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Kinetics of the superconducting charge qubit in the presence of a quasiparticle R. LUTCHYN, L. GLAZMAN, A. LARKIN, U of Minnesota — We investigate the energy and phase relaxation of a superconducting qubit caused by a quasiparticle. In our model, the qubit is an isolated system consisting of a small island (Cooper-pair box) and a larger superconductor (reservoir) connected by a Josephson junction. If such system contains an odd number of electrons, then even at lowest temperatures a single quasiparticle is present in the qubit. The quasiparticle resides in the reservoir with an overwhelming probability, but its quick round-trips to the box lead to the relaxation of the qubit. We derive master equations governing the evolution of the qubit coherences and populations. We find that the kinetics of the qubit can be characterized by two time scales - quasiparticle escape time from reservoir to the box Γ_{in}^{-1} and quasiparticle relaxation time τ. The former is determined by the normal-state conductance g_T of the Josephson junction and one-electron level spacing δ_r in the reservoir ($\Gamma_{in} \sim g_T \delta_r$), and the latter is due to electron-phonon interaction. The phase coherence is damped on the time scale of Γ_{in}^{-1}. The qubit energy relaxation depends on the ratio of the two characteristic times, τ and Γ_{in}^{-1}, and also on the ratio of temperature T to the Josephson energy E_J. In the limit $\Gamma_{in}\tau \gg 1$ and $T \ll E_J$, the relaxation of the qubit populations occurs in two stages. In the first stage, $t \sim 1/g_T\delta_r$, the initial population of the excited state changes only by a small amount $\sim (T/E_J)^{1/2}$. This quasi-stationary state relaxes to full equilibrium over a longer time scale $t \sim \tau(E_J/T)^{1/2}$.

Roman Lutchyn
University of Minnesota

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