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

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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	$(0, \mathbf{1}, \mathbf{1}, 5)$
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

$$
\begin{aligned}
L = & -\mu_p'|\mathrm{BiD}|^2 - \mu_h|H^0|^2 - \mu_h|H^+|^2 + \mathrm{BiD}^2\lambda_2\mathrm{conj}\Big(\mathrm{BiD}\Big)^2 + H^0\lambda_3|\mathrm{BiD}|^2H^{0,*} + H^{0,2}l_hH^{0,*,2} + H^+\lambda_3|\mathrm{BiD}|^2H^{+,*} \\
& + 2H^+l_h|H^0|^2H^{+,*} + H^{+,2}l_hH^{+,*,2} - H^0d^*_{L,k\gamma}Y^*_{d,jk}\delta_{\beta\gamma}d_{R,j\beta} - H^+u^*_{L,k\gamma}Y^*_{d,jk}\delta_{\beta\gamma}d_{R,j\beta} \\
& - \lambda_c\mathrm{conj}\Big(\mathrm{BiD}\Big)\mathrm{conj}\Big(\mathrm{epp}\Big(2\Big)\Big)\mathrm{ep}\Big(1\Big) - \lambda_gH^{0,*}\mathrm{conj}\Big(\mathrm{x5R}\Big(2\Big)\Big)\mathrm{ep}\Big(1\Big) - \lambda_c\mathrm{conj}\Big(\mathrm{BiD}\Big)\mathrm{conj}\Big(\mathrm{epp}\Big(1\Big)\Big)\mathrm{ep}\Big(2\Big) - \lambda_gH^{0,*}\mathrm{conj}\Big(\mathrm{x5R}\Big(1\Big)
\end{aligned}
$$

$$
\begin{aligned}
&- \lambda_h H^{0,*}\mathrm{conj}\Big(\mathrm{x6L}\Big(2\Big)\Big)\mathrm{epp}\Big(1\Big) - \mathrm{BiD}\lambda_c\mathrm{conj}\Big(\mathrm{ep}\Big(1\Big)\Big)\mathrm{epp}\Big(2\Big) - \lambda_h H^{0,*}\mathrm{conj}\Big(\mathrm{x6L}\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,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)\Big(2\Big)\Big)\mathrm{s1}\Big(\{\mathrm{gt1}\}\Big) - \mathrm{conj}\Big(\mathrm{ep}\Big(2\Big)\Big)\lambda^*_{d,ij}\mathrm{co}\\
&- |H^+|^2\mathrm{conj}\Big(\mathrm{s1}\Big(\{\mathrm{gt1}\}\Big)\Big)\lambda_{32,ij}\mathrm{s1}\Big(\{\mathrm{gt2}\}\Big) - \mathrm{conj}\Big(\mathrm{s1}\Big(\{\mathrm{gt1}\}\Big)\Big)\mu_{1,ij}\mathrm{s1}\Big(\{\mathrm{gt2}\}\Big) - \mathrm{conj}\Big(\mathrm{s1}\Big(\{\mathrm{gt1}\}\Big)\Big)\mathrm{conj}\Big(\mathrm{s1}\Big(\{\mathrm{gt3}\}\Big)\Big)\lambda_{22,ijkl}\mathrm{s1}\Big(\{\mathrm{gt}\\
&- |H^+|^2\mathrm{conj}\Big(\mathrm{s2}\Big(\{\mathrm{gt1}\}\Big)\Big)\lambda_{33,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) - \mathrm{conj}\Big(\mathrm{s2}\Big(\{\mathrm{gt1}\}\Big)\Big)\mathrm{conj}\Big(\mathrm{s2}\Big(\{\mathrm{gt3}\}\Big)\Big)\lambda_{23,ijkl}\mathrm{s2}\Big(\{\mathrm{gt}\\
&+ H^{0,*}u^*_{L,k\gamma}Y^*_{u,jk}\delta_{\beta\gamma}u_{R,j\beta} - \lambda_c\mathrm{conj}\Big(\mathrm{BiD}\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_c\mathrm{conj}\Big(\mathrm{BiD}\Big)\mathrm{conj}\Big(\mathrm{vpp}\Big(1\Big)\Big)\mathrm{v}\\
&- \mathrm{BiD}\lambda_c\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{BiD}\lambda_c\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_a\mathrm{conj}\Big(\mathrm{BiD}\Big)\mathrm{conj}\Big(\mathrm{x4R}\Big(1\Big)\Big)\mathrm{x3L}\Big(2\Big) - \mathrm{BiD}\lambda_a\mathrm{conj}\Big(\mathrm{x3L}\Big(2\Big)\Big)\mathrm{x4R}\Big(1\Big) - \mathrm{BiD}\lambda_a\mathrm{conj}\Big(\mathrm{x3L}\Big(1\Big)\Big)\mathrm{x4R}\Big(2\Big) - H^0\lambda^*_g\mathrm{conj}\Big(\mathrm{ep}\Big(2\Big)\Big)\mathrm{x5I}\\
&- \lambda_b\mathrm{conj}\Big(\mathrm{BiD}\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(1\Big)\Big)\mathrm{x5R}\Big(2\Big) - H^+\lambda^*_g\mathrm{conj}\Big(\mathrm{vp}\Big(1\Big)\Big)\mathrm{x5R}\Big(2\Big) - \lambda_b\mathrm{conj}\Big(\mathrm{BiD}\Big)\mathrm{conj}\Big(\mathrm{x6L}\Big(1\Big)\\
&- H^+\lambda_h\mathrm{conj}\Big(\mathrm{vpp}\Big(2\Big)\Big)\mathrm{x6L}\Big(1\Big) - \mathrm{BiD}\lambda_b\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) -\\
&- 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{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}\\
&- H^+u^*_{R,j\beta}\delta_{\beta\gamma}d_{L,k\gamma}Y_{u,jk} + H^0u^*_{R,j\beta}\delta_{\beta\gamma}u_{L,k\gamma}Y_{u,jk} + \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{conj}\Big(\mathrm{s1}\Big(\{\mathrm{gt1}\}\Big)\Big)\mathrm{ep}\Big(2\Big)\lambda_{d,ij}\mathrm{vL}\Big(\{\mathrm{gt2}\}\Big)\Big(1\Big) - \mathrm{conj}\Big(\mathrm{s1}\Big(\{\mathrm{gt1}\}\Big)\Big)\mathrm{ep}\Big(1\Big)\lambda_{d,ij}\mathrm{vL}\Big(\{\mathrm{gt2}\}\Big)\Big(2\Big) - \mathrm{conj}\Big(\mathrm{s2}\Big(\{\mathrm{gt1}\}\Big)\Big)\lambda^*_{e,ik}\mathrm{x5R}\Big(2\Big)\mathrm{vR}
\end{aligned}
\tag{1}
$$

2.2 Gauge fixing terms

2.2.1 Gauge fixing terms for eigenstates 'GaugeES'

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

2.2.2 Gauge fixing terms for eigenstates 'EWSB'

$$
\begin{aligned}
L_{GF} = &-\frac{1}{2}|\partial_\mu g|^2\xi_g^{-1} - \frac{1}{2}|\partial_\mu \gamma|^2\xi_\gamma^{-1} - |\frac{i}{2}g_2 v H^{+,*}\xi_{W^-} + \partial_\mu W^-|^2\xi_{W^-}^{-1}\\
&- \frac{1}{2}| - \frac{1}{2}\xi_Z\Big(- \Big(10g_B\mathrm{sigmaB}x + g_{BY}\mathrm{sigmaH}v\Big)\sin\Theta'_W + \Big(10g_{YB}\mathrm{sigmaB}x + g_1\mathrm{sigmaH}v\Big)\cos\Theta'_W\sin\Theta_W + g_2\mathrm{sigmaH}v\cos\\
&- \frac{1}{2}|\frac{1}{2}\Big(2\partial_\mu Z' + \xi_{Z'}\Big(\Big(10g_B\mathrm{sigmaB}x + g_{BY}\mathrm{sigmaH}v\Big)\cos\Theta'_W + \Big(10g_{YB}\mathrm{sigmaB}x\sin\Theta_W + g_1\mathrm{sigmaH}v\sin\Theta_W + g_2\mathrm{sigmaH}v
\end{aligned}
\tag{3}
$$

2.3 Fields integrated out

None

3 Field Rotations

3.1 Rotations in gauge sector for eigenstates 'EWSB'

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

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

$$\tag{6}$$

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

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

  This matrix is diagonalized by Z^H:

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

  with

$$\mathrm{phiH} = \sum_j Z_{j1}^H h_j\,, \qquad \mathrm{phiB} = \sum_j Z_{j2}^H h_j \tag{12}$$

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

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

Gauge fixing contributions:

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

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

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

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

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

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

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

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

This matrix is diagonalized by Z^A:

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

with

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

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

$$m^2_{H^-} = \begin{pmatrix} -\frac{1}{2}\lambda_3 x^2 - l_h v^2 + \mu_h & 0 & 0 \\ 0 & \frac{1}{2}\lambda_{32}v^2 + \mu_1 & \frac{1}{\sqrt{2}}x\lambda_f \\ 0 & \frac{1}{\sqrt{2}}x\lambda_f^T & \frac{1}{2}\lambda_{33}v^2 + \mu_2 \end{pmatrix} + \xi_{W^-}m^2(W^-) \tag{24}$$

Gauge fixing contributions:

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

This matrix is diagonalized by Z^+:

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

with

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

3.2.2 Mass Matrices for Fermions

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

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

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

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

with

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

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

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

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

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

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

with

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

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

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

$$m_e = \Big(\ \tfrac{1}{\sqrt{2}} v Y^T_e \ \Big) \tag{36}$$

This matrix is diagonalized by U^e_L and U^e_R

$$U^{e,*}_L m_e U^{e,\dagger}_R = m^{dia}_e \tag{37}$$

with

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

$$e_{R,i} = \sum_{t_2} U^{e}_{R,ij} E^*_{R,j} \tag{39}$$

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

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

This matrix is diagonalized by U^V:

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

with

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

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

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

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

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

with

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

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

4 Vacuum Expectation Values

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

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

5 Tadpole Equations

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

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

6 Particle content for eigenstates 'EWSB'

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

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

7.1 One Loop Self-Energy

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

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

$$
\begin{aligned}
&- B_0\Big(p^2, m^2_{\eta^+}, m^2_{\eta^+}\Big)\Gamma_{\check{h}_i,\bar{\eta^+},\eta^+}\Gamma_{\check{h}_j,\bar{\eta^+},\eta^+} - B_0\Big(p^2, m^2_{\eta^Z}, m^2_{\eta^Z}\Big)\Gamma_{\check{h}_i,\bar{\eta^Z},\eta^Z}\Gamma_{\check{h}_j,\bar{\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'}\\
&- \frac{1}{2}\sum_{a=1}^{2} 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}^{2} 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}^{2}\sum_{b=1}^{2} 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}^{2}\sum_{b=1}^{2} 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}^{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)\\
&- 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}^{2}\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}^{2}\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)\\
&+ \sum_{b=1}^{2}\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)
\end{aligned}
$$

$$
\begin{aligned}
&- 2B_0\Big(p^2, m^2_{\nu^d}, m^2_{\nu^d}\Big) m^2_{\nu^d} \Big(\Gamma^{L*}_{\check{h}_j,\bar{\nu}^d,\nu^d}\Gamma^{R}_{\check{h}_i,\bar{\nu}^d,\nu^d} + \Gamma^{R*}_{\check{h}_j,\bar{\nu}^d,\nu^d}\Gamma^{L}_{\check{h}_i,\bar{\nu}^d,\nu^d}\Big) \\
&+ G_0\Big(p^2, m^2_{\nu^d}, m^2_{\nu^d}\Big)\Big(\Gamma^{L*}_{\check{h}_j,\bar{\nu}^d,\nu^d}\Gamma^{L}_{\check{h}_i,\bar{\nu}^d,\nu^d} + \Gamma^{R*}_{\check{h}_j,\bar{\nu}^d,\nu^d}\Gamma^{R}_{\check{h}_i,\bar{\nu}^d,\nu^d}\Big) \\
&- 2B_0\Big(p^2, m^2_{\chi^0}, m^2_{\chi^0}\Big) m^2_{\chi^0} \Big(\Gamma^{L*}_{\check{h}_j,\bar{\chi}^0,\chi^0}\Gamma^{R}_{\check{h}_i,\bar{\chi}^0,\chi^0} + \Gamma^{R*}_{\check{h}_j,\bar{\chi}^0,\chi^0}\Gamma^{L}_{\check{h}_i,\bar{\chi}^0,\chi^0}\Big) \\
&+ G_0\Big(p^2, m^2_{\chi^0}, m^2_{\chi^0}\Big)\Big(\Gamma^{L*}_{\check{h}_j,\bar{\chi}^0,\chi^0}\Gamma^{L}_{\check{h}_i,\bar{\chi}^0,\chi^0} + \Gamma^{R*}_{\check{h}_j,\bar{\chi}^0,\chi^0}\Gamma^{R}_{\check{h}_i,\bar{\chi}^0,\chi^0}\Big) \qquad (51)
\end{aligned}
$$

- **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) - \frac{1}{2}\sum_{a=1}^{2} 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}^{2} A_0\Big(m^2_{h_a}\Big)\Gamma_{\check{A}_{h,i},\check{A}_{h,j},h_a,h_a} + \sum_{a=1}^{2}\sum_{b=1}^{2} 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}} \\
&- 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) \\
&- 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) \\
&+ 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}
\end{aligned}
$$

$$
\begin{aligned}
&+\sum_{b=1}^{2}\Gamma^{*}_{\check{A}_{h,j},\gamma,h_b}\Gamma_{\check{A}_{h,i},\gamma,h_b}F_0\Big(p^2,m^2_{h_b},0\Big)+\sum_{b=1}^{2}\Gamma^{*}_{\check{A}_{h,j},Z,h_b}\Gamma_{\check{A}_{h,i},Z,h_b}F_0\Big(p^2,m^2_{h_b},m^2_{Z}\Big)\\
&+\sum_{b=1}^{2}\Gamma^{*}_{\check{A}_{h,j},Z',h_b}\Gamma_{\check{A}_{h,i},Z',h_b}F_0\Big(p^2,m^2_{h_b},m^2_{Z'}\Big)+2\sum_{b=1}^{5}\Gamma^{*}_{\check{A}_{h,j},W^+,H_b^-}\Gamma_{\check{A}_{h,i},W^+,H_b^-}F_0\Big(p^2,m^2_{H_b^-},m^2_{W^-}\Big)\\
&-2B_0\Big(p^2,m^2_{\nu^d},m^2_{\nu^d}\Big)m^2_{\nu^d}\Big(\Gamma^{L*}_{\check{A}_{h,j},\bar{\nu}^d,\nu^d}\Gamma^{R}_{\check{A}_{h,i},\bar{\nu}^d,\nu^d}+\Gamma^{R*}_{\check{A}_{h,j},\bar{\nu}^d,\nu^d}\Gamma^{L}_{\check{A}_{h,i},\bar{\nu}^d,\nu^d}\Big)\\
&+G_0\Big(p^2,m^2_{\nu^d},m^2_{\nu^d}\Big)\Big(\Gamma^{L*}_{\check{A}_{h,j},\bar{\nu}^d,\nu^d}\Gamma^{L}_{\check{A}_{h,i},\bar{\nu}^d,\nu^d}+\Gamma^{R*}_{\check{A}_{h,j},\bar{\nu}^d,\nu^d}\Gamma^{R}_{\check{A}_{h,i},\bar{\nu}^d,\nu^d}\Big)\\
&-2B_0\Big(p^2,m^2_{\chi^0},m^2_{\chi^0}\Big)m^2_{\chi^0}\Big(\Gamma^{L*}_{\check{A}_{h,j},\bar{\chi}^0,\chi^0}\Gamma^{R}_{\check{A}_{h,i},\bar{\chi}^0,\chi^0}+\Gamma^{R*}_{\check{A}_{h,j},\bar{\chi}^0,\chi^0}\Gamma^{L}_{\check{A}_{h,i},\bar{\chi}^0,\chi^0}\Big)\\
&+G_0\Big(p^2,m^2_{\chi^0},m^2_{\chi^0}\Big)\Big(\Gamma^{L*}_{\check{A}_{h,j},\bar{\chi}^0,\chi^0}\Gamma^{L}_{\check{A}_{h,i},\bar{\chi}^0,\chi^0}+\Gamma^{R*}_{\check{A}_{h,j},\bar{\chi}^0,\chi^0}\Gamma^{R}_{\check{A}_{h,i},\bar{\chi}^0,\chi^0}\Big)
\end{aligned}
\tag{52}
$$

- **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}^{2}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}^{2}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^-}+\sum_{a=1}^{5}\sum_{b=1}^{2}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}^{2}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}^{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)\\
&+\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)
\end{aligned}
$$

$$
\begin{aligned}
&- 2\sum_{a=1}^{5} m_{\nu_a} \sum_{b=1}^{3} B_0\Big(p^2, m_{\nu_a}^2, m_{e_b}^2\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_{\nu_a}^2, m_{e_b}^2\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) \\
&+ \sum_{b=1}^{2} \Gamma^{*}_{\check{H}_j^+,W^-,A_{h,b}} \Gamma_{\check{H}_i^+,W^-,A_{h,b}} F_0\Big(p^2, m_{A_{h,b}}^2, m_{W^-}^2\Big) + \sum_{b=1}^{2} \Gamma^{*}_{\check{H}_j^+,W^-,h_b} \Gamma_{\check{H}_i^+,W^-,h_b} F_0\Big(p^2, m_{h_b}^2, m_{W^-}^2\Big) \\
&- 2m_{\nu^d} \sum_{b=1}^{2} B_0\Big(p^2, m_{\nu^d}^2, m_{eD_b}^2\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_{\nu^d}^2, m_{eD_b}^2\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) \\
&- 2m_{\nu^d} \sum_{b=1}^{3} B_0\Big(p^2, m_{\nu^d}^2, m_{e_b}^2\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_{\nu^d}^2, m_{e_b}^2\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_{H_b^-}^2, 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_{H_b^-}^2, m_Z^2\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_{H_b^-}^2, m_{Z'}^2\Big) \qquad (53)
\end{aligned}
$$

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

$$
\begin{aligned}
\Sigma^S_{i,j}(p^2) = &+ \sum_{a=1}^{2}\sum_{b=1}^{3} B_0\Big(p^2, m_{d_b}^2, m_{h_a}^2\Big) \Gamma^{L*}_{\check{\check{d}}_j,h_a,d_b} m_{d_b} \Gamma^{R}_{\check{\check{d}}_i,h_a,d_b} \\
&+ \sum_{a=1}^{3} m_{d_a} \sum_{b=1}^{2} B_0\Big(p^2, m_{d_a}^2, m_{A_{h,b}}^2\Big) \Gamma^{L*}_{\check{\check{d}}_j,d_a,A_{h,b}} \Gamma^{R}_{\check{\check{d}}_i,d_a,A_{h,b}} \\
&+ \sum_{a=1}^{5}\sum_{b=1}^{3} B_0\Big(p^2, m_{u_b}^2, m_{H_a^-}^2\Big) \Gamma^{L*}_{\check{\check{d}}_j,H_a^-,u_b} m_{u_b} \Gamma^{R}_{\check{\check{d}}_i,H_a^-,u_b} \\
&- \frac{16}{3}\sum_{b=1}^{3} \Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{d_b}^2, 0\Big)\Big) \Gamma^{R*}_{\check{\check{d}}_j,g,d_b} m_{d_b} \Gamma^{L}_{\check{\check{d}}_i,g,d_b} - 4\sum_{b=1}^{3} \Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{d_b}^2, 0\Big)\Big) \Gamma^{R*}_{\check{\check{d}}_j,\gamma,d_b} m_{d_b} \Gamma^{L}_{\check{\check{d}}_i,\gamma,d_b} \\
&- 4\sum_{b=1}^{3} \Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{u_b}^2, m_{W^-}^2\Big)\Big) \Gamma^{R*}_{\check{\check{d}}_j,W^-,u_b} m_{u_b} \Gamma^{L}_{\check{\check{d}}_i,W^-,u_b}
\end{aligned}
$$

$$
\begin{aligned}
&- 4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{d_b}^2, m_Z^2\Big)\Big)\Gamma^{R*}_{\check{\tilde{d}}_j, Z, d_b} m_{d_b} \Gamma^{L}_{\check{\tilde{d}}_i, Z, d_b} \\
&- 4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{d_b}^2, m_{Z'}^2\Big)\Big)\Gamma^{R*}_{\check{\tilde{d}}_j, Z', d_b} m_{d_b} \Gamma^{L}_{\check{\tilde{d}}_i, Z', d_b}
\end{aligned} \tag{54}
$$

$$
\begin{aligned}
\Sigma^{R}_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, m_{h_a}^2\Big)\Gamma^{R*}_{\check{\tilde{d}}_j, h_a, d_b}\Gamma^{R}_{\check{\tilde{d}}_i, h_a, d_b} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{2} B_1\Big(p^2, m_{d_a}^2, m_{A_{h,b}}^2\Big)\Gamma^{R*}_{\check{\tilde{d}}_j, d_a, A_{h,b}}\Gamma^{R}_{\check{\tilde{d}}_i, d_a, A_{h,b}} \\
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{3} B_1\Big(p^2, m_{u_b}^2, m_{H_a^-}^2\Big)\Gamma^{R*}_{\check{\tilde{d}}_j, H_a^-, u_b}\Gamma^{R}_{\check{\tilde{d}}_i, H_a^-, u_b} - \frac{4}{3}\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, 0\Big)\Big)\Gamma^{L*}_{\check{\tilde{d}}_j, g, d_b}\Gamma^{L}_{\check{\tilde{d}}_i, g, d_b} \\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, 0\Big)\Big)\Gamma^{L*}_{\check{\tilde{d}}_j, \gamma, d_b}\Gamma^{L}_{\check{\tilde{d}}_i, \gamma, d_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{u_b}^2, m_{W^-}^2\Big)\Big)\Gamma^{L*}_{\check{\tilde{d}}_j, W^-, u_b}\Gamma^{L}_{\check{\tilde{d}}_i, W^-, u_b} \\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, m_Z^2\Big)\Big)\Gamma^{L*}_{\check{\tilde{d}}_j, Z, d_b}\Gamma^{L}_{\check{\tilde{d}}_i, Z, d_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, m_{Z'}^2\Big)\Big)\Gamma^{L*}_{\check{\tilde{d}}_j, Z', d_b}\Gamma^{L}_{\check{\tilde{d}}_i, Z', d_b}
\end{aligned} \tag{55}
$$

$$
\begin{aligned}
\Sigma^{L}_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, m_{h_a}^2\Big)\Gamma^{L*}_{\check{\tilde{d}}_j, h_a, d_b}\Gamma^{L}_{\check{\tilde{d}}_i, h_a, d_b} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{2} B_1\Big(p^2, m_{d_a}^2, m_{A_{h,b}}^2\Big)\Gamma^{L*}_{\check{\tilde{d}}_j, d_a, A_{h,b}}\Gamma^{L}_{\check{\tilde{d}}_i, d_a, A_{h,b}} \\
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{3} B_1\Big(p^2, m_{u_b}^2, m_{H_a^-}^2\Big)\Gamma^{L*}_{\check{\tilde{d}}_j, H_a^-, u_b}\Gamma^{L}_{\check{\tilde{d}}_i, H_a^-, u_b} - \frac{4}{3}\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, 0\Big)\Big)\Gamma^{R*}_{\check{\tilde{d}}_j, g, d_b}\Gamma^{R}_{\check{\tilde{d}}_i, g, d_b} \\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, 0\Big)\Big)\Gamma^{R*}_{\check{\tilde{d}}_j, \gamma, d_b}\Gamma^{R}_{\check{\tilde{d}}_i, \gamma, d_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{u_b}^2, m_{W^-}^2\Big)\Big)\Gamma^{R*}_{\check{\tilde{d}}_j, W^-, u_b}\Gamma^{R}_{\check{\tilde{d}}_i, W^-, u_b} \\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, m_Z^2\Big)\Big)\Gamma^{R*}_{\check{\tilde{d}}_j, Z, d_b}\Gamma^{R}_{\check{\tilde{d}}_i, Z, d_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, m_{Z'}^2\Big)\Big)\Gamma^{R*}_{\check{\tilde{d}}_j, Z', d_b}\Gamma^{R}_{\check{\tilde{d}}_i, Z', d_b}
\end{aligned} \tag{56}
$$

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

$$
\begin{aligned}
\Sigma^{S}_{i,j}(p^2) = &+\sum_{a=1}^{2}\sum_{b=1}^{3} B_0\Big(p^2, m_{u_b}^2, m_{h_a}^2\Big)\Gamma^{L*}_{\check{\tilde{u}}_j, h_a, u_b} m_{u_b} \Gamma^{R}_{\check{\tilde{u}}_i, h_a, u_b} \\
&+ \sum_{a=1}^{3} m_{u_a} \sum_{b=1}^{2} B_0\Big(p^2, m_{u_a}^2, m_{A_{h,b}}^2\Big)\Gamma^{L*}_{\check{\tilde{u}}_j, u_a, A_{h,b}}\Gamma^{R}_{\check{\tilde{u}}_i, u_a, A_{h,b}}
\end{aligned}
$$

$$
\begin{aligned}
&+\sum_{a=1}^{5}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{d_b}, m^2_{H_a^-}\Big)\Gamma^{L*}_{\tilde{u}_j,H_a^+,d_b} m_{d_b}\Gamma^{R}_{\tilde{u}_i,H_a^+,d_b}\\
&-\frac{16}{3}\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m^2_{u_b},0\Big)\Big)\Gamma^{R*}_{\tilde{u}_j,g,u_b}m_{u_b}\Gamma^{L}_{\tilde{u}_i,g,u_b}-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m^2_{u_b},0\Big)\Big)\Gamma^{R*}_{\tilde{u}_j,\gamma,u_b}m_{u_b}\Gamma^{L}_{\tilde{u}_i,\gamma,u_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m^2_{u_b},m^2_{Z}\Big)\Big)\Gamma^{R*}_{\tilde{u}_j,Z,u_b}m_{u_b}\Gamma^{L}_{\tilde{u}_i,Z,u_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m^2_{u_b},m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\tilde{u}_j,Z',u_b}m_{u_b}\Gamma^{L}_{\tilde{u}_i,Z',u_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m^2_{d_b},m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\tilde{u}_j,W^+,d_b}m_{d_b}\Gamma^{L}_{\tilde{u}_i,W^+,d_b}
\end{aligned}
\tag{57}
$$

$$
\begin{aligned}
\Sigma^R_{i,j}(p^2) =&-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_b}, m^2_{h_a}\Big)\Gamma^{R*}_{\tilde{u}_j,h_a,u_b}\Gamma^{R}_{\tilde{u}_i,h_a,u_b}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{u_a}, m^2_{A_{h,b}}\Big)\Gamma^{R*}_{\tilde{u}_j,u_a,A_{h,b}}\Gamma^{R}_{\tilde{u}_i,u_a,A_{h,b}}\\
&-\frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{d_b}, m^2_{H_a^-}\Big)\Gamma^{R*}_{\tilde{u}_j,H_a^+,d_b}\Gamma^{R}_{\tilde{u}_i,H_a^+,d_b}-\frac{4}{3}\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2,m^2_{u_b},0\Big)\Big)\Gamma^{L*}_{\tilde{u}_j,g,u_b}\Gamma^{L}_{\tilde{u}_i,g,u_b}\\
&-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2,m^2_{u_b},0\Big)\Big)\Gamma^{L*}_{\tilde{u}_j,\gamma,u_b}\Gamma^{L}_{\tilde{u}_i,\gamma,u_b}-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2,m^2_{u_b},m^2_{Z}\Big)\Big)\Gamma^{L*}_{\tilde{u}_j,Z,u_b}\Gamma^{L}_{\tilde{u}_i,Z,u_b}\\
&-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2,m^2_{u_b},m^2_{Z'}\Big)\Big)\Gamma^{L*}_{\tilde{u}_j,Z',u_b}\Gamma^{L}_{\tilde{u}_i,Z',u_b}-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2,m^2_{d_b},m^2_{W^-}\Big)\Big)\Gamma^{L*}_{\tilde{u}_j,W^+,d_b}\Gamma^{L}_{\tilde{u}_i,W^+,d_b}
\end{aligned}
\tag{58}
$$

$$
\begin{aligned}
\Sigma^L_{i,j}(p^2) =&-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\tilde{u}_j,h_a,u_b}\Gamma^{L}_{\tilde{u}_i,h_a,u_b}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{u_a}, m^2_{A_{h,b}}\Big)\Gamma^{L*}_{\tilde{u}_j,u_a,A_{h,b}}\Gamma^{L}_{\tilde{u}_i,u_a,A_{h,b}}\\
&-\frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{d_b}, m^2_{H_a^-}\Big)\Gamma^{L*}_{\tilde{u}_j,H_a^+,d_b}\Gamma^{L}_{\tilde{u}_i,H_a^+,d_b}-\frac{4}{3}\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2,m^2_{u_b},0\Big)\Big)\Gamma^{R*}_{\tilde{u}_j,g,u_b}\Gamma^{R}_{\tilde{u}_i,g,u_b}\\
&-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2,m^2_{u_b},0\Big)\Big)\Gamma^{R*}_{\tilde{u}_j,\gamma,u_b}\Gamma^{R}_{\tilde{u}_i,\gamma,u_b}-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2,m^2_{u_b},m^2_{Z}\Big)\Big)\Gamma^{R*}_{\tilde{u}_j,Z,u_b}\Gamma^{R}_{\tilde{u}_i,Z,u_b}\\
&-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2,m^2_{u_b},m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\tilde{u}_j,Z',u_b}\Gamma^{R}_{\tilde{u}_i,Z',u_b}-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2,m^2_{d_b},m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\tilde{u}_j,W^+,d_b}\Gamma^{R}_{\tilde{u}_i,W^+,d_b}
\end{aligned}
\tag{59}
$$

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

$$
\begin{aligned}
\Sigma^S_{i,j}(p^2) = &+\sum_{a=1}^{2}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{e_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\check{e}_j,h_a,e_b} m_{e_b} \Gamma^{R}_{\check{e}_i,h_a,e_b} \\
&+\sum_{a=1}^{3} m_{e_a} \sum_{b=1}^{2} B_0\Big(p^2, m^2_{e_a}, m^2_{A_{h,b}}\Big)\Gamma^{L*}_{\check{e}_j,e_a,A_{h,b}} \Gamma^{R}_{\check{e}_i,e_a,A_{h,b}} \\
&+\sum_{a=1}^{5}\sum_{b=1}^{5} B_0\Big(p^2, m^2_{\nu_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\check{e}_j,H^-_a,\nu_b} m_{\nu_b} \Gamma^{R}_{\check{e}_i,H^-_a,\nu_b} \\
&- 4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{e_b}, 0\Big)\Big)\Gamma^{R*}_{\check{e}_j,\gamma,e_b} m_{e_b} \Gamma^{L}_{\check{e}_i,\gamma,e_b} - 4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{e_b}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\check{e}_j,Z,e_b} m_{e_b} \Gamma^{L}_{\check{e}_i,Z,e_b} \\
&- 4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{e_b}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\check{e}_j,Z',e_b} m_{e_b} \Gamma^{L}_{\check{e}_i,Z',e_b} \\
&- 4\sum_{b=1}^{5}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\nu_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\check{e}_j,W^-,\nu_b} m_{\nu_b} \Gamma^{L}_{\check{e}_i,W^-,\nu_b} \\
&+ m_{\nu^d}\sum_{b=1}^{5} B_0\Big(p^2, m^2_{\nu^d}, m^2_{H^-_b}\Big)\Gamma^{L*}_{\check{e}_j,\bar{\nu}^d,H^-_b} \Gamma^{R}_{\check{e}_i,\bar{\nu}^d,H^-_b} \qquad (60)
\end{aligned}
$$

$$
\begin{aligned}
\Sigma^R_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{h_a}\Big)\Gamma^{R*}_{\check{e}_j,h_a,e_b} \Gamma^{R}_{\check{e}_i,h_a,e_b} \\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{e_a}, m^2_{A_{h,b}}\Big)\Gamma^{R*}_{\check{e}_j,e_a,A_{h,b}} \Gamma^{R}_{\check{e}_i,e_a,A_{h,b}} \\
&-\frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\nu_b}, m^2_{H^-_a}\Big)\Gamma^{R*}_{\check{e}_j,H^-_a,\nu_b} \Gamma^{R}_{\check{e}_i,H^-_a,\nu_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{e_b}, 0\Big)\Big)\Gamma^{L*}_{\check{e}_j,\gamma,e_b} \Gamma^{L}_{\check{e}_i,\gamma,e_b} \\
&-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{e_b}, m^2_{Z}\Big)\Big)\Gamma^{L*}_{\check{e}_j,Z,e_b} \Gamma^{L}_{\check{e}_i,Z,e_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{e_b}, m^2_{Z'}\Big)\Big)\Gamma^{L*}_{\check{e}_j,Z',e_b} \Gamma^{L}_{\check{e}_i,Z',e_b} \\
&-\sum_{b=1}^{5}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu_b}, m^2_{W^-}\Big)\Big)\Gamma^{L*}_{\check{e}_j,W^-,\nu_b} \Gamma^{L}_{\check{e}_i,W^-,\nu_b} \\
&-\frac{1}{2}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\nu^d}, m^2_{H^-_b}\Big)\Gamma^{R*}_{\check{e}_j,\bar{\nu}^d,H^-_b} \Gamma^{R}_{\check{e}_i,\bar{\nu}^d,H^-_b} \qquad (61)
\end{aligned}
$$

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

$$
\begin{aligned}
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\nu_b}, m^2_{H_a^-}\Big)\Gamma^{L*}_{\check{e}_j,H_a^-,\nu_b}\Gamma^{L}_{\check{e}_i,H_a^-,\nu_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{e_b}, 0\Big)\Big)\Gamma^{R*}_{\check{e}_j,\gamma,e_b}\Gamma^{R}_{\check{e}_i,\gamma,e_b}\\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{e_b}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\check{e}_j,Z,e_b}\Gamma^{R}_{\check{e}_i,Z,e_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{e_b}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\check{e}_j,Z',e_b}\Gamma^{R}_{\check{e}_i,Z',e_b}\\
&- \sum_{b=1}^{5}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\check{e}_j,W^-,\nu_b}\Gamma^{R}_{\check{e}_i,W^-,\nu_b}\\
&- \frac{1}{2}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\nu^d}, m^2_{H_b^-}\Big)\Gamma^{L*}_{\check{e}_j,\bar{\nu}^d,H_b^-}\Gamma^{L}_{\check{e}_i,\bar{\nu}^d,H_b^-}
\end{aligned}
\tag{62}
$$

- **Self-Energy for Neutrinos** (ν)

$$
\begin{aligned}
\Sigma^S_{i,j}(p^2) = &+\sum_{a=1}^{2} m_{eD_a}\sum_{b=1}^{5} B_0\Big(p^2, m^2_{eD_a}, m^2_{H_b^-}\Big)\Gamma^{L*}_{\check{\nu}_j,e\bar{D}_a,H_b^-}\Gamma^{R}_{\check{\nu}_i,e\bar{D}_a,H_b^-}\\
&+\sum_{a=1}^{3} m_{e_a}\sum_{b=1}^{5} B_0\Big(p^2, m^2_{e_a}, m^2_{H_b^-}\Big)\Gamma^{L*}_{\check{\nu}_j,\bar{e}_a,H_b^-}\Gamma^{R}_{\check{\nu}_i,\bar{e}_a,H_b^-}\\
&- 4\sum_{a=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{e_a}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,\bar{e}_a,W^-} m_{e_a}\Gamma^{L}_{\check{\nu}_i,\bar{e}_a,W^-}\\
&+\sum_{a=1}^{5}\sum_{b=1}^{2} B_0\Big(p^2, m^2_{eD_b}, m^2_{H_a^-}\Big)\Gamma^{L*}_{\check{\nu}_j,H_a^+,eD_b} m_{eD_b}\Gamma^{R}_{\check{\nu}_i,H_a^+,eD_b}\\
&+\sum_{a=1}^{5}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{e_b}, m^2_{H_a^-}\Big)\Gamma^{L*}_{\check{\nu}_j,H_a^+,e_b} m_{e_b}\Gamma^{R}_{\check{\nu}_i,H_a^+,e_b}\\
&- 4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{e_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,W^+,e_b} m_{e_b}\Gamma^{L}_{\check{\nu}_i,W^+,e_b} - 4\sum_{b=1}^{5}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\nu_b}, 0\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,\gamma,\nu_b} m_{\nu_b}\Gamma^{L}_{\check{\nu}_i,\gamma,}\\
&- 4\sum_{b=1}^{5}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\nu_b}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,Z,\nu_b} m_{\nu_b}\Gamma^{L}_{\check{\nu}_i,Z,\nu_b} - 4\sum_{b=1}^{5}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\nu_b}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,Z',\nu_b} m_{\nu_b}\Gamma^{L}_{\check{\nu}_i,Z',\nu}
\end{aligned}
\tag{63}
$$

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

$$
\begin{aligned}
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{eD_b}, m^2_{H_a^-}\Big)\Gamma^{R*}_{\check{\nu}_j,H_a^+,eD_b}\Gamma^{R}_{\check{\nu}_i,H_a^+,eD_b}\\
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{H_a^-}\Big)\Gamma^{R*}_{\check{\nu}_j,H_a^+,e_b}\Gamma^{R}_{\check{\nu}_i,H_a^+,e_b}\\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{e_b}, m^2_{W^-}\Big)\Big)\Gamma^{L*}_{\check{\nu}_j,W^+,e_b}\Gamma^{L}_{\check{\nu}_i,W^+,e_b} - \sum_{b=1}^{5}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu_b}, 0\Big)\Big)\Gamma^{L*}_{\check{\nu}_j,\gamma,\nu_b}\Gamma^{L}_{\check{\nu}_i,\gamma,\nu_b}\\
&- \sum_{b=1}^{5}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu_b}, m^2_{Z}\Big)\Big)\Gamma^{L*}_{\check{\nu}_j,Z,\nu_b}\Gamma^{L}_{\check{\nu}_i,Z,\nu_b} - \sum_{b=1}^{5}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu_b}, m^2_{Z'}\Big)\Big)\Gamma^{L*}_{\check{\nu}_j,Z',\nu_b}\Gamma^{L}_{\check{\nu}_i,Z',\nu_b}
\end{aligned}
\tag{64}
$$

$$
\begin{aligned}
\Sigma^{L}_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{eD_a}, m^2_{H_b^-}\Big)\Gamma^{L*}_{\check{\nu}_j,e\bar{D}_a,H_b^-}\Gamma^{L}_{\check{\nu}_i,e\bar{D}_a,H_b^-}\\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{e_a}, m^2_{H_b^-}\Big)\Gamma^{L*}_{\check{\nu}_j,\bar{e}_a,H_b^-}\Gamma^{L}_{\check{\nu}_i,\bar{e}_a,H_b^-}\\
&- \sum_{a=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{e_a}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,\bar{e}_a,W^-}\Gamma^{R}_{\check{\nu}_i,\bar{e}_a,W^-}\\
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{eD_b}, m^2_{H_a^-}\Big)\Gamma^{L*}_{\check{\nu}_j,H_a^+,eD_b}\Gamma^{L}_{\check{\nu}_i,H_a^+,eD_b}\\
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{H_a^-}\Big)\Gamma^{L*}_{\check{\nu}_j,H_a^+,e_b}\Gamma^{L}_{\check{\nu}_i,H_a^+,e_b}\\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{e_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,W^+,e_b}\Gamma^{R}_{\check{\nu}_i,W^+,e_b} - \sum_{b=1}^{5}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu_b}, 0\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,\gamma,\nu_b}\Gamma^{R}_{\check{\nu}_i,\gamma,\nu_b}\\
&- \sum_{b=1}^{5}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu_b}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,Z,\nu_b}\Gamma^{R}_{\check{\nu}_i,Z,\nu_b} - \sum_{b=1}^{5}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu_b}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,Z',\nu_b}\Gamma^{R}_{\check{\nu}_i,Z',\nu_b}
\end{aligned}
\tag{65}
$$

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

$$
\begin{aligned}
\Sigma^{S}_{i,j}(p^2) = &+\sum_{a=1}^{2} m_{eD_a}\sum_{b=1}^{2} B_0\Big(p^2, m^2_{eD_a}, m^2_{A_{h,b}}\Big)\Gamma^{L*}_{e\check{\bar{D}}_j,eD_a,A_{h,b}}\Gamma^{R}_{e\check{\bar{D}}_i,eD_a,A_{h,b}}\\
&+\sum_{a=1}^{2}\sum_{b=1}^{2} B_0\Big(p^2, m^2_{eD_b}, m^2_{h_a}\Big)\Gamma^{L*}_{e\check{\bar{D}}_j,h_a,eD_b} m_{eD_b}\Gamma^{R}_{e\check{\bar{D}}_i,h_a,eD_b}\\
&+\sum_{a=1}^{5}\sum_{b=1}^{5} B_0\Big(p^2, m^2_{\nu_b}, m^2_{H_a^-}\Big)\Gamma^{L*}_{e\check{\bar{D}}_j,H_a^-,\nu_b} m_{\nu_b}\Gamma^{R}_{e\check{\bar{D}}_i,H_a^-,\nu_b}
\end{aligned}
$$

$$
\begin{aligned}
&+ m_{\nu^d}\sum_{a=1}^{5} B_0\Big(p^2, m^2_{\nu^d}, m^2_{H_a^-}\Big)\Gamma^{L*}_{e\tilde{D}_j,H_a^-,\nu^d}\Gamma^{R}_{e\tilde{D}_i,H_a^-,\nu^d}\\
&- 4\sum_{b=1}^{2}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{eD_b}, 0\Big)\Big)\Gamma^{R*}_{e\tilde{D}_j,\gamma,eD_b} m_{eD_b}\Gamma^{L}_{e\tilde{D}_i,\gamma,eD_b} - 4\sum_{b=1}^{2}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{eD_b}, m^2_Z\Big)\Big)\Gamma^{R*}_{e\tilde{D}_j,Z,eD_b} m\\
&- 4\sum_{b=1}^{2}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{eD_b}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{e\tilde{D}_j,Z',eD_b} m_{eD_b}\Gamma^{L}_{e\tilde{D}_i,Z',eD_b}\\
&- 4\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\nu^d}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{e\tilde{D}_j,W^-,\nu^d} m_{\nu^d}\Gamma^{L}_{e\tilde{D}_i,W^-,\nu^d} \qquad (66)
\end{aligned}
$$

$$
\begin{aligned}
\Sigma^R_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{eD_a}, m^2_{A_{h,b}}\Big)\Gamma^{R*}_{e\tilde{D}_j,eD_a,A_{h,b}}\Gamma^{R}_{e\tilde{D}_i,eD_a,A_{h,b}}\\
&- \frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{eD_b}, m^2_{h_a}\Big)\Gamma^{R*}_{e\tilde{D}_j,h_a,eD_b}\Gamma^{R}_{e\tilde{D}_i,h_a,eD_b}\\
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\nu_b}, m^2_{H_a^-}\Big)\Gamma^{R*}_{e\tilde{D}_j,H_a^-,\nu_b}\Gamma^{R}_{e\tilde{D}_i,H_a^-,\nu_b}\\
&- \frac{1}{2}\sum_{a=1}^{5} B_1\Big(p^2, m^2_{\nu^d}, m^2_{H_a^-}\Big)\Gamma^{R*}_{e\tilde{D}_j,H_a^-,\nu^d}\Gamma^{R}_{e\tilde{D}_i,H_a^-,\nu^d} - \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{eD_b}, 0\Big)\Big)\Gamma^{L*}_{e\tilde{D}_j,\gamma,eD_b}\Gamma^{L}_{e\tilde{D}_i,\gamma,eD_b}\\
&- \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{eD_b}, m^2_Z\Big)\Big)\Gamma^{L*}_{e\tilde{D}_j,Z,eD_b}\Gamma^{L}_{e\tilde{D}_i,Z,eD_b} - \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{eD_b}, m^2_{Z'}\Big)\Big)\Gamma^{L*}_{e\tilde{D}_j,Z',eD_b}\Gamma^{L}_{e\tilde{D}_i,Z',eD_b}\\
&- \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu^d}, m^2_{W^-}\Big)\Big)\Gamma^{L*}_{e\tilde{D}_j,W^-,\nu^d}\Gamma^{L}_{e\tilde{D}_i,W^-,\nu^d} \qquad (67)
\end{aligned}
$$

$$
\begin{aligned}
\Sigma^L_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{eD_a}, m^2_{A_{h,b}}\Big)\Gamma^{L*}_{e\tilde{D}_j,eD_a,A_{h,b}}\Gamma^{L}_{e\tilde{D}_i,eD_a,A_{h,b}}\\
&- \frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{eD_b}, m^2_{h_a}\Big)\Gamma^{L*}_{e\tilde{D}_j,h_a,eD_b}\Gamma^{L}_{e\tilde{D}_i,h_a,eD_b}\\
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\nu_b}, m^2_{H_a^-}\Big)\Gamma^{L*}_{e\tilde{D}_j,H_a^-,\nu_b}\Gamma^{L}_{e\tilde{D}_i,H_a^-,\nu_b}\\
&- \frac{1}{2}\sum_{a=1}^{5} B_1\Big(p^2, m^2_{\nu^d}, m^2_{H_a^-}\Big)\Gamma^{L*}_{e\tilde{D}_j,H_a^-,\nu^d}\Gamma^{L}_{e\tilde{D}_i,H_a^-,\nu^d} - \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{eD_b}, 0\Big)\Big)\Gamma^{R*}_{e\tilde{D}_j,\gamma,eD_b}\Gamma^{R}_{e\tilde{D}_i,\gamma,eD_b}\\
&- \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{eD_b}, m^2_Z\Big)\Big)\Gamma^{R*}_{e\tilde{D}_j,Z,eD_b}\Gamma^{R}_{e\tilde{D}_i,Z,eD_b} - \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{eD_b}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{e\tilde{D}_j,Z',eD_b}\Gamma^{R}_{e\tilde{D}_i,Z',eD_b}\\
&- \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu^d}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{e\tilde{D}_j,W^-,\nu^d}\Gamma^{R}_{e\tilde{D}_i,W^-,\nu^d} \qquad (68)
\end{aligned}
$$

- **Self-Energy for Fx** (χ^0)

$$
\begin{aligned}
\Sigma^S(p^2) = &+m_{\chi^0}\sum_{a=1}^{2} B_0\Big(p^2, m^2_{\chi^0}, m^2_{h_a}\Big)\Gamma^{L*}_{\bar{\chi}^0,h_a,\chi^0}\Gamma^{R}_{\bar{\chi}^0,h_a,\chi^0} \\
&+ m_{\chi^0}\sum_{b=1}^{2} B_0\Big(p^2, m^2_{\chi^0}, m^2_{A_{h,b}}\Big)\Gamma^{L*}_{\bar{\chi}^0,\chi^0,A_{h,b}}\Gamma^{R}_{\bar{\chi}^0,\chi^0,A_{h,b}} \\
&- 4\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\chi^0}, 0\Big)\Big)\Gamma^{R*}_{\bar{\chi}^0,\gamma,\chi^0} m_{\chi^0}\Gamma^{L}_{\bar{\chi}^0,\gamma,\chi^0} \\
&- 4\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\chi^0}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\bar{\chi}^0,Z,\chi^0} m_{\chi^0}\Gamma^{L}_{\bar{\chi}^0,Z,\chi^0} \\
&- 4\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\chi^0}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\bar{\chi}^0,Z',\chi^0} m_{\chi^0}\Gamma^{L}_{\bar{\chi}^0,Z',\chi^0}
\end{aligned} \tag{69}
$$

$$
\begin{aligned}
\Sigma^R(p^2) = &-\frac{1}{2}\sum_{a=1}^{2} B_1\Big(p^2, m^2_{\chi^0}, m^2_{h_a}\Big)\Gamma^{R*}_{\bar{\chi}^0,h_a,\chi^0}\Gamma^{R}_{\bar{\chi}^0,h_a,\chi^0} \\
&- \frac{1}{2}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\chi^0}, m^2_{A_{h,b}}\Big)\Gamma^{R*}_{\bar{\chi}^0,\chi^0,A_{h,b}}\Gamma^{R}_{\bar{\chi}^0,\chi^0,A_{h,b}} \\
&- \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\chi^0}, 0\Big)\Big)\Gamma^{L*}_{\bar{\chi}^0,\gamma,\chi^0}\Gamma^{L}_{\bar{\chi}^0,\gamma,\chi^0} - \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\chi^0}, m^2_{Z}\Big)\Big)\Gamma^{L*}_{\bar{\chi}^0,Z,\chi^0}\Gamma^{L}_{\bar{\chi}^0,Z,\chi^0} \\
&- \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\chi^0}, m^2_{Z'}\Big)\Big)\Gamma^{L*}_{\bar{\chi}^0,Z',\chi^0}\Gamma^{L}_{\bar{\chi}^0,Z',\chi^0}
\end{aligned} \tag{70}
$$

$$
\begin{aligned}
\Sigma^L(p^2) = &-\frac{1}{2}\sum_{a=1}^{2} B_1\Big(p^2, m^2_{\chi^0}, m^2_{h_a}\Big)\Gamma^{L*}_{\bar{\chi}^0,h_a,\chi^0}\Gamma^{L}_{\bar{\chi}^0,h_a,\chi^0} \\
&- \frac{1}{2}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\chi^0}, m^2_{A_{h,b}}\Big)\Gamma^{L*}_{\bar{\chi}^0,\chi^0,A_{h,b}}\Gamma^{L}_{\bar{\chi}^0,\chi^0,A_{h,b}} \\
&- \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\chi^0}, 0\Big)\Big)\Gamma^{R*}_{\bar{\chi}^0,\gamma,\chi^0}\Gamma^{R}_{\bar{\chi}^0,\gamma,\chi^0} - \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\chi^0}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\bar{\chi}^0,Z,\chi^0}\Gamma^{R}_{\bar{\chi}^0,Z,\chi^0} \\
&- \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\chi^0}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\bar{\chi}^0,Z',\chi^0}\Gamma^{R}_{\bar{\chi}^0,Z',\chi^0}
\end{aligned} \tag{71}
$$

- **Self-Energy for Fvv** (ν^d)

$$
\begin{aligned}
\Sigma^S(p^2) = &+m_{\nu^d}\sum_{a=1}^{2} B_0\Big(p^2, m^2_{\nu^d}, m^2_{h_a}\Big)\Gamma^{L*}_{\bar{\nu}^d,h_a,\nu^d}\Gamma^{R}_{\bar{\nu}^d,h_a,\nu^d} \\
&+ \sum_{a=1}^{3} m_{e_a}\sum_{b=1}^{5} B_0\Big(p^2, m^2_{e_a}, m^2_{H^-_b}\Big)\Gamma^{L*}_{\bar{\nu}^d,\bar{e}_a,H^-_b}\Gamma^{R}_{\bar{\nu}^d,\bar{e}_a,H^-_b} \\
&+ \sum_{a=1}^{5}\sum_{b=1}^{2} B_0\Big(p^2, m^2_{eD_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\bar{\nu}^d,H^+_a,eD_b} m_{eD_b}\Gamma^{R}_{\bar{\nu}^d,H^+_a,eD_b}
\end{aligned}
$$

$$
\begin{aligned}
&- 4\sum_{b=1}^{2}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m^2_{eD_b},m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\bar{\nu}^d,W^+,eD_b}m_{eD_b}\Gamma^{L}_{\bar{\nu}^d,W^+,eD_b}\\
&+ m_{\nu^d}\sum_{b=1}^{2}B_0\Big(p^2,m^2_{\nu^d},m^2_{A_{h,b}}\Big)\Gamma^{L*}_{\bar{\nu}^d,\nu^d,A_{h,b}}\Gamma^{R}_{\bar{\nu}^d,\nu^d,A_{h,b}}\\
&- 4\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m^2_{\nu^d},0\Big)\Big)\Gamma^{R*}_{\bar{\nu}^d,\gamma,\nu^d}m_{\nu^d}\Gamma^{L}_{\bar{\nu}^d,\gamma,\nu^d}\\
&- 4\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m^2_{\nu^d},m^2_{Z}\Big)\Big)\Gamma^{R*}_{\bar{\nu}^d,Z,\nu^d}m_{\nu^d}\Gamma^{L}_{\bar{\nu}^d,Z,\nu^d}\\
&- 4\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m^2_{\nu^d},m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\bar{\nu}^d,Z',\nu^d}m_{\nu^d}\Gamma^{L}_{\bar{\nu}^d,Z',\nu^d}
\end{aligned}
\tag{72}
$$

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

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

$$- \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu^d}, 0\Big)\Big)\Gamma^{R*}_{\bar{\nu}^d,\gamma,\nu^d}\Gamma^{R}_{\bar{\nu}^d,\gamma,\nu^d} - \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu^d}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\bar{\nu}^d,Z,\nu^d}\Gamma^{R}_{\bar{\nu}^d,Z,\nu^d}$$
$$- \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu^d}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\bar{\nu}^d,Z',\nu^d}\Gamma^{R}_{\bar{\nu}^d,Z',\nu^d} \tag{74}$$

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

$$\begin{aligned}
\Pi(p^2) = &+|\Gamma_{Z,\eta^-,\eta^-}|^2 B_{00}\Big(p^2, m^2_{\eta^-}, m^2_{\eta^-}\Big) + |\Gamma_{Z,\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) + \frac{1}{2}\sum_{a=1}^{2} A_0\Big(m^2_{A_{h,a}}\Big)\Gamma_{Z,Z,A} \\
&+ \frac{1}{2}\sum_{a=1}^{2} A_0\Big(m^2_{h_a}\Big)\Gamma_{Z,Z,h_a,h_a} - 4\sum_{a=1}^{2}\sum_{b=1}^{2}|\Gamma_{Z,h_a,A_{h,b}}|^2 B_{00}\Big(p^2, m^2_{A_{h,b}}, m^2_{h_a}\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] \\
&+ 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]
\end{aligned}$$

$$+\sum_{b=1}^{2}|\Gamma_{Z,\gamma,h_b}|^2B_0\Big(p^2,0,m_{h_b}^2\Big)+\sum_{b=1}^{2}|\Gamma_{Z,Z,h_b}|^2B_0\Big(p^2,m_Z^2,m_{h_b}^2\Big)+\sum_{b=1}^{2}|\Gamma_{Z,Z',h_b}|^2B_0\Big(p^2,m_{Z'}^2,m_{h_b}^2\Big)$$
$$+2\sum_{b=1}^{5}|\Gamma_{Z,W^+,H_b^-}|^2B_0\Big(p^2,m_{W^-}^2,m_{H_b^-}^2\Big)+2\mathrm{rMS}m_{W^-}^2\Gamma^1_{Z,Z,W^+,W^-}-A_0\Big(m_{W^-}^2\Big)\Big(4\Gamma^1_{Z,Z,W^+,W^-}+\Gamma^2_{Z,Z,W^+,W^-}+\Gamma^3_{Z,Z,W} \tag{75}$$

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

$$\begin{aligned}
\Pi(p^2) =& +|\Gamma_{Z',\eta^-,\eta^-}|^2B_{00}\Big(p^2,m_{\eta^-}^2,m_{\eta^-}^2\Big)+|\Gamma_{Z',\eta^+,\eta^+}|^2B_{00}\Big(p^2,m_{\eta^+}^2,m_{\eta^+}^2\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_{\nu^d}^2,m_{\nu^d}^2\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_{\chi^0}^2,m_{\chi^0}^2\Big)\\
&-|\Gamma_{Z',W^+,W^-}|^2\Big(10B_{00}\Big(p^2,m_{W^-}^2,m_{W^-}^2\Big)+2A_0\Big(m_{W^-}^2\Big)-2\mathrm{rMS}\Big(2m_{W^-}^2-\frac{1}{3}p^2\Big)+B_0\Big(p^2,m_{W^-}^2,m_{W^-}^2\Big)\Big(2m_{W^-}^2+4p^2\Big)\\
&+4B_0\Big(p^2,m_{\nu^d}^2,m_{\nu^d}^2\Big)m_{\nu^d}^2\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_{\chi^0}^2,m_{\chi^0}^2\Big)m_{\chi^0}^2\Re\Big(\Gamma^{L*}_{Z',\bar{\chi}^0,\chi^0}\Gamma^R_{Z',\bar{\chi}^0,\chi^0}\Big)+\frac{1}{2}\sum_{a=1}^{2}A_0\Big(m_{A_{h,a}}^2\Big)\Gamma_{Z',}\\
&+\frac{1}{2}\sum_{a=1}^{2}A_0\Big(m_{h_a}^2\Big)\Gamma_{Z',Z',h_a,h_a}-4\sum_{a=1}^{2}\sum_{b=1}^{2}|\Gamma_{Z',h_a,A_{h,b}}|^2B_{00}\Big(p^2,m_{A_{h,b}}^2,m_{h_a}^2\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_{eD_a}^2,m_{eD_b}^2\Big)\\
&+4B_0\Big(p^2,m_{eD_a}^2,m_{eD_b}^2\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]\\
&+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_{d_a}^2,m_{d_b}^2\Big)\\
&+4B_0\Big(p^2,m_{d_a}^2,m_{d_b}^2\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_{e_a}^2,m_{e_b}^2\Big)\\
&+4B_0\Big(p^2,m_{e_a}^2,m_{e_b}^2\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_{u_a}^2,m_{u_b}^2\Big)\\
&+4B_0\Big(p^2,m_{u_a}^2,m_{u_b}^2\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_{H_a^-}^2\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_{H_a^-}^2,m_{H_b^-}^2\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_{\nu_a}^2,m_{\nu_b}^2\Big)
\end{aligned}$$

$$
\begin{aligned}
&+ 4B_0\Big(p^2, m^2_{\nu_a}, m^2_{\nu_b}\Big) m_{\nu_a} m_{\nu_b} \Re\Big(\Gamma^{L*}_{Z',\nu_a,\nu_b} \Gamma^{R}_{Z',\nu_a,\nu_b}\Big)\Big] \\
&+ \sum_{b=1}^{2} |\Gamma_{Z',\gamma,h_b}|^2 B_0\Big(p^2, 0, m^2_{h_b}\Big) + \sum_{b=1}^{2} |\Gamma_{Z',Z,h_b}|^2 B_0\Big(p^2, m^2_Z, m^2_{h_b}\Big) + \sum_{b=1}^{2} |\Gamma_{Z',Z',h_b}|^2 B_0\Big(p^2, m^2_{Z'}, m^2_{h_b}\Big) \\
&+ 2\sum_{b=1}^{5} |\Gamma_{Z',W^+,H^-_b}|^2 B_0\Big(p^2, m^2_{W^-}, m^2_{H^-_b}\Big) + 2\mathrm{rMS} m^2_{W^-} \Gamma^1_{Z',Z',W^+,W^-} - A_0\Big(m^2_{W^-}\Big)\Big(4\Gamma^1_{Z',Z',W^+,W^-} + \Gamma^2_{Z',Z',W^+,W^-} + \Gamma
\end{aligned}
\tag{76}
$$

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

$$
\begin{aligned}
\Pi(p^2) = {} & 2\mathrm{rMS} m^2_{W^-} \Gamma^1_{W^-,W^+,W^+,W^-} + 3\sum_{a=1}^{3}\sum_{b=1}^{3}\Big[\Big(|\Gamma^L_{W^+,\bar{u}_a,d_b}|^2 + |\Gamma^R_{W^+,\bar{u}_a,d_b}|^2\Big) H_0\Big(p^2, m^2_{u_a}, m^2_{d_b}\Big) \\
&+ 4B_0\Big(p^2, m^2_{u_a}, m^2_{d_b}\Big) m_{d_b} m_{u_a} \Re\Big(\Gamma^{L*}_{W^+,\bar{u}_a,d_b} \Gamma^{R}_{W^+,\bar{u}_a,d_b}\Big)\Big] - 4\sum_{a=1}^{5}\sum_{b=1}^{2} |\Gamma_{W^+,H^-_a,A_{h,b}}|^2 B_{00}\Big(p^2, m^2_{A_{h,b}}, m^2_{H^-_a}\Big) - 4\sum_{a=1}^{5}\sum_{b=1}^{2} |\Gamma_{W^-} \\
&+ 4B_0\Big(p^2, m^2_{\nu_a}, m^2_{e_b}\Big) m_{e_b} m_{\nu_a} \Re\Big(\Gamma^{L*}_{W^+,\nu_a,e_b} \Gamma^{R}_{W^+,\nu_a,e_b}\Big)\Big] + \sum_{b=1}^{2} |\Gamma_{W^+,W^-,h_b}|^2 B_0\Big(p^2, m^2_{W^-}, m^2_{h_b}\Big) + \sum_{b=1}^{2}\Big[\Big(|\Gamma^L_{W^+,\bar{\nu}^d,eD_b}|^2 + |\Gamma \\
&+ 4B_0\Big(p^2, m^2_{\nu^d}, m^2_{eD_b}\Big) m_{\nu^d} m_{eD_b} \Re\Big(\Gamma^{L*}_{W^+,\bar{\nu}^d,eD_b} \Gamma^{R}_{W^+,\bar{\nu}^d,eD_b}\Big)\Big] + \sum_{b=1}^{5} |\Gamma_{W^+,\gamma,H^-_b}|^2 B_0\Big(p^2, 0, m^2_{H^-_b}\Big) + \sum_{b=1}^{5} |\Gamma_{W^+,Z,H^-_b}|^2 B_0\Big(p
\end{aligned}
\tag{77}
$$

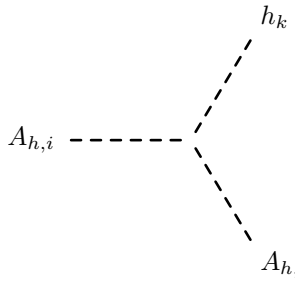
7.2 Tadpoles

$$
\begin{aligned}
\delta t^{(1)}_h = {} & + A_0\Big(m^2_{\eta^-}\Big)\Gamma_{\check{h}_i,\eta^+,\eta^-} + A_0\Big(m^2_{\eta^+}\Big)\Gamma_{\check{h}_i,\eta^-,\eta^+} + A_0\Big(m^2_{\eta^Z}\Big)\Gamma_{\check{h}_i,\eta^{\bar{Z}},\eta^Z} \\
&+ A_0\Big(m^2_{\eta^{Z'}}\Big)\Gamma_{\check{h}_i,\eta^{\bar{Z}'},\eta^{Z'}} + 4\Gamma_{\check{h}_i,W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS} m^2_{W^-} + A_0\Big(m^2_{W^-}\Big)\Big) + 2\Gamma_{\check{h}_i,Z,Z}\Big(-\frac{1}{2}\mathrm{rMS} m^2_Z + A_0\Big(m^2_Z\Big)\Big) \\
&+ 2\Gamma_{\check{h}_i,Z',Z'}\Big(-\frac{1}{2}\mathrm{rMS} m^2_{Z'} + A_0\Big(m^2_{Z'}\Big)\Big) - \frac{1}{2}\sum_{a=1}^{2} A_0\Big(m^2_{A_{h,a}}\Big)\Gamma_{\check{h}_i,A_{h,a},A_{h,a}} - \frac{1}{2}\sum_{a=1}^{2} A_0\Big(m^2_{h_a}\Big)\Gamma_{\check{h}_i,h_a,h_a} \\
&+ 2\sum_{a=1}^{2} A_0\Big(m^2_{eD_a}\Big) m_{eD_a}\Big(\Gamma^L_{\check{h}_i,e\bar{D}_a,eD_a} + \Gamma^R_{\check{h}_i,e\bar{D}_a,eD_a}\Big) \\
&+ 6\sum_{a=1}^{3} A_0\Big(m^2_{d_a}\Big) m_{d_a}\Big(\Gamma^L_{\check{h}_i,\bar{d}_a,d_a} + \Gamma^R_{\check{h}_i,\bar{d}_a,d_a}\Big) \\
&+ 2\sum_{a=1}^{3} A_0\Big(m^2_{e_a}\Big) m_{e_a}\Big(\Gamma^L_{\check{h}_i,\bar{e}_a,e_a} + \Gamma^R_{\check{h}_i,\bar{e}_a,e_a}\Big) \\
&+ 6\sum_{a=1}^{3} A_0\Big(m^2_{u_a}\Big) m_{u_a}\Big(\Gamma^L_{\check{h}_i,\bar{u}_a,u_a} + \Gamma^R_{\check{h}_i,\bar{u}_a,u_a}\Big) - \sum_{a=1}^{5} A_0\Big(m^2_{H^-_a}\Big)\Gamma_{\check{h}_i,H^+_a,H^-_a}
\end{aligned}
$$

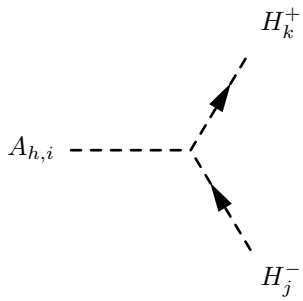
$$+ 2A_0\Big(m^2_{\nu^d}\Big)m_{\nu^d}\Big(\Gamma^L_{\tilde{h}_i,\bar{\nu}^d,\nu^d} + \Gamma^R_{\tilde{h}_i,\bar{\nu}^d,\nu^d}\Big) + 2A_0\Big(m^2_{\chi^0}\Big)m_{\chi^0}\Big(\Gamma^L_{\tilde{h}_i,\bar{\chi}^0,\chi^0} + \Gamma^R_{\tilde{h}_i,\bar{\chi}^0,\chi^0}\Big) \tag{78}$$

8 Interactions for eigenstates 'EWSB'

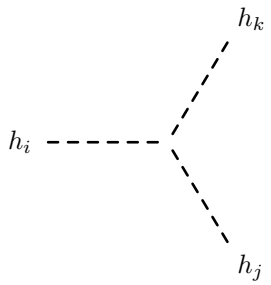
8.1 Three Scalar-Interaction



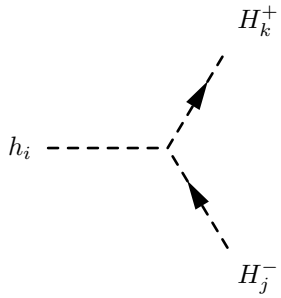
$$i\Big(Z^A_{i1}Z^A_{j1}\Big(2l_h v Z^H_{k1} + \lambda_3 x Z^H_{k2}\Big) + Z^A_{i2}Z^A_{j2}\Big(2\lambda_2 x Z^H_{k2} + \lambda_3 v Z^H_{k1}\Big)\Big) \tag{79}$$



$$-\frac{1}{\sqrt{2}}\Big(-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{f,ab}Z^+_{j1+a}Z^+_{k3+b} + \sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{f,ab}Z^+_{k1+a}Z^+_{j3+b}\Big)Z^A_{i2} \tag{80}$$

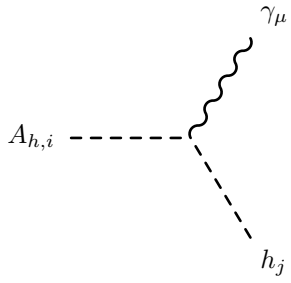


$$i\Big(Z_{i2}^{H}\Big(\lambda_3 Z_{j1}^{H}\Big(vZ_{k2}^{H}+xZ_{k1}^{H}\Big)+Z_{j2}^{H}\Big(6\lambda_2 xZ_{k2}^{H}+\lambda_3 vZ_{k1}^{H}\Big)\Big) + Z_{i1}^{H}\Big(\lambda_3 Z_{j2}^{H}\Big(vZ_{k2}^{H}+xZ_{k1}^{H}\Big)+Z_{j1}^{H}\Big(6l_h vZ_{k1}^{H}+\lambda_3 xZ_{k2}^{H}\Big)\Big)\Big) \tag{81}$$

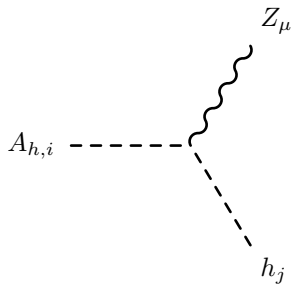


$$i\Big(-v\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{32,ab}Z_{k1+a}^{+}Z_{j1+b}^{+}Z_{i1}^{H}-v\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{33,ab}Z_{k3+a}^{+}Z_{j3+b}^{+}Z_{i1}^{H} - \frac{1}{\sqrt{2}}\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{f,ab}Z_{k1+a}^{+}Z_{j3+b}^{+}Z_{i2}^{H}-\frac{1}{\sqrt{2}}\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{f,ab}Z_{j1+a}^{+}Z_{k3+b}^{+}Z_{i2}^{H}+2l_h vZ_{i1}^{H}Z_{j1}^{+}Z_{k1}^{+} + \lambda_3 xZ_{i2}^{H}Z_{j1}^{+}Z_{k1}^{+}\Big) \tag{82}$$

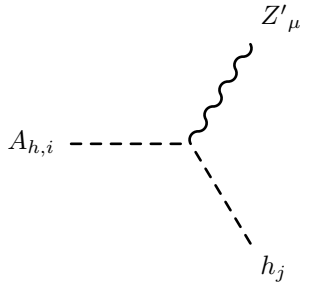
8.2 Two Scalar-One Vector Boson-Interaction



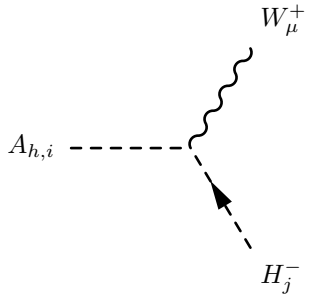
$$\frac{1}{2}\Big(10g_{YB}\cos\Theta_W Z_{i2}^{A}Z_{j2}^{H}+\Big(g_1\cos\Theta_W-g_2\sin\Theta_W\Big)Z_{i1}^{A}Z_{j1}^{H}\Big)\Big(-p_{\mu}^{h_j}+p_{\mu}^{A_{h,i}}\Big) \tag{83}$$



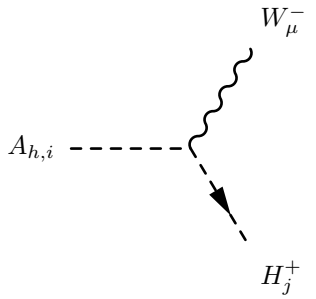
$$\frac{1}{2}\Big(-\Big(g_1 \cos\Theta'_W \sin\Theta_W + g_2 \cos\Theta_W \cos\Theta'_W - g_{BY} \sin\Theta'_W\Big) Z^A_{i1} Z^H_{j1} \\ - 10\Big(- g_B \sin\Theta'_W + g_{YB} \cos\Theta'_W \sin\Theta_W\Big) Z^A_{i2} Z^H_{j2}\Big)\Big(- p_\mu^{h_j} + p_\mu^{A_{h,i}}\Big) \tag{84}$$



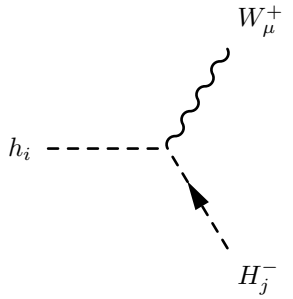
$$\frac{1}{2}\Big(\Big(\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W\Big) \sin\Theta'_W + g_{BY} \cos\Theta'_W\Big) Z^A_{i1} Z^H_{j1} \\ + 10\Big(g_B \cos\Theta'_W + g_{YB} \sin\Theta_W \sin\Theta'_W\Big) Z^A_{i2} Z^H_{j2}\Big)\Big(- p_\mu^{h_j} + p_\mu^{A_{h,i}}\Big) \tag{85}$$



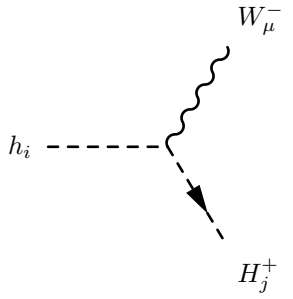
$$\frac{1}{2} g_2 Z^A_{i1} Z^+_{j1}\Big(- p_\mu^{H^-_j} + p_\mu^{A_{h,i}}\Big) \tag{86}$$



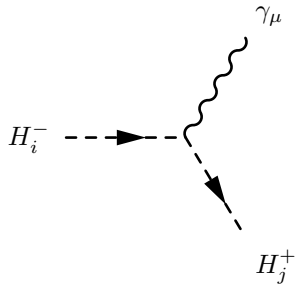
$$\frac{1}{2}g_2 Z^A_{i1} Z^+_{j1}\Big(- p_\mu^{H_j^+} + p_\mu^{A_{h,i}}\Big) \tag{87}$$



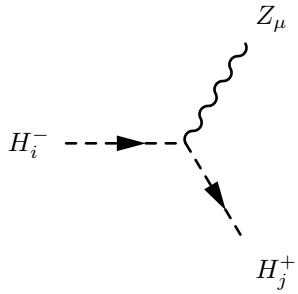
$$-\frac{i}{2}g_2 Z^H_{i1} Z^+_{j1}\Big(- p_\mu^{H_j^-} + p_\mu^{h_i}\Big) \tag{88}$$



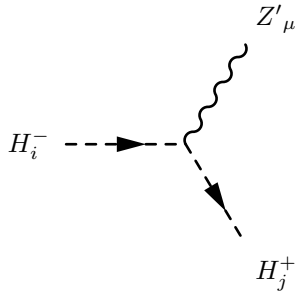
$$\frac{i}{2}g_2 Z^H_{i1} Z^+_{j1}\Big(- p_\mu^{H_j^+} + p_\mu^{h_i}\Big) \tag{89}$$



$$\frac{i}{2}\Big(2\Big(g_1+g_{YB}\Big)\cos\Theta_W\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}+2\Big(-4g_{YB}+g_1\Big)\cos\Theta_W\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}$$
$$+\Big(g_1\cos\Theta_W+g_2\sin\Theta_W\Big)Z^+_{i1}Z^+_{j1}\Big)\Big(-p_\mu^{H_j^+}+p_\mu^{H_i^-}\Big) \tag{90}$$

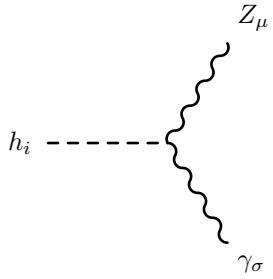


$$-\frac{i}{2}\Big(2\Big(\Big(g_1+g_{YB}\Big)\cos\Theta'_W\sin\Theta_W-\Big(g_{BY}+g_B\Big)\sin\Theta'_W\Big)\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$+2\Big(-\Big(-4g_B+g_{BY}\Big)\sin\Theta'_W+\Big(-4g_{YB}+g_1\Big)\cos\Theta'_W\sin\Theta_W\Big)\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}$$
$$-\Big(-g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W+g_{BY}\sin\Theta'_W\Big)Z^+_{i1}Z^+_{j1}\Big)\Big(-p_\mu^{H_j^+}+p_\mu^{H_i^-}\Big) \tag{91}$$

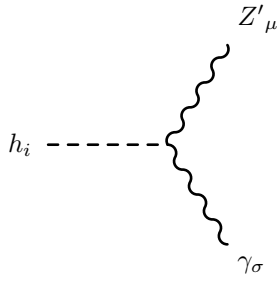


$$\frac{i}{2}\Big(2\Big(\Big(g_1+g_{YB}\Big)\sin\Theta_W\sin\Theta'_W+\Big(g_{BY}+g_B\Big)\cos\Theta'_W\Big)\sum_{a=1}^{2}Z^+_{i1+a}Z^+_{j1+a}$$
$$+2\Big(\Big(-4g_B+g_{BY}\Big)\cos\Theta'_W+\Big(-4g_{YB}+g_1\Big)\sin\Theta_W\sin\Theta'_W\Big)\sum_{a=1}^{2}Z^+_{i3+a}Z^+_{j3+a}$$
$$+\Big(\Big(g_1\sin\Theta_W-g_2\cos\Theta_W\Big)\sin\Theta'_W+g_{BY}\cos\Theta'_W\Big)Z^+_{i1}Z^+_{j1}\Big)\Big(-p_\mu^{H_j^+}+p_\mu^{H_i^-}\Big) \tag{92}$$

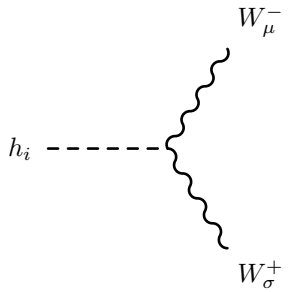
8.3 One Scalar-Two Vector Boson-Interaction



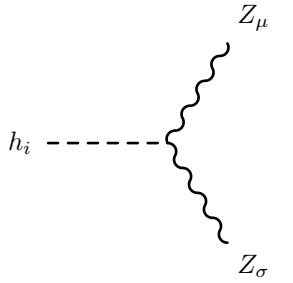
$$\frac{i}{2}\Big(-v\Big(g_1\cos\Theta_W-g_2\sin\Theta_W\Big)\Big(g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W-g_{BY}\sin\Theta'_W\Big)Z^H_{i1}$$
$$-50g_{YB}x\Big(-2g_B\cos\Theta_W\sin\Theta'_W+g_{YB}\cos\Theta'_W\sin2\Theta_W\Big)Z^H_{i2}\Big)\Big(g_{\sigma\mu}\Big) \tag{93}$$



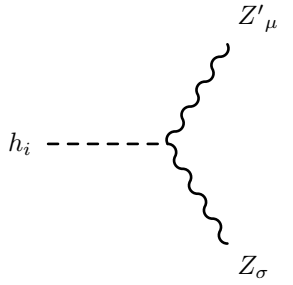
$$\frac{i}{2}\Big(v\Big(g_1\cos\Theta_W-g_2\sin\Theta_W\Big)\Big(\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W+g_{BY}\cos\Theta'_W\Big)Z^H_{i1}$$
$$+50g_{YB}x\Big(2g_B\cos\Theta_W\cos\Theta'_W+g_{YB}\sin2\Theta_W\sin\Theta'_W\Big)Z^H_{i2}\Big)\Big(g_{\sigma\mu}\Big) \tag{94}$$



$$\frac{i}{2}g_2^2 v Z_{i1}^H \Big(g_{\sigma\mu}\Big) \tag{95}$$

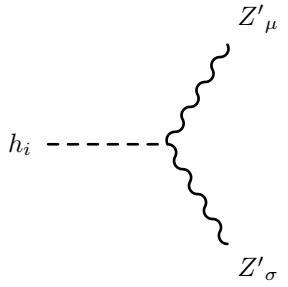


$$\begin{aligned}&\frac{i}{2}\Big(v\Big(g_1 \cos\Theta'_W \sin\Theta_W + g_2 \cos\Theta_W \cos\Theta'_W - g_{BY} \sin\Theta'_W\Big)^2 Z_{i1}^H \\ &+ 100x\Big(-g_B \sin\Theta'_W + g_{YB} \cos\Theta'_W \sin\Theta_W\Big)^2 Z_{i2}^H\Big)\Big(g_{\sigma\mu}\Big)\end{aligned} \tag{96}$$

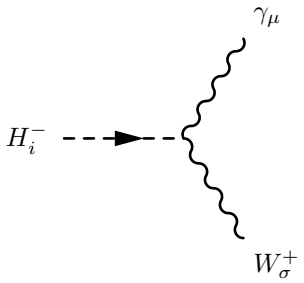


$$\begin{aligned}&\frac{i}{2}\Big(-v\Big(g_1 g_{BY} \cos\Theta'^2_W \sin\Theta_W + g_2^2 \cos\Theta_W^2 \cos\Theta'_W \sin\Theta'_W \\ &+ \cos\Theta'_W\Big(g_1^2 \sin\Theta_W^2 - g_{BY}^2\Big)\sin\Theta'_W - g_1 g_{BY} \sin\Theta_W \sin\Theta'^2_W\end{aligned}$$

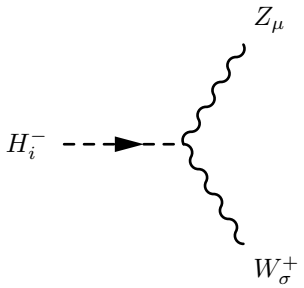
$$+ g_2 \cos\Theta_W \Big(g_1 \sin\Theta_W \sin 2\Theta'_W + g_{BY} \cos {\Theta'}^2_W - g_{BY} \sin {\Theta'}^2_W \Big) \Big) Z^H_{i1}$$
$$+ 50x \Big(- 2 g_B g_{YB} \cos {\Theta'}^2_W \sin\Theta_W + 2 g_B g_{YB} \sin\Theta_W \sin {\Theta'}^2_W + g_B^2 \sin 2\Theta'_W$$
$$- g_{YB}^2 \sin\Theta_W^2 \sin 2\Theta'_W \Big) Z^H_{i2} \Big) \Big(g_{\sigma\mu} \Big) \tag{97}$$



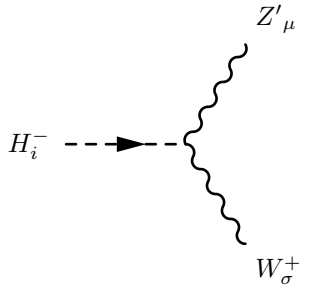
$$\frac{i}{2} \Big(v \Big(\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) \sin\Theta'_W + g_{BY} \cos\Theta'_W \Big)^2 Z^H_{i1}$$
$$+ 100x \Big(g_B \cos\Theta'_W + g_{YB} \sin\Theta_W \sin\Theta'_W \Big)^2 Z^H_{i2} \Big) \Big(g_{\sigma\mu} \Big) \tag{98}$$



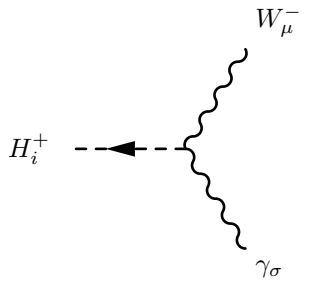
$$\frac{i}{2} g_1 g_2 v \cos\Theta_W Z^+_{i1} \Big(g_{\sigma\mu} \Big) \tag{99}$$



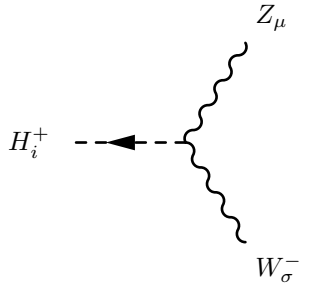
$$\frac{i}{2}g_2 v\Big(- g_1 \cos\Theta'_W \sin\Theta_W + g_{BY} \sin\Theta'_W\Big) Z^+_{i1}\Big(g_{\sigma\mu}\Big) \tag{100}$$



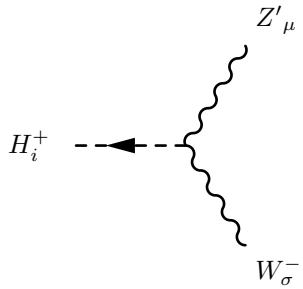
$$\frac{i}{2}g_2 v\Big(g_1 \sin\Theta_W \sin\Theta'_W + g_{BY} \cos\Theta'_W\Big) Z^+_{i1}\Big(g_{\sigma\mu}\Big) \tag{101}$$



$$\frac{i}{2}g_1 g_2 v \cos\Theta_W Z^+_{i1}\Big(g_{\sigma\mu}\Big) \tag{102}$$

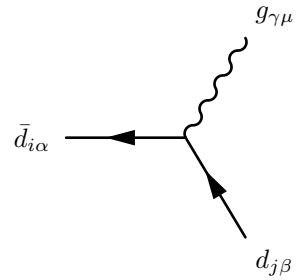


$$\frac{i}{2}g_2 v\Big(- g_1 \cos\Theta'_W \sin\Theta_W + g_{BY} \sin\Theta'_W\Big) Z^+_{i1}\Big(g_{\sigma\mu}\Big) \tag{103}$$



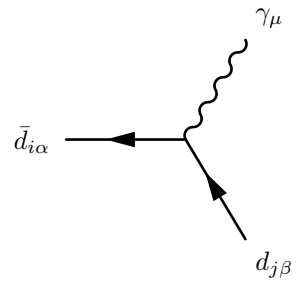
$$\frac{i}{2}g_2 v\Big(g_1 \sin\Theta_W \sin\Theta'_W + g_{BY}\cos\Theta'_W\Big) Z^+_{i1}\Big(g_{\sigma\mu}\Big) \tag{104}$$

8.4 Two Fermion-One Vector Boson-Interaction



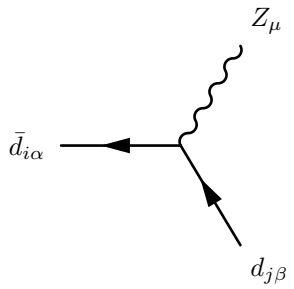
$$-\frac{i}{2}g_3\delta_{ij}\lambda^\gamma_{\alpha,\beta}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{105}$$

$$+\ -\frac{i}{2}g_3\delta_{ij}\lambda^\gamma_{\alpha,\beta}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{106}$$



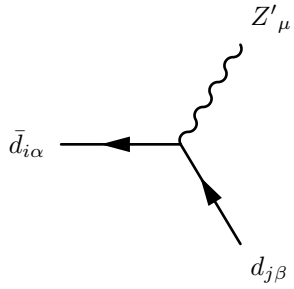
$$-\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-10g_{YB}+3g_1\Big)\cos\Theta_W - 9g_2\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{107}$$

$$+\ \frac{i}{9}\Big(3g_1+5g_{YB}\Big)\cos\Theta_W\delta_{\alpha\beta}\delta_{ij}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{108}$$



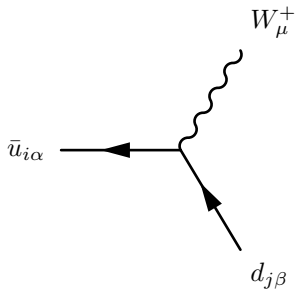
$$\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(10g_B - 3g_{BY}\Big)\sin\Theta'_W + \Big(-10g_{YB} + 3g_1\Big)\cos\Theta'_W\sin\Theta_W + 9g_2\cos\Theta_W\cos\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \quad (109)$$

$$+\ -\frac{i}{9}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(3g_1 + 5g_{YB}\Big)\cos\Theta'_W\sin\Theta_W - \Big(3g_{BY} + 5g_B\Big)\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \quad (110)$$

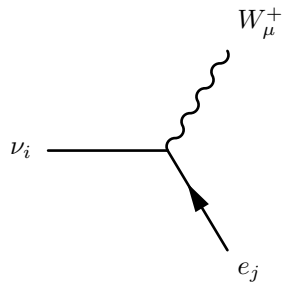


$$-\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-10g_B + 3g_{BY}\Big)\cos\Theta'_W + \Big(\Big(-10g_{YB} + 3g_1\Big)\sin\Theta_W + 9g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \quad (111)$$

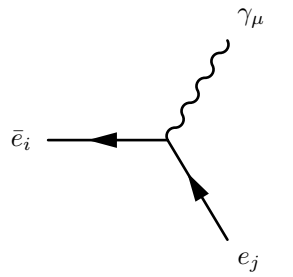
$$+\ \frac{i}{9}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(3g_1 + 5g_{YB}\Big)\sin\Theta_W\sin\Theta'_W + \Big(3g_{BY} + 5g_B\Big)\cos\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \quad (112)$$



$$-\,i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^{3}U^{d,*}_{L,ja}U^{u}_{L,ia}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \quad (113)$$

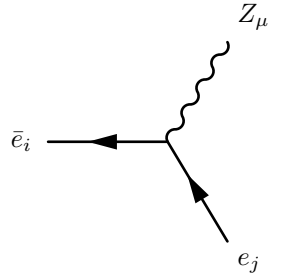


$$-i\frac{1}{\sqrt{2}}g_2\sum_{a=1}^{3}U^{e,*}_{L,ja}U^{V}_{ia}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{114}$$



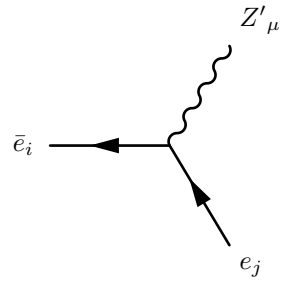
$$\frac{i}{2}\delta_{ij}\Big(g_1\cos\Theta_W+g_2\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{115}$$

$$+\ ig_1\cos\Theta_W\delta_{ij}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{116}$$



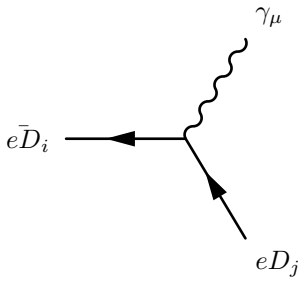
$$\frac{i}{2}\delta_{ij}\Big(-g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W+g_{BY}\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{117}$$

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



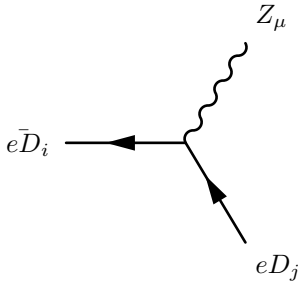
$$\frac{i}{2}\delta_{ij}\Big(\Big(g_1 \sin\Theta_W - g_2 \cos\Theta_W\Big)\sin\Theta'_W + g_{BY}\cos\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{119}$$

$$+\ i\delta_{ij}\Big(g_1 \sin\Theta_W \sin\Theta'_W + g_{BY}\cos\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{120}$$

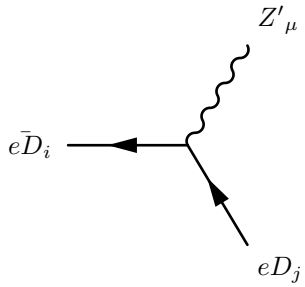


$$\frac{i}{2}\Big(2\Big(6g_{YB}+g_1\Big)UD^{e,*}_{L,j2}\cos\Theta_W UD^{e}_{L,i2} + UD^{e,*}_{L,j1}\Big(\Big(2g_{YB}+g_1\Big)\cos\Theta_W + g_2\sin\Theta_W\Big)UD^{e}_{L,i1}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{121}$$

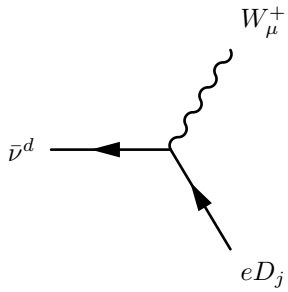
$$+\ \frac{i}{2}\Big(2\Big(g_1+g_{YB}\Big)UD^{e,*}_{R,i1}\cos\Theta_W UD^{e}_{R,j1} + UD^{e,*}_{R,i2}\Big(\Big(12g_{YB}+g_1\Big)\cos\Theta_W + g_2\sin\Theta_W\Big)UD^{e}_{R,j2}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{122}$$



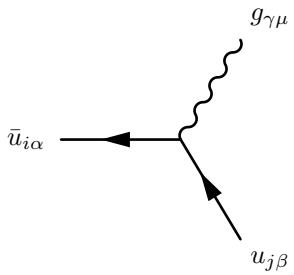
$$\frac{i}{2}\Big(UD^{e,*}_{L,j1}\Big(\Big(2g_B+g_{BY}\Big)\sin\Theta'_W-\Big(2g_{YB}+g_1\Big)\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)UD^{e}_{L,i1}$$
$$+2UD^{e,*}_{L,j2}\Big(\Big(6g_B+g_{BY}\Big)\sin\Theta'_W-\Big(6g_{YB}+g_1\Big)\cos\Theta'_W\sin\Theta_W\Big)UD^{e}_{L,i2}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{123}$$
$$+\ -\frac{i}{2}\Big(2UD^{e,*}_{R,i1}\Big(\Big(g_1+g_{YB}\Big)\cos\Theta'_W\sin\Theta_W-\Big(g_{BY}+g_B\Big)\sin\Theta'_W\Big)UD^{e}_{R,j1}$$
$$-UD^{e,*}_{R,i2}\Big(\Big(12g_B+g_{BY}\Big)\sin\Theta'_W-\Big(12g_{YB}+g_1\Big)\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)UD^{e}_{R,j2}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{124}$$



$$\frac{i}{2}\Big(UD^{e,*}_{L,j1}\Big(\Big(2g_B+g_{BY}\Big)\cos\Theta'_W+\Big(\Big(2g_{YB}+g_1\Big)\sin\Theta_W-g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)UD^{e}_{L,i1}$$
$$+2UD^{e,*}_{L,j2}\Big(\Big(6g_B+g_{BY}\Big)\cos\Theta'_W+\Big(6g_{YB}+g_1\Big)\sin\Theta_W\sin\Theta'_W\Big)UD^{e}_{L,i2}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{125}$$
$$+\ \frac{i}{2}\Big(2UD^{e,*}_{R,i1}\Big(\Big(g_1+g_{YB}\Big)\sin\Theta_W\sin\Theta'_W+\Big(g_{BY}+g_B\Big)\cos\Theta'_W\Big)UD^{e}_{R,j1}$$
$$+UD^{e,*}_{R,i2}\Big(\Big(12g_B+g_{BY}\Big)\cos\Theta'_W+\Big(\Big(12g_{YB}+g_1\Big)\sin\Theta_W-g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)UD^{e}_{R,j2}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{126}$$

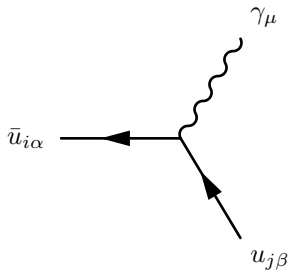


$$-\ i\frac{1}{\sqrt{2}}g_2UD^{e,*}_{L,j1}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{127}$$
$$+\ -i\frac{1}{\sqrt{2}}g_2UD^{e}_{R,j2}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{128}$$



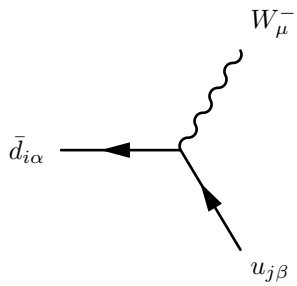
$$-\frac{i}{2}g_3\delta_{ij}\lambda^{\gamma}_{\alpha,\beta}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{129}$$

$$+\ -\frac{i}{2}g_3\delta_{ij}\lambda^{\gamma}_{\alpha,\beta}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{130}$$

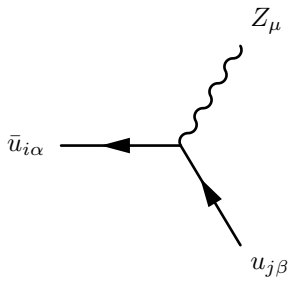


$$-\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-10g_{YB}+3g_1\Big)\cos\Theta_W+9g_2\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{131}$$

$$+\ -\frac{i}{9}\Big(-5g_{YB}+6g_1\Big)\cos\Theta_W\delta_{\alpha\beta}\delta_{ij}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{132}$$

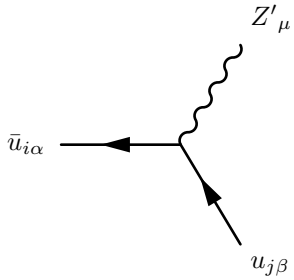


$$-i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^{3}U^{u,*}_{L,ja}U^{d}_{L,ia}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{133}$$



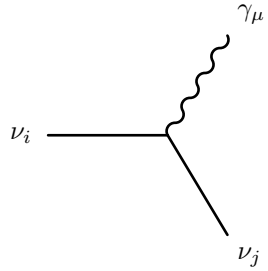
$$-\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-10g_B+3g_{BY}\Big)\sin\Theta'_W-\Big(-10g_{YB}+3g_1\Big)\cos\Theta'_W\sin\Theta_W+9g_2\cos\Theta_W\cos\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{134}$$

$$+\frac{i}{9}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(5g_B-6g_{BY}\Big)\sin\Theta'_W+\Big(-5g_{YB}+6g_1\Big)\cos\Theta'_W\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{135}$$



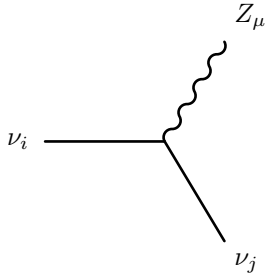
$$-\frac{i}{18}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-10g_B+3g_{BY}\Big)\cos\Theta'_W+\Big(\Big(-10g_{YB}+3g_1\Big)\sin\Theta_W-9g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{136}$$

$$+-\frac{i}{9}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-5g_B+6g_{BY}\Big)\cos\Theta'_W+\Big(-5g_{YB}+6g_1\Big)\sin\Theta_W\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{137}$$



$$\frac{i}{2}\Big(10g_{YB}\cos\Theta_W\sum_{a=1}^{2}U^{V,*}_{j3+a}U^{V}_{i3+a}+\Big(g_1\cos\Theta_W-g_2\sin\Theta_W\Big)\sum_{a=1}^{3}U^{V,*}_{ja}U^{V}_{ia}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{138}$$

$$+\,-\frac{i}{2}\Big(10g_{YB}\cos\Theta_W\sum_{a=1}^{2}U^{V,*}_{i3+a}U^{V}_{j3+a}+\Big(g_1\cos\Theta_W-g_2\sin\Theta_W\Big)\sum_{a=1}^{3}U^{V,*}_{ia}U^{V}_{ja}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{139}$$

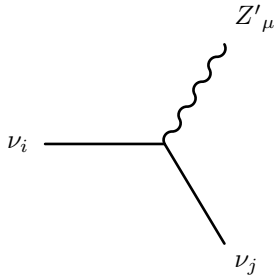


$$-\frac{i}{2}\Big(10\Big(-g_B\sin\Theta'_W+g_{YB}\cos\Theta'_W\sin\Theta_W\Big)\sum_{a=1}^{2}U^{V,*}_{j3+a}U^{V}_{i3+a}$$

$$+\Big(g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W-g_{BY}\sin\Theta'_W\Big)\sum_{a=1}^{3}U^{V,*}_{ja}U^{V}_{ia}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{140}$$

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

$$+\Big(g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W-g_{BY}\sin\Theta'_W\Big)\sum_{a=1}^{3}U^{V,*}_{ia}U^{V}_{ja}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{141}$$

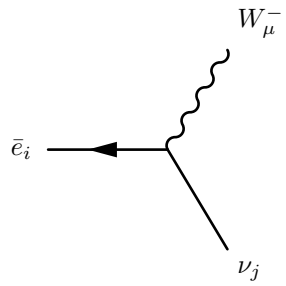


$$\frac{i}{2}\Big(10\Big(g_B\cos\Theta'_W+g_{YB}\sin\Theta_W\sin\Theta'_W\Big)\sum_{a=1}^{2}U^{V,*}_{j3+a}U^{V}_{i3+a}$$

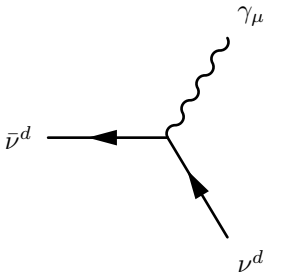
$$+\Big(\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W+g_{BY}\cos\Theta'_W\Big)\sum_{a=1}^{3}U^{V,*}_{ja}U^{V}_{ia}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{142}$$

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

$$+\Big(\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W+g_{BY}\cos\Theta'_W\Big)\sum_{a=1}^{3}U^{V,*}_{ia}U^{V}_{ja}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{143}$$

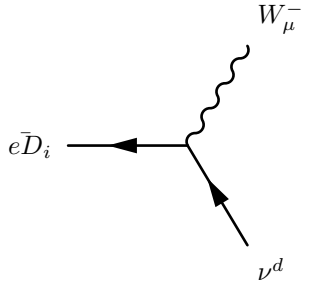


$$-i\frac{1}{\sqrt{2}}g_2\sum_{a=1}^{3}U^{V,*}_{ja}U^{e}_{L,ia}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{144}$$



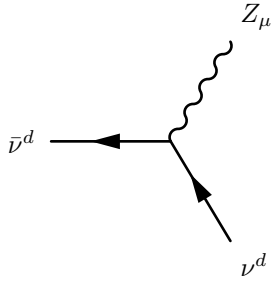
$$\frac{i}{2}\Big(\Big(2g_{YB}+g_1\Big)\cos\Theta_W-g_2\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{145}$$

$$+\ \frac{i}{2}\Big(\Big(12g_{YB}+g_1\Big)\cos\Theta_W-g_2\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{146}$$



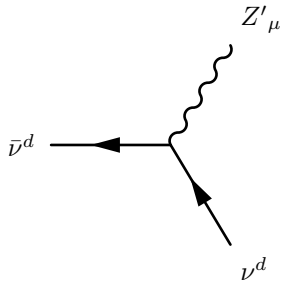
$$- i\frac{1}{\sqrt{2}}g_2 UD^e_{L,i1}\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{147}$$

$$+ -i\frac{1}{\sqrt{2}}g_2 UD^{e,*}_{R,i2}\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{148}$$



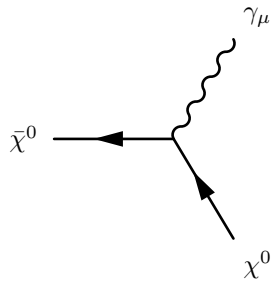
$$- \frac{i}{2}\Big(- \Big(2g_B + g_{BY}\Big)\sin\Theta'_W + \Big(2g_{YB} + g_1\Big)\cos\Theta'_W \sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{149}$$

$$+ -\frac{i}{2}\Big(- \Big(12g_B + g_{BY}\Big)\sin\Theta'_W + \Big(12g_{YB} + g_1\Big)\cos\Theta'_W \sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{150}$$



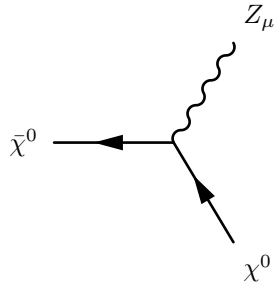
$$\frac{i}{2}\Big(\Big(2g_B + g_{BY}\Big)\cos\Theta'_W + \Big(\Big(2g_{YB} + g_1\Big)\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{151}$$

$$+\ \frac{i}{2}\Big(\Big(12g_B + g_{BY}\Big)\cos\Theta'_W + \Big(\Big(12g_{YB} + g_1\Big)\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{152}$$



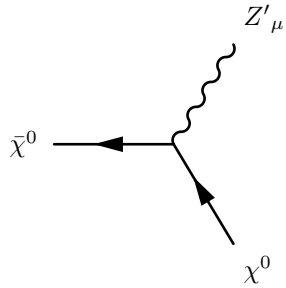
$$-\ 3ig_{YB}\cos\Theta_W\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{153}$$

$$+\ 2ig_{YB}\cos\Theta_W\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{154}$$



$$3i\Big(-g_B\sin\Theta'_W + g_{YB}\cos\Theta'_W\sin\Theta_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{155}$$

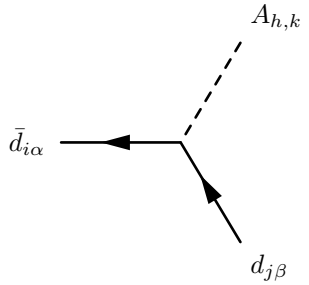
$$+\ -2i\Big(-g_B\sin\Theta'_W + g_{YB}\cos\Theta'_W\sin\Theta_W\Big)\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{156}$$



$$- 3i\Big(g_B \cos\Theta'_W + g_{YB} \sin\Theta_W \sin\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{157}$$

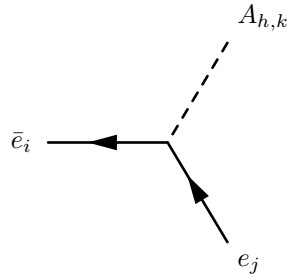
$$+ 2i\Big(g_B \cos\Theta'_W + g_{YB} \sin\Theta_W \sin\Theta'_W\Big)\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{158}$$

8.5 Two Fermion-One Scalar Boson-Interaction



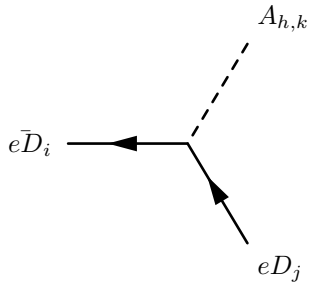
$$- \frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3} U^{d,*}_{L,jb}\sum_{a=1}^{3} U^{d,*}_{R,ia} Y_{d,ab} Z^A_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{159}$$

$$+ \frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^*_{d,ab} U^d_{R,ja} U^d_{L,ib} Z^A_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{160}$$



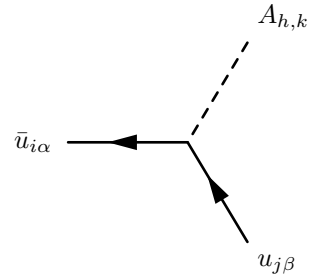
$$- \frac{1}{\sqrt{2}}\sum_{b=1}^{3} U^{e,*}_{L,jb}\sum_{a=1}^{3} U^{e,*}_{R,ia} Y_{e,ab} Z^A_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{161}$$

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



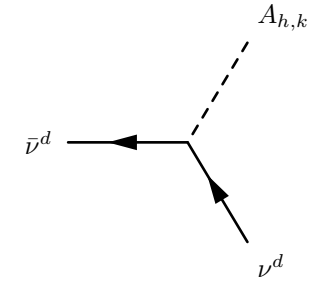
$$-\frac{1}{\sqrt{2}}\Big(UD^{e,*}_{R,i1}\Big(-\lambda_b UD^{e,*}_{L,j2}Z^A_{k2}+\lambda_g UD^{e,*}_{L,j1}Z^A_{k1}\Big)+UD^{e,*}_{R,i2}\Big(\lambda_c UD^{e,*}_{L,j1}Z^A_{k2}-\lambda_h UD^{e,*}_{L,j2}Z^A_{k1}\Big)\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{163}$$

$$+\frac{1}{\sqrt{2}}\Big(-\lambda_b UD^{e}_{R,j1}UD^{e}_{L,i2}Z^A_{k2}+\lambda^*_g UD^{e}_{R,j1}UD^{e}_{L,i1}Z^A_{k1}+UD^{e}_{R,j2}\Big(\lambda_c UD^{e}_{L,i1}Z^A_{k2}-\lambda_h UD^{e}_{L,i2}Z^A_{k1}\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{164}$$



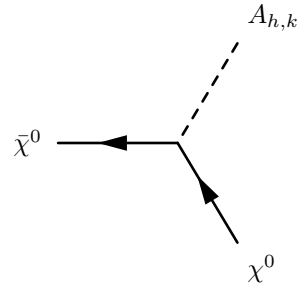
$$-\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}U^{u,*}_{L,jb}\sum_{a=1}^{3}U^{u,*}_{R,ia}Y_{u,ab}Z^A_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{165}$$

$$+\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{u,ab}U^{u}_{R,ja}U^{u}_{L,ib}Z^A_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{166}$$



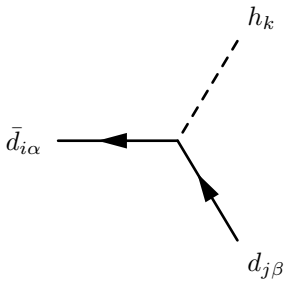
$$- \frac{1}{\sqrt{2}}\lambda_c Z^A_{k2}\Big(\frac{1-\gamma_5}{2}\Big) \tag{167}$$

$$+ \frac{1}{\sqrt{2}}\lambda_c Z^A_{k2}\Big(\frac{1+\gamma_5}{2}\Big) \tag{168}$$



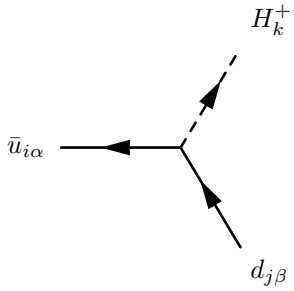
$$- \frac{1}{\sqrt{2}}\lambda_a Z^A_{k2}\Big(\frac{1-\gamma_5}{2}\Big) \tag{169}$$

$$+ \frac{1}{\sqrt{2}}\lambda_a Z^A_{k2}\Big(\frac{1+\gamma_5}{2}\Big) \tag{170}$$



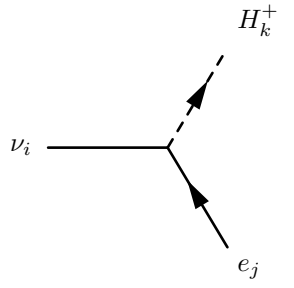
$$- i\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3} U^{d,*}_{L,jb}\sum_{a=1}^{3} U^{d,*}_{R,ia} Y_{d,ab} Z^H_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{171}$$

$$+ -i\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^*_{d,ab} U^d_{R,ja} U^d_{L,ib} Z^H_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{172}$$



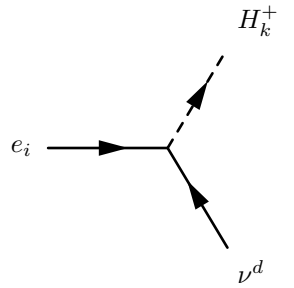
$$- i\delta_{\alpha\beta} \sum_{b=1}^{3} U_{L,jb}^{d,*} \sum_{a=1}^{3} U_{R,ia}^{u,*} Y_{u,ab} Z_{k1}^{+} \Big(\frac{1-\gamma_5}{2} \Big) \tag{173}$$

$$+ \; -i\delta_{\alpha\beta} \sum_{b=1}^{3} \sum_{a=1}^{3} Y_{d,ab}^{*} U_{R,ja}^{d} U_{L,ib}^{u} Z_{k1}^{+} \Big(\frac{1+\gamma_5}{2} \Big) \tag{174}$$

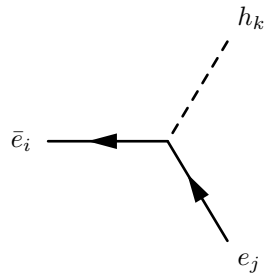


(175)

$$+ \; -i \sum_{b=1}^{3} \sum_{a=1}^{3} Y_{e,ab}^{*} U_{R,ja}^{e} U_{ib}^{V} Z_{k1}^{+} \Big(\frac{1+\gamma_5}{2} \Big) \tag{176}$$

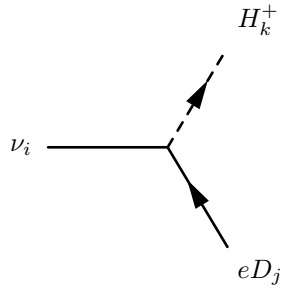


$$i\sum_{b=1}^{3} U^{e,*}_{L,ib} \sum_{a=1}^{2} \lambda_{d,ab} Z^{+}_{k1+a} \Big(\frac{1-\gamma_5}{2}\Big) \tag{177}$$



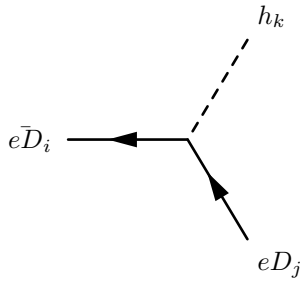
$$-i\frac{1}{\sqrt{2}}\sum_{b=1}^{3} U^{e,*}_{L,jb} \sum_{a=1}^{3} U^{e,*}_{R,ia} Y_{e,ab} Z^{H}_{k1} \Big(\frac{1-\gamma_5}{2}\Big) \tag{178}$$

$$+\ -i\frac{1}{\sqrt{2}}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{e,ab} U^{e}_{R,ja} U^{e}_{L,ib} Z^{H}_{k1} \Big(\frac{1+\gamma_5}{2}\Big) \tag{179}$$



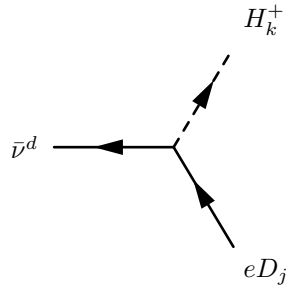
$$-iUD^{e,*}_{L,j1} \sum_{b=1}^{3} U^{V,*}_{ib} \sum_{a=1}^{2} \lambda_{d,ab} Z^{+}_{k1+a} \Big(\frac{1-\gamma_5}{2}\Big) \tag{180}$$

$$+\ -i\sum_{b=1}^{2}\sum_{a=1}^{2} \lambda^{*}_{e,ab} Z^{+}_{k3+a} U^{V}_{i3+b} UD^{e}_{R,j1} \Big(\frac{1+\gamma_5}{2}\Big) \tag{181}$$



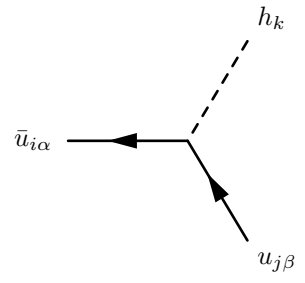
$$i\frac{1}{\sqrt{2}}\Big(-UD^{e,*}_{R,i1}\Big(\lambda_b UD^{e,*}_{L,j2}Z^H_{k2}+\lambda_g UD^{e,*}_{L,j1}Z^H_{k1}\Big)-UD^{e,*}_{R,i2}\Big(\lambda_c UD^{e,*}_{L,j1}Z^H_{k2}+\lambda_h UD^{e,*}_{L,j2}Z^H_{k1}\Big)\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{182}$$

$$+\ -i\frac{1}{\sqrt{2}}\Big(\lambda_b UD^{e}_{R,j1}UD^{e}_{L,i2}Z^H_{k2}+\lambda^*_g UD^{e}_{R,j1}UD^{e}_{L,i1}Z^H_{k1}+UD^{e}_{R,j2}\Big(\lambda_c UD^{e}_{L,i1}Z^H_{k2}+\lambda_h UD^{e}_{L,i2}Z^H_{k1}\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{183}$$



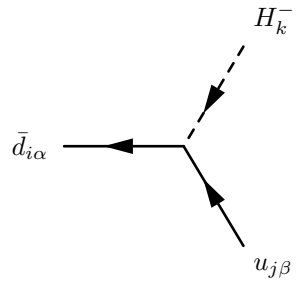
$$-i\lambda_h UD^{e,*}_{L,j2}Z^+_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{184}$$

$$+\ -i\lambda^*_g UD^{e}_{R,j1}Z^+_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{185}$$



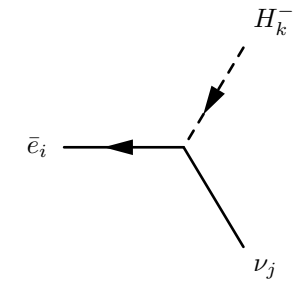
$$i\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}U^{u,*}_{L,jb}\sum_{a=1}^{3}U^{u,*}_{R,ia}Y_{u,ab}Z^H_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{186}$$

$$+\ i\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{u,ab}U^{u}_{R,ja}U^{u}_{L,ib}Z^{H}_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{187}$$

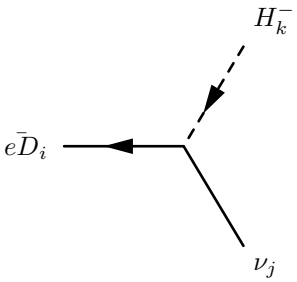


$$-\ i\delta_{\alpha\beta}\sum_{b=1}^{3}U^{u,*}_{L,jb}\sum_{a=1}^{3}U^{d,*}_{R,ia}Y_{d,ab}Z^{+}_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{188}$$

$$+\ -i\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{u,ab}U^{u}_{R,ja}U^{d}_{L,ib}Z^{+}_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{189}$$

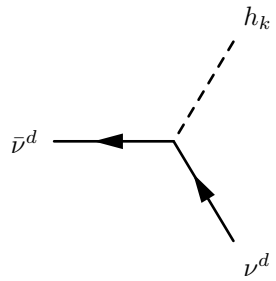


$$-\ i\sum_{b=1}^{3}U^{V,*}_{jb}\sum_{a=1}^{3}U^{e,*}_{R,ia}Y_{e,ab}Z^{+}_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{190}$$



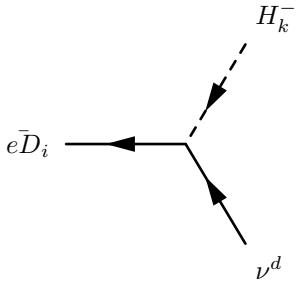
$$- iUD^{e,*}_{R,i1}\sum_{b=1}^{2} U^{V,*}_{j3+b}\sum_{a=1}^{2}\lambda_{e,ab}Z^{+}_{k3+a}\Big(\frac{1-\gamma_5}{2}\Big) \tag{191}$$

$$+ \; -i\sum_{b=1}^{3}\sum_{a=1}^{2}\lambda^{*}_{d,ab}Z^{+}_{k1+a}U^{V}_{jb}UD^{e}_{L,i1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{192}$$



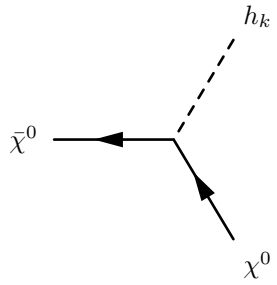
$$- i\frac{1}{\sqrt{2}}\lambda_c Z^{H}_{k2}\Big(\frac{1-\gamma_5}{2}\Big) \tag{193}$$

$$+ \; -i\frac{1}{\sqrt{2}}\lambda_c Z^{H}_{k2}\Big(\frac{1+\gamma_5}{2}\Big) \tag{194}$$



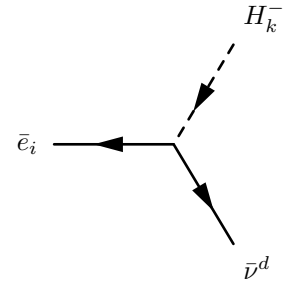
$$- i\lambda_g UD^{e,*}_{R,i1}Z^{+}_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{195}$$

$$+ \; -i\lambda_h UD^{e}_{L,i2}Z^{+}_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{196}$$



$$- i\frac{1}{\sqrt{2}}\lambda_a Z^H_{k2}\Big(\frac{1-\gamma_5}{2}\Big) \tag{197}$$

$$+ -i\frac{1}{\sqrt{2}}\lambda_a Z^H_{k2}\Big(\frac{1+\gamma_5}{2}\Big) \tag{198}$$



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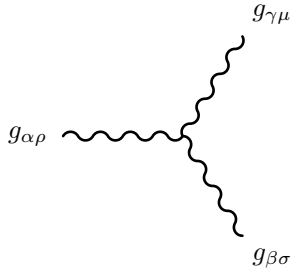
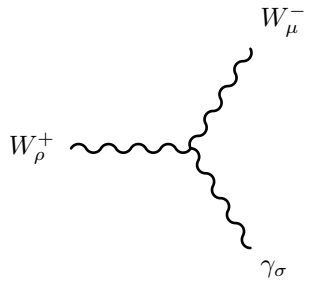
$$+ i\sum_{b=1}^{3}\sum_{a=1}^{2}\lambda^*_{d,ab}Z^+_{k1+a}U^e_{L,ib}\Big(\frac{1+\gamma_5}{2}\Big) \tag{200}$$

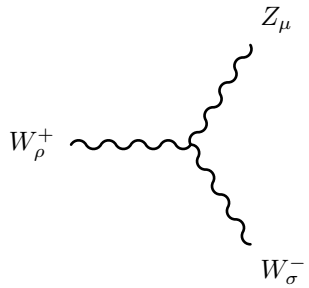
8.6 Three Vector Boson-Interaction



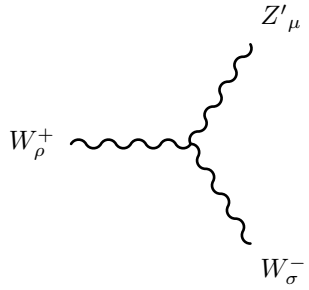
$$g_3 f_{\alpha,\beta,\gamma}\Big(g_{\rho\mu}\Big(-p_\sigma^{g_{\gamma\mu}}+p_\sigma^{g_{\alpha\rho}}\Big)+g_{\rho\sigma}\Big(-p_\mu^{g_{\alpha\rho}}+p_\mu^{g_{\beta\sigma}}\Big)+g_{\sigma\mu}\Big(-p_\rho^{g_{\beta\sigma}}+p_\rho^{g_{\gamma\mu}}\Big)\Big) \tag{201}$$



$$ig_2 \sin\Theta_W\Big(g_{\rho\mu}\Big(-p_\sigma^{W_\mu^-}+p_\sigma^{W_\rho^+}\Big)+g_{\rho\sigma}\Big(-p_\mu^{W_\rho^+}+p_\mu^{\gamma_\sigma}\Big)+g_{\sigma\mu}\Big(-p_\rho^{\gamma_\sigma}+p_\rho^{W_\mu^-}\Big)\Big) \tag{202}$$

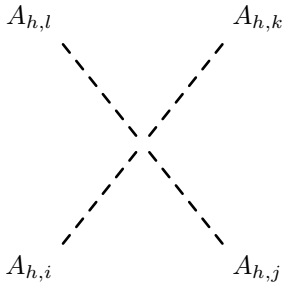


$$-ig_2 \cos\Theta_W \cos\Theta'_W\Big(g_{\rho\mu}\Big(-p_\sigma^{Z_\mu}+p_\sigma^{W_\rho^+}\Big)+g_{\rho\sigma}\Big(-p_\mu^{W_\rho^+}+p_\mu^{W_\sigma^-}\Big)+g_{\sigma\mu}\Big(-p_\rho^{W_\sigma^-}+p_\rho^{Z_\mu}\Big)\Big) \tag{203}$$

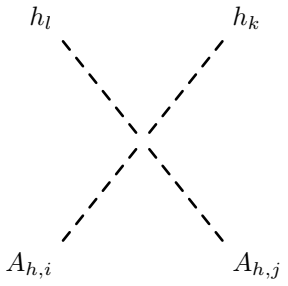


$$ig_2 \cos\Theta_W \sin\Theta'_W\Big(g_{\rho\mu}\Big(-p_\sigma^{Z'_\mu}+p_\sigma^{W_\rho^+}\Big)+g_{\rho\sigma}\Big(-p_\mu^{W_\rho^+}+p_\mu^{W_\sigma^-}\Big)+g_{\sigma\mu}\Big(-p_\rho^{W_\sigma^-}+p_\rho^{Z'_\mu}\Big)\Big) \tag{204}$$

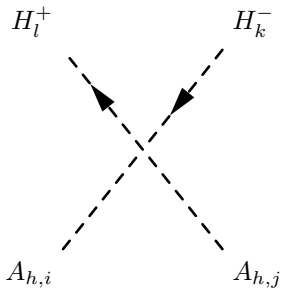
8.7 Four Scalar-Interaction



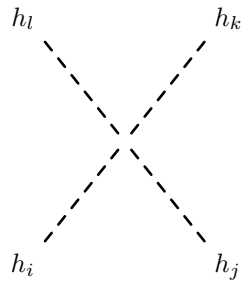
$$i\Big(Z^A_{i2}\Big(\lambda_3 Z^A_{j1}\Big(Z^A_{k1}Z^A_{l2}+Z^A_{k2}Z^A_{l1}\Big)+Z^A_{j2}\Big(6\lambda_2 Z^A_{k2}Z^A_{l2}+\lambda_3 Z^A_{k1}Z^A_{l1}\Big)\Big) + Z^A_{i1}\Big(\lambda_3 Z^A_{j2}\Big(Z^A_{k1}Z^A_{l2}+Z^A_{k2}Z^A_{l1}\Big)+Z^A_{j1}\Big(6l_h Z^A_{k1}Z^A_{l1}+\lambda_3 Z^A_{k2}Z^A_{l2}\Big)\Big)\Big) \tag{205}$$



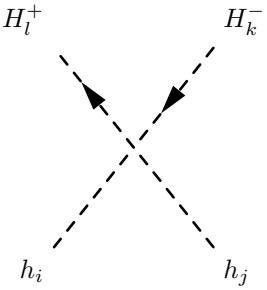
$$i\Big(Z^A_{i1}Z^A_{j1}\Big(2l_h Z^H_{k1}Z^H_{l1}+\lambda_3 Z^H_{k2}Z^H_{l2}\Big)+Z^A_{i2}Z^A_{j2}\Big(2\lambda_2 Z^H_{k2}Z^H_{l2}+\lambda_3 Z^H_{k1}Z^H_{l1}\Big)\Big) \tag{206}$$



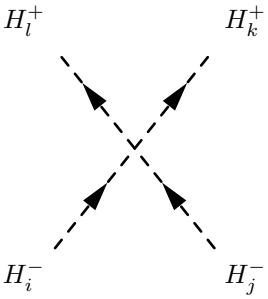
$$i\Big(-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{32,ab}Z^+_{l1+a}Z^+_{k1+b}Z^A_{i1}Z^A_{j1}-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{33,ab}Z^+_{l3+a}Z^+_{k3+b}Z^A_{i1}Z^A_{j1} + \Big(2l_h Z^A_{i1}Z^A_{j1}+\lambda_3 Z^A_{i2}Z^A_{j2}\Big)Z^+_{k1}Z^+_{l1}\Big) \tag{207}$$



$$i\Big(Z^H_{i2}\Big(\lambda_3 Z^H_{j1}\Big(Z^H_{k1}Z^H_{l2}+Z^H_{k2}Z^H_{l1}\Big)+Z^H_{j2}\Big(6\lambda_2 Z^H_{k2}Z^H_{l2}+\lambda_3 Z^H_{k1}Z^H_{l1}\Big)\Big) + Z^H_{i1}\Big(\lambda_3 Z^H_{j2}\Big(Z^H_{k1}Z^H_{l2}+Z^H_{k2}Z^H_{l1}\Big)+Z^H_{j1}\Big(6l_h Z^H_{k1}Z^H_{l1}+\lambda_3 Z^H_{k2}Z^H_{l2}\Big)\Big)\Big) \tag{208}$$



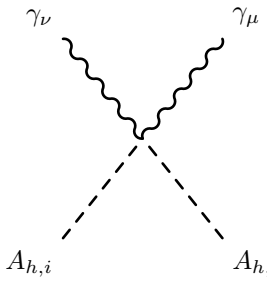
$$i\Big(-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{32,ab}Z^+_{l1+a}Z^+_{k1+b}Z^H_{i1}Z^H_{j1}-\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{33,ab}Z^+_{l3+a}Z^+_{k3+b}Z^H_{i1}Z^H_{j1} + \Big(2l_h Z^H_{i1}Z^H_{j1}+\lambda_3 Z^H_{i2}Z^H_{j2}\Big)Z^+_{k1}Z^+_{l1}\Big) \tag{209}$$



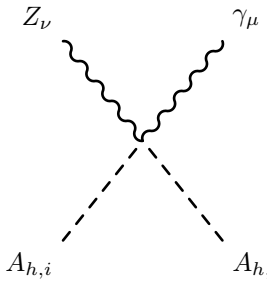
$$i\Big(-\sum_{d=1}^{2}\sum_{c=1}^{2}\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{22,abcd}Z^+_{l1+a}Z^+_{j1+b}Z^+_{k1+c}Z^+_{i1+d}$$

$$
\begin{aligned}
&- \sum_{d=1}^{2}\sum_{c=1}^{2}\sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{22,abcd} Z^{+}_{k1+a} Z^{+}_{j1+b} Z^{+}_{l1+c} Z^{+}_{i1+d} \\
&- \sum_{d=1}^{2}\sum_{c=1}^{2}\sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{23,abcd} Z^{+}_{l3+a} Z^{+}_{j3+b} Z^{+}_{k3+c} Z^{+}_{i3+d} \\
&- \sum_{d=1}^{2}\sum_{c=1}^{2}\sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{23,abcd} Z^{+}_{k3+a} Z^{+}_{j3+b} Z^{+}_{l3+c} Z^{+}_{i3+d} \\
&- \sum_{d=1}^{2}\sum_{c=1}^{2}\sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{22,abcd} Z^{+}_{l1+a} Z^{+}_{i1+b} Z^{+}_{k1+c} Z^{+}_{j1+d} \\
&- \sum_{d=1}^{2}\sum_{c=1}^{2}\sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{22,abcd} Z^{+}_{k1+a} Z^{+}_{i1+b} Z^{+}_{l1+c} Z^{+}_{j1+d} \\
&- \sum_{d=1}^{2}\sum_{c=1}^{2}\sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{23,abcd} Z^{+}_{l3+a} Z^{+}_{i3+b} Z^{+}_{k3+c} Z^{+}_{j3+d} \\
&- \sum_{d=1}^{2}\sum_{c=1}^{2}\sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{23,abcd} Z^{+}_{k3+a} Z^{+}_{i3+b} Z^{+}_{l3+c} Z^{+}_{j3+d} - \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{32,ab} Z^{+}_{l1+a} Z^{+}_{j1+b} Z^{+}_{i1} Z^{+}_{k1} \\
&- \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{33,ab} Z^{+}_{l3+a} Z^{+}_{j3+b} Z^{+}_{i1} Z^{+}_{k1} - \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{32,ab} Z^{+}_{l1+a} Z^{+}_{i1+b} Z^{+}_{j1} Z^{+}_{k1} \\
&- \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{33,ab} Z^{+}_{l3+a} Z^{+}_{i3+b} Z^{+}_{j1} Z^{+}_{k1} - \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{32,ab} Z^{+}_{k1+a} Z^{+}_{j1+b} Z^{+}_{i1} Z^{+}_{l1} \\
&- \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{33,ab} Z^{+}_{k3+a} Z^{+}_{j3+b} Z^{+}_{i1} Z^{+}_{l1} - \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{32,ab} Z^{+}_{k1+a} Z^{+}_{i1+b} Z^{+}_{j1} Z^{+}_{l1} \\
&- \sum_{b=1}^{2}\sum_{a=1}^{2} \lambda_{33,ab} Z^{+}_{k3+a} Z^{+}_{i3+b} Z^{+}_{j1} Z^{+}_{l1} + 4 l_h Z^{+}_{i1} Z^{+}_{j1} Z^{+}_{k1} Z^{+}_{l1} \Big)
\end{aligned}
\tag{210}
$$

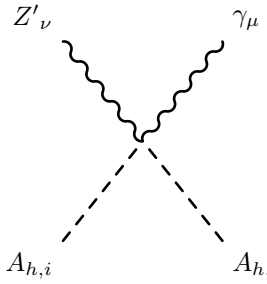
8.8 Two Scalar-Two Vector Boson-Interaction



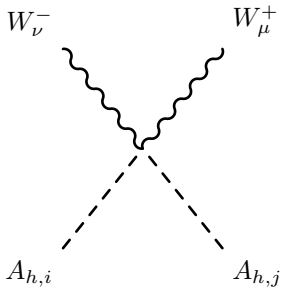
$$\Big(+ \frac{i}{2} g_1^2 \cos\Theta_W^2 Z_{i1}^A Z_{j1}^A - i g_1 g_2 \cos\Theta_W \sin\Theta_W Z_{i1}^A Z_{j1}^A + \frac{i}{2} g_2^2 \sin\Theta_W^2 Z_{i1}^A Z_{j1}^A + 50 i g_{Y\,B}^2 \cos\Theta_W^2 Z_{i2}^A Z_{j2}^A \Big) \Big(g_{\mu\nu} \Big) \tag{211}$$



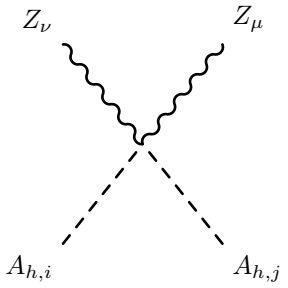
$$\Big(- \frac{i}{2} g_1 g_2 \cos\Theta_W^2 \cos\Theta'_W Z_{i1}^A Z_{j1}^A - \frac{i}{2} g_1^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i1}^A Z_{j1}^A + \frac{i}{2} g_2^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i1}^A Z_{j1}^A + \frac{i}{2} g_1 g_2 \cos\Theta'_W \sin\Theta_W^2 Z_{i1}^A Z_{j1}^A + \frac{i}{2} g_1 g_{BY} \cos\Theta_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A - \frac{i}{2} g_{BY} g_2 \sin\Theta_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A - 50 i g_{Y\,B}^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i2}^A Z_{j2}^A + 50 i g_B g_{Y\,B} \cos\Theta_W \sin\Theta'_W Z_{i2}^A Z_{j2}^A \Big) \Big(g_{\mu\nu} \Big) \tag{212}$$



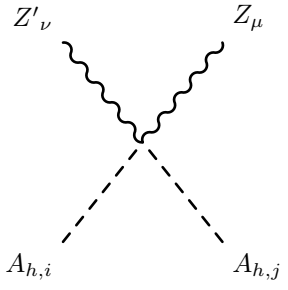
$$\Big(+ \frac{i}{2} g_1 g_{BY} \cos\Theta_W \cos\Theta'_W Z_{i1}^A Z_{j1}^A - \frac{i}{2} g_{BY} g_2 \cos\Theta'_W \sin\Theta_W Z_{i1}^A Z_{j1}^A + \frac{i}{2} g_1 g_2 \cos\Theta_W^2 \sin\Theta'_W Z_{i1}^A Z_{j1}^A + \frac{i}{2} g_1^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A - \frac{i}{2} g_2^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A - \frac{i}{2} g_1 g_2 \sin\Theta_W^2 \sin\Theta'_W Z_{i1}^A Z_{j1}^A + 50 i g_B g_{Y\,B} \cos\Theta_W \cos\Theta'_W Z_{i2}^A Z_{j2}^A + 25 i g_{Y\,B}^2 \sin 2\Theta_W \sin\Theta'_W Z_{i2}^A Z_{j2}^A \Big) \Big(g_{\mu\nu} \Big) \tag{213}$$



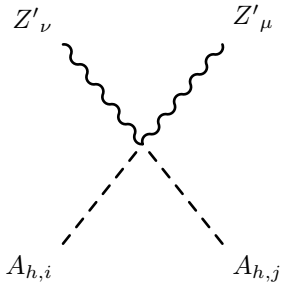
$$\frac{i}{2}g_2^2 Z_{i1}^A Z_{j1}^A \Big(g_{\mu\nu}\Big) \tag{214}$$



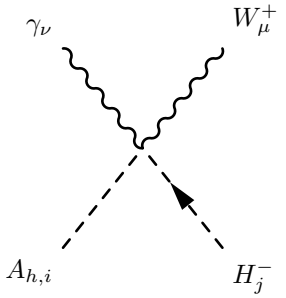
$$\begin{aligned}
&\Big(+ \frac{i}{2}g_2^2 \cos\Theta_W^2 \cos\Theta'^2_W Z_{i1}^A Z_{j1}^A + ig_1 g_2 \cos\Theta_W \cos\Theta'^2_W \sin\Theta_W Z_{i1}^A Z_{j1}^A \\
&+ \frac{i}{2}g_1^2 \cos\Theta'^2_W \sin\Theta_W^2 Z_{i1}^A Z_{j1}^A - ig_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A \\
&- ig_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i1}^A Z_{j1}^A + \frac{i}{2}g_{BY}^2 \sin\Theta'^2_W Z_{i1}^A Z_{j1}^A \\
&+ 50ig_{YB}^2 \cos\Theta'^2_W \sin\Theta_W^2 Z_{i2}^A Z_{j2}^A - 100ig_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i2}^A Z_{j2}^A \\
&+ 50ig_B^2 \sin\Theta'^2_W Z_{i2}^A Z_{j2}^A \Big) \Big(g_{\mu\nu}\Big)
\end{aligned} \tag{215}$$



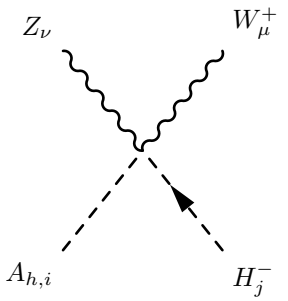
$$\Big(-\frac{i}{2} g_{BY} g_2 \cos\Theta_W \cos{\Theta'}^2_W Z^A_{i1} Z^A_{j1} - \frac{i}{2} g_1 g_{BY} \cos{\Theta'}^2_W \sin\Theta_W Z^A_{i1} Z^A_{j1}$$
$$+ \frac{i}{2} g^2_{BY} \cos\Theta'_W \sin\Theta'_W Z^A_{i1} Z^A_{j1} - \frac{i}{2} g^2_2 \cos\Theta^2_W \cos\Theta'_W \sin\Theta'_W Z^A_{i1} Z^A_{j1}$$
$$- \frac{i}{2} g^2_1 \cos\Theta'_W \sin\Theta^2_W \sin\Theta'_W Z^A_{i1} Z^A_{j1} + \frac{i}{2} g_{BY} g_2 \cos\Theta_W \sin{\Theta'}^2_W Z^A_{i1} Z^A_{j1}$$
$$+ \frac{i}{2} g_1 g_{BY} \sin\Theta_W \sin{\Theta'}^2_W Z^A_{i1} Z^A_{j1} - \frac{i}{2} g_1 g_2 \cos\Theta_W \sin\Theta_W \sin 2\Theta'_W Z^A_{i1} Z^A_{j1}$$
$$- 50 i g_B g_{YB} \cos{\Theta'}^2_W \sin\Theta_W Z^A_{i2} Z^A_{j2} + 50 i g_B g_{YB} \sin\Theta_W \sin{\Theta'}^2_W Z^A_{i2} Z^A_{j2}$$
$$+ 25 i g^2_B \sin 2\Theta'_W Z^A_{i2} Z^A_{j2} - 25 i g^2_{YB} \sin\Theta^2_W \sin 2\Theta'_W Z^A_{i2} Z^A_{j2} \Big) \Big(g_{\mu\nu} \Big) \tag{216}$$



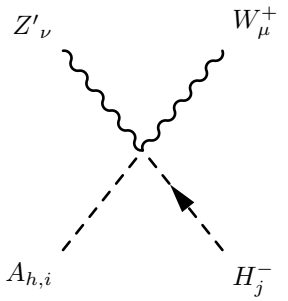
$$\Big(+ \frac{i}{2} g^2_{BY} \cos{\Theta'}^2_W Z^A_{i1} Z^A_{j1} + i g_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z^A_{i1} Z^A_{j1}$$
$$+ i g_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^A_{i1} Z^A_{j1} + \frac{i}{2} g^2_2 \cos\Theta^2_W \sin{\Theta'}^2_W Z^A_{i1} Z^A_{j1}$$
$$+ i g_1 g_2 \cos\Theta_W \sin\Theta_W \sin{\Theta'}^2_W Z^A_{i1} Z^A_{j1} + \frac{i}{2} g^2_1 \sin\Theta^2_W \sin{\Theta'}^2_W Z^A_{i1} Z^A_{j1}$$
$$+ 50 i g^2_B \cos{\Theta'}^2_W Z^A_{i2} Z^A_{j2} + 100 i g_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^A_{i2} Z^A_{j2}$$
$$+ 50 i g^2_{YB} \sin\Theta^2_W \sin{\Theta'}^2_W Z^A_{i2} Z^A_{j2} \Big) \Big(g_{\mu\nu} \Big) \tag{217}$$



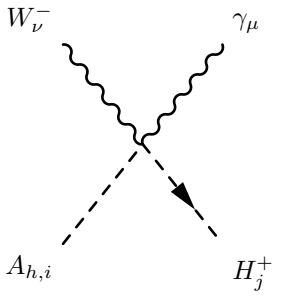
$$- \frac{1}{2} g_1 g_2 \cos\Theta_W Z^A_{i1} Z^+_{j1} \Big(g_{\mu\nu} \Big) \tag{218}$$



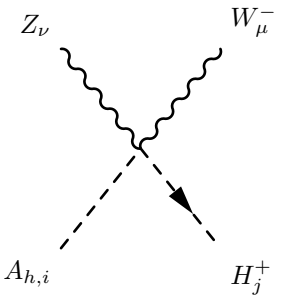
$$\Big(\frac{1}{2}g_1 g_2 \cos\Theta'_W \sin\Theta_W Z^A_{i1} Z^+_{j1} - \frac{1}{2} g_{BY} g_2 \sin\Theta'_W Z^A_{i1} Z^+_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{219}$$



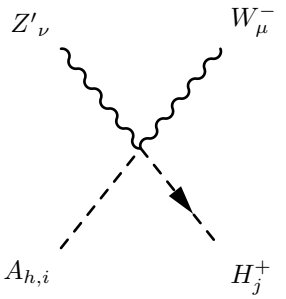
$$\Big(-\frac{1}{2}g_1 g_2 \sin\Theta_W \sin\Theta'_W Z^A_{i1} Z^+_{j1} - \frac{1}{2} g_{BY} g_2 \cos\Theta'_W Z^A_{i1} Z^+_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{220}$$



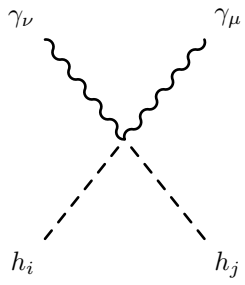
$$\frac{1}{2}g_1 g_2 \cos\Theta_W Z^A_{i1} Z^+_{j1}\Big(g_{\mu\nu}\Big) \tag{221}$$



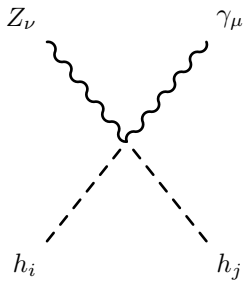
$$\Big(-\frac{1}{2} g_1 g_2 \cos\Theta'_W \sin\Theta_W Z^A_{i1} Z^+_{j1} + \frac{1}{2} g_{BY} g_2 \sin\Theta'_W Z^A_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big) \tag{222}$$



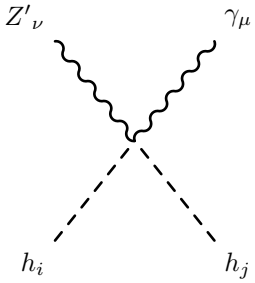
$$\Big(\frac{1}{2} g_1 g_2 \sin\Theta_W \sin\Theta'_W Z^A_{i1} Z^+_{j1} + \frac{1}{2} g_{BY} g_2 \cos\Theta'_W Z^A_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big) \tag{223}$$



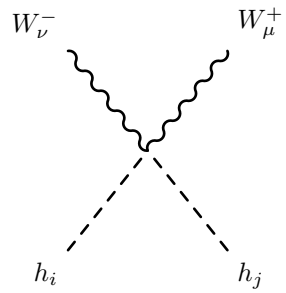
$$\begin{aligned} &\Big(+ \frac{i}{2} g_1^2 \cos\Theta_W^2 Z^H_{i1} Z^H_{j1} - i g_1 g_2 \cos\Theta_W \sin\Theta_W Z^H_{i1} Z^H_{j1} \\ &+ \frac{i}{2} g_2^2 \sin\Theta_W^2 Z^H_{i1} Z^H_{j1} + 50 i g_{YB}^2 \cos\Theta_W^2 Z^H_{i2} Z^H_{j2} \Big) \Big(g_{\mu\nu} \Big) \end{aligned} \tag{224}$$



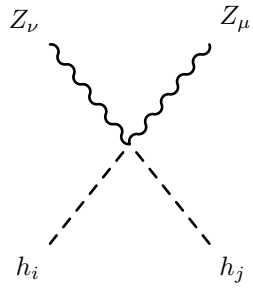
$$\Big(- \frac{i}{2} g_1 g_2 \cos\Theta_W^2 \cos\Theta'_W Z_{i1}^H Z_{j1}^H - \frac{i}{2} g_1^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i1}^H Z_{j1}^H$$
$$+ \frac{i}{2} g_2^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i1}^H Z_{j1}^H + \frac{i}{2} g_1 g_2 \cos\Theta'_W \sin\Theta_W^2 Z_{i1}^H Z_{j1}^H$$
$$+ \frac{i}{2} g_1 g_{BY} \cos\Theta_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H - \frac{i}{2} g_{BY} g_2 \sin\Theta_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H$$
$$- 50 i g_{YB}^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W Z_{i2}^H Z_{j2}^H + 50 i g_B g_{YB} \cos\Theta_W \sin\Theta'_W Z_{i2}^H Z_{j2}^H \Big) \Big(g_{\mu\nu} \Big) \tag{225}$$



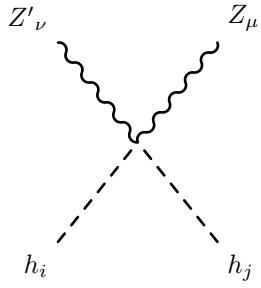
$$\Big(+ \frac{i}{2} g_1 g_{BY} \cos\Theta_W \cos\Theta'_W Z_{i1}^H Z_{j1}^H - \frac{i}{2} g_{BY} g_2 \cos\Theta'_W \sin\Theta_W Z_{i1}^H Z_{j1}^H$$
$$+ \frac{i}{2} g_1 g_2 \cos\Theta_W^2 \sin\Theta'_W Z_{i1}^H Z_{j1}^H + \frac{i}{2} g_1^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H$$
$$- \frac{i}{2} g_2^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H - \frac{i}{2} g_1 g_2 \sin\Theta_W^2 \sin\Theta'_W Z_{i1}^H Z_{j1}^H$$
$$+ 50 i g_B g_{YB} \cos\Theta_W \cos\Theta'_W Z_{i2}^H Z_{j2}^H + 25 i g_{YB}^2 \sin 2\Theta_W \sin\Theta'_W Z_{i2}^H Z_{j2}^H \Big) \Big(g_{\mu\nu} \Big) \tag{226}$$



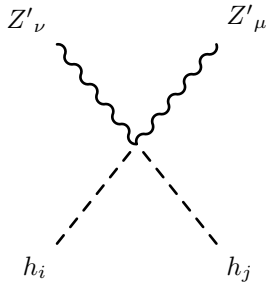
$$\frac{i}{2}g_2^2 Z_{i1}^H Z_{j1}^H \Big(g_{\mu\nu}\Big) \tag{227}$$



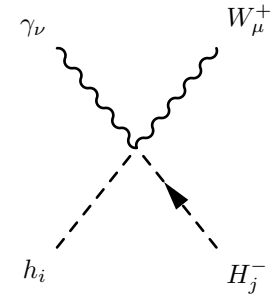
$$\begin{aligned}
&\Big(+ \frac{i}{2}g_2^2 \cos\Theta_W^2 \cos\Theta'^2_W Z_{i1}^H Z_{j1}^H + ig_1 g_2 \cos\Theta_W \cos\Theta'^2_W \sin\Theta_W Z_{i1}^H Z_{j1}^H \\
&+ \frac{i}{2}g_1^2 \cos\Theta'^2_W \sin\Theta_W^2 Z_{i1}^H Z_{j1}^H - ig_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H \\
&- ig_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i1}^H Z_{j1}^H + \frac{i}{2}g_{BY}^2 \sin\Theta'^2_W Z_{i1}^H Z_{j1}^H \\
&+ 50ig_{YB}^2 \cos\Theta'^2_W \sin\Theta_W^2 Z_{i2}^H Z_{j2}^H - 100ig_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z_{i2}^H Z_{j2}^H \\
&+ 50ig_B^2 \sin\Theta'^2_W Z_{i2}^H Z_{j2}^H \Big) \Big(g_{\mu\nu}\Big)
\end{aligned} \tag{228}$$



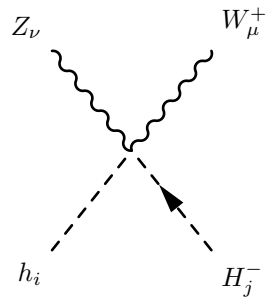
$$\Big(-\frac{i}{2} g_{BY} g_2 \cos\Theta_W \cos\Theta'^2_W Z^H_{i1} Z^H_{j1} - \frac{i}{2} g_1 g_{BY} \cos\Theta'^2_W \sin\Theta_W Z^H_{i1} Z^H_{j1}$$
$$+ \frac{i}{2} g^2_{BY} \cos\Theta'_W \sin\Theta'_W Z^H_{i1} Z^H_{j1} - \frac{i}{2} g^2_2 \cos\Theta^2_W \cos\Theta'_W \sin\Theta'_W Z^H_{i1} Z^H_{j1}$$
$$- \frac{i}{2} g^2_1 \cos\Theta'_W \sin\Theta^2_W \sin\Theta'_W Z^H_{i1} Z^H_{j1} + \frac{i}{2} g_{BY} g_2 \cos\Theta_W \sin\Theta'^2_W Z^H_{i1} Z^H_{j1}$$
$$+ \frac{i}{2} g_1 g_{BY} \sin\Theta_W \sin\Theta'^2_W Z^H_{i1} Z^H_{j1} - \frac{i}{2} g_1 g_2 \cos\Theta_W \sin\Theta_W \sin 2\Theta'_W Z^H_{i1} Z^H_{j1}$$
$$- 50 i g_B g_{YB} \cos\Theta'^2_W \sin\Theta_W Z^H_{i2} Z^H_{j2} + 50 i g_B g_{YB} \sin\Theta_W \sin\Theta'^2_W Z^H_{i2} Z^H_{j2}$$
$$+ 25 i g^2_B \sin 2\Theta'_W Z^H_{i2} Z^H_{j2} - 25 i g^2_{YB} \sin\Theta^2_W \sin 2\Theta'_W Z^H_{i2} Z^H_{j2} \Big) \Big(g_{\mu\nu} \Big) \tag{229}$$



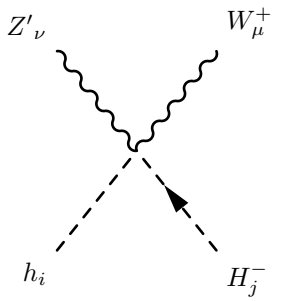
$$\Big(+ \frac{i}{2} g^2_{BY} \cos\Theta'^2_W Z^H_{i1} Z^H_{j1} + i g_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z^H_{i1} Z^H_{j1}$$
$$+ i g_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^H_{i1} Z^H_{j1} + \frac{i}{2} g^2_2 \cos\Theta^2_W \sin\Theta'^2_W Z^H_{i1} Z^H_{j1}$$
$$+ i g_1 g_2 \cos\Theta_W \sin\Theta_W \sin\Theta'^2_W Z^H_{i1} Z^H_{j1} + \frac{i}{2} g^2_1 \sin\Theta^2_W \sin\Theta'^2_W Z^H_{i1} Z^H_{j1}$$
$$+ 50 i g^2_B \cos\Theta'^2_W Z^H_{i2} Z^H_{j2} + 100 i g_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^H_{i2} Z^H_{j2}$$
$$+ 50 i g^2_{YB} \sin\Theta^2_W \sin\Theta'^2_W Z^H_{i2} Z^H_{j2} \Big) \Big(g_{\mu\nu} \Big) \tag{230}$$



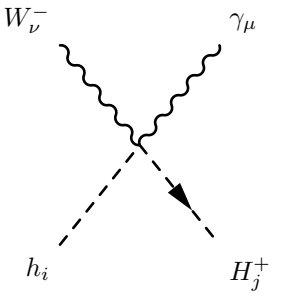
$$\frac{i}{2} g_1 g_2 \cos\Theta_W Z^H_{i1} Z^+_{j1} \Big(g_{\mu\nu} \Big) \tag{231}$$



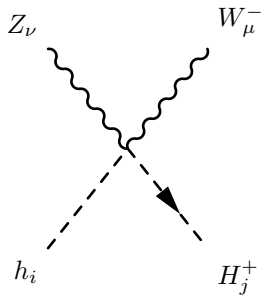
$$\Big(-\frac{i}{2} g_1 g_2 \cos\Theta'_W \sin\Theta_W Z^H_{i1} Z^+_{j1} + \frac{i}{2} g_{BY} g_2 \sin\Theta'_W Z^H_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big) \tag{232}$$



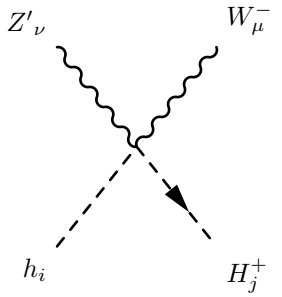
$$\Big(\frac{i}{2} g_1 g_2 \sin\Theta_W \sin\Theta'_W Z^H_{i1} Z^+_{j1} + \frac{i}{2} g_{BY} g_2 \cos\Theta'_W Z^H_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big) \tag{233}$$



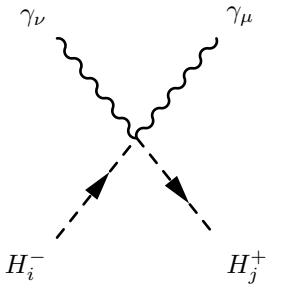
$$\frac{i}{2} g_1 g_2 \cos\Theta_W Z^H_{i1} Z^+_{j1} \Big(g_{\mu\nu} \Big) \tag{234}$$



$$\Big(-\frac{i}{2} g_1 g_2 \cos\Theta'_W \sin\Theta_W Z^H_{i1} Z^+_{j1} + \frac{i}{2} g_{BY} g_2 \sin\Theta'_W Z^H_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big) \tag{235}$$

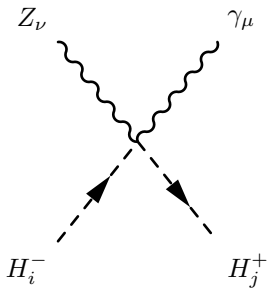


$$\Big(\frac{i}{2} g_1 g_2 \sin\Theta_W \sin\Theta'_W Z^H_{i1} Z^+_{j1} + \frac{i}{2} g_{BY} g_2 \cos\Theta'_W Z^H_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big) \tag{236}$$



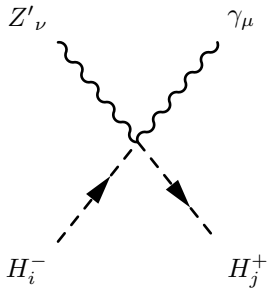
$$\Big(+ 2ig_1^2 \cos\Theta_W^2 \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} + 4ig_1 g_{YB} \cos\Theta_W^2 \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a}$$
$$+ 2ig_{YB}^2 \cos\Theta_W^2 \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} + 2ig_1^2 \cos\Theta_W^2 \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a}$$

$$- 16ig_1 g_{YB} \cos\Theta_W^2 \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+} + 32ig_{YB}^2 \cos\Theta_W^2 \sum_{a=1}^{2} Z_{i3+a}^{+} Z_{j3+a}^{+}$$
$$+ \frac{i}{2} g_1^2 \cos\Theta_W^2 Z_{i1}^{+} Z_{j1}^{+} + ig_1 g_2 \cos\Theta_W \sin\Theta_W Z_{i1}^{+} Z_{j1}^{+} + \frac{i}{2} g_2^2 \sin\Theta_W^2 Z_{i1}^{+} Z_{j1}^{+} \Big) \Big(g_{\mu\nu} \Big) \tag{237}$$



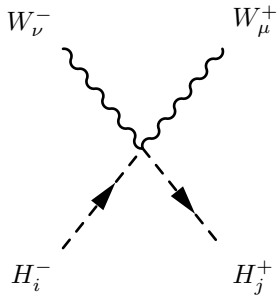
$$\Big(- 2ig_1^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W \sum_{a=1}^{2} Z_{i1+a}^{+} Z_{j1+a}^{+}$$
$$- 4ig_1 g_{YB} \cos\Theta_W \cos\Theta'_W \sin\Theta_W \sum_{a=1}^{2} Z_{i1+a}^{+} Z_{j1+a}^{+}$$
$$- 2ig_{YB}^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W \sum_{a=1}^{2} Z_{i1+a}^{+} Z_{j1+a}^{+}$$
$$+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

$$+\frac{i}{2}g_1g_2\cos\Theta_W^2\cos\Theta'_W Z_{i1}^+Z_{j1}^+ - \frac{i}{2}g_1^2\cos\Theta_W\cos\Theta'_W\sin\Theta_W Z_{i1}^+Z_{j1}^+$$
$$+\frac{i}{2}g_2^2\cos\Theta_W\cos\Theta'_W\sin\Theta_W Z_{i1}^+Z_{j1}^+ - \frac{i}{2}g_1g_2\cos\Theta'_W\sin\Theta_W^2 Z_{i1}^+Z_{j1}^+$$
$$+\frac{i}{2}g_1g_{BY}\cos\Theta_W\sin\Theta'_W Z_{i1}^+Z_{j1}^+ + \frac{i}{2}g_{BY}g_2\sin\Theta_W\sin\Theta'_W Z_{i1}^+Z_{j1}^+\Big)\Big(g_{\mu\nu}\Big) \quad (238)$$

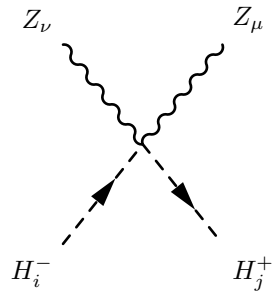


$$\Big(+2ig_1g_{BY}\cos\Theta_W\cos\Theta'_W\sum_{a=1}^{2}Z_{i1+a}^+Z_{j1+a}^+ + 2ig_1g_B\cos\Theta_W\cos\Theta'_W\sum_{a=1}^{2}Z_{i1+a}^+Z_{j1+a}^+$$
$$+2ig_{BY}g_{YB}\cos\Theta_W\cos\Theta'_W\sum_{a=1}^{2}Z_{i1+a}^+Z_{j1+a}^+ + 2ig_Bg_{YB}\cos\Theta_W\cos\Theta'_W\sum_{a=1}^{2}Z_{i1+a}^+Z_{j1+a}^+$$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

$$+\frac{i}{2}g_{BY}g_2\cos\Theta'_W\sin\Theta_W Z^+_{i1}Z^+_{j1}-\frac{i}{2}g_1g_2\cos\Theta^2_W\sin\Theta'_W Z^+_{i1}Z^+_{j1}$$
$$+\frac{i}{2}g_1^2\cos\Theta_W\sin\Theta_W\sin\Theta'_W Z^+_{i1}Z^+_{j1}-\frac{i}{2}g_2^2\cos\Theta_W\sin\Theta_W\sin\Theta'_W Z^+_{i1}Z^+_{j1}$$
$$+\frac{i}{2}g_1g_2\sin\Theta^2_W\sin\Theta'_W Z^+_{i1}Z^+_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{239}$$

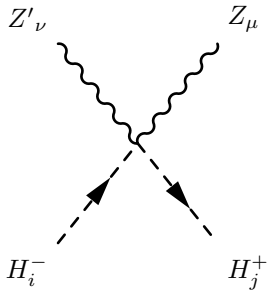


$$\frac{i}{2}g_2^2Z^+_{i1}Z^+_{j1}\Big(g_{\mu\nu}\Big) \tag{240}$$



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

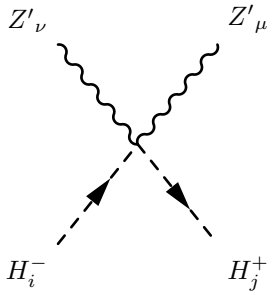
$$
\begin{aligned}
&- 4ig_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} + 2ig^2_{BY} \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} \\
&+ 4ig_{BY} g_B \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} + 2ig^2_B \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i1+a} Z^+_{j1+a} \\
&+ 2ig^2_1 \cos\Theta'^2_W \sin\Theta^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} - 16ig_1 g_{YB} \cos\Theta'^2_W \sin\Theta^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&+ 32ig^2_{YB} \cos\Theta'^2_W \sin\Theta^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&- 4ig_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&+ 16ig_1 g_B \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&+ 16ig_{BY} g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&- 64ig_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} + 2ig^2_{BY} \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&- 16ig_{BY} g_B \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} + 32ig^2_B \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&+ \frac{i}{2} g^2_2 \cos\Theta^2_W \cos\Theta'^2_W Z^+_{i1} Z^+_{j1} - ig_1 g_2 \cos\Theta_W \cos\Theta'^2_W \sin\Theta_W Z^+_{i1} Z^+_{j1} \\
&+ \frac{i}{2} g^2_1 \cos\Theta'^2_W \sin\Theta^2_W Z^+_{i1} Z^+_{j1} + ig_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z^+_{i1} Z^+_{j1} \\
&- ig_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^+_{i1} Z^+_{j1} + \frac{i}{2} g^2_{BY} \sin\Theta'^2_W Z^+_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big)
\end{aligned}
\tag{241}
$$



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

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

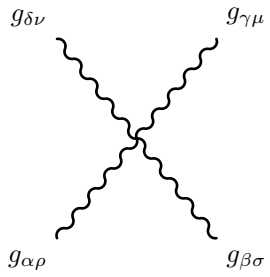
$$+\frac{i}{2}g_{BY}g_2\cos\Theta_W\cos{\Theta'}^2_W Z^+_{i1}Z^+_{j1}-\frac{i}{2}g_1g_{BY}\cos{\Theta'}^2_W\sin\Theta_W Z^+_{i1}Z^+_{j1}$$
$$+\frac{i}{2}g^2_{BY}\cos\Theta'_W\sin\Theta'_W Z^+_{i1}Z^+_{j1}-\frac{i}{2}g_2^2\cos\Theta_W^2\cos\Theta'_W\sin\Theta'_W Z^+_{i1}Z^+_{j1}$$
$$-\frac{i}{2}g_1^2\cos\Theta'_W\sin\Theta_W^2\sin\Theta'_W Z^+_{i1}Z^+_{j1}-\frac{i}{2}g_{BY}g_2\cos\Theta_W\sin{\Theta'}^2_W Z^+_{i1}Z^+_{j1}$$
$$+\frac{i}{2}g_1g_{BY}\sin\Theta_W\sin{\Theta'}^2_W Z^+_{i1}Z^+_{j1}+\frac{i}{2}g_1g_2\cos\Theta_W\sin\Theta_W\sin 2\Theta'_W Z^+_{i1}Z^+_{j1}\Big)\Big(g_{\mu\nu}\Big) \quad (242)$$



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

$$
\begin{aligned}
&- 16ig_1 g_B \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&- 16ig_{BY} g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&+ 64ig_B g_{YB} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&+ 2ig_1^2 \sin\Theta_W^2 \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} - 16ig_1 g_{YB} \sin\Theta_W^2 \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} \\
&+ 32ig_{YB}^2 \sin\Theta_W^2 \sin\Theta'^2_W \sum_{a=1}^{2} Z^+_{i3+a} Z^+_{j3+a} + \frac{i}{2} g_{BY}^2 \cos\Theta'^2_W Z^+_{i1} Z^+_{j1} \\
&- ig_{BY} g_2 \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z^+_{i1} Z^+_{j1} \\
&+ ig_1 g_{BY} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^+_{i1} Z^+_{j1} + \frac{i}{2} g_2^2 \cos\Theta_W^2 \sin\Theta'^2_W Z^+_{i1} Z^+_{j1} \\
&- ig_1 g_2 \cos\Theta_W \sin\Theta_W \sin\Theta'^2_W Z^+_{i1} Z^+_{j1} + \frac{i}{2} g_1^2 \sin\Theta_W^2 \sin\Theta'^2_W Z^+_{i1} Z^+_{j1} \Big) \Big(g_{\mu\nu} \Big)
\end{aligned} \tag{243}
$$

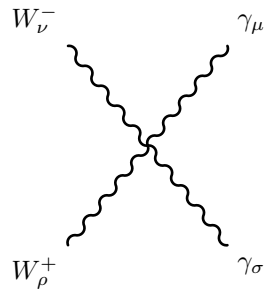
8.9 Four Vector Boson-Interaction



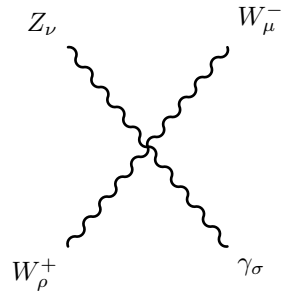
$$
ig_3^2 \Big(- \sum_{a=1}^{8} f_{\alpha,\delta,a} f_{\beta,\gamma,a} - \sum_{a=1}^{8} f_{\alpha,\gamma,a} f_{\beta,\delta,a} \Big) \Big(g_{\rho\sigma} g_{\mu\nu} \Big) \tag{244}
$$

$$
+ \; ig_3^2 \Big(- \sum_{a=1}^{8} f_{\alpha,\beta,a} f_{\gamma,\delta,a} + \sum_{a=1}^{8} f_{\alpha,\delta,a} f_{\beta,\gamma,a} \Big) \Big(g_{\rho\mu} g_{\sigma\nu} \Big) \tag{245}
$$

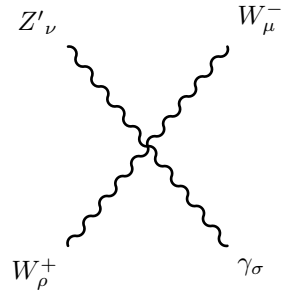
$$
+ \; ig_3^2 \Big(\sum_{a=1}^{8} f_{\alpha,\gamma,a} f_{\beta,\delta,a} + \sum_{a=1}^{8} f_{\alpha,\beta,a} f_{\gamma,\delta,a} \Big) \Big(g_{\rho\nu} g_{\sigma\mu} \Big) \tag{246}
$$



$$ig_2^2 \sin\Theta_W^2 \left(g_{\rho\sigma} g_{\mu\nu}\right) \tag{247}$$
$$+\ ig_2^2 \sin\Theta_W^2 \left(g_{\rho\mu} g_{\sigma\nu}\right) \tag{248}$$
$$+\ -2ig_2^2 \sin\Theta_W^2 \left(g_{\rho\nu} g_{\sigma\mu}\right) \tag{249}$$



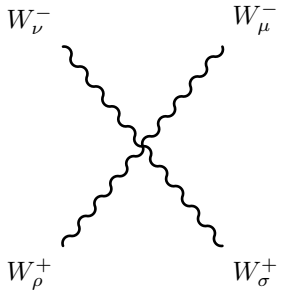
$$\frac{i}{2} g_2^2 \cos\Theta'_W \sin 2\Theta_W \left(g_{\rho\sigma} g_{\mu\nu}\right) \tag{250}$$
$$+\ -ig_2^2 \cos\Theta'_W \sin 2\Theta_W \left(g_{\rho\mu} g_{\sigma\nu}\right) \tag{251}$$
$$+\ \frac{i}{2} g_2^2 \cos\Theta'_W \sin 2\Theta_W \left(g_{\rho\nu} g_{\sigma\mu}\right) \tag{252}$$



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

$$+ \; i g_2^2 \sin 2\Theta_W \sin {\Theta'}_W \Big(g_{\rho\mu} g_{\sigma\nu} \Big) \tag{254}$$

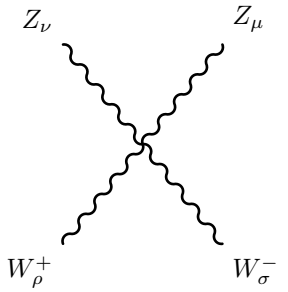
$$+ \; - \frac{i}{2} g_2^2 \sin 2\Theta_W \sin {\Theta'}_W \Big(g_{\rho\nu} g_{\sigma\mu} \Big) \tag{255}$$



$$2 i g_2^2 \Big(g_{\rho\sigma} g_{\mu\nu} \Big) \tag{256}$$

$$+ \; - i g_2^2 \Big(g_{\rho\mu} g_{\sigma\nu} \Big) \tag{257}$$

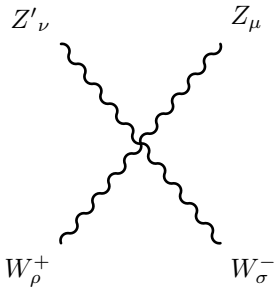
$$+ \; - i g_2^2 \Big(g_{\rho\nu} g_{\sigma\mu} \Big) \tag{258}$$



$$- 2 i g_2^2 \cos \Theta_W^2 \cos {\Theta'}_W^2 \Big(g_{\rho\sigma} g_{\mu\nu} \Big) \tag{259}$$

$$+ \; i g_2^2 \cos \Theta_W^2 \cos {\Theta'}_W^2 \Big(g_{\rho\mu} g_{\sigma\nu} \Big) \tag{260}$$

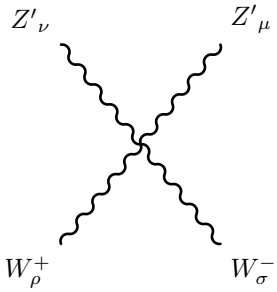
$$+ \; i g_2^2 \cos \Theta_W^2 \cos {\Theta'}_W^2 \Big(g_{\rho\nu} g_{\sigma\mu} \Big) \tag{261}$$



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

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

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

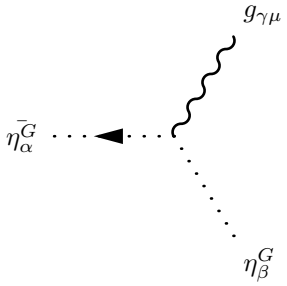


$$-\ 2ig_2^2 \cos\Theta_W^2 \sin \Theta'^2_W \left(g_{\rho\sigma} g_{\mu\nu}\right) \tag{265}$$

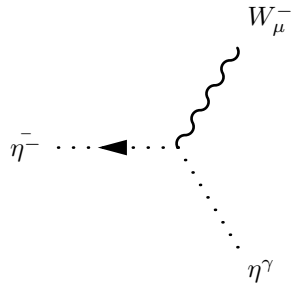
$$+\ ig_2^2 \cos\Theta_W^2 \sin \Theta'^2_W \left(g_{\rho\mu} g_{\sigma\nu}\right) \tag{266}$$

$$+\ ig_2^2 \cos\Theta_W^2 \sin \Theta'^2_W \left(g_{\rho\nu} g_{\sigma\mu}\right) \tag{267}$$

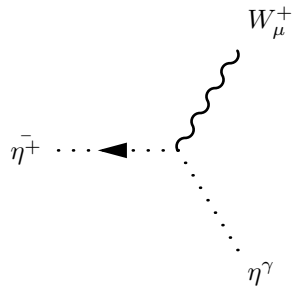
8.10 Two Ghosts-One Vector Boson-Interaction



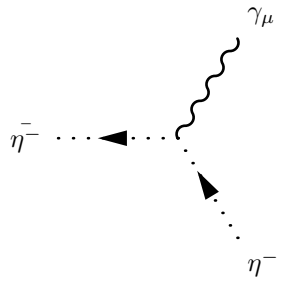
$$g_3 f_{\alpha,\beta,\gamma}\left(p_\mu^{\eta_\beta^G}\right) \tag{268}$$



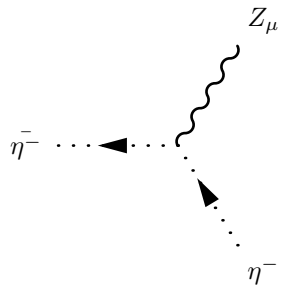
$$ig_2 \sin\Theta_W\left(p_\mu^{\eta^\gamma}\right) \tag{269}$$



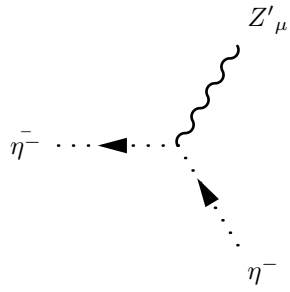
$$-ig_2 \sin\Theta_W\left(p_\mu^{\eta^\gamma}\right) \tag{270}$$



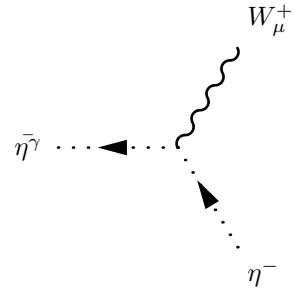
$$-ig_2 \sin\Theta_W\left(p_\mu^{\eta^-}\right) \tag{271}$$



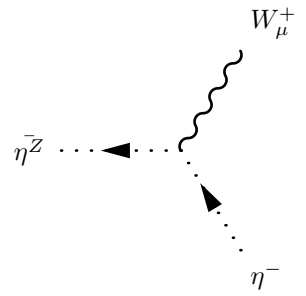
$$-ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^-}\right) \tag{272}$$



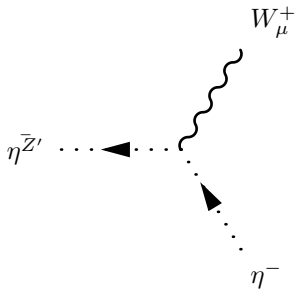
$$ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^-}\right) \tag{273}$$



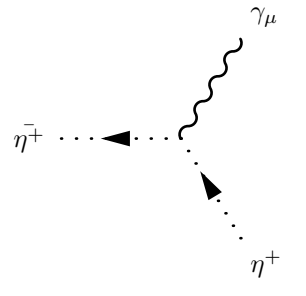
$$ig_2 \sin\Theta_W \left(p_\mu^{\eta^-}\right) \tag{274}$$



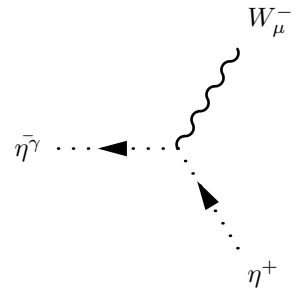
$$ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^-}\right) \tag{275}$$



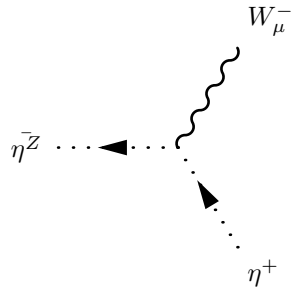
$$-ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^-}\right) \tag{276}$$



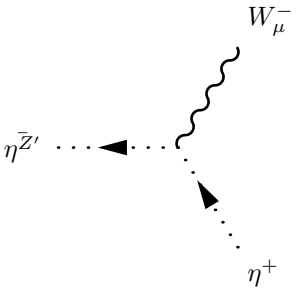
$$ig_2 \sin\Theta_W \left(p_\mu^{\eta^+}\right) \tag{277}$$



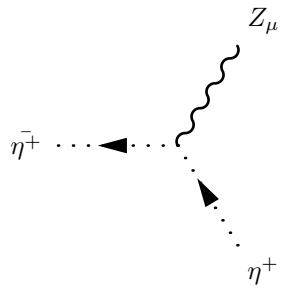
$$-ig_2 \sin\Theta_W \left(p_\mu^{\eta^+}\right) \tag{278}$$



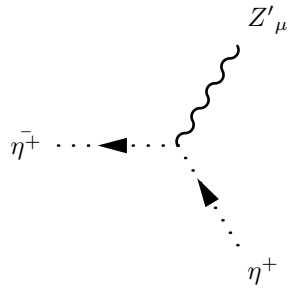
$$-ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^+}\right) \tag{279}$$



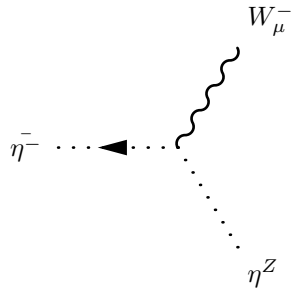
$$ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^+}\right) \tag{280}$$



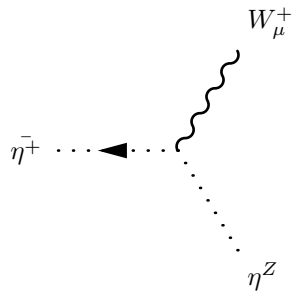
$$ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^+}\right) \tag{281}$$



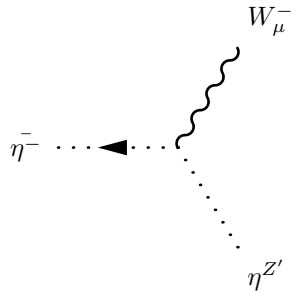
$$-ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^+}\right) \tag{282}$$



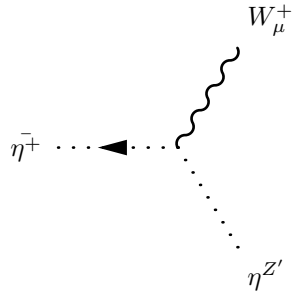
$$ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^Z}\right) \tag{283}$$



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

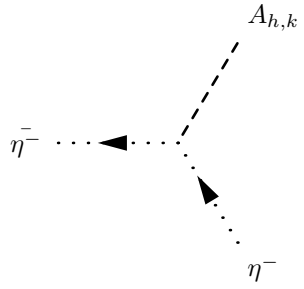


$$-ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^{Z'}}\right) \tag{285}$$

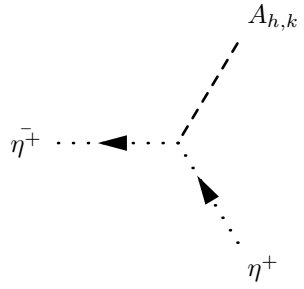


$$ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^{Z'}}\right) \tag{286}$$

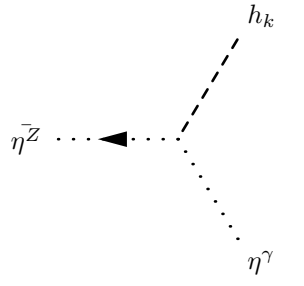
8.11 Two Ghosts-One Scalar-Interaction



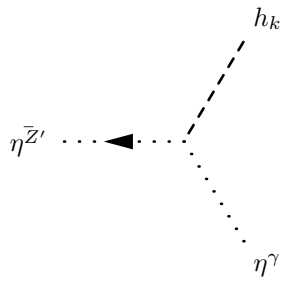
$$-\frac{1}{4}g_2^2 v \xi_{W^-} Z^A_{k1} \tag{287}$$



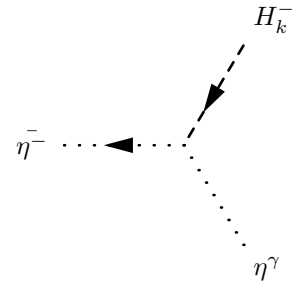
$$\frac{1}{4}g_2^2 v \xi_{W^-} Z^A_{k1} \tag{288}$$



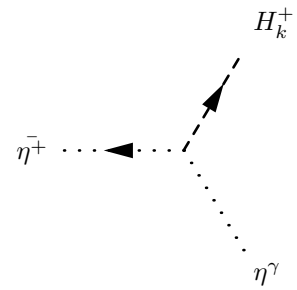
$$\begin{aligned}&\frac{i}{4}\xi_Z\Big(v\Big(g_1\cos\Theta_W - g_2\sin\Theta_W\Big)\Big(g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W - g_{BY}\sin\Theta'_W\Big)Z^H_{k1}\\&+ 50 g_{YB} x\Big(-2g_B\cos\Theta_W\sin\Theta'_W + g_{YB}\cos\Theta'_W\sin 2\Theta_W\Big)Z^H_{k2}\Big)\end{aligned} \tag{289}$$



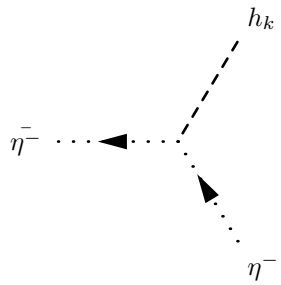
$$-\frac{i}{4}\xi_{Z'}\Big(v\Big(g_1\cos\Theta_W - g_2\sin\Theta_W\Big)\Big(\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W + g_{BY}\cos\Theta'_W\Big)Z^H_{k1}$$
$$+ 50g_{YB}x\Big(2g_B\cos\Theta_W\cos\Theta'_W + g_{YB}\sin 2\Theta_W\sin\Theta'_W\Big)Z^H_{k2}\Big) \tag{290}$$



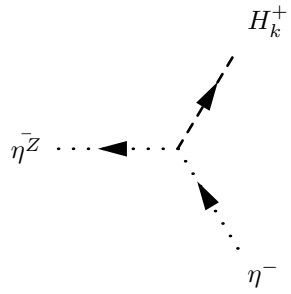
$$-\frac{i}{4}g_2 v\xi_{W^-}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)Z^+_{k1} \tag{291}$$



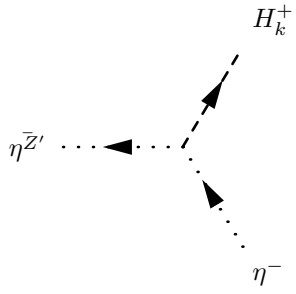
$$-\frac{i}{4}g_2 v\xi_{W^-}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)Z^+_{k1} \tag{292}$$



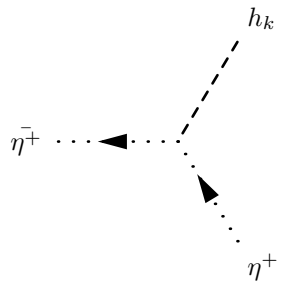
$$-\frac{i}{4}g_2^2 v \xi_{W^-} Z_{k1}^H \tag{293}$$



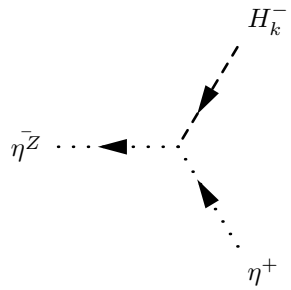
$$\frac{i}{4}g_2 v \xi_Z \Big(g_1 \cos\Theta'_W \sin\Theta_W + g_2 \cos\Theta_W \cos\Theta'_W - g_{BY} \sin\Theta'_W \Big) Z_{k1}^+ \tag{294}$$



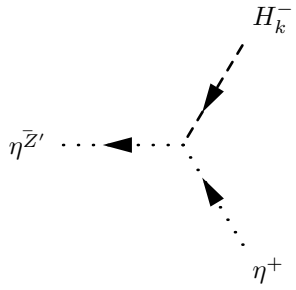
$$-\frac{i}{4}g_2 v \xi_{Z'} \Big(\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) \sin\Theta'_W + g_{BY} \cos\Theta'_W \Big) Z_{k1}^+ \tag{295}$$



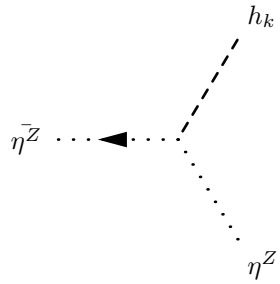
$$-\frac{i}{4}g_2^2 v\xi_{W^-}Z_{k1}^H \tag{296}$$



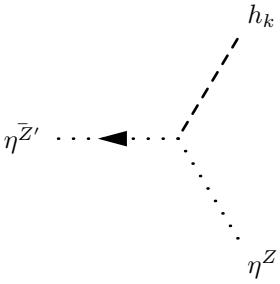
$$\frac{i}{4}g_2 v\xi_Z\Big(g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W - g_{BY}\sin\Theta'_W\Big)Z_{k1}^+ \tag{297}$$



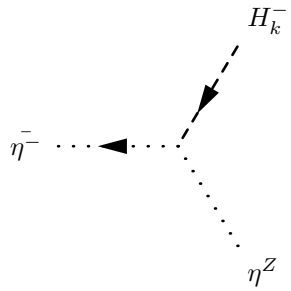
$$-\frac{i}{4}g_2 v\xi_{Z'}\Big(\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W + g_{BY}\cos\Theta'_W\Big)Z_{k1}^+ \tag{298}$$



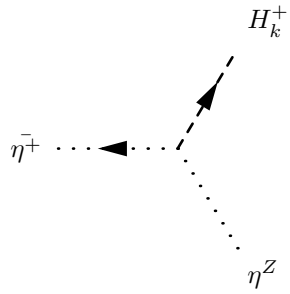
$$
\begin{aligned}
&-\frac{i}{4}\xi_Z\Big(v\Big(g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W-g_{BY}\sin\Theta'_W\Big)^2Z^H_{k1}\\
&+100x\Big(-g_B\sin\Theta'_W+g_{YB}\cos\Theta'_W\sin\Theta_W\Big)^2Z^H_{k2}\Big)
\end{aligned}
\tag{299}
$$



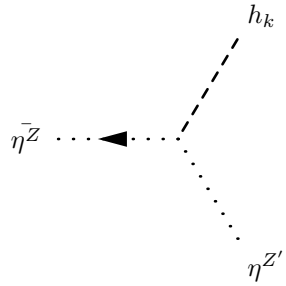
$$
\begin{aligned}
&\frac{i}{4}\xi_{Z'}\Big(v\Big(g_1g_{BY}\cos\Theta'^2_W\sin\Theta_W+g_2^2\cos\Theta^2_W\cos\Theta'_W\sin\Theta'_W\\
&+\cos\Theta'_W\Big(g_1^2\sin\Theta^2_W-g^2_{BY}\Big)\sin\Theta'_W-g_1g_{BY}\sin\Theta_W\sin\Theta'^2_W\\
&+g_2\cos\Theta_W\Big(g_1\sin\Theta_W\sin2\Theta'_W+g_{BY}\cos\Theta'^2_W-g_{BY}\sin\Theta'^2_W\Big)\Big)Z^H_{k1}\\
&-50x\Big(-2g_Bg_{YB}\cos\Theta'^2_W\sin\Theta_W+2g_Bg_{YB}\sin\Theta_W\sin\Theta'^2_W+g_B^2\sin2\Theta'_W\\
&-g^2_{YB}\sin\Theta^2_W\sin2\Theta'_W\Big)Z^H_{k2}\Big)
\end{aligned}
\tag{300}
$$



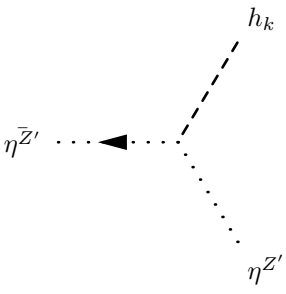
$$-\frac{i}{4}g_2 v\xi_{W^-}\Big(-g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W+g_{BY}\sin\Theta'_W\Big)Z^+_{k1} \tag{301}$$



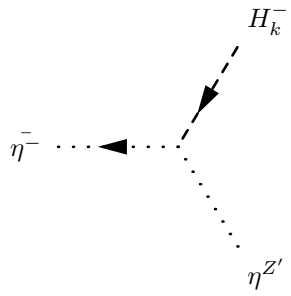
$$-\frac{i}{4}g_2 v\xi_{W^-}\Big(-g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W+g_{BY}\sin\Theta'_W\Big)Z^+_{k1} \tag{302}$$



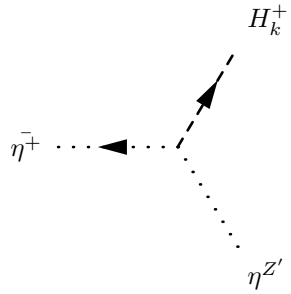
$$\begin{aligned}&\frac{i}{4}\xi_Z\Big(v\Big(g_1 g_{BY}\cos{\Theta'}^2_W\sin\Theta_W+g_2^2\cos\Theta_W^2\cos\Theta'_W\sin\Theta'_W\\&+\cos\Theta'_W\Big(g_1^2\sin\Theta_W^2-g_{BY}^2\Big)\sin\Theta'_W-g_1 g_{BY}\sin\Theta_W\sin{\Theta'}^2_W\\&+g_2\cos\Theta_W\Big(g_1\sin\Theta_W\sin2\Theta'_W+g_{BY}\cos{\Theta'}^2_W-g_{BY}\sin{\Theta'}^2_W\Big)\Big)Z^H_{k1}\\&-50x\Big(-2g_B g_{YB}\cos{\Theta'}^2_W\sin\Theta_W+2g_B g_{YB}\sin\Theta_W\sin{\Theta'}^2_W+g_B^2\sin2\Theta'_W\\&-g_{YB}^2\sin\Theta_W^2\sin2\Theta'_W\Big)Z^H_{k2}\Big)\end{aligned} \tag{303}$$



$$-\frac{i}{4}\xi_{Z'}\Big(v\Big(\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W+g_{BY}\cos\Theta'_W\Big)^2Z^H_{k1}$$
$$+100x\Big(g_B\cos\Theta'_W+g_{YB}\sin\Theta_W\sin\Theta'_W\Big)^2Z^H_{k2}\Big) \tag{304}$$



$$\frac{i}{4}g_2v\xi_{W^-}\Big(\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W-g_{BY}\cos\Theta'_W\Big)Z^+_{k1} \tag{305}$$



$$\frac{i}{4}g_2v\xi_{W^-}\Big(\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W-g_{BY}\cos\Theta'_W\Big)Z^+_{k1} \tag{306}$$

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9 Clebsch-Gordan Coefficients