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Observing interferences between past and future quantum states in resonance fluorescence[1]

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In quantum physics, measurement results are random but their statistics can be predicted at any time assuming some knowledge about the system in the past. Additional knowledge from a future measurement deeply changes these statistics in the present and leads to purely quantum features. In particular conditioned average outcomes of a weak measurement, so-called weak values, were shown to go beyond the conventional range, give a way to directly measure complex values, and can be used to enhance the sensitivity of quantum meters. Recently, these concepts have been considered in the general case of open quantum systems where decoherence occurs. Then, what are the properties of weak values for the unavoidable measurement associated to decoherence, the one performed by the environment? Here, we answer this question in the simplest open quantum system: a quantum bit in presence of a relaxation channel. We continuously monitor the fluorescence emitted by a superconducting qubit driven at resonance. Conditioned on initial preparation and final single shot measurement outcome of the qubit state, we probe weak values displaying all the above properties. The fluorescence signal exhibits interferences between oscillations associated to past or future quantum states. The measured data are in excellent agreement with a recently developed formalism.

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