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Error correction of a logical grid state qubit by dissipative pumping

Stabilization of logical qubits using quantum error correction is key to realizing quantum computers. While qubit codes require controlling many physical systems, oscillator codes allow error correction on a single physical entity. Here we introduce and implement a dissipative map designed for physically realistic finite grid states which performs quantum error correction of a logical qubit implemented in the motion of a single trapped ion. The correction cycle maps the finite grid state stabilizer information onto an internal electronic state ancilla qubit, and applies coherent feedback and ancilla repumping to correct small displacement errors. We demonstrate the extension of logical coherence achieving an increase in logical lifetime of a factor of three. The simple dissipative map used for the correction can be viewed as a type of reservoir engineering, which pumps into the logical subspace. These techniques also open new possibilities for quantum state control and sensing.