TRANSITIONAL CURRENTS FOR MASSIVE SPIN ONE-HALF PARTICLES

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Abstract

It is shown that bispinor bilinear forms $u_\alpha(p,s)\bar{u}_\beta(p',s')$ are expressible up to a phase factor in terms of explicitly covariant foldings of the vectors p, p' (particle momenta) and s, s' (polarizations) with the Dirac gamma-matrices. Using the covariant representation for these forms, explicit expressions for all transitional currents of spin-half particles are constructed.

1. INTRODUCTION

In the non-relativistic quantum mechanics, cross section of processes with participation of spin-half particles are determined by matrix elements containing transitional currents $\chi^+(\zeta')\chi(\zeta)$ and $\chi^+(\zeta')\sigma\chi(\zeta)$,where σ are Pauli matrices, $\chi(\zeta')$, $\chi(\zeta)$ are spinors describing particles with polarizations ζ', ζ. The dependence on the vectors ζ', ζ is not explicit. In order to determine dependence of the cross sections on the polarizations of particles, a standard trick is used (see e.g. Ref. 1): spinors are removed from absolute squares of matrix elements with the use of technique of the projection operators, as a result of which we obtain an algebraic expression which depends on the vectors ζ', ζ in an explicitly covariant form with respect to rotations in the three dimensional space. A question arises, whether it is possible to replace, already in the amplitudes, transitional currents by explicitly covariant algebraic expressions without any reference to spinors?

A similar problem exists in the relativistic quantum theory. Cross-sections and decay probabilities contain currents defined through the Dirac bispinors. In currents of this kind, explicit dependence on the particle momenta and polarizations remain hidden, putting some problems in analyzing asymptotics, polarization effects, etc. Like in the non-relativistic quantum mechanics, bispinors are removed covariantly from absolute squares of the matrix elements.[2] In the case of complicated Lorentz structure of transition probabilities, it appears desirable to work with explicitly covariant expressions for the amplitudes. For instance, the Compton amplitude is a folding of the rank two tensor with polarization vectors of two photons. The cross-section is determined already by a rank four tensor, which is more difficult to analyze.

In this work we consider the problem of finding algebraic representations for transitional currents of spin-half particles in the non-relativistic and relativistic quantum theory (see also Refs. 3,4). We start in the next section from a discussion of the bilinear

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