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Majorana Fermions and Topological Insulators[1]

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Zero energy Majorana fermion bound states offer a topologically protected method for storing and manipulating quantum information. Structures composed of topological insulators and superconductors offer a promising route to engineering these exotic states. In this talk we will discuss the theoretical foundation for the existence of Majorana fermions and describe a number of specific architectures involving topological insulators which allow various aspects of the Majorana fermions to be probed experimentally. Majorana bound states are associated with point like topological defects in a *three dimensional* Bogoliubov de Gennes theory. We will argue that they exhibit non-Abelian exchange statistics, despite the triviality of braids in three dimensions. A new feature of 3D non-Abelian statistics is the existence of "braidless" operations in which it is possible to manipulate the quantum information stored in the defects without moving or measuring them.

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