Semiclassical dynamics of disordered fermions with non-local interactions

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Using the truncated Wigner approximation (TWA) we study quench dynamics of one and two-dimensional lattice systems consisting of interacting spinless or spinful fermions with potential disorder.

First, we show that TWA can become very accurate for non-local interactions, provided that the semiclassical Hamiltonian is correctly identified (it becomes asymptotically exact in the infinite-range limit) [1]. For the Hubbard model with long-range interactions, different dynamical timescales of charges and spins can be clearly distinguished. It is shown that in contrast to the short-range model, strong inhomogeneities such as domain walls in the initial state can significantly slow down thermalization dynamics, especially at weak disorder. This behavior can put additional challenges in designing cold-atom experimental protocols aimed to analyze possible many-body localization in such systems. While within this approach we cannot make any definite statements about the existence of a many-body localized phase, we see a very fast crossover as a function of disorder strength from rapidly thermalizing to a slow glassylike regime both for the short-range and long-range models.

Second, we demonstrate that the semiclassical dynamics generally relaxes faster than the full quantum dynamics [2]. We obtain this result by comparing the semiclassical dynamics with exact diagonalization and Lanczos propagation of one-dimensional chains with spinless fermions. Next, exploiting the TWA capabilities of simulating large lattices, we investigate how the relaxation rates depend on the dimensionality of the studied system. We show that strongly disordered one-dimensional and two-dimensional systems exhibit a transient, logarithmic-in-time relaxation, which was recently established for one-dimensional chains. Such relaxation corresponds to the infamous 1/f noise at strong disorder.

References:

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