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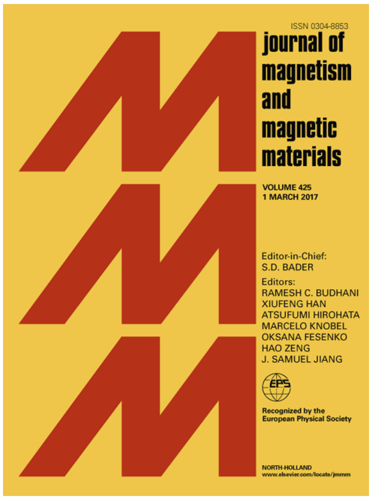

Geometry dependence of the magnetization reversal process in bridged dots

R.A. Escobar, E. Lage, J. d'Albuquerque e Castro, D. Altbir, C.A. Ross

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Geometry dependence of the magnetization reversal process in bridged dots

R. A. Escobar,[1] E. Lage,[2] J. d' Albuquerque e Castro,[3] D. Altbir,[1] and C. A. Ross[2]
[1] *Departamento de Física, CEDENNA, Universidad de Santiago de Chile, USACH, Av. Ecuador 3493, Santiago, Chile*
[2] *Department of Materials Science and Engineering, Massachusetts Institute of Technology, 02139 Cambridge, MA, USA*
[3] *Instituto de Física, Universidade Federal do Rio de Janeiro Caixa Postal 68528, Rio de Janeiro, RJ, Brazil, 21945-970*

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Based on Monte Carlo numerical simulations results for the magnetization reversal process in thin circular Ni dots connected by a bridge are presented. The dependence of the process on both the width of the bridge and the orientation of the applied magnetic field has been investigated. It was found that when the applied magnetic field is set parallel to the bridge, the hysteresis curves are weakly dependent on the width of the bridge, being rather close to that of a single dot of the same diameter. On the other hand, when the magnetic field is applied perpendicularly to the bridge, a significant reduction in the coercivity of the system is obtained, even in the case of narrower bridges.

Keywords: Magnetization reversal, magnetic vortex, bridged dots.

I. INTRODUCTION

Magnetic nanostructures find applications in a variety of fields, which include magnetic sensors[1–5], high-density storage media[6–9], medicines and therapies[10–14]. Progress in the techniques of material growth has made possible the preparation of nanoparticles with a wide range of shapes and sizes. Interest has been focused on their magnetic response, which is ultimately determined by geometrical and materials factors. Of particular relevance is the process of magnetization reversal in such particles, which might be exploited in technological applications[15–18]. The reversal process often involves the formation of rather complex micromagnetic structures, such as multiple domain walls and vortices[19–25].

Vortices are singular structures that appear in various two-dimensional systems, such as discs, cylinders and bars. They consist of an out-of-plane core magnetization and an in-plane curling magnetization. In addition to their role in the process of magnetization reversal, vortices exhibit non-trivial low-frequency translation modes, which might open the possibility of using them in the production of nano-oscillators[26–28].

The magnetic response of nano-dots has been intensively investigated in the last few decades in view of their potential for technological applications. Very often, theoretical studies focus on the magnetization reversal of single dots. However, from the experimental point of view, such structures are usually part of large arrays, in which inter-element interactions may be of relevance[29]. The issue of the magnetostatic interdot coupling has been addressed by K. Yu. Guslienko and collaborators in references[30–32]. Besides, J. Mejia Lopez *et al.*[33] and A. J. Bennet *et al.*[34] used Monte Carlo simulations to analyse the collective magnetic behavior of magnetic nanostructures. A similar approach considers the study of dots coupled by bridges. For instance, Zhu *et al.*[35], have investigated the phase-locking dynamics of vortices in bridge-coupled nanodisks.

In the present work, a detailed numerical analysis is carried out of the effects of the presence of a bridge connecting two nanodisks, as represented in Fig. 1, on the magnetic properties of the structure. In particular, attention is focused on the dependence of the magnetization curves on the orientation of the applied magnetic field relative to the bridge. We find a significant difference in the magnetization reversal process when the field is oriented parallel and perpendicular to the bridge.

II. MODEL

We have considered two Ni nanodisks of diameter $D =$ 80 nm and thickness $t = 10$ nm placed in the xy plane. The discs are separated by a distance $S = 44$ nm with a narrow bridge of width λ between them, as depicted in Fig. 1a, where $\lambda = 4$ or 20 nm. For the sake of comparison, we have also considered the case in which $\lambda = 0$ nm (disconnected nanodisks), as shown in Fig. 1b, and $\lambda = 60$ nm and 80 nm. In each case the total length L of the structure along the x-direction was equal to 204 nm (see Fig. 1).

For each configuration $\{\vec{\mu}_i\}$ of the magnetic moments, the total energy of the systems is given by

$$E_{tot} = \frac{1}{2}\sum\nolimits_{i\neq j}\left(E_{ij} - J_{ij}\hat{\mu}_i\cdot\hat{\mu}_j\right) + E_H \ , \qquad (1)$$

with

$$E_{ij} = \left[\vec{\mu}_i\cdot\vec{\mu}_j - 3(\vec{\mu}_i\cdot\hat{n}_{ij})(\vec{\mu}_j\cdot\hat{n}_{ij})\right]/r_{ij}^3 \, . \qquad (2)$$

The expression in Eq. 2 corresponds to the dipolar interaction between magnetic moments $\vec{\mu}_i$ and $\vec{\mu}_j$ located

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