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Quantum dynamics of a harmonic oscillator in a non-equilibrium bath without the rotating wave approximation

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Abstract

The aim of this paper is to investigate dynamical properties of a harmonic oscillator coupled to a non-equilibrium bath without the rotating wave approximation. At first, we investigate the theory of this model and obtain the Heisenberg equations of motion for the oscillator and bath annihilation operators in the absence and in the presence of a rotating wave approximation. Then, we obtain the fluctuation and fluctuation-dissipation relations in the absence and in the presence of a rotating wave approximation for the non-equilibrium bath annihilation operator, respectively. After that, we study the decay of system modes using the Wigner-Weisskopf approximation. Finally, we calculate the time-dependent spectrum of a cavity field mode coupled to a non-equilibrium reservoir. We show that even under the condition in which the RWA is considered to be valid (weak interaction), there are significant effects of virtual-photon field on the diffusion coefficient, the energy density, line width and the shift frequency.

Keywords: the rotating wave approximation, counter-rotating terms**,** virtual-photon, wigner-weisskopf approximation, langevin equation, diffusion coefficient

For full article, refer to the Persian section