Tunable charge-4e supercurrent in Ge-based JoFET

Axel LEBLANC
Chotivut TANGCHINGCHAI, Zahra SADRE MOMTAZ, Elyjah KIYOOKA, Jean-Michel Hartmann, Gonzalo TRONCOSO, Boris BRUN, Vivien SCHMITT, Simon ZIHLMANN, Romain MAURAND, Etienne DUMUR, Silvano DE FRANCESCHI and François LEFLOCH

Univ. Grenoble Alpes, CEA, Grenoble INP, IRIG, PHELIQS, 38000 Grenoble, France
axel.leblanc@cea.fr

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 [1, 2, 3]. 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 S-Sm-S Josephson field effect transistor (JoFET) fabricated from SiGe/Ge heterostructures. First, using a SQUID with a wide and a narrow JoFET, we show that the current phase relation is composed of multiple and gate tunable harmonics corresponding to charge-2ne (with n an integer) supercurrent. Their contribution is confirmed by DC measurements under radio-frequency irradiation that exhibit integer and half-integer Shapiro steps. Second, by harnessing the superconducting diode effect in a SQUID with two similar JoFETs, we identify the regime of perfect critical current symmetry (Fig.1)[4]. In this configuration, Shapiro steps measurements at half flux quantum reveal a pronounced reduction in the first harmonic thereby realizing a cos(2φ) Josephson element (Fig.2). These results pave the way for the realization of Ge-based parity-protected qubits using CMOS compatible processes.
Associated article: arXiv: 2311.15371

References

[1] T. W. Larsen et al., Physical Review Letters, 125 (2020)
[2] A. Maiani et al., PRX Quantum, 3 (2022)
[3] C. Schrade et al., PRX Quantum, 3 (2022)
[4] R. S. Souto et al., Physical Review Letters, 129 (2022)

Figures

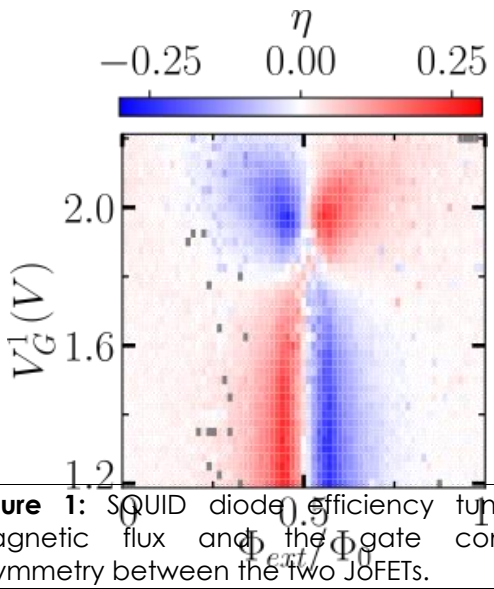
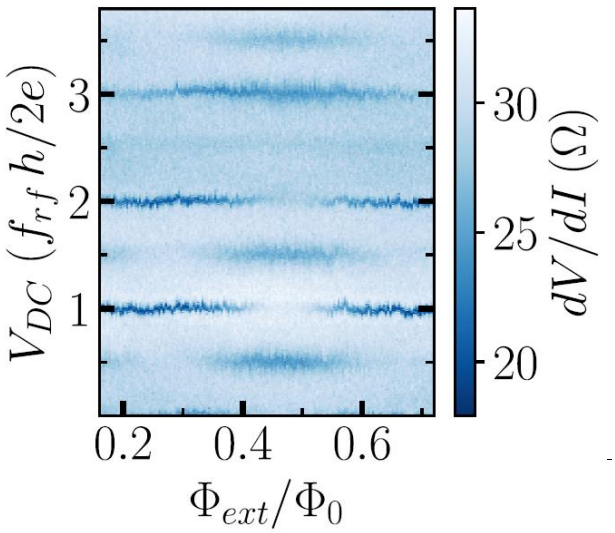


Figure 1: SQUID diode efficiency tuned by magnetic flux and the gate controlled asymmetry between the two JoFETs.



proximity to half of the flux quantum. At Φ0/2, the charge-4e supercurrent dominates, giving rise to half-integer steps.