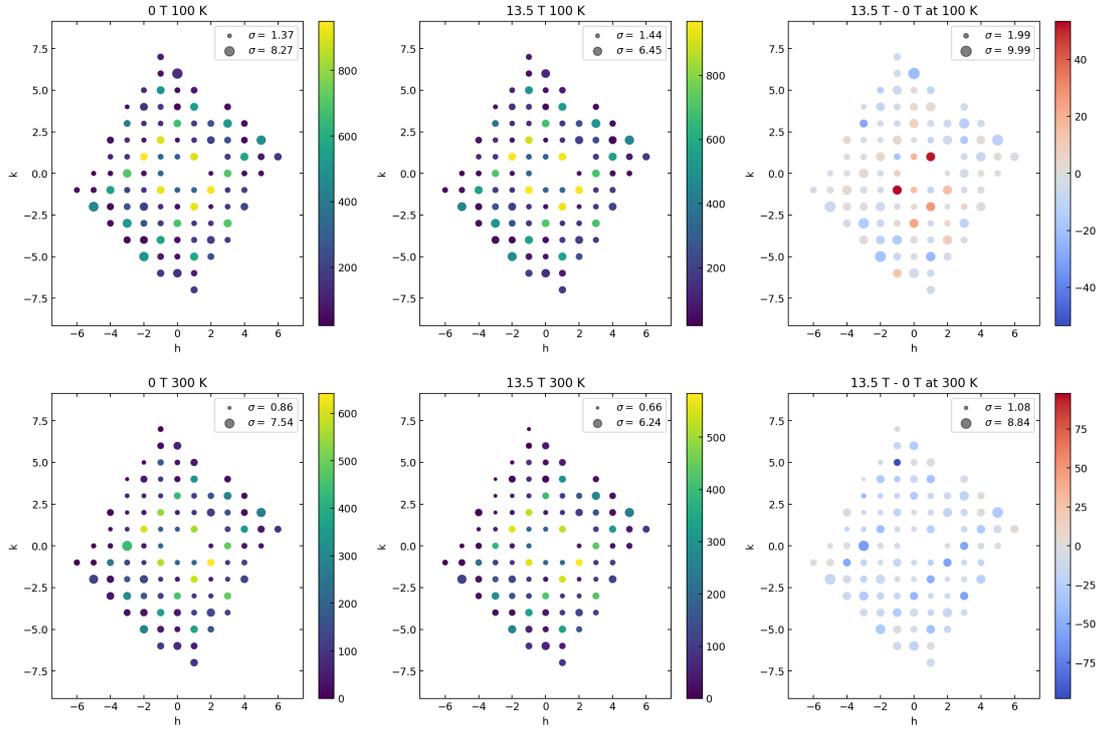


Figure 1: Integrated intensities of selected Bragg peaks and the difference of these at both 100 K and 300 K at 0 T and 13.5 T. The size of dots indicates the uncertainties in the measurements.

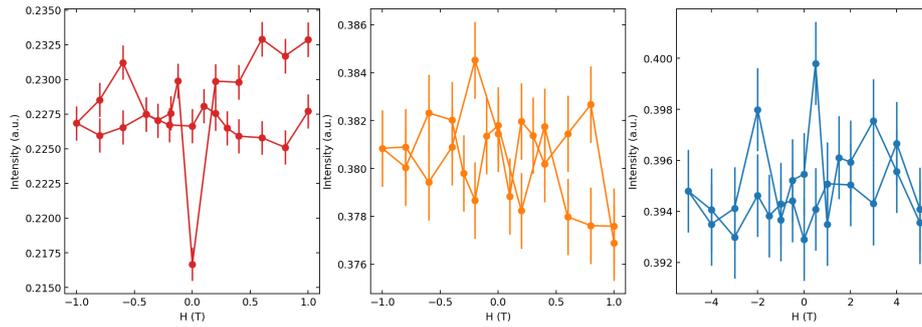


Figure 2: Hysteresis loop of the (1 1 0) Bragg peak for  $H = \pm 1$  T at 300 K (Red), 100 K (Orange) and 3 K (Blue).