Measuring Entanglement Entropy through the Interference of Quantum Many-Body twins

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Abstract

Entanglement is the most nonclassical manifestation of quantum mechanics. It is at the heart of quantum information sciences and rapidly gaining prominence in diverse fields ranging from condensed matter physics to quantum gravity. Measuring entanglement in an arbitrary quantum state, however, remains challenging. So far it was not possible to measure entanglement in interacting many-body systems of spatially delocalized particles. In my talk I will present recent work in which we probe entanglement in such itinerant systems by preparing and interfering two identical copies of a many-body quantum state. This is enabled by single-site resolved control of ultra-cold atoms in optical lattices. We directly measure quantum purity, Renyi entanglement entropy, and mutual information for itinerant, interacting bosons. These experiments pave the way for using entanglement to probe criticality, dynamics, and topological order in strongly-correlated quantum systems.

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