Large voltage tuning of Dzyalonshinskii-Moriya Interaction: a route towards dynamic control of skyrmion chirality.

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Abstract

Electric control of magnetism is a prerequisite for efficient and low power spintronic devices. More specifically, in heavy metal/ferromagnet/insulator (HM/FM/I) heterostructures, voltage gating has been shown to locally and dynamically tune magnetic properties like interface anisotropy and saturation magnetization [1,2]. A recent breakthrough concerning magnetic nano-objects called skyrmions, which are promising to code information bits, has attracted a specific interest on the interfacial interaction responsible for their existence, namely Dzyaloshinskii-Moriya Interaction (DMI) [3,4]. This interaction gives rise to non-collinear magnetic alignments; thus in HM/FM/I structures, magnetic bubbles are observed with Néel type domain wall of a specific chirality, determined by the sign of DMI.

The effect of electric field on DMI has been challenging to achieve and therefore has not been reported yet for ultrathin films. Here, we demonstrate 130% variation of DMI with electric field in Ta/FeCoB/TaOx trilayers through Brillouin Light Spectroscopy (BLS). We further show a monotonic variation of DMI and skyrmionic bubble size with electric field by polar-Magneto-Optical-Kerr-Effect (pMOKE) microscopy. Our experiments show an unprecedented electric field efficiency for DMI [5]: β_{DMI}=700 fJ/Vm. The efficient DMI manipulation with voltage thus establishes an additional degree of control over skyrmions and spin-orbitronic based devices. We anticipate through our observations that a sign reversal of DMI with electric field is possible, leading to a chirality switch. This dynamic engineering of DMI sets the foundation towards programmable skyrmion based memory or logic devices.

References

1. E. Y. Tsymbal, *Nat. Mater.* **11**, 12-13 (2012)
2. F. Matsukura, Y. Tokura and H. Ohno, *Nat. Nanotech.* **10**, 209-2020 (2015)
3. U.K. Rossler, A.N. Bogdanov and C. Pfleiderer, *Nature* **442**, 797 (2006)
4. N. Nagaosa and Y. Tokura, *Nature Nanotech.* **8**, 899-911 (2013)
5. T. Srivastava et al., *Nanolett.*, **18**, 4871 (2018)