Torsion and curvature induced effects in magnetic twisted nanotubes

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Abstract

Recently, researchers developed 3d magnetization models for magnetic shells with curvature and torsion [1]. For example, in a thin nanotube, the curvature induced a magnetostatic anisotropy [2]. Also, in the case of the nanocylinder, the curvature induces dipole-dipole interaction [3]. However, in these tubular systems, torsion has not been explored yet. Here we propose to study a nanocylinder with torsion that we call the twisted nanotube. In Figure 1, we present the system. It has an internal radius r and an external radius R, infinite length L, an elliptical transversal area, curvature κ and torsion τ .

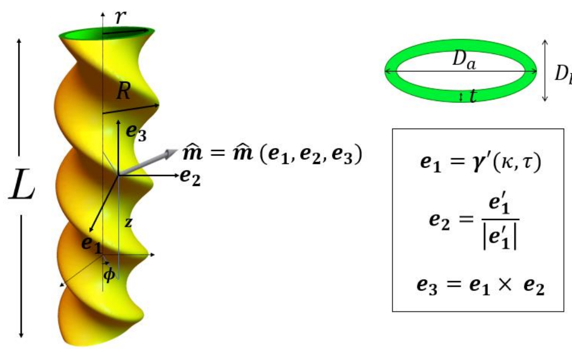

Figure 1. The magnetization vector $\boldsymbol{m}$ in terms of the base vectors $(\boldsymbol{e_1}, \boldsymbol{e_2}, \boldsymbol{e_3})$. The parametrization of a 2D tubular surface $\boldsymbol{\gamma}$, embedded in a 3D space defines these vectors.

For the twisted nanotube, we compute the dipolar interaction. Furthermore, the torsion is introduced by defining the reference frame for the magnetization. With this methodology, we show that in the twisted nanotube, there are volumetric charges because of the torsion of the system. In equation 1, we present the expression for the volumetric charges, where the term Γ_d is the contribution of the torsion. Also, the developed model shows that the torsion does not induce surface charges. This work represents a future contribution to future developments of spintronic, like the one developed for the nanocylinder [4].

$$\nabla \cdot \boldsymbol{M} = M sin\Theta \left(\frac{sinp}{\rho} - \partial_z \Theta + \Gamma_\mathrm{d}(\phi) \right) \qquad (1)$$

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References

[1] Y. Gaididei, K. Volodymyr and S. Denis, Phys. Rev Lett. 112, 257203 (2014)
[2] P. Landeros, A. Núñez, J. Appl. Phys. 108, 033917 (2010)
[3] J. Otálora, J. López, P. Landeros, P. Vargas and A. Núñez, J. Magn. Magn Mater. 341, 86-92 (2013).
[4] M. Salazar, L. Körber, H. Schultheiss, K. Lenz, A. Thomas, K. Nielsch, and J. Otálora, Appl. Phys. Lett. 118, 262411 (2021).