Fermionic quantum computation with Cooper pair splitters

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Abstract

We showed that Copper pair-splitting devices with tunable capacitors (Fig. 1) make up a building block of a fermionic quantum computer [1]. We derived the low-energy Hamiltonian and showed that it contains all the necessary processes to build a universal set of gate operations. Moreover, we showed how to use experimentally controllable parameters to implement the gate operations. We find that the presence of Zeeman splitting in the superconducting island complicates the implementation of gates and necessitates additional steps. Based on the low-energy theory, we also studied optimal regimes for the device operation. While our design was mostly inspired by recent experiments, we also discussed how to avoid foreseeable limitations such as (i) the use of neutral fermions to suppress charge noise; (ii) a floating superconducting island to simplify the layout; (iii) control of the superconducting gap to simplify gate operations.

References

[1] Kostas Vilkelis, Antonio Manesco, Juan Torres, Sebastian Miles, Michael Wimmer, Anton Akhmerov, arXiv:2310.15293 (2023)

Figures

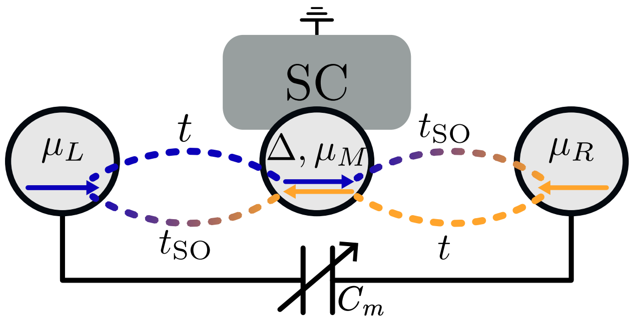

Figure 1: Schematics of the device. Two singly occupied spin-polarized quantum dots host the local fermionic modes. Two tunnel barriers enable normal and spin-dependent hopping. A middle superconducting island mediates superconducting correlations between the two local fermionic modes. An external mutual capacitor allows Coulomb interactions between the sites.