Polarized neutron scattering investigation of the spin wave excitations in YIG

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The observation of the spin Seebeck effect (SSE) by Uchida *et al.* [1] is attracting much attention because this effect can be directly applied to the construction of thermal spin generators for driving spintronics devices, thereby opening the door to thermo-spintronics. The recent discovery of the SSE in magnetic insulators [2] adds an essential piece of information for understanding the physics of the SSE.

Although a systematic investigation of the SSE both in ferromagnetic metals and ferrimagnetic insulators has been performed by means of inverse spin Hall effect (ISHE) measurements [3], no microscopic evidence has been found so far. Recently we performed an inelastic neutron scattering investigation of YIG using the HYSPEC TOF spectrometer. As shown in Fig.1, both magnetic and structural excitations at different zones can be clearly observed. Especially the temperature dependence of the magnetic optical branch at Γ point ($Q = (4, 4, -4)$) compares very nicely with the theoretical spin wave calculation. Since there are low-energy phonon modes clearly visible in these data, an unambiguous investigation of the interesting high temperature behavior of the spin excitations close to T_c and comparison with the theory calls for the utilization of the polarized neutrons. The unambiguous separation of the magnetic and structural excitations and chiral terms as well may also clarify the role of the magnon-phonon coupling in the SSE related compound.

Inelastic polarized neutron scattering experiment was carried out on the chopper spectrometer HYSPEC at SNS, ORNL. Single crystals (mass: 22 g) grown by an image furnace is oriented so that the [HHL] plane lies within the horizontal scattering plane. We used a cryofurnace to allow the temperature dependence to be studied between 35 and 350 K. The incident energy of neutrons was set to 35 meV to cover magnetic excitations from (-4, -4, 4). To achieve σ_x polarization configurations, we put permanent magnets with a yoke to apply magnetic field almost along the wave vector direction. Magnetic excitations are nicely observed, and subtracted chiral terms are also visible by utilizing half-polarized mode.

[1] K. Uchida *et al.*, Nature **455**, 778 (2008). [2] K. Uchida *et al.*, Nat. Mat. **9**, 894 (2010). [3] K. Uchida *et al.*, J. Appl. Phys. **111**, 103903 (2012).

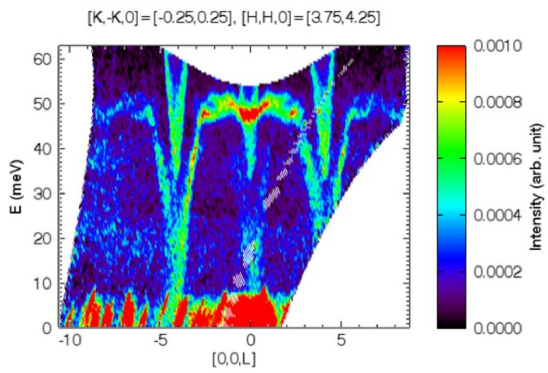

Fig. 1. Magnetic excitations in YIG taken at T = 35 K.