Experimental report

09/02/2016

Proposal: **4-02-444** **Council:** 10/2014

Title: Intrinsic instability of the helixspin structure in MnGe and order-disorder phase transition.

Research area: Physics

This proposal is a new proposal

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Samples: MnGe

Instrument	Requested days	Allocated days	From	To
IN11	7	5	14/10/2015	19/10/2015

Abstract:

The proposal aims to investigate the critical dynamics of the helix structure in MnGe by neutron spin echo technique. The magnetic system of MnGe compound has a cubic B20 structure with the lattice constant a=0.4806 nm has ordered below TC = 130 K in a ferromagnetic spiral along the <1 1 1> directions. The scattering patterns show dramatic changes in the temperature evolution of the magnetic structure. . A typical powder pattern, which can be observed below T = 80 K, becomes narrower and the inner part of the ring is contaminated by an additional scattering with temperature increase. The ring is smeared and the contaminating contribution inside the ring is comparable to the intensity of the ring at the critical temperature at TN = 130 K. We assume that this additional scattering has inelastic nature. Dynamics plays a crucial role in understanding of critical phenomena. We propose to measure the temperature and the wave number dependence of the relaxation rate of critical spin fluctuations. We expect to observe two crossovers in the temperature behaviour of the relaxation rate.

Intrinsic instability of the helixspin structure in MnGe and order-disorder phase transition.

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INTRODUCTION

The magnetic system of MnGe compound has a cubic B20 structure and orders in a helical spin structure with a wavevector $k \sim 2.2$ nm^1 at low temperatures [1]. There is a general belief that the helicity is realized by an antisymmetric Dzyaloshinskii-Moriya (DM) interaction caused by the lack of a center of symmetry in Mn atomic arrangement [2, 3]. The temperature evolution of pure MnGe compound has already been investigated carefully using SANS method [1].

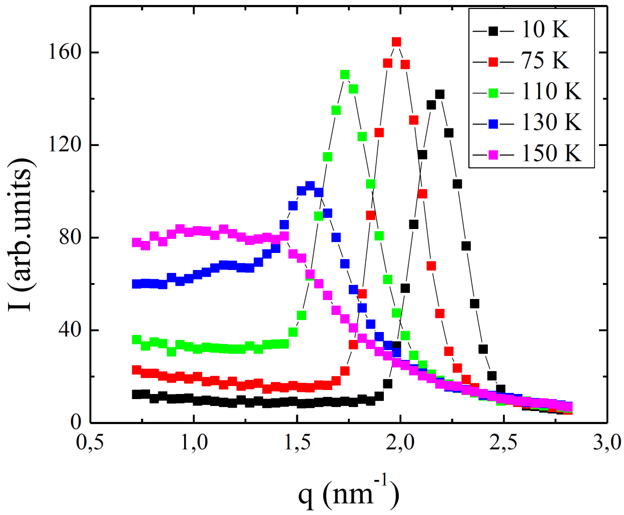

FIG. 1: Momentum transfer dependence of the scattering intensity of MnGe at different temperatures.

In work [1] we split the whole temperature scale for four parts. The low temperature part showing the coexistence of the Stable Helix and Fluctuating Helix below $T_C = 130$ K for pure MnGe. The contribution to the scattering which ascribed to the helical fluctuations is accompanied by and correlated with the strong abnormal scattering ascribed to the spin excitations. In the temperatures between 130 K and 150 K, the spin helix fluctuations and strong spin excitations result in the fluctuating spin helix state. The high temperature part showing the existence of the ferromagnetic short range correlations above $T_{SR} = 175$ K. The temperature region limited by the temperatures of 150 K and 175 K corresponds to the crossover between the high-temperature region and the region of helical fluctuations. The momentum transfer dependence of the scattering intensity at different temperatures is presented in Figure 1.

PERFORMED EXPERIMENT

In this experiment, we used IN11 spectrometer (ILL) in order to investigate magnetic dynamics of MnGe. The results of the experiment allow us to partially describe the properties of the temperature phase transition in this system, namely, the crossover between the region of helical fluctuations and short-range ferromagnetic correlations and the high temperature phase. Measurements of MnGe sample have been performed at different temperatures above and below T_N, using 6 Å wavelength and Fourier times from 0.01 ns up to 10 ns. The intermediate scattering function $S(Q, t)$, collected for MnGe at Q equal to the helical wavevector, $|Q - k| = 0$, for temperatures $T = 120$, 150, 160, 170, 180, 190 and 210 K is presented in Fig. 2. The measured intermediate scattering function was normalized over the elastic signal of reference measurement at lowest temperature ($T = 3$ K) and fitted with the function $S(q,t)/S(q,0) = S_{el} + \exp(t/\tau)$, where S_{el} is the elastic component in the scattering, and τ is the characteristic lifetime of the fluctuations.

RESULTS

As a result of the experiment, a single timescale of magnetic dynamics of the system has been observed and its temperature evolution has been followed. Despite the direct observation of the helical fluctuations at temperatures below $T_{SR} = 175$ K by SANS [1], the changes of the intermediate scattering function was not observed at temperatures below $T_N = 130$ K. As long as the magnetic dynamics observed only in the high-temperature region, it could be concluded that the observed timescale corresponds to the lifetime of the short-order ferromagnetic fluctuations.

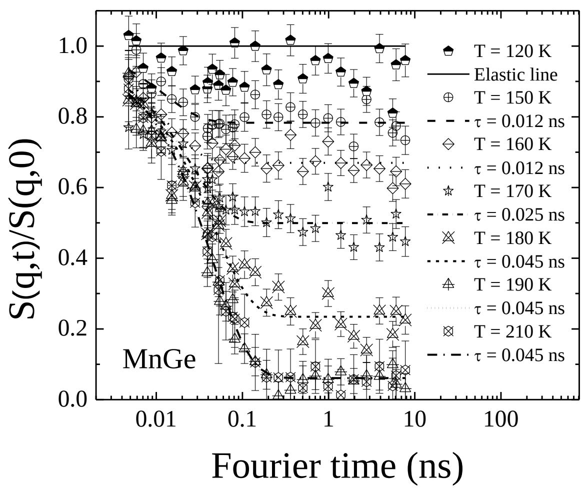

FIG. 2: The temperature evolution of the intermediate scattering function $S(Q,t)$, $|Q-k| = 0$. Spectra were collected for $T = 120$, 150, 160, 170, 180, 190 and 210 K. Lines are the best fit of data with function $S_{el} + \exp(t/\tau)$ (see text).

The lifetime of the ferromagnetic fluctuations is found to be equal to $\tau = 0.012$ ns at temperatures 150 K $< T <$ 170 K and increases with temperature up to $\tau = 0.045$ ns at $T > 170$ K. The increase of the lifetime with T can be connected with the coexistence of both, ferromagnetic fluctuations and helical fluctuations, at temperatures below $T_{SR} = 175$ K [1]. This fact leads to the conclusion that the helical fluctuations dominates over the ferromagnetic order at $T < T_{SR}$ and decreases the lifetime of ferromagnetic correlations. If this is the case then the further decrease of the intermediate scattering function is to be expected with the characteristic timescale $\tau_h > 100$ ns at temperatures below T_{SR}, which corresponds to the average lifetime of the helical fluctuations.

The results obtained during the experiment can be used as the starting point for the investigation of magnetic dynamics of B20-type helical magnets in general and Ge-based compounds in particular, using spin-echo spectroscopy measurements.

[1] E. Altynbaev, S.-A. Siegfried, V. Dyadkin, E. Moskvin, D. Menzel, A. Heinemann, C. Dewhurst, L. Fomicheva, A. Tsvyashchenko, and S. Grigoriev, *Phys. Rev. B* **90** 174420 (2014).

[2] I.E. Dzyaloshinskii, *Zh. Eksp. Teor. Fiz.* **46** 1420 (1964).

[3] T. Moriya, *Phys. Rev.* **120**, 91 (1960).