METASTABLE BOUND STATES OF THE TWO-DIMENSIONAL QUASI–BIMAGNETOEXCITONS

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The interactions and the bound states of the two-dimensional (2D) magnetoexcitons with different wave vectors $\vec{k}$ were considered. First of all the case of two magnetoexcitons with wave vectors $\vec{k}=0$ was investigated. Their gyration points coincide, their Landau quantization orbits overlap and such magnetoexcitons with electrons and holes situated on the lowest Landau levels look as neutral compound particles. The Coulomb interaction between them vanishes. Only the influence of the excited Landau levels (ELLs) and of the Rashba spin-orbit coupling (RSOC) can change the situation.

The interaction between the two-dimensional magnetoexcitons with in-plane wave vector $\vec{k}_{\|}=0,$ taking into account the influence of the excited Landau levels (ELLs) and of the external perpendicular electric field parallel with the strong magnetic field were investigated. The influence of the ELLs gives rise to the overall attraction between the spinless electrons and holes lying on the lowest Landau levels (LLLs), which in the Fock approximation leads to the repulsion between the magnetoexcitons with $\vec{k}_{\|}=0.$ The interaction constant g decreases inverse proportional with the increasing magnetic field strength B (g~1/B). In the presence of the perpendicular electric field the Landau quantization of the electrons and of the holes takes place under the influence of the Rashba spin-orbit coupling (RSOC), Zeeman splitting (ZS) and nonparabolicity of the heavy-hole dispersion law. The electrons and holes are withdrawn from the LLLs and are moving with new cyclotron orbits changing their Coulomb interactions as well as the affinities of the 2D magnetoexcitons with $\vec{k}_{\|}=0$ to interact between them. The changes of the Coulomb interactions imprinted by the electrons and by the holes moving in the new spinor states are characterized by the imprint coefficients, which in the absence of the electric field turn to be unity. The differences between the imprint coefficients of the electrons and of the holes forming the magnetoexcitons determine their affinities to the interactions. The interactions between six types of 2D magnetoexcitons F_n with n=1, 2…6 created by the combinations of two lowest electron states with three lowest heavy-hole states was studied. In these conditions 21 two-magnetoexciton pairs (F_n, F_m) can be formed. There are 6 pairs (F_i , F_i) of homogeneous magnetoexcitons with the same electron and hole states. The interaction between them is attractive, except one type of magnetoexciton with zero affinity. There are also 6 pairs of heterogeneous magnetoexcitons in which the electron and hole states are different. Two-magnetoexciton states created by four electron and hole states can be formed in two possible ways interchanging the electron and hole states. The superpositions of the two-magnetoexciton states with and without interchanging give rise to symmetric and antisymmetric states. There are also 9 semihomogeneous magnetoexciton pairs with either different electron states and with coincident hole states or vice versa. The semihomogeneous and heterogeneous magnetoexcitons forming the symmetric states attract each other, if their affinities have the same signs and undergo repulsion if their affinities have different signs. The interactions of the heterogeneous magnetoexcitons forming the antisymmetric states are of the opposite signs in comparison with the symmetric states. The interaction coefficients decrease with the increasing of the magnetic field strength B as $g \approx 1/\sqrt{B}$.

The magnetoexcitons with wave vectors $\vec{k} \neq 0$ look as 2D electric dipoles with their arms perpendicular to their in-plane wave vectors $\vec{k} \neq 0.$ The Coulomb interaction of such magnetoexcitons does not vanish and the creation of the Coulomb states of the molecule-type must be investigated. The wave function of the bimagnetoexciton was chosen introducing the magnetoexcitons creation operators with opposite wave vectors as well as the wave function of their relative motion.

The energy of the two bound magnetoexcitons with summary wave vector $\vec{k}=0$ was calculated using two trial wave functions of relative motion. In both cases the energy of the bound states are very close to the energy of two free magnetoexcitons with $\vec{k}=0.$