U(1)B extension for Bariogenesis
Lagrangian, Rotations and Interactions for eigenstates 'EWSB'

SARAH 4.12.3

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References: **arXiv: 1309.7223** , **Comput.Phys.Commun.184:1792-1809,2011 (1207.0906)** , **Comput.Phys.Commun.182:**
833,2011 (1002.0840) , **Comput.Phys.Commun.181:1077-1086,2010 (0909.2863)** , **arXiv: 0806.0538**
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Contents

1 Fields

1.1 Gauge Fields

Name	$SU(N)$	Coupling	Name
B	$U(1)$	g_1	hypercharge
W	SU(2)	g_2	left
g	SU(3)	g_3	color
VBp	$U(1)$	g_B	U1B

1.2 Matter Superfields

Name	Spin	Generations	$(U(1) \otimes \mathrm{SU}(2) \otimes \mathrm{SU}(3) \otimes U(1))$
H	0	1	$(\frac{1}{2}, \mathbf{2}, \mathbf{1}, 0)$
bi	0	1	$(0, \mathbf{1}, \mathbf{1}, 5)$
bj	0	1	$(0, \mathbf{1}, \mathbf{1}, 5)$
S1	0	2	$(-1, \mathbf{1}, \mathbf{1}, -1)$
S2	0	2	$(-1, \mathbf{1}, \mathbf{1}, 4)$
q	$\frac{1}{2}$	3	$(\frac{1}{6}, \mathbf{2}, \mathbf{3}, -\frac{5}{9})$
l	$\frac{1}{2}$	3	$(-\frac{1}{2}, \mathbf{2}, \mathbf{1}, 0)$
d	$\frac{1}{2}$	3	$(\frac{1}{3}, \mathbf{1}, \overline{\mathbf{3}}, \frac{5}{9})$
u	$\frac{1}{2}$	3	$(-\frac{2}{3}, \mathbf{1}, \overline{\mathbf{3}}, \frac{5}{9})$
e	$\frac{1}{2}$	3	$(1, \mathbf{1}, \mathbf{1}, 0)$
v	$\frac{1}{2}$	2	$(0, \mathbf{1}, \mathbf{1}, -5)$
x3	$\frac{1}{2}$	1	$(0, \mathbf{1}, \mathbf{1}, 3)$
x4	$\frac{1}{2}$	1	$(0, \mathbf{1}, \mathbf{1}, 2)$
x5	$\frac{1}{2}$	1	$(1, \mathbf{1}, \mathbf{1}, 1)$
x6	$\frac{1}{2}$	1	$(-1, \mathbf{1}, \mathbf{1}, -6)$
lp	$\frac{1}{2}$	1	$(-\frac{1}{2}, \mathbf{2}, \mathbf{1}, -1)$
lpp	$\frac{1}{2}$	1	$(\frac{1}{2}, \mathbf{2}, \mathbf{1}, 6)$

2 Lagrangian

2.1 Input Lagrangian for Eigenstates GaugeES

$$L = -\mu_i'|\mathrm{BiD}|^2 - \mu_j'|\mathrm{BjD}|^2 - \mu_h|H^0|^2 - \mu_h|H^+|^2 + \mathrm{BiD}^2\lambda_2\mathrm{conj}\Big(\mathrm{BiD}\Big)^2 + \mathrm{BjD}^2\lambda_4\mathrm{conj}\Big(\mathrm{BjD}\Big)^2 + H^0\lambda_3|\mathrm{BiD}|^2H^{0,*}$$
$$+ H^0\lambda_5|\mathrm{BjD}|^2H^{0,*} + H^{0,2}l_hH^{0,*,2} + H^+\lambda_3|\mathrm{BiD}|^2H^{+,*} + H^+\lambda_5|\mathrm{BjD}|^2H^{+,*} + 2H^+l_h|H^0|^2H^{+,*} + H^{+,2}l_hH^{+,*,2}$$

$$
\begin{aligned}
&- H^0 d^*_{L,k\gamma} Y^*_{d,jk} \delta_{\beta\gamma} d_{R,j\beta} - H^+ u^*_{L,k\gamma} Y^*_{d,jk} \delta_{\beta\gamma} d_{R,j\beta} - \lambda_{c1} \mathrm{conj}(\mathrm{BiD}) \mathrm{conj}(\mathrm{epp}(2)) \mathrm{ep}(1) - \lambda_{c2} \mathrm{conj}(\mathrm{BjD}) \mathrm{conj}(\mathrm{epp}(2)) \mathrm{ep}(1) \\
&- \lambda_g H^{0,*} \mathrm{conj}(\mathrm{x5R}(2)) \mathrm{ep}(1) - \lambda_{c1} \mathrm{conj}(\mathrm{BiD}) \mathrm{conj}(\mathrm{epp}(1)) \mathrm{ep}(2) - \lambda_{c2} \mathrm{conj}(\mathrm{BjD}) \mathrm{conj}(\mathrm{epp}(1)) \mathrm{ep}(2) - \lambda_g H^{0,*} \mathrm{conj}(\mathrm{x5R}(\\
&- \mathrm{BjD} \lambda_{c2} \mathrm{conj}(\mathrm{ep}(2)) \mathrm{epp}(1) - \lambda_h H^{0,*} \mathrm{conj}(\mathrm{x6L}(2)) \mathrm{epp}(1) - \mathrm{BiD} \lambda_{c1} \mathrm{conj}(\mathrm{ep}(1)) \mathrm{epp}(2) - \mathrm{BjD} \lambda_{c2} \mathrm{conj}(\mathrm{ep}(1)) \mathrm{epp}(2) - \\
&- H^0 e^*_{L,k} Y^*_{e,jk} e_{R,j} - H^+ \nu^*_{L,k} Y^*_{e,jk} e_{R,j} + \lambda^*_{d,ij} \mathrm{conj}(\mathrm{vp}(2)) \mathrm{conj}(\mathrm{eL}(\{\mathrm{gt2}\})(1)) \mathrm{s1}(\{\mathrm{gt1}\}) + \lambda^*_{d,ij} \mathrm{conj}(\mathrm{vp}(1)) \mathrm{conj}(\mathrm{eL}(\{\mathrm{gt2}\}) \\
&- \mathrm{conj}(\mathrm{ep}(1)) \lambda^*_{d,ij} \mathrm{conj}(\mathrm{vL}(\{\mathrm{gt2}\})(2)) \mathrm{s1}(\{\mathrm{gt1}\}) - \mathrm{BiD} \mathrm{conj}(\mathrm{s2}(\{\mathrm{gt2}\})) \lambda_{fi,ij} \mathrm{s1}(\{\mathrm{gt1}\}) - \mathrm{BjD} \mathrm{conj}(\mathrm{s2}(\{\mathrm{gt2}\})) \lambda_{fj,ij} \mathrm{s1}(\{\mathrm{g} \\
&- \mathrm{conj}(\mathrm{s1}(\{\mathrm{gt1}\})) \mu_{1,ij} \mathrm{s1}(\{\mathrm{gt2}\}) - \mathrm{conj}(\mathrm{x5R}(2)) \mathrm{conj}(\mathrm{vR}(\{\mathrm{gt3}\})(1)) \lambda_{e,ik} \mathrm{s2}(\{\mathrm{gt1}\}) - \mathrm{conj}(\mathrm{x5R}(1)) \mathrm{conj}(\mathrm{vR}(\{\mathrm{gt3}\})(2 \\
&- |H^0|^2 \mathrm{conj}(\mathrm{s2}(\{\mathrm{gt1}\})) \lambda_{7,ij} \mathrm{s2}(\{\mathrm{gt2}\}) - |H^+|^2 \mathrm{conj}(\mathrm{s2}(\{\mathrm{gt1}\})) \lambda_{7,ij} \mathrm{s2}(\{\mathrm{gt2}\}) - \mathrm{conj}(\mathrm{s2}(\{\mathrm{gt1}\})) \mu_{2,ij} \mathrm{s2}(\{\mathrm{gt2}\}) - H^{+,*} d^*_{L,} \\
&+ H^{0,*} u^*_{L,k\gamma} Y^*_{u,jk} \delta_{\beta\gamma} u_{R,j\beta} - \lambda_{c1} \mathrm{conj}(\mathrm{BiD}) \mathrm{conj}(\mathrm{vpp}(2)) \mathrm{vp}(1) - \lambda_{c2} \mathrm{conj}(\mathrm{BjD}) \mathrm{conj}(\mathrm{vpp}(2)) \mathrm{vp}(1) - \lambda_g H^{+,*} \mathrm{conj}(\mathrm{x5R}(2)) \\
&- \lambda_{c2} \mathrm{conj}(\mathrm{BjD}) \mathrm{conj}(\mathrm{vpp}(1)) \mathrm{vp}(2) - \lambda_g H^{+,*} \mathrm{conj}(\mathrm{x5R}(1)) \mathrm{vp}(2) - \mathrm{BiD} \lambda_{c1} \mathrm{conj}(\mathrm{vp}(2)) \mathrm{vpp}(1) - \mathrm{BjD} \lambda_{c2} \mathrm{conj}(\mathrm{vp}(2)) \mathrm{vp} \\
&- \mathrm{BiD} \lambda_{c1} \mathrm{conj}(\mathrm{vp}(1)) \mathrm{vpp}(2) - \mathrm{BjD} \lambda_{c2} \mathrm{conj}(\mathrm{vp}(1)) \mathrm{vpp}(2) - \lambda_h H^{+,*} \mathrm{conj}(\mathrm{x6L}(1)) \mathrm{vpp}(2) - \lambda_{a1} \mathrm{conj}(\mathrm{BiD}) \mathrm{conj}(\mathrm{x4R}(2)) \\
&- \lambda_{a1} \mathrm{conj}(\mathrm{BiD}) \mathrm{conj}(\mathrm{x4R}(1)) \mathrm{x3L}(2) - \lambda_{a2} \mathrm{conj}(\mathrm{BjD}) \mathrm{conj}(\mathrm{x4R}(1)) \mathrm{x3L}(2) - \mathrm{BiD} \lambda_{a1} \mathrm{conj}(\mathrm{x3L}(2)) \mathrm{x4R}(1) - \mathrm{BjD} \lambda_{a2} \mathrm{conj} \\
&- H^0 \lambda^*_g \mathrm{conj}(\mathrm{ep}(2)) \mathrm{x5R}(1) - H^+ \lambda^*_g \mathrm{conj}(\mathrm{vp}(2)) \mathrm{x5R}(1) - \lambda_{b1} \mathrm{conj}(\mathrm{BiD}) \mathrm{conj}(\mathrm{x6L}(2)) \mathrm{x5R}(1) - \lambda_{b2} \mathrm{conj}(\mathrm{BjD}) \mathrm{conj}(\mathrm{x6L}(\\
&- H^+ \lambda^*_g \mathrm{conj}(\mathrm{vp}(1)) \mathrm{x5R}(2) - \lambda_{b1} \mathrm{conj}(\mathrm{BiD}) \mathrm{conj}(\mathrm{x6L}(1)) \mathrm{x5R}(2) - \lambda_{b2} \mathrm{conj}(\mathrm{BjD}) \mathrm{conj}(\mathrm{x6L}(1)) \mathrm{x5R}(2) - H^0 \lambda_h \mathrm{conj}(\mathrm{epp} \\
&- \mathrm{BiD} \lambda_{b1} \mathrm{conj}(\mathrm{x5R}(2)) \mathrm{x6L}(1) - \mathrm{BjD} \lambda_{b2} \mathrm{conj}(\mathrm{x5R}(2)) \mathrm{x6L}(1) - H^0 \lambda_h \mathrm{conj}(\mathrm{epp}(1)) \mathrm{x6L}(2) - H^+ \lambda_h \mathrm{conj}(\mathrm{vpp}(1)) \mathrm{x6L}(2) \\
&- H^{0,*} d^*_{R,j\beta} \delta_{\beta\gamma} d_{L,k\gamma} Y_{d,jk} - H^{+,*} d^*_{R,j\beta} \delta_{\beta\gamma} u_{L,k\gamma} Y_{d,jk} - H^{0,*} e^*_{R,j} e_{L,k} Y_{e,jk} \\
&- H^{+,*} e^*_{R,j} \nu_{L,k} Y_{e,jk} - H^+ u^*_{R,j\beta} \delta_{\beta\gamma} d_{L,k\gamma} Y_{u,jk} + H^0 u^*_{R,j\beta} \delta_{\beta\gamma} u_{L,k\gamma} Y_{u,jk} + \mathrm{conj}(\mathrm{s1}(\{\mathrm{gt1}\})) \lambda_{d,ij} \mathrm{vp}(2) \mathrm{eL}(\{\mathrm{gt2}\})(1) \\
&+ \mathrm{conj}(\mathrm{s1}(\{\mathrm{gt1}\})) \lambda_{d,ij} \mathrm{vp}(1) \mathrm{eL}(\{\mathrm{gt2}\})(2) - \mathrm{conj}(\mathrm{s1}(\{\mathrm{gt1}\})) \mathrm{ep}(2) \lambda_{d,ij} \mathrm{vL}(\{\mathrm{gt2}\})(1) - \mathrm{conj}(\mathrm{s1}(\{\mathrm{gt1}\})) \mathrm{ep}(1) \lambda_{d,ij} \mathrm{vL}(\{
\end{aligned}
\tag{1}
$$

2.2 Gauge fixing terms

2.2.1 Gauge fixing terms for eigenstates 'GaugeES'

$$
L_{GF} = -\frac{1}{2}|\partial_\mu B|^2 \xi_B^{-1} - \frac{1}{2}|\partial_\mu g|^2 \xi_g^{-1} - \frac{1}{2}|\partial_\mu \mathrm{VBp}|^2 \xi_{\mathrm{VBp}}^{-1} - \frac{1}{2}|\partial_\mu W|^2 \xi_W^{-1} \tag{2}
$$

2.2.2 Gauge fixing terms for eigenstates 'EWSB'

$$
\begin{aligned}
L_{GF} = &-\frac{1}{2}|\partial_\mu g|^2 \xi_g^{-1} - \frac{1}{2}|\partial_\mu \gamma|^2 \xi_\gamma^{-1} - |\frac{i}{2} g_2 v H^{+,*} \xi_{W^-} + \partial_\mu W^-|^2 \xi_{W^-}^{-1} \\
&- \frac{1}{2}| + \partial_\mu Z
\end{aligned}
$$

$$-\frac{1}{2}\xi_Z\Big(-\Big(10g_B\Big(\text{sigmaBj}vx2+\text{sigmaB}vx\Big)+g_{BY}\text{sigmaH}v\Big)\sin\Theta'_W+\Big(10g_{YB}\Big(\text{sigmaBj}vx2+\text{sigmaB}vx\Big)+g_1\text{sigmaH}v\Big)c$$
$$-\frac{1}{2}|\frac{1}{2}\xi_{Z'}\Big(\Big(10g_B\Big(\text{sigmaBj}vx2+\text{sigmaB}vx\Big)+g_{BY}\text{sigmaH}v\Big)\cos\Theta'_W+\Big(\Big(10g_{YB}\Big(\text{sigmaBj}vx2+\text{sigmaB}vx\Big)+g_1\text{sigmaH}v\Big) \tag{3}$$

2.3 Fields integrated out

None

3 Field Rotations

3.1 Rotations in gauge sector for eigenstates 'EWSB'

$$\begin{pmatrix} B_\rho \\ W_{3\rho} \\ \text{VBp}\Big(\{\text{lt1}\}\Big) \end{pmatrix} = Z^{\gamma ZZ'}\begin{pmatrix} \gamma_\rho \\ Z_\rho \\ Z'_\rho \end{pmatrix} \tag{4}$$

$$\begin{pmatrix} W_{1\rho} \\ W_{2\rho} \end{pmatrix} = Z^W\begin{pmatrix} W^-_\rho \\ W^-_\rho \end{pmatrix} \tag{5}$$

$$\tag{6}$$

The mixing matrices are parametrized by

$$Z^{\gamma ZZ'} = \begin{pmatrix} \cos\Theta_W & -\cos\Theta'_W\sin\Theta_W & \sin\Theta_W\sin\Theta'_W \\ \sin\Theta_W & \cos\Theta_W\cos\Theta'_W & -\cos\Theta_W\sin\Theta'_W \\ 0 & \sin\Theta'_W & \cos\Theta'_W \end{pmatrix} \tag{7}$$

$$Z^W = \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ -i\frac{1}{\sqrt{2}} & i\frac{1}{\sqrt{2}} \end{pmatrix} \tag{8}$$

$$\tag{9}$$

3.2 Rotations in Mass sector for eigenstates 'EWSB'

3.2.1 Mass Matrices for Scalars

- **Mass matrix for Higgs**, Basis: (phiH, phiB, phiBj) , (phiH, phiB, phiBj)

$$m_h^2 = \begin{pmatrix} m_{\text{phiHphiH}} & -\lambda_3 vvx & -\lambda_5 vvx2 \\ -\lambda_3 vvx & -3\lambda_2 vx^2-\frac{1}{2}\lambda_3 v^2+\mu'_i & 0 \\ -\lambda_5 vvx2 & 0 & -3\lambda_4 vx2^2-\frac{1}{2}\lambda_5 v^2+\mu'_j \end{pmatrix} \tag{10}$$

$$m_{\text{phiHphiH}} = \frac{1}{2}\Big(-6 l_h v^2 - \lambda_3 v x^2 - \lambda_5 v x 2^2 \Big) + \mu_h \tag{11}$$

This matrix is diagonalized by Z^H:

$$Z^H m_h^2 Z^{H,\dagger} = m_{2,h}^{dia} \tag{12}$$

with

$$\text{phiH} = \sum_j Z_{j1}^H h_j \,, \qquad \text{phiB} = \sum_j Z_{j2}^H h_j \,, \qquad \text{phiBj} = \sum_j Z_{j3}^H h_j \tag{13}$$

- **Mass matrix for Pseudo-Scalar Higgs**, Basis: $(\text{sigmaH}, \text{sigmaB}, \text{sigmaBj})$, $(\text{sigmaH}, \text{sigmaB}, \text{sigmaBj})$

$$m_{A_h}^2 = \begin{pmatrix} m_{\text{sigmaHsigmaH}} & 0 & 0 \\ 0 & -\frac{1}{2}\lambda_3 v^2 - \lambda_2 v x^2 + \mu_i' & 0 \\ 0 & 0 & -\frac{1}{2}\lambda_5 v^2 - \lambda_4 v x 2^2 + \mu_j' \end{pmatrix} + \xi_Z m^2(Z) + \xi_{Z'} m^2(Z') \tag{14}$$

$$m_{\text{sigmaHsigmaH}} = \frac{1}{2}\Big(-2 l_h v^2 - \lambda_3 v x^2 - \lambda_5 v x 2^2 \Big) + \mu_h \tag{15}$$

Gauge fixing contributions:

$$m^2(\xi_Z) = \begin{pmatrix} m_{\text{sigmaHsigmaH}} & m_{\text{sigmaBsigmaH}} & m_{\text{sigmaBjsigmaH}} \\ m_{\text{sigmaHsigmaB}} & m_{\text{sigmaBsigmaB}} & m_{\text{sigmaBjsigmaB}} \\ m_{\text{sigmaHsigmaBj}} & m_{\text{sigmaBsigmaBj}} & m_{\text{sigmaBjsigmaBj}} \end{pmatrix} \tag{16}$$

$$m_{\text{sigmaHsigmaH}} = \frac{1}{4} v^2 \Big(\cos\Theta'_W \Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) - g_{BY} \sin\Theta'_W \Big)^2 \tag{17}$$

$$m_{\text{sigmaHsigmaB}} = \frac{5}{2} v v x \Big(\cos\Theta'_W \Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) - g_{BY} \sin\Theta'_W \Big) \Big(-g_B \sin\Theta'_W + g_{YB} \cos\Theta'_W \sin\Theta_W \Big) \tag{18}$$

$$m_{\text{sigmaBsigmaB}} = 25 v x^2 \Big(-g_B \sin\Theta'_W + g_{YB} \cos\Theta'_W \sin\Theta_W \Big)^2 \tag{19}$$

$$m_{\text{sigmaHsigmaBj}} = \frac{5}{2} v v x 2 \Big(\cos\Theta'_W \Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) - g_{BY} \sin\Theta'_W \Big) \Big(-g_B \sin\Theta'_W + g_{YB} \cos\Theta'_W \sin\Theta_W \Big) \tag{20}$$

$$m_{\text{sigmaBsigmaBj}} = 25 v x v x 2 \Big(-g_B \sin\Theta'_W + g_{YB} \cos\Theta'_W \sin\Theta_W \Big)^2 \tag{21}$$

$$m_{\text{sigmaBjsigmaBj}} = 25 v x 2^2 \Big(-g_B \sin\Theta'_W + g_{YB} \cos\Theta'_W \sin\Theta_W \Big)^2 \tag{22}$$

$$m^2(\xi_{Z'}) = \begin{pmatrix} m_{\text{sigmaHsigmaH}} & m_{\text{sigmaBsigmaH}} & m_{\text{sigmaBjsigmaH}} \\ m_{\text{sigmaHsigmaB}} & m_{\text{sigmaBsigmaB}} & m_{\text{sigmaBjsigmaB}} \\ m_{\text{sigmaHsigmaBj}} & m_{\text{sigmaBsigmaBj}} & m_{\text{sigmaBjsigmaBj}} \end{pmatrix} \tag{23}$$

$$m_{\text{sigmaHsigmaH}} = \frac{1}{4}v^2\Big(\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W\Big)\sin\Theta'_W + g_{BY}\cos\Theta'_W\Big)^2 \tag{24}$$

$$m_{\text{sigmaHsigmaB}} = \frac{5}{2}vvx\Big(g_B \cos\Theta'_W + g_{YB}\sin\Theta_W \sin\Theta'_W\Big)\Big(\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W\Big)\sin\Theta'_W + g_{BY}\cos\Theta'_W\Big) \tag{25}$$

$$m_{\text{sigmaBsigmaB}} = 25vx^2\Big(g_B \cos\Theta'_W + g_{YB}\sin\Theta_W \sin\Theta'_W\Big)^2 \tag{26}$$

$$m_{\text{sigmaHsigmaBj}} = \frac{5}{2}vvx2\Big(g_B \cos\Theta'_W + g_{YB}\sin\Theta_W \sin\Theta'_W\Big)\Big(\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W\Big)\sin\Theta'_W + g_{BY}\cos\Theta'_W\Big) \tag{27}$$

$$m_{\text{sigmaBsigmaBj}} = 25vxvx2\Big(g_B \cos\Theta'_W + g_{YB}\sin\Theta_W \sin\Theta'_W\Big)^2 \tag{28}$$

$$m_{\text{sigmaBjsigmaBj}} = 25vx2^2\Big(g_B \cos\Theta'_W + g_{YB}\sin\Theta_W \sin\Theta'_W\Big)^2 \tag{29}$$

This matrix is diagonalized by Z^A:

$$Z^A m^2_{A_h} Z^{A,\dagger} = m^{dia}_{2,A_h} \tag{30}$$

with

$$\text{sigmaH} = \sum_j Z^A_{j1} A_{h,j}\,, \qquad \text{sigmaB} = \sum_j Z^A_{j2} A_{h,j}\,, \qquad \text{sigmaBj} = \sum_j Z^A_{j3} A_{h,j} \tag{31}$$

- **Mass matrix for Charged Higgs**, Basis: $(H^{+,*}, \text{s1}, \text{s2})\,, \Big(H^+, \text{conj}\Big(\text{s1}\Big), \text{conj}\Big(\text{s2}\Big)\Big)$

$$m^2_{H^-} = \begin{pmatrix} m_{H^{+,*}H^+} & 0 & 0 \\ 0 & \frac{1}{2}\lambda_6 v^2 + \mu_1 & \frac{1}{\sqrt{2}}\Big(\lambda_{fi} vx + \lambda_{fj} vx2\Big) \\ 0 & \frac{1}{\sqrt{2}}\Big(vx2\lambda^T_{fj} + vx\lambda^T_{fi}\Big) & \frac{1}{2}\lambda_7 v^2 + \mu_2 \end{pmatrix} + \xi_{W^-} m^2(W^-) \tag{32}$$

$$m_{H^{+,*}H^+} = \frac{1}{2}\Big(-2l_h v^2 - \lambda_3 vx^2 - \lambda_5 vx2^2\Big) + \mu_h \tag{33}$$

Gauge fixing contributions:

$$m^2(\xi_{W^-}) = \begin{pmatrix} \frac{1}{4}g_2^2 v^2 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \tag{34}$$

This matrix is diagonalized by Z^+:

$$Z^+ m^2_{H^-} Z^{+,\dagger} = m^{dia}_{2,H^-} \tag{35}$$

with

$$H^+ = \sum_j Z^+_{j1} H^+_j\,, \qquad \text{s1}\Big(\{\text{gt1}\}\Big) = \sum_j Z^+_{ji} H^-_j\,, \qquad \text{s2}\Big(\{\text{gt1}\}\Big) = \sum_j Z^+_{ji} H^-_j \tag{36}$$

3.2.2 Mass Matrices for Fermions

- **Mass matrix for Down-Quarks**, Basis: $\left(d_{L,\alpha_1}\right), \left(d^*_{R,\beta_1}\right)$

$$m_d = \left(\begin{array}{c} \frac{1}{\sqrt{2}} v \delta_{\alpha_1 \beta_1} Y_d^T \end{array} \right) \tag{37}$$

This matrix is diagonalized by U_L^d and U_R^d

$$U_L^{d,*} m_d U_R^{d,\dagger} = m_d^{dia} \tag{38}$$

with

$$d_{L,i\alpha} = \sum_{t_2} U_{L,ji}^{d,*} D_{L,j\alpha} \tag{39}$$

$$d_{R,i\alpha} = \sum_{t_2} U_{R,ij}^{d} D_{R,j\alpha}^* \tag{40}$$

- **Mass matrix for Up-Quarks**, Basis: $\left(u_{L,\alpha_1}\right), \left(u^*_{R,\beta_1}\right)$

$$m_u = \left(\begin{array}{c} -\frac{1}{\sqrt{2}} v \delta_{\alpha_1 \beta_1} Y_u^T \end{array} \right) \tag{41}$$

This matrix is diagonalized by U_L^u and U_R^u

$$U_L^{u,*} m_u U_R^{u,\dagger} = m_u^{dia} \tag{42}$$

with

$$u_{L,i\alpha} = \sum_{t_2} U_{L,ji}^{u,*} U_{L,j\alpha} \tag{43}$$

$$u_{R,i\alpha} = \sum_{t_2} U_{R,ij}^{u} U_{R,j\alpha}^* \tag{44}$$

- **Mass matrix for Leptons**, Basis: $\left(e_L\right), \left(e^*_R\right)$

$$m_e = \left(\begin{array}{c} \frac{1}{\sqrt{2}} v Y_e^T \end{array} \right) \tag{45}$$

This matrix is diagonalized by U_L^e and U_R^e

$$U_L^{e,*} m_e U_R^{e,\dagger} = m_e^{dia} \tag{46}$$

with

$$e_{L,i} = \sum_{t_2} U_{L,ji}^{e,*} E_{L,j} \tag{47}$$

$$e_{R,i} = \sum_{t_2} U_{R,ij}^{e} E_{R,j}^* \tag{48}$$

- **Mass matrix for Neutrinos**, Basis: $(\nu_L, V_R^*)\,, (\nu_L, V_R^*)$

$$m_\nu = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix} \tag{49}$$

This matrix is diagonalized by U^V:

$$U^{V,*} m_\nu U^{V,\dagger} = m_\nu^{dia} \tag{50}$$

with

$$\nu_{L,i} = \sum_j U^{V,*}_{ji} V_{L,j}\,, \qquad V_{R,i} = \sum_j U^V_{ji} V^*_{L,j} \tag{51}$$

- **Mass matrix for FeD**, Basis: $(e_p, x6_L)\,, \left(x5_R^*, ep_p^*\right)$

$$m_{eD} = \begin{pmatrix} \frac{1}{\sqrt{2}} v\lambda_g & \frac{1}{\sqrt{2}}\Big(vx2\lambda_{c2} + vx\lambda_{c1}\Big) \\ \frac{1}{\sqrt{2}}\Big(vx2\lambda_{b2} + vx\lambda_{b1}\Big) & \frac{1}{\sqrt{2}} v\lambda_h \end{pmatrix} \tag{52}$$

This matrix is diagonalized by UD_L^e and UD_R^e

$$UD_L^{e,*} m_{eD} UD_R^{e,\dagger} = m_{eD}^{dia} \tag{53}$$

with

$$e_p = \sum_{t_2} UD^{e,*}_{L,j1} \mathrm{ELD}\Big(\{\mathrm{gt2}\}\Big)\,, \qquad x6_L = \sum_{t_2} UD^{e,*}_{L,j2} \mathrm{ELD}\Big(\{\mathrm{gt2}\}\Big) \tag{54}$$

$$x5_R = \sum_{t_2} UD^e_{R,1j} \mathrm{conj}\Big(\mathrm{ERD}\Big(\{\mathrm{gt2}\}\Big)\Big)\,, \qquad ep_p = \sum_{t_2} UD^e_{R,2j} \mathrm{conj}\Big(\mathrm{ERD}\Big(\{\mathrm{gt2}\}\Big)\Big) \tag{55}$$

4 Vacuum Expectation Values

$$H^0 = \frac{1}{\sqrt{2}}\mathrm{phiH} + \frac{1}{\sqrt{2}} v + i\frac{1}{\sqrt{2}}\mathrm{sigmaH} \tag{56}$$

$$\mathrm{BiD} = \frac{1}{\sqrt{2}}\mathrm{phiB} + \frac{1}{\sqrt{2}} vx + i\frac{1}{\sqrt{2}}\mathrm{sigmaB} \tag{57}$$

$$\mathrm{BjD} = \frac{1}{\sqrt{2}}\mathrm{phiBj} + \frac{1}{\sqrt{2}} vx2 + i\frac{1}{\sqrt{2}}\mathrm{sigmaBj} \tag{58}$$

5 Tadpole Equations

$$\frac{\partial V}{\partial \mathrm{phiH}} = -\frac{1}{2} v\Big(2l_h v^2 - 2\mu_h + \lambda_3 vx^2 + \lambda_5 vx2^2\Big) \tag{59}$$

$$\frac{\partial V}{\partial \mathrm{phiB}} = \Big(-\frac{1}{2}\lambda_3 v^2 + \mu_i'\Big) vx - \lambda_2 vx^3 \tag{60}$$

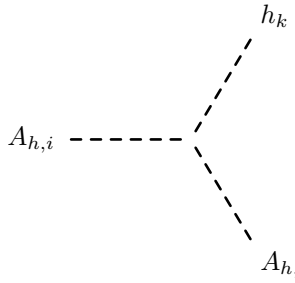
$$\frac{\partial V}{\partial \mathrm{phiBj}} = \Big(-\frac{1}{2}\lambda_5 v^2 + \mu_j'\Big) vx2 - \lambda_4 vx2^3 \tag{61}$$

6 Particle content for eigenstates 'EWSB'

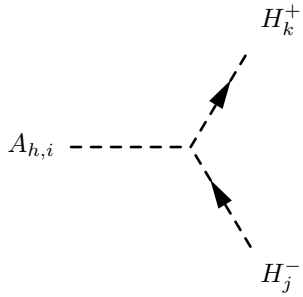
Name	Type	complex/real	Generations	Indices
h	Scalar	real	3	generation, 3
A_h	Scalar	real	3	generation, 3
H^-	Scalar	complex	5	generation, 5
χ^0	Fermion	Dirac	1	
ν^d	Fermion	Dirac	1	
d	Fermion	Dirac	3	generation, 3, color, 3
u	Fermion	Dirac	3	generation, 3, color, 3
e	Fermion	Dirac	3	generation, 3
ν	Fermion	Majorana	5	generation, 5
eD	Fermion	Dirac	2	generation, 2
g	Vector	real	1	color, 8, lorentz, 4
γ	Vector	real	1	lorentz, 4
Z	Vector	real	1	lorentz, 4
Z'	Vector	real	1	lorentz, 4
W^-	Vector	complex	1	lorentz, 4
η^G	Ghost	real	1	color, 8
η^γ	Ghost	real	1	
η^Z	Ghost	real	1	
$\eta^{Z'}$	Ghost	real	1	
η^-	Ghost	complex	1	
η^+	Ghost	complex	1	

7 Interactions for eigenstates 'EWSB'

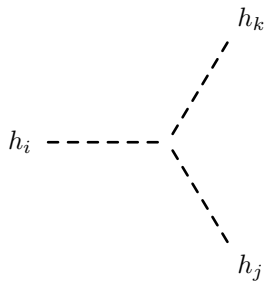
7.1 Three Scalar-Interaction



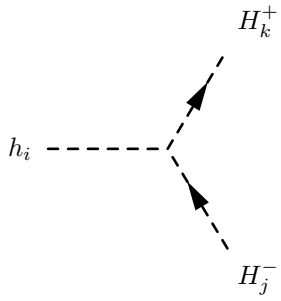
$$i\Big(Z^A_{i2}Z^A_{j2}\Big(2\lambda_2 vxZ^H_{k2}+\lambda_3 vZ^H_{k1}\Big)+Z^A_{i3}Z^A_{j3}\Big(2\lambda_4 vx2Z^H_{k3}+\lambda_5 vZ^H_{k1}\Big)$$
$$+Z^A_{i1}Z^A_{j1}\Big(2l_h vZ^H_{k1}+\lambda_3 vxZ^H_{k2}+\lambda_5 vx2Z^H_{k3}\Big)\Big) \tag{62}$$



$$-\frac{1}{\sqrt{2}}\Big(\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{fi,ab}Z^+_{k1+a}Z^+_{j3+b}Z^A_{i2}-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{fi,ab}Z^+_{j1+a}Z^+_{k3+b}Z^A_{i2}$$
$$+\Big(-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{fj,ab}Z^+_{j1+a}Z^+_{k3+b}+\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{fj,ab}Z^+_{k1+a}Z^+_{j3+b}\Big)Z^A_{i3}\Big) \tag{63}$$

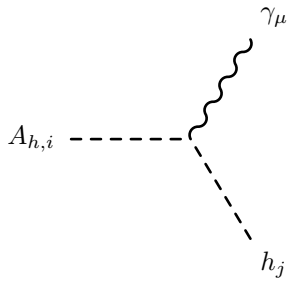


$$
\begin{aligned}
&i\Big(Z_{i2}^{H}\Big(\lambda_3 Z_{j1}^{H}\Big(vxZ_{k1}^{H}+vZ_{k2}^{H}\Big)+Z_{j2}^{H}\Big(6\lambda_2 vxZ_{k2}^{H}+\lambda_3 vZ_{k1}^{H}\Big)\Big)\\
&+Z_{i3}^{H}\Big(\lambda_5 Z_{j1}^{H}\Big(vx2Z_{k1}^{H}+vZ_{k3}^{H}\Big)+Z_{j3}^{H}\Big(6\lambda_4 vx2Z_{k3}^{H}+\lambda_5 vZ_{k1}^{H}\Big)\Big)\\
&+Z_{i1}^{H}\Big(\lambda_3 Z_{j2}^{H}\Big(vxZ_{k1}^{H}+vZ_{k2}^{H}\Big)+\lambda_5 Z_{j3}^{H}\Big(vx2Z_{k1}^{H}+vZ_{k3}^{H}\Big)\\
&+Z_{j1}^{H}\Big(6l_h vZ_{k1}^{H}+\lambda_3 vxZ_{k2}^{H}+\lambda_5 vx2Z_{k3}^{H}\Big)\Big)\Big)
\end{aligned}
\tag{64}
$$

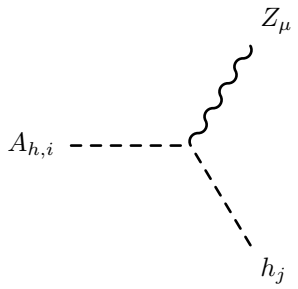


$$
\begin{aligned}
&i\Big(-v\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{6,ab}Z_{k1+a}^{+}Z_{j1+b}^{+}Z_{i1}^{H}-v\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{7,ab}Z_{k3+a}^{+}Z_{j3+b}^{+}Z_{i1}^{H}\\
&-\frac{1}{\sqrt{2}}\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{fi,ab}Z_{k1+a}^{+}Z_{j3+b}^{+}Z_{i2}^{H}-\frac{1}{\sqrt{2}}\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{fi,ab}Z_{j1+a}^{+}Z_{k3+b}^{+}Z_{i2}^{H}\\
&-\frac{1}{\sqrt{2}}\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{fj,ab}Z_{k1+a}^{+}Z_{j3+b}^{+}Z_{i3}^{H}-\frac{1}{\sqrt{2}}\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{fj,ab}Z_{j1+a}^{+}Z_{k3+b}^{+}Z_{i3}^{H}+2l_h vZ_{i1}^{H}Z_{j1}^{+}Z_{k1}^{+}\\
&+\lambda_3 vxZ_{i2}^{H}Z_{j1}^{+}Z_{k1}^{+}+\lambda_5 vx2Z_{i3}^{H}Z_{j1}^{+}Z_{k1}^{+}\Big)
\end{aligned}
\tag{65}
$$

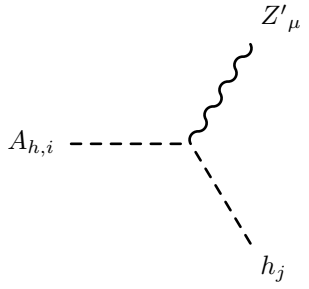
7.2 Two Scalar-One Vector Boson-Interaction



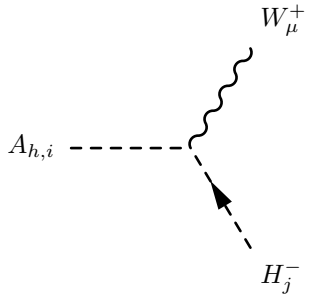
$$
\frac{1}{2}\Big(10g_{YB}\cos\Theta_W\Big(Z_{i2}^{A}Z_{j2}^{H}+Z_{i3}^{A}Z_{j3}^{H}\Big)+\Big(g_1\cos\Theta_W-g_2\sin\Theta_W\Big)Z_{i1}^{A}Z_{j1}^{H}\Big)\Big(-p_\mu^{h_j}+p_\mu^{A_{h,i}}\Big)
\tag{66}
$$



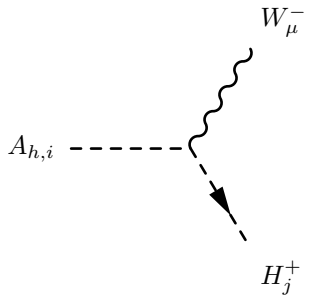
$$\frac{1}{2}\Big(- \Big(g_1 \cos\Theta'_W \sin\Theta_W + g_2 \cos\Theta_W \cos\Theta'_W - g_{BY} \sin\Theta'_W\Big) Z^A_{i1} Z^H_{j1} \\ - 10\Big(- g_B \sin\Theta'_W + g_{YB} \cos\Theta'_W \sin\Theta_W\Big)\Big(Z^A_{i2} Z^H_{j2} + Z^A_{i3} Z^H_{j3}\Big)\Big)\Big(- p^{h_j}_\mu + p^{A_{h,i}}_\mu\Big) \tag{67}$$



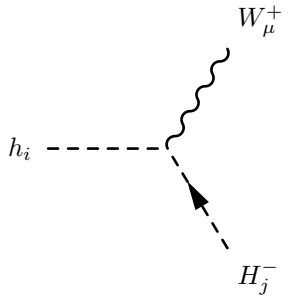
$$\frac{1}{2}\Big(\Big(\Big(\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W\Big) \sin\Theta'_W + g_{BY} \cos\Theta'_W\Big) Z^A_{i1} Z^H_{j1} \\ + 10\Big(g_B \cos\Theta'_W + g_{YB} \sin\Theta_W \sin\Theta'_W\Big)\Big(Z^A_{i2} Z^H_{j2} + Z^A_{i3} Z^H_{j3}\Big)\Big)\Big(- p^{h_j}_\mu + p^{A_{h,i}}_\mu\Big) \tag{68}$$



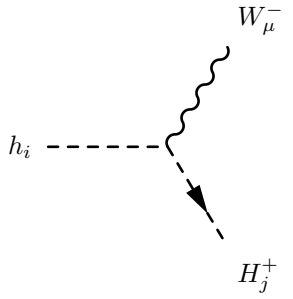
$$\frac{1}{2} g_2 Z^A_{i1} Z^+_{j1}\Big(- p^{H^-_j}_\mu + p^{A_{h,i}}_\mu\Big) \tag{69}$$



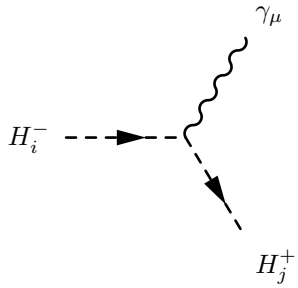
$$\frac{1}{2}g_2 Z^A_{i1} Z^+_{j1}\Big(- p_\mu^{H_j^+} + p_\mu^{A_{h,i}}\Big) \tag{70}$$



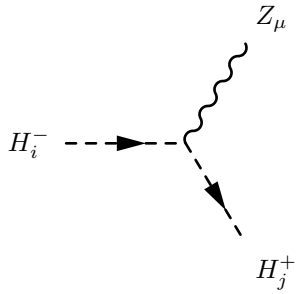
$$-\frac{i}{2}g_2 Z^H_{i1} Z^+_{j1}\Big(- p_\mu^{H_j^-} + p_\mu^{h_i}\Big) \tag{71}$$



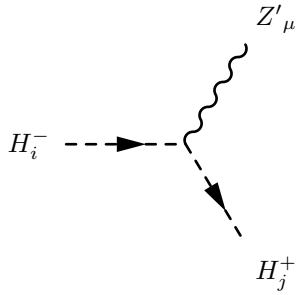
$$\frac{i}{2}g_2 Z^H_{i1} Z^+_{j1}\Big(- p_\mu^{H_j^+} + p_\mu^{h_i}\Big) \tag{72}$$



$$\frac{i}{2}\Big(2\Big(g_1+g_{YB}\Big)\cos\Theta_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}+2\Big(-4g_{YB}+g_1\Big)\cos\Theta_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}$$
$$+\Big(g_1\cos\Theta_W+g_2\sin\Theta_W\Big)Z^+_{i1}Z^+_{j1}\Big)\Big(-p_\mu^{H_j^+}+p_\mu^{H_i^-}\Big) \tag{73}$$

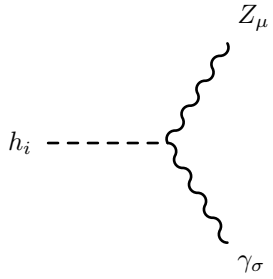


$$-\frac{i}{2}\Big(2\Big(\Big(g_1+g_{YB}\Big)\cos\Theta'_W\sin\Theta_W-\Big(g_{BY}+g_B\Big)\sin\Theta'_W\Big)\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$+2\Big(-\Big(-4g_B+g_{BY}\Big)\sin\Theta'_W+\Big(-4g_{YB}+g_1\Big)\cos\Theta'_W\sin\Theta_W\Big)\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}$$
$$-\Big(-g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W+g_{BY}\sin\Theta'_W\Big)Z^+_{i1}Z^+_{j1}\Big)\Big(-p_\mu^{H_j^+}+p_\mu^{H_i^-}\Big) \tag{74}$$

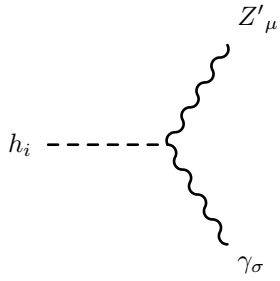


$$\frac{i}{2}\Big(2\Big(\Big(g_1+g_{YB}\Big)\sin\Theta_W\sin\Theta'_W+\Big(g_{BY}+g_B\Big)\cos\Theta'_W\Big)\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$+2\Big(\Big(-4g_B+g_{BY}\Big)\cos\Theta'_W+\Big(-4g_{YB}+g_1\Big)\sin\Theta_W\sin\Theta'_W\Big)\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}$$
$$+\Big(\Big(g_1\sin\Theta_W-g_2\cos\Theta_W\Big)\sin\Theta'_W+g_{BY}\cos\Theta'_W\Big)Z^+_{i1}Z^+_{j1}\Big)\Big(-p_\mu^{H_j^+}+p_\mu^{H_i^-}\Big) \tag{75}$$

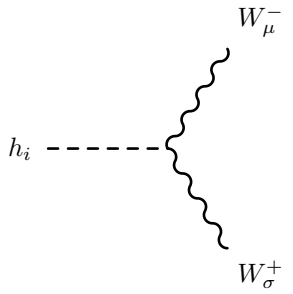
7.3 One Scalar-Two Vector Boson-Interaction



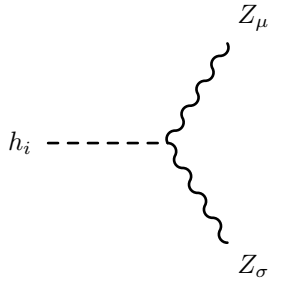
$$\frac{i}{2}\Big(-v\Big(g_1\cos\Theta_W-g_2\sin\Theta_W\Big)\Big(g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W-g_{BY}\sin\Theta'_W\Big)Z^H_{i1}$$
$$-100g_{YB}\cos\Theta_W\Big(-g_B\sin\Theta'_W+g_{YB}\cos\Theta'_W\sin\Theta_W\Big)\Big(vx2Z^H_{i3}+vxZ^H_{i2}\Big)\Big)\Big(g_{\sigma\mu}\Big) \tag{76}$$



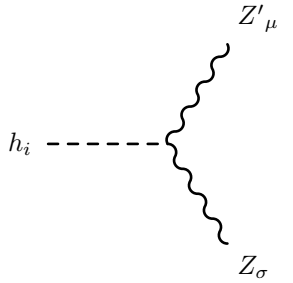
$$\frac{i}{2}\Big(v\Big(g_1\cos\Theta_W-g_2\sin\Theta_W\Big)\Big(\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W+g_{BY}\cos\Theta'_W\Big)Z^H_{i1}$$
$$+100g_{YB}\cos\Theta_W\Big(g_B\cos\Theta'_W+g_{YB}\sin\Theta_W\sin\Theta'_W\Big)\Big(vx2Z^H_{i3}+vxZ^H_{i2}\Big)\Big)\Big(g_{\sigma\mu}\Big) \tag{77}$$



$$\frac{i}{2}g_2^2 v Z_{i1}^H \Big(g_{\sigma\mu}\Big) \tag{78}$$

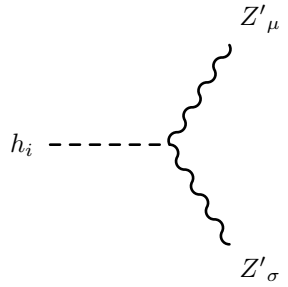


$$\begin{aligned}&\frac{i}{2}\Big(v\Big(g_1 \cos\Theta'_W \sin\Theta_W + g_2 \cos\Theta_W \cos\Theta'_W - g_{BY} \sin\Theta'_W\Big)^2 Z_{i1}^H \\ &+ 100\Big(-g_B \sin\Theta'_W + g_{YB} \cos\Theta'_W \sin\Theta_W\Big)^2 \Big(vx2Z_{i3}^H + vxZ_{i2}^H\Big)\Big)\Big(g_{\sigma\mu}\Big)\end{aligned} \tag{79}$$

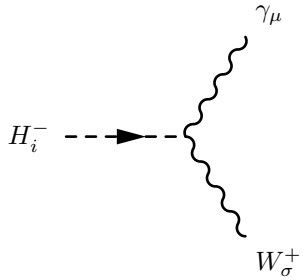


$$\begin{aligned}&\frac{i}{2}\Big(v\Big(-g_1 g_{BY} \cos\Theta'^2_W \sin\Theta_W - g_2^2 \cos\Theta_W^2 \cos\Theta'_W \sin\Theta'_W \\ &+ \cos\Theta'_W\Big(-g_1^2 \sin\Theta_W^2 + g_{BY}^2\Big) \sin\Theta'_W + g_1 g_{BY} \sin\Theta_W \sin\Theta'^2_W\end{aligned}$$

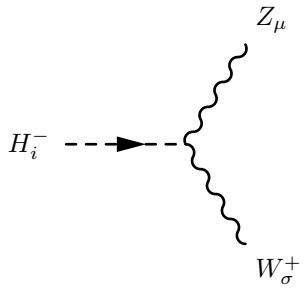
$$+ g_2 \cos\Theta_W \Big(- 2 g_1 \cos\Theta'_W \sin\Theta_W \sin\Theta'_W - g_{BY} \cos\Theta'^2_W + g_{BY} \sin\Theta'^2_W \Big) \Big) Z^H_{i1}$$
$$+ \frac{25}{2} \Big(- 8 g_B g_{YB} \cos\Theta'^2_W \sin\Theta_W + 8 g_B g_{YB} \sin\Theta_W \sin\Theta'^2_W$$
$$+ 2 \Big(2 g_B^2 - g_{YB}^2 + g_{YB}^2 \cos 2\Theta_W \Big) \sin 2\Theta'_W \Big) \Big(v x 2 Z^H_{i3} + v x Z^H_{i2} \Big) \Big) \Big(g_{\sigma\mu} \Big) \tag{80}$$



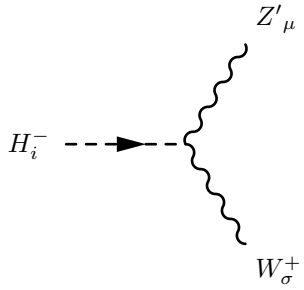
$$\frac{i}{2} \Big(v \Big(\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) \sin\Theta'_W + g_{BY} \cos\Theta'_W \Big)^2 Z^H_{i1}$$
$$+ 100 \Big(g_B \cos\Theta'_W + g_{YB} \sin\Theta_W \sin\Theta'_W \Big)^2 \Big(v x 2 Z^H_{i3} + v x Z^H_{i2} \Big) \Big) \Big(g_{\sigma\mu} \Big) \tag{81}$$



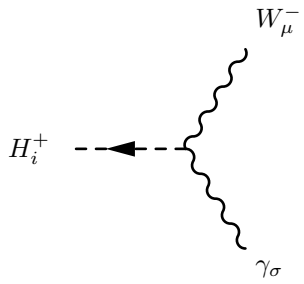
$$\frac{i}{2} g_1 g_2 v \cos\Theta_W Z^+_{i1} \Big(g_{\sigma\mu} \Big) \tag{82}$$



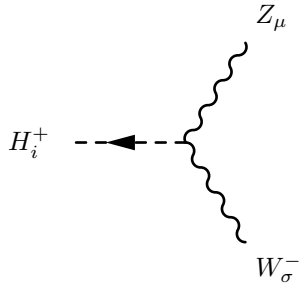
$$\frac{i}{2}g_2 v\Big(- g_1 \cos\Theta'_W \sin\Theta_W + g_{BY} \sin\Theta'_W\Big) Z^+_{i1}\Big(g_{\sigma\mu}\Big) \tag{83}$$



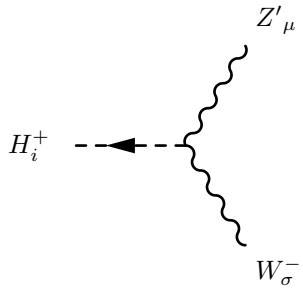
$$\frac{i}{2}g_2 v\Big(g_1 \sin\Theta_W \sin\Theta'_W + g_{BY} \cos\Theta'_W\Big) Z^+_{i1}\Big(g_{\sigma\mu}\Big) \tag{84}$$



$$\frac{i}{2}g_1 g_2 v \cos\Theta_W Z^+_{i1}\Big(g_{\sigma\mu}\Big) \tag{85}$$

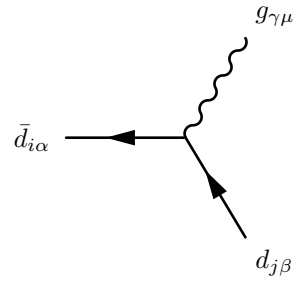


$$\frac{i}{2}g_2 v\Big(- g_1 \cos\Theta'_W \sin\Theta_W + g_{BY} \sin\Theta'_W\Big) Z^+_{i1}\Big(g_{\sigma\mu}\Big) \tag{86}$$



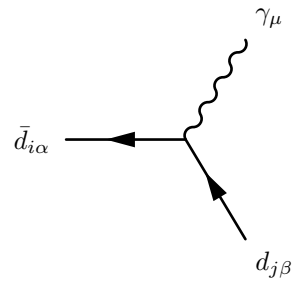
$$\frac{i}{2}g_2 v\Big(g_1 \sin\Theta_W \sin\Theta'_W + g_{BY}\cos\Theta'_W\Big) Z_{i1}^{+}\Big(g_{\sigma\mu}\Big) \tag{87}$$

7.4 Two Fermion-One Vector Boson-Interaction



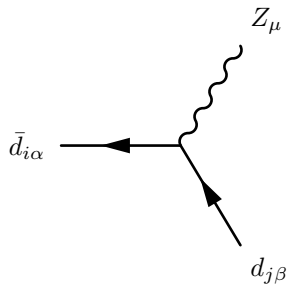
$$-\frac{i}{2}g_3\delta_{ij}\lambda^{\gamma}_{\alpha,\beta}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{88}$$

$$+\ -\frac{i}{2}g_3\delta_{ij}\lambda^{\gamma}_{\alpha,\beta}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{89}$$



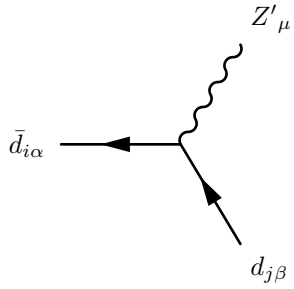
$$-\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-10g_{YB}+3g_1\Big)\cos\Theta_W - 9g_2\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{90}$$

$$+\ \frac{i}{9}\Big(3g_1+5g_{YB}\Big)\cos\Theta_W\delta_{\alpha\beta}\delta_{ij}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{91}$$



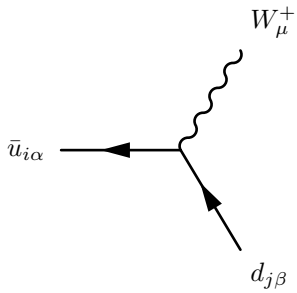
$$\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(10g_B - 3g_{BY}\Big)\sin\Theta'_W + \Big(-10g_{YB} + 3g_1\Big)\cos\Theta'_W\sin\Theta_W + 9g_2\cos\Theta_W\cos\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{92}$$

$$+\ -\frac{i}{9}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(3g_1 + 5g_{YB}\Big)\cos\Theta'_W\sin\Theta_W - \Big(3g_{BY} + 5g_B\Big)\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{93}$$

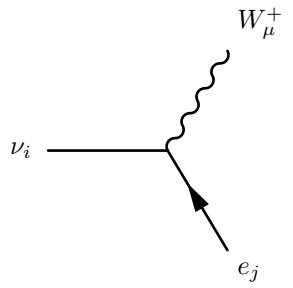


$$-\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-10g_B + 3g_{BY}\Big)\cos\Theta'_W + \Big(\Big(-10g_{YB} + 3g_1\Big)\sin\Theta_W + 9g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{94}$$

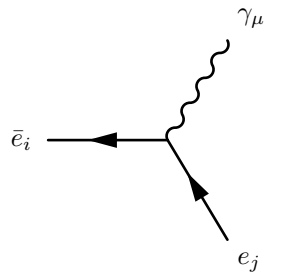
$$+\ \frac{i}{9}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(3g_1 + 5g_{YB}\Big)\sin\Theta_W\sin\Theta'_W + \Big(3g_{BY} + 5g_B\Big)\cos\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{95}$$



$$-\,i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^{3}U^{d,*}_{L,ja}U^{u}_{L,ia}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{96}$$

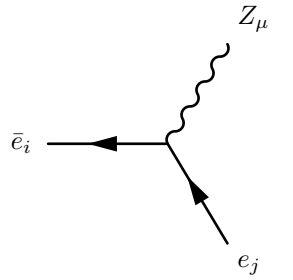


$$-i\frac{1}{\sqrt{2}}g_2\sum_{a=1}^{3}U_{L,ja}^{e,*}U_{ia}^{V}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{97}$$



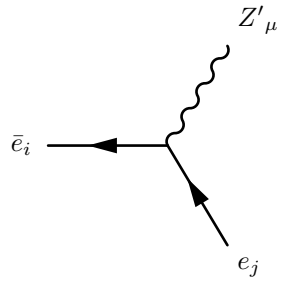
$$\frac{i}{2}\delta_{ij}\Big(g_1\cos\Theta_W+g_2\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{98}$$

$$+\ ig_1\cos\Theta_W\delta_{ij}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{99}$$



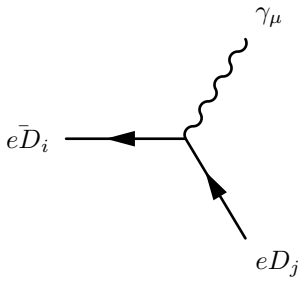
$$\frac{i}{2}\delta_{ij}\Big(-g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W+g_{BY}\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{100}$$

$$+\ -i\delta_{ij}\Big(g_1\cos\Theta'_W\sin\Theta_W-g_{BY}\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{101}$$



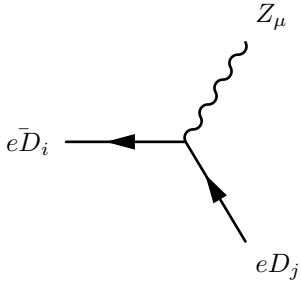
$$\frac{i}{2}\delta_{ij}\Big(\Big(g_1 \sin\Theta_W - g_2 \cos\Theta_W\Big)\sin\Theta'_W + g_{BY}\cos\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{102}$$

$$+\ i\delta_{ij}\Big(g_1 \sin\Theta_W \sin\Theta'_W + g_{BY}\cos\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{103}$$

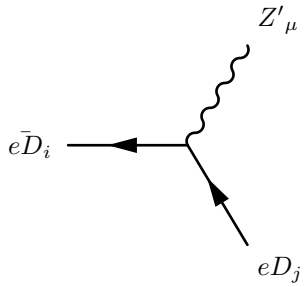


$$\frac{i}{2}\Big(2\Big(6g_{YB}+g_1\Big)UD^{e,*}_{L,j2}\cos\Theta_W UD^{e}_{L,i2} + UD^{e,*}_{L,j1}\Big(\Big(2g_{YB}+g_1\Big)\cos\Theta_W + g_2\sin\Theta_W\Big)UD^{e}_{L,i1}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{104}$$

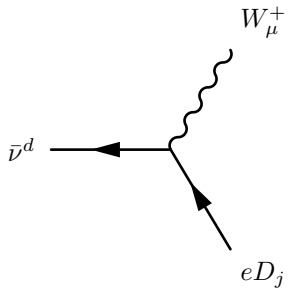
$$+\ \frac{i}{2}\Big(2\Big(g_1+g_{YB}\Big)UD^{e,*}_{R,i1}\cos\Theta_W UD^{e}_{R,j1} + UD^{e,*}_{R,i2}\Big(\Big(12g_{YB}+g_1\Big)\cos\Theta_W + g_2\sin\Theta_W\Big)UD^{e}_{R,j2}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{105}$$



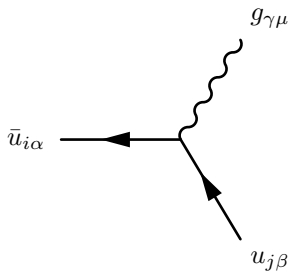
$$\frac{i}{2}\Big(UD^{e,*}_{L,j1}\Big(\Big(2g_B+g_{BY}\Big)\sin\Theta'_W-\Big(2g_{YB}+g_1\Big)\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)UD^{e}_{L,i1}$$
$$+2UD^{e,*}_{L,j2}\Big(\Big(6g_B+g_{BY}\Big)\sin\Theta'_W-\Big(6g_{YB}+g_1\Big)\cos\Theta'_W\sin\Theta_W\Big)UD^{e}_{L,i2}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{106}$$
$$+\ -\frac{i}{2}\Big(2UD^{e,*}_{R,i1}\Big(\Big(g_1+g_{YB}\Big)\cos\Theta'_W\sin\Theta_W-\Big(g_{BY}+g_B\Big)\sin\Theta'_W\Big)UD^{e}_{R,j1}$$
$$-UD^{e,*}_{R,i2}\Big(\Big(12g_B+g_{BY}\Big)\sin\Theta'_W-\Big(12g_{YB}+g_1\Big)\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)UD^{e}_{R,j2}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{107}$$



$$\frac{i}{2}\Big(UD^{e,*}_{L,j1}\Big(\Big(2g_B+g_{BY}\Big)\cos\Theta'_W+\Big(\Big(2g_{YB}+g_1\Big)\sin\Theta_W-g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)UD^{e}_{L,i1}$$
$$+2UD^{e,*}_{L,j2}\Big(\Big(6g_B+g_{BY}\Big)\cos\Theta'_W+\Big(6g_{YB}+g_1\Big)\sin\Theta_W\sin\Theta'_W\Big)UD^{e}_{L,i2}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{108}$$
$$+\ \frac{i}{2}\Big(2UD^{e,*}_{R,i1}\Big(\Big(g_1+g_{YB}\Big)\sin\Theta_W\sin\Theta'_W+\Big(g_{BY}+g_B\Big)\cos\Theta'_W\Big)UD^{e}_{R,j1}$$
$$+UD^{e,*}_{R,i2}\Big(\Big(12g_B+g_{BY}\Big)\cos\Theta'_W+\Big(\Big(12g_{YB}+g_1\Big)\sin\Theta_W-g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)UD^{e}_{R,j2}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{109}$$

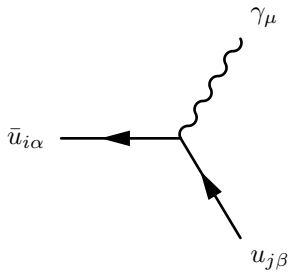


$$-\ i\frac{1}{\sqrt{2}}g_2UD^{e,*}_{L,j1}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{110}$$
$$+\ -i\frac{1}{\sqrt{2}}g_2UD^{e}_{R,j2}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{111}$$



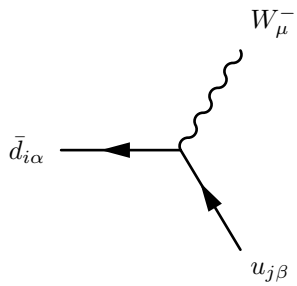
$$- \frac{i}{2} g_3 \delta_{ij} \lambda^{\gamma}_{\alpha,\beta} \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{112}$$

$$+ \; - \frac{i}{2} g_3 \delta_{ij} \lambda^{\gamma}_{\alpha,\beta} \Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2} \Big) \tag{113}$$

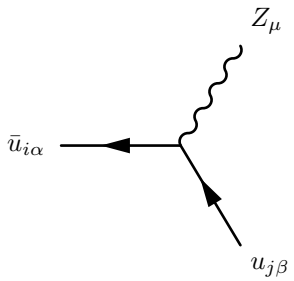


$$- \frac{i}{18} \delta_{\alpha\beta} \delta_{ij} \Big(\Big(-10 g_{YB} + 3 g_1 \Big) \cos\Theta_W + 9 g_2 \sin\Theta_W \Big) \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{114}$$

$$+ \; - \frac{i}{9} \Big(-5 g_{YB} + 6 g_1 \Big) \cos\Theta_W \delta_{\alpha\beta} \delta_{ij} \Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2} \Big) \tag{115}$$

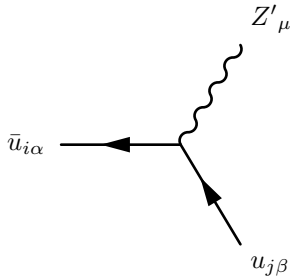


$$- i \frac{1}{\sqrt{2}} g_2 \delta_{\alpha\beta} \sum_{a=1}^{3} U^{u,*}_{L,ja} U^{d}_{L,ia} \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{116}$$



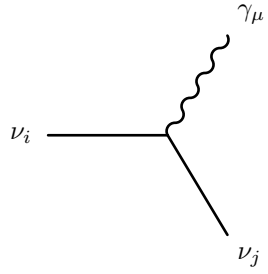
$$-\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-10g_B+3g_{BY}\Big)\sin\Theta'_W-\Big(-10g_{YB}+3g_1\Big)\cos\Theta'_W\sin\Theta_W+9g_2\cos\Theta_W\cos\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{117}$$

$$+\frac{i}{9}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(5g_B-6g_{BY}\Big)\sin\Theta'_W+\Big(-5g_{YB}+6g_1\Big)\cos\Theta'_W\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{118}$$



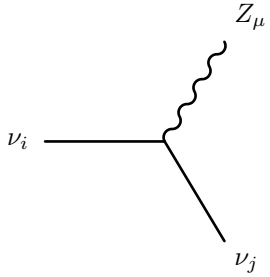
$$-\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-10g_B+3g_{BY}\Big)\cos\Theta'_W+\Big(\Big(-10g_{YB}+3g_1\Big)\sin\Theta_W-9g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{119}$$

$$+-\frac{i}{9}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-5g_B+6g_{BY}\Big)\cos\Theta'_W+\Big(-5g_{YB}+6g_1\Big)\sin\Theta_W\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{120}$$



$$\frac{i}{2}\Big(10g_{YB}\cos\Theta_W\sum_{a=1}^{2}U^{V,*}_{j3+a}U^{V}_{i3+a}+\Big(g_1\cos\Theta_W-g_2\sin\Theta_W\Big)\sum_{a=1}^{3}U^{V,*}_{ja}U^{V}_{ia}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{121}$$

$$+\,-\frac{i}{2}\Big(10g_{YB}\cos\Theta_W\sum_{a=1}^{2}U^{V,*}_{i3+a}U^{V}_{j3+a}+\Big(g_1\cos\Theta_W-g_2\sin\Theta_W\Big)\sum_{a=1}^{3}U^{V,*}_{ia}U^{V}_{ja}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{122}$$

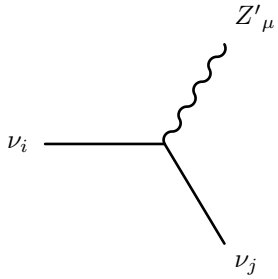


$$-\frac{i}{2}\Big(10\Big(-g_B\sin\Theta'_W+g_{YB}\cos\Theta'_W\sin\Theta_W\Big)\sum_{a=1}^{2}U^{V,*}_{j3+a}U^{V}_{i3+a}$$

$$+\Big(g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W-g_{BY}\sin\Theta'_W\Big)\sum_{a=1}^{3}U^{V,*}_{ja}U^{V}_{ia}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{123}$$

$$+\,\frac{i}{2}\Big(10\Big(-g_B\sin\Theta'_W+g_{YB}\cos\Theta'_W\sin\Theta_W\Big)\sum_{a=1}^{2}U^{V,*}_{i3+a}U^{V}_{j3+a}$$

$$+\Big(g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W-g_{BY}\sin\Theta'_W\Big)\sum_{a=1}^{3}U^{V,*}_{ia}U^{V}_{ja}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{124}$$

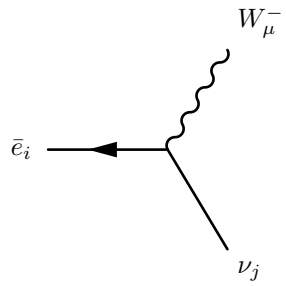


$$\frac{i}{2}\Big(10\Big(g_B\cos\Theta'_W+g_{YB}\sin\Theta_W\sin\Theta'_W\Big)\sum_{a=1}^{2}U^{V,*}_{j3+a}U^{V}_{i3+a}$$

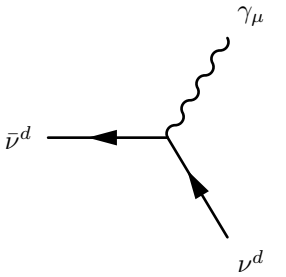
$$+\Big(\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W+g_{BY}\cos\Theta'_W\Big)\sum_{a=1}^{3}U^{V,*}_{ja}U^{V}_{ia}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{125}$$

$$+-\frac{i}{2}\Big(10\Big(g_B\cos\Theta'_W+g_{YB}\sin\Theta_W\sin\Theta'_W\Big)\sum_{a=1}^{2}U^{V,*}_{i3+a}U^{V}_{j3+a}$$

$$+\Big(\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W+g_{BY}\cos\Theta'_W\Big)\sum_{a=1}^{3}U^{V,*}_{ia}U^{V}_{ja}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{126}$$

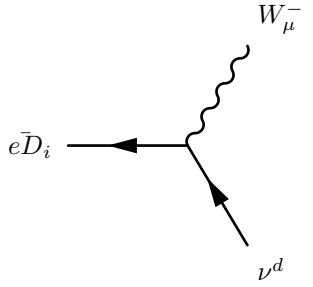


$$-i\frac{1}{\sqrt{2}}g_2\sum_{a=1}^{3}U^{V,*}_{ja}U^{e}_{L,ia}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{127}$$



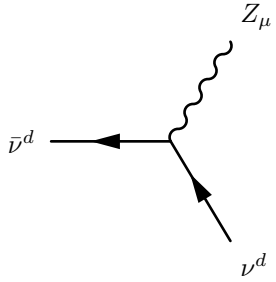
$$\frac{i}{2}\Big(\Big(2g_{YB}+g_1\Big)\cos\Theta_W-g_2\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{128}$$

$$+\ \frac{i}{2}\Big(\Big(12g_{YB}+g_1\Big)\cos\Theta_W-g_2\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{129}$$



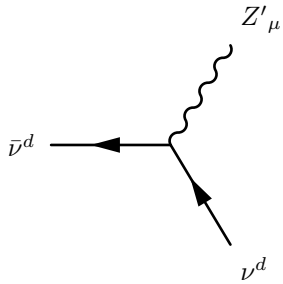
$$- i\frac{1}{\sqrt{2}}g_2 UD^e_{L,i1}\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{130}$$

$$+ -i\frac{1}{\sqrt{2}}g_2 UD^{e,*}_{R,i2}\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{131}$$



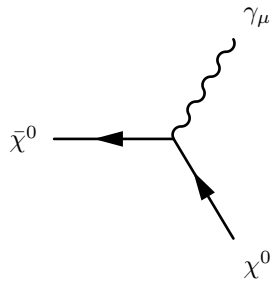
$$- \frac{i}{2}\Big(- \Big(2g_B + g_{BY}\Big)\sin\Theta'_W + \Big(2g_{YB} + g_1\Big)\cos\Theta'_W \sin\Theta_W + g_2 \cos\Theta_W \cos\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{132}$$

$$+ -\frac{i}{2}\Big(- \Big(12g_B + g_{BY}\Big)\sin\Theta'_W + \Big(12g_{YB} + g_1\Big)\cos\Theta'_W \sin\Theta_W + g_2 \cos\Theta_W \cos\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{133}$$



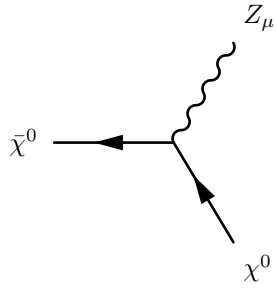
$$\frac{i}{2}\Big(\Big(2g_B + g_{BY}\Big)\cos\Theta'_W + \Big(\Big(2g_{YB} + g_1\Big)\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{134}$$

$$+\ \frac{i}{2}\Big(\Big(12g_B + g_{BY}\Big)\cos\Theta'_W + \Big(\Big(12g_{YB} + g_1\Big)\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{135}$$



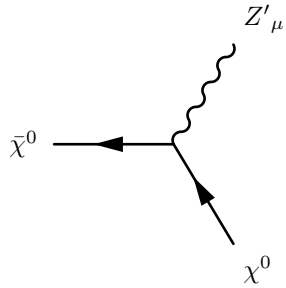
$$-\ 3ig_{YB}\cos\Theta_W\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{136}$$

$$+\ 2ig_{YB}\cos\Theta_W\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{137}$$



$$3i\Big(-g_B\sin\Theta'_W + g_{YB}\cos\Theta'_W\sin\Theta_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{138}$$

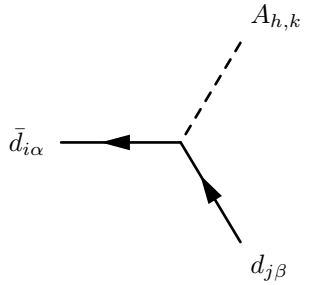
$$+\ -2i\Big(-g_B\sin\Theta'_W + g_{YB}\cos\Theta'_W\sin\Theta_W\Big)\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{139}$$



$$- 3i\Big(g_B \cos\Theta'_W + g_{YB} \sin\Theta_W \sin\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{140}$$

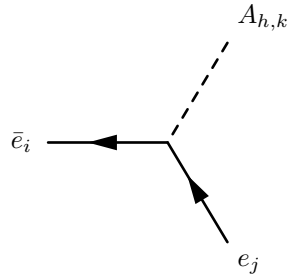
$$+ 2i\Big(g_B \cos\Theta'_W + g_{YB} \sin\Theta_W \sin\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{141}$$

7.5 Two Fermion-One Scalar Boson-Interaction



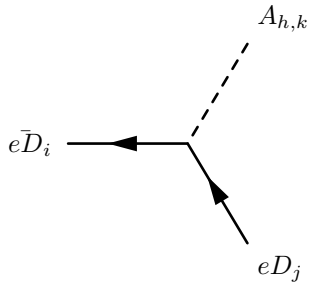
$$- \frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3} U^{d,*}_{L,jb}\sum_{a=1}^{3} U^{d,*}_{R,ia} Y_{d,ab} Z^A_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{142}$$

$$+ \frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^*_{d,ab} U^d_{R,ja} U^d_{L,ib} Z^A_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{143}$$

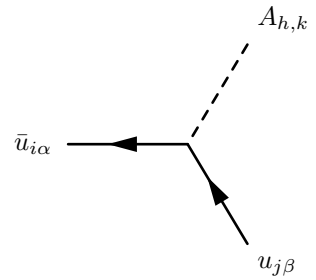


$$- \frac{1}{\sqrt{2}}\sum_{b=1}^{3} U^{e,*}_{L,jb}\sum_{a=1}^{3} U^{e,*}_{R,ia} Y_{e,ab} Z^A_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{144}$$

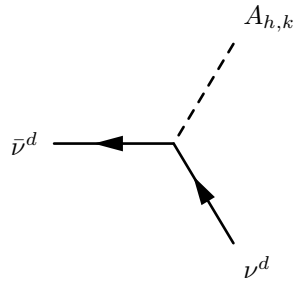
$$+ \frac{1}{\sqrt{2}}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^*_{e,ab} U^e_{R,ja} U^e_{L,ib} Z^A_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{145}$$



$$
\begin{aligned}
&- \frac{1}{\sqrt{2}}\Big(UD^{e,*}_{R,i1}\Big(\lambda_g UD^{e,*}_{L,j1}Z^A_{k1} - UD^{e,*}_{L,j2}\Big(\lambda_{b1}Z^A_{k2} + \lambda_{b2}Z^A_{k3}\Big)\Big) \\
&+ UD^{e,*}_{R,i2}\Big(-\lambda_h UD^{e,*}_{L,j2}Z^A_{k1} + UD^{e,*}_{L,j1}\Big(\lambda_{c1}Z^A_{k2} + \lambda_{c2}Z^A_{k3}\Big)\Big)\Big)\Big(\frac{1-\gamma_5}{2}\Big) \qquad (146)\\
&+ \frac{1}{\sqrt{2}}\Big(\lambda^*_g UD^{e}_{R,j1}UD^{e}_{L,i1}Z^A_{k1} - UD^{e}_{R,j1}UD^{e}_{L,i2}\Big(\lambda_{b1}Z^A_{k2} + \lambda_{b2}Z^A_{k3}\Big) \\
&+ UD^{e}_{R,j2}\Big(-\lambda_h UD^{e}_{L,i2}Z^A_{k1} + UD^{e}_{L,i1}\Big(\lambda_{c1}Z^A_{k2} + \lambda_{c2}Z^A_{k3}\Big)\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \qquad (147)
\end{aligned}
$$

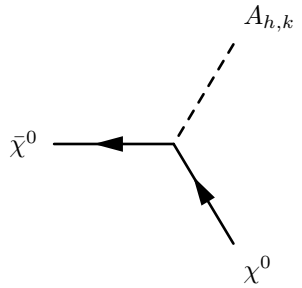


$$
\begin{aligned}
&- \frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}U^{u,*}_{L,jb}\sum_{a=1}^{3}U^{u,*}_{R,ia}Y_{u,ab}Z^A_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \qquad (148)\\
&+ \frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{u,ab}U^{u}_{R,ja}U^{u}_{L,ib}Z^A_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \qquad (149)
\end{aligned}
$$



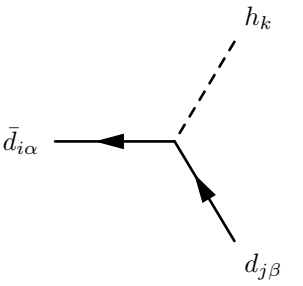
$$-\frac{1}{\sqrt{2}}\Big(\lambda_{c1}Z^A_{k2}+\lambda_{c2}Z^A_{k3}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{150}$$

$$+\frac{1}{\sqrt{2}}\Big(\lambda_{c1}Z^A_{k2}+\lambda_{c2}Z^A_{k3}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{151}$$



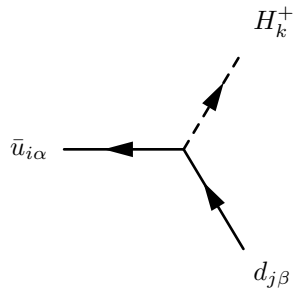
$$-\frac{1}{\sqrt{2}}\Big(\lambda_{a1}Z^A_{k2}+\lambda_{a2}Z^A_{k3}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{152}$$

$$+\frac{1}{\sqrt{2}}\Big(\lambda_{a1}Z^A_{k2}+\lambda_{a2}Z^A_{k3}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{153}$$



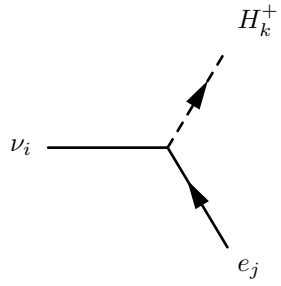
$$-i\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}U^{d,*}_{L,jb}\sum_{a=1}^{3}U^{d,*}_{R,ia}Y_{d,ab}Z^H_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{154}$$

$$+ \; -i\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{d,ab}U^{d}_{R,ja}U^{d}_{L,ib}Z^{H}_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{155}$$



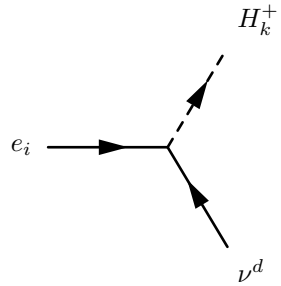
$$- \, i\delta_{\alpha\beta}\sum_{b=1}^{3} U^{d,*}_{L,jb}\sum_{a=1}^{3} U^{u,*}_{R,ia}Y_{u,ab}Z^{+}_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{156}$$

$$+ \; -i\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{d,ab}U^{d}_{R,ja}U^{u}_{L,ib}Z^{+}_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{157}$$

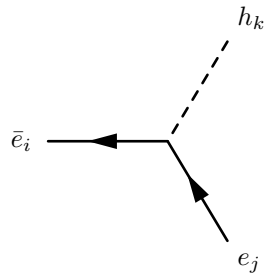


(158)

$$+ \; -i\sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{e,ab}U^{e}_{R,ja}U^{V}_{ib}Z^{+}_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{159}$$

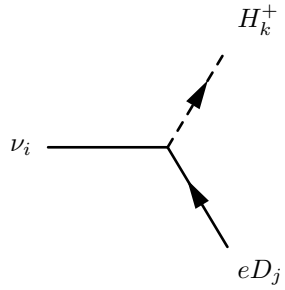


$$i\sum_{b=1}^{3} U^{e,*}_{L,ib} \sum_{a=1}^{2} \lambda_{d,ab} Z^{+}_{k1+a} \Big(\frac{1-\gamma_5}{2}\Big) \tag{160}$$



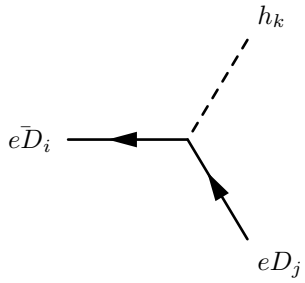
$$-i\frac{1}{\sqrt{2}}\sum_{b=1}^{3} U^{e,*}_{L,jb} \sum_{a=1}^{3} U^{e,*}_{R,ia} Y_{e,ab} Z^{H}_{k1} \Big(\frac{1-\gamma_5}{2}\Big) \tag{161}$$

$$+\ -i\frac{1}{\sqrt{2}}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{e,ab} U^{e}_{R,ja} U^{e}_{L,ib} Z^{H}_{k1} \Big(\frac{1+\gamma_5}{2}\Big) \tag{162}$$

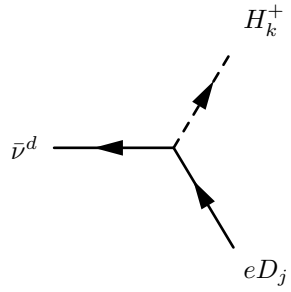


$$-iUD^{e,*}_{L,j1} \sum_{b=1}^{3} U^{V,*}_{ib} \sum_{a=1}^{2} \lambda_{d,ab} Z^{+}_{k1+a} \Big(\frac{1-\gamma_5}{2}\Big) \tag{163}$$

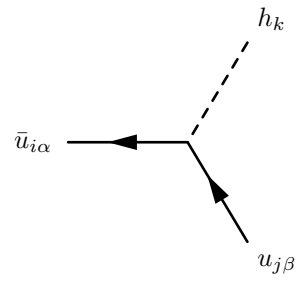
$$+\ -i\sum_{b=1}^{2}\sum_{a=1}^{2} \lambda^{*}_{e,ab} Z^{+}_{k3+a} U^{V}_{i3+b} UD^{e}_{R,j1} \Big(\frac{1+\gamma_5}{2}\Big) \tag{164}$$



$$
\begin{aligned}
&- i\frac{1}{\sqrt{2}}\Big(UD^{e,*}_{R,i1}\Big(\lambda_g UD^{e,*}_{L,j1}Z^H_{k1} + UD^{e,*}_{L,j2}\Big(\lambda_{b1}Z^H_{k2} + \lambda_{b2}Z^H_{k3}\Big)\Big) \\
&+ UD^{e,*}_{R,i2}\Big(\lambda_h UD^{e,*}_{L,j2}Z^H_{k1} + UD^{e,*}_{L,j1}\Big(\lambda_{c1}Z^H_{k2} + \lambda_{c2}Z^H_{k3}\Big)\Big)\Big)\Big(\frac{1-\gamma_5}{2}\Big) \qquad (165) \\
&+ \; -i\frac{1}{\sqrt{2}}\Big(\lambda^*_g UD^e_{R,j1}UD^e_{L,i1}Z^H_{k1} + UD^e_{R,j1}UD^e_{L,i2}\Big(\lambda_{b1}Z^H_{k2} + \lambda_{b2}Z^H_{k3}\Big) \\
&+ UD^e_{R,j2}\Big(\lambda_h UD^e_{L,i2}Z^H_{k1} + UD^e_{L,i1}\Big(\lambda_{c1}Z^H_{k2} + \lambda_{c2}Z^H_{k3}\Big)\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \qquad (166)
\end{aligned}
$$

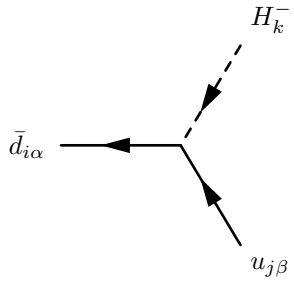


$$
\begin{aligned}
&- i\lambda_h UD^{e,*}_{L,j2}Z^+_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \qquad (167) \\
&+ \; -i\lambda^*_g UD^e_{R,j1}Z^+_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \qquad (168)
\end{aligned}
$$



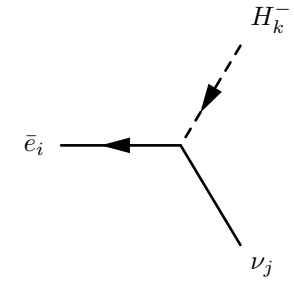
$$i\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}U_{L,jb}^{u,*}\sum_{a=1}^{3}U_{R,ia}^{u,*}Y_{u,ab}Z_{k1}^{H}\Big(\frac{1-\gamma_5}{2}\Big) \tag{169}$$

$$+\ i\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{u,ab}^{*}U_{R,ja}^{u}U_{L,ib}^{u}Z_{k1}^{H}\Big(\frac{1+\gamma_5}{2}\Big) \tag{170}$$

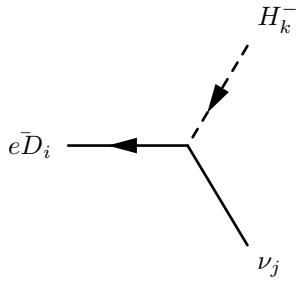


$$-\ i\delta_{\alpha\beta}\sum_{b=1}^{3}U_{L,jb}^{u,*}\sum_{a=1}^{3}U_{R,ia}^{d,*}Y_{d,ab}Z_{k1}^{+}\Big(\frac{1-\gamma_5}{2}\Big) \tag{171}$$

$$+\ -i\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{u,ab}^{*}U_{R,ja}^{u}U_{L,ib}^{d}Z_{k1}^{+}\Big(\frac{1+\gamma_5}{2}\Big) \tag{172}$$

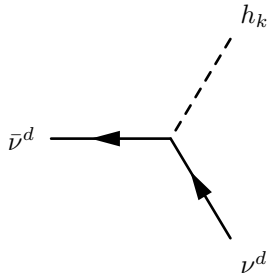


$$-\ i\sum_{b=1}^{3}U_{jb}^{V,*}\sum_{a=1}^{3}U_{R,ia}^{e,*}Y_{e,ab}Z_{k1}^{+}\Big(\frac{1-\gamma_5}{2}\Big) \tag{173}$$



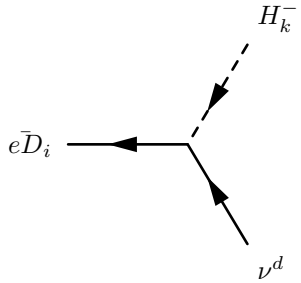
$$- iUD^{e,*}_{R,i1}\sum_{b=1}^{2}U^{V,*}_{j3+b}\sum_{a=1}^{2}\lambda_{e,ab}Z^{+}_{k3+a}\Big(\frac{1-\gamma_5}{2}\Big) \tag{174}$$

$$+ -i\sum_{b=1}^{3}\sum_{a=1}^{2}\lambda^{*}_{d,ab}Z^{+}_{k1+a}U^{V}_{jb}UD^{e}_{L,i1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{175}$$



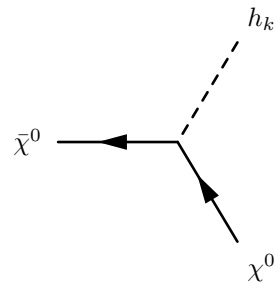
$$- i\frac{1}{\sqrt{2}}\Big(\lambda_{c1}Z^{H}_{k2}+\lambda_{c2}Z^{H}_{k3}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{176}$$

$$+ -i\frac{1}{\sqrt{2}}\Big(\lambda_{c1}Z^{H}_{k2}+\lambda_{c2}Z^{H}_{k3}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{177}$$



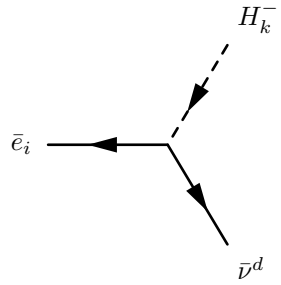
$$- i\lambda_g UD^{e,*}_{R,i1} Z^+_{k1} \Big(\frac{1-\gamma_5}{2}\Big) \tag{178}$$

$$+ \; -i\lambda_h UD^{e}_{L,i2} Z^+_{k1} \Big(\frac{1+\gamma_5}{2}\Big) \tag{179}$$



$$- i\frac{1}{\sqrt{2}} \Big(\lambda_{a1} Z^H_{k2} + \lambda_{a2} Z^H_{k3}\Big) \Big(\frac{1-\gamma_5}{2}\Big) \tag{180}$$

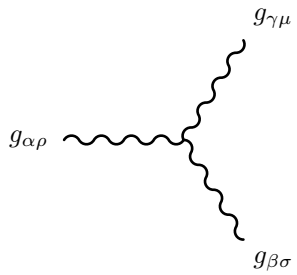
$$+ \; -i\frac{1}{\sqrt{2}} \Big(\lambda_{a1} Z^H_{k2} + \lambda_{a2} Z^H_{k3}\Big) \Big(\frac{1+\gamma_5}{2}\Big) \tag{181}$$



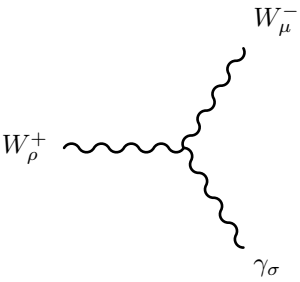
$$\tag{182}$$

$$+ \; i \sum_{b=1}^{3} \sum_{a=1}^{2} \lambda^*_{d,ab} Z^+_{k1+a} U^e_{L,ib} \Big(\frac{1+\gamma_5}{2}\Big) \tag{183}$$

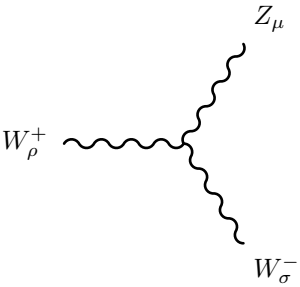
7.6 Three Vector Boson-Interaction



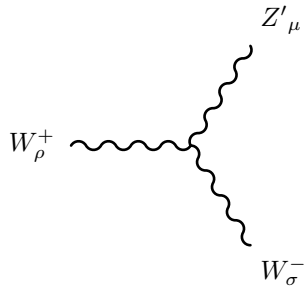
$$g_3 f_{\alpha,\beta,\gamma}\Big(g_{\rho\mu}\Big(-p_\sigma^{g_{\gamma\mu}}+p_\sigma^{g_{\alpha\rho}}\Big)+g_{\rho\sigma}\Big(-p_\mu^{g_{\alpha\rho}}+p_\mu^{g_{\beta\sigma}}\Big)+g_{\sigma\mu}\Big(-p_\rho^{g_{\beta\sigma}}+p_\rho^{g_{\gamma\mu}}\Big)\Big) \tag{184}$$



$$ig_2 \sin\Theta_W\Big(g_{\rho\mu}\Big(-p_\sigma^{W_\mu^-}+p_\sigma^{W_\rho^+}\Big)+g_{\rho\sigma}\Big(-p_\mu^{W_\rho^+}+p_\mu^{\gamma_\sigma}\Big)+g_{\sigma\mu}\Big(-p_\rho^{\gamma_\sigma}+p_\rho^{W_\mu^-}\Big)\Big) \tag{185}$$

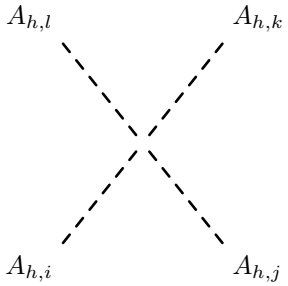


$$-ig_2 \cos\Theta_W \cos\Theta'_W\Big(g_{\rho\mu}\Big(-p_\sigma^{Z_\mu}+p_\sigma^{W_\rho^+}\Big)+g_{\rho\sigma}\Big(-p_\mu^{W_\rho^+}+p_\mu^{W_\sigma^-}\Big)+g_{\sigma\mu}\Big(-p_\rho^{W_\sigma^-}+p_\rho^{Z_\mu}\Big)\Big) \tag{186}$$

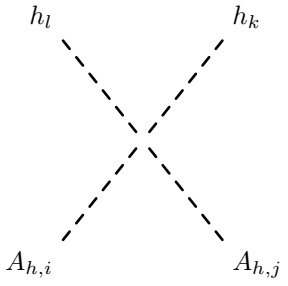


$$ig_2 \cos\Theta_W \sin\Theta'_W \Big(g_{\rho\mu}\Big(-p_\sigma^{Z'_\mu} + p_\sigma^{W^+_\rho}\Big) + g_{\rho\sigma}\Big(-p_\mu^{W^+_\rho} + p_\mu^{W^-_\sigma}\Big) + g_{\sigma\mu}\Big(-p_\rho^{W^-_\sigma} + p_\rho^{Z'_\mu}\Big)\Big) \tag{187}$$

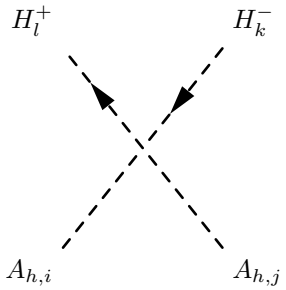
7.7 Four Scalar-Interaction



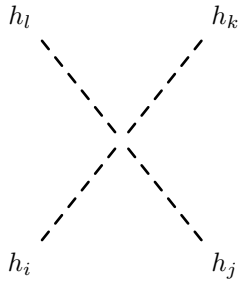
$$\begin{aligned}
&i\Big(Z_{i2}^A\Big(\lambda_3 Z_{j1}^A\Big(Z_{k1}^A Z_{l2}^A + Z_{k2}^A Z_{l1}^A\Big) + Z_{j2}^A\Big(6\lambda_2 Z_{k2}^A Z_{l2}^A + \lambda_3 Z_{k1}^A Z_{l1}^A\Big)\Big)\\
&+ Z_{i3}^A\Big(\lambda_5 Z_{j1}^A\Big(Z_{k1}^A Z_{l3}^A + Z_{k3}^A Z_{l1}^A\Big) + Z_{j3}^A\Big(6\lambda_4 Z_{k3}^A Z_{l3}^A + \lambda_5 Z_{k1}^A Z_{l1}^A\Big)\Big)\\
&+ Z_{i1}^A\Big(\lambda_3 Z_{j2}^A\Big(Z_{k1}^A Z_{l2}^A + Z_{k2}^A Z_{l1}^A\Big) + \lambda_5 Z_{j3}^A\Big(Z_{k1}^A Z_{l3}^A + Z_{k3}^A Z_{l1}^A\Big)\\
&+ Z_{j1}^A\Big(6l_h Z_{k1}^A Z_{l1}^A + \lambda_3 Z_{k2}^A Z_{l2}^A + \lambda_5 Z_{k3}^A Z_{l3}^A\Big)\Big)\Big)
\end{aligned} \tag{188}$$



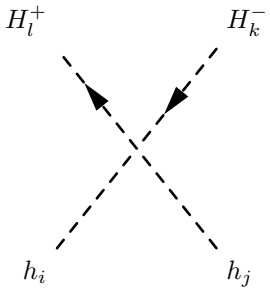
$$i\Big(Z^A_{i2}Z^A_{j2}\Big(2\lambda_2 Z^H_{k2}Z^H_{l2}+\lambda_3 Z^H_{k1}Z^H_{l1}\Big)+Z^A_{i3}Z^A_{j3}\Big(2\lambda_4 Z^H_{k3}Z^H_{l3}+\lambda_5 Z^H_{k1}Z^H_{l1}\Big)$$
$$+Z^A_{i1}Z^A_{j1}\Big(2l_h Z^H_{k1}Z^H_{l1}+\lambda_3 Z^H_{k2}Z^H_{l2}+\lambda_5 Z^H_{k3}Z^H_{l3}\Big)\Big) \tag{189}$$



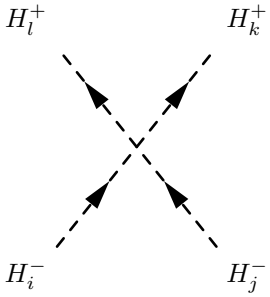
$$i\Big(-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{6,ab}Z^+_{l1+a}Z^+_{k1+b}Z^A_{i1}Z^A_{j1}-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{7,ab}Z^+_{l3+a}Z^+_{k3+b}Z^A_{i1}Z^A_{j1}$$
$$+\Big(2l_h Z^A_{i1}Z^A_{j1}+\lambda_3 Z^A_{i2}Z^A_{j2}+\lambda_5 Z^A_{i3}Z^A_{j3}\Big)Z^+_{k1}Z^+_{l1}\Big) \tag{190}$$



$$i\Big(Z^H_{i2}\Big(\lambda_3 Z^H_{j1}\Big(Z^H_{k1}Z^H_{l2}+Z^H_{k2}Z^H_{l1}\Big)+Z^H_{j2}\Big(6\lambda_2 Z^H_{k2}Z^H_{l2}+\lambda_3 Z^H_{k1}Z^H_{l1}\Big)\Big)$$
$$+Z^H_{i3}\Big(\lambda_5 Z^H_{j1}\Big(Z^H_{k1}Z^H_{l3}+Z^H_{k3}Z^H_{l1}\Big)+Z^H_{j3}\Big(6\lambda_4 Z^H_{k3}Z^H_{l3}+\lambda_5 Z^H_{k1}Z^H_{l1}\Big)\Big)$$
$$+Z^H_{i1}\Big(\lambda_3 Z^H_{j2}\Big(Z^H_{k1}Z^H_{l2}+Z^H_{k2}Z^H_{l1}\Big)+\lambda_5 Z^H_{j3}\Big(Z^H_{k1}Z^H_{l3}+Z^H_{k3}Z^H_{l1}\Big)$$
$$+Z^H_{j1}\Big(6l_h Z^H_{k1}Z^H_{l1}+\lambda_3 Z^H_{k2}Z^H_{l2}+\lambda_5 Z^H_{k3}Z^H_{l3}\Big)\Big)\Big) \tag{191}$$

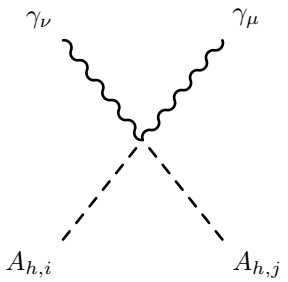


$$i\Big(-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{6,ab}Z^+_{l1+a}Z^+_{k1+b}Z^H_{i1}Z^H_{j1}-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{7,ab}Z^+_{l3+a}Z^+_{k3+b}Z^H_{i1}Z^H_{j1}$$
$$+\Big(2l_hZ^H_{i1}Z^H_{j1}+\lambda_3Z^H_{i2}Z^H_{j2}+\lambda_5Z^H_{i3}Z^H_{j3}\Big)Z^+_{k1}Z^+_{l1}\Big) \tag{192}$$

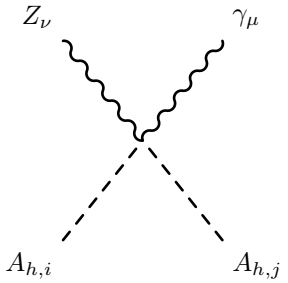


$$i\Big(-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{6,ab}Z^+_{l1+a}Z^+_{j1+b}Z^+_{i1}Z^+_{k1}-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{7,ab}Z^+_{l3+a}Z^+_{j3+b}Z^+_{i1}Z^+_{k1}$$
$$-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{6,ab}Z^+_{l1+a}Z^+_{i1+b}Z^+_{j1}Z^+_{k1}-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{7,ab}Z^+_{l3+a}Z^+_{i3+b}Z^+_{j1}Z^+_{k1}$$
$$-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{6,ab}Z^+_{k1+a}Z^+_{j1+b}Z^+_{i1}Z^+_{l1}-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{7,ab}Z^+_{k3+a}Z^+_{j3+b}Z^+_{i1}Z^+_{l1}$$
$$-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{6,ab}Z^+_{k1+a}Z^+_{i1+b}Z^+_{j1}Z^+_{l1}-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{7,ab}Z^+_{k3+a}Z^+_{i3+b}Z^+_{j1}Z^+_{l1}$$
$$+4l_hZ^+_{i1}Z^+_{j1}Z^+_{k1}Z^+_{l1}\Big) \tag{193}$$

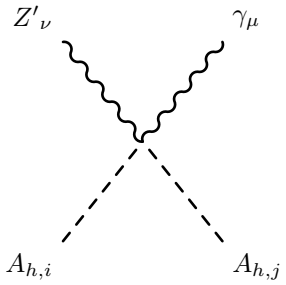
7.8 Two Scalar-Two Vector Boson-Interaction



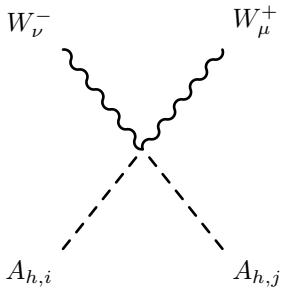
$$\Big(+ \frac{i}{2} g_1^2 \cos\Theta_W^2 Z_{i1}^A Z_{j1}^A - i g_1 g_2 \cos\Theta_W \sin\Theta_W Z_{i1}^A Z_{j1}^A + \frac{i}{2} g_2^2 \sin\Theta_W^2 Z_{i1}^A Z_{j1}^A + 50 i g_{YB}^2 \cos\Theta_W^2 Z_{i2}^A Z_{j2}^A + 50 i g_{YB}^2 \cos\Theta_W^2 Z_{i3}^A Z_{j3}^A \Big) \Big(g_{\mu\nu} \Big) \tag{194}$$



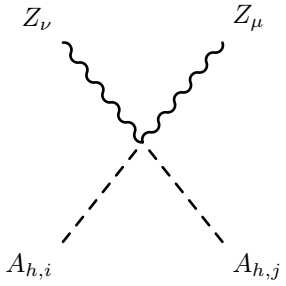
$$\begin{aligned}\Big(&- \frac{i}{2} g_1 g_2 \cos\Theta_W^2 \cos\Theta'_W Z_{i1}^A Z_{j1}^A - \frac{i}{2} g_1^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i1}^A Z_{j1}^A \\ &+ \frac{i}{2} g_2^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i1}^A Z_{j1}^A + \frac{i}{2} g_1 g_2 \cos\Theta'_W \sin\Theta_W^2 Z_{i1}^A Z_{j1}^A \\ &+ \frac{i}{2} g_1 g_{BY} \cos\Theta_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A - \frac{i}{2} g_{BY} g_2 \sin\Theta_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A \\ &- 50 i g_{YB}^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i2}^A Z_{j2}^A + 50 i g_B g_{YB} \cos\Theta_W \sin\Theta'_W Z_{i2}^A Z_{j2}^A \\ &- 50 i g_{YB}^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i3}^A Z_{j3}^A + 50 i g_B g_{YB} \cos\Theta_W \sin\Theta'_W Z_{i3}^A Z_{j3}^A \Big) \Big(g_{\mu\nu} \Big)\end{aligned} \tag{195}$$



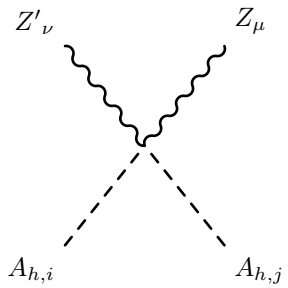
$$\Big(+ \frac{i}{2} g_1 g_{BY} \cos\Theta_W \cos\Theta'_W Z^A_{i1} Z^A_{j1} - \frac{i}{2} g_{BY} g_2 \cos\Theta'_W \sin\Theta_W Z^A_{i1} Z^A_{j1}$$
$$+ \frac{i}{2} g_1 g_2 \cos\Theta^2_W \sin\Theta'_W Z^A_{i1} Z^A_{j1} + \frac{i}{2} g_1^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z^A_{i1} Z^A_{j1}$$
$$- \frac{i}{2} g_2^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z^A_{i1} Z^A_{j1} - \frac{i}{2} g_1 g_2 \sin\Theta^2_W \sin\Theta'_W Z^A_{i1} Z^A_{j1}$$
$$+ 50 i g_B g_{YB} \cos\Theta_W \cos\Theta'_W Z^A_{i2} Z^A_{j2} + 50 i g^2_{YB} \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z^A_{i2} Z^A_{j2}$$
$$+ 50 i g_B g_{YB} \cos\Theta_W \cos\Theta'_W Z^A_{i3} Z^A_{j3} + 50 i g^2_{YB} \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z^A_{i3} Z^A_{j3} \Big) \Big(g_{\mu\nu} \Big) \tag{196}$$



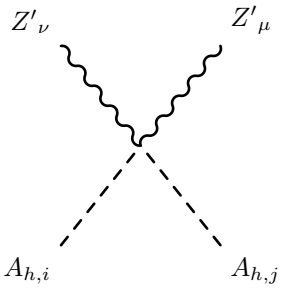
$$\frac{i}{2} g_2^2 Z^A_{i1} Z^A_{j1} \Big(g_{\mu\nu} \Big) \tag{197}$$



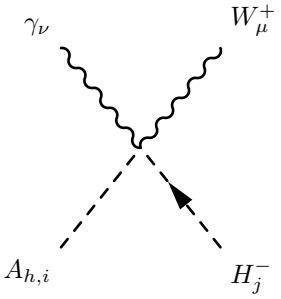
$$\Big(+ \frac{i}{2} g_2^2 \cos\Theta_W^2 \cos\Theta'^2_W Z_{i1}^A Z_{j1}^A + i g_1 g_2 \cos\Theta_W \cos\Theta'^2_W \sin\Theta_W Z_{i1}^A Z_{j1}^A$$
$$+ \frac{i}{2} g_1^2 \cos\Theta'^2_W \sin\Theta_W^2 Z_{i1}^A Z_{j1}^A - i g_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A$$
$$- i g_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A + \frac{i}{2} g_{BY}^2 \sin\Theta'^2_W Z_{i1}^A Z_{j1}^A$$
$$+ 50 i g_{YB}^2 \cos\Theta'^2_W \sin\Theta_W^2 Z_{i2}^A Z_{j2}^A - 100 i g_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i2}^A Z_{j2}^A$$
$$+ 50 i g_B^2 \sin\Theta'^2_W Z_{i2}^A Z_{j2}^A + 50 i g_{YB}^2 \cos\Theta'^2_W \sin\Theta_W^2 Z_{i3}^A Z_{j3}^A$$
$$- 100 i g_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i3}^A Z_{j3}^A + 50 i g_B^2 \sin\Theta'^2_W Z_{i3}^A Z_{j3}^A \Big) \Big(g_{\mu\nu} \Big) \tag{198}$$



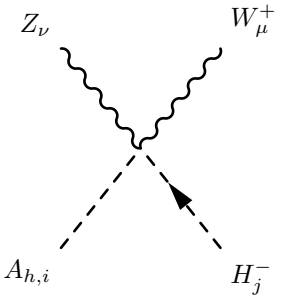
$$\Big(- \frac{i}{2} g_{BY} g_2 \cos\Theta_W \cos\Theta'^2_W Z_{i1}^A Z_{j1}^A - \frac{i}{2} g_1 g_{BY} \cos\Theta'^2_W \sin\Theta_W Z_{i1}^A Z_{j1}^A$$
$$+ \frac{i}{2} g_{BY}^2 \cos\Theta'_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A - \frac{i}{2} g_2^2 \cos\Theta_W^2 \cos\Theta'_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A$$
$$- i g_1 g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A$$
$$- \frac{i}{2} g_1^2 \cos\Theta'_W \sin\Theta_W^2 \sin\Theta'_W Z_{i1}^A Z_{j1}^A + \frac{i}{2} g_{BY} g_2 \cos\Theta_W \sin\Theta'^2_W Z_{i1}^A Z_{j1}^A$$
$$+ \frac{i}{2} g_1 g_{BY} \sin\Theta_W \sin\Theta'^2_W Z_{i1}^A Z_{j1}^A - 50 i g_B g_{YB} \cos\Theta'^2_W \sin\Theta_W Z_{i2}^A Z_{j2}^A$$
$$+ 50 i g_B g_{YB} \sin\Theta_W \sin\Theta'^2_W Z_{i2}^A Z_{j2}^A + 25 i g_B^2 \sin 2\Theta'_W Z_{i2}^A Z_{j2}^A$$
$$- \frac{25i}{2} g_{YB}^2 \sin 2\Theta'_W Z_{i2}^A Z_{j2}^A + \frac{25i}{2} g_{YB}^2 \cos 2\Theta_W \sin 2\Theta'_W Z_{i2}^A Z_{j2}^A$$
$$- 50 i g_B g_{YB} \cos\Theta'^2_W \sin\Theta_W Z_{i3}^A Z_{j3}^A + 50 i g_B g_{YB} \sin\Theta_W \sin\Theta'^2_W Z_{i3}^A Z_{j3}^A$$
$$+ 25 i g_B^2 \sin 2\Theta'_W Z_{i3}^A Z_{j3}^A - \frac{25i}{2} g_{YB}^2 \sin 2\Theta'_W Z_{i3}^A Z_{j3}^A$$
$$+ \frac{25i}{2} g_{YB}^2 \cos 2\Theta_W \sin 2\Theta'_W Z_{i3}^A Z_{j3}^A \Big) \Big(g_{\mu\nu} \Big) \tag{199}$$



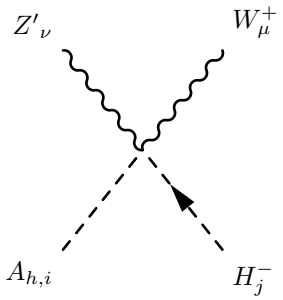
$$\Big(+ \frac{i}{2} g_{BY}^2 \cos\Theta'^2_W Z^A_{i1} Z^A_{j1} + i g_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z^A_{i1} Z^A_{j1}$$
$$+ i g_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^A_{i1} Z^A_{j1} + \frac{i}{2} g_2^2 \cos\Theta^2_W \sin\Theta'^2_W Z^A_{i1} Z^A_{j1}$$
$$+ i g_1 g_2 \cos\Theta_W \sin\Theta_W \sin\Theta'^2_W Z^A_{i1} Z^A_{j1} + \frac{i}{2} g_1^2 \sin\Theta^2_W \sin\Theta'^2_W Z^A_{i1} Z^A_{j1}$$
$$+ 50 i g_B^2 \cos\Theta'^2_W Z^A_{i2} Z^A_{j2} + 100 i g_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^A_{i2} Z^A_{j2}$$
$$+ 50 i g_{YB}^2 \sin\Theta^2_W \sin\Theta'^2_W Z^A_{i2} Z^A_{j2} + 50 i g_B^2 \cos\Theta'^2_W Z^A_{i3} Z^A_{j3}$$
$$+ 100 i g_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^A_{i3} Z^A_{j3} + 50 i g_{YB}^2 \sin\Theta^2_W \sin\Theta'^2_W Z^A_{i3} Z^A_{j3} \Big) \Big(g_{\mu\nu} \Big) \tag{200}$$



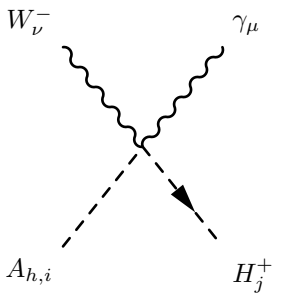
$$- \frac{1}{2} g_1 g_2 \cos\Theta_W Z^A_{i1} Z^+_{j1} \Big(g_{\mu\nu} \Big) \tag{201}$$



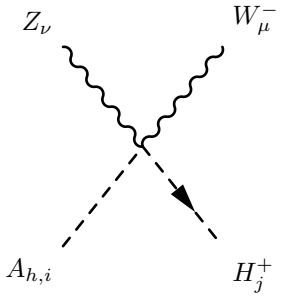
$$\Big(\frac{1}{2}g_1 g_2 \cos\Theta'_W \sin\Theta_W Z^A_{i1} Z^+_{j1} - \frac{1}{2} g_{BY} g_2 \sin\Theta'_W Z^A_{i1} Z^+_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{202}$$



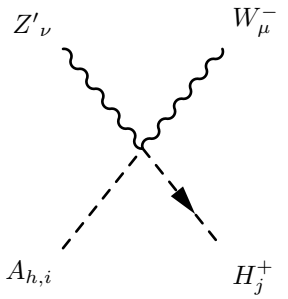
$$\Big(-\frac{1}{2}g_1 g_2 \sin\Theta_W \sin\Theta'_W Z^A_{i1} Z^+_{j1} - \frac{1}{2} g_{BY} g_2 \cos\Theta'_W Z^A_{i1} Z^+_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{203}$$



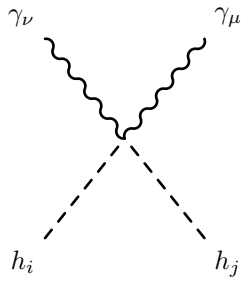
$$\frac{1}{2}g_1 g_2 \cos\Theta_W Z^A_{i1} Z^+_{j1}\Big(g_{\mu\nu}\Big) \tag{204}$$



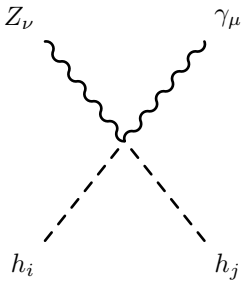
$$\Big(-\frac{1}{2}g_1 g_2 \cos\Theta'_W \sin\Theta_W Z^A_{i1} Z^+_{j1} + \frac{1}{2} g_{BY} g_2 \sin\Theta'_W Z^A_{i1} Z^+_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{205}$$



$$\Big(\frac{1}{2}g_1 g_2 \sin\Theta_W \sin\Theta'_W Z^A_{i1} Z^+_{j1} + \frac{1}{2}g_{BY} g_2 \cos\Theta'_W Z^A_{i1} Z^+_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{206}$$

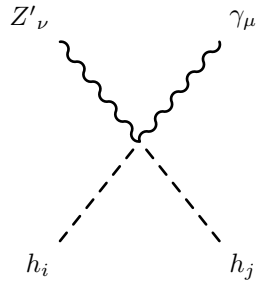


$$\begin{aligned}&\Big(+\frac{i}{2}g_1^2 \cos\Theta_W^2 Z^H_{i1} Z^H_{j1} - i g_1 g_2 \cos\Theta_W \sin\Theta_W Z^H_{i1} Z^H_{j1} \\ &+ \frac{i}{2}g_2^2 \sin\Theta_W^2 Z^H_{i1} Z^H_{j1} + 50 i g_{YB}^2 \cos\Theta_W^2 Z^H_{i2} Z^H_{j2} + 50 i g_{YB}^2 \cos\Theta_W^2 Z^H_{i3} Z^H_{j3}\Big)\Big(g_{\mu\nu}\Big)\end{aligned} \tag{207}$$

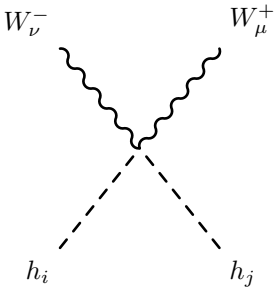


$$\begin{aligned}&\Big(-\frac{i}{2}g_1 g_2 \cos\Theta_W^2 \cos\Theta'_W Z^H_{i1} Z^H_{j1} - \frac{i}{2}g_1^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z^H_{i1} Z^H_{j1} \\ &+ \frac{i}{2}g_2^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z^H_{i1} Z^H_{j1} + \frac{i}{2}g_1 g_2 \cos\Theta'_W \sin\Theta_W^2 Z^H_{i1} Z^H_{j1}\end{aligned}$$

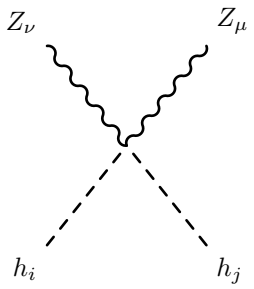
$$
\begin{aligned}
&+ \frac{i}{2} g_1 g_{BY} \cos\Theta_W \sin\Theta'_W Z^H_{i1} Z^H_{j1} - \frac{i}{2} g_{BY} g_2 \sin\Theta_W \sin\Theta'_W Z^H_{i1} Z^H_{j1} \\
&- 50 i g^2_{YB} \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z^H_{i2} Z^H_{j2} + 50 i g_B g_{YB} \cos\Theta_W \sin\Theta'_W Z^H_{i2} Z^H_{j2} \\
&- 50 i g^2_{YB} \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z^H_{i3} Z^H_{j3} + 50 i g_B g_{YB} \cos\Theta_W \sin\Theta'_W Z^H_{i3} Z^H_{j3} \Big) \Big(g_{\mu\nu} \Big)
\end{aligned} \tag{208}
$$



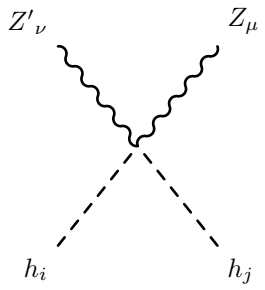
$$
\begin{aligned}
&\Big(+ \frac{i}{2} g_1 g_{BY} \cos\Theta_W \cos\Theta'_W Z^H_{i1} Z^H_{j1} - \frac{i}{2} g_{BY} g_2 \cos\Theta'_W \sin\Theta_W Z^H_{i1} Z^H_{j1} \\
&+ \frac{i}{2} g_1 g_2 \cos\Theta^2_W \sin\Theta'_W Z^H_{i1} Z^H_{j1} + \frac{i}{2} g^2_1 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z^H_{i1} Z^H_{j1} \\
&- \frac{i}{2} g^2_2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z^H_{i1} Z^H_{j1} - \frac{i}{2} g_1 g_2 \sin\Theta^2_W \sin\Theta'_W Z^H_{i1} Z^H_{j1} \\
&+ 50 i g_B g_{YB} \cos\Theta_W \cos\Theta'_W Z^H_{i2} Z^H_{j2} + 50 i g^2_{YB} \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z^H_{i2} Z^H_{j2} \\
&+ 50 i g_B g_{YB} \cos\Theta_W \cos\Theta'_W Z^H_{i3} Z^H_{j3} + 50 i g^2_{YB} \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z^H_{i3} Z^H_{j3} \Big) \Big(g_{\mu\nu} \Big)
\end{aligned} \tag{209}
$$



$$
\frac{i}{2} g^2_2 Z^H_{i1} Z^H_{j1} \Big(g_{\mu\nu} \Big) \tag{210}
$$

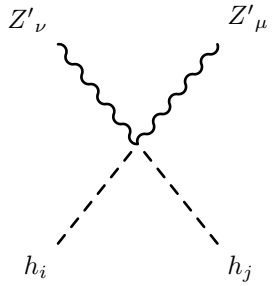


$$\Big(+ \frac{i}{2} g_2^2 \cos\Theta_W^2 \cos\Theta'^2_W Z_{i1}^H Z_{j1}^H + i g_1 g_2 \cos\Theta_W \cos\Theta'^2_W \sin\Theta_W Z_{i1}^H Z_{j1}^H$$
$$+ \frac{i}{2} g_1^2 \cos\Theta'^2_W \sin\Theta_W^2 Z_{i1}^H Z_{j1}^H - i g_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H$$
$$- i g_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H + \frac{i}{2} g_{BY}^2 \sin\Theta'^2_W Z_{i1}^H Z_{j1}^H$$
$$+ 50 i g_{YB}^2 \cos\Theta'^2_W \sin\Theta_W^2 Z_{i2}^H Z_{j2}^H - 100 i g_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i2}^H Z_{j2}^H$$
$$+ 50 i g_B^2 \sin\Theta'^2_W Z_{i2}^H Z_{j2}^H + 50 i g_{YB}^2 \cos\Theta'^2_W \sin\Theta_W^2 Z_{i3}^H Z_{j3}^H$$
$$- 100 i g_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i3}^H Z_{j3}^H + 50 i g_B^2 \sin\Theta'^2_W Z_{i3}^H Z_{j3}^H \Big) \Big(g_{\mu\nu} \Big) \tag{211}$$

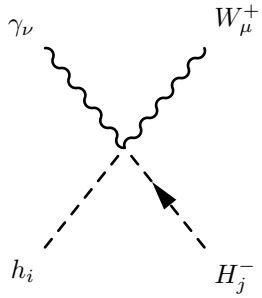


$$\Big(- \frac{i}{2} g_{BY} g_2 \cos\Theta_W \cos\Theta'^2_W Z_{i1}^H Z_{j1}^H - \frac{i}{2} g_1 g_{BY} \cos\Theta'^2_W \sin\Theta_W Z_{i1}^H Z_{j1}^H$$
$$+ \frac{i}{2} g_{BY}^2 \cos\Theta'_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H - \frac{i}{2} g_2^2 \cos\Theta_W^2 \cos\Theta'_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H$$
$$- i g_1 g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H$$
$$- \frac{i}{2} g_1^2 \cos\Theta'_W \sin\Theta_W^2 \sin\Theta'_W Z_{i1}^H Z_{j1}^H + \frac{i}{2} g_{BY} g_2 \cos\Theta_W \sin\Theta'^2_W Z_{i1}^H Z_{j1}^H$$
$$+ \frac{i}{2} g_1 g_{BY} \sin\Theta_W \sin\Theta'^2_W Z_{i1}^H Z_{j1}^H - 50 i g_B g_{YB} \cos\Theta'^2_W \sin\Theta_W Z_{i2}^H Z_{j2}^H$$
$$+ 50 i g_B g_{YB} \sin\Theta_W \sin\Theta'^2_W Z_{i2}^H Z_{j2}^H + 25 i g_B^2 \sin 2\Theta'_W Z_{i2}^H Z_{j2}^H$$

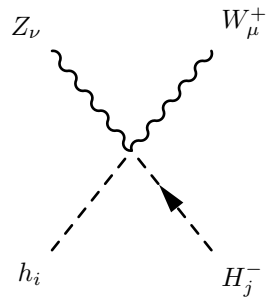
$$
\begin{aligned}
&- \frac{25i}{2} g_{YB}^2 \sin 2\Theta'_W Z_{i2}^H Z_{j2}^H + \frac{25i}{2} g_{YB}^2 \cos 2\Theta_W \sin 2\Theta'_W Z_{i2}^H Z_{j2}^H \\
&- 50i g_B g_{YB} \cos \Theta'^2_W \sin \Theta_W Z_{i3}^H Z_{j3}^H + 50i g_B g_{YB} \sin \Theta_W \sin \Theta'^2_W Z_{i3}^H Z_{j3}^H \\
&+ 25i g_B^2 \sin 2\Theta'_W Z_{i3}^H Z_{j3}^H - \frac{25i}{2} g_{YB}^2 \sin 2\Theta'_W Z_{i3}^H Z_{j3}^H \\
&+ \frac{25i}{2} g_{YB}^2 \cos 2\Theta_W \sin 2\Theta'_W Z_{i3}^H Z_{j3}^H \Big) \Big(g_{\mu\nu} \Big)
\end{aligned} \tag{212}
$$



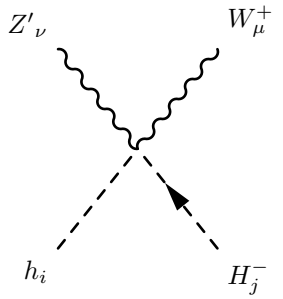
$$
\begin{aligned}
&\Big(+ \frac{i}{2} g_{BY}^2 \cos \Theta'^2_W Z_{i1}^H Z_{j1}^H + i g_{BY} g_2 \cos \Theta_W \cos \Theta'_W \sin \Theta'_W Z_{i1}^H Z_{j1}^H \\
&+ i g_1 g_{BY} \cos \Theta'_W \sin \Theta_W \sin \Theta'_W Z_{i1}^H Z_{j1}^H + \frac{i}{2} g_2^2 \cos \Theta_W^2 \sin \Theta'^2_W Z_{i1}^H Z_{j1}^H \\
&+ i g_1 g_2 \cos \Theta_W \sin \Theta_W \sin \Theta'^2_W Z_{i1}^H Z_{j1}^H + \frac{i}{2} g_1^2 \sin \Theta_W^2 \sin \Theta'^2_W Z_{i1}^H Z_{j1}^H \\
&+ 50i g_B^2 \cos \Theta'^2_W Z_{i2}^H Z_{j2}^H + 100i g_B g_{YB} \cos \Theta'_W \sin \Theta_W \sin \Theta'_W Z_{i2}^H Z_{j2}^H \\
&+ 50i g_{YB}^2 \sin \Theta_W^2 \sin \Theta'^2_W Z_{i2}^H Z_{j2}^H + 50i g_B^2 \cos \Theta'^2_W Z_{i3}^H Z_{j3}^H \\
&+ 100i g_B g_{YB} \cos \Theta'_W \sin \Theta_W \sin \Theta'_W Z_{i3}^H Z_{j3}^H + 50i g_{YB}^2 \sin \Theta_W^2 \sin \Theta'^2_W Z_{i3}^H Z_{j3}^H \Big) \Big(g_{\mu\nu} \Big)
\end{aligned} \tag{213}
$$



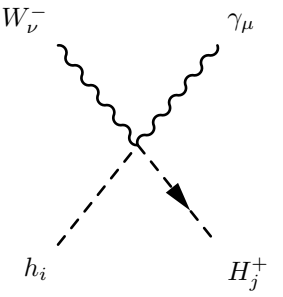
$$
\frac{i}{2} g_1 g_2 \cos \Theta_W Z_{i1}^H Z_{j1}^+ \Big(g_{\mu\nu} \Big) \tag{214}
$$



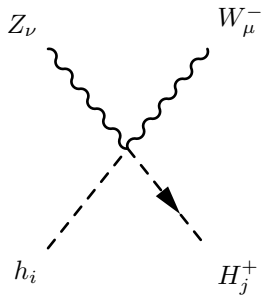
$$\Big(-\frac{i}{2} g_1 g_2 \cos\Theta'_W \sin\Theta_W Z^H_{i1} Z^+_{j1} + \frac{i}{2} g_{BY} g_2 \sin\Theta'_W Z^H_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big) \tag{215}$$



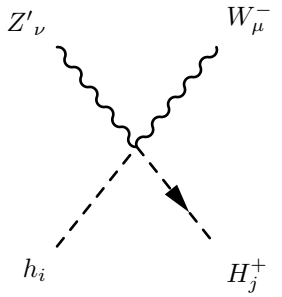
$$\Big(\frac{i}{2} g_1 g_2 \sin\Theta_W \sin\Theta'_W Z^H_{i1} Z^+_{j1} + \frac{i}{2} g_{BY} g_2 \cos\Theta'_W Z^H_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big) \tag{216}$$



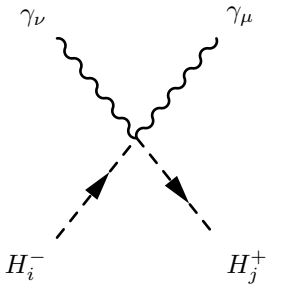
$$\frac{i}{2} g_1 g_2 \cos\Theta_W Z^H_{i1} Z^+_{j1} \Big(g_{\mu\nu} \Big) \tag{217}$$



$$\Big(-\frac{i}{2} g_1 g_2 \cos\Theta'_W \sin\Theta_W Z^H_{i1} Z^+_{j1} + \frac{i}{2} g_{BY} g_2 \sin\Theta'_W Z^H_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big) \tag{218}$$

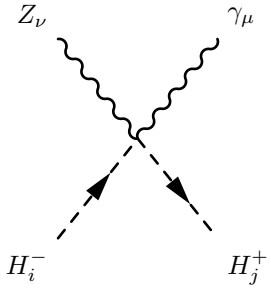


$$\Big(\frac{i}{2} g_1 g_2 \sin\Theta_W \sin\Theta'_W Z^H_{i1} Z^+_{j1} + \frac{i}{2} g_{BY} g_2 \cos\Theta'_W Z^H_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big) \tag{219}$$



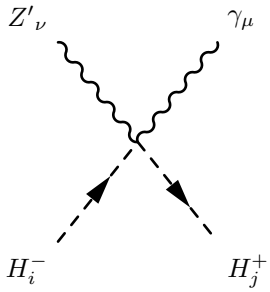
$$\Big(+ 2ig_1^2 \cos\Theta_W^2 \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} + 4ig_1 g_{YB} \cos\Theta_W^2 \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a}$$
$$+ 2ig_{YB}^2 \cos\Theta_W^2 \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} + 2ig_1^2 \cos\Theta_W^2 \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a}$$

$$- 16ig_1 g_{YB} \cos\Theta_W^2 \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+} + 32ig_{YB}^2 \cos\Theta_W^2 \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+}$$
$$+ \frac{i}{2} g_1^2 \cos\Theta_W^2 Z_{i1}^{+} Z_{j1}^{+} + ig_1 g_2 \cos\Theta_W \sin\Theta_W Z_{i1}^{+} Z_{j1}^{+} + \frac{i}{2} g_2^2 \sin\Theta_W^2 Z_{i1}^{+} Z_{j1}^{+} \Big) \Big(g_{\mu\nu} \Big) \tag{220}$$



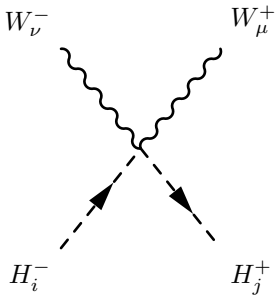
$$\Big(- 2ig_1^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W \sum_{a=1}^{2} Z_{i1+a}^{+} Z_{j1+a}^{+}$$
$$- 4ig_1 g_{YB} \cos\Theta_W \cos\Theta'_W \sin\Theta_W \sum_{a=1}^{2} Z_{i1+a}^{+} Z_{j1+a}^{+}$$
$$- 2ig_{YB}^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W \sum_{a=1}^{2} Z_{i1+a}^{+} Z_{j1+a}^{+}$$
$$+ 2ig_1 g_{BY} \cos\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z_{i1+a}^{+} Z_{j1+a}^{+} + 2ig_1 g_B \cos\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z_{i1+a}^{+} Z_{j1+a}^{+}$$
$$+ 2ig_{BY} g_{YB} \cos\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z_{i1+a}^{+} Z_{j1+a}^{+} + 2ig_B g_{YB} \cos\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z_{i1+a}^{+} Z_{j1+a}^{+}$$
$$- 2ig_1^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+}$$
$$+ 16ig_1 g_{YB} \cos\Theta_W \cos\Theta'_W \sin\Theta_W \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+}$$
$$- 32ig_{YB}^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+}$$
$$+ 2ig_1 g_{BY} \cos\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+} - 8ig_1 g_B \cos\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+}$$
$$- 8ig_{BY} g_{YB} \cos\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+} + 32ig_B g_{YB} \cos\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+}$$

$$+\frac{i}{2}g_1g_2\cos\Theta_W^2\cos\Theta'_W Z_{i1}^+Z_{j1}^+ - \frac{i}{2}g_1^2\cos\Theta_W\cos\Theta'_W\sin\Theta_W Z_{i1}^+Z_{j1}^+$$
$$+\frac{i}{2}g_2^2\cos\Theta_W\cos\Theta'_W\sin\Theta_W Z_{i1}^+Z_{j1}^+ - \frac{i}{2}g_1g_2\cos\Theta'_W\sin\Theta_W^2 Z_{i1}^+Z_{j1}^+$$
$$+\frac{i}{2}g_1g_{BY}\cos\Theta_W\sin\Theta'_W Z_{i1}^+Z_{j1}^+ + \frac{i}{2}g_{BY}g_2\sin\Theta_W\sin\Theta'_W Z_{i1}^+Z_{j1}^+\Big)\Big(g_{\mu\nu}\Big) \tag{221}$$

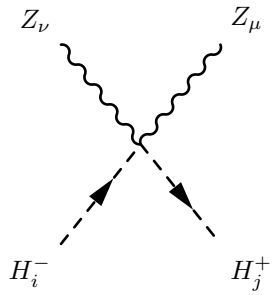


$$\Big(+2ig_1g_{BY}\cos\Theta_W\cos\Theta'_W\sum_{a=1}^{2}Z_{i1+a}^+Z_{j1+a}^+ + 2ig_1g_B\cos\Theta_W\cos\Theta'_W\sum_{a=1}^{2}Z_{i1+a}^+Z_{j1+a}^+$$
$$+2ig_{BY}g_{YB}\cos\Theta_W\cos\Theta'_W\sum_{a=1}^{2}Z_{i1+a}^+Z_{j1+a}^+ + 2ig_Bg_{YB}\cos\Theta_W\cos\Theta'_W\sum_{a=1}^{2}Z_{i1+a}^+Z_{j1+a}^+$$
$$+2ig_1^2\cos\Theta_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z_{i1+a}^+Z_{j1+a}^+$$
$$+4ig_1g_{YB}\cos\Theta_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z_{i1+a}^+Z_{j1+a}^+$$
$$+2ig_{YB}^2\cos\Theta_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z_{i1+a}^+Z_{j1+a}^+$$
$$+2ig_1g_{BY}\cos\Theta_W\cos\Theta'_W\sum_{a=1}^{2}Z_{i3+a}^+Z_{j3+a}^+ - 8ig_1g_B\cos\Theta_W\cos\Theta'_W\sum_{a=1}^{2}Z_{i3+a}^+Z_{j3+a}^+$$
$$-8ig_{BY}g_{YB}\cos\Theta_W\cos\Theta'_W\sum_{a=1}^{2}Z_{i3+a}^+Z_{j3+a}^+ + 32ig_Bg_{YB}\cos\Theta_W\cos\Theta'_W\sum_{a=1}^{2}Z_{i3+a}^+Z_{j3+a}^+$$
$$+2ig_1^2\cos\Theta_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z_{i3+a}^+Z_{j3+a}^+$$
$$-16ig_1g_{YB}\cos\Theta_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z_{i3+a}^+Z_{j3+a}^+$$
$$+32ig_{YB}^2\cos\Theta_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z_{i3+a}^+Z_{j3+a}^+ + \frac{i}{2}g_1g_{BY}\cos\Theta_W\cos\Theta'_W Z_{i1}^+Z_{j1}^+$$

$$+\frac{i}{2}g_{BY}g_2\cos\Theta'_W\sin\Theta_W Z^+_{i1}Z^+_{j1}-\frac{i}{2}g_1g_2\cos\Theta^2_W\sin\Theta'_W Z^+_{i1}Z^+_{j1}$$
$$+\frac{i}{2}g_1^2\cos\Theta_W\sin\Theta_W\sin\Theta'_W Z^+_{i1}Z^+_{j1}-\frac{i}{2}g_2^2\cos\Theta_W\sin\Theta_W\sin\Theta'_W Z^+_{i1}Z^+_{j1}$$
$$+\frac{i}{2}g_1g_2\sin\Theta^2_W\sin\Theta'_W Z^+_{i1}Z^+_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{222}$$

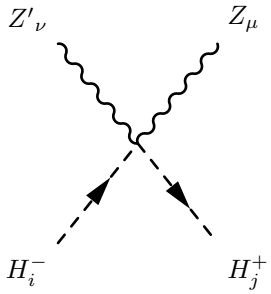


$$\frac{i}{2}g_2^2Z^+_{i1}Z^+_{j1}\Big(g_{\mu\nu}\Big) \tag{223}$$



$$\Big(+2ig_1^2\cos\Theta'^2_W\sin\Theta^2_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}+4ig_1g_{YB}\cos\Theta'^2_W\sin\Theta^2_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$+2ig_{YB}^2\cos\Theta'^2_W\sin\Theta^2_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$-4ig_1g_{BY}\cos\Theta'_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$-4ig_1g_B\cos\Theta'_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$-4ig_{BY}g_{YB}\cos\Theta'_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$

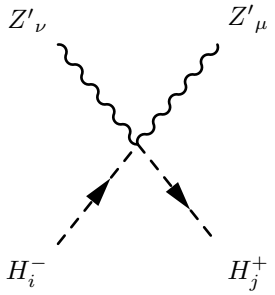
$$
\begin{aligned}
&- 4ig_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} + 2ig^2_{BY} \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} \\
&+ 4ig_{BY} g_B \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} + 2ig^2_B \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} \\
&+ 2ig^2_1 \cos\Theta'^2_W \sin\Theta^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} - 16ig_1 g_{YB} \cos\Theta'^2_W \sin\Theta^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&+ 32ig^2_{YB} \cos\Theta'^2_W \sin\Theta^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&- 4ig_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&+ 16ig_1 g_B \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&+ 16ig_{BY} g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&- 64ig_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} + 2ig^2_{BY} \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&- 16ig_{BY} g_B \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} + 32ig^2_B \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&+ \frac{i}{2} g^2_2 \cos\Theta^2_W \cos\Theta'^2_W Z^+_{i1} Z^+_{j1} - ig_1 g_2 \cos\Theta_W \cos\Theta'^2_W \sin\Theta_W Z^+_{i1} Z^+_{j1} \\
&+ \frac{i}{2} g^2_1 \cos\Theta'^2_W \sin\Theta^2_W Z^+_{i1} Z^+_{j1} + ig_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z^+_{i1} Z^+_{j1} \\
&- ig_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^+_{i1} Z^+_{j1} + \frac{i}{2} g^2_{BY} \sin\Theta'^2_W Z^+_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big)
\end{aligned}
\tag{224}
$$



$$
\Big(- 2ig_1 g_{BY} \cos\Theta'^2_W \sin\Theta_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} - 2ig_1 g_B \cos\Theta'^2_W \sin\Theta_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a}
$$

$$
\begin{aligned}
&- 2ig_{BY}g_{YB}\cos{\Theta'}^2_W \sin\Theta_W \sum_{a=1}^{2} Z^+_{i1+a}Z^+_{j1+a} - 2ig_Bg_{YB}\cos{\Theta'}^2_W \sin\Theta_W \sum_{a=1}^{2} Z^+_{i1+a}Z^+_{j1+a} \\
&+ 2ig^2_{BY}\cos\Theta'_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a}Z^+_{j1+a} + 4ig_{BY}g_B\cos\Theta'_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a}Z^+_{j1+a} \\
&+ 2ig^2_B\cos\Theta'_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a}Z^+_{j1+a} \\
&- 2ig^2_1\cos\Theta'_W \sin\Theta^2_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a}Z^+_{j1+a} \\
&- 2ig^2_{YB}\cos\Theta'_W \sin\Theta^2_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a}Z^+_{j1+a} \\
&+ 2ig_1g_{BY}\sin\Theta_W \sin{\Theta'}^2_W \sum_{a=1}^{2} Z^+_{i1+a}Z^+_{j1+a} + 2ig_1g_B\sin\Theta_W \sin{\Theta'}^2_W \sum_{a=1}^{2} Z^+_{i1+a}Z^+_{j1+a} \\
&+ 2ig_{BY}g_{YB}\sin\Theta_W \sin{\Theta'}^2_W \sum_{a=1}^{2} Z^+_{i1+a}Z^+_{j1+a} + 2ig_Bg_{YB}\sin\Theta_W \sin{\Theta'}^2_W \sum_{a=1}^{2} Z^+_{i1+a}Z^+_{j1+a} \\
&- 2ig_1g_{YB}\sin\Theta^2_W \sin 2\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a}Z^+_{j1+a} - 2ig_1g_{BY}\cos{\Theta'}^2_W \sin\Theta_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a} \\
&+ 8ig_1g_B\cos{\Theta'}^2_W \sin\Theta_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a} + 8ig_{BY}g_{YB}\cos{\Theta'}^2_W \sin\Theta_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a} \\
&- 32ig_Bg_{YB}\cos{\Theta'}^2_W \sin\Theta_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a} + 2ig^2_{BY}\cos\Theta'_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a} \\
&- 16ig_{BY}g_B\cos\Theta'_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a} \\
&- 2ig^2_1\cos\Theta'_W \sin\Theta^2_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a} \\
&+ 16ig_1g_{YB}\cos\Theta'_W \sin\Theta^2_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a} \\
&+ 2ig_1g_{BY}\sin\Theta_W \sin{\Theta'}^2_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a} - 8ig_1g_B\sin\Theta_W \sin{\Theta'}^2_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a} \\
&- 8ig_{BY}g_{YB}\sin\Theta_W \sin{\Theta'}^2_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a} + 32ig_Bg_{YB}\sin\Theta_W \sin{\Theta'}^2_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a} \\
&+ 16ig^2_B\sin 2\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a} - 16ig^2_{YB}\sin\Theta^2_W \sin 2\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a}
\end{aligned}
$$

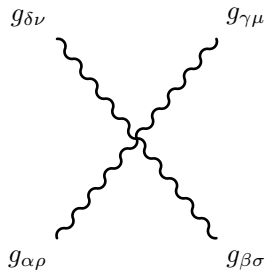
$$+\frac{i}{2}g_{BY}g_2\cos\Theta_W\cos{\Theta'}^2_W Z^+_{i1}Z^+_{j1}-\frac{i}{2}g_1g_{BY}\cos{\Theta'}^2_W\sin\Theta_W Z^+_{i1}Z^+_{j1}$$
$$+\frac{i}{2}g^2_{BY}\cos\Theta'_W\sin\Theta'_W Z^+_{i1}Z^+_{j1}-\frac{i}{2}g_2^2\cos\Theta_W^2\cos\Theta'_W\sin\Theta'_W Z^+_{i1}Z^+_{j1}$$
$$-\frac{i}{2}g_1^2\cos\Theta'_W\sin\Theta_W^2\sin\Theta'_W Z^+_{i1}Z^+_{j1}-\frac{i}{2}g_{BY}g_2\cos\Theta_W\sin{\Theta'}^2_W Z^+_{i1}Z^+_{j1}$$
$$+\frac{i}{2}g_1g_{BY}\sin\Theta_W\sin{\Theta'}^2_W Z^+_{i1}Z^+_{j1}+\frac{i}{2}g_1g_2\cos\Theta_W\sin\Theta_W\sin 2\Theta'_W Z^+_{i1}Z^+_{j1}\Big)\Big(g_{\mu\nu}\Big) \quad (225)$$



$$\Big(+2ig^2_{BY}\cos{\Theta'}^2_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}+4ig_{BY}g_B\cos{\Theta'}^2_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$+2ig^2_B\cos{\Theta'}^2_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}+4ig_1g_{BY}\cos\Theta'_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$+4ig_1g_B\cos\Theta'_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$+4ig_{BY}g_{YB}\cos\Theta'_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$+4ig_Bg_{YB}\cos\Theta'_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$+2ig_1^2\sin\Theta_W^2\sin{\Theta'}^2_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}+4ig_1g_{YB}\sin\Theta_W^2\sin{\Theta'}^2_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$+2ig^2_{YB}\sin\Theta_W^2\sin{\Theta'}^2_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}+2ig^2_{BY}\cos{\Theta'}^2_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}$$
$$-16ig_{BY}g_B\cos{\Theta'}^2_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}+32ig^2_B\cos{\Theta'}^2_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}$$
$$+4ig_1g_{BY}\cos\Theta'_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}$$

$$
\begin{aligned}
&- 16ig_1 g_B \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&- 16ig_{BY} g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&+ 64ig_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&+ 2ig_1^2 \sin\Theta_W^2 \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} - 16ig_1 g_{YB} \sin\Theta_W^2 \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&+ 32ig_{YB}^2 \sin\Theta_W^2 \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} + \frac{i}{2} g_{BY}^2 \cos\Theta'^2_W Z^+_{i1} Z^+_{j1} \\
&- ig_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z^+_{i1} Z^+_{j1} \\
&+ ig_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^+_{i1} Z^+_{j1} + \frac{i}{2} g_2^2 \cos\Theta_W^2 \sin\Theta'^2_W Z^+_{i1} Z^+_{j1} \\
&- ig_1 g_2 \cos\Theta_W \sin\Theta_W \sin\Theta'^2_W Z^+_{i1} Z^+_{j1} + \frac{i}{2} g_1^2 \sin\Theta_W^2 \sin\Theta'^2_W Z^+_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big)
\end{aligned} \tag{226}
$$

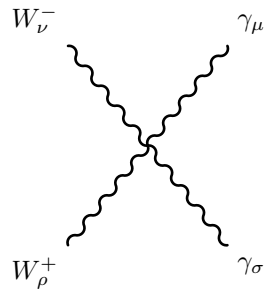
7.9 Four Vector Boson-Interaction



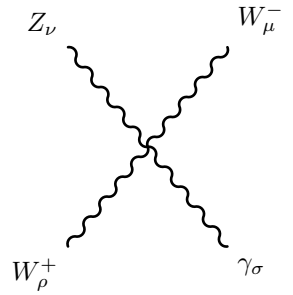
$$
ig_3^2 \Big(- \sum_{a=1}^{8} f_{\alpha,\delta,a} f_{\beta,\gamma,a} - \sum_{a=1}^{8} f_{\alpha,\gamma,a} f_{\beta,\delta,a} \Big) \Big(g_{\rho\sigma} g_{\mu\nu} \Big) \tag{227}
$$

$$
+ \; ig_3^2 \Big(- \sum_{a=1}^{8} f_{\alpha,\beta,a} f_{\gamma,\delta,a} + \sum_{a=1}^{8} f_{\alpha,\delta,a} f_{\beta,\gamma,a} \Big) \Big(g_{\rho\mu} g_{\sigma\nu} \Big) \tag{228}
$$

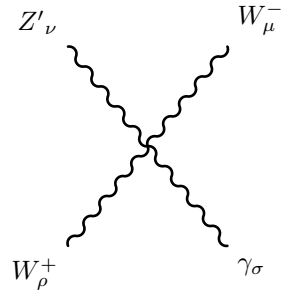
$$
+ \; ig_3^2 \Big(\sum_{a=1}^{8} f_{\alpha,\gamma,a} f_{\beta,\delta,a} + \sum_{a=1}^{8} f_{\alpha,\beta,a} f_{\gamma,\delta,a} \Big) \Big(g_{\rho\nu} g_{\sigma\mu} \Big) \tag{229}
$$



$$ig_2^2 \sin\Theta_W^2 \left(g_{\rho\sigma} g_{\mu\nu}\right) \tag{230}$$
$$+\ ig_2^2 \sin\Theta_W^2 \left(g_{\rho\mu} g_{\sigma\nu}\right) \tag{231}$$
$$+\ -2ig_2^2 \sin\Theta_W^2 \left(g_{\rho\nu} g_{\sigma\mu}\right) \tag{232}$$



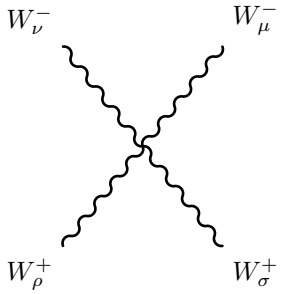
$$\frac{i}{2} g_2^2 \cos\Theta'_W \sin 2\Theta_W \left(g_{\rho\sigma} g_{\mu\nu}\right) \tag{233}$$
$$+\ -ig_2^2 \cos\Theta'_W \sin 2\Theta_W \left(g_{\rho\mu} g_{\sigma\nu}\right) \tag{234}$$
$$+\ \frac{i}{2} g_2^2 \cos\Theta'_W \sin 2\Theta_W \left(g_{\rho\nu} g_{\sigma\mu}\right) \tag{235}$$



$$- \frac{i}{2} g_2^2 \sin 2\Theta_W \sin {\Theta'}_W \Big(g_{\rho\sigma} g_{\mu\nu} \Big) \tag{236}$$

$$+ \; i g_2^2 \sin 2\Theta_W \sin {\Theta'}_W \Big(g_{\rho\mu} g_{\sigma\nu} \Big) \tag{237}$$

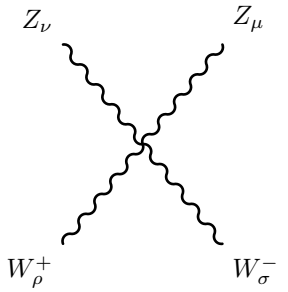
$$+ \; - \frac{i}{2} g_2^2 \sin 2\Theta_W \sin {\Theta'}_W \Big(g_{\rho\nu} g_{\sigma\mu} \Big) \tag{238}$$



$$2 i g_2^2 \Big(g_{\rho\sigma} g_{\mu\nu} \Big) \tag{239}$$

$$+ \; - i g_2^2 \Big(g_{\rho\mu} g_{\sigma\nu} \Big) \tag{240}$$

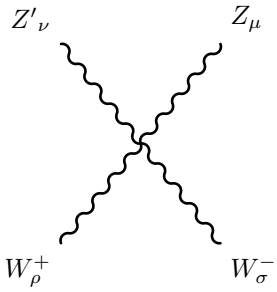
$$+ \; - i g_2^2 \Big(g_{\rho\nu} g_{\sigma\mu} \Big) \tag{241}$$



$$- 2 i g_2^2 \cos \Theta_W^2 \cos {\Theta'}_W^2 \Big(g_{\rho\sigma} g_{\mu\nu} \Big) \tag{242}$$

$$+ \; i g_2^2 \cos \Theta_W^2 \cos {\Theta'}_W^2 \Big(g_{\rho\mu} g_{\sigma\nu} \Big) \tag{243}$$

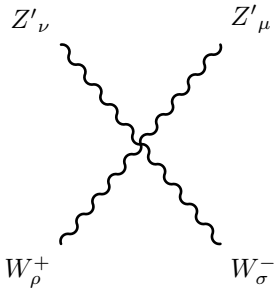
$$+ \; i g_2^2 \cos \Theta_W^2 \cos {\Theta'}_W^2 \Big(g_{\rho\nu} g_{\sigma\mu} \Big) \tag{244}$$



$$ig_2^2 \cos\Theta_W^2 \sin 2\Theta'_W \left(g_{\rho\sigma} g_{\mu\nu}\right) \tag{245}$$

$$+\ -\frac{i}{2} g_2^2 \cos\Theta_W^2 \sin 2\Theta'_W \left(g_{\rho\mu} g_{\sigma\nu}\right) \tag{246}$$

$$+\ -\frac{i}{2} g_2^2 \cos\Theta_W^2 \sin 2\Theta'_W \left(g_{\rho\nu} g_{\sigma\mu}\right) \tag{247}$$

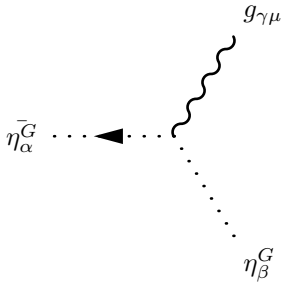


$$-\ 2ig_2^2 \cos\Theta_W^2 \sin \Theta'^2_W \left(g_{\rho\sigma} g_{\mu\nu}\right) \tag{248}$$

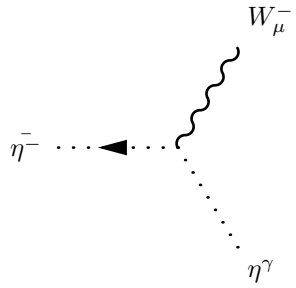
$$+\ ig_2^2 \cos\Theta_W^2 \sin \Theta'^2_W \left(g_{\rho\mu} g_{\sigma\nu}\right) \tag{249}$$

$$+\ ig_2^2 \cos\Theta_W^2 \sin \Theta'^2_W \left(g_{\rho\nu} g_{\sigma\mu}\right) \tag{250}$$

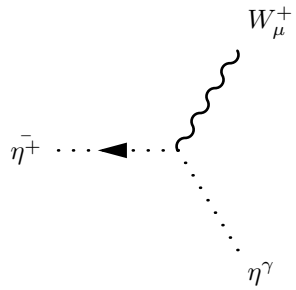
7.10 Two Ghosts-One Vector Boson-Interaction



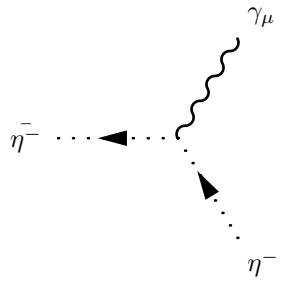
$$g_3 f_{\alpha,\beta,\gamma}\left(p_\mu^{\eta_\beta^G}\right) \tag{251}$$



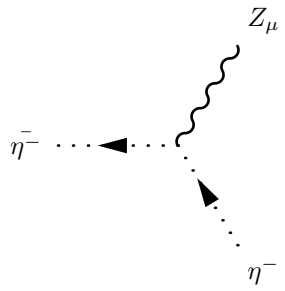
$$ig_2 \sin\Theta_W\left(p_\mu^{\eta^\gamma}\right) \tag{252}$$



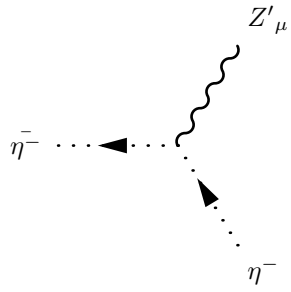
$$-ig_2 \sin\Theta_W\left(p_\mu^{\eta^\gamma}\right) \tag{253}$$



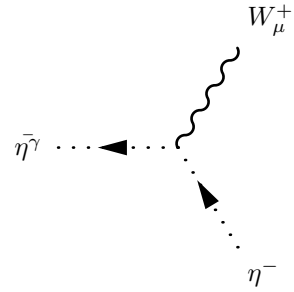
$$-ig_2 \sin\Theta_W\left(p_\mu^{\eta^-}\right) \tag{254}$$



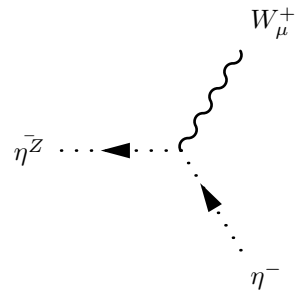
$$-ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^-}\right) \tag{255}$$



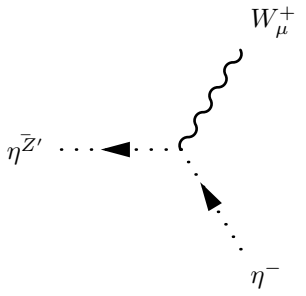
$$ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^-}\right) \tag{256}$$



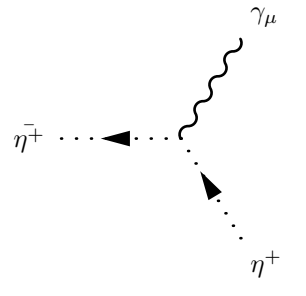
$$ig_2 \sin\Theta_W \left(p_\mu^{\eta^-}\right) \tag{257}$$



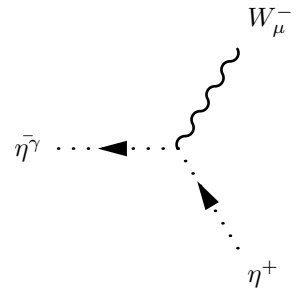
$$ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^-}\right) \tag{258}$$



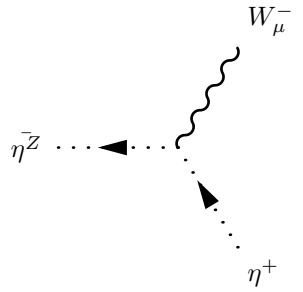
$$-ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^-}\right) \tag{259}$$



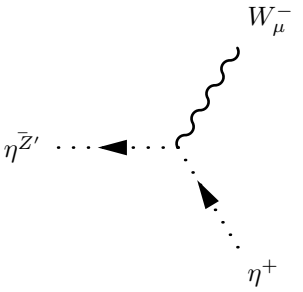
$$ig_2 \sin\Theta_W \left(p_\mu^{\eta^+}\right) \tag{260}$$



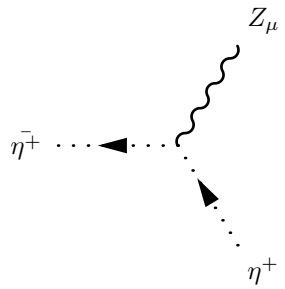
$$-ig_2 \sin\Theta_W \left(p_\mu^{\eta^+}\right) \tag{261}$$



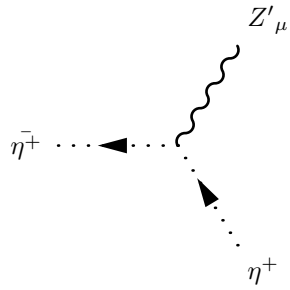
$$-ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^+}\right) \tag{262}$$



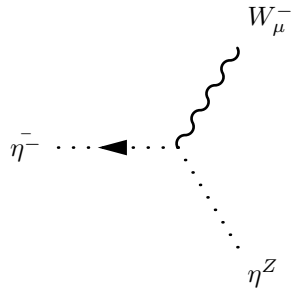
$$ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^+}\right) \tag{263}$$



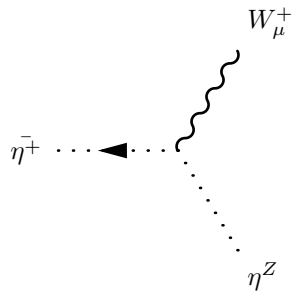
$$ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^+}\right) \tag{264}$$



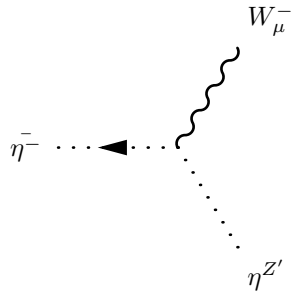
$$-ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^+}\right) \tag{265}$$



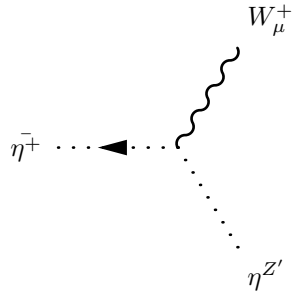
$$ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^Z}\right) \tag{266}$$



$$-ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^Z}\right) \tag{267}$$

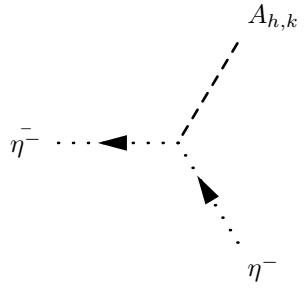


$$-ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^{Z'}}\right) \tag{268}$$

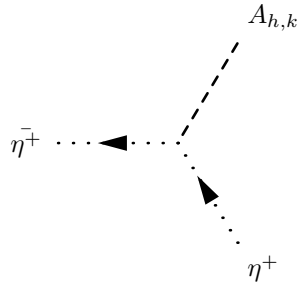


$$ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^{Z'}}\right) \tag{269}$$

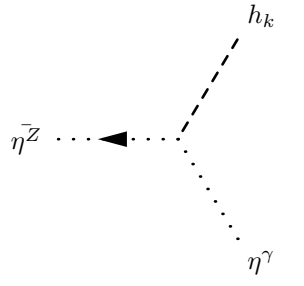
7.11 Two Ghosts-One Scalar-Interaction



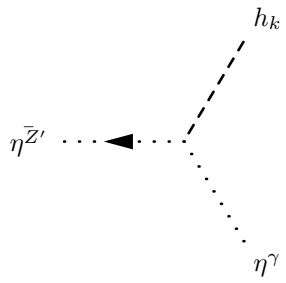
$$-\frac{1}{4}g_2^2 v \xi_{W^-} Z_{k1}^A \tag{270}$$



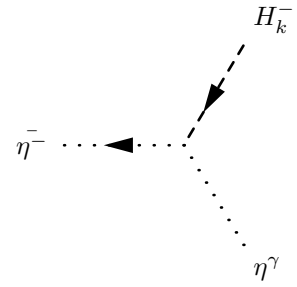
$$\frac{1}{4}g_2^2 v \xi_{W^-} Z_{k1}^A \tag{271}$$



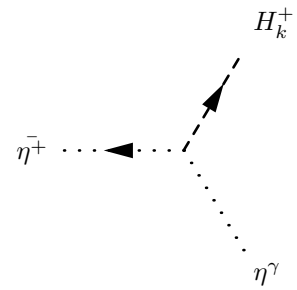
$$\begin{aligned}&\frac{i}{4}\xi_Z\Big(v\Big(g_1\cos\Theta_W - g_2\sin\Theta_W\Big)\Big(g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W - g_{BY}\sin\Theta'_W\Big)Z_{k1}^H\\&+100 g_{YB}\cos\Theta_W\Big(-g_B\sin\Theta'_W + g_{YB}\cos\Theta'_W\sin\Theta_W\Big)\Big(vx2Z_{k3}^H + vxZ_{k2}^H\Big)\Big)\end{aligned} \tag{272}$$



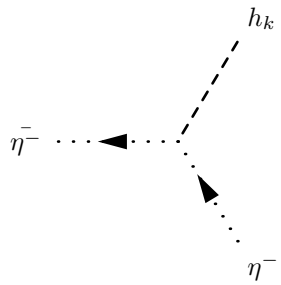
$$-\frac{i}{4}\xi_{Z'}\Big(v\Big(g_1\cos\Theta_W - g_2\sin\Theta_W\Big)\Big(\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W + g_{BY}\cos\Theta'_W\Big)Z^H_{k1}$$
$$+ 100 g_{YB}\cos\Theta_W\Big(g_B\cos\Theta'_W + g_{YB}\sin\Theta_W\sin\Theta'_W\Big)\Big(vx2Z^H_{k3} + vxZ^H_{k2}\Big)\Big) \tag{273}$$



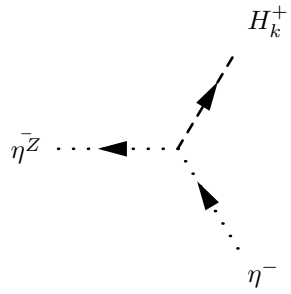
$$-\frac{i}{4}g_2 v\xi_{W^-}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)Z^+_{k1} \tag{274}$$



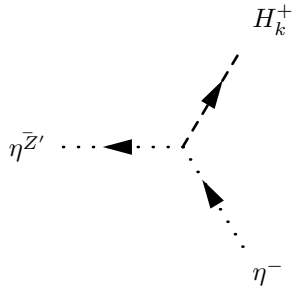
$$-\frac{i}{4}g_2 v\xi_{W^-}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)Z^+_{k1} \tag{275}$$



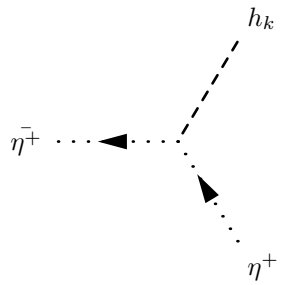
$$-\frac{i}{4}g_2^2 v\xi_{W^-}Z_{k1}^H \tag{276}$$



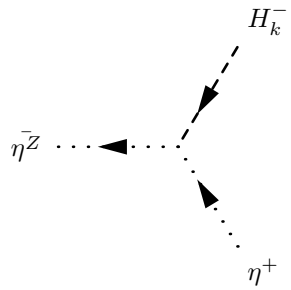
$$\frac{i}{4}g_2 v\xi_Z\Big(g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W - g_{BY}\sin\Theta'_W\Big)Z_{k1}^+ \tag{277}$$



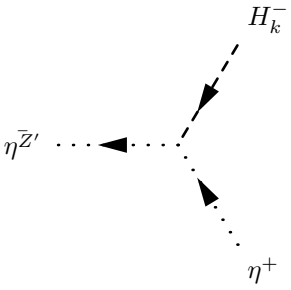
$$-\frac{i}{4}g_2 v\xi_{Z'}\Big(\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W + g_{BY}\cos\Theta'_W\Big)Z_{k1}^+ \tag{278}$$



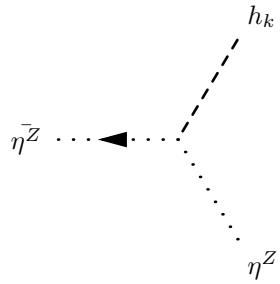
$$-\frac{i}{4}g_2^2 v \xi_{W^-} Z_{k1}^H \tag{279}$$



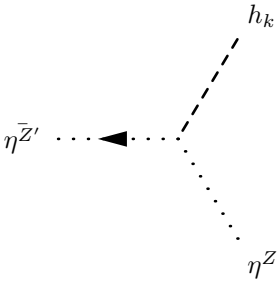
$$\frac{i}{4}g_2 v \xi_Z \Big(g_1 \cos\Theta'_W \sin\Theta_W + g_2 \cos\Theta_W \cos\Theta'_W - g_{BY} \sin\Theta'_W \Big) Z_{k1}^+ \tag{280}$$



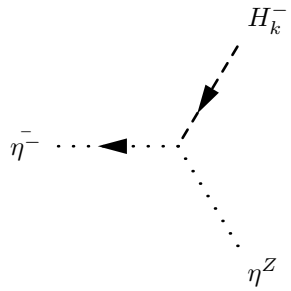
$$-\frac{i}{4}g_2 v \xi_{Z'} \Big(\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) \sin\Theta'_W + g_{BY} \cos\Theta'_W \Big) Z_{k1}^+ \tag{281}$$



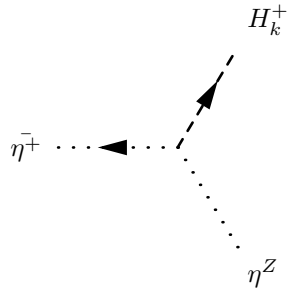
$$
\begin{aligned}
&-\frac{i}{4}\xi_Z\Big(v\Big(g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W-g_{BY}\sin\Theta'_W\Big)^2 Z^H_{k1}\\
&+100\Big(-g_B\sin\Theta'_W+g_{YB}\cos\Theta'_W\sin\Theta_W\Big)^2\Big(vx2Z^H_{k3}+vxZ^H_{k2}\Big)\Big)
\end{aligned}
\tag{282}
$$



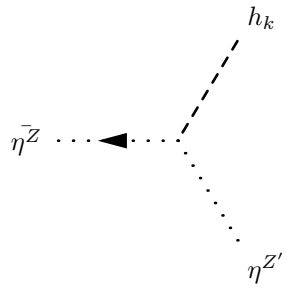
$$
\begin{aligned}
&\frac{i}{4}\xi_{Z'}\Big(v\Big(g_1g_{BY}\cos\Theta'^2_W\sin\Theta_W+g_2^2\cos\Theta_W^2\cos\Theta'_W\sin\Theta'_W\\
&+\cos\Theta'_W\Big(g_1^2\sin\Theta_W^2-g_{BY}^2\Big)\sin\Theta'_W-g_1g_{BY}\sin\Theta_W\sin\Theta'^2_W\\
&+g_2\cos\Theta_W\Big(g_1\sin\Theta_W\sin2\Theta'_W+g_{BY}\cos\Theta'^2_W-g_{BY}\sin\Theta'^2_W\Big)\Big)Z^H_{k1}\\
&-\frac{25}{2}\Big(-8g_Bg_{YB}\cos\Theta'^2_W\sin\Theta_W+8g_Bg_{YB}\sin\Theta_W\sin\Theta'^2_W\\
&+2\Big(2g_B^2-g_{YB}^2+g_{YB}^2\cos2\Theta_W\Big)\sin2\Theta'_W\Big)\Big(vx2Z^H_{k3}+vxZ^H_{k2}\Big)\Big)
\end{aligned}
\tag{283}
$$



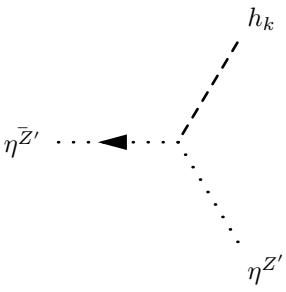
$$-\frac{i}{4}g_2 v\xi_{W^-}\Big(-g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W+g_{BY}\sin\Theta'_W\Big)Z^+_{k1} \tag{284}$$



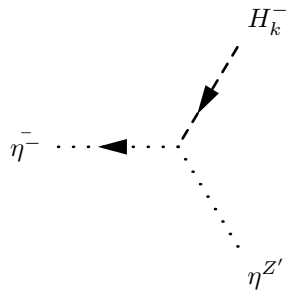
$$-\frac{i}{4}g_2 v\xi_{W^-}\Big(-g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W+g_{BY}\sin\Theta'_W\Big)Z^+_{k1} \tag{285}$$



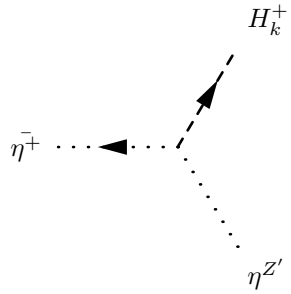
$$\begin{aligned}
&\frac{i}{4}\xi_Z\Big(v\Big(g_1 g_{BY}\cos\Theta'^2_W\sin\Theta_W+g_2^2\cos\Theta^2_W\cos\Theta'_W\sin\Theta'_W\\
&+\cos\Theta'_W\Big(g_1^2\sin\Theta^2_W-g_{BY}^2\Big)\sin\Theta'_W-g_1 g_{BY}\sin\Theta_W\sin\Theta'^2_W\\
&+g_2\cos\Theta_W\Big(g_1\sin\Theta_W\sin 2\Theta'_W+g_{BY}\cos\Theta'^2_W-g_{BY}\sin\Theta'^2_W\Big)\Big)Z^H_{k1}\\
&-\frac{25}{2}\Big(-8g_B g_{YB}\cos\Theta'^2_W\sin\Theta_W+8g_B g_{YB}\sin\Theta_W\sin\Theta'^2_W\\
&+2\Big(2g_B^2-g_{YB}^2+g_{YB}^2\cos 2\Theta_W\Big)\sin 2\Theta'_W\Big)\Big(vx2Z^H_{k3}+vxZ^H_{k2}\Big)\Big)
\end{aligned} \tag{286}$$



$$-\frac{i}{4}\xi_{Z'}\Big(v\Big(\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W+g_{BY}\cos\Theta'_W\Big)^2 Z^H_{k1}$$
$$+100\Big(g_B\cos\Theta'_W+g_{YB}\sin\Theta_W\sin\Theta'_W\Big)^2\Big(vx2Z^H_{k3}+vxZ^H_{k2}\Big)\Big) \tag{287}$$



$$\frac{i}{4}g_2 v\xi_{W^-}\Big(\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W-g_{BY}\cos\Theta'_W\Big)Z^+_{k1} \tag{288}$$



$$\frac{i}{4}g_2 v\xi_{W^-}\Big(\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W-g_{BY}\cos\Theta'_W\Big)Z^+_{k1} \tag{289}$$

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8 Clebsch-Gordan Coefficients