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Abstract

Measuring Interfacial Dzyaloshinskii-Moriya Interaction: A Review †

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† Presented at the 37th International Symposium on Dynamical Properties of Solids (DyProSo 2019), Ferrara, Italy, 8–12 September 2019.

Published: 5 September 2019

Topology is known to stabilize rather exotic states in condensed matter and in magnetic materials. A recent example is the formation of particle-like excitations of continuous fields, as predicted by Skyrme. These so called skyrmions occur in presence of inversion symmetry breaking and indirect exchange, both favouring chiral magnetic structures via the Dzyaloshinskii-Moriya Interaction (DMI) [1,2]. Recently, the DMI received broad attention from the magnetism community as it was found to occur in systems appealing for spintronic applications composed of a heavy metal (HM) layer and an ultrathin ferromagnetic (FM) film with perpendicular magnetic anisotropy (PMA). Here the inversion symmetry breaking is induced by the interface and the exchange interaction is mediated by the spin-orbit coupling in the HM layer. Chiral domain walls and skyrmions are emerging as promising information carriers for future spintronic technologies, as they can be driven by electric currents with an unprecedented level of efficiency [3]. A measure for the stability of chiral magnetic structures and the strength of the DMI is the related energy coefficient D [2]. Although DMI-based phenomena have created an extremely active research field, an established and reliable method to measure D is still lacking. As a matter of fact, a lot of disagreement is currently present in the literature, especially regarding measurements of small DMI ($D < 0.5$ mJ/m^2). Not only different measuring techniques are found to provide contradictory values for D, but controversies are also present when utilizing the same method on nominally identical stacks. We present here a review of interfacial DMI measurements, considering not only the different measurement techniques as domain wall based [4,5] and spin wave based [6] measurements, but also different compositions of the stacks investigated (e.g., FM: Co, CoFeB; HM: Pt, Ta, Ir, W). We try to clarify the differences of the various techniques describing their advantages and limitations and define a set of rules to be able to compare the data, quantitatively define the role of HM layer, considering its thickness, the production methodology, the annealing, etc. We also aim to introduce a standard coordinate system for the experimental quantities in order to define uniquely the sign of D.

Funding: This work was supported by the EMPIR project 17FUN08 TOPS. This project has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme.

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