Coherent dynamics of hybridized magnons and phonons

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When two oscillators are coupled, once oscillation is excited on the oscillator, the amplitude is transferred to the other oscillator in time, which comes back again after the same time it took to be transferred, a phenomenon called coherent oscillation. In a magnetic material, various elementary excitations are responsible for physical properties of the material, including the excitation of lattice and magnetic order, phonons and magnons. Owing to spin-orbit and dipole-dipole interactions, phonons and magnons are coupled to each other, which could lead to the coherent oscillation between magnons and phonons if the coupling is strong enough.

In this talk, the experimental direct observation of the coherent oscillation between magnons and phonons are presented, together with demonstration of anomalous reflection of magnons owing to magnon-phonon hybridization [1]. We developed time-resolved magneto-optical imaging technique by combining conventional magneto-optical imaging and pump-and-probe spectroscopy, which enables us to obtain snapshots of spin-wave propagation dynamics in real space with a temporal resolution of sub nanoseconds. In a Bi-doped magnetic garnet, $Lu_2Bi_1Fe_{3.4}Ga_{1.6}O_{12}$, we observed coherent temporal oscillation between magnons and phonons as a result of hybridization, where magnons and phonons are coherently interconverted to each other during propagation. It is also found that the magnon-phonon hybridized wave exhibits abnormal reflection at the sample edge owing to the mode degree of freedom of phonons [2]. Since phonons have longitudinal and transverse modes, both modes may not be an eigenstate where translational symmetry is broken down, such as a sample edge. Owing to the mode degree of freedom, the hybridized wave may split into two reflected waves with the same frequency, which is not the case for pure magnon propagation. The experimental demonstration of these dynamics of magnon- phonon hybridized waves will be presented in the talk.

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[2] T. Hioki, Y. Hashimoto, E. Saitoh, Commun. Phys. 3, 188 (2020)