# DYNAMICAL COUPLING OF BULK AND EDGE MODES IN ANTIDOT MULTILAYERS WITH PERPENDICULAR MAGNETIC ANISOTROPY

MATHIEU MOALIC*[1], MATEUSZ ZELENT[1], MACIEJ KRAWCZYK[1]

[1] *Department of Nanostructures, Institute of Spintronic and Quantum Information, Adam Miczkiewicz University, Poznan, Uniwersytetu Poznańskiego 2, Poznan, 61-614, Poland*

* *matmoa@amu.edu.pl*

Patterned arrays in thin films have shown a lot of potential due to their abilities to manipulate magnetic microwave excitation, called spin waves (SWs). These types of periodic nanostructures, also called magnonic crystals, are seen as the magnetic variant of the photonic crystals with the added advantage that SWs can have a wavelength smaller than their optical counterpart, which can lead to the creation of magnonic devices with very small footprint. In the case of antidot lattices, the inhomogeous material found around each antidot can bring forward an interesting range of complex, hybridized resonant SW modes. Thin films with out-of-plane magnetization are more interesting than in-plane magnetization thanks to the SWs dispersion relation being isotropic. The out-of-plane magnetization is achieved in ferromagnetic thin films with perpendicular magnetic anisotropy thanks to a multi-layered approach using multiple layers of alternating ferromagnetic metals and heavy metals.

The film we study is made up of 8 repetitions of Co (0.75nm) and Pd (0.9nm) bilayers for a total of 13.2 nm [1]. Periodically throughout this thin plane film, nanodots were etched out using a 10nm wide focused ion beam creating a pattern of antidots. This process not only removed some material, but also damaged the area around each antidot, creating a 'ring' of low anisotropy in the film. This results in the configuration of the magnetization at the edges of the antidot being almost in-plane. For a circular antidot shape, the ground state of such a system has magnetization in the edge ring in a vortex-like configuration as seen in Fig. 1. Through micromagnetic simulations, we are analysing dynamical coupling between edge localised and bulk modes in the film. We modify many parameters in this system such as: lattice constant, antidot shape, antidot size, ring width, external field direction, etc. Different types of modes are identified, such as the ferromagnetic resonant mode of the thin film around 9.5 GHz as well as higher frequency bulk modes resulting from the antidot lattice. A multitude of edge modes have also been identified in the low anisotropy rings at frequencies from 3 to 13 GHz with, for example, the one seen in Fig. 2. We show that the strong dynamical coupling between the rings can be obtained, which demonstrates collective behaviour on the lattice and promises usefulness for magnonic applications.

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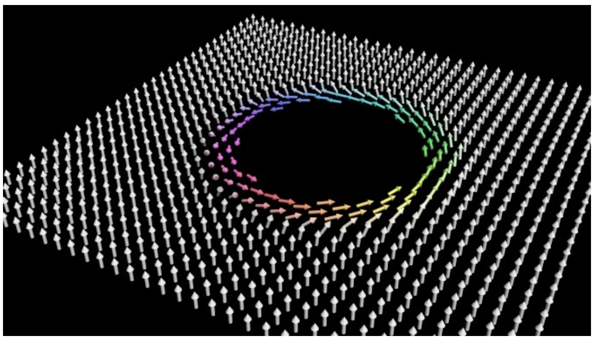
[1] Pan, S., et al. Physical Review B 101.1 (2020): 014403.



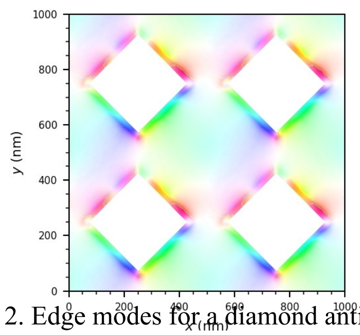



Figure 2. Edge modes for a diamond antidot lattice for a lattice constant of 500 nm.

Figure 1. Magnetization for one cell of the antidot lattice