Gauged Micromagnetic Model of the Dzyaloshinskii-Moriya Interaction Induced by Symmetry Breaking at the Co/Pt Interface

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The Dzyaloshinskii-Moriya-like interaction (DMI) is a source of chirality in magnetism [1]. This interaction is currently at the centre of a growing effort to search for new materials or realise tailored devices supporting novel applications in magnetism and spintronics. We focus both on the interpretation of the DMI in terms of a non-abelian gauge field [2] and on the application of the point groups symmetries to the micromagnetic free energy in thin films of cobalt on heavy metal substrates (*e.g.* platinum) [3]. The model sample, Figure 1, consists of a single-crystalline ultrathin magnetic film of hcp-cobalt with [0001] direction normal to the *x*-*y* film plane, with finite thickness and the magnetisation *m(x, y)* is independent of the *z*-coordinate.

The cobalt layer viewed along this direction consists of regularly distributed hexagons of Co atoms. The point group of hcp-cobalt is *6/mmm (D6h),* which is the direct product of the *6mm (C6v)* and *m (C1h)* point groups [4] and does not exhibit DMI interaction because of its centrosymmetry. By breaking the symmetry along e_z, the point group changes from the *6/mmm (D6h)* to the non-centrosymmetric *6mm (C6v)*, and the e_z and $-e_z$ directions are no longer equivalent. Experimentally this occurs when the Co film is epitaxially grown onto the Pt(111) single crystal surface, making the Co/Pt interface inversion-asymmetric [5], owing to the presence of an additional layer with a different stacking.

The gauge theory and the symmetry analysis, consistent with the Neumann's principle, applied to the micromagnetic exchange energy, predicts the emergence of the surface DMI in such a system. Moreover, we show a new possible effect of an exchange stiffness tensor [6] obeying the symmetry of the hexagonal lattice and its impact on the DMI.

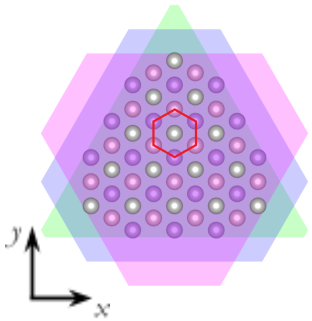

Figure 1. Sketch of the top view of the Pt/Co interface: the green (111) plane (at the bottom) contains the Pt-atoms on which (0001) planes of Co-atoms (pink and purple planes), with the *ABAB* stacking for hcp metals.

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