Extended Noise Model Details for QEC-C

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1 Noise Models

The QEC-C protocol is validated under the following noise models:

1.1 Amplitude Damping

Modeled as a single-qubit channel with Kraus operators:

$$K_0 = \begin{pmatrix} 1 & 0 \\ 0 & \sqrt{1-\gamma} \end{pmatrix}, \quad K_1 = \begin{pmatrix} 0 & \sqrt{\gamma} \\ 0 & 0 \end{pmatrix},$$

where $\gamma = 0.01$ represents damping rate.

1.2 Phase Damping

Defined by Kraus operators:

$$K_0 = \begin{pmatrix} 1 & 0 \\ 0 & \sqrt{1-\lambda} \end{pmatrix}, \quad K_1 = \begin{pmatrix} 0 & 0 \\ 0 & \sqrt{\lambda} \end{pmatrix},$$

with $\lambda = 0.015$.

1.3 Correlated Noise

Introduced via a two-qubit interaction term with correlation strength $C = 0.005$, affecting adjacent qubits.

1.4 Non-Markovian Noise

Simulated with a memory kernel $K(t) = e^{-t/\tau}$ where $\tau = 0.1$ ns, impacting temporal correlations.

2 Validation

Fidelity remains >99.95% across 5–20 qubits under these models, supporting QEC-C robustness.