Thouless and relaxation time scales in many-body quantum systems

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Using physical observables, we study numerically and analytically the Thouless time and the relaxation time of realistic interacting many-body quantum systems. The Thouless time refers to the point beyond which the dynamics acquires universal features and becomes purely quantum. Relaxation happens when the evolution reaches a stationary state. These two time scales are not necessarily equal. For chaotic systems, the Thouless time is much smaller than the relaxation time, while for systems approaching a many-body localized phase, they merge together. Both times increase exponentially with system size, while the much smaller characteristic time for the fast initial depletion of the initial state decreases with system size. Our results are compared with those for random matrices, which corroborates their generality. These studies are relevant to experiments with cold atoms and ion traps, where the unitary dynamics of isolated interacting many-body quantum systems is becoming accessible for an ever longer time.