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Ensembles of quantum trajectories– a window into qubit measurement dynamics

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A central feature of quantum mechanics is that a measurement result is intrinsically probabilistic. Consequently, continuously monitoring a quantum system will randomly perturb its natural unitary evolution. An accurate measurement record documents this stochastic evolution and can be used to reconstruct the quantum trajectory of the system state in a single experimental iteration. We use weak measurements to track the individual quantum trajectories of a superconducting qubit that evolves under the competing influences of continuous weak measurement and Rabi drive. We analyze large ensembles of such trajectories to examine their characteristics and to determine their statistical properties. For example, by considering only the subset of trajectories that evolve between any chosen initial and final states, we can deduce the most probably path through quantum state space. Our investigation reveals the rich interplay between measurement dynamics, typically associated with wavefunction collapse, and unitary evolution. Our results provide insight into the dynamics of open quantum systems and may enable new methods of quantum state tomography, quantum state steering through measurement, and active quantum control.