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Detecting bit-flip errors in a logical qubit using stabilizer measurements

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Quantum data is susceptible to decoherence induced by the environment and to control errors. A future fault-tolerant quantum computer will use quantum error correction (QEC) to actively protect against both. In the smallest QEC codes, the information in one logical qubit is encoded in a two-dimensional subspace of a larger Hilbert space of multiple physical qubits. For each code, a set of non-demolition multi-qubit measurements, termed stabilizers, can discretize and signal physical qubit errors without collapsing the encoded information. Using a 5-qubit superconducting processor, we realize the two parity measurements comprising the stabilizers of the three-qubit repetition code protecting one logical qubit from physical bit-flip errors. We construct these stabilizers as parallelized indirect measurements using ancillary qubits, and evidence their non-demolition character by generating three-qubit entanglement from superposition states. We demonstrate stabilizer-based quantum error detection (QED) by subjecting a logical qubit in any initial state to bit-flip errors on its constituent three physical qubits. Crucially, and in contrast to previous QED implementations, this approach keeps the quantum information encoded at all times, meeting a fundamental requirement for fault tolerance.