Magnetic Field Angle Dependence of Pulse Laser-Induced Magnetostatic Surface Wave in Permalloy Thin Film

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Magnetostatic surface waves (MSSWs) have been mainly studied by electrical ways using microwave antennas[1]. Recently, all-optical characterization of MSSWs has been demonstrated in magnetic metals[2]. However, there has been no study to systematically investigate the characteristics. Here, we report magnetic field angle dependence of pulse laser-induced MSSWs in permalloy thin film and demonstrate, for the first time, visualization of dispersion relation.

The 20-nm-thick permalloy film was deposited by magnetron sputtering. MSSWs were detected by space-and-time resolved magneto-optical Kerr effect microscope[2]. The fluence of pump is about 0.5 cm^2. The external magnetic field $\mu_0 H_0$ = 0.3 T with θ_0 = ± 4 and 13 deg. was applied, where θ_0 is measured from the film normal. In each θ_0, the MSSW packet was clearly observed for both of propagating direction. Fig. 1 shows dispersion relation visualized from FFT analysis of change in the Kerr rotation angle $\Delta\theta_K$ as a function of pump-probe distance and delay time measured at θ_0 = + 4 deg. The obtained data roughly agreed with the calculated one. Fig. 2 shows the θ_0 dependence of the group velocity v_g obtained by the Gaussian-type wave-packet fitting, same as ref. [2]. These v_g values are also consistent with the calculated one defined as $v_g = 2\pi\, \partial f/\partial k_0$, where k_0 = 0.87 rad/μm is the mean wave number, and show reciprocal propagation for both of $\pm k$ (inset in Fig. 2).

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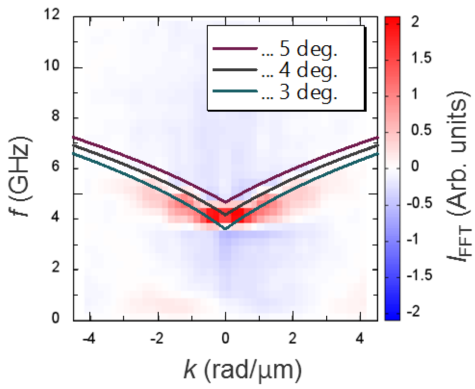

Fig. 1: Experimentally obtained dispersion relationship of MSSW for the field angle θ_0 = + 4 deg. I_{FFT} is the FFT intensity analyzed from pump laser-induced change in Kerr rotation angle $\Delta\theta_K$. The soled curves are calculated data.

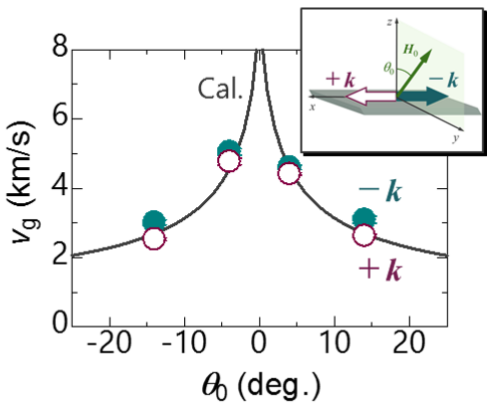

Fig. 2: The group velocity v_g as a function of the magnetic-field angle θ_0. Open and solid circles show $+k$ and $-k$ respectively. The curves are calculated from dispersion relations. In-set; geometry of the magnetic field and the propagating directions of MSSWs.