U(1)B extension for Bariogenesis
Lagrangian, Rotations and Interactions for eigenstates 'EWSB' including one-loop Self-Energies

SARAH 4.12.3

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Contents

1 Fields

1.1 Gauge Fields

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

1.2 Matter Superfields

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

2 Lagrangian

2.1 Input Lagrangian for Eigenstates GaugeES

$$L = -\mu_i'|\mathrm{BiD}|^2 - \mu_j'|\mathrm{BjD}|^2 - \mu_h|H^0|^2 - \mu_h|H^+|^2 + \mathrm{BiD}^2\lambda_{21}\mathrm{conj}\Big(\mathrm{BiD}\Big)^2 + \mathrm{BjD}^2\lambda_{22}\mathrm{conj}\Big(\mathrm{BjD}\Big)^2 + H^0\lambda_{31}|\mathrm{BiD}|^2H^{0,*}$$
$$+ H^0\lambda_{32}|\mathrm{BjD}|^2H^{0,*} + H^{0,2}l_hH^{0,*,2} + H^+\lambda_{31}|\mathrm{BiD}|^2H^{+,*} + H^+\lambda_{32}|\mathrm{BjD}|^2H^{+,*} + 2H^+l_h|H^0|^2H^{+,*} + H^{+,2}l_hH^{+,*,2}$$

$$
\begin{aligned}
&- H^0 d^*_{L,k\gamma} Y^*_{d,jk} \delta_{\beta\gamma} d_{R,j\beta} - H^+ u^*_{L,k\gamma} Y^*_{d,jk} \delta_{\beta\gamma} d_{R,j\beta} - \lambda_{c1} \mathrm{conj}\Big(\mathrm{BiD}\Big) \mathrm{conj}\Big(\mathrm{epp}\Big(2\Big)\Big) \mathrm{ep}\Big(1\Big) - \lambda_{c2} \mathrm{conj}\Big(\mathrm{BjD}\Big) \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} \mathrm{conj}\Big(\mathrm{BjD}\Big) \mathrm{conj}\Big(\mathrm{epp}\Big(1\Big)\Big) \mathrm{ep}\Big(2\Big) - \lambda_g H^{0,*} \mathrm{conj}\Big(\mathrm{x5R}\Big(\\
&- \mathrm{BjD} \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) - \mathrm{BjD} \lambda_{c2} \mathrm{conj}\Big(\mathrm{ep}\Big(1\Big)\Big) \mathrm{epp}\Big(2\Big) - \\
&- H^0 e^*_{L,k} Y^*_{e,jk} e_{R,j} - H^+ \nu^*_{L,k} Y^*_{e,jk} e_{R,j} + \mathrm{conj}\Big(\mathrm{vp}\Big(2\Big)\Big) \lambda^*_{d,ij} \mathrm{conj}\Big(\mathrm{eL}\Big(\{\mathrm{gt2}\}\Big)\Big(1\Big)\Big) \mathrm{s1}\Big(\{\mathrm{gt1}\}\Big) + \mathrm{conj}\Big(\mathrm{vp}\Big(1\Big)\Big) \lambda^*_{d,ij} \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) - |H^0|^2 \mathrm{conj}\Big(\mathrm{s1}\Big(\{\mathrm{gt1}\}\Big)\Big) \lambda_{41,ij} \mathrm{s1}\Big(\{\mathrm{gt2}\}\Big) - |H^+|^2 \mathrm{conj}\Big(\mathrm{s1}\Big(\{\mathrm{gt1}\}\Big)\Big) \lambda_{41,ij} \mathrm{s1} \\
&- |H^+|^2 \mathrm{conj}\Big(\mathrm{s2}\Big(\{\mathrm{gt1}\}\Big)\Big) \lambda_{42,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,k\gamma} Y^*_{u,jk} \delta_{\beta\gamma} u_{R,j\beta} + H^{0,*} u^*_{L,k\gamma} Y^*_{u,jk} \delta_{\beta\gamma} u_R \\
&- \lambda_{c1} \mathrm{conj}\Big(\mathrm{BiD}\Big) \mathrm{conj}\Big(\mathrm{vpp}\Big(2\Big)\Big) \mathrm{vp}\Big(1\Big) - \lambda_{c2} \mathrm{conj}\Big(\mathrm{BjD}\Big) \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_{c1} \mathrm{conj}\Big(\mathrm{BiD}\Big) \mathrm{co} \\
&- \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) - \mathrm{BjD} \lambda_{c2} \mathrm{conj}\Big(\mathrm{vp}\Big(2\Big)\Big) \mathrm{vpp}\Big(1\Big) - \lambda_h H^{+,*} \mathrm{conj}\Big(\mathrm{x6L}\Big(2\Big)\Big) \mathrm{vpp}\Big(1\Big) \\
&- \mathrm{BjD} \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{x3L}\Big(1\Big) - \lambda_{a2} \mathrm{conj}\Big(\mathrm{BjD}\Big) \mathrm{conj}\Big(\\
&- \lambda_{a2} \mathrm{conj}\Big(\mathrm{BjD}\Big) \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) - \mathrm{BjD} \lambda_{a2} \mathrm{conj}\Big(\mathrm{x3L}\Big(2\Big)\Big) \mathrm{x4R}\Big(1\Big) - \mathrm{BiD} \lambda_{a1} \mathrm{conj}\Big(\mathrm{x3L}\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(1\Big) - \lambda_{b2} \mathrm{conj}\Big(\mathrm{BjD}\Big) \mathrm{conj}\Big(\mathrm{x6L}\Big(2\Big)\Big) \mathrm{x5R}\Big(1\Big) - H^0 \lambda^*_g \mathrm{conj}\Big(\mathrm{ep}\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} \mathrm{conj}\Big(\mathrm{BjD}\Big) \mathrm{conj}\Big(\mathrm{x6L}\Big(1\Big)\Big) \mathrm{x5R}\Big(2\Big) - H^0 \lambda_h \mathrm{conj}\Big(\mathrm{epp}\Big(2\Big)\Big) \mathrm{x6L}\Big(1\Big) - H^+ \lambda_h \mathrm{conj}\Big(\mathrm{vp} \\
&- \mathrm{BjD} \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) - H^+ \lambda_h \mathrm{conj}\Big(\mathrm{vpp}\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) \\
&- 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} - \mathrm{BiDconj}\Big(\mathrm{s2}\Big(\{\mathrm{gt2}\}\Big)\Big) \mathrm{s1}\Big(\{\mathrm{gt1}\}\Big) \lambda_{f1,ij} - \mathrm{conj}\Big(\mathrm{BiD}\Big) \mathrm{conj}\Big(\mathrm{s1}\Big(\{\mathrm{gt1}\}\Big)\Big) \mathrm{s2}\Big(\{\mathrm{gt2}\}\Big) \lambda_{f1,ij} - \mathrm{BjDconj}\Big(\mathrm{s2}\Big(\{\mathrm{gt2} \\
&- \mathrm{conj}\Big(\mathrm{x5R}\Big(2\Big)\Big) \mathrm{conj}\Big(\mathrm{vR}\Big(\{\mathrm{gt3}\}\Big)\Big(1\Big)\Big) \mathrm{s2}\Big(\{\mathrm{gt1}\}\Big) \lambda_{e,ik} - \mathrm{conj}\Big(\mathrm{x5R}\Big(1\Big)\Big) \mathrm{conj}\Big(\mathrm{vR}\Big(\{\mathrm{gt3}\}\Big)\Big(2\Big)\Big) \mathrm{s2}\Big(\{\mathrm{gt1}\}\Big) \lambda_{e,ik} - H^+ u^*_{R,j\beta} \delta_{\beta\gamma} d_{L,} \\
&+ \mathrm{conj}\Big(\mathrm{s1}\Big(\{\mathrm{gt1}\}\Big)\Big) \mathrm{vp}\Big(2\Big) \lambda_{d,ij} \mathrm{eL}\Big(\{\mathrm{gt2}\}\Big)\Big(1\Big) + \mathrm{conj}\Big(\mathrm{s1}\Big(\{\mathrm{gt1}\}\Big)\Big) \mathrm{vp}\Big(1\Big) \lambda_{d,ij} \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(\\
&- \mathrm{conj}\Big(\mathrm{s2}\Big(\{\mathrm{gt1}\}\Big)\Big) \lambda^*_{e,ik} \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'

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

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

2.3 Fields integrated out

None

3 Field Rotations

3.1 Rotations in gauge sector for eigenstates 'EWSB'

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

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

$$\tag{6}$$

The mixing matrices are parametrized by

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

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

$$\tag{9}$$

3.2 Rotations in Mass sector for eigenstates 'EWSB'

3.2.1 Mass Matrices for Scalars

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

$$m_h^2 = \begin{pmatrix} m_{\text{phiHphiH}} & -\lambda_{31}vvx & -\lambda_{32}vvx2 \\ -\lambda_{31}vvx & -3\lambda_{21}vx^2-\frac{1}{2}\lambda_{31}v^2+\mu'_i & 0 \\ -\lambda_{32}vvx2 & 0 & -3\lambda_{22}vx2^2-\frac{1}{2}\lambda_{32}v^2+\mu'_j \end{pmatrix} \tag{10}$$

$$m_{\text{phiHphiH}} = \frac{1}{2}\Big(-6 l_h v^2 - \lambda_{31} v x^2 - \lambda_{32} v x 2^2 \Big) + \mu_h \tag{11}$$

This matrix is diagonalized by Z^H:

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

with

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

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

$$m_{A_h}^2 = \begin{pmatrix} m_{\text{sigmaHsigmaH}} & 0 & 0 \\ 0 & -\frac{1}{2}\lambda_{31} v^2 - \lambda_{21} v x^2 + \mu_i' & 0 \\ 0 & 0 & -\frac{1}{2}\lambda_{32} v^2 - \lambda_{22} v x 2^2 + \mu_j' \end{pmatrix} + \xi_Z m^2(Z) + \xi_{Z'} m^2(Z') \tag{14}$$

$$m_{\text{sigmaHsigmaH}} = \frac{1}{2}\Big(-2 l_h v^2 - \lambda_{31} v x^2 - \lambda_{32} v x 2^2 \Big) + \mu_h \tag{15}$$

Gauge fixing contributions:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

This matrix is diagonalized by Z^A:

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

with

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

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

$$m^2_{H^-} = \begin{pmatrix} m_{H^{+,*}H^+} & 0 & 0 \\ 0 & \frac{1}{2}\lambda_{41}v^2 + \mu_1 & \frac{1}{\sqrt{2}}\Big(vx2\lambda_{f2} + vx\lambda_{f1}\Big) \\ 0 & \frac{1}{\sqrt{2}}\Big(vx2\lambda^T_{f2} + vx\lambda^T_{f1}\Big) & \frac{1}{2}\lambda_{42}v^2 + \mu_2 \end{pmatrix} + \xi_{W^-}m^2(W^-) \tag{32}$$

$$m_{H^{+,*}H^+} = \frac{1}{2}\Big(-2l_hv^2 - \lambda_{31}vx^2 - \lambda_{32}vx2^2\Big) + \mu_h \tag{33}$$

Gauge fixing contributions:

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

This matrix is diagonalized by Z^+:

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

with

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

3.2.2 Mass Matrices for Fermions

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

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

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

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

with

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

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

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

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

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

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

with

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

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

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

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

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

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

with

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

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

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

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

This matrix is diagonalized by U^V:

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

with

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

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

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

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

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

with

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

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

4 Vacuum Expectation Values

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

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

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

5 Tadpole Equations

$$\frac{\partial V}{\partial \mathrm{phiH}} = -\frac{1}{2} v\Big(2l_h v^2 - 2\mu_h + \lambda_{31} vx^2 + \lambda_{32} vx2^2\Big) \tag{59}$$

$$\frac{\partial V}{\partial \mathrm{phiB}} = \Big(-\frac{1}{2}\lambda_{31} v^2 + \mu_i'\Big) vx - \lambda_{21} vx^3 \tag{60}$$

$$\frac{\partial V}{\partial \mathrm{phiBj}} = \Big(-\frac{1}{2}\lambda_{32} v^2 + \mu_j'\Big) vx2 - \lambda_{22} vx2^3 \tag{61}$$

6 Particle content for eigenstates 'EWSB'

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

7 One Loop Self-Energy and One Loop Tadpoles for eigenstates 'EWSB'

7.1 One Loop Self-Energy

- **Self-Energy for Higgs** (h)

$$\Pi_{i,j}(p^2) = +4\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2,0,m_Z^2\Big)\Big)\Gamma^*_{\check{h}_j,Z,\gamma}\Gamma_{\check{h}_i,Z,\gamma} + 2\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2,m_Z^2,m_Z^2\Big)\Big)\Gamma^*_{\check{h}_j,Z,Z}\Gamma_{\check{h}_i,Z,Z} + 4\Big(-\frac{1}{2}\mathrm{rMS} + B_0$$
$$+ 4\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2,m_Z^2,m_{Z'}^2\Big)\Big)\Gamma^*_{\check{h}_j,Z',Z}\Gamma_{\check{h}_i,Z',Z} + 2\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2,m_{Z'}^2,m_{Z'}^2\Big)\Big)\Gamma^*_{\check{h}_j,Z',Z'}\Gamma_{\check{h}_i,Z',Z'}$$

$$
\begin{aligned}
&+4\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m^2_{W^-},m^2_{W^-}\Big)\Big)\Gamma^*_{\check{h}_j,W^+,W^-}\Gamma_{\check{h}_i,W^+,W^-}-B_0\Big(p^2,m^2_{\eta^-},m^2_{\eta^-}\Big)\Gamma_{\check{h}_i,\eta^-,\eta^-}\Gamma_{\check{h}_j,\eta^-,\eta^-}\\
&-B_0\Big(p^2,m^2_{\eta^+},m^2_{\eta^+}\Big)\Gamma_{\check{h}_i,\eta^+,\eta^+}\Gamma_{\check{h}_j,\eta^+,\eta^+}-B_0\Big(p^2,m^2_{\eta^Z},m^2_{\eta^Z}\Big)\Gamma_{\check{h}_i,\eta^Z,\eta^Z}\Gamma_{\check{h}_j,\eta^Z,\eta^Z}\\
&-2B_0\Big(p^2,m^2_{\eta^Z},m^2_{\eta^{Z'}}\Big)\Gamma_{\check{h}_i,\eta^{\bar{Z}'},\eta^Z}\Gamma_{\check{h}_j,\eta^{\bar{Z}'},\eta^Z}-B_0\Big(p^2,m^2_{\eta^{Z'}},m^2_{\eta^{Z'}}\Big)\Gamma_{\check{h}_i,\eta^{\bar{Z}'},\eta^{Z'}}\Gamma_{\check{h}_j,\eta^{\bar{Z}'},\eta^{Z'}}\\
&+4\Gamma_{\check{h}_i,\check{h}_j,W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{W^-}+A_0\Big(m^2_{W^-}\Big)\Big)+2\Gamma_{\check{h}_i,\check{h}_j,Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m^2_Z+A_0\Big(m^2_Z\Big)\Big)+2\Gamma_{\check{h}_i,\check{h}_j,Z',Z'}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{Z'}\\
&-2\sum_{a=1}^{2}m_{eD_a}\sum_{b=1}^{2}B_0\Big(p^2,m^2_{eD_a},m^2_{eD_b}\Big)m_{eD_b}\Big(\Gamma^{L*}_{\check{h}_j,e\bar{D}_a,eD_b}\Gamma^R_{\check{h}_i,e\bar{D}_a,eD_b}+\Gamma^{R*}_{\check{h}_j,e\bar{D}_a,eD_b}\Gamma^L_{\check{h}_i,e\bar{D}_a,eD_b}\Big)\\
&+\sum_{a=1}^{2}\sum_{b=1}^{2}G_0\Big(p^2,m^2_{eD_a},m^2_{eD_b}\Big)\Big(\Gamma^{L*}_{\check{h}_j,e\bar{D}_a,eD_b}\Gamma^L_{\check{h}_i,e\bar{D}_a,eD_b}+\Gamma^{R*}_{\check{h}_j,e\bar{D}_a,eD_b}\Gamma^R_{\check{h}_i,e\bar{D}_a,eD_b}\Big)\\
&-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{A_{h,a}}\Big)\Gamma_{\check{h}_i,\check{h}_j,A_{h,a},A_{h,a}}-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{h_a}\Big)\Gamma_{\check{h}_i,\check{h}_j,h_a,h_a}\\
&+\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{A_{h,a}},m^2_{A_{h,b}}\Big)\Gamma^*_{\check{h}_j,A_{h,a},A_{h,b}}\Gamma_{\check{h}_i,A_{h,a},A_{h,b}}\\
&+\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{h_a},m^2_{h_b}\Big)\Gamma^*_{\check{h}_j,h_a,h_b}\Gamma_{\check{h}_i,h_a,h_b}\\
&-6\sum_{a=1}^{3}m_{d_a}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{d_a},m^2_{d_b}\Big)m_{d_b}\Big(\Gamma^{L*}_{\check{h}_j,\bar{d}_a,d_b}\Gamma^R_{\check{h}_i,\bar{d}_a,d_b}+\Gamma^{R*}_{\check{h}_j,\bar{d}_a,d_b}\Gamma^L_{\check{h}_i,\bar{d}_a,d_b}\Big)\\
&+3\sum_{a=1}^{3}\sum_{b=1}^{3}G_0\Big(p^2,m^2_{d_a},m^2_{d_b}\Big)\Big(\Gamma^{L*}_{\check{h}_j,\bar{d}_a,d_b}\Gamma^L_{\check{h}_i,\bar{d}_a,d_b}+\Gamma^{R*}_{\check{h}_j,\bar{d}_a,d_b}\Gamma^R_{\check{h}_i,\bar{d}_a,d_b}\Big)\\
&-2\sum_{a=1}^{3}m_{e_a}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{e_a},m^2_{e_b}\Big)m_{e_b}\Big(\Gamma^{L*}_{\check{h}_j,\bar{e}_a,e_b}\Gamma^R_{\check{h}_i,\bar{e}_a,e_b}+\Gamma^{R*}_{\check{h}_j,\bar{e}_a,e_b}\Gamma^L_{\check{h}_i,\bar{e}_a,e_b}\Big)\\
&+\sum_{a=1}^{3}\sum_{b=1}^{3}G_0\Big(p^2,m^2_{e_a},m^2_{e_b}\Big)\Big(\Gamma^{L*}_{\check{h}_j,\bar{e}_a,e_b}\Gamma^L_{\check{h}_i,\bar{e}_a,e_b}+\Gamma^{R*}_{\check{h}_j,\bar{e}_a,e_b}\Gamma^R_{\check{h}_i,\bar{e}_a,e_b}\Big)\\
&-6\sum_{a=1}^{3}m_{u_a}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{u_a},m^2_{u_b}\Big)m_{u_b}\Big(\Gamma^{L*}_{\check{h}_j,\bar{u}_a,u_b}\Gamma^R_{\check{h}_i,\bar{u}_a,u_b}+\Gamma^{R*}_{\check{h}_j,\bar{u}_a,u_b}\Gamma^L_{\check{h}_i,\bar{u}_a,u_b}\Big)\\
&+3\sum_{a=1}^{3}\sum_{b=1}^{3}G_0\Big(p^2,m^2_{u_a},m^2_{u_b}\Big)\Big(\Gamma^{L*}_{\check{h}_j,\bar{u}_a,u_b}\Gamma^L_{\check{h}_i,\bar{u}_a,u_b}+\Gamma^{R*}_{\check{h}_j,\bar{u}_a,u_b}\Gamma^R_{\check{h}_i,\bar{u}_a,u_b}\Big)\\
&-\sum_{a=1}^{5}A_0\Big(m^2_{H^-_a}\Big)\Gamma_{\check{h}_i,\check{h}_j,H^+_a,H^-_a}+\sum_{a=1}^{5}\sum_{b=1}^{5}B_0\Big(p^2,m^2_{H^-_a},m^2_{H^-_b}\Big)\Gamma^*_{\check{h}_j,H^+_a,H^-_b}\Gamma_{\check{h}_i,H^+_a,H^-_b}\\
&+\sum_{b=1}^{3}\Gamma^*_{\check{h}_j,\gamma,A_{h,b}}\Gamma_{\check{h}_i,\gamma,A_{h,b}}F_0\Big(p^2,m^2_{A_{h,b}},0\Big)+\sum_{b=1}^{3}\Gamma^*_{\check{h}_j,Z,A_{h,b}}\Gamma_{\check{h}_i,Z,A_{h,b}}F_0\Big(p^2,m^2_{A_{h,b}},m^2_Z\Big)
\end{aligned}
$$

$$
\begin{aligned}
&+\sum_{b=1}^{3}\Gamma^{*}_{\check{h}_j,Z',A_{h,b}}\Gamma_{\check{h}_i,Z',A_{h,b}}F_0\Big(p^2,m^2_{A_{h,b}},m^2_{Z'}\Big)+2\sum_{b=1}^{5}\Gamma^{*}_{\check{h}_j,W^+,H^-_b}\Gamma_{\check{h}_i,W^+,H^-_b}F_0\Big(p^2,m^2_{H^-_b},m^2_{W^-}\Big)\\
&-2B_0\Big(p^2,m^2_{\nu^d},m^2_{\nu^d}\Big)m^2_{\nu^d}\Big(\Gamma^{L*}_{\check{h}_j,\bar{\nu}^d,\nu^d}\Gamma^{R}_{\check{h}_i,\bar{\nu}^d,\nu^d}+\Gamma^{R*}_{\check{h}_j,\bar{\nu}^d,\nu^d}\Gamma^{L}_{\check{h}_i,\bar{\nu}^d,\nu^d}\Big)\\
&+G_0\Big(p^2,m^2_{\nu^d},m^2_{\nu^d}\Big)\Big(\Gamma^{L*}_{\check{h}_j,\bar{\nu}^d,\nu^d}\Gamma^{L}_{\check{h}_i,\bar{\nu}^d,\nu^d}+\Gamma^{R*}_{\check{h}_j,\bar{\nu}^d,\nu^d}\Gamma^{R}_{\check{h}_i,\bar{\nu}^d,\nu^d}\Big)\\
&-2B_0\Big(p^2,m^2_{\chi^0},m^2_{\chi^0}\Big)m^2_{\chi^0}\Big(\Gamma^{L*}_{\check{h}_j,\bar{\chi}^0,\chi^0}\Gamma^{R}_{\check{h}_i,\bar{\chi}^0,\chi^0}+\Gamma^{R*}_{\check{h}_j,\bar{\chi}^0,\chi^0}\Gamma^{L}_{\check{h}_i,\bar{\chi}^0,\chi^0}\Big)\\
&+G_0\Big(p^2,m^2_{\chi^0},m^2_{\chi^0}\Big)\Big(\Gamma^{L*}_{\check{h}_j,\bar{\chi}^0,\chi^0}\Gamma^{L}_{\check{h}_i,\bar{\chi}^0,\chi^0}+\Gamma^{R*}_{\check{h}_j,\bar{\chi}^0,\chi^0}\Gamma^{R}_{\check{h}_i,\bar{\chi}^0,\chi^0}\Big)
\end{aligned}
\tag{62}
$$

- **Self-Energy for Pseudo-Scalar Higgs** (A_h)

$$
\begin{aligned}
\Pi_{i,j}(p^2)=&-B_0\Big(p^2,m^2_{\eta^-},m^2_{\eta^-}\Big)\Gamma_{\check{A}_{h,i},\eta^-,\eta^-}\Gamma_{\check{A}_{h,j},\eta^-,\eta^-}-B_0\Big(p^2,m^2_{\eta^+},m^2_{\eta^+}\Big)\Gamma_{\check{A}_{h,i},\eta^+,\eta^+}\Gamma_{\check{A}_{h,j},\eta^+,\eta^+}\\
&+4\Gamma_{\check{A}_{h,i},\check{A}_{h,j},W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{W^-}+A_0\Big(m^2_{W^-}\Big)\Big)+2\Gamma_{\check{A}_{h,i},\check{A}_{h,j},Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{Z}+A_0\Big(m^2_{Z}\Big)\Big)\\
&+2\Gamma_{\check{A}_{h,i},\check{A}_{h,j},Z',Z'}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{Z'}+A_0\Big(m^2_{Z'}\Big)\Big)\\
&-2\sum_{a=1}^{2}m_{eD_a}\sum_{b=1}^{2}B_0\Big(p^2,m^2_{eD_a},m^2_{eD_b}\Big)m_{eD_b}\Big(\Gamma^{L*}_{\check{A}_{h,j},e\bar{D}_a,eD_b}\Gamma^{R}_{\check{A}_{h,i},e\bar{D}_a,eD_b}+\Gamma^{R*}_{\check{A}_{h,j},e\bar{D}_a,eD_b}\Gamma^{L}_{\check{A}_{h,i},e\bar{D}_a,eD_b}\Big)\\
&+\sum_{a=1}^{2}\sum_{b=1}^{2}G_0\Big(p^2,m^2_{eD_a},m^2_{eD_b}\Big)\Big(\Gamma^{L*}_{\check{A}_{h,j},e\bar{D}_a,eD_b}\Gamma^{L}_{\check{A}_{h,i},e\bar{D}_a,eD_b}+\Gamma^{R*}_{\check{A}_{h,j},e\bar{D}_a,eD_b}\Gamma^{R}_{\check{A}_{h,i},e\bar{D}_a,eD_b}\Big)\\
&-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{A_{h,a}}\Big)\Gamma_{\check{A}_{h,i},\check{A}_{h,j},A_{h,a},A_{h,a}}-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{h_a}\Big)\Gamma_{\check{A}_{h,i},\check{A}_{h,j},h_a,h_a}\\
&+\sum_{a=1}^{3}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{h_a},m^2_{A_{h,b}}\Big)\Gamma^{*}_{\check{A}_{h,j},h_a,A_{h,b}}\Gamma_{\check{A}_{h,i},h_a,A_{h,b}}\\
&-6\sum_{a=1}^{3}m_{d_a}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{d_a},m^2_{d_b}\Big)m_{d_b}\Big(\Gamma^{L*}_{\check{A}_{h,j},\bar{d}_a,d_b}\Gamma^{R}_{\check{A}_{h,i},\bar{d}_a,d_b}+\Gamma^{R*}_{\check{A}_{h,j},\bar{d}_a,d_b}\Gamma^{L}_{\check{A}_{h,i},\bar{d}_a,d_b}\Big)\\
&+3\sum_{a=1}^{3}\sum_{b=1}^{3}G_0\Big(p^2,m^2_{d_a},m^2_{d_b}\Big)\Big(\Gamma^{L*}_{\check{A}_{h,j},\bar{d}_a,d_b}\Gamma^{L}_{\check{A}_{h,i},\bar{d}_a,d_b}+\Gamma^{R*}_{\check{A}_{h,j},\bar{d}_a,d_b}\Gamma^{R}_{\check{A}_{h,i},\bar{d}_a,d_b}\Big)\\
&-2\sum_{a=1}^{3}m_{e_a}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{e_a},m^2_{e_b}\Big)m_{e_b}\Big(\Gamma^{L*}_{\check{A}_{h,j},\bar{e}_a,e_b}\Gamma^{R}_{\check{A}_{h,i},\bar{e}_a,e_b}+\Gamma^{R*}_{\check{A}_{h,j},\bar{e}_a,e_b}\Gamma^{L}_{\check{A}_{h,i},\bar{e}_a,e_b}\Big)\\
&+\sum_{a=1}^{3}\sum_{b=1}^{3}G_0\Big(p^2,m^2_{e_a},m^2_{e_b}\Big)\Big(\Gamma^{L*}_{\check{A}_{h,j},\bar{e}_a,e_b}\Gamma^{L}_{\check{A}_{h,i},\bar{e}_a,e_b}+\Gamma^{R*}_{\check{A}_{h,j},\bar{e}_a,e_b}\Gamma^{R}_{\check{A}_{h,i},\bar{e}_a,e_b}\Big)\\
&-6\sum_{a=1}^{3}m_{u_a}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{u_a},m^2_{u_b}\Big)m_{u_b}\Big(\Gamma^{L*}_{\check{A}_{h,j},\bar{u}_a,u_b}\Gamma^{R}_{\check{A}_{h,i},\bar{u}_a,u_b}+\Gamma^{R*}_{\check{A}_{h,j},\bar{u}_a,u_b}\Gamma^{L}_{\check{A}_{h,i},\bar{u}_a,u_b}\Big)
\end{aligned}
$$

$$
\begin{aligned}
&+3\sum_{a=1}^{3}\sum_{b=1}^{3}G_0\Big(p^2,m^2_{u_a},m^2_{u_b}\Big)\Big(\Gamma^{L*}_{\check{A}_{h,j},\bar{u}_a,u_b}\Gamma^{L}_{\check{A}_{h,i},\bar{u}_a,u_b}+\Gamma^{R*}_{\check{A}_{h,j},\bar{u}_a,u_b}\Gamma^{R}_{\check{A}_{h,i},\bar{u}_a,u_b}\Big)\\
&-\sum_{a=1}^{5}A_0\Big(m^2_{H^-_a}\Big)\Gamma_{\check{A}_{h,i},\check{A}_{h,j},H^+_a,H^-_a}+\sum_{a=1}^{5}\sum_{b=1}^{5}B_0\Big(p^2,m^2_{H^-_a},m^2_{H^-_b}\Big)\Gamma^{*}_{\check{A}_{h,j},H^+_a,H^-_b}\Gamma_{\check{A}_{h,i},H^+_a,H^-_b}\\
&+\sum_{b=1}^{3}\Gamma^{*}_{\check{A}_{h,j},\gamma,h_b}\Gamma_{\check{A}_{h,i},\gamma,h_b}F_0\Big(p^2,m^2_{h_b},0\Big)+\sum_{b=1}^{3}\Gamma^{*}_{\check{A}_{h,j},Z,h_b}\Gamma_{\check{A}_{h,i},Z,h_b}F_0\Big(p^2,m^2_{h_b},m^2_{Z}\Big)\\
&+\sum_{b=1}^{3}\Gamma^{*}_{\check{A}_{h,j},Z',h_b}\Gamma_{\check{A}_{h,i},Z',h_b}F_0\Big(p^2,m^2_{h_b},m^2_{Z'}\Big)+2\sum_{b=1}^{5}\Gamma^{*}_{\check{A}_{h,j},W^+,H^-_b}\Gamma_{\check{A}_{h,i},W^+,H^-_b}F_0\Big(p^2,m^2_{H^-_b},m^2_{W^-}\Big)\\
&-2B_0\Big(p^2,m^2_{\nu^d},m^2_{\nu^d}\Big)m^2_{\nu^d}\Big(\Gamma^{L*}_{\check{A}_{h,j},\bar{\nu}^d,\nu^d}\Gamma^{R}_{\check{A}_{h,i},\bar{\nu}^d,\nu^d}+\Gamma^{R*}_{\check{A}_{h,j},\bar{\nu}^d,\nu^d}\Gamma^{L}_{\check{A}_{h,i},\bar{\nu}^d,\nu^d}\Big)\\
&+G_0\Big(p^2,m^2_{\nu^d},m^2_{\nu^d}\Big)\Big(\Gamma^{L*}_{\check{A}_{h,j},\bar{\nu}^d,\nu^d}\Gamma^{L}_{\check{A}_{h,i},\bar{\nu}^d,\nu^d}+\Gamma^{R*}_{\check{A}_{h,j},\bar{\nu}^d,\nu^d}\Gamma^{R}_{\check{A}_{h,i},\bar{\nu}^d,\nu^d}\Big)\\
&-2B_0\Big(p^2,m^2_{\chi^0},m^2_{\chi^0}\Big)m^2_{\chi^0}\Big(\Gamma^{L*}_{\check{A}_{h,j},\bar{\chi}^0,\chi^0}\Gamma^{R}_{\check{A}_{h,i},\bar{\chi}^0,\chi^0}+\Gamma^{R*}_{\check{A}_{h,j},\bar{\chi}^0,\chi^0}\Gamma^{L}_{\check{A}_{h,i},\bar{\chi}^0,\chi^0}\Big)\\
&+G_0\Big(p^2,m^2_{\chi^0},m^2_{\chi^0}\Big)\Big(\Gamma^{L*}_{\check{A}_{h,j},\bar{\chi}^0,\chi^0}\Gamma^{L}_{\check{A}_{h,i},\bar{\chi}^0,\chi^0}+\Gamma^{R*}_{\check{A}_{h,j},\bar{\chi}^0,\chi^0}\Gamma^{R}_{\check{A}_{h,i},\bar{\chi}^0,\chi^0}\Big)
\end{aligned}
\tag{63}
$$

- **Self-Energy for Charged Higgs** (H^-)

$$
\begin{aligned}
\Pi_{i,j}(p^2)=&+4\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,0,m^2_{W^-}\Big)\Big)\Gamma^{*}_{\check{H}^+_j,W^-,\gamma}\Gamma_{\check{H}^+_i,W^-,\gamma}+4\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m^2_{W^-},m^2_{Z}\Big)\Big)\Gamma^{*}_{\check{H}^+_j,Z,W^-}\Gamma_{\check{H}^+_i,Z,W^-}\\
&+4\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m^2_{W^-},m^2_{Z'}\Big)\Big)\Gamma^{*}_{\check{H}^+_j,Z',W^-}\Gamma_{\check{H}^+_i,Z',W^-}-B_0\Big(p^2,m^2_{\eta^Z},m^2_{\eta^+}\Big)\Gamma_{\check{H}^+_i,\bar{\eta^+},\eta^Z}\Gamma_{\check{H}^-_j,\eta^+,\bar{\eta^Z}}\\
&-B_0\Big(p^2,m^2_{\eta^{Z'}},m^2_{\eta^+}\Big)\Gamma_{\check{H}^+_i,\bar{\eta^+},\eta^{Z'}}\Gamma_{\check{H}^-_j,\eta^+,\bar{\eta^{Z'}}}-B_0\Big(p^2,m^2_{\eta^-},m^2_{\eta^Z}\Big)\Gamma_{\check{H}^+_i,\bar{\eta^Z},\eta^-}\Gamma_{\check{H}^-_j,\eta^Z,\bar{\eta^-}}\\
&-B_0\Big(p^2,m^2_{\eta^-},m^2_{\eta^{Z'}}\Big)\Gamma_{\check{H}^+_i,\bar{\eta^{Z'}},\eta^-}\Gamma_{\check{H}^-_j,\eta^{Z'},\bar{\eta^-}}+4\Gamma_{\check{H}^-_i,\check{H}^+_j,W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{W^-}+A_0\Big(m^2_{W^-}\Big)\Big)\\
&+2\Gamma_{\check{H}^-_i,\check{H}^+_j,Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{Z}+A_0\Big(m^2_{Z}\Big)\Big)+2\Gamma_{\check{H}^-_i,\check{H}^+_j,Z',Z'}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{Z'}+A_0\Big(m^2_{Z'}\Big)\Big)\\
&-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{A_{h,a}}\Big)\Gamma_{\check{H}^-_i,\check{H}^+_j,A_{h,a},A_{h,a}}-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{h_a}\Big)\Gamma_{\check{H}^-_i,\check{H}^+_j,h_a,h_a}\\
&-6\sum_{a=1}^{3}m_{u_a}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{u_a},m^2_{d_b}\Big)m_{d_b}\Big(\Gamma^{L*}_{\check{H}^+_j,\bar{u}_a,d_b}\Gamma^{R}_{\check{H}^+_i,\bar{u}_a,d_b}+\Gamma^{R*}_{\check{H}^+_j,\bar{u}_a,d_b}\Gamma^{L}_{\check{H}^+_i,\bar{u}_a,d_b}\Big)\\
&+3\sum_{a=1}^{3}\sum_{b=1}^{3}G_0\Big(p^2,m^2_{u_a},m^2_{d_b}\Big)\Big(\Gamma^{L*}_{\check{H}^+_j,\bar{u}_a,d_b}\Gamma^{L}_{\check{H}^+_i,\bar{u}_a,d_b}+\Gamma^{R*}_{\check{H}^+_j,\bar{u}_a,d_b}\Gamma^{R}_{\check{H}^+_i,\bar{u}_a,d_b}\Big)\\
&-\sum_{a=1}^{5}A_0\Big(m^2_{H^-_a}\Big)\Gamma_{\check{H}^-_i,\check{H}^+_j,H^+_a,H^-_a}\\
&-2\sum_{a=1}^{5}m_{\nu_a}\sum_{b=1}^{2}B_0\Big(p^2,m^2_{\nu_a},m^2_{eD_b}\Big)m_{eD_b}\Big(\Gamma^{L*}_{\check{H}^+_j,\nu_a,eD_b}\Gamma^{R}_{\check{H}^+_i,\nu_a,eD_b}+\Gamma^{R*}_{\check{H}^+_j,\nu_a,eD_b}\Gamma^{L}_{\check{H}^+_i,\nu_a,eD_b}\Big)
\end{aligned}
$$

$$
\begin{aligned}
&+\sum_{a=1}^{5}\sum_{b=1}^{2} G_0\Big(p^2, m^2_{\nu_a}, m^2_{eD_b}\Big)\Big(\Gamma^{L*}_{\check{H}^+_j,\nu_a,eD_b}\Gamma^{L}_{\check{H}^+_i,\nu_a,eD_b} + \Gamma^{R*}_{\check{H}^+_j,\nu_a,eD_b}\Gamma^{R}_{\check{H}^+_i,\nu_a,eD_b}\Big)\\
&+\sum_{a=1}^{5}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{H^-_a}, m^2_{A_{h,b}}\Big)\Gamma^{*}_{\check{H}^+_j,H^-_a,A_{h,b}}\Gamma_{\check{H}^+_i,H^-_a,A_{h,b}}\\
&+\sum_{a=1}^{5}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{H^-_a}, m^2_{h_b}\Big)\Gamma^{*}_{\check{H}^+_j,H^-_a,h_b}\Gamma_{\check{H}^+_i,H^-_a,h_b}\\
&-2\sum_{a=1}^{5} m_{\nu_a}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{\nu_a}, m^2_{e_b}\Big)m_{e_b}\Big(\Gamma^{L*}_{\check{H}^+_j,\nu_a,e_b}\Gamma^{R}_{\check{H}^+_i,\nu_a,e_b} + \Gamma^{R*}_{\check{H}^+_j,\nu_a,e_b}\Gamma^{L}_{\check{H}^+_i,\nu_a,e_b}\Big)\\
&+\sum_{a=1}^{5}\sum_{b=1}^{3} G_0\Big(p^2, m^2_{\nu_a}, m^2_{e_b}\Big)\Big(\Gamma^{L*}_{\check{H}^+_j,\nu_a,e_b}\Gamma^{L}_{\check{H}^+_i,\nu_a,e_b} + \Gamma^{R*}_{\check{H}^+_j,\nu_a,e_b}\Gamma^{R}_{\check{H}^+_i,\nu_a,e_b}\Big)\\
&-2m_{\nu^d}\sum_{b=1}^{2} B_0\Big(p^2, m^2_{\nu^d}, m^2_{eD_b}\Big)m_{eD_b}\Big(\Gamma^{L*}_{\check{H}^+_j,\bar{\nu}^d,eD_b}\Gamma^{R}_{\check{H}^+_i,\bar{\nu}^d,eD_b} + \Gamma^{R*}_{\check{H}^+_j,\bar{\nu}^d,eD_b}\Gamma^{L}_{\check{H}^+_i,\bar{\nu}^d,eD_b}\Big)\\
&+\sum_{b=1}^{2} G_0\Big(p^2, m^2_{\nu^d}, m^2_{eD_b}\Big)\Big(\Gamma^{L*}_{\check{H}^+_j,\bar{\nu}^d,eD_b}\Gamma^{L}_{\check{H}^+_i,\bar{\nu}^d,eD_b} + \Gamma^{R*}_{\check{H}^+_j,\bar{\nu}^d,eD_b}\Gamma^{R}_{\check{H}^+_i,\bar{\nu}^d,eD_b}\Big)\\
&+\sum_{b=1}^{3}\Gamma^{*}_{\check{H}^+_j,W^-,A_{h,b}}\Gamma_{\check{H}^+_i,W^-,A_{h,b}}F_0\Big(p^2, m^2_{A_{h,b}}, m^2_{W^-}\Big) + \sum_{b=1}^{3}\Gamma^{*}_{\check{H}^+_j,W^-,h_b}\Gamma_{\check{H}^+_i,W^-,h_b}F_0\Big(p^2, m^2_{h_b}, m^2_{W^-}\Big)\\
&-2m_{\nu^d}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{\nu^d}, m^2_{e_b}\Big)m_{e_b}\Big(\Gamma^{L*}_{\check{H}^+_j,\nu^d,e_b}\Gamma^{R}_{\check{H}^+_i,\nu^d,e_b} + \Gamma^{R*}_{\check{H}^+_j,\nu^d,e_b}\Gamma^{L}_{\check{H}^+_i,\nu^d,e_b}\Big)\\
&+\sum_{b=1}^{3} G_0\Big(p^2, m^2_{\nu^d}, m^2_{e_b}\Big)\Big(\Gamma^{L*}_{\check{H}^+_j,\nu^d,e_b}\Gamma^{L}_{\check{H}^+_i,\nu^d,e_b} + \Gamma^{R*}_{\check{H}^+_j,\nu^d,e_b}\Gamma^{R}_{\check{H}^+_i,\nu^d,e_b}\Big)\\
&+\sum_{b=1}^{5}\Gamma^{*}_{\check{H}^+_j,\gamma,H^-_b}\Gamma_{\check{H}^+_i,\gamma,H^-_b}F_0\Big(p^2, m^2_{H^-_b}, 0\Big) + \sum_{b=1}^{5}\Gamma^{*}_{\check{H}^+_j,Z,H^-_b}\Gamma_{\check{H}^+_i,Z,H^-_b}F_0\Big(p^2, m^2_{H^-_b}, m^2_Z\Big)\\
&+\sum_{b=1}^{5}\Gamma^{*}_{\check{H}^+_j,Z',H^-_b}\Gamma_{\check{H}^+_i,Z',H^-_b}F_0\Big(p^2, m^2_{H^-_b}, m^2_{Z'}\Big) \qquad (64)
\end{aligned}
$$

- **Self-Energy for Down-Quarks** (d)

$$
\begin{aligned}
\Sigma^S_{i,j}(p^2) = &+\sum_{a=1}^{3} m_{d_a}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{d_a}, m^2_{A_{h,b}}\Big)\Gamma^{L*}_{\check{d}_j,d_a,A_{h,b}}\Gamma^{R}_{\check{d}_i,d_a,A_{h,b}}\\
&+\sum_{a=1}^{3}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{d_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\check{d}_j,h_a,d_b}m_{d_b}\Gamma^{R}_{\check{d}_i,h_a,d_b}
\end{aligned}
$$

$$
\begin{aligned}
&+\sum_{a=1}^{5}\sum_{b=1}^{3} B_0\Big(p^2, m_{u_b}^2, m_{H_a^-}^2\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,H_a^-,u_b} m_{u_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,H_a^-,u_b}\\
&-\frac{16}{3}\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m_{d_b}^2,0\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,g,d_b} m_{d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,g,d_b} - 4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m_{d_b}^2,0\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,\gamma,d_b} m_{d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,\gamma,d_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m_{u_b}^2,m_{W^-}^2\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,W^-,u_b} m_{u_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,W^-,u_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m_{d_b}^2,m_Z^2\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,Z,d_b} m_{d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,Z,d_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m_{d_b}^2,m_{Z'}^2\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,Z',d_b} m_{d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,Z',d_b}
\end{aligned}
\tag{65}
$$

$$
\begin{aligned}
\Sigma^R_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{d_a}^2, m_{A_{h,b}}^2\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,d_a,A_{h,b}}\Gamma^{R}_{\tilde{\tilde{d}}_i,d_a,A_{h,b}}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, m_{h_a}^2\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,h_a,d_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,h_a,d_b}\\
&-\frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{3} B_1\Big(p^2, m_{u_b}^2, m_{H_a^-}^2\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,H_a^-,u_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,H_a^-,u_b} - \frac{4}{3}\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2,m_{d_b}^2,0\Big)\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,g,d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,g,d_b}\\
&-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2,m_{d_b}^2,0\Big)\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,\gamma,d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,\gamma,d_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2,m_{u_b}^2,m_{W^-}^2\Big)\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,W^-,u_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,W^-,u_b}\\
&-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2,m_{d_b}^2,m_Z^2\Big)\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,Z,d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,Z,d_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2,m_{d_b}^2,m_{Z'}^2\Big)\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,Z',d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,Z',d_b}
\end{aligned}
\tag{66}
$$

$$
\begin{aligned}
\Sigma^L_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{d_a}^2, m_{A_{h,b}}^2\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,d_a,A_{h,b}}\Gamma^{L}_{\tilde{\tilde{d}}_i,d_a,A_{h,b}}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, m_{h_a}^2\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,h_a,d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,h_a,d_b}\\
&-\frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{3} B_1\Big(p^2, m_{u_b}^2, m_{H_a^-}^2\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,H_a^-,u_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,H_a^-,u_b} - \frac{4}{3}\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2,m_{d_b}^2,0\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,g,d_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,g,d_b}\\
&-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2,m_{d_b}^2,0\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,\gamma,d_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,\gamma,d_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2,m_{u_b}^2,m_{W^-}^2\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,W^-,u_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,W^-,u_b}\\
&-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2,m_{d_b}^2,m_Z^2\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,Z,d_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,Z,d_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2,m_{d_b}^2,m_{Z'}^2\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,Z',d_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,Z',d_b}
\end{aligned}
\tag{67}
$$

- **Self-Energy for Up-Quarks** (u)

$$
\begin{aligned}
\Sigma^S_{i,j}(p^2) = &+\sum_{a=1}^{3} m_{u_a} \sum_{b=1}^{3} B_0\Big(p^2, m^2_{u_a}, m^2_{A_{h,b}}\Big)\Gamma^{L*}_{\tilde{u}_j,u_a,A_{h,b}}\Gamma^{R}_{\tilde{u}_i,u_a,A_{h,b}} \\
&+\sum_{a=1}^{3}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{u_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\tilde{u}_j,h_a,u_b} m_{u_b}\Gamma^{R}_{\tilde{u}_i,h_a,u_b} \\
&+\sum_{a=1}^{5}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{d_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\tilde{u}_j,H^+_a,d_b} m_{d_b}\Gamma^{R}_{\tilde{u}_i,H^+_a,d_b} \\
&-\frac{16}{3}\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{u_b}, 0\Big)\Big)\Gamma^{R*}_{\tilde{u}_j,g,u_b} m_{u_b}\Gamma^{L}_{\tilde{u}_i,g,u_b} - 4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{u_b}, 0\Big)\Big)\Gamma^{R*}_{\tilde{u}_j,\gamma,u_b} m_{u_b}\Gamma^{L}_{\tilde{u}_i,\gamma,u_b} \\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{u_b}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\tilde{u}_j,Z,u_b} m_{u_b}\Gamma^{L}_{\tilde{u}_i,Z,u_b} \\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{u_b}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\tilde{u}_j,Z',u_b} m_{u_b}\Gamma^{L}_{\tilde{u}_i,Z',u_b} \\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{d_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\tilde{u}_j,W^+,d_b} m_{d_b}\Gamma^{L}_{\tilde{u}_i,W^+,d_b}
\end{aligned}
\tag{68}
$$

$$
\begin{aligned}
\Sigma^R_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_a}, m^2_{A_{h,b}}\Big)\Gamma^{R*}_{\tilde{u}_j,u_a,A_{h,b}}\Gamma^{R}_{\tilde{u}_i,u_a,A_{h,b}} \\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_b}, m^2_{h_a}\Big)\Gamma^{R*}_{\tilde{u}_j,h_a,u_b}\Gamma^{R}_{\tilde{u}_i,h_a,u_b} \\
&-\frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{d_b}, m^2_{H^-_a}\Big)\Gamma^{R*}_{\tilde{u}_j,H^+_a,d_b}\Gamma^{R}_{\tilde{u}_i,H^+_a,d_b} - \frac{4}{3}\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{u_b}, 0\Big)\Big)\Gamma^{L*}_{\tilde{u}_j,g,u_b}\Gamma^{L}_{\tilde{u}_i,g,u_b} \\
&-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{u_b}, 0\Big)\Big)\Gamma^{L*}_{\tilde{u}_j,\gamma,u_b}\Gamma^{L}_{\tilde{u}_i,\gamma,u_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{u_b}, m^2_{Z}\Big)\Big)\Gamma^{L*}_{\tilde{u}_j,Z,u_b}\Gamma^{L}_{\tilde{u}_i,Z,u_b} \\
&-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{u_b}, m^2_{Z'}\Big)\Big)\Gamma^{L*}_{\tilde{u}_j,Z',u_b}\Gamma^{L}_{\tilde{u}_i,Z',u_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{d_b}, m^2_{W^-}\Big)\Big)\Gamma^{L*}_{\tilde{u}_j,W^+,d_b}\Gamma^{L}_{\tilde{u}_i,W^+,d_b}
\end{aligned}
\tag{69}
$$

$$
\begin{aligned}
\Sigma^L_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_a}, m^2_{A_{h,b}}\Big)\Gamma^{L*}_{\tilde{u}_j,u_a,A_{h,b}}\Gamma^{L}_{\tilde{u}_i,u_a,A_{h,b}} \\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\tilde{u}_j,h_a,u_b}\Gamma^{L}_{\tilde{u}_i,h_a,u_b}
\end{aligned}
$$

$$
\begin{aligned}
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, m_{H_a^-}^2\Big)\Gamma^{L*}_{\check{u}_j,H_a^+,d_b}\Gamma^{L}_{\check{u}_i,H_a^+,d_b} - \frac{4}{3}\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{u_b}^2, 0\Big)\Big)\Gamma^{R*}_{\check{u}_j,g,u_b}\Gamma^{R}_{\check{u}_i,g,u_b}\\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{u_b}^2, 0\Big)\Big)\Gamma^{R*}_{\check{u}_j,\gamma,u_b}\Gamma^{R}_{\check{u}_i,\gamma,u_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{u_b}^2, m_Z^2\Big)\Big)\Gamma^{R*}_{\check{u}_j,Z,u_b}\Gamma^{R}_{\check{u}_i,Z,u_b}\\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{u_b}^2, m_{Z'}^2\Big)\Big)\Gamma^{R*}_{\check{u}_j,Z',u_b}\Gamma^{R}_{\check{u}_i,Z',u_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, m_{W^-}^2\Big)\Big)\Gamma^{R*}_{\check{u}_j,W^+,d_b}\Gamma^{R}_{\check{u}_i,W^+,d_b}
\end{aligned}
\tag{70}
$$

- **Self-Energy for Leptons** (e)

$$
\begin{aligned}
\Sigma^S_{i,j}(p^2) =& + \sum_{a=1}^{3} m_{e_a}\sum_{b=1}^{3} B_0\Big(p^2, m_{e_a}^2, m_{A_{h,b}}^2\Big)\Gamma^{L*}_{\check{e}_j,e_a,A_{h,b}}\Gamma^{R}_{\check{e}_i,e_a,A_{h,b}}\\
&+ \sum_{a=1}^{3}\sum_{b=1}^{3} B_0\Big(p^2, m_{e_b}^2, m_{h_a}^2\Big)\Gamma^{L*}_{\check{e}_j,h_a,e_b} m_{e_b}\Gamma^{R}_{\check{e}_i,h_a,e_b}\\
&+ \sum_{a=1}^{5}\sum_{b=1}^{5} B_0\Big(p^2, m_{\nu_b}^2, m_{H_a^-}^2\Big)\Gamma^{L*}_{\check{e}_j,H_a^-,\nu_b} m_{\nu_b}\Gamma^{R}_{\check{e}_i,H_a^-,\nu_b}\\
&- 4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{e_b}^2, 0\Big)\Big)\Gamma^{R*}_{\check{e}_j,\gamma,e_b} m_{e_b}\Gamma^{L}_{\check{e}_i,\gamma,e_b} - 4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{e_b}^2, m_Z^2\Big)\Big)\Gamma^{R*}_{\check{e}_j,Z,e_b} m_{e_b}\Gamma^{L}_{\check{e}_i,Z,e_b}\\
&- 4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{e_b}^2, m_{Z'}^2\Big)\Big)\Gamma^{R*}_{\check{e}_j,Z',e_b} m_{e_b}\Gamma^{L}_{\check{e}_i,Z',e_b}\\
&- 4\sum_{b=1}^{5}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{\nu_b}^2, m_{W^-}^2\Big)\Big)\Gamma^{R*}_{\check{e}_j,W^-,\nu_b} m_{\nu_b}\Gamma^{L}_{\check{e}_i,W^-,\nu_b}\\
&+ m_{\nu^d}\sum_{b=1}^{5} B_0\Big(p^2, m_{\nu^d}^2, m_{H_b^-}^2\Big)\Gamma^{L*}_{\check{e}_j,\bar{\nu}^d,H_b^-}\Gamma^{R}_{\check{e}_i,\bar{\nu}^d,H_b^-}
\end{aligned}
\tag{71}
$$

$$
\begin{aligned}
\Sigma^R_{i,j}(p^2) =& -\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{e_a}^2, m_{A_{h,b}}^2\Big)\Gamma^{R*}_{\check{e}_j,e_a,A_{h,b}}\Gamma^{R}_{\check{e}_i,e_a,A_{h,b}}\\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{e_b}^2, m_{h_a}^2\Big)\Gamma^{R*}_{\check{e}_j,h_a,e_b}\Gamma^{R}_{\check{e}_i,h_a,e_b}\\
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{5} B_1\Big(p^2, m_{\nu_b}^2, m_{H_a^-}^2\Big)\Gamma^{R*}_{\check{e}_j,H_a^-,\nu_b}\Gamma^{R}_{\check{e}_i,H_a^-,\nu_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{e_b}^2, 0\Big)\Big)\Gamma^{L*}_{\check{e}_j,\gamma,e_b}\Gamma^{L}_{\check{e}_i,\gamma,e_b}\\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{e_b}^2, m_Z^2\Big)\Big)\Gamma^{L*}_{\check{e}_j,Z,e_b}\Gamma^{L}_{\check{e}_i,Z,e_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{e_b}^2, m_{Z'}^2\Big)\Big)\Gamma^{L*}_{\check{e}_j,Z',e_b}\Gamma^{L}_{\check{e}_i,Z',e_b}
\end{aligned}
$$

$$
\begin{aligned}
&- \sum_{b=1}^{5} \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu_b}, m^2_{W^-}\Big)\Big) \Gamma^{L*}_{\check{\bar{e}}_j, W^-, \nu_b} \Gamma^{L}_{\check{\bar{e}}_i, W^-, \nu_b} \\
&- \frac{1}{2} \sum_{b=1}^{5} B_1\Big(p^2, m^2_{\nu^d}, m^2_{H_b^-}\Big) \Gamma^{R*}_{\check{\bar{e}}_j, \bar{\nu}^d, H_b^-} \Gamma^{R}_{\check{\bar{e}}_i, \bar{\nu}^d, H_b^-} \qquad (72)
\end{aligned}
$$

$$
\begin{aligned}
\Sigma^{L}_{i,j}(p^2) = &- \frac{1}{2} \sum_{a=1}^{3} \sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_a}, m^2_{A_{h,b}}\Big) \Gamma^{L*}_{\check{\bar{e}}_j, e_a, A_{h,b}} \Gamma^{L}_{\check{\bar{e}}_i, e_a, A_{h,b}} \\
&- \frac{1}{2} \sum_{a=1}^{3} \sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{h_a}\Big) \Gamma^{L*}_{\check{\bar{e}}_j, h_a, e_b} \Gamma^{L}_{\check{\bar{e}}_i, h_a, e_b} \\
&- \frac{1}{2} \sum_{a=1}^{5} \sum_{b=1}^{5} B_1\Big(p^2, m^2_{\nu_b}, m^2_{H_a^-}\Big) \Gamma^{L*}_{\check{\bar{e}}_j, H_a^-, \nu_b} \Gamma^{L}_{\check{\bar{e}}_i, H_a^-, \nu_b} - \sum_{b=1}^{3} \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{e_b}, 0\Big)\Big) \Gamma^{R*}_{\check{\bar{e}}_j, \gamma, e_b} \Gamma^{R}_{\check{\bar{e}}_i, \gamma, e_b} \\
&- \sum_{b=1}^{3} \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{e_b}, m^2_{Z}\Big)\Big) \Gamma^{R*}_{\check{\bar{e}}_j, Z, e_b} \Gamma^{R}_{\check{\bar{e}}_i, Z, e_b} - \sum_{b=1}^{3} \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{e_b}, m^2_{Z'}\Big)\Big) \Gamma^{R*}_{\check{\bar{e}}_j, Z', e_b} \Gamma^{R}_{\check{\bar{e}}_i, Z', e_b} \\
&- \sum_{b=1}^{5} \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu_b}, m^2_{W^-}\Big)\Big) \Gamma^{R*}_{\check{\bar{e}}_j, W^-, \nu_b} \Gamma^{R}_{\check{\bar{e}}_i, W^-, \nu_b} \\
&- \frac{1}{2} \sum_{b=1}^{5} B_1\Big(p^2, m^2_{\nu^d}, m^2_{H_b^-}\Big) \Gamma^{L*}_{\check{\bar{e}}_j, \bar{\nu}^d, H_b^-} \Gamma^{L}_{\check{\bar{e}}_i, \bar{\nu}^d, H_b^-} \qquad (73)
\end{aligned}
$$

- **Self-Energy for Neutrinos** (ν)

$$
\begin{aligned}
\Sigma^{S}_{i,j}(p^2) = &+ \sum_{a=1}^{2} m_{eD_a} \sum_{b=1}^{5} B_0\Big(p^2, m^2_{eD_a}, m^2_{H_b^-}\Big) \Gamma^{L*}_{\check{\nu}_j, e\bar{D}_a, H_b^-} \Gamma^{R}_{\check{\nu}_i, e\bar{D}_a, H_b^-} \\
&+ \sum_{a=1}^{3} m_{e_a} \sum_{b=1}^{5} B_0\Big(p^2, m^2_{e_a}, m^2_{H_b^-}\Big) \Gamma^{L*}_{\check{\nu}_j, \bar{e}_a, H_b^-} \Gamma^{R}_{\check{\nu}_i, \bar{e}_a, H_b^-} \\
&- 4 \sum_{a=1}^{3} \Big(- \frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{e_a}, m^2_{W^-}\Big)\Big) \Gamma^{R*}_{\check{\nu}_j, \bar{e}_a, W^-} m_{e_a} \Gamma^{L}_{\check{\nu}_i, \bar{e}_a, W^-} \\
&+ \sum_{a=1}^{5} \sum_{b=1}^{2} B_0\Big(p^2, m^2_{eD_b}, m^2_{H_a^-}\Big) \Gamma^{L*}_{\check{\nu}_j, H_a^+, eD_b} m_{eD_b} \Gamma^{R}_{\check{\nu}_i, H_a^+, eD_b} \\
&+ \sum_{a=1}^{5} \sum_{b=1}^{3} B_0\Big(p^2, m^2_{e_b}, m^2_{H_a^-}\Big) \Gamma^{L*}_{\check{\nu}_j, H_a^+, e_b} m_{e_b} \Gamma^{R}_{\check{\nu}_i, H_a^+, e_b} \\
&- 4 \sum_{b=1}^{3} \Big(- \frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{e_b}, m^2_{W^-}\Big)\Big) \Gamma^{R*}_{\check{\nu}_j, W^+, e_b} m_{e_b} \Gamma^{L}_{\check{\nu}_i, W^+, e_b} - 4 \sum_{b=1}^{5} \Big(- \frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\nu_b}, 0\Big)\Big) \Gamma^{R*}_{\check{\nu}_j, \gamma, \nu_b} m_{\nu_b} \Gamma^{L}_{\check{\nu}_i, \gamma,}
\end{aligned}
$$

$$- 4\sum_{b=1}^{5}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{\nu_b}^2, m_Z^2\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,Z,\nu_b} m_{\nu_b}\Gamma^{L}_{\check{\nu}_i,Z,\nu_b} - 4\sum_{b=1}^{5}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{\nu_b}^2, m_{Z'}^2\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,Z',\nu_b} m_{\nu_b}\Gamma^{L}_{\check{\nu}_i,Z',\nu} \tag{74}$$

$$\begin{aligned}
\Sigma^R_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{5} B_1\Big(p^2, m_{eD_a}^2, m_{H_b^-}^2\Big)\Gamma^{R*}_{\check{\nu}_j,e\bar{D}_a,H_b^-}\Gamma^{R}_{\check{\nu}_i,e\bar{D}_a,H_b^-} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{5} B_1\Big(p^2, m_{e_a}^2, m_{H_b^-}^2\Big)\Gamma^{R*}_{\check{\nu}_j,\bar{e}_a,H_b^-}\Gamma^{R}_{\check{\nu}_i,\bar{e}_a,H_b^-} \\
&- \sum_{a=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{e_a}^2, m_{W^-}^2\Big)\Big)\Gamma^{L*}_{\check{\nu}_j,\bar{e}_a,W^-}\Gamma^{L}_{\check{\nu}_i,\bar{e}_a,W^-} \\
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{2} B_1\Big(p^2, m_{eD_b}^2, m_{H_a^-}^2\Big)\Gamma^{R*}_{\check{\nu}_j,H_a^+,eD_b}\Gamma^{R}_{\check{\nu}_i,H_a^+,eD_b} \\
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{3} B_1\Big(p^2, m_{e_b}^2, m_{H_a^-}^2\Big)\Gamma^{R*}_{\check{\nu}_j,H_a^+,e_b}\Gamma^{R}_{\check{\nu}_i,H_a^+,e_b} \\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{e_b}^2, m_{W^-}^2\Big)\Big)\Gamma^{L*}_{\check{\nu}_j,W^+,e_b}\Gamma^{L}_{\check{\nu}_i,W^+,e_b} - \sum_{b=1}^{5}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{\nu_b}^2, 0\Big)\Big)\Gamma^{L*}_{\check{\nu}_j,\gamma,\nu_b}\Gamma^{L}_{\check{\nu}_i,\gamma,\nu_b} \\
&- \sum_{b=1}^{5}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{\nu_b}^2, m_Z^2\Big)\Big)\Gamma^{L*}_{\check{\nu}_j,Z,\nu_b}\Gamma^{L}_{\check{\nu}_i,Z,\nu_b} - \sum_{b=1}^{5}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{\nu_b}^2, m_{Z'}^2\Big)\Big)\Gamma^{L*}_{\check{\nu}_j,Z',\nu_b}\Gamma^{L}_{\check{\nu}_i,Z',\nu_b}
\end{aligned} \tag{75}$$

$$\begin{aligned}
\Sigma^L_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{5} B_1\Big(p^2, m_{eD_a}^2, m_{H_b^-}^2\Big)\Gamma^{L*}_{\check{\nu}_j,e\bar{D}_a,H_b^-}\Gamma^{L}_{\check{\nu}_i,e\bar{D}_a,H_b^-} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{5} B_1\Big(p^2, m_{e_a}^2, m_{H_b^-}^2\Big)\Gamma^{L*}_{\check{\nu}_j,\bar{e}_a,H_b^-}\Gamma^{L}_{\check{\nu}_i,\bar{e}_a,H_b^-} \\
&- \sum_{a=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{e_a}^2, m_{W^-}^2\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,\bar{e}_a,W^-}\Gamma^{R}_{\check{\nu}_i,\bar{e}_a,W^-} \\
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{2} B_1\Big(p^2, m_{eD_b}^2, m_{H_a^-}^2\Big)\Gamma^{L*}_{\check{\nu}_j,H_a^+,eD_b}\Gamma^{L}_{\check{\nu}_i,H_a^+,eD_b} \\
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{3} B_1\Big(p^2, m_{e_b}^2, m_{H_a^-}^2\Big)\Gamma^{L*}_{\check{\nu}_j,H_a^+,e_b}\Gamma^{L}_{\check{\nu}_i,H_a^+,e_b} \\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{e_b}^2, m_{W^-}^2\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,W^+,e_b}\Gamma^{R}_{\check{\nu}_i,W^+,e_b} - \sum_{b=1}^{5}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{\nu_b}^2, 0\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,\gamma,\nu_b}\Gamma^{R}_{\check{\nu}_i,\gamma,\nu_b}
\end{aligned}$$

$$- \sum_{b=1}^{5} \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{\nu_b}^2, m_Z^2\Big)\Big) \Gamma^{R*}_{\check{\nu}_j, Z, \nu_b} \Gamma^{R}_{\check{\nu}_i, Z, \nu_b} - \sum_{b=1}^{5} \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{\nu_b}^2, m_{Z'}^2\Big)\Big) \Gamma^{R*}_{\check{\nu}_j, Z', \nu_b} \Gamma^{R}_{\check{\nu}_i, Z', \nu_b} \tag{76}$$

- **Self-Energy for FeD** (eD)

$$\begin{aligned}
\Sigma^S_{i,j}(p^2) = &+ \sum_{a=1}^{2} m_{eD_a} \sum_{b=1}^{3} B_0\Big(p^2, m_{eD_a}^2, m_{A_{h,b}}^2\Big) \Gamma^{L*}_{\check{eD}_j, eD_a, A_{h,b}} \Gamma^{R}_{\check{eD}_i, eD_a, A_{h,b}} \\
&+ \sum_{a=1}^{3} \sum_{b=1}^{2} B_0\Big(p^2, m_{eD_b}^2, m_{h_a}^2\Big) \Gamma^{L*}_{\check{eD}_j, h_a, eD_b} m_{eD_b} \Gamma^{R}_{\check{eD}_i, h_a, eD_b} \\
&+ \sum_{a=1}^{5} \sum_{b=1}^{5} B_0\Big(p^2, m_{\nu_b}^2, m_{H_a^-}^2\Big) \Gamma^{L*}_{\check{eD}_j, H_a^-, \nu_b} m_{\nu_b} \Gamma^{R}_{\check{eD}_i, H_a^-, \nu_b} \\
&+ m_{\nu^d} \sum_{a=1}^{5} B_0\Big(p^2, m_{\nu^d}^2, m_{H_a^-}^2\Big) \Gamma^{L*}_{\check{eD}_j, H_a^-, \nu^d} \Gamma^{R}_{\check{eD}_i, H_a^-, \nu^d} \\
&- 4 \sum_{b=1}^{2} \Big(- \frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{eD_b}^2, 0\Big)\Big) \Gamma^{R*}_{\check{eD}_j, \gamma, eD_b} m_{eD_b} \Gamma^{L}_{\check{eD}_i, \gamma, eD_b} - 4 \sum_{b=1}^{2} \Big(- \frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{eD_b}^2, m_Z^2\Big)\Big) \Gamma^{R*}_{\check{eD}_j, Z, eD_b} m \\
&- 4 \sum_{b=1}^{2} \Big(- \frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{eD_b}^2, m_{Z'}^2\Big)\Big) \Gamma^{R*}_{\check{eD}_j, Z', eD_b} m_{eD_b} \Gamma^{L}_{\check{eD}_i, Z', eD_b} \\
&- 4 \Big(- \frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{\nu^d}^2, m_{W^-}^2\Big)\Big) \Gamma^{R*}_{\check{eD}_j, W^-, \nu^d} m_{\nu^d} \Gamma^{L}_{\check{eD}_i, W^-, \nu^d}
\end{aligned} \tag{77}$$

$$\begin{aligned}
\Sigma^R_{i,j}(p^2) = &- \frac{1}{2} \sum_{a=1}^{2} \sum_{b=1}^{3} B_1\Big(p^2, m_{eD_a}^2, m_{A_{h,b}}^2\Big) \Gamma^{R*}_{\check{eD}_j, eD_a, A_{h,b}} \Gamma^{R}_{\check{eD}_i, eD_a, A_{h,b}} \\
&- \frac{1}{2} \sum_{a=1}^{3} \sum_{b=1}^{2} B_1\Big(p^2, m_{eD_b}^2, m_{h_a}^2\Big) \Gamma^{R*}_{\check{eD}_j, h_a, eD_b} \Gamma^{R}_{\check{eD}_i, h_a, eD_b} \\
&- \frac{1}{2} \sum_{a=1}^{5} \sum_{b=1}^{5} B_1\Big(p^2, m_{\nu_b}^2, m_{H_a^-}^2\Big) \Gamma^{R*}_{\check{eD}_j, H_a^-, \nu_b} \Gamma^{R}_{\check{eD}_i, H_a^-, \nu_b} \\
&- \frac{1}{2} \sum_{a=1}^{5} B_1\Big(p^2, m_{\nu^d}^2, m_{H_a^-}^2\Big) \Gamma^{R*}_{\check{eD}_j, H_a^-, \nu^d} \Gamma^{R}_{\check{eD}_i, H_a^-, \nu^d} - \sum_{b=1}^{2} \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{eD_b}^2, 0\Big)\Big) \Gamma^{L*}_{\check{eD}_j, \gamma, eD_b} \Gamma^{L}_{\check{eD}_i, \gamma, eD_b} \\
&- \sum_{b=1}^{2} \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{eD_b}^2, m_Z^2\Big)\Big) \Gamma^{L*}_{\check{eD}_j, Z, eD_b} \Gamma^{L}_{\check{eD}_i, Z, eD_b} - \sum_{b=1}^{2} \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{eD_b}^2, m_{Z'}^2\Big)\Big) \Gamma^{L*}_{\check{eD}_j, Z', eD_b} \Gamma^{L}_{\check{eD}_i, Z', eD_b} \\
&- \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{\nu^d}^2, m_{W^-}^2\Big)\Big) \Gamma^{L*}_{\check{eD}_j, W^-, \nu^d} \Gamma^{L}_{\check{eD}_i, W^-, \nu^d}
\end{aligned} \tag{78}$$

$$\Sigma^L_{i,j}(p^2) = - \frac{1}{2} \sum_{a=1}^{2} \sum_{b=1}^{3} B_1\Big(p^2, m_{eD_a}^2, m_{A_{h,b}}^2\Big) \Gamma^{L*}_{\check{eD}_j, eD_a, A_{h,b}} \Gamma^{L}_{\check{eD}_i, eD_a, A_{h,b}}$$

$$
\begin{aligned}
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{eD_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\tilde{\tilde{eD}}_j,h_a,eD_b}\Gamma^{L}_{\tilde{\tilde{eD}}_i,h_a,eD_b}\\
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\nu_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\tilde{\tilde{eD}}_j,H^-_a,\nu_b}\Gamma^{L}_{\tilde{\tilde{eD}}_i,H^-_a,\nu_b}\\
&- \frac{1}{2}\sum_{a=1}^{5} B_1\Big(p^2, m^2_{\nu^d}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\tilde{\tilde{eD}}_j,H^-_a,\nu^d}\Gamma^{L}_{\tilde{\tilde{eD}}_i,H^-_a,\nu^d} - \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{eD_b}, 0\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{eD}}_j,\gamma,eD_b}\Gamma^{R}_{\tilde{\tilde{eD}}_i,\gamma,eD_b}\\
&- \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{eD_b}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{eD}}_j,Z,eD_b}\Gamma^{R}_{\tilde{\tilde{eD}}_i,Z,eD_b} - \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{eD_b}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{eD}}_j,Z',eD_b}\Gamma^{R}_{\tilde{\tilde{eD}}_i,Z',eD_b}\\
&- \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu^d}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{eD}}_j,W^-,\nu^d}\Gamma^{R}_{\tilde{\tilde{eD}}_i,W^-,\nu^d} \qquad (79)
\end{aligned}
$$

- **Self-Energy for Fx** (χ^0)

$$
\begin{aligned}
\Sigma^S(p^2) = &+ m_{\chi^0}\sum_{a=1}^{3} B_0\Big(p^2, m^2_{\chi^0}, m^2_{h_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0,h_a,\chi^0}\Gamma^{R}_{\tilde{\chi}^0,h_a,\chi^0}\\
&+ m_{\chi^0}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{\chi^0}, m^2_{A_{h,b}}\Big)\Gamma^{L*}_{\tilde{\chi}^0,\chi^0,A_{h,b}}\Gamma^{R}_{\tilde{\chi}^0,\chi^0,A_{h,b}}\\
&- 4\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\chi^0}, 0\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^0,\gamma,\chi^0}m_{\chi^0}\Gamma^{L}_{\tilde{\chi}^0,\gamma,\chi^0}\\
&- 4\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\chi^0}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^0,Z,\chi^0}m_{\chi^0}\Gamma^{L}_{\tilde{\chi}^0,Z,\chi^0}\\
&- 4\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\chi^0}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^0,Z',\chi^0}m_{\chi^0}\Gamma^{L}_{\tilde{\chi}^0,Z',\chi^0} \qquad (80)\\
\Sigma^R(p^2) = &- \frac{1}{2}\sum_{a=1}^{3} B_1\Big(p^2, m^2_{\chi^0}, m^2_{h_a}\Big)\Gamma^{R*}_{\tilde{\chi}^0,h_a,\chi^0}\Gamma^{R}_{\tilde{\chi}^0,h_a,\chi^0}\\
&- \frac{1}{2}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{\chi^0}, m^2_{A_{h,b}}\Big)\Gamma^{R*}_{\tilde{\chi}^0,\chi^0,A_{h,b}}\Gamma^{R}_{\tilde{\chi}^0,\chi^0,A_{h,b}}\\
&- \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\chi^0}, 0\Big)\Big)\Gamma^{L*}_{\tilde{\chi}^0,\gamma,\chi^0}\Gamma^{L}_{\tilde{\chi}^0,\gamma,\chi^0} - \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\chi^0}, m^2_{Z}\Big)\Big)\Gamma^{L*}_{\tilde{\chi}^0,Z,\chi^0}\Gamma^{L}_{\tilde{\chi}^0,Z,\chi^0}\\
&- \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\chi^0}, m^2_{Z'}\Big)\Big)\Gamma^{L*}_{\tilde{\chi}^0,Z',\chi^0}\Gamma^{L}_{\tilde{\chi}^0,Z',\chi^0} \qquad (81)\\
\Sigma^L(p^2) = &- \frac{1}{2}\sum_{a=1}^{3} B_1\Big(p^2, m^2_{\chi^0}, m^2_{h_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0,h_a,\chi^0}\Gamma^{L}_{\tilde{\chi}^0,h_a,\chi^0}\\
&- \frac{1}{2}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{\chi^0}, m^2_{A_{h,b}}\Big)\Gamma^{L*}_{\tilde{\chi}^0,\chi^0,A_{h,b}}\Gamma^{L}_{\tilde{\chi}^0,\chi^0,A_{h,b}}\\
&- \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\chi^0}, 0\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^0,\gamma,\chi^0}\Gamma^{R}_{\tilde{\chi}^0,\gamma,\chi^0} - \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\chi^0}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^0,Z,\chi^0}\Gamma^{R}_{\tilde{\chi}^0,Z,\chi^0}
\end{aligned}
$$

$$- \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\chi^0}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\bar{\chi}^0,Z',\chi^0}\Gamma^{R}_{\bar{\chi}^0,Z',\chi^0} \tag{82}$$

- **Self-Energy for Fvv** (ν^d)

$$\begin{aligned}
\Sigma^S(p^2) = &+\sum_{a=1}^{3} m_{e_a}\sum_{b=1}^{5} B_0\Big(p^2, m^2_{e_a}, m^2_{H^-_b}\Big)\Gamma^{L*}_{\bar{\nu}^d,\bar{e}_a,H^-_b}\Gamma^{R}_{\bar{\nu}^d,\bar{e}_a,H^-_b}\\
&+ m_{\nu^d}\sum_{a=1}^{3} B_0\Big(p^2, m^2_{\nu^d}, m^2_{h_a}\Big)\Gamma^{L*}_{\bar{\nu}^d,h_a,\nu^d}\Gamma^{R}_{\bar{\nu}^d,h_a,\nu^d}\\
&+\sum_{a=1}^{5}\sum_{b=1}^{2} B_0\Big(p^2, m^2_{eD_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\bar{\nu}^d,H^+_a,eD_b} m_{eD_b}\Gamma^{R}_{\bar{\nu}^d,H^+_a,eD_b}\\
&- 4\sum_{b=1}^{2}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{eD_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\bar{\nu}^d,W^+,eD_b} m_{eD_b}\Gamma^{L}_{\bar{\nu}^d,W^+,eD_b}\\
&+ m_{\nu^d}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{\nu^d}, m^2_{A_{h,b}}\Big)\Gamma^{L*}_{\bar{\nu}^d,\nu^d,A_{h,b}}\Gamma^{R}_{\bar{\nu}^d,\nu^d,A_{h,b}}\\
&- 4\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\nu^d}, 0\Big)\Big)\Gamma^{R*}_{\bar{\nu}^d,\gamma,\nu^d} m_{\nu^d}\Gamma^{L}_{\bar{\nu}^d,\gamma,\nu^d}\\
&- 4\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\nu^d}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\bar{\nu}^d,Z,\nu^d} m_{\nu^d}\Gamma^{L}_{\bar{\nu}^d,Z,\nu^d}\\
&- 4\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\nu^d}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\bar{\nu}^d,Z',\nu^d} m_{\nu^d}\Gamma^{L}_{\bar{\nu}^d,Z',\nu^d}
\end{aligned} \tag{83}$$

$$\begin{aligned}
\Sigma^R(p^2) = &-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{e_a}, m^2_{H^-_b}\Big)\Gamma^{R*}_{\bar{\nu}^d,\bar{e}_a,H^-_b}\Gamma^{R}_{\bar{\nu}^d,\bar{e}_a,H^-_b}\\
&- \frac{1}{2}\sum_{a=1}^{3} B_1\Big(p^2, m^2_{\nu^d}, m^2_{h_a}\Big)\Gamma^{R*}_{\bar{\nu}^d,h_a,\nu^d}\Gamma^{R}_{\bar{\nu}^d,h_a,\nu^d}\\
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{eD_b}, m^2_{H^-_a}\Big)\Gamma^{R*}_{\bar{\nu}^d,H^+_a,eD_b}\Gamma^{R}_{\bar{\nu}^d,H^+_a,eD_b}\\
&- \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{eD_b}, m^2_{W^-}\Big)\Big)\Gamma^{L*}_{\bar{\nu}^d,W^+,eD_b}\Gamma^{L}_{\bar{\nu}^d,W^+,eD_b}\\
&- \frac{1}{2}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{\nu^d}, m^2_{A_{h,b}}\Big)\Gamma^{R*}_{\bar{\nu}^d,\nu^d,A_{h,b}}\Gamma^{R}_{\bar{\nu}^d,\nu^d,A_{h,b}}\\
&- \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu^d}, 0\Big)\Big)\Gamma^{L*}_{\bar{\nu}^d,\gamma,\nu^d}\Gamma^{L}_{\bar{\nu}^d,\gamma,\nu^d} - \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu^d}, m^2_{Z}\Big)\Big)\Gamma^{L*}_{\bar{\nu}^d,Z,\nu^d}\Gamma^{L}_{\bar{\nu}^d,Z,\nu^d}\\
&- \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu^d}, m^2_{Z'}\Big)\Big)\Gamma^{L*}_{\bar{\nu}^d,Z',\nu^d}\Gamma^{L}_{\bar{\nu}^d,Z',\nu^d}
\end{aligned} \tag{84}$$

$$
\begin{aligned}
\Sigma^L(p^2) = &-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{e_a}, m^2_{H_b^-}\Big)\Gamma^{L*}_{\bar{\nu}^d,\bar{e}_a,H_b^-}\Gamma^{L}_{\bar{\nu}^d,\bar{e}_a,H_b^-} \\
&- \frac{1}{2}\sum_{a=1}^{3} B_1\Big(p^2, m^2_{\nu^d}, m^2_{h_a}\Big)\Gamma^{L*}_{\bar{\nu}^d,h_a,\nu^d}\Gamma^{L}_{\bar{\nu}^d,h_a,\nu^d} \\
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{eD_b}, m^2_{H_a^-}\Big)\Gamma^{L*}_{\bar{\nu}^d,H_a^+,eD_b}\Gamma^{L}_{\bar{\nu}^d,H_a^+,eD_b} \\
&- \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{eD_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\bar{\nu}^d,W^+,eD_b}\Gamma^{R}_{\bar{\nu}^d,W^+,eD_b} \\
&- \frac{1}{2}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{\nu^d}, m^2_{A_{h,b}}\Big)\Gamma^{L*}_{\bar{\nu}^d,\nu^d,A_{h,b}}\Gamma^{L}_{\bar{\nu}^d,\nu^d,A_{h,b}} \\
&- \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu^d}, 0\Big)\Big)\Gamma^{R*}_{\bar{\nu}^d,\gamma,\nu^d}\Gamma^{R}_{\bar{\nu}^d,\gamma,\nu^d} - \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu^d}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\bar{\nu}^d,Z,\nu^d}\Gamma^{R}_{\bar{\nu}^d,Z,\nu^d} \\
&- \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu^d}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\bar{\nu}^d,Z',\nu^d}\Gamma^{R}_{\bar{\nu}^d,Z',\nu^d} \qquad (85)
\end{aligned}
$$

- **Self-Energy for Z-Boson** (Z)

$$
\begin{aligned}
\Pi(p^2) = &+|\Gamma_{Z,\bar{\eta^-},\eta^-}|^2 B_{00}\Big(p^2, m^2_{\eta^-}, m^2_{\eta^-}\Big) + |\Gamma_{Z,\bar{\eta^+},\eta^+}|^2 B_{00}\Big(p^2, m^2_{\eta^+}, m^2_{\eta^+}\Big) \\
&+ \Big(|\Gamma^L_{Z,\bar{\nu}^d,\nu^d}|^2 + |\Gamma^R_{Z,\bar{\nu}^d,\nu^d}|^2\Big)H_0\Big(p^2, m^2_{\nu^d}, m^2_{\nu^d}\Big) + \Big(|\Gamma^L_{Z,\bar{\chi}^0,\chi^0}|^2 + |\Gamma^R_{Z,\bar{\chi}^0,\chi^0}|^2\Big)H_0\Big(p^2, m^2_{\chi^0}, m^2_{\chi^0}\Big) \\
&- |\Gamma_{Z,W^+,W^-}|^2\Big(10B_{00}\Big(p^2, m^2_{W^-}, m^2_{W^-}\Big) + 2A_0\Big(m^2_{W^-}\Big) - 2\mathrm{rMS}\Big(2m^2_{W^-} - \frac{1}{3}p^2\Big) + B_0\Big(p^2, m^2_{W^-}, m^2_{W^-}\Big)\Big(2m^2_{W^-} + 4p^2\Big)\Big) \\
&+ 4B_0\Big(p^2, m^2_{\nu^d}, m^2_{\nu^d}\Big)m^2_{\nu^d}\Re\Big(\Gamma^{L*}_{Z,\bar{\nu}^d,\nu^d}\Gamma^{R}_{Z,\bar{\nu}^d,\nu^d}\Big) + 4B_0\Big(p^2, m^2_{\chi^0}, m^2_{\chi^0}\Big)m^2_{\chi^0}\Re\Big(\Gamma^{L*}_{Z,\bar{\chi}^0,\chi^0}\Gamma^{R}_{Z,\bar{\chi}^0,\chi^0}\Big) \\
&+ \sum_{a=1}^{2}\sum_{b=1}^{2}\Big[\Big(|\Gamma^L_{Z,e\bar{D}_a,eD_b}|^2 + |\Gamma^R_{Z,e\bar{D}_a,eD_b}|^2\Big)H_0\Big(p^2, m^2_{eD_a}, m^2_{eD_b}\Big) \\
&+ 4B_0\Big(p^2, m^2_{eD_a}, m^2_{eD_b}\Big)m_{eD_a}m_{eD_b}\Re\Big(\Gamma^{L*}_{Z,e\bar{D}_a,eD_b}\Gamma^{R}_{Z,e\bar{D}_a,eD_b}\Big)\Big] \\
&+ \frac{1}{2}\sum_{a=1}^{3} A_0\Big(m^2_{A_{h,a}}\Big)\Gamma_{Z,Z,A_{h,a},A_{h,a}} + \frac{1}{2}\sum_{a=1}^{3} A_0\Big(m^2_{h_a}\Big)\Gamma_{Z,Z,h_a,h_a} \\
&- 4\sum_{a=1}^{3}\sum_{b=1}^{3}|\Gamma_{Z,h_a,A_{h,b}}|^2 B_{00}\Big(p^2, m^2_{A_{h,b}}, m^2_{h_a}\Big) \\
&+ 3\sum_{a=1}^{3}\sum_{b=1}^{3}\Big[\Big(|\Gamma^L_{Z,\bar{d}_a,d_b}|^2 + |\Gamma^R_{Z,\bar{d}_a,d_b}|^2\Big)H_0\Big(p^2, m^2_{d_a}, m^2_{d_b}\Big) \\
&+ 4B_0\Big(p^2, m^2_{d_a}, m^2_{d_b}\Big)m_{d_a}m_{d_b}\Re\Big(\Gamma^{L*}_{Z,\bar{d}_a,d_b}\Gamma^{R}_{Z,\bar{d}_a,d_b}\Big)\Big]
\end{aligned}
$$

$$
\begin{aligned}
&+\sum_{a=1}^{3}\sum_{b=1}^{3}\Big[\Big(|\Gamma^{L}_{Z,\bar{e}_a,e_b}|^2+|\Gamma^{R}_{Z,\bar{e}_a,e_b}|^2\Big)H_0\Big(p^2,m^2_{e_a},m^2_{e_b}\Big)\\
&+4B_0\Big(p^2,m^2_{e_a},m^2_{e_b}\Big)m_{e_a}m_{e_b}\Re\Big(\Gamma^{L*}_{Z,\bar{e}_a,e_b}\Gamma^{R}_{Z,\bar{e}_a,e_b}\Big)\Big]\\
&+3\sum_{a=1}^{3}\sum_{b=1}^{3}\Big[\Big(|\Gamma^{L}_{Z,\bar{u}_a,u_b}|^2+|\Gamma^{R}_{Z,\bar{u}_a,u_b}|^2\Big)H_0\Big(p^2,m^2_{u_a},m^2_{u_b}\Big)\\
&+4B_0\Big(p^2,m^2_{u_a},m^2_{u_b}\Big)m_{u_a}m_{u_b}\Re\Big(\Gamma^{L*}_{Z,\bar{u}_a,u_b}\Gamma^{R}_{Z,\bar{u}_a,u_b}\Big)\Big]\\
&+\sum_{a=1}^{5}A_0\Big(m^2_{H^-_a}\Big)\Gamma_{Z,Z,H^+_a,H^-_a}-4\sum_{a=1}^{5}\sum_{b=1}^{5}|\Gamma_{Z,H^+_a,H^-_b}|^2B_{00}\Big(p^2,m^2_{H^-_a},m^2_{H^-_b}\Big)\\
&+\frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{5}\Big[\Big(|\Gamma^{L}_{Z,\nu_a,\nu_b}|^2+|\Gamma^{R}_{Z,\nu_a,\nu_b}|^2\Big)H_0\Big(p^2,m^2_{\nu_a},m^2_{\nu_b}\Big)\\
&+4B_0\Big(p^2,m^2_{\nu_a},m^2_{\nu_b}\Big)m_{\nu_a}m_{\nu_b}\Re\Big(\Gamma^{L*}_{Z,\nu_a,\nu_b}\Gamma^{R}_{Z,\nu_a,\nu_b}\Big)\Big]\\
&+\sum_{b=1}^{3}|\Gamma_{Z,\gamma,h_b}|^2B_0\Big(p^2,0,m^2_{h_b}\Big)+\sum_{b=1}^{3}|\Gamma_{Z,Z,h_b}|^2B_0\Big(p^2,m^2_Z,m^2_{h_b}\Big)+\sum_{b=1}^{3}|\Gamma_{Z,Z',h_b}|^2B_0\Big(p^2,m^2_{Z'},m^2_{h_b}\Big)\\
&+2\sum_{b=1}^{5}|\Gamma_{Z,W^+,H^-_b}|^2B_0\Big(p^2,m^2_{W^-},m^2_{H^-_b}\Big)+2\mathrm{rMS}m^2_{W^-}\Gamma^1_{Z,Z,W^+,W^-}-A_0\Big(m^2_{W^-}\Big)\Big(4\Gamma^1_{Z,Z,W^+,W^-}+\Gamma^2_{Z,Z,W^+,W^-}+\Gamma^3_{Z,Z,W}
\end{aligned}
\tag{86}
$$

- **Self-Energy for Z'-Boson** (Z')

$$
\begin{aligned}
\Pi(p^2)=&+|\Gamma_{Z',\eta^-,\eta^-}|^2B_{00}\Big(p^2,m^2_{\eta^-},m^2_{\eta^-}\Big)+|\Gamma_{Z',\eta^+,\eta^+}|^2B_{00}\Big(p^2,m^2_{\eta^+},m^2_{\eta^+}\Big)\\
&+\Big(|\Gamma^{L}_{Z',\bar{\nu}^d,\nu^d}|^2+|\Gamma^{R}_{Z',\bar{\nu}^d,\nu^d}|^2\Big)H_0\Big(p^2,m^2_{\nu^d},m^2_{\nu^d}\Big)+\Big(|\Gamma^{L}_{Z',\bar{\chi}^0,\chi^0}|^2+|\Gamma^{R}_{Z',\bar{\chi}^0,\chi^0}|^2\Big)H_0\Big(p^2,m^2_{\chi^0},m^2_{\chi^0}\Big)\\
&-|\Gamma_{Z',W^+,W^-}|^2\Big(10B_{00}\Big(p^2,m^2_{W^-},m^2_{W^-}\Big)+2A_0\Big(m^2_{W^-}\Big)-2\mathrm{rMS}\Big(2m^2_{W^-}-\frac{1}{3}p^2\Big)+B_0\Big(p^2,m^2_{W^-},m^2_{W^-}\Big)\Big(2m^2_{W^-}+4p^2\Big)\\
&+4B_0\Big(p^2,m^2_{\nu^d},m^2_{\nu^d}\Big)m^2_{\nu^d}\Re\Big(\Gamma^{L*}_{Z',\bar{\nu}^d,\nu^d}\Gamma^{R}_{Z',\bar{\nu}^d,\nu^d}\Big)+4B_0\Big(p^2,m^2_{\chi^0},m^2_{\chi^0}\Big)m^2_{\chi^0}\Re\Big(\Gamma^{L*}_{Z',\bar{\chi}^0,\chi^0}\Gamma^{R}_{Z',\bar{\chi}^0,\chi^0}\Big)\\
&+\sum_{a=1}^{2}\sum_{b=1}^{2}\Big[\Big(|\Gamma^{L}_{Z',e\bar{D}_a,eD_b}|^2+|\Gamma^{R}_{Z',e\bar{D}_a,eD_b}|^2\Big)H_0\Big(p^2,m^2_{eD_a},m^2_{eD_b}\Big)\\
&+4B_0\Big(p^2,m^2_{eD_a},m^2_{eD_b}\Big)m_{eD_a}m_{eD_b}\Re\Big(\Gamma^{L*}_{Z',e\bar{D}_a,eD_b}\Gamma^{R}_{Z',e\bar{D}_a,eD_b}\Big)\Big]\\
&+\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{A_{h,a}}\Big)\Gamma_{Z',Z',A_{h,a},A_{h,a}}+\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{h_a}\Big)\Gamma_{Z',Z',h_a,h_a}\\
&-4\sum_{a=1}^{3}\sum_{b=1}^{3}|\Gamma_{Z',h_a,A_{h,b}}|^2B_{00}\Big(p^2,m^2_{A_{h,b}},m^2_{h_a}\Big)
\end{aligned}
$$

$$
\begin{aligned}
&+ 3\sum_{a=1}^{3}\sum_{b=1}^{3}\Big[\Big(|\Gamma^{L}_{Z',\bar{d}_a,d_b}|^2 + |\Gamma^{R}_{Z',\bar{d}_a,d_b}|^2\Big)H_0\Big(p^2, m^2_{d_a}, m^2_{d_b}\Big) \\
&+ 4B_0\Big(p^2, m^2_{d_a}, m^2_{d_b}\Big)m_{d_a}m_{d_b}\Re\Big(\Gamma^{L*}_{Z',\bar{d}_a,d_b}\Gamma^{R}_{Z',\bar{d}_a,d_b}\Big)\Big] \\
&+ \sum_{a=1}^{3}\sum_{b=1}^{3}\Big[\Big(|\Gamma^{L}_{Z',\bar{e}_a,e_b}|^2 + |\Gamma^{R}_{Z',\bar{e}_a,e_b}|^2\Big)H_0\Big(p^2, m^2_{e_a}, m^2_{e_b}\Big) \\
&+ 4B_0\Big(p^2, m^2_{e_a}, m^2_{e_b}\Big)m_{e_a}m_{e_b}\Re\Big(\Gamma^{L*}_{Z',\bar{e}_a,e_b}\Gamma^{R}_{Z',\bar{e}_a,e_b}\Big)\Big] \\
&+ 3\sum_{a=1}^{3}\sum_{b=1}^{3}\Big[\Big(|\Gamma^{L}_{Z',\bar{u}_a,u_b}|^2 + |\Gamma^{R}_{Z',\bar{u}_a,u_b}|^2\Big)H_0\Big(p^2, m^2_{u_a}, m^2_{u_b}\Big) \\
&+ 4B_0\Big(p^2, m^2_{u_a}, m^2_{u_b}\Big)m_{u_a}m_{u_b}\Re\Big(\Gamma^{L*}_{Z',\bar{u}_a,u_b}\Gamma^{R}_{Z',\bar{u}_a,u_b}\Big)\Big] \\
&+ \sum_{a=1}^{5}A_0\Big(m^2_{H^-_a}\Big)\Gamma_{Z',Z',H^+_a,H^-_a} - 4\sum_{a=1}^{5}\sum_{b=1}^{5}|\Gamma_{Z',H^+_a,H^-_b}|^2 B_{00}\Big(p^2, m^2_{H^-_a}, m^2_{H^-_b}\Big) \\
&+ \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{5}\Big[\Big(|\Gamma^{L}_{Z',\nu_a,\nu_b}|^2 + |\Gamma^{R}_{Z',\nu_a,\nu_b}|^2\Big)H_0\Big(p^2, m^2_{\nu_a}, m^2_{\nu_b}\Big) \\
&+ 4B_0\Big(p^2, m^2_{\nu_a}, m^2_{\nu_b}\Big)m_{\nu_a}m_{\nu_b}\Re\Big(\Gamma^{L*}_{Z',\nu_a,\nu_b}\Gamma^{R}_{Z',\nu_a,\nu_b}\Big)\Big] \\
&+ \sum_{b=1}^{3}|\Gamma_{Z',\gamma,h_b}|^2 B_0\Big(p^2, 0, m^2_{h_b}\Big) + \sum_{b=1}^{3}|\Gamma_{Z',Z,h_b}|^2 B_0\Big(p^2, m^2_{Z}, m^2_{h_b}\Big) + \sum_{b=1}^{3}|\Gamma_{Z',Z',h_b}|^2 B_0\Big(p^2, m^2_{Z'}, m^2_{h_b}\Big) \\
&+ 2\sum_{b=1}^{5}|\Gamma_{Z',W^+,H^-_b}|^2 B_0\Big(p^2, m^2_{W^-}, m^2_{H^-_b}\Big) + 2\mathrm{rMS}m^2_{W^-}\Gamma^{1}_{Z',Z',W^+,W^-} - A_0\Big(m^2_{W^-}\Big)\Big(4\Gamma^{1}_{Z',Z',W^+,W^-} + \Gamma^{2}_{Z',Z',W^+,W^-} + \Gamma
\end{aligned}
\tag{87}
$$

- **Self-Energy for W-Boson** (W^-)

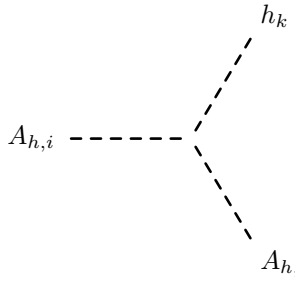
$$
\begin{aligned}
\Pi(p^2) = {} & 2\mathrm{rMS}m^2_{W^-}\Gamma^{1}_{W^-,W^+,W^+,W^-} + 3\sum_{a=1}^{3}\sum_{b=1}^{3}\Big[\Big(|\Gamma^{L}_{W^+,\bar{u}_a,d_b}|^2 + |\Gamma^{R}_{W^+,\bar{u}_a,d_b}|^2\Big)H_0\Big(p^2, m^2_{u_a}, m^2_{d_b}\Big) \\
&+ 4B_0\Big(p^2, m^2_{u_a}, m^2_{d_b}\Big)m_{d_b}m_{u_a}\Re\Big(\Gamma^{L*}_{W^+,\bar{u}_a,d_b}\Gamma^{R}_{W^+,\bar{u}_a,d_b}\Big)\Big] - 4\sum_{a=1}^{5}\sum_{b=1}^{3}|\Gamma_{W^+,H^-_a,A_{h,b}}|^2 B_{00}\Big(p^2, m^2_{A_{h,b}}, m^2_{H^-_a}\Big) - 4\sum_{a=1}^{5}\sum_{b=1}^{3}|\Gamma_{W^-} \\
&+ 4B_0\Big(p^2, m^2_{\nu_a}, m^2_{e_b}\Big)m_{e_b}m_{\nu_a}\Re\Big(\Gamma^{L*}_{W^+,\nu_a,e_b}\Gamma^{R}_{W^+,\nu_a,e_b}\Big)\Big] + \sum_{b=1}^{2}\Big[\Big(|\Gamma^{L}_{W^+,\bar{\nu}^d,eD_b}|^2 + |\Gamma^{R}_{W^+,\bar{\nu}^d,eD_b}|^2\Big)H_0\Big(p^2, m^2_{\nu^d}, m^2_{eD_b}\Big) \\
&+ 4B_0\Big(p^2, m^2_{\nu^d}, m^2_{eD_b}\Big)m_{\nu^d}m_{eD_b}\Re\Big(\Gamma^{L*}_{W^+,\bar{\nu}^d,eD_b}\Gamma^{R}_{W^+,\bar{\nu}^d,eD_b}\Big)\Big] + \sum_{b=1}^{3}|\Gamma_{W^+,W^-,h_b}|^2 B_0\Big(p^2, m^2_{W^-}, m^2_{h_b}\Big) + \sum_{b=1}^{5}|\Gamma_{W^+,\gamma,H^-_b}|^2 B
\end{aligned}
\tag{88}
$$

7.2 Tadpoles

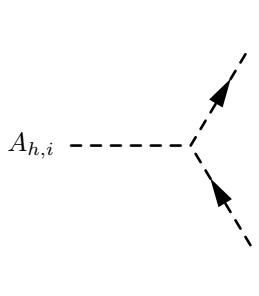
$$
\begin{aligned}
\delta t_h^{(1)} = &+ A_0\Big(m^2_{\eta^-}\Big)\Gamma_{\check{h}_i,\eta^-,\eta^-} + A_0\Big(m^2_{\eta^+}\Big)\Gamma_{\check{h}_i,\eta^+,\eta^+} + A_0\Big(m^2_{\eta^Z}\Big)\Gamma_{\check{h}_i,\eta^Z,\eta^Z} \\
&+ A_0\Big(m^2_{\eta^{Z'}}\Big)\Gamma_{\check{h}_i,\eta^{Z'},\eta^{Z'}} + 4\Gamma_{\check{h}_i,W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{W^-} + A_0\Big(m^2_{W^-}\Big)\Big) + 2\Gamma_{\check{h}_i,Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{Z} + A_0\Big(m^2_{Z}\Big)\Big) \\
&+ 2\Gamma_{\check{h}_i,Z',Z'}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{Z'} + A_0\Big(m^2_{Z'}\Big)\Big) + 2\sum_{a=1}^{2} A_0\Big(m^2_{eD_a}\Big)m_{eD_a}\Big(\Gamma^L_{\check{h}_i,e\bar{D}_a,eD_a} + \Gamma^R_{\check{h}_i,e\bar{D}_a,eD_a}\Big) \\
&- \frac{1}{2}\sum_{a=1}^{3} A_0\Big(m^2_{A_{h,a}}\Big)\Gamma_{\check{h}_i,A_{h,a},A_{h,a}} - \frac{1}{2}\sum_{a=1}^{3} A_0\Big(m^2_{h_a}\Big)\Gamma_{\check{h}_i,h_a,h_a} \\
&+ 6\sum_{a=1}^{3} A_0\Big(m^2_{d_a}\Big)m_{d_a}\Big(\Gamma^L_{\check{h}_i,\bar{d}_a,d_a} + \Gamma^R_{\check{h}_i,\bar{d}_a,d_a}\Big) \\
&+ 2\sum_{a=1}^{3} A_0\Big(m^2_{e_a}\Big)m_{e_a}\Big(\Gamma^L_{\check{h}_i,\bar{e}_a,e_a} + \Gamma^R_{\check{h}_i,\bar{e}_a,e_a}\Big) \\
&+ 6\sum_{a=1}^{3} A_0\Big(m^2_{u_a}\Big)m_{u_a}\Big(\Gamma^L_{\check{h}_i,\bar{u}_a,u_a} + \Gamma^R_{\check{h}_i,\bar{u}_a,u_a}\Big) - \sum_{a=1}^{5} A_0\Big(m^2_{H_a^-}\Big)\Gamma_{\check{h}_i,H_a^+,H_a^-} \\
&+ 2A_0\Big(m^2_{\nu^d}\Big)m_{\nu^d}\Big(\Gamma^L_{\check{h}_i,\bar{\nu}^d,\nu^d} + \Gamma^R_{\check{h}_i,\bar{\nu}^d,\nu^d}\Big) + 2A_0\Big(m^2_{\chi^0}\Big)m_{\chi^0}\Big(\Gamma^L_{\check{h}_i,\bar{\chi}^0,\chi^0} + \Gamma^R_{\check{h}_i,\bar{\chi}^0,\chi^0}\Big)
\end{aligned} \tag{89}
$$

8 Interactions for eigenstates 'EWSB'

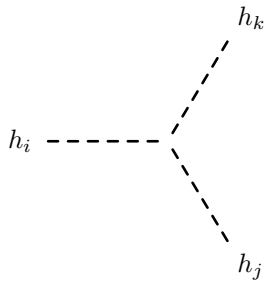
8.1 Three Scalar-Interaction



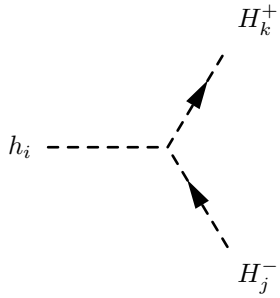
$$
\begin{aligned}
&i\Big(Z^A_{i2}Z^A_{j2}\Big(2\lambda_{21}vxZ^H_{k2} + \lambda_{31}vZ^H_{k1}\Big) + Z^A_{i3}Z^A_{j3}\Big(2\lambda_{22}vx2Z^H_{k3} + \lambda_{32}vZ^H_{k1}\Big) \\
&+ Z^A_{i1}Z^A_{j1}\Big(2l_hvZ^H_{k1} + \lambda_{31}vxZ^H_{k2} + \lambda_{32}vx2Z^H_{k3}\Big)\Big)
\end{aligned} \tag{90}
$$



$$-\frac{1}{\sqrt{2}}\Big(\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{f1,ab}Z^{+}_{k1+a}Z^{+}_{j3+b}Z^{A}_{i2}-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{f1,ab}Z^{+}_{j1+a}Z^{+}_{k3+b}Z^{A}_{i2}$$
$$+\Big(-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{f2,ab}Z^{+}_{j1+a}Z^{+}_{k3+b}+\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{f2,ab}Z^{+}_{k1+a}Z^{+}_{j3+b}\Big)Z^{A}_{i3}\Big) \tag{91}$$

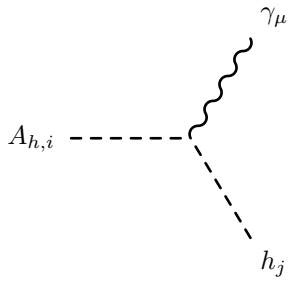


$$i\Big(Z^{H}_{i2}\Big(\lambda_{31}Z^{H}_{j1}\Big(vxZ^{H}_{k1}+vZ^{H}_{k2}\Big)+Z^{H}_{j2}\Big(6\lambda_{21}vxZ^{H}_{k2}+\lambda_{31}vZ^{H}_{k1}\Big)\Big)$$
$$+Z^{H}_{i3}\Big(\lambda_{32}Z^{H}_{j1}\Big(vx2Z^{H}_{k1}+vZ^{H}_{k3}\Big)+Z^{H}_{j3}\Big(6\lambda_{22}vx2Z^{H}_{k3}+\lambda_{32}vZ^{H}_{k1}\Big)\Big)$$
$$+Z^{H}_{i1}\Big(\lambda_{31}Z^{H}_{j2}\Big(vxZ^{H}_{k1}+vZ^{H}_{k2}\Big)+\lambda_{32}Z^{H}_{j3}\Big(vx2Z^{H}_{k1}+vZ^{H}_{k3}\Big)$$
$$+Z^{H}_{j1}\Big(6l_hvZ^{H}_{k1}+\lambda_{31}vxZ^{H}_{k2}+\lambda_{32}vx2Z^{H}_{k3}\Big)\Big)\Big) \tag{92}$$

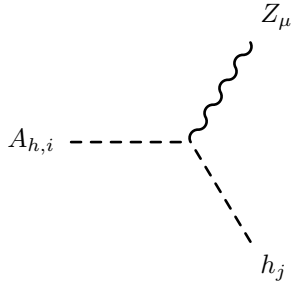


$$
\begin{aligned}
&i\Big(- v\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{41,ab}Z^{+}_{k1+a}Z^{+}_{j1+b}Z^{H}_{i1} - v\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{42,ab}Z^{+}_{k3+a}Z^{+}_{j3+b}Z^{H}_{i1} \\
&- \frac{1}{\sqrt{2}}\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{f1,ab}Z^{+}_{k1+a}Z^{+}_{j3+b}Z^{H}_{i2} - \frac{1}{\sqrt{2}}\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{f1,ab}Z^{+}_{j1+a}Z^{+}_{k3+b}Z^{H}_{i2} \\
&- \frac{1}{\sqrt{2}}\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{f2,ab}Z^{+}_{k1+a}Z^{+}_{j3+b}Z^{H}_{i3} - \frac{1}{\sqrt{2}}\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{f2,ab}Z^{+}_{j1+a}Z^{+}_{k3+b}Z^{H}_{i3} + 2l_h v Z^{H}_{i1}Z^{+}_{j1}Z^{+}_{k1} \\
&+ \lambda_{31}vxZ^{H}_{i2}Z^{+}_{j1}Z^{+}_{k1} + \lambda_{32}vx2Z^{H}_{i3}Z^{+}_{j1}Z^{+}_{k1}\Big)
\end{aligned} \tag{93}
$$

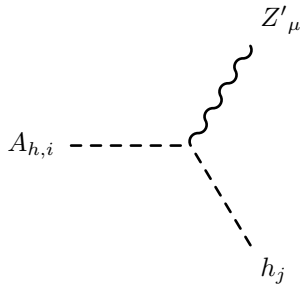
8.2 Two Scalar-One Vector Boson-Interaction



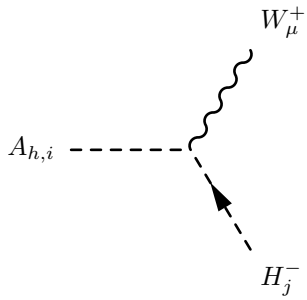
$$
\frac{1}{2}\Big(10g_{YB}\cos\Theta_W\Big(Z^{A}_{i2}Z^{H}_{j2} + Z^{A}_{i3}Z^{H}_{j3}\Big) + \Big(g_1\cos\Theta_W - g_2\sin\Theta_W\Big)Z^{A}_{i1}Z^{H}_{j1}\Big)\Big(- p^{h_j}_{\mu} + p^{A_{h,i}}_{\mu}\Big) \tag{94}
$$



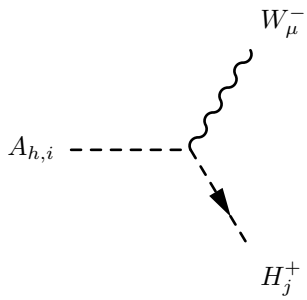
$$
\begin{aligned}
&\frac{1}{2}\Big(- \Big(g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W - g_{BY}\sin\Theta'_W\Big)Z^{A}_{i1}Z^{H}_{j1} \\
&- 10\Big(- g_B\sin\Theta'_W + g_{YB}\cos\Theta'_W\sin\Theta_W\Big)\Big(Z^{A}_{i2}Z^{H}_{j2} + Z^{A}_{i3}Z^{H}_{j3}\Big)\Big)\Big(- p^{h_j}_{\mu} + p^{A_{h,i}}_{\mu}\Big)
\end{aligned} \tag{95}
$$



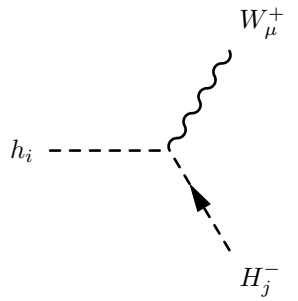
$$\frac{1}{2}\Big(\Big(\Big(\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W\Big)\sin\Theta'_W + g_{BY}\cos\Theta'_W\Big)Z^A_{i1}Z^H_{j1} + 10\Big(g_B\cos\Theta'_W + g_{YB}\sin\Theta_W\sin\Theta'_W\Big)\Big(Z^A_{i2}Z^H_{j2} + Z^A_{i3}Z^H_{j3}\Big)\Big)\Big(-p_\mu^{h_j} + p_\mu^{A_{h,i}}\Big) \tag{96}$$



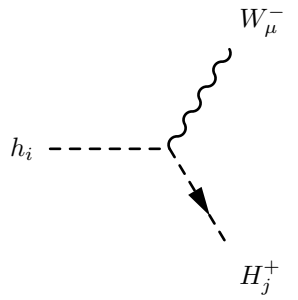
$$\frac{1}{2}g_2 Z^A_{i1}Z^+_{j1}\Big(-p_\mu^{H^-_j} + p_\mu^{A_{h,i}}\Big) \tag{97}$$



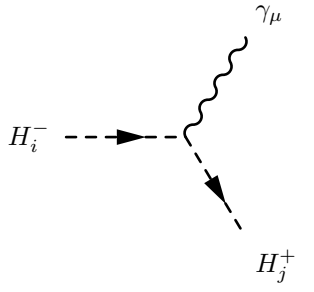
$$\frac{1}{2}g_2 Z^A_{i1}Z^+_{j1}\Big(-p_\mu^{H^+_j} + p_\mu^{A_{h,i}}\Big) \tag{98}$$



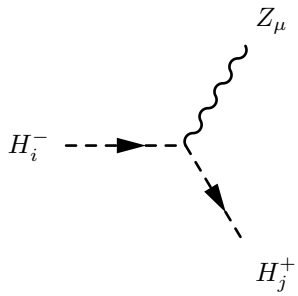
$$-\frac{i}{2}g_2 Z_{i1}^H Z_{j1}^+\Big(-p_\mu^{H_j^-}+p_\mu^{h_i}\Big) \tag{99}$$



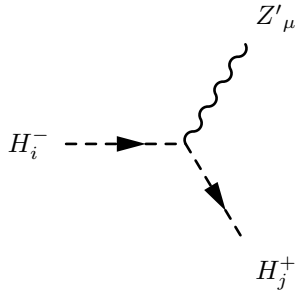
$$\frac{i}{2}g_2 Z_{i1}^H Z_{j1}^+\Big(-p_\mu^{H_j^+}+p_\mu^{h_i}\Big) \tag{100}$$



$$\begin{aligned}&\frac{i}{2}\Big(2\Big(g_1+g_{YB}\Big)\cos\Theta_W\sum_{a=1}^{2}Z_{i1+a}^+Z_{j1+a}^+ + 2\Big(-4g_{YB}+g_1\Big)\cos\Theta_W\sum_{a=1}^{2}Z_{i3+a}^+Z_{j3+a}^+\\&+\Big(g_1\cos\Theta_W+g_2\sin\Theta_W\Big)Z_{i1}^+Z_{j1}^+\Big)\Big(-p_\mu^{H_j^+}+p_\mu^{H_i^-}\Big)\end{aligned} \tag{101}$$

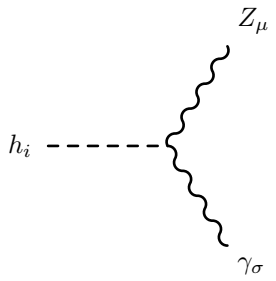


$$
\begin{aligned}
&-\frac{i}{2}\Big(2\Big(\Big(g_1+g_{YB}\Big)\cos\Theta'_W\sin\Theta_W-\Big(g_{BY}+g_B\Big)\sin\Theta'_W\Big)\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}\\
&+2\Big(-\Big(-4g_B+g_{BY}\Big)\sin\Theta'_W+\Big(-4g_{YB}+g_1\Big)\cos\Theta'_W\sin\Theta_W\Big)\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}\\
&-\Big(-g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W+g_{BY}\sin\Theta'_W\Big)Z^+_{i1}Z^+_{j1}\Big)\Big(-p_\mu^{H_j^+}+p_\mu^{H_i^-}\Big)
\end{aligned}
\tag{102}
$$

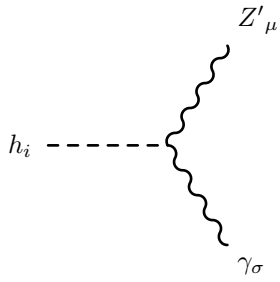


$$
\begin{aligned}
&\frac{i}{2}\Big(2\Big(\Big(g_1+g_{YB}\Big)\sin\Theta_W\sin\Theta'_W+\Big(g_{BY}+g_B\Big)\cos\Theta'_W\Big)\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}\\
&+2\Big(\Big(-4g_B+g_{BY}\Big)\cos\Theta'_W+\Big(-4g_{YB}+g_1\Big)\sin\Theta_W\sin\Theta'_W\Big)\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}\\
&+\Big(\Big(g_1\sin\Theta_W-g_2\cos\Theta_W\Big)\sin\Theta'_W+g_{BY}\cos\Theta'_W\Big)Z^+_{i1}Z^+_{j1}\Big)\Big(-p_\mu^{H_j^+}+p_\mu^{H_i^-}\Big)
\end{aligned}
\tag{103}
$$

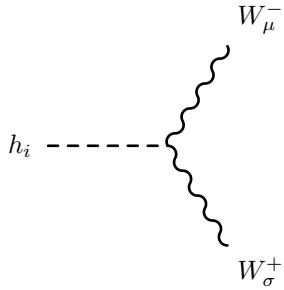
8.3 One Scalar-Two Vector Boson-Interaction



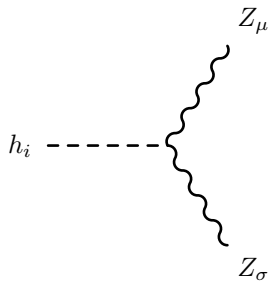
$$\frac{i}{2}\Big(- v\Big(g_1 \cos\Theta_W - g_2 \sin\Theta_W\Big)\Big(g_1 \cos\Theta'_W \sin\Theta_W + g_2 \cos\Theta_W \cos\Theta'_W - g_{BY} \sin\Theta'_W\Big) Z^H_{i1}$$
$$- 100 g_{YB} \cos\Theta_W\Big(- g_B \sin\Theta'_W + g_{YB} \cos\Theta'_W \sin\Theta_W\Big)\Big(vx2 Z^H_{i3} + vx Z^H_{i2}\Big)\Big)\Big(g_{\sigma\mu}\Big) \tag{104}$$



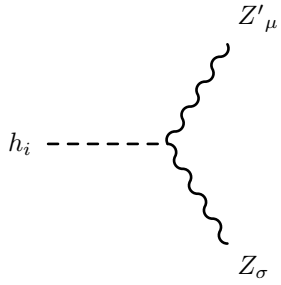
$$\frac{i}{2}\Big(v\Big(g_1 \cos\Theta_W - g_2 \sin\Theta_W\Big)\Big(\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W\Big) \sin\Theta'_W + g_{BY} \cos\Theta'_W\Big) Z^H_{i1}$$
$$+ 100 g_{YB} \cos\Theta_W\Big(g_B \cos\Theta'_W + g_{YB} \sin\Theta_W \sin\Theta'_W\Big)\Big(vx2 Z^H_{i3} + vx Z^H_{i2}\Big)\Big)\Big(g_{\sigma\mu}\Big) \tag{105}$$



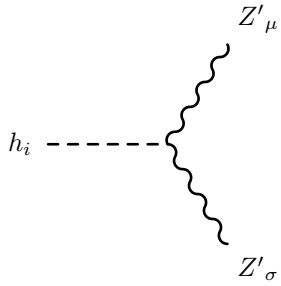
$$\frac{i}{2} g_2^2 v Z^H_{i1}\Big(g_{\sigma\mu}\Big) \tag{106}$$



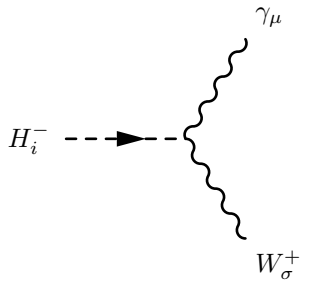
$$\frac{i}{2}\Big(v\Big(g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W-g_{BY}\sin\Theta'_W\Big)^2Z^H_{i1}$$
$$+100\Big(-g_B\sin\Theta'_W+g_{YB}\cos\Theta'_W\sin\Theta_W\Big)^2\Big(vx2Z^H_{i3}+vxZ^H_{i2}\Big)\Big)\Big(g_{\sigma\mu}\Big) \tag{107}$$



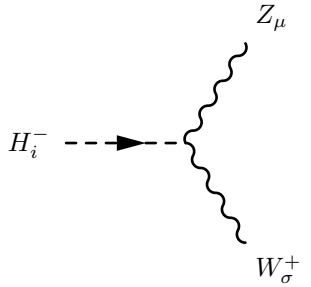
$$\frac{i}{2}\Big(v\Big(-g_1g_{BY}\cos\Theta'^2_W\sin\Theta_W-g_2^2\cos\Theta^2_W\cos\Theta'_W\sin\Theta'_W$$
$$+\cos\Theta'_W\Big(-g_1^2\sin\Theta^2_W+g^2_{BY}\Big)\sin\Theta'_W+g_1g_{BY}\sin\Theta_W\sin\Theta'^2_W$$
$$+g_2\cos\Theta_W\Big(-2g_1\cos\Theta'_W\sin\Theta_W\sin\Theta'_W-g_{BY}\cos\Theta'^2_W+g_{BY}\sin\Theta'^2_W\Big)\Big)Z^H_{i1}$$
$$+\frac{25}{2}\Big(-8g_Bg_{YB}\cos\Theta'^2_W\sin\Theta_W+8g_Bg_{YB}\sin\Theta_W\sin\Theta'^2_W$$
$$+2\Big(2g_B^2-g^2_{YB}+g^2_{YB}\cos2\Theta_W\Big)\sin2\Theta'_W\Big)\Big(vx2Z^H_{i3}+vxZ^H_{i2}\Big)\Big)\Big(g_{\sigma\mu}\Big) \tag{108}$$



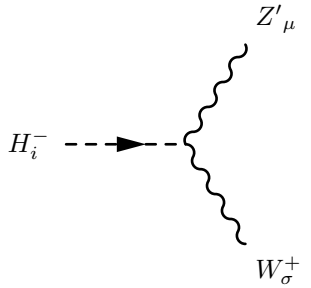
$$\frac{i}{2}\Big(v\Big(\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W+g_{BY}\cos\Theta'_W\Big)^2 Z^H_{i1}$$
$$+100\Big(g_B\cos\Theta'_W+g_{YB}\sin\Theta_W\sin\Theta'_W\Big)^2\Big(vx2Z^H_{i3}+vxZ^H_{i2}\Big)\Big)\Big(g_{\sigma\mu}\Big) \tag{109}$$



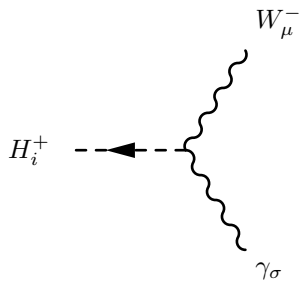
$$\frac{i}{2}g_1g_2v\cos\Theta_W Z^+_{i1}\Big(g_{\sigma\mu}\Big) \tag{110}$$



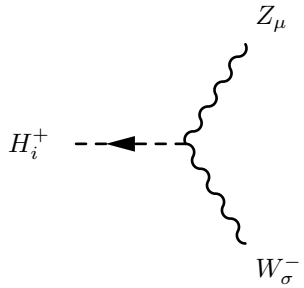
$$\frac{i}{2}g_2v\Big(-g_1\cos\Theta'_W\sin\Theta_W+g_{BY}\sin\Theta'_W\Big)Z^+_{i1}\Big(g_{\sigma\mu}\Big) \tag{111}$$



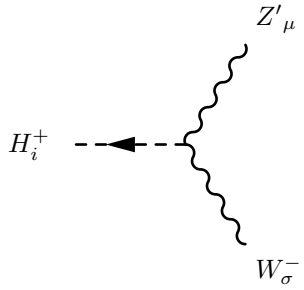
$$\frac{i}{2}g_2 v\Big(g_1 \sin\Theta_W \sin\Theta'_W + g_{BY}\cos\Theta'_W\Big) Z^+_{i1}\Big(g_{\sigma\mu}\Big) \tag{112}$$



$$\frac{i}{2}g_1 g_2 v\cos\Theta_W Z^+_{i1}\Big(g_{\sigma\mu}\Big) \tag{113}$$

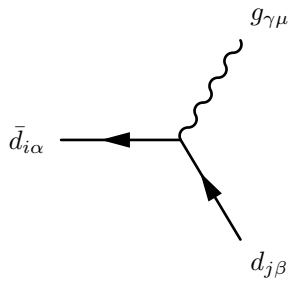


$$\frac{i}{2}g_2 v\Big(-g_1 \cos\Theta'_W \sin\Theta_W + g_{BY}\sin\Theta'_W\Big) Z^+_{i1}\Big(g_{\sigma\mu}\Big) \tag{114}$$



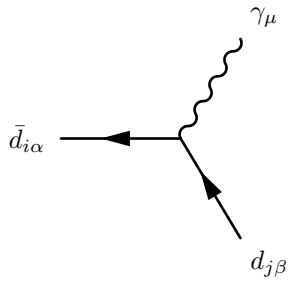
$$\frac{i}{2}g_2 v\Big(g_1 \sin\Theta_W \sin\Theta'_W + g_{BY}\cos\Theta'_W\Big) Z^+_{i1}\Big(g_{\sigma\mu}\Big) \tag{115}$$

8.4 Two Fermion-One Vector Boson-Interaction



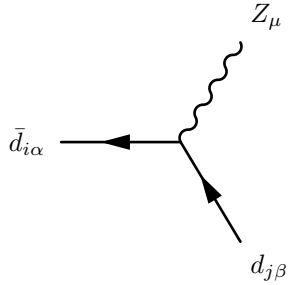
$$-\frac{i}{2}g_3\delta_{ij}\lambda^{\gamma}_{\alpha,\beta}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{116}$$

$$+\ -\frac{i}{2}g_3\delta_{ij}\lambda^{\gamma}_{\alpha,\beta}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{117}$$



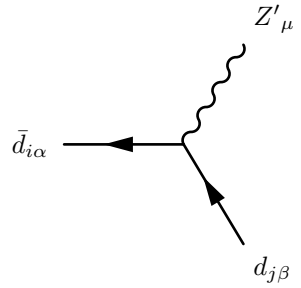
$$-\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-10g_{YB}+3g_1\Big)\cos\Theta_W-9g_2\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{118}$$

$$+\ \frac{i}{9}\Big(3g_1+5g_{YB}\Big)\cos\Theta_W\delta_{\alpha\beta}\delta_{ij}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{119}$$



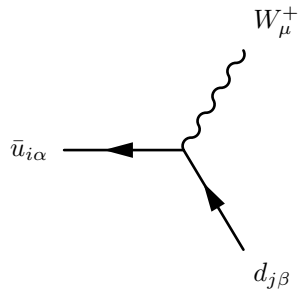
$$\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(10g_B - 3g_{BY}\Big)\sin\Theta'_W + \Big(-10g_{YB} + 3g_1\Big)\cos\Theta'_W\sin\Theta_W + 9g_2\cos\Theta_W\cos\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \quad (120)$$

$$+\ -\frac{i}{9}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(3g_1 + 5g_{YB}\Big)\cos\Theta'_W\sin\Theta_W - \Big(3g_{BY} + 5g_B\Big)\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \quad (121)$$

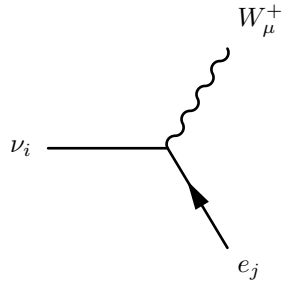


$$-\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-10g_B + 3g_{BY}\Big)\cos\Theta'_W + \Big(\Big(-10g_{YB} + 3g_1\Big)\sin\Theta_W + 9g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \quad (122)$$

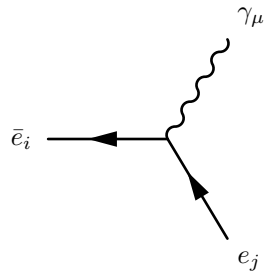
$$+\ \frac{i}{9}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(3g_1 + 5g_{YB}\Big)\sin\Theta_W\sin\Theta'_W + \Big(3g_{BY} + 5g_B\Big)\cos\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \quad (123)$$



$$-\,i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^{3}U^{d,*}_{L,ja}U^{u}_{L,ia}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \quad (124)$$

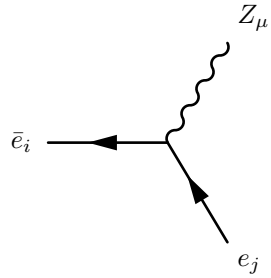


$$- i\frac{1}{\sqrt{2}}g_2 \sum_{a=1}^{3} U^{e,*}_{L,ja} U^{V}_{ia} \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{125}$$



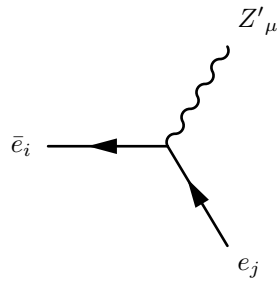
$$\frac{i}{2}\delta_{ij}\Big(g_1 \cos\Theta_W + g_2 \sin\Theta_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{126}$$

$$+\ ig_1 \cos\Theta_W \delta_{ij}\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{127}$$



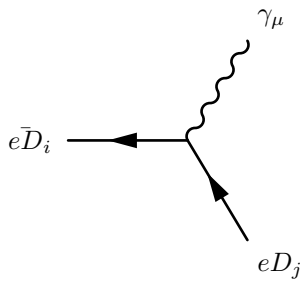
$$\frac{i}{2}\delta_{ij}\Big(-g_1 \cos\Theta'_W \sin\Theta_W + g_2 \cos\Theta_W \cos\Theta'_W + g_{BY} \sin\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{128}$$

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



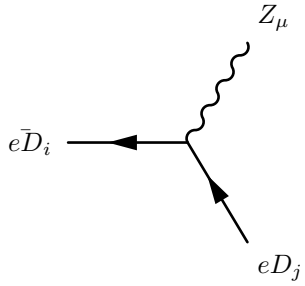
$$\frac{i}{2}\delta_{ij}\Big(\Big(g_1\sin\Theta_W - g_2\cos\Theta_W\Big)\sin\Theta'_W + g_{BY}\cos\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{130}$$

$$+\ i\delta_{ij}\Big(g_1\sin\Theta_W\sin\Theta'_W + g_{BY}\cos\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{131}$$



$$\frac{i}{2}\Big(2\Big(6g_{YB}+g_1\Big)UD^{e,*}_{L,j2}\cos\Theta_W UD^{e}_{L,i2} + UD^{e,*}_{L,j1}\Big(\Big(2g_{YB}+g_1\Big)\cos\Theta_W + g_2\sin\Theta_W\Big)UD^{e}_{L,i1}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{132}$$

$$+\ \frac{i}{2}\Big(2\Big(g_1+g_{YB}\Big)UD^{e,*}_{R,i1}\cos\Theta_W UD^{e}_{R,j1} + UD^{e,*}_{R,i2}\Big(\Big(12g_{YB}+g_1\Big)\cos\Theta_W + g_2\sin\Theta_W\Big)UD^{e}_{R,j2}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{133}$$

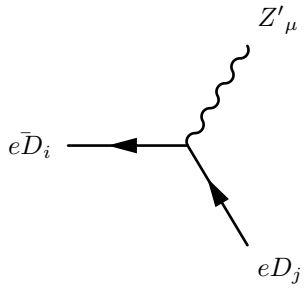


$$\frac{i}{2}\Big(UD^{e,*}_{L,j1}\Big(\Big(2g_B+g_{BY}\Big)\sin\Theta'_W - \Big(2g_{YB}+g_1\Big)\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W\Big)UD^{e}_{L,i1}$$

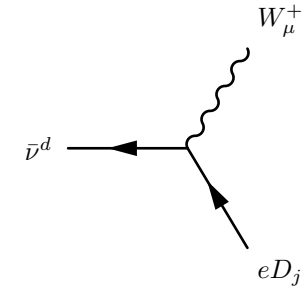
$$+ 2UD^{e,*}_{L,j2}\Big(\Big(6g_B+g_{BY}\Big)\sin\Theta'_W - \Big(6g_{YB}+g_1\Big)\cos\Theta'_W\sin\Theta_W\Big)UD^{e}_{L,i2}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{134}$$

$$+\ -\frac{i}{2}\Big(2UD^{e,*}_{R,i1}\Big(\Big(g_1+g_{YB}\Big)\cos\Theta'_W\sin\Theta_W - \Big(g_{BY}+g_B\Big)\sin\Theta'_W\Big)UD^{e}_{R,j1}$$

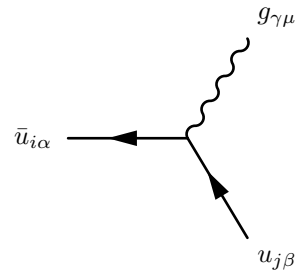
$$- UD^{e,*}_{R,i2}\Big(\Big(12g_B+g_{BY}\Big)\sin\Theta'_W - \Big(12g_{YB}+g_1\Big)\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W\Big)UD^{e}_{R,j2}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{135}$$



$$\frac{i}{2}\Big(UD^{e,*}_{L,j1}\Big(\Big(2g_B+g_{BY}\Big)\cos\Theta'_W+\Big(\Big(2g_{YB}+g_1\Big)\sin\Theta_W-g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)UD^{e}_{L,i1}$$
$$+2UD^{e,*}_{L,j2}\Big(\Big(6g_B+g_{BY}\Big)\cos\Theta'_W+\Big(6g_{YB}+g_1\Big)\sin\Theta_W\sin\Theta'_W\Big)UD^{e}_{L,i2}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{136}$$
$$+\ \frac{i}{2}\Big(2UD^{e,*}_{R,i1}\Big(\Big(g_1+g_{YB}\Big)\sin\Theta_W\sin\Theta'_W+\Big(g_{BY}+g_B\Big)\cos\Theta'_W\Big)UD^{e}_{R,j1}$$
$$+UD^{e,*}_{R,i2}\Big(\Big(12g_B+g_{BY}\Big)\cos\Theta'_W+\Big(\Big(12g_{YB}+g_1\Big)\sin\Theta_W-g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)UD^{e}_{R,j2}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{137}$$

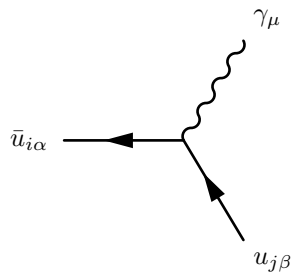


$$-\ i\frac{1}{\sqrt{2}}g_2UD^{e,*}_{L,j1}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{138}$$
$$+\ -i\frac{1}{\sqrt{2}}g_2UD^{e}_{R,j2}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{139}$$



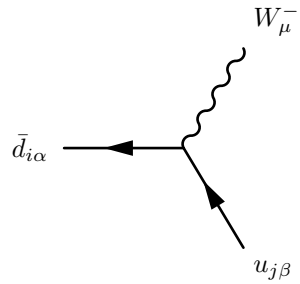
$$- \frac{i}{2} g_3 \delta_{ij} \lambda^{\gamma}_{\alpha,\beta} \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{140}$$

$$+ \; - \frac{i}{2} g_3 \delta_{ij} \lambda^{\gamma}_{\alpha,\beta} \Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2} \Big) \tag{141}$$

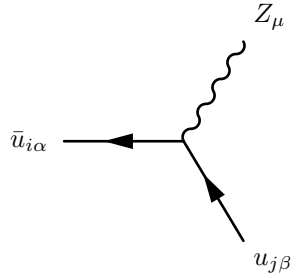


$$- \frac{i}{18} \delta_{\alpha\beta} \delta_{ij} \Big(\Big(-10 g_{YB} + 3 g_1 \Big) \cos\Theta_W + 9 g_2 \sin\Theta_W \Big) \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{142}$$

$$+ \; - \frac{i}{9} \Big(-5 g_{YB} + 6 g_1 \Big) \cos\Theta_W \delta_{\alpha\beta} \delta_{ij} \Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2} \Big) \tag{143}$$

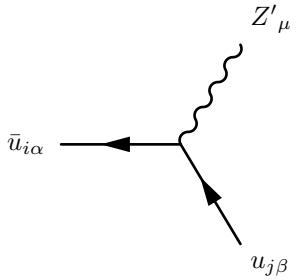


$$- i \frac{1}{\sqrt{2}} g_2 \delta_{\alpha\beta} \sum_{a=1}^{3} U^{u,*}_{L,ja} U^{d}_{L,ia} \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{144}$$



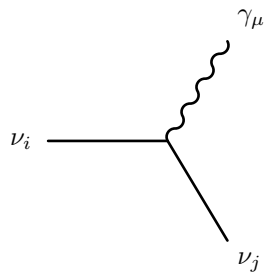
$$-\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-10g_B+3g_{BY}\Big)\sin\Theta'_W-\Big(-10g_{YB}+3g_1\Big)\cos\Theta'_W\sin\Theta_W+9g_2\cos\Theta_W\cos\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{145}$$

$$+\frac{i}{9}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(5g_B-6g_{BY}\Big)\sin\Theta'_W+\Big(-5g_{YB}+6g_1\Big)\cos\Theta'_W\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{146}$$



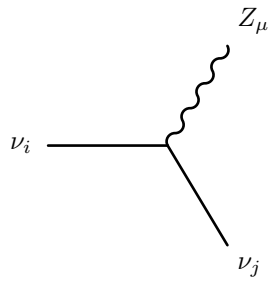
$$-\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-10g_B+3g_{BY}\Big)\cos\Theta'_W+\Big(\Big(-10g_{YB}+3g_1\Big)\sin\Theta_W-9g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{147}$$

$$+-\frac{i}{9}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-5g_B+6g_{BY}\Big)\cos\Theta'_W+\Big(-5g_{YB}+6g_1\Big)\sin\Theta_W\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{148}$$

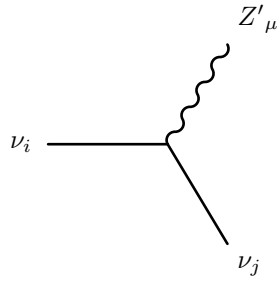


$$\frac{i}{2}\Big(10g_{YB}\cos\Theta_W\sum_{a=1}^{2}U^{V,*}_{j3+a}U^{V}_{i3+a}+\Big(g_1\cos\Theta_W-g_2\sin\Theta_W\Big)\sum_{a=1}^{3}U^{V,*}_{ja}U^{V}_{ia}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{149}$$

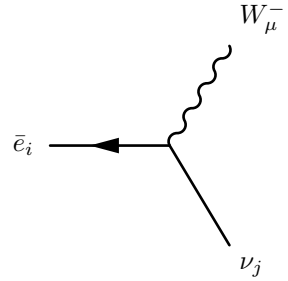
$$+-\frac{i}{2}\Big(10g_{YB}\cos\Theta_W\sum_{a=1}^{2}U^{V,*}_{i3+a}U^{V}_{j3+a}+\Big(g_1\cos\Theta_W-g_2\sin\Theta_W\Big)\sum_{a=1}^{3}U^{V,*}_{ia}U^{V}_{ja}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{150}$$



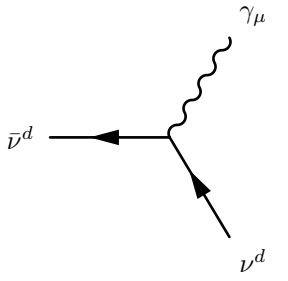
$$
\begin{aligned}
&-\frac{i}{2}\Big(10\Big(-g_B\sin\Theta'_W+g_{YB}\cos\Theta'_W\sin\Theta_W\Big)\sum_{a=1}^{2}U^{V,*}_{j3+a}U^{V}_{i3+a}\\
&+\Big(g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W-g_{BY}\sin\Theta'_W\Big)\sum_{a=1}^{3}U^{V,*}_{ja}U^{V}_{ia}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \qquad (151)\\
&+\frac{i}{2}\Big(10\Big(-g_B\sin\Theta'_W+g_{YB}\cos\Theta'_W\sin\Theta_W\Big)\sum_{a=1}^{2}U^{V,*}_{i3+a}U^{V}_{j3+a}\\
&+\Big(g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W-g_{BY}\sin\Theta'_W\Big)\sum_{a=1}^{3}U^{V,*}_{ia}U^{V}_{ja}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \qquad (152)
\end{aligned}
$$



$$
\begin{aligned}
&\frac{i}{2}\Big(10\Big(g_B\cos\Theta'_W+g_{YB}\sin\Theta_W\sin\Theta'_W\Big)\sum_{a=1}^{2}U^{V,*}_{j3+a}U^{V}_{i3+a}\\
&+\Big(\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W+g_{BY}\cos\Theta'_W\Big)\sum_{a=1}^{3}U^{V,*}_{ja}U^{V}_{ia}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \qquad (153)\\
&+-\frac{i}{2}\Big(10\Big(g_B\cos\Theta'_W+g_{YB}\sin\Theta_W\sin\Theta'_W\Big)\sum_{a=1}^{2}U^{V,*}_{i3+a}U^{V}_{j3+a}\\
&+\Big(\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W+g_{BY}\cos\Theta'_W\Big)\sum_{a=1}^{3}U^{V,*}_{ia}U^{V}_{ja}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \qquad (154)
\end{aligned}
$$

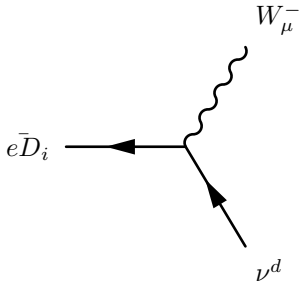


$$-i\frac{1}{\sqrt{2}}g_2\sum_{a=1}^{3}U_{ja}^{V,*}U_{L,ia}^{e}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{155}$$



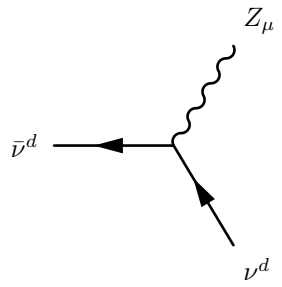
$$\frac{i}{2}\Big(\Big(2g_{YB}+g_1\Big)\cos\Theta_W-g_2\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{156}$$

$$+\ \frac{i}{2}\Big(\Big(12g_{YB}+g_1\Big)\cos\Theta_W-g_2\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{157}$$



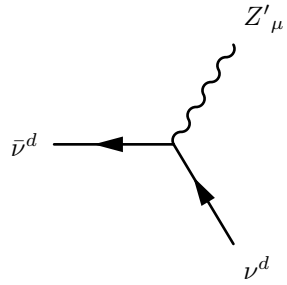
$$-i\frac{1}{\sqrt{2}}g_2UD_{L,i1}^{e}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{158}$$

$$+\ -i\frac{1}{\sqrt{2}}g_2UD_{R,i2}^{e,*}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{159}$$



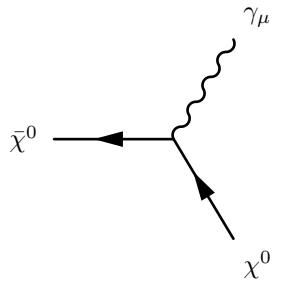
$$- \frac{i}{2}\Big(- \Big(2g_B + g_{BY}\Big) \sin\Theta'_W + \Big(2g_{YB} + g_1\Big) \cos\Theta'_W \sin\Theta_W + g_2 \cos\Theta_W \cos\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{160}$$

$$+ -\frac{i}{2}\Big(- \Big(12g_B + g_{BY}\Big) \sin\Theta'_W + \Big(12g_{YB} + g_1\Big) \cos\Theta'_W \sin\Theta_W + g_2 \cos\Theta_W \cos\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{161}$$



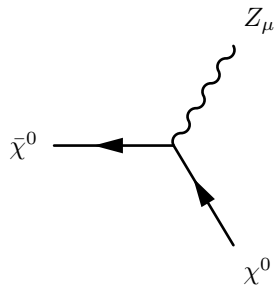
$$\frac{i}{2}\Big(\Big(2g_B + g_{BY}\Big) \cos\Theta'_W + \Big(\Big(2g_{YB} + g_1\Big) \sin\Theta_W + g_2 \cos\Theta_W\Big) \sin\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{162}$$

$$+ \frac{i}{2}\Big(\Big(12g_B + g_{BY}\Big) \cos\Theta'_W + \Big(\Big(12g_{YB} + g_1\Big) \sin\Theta_W + g_2 \cos\Theta_W\Big) \sin\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{163}$$



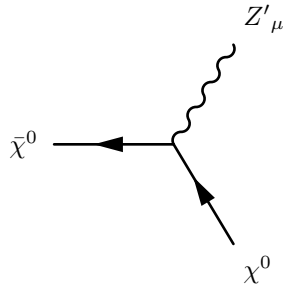
$$- 3ig_{YB} \cos\Theta_W \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{164}$$

$$+ 2ig_{YB} \cos\Theta_W \Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{165}$$



$$3i\Big(- g_B \sin\Theta'_W + g_{YB} \cos\Theta'_W \sin\Theta_W \Big) \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{166}$$

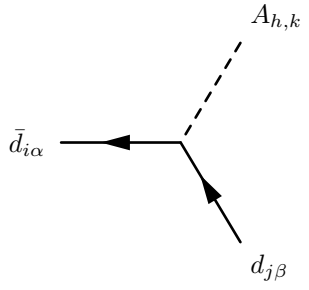
$$+ \; -2i\Big(- g_B \sin\Theta'_W + g_{YB} \cos\Theta'_W \sin\Theta_W \Big) \Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2} \Big) \tag{167}$$



$$- 3i\Big(g_B \cos\Theta'_W + g_{YB} \sin\Theta_W \sin\Theta'_W \Big) \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{168}$$

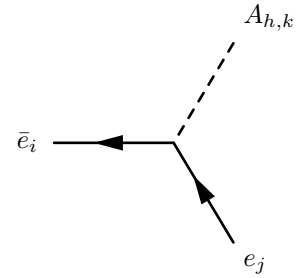
$$+ \; 2i\Big(g_B \cos\Theta'_W + g_{YB} \sin\Theta_W \sin\Theta'_W \Big) \Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2} \Big) \tag{169}$$

8.5 Two Fermion-One Scalar Boson-Interaction



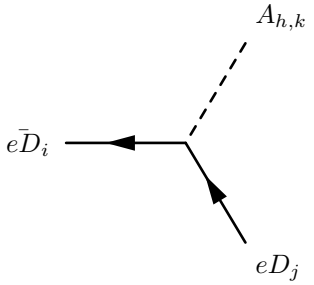
$$- \frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3} U^{d,*}_{L,jb}\sum_{a=1}^{3} U^{d,*}_{R,ia} Y_{d,ab} Z^{A}_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{170}$$

$$+ \frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{d,ab} U^{d}_{R,ja} U^{d}_{L,ib} Z^{A}_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{171}$$



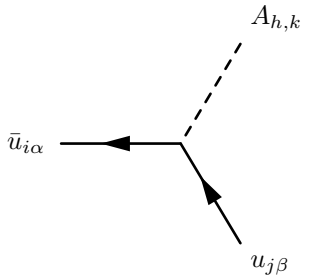
$$- \frac{1}{\sqrt{2}}\sum_{b=1}^{3} U^{e,*}_{L,jb}\sum_{a=1}^{3} U^{e,*}_{R,ia} Y_{e,ab} Z^{A}_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{172}$$

$$+ \frac{1}{\sqrt{2}}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{e,ab} U^{e}_{R,ja} U^{e}_{L,ib} Z^{A}_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{173}$$



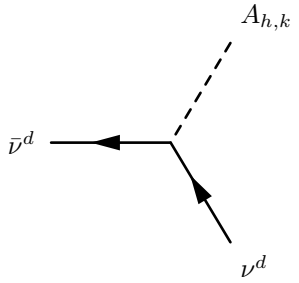
$$\begin{aligned}
&- \frac{1}{\sqrt{2}}\Big(UD^{e,*}_{R,i1}\Big(\lambda_g UD^{e,*}_{L,j1} Z^{A}_{k1} - UD^{e,*}_{L,j2}\Big(\lambda_{b1} Z^{A}_{k2} + \lambda_{b2} Z^{A}_{k3}\Big)\Big)\\
&+ UD^{e,*}_{R,i2}\Big(-\lambda_h UD^{e,*}_{L,j2} Z^{A}_{k1} + UD^{e,*}_{L,j1}\Big(\lambda_{c1} Z^{A}_{k2} + \lambda_{c2} Z^{A}_{k3}\Big)\Big)\Big)\Big(\frac{1-\gamma_5}{2}\Big)
\end{aligned} \tag{174}$$

$$\begin{aligned}
&+ \frac{1}{\sqrt{2}}\Big(\lambda^{*}_g UD^{e}_{R,j1} UD^{e}_{L,i1} Z^{A}_{k1} - UD^{e}_{R,j1} UD^{e}_{L,i2}\Big(\lambda_{b1} Z^{A}_{k2} + \lambda_{b2} Z^{A}_{k3}\Big)\\
&+ UD^{e}_{R,j2}\Big(-\lambda_h UD^{e}_{L,i2} Z^{A}_{k1} + UD^{e}_{L,i1}\Big(\lambda_{c1} Z^{A}_{k2} + \lambda_{c2} Z^{A}_{k3}\Big)\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big)
\end{aligned} \tag{175}$$



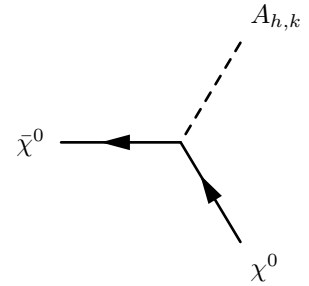
$$-\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}U_{L,jb}^{u,*}\sum_{a=1}^{3}U_{R,ia}^{u,*}Y_{u,ab}Z_{k1}^{A}\Big(\frac{1-\gamma_5}{2}\Big) \tag{176}$$

$$+\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{u,ab}^{*}U_{R,ja}^{u}U_{L,ib}^{u}Z_{k1}^{A}\Big(\frac{1+\gamma_5}{2}\Big) \tag{177}$$



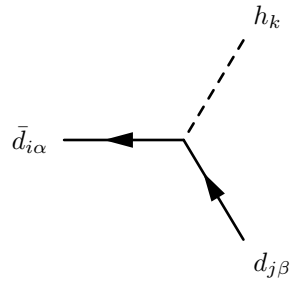
$$-\frac{1}{\sqrt{2}}\Big(\lambda_{c1}Z_{k2}^{A}+\lambda_{c2}Z_{k3}^{A}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{178}$$

$$+\frac{1}{\sqrt{2}}\Big(\lambda_{c1}Z_{k2}^{A}+\lambda_{c2}Z_{k3}^{A}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{179}$$



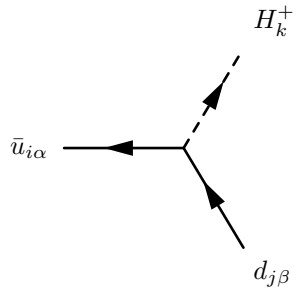
$$- \frac{1}{\sqrt{2}}\Big(\lambda_{a1} Z^A_{k2} + \lambda_{a2} Z^A_{k3}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{180}$$

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



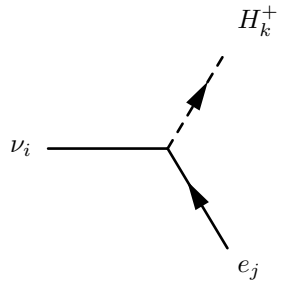
$$- i\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3} U^{d,*}_{L,jb}\sum_{a=1}^{3} U^{d,*}_{R,ia} Y_{d,ab} Z^H_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{182}$$

$$+ \; -i\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^*_{d,ab} U^d_{R,ja} U^d_{L,ib} Z^H_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{183}$$



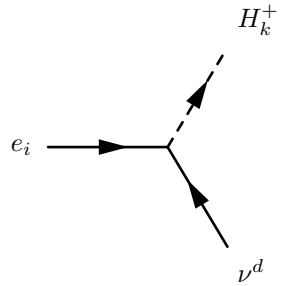
$$- i\delta_{\alpha\beta}\sum_{b=1}^{3} U^{d,*}_{L,jb}\sum_{a=1}^{3} U^{u,*}_{R,ia} Y_{u,ab} Z^+_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{184}$$

$$+ \; -i\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^*_{d,ab} U^d_{R,ja} U^u_{L,ib} Z^+_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{185}$$

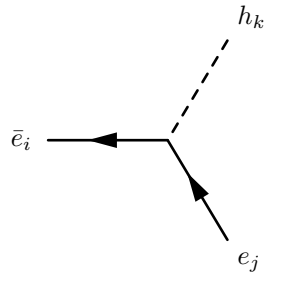


(186)

$$+ \; -i \sum_{b=1}^{3} \sum_{a=1}^{3} Y^*_{e,ab} U^e_{R,ja} U^V_{ib} Z^+_{k1} \Big(\frac{1+\gamma_5}{2} \Big) \tag{187}$$

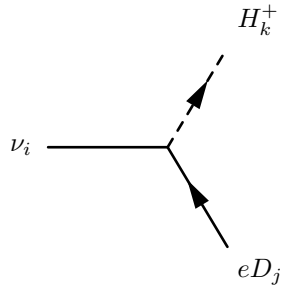


$$i \sum_{b=1}^{3} U^{e,*}_{L,ib} \sum_{a=1}^{2} \lambda_{d,ab} Z^+_{k1+a} \Big(\frac{1-\gamma_5}{2} \Big) \tag{188}$$



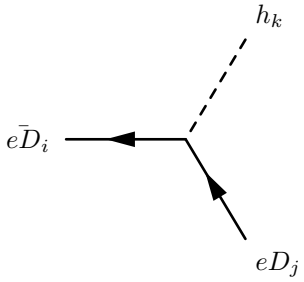
$$- \, i \frac{1}{\sqrt{2}} \sum_{b=1}^{3} U^{e,*}_{L,jb} \sum_{a=1}^{3} U^{e,*}_{R,ia} Y_{e,ab} Z^H_{k1} \Big(\frac{1-\gamma_5}{2} \Big) \tag{189}$$

$$+ \; -i\frac{1}{\sqrt{2}}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{e,ab} U^{e}_{R,ja} U^{e}_{L,ib} Z^{H}_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{190}$$



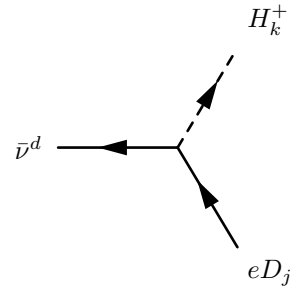
$$- iUD^{e,*}_{L,j1}\sum_{b=1}^{3} U^{V,*}_{ib}\sum_{a=1}^{2}\lambda_{d,ab} Z^{+}_{k1+a}\Big(\frac{1-\gamma_5}{2}\Big) \tag{191}$$

$$+ \; -i\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda^{*}_{e,ab} Z^{+}_{k3+a} U^{V}_{i3+b} UD^{e}_{R,j1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{192}$$



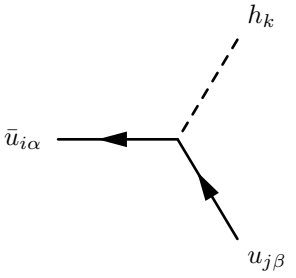
$$\begin{aligned}
&- i\frac{1}{\sqrt{2}}\Big(UD^{e,*}_{R,i1}\Big(\lambda_g UD^{e,*}_{L,j1} Z^{H}_{k1} + UD^{e,*}_{L,j2}\Big(\lambda_{b1} Z^{H}_{k2} + \lambda_{b2} Z^{H}_{k3}\Big)\Big) \\
&+ UD^{e,*}_{R,i2}\Big(\lambda_h UD^{e,*}_{L,j2} Z^{H}_{k1} + UD^{e,*}_{L,j1}\Big(\lambda_{c1} Z^{H}_{k2} + \lambda_{c2} Z^{H}_{k3}\Big)\Big)\Big)\Big(\frac{1-\gamma_5}{2}\Big)
\end{aligned} \tag{193}$$

$$\begin{aligned}
&+ \; -i\frac{1}{\sqrt{2}}\Big(\lambda^{*}_g UD^{e}_{R,j1} UD^{e}_{L,i1} Z^{H}_{k1} + UD^{e}_{R,j1} UD^{e}_{L,i2}\Big(\lambda_{b1} Z^{H}_{k2} + \lambda_{b2} Z^{H}_{k3}\Big) \\
&+ UD^{e}_{R,j2}\Big(\lambda_h UD^{e}_{L,i2} Z^{H}_{k1} + UD^{e}_{L,i1}\Big(\lambda_{c1} Z^{H}_{k2} + \lambda_{c2} Z^{H}_{k3}\Big)\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big)
\end{aligned} \tag{194}$$



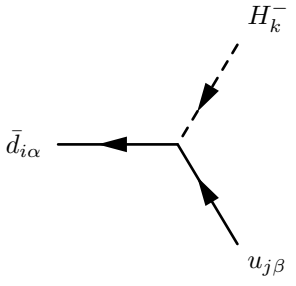
$$- i\lambda_h UD^{e,*}_{L,j2} Z^+_{k1} \Big(\frac{1-\gamma_5}{2}\Big) \tag{195}$$

$$+ \; -i\lambda^*_g UD^{e}_{R,j1} Z^+_{k1} \Big(\frac{1+\gamma_5}{2}\Big) \tag{196}$$



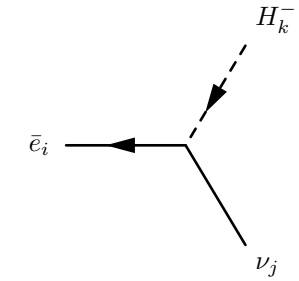
$$i\frac{1}{\sqrt{2}}\delta_{\alpha\beta} \sum_{b=1}^{3} U^{u,*}_{L,jb} \sum_{a=1}^{3} U^{u,*}_{R,ia} Y_{u,ab} Z^H_{k1} \Big(\frac{1-\gamma_5}{2}\Big) \tag{197}$$

$$+ \; i\frac{1}{\sqrt{2}}\delta_{\alpha\beta} \sum_{b=1}^{3} \sum_{a=1}^{3} Y^*_{u,ab} U^{u}_{R,ja} U^{u}_{L,ib} Z^H_{k1} \Big(\frac{1+\gamma_5}{2}\Big) \tag{198}$$

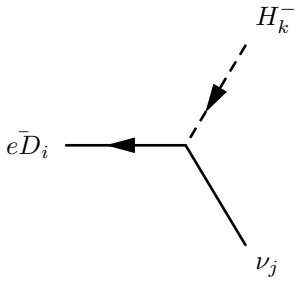


$$- i\delta_{\alpha\beta} \sum_{b=1}^{3} U_{L,jb}^{u,*} \sum_{a=1}^{3} U_{R,ia}^{d,*} Y_{d,ab} Z_{k1}^{+} \Big(\frac{1-\gamma_5}{2} \Big) \tag{199}$$

$$+ \; -i\delta_{\alpha\beta} \sum_{b=1}^{3} \sum_{a=1}^{3} Y_{u,ab}^{*} U_{R,ja}^{u} U_{L,ib}^{d} Z_{k1}^{+} \Big(\frac{1+\gamma_5}{2} \Big) \tag{200}$$

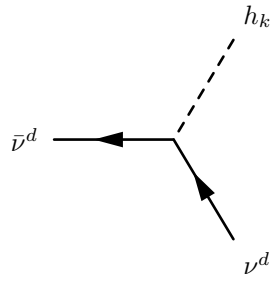


$$- i \sum_{b=1}^{3} U_{jb}^{V,*} \sum_{a=1}^{3} U_{R,ia}^{e,*} Y_{e,ab} Z_{k1}^{+} \Big(\frac{1-\gamma_5}{2} \Big) \tag{201}$$



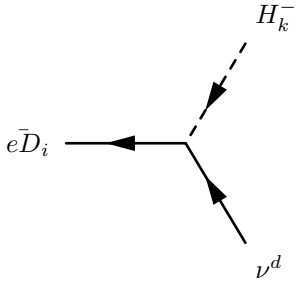
$$- iUD_{R,i1}^{e,*} \sum_{b=1}^{2} U_{j3+b}^{V,*} \sum_{a=1}^{2} \lambda_{e,ab} Z_{k3+a}^{+} \Big(\frac{1-\gamma_5}{2} \Big) \tag{202}$$

$$+ \; -i \sum_{b=1}^{3} \sum_{a=1}^{2} \lambda_{d,ab}^{*} Z_{k1+a}^{+} U_{jb}^{V} UD_{L,i1}^{e} \Big(\frac{1+\gamma_5}{2} \Big) \tag{203}$$



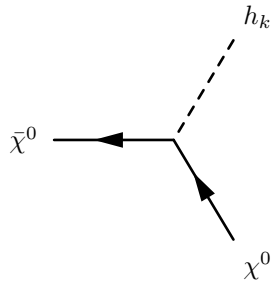
$$- i\frac{1}{\sqrt{2}}\Big(\lambda_{c1} Z^H_{k2} + \lambda_{c2} Z^H_{k3}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{204}$$

$$+ -i\frac{1}{\sqrt{2}}\Big(\lambda_{c1} Z^H_{k2} + \lambda_{c2} Z^H_{k3}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{205}$$



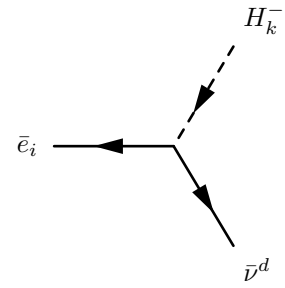
$$- i\lambda_g UD^{e,*}_{R,i1} Z^+_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{206}$$

$$+ -i\lambda_h UD^{e}_{L,i2} Z^+_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{207}$$



$$- i\frac{1}{\sqrt{2}}\Big(\lambda_{a1} Z^H_{k2} + \lambda_{a2} Z^H_{k3}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{208}$$

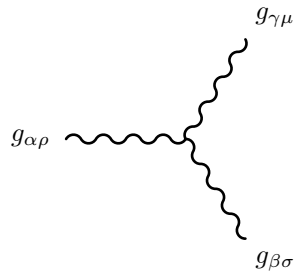
$$+ \; -i\frac{1}{\sqrt{2}}\Big(\lambda_{a1}Z^H_{k2} + \lambda_{a2}Z^H_{k3}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{209}$$



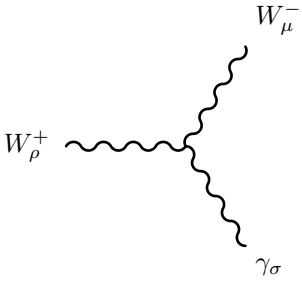
(210)

$$+ \; i\sum_{b=1}^{3}\sum_{a=1}^{2}\lambda^*_{d,ab}Z^+_{k1+a}U^e_{L,ib}\Big(\frac{1+\gamma_5}{2}\Big) \tag{211}$$

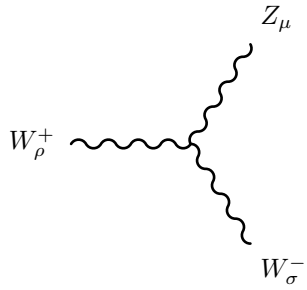
8.6 Three Vector Boson-Interaction



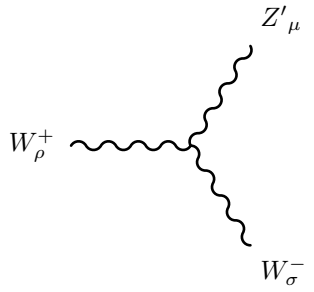
$$g_3 f_{\alpha,\beta,\gamma}\Big(g_{\rho\mu}\Big(-p_\sigma^{g_{\gamma\mu}} + p_\sigma^{g_{\alpha\rho}}\Big) + g_{\rho\sigma}\Big(-p_\mu^{g_{\alpha\rho}} + p_\mu^{g_{\beta\sigma}}\Big) + g_{\sigma\mu}\Big(-p_\rho^{g_{\beta\sigma}} + p_\rho^{g_{\gamma\mu}}\Big)\Big) \tag{212}$$



$$ig_2 \sin\Theta_W \Big(g_{\rho\mu} \Big(-p_\sigma^{W_\mu^-} + p_\sigma^{W_\rho^+} \Big) + g_{\rho\sigma} \Big(-p_\mu^{W_\rho^+} + p_\mu^{\gamma_\sigma} \Big) + g_{\sigma\mu} \Big(-p_\rho^{\gamma_\sigma} + p_\rho^{W_\mu^-} \Big) \Big) \tag{213}$$

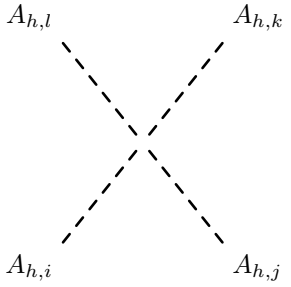


$$-ig_2 \cos\Theta_W \cos\Theta'_W \Big(g_{\rho\mu} \Big(-p_\sigma^{Z_\mu} + p_\sigma^{W_\rho^+} \Big) + g_{\rho\sigma} \Big(-p_\mu^{W_\rho^+} + p_\mu^{W_\sigma^-} \Big) + g_{\sigma\mu} \Big(-p_\rho^{W_\sigma^-} + p_\rho^{Z_\mu} \Big) \Big) \tag{214}$$

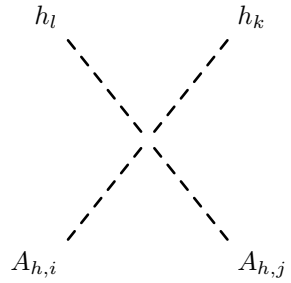


$$ig_2 \cos\Theta_W \sin\Theta'_W \Big(g_{\rho\mu} \Big(-p_\sigma^{Z'_\mu} + p_\sigma^{W_\rho^+} \Big) + g_{\rho\sigma} \Big(-p_\mu^{W_\rho^+} + p_\mu^{W_\sigma^-} \Big) + g_{\sigma\mu} \Big(-p_\rho^{W_\sigma^-} + p_\rho^{Z'_\mu} \Big) \Big) \tag{215}$$

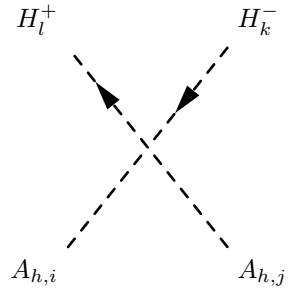
8.7 Four Scalar-Interaction



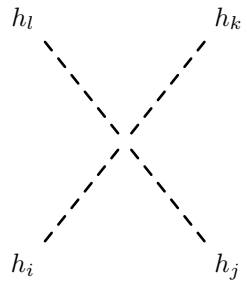
$$
\begin{aligned}
& i\Big(Z^A_{i2}\Big(\lambda_{31}Z^A_{j1}\Big(Z^A_{k1}Z^A_{l2}+Z^A_{k2}Z^A_{l1}\Big)+Z^A_{j2}\Big(6\lambda_{21}Z^A_{k2}Z^A_{l2}+\lambda_{31}Z^A_{k1}Z^A_{l1}\Big)\Big) \\
& +Z^A_{i3}\Big(\lambda_{32}Z^A_{j1}\Big(Z^A_{k1}Z^A_{l3}+Z^A_{k3}Z^A_{l1}\Big)+Z^A_{j3}\Big(6\lambda_{22}Z^A_{k3}Z^A_{l3}+\lambda_{32}Z^A_{k1}Z^A_{l1}\Big)\Big) \\
& +Z^A_{i1}\Big(\lambda_{31}Z^A_{j2}\Big(Z^A_{k1}Z^A_{l2}+Z^A_{k2}Z^A_{l1}\Big)+\lambda_{32}Z^A_{j3}\Big(Z^A_{k1}Z^A_{l3}+Z^A_{k3}Z^A_{l1}\Big) \\
& +Z^A_{j1}\Big(6l_hZ^A_{k1}Z^A_{l1}+\lambda_{31}Z^A_{k2}Z^A_{l2}+\lambda_{32}Z^A_{k3}Z^A_{l3}\Big)\Big)\Big)
\end{aligned}
\tag{216}
$$



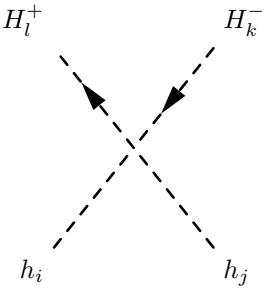
$$
\begin{aligned}
& i\Big(Z^A_{i2}Z^A_{j2}\Big(2\lambda_{21}Z^H_{k2}Z^H_{l2}+\lambda_{31}Z^H_{k1}Z^H_{l1}\Big)+Z^A_{i3}Z^A_{j3}\Big(2\lambda_{22}Z^H_{k3}Z^H_{l3}+\lambda_{32}Z^H_{k1}Z^H_{l1}\Big) \\
& +Z^A_{i1}Z^A_{j1}\Big(2l_hZ^H_{k1}Z^H_{l1}+\lambda_{31}Z^H_{k2}Z^H_{l2}+\lambda_{32}Z^H_{k3}Z^H_{l3}\Big)\Big)
\end{aligned}
\tag{217}
$$



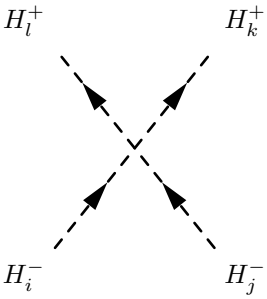
$$
\begin{aligned}
& i\Big(-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{41,ab}Z^+_{l1+a}Z^+_{k1+b}Z^A_{i1}Z^A_{j1}-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{42,ab}Z^+_{l3+a}Z^+_{k3+b}Z^A_{i1}Z^A_{j1} \\
& +\Big(2l_hZ^A_{i1}Z^A_{j1}+\lambda_{31}Z^A_{i2}Z^A_{j2}+\lambda_{32}Z^A_{i3}Z^A_{j3}\Big)Z^+_{k1}Z^+_{l1}\Big)
\end{aligned}
\tag{218}
$$



$$
\begin{aligned}
&i\Big(Z^H_{i2}\Big(\lambda_{31}Z^H_{j1}\Big(Z^H_{k1}Z^H_{l2}+Z^H_{k2}Z^H_{l1}\Big)+Z^H_{j2}\Big(6\lambda_{21}Z^H_{k2}Z^H_{l2}+\lambda_{31}Z^H_{k1}Z^H_{l1}\Big)\Big)\\
&+Z^H_{i3}\Big(\lambda_{32}Z^H_{j1}\Big(Z^H_{k1}Z^H_{l3}+Z^H_{k3}Z^H_{l1}\Big)+Z^H_{j3}\Big(6\lambda_{22}Z^H_{k3}Z^H_{l3}+\lambda_{32}Z^H_{k1}Z^H_{l1}\Big)\Big)\\
&+Z^H_{i1}\Big(\lambda_{31}Z^H_{j2}\Big(Z^H_{k1}Z^H_{l2}+Z^H_{k2}Z^H_{l1}\Big)+\lambda_{32}Z^H_{j3}\Big(Z^H_{k1}Z^H_{l3}+Z^H_{k3}Z^H_{l1}\Big)\\
&+Z^H_{j1}\Big(6l_hZ^H_{k1}Z^H_{l1}+\lambda_{31}Z^H_{k2}Z^H_{l2}+\lambda_{32}Z^H_{k3}Z^H_{l3}\Big)\Big)\Big)
\end{aligned}
\tag{219}
$$

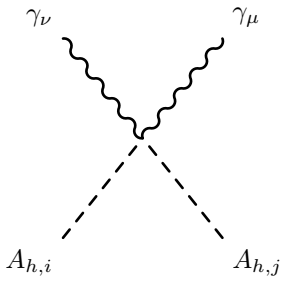


$$
\begin{aligned}
&i\Big(-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{41,ab}Z^+_{l1+a}Z^+_{k1+b}Z^H_{i1}Z^H_{j1}-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{42,ab}Z^+_{l3+a}Z^+_{k3+b}Z^H_{i1}Z^H_{j1}\\
&+\Big(2l_hZ^H_{i1}Z^H_{j1}+\lambda_{31}Z^H_{i2}Z^H_{j2}+\lambda_{32}Z^H_{i3}Z^H_{j3}\Big)Z^+_{k1}Z^+_{l1}\Big)
\end{aligned}
\tag{220}
$$

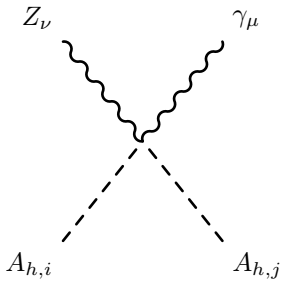


$$
\begin{aligned}
& i\Big(- \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{41,ab} Z^{+}_{l1+a} Z^{+}_{j1+b} Z^{+}_{i1} Z^{+}_{k1} - \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{42,ab} Z^{+}_{l3+a} Z^{+}_{j3+b} Z^{+}_{i1} Z^{+}_{k1} \\
& - \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{41,ab} Z^{+}_{l1+a} Z^{+}_{i1+b} Z^{+}_{j1} Z^{+}_{k1} - \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{42,ab} Z^{+}_{l3+a} Z^{+}_{i3+b} Z^{+}_{j1} Z^{+}_{k1} \\
& - \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{41,ab} Z^{+}_{k1+a} Z^{+}_{j1+b} Z^{+}_{i1} Z^{+}_{l1} - \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{42,ab} Z^{+}_{k3+a} Z^{+}_{j3+b} Z^{+}_{i1} Z^{+}_{l1} \\
& - \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{41,ab} Z^{+}_{k1+a} Z^{+}_{i1+b} Z^{+}_{j1} Z^{+}_{l1} - \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{42,ab} Z^{+}_{k3+a} Z^{+}_{i3+b} Z^{+}_{j1} Z^{+}_{l1} \\
& + 4 l_h Z^{+}_{i1} Z^{+}_{j1} Z^{+}_{k1} Z^{+}_{l1} \Big)
\end{aligned} \tag{221}
$$

8.8 Two Scalar-Two Vector Boson-Interaction

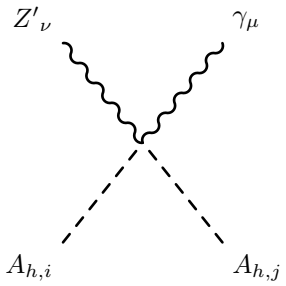


$$
\begin{aligned}
& \Big(+ \frac{i}{2} g_1^2 \cos\Theta_W^2 Z^A_{i1} Z^A_{j1} - i g_1 g_2 \cos\Theta_W \sin\Theta_W Z^A_{i1} Z^A_{j1} \\
& + \frac{i}{2} g_2^2 \sin\Theta_W^2 Z^A_{i1} Z^A_{j1} + 50 i g_{YB}^2 \cos\Theta_W^2 Z^A_{i2} Z^A_{j2} + 50 i g_{YB}^2 \cos\Theta_W^2 Z^A_{i3} Z^A_{j3} \Big) \Big(g_{\mu\nu} \Big)
\end{aligned} \tag{222}
$$

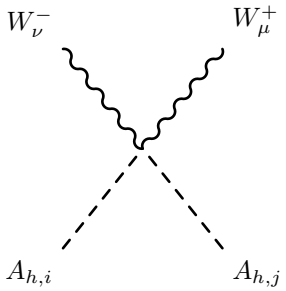


$$
\Big(- \frac{i}{2} g_1 g_2 \cos\Theta_W^2 \cos\Theta'_W Z^A_{i1} Z^A_{j1} - \frac{i}{2} g_1^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z^A_{i1} Z^A_{j1}
$$

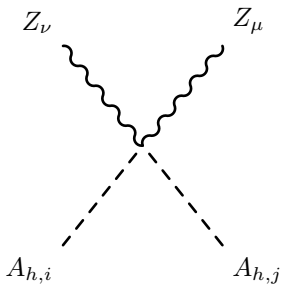
$$
\begin{aligned}
&+ \frac{i}{2} g_2^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i1}^A Z_{j1}^A + \frac{i}{2} g_1 g_2 \cos\Theta'_W \sin\Theta_W^2 Z_{i1}^A Z_{j1}^A \\
&+ \frac{i}{2} g_1 g_{BY} \cos\Theta_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A - \frac{i}{2} g_{BY} g_2 \sin\Theta_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A \\
&- 50 i g_{YB}^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i2}^A Z_{j2}^A + 50 i g_B g_{YB} \cos\Theta_W \sin\Theta'_W Z_{i2}^A Z_{j2}^A \\
&- 50 i g_{YB}^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i3}^A Z_{j3}^A + 50 i g_B g_{YB} \cos\Theta_W \sin\Theta'_W Z_{i3}^A Z_{j3}^A \Big) \Big(g_{\mu\nu} \Big)
\end{aligned} \tag{223}
$$



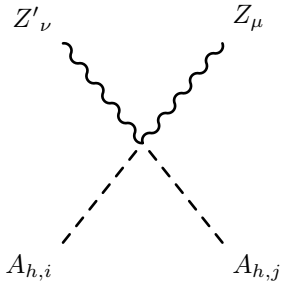
$$
\begin{aligned}
&\Big(+ \frac{i}{2} g_1 g_{BY} \cos\Theta_W \cos\Theta'_W Z_{i1}^A Z_{j1}^A - \frac{i}{2} g_{BY} g_2 \cos\Theta'_W \sin\Theta_W Z_{i1}^A Z_{j1}^A \\
&+ \frac{i}{2} g_1 g_2 \cos\Theta_W^2 \sin\Theta'_W Z_{i1}^A Z_{j1}^A + \frac{i}{2} g_1^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A \\
&- \frac{i}{2} g_2^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A - \frac{i}{2} g_1 g_2 \sin\Theta_W^2 \sin\Theta'_W Z_{i1}^A Z_{j1}^A \\
&+ 50 i g_B g_{YB} \cos\Theta_W \cos\Theta'_W Z_{i2}^A Z_{j2}^A + 50 i g_{YB}^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z_{i2}^A Z_{j2}^A \\
&+ 50 i g_B g_{YB} \cos\Theta_W \cos\Theta'_W Z_{i3}^A Z_{j3}^A + 50 i g_{YB}^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z_{i3}^A Z_{j3}^A \Big) \Big(g_{\mu\nu} \Big)
\end{aligned} \tag{224}
$$



$$
\frac{i}{2} g_2^2 Z_{i1}^A Z_{j1}^A \Big(g_{\mu\nu} \Big) \tag{225}
$$

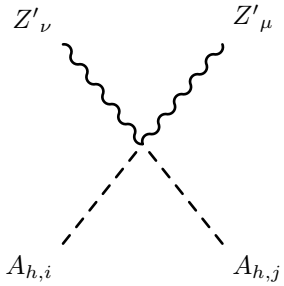


$$\Big(+ \frac{i}{2} g_2^2 \cos\Theta_W^2 \cos\Theta'^2_W Z_{i1}^A Z_{j1}^A + i g_1 g_2 \cos\Theta_W \cos\Theta'^2_W \sin\Theta_W Z_{i1}^A Z_{j1}^A$$
$$+ \frac{i}{2} g_1^2 \cos\Theta'^2_W \sin\Theta_W^2 Z_{i1}^A Z_{j1}^A - i g_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A$$
$$- i g_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A + \frac{i}{2} g_{BY}^2 \sin\Theta'^2_W Z_{i1}^A Z_{j1}^A$$
$$+ 50 i g_{YB}^2 \cos\Theta'^2_W \sin\Theta_W^2 Z_{i2}^A Z_{j2}^A - 100 i g_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i2}^A Z_{j2}^A$$
$$+ 50 i g_B^2 \sin\Theta'^2_W Z_{i2}^A Z_{j2}^A + 50 i g_{YB}^2 \cos\Theta'^2_W \sin\Theta_W^2 Z_{i3}^A Z_{j3}^A$$
$$- 100 i g_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i3}^A Z_{j3}^A + 50 i g_B^2 \sin\Theta'^2_W Z_{i3}^A Z_{j3}^A \Big) \Big(g_{\mu\nu} \Big) \tag{226}$$

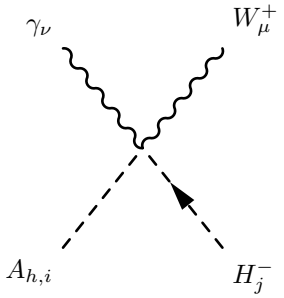


$$\Big(- \frac{i}{2} g_{BY} g_2 \cos\Theta_W \cos\Theta'^2_W Z_{i1}^A Z_{j1}^A - \frac{i}{2} g_1 g_{BY} \cos\Theta'^2_W \sin\Theta_W Z_{i1}^A Z_{j1}^A$$
$$+ \frac{i}{2} g_{BY}^2 \cos\Theta'_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A - \frac{i}{2} g_2^2 \cos\Theta_W^2 \cos\Theta'_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A$$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

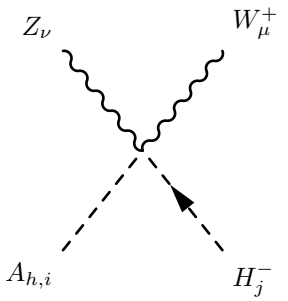
$$
\begin{aligned}
&- \frac{25i}{2} g_{YB}^2 \sin 2\Theta'_W Z_{i2}^A Z_{j2}^A + \frac{25i}{2} g_{YB}^2 \cos 2\Theta_W \sin 2\Theta'_W Z_{i2}^A Z_{j2}^A \\
&- 50 i g_B g_{YB} \cos \Theta'^2_W \sin \Theta_W Z_{i3}^A Z_{j3}^A + 50 i g_B g_{YB} \sin \Theta_W \sin \Theta'^2_W Z_{i3}^A Z_{j3}^A \\
&+ 25 i g_B^2 \sin 2\Theta'_W Z_{i3}^A Z_{j3}^A - \frac{25i}{2} g_{YB}^2 \sin 2\Theta'_W Z_{i3}^A Z_{j3}^A \\
&+ \frac{25i}{2} g_{YB}^2 \cos 2\Theta_W \sin 2\Theta'_W Z_{i3}^A Z_{j3}^A \Big) \Big(g_{\mu\nu} \Big)
\end{aligned} \tag{227}
$$



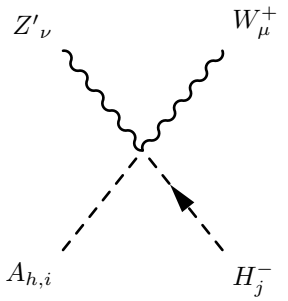
$$
\begin{aligned}
&\Big(+ \frac{i}{2} g_{BY}^2 \cos \Theta'^2_W Z_{i1}^A Z_{j1}^A + i g_{BY} g_2 \cos \Theta_W \cos \Theta'_W \sin \Theta'_W Z_{i1}^A Z_{j1}^A \\
&+ i g_1 g_{BY} \cos \Theta'_W \sin \Theta_W \sin \Theta'_W Z_{i1}^A Z_{j1}^A + \frac{i}{2} g_2^2 \cos \Theta_W^2 \sin \Theta'^2_W Z_{i1}^A Z_{j1}^A \\
&+ i g_1 g_2 \cos \Theta_W \sin \Theta_W \sin \Theta'^2_W Z_{i1}^A Z_{j1}^A + \frac{i}{2} g_1^2 \sin \Theta_W^2 \sin \Theta'^2_W Z_{i1}^A Z_{j1}^A \\
&+ 50 i g_B^2 \cos \Theta'^2_W Z_{i2}^A Z_{j2}^A + 100 i g_B g_{YB} \cos \Theta'_W \sin \Theta_W \sin \Theta'_W Z_{i2}^A Z_{j2}^A \\
&+ 50 i g_{YB}^2 \sin \Theta_W^2 \sin \Theta'^2_W Z_{i2}^A Z_{j2}^A + 50 i g_B^2 \cos \Theta'^2_W Z_{i3}^A Z_{j3}^A \\
&+ 100 i g_B g_{YB} \cos \Theta'_W \sin \Theta_W \sin \Theta'_W Z_{i3}^A Z_{j3}^A + 50 i g_{YB}^2 \sin \Theta_W^2 \sin \Theta'^2_W Z_{i3}^A Z_{j3}^A \Big) \Big(g_{\mu\nu} \Big)
\end{aligned} \tag{228}
$$



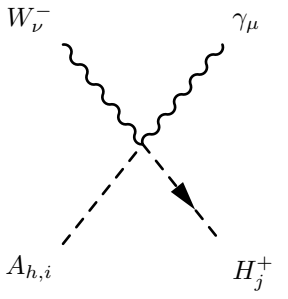
$$
- \frac{1}{2} g_1 g_2 \cos \Theta_W Z_{i1}^A Z_{j1}^+ \Big(g_{\mu\nu} \Big) \tag{229}
$$



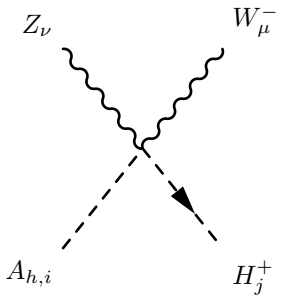
$$\Big(\frac{1}{2}g_1 g_2 \cos\Theta'_W \sin\Theta_W Z^A_{i1} Z^+_{j1} - \frac{1}{2} g_{BY} g_2 \sin\Theta'_W Z^A_{i1} Z^+_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{230}$$



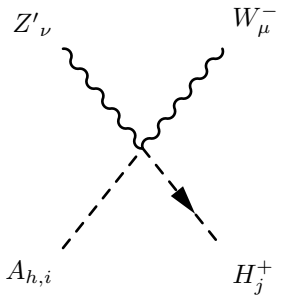
$$\Big(-\frac{1}{2}g_1 g_2 \sin\Theta_W \sin\Theta'_W Z^A_{i1} Z^+_{j1} - \frac{1}{2} g_{BY} g_2 \cos\Theta'_W Z^A_{i1} Z^+_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{231}$$



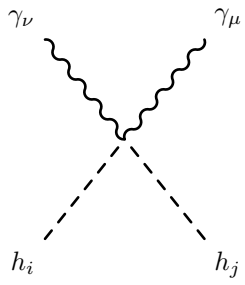
$$\frac{1}{2}g_1 g_2 \cos\Theta_W Z^A_{i1} Z^+_{j1}\Big(g_{\mu\nu}\Big) \tag{232}$$



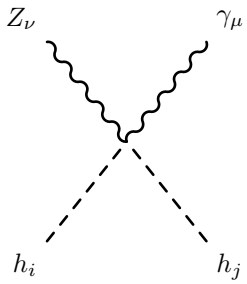
$$\Big(-\frac{1}{2} g_1 g_2 \cos\Theta'_W \sin\Theta_W Z^A_{i1} Z^+_{j1} + \frac{1}{2} g_{BY} g_2 \sin\Theta'_W Z^A_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big) \tag{233}$$



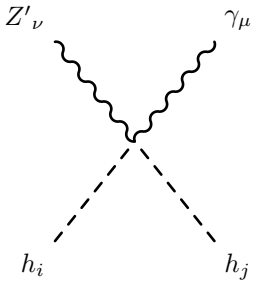
$$\Big(\frac{1}{2} g_1 g_2 \sin\Theta_W \sin\Theta'_W Z^A_{i1} Z^+_{j1} + \frac{1}{2} g_{BY} g_2 \cos\Theta'_W Z^A_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big) \tag{234}$$



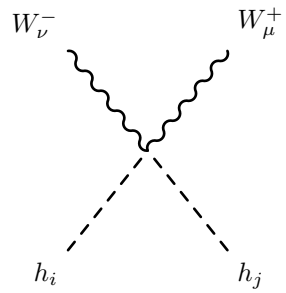
$$\begin{aligned} &\Big(+ \frac{i}{2} g_1^2 \cos\Theta_W^2 Z^H_{i1} Z^H_{j1} - i g_1 g_2 \cos\Theta_W \sin\Theta_W Z^H_{i1} Z^H_{j1} \\ &+ \frac{i}{2} g_2^2 \sin\Theta_W^2 Z^H_{i1} Z^H_{j1} + 50 i g_{YB}^2 \cos\Theta_W^2 Z^H_{i2} Z^H_{j2} + 50 i g_{YB}^2 \cos\Theta_W^2 Z^H_{i3} Z^H_{j3} \Big) \Big(g_{\mu\nu} \Big) \end{aligned} \tag{235}$$



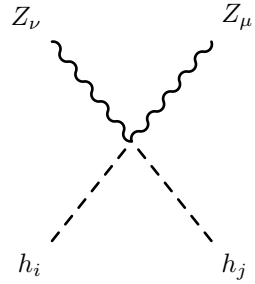
$$\Big(- \frac{i}{2} g_1 g_2 \cos\Theta_W^2 \cos\Theta'_W Z_{i1}^H Z_{j1}^H - \frac{i}{2} g_1^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i1}^H Z_{j1}^H$$
$$+ \frac{i}{2} g_2^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i1}^H Z_{j1}^H + \frac{i}{2} g_1 g_2 \cos\Theta'_W \sin\Theta_W^2 Z_{i1}^H Z_{j1}^H$$
$$+ \frac{i}{2} g_1 g_{BY} \cos\Theta_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H - \frac{i}{2} g_{BY} g_2 \sin\Theta_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H$$
$$- 50 i g_{YB}^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i2}^H Z_{j2}^H + 50 i g_B g_{YB} \cos\Theta_W \sin\Theta'_W Z_{i2}^H Z_{j2}^H$$
$$- 50 i g_{YB}^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i3}^H Z_{j3}^H + 50 i g_B g_{YB} \cos\Theta_W \sin\Theta'_W Z_{i3}^H Z_{j3}^H \Big) \Big(g_{\mu\nu} \Big) \tag{236}$$



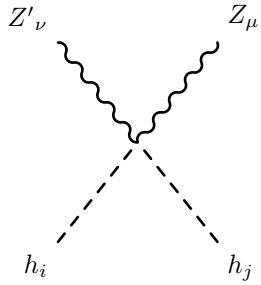
$$\Big(+ \frac{i}{2} g_1 g_{BY} \cos\Theta_W \cos\Theta'_W Z_{i1}^H Z_{j1}^H - \frac{i}{2} g_{BY} g_2 \cos\Theta'_W \sin\Theta_W Z_{i1}^H Z_{j1}^H$$
$$+ \frac{i}{2} g_1 g_2 \cos\Theta_W^2 \sin\Theta'_W Z_{i1}^H Z_{j1}^H + \frac{i}{2} g_1^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H$$
$$- \frac{i}{2} g_2^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H - \frac{i}{2} g_1 g_2 \sin\Theta_W^2 \sin\Theta'_W Z_{i1}^H Z_{j1}^H$$
$$+ 50 i g_B g_{YB} \cos\Theta_W \cos\Theta'_W Z_{i2}^H Z_{j2}^H + 50 i g_{YB}^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z_{i2}^H Z_{j2}^H$$
$$+ 50 i g_B g_{YB} \cos\Theta_W \cos\Theta'_W Z_{i3}^H Z_{j3}^H + 50 i g_{YB}^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z_{i3}^H Z_{j3}^H \Big) \Big(g_{\mu\nu} \Big) \tag{237}$$



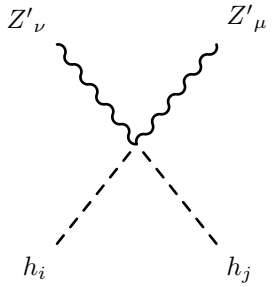
$$\frac{i}{2}g_2^2 Z_{i1}^H Z_{j1}^H \Big(g_{\mu\nu}\Big) \tag{238}$$



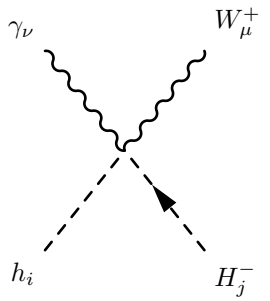
$$\begin{aligned}
&\Big(+ \frac{i}{2}g_2^2 \cos\Theta_W^2 \cos\Theta'^2_W Z_{i1}^H Z_{j1}^H + ig_1 g_2 \cos\Theta_W \cos\Theta'^2_W \sin\Theta_W Z_{i1}^H Z_{j1}^H \\
&+ \frac{i}{2}g_1^2 \cos\Theta'^2_W \sin\Theta_W^2 Z_{i1}^H Z_{j1}^H - ig_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H \\
&- ig_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H + \frac{i}{2}g_{BY}^2 \sin\Theta'^2_W Z_{i1}^H Z_{j1}^H \\
&+ 50ig_{YB}^2 \cos\Theta'^2_W \sin\Theta_W^2 Z_{i2}^H Z_{j2}^H - 100ig_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i2}^H Z_{j2}^H \\
&+ 50ig_B^2 \sin\Theta'^2_W Z_{i2}^H Z_{j2}^H + 50ig_{YB}^2 \cos\Theta'^2_W \sin\Theta_W^2 Z_{i3}^H Z_{j3}^H \\
&- 100ig_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i3}^H Z_{j3}^H + 50ig_B^2 \sin\Theta'^2_W Z_{i3}^H Z_{j3}^H \Big) \Big(g_{\mu\nu}\Big)
\end{aligned} \tag{239}$$



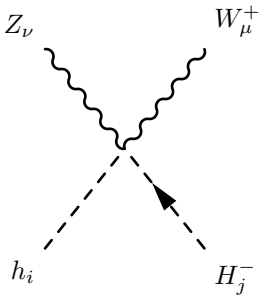
$$\Big(-\frac{i}{2} g_{BY} g_2 \cos\Theta_W \cos{\Theta'}^2_W Z^H_{i1} Z^H_{j1} - \frac{i}{2} g_1 g_{BY} \cos{\Theta'}^2_W \sin\Theta_W Z^H_{i1} Z^H_{j1}$$
$$+ \frac{i}{2} g^2_{BY} \cos\Theta'_W \sin\Theta'_W Z^H_{i1} Z^H_{j1} - \frac{i}{2} g^2_2 \cos\Theta^2_W \cos\Theta'_W \sin\Theta'_W Z^H_{i1} Z^H_{j1}$$
$$- i g_1 g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^H_{i1} Z^H_{j1}$$
$$- \frac{i}{2} g^2_1 \cos\Theta'_W \sin\Theta^2_W \sin\Theta'_W Z^H_{i1} Z^H_{j1} + \frac{i}{2} g_{BY} g_2 \cos\Theta_W \sin{\Theta'}^2_W Z^H_{i1} Z^H_{j1}$$
$$+ \frac{i}{2} g_1 g_{BY} \sin\Theta_W \sin{\Theta'}^2_W Z^H_{i1} Z^H_{j1} - 50 i g_B g_{YB} \cos{\Theta'}^2_W \sin\Theta_W Z^H_{i2} Z^H_{j2}$$
$$+ 50 i g_B g_{YB} \sin\Theta_W \sin{\Theta'}^2_W Z^H_{i2} Z^H_{j2} + 25 i g^2_B \sin 2\Theta'_W Z^H_{i2} Z^H_{j2}$$
$$- \frac{25i}{2} g^2_{YB} \sin 2\Theta'_W Z^H_{i2} Z^H_{j2} + \frac{25i}{2} g^2_{YB} \cos 2\Theta_W \sin 2\Theta'_W Z^H_{i2} Z^H_{j2}$$
$$- 50 i g_B g_{YB} \cos{\Theta'}^2_W \sin\Theta_W Z^H_{i3} Z^H_{j3} + 50 i g_B g_{YB} \sin\Theta_W \sin{\Theta'}^2_W Z^H_{i3} Z^H_{j3}$$
$$+ 25 i g^2_B \sin 2\Theta'_W Z^H_{i3} Z^H_{j3} - \frac{25i}{2} g^2_{YB} \sin 2\Theta'_W Z^H_{i3} Z^H_{j3}$$
$$+ \frac{25i}{2} g^2_{YB} \cos 2\Theta_W \sin 2\Theta'_W Z^H_{i3} Z^H_{j3} \Big) \Big(g_{\mu\nu} \Big) \tag{240}$$



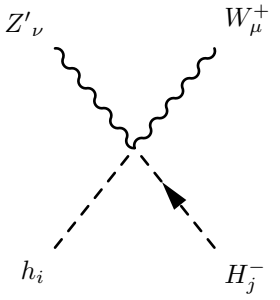
$$\Big(+ \frac{i}{2} g^2_{BY} \cos{\Theta'}^2_W Z^H_{i1} Z^H_{j1} + i g_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z^H_{i1} Z^H_{j1}$$
$$+ i g_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^H_{i1} Z^H_{j1} + \frac{i}{2} g^2_2 \cos\Theta^2_W \sin{\Theta'}^2_W Z^H_{i1} Z^H_{j1}$$
$$+ i g_1 g_2 \cos\Theta_W \sin\Theta_W \sin{\Theta'}^2_W Z^H_{i1} Z^H_{j1} + \frac{i}{2} g^2_1 \sin\Theta^2_W \sin{\Theta'}^2_W Z^H_{i1} Z^H_{j1}$$
$$+ 50 i g^2_B \cos{\Theta'}^2_W Z^H_{i2} Z^H_{j2} + 100 i g_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^H_{i2} Z^H_{j2}$$
$$+ 50 i g^2_{YB} \sin\Theta^2_W \sin{\Theta'}^2_W Z^H_{i2} Z^H_{j2} + 50 i g^2_B \cos{\Theta'}^2_W Z^H_{i3} Z^H_{j3}$$
$$+ 100 i g_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^H_{i3} Z^H_{j3} + 50 i g^2_{YB} \sin\Theta^2_W \sin{\Theta'}^2_W Z^H_{i3} Z^H_{j3} \Big) \Big(g_{\mu\nu} \Big) \tag{241}$$



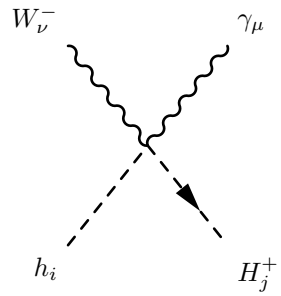
$$\frac{i}{2}g_1 g_2 \cos\Theta_W Z^H_{i1} Z^+_{j1}\Big(g_{\mu\nu}\Big) \tag{242}$$



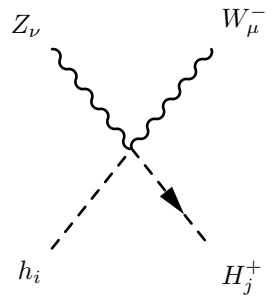
$$\Big(-\frac{i}{2}g_1 g_2 \cos\Theta'_W \sin\Theta_W Z^H_{i1} Z^+_{j1} + \frac{i}{2}g_{BY} g_2 \sin\Theta'_W Z^H_{i1} Z^+_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{243}$$



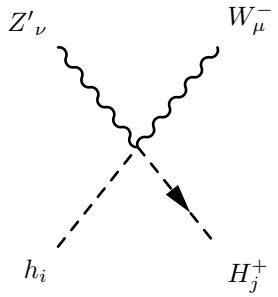
$$\Big(\frac{i}{2}g_1 g_2 \sin\Theta_W \sin\Theta'_W Z^H_{i1} Z^+_{j1} + \frac{i}{2}g_{BY} g_2 \cos\Theta'_W Z^H_{i1} Z^+_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{244}$$



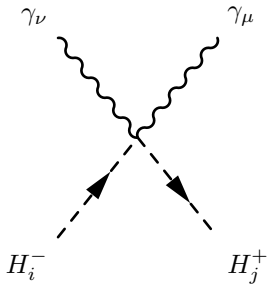
$$\frac{i}{2}g_1 g_2 \cos\Theta_W Z_{i1}^H Z_{j1}^+ \Big(g_{\mu\nu}\Big) \tag{245}$$



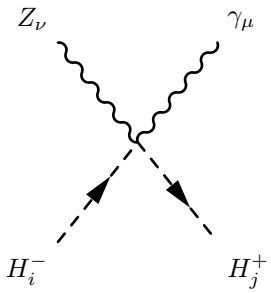
$$\Big(-\frac{i}{2}g_1 g_2 \cos\Theta'_W \sin\Theta_W Z_{i1}^H Z_{j1}^+ + \frac{i}{2}g_{BY} g_2 \sin\Theta'_W Z_{i1}^H Z_{j1}^+\Big)\Big(g_{\mu\nu}\Big) \tag{246}$$



$$\Big(\frac{i}{2}g_1 g_2 \sin\Theta_W \sin\Theta'_W Z_{i1}^H Z_{j1}^+ + \frac{i}{2}g_{BY} g_2 \cos\Theta'_W Z_{i1}^H Z_{j1}^+\Big)\Big(g_{\mu\nu}\Big) \tag{247}$$

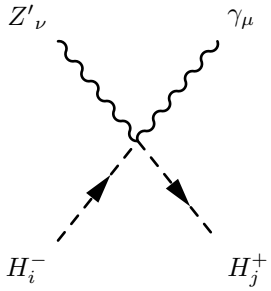


$$\Big(+ 2ig_1^2 \cos\Theta_W^2 \sum_{a=1}^{2} Z_{i1+a}^+ Z_{j1+a}^+ + 4ig_1 g_{YB} \cos\Theta_W^2 \sum_{a=1}^{2} Z_{i1+a}^+ Z_{j1+a}^+$$
$$+ 2ig_{YB}^2 \cos\Theta_W^2 \sum_{a=1}^{2} Z_{i1+a}^+ Z_{j1+a}^+ + 2ig_1^2 \cos\Theta_W^2 \sum_{a=1}^{2} Z_{i3+a}^+ Z_{j3+a}^+$$
$$- 16ig_1 g_{YB} \cos\Theta_W^2 \sum_{a=1}^{2} Z_{i3+a}^+ Z_{j3+a}^+ + 32ig_{YB}^2 \cos\Theta_W^2 \sum_{a=1}^{2} Z_{i3+a}^+ Z_{j3+a}^+$$
$$+ \frac{i}{2} g_1^2 \cos\Theta_W^2 Z_{i1}^+ Z_{j1}^+ + ig_1 g_2 \cos\Theta_W \sin\Theta_W Z_{i1}^+ Z_{j1}^+ + \frac{i}{2} g_2^2 \sin\Theta_W^2 Z_{i1}^+ Z_{j1}^+ \Big) \Big(g_{\mu\nu} \Big) \tag{248}$$



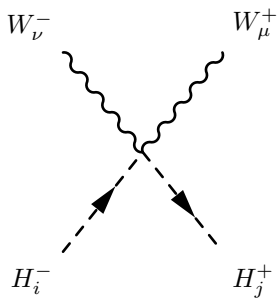
$$\Big(- 2ig_1^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W \sum_{a=1}^{2} Z_{i1+a}^+ Z_{j1+a}^+$$
$$- 4ig_1 g_{YB} \cos\Theta_W \cos\Theta'_W \sin\Theta_W \sum_{a=1}^{2} Z_{i1+a}^+ Z_{j1+a}^+$$
$$- 2ig_{YB}^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W \sum_{a=1}^{2} Z_{i1+a}^+ Z_{j1+a}^+$$
$$+ 2ig_1 g_{BY}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

$$+ 2ig_{BY}g_{YB}\cos\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a}Z^+_{j1+a} + 2ig_Bg_{YB}\cos\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a}Z^+_{j1+a}$$
$$- 2ig_1^2\cos\Theta_W \cos\Theta'_W \sin\Theta_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a}$$
$$+ 16ig_1g_{YB}\cos\Theta_W \cos\Theta'_W \sin\Theta_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a}$$
$$- 32ig_{YB}^2\cos\Theta_W \cos\Theta'_W \sin\Theta_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a}$$
$$+ 2ig_1g_{BY}\cos\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a} - 8ig_1g_B\cos\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a}$$
$$- 8ig_{BY}g_{YB}\cos\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a} + 32ig_Bg_{YB}\cos\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a}Z^+_{j3+a}$$
$$+ \frac{i}{2}g_1g_2\cos\Theta_W^2 \cos\Theta'_W Z^+_{i1}Z^+_{j1} - \frac{i}{2}g_1^2\cos\Theta_W \cos\Theta'_W \sin\Theta_W Z^+_{i1}Z^+_{j1}$$
$$+ \frac{i}{2}g_2^2\cos\Theta_W \cos\Theta'_W \sin\Theta_W Z^+_{i1}Z^+_{j1} - \frac{i}{2}g_1g_2\cos\Theta'_W \sin\Theta_W^2 Z^+_{i1}Z^+_{j1}$$
$$+ \frac{i}{2}g_1g_{BY}\cos\Theta_W \sin\Theta'_W Z^+_{i1}Z^+_{j1} + \frac{i}{2}g_{BY}g_2\sin\Theta_W \sin\Theta'_W Z^+_{i1}Z^+_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{249}$$

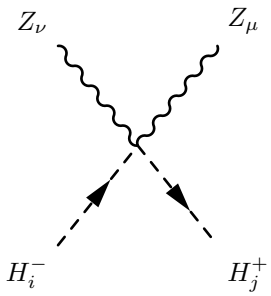


$$\Big(+ 2ig_1g_{BY}\cos\Theta_W \cos\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a}Z^+_{j1+a} + 2ig_1g_B\cos\Theta_W \cos\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a}Z^+_{j1+a}$$
$$+ 2ig_{BY}g_{YB}\cos\Theta_W \cos\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a}Z^+_{j1+a} + 2ig_Bg_{YB}\cos\Theta_W \cos\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a}Z^+_{j1+a}$$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

$$
\begin{aligned}
&+ 2ig_{YB}^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} \\
&+ 2ig_1 g_{BY} \cos\Theta_W \cos\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} - 8ig_1 g_B \cos\Theta_W \cos\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&- 8ig_{BY} g_{YB} \cos\Theta_W \cos\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} + 32ig_B g_{YB} \cos\Theta_W \cos\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&+ 2ig_1^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&- 16ig_1 g_{YB} \cos\Theta_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&+ 32ig_{YB}^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} + \frac{i}{2} g_1 g_{BY} \cos\Theta_W \cos\Theta'_W Z^+_{i1} Z^+_{j1} \\
&+ \frac{i}{2} g_{BY} g_2 \cos\Theta'_W \sin\Theta_W Z^+_{i1} Z^+_{j1} - \frac{i}{2} g_1 g_2 \cos\Theta^2_W \sin\Theta'_W Z^+_{i1} Z^+_{j1} \\
&+ \frac{i}{2} g_1^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z^+_{i1} Z^+_{j1} - \frac{i}{2} g_2^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z^+_{i1} Z^+_{j1} \\
&+ \frac{i}{2} g_1 g_2 \sin\Theta^2_W \sin\Theta'_W Z^+_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big)
\end{aligned}
\tag{250}
$$



$$
\frac{i}{2} g_2^2 Z^+_{i1} Z^+_{j1} \Big(g_{\mu\nu} \Big)
\tag{251}
$$



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

$$+ 2ig_{YB}^2 \cos\Theta'^2_W \sin\Theta^2_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a}$$

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

$$- 4ig_1 g_B \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a}$$

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

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

$$+ 4ig_{BY} g_B \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} + 2ig_B^2 \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a}$$

$$+ 2ig_1^2 \cos\Theta'^2_W \sin\Theta^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} - 16ig_1 g_{YB} \cos\Theta'^2_W \sin\Theta^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a}$$

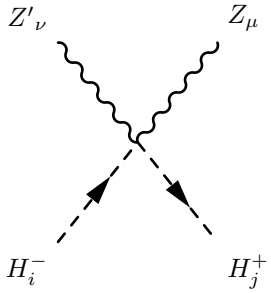
$$+ 32ig_{YB}^2 \cos\Theta'^2_W \sin\Theta^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a}$$

$$- 4ig_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a}$$

$$+ 16ig_1 g_B \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a}$$

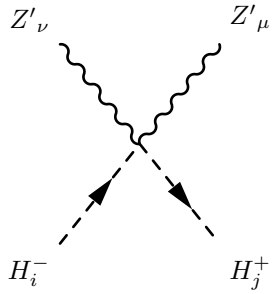
$$+ 16ig_{BY} g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a}$$

$$
\begin{aligned}
&- 64ig_B g_{YB}\cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} + 2ig^2_{BY}\sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&- 16ig_{BY} g_B \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} + 32ig^2_B \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&+ \frac{i}{2} g^2_2 \cos\Theta^2_W \cos\Theta'^2_W Z^+_{i1} Z^+_{j1} - ig_1 g_2 \cos\Theta_W \cos\Theta'^2_W \sin\Theta_W Z^+_{i1} Z^+_{j1} \\
&+ \frac{i}{2} g^2_1 \cos\Theta'^2_W \sin\Theta^2_W Z^+_{i1} Z^+_{j1} + ig_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z^+_{i1} Z^+_{j1} \\
&- ig_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^+_{i1} Z^+_{j1} + \frac{i}{2} g^2_{BY} \sin\Theta'^2_W Z^+_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big)
\end{aligned} \tag{252}
$$



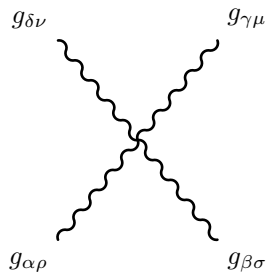
$$
\begin{aligned}
\Big(&- 2ig_1 g_{BY} \cos\Theta'^2_W \sin\Theta_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} - 2ig_1 g_B \cos\Theta'^2_W \sin\Theta_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} \\
&- 2ig_{BY} g_{YB} \cos\Theta'^2_W \sin\Theta_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} - 2ig_B g_{YB} \cos\Theta'^2_W \sin\Theta_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} \\
&+ 2ig^2_{BY} \cos\Theta'_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} + 4ig_{BY} g_B \cos\Theta'_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} \\
&+ 2ig^2_B \cos\Theta'_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} \\
&- 2ig^2_1 \cos\Theta'_W \sin\Theta^2_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} \\
&- 2ig^2_{YB} \cos\Theta'_W \sin\Theta^2_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} \\
&+ 2ig_1 g_{BY} \sin\Theta_W \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} + 2ig_1 g_B \sin\Theta_W \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} \\
&+ 2ig_{BY} g_{YB} \sin\Theta_W \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} + 2ig_B g_{YB} \sin\Theta_W \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a}
\end{aligned}
$$

$$
\begin{aligned}
&- 2ig_1 g_{YB} \sin\Theta_W^2 \sin 2{\Theta'}_W \sum_{a=1}^{2} Z_{i1+a}^{+} Z_{j1+a}^{+} - 2ig_1 g_{BY} \cos{\Theta'}_W^2 \sin\Theta_W \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+} \\
&+ 8ig_1 g_B \cos{\Theta'}_W^2 \sin\Theta_W \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+} + 8ig_{BY} g_{YB} \cos{\Theta'}_W^2 \sin\Theta_W \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+} \\
&- 32ig_B g_{YB} \cos{\Theta'}_W^2 \sin\Theta_W \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+} + 2ig_{BY}^2 \cos{\Theta'}_W \sin{\Theta'}_W \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+} \\
&- 16ig_{BY} g_B \cos{\Theta'}_W \sin{\Theta'}_W \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+} \\
&- 2ig_1^2 \cos{\Theta'}_W \sin\Theta_W^2 \sin{\Theta'}_W \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+} \\
&+ 16ig_1 g_{YB} \cos{\Theta'}_W \sin\Theta_W^2 \sin{\Theta'}_W \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+} \\
&+ 2ig_1 g_{BY} \sin\Theta_W \sin{\Theta'}_W^2 \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+} - 8ig_1 g_B \sin\Theta_W \sin{\Theta'}_W^2 \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+} \\
&- 8ig_{BY} g_{YB} \sin\Theta_W \sin{\Theta'}_W^2 \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+} + 32ig_B g_{YB} \sin\Theta_W \sin{\Theta'}_W^2 \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+} \\
&+ 16ig_B^2 \sin 2{\Theta'}_W \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+} - 16ig_{YB}^2 \sin\Theta_W^2 \sin 2{\Theta'}_W \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+} \\
&+ \frac{i}{2} g_{BY} g_2 \cos\Theta_W \cos{\Theta'}_W^2 Z_{i1}^{+} Z_{j1}^{+} - \frac{i}{2} g_1 g_{BY} \cos{\Theta'}_W^2 \sin\Theta_W Z_{i1}^{+} Z_{j1}^{+} \\
&+ \frac{i}{2} g_{BY}^2 \cos{\Theta'}_W \sin{\Theta'}_W Z_{i1}^{+} Z_{j1}^{+} - \frac{i}{2} g_2^2 \cos\Theta_W^2 \cos{\Theta'}_W \sin{\Theta'}_W Z_{i1}^{+} Z_{j1}^{+} \\
&- \frac{i}{2} g_1^2 \cos{\Theta'}_W \sin\Theta_W^2 \sin{\Theta'}_W Z_{i1}^{+} Z_{j1}^{+} - \frac{i}{2} g_{BY} g_2 \cos\Theta_W \sin{\Theta'}_W^2 Z_{i1}^{+} Z_{j1}^{+} \\
&+ \frac{i}{2} g_1 g_{BY} \sin\Theta_W \sin{\Theta'}_W^2 Z_{i1}^{+} Z_{j1}^{+} + \frac{i}{2} g_1 g_2 \cos\Theta_W \sin\Theta_W \sin 2{\Theta'}_W Z_{i1}^{+} Z_{j1}^{+} \Big) \Big(g_{\mu\nu} \Big)
\end{aligned}
\tag{253}
$$



$$\Big(+ 2ig_{BY}^2 \cos\Theta'^2_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} + 4ig_{BY} g_B \cos\Theta'^2_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a}$$
$$+ 2ig_B^2 \cos\Theta'^2_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} + 4ig_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a}$$
$$+ 4ig_1 g_B \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a}$$
$$+ 4ig_{BY} g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a}$$
$$+ 4ig_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a}$$
$$+ 2ig_1^2 \sin\Theta_W^2 \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} + 4ig_1 g_{YB} \sin\Theta_W^2 \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a}$$
$$+ 2ig_{YB}^2 \sin\Theta_W^2 \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} + 2ig_{BY}^2 \cos\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a}$$
$$- 16ig_{BY} g_B \cos\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} + 32ig_B^2 \cos\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a}$$
$$+ 4ig_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a}$$
$$- 16ig_1 g_B \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a}$$
$$- 16ig_{BY} g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a}$$
$$+ 64ig_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a}$$
$$+ 2ig_1^2 \sin\Theta_W^2 \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} - 16ig_1 g_{YB} \sin\Theta_W^2 \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a}$$
$$+ 32ig_{YB}^2 \sin\Theta_W^2 \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} + \frac{i}{2} g_{BY}^2 \cos\Theta'^2_W Z^+_{i1} Z^+_{j1}$$
$$- ig_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z^+_{i1} Z^+_{j1}$$
$$+ ig_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^+_{i1} Z^+_{j1} + \frac{i}{2} g_2^2 \cos\Theta_W^2 \sin\Theta'^2_W Z^+_{i1} Z^+_{j1}$$
$$- ig_1 g_2 \cos\Theta_W \sin\Theta_W \sin\Theta'^2_W Z^+_{i1} Z^+_{j1} + \frac{i}{2} g_1^2 \sin\Theta_W^2 \sin\Theta'^2_W Z^+_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big) \tag{254}$$

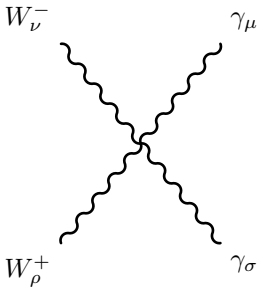
8.9 Four Vector Boson-Interaction



$$ig_3^2\Big(-\sum_{a=1}^{8} f_{\alpha,\delta,a}f_{\beta,\gamma,a} - \sum_{a=1}^{8} f_{\alpha,\gamma,a}f_{\beta,\delta,a}\Big)\Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{255}$$

$$+\ ig_3^2\Big(-\sum_{a=1}^{8} f_{\alpha,\beta,a}f_{\gamma,\delta,a} + \sum_{a=1}^{8} f_{\alpha,\delta,a}f_{\beta,\gamma,a}\Big)\Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{256}$$

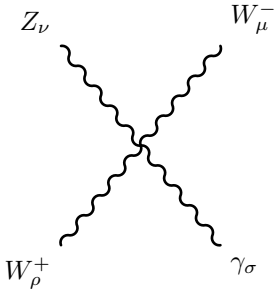
$$+\ ig_3^2\Big(\sum_{a=1}^{8} f_{\alpha,\gamma,a}f_{\beta,\delta,a} + \sum_{a=1}^{8} f_{\alpha,\beta,a}f_{\gamma,\delta,a}\Big)\Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{257}$$



$$ig_2^2\sin\Theta_W^2\Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{258}$$

$$+\ ig_2^2\sin\Theta_W^2\Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{259}$$

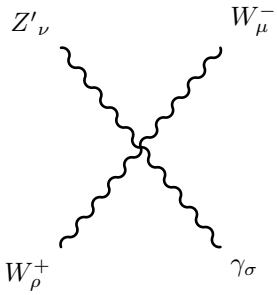
$$+\ -2ig_2^2\sin\Theta_W^2\Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{260}$$



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

$$+\ -ig_2^2 \cos\Theta'_W \sin 2\Theta_W \Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{262}$$

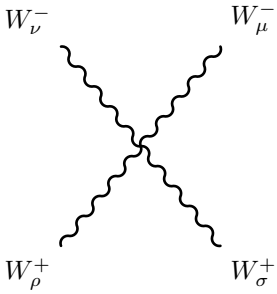
$$+\ \frac{i}{2}g_2^2 \cos\Theta'_W \sin 2\Theta_W \Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{263}$$



$$-\ \frac{i}{2}g_2^2 \sin 2\Theta_W \sin\Theta'_W \Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{264}$$

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

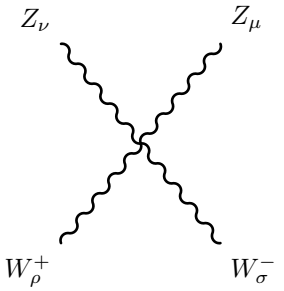
$$+\ -\frac{i}{2}g_2^2 \sin 2\Theta_W \sin\Theta'_W \Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{266}$$



$$2ig_2^2\Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{267}$$

$$+\ -ig_2^2\Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{268}$$

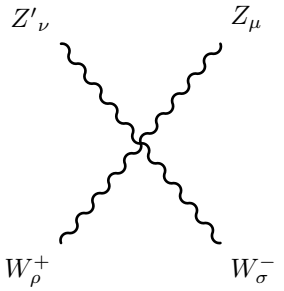
$$+\ -ig_2^2\Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{269}$$



$$-\ 2ig_2^2\cos\Theta_W^2\cos{\Theta'}_W^2\Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{270}$$

$$+\ ig_2^2\cos\Theta_W^2\cos{\Theta'}_W^2\Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{271}$$

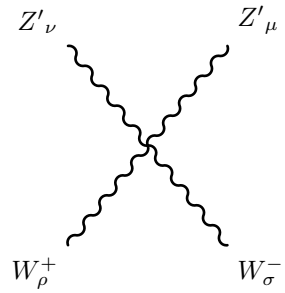
$$+\ ig_2^2\cos\Theta_W^2\cos{\Theta'}_W^2\Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{272}$$



$$ig_2^2\cos\Theta_W^2\sin 2{\Theta'}_W\Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{273}$$

$$+\ -\frac{i}{2}g_2^2\cos\Theta_W^2\sin 2{\Theta'}_W\Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{274}$$

$$+\ -\frac{i}{2}g_2^2\cos\Theta_W^2\sin 2{\Theta'}_W\Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{275}$$

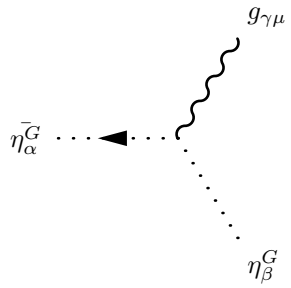


$$- 2ig_2^2 \cos\Theta_W^2 \sin\Theta'^2_W \left(g_{\rho\sigma} g_{\mu\nu}\right) \tag{276}$$

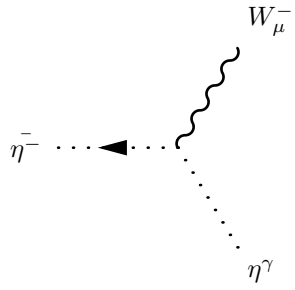
$$+ ig_2^2 \cos\Theta_W^2 \sin\Theta'^2_W \left(g_{\rho\mu} g_{\sigma\nu}\right) \tag{277}$$

$$+ ig_2^2 \cos\Theta_W^2 \sin\Theta'^2_W \left(g_{\rho\nu} g_{\sigma\mu}\right) \tag{278}$$

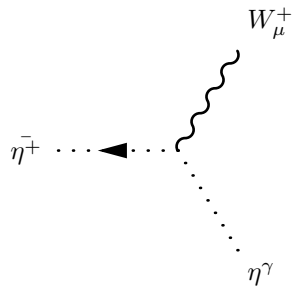
8.10 Two Ghosts-One Vector Boson-Interaction



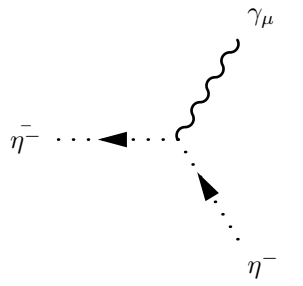
$$g_3 f_{\alpha,\beta,\gamma} \left(p_\mu^{\eta^G_\beta}\right) \tag{279}$$



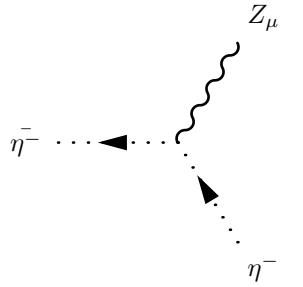
$$ig_2 \sin\Theta_W \left(p_\mu^{\eta^\gamma}\right) \tag{280}$$



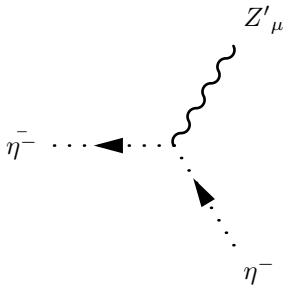
$$-ig_2 \sin\Theta_W \left(p_\mu^{\eta^\gamma}\right) \tag{281}$$



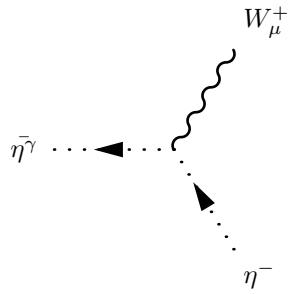
$$-ig_2 \sin\Theta_W \left(p_\mu^{\eta^-}\right) \tag{282}$$



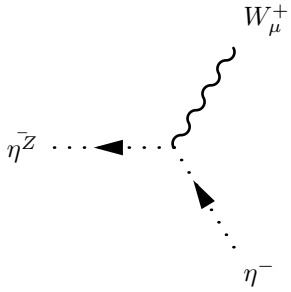
$$-ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^-}\right) \tag{283}$$



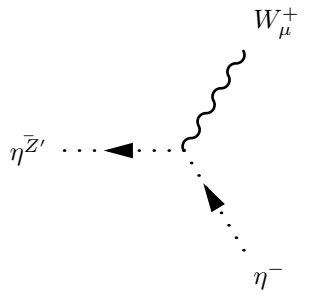
$$ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^-}\right) \tag{284}$$



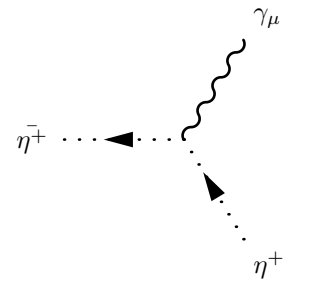
$$ig_2 \sin\Theta_W \left(p_\mu^{\eta^-}\right) \tag{285}$$



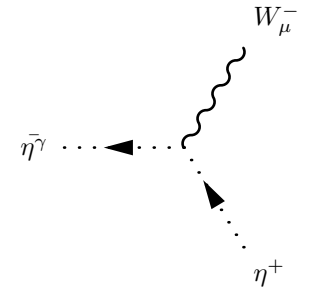
$$ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^-}\right) \tag{286}$$



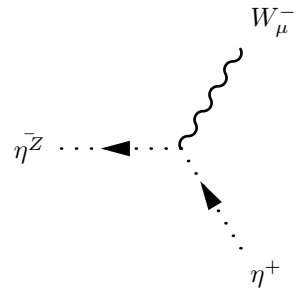
$$-ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^-}\right) \tag{287}$$



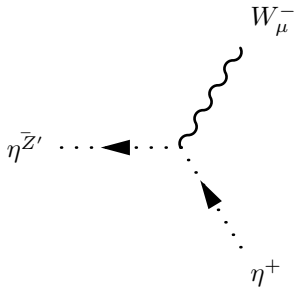
$$ig_2 \sin\Theta_W \left(p_\mu^{\eta^+}\right) \tag{288}$$



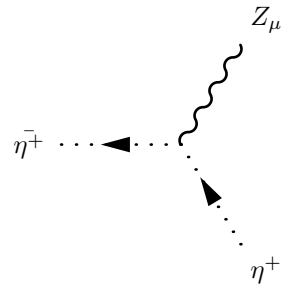
$$-ig_2 \sin\Theta_W \left(p_\mu^{\eta^+}\right) \tag{289}$$



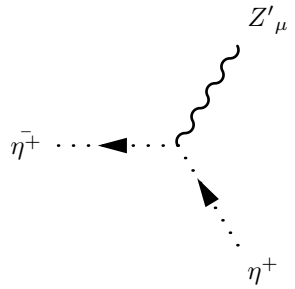
$$-ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^+}\right) \tag{290}$$



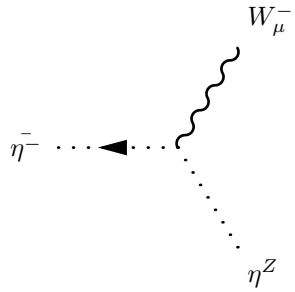
$$ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^+}\right) \tag{291}$$



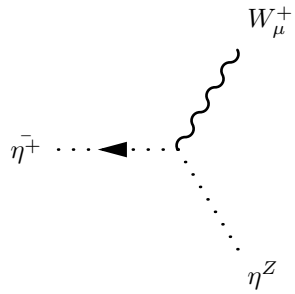
$$ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^+}\right) \tag{292}$$



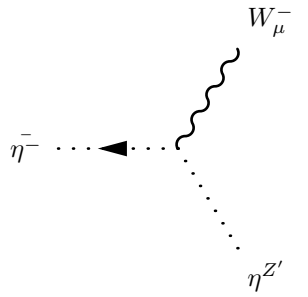
$$-ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^+}\right) \tag{293}$$



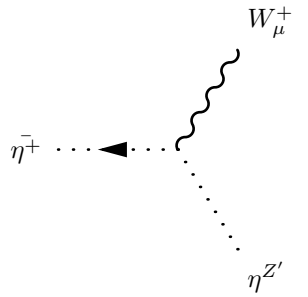
$$ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^Z}\right) \tag{294}$$



$$-ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^Z}\right) \tag{295}$$

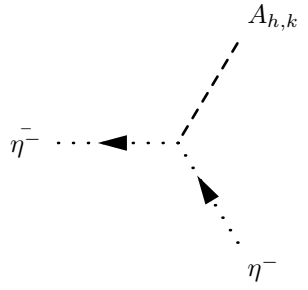


$$-ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^{Z'}}\right) \tag{296}$$

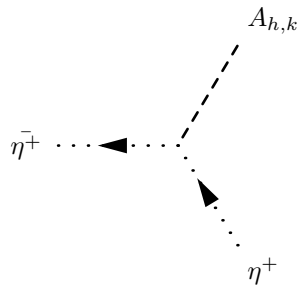


$$ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^{Z'}}\right) \tag{297}$$

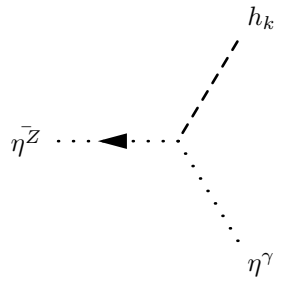
8.11 Two Ghosts-One Scalar-Interaction



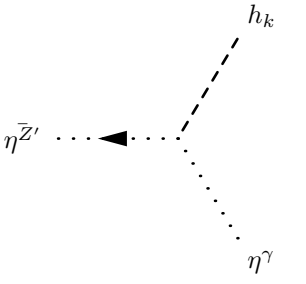
$$-\frac{1}{4} g_2^2 v \xi_{W^-} Z_{k1}^A \tag{298}$$



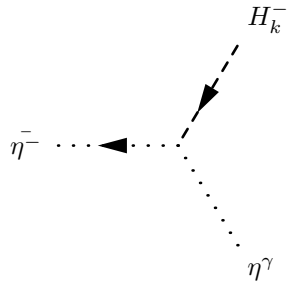
$$\frac{1}{4}g_2^2 v \xi_{W^-} Z_{k1}^A \tag{299}$$



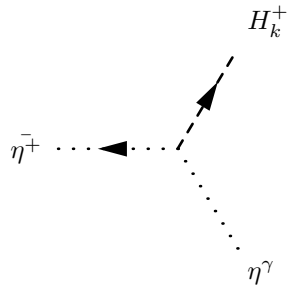
$$\frac{i}{4}\xi_Z \Big(v \Big(g_1 \cos\Theta_W - g_2 \sin\Theta_W \Big) \Big(g_1 \cos\Theta'_W \sin\Theta_W + g_2 \cos\Theta_W \cos\Theta'_W - g_{BY} \sin\Theta'_W \Big) Z_{k1}^H$$
$$+ 100 g_{YB} \cos\Theta_W \Big(- g_B \sin\Theta'_W + g_{YB} \cos\Theta'_W \sin\Theta_W \Big) \Big(vx2 Z_{k3}^H + vx Z_{k2}^H \Big) \Big) \tag{300}$$



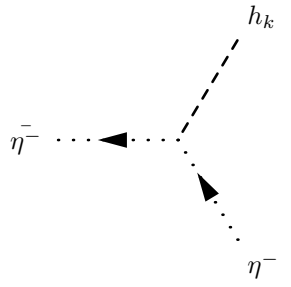
$$-\frac{i}{4}\xi_{Z'} \Big(v \Big(g_1 \cos\Theta_W - g_2 \sin\Theta_W \Big) \Big(\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) \sin\Theta'_W + g_{BY} \cos\Theta'_W \Big) Z_{k1}^H$$
$$+ 100 g_{YB} \cos\Theta_W \Big(g_B \cos\Theta'_W + g_{YB} \sin\Theta_W \sin\Theta'_W \Big) \Big(vx2 Z_{k3}^H + vx Z_{k2}^H \Big) \Big) \tag{301}$$



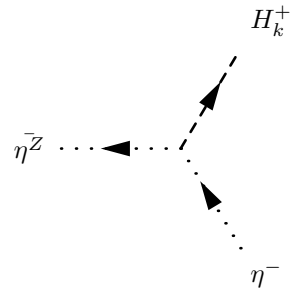
$$-\frac{i}{4}g_2 v \xi_{W^-}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)Z_{k1}^+ \tag{302}$$



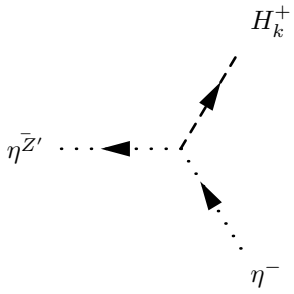
$$-\frac{i}{4}g_2 v \xi_{W^-}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)Z_{k1}^+ \tag{303}$$



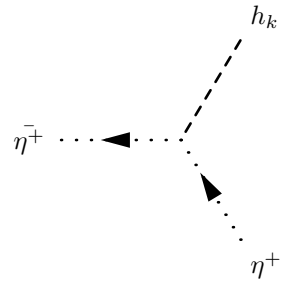
$$-\frac{i}{4}g_2^2 v \xi_{W^-} Z_{k1}^H \tag{304}$$



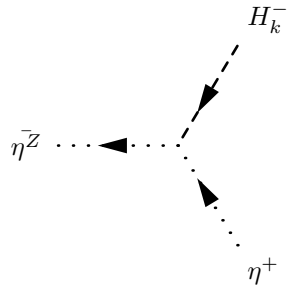
$$\frac{i}{4}g_2 v\xi_Z\Big(g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W - g_{BY}\sin\Theta'_W\Big)Z^+_{k1} \tag{305}$$



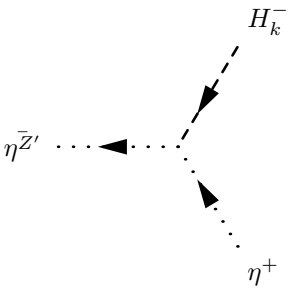
$$-\frac{i}{4}g_2 v\xi_{Z'}\Big(\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W + g_{BY}\cos\Theta'_W\Big)Z^+_{k1} \tag{306}$$



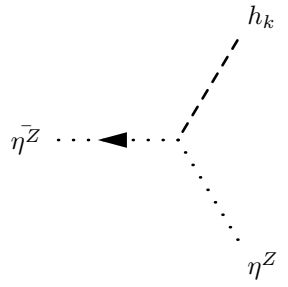
$$-\frac{i}{4}g_2^2 v\xi_{W^-}Z^H_{k1} \tag{307}$$



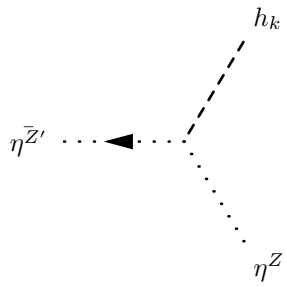
$$\frac{i}{4}g_2 v\xi_Z\Big(g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W - g_{BY}\sin\Theta'_W\Big)Z^+_{k1} \tag{308}$$



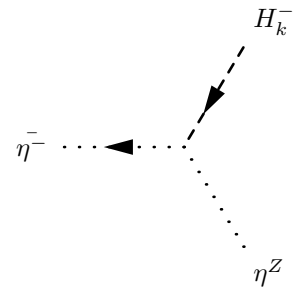
$$-\frac{i}{4}g_2 v\xi_{Z'}\Big(\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W + g_{BY}\cos\Theta'_W\Big)Z^+_{k1} \tag{309}$$



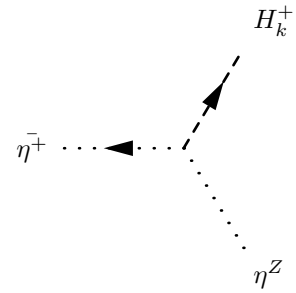
$$\begin{aligned}&-\frac{i}{4}\xi_Z\Big(v\Big(g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W - g_{BY}\sin\Theta'_W\Big)^2 Z^H_{k1}\\&+100\Big(-g_B\sin\Theta'_W + g_{YB}\cos\Theta'_W\sin\Theta_W\Big)^2\Big(vx2Z^H_{k3} + vxZ^H_{k2}\Big)\Big)\end{aligned} \tag{310}$$



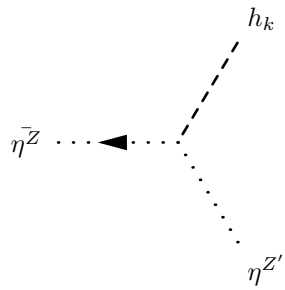
$$\begin{aligned}
&\frac{i}{4}\xi_{Z'}\Big(v\Big(g_1 g_{BY}\cos\Theta'^2_W\sin\Theta_W + g_2^2\cos\Theta_W^2\cos\Theta'_W\sin\Theta'_W\\
&+\cos\Theta'_W\Big(g_1^2\sin\Theta_W^2 - g_{BY}^2\Big)\sin\Theta'_W - g_1 g_{BY}\sin\Theta_W\sin\Theta'^2_W\\
&+g_2\cos\Theta_W\Big(g_1\sin\Theta_W\sin 2\Theta'_W + g_{BY}\cos\Theta'^2_W - g_{BY}\sin\Theta'^2_W\Big)\Big)Z_{k1}^H\\
&-\frac{25}{2}\Big(-8g_B g_{YB}\cos\Theta'^2_W\sin\Theta_W + 8g_B g_{YB}\sin\Theta_W\sin\Theta'^2_W\\
&+2\Big(2g_B^2 - g_{YB}^2 + g_{YB}^2\cos 2\Theta_W\Big)\sin 2\Theta'_W\Big)\Big(vx2Z_{k3}^H + vxZ_{k2}^H\Big)\Big)
\end{aligned} \tag{311}$$



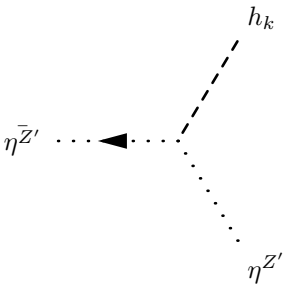
$$-\frac{i}{4}g_2 v\xi_{W^-}\Big(-g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W + g_{BY}\sin\Theta'_W\Big)Z_{k1}^+ \tag{312}$$



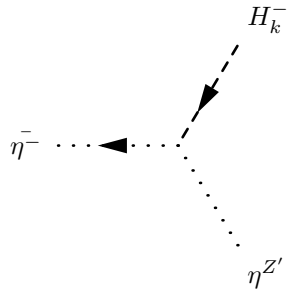
$$-\frac{i}{4}g_2 v\xi_{W^-}\Big(-g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W+g_{BY}\sin\Theta'_W\Big)Z^+_{k1} \tag{313}$$



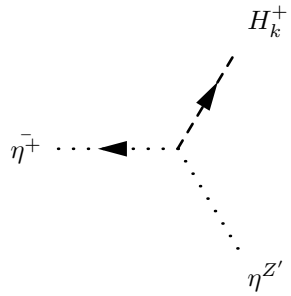
$$\begin{aligned}
&\frac{i}{4}\xi_Z\Big(v\Big(g_1 g_{BY}\cos\Theta'^2_W\sin\Theta_W+g_2^2\cos\Theta_W^2\cos\Theta'_W\sin\Theta'_W\\
&+\cos\Theta'_W\Big(g_1^2\sin\Theta_W^2-g_{BY}^2\Big)\sin\Theta'_W-g_1 g_{BY}\sin\Theta_W\sin\Theta'^2_W\\
&+g_2\cos\Theta_W\Big(g_1\sin\Theta_W\sin 2\Theta'_W+g_{BY}\cos\Theta'^2_W-g_{BY}\sin\Theta'^2_W\Big)\Big)Z^H_{k1}\\
&-\frac{25}{2}\Big(-8g_B g_{YB}\cos\Theta'^2_W\sin\Theta_W+8g_B g_{YB}\sin\Theta_W\sin\Theta'^2_W\\
&+2\Big(2g_B^2-g_{YB}^2+g_{YB}^2\cos 2\Theta_W\Big)\sin 2\Theta'_W\Big)\Big(vx2Z^H_{k3}+vxZ^H_{k2}\Big)\Big)
\end{aligned} \tag{314}$$



$$\begin{aligned}
&-\frac{i}{4}\xi_{Z'}\Big(v\Big(\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W+g_{BY}\cos\Theta'_W\Big)^2Z^H_{k1}\\
&+100\Big(g_B\cos\Theta'_W+g_{YB}\sin\Theta_W\sin\Theta'_W\Big)^2\Big(vx2Z^H_{k3}+vxZ^H_{k2}\Big)\Big)
\end{aligned} \tag{315}$$



$$\frac{i}{4}g_2 v \xi_{W^-}\Big(\Big(-g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W - g_{BY}\cos\Theta'_W\Big)Z^+_{k1} \tag{316}$$



$$\frac{i}{4}g_2 v \xi_{W^-}\Big(\Big(-g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W - g_{BY}\cos\Theta'_W\Big)Z^+_{k1} \tag{317}$$

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9 Clebsch-Gordan Coefficients