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Measuring entanglement entropy in a quantum many-body system MATTHEW RISPOLI, PHILIPP PREISS, ERIC TAI, ALEX LUKIN, ROBERT SCHITTKO, ADAM KAUFMAN, RUICHAO MA, RAJIBUL ISLAM, MARKUS GREINER, Harvard Univ — The presence of large-scale entanglement is a defining characteristic of exotic quantum phases of matter. It describes non-local correlations between quantum objects, and is at the heart of quantum information sciences. However, measuring entanglement remains a challenge. This is especially true in systems of interacting delocalized particles, for which a direct experimental measurement of spatial entanglement has been elusive. Here we measure entanglement in such a system of itinerant particles using quantum interference of many-body twins. We demonstrate a novel approach to the measurement of entanglement entropy of any bosonic system, using a quantum gas microscope with tailored potential landscapes. This protocol enables us to directly measure quantum purity, Rényi entanglement entropy, and mutual information. In general, these experiments exemplify a method enabling the measurement and characterization of quantum phase transitions and in particular would be apt for studying systems such as magnetic ordering within the quantum Ising model.

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