Break-even point of quantum repetition code[1]

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Enhancing the lifetime of qubits with quantum code-based memories on different quantum hardware is a significant step towards fault-tolerant quantum computing. We theoretically show that the break-even point, i.e., preserving arbitrary quantum information longer than the lifetime of a single idle qubit, can be beaten even with the quantum phase-flip repetition code in a dephasing-time-limited system. Applying circuit-based analytical calculation, we determine the efficiency of the phase-flip code as a quantum memory in the presence of relaxation, dephasing, and faulty quantum gates. Considering current platforms for quantum computing, we identify the gate error probabilities and optimal repetition number of quantum error correction cycles to reach the break-even point.

References

[1] Áron Rozgonyi and Gábor Széchenyi. Break-even point of the quantum repetition code. 2023. arXiv: 2303.17810 [quant-ph].

Figures

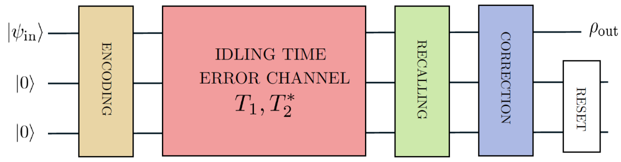

Figure 1: The schematic draw of a quantum code-based memory. In the decoding step, the initial state is entangled with a few ancillary qubits initialized in the ground state. During the idling time, every qubit is affected by the noise sources, e.g., dephasing and relaxation. After the correction, the state is recalled to one of the physical qubits. A reset of the ancilla qubits is necessary if we want to repeat this process. In many applications, the order of the recalling and correction processes is reversed.

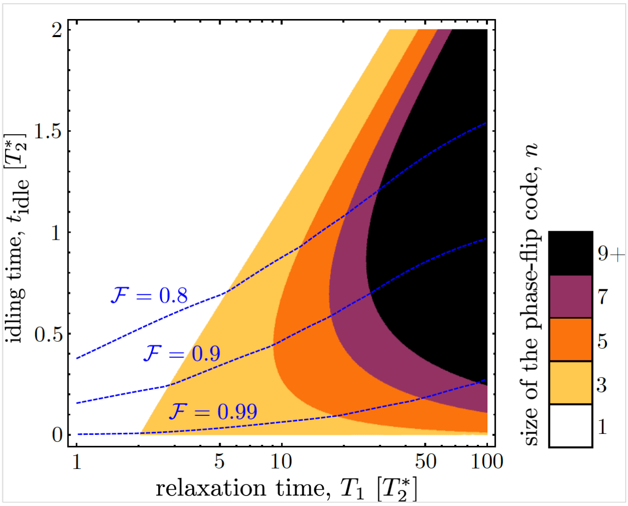

Figure 2: The size of the phase-flip repetition code giving the largest fidelity after one cycle of error correction as well as three iso-fidelity contours as a function of relaxation and idling times in units of T_2*. Gate errors are neglected. For n=1 (white region) the idle qubit gives better fidelity than a quantum code. In a dephasing-time limited system ($T_1 > 2T_2$*) if the idling time is shorter than a threshold value (colourful region) then the break-even point is beaten.