II-22

# Spin-Wave Interference

Sangkook Choi*, Ki-Suk Lee, and Sang-Koog Kim
Research Center for Spin Dynamics & Spin-Wave Devices (ReC-SDSW)
and Nanospintronics Laboratory Seoul National University

## 1. Introduction

Quite recently, the radiation behavior of spin waves driven by the motion of a magnetic vortex core and the annihilation of a magnetic vortex - antivortex pair was observed in a confined ferromagnetic thin-film model system [1]. From a technological point of view, the radiation of strong spin waves produced from a single magnetic vortex and their propagation at ultrafast speeds through variously shaped magnetic waveguides such as a nanowire, have the potential to be used for logical operations in one of the next generations of magnetic logic devices [2]. Herein, we report on the interference patterns of spin waves obtained from micromagnetic simulations conducted on a specially designed geometry that imitates the Young's double slit experiment [3]. In addition, the wave characteristics of those spin waves, such as their radiation, propagation, reflection, transmission, dispersion, and the filtering of specific frequencies, as well as their superposition principle, are reported.

## 2. Simulations

The geometry of a model system made of a 10-nm-thick Permalloy magnetic film used in this study is composed of three different components: a circular shaped disk, a Y-shaped nanowire waveguide incorporating a 100 nm long Fe segment in its single channel part, and a Ξ-shaped magnetic medium. An equilibrium spin configuration in the geometry under zero magnetic field is then perturbed by a sinusoidal magnetic field pulse with an amplitude of $H$ = 300 Oe and a period of $t$ = 0.2 ns, which is applied only to the circular disk along the + $y$ direction [4].

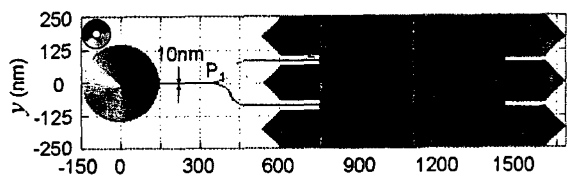


Fig. 1. The model geometry and its lateral dimensions used in the micromagnetic simulation of spin-wave interference.

## 3. Results and Discussion

Upon applying this pulse, spin waves start to radiate from the vortex core existing in the circular disk. The spin waves propagating along the single channel are separated into the two independent paths of a branched channel, and then followed by diffraction from the two openings marked by "$P_2$" in Fig. 1. Since the Y-shaped waveguide has a mirror symmetry with respect to the $x$-axis at $y$ = 0 nm, spin waves diffract coherently in the Ξ-shaped medium. Next, an interesting phenomenon occurring in the Ξ -shaped medium is that the wavefronts of the spin waves flare out into the medium in all of the in-plane directions. The spin waves diffracted from "$P_2$", indicated by the two small openings are superimposed on each other at every position in the Ξ -shaped medium, and interfere with each other constructively or destructively, thereby making distinct interference patterns, as illustrated in Fig. 2. The color image shows the spatial configuration of the $M_z$ / $M_s$ components taken at $t$ = 0.67 ns only in the area marked by the gray-colored rectangular box shown in Fig. 1.

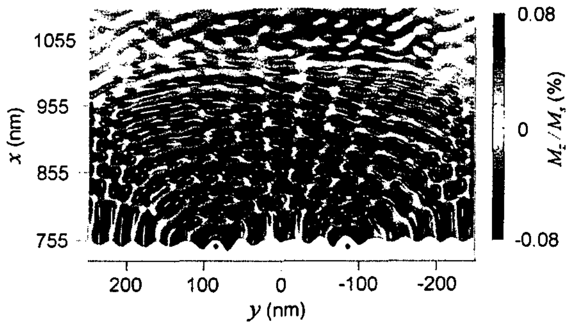


Fig. 2. Snapshot image taken at $t$ = 0.67 ns for the spatial distribution of the local $M_z$ /$M_s$ values, illustrating the interference pattern of the spin waves diffracted through the two openings marked by the two small points.

## 4. Conclusions

The radiation, propagation, transmission, and dispersion behaviors of spin waves as well as the filtering of their lower frequencies are investigated in the present modeling study. These results directly confirm not only the wave characteristics of spin waves traveling at ultrafast speeds in variously shaped magnetic waveguides, but also their superposition principle. (This work was supported by the Korean Ministry of Science & Technology through the Creative Research Initiative program.)

## 5. References


[1] K.-S. Lee, S. Choi, and S.-K. Kim, Appl. Phys. Lett. **87**, 192502 (2005).

[2] R. Hertel, W. Wulfhekel, and J. Kirschner, Phys. Rev. Lett. **93**, 257202 (2004).

[3] T. Young, Philos. Trans. R. Soc. Lond. **94**, 1 (1804).

[4] See http://math/nist.gov/oommf.