Gate- and flux-tunable sin(2) Josephson element with proximitized Ge-based junctions

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Résumé

In a recent work (A. Leblanc et al. Phys. Rev. Res. 2024, 6 (3)) we have shown that Al-Ge based gate tunable Josephson junctions (JoFETs) present multi-harmonic current phase relation (CPR). This was revealed by " direct " measurement of the CPR, the evidence of half integer Shapiro steps and a clear superconducting diode effect. In this new work, we exploit this multi-harmonicity to create a Josephson circuit element with an almost perfectly π-periodic CPR, indicative of a largely dominant charge-4e supercurrent transport. Such a Josephson element was recently proposed as the basic building block of a protected superconducting qubit. Here, it is realized using a superconducting quantum interference device (SQUID) with low-inductance aluminum arms and two nominally identical JoFETs. The latter are fabricated from a SiGe/Ge/SiGe quantum-well heterostructure embedding a high-mobility two-dimensional hole gas. By carefully adjusting the JoFET gate voltages and finely tuning the magnetic flux through the SQUID close to half a flux quantum, we achieve a regime where the sin(2) component accounts for more than 95 % of the total supercurrent. This result demonstrates a new promising route for the realization of superconducting qubits with enhanced coherence properties.

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