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NEW WEAK INTERACTION SIGNAL IN THE $SU(2)_1 \otimes SU(2)_2 \otimes U(1)_Y$ MODEL

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ABSTRACT

According to the framework of $SU(2)_1 \otimes SU(2)_2 \otimes U(1)_Y$ Model (2-2-1 model), $W_1^{\pm}$ (be like $W^{\pm}$ in the standard model), and $W_2^{\pm}, Z'$ decays will be discussed. The $W_1^{\pm}$ decay width is equal to 2.1 GeV, consistently to SM and experimental data. The $W_2^{\pm}$ decay width is very large, in which the main contribution to this decay is the channel containing exotic quarks. Furthermore, it is found that the lepton rate decay of Z' accounts for the bulk.

Keywords: weak decays, Extensions of SM, SM.

1. Introduction

The standard model (SM) has many successes in explaining physical phenomena at 100 GeV. However, this model still has many shortcomings, such as the inability to explain the material-antimatter asymmetry phenomenon or the matter of dark matter. Therefore, extending this model is a necessity.

Weak interactions are known as the swaps via Z^0 and $W^{\pm}$. These two bosons are fully covered in SM. However, at the energy scale larger than 200 GeV, weak interactions may occur throughout new bosons which can be described in the extended SM.

The $SU(2)_1 \otimes SU(2)_2 \otimes U(1)_Y$ Model (2-2-1 model) is one extension of SM, which has the simplest group structure. However, there are three coupling constants, three VEVs; two exotic quarks which are in a doublet of $SU(2)_2$ group; one new charged and one new neutral gauge bosons which are larger than 1.7 TeV (Chuan-Hung Chen and Takaaki Nomura, 2017). This model has two new gauge bosons which can play an essential role in the early universe.

The non-SM particles, such as Z' is searched by LHC, whose estimating mass is about a few TeV. The decay channel of this new particle is also an interesting concern and calculated. However, in different models, the decay channels are different, because of their interactions with SM particles.

Researchers work with the 2-2-1 model, find the vertex coefficients in the possible decay channels of the two new propagators (Z', W_2) and then calculate their decay width. These decay channels are the signals of the weak interaction in the TeV scale, larger than the energy scale in SM, 200GeV. After calculating these decay channels, we can know which is dominant and give experiment the range to look for signals of new particles, or when calculating the higher loop of interaction, we can choose which new particles contribute.

This article is organized as follows. In Sect.2, a short review of the 2-2-1 model. In Sect.3 and 4, We show and calculate the channels of W_2 and Z' which are the new signals of weak interaction at the 1-TeV scale. Finally, in Sect.5, we summarize and discuss these decay.

2. Review on 2-2-1 model

In this model, the SM gauge symmetry is extended to the 2-2-1 model, including the particles of the SM and some new particles. The SM particles belong to the representations of $SU(2)_1 \otimes U(1)_Y$ and are singlets of $SU(2)_2$. Some new particles include Higgs doublets of $SU(2)_2$, Higgs singlet S' and vector-like quarks (VLQ) doublets of $SU(2)_2, Q'^T = (U', D')$. The electric charge operator $Q = T_3^{(1)} + T_3^{(2)} + Y$, with $T_3^{(1,2)} = \frac{\sigma_3}{2}$ and σ_3 is Pauli matrix.

To clarify, the explicit representations of the particle generations in this model which include the particles in the standard model and the new particles are recorded as follows

$$Q_L^i = \begin{pmatrix} u_L \\ d_L \end{pmatrix}; \begin{pmatrix} c_L \\ s_L \end{pmatrix}; \begin{pmatrix} t_L \\ b_L \end{pmatrix}$$

$$L^i = \begin{pmatrix} \nu_{eL} \\ e_L \end{pmatrix}; \begin{pmatrix} \nu_{\mu L} \\ \mu_L \end{pmatrix}; \begin{pmatrix} \nu_{\tau L} \\ \tau_L \end{pmatrix}$$

$$U_R = u_R; c_R; t_R$$

$$D_R = d_R; s_R; b_R$$

$$E_R = e_R; \mu_R; \tau_R .$$

The particles in the new model include VLQ, Higgs H_2 doublet, and S' singlet. Unlike the standard model, VLQ doublet in this model includes both the left and right polarizations.

$$Q'_{L(R)} = \begin{pmatrix} U' \\ D' \end{pmatrix}_{L(R)}.$$

The covariant derivative is as

$$D_\mu = \partial_\mu - i g_i T_a^{(i)} A_{i\mu}^a - i g_Y Y B_\mu, \tag{1}$$

where g_i and $A_{i\mu}^a$ ($a = \overline{1,3}$) are the gauge coupling and gauge field of $SU(2)_i$. g_Y and B_μ are coupling and gauge field of $U(1)_Y$. $T_a^{(i)} = \frac{\sigma_a}{2}$ and σ_a are the Pauli matrices. Y is the hypercharge of a particle. When $SU(2)_1 \otimes SU(2)_2 \otimes U(1)_Y$ group breaks down to $U(1)_Y$, the gauge fields $A_{1\mu}^3$, $A_{2\mu}^3$ and B_μ of $U(1)_Y$ will be mixed so that we have two massive neutral gauge bosons Z and Z' and one massless photon. Moreover, we obtain charged gauge field $W_1^\pm$ and $W_2^\pm$ which are defined by $W_i^\pm = (A_i^1 \mp A_i^2)/\sqrt{2}$.

The new Yukawa interaction is written following as:

$$L = \left[-y_F \overline{Q}_{L'} Q'_R S' - y_b \overline{Q}_{L'} H_2 b_R - y_t \overline{Q}_{L'} \widetilde{H}_2 t_R - m_\psi \overline{Q}_{L'} Q'_R + h.c\right], \quad (2)$$

only quarks t and b in the standard model are coupled the VLQs in Yukawa interaction.

The Higgs potential has two doublets; H_1 is the SM Higgs doublet and H_2 is heavy Higgs doublet of $SU_2(2)$,

$$\begin{aligned} V(H_1, H_2, S') = &\sum_{i=1,2} [\mu_i^2 H_i^\dagger H_i + \lambda_i (H_i^\dagger H_i)^2] + \mu_S^2 S'^2 + \lambda_S S'^4 \\ &+\mu_S S'^3 + S'\left(\mu_{1S} H_1^\dagger H_1 + \mu_{2S} H_2^\dagger H_2\right) \\ &+\lambda_{12} H_1^\dagger H_1 H_2^\dagger H_2 + \lambda_{1S} S'^2 H_1^\dagger H_1 + \lambda_{2S} S'^2 H_2^\dagger H_2, \end{aligned} \quad (3)$$

$$H_i = \begin{pmatrix} G_i^\dagger \\ \frac{v_i + h_i + iG_i^0}{\sqrt{2}} \end{pmatrix}, \quad S' = \frac{v_S + S}{\sqrt{2}}, \quad (4)$$

where $G_i^{\pm,0}$ are unphysical Nambu-Goldstone bosons and $h_{1,2}$, S are the physical scalar bosons.

Table 1. *Masses of bosons and fermions in the 2-2-1 model*

Particles	$\boldsymbol{m^2(v, v_2, v_S)}$
$\boldsymbol{m^2_{W_1^\pm}}$	$\frac{g^2 v^2}{4}$
$\boldsymbol{m^2_{W_2^\pm}}$	$\frac{g_2^2 v_2^2}{4}$
$\boldsymbol{m^2_{Z_1} \sim m^2_Z}$	$\left(g^2 + g'^2\right)\frac{v^2}{4}$
$\boldsymbol{m^2_{Z_2} \sim m^2_{Z'}}$	$\frac{1}{4}\frac{g'^4 v^2 + g_2^4 v_2^2}{g_2^2 - g'^2}$
$\boldsymbol{m^2_h = m^2_{h_1}}$	$2\lambda_1 v^2$
$\boldsymbol{m^2_H = m^2_{h_2}}$	$2\lambda_2 v_2^2$
$\boldsymbol{m^2_{H_S} = m^2_S}$	$2\lambda_S v_S^2 + \frac{3\mu_S v_S}{2\sqrt{2}} - \frac{\mu_{1S} v^2 + \mu_{2S} v_2^2}{2\sqrt{2} v_S}$
$\boldsymbol{m^2_t}$	$f_t^2 v^2$
$\boldsymbol{m^2_T \sim m^2_{U'} = m^2_Q}$	$(m_\psi + \frac{y_F}{\sqrt{2}} v_S)^2$
$\boldsymbol{m^2_B \sim m^2_{D'} = m^2_Q}$	$(m_\psi + \frac{y_F}{\sqrt{2}} v_S)^2$

3. $W_1^{\pm}$ *and* $W_2^{\pm}$ Decay

the mixing between VLQ and SM-quarks will be not considered. In order to calculate the scattering vertex factor of fermions with W_1^- and W_2^-, we base on the Lagrangian,

$$L_{fermions} = \sum_f i\overline{Q'}_{L,R}\gamma^\mu D_\mu Q_{L,R} + \sum_f i\overline{L}_f\gamma^\mu D_\mu L_f.$$

W_i^-	Vertex
$W_1^- \to e + \bar{\nu}_e$	$-i\frac{g_1}{2\sqrt{2}}(\gamma^\mu - \gamma^\mu\gamma^5)$
$W_1^- \to \mu + \bar{\nu}_\mu$	$-i\frac{g_1}{2\sqrt{2}}(\gamma^\mu - \gamma^\mu\gamma^5)$
$W_1^- \to \tau + \bar{\nu}_\tau$	$-i\frac{g_1}{2\sqrt{2}}(\gamma^\mu - \gamma^\mu\gamma^5)$
$W_1^- \to d + \bar{u}$	$-i\frac{g_1}{2\sqrt{2}}V_{ud}(\gamma^\mu - \gamma^\mu\gamma^5)$
$W_1^- \to s + \bar{u}$	$-i\frac{g_1}{2\sqrt{2}}V_{us}(\gamma^\mu - \gamma^\mu\gamma^5)$
$W_1^- \to b + \bar{u}$	$-i\frac{g_1}{2\sqrt{2}}V_{ub}(\gamma^\mu - \gamma^\mu\gamma^5)$
$W_1^- \to d + \bar{c}$	$-i\frac{g_1}{2\sqrt{2}}V_{cd}(\gamma^\mu - \gamma^\mu\gamma^5)$
$W_1^- \to s + \bar{c}$	$-i\frac{g_1}{2\sqrt{2}}V_{cs}(\gamma^\mu - \gamma^\mu\gamma^5)$
$W_1^- \to b + \bar{c}$	$-i\frac{g_1}{2\sqrt{2}}V_{cb}(\gamma^\mu - \gamma^\mu\gamma^5)$
$W_2^- \to D' + \overline{U'}$	$-i\frac{g_2}{\sqrt{2}}\gamma^\mu$

According to the Golden rule for 2-body decays in the CM frame (see detail in C. Patrignani et al., 2016; D.Bardin and G.Passarino, 1999), the decay width is

$$\Gamma_{W\to m_1+m_2} = \frac{kN_C}{8\pi\hbar M_W^2 c}|M_{W\to m_1+m_2}|^2, \tag{5}$$

where k is the momentum of m_1 and m_2, and c=1 (in 'Godiven' unit). Besides, we consider in the CM frame and obtain as,

$$|M_{W\to l+\bar{\nu}_l}|^2 = a^2\frac{g^2}{3}\left[E^2 - \frac{1}{2}\left(\frac{-(m_2^2-m_1^2)^2}{E^2} - m_2^2 - m_1^2\right)\right], \tag{6}$$

$$|M_{W'\to D'+\overline{U'}}|^2 = \frac{2g_2^2}{3}\left[E^2 - \frac{1}{2}\left(\frac{-(m_2^2-m_1^2)^2}{E^2} - m_2^2 - m_1^2\right) + 3m_2m_1\right], \tag{7}$$

with $E = M_{W^-}$, a is the factor that depends on m_1 and m_2 (a=1 for leptons, $a = V_{ij}$ for quarks), V_{ij} is obtained from the experimental value (C. Patrignani et al., 2016),

$$|V_{ij}| = \begin{pmatrix} 0.97434 & 0.22506 & 0.00357 \\ 0.22492 & 0.97351 & 0.0411 \\ 0.00875 & 0.0403 & 0.99915 \end{pmatrix}. \tag{8}$$

In Eq. (5), the decay widths are calculated in tree order so we need to add QCD corrections. Finally, the formula for decay widths is obtained,

$$\begin{cases} \Gamma_{W_1} = \left(\Gamma_{W_1^- \to e+\bar{\nu}_e} + \Gamma_{W_1^- \to \mu+\bar{\nu}_\mu} + \Gamma_{W_1^- \to \tau+\bar{\nu}_\tau}\right)\left(1 + \frac{\alpha_s}{\pi}\right) \\ +\left(\Gamma_{W_1^- \to d+\bar{u}} + \Gamma_{W_1^- \to s+\bar{u}} + \Gamma_{W_1^- \to b+\bar{u}} + \Gamma_{W_1^- \to d+\bar{c}} + \Gamma_{W_1^- \to s+\bar{c}} + \Gamma_{W_1^- \to b+\bar{c}}\right)\left(1 + \frac{2\alpha_s}{3\pi}\right) N_c \\ = 2.108 \quad GeV, \\ \Gamma_{W_2} = \left(\Gamma_{W_2^- \to e+\bar{\nu}_e} + \Gamma_{W_2^- \to \mu+\bar{\nu}_\mu} + \Gamma_{W_2^- \to \tau+\bar{\nu}_\tau}\right)\left(1 + \frac{\alpha_s}{\pi}\right) \\ +\Gamma_{W_2^+ \to D'+\overline{U'}}\left(1 + \frac{2\alpha_s}{3\pi}\right) N_c, \end{cases} \tag{9}$$

where, a_s=a_s(M$_W$)=0.1255 (C. Patrignani et al., 2016) and

$$\begin{cases} N_c = 1; \text{lepton} \\ N_c = 3\left(1 + \frac{\alpha_s(M_W^2)}{\pi} + \frac{1.405\alpha_s^2(M_W^2)}{\pi^2} + \frac{12.77\alpha_s^3(M_W^2)}{\pi^3}\right); quark \end{cases} \tag{10}$$

In case $m_{W_2} = 1.7\,TeV$, $m_{U'} = m_{D'} = 750\,GeV$ and $g_2 = 2$, we obtain $\Gamma_{W_2} = 15.07243\,GeV$.

4. Z' Decay

The branch decay width of $Z' \to X_1X_2$ is given rule (S. M. Boucenna, A. Celis, J. Fuentes-Martin, A. Vicente and J. Virto, 2016a; 2016b),

$$\Gamma = \frac{\sqrt{\lambda\left(m_{Z'}^2, m_1^2, m_2^2\right)}}{16\pi m_{Z'}^3}|\bar{M}|^2, \tag{11}$$

with $|\bar{M}|^2$ is the average value of square amplitude respectively, $m_{1,2}$ is mass of two particles at final state, and

$$\lambda\left(m_{Z'}^2, m_1^2, m_2^2\right) = m_{Z'}^4 + m_1^4 + m_2^4 - 2\left(m_1^2 m_{Z'}^2 + m_2^2 m_{Z'}^2 + m_1^2 m_2^2\right). \tag{12}$$

We set $x_{1,2} = \frac{m_1, m_2}{m_{Z'}}$ and obtain

$$\sqrt{\lambda\left(m_{Z'}^2, m_1^2, m_2^2\right)} = \sqrt{m_{Z'}^4[1 + x_1^4 + x_2^4 - 2(x_1^2 + x_2^2 + x_1^2 x_2^2)]} = m_{Z'}^2\sqrt{\lambda(1, x_1^2.x_2^2)}. \tag{13}$$

The Eq. (11) is written as follows:

$$\Gamma = \frac{\lambda(1, x_1^2.x_2^2)}{16\pi m_{Z'}}|\bar{M}|^2, \tag{14}$$

$$|\bar{M}|^2_{(Z'ff)} = \frac{1}{3}|g_{Z'}|^2 m_{Z'}^2\{12 g_L g_R x_1 x_2 + (g_L^2 + g_R^2)[2 - x_1^2 - 2 - (x_1^2 - x_2^2)^2]\}, \tag{15}$$

where, $f = \nu_e, e, q$ are fermions in SM. $x_1 = x_2 = x_f = \frac{m_f}{m_{Z'}}$ with fermions are slighter than quarks top, the decay width $\left(Z' \to \bar{f}f\right)$ is calculated in SM with $x_1 = x_2 = 0$, $g_{Z'} = \frac{g}{c_W}$ and $|g'^f_L|^2 + |g'^f_R|^2 = |g'^f_V|^2 + |g'^f_A|^2$,

$$\Gamma(Z' \to \bar{f}f) = \frac{N_c g^2 m_{Z'}}{24\pi c_W^2}\left(|g'^f_V|^2 + |g'^f_A|^2\right), \tag{16}$$

$$\Gamma(Z' \to \bar{t}t) = \frac{g^2 m_{Z'}}{8\pi c_W^2}\left(|g'^t_V|^2 + |g'^t_A|^2\right)(1 - x_t^2). \tag{17}$$

Quark top has $x_1 = x_2 = \frac{m_t}{m_{Z'}}$, where $m_t = 173.21 GeV$. Within limit $s_Z = 0, c_Z = 1$.

We have the interaction coupling in table 2 with $t_\theta = \frac{s_W^2}{s_\theta c_\theta}$ and $s_L^{t,b} = 0, s_R^{t,b} = s_R = 0.3$.

Table 2. *g'_V and g'_A in limit $c_Z = 1, s_Z = 0, s_L^{t,b} = 0$*

f	g'_V	g'_A	$\lvert g'_V\rvert^2 + \lvert g'_A\rvert^2$
$\nu_l = \nu_{e,\mu,\tau}$	$\frac{1}{2}s_W t_\theta$	$\frac{1}{2}s_W t_\theta$	$\frac{1}{2}s_W^2 t_\theta^2$
$l = e, \mu.\tau$	$\frac{3}{2}s_W t_\theta$	$-\frac{1}{2}s_W t_\theta$	$\frac{5}{2}s_W^2 t_\theta^2$
u, c	$\frac{-5}{6}s_W t_\theta$	$\frac{1}{2}s_W t_\theta$	$\frac{17}{18}s_W^2 t_\theta^2$
d, s	$\frac{1}{2}s_W t_\theta$	$-\frac{1}{6}s_W t_\theta$	$\frac{5}{18}s_W^2 t_\theta^2$
t	$(s_R^t)^2(\frac{1}{2}-\frac{2}{3}s_\theta^2)\frac{s_W}{s_\theta c_\theta}$	0	$(s_R^t)^4(\frac{1}{2}-\frac{2}{3}s_\theta^2)^2\frac{s_W^2}{s_\theta^2 c_\theta^2}$
b	$(s_R^b)^2(-\frac{1}{2}+\frac{1}{3}s_\theta^2)\frac{s_W}{s_\theta c_\theta}$	0	$(s_R^b)^4(-\frac{1}{2}+\frac{1}{3}s_\theta^2)^2\frac{s_W^2}{s_\theta^2 c_\theta^2}$

Finally, the decay width for the different decay modes are:

$$\Gamma(Z' \to \bar{\nu}\nu) = \frac{g^2 m_{Z'}}{24\pi c_W^2} \times \frac{1}{2}s_W^2 t_\theta^2, \quad (18)$$

$$\Gamma(Z' \to \bar{l}l) = \frac{g^2 m_{Z'}}{24\pi c_W^2} \times \frac{5}{2}s_W^2 t_\theta^2, \quad (19)$$

$$\Gamma(Z' \to \bar{u}u, \bar{c}c) = \frac{g^2 m_{Z'}}{8\pi c_W^2} \times \frac{17}{18}s_W^2 t_\theta^2, \quad (20)$$

$$\Gamma(Z' \to \bar{d}d, \bar{s}s) = \frac{g^2 m_{Z'}}{8\pi c_W^2} \times \frac{5}{18}s_W^2 t_\theta^2, \quad (21)$$

$$\Gamma(Z' \to \bar{t}t) = \frac{g^2 m_{Z'}}{8\pi c_W^2} \times (s_R^t)^4(\frac{1}{2}-\frac{2}{3}s_\theta^2)^2\frac{s_W^2}{s_\theta^2 c_\theta^2}(1-x_t^2), \quad (22)$$

$$\Gamma(Z' \to \bar{b}b) = \frac{g^2 m_{Z'}}{8\pi c_W^2} \times (s_R^b)^4(-\frac{1}{2}+\frac{1}{3}s_\theta^2)^2\frac{s_W^2}{s_\theta^2 c_\theta^2}(1-x_b^2). \quad (23)$$

Besides $(Z' \to Zh)$, an important decay, we have

$$M_{Zh} = c_{Z'Zh} g_{\mu\nu}\varepsilon_{Z'}^{\nu}\varepsilon_Z^{*\mu},$$

$$M_{Zh}^* = c_{Z'Zh}^* g_{\mu'\nu'}\varepsilon_{Z'}^{*\nu'}\varepsilon_Z^{\mu'},$$

$$|\bar{M}_{Zh}|^2 = \frac{1}{3}|M_{Zh}|^2 = \frac{1}{3}|c_{Z'Zh}|^2[2 + \frac{m_{Z'}^2}{4m_Z^2}(1 + x_Z^2 - x_h^2)^2], \quad (24)$$

with $x_{h,z} = \frac{m_{h,Z}}{m_{Z'}}$ and vertex factor $c_{Z'Zh} = \frac{g t_W t_\theta m_Z}{2}$. Where ε^μ is orthogonal polarization vector and $\varepsilon_\mu(p)\varepsilon_\nu^*(p) = -g_{\mu\nu}\frac{p_\mu p_\nu}{(M_{W^-c})^2}$. So, the decay width $Z' \to Zh$ is

$$\Gamma(Z' \to Zh) = \frac{g^2 t_W^2 t_\theta^2 m_{Z'}}{192\pi} \times \lambda^{\frac{1}{2}}(1, x_h^2, x_z^2)[2x_z^2 + \frac{1}{4}(1 + x_z^2 - x_h^2)^2]. \quad (25)$$

The last is the decay $(Z' \to W^+W^-)$ with the average value of decay square amplitude

$$M_{ZW^+W^-} = c_{Z'W^+W^-}\Gamma_{\mu\nu\alpha}\varepsilon_{Z'}^{\mu}\varepsilon_{W^+}^{*\nu}\varepsilon_{W^-}^{*\alpha},$$

$$M_{ZW^+W^-}^* = c_{Z'W^+W^-}^*\Gamma_{\mu'\nu'\alpha'}\varepsilon_{Z'}^{*\mu'}\varepsilon_{W^+}^{\nu'}\varepsilon_{W^-}^{\alpha'},$$

$$|\bar{M}_{ZW}|^2 = \frac{1}{3}\left|M_{ZW}\right|^2 = \frac{1}{3}\left|c_{Z'W^+W^-}\right|^2 m_{Z'}^2 \lambda(1, x_W^2, x_W^2)(1 + 20x_W^2 + 12x_W^4), \quad (26)$$

where $x_W = \frac{m_W}{m_{Z'}}$ and

$$|c_{Z'W^+W^-}|^2 = gc_W s_Z \approx gc_W \times \frac{s_{2Z}}{2} \approx gc_W \times \frac{m_{Z_1Z_2}^2}{m_{Z'}^2} = gs_W^2 t_\theta \times x_W^2. \quad (27)$$

We get approximate to $o(x_W^2)$ if $m_{Z'}^2 \gg m_W^2$ so the decay width $Z' \to W^+W^-$ is

$$\Gamma_{Z' \to W^+W^-} = \frac{g^2 s_W^4 t_\theta^2 m_{Z'}}{48\pi} \times (1 - x_W^2)^{\frac{3}{2}} \times x_W^4 (1 + 20x_W^2 + 12x_W^4), \quad (28)$$

with $\lambda(1, x_W^2, x_W^2) = 1 - 4x_W^2$.

The total decay width of Z', $\Gamma_{Z'}$ is calculated by summing all the decay width above. The result obtain as:

$$\Gamma_{Z'} = 3\Gamma(Z' \to \bar{\nu}\nu) + 3\Gamma(Z' \to \bar{l}l) + 2\Gamma(Z' \to \bar{u}u) + 2\Gamma(Z' \to \bar{d}d) + \Gamma(Z' \to \bar{t}t)$$
$$+\Gamma(Z' \to \bar{b}b) + \Gamma(Z' \to Zh) + \Gamma(Z' \to W^+W^-). \quad (29)$$

The branching ratios is

$$Br(Z' \to XY) = \frac{\Gamma_{(Z' \to XY)}}{\Gamma_{Z'}}. \quad (30)$$

If we assume $M_{Z'} = 1.7$ TeV, $S_R = 0.3$, $g_2 = 2$, $Br(Z' \to l\bar{l}) \approx 0.1$, $Br(Z' \to Zh) \approx 0.001$, $Br(Z' \to WW) \approx 10^{-8}$.

5. Conclusion & discussion

the Z' and W_1, W_2 decays are performed in the 2-2-1 model. The decay width of W_1 is the same as in SM, about 2.108 GeV. The Z' decays mostly lepton, therefore, we can seek for its signal in the lepton interactions.

Decay width of particle has a huge effect on the transfer functions of force carriers. The larger the decay width of a particle is, the shorter its lifetime gets. For that reason, detecting them in a low energy scale is a difficult task. However, the signals of those kinds of particles can be found by LHC because its scale is about a few TeV.

In this model, there is the mixing between exotic quarks and the existence of FCNC, therefore, will not be considered. In the future, we will work with these problems.

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TÍN HIỆU TƯƠNG TÁC YẾU MỚI TRONG MÔ HÌNH $\mathbf{SU(2)_1 \otimes SU(2)_2 \otimes U(1)_Y}$

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TÓM TẮT

Theo mô hình $SU(2)_1 \otimes SU(2)_2 \otimes U(1)_Y$ (mô hình 2-2-1), phân rã $W_1^{\pm}$ (giống như $W_1^{\pm}$ trong mô hình chuẩn) và $W_2^{\pm}, Z'$ sẽ được nghiên cứu. Bề rộng phân rã $W_1^{\pm}$ bằng 2,1 GeV, phù hợp với SM và dữ liệu thử nghiệm. Bề rộng phân rã $W_2^{\pm}$ rất lớn mà đóng góp chính cho sự phân rã này là kênh chứa các quark ngoại lai. Hơn nữa, nghiên cứu cho thấy rằng tỉ lệ rã nhánh lepton của Z' chiếm phần lớn.

Từ khóa: phân rã yếu, mở rộng mô hình chuẩn, mô hình chuẩn.