Excitons in coherently-coupled quantum-confined systems

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Excitons in coherently coupled quantum confined systems, such as quantum dot molecules (QDMs), electron bilayers, and spatially separated electron-hole layers in heterostructures, will be reviewed and discussed. In such systems, it is possible to realize coherent coupling of single particle and collective states and due to that such systems may be of some interest for computation.

In the case of QDMs, the relative positions of the two dot structures coupled to form the molecule are well defined and the barrier width between dots can be varied by the fabrication technique. The coupling of the dots in molecular pairs and appearance of coherently entangled states can be demonstrated by optical spectroscopy measurements performed on a single molecule structure. It turns out that the fine structure of the ground state of exciton emission in an external magnetic field provides an efficient tool in such studies. In a magnetic field, distinctive anticrossings have been observed in the ground state of exciton multiplet (eight mixed spin components), which can occur only if the dots are quantum mechanically coherently coupled. With the use of model calculations it is found that these anticrossings occur for structures with "broken axial symmetry", namely with a lateral displacement of the dots relative to each other. Other evidence for the coherent coupling was obtained from measurements of the diamagnetic shift of the exciton luminescence in magnetic field applied in the Voight geometry, as the extension of the exciton wavefunction along the molecule axis is found to increase significantly. I will discuss other studies of the "bonding" and "antibonding" exciton states in QDMs that contribute to a more complete and systematic physical picture. Finally, I will discuss the coherent coupling of quantum dots in a molecule as a function vertical electric field in a Schottky-photodiode structure.

In the case of 2D-electron bilayers and coupled quantum wells, Bose condensation of interwell excitons in lateral traps will be the focus of my discussion. I will demonstrate that the luminescence of Bose-condensed collective state in a lateral trap is manifested in real space by a periodic coherent bright spot pattern. I will show that the vortex character of the Bose condensate of laterally confined interwell excitons is manifested in Fourier-transformed images (in k-space at a given frequency) by a peculiar angular distribution of luminescence intensity due to destructive interference. Therefore these systems also exhibit coherent coupling.