MAR12-2011-000281

Abstract for an Invited Paper
for the MAR12 Meeting of
the American Physical Society

Relaxation Dynamics and Pre-thermalization in an isolated Quantum System[1]

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Understanding non-equilibrium dynamics of many-body quantum systems is crucial for understanding many fundamental and applied physics problems ranging from decoherence 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]. To reveal the nature of the quantum states behind this de-coherence we analyze the interference of the two evolving quantum systems. 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 in the experiment: 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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[6] Gring *et al.*, to be published

[1]The experiments in Vienna were supported by the European Union integrated project AQUTE, the FWF and the Wittgenstein Prize. Understanding the theory came through our collaboration with T. Kitagawa and E. Demler.