Diagnosing measurement-induced phase transitions without trajectory post-selection through predetermined measurements

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State-of-the-art quantum devices can be exploited to perform quantum simulations that explore exotic and novel physics. In this sense, a new phase transition in the entanglement properties of many-body dynamics has been described when the unitary evolution is interspersed with measurements [1], thus exhibiting universal properties. These measurement-induced phase transitions can be interpreted as a phase transition in the purification capabilities or error correction properties of quantum circuits, which is especially relevant in the context of state-of-the-art noisy intermediate-scale quantum devices. Measurement-induced phase transitions have been realized with quantum devices based on trapped ions or superconducting circuits [2], although they require large amounts of resources due to the need to post-select trajectories, which consists of keeping track classically of the outcome of each measurement [3]. In this work [4], we first describe the statistical properties of an interacting transmon array which is repeatedly measured and predict the behavior of relevant quantities in the area-law phase using a combination of the replica method and non-Hermitian perturbation theory. Most importantly, we show that, by using predetermined measurements that force the system to be locally in a certain state after performing a measurement, we can make use of the distribution of the number of bosons measured at a single site as a diagnostic for a measurement-induced phase transition (Fig. 1). This indicates that the method of predetermined measurements is a suitable experimental candidate to alleviate post-selection-related issues. We also show numerically that a transmon array, modeled by an attractive Bose-Hubbard model, in which local measurements of the number of bosons are probabilistically interleaved, exhibits a phase transition in the entanglement entropy properties of the ensemble of trajectories in the steady state.

References

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Figures

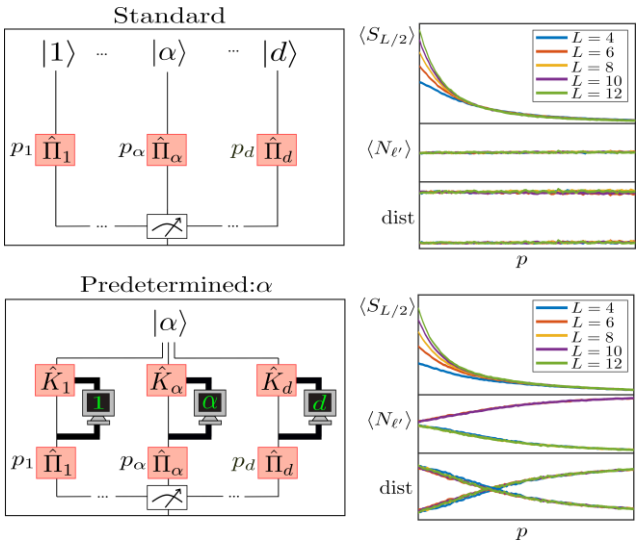

Figure 1: The scheme for the information about critical properties in the statistics of simple observables for standard and predetermined measurements.