Propagation of charge and energy density in disordered interacting quantum wires - ergodic phases with subdiffusive dynamics?

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We investigate charge relaxation in the spin-less disordered fermionic Hubbard chain (t-V model). Our observable is the time-dependent density propagator, $\Pi_\varepsilon(x,t)$, calculated in windows of different energy density, ε, of the many-body Hamiltonian.

The width $\Delta x_\varepsilon(t)$ of $\Pi_\varepsilon : (x,t)$ exhibits a behavior that is best described by an effective exponent: $\beta_\varepsilon(t){=}d\ln\Delta x_\varepsilon(t)/d\ln t$. While for diffusive dynamics the exponent equals $1/2$, an impressive body of numerical data has been accumulated that currently is interpreted as suggesting a subdiffusive behavior $\beta_\varepsilon(t){\lesssim}1/2$ in large regions of phase space.

Our numerical work does not lend support to this interpretation, because we observe that β_ε depends strongly on the system size L at all investigated parameter combinations. Specifically, we do not find a region in phase space that exhibits subdiffusive dynamics in the sense that $\beta{<}1/2$ in the thermodynamic limit. Instead, subdiffusion may well be transient, giving way eventually to conventional diffusive behavior, $\beta{=}1/2$.

Interestingly, (transient) subdiffusion $0{<}\beta_\varepsilon(t) \lesssim 1/2$, coexists with an enhanced probability for returning to the origin, $\Pi_\varepsilon(0,t)$, decaying much slower than $1/\Delta x_\varepsilon(t)$. Correspondingly, the spatial decay of $\Pi_\varepsilon(x,t)$ is far from Gaussian, i.e. exponential or even slower.

[1] https://arxiv.org/abs/1610.03085