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The Dirac impenetrable barrier in the limit point of the Klein energy zone

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We reanalyze the problem of a 1D Dirac single-particle colliding with the electrostatic potential step of height V_0 with an incoming energy that tends to the limit point of the so-called Klein energy zone, i.e., $E \to V_0 - \mathrm{m}c^2$, for a given V_0. In this situation, the particle is actually colliding with an impenetrable barrier. In fact, $V_0 \to E + \mathrm{m}c^2$, for a given high relativistic energy $E\,(< V_0)$, is the maximum value that the height of the step can reach and that ensures the perfect impenetrability of the barrier. Nevertheless, we notice that, unlike the non-relativistic case, the entire eigensolution never completely vanishes, neither at the barrier nor in the region under the step, but its upper component does satisfy the Dirichlet boundary condition at the barrier. More importantly, by calculating the mean value of the force exerted by the wall on the particle in this eigenstate and taking its non-relativistic limit, we recover the expected result.

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