
Pure dephasing of superconducting qubits due to Bogolyubov quasiparticles' tunneling.

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Abstract

Bogolyubov quasiparticles represent an important sources of errors in superconducting qubits. Unlike the quasiparticle contribution to 1/T1 qubit relaxation rate, the pure dephasing rate 1/Tϕ can not be obtained by the perturbative golden rule calculation due to the logarithmic divergence of the quasiparticle noise correlator at low frequency (1). For such noises with a divergent correlator, non-perturbative calculations usually reveal a non-exponential decay of the qubit coherence. Particularly, for the quasiparticles in the work (2) the dephasing function of the form F(t) = exp(-t log(tT)) was found for qubits based on Josephson junctions with a large number of transmission channels N at temperature T. We treat this problem for a finite number of channels and find that the exponential form of the decay is restored at large times. Instead of expanding in the coupling strength or inverse number of channels 1/N we take of advantage of the low quasiparticle concentration xqp $<<$ 1 and use it a small parameter. In this case the fermionic nature of the quasiparticle bath becomes important; it can be handled using Levitov formula (3), which allows to rewrite the dephasing function F(t) as a determinant of single-particle operators. We find that the non-exponential decay of the dephasing function F(t) described in (2) is followed by the longest-time exponential regime. It is governed by the energy scale of Andreev-like bound states ϵA in the Josephson junction, namely F(t) = exp(-t log(T/ϵA)) for t $>>$ 1/ϵA. Our results are especially relevant for qubits built on medium- or small-area junctions for which the time scale 1/ϵA is comparable to the qubit lifetimes.

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