433(1): Method of Quantization of the Strong Field

In the theory, the strong field is defined by the force magnitude:

$$F = -\left(\frac{dm(r)}{dr}\,\frac{m^{1/2}(r)}{2m(r) - r\dfrac{dm(r)}{dr}}\right)E \quad -(1)$$

where

$$E^2 = p^2c^2 + m(r)\,m^2c^4 \quad -(2)$$

is an expression for the energy of the field. Eq. (1) can represent the strong force between neutrons and protons or the strong force between quarks inside a proton or neutron.

Eq. (2) can be be quantized into a wave equation as in UFT 431 using:

$$E = i\hbar\frac{\partial}{\partial t}, \quad \underline{p} = -i\hbar\underline{\nabla} \quad -(3)$$

to obtain:

$$\left(\Box + m(r)\left(\frac{mc}{\hbar}\right)^2\right)\phi = 0 \quad -(4)$$

where

$$m(r) = -\frac{\hbar}{mc}\,q^{\nu}_{a}\,\partial^{\mu}\left(\omega^{a}_{\mu\nu} - \Gamma^{a}_{\mu\nu}\right) \quad -(5)$$

Eq. (4) was developed in UFT 431, where it was shown that ϕ has features reminiscent of the Bessel equation. It is immediately clear from eq. (4) that the pion masses are determined by $m(r)$ and ϕ. There are three pions, so eq. (4) should give three masses through choice of $m(r)$ and ϕ.

Second quantization occurs through the de Broglie Einstein equation:

$$E^2 = p^2c^2 + n(r)m^2c^4 = \hbar^2\omega^2 \quad -(6)$$

and because of the fact that the pion travels at close to the speed of light:

$$E^2 = \hbar^2\kappa^2c^2 + n(r)m^2c^4 = \hbar^2\omega^2 \quad -(7)$$

with

$$\omega \sim \kappa c \quad -(8)$$

so

$$E = \hbar\omega \quad -(9)$$

to a good approximation. Eq. (9) is always true provided that

$$\hbar^2\omega^2 = \hbar^2\kappa^2c^2 + n(r)m^2c^4 \quad -(10)$$

i.e.

$$\omega^2 = \kappa^2c^2 + n(r)\frac{m^2c^4}{\hbar^2} \quad -(11)$$

The energy levels of the field can be obtained by writing Eq. (2) as:

$$E^2 - n(r)m^2c^4 = p^2c^2 \quad -(12)$$

i.e.

$$\left(E - n(r)^{1/2}mc^2\right)\left(E + n(r)^{1/2}mc^2\right) = p^2c^2 \quad -(13)$$

so

$$E = \frac{p^2c^2}{E + n(r)^{1/2}mc^2} + n(r)^{1/2}mc^2 \quad -(14)$$

The usual Dirac theory assumes that E in the denominator of eq. (14) can be approximated by the rest energy

$$E_0 = n(r)^{1/2}mc^2 \quad -(15)$$

) but if the pion travels close to the speed of light this approximation can no longer be used.

However, from eqs. (9) and (14):

$$E = \frac{p^2c^2}{\hbar\omega + m(r)^{1/2}mc^2} + m(r)^{1/2}mc^2 \quad -(16)$$

so

$$E\phi = \frac{-\hbar^2c^2\nabla^2\phi}{\hbar\omega + m(r)^{1/2}mc^2} + m(r)^{1/2}mc^2\phi \quad -(17)$$

From Eq. (12):

$$(\hbar\omega)^2 = p^2c^2 + m(r)m^2c^4 \quad -(18)$$

and using the quantization:

$$\underline{p}\phi = -i\hbar\underline{\nabla}\phi \quad -(19)$$

$$-(20)$$

eq. (18) quantizes to:

$$(\hbar\omega)^2 = -\hbar^2c^2\int\phi^*\nabla^2\phi\, d\tau + m^2c^4\int\phi^* m(r)\phi\, d\tau$$

so:

$$m^2c^4 = \frac{(\hbar\omega)^2 + \hbar^2c^2\int\phi^*\nabla^2\phi\, d\tau}{\int\phi^* m(r)\phi\, d\tau} \quad -(21)$$

Therefore the masses of the pions are given by the equation:

$$m^2 = \frac{1}{c^4}\left(\frac{(\hbar\omega)^2 + \hbar^2 c^2 \int \phi^* \nabla^2 \phi \, d\tau}{\int \phi^* n(r) \phi \, d\tau} \right) \quad -(22)$$

The masses of the rest pions are given by:

$$m^2 = \frac{1}{c^4}\left(\frac{(\hbar\omega)^2}{\int \phi^* n(r) \phi \, d\tau} \right) \quad -(23)$$

and in Minkowski spacetime:

$$\hbar\omega = mc^2 \quad -(24)$$

which is the de Broglie rest mass equation, because in Minkowski spacetime:

$$n(r) = 1 \quad -(25)$$

and

$$\int \phi^* \phi \, d\tau = 1. \quad -(26)$$