Spin excitations in the skyrmion lattice phase of $MnSi_{1-x}Ge_x$

Seno Aji[A], Daisuke Okuyama[A], Kazuhiro Nawa[A], Shinichiro Yano[B], and Taku J. Sato[A]
[A]*IMRAM, Tohoku University,* [B]*NSRRC*

MnSi is the chiral magnetic compound and attracts renewed interest because of the discovery of the skyrmion-lattice structure under finite magnetic field [1]. The magnetic skyrmion is a topological spin texture made of swirling magnetic moments. Recently, the spin excitations so called ' magnon ' in such spin texture was studied theoretically and was found that topological nature of skyrmion will give non-trivial topological number (Chern number) for each magnon bands, resulting in the formation of the topological magnon band [2]. Here, we study such a topological magnon bands experimentally in MnSi and Ge-doped MnSi. Single crystal samples of MnSi (18 grams) and $MnSi_{0.98}Ge_{0.02}$ (15.5 grams) were used in the experiments. The single crystals were grown using Bridgmann furnace with temperature and transport speed of 1573 K and 4 mm/hour, respectively. We performed elastic and inelastic neutron experiments using SIKA spectrometer in ANSTO. For the neutron experiment, the samples were mounted in the aluminum plate and aligned with 110 and 001 in the scattering plane. This configuration will set 110 as the magnetic field direction. The samples were placed in the cryostat equipped with a vertical superconducting magnet. Pyrolytic graphite PG 002 reflections were used for monochromator and analyzer. The collimation settings were Open-20 '-20 '-60 'with vertically focusing monochrome tor mode. The final neutron energy was fixed to 2.75 meV.

The magnetic modulation vector Q of MnSi and $MnSi_{0.98}Ge_{0.02}$ were obtained as 0.035 and 0.046 Å from elastic scattering measurement. The inelastic scattering experiment was carried out by setting the temperature of 28.6 K (MnSi) and 30.5 K ($MnSi_{0.98}Ge_{0.02}$) and magnetic field of 0.2 T for both samples judging from the optimum intensity of the magnetic field scan in the skyrmion lattice phase by the elastic experiment. The low-energy magnetic excitation modes were observed at several Q points. Fig. 1(a) is a representative result of low-energy magnetic excitations observed at M point for both samples. Excitation spectra for $MnSi_{0.98}Ge_{0.02}$ are weaker and broader. Excitation spectra also get weaker at higher Q-positions (Fig 1(b)). We confirmed that this excitation is intrinsic in the skyrmion-lattice phase, by comparing it to the excitation spectra both in the fully-polarized and helical phases.

[1] S. Muhlbauer et al., Science 323, 915 (2009).

[2] A Roldan-Molina et al., New J. Phys. 18, 045015 (2016).

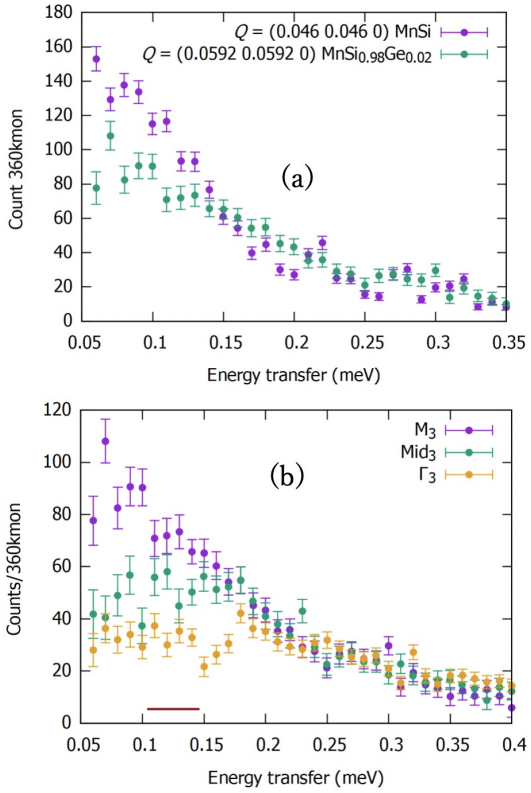

Fig. 1. (a) The observed low-energy magnetic excitations at M point for MnSi and $MnSi_{0.98}Ge_{0.02}$, and (b) Q-position dependence of inelastic spectra for $MnSi_{0.98}Ge_{0.02}$.