Introduction to Bose-Einstein condensation of microcavity polaritons

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Polaritons in semiconductor microcavities are two-dimensional quasi-particles which result from the strong coupling between exciton modes confined in quantum wells and photon modes confined in the planar microcavity embedding the quantum wells. These bosons are 10^9 times lighter than rubidium atoms, which would permit Bose-Einstein condensation (BEC) at low density and high temperature. On the other hand, since BEC is a thermodynamic phase transition, thermal equilibration in the polariton gas could be highly challenging due to the extremely short polariton lifetime on the order of one picosecond. Nevertheless BEC has been claimed in various polariton systems in recent years [1].

The purpose of this talk is to provide a basic understanding of BEC in microcavity polaritons to non specialists, leaving more specific and hot issues of polariton condensation to be addressed in other talks during this conference. First we present the polariton system, whose dispersion in the plane perpendicular to the microcavity and quantum well confinement axis is displayed in Figure 1. Polariton states of interest for BEC are those at $k_{//} \sim 0$ in the lower polariton branch. Then we examine the two defining BEC signatures, as observed in CdTe microcavities, i.e. massive occupation of the ground state and macroscopic spatial coherence (see J. Kasprzak et al. in Ref. [1]). Figure 2 shows the polariton population in the lower polariton branch and how the bimodal distribution, typical of BEC at finite temperature, appears when increasing the polariton density at around 20 K. Finally, an overview of issues and recent advances in the field of polariton BEC and "lasing" will be given.

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References

[1] J. Kasprzak et al., *Bose-Einstein Condensation of Exciton Polaritons*, Nature 443, 409 (2006); R. Balili et al., *Bose-Einstein Condensation of Microcavity Polaritons in a Trap*, Science 316, 1007 (2007); H. Deng et al., *Spatial Coherence of Polariton Condensate*, Phys. Rev. Lett. 99, 126403 (2007).

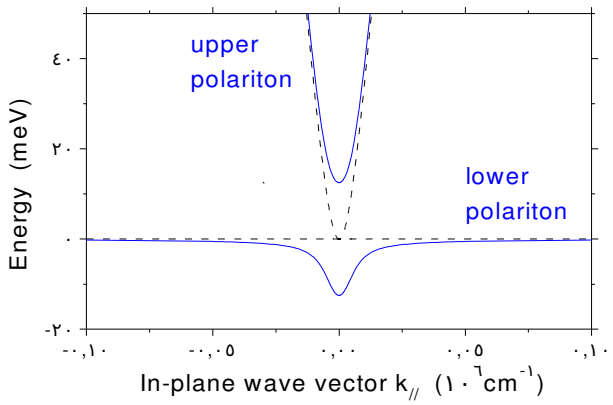

Figure 1. In-plane dispersion of polaritons (solid lines), exciton and photon modes (dashed lines) calculated for a CdTe microcavity embedding 16 quantum wells. Energy is scaled with respect to the exciton energy at 1690 meV in CdTe quantum wells. Polaritons at $k_{//} \sim 0$ in the lower polariton branch can undergo BEC.

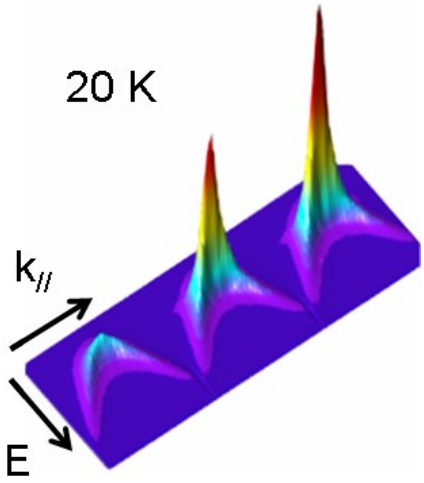

Figure 2. Pseudo-3D images of the population distribution in the lower polariton branch in energy-momentum space (E, $k_{//}$), for polariton densities just below (left) and above condensation threshold (center and right).