Avoiding exponential bottlenecks in the measurement-induced entanglement phase transition

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Abstract

Measurement-induced entanglement phase transitions in monitored quantum circuits have stimulated activity of an unusually diverse research community. However, a direct verification of the phenomenon requires exponentially complex postselected ensemble preparation as well as exponentially complex quantum state tomography. These issues limit experimental studies of entanglement properties to modest systems. We propose a solution to this impasse by introducing a protocol, with which the entanglement volume law- area law transition can be probed in U(1) conserving circuits without exponential cos.

First, the state tomography can be avoided by studying the fluctuations of conserved quantity, as shown in Ref. [1]. The fluctuations faithfully reproduce the entanglement entropy behaviour without needing to resort to the state tomography. Moreover, we employ a steering protocol to approximate a single pure state trajectory with a mixed state, from which one can efficiently filter out coherent U(1) charge fluctuation in a subsystem. The coherent subsystem fluctuations exhibit the same spatial scaling as the entanglement entropy of the target pure state. This protocol avoids the need to carry out the exponentially costly postselection ensemble preparation, providing a scalable method to explore entanglement phase transitions. Thus, the method introduced in our work removes the fundamental obstacles impeding experimental progress in monitored circuits [2].

References

[1] A. G. Moghaddam, K. Pöyhönen and T. Ojanen, Physical Review Letters, 131 (2023), 020401.
[2] K. Pöyhönen, M. N. Ivaki, A. G. Moghaddam and T. Ojanen, in preparation