Dynamics of Edge and Bulk Modes in an Antidot Lattice with Perpendicular Magnetic Anisotropy

(Poster)

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Magnonic crystals (MCs) exhibit substantial potential for manipulating the propagation of spin waves (SWs). The capability to generate and manipulate SWs holds the promise of developing magnonic devices that boast superior spatial efficiency compared to optical devices and enhanced energy efficiency compared to current electronics. In the scope of this research, our focus is on the investigation of a specific MC configuration implemented in a thin film composed of eight repetitions of Co (0.75nm) and Pd (0.9nm) bilayers, resulting in a total thickness of 13.2 nm [1]. This particular combination, consisting of a ferromagnetic layer and a heavy metal layer, yields a robust perpendicular magnetic anisotropy (PMA), which is of particular interest due to its role in rendering SW dispersion isotropic.

In the fabrication process of this thin film, nanodots were precisely etched out at regular intervals using a 10nm wide focused ion beam, creating a well-defined pattern of antidots. This procedure not only removed material but also induced alterations in the surrounding region of each antidot, leading to the formation of a 'rim.' Notably, these modifications affected the magnetic properties, particularly the PMA. Consequently, the magnetization at the edges of the antidots adopts an almost in-plane orientation. As depicted in Fig. 1, the ground state of a circular antidot exhibits magnetization in its edge ring, resembling a vortex-like configuration.

To gain a comprehensive understanding of the dynamic interaction between locally confined and bulk modes within the film, we employ micromagnetic simulations. Initially, our analysis is focused on non-propagating SWs, wherein we manipulate the excitation field and the intensity of the globally applied external static magnetic field, oriented out-of-plane. This manipulation allows us to investigate the SW modes present in both the rim and the bulk regions.Subsequently, we delve into the dynamic coupling between the rim and bulk regions, revealing collective behaviors within the lattice structure, as illustrated in Fig. 2. These findings hold significant promise for advancing magnonic applications.

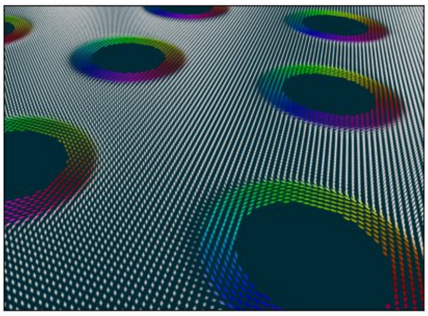

Figure 1. Magnetization in the magnonic crystal

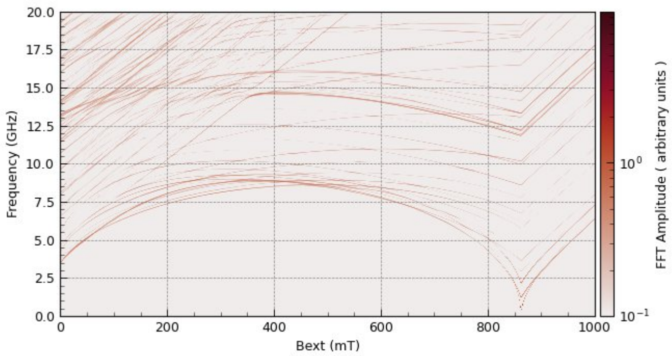

Figure 2. Resonnance spectra of spin waves depending on the saturating field

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[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).