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Functional Spintronic Nanomaterials for Radiation Detection and Energy Harvesting

Cryogenic Fluxon Magnonics

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Ferromagnetism (F) and superconductivity (S) belong to the most fundamental cooperative states in condensed-matter physics, with exciting phenomena emerging at F/S interfaces. In this regard, interactions between the fundamental excitations – magnetic flux quanta (fluxons) in superconductors and quanta of spin waves (magnons) in magnets – are especially fascinating. Nanoscale 2D and 3D systems offer unique platforms for the exploration of such interactions.

In my talk, I will present our experimental findings on magnon-fluxon interactions, namely (i) formation of Bloch-like band structures in magnon spectra because of spin-wave scattering on the Abrikosov vortex lattice [1] and (ii) Doppler effect and non-reciprocity in the spin-wave dynamics induced by vortex motion in asymmetric pinning potential landscapes [2]. Next, I will introduce direct-write superconductors [3,4] as materials which support high (up to 20 km/s) vortex velocities and enable the generation of magnons by a Cherenkov-type mechanism [5]. The magnon radiation has been detected in a Nb-C/Co-Fe hybrid structure by the current-voltage control of the superconductor (magnon Shapiro step) and by the direct spin-wave detection using a microwave detection technique. These findings constitute the stage for the rapidly developing field of magnon fluxonics dealing with non-equilibrium coupled dynamics of quasiparticles in F/S hybrid nanomaterials.

Reference list

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5. O.V. Dobrovolskiy, *et al.*, arXiv:2103.10156.