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Observing a self-thermalizing many-body state ALEXANDER LUKIN, ERIC TAI, PHILIPP PREISS, MATTHEW RISPOLI, SCHITTKO ROBERT, ADAM KAUFMAN, MARKUS GREINER, Harvard University — There is a clear intuition for the dynamics of a classical many-body system that is suddenly displaced from thermal equilibrium: Unless there are conserved quantities, the system re-thermalizes and reaches a new equilibrium distribution constrained by only a few thermodynamic variables. In contrast, an isolated quantum many-body system subject to a sudden perturbation undergoes unitary evolution. The dynamics is reversible and preserves memory of the microscopic details of the initial state. Yet, the long-time behavior of local observables in quenched, non-integrable systems is very well described by thermal ensembles. This thermalization within globally pure quantum states is mediated by the growth of entanglement entropy, which takes on the role of thermodynamic entropy. We use recently developed methods to study the global and local quantum purity in the dynamics of quenched Bose-Hubbard systems. We observe a rapid growth and saturation of the entanglement entropy, during which the full system remains verifiably pure. Using number-resolved measurements in a quantum gas microscope, we show that local observables thermalize in agreement with the Eigenstate Thermalization Hypothesis, and we detect a near-volume law in the entanglement entropy.

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