The merging of superconducting qubits with topological superconductors: microwave transitions as a signature of coherent parity mixing effects

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In this talk we will review recent advances in circuit quantum electrodynamics, a framework that applies quantum optics to superconducting circuits. In particular, we will discuss the light-matter effects that could arise if Majorana fermions are added to this framework. Coupling Majorana fermion excitations to coherent external fields is an important stepping stone towards their manipulation and detection. We argue that such a device could contribute to the spectroscopic detection of topological-superconductor Majorana excitations. We analyse the charge and transmon regimes of a topological nano-wire embedded within a Cooper-Pair-Box, where the superconducting phase difference is coupled to the zero energy parity states that arise from Majorana quasi-particles. We show that at special gate bias points, the microwave photon-qubit coupling can be switched off via quantum interference, and in other points it is exponentially dependent on the control parameter E_J/E_C. We propose that this type of device could perform as a high coherence four-level system in the superconducting circuits architecture with tunability of the coupling to photons, a coveted property which is difficult to achieve with regular devices.