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Masses and Structures of Bottom and Top Mesons

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Masses of bottom and top mesons are evaluated in connection with tau lepton and weak boson. Our fundamental particles are electron, proton, neutrinos, Mayorana neutrinos and hidden scalar boson. Fractional charge of quark as composite is interpreted. Masses of bottom mesons, which have similar structures to top mesons, are consistent to the data. Internal state of top quark is supposed to be common with that of weak boson. We predict top quark mass range to be 108GeV to 218GeV as one half of top meson mass.

1. Introduction

The accurate measurements of high energy electron-positron collision cross sections have decided the number of light neutrino species¹⁾. Then there have been three neutrinos, three leptons, six quarks and four gauge bosons, but there remain various mysteries for these properties. For example, although leptons have unity charge, it is a question why quarks have fractional charge. It is also mystery why muon, tau and quarks have these specific masses. The high energy experiments and theoretical analysis have predicted the mass range of top quark to be 124^{+28+20}_{-34-15} GeV²⁾. Recently the experimental mass range of top quark is informed as 125-175 GeV by the Fermilab protonantiproton collider³⁾, and there is more recent information that the mean value of top mass may be 174 GeV⁴⁾. This enormous top mass constitutes a major puzzle for fundamental theory.

We have ever evaluated the masses of leptons, hadrons⁵⁾, quarks⁶⁾ and gauge bosons⁷⁾ by our hypothetical hidden coupling on the basis of composite structures of our fundamental fermions except for tau neutrino. We have supposed that the internal states of tau, charmed and bottom mesons are common, while that of weak boson is common with that of top, which has the deepest inner state.

In this paper we shall assume our three kinds of hidden neutrinos to be the Majorana neutrinos in the fundamental hidden coupling. Then the deepest inner state, which connects with the masses of top quark and weak boson, will be re-deduced theoretically and experimentally. Fractional charge of quark will be interpreted under our composite model. We shall estimate all masses of bottom mesons, which are

consistent to data, under such a picture that bottom quark has same inner state as that of tau lepton. It will be predicted that the top quark mass range may be 108GeV to 218GeV as one half of top meson mass deduced from similar structure of top meson to bottom one.

2. Fundamental coupling and internal energy

Taking account of the confirmed three kinds of neutrinos¹⁾ and the unobserved proton decay, we assume that the fundamental fermions must be stable and then these are electron, proton, three neutrinos $\nu_\lambda (\lambda=e, \mu, \tau)$ and hypothetical three hidden neutrinos h_λ , although the tau neutrino interaction has been omitted in our previous papers⁵⁾⁷⁾

We suppose that the interchange between hidden neutrinos and other fermions takes place by the medium of hidden scalar boson $\phi(\phi^0, \phi^\pm)$, which carries the z-number -1 and has mean mass $M = 15.1\text{GeV}$ ($M_0=15.3\text{GeV}$, $M_\pm=14.9\text{GeV}$)⁵⁾. Hidden property has been introduced in order to avoid unobserved processes. The z-numbers are 1 for nucleon, 0 for muonic lepton, -1 for electronic one and -2 for tau one, and conserved in each vertex of following coupling. We assume our fundamental coupling as follow

$$\mathcal{L} = \mathcal{L}_1 + \mathcal{L}_2 + \mathcal{L}_3 + \mathcal{L}_4 + \mathcal{L}_5 . \quad (1)$$

$$\mathcal{L}_1 = f[\bar{h}_\mu O_- l_e \phi^* + \bar{l}_e O_+ h_\mu \phi] , \quad (1a)$$

$$\mathcal{L}_2 = f[\bar{h}_e O_- l_\mu \phi + \bar{l}_\mu O_+ h_e \phi^*] , \quad (1b)$$

$$\mathcal{L}_3 = f[\bar{h}_e O_- l_\tau \phi^* + \bar{l}_\tau O_+ h_e \phi] , \quad (1c)$$

$$\mathcal{L}_4 = f[\bar{h}_\tau O_- l_e \phi + \bar{l}_e O_+ h_\tau \phi^*] , \quad (1d)$$

$$\mathcal{L}_5 = f[\bar{h}_\mu O_- N \phi + \bar{N} O_+ h_\mu \phi^*] , \quad (1e)$$

$$O_\pm = (1 \pm \gamma_5)/2 . \quad (2)$$

This coupling gives rise to the interchange between different kinds of fermions and will induce the masses. The formalism (1) includes (2) in order to deduce weak interaction and also conventionally the coupling for muon, tau and neutron which have been assumed as composites of our fundamental particles³⁾.

Next we assume our hidden neutrinos are the Mayorana neutrinos

$$h_{\lambda} = \nu_{\lambda M} = \nu_{\lambda L} + \nu_{\lambda R}^c = \overline{\nu_{\lambda M}} \quad (3)$$

where $\nu_{\lambda L} = O_- \nu_{\lambda}$ and $\nu_{\lambda R} = O_+ \nu_{\lambda}$. Then the coupling (1) is rewritten as follows

$$\mathcal{L}' = \mathcal{L}'_1 + \mathcal{L}'_2 + \mathcal{L}'_3 + \mathcal{L}'_4 + \mathcal{L}'_5 \quad (4)$$

$$\mathcal{L}'_1 = f[\nu_{\mu R}^c l_{eL} \phi^* + \overline{l_{eL}} \nu_{\mu R}^c \phi] \quad (4a)$$

$$\mathcal{L}'_2 = f[\nu_{eR}^c l_{\mu L} \phi + \overline{l_{\mu L}} \nu_{eR}^c \phi^*] \quad (4b)$$

$$\mathcal{L}'_3 = f[\nu_{eR}^c l_{\tau L} \phi^* + \overline{l_{\tau L}} \nu_{eR}^c \phi] \quad (4c)$$

$$\mathcal{L}'_4 = f[\nu_{\tau R}^c l_{eL} \phi + \overline{l_{eL}} \nu_{\tau R}^c \phi^*] \quad (4d)$$

$$\mathcal{L}'_5 = f[\nu_{\mu R}^c N_L \phi + \overline{N_L} \nu_{\mu R}^c \phi^*] \quad (4e)$$

It is noted that one partner $\nu_{\lambda L}$ in (3) is hidden in this coupling (4).

Coupling constant f has been so defined as to make the electromagnetic self energy of electron finite. The logarithmic divergence of electromagnetic self energy of electron Δm_{γ} will be cancelled by that of self energy Δm_{ϕ} induced from (1a) or (4a), if

one assumes

$$f^2/4\pi = -6\alpha . \quad (5)$$

Then one has the finite electromagnetic self energy of electron or proton with mass m ⁵⁾

$$\Delta m = \Delta m_r + \Delta m_\phi = (3\alpha m/4\pi)[2\ln(M_-/m)+1] . \quad (6)$$

Hence the coupling (1) or (4) is not hermitic, so that this cannot be directly observed by us and is hidden interaction. We suppose that hidden neutrinos and hidden scalar boson cannot exist in external state, but only in virtual state or internal state.

Fig.1

The mass of composite is given by the sum of component masses, internal energies and self energy. The internal energy is estimated by use of (4) and fig.1a. It is characteristic that the matrix element for such a diagram as fig.1 can have a diagonal element by virtue of coupling (1), which induces positive interaction energy by (5), so that external lines of same particles can be connected. For example the energy between electronic lepton(A) and hidden neutrino(1) is given by

$$E(l_e h_\mu) = \int \langle p_A, q_1 | \mathcal{L}_1 \mathcal{L}_1 | q_1, p_A \rangle d\mathbf{k}/(2\pi)^3 \equiv \langle A1 | H(1A) | 1A \rangle , \quad (7)$$

$$H(1A) = \int [3\alpha/\pi^2(k^2+M^2)] d\mathbf{k} (1-h_1 h_A | p_A | /p_{A0}) \exp(i\mathbf{k} \cdot \mathbf{r}) , \quad (8)$$

where $\mathbf{k} = \mathbf{q}_1 - \mathbf{p}_A$, $\mathbf{r}$ is the distance between 1 and A and h is helicity.

As helicity of h_μ is that of ν_R in (4a), one has the internal energy

$$E(\nu_e h_\mu) = E(\bar{\nu}_e \bar{h}_\mu) = 2V(\mathbf{r}) , \quad E(\nu_e \bar{h}_\mu) = E(\bar{\nu}_e h_\mu) = 0 , \quad (9)$$

$$V(\mathbf{r}) = (6\alpha/r) \exp(-M_0 r) . \quad (10a)$$

When electron and nucleon are at rest one has

$$E(e^{\pm} h_{\mu}^{\pm}) = E(e^{\pm} h_{\mu}^{\pm}) = V'(\tau) , \quad (11)$$

$$V'(\tau) = (6\alpha/\tau)\exp(-M\tau) , \quad (10b)$$

$$E(nh_{\mu}) = E(nh_{\mu}^{\pm}) = V(\tau) , \quad E(ph_{\mu}) = E(ph_{\mu}^{\pm}) = V'(\tau) . \quad (12)$$

It is noted that the internal energy depends on the helicity of neutrino. The internal energy is positive, so that we may suppose the component particle of composite system to have effective mass induced from coupling (4).

3. Internal state and composite condition

We have defined such an inner potential⁵⁾⁷⁾

$$U_n(\tau) = \frac{n}{2}(1+c)V(\tau) - \alpha/\tau = (\alpha/\tau)[3n(1+c)\exp(-M\tau) - 1] . \quad (13)$$

Here n is the number of scalar boson bond lines in a composite system, so that $n/2$ may mean the number of bosons existing near by one fermions of two neighbors. The factor c is the higher order correction for internal potential (10) deduced from higher order interaction diagrams between h_{μ} and l_e , e. g., figs.1b-1f under the coupling (1) or (4). Approximately each of possible same order diagrams as figs.1c-1f yields same correction c_2 . We shall have

$$c = \begin{cases} c_1 + 5c_2 & \text{for charged fermion} \\ 7c_2 & \text{for neutral fermion} \end{cases} \quad (14)$$

$$c_1 = \frac{\alpha}{4\pi} \int_0^1 \exp \left[M\tau \left(1 - \sqrt{\frac{1-y}{1-x}} \right) \right] \frac{dx dy}{1-x} \quad (14a)$$

$$c_2 = \left(\frac{3\alpha}{2\pi} \right)^2 \int_0^1 \exp \left[M\tau \left(1 - \sqrt{\frac{1-xy}{ux(1-x)} + \frac{1-v}{1-u}} \right) \right] \frac{du dv dx dy}{(1-u)(1-x)} , \quad (14b)$$

neglecting the higher order electromagnetic corrections than fig.1b.

The minimal point of (13) namely the equilibrium position τ_n is given by

$$\exp(M\tau_n) = 3n(1+c)(1+M\tau_n). \quad (15)$$

In order to have τ_n yielding finite internal energy or (10) there need be $n \geq 1/3$. On the one hand our composite condition, which is $\tau_n < 2\tau_1$, requires $n \leq 4$. Hence we assume the series

$$n = 1/3, 1/2, 1, 2, 4 \quad (16)$$

which are defined as new quantum numbers specifying internal states⁵⁾⁷⁾

. The number 1/3 specifies top quark and weak boson, 1/2 charm and bottom, 1 pion and muon, 2 baryon and 4 kaon. The correction (14) is effective for $n=1/3$ and gives theoretical values

$$\tau_{1/3} = \tau_- = 1/163m_p, \quad \tau_{1/3} = \tau_0 = 1/222m_p \quad (17)$$

by numerical calculations of (14) and (15). Each of these is larger than each of $\tau_- = 1/179m_p$ and $\tau_0 = 1/473m_p$ that have been deduced from two neutrino interactions⁵⁾. If the higher order interaction between h_τ and l_e is considered, the correction c will be $c_1 + 3c_2$ for charged one and $3c_2$ for neutral, so that theoretical lengths τ_- and τ_0 will be less than (17).

Table I

Table I shows theoretical and experimental values of τ_n . It is important to notice the relations $\tau_2 < \tau_4 < 2\tau_1$ and $\tau_1 < 2\tau_{1/2}$, which assure our composite structures connected deeply with observability. If the physical electron or photon has e. g., Gaussian expansion with standard deviation τ_1 or $\tau_{1/2}$, two neighboring points at such a

distance R as

$$R < 2\tau_1 \text{ or } 2\tau_{1/2} \quad (18)$$

will be no longer observed as two points in analogous to the optical resolving power. We conclude that only the system satisfying (18) can be a composite, so that the condition (18) is the criterion of our composite structure⁵⁾. This condition determines also the compound expansion.

4. Masses of muon and tau

We supposed π^- to be composite⁵⁾ $(e\bar{\nu}_e h_{\mu} \bar{h}_{\mu})$, and then assume negative muon to have such a constitution as

$$\mu^- = \begin{pmatrix} e \\ \nu_e h_{\mu} \end{pmatrix} \quad (19)$$

where upper column belongs to normal fermion while lower to antifermion, $\nu = \nu_e$ and h is h_{μ} at state $n=1$. This internal state function is expressed by

$$|\mu\rangle = \sum |1A\rangle \quad (20)$$

where $\sum$ implies the sum for normal and antifermions, and the muon mass is given by

$$m(\mu^-) = E(eh) + E(\bar{\nu}h) + m_e + \Delta m = \omega_1 + 0.5\omega'_1 + m_e + \Delta m = 105.7 \text{ MeV} \quad (21)$$

which fits the experimental value⁸⁾ $105.658389 \pm 0.000034 \text{ MeV}$, by use of

$$\omega_n = 2V(\tau_n), \quad \omega'_n = 2V'(\tau_n) \quad (22)$$

$$\omega_1 = 67.5 \text{ MeV}, \quad \omega'_1 = 71.4 \text{ MeV} \quad (23)$$

deduced from pion masses⁵⁾. Although the structure (19) appears that negative muon is antifermion, hidden neutrino is Majorana neutrino (3) that is fermion as well as antifermion, so that negative muon may be interpreted to be a normal one.

We next assume tau lepton has such a composite structure as

$$\tau^- = \begin{pmatrix} e & h' & \nu & h' \\ \nu & h' & \nu & \tau \end{pmatrix} . \quad (24)$$

where h' is h_μ and h'_τ at state $n=1/2$. When rows are assigned by A, 1, B and 2 from left to right in (24) the tau mass is evaluated by use of internal state function⁵⁾

$$|I\rangle = (1/\sqrt{2}) \sum |1A-1B\rangle |2A-2B\rangle , \quad |1A \pm 1B\rangle = |1A\rangle \pm |1B\rangle \quad (25)$$

which yields the total internal energy

$$E(I) = \langle I | H | I \rangle = \sum_{i=1}^2 \sum [E(iA) + E(iB) - 2E(iAB)] , \quad H = \sum_{ij} H(ij) \quad (26)$$

$$E(iAB) = \langle iA | H | iB \rangle = [1 - h_i(h_A + h_B)] |p|/2p_0 V(R) S_{AB} , \quad (27)$$

where $S_{AB} = S_{AB}^- = 1$ and $S_{AB}^- = S_{AB}^- = 0$ for triplet spin state of two particles in suffix, while $S_{AB} = S_{AB}^- = 0$ and $S_{AB}^- = S_{AB}^- = 1$ for singlet, by means of helicity and $\mathbf{p} = \mathbf{p}_A = \mathbf{p}_B$. We then have

$$E(h_\mu \nu_A \nu_B) = E(\bar{h}_\mu \bar{\nu}_A \bar{\nu}_B) = 2V(R) S_{AB} , \quad (28a)$$

$$E(h_\mu \nu_A \bar{\nu}_B) = E(\bar{h}_\mu \nu_A \bar{\nu}_B) = V(R) S_{AB}^- , \quad (28b)$$

$$E(\bar{h}_\mu \nu_A \nu_B) = E(h_\mu \bar{\nu}_A \bar{\nu}_B) = 0 . \quad (28c)$$

On the other hand, helicity of h_τ is also right, so that one will have

$$E(h_\tau \nu) = 2V(\tau) , \quad E(h_\tau \bar{\nu}) = 0 , \quad (29)$$

$$E(h_\tau \bar{\nu}_A \bar{\nu}_B) = 0 , \quad E(h_\tau \bar{\nu}_A \nu_B) = V(R) S_{AB}^- . \quad (30)$$

Taking account of (18) and (19), we assume the distance of A and B to be $R = \tau_1$ and then have the tau mass

$$m(\tau^-)_{t(s)} = 4\omega_{1/2} + 1.5\omega'_{1/2} - 5\omega_1 + m_e + \Delta m_\tau = 1782.9 \text{ MeV} , \quad (31)$$

$$\omega_{1/2} = 379.4 \text{ MeV} , \quad \omega'_{1/2} = 390.4 \text{ MeV} \quad (32)$$

when one assumes

$$\tau_{1/2} = 0.072/m_p . \quad (33)$$

Here the under-suffix t(s) means triplet spin state for A and B, while singlet state for each pair at same row. This spin state yields the lowest mass of (24). Such a spin state for two neutrinos may be permitted by different energy states caused from self energy of electron induced from virtual photon as a pair of hidden neutrinos. This value agrees with the experimental mass⁸⁾ $1784.1^{+2.7}_{-3.6}$ MeV. The characteristic values (32) and (33) will yield the masses of bottom mesons.

Recent measurement⁹⁾ has assured the helicity of tau lepton is negative. It is interesting that the helicity of lepton as composite is opposite to total helicity of components in each of tau and muon. This might imply that the helicity of partner neutrino in (3), which is hidden in mass generation, appears as the helicity of composite.

5. Charge and mass of quark

We have assumed the composite structures of quarks⁶⁾, which are symmetry for same rank, from hadron structures, for example, as follow

$$u = \begin{bmatrix} h \\ e \ h \end{bmatrix} , \quad d = \begin{bmatrix} h \\ \nu \ h \end{bmatrix} . \quad (34a)$$

$$b_1 = \begin{bmatrix} h' \ p \ h' \ \nu \\ \nu \ h' \ \nu \ h' \ p \end{bmatrix} , \quad b_2 = \begin{bmatrix} h' \ l \ h' \\ l \ h' \ \nu \ h' \end{bmatrix} , \quad (34b)$$

$$t_1 = \begin{bmatrix} h'' \ e \ h'' \ \nu \\ e \ h'' \ \nu \ h'' \ e \end{bmatrix} , \quad t_2 = \begin{bmatrix} h'' \ \nu \ h'' \\ e \ h'' \ \nu \ h'' \end{bmatrix} . \quad (34c)$$

where h'' belongs to the state $n=1/3$. Components of b_2 and t_1 are different from those of Ref.6 in the replacement of neutrino pair by

electronic lepton pair ($\bar{l}l$) in b_2 and by electron pair in t_1 . Our composite structures of quarks could explain the CKM-matrix⁶⁾¹⁰⁾. If one assumes $p=(uud)$, neutron will be (udd) from our composite $(pe\bar{\nu})$ ⁵⁾.

We shall speculate why the composites (34) have charge $2e/3$ or $e/3$. Our quarks u , d , c and b have an expansion τ_1 . Let us suppose u and $\bar{d}$ (34a) have Gaussian expansion with standard deviation τ_1 , and these approach to overlap with each another. When these approach by R the expansion of $\bar{d}$ overlaps with the charge distribution of u at $x=0$ we shall observe the charge of $\bar{d}$ at $x=R$ to be

$$\rho(R) = (2e/\sqrt{2\pi}\tau_1) \int_{R/2}^{\infty} \exp(-x^2/2\tau_1^2) dx. \quad (35)$$

This partial charge increases with decreasing R , and when R is

$$R_0 = 1.9348\tau_1 \quad (36)$$

the charge (35) becomes $e/3$, so that one would observe as if $\bar{d}$ had charge $e/3$. Hence the charge of u appears to be $2e/3$ since total charge is e . Similarly when u and $\bar{u}$ approach by (36) the overlapping part (35) of charges is cancelled, so that one would observe as if u had charge $2e/3$.

The relation $\tau_2 < \tau_4 (=1.748\tau_1) < R_0 < 2\tau_1$ implies that the distance (36) satisfies the composite condition (18). On the other hand when the Gaussian expansion has standard deviation $\tau_{1/2}$ two quarks at distance τ_1 satisfies also this condition since $\tau_1 (=1.875\tau_{1/2}) < 1.9348\tau_{1/2} < 2\tau_{1/2}$. Such situations are seen in tau lepton and bottom particle. Thus we conclude that when the condition (18) is satisfied the charge of our quark is observed as if it had fractional charge in composite system.

We estimate the masses of quarks (34b) and (34c). We call A, 1, B, 2 and C for each row from left in (34). Then we suppose the structure of b_1 and t_1 to be regular triangle with side $R=\tau_1$ and $\tau_{1/3}$ respectively by virtue of (18) or similar condition. This internal state function and internal energy are⁵⁾⁶⁾

$$|III\rangle = (1/2) \sum_P \sum_{(-1)}^P P |1A+1B\rangle |2A+2C\rangle, \quad (37)$$

$$E(III) = \langle III | H | III \rangle = (1/2) \sum_{i=1}^2 \sum_{j=A}^C [E(ij) + E(iAB) + E(iAC) - E(iBC)] \quad (38)$$

where P is any permutation for hidden neutrinos. By use of (17), (33) and (38) we have masses

$$m(b_1)_{ts(s)} = 3\omega'_{1/2} + 4\omega_{1/2} + \omega_1 + 2m_p = 4.6\text{GeV} \quad (39a)$$

$$m(t_1)_{ts(s)} = 4\omega'_{1/3} + 3\omega_{1/3} = 100\text{GeV} \quad (39b)$$

$$m(t'_1)_{st(t)} = 4(\omega'_{1/3} + \omega_{1/3}) = 115\text{GeV} \quad (39c)$$

where rows in (34) for t' are assigned by C, 1, A, 2 and B from left.

Similarly to tau mass we have

$$m(b_2)_{s(s)} = 5\omega_{1/2} = 1.9\text{GeV} \quad (40a)$$

$$m(t_2)_{s(s)} = m(t_2)_{t(s)} = \omega'_{1/3} + 4\omega_{1/3} = 75\text{GeV} \quad (40b)$$

The top quark masses thus deduced are consistent to the predicated mass range²⁾ $124^{+28+20}_{-34-15}\text{GeV}$. However, above bottom quark masses are less than the standard ones 4.7-5.3GeV, which is one half of mass of $T(1S)-T(4S)$.

7. Masses of bottom mesons

We shall estimate the masses of bottom bosons as the composites $(b_1 \bar{b}_2)$ on the basis of structures (34b). We then suppose that the internal states of leptons in b_1 are different from those in b_2 .

This composite has the following constituents as

$$(b_1 \bar{b}_2) = \begin{pmatrix} \nu & h' & p & h' & l & h' & \nu & h' \\ p & h' & \nu & h' & \nu & h' & l & h' \end{pmatrix} \quad (41)$$

where we assign A, 1, B, 2, C, 3, D and 4 from left row to right.

Then this system was supposed to have the structure of regular tetrahedron ABCD with edge of length r_1 . This internal state function and energy are⁵⁾

$$|V\rangle = (1/\sqrt{4!}) \sum_P \sum (-1)^P P |1A+1B\rangle |2A+2D\rangle |3B+3C\rangle |4C+4D\rangle, \quad (42)$$

$$E(V) = \langle V | H | V \rangle = \sum_{i=1}^4 \sum \left\{ \frac{5}{6} [E(iA)+E(iC)] + \frac{1}{2} [E(iB)+E(iD)] - E(iAC) \right. \\ \left. + \frac{1}{3} [E(iAB)+E(iAD)+E(iBC)+E(iCD)-E(iBD)] \right\}. \quad (43)$$

Inner states of same kind of leptons may be different unless all neighbors of each are equal in expression (41). There are then possible 16 internal spin states of A, B, C and D pairs, some states of which have been missed in our previous paper⁵⁾. These masses are given by use of (9)-(12), (23), (27), (28), (32) and

$$E(h_{\mu} e_A \bar{e}_B) = E(h_{\mu} p_A \bar{p}_B) = \frac{1}{2} \omega'_1 S_{AB} \quad (28b')$$

as follow

$$E(b_1 \bar{h}_2)_{sss(s)} = 16[2(\omega_{1/2} + \omega'_{1/2}) - \omega_1]/3 \quad (44)$$

which is total internal energy of bottom meson including b_2 with $l=e$ in (34b) or (41). Similarly one has the mean masses of bottom mesons

$$M_{sss(s)} = m(b_1 \bar{b}_2)_{sss(s)} = M_1 - 6\omega_1 - 2\omega'_1, \quad (45a)$$

$$M_1 = 2m_p + m_e + 8(5\omega_{1/2}/3 + \omega'_{1/2}), \quad (46a)$$

$$M_{sst(s,t)} = m(b_1 \bar{b}_2)_{sst(s,t)} = M_2 + 4(\omega'_1 - \omega_1)/3, \quad (45b)$$

$$M_2 = 2(m_p + m_e) + 32(\omega_{1/2} + \omega'_{1/2})/3, \quad (46b)$$

$$M_{ttt(s)} = M_2 + 8\omega'_1/3, \quad (45c)$$

$$M_{tst(s)} = M_2 + 8(\omega_1 + \omega'_1)/3 \quad (45d)$$

where under-suffix means the internal spin state of successive pairs of A, B, C and D, s singlet state, t triplet state and (s) or (t) spin state of each row in (41). The mass including M_1 is mean value of two cases of b_2 containing $l=e$ and ν , while M_2 appears in the case of b_2 for $l=e$. Above four mass states correspond to $\Upsilon(1S)$ - $\Upsilon(4S)$.

Other states that may correspond to six χ are

$$M_{sts(s)} = M_1 - 20\omega_1/3 \quad (47a)$$

$$M_{ttt(t)} = M_2 - 16\omega_1/3 \quad (47b)$$

$$M_{tts(t)} = M_1 \quad (47c)$$

$$M_{tss(t)} = M_1 + 2(\omega_1 + \omega'_1)/3 \quad (49d)$$

$$M_{tss(s)} = M_{tts(s)} = M_{sts(t)} = M_1 + 4(\omega_1 + \omega'_1)/3 \quad (47e)$$

$$M_{sss(t)} = M_1 + 2(\omega'_1 + \omega_1/3) \quad (47f)$$

$$M_{tst(t)} = M_2 + 8\omega_1/3 \quad (47g)$$

$$M_{stt(s)} = M_{stt(t)} = M_2 + 4(\omega_1 + \omega'_1)/3 \quad (47h)$$

Comparison of these numerical theoretical mass values with experimental ones are shown by Table II.

Table II

In general the agreement of theoretical and experimental masses are good and the deviations of both values are 2.5% at most, although χ_{b2} (2P) appears to have double close mass states. Heavier bosons than Υ (4S) will be the excited states of Υ .

8. Masses of top mesons

We estimate the masses of top mesons, which have similar constituents to (41) and regular tetrahedron structure with each edge $R=\tau_{1/3}$ by means of similar condition to (18). We suppose that internal states of leptons in t_1 are different from those of t_2 . We suppose the following structure as

$$(t_1 \bar{t}_2) = \begin{bmatrix} \nu & h'' & e & h'' & e & h'' & \nu & h'' \\ e & h'' & \nu & h'' & e & h'' & \nu & h'' \end{bmatrix} . \quad (48)$$

Similarly to bottom meson we have the mass of this composite by use of (43), for example,

$$\mathcal{M}_{sss(s)} = m(t_1 \bar{t}_2)_{sss(s)} = 16(\omega_{1/3} + 2\omega'_{1/3})/3 \quad (49a)$$

by the replacement of $n=1$ and $1/2$ by $1/3$ in (44). Other meson masses are given by

$$\mathcal{M}_{sst(s,t)} = 4(7\omega_{1/3} + 9\omega'_{1/3})/3 , \quad (49b)$$

$$\mathcal{M}_{ttt(s)} = 8(4\omega_{1/3} + 5\omega'_{1/3})/3 , \quad (49c)$$

$$\mathcal{M}_{tst(s)} = 40(\omega_{1/3} + \omega'_{1/3})/3 . \quad (49d)$$

Above four top meson masses correspond to those of $T(1S)-T(4S)$.

Other mass states are

$$\mathcal{M}_{sts(s)} = 2(7\omega_{1/3} + 19\omega'_{1/3})/3 , \quad (50a)$$

$$\mathcal{M}_{ttt(t)} = 4(5\omega_{1/3} + 7\omega'_{1/3})/3 , \quad (50b)$$

$$\mathcal{M}_{tts(t)} = 2(17\omega_{1/3} + 19\omega'_{1/3})/3 , \quad (50c)$$

$$\mathcal{M}_{tss(t)} = 4(9\omega_{1/3} + 10\omega'_{1/3})/3 , \quad (50d)$$

$$\mathcal{M}_{tss(s)} = \mathcal{M}_{tts(s)} = \mathcal{M}_{sts(t)} = 2(19\omega_{1/3} + 21\omega'_{1/3})/3 , \quad (49e)$$

$$\mathcal{M}_{sss(t)} = 4(9\omega_{1/3} + 11\omega'_{1/3})/3 , \quad (50f)$$

$$\mathcal{M}_{tst(t)} = 4(11\omega_{1/3} + 7\omega'_{1/3})/3 , \quad (50g)$$

$$\mathcal{M}_{stt(s)} = \mathcal{M}_{stt(t)} = 8(5\omega_{1/3} + 4\omega'_{1/3})/3 . \quad (50h)$$

One half of these masses, which are 110GeV to 181GeV by use of theoretical values (17), will be the top quark mass because the bottom

quark mass is given by one half of masse of Υ in the standard quark theory. Lately we shall compare these predictions with those deduced from weak boson mass.

9. Masses of weak bosons

Considering the relation of coupling (1) with weak interacting fermions⁵⁾, we assumed that weak bosons are composed of hidden scalar bosons and neutrinos⁷⁾;

$$W^{\pm} = (\bar{\phi}^0_{\mu} h_{\mu} \bar{h}_{\mu} \phi^{\pm}) , \quad (51a)$$

$$Z = (\bar{\phi}^0_{\mu} h_{\mu} \bar{h}_{\mu} \phi^0) = Z_0 \quad \text{or} \quad (\bar{\phi}^{\pm}_{\mu} h_{\mu} \bar{h}_{\mu} \phi^{\pm}) = Z_{\pm} . \quad (51b)$$

According to (1) and figs.2a and 2b the internal energy between ϕ and h is estimated as follow

$$E(\bar{\phi} h_{\mu}) = E(\phi \bar{h}_{\mu}) = E(\phi h_{\mu}) = E(\bar{\phi} \bar{h}_{\mu}) = \mathcal{E}_1 = \mathcal{E}_{11} + \mathcal{E}_{12} \quad (52)$$

$$\mathcal{E}_{11} = 6\alpha/\tau , \quad (52a)$$

$$\mathcal{E}_{12} = \frac{(6\alpha)^2}{\pi\tau} \int_0^1 \exp \left[-Mr \sqrt{1 + \frac{1-xy}{1-x}} \right] \frac{xdx}{1-x} \quad (52b)$$

if ϕ is at rest and virtual fermion mass is omitted.

Fig.2

The fourth order process between scalar boson and hidden neutrino yields $\mathcal{E}_{12}$ given by fig.2b. On the other hand the internal energy between hidden neutrinos is zero because of nonlocal structure⁷⁾. The internal energy between two scalar bosons was given by five diagrams, e. g., fig.2c and then

$$E(\phi \phi) = 5\mathcal{E}_2 \quad (53)$$

$$\mathcal{E}_2 = [(6\alpha)^2/\pi r] \exp(-Mr) \ln(M_P/M) \quad (53a)$$

where $M_P = 1.221 \cdot 10^{19}$ GeV is the Planck mass as the cut-off momentum. This procedure should be justified by the fact that the elementary charge has been expressed very well by¹¹⁾

$$e = (3\alpha/\pi) \ln(M_P/M_-)$$

as the electromagnetic coupling constant on the basis of (1a).

According to Sirlin¹²⁾ the self energy ΔM of W-boson is 3.2-3.9% of its bare mass, and then we have the weak boson masses

$$m(W) = 2(\mathcal{E}_1^0 + \mathcal{E}_1^-) + 5\mathcal{E}_2^- + M_0 + M_- + \Delta M \quad (54)$$

$$m(Z) = [m(Z_0) + m(Z_-)]/2 = 2(\mathcal{E}_1^0 + \mathcal{E}_1^-) + 2.5(\mathcal{E}_2^0 + \mathcal{E}_2^-) + M_0 + M_- \quad (55)$$

$$m(Z_0) = 4\mathcal{E}_1^0 + 5\mathcal{E}_2^0 + 2M_0 \quad (55a)$$

$$m(Z_-) = 4\mathcal{E}_1^- + 5\mathcal{E}_2^- + 2M_- \quad (55b)$$

where the upper-suffixes 0 and - mean the energies deduced from r_0 and r_- (or M_0 and M_-) respectively, taking account of whether virtual fermions includes charged one or not.

Using (17) and (51)-(55), we shall have the weak boson masses

$$m(W) = 84 \text{ GeV}, \quad m(Z) = 85 \text{ GeV} \quad (56)$$

which deviate from the experimental masses⁸⁾ $m(W) = 80.6 \pm 0.4 \text{ GeV}$ and $m(Z) = 91.161 \pm 0.031 \text{ GeV}$ by about 4 and 7% respectively. On the one hand these experimental masses yield the approximate values

$$r_0 = 1/315 m_p, \quad r_- = 1/110 m_p. \quad (57)$$

Now we can predict the top quark masses on the basis of (39), (40) and (57) as follow

$$m(t_{1ts(s)}) = 105 \text{ GeV}, \quad m(t_{2t(s)}) = 82 \text{ GeV}, \quad m(t'_{1st(s)}) = 123 \text{ GeV}. \quad (58)$$

These masses are very near by our theoretical predictions. On the other hand the top meson masses are evaluated by use of (57) and

shown in Table II, and then top quark mass as one half of meson masses (49) and (50) are 108-218GeV. This top mass range covers the present mass range of top mass²⁾³⁾, and the mean mass value of top quark may be about 178GeV, which is near by the Fermilab experimental value 174GeV⁴⁾. Hence such circumstances appear to imply that our composite pictures for weak boson and top quark are reasonable.

10. Conclusions

We have estimated the masses of leptons, bottom mesons, top mesons and weak boson as composites on the basis of our fundamental hidden coupling under the assumption that our hidden neutrinos are Majorana neutrinos. These results appear to be consistent to the present data. We then predict the top mass range to be 108GeV to 218GeV from theoretical and experimental results. These were resulted from introducing the tau neutrino interaction in our fundamental coupling, especially the masses of top quark and weak boson were deduced from the deepest inner quantum state.

Thus we have been able to explain uniformly most of particles masses by virtue of non-hermitic fundamental coupling, although properties of Majorana neutrinos should take place various problems. We also interpreted the quark charge under our model. The fractional charge of quark as composite was understood only in composite state of two quarks. Hence none can detect the quark as a single particle with fractional charged one.

However, there still remain questions why our quark cannot be detected as a single fermion with unity charge, how our and standard

quark models connect in the bottom meson spectroscopy, although our theoretical masses of composites ($b_1 \bar{b}_2$) agree with experimental ones. It must be investigated what induces the differences between theoretical and experimental fundamental lengths τ_n . If hidden tau neutrino is taken instead of muon one as component of top quark, the heavier mass of top quark or top meson would be yielded. It is desirable to integrate the top meson mass data by the Fermilab. proton-antiproton collider experiment.

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Table I. Fundamental lengths deduced from inner potentials

n	4	2	1	1/2	1/3
Theoretical $r_n^{m_p}$	0.253	0.198	0.140	0.073	0.0053
Experimental $r_n^{m_p}$	0.236	0.202	0.135	0.072	0.0061

Table II. Inner spin states and masses of bottom and top mesons

Inner spin states	Theoretical bottom meson masses (MeV)	Experimental bottom meson masses (MeV) ⁸⁾	Theoretical top meson masses (GeV)
sss(s)	9512	T_{1S} (9460)	216
sts(s)	9610	$\chi_{b0,1P}$ (9859)	215
ttt(t)	9730	$\chi_{b1,1P}$ (9892)	238
tts(t)	10060	$\chi_{b2,1P}$ (9913)	380
sst(s,t)	10095	T_{2S} (10023)	325
tss(t)	10152	$\chi_{b0,2P}$ (10232)	402
tts(s), tss(s), sss(t), sts(t)	10247	$\chi_{b1,2P}$ (10255)	423
tst(t)	10270	$\chi_{b2,2P}$ (10268)	435
stt(s,t)	10275		413
ttt(s)	10280	T_{3S} (10355)	368
tst(s)	10460	T_{4S} (10580)	434

Captions of figures

Fig.1 Fundamental coupling of hidden muonic neutrino and electronic lepton. (a) The lowest order interaction, (b) electromagnetic correction and (c)-(f) higher order interactions. Diagram (c) includes four-fold virtual interactions for $l=e, \nu$ and $N=p, n$.

Fig.2 Interaction diagrams yielding $\mathcal{E}_1$ and $\mathcal{E}_2$. Diagram (a) is an example giving $\mathcal{E}_{11}$, (b) $\mathcal{E}_{12}$ and (c) $\mathcal{E}_2$. Five similar diagrams as (c) between scalar bosons through virtual square loops are deduced from five couplings (1a)-(1e).

Fig. 1

Fig. 2