Two-dimensional Klein tunnelling for massive Dirac fermions with a defined helicity[1]

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Abstract

We study the role played by the helicity in the two-dimensional Klein tunnelling for massive Dirac fermions. To this end, we consider the cases in which massive Dirac fermions with a defined helicity are scattered by step and barrier electrostatic potentials. For each potential, we first calculate the contributions of fermion states with conserved and inverted helicity to the reflection and transmission coefficients, analysing how the potential (V_0), fermion's mass, energy (E) and angle of incidence affect them. In the step potential case, we find that the transmission probability for fermion states with inverted helicity is small when $V_0 < E$, but becomes dominant when $V_0 > E$. In the barrier potential case, this probability is always null. This behaviour is explained by the breaking of the helicity conservation by the mass term, allowing the reflection of states with inverted helicity in both potentials, and transmission of inverted helicity states only in the step potential. Finally, we give some insights on the consequences of our results in materials with Dirac-like quasiparticles, such as graphene, topological insulators, and Weyl semimetals.

References

[1] Navarro-Giraldo J and Quimbay C 2020 Two-dimensional Klein tunneling for massive Dirac fermions with a defined helicity *Ann. Phys. (N. Y)*. **412** 168022