Energy levels of a particle confined in a potential well of ellipsoidal shape

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The theoretical and experimental investigation of nanosized crystalline semiconductor objects continues to attract a great attention. The most important result that has been revealed in the previous investigations is the strong interdependence between the character of energy spectrum of the nanosized object and its geometrical parameters, such as size and shape.

The geometrical parameters of nanoobjects depend strongly on the way in which they are produced. Thus at the growing of semiconductor nanoobjects by means of different methods, the energy spectrum continually changes depending on the size and shape of nanoobjects. The experimental studies of nanoobjects indicate that the smaller nanoparticles have nearly rounded shape, whereas the large nanoparticles have an ellipsoidal shape. For applications the ellipsoidal nanoparticles play very important role and the most promising candidate for the technological applications are the ellipsoidal prolonged nanoparticles. Therefore, knowledge of the electronic and optical properties of ellipsoidal nanoparticles is crucial for the further technological advance. For the nanoparticles of ellipsoidal shape analytical calculation of the energy spectrum and appropriate wave functions is a complicated task even in the one-particle approximation. The problem can be solved analytically in the two limiting cases: for the nanoparticles of nearly rounded shape and strongly prolate ellipsoidal shape by using the small parameters appearing in these cases.

From the theoretical point of view, spherical quantum dots are the most easier to investigate. The effects of the departure from sphericity of the quantum dots on the energy spectrum have been studied theoretically by several authors. Obviously, the first attempt to consider a charged particle confined inside a spheroid has been done in [1]. In this work has been assumed that a spherical potential well with infinitely high walls is subject to a small deformation, which gives it the form of a slightly prolate or oblate spheroid. The splitting of the energy levels of a particle has been found using perturbation theory. The expression derived in [1] for the energy spectrum is obtained under assumption that the deformation does not change volume of spherical quantum dot.

In the present study we investigate an alteration of the energy spectrum when the shape anisotropy of nanoparticle increases. For this we solve the problem for slightly deformed spherical quantum dot (without making any restriction on a volume of quantum dot), and then we treat the problem for nanorod of strongly prolate ellipsoidal shape. After that we suggest the correlation rule for the obtained two sets of states and thereby we determine an alteration of the energy spectrum when the nanoparticle aspect ratio changes.

References

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