Magnonic dynamics of one-dimensional vortex-antivortex lattice arrays

Hanbyeol Jeong*, Dong-Soo Han, Sang-Koog Kim†
National Creative Research Initiative Center for Spin Dynamics and Spin-Wave Devices, Nanospinics Laboratory, Research Institute of Advanced Materials, and Department of Materials Science and Engineering, Seoul National University, Seoul 151-744, Republic of Korea
†Corresponding author: sangkoog@snu.ac.kr

1. Introduction

Magnetic vortices in confined geometries of ferromagnetic nano-dots have been studied owing to their potential applications in information storage [1] and microwave devices [2]. Magnetic antivortices, the topological counterpart of the vortex, have been investigated less intensively because of the difficulty to form stable antivortex states due to their own stray fields[3]. However, periodically arranged vortex-antivortex (V-AV) pairs can be formed stably as in crosstie domain walls that are typically found in thin films. Although several earlier studies focus on fundamentals and application of V-AV systems, it has still been lacking in a complete understanding of novel dynamic behaviors of V-AV lattice arrays.

2. Simulation Method

In the present simulations, we used V-AV lattice arrays that consist of 3 vortices and 2 antivortices in a connected triple-disk structure, which was defined by overlapping disks of 303 nm diameter, 20 nm thickness and the overlapped length of 60 nm between disks. We applied a static local field of + 200Oe along the + y axis in the left end disk of the connected triple-disk structure, in order to displace vortex core. After the field was turned off, we obtained the simulation result of dynamics for 200 ns. We conducted additional micromagnetic simulation for extended lattice arrays of alternating vortex and antivortex up to 13 vortices and 12 antivortices. Other simulation conditions were not changed except for the thickness of 40 nm.

3. Results and Discussion

The simulation results revealed the existence of several discrete modes of collective V-AV gyrations. Each mode has a characteristic distinct eigenfrequency that is related to the evolution of coupled effective magnetizations of individual vortices and antivortices. Spatial profiles of low frequency modes were described by a standing wave form, however, those of high frequency modes were described by two- branch standing wave forms.[5] These two types of collective V-AV oscillations were analogous to the “acoustic mode” and “optical mode” of the lattice vibrations of a diatomic system. In addition, dispersion curves obtained from the V-AV chains showed that two distinct low and high branches and curvature of the high branch are strongly influenced by the polarization ordering of the antivortices. This work provides a new mechanism of signal transfer via coupled V-AV gyrations and building blocks for further investigations of V-AV based magnonic crystals.

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4. References

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