## 4?(?): The Full Extent of the Particle Spectrum

This is realized by considering papers such as UFT247 to UFT249. The semi classical interaction is essentially the minimal prescription:

$$E \rightarrow E - e\phi \quad -(1)$$

and

$$\underline{p} \rightarrow \underline{p} - e\underline{A} \quad -(2)$$

in electromagnetism. So the Einstein energy equation becomes:

$$(E - e\phi)^2 = c^2 (\underline{p} - e\underline{A})^2 + m^2 c^4 \quad -(3)$$

After quantization, Eq. (3) leads to:

$$(H_1 + H_2 + H_3)\phi = E\phi \quad -(4)$$

where:

$$H_1 = mc^2 + e\phi \quad -(5)$$

$$H_2 = \frac{1}{2m} \underline{\sigma} \cdot (-i\hbar \underline{\nabla} - e\underline{A}) \underline{\sigma} \cdot (-i\hbar \underline{\nabla} - e\underline{A}) \quad -(6)$$

$$H_3 = \frac{1}{2m} \left( \underline{\sigma} \cdot (-i\hbar \underline{\nabla} - e\underline{A}) e\phi \, \underline{\sigma} \cdot (-i\hbar \underline{\nabla} - e\underline{A}) \right) \quad -(7)$$

Considering initially the interaction between a proton and neutron in Minkowski spacetime, where:

$$n(r) = 1 \quad -(8)$$

then the electromagnetic momentum $e\underline{A}$ is replaced by the momentum $\underline{v}$ of the strong field, and $e\phi$ is replaced by the potential of interaction between the strong field and neutron. So eq. (4) becomes:

$$(H_1 + H_2 + H_3)\phi = E\phi \quad -(9)$$

where:

$$H_1 = mc^2 + U \quad -(10)$$

$$H_2 = \frac{1}{2m} \underline{\sigma} \cdot (-i\hbar \underline{\nabla} - \underline{v}) \underline{\sigma} \cdot (-i\hbar \underline{\nabla} - \underline{v}) \quad -(11)$$

2)

and:

$$H_3 = \frac{1}{2m} \underline{\sigma} \cdot \left( -i\hbar \underline{\nabla} - q \right) U \underline{\sigma} \cdot \left( -i\hbar \underline{\nabla} - \underline{V} \right) \quad -(12)$$

At this stage, the strong force between the proton and neutron is being treated as classical, but there is already a lot of structure in these equations. This structure parallels that of the semiclassical interaction between the electromagnetic field and the electron in the Dirac theory: the g factor of two, the half integral spin, the Zeeman effects and spin orbit coupling.

The expectation value of eq. (10) is:

$$E = \langle H_1 \rangle = mc^2 + \langle U \rangle \quad -(13)$$

where

$$U = \frac{q_1 q_2}{4\pi \epsilon_0 r^2} \quad -(14)$$

so

$$E = \langle U \rangle = \int \psi^* \frac{q_1 q_2}{4\pi \epsilon_0 r^2} \psi \, d\tau \quad -(15)$$

and produces quantized energy levels and a mass spectrum defined by:

$$m = \frac{E}{c^2} \quad -(16)$$

A mass spectrum appears even on the semi classical level, and even from the simplest hamiltonian, $H_1$. These masses can be observed in the collision of a proton and atom, specifically from the repulsive potential (14) between the proton and the protons of the atomic nucleus. The particles released in this collision are observed as energies.

Note carefully that on the Minkowski level there is no strong force, because in m theory the strong force is produced by

$$m(r) \neq 0; \quad \frac{dm(r)}{dr} \neq 0 \quad -(17)$$

Next consider the hamiltonian (11) of the Minkowski level. It can be developed as:

$$H_2 \psi = \frac{1}{2m} \left( -\hbar^2 \nabla^2 \psi + q^2 \psi + i\hbar \underline{\nabla} \cdot (\underline{q} \psi) + i\hbar \underline{q} \cdot \underline{\nabla} \psi - \hbar \underline{\sigma} \cdot \underline{q} \times \underline{\nabla} \psi - \hbar \underline{\sigma} \cdot \underline{\nabla} \times (\underline{q} \psi) \right) = E \psi. \quad -(18)$$

So many new energy levels and masses are produced from the expectation values:

$$E = \langle H_2 \rangle \quad -(19)$$

and there are energy levels produced by the $\underline{q}$ dependent terms:

$$E = \frac{1}{2m} \int \psi^* \left( q^2 \psi + i\hbar \underline{\nabla} \cdot (\underline{q} \psi) + i\hbar \underline{q} \cdot \underline{\nabla} \psi - \hbar \underline{\sigma} \cdot \underline{q} \times \underline{\nabla} \psi - \hbar \underline{\sigma} \cdot \underline{\nabla} \times (\underline{q} \psi) \right) d\tau \quad -(20)$$

Finally there are energy levels produced in Minkowski space by the hamiltonian $H_3$

$$E = \langle H_3 \rangle = \int \psi^* H_3 \psi \, d\tau \quad -(21)$$

In order to describe the interaction between a proton and neutron in a fully self consistent way, the strong force is needed as described in Eq. (47) of 4FT428:

4)

$$H = m(r)^{1/2}\left(mc^2 + U\right) + H_1 + H_2 + H_3 + H_4 \quad -(22)$$

where:

$$H_1 = \frac{1}{2m}\,\underline{\sigma}\cdot\underline{p}\,\frac{1}{m(r)^{1/2}}\,\underline{\sigma}\cdot\underline{p} \quad -(23) \qquad -(24)$$

$$H_2 = -\frac{1}{2m}\left(\underline{\sigma}\cdot\underline{V}\,\frac{1}{m(r)^{1/2}}\,\underline{\sigma}\cdot\underline{p} + \underline{\sigma}\cdot\underline{p}\,\frac{1}{m(r)^{1/2}}\,\underline{\sigma}\cdot\underline{V}\right)$$

$$H_3 = \frac{1}{2m}\,\underline{\sigma}\cdot\underline{V}\,\frac{1}{m(r)^{1/2}}\,\underline{\sigma}\cdot\underline{V} \quad -(25)$$

$$H_4 = \frac{1}{2m}\,\underline{\sigma}\cdot\left(\underline{p} - \underline{V}\right)\frac{U}{2mc^2 m(r)^{1/2}}\,\underline{\sigma}\cdot\left(\underline{p} - \underline{V}\right) \quad -(26)$$

The potential U in these equations is the sum of the potential of the m force and the potential of the Coulombic repulsion. The strong force is identified with the m force:

$$F = -\frac{\partial m(r)}{\partial r}\,\frac{m^{1/2}(r)}{2m(r) - r\frac{dm(r)}{dr}}\,E \quad -(27)$$

where:

$$E^2 = p^2c^2 + m(r)\,m^2c^4 \quad -(28)$$

is the energy of the m force.

In eqs. (22) to (26), m is the mass of the proton or neutron and V is the vector potential of the strong field, i.e. its momentum. In eq. (28), m is the mass of the pion being considered. The energy from eq. (28) is

$$E = \frac{p^2c^2}{E + m(r)^{1/2}mc^2} + m(r)^{1/2}mc^2 \quad -(29)$$

In the low velocity approximation:

$$E = \frac{p^2}{2m(r)^{1/2} m} + m(r)^{1/2} mc^2 \quad -(30)$$

The expectation value of energy are:

$$\langle E \rangle = -\frac{\hbar^2}{2m} \int \psi^* \nabla^2 \left( \frac{\psi}{m(r)^{1/2}} \right) d\tau \quad -(31)$$

$$+ mc^2 \int \psi^* m(r)^{1/2} \psi \, d\tau$$

and this gives a mass spectrum. If $m$ is considered to be the mean mass of the pion, it is known from experiment that eq. (31) should give three pions.

Quark Structure of the Proton and Neutron

From an equation such as (23), a particle such as a proton of mass $m$ gives energy levels:

$$E = \langle H_1 \rangle = -\frac{\hbar^2}{2m} \int \sigma \cdot \underline{\nabla} \left( \frac{1}{m(r)^{1/2}} \underline{\sigma} \cdot \underline{\nabla} \psi \right) \quad -(32)$$

which is a mass spectrum. This can be identified with the quark masses inside the proton.