Potential Scattering in Dirac Field Theory

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We have developed the potential scattering of a spinor within the context of perturbation field theory [1]. As an application, we have reproduced, up to second order in the potential, the diffusion results for a potential barrier of quantum mechanics. An immediate consequence is a simple generalization to arbitrary potential forms, a feature not possible in quantum mechanics.

The agreement between our field theory calculations and the diffusion results for a potential barrier of quantum mechanics is not an obvious prediction, a priori. First, because the calculational methods are very different. Secondly, because, while in quantum mechanics continuity plays a major role, in field theory continuity never appears, but antiparticles do. For example they are intrinsic in the Feynman propagator. Furthermore, while for diffusion there are no particular surprises with the quantum mechanical results, this is not true for tunnelling. In tunnelling, it has been shown elsewhere that the Hartman effect exists. This is an apparent violation of causality which we do not expect in any field theory calculation. Indeed, it was one of the original stimuli for developing the above formalism. Unfortunately, our results do not extend into the tunnelling region. However, one of the advantages of the above agreement, which we postulate holds to all orders, is that it confirms the correctness of our procedures. An important consequence of our formalism is that, since the potential functions are merely integrated over, the application of our procedures to any potential shape is straightforward, and in some cases, when the integrations can be performed analytically, even simple. This is not the case for general step-wise potentials in quantum mechanics. There, the calculational difficulties (coupled matrix equations) grow at least linearly with the number of potential discontinuities.

• The collaboration is now formalized as part of the interuniversity agreement between the State University of Campinas (Brazil) and the University of Salento (Lecce, Italy).

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