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 wave-
functions 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 Joseph-
son field effect transistor (JoFET) fabricated from SiGe/Ge/SiGe heterostructures. First, em-
ploying 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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