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Experimental quantum error correction with trapped ions

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The computational potential of a quantum information processor can only be utilized if errors occurring during a quantum computation can be controlled and corrected for. Quantum error correction protocols encode the quantum information of a single qubit in a larger register. Errors are then corrected by a quantum-feedback algorithm that is applied repeatedly. We encode a single logical qubit into three physical qubits and perform multiple rounds of error correction with the aid of high-fidelity gate operations and a reset technique for the auxiliary qubits. Furthermore we demonstrate that the same technique can be used to undo a quantum measurement. Full quantum error correction schemes are able to correct for arbitrary errors and enable universal quantum computation, but they require a significant overhead in the number of qubits. This prevents them to be useful for medium-scale systems used for quantum simulation. Therefore, we develop a quantum feedback scheme to reduce the dominant errors in an open-system quantum simulator. Our scheme requires only a single auxiliary qubit regardless of the system size.