2nd Transnational Round Table on Magnonics, High-Frequency Spintronics, and Ultrafast Magnetism

Magnonic Fabry-Pérot resonators: A building block for programmable and neuromorphic computing

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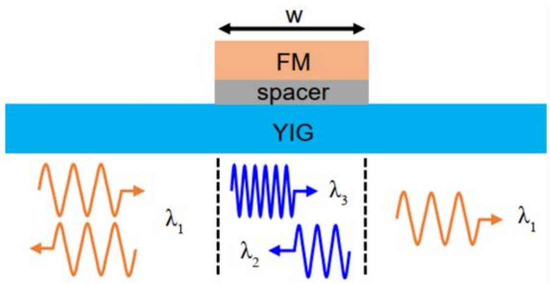
A magnonic Fabry-Pérot resonator consists of a low-loss magnetic medium, typically an yttrium iron garnet (YIG) film, with a patterned magnetic nanostripe positioned on top (Fig. 1) [1]. It operates in a frequency range where spin waves propagate in the YIG film while remaining below the ferromagnetic resonance (FMR) frequency of the nanostripe. Chiral dipolar coupling between the YIG film and the nanostripe induces an asymmetric spin-wave dispersion inside the resonator. As a result, the resonator's edges act as interfaces that modify spin-wave wavelengths upon reflection and transmission [2]. Similar to an optical Fabry-Pérot resonator, destructive interference between incident and circulating spin waves creates transmission gaps at discrete frequencies while minimizing signal losses at intermediate frequencies. This enables efficient, low-loss spin-wave control. Additionally, the downward shift in the dispersion within the resonator significantly reduces the wavelength, facilitating nanoscale manipulation of micrometer-scale spin waves.

In this talk, I will provide an overview of the key properties of magnonic Fabry-Pérot resonators, including wavelength conversion, amplitude and phase modulation [3], nonlinearity, and scalability. I will then present recent results on spin-wave diffraction patterns and programmable Talbot carpets in YIG films with Fabry-Pérot resonator gratings [4], as well as spin-wave transport in devices that combine Bragg reflection with Fabry-Pérot resonances. Finally, I will discuss the potential of these resonators as fundamental building blocks for magnonic neuromorphic computing.



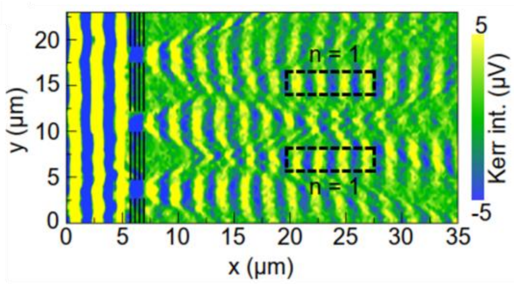


Fig. 1. (left) Schematic of a magnonic Fabry-Pérot resonator structure and illustration of wavelength conversion in the YIG film at the edges of the ferromagnetic nanostripe. (right) Time-resolve magneto-optical Kerr effect microscopy image of spin-wave interference in a Fabry-Pérot resonator grating with three slits.

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[2] A. Talapatra, H. Qin, F. Schulz, L. Yao, L. Flajšman, M. Weigand, S. Wintz, and S. van Dijken, *Imaging of short-wavelength spin waves in a nanometer-thick YIG/Co bilayer*, Applied Physics Letters **122**, 202404 (2023).
[3] A. Lutsenko, K. G. Fripp, L. Flajšman, A. V. Shytov, V. V. Kruglyak, and S. van Dijken, *Magnonic Fabry-Pérot resonators as programmable phase shifters*, arXiv:2412.01382.
[4] Y. Wang, W. Yan, N. Kuznetsov, L. Flajšman, H. Qin, and S. van Dijken, *Spin-wave diffraction, caustic beam emission, and Talbot carpets in an yttrium iron garnet film with magnonic Fabry-Perot resonator gratings*, Physical Review Applied **22**, 014038 (2024).