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Snapshotting Quantum Dynamics at Multiple Time Points

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Measurement-induced state disturbance is a main challenge in obtaining quantum statistics at multiple time points. We propose a method to extract dynamic information from a quantum system at intermediate time points, namely snapshotting quantum dynamics. In order to do this, we introduce a multi-time quasi-probability distribution (QPD) that correctly recovers probability distributions at respective times and construct a systematic protocol to reconstruct the multi-time QPD from measured data. Our approach can also be applied to extract correlation functions for various time orderings. We provide a proof-of-principle experimental demonstration of the proposed protocol using a dual-species trapped-ion system. We employ 171Yb+ and 138Ba+ ions, respectively, as the system and the ancilla to perform multi-time measurements that consist of repeated initialization and detection of the ancilla state without directly measuring the system state. The two- and three-time QPDs are reconstructed, where the dynamics of the system are faithfully monitored. We also observe negativity and complex values in multi-time QPDs which clearly indicate a contribution of quantum coherence in the dynamics. Our scheme can be applied to any multi-time measurements of a general quantum process to explore the properties of quantum dynamics.

[1] arXiv:2207.06106

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