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Topological superconductivity and Majorana modes for quantum computation: a materials science perspective

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My name is Elsa Prada and I am a theorist with 20 year experience in condensed matter physics. I am interested in systems where quantum phenomena play an important role, such as low dimensional materials and nanostructures, and the technological applications we can derive from such quantum properties. This is nowadays dubbed the field of "Quantum Technologies". During my career I have worked on a diverse range of problems within condensed matter, including quantum information and entanglement based on superconducting heterostructures; electronic, spintronic and optoelectronic properties of two-dimensional crystals such as graphene, phosphorene or transition metal dichalcogenides; and more recently theory and applications of topological insulators and superconductors.

In this talk I will focus on my work in topological superconductors based on superconducting-semiconducting nanowires. These hybrid wires are by far the most explored (both theoretically and experimentally) and the most advanced candidates to achieve topological superconductivity. I will discuss the appearance of exotic emergent quasiparticles at the edges of these wires, called Majorana bound states or Majorana modes. These quasiparticles share properties with the fundamental particle Majorana fermion, but they possess non-trivial exchange statistics that turn them into anyons, which could make them useful candidates for quantum-bits, qubits, of future topologically protected quantum computers. I will summarize the advancements of the field during the last decade and the problems we still face to unambiguously create and detect Majorana modes in condensed matter systems.

Presenter(s) : Prof. PRADA, Elsa (ICMM-CSIC)

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