Higgs-like pair amplitude dynamics in superconductor-quantum dot hybrids

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The order parameter of a bulk superconductor is a dynamic quantity that can exhibit collective excitations such as the Nambu-Goldstone mode and the Higgs mode. The former is an excitation of the superconducting phase which is shifted to the plasma frequency by the Anderson-Higgs mechanism. The latter is a massive excitation of the absolute value of the order parameter with an excitation energy equal to the superconducting gap. The experimental detection of the Higgs mode is challenging as it couples only quadratically to light and its energy is typically in the Terahertz regime.

Here, we consider an analogue of the Higgs dynamics in bulk superconductors. To this end, we study a single-level quantum dot tunnel-coupled to superconducting reservoirs. We analyze the dynamics of the pair amplitude induced on the quantum dot via the proximity effect. We focus on two different parameter regimes, namely the case of weak-tunnel coupling to superconductors with a finite gap [1] and the case of strong coupling in the infinite-gap limit [2]. We find that the pair amplitude exhibits a rich dynamics including coherent oscillations due to Cooper pair tunneling and exponential decay due to quasiparticle processes.

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[1] M. Kamp and B. Sothmann, Phys. Rev. B **103**, 045414 (2021).

[2] M. Heckschen and B. Sothmann, Phys. Rev. B **105**, 045420 (2022).