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Rest Mass Quantisation of Elementary Particles and Possible Existence of Hitherto Unknown Particles

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Abstract

A general mass formula, based on the principle of quantisation of rest mass, gives accurate mass ratios for many of the known elementary particles, predicting the muon mass to within 1 part in 10,000 of the experimental value and indicates the possibility for the existence of a number of particles which have not yet been identified experimentally.

1. *Introduction*

The possibility that matter might be created when space-time develops a highly localised curvature and breaks up like an ocean wave near the crest, was pointed out by Wheeler (1962). A novel method of incorporating the quantum principle and the concept of the density dependent space-curvature of general relativity, is to postulate that the rest-mass action content of the super dense space-time droplet, formed by the break-up, is equal to half the Planck's constant of action. This gives Planck's characteristic length (Planck, 1959) as the radius of the spherical model and leads to a rest-mass quantisation rule. The mass ratios for elementary particles can then be obtained, semi-phenomenologically, based on structures indicated by their known interactions.

2. *Basic Model for Particles*

To apply the quantisation rule, the elementary particles are pictured as 'combinations' of the super-dense geometrodynamical model 'particles' confined to 'travel' with the velocity of light in circular 'paths' of radius r_0 which may be considered as the radius of the nucleon, and exchanged particles with figure of 8 or quasi-elliptical paths around two or more closely packed nucleons. The quantum postulate restricts the rest masses of the components to such values that the rest mass energy multiplied by the time taken to travel once round the closed path, with the velocity of light c, is equal to half the quantum of action h. The periodic motion with the velocity of light resulting in mass quantisation is a characteristic of all particles which can be inferred from the solution of the relativistic wave equation.

We will postulate that nucleons contain particles confined to a single orbit and that the exchanged particles move around two or more nucleons. By the quantisation rule single orbit particles have rest-mass

$$m_1 = \frac{\hbar}{2r_0c}, \qquad \hbar \equiv \frac{h}{2\pi} \tag{2.1}$$

Those with figure of 8 paths around two nucleons have rest-mass

$$m_0 = \frac{\hbar}{4r_0c} \tag{2.2}$$

and particles with circular or quasi-elliptical paths around two or more nucleons have rest mass given by

$$m' = \frac{\hbar\phi}{4r_0c} \tag{2.3}$$

where ϕ is the ratio of the perimeter of the figure of 8 path around two nucleons of radius r_0 to the perimeter of the actual path of semi-major axis

$$a = 2r_0, \left(1 + \frac{2}{\sqrt{3}}\right)r_0, (1 + \sqrt{2})r_0 \qquad \text{or } (1 + \sqrt{3})r_0 \tag{2.4}$$

and semi-minor axis b, given by

$$\frac{a}{b} = 1, \frac{1 + \sqrt{2}}{2}, \frac{1 + \sqrt{3}}{2}, \sqrt{2}, \sqrt{3} \text{ or } 2, \tag{2.5}$$

the path deviating from a strictly elliptical one to keep a minimum radius of curvature r_0 when going around each nucleon and due to perturbations when travelling between the nucleons.

In the free state these basic particles undergo transitions to become electrons, muon-neutrinos, electron-neutrinos and their anti-particles. For computing the resultant rest-mass of the elementary particle, the masses of the basic particles which in the bound state contribute the electric charge and change in the free state to electrons and electron-neutrinos are to be normalised by a factor $1/\sqrt{2}$.

3. *The Radius of the Nucleon*

The very nature of the nucleon, as visualised in the theory, makes an accurate measurement of its size difficult. The parameter r_0 which occurs in the mass formulas can however be computed from the known mass of any particle, whose mass formula is known exactly.

The charged pion, for example, has the mass formula

$$m_{\pi^\pm} = (2 + \sqrt{2}) \frac{\hbar}{4r_0 c} \tag{3.1}$$

Using the experimentally known values of h, c and

$$m_{\pi^\pm} = 139{\cdot}576 \text{ MeV} \tag{3.2}$$

in equation (6) gives

$$r_0 = 1{\cdot}20670 \times 10^{-13} \text{ cm} \tag{3.3}$$

The above value of r_0 can be used to compute the masses of other particles.

4. *General Mass Formula*

The mass formulas obtained semi-phenomenologically for the known particles suggest the general equation

$$4mcr_0 = [(n_\nu + n_e\sqrt{2})^2 + 4n_s^{\,2}]^{1/2}\hbar\phi \tag{4.1}$$

where m is the rest mass of the elementary particle, n_ν is the neutrino number which can take only integral values including zero, being the number of components which can ultimately decay into muon-neutrinos, n_e is the electron number which is an odd integer for a charged particle and zero or an even integer for a neutral particle and n_s is the same as the spin quantum number J, taking zero, half integral or whole number values.

For the charged pion, $n_\nu = 2$, $n_e = 1$, $n_s = 0$ and $a/b = 1$ giving $\phi = 1$ as in (3.1).

For the neutral pion $n_\nu = 0$, $n_e = 2$, $n_s = 0$ and $a/b = \sqrt{2}$ giving $\phi \simeq \pi/2{\cdot}6914$ and $m_{\pi 0} \simeq 134{\cdot}97$ MeV against the experimental value of 135·01 MeV.

The formula has not yet been checked for all the known particles but seems to be flexible enough to account for all as quantised states and exchanged particles. For particles with spin, however, correction has to be applied for magnetic effects.

The corrected formula for the muon mass can be obtained from (9) by putting $n_\nu = 1$, $n_e = 1$, $n_s = \frac{1}{2}$ and $\phi = 1$ and then correcting for magnetic effects.

This gives

$$m_\mu = \frac{\left[(1 + \sqrt{2})^2 \left(1 - \frac{m_e}{m_0}\right)^2 + 1^2\right]^{1/2} m_0}{1 + (1 + \sqrt{2})\alpha \frac{m_e}{m_0}} \tag{4.2}$$

where m_e = mass of electron, $m_0 = \hbar/4r_0c$ and $\alpha = e^2/\hbar c$ is the fine structure constant. Substitution of the known values of m_e, h, c and α and the value of r_0 from (3.3) gives

$$m_\mu = 105{\cdot}665 \text{ MeV}$$

agreeing with the experimental value of 105·659 MeV.

5. *Unidentified Particles*

The already known elementary particles correspond to only a few of the possible quantum states given by (4.1) and possible transitions between them. Others are yet to be identified. The theory in its present state of development does not give any idea about the probability for the various possible transitions. Hence it is not possible to predict whether the unidentified quantum states and exchanged particles are detectable by current experimental techniques. It is also possible that several of the already identified particles are degenerate states or may show mass splits.

Additional experimental data may guide to relations connecting n_ν, n_e, n_s and ϕ with the stability of the quantum states and the probability for the various transitions. It will be especially worthwhile looking for particles with rest masses of about 41, 58, 82, 116, 150, 163, 174, 234, 294, 314, 350 and 400 MeV.

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