Domain wall propagation in materials with out of plane anisotropy

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PhD may follow: Yes

Summary :

The possibility to create unidirectional DW motion by applying an electric current is essential for new memory and logic devices.

Current induced DW motion in perpendicular media, initially predicted to be a particularly suitable environment for this phenomenon as DWs are very narrow and the spin transfer is more efficient, has remained elusive until very recently. We have discovered that a second ingredient was required to render the DW motion efficient in these materials: the crystalline structure must have broken inversion symmetry. In the case of a Co layer sandwiched between a Pt and AlO the DW motion is extremely fast, approaching 400 m/s, whereas if the top layer is replaced by Pt, the DWs do not move at all.

The fact that the DW motion is conditioned by the structural symmetry breaking points to the Spin Orbit interaction as the driving force through the spin orbit torque and the Dzyaloshinskii-Moriya interaction that favors non-uniform magnetic textures with a fixed chirality.

The goal of this internship will be to study the DW motion in materials with perpendicular anisotropy and SIA in order to disentangle the different contributions among the possible mechanisms.

Full description :

The possibility to create unidirectional DW motion by applying an electric current is essential for race-track memory devices (IBM) as well as fro three terminal DW random access memories (NEC).

Current induced DW motion in perpendicular media, initially predicted to be a particularly suitable environment for this phenomenon as DWs are very narrow and the spin transfer is more efficient, has remained elusive until very recently. We have discovered that a second ingredient was required to render the DW motion efficient in these materials: the crystalline structure must have broken inversion symmetry. In the case of a Co layer sandwiched between a Pt and AlO the DW motion is extremely fast, approaching 400 m/s [1], whereas if the top layer is replaced by Pt, the DWs do not move at all. This discovery has stimulated a strong interest in the scientific community, and in a short lapse of time, several models have been proposed to explain in detail this phenomenon. The fact that the DW motion is conditioned by the structural symmetry breaking points to the Spin Orbit interaction as the driving force. First, the effect created by the current in magnetic materials with large SO and SIA is the spin orbit torque [2, 3]. Besides this non-equilibrium effect, the SIA may also affect the equilibrium properties of the magnetization. Namely through the Dzyaloshinskii-Moriya (DMI) interaction favors non-uniform magnetic textures with a fixed chirality [4].

The goal of this internship will be to study the DW motion in materials with perpendicular anisotropy and SIA in order to disentangle the different contributions among the possible mechanisms. We will fabricate samples by patterning the magnetic nano-structures in the PTA and NANOFAB clean rooms. The DW velocity will be measured using wide field Kerr microscopy and also using magneto-transport techniques. Micromagnetic simulations will be used to model the physical behavior within the different scenarios.

This internship will be followed by a thesis.

[1] I. M. Miron, et al., Nature Materials, 10, 419-423 (2011)

[2] I. M. Miron, et al., Nature Materials, 9, 230-234 (2010)

[3] I. M. Miron, et al. Nature, 476, 189-193 (2011)

[4] A. Thiaville, et al. European Phys. Lett., 100, 57002 (2012)

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Requested skills :

Master 2 Nanophysics, condensed matter