Current induced skyrmion dynamics via spin orbit coupling types

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1. Introduction

Inversion asymmetry existed in magnetic system, the system have specific exchange interaction which called Dzyaloshinskii-Moriya interaction(DM interaction) [1, 2].

Recently magnetic skyrmions stabilized by DMI are expected to have potential as information unit for storage and logic devices [3]. There are two main streams of SOCs in skyrmion studies. One is for Rashba SOC induced by structural inversion asymmetry. The other is Weyl SOC induced by bulk inversion asymmetry, typically observed in B20 structures. However, studies on magnetic skyrmion stabilized by Dresselhaus SOC have lacked. In this work, we investigate current-induced skyrmion dynamics in ferromagnet nanowire with three types of SOCs. We consider DMI and spin orbit spin transfer torque(SOT) having the symmetry of respective SOCs.

2. Simulation Scheme

We investigate skyrmion velocity using Landau-Lifshitz-Gilbert equation with a SOT corresponding SOC with following parameter. nanowire width is 40nm, thickness is 1nm, cell size is $1\times1\times1nm^3$, saturation magnetization is 800 emu/cm^3, exchange stiffness constant is 1.2×10^6 erg/cm, DM constant is –2 erg/cm^2, perpendicular magnetocrystalline anisotropy K_u is 0.8×10^7 erg/cm^3.

3. Result and Discussion

Figure 1 shows that all skyrmion velocity have linear dependence with current density, which are consistent with the prediction based on collective coordinate approach. For all SOCs, skyrmion velocity are given by $v_x \approx -F^{SOT}/\alpha D$ (current flow in x-axis) and $v_x \approx -F^{SOT}/G$ (current flow in y-axis) [6]. Where α is the damping constant, D is the factor of disspation matrix, G is the magnitude of gyrovector and $-F^{SOT}=-h\theta_{SHE}j_e\lambda/4\pi e$ is the force originating from spin orbit spin transfer torques. It is because spin orbit torques symmetry have same with DMI symmetry driven by each SOCs. Figure 1 shows the velocity of skyrmion is linearly increase about current density and $1/\alpha$

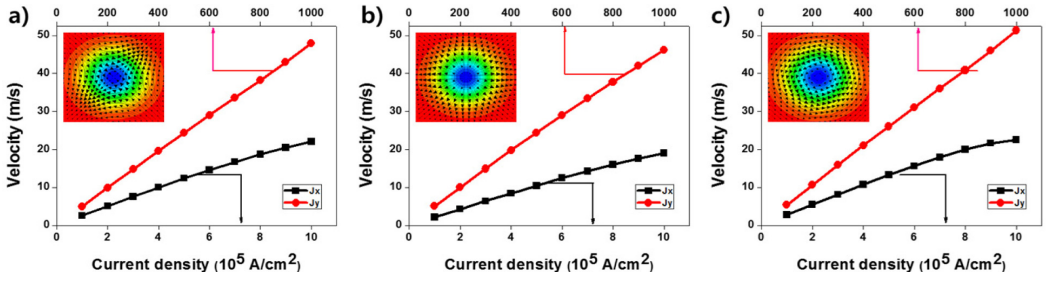

Fig. 1 Skyrmion velocity as a function of current density J for different current flow direction. (a) DM induced by Dresselhaus SOC, (b) Rashba SOC, (c) Weyl SOC

4. References

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