Magnetic vortex dynamics with interfacial Dzyaloshinskii-Moriya interation

문정환[1*], 이경진[1,2]
[1]Department of Materials Science and Engineering, Korea University, Seoul, Korea
[2]KU-KIST Graduate School of Converging Science and Technology, Korea University, Seoul, Korea

Dzyaloshinskii-Moriya interaction (DMI) is the asymmetric exchange interaction caused by combined effects of inversion symmetry breaking and spin-orbit coupling [1,2]. The effective magnetic field induced by the interfacial DMI is

$$H_{DM} = -\frac{2D}{M_s}\left(\hat{y}\times\frac{\partial \boldsymbol{m}}{\partial x} - \hat{x}\times\frac{\partial \boldsymbol{m}}{\partial y}\right),$$

where D is the DM energy density, M_s is the saturation magnetization, and z is the direction of inversion asymmetry.

Vortex dynamics was investigated by solving Landau-Lifshitz-Gilbert equation with an effective DM field. We assumed a Permalloy disk with the diameter of 270 nm and the thickness of 20 nm, discretized by the unit cells of 2x2x20 nm^3. Standard material parameters of Permalloy were used. An external a.c. magnetic field was applied to excite a vortex.

Figure 1 shows the equilibrium magnetization state with or without DMI. When assuming DMI, the equilibrium magnetization texture near a vortex core is distorted as shown in Fig.1(b) and ©.

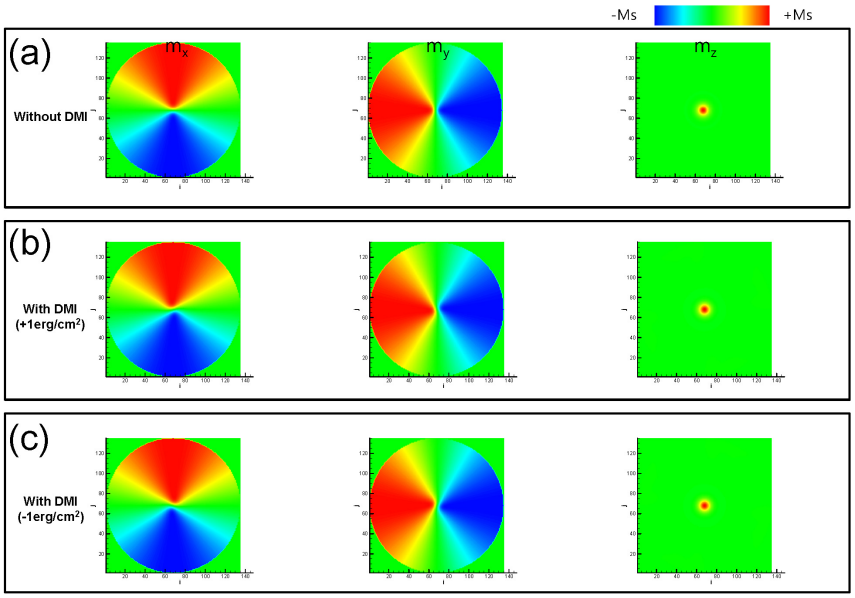
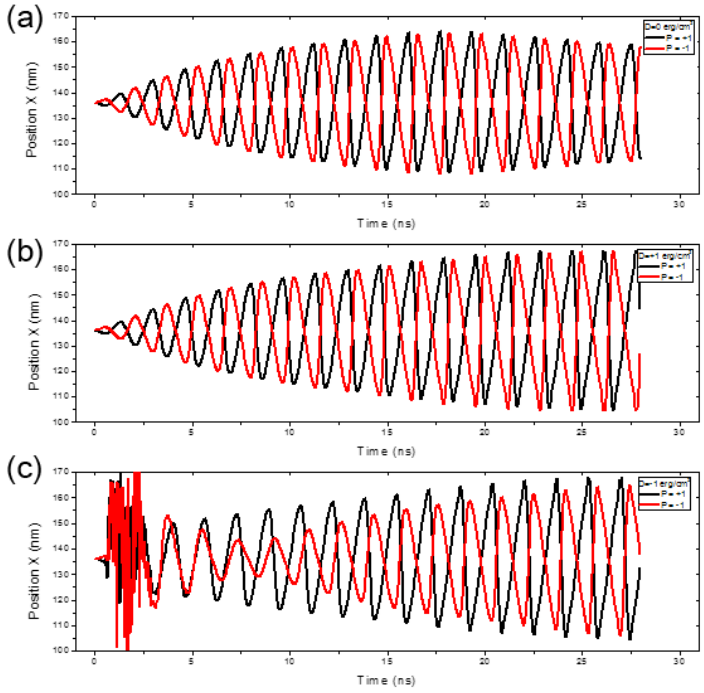


Figure 2 shows the x-position of a vortex core under external a.c. magnetic field when chirality is fixed to clockwise direction. With or without DM interaction (Fig. 2(a)), a core shows gyrotropic motion when excited. However, as shown in Fig. 2(b)-(c), initial responses of a vortex are very different depending on the sign of DM. Interfacial DM interaction favors one type of chirality, thus vortex which has unfavored chirality changes its chirality in the beginning of excitation (Fig. 2(c)). Further study such as resonance frequency and core reversal will be discussed in detail.



References

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