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Stability of Topological Superconductors to Interactions and Surface Topological Order

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Three-dimensional topological superconductors protected by time reversal symmetry are characterized by gapless Majorana cones on their surface. Free-fermion phases with this symmetry (class DIII) are indexed by an integer Z, of which $\nu = 1$ is realized by the B phase of superfluid ^3He. Previously, it was believed that the surface must be gapless unless time-reversal symmetry is broken. In this talk, we argue that a fully symmetric and gapped surface is possible in the presence of strong interactions, if a special type of topological order appears on the surface. The topological order realizes time reversal symmetry in an anomalous way, one that is impossible to achieve in purely two dimensions. For odd ν, the surface topological order must be non-Abelian, and propose the simplest non-Abelian topological order that contains electronlike excitations, $SO(3)_6$, with four quasiparticles, as a candidate surface state. We also discuss Abelian theories for the surface $\nu = 2, 4, 8$; one particular consequence of our scheme is that $\nu = 16$ admits a trivially gapped time reversal symmetric surface.