Prethermalization and thermalization of weakly interacting quantum systems

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When a quantum many-body system is suddenly forced out of equilibrium, it is expected to relax to the thermal state predicted by statistical mechanics, which depends only on energy and particle number. However, integrable systems usually relax instead to a nonthermal state, because a detailed memory on the initial conditions persists due to the many constants of motion. On the other hand generic, nonintegrable systems are expected to relax to a thermal state, as observed, e.g., for quenches to intermediate Hubbard interaction [1]. A special situation arises for weakly interacting systems: because of the nearby integrable, noninteracting Hamiltonian they are first trapped in a so-called prethermalized state, and can thermalize only at a later stage [2].
We show that this prethermalization plateau is again due to a large number of - now only approximate - constants of motion and can be represented by generalized Gibbs ensemble [3]. As the time evolution continues, we can describe the decay of this quasistationary state and the crossover to the thermal state by a kinetic integro-differential equation, with good quantitative agreement for quenches to small Hubbard interaction [4]. This approach provides a controlled and conceptually straightforward description of the thermalization dynamics and establishes that thermalization can occur even in the perturbative regime.

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