SEMINARIO

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Point interactions in 1D relativistic quantum mechanics: physical parameters and symmetries

Abstract: Appart from the applications in several models, point interactions in one dimension also serve as a theoretical laboratory to investigate properties of some methods of regularisation and/or renormalisation, which are ubiquitous in quantum field theory, in simpler models in quantum mechanics. In the Schrödinger or Dirac equation, the term describing the particle's interaction with an external potential is usually given in terms of a product between the potential and the wave function. However, point potentials are described by singular distributions, like the Dirac delta distribution or its derivatives, and products involving distributions are not universally defined in the (Schwarz's) theory of distributions. Mathematically, this problem is usually addressed by using the approach of self-adjoint extensions (SAE) of symmetric operators. From this approach all the admissible point interactions are members of a family characterised by 4 real parameters, related to the boundary conditions the wave function must satisfy around the singular points. However, from a physicist's point of view, the SAE approach is somewhat abstract, and the physical interpretations of such parameters are not clear. Recently, we proposed an alternative and also mathematical consistent approach, based on Schwarz's theory of distributions, to deal with this problem. This distributional approach seems to be more physically appealing, and it results in the same family of admissible interactions obtained from SAE, with the advantage of specifying the details of the interaction as a distribution concentrated at the singular points. More recently, we applied this approach to the Dirac equation with an external point interaction, and were able to establish a relationship between the set of the original 4 parameters and a set of 4 physical parameters describing the singular potential, namely the strengths of a scalar, the two components of a Lorentz 2-vector and a pseudo scalar point potential. The identification of these relationships allowed us to study some physical symmetries of the system. In particular, by considering space inversion, we were able to define the notions of even and odd point interactions. The existence of odd point interactions in relativistic quantum mechanics may shed some light on the non relativistic problem of defining a point interaction properly associated to the derivative of a delta potential (an odd distribution).

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