Design of supercurrent diode by vortex phase texture

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After the observation of nonreciprocal effect in superconductors [1], how to design of supercurrent diode effect is recently challenging issue in condensed matter physics. Here, we investigate supercurrent nonreciprocal effects in a superconducting weak-link hosting distinct types of vortices [2]. We demonstrate how the winding number of the vortex, its spatial configuration, and the shape of the superconducting lead can steer the sign and amplitude of the supercurrent rectification. We find a general criterion for the vortex pattern to maximize the rectification amplitude of the supercurrent. The underlying strategy is the search of specific vortex core position yielding a vanishing amplitude of the supercurrent first harmonic. We also prove that supercurrent nonreciprocal effects can be used to diagnose high-winding vortex and to distinguish between different types of vorticity. Our results provide a toolkit to control the supercurrent rectification by means of vortex phase textures and nonreciprocal signatures to detect vortex states with nonstandard phase patterns.

References: [1] F. Ando, et. al., Nature **584**, 373 (2020). [2] Y. Fukaya, et. al., arXiv: 2403.04421.