Experimental report

19/02/2020

Proposal: **INTER-490** **Council:** 10/2019

Title: Temperature and magnetic field dependence of spin fluctuations in Mn5Si3

Research area:

This proposal is a new proposal

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Samples: Mn5Si3

Instrument	Requested days	Allocated days	From	To
IN12	3	3	10/02/2020	13/02/2020

Abstract:

Background:

The search for more efficient use of energy has been leading to a growing interest for the research field of magnetocaloric (MC) materials. The MC cooling process is based on the magnetocaloric effect (MCE). MCE is the reversible temperature change of a magnetic material upon the application or removal of a magnetic field. The MCE can be characterized as direct or inverse if a MC compound heats up or cools down by applying an external magnetic field adiabatically. An entropy transfer between crystal lattice and the magnetic spin system has to take place. Among different compounds under investigation, the system $Mn_{5-x}Fe_xSi_3$ shows a modestly large MCE close to room temperature at low magnetic fields, which is promising for magnetic refrigeration applications. The parent compound Mn_5Si_3 on cooling undergoes a first phase transition at $T_{N2} \approx 100$ K toward a collinear antiferromagnetic ground state (AF2) and a second transition to a non-collinear antiferromagnetic phase (AF1) that occurs at $T_{N1} \approx 66$ K. Its specificity is to exhibit positive and negative magnetic entropy change in relation with two distinct magnetic phase transitions at $T_{N1} \approx 66$ K and $T_{N2} \approx 100$ K, respectively.

Aim of the experiment:

The aim of this experiment was to investigate the in-plane spin dynamics under a vertical magnetic field applied parallel to c axis at 50K (the orthorhombic cell is derived from the ortho-hexagonal cell of the PM space group $P6_3/mcm$, therefore the a, b plane will be referred to as ‘‘in-plane’’).

Experimental setup:

The IN12 spectrometer was set up in W configuration and a collimation 80’-open-open has been installed after the monochromator. We used a PG monochromator (double focusing mode), a monitor, slits before and after the sample and a PG analyser. All data have been collected with a fixed $k_f=1.5Å^{-1}$. The single crystal (with a mass of about 6g) was mounted with the [100] – [010] directions in the scattering plane inside a vertical 10T magnet.

Results:

Experiments were performed on a single crystal of about 1.5 cm^3 on the IN12 spectrometer. In order to investigate the spin dynamics under magnetic field along the [100] direction spectra were collected in the non collinear antiferromagnetic AF1 phase (T=50K). Scans were performed for an energy transfer of 3meV around the **Q**=(1 2 0) Bragg position.

In Figure 1 one can see characteristic const. E spectra collected at 50K and different magnetic fields around the (1 2 0) magnetic Bragg position. In the AF1 phase (T=50K) the sharp spin waves observed at zero field are substituted with a diffused signal for magnetic fields H≥3T, indicating a transition from AF1 to AF1’. As the magnetic field increases (H>7T) the sample enters the AF2 phase. This is consistent with the recent established (T-H) magnetic phase diagram, early neutron diffraction measurements and our recent INS data where it is shown that a magnetic transition from AF1 to AF2 occurs when field is applied along the c-axis [1,2,3].

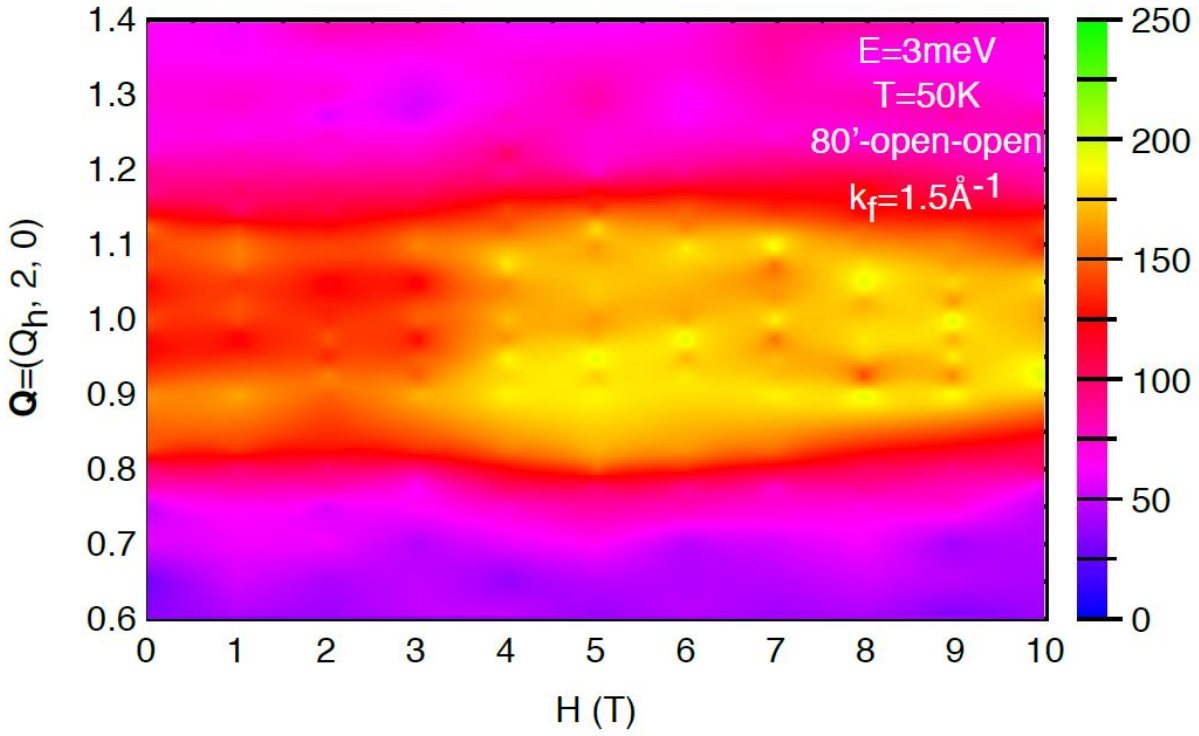

Figure 1: Colour-coded intensity plot of the INS data collected at 3meV as a function of **Q**=(Qh, 2, 0) and H at 50K.

[1] C. Suergers, et al., Nat. Commun. 5, 3004 (2014).
[2] M. R. Silva et al., J. Phys. Condens. Matter. 14, 8707–8713 (2002).
[3] N. Biniskos, et al., Physical Review Letters 120, 257205 (2018).