Epion – The Charged Pion's Ground State SUSY Boson

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Abstract: With reference to the previously proposed [1,2] SUSY fermion-boson mass ratio $\Psi \cong 2.2627$, based on the muon and proton rest masses, charged pion rest energy can be expressed as $\frac{\sqrt{m_p m_\mu}c^2}{\Psi} \cong (m_\pi)^\pm c^2 \cong 139.15$ MeV. In the similar way a new boson related to electron-proton can be predicted as $\frac{\sqrt{m_p m_e}c^2}{\Psi} \cong (m_\varepsilon)^\pm c^2 \cong 9.677$ MeV. It can be called as the "EPION". It can be suggested that, nuclear binding force is mediated by this hidden boson $(m_\varepsilon)^\pm$ and charged pion is its excited state. In support of the existence the epion, rest mass of the neutral electro weak boson can be expressed as $m_Z \cong \frac{m_n^2}{m_\varepsilon} \cong 91225$ MeV where m_n is the rest mass of neutron. In this new direction fitted semi empirical mass formula energy constants are $a_v \cong 16.29$ MeV, $a_s \cong 19.354$ MeV, $a_c \cong 0.766$ MeV, $a_p \cong 23.76$ MeV and $a_p \cong 11.88$ MeV respectively.

Key words: SUSY; Fermion-boson mass ratio; Pion; Z boson; Epion – the new SUSY boson; SEMF;

1. INTEGRAL CHARGE QUARK SUSY - A BRIEF INTRODUCTION

Till today there is no reason for the question: why there exist 6 individual quarks? Till today no experiment reported a free fractional charge quark. Authors' humble opinion is nuclear charge (either positive or negative) constitutes 6 different flavors and each flavor holds certain mass. Charged flavor can be called as a quark. It is neither a fermion nor a boson. A fermion is a container for different charges, a charge is a container for different flavors and each flavor is a container for certain matter. If charged matter rests in a fermionic container it is a fermion and if charged matter rests in a bosonic container it is a boson. The fundamental questions to be answered are : what is a charge? why and how opposite charges attracts each other? why and how there exists a fermion? and why and how there exists a boson? Here interesting thing is that if 6 flavors are existing with 6 different masses then a single charge can have one or two or more flavors simultaneously. Since charge is a common property, mass of the multiple flavor charge seems to be the geometric mean of the mass of each flavor. If charge with flavor is called as a quark then charge with multi flavors can be called as a hybrid quark. Hybrid quark generates a multi flavor baryon. It is a property of the strong interaction space - time - charge. This is just like different tastes or different smells of matter. Important consequence of this idea is that- for generating a baryon there is no need to couple 3 fractional charge quarks [1- 6]. It can be suggested that: 1) There exist nature friendly integral charge quark fermions. 2) For every integral charge quark fermion (Q_f) there exists a corresponding integral charge quark boson (Q_b). Quark fermion and quark boson mass ratio is close to $\frac{Q_f}{Q_b} \cong \Psi \cong 2.2627$. Proposed quark masses are given in table-1. For details see our published papers [1- 5].

Table-1: Fitting of quark fermion and quark boson masses

Quark	$Q_f c^2$ in MeV	$Q_b c^2$ in MeV
Up	4.401	1.945
Down	9.4755	4.188
Strange	152.5427	67.416
Charm	1313.796	580.63
Bottom	5287.579	2336.839
Top	182160.18	80505.46

The observed baryon and meson charge-mass spectrum can be generated from these mass units. Strange quark boson pair generates the neutral pion of rest energy 134.83 MeV [7]. Obtained top quark boson rest energy is 80505 MeV and is very close to the observed W boson rest energy 80.385 ± 0.015 GeV [7]. Really this is a great coincidence and support for the proposed new idea of ''fermion-boson" unification scheme. This strongly supports super symmetry with small modifications. 3) $Q_{ef} \cong Q_f - Q_b \cong \left(1-\frac{1}{\Psi}\right)Q_f$ acts as the effective quark fermion. 4) Characteristic nuclear fermion is 938.272 MeV and its corresponding nuclear boson is $938.272/\Psi \cong 414.67$ MeV. This boson couples with the light quark bosons or light quark mesons and generates neutral ground states. Thus it is the mother of presently believed strange mesons like 493, 548, 1020 MeV and 783, 890 MeV etc. For further information see our published papers [1- 5].

2. THE CHARGED PION & ITS GROUND STATE 'EPION' AND THE NEUTRAL Z BOSON

With these ideas it is noticed that, the charged pion is a super symmetric boson of proton and muon. It can be expressed as

$$m_{\pi}^{\pm}c^2 \cong \frac{1}{\Psi}\sqrt{m_p m_\mu}\,c^2 \cong 139.15 \text{ MeV} \qquad (1)$$

This can be compared with the experimental rest energy of charged pion = 139.57 MeV [7]. Keeping this idea in view it is very natural to apply this idea to electron and proton system. When muon is the excited form of electron and if pion is the SUSY boson of muon, then it is natural to think that there exists a SUSY boson of electron-proton system. It can be called as 'EPION'. Its rest energy can be obtained as

$$m_{\varepsilon}^{\pm}c^2 \cong \frac{1}{\Psi}\sqrt{m_p m_e}\,c^2 \cong 9.677 \text{ MeV} \qquad (2)$$

Considering the neutron rest mass and with this new epion, the neutral electro weak boson rest energy rest mass can be fitted as

$$m_Z \cong \frac{m_n^2}{m_\varepsilon} \cong 91224.86 \text{ MeV} \qquad (3)$$

Really this is a very surprising coincidence [7]. In a simple form,

$$m_n \cong \sqrt{m_Z m_e} \qquad (4)$$

Lhs of this relation represents a fermion where as Rhs represents a boson. Even though it is odd from SUSY point of view, this coincidence cannot be ignored. Its SUSY relation seems to be connected with the fine structure ratio in the following way.

$$m_Z c^2 \cong \left(\frac{1}{2\alpha}\right)^2 2m_\varepsilon c^2 \cong \left(\frac{1}{2\alpha}\right)^2 \left(m_\varepsilon^+ + m_\varepsilon^-\right)c^2 \qquad (5)$$

$\cong 90861.54$ MeV. Life time of Z boson is close to

$$\sqrt{\frac{m_\varepsilon}{m_Z}} \cdot \frac{\hbar}{2m_\varepsilon c^2} \cong \frac{\hbar}{2\sqrt{m_\varepsilon m_Z}\,c^2} \cong 3.5\times10^{-25} \text{ sec} \qquad (6)$$

From these coincidences it can be suggested that, 1) Pion is the excited state of Epion. 2) 'Epion' can be considered as the basic nuclear force carrier. If so Epion must have some role in basic nuclear structure and nuclear binding energy. In this paper an attempt is made to implement and understand the applications of Epion in nuclear binding energy scheme.

3. HISTORY OF THE SEMI EMPIRICAL MASS FORMULA

In nuclear physics, the semi-empirical mass formula [8,9] is used to approximate the mass and various other properties of an atomic nucleus. As the name suggests, it is based partly on theory and partly on empirical measurements. The theory is based on the liquid drop model proposed by George Gamow, which can account for most of the terms in the formula and gives rough estimates for the values of the coefficients. It was first formulated in 1935 by German physicist Carl Friedrich von Weizsacker, and although refinements have been made to the coefficients over the years, the structure of the formula remains the same today. It gives a good approximation for atomic masses and several other effects, but does not explain the appearance of magic numbers.

The liquid drop model in nuclear physics treats the nucleus as a drop of incompressible nuclear fluid. It was first proposed by George Gamow and then developed by Niels Bohr and John Archibald Wheeler. The fluid is made of nucleons (protons and neutrons), which are held together by the strong nuclear force. This is a crude model that does not explain all the properties of the nucleus, but does explain the spherical shape of most nuclei. It also helps to predict the binding energy of the nucleus. Mathematical analysis of the theory delivers an equation which attempts to predict the binding energy of a nucleus in terms of the numbers of protons and neutrons it contains. This equation has five terms on its right hand side. These correspond to the cohesive binding of all the nucleons by the strong nuclear force, the electrostatic mutual repulsion of the protons, a surface energy term, an asymmetry term (derivable from the protons and neutrons occupying independent quantum momentum states) and a pairing term (partly derivable from the protons and neutrons occupying independent quantum spin states).

The semi-empirical mass formula provides a good fit to heavier nuclei, and a poor fit to very light nuclei, especially ^4He. This is because the formula does not consider the internal shell structure of the nucleus. For light nuclei, it is usually better to use a model that takes this structure into account. The coefficients are calculated by fitting to experimentally measured masses of nuclei. Their values can vary depending on how they are fitted to the data. In the following formulae, let A be the total number of nucleons, Z the number of protons, and N the number of neutrons. The mass of an atomic nucleus is given by

$$m = Zm_p + Nm_n - \left(B/c^2\right) \qquad (7)$$

where m_p and m_n are the rest mass of a proton and a neutron, respectively, and B is the binding energy of the nucleus. The semi-empirical mass formula states that the binding energy will take the following form,

$$B = a_v A - a_s A^{2/3} - a_c \frac{Z(Z-1)}{A^{1/3}} - a_a \frac{(A-2Z)^2}{A} + \delta(A,Z) \quad (8)$$

Its modern representation is

$$B = a_v A - a_s A^{2/3} - a_c \frac{Z(Z-1)}{A^{1/3}} - a_a \frac{(A-2Z)^2}{A} \pm \frac{a_p}{\sqrt{A}} \quad (9)$$

Here a_v = volume energy coefficient, a_s is the surface energy coefficient, a_c is the coulomb energy coefficient, a_a is the asymmetry energy coefficient and a_p is the pairing energy coefficient. If we consider the sum of the volume energy, surface energy, coulomb energy, asymmetry energy and pairing energy, then the picture of a nucleus as a drop of incompressible liquid roughly accounts for the observed variation of binding energy of the nucleus. By maximizing $B(A,Z)$ with respect to Z, we find the number of protons Z of the stable nucleus of atomic weight A as,

$$Z \approx \frac{A}{2 + (a_c/2a_a) A^{2/3}}. \quad (10)$$

This is roughly $A/2$ for light nuclei, but for heavy nuclei there is an even better agreement with nature. By substituting the above value of Z back into B one obtains the binding energy as a function of the atomic weight, $B(A)$. Maximizing $B(A)/A$ with respect to A gives the nucleus which is most strongly bound or most stable.

4. COMBINED ROLE OF UP & DOWN QUARKS AND THE NEW EPION

Considering the up and down quark masses and with reference to the electron rest mass a new mass ratio can be expressed in the following way.

$$x \cong \frac{m_e}{\sqrt{m_u m_d}} \cong 0.07913 \quad (11)$$

here, m_u = mass of up quark = 4.401 MeV and m_d = mass of down quark = 9.4755 MeV and m_e = mass of electron = 0.511 MeV. It is noticed that, this new number x is having serious role in basic nuclear physics. The various applications can be expressed in the following way.

1) Neutron and proton mass difference can be expressed as

$$\frac{m_n - m_p}{m_e} \cong \ln\left(\frac{1}{x}\right) \quad (12)$$

2) Direct proton – nucleon beta stability relation can be expressed as

$$A_s \cong 2Z + (Z.x)^2 \quad (13)$$

3) The maximum nuclear binding energy per nucleon can be expressed as

$$B_{Am} \cong (1-x) m_\varepsilon c^2 \cong 8.911 \text{ MeV} \quad (14)$$

4) The coulombic energy constant can be expressed as

$$a_c \cong x \cdot m_\varepsilon c^2 \cong 0.766 \text{ MeV} \quad (15)$$

5) The surface energy constant can be expressed as

$$a_s \cong 2(B_{Am} + a_c) \cong 2 m_\varepsilon c^2 \cong 19.354 \text{ MeV} \quad (16)$$

6) The volume energy constant can be expressed as

$$a_v \cong 2(B_{Am} - a_c) \cong 16.29 \text{ MeV} \quad (17)$$

7) The pairing energy constant can be expressed as

$$a_p \cong \frac{4}{3} B_{Am} \cong 11.88 \text{ MeV} \quad (18)$$

8) The asymmetry energy constant can be expressed as

$$a_a \cong 2a_p \cong \frac{8}{3} B_{Am} \cong 23.76 \text{ MeV} \quad (19)$$

Thus $a_v + a_s \cong a_p + a_a \cong 3a_p \cong 35.64$ MeV (20)

With these energy constants nuclear binding is calculated with equation (9) and compared with the measured binding energy [10] in table-2.

9) One surprising observation is

$$m_\pi^\pm c^2 \cong \frac{1}{\Psi}\left(m_p^2 (a_s + a_v)\right)^{\frac{1}{3}} \cong \frac{1}{\Psi}\left(m_p^2 (a_s + a_v)\right)^{\frac{1}{3}} \quad (21)$$

$\cong 139.4$ MeV and can be compared with the charged pion rest energy. Authors are working in this new direction.

Table-2: SEMF binding energy with the proposed energy coefficients

Z	A	$(BE)_{cal}$ in MeV	$(BE)_{mes}$ in MeV
26	56	493.61	492.254
28	62	548.2	545.259
34	84	729.79	727.341
50	118	1009.84	1004.950
60	142	1186.65	1185.145
79	197	1559.22	1559.40
82	208	1629.86	1636.44
92	238	1808.57	1801.693

In this table column 3 represents the calculated binding energy and column 4 represents the measured binding energy [10].

5. CONCLUSIONS

From the proposed concepts and semi empirical relations it is possible to suggest that, there exists a strongly interacting charged boson of rest energy

9.677 MeV and its mass is interlinked with electron and proton rest masses via SUSY. Charged pion can be considered as its excited state. Further research and analysis may bring these concepts into main stream physics.

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