

Dynamics of quantum dot coupled to superconductors

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We investigate the nonequilibrium dynamics of an interacting quantum dot coupled to normal and superconducting reservoirs. To account for electronic correlations beyond the mean-field approximation, we develop a time-dependent formulation based on the Hubbard-I approach and solve the resulting equations of motion numerically. Particular attention is devoted to the dynamics associated with the singlet–doublet quantum phase transition induced by the competition between Coulomb interaction and superconducting proximity effect. We analyze the response of the system to sudden changes of the dot parameters, including interaction quenches across the singlet–doublet transition. The calculated time evolution of the induced pairing amplitude reveals a pronounced suppression of superconducting correlations upon entering the doublet regime and allows us to follow the transient formation of the new many-body state. We further consider finite-duration interaction pulses, in which the system is temporarily driven towards or across the transition and subsequently returned to its initial parameters. Remarkably, after the pulse is switched off and the system parameters are restored to the singlet regime, the pairing amplitude may continue to decrease for a finite time before recovering. This delayed response shows that the system retains memory of the preceding nonequilibrium evolution.