Determination of the Dzyaloshinskii-Moriya Interaction Energy density in the heavy metal/ferromagnetic layer/insulator structure

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We determined the interfacial Dzyaloshinskii-Moriya (iDM) energy density by using Brillouin Light Scattering (BLS). Since BLS measurement provides Stokes and anti-Stokes spin waves, corresponding to ± propagation spin wave vectors, simultaneously, the frequency difference, $\Delta f = f(+k_x) - f(-k_x)$, can be obtained, where finite Δf is a finger point of the iDM [2]. We performed three different measurements (1) Δf as a function of the external field, (2) Δf as a function of the angle between spin wave propagation direction, and (3) spin wave dispersion relations as shown in Fig. 1 (a)~(c). Based those three independent measurements, we can successfully rule out other possible sources of Δf in our experiments, and determine iDM energy density precisely. By virtue of local probing nature of BLS, we investigated the thickness dependent iDM in Pt/Co(t_{Co})/AlO_x and Pt/CoFeB(t_{CoFeB})/ AlO_xwedge samples. In order to extract iDM energy density from the $\Delta f = \frac{2\gamma D}{\pi M_s} k_x$, the only additional necessary physical quantity is the saturation magnetization M_s, and it can be determined in the BLS measurement, which is one of the strong advantages of the BLS measurement compared to other methods. The maximum iDM energy densities are 1.2 mJ/m^2 for 1-nm thick Co and 0.7 mJ/m^2 for 1.6-nm thick CoFeB samples. Furthermore, we found the inverse proportionality of iDM energy density to the t_{Co} and t_{CoFeB}, it implies the measured iDM in our system is true interfacial term.

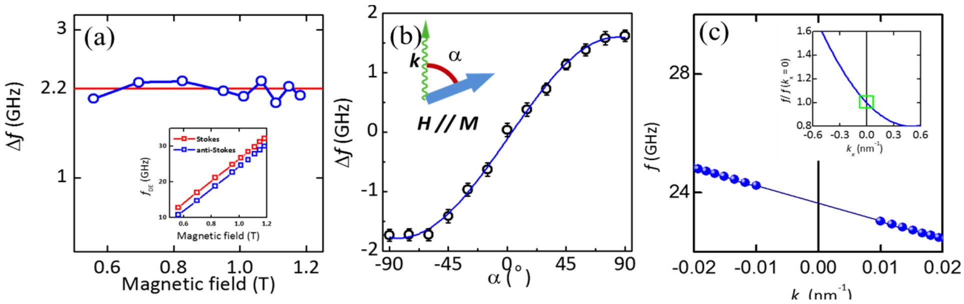

Fig. 1 (a) Δf as a function of the external field. Inset: Stokes and anti-Stokes spin wave frequencies as a function of the external field. (b) Δf as a function of the angleα between spin wave propagation direction and the magnetization direction. (c) Spin wave dispersion relations as a function of wave vector k_P. Inset: Theoretical spin wave dispersion relation with wider range of wave vector, and green box indicates the experimental range.

References

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