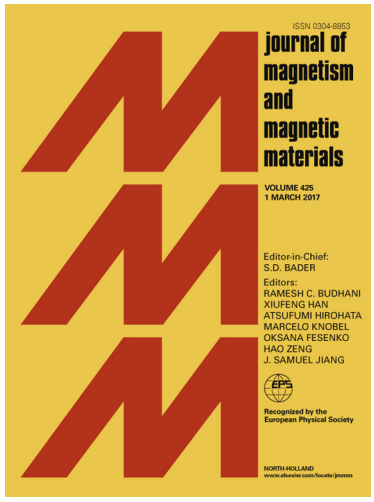

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E. Haber, R. Badea, J. Berezovsky

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Simulating the room-temperature dynamic motion of a ferromagnetic vortex in a bistable potential

E. Haber[a], R. Badea[a], J. Berezovsky[a,*]

[a]*Department of Physics, Case Western Reserve University, Cleveland, Ohio 44106, USA.*

Abstract

The ability to precisely and reliably control the dynamics of ferromagnetic (FM) vortices could lead to novel nonvolatile memory devices and logic gates. Intrinsic and fabricated defects in the FM material can pin vortices and complicate the dynamics. Here, we simulated switching a vortex between bistable pinning sites using magnetic field pulses. The dynamic motion was modeled with the Thiele equation for a massless, rigid vortex subject to room-temperature thermal noise. The dynamics were explored both when the system was at zero temperature and at room-temperature. The probability of switching for different pulses was calculated, and the major features are explained using the basins of attraction map of the two pinning sites.

Keywords: magnetic vortex, magnetization switching, thermal noise

1. Introduction

Precise control over the dynamic motion of ferromagnetic (FM) vortices could be used to create new spin-based memory and quantum computing devices. Quickly and reliably moving a vortex domain wall out of one pinning site and into another (switching) in magnetic nanowires has been proposed as a method to build faster non-volatile magnetic memory devices. [1] Similarly, switching between two bistable pinning sites can be used for logic operations. [2] Nitrogen-vacancy spins have been used to create potentially scalable room-temperature quantum registers, [3] and vortices provide a strong, localized magnetic field gradient capable of addressing and controlling the individual spins. [4, 5] Furthermore, much recent attention has focused on vortex-like topologically stabilized spin textures (e.g. skyrmions) [6], which likely will display qualitatively similar dynamics to the vortices studied here. In all of these devices, pinning sites that are intrinsic to the fabrication process can impact the dynamics, and this effect must be understood in order to reliably control the vortex motion.

*Corresponding author
Email address: jab298@case.edu (J. Berezovsky)