Skyrmion dynamics in ultrathin ferromagnetic films driven by spin-orbit torques

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The absence of inversion symmetry in magnetic films can allow chiral interactions such as anisotropic exchange of the Dzyaloshinskii-Moriya form to exist. In ultrathin ferromagnets on heavy-metal buffer layers, such as Pt, W, and Ir, the Dzyaloshinskii-Moriya interaction (DMI) is induced by the strong spin-orbit coupling at the interface [1]. The DMI can give rise to different nontrivial magnetic states, such as chiral domain walls [2] and magnetic skyrmions [3].

Here, we will describe some recent theoretical work on the dynamics of magnetic skyrmions driven by spin-orbit torques. By using micromagnetics simulations, we show how disorder in the form of random fluctuations in the anisotropy can lead to significant pinning and give rise to an extrinsic component to the skyrmion Hall angle [4], which is consistent with recent experimental observations. The resulting velocity versus current relations are reminiscent of domain wall dynamics in the creep regime. We will also describe how the nature of the DMI can have a profound effect on the current-driven motion, where different metastable skyrmion states [5] respond to the spin-orbit torques in qualitatively different ways. These results serve to highlight some different avenues for exploiting skyrmion states for spintronics applications.

This work was partially supported by the Horizon2020 Framework Programme of the European Commission (H2020-FETOPEN-2014-2015-RIA) under Contract No. 665095 (MAGicSky).

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