Electric-field-induced multiferroic topological solitons

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Résumé

Topological protected magnetic textures like skyrmions have been studied intensively in ferromagnets in the view of information technology applications. However, it appeared soon that the future of skyrmionics may rely on antiferromagnets owing to their immunity to dipolar fields, straight motion along the driving force and ultrafast dynamics. Several directions have been pursued towards this goal, like the use of synthetic antiferromagnetic tracks (1). Here I will present another approach relying on a multiferroic material, bismuth ferrite, which offers the possibility to combine ferroelectric and antiferromagnetic topologies, and provides a way to control electrically the magnetic texture.

I will start with a presentation of the complex magnetic state of bismuth ferrite and the technique we use to image it: scanning Nitrogen-Vacancy (NV) center magnetometry (2). In thin films, epitaxial strain is very efficient to control magnetism in this material, allowing the stabilization of either a cycloidal state or of a G-type antiferromagnetic order (3), while in bulk crystals we observed a surface effect leading to the formation of topological defects inside the cycloidal texture (4).

I will finally detail our recent work about the creation of multiferroic solitons using radial electric field in discs of bismuth ferrite (5). This process creates ferroelectric center states containing flux closures of antiferromagnetic cycloids or quadrants of canted antiferromagnetic domains depending on the epitaxial strain. These results open the path to reconfigurable topological states in multiferroic antiferromagnets.

(1) Pham et al, Science 384, 307 (2024)
(2) Finco et Jacques, APL Materials 11, 100901 (2024)
(3) Haykal et al, Nature Communications 11, 1704 (2020)
(4) Finco et al, Physcial Review Letters 123, 187201 (2022)
(5) Chaudron et al, Nature Materials 23, 905 (2024)

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