Quantum description of light propagation in generalized media - DTU Orbit (08/11/2017)

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Linear quantum input-output relation based models are widely applied to describe the light propagation in a lossy medium. The details of the interaction and the associated added noise depend on whether the device is configured to operate as an amplifier or an attenuator. Using the traveling wave (TW) approach, we generalize the linear material model to simultaneously account for both the emission and absorption processes and to have point-wise defined noise field statistics and intensity dependent interaction strengths. Thus, our approach describes the quantum input-output relations of linear media with net attenuation, amplification or transparency without pre-selection of the operation point. The TW approach is then applied to investigate materials at thermal equilibrium, inverted materials, the transparency limit where losses are compensated, and the saturating amplifiers. We also apply the approach to investigate media in nonuniform states which can be e.g. consequences of a temperature gradient over the medium or a position dependent inversion of the amplifier. Furthermore, by using the generalized model we investigate devices with intensity dependent interactions and show how an initial thermal field transforms to a field having coherent statistics due to gain saturation.

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