Tunable charge-4e supercurrent in germanium based JoFET

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Résumé

Parity-protected superconducting qubits, in which the quantum information is encoded in wavefunctions with disjoint support, have recently emerged as promising candidates to enhance the lifetime of quantum states. This innovative approach leverages cos(2φ) Josephson elements dominated by charge-4e supercurrent – the coherent transfer of pairs of Cooper pairs.

In this work, we investigate highly transparent superconductor-semiconductor-superconductor Josephson field effect transistor (JoFET) fabricated from SiGe/Ge/SiGe heterostructures. First, employing a SQUID featuring a wide and a narrow JoFET, we explore the current phase relation (CPR). It exhibits gate-tunable higher order harmonics, revealing both charge-2e and charge-4e dissipationless transport, a finding confirmed by Shapiro steps measurements. Second, by harnessing the superconducting diode effect within a SQUID made of two similar JoFETs, we identify the regime of perfect critical current symmetry. In this configuration, Shapiro steps measurements at half flux quantum bias exhibit a pronounced reduction in the first harmonic, thereby realizing a cos(2φ) Josephson element.

These results pave the way for the realization of Ge-based parity-protected qubits using CMOS compatible processes.

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