Magnon polaron induced longevity of the magnon lifetime

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Magnon (spin wave) and phonon (sound wave) are collective excitations of ordered magnetic moments and lattice vibrations, respectively. When the sound wave travels in a magnet, local distortions exert torques on the magnetic order through the magneto-elastic coupling. Propagating magnons affect the lattice dynamics, vice versa. The coupling between spin and sound waves has thus been intensively studied in the last half-century. Nowadays they are known to hybridize at (anti-)crossing points of their dispersion relations [1], forming coherently mixed quasiparticles "magnon polarons," when the lifetime of quasiparticles is well-defined compared to the magnitude of the anticrossing gap.

Although hybridized magnon-phonon states (or magnon polaron) were predicted a long time ago [1], their effects on magnon spin transport have been elucidated quite recently in yttrium iron garnet ($Y_3Fe_5O_{12}$: YIG) by the spin Seebeck effect (SSE) observations. The measurement was made through the generation of a spin current with a temperature gradient in YIG [2,3]. Reference [2] showed that the hybridization of magnon and phonon could lead to resonant enhancement of the SSE signal. The enhancement emerges by the magnetic field application, where the acoustic phonon dispersion becomes tangential to the magnon one. The result in Ref. [2] is indeed well explained in terms of the longevity of phonon than magnon; owing to the phononic constituent of magnon polarons, the condition makes magnon-polaron lifetime longer than pure magnon lifetime, leading to the enhanced spin current by the hybridization [2]. This lifetime enhancement of magnon through magnon polaron hybridization is indeed observed by our recent neutron scattering experiment. Here we would like to clarify such an enhancement of the magnon lifetime using polarized neutrons.

In the polarized neutron scattering experiment on the cold neutron triple-axis spectrometer V2 FLEXX at Helmholtz Zentrum Berlin, Germany, we used a single crystal (mass $\sim$ 8 g) of YIG with a horizontal scattering zone $[HHL]$. We chose the P_x polarization (neutron polarization parallel to the momentum transfer) and recorded all the four channels such as σ^{++}, σ^{+-}, σ^{-+} and σ^{--} with applying horizontal magnetic fields. First, the (220) Bragg reflection was confirmed by the diffraction mode. Phonon and magnon dispersion relations were already known from our previous experiment [4], we then planned to collect energy scans at several displaced positions from (220) for both longitudinal and transverse directions. All the measurements were performed at temperature 100 K, and as a function of fields up to 3 T. We successfully observed magnon lifetime enhancement at 2.5 T that is consistent with the peak formation of the SSE signal from YIG. Detailed analysis including polarization correction and Eckold-Sobolev-type resolution convolution, are now underway.

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