Séminaire de physique statistique

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Orme des Merisiers Salle Claude Itzykson, Bât. 774

Majorana and Andreev bound states in semiconductor-superconductor heterostructures

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In this talk, I will discuss Majorana bound states in topological superconductors and Andreev bound states in normal-superconductor junctions. Experiments performed in setups consisting of a proximitized nanowire coupled to a lead via a normal region that is left uncovered by the superconductor have demonstrated an ability to reliably generate coalescing Andreev bound states that give rise to zero-bias conductance peaks persisting over large ranges of applied magnetic field strength, consistent with what one might expect to observe in the presence of Majorana bound states. However, an alternative explanation that the observed zero-bias peaks are due to topologically trivial Andreev bound states originating within the quantum dot has been put forth. We considered a minimal analytical model of a quantum dot/nanowire junction in which we took the proximitized region of the nanowire to have no spin-orbit interaction, such that there is no topological superconducting phase possible. We found that there is a trivial Andreev bound state that can be pinned exponentially close to zero energy as a function of magnetic field, thus mimicking a topological zero-energy Majorana bound state [1]. This leads me to the question, whether one can use an alternative way to probe Majorana bound states that goes beyond transport measurements. Circuit quantum electrodynamics (QED) has been demonstrated as a powerful experimental technique to study and manipulate mesoscopic systems by means of microwave photons. We studied several models of topological superconductors capacitively coupled to a microwave cavity. We analyzed the electronic charge susceptibility of these systems that is revealed in the photonic transport. We showed that this electronic susceptibility can be used to detect the topological phase transition, the presence of Majorana bound states, and the parity of the Majorana state in a noninvasive fashion [2]. Moreover, the same circuit QED setup can be used to probe the fractional Josephson effect in normal-superconductor junctions, which is associated with the presence of the Majorana bound states in the system [3,4].

[1] C. Reeg, O. Dmytruk, D. Chevallier, D. Loss, and J. Klinovaja, Phys. Rev. B 98, 245407 (2018). [2] O. Dmytruk, M. Trif, and P. Simon, Phys. Rev. B 92, 245432 (2015). [3] O. Dmytruk, M. Trif, and P. Simon, Phys. Rev. B 94, 115423 (2016). [4] M. Trif, O. Dmytruk, H. Bouchiat, R. Aguado, and P. Simon, Phys. Rev. B 97, 041415 (R) (2018).