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Enhancing dissipative cat qubit protection by squeezing

Dissipative cat-qubits are a promising architecture for quantum processors due to their built-in quantum error correction. By leveraging two-photon stabilization, they achieve an exponentially suppressed bit-flip error rate as the distance in phase-space between their basis states increases, incurring only a linear increase in phase-flip rate.

This property substantially reduces the number of qubits required for fault-tolerant quantum computation. Here, we implement a squeezing deformation of the cat qubit basis states, further extending the bit-flip time while minimally affecting the phase-flip rate. We demonstrate a steep reduction in the bit-flip error rate with increasing mean photon number, characterized by a scaling exponent $\gamma=4.3$, decreasing by a factor of 74 per added photon. Specifically, we measure bit-flip times of 22 seconds for a phase-flip time of 1.3 μs in a squeezed cat qubit with an average photon number of 4.1 photons, a 160-fold improvement in bit-flip time compared to a standard cat.

Moreover, we demonstrate a two-fold reduction in Z-gate infidelity, with an estimated phase-flip probability of $\epsilon X=0.085$ and a bit-flip probability of $\epsilon Z=2.65\cdot 10-9$ which confirms the gate bias-preserving property. This simple yet effective technique enhances cat qubit performances without requiring design modification, moving multi-cat architectures closer to fault-tolerant quantum computation.