Towards controlled chirality in disordered systems: Bi on 2Ni/Co multilayers

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Ultrathin magnetic metal films in contact to heavy metal (HM) layers are well known to develop robust spin-orbit (SO) derived properties ultimately leading to stabilization of chiral objects. At the basis of these phenomena are local interface Dzyaloshinskii-Moriya interactions (DMIs) that can be manipulated through different designs. The magnitude and sign of the DMI can be tuned by interface engineering, which allows to stabilize chiral or non-chiral Néel and Bloch domain walls in a given magnetic system, opening technological opportunities to handle information in electronic devices without the need of magnetic fields. The main drawback of the approach is the lack of descriptors easing prediction of the best conditions to enhance the DMI and gain control on the chirality sign. This confers additional interest to explore different systems and conditions that make possible the identification of trends.

Here we investigate a special system that adds new ingredients to previously explored metal/HM heterostructures: epitaxial [2Ni/Co] stacks on Cu(111) modified by Bi. Spin Polarized Low Energy Electron Microscopy (SPLEEM) measurements demonstrate that Bi influences the spin texture of the system, with magnetic domain walls evolving from non-chiral Bloch to homo-chiral Néel configurations when Bi is added. Eventhough the surfactant properties of Bi render a disordered distribution, the system preserves constant homochirality both at low and room temperatures. Here we will focus on understanding the origin of this behavior based on ab initio calculations within the density functional theory, exploring the balance of magnetic energy terms (exchange and SO-derived) under different geometries. Bi contributes with singular properties: it has a large size, that introduces incomplete interface layer coverage; and it is a p valence band metal, weakly polarizable. Also the 2Ni/Co stacks confer an inherent asymmetry that conditions interface additive effects, further supported by the different chiral response of Ni and Co. Our results evidence 2Co/Ni heterostructures combined with Bi as unique systems to tune and control stable homochiral structures where the DMI can even be made the dominant energy scale.

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