Realizing Repeated Quantum Error Correction in a Surface Code with Superconducting Circuits

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Abstract

Quantum computers hold the promise of solving computational problems which are intractable using conventional methods. For fault-tolerant operation quantum computers must correct errors occurring due to unavoidable decoherence and limited control accuracy. In this talk, I will discuss quantum error correction implemented using the surface code, which is known for its exceptionally high tolerance to errors. Using 17 physical qubits in a superconducting circuit we encode quantum information in a distance-three logical qubit building up on recent distance-two error detection experiments [1]. In an error correction cycle taking only 1.1µs, we demonstrate the preservation of four cardinal states of the logical qubit. Repeatedly executing the cycle, we measure and decode both bit- and phase-flip error syndromes using a minimum-weight perfect-matching algorithm in an error-model-free approach and apply corrections in postprocessing. We find a low error probability of 3% per cycle when rejecting experimental runs in which leakage is detected [2]. The measured characteristics of our device agree well with a numerical model. Our demonstration of repeated, fast and high-performance quantum error correction cycles, together with recent advances in ion traps, support our understanding that fault-tolerant quantum computation will be practically realizable.

References

[1] C. K. Andersen et al., Nature Physics 16, 875–880 (2020)

[2] S. Krinner, N. Lacroix et al., arXiv:2112.03708 [quant-ph] (2021)

Figures

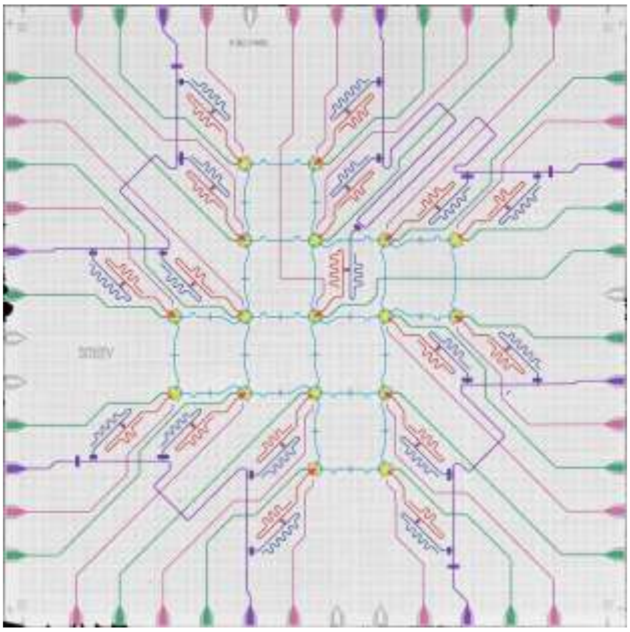

Figure 1: False-colour micrograph of a superconducting circuit with 17 qubits used for realizing quantum error correction in the surface code.