Non-Markovian dynamics of a two-mode Bose–Einstein condensate

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**Highlights**

- We provided new technique to understand the physics of two-mode BEC-environment coupling system.
- Single mode system is given as an example using our method.
- Two mode BEC numerical calculation provided for the non-interacting system.
- Our technique may pave the way for studying on more challenging thermodynamical systems.

**Abstract**

We study the dynamics of an atomic condensate loaded in two symmetric traps where one of the trap is coupled to a non-Markovian reservoir. The system is fully described by the quantum-Langevin equations subjecting to Ornstein–Uhlenbeck dissipation kernel. We consider Ohmic dissipation with Lorentzian cutoff in our calculation. In this model dissipation is induced by the reservoir fluctuation in agreement with the Fluctuation–Dissipation theorem. We use simple numerical method to calculate the non-Markovian population evolution of the system. We found that stronger dissipation and higher temperature significantly effecting the population evolution of the non-Markovian two-mode system. Surprising dynamics is observed when the tunneling between the traps was inhibited as the system reaches it equilibrium.

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1. Introduction

A two-mode Bose–Einstein Condensate (BEC) system is the simplest many-body physics model that exhibits the effects of interactions, quantum tunneling and decoherence. It serves as a good candidate for basic understanding of complex many-body lattice models. However, under the experimental conditions, the condensate in a double-well (two-mode) system suffers atom losses, dissipation and noise. At finite temperature, the presence of thermal cloud of non-condensate atoms cannot be neglected. Collisions between the condensate and thermal cloud atoms cause phase noise in the system. Many theoretical works have discussed the effect of noise and dissipation in the two-mode BEC which can be found in the literatures [1–4] and references therein. Beyond mean-field calculation based on the mentioned model can be traced in Refs. [5–8]. Earlier works reported that phase noise and atom losses enhance and can restore BEC [5,7,9,10]. Decoherence and dissipation were believed to be the major obstacles to the long time control of coherence in the quantum system [11], however it was shown later that they can be a versatile tool to quantum control [12–14]. Recent study has shown that

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