Implementing an erasure check for dual-rail qubits in 3D superconducting cavities

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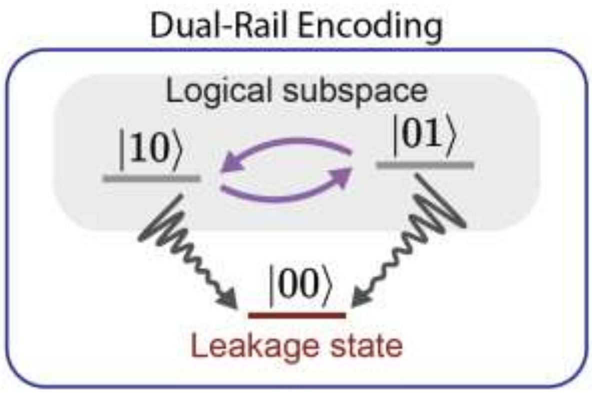
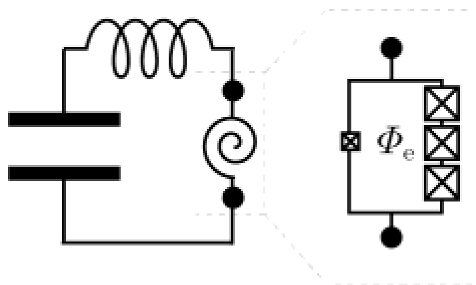
Erasure qubits, designed to error-detect the most likely errors as they occur at the hardware level, have drawn interest on various platforms as a means of achieving scalable quantum error correction with fewer requirements on coherence[1]. The challenge is that such a scheme relies on a high fidelity error detecting measurement.

We solve this problem in the context of circuit-QED for the superconducting dual rail qubit[2], comprising a single microwave photon in two high-Q superconducting cavities, for which the dominant error is photon loss, by engineering a non-destructive measurement of the total photon number parity in the two cavities. This measurement scheme[3] makes use of a strong tunable beamsplitter interaction between the two cavity modes, here enabled by a nonlinear SNAIL coupler[4], and the existing auxiliary transmon qubit used for state preparation. Crucially, we show that this implementation can be made fault-tolerant to both dephasing and relaxation errors on this auxiliary qubit. Further, we discuss how particular operating points of the SNAIL may be used to shield against residual noise originating in this coupler.





References

[1] Wu et al., *Nat Commun* **13**, 4657 (2022)
[2] Teoh et al., arXiv:2212.12077 (2022)
[3] Tsunoda et al., arXiv:2212.11196 (2022)
[4] Chapman, de Graaf et al., arXiv:2212.11929 (2022)