Spontaneous Coherence Buildup in a Polariton Laser

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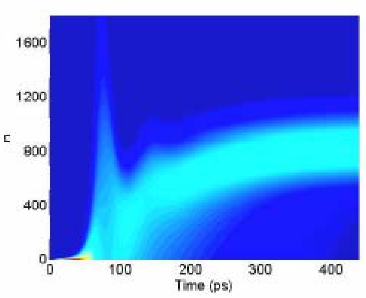
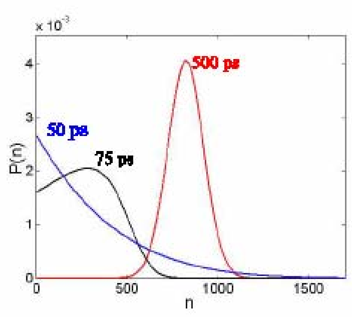
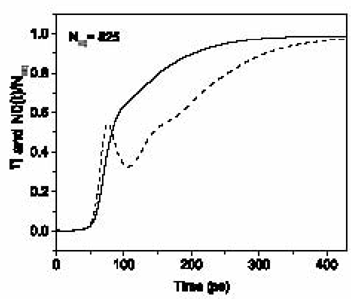
A *polariton laser* [1] is a device which sits between conventional laser and conventional Bose-Einstein Condensate: a net flux of polaritons is injected into the ground state though not because of a population inversion but because of stimulated relaxation of polaritons. The kinetics of this assembly of polaritons has been mainly investigated with semi-classical Boltzmann equations [2] studying dynamics of $\overline{n}_k$ the mean number of polaritons with momentum **k**. However, this does not allow one to obtain the statistics of polaritons in the condensate, important for its link with second-order coherence degree $g^{(2)}(0)=\langle a_0^{+2}a_0^2\rangle/\langle a_0^{+}a_0\rangle^2$ (a_0 the ground state polariton annihilation operator) which is measured by experimentalists as evidence of condensation [3].

Recently we have reported a theoretical study of the dynamics of $g^{(2)}(0)$ in microcavities in the Born-Markov approximation. We showed that coherence can survive a macroscopically long time if initially introduced in the system [4], though in absence of this seed coherence cannot appear spontaneously. We present here a formalism relaxing the Born approximation in the master equation for the ground state density matrix now taking into account correlations between population numbers of ground and excited states. We obtain extended Boltzmann equations enabling us to compute the statistics of polaritons in ground state $p(n_0)$ - the probability to have n_0 particles in the condensate - from which the (zero time delay) second order coherence degree is readily obtained as $g^{(2)}(0)=\sum_{n_0} n_0(n_0-1)p(n_0)/(\sum n_0 p(n_0))^2$.

Below are displayed some of the results we obtained for a typical structure above threshold. Left figure shows a density plot of $p(n_0)$ as a function of time (continuous pumping, starting from an empty cavity). No seed is introduced, population and coherence spontaneously build up in the system. Middle figure displays $p(n_0)$ for three times: thermal statistics near initial conditions ($p(n_0)=\delta_{n_0,0}$ at t = 0), coherent in the steady state and intermediate statistics in between. Rightmost figure displays $\eta\equiv 2-g^{(2)}(0)$ (defined to vary between 0 for thermal and 1 for coherent states) and ground state population normalised to its steady state value. We also present results of this formalism as a function of pumping, exhibiting a threshold.







References

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