SYNOPSIS

Many-Body Localized States Inch Toward Equilibrium

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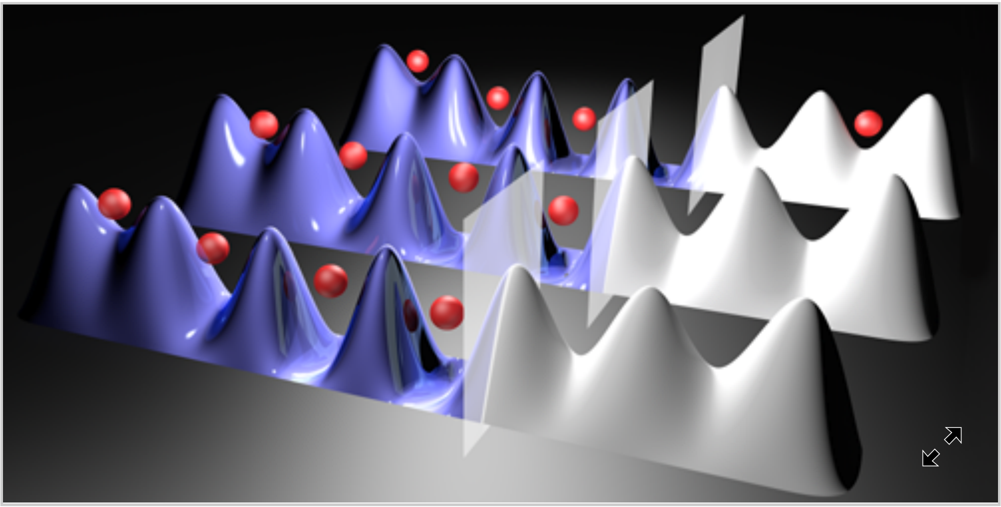
Simulations show that an isolated quantum system—previously thought to remain out of equilibrium indefinitely—may thermalize after all.



Maximilian Kiefer-Emmanouilidis/University of Kaiserslautern

In 1958, the physicist Philip Anderson showed that an electron in a disordered material could become localized, staying bound to a small region of the material rather than wandering freely. Researchers have since wondered whether an isolated system of many interacting particles could remain in a similar state, avoiding thermalization in a phenomenon called many-body localization (MBL). If so, such systems could one day be used to store quantum information. Now, Jesko Sirker of the University of Manitoba, Canada, and colleagues find that particles in a system previously thought to show MBL actually continue to spread through it, erasing information about the system's initial state.

The contribution to a system's entropy that comes from fluctuations in the numbers of particles moving between the system's different regions is called the number entropy.

In a system exhibiting MBL, the number entropy should reach a constant, since particles only travel short distances and particle-number fluctuations are therefore very small. To test this prediction, Sirker and colleagues numerically simulated a many-body system that is expected to show MBL behavior—a 1D lattice model of mutually repulsive particles. They saw that even when the system evolved over long periods, its number entropy continued to grow, never reaching a constant value. This indicated that particles continued to travel through the system, albeit extremely slowly. The unexpected result suggests either that an unknown effect makes the system take much longer to become localized than previously thought or—more speculatively—that true MBL phases don't actually exist. Either way, such systems might still serve as quantum memories, as the long thermalization timescales are sufficient for most purposes, the researchers say.

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–Erika K. Carlson

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Subject Areas

Quantum Information | Statistical Physics

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Evidence for Unbounded Growth of the Number Entropy in Many-Body Localized Phases

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