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Exotic superconducting states in altermagnets

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The interplay between magnetism and superconductivity is one of the central topics of condensed matter physics, which has recently been put into new light by the discovery of altermagnets. Here, we study this interplay from a fundamental symmetry perspective using irreducible co-representations of the altermagnetic spin-point groups. We construct and tabulate all symmetry-allowed pairing functions for altermagnets, which uncovers numerous exotic pairing states. We focus on three of them, namely: (i) a non-unitary superconductor with different spatial anisotropies for the spin-up and spin-down condensates, (ii) a half-and-half metal-superconductor where only electrons with one of the two spin components form Cooper pairs, and (iii) a spin chiral superconductor with spin-polarized edge states. Interestingly, the first of these three superconductors exhibits an unusual fractional ac Josephson current for only one of the two spin polarizations. We present phenomenological Ginzburg-Landau theories for these unconventional superconductors and show that they correspond to stable minima of the free energies. We examine their topological properties, study the effects of small spin-orbit coupling, consider possible material examples, and investigate their topological responses.

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