Tuned spin-textures at heavy metal/magnetic multilayered heterostructures

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Interface engineering to tune the sign and intensity of the Dzyaloshinskii-Moriya interaction (DMI) has received large attention in the last decade. It has important prospects for emergent spintronics applications that rely on the stabilization of chiral spin textures, such as the manipulation of magnetic domain walls (DWs) through spin Hall effect induced torques. As most magnetic materials are non-chiral, insertion of heavy metal layers is currently used to lift the degeneracy between left- and right-handed DWs. However, the delicate balance between magnetic exchange, magnetic anisotropies and DMI depends on the specific materials and the details of the structure.
We have recently proved the interest to replace conventional uniform magnetic layers such as Co by multilayered Co/Ni heterostructures, using Bi as a heavy metal. The heterostructure inhibits stacking faults that could significantly alter the magnetic anisotropy, and serves to stabilize configurations minimizing Heisenberg exchange in favor of a dominant DMI. Furthermore, Bi guarantees the homochirality of the system even under disordered distributions, that naturally emerge due to the strong tendency of Bi atoms to float on the surface. Here we explore the effect of replacing Bi by other heavy metals, namely Pt and Ir, with a lower trend to seggregate to the surface and a reduced lattice mismatch with respect to the Co/Ni multilayers. Both features favor the control over the finally grown heterostructure, enabling the design of multilayer stacks with tuned chirality.
Based on a density functional theory approach, we determine the influence of band filling effects, strains and heavy metal distributions on the balance of the relevant magnetic energies, identifying the conditions that enhance the DMI leading to chiral spin textures. Our results confirm the uniqueness of Bi to stabilize robust homochiral structures with dominant DMI, but also serve to identify interesting alternatives to tune magnetic handness by wiseful heterostructure design.

References:

[1] M. Benito, Master Thesis, Complutense University of Madrid (2020)