Dynamical Invariants and Robertson-Schrödinger Correlated States of Electromagnetic Field in Nonstationary Linear Media

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Abstract. Dynamical invariants and statistical properties of the quantized electromagnetic field in nonstationary linear media (dielectric and/or conductive) are considered in the framework of Choi-Yeon quantization scheme. It is shown that in the eigenstates of linear dynamical invariant the Robertson-Schrödinger uncertainty relation is minimized, both for the photon annihilation operator quadratures and for the electric and magnetic field components. The time evolution of initial Glauber coherent states and Fock (photon number) states is considered. On an initial coherent state the medium conductivity and the time-dependent electric permeability both are shown to act as squeezing and correlating factors.

Keywords: dynamical invariants, correlated states, quantization, electromagnetic field, nonstationary media, Ermakov equations
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INTRODUCTION

Although the remarkable achievements have been made in classical and quantum optics, yet probably many properties of light still remain to be uncovered. For deeper understanding of its nature and more precise manipulation the light needs be quantized. The method of quantizing light propagating in free space is well known and appears in most quantum optics text books (see e.g. the book of Louisell [1], Scully and Zubairy [2], Walls and Milburn [3]). Practically the same is the light quantization procedure in a stationary homogeneous and isotropic dielectric media, the only new feature being the reduced light velocity. The quantization of damped light is somewhat more subtle. It involves the quantum description of a single (or several) field oscillator(s) interacting with a reservoir with a large (infinite) number of degrees of freedom (see e.g. [4] and references therein) that makes the calculations rather lengthy. Besides, the Hamiltonians they used in the development of the theory are somewhat assumed ones, rather than having been derived in a consistent way from the classical electrodynamics. Recently publications by Choi and Yeon appeared [5, 6, 7, 8, 9] (see also [10, 11]) where a scheme was proposed for quantizing the damped light in conducting (and nonstationary) linear media without link to a reservoir, resorting to the Caldirola-Kanai Hamiltonian [12] and to the Lewis-Riesenfeld dynamical invariant theory [13].

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