TRANSMISSION OF ELECTRONS THROUGH THE BARRIERS OF VARIOUS ORIGIN IN THE 3D TOPOLOGICAL INSULATORS

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The object of our investigation is a 3D topological insulator the surface states of which are described by the Dirac-like equation and the pseudospin of the quasiparticles that obey this equation is equal to one. We use the continuum model and the transfer matrix method for our evaluations. The transmission spectra, i.e. the dependencies of the transmission rates on the quasiparticles energy and on the angle of incidence through the electrostatic, magnetic and the Fermi velocity barriers are calculated. It is shown that these spectra display the resonant tunneling character. The dependence of spectra on the magnitude of the electrostatic and the magnetic potentials, as well as on the values ​​of the Fermi velocity in the barrier and in the out-of-barrier regions, is studied.

The most characteristic and interesting property of the investigated structures is the manifestation in them of a phenomenon known as the Klein supertunneling: for energy values ​​equal to half the electrostatic barrier, its quantum transparency is perfect for all angles of incidence of quasiparticles on the barrier. We also show that for the case of tunneling through the combined electrostatic and the Fermi velocities barriers the Klein supertunneling also takes place, but for some other energy values not equal to half the electrostatic barrier, these values ​​being dependent on the Fermi velocity barrier magnitude. An analytical formula for this dependence is obtained.

In the case of magnetic barriers, the Klein supertunneling is suppressed.

In the considered structures, the Klein tunneling phenomenon is also observed, that is, the transmission of fermions through the barriers is the perfect one (T = 1) for the case of normal incidence of quasiparticles on the barriers. The presence of magnetic barriers leads to the fact that the Klein tunneling occurs not for the normal, but for the inclined incidence of quasiparticles on the barriers.

It is shown that the dependence of the transmission coefficient T on the value of the electrostatic potential is a periodic function.

An important feature is also the presence in the transmission spectra of the critical angle of incidence of quasiparticles on the barriers. In a wide range of parameter values, barriers become opaque for particles that fall on them at an angle that exceeds a critical angle. This feature allows you to use the investigated structures, in particular, as wavevector filters. The results of our work can be applied for controlling the transmission spectra of the 3D topological insulators.