Spin-Wave Propagation Properties in Gyroid Nanostructures

(complete result)

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The exploration of three-dimensional (3D) networks in the realm of magnonics heralds a new era of spin wave manipulation and control, promising significant advancements in the field [1]. Gyroid nanostructures, characterized by their unique chiral triple bonds (Fig. 1) and periodicities in all spatial directions, emerge as particularly promising candidates in this exploration, offering untapped potential in magnetism research.

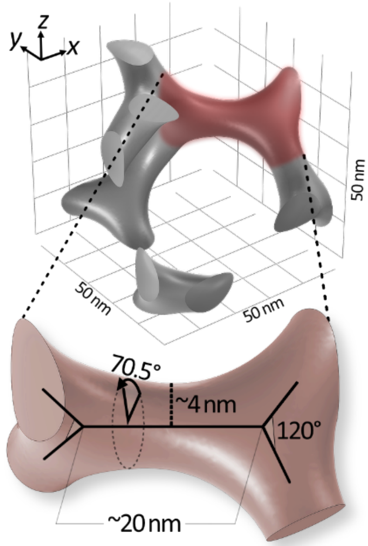

Fig. 1. A geometric model of the gyroid unit cell.

Our study delves into the properties of nickel gyroid nanostructures, with a specific focus on the impact of their orientation relative to the static magnetic field axis. This aspect proved to be crucial, as broadband ferromagnetic resonance measurements indicated a substantial influence of crystallography on spectral signals and their linewidth. To augment these experimental observations, we employed finite element solver-based micromagnetic simulations [2], which provided deeper insights into the gyroid systems. These simulations revealed that gyroid networks exhibit significant metamaterial-like effects on magnetic properties, including tunable effective values of saturation magnetization and g-factor, as well as a notable influence on the Gilbert damping parameter [3].

Building on these findings, our research took a further leap by analyzing the spin-wave propagation properties in 3D gyroidal nickel nanostructures. This approach marks a significant advancement in magnonics, moving beyond conventional planar systems. Through meticulous micromagnetic simulations, we systematically investigated magnetic gyroids, focusing on how spin-wave propagation is influenced by the thickness and filling factor of the ferromagnetic gyroid structures, as well as the orientation of an external magnetic field. Employing advanced numerical simulations in Comsol Multiphysics, we elucidated the magnonic dispersion relations, highlighting the potential of gyroidal configurations as efficient carriers of spin waves.

Our comprehensive study not only deepens the understanding of spin wave dynamics within these intricate 3D nanostructures but also opens up new possibilities for their application. The unique properties of gyroid nanostructures underscore their potential as versatile and efficient components in future magnonic devices, paving the way for innovative approaches in data processing and storage at the nanoscale.

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