Self-organized weak stripe domains as natural magnonic textures in thick permalloy films

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We investigate spin-wave propagation in thick Permalloy films hosting weak stripe domains at zero applied magnetic field. Using Brillouin light scattering (BLS) spectroscopy, we show that these self-organized textures generate a pronounced magnonic anisotropy. For backward-volume (BV) propagation parallel to the stripe orientation, the dispersions closely resemble those of a uniform film, with no evidence of Bragg scattering or band-gap opening. In contrast, Damon–Eshbach (DE) propagation perpendicular to the stripes exhibits clear frequency shifts induced by the periodic magnetic configuration, revealing the magnonic influence of the stripe pattern. Despite this one-dimensional periodicity, which could in principle support a magnonic crystal behavior, no band folding is observed within the experimentally accessible wave-vector range.

To understand this apparent discrepancy between magnetic periodicity and the absence of strong magnonic-crystal features, we rely on comprehensive micromagnetic simulations [1]. These simulations show that the spin-wave dynamics effectively probed by BLS are largely confined to a near-surface region, where the mode amplitudes are maximal. Because this effective probing depth is much smaller than the total film thickness, the interaction between propagating magnons and the stripe-induced periodic modulation of the internal field is significantly reduced. As a result, Bragg scattering is weak and band-gap formation is strongly suppressed. Simulations performed directly in the stripe state further confirm the limited mode coupling and the spatial nonuniformity of the dynamical magnetization in thick films.

Overall, our results clarify how self-organized stripe domains influence magnon transport in thick ferromagnetic films. They identify the conditions under which such weak stripe textures can provide magnonic functionalities, and the limitations that arise when the probing technique is sensitive only to a reduced effective thickness.

References:

[1] Chiroli, S. and Faurie, D. and Haboussi, M. and Adeyeye, A. O. and Zighem, F., Phys. Rev. B 108, 024406 (2023)