Does an isolated quantum system relax?

Jörg Schmiedmayer
Vienna Center for Quantum Science and Technology (VCQ),
Atominstitut, TU-Wien, Austria

Understanding non-equilibrium dynamics of many-body quantum systems is crucial for many fundamental and applied physics problems ranging from de-coherence and equilibration to the development of future quantum technologies such as quantum computers which are inherently non-equilibrium quantum systems.

One of the biggest challenges in probing non-equilibrium dynamics of many-body quantum systems is that there is no general approach to characterize the resulting quantum states. Using the full distribution functions of a quantum observable [1,2], and the full phase correlation functions allows us to study the relaxation dynamics in one-dimensional quantum systems and to characterize the underlying many body states.

Interfering two isolated one-dimensional quantum gases we study how the coherence created between the two many body systems by the splitting process slowly dies by coupling to the many internal degrees of freedom available. Two distinct regimes are clearly visible: for short length scales the system is characterized by spin diffusion, for long length scales by spin decay [3]. The system approaches a pre-thermalized state [4], which is characterized by thermal like distribution functions but exhibits an effective temperature over five times lower than the kinetic temperature of the initial system. A detailed study of the correlation functions reveals that these thermal-like properties emerge locally in their final form and propagate through the system in a light-cone-like evolution [5]. Furthermore we demonstrate that the pre-thermalized state is connected to a Generalized Gibbs Ensemble, that its higher order correlation functions factorize and I will give evidence for further relaxation towards thermal equilibrium.

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