Relaxation Dynamics and Pre-thermalization in an isolated Quantum System

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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 is that there is no general approach to characterize the resulting quantum states.

In this talk I will present how to use the full distribution functions of a quantum observable to study the relaxation dynamics in one-dimensional quantum systems and to characterize the underlying many body states.

Interfering two 1 dimensional quantum gases allows to study how the coherence created between the two many body systems by the splitting process [1] slowly dies by coupling to the many internal degrees of freedom available [2]. The full distribution function of the shot to shot variations of the interference patterns [3,4], especially its higher moments, allows characterizing the underlying physical processes [5]. Two distinct regimes are clearly visible: for short length scales the system is characterized by spin diffusion, for long length scales by spin decay [6]. After a rapid evolution the distributions approach a steady state which can be characterized by thermal distribution functions. Interestingly, its (effective) temperature is over five times lower than the kinetic temperature of the initial system.

Our system, being a weakly-interacting Bosons in one dimension, is nearly integrable and the dynamics is constrained by constants of motion which leads to the establishment of a generalized Gibbs ensemble and pre-thermalization. We therefore interpret our observations as an illustration of the fast relaxation of a nearly integrable many-body system to a quasi-steady state through de-phasing. The observation of an effective temperature significant different from the expected kinetic temperature supports the observation of the generalized Gibbs state [6].

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