Quantum Circuits with Multiterminal Josephson-Andreev Junctions

Alfredo Levy Yeyati[1]
Francisco Matute-Cañadas[1] and Leandro Tosi[2]

1 IFIMAC, Universidad Autónoma de Madrid, Campus de Cantoblanco, Madrid, Spain
2 Centro Atómico Bariloche and Instituto Balseiro, San Carlos de Bariloche, Argentina
Contact email: a.l.yeyati@uam.es

Abstract

Designing qubits with intrinsic protection against the environmental noise is an attractive strategy to reduce the concomitant decoherence [1]. Hybrid devices combining semiconductors and superconductors constitute a candidate platform in this direction [2]: they provide tunable Josephson junctions, potentially well beyond the conventional tunneling regime. In this case, the fermionic excitations (the so-called Andreev bound states) might hybridize with the collective bosonic modes associated with the current and voltage fluctuations of the circuit in which the mesoscopic junction is embedded.

In the present work [3], we consider multiterminal junctions of this kind and discuss how to model their embedding in different circuits with capacitive and inductive elements and how certain configurations may implement protected qubits. Using a simple model of single-channel contacts and a single level in the middle region, we discuss different circuit configurations where the leads are islands with finite capacitance and/or form loops with finite inductance. We find situations of practical interest where the circuits can be used to define noise-protected qubits, which map to the bifluxon and $0-\pi$ qubits in the tunneling regime.

References

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[2] A. Kringhøj, B. van Heck, T. W. Larsen, O. Erlandsson, D. Sabonis, P. Krogstrup, L. Casparis, K. D. Petersson, and C. M. Marcus, Suppressed charge dispersion via resonant tunneling in a single-channel transmon, Phys. Rev. Lett. 124, 246803 (2020).
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Figures

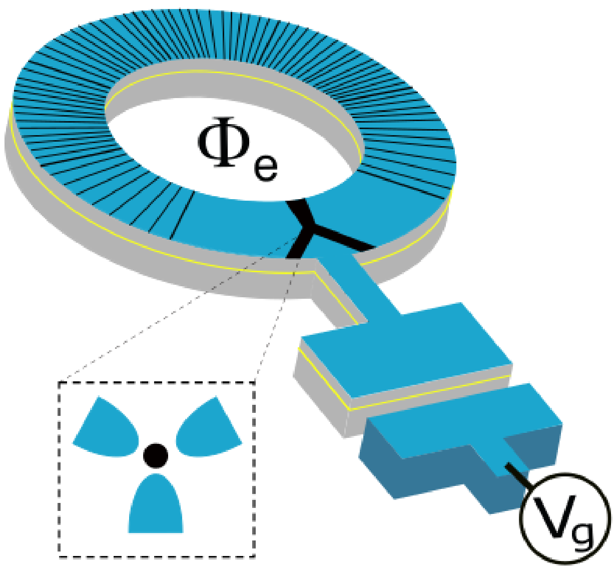

Figure 1: Schematic representation of one of the proposed designs: a three terminal superconducting junction defined on a 2DEG, connected to a loop with a large inductance and a floating superconducting island.