T-matrix Approach to Studying Electronic Properties of Graphene Nanostructures

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Abstract: The T-matrix approach well-known in physics of semiconductor nanostructures is developed for studying electronic properties of graphene nanostructures. In difference from conventional semiconductors, the charge carriers in pristine graphene obey the Dirac relativistic equation for massless fermions. As a result, Dirac electrons in graphene can tunnel through any potential barrier regardless of its height and width. Such the so-called Klein tunneling is a challenging task one has to solve in the way of confining charge carriers to form desired nanostructures such as quantum wells or quantum dots. For the graphene under any one-dimensional potential barrier we have (1) suggested the T-matrix based simple equation the solutions of which entirely determine both the position and the width of the resonant levels induced, (2) derived the expressions for the current as well as the conductance, (3) calculated the electronic band structures showing an existence of additional Dirac points and the conductivity demonstrating an anisotropic renormalization of the group velocity for the electrostatic potential induced graphene Kronig-Penny superlattice, calculated the electronic band structures of the magnetic field induced superlattices showing an existence of new Dirac points at non-zero energies, and critically studied the conduction and the shot noise in the gate-controlled graphene pn / pnp-junctions, taking into account the minimum conductivity widely observed in experiments.

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