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# Virtual Photon Effects on Chaos in Generalized Lorenz-Haken Equation

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Abstract: The dynamics of an ensemble of two-level atoms injected into a single-mode cavity is studied in the exact atom-field interaction situation, in which the counter-rotating terms describing the so-called virtual photon processes neglected in the rotating-wave approximation, are considered. The cavity mode is driven by the injected classical field, and the atom is prepared in a coherent superposition of the two levels. We first derive the generalized Lorenz-Haken equation by using the technique of quantum Langevin equation, and then numerically study the dynamics of this equation. We find that the virtual photon processes have strong effects on the dynamics, which can cause the trajectory in phase space of strange attractor spiral around four focus points, and the trajectory is modulated by virtual photon processes. The chaos region in parameter space is now enlarged. It should be stressed that the strange attractor can exist in optical bistability, and whether the atomic coherences and classical field can inhibit chaos depends on the laser frequency.

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