Control and Manipulation of a Magnetic Skyrmionium in Nanostructures

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Magnetic skyrmionium is a non-topological soliton with a doughnut-like spin texture in magnetic thin film, which can be phenomenologically viewed as a coalition of a magnetic skyrmion and a magnetic anti-skyrmion. Due to its zero topological number, that is, $Q = 0$, the skyrmionium has distinctive characteristics as compared to its topological skyrmion counterpart with $Q = \pm 1$. In this work, we systematically study the generation, manipulation and motion of a skyrmionium in nanostructures in the presence of a magnetic field or a spin current [1]. We demonstrate the degeneration of a skyrmionium with $Q = 0$ into a skyrmion with $Q = +1$ or $Q = -1$ triggered by a magnetic field pulse in a nanodisk. We show the transformation of a skyrmionium with $Q = 0$ into two skyrmions with $Q = +1$ in a nanotrack. In addition, we investigate the motion dynamics of a skyrmionium as well as a bilayer-skyrmionium compared to that of a skyrmion. The velocity of a skyrmionium driven by vertical current can be faster than that of a skyrmion at a reasonable driving current density. The results have technological implications in the emerging field of skyrmionics.

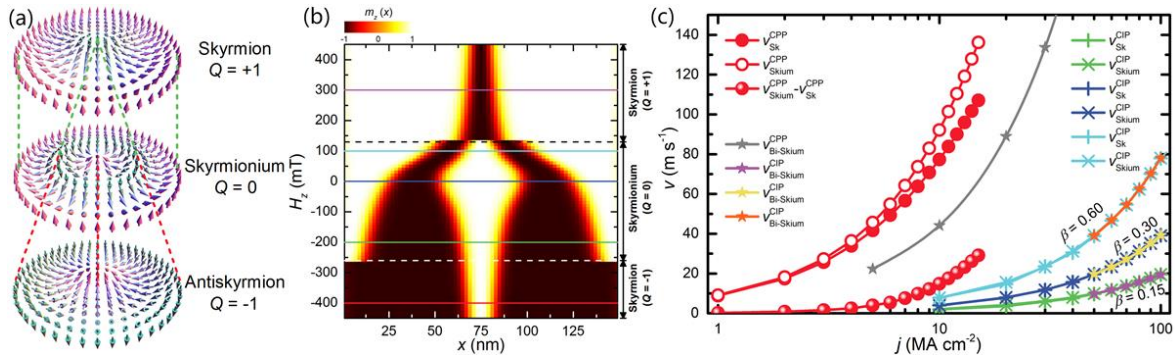

Figure 1. (a) Illustrations of a magnetic skyrmionium, which can be seen as composed of a skyrmion and an anti-skyrmion. (b) The out-of-plane magnetization component $m_z(x)$ along the diameter of the skyrmionium as a function of the external perpendicular magnetic field H_z. (c) Velocities of the skyrmion (v_{Sk}), skyrmionium (v_{Skium}), and bilayer-skyrmionium ($v_{Bi\text{-}Skium}$) driven by perpendicular-to-plane (CPP) and in-plane (CIP) spin-polarized current as functions of the driving current density j.

Reference

[1] Xichao Zhang, Jing Xia, Yan Zhou, Daowei Wang, Xiaoxi Liu, Weisheng Zhao and Motohiko Ezawa. "Control and manipulation of a magnetic skyrmionium in nanostructures", cond-mat/arXiv:1604.05909.

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