Dr Michael Gring

Prethermalization in an Isolated Many Body System

Supervisor: Jörg Schmiedmayer

ABSTRACT

Understanding the relaxation dynamics of complex non-equilibrium many-body quantum systems is a fundamental problem, arising in many areas of physics. However, experimental examples of non-equilibrium systems that are both controllable and suitable for detailed study are extremely rare. In this thesis one such example in the form of a coherently split one-dimensional (1d) ultra-cold Bose gas in a double-well potential is studied in detail. Typical for the analysis of non-equilibrium systems, the key challenge in this study is the characterization of the complex transient states of the system. In the presented work this task is solved by employing measurements of the time evolution of the full quantum mechanical probability distribution functions (FDFs) of time-of-flight matter-wave interference patterns between the two halves of the split system. The dynamics of the FDFs reveal two distinct regimes of relaxation clearly demonstrating the multi-mode nature of 1d Bose gases. Moreover, after an initial rapid evolution, the FDFs exhibit the approach towards a thermal-like steady state of the system which however does not correspond to the true thermal equilibrium of the system. This surprising behaviour is also predicted by a recent theoretical work which puts the observations in a much broader context and classifies them as an example of prethermalization. Prethermalization is a general concept from relativistic quantum field theory and is currently the subject of intense theoretical research. Accordingly prethermalized states were recently predicted for a series of other many-body quantum systems. The work presented in this thesis represents a direct experimental observation of this phenomenon of prethermalization.