Stationary and quasistationary electron spectrum in quantum wire and quantum anti-dot with impurity

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Recently, the investigation of open or resonance-tunnel semiconductor heterostructures has been essentially accelerated. It is caused by the unique perspectives of their utilization for the creation of field transistors, diodes and quantum cascade lasers.

The theory of electron energy spectrum and wave functions in open spherical quantum dots has been developed using the S-matrix method within the effective masses and rectangular potentials approximations. It allows obtaining the dependences of electron energy spectrum and life times on the geometrical parameters. However, using it for the investigation of exciton spectrum or interaction between electron and impurity in open nanosystem is rather sophisticated or simply impossible. We propose the alternative method of electron energy spectrum investigation in open quantum dots at the base of two models:

1. For open semiconductor cylindrical quantum dot (CQD) embedded into the quantum wire, the one-well open CQD is approximated by the respective complicated closed three-well CQD with the very big heights of outer QD's. When the heights of outer QD's are varying till the physical infinity, the stationary electron spectrum is transforming into the quasi-stationary one with the respective resonance energies and widths. The proposed mechanism of three-well closed CQD (inside of QW) transformation into the single one-well open CQD (inside of QW) allows solving the problem of exciton spectra in open CQD (inside of QW).

2. The electron in the Coulomb field of donor impurity, placed into the center of spherical anti-dot is under study. Due to the presence of both Coulomb potential of impurity and rectangular potential of quantum anti-dot, the electron potential consists of two potential wells: inner-deep and outer-shallow. Consequently, the electron energy spectrum consists of stationary and quasi-stationary states. The energy spectrum and life times in the open nanosystem are obtained within the probability distribution of electron location in the inner well and barrier.