Magnetic Skyrmions in Bilayer and Multilayer Nanotracks

Univ. of Hong Kong [1], Nanjing Univ. [2], Shinshu Univ. [3], Univ. of Tokyo [4],

Xichao Zhang [1, 2], Xiaoxi Liu [3], Motohiko Ezawa [3], Yan Zhou [1, 2]

E-mail: xichaozhang@gmail.com

Magnetic skyrmions are nanoscale topological spin structures, which might be used as essential building blocks in future advanced memories and logic computing devices. However, there exists a significant obstacle to applications based on in-line motion of skyrmions, i.e., the so-called skyrmion Hall effect (SkHE), which refers to the phenomenon that the skyrmion trajectories bend away from the driving current direction due to the Magnus force. Consequently, the skyrmions in confined geometries may be destroyed by touching the edges. In this work, we theoretically propose that the SkHE can be suppressed in an antiferromagnetically (AFM) exchange-coupled bilayer nanotrack, since the Magnus forces in the top and bottom layers are exactly cancelled [1]. We show that such a pair of SkHE-free magnetic skyrmions (see Fig. 1) can be nucleated and be driven by the current-induced torque. Furthermore, we study the motion of magnetic skyrmions in AFM-coupled multilayer nanotracks as well as in a conventional ferromagnetic (FM) monolayer nanotrack at finite temperature [2]. There is an odd-even effect of the constituent FM layer number on the SkHE. Namely, due to the suppression of the SkHE, the magnetic skyrmions have no transverse motion in AFM-coupled nanotracks packed with even FM layers. It is numerically shown that a moving magnetic skyrmion is stable even at room temperature (T = 300 K) in an AFM-coupled bilayer nanotrack but it is destructed at T = 100 K in a FM monolayer nanotrack. Our proposal provides a promising means to move magnetic skyrmions in a perfectly straight trajectory in ultra-dense devices with ultra-fast processing speed. The results also indicate that the AFM-coupled structures are reliable candidates for designing future skyrmion-based spintronic devices.

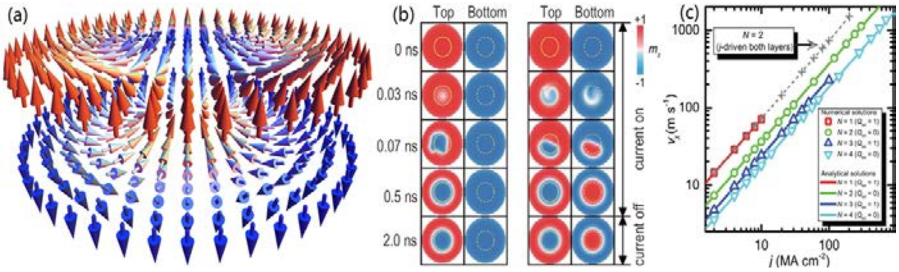

Figure 1. (a) An antiferromagnetically exchange-coupled bilayer skyrmion, which is immune to the skyrmion Hall effect. (b) Generation of a skyrmion and a bilayer skyrmion in a bilayer nanodisk. (c) Velocity as a function of driving current density for the motion of N-layer skyrmions driven by a vertical spin current.

References

[1] Xichao Zhang, Yan Zhou, and Motohiko Ezawa. "Magnetic bilayer-skyrmions without skyrmion Hall effect", Nature Communications **7**, 10293 (2016).

[2] Xichao Zhang, Motohiko Ezawa, and Yan Zhou, cond-mat/arXiv:1601.03893.