Quantum thermalization in closed systems through many-body Weak Values

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The main question addressed in the study of quantum thermalization in closed systems is how an initial non-equilibrium state may thermalize. The limitation due to quantum randomness and backaction, to get empirical dynamic information on the thermalization process, is overcome in our work by using Weak Values [1,2,3] for many-body scenarios in a way accessible from laboratories. We show that quantum systems satisfying the Eigenstate Thermalization Hypothesis [4,5] can simultaneously provide both thermalized ensemble expectation values (Figure 1) and non-thermalized Weak Values (Figure 2). The reason why local-in-position Weak Values of the momentum may escape Eigenstate Thermalization Hypothesis is because they are linked only to off-diagonal matrix elements in energy representation. Our model considers a harmonic trap underneath a random disorder potential typical in fermionic optical lattice experiments, and our calculations are based on the exact time-evolution of a correlated few-body Schrodinger equation of an initial non-equilibrium antisymmetric state. The same disorder model can be adapted to the study of localization, which in general works against thermalization (decoherence), and used to simulate semiconductor systems. We claim that our results provide evidence that memory, in the unitary evolution of a non-equilibrium initial state, is not effectively lost after thermalization, but it requires more sophisticated measurement protocols.

References

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Figures

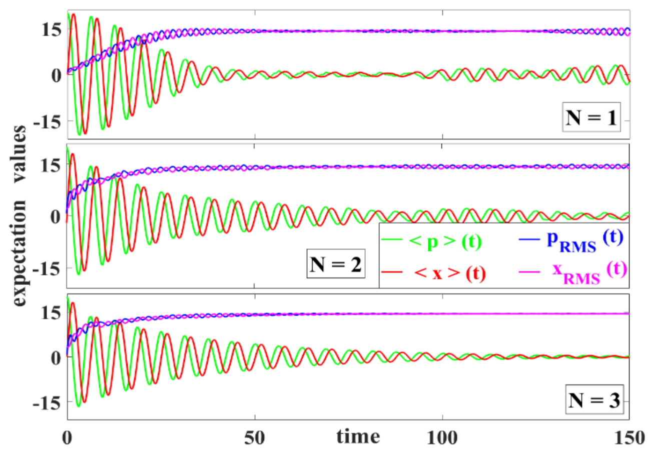

Figure 1: Thermalized expectation values. Time-evolution of position <x>(t) (red) and momentum <p>(t) (green) expectation values, as well as their respective root-mean-squares (magenta, blue) for closed systems with N=1,2,3 particles.

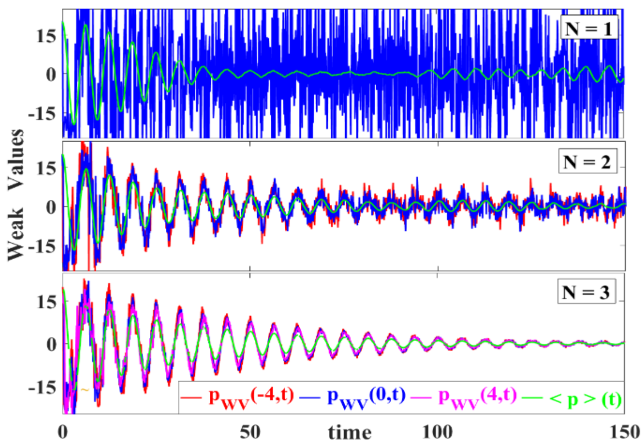

Figure 2: Non-thermalized Weak Values. Time-evolution of the local-in-position Weak Values of the momentum $p_{WV}(x_0,t)$ for closed systems with N=1,2,3 particles, from the same dynamics as in Figure 1. The initial values of x_0 are taken as the centres of the respective initial wave packets.