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Observation of quantum jumps in a superconducting quantum bit[1]

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Superconducting qubit technology has made great advances since the first demonstration of coherent oscillations more than 10 years ago. Coherence times have improved by several orders of magnitude and significant progress has been made in qubit state readout fidelity. However, a fast, high-fidelity, quantum non-demolition measurement scheme which is essential to implement quantum error correction has so far been missing. We demonstrate such a scheme for the first time where we continuously measure the state of a superconducting quantum bit using a fast, ultralow-noise parametric amplifier. This arrangement allows us to observe quantum jumps between the qubit states in real time. The key development enabling this experiment is the use of a low quality factor (Q), nonlinear resonator to implement a phase-sensitive parametric amplifier operating near the quantum limit. The nonlinear resonator was constructed using a two junction SQUID shunted with an on-chip capacitor. The SQUID allowed us to tune the operating band of the amplifier and the low Q provided us with a bandwidth greater than 10 MHz, sufficient to observe jumps in the qubit state in real time. I will briefly describe the operation of the parametric amplifier and discuss how it was used to measure the state of a transmon qubit in the circuit QED architecture. I will discuss measurement fidelity and the statistics of the quantum jumps. I will conclude by discussing the implications of this development for quantum information processing and further improvements to the measurement technique.

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