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An Experimental Extraction of Entanglement Entropy in an Ultracold Atomic Gas CRAIG PRICE, QI LIU, NATHAN GEMELKE, The Pennsylvania State University — Entanglement is a widespread phenomenon present throughout much of condensed matter physics that governs the behavior of the thermodynamic ground state of many materials. Despite its dominant role in determining the character of a manybody sample, the quantification and direct experimental extraction of the degree to which a sample is entangled has presented a significant challenge. We describe methods for experimentally extracting entanglement entropy from a cold atomic sample held in an optical lattice. To do so, controlled collisions are induced between atoms in the sample and an array of auxiliary probe atoms which are followed by destructive optical detection of the probes. For a sample with significant preexisting long range entanglement, such as topologically ordered matter or quantum critical systems, quantum backaction affects the sample in regions extending beyond where probed resulting in a non-local thermal effect. Subsequent measurement of the local equation of state can reveal the entanglement entropy. We discuss a unique apparatus to perform these manipulations and its application to interrogating strongly correlated gases in optical lattices, including phenomena of quantum magnetism, cooling of a Mott Insulator, and non-equilibrium phenomena.

Craig Price
The Pennsylvania State University

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