NMSSM
Superpotential, Rotations and Interactions for eigenstates 'EWSB' including Renormalization Group Equations including one-loop Self-Energies

SARAH 4.6.0

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

1 Superfields

1.1 Vector Superfields

SF	Spin $\frac{1}{2}$	Spin 1	$SU(N)$	Coupling	Name
$\hat{B}$	$\lambda_{\tilde{B}}$	B	$U(1)$	g_1	hypercharge
$\hat{W}$	$\lambda_{\tilde{W}}$	W	SU(2)	g_2	left
$\hat{g}$	$\lambda_{\tilde{g}}$	g	SU(3)	g_3	color

1.2 Chiral Superfields

SF	Spin 0	Spin $\frac{1}{2}$	Generations	$(U(1) \otimes \mathrm{SU}(2) \otimes \mathrm{SU}(3))$
$\hat{q}$	$\tilde{q}$	q	3	$(\frac{1}{6}, \mathbf{2}, \mathbf{3})$
$\hat{l}$	$\tilde{l}$	l	3	$(-\frac{1}{2}, \mathbf{2}, \mathbf{1})$
$\hat{H}_d$	H_d	$\tilde{H}_d$	1	$(-\frac{1}{2}, \mathbf{2}, \mathbf{1})$
$\hat{H}_u$	H_u	$\tilde{H}_u$	1	$(\frac{1}{2}, \mathbf{2}, \mathbf{1})$
$\hat{d}$	$\tilde{d}^*_R$	d^*_R	3	$(\frac{1}{3}, \mathbf{1}, \overline{\mathbf{3}})$
$\hat{u}$	$\tilde{u}^*_R$	u^*_R	3	$(-\frac{2}{3}, \mathbf{1}, \overline{\mathbf{3}})$
$\hat{e}$	$\tilde{e}^*_R$	e^*_R	3	$(1, \mathbf{1}, \mathbf{1})$
$\hat{s}$	S	$\tilde{S}$	1	$(0, \mathbf{1}, \mathbf{1})$

2 Superpotential and Lagrangian

2.1 Superpotential

$$W = -Y_d\,\hat{d}\,\hat{q}\,\hat{H}_d\; - Y_e\,\hat{e}\,\hat{l}\,\hat{H}_d\; + \lambda\,\hat{H}_u\,\hat{H}_d\,\hat{s}\; + \frac{1}{3}\kappa\,\hat{s}\,\hat{s}\,\hat{s}\; + Y_u\,\hat{u}\,\hat{q}\,\hat{H}_u \tag{1}$$

2.2 Softbreaking terms

$$\begin{aligned}
-L_{SB,W} = &+ \frac{1}{3}S^3 T_\kappa - H_d^0 H_u^0 S T_\lambda + H_d^- H_u^+ S T_\lambda + H_d^0 \tilde{d}^*_{R,i\alpha}\delta_{\alpha\beta}\tilde{d}_{L,j\beta}T_{d,ij} - H_d^-\tilde{d}^*_{R,i\alpha}\delta_{\alpha\beta}\tilde{u}_{L,j\beta}T_{d,ij} \\
&+ H_d^0\tilde{e}^*_{R,i}\tilde{e}_{L,j}T_{e,ij} - H_d^-\tilde{e}^*_{R,i}\tilde{\nu}_{L,j}T_{e,ij} - H_u^+\tilde{u}^*_{R,i\alpha}\delta_{\alpha\beta}\tilde{d}_{L,j\beta}T_{u,ij} + H_u^0\tilde{u}^*_{R,i\alpha}\delta_{\alpha\beta}\tilde{u}_{L,j\beta}T_{u,ij} + \text{h.c.} \qquad (2) \\
-L_{SB,\phi} = &+ m^2_{H_d}|H_d^0|^2 + m^2_{H_d}|H_d^-|^2 + m^2_{H_u}|H_u^0|^2 + m^2_{H_u}|H_u^+|^2 + m_S^2|S|^2 + \tilde{d}^*_{L,i\alpha}\delta_{\alpha\beta}m^2_{q,ij}\tilde{d}_{L,j\beta} \\
&+ \tilde{d}^*_{R,i\alpha}\delta_{\alpha\beta}m^2_{d,ij}\tilde{d}_{R,j\beta} + \tilde{e}^*_{L,i}m^2_{l,ij}\tilde{e}_{L,j} + \tilde{e}^*_{R,i}m^2_{e,ij}\tilde{e}_{R,j} + \tilde{u}^*_{L,i\alpha}\delta_{\alpha\beta}m^2_{q,ij}\tilde{u}_{L,j\beta} \\
&+ \tilde{u}^*_{R,i\alpha}\delta_{\alpha\beta}m^2_{u,ij}\tilde{u}_{R,j\beta} + \tilde{\nu}^*_{L,i}m^2_{l,ij}\tilde{\nu}_{L,j} \qquad (3) \\
-L_{SB,\lambda} = &\frac{1}{2}\left(\lambda_{\tilde{B}}^2 M_1\delta_{ij} + M_2\delta_{ij}\lambda_{\tilde{W},i}\lambda_{\tilde{W},j} + M_3\delta_{ij}\lambda_{\tilde{g},\alpha}\lambda_{\tilde{g},\beta} + \text{h.c.}\right) \qquad (4)
\end{aligned}$$

2.3 Gauge fixing terms

2.3.1 Gauge fixing terms for eigenstates 'GaugeES'

$$L_{GF} = -\frac{1}{2}|\partial_\mu B|^2\xi_B^{-1} - \frac{1}{2}|\partial_\mu g|^2\xi_g^{-1} - \frac{1}{2}|\partial_\mu W|^2\xi_W^{-1} \tag{5}$$

2.3.2 Gauge fixing terms for eigenstates 'EWSB'

$$\begin{aligned} L_{GF} = &-\frac{1}{2}|\partial_\mu g|^2\xi_g^{-1} - \frac{1}{2}|\partial_\mu \gamma|^2\xi_\gamma^{-1} - |-\frac{i}{2}g_2\Big(H_d^- v_d - v_u H_u^{+,*}\Big)\xi_{W^-} + \partial_\mu W^-|^2\xi_{W^-}^{-1} \\ &-\frac{1}{2}|\frac{1}{2}\Big(2\partial_\mu Z + \Big(\sigma_d v_d - \sigma_u v_u\Big)\xi_Z\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\Big)|^2\xi_Z^{-1} \end{aligned} \tag{6}$$

2.4 Fields integrated out

None

3 Renormalization Group Equations

3.1 Anomalous Dimensions

$$\gamma_{\hat{q}}^{(1)} = -\frac{1}{30}\Big(45g_2^2 + 80g_3^2 + g_1^2\Big)\mathbf{1} + Y_d^\dagger Y_d + Y_u^\dagger Y_u \tag{7}$$

$$\begin{aligned} \gamma_{\hat{q}}^{(2)} = &+\Big(8g_2^2g_3^2 + \frac{15}{4}g_2^4 + \frac{1}{90}g_1^2\Big(16g_3^2 + 9g_2^2\Big) + \frac{199}{900}g_1^4 - \frac{8}{9}g_3^4\Big)\mathbf{1} + \frac{4}{5}g_1^2Y_u^\dagger Y_u - |\lambda|^2Y_u^\dagger Y_u \\ &- 2Y_d^\dagger Y_dY_d^\dagger Y_d - 2Y_u^\dagger Y_uY_u^\dagger Y_u + Y_d^\dagger Y_d\Big(-3\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + \frac{2}{5}g_1^2 - |\lambda|^2 - \mathrm{Tr}\Big(Y_eY_e^\dagger\Big)\Big) \\ &- 3Y_u^\dagger Y_u\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) \end{aligned} \tag{8}$$

$$\gamma_{\hat{l}}^{(1)} = -\frac{3}{10}\Big(5g_2^2 + g_1^2\Big)\mathbf{1} + Y_e^\dagger Y_e \tag{9}$$

$$\begin{aligned} \gamma_{\hat{l}}^{(2)} = &+\frac{3}{100}\Big(125g_2^4 + 30g_1^2g_2^2 + 69g_1^4\Big)\mathbf{1} - 2Y_e^\dagger Y_eY_e^\dagger Y_e \\ &+ Y_e^\dagger Y_e\Big(-3\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + \frac{6}{5}g_1^2 - |\lambda|^2 - \mathrm{Tr}\Big(Y_eY_e^\dagger\Big)\Big) \end{aligned} \tag{10}$$

$$\gamma_{\hat{H}_d}^{(1)} = 3\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - \frac{3}{10}g_1^2 - \frac{3}{2}g_2^2 + |\lambda|^2 + \mathrm{Tr}\Big(Y_eY_e^\dagger\Big) \tag{11}$$

$$\begin{aligned} \gamma_{\hat{H}_d}^{(2)} = &+\frac{207}{100}g_1^4 + \frac{9}{10}g_1^2g_2^2 + \frac{15}{4}g_2^4 - 2\lambda|\kappa|^2\lambda^* - 3\lambda^2\lambda^{*,2} - \frac{2}{5}g_1^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + 16g_3^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) \\ &+ \frac{6}{5}g_1^2\mathrm{Tr}\Big(Y_eY_e^\dagger\Big) - 3|\lambda|^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - 9\mathrm{Tr}\Big(Y_dY_d^\dagger Y_dY_d^\dagger\Big) - 3\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big) \\ &- 3\mathrm{Tr}\Big(Y_eY_e^\dagger Y_eY_e^\dagger\Big) \end{aligned} \tag{12}$$

$$\gamma_{\hat{H}_u}^{(1)} = -\frac{3}{10}\Big(-10\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 5g_2^2 + g_1^2\Big) + |\lambda|^2 \tag{13}$$

$$\gamma^{(2)}_{\hat{H}_u} = +\frac{207}{100}g_1^4 + \frac{9}{10}g_1^2g_2^2 + \frac{15}{4}g_2^4 - 2\lambda|\kappa|^2\lambda^* - 3\lambda^2\lambda^{*,2} - |\lambda|^2\Big(3\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + \mathrm{Tr}\Big(Y_eY_e^\dagger\Big)\Big)$$
$$+ \frac{4}{5}g_1^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 16g_3^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - 3\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big) - 9\mathrm{Tr}\Big(Y_uY_u^\dagger Y_uY_u^\dagger\Big) \tag{14}$$
$$\gamma^{(1)}_{\hat{d}} = 2Y_d^*Y_d^T - \frac{2}{15}\Big(20g_3^2 + g_1^2\Big)\mathbf{1} \tag{15}$$
$$\gamma^{(2)}_{\hat{d}} = +\frac{2}{225}\Big(-100g_3^4 + 101g_1^4 + 80g_1^2g_3^2\Big)\mathbf{1} - 2\Big(Y_d^*Y_d^TY_d^*Y_d^T + Y_d^*Y_u^TY_u^*Y_d^T\Big)$$
$$+ Y_d^*Y_d^T\Big(-2|\lambda|^2 - 2\mathrm{Tr}\Big(Y_eY_e^\dagger\Big) + 6g_2^2 - 6\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + \frac{2}{5}g_1^2\Big) \tag{16}$$
$$\gamma^{(1)}_{\hat{u}} = 2Y_u^*Y_u^T - \frac{8}{15}\Big(5g_3^2 + g_1^2\Big)\mathbf{1} \tag{17}$$
$$\gamma^{(2)}_{\hat{u}} = +\frac{8}{225}\Big(107g_1^4 - 25g_3^4 + 80g_1^2g_3^2\Big)\mathbf{1}$$
$$- \frac{2}{5}\Big(5\Big(Y_u^*Y_d^TY_d^*Y_u^T + Y_u^*Y_u^TY_u^*Y_u^T\Big) + Y_u^*Y_u^T\Big(-15g_2^2 + 15\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 5|\lambda|^2 + g_1^2\Big)\Big) \tag{18}$$
$$\gamma^{(1)}_{\hat{e}} = 2Y_e^*Y_e^T - \frac{6}{5}g_1^2\mathbf{1} \tag{19}$$
$$\gamma^{(2)}_{\hat{e}} = -2Y_e^*Y_e^TY_e^*Y_e^T + \frac{234}{25}g_1^4\mathbf{1} + Y_e^*Y_e^T\Big(-2|\lambda|^2 - 2\mathrm{Tr}\Big(Y_eY_e^\dagger\Big) + 6g_2^2 - 6\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - \frac{6}{5}g_1^2\Big) \tag{20}$$
$$\gamma^{(1)}_{\hat{s}} = 2\Big(|\kappa|^2 + |\lambda|^2\Big) \tag{21}$$
$$\gamma^{(2)}_{\hat{s}} = -8\kappa^2\kappa^{*,2} - 8\lambda|\kappa|^2\lambda^*$$
$$- \frac{2}{5}|\lambda|^2\Big(10\lambda\lambda^* - 15g_2^2 + 15\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + 15\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - 3g_1^2 + 5\mathrm{Tr}\Big(Y_eY_e^\dagger\Big)\Big) \tag{22}$$

3.2 Gauge Couplings

$$\beta^{(1)}_{g_1} = \frac{33}{5}g_1^3 \tag{23}$$
$$\beta^{(2)}_{g_1} = \frac{1}{25}g_1^3\Big(-130\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 135g_2^2 + 199g_1^2 - 30|\lambda|^2 + 440g_3^2 - 70\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 90\mathrm{Tr}\Big(Y_eY_e^\dagger\Big)\Big) \tag{24}$$
$$\beta^{(1)}_{g_2} = g_2^3 \tag{25}$$
$$\beta^{(2)}_{g_2} = \frac{1}{5}g_2^3\Big(-10|\lambda|^2 - 10\mathrm{Tr}\Big(Y_eY_e^\dagger\Big) + 120g_3^2 + 125g_2^2 - 30\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 30\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 9g_1^2\Big) \tag{26}$$
$$\beta^{(1)}_{g_3} = -3g_3^3 \tag{27}$$
$$\beta^{(2)}_{g_3} = \frac{1}{5}g_3^3\Big(11g_1^2 - 20\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 20\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 45g_2^2 + 70g_3^2\Big) \tag{28}$$

3.3 Gaugino Mass Parameters

$$\beta^{(1)}_{M_1} = \frac{66}{5}g_1^2M_1 \tag{29}$$

$$\beta^{(2)}_{M_1} = \frac{2}{25}g_1^2\Big(398g_1^2M_1 + 135g_2^2M_1 + 440g_3^2M_1 + 440g_3^2M_3 + 135g_2^2M_2 - 30\lambda^*\Big(M_1\lambda - T_\lambda\Big) - 70M_1\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)$$
$$- 90M_1\mathrm{Tr}\Big(Y_eY_e^\dagger\Big) - 130M_1\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 70\mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + 90\mathrm{Tr}\Big(Y_e^\dagger T_e\Big) + 130\mathrm{Tr}\Big(Y_u^\dagger T_u\Big)\Big) \tag{30}$$
$$\beta^{(1)}_{M_2} = 2g_2^2M_2 \tag{31}$$
$$\beta^{(2)}_{M_2} = \frac{2}{5}g_2^2\Big(9g_1^2M_1 + 120g_3^2M_3 + 9g_1^2M_2 + 250g_2^2M_2 + 120g_3^2M_2 - 10\lambda^*\Big(M_2\lambda - T_\lambda\Big) - 30M_2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)$$
$$- 10M_2\mathrm{Tr}\Big(Y_eY_e^\dagger\Big) - 30M_2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 30\mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + 10\mathrm{Tr}\Big(Y_e^\dagger T_e\Big) + 30\mathrm{Tr}\Big(Y_u^\dagger T_u\Big)\Big) \tag{32}$$
$$\beta^{(1)}_{M_3} = -6g_3^2M_3 \tag{33}$$
$$\beta^{(2)}_{M_3} = \frac{2}{5}g_3^2\Big(11g_1^2M_1 + 11g_1^2M_3 + 45g_2^2M_3 + 140g_3^2M_3 + 45g_2^2M_2 - 20M_3\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 20M_3\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)$$
$$+ 20\mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + 20\mathrm{Tr}\Big(Y_u^\dagger T_u\Big)\Big) \tag{34}$$

3.4 Trilinear Superpotential Parameters

$$\beta^{(1)}_{Y_d} = 3Y_dY_d^\dagger Y_d + Y_d\Big(-3g_2^2 + 3\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - \frac{16}{3}g_3^2 - \frac{7}{15}g_1^2 + |\lambda|^2 + \mathrm{Tr}\Big(Y_eY_e^\dagger\Big)\Big) + Y_dY_u^\dagger Y_u \tag{35}$$
$$\beta^{(2)}_{Y_d} = +\frac{4}{5}g_1^2Y_dY_u^\dagger Y_u - |\lambda|^2Y_dY_u^\dagger Y_u - 4Y_dY_d^\dagger Y_dY_d^\dagger Y_d - 2Y_dY_u^\dagger Y_uY_d^\dagger Y_d$$
$$- 2Y_dY_u^\dagger Y_uY_u^\dagger Y_u + Y_dY_d^\dagger Y_d\Big(-3|\lambda|^2 - 3\mathrm{Tr}\Big(Y_eY_e^\dagger\Big) + 6g_2^2 - 9\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + \frac{4}{5}g_1^2\Big)$$
$$- 3Y_dY_u^\dagger Y_u\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)$$
$$+ Y_d\Big(\frac{287}{90}g_1^4 + g_1^2g_2^2 + \frac{15}{2}g_2^4 + \frac{8}{9}g_1^2g_3^2 + 8g_2^2g_3^2 - \frac{16}{9}g_3^4 - 2\lambda|\kappa|^2\lambda^* - 3\lambda^2\lambda^{*,2}$$
$$- \frac{2}{5}g_1^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + 16g_3^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + \frac{6}{5}g_1^2\mathrm{Tr}\Big(Y_eY_e^\dagger\Big) - 3|\lambda|^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - 9\mathrm{Tr}\Big(Y_dY_d^\dagger Y_dY_d^\dagger\Big)$$
$$- 3\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big) - 3\mathrm{Tr}\Big(Y_eY_e^\dagger Y_eY_e^\dagger\Big)\Big) \tag{36}$$
$$\beta^{(1)}_{Y_e} = 3Y_eY_e^\dagger Y_e + Y_e\Big(-3g_2^2 + 3\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - \frac{9}{5}g_1^2 + |\lambda|^2 + \mathrm{Tr}\Big(Y_eY_e^\dagger\Big)\Big) \tag{37}$$
$$\beta^{(2)}_{Y_e} = -4Y_eY_e^\dagger Y_eY_e^\dagger Y_e + Y_eY_e^\dagger Y_e\Big(-3|\lambda|^2 - 3\mathrm{Tr}\Big(Y_eY_e^\dagger\Big) + 6g_2^2 - 9\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)\Big)$$
$$+ Y_e\Big(\frac{27}{2}g_1^4 + \frac{9}{5}g_1^2g_2^2 + \frac{15}{2}g_2^4 - 2\lambda|\kappa|^2\lambda^* - 3\lambda^2\lambda^{*,2} - \frac{2}{5}g_1^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + 16g_3^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)$$
$$+ \frac{6}{5}g_1^2\mathrm{Tr}\Big(Y_eY_e^\dagger\Big) - 3|\lambda|^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - 9\mathrm{Tr}\Big(Y_dY_d^\dagger Y_dY_d^\dagger\Big) - 3\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big)$$
$$- 3\mathrm{Tr}\Big(Y_eY_e^\dagger Y_eY_e^\dagger\Big)\Big) \tag{38}$$
$$\beta^{(1)}_{\lambda} = 2\lambda|\kappa|^2 - 3g_2^2\lambda + 3\lambda\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + 3\lambda\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 4\lambda^2\lambda^* - \frac{3}{5}g_1^2\lambda + \lambda\mathrm{Tr}\Big(Y_eY_e^\dagger\Big) \tag{39}$$
$$\beta^{(2)}_{\lambda} = -\frac{1}{50}\lambda\Big(-207g_1^4 - 90g_1^2g_2^2 - 375g_2^4 + 400\kappa^2\kappa^{*,2} + 600\lambda|\kappa|^2\lambda^* + 500\lambda^2\lambda^{*,2} + 20g_1^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)$$

$$
\begin{aligned}
&- 800 g_3^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 60 g_1^2 \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) \\
&- 30|\lambda|^2\Big(10 g_2^2 - 15\mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 15\mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) + 2 g_1^2 - 5\mathrm{Tr}\Big(Y_e Y_e^\dagger\Big)\Big) - 40 g_1^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) \\
&- 800 g_3^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) + 450\mathrm{Tr}\Big(Y_d Y_d^\dagger Y_d Y_d^\dagger\Big) + 300\mathrm{Tr}\Big(Y_d Y_u^\dagger Y_u Y_d^\dagger\Big) + 150\mathrm{Tr}\Big(Y_e Y_e^\dagger Y_e Y_e^\dagger\Big) \\
&+ 450\mathrm{Tr}\Big(Y_u Y_u^\dagger Y_u Y_u^\dagger\Big)\Big)
\end{aligned} \tag{40}
$$

$$
\beta_\kappa^{(1)} = 6\kappa\Big(|\kappa|^2 + |\lambda|^2\Big) \tag{41}
$$

$$
\begin{aligned}
\beta_\kappa^{(2)} = &-\frac{6}{5}\kappa\Big(20\kappa^2\kappa^{*,2} + 20\lambda|\kappa|^2\lambda^* \\
&+ |\lambda|^2\Big(10\lambda\lambda^* - 15 g_2^2 + 15\mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + 15\mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 3 g_1^2 + 5\mathrm{Tr}\Big(Y_e Y_e^\dagger\Big)\Big)\Big)
\end{aligned} \tag{42}
$$

$$
\beta_{Y_u}^{(1)} = 3 Y_u Y_u^\dagger Y_u + Y_u\Big(-3 g_2^2 + 3\mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - \frac{13}{15} g_1^2 - \frac{16}{3} g_3^2 + |\lambda|^2\Big) + Y_u Y_d^\dagger Y_d \tag{43}
$$

$$
\begin{aligned}
\beta_{Y_u}^{(2)} = &+\frac{2}{5} g_1^2 Y_u Y_u^\dagger Y_u + 6 g_2^2 Y_u Y_u^\dagger Y_u - 3|\lambda|^2 Y_u Y_u^\dagger Y_u - 2 Y_u Y_d^\dagger Y_d Y_d^\dagger Y_d \\
&- 2 Y_u Y_d^\dagger Y_d Y_u^\dagger Y_u - 4 Y_u Y_u^\dagger Y_u Y_u^\dagger Y_u \\
&+ Y_u Y_d^\dagger Y_d\Big(-3\mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + \frac{2}{5} g_1^2 - |\lambda|^2 - \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big)\Big) - 9 Y_u Y_u^\dagger Y_u \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) \\
&+ Y_u\Big(\frac{2743}{450} g_1^4 + g_1^2 g_2^2 + \frac{15}{2} g_2^4 + \frac{136}{45} g_1^2 g_3^2 + 8 g_2^2 g_3^2 - \frac{16}{9} g_3^4 - 2\lambda|\kappa|^2\lambda^* - 3\lambda^2\lambda^{*,2} \\
&- |\lambda|^2\Big(3\mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big)\Big) + \frac{4}{5} g_1^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) + 16 g_3^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 3\mathrm{Tr}\Big(Y_d Y_u^\dagger Y_u Y_d^\dagger\Big) \\
&- 9\mathrm{Tr}\Big(Y_u Y_u^\dagger Y_u Y_u^\dagger\Big)\Big)
\end{aligned} \tag{44}
$$

3.5 Trilinear Soft-Breaking Parameters

$$
\begin{aligned}
\beta_{T_d}^{(1)} = &+4 Y_d Y_d^\dagger T_d + 2 Y_d Y_u^\dagger T_u + 5 T_d Y_d^\dagger Y_d + T_d Y_u^\dagger Y_u - \frac{7}{15} g_1^2 T_d - 3 g_2^2 T_d - \frac{16}{3} g_3^2 T_d \\
&+ |\lambda|^2 T_d + 3 T_d \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + T_d \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) \\
&+ Y_d\Big(2\lambda^* T_\lambda + 2\mathrm{Tr}\Big(Y_e^\dagger T_e\Big) + 6 g_2^2 M_2 + 6\mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + \frac{14}{15} g_1^2 M_1 + \frac{32}{3} g_3^2 M_3\Big)
\end{aligned} \tag{45}
$$

$$
\begin{aligned}
\beta_{T_d}^{(2)} = &+\frac{6}{5} g_1^2 Y_d Y_d^\dagger T_d + 6 g_2^2 Y_d Y_d^\dagger T_d - 4|\lambda|^2 Y_d Y_d^\dagger T_d - \frac{8}{5} g_1^2 M_1 Y_d Y_u^\dagger Y_u \\
&+ \frac{8}{5} g_1^2 Y_d Y_u^\dagger T_u - 2|\lambda|^2 Y_d Y_u^\dagger T_u + \frac{6}{5} g_1^2 T_d Y_d^\dagger Y_d + 12 g_2^2 T_d Y_d^\dagger Y_d \\
&- 5|\lambda|^2 T_d Y_d^\dagger Y_d + \frac{4}{5} g_1^2 T_d Y_u^\dagger Y_u - |\lambda|^2 T_d Y_u^\dagger Y_u - 6 Y_d Y_d^\dagger Y_d Y_d^\dagger T_d \\
&- 8 Y_d Y_d^\dagger T_d Y_d^\dagger Y_d - 2 Y_d Y_u^\dagger Y_u Y_d^\dagger T_d - 4 Y_d Y_u^\dagger Y_u Y_u^\dagger T_u - 4 Y_d Y_u^\dagger T_u Y_d^\dagger Y_d \\
&- 4 Y_d Y_u^\dagger T_u Y_u^\dagger Y_u - 6 T_d Y_d^\dagger Y_d Y_d^\dagger Y_d - 4 T_d Y_u^\dagger Y_u Y_d^\dagger Y_d - 2 T_d Y_u^\dagger Y_u Y_u^\dagger Y_u
\end{aligned}
$$

$$
\begin{aligned}
&+\frac{287}{90}g_1^4T_d+g_1^2g_2^2T_d+\frac{15}{2}g_2^4T_d+\frac{8}{9}g_1^2g_3^2T_d+8g_2^2g_3^2T_d-\frac{16}{9}g_3^4T_d-2\lambda|\kappa|^2\lambda^*T_d\\
&-3\lambda^2\lambda^{*,2}T_d-2\lambda^*Y_dY_u^\dagger Y_uT_\lambda-12Y_dY_d^\dagger T_d\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)\\
&-15T_dY_d^\dagger Y_d\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)-\frac{2}{5}g_1^2T_d\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)+16g_3^2T_d\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)\\
&-4Y_dY_d^\dagger T_d\mathrm{Tr}\Big(Y_eY_e^\dagger\Big)-5T_dY_d^\dagger Y_d\mathrm{Tr}\Big(Y_eY_e^\dagger\Big)+\frac{6}{5}g_1^2T_d\mathrm{Tr}\Big(Y_eY_e^\dagger\Big)\\
&-6Y_dY_u^\dagger T_u\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)-3T_dY_u^\dagger Y_u\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)-3|\lambda|^2T_d\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)\\
&-\frac{2}{5}Y_dY_d^\dagger Y_d\Big(15\lambda^*T_\lambda+15\mathrm{Tr}\Big(Y_e^\dagger T_e\Big)+30g_2^2M_2+45\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)+4g_1^2M_1\Big)\\
&-6Y_dY_u^\dagger Y_u\mathrm{Tr}\Big(Y_u^\dagger T_u\Big)-9T_d\mathrm{Tr}\Big(Y_dY_d^\dagger Y_dY_d^\dagger\Big)-3T_d\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big)\\
&-3T_d\mathrm{Tr}\Big(Y_eY_e^\dagger Y_eY_e^\dagger\Big)\\
&-\frac{2}{45}Y_d\Big(287g_1^4M_1+45g_1^2g_2^2M_1+40g_1^2g_3^2M_1+40g_1^2g_3^2M_3+360g_2^2g_3^2M_3-160g_3^4M_3\\
&+45g_1^2g_2^2M_2+675g_2^4M_2+360g_2^2g_3^2M_2+270\lambda\lambda^{*,2}T_\lambda+90\kappa^*\lambda^*\Big(\kappa T_\lambda+\lambda T_\kappa\Big)\\
&-18g_1^2M_1\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)+720g_3^2M_3\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)+54g_1^2M_1\mathrm{Tr}\Big(Y_eY_e^\dagger\Big)+18g_1^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)\\
&-720g_3^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)-54g_1^2\mathrm{Tr}\Big(Y_e^\dagger T_e\Big)+135\lambda^*\Big(\lambda\mathrm{Tr}\Big(Y_u^\dagger T_u\Big)+T_\lambda\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)\Big)\\
&+810\mathrm{Tr}\Big(Y_dY_d^\dagger T_dY_d^\dagger\Big)+135\mathrm{Tr}\Big(Y_dY_u^\dagger T_uY_d^\dagger\Big)+270\mathrm{Tr}\Big(Y_eY_e^\dagger T_eY_e^\dagger\Big)+135\mathrm{Tr}\Big(Y_uY_d^\dagger T_dY_u^\dagger\Big)\Big) \qquad (46)\\
\beta_{T_e}^{(1)}&=+4Y_eY_e^\dagger T_e+5T_eY_e^\dagger Y_e-\frac{9}{5}g_1^2T_e-3g_2^2T_e+|\lambda|^2T_e+3T_e\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)+T_e\mathrm{Tr}\Big(Y_eY_e^\dagger\Big)\\
&+Y_e\Big(2\lambda^*T_\lambda+2\mathrm{Tr}\Big(Y_e^\dagger T_e\Big)+6g_2^2M_2+6\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)+\frac{18}{5}g_1^2M_1\Big) \qquad (47)\\
\beta_{T_e}^{(2)}&=+\frac{6}{5}g_1^2Y_eY_e^\dagger T_e+6g_2^2Y_eY_e^\dagger T_e-4|\lambda|^2Y_eY_e^\dagger T_e-\frac{6}{5}g_1^2T_eY_e^\dagger Y_e\\
&+12g_2^2T_eY_e^\dagger Y_e-5|\lambda|^2T_eY_e^\dagger Y_e-6Y_eY_e^\dagger Y_eY_e^\dagger T_e-8Y_eY_e^\dagger T_eY_e^\dagger Y_e\\
&-6T_eY_e^\dagger Y_eY_e^\dagger Y_e+\frac{27}{2}g_1^4T_e+\frac{9}{5}g_1^2g_2^2T_e+\frac{15}{2}g_2^4T_e-2\lambda|\kappa|^2\lambda^*T_e-3\lambda^2\lambda^{*,2}T_e\\
&-12Y_eY_e^\dagger T_e\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)-15T_eY_e^\dagger Y_e\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)-\frac{2}{5}g_1^2T_e\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)\\
&+16g_3^2T_e\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)-4Y_eY_e^\dagger T_e\mathrm{Tr}\Big(Y_eY_e^\dagger\Big)-5T_eY_e^\dagger Y_e\mathrm{Tr}\Big(Y_eY_e^\dagger\Big)\\
&+\frac{6}{5}g_1^2T_e\mathrm{Tr}\Big(Y_eY_e^\dagger\Big)-3|\lambda|^2T_e\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)\\
&-6Y_eY_e^\dagger Y_e\Big(2g_2^2M_2+3\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)+\lambda^*T_\lambda+\mathrm{Tr}\Big(Y_e^\dagger T_e\Big)\Big)-9T_e\mathrm{Tr}\Big(Y_dY_d^\dagger Y_dY_d^\dagger\Big)\\
&-3T_e\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big)-3T_e\mathrm{Tr}\Big(Y_eY_e^\dagger Y_eY_e^\dagger\Big)\\
&-\frac{2}{5}Y_e\Big(135g_1^4M_1+9g_1^2g_2^2M_1+9g_1^2g_2^2M_2+75g_2^4M_2+30\lambda\lambda^{*,2}T_\lambda+10\kappa^*\lambda^*\Big(\kappa T_\lambda+\lambda T_\kappa\Big)
\end{aligned}
$$

$$
\begin{aligned}
&- 2g_1^2 M_1 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + 80 g_3^2 M_3 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + 6 g_1^2 M_1 \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) + 2 g_1^2 \mathrm{Tr}\Big(Y_d^\dagger T_d\Big) \\
&- 80 g_3^2 \mathrm{Tr}\Big(Y_d^\dagger T_d\Big) - 6 g_1^2 \mathrm{Tr}\Big(Y_e^\dagger T_e\Big) + 15 \lambda^* \Big(\lambda \mathrm{Tr}\Big(Y_u^\dagger T_u\Big) + T_\lambda \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big)\Big) + 90 \mathrm{Tr}\Big(Y_d Y_d^\dagger T_d Y_d^\dagger\Big) \\
&+ 15 \mathrm{Tr}\Big(Y_d Y_u^\dagger T_u Y_d^\dagger\Big) + 30 \mathrm{Tr}\Big(Y_e Y_e^\dagger T_e Y_e^\dagger\Big) + 15 \mathrm{Tr}\Big(Y_u Y_d^\dagger T_d Y_u^\dagger\Big)\Big) \qquad (48)
\end{aligned}
$$

$$
\begin{aligned}
\beta_{T_\lambda}^{(1)} = &+ \frac{6}{5} g_1^2 M_1 \lambda + 6 g_2^2 M_2 \lambda + 2\kappa^* \Big(2\lambda T_\kappa + \kappa T_\lambda\Big) \\
&+ T_\lambda \Big(12 |\lambda|^2 - 3 g_2^2 + 3 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + 3 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - \frac{3}{5} g_1^2 + \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big)\Big) + 6\lambda \mathrm{Tr}\Big(Y_d^\dagger T_d\Big) \\
&+ 2\lambda \mathrm{Tr}\Big(Y_e^\dagger T_e\Big) + 6\lambda \mathrm{Tr}\Big(Y_u^\dagger T_u\Big) \qquad (49)
\end{aligned}
$$

$$
\begin{aligned}
\beta_{T_\lambda}^{(2)} = &- \frac{414}{25} g_1^4 M_1 \lambda - \frac{18}{5} g_1^2 g_2^2 M_1 \lambda - \frac{18}{5} g_1^2 g_2^2 M_2 \lambda - 30 g_2^4 M_2 \lambda + \frac{207}{50} g_1^4 T_\lambda + \frac{9}{5} g_1^2 g_2^2 T_\lambda \\
&+ \frac{15}{2} g_2^4 T_\lambda - 50 \lambda^2 \lambda^{*,2} T_\lambda - 8\kappa\kappa^{*,2} \Big(4\lambda T_\kappa + \kappa T_\lambda\Big) + \frac{4}{5} g_1^2 M_1 \lambda \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) \\
&- 32 g_3^2 M_3 \lambda \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - \frac{2}{5} g_1^2 T_\lambda \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + 16 g_3^2 T_\lambda \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - \frac{12}{5} g_1^2 M_1 \lambda \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) \\
&+ \frac{6}{5} g_1^2 T_\lambda \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) - \frac{8}{5} g_1^2 M_1 \lambda \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 32 g_3^2 M_3 \lambda \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) + \frac{4}{5} g_1^2 T_\lambda \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) \\
&+ 16 g_3^2 T_\lambda \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - \frac{4}{5} g_1^2 \lambda \mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + 32 g_3^2 \lambda \mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + \frac{12}{5} g_1^2 \lambda \mathrm{Tr}\Big(Y_e^\dagger T_e\Big) \\
&+ \frac{8}{5} g_1^2 \lambda \mathrm{Tr}\Big(Y_u^\dagger T_u\Big) + 32 g_3^2 \lambda \mathrm{Tr}\Big(Y_u^\dagger T_u\Big) \\
&- \frac{3}{5} |\lambda|^2 \Big(20\kappa^* \Big(2\lambda T_\kappa + 3\kappa T_\lambda\Big) + T_\lambda \Big(15 \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) - 30 g_2^2 + 45 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + 45 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 6 g_1^2\Big) \\
&+ 2\lambda \Big(10 g_2^2 M_2 + 15 \mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + 15 \mathrm{Tr}\Big(Y_u^\dagger T_u\Big) + 2 g_1^2 M_1 + 5 \mathrm{Tr}\Big(Y_e^\dagger T_e\Big)\Big)\Big) \\
&- 9 T_\lambda \mathrm{Tr}\Big(Y_d Y_d^\dagger Y_d Y_d^\dagger\Big) - 36 \lambda \mathrm{Tr}\Big(Y_d Y_d^\dagger T_d Y_d^\dagger\Big) - 6 T_\lambda \mathrm{Tr}\Big(Y_d Y_u^\dagger Y_u Y_d^\dagger\Big) - 12 \lambda \mathrm{Tr}\Big(Y_d Y_u^\dagger T_u Y_d^\dagger\Big) \\
&- 3 T_\lambda \mathrm{Tr}\Big(Y_e Y_e^\dagger Y_e Y_e^\dagger\Big) - 12 \lambda \mathrm{Tr}\Big(Y_e Y_e^\dagger T_e Y_e^\dagger\Big) - 12 \lambda \mathrm{Tr}\Big(Y_u Y_d^\dagger T_d Y_u^\dagger\Big) - 9 T_\lambda \mathrm{Tr}\Big(Y_u Y_u^\dagger Y_u Y_u^\dagger\Big) \\
&- 36 \lambda \mathrm{Tr}\Big(Y_u Y_u^\dagger T_u Y_u^\dagger\Big) \qquad (50)
\end{aligned}
$$

$$
\beta_{T_\kappa}^{(1)} = 6\Big(3|\kappa|^2 T_\kappa + \lambda^* \Big(2\kappa T_\lambda + \lambda T_\kappa\Big)\Big) \qquad (51)
$$

$$
\begin{aligned}
\beta_{T_\kappa}^{(2)} = &- \frac{6}{5} \Big(100 \kappa^2 \kappa^{*,2} T_\kappa + 10 \lambda \lambda^{*,2} \Big(4\kappa T_\lambda + \lambda T_\kappa\Big) \\
&+ \lambda^* \Big(\lambda T_\kappa \Big(-15 g_2^2 + 15 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + 15 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 3 g_1^2 + 5 \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) + 60 |\kappa|^2\Big) \\
&+ 2\kappa \Big(T_\lambda \Big(-15 g_2^2 + 15 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + 15 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) + 20 |\kappa|^2 - 3 g_1^2 + 5 \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big)\Big) \\
&+ \lambda \Big(15 g_2^2 M_2 + 15 \mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + 15 \mathrm{Tr}\Big(Y_u^\dagger T_u\Big) + 3 g_1^2 M_1 + 5 \mathrm{Tr}\Big(Y_e^\dagger T_e\Big)\Big)\Big)\Big)\Big) \qquad (52)
\end{aligned}
$$

$$
\begin{aligned}
\beta_{T_u}^{(1)} = &+ 2 Y_u Y_d^\dagger T_d + 4 Y_u Y_u^\dagger T_u + T_u Y_d^\dagger Y_d + 5 T_u Y_u^\dagger Y_u - \frac{13}{15} g_1^2 T_u - 3 g_2^2 T_u - \frac{16}{3} g_3^2 T_u \\
&+ |\lambda|^2 T_u + 3 T_u \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) + Y_u \Big(2\lambda^* T_\lambda + 6 g_2^2 M_2 + 6 \mathrm{Tr}\Big(Y_u^\dagger T_u\Big) + \frac{26}{15} g_1^2 M_1 + \frac{32}{3} g_3^2 M_3\Big) \qquad (53)
\end{aligned}
$$

$$
\begin{aligned}
\beta^{(2)}_{T_u} =& +\frac{4}{5}g_1^2 Y_u Y_d^\dagger T_d - 2|\lambda|^2 Y_u Y_d^\dagger T_d - \frac{4}{5}g_1^2 M_1 Y_u Y_u^\dagger Y_u - 12 g_2^2 M_2 Y_u Y_u^\dagger Y_u \\
&+ \frac{6}{5}g_1^2 Y_u Y_u^\dagger T_u + 6 g_2^2 Y_u Y_u^\dagger T_u - 4|\lambda|^2 Y_u Y_u^\dagger T_u + \frac{2}{5}g_1^2 T_u Y_d^\dagger Y_d \\
&- |\lambda|^2 T_u Y_d^\dagger Y_d + 12 g_2^2 T_u Y_u^\dagger Y_u - 5|\lambda|^2 T_u Y_u^\dagger Y_u - 4 Y_u Y_d^\dagger Y_d Y_d^\dagger T_d \\
&- 2 Y_u Y_d^\dagger Y_d Y_u^\dagger T_u - 4 Y_u Y_d^\dagger T_d Y_d^\dagger Y_d - 4 Y_u Y_d^\dagger T_d Y_u^\dagger Y_u - 6 Y_u Y_u^\dagger Y_u Y_u^\dagger T_u \\
&- 8 Y_u Y_u^\dagger T_u Y_u^\dagger Y_u - 2 T_u Y_d^\dagger Y_d Y_d^\dagger Y_d - 4 T_u Y_d^\dagger Y_d Y_u^\dagger Y_u - 6 T_u Y_u^\dagger Y_u Y_u^\dagger Y_u + \frac{2743}{450}g_1^4 T_u \\
&+ g_1^2 g_2^2 T_u + \frac{15}{2}g_2^4 T_u + \frac{136}{45}g_1^2 g_3^2 T_u + 8 g_2^2 g_3^2 T_u - \frac{16}{9}g_3^4 T_u - 2\lambda|\kappa|^2 \lambda^* T_u - 3\lambda^2 \lambda^{*,2} T_u \\
&- 6\lambda^* Y_u Y_u^\dagger Y_u T_\lambda - 6 Y_u Y_d^\dagger T_d \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 3 T_u Y_d^\dagger Y_d \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) \\
&- 3|\lambda|^2 T_u \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 2 Y_u Y_d^\dagger T_d \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) - T_u Y_d^\dagger Y_d \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) \\
&- |\lambda|^2 T_u \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) - 12 Y_u Y_u^\dagger T_u \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 15 T_u Y_u^\dagger Y_u \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) \\
&+ \frac{4}{5}g_1^2 T_u \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) + 16 g_3^2 T_u \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) \\
&- \frac{2}{5}Y_u Y_d^\dagger Y_d \Big(15 \mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + 2 g_1^2 M_1 + 5\lambda^* T_\lambda + 5 \mathrm{Tr}\Big(Y_e^\dagger T_e\Big)\Big) - 18 Y_u Y_u^\dagger Y_u \mathrm{Tr}\Big(Y_u^\dagger T_u\Big) \\
&- 3 T_u \mathrm{Tr}\Big(Y_d Y_u^\dagger Y_u Y_d^\dagger\Big) - 9 T_u \mathrm{Tr}\Big(Y_u Y_u^\dagger Y_u Y_u^\dagger\Big) \\
&- \frac{2}{225}Y_u \Big(2743 g_1^4 M_1 + 225 g_1^2 g_2^2 M_1 + 680 g_1^2 g_3^2 M_1 + 680 g_1^2 g_3^2 M_3 + 1800 g_2^2 g_3^2 M_3 - 800 g_3^4 M_3 \\
&+ 225 g_1^2 g_2^2 M_2 + 3375 g_2^4 M_2 + 1800 g_2^2 g_3^2 M_2 + 1350 \lambda \lambda^{*,2} T_\lambda + 450 \kappa^* \lambda^* \Big(\kappa T_\lambda + \lambda T_\kappa\Big) \\
&+ 180 g_1^2 M_1 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) + 3600 g_3^2 M_3 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) \\
&+ 225 \lambda^* \Big(\lambda \Big(3 \mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + \mathrm{Tr}\Big(Y_e^\dagger T_e\Big)\Big) + T_\lambda \Big(3 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big)\Big)\Big) - 180 g_1^2 \mathrm{Tr}\Big(Y_u^\dagger T_u\Big) \\
&- 3600 g_3^2 \mathrm{Tr}\Big(Y_u^\dagger T_u\Big) + 675 \mathrm{Tr}\Big(Y_d Y_u^\dagger T_u Y_d^\dagger\Big) + 675 \mathrm{Tr}\Big(Y_u Y_d^\dagger T_d Y_u^\dagger\Big) + 4050 \mathrm{Tr}\Big(Y_u Y_u^\dagger T_u Y_u^\dagger\Big)\Big)
\end{aligned} \tag{54}
$$

3.6 Soft-Breaking Scalar Masses

$$
\sigma_{1,1} = \sqrt{\frac{3}{5}}g_1 \Big(-2 \mathrm{Tr}\Big(m_u^2\Big) - \mathrm{Tr}\Big(m_l^2\Big) - m_{H_d}^2 + m_{H_u}^2 + \mathrm{Tr}\Big(m_d^2\Big) + \mathrm{Tr}\Big(m_e^2\Big) + \mathrm{Tr}\Big(m_q^2\Big)\Big) \tag{55}
$$

$$
\sigma_{2,11} = \frac{1}{10}g_1^2 \Big(2 \mathrm{Tr}\Big(m_d^2\Big) + 3 \mathrm{Tr}\Big(m_l^2\Big) + 3 m_{H_d}^2 + 3 m_{H_u}^2 + 6 \mathrm{Tr}\Big(m_e^2\Big) + 8 \mathrm{Tr}\Big(m_u^2\Big) + \mathrm{Tr}\Big(m_q^2\Big)\Big) \tag{56}
$$

$$
\begin{aligned}
\sigma_{3,1} =& \frac{1}{20}\frac{1}{\sqrt{15}}g_1 \Big(-9 g_1^2 m_{H_d}^2 - 45 g_2^2 m_{H_d}^2 + 9 g_1^2 m_{H_u}^2 + 45 g_2^2 m_{H_u}^2 + 30 \Big(-m_{H_u}^2 + m_{H_d}^2\Big)|\lambda|^2 + 4 \Big(20 g_3^2 + g_1^2\Big) \mathrm{Tr}\Big(m_d^2\Big) \\
&+ 36 g_1^2 \mathrm{Tr}\Big(m_e^2\Big) - 9 g_1^2 \mathrm{Tr}\Big(m_l^2\Big) - 45 g_2^2 \mathrm{Tr}\Big(m_l^2\Big) + g_1^2 \mathrm{Tr}\Big(m_q^2\Big) + 45 g_2^2 \mathrm{Tr}\Big(m_q^2\Big) + 80 g_3^2 \mathrm{Tr}\Big(m_q^2\Big) \\
&- 32 g_1^2 \mathrm{Tr}\Big(m_u^2\Big) - 160 g_3^2 \mathrm{Tr}\Big(m_u^2\Big) + 90 m_{H_d}^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + 30 m_{H_d}^2 \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) - 90 m_{H_u}^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big)
\end{aligned}
$$

$$- 60\mathrm{Tr}\Big(Y_d Y_d^\dagger m_d^{2*}\Big) - 30\mathrm{Tr}\Big(Y_d m_q^{2*} Y_d^\dagger\Big) - 60\mathrm{Tr}\Big(Y_e Y_e^\dagger m_e^{2*}\Big) + 30\mathrm{Tr}\Big(Y_e m_l^{2*} Y_e^\dagger\Big)$$
$$+ 120\mathrm{Tr}\Big(Y_u Y_u^\dagger m_u^{2*}\Big) - 30\mathrm{Tr}\Big(Y_u m_q^{2*} Y_u^\dagger\Big)\Big) \tag{57}$$

$$\sigma_{2,2} = \frac{1}{2}\Big(3\mathrm{Tr}\Big(m_q^2\Big) + m_{H_d}^2 + m_{H_u}^2 + \mathrm{Tr}\Big(m_l^2\Big)\Big) \tag{58}$$

$$\sigma_{2,3} = \frac{1}{2}\Big(2\mathrm{Tr}\Big(m_q^2\Big) + \mathrm{Tr}\Big(m_d^2\Big) + \mathrm{Tr}\Big(m_u^2\Big)\Big) \tag{59}$$

$$\beta^{(1)}_{m_q^2} = -\frac{2}{15}g_1^2\mathbf{1}|M_1|^2 - \frac{32}{3}g_3^2\mathbf{1}|M_3|^2 - 6g_2^2\mathbf{1}|M_2|^2 + 2m_{H_d}^2 Y_d^\dagger Y_d + 2m_{H_u}^2 Y_u^\dagger Y_u + 2T_d^\dagger T_d$$
$$+ 2T_u^\dagger T_u + m_q^2 Y_d^\dagger Y_d + m_q^2 Y_u^\dagger Y_u + 2Y_d^\dagger m_d^2 Y_d + Y_d^\dagger Y_d m_q^2 + 2Y_u^\dagger m_u^2 Y_u$$
$$+ Y_u^\dagger Y_u m_q^2 + \frac{1}{\sqrt{15}}g_1\mathbf{1}\sigma_{1,1} \tag{60}$$

$$\beta^{(2)}_{m_q^2} = +\frac{2}{5}g_1^2 g_2^2\mathbf{1}|M_2|^2 + 33g_2^4\mathbf{1}|M_2|^2 + 32g_2^2 g_3^2\mathbf{1}|M_2|^2$$
$$+ \frac{16}{45}g_3^2\Big(15\Big(3g_2^2\Big(2M_3 + M_2\Big) - 8g_3^2 M_3\Big) + g_1^2\Big(2M_3 + M_1\Big)\Big)\mathbf{1}M_3^* + \frac{1}{5}g_1^2 g_2^2 M_1\mathbf{1}M_2^* + 16g_2^2 g_3^2 M_3\mathbf{1}M_2^*$$
$$+ \frac{4}{5}g_1^2 m_{H_d}^2 Y_d^\dagger Y_d - 4m_{H_d}^2|\lambda|^2 Y_d^\dagger Y_d - 2m_{H_u}^2|\lambda|^2 Y_d^\dagger Y_d$$
$$- 2m_S^2|\lambda|^2 Y_d^\dagger Y_d - 2|T_\lambda|^2 Y_d^\dagger Y_d - 2\lambda T_\lambda^* Y_d^\dagger T_d + \frac{8}{5}g_1^2 m_{H_u}^2 Y_u^\dagger Y_u$$
$$- 2m_{H_d}^2|\lambda|^2 Y_u^\dagger Y_u - 4m_{H_u}^2|\lambda|^2 Y_u^\dagger Y_u - 2m_S^2|\lambda|^2 Y_u^\dagger Y_u - 2|T_\lambda|^2 Y_u^\dagger Y_u$$
$$+ \frac{1}{225}g_1^2 M_1^*\Big(\Big(5\Big(16g_3^2\Big(2M_1 + M_3\Big) + 9g_2^2\Big(2M_1 + M_2\Big)\Big) + 597g_1^2 M_1\Big)\mathbf{1}$$
$$+ 180\Big(2M_1 Y_d^\dagger Y_d - 2Y_u^\dagger T_u + 4M_1 Y_u^\dagger Y_u - Y_d^\dagger T_d\Big)\Big)$$
$$- 2\lambda T_\lambda^* Y_u^\dagger T_u - \frac{4}{5}g_1^2 M_1 T_d^\dagger Y_d + \frac{4}{5}g_1^2 T_d^\dagger T_d - 2|\lambda|^2 T_d^\dagger T_d$$
$$- \frac{8}{5}g_1^2 M_1 T_u^\dagger Y_u + \frac{8}{5}g_1^2 T_u^\dagger T_u - 2|\lambda|^2 T_u^\dagger T_u + \frac{2}{5}g_1^2 m_q^2 Y_d^\dagger Y_d$$
$$- |\lambda|^2 m_q^2 Y_d^\dagger Y_d + \frac{4}{5}g_1^2 m_q^2 Y_u^\dagger Y_u - |\lambda|^2 m_q^2 Y_u^\dagger Y_u + \frac{4}{5}g_1^2 Y_d^\dagger m_d^2 Y_d$$
$$- 2|\lambda|^2 Y_d^\dagger m_d^2 Y_d + \frac{2}{5}g_1^2 Y_d^\dagger Y_d m_q^2 - |\lambda|^2 Y_d^\dagger Y_d m_q^2 + \frac{8}{5}g_1^2 Y_u^\dagger m_u^2 Y_u$$
$$- 2|\lambda|^2 Y_u^\dagger m_u^2 Y_u + \frac{4}{5}g_1^2 Y_u^\dagger Y_u m_q^2 - |\lambda|^2 Y_u^\dagger Y_u m_q^2 - 8m_{H_d}^2 Y_d^\dagger Y_d Y_d^\dagger Y_d$$
$$- 4Y_d^\dagger Y_d T_d^\dagger T_d - 4Y_d^\dagger T_d T_d^\dagger Y_d - 8m_{H_u}^2 Y_u^\dagger Y_u Y_u^\dagger Y_u - 4Y_u^\dagger Y_u T_u^\dagger T_u$$
$$- 4Y_u^\dagger T_u T_u^\dagger Y_u - 4T_d^\dagger Y_d Y_d^\dagger T_d - 4T_d^\dagger T_d Y_d^\dagger Y_d - 4T_u^\dagger Y_u Y_u^\dagger T_u$$
$$- 4T_u^\dagger T_u Y_u^\dagger Y_u - 2m_q^2 Y_d^\dagger Y_d Y_d^\dagger Y_d - 2m_q^2 Y_u^\dagger Y_u Y_u^\dagger Y_u - 4Y_d^\dagger m_d^2 Y_d Y_d^\dagger Y_d$$
$$- 4Y_d^\dagger Y_d m_q^2 Y_d^\dagger Y_d - 4Y_d^\dagger Y_d Y_d^\dagger m_d^2 Y_d - 2Y_d^\dagger Y_d Y_d^\dagger Y_d m_q^2 - 4Y_u^\dagger m_u^2 Y_u Y_u^\dagger Y_u$$
$$- 4Y_u^\dagger Y_u m_q^2 Y_u^\dagger Y_u - 4Y_u^\dagger Y_u Y_u^\dagger m_u^2 Y_u - 2Y_u^\dagger Y_u Y_u^\dagger Y_u m_q^2 - 2\lambda^* T_d^\dagger Y_d T_\lambda$$

$$
\begin{aligned}
&- 2\lambda^* T_u^\dagger Y_u T_\lambda + 6 g_2^4 \mathbf{1}\sigma_{2,2} + \frac{32}{3} g_3^4 \mathbf{1}\sigma_{2,3} + \frac{2}{15} g_1^2 \mathbf{1}\sigma_{2,11} + 4\frac{1}{\sqrt{15}} g_1 \mathbf{1}\sigma_{3,1} \\
&- 12 m_{H_d}^2 Y_d^\dagger Y_d \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 6 T_d^\dagger T_d \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 3 m_q^2 Y_d^\dagger Y_d \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) \\
&- 6 Y_d^\dagger m_d^2 Y_d \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 3 Y_d^\dagger Y_d m_q^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 4 m_{H_d}^2 Y_d^\dagger Y_d \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) \\
&- 2 T_d^\dagger T_d \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) - m_q^2 Y_d^\dagger Y_d \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) - 2 Y_d^\dagger m_d^2 Y_d \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) \\
&- Y_d^\dagger Y_d m_q^2 \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) - 12 m_{H_u}^2 Y_u^\dagger Y_u \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 6 T_u^\dagger T_u \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) \\
&- 3 m_q^2 Y_u^\dagger Y_u \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 6 Y_u^\dagger m_u^2 Y_u \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 3 Y_u^\dagger Y_u m_q^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) \\
&- 6 T_d^\dagger Y_d \mathrm{Tr}\Big(Y_d^\dagger T_d\Big) - 2 T_d^\dagger Y_d \mathrm{Tr}\Big(Y_e^\dagger T_e\Big) - 6 T_u^\dagger Y_u \mathrm{Tr}\Big(Y_u^\dagger T_u\Big) \\
&- 6 Y_d^\dagger T_d \mathrm{Tr}\Big(T_d^* Y_d^T\Big) - 6 Y_d^\dagger Y_d \mathrm{Tr}\Big(T_d^* T_d^T\Big) - 2 Y_d^\dagger T_d \mathrm{Tr}\Big(T_e^* Y_e^T\Big) \\
&- 2 Y_d^\dagger Y_d \mathrm{Tr}\Big(T_e^* T_e^T\Big) - 6 Y_u^\dagger T_u \mathrm{Tr}\Big(T_u^* Y_u^T\Big) - 6 Y_u^\dagger Y_u \mathrm{Tr}\Big(T_u^* T_u^T\Big) \\
&- 6 Y_d^\dagger Y_d \mathrm{Tr}\Big(m_d^2 Y_d Y_d^\dagger\Big) - 2 Y_d^\dagger Y_d \mathrm{Tr}\Big(m_e^2 Y_e Y_e^\dagger\Big) - 2 Y_d^\dagger Y_d \mathrm{Tr}\Big(m_l^2 Y_e^\dagger Y_e\Big) \\
&- 6 Y_d^\dagger Y_d \mathrm{Tr}\Big(m_q^2 Y_d^\dagger Y_d\Big) - 6 Y_u^\dagger Y_u \mathrm{Tr}\Big(m_q^2 Y_u^\dagger Y_u\Big) - 6 Y_u^\dagger Y_u \mathrm{Tr}\Big(m_u^2 Y_u Y_u^\dagger\Big)
\end{aligned} \tag{61}
$$

$$
\begin{aligned}
\beta_{m_l^2}^{(1)} = &- \frac{6}{5} g_1^2 \mathbf{1} |M_1|^2 - 6 g_2^2 \mathbf{1} |M_2|^2 + 2 m_{H_d}^2 Y_e^\dagger Y_e + 2 T_e^\dagger T_e + m_l^2 Y_e^\dagger Y_e + 2 Y_e^\dagger m_e^2 Y_e \\
&+ Y_e^\dagger Y_e m_l^2 - \sqrt{\frac{3}{5}} g_1 \mathbf{1} \sigma_{1,1}
\end{aligned} \tag{62}
$$

$$
\begin{aligned}
\beta_{m_l^2}^{(2)} = &+ \frac{3}{5} g_2^2 \Big(3 g_1^2 \Big(2M_2 + M_1\Big) + 55 g_2^2 M_2\Big) \mathbf{1} M_2^* + \frac{12}{5} g_1^2 m_{H_d}^2 Y_e^\dagger Y_e - 4 m_{H_d}^2 |\lambda|^2 Y_e^\dagger Y_e \\
&- 2 m_{H_u}^2 |\lambda|^2 Y_e^\dagger Y_e - 2 m_S^2 |\lambda|^2 Y_e^\dagger Y_e - 2 |T_\lambda|^2 Y_e^\dagger Y_e \\
&+ \frac{3}{25} g_1^2 M_1^* \Big(- 20 Y_e^\dagger T_e + 3 \Big(5 g_2^2 \Big(2M_1 + M_2\Big) + 69 g_1^2 M_1\Big) \mathbf{1} + 40 M_1 Y_e^\dagger Y_e\Big) - 2\lambda T_\lambda^* Y_e^\dagger T_e \\
&- \frac{12}{5} g_1^2 M_1 T_e^\dagger Y_e + \frac{12}{5} g_1^2 T_e^\dagger T_e - 2 |\lambda|^2 T_e^\dagger T_e + \frac{6}{5} g_1^2 m_l^2 Y_e^\dagger Y_e \\
&- |\lambda|^2 m_l^2 Y_e^\dagger Y_e + \frac{12}{5} g_1^2 Y_e^\dagger m_e^2 Y_e - 2 |\lambda|^2 Y_e^\dagger m_e^2 Y_e + \frac{6}{5} g_1^2 Y_e^\dagger Y_e m_l^2 \\
&- |\lambda|^2 Y_e^\dagger Y_e m_l^2 - 8 m_{H_d}^2 Y_e^\dagger Y_e Y_e^\dagger Y_e - 4 Y_e^\dagger Y_e T_e^\dagger T_e - 4 Y_e^\dagger T_e T_e^\dagger Y_e \\
&- 4 T_e^\dagger Y_e Y_e^\dagger T_e - 4 T_e^\dagger T_e Y_e^\dagger Y_e - 2 m_l^2 Y_e^\dagger Y_e Y_e^\dagger Y_e - 4 Y_e^\dagger m_e^2 Y_e Y_e^\dagger Y_e \\
&- 4 Y_e^\dagger Y_e m_l^2 Y_e^\dagger Y_e - 4 Y_e^\dagger Y_e Y_e^\dagger m_e^2 Y_e - 2 Y_e^\dagger Y_e Y_e^\dagger Y_e m_l^2 - 2\lambda^* T_e^\dagger Y_e T_\lambda + 6 g_2^4 \mathbf{1} \sigma_{2,2} \\
&+ \frac{6}{5} g_1^2 \mathbf{1} \sigma_{2,11} - 4 \sqrt{\frac{3}{5}} g_1 \mathbf{1} \sigma_{3,1} - 12 m_{H_d}^2 Y_e^\dagger Y_e \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 6 T_e^\dagger T_e \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) \\
&- 3 m_l^2 Y_e^\dagger Y_e \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 6 Y_e^\dagger m_e^2 Y_e \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 3 Y_e^\dagger Y_e m_l^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) \\
&- 4 m_{H_d}^2 Y_e^\dagger Y_e \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) - 2 T_e^\dagger T_e \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) - m_l^2 Y_e^\dagger Y_e \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) \\
&- 2 Y_e^\dagger m_e^2 Y_e \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) - Y_e^\dagger Y_e m_l^2 \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) - 6 T_e^\dagger Y_e \mathrm{Tr}\Big(Y_d^\dagger T_d\Big)
\end{aligned}
$$

$$
\begin{aligned}
&- 2T_e^\dagger Y_e \mathrm{Tr}\Big(Y_e^\dagger T_e\Big) - 6Y_e^\dagger T_e \mathrm{Tr}\Big(T_d^* Y_d^T\Big) - 6Y_e^\dagger Y_e \mathrm{Tr}\Big(T_d^* T_d^T\Big) \\
&- 2Y_e^\dagger T_e \mathrm{Tr}\Big(T_e^* Y_e^T\Big) - 2Y_e^\dagger Y_e \mathrm{Tr}\Big(T_e^* T_e^T\Big) - 6Y_e^\dagger Y_e \mathrm{Tr}\Big(m_d^2 Y_d Y_d^\dagger\Big) \\
&- 2Y_e^\dagger Y_e \mathrm{Tr}\Big(m_e^2 Y_e Y_e^\dagger\Big) - 2Y_e^\dagger Y_e \mathrm{Tr}\Big(m_l^2 Y_e^\dagger Y_e\Big) - 6Y_e^\dagger Y_e \mathrm{Tr}\Big(m_q^2 Y_d^\dagger Y_d\Big) \qquad (63)
\end{aligned}
$$

$$
\begin{aligned}
\beta^{(1)}_{m^2_{H_d}} &= -\frac{6}{5} g_1^2 |M_1|^2 - 6 g_2^2 |M_2|^2 + 2 m_{H_d}^2 |\lambda|^2 + 2 m_{H_u}^2 |\lambda|^2 + 2 m_S^2 |\lambda|^2 + 2|T_\lambda|^2 - \sqrt{\frac{3}{5}} g_1 \sigma_{1,1} \\
&+ 6 m_{H_d}^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + 2 m_{H_d}^2 \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) + 6 \mathrm{Tr}\Big(T_d^* T_d^T\Big) + 2 \mathrm{Tr}\Big(T_e^* T_e^T\Big) + 6 \mathrm{Tr}\Big(m_d^2 Y_d Y_d^\dagger\Big) \\
&+ 2 \mathrm{Tr}\Big(m_e^2 Y_e Y_e^\dagger\Big) + 2 \mathrm{Tr}\Big(m_l^2 Y_e^\dagger Y_e\Big) + 6 \mathrm{Tr}\Big(m_q^2 Y_d^\dagger Y_d\Big) \qquad (64)
\end{aligned}
$$

$$
\begin{aligned}
\beta^{(2)}_{m^2_{H_d}} &= \frac{1}{25}\Big(g_1^2 M_1^* \Big(621 g_1^2 M_1 + 90 g_2^2 M_1 + 45 g_2^2 M_2 - 40 M_1 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + 120 M_1 \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) + 20 \mathrm{Tr}\Big(Y_d^\dagger T_d\Big) \\
&- 60 \mathrm{Tr}\Big(Y_e^\dagger T_e\Big)\Big) \\
&+ 5\Big(3 g_2^2 \Big(3 g_1^2 \Big(2M_2 + M_1\Big) + 55 g_2^2 M_2\Big) M_2^* \\
&- 2\Big(30\Big(m_{H_d}^2 + m_{H_u}^2 + m_S^2\Big)\lambda^2 \lambda^{*,2} + 10\kappa^* \Big(\Big(4 m_S^2 + m_{H_d}^2 + m_{H_u}^2\Big)\kappa |\lambda|^2 + T_\lambda^* \Big(\kappa T_\lambda + \lambda T_\kappa\Big)\Big) - 15 g_2^4 \sigma_{2,2} - 3 g_1^2 \sigma_{2,11} \\
&+ 2\sqrt{15} g_1 \sigma_{3,1} + 2 g_1^2 m_{H_d}^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 80 g_3^2 m_{H_d}^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 160 g_3^2 |M_3|^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) \\
&- 6 g_1^2 m_{H_d}^2 \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) + 15 |T_\lambda|^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) + 80 g_3^2 M_3^* \mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + 15 \lambda T_\lambda^* \mathrm{Tr}\Big(Y_u^\dagger T_u\Big) \\
&- 2 g_1^2 M_1 \mathrm{Tr}\Big(T_d^* Y_d^T\Big) + 80 g_3^2 M_3 \mathrm{Tr}\Big(T_d^* Y_d^T\Big) + 2 g_1^2 \mathrm{Tr}\Big(T_d^* T_d^T\Big) - 80 g_3^2 \mathrm{Tr}\Big(T_d^* T_d^T\Big) \\
&+ 6 g_1^2 M_1 \mathrm{Tr}\Big(T_e^* Y_e^T\Big) - 6 g_1^2 \mathrm{Tr}\Big(T_e^* T_e^T\Big) + 2 g_1^2 \mathrm{Tr}\Big(m_d^2 Y_d Y_d^\dagger\Big) - 80 g_3^2 \mathrm{Tr}\Big(m_d^2 Y_d Y_d^\dagger\Big) \\
&- 6 g_1^2 \mathrm{Tr}\Big(m_e^2 Y_e Y_e^\dagger\Big) - 6 g_1^2 \mathrm{Tr}\Big(m_l^2 Y_e^\dagger Y_e\Big) + 2 g_1^2 \mathrm{Tr}\Big(m_q^2 Y_d^\dagger Y_d\Big) - 80 g_3^2 \mathrm{Tr}\Big(m_q^2 Y_d^\dagger Y_d\Big) \\
&+ 5\lambda^* \Big(2 T_\kappa^* \Big(\kappa T_\lambda + \lambda T_\kappa\Big) \\
&+ 3\Big(4\lambda |T_\lambda|^2 + \Big(2 m_{H_u}^2 + m_{H_d}^2 + m_S^2\Big)\lambda \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) + T_\lambda \mathrm{Tr}\Big(T_u^* Y_u^T\Big) + \lambda \mathrm{Tr}\Big(T_u^* T_u^T\Big) + \lambda \mathrm{Tr}\Big(m_q^2 Y_u^\dagger Y_u\Big) \\
&+ \lambda \mathrm{Tr}\Big(m_u^2 Y_u Y_u^\dagger\Big)\Big)\Big) \\
&+ 90 m_{H_d}^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger Y_d Y_d^\dagger\Big) + 90 \mathrm{Tr}\Big(Y_d Y_d^\dagger T_d T_d^\dagger\Big) + 15 m_{H_d}^2 \mathrm{Tr}\Big(Y_d Y_u^\dagger Y_u Y_d^\dagger\Big) \\
&+ 15 m_{H_u}^2 \mathrm{Tr}\Big(Y_d Y_u^\dagger Y_u Y_d^\dagger\Big) + 15 \mathrm{Tr}\Big(Y_d Y_u^\dagger T_u T_d^\dagger\Big) + 90 \mathrm{Tr}\Big(Y_d T_d^\dagger T_d Y_d^\dagger\Big) \\
&+ 15 \mathrm{Tr}\Big(Y_d T_u^\dagger T_u Y_d^\dagger\Big) + 30 m_{H_d}^2 \mathrm{Tr}\Big(Y_e Y_e^\dagger Y_e Y_e^\dagger\Big) + 30 \mathrm{Tr}\Big(Y_e Y_e^\dagger T_e T_e^\dagger\Big) + 30 \mathrm{Tr}\Big(Y_e T_e^\dagger T_e Y_e^\dagger\Big) \\
&+ 15 \mathrm{Tr}\Big(Y_u Y_d^\dagger T_d T_u^\dagger\Big) + 15 \mathrm{Tr}\Big(Y_u T_d^\dagger T_d Y_u^\dagger\Big) + 90 \mathrm{Tr}\Big(m_d^2 Y_d Y_d^\dagger Y_d Y_d^\dagger\Big) + 15 \mathrm{Tr}\Big(m_d^2 Y_d Y_u^\dagger Y_u Y_d^\dagger\Big) \\
&+ 30 \mathrm{Tr}\Big(m_e^2 Y_e Y_e^\dagger Y_e Y_e^\dagger\Big) + 30 \mathrm{Tr}\Big(m_l^2 Y_e^\dagger Y_e Y_e^\dagger Y_e\Big) + 90 \mathrm{Tr}\Big(m_q^2 Y_d^\dagger Y_d Y_d^\dagger Y_d\Big) + 15 \mathrm{Tr}\Big(m_q^2 Y_d^\dagger Y_d Y_u^\dagger Y_u\Big) \\
&+ 15 \mathrm{Tr}\Big(m_q^2 Y_u^\dagger Y_u Y_d^\dagger Y_d\Big) + 15 \mathrm{Tr}\Big(m_u^2 Y_u Y_d^\dagger Y_d Y_u^\dagger\Big)\Big)\Big)\Big) \qquad (65)
\end{aligned}
$$

$$\beta^{(1)}_{m^2_{H_u}} = -\frac{6}{5}g_1^2|M_1|^2 - 6g_2^2|M_2|^2 + 2m^2_{H_d}|\lambda|^2 + 2m^2_{H_u}|\lambda|^2 + 2m_S^2|\lambda|^2 + 2|T_\lambda|^2 + \sqrt{\frac{3}{5}}g_1\sigma_{1,1}$$
$$+ 6m^2_{H_u}\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 6\mathrm{Tr}\Big(T_u^*T_u^T\Big) + 6\mathrm{Tr}\Big(m_q^2Y_u^\dagger Y_u\Big) + 6\mathrm{Tr}\Big(m_u^2Y_uY_u^\dagger\Big) \tag{66}$$

$$\beta^{(2)}_{m^2_{H_u}} = \frac{1}{25}\Big(g_1^2M_1^*\Big(-40\mathrm{Tr}\Big(Y_u^\dagger T_u\Big) + 45g_2^2M_2 + 621g_1^2M_1 + 80M_1\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 90g_2^2M_1\Big)$$
$$+ 5\Big(3g_2^2\Big(3g_1^2\Big(2M_2 + M_1\Big) + 55g_2^2M_2\Big)M_2^*$$
$$- 2\Big(30\Big(m^2_{H_d} + m^2_{H_u} + m_S^2\Big)\lambda^2\lambda^{*,2} + 10\kappa^*\Big(\Big(4m_S^2 + m^2_{H_d} + m^2_{H_u}\Big)\kappa|\lambda|^2 + T_\lambda^*\Big(\kappa T_\lambda + \lambda T_\kappa\Big)\Big) - 15g_2^4\sigma_{2,2} - 3g_1^2\sigma_{2,11}$$
$$- 2\sqrt{15}g_1\sigma_{3,1} + 15|T_\lambda|^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + 5|T_\lambda|^2\mathrm{Tr}\Big(Y_eY_e^\dagger\Big) - 4g_1^2m^2_{H_u}\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)$$
$$- 80g_3^2m^2_{H_u}\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - 160g_3^2|M_3|^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 15\lambda T_\lambda^*\mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + 5\lambda T_\lambda^*\mathrm{Tr}\Big(Y_e^\dagger T_e\Big)$$
$$+ 80g_3^2M_3^*\mathrm{Tr}\Big(Y_u^\dagger T_u\Big) + 4g_1^2M_1\mathrm{Tr}\Big(T_u^*Y_u^T\Big) + 80g_3^2M_3\mathrm{Tr}\Big(T_u^*Y_u^T\Big) - 4g_1^2\mathrm{Tr}\Big(T_u^*T_u^T\Big)$$
$$- 80g_3^2\mathrm{Tr}\Big(T_u^*T_u^T\Big)$$
$$+ 5\lambda^*\Big(12\lambda|T_\lambda|^2 + 2T_\kappa^*\Big(\kappa T_\lambda + \lambda T_\kappa\Big) + 6m^2_{H_d}\lambda\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + 3m^2_{H_u}\lambda\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + 3m_S^2\lambda\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)$$
$$+ 2m^2_{H_d}\lambda\mathrm{Tr}\Big(Y_eY_e^\dagger\Big) + m^2_{H_u}\lambda\mathrm{Tr}\Big(Y_eY_e^\dagger\Big) + m_S^2\lambda\mathrm{Tr}\Big(Y_eY_e^\dagger\Big) + 3T_\lambda\mathrm{Tr}\Big(T_d^*Y_d^T\Big) + 3\lambda\mathrm{Tr}\Big(T_d^*T_d^T\Big)$$
$$+ T_\lambda\mathrm{Tr}\Big(T_e^*Y_e^T\Big) + \lambda\mathrm{Tr}\Big(T_e^*T_e^T\Big) + 3\lambda\mathrm{Tr}\Big(m_d^2Y_dY_d^\dagger\Big) + \lambda\mathrm{Tr}\Big(m_e^2Y_eY_e^\dagger\Big) + \lambda\mathrm{Tr}\Big(m_l^2Y_e^\dagger Y_e\Big)$$
$$+ 3\lambda\mathrm{Tr}\Big(m_q^2Y_d^\dagger Y_d\Big)\Big)$$
$$- 4g_1^2\mathrm{Tr}\Big(m_q^2Y_u^\dagger Y_u\Big) - 80g_3^2\mathrm{Tr}\Big(m_q^2Y_u^\dagger Y_u\Big) - 4g_1^2\mathrm{Tr}\Big(m_u^2Y_uY_u^\dagger\Big) - 80g_3^2\mathrm{Tr}\Big(m_u^2Y_uY_u^\dagger\Big)$$
$$+ 15m^2_{H_d}\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big) + 15m^2_{H_u}\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big) + 15\mathrm{Tr}\Big(Y_dY_u^\dagger T_uT_d^\dagger\Big)$$
$$+ 15\mathrm{Tr}\Big(Y_dT_u^\dagger T_uY_d^\dagger\Big) + 15\mathrm{Tr}\Big(Y_uY_d^\dagger T_dT_u^\dagger\Big) + 90m^2_{H_u}\mathrm{Tr}\Big(Y_uY_u^\dagger Y_uY_u^\dagger\Big) + 90\mathrm{Tr}\Big(Y_uY_u^\dagger T_uT_u^\dagger\Big)$$
$$+ 15\mathrm{Tr}\Big(Y_uT_d^\dagger T_dY_u^\dagger\Big) + 90\mathrm{Tr}\Big(Y_uT_u^\dagger T_uY_u^\dagger\Big) + 15\mathrm{Tr}\Big(m_d^2Y_dY_u^\dagger Y_uY_d^\dagger\Big)$$
$$+ 15\mathrm{Tr}\Big(m_q^2Y_d^\dagger Y_dY_u^\dagger Y_u\Big) + 15\mathrm{Tr}\Big(m_q^2Y_u^\dagger Y_uY_d^\dagger Y_d\Big) + 90\mathrm{Tr}\Big(m_q^2Y_u^\dagger Y_uY_u^\dagger Y_u\Big)$$
$$+ 15\mathrm{Tr}\Big(m_u^2Y_uY_d^\dagger Y_dY_u^\dagger\Big) + 90\mathrm{Tr}\Big(m_u^2Y_uY_u^\dagger Y_uY_u^\dagger\Big)\Big)\Big)\Big) \tag{67}$$

$$\beta^{(1)}_{m_d^2} = -\frac{8}{15}g_1^2\mathbf{1}|M_1|^2 - \frac{32}{3}g_3^2\mathbf{1}|M_3|^2 + 4m^2_{H_d}Y_dY_d^\dagger + 4T_dT_d^\dagger + 2m_d^2Y_dY_d^\dagger + 4Y_dm_q^2Y_d^\dagger$$
$$+ 2Y_dY_d^\dagger m_d^2 + 2\frac{1}{\sqrt{15}}g_1\mathbf{1}\sigma_{1,1} \tag{68}$$

$$\beta^{(2)}_{m_d^2} = +\frac{64}{45}g_3^2\Big(-30g_3^2M_3 + g_1^2\Big(2M_3 + M_1\Big)\Big)\mathbf{1}M_3^* + \frac{4}{5}g_1^2m^2_{H_d}Y_dY_d^\dagger + 12g_2^2m^2_{H_d}Y_dY_d^\dagger$$
$$+ 24g_2^2|M_2|^2Y_dY_d^\dagger - 8m^2_{H_d}|\lambda|^2Y_dY_d^\dagger - 4m^2_{H_u}|\lambda|^2Y_dY_d^\dagger$$
$$- 4m_S^2|\lambda|^2Y_dY_d^\dagger - 4|T_\lambda|^2Y_dY_d^\dagger - \frac{4}{5}g_1^2M_1Y_dT_d^\dagger - 12g_2^2M_2Y_dT_d^\dagger$$

$$
\begin{aligned}
&+\frac{4}{225}g_1^2M_1^*\Big(2\Big(303g_1^2M_1+40g_3^2\Big(2M_1+M_3\Big)\Big)\mathbf{1}-45T_dY_d^\dagger+90M_1Y_dY_d^\dagger\Big)-12g_2^2M_2^*T_dY_d^\dagger\\
&-4\lambda T_\lambda^*T_dY_d^\dagger+\frac{4}{5}g_1^2T_dT_d^\dagger+12g_2^2T_dT_d^\dagger-4|\lambda|^2T_dT_d^\dagger\\
&+\frac{2}{5}g_1^2m_d^2Y_dY_d^\dagger+6g_2^2m_d^2Y_dY_d^\dagger-2|\lambda|^2m_d^2Y_dY_d^\dagger+\frac{4}{5}g_1^2Y_dm_q^2Y_d^\dagger\\
&+12g_2^2Y_dm_q^2Y_d^\dagger-4|\lambda|^2Y_dm_q^2Y_d^\dagger+\frac{2}{5}g_1^2Y_dY_d^\dagger m_d^2+6g_2^2Y_dY_d^\dagger m_d^2\\
&-2|\lambda|^2Y_dY_d^\dagger m_d^2-8m_{H_d}^2Y_dY_d^\dagger Y_dY_d^\dagger-4Y_dY_d^\dagger T_dT_d^\dagger-4m_{H_d}^2Y_dY_u^\dagger Y_uY_d^\dagger\\
&-4m_{H_u}^2Y_dY_u^\dagger Y_uY_d^\dagger-4Y_dY_u^\dagger T_uT_d^\dagger-4Y_dT_d^\dagger T_dY_d^\dagger-4Y_dT_u^\dagger T_uY_d^\dagger\\
&-4T_dY_d^\dagger Y_dT_d^\dagger-4T_dY_u^\dagger Y_uT_d^\dagger-4T_dT_d^\dagger Y_dY_d^\dagger-4T_dT_u^\dagger Y_uY_d^\dagger\\
&-2m_d^2Y_dY_d^\dagger Y_dY_d^\dagger-2m_d^2Y_dY_u^\dagger Y_uY_d^\dagger-4Y_dm_q^2Y_d^\dagger Y_dY_d^\dagger-4Y_dm_q^2Y_u^\dagger Y_uY_d^\dagger\\
&-4Y_dY_d^\dagger m_d^2Y_dY_d^\dagger-4Y_dY_d^\dagger Y_dm_q^2Y_d^\dagger-2Y_dY_d^\dagger Y_dY_d^\dagger m_d^2-4Y_dY_u^\dagger m_u^2Y_uY_d^\dagger\\
&-4Y_dY_u^\dagger Y_um_q^2Y_d^\dagger-2Y_dY_u^\dagger Y_uY_d^\dagger m_d^2-4\lambda^*Y_dT_d^\dagger T_\lambda+\frac{32}{3}g_3^4\mathbf{1}\sigma_{2,3}+\frac{8}{15}g_1^2\mathbf{1}\sigma_{2,11}\\
&+8\frac{1}{\sqrt{15}}g_1\mathbf{1}\sigma_{3,1}-24m_{H_d}^2Y_dY_d^\dagger\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)-12T_dT_d^\dagger\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)\\
&-6m_d^2Y_dY_d^\dagger\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)-12Y_dm_q^2Y_d^\dagger\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)-6Y_dY_d^\dagger m_d^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)\\
&-8m_{H_d}^2Y_dY_d^\dagger\mathrm{Tr}\Big(Y_eY_e^\dagger\Big)-4T_dT_d^\dagger\mathrm{Tr}\Big(Y_eY_e^\dagger\Big)-2m_d^2Y_dY_d^\dagger\mathrm{Tr}\Big(Y_eY_e^\dagger\Big)\\
&-4Y_dm_q^2Y_d^\dagger\mathrm{Tr}\Big(Y_eY_e^\dagger\Big)-2Y_dY_d^\dagger m_d^2\mathrm{Tr}\Big(Y_eY_e^\dagger\Big)-12Y_dT_d^\dagger\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)\\
&-4Y_dT_d^\dagger\mathrm{Tr}\Big(Y_e^\dagger T_e\Big)-12T_dY_d^\dagger\mathrm{Tr}\Big(T_d^*Y_d^T\Big)-12Y_dY_d^\dagger\mathrm{Tr}\Big(T_d^*T_d^T\Big)\\
&-4T_dY_d^\dagger\mathrm{Tr}\Big(T_e^*Y_e^T\Big)-4Y_dY_d^\dagger\mathrm{Tr}\Big(T_e^*T_e^T\Big)-12Y_dY_d^\dagger\mathrm{Tr}\Big(m_d^2Y_dY_d^\dagger\Big)
\end{aligned}
$$

$$
\begin{aligned}
&-4Y_dY_d^\dagger\mathrm{Tr}\Big(m_e^2Y_eY_e^\dagger\Big)-4Y_dY_d^\dagger\mathrm{Tr}\Big(m_l^2Y_e^\dagger Y_e\Big)-12Y_dY_d^\dagger\mathrm{Tr}\Big(m_q^2Y_d^\dagger Y_d\Big) \qquad (69)\\
\beta_{m_u^2}^{(1)}&=-\frac{32}{15}g_1^2\mathbf{1}|M_1|^2-\frac{32}{3}g_3^2\mathbf{1}|M_3|^2+4m_{H_u}^2Y_uY_u^\dagger+4T_uT_u^\dagger+2m_u^2Y_uY_u^\dagger+4Y_um_q^2Y_u^\dagger\\
&\quad+2Y_uY_u^\dagger m_u^2-4\frac{1}{\sqrt{15}}g_1\mathbf{1}\sigma_{1,1} \qquad (70)\\
\beta_{m_u^2}^{(2)}&=-\frac{128}{45}g_3^2\Big(15g_3^2M_3-2g_1^2\Big(2M_3+M_1\Big)\Big)\mathbf{1}M_3^*-\frac{4}{5}g_1^2m_{H_u}^2Y_uY_u^\dagger+12g_2^2m_{H_u}^2Y_uY_u^\dagger\\
&\quad+24g_2^2|M_2|^2Y_uY_u^\dagger-4m_{H_d}^2|\lambda|^2Y_uY_u^\dagger-8m_{H_u}^2|\lambda|^2Y_uY_u^\dagger\\
&\quad-4m_S^2|\lambda|^2Y_uY_u^\dagger-4|T_\lambda|^2Y_uY_u^\dagger+\frac{4}{5}g_1^2M_1Y_uT_u^\dagger-12g_2^2M_2Y_uT_u^\dagger\\
&\quad-12g_2^2M_2^*T_uY_u^\dagger-4\lambda T_\lambda^*T_uY_u^\dagger\\
&\quad+\frac{4}{225}g_1^2M_1^*\Big(45\Big(-2M_1Y_uY_u^\dagger+T_uY_u^\dagger\Big)+8\Big(321g_1^2M_1+40g_3^2\Big(2M_1+M_3\Big)\Big)\mathbf{1}\Big)-\frac{4}{5}g_1^2T_uT_u^\dagger\\
&\quad+12g_2^2T_uT_u^\dagger-4|\lambda|^2T_uT_u^\dagger-\frac{2}{5}g_1^2m_u^2Y_uY_u^\dagger+6g_2^2m_u^2Y_uY_u^\dagger
\end{aligned}
$$

$$
\begin{aligned}
&- 2|\lambda|^2 m_u^2 Y_u Y_u^\dagger - \frac{4}{5} g_1^2 Y_u m_q^2 Y_u^\dagger + 12 g_2^2 Y_u m_q^2 Y_u^\dagger - 4|\lambda|^2 Y_u m_q^2 Y_u^\dagger \\
&- \frac{2}{5} g_1^2 Y_u Y_u^\dagger m_u^2 + 6 g_2^2 Y_u Y_u^\dagger m_u^2 - 2|\lambda|^2 Y_u Y_u^\dagger m_u^2 - 4 m_{H_d}^2 Y_u Y_d^\dagger Y_d Y_u^\dagger \\
&- 4 m_{H_u}^2 Y_u Y_d^\dagger Y_d Y_u^\dagger - 4 Y_u Y_d^\dagger T_d T_u^\dagger - 8 m_{H_u}^2 Y_u Y_u^\dagger Y_u Y_u^\dagger - 4 Y_u Y_u^\dagger T_u T_u^\dagger \\
&- 4 Y_u T_d^\dagger T_d Y_u^\dagger - 4 Y_u T_u^\dagger T_u Y_u^\dagger - 4 T_u Y_d^\dagger Y_d T_u^\dagger - 4 T_u Y_u^\dagger Y_u T_u^\dagger \\
&- 4 T_u T_d^\dagger Y_d Y_u^\dagger - 4 T_u T_u^\dagger Y_u Y_u^\dagger - 2 m_u^2 Y_u Y_d^\dagger Y_d Y_u^\dagger - 2 m_u^2 Y_u Y_u^\dagger Y_u Y_u^\dagger \\
&- 4 Y_u m_q^2 Y_d^\dagger Y_d Y_u^\dagger - 4 Y_u m_q^2 Y_u^\dagger Y_u Y_u^\dagger - 4 Y_u Y_d^\dagger m_d^2 Y_d Y_u^\dagger \\
&- 4 Y_u Y_d^\dagger Y_d m_q^2 Y_u^\dagger - 2 Y_u Y_d^\dagger Y_d Y_u^\dagger m_u^2 - 4 Y_u Y_u^\dagger m_u^2 Y_u Y_u^\dagger - 4 Y_u Y_u^\dagger Y_u m_q^2 Y_u^\dagger \\
&- 2 Y_u Y_u^\dagger Y_u Y_u^\dagger m_u^2 - 4 \lambda^* Y_u T_u^\dagger T_\lambda + \frac{32}{3} g_3^4 \mathbf{1} \sigma_{2,3} + \frac{32}{15} g_1^2 \mathbf{1} \sigma_{2,11} - 16 \frac{1}{\sqrt{15}} g_1 \mathbf{1} \sigma_{3,1} \\
&- 24 m_{H_u}^2 Y_u Y_u^\dagger \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 12 T_u T_u^\dagger \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 6 m_u^2 Y_u Y_u^\dagger \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) \\
&- 12 Y_u m_q^2 Y_u^\dagger \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 6 Y_u Y_u^\dagger m_u^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 12 Y_u T_u^\dagger \mathrm{Tr}\Big(Y_u^\dagger T_u\Big) \\
&- 12 T_u Y_u^\dagger \mathrm{Tr}\Big(T_u^* Y_u^T\Big) - 12 Y_u Y_u^\dagger \mathrm{Tr}\Big(T_u^* T_u^T\Big) - 12 Y_u Y_u^\dagger \mathrm{Tr}\Big(m_q^2 Y_u^\dagger Y_u\Big) \\
&- 12 Y_u Y_u^\dagger \mathrm{Tr}\Big(m_u^2 Y_u Y_u^\dagger\Big)
\end{aligned} \tag{71}
$$

$$
\begin{aligned}
\beta_{m_e^2}^{(1)} = &- \frac{24}{5} g_1^2 \mathbf{1} |M_1|^2 + 2\Big(2 m_{H_d}^2 Y_e Y_e^\dagger + 2 T_e T_e^\dagger + 2 Y_e m_l^2 Y_e^\dagger + m_e^2 Y_e Y_e^\dagger + Y_e Y_e^\dagger m_e^2\Big) \\
&+ 2\sqrt{\frac{3}{5}} g_1 \mathbf{1} \sigma_{1,1}
\end{aligned} \tag{72}
$$

$$
\begin{aligned}
\beta_{m_e^2}^{(2)} = &\frac{2}{25}\Big(6 g_1^2 M_1^* \Big(234 g_1^2 M_1 \mathbf{1} + 5\Big(-2 M_1 Y_e Y_e^\dagger + T_e Y_e^\dagger\Big)\Big) + 20 g_1 \mathbf{1}\Big(3 g_1 \sigma_{2,11} + \sqrt{15}\sigma_{3,1}\Big) \\
&- 5\Big(30 g_2^2 M_2^* T_e Y_e^\dagger + 10 \lambda T_\lambda^* T_e Y_e^\dagger + 6 g_1^2 T_e T_e^\dagger - 30 g_2^2 T_e T_e^\dagger \\
&+ 10|\lambda|^2 T_e T_e^\dagger + 3 g_1^2 m_e^2 Y_e Y_e^\dagger - 15 g_2^2 m_e^2 Y_e Y_e^\dagger + 5|\lambda|^2 m_e^2 Y_e Y_e^\dagger \\
&+ 6 g_1^2 Y_e m_l^2 Y_e^\dagger - 30 g_2^2 Y_e m_l^2 Y_e^\dagger + 10|\lambda|^2 Y_e m_l^2 Y_e^\dagger + 3 g_1^2 Y_e Y_e^\dagger m_e^2 \\
&- 15 g_2^2 Y_e Y_e^\dagger m_e^2 + 5|\lambda|^2 Y_e Y_e^\dagger m_e^2 + 20 m_{H_d}^2 Y_e Y_e^\dagger Y_e Y_e^\dagger + 10 Y_e Y_e^\dagger T_e T_e^\dagger \\
&+ 10 Y_e T_e^\dagger T_e Y_e^\dagger + 10 T_e Y_e^\dagger Y_e T_e^\dagger + 10 T_e T_e^\dagger Y_e Y_e^\dagger + 5 m_e^2 Y_e Y_e^\dagger Y_e Y_e^\dagger \\
&+ 10 Y_e m_l^2 Y_e^\dagger Y_e Y_e^\dagger + 10 Y_e Y_e^\dagger m_e^2 Y_e Y_e^\dagger + 10 Y_e Y_e^\dagger Y_e m_l^2 Y_e^\dagger + 5 Y_e Y_e^\dagger Y_e Y_e^\dagger m_e^2 \\
&+ 30 T_e T_e^\dagger \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + 15 m_e^2 Y_e Y_e^\dagger \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + 30 Y_e m_l^2 Y_e^\dagger \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) \\
&+ 15 Y_e Y_e^\dagger m_e^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + 10 T_e T_e^\dagger \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) + 5 m_e^2 Y_e Y_e^\dagger \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) \\
&+ 10 Y_e m_l^2 Y_e^\dagger \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) + 5 Y_e Y_e^\dagger m_e^2 \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) \\
&+ Y_e T_e^\dagger \Big(10 \lambda^* T_\lambda + 10 \mathrm{Tr}\Big(Y_e^\dagger T_e\Big) + 30 g_2^2 M_2 + 30 \mathrm{Tr}\Big(Y_d^\dagger T_d\Big) - 6 g_1^2 M_1\Big) + 30 T_e Y_e^\dagger \mathrm{Tr}\Big(T_d^* Y_d^T\Big) \\
&+ 10 T_e Y_e^\dagger \mathrm{Tr}\Big(T_e^* Y_e^T\Big)
\end{aligned}
$$

$$+ 2Y_e Y_e^\dagger \Big(3g_1^2 m_{H_d}^2 - 15g_2^2 m_{H_d}^2 - 30g_2^2 |M_2|^2 + 5\Big(2m_{H_d}^2 + m_{H_u}^2 + m_S^2\Big)|\lambda|^2 + 5|T_\lambda|^2 + 30m_{H_d}^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big)$$
$$+ 10m_{H_d}^2 \mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) + 15\mathrm{Tr}\Big(T_d^* T_d^T\Big) + 5\mathrm{Tr}\Big(T_e^* T_e^T\Big) + 15\mathrm{Tr}\Big(m_d^2 Y_d Y_d^\dagger\Big) + 5\mathrm{Tr}\Big(m_e^2 Y_e Y_e^\dagger\Big)$$
$$+ 5\mathrm{Tr}\Big(m_l^2 Y_e^\dagger Y_e\Big) + 15\mathrm{Tr}\Big(m_q^2 Y_d^\dagger Y_d\Big)\Big)\Big)\Big) \tag{73}$$

$$\beta^{(1)}_{m_S^2} = 4\Big(3m_S^2|\kappa|^2 + \Big(m_{H_d}^2 + m_{H_u}^2 + m_S^2\Big)|\lambda|^2 + |T_\kappa|^2 + |T_\lambda|^2\Big) \tag{74}$$

$$\beta^{(2)}_{m_S^2} = -\frac{4}{5}\Big(120m_S^2\kappa^2\kappa^{*,2} + 20\Big(m_{H_d}^2 + m_{H_u}^2 + m_S^2\Big)\lambda^2\lambda^{*,2}$$
$$+ 20\kappa^*\Big(4\kappa|T_\kappa|^2 + \Big(4m_S^2 + m_{H_d}^2 + m_{H_u}^2\Big)\kappa|\lambda|^2 + T_\lambda^*\Big(\kappa T_\lambda + \lambda T_\kappa\Big)\Big)$$
$$+ T_\lambda^*\Big(T_\lambda\Big(15\mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 3\Big(5g_2^2 - 5\mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) + g_1^2\Big) + 5\mathrm{Tr}\Big(Y_e Y_e^\dagger\Big)\Big)$$
$$+ \lambda\Big(15\mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + 3\Big(5g_2^2 M_2 + 5\mathrm{Tr}\Big(Y_u^\dagger T_u\Big) + g_1^2 M_1\Big) + 5\mathrm{Tr}\Big(Y_e^\dagger T_e\Big)\Big)\Big)$$
$$+ \lambda^*\Big(- 3g_1^2 m_{H_d}^2\lambda - 15g_2^2 m_{H_d}^2\lambda - 3g_1^2 m_{H_u}^2\lambda - 15g_2^2 m_{H_u}^2\lambda - 3g_1^2 m_S^2\lambda - 15g_2^2 m_S^2\lambda$$
$$+ 20\lambda|T_\kappa|^2 + 40\lambda|T_\lambda|^2 + 20\kappa T_\kappa^* T_\lambda + 3g_1^2 M_1^*\Big(- 2M_1\lambda + T_\lambda\Big) + 15g_2^2 M_2^*\Big(- 2M_2\lambda + T_\lambda\Big)$$
$$+ 30m_{H_d}^2\lambda\mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + 15m_{H_u}^2\lambda\mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + 15m_S^2\lambda\mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + 10m_{H_d}^2\lambda\mathrm{Tr}\Big(Y_e Y_e^\dagger\Big)$$
$$+ 5m_{H_u}^2\lambda\mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) + 5m_S^2\lambda\mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) + 15m_{H_d}^2\lambda\mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) + 30m_{H_u}^2\lambda\mathrm{Tr}\Big(Y_u Y_u^\dagger\Big)$$
$$+ 15m_S^2\lambda\mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) + 15T_\lambda\mathrm{Tr}\Big(T_d^* Y_d^T\Big) + 15\lambda\mathrm{Tr}\Big(T_d^* T_d^T\Big) + 5T_\lambda\mathrm{Tr}\Big(T_e^* Y_e^T\Big) + 5\lambda\mathrm{Tr}\Big(T_e^* T_e^T\Big)$$
$$+ 15T_\lambda\mathrm{Tr}\Big(T_u^* Y_u^T\Big) + 15\lambda\mathrm{Tr}\Big(T_u^* T_u^T\Big) + 15\lambda\mathrm{Tr}\Big(m_d^2 Y_d Y_d^\dagger\Big) + 5\lambda\mathrm{Tr}\Big(m_e^2 Y_e Y_e^\dagger\Big) + 5\lambda\mathrm{Tr}\Big(m_l^2 Y_e^\dagger Y_e\Big)$$
$$+ 15\lambda\mathrm{Tr}\Big(m_q^2 Y_d^\dagger Y_d\Big) + 15\lambda\mathrm{Tr}\Big(m_q^2 Y_u^\dagger Y_u\Big) + 15\lambda\mathrm{Tr}\Big(m_u^2 Y_u Y_u^\dagger\Big)\Big)\Big) \tag{75}$$

3.7 Vacuum expectation values

$$\beta^{(1)}_{v_d} = \frac{1}{20}v_d\Big(15g_2^2 + 15g_2^2\mathrm{Xi} - 20|\lambda|^2 - 20\mathrm{Tr}\Big(Y_e Y_e^\dagger\Big) + 3g_1^2 + 3g_1^2\mathrm{Xi} - 60\mathrm{Tr}\Big(Y_d Y_d^\dagger\Big)\Big) \tag{76}$$

$$\beta^{(2)}_{v_d} = \frac{1}{400}v_d\Big(- 414g_1^4 - 180g_1^2 g_2^2 - 1200g_2^4 - 9g_1^4\mathrm{Xi} - 90g_1^2 g_2^2\mathrm{Xi} + 875g_2^4\mathrm{Xi} + 9g_1^4\mathrm{Xi}^2 + 90g_1^2 g_2^2\mathrm{Xi}^2$$
$$- 225g_2^4\mathrm{Xi}^2 + 1200\lambda^2\lambda^{*,2} - 40\Big(5\Big(32g_3^2 + 9g_2^2\mathrm{Xi}\Big) + g_1^2\Big(9\mathrm{Xi} - 4\Big)\Big)\mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 480g_1^2\mathrm{Tr}\Big(Y_e Y_e^\dagger\Big)$$
$$- 120g_1^2\mathrm{XiTr}\Big(Y_e Y_e^\dagger\Big) - 600g_2^2\mathrm{XiTr}\Big(Y_e Y_e^\dagger\Big) - 40|\lambda|^2\Big(15g_2^2\mathrm{Xi} - 20\kappa\kappa^* - 30\mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) + 3g_1^2\mathrm{Xi}\Big)$$
$$+ 3600\mathrm{Tr}\Big(Y_d Y_d^\dagger Y_d Y_d^\dagger\Big) + 1200\mathrm{Tr}\Big(Y_d Y_u^\dagger Y_u Y_d^\dagger\Big) + 1200\mathrm{Tr}\Big(Y_e Y_e^\dagger Y_e Y_e^\dagger\Big)\Big) \tag{77}$$

$$\beta^{(1)}_{v_u} = \frac{1}{20}v_u\Big(- 20|\lambda|^2 + 3\Big(- 20\mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) + \Big(5g_2^2 + g_1^2\Big)\Big(1 + \mathrm{Xi}\Big)\Big)\Big) \tag{78}$$

$$\beta^{(2)}_{v_u} = \frac{1}{400}v_u\Big(- 414g_1^4 - 180g_1^2 g_2^2 - 1200g_2^4 - 9g_1^4\mathrm{Xi} - 90g_1^2 g_2^2\mathrm{Xi} + 875g_2^4\mathrm{Xi} + 9g_1^4\mathrm{Xi}^2 + 90g_1^2 g_2^2\mathrm{Xi}^2$$

$$- 225 g_2^4 \mathrm{Xi}^2 + 1200 \lambda^2 \lambda^{*,2} - 40 |\lambda|^2 \Big(- 10 \mathrm{Tr}\Big(Y_e Y_e^\dagger \Big) + 15 g_2^2 \mathrm{Xi} - 20 \kappa \kappa^* - 30 \mathrm{Tr}\Big(Y_d Y_d^\dagger \Big) + 3 g_1^2 \mathrm{Xi} \Big)$$
$$- 40 \Big(5 \Big(32 g_3^2 + 9 g_2^2 \mathrm{Xi} \Big) + g_1^2 \Big(9 \mathrm{Xi} + 8 \Big) \Big) \mathrm{Tr}\Big(Y_u Y_u^\dagger \Big) + 1200 \mathrm{Tr}\Big(Y_d Y_u^\dagger Y_u Y_d^\dagger \Big) + 3600 \mathrm{Tr}\Big(Y_u Y_u^\dagger Y_u Y_u^\dagger \Big) \Big) \tag{79}$$

$$\beta_{v_s}^{(1)} = -2 v_s \Big(|\kappa|^2 + |\lambda|^2 \Big) \tag{80}$$

$$\beta_{v_s}^{(2)} = +8 v_s \kappa^2 \kappa^{*,2} + 8 v_s \lambda |\kappa|^2 \lambda^*$$
$$+ \frac{2}{5} v_s |\lambda|^2 \Big(10 \lambda \lambda^* - 15 g_2^2 + 15 \mathrm{Tr}\Big(Y_d Y_d^\dagger \Big) + 15 \mathrm{Tr}\Big(Y_u Y_u^\dagger \Big) - 3 g_1^2 + 5 \mathrm{Tr}\Big(Y_e Y_e^\dagger \Big) \Big) \tag{81}$$

4 Field Rotations

4.1 Rotations in gauge sector for eigenstates 'EWSB'

$$\begin{pmatrix} B_\rho \\ W_{3\rho} \end{pmatrix} = Z^{\gamma Z} \begin{pmatrix} \gamma_\rho \\ Z_\rho \end{pmatrix} \tag{82}$$

$$\begin{pmatrix} W_{1\rho} \\ W_{2\rho} \end{pmatrix} = Z^{W} \begin{pmatrix} W_\rho^- \\ W_\rho^- \end{pmatrix} \tag{83}$$

$$\begin{pmatrix} \lambda_{\tilde{W},1} \\ \lambda_{\tilde{W},2} \\ \lambda_{\tilde{W},3} \end{pmatrix} = Z^{\tilde{W}} \begin{pmatrix} \tilde{W}^- \\ \tilde{W}^+ \\ \tilde{W}^0 \end{pmatrix} \tag{84}$$

$$\tag{85}$$

The mixing matrices are parametrized by

$$Z^{\gamma Z} = \begin{pmatrix} \cos\Theta_W & -\sin\Theta_W \\ \sin\Theta_W & \cos\Theta_W \end{pmatrix} \tag{86}$$

$$Z^{W} = \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ -i\frac{1}{\sqrt{2}} & i\frac{1}{\sqrt{2}} \end{pmatrix} \tag{87}$$

$$Z^{\tilde{W}} = \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \\ -i\frac{1}{\sqrt{2}} & i\frac{1}{\sqrt{2}} & 0 \\ 0 & 0 & 1 \end{pmatrix} \tag{88}$$

$$\tag{89}$$

4.2 Rotations in Mass sector for eigenstates 'EWSB'

4.2.1 Mass Matrices for Scalars

- **Mass matrix for Down-Squarks**, Basis: $\Big(\tilde{d}_{L,\alpha_1}, \tilde{d}_{R,\alpha_2} \Big), \Big(\tilde{d}^*_{L,\beta_1}, \tilde{d}^*_{R,\beta_2} \Big)$

$$m^2_{\tilde{d}} = \begin{pmatrix} m_{\tilde{d}_L \tilde{d}_L^*} & \frac{1}{2}\Big(\sqrt{2} v_d T_d^\dagger - v_s v_u \lambda Y_d^\dagger\Big)\delta_{\alpha_1\beta_2} \\ \frac{1}{2}\delta_{\alpha_2\beta_1}\Big(\sqrt{2} v_d T_d - v_s v_u Y_d \lambda^*\Big) & m_{\tilde{d}_R \tilde{d}_R^*} \end{pmatrix} \tag{90}$$

$$m_{\tilde{d}_L \tilde{d}_L^*} = -\frac{1}{24}\Big(3g_2^2 + g_1^2\Big)\mathbf{1}\Big(-v_u^2 + v_d^2\Big)\delta_{\alpha_1\beta_1} + \frac{1}{2}\delta_{\alpha_1\beta_1}\Big(2m_q^2 + v_d^2 Y_d^\dagger Y_d\Big) \tag{91}$$

$$m_{\tilde{d}_R \tilde{d}_R^*} = \frac{1}{12} g_1^2 \mathbf{1}\Big(-v_d^2 + v_u^2\Big)\delta_{\alpha_2\beta_2} + \frac{1}{2}\delta_{\alpha_2\beta_2}\Big(2m_d^2 + v_d^2 Y_d Y_d^\dagger\Big) \tag{92}$$

This matrix is diagonalized by Z^D:

$$Z^D m^2_{\tilde{d}} Z^{D,\dagger} = m^{dia}_{2,\tilde{d}} \tag{93}$$

with

$$\tilde{d}_{L,i\alpha} = \sum_j Z^{D,*}_{ji} \tilde{d}_{j\alpha}\,, \qquad \tilde{d}_{R,i\alpha} = \sum_j Z^{D,*}_{ji} \tilde{d}_{j\alpha} \tag{94}$$

- **Mass matrix for Sneutrinos**, Basis: $(\tilde{\nu}_L)\,, (\tilde{\nu}_L^*)$

$$m^2_{\tilde{\nu}} = \Big(\ \frac{1}{8}\Big(g_1^2 + g_2^2\Big)\mathbf{1}\Big(-v_u^2 + v_d^2\Big) + m_l^2\ \Big) \tag{95}$$

This matrix is diagonalized by Z^V:

$$Z^V m^2_{\tilde{\nu}} Z^{V,\dagger} = m^{dia}_{2,\tilde{\nu}} \tag{96}$$

with

$$\tilde{\nu}_{L,i} = \sum_j Z^{V,*}_{ji} \tilde{\nu}_j \tag{97}$$

- **Mass matrix for Up-Squarks**, Basis: $(\tilde{u}_{L,\alpha_1}, \tilde{u}_{R,\alpha_2})\,, \Big(\tilde{u}^*_{L,\beta_1}, \tilde{u}^*_{R,\beta_2}\Big)$

$$m^2_{\tilde{u}} = \begin{pmatrix} m_{\tilde{u}_L \tilde{u}_L^*} & \frac{1}{2}\Big(\sqrt{2} v_u T_u^\dagger - v_d v_s \lambda Y_u^\dagger\Big)\delta_{\alpha_1\beta_2} \\ \frac{1}{2}\delta_{\alpha_2\beta_1}\Big(\sqrt{2} v_u T_u - v_d v_s Y_u \lambda^*\Big) & m_{\tilde{u}_R \tilde{u}_R^*} \end{pmatrix} \tag{98}$$

$$m_{\tilde{u}_L \tilde{u}_L^*} = -\frac{1}{24}\Big(-3g_2^2 + g_1^2\Big)\mathbf{1}\Big(-v_u^2 + v_d^2\Big)\delta_{\alpha_1\beta_1} + \frac{1}{2}\delta_{\alpha_1\beta_1}\Big(2m_q^2 + v_u^2 Y_u^\dagger Y_u\Big) \tag{99}$$

$$m_{\tilde{u}_R \tilde{u}_R^*} = \frac{1}{2}\delta_{\alpha_2\beta_2}\Big(2m_u^2 + v_u^2 Y_u Y_u^\dagger\Big) + \frac{1}{6} g_1^2 \mathbf{1}\Big(-v_u^2 + v_d^2\Big)\delta_{\alpha_2\beta_2} \tag{100}$$

This matrix is diagonalized by Z^U:

$$Z^U m^2_{\tilde{u}} Z^{U,\dagger} = m^{dia}_{2,\tilde{u}} \tag{101}$$

with

$$\tilde{u}_{L,i\alpha} = \sum_j Z^{U,*}_{ji} \tilde{u}_{j\alpha}\,, \qquad \tilde{u}_{R,i\alpha} = \sum_j Z^{U,*}_{ji} \tilde{u}_{j\alpha} \tag{102}$$

- **Mass matrix for Sleptons**, Basis: $(\tilde{e}_L, \tilde{e}_R), (\tilde{e}_L^*, \tilde{e}_R^*)$

$$m_{\tilde{e}}^2 = \begin{pmatrix} m_{\tilde{e}_L\tilde{e}_L^*} & -\frac{1}{2}v_s v_u \lambda Y_e^\dagger + \frac{1}{\sqrt{2}} v_d T_e^\dagger \\ -\frac{1}{2}v_s v_u Y_e \lambda^* + \frac{1}{\sqrt{2}} v_d T_e & m_{\tilde{e}_R\tilde{e}_R^*} \end{pmatrix} \tag{103}$$

$$m_{\tilde{e}_L\tilde{e}_L^*} = \frac{1}{2}v_d^2 Y_e^\dagger Y_e + \frac{1}{8}\Big(-g_2^2 + g_1^2\Big)\mathbf{1}\Big(-v_u^2 + v_d^2\Big) + m_l^2 \tag{104}$$

$$m_{\tilde{e}_R\tilde{e}_R^*} = \frac{1}{2}v_d^2 Y_e Y_e^\dagger + \frac{1}{4}g_1^2\mathbf{1}\Big(-v_d^2 + v_u^2\Big) + m_e^2 \tag{105}$$

This matrix is diagonalized by Z^E:

$$Z^E m_{\tilde{e}}^2 Z^{E,\dagger} = m_{2,\tilde{e}}^{dia} \tag{106}$$

with

$$\tilde{e}_{L,i} = \sum_j Z_{ji}^{E,*}\tilde{e}_j\,, \qquad \tilde{e}_{R,i} = \sum_j Z_{ji}^{E,*}\tilde{e}_j \tag{107}$$

- **Mass matrix for Higgs**, Basis: $(\phi_d, \phi_u, \phi_s), (\phi_d, \phi_u, \phi_s)$

$$m_h^2 = \begin{pmatrix} m_{\phi_d\phi_d} & m_{\phi_u\phi_d} & m_{\phi_s\phi_d} \\ m_{\phi_d\phi_u} & m_{\phi_u\phi_u} & m_{\phi_s\phi_u} \\ m_{\phi_d\phi_s} & m_{\phi_u\phi_s} & m_{\phi_s\phi_s} \end{pmatrix} \tag{108}$$

$$m_{\phi_d\phi_d} = \frac{1}{2}\Big(v_s^2 + v_u^2\Big)|\lambda|^2 + \frac{1}{8}\Big(g_1^2 + g_2^2\Big)\Big(3v_d^2 - v_u^2\Big) + m_{H_d}^2 \tag{109}$$

$$m_{\phi_d\phi_u} = \frac{1}{4}\Big(-2\sqrt{2}v_s\Re\Big(T_\lambda\Big) + \Big(4v_d v_u\lambda - v_s^2\kappa\Big)\lambda^* - v_s^2\lambda\kappa^*\Big) - \frac{1}{4}\Big(g_1^2 + g_2^2\Big)v_d v_u \tag{110}$$

$$m_{\phi_u\phi_u} = \frac{1}{2}\Big(v_d^2 + v_s^2\Big)|\lambda|^2 - \frac{1}{8}\Big(g_1^2 + g_2^2\Big)\Big(-3v_u^2 + v_d^2\Big) + m_{H_u}^2 \tag{111}$$

$$m_{\phi_d\phi_s} = -\frac{1}{\sqrt{2}}v_u\Re\Big(T_\lambda\Big) + v_s\Big(\Big(-\frac{1}{2}v_u\kappa + v_d\lambda\Big)\lambda^* - \frac{1}{2}v_u\lambda\kappa^*\Big) \tag{112}$$

$$m_{\phi_u\phi_s} = \frac{1}{2}\Big(-v_d\Big(\sqrt{2}\Re\Big(T_\lambda\Big) + v_s\lambda\kappa^*\Big) - v_s\Big(-2v_u\lambda + v_d\kappa\Big)\lambda^*\Big) \tag{113}$$

$$m_{\phi_s\phi_s} = \frac{1}{2}\Big(2\sqrt{2}v_s\Re\Big(T_\kappa\Big) + \Big(6v_s^2\kappa - v_d v_u\lambda\Big)\kappa^* + \Big(\Big(v_d^2 + v_u^2\Big)\lambda - v_d v_u\kappa\Big)\lambda^*\Big) + m_S^2 \tag{114}$$

This matrix is diagonalized by Z^H:

$$Z^H m_h^2 Z^{H,\dagger} = m_{2,h}^{dia} \tag{115}$$

with

$$\phi_d = \sum_j Z_{j1}^H h_j\,, \qquad \phi_u = \sum_j Z_{j2}^H h_j\,, \qquad \phi_s = \sum_j Z_{j3}^H h_j \tag{116}$$

- **Mass matrix for Pseudo-Scalar Higgs**, Basis: $(\sigma_d, \sigma_u, \sigma_s), (\sigma_d, \sigma_u, \sigma_s)$

$$m^2_{A^0} = \begin{pmatrix} m_{\sigma_d\sigma_d} & \frac{1}{4}v_s\Big(2\sqrt{2}\Re\Big(T_\lambda\Big) + 2v_s\Re\Big(\lambda\kappa^*\Big)\Big) & m_{\sigma_s\sigma_d} \\ \frac{1}{4}v_s\Big(2\sqrt{2}\Re\Big(T_\lambda\Big) + 2v_s\Re\Big(\lambda\kappa^*\Big)\Big) & m_{\sigma_u\sigma_u} & m_{\sigma_s\sigma_u} \\ m_{\sigma_d\sigma_s} & m_{\sigma_u\sigma_s} & m_{\sigma_s\sigma_s} \end{pmatrix} + \xi_Z m^2(Z) \tag{117}$$

$$m_{\sigma_d\sigma_d} = \frac{1}{2}\Big(v_s^2 + v_u^2\Big)|\lambda|^2 + \frac{1}{8}\Big(g_1^2 + g_2^2\Big)\Big(-v_u^2 + v_d^2\Big) + m^2_{H_d} \tag{118}$$

$$m_{\sigma_u\sigma_u} = \frac{1}{2}\Big(v_d^2 + v_s^2\Big)|\lambda|^2 - \frac{1}{8}\Big(g_1^2 + g_2^2\Big)\Big(-v_u^2 + v_d^2\Big) + m^2_{H_u} \tag{119}$$

$$m_{\sigma_d\sigma_s} = -\frac{1}{2}v_u\Big(2v_s\Re\Big(\lambda\kappa^*\Big) - \sqrt{2}\Re\Big(T_\lambda\Big)\Big) \tag{120}$$

$$m_{\sigma_u\sigma_s} = -\frac{1}{2}v_d\Big(2v_s\Re\Big(\lambda\kappa^*\Big) - \sqrt{2}\Re\Big(T_\lambda\Big)\Big) \tag{121}$$

$$m_{\sigma_s\sigma_s} = \frac{1}{2}\Big(-2\sqrt{2}v_s\Re\Big(T_\kappa\Big) + \Big(2v_s^2\kappa + v_d v_u\lambda\Big)\kappa^* + \Big(\Big(v_d^2 + v_u^2\Big)\lambda + v_d v_u\kappa\Big)\lambda^*\Big) + m_S^2 \tag{122}$$

Gauge fixing contributions:

$$m^2(\xi_Z) = \begin{pmatrix} m_{\sigma_d\sigma_d} & m_{\sigma_u\sigma_d} & 0 \\ m_{\sigma_d\sigma_u} & m_{\sigma_u\sigma_u} & 0 \\ 0 & 0 & 0 \end{pmatrix} \tag{123}$$

$$m_{\sigma_d\sigma_d} = \frac{1}{4}v_d^2\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)^2 \tag{124}$$

$$m_{\sigma_d\sigma_u} = -\frac{1}{4}v_d v_u\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)^2 \tag{125}$$

$$m_{\sigma_u\sigma_u} = \frac{1}{4}v_u^2\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)^2 \tag{126}$$

This matrix is diagonalized by Z^A:

$$Z^A m^2_{A^0} Z^{A,\dagger} = m^{dia}_{2,A^0} \tag{127}$$

with

$$\sigma_d = \sum_j Z^A_{j1}A^0_j\,, \qquad \sigma_u = \sum_j Z^A_{j2}A^0_j\,, \qquad \sigma_s = \sum_j Z^A_{j3}A^0_j \tag{128}$$

- **Mass matrix for Charged Higgs**, Basis: $\big(H_d^-, H_u^{+,*}\big), \big(H_d^{-,*}, H_u^+\big)$

$$m^2_{H^-} = \begin{pmatrix} m_{H_d^- H_d^{-,*}} & m^*_{H_u^{+,*}H_d^{-,*}} \\ m_{H_d^- H_u^+} & m_{H_u^{+,*}H_u^+} \end{pmatrix} + \xi_{W^-} m^2(W^-) \tag{129}$$

$$m_{H_d^- H_d^{-,*}} = \frac{1}{2}v_s^2|\lambda|^2 + \frac{1}{8}\Big(g_1^2\Big(-v_u^2+v_d^2\Big) + g_2^2\Big(v_d^2+v_u^2\Big)\Big) + m_{H_d}^2 \tag{130}$$

$$m_{H_d^- H_u^+} = \frac{1}{2}\Big(\lambda\Big(-v_d v_u\lambda^* + v_s^2\kappa^*\Big) + \sqrt{2}v_s T_\lambda\Big) + \frac{1}{4}g_2^2 v_d v_u \tag{131}$$

$$m_{H_u^{+,*} H_u^+} = \frac{1}{2}v_s^2|\lambda|^2 + \frac{1}{8}\Big(g_1^2\Big(-v_d^2+v_u^2\Big) + g_2^2\Big(v_d^2+v_u^2\Big)\Big) + m_{H_u}^2 \tag{132}$$

Gauge fixing contributions:

$$m^2(\xi_{W^-}) = \begin{pmatrix} \frac{1}{4}g_2^2 v_d^2 & -\frac{1}{4}g_2^2 v_d v_u \\ -\frac{1}{4}g_2^2 v_d v_u & \frac{1}{4}g_2^2 v_u^2 \end{pmatrix} \tag{133}$$

This matrix is diagonalized by Z^+:

$$Z^+ m_{H^-}^2 Z^{+,\dagger} = m_{2,H^-}^{dia} \tag{134}$$

with

$$H_d^- = \sum_j Z_{j1}^+ H_j^- \,, \qquad H_u^+ = \sum_j Z_{j2}^+ H_j^+ \tag{135}$$

4.2.2 Mass Matrices for Fermions

- **Mass matrix for Neutralinos**, Basis: $\Big(\lambda_{\tilde{B}}, \tilde{W}^0, \tilde{H}_d^0, \tilde{H}_u^0, \tilde{S}\Big), \Big(\lambda_{\tilde{B}}, \tilde{W}^0, \tilde{H}_d^0, \tilde{H}_u^0, \tilde{S}\Big)$

$$m_{\tilde{\chi}^0} = \begin{pmatrix} M_1 & 0 & -\frac{1}{2}g_1 v_d & \frac{1}{2}g_1 v_u & 0 \\ 0 & M_2 & \frac{1}{2}g_2 v_d & -\frac{1}{2}g_2 v_u & 0 \\ -\frac{1}{2}g_1 v_d & \frac{1}{2}g_2 v_d & 0 & -\frac{1}{\sqrt{2}}v_s\lambda & -\frac{1}{\sqrt{2}}v_u\lambda \\ \frac{1}{2}g_1 v_u & -\frac{1}{2}g_2 v_u & -\frac{1}{\sqrt{2}}v_s\lambda & 0 & -\frac{1}{\sqrt{2}}v_d\lambda \\ 0 & 0 & -\frac{1}{\sqrt{2}}v_u\lambda & -\frac{1}{\sqrt{2}}v_d\lambda & \sqrt{2}v_s\kappa \end{pmatrix} \tag{136}$$

This matrix is diagonalized by N:

$$N^* m_{\tilde{\chi}^0} N^\dagger = m_{\tilde{\chi}^0}^{dia} \tag{137}$$

with

$$\lambda_{\tilde{B}} = \sum_j N_{j1}^* \lambda_j^0 \,, \qquad \tilde{W}^0 = \sum_j N_{j2}^* \lambda_j^0 \,, \qquad \tilde{H}_d^0 = \sum_j N_{j3}^* \lambda_j^0 \tag{138}$$

$$\tilde{H}_u^0 = \sum_j N_{j4}^* \lambda_j^0 \,, \qquad \tilde{S} = \sum_j N_{j5}^* \lambda_j^0 \tag{139}$$

- **Mass matrix for Charginos**, Basis: $\Big(\tilde{W}^-, \tilde{H}_d^-\Big), \Big(\tilde{W}^+, \tilde{H}_u^+\Big)$

$$m_{\tilde{\chi}^-} = \begin{pmatrix} M_2 & \frac{1}{\sqrt{2}}g_2 v_u \\ \frac{1}{\sqrt{2}}g_2 v_d & \frac{1}{\sqrt{2}}v_s\lambda \end{pmatrix} \tag{140}$$

This matrix is diagonalized by U and V

$$U^* m_{\tilde{\chi}^-} V^\dagger = m_{\tilde{\chi}^-}^{dia} \tag{141}$$

with

$$\tilde{W}^- = \sum_{t_2} U^*_{j1} \lambda^-_j \,, \qquad \tilde{H}^-_d = \sum_{t_2} U^*_{j2} \lambda^-_j \tag{142}$$

$$\tilde{W}^+ = \sum_{t_2} V^*_{1j} \lambda^+_j \,, \qquad \tilde{H}^+_u = \sum_{t_2} V^*_{2j} \lambda^+_j \tag{143}$$

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

$$m_e = \left(\begin{array}{c} \frac{1}{\sqrt{2}} v_d Y_e^T \end{array} \right) \tag{144}$$

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

$$U^{e,*}_L m_e U^{e,\dagger}_R = m^{dia}_e \tag{145}$$

with

$$e_{L,i} = \sum_{t_2} U^{e,*}_{L,ji} E_{L,j} \tag{146}$$

$$e_{R,i} = \sum_{t_2} U^e_{R,ij} E^*_{R,j} \tag{147}$$

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

$$m_d = \left(\begin{array}{c} \frac{1}{\sqrt{2}} v_d \delta_{\alpha_1\beta_1} Y_d^T \end{array} \right) \tag{148}$$

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

$$U^{d,*}_L m_d U^{d,\dagger}_R = m^{dia}_d \tag{149}$$

with

$$d_{L,i\alpha} = \sum_{t_2} U^{d,*}_{L,ji} D_{L,j\alpha} \tag{150}$$

$$d_{R,i\alpha} = \sum_{t_2} U^d_{R,ij} D^*_{R,j\alpha} \tag{151}$$

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

$$m_u = \left(\begin{array}{c} \frac{1}{\sqrt{2}} v_u \delta_{\alpha_1\beta_1} Y_u^T \end{array} \right) \tag{152}$$

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

$$U^{u,*}_L m_u U^{u,\dagger}_R = m^{dia}_u \tag{153}$$

with

$$u_{L,i\alpha} = \sum_{t_2} U^{u,*}_{L,ji} U_{L,j\alpha} \tag{154}$$

$$u_{R,i\alpha} = \sum_{t_2} U^u_{R,ij} U^*_{R,j\alpha} \tag{155}$$

5 Vacuum Expectation Values

$$H_d^0 = \frac{1}{\sqrt{2}}\phi_d + \frac{1}{\sqrt{2}}v_d + i\frac{1}{\sqrt{2}}\sigma_d \tag{156}$$

$$H_u^0 = \frac{1}{\sqrt{2}}\phi_u + \frac{1}{\sqrt{2}}v_u + i\frac{1}{\sqrt{2}}\sigma_u \tag{157}$$

$$S = \frac{1}{\sqrt{2}}\phi_s + \frac{1}{\sqrt{2}}v_s + i\frac{1}{\sqrt{2}}\sigma_s \tag{158}$$

6 Tadpole Equations

$$\frac{\partial V}{\partial \phi_d} = \frac{1}{4}\Big(\Big(2v_d\Big(v_s^2 + v_u^2\Big)\lambda - v_s^2 v_u \kappa\Big)\lambda^* + 4m_{H_d}^2 v_d - v_s v_u\Big(2\sqrt{2}\Re\Big(T_\lambda\Big) + v_s\lambda\kappa^*\Big)\Big) + \frac{1}{8}\Big(g_1^2 + g_2^2\Big)v_d\Big(-v_u + v_d\Big)\Big(v_d + v_u\Big) \tag{159}$$

$$\begin{aligned}\frac{\partial V}{\partial \phi_u} = &+\frac{1}{8}\Big(g_1^2 + g_2^2\Big)v_u\Big(-v_d^2 + v_u^2\Big) \\ &+ \frac{1}{4}\Big(\Big(2\Big(v_d^2 + v_s^2\Big)v_u\lambda - v_d v_s^2\kappa\Big)\lambda^* + 4m_{H_u}^2 v_u - v_d v_s\Big(2\sqrt{2}\Re\Big(T_\lambda\Big) + v_s\lambda\kappa^*\Big)\Big)\end{aligned} \tag{160}$$

$$\begin{aligned}\frac{\partial V}{\partial \phi_s} = &\frac{1}{4}\Big(\Big(-2v_d v_s v_u\lambda + 4v_s^3\kappa\Big)\kappa^* + v_s\Big(2\Big(\Big(v_d^2 + v_u^2\Big)\lambda - v_d v_u\kappa\Big)\lambda^* + 4m_S^2\Big) \\ &+ \sqrt{2}\Big(-v_d v_u\Big(T_\lambda^* + T_\lambda\Big) + v_s^2\Big(T_\kappa^* + T_\kappa\Big)\Big)\Big)\end{aligned} \tag{161}$$

7 Particle content for eigenstates 'EWSB'

Name	Type	complex/real	Generations	Indices
$\tilde{d}$	Scalar	complex	6	generation, 6, color, 3
$\tilde{\nu}$	Scalar	complex	3	generation, 3
$\tilde{u}$	Scalar	complex	6	generation, 6, color, 3
$\tilde{e}$	Scalar	complex	6	generation, 6
h	Scalar	real	3	generation, 3
A^0	Scalar	real	3	generation, 3
H^-	Scalar	complex	2	generation, 2
$\tilde{g}$	Fermion	Majorana	1	color, 8
ν	Fermion	Dirac	3	generation, 3
$\tilde{\chi}^0$	Fermion	Majorana	5	generation, 5
$\tilde{\chi}^-$	Fermion	Dirac	2	generation, 2
e	Fermion	Dirac	3	generation, 3

d	Fermion	Dirac	3	generation, 3, color, 3
u	Fermion	Dirac	3	generation, 3, color, 3
g	Vector	real	1	color, 8, lorentz, 4
γ	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	
η^-	Ghost	complex	1	
η^+	Ghost	complex	1	

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

8.1 One Loop Self-Energy

- **Self-Energy for Down-Squarks** $(\tilde{d})$

$$
\begin{aligned}
\Pi_{i,j}(p^2) = {} & +4\Gamma_{\overset{\circ}{\tilde{d}}_i,\overset{\circ}{\tilde{d}}_j^*,W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m_{W^-}^2 + A_0\Big(m_{W^-}^2\Big)\Big) + 2\Gamma_{\overset{\circ}{\tilde{d}}_i,\overset{\circ}{\tilde{d}}_j^*,Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m_Z^2 + A_0\Big(m_Z^2\Big)\Big) \\
& - \sum_{a=1}^{2} A_0\Big(m_{H_a^-}^2\Big)\Gamma_{\overset{\circ}{\tilde{d}}_i,\overset{\circ}{\tilde{d}}_j^*,H_a^+,H_a^-} - \frac{1}{2}\sum_{a=1}^{3} A_0\Big(m_{A_a^0}^2\Big)\Gamma_{\overset{\circ}{\tilde{d}}_i,\overset{\circ}{\tilde{d}}_j^*,A_a^0,A_a^0} \\
& - \sum_{a=1}^{3} A_0\Big(m_{\tilde{\nu}_a}^2\Big)\Gamma_{\overset{\circ}{\tilde{d}}_i,\overset{\circ}{\tilde{d}}_j^*,\tilde{\nu}_a^*,\tilde{\nu}_a} - \frac{1}{2}\sum_{a=1}^{3} A_0\Big(m_{h_a}^2\Big)\Gamma_{\overset{\circ}{\tilde{d}}_i,\overset{\circ}{\tilde{d}}_j^*,h_a,h_a} \\
& - 2\sum_{a=1}^{3} m_{u_a}\sum_{b=1}^{2} B_0\Big(p^2,m_{u_a}^2,m_{\tilde{\chi}_b^-}^2\Big)m_{\tilde{\chi}_b^-}\Big(\Gamma^{L*}_{\overset{\circ}{\tilde{d}}_j^*,u_a,\tilde{\chi}_b^-}\Gamma^{R}_{\overset{\circ}{\tilde{d}}_i^*,u_a,\tilde{\chi}_b^-} + \Gamma^{R*}_{\overset{\circ}{\tilde{d}}_j^*,u_a,\tilde{\chi}_b^-}\Gamma^{L}_{\overset{\circ}{\tilde{d}}_i^*,u_a,\tilde{\chi}_b^-}\Big) \\
& + \sum_{a=1}^{3}\sum_{b=1}^{2} G_0\Big(p^2,m_{u_a}^2,m_{\tilde{\chi}_b^-}^2\Big)\Big(\Gamma^{L*}_{\overset{\circ}{\tilde{d}}_j^*,u_a,\tilde{\chi}_b^-}\Gamma^{L}_{\overset{\circ}{\tilde{d}}_i^*,u_a,\tilde{\chi}_b^-} + \Gamma^{R*}_{\overset{\circ}{\tilde{d}}_j^*,u_a,\tilde{\chi}_b^-}\Gamma^{R}_{\overset{\circ}{\tilde{d}}_i^*,u_a,\tilde{\chi}_b^-}\Big) \\
& - 2\sum_{a=1}^{3} m_{d_a}\sum_{b=1}^{5} B_0\Big(p^2,m_{d_a}^2,m_{\tilde{\chi}_b^0}^2\Big)m_{\tilde{\chi}_b^0}\Big(\Gamma^{L*}_{\overset{\circ}{\tilde{d}}_j^*,d_a,\tilde{\chi}_b^0}\Gamma^{R}_{\overset{\circ}{\tilde{d}}_i^*,d_a,\tilde{\chi}_b^0} + \Gamma^{R*}_{\overset{\circ}{\tilde{d}}_j^*,d_a,\tilde{\chi}_b^0}\Gamma^{L}_{\overset{\circ}{\tilde{d}}_i^*,d_a,\tilde{\chi}_b^0}\Big) \\
& + \sum_{a=1}^{3}\sum_{b=1}^{5} G_0\Big(p^2,m_{d_a}^2,m_{\tilde{\chi}_b^0}^2\Big)\Big(\Gamma^{L*}_{\overset{\circ}{\tilde{d}}_j^*,d_a,\tilde{\chi}_b^0}\Gamma^{L}_{\overset{\circ}{\tilde{d}}_i^*,d_a,\tilde{\chi}_b^0} + \Gamma^{R*}_{\overset{\circ}{\tilde{d}}_j^*,d_a,\tilde{\chi}_b^0}\Gamma^{R}_{\overset{\circ}{\tilde{d}}_i^*,d_a,\tilde{\chi}_b^0}\Big) \\
& - C\sum_{a=1}^{6} A_0\Big(m_{\tilde{d}_a}^2\Big)\Gamma_{\overset{\circ}{\tilde{d}}_i,\overset{\circ}{\tilde{d}}_j^*,\tilde{d}_a^*,\tilde{d}_a} - \sum_{a=1}^{6} A_0\Big(m_{\tilde{e}_a}^2\Big)\Gamma_{\overset{\circ}{\tilde{d}}_i,\overset{\circ}{\tilde{d}}_j^*,\tilde{e}_a^*,\tilde{e}_a}
\end{aligned}
$$

$$
\begin{aligned}
&- C\sum_{a=1}^{6} A_0\Big(m^2_{\tilde{u}_a}\Big)\Gamma_{\check{\tilde{d}}_i,\check{\tilde{d}}^*_j,\tilde{u}^*_a,\tilde{u}_a} + \sum_{a=1}^{6}\sum_{b=1}^{2} B_0\Big(p^2,m^2_{\tilde{u}_a},m^2_{H^-_b}\Big)\Gamma^*_{\check{\tilde{d}}^*_j,\tilde{u}_a,H^-_b}\Gamma_{\check{\tilde{d}}^*_i,\tilde{u}_a,H^-_b}\\
&+\sum_{a=1}^{6}\sum_{b=1}^{3} B_0\Big(p^2,m^2_{\tilde{d}_a},m^2_{A^0_b}\Big)\Gamma^*_{\check{\tilde{d}}^*_j,\tilde{d}_a,A^0_b}\Gamma_{\check{\tilde{d}}^*_i,\tilde{d}_a,A^0_b} + \sum_{a=1}^{6}\sum_{b=1}^{3} B_0\Big(p^2,m^2_{\tilde{d}_a},m^2_{h_b}\Big)\Gamma^*_{\check{\tilde{d}}^*_j,\tilde{d}_a,h_b}\Gamma_{\check{\tilde{d}}^*_i,\tilde{d}_a,h_b}\\
&-\frac{8}{3}m_{\tilde{g}}\sum_{b=1}^{3} B_0\Big(p^2,m^2_{\tilde{g}},m^2_{d_b}\Big)m_{d_b}\Big(\Gamma^{L*}_{\check{\tilde{d}}^*_j,\tilde{g}_1,d_b}\Gamma^{R}_{\check{\tilde{d}}^*_i,\tilde{g}_1,d_b}+\Gamma^{R*}_{\check{\tilde{d}}^*_j,\tilde{g}_1,d_b}\Gamma^{L}_{\check{\tilde{d}}^*_i,\tilde{g}_1,d_b}\Big)\\
&+\frac{4}{3}\sum_{b=1}^{3} G_0\Big(p^2,m^2_{\tilde{g}},m^2_{d_b}\Big)\Big(\Gamma^{L*}_{\check{\tilde{d}}^*_j,\tilde{g}_1,d_b}\Gamma^{L}_{\check{\tilde{d}}^*_i,\tilde{g}_1,d_b}+\Gamma^{R*}_{\check{\tilde{d}}^*_j,\tilde{g}_1,d_b}\Gamma^{R}_{\check{\tilde{d}}^*_i,\tilde{g}_1,d_b}\Big)\\
&+\frac{4}{3}\sum_{b=1}^{6}\Gamma^*_{\check{\tilde{d}}^*_j,g,\tilde{d}_b}\Gamma_{\check{\tilde{d}}^*_i,g,\tilde{d}_b}F_0\Big(p^2,m^2_{\tilde{d}_b},0\Big)+\sum_{b=1}^{6}\Gamma^*_{\check{\tilde{d}}^*_j,\gamma,\tilde{d}_b}\Gamma_{\check{\tilde{d}}^*_i,\gamma,\tilde{d}_b}F_0\Big(p^2,m^2_{\tilde{d}_b},0\Big)\\
&+\sum_{b=1}^{6}\Gamma^*_{\check{\tilde{d}}^*_j,Z,\tilde{d}_b}\Gamma_{\check{\tilde{d}}^*_i,Z,\tilde{d}_b}F_0\Big(p^2,m^2_{\tilde{d}_b},m^2_Z\Big)+\sum_{b=1}^{6}\Gamma^*_{\check{\tilde{d}}^*_j,W^-,\tilde{u}_b}\Gamma_{\check{\tilde{d}}^*_i,W^-,\tilde{u}_b}F_0\Big(p^2,m^2_{\tilde{u}_b},m^2_{W^-}\Big)
\end{aligned}
\tag{162}
$$

- **Self-Energy for Sneutrinos** $(\tilde{\nu})$

$$
\begin{aligned}
\Pi_{i,j}(p^2) = &+4\Gamma_{\check{\tilde{\nu}}_i,\check{\tilde{\nu}}^*_j,W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{W^-}+A_0\Big(m^2_{W^-}\Big)\Big)+2\Gamma_{\check{\tilde{\nu}}_i,\check{\tilde{\nu}}^*_j,Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{Z}+A_0\Big(m^2_{Z}\Big)\Big)\\
&-\sum_{a=1}^{2}A_0\Big(m^2_{H^-_a}\Big)\Gamma_{\check{\tilde{\nu}}_i,\check{\tilde{\nu}}^*_j,H^+_a,H^-_a}\\
&-2\sum_{a=1}^{2}m_{\tilde{\chi}^-_a}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{\chi}^-_a},m^2_{e_b}\Big)m_{e_b}\Big(\Gamma^{L*}_{\check{\tilde{\nu}}^*_j,\tilde{\chi}^+_a,e_b}\Gamma^{R}_{\check{\tilde{\nu}}^*_i,\tilde{\chi}^+_a,e_b}+\Gamma^{R*}_{\check{\tilde{\nu}}^*_j,\tilde{\chi}^+_a,e_b}\Gamma^{L}_{\check{\tilde{\nu}}^*_i,\tilde{\chi}^+_a,e_b}\Big)\\
&+\sum_{a=1}^{2}\sum_{b=1}^{3}G_0\Big(p^2,m^2_{\tilde{\chi}^-_a},m^2_{e_b}\Big)\Big(\Gamma^{L*}_{\check{\tilde{\nu}}^*_j,\tilde{\chi}^+_a,e_b}\Gamma^{L}_{\check{\tilde{\nu}}^*_i,\tilde{\chi}^+_a,e_b}+\Gamma^{R*}_{\check{\tilde{\nu}}^*_j,\tilde{\chi}^+_a,e_b}\Gamma^{R}_{\check{\tilde{\nu}}^*_i,\tilde{\chi}^+_a,e_b}\Big)\\
&+\sum_{a=1}^{2}\sum_{b=1}^{6}B_0\Big(p^2,m^2_{H^-_a},m^2_{\tilde{e}_b}\Big)\Gamma^*_{\check{\tilde{\nu}}^*_j,H^+_a,\tilde{e}_b}\Gamma_{\check{\tilde{\nu}}^*_i,H^+_a,\tilde{e}_b}-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{A^0_a}\Big)\Gamma_{\check{\tilde{\nu}}_i,\check{\tilde{\nu}}^*_j,A^0_a,A^0_a}\\
&-\sum_{a=1}^{3}A_0\Big(m^2_{\tilde{\nu}_a}\Big)\Gamma_{\check{\tilde{\nu}}_i,\check{\tilde{\nu}}^*_j,\tilde{\nu}^*_a,\tilde{\nu}_a}-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{h_a}\Big)\Gamma_{\check{\tilde{\nu}}_i,\check{\tilde{\nu}}^*_j,h_a,h_a}\\
&+\sum_{a=1}^{3}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{\nu}_a},m^2_{h_b}\Big)\Gamma^*_{\check{\tilde{\nu}}^*_j,\tilde{\nu}_a,h_b}\Gamma_{\check{\tilde{\nu}}^*_i,\tilde{\nu}_a,h_b}\\
&-2\sum_{a=1}^{3}m_{\nu_a}\sum_{b=1}^{5}B_0\Big(p^2,m^2_{\nu_a},m^2_{\tilde{\chi}^0_b}\Big)m_{\tilde{\chi}^0_b}\Big(\Gamma^{L*}_{\check{\tilde{\nu}}^*_j,\nu_a,\tilde{\chi}^0_b}\Gamma^{R}_{\check{\tilde{\nu}}^*_i,\nu_a,\tilde{\chi}^0_b}+\Gamma^{R*}_{\check{\tilde{\nu}}^*_j,\nu_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{\tilde{\nu}}^*_i,\nu_a,\tilde{\chi}^0_b}\Big)\\
&+\sum_{a=1}^{3}\sum_{b=1}^{5}G_0\Big(p^2,m^2_{\nu_a},m^2_{\tilde{\chi}^0_b}\Big)\Big(\Gamma^{L*}_{\check{\tilde{\nu}}^*_j,\nu_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{\tilde{\nu}}^*_i,\nu_a,\tilde{\chi}^0_b}+\Gamma^{R*}_{\check{\tilde{\nu}}^*_j,\nu_a,\tilde{\chi}^0_b}\Gamma^{R}_{\check{\tilde{\nu}}^*_i,\nu_a,\tilde{\chi}^0_b}\Big)
\end{aligned}
$$

$$
\begin{aligned}
&- 3\sum_{a=1}^{6} A_0\Big(m^2_{\tilde{d}_a}\Big)\Gamma_{\check{\tilde{\nu}}_i,\check{\tilde{\nu}}^*_j,\tilde{d}^*_a,\tilde{d}_a} - \sum_{a=1}^{6} A_0\Big(m^2_{\tilde{e}_a}\Big)\Gamma_{\check{\tilde{\nu}}_i,\check{\tilde{\nu}}^*_j,\tilde{e}^*_a,\tilde{e}_a}\\
&- 3\sum_{a=1}^{6} A_0\Big(m^2_{\tilde{u}_a}\Big)\Gamma_{\check{\tilde{\nu}}_i,\check{\tilde{\nu}}^*_j,\tilde{u}^*_a,\tilde{u}_a} + \sum_{b=1}^{3} \Gamma^*_{\check{\tilde{\nu}}^*_j,Z,\tilde{\nu}_b}\Gamma_{\check{\tilde{\nu}}^*_i,Z,\tilde{\nu}_b} F_0\Big(p^2, m^2_{\tilde{\nu}_b}, m^2_Z\Big)\\
&+ \sum_{b=1}^{6} \Gamma^*_{\check{\tilde{\nu}}^*_j,W^+,\tilde{e}_b}\Gamma_{\check{\tilde{\nu}}^*_i,W^+,\tilde{e}_b} F_0\Big(p^2, m^2_{\tilde{e}_b}, m^2_{W^-}\Big)
\end{aligned}
\tag{163}
$$

- **Self-Energy for Up-Squarks** $(\tilde{u})$

$$
\begin{aligned}
\Pi_{i,j}(p^2) = &+4\Gamma_{\check{\tilde{u}}_i,\check{\tilde{u}}^*_j,W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{W^-} + A_0\Big(m^2_{W^-}\Big)\Big) + 2\Gamma_{\check{\tilde{u}}_i,\check{\tilde{u}}^*_j,Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m^2_Z + A_0\Big(m^2_Z\Big)\Big)\\
&- \sum_{a=1}^{2} A_0\Big(m^2_{H^-_a}\Big)\Gamma_{\check{\tilde{u}}_i,\check{\tilde{u}}^*_j,H^+_a,H^-_a}\\
&- 2\sum_{a=1}^{2} m_{\tilde{\chi}^-_a}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{\tilde{\chi}^-_a}, m^2_{d_b}\Big) m_{d_b}\Big(\Gamma^{L*}_{\check{\tilde{u}}^*_j,\tilde{\chi}^+_a,d_b}\Gamma^{R}_{\check{\tilde{u}}^*_i,\tilde{\chi}^+_a,d_b} + \Gamma^{R*}_{\check{\tilde{u}}^*_j,\tilde{\chi}^+_a,d_b}\Gamma^{L}_{\check{\tilde{u}}^*_i,\tilde{\chi}^+_a,d_b}\Big)\\
&+ \sum_{a=1}^{2}\sum_{b=1}^{3} G_0\Big(p^2, m^2_{\tilde{\chi}^-_a}, m^2_{d_b}\Big)\Big(\Gamma^{L*}_{\check{\tilde{u}}^*_j,\tilde{\chi}^+_a,d_b}\Gamma^{L}_{\check{\tilde{u}}^*_i,\tilde{\chi}^+_a,d_b} + \Gamma^{R*}_{\check{\tilde{u}}^*_j,\tilde{\chi}^+_a,d_b}\Gamma^{R}_{\check{\tilde{u}}^*_i,\tilde{\chi}^+_a,d_b}\Big)\\
&+ \sum_{a=1}^{2}\sum_{b=1}^{6} B_0\Big(p^2, m^2_{H^-_a}, m^2_{\tilde{d}_b}\Big)\Gamma^*_{\check{\tilde{u}}^*_j,H^+_a,\tilde{d}_b}\Gamma_{\check{\tilde{u}}^*_i,H^+_a,\tilde{d}_b} - \frac{1}{2}\sum_{a=1}^{3} A_0\Big(m^2_{A^0_a}\Big)\Gamma_{\check{\tilde{u}}_i,\check{\tilde{u}}^*_j,A^0_a,A^0_a}\\
&- \sum_{a=1}^{3} A_0\Big(m^2_{\tilde{\nu}_a}\Big)\Gamma_{\check{\tilde{u}}_i,\check{\tilde{u}}^*_j,\tilde{\nu}^*_a,\tilde{\nu}_a} - \frac{1}{2}\sum_{a=1}^{3} A_0\Big(m^2_{h_a}\Big)\Gamma_{\check{\tilde{u}}_i,\check{\tilde{u}}^*_j,h_a,h_a}\\
&- 2\sum_{a=1}^{3} m_{u_a}\sum_{b=1}^{5} B_0\Big(p^2, m^2_{u_a}, m^2_{\tilde{\chi}^0_b}\Big) m_{\tilde{\chi}^0_b}\Big(\Gamma^{L*}_{\check{\tilde{u}}^*_j,u_a,\tilde{\chi}^0_b}\Gamma^{R}_{\check{\tilde{u}}^*_i,u_a,\tilde{\chi}^0_b} + \Gamma^{R*}_{\check{\tilde{u}}^*_j,u_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{\tilde{u}}^*_i,u_a,\tilde{\chi}^0_b}\Big)\\
&+ \sum_{a=1}^{3}\sum_{b=1}^{5} G_0\Big(p^2, m^2_{u_a}, m^2_{\tilde{\chi}^0_b}\Big)\Big(\Gamma^{L*}_{\check{\tilde{u}}^*_j,u_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{\tilde{u}}^*_i,u_a,\tilde{\chi}^0_b} + \Gamma^{R*}_{\check{\tilde{u}}^*_j,u_a,\tilde{\chi}^0_b}\Gamma^{R}_{\check{\tilde{u}}^*_i,u_a,\tilde{\chi}^0_b}\Big)\\
&- C\sum_{a=1}^{6} A_0\Big(m^2_{\tilde{d}_a}\Big)\Gamma_{\check{\tilde{u}}_i,\check{\tilde{u}}^*_j,\tilde{d}^*_a,\tilde{d}_a} - \sum_{a=1}^{6} A_0\Big(m^2_{\tilde{e}_a}\Big)\Gamma_{\check{\tilde{u}}_i,\check{\tilde{u}}^*_j,\tilde{e}^*_a,\tilde{e}_a}\\
&- C\sum_{a=1}^{6} A_0\Big(m^2_{\tilde{u}_a}\Big)\Gamma_{\check{\tilde{u}}_i,\check{\tilde{u}}^*_j,\tilde{u}^*_a,\tilde{u}_a} + \sum_{a=1}^{6}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{\tilde{u}_a}, m^2_{A^0_b}\Big)\Gamma^*_{\check{\tilde{u}}^*_j,\tilde{u}_a,A^0_b}\Gamma_{\check{\tilde{u}}^*_i,\tilde{u}_a,A^0_b}\\
&+ \sum_{a=1}^{6}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{\tilde{u}_a}, m^2_{h_b}\Big)\Gamma^*_{\check{\tilde{u}}^*_j,\tilde{u}_a,h_b}\Gamma_{\check{\tilde{u}}^*_i,\tilde{u}_a,h_b}\\
&- \frac{8}{3} m_{\tilde{g}}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{\tilde{g}}, m^2_{u_b}\Big) m_{u_b}\Big(\Gamma^{L*}_{\check{\tilde{u}}^*_j,\tilde{g}_1,u_b}\Gamma^{R}_{\check{\tilde{u}}^*_i,\tilde{g}_1,u_b} + \Gamma^{R*}_{\check{\tilde{u}}^*_j,\tilde{g}_1,u_b}\Gamma^{L}_{\check{\tilde{u}}^*_i,\tilde{g}_1,u_b}\Big)
\end{aligned}
$$

$$+\frac{4}{3}\sum_{b=1}^{3}G_0\Big(p^2,m^2_{\tilde g},m^2_{u_b}\Big)\Big(\Gamma^{L*}_{\check{\tilde u}^*_j,\tilde g_1,u_b}\Gamma^{L}_{\check{\tilde u}^*_i,\tilde g_1,u_b}+\Gamma^{R*}_{\check{\tilde u}^*_j,\tilde g_1,u_b}\Gamma^{R}_{\check{\tilde u}^*_i,\tilde g_1,u_b}\Big)$$
$$+\sum_{b=1}^{6}\Gamma^{*}_{\check{\tilde u}^*_j,W^+,\tilde d_b}\Gamma_{\check{\tilde u}^*_i,W^+,\tilde d_b}F_0\Big(p^2,m^2_{\tilde d_b},m^2_{W^-}\Big)+\frac{4}{3}\sum_{b=1}^{6}\Gamma^{*}_{\check{\tilde u}^*_j,g,\tilde u_b}\Gamma_{\check{\tilde u}^*_i,g,\tilde u_b}F_0\Big(p^2,m^2_{\tilde u_b},0\Big)$$
$$+\sum_{b=1}^{6}\Gamma^{*}_{\check{\tilde u}^*_j,\gamma,\tilde u_b}\Gamma_{\check{\tilde u}^*_i,\gamma,\tilde u_b}F_0\Big(p^2,m^2_{\tilde u_b},0\Big)+\sum_{b=1}^{6}\Gamma^{*}_{\check{\tilde u}^*_j,Z,\tilde u_b}\Gamma_{\check{\tilde u}^*_i,Z,\tilde u_b}F_0\Big(p^2,m^2_{\tilde u_b},m^2_Z\Big) \tag{164}$$

- **Self-Energy for Sleptons** $(\tilde e)$

$$\begin{aligned}\Pi_{i,j}(p^2)=&+4\Gamma_{\check{\tilde e}_i,\check{\tilde e}^*_j,W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{W^-}+A_0\Big(m^2_{W^-}\Big)\Big)+2\Gamma_{\check{\tilde e}_i,\check{\tilde e}^*_j,Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{Z}+A_0\Big(m^2_{Z}\Big)\Big)\\
&-\sum_{a=1}^{2}A_0\Big(m^2_{H^-_a}\Big)\Gamma_{\check{\tilde e}_i,\check{\tilde e}^*_j,H^+_a,H^-_a}-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{A^0_a}\Big)\Gamma_{\check{\tilde e}_i,\check{\tilde e}^*_j,A^0_a,A^0_a}\\
&-\sum_{a=1}^{3}A_0\Big(m^2_{\tilde\nu_a}\Big)\Gamma_{\check{\tilde e}_i,\check{\tilde e}^*_j,\tilde\nu^*_a,\tilde\nu_a}-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{h_a}\Big)\Gamma_{\check{\tilde e}_i,\check{\tilde e}^*_j,h_a,h_a}\\
&+\sum_{a=1}^{3}\sum_{b=1}^{2}B_0\Big(p^2,m^2_{\tilde\nu_a},m^2_{H^-_b}\Big)\Gamma^{*}_{\check{\tilde e}^*_j,\tilde\nu_a,H^-_b}\Gamma_{\check{\tilde e}^*_i,\tilde\nu_a,H^-_b}\\
&-2\sum_{a=1}^{3}m_{\nu_a}\sum_{b=1}^{2}B_0\Big(p^2,m^2_{\nu_a},m^2_{\tilde\chi^-_b}\Big)m_{\tilde\chi^-_b}\Big(\Gamma^{L*}_{\check{\tilde e}^*_j,\nu_a,\tilde\chi^-_b}\Gamma^{R}_{\check{\tilde e}^*_i,\nu_a,\tilde\chi^-_b}+\Gamma^{R*}_{\check{\tilde e}^*_j,\nu_a,\tilde\chi^-_b}\Gamma^{L}_{\check{\tilde e}^*_i,\nu_a,\tilde\chi^-_b}\Big)\\
&+\sum_{a=1}^{3}\sum_{b=1}^{2}G_0\Big(p^2,m^2_{\nu_a},m^2_{\tilde\chi^-_b}\Big)\Big(\Gamma^{L*}_{\check{\tilde e}^*_j,\nu_a,\tilde\chi^-_b}\Gamma^{L}_{\check{\tilde e}^*_i,\nu_a,\tilde\chi^-_b}+\Gamma^{R*}_{\check{\tilde e}^*_j,\nu_a,\tilde\chi^-_b}\Gamma^{R}_{\check{\tilde e}^*_i,\nu_a,\tilde\chi^-_b}\Big)\\
&-2\sum_{a=1}^{3}m_{e_a}\sum_{b=1}^{5}B_0\Big(p^2,m^2_{e_a},m^2_{\tilde\chi^0_b}\Big)m_{\tilde\chi^0_b}\Big(\Gamma^{L*}_{\check{\tilde e}^*_j,e_a,\tilde\chi^0_b}\Gamma^{R}_{\check{\tilde e}^*_i,e_a,\tilde\chi^0_b}+\Gamma^{R*}_{\check{\tilde e}^*_j,e_a,\tilde\chi^0_b}\Gamma^{L}_{\check{\tilde e}^*_i,e_a,\tilde\chi^0_b}\Big)\\
&+\sum_{a=1}^{3}\sum_{b=1}^{5}G_0\Big(p^2,m^2_{e_a},m^2_{\tilde\chi^0_b}\Big)\Big(\Gamma^{L*}_{\check{\tilde e}^*_j,e_a,\tilde\chi^0_b}\Gamma^{L}_{\check{\tilde e}^*_i,e_a,\tilde\chi^0_b}+\Gamma^{R*}_{\check{\tilde e}^*_j,e_a,\tilde\chi^0_b}\Gamma^{R}_{\check{\tilde e}^*_i,e_a,\tilde\chi^0_b}\Big)\\
&-3\sum_{a=1}^{6}A_0\Big(m^2_{\tilde d_a}\Big)\Gamma_{\check{\tilde e}_i,\check{\tilde e}^*_j,\tilde d^*_a,\tilde d_a}-\sum_{a=1}^{6}A_0\Big(m^2_{\tilde e_a}\Big)\Gamma_{\check{\tilde e}_i,\check{\tilde e}^*_j,\tilde e^*_a,\tilde e_a}\\
&-3\sum_{a=1}^{6}A_0\Big(m^2_{\tilde u_a}\Big)\Gamma_{\check{\tilde e}_i,\check{\tilde e}^*_j,\tilde u^*_a,\tilde u_a}+\sum_{a=1}^{6}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde e_a},m^2_{A^0_b}\Big)\Gamma^{*}_{\check{\tilde e}^*_j,\tilde e_a,A^0_b}\Gamma_{\check{\tilde e}^*_i,\tilde e_a,A^0_b}\\
&+\sum_{a=1}^{6}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde e_a},m^2_{h_b}\Big)\Gamma^{*}_{\check{\tilde e}^*_j,\tilde e_a,h_b}\Gamma_{\check{\tilde e}^*_i,\tilde e_a,h_b}+\sum_{b=1}^{3}\Gamma^{*}_{\check{\tilde e}^*_j,W^-,\tilde\nu_b}\Gamma_{\check{\tilde e}^*_i,W^-,\tilde\nu_b}F_0\Big(p^2,m^2_{\tilde\nu_b},m^2_{W^-}\Big)\\
&+\sum_{b=1}^{6}\Gamma^{*}_{\check{\tilde e}^*_j,\gamma,\tilde e_b}\Gamma_{\check{\tilde e}^*_i,\gamma,\tilde e_b}F_0\Big(p^2,m^2_{\tilde e_b},0\Big)+\sum_{b=1}^{6}\Gamma^{*}_{\check{\tilde e}^*_j,Z,\tilde e_b}\Gamma_{\check{\tilde e}^*_i,Z,\tilde e_b}F_0\Big(p^2,m^2_{\tilde e_b},m^2_Z\Big)\end{aligned} \tag{165}$$

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

$$
\begin{aligned}
\Pi_{i,j}(p^2) = &+2\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m_Z^2,m_Z^2\Big)\Big)\Gamma^*_{\check{h}_j,Z,Z}\Gamma_{\check{h}_i,Z,Z}+4\Big(-\frac{1}{2}\mathrm{rMS}+B_0\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^-}-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^+}\\
&-B_0\Big(p^2,m_{\eta^Z}^2,m_{\eta^Z}^2\Big)\Gamma_{\check{h}_i,\bar{\eta^Z},\eta^Z}\Gamma_{\check{h}_j,\bar{\eta^Z},\eta^Z}+4\Gamma_{\check{h}_i,\check{h}_j,W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m_{W^-}^2+A_0\Big(m_{W^-}^2\Big)\Big)\\
&+2\Gamma_{\check{h}_i,\check{h}_j,Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m_Z^2+A_0\Big(m_Z^2\Big)\Big)-\sum_{a=1}^{2}A_0\Big(m_{H_a^-}^2\Big)\Gamma_{\check{h}_i,\check{h}_j,H_a^+,H_a^-}\\
&+\sum_{a=1}^{2}\sum_{b=1}^{2}B_0\Big(p^2,m_{H_a^-}^2,m_{H_b^-}^2\Big)\Gamma^*_{\check{h}_j,H_a^+,H_b^-}\Gamma_{\check{h}_i,H_a^+,H_b^-}\\
&-2\sum_{a=1}^{2}m_{\tilde{\chi}_a^-}\sum_{b=1}^{2}B_0\Big(p^2,m_{\tilde{\chi}_a^-}^2,m_{\tilde{\chi}_b^-}^2\Big)m_{\tilde{\chi}_b^-}\Big(\Gamma^{L*}_{\check{h}_j,\tilde{\chi}_a^+,\tilde{\chi}_b^-}\Gamma^{R}_{\check{h}_i,\tilde{\chi}_a^+,\tilde{\chi}_b^-}+\Gamma^{R*}_{\check{h}_j,\tilde{\chi}_a^+,\tilde{\chi}_b^-}\Gamma^{L}_{\check{h}_i,\tilde{\chi}_a^+,\tilde{\chi}_b^-}\Big)\\
&+\sum_{a=1}^{2}\sum_{b=1}^{2}G_0\Big(p^2,m_{\tilde{\chi}_a^-}^2,m_{\tilde{\chi}_b^-}^2\Big)\Big(\Gamma^{L*}_{\check{h}_j,\tilde{\chi}_a^+,\tilde{\chi}_b^-}\Gamma^{L}_{\check{h}_i,\tilde{\chi}_a^+,\tilde{\chi}_b^-}+\Gamma^{R*}_{\check{h}_j,\tilde{\chi}_a^+,\tilde{\chi}_b^-}\Gamma^{R}_{\check{h}_i,\tilde{\chi}_a^+,\tilde{\chi}_b^-}\Big)\\
&-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m_{A_a^0}^2\Big)\Gamma_{\check{h}_i,\check{h}_j,A_a^0,A_a^0}-\sum_{a=1}^{3}A_0\Big(m_{\tilde{\nu}_a}^2\Big)\Gamma_{\check{h}_i,\check{h}_j,\tilde{\nu}_a^*,\tilde{\nu}_a}\\
&-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m_{\check{h}_a}^2\Big)\Gamma_{\check{h}_i,\check{h}_j,h_a,h_a}+\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3}B_0\Big(p^2,m_{A_a^0}^2,m_{A_b^0}^2\Big)\Gamma^*_{\check{h}_j,A_a^0,A_b^0}\Gamma_{\check{h}_i,A_a^0,A_b^0}\\
&+\sum_{a=1}^{3}\sum_{b=1}^{3}B_0\Big(p^2,m_{\tilde{\nu}_a}^2,m_{\tilde{\nu}_b}^2\Big)\Gamma^*_{\check{h}_j,\tilde{\nu}_a^*,\tilde{\nu}_b}\Gamma_{\check{h}_i,\tilde{\nu}_a^*,\tilde{\nu}_b}+\sum_{a=1}^{3}\sum_{b=1}^{3}B_0\Big(p^2,m_{\check{h}_a}^2,m_{A_b^0}^2\Big)\Gamma^*_{\check{h}_j,h_a,A_b^0}\Gamma_{\check{h}_i,h_a,A_b^0}\\
&+\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3}B_0\Big(p^2,m_{\check{h}_a}^2,m_{\check{h}_b}^2\Big)\Gamma^*_{\check{h}_j,h_a,h_b}\Gamma_{\check{h}_i,h_a,h_b}\\
&-6\sum_{a=1}^{3}m_{d_a}\sum_{b=1}^{3}B_0\Big(p^2,m_{d_a}^2,m_{d_b}^2\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_{d_a}^2,m_{d_b}^2\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_{e_a}^2,m_{e_b}^2\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_{e_a}^2,m_{e_b}^2\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_{u_a}^2,m_{u_b}^2\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)
\end{aligned}
$$

$$
\begin{aligned}
&+3\sum_{a=1}^{3}\sum_{b=1}^{3}G_0\Big(p^2,m^2_{u_a},m^2_{u_b}\Big)\Big(\Gamma^{L*}_{\check{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}m_{\tilde{\chi}^0_a}\sum_{b=1}^{5}B_0\Big(p^2,m^2_{\tilde{\chi}^0_a},m^2_{\tilde{\chi}^0_b}\Big)m_{\tilde{\chi}^0_b}\Big(\Gamma^{L*}_{\check{h}_j,\tilde{\chi}^0_a,\tilde{\chi}^0_b}\Gamma^{R}_{\check{h}_i,\tilde{\chi}^0_a,\tilde{\chi}^0_b}+\Gamma^{R*}_{\check{h}_j,\tilde{\chi}^0_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{h}_i,\tilde{\chi}^0_a,\tilde{\chi}^0_b}\Big)\\
&+\frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{5}G_0\Big(p^2,m^2_{\tilde{\chi}^0_a},m^2_{\tilde{\chi}^0_b}\Big)\Big(\Gamma^{L*}_{\check{h}_j,\tilde{\chi}^0_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{h}_i,\tilde{\chi}^0_a,\tilde{\chi}^0_b}+\Gamma^{R*}_{\check{h}_j,\tilde{\chi}^0_a,\tilde{\chi}^0_b}\Gamma^{R}_{\check{h}_i,\tilde{\chi}^0_a,\tilde{\chi}^0_b}\Big)\\
&-3\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{d}_a}\Big)\Gamma_{\check{h}_i,\check{h}_j,\tilde{d}^*_a,\tilde{d}_a}-\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{e}_a}\Big)\Gamma_{\check{h}_i,\check{h}_j,\tilde{e}^*_a,\tilde{e}_a}\\
&-3\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{u}_a}\Big)\Gamma_{\check{h}_i,\check{h}_j,\tilde{u}^*_a,\tilde{u}_a}+3\sum_{a=1}^{6}\sum_{b=1}^{6}B_0\Big(p^2,m^2_{\tilde{d}_a},m^2_{\tilde{d}_b}\Big)\Gamma^*_{\check{h}_j,\tilde{d}^*_a,\tilde{d}_b}\Gamma_{\check{h}_i,\tilde{d}^*_a,\tilde{d}_b}\\
&+\sum_{a=1}^{6}\sum_{b=1}^{6}B_0\Big(p^2,m^2_{\tilde{e}_a},m^2_{\tilde{e}_b}\Big)\Gamma^*_{\check{h}_j,\tilde{e}^*_a,\tilde{e}_b}\Gamma_{\check{h}_i,\tilde{e}^*_a,\tilde{e}_b}+3\sum_{a=1}^{6}\sum_{b=1}^{6}B_0\Big(p^2,m^2_{\tilde{u}_a},m^2_{\tilde{u}_b}\Big)\Gamma^*_{\check{h}_j,\tilde{u}^*_a,\tilde{u}_b}\Gamma_{\check{h}_i,\tilde{u}^*_a,\tilde{u}_b}\\
&+2\sum_{b=1}^{2}\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)+\sum_{b=1}^{3}\Gamma^*_{\check{h}_j,Z,A^0_b}\Gamma_{\check{h}_i,Z,A^0_b}F_0\Big(p^2,m^2_{A^0_b},m^2_Z\Big)
\end{aligned}
\tag{166}
$$

- **Self-Energy for Pseudo-Scalar Higgs** (A^0)

$$
\begin{aligned}
\Pi_{i,j}(p^2)=&-B_0\Big(p^2,m^2_{\eta^-},m^2_{\eta^-}\Big)\Gamma_{\check{A}^0_i,\eta^-,\eta^-}\Gamma_{\check{A}^0_j,\eta^-,\eta^-}-B_0\Big(p^2,m^2_{\eta^+},m^2_{\eta^+}\Big)\Gamma_{\check{A}^0_i,\eta^+,\eta^+}\Gamma_{\check{A}^0_j,\eta^+,\eta^+}\\
&+4\Gamma_{\check{A}^0_i,\check{A}^0_j,W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{W^-}+A_0\Big(m^2_{W^-}\Big)\Big)+2\Gamma_{\check{A}^0_i,\check{A}^0_j,Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m^2_Z+A_0\Big(m^2_Z\Big)\Big)\\
&-\sum_{a=1}^{2}A_0\Big(m^2_{H^-_a}\Big)\Gamma_{\check{A}^0_i,\check{A}^0_j,H^+_a,H^-_a}+\sum_{a=1}^{2}\sum_{b=1}^{2}B_0\Big(p^2,m^2_{H^-_a},m^2_{H^-_b}\Big)\Gamma^*_{\check{A}^0_j,H^+_a,H^-_b}\Gamma_{\check{A}^0_i,H^+_a,H^-_b}\\
&-2\sum_{a=1}^{2}m_{\tilde{\chi}^-_a}\sum_{b=1}^{2}B_0\Big(p^2,m^2_{\tilde{\chi}^-_a},m^2_{\tilde{\chi}^-_b}\Big)m_{\tilde{\chi}^-_b}\Big(\Gamma^{L*}_{\check{A}^0_j,\tilde{\chi}^+_a,\tilde{\chi}^-_b}\Gamma^{R}_{\check{A}^0_i,\tilde{\chi}^+_a,\tilde{\chi}^-_b}+\Gamma^{R*}_{\check{A}^0_j,\tilde{\chi}^+_a,\tilde{\chi}^-_b}\Gamma^{L}_{\check{A}^0_i,\tilde{\chi}^+_a,\tilde{\chi}^-_b}\Big)\\
&+\sum_{a=1}^{2}\sum_{b=1}^{2}G_0\Big(p^2,m^2_{\tilde{\chi}^-_a},m^2_{\tilde{\chi}^-_b}\Big)\Big(\Gamma^{L*}_{\check{A}^0_j,\tilde{\chi}^+_a,\tilde{\chi}^-_b}\Gamma^{L}_{\check{A}^0_i,\tilde{\chi}^+_a,\tilde{\chi}^-_b}+\Gamma^{R*}_{\check{A}^0_j,\tilde{\chi}^+_a,\tilde{\chi}^-_b}\Gamma^{R}_{\check{A}^0_i,\tilde{\chi}^+_a,\tilde{\chi}^-_b}\Big)\\
&-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{A^0_a}\Big)\Gamma_{\check{A}^0_i,\check{A}^0_j,A^0_a,A^0_a}-\sum_{a=1}^{3}A_0\Big(m^2_{\tilde{\nu}_a}\Big)\Gamma_{\check{A}^0_i,\check{A}^0_j,\tilde{\nu}^*_a,\tilde{\nu}_a}\\
&-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{h_a}\Big)\Gamma_{\check{A}^0_i,\check{A}^0_j,h_a,h_a}+\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{A^0_a},m^2_{A^0_b}\Big)\Gamma^*_{\check{A}^0_j,A^0_a,A^0_b}\Gamma_{\check{A}^0_i,A^0_a,A^0_b}\\
&+\sum_{a=1}^{3}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{h_a},m^2_{A^0_b}\Big)\Gamma^*_{\check{A}^0_j,h_a,A^0_b}\Gamma_{\check{A}^0_i,h_a,A^0_b}
\end{aligned}
$$

$$
\begin{aligned}
&+\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3}B_0\Big(p^2,m_{h_a}^2,m_{h_b}^2\Big)\Gamma^*_{\check{A}^0_j,h_a,h_b}\Gamma_{\check{A}^0_i,h_a,h_b}\\
&-6\sum_{a=1}^{3}m_{d_a}\sum_{b=1}^{3}B_0\Big(p^2,m_{d_a}^2,m_{d_b}^2\Big)m_{d_b}\Big(\Gamma^{L*}_{\check{A}^0_j,\bar{d}_a,d_b}\Gamma^{R}_{\check{A}^0_i,\bar{d}_a,d_b}+\Gamma^{R*}_{\check{A}^0_j,\bar{d}_a,d_b}\Gamma^{L}_{\check{A}^0_i,\bar{d}_a,d_b}\Big)\\
&+3\sum_{a=1}^{3}\sum_{b=1}^{3}G_0\Big(p^2,m_{d_a}^2,m_{d_b}^2\Big)\Big(\Gamma^{L*}_{\check{A}^0_j,\bar{d}_a,d_b}\Gamma^{L}_{\check{A}^0_i,\bar{d}_a,d_b}+\Gamma^{R*}_{\check{A}^0_j,\bar{d}_a,d_b}\Gamma^{R}_{\check{A}^0_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_{e_a}^2,m_{e_b}^2\Big)m_{e_b}\Big(\Gamma^{L*}_{\check{A}^0_j,\bar{e}_a,e_b}\Gamma^{R}_{\check{A}^0_i,\bar{e}_a,e_b}+\Gamma^{R*}_{\check{A}^0_j,\bar{e}_a,e_b}\Gamma^{L}_{\check{A}^0_i,\bar{e}_a,e_b}\Big)\\
&+\sum_{a=1}^{3}\sum_{b=1}^{3}G_0\Big(p^2,m_{e_a}^2,m_{e_b}^2\Big)\Big(\Gamma^{L*}_{\check{A}^0_j,\bar{e}_a,e_b}\Gamma^{L}_{\check{A}^0_i,\bar{e}_a,e_b}+\Gamma^{R*}_{\check{A}^0_j,\bar{e}_a,e_b}\Gamma^{R}_{\check{A}^0_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_{u_a}^2,m_{u_b}^2\Big)m_{u_b}\Big(\Gamma^{L*}_{\check{A}^0_j,\bar{u}_a,u_b}\Gamma^{R}_{\check{A}^0_i,\bar{u}_a,u_b}+\Gamma^{R*}_{\check{A}^0_j,\bar{u}_a,u_b}\Gamma^{L}_{\check{A}^0_i,\bar{u}_a,u_b}\Big)\\
&+3\sum_{a=1}^{3}\sum_{b=1}^{3}G_0\Big(p^2,m_{u_a}^2,m_{u_b}^2\Big)\Big(\Gamma^{L*}_{\check{A}^0_j,\bar{u}_a,u_b}\Gamma^{L}_{\check{A}^0_i,\bar{u}_a,u_b}+\Gamma^{R*}_{\check{A}^0_j,\bar{u}_a,u_b}\Gamma^{R}_{\check{A}^0_i,\bar{u}_a,u_b}\Big)\\
&-\sum_{a=1}^{5}m_{\tilde{\chi}^0_a}\sum_{b=1}^{5}B_0\Big(p^2,m_{\tilde{\chi}^0_a}^2,m_{\tilde{\chi}^0_b}^2\Big)m_{\tilde{\chi}^0_b}\Big(\Gamma^{L*}_{\check{A}^0_j,\tilde{\chi}^0_a,\tilde{\chi}^0_b}\Gamma^{R}_{\check{A}^0_i,\tilde{\chi}^0_a,\tilde{\chi}^0_b}+\Gamma^{R*}_{\check{A}^0_j,\tilde{\chi}^0_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{A}^0_i,\tilde{\chi}^0_a,\tilde{\chi}^0_b}\Big)\\
&+\frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{5}G_0\Big(p^2,m_{\tilde{\chi}^0_a}^2,m_{\tilde{\chi}^0_b}^2\Big)\Big(\Gamma^{L*}_{\check{A}^0_j,\tilde{\chi}^0_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{A}^0_i,\tilde{\chi}^0_a,\tilde{\chi}^0_b}+\Gamma^{R*}_{\check{A}^0_j,\tilde{\chi}^0_a,\tilde{\chi}^0_b}\Gamma^{R}_{\check{A}^0_i,\tilde{\chi}^0_a,\tilde{\chi}^0_b}\Big)\\
&-3\sum_{a=1}^{6}A_0\Big(m_{\tilde{d}_a}^2\Big)\Gamma_{\check{A}^0_i,\check{A}^0_j,\tilde{d}^*_a,\tilde{d}_a}-\sum_{a=1}^{6}A_0\Big(m_{\tilde{e}_a}^2\Big)\Gamma_{\check{A}^0_i,\check{A}^0_j,\tilde{e}^*_a,\tilde{e}_a}\\
&-3\sum_{a=1}^{6}A_0\Big(m_{\tilde{u}_a}^2\Big)\Gamma_{\check{A}^0_i,\check{A}^0_j,\tilde{u}^*_a,\tilde{u}_a}+3\sum_{a=1}^{6}\sum_{b=1}^{6}B_0\Big(p^2,m_{\tilde{d}_a}^2,m_{\tilde{d}_b}^2\Big)\Gamma^*_{\check{A}^0_j,\tilde{d}^*_a,\tilde{d}_b}\Gamma_{\check{A}^0_i,\tilde{d}^*_a,\tilde{d}_b}\\
&+\sum_{a=1}^{6}\sum_{b=1}^{6}B_0\Big(p^2,m_{\tilde{e}_a}^2,m_{\tilde{e}_b}^2\Big)\Gamma^*_{\check{A}^0_j,\tilde{e}^*_a,\tilde{e}_b}\Gamma_{\check{A}^0_i,\tilde{e}^*_a,\tilde{e}_b}\\
&+3\sum_{a=1}^{6}\sum_{b=1}^{6}B_0\Big(p^2,m_{\tilde{u}_a}^2,m_{\tilde{u}_b}^2\Big)\Gamma^*_{\check{A}^0_j,\tilde{u}^*_a,\tilde{u}_b}\Gamma_{\check{A}^0_i,\tilde{u}^*_a,\tilde{u}_b}\\
&+2\sum_{b=1}^{2}\Gamma^*_{\check{A}^0_j,W^+,H^-_b}\Gamma_{\check{A}^0_i,W^+,H^-_b}F_0\Big(p^2,m_{H^-_b}^2,m_{W^-}^2\Big)+\sum_{b=1}^{3}\Gamma^*_{\check{A}^0_j,Z,h_b}\Gamma_{\check{A}^0_i,Z,h_b}F_0\Big(p^2,m_{h_b}^2,m_Z^2\Big)
\end{aligned}
\tag{167}
$$

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

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

$$
\begin{aligned}
&- 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^-}} \\
&+ 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) \\
&- \sum_{a=1}^{2} A_0\Big(m^2_{H_a^-}\Big)\Gamma_{\check{H}_i^-,\check{H}_j^+,H_a^+,H_a^-} + \sum_{a=1}^{2}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{H_a^-}, m^2_{A_b^0}\Big)\Gamma^*_{\check{H}_j^+,H_a^-,A_b^0}\Gamma_{\check{H}_i^+,H_a^-,A_b^0} \\
&+ \sum_{a=1}^{2}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{H_a^-}, m^2_{h_b}\Big)\Gamma^*_{\check{H}_j^+,H_a^-,h_b}\Gamma_{\check{H}_i^+,H_a^-,h_b} - \frac{1}{2}\sum_{a=1}^{3} A_0\Big(m^2_{A_a^0}\Big)\Gamma_{\check{H}_i^-,\check{H}_j^+,A_a^0,A_a^0} \\
&- \sum_{a=1}^{3} A_0\Big(m^2_{\tilde{\nu}_a}\Big)\Gamma_{\check{H}_i^-,\check{H}_j^+,\tilde{\nu}_a^*,\tilde{\nu}_a} - \frac{1}{2}\sum_{a=1}^{3} A_0\Big(m^2_{h_a}\Big)\Gamma_{\check{H}_i^-,\check{H}_j^+,h_a,h_a} \\
&- 6\sum_{a=1}^{3} m_{u_a}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{u_a}, m^2_{d_b}\Big)m_{d_b}\Big(\Gamma^{L*}_{\check{H}_j^+,\bar{u}_a,d_b}\Gamma^{R}_{\check{H}_i^+,\bar{u}_a,d_b} + \Gamma^{R*}_{\check{H}_j^+,\bar{u}_a,d_b}\Gamma^{L}_{\check{H}_i^+,\bar{u}_a,d_b}\Big) \\
&+ 3\sum_{a=1}^{3}\sum_{b=1}^{3} G_0\Big(p^2, m^2_{u_a}, m^2_{d_b}\Big)\Big(\Gamma^{L*}_{\check{H}_j^+,\bar{u}_a,d_b}\Gamma^{L}_{\check{H}_i^+,\bar{u}_a,d_b} + \Gamma^{R*}_{\check{H}_j^+,\bar{u}_a,d_b}\Gamma^{R}_{\check{H}_i^+,\bar{u}_a,d_b}\Big) \\
&- 2\sum_{a=1}^{3} m_{\nu_a}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{\nu_a}, m^2_{e_b}\Big)m_{e_b}\Big(\Gamma^{L*}_{\check{H}_j^+,\bar{\nu}_a,e_b}\Gamma^{R}_{\check{H}_i^+,\bar{\nu}_a,e_b} + \Gamma^{R*}_{\check{H}_j^+,\bar{\nu}_a,e_b}\Gamma^{L}_{\check{H}_i^+,\bar{\nu}_a,e_b}\Big) \\
&+ \sum_{a=1}^{3}\sum_{b=1}^{3} G_0\Big(p^2, m^2_{\nu_a}, m^2_{e_b}\Big)\Big(\Gamma^{L*}_{\check{H}_j^+,\bar{\nu}_a,e_b}\Gamma^{L}_{\check{H}_i^+,\bar{\nu}_a,e_b} + \Gamma^{R*}_{\check{H}_j^+,\bar{\nu}_a,e_b}\Gamma^{R}_{\check{H}_i^+,\bar{\nu}_a,e_b}\Big) \\
&+ \sum_{a=1}^{3}\sum_{b=1}^{6} B_0\Big(p^2, m^2_{\tilde{\nu}_a}, m^2_{\tilde{e}_b}\Big)\Gamma^*_{\check{H}_j^+,\tilde{\nu}_a^*,\tilde{e}_b}\Gamma_{\check{H}_i^+,\tilde{\nu}_a^*,\tilde{e}_b} \\
&- 2\sum_{a=1}^{5} m_{\tilde{\chi}_a^0}\sum_{b=1}^{2} B_0\Big(p^2, m^2_{\tilde{\chi}_a^0}, m^2_{\tilde{\chi}_b^-}\Big)m_{\tilde{\chi}_b^-}\Big(\Gamma^{L*}_{\check{H}_j^+,\tilde{\chi}_a^0,\tilde{\chi}_b^-}\Gamma^{R}_{\check{H}_i^+,\tilde{\chi}_a^0,\tilde{\chi}_b^-} + \Gamma^{R*}_{\check{H}_j^+,\tilde{\chi}_a^0,\tilde{\chi}_b^-}\Gamma^{L}_{\check{H}_i^+,\tilde{\chi}_a^0,\tilde{\chi}_b^-}\Big) \\
&+ \sum_{a=1}^{5}\sum_{b=1}^{2} G_0\Big(p^2, m^2_{\tilde{\chi}_a^0}, m^2_{\tilde{\chi}_b^-}\Big)\Big(\Gamma^{L*}_{\check{H}_j^+,\tilde{\chi}_a^0,\tilde{\chi}_b^-}\Gamma^{L}_{\check{H}_i^+,\tilde{\chi}_a^0,\tilde{\chi}_b^-} + \Gamma^{R*}_{\check{H}_j^+,\tilde{\chi}_a^0,\tilde{\chi}_b^-}\Gamma^{R}_{\check{H}_i^+,\tilde{\chi}_a^0,\tilde{\chi}_b^-}\Big) \\
&- 3\sum_{a=1}^{6} A_0\Big(m^2_{\tilde{d}_a}\Big)\Gamma_{\check{H}_i^-,\check{H}_j^+,\tilde{d}_a^*,\tilde{d}_a} - \sum_{a=1}^{6} A_0\Big(m^2_{\tilde{e}_a}\Big)\Gamma_{\check{H}_i^-,\check{H}_j^+,\tilde{e}_a^*,\tilde{e}_a} \\
&- 3\sum_{a=1}^{6} A_0\Big(m^2_{\tilde{u}_a}\Big)\Gamma_{\check{H}_i^-,\check{H}_j^+,\tilde{u}_a^*,\tilde{u}_a} + 3\sum_{a=1}^{6}\sum_{b=1}^{6} B_0\Big(p^2, m^2_{\tilde{u}_a}, m^2_{\tilde{d}_b}\Big)\Gamma^*_{\check{H}_j^+,\tilde{u}_a^*,\tilde{d}_b}\Gamma_{\check{H}_i^+,\tilde{u}_a^*,\tilde{d}_b} \\
&+ \sum_{b=1}^{2}\Gamma^*_{\check{H}_j^+,\gamma,H_b^-}\Gamma_{\check{H}_i^+,\gamma,H_b^-}F_0\Big(p^2, m^2_{H_b^-}, 0\Big) + \sum_{b=1}^{2}\Gamma^*_{\check{H}_j^+,Z,H_b^-}\Gamma_{\check{H}_i^+,Z,H_b^-}F_0\Big(p^2, m^2_{H_b^-}, m^2_Z\Big) \\
&+ \sum_{b=1}^{3}\Gamma^*_{\check{H}_j^+,W^-,A_b^0}\Gamma_{\check{H}_i^+,W^-,A_b^0}F_0\Big(p^2, m^2_{A_b^0}, m^2_{W^-}\Big) + \sum_{b=1}^{3}\Gamma^*_{\check{H}_j^+,W^-,h_b}\Gamma_{\check{H}_i^+,W^-,h_b}F_0\Big(p^2, m^2_{h_b}, m^2_{W^-}\Big) \quad (168)
\end{aligned}
$$

- **Self-Energy for Neutralinos** $(\tilde{\chi}^0)$

$$
\begin{aligned}
\Sigma^S_{i,j}(p^2) = &+2\sum_{a=1}^{2}\sum_{b=1}^{2} B_0\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,H^+_a,\tilde{\chi}^-_b} m_{\tilde{\chi}^-_b}\Gamma^{R}_{\tilde{\chi}^0_i,H^+_a,\tilde{\chi}^-_b}\\
&+2\sum_{a=1}^{3}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{\nu_b}, m^2_{\tilde{\nu}_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{\nu}^*_a,\nu_b} m_{\nu_b}\Gamma^{R}_{\tilde{\chi}^0_i,\tilde{\nu}^*_a,\nu_b}\\
&+\sum_{a=1}^{3}\sum_{b=1}^{5} B_0\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,h_a,\tilde{\chi}^0_b} m_{\tilde{\chi}^0_b}\Gamma^{R}_{\tilde{\chi}^0_i,h_a,\tilde{\chi}^0_b}\\
&+\sum_{a=1}^{5} m_{\tilde{\chi}^0_a}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{\tilde{\chi}^0_a}, m^2_{A^0_b}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{\chi}^0_a,A^0_b}\Gamma^{R}_{\tilde{\chi}^0_i,\tilde{\chi}^0_a,A^0_b}\\
&+6\sum_{a=1}^{6}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{d_b}, m^2_{\tilde{d}_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{d}^*_a,d_b} m_{d_b}\Gamma^{R}_{\tilde{\chi}^0_i,\tilde{d}^*_a,d_b}\\
&+2\sum_{a=1}^{6}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{e_b}, m^2_{\tilde{e}_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{e}^*_a,e_b} m_{e_b}\Gamma^{R}_{\tilde{\chi}^0_i,\tilde{e}^*_a,e_b}\\
&+6\sum_{a=1}^{6}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{u_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{u}^*_a,u_b} m_{u_b}\Gamma^{R}_{\tilde{\chi}^0_i,\tilde{u}^*_a,u_b}\\
&-8\sum_{b=1}^{2}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,W^+,\tilde{\chi}^-_b} m_{\tilde{\chi}^-_b}\Gamma^{L}_{\tilde{\chi}^0_i,W^+,\tilde{\chi}^-_b}\\
&-4\sum_{b=1}^{5}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,Z,\tilde{\chi}^0_b} m_{\tilde{\chi}^0_b}\Gamma^{L}_{\tilde{\chi}^0_i,Z,\tilde{\chi}^0_b}
\end{aligned}
\tag{169}
$$

$$
\begin{aligned}
\Sigma^R_{i,j}(p^2) = &-\sum_{a=1}^{2}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{H^-_a}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,H^+_a,\tilde{\chi}^-_b}\Gamma^{R}_{\tilde{\chi}^0_i,H^+_a,\tilde{\chi}^-_b}\\
&-\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{\nu_b}, m^2_{\tilde{\nu}_a}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,\tilde{\nu}^*_a,\nu_b}\Gamma^{R}_{\tilde{\chi}^0_i,\tilde{\nu}^*_a,\nu_b}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{h_a}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,h_a,\tilde{\chi}^0_b}\Gamma^{R}_{\tilde{\chi}^0_i,h_a,\tilde{\chi}^0_b}\\
&-\frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{\tilde{\chi}^0_a}, m^2_{A^0_b}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,\tilde{\chi}^0_a,A^0_b}\Gamma^{R}_{\tilde{\chi}^0_i,\tilde{\chi}^0_a,A^0_b}\\
&-3\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{d_b}, m^2_{\tilde{d}_a}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,\tilde{d}^*_a,d_b}\Gamma^{R}_{\tilde{\chi}^0_i,\tilde{d}^*_a,d_b}\\
&-\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{\tilde{e}_a}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,\tilde{e}^*_a,e_b}\Gamma^{R}_{\tilde{\chi}^0_i,\tilde{e}^*_a,e_b}
\end{aligned}
$$

$$
\begin{aligned}
&- 3\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,\tilde{u}^*_a,u_b}\Gamma^{R}_{\tilde{\chi}^0_i,\tilde{u}^*_a,u_b} \\
&- 2\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{W^-}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,W^+,\tilde{\chi}^-_b}\Gamma^{L}_{\tilde{\chi}^0_i,W^+,\tilde{\chi}^-_b} - \sum_{b=1}^{5} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{Z}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,Z,\tilde{\chi}^0_b}\Gamma^{L}_{\tilde{\chi}^0_i,Z,\tilde{\chi}^0_b} \qquad (170)
\end{aligned}
$$

$$
\begin{aligned}
\Sigma^L_{i,j}(p^2) = &- \sum_{a=1}^{2}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,H^+_a,\tilde{\chi}^-_b}\Gamma^{L}_{\tilde{\chi}^0_i,H^+_a,\tilde{\chi}^-_b} \\
&- \sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{\nu_b}, m^2_{\tilde{\nu}_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{\nu}^*_a,\nu_b}\Gamma^{L}_{\tilde{\chi}^0_i,\tilde{\nu}^*_a,\nu_b} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,h_a,\tilde{\chi}^0_b}\Gamma^{L}_{\tilde{\chi}^0_i,h_a,\tilde{\chi}^0_b} \\
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{\tilde{\chi}^0_a}, m^2_{A^0_b}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{\chi}^0_a,A^0_b}\Gamma^{L}_{\tilde{\chi}^0_i,\tilde{\chi}^0_a,A^0_b} \\
&- 3\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{d_b}, m^2_{\tilde{d}_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{d}^*_a,d_b}\Gamma^{L}_{\tilde{\chi}^0_i,\tilde{d}^*_a,d_b} \\
&- \sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{\tilde{e}_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{e}^*_a,e_b}\Gamma^{L}_{\tilde{\chi}^0_i,\tilde{e}^*_a,e_b} \\
&- 3\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{u}^*_a,u_b}\Gamma^{L}_{\tilde{\chi}^0_i,\tilde{u}^*_a,u_b} \\
&- 2\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{W^-}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,W^+,\tilde{\chi}^-_b}\Gamma^{R}_{\tilde{\chi}^0_i,W^+,\tilde{\chi}^-_b} - \sum_{b=1}^{5} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{Z}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,Z,\tilde{\chi}^0_b}\Gamma^{R}_{\tilde{\chi}^0_i,Z,\tilde{\chi}^0_b} \qquad (171)
\end{aligned}
$$

- **Self-Energy for Charginos** $(\tilde{\chi}^-)$

$$
\begin{aligned}
\Sigma^S_{i,j}(p^2) = &+ \sum_{a=1}^{2} m_{\tilde{\chi}^-_a}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{\tilde{\chi}^-_a}, m^2_{A^0_b}\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,\tilde{\chi}^-_a,A^0_b}\Gamma^{R}_{\tilde{\chi}^+_i,\tilde{\chi}^-_a,A^0_b} \\
&+ \sum_{a=1}^{2}\sum_{b=1}^{5} B_0\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,H^-_a,\tilde{\chi}^0_b} m_{\tilde{\chi}^0_b}\Gamma^{R}_{\tilde{\chi}^+_i,H^-_a,\tilde{\chi}^0_b} \\
&+ \sum_{a=1}^{3}\sum_{b=1}^{2} B_0\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,h_a,\tilde{\chi}^-_b} m_{\tilde{\chi}^-_b}\Gamma^{R}_{\tilde{\chi}^+_i,h_a,\tilde{\chi}^-_b} \\
&+ \sum_{a=1}^{3}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{e_b}, m^2_{\tilde{\nu}_a}\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,\tilde{\nu}^*_a,e_b} m_{e_b}\Gamma^{R}_{\tilde{\chi}^+_i,\tilde{\nu}^*_a,e_b}
\end{aligned}
$$

$$
\begin{aligned}
&+ 3\sum_{a=1}^{3} m_{u_a} \sum_{b=1}^{6} B_0\Big(p^2, m_{u_a}^2, m_{\tilde{d}_b}^2\Big)\Gamma^{L*}_{\tilde{\chi}_j^+,\bar{u}_a,\tilde{d}_b}\Gamma^{R}_{\tilde{\chi}_i^+,\bar{u}_a,\tilde{d}_b} \\
&+ \sum_{a=1}^{3} m_{\nu_a} \sum_{b=1}^{6} B_0\Big(p^2, m_{\nu_a}^2, m_{\tilde{e}_b}^2\Big)\Gamma^{L*}_{\tilde{\chi}_j^+,\bar{\nu}_a,\tilde{e}_b}\Gamma^{R}_{\tilde{\chi}_i^+,\bar{\nu}_a,\tilde{e}_b} \\
&+ 3\sum_{a=1}^{6} \sum_{b=1}^{3} B_0\Big(p^2, m_{d_b}^2, m_{\tilde{u}_a}^2\Big)\Gamma^{L*}_{\tilde{\chi}_j^+,\tilde{u}_a^*,d_b} m_{d_b}\Gamma^{R}_{\tilde{\chi}_i^+,\tilde{u}_a^*,d_b} \\
&- 4\sum_{b=1}^{2} \Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{\tilde{\chi}_b^-}^2, 0\Big)\Big)\Gamma^{R*}_{\tilde{\chi}_j^+,\gamma,\tilde{\chi}_b^-} m_{\tilde{\chi}_b^-}\Gamma^{L}_{\tilde{\chi}_i^+,\gamma,\tilde{\chi}_b^-} \\
&- 4\sum_{b=1}^{2} \Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{\tilde{\chi}_b^-}^2, m_Z^2\Big)\Big)\Gamma^{R*}_{\tilde{\chi}_j^+,Z,\tilde{\chi}_b^-} m_{\tilde{\chi}_b^-}\Gamma^{L}_{\tilde{\chi}_i^+,Z,\tilde{\chi}_b^-} \\
&- 4\sum_{b=1}^{5} \Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{W^-}^2\Big)\Big)\Gamma^{R*}_{\tilde{\chi}_j^+,W^-,\tilde{\chi}_b^0} m_{\tilde{\chi}_b^0}\Gamma^{L}_{\tilde{\chi}_i^+,W^-,\tilde{\chi}_b^0}
\end{aligned} \tag{172}
$$

$$
\begin{aligned}
\Sigma^R_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m_{\tilde{\chi}_a^-}^2, m_{A_b^0}^2\Big)\Gamma^{R*}_{\tilde{\chi}_j^+,\tilde{\chi}_a^-,A_b^0}\Gamma^{R}_{\tilde{\chi}_i^+,\tilde{\chi}_a^-,A_b^0} \\
&- \frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{5} B_1\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{H_a^-}^2\Big)\Gamma^{R*}_{\tilde{\chi}_j^+,H_a^-,\tilde{\chi}_b^0}\Gamma^{R}_{\tilde{\chi}_i^+,H_a^-,\tilde{\chi}_b^0} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{2} B_1\Big(p^2, m_{\tilde{\chi}_b^-}^2, m_{h_a}^2\Big)\Gamma^{R*}_{\tilde{\chi}_j^+,h_a,\tilde{\chi}_b^-}\Gamma^{R}_{\tilde{\chi}_i^+,h_a,\tilde{\chi}_b^-} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{e_b}^2, m_{\tilde{\nu}_a}^2\Big)\Gamma^{R*}_{\tilde{\chi}_j^+,\tilde{\nu}_a^*,e_b}\Gamma^{R}_{\tilde{\chi}_i^+,\tilde{\nu}_a^*,e_b} \\
&- \frac{3}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m_{u_a}^2, m_{\tilde{d}_b}^2\Big)\Gamma^{R*}_{\tilde{\chi}_j^+,\bar{u}_a,\tilde{d}_b}\Gamma^{R}_{\tilde{\chi}_i^+,\bar{u}_a,\tilde{d}_b} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m_{\nu_a}^2, m_{\tilde{e}_b}^2\Big)\Gamma^{R*}_{\tilde{\chi}_j^+,\bar{\nu}_a,\tilde{e}_b}\Gamma^{R}_{\tilde{\chi}_i^+,\bar{\nu}_a,\tilde{e}_b} \\
&- \frac{3}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, m_{\tilde{u}_a}^2\Big)\Gamma^{R*}_{\tilde{\chi}_j^+,\tilde{u}_a^*,d_b}\Gamma^{R}_{\tilde{\chi}_i^+,\tilde{u}_a^*,d_b} - \sum_{b=1}^{2} B_1\Big(p^2, m_{\tilde{\chi}_b^-}^2, 0\Big)\Gamma^{L*}_{\tilde{\chi}_j^+,\gamma,\tilde{\chi}_b^-}\Gamma^{L}_{\tilde{\chi}_i^+,\gamma,\tilde{\chi}_b^-} \\
&- \sum_{b=1}^{2} B_1\Big(p^2, m_{\tilde{\chi}_b^-}^2, m_Z^2\Big)\Gamma^{L*}_{\tilde{\chi}_j^+,Z,\tilde{\chi}_b^-}\Gamma^{L}_{\tilde{\chi}_i^+,Z,\tilde{\chi}_b^-} - \sum_{b=1}^{5} B_1\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{W^-}^2\Big)\Gamma^{L*}_{\tilde{\chi}_j^+,W^-,\tilde{\chi}_b^0}\Gamma^{L}_{\tilde{\chi}_i^+,W^-,\tilde{\chi}_b^0}
\end{aligned} \tag{173}
$$

$$
\Sigma^L_{i,j}(p^2) = -\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m_{\tilde{\chi}_a^-}^2, m_{A_b^0}^2\Big)\Gamma^{L*}_{\tilde{\chi}_j^+,\tilde{\chi}_a^-,A_b^0}\Gamma^{L}_{\tilde{\chi}_i^+,\tilde{\chi}_a^-,A_b^0}
$$

$$
\begin{aligned}
&- \frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\check{\tilde{\chi}}^+_j,H^-_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{\tilde{\chi}}^+_i,H^-_a,\tilde{\chi}^0_b}\\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\check{\tilde{\chi}}^+_j,h_a,\tilde{\chi}^-_b}\Gamma^{L}_{\check{\tilde{\chi}}^+_i,h_a,\tilde{\chi}^-_b}\\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{\tilde{\nu}_a}\Big)\Gamma^{L*}_{\check{\tilde{\chi}}^+_j,\tilde{\nu}^*_a,e_b}\Gamma^{L}_{\check{\tilde{\chi}}^+_i,\tilde{\nu}^*_a,e_b}\\
&- \frac{3}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{u_a}, m^2_{\tilde{d}_b}\Big)\Gamma^{L*}_{\check{\tilde{\chi}}^+_j,\bar{u}_a,\tilde{d}_b}\Gamma^{L}_{\check{\tilde{\chi}}^+_i,\bar{u}_a,\tilde{d}_b}\\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{\nu_a}, m^2_{\tilde{e}_b}\Big)\Gamma^{L*}_{\check{\tilde{\chi}}^+_j,\bar{\nu}_a,\tilde{e}_b}\Gamma^{L}_{\check{\tilde{\chi}}^+_i,\bar{\nu}_a,\tilde{e}_b}\\
&- \frac{3}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{d_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{L*}_{\check{\tilde{\chi}}^+_j,\tilde{u}^*_a,d_b}\Gamma^{L}_{\check{\tilde{\chi}}^+_i,\tilde{u}^*_a,d_b} - \sum_{b=1}^{2} B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, 0\Big)\Gamma^{R*}_{\check{\tilde{\chi}}^+_j,\gamma,\tilde{\chi}^-_b}\Gamma^{R}_{\check{\tilde{\chi}}^+_i,\gamma,\tilde{\chi}^-_b}\\
&- \sum_{b=1}^{2} B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_Z\Big)\Gamma^{R*}_{\check{\tilde{\chi}}^+_j,Z,\tilde{\chi}^-_b}\Gamma^{R}_{\check{\tilde{\chi}}^+_i,Z,\tilde{\chi}^-_b} - \sum_{b=1}^{5} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{W^-}\Big)\Gamma^{R*}_{\check{\tilde{\chi}}^+_j,W^-,\tilde{\chi}^0_b}\Gamma^{R}_{\check{\tilde{\chi}}^+_i,W^-,\tilde{\chi}^0_b} \qquad (174)
\end{aligned}
$$

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

$$
\begin{aligned}
\Sigma^S_{i,j}(p^2) = &+\sum_{a=1}^{2}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{\nu_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\check{\tilde{e}}_j,H^-_a,\nu_b} m_{\nu_b}\Gamma^{R}_{\check{\tilde{e}}_i,H^-_a,\nu_b}\\
&+\sum_{a=1}^{3}\sum_{b=1}^{2} B_0\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{\tilde{\nu}_a}\Big)\Gamma^{L*}_{\check{\tilde{e}}_j,\tilde{\nu}_a,\tilde{\chi}^-_b} m_{\tilde{\chi}^-_b}\Gamma^{R}_{\check{\tilde{e}}_i,\tilde{\nu}_a,\tilde{\chi}^-_b}\\
&+\sum_{a=1}^{3} m_{e_a}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{e_a}, m^2_{A^0_b}\Big)\Gamma^{L*}_{\check{\tilde{e}}_j,e_a,A^0_b}\Gamma^{R}_{\check{\tilde{e}}_i,e_a,A^0_b}\\
&+\sum_{a=1}^{3}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{e_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\check{\tilde{e}}_j,h_a,e_b} m_{e_b}\Gamma^{R}_{\check{\tilde{e}}_i,h_a,e_b}\\
&+\sum_{a=1}^{6}\sum_{b=1}^{5} B_0\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{\tilde{e}_a}\Big)\Gamma^{L*}_{\check{\tilde{e}}_j,\tilde{e}_a,\tilde{\chi}^0_b} m_{\tilde{\chi}^0_b}\Gamma^{R}_{\check{\tilde{e}}_i,\tilde{e}_a,\tilde{\chi}^0_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{e_b}, 0\Big)\Big)\Gamma^{R*}_{\check{\tilde{e}}_j,\gamma,e_b} m_{e_b}\Gamma^{L}_{\check{\tilde{e}}_i,\gamma,e_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\nu_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\check{\tilde{e}}_j,W^-,\nu_b} m_{\nu_b}\Gamma^{L}_{\check{\tilde{e}}_i,W^-,\nu_b}
\end{aligned}
$$

$$- 4\sum_{b=1}^{3}\Big(-\frac{1}{2}\text{rMS} + B_0\Big(p^2, m_{e_b}^2, m_Z^2\Big)\Big)\Gamma^{R*}_{\check{\bar{e}}_j,Z,e_b} m_{e_b}\Gamma^{L}_{\check{\bar{e}}_i,Z,e_b} \tag{175}$$

$$\begin{aligned}
\Sigma^R_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m_{\nu_b}^2, m_{H_a^-}^2\Big)\Gamma^{R*}_{\check{\bar{e}}_j,H_a^-,\nu_b}\Gamma^{R}_{\check{\bar{e}}_i,H_a^-,\nu_b}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{2} B_1\Big(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{\nu}_a}^2\Big)\Gamma^{R*}_{\check{\bar{e}}_j,\tilde{\nu}_a,\tilde{\chi}_b^-}\Gamma^{R}_{\check{\bar{e}}_i,\tilde{\nu}_a,\tilde{\chi}_b^-}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{e_a}^2, m_{A_b^0}^2\Big)\Gamma^{R*}_{\check{\bar{e}}_j,e_a,A_b^0}\Gamma^{R}_{\check{\bar{e}}_i,e_a,A_b^0}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{e_b}^2, m_{h_a}^2\Big)\Gamma^{R*}_{\check{\bar{e}}_j,h_a,e_b}\Gamma^{R}_{\check{\bar{e}}_i,h_a,e_b}\\
&-\frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{5} B_1\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2\Big)\Gamma^{R*}_{\check{\bar{e}}_j,\tilde{e}_a,\tilde{\chi}_b^0}\Gamma^{R}_{\check{\bar{e}}_i,\tilde{e}_a,\tilde{\chi}_b^0} - \sum_{b=1}^{3} B_1\Big(p^2, m_{e_b}^2, 0\Big)\Gamma^{L*}_{\check{\bar{e}}_j,\gamma,e_b}\Gamma^{L}_{\check{\bar{e}}_i,\gamma,e_b}\\
&-\sum_{b=1}^{3} B_1\Big(p^2, m_{\nu_b}^2, m_{W^-}^2\Big)\Gamma^{L*}_{\check{\bar{e}}_j,W^-,\nu_b}\Gamma^{L}_{\check{\bar{e}}_i,W^-,\nu_b} - \sum_{b=1}^{3} B_1\Big(p^2, m_{e_b}^2, m_Z^2\Big)\Gamma^{L*}_{\check{\bar{e}}_j,Z,e_b}\Gamma^{L}_{\check{\bar{e}}_i,Z,e_b}
\end{aligned} \tag{176}$$

$$\begin{aligned}
\Sigma^L_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m_{\nu_b}^2, m_{H_a^-}^2\Big)\Gamma^{L*}_{\check{\bar{e}}_j,H_a^-,\nu_b}\Gamma^{L}_{\check{\bar{e}}_i,H_a^-,\nu_b}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{2} B_1\Big(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{\nu}_a}^2\Big)\Gamma^{L*}_{\check{\bar{e}}_j,\tilde{\nu}_a,\tilde{\chi}_b^-}\Gamma^{L}_{\check{\bar{e}}_i,\tilde{\nu}_a,\tilde{\chi}_b^-}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{e_a}^2, m_{A_b^0}^2\Big)\Gamma^{L*}_{\check{\bar{e}}_j,e_a,A_b^0}\Gamma^{L}_{\check{\bar{e}}_i,e_a,A_b^0}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{e_b}^2, m_{h_a}^2\Big)\Gamma^{L*}_{\check{\bar{e}}_j,h_a,e_b}\Gamma^{L}_{\check{\bar{e}}_i,h_a,e_b}\\
&-\frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{5} B_1\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2\Big)\Gamma^{L*}_{\check{\bar{e}}_j,\tilde{e}_a,\tilde{\chi}_b^0}\Gamma^{L}_{\check{\bar{e}}_i,\tilde{e}_a,\tilde{\chi}_b^0} - \sum_{b=1}^{3} B_1\Big(p^2, m_{e_b}^2, 0\Big)\Gamma^{R*}_{\check{\bar{e}}_j,\gamma,e_b}\Gamma^{R}_{\check{\bar{e}}_i,\gamma,e_b}\\
&-\sum_{b=1}^{3} B_1\Big(p^2, m_{\nu_b}^2, m_{W^-}^2\Big)\Gamma^{R*}_{\check{\bar{e}}_j,W^-,\nu_b}\Gamma^{R}_{\check{\bar{e}}_i,W^-,\nu_b} - \sum_{b=1}^{3} B_1\Big(p^2, m_{e_b}^2, m_Z^2\Big)\Gamma^{R*}_{\check{\bar{e}}_j,Z,e_b}\Gamma^{R}_{\check{\bar{e}}_i,Z,e_b}
\end{aligned} \tag{177}$$

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

$$\Sigma^S_{i,j}(p^2) = +\sum_{a=1}^{2}\sum_{b=1}^{3} B_0\Big(p^2, m_{u_b}^2, m_{H_a^-}^2\Big)\Gamma^{L*}_{\check{\bar{d}}_j,H_a^-,u_b} m_{u_b}\Gamma^{R}_{\check{\bar{d}}_i,H_a^-,u_b}$$

$$
\begin{aligned}
&+\sum_{a=1}^{3} m_{d_a} \sum_{b=1}^{3} B_0\Big(p^2, m_{d_a}^2, m_{A_b^0}^2\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,d_a,A_b^0}\Gamma^{R}_{\tilde{\tilde{d}}_i,d_a,A_b^0}\\
&+\sum_{a=1}^{3}\sum_{b=1}^{3} B_0\Big(p^2, m_{d_b}^2, m_{h_a}^2\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,h_a,d_b} m_{d_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,h_a,d_b}\\
&+\sum_{a=1}^{6}\sum_{b=1}^{2} B_0\Big(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,\tilde{u}_a,\tilde{\chi}_b^-} m_{\tilde{\chi}_b^-}\Gamma^{R}_{\tilde{\tilde{d}}_i,\tilde{u}_a,\tilde{\chi}_b^-}\\
&+\sum_{a=1}^{6}\sum_{b=1}^{5} B_0\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,\tilde{d}_a,\tilde{\chi}_b^0} m_{\tilde{\chi}_b^0}\Gamma^{R}_{\tilde{\tilde{d}}_i,\tilde{d}_a,\tilde{\chi}_b^0}\\
&+\frac{4}{3} m_{\tilde{g}} \sum_{a=1}^{6} B_0\Big(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,\tilde{d}_a,\tilde{g}_1}\Gamma^{R}_{\tilde{\tilde{d}}_i,\tilde{d}_a,\tilde{g}_1} - \frac{16}{3}\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{d_b}^2, 0\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,g,d_b} m_{d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,g,d_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{d_b}^2, 0\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,\gamma,d_b} m_{d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,\gamma,d_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{u_b}^2, m_{W^-}^2\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,W^-,u_b} m_{u_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,W^-,u_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{d_b}^2, m_Z^2\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,Z,d_b} m_{d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,Z,d_b} \qquad (178)\\
\Sigma^R_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m_{u_b}^2, m_{H_a^-}^2\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,H_a^-,u_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,H_a^-,u_b}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{d_a}^2, m_{A_b^0}^2\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,d_a,A_b^0}\Gamma^{R}_{\tilde{\tilde{d}}_i,d_a,A_b^0}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, m_{h_a}^2\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,h_a,d_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,h_a,d_b}\\
&-\frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{2} B_1\Big(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,\tilde{u}_a,\tilde{\chi}_b^-}\Gamma^{R}_{\tilde{\tilde{d}}_i,\tilde{u}_a,\tilde{\chi}_b^-}\\
&-\frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{5} B_1\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,\tilde{d}_a,\tilde{\chi}_b^0}\Gamma^{R}_{\tilde{\tilde{d}}_i,\tilde{d}_a,\tilde{\chi}_b^0}\\
&-\frac{2}{3}\sum_{a=1}^{6} B_1\Big(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,\tilde{d}_a,\tilde{g}_1}\Gamma^{R}_{\tilde{\tilde{d}}_i,\tilde{d}_a,\tilde{g}_1} - \frac{4}{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, 0\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,g,d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,g,d_b}\\
&-\sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, 0\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,\gamma,d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,\gamma,d_b} - \sum_{b=1}^{3} B_1\Big(p^2, m_{u_b}^2, m_{W^-}^2\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,W^-,u_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,W^-,u_b}
\end{aligned}
$$

$$
\begin{aligned}
&- \sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, m_Z^2\Big) \Gamma^{L*}_{\tilde{\tilde{d}}_j, Z, d_b} \Gamma^{L}_{\tilde{\tilde{d}}_i, Z, d_b} \qquad (179)\\
\Sigma^L_{i,j}(p^2) = &-\frac{1}{2} \sum_{a=1}^{2} \sum_{b=1}^{3} B_1\Big(p^2, m_{u_b}^2, m_{H_a^-}^2\Big) \Gamma^{L*}_{\tilde{\tilde{d}}_j, H_a^-, u_b} \Gamma^{L}_{\tilde{\tilde{d}}_i, H_a^-, u_b}\\
&- \frac{1}{2} \sum_{a=1}^{3} \sum_{b=1}^{3} B_1\Big(p^2, m_{d_a}^2, m_{A_b^0}^2\Big) \Gamma^{L*}_{\tilde{\tilde{d}}_j, d_a, A_b^0} \Gamma^{L}_{\tilde{\tilde{d}}_i, d_a, A_b^0}\\
&- \frac{1}{2} \sum_{a=1}^{3} \sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, m_{h_a}^2\Big) \Gamma^{L*}_{\tilde{\tilde{d}}_j, h_a, d_b} \Gamma^{L}_{\tilde{\tilde{d}}_i, h_a, d_b}\\
&- \frac{1}{2} \sum_{a=1}^{6} \sum_{b=1}^{2} B_1\Big(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2\Big) \Gamma^{L*}_{\tilde{\tilde{d}}_j, \tilde{u}_a, \tilde{\chi}_b^-} \Gamma^{L}_{\tilde{\tilde{d}}_i, \tilde{u}_a, \tilde{\chi}_b^-}\\
&- \frac{1}{2} \sum_{a=1}^{6} \sum_{b=1}^{5} B_1\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2\Big) \Gamma^{L*}_{\tilde{\tilde{d}}_j, \tilde{d}_a, \tilde{\chi}_b^0} \Gamma^{L}_{\tilde{\tilde{d}}_i, \tilde{d}_a, \tilde{\chi}_b^0}\\
&- \frac{2}{3} \sum_{a=1}^{6} B_1\Big(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2\Big) \Gamma^{L*}_{\tilde{\tilde{d}}_j, \tilde{d}_a, \tilde{g}_1} \Gamma^{L}_{\tilde{\tilde{d}}_i, \tilde{d}_a, \tilde{g}_1} - \frac{4}{3} \sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, 0\Big) \Gamma^{R*}_{\tilde{\tilde{d}}_j, g, d_b} \Gamma^{R}_{\tilde{\tilde{d}}_i, g, d_b}\\
&- \sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, 0\Big) \Gamma^{R*}_{\tilde{\tilde{d}}_j, \gamma, d_b} \Gamma^{R}_{\tilde{\tilde{d}}_i, \gamma, d_b} - \sum_{b=1}^{3} B_1\Big(p^2, m_{u_b}^2, m_{W^-}^2\Big) \Gamma^{R*}_{\tilde{\tilde{d}}_j, W^-, u_b} \Gamma^{R}_{\tilde{\tilde{d}}_i, W^-, u_b}\\
&- \sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, m_Z^2\Big) \Gamma^{R*}_{\tilde{\tilde{d}}_j, Z, d_b} \Gamma^{R}_{\tilde{\tilde{d}}_i, Z, d_b} \qquad (180)
\end{aligned}
$$

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

$$
\begin{aligned}
\Sigma^S_{i,j}(p^2) = &+ \sum_{a=1}^{2} \sum_{b=1}^{3} B_0\Big(p^2, m_{d_b}^2, m_{H_a^-}^2\Big) \Gamma^{L*}_{\tilde{\tilde{u}}_j, H_a^+, d_b} m_{d_b} \Gamma^{R}_{\tilde{\tilde{u}}_i, H_a^+, d_b}\\
&+ \sum_{a=1}^{2} m_{\tilde{\chi}_a^-} \sum_{b=1}^{6} B_0\Big(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{d}_b}^2\Big) \Gamma^{L*}_{\tilde{\tilde{u}}_j, \tilde{\chi}_a^+, \tilde{d}_b} \Gamma^{R}_{\tilde{\tilde{u}}_i, \tilde{\chi}_a^+, \tilde{d}_b}\\
&+ \sum_{a=1}^{3} m_{u_a} \sum_{b=1}^{3} B_0\Big(p^2, m_{u_a}^2, m_{A_b^0}^2\Big) \Gamma^{L*}_{\tilde{\tilde{u}}_j, u_a, A_b^0} \Gamma^{R}_{\tilde{\tilde{u}}_i, u_a, A_b^0}\\
&+ \sum_{a=1}^{3} \sum_{b=1}^{3} B_0\Big(p^2, m_{u_b}^2, m_{h_a}^2\Big) \Gamma^{L*}_{\tilde{\tilde{u}}_j, h_a, u_b} m_{u_b} \Gamma^{R}_{\tilde{\tilde{u}}_i, h_a, u_b}\\
&+ \sum_{a=1}^{6} \sum_{b=1}^{5} B_0\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{u}_a}^2\Big) \Gamma^{L*}_{\tilde{\tilde{u}}_j, \tilde{u}_a, \tilde{\chi}_b^0} m_{\tilde{\chi}_b^0} \Gamma^{R}_{\tilde{\tilde{u}}_i, \tilde{u}_a, \tilde{\chi}_b^0}
\end{aligned}
$$

$$
\begin{aligned}
&+\frac{4}{3}m_{\tilde{g}}\sum_{a=1}^{6}B_0\Big(p^2,m_{\tilde{g}}^2,m_{\tilde{u}_a}^2\Big)\Gamma^{L*}_{\check{\tilde{u}}_j,\tilde{u}_a,\tilde{g}_1}\Gamma^{R}_{\check{\tilde{u}}_i,\tilde{u}_a,\tilde{g}_1}-\frac{16}{3}\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m_{u_b}^2,0\Big)\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,g,u_b}m_{u_b}\Gamma^{L}_{\check{\tilde{u}}_i,g,u_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m_{u_b}^2,0\Big)\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,\gamma,u_b}m_{u_b}\Gamma^{L}_{\check{\tilde{u}}_i,\gamma,u_b}-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m_{u_b}^2,m_Z^2\Big)\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,Z,u_b}m_{u_b}\Gamma^{L}_{\check{\tilde{u}}_i,Z,u_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m_{d_b}^2,m_{W^-}^2\Big)\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,W^+,d_b}m_{d_b}\Gamma^{L}_{\check{\tilde{u}}_i,W^+,d_b} \qquad (181)
\end{aligned}
$$

$$
\begin{aligned}
\Sigma^R_{i,j}(p^2)=&-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3}B_1\Big(p^2,m_{d_b}^2,m_{H_a^-}^2\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,H_a^+,d_b}\Gamma^{R}_{\check{\tilde{u}}_i,H_a^+,d_b}\\
&-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{6}B_1\Big(p^2,m_{\tilde{\chi}_a^-}^2,m_{\tilde{d}_b}^2\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,\tilde{\chi}_a^+,\tilde{d}_b}\Gamma^{R}_{\check{\tilde{u}}_i,\tilde{\chi}_a^+,\tilde{d}_b}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3}B_1\Big(p^2,m_{u_a}^2,m_{A_b^0}^2\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,u_a,A_b^0}\Gamma^{R}_{\check{\tilde{u}}_i,u_a,A_b^0}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3}B_1\Big(p^2,m_{u_b}^2,m_{h_a}^2\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,h_a,u_b}\Gamma^{R}_{\check{\tilde{u}}_i,h_a,u_b}\\
&-\frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{5}B_1\Big(p^2,m_{\tilde{\chi}_b^0}^2,m_{\tilde{u}_a}^2\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,\tilde{u}_a,\tilde{\chi}_b^0}\Gamma^{R}_{\check{\tilde{u}}_i,\tilde{u}_a,\tilde{\chi}_b^0}\\
&-\frac{2}{3}\sum_{a=1}^{6}B_1\Big(p^2,m_{\tilde{g}}^2,m_{\tilde{u}_a}^2\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,\tilde{u}_a,\tilde{g}_1}\Gamma^{R}_{\check{\tilde{u}}_i,\tilde{u}_a,\tilde{g}_1}-\frac{4}{3}\sum_{b=1}^{3}B_1\Big(p^2,m_{u_b}^2,0\Big)\Gamma^{L*}_{\check{\tilde{u}}_j,g,u_b}\Gamma^{L}_{\check{\tilde{u}}_i,g,u_b}\\
&-\sum_{b=1}^{3}B_1\Big(p^2,m_{u_b}^2,0\Big)\Gamma^{L*}_{\check{\tilde{u}}_j,\gamma,u_b}\Gamma^{L}_{\check{\tilde{u}}_i,\gamma,u_b}-\sum_{b=1}^{3}B_1\Big(p^2,m_{u_b}^2,m_Z^2\Big)\Gamma^{L*}_{\check{\tilde{u}}_j,Z,u_b}\Gamma^{L}_{\check{\tilde{u}}_i,Z,u_b}\\
&-\sum_{b=1}^{3}B_1\Big(p^2,m_{d_b}^2,m_{W^-}^2\Big)\Gamma^{L*}_{\check{\tilde{u}}_j,W^+,d_b}\Gamma^{L}_{\check{\tilde{u}}_i,W^+,d_b} \qquad (182)
\end{aligned}
$$

$$
\begin{aligned}
\Sigma^L_{i,j}(p^2)=&-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3}B_1\Big(p^2,m_{d_b}^2,m_{H_a^-}^2\Big)\Gamma^{L*}_{\check{\tilde{u}}_j,H_a^+,d_b}\Gamma^{L}_{\check{\tilde{u}}_i,H_a^+,d_b}\\
&-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{6}B_1\Big(p^2,m_{\tilde{\chi}_a^-}^2,m_{\tilde{d}_b}^2\Big)\Gamma^{L*}_{\check{\tilde{u}}_j,\tilde{\chi}_a^+,\tilde{d}_b}\Gamma^{L}_{\check{\tilde{u}}_i,\tilde{\chi}_a^+,\tilde{d}_b}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3}B_1\Big(p^2,m_{u_a}^2,m_{A_b^0}^2\Big)\Gamma^{L*}_{\check{\tilde{u}}_j,u_a,A_b^0}\Gamma^{L}_{\check{\tilde{u}}_i,u_a,A_b^0}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3}B_1\Big(p^2,m_{u_b}^2,m_{h_a}^2\Big)\Gamma^{L*}_{\check{\tilde{u}}_j,h_a,u_b}\Gamma^{L}_{\check{\tilde{u}}_i,h_a,u_b}
\end{aligned}
$$

$$
\begin{aligned}
&- \frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{L*}_{\tilde{\tilde{u}}_j,\tilde{u}_a,\tilde{\chi}^0_b}\Gamma^{L}_{\tilde{\tilde{u}}_i,\tilde{u}_a,\tilde{\chi}^0_b}\\
&- \frac{2}{3}\sum_{a=1}^{6} B_1\Big(p^2, m^2_{\tilde{g}}, m^2_{\tilde{u}_a}\Big)\Gamma^{L*}_{\tilde{\tilde{u}}_j,\tilde{u}_a,\tilde{g}_1}\Gamma^{L}_{\tilde{\tilde{u}}_i,\tilde{u}_a,\tilde{g}_1} - \frac{4}{3}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_b}, 0\Big)\Gamma^{R*}_{\tilde{\tilde{u}}_j,g,u_b}\Gamma^{R}_{\tilde{\tilde{u}}_i,g,u_b}\\
&- \sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_b}, 0\Big)\Gamma^{R*}_{\tilde{\tilde{u}}_j,\gamma,u_b}\Gamma^{R}_{\tilde{\tilde{u}}_i,\gamma,u_b} - \sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_b}, m^2_Z\Big)\Gamma^{R*}_{\tilde{\tilde{u}}_j,Z,u_b}\Gamma^{R}_{\tilde{\tilde{u}}_i,Z,u_b}\\
&- \sum_{b=1}^{3} B_1\Big(p^2, m^2_{d_b}, m^2_{W^-}\Big)\Gamma^{R*}_{\tilde{\tilde{u}}_j,W^+,d_b}\Gamma^{R}_{\tilde{\tilde{u}}_i,W^+,d_b}
\end{aligned}
\tag{183}
$$

- **Self-Energy for Gluino** $(\tilde{g})$

$$
\begin{aligned}
\Sigma^S(p^2) = &+\sum_{a=1}^{6}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{d_b}, m^2_{\tilde{d}_a}\Big)\Gamma^{L*}_{\tilde{g}_j,\tilde{d}^*_a,d_b} m_{d_b}\Gamma^{R}_{\tilde{g}_i,\tilde{d}^*_a,d_b}\\
&+\sum_{a=1}^{6}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{u_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{L*}_{\tilde{g}_j,\tilde{u}^*_a,u_b} m_{u_b}\Gamma^{R}_{\tilde{g}_i,\tilde{u}^*_a,u_b} - 12\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\tilde{g}}, 0\Big)\Big)\Gamma^{R*}_{\tilde{g}_j,g,\tilde{g}_1} m_{\tilde{g}}\Gamma^{L}_{\tilde{g}_i,g,\tilde{g}_1}
\end{aligned}
\tag{184}
$$

$$
\begin{aligned}
\Sigma^R(p^2) = &-\frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{d_b}, m^2_{\tilde{d}_a}\Big)\Gamma^{R*}_{\tilde{g}_j,\tilde{d}^*_a,d_b}\Gamma^{R}_{\tilde{g}_i,\tilde{d}^*_a,d_b}\\
&-\frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{R*}_{\tilde{g}_j,\tilde{u}^*_a,u_b}\Gamma^{R}_{\tilde{g}_i,\tilde{u}^*_a,u_b} - 3B_1\Big(p^2, m^2_{\tilde{g}}, 0\Big)\Gamma^{L*}_{\tilde{g}_j,g,\tilde{g}_1}\Gamma^{L}_{\tilde{g}_i,g,\tilde{g}_1}
\end{aligned}
\tag{185}
$$

$$
\begin{aligned}
\Sigma^L(p^2) = &-\frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{d_b}, m^2_{\tilde{d}_a}\Big)\Gamma^{L*}_{\tilde{g}_j,\tilde{d}^*_a,d_b}\Gamma^{L}_{\tilde{g}_i,\tilde{d}^*_a,d_b}\\
&-\frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{L*}_{\tilde{g}_j,\tilde{u}^*_a,u_b}\Gamma^{L}_{\tilde{g}_i,\tilde{u}^*_a,u_b} - 3B_1\Big(p^2, m^2_{\tilde{g}}, 0\Big)\Gamma^{R*}_{\tilde{g}_j,g,\tilde{g}_1}\Gamma^{R}_{\tilde{g}_i,g,\tilde{g}_1}
\end{aligned}
\tag{186}
$$

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

$$
\begin{aligned}
\Pi(p^2) = &+|\Gamma_{Z,\eta^-,\eta^-}|^2 B_{00}\Big(p^2, m^2_{\eta^-}, m^2_{\eta^-}\Big) + |\Gamma_{Z,\eta^+,\eta^+}|^2 B_{00}\Big(p^2, m^2_{\eta^+}, m^2_{\eta^+}\Big)\\
&-|\Gamma_{Z,W^+,W^-}|^2\Big(10B_{00}\Big(p^2, m^2_{W^-}, m^2_{W^-}\Big) + 2A_0\Big(m^2_{W^-}\Big) - 2\mathrm{rMS}\Big(2m^2_{W^-} - \frac{1}{3}p^2\Big) + B_0\Big(p^2, m^2_{W^-}, m^2_{W^-}\Big)\Big(2m^2_{W^-} + 4p^2\Big)\Big)\\
&+\sum_{a=1}^{2} A_0\Big(m^2_{H^-_a}\Big)\Gamma_{Z,Z,H^+_a,H^-_a} - 4\sum_{a=1}^{2}\sum_{b=1}^{2}|\Gamma_{Z,H^+_a,H^-_b}|^2 B_{00}\Big(p^2, m^2_{H^-_a}, m^2_{H^-_b}\Big)\\
&+\sum_{a=1}^{2}\sum_{b=1}^{2}\Big[\Big(|\Gamma^L_{Z,\tilde{\chi}^+_a,\tilde{\chi}^-_b}|^2 + |\Gamma^R_{Z,\tilde{\chi}^+_a,\tilde{\chi}^-_b}|^2\Big)H_0\Big(p^2, m^2_{\tilde{\chi}^-_a}, m^2_{\tilde{\chi}^-_b}\Big)
\end{aligned}
$$

$$
\begin{aligned}
&+ 4B_0\Big(p^2, m^2_{\tilde{\chi}^-_a}, m^2_{\tilde{\chi}^-_b}\Big) m_{\tilde{\chi}^-_a} m_{\tilde{\chi}^-_b} \Re\Big(\Gamma^{L*}_{Z,\tilde{\chi}^+_a,\tilde{\chi}^-_b} \Gamma^{R}_{Z,\tilde{\chi}^+_a,\tilde{\chi}^-_b}\Big)\Big] \\
&+ \frac{1}{2}\sum_{a=1}^{3} A_0\Big(m^2_{A^0_a}\Big)\Gamma_{Z,Z,A^0_a,A^0_a} + \sum_{a=1}^{3} A_0\Big(m^2_{\tilde{\nu}_a}\Big)\Gamma_{Z,Z,\tilde{\nu}^*_a,\tilde{\nu}_a} + \frac{1}{2}\sum_{a=1}^{3} A_0\Big(m^2_{h_a}\Big)\Gamma_{Z,Z,h_a,h_a} \\
&- 4\sum_{a=1}^{3}\sum_{b=1}^{3} |\Gamma_{Z,h_a,A^0_b}|^2 B_{00}\Big(p^2, m^2_{A^0_b}, m^2_{h_a}\Big) - 4\sum_{a=1}^{3}\sum_{b=1}^{3} |\Gamma_{Z,\tilde{\nu}^*_a,\tilde{\nu}_b}|^2 B_{00}\Big(p^2, m^2_{\tilde{\nu}_a}, m^2_{\tilde{\nu}_b}\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}^{3}\sum_{b=1}^{3}\Big[\Big(|\Gamma^L_{Z,\bar{\nu}_a,\nu_b}|^2 + |\Gamma^R_{Z,\bar{\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,\bar{\nu}_a,\nu_b} \Gamma^{R}_{Z,\bar{\nu}_a,\nu_b}\Big)\Big] \\
&+ \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{5}\Big[\Big(|\Gamma^L_{Z,\tilde{\chi}^0_a,\tilde{\chi}^0_b}|^2 + |\Gamma^R_{Z,\tilde{\chi}^0_a,\tilde{\chi}^0_b}|^2\Big) H_0\Big(p^2, m^2_{\tilde{\chi}^0_a}, m^2_{\tilde{\chi}^0_b}\Big) \\
&+ 4B_0\Big(p^2, m^2_{\tilde{\chi}^0_a}, m^2_{\tilde{\chi}^0_b}\Big) m_{\tilde{\chi}^0_a} m_{\tilde{\chi}^0_b} \Re\Big(\Gamma^{L*}_{Z,\tilde{\chi}^0_a,\tilde{\chi}^0_b} \Gamma^{R}_{Z,\tilde{\chi}^0_a,\tilde{\chi}^0_b}\Big)\Big] \\
&+ 3\sum_{a=1}^{6} A_0\Big(m^2_{\tilde{d}_a}\Big)\Gamma_{Z,Z,\tilde{d}^*_a,\tilde{d}_a} + \sum_{a=1}^{6} A_0\Big(m^2_{\tilde{e}_a}\Big)\Gamma_{Z,Z,\tilde{e}^*_a,\tilde{e}_a} + 3\sum_{a=1}^{6} A_0\Big(m^2_{\tilde{u}_a}\Big)\Gamma_{Z,Z,\tilde{u}^*_a,\tilde{u}_a} \\
&- 12\sum_{a=1}^{6}\sum_{b=1}^{6} |\Gamma_{Z,\tilde{d}^*_a,\tilde{d}_b}|^2 B_{00}\Big(p^2, m^2_{\tilde{d}_a}, m^2_{\tilde{d}_b}\Big) - 4\sum_{a=1}^{6}\sum_{b=1}^{6} |\Gamma_{Z,\tilde{e}^*_a,\tilde{e}_b}|^2 B_{00}\Big(p^2, m^2_{\tilde{e}_a}, m^2_{\tilde{e}_b}\Big) \\
&- 12\sum_{a=1}^{6}\sum_{b=1}^{6} |\Gamma_{Z,\tilde{u}^*_a,\tilde{u}_b}|^2 B_{00}\Big(p^2, m^2_{\tilde{u}_a}, m^2_{\tilde{u}_b}\Big) + 2\sum_{b=1}^{2} |\Gamma_{Z,W^+,H^-_b}|^2 B_0\Big(p^2, m^2_{W^-}, m^2_{H^-_b}\Big) \\
&+ \sum_{b=1}^{3} |\Gamma_{Z,Z,h_b}|^2 B_0\Big(p^2, m^2_Z, m^2_{h_b}\Big) + 2\mathrm{rMS} m^2_{W^-}\Gamma^1_{Z,Z,W^+,W^-} - A_0\Big(m^2_{W^-}\Big)\Big(4\Gamma^1_{Z,Z,W^+,W^-} + \Gamma^2_{Z,Z,W^+,W^-} + \Gamma^3_{Z,Z,W^+,W^-}\Big)
\end{aligned}
\tag{187}
$$

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

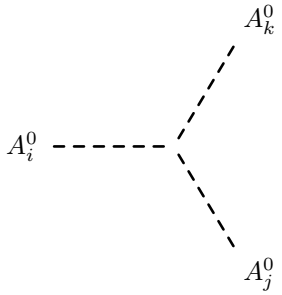
$$\Pi(p^2) = -12\sum_{a=1}^{6}\sum_{b=1}^{6}|\Gamma_{W^+,\tilde{u}_a^*,\tilde{d}_b}|^2 B_{00}\Big(p^2,m^2_{\tilde{d}_b},m^2_{\tilde{u}_a}\Big) + 2\mathrm{rMS}m^2_{W^-}\Gamma^1_{W^-,W^+,W^+,W^-} + 3\sum_{a=1}^{3}\sum_{b=1}^{3}\Big[\Big(|\Gamma^L_{W^+,\bar{u}_a,d_b}|^2+|\Gamma^R_{W^+,\bar{u}_a,d_b}|^2\Big)H$$
$$+ 4B_0\Big(p^2,m^2_{u_a},m^2_{d_b}\Big)m_{d_b}m_{u_a}\Re\Big(\Gamma^{L*}_{W^+,\bar{u}_a,d_b}\Gamma^R_{W^+,\bar{u}_a,d_b}\Big)\Big] + 3\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{d}_a}\Big)\Gamma_{W^-,W^+,\tilde{d}_a^*,\tilde{d}_a} + 3\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{u}_a}\Big)\Gamma_{W^-,W^+,\tilde{u}_a^*,\tilde{u}_a} -$$
$$+ 4B_0\Big(p^2,m^2_{\nu_a},m^2_{e_b}\Big)m_{e_b}m_{\nu_a}\Re\Big(\Gamma^{L*}_{W^+,\bar{\nu}_a,e_b}\Gamma^R_{W^+,\bar{\nu}_a,e_b}\Big)\Big] + \sum_{a=1}^{5}\sum_{b=1}^{2}\Big[\Big(|\Gamma^L_{W^+,\tilde{\chi}^0_a,\tilde{\chi}^-_b}|^2+|\Gamma^R_{W^+,\tilde{\chi}^0_a,\tilde{\chi}^-_b}|^2\Big)H_0\Big(p^2,m^2_{\tilde{\chi}^0_a},m^2_{\tilde{\chi}^-_b}\Big)$$
$$+ 4B_0\Big(p^2,m^2_{\tilde{\chi}^0_a},m^2_{\tilde{\chi}^-_b}\Big)m_{\tilde{\chi}^-_b}m_{\tilde{\chi}^0_a}\Re\Big(\Gamma^{L*}_{W^+,\tilde{\chi}^0_a,\tilde{\chi}^-_b}\Gamma^R_{W^+,\tilde{\chi}^0_a,\tilde{\chi}^-_b}\Big)\Big] + \sum_{a=1}^{6}A_0\Big(m^2_{\tilde{e}_a}\Big)\Gamma_{W^-,W^+,\tilde{e}_a^*,\tilde{e}_a} + \sum_{b=1}^{2}|\Gamma_{W^+,\gamma,H_b^-}|^2 B_0\Big(p^2,0,m^2_H \tag{188}$$

8.2 Tadpoles

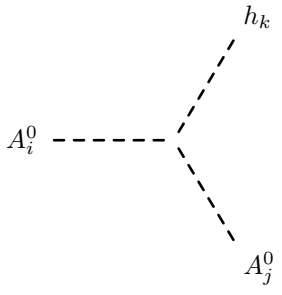
$$\delta t_h^{(1)} = + A_0\Big(m^2_{\eta^-}\Big)\Gamma_{\check{h}_i,\eta^-,\eta^-} + A_0\Big(m^2_{\eta^+}\Big)\Gamma_{\check{h}_i,\eta^+,\eta^+} + A_0\Big(m^2_{\eta^Z}\Big)\Gamma_{\check{h}_i,\eta^Z,\eta^Z}$$
$$+ 4\Gamma_{\check{h}_i,W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{W^-} + A_0\Big(m^2_{W^-}\Big)\Big) + 2\Gamma_{\check{h}_i,Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m^2_Z + A_0\Big(m^2_Z\Big)\Big) - \sum_{a=1}^{2}A_0\Big(m^2_{H^-_a}\Big)\Gamma_{\check{h}_i,H^+_a,H^-_a}$$
$$+ 2\sum_{a=1}^{2}A_0\Big(m^2_{\tilde{\chi}^-_a}\Big)m_{\tilde{\chi}^-_a}\Big(\Gamma^L_{\check{h}_i,\tilde{\chi}^+_a,\tilde{\chi}^-_a} + \Gamma^R_{\check{h}_i,\tilde{\chi}^+_a,\tilde{\chi}^-_a}\Big) - \frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{A^0_a}\Big)\Gamma_{\check{h}_i,A^0_a,A^0_a}$$
$$- \sum_{a=1}^{3}A_0\Big(m^2_{\tilde{\nu}_a}\Big)\Gamma_{\check{h}_i,\tilde{\nu}^*_a,\tilde{\nu}_a} - \frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{h_a}\Big)\Gamma_{\check{h}_i,h_a,h_a}$$
$$+ 6\sum_{a=1}^{3}A_0\Big(m^2_{d_a}\Big)m_{d_a}\Big(\Gamma^L_{\check{h}_i,\bar{d}_a,d_a} + \Gamma^R_{\check{h}_i,\bar{d}_a,d_a}\Big)$$
$$+ 2\sum_{a=1}^{3}A_0\Big(m^2_{e_a}\Big)m_{e_a}\Big(\Gamma^L_{\check{h}_i,\bar{e}_a,e_a} + \Gamma^R_{\check{h}_i,\bar{e}_a,e_a}\Big)$$
$$+ 6\sum_{a=1}^{3}A_0\Big(m^2_{u_a}\Big)m_{u_a}\Big(\Gamma^L_{\check{h}_i,\bar{u}_a,u_a} + \Gamma^R_{\check{h}_i,\bar{u}_a,u_a}\Big) + \sum_{a=1}^{5}A_0\Big(m^2_{\tilde{\chi}^0_a}\Big)m_{\tilde{\chi}^0_a}\Big(\Gamma^L_{\check{h}_i,\tilde{\chi}^0_a,\tilde{\chi}^0_a} + \Gamma^R_{\check{h}_i,\tilde{\chi}^0_a,\tilde{\chi}^0_a}\Big)$$
$$- 3\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{d}_a}\Big)\Gamma_{\check{h}_i,\tilde{d}^*_a,\tilde{d}_a} - \sum_{a=1}^{6}A_0\Big(m^2_{\tilde{e}_a}\Big)\Gamma_{\check{h}_i,\tilde{e}^*_a,\tilde{e}_a} - 3\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{u}_a}\Big)\Gamma_{\check{h}_i,\tilde{u}^*_a,\tilde{u}_a} \tag{189}$$

9 Interactions for eigenstates 'EWSB'

9.1 Three Scalar-Interaction

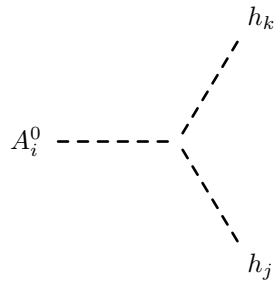


$$\begin{aligned}
&\frac{1}{4}\Big(- 2\lambda\kappa^*\Big(Z_{i2}^A\Big(v_s Z_{j1}^A Z_{k3}^A + Z_{j3}^A\Big(- v_d Z_{k3}^A + v_s Z_{k1}^A\Big)\Big) + Z_{i1}^A\Big(v_s Z_{j2}^A Z_{k3}^A + Z_{j3}^A\Big(v_s Z_{k2}^A - v_u Z_{k3}^A\Big)\Big)\\
&- Z_{i3}^A\Big(Z_{j1}^A\Big(- v_s Z_{k2}^A + v_u Z_{k3}^A\Big) + Z_{j2}^A\Big(v_d Z_{k3}^A - v_s Z_{k1}^A\Big) + Z_{j3}^A\Big(v_d Z_{k2}^A + v_u Z_{k1}^A\Big)\Big)\Big)\\
&+ 2\kappa\lambda^*\Big(Z_{i2}^A\Big(v_s Z_{j1}^A Z_{k3}^A + Z_{j3}^A\Big(- v_d Z_{k3}^A + v_s Z_{k1}^A\Big)\Big) + Z_{i1}^A\Big(v_s Z_{j2}^A Z_{k3}^A + Z_{j3}^A\Big(v_s Z_{k2}^A - v_u Z_{k3}^A\Big)\Big)\\
&- Z_{i3}^A\Big(Z_{j1}^A\Big(- v_s Z_{k2}^A + v_u Z_{k3}^A\Big) + Z_{j2}^A\Big(v_d Z_{k3}^A - v_s Z_{k1}^A\Big) + Z_{j3}^A\Big(v_d Z_{k2}^A + v_u Z_{k1}^A\Big)\Big)\Big)\\
&+ \sqrt{2}\Big(2\Big(- T_\kappa + T_\kappa^*\Big) Z_{i3}^A Z_{j3}^A Z_{k3}^A\\
&- T_\lambda^*\Big(Z_{i1}^A\Big(Z_{j2}^A Z_{k3}^A + Z_{j3}^A Z_{k2}^A\Big) + Z_{i2}^A\Big(Z_{j1}^A Z_{k3}^A + Z_{j3}^A Z_{k1}^A\Big) + Z_{i3}^A\Big(Z_{j1}^A Z_{k2}^A + Z_{j2}^A Z_{k1}^A\Big)\Big)\\
&+ T_\lambda\Big(Z_{i1}^A\Big(Z_{j2}^A Z_{k3}^A + Z_{j3}^A Z_{k2}^A\Big) + Z_{i2}^A\Big(Z_{j1}^A Z_{k3}^A + Z_{j3}^A Z_{k1}^A\Big) + Z_{i3}^A\Big(Z_{j1}^A Z_{k2}^A + Z_{j2}^A Z_{k1}^A\Big)\Big)\Big)\Big)
\end{aligned} \tag{190}$$

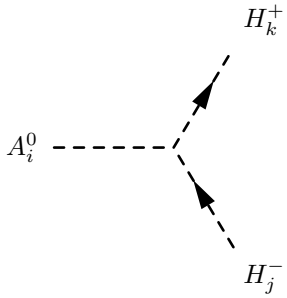


$$\begin{aligned}
&- \frac{i}{4}\Big(Z_{i1}^A\Big(- 2v_s\lambda\kappa^* Z_{j3}^A Z_{k2}^H - 2v_s\kappa\lambda^* Z_{j3}^A Z_{k2}^H + \sqrt{2}T_\lambda^* Z_{j3}^A Z_{k2}^H + \sqrt{2}T_\lambda Z_{j3}^A Z_{k2}^H\\
&+ 2v_s\lambda\kappa^* Z_{j2}^A Z_{k3}^H + 2v_s\kappa\lambda^* Z_{j2}^A Z_{k3}^H + \sqrt{2}T_\lambda^* Z_{j2}^A Z_{k3}^H + \sqrt{2}T_\lambda Z_{j2}^A Z_{k3}^H\\
&- 2v_u\lambda\kappa^* Z_{j3}^A Z_{k3}^H - 2v_u\kappa\lambda^* Z_{j3}^A Z_{k3}^H\\
&+ Z_{j1}^A\Big(4v_s|\lambda|^2 Z_{k3}^H + \Big(g_1^2 + g_2^2\Big)v_d Z_{k1}^H - v_u\Big(- 4|\lambda|^2 + g_1^2 + g_2^2\Big) Z_{k2}^H\Big)\Big)
\end{aligned}$$

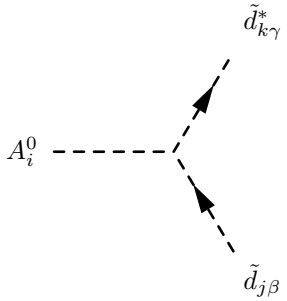
$$
\begin{aligned}
&+ Z^A_{i2}\Big(- 2v_s\kappa\lambda^* Z^A_{j3}Z^H_{k1} + \sqrt{2}T^*_\lambda Z^A_{j3}Z^H_{k1} + \sqrt{2}T_\lambda Z^A_{j3}Z^H_{k1} + 2v_s\kappa\lambda^* Z^A_{j1}Z^H_{k3} \\
&+ \sqrt{2}T^*_\lambda Z^A_{j1}Z^H_{k3} + \sqrt{2}T_\lambda Z^A_{j1}Z^H_{k3} - 2v_d\kappa\lambda^* Z^A_{j3}Z^H_{k3} \\
&+ Z^A_{j2}\Big(4v_s|\lambda|^2 Z^H_{k3} + \Big(g_1^2 + g_2^2\Big)v_u Z^H_{k2} - v_d\Big(- 4|\lambda|^2 + g_1^2 + g_2^2\Big)Z^H_{k1}\Big) \\
&- 2\lambda\kappa^*\Big(- v_s Z^A_{j1}Z^H_{k3} + Z^A_{j3}\Big(v_d Z^H_{k3} + v_s Z^H_{k1}\Big)\Big)\Big) \\
&+ Z^A_{i3}\Big(\sqrt{2}\Big(- 2\Big(T^*_\kappa + T_\kappa\Big)Z^A_{j3}Z^H_{k3} + T^*_\lambda\Big(Z^A_{j1}Z^H_{k2} + Z^A_{j2}Z^H_{k1}\Big) + T_\lambda\Big(Z^A_{j1}Z^H_{k2} + Z^A_{j2}Z^H_{k1}\Big)\Big) \\
&- 2\lambda^*\Big(- Z^A_{j3}\Big(\Big(2v_d\lambda + v_u\kappa\Big)Z^H_{k1} + \Big(2v_u\lambda + v_d\kappa\Big)Z^H_{k2}\Big) + \kappa Z^A_{j2}\Big(v_d Z^H_{k3} + v_s Z^H_{k1}\Big) \\
&+ \kappa Z^A_{j1}\Big(v_s Z^H_{k2} + v_u Z^H_{k3}\Big)\Big) \\
&- 2\kappa^*\Big(\lambda Z^A_{j2}\Big(v_d Z^H_{k3} + v_s Z^H_{k1}\Big) + \lambda Z^A_{j1}\Big(v_s Z^H_{k2} + v_u Z^H_{k3}\Big) \\
&- Z^A_{j3}\Big(4v_s\kappa Z^H_{k3} + v_d\lambda Z^H_{k2} + v_u\lambda Z^H_{k1}\Big)\Big)\Big)\Big)
\end{aligned}
\tag{191}
$$



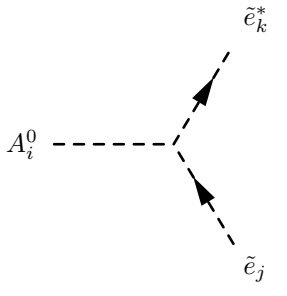
$$
\begin{aligned}
&\frac{1}{4}\Big(2\lambda\kappa^*\Big(- Z^A_{i2}\Big(v_s Z^H_{j1}Z^H_{k3} + Z^H_{j3}\Big(v_d Z^H_{k3} + v_s Z^H_{k1}\Big)\Big) \\
&+ Z^A_{i3}\Big(Z^H_{j1}\Big(v_s Z^H_{k2} + v_u Z^H_{k3}\Big) + Z^H_{j2}\Big(v_d Z^H_{k3} + v_s Z^H_{k1}\Big) + Z^H_{j3}\Big(v_d Z^H_{k2} + v_u Z^H_{k1}\Big)\Big) \\
&- Z^A_{i1}\Big(v_s Z^H_{j2}Z^H_{k3} + Z^H_{j3}\Big(v_s Z^H_{k2} + v_u Z^H_{k3}\Big)\Big)\Big) \\
&- 2\kappa\lambda^*\Big(- Z^A_{i2}\Big(v_s Z^H_{j1}Z^H_{k3} + Z^H_{j3}\Big(v_d Z^H_{k3} + v_s Z^H_{k1}\Big)\Big) \\
&+ Z^A_{i3}\Big(Z^H_{j1}\Big(v_s Z^H_{k2} + v_u Z^H_{k3}\Big) + Z^H_{j2}\Big(v_d Z^H_{k3} + v_s Z^H_{k1}\Big) + Z^H_{j3}\Big(v_d Z^H_{k2} + v_u Z^H_{k1}\Big)\Big) \\
&- Z^A_{i1}\Big(v_s Z^H_{j2}Z^H_{k3} + Z^H_{j3}\Big(v_s Z^H_{k2} + v_u Z^H_{k3}\Big)\Big)\Big) \\
&+ \sqrt{2}\Big(2\Big(- T^*_\kappa + T_\kappa\Big)Z^A_{i3}Z^H_{j3}Z^H_{k3} \\
&+ T^*_\lambda\Big(Z^A_{i1}\Big(Z^H_{j2}Z^H_{k3} + Z^H_{j3}Z^H_{k2}\Big) + Z^A_{i2}\Big(Z^H_{j1}Z^H_{k3} + Z^H_{j3}Z^H_{k1}\Big) + Z^A_{i3}\Big(Z^H_{j1}Z^H_{k2} + Z^H_{j2}Z^H_{k1}\Big)\Big) \\
&- T_\lambda\Big(Z^A_{i1}\Big(Z^H_{j2}Z^H_{k3} + Z^H_{j3}Z^H_{k2}\Big) + Z^A_{i2}\Big(Z^H_{j1}Z^H_{k3} + Z^H_{j3}Z^H_{k1}\Big) + Z^A_{i3}\Big(Z^H_{j1}Z^H_{k2} + Z^H_{j2}Z^H_{k1}\Big)\Big)\Big)\Big)
\end{aligned}
\tag{192}
$$



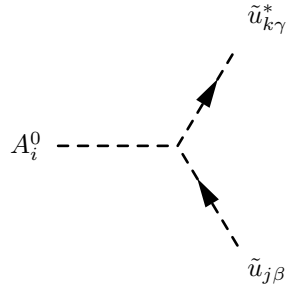
$$\frac{1}{4}\Big(v_u\Big(-2|\lambda|^2+g_2^2\Big)Z_{i1}^A\Big(-Z_{j1}^+Z_{k2}^++Z_{j2}^+Z_{k1}^+\Big)$$
$$+v_d\Big(-2|\lambda|^2+g_2^2\Big)Z_{i2}^A\Big(-Z_{j1}^+Z_{k2}^++Z_{j2}^+Z_{k1}^+\Big)$$
$$+2Z_{i3}^A\Big(2v_s\kappa\lambda^*Z_{j2}^+Z_{k1}^++\Big(-2v_s\lambda\kappa^*+\sqrt{2}T_\lambda\Big)Z_{j1}^+Z_{k2}^+-\sqrt{2}T_\lambda^*Z_{j2}^+Z_{k1}^+\Big)\Big) \tag{193}$$



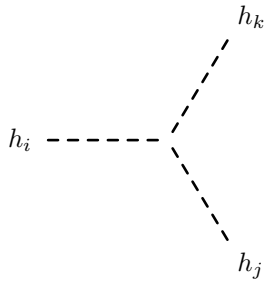
$$\frac{1}{2}\delta_{\beta\gamma}\Big(\sqrt{2}\sum_{b=1}^{3}Z_{jb}^{D,*}\sum_{a=1}^{3}Z_{k3+a}^{D}T_{d,ab}Z_{i1}^A-\sqrt{2}\sum_{b=1}^{3}\sum_{a=1}^{3}Z_{j3+a}^{D,*}T_{d,ab}^*Z_{kb}^DZ_{i1}^A$$
$$+\Big(-\lambda\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{d,ab}^*Z_{j3+a}^{D,*}Z_{kb}^D+\lambda^*\sum_{b=1}^{3}Z_{jb}^{D,*}\sum_{a=1}^{3}Y_{d,ab}Z_{k3+a}^D\Big)\Big(v_sZ_{i2}^A+v_uZ_{i3}^A\Big)\Big) \tag{194}$$



$$\frac{1}{2}\Big(\sqrt{2}\sum_{b=1}^{3} Z^{E,*}_{jb}\sum_{a=1}^{3} Z^{E}_{k3+a}T_{e,ab}Z^{A}_{i1} - \sqrt{2}\sum_{b=1}^{3}\sum_{a=1}^{3} Z^{E,*}_{j3+a}T^{*}_{e,ab}Z^{E}_{kb}Z^{A}_{i1}$$
$$+\Big(-\lambda\sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{e,ab}Z^{E,*}_{j3+a}Z^{E}_{kb} + \lambda^{*}\sum_{b=1}^{3} Z^{E,*}_{jb}\sum_{a=1}^{3} Y_{e,ab}Z^{E}_{k3+a}\Big)\Big(v_s Z^{A}_{i2} + v_u Z^{A}_{i3}\Big)\Big) \tag{195}$$

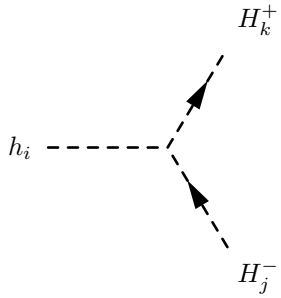


$$\frac{1}{2}\delta_{\beta\gamma}\Big(\sqrt{2}\Big(-\sum_{b=1}^{3}\sum_{a=1}^{3} Z^{U,*}_{j3+a}T^{*}_{u,ab}Z^{U}_{kb} + \sum_{b=1}^{3} Z^{U,*}_{jb}\sum_{a=1}^{3} Z^{U}_{k3+a}T_{u,ab}\Big)Z^{A}_{i2}$$
$$+\lambda^{*}\sum_{b=1}^{3} Z^{U,*}_{jb}\sum_{a=1}^{3} Y_{u,ab}Z^{U}_{k3+a}\Big(v_d Z^{A}_{i3} + v_s Z^{A}_{i1}\Big)$$
$$-\lambda\sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{u,ab}Z^{U,*}_{j3+a}Z^{U}_{kb}\Big(v_d Z^{A}_{i3} + v_s Z^{A}_{i1}\Big)\Big) \tag{196}$$

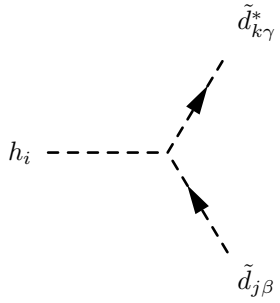


$$-\frac{i}{4}\Big(Z^{H}_{i1}\Big(Z^{H}_{j1}\Big(3\Big(g_1^2+g_2^2\Big)v_d Z^{H}_{k1} + 4v_s|\lambda|^2 Z^{H}_{k3} - v_u\Big(-4|\lambda|^2+g_1^2+g_2^2\Big)Z^{H}_{k2}\Big)$$
$$-Z^{H}_{j2}\Big(v_u\Big(-4|\lambda|^2+g_1^2+g_2^2\Big)Z^{H}_{k1} + v_d\Big(-4|\lambda|^2+g_1^2+g_2^2\Big)Z^{H}_{k2}$$
$$+\Big(2v_s\kappa\lambda^{*} + 2v_s\lambda\kappa^{*} + \sqrt{2}\Big(T^{*}_{\lambda}+T_{\lambda}\Big)\Big)Z^{H}_{k3}\Big)$$
$$-Z^{H}_{j3}\Big(\sqrt{2}\Big(T^{*}_{\lambda}+T_{\lambda}\Big)Z^{H}_{k2} + 2\lambda\kappa^{*}\Big(v_s Z^{H}_{k2} + v_u Z^{H}_{k3}\Big)$$

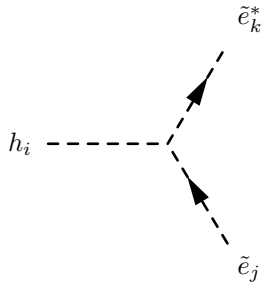
$$
\begin{aligned}
&+ 2\lambda^*\Big(\Big(- 2v_d\lambda + v_u\kappa\Big)Z^H_{k3} - 2v_s\lambda Z^H_{k1} + v_s\kappa Z^H_{k2}\Big)\Big)\Big)\\
&- Z^H_{i2}\Big(Z^H_{j2}\Big(- 3\Big(g_1^2 + g_2^2\Big)v_u Z^H_{k2} - 4v_s|\lambda|^2 Z^H_{k3} + v_d\Big(- 4|\lambda|^2 + g_1^2 + g_2^2\Big)Z^H_{k1}\Big)\\
&+ Z^H_{j1}\Big(v_u\Big(- 4|\lambda|^2 + g_1^2 + g_2^2\Big)Z^H_{k1} + v_d\Big(- 4|\lambda|^2 + g_1^2 + g_2^2\Big)Z^H_{k2}\\
&+ \Big(2v_s\kappa\lambda^* + 2v_s\lambda\kappa^* + \sqrt{2}\Big(T^*_\lambda + T_\lambda\Big)\Big)Z^H_{k3}\Big)\\
&+ Z^H_{j3}\Big(\sqrt{2}\Big(T^*_\lambda + T_\lambda\Big)Z^H_{k1} + 2\lambda\kappa^*\Big(v_d Z^H_{k3} + v_s Z^H_{k1}\Big)\\
&+ 2\lambda^*\Big(- 2v_s\lambda Z^H_{k2} + \Big(- 2v_u\lambda + v_d\kappa\Big)Z^H_{k3} + v_s\kappa Z^H_{k1}\Big)\Big)\Big)\\
&+ Z^H_{i3}\Big(- \sqrt{2}\Big(- 2\Big(T^*_\kappa + T_\kappa\Big)Z^H_{j3}Z^H_{k3} + T^*_\lambda\Big(Z^H_{j1}Z^H_{k2} + Z^H_{j2}Z^H_{k1}\Big) + T_\lambda\Big(Z^H_{j1}Z^H_{k2} + Z^H_{j2}Z^H_{k1}\Big)\Big)\\
&- 2\kappa^*\Big(\lambda Z^H_{j2}\Big(v_d Z^H_{k3} + v_s Z^H_{k1}\Big) + \lambda Z^H_{j1}\Big(v_s Z^H_{k2} + v_u Z^H_{k3}\Big)\\
&+ Z^H_{j3}\Big(- 12v_s\kappa Z^H_{k3} + v_d\lambda Z^H_{k2} + v_u\lambda Z^H_{k1}\Big)\Big)\\
&- 2\lambda^*\Big(Z^H_{j3}\Big(\Big(- 2v_d\lambda + v_u\kappa\Big)Z^H_{k1} + \Big(- 2v_u\lambda + v_d\kappa\Big)Z^H_{k2}\Big)\\
&+ Z^H_{j1}\Big(\Big(- 2v_d\lambda + v_u\kappa\Big)Z^H_{k3} - 2v_s\lambda Z^H_{k1} + v_s\kappa Z^H_{k2}\Big)\\
&+ Z^H_{j2}\Big(- 2v_s\lambda Z^H_{k2} + \Big(- 2v_u\lambda + v_d\kappa\Big)Z^H_{k3} + v_s\kappa Z^H_{k1}\Big)\Big)\Big)\Big)
\end{aligned}
\tag{197}
$$



$$
\begin{aligned}
&- \frac{i}{4}\Big(Z^H_{i2}\Big(Z^+_{j2}\Big(\Big(g_1^2 + g_2^2\Big)v_u Z^+_{k2} + v_d\Big(- 2|\lambda|^2 + g_2^2\Big)Z^+_{k1}\Big)\\
&+ Z^+_{j1}\Big(\Big(- g_1^2 + g_2^2\Big)v_u Z^+_{k1} + v_d\Big(- 2|\lambda|^2 + g_2^2\Big)Z^+_{k2}\Big)\Big)\\
&+ Z^H_{i1}\Big(Z^+_{j2}\Big(\Big(- g_1^2 + g_2^2\Big)v_d Z^+_{k2} + v_u\Big(- 2|\lambda|^2 + g_2^2\Big)Z^+_{k1}\Big)\\
&+ Z^+_{j1}\Big(\Big(g_1^2 + g_2^2\Big)v_d Z^+_{k1} + v_u\Big(- 2|\lambda|^2 + g_2^2\Big)Z^+_{k2}\Big)\Big)\\
&+ 2Z^H_{i3}\Big(\Big(2v_s\lambda\kappa^* + \sqrt{2}T_\lambda\Big)Z^+_{j1}Z^+_{k2} + 2v_s\lambda^*\Big(\lambda Z^+_{j1}Z^+_{k1} + Z^+_{j2}\Big(\kappa Z^+_{k1} + \lambda Z^+_{k2}\Big)\Big) + \sqrt{2}T^*_\lambda Z^+_{j2}Z^+_{k1}\Big)\Big)
\end{aligned}
\tag{198}
$$

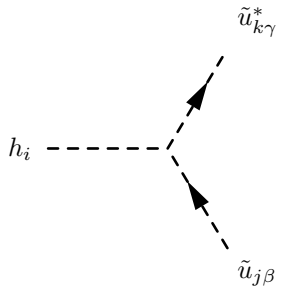


$$
\begin{aligned}
&\frac{i}{12}\delta_{\beta\gamma}\Big(\Big(3g_2^2+g_1^2\Big)\sum_{a=1}^{3}Z^{D,*}_{ja}Z^{D}_{ka}\Big(v_dZ^H_{i1}-v_uZ^H_{i2}\Big)\\
&+2\Big(g_1^2\sum_{a=1}^{3}Z^{D,*}_{j3+a}Z^{D}_{k3+a}\Big(v_dZ^H_{i1}-v_uZ^H_{i2}\Big)\\
&+3\Big(-\sqrt{2}\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}Z^{D}_{k3+a}T_{d,ab}Z^H_{i1}-\sqrt{2}\sum_{b=1}^{3}\sum_{a=1}^{3}Z^{D,*}_{j3+a}T^*_{d,ab}Z^D_{kb}Z^H_{i1}\\
&-2v_d\sum_{c=1}^{3}Z^{D,*}_{j3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{d,ca}Y_{d,ba}Z^D_{k3+b}Z^H_{i1}-2v_d\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}Y^*_{d,ac}Y_{d,ab}Z^D_{kc}Z^H_{i1}\\
&+v_s\lambda^*\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}Y_{d,ab}Z^D_{k3+a}Z^H_{i2}+v_s\lambda\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{d,ab}Z^{D,*}_{j3+a}Z^D_{kb}Z^H_{i2}\\
&+v_u\lambda^*\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}Y_{d,ab}Z^D_{k3+a}Z^H_{i3}+v_u\lambda\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{d,ab}Z^{D,*}_{j3+a}Z^D_{kb}Z^H_{i3}\Big)\Big)\Big)
\end{aligned}
\tag{199}
$$

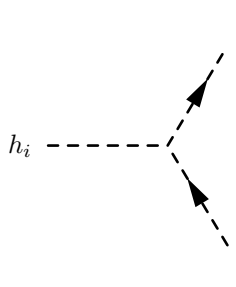


$$
\begin{aligned}
&-\frac{i}{4}\Big(\Big(-g_2^2+g_1^2\Big)\sum_{a=1}^{3}Z^{E,*}_{ja}Z^{E}_{ka}\Big(v_dZ^H_{i1}-v_uZ^H_{i2}\Big)\\
&-2\Big(-\sqrt{2}\sum_{b=1}^{3}Z^{E,*}_{jb}\sum_{a=1}^{3}Z^{E}_{k3+a}T_{e,ab}Z^H_{i1}-\sqrt{2}\sum_{b=1}^{3}\sum_{a=1}^{3}Z^{E,*}_{j3+a}T^*_{e,ab}Z^E_{kb}Z^H_{i1}
\end{aligned}
$$

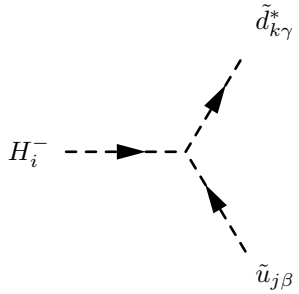
$$
\begin{aligned}
&- 2v_d \sum_{c=1}^{3} Z^{E,*}_{j3+c} \sum_{b=1}^{3} \sum_{a=1}^{3} Y^*_{e,ca} Y_{e,ba} Z^E_{k3+b} Z^H_{i1} - 2v_d \sum_{c=1}^{3} \sum_{b=1}^{3} Z^{E,*}_{jb} \sum_{a=1}^{3} Y^*_{e,ac} Y_{e,ab} Z^E_{kc} Z^H_{i1} \\
&+ v_s \lambda^* \sum_{b=1}^{3} Z^{E,*}_{jb} \sum_{a=1}^{3} Y_{e,ab} Z^E_{k3+a} Z^H_{i2} + v_s \lambda \sum_{b=1}^{3} \sum_{a=1}^{3} Y^*_{e,ab} Z^{E,*}_{j3+a} Z^E_{kb} Z^H_{i2} \\
&+ g_1^2 \sum_{a=1}^{3} Z^{E,*}_{j3+a} Z^E_{k3+a} \Big(v_d Z^H_{i1} - v_u Z^H_{i2} \Big) + v_u \lambda^* \sum_{b=1}^{3} Z^{E,*}_{jb} \sum_{a=1}^{3} Y_{e,ab} Z^E_{k3+a} Z^H_{i3} \\
&+ v_u \lambda \sum_{b=1}^{3} \sum_{a=1}^{3} Y^*_{e,ab} Z^{E,*}_{j3+a} Z^E_{kb} Z^H_{i3} \Big) \Big)
\end{aligned} \tag{200}
$$



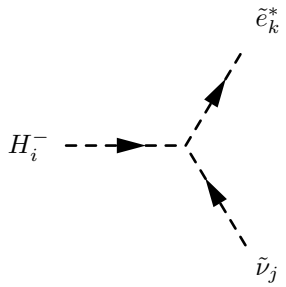
$$
\begin{aligned}
&\frac{i}{12} \delta_{\beta\gamma} \Big(\Big(- 3g_2^2 + g_1^2 \Big) \sum_{a=1}^{3} Z^{U,*}_{ja} Z^U_{ka} \Big(v_d Z^H_{i1} - v_u Z^H_{i2} \Big) + 4g_1^2 \sum_{a=1}^{3} Z^{U,*}_{j3+a} Z^U_{k3+a} \Big(- v_d Z^H_{i1} + v_u Z^H_{i2} \Big) \\
&+ 6 \Big(- \Big(\sqrt{2} \sum_{b=1}^{3} Z^{U,*}_{jb} \sum_{a=1}^{3} Z^U_{k3+a} T_{u,ab} + \sqrt{2} \sum_{b=1}^{3} \sum_{a=1}^{3} Z^{U,*}_{j3+a} T^*_{u,ab} Z^U_{kb} \\
&+ 2v_u \Big(\sum_{c=1}^{3} Z^{U,*}_{j3+c} \sum_{b=1}^{3} \sum_{a=1}^{3} Y^*_{u,ca} Y_{u,ba} Z^U_{k3+b} + \sum_{c=1}^{3} \sum_{b=1}^{3} Z^{U,*}_{jb} \sum_{a=1}^{3} Y^*_{u,ac} Y_{u,ab} Z^U_{kc} \Big) \Big) Z^H_{i2} \\
&+ \lambda^* \sum_{b=1}^{3} Z^{U,*}_{jb} \sum_{a=1}^{3} Y_{u,ab} Z^U_{k3+a} \Big(v_d Z^H_{i3} + v_s Z^H_{i1} \Big) \\
&+ \lambda \sum_{b=1}^{3} \sum_{a=1}^{3} Y^*_{u,ab} Z^{U,*}_{j3+a} Z^U_{kb} \Big(v_d Z^H_{i3} + v_s Z^H_{i1} \Big) \Big) \Big)
\end{aligned} \tag{201}
$$



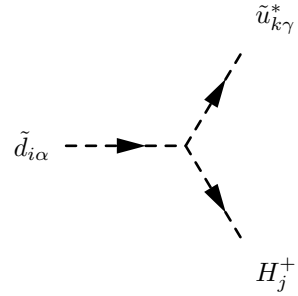
$$-\frac{i}{4}\Big(g_1^2+g_2^2\Big)\delta_{jk}\Big(v_d Z_{i1}^H - v_u Z_{i2}^H\Big) \tag{202}$$



$$\begin{aligned}
&-\frac{i}{4}\delta_{\beta\gamma}\Big(\sqrt{2}g_2^2\sum_{a=1}^{3}Z_{ja}^{U,*}Z_{ka}^{D}\Big(v_d Z_{i1}^{+}+v_u Z_{i2}^{+}\Big)\\
&-2\Big(2\sum_{b=1}^{3}Z_{jb}^{U,*}\sum_{a=1}^{3}Z_{k3+a}^{D}T_{d,ab}Z_{i1}^{+}+\sqrt{2}v_s\lambda\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{u,ab}^{*}Z_{j3+a}^{U,*}Z_{kb}^{D}Z_{i1}^{+}\\
&+\sqrt{2}v_u\sum_{c=1}^{3}Z_{j3+c}^{U,*}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{u,ca}^{*}Y_{d,ba}Z_{k3+b}^{D}Z_{i1}^{+}\\
&+\sqrt{2}v_d\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{jb}^{U,*}\sum_{a=1}^{3}Y_{d,ac}^{*}Y_{d,ab}Z_{kc}^{D}Z_{i1}^{+}+\sqrt{2}v_s\lambda^{*}\sum_{b=1}^{3}Z_{jb}^{U,*}\sum_{a=1}^{3}Y_{d,ab}Z_{k3+a}^{D}Z_{i2}^{+}\\
&+2\sum_{b=1}^{3}\sum_{a=1}^{3}Z_{j3+a}^{U,*}T_{u,ab}^{*}Z_{kb}^{D}Z_{i2}^{+}+\sqrt{2}v_d\sum_{c=1}^{3}Z_{j3+c}^{U,*}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{u,ca}^{*}Y_{d,ba}Z_{k3+b}^{D}Z_{i2}^{+}\\
&+\sqrt{2}v_u\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{jb}^{U,*}\sum_{a=1}^{3}Y_{u,ac}^{*}Y_{u,ab}Z_{kc}^{D}Z_{i2}^{+}\Big)\Big)
\end{aligned} \tag{203}$$

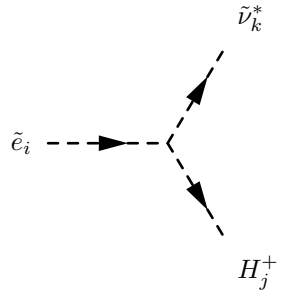


$$
\begin{aligned}
&-\frac{i}{4}\Big(\sqrt{2}g_2^2\sum_{a=1}^{3}Z_{ja}^{V,*}Z_{ka}^{E}\Big(v_dZ_{i1}^{+}+v_uZ_{i2}^{+}\Big)\\
&-2\Big(2\sum_{b=1}^{3}Z_{jb}^{V,*}\sum_{a=1}^{3}Z_{k3+a}^{E}T_{e,ab}Z_{i1}^{+}\\
&+\sqrt{2}\Big(v_d\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{jb}^{V,*}\sum_{a=1}^{3}Y_{e,ac}^{*}Y_{e,ab}Z_{kc}^{E}Z_{i1}^{+}+v_s\lambda^{*}\sum_{b=1}^{3}Z_{jb}^{V,*}\sum_{a=1}^{3}Y_{e,ab}Z_{k3+a}^{E}Z_{i2}^{+}\Big)\Big)\Big)
\end{aligned}
\tag{204}
$$



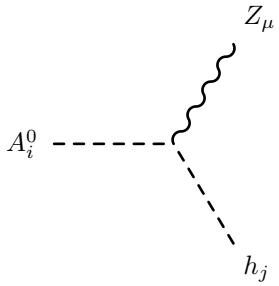
$$
\begin{aligned}
&-\frac{i}{4}\delta_{\alpha\gamma}\Big(\sqrt{2}g_2^2\sum_{a=1}^{3}Z_{ia}^{D,*}Z_{ka}^{U}\Big(v_dZ_{j1}^{+}+v_uZ_{j2}^{+}\Big)\\
&-2\Big(\sqrt{2}v_s\lambda^{*}\sum_{b=1}^{3}Z_{ib}^{D,*}\sum_{a=1}^{3}Y_{u,ab}Z_{k3+a}^{U}Z_{j1}^{+}+2\sum_{b=1}^{3}\sum_{a=1}^{3}Z_{i3+a}^{D,*}T_{d,ab}^{*}Z_{kb}^{U}Z_{j1}^{+}\\
&+\sqrt{2}v_u\sum_{c=1}^{3}Z_{i3+c}^{D,*}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{d,ca}^{*}Y_{u,ba}Z_{k3+b}^{U}Z_{j1}^{+}\\
&+\sqrt{2}v_d\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{ib}^{D,*}\sum_{a=1}^{3}Y_{d,ac}^{*}Y_{d,ab}Z_{kc}^{U}Z_{j1}^{+}+2\sum_{b=1}^{3}Z_{ib}^{D,*}\sum_{a=1}^{3}Z_{k3+a}^{U}T_{u,ab}Z_{j2}^{+}\\
&+\sqrt{2}v_s\lambda\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{d,ab}^{*}Z_{i3+a}^{D,*}Z_{kb}^{U}Z_{j2}^{+}+\sqrt{2}v_d\sum_{c=1}^{3}Z_{i3+c}^{D,*}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{d,ca}^{*}Y_{u,ba}Z_{k3+b}^{U}Z_{j2}^{+}
\end{aligned}
$$

$$+\sqrt{2}v_u\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{ib}^{D,*}\sum_{a=1}^{3}Y_{u,ac}^{*}Y_{u,ab}Z_{kc}^{U}Z_{j2}^{+}\Big)\Big) \tag{205}$$

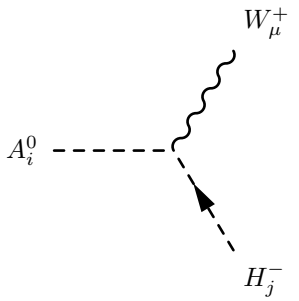


$$\begin{aligned}
&-\frac{i}{4}\Big(\sqrt{2}g_2^2\sum_{a=1}^{3}Z_{ia}^{E,*}Z_{ka}^{V}\Big(v_dZ_{j1}^{+}+v_uZ_{j2}^{+}\Big)\\
&-2\Big(2\sum_{b=1}^{3}\sum_{a=1}^{3}Z_{i3+a}^{E,*}T_{e,ab}^{*}Z_{kb}^{V}Z_{j1}^{+}\\
&+\sqrt{2}\Big(v_d\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{ib}^{E,*}\sum_{a=1}^{3}Y_{e,ac}^{*}Y_{e,ab}Z_{kc}^{V}Z_{j1}^{+}+v_s\lambda\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{e,ab}^{*}Z_{i3+a}^{E,*}Z_{kb}^{V}Z_{j2}^{+}\Big)\Big)\Big)
\end{aligned} \tag{206}$$

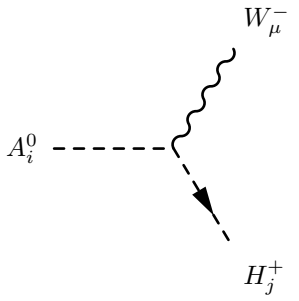
9.2 Two Scalar-One Vector Boson-Interaction



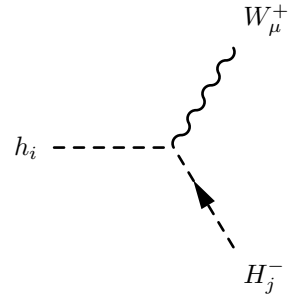
$$\frac{1}{2}\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\Big(Z_{i1}^{A}Z_{j1}^{H}-Z_{i2}^{A}Z_{j2}^{H}\Big)\Big(-p_\mu^{h_j}+p_\mu^{A_i^0}\Big) \tag{207}$$



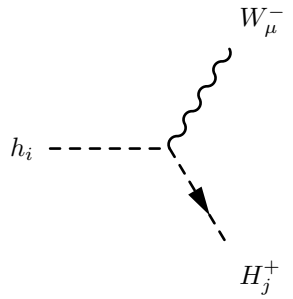
$$\frac{1}{2}g_2\Big(Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+\Big)\Big(-p_\mu^{H_j^-} + p_\mu^{A_i^0}\Big) \tag{208}$$



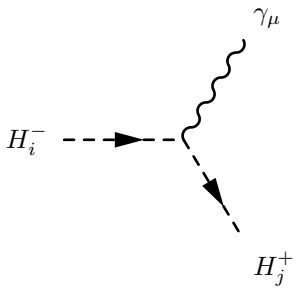
$$\frac{1}{2}g_2\Big(Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+\Big)\Big(-p_\mu^{H_j^+} + p_\mu^{A_i^0}\Big) \tag{209}$$



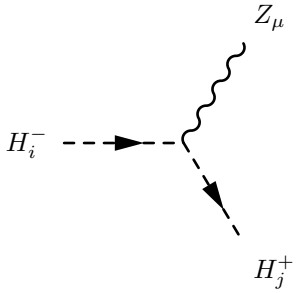
$$\frac{i}{2}g_2\Big(Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+\Big)\Big(-p_\mu^{H_j^-} + p_\mu^{h_i}\Big) \tag{210}$$



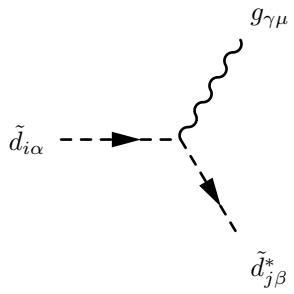
$$-\frac{i}{2}g_2\Big(Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+\Big)\Big(-p_\mu^{H_j^+} + p_\mu^{h_i}\Big) \tag{211}$$



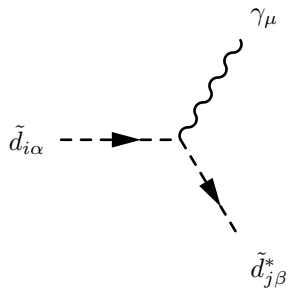
$$\frac{i}{2}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)\Big(Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+\Big)\Big(-p_\mu^{H_j^+} + p_\mu^{H_i^-}\Big) \tag{212}$$



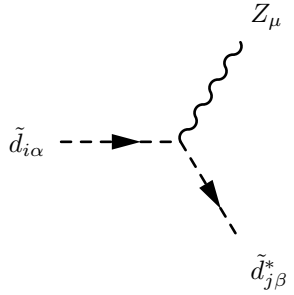
$$\frac{i}{2}\Big(-g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\Big(Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+\Big)\Big(-p_\mu^{H_j^+} + p_\mu^{H_i^-}\Big) \tag{213}$$



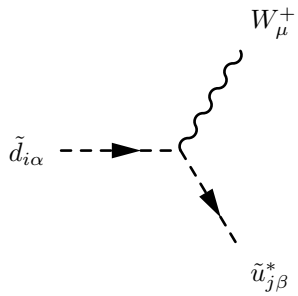
$$-\frac{i}{2}g_3\delta_{ij}\lambda^{\gamma}_{\beta,\alpha}\Big(-p_\mu^{\tilde{d}^*_{j\beta}}+p_\mu^{\tilde{d}_{i\alpha}}\Big) \tag{214}$$



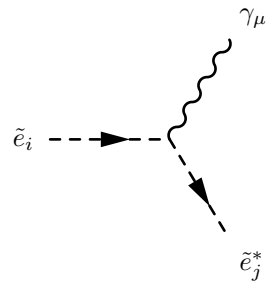
$$-\frac{i}{6}\delta_{\alpha\beta}\Big(-2g_1\cos\Theta_W\sum_{a=1}^{3}Z^{D,*}_{i3+a}Z^{D}_{j3+a}+\Big(-3g_2\sin\Theta_W+g_1\cos\Theta_W\Big)\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{D}_{ja}\Big)\Big(-p_\mu^{\tilde{d}^*_{j\beta}}+p_\mu^{\tilde{d}_{i\alpha}}\Big) \tag{215}$$



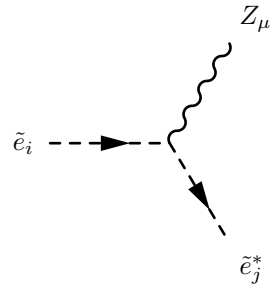
$$\frac{i}{6}\delta_{\alpha\beta}\Big(-2g_1\sin\Theta_W\sum_{a=1}^{3}Z^{D,*}_{i3+a}Z^{D}_{j3+a}+\Big(3g_2\cos\Theta_W+g_1\sin\Theta_W\Big)\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{D}_{ja}\Big)\Big(-p_\mu^{\tilde{d}^*_{j\beta}}+p_\mu^{\tilde{d}_{i\alpha}}\Big) \tag{216}$$



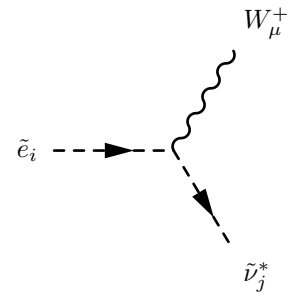
$$-i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{U}_{ja}\Big(-p_\mu^{\tilde{u}^*_{j\beta}}+p_\mu^{\tilde{d}_{i\alpha}}\Big) \tag{217}$$



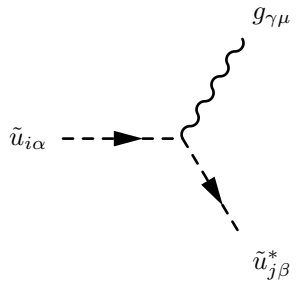
$$\frac{i}{2}\Big(2g_1\cos\Theta_W\sum_{a=1}^{3}Z^{E,*}_{i3+a}Z^{E}_{j3+a}+\Big(g_1\cos\Theta_W+g_2\sin\Theta_W\Big)\sum_{a=1}^{3}Z^{E,*}_{ia}Z^{E}_{ja}\Big)\Big(-p_\mu^{\tilde{e}^*_j}+p_\mu^{\tilde{e}_i}\Big) \tag{218}$$



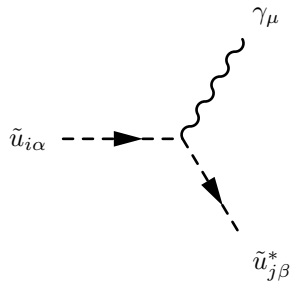
$$\frac{i}{2}\Big(-2g_1\sin\Theta_W\sum_{a=1}^{3}Z^{E,*}_{i3+a}Z^{E}_{j3+a}+\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sum_{a=1}^{3}Z^{E,*}_{ia}Z^{E}_{ja}\Big)\Big(-p_\mu^{\tilde{e}^*_j}+p_\mu^{\tilde{e}_i}\Big) \tag{219}$$



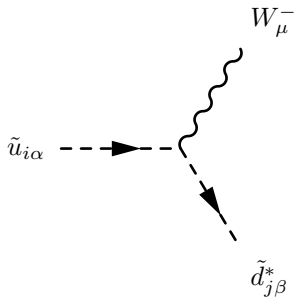
$$-i\frac{1}{\sqrt{2}}g_2\sum_{a=1}^{3}Z^{E,*}_{ia}Z^{V}_{ja}\Big(-p_\mu^{\tilde{\nu}^*_j}+p_\mu^{\tilde{e}_i}\Big) \tag{220}$$



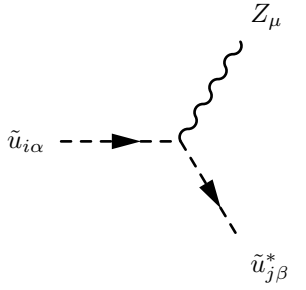
$$-\frac{i}{2}g_3\delta_{ij}\lambda^{\gamma}_{\beta,\alpha}\Big(-p_\mu^{\tilde{u}^*_{j\beta}}+p_\mu^{\tilde{u}_{i\alpha}}\Big) \tag{221}$$



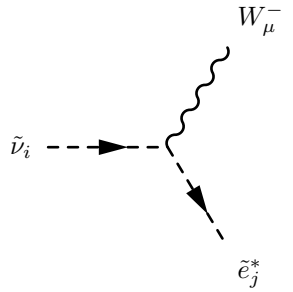
$$-\frac{i}{6}\delta_{\alpha\beta}\Big(\Big(3g_2\sin\Theta_W+g_1\cos\Theta_W\Big)\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{U}_{ja}+4g_1\cos\Theta_W\sum_{a=1}^{3}Z^{U,*}_{i3+a}Z^{U}_{j3+a}\Big)\Big(-p_\mu^{\tilde{u}^*_{j\beta}}+p_\mu^{\tilde{u}_{i\alpha}}\Big) \tag{222}$$



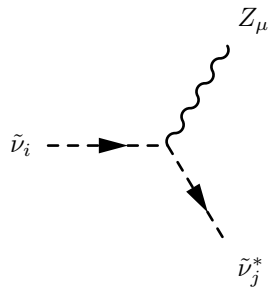
$$-i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{D}_{ja}\Big(-p_\mu^{\tilde{d}^*_{j\beta}}+p_\mu^{\tilde{u}_{i\alpha}}\Big) \tag{223}$$



$$-\frac{i}{6}\delta_{\alpha\beta}\Big(\Big(3g_2\cos\Theta_W-g_1\sin\Theta_W\Big)\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{U}_{ja}-4g_1\sin\Theta_W\sum_{a=1}^{3}Z^{U,*}_{i3+a}Z^{U}_{j3+a}\Big)\Big(-p_\mu^{\tilde{u}^*_{j\beta}}+p_\mu^{\tilde{u}_{i\alpha}}\Big) \tag{224}$$

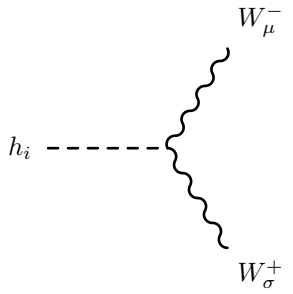


$$-i\frac{1}{\sqrt{2}}g_2\sum_{a=1}^{3}Z^{V,*}_{ia}Z^{E}_{ja}\Big(-p_\mu^{\tilde{e}^*_j}+p_\mu^{\tilde{\nu}_i}\Big) \tag{225}$$

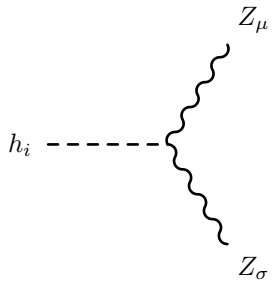


$$-\frac{i}{2}\delta_{ij}\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\Big(-p_\mu^{\tilde{\nu}_j^*}+p_\mu^{\tilde{\nu}_i}\Big) \tag{226}$$

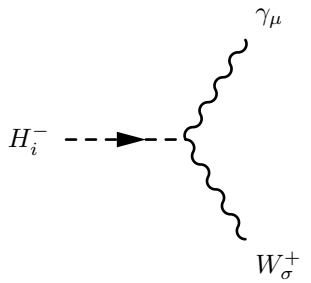
9.3 One Scalar-Two Vector Boson-Interaction



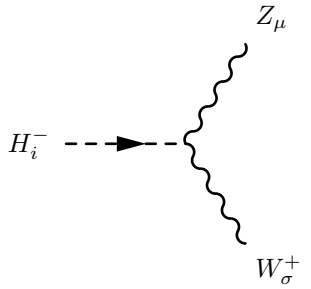
$$\frac{i}{2}g_2^2\Big(v_dZ_{i1}^H+v_uZ_{i2}^H\Big)\Big(g_{\sigma\mu}\Big) \tag{227}$$



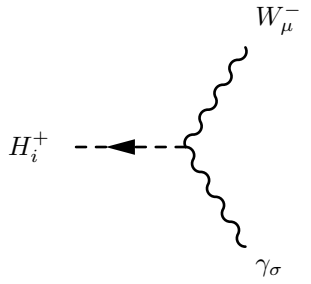
$$\frac{i}{2}\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)^2\Big(v_dZ_{i1}^H+v_uZ_{i2}^H\Big)\Big(g_{\sigma\mu}\Big) \tag{228}$$



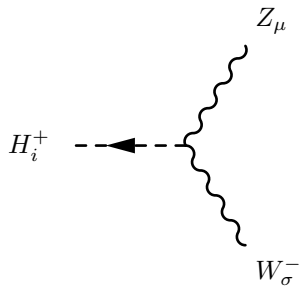
$$-\frac{i}{2}g_1 g_2 \cos\Theta_W \Big(v_d Z_{i1}^+ - v_u Z_{i2}^+\Big)\Big(g_{\sigma\mu}\Big) \tag{229}$$



$$\frac{i}{2}g_1 g_2 \sin\Theta_W \Big(v_d Z_{i1}^+ - v_u Z_{i2}^+\Big)\Big(g_{\sigma\mu}\Big) \tag{230}$$

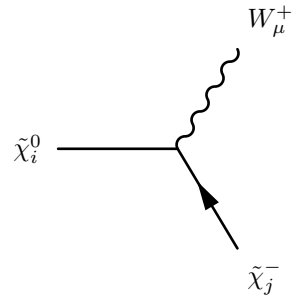


$$-\frac{i}{2}g_1 g_2 \cos\Theta_W \Big(v_d Z_{i1}^+ - v_u Z_{i2}^+\Big)\Big(g_{\sigma\mu}\Big) \tag{231}$$



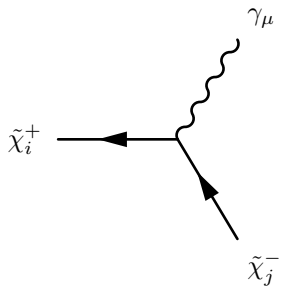
$$\frac{i}{2} g_1 g_2 \sin\Theta_W \Big(v_d Z_{i1}^+ - v_u Z_{i2}^+ \Big) \Big(g_{\sigma\mu} \Big) \tag{232}$$

9.4 Two Fermion-One Vector Boson-Interaction



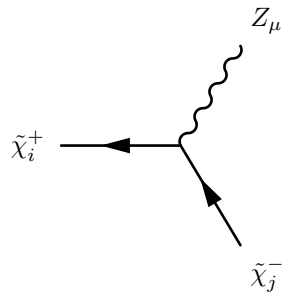
$$-\frac{i}{2} g_2 \Big(2 U_{j1}^* N_{i2} + \sqrt{2} U_{j2}^* N_{i3} \Big) \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{233}$$

$$+ \Big(i \frac{1}{\sqrt{2}} g_2 N_{i4}^* V_{j2} - i g_2 N_{i2}^* V_{j1} \Big) \Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2} \Big) \tag{234}$$



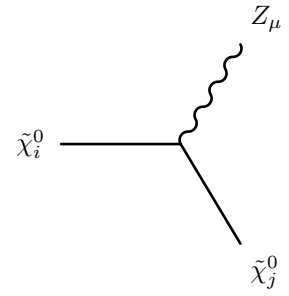
$$\frac{i}{2} \Big(2 g_2 U_{j1}^* \sin\Theta_W U_{i1} + U_{j2}^* \Big(g_1 \cos\Theta_W + g_2 \sin\Theta_W \Big) U_{i2} \Big) \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{235}$$

$$+ \frac{i}{2} \Big(2 g_2 V_{i1}^* \sin\Theta_W V_{j1} + V_{i2}^* \Big(g_1 \cos\Theta_W + g_2 \sin\Theta_W \Big) V_{j2} \Big) \Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2} \Big) \tag{236}$$



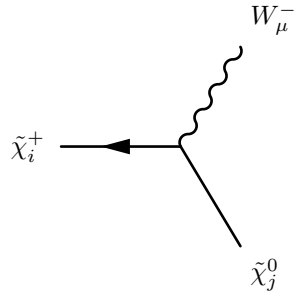
$$\frac{i}{2}\Big(2g_2 U^*_{j1}\cos\Theta_W U_{i1} + U^*_{j2}\Big(-g_1\sin\Theta_W + g_2\cos\Theta_W\Big)U_{i2}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{237}$$

$$+\ \frac{i}{2}\Big(2g_2 V^*_{i1}\cos\Theta_W V_{j1} + V^*_{i2}\Big(-g_1\sin\Theta_W + g_2\cos\Theta_W\Big)V_{j2}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{238}$$



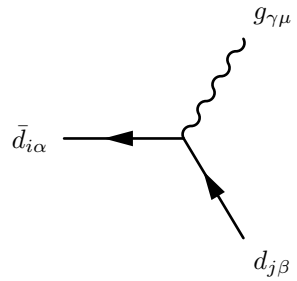
$$-\frac{i}{2}\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\Big(N^*_{j3}N_{i3} - N^*_{j4}N_{i4}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{239}$$

$$+\ \frac{i}{2}\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\Big(N^*_{i3}N_{j3} - N^*_{i4}N_{j4}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{240}$$

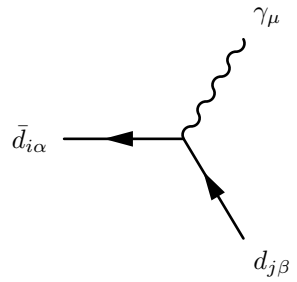


$$-\frac{i}{2}g_2\Big(2N^*_{j2}U_{i1} + \sqrt{2}N^*_{j3}U_{i2}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{241}$$

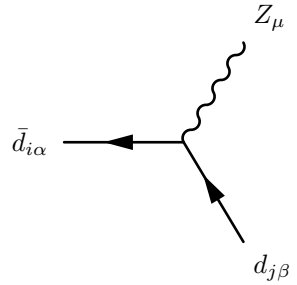
$$+ \Big(i\frac{1}{\sqrt{2}}g_2 V_{i2}^* N_{j4} - ig_2 V_{i1}^* N_{j2}\Big)\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{242}$$



$$-\frac{i}{2}g_3\delta_{ij}\lambda^\gamma_{\alpha,\beta}\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{243}$$
$$+\ -\frac{i}{2}g_3\delta_{ij}\lambda^\gamma_{\alpha,\beta}\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{244}$$

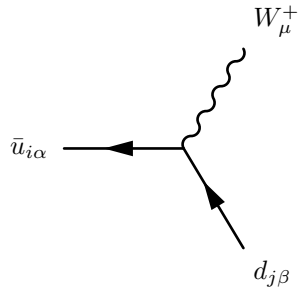


$$-\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\Big(-3g_2\sin\Theta_W + g_1\cos\Theta_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{245}$$
$$+\ \frac{i}{3}g_1\cos\Theta_W\delta_{\alpha\beta}\delta_{ij}\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{246}$$

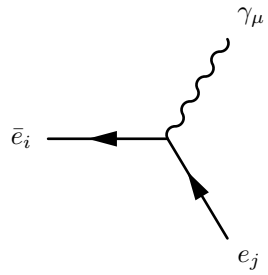


$$\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\Big(3g_2\cos\Theta_W + g_1\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{247}$$

$$+\ -\frac{i}{3}g_1\delta_{\alpha\beta}\delta_{ij}\sin\Theta_W\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{248}$$

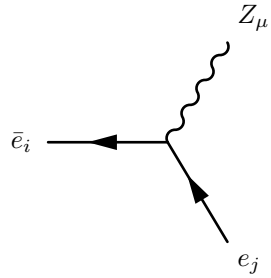


$$-\,i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^{3}U^{d,*}_{L,ja}U^{u}_{L,ia}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{249}$$



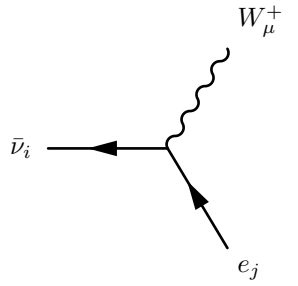
$$\frac{i}{2}\delta_{ij}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{250}$$

$$+\ ig_1\cos\Theta_W\delta_{ij}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{251}$$

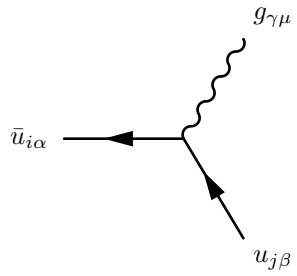


$$\frac{i}{2}\delta_{ij}\Big(- g_1 \sin\Theta_W + g_2 \cos\Theta_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{252}$$

$$+ \; -ig_1\delta_{ij}\sin\Theta_W\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{253}$$

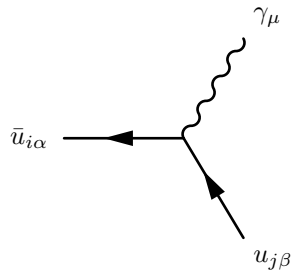


$$- \, i\frac{1}{\sqrt{2}}g_2 U^{e,*}_{L,ji}\Theta_{i,3}\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{254}$$



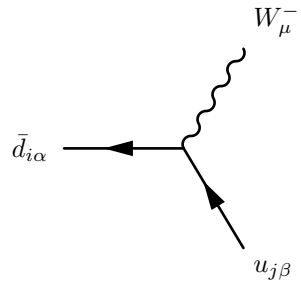
$$- \, \frac{i}{2}g_3\delta_{ij}\lambda^\gamma_{\alpha,\beta}\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{255}$$

$$+ \; -\frac{i}{2}g_3\delta_{ij}\lambda^\gamma_{\alpha,\beta}\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{256}$$

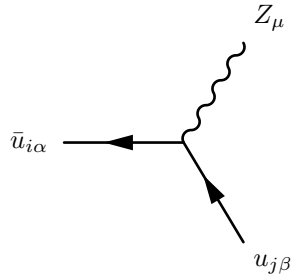


$$- \frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\Big(3g_2 \sin\Theta_W + g_1 \cos\Theta_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{257}$$

$$+ \; -\frac{2i}{3} g_1 \cos\Theta_W \delta_{\alpha\beta}\delta_{ij}\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{258}$$

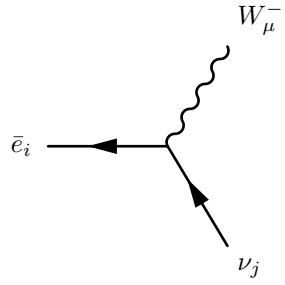


$$- i\frac{1}{\sqrt{2}} g_2 \delta_{\alpha\beta} \sum_{a=1}^{3} U^{u,*}_{L,ja} U^{d}_{L,ia}\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{259}$$

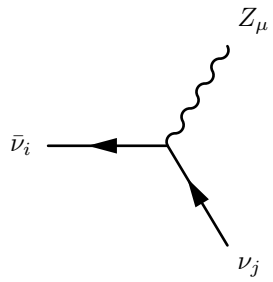


$$- \frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\Big(3g_2 \cos\Theta_W - g_1 \sin\Theta_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{260}$$

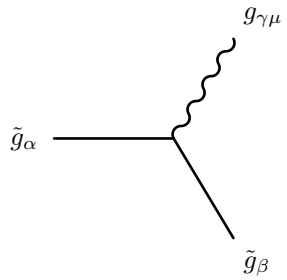
$$+ \; \frac{2i}{3} g_1 \delta_{\alpha\beta}\delta_{ij} \sin\Theta_W \Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{261}$$



$$-i\frac{1}{\sqrt{2}}g_2\Theta_{j,3}U^e_{L,ij}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{262}$$



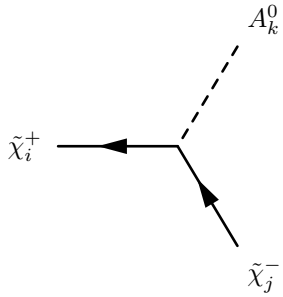
$$-\frac{i}{2}\delta_{ij}\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{263}$$



$$-g_3|\phi_{\tilde{g}}|^2 f_{\alpha,\beta,\gamma}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{264}$$

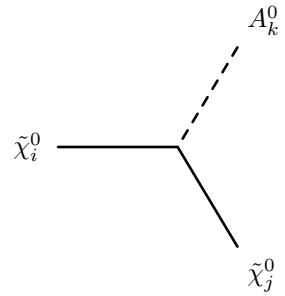
$$+\ -g_3|\phi_{\tilde{g}}|^2 f_{\alpha,\beta,\gamma}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{265}$$

9.5 Two Fermion-One Scalar Boson-Interaction



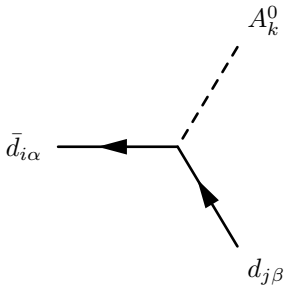
$$\frac{1}{\sqrt{2}}\Big(- g_2 U_{j1}^* V_{i2}^* Z_{k2}^A + U_{j2}^*\Big(- g_2 V_{i1}^* Z_{k1}^A + \lambda V_{i2}^* Z_{k3}^A\Big)\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{266}$$

$$+\ \frac{1}{\sqrt{2}}\Big(g_2 U_{i1} V_{j2} Z_{k2}^A + U_{i2}\Big(g_2 V_{j1} Z_{k1}^A - \lambda^* V_{j2} Z_{k3}^A\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{267}$$



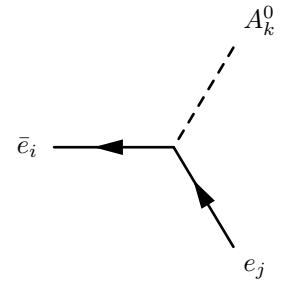
$$\begin{aligned}
&\frac{1}{2}\Big(- g_2 N_{i2}^* N_{j3}^* Z_{k1}^A - \sqrt{2}\lambda N_{i5}^* N_{j4}^* Z_{k1}^A - \sqrt{2}\lambda N_{i4}^* N_{j5}^* Z_{k1}^A - g_1 N_{i4}^* N_{j1}^* Z_{k2}^A \\
&+ g_2 N_{i4}^* N_{j2}^* Z_{k2}^A - \sqrt{2}\lambda N_{i5}^* N_{j3}^* Z_{k2}^A + g_2 N_{i2}^* N_{j4}^* Z_{k2}^A \\
&+ g_1 N_{i1}^*\Big(N_{j3}^* Z_{k1}^A - N_{j4}^* Z_{k2}^A\Big) - \sqrt{2}\lambda N_{i4}^* N_{j3}^* Z_{k3}^A + 2\sqrt{2}\kappa N_{i5}^* N_{j5}^* Z_{k3}^A \\
&+ N_{i3}^*\Big(g_1 N_{j1}^* Z_{k1}^A - g_2 N_{j2}^* Z_{k1}^A - \sqrt{2}\lambda\Big(N_{j4}^* Z_{k3}^A + N_{j5}^* Z_{k2}^A\Big)\Big)\Big)\Big(\frac{1-\gamma_5}{2}\Big)
\end{aligned} \tag{268}$$

$$\begin{aligned}
&+\ \frac{1}{2}\Big(Z_{k1}^A\Big(- g_1 N_{i1} N_{j3} + g_2 N_{i2} N_{j3} + N_{i3}\Big(- g_1 N_{j1} + g_2 N_{j2}\Big) + \sqrt{2}\lambda^* N_{i4} N_{j5} + \sqrt{2}\lambda^* N_{i5} N_{j4}\Big) \\
&+ \sqrt{2} Z_{k3}^A\Big(- 2\kappa^* N_{i5} N_{j5} + \lambda^*\Big(N_{i3} N_{j4} + N_{i4} N_{j3}\Big)\Big) \\
&+ Z_{k2}^A\Big(\Big(g_1 N_{i1} - g_2 N_{i2}\Big) N_{j4} + N_{i4}\Big(g_1 N_{j1} - g_2 N_{j2}\Big) + \sqrt{2}\lambda^*\Big(N_{i3} N_{j5} + N_{i5} N_{j3}\Big)\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big)
\end{aligned} \tag{269}$$



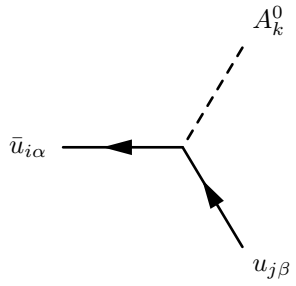
$$\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3} U_{L,jb}^{d,*}\sum_{a=1}^{3} U_{R,ia}^{d,*} Y_{d,ab} Z_{k1}^A\Big(\frac{1-\gamma_5}{2}\Big) \tag{270}$$

$$+ -\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{d,ab}^{*}U_{R,ja}^{d}U_{L,ib}^{d}Z_{k1}^{A}\Big(\frac{1+\gamma_5}{2}\Big) \tag{271}$$



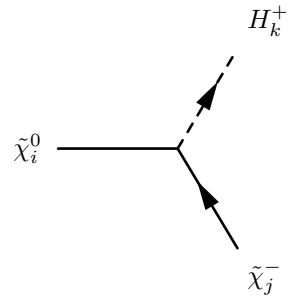
$$\frac{1}{\sqrt{2}}\sum_{b=1}^{3}U_{L,jb}^{e,*}\sum_{a=1}^{3}U_{R,ia}^{e,*}Y_{e,ab}Z_{k1}^{A}\Big(\frac{1-\gamma_5}{2}\Big) \tag{272}$$

$$+ -\frac{1}{\sqrt{2}}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{e,ab}^{*}U_{R,ja}^{e}U_{L,ib}^{e}Z_{k1}^{A}\Big(\frac{1+\gamma_5}{2}\Big) \tag{273}$$



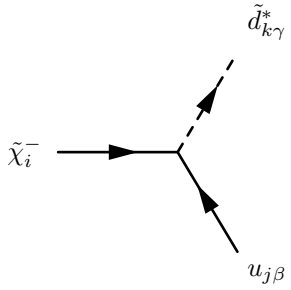
$$\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}U_{L,jb}^{u,*}\sum_{a=1}^{3}U_{R,ia}^{u,*}Y_{u,ab}Z_{k2}^{A}\Big(\frac{1-\gamma_5}{2}\Big) \tag{274}$$

$$+ -\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{u,ab}^{*}U_{R,ja}^{u}U_{L,ib}^{u}Z_{k2}^{A}\Big(\frac{1+\gamma_5}{2}\Big) \tag{275}$$



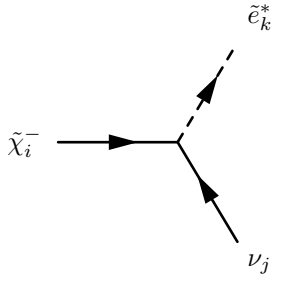
$$\frac{i}{2}\Big(-2g_2U_{j1}^*N_{i3}^*Z_{k1}^+ + U_{j2}^*\Big(-2\lambda N_{i5}^*Z_{k2}^+ + \sqrt{2}g_1N_{i1}^*Z_{k1}^+ + \sqrt{2}g_2N_{i2}^*Z_{k1}^+\Big)\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{276}$$

$$+\ -\frac{i}{2}\Big(\Big(2g_2V_{j1}N_{i4} + \sqrt{2}V_{j2}\Big(g_1N_{i1} + g_2N_{i2}\Big)\Big)Z_{k2}^+ + 2\lambda^*V_{j2}N_{i5}Z_{k1}^+\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{277}$$

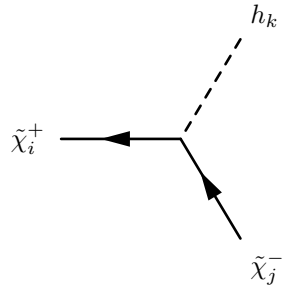


$$-i\delta_{\beta\gamma}\Big(g_2U_{i1}^*\sum_{a=1}^{3}U_{L,ja}^{u,*}Z_{ka}^D - U_{i2}^*\sum_{b=1}^{3}U_{L,jb}^{u,*}\sum_{a=1}^{3}Y_{d,ab}Z_{k3+a}^D\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{278}$$

$$+\ i\delta_{\beta\gamma}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{u,ab}^*U_{R,ja}^uZ_{kb}^DV_{i2}\Big(\frac{1+\gamma_5}{2}\Big) \tag{279}$$

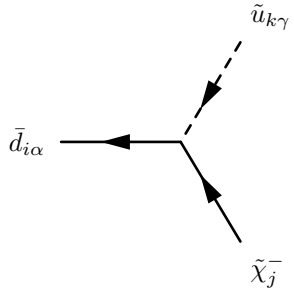


$$i\Big(- g_2 U^*_{i1} \Theta_{j,3} Z^E_{kj} + U^*_{i2} \sum_{a=1}^{3} Y_{e,aj} Z^E_{k3+a} \Big) \Big(\frac{1-\gamma_5}{2} \Big) \tag{280}$$



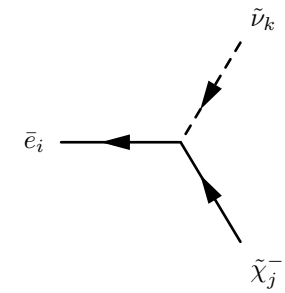
$$- i \frac{1}{\sqrt{2}} \Big(g_2 U^*_{j1} V^*_{i2} Z^H_{k2} + U^*_{j2} \Big(g_2 V^*_{i1} Z^H_{k1} + \lambda V^*_{i2} Z^H_{k3} \Big) \Big) \Big(\frac{1-\gamma_5}{2} \Big) \tag{281}$$

$$+ \; -i \frac{1}{\sqrt{2}} \Big(g_2 U_{i1} V_{j2} Z^H_{k2} + U_{i2} \Big(g_2 V_{j1} Z^H_{k1} + \lambda^* V_{j2} Z^H_{k3} \Big) \Big) \Big(\frac{1+\gamma_5}{2} \Big) \tag{282}$$



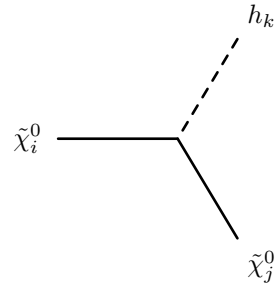
$$i U^*_{j2} \delta_{\alpha\gamma} \sum_{b=1}^{3} Z^{U,*}_{kb} \sum_{a=1}^{3} U^{d,*}_{R,ia} Y_{d,ab} \Big(\frac{1-\gamma_5}{2} \Big) \tag{283}$$

$$+ \; -i \delta_{\alpha\gamma} \Big(g_2 \sum_{a=1}^{3} Z^{U,*}_{ka} U^d_{L,ia} V_{j1} - \sum_{b=1}^{3} \sum_{a=1}^{3} Y^*_{u,ab} Z^{U,*}_{k3+a} U^d_{L,ib} V_{j2} \Big) \Big(\frac{1+\gamma_5}{2} \Big) \tag{284}$$



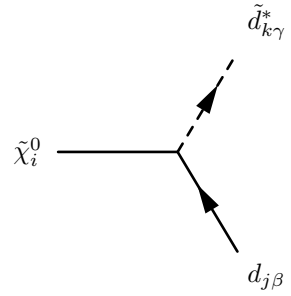
$$iU^*_{j2}\sum_{b=1}^{3} Z^{V,*}_{kb}\sum_{a=1}^{3} U^{e,*}_{R,ia}Y_{e,ab}\Big(\frac{1-\gamma_5}{2}\Big) \tag{285}$$

$$+\ -ig_2\sum_{a=1}^{3} Z^{V,*}_{ka}U^{e}_{L,ia}V_{j1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{286}$$



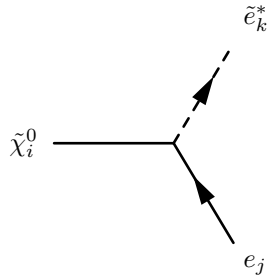
$$\begin{aligned}
&\frac{i}{2}\Big(-g_2N^*_{i2}N^*_{j3}Z^H_{k1}+\sqrt{2}\lambda N^*_{i5}N^*_{j4}Z^H_{k1}+\sqrt{2}\lambda N^*_{i4}N^*_{j5}Z^H_{k1}-g_1N^*_{i4}N^*_{j1}Z^H_{k2}\\
&+g_2N^*_{i4}N^*_{j2}Z^H_{k2}+\sqrt{2}\lambda N^*_{i5}N^*_{j3}Z^H_{k2}+g_2N^*_{i2}N^*_{j4}Z^H_{k2}\\
&+g_1N^*_{i1}\Big(N^*_{j3}Z^H_{k1}-N^*_{j4}Z^H_{k2}\Big)+\sqrt{2}\lambda N^*_{i4}N^*_{j3}Z^H_{k3}-2\sqrt{2}\kappa N^*_{i5}N^*_{j5}Z^H_{k3}\\
&+N^*_{i3}\Big(g_1N^*_{j1}Z^H_{k1}-g_2N^*_{j2}Z^H_{k1}+\sqrt{2}\lambda\Big(N^*_{j4}Z^H_{k3}+N^*_{j5}Z^H_{k2}\Big)\Big)\Big)\Big(\frac{1-\gamma_5}{2}\Big)
\end{aligned} \tag{287}$$

$$\begin{aligned}
&+\ \frac{i}{2}\Big(Z^H_{k1}\Big(g_1N_{i1}N_{j3}-g_2N_{i2}N_{j3}+N_{i3}\Big(g_1N_{j1}-g_2N_{j2}\Big)+\sqrt{2}\lambda^*N_{i4}N_{j5}+\sqrt{2}\lambda^*N_{i5}N_{j4}\Big)\\
&+\sqrt{2}Z^H_{k3}\Big(-2\kappa^*N_{i5}N_{j5}+\lambda^*\Big(N_{i3}N_{j4}+N_{i4}N_{j3}\Big)\Big)\\
&+Z^H_{k2}\Big(\Big(-g_1N_{i1}+g_2N_{i2}\Big)N_{j4}+N_{i4}\Big(-g_1N_{j1}+g_2N_{j2}\Big)+\sqrt{2}\lambda^*\Big(N_{i3}N_{j5}+N_{i5}N_{j3}\Big)\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big)
\end{aligned} \tag{288}$$



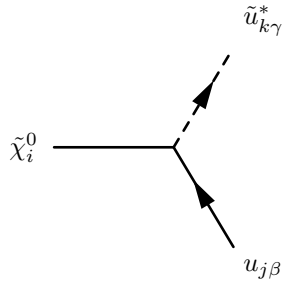
$$-\frac{i}{6}\delta_{\beta\gamma}\Big(-3\sqrt{2}g_2N^*_{i2}\sum_{a=1}^{3}U^{d,*}_{L,ja}Z^D_{ka}+6N^*_{i3}\sum_{b=1}^{3}U^{d,*}_{L,jb}\sum_{a=1}^{3}Y_{d,ab}Z^D_{k3+a}+\sqrt{2}g_1N^*_{i1}\sum_{a=1}^{3}U^{d,*}_{L,ja}Z^D_{ka}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{289}$$

$$+\ -\frac{i}{3}\delta_{\beta\gamma}\Big(3\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{d,ab}U^{d}_{R,ja}Z^{D}_{kb}N_{i3}+\sqrt{2}g_1\sum_{a=1}^{3}Z^{D}_{k3+a}U^{d}_{R,ja}N_{i1}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{290}$$



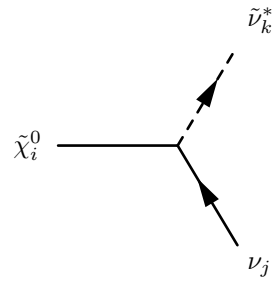
$$\frac{i}{2}\Big(-2N^{*}_{i3}\sum_{b=1}^{3}U^{e,*}_{L,jb}\sum_{a=1}^{3}Y_{e,ab}Z^{E}_{k3+a}+\sqrt{2}g_1N^{*}_{i1}\sum_{a=1}^{3}U^{e,*}_{L,ja}Z^{E}_{ka}+\sqrt{2}g_2N^{*}_{i2}\sum_{a=1}^{3}U^{e,*}_{L,ja}Z^{E}_{ka}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{291}$$

$$+\ -i\Big(\sqrt{2}g_1\sum_{a=1}^{3}Z^{E}_{k3+a}U^{e}_{R,ja}N_{i1}+\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{e,ab}U^{e}_{R,ja}Z^{E}_{kb}N_{i3}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{292}$$

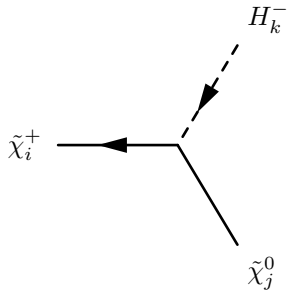


$$-\frac{i}{6}\delta_{\beta\gamma}\Big(3\sqrt{2}g_2N^{*}_{i2}\sum_{a=1}^{3}U^{u,*}_{L,ja}Z^{U}_{ka}+6N^{*}_{i4}\sum_{b=1}^{3}U^{u,*}_{L,jb}\sum_{a=1}^{3}Y_{u,ab}Z^{U}_{k3+a}+\sqrt{2}g_1N^{*}_{i1}\sum_{a=1}^{3}U^{u,*}_{L,ja}Z^{U}_{ka}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{293}$$

$$+\ \frac{i}{3}\delta_{\beta\gamma}\Big(2\sqrt{2}g_1\sum_{a=1}^{3}Z^{U}_{k3+a}U^{u}_{R,ja}N_{i1}-3\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{u,ab}U^{u}_{R,ja}Z^{U}_{kb}N_{i4}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{294}$$

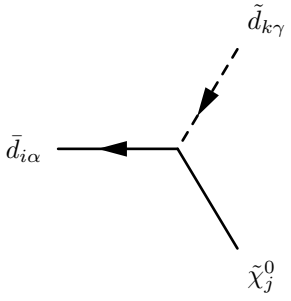


$$i\frac{1}{\sqrt{2}}\Big(g_1 N_{i1}^* - g_2 N_{i2}^*\Big)\Theta_{j,3} Z_{kj}^V \Big(\frac{1-\gamma_5}{2}\Big) \tag{295}$$



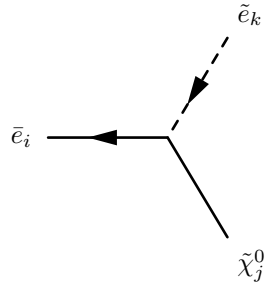
$$-\frac{i}{2}\Big(2g_2 V_{i1}^* N_{j4}^* Z_{k2}^+ + V_{i2}^*\Big(2\lambda N_{j5}^* Z_{k1}^+ + \sqrt{2}\Big(g_1 N_{j1}^* + g_2 N_{j2}^*\Big) Z_{k2}^+\Big)\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{296}$$

$$+\frac{i}{2}\Big(-2g_2 U_{i1} N_{j3} Z_{k1}^+ + U_{i2}\Big(-2\lambda^* N_{j5} Z_{k2}^+ + \sqrt{2} g_1 N_{j1} Z_{k1}^+ + \sqrt{2} g_2 N_{j2} Z_{k1}^+\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{297}$$



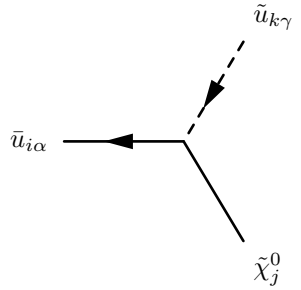
$$-\frac{i}{3}\delta_{\alpha\gamma}\Big(3N_{j3}^* \sum_{b=1}^{3} Z_{kb}^{D,*} \sum_{a=1}^{3} U_{R,ia}^{d,*} Y_{d,ab} + \sqrt{2} g_1 N_{j1}^* \sum_{a=1}^{3} Z_{k3+a}^{D,*} U_{R,ia}^{d,*}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{298}$$

$$+ -\frac{i}{6}\delta_{\alpha\gamma}\Big(6\sum_{b=1}^{3}\sum_{a=1}^{3} Y_{d,ab}^* Z_{k3+a}^{D,*} U_{L,ib}^{d} N_{j3} + \sqrt{2}\sum_{a=1}^{3} Z_{ka}^{D,*} U_{L,ia}^{d}\Big(-3g_2 N_{j2} + g_1 N_{j1}\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{299}$$



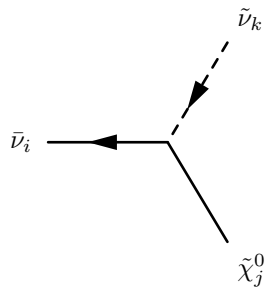
$$- i\Big(N_{j3}^{*}\sum_{b=1}^{3}Z_{kb}^{E,*}\sum_{a=1}^{3}U_{R,ia}^{e,*}Y_{e,ab} + \sqrt{2}g_1N_{j1}^{*}\sum_{a=1}^{3}Z_{k3+a}^{E,*}U_{R,ia}^{e,*}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{300}$$

$$+ \frac{i}{2}\Big(-2\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{e,ab}^{*}Z_{k3+a}^{E,*}U_{L,ib}^{e}N_{j3} + \sqrt{2}\sum_{a=1}^{3}Z_{ka}^{E,*}U_{L,ia}^{e}\Big(g_1N_{j1} + g_2N_{j2}\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{301}$$



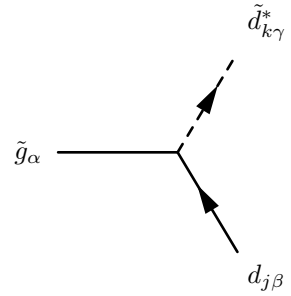
$$\frac{i}{3}\delta_{\alpha\gamma}\Big(2\sqrt{2}g_1N_{j1}^{*}\sum_{a=1}^{3}Z_{k3+a}^{U,*}U_{R,ia}^{u,*} - 3N_{j4}^{*}\sum_{b=1}^{3}Z_{kb}^{U,*}\sum_{a=1}^{3}U_{R,ia}^{u,*}Y_{u,ab}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{302}$$

$$+ -\frac{i}{6}\delta_{\alpha\gamma}\Big(6\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{u,ab}^{*}Z_{k3+a}^{U,*}U_{L,ib}^{u}N_{j4} + \sqrt{2}\sum_{a=1}^{3}Z_{ka}^{U,*}U_{L,ia}^{u}\Big(3g_2N_{j2} + g_1N_{j1}\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{303}$$



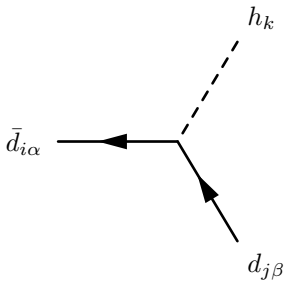
$$(304)$$

$$+\ i\frac{1}{\sqrt{2}}Z^{V,*}_{ki}\Theta_{i,3}\Big(g_1N_{j1}-g_2N_{j2}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{305}$$



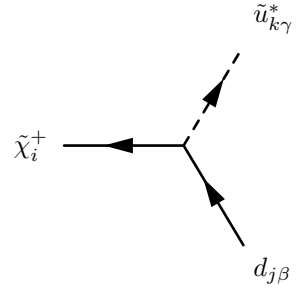
$$-\ i\frac{1}{\sqrt{2}}g_3\phi_{\tilde{g}}\lambda^{\alpha}_{\gamma,\beta}\sum_{a=1}^{3}U^{d,*}_{L,ja}Z^{D}_{ka}\Big(\frac{1-\gamma_5}{2}\Big) \tag{306}$$

$$+\ i\frac{1}{\sqrt{2}}g_3\phi^*_{\tilde{g}}\lambda^{\alpha}_{\gamma,\beta}\sum_{a=1}^{3}Z^{D}_{k3+a}U^{d}_{R,ja}\Big(\frac{1+\gamma_5}{2}\Big) \tag{307}$$



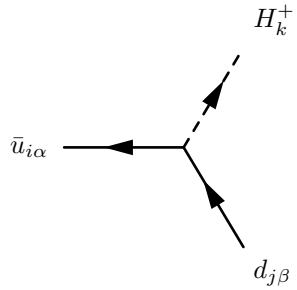
$$-\ i\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}U^{d,*}_{L,jb}\sum_{a=1}^{3}U^{d,*}_{R,ia}Y_{d,ab}Z^{H}_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{308}$$

$$+\ -i\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{d,ab}U^{d}_{R,ja}U^{d}_{L,ib}Z^{H}_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{309}$$



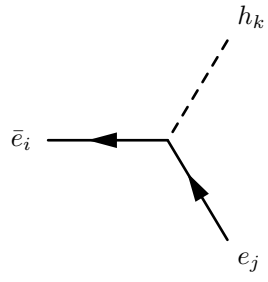
$$- i\delta_{\beta\gamma}\Big(g_2 V^*_{i1}\sum_{a=1}^{3} U^{d,*}_{L,ja} Z^U_{ka} - V^*_{i2}\sum_{b=1}^{3} U^{d,*}_{L,jb}\sum_{a=1}^{3} Y_{u,ab} Z^U_{k3+a}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{310}$$

$$+\ i\delta_{\beta\gamma}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^*_{d,ab} U^d_{R,ja} Z^U_{kb} U_{i2}\Big(\frac{1+\gamma_5}{2}\Big) \tag{311}$$



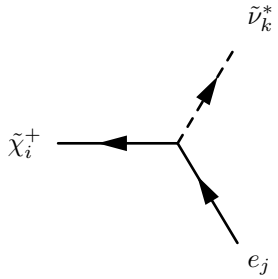
$$i\delta_{\alpha\beta}\sum_{b=1}^{3} U^{d,*}_{L,jb}\sum_{a=1}^{3} U^{u,*}_{R,ia} Y_{u,ab} Z^+_{k2}\Big(\frac{1-\gamma_5}{2}\Big) \tag{312}$$

$$+\ i\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^*_{d,ab} U^d_{R,ja} U^u_{L,ib} Z^+_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{313}$$



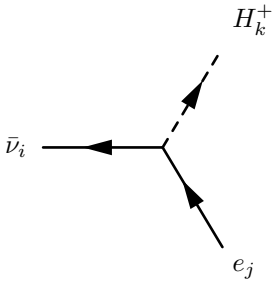
$$- i\frac{1}{\sqrt{2}}\sum_{b=1}^{3} U^{e,*}_{L,jb}\sum_{a=1}^{3} U^{e,*}_{R,ia} Y_{e,ab} Z^{H}_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{314}$$

$$+\ -i\frac{1}{\sqrt{2}}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{e,ab} U^{e}_{R,ja} U^{e}_{L,ib} Z^{H}_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{315}$$



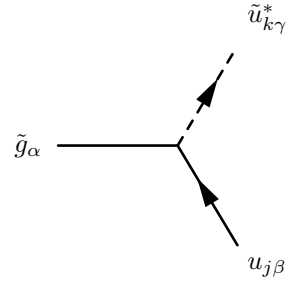
$$- ig_2 V^{*}_{i1}\sum_{a=1}^{3} U^{e,*}_{L,ja} Z^{V}_{ka}\Big(\frac{1-\gamma_5}{2}\Big) \tag{316}$$

$$+\ i\sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{e,ab} U^{e}_{R,ja} Z^{V}_{kb} U_{i2}\Big(\frac{1+\gamma_5}{2}\Big) \tag{317}$$



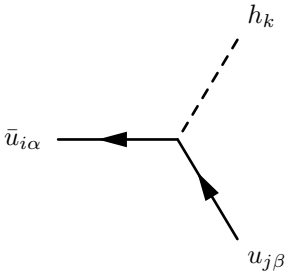
(318)

$$+\ i\sum_{a=1}^{3} Y^{*}_{e,ai} U^{e}_{R,ja} Z^{+}_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{319}$$



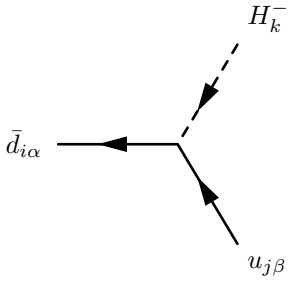
$$- i\frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}} \lambda^{\alpha}_{\gamma,\beta} \sum_{a=1}^{3} U^{u,*}_{L,ja} Z^{U}_{ka} \Big(\frac{1-\gamma_5}{2} \Big) \tag{320}$$

$$+ \; i\frac{1}{\sqrt{2}} g_3 \phi^*_{\tilde{g}} \lambda^{\alpha}_{\gamma,\beta} \sum_{a=1}^{3} Z^{U}_{k3+a} U^{u}_{R,ja} \Big(\frac{1+\gamma_5}{2} \Big) \tag{321}$$



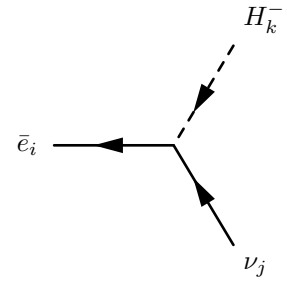
$$- i\frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{b=1}^{3} U^{u,*}_{L,jb} \sum_{a=1}^{3} U^{u,*}_{R,ia} Y_{u,ab} Z^{H}_{k2} \Big(\frac{1-\gamma_5}{2} \Big) \tag{322}$$

$$+ \; -i\frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{b=1}^{3} \sum_{a=1}^{3} Y^*_{u,ab} U^{u}_{R,ja} U^{u}_{L,ib} Z^{H}_{k2} \Big(\frac{1+\gamma_5}{2} \Big) \tag{323}$$

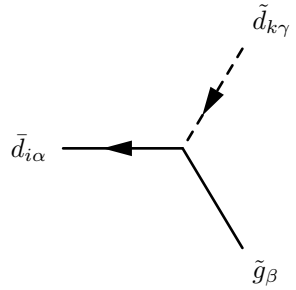


$$i\delta_{\alpha\beta}\sum_{b=1}^{3}U_{L,jb}^{u,*}\sum_{a=1}^{3}U_{R,ia}^{d,*}Y_{d,ab}Z_{k1}^{+}\Big(\frac{1-\gamma_5}{2}\Big) \tag{324}$$

$$+\ i\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{u,ab}^{*}U_{R,ja}^{u}U_{L,ib}^{d}Z_{k2}^{+}\Big(\frac{1+\gamma_5}{2}\Big) \tag{325}$$

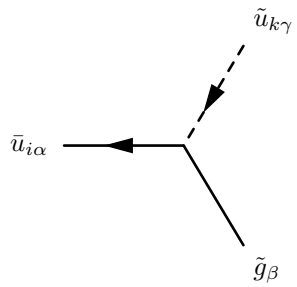


$$i\sum_{a=1}^{3}U_{R,ia}^{e,*}Y_{e,aj}Z_{k1}^{+}\Big(\frac{1-\gamma_5}{2}\Big) \tag{326}$$



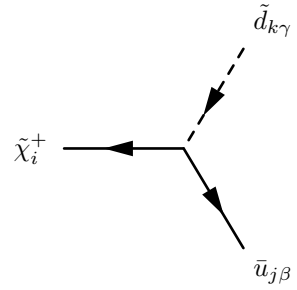
$$i\frac{1}{\sqrt{2}}g_3\phi_{\tilde{g}}\lambda_{\alpha,\gamma}^{\beta}\sum_{a=1}^{3}Z_{k3+a}^{D,*}U_{R,ia}^{d,*}\Big(\frac{1-\gamma_5}{2}\Big) \tag{327}$$

$$+\ -i\frac{1}{\sqrt{2}}g_3\phi_{\tilde{g}}^{*}\lambda_{\alpha,\gamma}^{\beta}\sum_{a=1}^{3}Z_{ka}^{D,*}U_{L,ia}^{d}\Big(\frac{1+\gamma_5}{2}\Big) \tag{328}$$



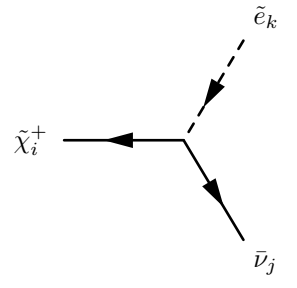
$$i\frac{1}{\sqrt{2}}g_3\phi_{\tilde{g}}\lambda^{\beta}_{\alpha,\gamma}\sum_{a=1}^{3}Z^{U,*}_{k3+a}U^{u,*}_{R,ia}\Big(\frac{1-\gamma_5}{2}\Big) \tag{329}$$

$$+\ -i\frac{1}{\sqrt{2}}g_3\phi^{*}_{\tilde{g}}\lambda^{\beta}_{\alpha,\gamma}\sum_{a=1}^{3}Z^{U,*}_{ka}U^{u}_{L,ia}\Big(\frac{1+\gamma_5}{2}\Big) \tag{330}$$



$$iV^{*}_{i2}\delta_{\beta\gamma}\sum_{b=1}^{3}Z^{D,*}_{kb}\sum_{a=1}^{3}U^{u,*}_{R,ja}Y_{u,ab}\Big(\frac{1-\gamma_5}{2}\Big) \tag{331}$$

$$+\ -i\delta_{\beta\gamma}\Big(g_2\sum_{a=1}^{3}Z^{D,*}_{ka}U^{u}_{L,ja}U_{i1}-\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{d,ab}Z^{D,*}_{k3+a}U^{u}_{L,jb}U_{i2}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{332}$$



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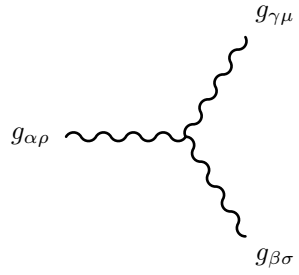
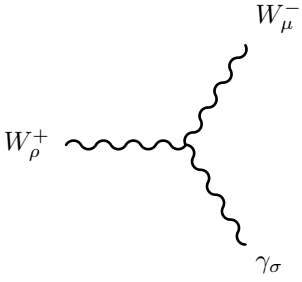
$$+ \; -i\Big(g_2 Z^{E,*}_{kj}\Theta_{j,3}U_{i1} - \sum_{a=1}^{3} Y^{*}_{e,aj} Z^{E,*}_{k3+a} U_{i2}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{334}$$

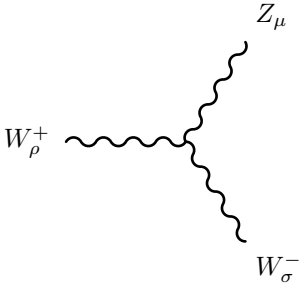
9.6 Three Vector Boson-Interaction



$$g_3 f_{\alpha,\beta,\gamma}\Big(g_{\rho\mu}\Big(-p_\sigma^{g_{\gamma\mu}} + p_\sigma^{g_{\alpha\rho}}\Big) + g_{\rho\sigma}\Big(-p_\mu^{g_{\alpha\rho}} + p_\mu^{g_{\beta\sigma}}\Big) + g_{\sigma\mu}\Big(-p_\rho^{g_{\beta\sigma}} + p_\rho^{g_{\gamma\mu}}\Big)\Big) \tag{335}$$

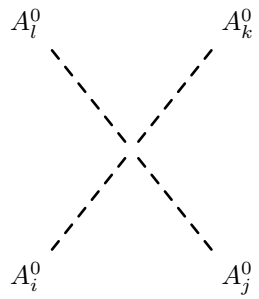


$$ig_2 \sin\Theta_W\Big(g_{\rho\mu}\Big(-p_\sigma^{W^-_\mu} + p_\sigma^{W^+_\rho}\Big) + g_{\rho\sigma}\Big(-p_\mu^{W^+_\rho} + p_\mu^{\gamma_\sigma}\Big) + g_{\sigma\mu}\Big(-p_\rho^{\gamma_\sigma} + p_\rho^{W^-_\mu}\Big)\Big) \tag{336}$$

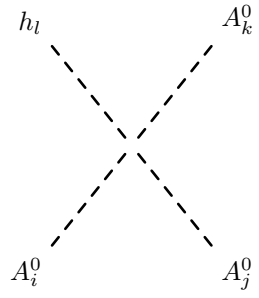


$$-ig_2 \cos\Theta_W\Big(g_{\rho\mu}\Big(-p_\sigma^{Z_\mu} + p_\sigma^{W^+_\rho}\Big) + g_{\rho\sigma}\Big(-p_\mu^{W^+_\rho} + p_\mu^{W^-_\sigma}\Big) + g_{\sigma\mu}\Big(-p_\rho^{W^-_\sigma} + p_\rho^{Z_\mu}\Big)\Big) \tag{337}$$

9.7 Four Scalar-Interaction

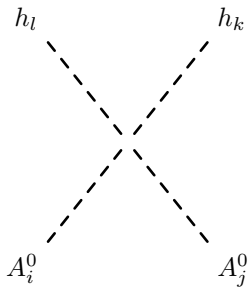


$$
\begin{aligned}
&-\frac{i}{4}\Big(Z_{i1}^A\Big(Z_{j1}^A\Big(3\Big(g_1^2+g_2^2\Big)Z_{k1}^AZ_{l1}^A-\Big(-4|\lambda|^2+g_1^2+g_2^2\Big)Z_{k2}^AZ_{l2}^A+4|\lambda|^2Z_{k3}^AZ_{l3}^A\Big)\\
&-Z_{j2}^A\Big(2\Big(\kappa\lambda^*+\lambda\kappa^*\Big)Z_{k3}^AZ_{l3}^A+\Big(-4|\lambda|^2+g_1^2+g_2^2\Big)Z_{k1}^AZ_{l2}^A+\Big(-4|\lambda|^2+g_1^2+g_2^2\Big)Z_{k2}^AZ_{l1}^A\Big)\\
&+2Z_{j3}^A\Big(\lambda^*\Big(\Big(2\lambda Z_{k1}^A-\kappa Z_{k2}^A\Big)Z_{l3}^A+Z_{k3}^A\Big(2\lambda Z_{l1}^A-\kappa Z_{l2}^A\Big)\Big)-\lambda\kappa^*\Big(Z_{k2}^AZ_{l3}^A+Z_{k3}^AZ_{l2}^A\Big)\Big)\Big)\\
&-Z_{i2}^A\Big(Z_{j2}^A\Big(-3\Big(g_1^2+g_2^2\Big)Z_{k2}^AZ_{l2}^A+\Big(-4|\lambda|^2+g_1^2+g_2^2\Big)Z_{k1}^AZ_{l1}^A-4|\lambda|^2Z_{k3}^AZ_{l3}^A\Big)\\
&+Z_{j1}^A\Big(2\Big(\kappa\lambda^*+\lambda\kappa^*\Big)Z_{k3}^AZ_{l3}^A+\Big(-4|\lambda|^2+g_1^2+g_2^2\Big)Z_{k1}^AZ_{l2}^A+\Big(-4|\lambda|^2+g_1^2+g_2^2\Big)Z_{k2}^AZ_{l1}^A\Big)\\
&+2Z_{j3}^A\Big(\lambda^*\Big(\Big(-2\lambda Z_{k2}^A+\kappa Z_{k1}^A\Big)Z_{l3}^A+Z_{k3}^A\Big(-2\lambda Z_{l2}^A+\kappa Z_{l1}^A\Big)\Big)+\lambda\kappa^*\Big(Z_{k1}^AZ_{l3}^A+Z_{k3}^AZ_{l1}^A\Big)\Big)\Big)\\
&+2Z_{i3}^A\Big(\lambda^*\Big(Z_{j3}^A\Big(Z_{k1}^A\Big(2\lambda Z_{l1}^A-\kappa Z_{l2}^A\Big)+Z_{k2}^A\Big(2\lambda Z_{l2}^A-\kappa Z_{l1}^A\Big)\Big)\\
&+Z_{j1}^A\Big(\Big(2\lambda Z_{k1}^A-\kappa Z_{k2}^A\Big)Z_{l3}^A+Z_{k3}^A\Big(2\lambda Z_{l1}^A-\kappa Z_{l2}^A\Big)\Big)\\
&-Z_{j2}^A\Big(\Big(-2\lambda Z_{k2}^A+\kappa Z_{k1}^A\Big)Z_{l3}^A+Z_{k3}^A\Big(-2\lambda Z_{l2}^A+\kappa Z_{l1}^A\Big)\Big)\Big)\\
&-\kappa^*\Big(Z_{j3}^A\Big(-12\kappa Z_{k3}^AZ_{l3}^A+\lambda Z_{k1}^AZ_{l2}^A+\lambda Z_{k2}^AZ_{l1}^A\Big)\\
&+\lambda\Big(Z_{j1}^A\Big(Z_{k2}^AZ_{l3}^A+Z_{k3}^AZ_{l2}^A\Big)+Z_{j2}^A\Big(Z_{k1}^AZ_{l3}^A+Z_{k3}^AZ_{l1}^A\Big)\Big)\Big)\Big)\Big)
\end{aligned}
\tag{338}
$$

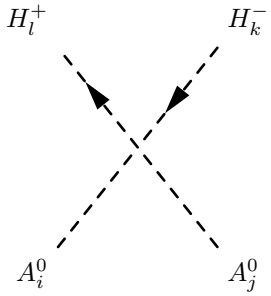


$$
\frac{1}{2}\Big(-\kappa\lambda^*+\lambda\kappa^*\Big)\Big(Z_{i2}^A\Big(-Z_{j1}^AZ_{k3}^AZ_{l3}^H+Z_{j3}^A\Big(-Z_{k1}^AZ_{l3}^H+Z_{k3}^AZ_{l1}^H\Big)\Big)
$$

$$+ Z_{i3}^{A}\Big(Z_{j1}^{A}\Big(- Z_{k2}^{A}Z_{l3}^{H} + Z_{k3}^{A}Z_{l2}^{H}\Big) + Z_{j2}^{A}\Big(- Z_{k1}^{A}Z_{l3}^{H} + Z_{k3}^{A}Z_{l1}^{H}\Big) + Z_{j3}^{A}\Big(Z_{k1}^{A}Z_{l2}^{H} + Z_{k2}^{A}Z_{l1}^{H}\Big)\Big)$$
$$+ Z_{i1}^{A}\Big(- Z_{j2}^{A}Z_{k3}^{A}Z_{l3}^{H} + Z_{j3}^{A}\Big(- Z_{k2}^{A}Z_{l3}^{H} + Z_{k3}^{A}Z_{l2}^{H}\Big)\Big)\Big) \tag{339}$$

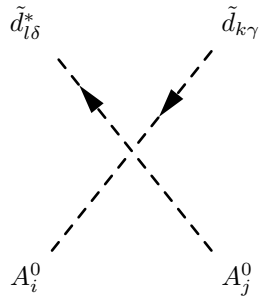


$$- \frac{i}{4}\Big(Z_{i2}^{A}\Big(Z_{j2}^{A}\Big(- \Big(- 4|\lambda|^2 + g_1^2 + g_2^2\Big)Z_{k1}^{H}Z_{l1}^{H} + 4|\lambda|^2 Z_{k3}^{H}Z_{l3}^{H} + \Big(g_1^2 + g_2^2\Big)Z_{k2}^{H}Z_{l2}^{H}\Big)$$
$$- 2\Big(\kappa\lambda^* + \lambda\kappa^*\Big)\Big(- Z_{j1}^{A}Z_{k3}^{H}Z_{l3}^{H} + Z_{j3}^{A}\Big(Z_{k1}^{H}Z_{l3}^{H} + Z_{k3}^{H}Z_{l1}^{H}\Big)\Big)\Big)$$
$$+ Z_{i1}^{A}\Big(Z_{j1}^{A}\Big(- \Big(- 4|\lambda|^2 + g_1^2 + g_2^2\Big)Z_{k2}^{H}Z_{l2}^{H} + 4|\lambda|^2 Z_{k3}^{H}Z_{l3}^{H} + \Big(g_1^2 + g_2^2\Big)Z_{k1}^{H}Z_{l1}^{H}\Big)$$
$$- 2\Big(\kappa\lambda^* + \lambda\kappa^*\Big)\Big(- Z_{j2}^{A}Z_{k3}^{H}Z_{l3}^{H} + Z_{j3}^{A}\Big(Z_{k2}^{H}Z_{l3}^{H} + Z_{k3}^{H}Z_{l2}^{H}\Big)\Big)\Big)$$
$$+ 2Z_{i3}^{A}\Big(\lambda^*\Big(Z_{j3}^{A}\Big(Z_{k1}^{H}\Big(2\lambda Z_{l1}^{H} + \kappa Z_{l2}^{H}\Big) + Z_{k2}^{H}\Big(2\lambda Z_{l2}^{H} + \kappa Z_{l1}^{H}\Big)\Big)$$
$$- \kappa\Big(Z_{j1}^{A}\Big(Z_{k2}^{H}Z_{l3}^{H} + Z_{k3}^{H}Z_{l2}^{H}\Big) + Z_{j2}^{A}\Big(Z_{k1}^{H}Z_{l3}^{H} + Z_{k3}^{H}Z_{l1}^{H}\Big)\Big)\Big)$$
$$+ \kappa^*\Big(Z_{j3}^{A}\Big(4\kappa Z_{k3}^{H}Z_{l3}^{H} + \lambda Z_{k1}^{H}Z_{l2}^{H} + \lambda Z_{k2}^{H}Z_{l1}^{H}\Big)$$
$$- \lambda\Big(Z_{j1}^{A}\Big(Z_{k2}^{H}Z_{l3}^{H} + Z_{k3}^{H}Z_{l2}^{H}\Big) + Z_{j2}^{A}\Big(Z_{k1}^{H}Z_{l3}^{H} + Z_{k3}^{H}Z_{l1}^{H}\Big)\Big)\Big)\Big)\Big) \tag{340}$$

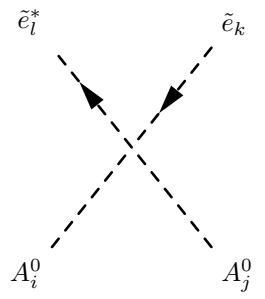


$$- \frac{i}{4}\Big(Z_{i1}^{A}\Big(- \Big(- 2|\lambda|^2 + g_2^2\Big)Z_{j2}^{A}\Big(Z_{k1}^{+}Z_{l2}^{+} + Z_{k2}^{+}Z_{l1}^{+}\Big)$$

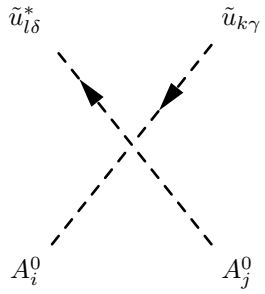
$$
\begin{aligned}
&+ Z^A_{j1}\Big(\Big(g_1^2+g_2^2\Big)Z^+_{k1}Z^+_{l1} + \Big(-g_1^2+g_2^2\Big)Z^+_{k2}Z^+_{l2}\Big)\Big)\\
&+ Z^A_{i2}\Big(-\Big(-2|\lambda|^2+g_2^2\Big)Z^A_{j1}\Big(Z^+_{k1}Z^+_{l2}+Z^+_{k2}Z^+_{l1}\Big)\\
&+ Z^A_{j2}\Big(\Big(-g_1^2+g_2^2\Big)Z^+_{k1}Z^+_{l1} + \Big(g_1^2+g_2^2\Big)Z^+_{k2}Z^+_{l2}\Big)\Big)\\
&+ 4Z^A_{i3}Z^A_{j3}\Big(-\lambda\kappa^* Z^+_{k1}Z^+_{l2} + \lambda^*\Big(\lambda Z^+_{k1}Z^+_{l1} + Z^+_{k2}\Big(-\kappa Z^+_{l1}+\lambda Z^+_{l2}\Big)\Big)\Big)\Big)
\end{aligned}
\tag{341}
$$



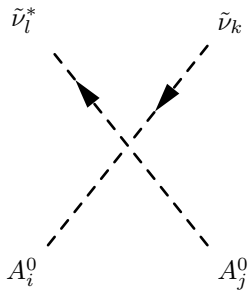
$$
\begin{aligned}
&\frac{i}{12}\delta_{\gamma\delta}\Big(\Big(3g_2^2+g_1^2\Big)\sum_{a=1}^{3} Z^{D,*}_{ka}Z^D_{la}\Big(Z^A_{i1}Z^A_{j1}-Z^A_{i2}Z^A_{j2}\Big)\\
&+ 2\Big(g_1^2\sum_{a=1}^{3} Z^{D,*}_{k3+a}Z^D_{l3+a}\Big(Z^A_{i1}Z^A_{j1}-Z^A_{i2}Z^A_{j2}\Big)\\
&- 3\Big(2\sum_{c=1}^{3} Z^{D,*}_{k3+c}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^*_{d,ca}Y_{d,ba}Z^D_{l3+b}Z^A_{i1}Z^A_{j1}\\
&+ 2\sum_{c=1}^{3}\sum_{b=1}^{3} Z^{D,*}_{kb}\sum_{a=1}^{3} Y^*_{d,ac}Y_{d,ab}Z^D_{lc}Z^A_{i1}Z^A_{j1}\\
&+ \Big(\lambda\sum_{b=1}^{3}\sum_{a=1}^{3} Y^*_{d,ab}Z^{D,*}_{k3+a}Z^D_{lb} + \lambda^*\sum_{b=1}^{3} Z^{D,*}_{kb}\sum_{a=1}^{3} Y_{d,ab}Z^D_{l3+a}\Big)\Big(Z^A_{i2}Z^A_{j3}+Z^A_{i3}Z^A_{j2}\Big)\Big)\Big)\Big)
\end{aligned}
\tag{342}
$$



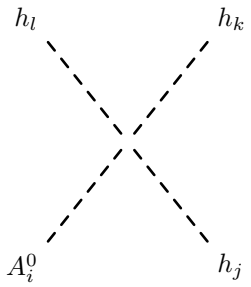
$$
\begin{aligned}
&-\frac{i}{4}\Big(\Big(-g_2^2+g_1^2\Big)\sum_{a=1}^{3}Z^{E,*}_{ka}Z^{E}_{la}\Big(Z^{A}_{i1}Z^{A}_{j1}-Z^{A}_{i2}Z^{A}_{j2}\Big)\\
&+2\Big(2\sum_{c=1}^{3}Z^{E,*}_{k3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{e,ca}Y_{e,ba}Z^{E}_{l3+b}Z^{A}_{i1}Z^{A}_{j1}\\
&+2\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{E,*}_{kb}\sum_{a=1}^{3}Y^{*}_{e,ac}Y_{e,ab}Z^{E}_{lc}Z^{A}_{i1}Z^{A}_{j1}+\lambda^{*}\sum_{b=1}^{3}Z^{E,*}_{kb}\sum_{a=1}^{3}Y_{e,ab}Z^{E}_{l3+a}Z^{A}_{i3}Z^{A}_{j2}\\
&+\lambda\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{e,ab}Z^{E,*}_{k3+a}Z^{E}_{lb}Z^{A}_{i3}Z^{A}_{j2}+g_1^2\sum_{a=1}^{3}Z^{E,*}_{k3+a}Z^{E}_{l3+a}\Big(-Z^{A}_{i1}Z^{A}_{j1}+Z^{A}_{i2}Z^{A}_{j2}\Big)\\
&+\lambda^{*}\sum_{b=1}^{3}Z^{E,*}_{kb}\sum_{a=1}^{3}Y_{e,ab}Z^{E}_{l3+a}Z^{A}_{i2}Z^{A}_{j3}+\lambda\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{e,ab}Z^{E,*}_{k3+a}Z^{E}_{lb}Z^{A}_{i2}Z^{A}_{j3}\Big)\Big)
\end{aligned}
\tag{343}
$$



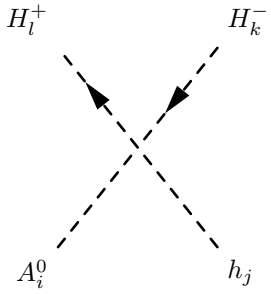
$$
\begin{aligned}
&\frac{i}{12}\delta_{\gamma\delta}\Big(\Big(-3g_2^2+g_1^2\Big)\sum_{a=1}^{3}Z^{U,*}_{ka}Z^{U}_{la}\Big(Z^{A}_{i1}Z^{A}_{j1}-Z^{A}_{i2}Z^{A}_{j2}\Big)\\
&-2\Big(2g_1^2\sum_{a=1}^{3}Z^{U,*}_{k3+a}Z^{U}_{l3+a}\Big(Z^{A}_{i1}Z^{A}_{j1}-Z^{A}_{i2}Z^{A}_{j2}\Big)\\
&+3\Big(2\Big(\sum_{c=1}^{3}Z^{U,*}_{k3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{u,ca}Y_{u,ba}Z^{U}_{l3+b}+\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{U,*}_{kb}\sum_{a=1}^{3}Y^{*}_{u,ac}Y_{u,ab}Z^{U}_{lc}\Big)Z^{A}_{i2}Z^{A}_{j2}\\
&+\lambda^{*}\sum_{b=1}^{3}Z^{U,*}_{kb}\sum_{a=1}^{3}Y_{u,ab}Z^{U}_{l3+a}\Big(Z^{A}_{i1}Z^{A}_{j3}+Z^{A}_{i3}Z^{A}_{j1}\Big)\\
&+\lambda\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{u,ab}Z^{U,*}_{k3+a}Z^{U}_{lb}\Big(Z^{A}_{i1}Z^{A}_{j3}+Z^{A}_{i3}Z^{A}_{j1}\Big)\Big)\Big)\Big)
\end{aligned}
\tag{344}
$$



$$-\frac{i}{4}\Big(g_1^2+g_2^2\Big)\delta_{kl}\Big(Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A\Big) \tag{345}$$

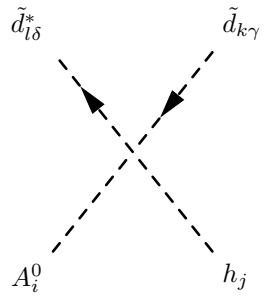


$$\begin{aligned}&\frac{1}{2}\Big(-\kappa\lambda^*+\lambda\kappa^*\Big)\Big(-Z_{i2}^A\Big(Z_{j1}^H Z_{k3}^H Z_{l3}^H + Z_{j3}^H\Big(Z_{k1}^H Z_{l3}^H + Z_{k3}^H Z_{l1}^H\Big)\Big)\\&+Z_{i3}^A\Big(Z_{j1}^H\Big(Z_{k2}^H Z_{l3}^H + Z_{k3}^H Z_{l2}^H\Big) + Z_{j2}^H\Big(Z_{k1}^H Z_{l3}^H + Z_{k3}^H Z_{l1}^H\Big) + Z_{j3}^H\Big(Z_{k1}^H Z_{l2}^H + Z_{k2}^H Z_{l1}^H\Big)\Big)\\&-Z_{i1}^A\Big(Z_{j2}^H Z_{k3}^H Z_{l3}^H + Z_{j3}^H\Big(Z_{k2}^H Z_{l3}^H + Z_{k3}^H Z_{l2}^H\Big)\Big)\Big)\end{aligned} \tag{346}$$

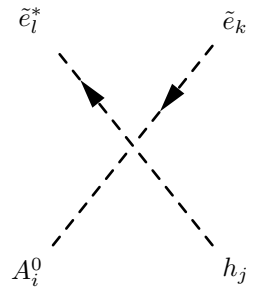


$$\frac{1}{4}\Big(\Big(-2|\lambda|^2+g_2^2\Big)Z_{i2}^A Z_{j1}^H\Big(-Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+\Big)$$

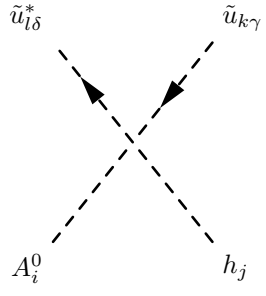
$$+\Big(-2|\lambda|^2+g_2^2\Big)Z^A_{i1}Z^H_{j2}\Big(-Z^+_{k1}Z^+_{l2}+Z^+_{k2}Z^+_{l1}\Big)$$
$$+4Z^A_{i3}Z^H_{j3}\Big(\kappa\lambda^*Z^+_{k2}Z^+_{l1}-\lambda\kappa^*Z^+_{k1}Z^+_{l2}\Big)\Big) \tag{347}$$



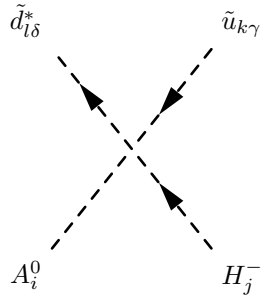
$$\frac{1}{2}\delta_{\gamma\delta}\Big(-\lambda\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{d,ab}Z^{D,*}_{k3+a}Z^D_{lb}+\lambda^*\sum_{b=1}^{3}Z^{D,*}_{kb}\sum_{a=1}^{3}Y_{d,ab}Z^D_{l3+a}\Big)\Big(Z^A_{i2}Z^H_{j3}+Z^A_{i3}Z^H_{j2}\Big) \tag{348}$$



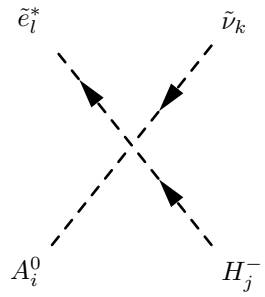
$$\frac{1}{2}\Big(-\lambda\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{e,ab}Z^{E,*}_{k3+a}Z^E_{lb}+\lambda^*\sum_{b=1}^{3}Z^{E,*}_{kb}\sum_{a=1}^{3}Y_{e,ab}Z^E_{l3+a}\Big)\Big(Z^A_{i2}Z^H_{j3}+Z^A_{i3}Z^H_{j2}\Big) \tag{349}$$



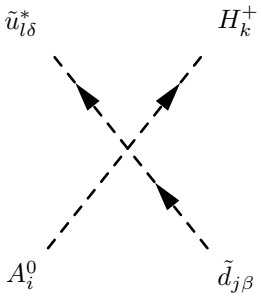
$$\frac{1}{2}\delta_{\gamma\delta}\Big(-\lambda\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{u,ab}Z^{U,*}_{k3+a}Z^{U}_{lb}+\lambda^{*}\sum_{b=1}^{3}Z^{U,*}_{kb}\sum_{a=1}^{3}Y_{u,ab}Z^{U}_{l3+a}\Big)\Big(Z^{A}_{i1}Z^{H}_{j3}+Z^{A}_{i3}Z^{H}_{j1}\Big) \tag{350}$$



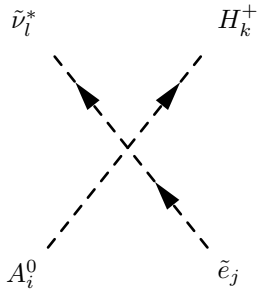
$$\begin{aligned}
&\frac{1}{2}\frac{1}{\sqrt{2}}\delta_{\gamma\delta}\Big(g_2^2\sum_{a=1}^{3}Z^{U,*}_{ka}Z^{D}_{la}\Big(-Z^{A}_{i1}Z^{+}_{j1}+Z^{A}_{i2}Z^{+}_{j2}\Big)\\
&+2\Big(\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{U,*}_{kb}\sum_{a=1}^{3}Y^{*}_{d,ac}Y_{d,ab}Z^{D}_{lc}Z^{A}_{i1}Z^{+}_{j1}-\lambda\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{u,ab}Z^{U,*}_{k3+a}Z^{D}_{lb}Z^{A}_{i3}Z^{+}_{j1}\\
&-\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{U,*}_{kb}\sum_{a=1}^{3}Y^{*}_{u,ac}Y_{u,ab}Z^{D}_{lc}Z^{A}_{i2}Z^{+}_{j2}+\lambda^{*}\sum_{b=1}^{3}Z^{U,*}_{kb}\sum_{a=1}^{3}Y_{d,ab}Z^{D}_{l3+a}Z^{A}_{i3}Z^{+}_{j2}\\
&+\sum_{c=1}^{3}Z^{U,*}_{k3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{u,ca}Y_{d,ba}Z^{D}_{l3+b}\Big(-Z^{A}_{i1}Z^{+}_{j2}+Z^{A}_{i2}Z^{+}_{j1}\Big)\Big)\Big)
\end{aligned} \tag{351}$$



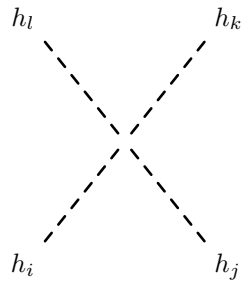
$$\begin{aligned}
&\frac{1}{2}\frac{1}{\sqrt{2}}\Big(g_2^2\sum_{a=1}^{3}Z^{V,*}_{ka}Z^{E}_{la}\Big(-Z^{A}_{i1}Z^{+}_{j1}+Z^{A}_{i2}Z^{+}_{j2}\Big)\\
&+2\Big(\lambda^{*}\sum_{b=1}^{3}Z^{V,*}_{kb}\sum_{a=1}^{3}Y_{e,ab}Z^{E}_{l3+a}Z^{A}_{i3}Z^{+}_{j2}+\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{V,*}_{kb}\sum_{a=1}^{3}Y^{*}_{e,ac}Y_{e,ab}Z^{E}_{lc}Z^{A}_{i1}Z^{+}_{j1}\Big)\Big)
\end{aligned} \tag{352}$$



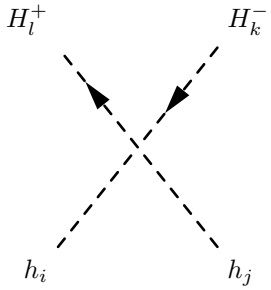
$$\frac{1}{2}\frac{1}{\sqrt{2}}\delta_{\beta\delta}\Big(g_2^2\sum_{a=1}^{3}Z^{D,*}_{ja}Z^{U}_{la}\Big(Z^{A}_{i1}Z^{+}_{k1}-Z^{A}_{i2}Z^{+}_{k2}\Big)$$
$$+2\Big(-\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}Y^{*}_{d,ac}Y_{d,ab}Z^{U}_{lc}Z^{A}_{i1}Z^{+}_{k1}+\lambda^{*}\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}Y_{u,ab}Z^{U}_{l3+a}Z^{A}_{i3}Z^{+}_{k1}$$
$$+\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}Y^{*}_{u,ac}Y_{u,ab}Z^{U}_{lc}Z^{A}_{i2}Z^{+}_{k2}-\lambda\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{d,ab}Z^{D,*}_{j3+a}Z^{U}_{lb}Z^{A}_{i3}Z^{+}_{k2}$$
$$+\sum_{c=1}^{3}Z^{D,*}_{j3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{d,ca}Y_{u,ba}Z^{U}_{l3+b}\Big(Z^{A}_{i1}Z^{+}_{k2}-Z^{A}_{i2}Z^{+}_{k1}\Big)\Big)\Big) \tag{353}$$



$$\frac{1}{2}\frac{1}{\sqrt{2}}\Big(g_2^2\sum_{a=1}^{3}Z^{E,*}_{ja}Z^{V}_{la}\Big(Z^{A}_{i1}Z^{+}_{k1}-Z^{A}_{i2}Z^{+}_{k2}\Big)$$
$$-2\Big(\lambda\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{e,ab}Z^{E,*}_{j3+a}Z^{V}_{lb}Z^{A}_{i3}Z^{+}_{k2}+\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{E,*}_{jb}\sum_{a=1}^{3}Y^{*}_{e,ac}Y_{e,ab}Z^{V}_{lc}Z^{A}_{i1}Z^{+}_{k1}\Big)\Big) \tag{354}$$

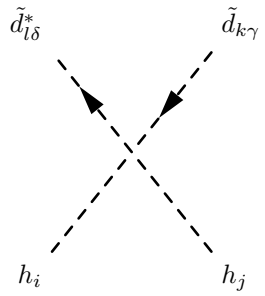


$$
\begin{aligned}
&-\frac{i}{4}\Big(Z_{i1}^H\Big(Z_{j1}^H\Big(3\Big(g_1^2+g_2^2\Big)Z_{k1}^H Z_{l1}^H-\Big(-4|\lambda|^2+g_1^2+g_2^2\Big)Z_{k2}^H Z_{l2}^H+4|\lambda|^2 Z_{k3}^H Z_{l3}^H\Big)\\
&-Z_{j2}^H\Big(2\Big(\kappa\lambda^*+\lambda\kappa^*\Big)Z_{k3}^H Z_{l3}^H+\Big(-4|\lambda|^2+g_1^2+g_2^2\Big)Z_{k1}^H Z_{l2}^H+\Big(-4|\lambda|^2+g_1^2+g_2^2\Big)Z_{k2}^H Z_{l1}^H\Big)\\
&+2Z_{j3}^H\Big(\lambda^*\Big(\Big(2\lambda Z_{k1}^H-\kappa Z_{k2}^H\Big)Z_{l3}^H+Z_{k3}^H\Big(2\lambda Z_{l1}^H-\kappa Z_{l2}^H\Big)\Big)-\lambda\kappa^*\Big(Z_{k2}^H Z_{l3}^H+Z_{k3}^H Z_{l2}^H\Big)\Big)\Big)\\
&-Z_{i2}^H\Big(Z_{j2}^H\Big(-3\Big(g_1^2+g_2^2\Big)Z_{k2}^H Z_{l2}^H+\Big(-4|\lambda|^2+g_1^2+g_2^2\Big)Z_{k1}^H Z_{l1}^H-4|\lambda|^2 Z_{k3}^H Z_{l3}^H\Big)\\
&+Z_{j1}^H\Big(2\Big(\kappa\lambda^*+\lambda\kappa^*\Big)Z_{k3}^H Z_{l3}^H+\Big(-4|\lambda|^2+g_1^2+g_2^2\Big)Z_{k1}^H Z_{l2}^H+\Big(-4|\lambda|^2+g_1^2+g_2^2\Big)Z_{k2}^H Z_{l1}^H\Big)\\
&+2Z_{j3}^H\Big(\lambda^*\Big(\Big(-2\lambda Z_{k2}^H+\kappa Z_{k1}^H\Big)Z_{l3}^H+Z_{k3}^H\Big(-2\lambda Z_{l2}^H+\kappa Z_{l1}^H\Big)\Big)+\lambda\kappa^*\Big(Z_{k1}^H Z_{l3}^H+Z_{k3}^H Z_{l1}^H\Big)\Big)\Big)\\
&+2Z_{i3}^H\Big(\lambda^*\Big(Z_{j3}^H\Big(Z_{k1}^H\Big(2\lambda Z_{l1}^H-\kappa Z_{l2}^H\Big)+Z_{k2}^H\Big(2\lambda Z_{l2}^H-\kappa Z_{l1}^H\Big)\Big)\\
&+Z_{j1}^H\Big(\Big(2\lambda Z_{k1}^H-\kappa Z_{k2}^H\Big)Z_{l3}^H+Z_{k3}^H\Big(2\lambda Z_{l1}^H-\kappa Z_{l2}^H\Big)\Big)\\
&-Z_{j2}^H\Big(\Big(-2\lambda Z_{k2}^H+\kappa Z_{k1}^H\Big)Z_{l3}^H+Z_{k3}^H\Big(-2\lambda Z_{l2}^H+\kappa Z_{l1}^H\Big)\Big)\Big)\\
&-\kappa^*\Big(Z_{j3}^H\Big(-12\kappa Z_{k3}^H Z_{l3}^H+\lambda Z_{k1}^H Z_{l2}^H+\lambda Z_{k2}^H Z_{l1}^H\Big)\\
&+\lambda\Big(Z_{j1}^H\Big(Z_{k2}^H Z_{l3}^H+Z_{k3}^H Z_{l2}^H\Big)+Z_{j2}^H\Big(Z_{k1}^H Z_{l3}^H+Z_{k3}^H Z_{l1}^H\Big)\Big)\Big)\Big)\Big)
\end{aligned}
\tag{355}
$$

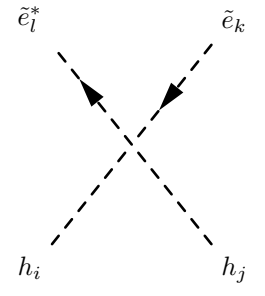


$$
-\frac{i}{4}\Big(Z_{i1}^H\Big(\Big(-2|\lambda|^2+g_2^2\Big)Z_{j2}^H\Big(Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+\Big)+Z_{j1}^H\Big(\Big(g_1^2+g_2^2\Big)Z_{k1}^+ Z_{l1}^+ + \Big(-g_1^2+g_2^2\Big)Z_{k2}^+ Z_{l2}^+\Big)\Big)
$$

$$+ Z_{i2}^{H}\Big(\Big(- 2|\lambda|^2 + g_2^2\Big) Z_{j1}^{H}\Big(Z_{k1}^{+} Z_{l2}^{+} + Z_{k2}^{+} Z_{l1}^{+}\Big) + Z_{j2}^{H}\Big(\Big(- g_1^2 + g_2^2\Big) Z_{k1}^{+} Z_{l1}^{+} + \Big(g_1^2 + g_2^2\Big) Z_{k2}^{+} Z_{l2}^{+}\Big)\Big)$$
$$+ 4 Z_{i3}^{H} Z_{j3}^{H}\Big(\lambda \kappa^{*} Z_{k1}^{+} Z_{l2}^{+} + \lambda^{*}\Big(\lambda Z_{k1}^{+} Z_{l1}^{+} + Z_{k2}^{+}\Big(\kappa Z_{l1}^{+} + \lambda Z_{l2}^{+}\Big)\Big)\Big)\Big) \tag{356}$$

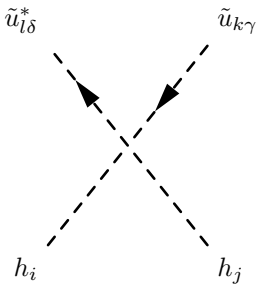


$$\frac{i}{12}\delta_{\gamma\delta}\Big(\Big(3g_2^2 + g_1^2\Big)\sum_{a=1}^{3} Z_{ka}^{D,*} Z_{la}^{D}\Big(Z_{i1}^{H} Z_{j1}^{H} - Z_{i2}^{H} Z_{j2}^{H}\Big)$$
$$+ 2\Big(g_1^2 \sum_{a=1}^{3} Z_{k3+a}^{D,*} Z_{l3+a}^{D}\Big(Z_{i1}^{H} Z_{j1}^{H} - Z_{i2}^{H} Z_{j2}^{H}\Big)$$
$$+ 3\Big(- 2\sum_{c=1}^{3} Z_{k3+c}^{D,*} \sum_{b=1}^{3}\sum_{a=1}^{3} Y_{d,ca}^{*} Y_{d,ba} Z_{l3+b}^{D} Z_{i1}^{H} Z_{j1}^{H}$$
$$- 2\sum_{c=1}^{3}\sum_{b=1}^{3} Z_{kb}^{D,*} \sum_{a=1}^{3} Y_{d,ac}^{*} Y_{d,ab} Z_{lc}^{D} Z_{i1}^{H} Z_{j1}^{H}$$
$$+ \Big(\lambda \sum_{b=1}^{3}\sum_{a=1}^{3} Y_{d,ab}^{*} Z_{k3+a}^{D,*} Z_{lb}^{D} + \lambda^{*} \sum_{b=1}^{3} Z_{kb}^{D,*} \sum_{a=1}^{3} Y_{d,ab} Z_{l3+a}^{D}\Big)\Big(Z_{i2}^{H} Z_{j3}^{H} + Z_{i3}^{H} Z_{j2}^{H}\Big)\Big)\Big)\Big) \tag{357}$$

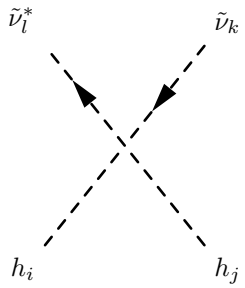


$$- \frac{i}{4}\Big(\Big(- g_2^2 + g_1^2\Big)\sum_{a=1}^{3} Z_{ka}^{E,*} Z_{la}^{E}\Big(Z_{i1}^{H} Z_{j1}^{H} - Z_{i2}^{H} Z_{j2}^{H}\Big)$$

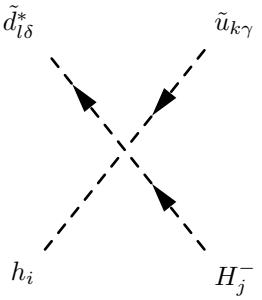
$$
\begin{aligned}
&- 2\Big(- 2\sum_{c=1}^{3} Z^{E,*}_{k3+c} \sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{e,ca} Y_{e,ba} Z^{E}_{l3+b} Z^{H}_{i1} Z^{H}_{j1} \\
&- 2\sum_{c=1}^{3}\sum_{b=1}^{3} Z^{E,*}_{kb} \sum_{a=1}^{3} Y^{*}_{e,ac} Y_{e,ab} Z^{E}_{lc} Z^{H}_{i1} Z^{H}_{j1} + \lambda^{*} \sum_{b=1}^{3} Z^{E,*}_{kb} \sum_{a=1}^{3} Y_{e,ab} Z^{E}_{l3+a} Z^{H}_{i3} Z^{H}_{j2} \\
&+ \lambda \sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{e,ab} Z^{E,*}_{k3+a} Z^{E}_{lb} Z^{H}_{i3} Z^{H}_{j2} + g_1^2 \sum_{a=1}^{3} Z^{E,*}_{k3+a} Z^{E}_{l3+a} \Big(Z^{H}_{i1} Z^{H}_{j1} - Z^{H}_{i2} Z^{H}_{j2} \Big) \\
&+ \lambda^{*} \sum_{b=1}^{3} Z^{E,*}_{kb} \sum_{a=1}^{3} Y_{e,ab} Z^{E}_{l3+a} Z^{H}_{i2} Z^{H}_{j3} + \lambda \sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{e,ab} Z^{E,*}_{k3+a} Z^{E}_{lb} Z^{H}_{i2} Z^{H}_{j3} \Big) \Big)
\end{aligned}
\tag{358}
$$



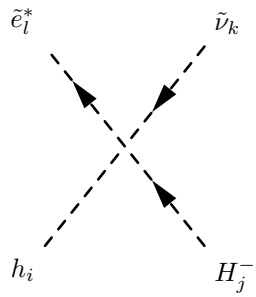
$$
\begin{aligned}
&\frac{i}{12}\delta_{\gamma\delta} \Big(\Big(- 3g_2^2 + g_1^2 \Big) \sum_{a=1}^{3} Z^{U,*}_{ka} Z^{U}_{la} \Big(Z^{H}_{i1} Z^{H}_{j1} - Z^{H}_{i2} Z^{H}_{j2} \Big) \\
&+ 4g_1^2 \sum_{a=1}^{3} Z^{U,*}_{k3+a} Z^{U}_{l3+a} \Big(- Z^{H}_{i1} Z^{H}_{j1} + Z^{H}_{i2} Z^{H}_{j2} \Big) \\
&+ 6\Big(- 2\Big(\sum_{c=1}^{3} Z^{U,*}_{k3+c} \sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{u,ca} Y_{u,ba} Z^{U}_{l3+b} + \sum_{c=1}^{3}\sum_{b=1}^{3} Z^{U,*}_{kb} \sum_{a=1}^{3} Y^{*}_{u,ac} Y_{u,ab} Z^{U}_{lc} \Big) Z^{H}_{i2} Z^{H}_{j2} \\
&+ \lambda^{*} \sum_{b=1}^{3} Z^{U,*}_{kb} \sum_{a=1}^{3} Y_{u,ab} Z^{U}_{l3+a} \Big(Z^{H}_{i1} Z^{H}_{j3} + Z^{H}_{i3} Z^{H}_{j1} \Big) \\
&+ \lambda \sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{u,ab} Z^{U,*}_{k3+a} Z^{U}_{lb} \Big(Z^{H}_{i1} Z^{H}_{j3} + Z^{H}_{i3} Z^{H}_{j1} \Big) \Big) \Big)
\end{aligned}
\tag{359}
$$



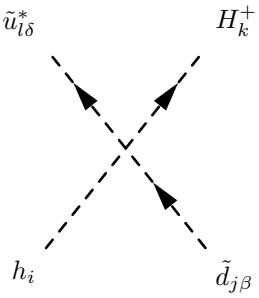
$$-\frac{i}{4}\Big(g_1^2+g_2^2\Big)\delta_{kl}\Big(Z_{i1}^H Z_{j1}^H - Z_{i2}^H Z_{j2}^H\Big) \tag{360}$$



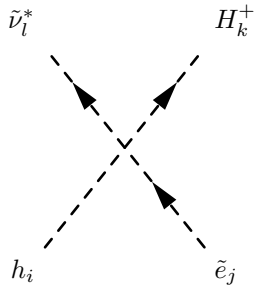
$$\begin{aligned}
&-\frac{i}{2}\frac{1}{\sqrt{2}}\delta_{\gamma\delta}\Big(g_2^2\sum_{a=1}^{3} Z_{ka}^{U,*} Z_{la}^D\Big(Z_{i1}^H Z_{j1}^+ + Z_{i2}^H Z_{j2}^+\Big)\\
&-2\Big(\sum_{c=1}^{3}\sum_{b=1}^{3} Z_{kb}^{U,*}\sum_{a=1}^{3} Y_{d,ac}^* Y_{d,ab} Z_{lc}^D Z_{i1}^H Z_{j1}^+ + \lambda\sum_{b=1}^{3}\sum_{a=1}^{3} Y_{u,ab}^* Z_{k3+a}^{U,*} Z_{lb}^D Z_{i3}^H Z_{j1}^+\\
&+\sum_{c=1}^{3}\sum_{b=1}^{3} Z_{kb}^{U,*}\sum_{a=1}^{3} Y_{u,ac}^* Y_{u,ab} Z_{lc}^D Z_{i2}^H Z_{j2}^+ + \lambda^*\sum_{b=1}^{3} Z_{kb}^{U,*}\sum_{a=1}^{3} Y_{d,ab} Z_{l3+a}^D Z_{i3}^H Z_{j2}^+\\
&+\sum_{c=1}^{3} Z_{k3+c}^{U,*}\sum_{b=1}^{3}\sum_{a=1}^{3} Y_{u,ca}^* Y_{d,ba} Z_{l3+b}^D\Big(Z_{i1}^H Z_{j2}^+ + Z_{i2}^H Z_{j1}^+\Big)\Big)\Big)
\end{aligned} \tag{361}$$



$$
\begin{aligned}
&-\frac{i}{2}\frac{1}{\sqrt{2}}\Big(g_2^2\sum_{a=1}^{3}Z_{ka}^{V,*}Z_{la}^{E}\Big(Z_{i1}^{H}Z_{j1}^{+}+Z_{i2}^{H}Z_{j2}^{+}\Big)\\
&-2\Big(\lambda^{*}\sum_{b=1}^{3}Z_{kb}^{V,*}\sum_{a=1}^{3}Y_{e,ab}Z_{l3+a}^{E}Z_{i3}^{H}Z_{j2}^{+}+\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{kb}^{V,*}\sum_{a=1}^{3}Y_{e,ac}^{*}Y_{e,ab}Z_{lc}^{E}Z_{i1}^{H}Z_{j1}^{+}\Big)\Big)
\end{aligned}
\tag{362}
$$

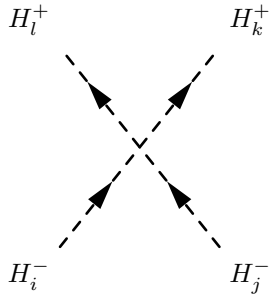


$$
\begin{aligned}
&-\frac{i}{2}\frac{1}{\sqrt{2}}\delta_{\beta\delta}\Big(g_2^2\sum_{a=1}^{3}Z_{ja}^{D,*}Z_{la}^{U}\Big(Z_{i1}^{H}Z_{k1}^{+}+Z_{i2}^{H}Z_{k2}^{+}\Big)\\
&-2\Big(\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{jb}^{D,*}\sum_{a=1}^{3}Y_{d,ac}^{*}Y_{d,ab}Z_{lc}^{U}Z_{i1}^{H}Z_{k1}^{+}+\lambda^{*}\sum_{b=1}^{3}Z_{jb}^{D,*}\sum_{a=1}^{3}Y_{u,ab}Z_{l3+a}^{U}Z_{i3}^{H}Z_{k1}^{+}\\
&+\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{jb}^{D,*}\sum_{a=1}^{3}Y_{u,ac}^{*}Y_{u,ab}Z_{lc}^{U}Z_{i2}^{H}Z_{k2}^{+}+\lambda\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{d,ab}^{*}Z_{j3+a}^{D,*}Z_{lb}^{U}Z_{i3}^{H}Z_{k2}^{+}\\
&+\sum_{c=1}^{3}Z_{j3+c}^{D,*}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{d,ca}^{*}Y_{u,ba}Z_{l3+b}^{U}\Big(Z_{i1}^{H}Z_{k2}^{+}+Z_{i2}^{H}Z_{k1}^{+}\Big)\Big)\Big)
\end{aligned}
\tag{363}
$$

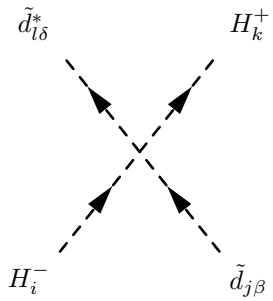


$$
-\frac{i}{2}\frac{1}{\sqrt{2}}\Big(g_2^2\sum_{a=1}^{3}Z_{ja}^{E,*}Z_{la}^{V}\Big(Z_{i1}^{H}Z_{k1}^{+}+Z_{i2}^{H}Z_{k2}^{+}\Big)
$$

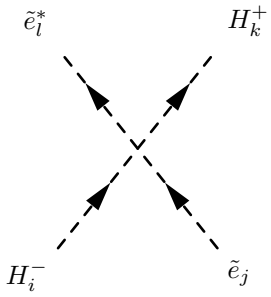
$$- 2\Big(\lambda \sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{e,ab} Z^{E,*}_{j3+a} Z^{V}_{lb} Z^{H}_{i3} Z^{+}_{k2} + \sum_{c=1}^{3}\sum_{b=1}^{3} Z^{E,*}_{jb} \sum_{a=1}^{3} Y^{*}_{e,ac} Y_{e,ab} Z^{V}_{lc} Z^{H}_{i1} Z^{+}_{k1}\Big)\Big) \tag{364}$$



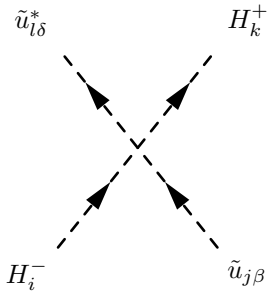
$$\begin{aligned}
&- \frac{i}{4}\Big(- Z^{+}_{i2}\Big(- 2\Big(g_1^2 + g_2^2\Big) Z^{+}_{j2} Z^{+}_{k2} Z^{+}_{l2} + \Big(- 4|\lambda|^2 + g_1^2 + g_2^2\Big) Z^{+}_{j1}\Big(Z^{+}_{k1} Z^{+}_{l2} + Z^{+}_{k2} Z^{+}_{l1}\Big)\Big) \\
&+ Z^{+}_{i1}\Big(2\Big(g_1^2 + g_2^2\Big) Z^{+}_{j1} Z^{+}_{k1} Z^{+}_{l1} - \Big(- 4|\lambda|^2 + g_1^2 + g_2^2\Big) Z^{+}_{j2}\Big(Z^{+}_{k1} Z^{+}_{l2} + Z^{+}_{k2} Z^{+}_{l1}\Big)\Big)\Big)
\end{aligned} \tag{365}$$



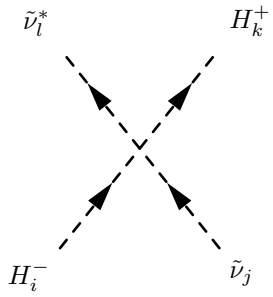
$$\begin{aligned}
&\frac{i}{12}\delta_{\beta\delta}\Big(\Big(- 3g_2^2 + g_1^2\Big) \sum_{a=1}^{3} Z^{D,*}_{ja} Z^{D}_{la}\Big(Z^{+}_{i1} Z^{+}_{k1} - Z^{+}_{i2} Z^{+}_{k2}\Big) \\
&+ 2\Big(g_1^2 \sum_{a=1}^{3} Z^{D,*}_{j3+a} Z^{D}_{l3+a}\Big(Z^{+}_{i1} Z^{+}_{k1} - Z^{+}_{i2} Z^{+}_{k2}\Big) \\
&- 6\Big(\sum_{c=1}^{3}\sum_{b=1}^{3} Z^{D,*}_{jb} \sum_{a=1}^{3} Y^{*}_{u,ac} Y_{u,ab} Z^{D}_{lc} Z^{+}_{i2} Z^{+}_{k2} + \sum_{c=1}^{3} Z^{D,*}_{j3+c} \sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{d,ca} Y_{d,ba} Z^{D}_{l3+b} Z^{+}_{i1} Z^{+}_{k1}\Big)\Big)\Big)
\end{aligned} \tag{366}$$



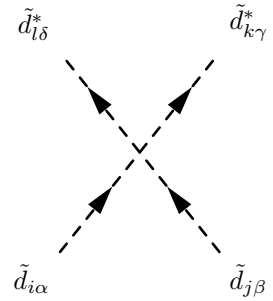
$$
\begin{aligned}
&-\frac{i}{4}\Big(4\sum_{c=1}^{3} Z^{E,*}_{j3+c}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{e,ca}Y_{e,ba}Z^{E}_{l3+b}Z^{+}_{i1}Z^{+}_{k1}\\
&+\Big(g_1^2+g_2^2\Big)\sum_{a=1}^{3} Z^{E,*}_{ja}Z^{E}_{la}\Big(Z^{+}_{i1}Z^{+}_{k1}-Z^{+}_{i2}Z^{+}_{k2}\Big)\\
&+2g_1^2\sum_{a=1}^{3} Z^{E,*}_{j3+a}Z^{E}_{l3+a}\Big(-Z^{+}_{i1}Z^{+}_{k1}+Z^{+}_{i2}Z^{+}_{k2}\Big)\Big)
\end{aligned}
\tag{367}
$$



$$
\begin{aligned}
&\frac{i}{12}\delta_{\beta\delta}\Big(\Big(3g_2^2+g_1^2\Big)\sum_{a=1}^{3} Z^{U,*}_{ja}Z^{U}_{la}\Big(Z^{+}_{i1}Z^{+}_{k1}-Z^{+}_{i2}Z^{+}_{k2}\Big)\\
&-4\Big(g_1^2\sum_{a=1}^{3} Z^{U,*}_{j3+a}Z^{U}_{l3+a}\Big(Z^{+}_{i1}Z^{+}_{k1}-Z^{+}_{i2}Z^{+}_{k2}\Big)\\
&+3\Big(\sum_{c=1}^{3}\sum_{b=1}^{3} Z^{U,*}_{jb}\sum_{a=1}^{3} Y^{*}_{d,ac}Y_{d,ab}Z^{U}_{lc}Z^{+}_{i1}Z^{+}_{k1}+\sum_{c=1}^{3} Z^{U,*}_{j3+c}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{u,ca}Y_{u,ba}Z^{U}_{l3+b}Z^{+}_{i2}Z^{+}_{k2}\Big)\Big)\Big)
\end{aligned}
\tag{368}
$$



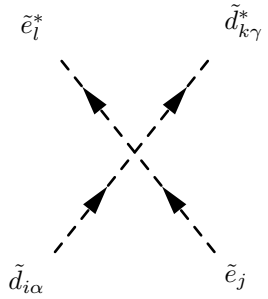
$$-\frac{i}{4}\Big(4\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{jb}^{V,*}\sum_{a=1}^{3}Y_{e,ac}^{*}Y_{e,ab}Z_{lc}^{V}Z_{i1}^{+}Z_{k1}^{+}+\Big(-g_2^2+g_1^2\Big)\delta_{jl}\Big(Z_{i1}^{+}Z_{k1}^{+}-Z_{i2}^{+}Z_{k2}^{+}\Big)\Big) \tag{369}$$



$$\begin{aligned}
&-\frac{i}{72}\Big(\delta_{\alpha\delta}\delta_{\beta\gamma}\Big(g_1^2\sum_{a=1}^{3}Z_{ia}^{D,*}Z_{la}^{D}\sum_{b=1}^{3}Z_{jb}^{D,*}Z_{kb}^{D}+9g_2^2\sum_{a=1}^{3}Z_{ia}^{D,*}Z_{la}^{D}\sum_{b=1}^{3}Z_{jb}^{D,*}Z_{kb}^{D}\\
&-6g_3^2\sum_{a=1}^{3}Z_{ia}^{D,*}Z_{la}^{D}\sum_{b=1}^{3}Z_{jb}^{D,*}Z_{kb}^{D}+2g_1^2\sum_{a=1}^{3}Z_{i3+a}^{D,*}Z_{l3+a}^{D}\sum_{b=1}^{3}Z_{jb}^{D,*}Z_{kb}^{D}\\
&+6g_3^2\sum_{a=1}^{3}Z_{i3+a}^{D,*}Z_{l3+a}^{D}\sum_{b=1}^{3}Z_{jb}^{D,*}Z_{kb}^{D}\\
&+18g_3^2\sum_{a=1}^{3}Z_{ja}^{D,*}Z_{la}^{D}\Big(-\sum_{b=1}^{3}Z_{i3+b}^{D,*}Z_{k3+b}^{D}+\sum_{b=1}^{3}Z_{ib}^{D,*}Z_{kb}^{D}\Big)\\
&-18g_3^2\sum_{a=1}^{3}Z_{j3+a}^{D,*}Z_{l3+a}^{D}\Big(-\sum_{b=1}^{3}Z_{i3+b}^{D,*}Z_{k3+b}^{D}+\sum_{b=1}^{3}Z_{ib}^{D,*}Z_{kb}^{D}\Big)\\
&+2g_1^2\sum_{a=1}^{3}Z_{ia}^{D,*}Z_{la}^{D}\sum_{b=1}^{3}Z_{j3+b}^{D,*}Z_{k3+b}^{D}+6g_3^2\sum_{a=1}^{3}Z_{ia}^{D,*}Z_{la}^{D}\sum_{b=1}^{3}Z_{j3+b}^{D,*}Z_{k3+b}^{D}\\
&+4g_1^2\sum_{a=1}^{3}Z_{i3+a}^{D,*}Z_{l3+a}^{D}\sum_{b=1}^{3}Z_{j3+b}^{D,*}Z_{k3+b}^{D}-6g_3^2\sum_{a=1}^{3}Z_{i3+a}^{D,*}Z_{l3+a}^{D}\sum_{b=1}^{3}Z_{j3+b}^{D,*}Z_{k3+b}^{D}
\end{aligned}$$

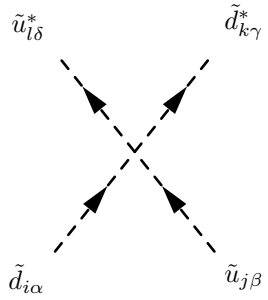
$$
\begin{aligned}
&+ g_1^2 \sum_{a=1}^{3} Z_{ja}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{lb}^{D} + 9g_2^2 \sum_{a=1}^{3} Z_{ja}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{lb}^{D} \\
&- 6g_3^2 \sum_{a=1}^{3} Z_{ja}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{lb}^{D} + 2g_1^2 \sum_{a=1}^{3} Z_{j3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{lb}^{D} \\
&+ 6g_3^2 \sum_{a=1}^{3} Z_{j3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{lb}^{D} + 18g_3^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{jb}^{D,*} Z_{lb}^{D} \\
&- 18g_3^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{jb}^{D,*} Z_{lb}^{D} + 2g_1^2 \sum_{a=1}^{3} Z_{ja}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{l3+b}^{D} \\
&+ 6g_3^2 \sum_{a=1}^{3} Z_{ja}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{l3+b}^{D} + 4g_1^2 \sum_{a=1}^{3} Z_{j3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{l3+b}^{D} \\
&- 6g_3^2 \sum_{a=1}^{3} Z_{j3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{l3+b}^{D} - 18g_3^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{l3+b}^{D} \\
&+ 18g_3^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{l3+b}^{D} \\
&+ 72 \sum_{b=1}^{3} Z_{ib}^{D,*} \sum_{a=1}^{3} Y_{d,ab} Z_{l3+a}^{D} \sum_{d=1}^{3} \sum_{c=1}^{3} Y_{d,cd}^{*} Z_{j3+c}^{D,*} Z_{kd}^{D} \\
&+ 72 \sum_{b=1}^{3} Z_{jb}^{D,*} \sum_{a=1}^{3} Y_{d,ab} Z_{k3+a}^{D} \sum_{d=1}^{3} \sum_{c=1}^{3} Y_{d,cd}^{*} Z_{i3+c}^{D,*} Z_{ld}^{D} \Big) \\
&+ \delta_{\alpha\gamma}\delta_{\beta\delta} \Big(18g_3^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{la}^{D} \sum_{b=1}^{3} Z_{jb}^{D,*} Z_{kb}^{D} - 18g_3^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{l3+a}^{D} \sum_{b=1}^{3} Z_{jb}^{D,*} Z_{kb}^{D} \\
&+ 2 \sum_{a=1}^{3} Z_{j3+a}^{D,*} Z_{l3+a}^{D} \Big(\Big(2g_1^2 - 3g_3^2 \Big) \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{k3+b}^{D} + \Big(3g_3^2 + g_1^2 \Big) \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{kb}^{D} \Big) \\
&+ \sum_{a=1}^{3} Z_{ja}^{D,*} Z_{la}^{D} \Big(2 \Big(3g_3^2 + g_1^2 \Big) \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{k3+b}^{D} + \Big(-6g_3^2 + 9g_2^2 + g_1^2 \Big) \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{kb}^{D} \Big) \\
&- 18g_3^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{la}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{k3+b}^{D} + 18g_3^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{l3+a}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{k3+b}^{D} \\
&+ 18g_3^2 \sum_{a=1}^{3} Z_{ja}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{lb}^{D} - 18g_3^2 \sum_{a=1}^{3} Z_{j3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{lb}^{D} \\
&+ g_1^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{jb}^{D,*} Z_{lb}^{D} + 9g_2^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{jb}^{D,*} Z_{lb}^{D}
\end{aligned}
$$

$$
\begin{aligned}
&- 6g_3^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{jb}^{D,*} Z_{lb}^{D} + 2g_1^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{jb}^{D,*} Z_{lb}^{D} \\
&+ 6g_3^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{jb}^{D,*} Z_{lb}^{D} - 18g_3^2 \sum_{a=1}^{3} Z_{ja}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{l3+b}^{D} \\
&+ 18g_3^2 \sum_{a=1}^{3} Z_{j3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{l3+b}^{D} + 2g_1^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{l3+b}^{D} \\
&+ 6g_3^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{l3+b}^{D} + 4g_1^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{l3+b}^{D} \\
&- 6g_3^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{l3+b}^{D} \\
&+ 72 \sum_{b=1}^{3} Z_{jb}^{D,*} \sum_{a=1}^{3} Y_{d,ab} Z_{l3+a}^{D} \sum_{d=1}^{3} \sum_{c=1}^{3} Y_{d,cd}^{*} Z_{i3+c}^{D,*} Z_{kd}^{D} \\
&+ 72 \sum_{b=1}^{3} Z_{ib}^{D,*} \sum_{a=1}^{3} Y_{d,ab} Z_{k3+a}^{D} \sum_{d=1}^{3} \sum_{c=1}^{3} Y_{d,cd}^{*} Z_{j3+c}^{D,*} Z_{ld}^{D} \Big) \Big)
\end{aligned}
\tag{370}
$$



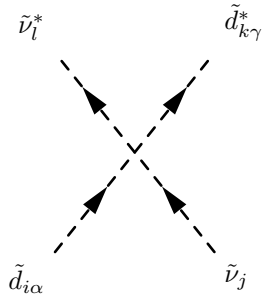
$$
\begin{aligned}
&\frac{i}{24}\delta_{\alpha\gamma}\Big(- 2g_1^2 \sum_{a=1}^{3} Z_{j3+a}^{E,*} Z_{l3+a}^{E} \Big(2 \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{k3+b}^{D} + \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{kb}^{D} \Big) \\
&+ \sum_{a=1}^{3} Z_{ja}^{E,*} Z_{la}^{E} \Big(2g_1^2 \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{k3+b}^{D} + \Big(- 3g_2^2 + g_1^2 \Big) \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{kb}^{D} \Big) \\
&+ g_1^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{jb}^{E,*} Z_{lb}^{E} - 3g_2^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{jb}^{E,*} Z_{lb}^{E} \\
&+ 2g_1^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{jb}^{E,*} Z_{lb}^{E} - 2g_1^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{j3+b}^{E,*} Z_{l3+b}^{E} \\
&- 4g_1^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{j3+b}^{E,*} Z_{l3+b}^{E}
\end{aligned}
$$

$$- 24\sum_{b=1}^{3} Z_{jb}^{E,*}\sum_{a=1}^{3} Y_{e,ab} Z_{l3+a}^{E}\sum_{d=1}^{3}\sum_{c=1}^{3} Y_{d,cd}^{*} Z_{i3+c}^{D,*} Z_{kd}^{D}$$
$$- 24\sum_{b=1}^{3} Z_{ib}^{D,*}\sum_{a=1}^{3} Y_{d,ab} Z_{k3+a}^{D}\sum_{d=1}^{3}\sum_{c=1}^{3} Y_{e,cd}^{*} Z_{j3+c}^{E,*} Z_{ld}^{E}\Big) \tag{371}$$

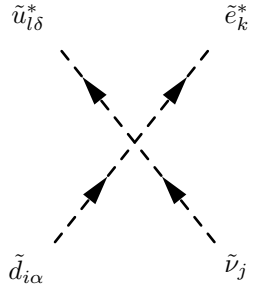


$$- \frac{i}{72}\Big(\delta_{\alpha\gamma}\delta_{\beta\delta}\Big(\sum_{a=1}^{3} Z_{ja}^{U,*} Z_{la}^{U}\Big(2\Big(3g_3^2+g_1^2\Big)\sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{k3+b}^{D} + \Big(-6g_3^2-9g_2^2+g_1^2\Big)\sum_{b=1}^{3} Z_{ib}^{D,*} Z_{kb}^{D}\Big)$$
$$- 2\sum_{a=1}^{3} Z_{j3+a}^{U,*} Z_{l3+a}^{U}\Big(\Big(2g_1^2-3g_3^2\Big)\sum_{b=1}^{3} Z_{ib}^{D,*} Z_{kb}^{D} + \Big(3g_3^2+4g_1^2\Big)\sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{k3+b}^{D}\Big)$$
$$+ g_1^2\sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D}\sum_{b=1}^{3} Z_{jb}^{U,*} Z_{lb}^{U} - 9g_2^2\sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D}\sum_{b=1}^{3} Z_{jb}^{U,*} Z_{lb}^{U}$$
$$- 6g_3^2\sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D}\sum_{b=1}^{3} Z_{jb}^{U,*} Z_{lb}^{U} + 2g_1^2\sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D}\sum_{b=1}^{3} Z_{jb}^{U,*} Z_{lb}^{U}$$
$$+ 6g_3^2\sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D}\sum_{b=1}^{3} Z_{jb}^{U,*} Z_{lb}^{U} - 4g_1^2\sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D}\sum_{b=1}^{3} Z_{j3+b}^{U,*} Z_{l3+b}^{U}$$
$$+ 6g_3^2\sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D}\sum_{b=1}^{3} Z_{j3+b}^{U,*} Z_{l3+b}^{U} - 8g_1^2\sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D}\sum_{b=1}^{3} Z_{j3+b}^{U,*} Z_{l3+b}^{U}$$
$$- 6g_3^2\sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D}\sum_{b=1}^{3} Z_{j3+b}^{U,*} Z_{l3+b}^{U}\Big)$$
$$+ 18\delta_{\alpha\delta}\delta_{\beta\gamma}\Big(g_2^2\sum_{a=1}^{3} Z_{ia}^{D,*} Z_{la}^{U}\sum_{b=1}^{3} Z_{jb}^{U,*} Z_{kb}^{D} + g_3^2\sum_{a=1}^{3} Z_{ja}^{U,*} Z_{la}^{U}\Big(-\sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{k3+b}^{D} + \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{kb}^{D}\Big)$$
$$+ g_3^2\sum_{a=1}^{3} Z_{j3+a}^{U,*} Z_{l3+a}^{U}\Big(-\sum_{b=1}^{3} Z_{ib}^{D,*} Z_{kb}^{D} + \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{k3+b}^{D}\Big)$$
$$+ g_2^2\sum_{a=1}^{3} Z_{ja}^{U,*} Z_{ka}^{D}\sum_{b=1}^{3} Z_{ib}^{D,*} Z_{lb}^{U} + g_3^2\sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D}\sum_{b=1}^{3} Z_{jb}^{U,*} Z_{lb}^{U}$$

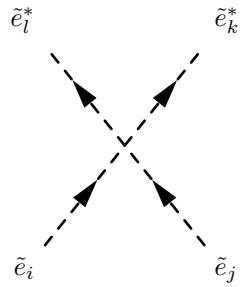
$$
\begin{aligned}
&- g_3^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{jb}^{U,*} Z_{lb}^{U} - g_3^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{j3+b}^{U,*} Z_{l3+b}^{U} \\
&+ g_3^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{j3+b}^{U,*} Z_{l3+b}^{U} + 4 \sum_{b=1}^{3} Z_{ib}^{D,*} \sum_{a=1}^{3} Y_{u,ab} Z_{l3+a}^{U} \sum_{d=1}^{3} \sum_{c=1}^{3} Y_{u,cd}^{*} Z_{j3+c}^{U,*} Z_{kd}^{D} \\
&+ 4 \sum_{b=1}^{3} Z_{jb}^{U,*} \sum_{a=1}^{3} Y_{d,ab} Z_{k3+a}^{D} \sum_{d=1}^{3} \sum_{c=1}^{3} Y_{d,cd}^{*} Z_{i3+c}^{D,*} Z_{ld}^{U} \Big) \Big)
\end{aligned} \tag{372}
$$



$$
\frac{i}{12} \delta_{\alpha\gamma} \delta_{jl} \Big(2 g_1^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D} + \Big(3 g_2^2 + g_1^2 \Big) \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \Big) \tag{373}
$$

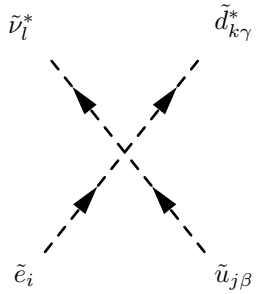


$$
\begin{aligned}
&- \frac{i}{4} \delta_{\alpha\delta} \Big(g_2^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{la}^{U} \sum_{b=1}^{3} Z_{jb}^{V,*} Z_{kb}^{E} + g_2^2 \sum_{a=1}^{3} Z_{ja}^{V,*} Z_{ka}^{E} \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{lb}^{U} \\
&+ 4 \sum_{b=1}^{3} Z_{jb}^{V,*} \sum_{a=1}^{3} Y_{e,ab} Z_{k3+a}^{E} \sum_{d=1}^{3} \sum_{c=1}^{3} Y_{d,cd}^{*} Z_{i3+c}^{D,*} Z_{ld}^{U} \Big)
\end{aligned} \tag{374}
$$

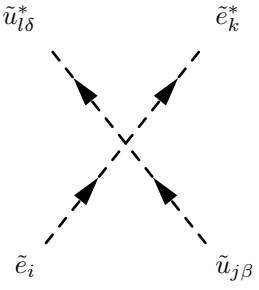


$$
\begin{aligned}
&-\frac{i}{8}\Big(g_1^2\sum_{a=1}^{3}Z_{ia}^{E,*}Z_{la}^{E}\sum_{b=1}^{3}Z_{jb}^{E,*}Z_{kb}^{E}+g_2^2\sum_{a=1}^{3}Z_{ia}^{E,*}Z_{la}^{E}\sum_{b=1}^{3}Z_{jb}^{E,*}Z_{kb}^{E}\\
&-2g_1^2\sum_{a=1}^{3}Z_{i3+a}^{E,*}Z_{l3+a}^{E}\sum_{b=1}^{3}Z_{jb}^{E,*}Z_{kb}^{E}\\
&-2g_1^2\sum_{a=1}^{3}Z_{j3+a}^{E,*}Z_{l3+a}^{E}\Big(-2\sum_{b=1}^{3}Z_{i3+b}^{E,*}Z_{k3+b}^{E}+\sum_{b=1}^{3}Z_{ib}^{E,*}Z_{kb}^{E}\Big)\\
&+\sum_{a=1}^{3}Z_{ja}^{E,*}Z_{la}^{E}\Big(-2g_1^2\sum_{b=1}^{3}Z_{i3+b}^{E,*}Z_{k3+b}^{E}+\Big(g_1^2+g_2^2\Big)\sum_{b=1}^{3}Z_{ib}^{E,*}Z_{kb}^{E}\Big)\\
&-2g_1^2\sum_{a=1}^{3}Z_{ia}^{E,*}Z_{la}^{E}\sum_{b=1}^{3}Z_{j3+b}^{E,*}Z_{k3+b}^{E}+4g_1^2\sum_{a=1}^{3}Z_{i3+a}^{E,*}Z_{l3+a}^{E}\sum_{b=1}^{3}Z_{j3+b}^{E,*}Z_{k3+b}^{E}\\
&+g_1^2\sum_{a=1}^{3}Z_{ja}^{E,*}Z_{ka}^{E}\sum_{b=1}^{3}Z_{ib}^{E,*}Z_{lb}^{E}+g_2^2\sum_{a=1}^{3}Z_{ja}^{E,*}Z_{ka}^{E}\sum_{b=1}^{3}Z_{ib}^{E,*}Z_{lb}^{E}\\
&-2g_1^2\sum_{a=1}^{3}Z_{j3+a}^{E,*}Z_{k3+a}^{E}\sum_{b=1}^{3}Z_{ib}^{E,*}Z_{lb}^{E}+g_1^2\sum_{a=1}^{3}Z_{ia}^{E,*}Z_{ka}^{E}\sum_{b=1}^{3}Z_{jb}^{E,*}Z_{lb}^{E}\\
&+g_2^2\sum_{a=1}^{3}Z_{ia}^{E,*}Z_{ka}^{E}\sum_{b=1}^{3}Z_{jb}^{E,*}Z_{lb}^{E}-2g_1^2\sum_{a=1}^{3}Z_{i3+a}^{E,*}Z_{k3+a}^{E}\sum_{b=1}^{3}Z_{jb}^{E,*}Z_{lb}^{E}\\
&-2g_1^2\sum_{a=1}^{3}Z_{ja}^{E,*}Z_{ka}^{E}\sum_{b=1}^{3}Z_{i3+b}^{E,*}Z_{l3+b}^{E}+4g_1^2\sum_{a=1}^{3}Z_{j3+a}^{E,*}Z_{k3+a}^{E}\sum_{b=1}^{3}Z_{i3+b}^{E,*}Z_{l3+b}^{E}\\
&-2g_1^2\sum_{a=1}^{3}Z_{ia}^{E,*}Z_{ka}^{E}\sum_{b=1}^{3}Z_{j3+b}^{E,*}Z_{l3+b}^{E}+4g_1^2\sum_{a=1}^{3}Z_{i3+a}^{E,*}Z_{k3+a}^{E}\sum_{b=1}^{3}Z_{j3+b}^{E,*}Z_{l3+b}^{E}\\
&+8\sum_{b=1}^{3}Z_{jb}^{E,*}\sum_{a=1}^{3}Y_{e,ab}Z_{l3+a}^{E}\sum_{d=1}^{3}\sum_{c=1}^{3}Y_{e,cd}^{*}Z_{i3+c}^{E,*}Z_{kd}^{E}\\
&+8\sum_{b=1}^{3}Z_{ib}^{E,*}\sum_{a=1}^{3}Y_{e,ab}Z_{l3+a}^{E}\sum_{d=1}^{3}\sum_{c=1}^{3}Y_{e,cd}^{*}Z_{j3+c}^{E,*}Z_{kd}^{E}
\end{aligned}
$$

$$+ 8\sum_{b=1}^{3} Z_{jb}^{E,*} \sum_{a=1}^{3} Y_{e,ab} Z_{k3+a}^{E} \sum_{d=1}^{3}\sum_{c=1}^{3} Y_{e,cd}^{*} Z_{i3+c}^{E,*} Z_{ld}^{E}$$
$$+ 8\sum_{b=1}^{3} Z_{ib}^{E,*} \sum_{a=1}^{3} Y_{e,ab} Z_{k3+a}^{E} \sum_{d=1}^{3}\sum_{c=1}^{3} Y_{e,cd}^{*} Z_{j3+c}^{E,*} Z_{ld}^{E}\Big) \tag{375}$$

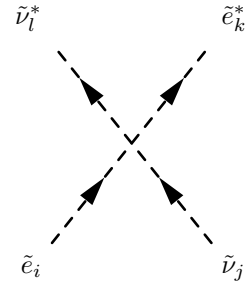


$$-\frac{i}{4}\delta_{\beta\gamma}\Big(g_2^2 \sum_{a=1}^{3} Z_{ia}^{E,*} Z_{la}^{V} \sum_{b=1}^{3} Z_{jb}^{U,*} Z_{kb}^{D} + g_2^2 \sum_{a=1}^{3} Z_{ja}^{U,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{ib}^{E,*} Z_{lb}^{V}$$
$$+ 4\sum_{b=1}^{3} Z_{jb}^{U,*} \sum_{a=1}^{3} Y_{d,ab} Z_{k3+a}^{D} \sum_{d=1}^{3}\sum_{c=1}^{3} Y_{e,cd}^{*} Z_{i3+c}^{E,*} Z_{ld}^{V}\Big) \tag{376}$$

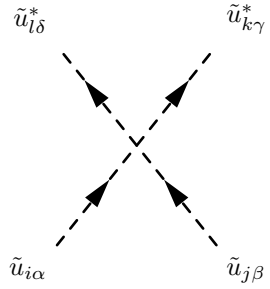


$$\frac{i}{24}\delta_{\beta\delta}\Big(-4g_1^2 \sum_{a=1}^{3} Z_{j3+a}^{U,*} Z_{l3+a}^{U}\Big(-2\sum_{b=1}^{3} Z_{i3+b}^{E,*} Z_{k3+b}^{E} + \sum_{b=1}^{3} Z_{ib}^{E,*} Z_{kb}^{E}\Big)$$
$$+ \sum_{a=1}^{3} Z_{ja}^{U,*} Z_{la}^{U}\Big(-2g_1^2 \sum_{b=1}^{3} Z_{i3+b}^{E,*} Z_{k3+b}^{E} + \Big(3g_2^2 + g_1^2\Big)\sum_{b=1}^{3} Z_{ib}^{E,*} Z_{kb}^{E}\Big)$$
$$+ g_1^2 \sum_{a=1}^{3} Z_{ia}^{E,*} Z_{ka}^{E} \sum_{b=1}^{3} Z_{jb}^{U,*} Z_{lb}^{U} + 3g_2^2 \sum_{a=1}^{3} Z_{ia}^{E,*} Z_{ka}^{E} \sum_{b=1}^{3} Z_{jb}^{U,*} Z_{lb}^{U}$$

$$
\begin{aligned}
&- 2g_1^2 \sum_{a=1}^{3} Z^{E,*}_{i3+a} Z^{E}_{k3+a} \sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb} - 4g_1^2 \sum_{a=1}^{3} Z^{E,*}_{ia} Z^{E}_{ka} \sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{l3+b} \\
&+ 8g_1^2 \sum_{a=1}^{3} Z^{E,*}_{i3+a} Z^{E}_{k3+a} \sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{l3+b} \Big) \qquad (377)
\end{aligned}
$$



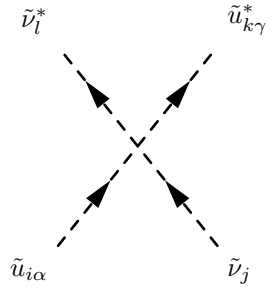
$$
\begin{aligned}
&- \frac{i}{4}\Big(\delta_{jl}\Big(- 2g_1^2 \sum_{a=1}^{3} Z^{E,*}_{i3+a} Z^{E}_{k3+a} + \Big(- g_2^2 + g_1^2\Big) \sum_{a=1}^{3} Z^{E,*}_{ia} Z^{E}_{ka}\Big) \\
&+ g_2^2 \sum_{a=1}^{3} Z^{E,*}_{ia} Z^{V}_{la} \sum_{b=1}^{3} Z^{V,*}_{jb} Z^{E}_{kb} + g_2^2 \sum_{a=1}^{3} Z^{V,*}_{ja} Z^{E}_{ka} \sum_{b=1}^{3} Z^{E,*}_{ib} Z^{V}_{lb} \\
&+ 4 \sum_{b=1}^{3} Z^{V,*}_{jb} \sum_{a=1}^{3} Y_{e,ab} Z^{E}_{k3+a} \sum_{d=1}^{3} \sum_{c=1}^{3} Y^{*}_{e,cd} Z^{E,*}_{i3+c} Z^{V}_{ld} \Big) \qquad (378)
\end{aligned}
$$



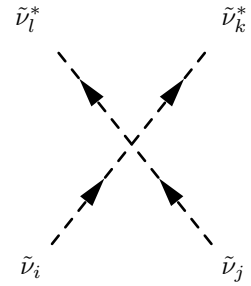
$$
\begin{aligned}
&- \frac{i}{72}\Big(\delta_{\alpha\delta}\delta_{\beta\gamma}\Big(g_1^2 \sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{la} \sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{kb} + 9g_2^2 \sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{la} \sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{kb} \\
&- 6g_3^2 \sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{la} \sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{kb} - 4g_1^2 \sum_{a=1}^{3} Z^{U,*}_{i3+a} Z^{U}_{l3+a} \sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{kb}
\end{aligned}
$$

$$
\begin{aligned}
&+ 6g_3^2 \sum_{a=1}^{3} Z^{U,*}_{i3+a} Z^{U}_{l3+a} \sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{kb} \\
&+ 18g_3^2 \sum_{a=1}^{3} Z^{U,*}_{ja} Z^{U}_{la} \Big(- \sum_{b=1}^{3} Z^{U,*}_{i3+b} Z^{U}_{k3+b} + \sum_{b=1}^{3} Z^{U,*}_{ib} Z^{U}_{kb} \Big) \\
&- 18g_3^2 \sum_{a=1}^{3} Z^{U,*}_{j3+a} Z^{U}_{l3+a} \Big(- \sum_{b=1}^{3} Z^{U,*}_{i3+b} Z^{U}_{k3+b} + \sum_{b=1}^{3} Z^{U,*}_{ib} Z^{U}_{kb} \Big) \\
&- 4g_1^2 \sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{la} \sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{k3+b} + 6g_3^2 \sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{la} \sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{k3+b} \\
&+ 16g_1^2 \sum_{a=1}^{3} Z^{U,*}_{i3+a} Z^{U}_{l3+a} \sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{k3+b} - 6g_3^2 \sum_{a=1}^{3} Z^{U,*}_{i3+a} Z^{U}_{l3+a} \sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{k3+b} \\
&+ g_1^2 \sum_{a=1}^{3} Z^{U,*}_{ja} Z^{U}_{ka} \sum_{b=1}^{3} Z^{U,*}_{ib} Z^{U}_{lb} + 9g_2^2 \sum_{a=1}^{3} Z^{U,*}_{ja} Z^{U}_{ka} \sum_{b=1}^{3} Z^{U,*}_{ib} Z^{U}_{lb} \\
&- 6g_3^2 \sum_{a=1}^{3} Z^{U,*}_{ja} Z^{U}_{ka} \sum_{b=1}^{3} Z^{U,*}_{ib} Z^{U}_{lb} - 4g_1^2 \sum_{a=1}^{3} Z^{U,*}_{j3+a} Z^{U}_{k3+a} \sum_{b=1}^{3} Z^{U,*}_{ib} Z^{U}_{lb} \\
&+ 6g_3^2 \sum_{a=1}^{3} Z^{U,*}_{j3+a} Z^{U}_{k3+a} \sum_{b=1}^{3} Z^{U,*}_{ib} Z^{U}_{lb} + 18g_3^2 \sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{ka} \sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb} \\
&- 18g_3^2 \sum_{a=1}^{3} Z^{U,*}_{i3+a} Z^{U}_{k3+a} \sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb} - 4g_1^2 \sum_{a=1}^{3} Z^{U,*}_{ja} Z^{U}_{ka} \sum_{b=1}^{3} Z^{U,*}_{i3+b} Z^{U}_{l3+b} \\
&+ 6g_3^2 \sum_{a=1}^{3} Z^{U,*}_{ja} Z^{U}_{ka} \sum_{b=1}^{3} Z^{U,*}_{i3+b} Z^{U}_{l3+b} + 16g_1^2 \sum_{a=1}^{3} Z^{U,*}_{j3+a} Z^{U}_{k3+a} \sum_{b=1}^{3} Z^{U,*}_{i3+b} Z^{U}_{l3+b} \\
&- 6g_3^2 \sum_{a=1}^{3} Z^{U,*}_{j3+a} Z^{U}_{k3+a} \sum_{b=1}^{3} Z^{U,*}_{i3+b} Z^{U}_{l3+b} - 18g_3^2 \sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{ka} \sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{l3+b} \\
&+ 18g_3^2 \sum_{a=1}^{3} Z^{U,*}_{i3+a} Z^{U}_{k3+a} \sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{l3+b} \\
&+ 72 \sum_{b=1}^{3} Z^{U,*}_{ib} \sum_{a=1}^{3} Y_{u,ab} Z^{U}_{l3+a} \sum_{d=1}^{3} \sum_{c=1}^{3} Y^{*}_{u,cd} Z^{U,*}_{j3+c} Z^{U}_{kd} \\
&+ 72 \sum_{b=1}^{3} Z^{U,*}_{jb} \sum_{a=1}^{3} Y_{u,ab} Z^{U}_{k3+a} \sum_{d=1}^{3} \sum_{c=1}^{3} Y^{*}_{u,cd} Z^{U,*}_{i3+c} Z^{U}_{ld} \Big) \\
&+ \delta_{\alpha\gamma}\delta_{\beta\delta} \Big(18g_3^2 \sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{la} \sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{kb} - 18g_3^2 \sum_{a=1}^{3} Z^{U,*}_{i3+a} Z^{U}_{l3+a} \sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{kb}
\end{aligned}
$$

$$
\begin{aligned}
&+\sum_{a=1}^{3} Z^{U,*}_{j3+a} Z^{U}_{l3+a}\Big(2\Big(-3g_3^2+8g_1^2\Big)\sum_{b=1}^{3} Z^{U,*}_{i3+b} Z^{U}_{k3+b}+\Big(-4g_1^2+6g_3^2\Big)\sum_{b=1}^{3} Z^{U,*}_{ib} Z^{U}_{kb}\Big)\\
&+\sum_{a=1}^{3} Z^{U,*}_{ja} Z^{U}_{la}\Big(2\Big(-2g_1^2+3g_3^2\Big)\sum_{b=1}^{3} Z^{U,*}_{i3+b} Z^{U}_{k3+b}+\Big(-6g_3^2+9g_2^2+g_1^2\Big)\sum_{b=1}^{3} Z^{U,*}_{ib} Z^{U}_{kb}\Big)\\
&-18g_3^2\sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{la}\sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{k3+b}+18g_3^2\sum_{a=1}^{3} Z^{U,*}_{i3+a} Z^{U}_{l3+a}\sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{k3+b}\\
&+18g_3^2\sum_{a=1}^{3} Z^{U,*}_{ja} Z^{U}_{ka}\sum_{b=1}^{3} Z^{U,*}_{ib} Z^{U}_{lb}-18g_3^2\sum_{a=1}^{3} Z^{U,*}_{j3+a} Z^{U}_{k3+a}\sum_{b=1}^{3} Z^{U,*}_{ib} Z^{U}_{lb}\\
&+g_1^2\sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{ka}\sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb}+9g_2^2\sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{ka}\sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb}\\
&-6g_3^2\sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{ka}\sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb}-4g_1^2\sum_{a=1}^{3} Z^{U,*}_{i3+a} Z^{U}_{k3+a}\sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb}\\
&+6g_3^2\sum_{a=1}^{3} Z^{U,*}_{i3+a} Z^{U}_{k3+a}\sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb}-18g_3^2\sum_{a=1}^{3} Z^{U,*}_{ja} Z^{U}_{ka}\sum_{b=1}^{3} Z^{U,*}_{i3+b} Z^{U}_{l3+b}\\
&+18g_3^2\sum_{a=1}^{3} Z^{U,*}_{j3+a} Z^{U}_{k3+a}\sum_{b=1}^{3} Z^{U,*}_{i3+b} Z^{U}_{l3+b}-4g_1^2\sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{ka}\sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{l3+b}\\
&+6g_3^2\sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{ka}\sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{l3+b}+16g_1^2\sum_{a=1}^{3} Z^{U,*}_{i3+a} Z^{U}_{k3+a}\sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{l3+b}\\
&-6g_3^2\sum_{a=1}^{3} Z^{U,*}_{i3+a} Z^{U}_{k3+a}\sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{l3+b}\\
&+72\sum_{b=1}^{3} Z^{U,*}_{jb}\sum_{a=1}^{3} Y_{u,ab} Z^{U}_{l3+a}\sum_{d=1}^{3}\sum_{c=1}^{3} Y^{*}_{u,cd} Z^{U,*}_{i3+c} Z^{U}_{kd}\\
&+72\sum_{b=1}^{3} Z^{U,*}_{ib}\sum_{a=1}^{3} Y_{u,ab} Z^{U}_{k3+a}\sum_{d=1}^{3}\sum_{c=1}^{3} Y^{*}_{u,cd} Z^{U,*}_{j3+c} Z^{U}_{ld}\Big)\Big)
\end{aligned}
\tag{379}
$$

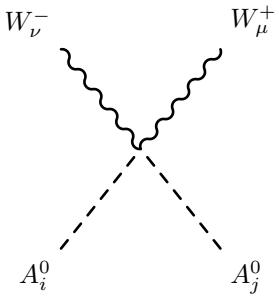


$$\frac{i}{12}\delta_{\alpha\gamma}\delta_{jl}\Big(\Big(-3g_2^2+g_1^2\Big)\sum_{a=1}^{3}Z_{ia}^{U,*}Z_{ka}^{U}-4g_1^2\sum_{a=1}^{3}Z_{i3+a}^{U,*}Z_{k3+a}^{U}\Big) \tag{380}$$

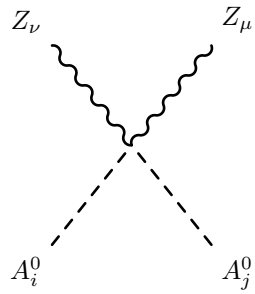


$$-\frac{i}{4}\Big(g_1^2+g_2^2\Big)\Big(\delta_{ik}\delta_{jl}+\delta_{il}\delta_{jk}\Big) \tag{381}$$

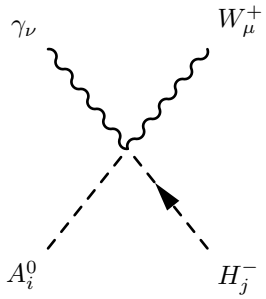
9.8 Two Scalar-Two Vector Boson-Interaction



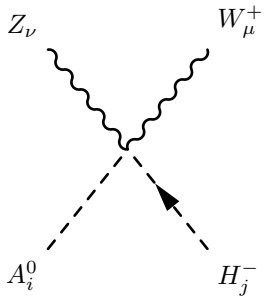
$$\frac{i}{2}g_2^2\Big(Z_{i1}^{A}Z_{j1}^{A}+Z_{i2}^{A}Z_{j2}^{A}\Big)\Big(g_{\mu\nu}\Big) \tag{382}$$



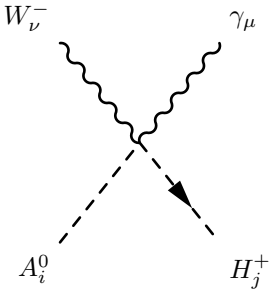
$$\frac{i}{2}\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W\Big)^2 \Big(Z^A_{i1} Z^A_{j1} + Z^A_{i2} Z^A_{j2}\Big)\Big(g_{\mu\nu}\Big) \tag{383}$$



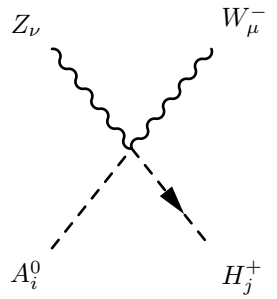
$$-\frac{1}{2} g_1 g_2 \cos\Theta_W \Big(Z^A_{i1} Z^+_{j1} + Z^A_{i2} Z^+_{j2}\Big)\Big(g_{\mu\nu}\Big) \tag{384}$$



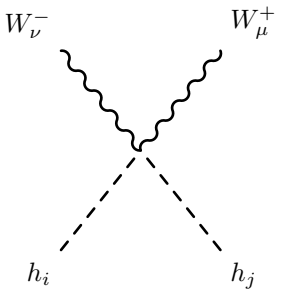
$$\frac{1}{2} g_1 g_2 \sin\Theta_W \Big(Z^A_{i1} Z^+_{j1} + Z^A_{i2} Z^+_{j2}\Big)\Big(g_{\mu\nu}\Big) \tag{385}$$



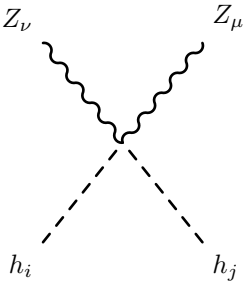
$$\frac{1}{2} g_1 g_2 \cos\Theta_W \Big(Z^A_{i1} Z^+_{j1} + Z^A_{i2} Z^+_{j2}\Big)\Big(g_{\mu\nu}\Big) \tag{386}$$



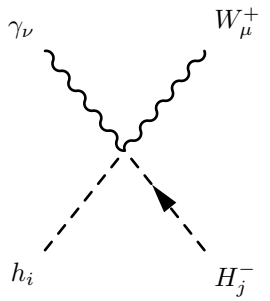
$$-\frac{1}{2}g_1 g_2 \sin\Theta_W \Big(Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big) \tag{387}$$



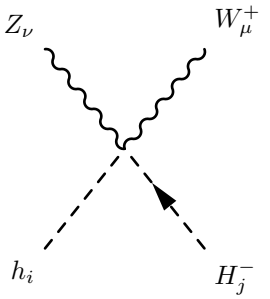
$$\frac{i}{2}g_2^2\Big(Z_{i1}^H Z_{j1}^H + Z_{i2}^H Z_{j2}^H\Big)\Big(g_{\mu\nu}\Big) \tag{388}$$



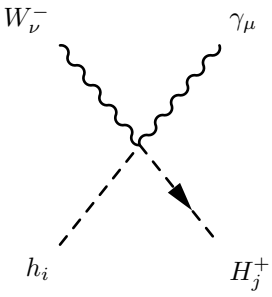
$$\frac{i}{2}\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W\Big)^2\Big(Z_{i1}^H Z_{j1}^H + Z_{i2}^H Z_{j2}^H\Big)\Big(g_{\mu\nu}\Big) \tag{389}$$



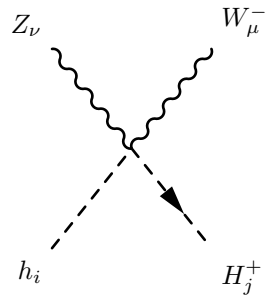
$$-\frac{i}{2}g_1 g_2 \cos\Theta_W \Big(Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big) \tag{390}$$



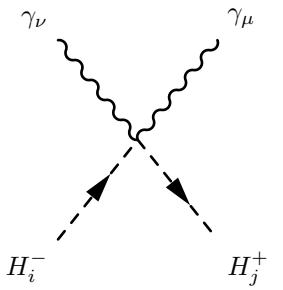
$$\frac{i}{2}g_1 g_2 \sin\Theta_W \Big(Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big) \tag{391}$$



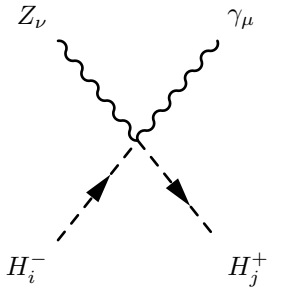
$$-\frac{i}{2}g_1 g_2 \cos\Theta_W \Big(Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big) \tag{392}$$



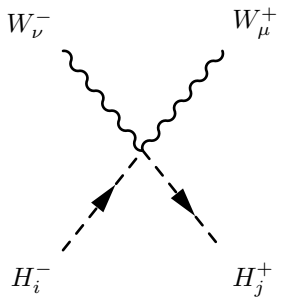
$$\frac{i}{2}g_1 g_2 \sin\Theta_W \Big(Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big) \tag{393}$$



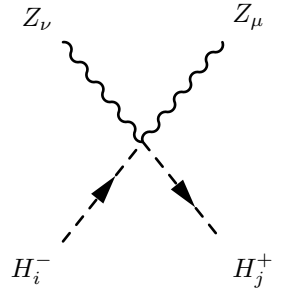
$$\frac{i}{2}\Big(g_1 \cos\Theta_W + g_2 \sin\Theta_W\Big)^2 \Big(Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big) \tag{394}$$



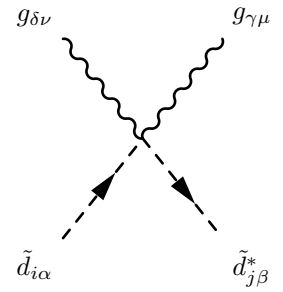
$$-\frac{i}{4}\Big(-2g_1 g_2 \cos 2\Theta_W + \Big(-g_2^2 + g_1^2\Big)\sin 2\Theta_W\Big)\Big(Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big) \tag{395}$$



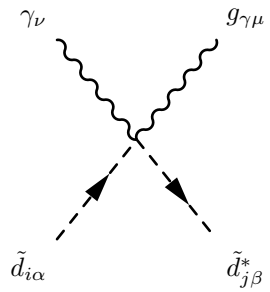
$$\frac{i}{2}g_2^2\Big(Z_{i1}^+Z_{j1}^+ + Z_{i2}^+Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big) \tag{396}$$



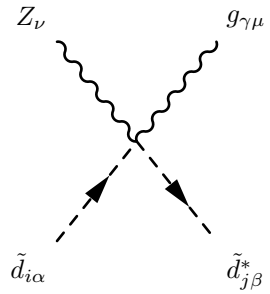
$$\frac{i}{2}\Big(-g_1\sin\Theta_W + g_2\cos\Theta_W\Big)^2\Big(Z_{i1}^+Z_{j1}^+ + Z_{i2}^+Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big) \tag{397}$$



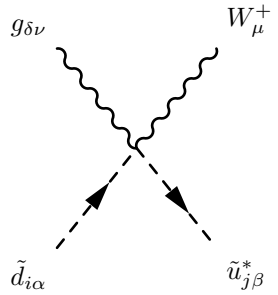
$$\frac{i}{4}g_3^2\delta_{ij}\Big(\sum_{a=1}^{3}\lambda_{a,\alpha}^{\gamma}\lambda_{\beta,a}^{\delta} + \sum_{a=1}^{3}\lambda_{\beta,a}^{\gamma}\lambda_{a,\alpha}^{\delta}\Big)\Big(g_{\mu\nu}\Big) \tag{398}$$



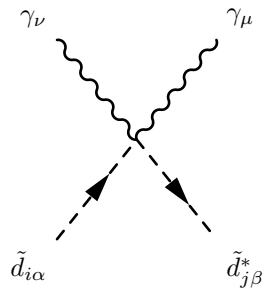
$$\frac{i}{6}g_3\lambda^{\gamma}_{\beta,\alpha}\Big(-2g_1\cos\Theta_W\sum_{a=1}^{3}Z^{D,*}_{i3+a}Z^{D}_{j3+a}+\Big(-3g_2\sin\Theta_W+g_1\cos\Theta_W\Big)\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{D}_{ja}\Big)\Big(g_{\mu\nu}\Big) \tag{399}$$



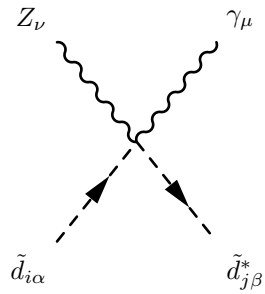
$$-\frac{i}{6}g_3\lambda^{\gamma}_{\beta,\alpha}\Big(-2g_1\sin\Theta_W\sum_{a=1}^{3}Z^{D,*}_{i3+a}Z^{D}_{j3+a}+\Big(3g_2\cos\Theta_W+g_1\sin\Theta_W\Big)\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{D}_{ja}\Big)\Big(g_{\mu\nu}\Big) \tag{400}$$



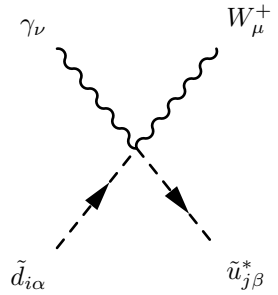
$$i\frac{1}{\sqrt{2}}g_2g_3\lambda^{\delta}_{\beta,\alpha}\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{U}_{ja}\Big(g_{\mu\nu}\Big) \tag{401}$$



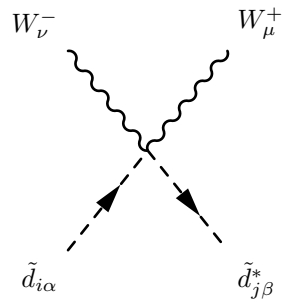
$$\frac{i}{18}\delta_{\alpha\beta}\Big(\Big(-3g_2\sin\Theta_W+g_1\cos\Theta_W\Big)^2\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{D}_{ja}+4g_1^2\cos\Theta_W^2\sum_{a=1}^{3}Z^{D,*}_{i3+a}Z^{D}_{j3+a}\Big)\Big(g_{\mu\nu}\Big) \tag{402}$$



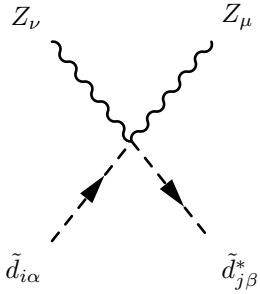
$$-\frac{i}{36}\delta_{\alpha\beta}\Big(\Big(6g_1g_2\cos 2\Theta_W+\Big(-9g_2^2+g_1^2\Big)\sin 2\Theta_W\Big)\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{D}_{ja}$$
$$+4g_1^2\sin 2\Theta_W\sum_{a=1}^{3}Z^{D,*}_{i3+a}Z^{D}_{j3+a}\Big)\Big(g_{\mu\nu}\Big) \tag{403}$$



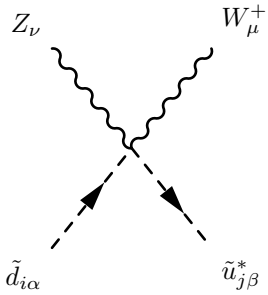
$$\frac{i}{3}\frac{1}{\sqrt{2}}g_1g_2\cos\Theta_W\delta_{\alpha\beta}\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{U}_{ja}\Big(g_{\mu\nu}\Big) \tag{404}$$



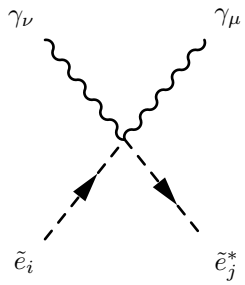
$$\frac{i}{2}g_2^2\delta_{\alpha\beta}\sum_{a=1}^{3}Z_{ia}^{D,*}Z_{ja}^{D}\Big(g_{\mu\nu}\Big) \tag{405}$$



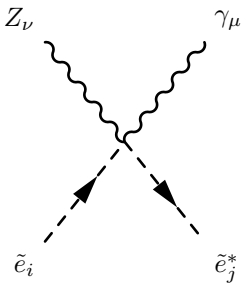
$$\frac{i}{18}\delta_{\alpha\beta}\Big(\Big(3g_2\cos\Theta_W+g_1\sin\Theta_W\Big)^2\sum_{a=1}^{3}Z_{ia}^{D,*}Z_{ja}^{D}+4g_1^2\sin\Theta_W^2\sum_{a=1}^{3}Z_{i3+a}^{D,*}Z_{j3+a}^{D}\Big)\Big(g_{\mu\nu}\Big) \tag{406}$$



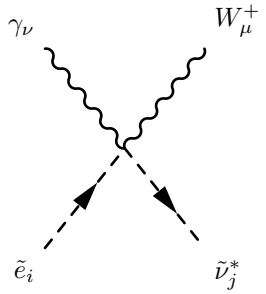
$$-\frac{i}{3}\frac{1}{\sqrt{2}}g_1g_2\delta_{\alpha\beta}\sin\Theta_W\sum_{a=1}^{3}Z_{ia}^{D,*}Z_{ja}^{U}\Big(g_{\mu\nu}\Big) \tag{407}$$



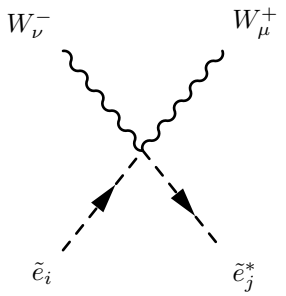
$$\frac{i}{2}\Big(4g_1^2\cos\Theta_W^2\sum_{a=1}^{3}Z_{i3+a}^{E,*}Z_{j3+a}^{E}+\Big(g_1\cos\Theta_W+g_2\sin\Theta_W\Big)^2\sum_{a=1}^{3}Z_{ia}^{E,*}Z_{ja}^{E}\Big)\Big(g_{\mu\nu}\Big) \tag{408}$$



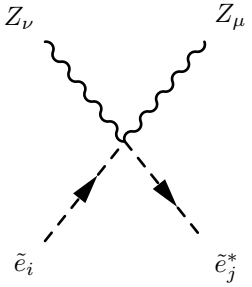
$$\begin{aligned}&-\frac{i}{4}\Big(\Big(-2g_1g_2\cos 2\Theta_W+\Big(-g_2^2+g_1^2\Big)\sin 2\Theta_W\Big)\sum_{a=1}^{3}Z_{ia}^{E,*}Z_{ja}^{E}\\&+4g_1^2\sin 2\Theta_W\sum_{a=1}^{3}Z_{i3+a}^{E,*}Z_{j3+a}^{E}\Big)\Big(g_{\mu\nu}\Big)\end{aligned} \tag{409}$$



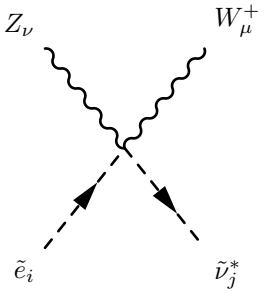
$$-i\frac{1}{\sqrt{2}}g_1g_2\cos\Theta_W\sum_{a=1}^{3}Z_{ia}^{E,*}Z_{ja}^{V}\Big(g_{\mu\nu}\Big) \tag{410}$$



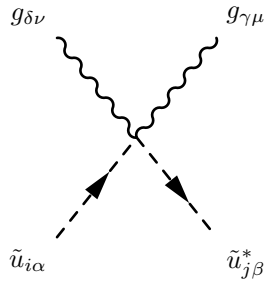
$$\frac{i}{2} g_2^2 \sum_{a=1}^{3} Z_{ia}^{E,*} Z_{ja}^{E} \Big(g_{\mu\nu} \Big) \tag{411}$$



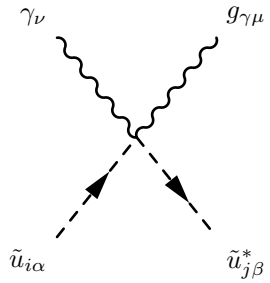
$$\frac{i}{2} \Big(4 g_1^2 \sin\Theta_W^2 \sum_{a=1}^{3} Z_{i3+a}^{E,*} Z_{j3+a}^{E} + \Big(-g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big)^2 \sum_{a=1}^{3} Z_{ia}^{E,*} Z_{ja}^{E} \Big) \Big(g_{\mu\nu} \Big) \tag{412}$$



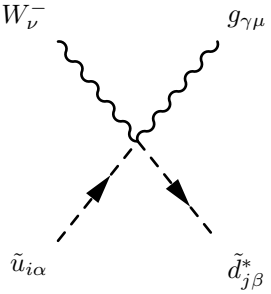
$$i \frac{1}{\sqrt{2}} g_1 g_2 \sin\Theta_W \sum_{a=1}^{3} Z_{ia}^{E,*} Z_{ja}^{V} \Big(g_{\mu\nu} \Big) \tag{413}$$



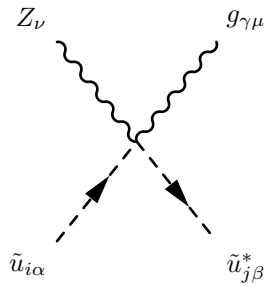
$$\frac{i}{4}g_3^2\delta_{ij}\Big(\sum_{a=1}^{3}\lambda^{\gamma}_{a,\alpha}\lambda^{\delta}_{\beta,a}+\sum_{a=1}^{3}\lambda^{\gamma}_{\beta,a}\lambda^{\delta}_{a,\alpha}\Big)\Big(g_{\mu\nu}\Big) \tag{414}$$



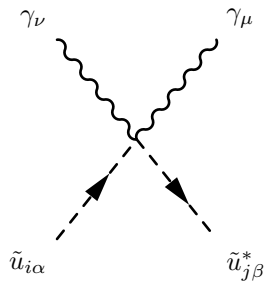
$$\frac{i}{6}g_3\lambda^{\gamma}_{\beta,\alpha}\Big(\Big(3g_2\sin\Theta_W+g_1\cos\Theta_W\Big)\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{U}_{ja}+4g_1\cos\Theta_W\sum_{a=1}^{3}Z^{U,*}_{i3+a}Z^{U}_{j3+a}\Big)\Big(g_{\mu\nu}\Big) \tag{415}$$



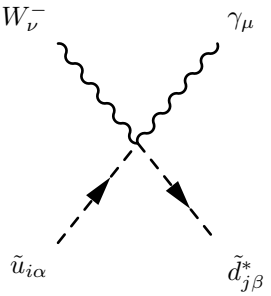
$$i\frac{1}{\sqrt{2}}g_2g_3\lambda^{\gamma}_{\beta,\alpha}\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{D}_{ja}\Big(g_{\mu\nu}\Big) \tag{416}$$



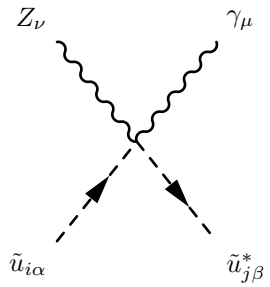
$$\frac{i}{6}g_3\lambda^{\gamma}_{\beta,\alpha}\Big(\Big(3g_2\cos\Theta_W - g_1\sin\Theta_W\Big)\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{U}_{ja} - 4g_1\sin\Theta_W\sum_{a=1}^{3}Z^{U,*}_{i3+a}Z^{U}_{j3+a}\Big)\Big(g_{\mu\nu}\Big) \tag{417}$$



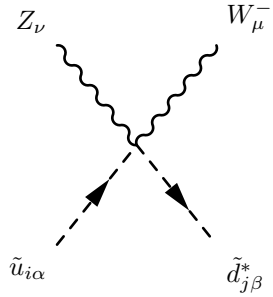
$$\frac{i}{18}\delta_{\alpha\beta}\Big(16g_1^2\cos\Theta_W^2\sum_{a=1}^{3}Z^{U,*}_{i3+a}Z^{U}_{j3+a} + \Big(3g_2\sin\Theta_W + g_1\cos\Theta_W\Big)^2\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{U}_{ja}\Big)\Big(g_{\mu\nu}\Big) \tag{418}$$



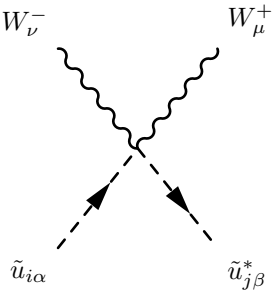
$$\frac{i}{3}\frac{1}{\sqrt{2}}g_1g_2\cos\Theta_W\delta_{\alpha\beta}\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{D}_{ja}\Big(g_{\mu\nu}\Big) \tag{419}$$



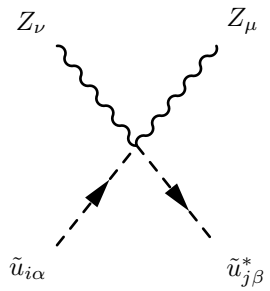
$$-\frac{i}{36}\delta_{\alpha\beta}\Big(\Big(-6g_1g_2\cos 2\Theta_W+\Big(-9g_2^2+g_1^2\Big)\sin 2\Theta_W\Big)\sum_{a=1}^{3}Z_{ia}^{U,*}Z_{ja}^{U}$$
$$+16g_1^2\sin 2\Theta_W\sum_{a=1}^{3}Z_{i3+a}^{U,*}Z_{j3+a}^{U}\Big)\Big(g_{\mu\nu}\Big) \tag{420}$$



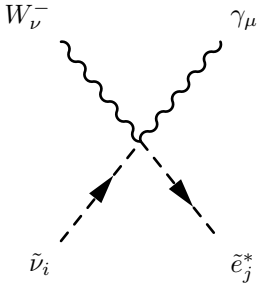
$$-\frac{i}{3}\frac{1}{\sqrt{2}}g_1g_2\delta_{\alpha\beta}\sin\Theta_W\sum_{a=1}^{3}Z_{ia}^{U,*}Z_{ja}^{D}\Big(g_{\mu\nu}\Big) \tag{421}$$



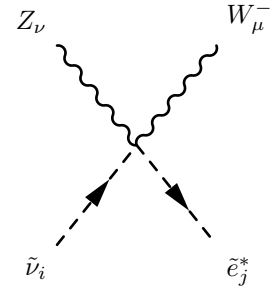
$$\frac{i}{2}g_2^2\delta_{\alpha\beta}\sum_{a=1}^{3}Z_{ia}^{U,*}Z_{ja}^{U}\Big(g_{\mu\nu}\Big) \tag{422}$$



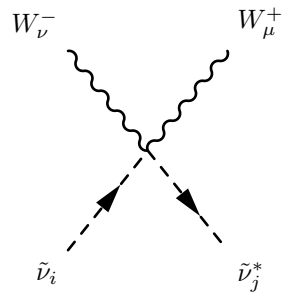
$$\frac{i}{18}\delta_{\alpha\beta}\Big(16g_1^2\sin\Theta_W^2\sum_{a=1}^{3}Z^{U,*}_{i3+a}Z^{U}_{j3+a}+\Big(-3g_2\cos\Theta_W+g_1\sin\Theta_W\Big)^2\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{U}_{ja}\Big)\Big(g_{\mu\nu}\Big) \tag{423}$$



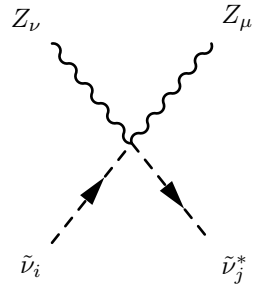
$$-i\frac{1}{\sqrt{2}}g_1g_2\cos\Theta_W\sum_{a=1}^{3}Z^{V,*}_{ia}Z^{E}_{ja}\Big(g_{\mu\nu}\Big) \tag{424}$$



$$i\frac{1}{\sqrt{2}}g_1g_2\sin\Theta_W\sum_{a=1}^{3}Z^{V,*}_{ia}Z^{E}_{ja}\Big(g_{\mu\nu}\Big) \tag{425}$$

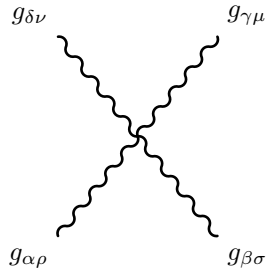


$$\frac{i}{2}g_2^2\delta_{ij}\Big(g_{\mu\nu}\Big) \tag{426}$$



$$\frac{i}{2}\delta_{ij}\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)^2\Big(g_{\mu\nu}\Big) \tag{427}$$

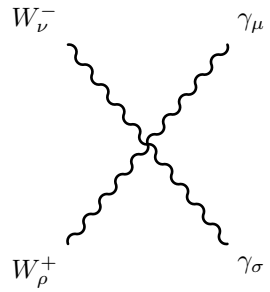
9.9 Four Vector Boson-Interaction



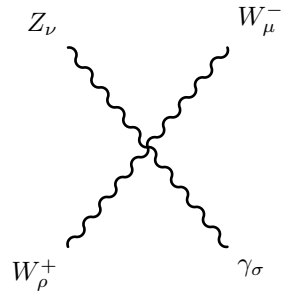
$$-ig_3^2\Big(\sum_{a=1}^{8} f_{\alpha,\delta,a}f_{\beta,\gamma,a} + \sum_{a=1}^{8} f_{\alpha,\gamma,a}f_{\beta,\delta,a}\Big)\Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{428}$$

$$+\ ig_3^2\Big(-\sum_{a=1}^{8} f_{\alpha,\beta,a}f_{\gamma,\delta,a} + \sum_{a=1}^{8} f_{\alpha,\delta,a}f_{\beta,\gamma,a}\Big)\Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{429}$$

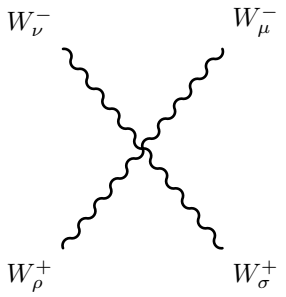
$$+\ ig_3^2\Big(\sum_{a=1}^{8} f_{\alpha,\gamma,a}f_{\beta,\delta,a} + \sum_{a=1}^{8} f_{\alpha,\beta,a}f_{\gamma,\delta,a}\Big)\Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{430}$$



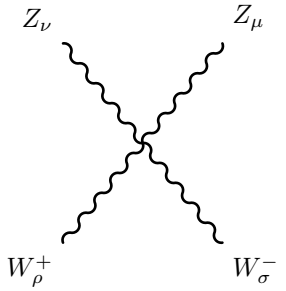
$$ig_2^2 \sin\Theta_W^2\Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{431}$$
$$+\ ig_2^2 \sin\Theta_W^2\Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{432}$$
$$+\ -2ig_2^2 \sin\Theta_W^2\Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{433}$$



$$ig_2^2 \cos\Theta_W \sin\Theta_W\Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{434}$$
$$+\ -ig_2^2 \sin 2\Theta_W\Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{435}$$
$$+\ ig_2^2 \cos\Theta_W \sin\Theta_W\Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{436}$$

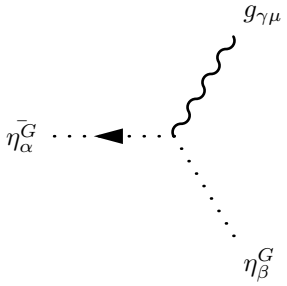


$$2ig_2^2\Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{437}$$
$$+\ -ig_2^2\Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{438}$$
$$+\ -ig_2^2\Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{439}$$

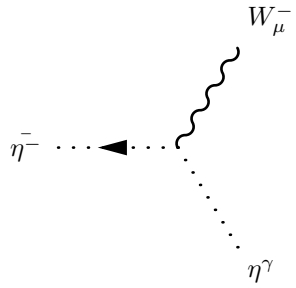


$$-\ 2ig_2^2\cos\Theta_W^2\Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{440}$$
$$+\ ig_2^2\cos\Theta_W^2\Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{441}$$
$$+\ ig_2^2\cos\Theta_W^2\Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{442}$$

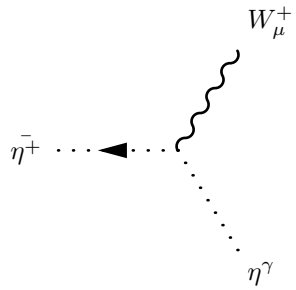
9.10 Two Ghosts-One Vector Boson-Interaction



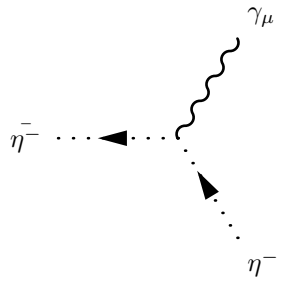
$$g_3 f_{\alpha,\beta,\gamma}\left(p_\mu^{\eta_\beta^G}\right) \tag{443}$$



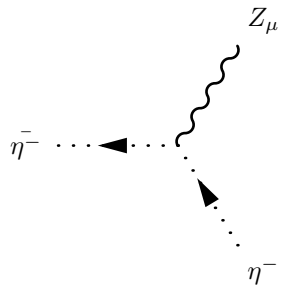
$$ig_2 \sin\Theta_W\left(p_\mu^{\eta^\gamma}\right) \tag{444}$$



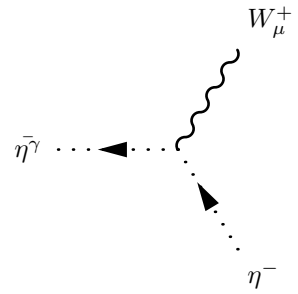
$$-ig_2 \sin\Theta_W\left(p_\mu^{\eta^\gamma}\right) \tag{445}$$



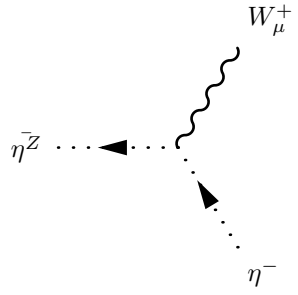
$$-ig_2 \sin\Theta_W\left(p_\mu^{\eta^-}\right) \tag{446}$$



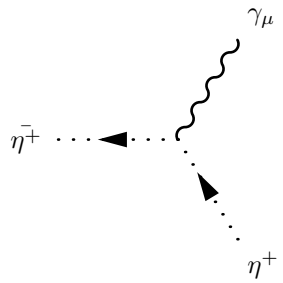
$$-ig_2 \cos\Theta_W \left(p_\mu^{\eta^-}\right) \tag{447}$$



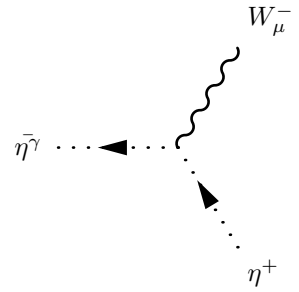
$$ig_2 \sin\Theta_W \left(p_\mu^{\eta^-}\right) \tag{448}$$



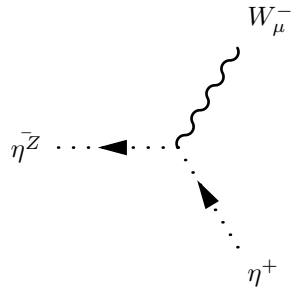
$$ig_2 \cos\Theta_W \left(p_\mu^{\eta^-}\right) \tag{449}$$



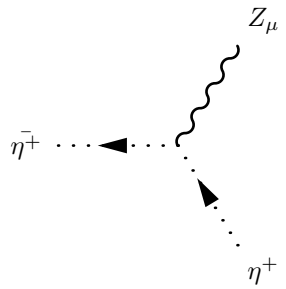
$$ig_2 \sin\Theta_W \left(p_\mu^{\eta^+}\right) \tag{450}$$



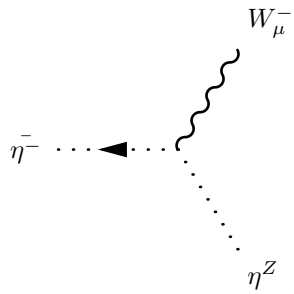
$$-ig_2 \sin\Theta_W \left(p_\mu^{\eta^+}\right) \tag{451}$$



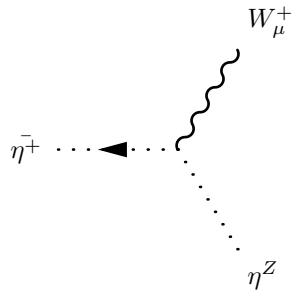
$$-ig_2 \cos\Theta_W \left(p_\mu^{\eta^+}\right) \tag{452}$$



$$ig_2 \cos\Theta_W \left(p_\mu^{\eta^+}\right) \tag{453}$$

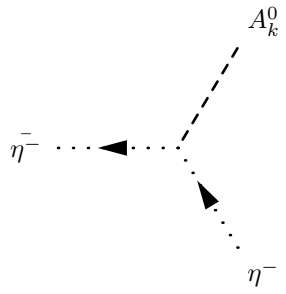


$$ig_2 \cos\Theta_W \left(p_\mu^{\eta^Z}\right) \tag{454}$$

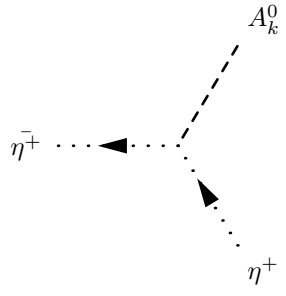


$$-ig_2 \cos\Theta_W \left(p_\mu^{\eta^Z}\right) \tag{455}$$

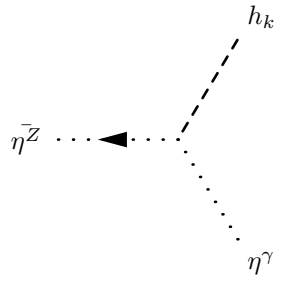
9.11 Two Ghosts-One Scalar-Interaction



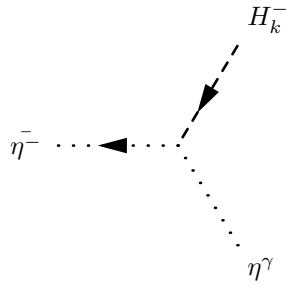
$$\frac{1}{4}g_2^2\xi_{W^-}\Big(v_d Z_{k1}^A - v_u Z_{k2}^A\Big) \tag{456}$$



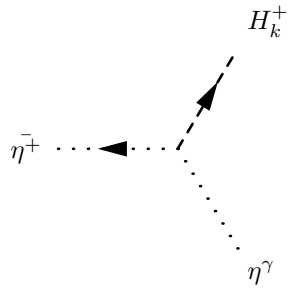
$$\frac{1}{4}g_2^2\xi_{W^-}\Big(-v_d Z_{k1}^A + v_u Z_{k2}^A\Big) \tag{457}$$



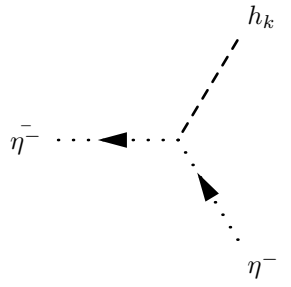
$$\frac{i}{8}\xi_Z\Big(2g_1g_2\cos 2\Theta_W + \Big(-g_2^2+g_1^2\Big)\sin 2\Theta_W\Big)\Big(v_d Z_{k1}^H + v_u Z_{k2}^H\Big) \tag{458}$$



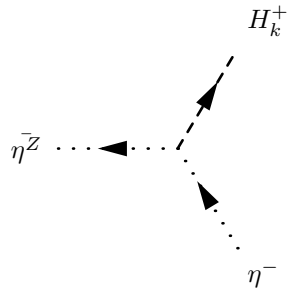
$$\frac{i}{4}g_2\xi_{W^-}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)\Big(v_d Z_{k1}^+ - v_u Z_{k2}^+\Big) \tag{459}$$



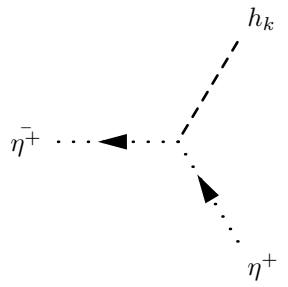
$$\frac{i}{4}g_2\xi_{W^-}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)\Big(v_d Z_{k1}^+ - v_u Z_{k2}^+\Big) \tag{460}$$



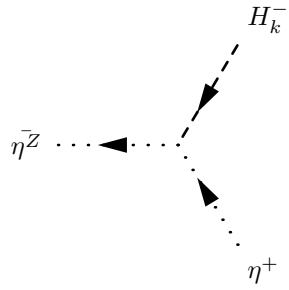
$$-\frac{i}{4}g_2^2\xi_{W^-}\Big(v_d Z_{k1}^H + v_u Z_{k2}^H\Big) \tag{461}$$



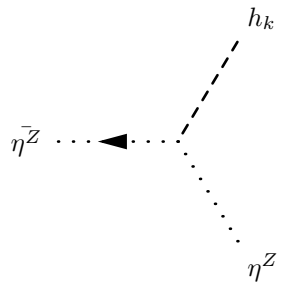
$$-\frac{i}{4}g_2\xi_Z\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\Big(v_dZ_{k1}^+-v_uZ_{k2}^+\Big) \tag{462}$$



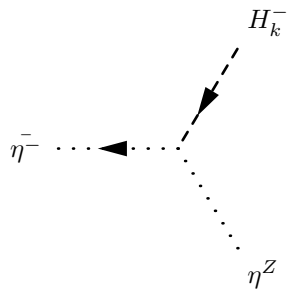
$$-\frac{i}{4}g_2^2\xi_{W^-}\Big(v_dZ_{k1}^H+v_uZ_{k2}^H\Big) \tag{463}$$



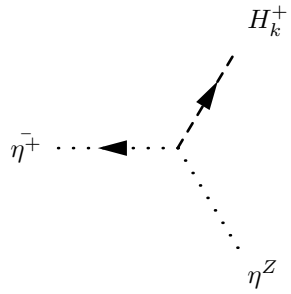
$$-\frac{i}{4}g_2\xi_Z\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\Big(v_dZ_{k1}^+-v_uZ_{k2}^+\Big) \tag{464}$$



$$-\frac{i}{4}\xi_Z\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)^2\Big(v_dZ^H_{k1}+v_uZ^H_{k2}\Big) \tag{465}$$



$$\frac{i}{4}g_2\xi_{W^-}\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\Big(v_dZ^+_{k1}-v_uZ^+_{k2}\Big) \tag{466}$$



$$\frac{i}{4}g_2\xi_{W^-}\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\Big(v_dZ^+_{k1}-v_uZ^+_{k2}\Big) \tag{467}$$

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10 Clebsch-Gordan Coefficients