Dynamics of chiral magnetic patterns under spin orbit torques

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Spin-orbit torques (SOTs) are rapidly emerging as the key for enabling efficient current-controlled spintronic devices. The archetype heterostructure for these studies consists on an ultrathin ferromagnetic (FM) strip sandwiched between a heavy metal (HM) and an oxide (HM/FM/O), or between asymmetric stacks with two dissimilar HMs (HM1/FM/HM2). These multilayers exhibit high perpendicular magnetocrystalline anisotropy, and the broken inversion symmetry at the interfaces promotes a spin-orbit-derived Dzyaloshinskii-Moriya interaction (DMI) on the magnetic textures which is now becoming apparent. Chiral domain walls (DWs) and skyrmions, as recently observed [1,2], are efficiently driven by current as due to the spin Hall effect (SHE) in the HM. The current-induced magnetization switching has been also recently explored in micro-sized confined FM samples independently patterned on top of the HM [3]. The magnetization does not switch uniformly, but reverses through domain nucleation and the subsequent propagation of DWs [4,5]. Therefore, the effect of the current on DW nucleation and propagation has to be fully characterized.

Here we firstly review the static and dynamics properties of chiral DWs in HM/FM/O multilayers [1]. Once reviewed the current-driven propagation by current pulses in these systems, we will move to the analysis the nucleation of DWs [4]. We will show that the SOT assisted by the Oersted field of a double bit line allow the controlled injection of a series of DWs, giving rise to a controlled manner for writing binary information and, consequently, to the design of a simple and efficient DW shift register.

The second part of the talk will analyze the current-induced magnetization switching in micro-sized confined FM samples independently lithographically patterned on the HM [3]. By coupling the magnetization dynamics to the heat transport over the whole HM/FM/O heterostructure, we can disentangle the fundaments of the current-induced domain nucleation, and the subsequent DW propagation which promotes the geometrically-controlled switching [5]. Additionally, we will discuss the conditions under which the magnetization reversal can be deterministically achieved under realistic conditions [5]. These findings, not seen in conventional materials, provide essential insights for understanding and exploiting chiral magnetism for emerging spintronics applications.

[1] S. Emori, U. Bauer, S.-M. Ahn, E. Martínez, and G. Beach. Nat. Materials, 12, 611 (2013).

[2] O. Boulle et al. Nat. Nano., 11, 449 (2016); S. Woo et al. Nat. Materials, 15, 501 (2016).

[3] C. K. Safeer et al. Nat. Nano., 11, 143 (2016).

[4] O. Alejos et al. Sci. Rep., 7, 1190 (2017).

[5] E. Martinez et al. Sci. Rep. 5, 10156 (2015); O. Alejos et al. 110, 072407 (2017).