

Phase Modulation of Spin Waves in Stripe–YIG Systems with Paired Domain Walls

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Magnonic and spintronic devices based on propagating spin waves are considered promising building blocks for energy-efficient information processing and neuromorphic computing [1,2]. Non-linear spin-wave interference has already enabled functional nanoscale neural networks, demonstrating the computational potential of phase-encoded magnonic signals [3]. Precise and reconfigurable phase control is therefore essential, and has recently been achieved using programmable Fabry–Pérot–type YIG–metal resonators [4]. In parallel, magnetic racetrack that utilize controllable domain-wall (DW) motion provide robust bistable magnetic textures for memory and logic applications [5].

The uniformly magnetized Permalloy stripe above a thin YIG waveguide can strongly alter the spin-wave dispersion and phase for one branch of the spectrum (negative wavevectors), but produces negligible phase modification for the opposite branch (positive wavevectors). Guided by this behaviour, we intentionally select positive-k Damon–Eshbach modes, for which the bilayer dispersion nearly coincides with that of bare YIG. This choice suppresses bilayer-induced effects and enables us to isolate the pure phase-shifting effect arising from DW-induced stray fields.

Introducing two domain walls into the racetrack placed on YIG layer with small gap generates strong, localized transverse fields that increase or decrease the local effective field and thereby modify the spin-wave wavevector, resulting in large, frequency-independent phase shifts approaching $\pm\pi$ in the 2.0–3.0 GHz range. Different DW configurations provide phase shifts of opposite sign while maintaining almost constant transmitted amplitude, defining two well-separated operational states suitable for binary phase encoding in magnonic circuits.

References:

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