Transport of the relativistic quasielectrons through the potential barrier in the alfa-T3 model

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We consider here one of the modern structures: the so called alfa-T3 model [1] which interpolates between the dice lattice and the graphene one with the help of the parameter α that allows to change the coupling strength between the honeycomb lattice (HCL, graphene) and the HCL with the central cite (dice lattice) and varies from zero to unity.

It is shown that this object in the general case is a resonant-tunneling structure, that is, its transmission spectra are represented by a set of resonance peaks with the values of the transmission coefficient T close to unity. In particular, for the values of = < 1, where *vF2*, *vF1* - Fermi velocities in the barrier and out-of-barrier regions, there is a clear structure of the resonance peaks of the Fabry-Perot type for any α values; their position on the energy axis depends on the value of n.

In the case of a zero incidence angle (Θ = 0), there is a Klein paradox phenomenon which occurs for all values ​​of n and α and for any values ​​of the height and width of the potential barrier (U and d respectively). In the vicinity of the energy values ​​close to the height of the potential barrier E ~ U there is a forbidden band (gap) whose width and position are regulated by the values ​​of the quantities n, Θ and do not depend on α. Also for certain values ​​of n there exists a critical angle of incidence Θс such that for the angles Θ> Θc the barrier is completely opaque for the quasielectrons. The value of Θc definitely depends on α.

As the value of α increases, a significant increase of the transmission coefficient for all values of E and n is observed. For the magnitude α = 1, there is a phenomenon of supertunneling. The energy for which the supertunneling takes place is the function of n and is expressed by the formula E = U / (1 ± n), n <1, provided that α = 1.

The conductivity of the given structure G (E) is evaluated with the help of the Landauer-Buttiker formula and, as shown, essentially depends both on the value of α and on the value of n. Specifically, the conductivity increases with increasing in α and has a complex dependence on n. In particular, for values n> 1, the quantity G (E) decreases with increasing n for all α. For n <1, the function G (E) is characterized by regions with the conduction oscillations, as well as with the regions with a wide minimum in the vicinity of the energy close to the potential barrier height.

1. Klein tunneling in the alfa-T3 model. E. Illes, E.J. Nicol, Phys. Rev. B 95, 235432 (2017).