Experimental report

15/09/2022

Proposal:	**CRG-2755**	**Council:**	4/2020
Title:	Investigation of phonon-magnon interaction in a giant inverse magnetocaloric compound		
Research area:	Physics		

This proposal is a new proposal

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Samples: Mn_5Ge_3
$Mn_{1.9}Cr_{0.1}Sb$

Instrument	Requested days	Allocated days	From	To
IN12	7	4	08/07/2021	14/07/2021

Abstract:

The study of phonons, magnons and their coupling is of great importance for the understanding of the mechanism of the magnetocaloric effect (MCE). Therefore, inelastic scattering measurements with a cold triple axis spectrometer on the compound $Mn_{1.9}Cr_{0.1}Sb$, which exhibits a giant inverse MCE (cooling by adiabatic magnetization) are highly important in order to highlighten the microscopic ingredients that favor a giant MCE. The results could provide new insights for magnetic refrigeration applications. The need to design functional materials connects with a fundamental understanding of magnetism, lattice dynamics and their interaction.

Aim of the proposal:

Our original plan was to perform an inelastic neutron scattering study on the inverse magnetocaloric compound $Mn_{1.9}Cr_{0.1}Sb$ with a cold TAS in order to map out magnetic and lattice excitations. However, we encountered several problems during the crystal growth with the Czochralski method, which we were unable to solve on time due to the pandemic and the limited access to laboratories. Instead we used this beam time to finalize our study on another compound. We investigated the magnon dispersion of Mn_5Ge_3 at T=10K and under the application of magnetic field with good resolution. We focused along the high symmetry hexagonal directions Γ-M and Γ-K-M and especially at the symmetry points M and K.

Scientific background:

The intermetallic ferromagnetic Mn_5Ge_3 compound has attracted great scientific interest in the recent years because it is considered as a promising candidate material for spintronic and magnetocaloric applications. Mn_5Ge_3 exhibits a 2nd order phase transition from the paramagnetic state towards the ferromagnetic phase at approximately 295K. It crystallizes in the hexagonal space group $P6_3/mcm$, with two distinct crystallographic positions for manganese atoms (Wyckoff positions (WP) *6g* for Mn2 and *4d* for Mn1). The magnetic structure of Mn_5Ge_3 was determined by polarized single-crystal neutron diffraction, which revealed a different size of the magnetic moments on the *4d* ($1.96\mu_B$) and the *6g* site ($3.23\mu_B$). In both sites the magnetic moments lie parallel to the *c*-axis of the hexagonal unit cell. The magnetic entropy change, ΔS_m, is of 7.2 J/kgK for a magnetic field change of 5T near room temperature. In addition, electrical resistivity and magnetization measurements in Mn_5Ge_3 indicated an anisotropic magnetoresistance and an anomalous Hall effect.

Experimental setup and preliminary results:

IN12 was set up in W-configuration. We used a double focusing PG monochromator and a PG analyzer. The data have been collected with a fixed k_f. The velocity selector was not available during this beam time. Depending on the working wavelength, we used different filters (PG, Be) in the neutron scattered beam. The single crystal (with a mass of about 10g) was mounted with the [100] – [010] directions in the scattering plane. We used a horizontal magnet as sample environment.

Inelastic neutron scattering measurements on IN12 were performed at T=10K. Before fitting, every spectrum was analyzed carefully looking for spurions, in particular Aluminum contamination and inelastic spurions appearing when the condition $k_i/k_f=2$ is fulfilled. The corresponding spurion regions were cut out during data evaluation. Gaussian functions were used to fit the observed peaks. Characteristic spectra with the corresponding fits at a high symmetry K point are shown in Fig.1.

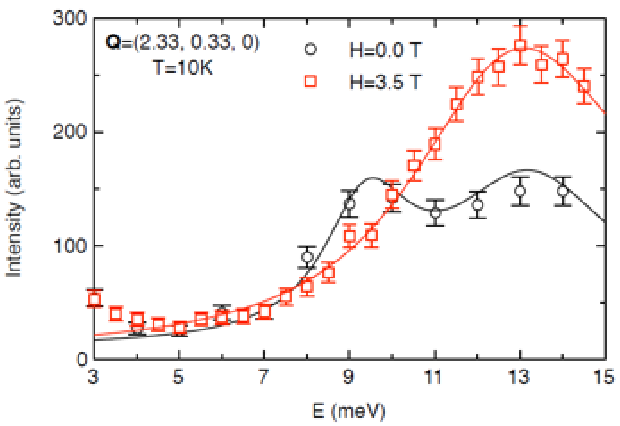

Fig.1: E-scans performed at **Q**=(2.33, 0.33, 0) at T=10K and at H=0T (black circles) and at H=3.5T (red squares). The solid lines indicates fits with Gaussian functions.