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_{1p}	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

$$L = -\mu_i'|\mathrm{BiD}|^2 - \mu_h|H^0|^2 - \mu_h|H^+|^2 - \mu_j'|S|^2 + \mathrm{BiD}^2\lambda_2\mathrm{conj}\Big(\mathrm{BiD}\Big)^2 + H^0\lambda_3|\mathrm{BiD}|^2H^{0,*} + H^{0,2}l_hH^{0,*,2}$$
$$+ H^+\lambda_3|\mathrm{BiD}|^2H^{+,*} + 2H^+l_h|H^0|^2H^{+,*} + H^{+,2}l_hH^{+,*,2} + \lambda_5S|H^0|^2S^* + \lambda_5S|H^+|^2S^* + \lambda_4S^2S^{*,2}$$

$$
\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}\Big(\mathrm{BiD}\Big) \mathrm{conj}\Big(\mathrm{epp}\Big(2\Big)\Big) \mathrm{ep}\Big(1\Big) - \lambda_{c2} S^* \mathrm{conj}\Big(\mathrm{epp}\Big(2\Big)\Big) \mathrm{ep}\Big(1\Big) \\
&- \lambda_g H^{0,*} \mathrm{conj}\Big(\mathrm{x5R}\Big(2\Big)\Big) \mathrm{ep}\Big(1\Big) - \lambda_{c1} \mathrm{conj}\Big(\mathrm{BiD}\Big) \mathrm{conj}\Big(\mathrm{epp}\Big(1\Big)\Big) \mathrm{ep}\Big(2\Big) - \lambda_{c2} S^* \mathrm{conj}\Big(\mathrm{epp}\Big(1\Big)\Big) \mathrm{ep}\Big(2\Big) - \lambda_g H^{0,*} \mathrm{conj}\Big(\mathrm{x5R}\Big(1\Big)\Big) \mathrm{ep}\Big(2 \\
&- S\lambda_{c2} \mathrm{conj}\Big(\mathrm{ep}\Big(2\Big)\Big) \mathrm{epp}\Big(1\Big) - \lambda_h H^{0,*} \mathrm{conj}\Big(\mathrm{x6L}\Big(2\Big)\Big) \mathrm{epp}\Big(1\Big) - \mathrm{BiD}\lambda_{c1} \mathrm{conj}\Big(\mathrm{ep}\Big(1\Big)\Big) \mathrm{epp}\Big(2\Big) - S\lambda_{c2} \mathrm{conj}\Big(\mathrm{ep}\Big(1\Big)\Big) \mathrm{epp}\Big(2\Big) - \lambda_h H^0 \\
&- 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}\Big(\mathrm{vp}\Big(2\Big)\Big) \mathrm{conj}\Big(\mathrm{eL}\Big(\{\mathrm{gt2}\}\Big)\Big(1\Big)\Big) \mathrm{s1}\Big(\{\mathrm{gt1}\}\Big) + \lambda^*_{d,ij} \mathrm{conj}\Big(\mathrm{vp}\Big(1\Big)\Big) \mathrm{conj}\Big(\mathrm{eL}\Big(\{\mathrm{gt2}\}\Big) \\
&- \mathrm{conj}\Big(\mathrm{ep}\Big(1\Big)\Big) \lambda^*_{d,ij} \mathrm{conj}\Big(\mathrm{vL}\Big(\{\mathrm{gt2}\}\Big)\Big(2\Big)\Big) \mathrm{s1}\Big(\{\mathrm{gt1}\}\Big) - \mathrm{BiD} \mathrm{conj}\Big(\mathrm{s2}\Big(\{\mathrm{gt2}\}\Big)\Big) \lambda_{fi,ij} \mathrm{s1}\Big(\{\mathrm{gt1}\}\Big) - S \mathrm{conj}\Big(\mathrm{s2}\Big(\{\mathrm{gt2}\}\Big)\Big) \lambda_{fj,ij} \mathrm{s1}\Big(\{\mathrm{gt1} \\
&- \mathrm{conj}\Big(\mathrm{s1}\Big(\{\mathrm{gt1}\}\Big)\Big) \mu_{1,ij} \mathrm{s1}\Big(\{\mathrm{gt2}\}\Big) - \mathrm{conj}\Big(\mathrm{x5R}\Big(2\Big)\Big) \mathrm{conj}\Big(\mathrm{vR}\Big(\{\mathrm{gt3}\}\Big)\Big(1\Big)\Big) \lambda_{e,ik} \mathrm{s2}\Big(\{\mathrm{gt1}\}\Big) - \mathrm{conj}\Big(\mathrm{x5R}\Big(1\Big)\Big) \mathrm{conj}\Big(\mathrm{vR}\Big(\{\mathrm{gt3}\}\Big)\Big(2\Big) \\
&- |H^0|^2 \mathrm{conj}\Big(\mathrm{s2}\Big(\{\mathrm{gt1}\}\Big)\Big) \lambda_{7,ij} \mathrm{s2}\Big(\{\mathrm{gt2}\}\Big) - |H^+|^2 \mathrm{conj}\Big(\mathrm{s2}\Big(\{\mathrm{gt1}\}\Big)\Big) \lambda_{7,ij} \mathrm{s2}\Big(\{\mathrm{gt2}\}\Big) - \mathrm{conj}\Big(\mathrm{s2}\Big(\{\mathrm{gt1}\}\Big)\Big) \mu_{2,ij} \mathrm{s2}\Big(\{\mathrm{gt2}\}\Big) - H^{+,*} d^*_{L,} \\
&+ H^{0,*} u^*_{L,k\gamma} Y^*_{u,jk} \delta_{\beta\gamma} u_{R,j\beta} - \lambda_{c1} \mathrm{conj}\Big(\mathrm{BiD}\Big) \mathrm{conj}\Big(\mathrm{vpp}\Big(2\Big)\Big) \mathrm{vp}\Big(1\Big) - \lambda_{c2} S^* \mathrm{conj}\Big(\mathrm{vpp}\Big(2\Big)\Big) \mathrm{vp}\Big(1\Big) - \lambda_g H^{+,*} \mathrm{conj}\Big(\mathrm{x5R}\Big(2\Big)\Big) \mathrm{vp}\Big(1\Big) - \\
&- \lambda_{c2} S^* \mathrm{conj}\Big(\mathrm{vpp}\Big(1\Big)\Big) \mathrm{vp}\Big(2\Big) - \lambda_g H^{+,*} \mathrm{conj}\Big(\mathrm{x5R}\Big(1\Big)\Big) \mathrm{vp}\Big(2\Big) - \mathrm{BiD}\lambda_{c1} \mathrm{conj}\Big(\mathrm{vp}\Big(2\Big)\Big) \mathrm{vpp}\Big(1\Big) - S\lambda_{c2} \mathrm{conj}\Big(\mathrm{vp}\Big(2\Big)\Big) \mathrm{vpp}\Big(1\Big) - \lambda_h H \\
&- \mathrm{BiD}\lambda_{c1} \mathrm{conj}\Big(\mathrm{vp}\Big(1\Big)\Big) \mathrm{vpp}\Big(2\Big) - S\lambda_{c2} \mathrm{conj}\Big(\mathrm{vp}\Big(1\Big)\Big) \mathrm{vpp}\Big(2\Big) - \lambda_h H^{+,*} \mathrm{conj}\Big(\mathrm{x6L}\Big(1\Big)\Big) \mathrm{vpp}\Big(2\Big) - \lambda_{a1} \mathrm{conj}\Big(\mathrm{BiD}\Big) \mathrm{conj}\Big(\mathrm{x4R}\Big(2\Big)\Big) \mathrm{x3} \\
&- \lambda_{a1} \mathrm{conj}\Big(\mathrm{BiD}\Big) \mathrm{conj}\Big(\mathrm{x4R}\Big(1\Big)\Big) \mathrm{x3L}\Big(2\Big) - \lambda_{a2} S^* \mathrm{conj}\Big(\mathrm{x4R}\Big(1\Big)\Big) \mathrm{x3L}\Big(2\Big) - \mathrm{BiD}\lambda_{a1} \mathrm{conj}\Big(\mathrm{x3L}\Big(2\Big)\Big) \mathrm{x4R}\Big(1\Big) - S\lambda_{a2} \mathrm{conj}\Big(\mathrm{x3L}\Big(2\Big)\Big) \mathrm{x} \\
&- S\lambda_{a2} \mathrm{conj}\Big(\mathrm{x3L}\Big(1\Big)\Big) \mathrm{x4R}\Big(2\Big) - H^0 \lambda^*_g \mathrm{conj}\Big(\mathrm{ep}\Big(2\Big)\Big) \mathrm{x5R}\Big(1\Big) - H^+ \lambda^*_g \mathrm{conj}\Big(\mathrm{vp}\Big(2\Big)\Big) \mathrm{x5R}\Big(1\Big) - \lambda_{b1} \mathrm{conj}\Big(\mathrm{BiD}\Big) \mathrm{conj}\Big(\mathrm{x6L}\Big(2\Big)\Big) \mathrm{x5R}\Big(\\
&- H^0 \lambda^*_g \mathrm{conj}\Big(\mathrm{ep}\Big(1\Big)\Big) \mathrm{x5R}\Big(2\Big) - H^+ \lambda^*_g \mathrm{conj}\Big(\mathrm{vp}\Big(1\Big)\Big) \mathrm{x5R}\Big(2\Big) - \lambda_{b1} \mathrm{conj}\Big(\mathrm{BiD}\Big) \mathrm{conj}\Big(\mathrm{x6L}\Big(1\Big)\Big) \mathrm{x5R}\Big(2\Big) - \lambda_{b2} S^* \mathrm{conj}\Big(\mathrm{x6L}\Big(1\Big)\Big) \mathrm{x5R}\Big(\\
&- H^+ \lambda_h \mathrm{conj}\Big(\mathrm{vpp}\Big(2\Big)\Big) \mathrm{x6L}\Big(1\Big) - \mathrm{BiD}\lambda_{b1} \mathrm{conj}\Big(\mathrm{x5R}\Big(2\Big)\Big) \mathrm{x6L}\Big(1\Big) - S\lambda_{b2} \mathrm{conj}\Big(\mathrm{x5R}\Big(2\Big)\Big) \mathrm{x6L}\Big(1\Big) - H^0 \lambda_h \mathrm{conj}\Big(\mathrm{epp}\Big(1\Big)\Big) \mathrm{x6L}\Big(2\Big) - \\
&- \mathrm{BiD}\lambda_{b1} \mathrm{conj}\Big(\mathrm{x5R}\Big(1\Big)\Big) \mathrm{x6L}\Big(2\Big) - S\lambda_{b2} \mathrm{conj}\Big(\mathrm{x5R}\Big(1\Big)\Big) \mathrm{x6L}\Big(2\Big) - 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}\Big(\mathrm{s1}\Big(\{\mathrm{gt1}\}\Big)\Big) \lambda_{d,ij} \mathrm{vp}\Big(2\Big) \mathrm{eL}\Big(\{\mathrm{gt2}\}\Big)\Big(1\Big) + \mathrm{conj}\Big(\mathrm{s1}\Big(\{\mathrm{gt1}\}\Big)\Big) \lambda_{d,ij} \mathrm{vp}\Big(1\Big) \mathrm{eL}\Big(\{\mathrm{gt2}\}\Big)\Big(2\Big) - \mathrm{conj}\Big(\mathrm{s1}\Big(\{\mathrm{gt1}\}\Big)\Big) \mathrm{ep}\Big(2\Big) \lambda_{d,ij} \mathrm{vL}\Big(\{ \\
&- \lambda^*_{e,ik} \mathrm{conj}\Big(\mathrm{s2}\Big(\{\mathrm{gt1}\}\Big)\Big) \mathrm{x5R}\Big(1\Big) \mathrm{vR}\Big(\{\mathrm{gt3}\}\Big)\Big(2\Big) \qquad (1)
\end{aligned}
$$

2.2 Gauge fixing terms

2.2.1 Gauge fixing terms for eigenstates 'GaugeES'

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

2.2.2 Gauge fixing terms for eigenstates 'EWSB'

$$
\begin{aligned}
L_{GF} = &- \frac{1}{2}|\partial_\mu g|^2 \xi_g^{-1} - \frac{1}{2}|\partial_\mu \gamma|^2 \xi_\gamma^{-1} - |\frac{i}{2} g_2 v H^{+,*} \xi_{W^-} + \partial_\mu W^-|^2 \xi_{W^-}^{-1} \\
&- \frac{1}{2}| - \frac{1}{2}\xi_Z \Big(- \Big(10 g_{1p} \mathrm{sigmaB} vx + g_{BY} \mathrm{sigmaH} v\Big) \sin\Theta'_W + \Big(10 g_{YB} \mathrm{sigmaB} vx + g_1 \mathrm{sigmaH} v\Big) \cos\Theta'_W \sin\Theta_W + g_2 \mathrm{sigmaH} v
\end{aligned}
$$

$$-\frac{1}{2}|\frac{1}{2}\Big(2\partial_\mu Z' + \xi_{Z'}\Big(\Big(10g_{1p}\text{sigmaB}vx + g_{BY}\text{sigmaH}v\Big)\cos\Theta'_W + \Big(10g_{YB}\text{sigmaB}vx\sin\Theta_W + g_1\text{sigmaH}v\sin\Theta_W + g_2\text{sigmaI} \tag{3}$$

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: $(\text{phiH}, \text{phiB}), (\text{phiH}, \text{phiB})$

$$m_h^2 = \begin{pmatrix} -3l_h v^2 - \frac{1}{2}\lambda_3 vx^2 + \mu_h & -\lambda_3 vvx \\ -\lambda_3 vvx & -3\lambda_2 vx^2 - \frac{1}{2}\lambda_3 v^2 + \mu'_i \end{pmatrix} \tag{10}$$

This matrix is diagonalized by Z^H:

$$Z^H m_h^2 Z^{H,\dagger} = m_{2,h}^{dia} \tag{11}$$

with

$$\text{phiH} = \sum_j Z^H_{j1} h_j \,, \qquad \text{phiB} = \sum_j Z^H_{j2} h_j \tag{12}$$

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

$$m^2_{A_h} = \begin{pmatrix} -\frac{1}{2}\lambda_3 v x^2 - l_h v^2 + \mu_h & 0 \\ 0 & -\frac{1}{2}\lambda_3 v^2 - \lambda_2 v x^2 + \mu'_i \end{pmatrix} + \xi_Z m^2(Z) + \xi_{Z'} m^2(Z') \tag{13}$$

Gauge fixing contributions:

$$m^2(\xi_Z) = \begin{pmatrix} m_{\text{sigmaHsigmaH}} & m_{\text{sigmaBsigmaH}} \\ m_{\text{sigmaHsigmaB}} & m_{\text{sigmaBsigmaB}} \end{pmatrix} \tag{14}$$

$$m_{\text{sigmaHsigmaH}} = \frac{1}{4} v^2 \Big(\cos\Theta'_W \Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) - g_{BY} \sin\Theta'_W \Big)^2 \tag{15}$$

$$m_{\text{sigmaHsigmaB}} = \frac{5}{2} v v x \Big(\cos\Theta'_W \Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) - g_{BY} \sin\Theta'_W \Big) \Big(- g_{1p} \sin\Theta'_W + g_{YB} \cos\Theta'_W \sin\Theta_W \Big) \tag{16}$$

$$m_{\text{sigmaBsigmaB}} = 25 v x^2 \Big(- g_{1p} \sin\Theta'_W + g_{YB} \cos\Theta'_W \sin\Theta_W \Big)^2 \tag{17}$$

$$m^2(\xi_{Z'}) = \begin{pmatrix} m_{\text{sigmaHsigmaH}} & m_{\text{sigmaBsigmaH}} \\ m_{\text{sigmaHsigmaB}} & m_{\text{sigmaBsigmaB}} \end{pmatrix} \tag{18}$$

$$m_{\text{sigmaHsigmaH}} = \frac{1}{4} v^2 \Big(\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) \sin\Theta'_W + g_{BY} \cos\Theta'_W \Big)^2 \tag{19}$$

$$m_{\text{sigmaHsigmaB}} = \frac{5}{2} v v x \Big(g_{1p} \cos\Theta'_W + g_{YB} \sin\Theta_W \sin\Theta'_W \Big) \Big(\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) \sin\Theta'_W + g_{BY} \cos\Theta'_W \Big) \tag{20}$$

$$m_{\text{sigmaBsigmaB}} = 25 v x^2 \Big(g_{1p} \cos\Theta'_W + g_{YB} \sin\Theta_W \sin\Theta'_W \Big)^2 \tag{21}$$

This matrix is diagonalized by Z^A:

$$Z^A m^2_{A_h} Z^{A,\dagger} = m^{dia}_{2,A_h} \tag{22}$$

with

$$\text{sigmaH} = \sum_j Z^A_{j1} A_{h,j} \,, \qquad \text{sigmaB} = \sum_j Z^A_{j2} A_{h,j} \tag{23}$$

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

$$m^2_{H^-} = \begin{pmatrix} -\frac{1}{2}\lambda_3 v x^2 - l_h v^2 + \mu_h & 0 & 0 \\ 0 & \frac{1}{2}\lambda_6 v^2 + \mu_1 & \frac{1}{\sqrt{2}}\lambda_{fi} v x \\ 0 & \frac{1}{\sqrt{2}} v x \lambda^T_{fi} & \frac{1}{2}\lambda_7 v^2 + \mu_2 \end{pmatrix} + \xi_{W^-} m^2(W^-) \tag{24}$$

Gauge fixing contributions:

$$m^2(\xi_{W^-}) = \begin{pmatrix} \frac{1}{4}g_2^2v^2 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \tag{25}$$

This matrix is diagonalized by Z^+:

$$Z^+ m^2_{H^-} Z^{+,\dagger} = m^{dia}_{2,H^-} \tag{26}$$

with

$$H^+ = \sum_j Z^+_{j1} H^+_j \,, \qquad \mathrm{s1}\Big(\{\mathrm{gt1}\}\Big) = \sum_j Z^+_{ji} H^-_j \,, \qquad \mathrm{s2}\Big(\{\mathrm{gt1}\}\Big) = \sum_j Z^+_{ji} H^-_j \tag{27}$$

3.2.2 Mass Matrices for Fermions

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

$$m_d = \Big(\ \tfrac{1}{\sqrt{2}} v \delta_{\alpha_1\beta_1} Y_d^T \ \Big) \tag{28}$$

This matrix is diagonalized by U^d_L and U^d_R

$$U^{d,*}_L m_d U^{d,\dagger}_R = m^{dia}_d \tag{29}$$

with

$$d_{L,i\alpha} = \sum_{t_2} U^{d,*}_{L,ji} D_{L,j\alpha} \tag{30}$$

$$d_{R,i\alpha} = \sum_{t_2} U^{d}_{R,ij} D^*_{R,j\alpha} \tag{31}$$

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

$$m_u = \Big(\ -\tfrac{1}{\sqrt{2}} v \delta_{\alpha_1\beta_1} Y_u^T \ \Big) \tag{32}$$

This matrix is diagonalized by U^u_L and U^u_R

$$U^{u,*}_L m_u U^{u,\dagger}_R = m^{dia}_u \tag{33}$$

with

$$u_{L,i\alpha} = \sum_{t_2} U^{u,*}_{L,ji} U_{L,j\alpha} \tag{34}$$

$$u_{R,i\alpha} = \sum_{t_2} U^{u}_{R,ij} U^*_{R,j\alpha} \tag{35}$$

- **Mass matrix for Leptons**, Basis: $(e_L), (e_R^*)$

$$m_e = \begin{pmatrix} \frac{1}{\sqrt{2}} v Y_e^T \end{pmatrix} \tag{36}$$

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

$$U_L^{e,*} m_e U_R^{e,\dagger} = m_e^{dia} \tag{37}$$

with

$$e_{L,i} = \sum_{t_2} U_{L,ji}^{e,*} E_{L,j} \tag{38}$$

$$e_{R,i} = \sum_{t_2} U_{R,ij}^{e} E_{R,j}^* \tag{39}$$

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

$$m_\nu = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix} \tag{40}$$

This matrix is diagonalized by U^V:

$$U^{V,*} m_\nu U^{V,\dagger} = m_\nu^{dia} \tag{41}$$

with

$$\nu_{L,i} = \sum_j U_{ji}^{V,*} V_{L,j}\,, \qquad V_{R,i} = \sum_j U_{ji}^{V} V_{L,j}^* \tag{42}$$

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

$$m_{eD} = \begin{pmatrix} \frac{1}{\sqrt{2}} v \lambda_g & \frac{1}{\sqrt{2}} v x \lambda_{c1} \\ \frac{1}{\sqrt{2}} v x \lambda_{b1} & \frac{1}{\sqrt{2}} v \lambda_h \end{pmatrix} \tag{43}$$

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

$$UD_L^{e,*} m_{eD} UD_R^{e,\dagger} = m_{eD}^{dia} \tag{44}$$

with

$$e_p = \sum_{t_2} UD_{L,j1}^{e,*} \mathrm{ELD}\Big(\{\mathrm{gt2}\}\Big)\,, \qquad x6_L = \sum_{t_2} UD_{L,j2}^{e,*} \mathrm{ELD}\Big(\{\mathrm{gt2}\}\Big) \tag{45}$$

$$x5_R = \sum_{t_2} UD_{R,1j}^{e} \mathrm{conj}\Big(\mathrm{ERD}\Big(\{\mathrm{gt2}\}\Big)\Big)\,, \qquad ep_p = \sum_{t_2} UD_{R,2j}^{e} \mathrm{conj}\Big(\mathrm{ERD}\Big(\{\mathrm{gt2}\}\Big)\Big) \tag{46}$$

4 Vacuum Expectation Values

$$H^0 = \frac{1}{\sqrt{2}}\text{phiH} + \frac{1}{\sqrt{2}}v + i\frac{1}{\sqrt{2}}\text{sigmaH} \tag{47}$$

$$\text{BiD} = \frac{1}{\sqrt{2}}\text{phiB} + \frac{1}{\sqrt{2}}vx + i\frac{1}{\sqrt{2}}\text{sigmaB} \tag{48}$$

5 Tadpole Equations

$$\frac{\partial V}{\partial \text{phiH}} = -l_h v^3 + v\Big(-\frac{1}{2}\lambda_3 v x^2 + \mu_h\Big) \tag{49}$$

$$\frac{\partial V}{\partial \text{phiB}} = \Big(-\frac{1}{2}\lambda_3 v^2 + \mu_i'\Big)vx - \lambda_2 v x^3 \tag{50}$$

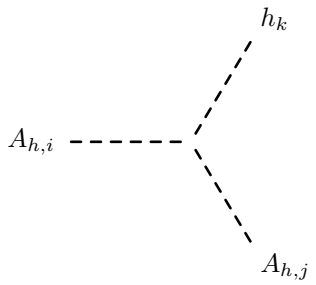
6 Particle content for eigenstates 'EWSB'

Name	Type	complex/real	Generations	Indices
S	Scalar	complex	1	
h	Scalar	real	2	generation, 2
A_h	Scalar	real	2	generation, 2
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	

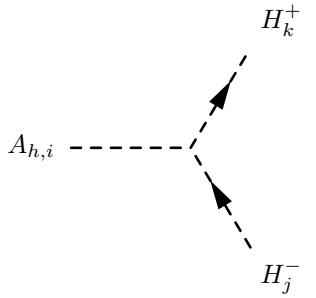
$\eta^{Z'}$	Ghost	real	1
η^-	Ghost	complex	1
η^+	Ghost	complex	1

7 Interactions for eigenstates 'EWSB'

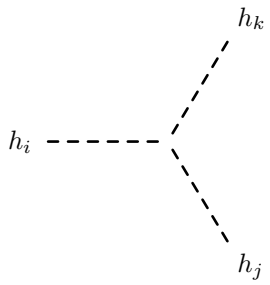
7.1 Three Scalar-Interaction



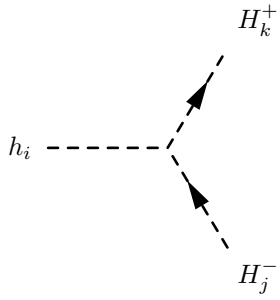
$$i\Big(Z^A_{i1}Z^A_{j1}\Big(2l_h v Z^H_{k1} + \lambda_3 v x Z^H_{k2}\Big) + Z^A_{i2}Z^A_{j2}\Big(2\lambda_2 v x Z^H_{k2} + \lambda_3 v Z^H_{k1}\Big)\Big) \tag{51}$$



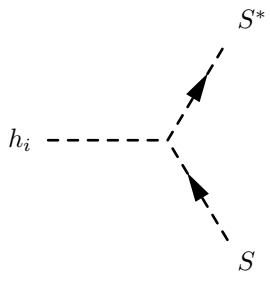
$$-\frac{1}{\sqrt{2}}\Big(-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{fi,ab}Z^+_{j1+a}Z^+_{k3+b} + \sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{fi,ab}Z^+_{k1+a}Z^+_{j3+b}\Big)Z^A_{i2} \tag{52}$$



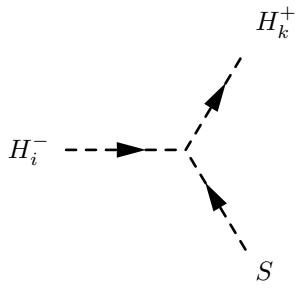
$$
\begin{aligned}
&i\Big(Z_{i2}^{H}\Big(\lambda_3 Z_{j1}^{H}\Big(vxZ_{k1}^{H}+vZ_{k2}^{H}\Big)+Z_{j2}^{H}\Big(6\lambda_2 vxZ_{k2}^{H}+\lambda_3 vZ_{k1}^{H}\Big)\Big)\\
&+Z_{i1}^{H}\Big(\lambda_3 Z_{j2}^{H}\Big(vxZ_{k1}^{H}+vZ_{k2}^{H}\Big)+Z_{j1}^{H}\Big(6l_h vZ_{k1}^{H}+\lambda_3 vxZ_{k2}^{H}\Big)\Big)\Big)
\end{aligned}
\tag{53}
$$



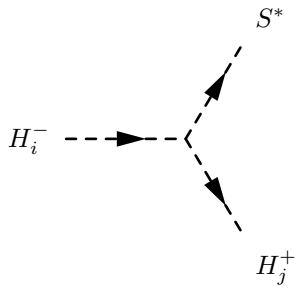
$$
\begin{aligned}
&i\Big(-v\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{6,ab}Z_{k1+a}^{+}Z_{j1+b}^{+}Z_{i1}^{H}-v\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{7,ab}Z_{k3+a}^{+}Z_{j3+b}^{+}Z_{i1}^{H}\\
&-\frac{1}{\sqrt{2}}\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{fi,ab}Z_{k1+a}^{+}Z_{j3+b}^{+}Z_{i2}^{H}-\frac{1}{\sqrt{2}}\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{fi,ab}Z_{j1+a}^{+}Z_{k3+b}^{+}Z_{i2}^{H}+2l_h vZ_{i1}^{H}Z_{j1}^{+}Z_{k1}^{+}\\
&+\lambda_3 vxZ_{i2}^{H}Z_{j1}^{+}Z_{k1}^{+}\Big)
\end{aligned}
\tag{54}
$$



$$i\lambda_5 v Z^H_{i1} \tag{55}$$

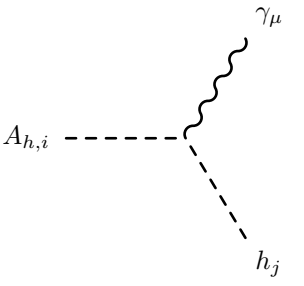


$$-i\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{fj,ab}Z^+_{i1+a}Z^+_{k3+b} \tag{56}$$

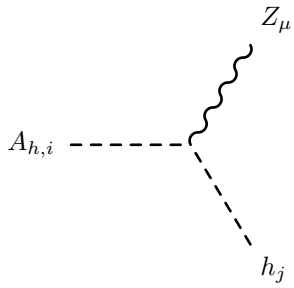


$$-i\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{fj,ab}Z^+_{j1+a}Z^+_{i3+b} \tag{57}$$

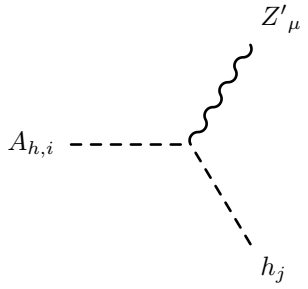
7.2 Two Scalar-One Vector Boson-Interaction



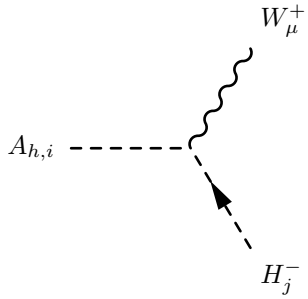
$$\frac{1}{2}\Big(10g_{YB}\cos\Theta_W Z^A_{i2}Z^H_{j2} + \Big(g_1\cos\Theta_W - g_2\sin\Theta_W\Big)Z^A_{i1}Z^H_{j1}\Big)\Big(-p_\mu^{h_j} + p_\mu^{A_{h,i}}\Big) \tag{58}$$



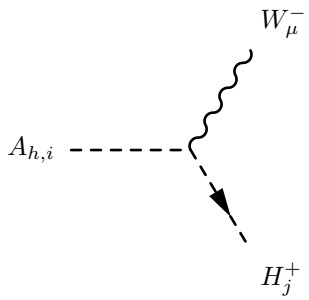
$$\begin{aligned}&\frac{1}{2}\Big(-\Big(g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W - g_{BY}\sin\Theta'_W\Big)Z^A_{i1}Z^H_{j1}\\&-10\Big(-g_{1p}\sin\Theta'_W + g_{YB}\cos\Theta'_W\sin\Theta_W\Big)Z^A_{i2}Z^H_{j2}\Big)\Big(-p_\mu^{h_j} + p_\mu^{A_{h,i}}\Big)\end{aligned} \tag{59}$$



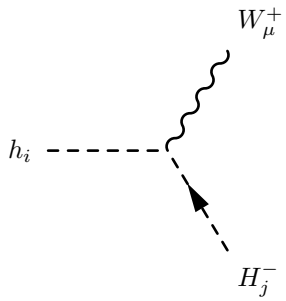
$$\begin{aligned}&\frac{1}{2}\Big(\Big(\Big(\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W + g_{BY}\cos\Theta'_W\Big)Z^A_{i1}Z^H_{j1}\\&+10\Big(g_{1p}\cos\Theta'_W + g_{YB}\sin\Theta_W\sin\Theta'_W\Big)Z^A_{i2}Z^H_{j2}\Big)\Big(-p_\mu^{h_j} + p_\mu^{A_{h,i}}\Big)\end{aligned} \tag{60}$$



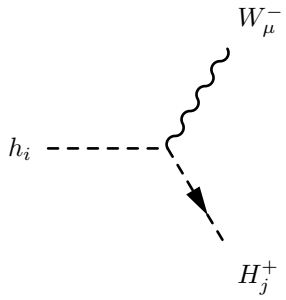
$$\frac{1}{2}g_2 Z^A_{i1} Z^+_{j1}\Big(- p_\mu^{H_j^-} + p_\mu^{A_{h,i}}\Big) \tag{61}$$



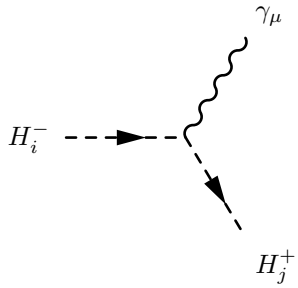
$$\frac{1}{2}g_2 Z^A_{i1} Z^+_{j1}\Big(- p_\mu^{H_j^+} + p_\mu^{A_{h,i}}\Big) \tag{62}$$



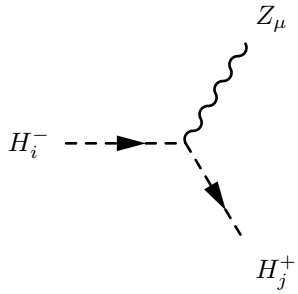
$$-\frac{i}{2}g_2 Z^H_{i1} Z^+_{j1}\Big(- p_\mu^{H_j^-} + p_\mu^{h_i}\Big) \tag{63}$$



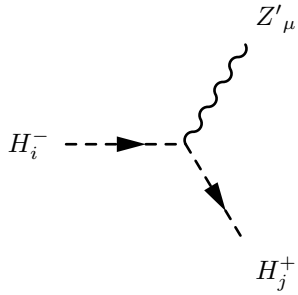
$$\frac{i}{2}g_2 Z^H_{i1} Z^+_{j1}\Big(- p_\mu^{H_j^+} + p_\mu^{h_i}\Big) \tag{64}$$



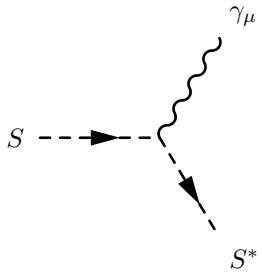
$$\frac{i}{2}\Big(2\Big(g_1+g_{YB}\Big)\cos\Theta_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}+2\Big(-4g_{YB}+g_1\Big)\cos\Theta_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}$$
$$+\Big(g_1\cos\Theta_W+g_2\sin\Theta_W\Big)Z^+_{i1}Z^+_{j1}\Big)\Big(-p_\mu^{H_j^+}+p_\mu^{H_i^-}\Big) \tag{65}$$



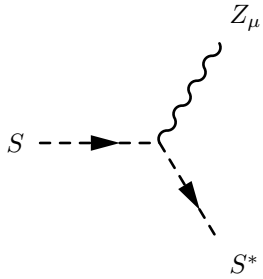
$$-\frac{i}{2}\Big(2\Big(\Big(g_1+g_{YB}\Big)\cos\Theta'_W\sin\Theta_W-\Big(g_{BY}+g_{1p}\Big)\sin\Theta'_W\Big)\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$+2\Big(-\Big(-4g_{1p}+g_{BY}\Big)\sin\Theta'_W+\Big(-4g_{YB}+g_1\Big)\cos\Theta'_W\sin\Theta_W\Big)\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}$$
$$-\Big(-g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W+g_{BY}\sin\Theta'_W\Big)Z^+_{i1}Z^+_{j1}\Big)\Big(-p_\mu^{H_j^+}+p_\mu^{H_i^-}\Big) \tag{66}$$



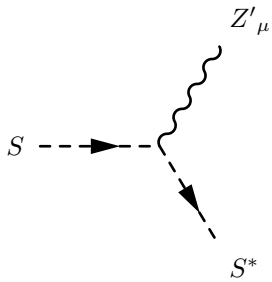
$$\frac{i}{2}\Big(2\Big(\Big(g_1+g_{YB}\Big)\sin\Theta_W\sin\Theta'_W+\Big(g_{BY}+g_{1p}\Big)\cos\Theta'_W\Big)\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$+2\Big(\Big(-4g_{1p}+g_{BY}\Big)\cos\Theta'_W+\Big(-4g_{YB}+g_1\Big)\sin\Theta_W\sin\Theta'_W\Big)\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}$$
$$+\Big(\Big(g_1\sin\Theta_W-g_2\cos\Theta_W\Big)\sin\Theta'_W+g_{BY}\cos\Theta'_W\Big)Z^+_{i1}Z^+_{j1}\Big)\Big(-p_\mu^{H_j^+}+p_\mu^{H_i^-}\Big) \tag{67}$$



$$-5ig_{YB}\cos\Theta_W\Big(-p_\mu^{S^*}+p_\mu^{S}\Big) \tag{68}$$

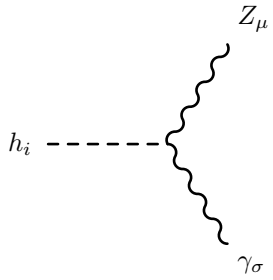


$$5i\Big(-g_{1p}\sin\Theta'_W+g_{YB}\cos\Theta'_W\sin\Theta_W\Big)\Big(-p_\mu^{S^*}+p_\mu^{S}\Big) \tag{69}$$

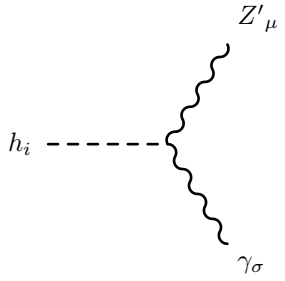


$$- 5i\Big(g_{1p}\cos\Theta'_W + g_{YB}\sin\Theta_W\sin\Theta'_W\Big)\Big(-p_\mu^{S^*} + p_\mu^S\Big) \tag{70}$$

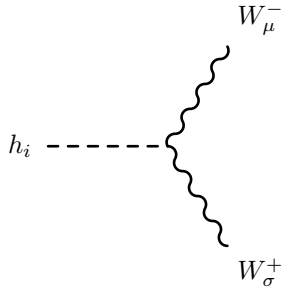
7.3 One Scalar-Two Vector Boson-Interaction



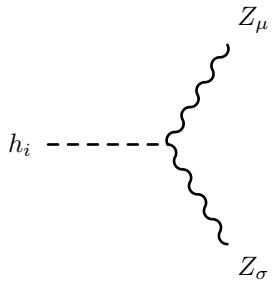
$$\frac{i}{2}\Big(-v\Big(g_1\cos\Theta_W - g_2\sin\Theta_W\Big)\Big(g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W - g_{BY}\sin\Theta'_W\Big)Z_{i1}^H$$
$$- 50g_{YB}vx\Big(-2g_{1p}\cos\Theta_W\sin\Theta'_W + g_{YB}\cos\Theta'_W\sin 2\Theta_W\Big)Z_{i2}^H\Big)\Big(g_{\sigma\mu}\Big) \tag{71}$$



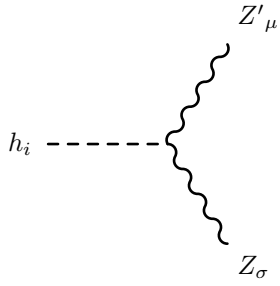
$$\frac{i}{2}\Big(v\Big(g_1\cos\Theta_W - g_2\sin\Theta_W\Big)\Big(\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W + g_{BY}\cos\Theta'_W\Big)Z_{i1}^H$$
$$+ 50g_{YB}vx\Big(2g_{1p}\cos\Theta_W\cos\Theta'_W + g_{YB}\sin 2\Theta_W\sin\Theta'_W\Big)Z_{i2}^H\Big)\Big(g_{\sigma\mu}\Big) \tag{72}$$



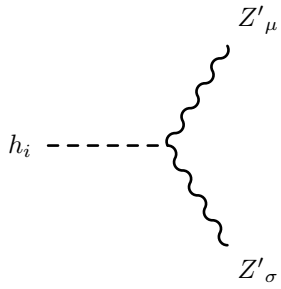
$$\frac{i}{2}g_2^2 v Z_{i1}^H \Big(g_{\sigma\mu}\Big) \tag{73}$$



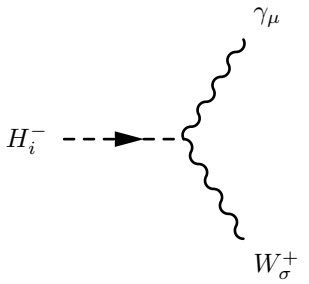
$$\begin{aligned}&\frac{i}{2}\Big(v\Big(g_1 \cos\Theta'_W \sin\Theta_W + g_2 \cos\Theta_W \cos\Theta'_W - g_{BY} \sin\Theta'_W\Big)^2 Z_{i1}^H \\ &+ 100vx\Big(-g_{1p} \sin\Theta'_W + g_{YB} \cos\Theta'_W \sin\Theta_W\Big)^2 Z_{i2}^H\Big)\Big(g_{\sigma\mu}\Big)\end{aligned} \tag{74}$$



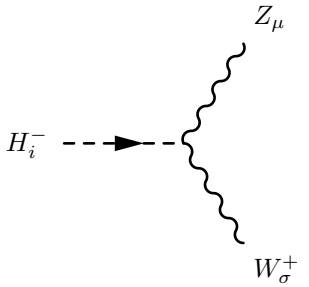
$$\begin{aligned}&\frac{i}{2}\Big(-v\Big(g_1 g_{BY} \cos\Theta'^2_W \sin\Theta_W + g_2^2 \cos\Theta_W^2 \cos\Theta'_W \sin\Theta'_W \\ &+ \cos\Theta'_W\Big(g_1^2 \sin\Theta_W^2 - g_{BY}^2\Big)\sin\Theta'_W - g_1 g_{BY} \sin\Theta_W \sin\Theta'^2_W \\ &+ g_2 \cos\Theta_W\Big(g_1 \sin\Theta_W \sin 2\Theta'_W + g_{BY} \cos\Theta'^2_W - g_{BY} \sin\Theta'^2_W\Big)\Big) Z_{i1}^H \\ &+ 50vx\Big(-2g_{1p} g_{YB} \cos\Theta'^2_W \sin\Theta_W + 2g_{1p} g_{YB} \sin\Theta_W \sin\Theta'^2_W + g_{1p}^2 \sin 2\Theta'_W \\ &- g_{YB}^2 \sin\Theta_W^2 \sin 2\Theta'_W\Big) Z_{i2}^H\Big)\Big(g_{\sigma\mu}\Big)\end{aligned} \tag{75}$$



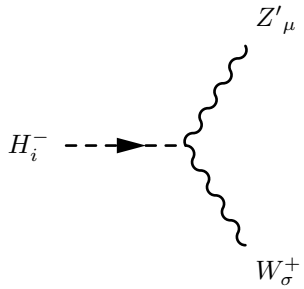
$$\frac{i}{2}\Big(v\Big(\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W + g_{BY}\cos\Theta'_W\Big)^2 Z^H_{i1} + 100vx\Big(g_{1p}\cos\Theta'_W + g_{YB}\sin\Theta_W\sin\Theta'_W\Big)^2 Z^H_{i2}\Big)\Big(g_{\sigma\mu}\Big) \tag{76}$$



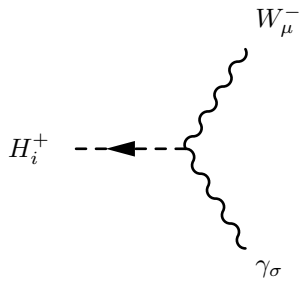
$$\frac{i}{2}g_1 g_2 v\cos\Theta_W Z^+_{i1}\Big(g_{\sigma\mu}\Big) \tag{77}$$



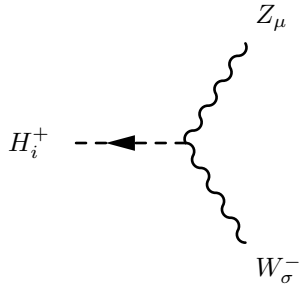
$$\frac{i}{2}g_2 v\Big(-g_1\cos\Theta'_W\sin\Theta_W + g_{BY}\sin\Theta'_W\Big)Z^+_{i1}\Big(g_{\sigma\mu}\Big) \tag{78}$$



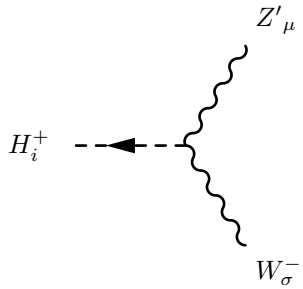
$$\frac{i}{2}g_2 v\Big(g_1 \sin\Theta_W \sin\Theta'_W + g_{BY}\cos\Theta'_W\Big) Z_{i1}^{+}\Big(g_{\sigma\mu}\Big) \tag{79}$$



$$\frac{i}{2}g_1 g_2 v\cos\Theta_W Z_{i1}^{+}\Big(g_{\sigma\mu}\Big) \tag{80}$$

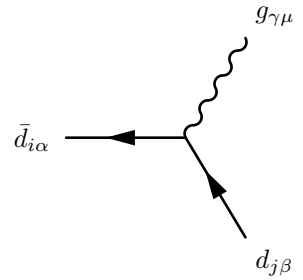


$$\frac{i}{2}g_2 v\Big(-g_1 \cos\Theta'_W \sin\Theta_W + g_{BY}\sin\Theta'_W\Big) Z_{i1}^{+}\Big(g_{\sigma\mu}\Big) \tag{81}$$



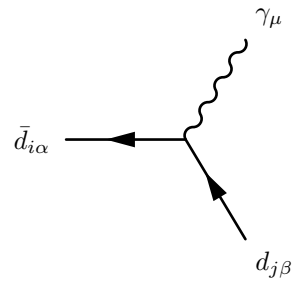
$$\frac{i}{2}g_2 v\Big(g_1 \sin\Theta_W \sin\Theta'_W + g_{BY}\cos\Theta'_W\Big) Z_{i1}^+\Big(g_{\sigma\mu}\Big) \tag{82}$$

7.4 Two Fermion-One Vector Boson-Interaction



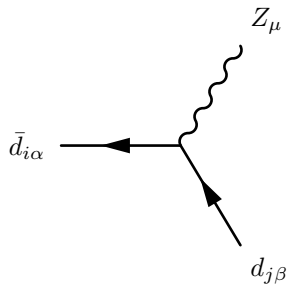
$$-\frac{i}{2}g_3\delta_{ij}\lambda^\gamma_{\alpha,\beta}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{83}$$

$$+\ -\frac{i}{2}g_3\delta_{ij}\lambda^\gamma_{\alpha,\beta}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{84}$$



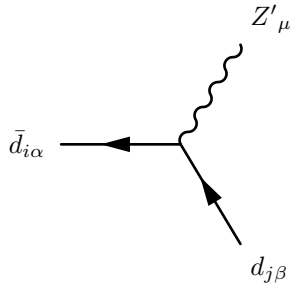
$$-\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-10g_{YB}+3g_1\Big)\cos\Theta_W - 9g_2\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{85}$$

$$+\ \frac{i}{9}\Big(3g_1+5g_{YB}\Big)\cos\Theta_W\delta_{\alpha\beta}\delta_{ij}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{86}$$



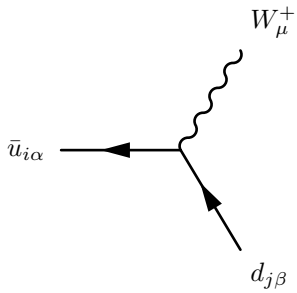
$$\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(10g_{1p}-3g_{BY}\Big)\sin\Theta'_W+\Big(-10g_{YB}+3g_1\Big)\cos\Theta'_W\sin\Theta_W+9g_2\cos\Theta_W\cos\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \quad (87)$$

$$+\ -\frac{i}{9}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(3g_1+5g_{YB}\Big)\cos\Theta'_W\sin\Theta_W-\Big(3g_{BY}+5g_{1p}\Big)\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \quad (88)$$

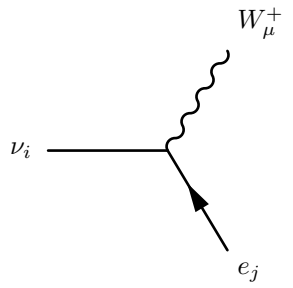


$$-\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-10g_{1p}+3g_{BY}\Big)\cos\Theta'_W+\Big(\Big(-10g_{YB}+3g_1\Big)\sin\Theta_W+9g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \quad (89)$$

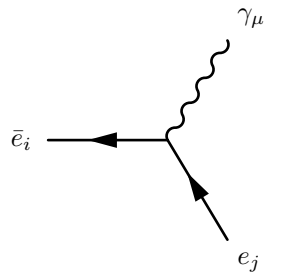
$$+\ \frac{i}{9}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(3g_1+5g_{YB}\Big)\sin\Theta_W\sin\Theta'_W+\Big(3g_{BY}+5g_{1p}\Big)\cos\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \quad (90)$$



$$-\,i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^{3}U^{d,*}_{L,ja}U^{u}_{L,ia}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \quad (91)$$

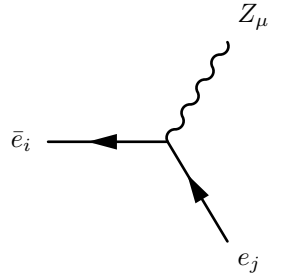


$$-i\frac{1}{\sqrt{2}}g_2\sum_{a=1}^{3}U_{L,ja}^{e,*}U_{ia}^{V}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{92}$$



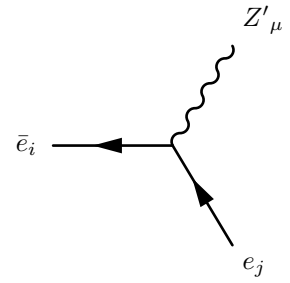
$$\frac{i}{2}\delta_{ij}\Big(g_1\cos\Theta_W+g_2\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{93}$$

$$+\ ig_1\cos\Theta_W\delta_{ij}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{94}$$



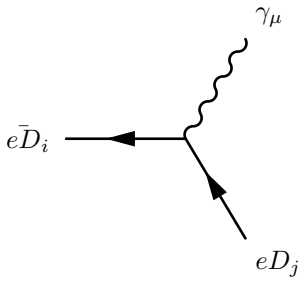
$$\frac{i}{2}\delta_{ij}\Big(-g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W+g_{BY}\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{95}$$

$$+\ -i\delta_{ij}\Big(g_1\cos\Theta'_W\sin\Theta_W-g_{BY}\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{96}$$



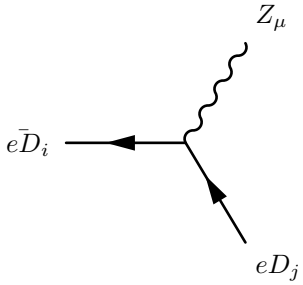
$$\frac{i}{2}\delta_{ij}\Big(\Big(g_1\sin\Theta_W - g_2\cos\Theta_W\Big)\sin\Theta'_W + g_{BY}\cos\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{97}$$

$$+\ i\delta_{ij}\Big(g_1\sin\Theta_W\sin\Theta'_W + g_{BY}\cos\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{98}$$

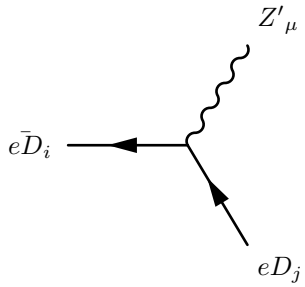


$$\frac{i}{2}\Big(2\Big(6g_{YB}+g_1\Big)UD^{e,*}_{L,j2}\cos\Theta_W UD^{e}_{L,i2} + UD^{e,*}_{L,j1}\Big(\Big(2g_{YB}+g_1\Big)\cos\Theta_W + g_2\sin\Theta_W\Big)UD^{e}_{L,i1}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{99}$$

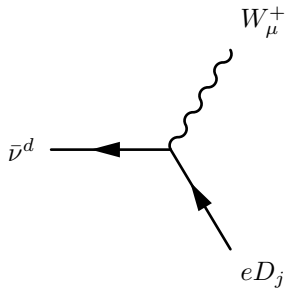
$$+\ \frac{i}{2}\Big(2\Big(g_1+g_{YB}\Big)UD^{e,*}_{R,i1}\cos\Theta_W UD^{e}_{R,j1} + UD^{e,*}_{R,i2}\Big(\Big(12g_{YB}+g_1\Big)\cos\Theta_W + g_2\sin\Theta_W\Big)UD^{e}_{R,j2}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{100}$$



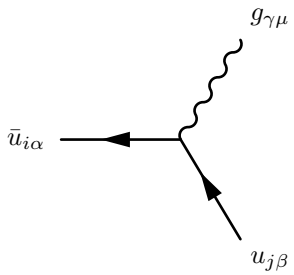
$$\frac{i}{2}\Big(UD^{e,*}_{L,j1}\Big(\Big(2g_{1p}+g_{BY}\Big)\sin\Theta'_W-\Big(2g_{YB}+g_1\Big)\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)UD^{e}_{L,i1}$$
$$+2UD^{e,*}_{L,j2}\Big(\Big(6g_{1p}+g_{BY}\Big)\sin\Theta'_W-\Big(6g_{YB}+g_1\Big)\cos\Theta'_W\sin\Theta_W\Big)UD^{e}_{L,i2}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{101}$$
$$+-\frac{i}{2}\Big(2UD^{e,*}_{R,i1}\Big(\Big(g_1+g_{YB}\Big)\cos\Theta'_W\sin\Theta_W-\Big(g_{BY}+g_{1p}\Big)\sin\Theta'_W\Big)UD^{e}_{R,j1}$$
$$-UD^{e,*}_{R,i2}\Big(\Big(12g_{1p}+g_{BY}\Big)\sin\Theta'_W-\Big(12g_{YB}+g_1\Big)\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)UD^{e}_{R,j2}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{102}$$



$$\frac{i}{2}\Big(UD^{e,*}_{L,j1}\Big(\Big(2g_{1p}+g_{BY}\Big)\cos\Theta'_W+\Big(\Big(2g_{YB}+g_1\Big)\sin\Theta_W-g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)UD^{e}_{L,i1}$$
$$+2UD^{e,*}_{L,j2}\Big(\Big(6g_{1p}+g_{BY}\Big)\cos\Theta'_W+\Big(6g_{YB}+g_1\Big)\sin\Theta_W\sin\Theta'_W\Big)UD^{e}_{L,i2}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{103}$$
$$+\frac{i}{2}\Big(2UD^{e,*}_{R,i1}\Big(\Big(g_1+g_{YB}\Big)\sin\Theta_W\sin\Theta'_W+\Big(g_{BY}+g_{1p}\Big)\cos\Theta'_W\Big)UD^{e}_{R,j1}$$
$$+UD^{e,*}_{R,i2}\Big(\Big(12g_{1p}+g_{BY}\Big)\cos\Theta'_W+\Big(\Big(12g_{YB}+g_1\Big)\sin\Theta_W-g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)UD^{e}_{R,j2}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{104}$$

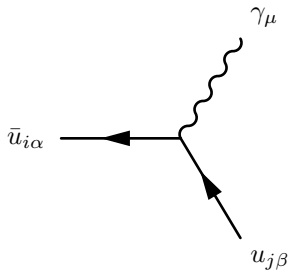


$$-i\frac{1}{\sqrt{2}}g_2UD^{e,*}_{L,j1}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{105}$$
$$+-i\frac{1}{\sqrt{2}}g_2UD^{e}_{R,j2}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{106}$$



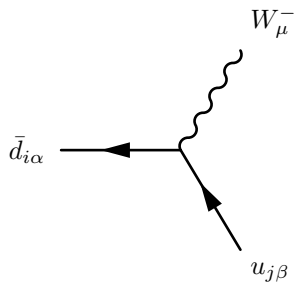
$$- \frac{i}{2} g_3 \delta_{ij} \lambda^{\gamma}_{\alpha,\beta} \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{107}$$

$$+ \; - \frac{i}{2} g_3 \delta_{ij} \lambda^{\gamma}_{\alpha,\beta} \Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2} \Big) \tag{108}$$

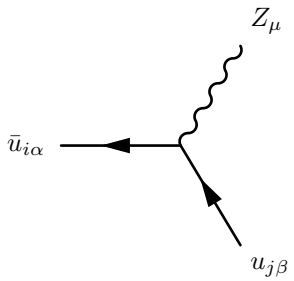


$$- \frac{i}{18} \delta_{\alpha\beta} \delta_{ij} \Big(\Big(-10 g_{YB} + 3 g_1 \Big) \cos\Theta_W + 9 g_2 \sin\Theta_W \Big) \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{109}$$

$$+ \; - \frac{i}{9} \Big(-5 g_{YB} + 6 g_1 \Big) \cos\Theta_W \delta_{\alpha\beta} \delta_{ij} \Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2} \Big) \tag{110}$$

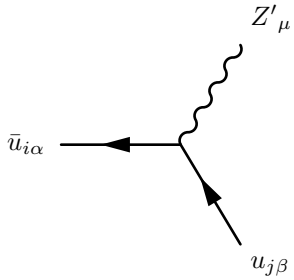


$$- i \frac{1}{\sqrt{2}} g_2 \delta_{\alpha\beta} \sum_{a=1}^{3} U^{u,*}_{L,ja} U^{d}_{L,ia} \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{111}$$



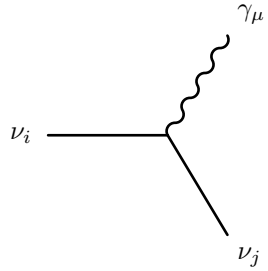
$$-\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-10g_{1p}+3g_{BY}\Big)\sin\Theta'_W-\Big(-10g_{YB}+3g_1\Big)\cos\Theta'_W\sin\Theta_W+9g_2\cos\Theta_W\cos\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{112}$$

$$+\frac{i}{9}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(5g_{1p}-6g_{BY}\Big)\sin\Theta'_W+\Big(-5g_{YB}+6g_1\Big)\cos\Theta'_W\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{113}$$



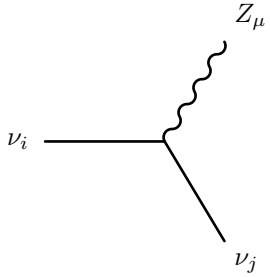
$$-\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-10g_{1p}+3g_{BY}\Big)\cos\Theta'_W+\Big(\Big(-10g_{YB}+3g_1\Big)\sin\Theta_W-9g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{114}$$

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



$$\frac{i}{2}\Big(10g_{YB}\cos\Theta_W\sum_{a=1}^{2}U^{V,*}_{j3+a}U^{V}_{i3+a}+\Big(g_1\cos\Theta_W-g_2\sin\Theta_W\Big)\sum_{a=1}^{3}U^{V,*}_{ja}U^{V}_{ia}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{116}$$

$$+\,-\frac{i}{2}\Big(10g_{YB}\cos\Theta_W\sum_{a=1}^{2}U^{V,*}_{i3+a}U^{V}_{j3+a}+\Big(g_1\cos\Theta_W-g_2\sin\Theta_W\Big)\sum_{a=1}^{3}U^{V,*}_{ia}U^{V}_{ja}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{117}$$

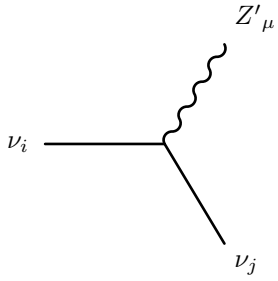


$$-\frac{i}{2}\Big(10\Big(-g_{1p}\sin\Theta'_W+g_{YB}\cos\Theta'_W\sin\Theta_W\Big)\sum_{a=1}^{2}U^{V,*}_{j3+a}U^{V}_{i3+a}$$

$$+\Big(g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W-g_{BY}\sin\Theta'_W\Big)\sum_{a=1}^{3}U^{V,*}_{ja}U^{V}_{ia}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{118}$$

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

$$+\Big(g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W-g_{BY}\sin\Theta'_W\Big)\sum_{a=1}^{3}U^{V,*}_{ia}U^{V}_{ja}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{119}$$

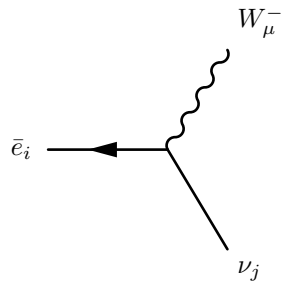


$$\frac{i}{2}\Big(10\Big(g_{1p}\cos\Theta'_W+g_{YB}\sin\Theta_W\sin\Theta'_W\Big)\sum_{a=1}^{2}U^{V,*}_{j3+a}U^{V}_{i3+a}$$

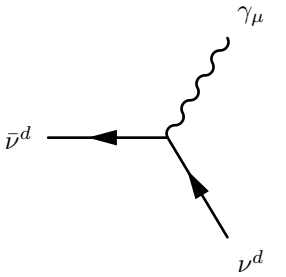
$$+\Big(\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W+g_{BY}\cos\Theta'_W\Big)\sum_{a=1}^{3}U^{V,*}_{ja}U^{V}_{ia}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{120}$$

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

$$+\Big(\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W+g_{BY}\cos\Theta'_W\Big)\sum_{a=1}^{3}U^{V,*}_{ia}U^{V}_{ja}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{121}$$

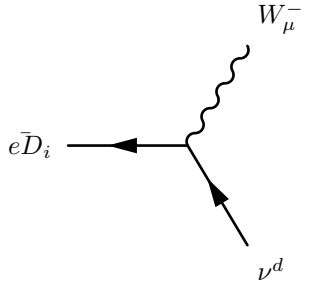


$$-i\frac{1}{\sqrt{2}}g_2\sum_{a=1}^{3}U^{V,*}_{ja}U^{e}_{L,ia}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{122}$$



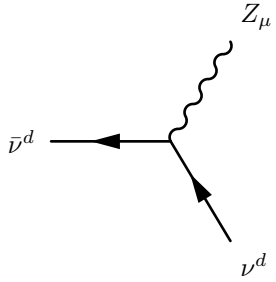
$$\frac{i}{2}\Big(\Big(2g_{YB}+g_1\Big)\cos\Theta_W-g_2\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{123}$$

$$+\frac{i}{2}\Big(\Big(12g_{YB}+g_1\Big)\cos\Theta_W-g_2\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{124}$$



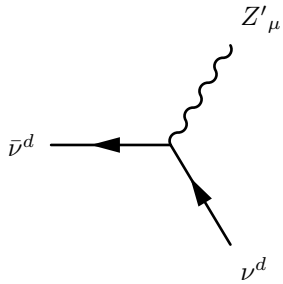
$$- i\frac{1}{\sqrt{2}}g_2 UD^e_{L,i1}\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{125}$$

$$+ -i\frac{1}{\sqrt{2}}g_2 UD^{e,*}_{R,i2}\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{126}$$



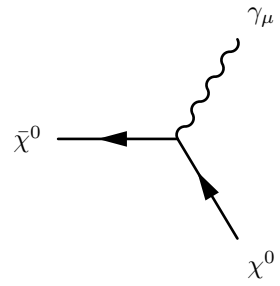
$$- \frac{i}{2}\Big(- \Big(2g_{1p} + g_{BY}\Big)\sin\Theta'_W + \Big(2g_{YB} + g_1\Big)\cos\Theta'_W \sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{127}$$

$$+ -\frac{i}{2}\Big(- \Big(12g_{1p} + g_{BY}\Big)\sin\Theta'_W + \Big(12g_{YB} + g_1\Big)\cos\Theta'_W \sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{128}$$



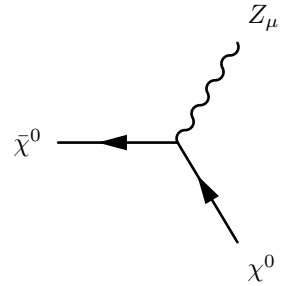
$$\frac{i}{2}\Big(\Big(2g_{1p} + g_{BY}\Big)\cos\Theta'_W + \Big(\Big(2g_{YB} + g_1\Big)\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{129}$$

$$+\ \frac{i}{2}\Big(\Big(12g_{1p}+g_{BY}\Big)\cos\Theta'_W+\Big(\Big(12g_{YB}+g_1\Big)\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{130}$$



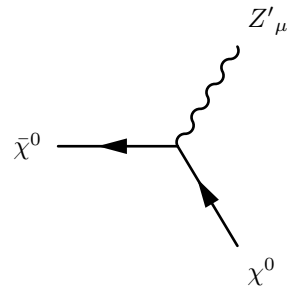
$$-\ 3ig_{YB}\cos\Theta_W\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{131}$$

$$+\ 2ig_{YB}\cos\Theta_W\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{132}$$



$$3i\Big(-g_{1p}\sin\Theta'_W+g_{YB}\cos\Theta'_W\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{133}$$

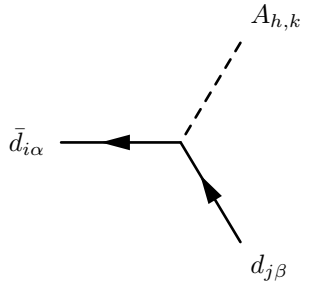
$$+\ -2i\Big(-g_{1p}\sin\Theta'_W+g_{YB}\cos\Theta'_W\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{134}$$



$$- 3i\Big(g_{1p}\cos\Theta'_W + g_{YB}\sin\Theta_W\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{135}$$

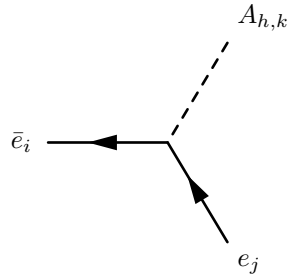
$$+ 2i\Big(g_{1p}\cos\Theta'_W + g_{YB}\sin\Theta_W\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{136}$$

7.5 Two Fermion-One Scalar Boson-Interaction



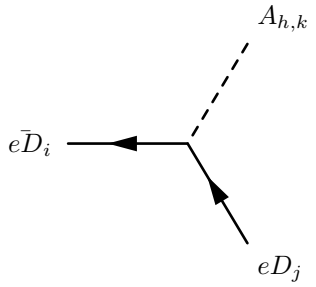
$$- \frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}U^{d,*}_{L,jb}\sum_{a=1}^{3}U^{d,*}_{R,ia}Y_{d,ab}Z^A_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{137}$$

$$+ \frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{d,ab}U^d_{R,ja}U^d_{L,ib}Z^A_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{138}$$



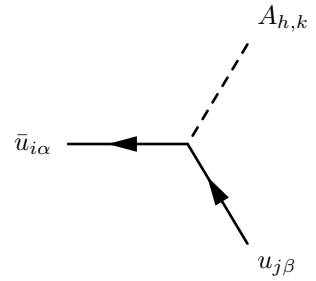
$$- \frac{1}{\sqrt{2}}\sum_{b=1}^{3}U^{e,*}_{L,jb}\sum_{a=1}^{3}U^{e,*}_{R,ia}Y_{e,ab}Z^A_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{139}$$

$$+ \frac{1}{\sqrt{2}}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{e,ab}U^e_{R,ja}U^e_{L,ib}Z^A_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{140}$$



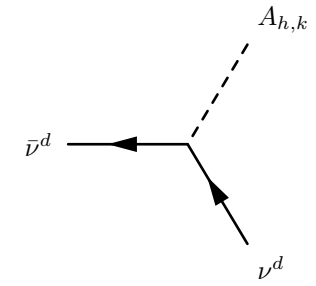
$$- \frac{1}{\sqrt{2}}\Big(UD^{e,*}_{R,i1}\Big(- \lambda_{b1}UD^{e,*}_{L,j2}Z^A_{k2} + \lambda_g UD^{e,*}_{L,j1}Z^A_{k1}\Big) + UD^{e,*}_{R,i2}\Big(\lambda_{c1}UD^{e,*}_{L,j1}Z^A_{k2} - \lambda_h UD^{e,*}_{L,j2}Z^A_{k1}\Big)\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{141}$$

$$+ \frac{1}{\sqrt{2}}\Big(- \lambda_{b1}UD^{e}_{R,j1}UD^{e}_{L,i2}Z^A_{k2} + \lambda^*_g UD^{e}_{R,j1}UD^{e}_{L,i1}Z^A_{k1} + UD^{e}_{R,j2}\Big(\lambda_{c1}UD^{e}_{L,i1}Z^A_{k2} - \lambda_h UD^{e}_{L,i2}Z^A_{k1}\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{142}$$



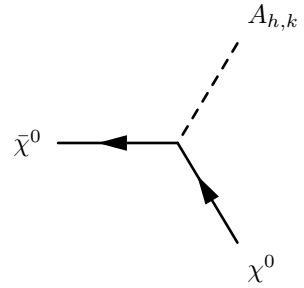
$$- \frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}U^{u,*}_{L,jb}\sum_{a=1}^{3}U^{u,*}_{R,ia}Y_{u,ab}Z^A_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{143}$$

$$+ \frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{u,ab}U^{u}_{R,ja}U^{u}_{L,ib}Z^A_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{144}$$



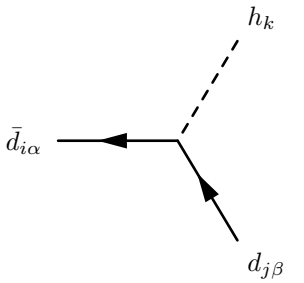
$$- \frac{1}{\sqrt{2}}\lambda_{c1} Z^A_{k2}\Big(\frac{1-\gamma_5}{2}\Big) \tag{145}$$

$$+ \frac{1}{\sqrt{2}}\lambda_{c1} Z^A_{k2}\Big(\frac{1+\gamma_5}{2}\Big) \tag{146}$$



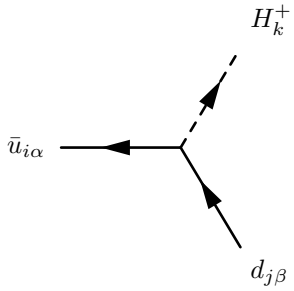
$$- \frac{1}{\sqrt{2}}\lambda_{a1} Z^A_{k2}\Big(\frac{1-\gamma_5}{2}\Big) \tag{147}$$

$$+ \frac{1}{\sqrt{2}}\lambda_{a1} Z^A_{k2}\Big(\frac{1+\gamma_5}{2}\Big) \tag{148}$$



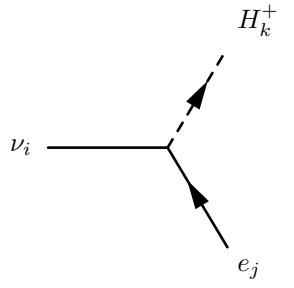
$$- i\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3} U^{d,*}_{L,jb}\sum_{a=1}^{3} U^{d,*}_{R,ia} Y_{d,ab} Z^H_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{149}$$

$$+ -i\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^*_{d,ab} U^d_{R,ja} U^d_{L,ib} Z^H_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{150}$$



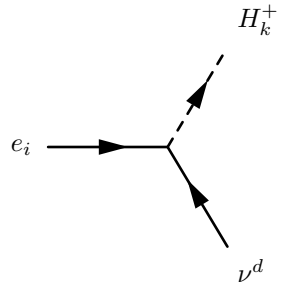
$$- i\delta_{\alpha\beta} \sum_{b=1}^{3} U_{L,jb}^{d,*} \sum_{a=1}^{3} U_{R,ia}^{u,*} Y_{u,ab} Z_{k1}^{+} \Big(\frac{1-\gamma_5}{2} \Big) \tag{151}$$

$$+ \; -i\delta_{\alpha\beta} \sum_{b=1}^{3} \sum_{a=1}^{3} Y_{d,ab}^{*} U_{R,ja}^{d} U_{L,ib}^{u} Z_{k1}^{+} \Big(\frac{1+\gamma_5}{2} \Big) \tag{152}$$

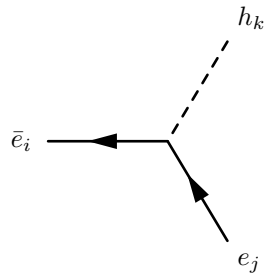


(153)

$$+ \; -i \sum_{b=1}^{3} \sum_{a=1}^{3} Y_{e,ab}^{*} U_{R,ja}^{e} U_{ib}^{V} Z_{k1}^{+} \Big(\frac{1+\gamma_5}{2} \Big) \tag{154}$$

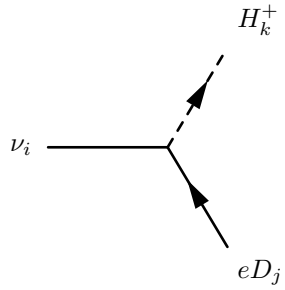


$$i\sum_{b=1}^{3} U^{e,*}_{L,ib} \sum_{a=1}^{2} \lambda_{d,ab} Z^{+}_{k1+a} \Big(\frac{1-\gamma_5}{2}\Big) \tag{155}$$



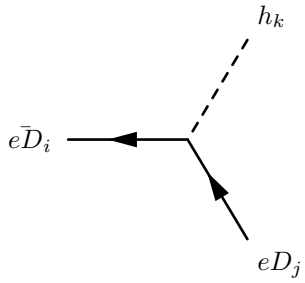
$$-i\frac{1}{\sqrt{2}}\sum_{b=1}^{3} U^{e,*}_{L,jb} \sum_{a=1}^{3} U^{e,*}_{R,ia} Y_{e,ab} Z^{H}_{k1} \Big(\frac{1-\gamma_5}{2}\Big) \tag{156}$$

$$+\ -i\frac{1}{\sqrt{2}}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{e,ab} U^{e}_{R,ja} U^{e}_{L,ib} Z^{H}_{k1} \Big(\frac{1+\gamma_5}{2}\Big) \tag{157}$$



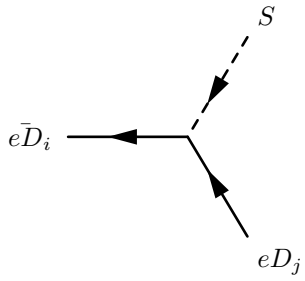
$$-iUD^{e,*}_{L,j1} \sum_{b=1}^{3} U^{V,*}_{ib} \sum_{a=1}^{2} \lambda_{d,ab} Z^{+}_{k1+a} \Big(\frac{1-\gamma_5}{2}\Big) \tag{158}$$

$$+\ -i\sum_{b=1}^{2}\sum_{a=1}^{2} \lambda^{*}_{e,ab} Z^{+}_{k3+a} U^{V}_{i3+b} UD^{e}_{R,j1} \Big(\frac{1+\gamma_5}{2}\Big) \tag{159}$$



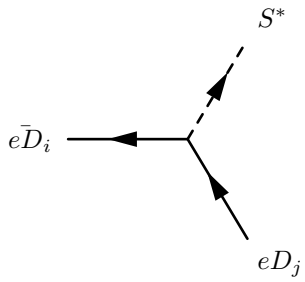
$$i\frac{1}{\sqrt{2}}\Big(-UD^{e,*}_{R,i1}\Big(\lambda_{b1}UD^{e,*}_{L,j2}Z^H_{k2}+\lambda_g UD^{e,*}_{L,j1}Z^H_{k1}\Big)-UD^{e,*}_{R,i2}\Big(\lambda_{c1}UD^{e,*}_{L,j1}Z^H_{k2}+\lambda_h UD^{e,*}_{L,j2}Z^H_{k1}\Big)\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{160}$$

$$+\ -i\frac{1}{\sqrt{2}}\Big(\lambda_{b1}UD^{e}_{R,j1}UD^{e}_{L,i2}Z^H_{k2}+\lambda^*_g UD^{e}_{R,j1}UD^{e}_{L,i1}Z^H_{k1}+UD^{e}_{R,j2}\Big(\lambda_{c1}UD^{e}_{L,i1}Z^H_{k2}+\lambda_h UD^{e}_{L,i2}Z^H_{k1}\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{161}$$



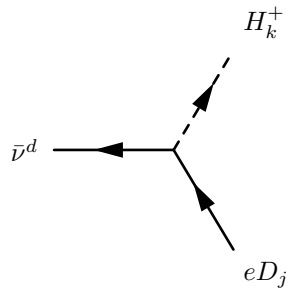
$$-i\lambda_{b2}UD^{e,*}_{R,i1}UD^{e,*}_{L,j2}\Big(\frac{1-\gamma_5}{2}\Big) \tag{162}$$

$$+\ -i\lambda_{c2}UD^{e}_{R,j2}UD^{e}_{L,i1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{163}$$



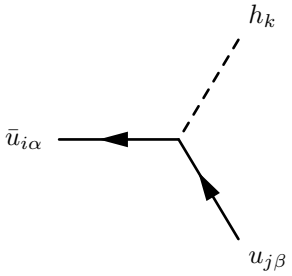
$$-i\lambda_{c2}UD^{e,*}_{R,i2}UD^{e,*}_{L,j1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{164}$$

$$+\ -i\lambda_{b2} UD^{e}_{R,j1} UD^{e}_{L,i2} \Big(\frac{1+\gamma_5}{2}\Big) \tag{165}$$



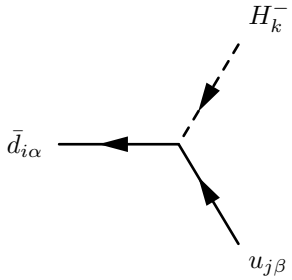
$$-\ i\lambda_h UD^{e,*}_{L,j2} Z^{+}_{k1} \Big(\frac{1-\gamma_5}{2}\Big) \tag{166}$$

$$+\ -i\lambda^{*}_{g} UD^{e}_{R,j1} Z^{+}_{k1} \Big(\frac{1+\gamma_5}{2}\Big) \tag{167}$$



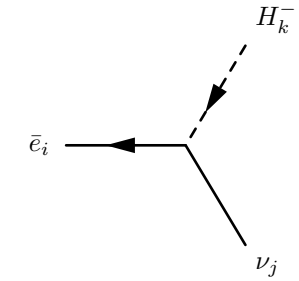
$$i\frac{1}{\sqrt{2}}\delta_{\alpha\beta} \sum_{b=1}^{3} U^{u,*}_{L,jb} \sum_{a=1}^{3} U^{u,*}_{R,ia} Y_{u,ab} Z^{H}_{k1} \Big(\frac{1-\gamma_5}{2}\Big) \tag{168}$$

$$+\ i\frac{1}{\sqrt{2}}\delta_{\alpha\beta} \sum_{b=1}^{3} \sum_{a=1}^{3} Y^{*}_{u,ab} U^{u}_{R,ja} U^{u}_{L,ib} Z^{H}_{k1} \Big(\frac{1+\gamma_5}{2}\Big) \tag{169}$$

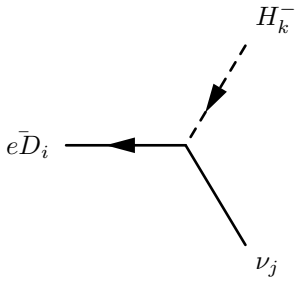


$$- i\delta_{\alpha\beta} \sum_{b=1}^{3} U_{L,jb}^{u,*} \sum_{a=1}^{3} U_{R,ia}^{d,*} Y_{d,ab} Z_{k1}^{+} \Big(\frac{1-\gamma_5}{2} \Big) \tag{170}$$

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

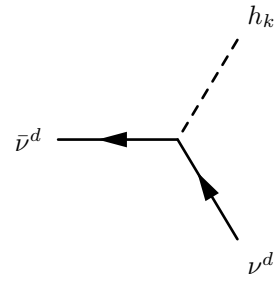


$$- i \sum_{b=1}^{3} U_{jb}^{V,*} \sum_{a=1}^{3} U_{R,ia}^{e,*} Y_{e,ab} Z_{k1}^{+} \Big(\frac{1-\gamma_5}{2} \Big) \tag{172}$$



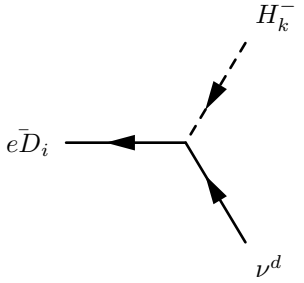
$$- iUD_{R,i1}^{e,*} \sum_{b=1}^{2} U_{j3+b}^{V,*} \sum_{a=1}^{2} \lambda_{e,ab} Z_{k3+a}^{+} \Big(\frac{1-\gamma_5}{2} \Big) \tag{173}$$

$$+ \; -i \sum_{b=1}^{3} \sum_{a=1}^{2} \lambda_{d,ab}^{*} Z_{k1+a}^{+} U_{jb}^{V} UD_{L,i1}^{e} \Big(\frac{1+\gamma_5}{2} \Big) \tag{174}$$



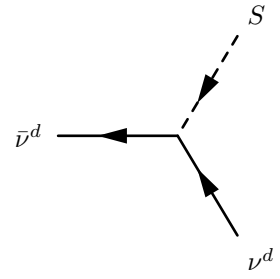
$$- i\frac{1}{\sqrt{2}}\lambda_{c1} Z^H_{k2}\Big(\frac{1-\gamma_5}{2}\Big) \tag{175}$$

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



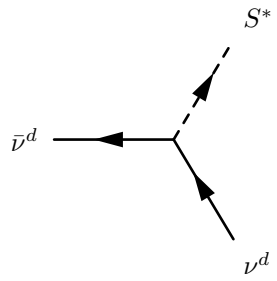
$$- i\lambda_g UD^{e,*}_{R,i1} Z^+_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{177}$$

$$+ -i\lambda_h UD^{e}_{L,i2} Z^+_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{178}$$

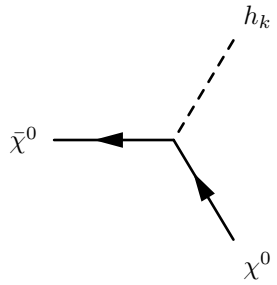


$$\tag{179}$$

$$+ -i\lambda_{c2}\Big(\frac{1+\gamma_5}{2}\Big) \tag{180}$$

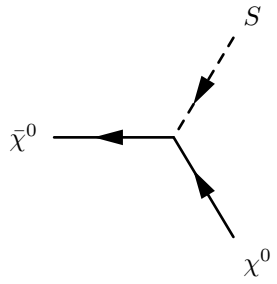


$$-i\lambda_{c2}\Big(\frac{1-\gamma_5}{2}\Big) \tag{181}$$



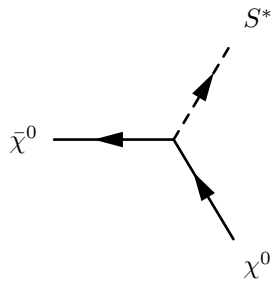
$$-i\frac{1}{\sqrt{2}}\lambda_{a1}Z^H_{k2}\Big(\frac{1-\gamma_5}{2}\Big) \tag{182}$$

$$+\ -i\frac{1}{\sqrt{2}}\lambda_{a1}Z^H_{k2}\Big(\frac{1+\gamma_5}{2}\Big) \tag{183}$$

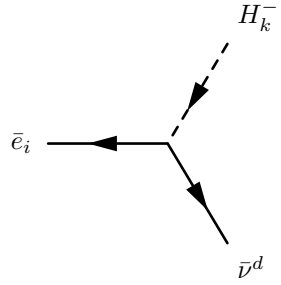


(184)

$$+\ -i\lambda_{a2}\Big(\frac{1+\gamma_5}{2}\Big) \tag{185}$$



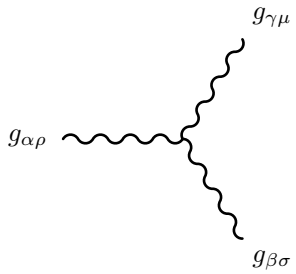
$$-i\lambda_{a2}\Big(\frac{1-\gamma_5}{2}\Big) \tag{186}$$



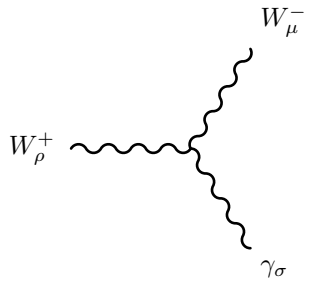
(187)

$$+\ i\sum_{b=1}^{3}\sum_{a=1}^{2}\lambda^*_{d,ab}Z^+_{k1+a}U^e_{L,ib}\Big(\frac{1+\gamma_5}{2}\Big) \tag{188}$$

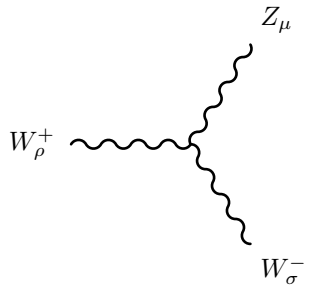
7.6 Three Vector Boson-Interaction



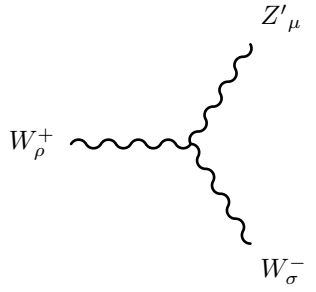
$$g_3 f_{\alpha,\beta,\gamma}\Big(g_{\rho\mu}\Big(-p_\sigma^{g_{\gamma\mu}}+p_\sigma^{g_{\alpha\rho}}\Big)+g_{\rho\sigma}\Big(-p_\mu^{g_{\alpha\rho}}+p_\mu^{g_{\beta\sigma}}\Big)+g_{\sigma\mu}\Big(-p_\rho^{g_{\beta\sigma}}+p_\rho^{g_{\gamma\mu}}\Big)\Big) \tag{189}$$



$$ig_2 \sin\Theta_W \Big(g_{\rho\mu}\Big(-p_\sigma^{W_\mu^-} + p_\sigma^{W_\rho^+}\Big) + g_{\rho\sigma}\Big(-p_\mu^{W_\rho^+} + p_\mu^{\gamma_\sigma}\Big) + g_{\sigma\mu}\Big(-p_\rho^{\gamma_\sigma} + p_\rho^{W_\mu^-}\Big)\Big) \tag{190}$$

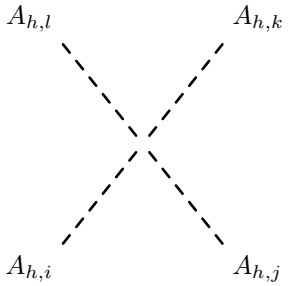


$$-ig_2 \cos\Theta_W \cos\Theta'_W \Big(g_{\rho\mu}\Big(-p_\sigma^{Z_\mu} + p_\sigma^{W_\rho^+}\Big) + g_{\rho\sigma}\Big(-p_\mu^{W_\rho^+} + p_\mu^{W_\sigma^-}\Big) + g_{\sigma\mu}\Big(-p_\rho^{W_\sigma^-} + p_\rho^{Z_\mu}\Big)\Big) \tag{191}$$

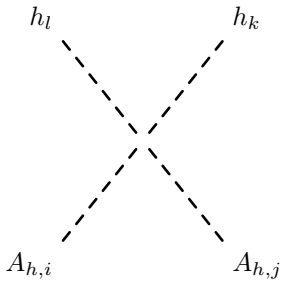


$$ig_2 \cos\Theta_W \sin\Theta'_W \Big(g_{\rho\mu}\Big(-p_\sigma^{Z'_\mu} + p_\sigma^{W_\rho^+}\Big) + g_{\rho\sigma}\Big(-p_\mu^{W_\rho^+} + p_\mu^{W_\sigma^-}\Big) + g_{\sigma\mu}\Big(-p_\rho^{W_\sigma^-} + p_\rho^{Z'_\mu}\Big)\Big) \tag{192}$$

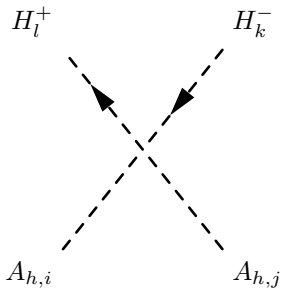
7.7 Four Scalar-Interaction



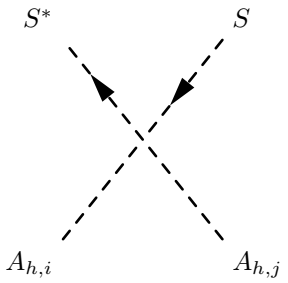
$$i\Big(Z^A_{i2}\Big(\lambda_3 Z^A_{j1}\Big(Z^A_{k1}Z^A_{l2}+Z^A_{k2}Z^A_{l1}\Big)+Z^A_{j2}\Big(6\lambda_2 Z^A_{k2}Z^A_{l2}+\lambda_3 Z^A_{k1}Z^A_{l1}\Big)\Big) \\ +Z^A_{i1}\Big(\lambda_3 Z^A_{j2}\Big(Z^A_{k1}Z^A_{l2}+Z^A_{k2}Z^A_{l1}\Big)+Z^A_{j1}\Big(6l_h Z^A_{k1}Z^A_{l1}+\lambda_3 Z^A_{k2}Z^A_{l2}\Big)\Big)\Big) \tag{193}$$



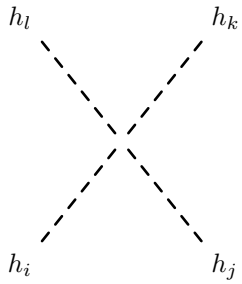
$$i\Big(Z^A_{i1}Z^A_{j1}\Big(2l_h Z^H_{k1}Z^H_{l1}+\lambda_3 Z^H_{k2}Z^H_{l2}\Big)+Z^A_{i2}Z^A_{j2}\Big(2\lambda_2 Z^H_{k2}Z^H_{l2}+\lambda_3 Z^H_{k1}Z^H_{l1}\Big)\Big) \tag{194}$$



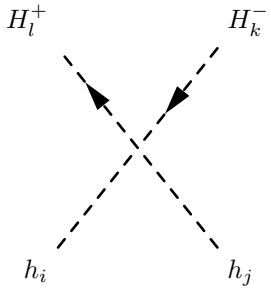
$$i\Big(-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{6,ab}Z^+_{l1+a}Z^+_{k1+b}Z^A_{i1}Z^A_{j1}-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{7,ab}Z^+_{l3+a}Z^+_{k3+b}Z^A_{i1}Z^A_{j1} \\ +\Big(2l_h Z^A_{i1}Z^A_{j1}+\lambda_3 Z^A_{i2}Z^A_{j2}\Big)Z^+_{k1}Z^+_{l1}\Big) \tag{195}$$



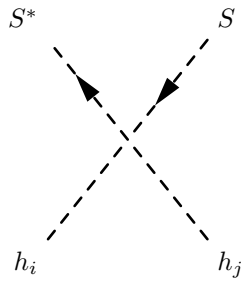
$$i\lambda_5 Z^A_{i1} Z^A_{j1} \tag{196}$$



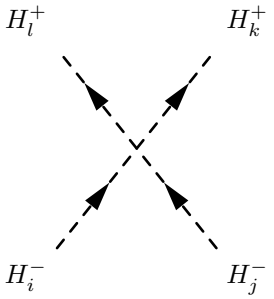
$$\begin{aligned} &i\Big(Z^H_{i2}\Big(\lambda_3 Z^H_{j1}\Big(Z^H_{k1}Z^H_{l2} + Z^H_{k2}Z^H_{l1}\Big) + Z^H_{j2}\Big(6\lambda_2 Z^H_{k2}Z^H_{l2} + \lambda_3 Z^H_{k1}Z^H_{l1}\Big)\Big) \\ &+ Z^H_{i1}\Big(\lambda_3 Z^H_{j2}\Big(Z^H_{k1}Z^H_{l2} + Z^H_{k2}Z^H_{l1}\Big) + Z^H_{j1}\Big(6l_h Z^H_{k1}Z^H_{l1} + \lambda_3 Z^H_{k2}Z^H_{l2}\Big)\Big)\Big) \end{aligned} \tag{197}$$



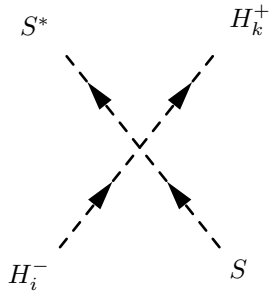
$$\begin{aligned} &i\Big(-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{6,ab} Z^+_{l1+a} Z^+_{k1+b} Z^H_{i1} Z^H_{j1} - \sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{7,ab} Z^+_{l3+a} Z^+_{k3+b} Z^H_{i1} Z^H_{j1} \\ &+ \Big(2l_h Z^H_{i1} Z^H_{j1} + \lambda_3 Z^H_{i2} Z^H_{j2}\Big) Z^+_{k1} Z^+_{l1}\Big) \end{aligned} \tag{198}$$



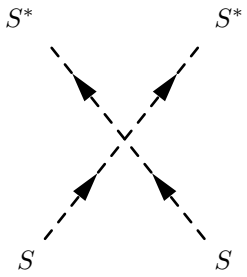
$$i\lambda_5 Z^H_{i1} Z^H_{j1} \tag{199}$$



$$\begin{aligned}
&i\Big(-\sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{6,ab} Z^+_{l1+a} Z^+_{j1+b} Z^+_{i1} Z^+_{k1} - \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{7,ab} Z^+_{l3+a} Z^+_{j3+b} Z^+_{i1} Z^+_{k1} \\
&- \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{6,ab} Z^+_{l1+a} Z^+_{i1+b} Z^+_{j1} Z^+_{k1} - \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{7,ab} Z^+_{l3+a} Z^+_{i3+b} Z^+_{j1} Z^+_{k1} \\
&- \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{6,ab} Z^+_{k1+a} Z^+_{j1+b} Z^+_{i1} Z^+_{l1} - \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{7,ab} Z^+_{k3+a} Z^+_{j3+b} Z^+_{i1} Z^+_{l1} \\
&- \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{6,ab} Z^+_{k1+a} Z^+_{i1+b} Z^+_{j1} Z^+_{l1} - \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{7,ab} Z^+_{k3+a} Z^+_{i3+b} Z^+_{j1} Z^+_{l1} \\
&+ 4 l_h Z^+_{i1} Z^+_{j1} Z^+_{k1} Z^+_{l1} \Big)
\end{aligned} \tag{200}$$

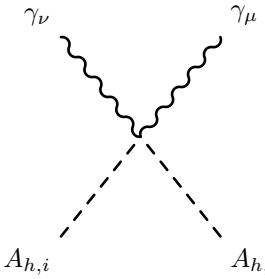


$$i\lambda_5 Z_{i1}^+ Z_{k1}^+ \tag{201}$$

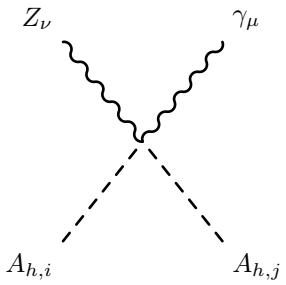


$$4i\lambda_4 \tag{202}$$

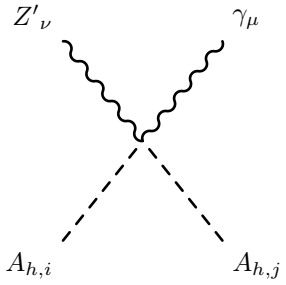
7.8 Two Scalar-Two Vector Boson-Interaction



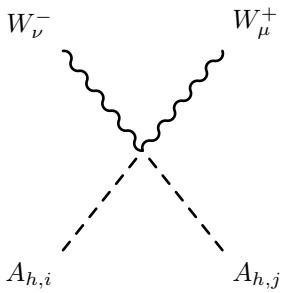
$$\begin{aligned}&\Big(+ \frac{i}{2} g_1^2 \cos\Theta_W^2 Z_{i1}^A Z_{j1}^A - i g_1 g_2 \cos\Theta_W \sin\Theta_W Z_{i1}^A Z_{j1}^A \\ &+ \frac{i}{2} g_2^2 \sin\Theta_W^2 Z_{i1}^A Z_{j1}^A + 50 i g_{Y\,B}^2 \cos\Theta_W^2 Z_{i2}^A Z_{j2}^A \Big) \Big(g_{\mu\nu} \Big)\end{aligned} \tag{203}$$



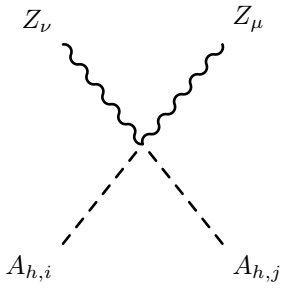
$$\Big(-\frac{i}{2} g_1 g_2 \cos\Theta_W^2 \cos\Theta'_W Z_{i1}^A Z_{j1}^A - \frac{i}{2} g_1^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i1}^A Z_{j1}^A$$
$$+ \frac{i}{2} g_2^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i1}^A Z_{j1}^A + \frac{i}{2} g_1 g_2 \cos\Theta'_W \sin\Theta_W^2 Z_{i1}^A Z_{j1}^A$$
$$+ \frac{i}{2} g_1 g_{BY} \cos\Theta_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A - \frac{i}{2} g_{BY} g_2 \sin\Theta_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A$$
$$- 50 i g_{YB}^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i2}^A Z_{j2}^A + 50 i g_{1p} g_{YB} \cos\Theta_W \sin\Theta'_W Z_{i2}^A Z_{j2}^A \Big) \Big(g_{\mu\nu} \Big) \tag{204}$$



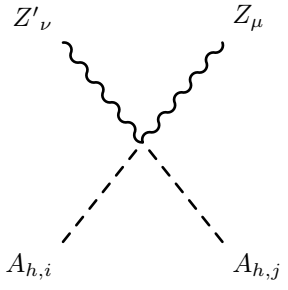
$$\Big(+ \frac{i}{2} g_1 g_{BY} \cos\Theta_W \cos\Theta'_W Z_{i1}^A Z_{j1}^A - \frac{i}{2} g_{BY} g_2 \cos\Theta'_W \sin\Theta_W Z_{i1}^A Z_{j1}^A$$
$$+ \frac{i}{2} g_1 g_2 \cos\Theta_W^2 \sin\Theta'_W Z_{i1}^A Z_{j1}^A + \frac{i}{2} g_1^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A$$
$$- \frac{i}{2} g_2^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A - \frac{i}{2} g_1 g_2 \sin\Theta_W^2 \sin\Theta'_W Z_{i1}^A Z_{j1}^A$$
$$+ 50 i g_{1p} g_{YB} \cos\Theta_W \cos\Theta'_W Z_{i2}^A Z_{j2}^A + 25 i g_{YB}^2 \sin 2\Theta_W \sin\Theta'_W Z_{i2}^A Z_{j2}^A \Big) \Big(g_{\mu\nu} \Big) \tag{205}$$



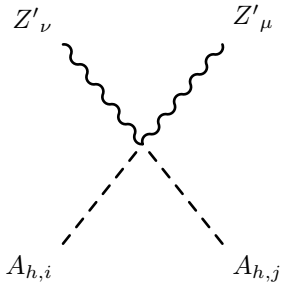
$$\frac{i}{2}g_2^2 Z_{i1}^A Z_{j1}^A \Big(g_{\mu\nu}\Big) \tag{206}$$



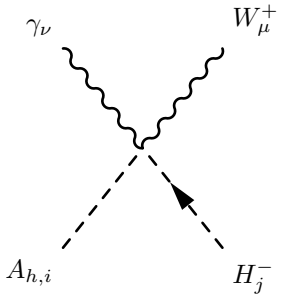
$$\begin{aligned}
&\Big(+ \frac{i}{2}g_2^2 \cos\Theta_W^2 \cos\Theta'^2_W Z_{i1}^A Z_{j1}^A + ig_1 g_2 \cos\Theta_W \cos\Theta'^2_W \sin\Theta_W Z_{i1}^A Z_{j1}^A \\
&+ \frac{i}{2}g_1^2 \cos\Theta'^2_W \sin\Theta_W^2 Z_{i1}^A Z_{j1}^A - ig_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A \\
&- ig_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A + \frac{i}{2}g_{BY}^2 \sin\Theta'^2_W Z_{i1}^A Z_{j1}^A \\
&+ 50ig_{YB}^2 \cos\Theta'^2_W \sin\Theta_W^2 Z_{i2}^A Z_{j2}^A - 100ig_{1p} g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i2}^A Z_{j2}^A \\
&+ 50ig_{1p}^2 \sin\Theta'^2_W Z_{i2}^A Z_{j2}^A \Big) \Big(g_{\mu\nu}\Big)
\end{aligned} \tag{207}$$



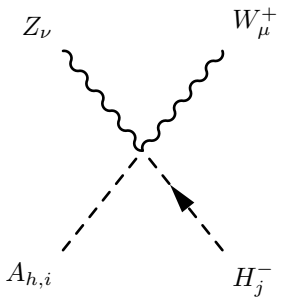
$$\Big(-\frac{i}{2} g_{BY} g_2 \cos\Theta_W \cos\Theta'^2_W Z^A_{i1} Z^A_{j1} - \frac{i}{2} g_1 g_{BY} \cos\Theta'^2_W \sin\Theta_W Z^A_{i1} Z^A_{j1}$$
$$+ \frac{i}{2} g^2_{BY} \cos\Theta'_W \sin\Theta'_W Z^A_{i1} Z^A_{j1} - \frac{i}{2} g^2_2 \cos\Theta^2_W \cos\Theta'_W \sin\Theta'_W Z^A_{i1} Z^A_{j1}$$
$$- \frac{i}{2} g^2_1 \cos\Theta'_W \sin\Theta^2_W \sin\Theta'_W Z^A_{i1} Z^A_{j1} + \frac{i}{2} g_{BY} g_2 \cos\Theta_W \sin\Theta'^2_W Z^A_{i1} Z^A_{j1}$$
$$+ \frac{i}{2} g_1 g_{BY} \sin\Theta_W \sin\Theta'^2_W Z^A_{i1} Z^A_{j1} - \frac{i}{2} g_1 g_2 \cos\Theta_W \sin\Theta_W \sin 2\Theta'_W Z^A_{i1} Z^A_{j1}$$
$$- 50 i g_{1p} g_{YB} \cos\Theta'^2_W \sin\Theta_W Z^A_{i2} Z^A_{j2} + 50 i g_{1p} g_{YB} \sin\Theta_W \sin\Theta'^2_W Z^A_{i2} Z^A_{j2}$$
$$+ 25 i g^2_{1p} \sin 2\Theta'_W Z^A_{i2} Z^A_{j2} - 25 i g^2_{YB} \sin\Theta^2_W \sin 2\Theta'_W Z^A_{i2} Z^A_{j2} \Big) \Big(g_{\mu\nu} \Big) \tag{208}$$



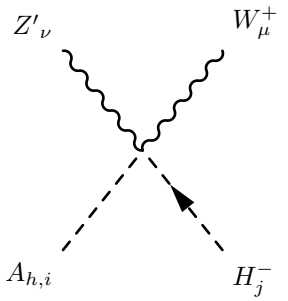
$$\Big(+ \frac{i}{2} g^2_{BY} \cos\Theta'^2_W Z^A_{i1} Z^A_{j1} + i g_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z^A_{i1} Z^A_{j1}$$
$$+ i g_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^A_{i1} Z^A_{j1} + \frac{i}{2} g^2_2 \cos\Theta^2_W \sin\Theta'^2_W Z^A_{i1} Z^A_{j1}$$
$$+ i g_1 g_2 \cos\Theta_W \sin\Theta_W \sin\Theta'^2_W Z^A_{i1} Z^A_{j1} + \frac{i}{2} g^2_1 \sin\Theta^2_W \sin\Theta'^2_W Z^A_{i1} Z^A_{j1}$$
$$+ 50 i g^2_{1p} \cos\Theta'^2_W Z^A_{i2} Z^A_{j2} + 100 i g_{1p} g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^A_{i2} Z^A_{j2}$$
$$+ 50 i g^2_{YB} \sin\Theta^2_W \sin\Theta'^2_W Z^A_{i2} Z^A_{j2} \Big) \Big(g_{\mu\nu} \Big) \tag{209}$$



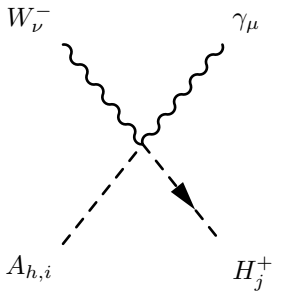
$$- \frac{1}{2} g_1 g_2 \cos\Theta_W Z^A_{i1} Z^+_{j1} \Big(g_{\mu\nu} \Big) \tag{210}$$



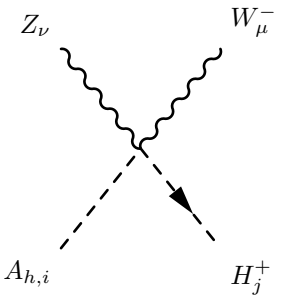
$$\Big(\frac{1}{2}g_1 g_2 \cos\Theta'_W \sin\Theta_W Z^A_{i1} Z^+_{j1} - \frac{1}{2}g_{BY} g_2 \sin\Theta'_W Z^A_{i1} Z^+_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{211}$$



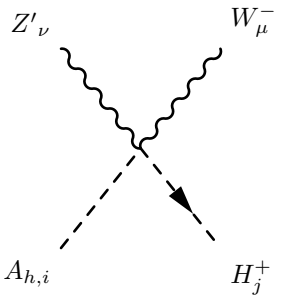
$$\Big(-\frac{1}{2}g_1 g_2 \sin\Theta_W \sin\Theta'_W Z^A_{i1} Z^+_{j1} - \frac{1}{2}g_{BY} g_2 \cos\Theta'_W Z^A_{i1} Z^+_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{212}$$



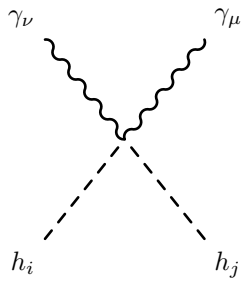
$$\frac{1}{2}g_1 g_2 \cos\Theta_W Z^A_{i1} Z^+_{j1}\Big(g_{\mu\nu}\Big) \tag{213}$$



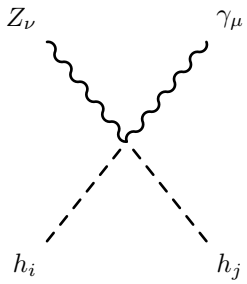
$$\Big(-\frac{1}{2} g_1 g_2 \cos\Theta'_W \sin\Theta_W Z^A_{i1} Z^+_{j1} + \frac{1}{2} g_{BY} g_2 \sin\Theta'_W Z^A_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big) \tag{214}$$



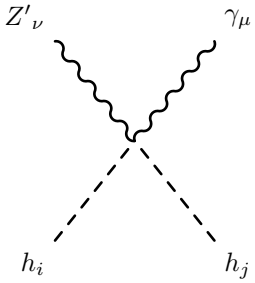
$$\Big(\frac{1}{2} g_1 g_2 \sin\Theta_W \sin\Theta'_W Z^A_{i1} Z^+_{j1} + \frac{1}{2} g_{BY} g_2 \cos\Theta'_W Z^A_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big) \tag{215}$$



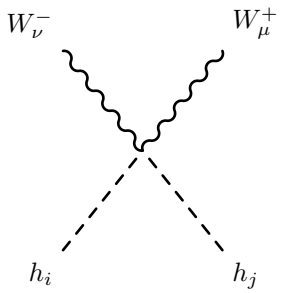
$$\begin{aligned} &\Big(+ \frac{i}{2} g_1^2 \cos\Theta_W^2 Z^H_{i1} Z^H_{j1} - i g_1 g_2 \cos\Theta_W \sin\Theta_W Z^H_{i1} Z^H_{j1} \\ &+ \frac{i}{2} g_2^2 \sin\Theta_W^2 Z^H_{i1} Z^H_{j1} + 50 i g_{YB}^2 \cos\Theta_W^2 Z^H_{i2} Z^H_{j2} \Big) \Big(g_{\mu\nu} \Big) \end{aligned} \tag{216}$$



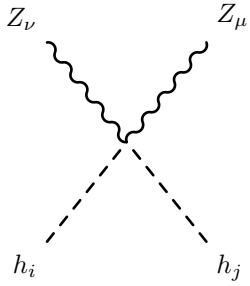
$$\Big(-\frac{i}{2} g_1 g_2 \cos\Theta_W^2 \cos\Theta'_W Z_{i1}^H Z_{j1}^H - \frac{i}{2} g_1^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i1}^H Z_{j1}^H$$
$$+ \frac{i}{2} g_2^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i1}^H Z_{j1}^H + \frac{i}{2} g_1 g_2 \cos\Theta'_W \sin\Theta_W^2 Z_{i1}^H Z_{j1}^H$$
$$+ \frac{i}{2} g_1 g_{BY} \cos\Theta_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H - \frac{i}{2} g_{BY} g_2 \sin\Theta_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H$$
$$- 50 i g_{YB}^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i2}^H Z_{j2}^H + 50 i g_{1p} g_{YB} \cos\Theta_W \sin\Theta'_W Z_{i2}^H Z_{j2}^H \Big) \Big(g_{\mu\nu} \Big) \tag{217}$$



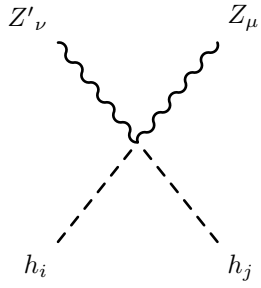
$$\Big(+ \frac{i}{2} g_1 g_{BY} \cos\Theta_W \cos\Theta'_W Z_{i1}^H Z_{j1}^H - \frac{i}{2} g_{BY} g_2 \cos\Theta'_W \sin\Theta_W Z_{i1}^H Z_{j1}^H$$
$$+ \frac{i}{2} g_1 g_2 \cos\Theta_W^2 \sin\Theta'_W Z_{i1}^H Z_{j1}^H + \frac{i}{2} g_1^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H$$
$$- \frac{i}{2} g_2^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H - \frac{i}{2} g_1 g_2 \sin\Theta_W^2 \sin\Theta'_W Z_{i1}^H Z_{j1}^H$$
$$+ 50 i g_{1p} g_{YB} \cos\Theta_W \cos\Theta'_W Z_{i2}^H Z_{j2}^H + 25 i g_{YB}^2 \sin 2\Theta_W \sin\Theta'_W Z_{i2}^H Z_{j2}^H \Big) \Big(g_{\mu\nu} \Big) \tag{218}$$



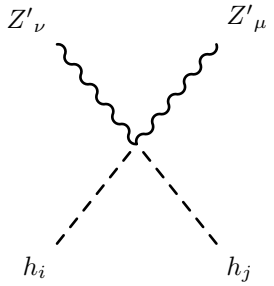
$$\frac{i}{2}g_2^2 Z_{i1}^H Z_{j1}^H \Big(g_{\mu\nu}\Big) \tag{219}$$



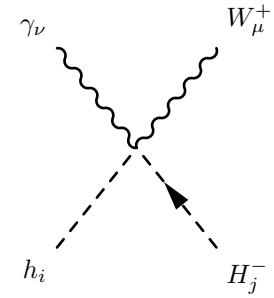
$$\begin{aligned}
&\Big(+ \frac{i}{2}g_2^2 \cos\Theta_W^2 \cos\Theta'^2_W Z_{i1}^H Z_{j1}^H + ig_1 g_2 \cos\Theta_W \cos\Theta'^2_W \sin\Theta_W Z_{i1}^H Z_{j1}^H \\
&+ \frac{i}{2}g_1^2 \cos\Theta'^2_W \sin\Theta_W^2 Z_{i1}^H Z_{j1}^H - ig_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H \\
&- ig_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H + \frac{i}{2}g_{BY}^2 \sin\Theta'^2_W Z_{i1}^H Z_{j1}^H \\
&+ 50ig_{YB}^2 \cos\Theta'^2_W \sin\Theta_W^2 Z_{i2}^H Z_{j2}^H - 100ig_{1p} g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i2}^H Z_{j2}^H \\
&+ 50ig_{1p}^2 \sin\Theta'^2_W Z_{i2}^H Z_{j2}^H \Big) \Big(g_{\mu\nu}\Big)
\end{aligned} \tag{220}$$



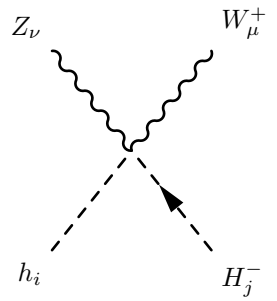
$$\Big(-\frac{i}{2} g_{BY} g_2 \cos\Theta_W \cos\Theta'^2_W Z^H_{i1} Z^H_{j1} - \frac{i}{2} g_1 g_{BY} \cos\Theta'^2_W \sin\Theta_W Z^H_{i1} Z^H_{j1}$$
$$+ \frac{i}{2} g^2_{BY} \cos\Theta'_W \sin\Theta'_W Z^H_{i1} Z^H_{j1} - \frac{i}{2} g^2_2 \cos\Theta^2_W \cos\Theta'_W \sin\Theta'_W Z^H_{i1} Z^H_{j1}$$
$$- \frac{i}{2} g^2_1 \cos\Theta'_W \sin\Theta^2_W \sin\Theta'_W Z^H_{i1} Z^H_{j1} + \frac{i}{2} g_{BY} g_2 \cos\Theta_W \sin\Theta'^2_W Z^H_{i1} Z^H_{j1}$$
$$+ \frac{i}{2} g_1 g_{BY} \sin\Theta_W \sin\Theta'^2_W Z^H_{i1} Z^H_{j1} - \frac{i}{2} g_1 g_2 \cos\Theta_W \sin\Theta_W \sin 2\Theta'_W Z^H_{i1} Z^H_{j1}$$
$$- 50 i g_{1p} g_{YB} \cos\Theta'^2_W \sin\Theta_W Z^H_{i2} Z^H_{j2} + 50 i g_{1p} g_{YB} \sin\Theta_W \sin\Theta'^2_W Z^H_{i2} Z^H_{j2}$$
$$+ 25 i g^2_{1p} \sin 2\Theta'_W Z^H_{i2} Z^H_{j2} - 25 i g^2_{YB} \sin\Theta^2_W \sin 2\Theta'_W Z^H_{i2} Z^H_{j2} \Big) \Big(g_{\mu\nu} \Big) \tag{221}$$



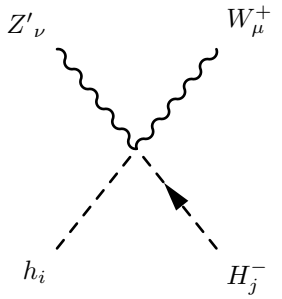
$$\Big(+ \frac{i}{2} g^2_{BY} \cos\Theta'^2_W Z^H_{i1} Z^H_{j1} + i g_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z^H_{i1} Z^H_{j1}$$
$$+ i g_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^H_{i1} Z^H_{j1} + \frac{i}{2} g^2_2 \cos\Theta^2_W \sin\Theta'^2_W Z^H_{i1} Z^H_{j1}$$
$$+ i g_1 g_2 \cos\Theta_W \sin\Theta_W \sin\Theta'^2_W Z^H_{i1} Z^H_{j1} + \frac{i}{2} g^2_1 \sin\Theta^2_W \sin\Theta'^2_W Z^H_{i1} Z^H_{j1}$$
$$+ 50 i g^2_{1p} \cos\Theta'^2_W Z^H_{i2} Z^H_{j2} + 100 i g_{1p} g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^H_{i2} Z^H_{j2}$$
$$+ 50 i g^2_{YB} \sin\Theta^2_W \sin\Theta'^2_W Z^H_{i2} Z^H_{j2} \Big) \Big(g_{\mu\nu} \Big) \tag{222}$$



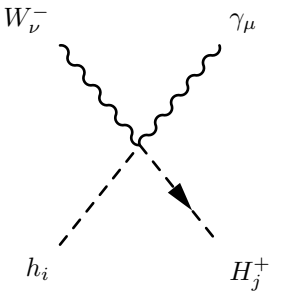
$$\frac{i}{2} g_1 g_2 \cos\Theta_W Z^H_{i1} Z^+_{j1} \Big(g_{\mu\nu} \Big) \tag{223}$$



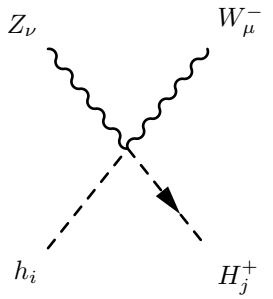
$$\Big(-\frac{i}{2} g_1 g_2 \cos\Theta'_W \sin\Theta_W Z^H_{i1} Z^+_{j1} + \frac{i}{2} g_{BY} g_2 \sin\Theta'_W Z^H_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big) \tag{224}$$



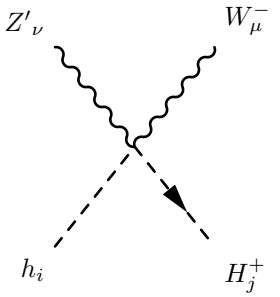
$$\Big(\frac{i}{2} g_1 g_2 \sin\Theta_W \sin\Theta'_W Z^H_{i1} Z^+_{j1} + \frac{i}{2} g_{BY} g_2 \cos\Theta'_W Z^H_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big) \tag{225}$$



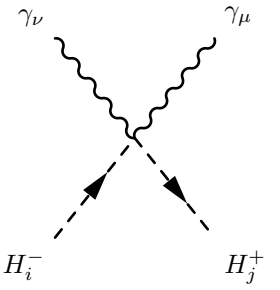
$$\frac{i}{2} g_1 g_2 \cos\Theta_W Z^H_{i1} Z^+_{j1} \Big(g_{\mu\nu} \Big) \tag{226}$$



$$\Big(-\frac{i}{2} g_1 g_2 \cos\Theta'_W \sin\Theta_W Z^H_{i1} Z^+_{j1} + \frac{i}{2} g_{BY} g_2 \sin\Theta'_W Z^H_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big) \tag{227}$$

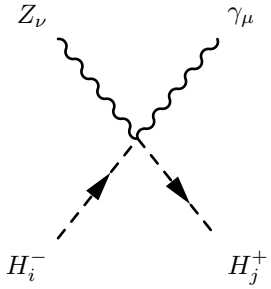


$$\Big(\frac{i}{2} g_1 g_2 \sin\Theta_W \sin\Theta'_W Z^H_{i1} Z^+_{j1} + \frac{i}{2} g_{BY} g_2 \cos\Theta'_W Z^H_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big) \tag{228}$$



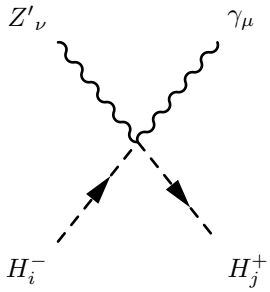
$$\Big(+ 2ig_1^2 \cos\Theta_W^2 \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} + 4ig_1 g_{YB} \cos\Theta_W^2 \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a}$$
$$+ 2ig_{YB}^2 \cos\Theta_W^2 \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} + 2ig_1^2 \cos\Theta_W^2 \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a}$$

$$- 16ig_1g_{YB}\cos\Theta_W^2\sum_{a=1}^{2}Z_{i3+a}^{+}Z_{j3+a}^{+} + 32ig_{YB}^2\cos\Theta_W^2\sum_{a=1}^{2}Z_{i3+a}^{+}Z_{j3+a}^{+}$$
$$+ \frac{i}{2}g_1^2\cos\Theta_W^2 Z_{i1}^{+}Z_{j1}^{+} + ig_1g_2\cos\Theta_W\sin\Theta_W Z_{i1}^{+}Z_{j1}^{+} + \frac{i}{2}g_2^2\sin\Theta_W^2 Z_{i1}^{+}Z_{j1}^{+}\Big)\Big(g_{\mu\nu}\Big) \tag{229}$$



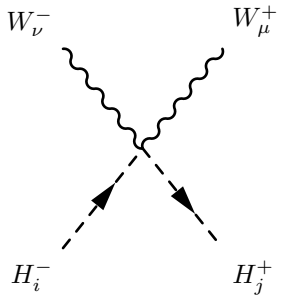
$$\Big(-2ig_1^2\cos\Theta_W\cos\Theta'_W\sin\Theta_W\sum_{a=1}^{2}Z_{i1+a}^{+}Z_{j1+a}^{+}$$
$$- 4ig_1g_{YB}\cos\Theta_W\cos\Theta'_W\sin\Theta_W\sum_{a=1}^{2}Z_{i1+a}^{+}Z_{j1+a}^{+}$$
$$- 2ig_{YB}^2\cos\Theta_W\cos\Theta'_W\sin\Theta_W\sum_{a=1}^{2}Z_{i1+a}^{+}Z_{j1+a}^{+}$$
$$+ 2ig_1g_{BY}\cos\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z_{i1+a}^{+}Z_{j1+a}^{+}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

$$+\frac{i}{2}g_1g_2\cos\Theta_W^2\cos\Theta'_W Z_{i1}^+Z_{j1}^+ - \frac{i}{2}g_1^2\cos\Theta_W\cos\Theta'_W\sin\Theta_W Z_{i1}^+Z_{j1}^+$$
$$+\frac{i}{2}g_2^2\cos\Theta_W\cos\Theta'_W\sin\Theta_W Z_{i1}^+Z_{j1}^+ - \frac{i}{2}g_1g_2\cos\Theta'_W\sin\Theta_W^2 Z_{i1}^+Z_{j1}^+$$
$$+\frac{i}{2}g_1g_{BY}\cos\Theta_W\sin\Theta'_W Z_{i1}^+Z_{j1}^+ + \frac{i}{2}g_{BY}g_2\sin\Theta_W\sin\Theta'_W Z_{i1}^+Z_{j1}^+\Big)\Big(g_{\mu\nu}\Big) \tag{230}$$

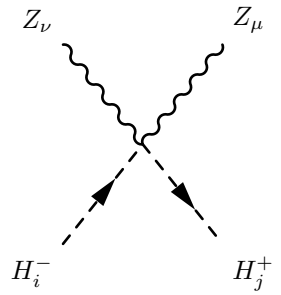


$$\Big(+2ig_1g_{BY}\cos\Theta_W\cos\Theta'_W\sum_{a=1}^{2}Z_{i1+a}^+Z_{j1+a}^+ + 2ig_1g_{1p}\cos\Theta_W\cos\Theta'_W\sum_{a=1}^{2}Z_{i1+a}^+Z_{j1+a}^+$$
$$+2ig_{BY}g_{YB}\cos\Theta_W\cos\Theta'_W\sum_{a=1}^{2}Z_{i1+a}^+Z_{j1+a}^+ + 2ig_{1p}g_{YB}\cos\Theta_W\cos\Theta'_W\sum_{a=1}^{2}Z_{i1+a}^+Z_{j1+a}^+$$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

$$+\frac{i}{2}g_{BY}g_2\cos\Theta'_W\sin\Theta_W Z^+_{i1}Z^+_{j1}-\frac{i}{2}g_1g_2\cos\Theta^2_W\sin\Theta'_W Z^+_{i1}Z^+_{j1}$$
$$+\frac{i}{2}g_1^2\cos\Theta_W\sin\Theta_W\sin\Theta'_W Z^+_{i1}Z^+_{j1}-\frac{i}{2}g_2^2\cos\Theta_W\sin\Theta_W\sin\Theta'_W Z^+_{i1}Z^+_{j1}$$
$$+\frac{i}{2}g_1g_2\sin\Theta^2_W\sin\Theta'_W Z^+_{i1}Z^+_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{231}$$

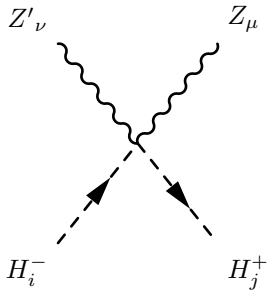


$$\frac{i}{2}g_2^2Z^+_{i1}Z^+_{j1}\Big(g_{\mu\nu}\Big) \tag{232}$$



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

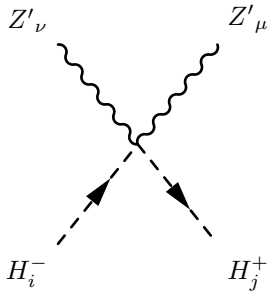
$$
\begin{aligned}
&- 4ig_{1p}g_{YB}\cos\Theta'_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a} + 2ig^2_{BY}\sin\Theta'^2_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}\\
&+ 4ig_{BY}g_{1p}\sin\Theta'^2_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a} + 2ig^2_{1p}\sin\Theta'^2_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}\\
&+ 2ig^2_1\cos\Theta'^2_W\sin\Theta^2_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a} - 16ig_1g_{YB}\cos\Theta'^2_W\sin\Theta^2_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}\\
&+ 32ig^2_{YB}\cos\Theta'^2_W\sin\Theta^2_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}\\
&- 4ig_1g_{BY}\cos\Theta'_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}\\
&+ 16ig_1g_{1p}\cos\Theta'_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}\\
&+ 16ig_{BY}g_{YB}\cos\Theta'_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}\\
&- 64ig_{1p}g_{YB}\cos\Theta'_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a} + 2ig^2_{BY}\sin\Theta'^2_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}\\
&- 16ig_{BY}g_{1p}\sin\Theta'^2_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a} + 32ig^2_{1p}\sin\Theta'^2_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}\\
&+ \frac{i}{2}g_2^2\cos\Theta^2_W\cos\Theta'^2_W Z^+_{i1}Z^+_{j1} - ig_1g_2\cos\Theta_W\cos\Theta'^2_W\sin\Theta_W Z^+_{i1}Z^+_{j1}\\
&+ \frac{i}{2}g_1^2\cos\Theta'^2_W\sin\Theta^2_W Z^+_{i1}Z^+_{j1} + ig_{BY}g_2\cos\Theta_W\cos\Theta'_W\sin\Theta'_W Z^+_{i1}Z^+_{j1}\\
&- ig_1g_{BY}\cos\Theta'_W\sin\Theta_W\sin\Theta'_W Z^+_{i1}Z^+_{j1} + \frac{i}{2}g^2_{BY}\sin\Theta'^2_W Z^+_{i1}Z^+_{j1}\Big)\Big(g_{\mu\nu}\Big)
\end{aligned}
\tag{233}
$$



$$
\Big(-2ig_1g_{BY}\cos\Theta'^2_W\sin\Theta_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a} - 2ig_1g_{1p}\cos\Theta'^2_W\sin\Theta_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}
$$

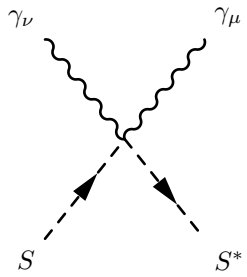
$$
\begin{aligned}
&- 2ig_{BY}g_{YB}\cos\Theta'^{2}_{W}\sin\Theta_{W}\sum_{a=1}^{2}Z^{+}_{i1+a}Z^{+}_{j1+a} - 2ig_{1p}g_{YB}\cos\Theta'^{2}_{W}\sin\Theta_{W}\sum_{a=1}^{2}Z^{+}_{i1+a}Z^{+}_{j1+a}\\
&+ 2ig^{2}_{BY}\cos\Theta'_{W}\sin\Theta'_{W}\sum_{a=1}^{2}Z^{+}_{i1+a}Z^{+}_{j1+a} + 4ig_{BY}g_{1p}\cos\Theta'_{W}\sin\Theta'_{W}\sum_{a=1}^{2}Z^{+}_{i1+a}Z^{+}_{j1+a}\\
&+ 2ig^{2}_{1p}\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_{1}g_{BY}\sin\Theta_{W}\sin\Theta'^{2}_{W}\sum_{a=1}^{2}Z^{+}_{i1+a}Z^{+}_{j1+a} + 2ig_{1}g_{1p}\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_{1p}g_{YB}\sin\Theta_{W}\sin\Theta'^{2}_{W}\sum_{a=1}^{2}Z^{+}_{i1+a}Z^{+}_{j1+a}\\
&- 2ig_{1}g_{YB}\sin\Theta^{2}_{W}\sin 2\Theta'_{W}\sum_{a=1}^{2}Z^{+}_{i1+a}Z^{+}_{j1+a} - 2ig_{1}g_{BY}\cos\Theta'^{2}_{W}\sin\Theta_{W}\sum_{a=1}^{2}Z^{+}_{i3+a}Z^{+}_{j3+a}\\
&+ 8ig_{1}g_{1p}\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_{1p}g_{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_{1p}\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_{1}g_{YB}\cos\Theta'_{W}\sin\Theta^{2}_{W}\sin\Theta'_{W}\sum_{a=1}^{2}Z^{+}_{i3+a}Z^{+}_{j3+a}\\
&+ 2ig_{1}g_{BY}\sin\Theta_{W}\sin\Theta'^{2}_{W}\sum_{a=1}^{2}Z^{+}_{i3+a}Z^{+}_{j3+a} - 8ig_{1}g_{1p}\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_{1p}g_{YB}\sin\Theta_{W}\sin\Theta'^{2}_{W}\sum_{a=1}^{2}Z^{+}_{i3+a}Z^{+}_{j3+a}\\
&+ 16ig^{2}_{1p}\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}
$$

$$+\frac{i}{2}g_{BY}g_2\cos\Theta_W\cos{\Theta'}^2_W Z^+_{i1}Z^+_{j1}-\frac{i}{2}g_1g_{BY}\cos{\Theta'}^2_W\sin\Theta_W Z^+_{i1}Z^+_{j1}$$
$$+\frac{i}{2}g^2_{BY}\cos\Theta'_W\sin\Theta'_W Z^+_{i1}Z^+_{j1}-\frac{i}{2}g^2_2\cos\Theta^2_W\cos\Theta'_W\sin\Theta'_W Z^+_{i1}Z^+_{j1}$$
$$-\frac{i}{2}g^2_1\cos\Theta'_W\sin\Theta^2_W\sin\Theta'_W Z^+_{i1}Z^+_{j1}-\frac{i}{2}g_{BY}g_2\cos\Theta_W\sin{\Theta'}^2_W Z^+_{i1}Z^+_{j1}$$
$$+\frac{i}{2}g_1g_{BY}\sin\Theta_W\sin{\Theta'}^2_W Z^+_{i1}Z^+_{j1}+\frac{i}{2}g_1g_2\cos\Theta_W\sin\Theta_W\sin 2\Theta'_W Z^+_{i1}Z^+_{j1}\Big)\Big(g_{\mu\nu}\Big) \quad (234)$$

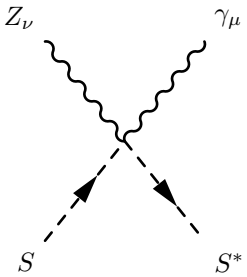


$$\Big(+2ig^2_{BY}\cos{\Theta'}^2_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}+4ig_{BY}g_{1p}\cos{\Theta'}^2_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$+2ig^2_{1p}\cos{\Theta'}^2_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}+4ig_1g_{BY}\cos\Theta'_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$+4ig_1g_{1p}\cos\Theta'_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$+4ig_{BY}g_{YB}\cos\Theta'_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$+4ig_{1p}g_{YB}\cos\Theta'_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$+2ig^2_1\sin\Theta^2_W\sin{\Theta'}^2_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}+4ig_1g_{YB}\sin\Theta^2_W\sin{\Theta'}^2_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$+2ig^2_{YB}\sin\Theta^2_W\sin{\Theta'}^2_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}+2ig^2_{BY}\cos{\Theta'}^2_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}$$
$$-16ig_{BY}g_{1p}\cos{\Theta'}^2_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}+32ig^2_{1p}\cos{\Theta'}^2_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}$$
$$+4ig_1g_{BY}\cos\Theta'_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}$$

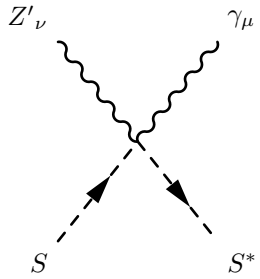
$$
\begin{aligned}
&- 16ig_1 g_{1p} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&- 16ig_{BY} g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&+ 64ig_{1p} g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&+ 2ig_1^2 \sin\Theta_W^2 \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} - 16ig_1 g_{YB} \sin\Theta_W^2 \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&+ 32ig_{YB}^2 \sin\Theta_W^2 \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} + \frac{i}{2} g_{BY}^2 \cos\Theta'^2_W Z^+_{i1} Z^+_{j1} \\
&- ig_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z^+_{i1} Z^+_{j1} \\
&+ ig_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^+_{i1} Z^+_{j1} + \frac{i}{2} g_2^2 \cos\Theta_W^2 \sin\Theta'^2_W Z^+_{i1} Z^+_{j1} \\
&- ig_1 g_2 \cos\Theta_W \sin\Theta_W \sin\Theta'^2_W Z^+_{i1} Z^+_{j1} + \frac{i}{2} g_1^2 \sin\Theta_W^2 \sin\Theta'^2_W Z^+_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big)
\end{aligned} \tag{235}
$$



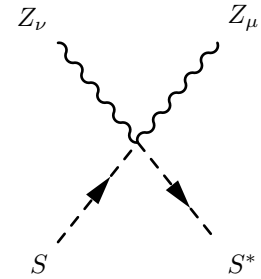
$$
50ig_{YB}^2 \cos\Theta_W^2 \Big(g_{\mu\nu} \Big) \tag{236}
$$



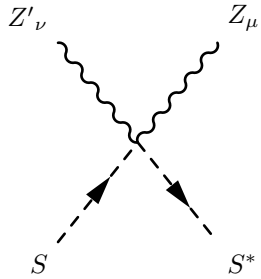
$$\Big(50ig_{1p}g_{YB}\cos\Theta_W\sin\Theta'_W - 50ig_{YB}^2\cos\Theta_W\cos\Theta'_W\sin\Theta_W\Big)\Big(g_{\mu\nu}\Big) \tag{237}$$



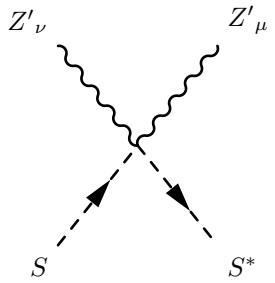
$$\Big(50ig_{1p}g_{YB}\cos\Theta_W\cos\Theta'_W + 50ig_{YB}^2\cos\Theta_W\sin\Theta_W\sin\Theta'_W\Big)\Big(g_{\mu\nu}\Big) \tag{238}$$



$$\Big(-100ig_{1p}g_{YB}\cos\Theta'_W\sin\Theta_W\sin\Theta'_W + 50ig_{1p}^2\sin\Theta'^2_W + 50ig_{YB}^2\cos\Theta'^2_W\sin\Theta_W^2\Big)\Big(g_{\mu\nu}\Big) \tag{239}$$

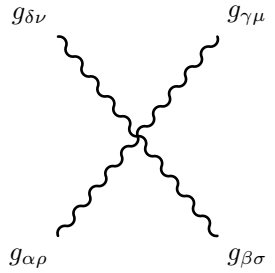


$$\Big(-50ig_{1p}g_{YB}\cos\Theta'^2_W\sin\Theta_W + 50ig_{1p}^2\cos\Theta'_W\sin\Theta'_W - 50ig_{YB}^2\cos\Theta'_W\sin\Theta_W^2\sin\Theta'_W$$
$$+ 50ig_{1p}g_{YB}\sin\Theta_W\sin\Theta'^2_W\Big)\Big(g_{\mu\nu}\Big) \tag{240}$$



$$\Big(100ig_{1p}g_{Y\,B}\cos\Theta'_W\sin\Theta_W\sin\Theta'_W + 50ig_{1p}^2\cos\Theta'^2_W + 50ig_{Y\,B}^2\sin\Theta_W^2\sin\Theta'^2_W\Big)\Big(g_{\mu\nu}\Big) \tag{241}$$

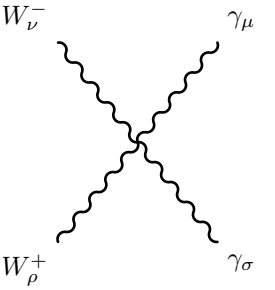
7.9 Four Vector Boson-Interaction



$$ig_3^2\Big(-\sum_{a=1}^{8} f_{\alpha,\delta,a}f_{\beta,\gamma,a} - \sum_{a=1}^{8} f_{\alpha,\gamma,a}f_{\beta,\delta,a}\Big)\Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{242}$$

$$+\ ig_3^2\Big(-\sum_{a=1}^{8} f_{\alpha,\beta,a}f_{\gamma,\delta,a} + \sum_{a=1}^{8} f_{\alpha,\delta,a}f_{\beta,\gamma,a}\Big)\Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{243}$$

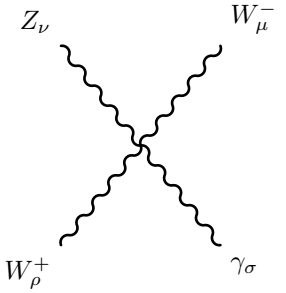
$$+\ ig_3^2\Big(\sum_{a=1}^{8} f_{\alpha,\gamma,a}f_{\beta,\delta,a} + \sum_{a=1}^{8} f_{\alpha,\beta,a}f_{\gamma,\delta,a}\Big)\Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{244}$$



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

$$+\ ig_2^2 \sin\Theta_W^2 \left(g_{\rho\mu} g_{\sigma\nu}\right) \tag{246}$$

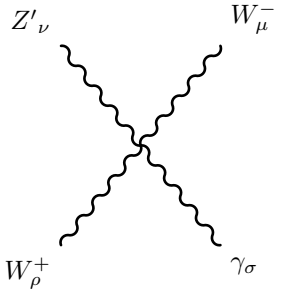
$$+\ -2ig_2^2 \sin\Theta_W^2 \left(g_{\rho\nu} g_{\sigma\mu}\right) \tag{247}$$



$$\frac{i}{2} g_2^2 \cos\Theta'_W \sin 2\Theta_W \left(g_{\rho\sigma} g_{\mu\nu}\right) \tag{248}$$

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

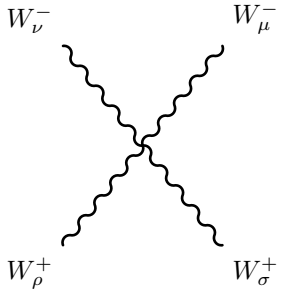
$$+\ \frac{i}{2} g_2^2 \cos\Theta'_W \sin 2\Theta_W \left(g_{\rho\nu} g_{\sigma\mu}\right) \tag{250}$$



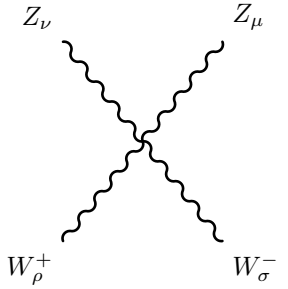
$$-\ \frac{i}{2} g_2^2 \sin 2\Theta_W \sin\Theta'_W \left(g_{\rho\sigma} g_{\mu\nu}\right) \tag{251}$$

$$+\ ig_2^2 \sin 2\Theta_W \sin\Theta'_W \left(g_{\rho\mu} g_{\sigma\nu}\right) \tag{252}$$

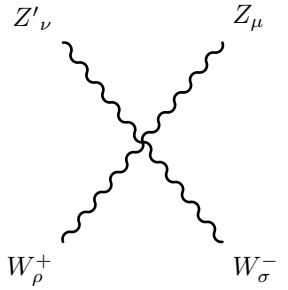
$$+\ -\frac{i}{2} g_2^2 \sin 2\Theta_W \sin\Theta'_W \left(g_{\rho\nu} g_{\sigma\mu}\right) \tag{253}$$



$$2ig_2^2\Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{254}$$
$$+\ -ig_2^2\Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{255}$$
$$+\ -ig_2^2\Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{256}$$



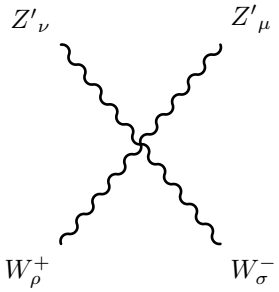
$$-\ 2ig_2^2\cos\Theta_W^2\cos{\Theta'}_W^2\Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{257}$$
$$+\ ig_2^2\cos\Theta_W^2\cos{\Theta'}_W^2\Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{258}$$
$$+\ ig_2^2\cos\Theta_W^2\cos{\Theta'}_W^2\Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{259}$$



$$ig_2^2 \cos\Theta_W^2 \sin 2\Theta'_W \Big(g_{\rho\sigma} g_{\mu\nu}\Big) \tag{260}$$

$$+\ -\frac{i}{2} g_2^2 \cos\Theta_W^2 \sin 2\Theta'_W \Big(g_{\rho\mu} g_{\sigma\nu}\Big) \tag{261}$$

$$+\ -\frac{i}{2} g_2^2 \cos\Theta_W^2 \sin 2\Theta'_W \Big(g_{\rho\nu} g_{\sigma\mu}\Big) \tag{262}$$

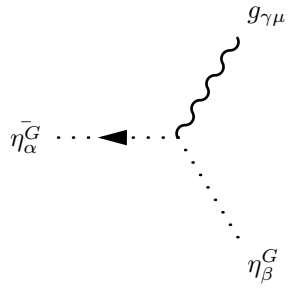


$$-\ 2ig_2^2 \cos\Theta_W^2 \sin\Theta'^2_W \Big(g_{\rho\sigma} g_{\mu\nu}\Big) \tag{263}$$

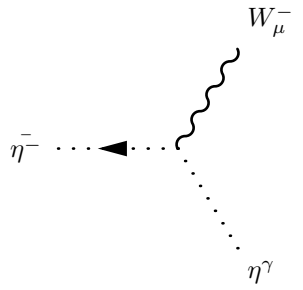
$$+\ ig_2^2 \cos\Theta_W^2 \sin\Theta'^2_W \Big(g_{\rho\mu} g_{\sigma\nu}\Big) \tag{264}$$

$$+\ ig_2^2 \cos\Theta_W^2 \sin\Theta'^2_W \Big(g_{\rho\nu} g_{\sigma\mu}\Big) \tag{265}$$

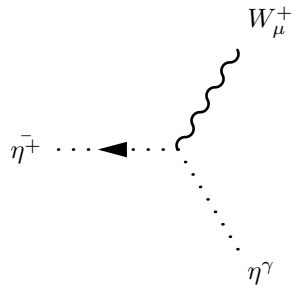
7.10 Two Ghosts-One Vector Boson-Interaction



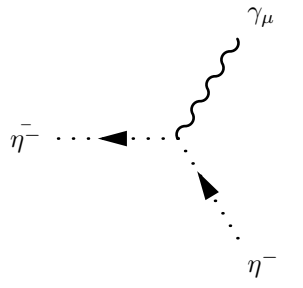
$$g_3 f_{\alpha,\beta,\gamma} \Big(p_\mu^{\eta^G_\beta}\Big) \tag{266}$$



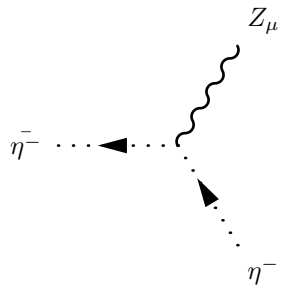
$$ig_2 \sin\Theta_W \left(p_\mu^{\eta^\gamma}\right) \tag{267}$$



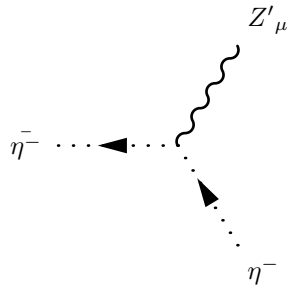
$$-ig_2 \sin\Theta_W \left(p_\mu^{\eta^\gamma}\right) \tag{268}$$



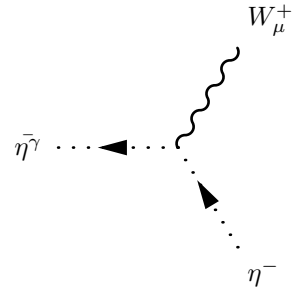
$$-ig_2 \sin\Theta_W \left(p_\mu^{\eta^-}\right) \tag{269}$$



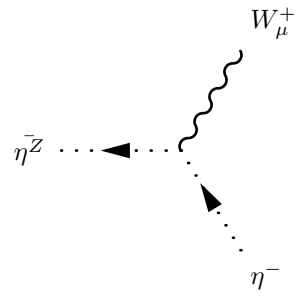
$$-ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^-}\right) \tag{270}$$



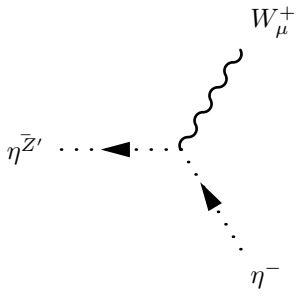
$$ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^-}\right) \tag{271}$$



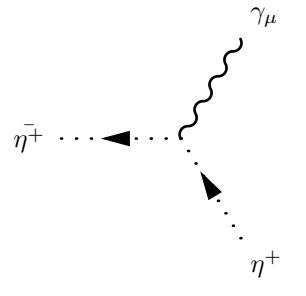
$$ig_2 \sin\Theta_W \left(p_\mu^{\eta^-}\right) \tag{272}$$



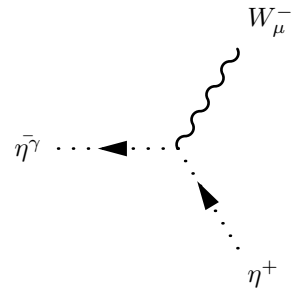
$$ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^-}\right) \tag{273}$$



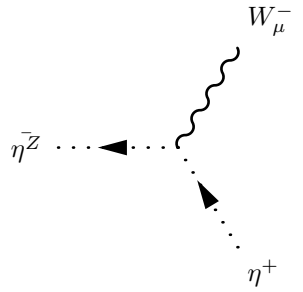
$$-ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^-}\right) \tag{274}$$



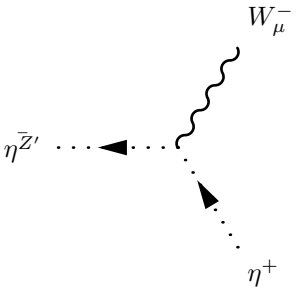
$$ig_2 \sin\Theta_W \left(p_\mu^{\eta^+}\right) \tag{275}$$



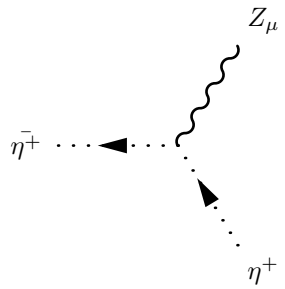
$$-ig_2 \sin\Theta_W \left(p_\mu^{\eta^+}\right) \tag{276}$$



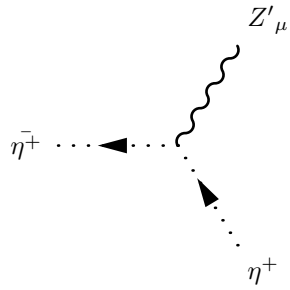
$$-ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^+}\right) \tag{277}$$



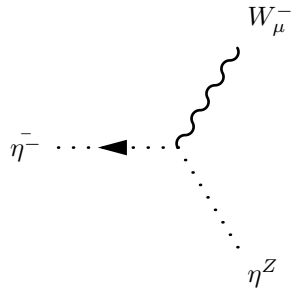
$$ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^+}\right) \tag{278}$$



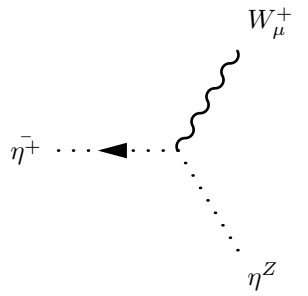
$$ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^+}\right) \tag{279}$$



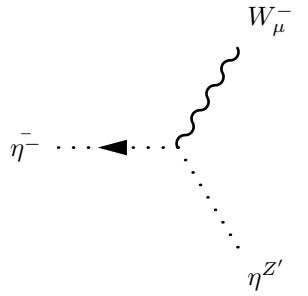
$$-ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^+}\right) \tag{280}$$



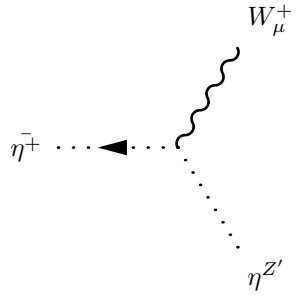
$$ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^Z}\right) \tag{281}$$



$$-ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^Z}\right) \tag{282}$$

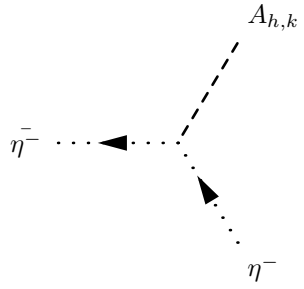


$$-ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^{Z'}}\right) \tag{283}$$

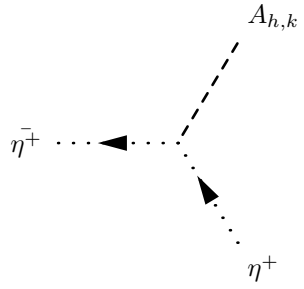


$$ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^{Z'}}\right) \tag{284}$$

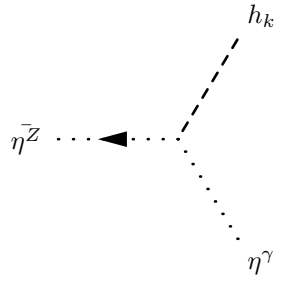
7.11 Two Ghosts-One Scalar-Interaction



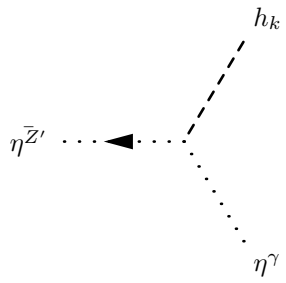
$$-\frac{1}{4}g_2^2 v\xi_{W^-}Z^A_{k1} \tag{285}$$



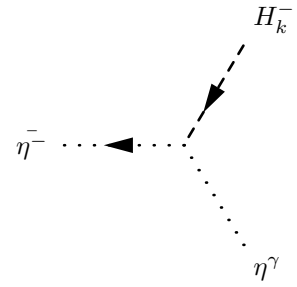
$$\frac{1}{4}g_2^2 v\xi_{W^-}Z^A_{k1} \tag{286}$$



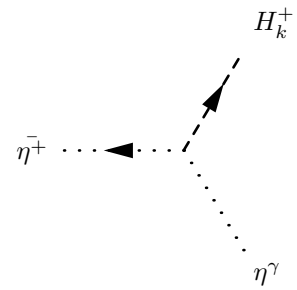
$$\begin{aligned}&\frac{i}{4}\xi_Z\Big(v\Big(g_1\cos\Theta_W - g_2\sin\Theta_W\Big)\Big(g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W - g_{BY}\sin\Theta'_W\Big)Z^H_{k1}\\&+50g_{YB}vx\Big(-2g_{1p}\cos\Theta_W\sin\Theta'_W + g_{YB}\cos\Theta'_W\sin 2\Theta_W\Big)Z^H_{k2}\Big)\end{aligned} \tag{287}$$



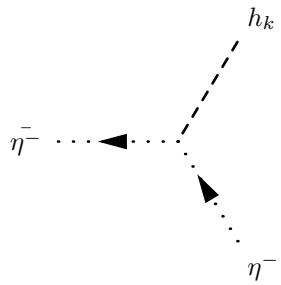
$$-\frac{i}{4}\xi_{Z'}\Big(v\Big(g_1\cos\Theta_W - g_2\sin\Theta_W\Big)\Big(\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W + g_{BY}\cos\Theta'_W\Big)Z^H_{k1}$$
$$+ 50 g_{YB} v x\Big(2g_{1p}\cos\Theta_W\cos\Theta'_W + g_{YB}\sin 2\Theta_W\sin\Theta'_W\Big)Z^H_{k2}\Big) \tag{288}$$



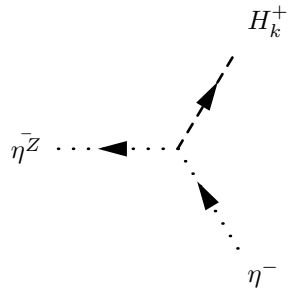
$$-\frac{i}{4}g_2 v\xi_{W^-}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)Z^+_{k1} \tag{289}$$



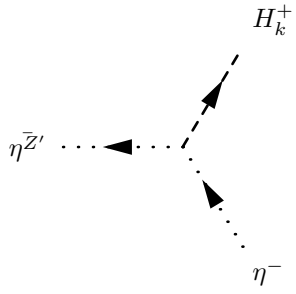
$$-\frac{i}{4}g_2 v\xi_{W^-}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)Z^+_{k1} \tag{290}$$



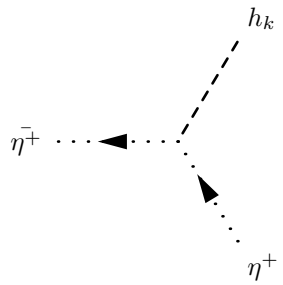
$$-\frac{i}{4}g_2^2 v \xi_{W^-} Z_{k1}^H \tag{291}$$



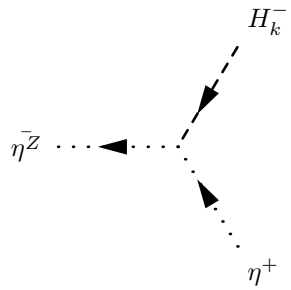
$$\frac{i}{4}g_2 v \xi_Z \Big(g_1 \cos\Theta'_W \sin\Theta_W + g_2 \cos\Theta_W \cos\Theta'_W - g_{BY} \sin\Theta'_W \Big) Z_{k1}^+ \tag{292}$$



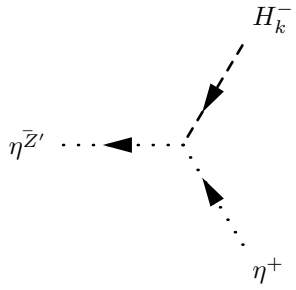
$$-\frac{i}{4}g_2 v \xi_{Z'} \Big(\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) \sin\Theta'_W + g_{BY} \cos\Theta'_W \Big) Z_{k1}^+ \tag{293}$$



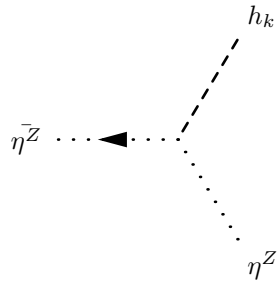
$$-\frac{i}{4}g_2^2 v \xi_{W^-} Z_{k1}^H \tag{294}$$



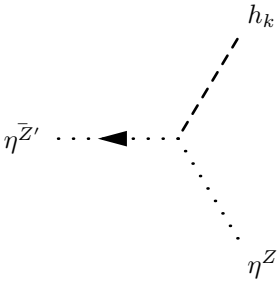
$$\frac{i}{4}g_2 v \xi_Z \Big(g_1 \cos\Theta'_W \sin\Theta_W + g_2 \cos\Theta_W \cos\Theta'_W - g_{BY} \sin\Theta'_W \Big) Z_{k1}^+ \tag{295}$$



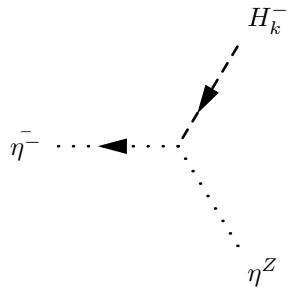
$$-\frac{i}{4}g_2 v \xi_{Z'} \Big(\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) \sin\Theta'_W + g_{BY} \cos\Theta'_W \Big) Z_{k1}^+ \tag{296}$$



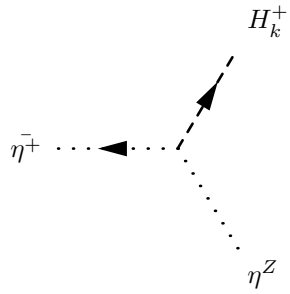
$$
\begin{aligned}
&-\frac{i}{4}\xi_Z\Big(v\Big(g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W-g_{BY}\sin\Theta'_W\Big)^2 Z^H_{k1}\\
&+100vx\Big(-g_{1p}\sin\Theta'_W+g_{YB}\cos\Theta'_W\sin\Theta_W\Big)^2 Z^H_{k2}\Big)
\end{aligned}
\tag{297}
$$



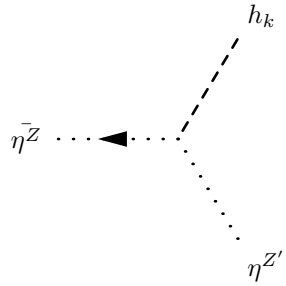
$$
\begin{aligned}
&\frac{i}{4}\xi_{Z'}\Big(v\Big(g_1g_{BY}\cos\Theta'^2_W\sin\Theta_W+g_2^2\cos\Theta^2_W\cos\Theta'_W\sin\Theta'_W\\
&+\cos\Theta'_W\Big(g_1^2\sin\Theta^2_W-g^2_{BY}\Big)\sin\Theta'_W-g_1g_{BY}\sin\Theta_W\sin\Theta'^2_W\\
&+g_2\cos\Theta_W\Big(g_1\sin\Theta_W\sin2\Theta'_W+g_{BY}\cos\Theta'^2_W-g_{BY}\sin\Theta'^2_W\Big)\Big)Z^H_{k1}\\
&-50vx\Big(-2g_{1p}g_{YB}\cos\Theta'^2_W\sin\Theta_W+2g_{1p}g_{YB}\sin\Theta_W\sin\Theta'^2_W+g^2_{1p}\sin2\Theta'_W\\
&-g^2_{YB}\sin\Theta^2_W\sin2\Theta'_W\Big)Z^H_{k2}\Big)
\end{aligned}
\tag{298}
$$



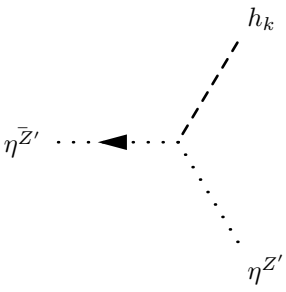
$$-\frac{i}{4}g_2 v\xi_{W^-}\Big(-g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W+g_{BY}\sin\Theta'_W\Big)Z^+_{k1} \tag{299}$$



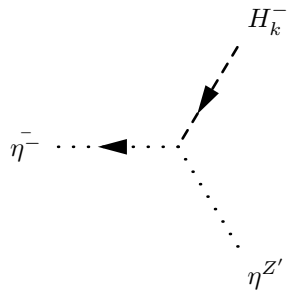
$$-\frac{i}{4}g_2 v\xi_{W^-}\Big(-g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W+g_{BY}\sin\Theta'_W\Big)Z^+_{k1} \tag{300}$$



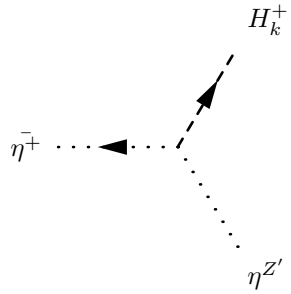
$$\begin{aligned}&\frac{i}{4}\xi_Z\Big(v\Big(g_1 g_{BY}\cos\Theta'^2_W\sin\Theta_W+g_2^2\cos\Theta_W^2\cos\Theta'_W\sin\Theta'_W\\&+\cos\Theta'_W\Big(g_1^2\sin\Theta_W^2-g_{BY}^2\Big)\sin\Theta'_W-g_1 g_{BY}\sin\Theta_W\sin\Theta'^2_W\\&+g_2\cos\Theta_W\Big(g_1\sin\Theta_W\sin 2\Theta'_W+g_{BY}\cos\Theta'^2_W-g_{BY}\sin\Theta'^2_W\Big)\Big)Z^H_{k1}\\&-50vx\Big(-2g_{1p}g_{YB}\cos\Theta'^2_W\sin\Theta_W+2g_{1p}g_{YB}\sin\Theta_W\sin\Theta'^2_W+g_{1p}^2\sin 2\Theta'_W\\&-g_{YB}^2\sin\Theta_W^2\sin 2\Theta'_W\Big)Z^H_{k2}\Big)\end{aligned} \tag{301}$$



$$-\frac{i}{4}\xi_{Z'}\Big(v\Big(\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W+g_{BY}\cos\Theta'_W\Big)^2Z^H_{k1}$$
$$+100vx\Big(g_{1p}\cos\Theta'_W+g_{YB}\sin\Theta_W\sin\Theta'_W\Big)^2Z^H_{k2}\Big) \tag{302}$$



$$\frac{i}{4}g_2v\xi_{W^-}\Big(\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W-g_{BY}\cos\Theta'_W\Big)Z^+_{k1} \tag{303}$$



$$\frac{i}{4}g_2v\xi_{W^-}\Big(\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W-g_{BY}\cos\Theta'_W\Big)Z^+_{k1} \tag{304}$$

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8 Clebsch-Gordan Coefficients