Experimental realization of a cos(2φ) transmon qubit

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We report the experimental realization of a cos(2φ) transmon [1], in which a superconducting island is shunted to ground by a tunnelling element that selectively transfers pairs of Cooper pairs (Fig. 1). This enforced pairing symmetry endows the circuit with intrinsic protection against charge-induced decay mechanisms. At the flux symmetry point, we observe a doublet of opposite Cooper-pair parity split by $13.6\ \mathrm{MHz}$. Operating in a soft-transmon regime, this splitting is two orders of magnitude smaller than in previous implementations, pushing charge-induced losses well beyond the measured coherence times. Despite the low transition frequency, we demonstrate coherent control of the doublet (Fig. 2), single-shot readout, and resolve quantum jumps between thermally occupied states. We measure $T_1 = 70\,\mu\mathrm{s}$ and $T_2^{\mathrm{echo}} = 2.5\,\mu\mathrm{s}$. Charge protection is directly evidenced by a 100-fold suppression of the island charge matrix element between the protected doublet and higher plasmonic transitions, placing dielectric loss limits above 10 ms. Coherence is instead limited by *1/f* flux noise coupling to internal degrees of freedom of the tunnelling element. This experiment shows that Cooper-pair pairing enables robust suppression of charge-induced losses while preserving coherent control and single-shot readout of a low-frequency qubit, and identifies flux noise as the dominant remaining limitation, motivating designs stabilized by fluxoid quantization.

References

[1] Smith *et. al.* NPJQI, 6:8 (2020)
[2] Bell *et. al.* PRL 112, 167001(2014)

Figures

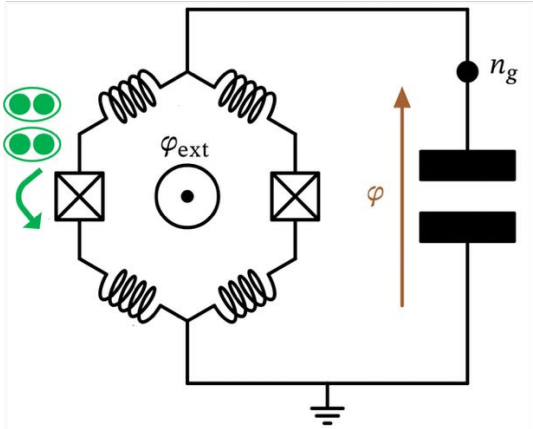

Figure 1: Electrical circuit of our device. Pairs of Cooper pairs (green) tunnel from one capacitor pad to another through a KITE element (diamond ring).

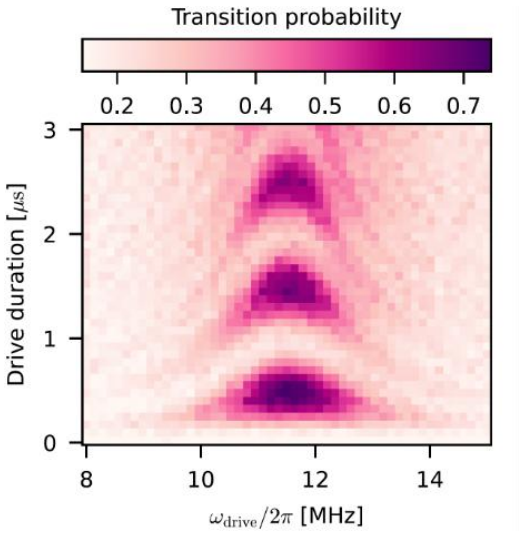

Figure 2: Measured Rabi chevrons of the ground state doublet.