Magnetic field effect on the optical properties core-shell type II quantum dot

Holovatsky V.A.[1], Chubrei M.V.[1], Duque C.A.[2]

[1]Depatment of theoretical physics and computing modelling, Chernivtsi National University after Yuriy Fed'kovych. Kotsyubynsky, 2, Chernivtsi - 58012, Ukraine, E-mail: v.holovatsky@chnu.edu.ua

2 Grupo de Materia Condensada-UdeA, Facultad de Ciencias Exactas y Naturales, Instituto de Física, Universidad de Antioquia, Medellín AA 1226, Colombia

INTRODUCTION

This study presents a simple model within the effective mass approximation to describe the magnetic field impact on the energy structure and interband optical quantum transitions in type-II ZnTe/CdSe and CdSe/ZnTe spherical quantum dots. The dependencies energy spectra and wave functions of an electron and hole on the magnetic field are calculated by the diagonalization method for spherical quantum dots different sizes.

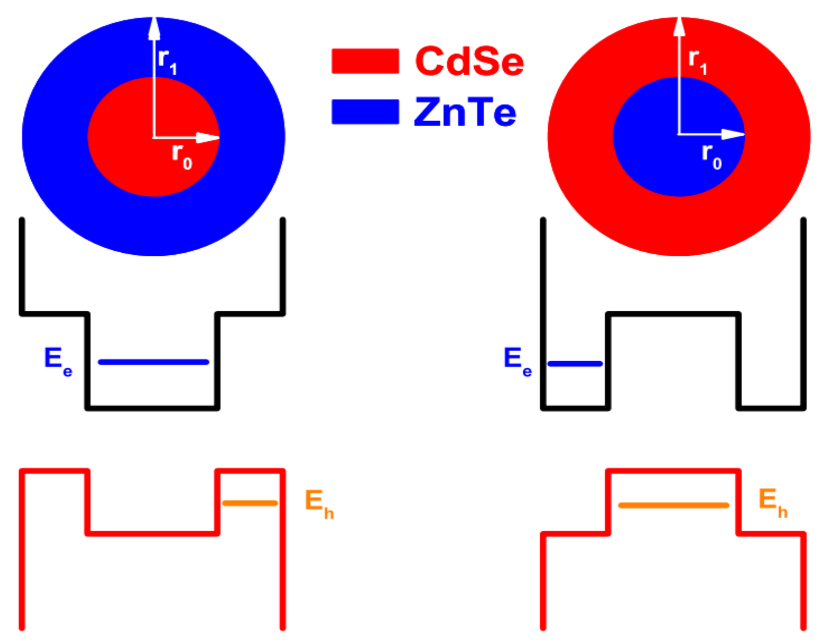


Fig. 1. Geometrical and potential shemes of CdSe/ZnTe and ZnTe/CdSe QDs

THEORETHICAL FRAMEWORK

In order to investigate the magnetic field effect on the electron energy spectrum and wave functions in the nanosystem with impurity it is necessary to solve the Schrodinger equation $H\psi_{jm}(\vec{r}) = E_{jm}\psi_{jm}(\vec{r})$ with the Hamiltonian

$$H = \left(\vec{p} - \frac{e}{c}\vec{A}\right)\frac{1}{2\mu(r)}\left(\vec{p} - \frac{e}{c}\vec{A}\right) + U_{e,h} \qquad (1)$$

where $\vec{A}$ is the vector potential, $U_{e,h}(r)$ is the confining potential.

$U_{e,h}(r)$ for CdSe/ZnTe has forms

$$U_e(r) = \begin{cases} 0, & 0 < r \le r_0 \\ V_e, & r_0 < r \le r_1 \\ \infty, & r > r_1 \end{cases} \qquad U_h(r) = \begin{cases} V_h, & 0 < r \le r_0 \\ 0, & r_0 < r \le r_1 \\ \infty, & r > r_1 \end{cases} \qquad (2)$$

$$\hat{H} = \vec{\nabla}\frac{\hbar^2}{2\mu_{e,h}(r)}\vec{\nabla} + \frac{eB}{2c\mu_{e,h}(r)}L_z + \frac{e^2B^2r^2\sin^2\theta}{8c^2\mu_{e,h}(r)} + U_{e,h}(r)$$

In order to solve the equation (1), the wave functions are expanded over the complete set of exact functions obtained without external fields [1-2].

$$\psi_{jm}(\vec{r}) = \sum_n \sum_l c_{nl}^{jm}\Phi_{nlm}(\vec{r}) \qquad (3)$$

To determine the coefficients c_{nl}^{jm} and energy spectrum E_{jm} we obtain the secular equation

$$\left|H_{n\ell,n'\ell'} - E_{jm}\delta_{n,n'}\delta_{\ell,\ell'}\right| = 0 \qquad (4)$$

RESULTS AND DISCUSSION

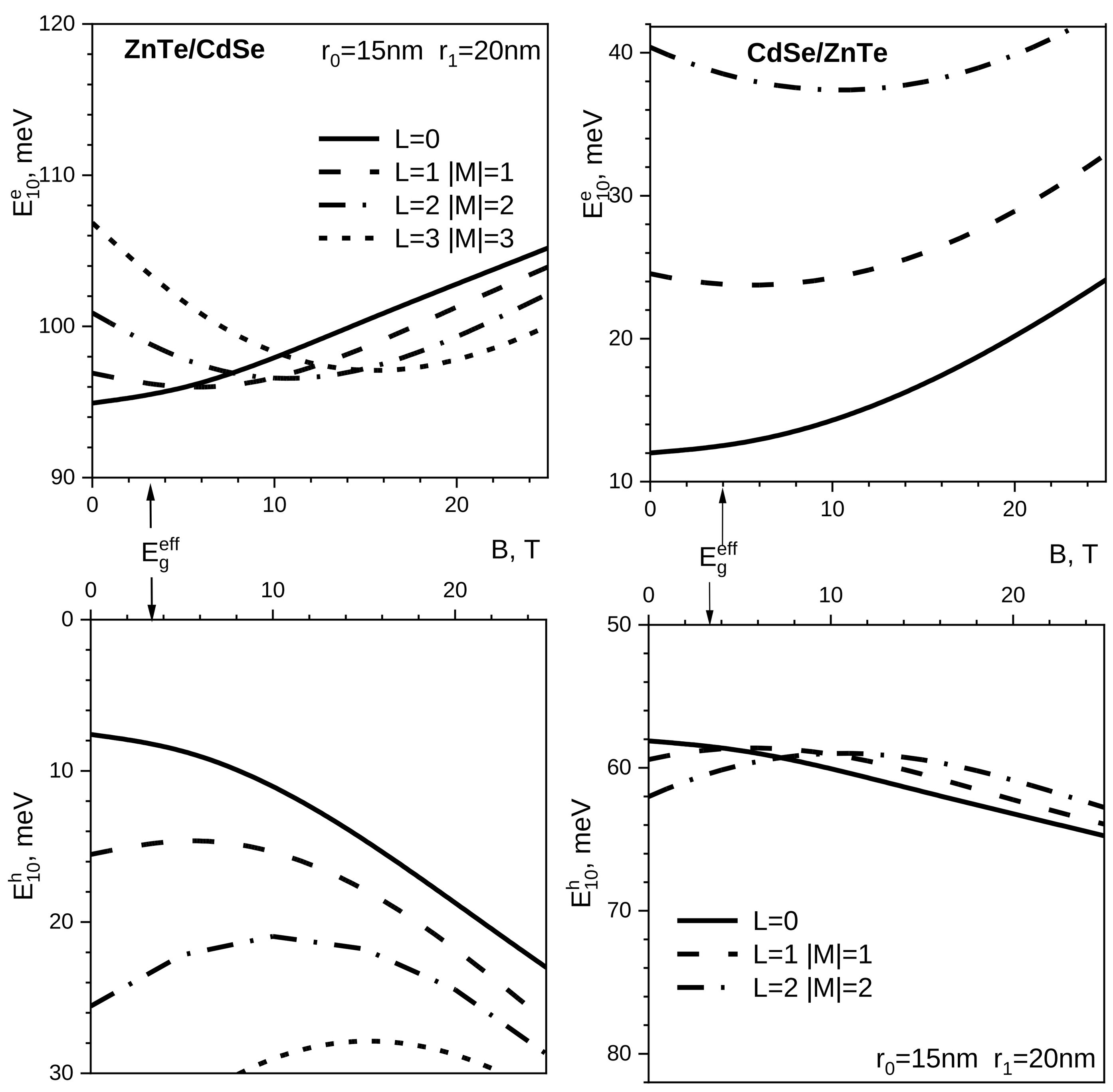
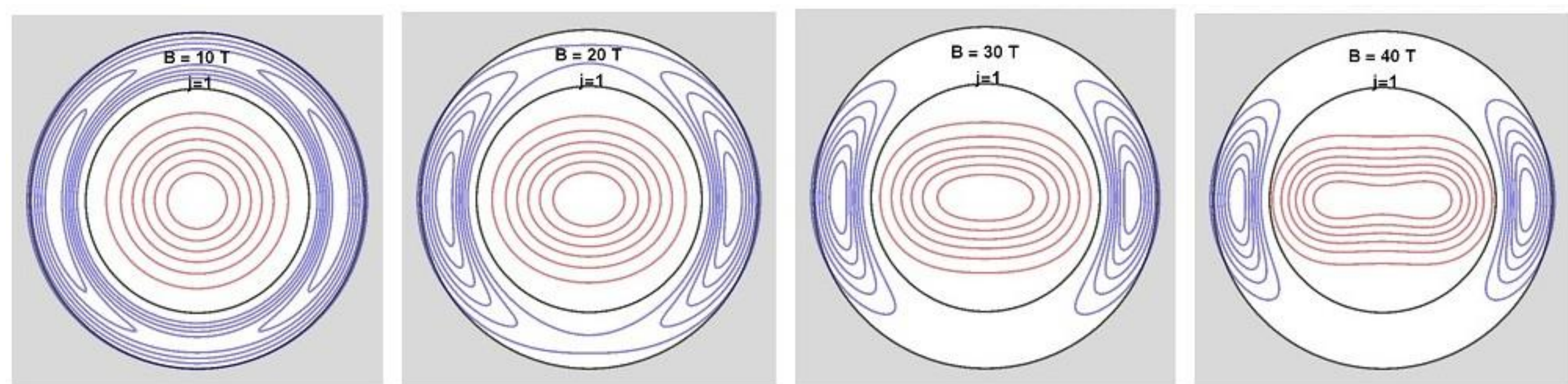
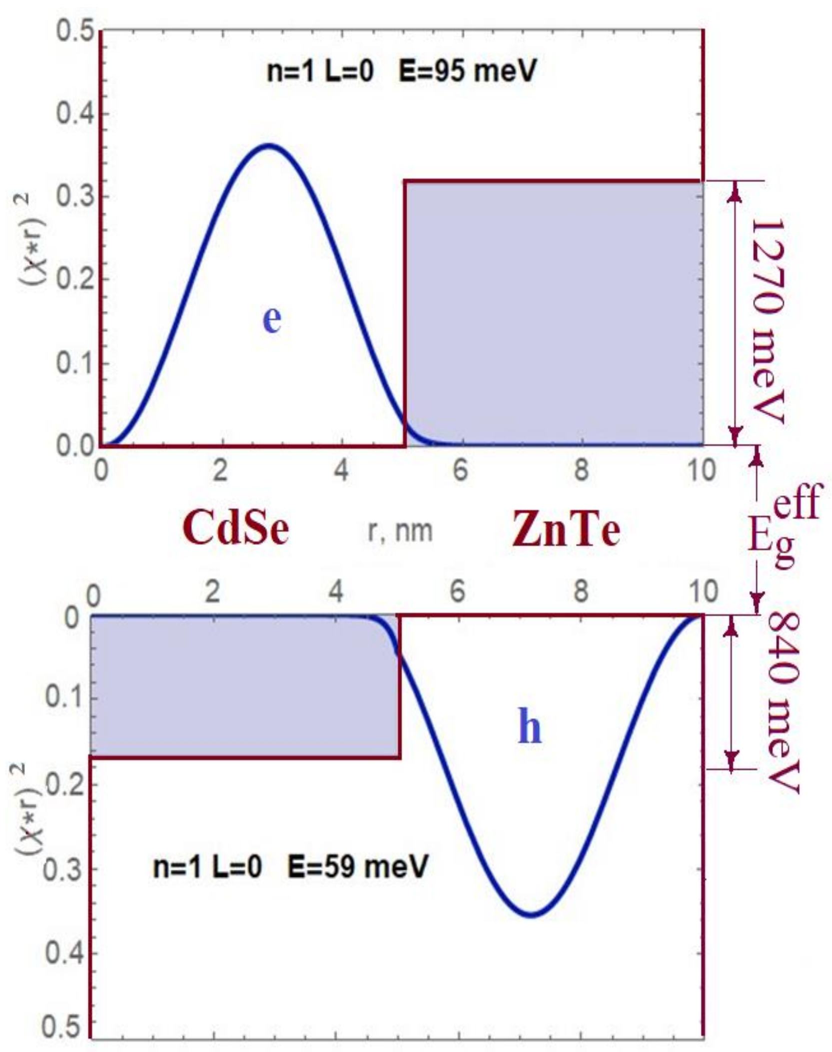


Fig. 2. Dependence of electron and hole energy in different statesin ZnTe/CdSe and CdSe/ZnTe nanosystems from the magnetic field strength.

Impact magnetic field on the electron and hole wave functions





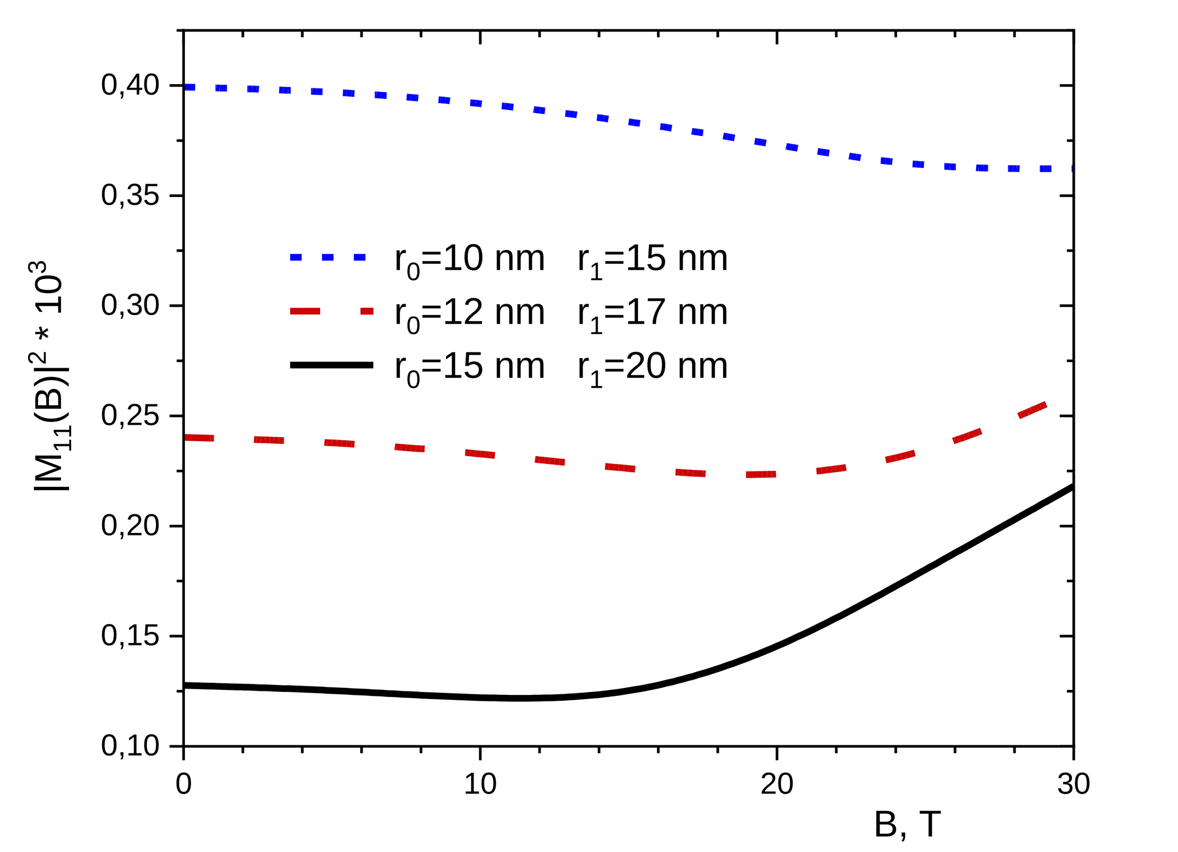


Fig. 3 Dependence of the overlap of the electron and hole wave functions in the |10> states in the ZnTe/CdSe nanosystem with different core radii on the magnetic field strength.

CONCLUSIONS

1. It is shown that the ground state of a quasiparticle localized in outer shell of a spherical nanosystem (an electron in a ZnTe/CdSe nanosystemand a hole in the CdSe/ZnTe nanosystem) with increasing magnetic field inductionis successively formed by the lowest energy states with |m|=0, 1, 2...(Aaronov-Bohm effect)

2. When the intensity of the magnetic field increases, the energy of the quantum transitionbetween the electron and hole ground states increases

3. The overlap of wave functions decreases as the size of the core of the nanosystem increases,and when the magnetic field increases, it has a non-monotonic dependence: slowly at firstdecreases, and then sharply increases

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