Experimental report

28/07/2023

Proposal: **INTER-576**

Council: 4/2023

Title: Paramagnetic state in $MnFe_4Si_3$

Research area:

This proposal is a new proposal

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Samples: $MnFe_4Si_3$

Instrument	Requested days	Allocated days	From	To
IN12	3	3	30/05/2023	02/06/2023

Abstract:

Scientific background:

One way for saving energy in daily life is using the magnetocaloric effect (MCE) and this has led to a growing interest for the research field of magnetocaloric materials. The MCE corresponds to the change of magnetic entropy and adiabatic temperature following a change in an applied magnetic field around the magnetic transition temperature. A large MCE at room temperature and low magnetic field for a material with abundant and environment friendly elements opens the way for magnetic cooling devices. The ferromagnetic compound $MnFe_4Si_3$ (S.G.: $P\overline{6}$) is a promising candidate material for such devices as it has a magnetic phase transition in the range of 300 K and shows a moderate MCE of 2.9 J/(kg·K) at a reasonable magnetic field change from 0T to 2T.

In order to understand the fundamental driving force of the MCE on the magnetocaloric compound Mn_4FeSi_3, a study of magnetism, lattice dynamics, spin dynamics and their interaction is necessary with inelastic neutron scattering experiments.

Aim of the experiment:

The aim of the experiment was to investigate the paramagnetic scattering close to the Γ-point in the magnetocaloric compound $MnFe_4Si_3$ above T_c.

Experimental setup:

IN12 was set up in W configuration. The incident neutron beam spin state was prepared with a transmission polarizing cavity located after the velocity selector. For the experiment, a PG monochromator, a monitor, and a Heusler analyzer were used. All along the neutron path, guide fields were installed to maintain the polarization of the beam. In order to access different polarization channels Helmholtz coils were employed. The single crystal (with a mass of about 7g) was mounted with the [100] – [001] directions in the scattering plane inside a cryofurnace. Data have been collected with fixed k_f. The offset of the analyzer was measured with a vanadium sample (see Fig.1 Left). A flipping ratio of about 22 was measured on a graphite sample.

Results:

Inelastic neutron scattering measurements were performed on a $MnFe_4Si_3$ single crystal at 1.4xTc and 1.5x Tc (Tc=305 K). Data have been collected along the hexagonal reciprocal direction (*h00*) around the zone centers $\boldsymbol{Q}$=(2,0,0) for energy transfers between $-3 \leq E \leq 3$meV in two non-spin flip channels (NSF_{xx} and NSF_{zz}). The measuring time per point per channel was about 10 minutes. Using canonical subtractions of intensities measured in the two different polarization channels we managed to remove the complex background which is $\boldsymbol{q}$, *E* and T dependent (see Fig.1 Right). Further analysis allowed us to extract the magnetic relaxation rates $\Gamma(q)$ and the *q*-dependent susceptibility $\chi(q)$ along (*h00*) at different temperatures.

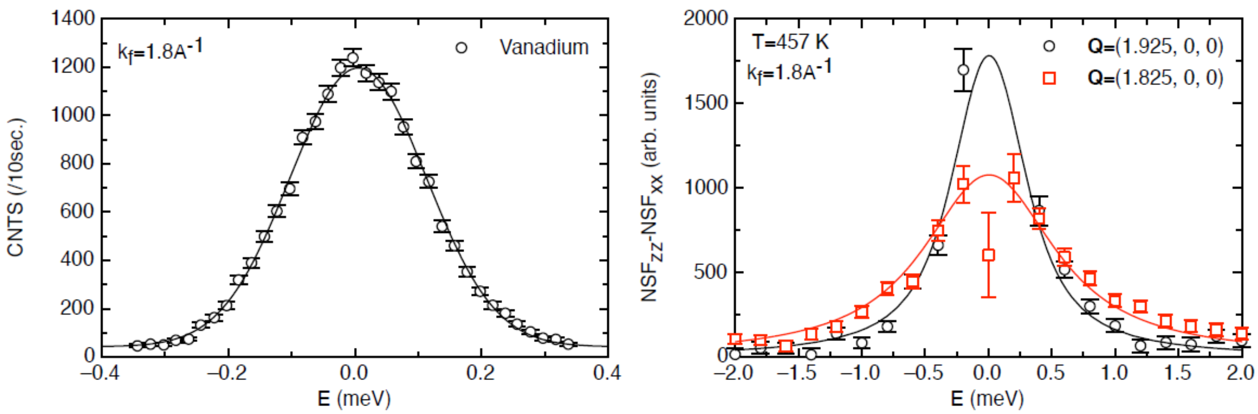

Fig. 1: (Left) Vanadium measurement. The line is a fit with a Gaussian function. (Right) Energy dependence of magnetic fluctuations at q_h=0.075 and q_h=0.175 r.l.u. at T=1.5xTc=457 K. The lines represent a fit corresponding to a relaxation function. Monitor corrections were applied to the data and for all fittings the center was fixed. The center was determined from a measurement of the incoherent scattering of the sample.