Study on the spin current mechanism in $Tb_3Fe_5O_{12}$ through a measurement of magnetic excitations

Yo Kawamoto[1], Kazuhiko Ikeuchi[2], Kazuya Kamazawa[2], Takashi Kikkawa[3], Eiji Saitoh[3,4], Masaki Fujita[5], Kazuhisa Kakurai[2], and Yusuke Nambu[5]

[1] Department of Physics, Tohoku Univ., Sendai 980-8578, Japan

[2]CROSS, Tokai 319-1106, Japan

[3]Department of Applied Physics, Univ. Tokyo, Tokyo 113-8656, Japan

[4]Advanced Science Research Center (ASRC), JAEA, Tokai 319-1195, Japan

[5] Institute for Materials Research, Tohoku Univ., Sendai 980-8577, Japan

Spin Seebeck effect (SSE) is the phenomenon that generates spin currents in ferromagnetic or ferrimagnetic materials with a temperature gradient. In early stage of research of SSE using the ferrimagnetic insulator $Y_3Fe_5O_{12}$ (YIG), magnetic excitations have been treated as a single parabolic branch similar to ferromagnets. However, recent theoretical [1] and experimental [2] works have shown that the gapped optical magnon mode-characteristic to the ferrimagnetism-is also important to elucidate the temperature dependence of the SSE signal in YIG.

In $RE_3Fe_5O_{12}$ (RE = Gd, Dy), the optical magnon mode remarkably affects the spin current due to the magnetic 4*f* electrons. Temperature dependence of the SSE signal shows a sign change in low temperatures in which no anomaly is found in the magnetization [3, 4]. Previous research work [3] indicates that the sign change is due to thermal activation of the optical mode which can carry the spin current in the opposite direction against the acoustic mode [3]. For studying magnetic excitations, neutron scattering is powerful probe. Then we focused on the $Tb_3Fe_5O_{12}$ (TbIG) as one of the best materials for studying magnetic excitations since terbium has much smaller neutron absorption cross section than gadolinium and dysprosium.

In this presentation, we report the experimental results of magnetic excitations in TbIG showing three major magnon branches. We succeeded in reproducing magnon dispersion relations based upon the linear spin wave calculation, and the temperature dependent spin currents can be understood by a competition between the acoustic and the low-energy optical mode.

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