Hybrid structure based on soft ferromagnetic film and multilayer nanodots as a platform for spin wave computing

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Materials with perpendicular magnetic anisotropy and antisymmetric exchange interactions have been widely explored in spintronics, but have been of limited use in magnonics due to high attenuation. We propose a hybrid structure that exploits a mutual skyrmion-ferromagnetic film interaction and the rich dynamical properties of skyrmions to control skyrmion dynamics in a ferromagnetic multilayer and spin-wave propagation in a low-damping ferromagnetic strip [1]. The proposed hybrid system consists of skyrmions confined in a strip or circular multilayer above a permalloy film. Numerical results show improved stability of the skyrmion and 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, overcoming 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 analogue computing, in particular in the realisation of magnonic neural networks.

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References

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