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The search for Majorana zero-energy modes in solid-state systems

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The search for topological phases of matter has become an active and exciting pursuit in condensed matter physics. Among the notable recent developments in this direction are the discoveries of topological insulators and superconductors. In this talk, I will focus on topological superconductors and discuss how one can engineer non-trivial superconductivity in the laboratory at the interface of a conventional s-wave superconductor and a semiconductor with a spin-orbit interaction. I will show that the topological superconducting state emerging at the interface supports Majorana zero-energy modes. The defects carrying these modes are Ising anyons and obey unconventional (non-Abelian) exchange statistics. The unique properties of Majoranas can be exploited for implementing fault-tolerant quantum computation schemes that are inherently decoherence-free. I will conclude this talk by reviewing recent experimental efforts in realizing and detecting Majorana zero-energy modes in one-dimensional nanowires.