Fundamental limit on parametric readout of a flux-tunable transmon qubit

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A path to reaching fault-tolerant quantum computation is provided by the successful implementation of quantum error correction protocols, which require the error rates of qubit operations to be below certain thresholds. In superconducting quantum processors, the error rate of readout lags behind that of single- and two-qubit gates. The main reason is that state-of-the art dispersive readout based on transverse capacitive coupling is plagued by measurement-induced state transitions (MIST) [1]. Recent theoretical and experimental work [2,3] has shown that parametric readout, also referred to as longitudinal readout, is more robust against MIST, providing a viable high-fidelity, quantum nondemolition alternative to standard dispersive readout. In parametric readout, the Josephson energy of the qubit is modulated by the phase of the resonator. This realizes a nonperturbative cross-Kerr coupling that facilitates qubit readout. In this work, we experimentally demonstrate parametric readout by galvanically coupling the resonator's inductor to the SQUID of a grounded transmon, see Fig. 1. At high power, contrary to previous implementations, we uncover that our readout is not limited by multi-excitation resonances, but rather by a fundamental limit of the coupling mechanism. Under strong driving, the parametric modulation of the Josephson energy leads to an effective flattening of the Josephson potential (see Fig. 2), which ultimately limits the readout capabilities.

References

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[2] A. A. Chapple, A. McDonald, M. H. Muñoz-Arias, M. Lachapelle, and A. Blais, Robustness of longitudinal transmon readout to ionization, Phys. Rev. Applied 24, 034026 (2025).
[3] C. Mori et al., Suppression of Measurement-Induced State Transitions in Cosφ-Coupling Transmon Readout, arXiv:2509.05126.

Figures

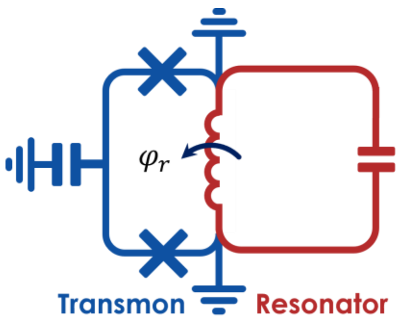

Fig. 1: Circuit schematic of the coupled transmon-resonator system. The current through the resonator's inductor induces a flux φ_r in the SQUID of the transmon.

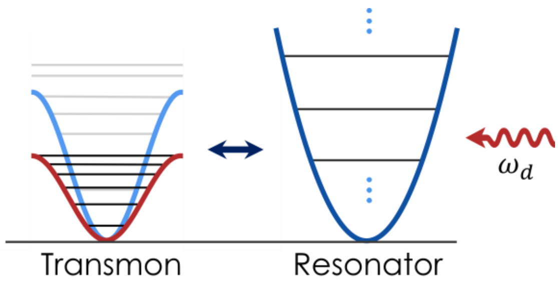

Fig. 2: Under application of a strong resonator drive at frequency ω_d, the modulation of the Josephson energy effectively flattens the transmon potential.