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Suppressing quantum errors by scaling a surface code logical qubit

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Abstract

Practical quantum computing will require error rates that are well below what is achievable with physical qubits. Quantum error correction offers a path to algorithmically-relevant error rates by encoding logical qubits within many physical qubits, where increasing the number of physical qubits enhances protection against physical errors. However, introducing more qubits also increases the number of error sources, so the density of errors must be sufficiently low in order for logical performance to improve with increasing code size. In this talk, I will discuss recent work measuring logical qubit performance scaling across multiple code sizes, and demonstrate that our system of superconducting qubits has sufficient performance to overcome the additional errors from increasing qubit number. We find our distance-5 surface code logical qubit modestly outperforms an ensemble of distance-3 logical qubits on average, both in terms of logical error probability over 25 cycles and logical error per cycle. We are able to accurately model our experiment, and from this model we can extract error budgets that highlight the biggest challenges for future systems. These results mark the first experimental demonstration where quantum error correction begins to improve performance with increasing qubit number, illuminating the path to reaching the logical error rates required for computation.