

Reconfigurable magnonic crystals with Bragg-Fabry-Pérot hybridization

Jiahui Bi,^a Weizhi Yan,^a Yifan Wang,^a Lukáš Flajšman,^b Andrey V. Shytov,^c Volodymyr V. Kruglyak,^c Sebastiaan van Dijken,^b and Huajun Qin^a

a: School of Physics and Technology, Wuhan University, China;

b: University of Exeter, United Kingdom;

c: Department of Applied Physics, Aalto University, Finland.

Magnonics uses spin waves or magnons as information carriers for data transport and processing, in which precise manipulation of spin-wave amplitude and phase is crucial [1]. In this work, we demonstrate low-loss, reconfigurable magnonic crystals and hybridized Bragg modes in periodic Fabry-Pérot (FP) resonators formed by ferromagnetic metal nanostripes on a continuous YIG film (Fig. 1a). The crystals, arising from Bragg reflection at individual resonators, exhibit multiple deep bandgaps and minibands with losses comparable to bare YIG (Fig. 1b). In this system, spin-wave reflection is jointly governed by the Bragg condition and FP resonances, enabling selective deepening of bandgaps via tuning of FP frequencies and dynamic reconfiguration through controlled resetting of stripe and YIG magnetizations. When FP-induced gaps intersect crystal bandgaps, pronounced anticrossings appear, providing clear evidence of Bragg-FP mode coupling (Fig. 1c). By varying stripe period, width, or external magnetic field, the coupling strength can be tuned from 30 to 120 MHz, approaching the strong-coupling regime (Fig. 1d). This hybridization produces nonreciprocal spin-wave modes within the bandgap, opening a pathway toward chiral magnonics with reprogrammable band structure [3].

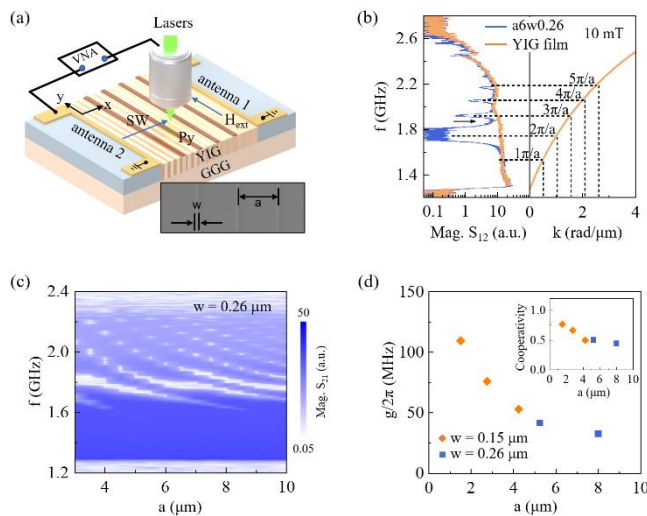


Fig. 1: (a) Schematic of the measurement geometry. The magnonic crystal (MC) consists of periodic Py nanostripes patterned on a continuous YIG film. Each Py/YIG bilayer region acts as a Fabry-Pérot (FP) resonator. Spin waves are excited by a microwave antenna and detected using a vector network analyzer (VNA) and super-Nyquist-sampling magneto-optical Kerr effect microscope (SNS-MOKE) in the Damon-Eshbach configuration. (b) Spin-wave transmission spectra (magnitude of S_{12}) measured from the MC (blue) and a bare YIG film (orange) at a bias field of 10 mT. The right panel shows the calculated dispersion relation of the bare YIG film at the same field. Dashed lines indicate the MC bandgaps for $n = 1-5$,

calculated using the Bragg condition $k = n\pi/a$ with $a = 6 \mu\text{m}$. (c) Contour plot of the spin-wave transmission spectra (magnitude of S_{21}) as a function of lattice constant ($a = 3 - 10 \mu\text{m}$) at a bias field of 10 mT. The stripe width is $w = 0.26 \mu\text{m}$. Anticrossings emerge when FP-induced gaps intersect the crystal bandgaps. (d) Coupling strength $g/2\pi$ as a function of lattice constant. The coupling between the FP gap and the $n = 1-3$ bandgaps for MCs with $w = 0.15 \mu\text{m}$ (orange), and the $n = 2-3$ bandgaps for MCs with $w = 0.26 \mu\text{m}$ (blue), is shown. The inset displays the cooperativity $C = g^2/\Gamma_{\text{MC}}\Gamma_{\text{FP}}$, where Γ_{MC} and Γ_{FP} are the linewidth of the MC and FP bandgap, respectively.

References:

- [1] A.V. Chumak *et al.*, IEEE Transactions on Magnetics 58, 1-72 (2022)
- [2] Jiahui Bi *et al.*, unpublished