From Bogoliubov to Majorana quasiparticles in topological superconductors

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In his seminal paper Bogoliubov has shown [1] that electrons bound (via effective pairing interactions) into the Cooper pairs are featured by the gaped quasiparticle excitations, comprising a superposition of the particle and hole contributions. This concept is nowadays getting a great deal of renewed interests because in topological materials such Bogoliubov quasiparticles can evolve into the Majorana-type objects, being identical to their own antiparticles. They are regarded as very promising candidates for quantum bits, because of their exotic (non-Abelian) statistical nature and protection against any perturbation [2].

Mutation from the Bogoliubov to Majorana quasiparticles can be realized in nanoscopic-size wires within two popular scenarios, relying either on: (i) the spin-momentum locking or (ii) the self-sustained helical magnetic order, both combined with the proximity-induced electron pairing [3]. We shall discuss the underlying microscopic mechanism responsible for topological superconductivity and present unique properties of the Majorana modes. We shall also give an overview of the experimental evidence for such quasiparticles localized at the boundaries of topologically nontrivial superconductors, and illustrate their robustness on internal defects [3] and leakage on the side-attached quantum impurities [4]. Finally, we will address recent signatures of the delocalized Majorana modes in two-dimensional structures.

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