Braiding Majoranas in linear quantum dot-superconductor arrays: Mitigating Coulomb repulsion and residual tunneling

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Exchanging the positions of two non-Abelian anyons transforms between many-body wavefunctions within a degenerate ground-state manifold. This behavior is fundamentally distinct from fermions, bosons and Abelian anyons. Recently, quantum dot-superconductor arrays have emerged as a promising platform for creating topological Kitaev chains that can host non-Abelian Majorana zero modes [1,2]. Building on the insight of [3], we propose a braiding protocol for two minimal Kitaev chains coupled through an ancillary quantum dot (see Fig. 1). We focus on the physical effects that are peculiar to quantum dot devices, such as interdot Coulomb repulsion and residual single electron tunneling. We find that the errors caused by either of these effects can be efficiently mitigated by optimal control of the ancillary quantum dot that mediates the exchange of the non-Abelian anyons. Moreover, we propose experimentally accessible methods to find this optimal operating regime and predict signatures of a successful Majorana braiding experiment.

References

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[2] ten Haaf, S.L.D., Wang, Q., Bozkurt, A.M. *et al.* A two-site Kitaev chain in a two-dimensional electron gas. *Nature* **630**, 329–334 (2024).

[3] Liu, J., Chen, W., Gong, M. *et al.* Minimal setup for non-Abelian braiding of Majorana zero modes. *Sci. China Phys. Mech. Astron.* **64**, 117811 (2021).

Figures

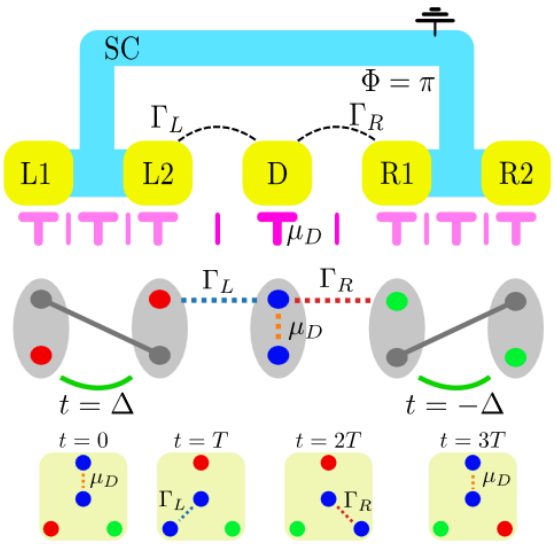

Figure 1: Minimal device for quantum dot array based braiding. The ancillary dot, tunnel coupled to the Kitaev chains, acts as an effective T-junction when tuning the chemical potential on and off resonance. By sequentially tuning the coupling between the Majoranas we can exchange a pair of Majoranas between the Kitaev chains.