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Magnetic ground states in nanocuboids of cubic magnetocrystalline anisotropy

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Highlights

- The <111> vortex is numerically determined in nanocubes of cubic anisotropy.
- It constitutes an intermediate state in the single-domain limit.
- Such a vortex can only be stabilized in perfect or slightly deformed nanocuboids.
- It exists in nanocuboids made of materials with zero or positive cubic anisotropy.
- The associated magnetization reversal is described by a rotation of the vortex axis.

Abstract

Flower and easy-axis vortex states are well-known magnetic configurations that can be stabilized in small particles. However, <111> vortex (V<111>), *i.e.* a vortex state with its core axis along the hard-axis direction, has been recently evidenced as a stable configuration in Fe nanocubes of intermediate sizes in the flower/vortex transition. In this context, we present here extensive micromagnetic simulations to determine the different magnetic ground states in ferromagnetic nanocuboids exhibiting cubic magnetocrystalline anisotropy (MCA). Focusing our study in the single-domain/multidomain size range (10–50 nm), we showed that V<111> is only stable in nanocuboids exhibiting peculiar features, such as a specific size, shape and magnetic environment, contrarily to the classical flower and easy-axis vortex states. Thus, to track experimentally these V<111> states, one should focused on (i) nanocuboids exhibiting a nearly perfect cubic shape (size distorsion <12%) made of (ii) a material which combines a zero or positive MCA and a high saturation magnetization, such as Fe or FeCo; and (iii) a low magnetic field environment, V<111> being only observed in virgin or remanent states.

Keywords

Magnetic nanocubes; Hard-axis vortex; Flower-vortex transition; Single-domain limit