Quantum properties of radiation propagating in a nonlinear medium

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Photon statistics can have a significant impact on the propagation of radiation in a nonlinear medium. In addition, the presence of nonlinearity affects photon statistics: in particular, dephasing, which is a consequence of nonlinearity, destroys the coherence of radiation.

Within a classical description of such a system, it is difficult to explicitly account for the statistical properties of fluctuations and the possibility of spontaneous radiation generation; therefore, such a description may be inaccurate. To overcome these difficulties, we employed a standard procedure [1, 2] based on a field-theoretical approach using the Schwinger–Keldysh diagrammatic technique and Legendre transformations in the Nambu representation for bosons propagating in a medium with quartic nonlinearity in the field. We show that coherent radiation in this system provides parametric pumping of squeezed radiation. This effect appears already in the first order with respect to the interaction between radiation modes. At the same time, in the second order in the interaction, dephasing effects arise that suppress the parametric pumping process described above and destroys the squeezing. Moreover, dephasing is enhanced with increasing radiation power. The competition between the pumping and dephasing processes makes it possible to estimate the propagation length at which generated radiation squeezing is maximal.

[1] Buchhold M and Diehl S 2015 *The European Physical Journal D* **69**
[2] Vasiliev A 1998 *Functional Methods in Quantum Field Theory and Statistical Physics* (Taylor & Francis)