Unification of strong force, weak force, and electromagnetism

By Wan-Jiung Hu MD PhD

In previous research, Professor Weinberg proposed an electroweak interaction to predict the masses of W and Z particles. His theory is very successful. However, it is actually the interaction of photon and W/Z bosons. So, it is Weak-Light Interaction. It is the interaction between weak force and light. Here, I propose an interaction between strong force and light. Thus, it can solve the problem of gluon mass.

Based on Yang-Mills theory of standard model, we know the Yang-Mills equation is:

$$\mathrm{Fuv} = \partial \mathrm{uAv} - \partial \mathrm{vAu} - [\mathrm{Au}, \mathrm{Av}]$$

In addition, the QHD formula is:

$$\mathrm{U(SU(2))} = \exp[\mathrm{ig} \sum_{j=1}^{8} \mathrm{F_j}\, \mathrm{G_j(x)}]$$

Thus, the covariant derivative is:

$$\partial^{\mu} = \partial^{\mu} + \mathrm{igF} * \mathrm{G(x)}$$

Besides, F=1/2λ, and λ is Gell-Mann matrix:

$$\lambda_1 = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$\lambda_2 = \begin{bmatrix} 0 & -i & 0 \\ i & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$\lambda_3 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$\lambda_4 = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{bmatrix}$$

$$\lambda_5 = \begin{bmatrix} 0 & 0 & -i \\ 0 & 0 & 0 \\ i & 0 & 0 \end{bmatrix}$$

$$\lambda_6 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

$$\lambda_7 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & -i \\ 0 & i & 0 \end{bmatrix}$$

$$\lambda_8 = \frac{1}{\sqrt{3}}\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -2 \end{bmatrix}$$

For photon, there is another matrix:

$$\lambda_9 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

We let r or |r>=(1,0,0), b or |b>=(0,1,0), and g or |g>=(0,0,1). Then, the whole matrix is:

$$\begin{bmatrix} r\bar{r} & b\bar{r} & g\bar{r} \\ r\bar{b} & b\bar{b} & g\bar{b} \\ r\bar{g} & b\bar{g} & g\bar{g} \end{bmatrix}$$

In addition, each matrix has its corresponding gluons and photon:

$$G_1 = \frac{1}{\sqrt{2}}\left(r\bar{b} + b\bar{r}\right)$$

$$G_2 = \frac{i}{\sqrt{2}}\left(r\bar{b} - b\bar{r}\right)$$

$$G_3 = \frac{1}{\sqrt{2}}\left(r\bar{r} - b\bar{b}\right)$$

$$G_4 = \frac{1}{\sqrt{2}}\left(r\bar{g} + g\bar{r}\right)$$

$$G_5 = \frac{i}{\sqrt{2}}\left(r\bar{g} - g\bar{r}\right)$$

$$G_6 = \frac{1}{\sqrt{2}}\left(g\bar{b} + b\bar{g}\right)$$

$$G_7 = \frac{i}{\sqrt{2}}\left(b\bar{g} - g\bar{b}\right)$$

$$G_8 = \frac{1}{\sqrt{6}}\left(r\bar{r} + b\bar{b} - 2g\bar{g}\right)$$

Besides, the photon boson is:

$$B = G_9 = \frac{1}{\sqrt{3}}\left(r\bar{r} + b\bar{b} + g\bar{g}\right)$$

Thus, there are totally 9 bosons(8 gluons plus 1 photon) for the whole 3X3 matrix, and they are acquiring masses due to the interaction with Higgs bosons. In order to maximize the total gluons, we need to use complex scalar field here to include 6 Higgs bosons. We predict that six of the bosons will interact with Higgs field, and three gluons will have no mass. The Higgs field is:

$$\varphi(x) \equiv \frac{1}{\sqrt{2}}\begin{pmatrix}\varphi 1 + i\varphi 2\\ \varphi 3 + i\varphi 4\\ \varphi 5 + i\varphi 6\end{pmatrix}$$

And, we let$\varphi 1 = \varphi 2 = \varphi 3 = \varphi 4 = \varphi 6 = 0$ and $\varphi 5 = v$. Thus, the Higgs field should be (0,0,V/$\sqrt{2}$)

The lagrangian for the complexl scalar field is:

$$L(\varphi) = (\partial_v \varphi)(\partial^v \varphi) - \mu^2(\varphi(x))^2 - \lambda(\varphi(x))^4$$

Then, we introduce the covariant derivative of QCD and Gell-Mann matrixinto the lagrangian. It becomes:

$$\frac{1}{4}|\left[\left(ig\lambda G(x)\right) * \varphi(x)\right]^{+}\left[\left(ig\lambda G(x)\right) * \varphi(x)\right]| =$$

$$\mathbf{\frac{1}{8}(\frac{1}{\sqrt{2}}\,gv(G_4 - iG_5), \frac{1}{\sqrt{2}}\,gv(G_6 - iG_7), v\left(\frac{1}{\sqrt{3}}kB - \frac{\sqrt{2}}{\sqrt{3}}gG_8\right))}$$
$$\mathbf{\times\,(\frac{1}{\sqrt{2}}\,gv(G_4 + iG_5), \frac{1}{\sqrt{2}}\,gv(G_6 + iG_7), v\left(\frac{1}{\sqrt{3}}kB - \frac{\sqrt{2}}{\sqrt{3}}gG_8\right))}$$

We let G^4=1/$\sqrt{2}$(G_4+iG_5), G^5=1/$\sqrt{2}$(G_4-iG_5) and so for G^6 and G^7. And we let $\boldsymbol{\sqrt{2}/\sqrt{3}g}$**=g''及** $\boldsymbol{1/\sqrt{3}k = g'}$. Then, we get the above formula:

$$\mathbf{\frac{1}{8}(\frac{1}{\sqrt{2}}\,gv(G_4 - iG_5), \frac{1}{\sqrt{2}}\,gv(G_6 - iG_7), v\left(\frac{1}{\sqrt{3}}kB - \frac{\sqrt{2}}{\sqrt{3}}gG_8\right))}$$
$$\mathbf{\times\,(\frac{1}{\sqrt{2}}\,gv(G_4 + iG_5), \frac{1}{\sqrt{2}}\,gv(G_6 + iG_7), v\left(\frac{1}{\sqrt{3}}kB - \frac{\sqrt{2}}{\sqrt{3}}gG_8\right))}$$
$$=$$

$$\frac{g^2v^2}{8}G^4G^5 + \frac{g^2v^2}{8}G^6G^7 + \frac{v^2}{8}(G_{8u}, B_u)\begin{pmatrix} g''^2 & -g'g'' \\ -g''g' & g'^2\end{pmatrix}\begin{pmatrix} G_8^u \\ B^u\end{pmatrix} + 0 * (g''G_8^u + g'B^u)(g''G_{8u} + g'B_u)$$

$$\div (g'^2 + g''^2) = \frac{g^2v^2}{8}G^4G^5 + \frac{g^2v^2}{8}G^6G^7 + \frac{1}{2}M_{G8}^2 G_u^8 G^{8u} + 0 * A^u A_u$$

We let G^{8u}=$(g'B^u - g''G_8^u)/\sqrt{(g'^2 + g''^2)}$ and
A^u=$(g'G_8^u + g''B^u)/\sqrt{(g'^2 + g''^2)}$

Similar to electroweak theory, we get the mass of G^8

$$m\,G^8 = \frac{1}{2}v\sqrt{g'^2 + g''^2}$$

And the mass of photon A^u is still zero. Similar to electroweak theory, we get G^8 field and photon field:

$$G^8 = \frac{g'}{\sqrt{g''^2 + g'^2}}B - \frac{g''}{\sqrt{g''^2 + g'^2}}G_8 = B\sin\theta - G_8\cos\theta$$

$$A = \frac{g'}{\sqrt{g''^2 + g'^2}}G_8 + \frac{g''}{\sqrt{g''^2 + g'^2}}B = G_8\sin\theta \quad + B\cos\theta$$

In addition, the mass of the new gluons G^1, G^2, and G^3 is still zero after the Higgs mechanism. Besides, the mass of gluons G^4, G^5, G^6, and G^7 is $1/2\sqrt{2}$vg($1/2\sqrt{2}$v). The G^8 gluon becomes g<u>g</u> (mass 1/2v) after the Higgs mechanism. Besides, we know

$\frac{1}{\sqrt{2}}(G_1 - iG_2) = r\bar{b}$, and $\frac{1}{\sqrt{2}}(G_1 + iG_2) = b\bar{r}$_etc

G_8 and photon Higgs interaction is in the right and bottom most position of the matrix, and we get a final g<u>g</u> gluon. The form of r<u>r</u>-b<u>b</u>(λ3) is (which is similar to neutral pion):

$$\frac{1}{\sqrt{2}}(r\bar{r} - b\bar{b})$$

I don't know the exact coupling constant ratio between photon and strong force. However, if the alpha ratio (strong) is 1 which is similar to the color force, we can get:

$$\sin\theta = \frac{1}{\sqrt{3}}$$

$$\cos\theta = \frac{\sqrt{2}}{\sqrt{3}}$$

Thus, we will get the results of G^8-A interaction (mixing).

$$G^8 = g\bar{g}$$

$$A = \frac{1}{\sqrt{2}}(r\bar{r} + b\bar{b})$$

Thus, we can get the new sets of the massive gluons $G^{4\text{-}8}$: b<u>g</u>,g<u>b</u>,g<u>r</u>,r<u>g</u>, and g<u>g</u>. Besides, there are four non-massive gluons: λ1, λ2, λ3,& A. These four gluons can interact with higgs boson (0,V/$\sqrt{2}$) again via electrostrong interaction. Thus, massive r<u>b</u> and b<u>r</u> can be generated (mass $1/2\sqrt{2}$v) as well as massive b<u>b</u> (mass 1/2v) and massless r<u>r</u>. Totally, there are eight massive gluons to mediated short range strong force (no red-antired gluon). Besides, A is the same as B0 boson in Weinberg's electroweak interaction. The four no-massive ones can also then undergo a SU(2) electroweak mechanism via Pauli matrix to interact with a Higgs(0,V/$\sqrt{2}$) to generate massive W+, W-, Z, and massless γ. Thus, we can link strong force, weak force, and light together.

Green-related gluons have masses, and non-green gluons have no mass. This solves Yang-Mills mass gap problem for gluons. That's why neutron/proton has more mass than its quarks. From above, we know alpha decay is related to meson and beta decay is related to W boson. Both are SU(2).

Then, we state why quarks and leptons have three generations. The electroweak

interaction is the main source of the three generations of leptons such as electron and neutrino. After Higgs interaction, W and Z bosons acquire mass to generate electron and neutrino. We know the massive fermions do not exhibit chiral symmetry. That is because mass term in the langragian $m\Psi\underline{\Psi}$ breaks the chiral symmetry. And we know the NXN Cabibbo-Kobayashi-Maskawa (CKM) matrix's principle to decide the generations of quarks and leptons. The factor is (N-1)(N-2)/2. If N=1, there is no quark mixing angle and CP violation. If N=2, there is one quark mixing angle and no CP violation. If N=3, there is 3 mixing angle and one CP violation. As our above discussion, weak-light and strong-light both cause spontaneous symmetry breaking with one CP violation after gauge bosons acquire mass. Neutral terms in the QCD langragian are able to break CP symmetry like electroweak theory. This can help to solve strong CP problem. Thus, there must be a 3x3 CKM matrix for quarks and leptons. Quarks and leptons have three generations.
Finally, I want to discuss the relation of charge, hypercharge, and isospin. By applying the above Higgs mechanism, we can easily explain the phenomenon of this relationship. We use left handed quarks and leptons as examples. In strong interaction, we have Gell-Mann Nishijima Formula:

$Q=T_3+1/2Y$
(Q: charge, T:isospin, Y:hypercharge)

First, we look at the Higgs-gluon interaction. From above, we can see a three component Higgs (V,0,0) interacts with gluons to let gluon acquire mass. If a whole neutron or proton is generated, we can see if the above equation is achieved. We know the isospin Iz and charge of neutron is -1/2 and 0, and the isospin Iz and charge of proton is +1/2 and +1. From the Gell-Mann equation, we can get both proton and neutron has hypercharge Y=1. Besides, we can get hypercharge Y=-1 for both anti-proton or anti-neutron.

Then, we look at up quark and down quark which make the neutron and proton. The isospin Iz and charge of up quark is +1/2 and +2/3. The isospin Iz and charge of down quark is -1/2 and -1/3. Then, we can get that both up quark and down quark has hypercharge Y=1/3. And, the anti-up or anti-down quark is -1/3. Thus, there must be three quarks which make one proton or one neutron(Y:1/3*3=1). And, this matches three component of original Higgs (v,0,0). This can also apply for strange quark, charm quark, top quark, and bottom quark. Besides, we know strong interaction is SU(3).

We can also apply the above principle to meson such as pion. The hypercharge of pions are zero. Pion+ has +1 charge and +1 isospin, Pion- has -1 charge and -1 isospin, and Pion0 has 0 charge and 0 isospin. Because pion is made of quarks with hypercharge 1/3, pion hypercharge 0=1/3-1/3 is with one quark and one anti-quark. The two components of hypercharge means it is also SU(2) interaction. 1/3 means it needs quark matrix with higgs field(V,0,0) with three components.

Then, we look at Higgs electroweak interaction. There is a two component Higgs (v,0). Here, we will use a weak hypercharge formula for weak interaction:

$Q=I_3+Y_W$ (I_3:weak isospin, Y_W:weak hypercharge)

We know W boson will decay into two components: electron and anti-neutrino. $W^- \to e^-$+anti-ν. We know the isospin Iz and charge of electron is -1/2 and -1, and the isospin Iz and charge of anti-neutrino is -1/2 and 0. Thus, we can get the weak hypercharge of electron is -1/2 and the hypercharge for anti-neutrino is +1/2. The 1/2 means two component Higgs and two products of W boson decay. We can also view this relation in Z boson decay. Z boson will decay into neutrino and anti-neutrino pair. The isospin Iz and charge of neutrino is 1/2 and 0 and the isospin Iz and charge of anti-neutrino is -1/2 and 0. Thus, from the above weak hypercharge formula, we can get the hypercharge of neutrino is -1/2 and for anti-neutrino is +1/2. Z boson also decays into two components which match the two components of original Higgs sectors. Both the hypercharge of Z or W bosons is zero, and it is the combination of the two parts of electron and neutrino hypercharge.(Yw=1/2-1/2=0) Moreover, we know electroweak is SU(2).

Finally, I would like to discuss the basic phenomenon of natural radiative decays. We know basic radiative decays include alpha decay, beta decay, and gamma decay. Here, I will propose that alpha decay is to release meson(pion) particle. Beta decay is to release W particle(SU(2)). And, gamma decay is to release gluon particle(and/or Higgs boson)(SU(3)). Alpha particle is also a helium nucleus with two protons with opposite spin and two neutrons with opposite spin. Between neutron and proton, there is pion mediated nuclear force. The release of alpha particle must be involved in a dropping out of a neural meson(pion) from the atomic nucleus. Thus, I say alpha decay is related to the release of meson(pion). And, we all know that beta decay is related to the emission or absorption of W^+ or W^- boson. The releasing of W^- boson with decaying into electron and neutrino is more common. And, nuclear neutron will become proton. Thus, I say beta decay is related to release of W (SU(2)) particle. In gamma decay, gamma ray can be released from an excited nucleus. However, the charge-mass of nucleus is not affected. Gluon can absorb gluon or emit gluon. Two fused gluons can generate higgs boson and then turn into gamma ray. Thus, I propose here that gamma decay is the release of gluon(SU(3)) from the nucleus. Thus, it will help to explain the characteristics of the three fundamental nuclear decays.