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Higher dimensional topological textures in multiferroics

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Magnetic skyrmions are localized, non-collinear chiral magnetic textures which are envisioned to play a major role in spintronics [1] and neuromorphic computing [2] applications. Thanks to their topological properties that enhance their stability, ferromagnetic (FM) skyrmions in metals have been the subject of intense research in metals since the last 10 years.
Recently, antiferromagnetic (AFM) topological magnetic structures have been explored such as bi-meron or AFM-skyrmions in insultors [3]. Antiferromagnetic (AFM) skyrmions have drawn attention due to their fast dynamics and their robustness against stray fields [4]. In particular, AFM skyrmion are characterized by a non-zero winding number associated to the AFM vector **L**. Although AFM skyrmions in a synthetic antiferromagnet have recently been reported, AFM skyrmions are still elusive in single-phase antiferromagnets.

Here, we first review the different stabilization and nucleation mechanisms of FM skyrmions in metals [5,6]. Both FM and AFM skyrmions are stabilized by similar interactions: the magnetic exchange interaction, the Dzyaloshinskii-Moriya (DM) interaction and the magnetic anisotropy. We especially focus on the different algorithm implemented in our home-made code *Matjes* to obtain ground states of topologically protected magnetic textures [7]. We explore also the dynamics of these magnetic textures via different external stimuli such spin torques or laser pulses.
Finally, via density functional theory, we explore the magnetic ground state of the AFM multiferroics $BiFeO_3$ as a function of symmetry and strain [8] and show that – in multiferroic insultators - new coupling terms my emerge and have a significant impact on the symmetry of topological objects. These findings open up the possibility to stabilize skyrmions characterized by non-zero winding numbers in 6 dimensions.

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