Digital simulation of non-Abelian anyons with superconducting qubits

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Abstract

Non-Abelian anyons are exotic quasiparticle excitations hosted by certain topological phases of matter. They are the building blocks of topological quantum computing. In this talk, I will report an experimental quantum digital simulation of projective non-Abelian anyons and their braiding statistics with up to 68 programmable superconducting qubits arranged on a two-dimensional lattice. By implementing the ground states of the toric-code model with twists through quantum circuits, we demonstrate that twists exchange electric and magnetic charges and behave as a particular type of non-Abelian anyons, i.e., the Ising anyons. In particular, we show experimentally that these twists follow the fusion rules and non-Abelian braiding statistics of the Ising type, and can be explored to encode topological logical qubits. Furthermore, we demonstrate how to implement both single- and two-qubit logic gates through applying a sequence of elementary Pauli gates on the underlying physical qubits.

Figures

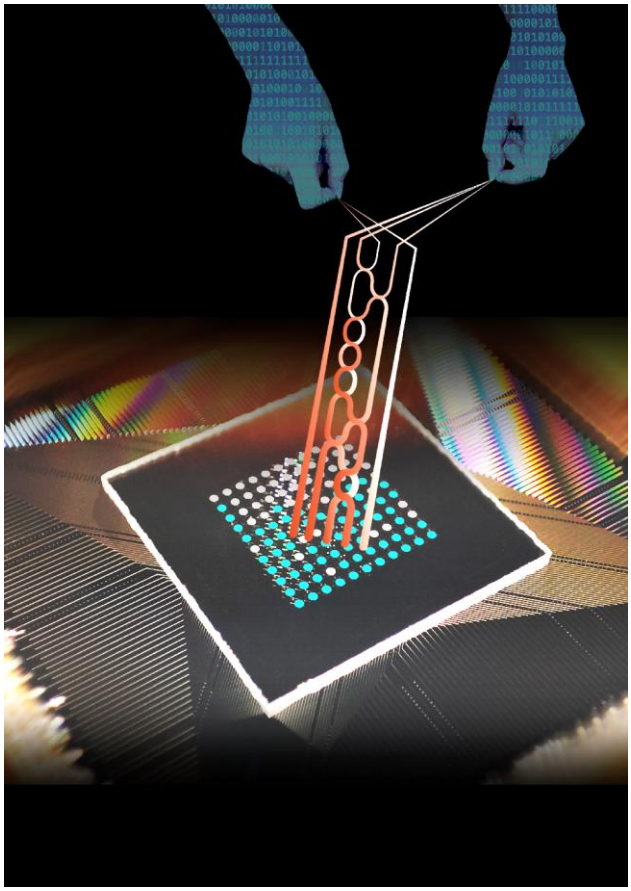

Figure 1: A schematic illustration of digital simulations of non-Abelian anyons.

References

[1] Xu *et al.*, Chin. Phys. Lett. 40, 060301 (2023).