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Controllably irradiating superconducting qubits with gamma rays to characterize quasiparticle poisoning

High-energy radiation, such as gamma rays or muons, poses a threat to the use of superconducting qubit arrays to create a fault-tolerant quantum computer. When such radiation impacts a superconducting qubit chip, many electron-hole pairs and energetic phonons are produced. The electrons and holes can travel some distance and affect the charge environment for the qubits nearby. However, the phonons can travel throughout the chip and have sufficient energy to break Cooper pairs in the device layer, creating quasiparticles and causing errors. Since the phonons can reach all the qubits on the chip, this makes the errors correlated, which challenges standard error correction schemes necessary to implement a fault-tolerant quantum computer. In order to study the effects of radiation, we use a gamma-ray source outside the dilution refrigerator to controllably dose the chip through the cryostat shielding. By using charge-sensitive transmons, we observe both single and correlated events in the charge environment and quasiparticle poisoning in relation to the applied gamma-ray dose. We look at two types of chips: a control chip and one with copper on the back side for phonon downconversion leading to reduced quasiparticle poisoning. With this method, we show that we can characterize quasiparticle poisoning in superconducting qubit chips by controlling the surrounding radiation environment with a gamma-ray source.

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