Asymmetric propagation of spin wave generated by light pulses

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Spin wave is propagating disturbance in magnetically ordered materials without Joule heating because net electron charges do not flow. It is expected that spin wave can be applied to information processing devices with low energy consumption. Spin wave can be generated using polarized light pulses. This method does not need attaching electrodes to generate spin wave as conventional methods, and the shape of the spin wave can be controlled by spatial shape of the light spot [1]. More arbitral control of spin wave will be realized using multiple spots of the optically excitation pulses [2]. Here we demonstrate asymmetrically propagating of the spin wave excited by two parallel line-shaped optical spots.

We generated a spin wave by inverse Faraday effect and measured with our optical pump-probe imaging method [3]. Two circularly polarized pump pulses were focused on the sample in line-shaped spots with spatial width of 130 μm (FWHM). Distance of two pump spots were optimized to make unidirectional propagation by simulation. As a result, we set the distance of pump pulses 80 μm. Phase difference π/2 was made by temporal delay between two pump pulses.

Fig. 1 is an experimental result shown as a spatiotemporal plot of the spin wave. Horizontal(x) axis is the spatial position along the direction of the spin wave propagation which is perpendicular to the pump spots, and vertical(y) axis is the time delay from pump pulse. Amplitude of the spin wave propagating to the positive direction of the x-axis was larger than that to the negative direction, so spin wave propagation to positive direction is realized. Next, we reversed polarization helicity of the pump pulses focused on the spot at -80 μm. Then, initial phase of the spin wave packets generated by that those pulses shifts by π and phase difference changes from π/2 to -π/2, then spin wave propagation to negative direction is observed as seen in Fig.2. As a result, we showed asymmetric propagation of spin wave generated by light pulses, whose direction can be controlled by the helicity of pump pulses.

[1] T. Satoh *et al.*, *Nature Photon.*, **6**, 662 (2012).

[2] I. Yoshimine *et al.*,the 74th JSAP Autumn Meeting (2013).

[3] I. Yoshimine *et al.*, *J. Appl. Phys.* **116**, 043907 (2014).

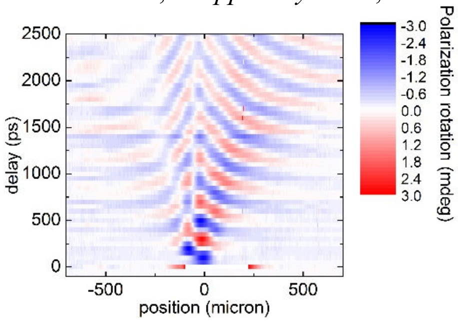

Fig.1 Waveform of the spin wave generated by pump pulses focused to two spots (position: 0 and -80 μm). Polarization helicity of two pump pulses were the same.

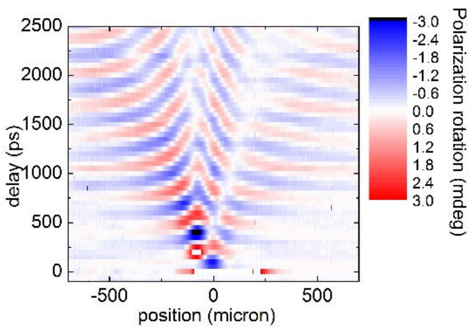

Fig.2 Waveform of the spin wave generated by pump pulses focused to two spots (position: 0 and -80 μm). Polarization helicity of two pump pulses were the opposite.