H, W, Z Bosons, Dark Matter: Composite Particles?

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Abstract

The present article develops a model initially published in ref. [1]. It is a quasi-classical quantum model of composite particles with ultra-relativistic (UR) constituents (leptons and quarks). The model is used to calculate the mass energy of three composite particles: a UR tauonium, a UR bottomonium and a UR leptoquarkonium. The result is that these three hypothetic particles have masses close to 125 GeV: the Higgs boson mass energy. These results are recalled in the present article. Then the model is extended to calculate the mass energy of *pi*-mesons, *W* and *Z* bosons. Finally, the model provides a hypothesis on dark matter.

Keywords

Higgs Boson, *W* and *Z* bosons, Dark Matter, *Pi*-Mesons, Composite Particle

1. Introduction

The present article develops a model introduced in the article ref. [1]. This was a quasi-classical model quantifying the energy states of a pair of ultra-relativistic tau-antitau (UR tauonium). Then the model was extrapolated in ultra-relativistic bottomonium and a tau-bottom mixed particle. Quantization was achieved by applying the pre-quantum Bohr rule to the particle vertices in a classical trajectory.

The model gives for these composite particles 3 different values for the mass energy close to 125 GeV, which is the mass energy of the Higgs boson (see ref. [2]). But the CMS detector at CERN gives precisely 3 values for the *H* boson, with disjoint error bars, according to the boson decay mode: 124.7 GeV for the 2-photon decay, 126 GeV for the 4-lepton decay and 125.35 for the combined measures. The results of the model, according to the CMS measures, are recalled in the present article. It therefore invites us to wonder if the H boson is really an

elementary particle.

The present article extends the model to all quarks interactions and shows that W and Z bosons could be UR tauonia supporting some quarks interactions. A comparison with pions is achieved.

Developing results presented in ref. [3], we also extend the model in order to show that dark matter could be a UR dark quarkonium.

2. Modeling Leptonium with Ultra-Relativistic Constituents (UR Leptonium)

Initially, we will consider the classical movement of a lepton and its antilepton bound by electrostatic interaction within the framework of special relativity. We must consider the fact that the moving charges create an electric field as a function of their speed. Here, both charges are moving along symmetrical trajectories according to their common center of gravity (with at all times opposite velocity vectors and equal in modulus), therefore the strength of their interaction is a direct result of their speed.

For the quantum-setting equation, the situation is different than that of the electron movement in the atom, because in this case the nucleus is assumed immobile; the electric field it generates is derived from a Coulomb potential and therefore depends only on the distance to the center.

For the above reason, we cannot use the Dirac equation and the results it provides for positronium here. It has not been studied for the present case, where the electrostatic bond strength of the particles depends on their speed and does not derive from an electrostatic Coulomb potential, which is based only on the distance to the center of gravity of the system.

We will simplify the problem by writing the equations of motion for the peak classical trajectories of both particles and applying to these points the pre-quantum Bohr rule relating to their kinetic momentum. We will see that this method allows calculation of the mass-energy of the composite particle without requiring determination of the wave function.

The diagram (Figure 1) shows two leptons (one lepton and its anti-particle) moving around their common center of gravity G to one of the peaks of their classical trajectory:

Lepton+ o $\rightarrow$ v
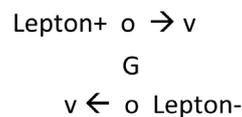
G

v $\leftarrow$ o Lepton-

Figure 1. Trajectory vertices of a lepton-antilepton pair

$$l^- \oplus \rightarrow v$$

Velocities v of both particles are equal and opposite in module, perpendicular to the radius length r of their distance from the center of gravity G.

The attractive force acting between the two leptons is (ref. [4]):

$$f = -\frac{\alpha\hbar c}{4r^2\sqrt{1-\dfrac{v^2}{c^2}}} \tag{1}$$

$$\alpha = \frac{e^2}{\hbar c} = \frac{1}{137.04}$$

e is the electric charge of the electron.

Furthermore, the momentum of each lepton (where m is its mass) is:

$$\boldsymbol{p} = \frac{m\boldsymbol{v}}{\sqrt{1-\dfrac{v^2}{c^2}}} \tag{2}$$

$\boldsymbol{p}$ and $\boldsymbol{v}$ are collinear vectors tangent to the trajectory of the lepton, and therefore perpendicular to the attractive force $\boldsymbol{f}$. In this case, the derivative of the pulse:

$$\frac{\mathrm{d}\boldsymbol{p}}{\mathrm{d}t} = m\frac{\dfrac{\mathrm{d}\boldsymbol{v}}{\mathrm{d}t}}{\sqrt{1-\dfrac{v^2}{c^2}}} \tag{3}$$

is radial; expression of this component is, by introducing the radius of curvature ρ of the path:

$$\frac{mv^2}{\rho\sqrt{1-\dfrac{v^2}{c^2}}} = \frac{pv}{\rho} \tag{4}$$

Here, $\boldsymbol{p}$ and $\boldsymbol{v}$ represent the modules of the momentum and speed at that point.

Equating (1) and (4) we have:

$$\frac{pvr^2}{\rho} = \frac{\alpha\hbar c}{4\sqrt{1-\dfrac{v^2}{c^2}}} \tag{5}$$

We now introduce Bohr's quantization rule, applied to both lepton systems, as follows:

$$2p\rho = n\hbar \tag{6}$$

n: integer.

which consists of taking as principle the quantization of angular momentum.

The relation (5) becomes:

$$\frac{vr^2}{c\rho^2} = \frac{\alpha}{2n\sqrt{1-\dfrac{v^2}{c^2}}} \tag{7}$$

Let: $s = \dfrac{\rho^2}{r^2}$

It is possible to fix the value of the relationship between the radius of curvature and the distance to the center of gravity by referring to the classical move-

ment. The simplest case is that of a circular path for which we have $s = 1$. In general, the standard trajectory is not an ellipse but a rosette, because the issue is dealt with in the relativistic framework. However, at the vertices of this trajectory, the curve traced by each tau is very close to an ellipse, as the equations of motion at these points are identical to those that result in anellipse in non-relativistic mechanics.

In the case of an ellipse with high eccentricity, the ratio ρ/r is near 2 for the vertex close to the foci coinciding with the center of gravity, so $s \simeq 4$.

Equation (7) is in fact an equation v (velocity at the peak trajectory of each lepton), which can be put as follows:

$$\frac{v^2}{c^2}\left(1 - \frac{v^2}{c^2}\right) = \frac{s^2\alpha^2}{4n^2} \tag{8}$$

That simple equation has the following solutions:

Solution 1:

$$\frac{v^2}{c^2} = \frac{1}{2}\left(1 - \sqrt{1 - 4\frac{s^2\alpha^2}{4n^2}}\right) \cong \frac{s^2\alpha^2}{4n^2} \tag{9}$$

Solution 2:

$$\frac{v^2}{c^2} = \frac{1}{2}\left(1 + \sqrt{1 - 4\frac{s^2\alpha^2}{4n^2}}\right) \cong 1 - \frac{s^2\alpha^2}{4n^2} \cong 1 \tag{10}$$

3. Discussion

1) The first solution (9) is weakly relativistic, v is greatly inferior to c.

In this case, using the classical expression of the kinetic energy for the system of two tau leptons, we obtain the energy levels (in absolute values):

$$E_n \simeq \frac{s^2\alpha^2 mc^2}{4n^2} \tag{11}$$

Assuming that the classical trajectory is a circle or $s = 1$, we find the inferred relations for the positronium by quantum theory, (ref. [5]), corresponding to the principal quantum number n (for the Hamiltonian "undisturbed"). In absolute terms, these energy levels are defined by:

$$E_n = \frac{\alpha^2 mc^2}{4n^2} \tag{12}$$

2) The second solution (10), the one that interests us here, is ultra-relativistic, the velocity of the two particles is close to that of light; using the relationship:

$$E = \frac{mc^2}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{13}$$

with (8) the energy levels are obtained:

$$E_n = n\frac{2mc^2}{s\alpha} \tag{14}$$

We have to distinguish again two cases:

a) The classical trajectory is circular: $s = 1$

$$E_1 = \frac{2mc^2}{\alpha} \tag{15}$$

The mass-energy of the UR leptonium is in this caseis (the antiparticle is denoted by *):

$$m_{l,l^*(circular)} = \frac{2m_l}{\alpha} \tag{16}$$

Note: The mass of the two charged *pi*-mesons is very close to the mass of the "circular" UR positronium.

$$m_{e,e^*(cicular)} = \frac{2m_e}{\alpha} = 140.0 \text{ GeV}; \quad m_\pi(exp.) = 139.6 \text{ GeV}$$

b) The classical trajectory is elliptic, with necessary a high eccentricity: $s = 4$

$$E_1 = \frac{mc^2}{2\alpha} \tag{17}$$

The mass-energy of the UR-leptonium in this case is the sum of two states: the kinetic energy at the studied vertex and the inertial mass energy at the other vertex.

$$m_{l,l^*(elliptic)} = \left(\frac{1}{2\alpha} + 2\right)m_l \tag{18}$$

4. The Mass of UR Tauonium

We apply the results above in the case of the tau quark with an elliptic trajectory:

$$m_{\tau,\tau^*} = \left(\frac{1}{2\alpha} + 2\right)m_\tau \tag{19}$$

Numerically, the mass of tau being equal to 1777 MeV, we obtain for the UR-tauonium:

$$m_{\tau,\tau^*} = 125.314 \text{ GeV} \tag{20}$$

The most precise mass of the Higgs boson given by the CMS detector of the CERN in 2019 (combined measurements) is:

$$m_H(exp) = 125.35 \pm 0.15 \text{ GeV} \tag{21}$$

It can be seen that the calculated value of ultra-relativistic tauonium corresponds closely to the measured value of the particle observed at CERN.

5. A Soft Approach of QCD; the Mass of UR Bottomonium

This particle is a pair of *b* quark-antiquark; it should normally be studied within the QCD theoretical framework. We know that in this context, numerical calculation of the mass of a composite particle from the mass of its components is extremely difficult and out of reach of the author of this article. We will return to the previous case of tauonium, arguing that the intensity of the strong interac-

tion of quarks tends toward the constant of the electrostatic interaction α at high energies, which is the case here. We can then venture the hypothesis that the above model for tauonium also applies to bottomonium.

If the coupling of the strong interaction at high energy is α, and if f denotes the full elementary strong charge, taking into account the fact we have 3 colors and 3 anti-colors, we can write:

$$f^2 = 6e^2 = 6\alpha\hbar c \tag{22}$$

The strong (or color) charge and the electric charge of both tau particles must intervene in the equations written above.

It is known that the electric charge of the bottom is $e/3$, thus the corresponding electric coupling with the anti-bottom is $\alpha/9$.

Assume that the value of the color charge is $2f/3$ for this quark, the value of color couplingb, anti-b is $24\alpha/9$ (cf. 22).

Adding the value of the interactions of the partial electric charge, we find the total value of the b, b^* interaction coupling

$$IC\left(b,b^*\right) = \frac{25\alpha}{9} \tag{23}$$

Using (17) we can write the expression of the level 1 of the UR bottomonium in the elliptic case:

$$E_1 = \frac{m_b c^2}{2IC\left(b,b^*\right)} = \frac{9m_b c^2}{50\alpha} \tag{24}$$

with the same relationship as (19), we obtain for the mass of bottomonium:

$$m_{b,b^*} = \left(\frac{9}{50\alpha} + 2\right)m_b \tag{25}$$

Here, the bottom quark mass we will take is equal to half that of the Upsilon boson mass which is clearly not an ultra-relativistic composite particle; then the quantum kinetic energy levels should be negligible compared to the rest mass of the constituents.

$$m_b = 4.73 \,\text{GeV} \tag{26}$$

Numerically: $m_{b,b^*} = 126.136 \,\text{GeV}$

This value is very close to the experimental value measured by the CMS detector for the 4-leptons decay of H boson (126 GeV).

6. The Mass of UR Taubottomonium

Leptoquarks are particles imagined in some theories beyond the standard model. Imagine a taubottom particle with amass equal to the half sum of tau and bottom masses, and whose coupling is the half sum of the 2 couplings

$$m_{\tau b} = \frac{m_\tau + m_b}{2}; \ IC\left(\tau b, \tau b^*\right) = \frac{1}{2}\left(\frac{25\alpha}{9} + \alpha\right) = \frac{34\alpha}{2 \times 9} \tag{27}$$

Using the same calculation as above, we obtain for the mass energy of this hy-

pothetic taubottomonium:

$$m_{\tau b, \tau b^*} = \frac{(m_\tau + m_b)}{2}\left(\frac{9}{34\alpha} + 2\right) = 124.53\,\text{GeV} \tag{28}$$

This value is very close to the measure of the H boson by CMS in the case of 2-photons decay (124.7 GeV).

7. *Pi* Mesons, *W* and *Z* Bosons

7.1. *Pi* Meson

We noted in (3) that the mass of charged *pi* mesons (*u*, *d* and *u*˙, *d*) is close to the mass of the UR positronium. These bosons change proton ⇔ neutron. *W* and *Z* bosons are the vectors of the weak interaction. The role of these two kinds of bosons is similar. So we now seek if the *W*, *Z* bosons are composite particles consisting of a pair of leptons (here the tau lepton because the heavy mass of *W* and *Z*) supporting quark interactions. Before, we show that *pi* mesons can be considered as UR pair of particles with the electron mass wearing some quarks interactions considered as a **superposition of quantum states**.

Using the calculation above, we can give the coupling of UR interaction pairs of quarks as below, adding for each pair the color (always attractive) and the electric (attractive or repulsive) interactions. Note that we can replace in these relationships "up" by "charm" or "top" and "down" by "strange" or "bottom", and each particle by its antiparticle.

$$IC(u, u^*) = \frac{6\alpha}{9} + \frac{4\alpha}{9} = \frac{10\alpha}{9}$$

$$IC(u, u) = \frac{6\alpha}{9} - \frac{4\alpha}{9} = \frac{2\alpha}{9}$$

$$IC(d, d^*) = \frac{24\alpha}{9} + \frac{\alpha}{9} = \frac{25\alpha}{9}$$

$$IC(d, d) = \frac{24\alpha}{9} - \frac{\alpha}{9} = \frac{23\alpha}{9}$$

$$IC(u, d) = \frac{12\alpha}{9} + \frac{2\alpha}{9} = \frac{14\alpha}{9}$$

$$IC(u, d^*) = \frac{12\alpha}{9} - \frac{2\alpha}{9} = \frac{10\alpha}{9}$$

Present now the empirical calculations below.

Suppose that the charged *pi* meson mass (here the *pi*+) is that of an UR positronium wearing 4 "circular" quark interactions: {*u*,*u*; *u*˙,*d*; *u*,*d*; *u*˙,*d*}with an interaction coupling equal to the average of that of these 4 interactions (we have the same result with the *pi*−):

$$IC(pi+) = \frac{\alpha}{4}\left(\frac{2}{9} + \frac{14}{9} + \frac{10}{9} + \frac{10}{9}\right) = \alpha \tag{29}$$

We obtain:

$$m_{pi+} = \frac{2m_e}{IC(pi+)} = \frac{2m_e}{\alpha} = 140.0 \text{ MeV}; \quad m_{pi+}(exp.) = 139.6 \text{ MeV} \qquad (30)$$

Suppose now that the neutral pi meson (*pi0*) mass is calculated as that of an UR positronium wearing 3 "circular" interactions: $\{d,d;\ d^*,d^*;\ u,u^*\}$ with an interaction coupling equal to the half average of that of these 3 interactions:

$$IC(pi0) = \frac{\alpha}{6}\left(\frac{23}{9} + \frac{23}{9} + \frac{10}{9}\right) = \frac{28\alpha}{27} \qquad (31)$$

We obtain:

$$m_{pi0} = \frac{2m_e}{IC(pi0)} = \frac{27m_e}{14\alpha} = 135.05 \text{ MeV}; \quad m_{pi0}(exp.) = 134.97 \text{ MeV} \qquad (32)$$

7.2. *W* and *Z* Bosons

- Assume the *Z* boson mass has the mass energy corresponding to the following "elliptic" UR quark interactions (sum of electric charges = 0) supported by a pair tau-antitau:

$\{u,u;\ d,d;\ u^*u^*;\ d^*d^*\}$; with the pair $\tau\ \tau^*$ leptons as a support of these quarks. The average coupling is:

$$IC(Z) = \frac{\alpha}{4\times 9}(2 + 23 + 2 + 23) = \frac{25\alpha}{18} \qquad (33)$$

Note that we obtain the same result if we only consider the half interaction coupling of $\{d,\ d^*\}$. We can say that the *Z* boson is an UR tauonium with the half interaction coupling of a bottomonium.

The corresponding mass is:

$$m_Z = \left(\frac{9}{25\alpha} + 2\right)m_\tau = 91.2212 \text{ GeV} \qquad (34)$$

The *Z* boson experimental mass is: $m_Z(exp.) = 91.1876(21) \text{ GeV}$

- For the *W+* boson, we assume the average of the following UR quark interactions:

$\{u,d;\ d^*d^*;\ u,d;\ u^*d^*\}$; (sum of electric charges = $+|e|$), the average coupling is:

$$IC(W+) = \frac{\alpha}{4\times 9}(14 + 23 + 10 + 10) = \frac{57\alpha}{4\times 9} \qquad (35)$$

The corresponding mass for a circular movement is:

$$m_W = \left(\frac{18}{57\alpha} + 2\right)m_\tau = 80.455 \text{ GeV} \qquad (36)$$

The *W* experimental mass is: $m_W(exp.) = 80.403(29) \text{ GeV}$

The calculation and the result are the same for the *W−*, taking into account all the antiquarks in the sum of interactions (sum of electric charges = $-|e|$).

7.3. Synthetic Comparison Table of Average Interaction for *Pi* Mesons, *W* and *Z* Bosons

Pi+: circular movement of electrons: {*u,u*; *u⁺d⁺*; *u,d⁺*; *u⁺d⁺*}

W+: elliptic movement of tau leptons; {*d⁺d⁺*; *u, d*; *u, d⁺*; *u⁺d⁺*}.

We have the same relationships for *Pi–* and *W–* with all quarks replaced by their antiquarks.

Pi0: circular movement of electrons: {*d,d*; *d⁺d⁺*; *u,u⁺*}.

Z: elliptic movement of tau leptons: {*d,d*; *d⁺d⁺*; *u, u*; u⁺*u⁺*} or {*d, d⁺*}.

8. Dark Matter

In ref [3] [6], we give the below relationship on elementary particle masses:

$$m = m_p \exp\left(-\frac{na}{2\theta}\right) \tag{37}$$

The parameter θ and the quantum number n characterize the elementary particle.

For the 3 elementary charged particles of the first family, we empirically determined the below values of θ and n, with the electron experimental mass as a reference (other masses are calculated).

Electron:

$$\theta = 3\sqrt{2}; \quad n = 3; \quad m_e = 0.511 \,\text{MeV}\,(exp.)$$

Up quark:

$$\theta = 2\sqrt{2} + 3; \quad n = 4; \quad m_u = 2.13 \,\text{MeV}$$

Down quark:

$$\theta = \sqrt{2} + 6; \quad n = 5; \quad m_d = 4.80 \,\text{MeV}$$

We have the empirical relationships below for the parameters:

$$\theta(k,l) = \sqrt{2}k + 3l; \quad n = k + 2l; \quad k,l = [0,1,2,3]; \quad k+l = 3$$

These numerical relationships that appear between parameters of the electric charge and the color charge of these 3 particles allow us to suppose the existence of a dark quark with parameters and mass below:

$$k = 0; \; l = 3; \; \Rightarrow \theta = 3 \times 3 = 9; \; n = 6; \; m_{dq} = 8.163 \,\text{MeV} \tag{38}$$

We can assume now a neutral color dark baryon composed of 3 dark quarks of 3 different colors (each with a strong charge = *f*/3). As there are 3 pairs of dark quarks, then 3 possible movements, we can calculate the dark boson mass as 3 times the mass of an elliptic UR dark quarkonium. Using the above calculation of the model mass:

$$IC(dq,dq) = \frac{6\alpha}{9}; \quad m_{db} = 3\left(\frac{9}{12\alpha} + 2\right)m_{dq} = 2566 \,\text{GeV} \tag{39}$$

Calculate now the ratio:

$$\frac{2m_{db}}{m_p + m_e} = 5.467 \tag{40}$$

We can see that this ratio is very close to the ratio: dark matter/ordinary matter:

$$\frac{\%\ dark\ matter}{\%\ ordinary\ matter} = \frac{26.8}{4.9} = 5.469 \tag{41}$$

Then, the existence in the Universe of two dark baryons for one proton and one electron can explain the ratio "dark matter/ordinary matter". This can be justified as below when elementary particles appeared at the end of the quadratic period of the expansion (see ref. 3). The table below presents all possible color (noted *a*, *b*, *c*) combinations allowing to form dark quarks with a constraint: only one active color per dark quark (example: *a*, *a** is not active). We then obtain 9 dark quarks allowing to form 3 color neutral dark baryons. We assume that combinations type *a*, *a**, *a*; are unstable, decay and give u or d quarks. Then the corresponding dark baryon decay to one proton and one electron or one neutron.

Dark baryons table

	2 dark quarks +1 quark *d*;	2 dark quarks +1 quark u or *d*;	2 dark quarks +1 quark *u*
Dark baryon 1	*a*, *a**, *c*	*b*, *b**, *a*	*c*, *c**, *b*
Dark baryon 2	*a*, *a**, *b*	*b*, *b**, *c*	*c*, *c**, *a*
Dark baryon decays	*a*, *a**, *a*	*b*, *b**, *b*	*c*, *c**, *c*
=> Proton + Electron	−|e|/3, *a*, *a*	2|e|/3, *b*	2|e|/3, *c*
or Neutron	−|e|/3, *a*, *a*	−|e|/3, *b*, *b*	2|e|/3, *c*

This approach gives 2 dark baryons per 1 proton and 1 electron (or 1 neutron).

It is possible that exits a neutral dark quark wearing 3 colors *a*, *b*, *c*; its mass would also be: 8.163 MeV.

Notes:

The model allows us to calculate the neutron {*u*, *d*, *d*} mass as 1.5 times the mass energy of anelliptic {*u*,*u*} quark interaction + 2 times the down quark mass ($m_n(exp.) = 939.57$ MeV):

$$m_n = \frac{3}{2}\left(\frac{9m_u}{4\alpha} + 2m_d\right) = 939.42\ \text{MeV};\ \text{with}: m_u = 2\ \text{MeV}; m_d = 4.8\ \text{MeV} \tag{42}$$

The previous note is an example that, for baryons and mesons, the mass taking into account in the movement of their constituent quarks does not always equal their rest mass. Give another example showed by the model. The mass energy of all delta baryons is 1232 MeV; the model shows that its equals the half mass energy of a pair {*u*,*u*} doted of an UR circular movement:

$$\frac{m_{u,u,(circular)}}{2} = \frac{9m_u}{2\alpha} = 1233.36\ \text{MeV} \tag{43}$$

Then the mass energy of all the delta baryons is given by the same relationship

concerning only the u quark mass although they have different compositions of u and d quarks: $\{u,u,u\}$, $\{u,u,d\}$, $\{u,d,d\}$ $\{d,d,d\}$. Masses of nucleons and delta baryons are given by two different relationships because there are several three body movements.

The problem of dark matter can be also achieved in principle in the framework of extended gravity; see [7].

9. Conclusions

This article does not prove that the Higgs boson is a composite particle. It only shows that three hypothetic composite particles have a mass close to 125 GeV. Perhaps an analysis of the signal at this energy by the CERN detectors allows us to know if these particles really exist.

We can make the same observation for W and Z bosons. In this case, another observation is necessary: pimesons, with properties close to that of these two bosons, are composite particles.

Finally, the model presented here provides an approach to the mystery of dark matter.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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