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Simultaneous measurement of non-commuting observables in circuit QED: Experiment[1] SHAY HACOHEN-GOURGY, LEIGH MARTIN, EMMANUEL FLURIN, Quantum Nanoelectronics Laboratory, UC Berkeley, BRIGITTA WHALEY, Berkeley Quantum Information Center, UC Berkeley, IRFAN SIDDIQI, Quantum Nanoelectronics Laboratory, UC Berkeley — The existence of incompatible measurements lies at the heart of numerous fundamental concepts in quantum mechanics, such as entanglement, contextuality and measurement-disturbance tradeoffs. We implement a novel technique for simultaneously and continuously measuring a pair of non-commuting observables in a circuit-QED architecture, which features a transmon qubit coupled to two modes of an electromagnetic cavity. By driving the transmon on resonance, we form an effective, low-frequency two-level system on which we perform the non-commuting measurements. To this end, we use microwave tones near the cavity's resonances to implement cooling and backaction-evading measurements familiar from optomechanics. Control of the relative amplitude and phase of these sideband tones enables qubit state measurement along an arbitrary axis of the Bloch sphere. We apply this technique to both modes of the cavity simultaneously, with distinct axes chosen for each mode. This realizes a continuous and simultaneous measurement of two non-commuting observables. We use high quantum-efficiency parametric amplifiers to track the resulting quantum trajectories of the qubit, enabling a measurement of the mutual disturbance of the two observables.

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