Theory of electric field effect on the optical properties of elliptical quantum wires

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Modern technologies allow the growth of semiconductor quantum wires with various cross-sectional shapes. Theoretical studies are mainly carried out for cylindrical quantum wires, as exact solutions of the Schrödinger equation exist in this case. Wave functions are obtained analytically using Bessel functions, enabling their use in constructing solutions for more complex problems.

Elliptical nanowires, due to the anisotropy of their shape, possess unique physical properties that can be utilized to create new electronic nanostructures with pronounced anisotropy of intensity and polarization of emitted light.

In this study, the effect of a perpendicular electric field on the energy spectrum and wave functions of quasiparticles in an elliptical quantum wire is investigated. For this, solutions of the Schrödinger equation were calculated by the matrix method on the base exact wave functions for the case of an absent electrical field. The angular and radial parts of the exact quasiparticle wave function are expressed in terms of even and odd angular and radial Mathieu functions of the first kind.

It is shown that the spectra of electrons consisting of energy subbands correspond to the even and odd states of quasiparticle, which depend differently on the ellipticity of the nanosystem. In the case of a cylindrical quantum wire, the energy levels are degenerate. Only the quasiparticle ground state, which is an even state, is nondegenerate.

The selection rules were established and the dependences of the oscillator strength of the electron intersubband quantum transitions in the dipole approximation on the ellipticity of the nanosystem and the electric field strength were obtained.

As a result of the calculations, it is shown that the ground state of the electron undergoes the largest shift under the action of the electric field. Its wave function is the most deformed. This is reflected in the electric field dependencies of the elliptical quantum wire's optical properties.

1. Holovatsky V., Gutsul, V. Electron energy spectrum in core-shell elliptic quantum wire// Condensed Matter Physics.-2007.-10.-P. 61.