Superconducting qubits at elevated frequencies

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Quantum processors based on superconducting qubits typically operate in a frequency range from 3 to 7 GHz. Raising the qubit frequencies beyond this well-established frequency range could result in significant advantages including reduced residual mode populations, enhanced anharmonicities and the potential for operation at elevated cryogenic temperatures [1]. In this work, we study the properties of transmon-type superconducting qubits based on niobium electrodes and standard Al/AlOx/Al junctions with resonance frequencies up to 20GHz. We observe a reduction in qubit lifetimes by two orders of magnitude for high-frequency qubits compared to standard devices operating around 4.5 GHz. To investigate the source of the additional losses we measure the behavior of niobium (Nb) resonators in the same range. We find that the quality factors of the Nb resonators are nearly constant as a function of frequency, suggesting that Josephson junctions, particularly AlOx [2], are responsible for losses at higher frequencies.

References

[1] A. Anferov et al., arXiv:2402.03031(2024)

[2] H.J. Mamin et al., Phys. Rev. Applied 16, 024023 (2021)

Figures

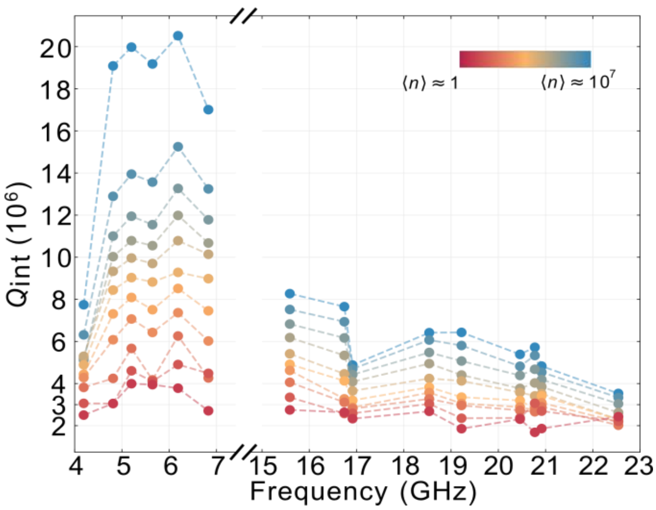

Figure 1: Comparison of low- and high-frequency resonators Q*int* vs photon number. Low frequency 4-7 GHz: Q*int* ≈ 3.3M at n ≈ 1
High frequency 15-21 GHz: Q*int* ≈ 2.4M at n ≈ 1

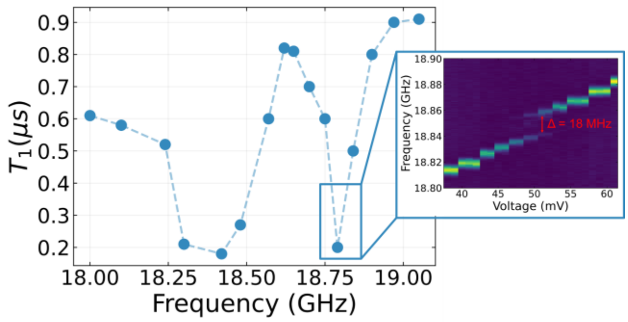

Figure 2: Relaxation time vs frequency of the planar on-chip flux-tunable transmon qubit. The inset shows spectroscopically resolvable interaction with low-coherent TLS.