Passive leakage removal unit based on a disordered transmon array

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Leakage out from the qubit subspace compromises standard quantum error correction protocols and is a challenge for practical quantum computing [1, 2]. We propose a passive leakage removal unit based on an array of coupled disordered transmons and last-site reset by feedback-measurement or dissipation [3]. The transmons have parametric disorder both in frequency and anharmonicity (Fig. 1a) such that the qubit subspace is protected by localization through energy level mismatch (Fig. 1b) while the energy level for leakage excitations are in resonance for maximized leakage mobility (Fig. 1c). Leakage excitations propagate [4] through the idle transmons until reaching the last site with feedback-measurement or dissipation removing them. For removing leakage excitations, we find two optimal measurement rates (Fig. 2), which are comprehensively understood through two distinct timescales between the propagation and disintegration of leakage excitations. Based only on an array of standard transmon devices, our approach is readily compatible with existing superconducting quantum processor designs under realistic conditions.

References

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Figures

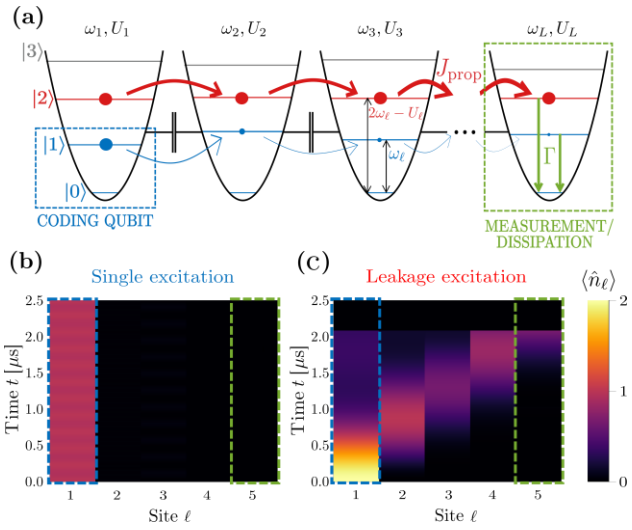

Figure 1: Schematic of the leakage removal unit protocol. (a) Transmon array with disordered frequency and anharmonicity. An example trajectory for transmon population as function of time and site for an initial qubit (b) and leakage (c) excitations.

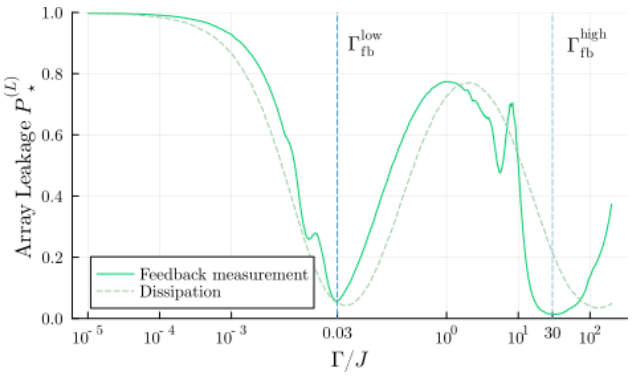

Figure 2: Dependence of the leakage population on the measurement and dissipation rates.