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Numerical studies of integrable systems after a quench: what we have learned about the full single-particle density matrix and disorder

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After a sudden quench, the dynamics and thermalization of isolated quantum systems are topics that have generated increasing attention in recent years. This is in part motivated be the desire of gaining a deeper understanding of how statistical behavior emerges out of the unitary evolution in isolated quantum systems and in part by novel experiments with ultracold gases. For integrable systems, numerical and analytical studies have found that, generally, unitary dynamics does not lead to thermal expectation values of few-body observables after relaxation. Instead, those expectation values can be described using the generalized Gibbs ensemble, which takes into account the existence of nontrivial sets of conserved quantities [1]. Here we show that the entire single-particle density matrix of an integrable system and, therefore, all one-body observables, can relax to the predictions of the generalized Gibbs ensemble. This relaxation does not depend on translational invariance or the tracing out of any spatial domain of the system [2]. Furthermore, we discuss how a delocalization-to-localization transition in a quasi-periodic system changes the picture above. In the localized regime, we show that some observables equilibrate while others fail to do so, and that the GGE fails to describe observables after equilibration [3,4].

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