p-n and $\pi^+ - \pi^0$ Electromagnetic Mass Differences in Nonlocal Field Theory (*)

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Summary. — We perform a calculation of p-n and $\pi^+ - \pi^0$ electromagnetic mass differences using form factors derived from a nonlocal field theory. This theory requires the introduction of a fundamental length ($l \approx 1/2m_e$) and of one timelike vector $u(L)$ associated with a particular Lorentz frame (vertex frame).

1. - Introduction.

The purpose of this work is to perform the calculation of mass differences, due to the deviations from isotopic-spin symmetry, using a nonlocal theory of space-time.

Such a theory requires not only a certain small length (fundamental length $l$) but also the presence of one (or several) fixed timelike vectors $u(L)$ associated with a class of Lorentz frames $L$. The necessity for this frame dependence arises from the fact that space-time has an indefinite metric which makes it impossible to define notions such as «nearness» or «smallness» without introducing any additional structure.

The choice of the vector $u(L)$ may be made in two principally different ways:

a) The vector $u(L)$ is «exterior» to the system of interacting particles. A similar possibility is treated by INGRAHAM (1).

(*) To speed up publication, the authors of this paper have agreed to not receive the proofs for correction.

b) The vector \( u(L) \) is «interior» to the system of interacting particles and may be connected with their four-momenta. This possibility was investigated by G. Wataghin \(^{(2)}\) and later by Blokhintsev and Kolerov \(^{(3)}\).

Our method of inserting \( l \) and the whole ensemble \( u(L) \) in the \( S \)-matrix is the «interior» one, following the prescriptions given by G. Wataghin \(^{(4)}\).

The calculated mass differences are considered as an electromagnetic perturbation on mass renormalization due to the strong interaction.

2. - Form factors.

Using the nonlocal theory of G. Wataghin \(^{(4-5)}\), we formulate the rules of the cut-off in momentum space in the following way.

Let \( P_{\mu} \) be the momentum-energy four-vector of the physical particles created or annihilated in the given vertex and let \( P_{\mu} P_{\mu} = -M^2 \); to this vertex we associate a frame \( V \) (the vertex frame) defined by the condition \( P = 0 \). Putting

\[
\mu = \frac{P_{\mu}}{M},
\]

which in the \( V \)-frame reduces to \( u_\mu = (0, 0, 0, i) \), we can define for each four-vector \( K_\mu = (K, iK_0) \) the invariants

\[
I_+ = [K_\mu K_\mu + (K_\mu u_\mu)^2]^{1/2}, \quad I_\mu = |K_\mu u_\mu|.
\]

Finally we associate with any creation operator of a particle, having four-momentum \( K_\mu \) and rest mass \( m \), the invariant cut-off operator

\[
G^+(K, u) = \frac{1}{1 + l^2 I_+^2} \frac{1 + ilm}{1 + ilI_\mu},
\]

and with any annihilation operator, the invariant cut-off operator

\[
G^-(K, u) = \frac{1}{1 + l^2 I_+^2} \frac{1 - ilm}{1 - ilI_\mu},
\]

where \( l \) is the «fundamental length ».

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