Tunable magnetic equilibrium configurations in dipolar helices

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The role that geometry and topology play in emergent order parameters has become an important topic in theoretical and experimental studies in different areas of physics [1]. A general theoretical framework to describe statics and dynamics of curved magnetic wires and surfaces has been developed recently, providing a starting point to study magnetization configurations in curvilinear structures [2]. New terms such as induced effective anisotropies and emergent Dzyaloshinskii-Moriya interactions appear as a consequence of curvature, which are responsible for magnetochiral effects, not present in the conventional cases. In this work, we have particularized the study to anti- and ferromagnetic (FM) helices, that are the simplest curves with constant κ and τ. By performing atomistic Monte Carlo simulations, we have validated the micromagnetic theoretical framework that predicts stable magnetization transitions between quasi-tangential (QT) to onion-like configurations [2]. Varying the curvature κ (or radius R) and torsion τ (or pitch p), we have obtained phase diagrams for the FM and AF cases for different kinds of magnetocrystalline anisotropies, extending them beyond the limits of application of the micromagnetic model. In a second part of the work, we will study the effects of curvature in systems where exchange determines the global magnetization direction, but the global magnetic order is dominated by dipolar interactions. This is the case of nanoparticle assemblies, colloidal magnets, magnetic beads or molecular clusters, that can be treated as magnetic macro-dipoles [3]. We will show that in dipolar helices a rich variety of equilibrium configurations can be reached by tuning the angle between consecutive dipoles. They include QT states, entwined head-to-tail magnetic helices that have a periodicity different from the generative helix and FM or AF ordered chains along the helix axis. Varying the radius or the pitch of the helix, abrupt transitions between states having zero and sizable net magnetization can be induced, which could be achieved experimentally by applying stress to the helix ends and be used as magneto-mechanic sensors. Work supported by Spanish MINECO (PGC2018-097789-B-I00, PID2019-109514RJ-I00), Catalan DURSI (2017SGR0598) and EU FEDER funds (Una manera de hacer Europa) also CSUC for supercomputer facilities.

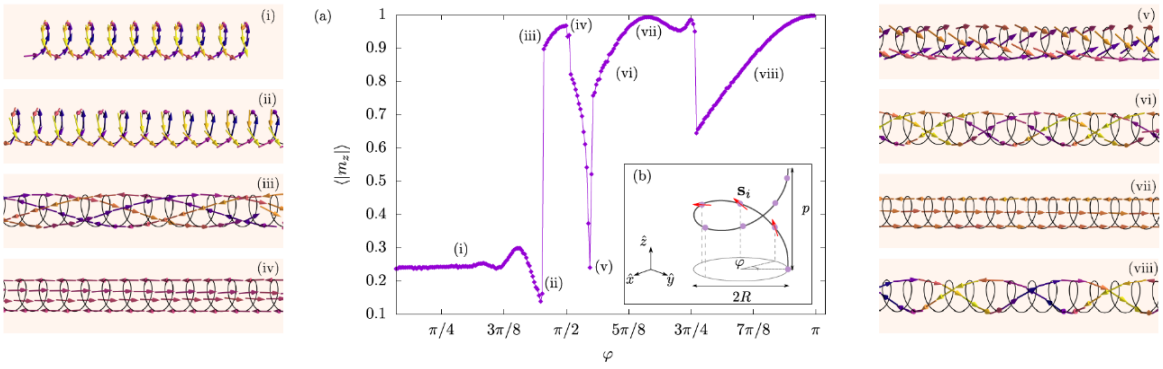

Figure 1: Ground states of a dipolar helix (R=1, p=π/2) and their staggered magnetization along the helix axis.

References

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