Influence of quantum effects on wave propagation in a nonlinear medium

Remizov S.V.[1,2,3,@], **Elistratov A.A.**[2] **and Lebedev A.V.**[2]

[1] National Research University Higher School of Economics, Myasnitskaya 20, Moscow, 101000, None
[2] Dukhov Research Institute of Automatics (VNIIA), Sushchevskaya 22, Moscow, 127055, None
[3] Kotelnikov Institute of Radioengineering and Electronics of the Russian Academy of Sciences, Mokhovaya 11-7, Moscow, 125009, None

[@] s.v.remizov@yandex.ru

Radiation photons can have different statistics. This fact makes the classical approach inapplicable in the general case. Squeezed light is an example. It is a challenging problem to study the propagation of such radiation in a nonlinear medium. One possible realization of this scenario is the propagation of the radiation in a set of Josephson junctions organized into a superconducting travelling wave parametric amplifier (TWPA). In such a system, driving mode decays into radiation in a wide frequency range. To describe this process, we offer a universal approach based on the Schwinger-Keldysh diagram technique in Nambu representation. We managed to derive kinetic equations for normal and anomalous photon occupation numbers of the modes of the generated radiation, as well as for the biases of the fields. Since these equations describe relations between the first and second moments of bosonic fields, a complete description of the kinetics of an arbitrary Gaussian state is formed. We show that in this picture the bosonic field biases play an important role. They can either suppress the parametric instability of the driving mode or, on the contrary, lead to the appearance of such instability depending on the shape of the spectrum of the medium and the driving frequency. This effect greatly affects the generation efficiency.