

Formation of the cavity polariton condensate: thermodynamic versus kinetic regimes

J. Kasprzak^{1,2}, D.D. Solnyshkov³, R. André¹, Le Si Dang¹, and G. Malpuech^{3*}

¹*Institut Néel, CNRS, 25 avenue des Martyrs, 38042 Grenoble, France*

²*School of Physics and Astronomy, Cardiff University, Queens Buildings, 5 The Parade, Cardiff, CF24 3AA, UK*

³*LASMEA, CNRS and University Blaise Pascal, 24 Avenue des Landais, 63177 Aubière cedex, France*

*Presenting author

Imamoglu first proposed in 1996 [1] to use cavity polaritons to make a new kind of laser without inversion, for which the driving force is not the stimulated emission of photons, but stimulated scattering of polaritons towards a condensate, which leaks out of the microcavity by spontaneously emitting coherent photons. This was a dual-sided concept. It can be interpreted as a new proposal for the realization of laser-type sources [2, 3, 4, 5]. It can also be seen as an example of Bose-Einstein condensation of quasi-particles in a solid state system [6, 7, 8, 9]. The question of the interpretation of the recent experimental findings in terms of polariton lasing or in terms of Bose-Einstein condensation remains hot nowadays. The arguments for the first point of view are that the achievement of a quasi-equilibrium distribution of polaritons is not needed for a coherent emission to take place and that the driving force of the condensate formation is not the constitution of a Bose-Einstein distribution function for the Bose gas. The arguments supporting the second point of view are that, in well defined experimental situations, in spite of the short polariton lifetime, the relaxation kinetics can be fast enough to achieve a steady state Bose distribution.

In this presentation we give an answer to this question. We report the measurements of the polariton distribution function and of the condensation threshold versus the exciton-photon detuning and the lattice temperature in a CdTe microcavity under non-resonant pumping. The results are reproduced by simulations using semi-classical Boltzmann equations. At negative detuning we find a kinetic condensation regime: the distribution is not thermal both below and above the condensation threshold which is governed by the relaxation kinetics. It is found to increase when decreasing the temperature and going to more negative detuning as shown on the figure. At positive detuning, the situation is dramatically different. The distribution function is thermal both below and above the threshold which is now governed by the thermodynamic parameters of the system. Its value is found to increase with temperature and detuning and is well reproduced by thermodynamic calculations. Both regimes are a manifestation of polariton lasing, whereas only the latter is related to the text book Bose Einstein condensation defined as an equilibrium phase transition. Finally we identify a 3rd case close of zero detuning when the transition takes place between the non-equilibrium non condensed state and the equilibrium condensed state. We propose to call this intermediate case kinetically driven Bose condensation because the final state is the state which should be reached by the system at thermal equilibrium.

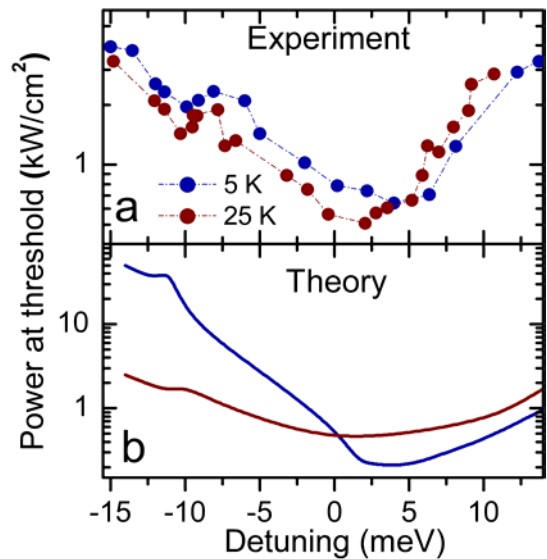


Figure: Pump threshold versus cavity-exciton detuning at 5 K and 25 K. Experiment (a) and theory (b)

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