Andreev and Majorana Bound States in Condensed Matter

In the superconducting state, quasiparticle excitations are a combination of electrons and holes. Although they are fermionic in nature, they do not have a well-defined charge. In inhomogeneous situations, in which the superconducting order parameter varies spatially, some of these excitations correspond to bound states called "Andreev states". While the emergence of these types of states has been theoretically predicted since the 1960s in numerous situations, their study in artificial nanostructures is much more recent. One case that arouses great interest is that of systems in which a special type of superconductivity called "topological" is induced. The quasiparticle bound states in this case correspond to "Majorana states" due to their similarity to "Majorana particles", which have the property of being their own antiparticles.

The proposed work consists of familiarizing oneself with recent theoretical and experimental advances related to this topic. In a first stage, simple models that describe Andreev states in situations of experimental interest will be analyzed. In a subsequent phase, the dynamics of these types of states in the presence of external radiation and/or coupling with a resonant circuit will be studied with a view to their possible use as qubits for quantum information processing.

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