Nonlinear dynamics of atoms in a cavity: The role of finite temperature effects

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Cavity quantum electrodynamics is an area of physics studying the interaction of atoms with photons in high-finesse cavities in a wide range of the electromagnetic spectrum from microwaves to visible light. The fact that the system "atom + cavity mode" is a quantum system makes cavity quantum electrodynamics (QED) an excellent testing ground for such important issues of modern quantum physics as quantum measurement theory, entanglement, quantum computation, quantum interference and at the same time provides a unique possibility for trapping, cooling and manipulating of atoms. Practical importance of cavity QED is mainly related to potential possibility for manipulating atoms and photons in mesoscopic scales. Therefore, in recent years cavity QED has become one of the hot topics both in theoretical and experimental physics [1]- [3]. Since the dynamics of a single atom trapped in a microcavity is governed by quantum electrodynamics, the cavity QED can be considered as an interdisciplinary area. Many subfield of physics, such as quantum and atomic optics, cold atom physics, physics of nanosized systems and quantum information, may use important results of the cavity QED. Recently cavity QED is considered in the context of nonlinear dynamics [3]. Mapping quantum equations of motion onto classical ones, for the Jaynes-Cummings Hamiltonian, which includes recoil motion of the atom, Prants et. al., explored phase-space dynamics of the atom interacting with a single cavity mode by analyzing Poincare surface sections and calculating Lyapunov exponents [3]. In this work we explore finite-temperature nonlinear dynamics of an atom coupled to a single mode of the cavity field. Applying the formalism of a real-time finite-temperature field theory to the Jaynes-Cummings Hamiltonian and using the same approach as that used in we have studied classical dynamics of the "atom + cavity mode" system in the presence of coupling to a thermal bath. Using the temperature-dependence of the equations of motion, dependence of the dynamics on heat-bath effects or finite temperature effects are considered. The results show that the dynamics is quite sensitive to the small changes of temperature. This implies that temperature of a thermal bath can be considered as an additional control parameter for the dynamics of an atom coupling to cavity modes.

[1] Cavity Quantum Electrodynamics. Edited by P. R. Berman, (Academic, New York 1994).

[2] Special Issue on Modern Studies of Basic Quantum Concepts., Phys. Scr., **T76** (1998).

[3] S. V. Prants, M. Edelman and G. M. Zaslavsky., Phys. Rev. E., **66** (2002) 046222.