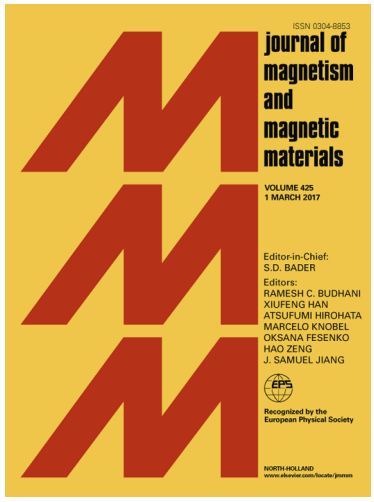

Research articles

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Spin current induced dynamics and polarity switching of coupled magnetic vertices in three-layer nanopillars

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Abstract

We study dynamics of two magnetostatically coupled magnetic vortices excited by spin-polarized electrical current in a nanopillar consisting of permalloy magnetic layers with different thickness separated by a nonmagnetic spacer. We demonstrate three dynamical regimes of the vortices bound motion: damped oscillations, stationary oscillations and a regime of the polarity switching of one of the vortices; the critical currents for each dynamical phase are identified. The structure and trajectory of the vortex core motion in each magnetic layer are studied for the case of the vortex polarity switching in a thick layer. We show that the vortex polarity switching process has a dynamic nature and is associated with a vortex-antivortex pair formation.

Keywords: magnetic vortices, nanopillar, spin torque effect, coupled dynamics, vortex polarity switch

1. Introduction

The spin torque effect, which is magnetization dynamics excitation due to the transfer of angular momentum to the magnetic system by spin-polarazed electrical current, plays an important role in spintronics [1-3]. Among a variety of spintronic systems, a magnetic vortex [4-5] in soft magnet nanodots attracts significant interest due to rich physics and unique functionalities [6-8]. Magnetic vortex is a magnetic state characterized by two topological parameters, namely vorticity (V), which determines the curling direction of the in-plane magnetization, such that $V = +1$ (resp. $V = -1$) stands for counterclockwise (resp. clockwise) direction and the orientation of the vortex core out-of-plane magnetization, polarity (Pol), which can be $Pol = +1$ or-1 depending on its alignment to the out-of-plane (z) axis. The magnetization switching and excitation of self-sustained oscillations of magnetic vortex by means of a spin-polarized current have been widely studied, both experimentally [9-16] and theoretically [17-22].

The stability of the vortex state is studied as a function of the system parameters and external influences [17]. It is found that, depending on the magnitude of the spin-polarized current passing through the magnetic nanopillar, the vortex can move along different types of trajectories [23-25]. Using the method of collective variables effective