Spin current on garnet ferrite $Y_3Fe_5O_{12}$ induced by temperature gradient

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1. Introduction

Series of novel phenomena such as spin Seebeck effect, have been discovered in spintronics. So far, the phenomena have been studied only in fabricated nanomaterials due to a short diffusion length of spin current. Recent experiment suggests that the spin diffusion length in a permalloy $Ni_{80}Fe_{20}$ is about 10 nm. As for the spin-Seebeck effect, however, characteristic length is much longer than the spin diffusion length. For example, the spin-Seebeck effect of La doped $Y_3Fe_5O_{12}$ shows 7 mm size at room temperature as the characteristic length. This long characteristic length may enable us to observe the spin current in a bulk material even by using inelastic neutron scattering measurement at high intensity spectrometers in J-PARC MLF. $Y_3Fe_5O_{12}$ (YIG) crystal is very suitable to obtain strong inelastic magnetic signals because of large magnetic moments at Fe sites such as about $4\mu_B$.

2. Experiment

A single crystal of $Y_3Fe_5O_{12}$ (YIG) grown along [111] axis by traveling solvent floating zone method was measured under a magnetic field of about 0.1 T at a magnetic Bragg peak position, (220), with temperature gradient along the vertical [111] axis, which is set along Q_c. The scattering plane was set in The YIG crystal has a cylindrical shape with about 6 mm diameter and 29 mm length. The crystal end temperatures were 21 K and 25.7 K for low-T and high-T sides for example. The magnet our crystal setting configuration will be $Q=Q_a(2,-1,-1) + Q_b (0,-1,1) + Q_c(1,1,1)$, where grad T// Q_b//[0-11], **H**//[111] at Q_b =2 rlu for (0-22). ic field at the crystal end was about 0.16 T. It became 0.06 T at the center of magnetic circuit without YIG crystal. Our crystal setting configuration was $Q=Q_a(2,-1,-1) + Q_b (0,-1,1) + Q_c(1,1,1)$, where grad T// Q_c//[111], Magnetic field was applied along [111]..

3. Results

The obtained magnetic excitations at around (220) are shown in Figs. 1, 2, and 3.

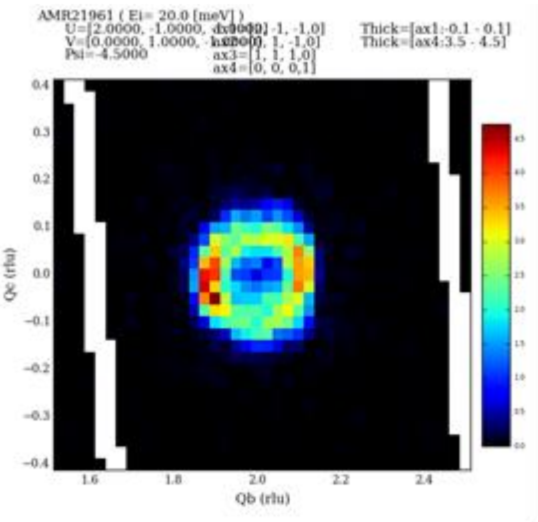

Fig. 1. Spin wave intensity map in Qb-Qc space at (220) and E~4 meV. The temperature gradient was applied along the vertical direction (Qc).

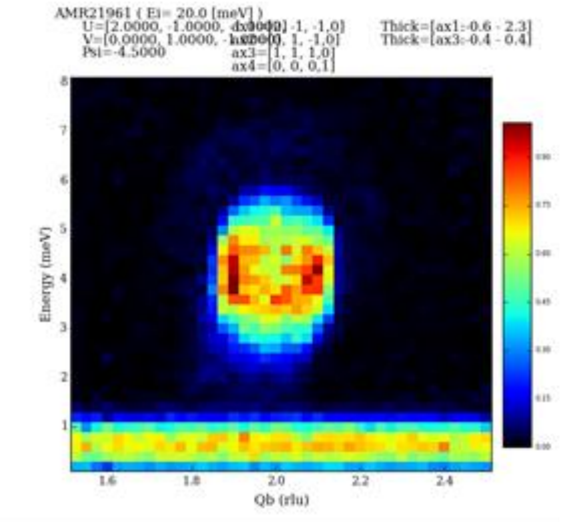

Fig. 2. Spin wave intensity map in Qb-E space at (220).

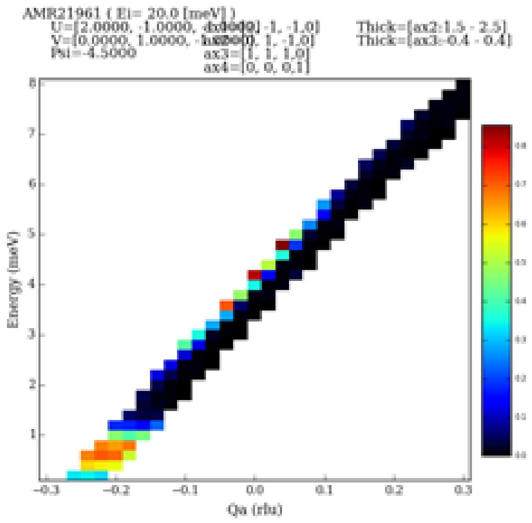

Fig. 3. Spin wave intensity map in Qa-E space at (220)..

4. Conclusion

The obtained magnetic excitations were rather homogeneous than we expected from our previous experimental results at 4SEASONS. One possible reason is the higher temperature than that of the previous experiment. This is related to the sample cell. This difference may produce large heat flow by phonons. So far, even at the spin Seebeck measurement, positive and negative voltages are observed in a single measurement for temperature gradient and ultrasonic irradiation, respectively. In the next measurement, we would like to use self-made Hermholtz compact magnet to produce a homogeneous magnetic field on our crystal in addition to the application of ultrasonic wave on the crystal.