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

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Abstract

In a first work [1] we have studied the current phase relation (CPR) of an AlGe based gate tunable Josephson junctions (JoFETs). Those are fabricated from a SiGe/Ge/SiGe quantum-well hetero-structure embedding a high-mobility two-dimensional hole gas. We have shown that the CPR presents multi-harmonic components. This was revealed by " direct " measurement of the CPR, the evidence of half integer Shapiro steps and a clear superconducting diode effect. In a second work [2], 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. It is realized using a superconducting quantum interference device (SQUID) with low-inductance aluminum arms and two nominally identical JoFETs. 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(2φ) 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.

References

[1] A. Leblanc et al. Phys. Rev. Res. 6 (2024) 033281
[2] Leblanc et al. Nature Comm 16 (2025) 1010

Figures

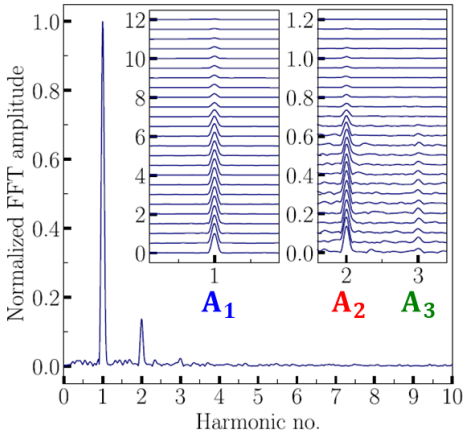

Figure 1:Fourier components of the CPR of a single JoFET measured with an very assymetric SQUID.

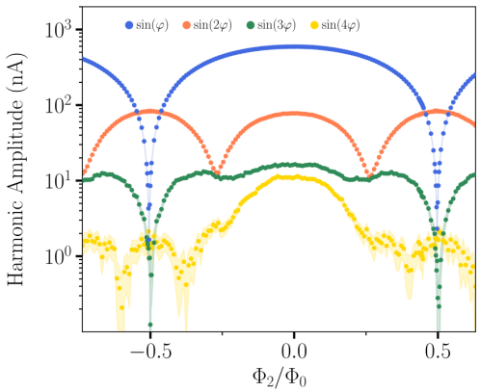

Figure 2: Harmonic amplitude of a symmetric SQUID showing modulation of the various components.