Magnonic Fabry-Pérot resonators as programmable phase shifters

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Previously, the selective suppression of spin waves propagating in magnonic media was demonstrated experimentally using Fabry-Pérot resonances [1,2]. This effect was observed in structures composed of an yttrium-iron garnet (YIG) film with a metallic ferromagnetic nanostripe deposited on top. The resulting magnetic bilayer modifies the magnonic dispersion, leading to strong reflections at the bilayer interfaces and the formation of a magnonic cavity.

In this work, we demonstrate that these resonators can also function as programmable spin-wave phase shifters [3]. Our experimental results, obtained using super-Nyquist sampling magneto-optic Kerr effect (SNS-MOKE) microscopy and supported by micromagnetic simulation in MuMax3, reveal a π phase shift in transmitted spin waves at frequencies above the Fabry-Pérot resonance. The resonance frequency varies depending on the relative magnetization alignment of the film and the stripe. Consequently, within a specific frequency range, the phase of the transmitted wave can be controllably inverted by reversing the magnetization direction in either the stripe or the film. Figure 1 shows the measured frequency dependence of the amplitude and phase of transmitted spin waves for a magnonic Fabry-Pérot resonator formed by an 850 nm wide, 30-nm-thick CoFeB stripe, spaced by 5 nm from an 85-nm-thick YIG film. A π phase shift is achieved at 1.2 GHz by switching the magnetization of the CoFeB stripe in a 3 mT longitudinal field, with no change in amplitude between the two orientations. These findings highlight the potential of magnonic Fabry-Pérot resonators as programmable phase-shifting elements for reconfigurable magnonic circuits.

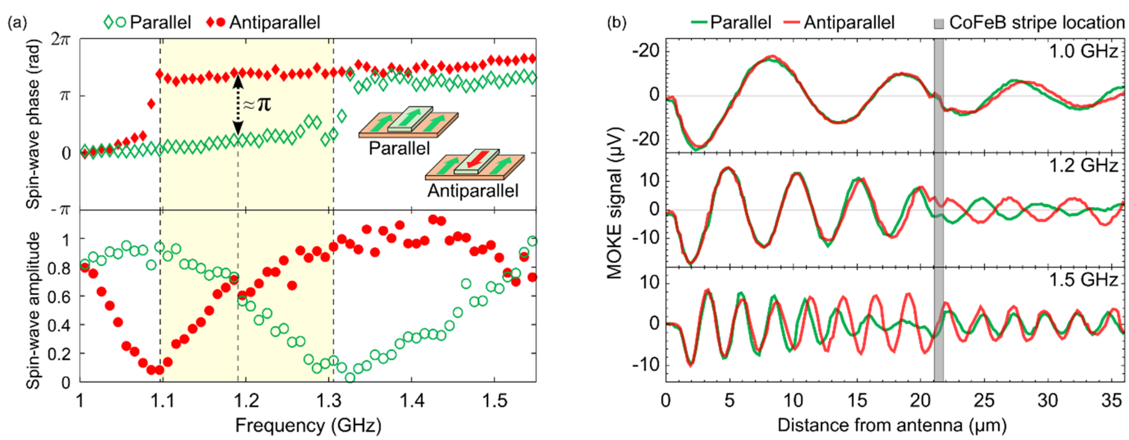

Fig. 1: Influence of magnetization alignment on spin-wave transmission in a magnonic Fabry-Pérot resonator. The magnetization of the YIG film is aligned parallel to an 3 mT external magnetic field, while the magnetization in the CoFeB stripe is switched between parallel and antiparallel orientations. Spin waves propagate from the left. (a) Around 1.2 GHz, the spin-wave amplitude measured 4.8 µm behind the resonator is identical for the antiparallel (red symbols) and parallel (green symbols) magnetization configuration (bottom panel), whereas the phase differs by π (top panel). The schematics illustrate the respective magnetization states. (b) SNS-MOKE linescans recorded along a horizontal line across the center of the CoFeB nanostripe for the parallel and antiparallel magnetization configurations at 1.0 GHz, 1.2 GHz, and 1.5 GHz. The position of the CoFeB nanostripe is marked by a grey stripe. At 1.0 GHz and 1.5 GHz, spin waves transmit similarly for both magnetization states. However, at 1.2 GHz, the phase of the transmitted wave shifts by π when the resonator's magnetization is switched.

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