Measuring entanglement in quench dynamics for bosons in an optical lattice

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Abstract:

The best available classical simulations of time-dependent many-body dynamics rely on the entanglement in the system being relatively weak, and their efficiency can be quantified based on the amount of spatial entanglement in a many-body system. In this sense, the amount of many-body entanglement underlies the complexity of simulating such dynamics on a classical computer.

Over the last few years much progress has been made in developing analogue and digital quantum simulators, and recent experiments have studied dynamics in quantum quenches in regimes that go beyond what can be reasonably computed using classical methods. An outstanding challenge, however, is direct measurement of the (potentially large scale) entanglement, and monitoring entanglement growth in non-equilibrium dynamics. We address these questions by discussing measurement scenarios for entanglement entropies, using multiple copies of a quantum system and measurements that are available in current experiments with a quantum gas microscope. These techniques have important potential applications in quantifying the complexity of quantum simulators, and in studying both quantum quenches and the intrinsic properties of many-body states.