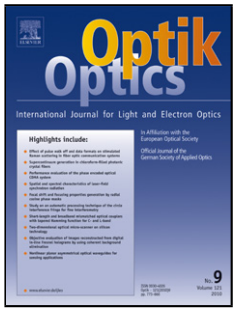

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Photon enhanced chaotic light and its dissipation in an amplitude damping channel

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Abstract

In this paper, we investigate how a m-photon enhanced chaotic field (PACF) , denoted by $\left(1-e^{-\lambda}\right)^{m+1} a^{\dagger m} e^{-\lambda a^{\dagger} a} a^{m}/m!$, evolves in an amplitude damping channel with a damping constant κ. By using the technique of integration within ordered product of operators (IWOP), we find that it evolves into a Laguerre function-weighted chaotic field which is described by $\vdots e^{\left(1-e^{\lambda}\right) e^{2\kappa t} a a^{\dagger}} L_m\left(e^{\lambda+2\kappa t} a a^{\dagger}\right) \vdots$, which is in antinormal ordering. Time evolution of photon number average and fluctuation in this process are also derived. The corresponding evolution law of the Wigner function is also deduced analytically.

Keywords Photon enhanced chaotic field; Amplitude damping channel; Wigner function; Evolution law

1 Introduction

In order to understand the nature of light, physicists continue to explore various kinds of optical fields experimently and investigate them theoretically. Although we have known the character of chaotic light [1], the behaviour of laser light and squeezed light [2], etc, we still need to generate new light fields and study them. There is an effective method to get various new optical fields by quantum superpositions, e.g., subtracting or adding photons from/to traditional quantum states. For example, for a chaotic field described by the density operator

$$\rho_c = \left(1-e^{-\lambda}\right) e^{-\lambda a^{\dagger} a}, \tag{1}$$

a new photon field named photon added chaotic field (PACF) will be proposed theoretically in this paper, it can be obtained by repeatedly operating the photon creation operator $a^{\dagger}$ on the chaotic field. Its density operator is

$$\rho_0 = C_m a^{\dagger m} e^{-\lambda a^{\dagger} a} a^{m}, \tag{2}$$

where C_m is the normalization constant which will to be determined shortly by evaluating $Tr\rho_0 = 1$. Then we examine how this new photon field dissipates in an amplitude damping channel. We hope to see if the final density operator is new.

The paper is arranged as follows. In Section 2, the explicit analytical expression of the normalization factor for PACF is derived by using the coherent state representation. In Section 3, using

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