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RADIAL-DEPENDENT BLOCH POINT IN MAGNETIC NANOSPHERE

Pylypovskyi O.V.[1], **Sheka D.D.**[1], **Gaididei Yu. B.**[2]

[1]*Taras Shevchenko National University of Kyiv, 64, Volodymyrs'ka St., 01601, Kyiv, Ukraine*
[2]*Bogolyubov Institute for Theoretical Physics, 14-b Metrolohichna St., Kyiv, 03680, Ukraine*
e-mail: engraver@univ.net.ua

Bloch point is the simplest 3D topological singularity in micromagnetism [1]. Such a singularity naturally appears during the process of the vortex polarity switching i. e. the reversal of the vortex core magnetization (polarity) [2]. The ultrafast switching of the vortex polarity is a key point for usage them as elements of high-speed magnetic random access memory.

We consider different types of Bloch Points $\left(\mathrm{BP}_q^p\right)$ in a spherical sample of radius R, which are described by the singular distribution of normalized magnetization $\mathbf{m}(\mathbf{r}) = (\sin\Theta\cos\Phi, \sin\Theta\sin\Phi, \cos\Theta)$ of the form: $\Theta = p\vartheta + \pi(1-p)/2$, $\Phi = q\varphi + \gamma(r)$, where $\mathbf{r} = (r, \vartheta, \varphi)$ is a radius-vector, $p = \pm 1$ and $q = \pm 1$. Such BP_q^p singularities correspond to different observed structures during vortex polarity switching [2, 3]. The BP_q^p does not form a remanent state in a spherical particle; we stabilize it by external gradient field $\mathbf{H} = h\mathbf{r}$. The purpose of the current study is to find the rotational angle $\gamma_h(r)$: analytically for small h and numerically for a wide range of fields; its value is mainly defined by competition between stray field and external one. In fields lower than some critical value h_c a spatially non-uniform distribution $\gamma_h(r)$ is realized and for $h > h_c$ one has $\gamma_h \equiv 0$. We calculated the critical field amplitude h_c, which depends on a ratio between exchange length and radius of the sample. We found the equilibrium value $\gamma_{h=0} = \arccos(-p/4)$ for $q = 1$, which provides smaller energy than previous estimations [4].

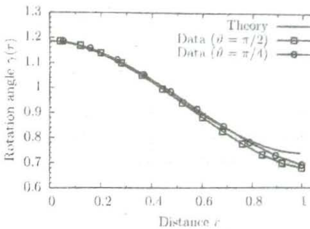

Figure 1: Radial dependency of rotation angle γ in spherical particle with diameter $35a$ (a is a lattice constant). Symbols corresponds crystallographic directions [111] ($\vartheta = \pi/4$) and [110] ($\vartheta \approx \pi/2$).

We verify our theoretical predictions for BP_1^1 structure by in-house developed spin-lattice simulator SLaSi [5-7]: numerical data for azimuthal angle are well confirmed by analytical curve (see Figure 1). The polar Bloch point angle Θ does not deviate from ϑ within accuracy 0.099. Stability check in wide range of magnetic fields was performed by shifting Bloch point from the origin and controlling total spin projections (only for the Bloch point, situated at the sample origin, the total spin $S_x^{\text{tot}} = S_y^{\text{tot}} = S_z^{\text{tot}} = 0$).

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