Antidot Lattice with Perpendicular Magnetic Anisotropy: Dynamics between Edge Modes and Bulk Modes

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Magnonic crystals (MCs) have demonstrated a lot of potential as a way to control the propagation of spin waves (SWs). Having the ability to create and control SWs could lead to the creation of magnonic devices that are more space efficient than optical devices and more energy efficient than current electronics. In this research, we study a MC created in a thin film made up of 8 repetitions of Co (0.75nm) and Pd (0.9nm) bilayers for a total thickness of 13.2 nm [1]. This particular combination of a ferromagnetic layer and a heavy metal layer results in a strong perpendicular magnetic anisotropy (PMA) which is interesting as it makes the SW dispersion isotropic. Periodically throughout this thin-plane film, nanodots were etched out using a 10nm wide focused ion beam producing a pattern of antidots. This process not only removed some material, but also damaged the area around each antidot, creating a ring around the antidots where the magnetic properties, notably the PMA have been modified. Due to this, the magnetization at the antidot's edges is almost in-plane. As shown in Fig.1, the ground state of a circular antidot is magnetized in its edge ring in a vortex-like configuration. Through micromagnetic simulations, we analyse the dynamic coupling between edge localised and bulk modes in the film. At first, we limit our analysis to non-propagating SWs and we modify the exciting field as well as the strength of the global external static magnetic field which is oriented out-of-plane and we analyze the SW modes that exist in the rim or in the bulk as shown in Fig.2. Next we show the dynamic coupling between rims and bulk, demonstrating collective behavior on the lattice and promising magnonic applications.

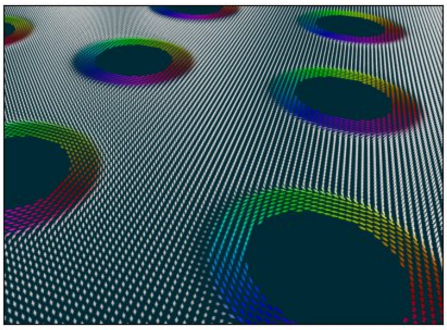

Figure 1: Magnetization in the magnonic crystal.

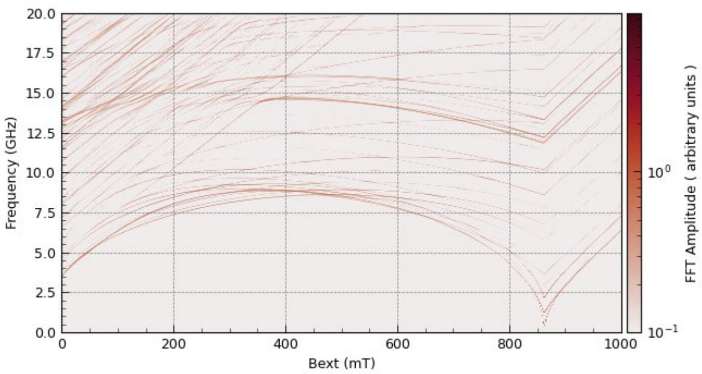

Figure 2: Resonnance spectra of spin waves in the MC depending on the external field.

[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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