Domain wall propagation by spin-orbit torques in in-plane magnetized systems

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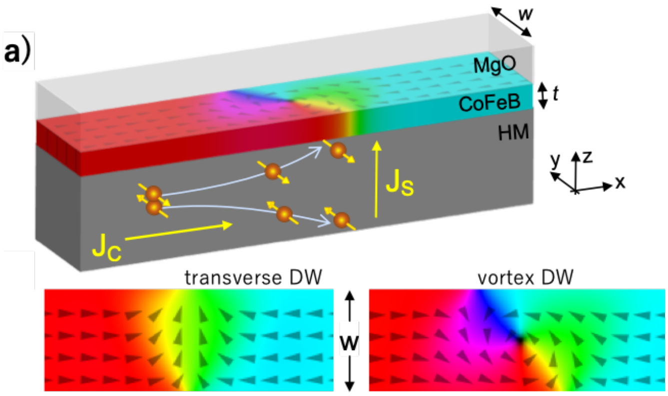
The effect of damping-like spin-orbit torque (DL SOT) on in-plane domain walls (DWs) in tracks was studied by micromagnetic simulations and analytically. We considered a magnetic thin film on a heavy metal layer and investigated the situation where spin polarized current from the heavy layer is injected to the magnetic layer (Fig. a). We find that DL SOT can drive vortex DWs (VDWs) more efficiently than spin-transfer torque (STT) in a comparable system, whereas transverse DWs (TDWs), the other typical DW structure in soft tracks, are not driven in the absence of Dzyaloshinskii-Moriya interaction (DMI). The trajectories of VDWs with different core polarities and windings have different propagation directions and dissipations toward the edge (Fig. b). Our analysis based on the Thiele equation shows that the driving force for the vortex DW is associated with a distortion from the perfect vortex configuration due to geometrical confinement. This distortion is higher, and the SOT DW driving is more efficient, in narrower, thinner tracks. Also it is revealed that the propagation direction depends on the core polarities, and the dissipation depends on the windings. In the presence of DMI, this distortion is also enhanced only in a certain direction, leading to faster movements with one core polarity and slower movements with the other. Interestingly DMI enhances the distortion of TDWs as well and it produces the driving force. In the end TDWs can propagate even faster than VDWs by SOT if the system has the DMI. We show also that it is possible to determine the relative amplitudes of STT and DL SOT by comparing the motion of different vortex DW structures in the same track.



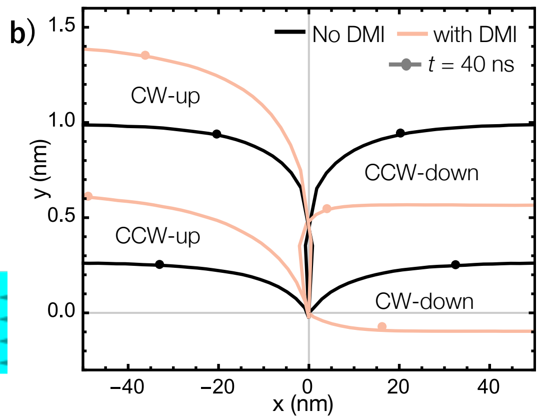


Fig. a: Schematic of SOT in a track of HM/CoFeB/MgO with in-plane DW structures. A charge current J_C flows mainly in the HM layer and induces a spin accumulation in the CoFeB layer

Fig. b: Trajectories of VDW cores with (black) and without (brown) DMI (J = 10 GA/m^2, t=5 nm, w=150 nm).