Size dependence of spin-wave amplitude enhancement and scattering in magnonic Fabry-Pérot resonators

A. Lutsenko[a] and S. van Dijken[a]

a: Department of Applied Physics, Aalto University, Espoo, Finland.

Spin-wave resonators have been proposed as key building blocks for magnonic devices that rely on spin-wave scattering and interference [1]. Single-material implementations include nanoring resonators [2] and chiral resonators [1,3–4]. An alternative approach employs a hybrid system consisting of a low-loss yttrium iron garnet (YIG) film coupled to a ferromagnetic metal stripe, forming a Fabry-Pérot resonator [5]. Such systems exhibit selective spin-wave filtering [5], tunable phase shifts [6], and nonlinear transport behavior [7]. However, their practical use in spin-wave scattering networks is constrained by their relatively large size perpendicular to the spin-wave propagation direction.

In this work, we investigate the size-dependent spin-wave scattering and amplitude enhancement in Fabry-Pérot resonators consisting of a YIG film coupled to CoFeB nanostripes of varying length, using micromagnetic simulations. For stripes lengths on the order of a few micrometers, we observe mode quantization along the stripe's long axis, in addition to Fabry-Pérot resonances arising from interference across the stripe width (Fig. 1a). The resulting spatial modulation of spin-wave intensity is attributed to wave excitation from the resonator edges. When the stripe length is reduced to the submicron scale, Fabry-Pérot resonances are suppressed, and quantization perpendicular to the incident spin-wave direction becomes dominant (Fig. 1b). In this regime, an antiparallel alignment of magnetization between the CoFeB stripe and the YIG film significantly enhances the resonance intensity (Fig. 2). Combined with large-angle spin-wave scattering and magnetic-field reconfigurability, these compact resonators offer promising functionality for inverse-designed magnonic networks and neuromorphic computing applications [8].

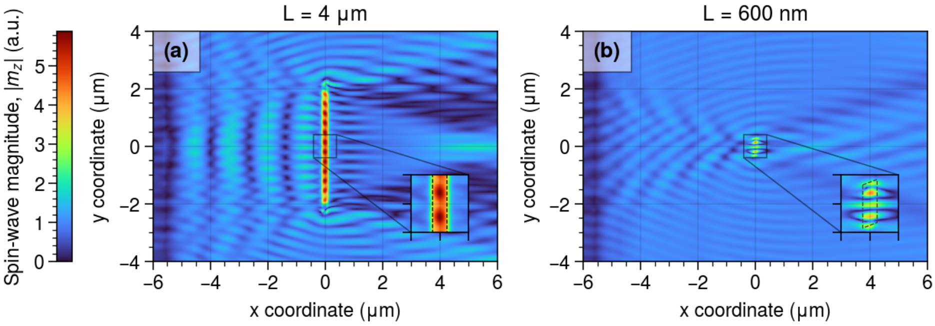

Figure 1: Spatial distribution of spin-wave magnitude in a 55 nm-thick YIG film under an in-plane external magnetic field of 10 mT applied parallel to the long axis of the CoFeB stripe. Results are shown for stripe lengths of (a) 4 µm and (b) 600 nm. The magnetizations of the CoFeB stripe and the YIG film are aligned parallel to the external field. Spin waves are excited at the left edge of each map at a frequency of 1.7 GHz.

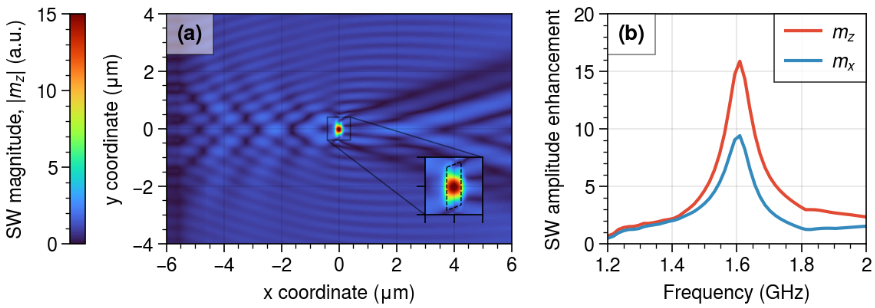

Figure 2. (a) Spin-wave scattering from a 600 nm-long resonator in an antiparallel magnetization configuration at 1.61 GHz. (b) Spin-wave amplitude enhancement in the YIG film within the resonator, shown relative to a bare YIG film.

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