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Topological order, symmetry, and Hall response of two-dimensional spin-singlet superconductors SERGEJ MOROZ, Technical University of Munich, ABHINAV PREM, VICTOR GURARIE, LEO RADZIHOVSKY, University of Colorado, Boulder — Fully gapped two-dimensional superconductors coupled to dynamical electromagnetism are known to exhibit topological order. In this work, we develop a unified low-energy description for spin-singlet paired states by deriving topological Chern-Simons field theories for s-wave, $d + id$, and chiral higher even-wave superconductors. These theories capture the quantum statistics and fusion rules of Bogoliubov quasiparticles and vortices and incorporate global continuous symmetries - specifically, spin rotation and conservation of magnetic flux - present in all singlet superconductors. For all such systems, we compute the Hall response for these symmetries and investigate the physics at the edge. In particular, the weakly-coupled phase of a chiral $d + id$ chiral state has a spin Hall coefficient $\nu_s = 2$ and a vanishing Hall response for the magnetic flux symmetry. We argue that the latter is a generic result for two-dimensional superconductors with gapped photons, thereby demonstrating the absence of a spontaneous magnetic field in the ground state of chiral superconductors. It is also shown that the Chern-Simons theories of chiral spin-singlet superconductors derived here fall into Kitaev's 16-fold classification of topological superconductors.

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