Phase Slips in Voltage-Biased Superconducting Rings

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Superconducting rings represent a versatile playground for studying various phenomena related to the phase coherence of the superconducting order parameter, among which are phase slips, topological fluctuations of the order parameter. Employing the time-dependent Ginzburg-Landau equations, phase-slips in voltage-biased superconducting rings are investigated. We demonstrate that the bias voltage locally suppresses the order parameter, resulting in two weak links in the ring. Eventually, for a high enough bias voltage, two simultaneous phase slips take place, corresponding to a vortex and an anti-vortex, thereby preserving the winding number of the superconducting ring. Furthermore, in the presence of a perpendicular magnetic field, the bias voltage can lead to oscillations between two successive fluxoid states. Accordingly, we explore the possibility of realizing a junctionless flux qubit where the in-plane electric field, arising from the bias voltage, is analogous to interrupting the superconductor with a thin insulator. One distinctive advantage of the proposed qubit is the electric-tunability of the transition frequency, a desired feature for multi-qubit systems since it renders the circuit more robust to magnetic noise. Improving the coherence time of superconducting qubits, along with electric tunability, constitute an essential building block for scaling up superconducting quantum computers.

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