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Simultaneous measurement of non-commuting observables in circuit QED: Theory[1] LEIGH MARTIN, SHAY HACOHEN-GOURGY, EMMANUEL FLURIN, Quantum Nanoelectronics Laboratory, UC Berkeley, BIRGITTA WHALEY, Berkeley Quantum Information and Computation Center, UC Berkeley, IRFAN SIDDIQI, Quantum Nanoelectronics Laboratory, UC Berkeley — We describe the theory of a novel technique for simultaneously and continuously measuring a pair of non-commuting qubit observables, which has until now not been realized experimentally. Our proposed experimental platform consists of a qubit dispersively coupled to two linear cavity modes. Driving the qubit on resonance realizes an effective two-level system with energy splitting given by the Rabi frequency. Non-commuting measurements are performed on this system by application of sideband tones detuned from the cavity resonance frequencies by the Rabi frequency. We show that this realizes cooling and back-action free measurements constituting destructive and QND measurements, respectively, along an arbitrary axis of the Bloch sphere. Simultaneous application of a distinct pair of measurements may then be achieved by choosing a different axis for each cavity mode. We show that existing high quantum efficiency homodyne measurement techniques will enable the reconstruction of quantum trajectories of the qubit. Finally, we describe methods for characterizing the system's dynamics and verifying that the scheme does enable access to incommensurate, competing degrees of freedom.

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