Curvature-induced stabilization and field-driven dynamics of magnetic hopfions in toroidal nanorings

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Abstract
Three dimensional magnetic textures are a cornerstone in magnetism research. In this work, we analyze the stabilization and dynamic response of a magnetic hopfion hosted in a toroidal nanoring with intrinsic Dzyaloshinskii-Moriya interaction simulating FeGe. Our results evidence that unlike their planar counterparts, where perpendicular magnetic anisotropies are necessary to stabilize hopfions, the shape anisotropy originated on the torus symmetry naturally yields the nucleation of these topological textures. We also analyze the magnetization dynamical response by applying a magnetic field pulse to differentiate among several magnetic patterns. Finally, to understand the nature of spin wave modes, we analyze the spatial distributions of the resonant mode amplitudes and phases and describe the differences among bulk and surface modes. Importantly, hopfions lying in toroidal nanorings present a non-circularly symmetric poloidal resonant mode, which is not observed in other systems hosting hopfions.

Author keywords
dynamic susceptibility; magnetic
textures; magnetization; micromagnetism; ressonant modes; topological solitons