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Higgs-Like Boson and Bound State of Gauge Bosons $\underline{W}^+\underline{W}^-$ II

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Abstract

The Higgs-like boson discovered at CERN in 2012 is tentatively assigned to a newly found bound state of two charged gauge bosons W^+W^- with a mass of $E_B \approx 117$ GeV, much closer to the measured 125 GeV than 110 GeV predicted in a paper with the same title earlier this year. The improvement is due to a shift from the earlier SU(2) representation assignment for the gauge bosons to the more realistic SU(3) one and that the computations are carried out with much greater accuracy.

Keywords

Bound State of W^+W^-, Higgs-Like Boson, SU(3) Group

1. Introduction

This note is a further development of the recent paper [1], in which the Higgs-like boson H(125) discovered in 2012 with mass 125.09 GeV [2] was tentatively assigned to a bound state of two charged gauge bosons W^+W^- with a mass of $E_B \approx 110$ GeV. The starting point is the action for gauge bosons ([3], 7.1.2),

$$\begin{aligned}
S_{GBI} &= -\frac{1}{4}\int \mathrm{d}^4 x_I \sum_{l=1}^{8} G_{Al}^{\mu\nu}(x_I) G_{Al\mu\nu}(x_I) \\
G_{Al}^{\mu\nu}(x_I) &= \frac{\partial W_{Al}^{\nu}(x_I)}{\partial x_{I\mu}} - \frac{\partial W_{Al}^{\mu}(x_I)}{\partial x_{I\nu}} - \varepsilon_{jkl}\, g W_{Aj}^{\mu}(x_I) W_{Ak}^{\nu}(x_I) \\
W_A^{\mu\pm}(x_I) &= \left[W_{A1}^{\mu}(x_I) \pm i W_{A2}^{\mu}(x_I)\right]\big/\sqrt{2} = \left(W_A^{0\pm}(x_I), \underline{W}_A^{\pm}(x_I)\right)
\end{aligned} \quad (1)$$

where $W_A^{\pm}(x_I)$ denotes the charged gauge bosons and the superscript 0 its time component. In ([1], 1), however, the flavour index l was limited to run from 1 to 3 to reflect the assumption that these gauge bosons W^+W^-

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belong to a SU(2) representation, the lowest ranked one of a SU group. In this representation, the other gauge bosons, the massive neutral Z and the massless A are absent.

2. SU(2) vs SU(3)

Now, H(125) was generated in high energy proton-proton collisions in which all these 4 gauge bosons appear and a SU(3) representation is more appropriate. The 4 extra gauge bosons of the 8 gauge bosons in this representation degenerate to the 4 observed ones ([3], §7.2.3).

Further development is the same as that in [1] with the change of SU(2) to SU(3). This change only affects the running coupling constant ([1], 19) where the coefficient of the logarithmic term is proportional to the eigenvalue of the quadratic Casimir operator C_2 which is 2 for SU(2) and 3 for SU(3) ([4], 18.106). The renormalized coupling constant ([1], 20) now reads

$$g_R^2 = g^2\left[1 + C_2\frac{11g^2}{24\pi^2}\log\left(\frac{L_f}{L_R}\right)\right]^{-1}, \qquad L_R \to r, \qquad L_f > r \tag{2}$$

which corresponds to ([4], 18.133) for $C_2 = 3$ and is used here. The same computations that led to **Table 1** in [1] will be repeated here using (2) and with much greater accuracy.

3. Detailed Computation

In the Fortran 77 "dverk" integration subroutine, denote the integration step length by d_s. The inter gauge boson distance r that enter the computations is $r_c = k_d d_s$, where k_d is the number of steps needed to reach r_c. Only at these discrete r_c values can the solutions be printed out. This subroutine only allows $k_d \le 2^{10} = 1024$. Since the backward integrations has to start from some large r value, taken to be ≈ 0.5 GeV^{-1} in [1], d_s has a minimum $d_{sm} = 0.5/1024 \approx 0.000488$ GeV^{-1}. Let r_{ci} be the r_c closest to r_i and $r_{ci} = k_{di} d_s$. Three step lengths, $d_s = d_{sm}$, $2d_{sm}$ and $4d_{sm}$, corresponding to k_{di}, $k_{di}/2$ and $k_{di}/4$, respectively, for a given r_{ci} will be used.

A bound state solution exists when the three conditions of ([1], 17) is exactly satisfied. This requires that $\Delta_{max} = 0$. Among the three parameters that fix ([1], 17), E_b and b_0 are continuous and can be specified to any degree of accuracy. But the third parameter r_i is according to the last paragraph limited to the discrete r_{ci} which can differ from r_i by $< d_{sm} \neq 0$. Therefore, $\Delta_{max} \neq 0$ and minima of Δ_{max} are sought. For such minima encountered here, it is sufficient to specify Δ_{max} up to 0.01%. This error margin leads to that E_B needs be accurate up to 0.001 GeV and b_0 up to 0.0001.

In [1], only $d_s = 2d_{sm} \approx 0.001$ GeV^{-1} was used. As was mentioned near ([1], 18), a criterion for the existence of a bound state solution has been taken to be $\Delta_{max} < \Delta_{err}$, an error due to the finite integration step length; $\Delta_{err} = d_s/r_{ci} = 2d_{sm}/r_{ci}$. As is seen in **Table 1** of [1] and **Table 1** below, only $r_i \approx 0.032$ - 0.033 are of interest. In [1], $\Delta_{err} = 2d_{sm}/r_i \approx 3\%$ and the criterion $\Delta_{max} < 3\%$ was used. This criterion is not absolute or derivable but is regarded as a plausible first approximation. It is satisfied by the solution ([1], 18) with $\Delta_{max} = 2.69\%$ and the 2 underlined entries in **Table 1** of [1] with $\Delta_{max} = 2.71\%$ and 2.23%.

Here, $\Delta_{err} = d_{sm}/r_i \approx 1.5\%$ and $\Delta_{err} = 4d_{sm}/r_i \approx 6\%$ are also considered. The corresponding criteria are $\Delta_{max} < \Delta_{err} \approx 1.5\%$ and $\Delta_{max} < \Delta_{err} \approx 6\%$, respectively.

Table 1. This table is the same as **Table 1** of [1] with ([1], 20) replaced by (2) here to reflect the change of the eigenvalue of the Casimir operator C_2 from 2 to 3. Only the underlined two cases satisfy the extrapolated criterion $\Delta_{max} < \Delta_{err} \approx 0.75\%$ below and can be solutions. k_{di} is the number of integration steps needed to reach r_{ci}, the printout r_c value nearest to the joint distance r_i in ([1], 17), for three different integration step lengths, $4d_{sm}$, $2d_{sm}$ and d_{sm}. * denotes that $k_{di} = 60$ was excluded due the above $k_d \le 2^{10} = 1024$ limitation in the backward integration.

L_f GeV^{-1}	0.20	0.20	0.30	0.30	0.34	0.35	0.36	0.40	0.50
k_{di}	16	33, 66	17	33, 66	17, 34, 68	17, 34, 68	17, 34, 68	17, 34, 68	15, 30*
Δ_{max} %	33.57	30.18	6.20	1.71	<u>0.50</u>	<u>0.35</u>	1.04	2.42	32.73
b_0	1.2753	1.3466	1.5277	1.4108	1.6792	1.7143	1.7486	1.8760	1.9161
E_b GeV	104.635	105.337	112.708	113.179	115.951	116.845	117.773	121.825	131.227

4. New Results

The computations in [1] are repeated using the more accurate specifications above. The changed results are Δ_{max} = 2.69% → 2.67% in ([1], 18), and 2.71% → 2.52% and 2.23% → 1.44% in ([1], Table 1). But now the criterion becomes Δ_{max} < 1.5% and is not satisfied by the solution ([1], 18) with bare g and M_W values and such a bound state no longer exists. Using SU(2) representation, the L_f = 0.30 GeV^{-1} case in ([1], Table 1) with Δ_{max} = 2.71% → 2.52% is also no longer a solution. The L_f = 0.35 GeV^{-1} case with Δ_{max} = 2.23% → 1.44% is barely < 1.5% but will not survive the extrapolated criterion Δ_{err} → 0.75% below.

Now, employ (2) with SU(3) and the more accurate E_B, b_0 and r_{ci} values mentioned above, the results are given in **Table 1**.

For L_f = 0.20 and 0.30, k_{di} = 33 and 66 refer to the same r_{ci}. Since 33/2 = 16.5 is not an integer, k_{di} = 17 and 16 refer to this r_{ci} + and − $2d_{sm}$ respectively. It is seen that Δ_{max} is lower for the smallest step length d_{sm} accompanying k_{di} = 66, as expected. The four cases with k_{di} = 17, 34 and 68 are accompanied by the step lengths d_s = $4d_{sm}$, $2d_{sm}$ and d_{sm}, respectively, correspond to the same r_{ci} and yield the same integration results. This shows that the computer accuracy is independent of these step lengths; only printouts do. Extrapolating these cases by reducing d_s one more step down to $d_{sm}/2$, $\Delta_{err} \to d_{sm}/2r_i$. The so-extrapolated criterion becomes Δ_{max} < 0.75% which is satisfied only by the two underlined cases in **Table 1**. A further reduction leads to Δ_{max} < 0.375% which is only satisfied by the L_f = 0.35 case. If the step length is reduced by half once more, Δ_{max} < 0.1875% and there is no solution for any case in **Table 1** and also in **Table 2**.

The L_f = 0.35 case with Δ_{max} = 0.35% in **Table 1** using SU(3) representation is far more close to 0 than does the 2.23% from **Table 1** of [1]. It may be regarded as a solution to the bound state and is tentatively assigned to H(125) instead. The calculated mass E_b = 116.845 GeV is much closer to 125.09 GeV [2] than does 110.02 GeV in [1]. The wave functions for these cases are close to that given by the dotted curve in Figure 1 of [1].

Equation (2) shows that L_f is an infrared cutoff and represents the size of the normalization box for a $W^{\pm}$ boson. Its mass M_W = 80.385 GeV is interpreted to have been determined when this boson is separated from other interacting particles by >L_f. L_f = 0.35 GeV^{-1} in **Table 1** appears to be compatible to some of the experimental conditions determining M_W. Also, E_b gets closer to the measured 125 GeV with increasing L_f. But why Δ_{max} is small enough for the present bound state to exist only when $L_f \approx$ 0.35 GeV^{-1} is not understood.

Table 2. Deviations Δ_{max} for different Casimir operator eigenvalues C_2 for L_f = 0.35. The underlined values satisfy the above twice extrapolated criterion Δ_{max} < 0.375%. C_2 = 3 for SU(3) is preferred by the bound state.

C_2	E_B GeV	b_0	Δ_{max} %	k_{di}
2.0	108.101	1.4113	21.30	16
2.0	109.833	1.4119	1.44	33, 66
2.0	110.083	1.4348	22.35	17
2.4	112.351	1.5818	5.57	17, 34, 68
2.8	115.372	1.6645	1.83	17, 34, 68
2.9	116.098	1.6899	0.62	17, 34, 68
2.94	116.396	1.6996	<u>0.23</u>	17, 34, 68
2.97	116.594	1.7094	<u>0.35</u>	17, 34, 68
2.99	116.771	1.7119	<u>0.26</u>	17, 34, 68
3.0	116.845	1.7143	<u>0.35</u>	17, 34, 68
3.02	116.995	1.7193	0.54	17, 34, 68
3.1	117.579	1.7407	1.43	17, 34, 68
3.2	118.345	1.7651	2.18	17, 34, 68

5. Variation of C_2

The calculations leading to **Table 1** has been repeated for $L_f = 0.35\ \text{GeV}^{-1}$ using different C_2 in (2). The results are shown in **Table 2**.

This table shows that solutions according to the twice extrapolated criterion $\Delta_{max} < 0.375\%$ exist only for $2.94 \le C_2 \le 3.0$. The bound state bosons W^+W^- prefer SU(3) and reject SU(2).

To obtain more precise prediction on the existence of bound state solutions, the Fortran 77's "dverk" subroutine may be replaced by more modern routines including finite element method.

6. Consequences

If the 2012 H(125) is indeed a bound state W^+W, it can no longer be the SM Higgs and at least the low energy end of SM is without foundation and has to be abandoned. No appreciable predictive power is lost; SM has not been able to account for basic hadron spectra and decays. SSI [3] is far more successful in this region. Mass generation of $W^{\pm}$ comes from pseudoscalar mesons when the relative time between the both quarks in the meson is taken into account.

Further, the presence of a Higgs condensate, disregarding the requirement that its isospin must be >0, will lead to a cosmological impasse ([5], p. 247). Such a condensate originated in the hypothesis (Nambu…) that vacuum contains a spin 0 background field that is spontaneously symmetry broken. It is reminiscent of the aether of the late 19th century that permeates the vacuum as a medium carrying light waves. Such attempts to put physics into the vacuum are against the historical examples that new physics come from some basic principles and mathematics ([3], Appendix G, Sec. 6). They do not work.

References

[1] Hoh, F.C. (2016) *Journal of Modern Physics*, **7**, 36-42. http://dx.doi.org/10.4236/jmp.2016.71004

[2] Olive, K.A., *et al.* (2015) *Chinese Physics C*, **38**, 090001. http://dx.doi.org/10.1088/1674-1137/38/9/090001

[3] Hoh, F.C. (2011) Scalar Strong Interaction Hadron Theory. Nova Science Publishers, Hauppauge.

[4] Lee, T.D. (1981) Particle Physics and an Introduction to Field Theory. Harwood Academic Publisher, New York.

[5] Wilczek, F. (2005) *Nature*, **433**, 239-247. http://dx.doi.org/10.1038/nature03281