Photonic band gap structures in planar nonlinear waveguides: application to squeezing light generation

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Abstract : Quadrature –amplitude and phase squeezing are investigated in a nonlinear planar waveguide geometry under conditions for which the use of a linear grating fabricated on top of the waveguide reproduces a photonic band gap structures.

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Although nonlinear optics of photonic crystals is very promising [1,2], the study of these structures, until now, has been mainly limited to the description of classical phenomena. Here we want to investigate some aspects of nonlinear optics of photonic crystals from a quantum point of view.

The possibility of creating a squeezed state from a coherent state using a nonlinear photonic crystal has been already predicted [3] in an optical parametric amplification caused by the second order nonlinear susceptibility , by means of a perturbation theory based on Green Function formalism; it has been shown , for a 3D photonic crystal, that quadrature-phase squeezing is enhanced by small group velocity achieved close to the band gap.

In the present work we discuss how the combination of several effects , such us the longitudinal localisation of light in a finite photonic band gap structure in a waveguide configuration, the mismatch in the nonlinear conversion process , driven externally from an intense second harmonic field which induces a nonlinear refraction , produce a noise reduction on the fundamental field , without strong modifying its intensity. In others words we can obtain a light source with a controllable noise .

We have recently discussed [4] SHG in a planar waveguide geometry reproducing a photonic band gap structure through a linear grating designed on the top of the waveguide ; the linear grating alone is not able to produce field confinement and phase matching for the nonlinear conversion process, however this can be achieved with the spatial modulation of the chi(2), as in a Periodically Poled $LiNbO_3$waveguide. In the present work we search condition to get a reasonable amount of squeezing in the fundamental field , without arriving to a large conversion efficiency , in such a way to get a "low noise" source at the fundamental wavelength.

The analysis we perform is based on the coupled mode theory, by adopting a linearized technique in which the quantum fluctuations of the electric field are assumed to be small compared with the mean (classical) field . With this method the evolution of the fluctuations in the nonlinear medium is governed by a set of linear differential equation.

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