Shaping the spin wave spectra of planar 1D magnonic crystals by the geometrical constraints

Justyna Rychły-Gruszecka,[1] Jakob Walowski,[2] Grzegorz Centała,[3] and Jarosław W. Kłos[3]

[1]*Institute of Molecular Physics, Polish Academy of Sciences, Mariana Smoluchowskiego 17, 60-179, Poznan, Poland*

[2]*Institut für Physik, Universität Greifswald, Felix-Hausdorff-Straße 6, 17489, Greifswald, Germany*

[3]*ISQI, Faculty of Physics, Adam Mickiewicz University Poznań, Uniwersytetu Poznańskiego 2, 61-614, Poznan, Poland*

We present experimental and numerical studies demonstrating the influence of geometrical parameters on the fundamental spin-wave mode in planar 1D magnonic crystals. The investigated magnonic crystals consist of flat stripes separated by air gaps. The adjustment of geometrical parameters allows tailoring of the spin-wave frequencies. The width of stripes and the width of gaps between them affect spin-wave frequencies in two ways. First, directly by geometrical constraints confining the spin waves inside the stripes. Second, indirectly by spin-wave pinning, freeing the spin waves to a different extent on the edges of stripes. Experimentally, the fundamental spin-wave mode frequencies are measured using an all-optical pump-probe time-resolved magneto-optical Kerr-effect setup. Our studies address the problem of spin-wave confinement and spin-wave dipolar pinning in an array of coupled stripes. We show that the frequency of fundamental mode can be tuned to a large extent by adjusting the width of the stripes and the width of gaps between them. The study is complemented by numerical studies on the effect of spin wave pinning on the frequency of fundamental mode in a array square of planar square dots.

The main outcomes of this research can be summarized as follows. (i) The fundamental mode frequency increases with the stripes' separation. (ii) The dipolar interactions between the constituting nanoelements of magnonic planar nanostructure must be considered even if the distance between successive stripes is within a single micrometer. (iii) The TR-MOKE measurements allow for the investigation of the frequency of fundamental mode which is inaccessible for BLS measurements. (iv) The FEM computations can be used to investigate the spin-wave dynamics in the frequency domain in considered systems. However, the semi-analytical calculations (based on the formalism of magnetostatic Green functions) provide sufficiently accurate results.

References:

[1] Rychły-Gruszecka, J., Walowski, J., Denker, C. et al. Shaping the spin wave spectra of planar 1D magnonic crystals by the geometrical constraints. Sci Rep 12, 20678 (2022).

G.C. and J.W.K. would like to acknowledge the support of the National Science Centre - Poland under projects: No: 2021/43/I/ST3/00550, and 2020/39/O/ST5/02110. GC acknowledges Polish National Agency for Academic Exchange grant BPN/PRE/2022/1/00014/U/00001.