Gyroid Nanostructures in Magnonics

M. Gołębiewski,[1] R. Hertel,[2] V. Vasyuchka,[3] P. Pirro,[3] M. Krawczyk,[1] and J. Llandro[4]

[1] *Faculty of Physics, Adam Mickiewicz University, Poznań, Poland*
[2] *Institut de Physique et Chimie des Matériaux de Strasbourg, France*
[3] *Landesforschungszentrum OPTIMAS, TU Kaiserslautern, Germany*
[4] *Research Institute of Electrical Communication, Tohoku University, Japan*

Artificial media with topological or non-uniform geometrical characteristics may provide new possibilities for manipulating spin waves (SWs) [1]. A fully connected 3D network enables interactions and collective effects in all three dimensions, offering vibrant perspectives on new phenomena [2]. Gyroids were first discovered and presented in 1970 [3] and are a promising yet almost unexplored structure in magnetism. It is defined by chiral triple junctions and periodicity in all three spatial directions, classified as the $I4_132$ space group [4].

The analyzed nickel (Ni) gyroid nanostructure was fabricated by thermally annealing a block copolymer template, selectively dissolving one of the gyroid-forming blocks, and filling the voided right-handed gyroid network with Ni by electrodeposition. For broadband ferromagnetic resonance measurements (BBFMR), the orientation of the gyroid network toward the static magnetic field axis is significant. We have observed a strong impact of crystallography to the BBFMR spectra signals as a variation in its main intensities. To better understand and explain the experimental results, we performed micromagnetic simulations of gyroid systems in the finite element method solver. They qualitatively confirmed our findings from the BBFMR and determined how complexity, chirality, and curvature allow the crystallographic direction to affect the resonance frequency.

The results demonstrate that geometric anisotropy can contribute significantly to the alternation in the power of resonance signals in rotating gyroid samples. Furthermore, with FMR measurements and micromagnetic simulations, we showed that SW spectra of nm-scale gyroids depend on the orientation of the external magnetic field to the crystallographic structure. The results offer much potential for developing 3D nanomaterials for magnonic applications.

References:

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