Behavior of Edge and Bulk Modes in an Antidot Lattice Exhibiting Perpendicular Magnetic Anisotropy

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Magnonic crystals (MCs) demonstrate remarkable capabilities for controlling the transmission of spin waves (SWs). Their ability to create and steer SWs offers the potential for the development of magnonic devices that outperform optical devices in spatial efficiency and surpass current electronic devices in energy efficiency. Our research specifically concentrates on examining a unique MC structure in a thin film, composed of eight layers of alternating Co (0.75nm) and Pd (0.9nm) bilayers, culminating in a cumulative thickness of 13.2 nm [1]. This specific arrangement, comprising a ferromagnetic and a heavy metal layer, establishes a strong perpendicular magnetic anisotropy (PMA). This PMA is notably significant for its contribution in making SW dispersion isotropic.
During the manufacturing of this thin film, a pattern of antidots was meticulously created at uniform intervals by precisely etching out nanodots using a 10nm wide focused ion beam. This process not only involved the removal of material but also brought about modifications in the nearby areas of each antidot, resulting in the formation of a 'rim.' These changes notably influenced the magnetic characteristics, especially the PMA, causing the magnetization near the antidot edges to align nearly in-plane. As shown in Fig. 1, the foundational state of a circular antidot displays magnetization around its edge ring, forming a vortex-like structure.To thoroughly examine the interplay between localized and bulk modes within the film, we conduct micromagnetic simulations. Our initial investigation focuses on stationary SWs, where we adjust the excitation field and the strength of the externally applied static magnetic field, which is oriented perpendicularly. This adjustment enables us to explore the SW modes in both the rim and bulk areas. We then explore the dynamic interactions between the rim and bulk areas, uncovering collective dynamics within the lattice, as depicted in Fig. 2. These insights are highly promising for future advancements in magnonic technologies.

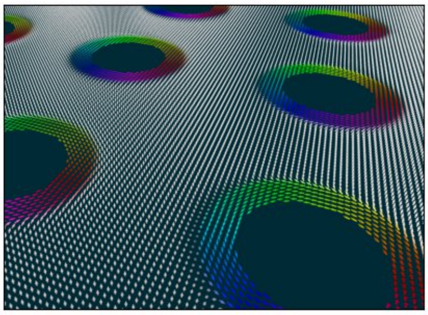

Figure 1. Magnetization in the magnonic crystal

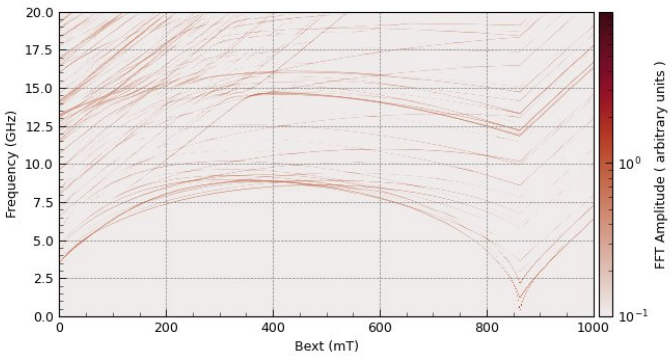

Figure 2. Resonnance spectra of spin waves depending on the saturating field

[1] S. Pan, S. Mondal, M. Zelent, R. Szwierz, S. Pal, O. Hellwig, M. Krawczyk, and A. Barman, “Edge localization of spin waves in antidot multilayers with perpendicular magnetic anisotropy”, Physical Review B 101, 014403 (2020).

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