Secondary quantization of electromagnetic field in inhomogeneous structures based on formalism of scattering matrix.

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Loudon was one of the first who developed a procedure for the secondary quantization of an electromagnetic field in layered structures [1]. In his work, the electromagnetic field is quantized in terms of a continuous set of mode creation and destruction operators. Later De Martini [2] used second quantization in inhomogeneous structures to calculate the probability of spontaneous emission in layered structures which are limited with semi-infinite media. In these studies, the mode structure of the field in the space with the inhomogeneity was assumed to be identical to the mode structure of a homogeneous medium obtained using periodic BC (Born–von Karman boundary condition).

In case of an inhomogeneous structures, the approach to the problem of the mode structure of the field on the basis of periodic BC is not exact and self-consistent, because the presence of inhomogeneity can lead to significant changes in the mode structure, which is obtained by applying the periodic BC, which in turn may lead to inaccuracies in the analysis of systems of finite size.

In [3], a method for quantizing an electromagnetic field in media containing inhomogeneity (which is proposed to be called S-quantization) was developed. The method is based on equating the amplitudes of the wave's incident on a quantization box containing inhomogeneity with the amplitudes of the transmitted waves, which is equivalent to equating of eigenvalues of the scattering matrix to the unit. Unlike to the traditional quantization procedure, based on the periodic boundary conditions, S-quantization provides a strict and self-consistent description of the modes of the electromagnetic field and the density of states.

This paper demonstrates the orthogonality of the states of the electromagnetic field in a layered medium, obtained by using the boundary conditions used in the s-quantization procedure for finite and infinite systems (S-conditions). It is developed a procedure for the secondary quantization of an electromagnetic field in layered structures, by introducing the creation and destruction operators for the field modes obtained from S-conditions. They are obtained Fock and coherent states which characterizing the electromagnetic field in a layered medium. In this paper we have analyzed various effects of electromagnetic radiation in inhomogeneous media within the framework of the secondary quantization based on the S-quantization formalism.

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