

Majorana Signatures in Quantum Dot-Topological Superconductor Junctions with Electron-Phonon Coupling

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We theoretically study quantum transport through a quantum dot coupled to Majorana bound states confined at the ends of a topological superconducting nanowire. The topological superconductor forms a loop and is threaded by a tunable magnetic flux, which allows one to control the electron transport in the system. In particular, we investigate phonon-assisted transport properties in the device when the central quantum dot interacts with a single long-wave optical phonon mode. We find that when the two Majorana bound states are unhybridized, the zero-temperature linear conductance has a 2π periodicity as a function of magnetic flux phase, independent of the electron-phonon interaction, the quantum dot energy, or the finite values of dot-Majorana couplings. For a finite overlap between the Majorana bound states, the linear conductance periodicity generally changes to 4π either due to a finite electron-phonon coupling strength, or a dot energy level that is tuned away from the Fermi level. Additionally, the differential conductance periodicity changes from 2π to 4π when the Majorana bound states hybridize and the electron-phonon coupling is finite. Our results provide insight into transport signatures expected in topological quantum computational platforms that integrate quantum dots as a means for Majorana qubit readout. The energy exchange with an environmental bath, here a single phonon mode, significantly alters the current signatures expected from Majorana modes [1].

This work was supported through the “Nucleu” Program within the National Research Development and Innovation Plan 2022–2027, Romania, carried out with the support of MEC, project no. 27N/03.01.2023, component project code PN 23 24 01 04, and also received financial support from CNCS/CCCDI-UEFISCDI, under project number PN-IV-P1-PCE-2023-0987.

[1] L. Máthé, D. Sticlet, L. P. Zârbo, Phys. Rev. B105 (2022) 155409 .