Zernike Colloquium

January 9th, 2025
16:00h
5111.0080

Skyrmions in chiral magnetic multilayers

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Magnetic skyrmions are topologically-nontrivial spin textures with particle-like properties [1]. Their size, topological stability, and mobility suggest their use in future generations of spintronic devices [2], the prototype of which is the skyrmion racetrack [3]. To realise a racetrack requires three basic operations: the nucleation (writing), propagation (manipulation), and detection (reading) of a skyrmion, all by electrical means.

Here we show that all three are experimental feasible at room temperature in Pt/Co/Ir or Pt/CoB/Ir multilayers in which the different heavy metals above and below the magnetic layer break inversion symmetry and induce chirality by means of the Dzyaloshinskii-Moriya interaction, defining the structure of Néel skyrmion spin textures [4]. We show deterministic nucleation on nanosecond timescales using an electrical point contact on top of the multilayer [5] (Figure 1), current-driven propagation along a wire in which the skyrmions are channelled by defects in the multilayer [6], and their detection by means of the Hall effect (Figure 2) that reveals an unexpectedly large contribution to the Hall signal that correlates with the topological winding number [7].

New directions in skyrmion research include spin wave-driven motion [8] and synthetic antiferromagnetic skyrmions [9].

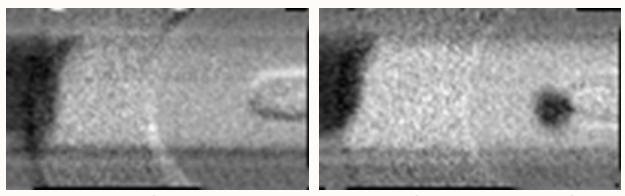

Figure 1. STXM images before and after nucleation of a skyrmion at a 500 nm wide injector contact to a Pt/CoB/Ir multilayer.

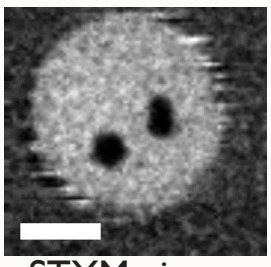

Figure 2. STXM image of two skyrmions in an electrically-connected 1 μm diameter Pt/Co/Ir multilayer dot. 500 nm scale bar.

[1] N. Nagaosa & Y. Tokura, Nat. Nanotech. 8, 899 (2013).
[2] C. H. Marrows & K. Zeissler, Appl. Phys. Lett. 119, 250502 (2021).
[3] A. Fert et al. Nature Nanotech. 8, 152 (2013).
[4] K. Zeissler et al. Sci. Rep. 7, 15125 (2017).
[5] S. Finizio et al., Nano Lett. 19, 7246 (2019).
[6] K. Zeissler et al., Nature Comm. 11, 428 (2020)
[7] K. Zeissler et al. Nature Nanotech. 13, 1161 (2018).
[8] L. Huang et al., Phys. Rev. B 107, 224418 (2023).
[9] C. E.A. Barker et al., Phys. Rev. B 109, 134437 (2024).

Coffee from 15:30h
Drinks & Snacks after

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