Polariton Self-Modulation of an Asymmetric Steady-State of a Superradiant Laser with a Low-Q Symmetric Fabry-Pérot Cavity

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We find that the polariton resonances are responsible for a self-modulation of an asymmetric superradiant lasing in a low-Q symmetric Fabry-Pérot cavity. Based on a representative set of numerical solutions to the semiclassical Maxwell-Bloch equations, we carry out a comparative analysis of the spectrum of polariton modes of the linearized problem and the discrete spectrum of the quasi-monochromatic generation with weak self-modulation under the condition of strong spontaneous mirror-symmetry breaking of the counterpropagating electromagnetic waves, population inversion and polarization of an active medium [1,2].

We describe typical examples demonstrating that the main frequencies of resonant self-modulation of a steady asymmetric superradiant phase state are close to the frequencies of polariton modes if the latter are calculated in the linearized problem for the average level of the population inversion taken from the nonlinear problem. Such modes differ strongly from usual electromagnetic modes of a laser, have small decay rates and can be excited due to resonant nonlinear Rabi-oscillations of the population inversion and polarization of an active medium in the region where both quantities are close to their maximum values.

We show that the required polariton modes exist only if (i) the active medium consists of the active centers with weak inhomogeneous broadening and (ii) a polarization (optical dipole) lifetime is much longer than a photon (cavity) lifetime. We obtain an approximate analytical formula for the frequencies of these polariton modes and validate it using numerical modelling in a broad range of parameters admitting the steady asymmetric superradiant lasing.

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References

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