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Realization and detection of Majorana modes at generic spin-orbit coupled semiconductor/s-wave superconductor interfaces[1]

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Majorana fermions are hitherto unobserved particles that have been theoretically predicted to have non-Abelian statistics that may be used for Topological Quantum Computation. For over a decade the only candidate systems for observing Majorana fermions were the non-Abelian $\nu = 5/2$ fractional quantum Hall state and chiral p-wave superconductors. More recently, motivated by developments in the area of topological insulators it was realized that a more general class of topological superconductors, some of which may be as simple as the interface of InAs and Al, should support such excitations. This talk will start by explaining why superconductors are a natural host for Majorana fermions. Following this, it will be argued that Majorana fermions should exist in generic semiconductor/superconductor interfaces, both in 1D and 2D, the crucial ingredients being s-wave superconductivity, spin-orbit coupling, and Zeeman splitting. Such Majorana fermions at the end of a nanowire appear as a magnetic-field tunable zero-bias peak in the STM spectrum with quantized conductance. Following this experimental challenges *en route* to realizing Majorana fermions in these structures such as disorder and the required tuning of the chemical potential of the semiconductor, will be discussed. Finally, we will conclude by showing how the spin-orbit coupled nanowires motivate a class of intrinsically number conserving microscopic models for topological superconductor with end Majorana fermions. The bosonization approach used to study this one-dimensional model, directly connects the Majorana fermions, which are typically described as Bogoliubov quasiparticles in mean-field theory, to an emergent Ising order in the one-dimensional nanowire model. The robustness of the topological degeneracy to weak local perturbations can be explicitly demonstrated.

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