Equilibration, memory loss and memory preservation in one-dimensional quantum gases

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Ergodicity, one of the fundamental assumptions of statistical physics, is known to be violated in systems that exhibit localisation. By studying quantum dynamics in isolated lattice systems, it has been recently argued that the emergence of local equilibrium is linked to two broadly applicable physical conditions: clustering of initial correlations and delocalising dynamics. We demonstrate this connection in the context of continuous models, focusing on field theoretical descriptions of one-dimensional quantum gases of both experimental and theoretical interest. Using the standard Luttinger model, the more general theory of nonlinear Luttinger liquids, the Tonks-Girardeau limit and recent advances in the emerging field of one-dimensional quantum hydrodynamics and in particular the quantum KdV equation, we show that the information content of the large time steady state is strongly related to the presence or absence of ballistically moving localised excitations. More specifically we show that in the standard Luttinger model, memory of all initial correlations is preserved by the dynamics up to infinitely large times, as a result of the purely ballistic dynamics due to the linear dispersion relation. However, nonlinear dispersion or interactions, when separately present, lead to loss of memory of the initial correlations as a consequence of the spreading of initially localised fluctuations. This memory loss is reflected in the fact that for any initial state that satisfies sufficient clustering of correlations, the steady state is simply Gaussian in terms of the bosonised or fermionised fields respectively. When nonlinear dispersion and interactions are simultaneously present on the other hand, they could cancel each other's effect and restore localisation through the emergence of solitary waves, as suggested at least by the semiclassical approximation. We therefore find that quantum solitary waves, whose existence and stability beyond the semiclassical approximation remains a challenging open problem, would lead to a novel type of hydrodynamic localisation that opens up a new way to evade decoherence in closed quantum systems.

[l] S. Sotiriadis, P. Calabrese, J. Stat. Mech. **2014**, P07024 (2014).

[2] Spyros Sotiriadis, Phys. Rev. A **94**, 031605 (2016).

[3] S. Sotiriadis, G. Martelloni, J. Phys. A: Math. Th. **49**, 095002 (2016).