Abstract

The inexorable miniaturization of technologies stimulated the study of quantum thermodynamics. Quantum thermodynamics aims to explain the emergence of thermodynamic laws from quantum mechanics. The open quantum system is a benchmark to understand the non-equilibrium quantum system. Our main interest of this thesis is to understand the finite time thermodynamics study of the quantum thermal machine. Quantum thermodynamics provides a consistent explanation of quantum heat engines and refrigerators up to a single few-level system coupled to the environment. Once the environment is split into three (a hot, cold, and work bath), a heat engine can operate. The device converts the positive gain into power, with the gain obtained from population inversion between the components of the device. Reversing the operation transforms the device into a quantum refrigerator. We are devoted to find out the performance of the thermal machine at the high-temperature limit and find out the resemblance in the performance quantum thermal machine with finite time irreversible thermal device. Study of optimized performance helped us to understand the role of different parameters on the performance of the thermal machine.

In this work of optimal performance of three-level quantum refrigerator, we study a three-level quantum refrigerator operating at maximum χ criterion and cooling power. We study analytic expressions for the coefficient of performance (COP) under the assumptions of strong matter-field coupling and high bath temperatures. We also discuss the optimization of the χ criterion cannot be carried out for general due to **Casus Irreducibilis** of the cubic equation. The role of tight coupling assumption has been discussed in the context of two parameter optimization of χ criterion. In this model, we study the optimization of cooling power, and we describe why two parameter optimization of cooling power is not possible.