Exciton-polariton condensation in semiconductor microcavities

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An experimental technique of controlling spontaneous emission of an atom by use of a cavity is referred to as cavity quantum electrodynamics and has been extensively studied for atoms [1] and excitons [2]. Due to a strong collective dipole coupling between microcavity photon fields and QW excitons, a semiconductor planar microcavity features a reversible spontaneous emission or normal mode splitting into upper and lower branches of exciton-polaritons [3]. A metastable state of lower polariton at zero in-plane momentum (k=0) has emerged as a new candidate for observation of Bose-Einstein condensation (BEC) in solids [4]. An exciton-polariton has an effective mass of four orders of magnitude lighter than an exciton mass, so the critical temperature for polariton BEC is four orders of magnitude higher than that for exciton BEC at the same particle density. An exciton-polariton can easily extend a phase coherent wavefunction in space through its photonic component in spite of crystal defects and disorders, which is known as a serious enemy to exciton BEC.

In this talk we will discuss the recent progress on the dynamic condensation of exciton-polaritons and the application to quantum emulation of many body physics. Quantum degeneracy at thermal equilibrium condition was achieved by using a device structure with multiple quantum wells and a blue detuning regime [5]. The formation of a first order coherence (off-diagonal long range order) was confirmed by the Young's double slit interferometer [6] and the bosonic final state stimulation (photon bunching effect) was observed by the Hanbury-Brown and Twiss interferometer [7]. The spontaneous spin polarization was confirmed at condensation threshold [8], and the Bogoliubov excitation spectrum was observed above threshold [9]. Finally the Bose-Hubbard model was implemented in a one-dimensional array of polariton condensates, in which the competition between a superfluid zero state and pi state was observed [10].

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