

Unravelling the emergence of quantum jumps in a monitored qubit

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Quantum jumps — the sudden collapse of a quantum system into one of several definite states upon measurement — are among the most striking manifestations of quantum physics. Traditionally viewed as instantaneous, recent work has shown that they can also evolve continuously [1]. In this talk, I will present experiments that explore how quantum jumps emerge as we tune the measurement strength in a coherently driven superconducting qubit continuously monitored by an ancillary detector.

By gradually increasing the measurement strength, we uncover a sequence of three distinct transitions [2] that divide the dynamics into four regimes. Coherent Rabi oscillations first give way abruptly to jump-like evolution; the system then begins to “freeze” near a stable eigenstate; and, at even stronger measurement, the ensemble dynamics slow down, signaling entry into the quantum Zeno regime.

Our measurements, supported by analytical and numerical modeling that include decoherence and detector imperfections, reveal that the transition from coherent quantum motion to measurement-dominated behavior can occur through a cascade of distinct stages, rather than a smooth crossover or a single sharp transition.

These results shed light on how classical behavior emerges in monitored quantum systems and demonstrate the rich measurement-induced dynamics accessible with superconducting quantum circuits.

References

[1] Z. K. Mineev, S. O. Mundhada, S. Shankar, P. Reinhold, R. Gutiérrez-Jáuregui, R. J. Schoelkopf, M. Mirrahimi, H. J. Carmichael, and M. H. Devoret, To catch and reverse a quantum jump mid-flight, *Nature (London)* 570, 200 (2019).

[2] K. Snizhko, P. Kumar, and A. Romito, Quantum Zeno effect appears in stages, *Phys. Rev. Res.* 2, 033512 (2020).

Figure

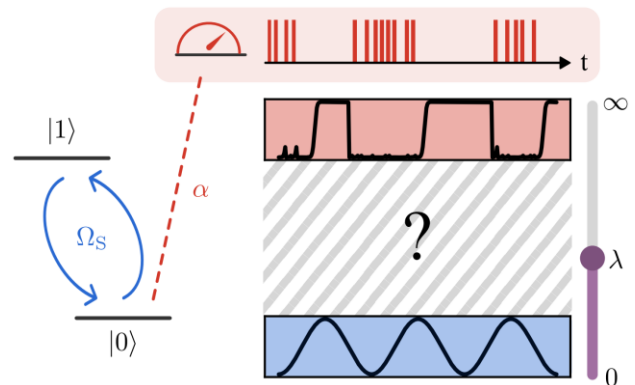


Figure 1: Monitored quantum system with tunable measurement strength. A qubit is resonantly driven at a rate Ω_S (blue arrows) while being continuously monitored by a detector. The detector produces clicks (red bars) at a rate α whenever the qubit is in the ground state $|0\rangle$. By tuning the dimensionless measurement strength $\lambda = \alpha/(2\Omega_S)$, we drive a crossover in the qubit dynamics from Rabi oscillations to jump-like trajectories, illustrated by the excited-state population traces (blue and red shaded, respectively).