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Ergodic dynamics and thermalization in an isolated quantum system

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Statistical mechanics is founded on the assumption that all accessible configurations of a system are equally likely. This requires dynamics that explore all states over time, known as ergodic dynamics. In isolated quantum systems, however, the occurrence of ergodic behavior has remained an outstanding question. Here, we demonstrate ergodic dynamics in a small quantum system consisting of only three superconducting qubits. The qubits undergo a sequence of rotations and interactions and we measure the evolution of the density matrix. Maps of the entanglement entropy show that the full system can act like a reservoir for individual qubits, increasing their entropy through entanglement. Surprisingly, these maps bear a strong resemblance to the phase space dynamics in the classical limit; classically, chaotic motion coincides with higher entanglement entropy. We further show that in regions of high entropy the full multi-qubit system undergoes ergodic dynamics. Our work illustrates how controllable quantum systems can investigate fundamental questions in non-equilibrium thermodynamics.