Andreev levels as a quantum dissipative environment for superconducting nanojunctions

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Making use of the effective action theory [1,2] we demonstrate that at subgap energies quantum behaviour of highly transparent superconducting hybrid nanojunctions can be exactly described by an effective Hamiltonian for a Josephson particle in a quantum dissipative environment formed by a collection of harmonic oscillators with parameters directly related to those of subgap Andreev levels inside the junction. We investigate the problem of macroscopic quantum tunneling of the superconducting phase in such hybrid structures, evaluate both quantum and thermally activated supercurrent decay rates and identify the crossover conditions between these regimes. We also predict the possibility for non-monotonous dependence of the switching current distributions on temperature and elucidate the physics behind this non-trivial effect. In addition, we demonstrate that superconducting qubits fabricated with such highly transparent hybrid nanojunctions may be subjected to intrinsic dephasing caused by an effective dissipative environment formed by Andreev levels.

[1] A.V. Galaktionov and A.D. Zaikin. Phys. Rev. B 82, 184520 (2010).

[2] A.V. Galaktionov and A.D. Zaikin. Phys. Rev. B 92, 214511 (2015).