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Local control of magnetization dynamics in ferromagnetic-superconducting hybrids

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The one of the key challenges which faces magnonics is achieving local control over the static magnetization configuration and magnetization dynamics. A potential solution lies in using a combination of ferromagnetic (FM) and superconducting (SC) nanostructures. Superconductors respond to external magnetic fields by generating eddy currents, which create magnetic field landscapes, significantly influencing magnetization dynamics in nearby FM elements.

We investigated spin wave (SW) confinement induced in a uniform perpendicular magnetic anisotropy (PMA) layer by the stray field of an SC strip [1] positioned above it (Fig. 1(a)). The SC strip produces in an effective field well within the FM layer, capable of confining spin waves with frequencies lower than the ferromagnetic resonance frequency of the FM layer in the absence of the SC strip (blue-dashed line in Fig. 1(c)). The depth of this well and the number of bound states (blue and green lines in Fig. 1(c)) depend on the strength of the applied field.

Furthermore, we examined the possibility of inducing a magnonic crystal (Fig.1(b)) on demand in a pristine FM layer by applying a periodic sequence of SC strips [2]. The depth of the internal field modulation, and consequently the width of the magnonic band gaps, can be controlled via the applied uniform field.

Our studies demonstrate the feasibility of local spin wave control through the application of a uniform magnetic field in hybrid FM-SC systems.

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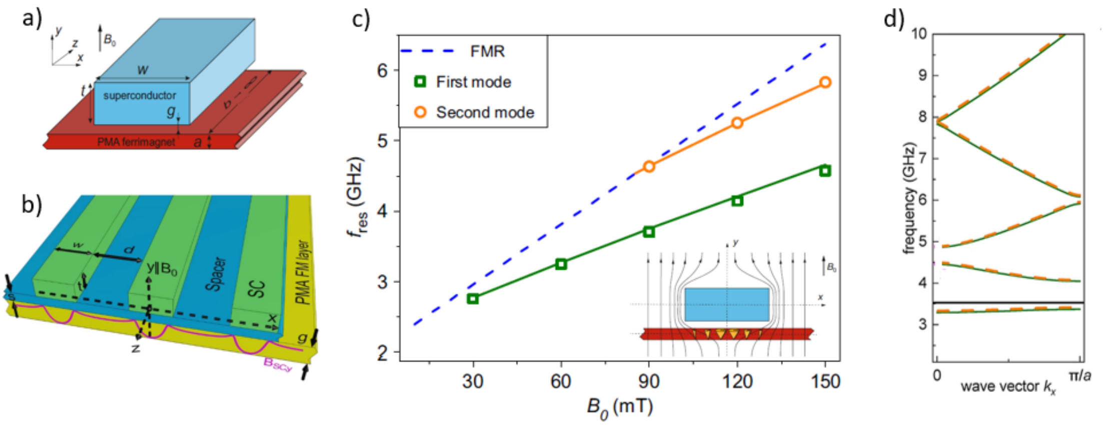

Fig. 1. A single superconducting strip (a) and a periodic sequence of superconducting strips (b) create a well in the internal magnetic field or a periodic field profile, which can confine (c) and scatter (d) spin waves.

[1] J. Kharlan, K. Sobucki, K. Szulc, S. Memarzadeh, J. W. Kłos, *Spin-wave confinement in a hybrid superconductor-ferrimagnet nanostructure*, Phys. Rev. Appl., **21**, 064007 (2024).

[2] J. Kharlan, K. Szulc, J. W. Kłos, G. Centała, *Tunable magnonic crystal in a hybrid superconductor–ferrimagnet nanostructure*, Sci. Rep., **14**, 25594 (2024).