Experimental report

15/06/2018

Proposal: **CRG-2432** **Council:** 4/2017

Title: Nuclear Magnetic Interference termassociated with a phonon branch inthe magnetocaloric compound MnFe4Si3

Research area: Physics

This proposal is a new proposal

Main proposer: **Nikolaos BINISKOS**

Experimental team: Nikolaos BINISKOS

Local contacts: Stephane RAYMOND

Samples: MnFe4Si3

Instrument	Requested days	Allocated days	From	To
IN12	7	5	08/03/2018	12/03/2018

Abstract:

The study of the temperature and magnetic field dependence of phonons, magnetic excitations and their coupling is of great importance for the understanding of the mechanism of the magnetocaloric effect (MCE). Recently we evidenced a Nuclear Magnetic Interference (NMI) term associated with a phonon branch in the magnetocaloric compound MnFe4Si3. In order to understand the origin of this scattering we would like to investigate how the NMI evolves under different magnetic fields and in the region where acoustic phonons and magnons cross.

Background:

One way for saving energy in daily life is using the magnetocaloric effect (MCE), i.e. the change of magnetic entropy and adiabatic temperature following a change in an applied magnetic field. 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 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 0 T to 2 T. The MCE requires the exchange of magnetic entropy, lattice entropy and/or electronic entropy during an adiabatic (de-)magnetization process. Using inelastic neutron scattering measurements we might get more microscopic insight into the lattice-magnetic interactions in order to understand the fundamental driving force of the MCE in this material.

Aim of the experiment:

The aim of the experiment was to investigate further possible phonon-magnon coupling in complement to measurements already performed[1-3].

Experimental setup:

The IN12 spectrometer was set up in W configuration. We used a PG monochromator, a monitor, slits before and after the sample and a PG analyser. Fully focussing setups were employed. All data have been collected with a fixed k_f. To investigate possible phonon-magnon coupling the single crystal (with a mass of about 7g) was mounted with the [100] – [001] directions in the scattering plane inside an orange cryostat.

Results:

Experiments were performed on a single crystal of about 1.5 cm^3 on the IN12 spectrometer. In order to investigate possible phonon-magnon coupling, measurements were performed in a Brillouin zone where both types of excitations are observed with good resolution. To this aim, constant E scans around **Q**=(Q_h, 0, 2) were carried out at energy transfers below 13 meV at T=1.5K with unpolarized neutron beam. The resulting TA phonon and magnon dispersion curves are shown in Fig.1 in the form of a colour map.

In the beginning data have been collected with a fixed $k_f=1.5Å^{-1}$. Due to spurius scattering appearing in the q-scans at constant energies 5, 6, 8, 11 and 12meV (see Fig1(a)), k_f was changed to $k_f=2Å^{-1}$ and all measurements have been repeated (see Fig1(b)). For $k_f=2Å^{-1}$ no spurius scattering was observed. For energy transfers 2<E<7 meV the phonon and the magnon are well separated, although they originate from the same zone center **G**=(0, 0, 2). For increasing energy transfers and close to the Brillouin zone boundary, an increase of intensity is observed. However, the signal arising from the individual excitations cannot be distinguished from the unpolarized INS data. Measurements with polarized neutrons at the crossing point of phonons and magnons would be ideal to separate the signal arising from the lattice and magnetic excitations and to point out possible energy gaps due to the hybridization of the modes.

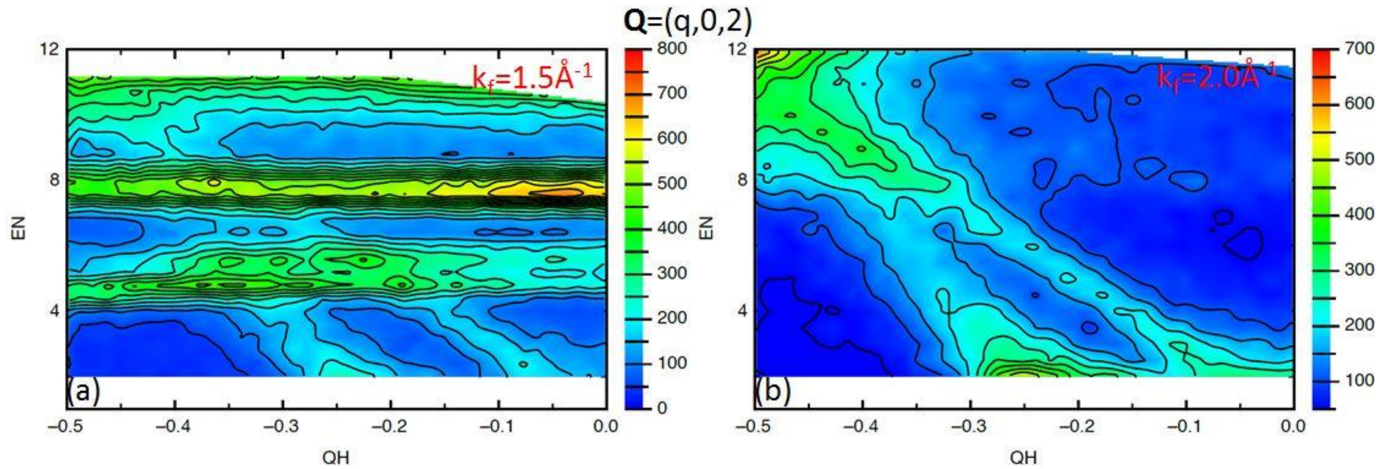

Fig.1: Colour maps constructed from Q scans around **Q**=(Q_h, 0, 2) at constant energy transfers 2<E<13 meV at T=1.5 K with fixed (a) k_f=1.5$Å^{-1}$ and (b) k_f=2.0$Å^{-1}$. Data were obtained with unpolarized neutrons at IN12.

[1] CRG-2263 Experimental Report
[2] CRG-2172 Experimental Report
[3] CRG-2292 Experimental Report