Multifunctional spin-wave platform based on hybrid magnonic crystal with confined skyrmions and soft ferromagnetic film

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Materials with perpendicular magnetic anisotropy and antisymmetric exchange interactions are widely explored in spintronics, but have so far been of limited use in magnonics due to high damping. We propose a hybrid structure that exploits the rich dynamic properties of skyrmions in high-damping materials to control spin-wave propagation in a low-damping ferromagnetic strip [1]. The proposed hybrid magnonic crystal consists of a chain of skyrmions confined in circular multilayer nanodots located above a permalloy strip. Numerical results show complex spin-wave spectra with several key features for magnonics: dispersive bands with Bragg band gaps, anti-crossing gaps related to a coupling between two magnon modes of different origin; the flat bands and bound states related to the skyrmion azimuthal modes with frequencies below and above the ferromagnetic resonance frequency of the permalloy strip, respectively. In addition, the system offers reprogrammability due to two stable magnetisation states in the nanodots, a single domain state and a skyrmion state. With these properties, the proposed hybrid structure has multiple functionalities useful for magnonics that overcome the damping limitations of materials with perpendicular magnetic anisotropy and antisymmetric exchange interactions, opening up potential applications in spin-wave filtering, spin-wave generation and analog computing, in particular in the realisation of magnonic neural networks.

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[1] K. Szulc, M. Zelent, M. Krawczyk, https://arxiv.org/abs/2404.10493

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