$U(1)$ extended MSSM
Superpotential, Rotations and Interactions for eigenstates 'EWSB' including Renormalization Group Equations including one-loop Self-Energies

SARAH 4.14.3

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

1 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
$\hat{U}$	λ_U	U	$U(1)$	g_p	additional

1.2 Chiral Superfields

SF	Spin 0	Spin $\frac{1}{2}$	Generations	$(U(1) \otimes \mathrm{SU}(2) \otimes \mathrm{SU}(3) \otimes U(1))$
$\hat{q}$	$\tilde{q}$	q	3	$(\frac{1}{6}, \mathbf{2}, \mathbf{3}, Q_q)$
$l4$	Sl4	Fl4	1	$(-\frac{1}{2}, \mathbf{2}, \mathbf{1}, Q_{l_4})$
$l9$	Sl9	Fl9	2	$(-\frac{1}{2}, \mathbf{2}, \mathbf{1}, Q_{l_9})$
$\hat{H}_d$	H_d	$\tilde{H}_d$	1	$(-\frac{1}{2}, \mathbf{2}, \mathbf{1}, Q_{H_d})$
$\hat{H}_u$	H_u	$\tilde{H}_u$	1	$(\frac{1}{2}, \mathbf{2}, \mathbf{1}, Q_{H_u})$
$\hat{d}$	$\tilde{d}_R^*$	d_R^*	3	$(\frac{1}{3}, \mathbf{1}, \overline{\mathbf{3}}, Q_d)$
$\hat{u}$	$\tilde{u}_R^*$	u_R^*	3	$(-\frac{2}{3}, \mathbf{1}, \overline{\mathbf{3}}, Q_u)$
$e4$	$Se4R^*$	$Fe4R^*$	1	$(1, \mathbf{1}, \mathbf{1}, Q_{e_4})$
$e9$	$Se9R^*$	$Fe9R^*$	2	$(1, \mathbf{1}, \mathbf{1}, Q_{e_9})$
$\hat{s}$	S	$\tilde{S}$	1	$(0, \mathbf{1}, \mathbf{1}, Q_s)$

2 Superpotential and Lagrangian

2.1 Superpotential

$$W = -Y_d\,\hat{d}\,\hat{q}\,\hat{H}_d - Y1\,e4\,l4\,\hat{H}_d - Y2\,e9\,l9\,\hat{H}_d + \lambda\,\hat{H}_u\,\hat{H}_d\,\hat{s} + Y_u\,\hat{u}\,\hat{q}\,\hat{H}_u \tag{1}$$

2.2 Softbreaking terms

$$\begin{aligned}
-L_{SB,W} = &+ Se4L H_d^0 Se4R^* TY1 - H_d^- Sv4L Se4R^* TY1 - H_d^0 H_u^0 ST_\lambda + H_d^- H_u^+ ST_\lambda + H_d^0 Se9R_i^* Se9L_j TY2_{ij} - H_d^- Se9R_i^* Sv9L_j TY \\
&+ H_d^0 \tilde{d}_{R,i\alpha}^* \delta_{\alpha\beta} \tilde{d}_{L,j\beta} T_{d,ij} - H_d^- \tilde{d}_{R,i\alpha}^* \delta_{\alpha\beta} \tilde{u}_{L,j\beta} T_{d,ij} - H_u^+ \tilde{u}_{R,i\alpha}^* \delta_{\alpha\beta} \tilde{d}_{L,j\beta} T_{u,ij} \\
&+ H_u^0 \tilde{u}_{R,i\alpha}^* \delta_{\alpha\beta} \tilde{u}_{L,j\beta} T_{u,ij} + \text{h.c.} \qquad (2) \\
-L_{SB,\phi} = &+ m_{l_4}^2 |Se4L|^2 + m_{e_4}^2 |Se4R|^2 + m_{H_d}^2 |H_d^0|^2 + m_{H_d}^2 |H_d^-|^2 + m_{H_u}^2 |H_u^0|^2 + m_{H_u}^2 |H_u^+|^2 + m_s^2 |S|^2 \\
&+ m_{l_4}^2 |Sv4L|^2 + \tilde{d}_{L,i\alpha}^* \delta_{\alpha\beta} m_{q,ij}^2 \tilde{d}_{L,j\beta} + \tilde{d}_{R,i\alpha}^* \delta_{\alpha\beta} m_{d,ij}^2 \tilde{d}_{R,j\beta} + Se9L_i^* m_{l_9,ij}^2 Se9L_j + Se9R_i^* m_{e_9,ij}^2 Se9R_j
\end{aligned}$$

$$+ \tilde{u}^*_{L,i\alpha}\delta_{\alpha\beta}m^2_{q,ij}\tilde{u}_{L,j\beta} + \tilde{u}^*_{R,i\alpha}\delta_{\alpha\beta}m^2_{u,ij}\tilde{u}_{R,j\beta} + Sv9L^*_i m^2_{l_9,ij} Sv9L_j \tag{3}$$

$$-L_{SB,\lambda} = \frac{1}{2}\Big(\lambda^2_{\tilde{B}} M_1 \delta_{ij} + \lambda^2_U M_Z \delta_{ij} + M_2 \delta_{ij}\lambda_{\tilde{W},i}\lambda_{\tilde{W},j} + M_3 \delta_{ij}\lambda_{\tilde{g},\alpha}\lambda_{\tilde{g},\beta} + \text{h.c.}\Big) \tag{4}$$

2.3 Input Lagrangian for Eigenstates GaugeES

$$\begin{aligned} L = &+ H^0_u \tilde{d}^*_{L,k\gamma} T'^{,*}_{d,jk}\delta_{\beta\gamma}\tilde{d}_{R,j\beta} + H^+_u \tilde{u}^*_{L,k\gamma} T'^{,*}_{d,jk}\delta_{\beta\gamma}\tilde{d}_{R,j\beta} + H^0_u Se9L^*_k T'^{,*}_{e,jk} Se9R_j + H^+_u Sv9L^*_k T'^{,*}_{e,jk} Se9R_j \\ &+ H^{0,*}_u \tilde{d}^*_{R,j\beta}\delta_{\beta\gamma}\tilde{d}_{L,k\gamma} T'_{d,jk} + H^{+,*}_u \tilde{d}^*_{R,j\beta}\delta_{\beta\gamma}\tilde{u}_{L,k\gamma} T'_{d,jk} + H^{0,*}_u Se9R^*_j Se9L_k T'_{e,jk} + H^{+,*}_u Se9R^*_j Sv9L_k T'_{e,jk} \end{aligned} \tag{5}$$

2.4 Gauge fixing terms

2.4.1 Gauge fixing terms for eigenstates 'GaugeES'

$$L_{GF} = -\frac{1}{2}|\partial_\mu B|^2 \xi_B^{-1} - \frac{1}{2}|\partial_\mu g|^2 \xi_g^{-1} - \frac{1}{2}|\partial_\mu U|^2 \xi_U^{-1} - \frac{1}{2}|\partial_\mu W|^2 \xi_W^{-1} \tag{6}$$

2.4.2 Gauge fixing terms for eigenstates 'EWSB'

$$\begin{aligned} L_{GF} = &-\frac{1}{2}|\partial_\mu g|^2 \xi_g^{-1} - \frac{1}{2}|\partial_\mu \gamma|^2 \xi_\gamma^{-1} - | - \frac{i}{2} g_2 \Big(H_d^- v_d - v_u H_u^{+,*}\Big)\xi_{W^-} + \partial_\mu W^-|^2 \xi_{W^-}^{-1} \\ &- \frac{1}{2}| + \partial_\mu Z \\ &+ \frac{1}{2}\xi_Z \Big(g_2\Big(\sigma_d v_d - \sigma_u v_u\Big)\cos\Theta_W \cos\Theta'_W + g_1\Big(\sigma_d v_d - \sigma_u v_u\Big)\cos\Theta'_W \sin\Theta_W \\ &+ 2 g_p \Big(Q_{H_d}\sigma_d v_d + Q_{H_u}\sigma_u v_u + Q_s \phi_s v_S\Big)\sin\Theta'_W\Big)|^2 \xi_Z^{-1} \\ &- \frac{1}{2}| + \partial_\mu Z' + g_p\Big(Q_{H_d}\sigma_d v_d + Q_{H_u}\sigma_u v_u + Q_s\phi_s v_S\Big)\cos\Theta'_W \xi_{Z'} \\ &- \frac{1}{2}\Big(\sigma_d v_d - \sigma_u v_u\Big)\xi_{Z'}\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W\Big)\sin\Theta'_W|^2 \xi_{Z'}^{-1} \end{aligned} \tag{7}$$

2.5 Fields integrated out

None

3 Renormalization Group Equations

3.1 Anomalous Dimensions

$$\gamma^{(1)}_{\hat{q}} = -\frac{1}{30}\Big(45 g_2^2 + 60 g_p^2 Q_q^2 + 80 g_3^2 + g_1^2\Big)\mathbf{1} + Y_d^\dagger Y_d + Y_u^\dagger Y_u \tag{8}$$

$$\begin{aligned} \gamma^{(2)}_{\hat{q}} = &+\frac{1}{900}\Big(199 g_1^4 + 10 g_1^2\Big(12 g_p^2 Q_q\Big(10 Q_q - 18 Q_u + 3 Q_{e_4} - 3 Q_{H_d} + 3 Q_{H_u} - 3 Q_{l_4} + 6 Q_{e_9} - 6 Q_{l_9} + 9 Q_d\Big) + 16 g_3^2 + 9 g_2^2\Big) \\ &+ 25\Big(135 g_2^4 + 72 g_2^2\Big(3 g_p^2 Q_q^2 + 4 g_3^2\Big)\Big) \end{aligned}$$

$$
\begin{aligned}
&+8\Big(-4g_3^4+48g_3^2g_p^2Q_q^2\\
&+9g_p^4Q_q^2\Big(20Q_q^2+2Q_{e_9}^2+2Q_{H_d}^2+2Q_{H_u}^2+2Q_{l_4}^2+4Q_{l_9}^2+9Q_d^2+9Q_u^2+Q_{e_4}^2+Q_s^2\Big)\Big)\Big)\Big)\mathbf{1}\\
&+\frac{4}{5}g_1^2Y_u^\dagger Y_u+2g_p^2Q_{H_u}^2Y_u^\dagger Y_u-2g_p^2Q_q^2Y_u^\dagger Y_u+2g_p^2Q_u^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(2g_p^2Q_d^2+2g_p^2Q_{H_d}^2-2g_p^2Q_q^2-3\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)+\frac{2}{5}g_1^2-\lambda^2-\mathrm{Tr}\Big(Y2Y2^\dagger\Big)-|Y1|^2\Big)\\
&-3Y_u^\dagger Y_u\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) \qquad (9)\\
\gamma_{l4}^{(1)}&=-2g_p^2Q_{l_4}^2-\frac{3}{10}g_1^2-\frac{3}{2}g_2^2+|Y1|^2 \qquad (10)\\
\gamma_{l4}^{(2)}&=+\frac{207}{100}g_1^4+\frac{15}{4}g_2^4+6g_2^2g_p^2Q_{l_4}^2+18g_p^4Q_d^2Q_{l_4}^2+2g_p^4Q_{e_4}^2Q_{l_4}^2+4g_p^4Q_{e_9}^2Q_{l_4}^2\\
&+4g_p^4Q_{H_d}^2Q_{l_4}^2+4g_p^4Q_{H_u}^2Q_{l_4}^2+8g_p^4Q_{l_4}^4+8g_p^4Q_{l_4}^2Q_{l_9}^2+36g_p^4Q_{l_4}^2Q_q^2\\
&+2g_p^4Q_{l_4}^2Q_s^2+\frac{3}{10}g_1^2\Big(3g_2^2-4g_p^2Q_{l_4}\Big(2Q_{e_9}-2Q_{l_4}-2Q_{l_9}+3Q_d+3Q_q-6Q_u-Q_{H_d}+Q_{e_4}+Q_{H_u}\Big)\Big)\\
&+18g_p^4Q_{l_4}^2Q_u^2-3|Y1|^4\\
&+\frac{1}{5}|Y1|^2\Big(10g_p^2Q_{e_4}^2+10g_p^2Q_{H_d}^2-10g_p^2Q_{l_4}^2-15\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)-5\lambda^2-5\mathrm{Tr}\Big(Y2Y2^\dagger\Big)+6g_1^2\Big) \qquad (11)\\
\gamma_{l9}^{(1)}&=-\frac{1}{10}\Big(15g_2^2+20g_p^2Q_{l_9}^2+3g_1^2\Big)\mathbf{1}+Y2^\dagger Y2 \qquad (12)\\
\gamma_{l9}^{(2)}&=+\frac{1}{100}\Big(207g_1^4+30g_1^2\Big(3g_2^2+4g_p^2Q_{l_9}\Big(-2Q_{e_9}-3Q_d+3Q_{l_9}-3Q_q+6Q_u-Q_{e_4}-Q_{H_u}+Q_{H_d}+Q_{l_4}\Big)\Big)\\
&+25\Big(15g_2^4+24g_2^2g_p^2Q_{l_9}^2\\
&+8g_p^4Q_{l_9}^2\Big(18Q_q^2+2Q_{e_9}^2+2Q_{H_d}^2+2Q_{H_u}^2+2Q_{l_4}^2+6Q_{l_9}^2+9Q_d^2+9Q_u^2+Q_{e_4}^2+Q_s^2\Big)\Big)\Big)\mathbf{1}\\
&-2Y2^\dagger Y2Y2^\dagger Y2\\
&+Y2^\dagger Y2\Big(2g_p^2Q_{e_9}^2+2g_p^2Q_{H_d}^2-2g_p^2Q_{l_9}^2-3\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)+\frac{6}{5}g_1^2-\lambda^2-\mathrm{Tr}\Big(Y2Y2^\dagger\Big)-|Y1|^2\Big) \qquad (13)\\
\gamma_{\hat{H}_d}^{(1)}&=-2g_p^2Q_{H_d}^2+3\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)-\frac{3}{10}g_1^2-\frac{3}{2}g_2^2+\lambda^2+|Y1|^2+\mathrm{Tr}\Big(Y2Y2^\dagger\Big) \qquad (14)\\
\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-\frac{18}{5}g_1^2g_p^2Q_dQ_{H_d}-\frac{6}{5}g_1^2g_p^2Q_{e_4}Q_{H_d}-\frac{12}{5}g_1^2g_p^2Q_{e_9}Q_{H_d}\\
&+\frac{12}{5}g_1^2g_p^2Q_{H_d}^2+6g_2^2g_p^2Q_{H_d}^2+18g_p^4Q_d^2Q_{H_d}^2+2g_p^4Q_{e_4}^2Q_{H_d}^2+4g_p^4Q_{e_9}^2Q_{H_d}^2\\
&+8g_p^4Q_{H_d}^4-\frac{6}{5}g_1^2g_p^2Q_{H_d}Q_{H_u}+4g_p^4Q_{H_d}^2Q_{H_u}^2+\frac{6}{5}g_1^2g_p^2Q_{H_d}Q_{l_4}+4g_p^4Q_{H_d}^2Q_{l_4}^2\\
&+\frac{12}{5}g_1^2g_p^2Q_{H_d}Q_{l_9}+8g_p^4Q_{H_d}^2Q_{l_9}^2-\frac{18}{5}g_1^2g_p^2Q_{H_d}Q_q+36g_p^4Q_{H_d}^2Q_q^2+2g_p^4Q_{H_d}^2Q_s^2\\
&+\frac{36}{5}g_1^2g_p^2Q_{H_d}Q_u+18g_p^4Q_{H_d}^2Q_u^2-2g_p^2Q_{H_d}^2\lambda^2+2g_p^2Q_{H_u}^2\lambda^2+2g_p^2Q_s^2\lambda^2-3\lambda^4
\end{aligned}
$$

$$+\frac{2}{5}\Big(3g_1^2+5g_p^2\Big(-Q_{H_d}^2+Q_{e_4}^2+Q_{l_4}^2\Big)\Big)|Y1|^2-3|Y1|^4+\frac{2}{5}\Big(3g_1^2+5g_p^2\Big(-Q_{H_d}^2+Q_{e_9}^2+Q_{l_9}^2\Big)\Big)\mathrm{Tr}\Big(Y2Y2^\dagger\Big)$$
$$-\frac{2}{5}g_1^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)+16g_3^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)+6g_p^2Q_d^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)-6g_p^2Q_{H_d}^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)$$
$$+6g_p^2Q_q^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)-3\lambda^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)-3\mathrm{Tr}\Big(Y2Y2^\dagger Y2Y2^\dagger\Big)-9\mathrm{Tr}\Big(Y_dY_d^\dagger Y_dY_d^\dagger\Big)$$
$$-3\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big) \tag{15}$$

$$\gamma_{H_u}^{(1)}=-2g_p^2Q_{H_u}^2+3\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)-\frac{3}{10}g_1^2-\frac{3}{2}g_2^2+\lambda^2 \tag{16}$$

$$\gamma_{H_u}^{(2)}=+\frac{207}{100}g_1^4+\frac{9}{10}g_1^2g_2^2+\frac{15}{4}g_2^4+\frac{18}{5}g_1^2g_p^2Q_dQ_{H_u}+\frac{6}{5}g_1^2g_p^2Q_{e_4}Q_{H_u}+\frac{12}{5}g_1^2g_p^2Q_{e_9}Q_{H_u}$$
$$-\frac{6}{5}g_1^2g_p^2Q_{H_d}Q_{H_u}+\frac{12}{5}g_1^2g_p^2Q_{H_u}^2+6g_2^2g_p^2Q_{H_u}^2+18g_p^4Q_d^2Q_{H_u}^2+2g_p^4Q_{e_4}^2Q_{H_u}^2$$
$$+4g_p^4Q_{e_9}^2Q_{H_u}^2+4g_p^4Q_{H_d}^2Q_{H_u}^2+8g_p^4Q_{H_u}^4-\frac{6}{5}g_1^2g_p^2Q_{H_u}Q_{l_4}+4g_p^4Q_{H_u}^2Q_{l_4}^2$$
$$-\frac{12}{5}g_1^2g_p^2Q_{H_u}Q_{l_9}+8g_p^4Q_{H_u}^2Q_{l_9}^2+\frac{18}{5}g_1^2g_p^2Q_{H_u}Q_q+36g_p^4Q_{H_u}^2Q_q^2+2g_p^4Q_{H_u}^2Q_s^2$$
$$-\frac{36}{5}g_1^2g_p^2Q_{H_u}Q_u+18g_p^4Q_{H_u}^2Q_u^2+2g_p^2Q_{H_d}^2\lambda^2-2g_p^2Q_{H_u}^2\lambda^2+2g_p^2Q_s^2\lambda^2-3\lambda^4$$
$$-\lambda^2|Y1|^2-\lambda^2\mathrm{Tr}\Big(Y2Y2^\dagger\Big)-3\lambda^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)+\frac{4}{5}g_1^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)+16g_3^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)$$
$$-6g_p^2Q_{H_u}^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)+6g_p^2Q_q^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)+6g_p^2Q_u^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)-3\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big)$$
$$-9\mathrm{Tr}\Big(Y_uY_u^\dagger Y_uY_u^\dagger\Big) \tag{17}$$

$$\gamma_{\hat{d}}^{(1)}=2Y_d^*Y_d^T-\frac{2}{15}\Big(15g_p^2Q_d^2+20g_3^2+g_1^2\Big)\mathbf{1} \tag{18}$$

$$\gamma_{\hat{d}}^{(2)}=+\frac{2}{225}\Big(101g_1^4+10g_1^2\Big(3g_p^2Q_d\Big(11Q_d+3\Big(2Q_{e_9}-2Q_{l_9}+3Q_q-6Q_u-Q_{H_d}-Q_{l_4}+Q_{e_4}+Q_{H_u}\Big)\Big)+8g_3^2\Big)$$
$$-25\Big(4g_3^4-48g_3^2g_p^2Q_d^2$$
$$-9g_p^4Q_d^2\Big(11Q_d^2+18Q_q^2+2Q_{e_9}^2+2Q_{H_d}^2+2Q_{H_u}^2+2Q_{l_4}^2+4Q_{l_9}^2+9Q_u^2+Q_{e_4}^2+Q_s^2\Big)\Big)\Big)\mathbf{1}$$
$$-2\Big(Y_d^*Y_d^TY_d^*Y_d^T+Y_d^*Y_u^TY_u^*Y_d^T\Big)$$
$$+Y_d^*Y_d^T\Big(-2\lambda^2-2\mathrm{Tr}\Big(Y2Y2^\dagger\Big)-2|Y1|^2-4g_p^2Q_d^2+4g_p^2Q_{H_d}^2+4g_p^2Q_q^2+6g_2^2-6\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)+\frac{2}{5}g_1^2\Big) \tag{19}$$

$$\gamma_{\hat{u}}^{(1)}=2Y_u^*Y_u^T-\frac{2}{15}\Big(15g_p^2Q_u^2+20g_3^2+4g_1^2\Big)\mathbf{1} \tag{20}$$

$$\gamma_{\hat{u}}^{(2)}=+\frac{2}{225}\Big(428g_1^4+20g_1^2\Big(16g_3^2-3g_p^2\Big(-22Q_u+3Q_{e_4}-3Q_{H_d}+3Q_{H_u}-3Q_{l_4}+6Q_{e_9}-6Q_{l_9}+9Q_d+9Q_q\Big)Q_u\Big)$$
$$-25\Big(4g_3^4-48g_3^2g_p^2Q_u^2$$
$$-9g_p^4Q_u^2\Big(11Q_u^2+18Q_q^2+2Q_{e_9}^2+2Q_{H_d}^2+2Q_{H_u}^2+2Q_{l_4}^2+4Q_{l_9}^2+9Q_d^2+Q_{e_4}^2+Q_s^2\Big)\Big)\Big)\mathbf{1}$$
$$-2\Big(Y_u^*Y_d^TY_d^*Y_u^T+Y_u^*Y_u^TY_u^*Y_u^T\Big)$$

$$- \frac{2}{5}Y_u^* Y_u^T \Big(- 10 g_p^2 \Big(- Q_u^2 + Q_{H_u}^2 + Q_q^2 \Big) - 15 g_2^2 + 15 \mathrm{Tr}\Big(Y_u Y_u^\dagger \Big) + 5\lambda^2 + g_1^2 \Big) \tag{21}$$

$$\gamma_{e4}^{(1)} = -2 g_p^2 Q_{e_4}^2 + 2|Y1|^2 - \frac{6}{5} g_1^2 \tag{22}$$

$$\begin{aligned}\gamma_{e4}^{(2)} = &+ \frac{234}{25} g_1^4 + \frac{12}{5} g_1^2 g_p^2 Q_{e_4} \Big(2Q_{e_9} - 2Q_{l_9} + 3Q_d + 3Q_{e_4} + 3Q_q - 6Q_u - Q_{H_d} - Q_{l_4} + Q_{H_u} \Big) \\ &+ 2 g_p^4 Q_{e_4}^2 \Big(18 Q_q^2 + 2Q_{e_9}^2 + 2Q_{H_d}^2 + 2Q_{H_u}^2 + 2Q_{l_4}^2 + 3Q_{e_4}^2 + 4Q_{l_9}^2 + 9Q_d^2 + 9Q_u^2 + Q_s^2 \Big) - 4|Y1|^4 \\ &- \frac{2}{5}|Y1|^2 \Big(10 g_p^2 Q_{e_4}^2 - 10 g_p^2 Q_{H_d}^2 - 10 g_p^2 Q_{l_4}^2 - 15 g_2^2 + 15 \mathrm{Tr}\Big(Y_d Y_d^\dagger \Big) + 3 g_1^2 + 5\lambda^2 + 5 \mathrm{Tr}\Big(Y2Y2^\dagger \Big) \Big)\end{aligned} \tag{23}$$

$$\gamma_{e9}^{(1)} = 2Y2^* Y2^T - \frac{2}{5}\Big(3 g_1^2 + 5 g_p^2 Q_{e_9}^2 \Big) \mathbf{1} \tag{24}$$

$$\begin{aligned}\gamma_{e9}^{(2)} = &+ \frac{2}{25} \Big(117 g_1^4 + 30 g_1^2 g_p^2 Q_{e_9} \Big(- 2Q_{l_9} + 3Q_d + 3Q_q + 4Q_{e_9} - 6Q_u - Q_{H_d} - Q_{l_4} + Q_{e_4} + Q_{H_u} \Big) \\ &+ 25 g_p^4 Q_{e_9}^2 \Big(18 Q_q^2 + 2Q_{H_d}^2 + 2Q_{H_u}^2 + 2Q_{l_4}^2 + 4Q_{e_9}^2 + 4Q_{l_9}^2 + 9Q_d^2 + 9Q_u^2 + Q_{e_4}^2 + Q_s^2 \Big) \Big) \mathbf{1} \\ &- 2Y2^* Y2^T Y2^* Y2^T \\ &+ Y2^* Y2^T \Big(- 2\lambda^2 - 2 \mathrm{Tr}\Big(Y2Y2^\dagger \Big) - 2|Y1|^2 - 4 g_p^2 Q_{e_9}^2 + 4 g_p^2 Q_{H_d}^2 + 4 g_p^2 Q_{l_9}^2 + 6 g_2^2 - 6 \mathrm{Tr}\Big(Y_d Y_d^\dagger \Big) - \frac{6}{5} g_1^2 \Big)\end{aligned} \tag{25}$$

$$\gamma_s^{(1)} = -2 g_p^2 Q_s^2 + 2\lambda^2 \tag{26}$$

$$\begin{aligned}\gamma_s^{(2)} = &+ 18 g_p^4 Q_d^2 Q_s^2 + 2 g_p^4 Q_{e_4}^2 Q_s^2 + 4 g_p^4 Q_{e_9}^2 Q_s^2 + 4 g_p^4 Q_{H_d}^2 Q_s^2 + 4 g_p^4 Q_{H_u}^2 Q_s^2 \\ &+ 4 g_p^4 Q_{l_4}^2 Q_s^2 + 8 g_p^4 Q_{l_9}^2 Q_s^2 + 36 g_p^4 Q_q^2 Q_s^2 + 6 g_p^4 Q_s^4 + 18 g_p^4 Q_s^2 Q_u^2 + \frac{6}{5} g_1^2 \lambda^2 \\ &+ 6 g_2^2 \lambda^2 + 4 g_p^2 Q_{H_d}^2 \lambda^2 + 4 g_p^2 Q_{H_u}^2 \lambda^2 - 4 g_p^2 Q_s^2 \lambda^2 - 4\lambda^4 - 2\lambda^2 |Y1|^2 - 2\lambda^2 \mathrm{Tr}\Big(Y2Y2^\dagger \Big) \\ &- 6\lambda^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger \Big) - 6\lambda^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger \Big)\end{aligned} \tag{27}$$

3.2 Gauge Couplings

$$\beta_{g_1}^{(1)} = \frac{33}{5} g_1^3 \tag{28}$$

$$\begin{aligned}\beta_{g_1}^{(2)} = &\frac{1}{25} g_1^3 \Big(199 g_1^2 + 135 g_2^2 + 440 g_3^2 + 60 g_p^2 Q_d^2 + 60 g_p^2 Q_{e_4}^2 + 120 g_p^2 Q_{e_9}^2 + 30 g_p^2 Q_{H_d}^2 + 30 g_p^2 Q_{H_u}^2 \\ &+ 30 g_p^2 Q_{l_4}^2 + 60 g_p^2 Q_{l_9}^2 + 30 g_p^2 Q_q^2 + 240 g_p^2 Q_u^2 - 30\lambda^2 - 90|Y1|^2 - 90 \mathrm{Tr}\Big(Y2Y2^\dagger \Big) - 70 \mathrm{Tr}\Big(Y_d Y_d^\dagger \Big) \\ &- 130 \mathrm{Tr}\Big(Y_u Y_u^\dagger \Big) \Big)\end{aligned} \tag{29}$$

$$\beta_{g_2}^{(1)} = g_2^3 \tag{30}$$

$$\begin{aligned}\beta_{g_2}^{(2)} = &\frac{1}{5} g_2^3 \Big(9 g_1^2 + 125 g_2^2 + 120 g_3^2 + 10 g_p^2 Q_{H_d}^2 + 10 g_p^2 Q_{H_u}^2 + 10 g_p^2 Q_{l_4}^2 + 20 g_p^2 Q_{l_9}^2 + 90 g_p^2 Q_q^2 - 10\lambda^2 \\ &- 10|Y1|^2 - 10 \mathrm{Tr}\Big(Y2Y2^\dagger \Big) - 30 \mathrm{Tr}\Big(Y_d Y_d^\dagger \Big) - 30 \mathrm{Tr}\Big(Y_u Y_u^\dagger \Big) \Big)\end{aligned} \tag{31}$$

$$\beta_{g_3}^{(1)} = -3 g_3^3 \tag{32}$$

$$\beta^{(2)}_{g_3} = \frac{1}{5}g_3^3\Big(11g_1^2 - 20\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 20\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 30g_p^2Q_d^2 + 30g_p^2Q_u^2 + 45g_2^2 + 60g_p^2Q_q^2 + 70g_3^2\Big) \tag{33}$$

$$\beta^{(1)}_{g_p} = g_p^3\Big(18Q_q^2 + 2Q_{e_9}^2 + 2Q_{H_d}^2 + 2Q_{H_u}^2 + 2Q_{l_4}^2 + 4Q_{l_9}^2 + 9Q_d^2 + 9Q_u^2 + Q_{e_4}^2 + Q_s^2\Big) \tag{34}$$

$$\begin{aligned}\beta^{(2)}_{g_p} = \frac{2}{5}g_p^3\Big(&6g_1^2Q_d^2 + 120g_3^2Q_d^2 + 90g_p^2Q_d^4 + 6g_1^2Q_{e_4}^2 + 10g_p^2Q_{e_4}^4 + 12g_1^2Q_{e_9}^2 + 20g_p^2Q_{e_9}^4\\
&+ 3g_1^2Q_{H_d}^2 + 15g_2^2Q_{H_d}^2 + 20g_p^2Q_{H_d}^4 + 3g_1^2Q_{H_u}^2 + 15g_2^2Q_{H_u}^2 + 20g_p^2Q_{H_u}^4 + 3g_1^2Q_{l_4}^2\\
&+ 15g_2^2Q_{l_4}^2 + 20g_p^2Q_{l_4}^4 + 6g_1^2Q_{l_9}^2 + 30g_2^2Q_{l_9}^2 + 40g_p^2Q_{l_9}^4 + 3g_1^2Q_q^2 + 135g_2^2Q_q^2\\
&+ 240g_3^2Q_q^2 + 180g_p^2Q_q^4 + 10g_p^2Q_s^4 + 24g_1^2Q_u^2 + 120g_3^2Q_u^2 + 90g_p^2Q_u^4 - 10Q_{H_d}^2\lambda^2\\
&- 10Q_{H_u}^2\lambda^2 - 10Q_s^2\lambda^2 - 10\Big(Q_{e_4}^2 + Q_{H_d}^2 + Q_{l_4}^2\Big)|Y1|^2 - 10\Big(Q_{e_9}^2 + Q_{H_d}^2 + Q_{l_9}^2\Big)\mathrm{Tr}\Big(Y2Y2^\dagger\Big)\\
&- 30Q_d^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 30Q_{H_d}^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 30Q_q^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 30Q_{H_u}^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)\\
&- 30Q_q^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - 30Q_u^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)\Big)\end{aligned} \tag{35}$$

3.3 Gaugino Mass Parameters

$$\beta^{(1)}_{M_1} = \frac{66}{5}g_1^2M_1 \tag{36}$$

$$\begin{aligned}\beta^{(2)}_{M_1} = \frac{2}{25}g_1^2\Big(&398g_1^2M_1 + 135g_2^2M_1 + 440g_3^2M_1 + 440g_3^2M_3 + 135g_2^2M_2 + 60g_p^2M_1Q_d^2 + 60g_p^2M_ZQ_d^2\\
&+ 60g_p^2M_1Q_{e_4}^2 + 60g_p^2M_ZQ_{e_4}^2 + 120g_p^2M_1Q_{e_9}^2 + 120g_p^2M_ZQ_{e_9}^2 + 30g_p^2M_1Q_{H_d}^2\\
&+ 30g_p^2M_ZQ_{H_d}^2 + 30g_p^2M_1Q_{H_u}^2 + 30g_p^2M_ZQ_{H_u}^2 + 30g_p^2M_1Q_{l_4}^2 + 30g_p^2M_ZQ_{l_4}^2 + 60g_p^2M_1Q_{l_9}^2\\
&+ 60g_p^2M_ZQ_{l_9}^2 + 30g_p^2M_1Q_q^2 + 30g_p^2M_ZQ_q^2 + 240g_p^2M_1Q_u^2 + 240g_p^2M_ZQ_u^2 - 30M_1\lambda^2\\
&- 90Y1^*\Big(M_1Y1 - TY1\Big) + 30\lambda T_\lambda - 90M_1\mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 70M_1\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 130M_1\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 90\mathrm{Tr}\Big(Y2^\dagger TY2\Big)\\
&+ 70\mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + 130\mathrm{Tr}\Big(Y_u^\dagger T_u\Big)\Big)\end{aligned} \tag{37}$$

$$\beta^{(1)}_{M_2} = 2g_2^2M_2 \tag{38}$$

$$\begin{aligned}\beta^{(2)}_{M_2} = \frac{2}{5}g_2^2\Big(&9g_1^2M_1 + 120g_3^2M_3 + 9g_1^2M_2 + 250g_2^2M_2 + 120g_3^2M_2 + 10g_p^2M_ZQ_{H_d}^2 + 10g_p^2M_2Q_{H_d}^2\\
&+ 10g_p^2M_ZQ_{H_u}^2 + 10g_p^2M_2Q_{H_u}^2 + 10g_p^2M_ZQ_{l_4}^2 + 10g_p^2M_2Q_{l_4}^2 + 20g_p^2M_ZQ_{l_9}^2 + 20g_p^2M_2Q_{l_9}^2\\
&+ 90g_p^2M_ZQ_q^2 + 90g_p^2M_2Q_q^2 - 10M_2\lambda^2 - 10Y1^*\Big(M_2Y1 - TY1\Big) + 10\lambda T_\lambda - 10M_2\mathrm{Tr}\Big(Y2Y2^\dagger\Big)\\
&- 30M_2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 30M_2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 10\mathrm{Tr}\Big(Y2^\dagger TY2\Big) + 30\mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + 30\mathrm{Tr}\Big(Y_u^\dagger T_u\Big)\Big)\end{aligned} \tag{39}$$

$$\beta^{(1)}_{M_3} = -6g_3^2M_3 \tag{40}$$

$$\begin{aligned}\beta^{(2)}_{M_3} = \frac{2}{5}g_3^2\Big(&11g_1^2M_1 + 11g_1^2M_3 + 45g_2^2M_3 + 140g_3^2M_3 + 45g_2^2M_2 + 30g_p^2M_3Q_d^2 + 30g_p^2M_ZQ_d^2\\
&+ 60g_p^2M_3Q_q^2 + 60g_p^2M_ZQ_q^2 + 30g_p^2M_3Q_u^2 + 30g_p^2M_ZQ_u^2 - 20M_3\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)\end{aligned}$$

$$- 20M_3\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 20\mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + 20\mathrm{Tr}\Big(Y_u^\dagger T_u\Big)\Big) \tag{41}$$

$$\beta^{(1)}_{M_Z} = 2g_p^2M_Z\Big(18Q_q^2 + 2Q_{e_9}^2 + 2Q_{H_d}^2 + 2Q_{H_u}^2 + 2Q_{l_4}^2 + 4Q_{l_9}^2 + 9Q_d^2 + 9Q_u^2 + Q_{e_4}^2 + Q_s^2\Big) \tag{42}$$

$$\begin{aligned}\beta^{(2)}_{M_Z} = {}& \frac{4}{5}g_p^2\Big(6g_1^2M_1Q_d^2 + 120g_3^2M_3Q_d^2 + 6g_1^2M_ZQ_d^2 + 120g_3^2M_ZQ_d^2 + 180g_p^2M_ZQ_d^4 + 6g_1^2M_1Q_{e_4}^2\\
&+ 6g_1^2M_ZQ_{e_4}^2 + 20g_p^2M_ZQ_{e_4}^4 + 12g_1^2M_1Q_{e_9}^2 + 12g_1^2M_ZQ_{e_9}^2 + 40g_p^2M_ZQ_{e_9}^4 + 3g_1^2M_1Q_{H_d}^2\\
&+ 3g_1^2M_ZQ_{H_d}^2 + 15g_2^2M_ZQ_{H_d}^2 + 15g_2^2M_2Q_{H_d}^2 + 40g_p^2M_ZQ_{H_d}^4 + 3g_1^2M_1Q_{H_u}^2 + 3g_1^2M_ZQ_{H_u}^2\\
&+ 15g_2^2M_ZQ_{H_u}^2 + 15g_2^2M_2Q_{H_u}^2 + 40g_p^2M_ZQ_{H_u}^4 + 3g_1^2M_1Q_{l_4}^2 + 3g_1^2M_ZQ_{l_4}^2 + 15g_2^2M_ZQ_{l_4}^2\\
&+ 15g_2^2M_2Q_{l_4}^2 + 40g_p^2M_ZQ_{l_4}^4 + 6g_1^2M_1Q_{l_9}^2 + 6g_1^2M_ZQ_{l_9}^2 + 30g_2^2M_ZQ_{l_9}^2 + 30g_2^2M_2Q_{l_9}^2\\
&+ 80g_p^2M_ZQ_{l_9}^4 + 3g_1^2M_1Q_q^2 + 240g_3^2M_3Q_q^2 + 3g_1^2M_ZQ_q^2 + 135g_2^2M_ZQ_q^2 + 240g_3^2M_ZQ_q^2\\
&+ 135g_2^2M_2Q_q^2 + 360g_p^2M_ZQ_q^4 + 20g_p^2M_ZQ_s^4 + 24g_1^2M_1Q_u^2 + 120g_3^2M_3Q_u^2 + 24g_1^2M_ZQ_u^2\\
&+ 120g_3^2M_ZQ_u^2 + 180g_p^2M_ZQ_u^4 - 10M_ZQ_{H_d}^2\lambda^2 - 10M_ZQ_{H_u}^2\lambda^2 - 10M_ZQ_s^2\lambda^2\\
&- 10\Big(Q_{e_4}^2 + Q_{H_d}^2 + Q_{l_4}^2\Big)Y1^*\Big(M_ZY1 - TY1\Big) + 10\Big(Q_{H_d}^2 + Q_{H_u}^2 + Q_s^2\Big)\lambda T_\lambda - 10M_ZQ_{e_9}^2\mathrm{Tr}\Big(Y2Y2^\dagger\Big)\\
&- 10M_ZQ_{H_d}^2\mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 10M_ZQ_{l_9}^2\mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 30M_ZQ_d^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 30M_ZQ_{H_d}^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)\\
&- 30M_ZQ_q^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 30M_ZQ_{H_u}^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - 30M_ZQ_q^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - 30M_ZQ_u^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)\\
&+ 10Q_{e_9}^2\mathrm{Tr}\Big(Y2^\dagger TY2\Big) + 10Q_{H_d}^2\mathrm{Tr}\Big(Y2^\dagger TY2\Big) + 10Q_{l_9}^2\mathrm{Tr}\Big(Y2^\dagger TY2\Big) + 30Q_d^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + 30Q_{H_d}^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)\\
&+ 30Q_q^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + 30Q_{H_u}^2\mathrm{Tr}\Big(Y_u^\dagger T_u\Big) + 30Q_q^2\mathrm{Tr}\Big(Y_u^\dagger T_u\Big) + 30Q_u^2\mathrm{Tr}\Big(Y_u^\dagger T_u\Big)\Big)\end{aligned} \tag{43}$$

3.4 Trilinear Superpotential Parameters

$$\begin{aligned}\beta^{(1)}_{Y_d} = {}& +3Y_dY_d^\dagger Y_d + Y_dY_u^\dagger Y_u\\
&+ Y_d\Big(-2g_p^2Q_d^2 - 2g_p^2Q_{H_d}^2 - 2g_p^2Q_q^2 - 3g_2^2 + 3\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - \frac{16}{3}g_3^2 - \frac{7}{15}g_1^2 + \lambda^2 + |Y1|^2 + \mathrm{Tr}\Big(Y2Y2^\dagger\Big)\Big)\end{aligned} \tag{44}$$

$$\begin{aligned}\beta^{(2)}_{Y_d} = {}& +\frac{4}{5}g_1^2Y_dY_u^\dagger Y_u + 2g_p^2Q_{H_u}^2Y_dY_u^\dagger Y_u - 2g_p^2Q_q^2Y_dY_u^\dagger Y_u\\
&+ 2g_p^2Q_u^2Y_dY_u^\dagger Y_u - \lambda^2Y_dY_u^\dagger Y_u - 4Y_dY_d^\dagger Y_dY_d^\dagger Y_d - 2Y_dY_u^\dagger Y_uY_d^\dagger Y_d\\
&- 2Y_dY_u^\dagger Y_uY_u^\dagger Y_u\\
&+ Y_dY_d^\dagger Y_d\Big(-2g_p^2Q_d^2 + 2g_p^2Q_q^2 - 3\lambda^2 - 3\mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 3|Y1|^2 + 6g_2^2 + 6g_p^2Q_{H_d}^2 - 9\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + \frac{4}{5}g_1^2\Big)\\
&- 3Y_dY_u^\dagger Y_u\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)\\
&+ Y_d\Big(\frac{287}{90}g_1^4 + g_1^2g_2^2 + \frac{15}{2}g_2^4 + \frac{8}{9}g_1^2g_3^2 + 8g_2^2g_3^2 - \frac{16}{9}g_3^4 + \frac{44}{15}g_1^2g_p^2Q_d^2 + \frac{32}{3}g_3^2g_p^2Q_d^2\\
&+ 22g_p^4Q_d^4 + \frac{4}{5}g_1^2g_p^2Q_dQ_{e_4} + 2g_p^4Q_d^2Q_{e_4}^2 + \frac{8}{5}g_1^2g_p^2Q_dQ_{e_9} + 4g_p^4Q_d^2Q_{e_9}^2\end{aligned}$$

$$
\begin{aligned}
&- \frac{22}{5}g_1^2g_p^2Q_dQ_{H_d} - \frac{6}{5}g_1^2g_p^2Q_{e_4}Q_{H_d} - \frac{12}{5}g_1^2g_p^2Q_{e_9}Q_{H_d} + \frac{12}{5}g_1^2g_p^2Q_{H_d}^2 + 6g_2^2g_p^2Q_{H_d}^2 \\
&+ 22g_p^4Q_d^2Q_{H_d}^2 + 2g_p^4Q_{e_4}^2Q_{H_d}^2 + 4g_p^4Q_{e_9}^2Q_{H_d}^2 + 8g_p^4Q_{H_d}^4 + \frac{4}{5}g_1^2g_p^2Q_dQ_{H_u} \\
&- \frac{6}{5}g_1^2g_p^2Q_{H_d}Q_{H_u} + 4g_p^4Q_d^2Q_{H_u}^2 + 4g_p^4Q_{H_d}^2Q_{H_u}^2 - \frac{4}{5}g_1^2g_p^2Q_dQ_{l_4} + \frac{6}{5}g_1^2g_p^2Q_{H_d}Q_{l_4} \\
&+ 4g_p^4Q_d^2Q_{l_4}^2 + 4g_p^4Q_{H_d}^2Q_{l_4}^2 - \frac{8}{5}g_1^2g_p^2Q_dQ_{l_9} + \frac{12}{5}g_1^2g_p^2Q_{H_d}Q_{l_9} + 8g_p^4Q_d^2Q_{l_9}^2 \\
&+ 8g_p^4Q_{H_d}^2Q_{l_9}^2 + \frac{18}{5}g_1^2g_p^2Q_dQ_q + \frac{2}{5}g_1^2g_p^2Q_{e_4}Q_q + \frac{4}{5}g_1^2g_p^2Q_{e_9}Q_q - 4g_1^2g_p^2Q_{H_d}Q_q \\
&+ \frac{2}{5}g_1^2g_p^2Q_{H_u}Q_q - \frac{2}{5}g_1^2g_p^2Q_{l_4}Q_q - \frac{4}{5}g_1^2g_p^2Q_{l_9}Q_q + \frac{4}{3}g_1^2g_p^2Q_q^2 + 6g_2^2g_p^2Q_q^2 \\
&+ \frac{32}{3}g_3^2g_p^2Q_q^2 + 54g_p^4Q_d^2Q_q^2 + 2g_p^4Q_{e_4}^2Q_q^2 + 4g_p^4Q_{e_9}^2Q_q^2 + 40g_p^4Q_{H_d}^2Q_q^2 \\
&+ 4g_p^4Q_{H_u}^2Q_q^2 + 4g_p^4Q_{l_4}^2Q_q^2 + 8g_p^4Q_{l_9}^2Q_q^2 + 40g_p^4Q_q^4 + 2g_p^4Q_d^2Q_s^2 + 2g_p^4Q_{H_d}^2Q_s^2 \\
&+ 2g_p^4Q_q^2Q_s^2 - \frac{24}{5}g_1^2g_p^2Q_dQ_u + \frac{36}{5}g_1^2g_p^2Q_{H_d}Q_u - \frac{12}{5}g_1^2g_p^2Q_qQ_u + 18g_p^4Q_d^2Q_u^2 \\
&+ 18g_p^4Q_{H_d}^2Q_u^2 + 18g_p^4Q_q^2Q_u^2 - 2g_p^2Q_{H_d}^2\lambda^2 + 2g_p^2Q_{H_u}^2\lambda^2 + 2g_p^2Q_s^2\lambda^2 - 3\lambda^4 \\
&+ \frac{2}{5}\Big(3g_1^2 + 5g_p^2\Big(-Q_{H_d}^2 + Q_{e_4}^2 + Q_{l_4}^2\Big)\Big)|Y1|^2 - 3|Y1|^4 + \frac{2}{5}\Big(3g_1^2 + 5g_p^2\Big(-Q_{H_d}^2 + Q_{e_9}^2 + Q_{l_9}^2\Big)\Big)\mathrm{Tr}\Big(Y2Y2^\dagger\Big) \\
&- \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) + 6g_p^2Q_d^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 6g_p^2Q_{H_d}^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) \\
&+ 6g_p^2Q_q^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 3\lambda^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - 3\mathrm{Tr}\Big(Y2Y2^\dagger Y2Y2^\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)\Big)
\end{aligned} \tag{45}
$$

$$
\begin{aligned}
\beta_{Y1}^{(1)} = &-\frac{9}{5}g_1^2Y1 - 3g_2^2Y1 - 2g_p^2Q_{e_4}^2Y1 - 2g_p^2Q_{H_d}^2Y1 - 2g_p^2Q_{l_4}^2Y1 + Y1\lambda^2 + 4Y1^2Y1^* + Y1\mathrm{Tr}\Big(Y2Y2^\dagger\Big) \\
&+ 3Y1\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)
\end{aligned} \tag{46}
$$

$$
\begin{aligned}
\beta_{Y1}^{(2)} = &-\frac{1}{10}Y1\Big(-135g_1^4 - 18g_1^2g_2^2 - 75g_2^4 - 72g_1^2g_p^2Q_dQ_{e_4} - 72g_1^2g_p^2Q_{e_4}^2 - 180g_p^4Q_d^2Q_{e_4}^2 \\
&- 60g_p^4Q_{e_4}^4 - 48g_1^2g_p^2Q_{e_4}Q_{e_9} - 40g_p^4Q_{e_4}^2Q_{e_9}^2 + 36g_1^2g_p^2Q_dQ_{H_d} + 36g_1^2g_p^2Q_{e_4}Q_{H_d} \\
&+ 24g_1^2g_p^2Q_{e_9}Q_{H_d} - 24g_1^2g_p^2Q_{H_d}^2 - 60g_2^2g_p^2Q_{H_d}^2 - 180g_p^4Q_d^2Q_{H_d}^2 - 60g_p^4Q_{e_4}^2Q_{H_d}^2 \\
&- 40g_p^4Q_{e_9}^2Q_{H_d}^2 - 80g_p^4Q_{H_d}^4 - 24g_1^2g_p^2Q_{e_4}Q_{H_u} + 12g_1^2g_p^2Q_{H_d}Q_{H_u} - 40g_p^4Q_{e_4}^2Q_{H_u}^2 \\
&- 40g_p^4Q_{H_d}^2Q_{H_u}^2 + 36g_1^2g_p^2Q_dQ_{l_4} + 36g_1^2g_p^2Q_{e_4}Q_{l_4} + 24g_1^2g_p^2Q_{e_9}Q_{l_4} \\
&- 24g_1^2g_p^2Q_{H_d}Q_{l_4} + 12g_1^2g_p^2Q_{H_u}Q_{l_4} - 24g_1^2g_p^2Q_{l_4}^2 - 60g_2^2g_p^2Q_{l_4}^2 \\
&- 180g_p^4Q_d^2Q_{l_4}^2 - 60g_p^4Q_{e_4}^2Q_{l_4}^2 - 40g_p^4Q_{e_9}^2Q_{l_4}^2 - 80g_p^4Q_{H_d}^2Q_{l_4}^2 - 40g_p^4Q_{H_u}^2Q_{l_4}^2 \\
&- 80g_p^4Q_{l_4}^4 + 48g_1^2g_p^2Q_{e_4}Q_{l_9} - 24g_1^2g_p^2Q_{H_d}Q_{l_9} - 24g_1^2g_p^2Q_{l_4}Q_{l_9} - 80g_p^4Q_{e_4}^2Q_{l_9}^2 \\
&- 80g_p^4Q_{H_d}^2Q_{l_9}^2 - 80g_p^4Q_{l_4}^2Q_{l_9}^2 - 72g_1^2g_p^2Q_{e_4}Q_q + 36g_1^2g_p^2Q_{H_d}Q_q \\
&+ 36g_1^2g_p^2Q_{l_4}Q_q - 360g_p^4Q_{e_4}^2Q_q^2 - 360g_p^4Q_{H_d}^2Q_q^2 - 360g_p^4Q_{l_4}^2Q_q^2 - 20g_p^4Q_{e_4}^2Q_s^2 \\
&- 20g_p^4Q_{H_d}^2Q_s^2 - 20g_p^4Q_{l_4}^2Q_s^2 + 144g_1^2g_p^2Q_{e_4}Q_u - 72g_1^2g_p^2Q_{H_d}Q_u
\end{aligned}
$$

$$
\begin{aligned}
&- 72g_1^2g_p^2Q_{l_4}Q_u - 180g_p^4Q_{e_4}^2Q_u^2 - 180g_p^4Q_{H_d}^2Q_u^2 - 180g_p^4Q_{l_4}^2Q_u^2 + 20g_p^2Q_{H_d}^2\lambda^2 \\
&- 20g_p^2Q_{H_u}^2\lambda^2 - 20g_p^2Q_s^2\lambda^2 + 30\lambda^4 + 100|Y1|^4 - 4\Big(3g_1^2 + 5g_p^2\Big(- Q_{H_d}^2 + Q_{e_9}^2 + Q_{l_9}^2\Big)\Big)\mathrm{Tr}\Big(Y2Y2^\dagger\Big) \\
&- 2|Y1|^2\Big(- 15\lambda^2 - 15\mathrm{Tr}\Big(Y2Y2^\dagger\Big) + 20g_p^2Q_{H_d}^2 + 20g_p^2Q_{l_4}^2 + 30g_2^2 - 45\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + 6g_1^2\Big) \\
&+ 4g_1^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 160g_3^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 60g_p^2Q_d^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + 60g_p^2Q_{H_d}^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) \\
&- 60g_p^2Q_q^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + 30\lambda^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 30\mathrm{Tr}\Big(Y2Y2^\dagger Y2Y2^\dagger\Big) + 90\mathrm{Tr}\Big(Y_dY_d^\dagger Y_dY_d^\dagger\Big) \\
&+ 30\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big)\Big)
\end{aligned} \tag{47}
$$

$$
\begin{aligned}
\beta_{Y2}^{(1)} &= +3Y2Y2^\dagger Y2 \\
&+ Y2\Big(- 2g_p^2Q_{e_9}^2 - 2g_p^2Q_{H_d}^2 - 2g_p^2Q_{l_9}^2 - 3g_2^2 + 3\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - \frac{9}{5}g_1^2 + \lambda^2 + |Y1|^2 + \mathrm{Tr}\Big(Y2Y2^\dagger\Big)\Big)
\end{aligned} \tag{48}
$$

$$
\begin{aligned}
\beta_{Y2}^{(2)} &= -4Y2Y2^\dagger Y2Y2^\dagger Y2 \\
&+ Y2Y2^\dagger Y2\Big(- 2g_p^2Q_{e_9}^2 + 2g_p^2Q_{l_9}^2 - 3\lambda^2 - 3\mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 3|Y1|^2 + 6g_2^2 + 6g_p^2Q_{H_d}^2 - 9\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)\Big) \\
&+ \frac{1}{10}Y2\Big(135g_1^4 + 18g_1^2g_2^2 + 75g_2^4 + 72g_1^2g_p^2Q_dQ_{e_9} + 24g_1^2g_p^2Q_{e_4}Q_{e_9} + 96g_1^2g_p^2Q_{e_9}^2 \\
&+ 180g_p^4Q_d^2Q_{e_9}^2 + 20g_p^4Q_{e_4}^2Q_{e_9}^2 + 80g_p^4Q_{e_9}^4 - 36g_1^2g_p^2Q_dQ_{H_d} - 12g_1^2g_p^2Q_{e_4}Q_{H_d} \\
&- 48g_1^2g_p^2Q_{e_9}Q_{H_d} + 24g_1^2g_p^2Q_{H_d}^2 + 60g_2^2g_p^2Q_{H_d}^2 + 180g_p^4Q_d^2Q_{H_d}^2 + 20g_p^4Q_{e_4}^2Q_{H_d}^2 \\
&+ 80g_p^4Q_{e_9}^2Q_{H_d}^2 + 80g_p^4Q_{H_d}^4 + 24g_1^2g_p^2Q_{e_9}Q_{H_u} - 12g_1^2g_p^2Q_{H_d}Q_{H_u} + 40g_p^4Q_{e_9}^2Q_{H_u}^2 \\
&+ 40g_p^4Q_{H_d}^2Q_{H_u}^2 - 24g_1^2g_p^2Q_{e_9}Q_{l_4} + 12g_1^2g_p^2Q_{H_d}Q_{l_4} + 40g_p^4Q_{e_9}^2Q_{l_4}^2 + 40g_p^4Q_{H_d}^2Q_{l_4}^2 \\
&- 36g_1^2g_p^2Q_dQ_{l_9} - 12g_1^2g_p^2Q_{e_4}Q_{l_9} - 72g_1^2g_p^2Q_{e_9}Q_{l_9} + 36g_1^2g_p^2Q_{H_d}Q_{l_9} \\
&- 12g_1^2g_p^2Q_{H_u}Q_{l_9} + 12g_1^2g_p^2Q_{l_4}Q_{l_9} + 36g_1^2g_p^2Q_{l_9}^2 + 60g_2^2g_p^2Q_{l_9}^2 + 180g_p^4Q_d^2Q_{l_9}^2 \\
&+ 20g_p^4Q_{e_4}^2Q_{l_9}^2 + 120g_p^4Q_{e_9}^2Q_{l_9}^2 + 120g_p^4Q_{H_d}^2Q_{l_9}^2 + 40g_p^4Q_{H_u}^2Q_{l_9}^2 + 40g_p^4Q_{l_4}^2Q_{l_9}^2 \\
&+ 120g_p^4Q_{l_9}^4 + 72g_1^2g_p^2Q_{e_9}Q_q - 36g_1^2g_p^2Q_{H_d}Q_q - 36g_1^2g_p^2Q_{l_9}Q_q + 360g_p^4Q_{e_9}^2Q_q^2 \\
&+ 360g_p^4Q_{H_d}^2Q_q^2 + 360g_p^4Q_{l_9}^2Q_q^2 + 20g_p^4Q_{e_9}^2Q_s^2 + 20g_p^4Q_{H_d}^2Q_s^2 + 20g_p^4Q_{l_9}^2Q_s^2 \\
&- 144g_1^2g_p^2Q_{e_9}Q_u + 72g_1^2g_p^2Q_{H_d}Q_u + 72g_1^2g_p^2Q_{l_9}Q_u + 180g_p^4Q_{e_9}^2Q_u^2 + 180g_p^4Q_{H_d}^2Q_u^2 \\
&+ 180g_p^4Q_{l_9}^2Q_u^2 - 20g_p^2Q_{H_d}^2\lambda^2 + 20g_p^2Q_{H_u}^2\lambda^2 + 20g_p^2Q_s^2\lambda^2 - 30\lambda^4 \\
&+ 4\Big(3g_1^2 + 5g_p^2\Big(- Q_{H_d}^2 + Q_{e_4}^2 + Q_{l_4}^2\Big)\Big)|Y1|^2 - 30|Y1|^4 + 4\Big(3g_1^2 + 5g_p^2\Big(- Q_{H_d}^2 + Q_{e_9}^2 + Q_{l_9}^2\Big)\Big)\mathrm{Tr}\Big(Y2Y2^\dagger\Big) \\
&- 4g_1^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + 160g_3^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + 60g_p^2Q_d^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 60g_p^2Q_{H_d}^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) \\
&+ 60g_p^2Q_q^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 30\lambda^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - 30\mathrm{Tr}\Big(Y2Y2^\dagger Y2Y2^\dagger\Big) - 90\mathrm{Tr}\Big(Y_dY_d^\dagger Y_dY_d^\dagger\Big) \\
&- 30\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big)\Big)
\end{aligned} \tag{49}
$$

$$
\begin{aligned}
\beta_\lambda^{(1)} &= -\frac{3}{5}g_1^2\lambda - 3g_2^2\lambda - 2g_p^2Q_{H_d}^2\lambda - 2g_p^2Q_{H_u}^2\lambda - 2g_p^2Q_s^2\lambda + 4\lambda^3 + \lambda|Y1|^2 + \lambda\mathrm{Tr}\Big(Y2Y2^\dagger\Big) \\
&+ 3\lambda\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + 3\lambda\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)
\end{aligned} \tag{50}
$$

$$
\begin{aligned}
\beta_{\lambda}^{(2)} &= +\frac{207}{50}g_1^4\lambda + \frac{9}{5}g_1^2g_2^2\lambda + \frac{15}{2}g_2^4\lambda - \frac{18}{5}g_1^2g_p^2Q_dQ_{H_d}\lambda - \frac{6}{5}g_1^2g_p^2Q_{e_4}Q_{H_d}\lambda \\
&- \frac{12}{5}g_1^2g_p^2Q_{e_9}Q_{H_d}\lambda + \frac{12}{5}g_1^2g_p^2Q_{H_d}^2\lambda + 6g_2^2g_p^2Q_{H_d}^2\lambda + 18g_p^4Q_d^2Q_{H_d}^2\lambda \\
&+ 2g_p^4Q_{e_4}^2Q_{H_d}^2\lambda + 4g_p^4Q_{e_9}^2Q_{H_d}^2\lambda + 8g_p^4Q_{H_d}^4\lambda + \frac{18}{5}g_1^2g_p^2Q_dQ_{H_u}\lambda \\
&+ \frac{6}{5}g_1^2g_p^2Q_{e_4}Q_{H_u}\lambda + \frac{12}{5}g_1^2g_p^2Q_{e_9}Q_{H_u}\lambda - \frac{12}{5}g_1^2g_p^2Q_{H_d}Q_{H_u}\lambda + \frac{12}{5}g_1^2g_p^2Q_{H_u}^2\lambda \\
&+ 6g_2^2g_p^2Q_{H_u}^2\lambda + 18g_p^4Q_d^2Q_{H_u}^2\lambda + 2g_p^4Q_{e_4}^2Q_{H_u}^2\lambda + 4g_p^4Q_{e_9}^2Q_{H_u}^2\lambda \\
&+ 8g_p^4Q_{H_d}^2Q_{H_u}^2\lambda + 8g_p^4Q_{H_u}^4\lambda + \frac{6}{5}g_1^2g_p^2Q_{H_d}Q_{l_4}\lambda - \frac{6}{5}g_1^2g_p^2Q_{H_u}Q_{l_4}\lambda \\
&+ 4g_p^4Q_{H_d}^2Q_{l_4}^2\lambda + 4g_p^4Q_{H_u}^2Q_{l_4}^2\lambda + \frac{12}{5}g_1^2g_p^2Q_{H_d}Q_{l_9}\lambda - \frac{12}{5}g_1^2g_p^2Q_{H_u}Q_{l_9}\lambda \\
&+ 8g_p^4Q_{H_d}^2Q_{l_9}^2\lambda + 8g_p^4Q_{H_u}^2Q_{l_9}^2\lambda - \frac{18}{5}g_1^2g_p^2Q_{H_d}Q_q\lambda + \frac{18}{5}g_1^2g_p^2Q_{H_u}Q_q\lambda \\
&+ 36g_p^4Q_{H_d}^2Q_q^2\lambda + 36g_p^4Q_{H_u}^2Q_q^2\lambda + 18g_p^4Q_d^2Q_s^2\lambda + 2g_p^4Q_{e_4}^2Q_s^2\lambda \\
&+ 4g_p^4Q_{e_9}^2Q_s^2\lambda + 6g_p^4Q_{H_d}^2Q_s^2\lambda + 6g_p^4Q_{H_u}^2Q_s^2\lambda + 4g_p^4Q_{l_4}^2Q_s^2\lambda + 8g_p^4Q_{l_9}^2Q_s^2\lambda \\
&+ 36g_p^4Q_q^2Q_s^2\lambda + 6g_p^4Q_s^4\lambda + \frac{36}{5}g_1^2g_p^2Q_{H_d}Q_u\lambda - \frac{36}{5}g_1^2g_p^2Q_{H_u}Q_u\lambda + 18g_p^4Q_{H_d}^2Q_u^2\lambda \\
&+ 18g_p^4Q_{H_u}^2Q_u^2\lambda + 18g_p^4Q_s^2Q_u^2\lambda + \frac{6}{5}g_1^2\lambda^3 + 6g_2^2\lambda^3 + 4g_p^2Q_{H_d}^2\lambda^3 + 4g_p^2Q_{H_u}^2\lambda^3 \\
&- 10\lambda^5 + \frac{1}{5}\lambda\Big(10g_p^2\Big(-Q_{H_d}^2 + Q_{e_4}^2 + Q_{l_4}^2\Big) - 15\lambda^2 + 6g_1^2\Big)|Y1|^2 - 3\lambda|Y1|^4 \\
&+ \frac{1}{5}\lambda\Big(10g_p^2\Big(-Q_{H_d}^2 + Q_{e_9}^2 + Q_{l_9}^2\Big) - 15\lambda^2 + 6g_1^2\Big)\mathrm{Tr}\Big(Y2Y2^\dagger\Big) - \frac{2}{5}g_1^2\lambda\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) \\
&+ 16g_3^2\lambda\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + 6g_p^2Q_d^2\lambda\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 6g_p^2Q_{H_d}^2\lambda\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) \\
&+ 6g_p^2Q_q^2\lambda\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 9\lambda^3\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + \frac{4}{5}g_1^2\lambda\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 16g_3^2\lambda\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) \\
&- 6g_p^2Q_{H_u}^2\lambda\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 6g_p^2Q_q^2\lambda\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 6g_p^2Q_u^2\lambda\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) \\
&- 9\lambda^3\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - 3\lambda\mathrm{Tr}\Big(Y2Y2^\dagger Y2Y2^\dagger\Big) - 9\lambda\mathrm{Tr}\Big(Y_dY_d^\dagger Y_dY_d^\dagger\Big) - 6\lambda\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big) \\
&- 9\lambda\mathrm{Tr}\Big(Y_uY_u^\dagger Y_uY_u^\dagger\Big) \qquad (51)
\end{aligned}
$$

$$
\begin{aligned}
\beta_{Y_u}^{(1)} &= +Y_uY_d^\dagger Y_d + 3Y_uY_u^\dagger Y_u \\
&+ Y_u\Big(-2g_p^2Q_{H_u}^2 - 2g_p^2Q_q^2 - 2g_p^2Q_u^2 - 3g_2^2 + 3\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - \frac{13}{15}g_1^2 - \frac{16}{3}g_3^2 + \lambda^2\Big) \qquad (52)
\end{aligned}
$$

$$
\begin{aligned}
\beta_{Y_u}^{(2)} &= +\frac{2}{5}g_1^2Y_uY_u^\dagger Y_u + 6g_2^2Y_uY_u^\dagger Y_u + 6g_p^2Q_{H_u}^2Y_uY_u^\dagger Y_u + 2g_p^2Q_q^2Y_uY_u^\dagger Y_u \\
&- 2g_p^2Q_u^2Y_uY_u^\dagger Y_u - 3\lambda^2Y_uY_u^\dagger Y_u - 2Y_uY_d^\dagger Y_dY_d^\dagger Y_d - 2Y_uY_d^\dagger Y_dY_u^\dagger Y_u \\
&- 4Y_uY_u^\dagger Y_uY_u^\dagger Y_u \\
&+ Y_uY_d^\dagger Y_d\Big(2g_p^2Q_d^2 + 2g_p^2Q_{H_d}^2 - 2g_p^2Q_q^2 - 3\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + \frac{2}{5}g_1^2 - \lambda^2 - \mathrm{Tr}\Big(Y2Y2^\dagger\Big) - |Y1|^2\Big)
\end{aligned}
$$

$$
\begin{aligned}
&- 9Y_uY_u^\dagger Y_u\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)\\
&+ Y_u\Big(\frac{2743}{450}g_1^4 + g_1^2g_2^2 + \frac{15}{2}g_2^4 + \frac{136}{45}g_1^2g_3^2 + 8g_2^2g_3^2 - \frac{16}{9}g_3^4 + \frac{18}{5}g_1^2g_p^2Q_dQ_{H_u} + \frac{6}{5}g_1^2g_p^2Q_{e_4}Q_{H_u}\\
&+ \frac{12}{5}g_1^2g_p^2Q_{e_9}Q_{H_u} - \frac{6}{5}g_1^2g_p^2Q_{H_d}Q_{H_u} + \frac{12}{5}g_1^2g_p^2Q_{H_u}^2 + 6g_2^2g_p^2Q_{H_u}^2 + 18g_p^4Q_d^2Q_{H_u}^2\\
&+ 2g_p^4Q_{e_4}^2Q_{H_u}^2 + 4g_p^4Q_{e_9}^2Q_{H_u}^2 + 4g_p^4Q_{H_d}^2Q_{H_u}^2 + 8g_p^4Q_{H_u}^4 - \frac{6}{5}g_1^2g_p^2Q_{H_u}Q_{l_4}\\
&+ 4g_p^4Q_{H_u}^2Q_{l_4}^2 - \frac{12}{5}g_1^2g_p^2Q_{H_u}Q_{l_9} + 8g_p^4Q_{H_u}^2Q_{l_9}^2 + \frac{6}{5}g_1^2g_p^2Q_dQ_q + \frac{2}{5}g_1^2g_p^2Q_{e_4}Q_q\\
&+ \frac{4}{5}g_1^2g_p^2Q_{e_9}Q_q - \frac{2}{5}g_1^2g_p^2Q_{H_d}Q_q + 4g_1^2g_p^2Q_{H_u}Q_q - \frac{2}{5}g_1^2g_p^2Q_{l_4}Q_q - \frac{4}{5}g_1^2g_p^2Q_{l_9}Q_q\\
&+ \frac{4}{3}g_1^2g_p^2Q_q^2 + 6g_2^2g_p^2Q_q^2 + \frac{32}{3}g_3^2g_p^2Q_q^2 + 18g_p^4Q_d^2Q_q^2 + 2g_p^4Q_{e_4}^2Q_q^2\\
&+ 4g_p^4Q_{e_9}^2Q_q^2 + 4g_p^4Q_{H_d}^2Q_q^2 + 40g_p^4Q_{H_u}^2Q_q^2 + 4g_p^4Q_{l_4}^2Q_q^2 + 8g_p^4Q_{l_9}^2Q_q^2\\
&+ 40g_p^4Q_q^4 + 2g_p^4Q_{H_u}^2Q_s^2 + 2g_p^4Q_q^2Q_s^2 - \frac{24}{5}g_1^2g_p^2Q_dQ_u - \frac{8}{5}g_1^2g_p^2Q_{e_4}Q_u\\
&- \frac{16}{5}g_1^2g_p^2Q_{e_9}Q_u + \frac{8}{5}g_1^2g_p^2Q_{H_d}Q_u - \frac{44}{5}g_1^2g_p^2Q_{H_u}Q_u + \frac{8}{5}g_1^2g_p^2Q_{l_4}Q_u + \frac{16}{5}g_1^2g_p^2Q_{l_9}Q_u\\
&- \frac{36}{5}g_1^2g_p^2Q_qQ_u + \frac{176}{15}g_1^2g_p^2Q_u^2 + \frac{32}{3}g_3^2g_p^2Q_u^2 + 18g_p^4Q_d^2Q_u^2 + 2g_p^4Q_{e_4}^2Q_u^2\\
&+ 4g_p^4Q_{e_9}^2Q_u^2 + 4g_p^4Q_{H_d}^2Q_u^2 + 22g_p^4Q_{H_u}^2Q_u^2 + 4g_p^4Q_{l_4}^2Q_u^2 + 8g_p^4Q_{l_9}^2Q_u^2\\
&+ 54g_p^4Q_q^2Q_u^2 + 2g_p^4Q_s^2Q_u^2 + 22g_p^4Q_u^4 + 2g_p^2Q_{H_d}^2\lambda^2 - 2g_p^2Q_{H_u}^2\lambda^2 + 2g_p^2Q_s^2\lambda^2\\
&- 3\lambda^4 - \lambda^2|Y1|^2 - \lambda^2\mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 3\lambda^2\mathrm{Tr}\Big(Y_dY_d^\dagger\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)\\
&- 6g_p^2Q_{H_u}^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 6g_p^2Q_q^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 6g_p^2Q_u^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)\Big)
\end{aligned}
\tag{53}
$$

3.5 Trilinear Soft-Breaking Parameters

$$
\begin{aligned}
\beta_{T_d}^{(1)} &= +4Y_dY_d^\dagger T_d + 2Y_dY_u^\dagger T_u + 5T_dY_d^\dagger Y_d + T_dY_u^\dagger Y_u - \frac{7}{15}g_1^2T_d - 3g_2^2T_d - \frac{16}{3}g_3^2T_d\\
&- 2g_p^2Q_d^2T_d - 2g_p^2Q_{H_d}^2T_d - 2g_p^2Q_q^2T_d + \lambda^2T_d + |Y1|^2T_d + T_d\mathrm{Tr}\Big(Y2Y2^\dagger\Big) + 3T_d\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)\\
&+ Y_d\Big(\frac{14}{15}g_1^2M_1 + \frac{32}{3}g_3^2M_3 + 6g_2^2M_2 + 4g_p^2M_ZQ_d^2 + 4g_p^2M_ZQ_{H_d}^2 + 4g_p^2M_ZQ_q^2 + 2Y1^*TY1 + 2\lambda T_\lambda\\
&+ 2\mathrm{Tr}\Big(Y2^\dagger TY2\Big) + 6\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)\Big)
\end{aligned}
\tag{54}
$$

$$
\begin{aligned}
\beta_{T_d}^{(2)} &= +\frac{6}{5}g_1^2Y_dY_d^\dagger T_d + 6g_2^2Y_dY_d^\dagger T_d + 8g_p^2Q_{H_d}^2Y_dY_d^\dagger T_d - 4\lambda^2Y_dY_d^\dagger T_d\\
&- 4|Y1|^2Y_dY_d^\dagger T_d - \frac{8}{5}g_1^2M_1Y_dY_u^\dagger Y_u - 4g_p^2M_ZQ_{H_u}^2Y_dY_u^\dagger Y_u
\end{aligned}
$$

$$
\begin{aligned}
&+ 4g_p^2 M_Z Q_q^2 Y_d Y_u^\dagger Y_u - 4g_p^2 M_Z Q_u^2 Y_d Y_u^\dagger Y_u + \frac{8}{5} g_1^2 Y_d Y_u^\dagger T_u \\
&+ 4g_p^2 Q_{H_u}^2 Y_d Y_u^\dagger T_u - 4g_p^2 Q_q^2 Y_d Y_u^\dagger T_u + 4g_p^2 Q_u^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 - 6 g_p^2 Q_d^2 T_d Y_d^\dagger Y_d \\
&+ 10 g_p^2 Q_{H_d}^2 T_d Y_d^\dagger Y_d + 6 g_p^2 Q_q^2 T_d Y_d^\dagger Y_d - 5\lambda^2 T_d Y_d^\dagger Y_d \\
&- 5|Y1|^2 T_d Y_d^\dagger Y_d + \frac{4}{5} g_1^2 T_d Y_u^\dagger Y_u + 2 g_p^2 Q_{H_u}^2 T_d Y_u^\dagger Y_u \\
&- 2 g_p^2 Q_q^2 T_d Y_u^\dagger Y_u + 2 g_p^2 Q_u^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 \\
&+ \frac{287}{90} g_1^4 T_d + g_1^2 g_2^2 T_d + \frac{15}{2} g_2^4 T_d + \frac{8}{9} g_1^2 g_3^2 T_d + 8 g_2^2 g_3^2 T_d - \frac{16}{9} g_3^4 T_d + \frac{44}{15} g_1^2 g_p^2 Q_d^2 T_d \\
&+ \frac{32}{3} g_3^2 g_p^2 Q_d^2 T_d + 22 g_p^4 Q_d^4 T_d + \frac{4}{5} g_1^2 g_p^2 Q_d Q_{e_4} T_d + 2 g_p^4 Q_d^2 Q_{e_4}^2 T_d \\
&+ \frac{8}{5} g_1^2 g_p^2 Q_d Q_{e_9} T_d + 4 g_p^4 Q_d^2 Q_{e_9}^2 T_d - \frac{22}{5} g_1^2 g_p^2 Q_d Q_{H_d} T_d - \frac{6}{5} g_1^2 g_p^2 Q_{e_4} Q_{H_d} T_d \\
&- \frac{12}{5} g_1^2 g_p^2 Q_{e_9} Q_{H_d} T_d + \frac{12}{5} g_1^2 g_p^2 Q_{H_d}^2 T_d + 6 g_2^2 g_p^2 Q_{H_d}^2 T_d + 22 g_p^4 Q_d^2 Q_{H_d}^2 T_d \\
&+ 2 g_p^4 Q_{e_4}^2 Q_{H_d}^2 T_d + 4 g_p^4 Q_{e_9}^2 Q_{H_d}^2 T_d + 8 g_p^4 Q_{H_d}^4 T_d + \frac{4}{5} g_1^2 g_p^2 Q_d Q_{H_u} T_d \\
&- \frac{6}{5} g_1^2 g_p^2 Q_{H_d} Q_{H_u} T_d + 4 g_p^4 Q_d^2 Q_{H_u}^2 T_d + 4 g_p^4 Q_{H_d}^2 Q_{H_u}^2 T_d - \frac{4}{5} g_1^2 g_p^2 Q_d Q_{l_4} T_d \\
&+ \frac{6}{5} g_1^2 g_p^2 Q_{H_d} Q_{l_4} T_d + 4 g_p^4 Q_d^2 Q_{l_4}^2 T_d + 4 g_p^4 Q_{H_d}^2 Q_{l_4}^2 T_d - \frac{8}{5} g_1^2 g_p^2 Q_d Q_{l_9} T_d \\
&+ \frac{12}{5} g_1^2 g_p^2 Q_{H_d} Q_{l_9} T_d + 8 g_p^4 Q_d^2 Q_{l_9}^2 T_d + 8 g_p^4 Q_{H_d}^2 Q_{l_9}^2 T_d + \frac{18}{5} g_1^2 g_p^2 Q_d Q_q T_d \\
&+ \frac{2}{5} g_1^2 g_p^2 Q_{e_4} Q_q T_d + \frac{4}{5} g_1^2 g_p^2 Q_{e_9} Q_q T_d - 4 g_1^2 g_p^2 Q_{H_d} Q_q T_d + \frac{2}{5} g_1^2 g_p^2 Q_{H_u} Q_q T_d \\
&- \frac{2}{5} g_1^2 g_p^2 Q_{l_4} Q_q T_d - \frac{4}{5} g_1^2 g_p^2 Q_{l_9} Q_q T_d + \frac{4}{3} g_1^2 g_p^2 Q_q^2 T_d + 6 g_2^2 g_p^2 Q_q^2 T_d \\
&+ \frac{32}{3} g_3^2 g_p^2 Q_q^2 T_d + 54 g_p^4 Q_d^2 Q_q^2 T_d + 2 g_p^4 Q_{e_4}^2 Q_q^2 T_d + 4 g_p^4 Q_{e_9}^2 Q_q^2 T_d \\
&+ 40 g_p^4 Q_{H_d}^2 Q_q^2 T_d + 4 g_p^4 Q_{H_u}^2 Q_q^2 T_d + 4 g_p^4 Q_{l_4}^2 Q_q^2 T_d + 8 g_p^4 Q_{l_9}^2 Q_q^2 T_d + 40 g_p^4 Q_q^4 T_d \\
&+ 2 g_p^4 Q_d^2 Q_s^2 T_d + 2 g_p^4 Q_{H_d}^2 Q_s^2 T_d + 2 g_p^4 Q_q^2 Q_s^2 T_d - \frac{24}{5} g_1^2 g_p^2 Q_d Q_u T_d \\
&+ \frac{36}{5} g_1^2 g_p^2 Q_{H_d} Q_u T_d - \frac{12}{5} g_1^2 g_p^2 Q_q Q_u T_d + 18 g_p^4 Q_d^2 Q_u^2 T_d + 18 g_p^4 Q_{H_d}^2 Q_u^2 T_d \\
&+ 18 g_p^4 Q_q^2 Q_u^2 T_d - 2 g_p^2 Q_{H_d}^2 \lambda^2 T_d + 2 g_p^2 Q_{H_u}^2 \lambda^2 T_d + 2 g_p^2 Q_s^2 \lambda^2 T_d - 3\lambda^4 T_d \\
&+ \frac{6}{5} g_1^2 |Y1|^2 T_d + 2 g_p^2 Q_{e_4}^2 |Y1|^2 T_d - 2 g_p^2 Q_{H_d}^2 |Y1|^2 T_d + 2 g_p^2 Q_{l_4}^2 |Y1|^2 T_d - 3|Y1|^4 T_d \\
&- 2\lambda Y_d Y_u^\dagger Y_u T_\lambda - 4 Y_d Y_d^\dagger T_d \mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 5 T_d Y_d^\dagger Y_d \mathrm{Tr}\Big(Y2Y2^\dagger\Big)
\end{aligned}
$$

$$
+\frac{6}{5}g_1^2T_d\mathrm{Tr}\Big(Y2Y2^\dagger\Big)+2g_p^2Q_{e_9}^2T_d\mathrm{Tr}\Big(Y2Y2^\dagger\Big)-2g_p^2Q_{H_d}^2T_d\mathrm{Tr}\Big(Y2Y2^\dagger\Big)
$$
$$
+2g_p^2Q_{l_9}^2T_d\mathrm{Tr}\Big(Y2Y2^\dagger\Big)-12Y_dY_d^\dagger T_d\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)-15T_dY_d^\dagger Y_d\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)
$$
$$
-\frac{2}{5}g_1^2T_d\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)+16g_3^2T_d\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)+6g_p^2Q_d^2T_d\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)
$$
$$
-6g_p^2Q_{H_d}^2T_d\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)+6g_p^2Q_q^2T_d\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)-6Y_dY_u^\dagger T_u\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)
$$
$$
-3T_dY_u^\dagger Y_u\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)-3\lambda^2T_d\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)
$$
$$
-\frac{2}{5}Y_dY_d^\dagger Y_d\Big(4g_1^2M_1+30g_2^2M_2-10g_p^2M_ZQ_d^2+30g_p^2M_ZQ_{H_d}^2+10g_p^2M_ZQ_q^2+15Y1^*TY1+15\lambda T_\lambda+15\mathrm{Tr}\Big(Y2^\dagger TY2\Big)
$$
$$
+45\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)\Big)
$$
$$
-6Y_dY_u^\dagger Y_u\mathrm{Tr}\Big(Y_u^\dagger T_u\Big)-3T_d\mathrm{Tr}\Big(Y2Y2^\dagger Y2Y2^\dagger\Big)-9T_d\mathrm{Tr}\Big(Y_dY_d^\dagger Y_dY_d^\dagger\Big)-3T_d\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big)
$$
$$
-\frac{2}{45}Y_d\Big(287g_1^4M_1+45g_1^2g_2^2M_1+40g_1^2g_3^2M_1+40g_1^2g_3^2M_3+360g_2^2g_3^2M_3-160g_3^4M_3
$$
$$
+45g_1^2g_2^2M_2+675g_2^4M_2+360g_2^2g_3^2M_2+132g_1^2g_p^2M_1Q_d^2+480g_3^2g_p^2M_3Q_d^2
$$
$$
+132g_1^2g_p^2M_ZQ_d^2+480g_3^2g_p^2M_ZQ_d^2+1980g_p^4M_ZQ_d^4+36g_1^2g_p^2M_1Q_dQ_{e_4}
$$
$$
+36g_1^2g_p^2M_ZQ_dQ_{e_4}+180g_p^4M_ZQ_d^2Q_{e_4}^2+72g_1^2g_p^2M_1Q_dQ_{e_9}+72g_1^2g_p^2M_ZQ_dQ_{e_9}
$$
$$
+360g_p^4M_ZQ_d^2Q_{e_9}^2-198g_1^2g_p^2M_1Q_dQ_{H_d}-198g_1^2g_p^2M_ZQ_dQ_{H_d}-54g_1^2g_p^2M_1Q_{e_4}Q_{H_d}
$$
$$
-54g_1^2g_p^2M_ZQ_{e_4}Q_{H_d}-108g_1^2g_p^2M_1Q_{e_9}Q_{H_d}-108g_1^2g_p^2M_ZQ_{e_9}Q_{H_d}+108g_1^2g_p^2M_1Q_{H_d}^2
$$
$$
+108g_1^2g_p^2M_ZQ_{H_d}^2+270g_2^2g_p^2M_ZQ_{H_d}^2+270g_2^2g_p^2M_2Q_{H_d}^2+1980g_p^4M_ZQ_d^2Q_{H_d}^2
$$
$$
+180g_p^4M_ZQ_{e_4}^2Q_{H_d}^2+360g_p^4M_ZQ_{e_9}^2Q_{H_d}^2+720g_p^4M_ZQ_{H_d}^4+36g_1^2g_p^2M_1Q_dQ_{H_u}
$$
$$
+36g_1^2g_p^2M_ZQ_dQ_{H_u}-54g_1^2g_p^2M_1Q_{H_d}Q_{H_u}-54g_1^2g_p^2M_ZQ_{H_d}Q_{H_u}+360g_p^4M_ZQ_d^2Q_{H_u}^2
$$
$$
+360g_p^4M_ZQ_{H_d}^2Q_{H_u}^2-36g_1^2g_p^2M_1Q_dQ_{l_4}-36g_1^2g_p^2M_ZQ_dQ_{l_4}+54g_1^2g_p^2M_1Q_{H_d}Q_{l_4}
$$
$$
+54g_1^2g_p^2M_ZQ_{H_d}Q_{l_4}+360g_p^4M_ZQ_d^2Q_{l_4}^2+360g_p^4M_ZQ_{H_d}^2Q_{l_4}^2-72g_1^2g_p^2M_1Q_dQ_{l_9}
$$
$$
-72g_1^2g_p^2M_ZQ_dQ_{l_9}+108g_1^2g_p^2M_1Q_{H_d}Q_{l_9}+108g_1^2g_p^2M_ZQ_{H_d}Q_{l_9}+720g_p^4M_ZQ_d^2Q_{l_9}^2
$$
$$
+720g_p^4M_ZQ_{H_d}^2Q_{l_9}^2+162g_1^2g_p^2M_1Q_dQ_q+162g_1^2g_p^2M_ZQ_dQ_q+18g_1^2g_p^2M_1Q_{e_4}Q_q
$$
$$
+18g_1^2g_p^2M_ZQ_{e_4}Q_q+36g_1^2g_p^2M_1Q_{e_9}Q_q+36g_1^2g_p^2M_ZQ_{e_9}Q_q-180g_1^2g_p^2M_1Q_{H_d}Q_q
$$
$$
-180g_1^2g_p^2M_ZQ_{H_d}Q_q+18g_1^2g_p^2M_1Q_{H_u}Q_q+18g_1^2g_p^2M_ZQ_{H_u}Q_q-18g_1^2g_p^2M_1Q_{l_4}Q_q
$$
$$
-18g_1^2g_p^2M_ZQ_{l_4}Q_q-36g_1^2g_p^2M_1Q_{l_9}Q_q-36g_1^2g_p^2M_ZQ_{l_9}Q_q+60g_1^2g_p^2M_1Q_q^2
$$
$$
+480g_3^2g_p^2M_3Q_q^2+60g_1^2g_p^2M_ZQ_q^2+270g_2^2g_p^2M_ZQ_q^2+480g_3^2g_p^2M_ZQ_q^2
$$
$$
+270g_2^2g_p^2M_2Q_q^2+4860g_p^4M_ZQ_d^2Q_q^2+180g_p^4M_ZQ_{e_4}^2Q_q^2+360g_p^4M_ZQ_{e_9}^2Q_q^2
$$
$$
+3600g_p^4M_ZQ_{H_d}^2Q_q^2+360g_p^4M_ZQ_{H_u}^2Q_q^2+360g_p^4M_ZQ_{l_4}^2Q_q^2+720g_p^4M_ZQ_{l_9}^2Q_q^2
$$
$$
+3600g_p^4M_ZQ_q^4+180g_p^4M_ZQ_d^2Q_s^2+180g_p^4M_ZQ_{H_d}^2Q_s^2+180g_p^4M_ZQ_q^2Q_s^2
$$
$$
-216g_1^2g_p^2M_1Q_dQ_u-216g_1^2g_p^2M_ZQ_dQ_u+324g_1^2g_p^2M_1Q_{H_d}Q_u+324g_1^2g_p^2M_ZQ_{H_d}Q_u
$$
$$
-108g_1^2g_p^2M_1Q_qQ_u-108g_1^2g_p^2M_ZQ_qQ_u+1620g_p^4M_ZQ_d^2Q_u^2+1620g_p^4M_ZQ_{H_d}^2Q_u^2
$$

$$
\begin{aligned}
&+1620g_p^4M_ZQ_q^2Q_u^2-90g_p^2M_ZQ_{H_d}^2\lambda^2+90g_p^2M_ZQ_{H_u}^2\lambda^2+90g_p^2M_ZQ_s^2\lambda^2+270Y1Y1^{*,2}TY1\\
&+18Y1^*\Big(3g_1^2M_1Y1-3g_1^2TY1+5g_p^2M_Z\Big(-Q_{H_d}^2+Q_{e_4}^2+Q_{l_4}^2\Big)Y1-5g_p^2\Big(-Q_{H_d}^2+Q_{e_4}^2+Q_{l_4}^2\Big)TY1\Big)\\
&+54g_1^2M_1\mathrm{Tr}\Big(Y2Y2^\dagger\Big)+90g_p^2M_ZQ_{e_9}^2\mathrm{Tr}\Big(Y2Y2^\dagger\Big)-90g_p^2M_ZQ_{H_d}^2\mathrm{Tr}\Big(Y2Y2^\dagger\Big)\\
&+90g_p^2M_ZQ_{l_9}^2\mathrm{Tr}\Big(Y2Y2^\dagger\Big)-18g_1^2M_1\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)+720g_3^2M_3\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)\\
&+270g_p^2M_ZQ_d^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)-270g_p^2M_ZQ_{H_d}^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)+270g_p^2M_ZQ_q^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)\\
&+45\lambda T_\lambda\Big(2g_p^2\Big(-Q_{H_u}^2-Q_s^2+Q_{H_d}^2\Big)+3\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)+6\lambda^2\Big)-54g_1^2\mathrm{Tr}\Big(Y2^\dagger TY2\Big)\\
&-90g_p^2Q_{e_9}^2\mathrm{Tr}\Big(Y2^\dagger TY2\Big)+90g_p^2Q_{H_d}^2\mathrm{Tr}\Big(Y2^\dagger TY2\Big)-90g_p^2Q_{l_9}^2\mathrm{Tr}\Big(Y2^\dagger TY2\Big)+18g_1^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)\\
&-720g_3^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)-270g_p^2Q_d^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)+270g_p^2Q_{H_d}^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)\\
&-270g_p^2Q_q^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)+135\lambda^2\mathrm{Tr}\Big(Y_u^\dagger T_u\Big)+270\mathrm{Tr}\Big(Y2Y2^\dagger TY2Y2^\dagger\Big)+810\mathrm{Tr}\Big(Y_dY_d^\dagger T_dY_d^\dagger\Big)\\
&+135\mathrm{Tr}\Big(Y_dY_u^\dagger T_uY_d^\dagger\Big)+135\mathrm{Tr}\Big(Y_uY_d^\dagger T_dY_u^\dagger\Big)\Big)
\end{aligned}
\tag{55}
$$

$$
\begin{aligned}
\beta_{TY1}^{(1)}=&+TY1\Big(12|Y1|^2-2g_p^2Q_{e_4}^2-2g_p^2Q_{H_d}^2-2g_p^2Q_{l_4}^2-3g_2^2+3\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)-\frac{9}{5}g_1^2+\lambda^2+\mathrm{Tr}\Big(Y2Y2^\dagger\Big)\Big)\\
&+\frac{2}{5}Y1\Big(9g_1^2M_1+15g_2^2M_2+10g_p^2M_ZQ_{e_4}^2+10g_p^2M_ZQ_{H_d}^2+10g_p^2M_ZQ_{l_4}^2+5\lambda T_\lambda+5\mathrm{Tr}\Big(Y2^\dagger TY2\Big)\\
&+15\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)\Big)
\end{aligned}
\tag{56}
$$

$$
\begin{aligned}
\beta_{TY1}^{(2)}=&\frac{1}{10}\Big(-500|Y1|^4TY1\\
&-2|Y1|^2\Big(-3TY1\Big(-15\lambda^2-15\mathrm{Tr}\Big(Y2Y2^\dagger\Big)+20g_p^2Q_{H_d}^2+20g_p^2Q_{l_4}^2+30g_2^2-45\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)+6g_1^2\Big)\\
&+2Y1\Big(15\lambda T_\lambda+15\mathrm{Tr}\Big(Y2^\dagger TY2\Big)+20g_p^2M_ZQ_{H_d}^2+20g_p^2M_ZQ_{l_4}^2+30g_2^2M_2+45\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)+6g_1^2M_1\Big)\Big)\\
&+TY1\Big(135g_1^4+18g_1^2g_2^2+75g_2^4+72g_1^2g_p^2Q_dQ_{e_4}+72g_1^2g_p^2Q_{e_4}^2+180g_p^4Q_d^2Q_{e_4}^2+60g_p^4Q_{e_4}^4\\
&+48g_1^2g_p^2Q_{e_4}Q_{e_9}+40g_p^4Q_{e_4}^2Q_{e_9}^2-36g_1^2g_p^2Q_dQ_{H_d}-36g_1^2g_p^2Q_{e_4}Q_{H_d}\\
&-24g_1^2g_p^2Q_{e_9}Q_{H_d}+24g_1^2g_p^2Q_{H_d}^2+60g_2^2g_p^2Q_{H_d}^2+180g_p^4Q_d^2Q_{H_d}^2+60g_p^4Q_{e_4}^2Q_{H_d}^2\\
&+40g_p^4Q_{e_9}^2Q_{H_d}^2+80g_p^4Q_{H_d}^4+24g_1^2g_p^2Q_{e_4}Q_{H_u}-12g_1^2g_p^2Q_{H_d}Q_{H_u}+40g_p^4Q_{e_4}^2Q_{H_u}^2\\
&+40g_p^4Q_{H_d}^2Q_{H_u}^2-36g_1^2g_p^2Q_dQ_{l_4}-36g_1^2g_p^2Q_{e_4}Q_{l_4}-24g_1^2g_p^2Q_{e_9}Q_{l_4}\\
&+24g_1^2g_p^2Q_{H_d}Q_{l_4}-12g_1^2g_p^2Q_{H_u}Q_{l_4}+24g_1^2g_p^2Q_{l_4}^2+60g_2^2g_p^2Q_{l_4}^2+180g_p^4Q_d^2Q_{l_4}^2\\
&+60g_p^4Q_{e_4}^2Q_{l_4}^2+40g_p^4Q_{e_9}^2Q_{l_4}^2+80g_p^4Q_{H_d}^2Q_{l_4}^2+40g_p^4Q_{H_u}^2Q_{l_4}^2+80g_p^4Q_{l_4}^4\\
&-48g_1^2g_p^2Q_{e_4}Q_{l_9}+24g_1^2g_p^2Q_{H_d}Q_{l_9}+24g_1^2g_p^2Q_{l_4}Q_{l_9}+80g_p^4Q_{e_4}^2Q_{l_9}^2\\
&+80g_p^4Q_{H_d}^2Q_{l_9}^2+80g_p^4Q_{l_4}^2Q_{l_9}^2+72g_1^2g_p^2Q_{e_4}Q_q-36g_1^2g_p^2Q_{H_d}Q_q-36g_1^2g_p^2Q_{l_4}Q_q\\
&+360g_p^4Q_{e_4}^2Q_q^2+360g_p^4Q_{H_d}^2Q_q^2+360g_p^4Q_{l_4}^2Q_q^2+20g_p^4Q_{e_4}^2Q_s^2+20g_p^4Q_{H_d}^2Q_s^2\\
&+20g_p^4Q_{l_4}^2Q_s^2-144g_1^2g_p^2Q_{e_4}Q_u+72g_1^2g_p^2Q_{H_d}Q_u+72g_1^2g_p^2Q_{l_4}Q_u+180g_p^4Q_{e_4}^2Q_u^2\\
&+180g_p^4Q_{H_d}^2Q_u^2+180g_p^4Q_{l_4}^2Q_u^2-20g_p^2Q_{H_d}^2\lambda^2+20g_p^2Q_{H_u}^2\lambda^2+20g_p^2Q_s^2\lambda^2-30\lambda^4
\end{aligned}
$$

$$
\begin{aligned}
&+4\Big(3g_1^2+5g_p^2\Big(-Q_{H_d}^2+Q_{e_9}^2+Q_{l_9}^2\Big)\Big)\mathrm{Tr}\Big(Y2Y2^\dagger\Big)-4\Big(-5\Big(3g_p^2\Big(-Q_{H_d}^2+Q_d^2+Q_q^2\Big)+8g_3^2\Big)+g_1^2\Big)\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)\\
&-30\lambda^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)-30\mathrm{Tr}\Big(Y2Y2^\dagger Y2Y2^\dagger\Big)-90\mathrm{Tr}\Big(Y_dY_d^\dagger Y_dY_d^\dagger\Big)-30\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big)\Big)\\
&-4Y1\Big(135g_1^4M_1+9g_1^2g_2^2M_1+9g_1^2g_2^2M_2+75g_2^4M_2+36g_1^2g_p^2M_1Q_dQ_{e_4}+36g_1^2g_p^2M_ZQ_dQ_{e_4}\\
&+36g_1^2g_p^2M_1Q_{e_4}^2+36g_1^2g_p^2M_ZQ_{e_4}^2+180g_p^4M_ZQ_d^2Q_{e_4}^2+60g_p^4M_ZQ_{e_4}^4\\
&+24g_1^2g_p^2M_1Q_{e_4}Q_{e_9}+24g_1^2g_p^2M_ZQ_{e_4}Q_{e_9}+40g_p^4M_ZQ_{e_4}^2Q_{e_9}^2-18g_1^2g_p^2M_1Q_dQ_{H_d}\\
&-18g_1^2g_p^2M_ZQ_dQ_{H_d}-18g_1^2g_p^2M_1Q_{e_4}Q_{H_d}-18g_1^2g_p^2M_ZQ_{e_4}Q_{H_d}-12g_1^2g_p^2M_1Q_{e_9}Q_{H_d}\\
&-12g_1^2g_p^2M_ZQ_{e_9}Q_{H_d}+12g_1^2g_p^2M_1Q_{H_d}^2+12g_1^2g_p^2M_ZQ_{H_d}^2+30g_2^2g_p^2M_ZQ_{H_d}^2\\
&+30g_2^2g_p^2M_2Q_{H_d}^2+180g_p^4M_ZQ_d^2Q_{H_d}^2+60g_p^4M_ZQ_{e_4}^2Q_{H_d}^2+40g_p^4M_ZQ_{e_9}^2Q_{H_d}^2\\
&+80g_p^4M_ZQ_{H_d}^4+12g_1^2g_p^2M_1Q_{e_4}Q_{H_u}+12g_1^2g_p^2M_ZQ_{e_4}Q_{H_u}-6g_1^2g_p^2M_1Q_{H_d}Q_{H_u}\\
&-6g_1^2g_p^2M_ZQ_{H_d}Q_{H_u}+40g_p^4M_ZQ_{e_4}^2Q_{H_u}^2+40g_p^4M_ZQ_{H_d}^2Q_{H_u}^2-18g_1^2g_p^2M_1Q_dQ_{l_4}\\
&-18g_1^2g_p^2M_ZQ_dQ_{l_4}-18g_1^2g_p^2M_1Q_{e_4}Q_{l_4}-18g_1^2g_p^2M_ZQ_{e_4}Q_{l_4}-12g_1^2g_p^2M_1Q_{e_9}Q_{l_4}\\
&-12g_1^2g_p^2M_ZQ_{e_9}Q_{l_4}+12g_1^2g_p^2M_1Q_{H_d}Q_{l_4}+12g_1^2g_p^2M_ZQ_{H_d}Q_{l_4}-6g_1^2g_p^2M_1Q_{H_u}Q_{l_4}\\
&-6g_1^2g_p^2M_ZQ_{H_u}Q_{l_4}+12g_1^2g_p^2M_1Q_{l_4}^2+12g_1^2g_p^2M_ZQ_{l_4}^2+30g_2^2g_p^2M_ZQ_{l_4}^2\\
&+30g_2^2g_p^2M_2Q_{l_4}^2+180g_p^4M_ZQ_d^2Q_{l_4}^2+60g_p^4M_ZQ_{e_4}^2Q_{l_4}^2+40g_p^4M_ZQ_{e_9}^2Q_{l_4}^2\\
&+80g_p^4M_ZQ_{H_d}^2Q_{l_4}^2+40g_p^4M_ZQ_{H_u}^2Q_{l_4}^2+80g_p^4M_ZQ_{l_4}^4-24g_1^2g_p^2M_1Q_{e_4}Q_{l_9}\\
&-24g_1^2g_p^2M_ZQ_{e_4}Q_{l_9}+12g_1^2g_p^2M_1Q_{H_d}Q_{l_9}+12g_1^2g_p^2M_ZQ_{H_d}Q_{l_9}+12g_1^2g_p^2M_1Q_{l_4}Q_{l_9}\\
&+12g_1^2g_p^2M_ZQ_{l_4}Q_{l_9}+80g_p^4M_ZQ_{e_4}^2Q_{l_9}^2+80g_p^4M_ZQ_{H_d}^2Q_{l_9}^2+80g_p^4M_ZQ_{l_4}^2Q_{l_9}^2\\
&+36g_1^2g_p^2M_1Q_{e_4}Q_q+36g_1^2g_p^2M_ZQ_{e_4}Q_q-18g_1^2g_p^2M_1Q_{H_d}Q_q-18g_1^2g_p^2M_ZQ_{H_d}Q_q\\
&-18g_1^2g_p^2M_1Q_{l_4}Q_q-18g_1^2g_p^2M_ZQ_{l_4}Q_q+360g_p^4M_ZQ_{e_4}^2Q_q^2+360g_p^4M_ZQ_{H_d}^2Q_q^2\\
&+360g_p^4M_ZQ_{l_4}^2Q_q^2+20g_p^4M_ZQ_{e_4}^2Q_s^2+20g_p^4M_ZQ_{H_d}^2Q_s^2+20g_p^4M_ZQ_{l_4}^2Q_s^2\\
&-72g_1^2g_p^2M_1Q_{e_4}Q_u-72g_1^2g_p^2M_ZQ_{e_4}Q_u+36g_1^2g_p^2M_1Q_{H_d}Q_u+36g_1^2g_p^2M_ZQ_{H_d}Q_u\\
&+36g_1^2g_p^2M_1Q_{l_4}Q_u+36g_1^2g_p^2M_ZQ_{l_4}Q_u+180g_p^4M_ZQ_{e_4}^2Q_u^2+180g_p^4M_ZQ_{H_d}^2Q_u^2\\
&+180g_p^4M_ZQ_{l_4}^2Q_u^2-10g_p^2M_ZQ_{H_d}^2\lambda^2+10g_p^2M_ZQ_{H_u}^2\lambda^2+10g_p^2M_ZQ_s^2\lambda^2\\
&+2\Big(3g_1^2M_1+5g_p^2M_Z\Big(-Q_{H_d}^2+Q_{e_9}^2+Q_{l_9}^2\Big)\Big)\mathrm{Tr}\Big(Y2Y2^\dagger\Big)-2g_1^2M_1\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)+80g_3^2M_3\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)\\
&+30g_p^2M_ZQ_d^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)-30g_p^2M_ZQ_{H_d}^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)+30g_p^2M_ZQ_q^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)\\
&+5\lambda T_\lambda\Big(2g_p^2\Big(-Q_{H_u}^2-Q_s^2+Q_{H_d}^2\Big)+3\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)+6\lambda^2\Big)-6g_1^2\mathrm{Tr}\Big(Y2^\dagger TY2\Big)-10g_p^2Q_{e_9}^2\mathrm{Tr}\Big(Y2^\dagger TY2\Big)\\
&+10g_p^2Q_{H_d}^2\mathrm{Tr}\Big(Y2^\dagger TY2\Big)-10g_p^2Q_{l_9}^2\mathrm{Tr}\Big(Y2^\dagger TY2\Big)+2g_1^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)-80g_3^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)\\
&-30g_p^2Q_d^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)+30g_p^2Q_{H_d}^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)-30g_p^2Q_q^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)+15\lambda^2\mathrm{Tr}\Big(Y_u^\dagger T_u\Big)\\
&+30\mathrm{Tr}\Big(Y2Y2^\dagger TY2Y2^\dagger\Big)+90\mathrm{Tr}\Big(Y_dY_d^\dagger T_dY_d^\dagger\Big)+15\mathrm{Tr}\Big(Y_dY_u^\dagger T_uY_d^\dagger\Big)+15\mathrm{Tr}\Big(Y_uY_d^\dagger T_dY_u^\dagger\Big)\Big)\Big)
\end{aligned}
\tag{57}
$$

$$
\beta_{TY2}^{(1)}=+4Y2Y2^\dagger TY2+5TY2Y2^\dagger Y2-\frac{9}{5}g_1^2TY2-3g_2^2TY2-2g_p^2Q_{e_9}^2TY2-2g_p^2Q_{H_d}^2TY2-2g_p^2Q_{l_9}^2TY2
$$

$$
\begin{aligned}
&+\lambda^2 TY2+|Y1|^2 TY2+TY2\mathrm{Tr}\Big(Y2Y2^\dagger\Big)+3TY2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)\\
&+Y2\Big(\frac{18}{5}g_1^2M_1+6g_2^2M_2+4g_p^2M_ZQ_{e_9}^2+4g_p^2M_ZQ_{H_d}^2+4g_p^2M_ZQ_{l_9}^2+2Y1^*TY1+2\lambda T_\lambda+2\mathrm{Tr}\Big(Y2^\dagger TY2\Big)\\
&+6\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)\Big) \qquad (58)\\
\beta^{(2)}_{TY2}=&+\frac{6}{5}g_1^2Y2Y2^\dagger TY2+6g_2^2Y2Y2^\dagger TY2+8g_p^2Q_{H_d}^2Y2Y2^\dagger TY2-4\lambda^2Y2Y2^\dagger TY2\\
&-4|Y1|^2Y2Y2^\dagger TY2-\frac{6}{5}g_1^2TY2Y2^\dagger Y2+12g_2^2TY2Y2^\dagger Y2-6g_p^2Q_{e_9}^2TY2Y2^\dagger Y2\\
&+10g_p^2Q_{H_d}^2TY2Y2^\dagger Y2+6g_p^2Q_{l_9}^2TY2Y2^\dagger Y2-5\lambda^2TY2Y2^\dagger Y2-5|Y1|^2TY2Y2^\dagger Y2\\
&-6Y2Y2^\dagger Y2Y2^\dagger TY2-8Y2Y2^\dagger TY2Y2^\dagger Y2-6TY2Y2^\dagger Y2Y2^\dagger Y2+\frac{27}{2}g_1^4TY2+\frac{9}{5}g_1^2g_2^2TY2+\frac{15}{2}g_2^4TY2\\
&+\frac{36}{5}g_1^2g_p^2Q_dQ_{e_9}TY2+\frac{12}{5}g_1^2g_p^2Q_{e_4}Q_{e_9}TY2+\frac{48}{5}g_1^2g_p^2Q_{e_9}^2TY2+18g_p^4Q_d^2Q_{e_9}^2TY2\\
&+2g_p^4Q_{e_4}^2Q_{e_9}^2TY2+8g_p^4Q_{e_9}^4TY2-\frac{18}{5}g_1^2g_p^2Q_dQ_{H_d}TY2-\frac{6}{5}g_1^2g_p^2Q_{e_4}Q_{H_d}TY2\\
&-\frac{24}{5}g_1^2g_p^2Q_{e_9}Q_{H_d}TY2+\frac{12}{5}g_1^2g_p^2Q_{H_d}^2TY2+6g_2^2g_p^2Q_{H_d}^2TY2+18g_p^4Q_d^2Q_{H_d}^2TY2\\
&+2g_p^4Q_{e_4}^2Q_{H_d}^2TY2+8g_p^4Q_{e_9}^2Q_{H_d}^2TY2+8g_p^4Q_{H_d}^4TY2+\frac{12}{5}g_1^2g_p^2Q_{e_9}Q_{H_u}TY2\\
&-\frac{6}{5}g_1^2g_p^2Q_{H_d}Q_{H_u}TY2+4g_p^4Q_{e_9}^2Q_{H_u}^2TY2+4g_p^4Q_{H_d}^2Q_{H_u}^2TY2-\frac{12}{5}g_1^2g_p^2Q_{e_9}Q_{l_4}TY2\\
&+\frac{6}{5}g_1^2g_p^2Q_{H_d}Q_{l_4}TY2+4g_p^4Q_{e_9}^2Q_{l_4}^2TY2+4g_p^4Q_{H_d}^2Q_{l_4}^2TY2-\frac{18}{5}g_1^2g_p^2Q_dQ_{l_9}TY2\\
&-\frac{6}{5}g_1^2g_p^2Q_{e_4}Q_{l_9}TY2-\frac{36}{5}g_1^2g_p^2Q_{e_9}Q_{l_9}TY2+\frac{18}{5}g_1^2g_p^2Q_{H_d}Q_{l_9}TY2-\frac{6}{5}g_1^2g_p^2Q_{H_u}Q_{l_9}TY2\\
&+\frac{6}{5}g_1^2g_p^2Q_{l_4}Q_{l_9}TY2+\frac{18}{5}g_1^2g_p^2Q_{l_9}^2TY2+6g_2^2g_p^2Q_{l_9}^2TY2+18g_p^4Q_d^2Q_{l_9}^2TY2\\
&+2g_p^4Q_{e_4}^2Q_{l_9}^2TY2+12g_p^4Q_{e_9}^2Q_{l_9}^2TY2+12g_p^4Q_{H_d}^2Q_{l_9}^2TY2+4g_p^4Q_{H_u}^2Q_{l_9}^2TY2\\
&+4g_p^4Q_{l_4}^2Q_{l_9}^2TY2+12g_p^4Q_{l_9}^4TY2+\frac{36}{5}g_1^2g_p^2Q_{e_9}Q_qTY2-\frac{18}{5}g_1^2g_p^2Q_{H_d}Q_qTY2\\
&-\frac{18}{5}g_1^2g_p^2Q_{l_9}Q_qTY2+36g_p^4Q_{e_9}^2Q_q^2TY2+36g_p^4Q_{H_d}^2Q_q^2TY2+36g_p^4Q_{l_9}^2Q_q^2TY2\\
&+2g_p^4Q_{e_9}^2Q_s^2TY2+2g_p^4Q_{H_d}^2Q_s^2TY2+2g_p^4Q_{l_9}^2Q_s^2TY2-\frac{72}{5}g_1^2g_p^2Q_{e_9}Q_uTY2\\
&+\frac{36}{5}g_1^2g_p^2Q_{H_d}Q_uTY2+\frac{36}{5}g_1^2g_p^2Q_{l_9}Q_uTY2+18g_p^4Q_{e_9}^2Q_u^2TY2+18g_p^4Q_{H_d}^2Q_u^2TY2\\
&+18g_p^4Q_{l_9}^2Q_u^2TY2-2g_p^2Q_{H_d}^2\lambda^2TY2+2g_p^2Q_{H_u}^2\lambda^2TY2+2g_p^2Q_s^2\lambda^2TY2-3\lambda^4TY2\\
&+\frac{6}{5}g_1^2|Y1|^2TY2+2g_p^2Q_{e_4}^2|Y1|^2TY2-2g_p^2Q_{H_d}^2|Y1|^2TY2+2g_p^2Q_{l_4}^2|Y1|^2TY2-3|Y1|^4TY2\\
&-4Y2Y2^\dagger TY2\mathrm{Tr}\Big(Y2Y2^\dagger\Big)-5TY2Y2^\dagger Y2\mathrm{Tr}\Big(Y2Y2^\dagger\Big)+\frac{6}{5}g_1^2TY2\mathrm{Tr}\Big(Y2Y2^\dagger\Big)+2g_p^2Q_{e_9}^2TY2\mathrm{Tr}\Big(Y2Y2^\dagger\Big)\\
&-2g_p^2Q_{H_d}^2TY2\mathrm{Tr}\Big(Y2Y2^\dagger\Big)+2g_p^2Q_{l_9}^2TY2\mathrm{Tr}\Big(Y2Y2^\dagger\Big)-12Y2Y2^\dagger TY2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)
\end{aligned}
$$

$$
\begin{aligned}
&- 15TY2Y2^{\dagger}Y2\mathrm{Tr}\Big(Y_dY_d^{\dagger}\Big) - \frac{2}{5}g_1^2TY2\mathrm{Tr}\Big(Y_dY_d^{\dagger}\Big) + 16g_3^2TY2\mathrm{Tr}\Big(Y_dY_d^{\dagger}\Big) + 6g_p^2Q_d^2TY2\mathrm{Tr}\Big(Y_dY_d^{\dagger}\Big) \\
&- 6g_p^2Q_{H_d}^2TY2\mathrm{Tr}\Big(Y_dY_d^{\dagger}\Big) + 6g_p^2Q_q^2TY2\mathrm{Tr}\Big(Y_dY_d^{\dagger}\Big) - 3\lambda^2TY2\mathrm{Tr}\Big(Y_uY_u^{\dagger}\Big) \\
&- 2Y2Y2^{\dagger}Y2\Big(-2g_p^2M_ZQ_{e_9}^2 + 2g_p^2M_ZQ_{l_9}^2 + 3\lambda T_\lambda + 3\mathrm{Tr}\Big(Y2^{\dagger}TY2\Big) + 3Y1^*TY1 + 6g_2^2M_2 + 6g_p^2M_ZQ_{H_d}^2 + 9\mathrm{Tr}\Big(Y_d^{\dagger}T_d\Big)\Big) \\
&- 3TY2\mathrm{Tr}\Big(Y2Y2^{\dagger}Y2Y2^{\dagger}\Big) - 9TY2\mathrm{Tr}\Big(Y_dY_d^{\dagger}Y_dY_d^{\dagger}\Big) - 3TY2\mathrm{Tr}\Big(Y_dY_u^{\dagger}Y_uY_d^{\dagger}\Big) \\
&- \frac{2}{5}Y2\Big(135g_1^4M_1 + 9g_1^2g_2^2M_1 + 9g_1^2g_2^2M_2 + 75g_2^4M_2 + 36g_1^2g_p^2M_1Q_dQ_{e_9} + 36g_1^2g_p^2M_ZQ_dQ_{e_9} \\
&+ 12g_1^2g_p^2M_1Q_{e_4}Q_{e_9} + 12g_1^2g_p^2M_ZQ_{e_4}Q_{e_9} + 48g_1^2g_p^2M_1Q_{e_9}^2 + 48g_1^2g_p^2M_ZQ_{e_9}^2 \\
&+ 180g_p^4M_ZQ_d^2Q_{e_9}^2 + 20g_p^4M_ZQ_{e_4}^2Q_{e_9}^2 + 80g_p^4M_ZQ_{e_9}^4 - 18g_1^2g_p^2M_1Q_dQ_{H_d} \\
&- 18g_1^2g_p^2M_ZQ_dQ_{H_d} - 6g_1^2g_p^2M_1Q_{e_4}Q_{H_d} - 6g_1^2g_p^2M_ZQ_{e_4}Q_{H_d} - 24g_1^2g_p^2M_1Q_{e_9}Q_{H_d} \\
&- 24g_1^2g_p^2M_ZQ_{e_9}Q_{H_d} + 12g_1^2g_p^2M_1Q_{H_d}^2 + 12g_1^2g_p^2M_ZQ_{H_d}^2 + 30g_2^2g_p^2M_ZQ_{H_d}^2 \\
&+ 30g_2^2g_p^2M_2Q_{H_d}^2 + 180g_p^4M_ZQ_d^2Q_{H_d}^2 + 20g_p^4M_ZQ_{e_4}^2Q_{H_d}^2 + 80g_p^4M_ZQ_{e_9}^2Q_{H_d}^2 \\
&+ 80g_p^4M_ZQ_{H_d}^4 + 12g_1^2g_p^2M_1Q_{e_9}Q_{H_u} + 12g_1^2g_p^2M_ZQ_{e_9}Q_{H_u} - 6g_1^2g_p^2M_1Q_{H_d}Q_{H_u} \\
&- 6g_1^2g_p^2M_ZQ_{H_d}Q_{H_u} + 40g_p^4M_ZQ_{e_9}^2Q_{H_u}^2 + 40g_p^4M_ZQ_{H_d}^2Q_{H_u}^2 - 12g_1^2g_p^2M_1Q_{e_9}Q_{l_4} \\
&- 12g_1^2g_p^2M_ZQ_{e_9}Q_{l_4} + 6g_1^2g_p^2M_1Q_{H_d}Q_{l_4} + 6g_1^2g_p^2M_ZQ_{H_d}Q_{l_4} + 40g_p^4M_ZQ_{e_9}^2Q_{l_4}^2 \\
&+ 40g_p^4M_ZQ_{H_d}^2Q_{l_4}^2 - 18g_1^2g_p^2M_1Q_dQ_{l_9} - 18g_1^2g_p^2M_ZQ_dQ_{l_9} - 6g_1^2g_p^2M_1Q_{e_4}Q_{l_9} \\
&- 6g_1^2g_p^2M_ZQ_{e_4}Q_{l_9} - 36g_1^2g_p^2M_1Q_{e_9}Q_{l_9} - 36g_1^2g_p^2M_ZQ_{e_9}Q_{l_9} + 18g_1^2g_p^2M_1Q_{H_d}Q_{l_9} \\
&+ 18g_1^2g_p^2M_ZQ_{H_d}Q_{l_9} - 6g_1^2g_p^2M_1Q_{H_u}Q_{l_9} - 6g_1^2g_p^2M_ZQ_{H_u}Q_{l_9} + 6g_1^2g_p^2M_1Q_{l_4}Q_{l_9} \\
&+ 6g_1^2g_p^2M_ZQ_{l_4}Q_{l_9} + 18g_1^2g_p^2M_1Q_{l_9}^2 + 18g_1^2g_p^2M_ZQ_{l_9}^2 + 30g_2^2g_p^2M_ZQ_{l_9}^2 \\
&+ 30g_2^2g_p^2M_2Q_{l_9}^2 + 180g_p^4M_ZQ_d^2Q_{l_9}^2 + 20g_p^4M_ZQ_{e_4}^2Q_{l_9}^2 + 120g_p^4M_ZQ_{e_9}^2Q_{l_9}^2 \\
&+ 120g_p^4M_ZQ_{H_d}^2Q_{l_9}^2 + 40g_p^4M_ZQ_{H_u}^2Q_{l_9}^2 + 40g_p^4M_ZQ_{l_4}^2Q_{l_9}^2 + 120g_p^4M_ZQ_{l_9}^4 \\
&+ 36g_1^2g_p^2M_1Q_{e_9}Q_q + 36g_1^2g_p^2M_ZQ_{e_9}Q_q - 18g_1^2g_p^2M_1Q_{H_d}Q_q - 18g_1^2g_p^2M_ZQ_{H_d}Q_q \\
&- 18g_1^2g_p^2M_1Q_{l_9}Q_q - 18g_1^2g_p^2M_ZQ_{l_9}Q_q + 360g_p^4M_ZQ_{e_9}^2Q_q^2 + 360g_p^4M_ZQ_{H_d}^2Q_q^2 \\
&+ 360g_p^4M_ZQ_{l_9}^2Q_q^2 + 20g_p^4M_ZQ_{e_9}^2Q_s^2 + 20g_p^4M_ZQ_{H_d}^2Q_s^2 + 20g_p^4M_ZQ_{l_9}^2Q_s^2 \\
&- 72g_1^2g_p^2M_1Q_{e_9}Q_u - 72g_1^2g_p^2M_ZQ_{e_9}Q_u + 36g_1^2g_p^2M_1Q_{H_d}Q_u + 36g_1^2g_p^2M_ZQ_{H_d}Q_u \\
&+ 36g_1^2g_p^2M_1Q_{l_9}Q_u + 36g_1^2g_p^2M_ZQ_{l_9}Q_u + 180g_p^4M_ZQ_{e_9}^2Q_u^2 + 180g_p^4M_ZQ_{H_d}^2Q_u^2 \\
&+ 180g_p^4M_ZQ_{l_9}^2Q_u^2 - 10g_p^2M_ZQ_{H_d}^2\lambda^2 + 10g_p^2M_ZQ_{H_u}^2\lambda^2 + 10g_p^2M_ZQ_s^2\lambda^2 + 30Y1Y1^{*,2}TY1 \\
&+ 2Y1^*\Big(3g_1^2M_1Y1 - 3g_1^2TY1 + 5g_p^2M_Z\Big(-Q_{H_d}^2 + Q_{e_4}^2 + Q_{l_4}^2\Big)Y1 - 5g_p^2\Big(-Q_{H_d}^2 + Q_{e_4}^2 + Q_{l_4}^2\Big)TY1\Big) \\
&+ 6g_1^2M_1\mathrm{Tr}\Big(Y2Y2^{\dagger}\Big) + 10g_p^2M_ZQ_{e_9}^2\mathrm{Tr}\Big(Y2Y2^{\dagger}\Big) - 10g_p^2M_ZQ_{H_d}^2\mathrm{Tr}\Big(Y2Y2^{\dagger}\Big) \\
&+ 10g_p^2M_ZQ_{l_9}^2\mathrm{Tr}\Big(Y2Y2^{\dagger}\Big) - 2g_1^2M_1\mathrm{Tr}\Big(Y_dY_d^{\dagger}\Big) + 80g_3^2M_3\mathrm{Tr}\Big(Y_dY_d^{\dagger}\Big) \\
&+ 30g_p^2M_ZQ_d^2\mathrm{Tr}\Big(Y_dY_d^{\dagger}\Big) - 30g_p^2M_ZQ_{H_d}^2\mathrm{Tr}\Big(Y_dY_d^{\dagger}\Big) + 30g_p^2M_ZQ_q^2\mathrm{Tr}\Big(Y_dY_d^{\dagger}\Big) \\
&+ 5\lambda T_\lambda\Big(2g_p^2\Big(-Q_{H_u}^2 - Q_s^2 + Q_{H_d}^2\Big) + 3\mathrm{Tr}\Big(Y_uY_u^{\dagger}\Big) + 6\lambda^2\Big) - 6g_1^2\mathrm{Tr}\Big(Y2^{\dagger}TY2\Big) - 10g_p^2Q_{e_9}^2\mathrm{Tr}\Big(Y2^{\dagger}TY2\Big)
\end{aligned}
$$

$$+10g_p^2Q_{H_d}^2\mathrm{Tr}\Big(Y2^\dagger TY2\Big)-10g_p^2Q_{l_9}^2\mathrm{Tr}\Big(Y2^\dagger TY2\Big)+2g_1^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)-80g_3^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)$$
$$-30g_p^2Q_d^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)+30g_p^2Q_{H_d}^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)-30g_p^2Q_q^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)+15\lambda^2\mathrm{Tr}\Big(Y_u^\dagger T_u\Big)$$
$$+30\mathrm{Tr}\Big(Y2Y2^\dagger TY2Y2^\dagger\Big)+90\mathrm{Tr}\Big(Y_dY_d^\dagger T_dY_d^\dagger\Big)+15\mathrm{Tr}\Big(Y_dY_u^\dagger T_uY_d^\dagger\Big)+15\mathrm{Tr}\Big(Y_uY_d^\dagger T_dY_u^\dagger\Big)\Big) \tag{59}$$

$$\beta_{T_\lambda}^{(1)}=+\frac{6}{5}g_1^2M_1\lambda+6g_2^2M_2\lambda+4g_p^2M_ZQ_{H_d}^2\lambda+4g_p^2M_ZQ_{H_u}^2\lambda+4g_p^2M_ZQ_s^2\lambda+Y1^*\Big(2\lambda TY1+Y1T_\lambda\Big)$$
$$+T_\lambda\Big(12\lambda^2-2g_p^2Q_{H_d}^2-2g_p^2Q_{H_u}^2-2g_p^2Q_s^2-3g_2^2+3\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)+3\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)-\frac{3}{5}g_1^2+\mathrm{Tr}\Big(Y2Y2^\dagger\Big)\Big)$$
$$+2\lambda\mathrm{Tr}\Big(Y2^\dagger TY2\Big)+6\lambda\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)+6\lambda\mathrm{Tr}\Big(Y_u^\dagger T_u\Big) \tag{60}$$

$$\beta_{T_\lambda}^{(2)}=-3Y1Y1^{*,2}\Big(4\lambda TY1+Y1T_\lambda\Big)$$
$$-\frac{1}{5}Y1^*\Big(-2\lambda\Big(10g_p^2\Big(-Q_{H_d}^2+Q_{e_4}^2+Q_{l_4}^2\Big)-15\lambda^2+6g_1^2\Big)TY1$$
$$+Y1\Big(\Big(-10g_p^2\Big(-Q_{H_d}^2+Q_{e_4}^2+Q_{l_4}^2\Big)+45\lambda^2-6g_1^2\Big)T_\lambda+4\Big(3g_1^2M_1+5g_p^2M_Z\Big(-Q_{H_d}^2+Q_{e_4}^2+Q_{l_4}^2\Big)\Big)\lambda\Big)\Big)$$
$$+T_\lambda\Big(\frac{207}{50}g_1^4+\frac{9}{5}g_1^2g_2^2+\frac{15}{2}g_2^4-\frac{18}{5}g_1^2g_p^2Q_dQ_{H_d}-\frac{6}{5}g_1^2g_p^2Q_{e_4}Q_{H_d}-\frac{12}{5}g_1^2g_p^2Q_{e_9}Q_{H_d}$$
$$+\frac{12}{5}g_1^2g_p^2Q_{H_d}^2+6g_2^2g_p^2Q_{H_d}^2+18g_p^4Q_d^2Q_{H_d}^2+2g_p^4Q_{e_4}^2Q_{H_d}^2+4g_p^4Q_{e_9}^2Q_{H_d}^2$$
$$+8g_p^4Q_{H_d}^4+\frac{18}{5}g_1^2g_p^2Q_dQ_{H_u}+\frac{6}{5}g_1^2g_p^2Q_{e_4}Q_{H_u}+\frac{12}{5}g_1^2g_p^2Q_{e_9}Q_{H_u}-\frac{12}{5}g_1^2g_p^2Q_{H_d}Q_{H_u}$$
$$+\frac{12}{5}g_1^2g_p^2Q_{H_u}^2+6g_2^2g_p^2Q_{H_u}^2+18g_p^4Q_d^2Q_{H_u}^2+2g_p^4Q_{e_4}^2Q_{H_u}^2+4g_p^4Q_{e_9}^2Q_{H_u}^2$$
$$+8g_p^4Q_{H_d}^2Q_{H_u}^2+8g_p^4Q_{H_u}^4+\frac{6}{5}g_1^2g_p^2Q_{H_d}Q_{l_4}-\frac{6}{5}g_1^2g_p^2Q_{H_u}Q_{l_4}+4g_p^4Q_{H_d}^2Q_{l_4}^2$$
$$+4g_p^4Q_{H_u}^2Q_{l_4}^2+\frac{12}{5}g_1^2g_p^2Q_{H_d}Q_{l_9}-\frac{12}{5}g_1^2g_p^2Q_{H_u}Q_{l_9}+8g_p^4Q_{H_d}^2Q_{l_9}^2+8g_p^4Q_{H_u}^2Q_{l_9}^2$$
$$-\frac{18}{5}g_1^2g_p^2Q_{H_d}Q_q+\frac{18}{5}g_1^2g_p^2Q_{H_u}Q_q+36g_p^4Q_{H_d}^2Q_q^2+36g_p^4Q_{H_u}^2Q_q^2+18g_p^4Q_d^2Q_s^2$$
$$+2g_p^4Q_{e_4}^2Q_s^2+4g_p^4Q_{e_9}^2Q_s^2+6g_p^4Q_{H_d}^2Q_s^2+6g_p^4Q_{H_u}^2Q_s^2+4g_p^4Q_{l_4}^2Q_s^2$$
$$+8g_p^4Q_{l_9}^2Q_s^2+36g_p^4Q_q^2Q_s^2+6g_p^4Q_s^4+\frac{36}{5}g_1^2g_p^2Q_{H_d}Q_u-\frac{36}{5}g_1^2g_p^2Q_{H_u}Q_u$$
$$+18g_p^4Q_{H_d}^2Q_u^2+18g_p^4Q_{H_u}^2Q_u^2+18g_p^4Q_s^2Q_u^2+\frac{18}{5}g_1^2\lambda^2+18g_2^2\lambda^2+12g_p^2Q_{H_d}^2\lambda^2$$
$$+12g_p^2Q_{H_u}^2\lambda^2-50\lambda^4+\frac{1}{5}\Big(10g_p^2\Big(-Q_{H_d}^2+Q_{e_9}^2+Q_{l_9}^2\Big)-45\lambda^2+6g_1^2\Big)\mathrm{Tr}\Big(Y2Y2^\dagger\Big)$$
$$-\frac{1}{5}\Big(135\lambda^2+2g_1^2-30g_p^2\Big(-Q_{H_d}^2+Q_d^2+Q_q^2\Big)-80g_3^2\Big)\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)+\frac{4}{5}g_1^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)$$
$$+16g_3^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)-6g_p^2Q_{H_u}^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)+6g_p^2Q_q^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)+6g_p^2Q_u^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)$$
$$-27\lambda^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)-3\mathrm{Tr}\Big(Y2Y2^\dagger Y2Y2^\dagger\Big)-9\mathrm{Tr}\Big(Y_dY_d^\dagger Y_dY_d^\dagger\Big)-6\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big)-9\mathrm{Tr}\Big(Y_uY_u^\dagger Y_uY_u^\dagger\Big)\Big)$$
$$-\frac{2}{25}\lambda\Big(207g_1^4M_1+45g_1^2g_2^2M_1+45g_1^2g_2^2M_2+375g_2^4M_2-90g_1^2g_p^2M_1Q_dQ_{H_d}$$

$$
\begin{aligned}
&- 90g_1^2g_p^2M_ZQ_dQ_{H_d} - 30g_1^2g_p^2M_1Q_{e_4}Q_{H_d} - 30g_1^2g_p^2M_ZQ_{e_4}Q_{H_d} - 60g_1^2g_p^2M_1Q_{e_9}Q_{H_d} \\
&- 60g_1^2g_p^2M_ZQ_{e_9}Q_{H_d} + 60g_1^2g_p^2M_1Q_{H_d}^2 + 60g_1^2g_p^2M_ZQ_{H_d}^2 + 150g_2^2g_p^2M_ZQ_{H_d}^2 \\
&+ 150g_2^2g_p^2M_2Q_{H_d}^2 + 900g_p^4M_ZQ_d^2Q_{H_d}^2 + 100g_p^4M_ZQ_{e_4}^2Q_{H_d}^2 + 200g_p^4M_ZQ_{e_9}^2Q_{H_d}^2 \\
&+ 400g_p^4M_ZQ_{H_d}^4 + 90g_1^2g_p^2M_1Q_dQ_{H_u} + 90g_1^2g_p^2M_ZQ_dQ_{H_u} + 30g_1^2g_p^2M_1Q_{e_4}Q_{H_u} \\
&+ 30g_1^2g_p^2M_ZQ_{e_4}Q_{H_u} + 60g_1^2g_p^2M_1Q_{e_9}Q_{H_u} + 60g_1^2g_p^2M_ZQ_{e_9}Q_{H_u} - 60g_1^2g_p^2M_1Q_{H_d}Q_{H_u} \\
&- 60g_1^2g_p^2M_ZQ_{H_d}Q_{H_u} + 60g_1^2g_p^2M_1Q_{H_u}^2 + 60g_1^2g_p^2M_ZQ_{H_u}^2 + 150g_2^2g_p^2M_ZQ_{H_u}^2 \\
&+ 150g_2^2g_p^2M_2Q_{H_u}^2 + 900g_p^4M_ZQ_d^2Q_{H_u}^2 + 100g_p^4M_ZQ_{e_4}^2Q_{H_u}^2 + 200g_p^4M_ZQ_{e_9}^2Q_{H_u}^2 \\
&+ 400g_p^4M_ZQ_{H_d}^2Q_{H_u}^2 + 400g_p^4M_ZQ_{H_u}^4 + 30g_1^2g_p^2M_1Q_{H_d}Q_{l_4} + 30g_1^2g_p^2M_ZQ_{H_d}Q_{l_4} \\
&- 30g_1^2g_p^2M_1Q_{H_u}Q_{l_4} - 30g_1^2g_p^2M_ZQ_{H_u}Q_{l_4} + 200g_p^4M_ZQ_{H_d}^2Q_{l_4}^2 + 200g_p^4M_ZQ_{H_u}^2Q_{l_4}^2 \\
&+ 60g_1^2g_p^2M_1Q_{H_d}Q_{l_9} + 60g_1^2g_p^2M_ZQ_{H_d}Q_{l_9} - 60g_1^2g_p^2M_1Q_{H_u}Q_{l_9} - 60g_1^2g_p^2M_ZQ_{H_u}Q_{l_9} \\
&+ 400g_p^4M_ZQ_{H_d}^2Q_{l_9}^2 + 400g_p^4M_ZQ_{H_u}^2Q_{l_9}^2 - 90g_1^2g_p^2M_1Q_{H_d}Q_q - 90g_1^2g_p^2M_ZQ_{H_d}Q_q \\
&+ 90g_1^2g_p^2M_1Q_{H_u}Q_q + 90g_1^2g_p^2M_ZQ_{H_u}Q_q + 1800g_p^4M_ZQ_{H_d}^2Q_q^2 + 1800g_p^4M_ZQ_{H_u}^2Q_q^2 \\
&+ 900g_p^4M_ZQ_d^2Q_s^2 + 100g_p^4M_ZQ_{e_4}^2Q_s^2 + 200g_p^4M_ZQ_{e_9}^2Q_s^2 + 300g_p^4M_ZQ_{H_d}^2Q_s^2 \\
&+ 300g_p^4M_ZQ_{H_u}^2Q_s^2 + 200g_p^4M_ZQ_{l_4}^2Q_s^2 + 400g_p^4M_ZQ_{l_9}^2Q_s^2 + 1800g_p^4M_ZQ_q^2Q_s^2 \\
&+ 300g_p^4M_ZQ_s^4 + 180g_1^2g_p^2M_1Q_{H_d}Q_u + 180g_1^2g_p^2M_ZQ_{H_d}Q_u - 180g_1^2g_p^2M_1Q_{H_u}Q_u \\
&- 180g_1^2g_p^2M_ZQ_{H_u}Q_u + 900g_p^4M_ZQ_{H_d}^2Q_u^2 + 900g_p^4M_ZQ_{H_u}^2Q_u^2 + 900g_p^4M_ZQ_s^2Q_u^2 \\
&+ 30g_1^2M_1\lambda^2 + 150g_2^2M_2\lambda^2 + 100g_p^2M_ZQ_{H_d}^2\lambda^2 + 100g_p^2M_ZQ_{H_u}^2\lambda^2 \\
&+ 10\Big(3g_1^2M_1 + 5g_p^2M_Z\Big(-Q_{H_d}^2 + Q_{e_9}^2 + Q_{l_9}^2\Big)\Big)\mathrm{Tr}\Big(Y2Y2^\dagger\Big) \\
&- 10\Big(-5\Big(3g_p^2M_Z\Big(-Q_{H_d}^2 + Q_d^2 + Q_q^2\Big) + 8g_3^2M_3\Big) + g_1^2M_1\Big)\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + 20g_1^2M_1\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) \\
&+ 400g_3^2M_3\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - 150g_p^2M_ZQ_{H_u}^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 150g_p^2M_ZQ_q^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) \\
&+ 150g_p^2M_ZQ_u^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - 30g_1^2\mathrm{Tr}\Big(Y2^\dagger TY2\Big) - 50g_p^2Q_{e_9}^2\mathrm{Tr}\Big(Y2^\dagger TY2\Big) + 50g_p^2Q_{H_d}^2\mathrm{Tr}\Big(Y2^\dagger TY2\Big) \\
&- 50g_p^2Q_{l_9}^2\mathrm{Tr}\Big(Y2^\dagger TY2\Big) + 75\lambda^2\mathrm{Tr}\Big(Y2^\dagger TY2\Big) + 10g_1^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big) - 400g_3^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big) \\
&- 150g_p^2Q_d^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + 150g_p^2Q_{H_d}^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big) - 150g_p^2Q_q^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + 225\lambda^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big) \\
&- 20g_1^2\mathrm{Tr}\Big(Y_u^\dagger T_u\Big) - 400g_3^2\mathrm{Tr}\Big(Y_u^\dagger T_u\Big) + 150g_p^2Q_{H_u}^2\mathrm{Tr}\Big(Y_u^\dagger T_u\Big) - 150g_p^2Q_q^2\mathrm{Tr}\Big(Y_u^\dagger T_u\Big) \\
&- 150g_p^2Q_u^2\mathrm{Tr}\Big(Y_u^\dagger T_u\Big) + 225\lambda^2\mathrm{Tr}\Big(Y_u^\dagger T_u\Big) + 150\mathrm{Tr}\Big(Y2Y2^\dagger TY2Y2^\dagger\Big) + 450\mathrm{Tr}\Big(Y_dY_d^\dagger T_dY_d^\dagger\Big) \\
&+ 150\mathrm{Tr}\Big(Y_dY_u^\dagger T_uY_d^\dagger\Big) + 150\mathrm{Tr}\Big(Y_uY_d^\dagger T_dY_u^\dagger\Big) + 450\mathrm{Tr}\Big(Y_uY_u^\dagger T_uY_u^\dagger\Big)\Big) \qquad (61)
\end{aligned}
$$

$$
\begin{aligned}
\beta_{T_u}^{(1)} = &+2Y_uY_d^\dagger T_d + 4Y_uY_u^\dagger T_u + T_uY_d^\dagger Y_d + 5T_uY_u^\dagger Y_u - \frac{13}{15}g_1^2T_u - 3g_2^2T_u - \frac{16}{3}g_3^2T_u \\
&- 2g_p^2Q_{H_u}^2T_u - 2g_p^2Q_q^2T_u - 2g_p^2Q_u^2T_u + \lambda^2T_u + 3T_u\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) \\
&+ Y_u\Big(2\lambda T_\lambda + 4g_p^2M_ZQ_{H_u}^2 + 4g_p^2M_ZQ_q^2 + 4g_p^2M_ZQ_u^2 + 6g_2^2M_2 + 6\mathrm{Tr}\Big(Y_u^\dagger T_u\Big) + \frac{26}{15}g_1^2M_1 + \frac{32}{3}g_3^2M_3\Big) \qquad (62)
\end{aligned}
$$

$$
\begin{aligned}
\beta_{T_u}^{(2)} = &+\frac{4}{5}g_1^2 Y_u Y_d^\dagger T_d + 4g_p^2 Q_d^2 Y_u Y_d^\dagger T_d + 4g_p^2 Q_{H_d}^2 Y_u Y_d^\dagger T_d \\
&- 4g_p^2 Q_q^2 Y_u Y_d^\dagger T_d - 2\lambda^2 Y_u Y_d^\dagger T_d - 2|Y1|^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 - 12 g_p^2 M_Z Q_{H_u}^2 Y_u Y_u^\dagger Y_u - 4 g_p^2 M_Z Q_q^2 Y_u Y_u^\dagger Y_u \\
&+ 4 g_p^2 M_Z Q_u^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 + 8 g_p^2 Q_{H_u}^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 + 2 g_p^2 Q_d^2 T_u Y_d^\dagger Y_d + 2 g_p^2 Q_{H_d}^2 T_u Y_d^\dagger Y_d \\
&- 2 g_p^2 Q_q^2 T_u Y_d^\dagger Y_d - \lambda^2 T_u Y_d^\dagger Y_d - |Y1|^2 T_u Y_d^\dagger Y_d + 12 g_2^2 T_u Y_u^\dagger Y_u \\
&+ 10 g_p^2 Q_{H_u}^2 T_u Y_u^\dagger Y_u + 6 g_p^2 Q_q^2 T_u Y_u^\dagger Y_u - 6 g_p^2 Q_u^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 + \frac{18}{5}g_1^2 g_p^2 Q_d Q_{H_u} T_u + \frac{6}{5}g_1^2 g_p^2 Q_{e_4} Q_{H_u} T_u + \frac{12}{5}g_1^2 g_p^2 Q_{e_9} Q_{H_u} T_u \\
&- \frac{6}{5}g_1^2 g_p^2 Q_{H_d} Q_{H_u} T_u + \frac{12}{5}g_1^2 g_p^2 Q_{H_u}^2 T_u + 6 g_2^2 g_p^2 Q_{H_u}^2 T_u + 18 g_p^4 Q_d^2 Q_{H_u}^2 T_u \\
&+ 2 g_p^4 Q_{e_4}^2 Q_{H_u}^2 T_u + 4 g_p^4 Q_{e_9}^2 Q_{H_u}^2 T_u + 4 g_p^4 Q_{H_d}^2 Q_{H_u}^2 T_u + 8 g_p^4 Q_{H_u}^4 T_u \\
&- \frac{6}{5}g_1^2 g_p^2 Q_{H_u} Q_{l_4} T_u + 4 g_p^4 Q_{H_u}^2 Q_{l_4}^2 T_u - \frac{12}{5}g_1^2 g_p^2 Q_{H_u} Q_{l_9} T_u + 8 g_p^4 Q_{H_u}^2 Q_{l_9}^2 T_u \\
&+ \frac{6}{5}g_1^2 g_p^2 Q_d Q_q T_u + \frac{2}{5}g_1^2 g_p^2 Q_{e_4} Q_q T_u + \frac{4}{5}g_1^2 g_p^2 Q_{e_9} Q_q T_u - \frac{2}{5}g_1^2 g_p^2 Q_{H_d} Q_q T_u \\
&+ 4 g_1^2 g_p^2 Q_{H_u} Q_q T_u - \frac{2}{5}g_1^2 g_p^2 Q_{l_4} Q_q T_u - \frac{4}{5}g_1^2 g_p^2 Q_{l_9} Q_q T_u + \frac{4}{3}g_1^2 g_p^2 Q_q^2 T_u \\
&+ 6 g_2^2 g_p^2 Q_q^2 T_u + \frac{32}{3}g_3^2 g_p^2 Q_q^2 T_u + 18 g_p^4 Q_d^2 Q_q^2 T_u + 2 g_p^4 Q_{e_4}^2 Q_q^2 T_u \\
&+ 4 g_p^4 Q_{e_9}^2 Q_q^2 T_u + 4 g_p^4 Q_{H_d}^2 Q_q^2 T_u + 40 g_p^4 Q_{H_u}^2 Q_q^2 T_u + 4 g_p^4 Q_{l_4}^2 Q_q^2 T_u \\
&+ 8 g_p^4 Q_{l_9}^2 Q_q^2 T_u + 40 g_p^4 Q_q^4 T_u + 2 g_p^4 Q_{H_u}^2 Q_s^2 T_u + 2 g_p^4 Q_q^2 Q_s^2 T_u - \frac{24}{5}g_1^2 g_p^2 Q_d Q_u T_u \\
&- \frac{8}{5}g_1^2 g_p^2 Q_{e_4} Q_u T_u - \frac{16}{5}g_1^2 g_p^2 Q_{e_9} Q_u T_u + \frac{8}{5}g_1^2 g_p^2 Q_{H_d} Q_u T_u - \frac{44}{5}g_1^2 g_p^2 Q_{H_u} Q_u T_u \\
&+ \frac{8}{5}g_1^2 g_p^2 Q_{l_4} Q_u T_u + \frac{16}{5}g_1^2 g_p^2 Q_{l_9} Q_u T_u - \frac{36}{5}g_1^2 g_p^2 Q_q Q_u T_u + \frac{176}{15}g_1^2 g_p^2 Q_u^2 T_u \\
&+ \frac{32}{3}g_3^2 g_p^2 Q_u^2 T_u + 18 g_p^4 Q_d^2 Q_u^2 T_u + 2 g_p^4 Q_{e_4}^2 Q_u^2 T_u + 4 g_p^4 Q_{e_9}^2 Q_u^2 T_u \\
&+ 4 g_p^4 Q_{H_d}^2 Q_u^2 T_u + 22 g_p^4 Q_{H_u}^2 Q_u^2 T_u + 4 g_p^4 Q_{l_4}^2 Q_u^2 T_u + 8 g_p^4 Q_{l_9}^2 Q_u^2 T_u \\
&+ 54 g_p^4 Q_q^2 Q_u^2 T_u + 2 g_p^4 Q_s^2 Q_u^2 T_u + 22 g_p^4 Q_u^4 T_u + 2 g_p^2 Q_{H_d}^2 \lambda^2 T_u - 2 g_p^2 Q_{H_u}^2 \lambda^2 T_u \\
&+ 2 g_p^2 Q_s^2 \lambda^2 T_u - 3\lambda^4 T_u - \lambda^2 |Y1|^2 T_u - 6\lambda Y_u Y_u^\dagger Y_u T_\lambda - 2 Y_u Y_d^\dagger T_d \mathrm{Tr}\Big(Y2Y2^\dagger\Big) \\
&- T_u Y_d^\dagger Y_d \mathrm{Tr}\Big(Y2Y2^\dagger\Big) - \lambda^2 T_u \mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 6 Y_u Y_d^\dagger T_d \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big)
\end{aligned}
$$

$$
\begin{aligned}
&- 3T_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) - 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) \\
&- 6 g_p^2 Q_{H_u}^2 T_u \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) + 6 g_p^2 Q_q^2 T_u \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) + 6 g_p^2 Q_u^2 T_u \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) \\
&- \frac{2}{5} Y_u Y_d^\dagger Y_d \Big(2 g_1^2 M_1 + 10 g_p^2 M_Z Q_d^2 + 10 g_p^2 M_Z Q_{H_d}^2 - 10 g_p^2 M_Z Q_q^2 + 5 Y1^* T Y1 + 5\lambda T_\lambda + 5\mathrm{Tr}\Big(Y2^\dagger T Y2\Big) \\
&+ 15 \mathrm{Tr}\Big(Y_d^\dagger T_d\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) \\
&+ Y_u \Big(- \frac{5486}{225} g_1^4 M_1 - 2 g_1^2 g_2^2 M_1 - \frac{272}{45} g_1^2 g_3^2 M_1 - \frac{272}{45} g_1^2 g_3^2 M_3 - 16 g_2^2 g_3^2 M_3 + \frac{64}{9} g_3^4 M_3 \\
&- 2 g_1^2 g_2^2 M_2 - 30 g_2^4 M_2 - 16 g_2^2 g_3^2 M_2 - \frac{36}{5} g_1^2 g_p^2 M_1 Q_d Q_{H_u} - \frac{36}{5} g_1^2 g_p^2 M_Z Q_d Q_{H_u} \\
&- \frac{12}{5} g_1^2 g_p^2 M_1 Q_{e_4} Q_{H_u} - \frac{12}{5} g_1^2 g_p^2 M_Z Q_{e_4} Q_{H_u} - \frac{24}{5} g_1^2 g_p^2 M_1 Q_{e_9} Q_{H_u} - \frac{24}{5} g_1^2 g_p^2 M_Z Q_{e_9} Q_{H_u} \\
&+ \frac{12}{5} g_1^2 g_p^2 M_1 Q_{H_d} Q_{H_u} + \frac{12}{5} g_1^2 g_p^2 M_Z Q_{H_d} Q_{H_u} - \frac{24}{5} g_1^2 g_p^2 M_1 Q_{H_u}^2 - \frac{24}{5} g_1^2 g_p^2 M_Z Q_{H_u}^2 \\
&- 12 g_2^2 g_p^2 M_Z Q_{H_u}^2 - 12 g_2^2 g_p^2 M_2 Q_{H_u}^2 - 72 g_p^4 M_Z Q_d^2 Q_{H_u}^2 - 8 g_p^4 M_Z Q_{e_4}^2 Q_{H_u}^2 \\
&- 16 g_p^4 M_Z Q_{e_9}^2 Q_{H_u}^2 - 16 g_p^4 M_Z Q_{H_d}^2 Q_{H_u}^2 - 32 g_p^4 M_Z Q_{H_u}^4 + \frac{12}{5} g_1^2 g_p^2 M_1 Q_{H_u} Q_{l_4} \\
&+ \frac{12}{5} g_1^2 g_p^2 M_Z Q_{H_u} Q_{l_4} - 16 g_p^4 M_Z Q_{H_u}^2 Q_{l_4}^2 + \frac{24}{5} g_1^2 g_p^2 M_1 Q_{H_u} Q_{l_9} + \frac{24}{5} g_1^2 g_p^2 M_Z Q_{H_u} Q_{l_9} \\
&- 32 g_p^4 M_Z Q_{H_u}^2 Q_{l_9}^2 - \frac{12}{5} g_1^2 g_p^2 M_1 Q_d Q_q - \frac{12}{5} g_1^2 g_p^2 M_Z Q_d Q_q - \frac{4}{5} g_1^2 g_p^2 M_1 Q_{e_4} Q_q \\
&- \frac{4}{5} g_1^2 g_p^2 M_Z Q_{e_4} Q_q - \frac{8}{5} g_1^2 g_p^2 M_1 Q_{e_9} Q_q - \frac{8}{5} g_1^2 g_p^2 M_Z Q_{e_9} Q_q + \frac{4}{5} g_1^2 g_p^2 M_1 Q_{H_d} Q_q \\
&+ \frac{4}{5} g_1^2 g_p^2 M_Z Q_{H_d} Q_q - 8 g_1^2 g_p^2 M_1 Q_{H_u} Q_q - 8 g_1^2 g_p^2 M_Z Q_{H_u} Q_q + \frac{4}{5} g_1^2 g_p^2 M_1 Q_{l_4} Q_q \\
&+ \frac{4}{5} g_1^2 g_p^2 M_Z Q_{l_4} Q_q + \frac{8}{5} g_1^2 g_p^2 M_1 Q_{l_9} Q_q + \frac{8}{5} g_1^2 g_p^2 M_Z Q_{l_9} Q_q - \frac{8}{3} g_1^2 g_p^2 M_1 Q_q^2 \\
&- \frac{64}{3} g_3^2 g_p^2 M_3 Q_q^2 - \frac{8}{3} g_1^2 g_p^2 M_Z Q_q^2 - 12 g_2^2 g_p^2 M_Z Q_q^2 - \frac{64}{3} g_3^2 g_p^2 M_Z Q_q^2 \\
&- 12 g_2^2 g_p^2 M_2 Q_q^2 - 72 g_p^4 M_Z Q_d^2 Q_q^2 - 8 g_p^4 M_Z Q_{e_4}^2 Q_q^2 - 16 g_p^4 M_Z Q_{e_9}^2 Q_q^2 \\
&- 16 g_p^4 M_Z Q_{H_d}^2 Q_q^2 - 160 g_p^4 M_Z Q_{H_u}^2 Q_q^2 - 16 g_p^4 M_Z Q_{l_4}^2 Q_q^2 - 32 g_p^4 M_Z Q_{l_9}^2 Q_q^2 \\
&- 160 g_p^4 M_Z Q_q^4 - 8 g_p^4 M_Z Q_{H_u}^2 Q_s^2 - 8 g_p^4 M_Z Q_q^2 Q_s^2 + \frac{48}{5} g_1^2 g_p^2 M_1 Q_d Q_u \\
&+ \frac{48}{5} g_1^2 g_p^2 M_Z Q_d Q_u + \frac{16}{5} g_1^2 g_p^2 M_1 Q_{e_4} Q_u + \frac{16}{5} g_1^2 g_p^2 M_Z Q_{e_4} Q_u + \frac{32}{5} g_1^2 g_p^2 M_1 Q_{e_9} Q_u \\
&+ \frac{32}{5} g_1^2 g_p^2 M_Z Q_{e_9} Q_u - \frac{16}{5} g_1^2 g_p^2 M_1 Q_{H_d} Q_u - \frac{16}{5} g_1^2 g_p^2 M_Z Q_{H_d} Q_u + \frac{88}{5} g_1^2 g_p^2 M_1 Q_{H_u} Q_u \\
&+ \frac{88}{5} g_1^2 g_p^2 M_Z Q_{H_u} Q_u - \frac{16}{5} g_1^2 g_p^2 M_1 Q_{l_4} Q_u - \frac{16}{5} g_1^2 g_p^2 M_Z Q_{l_4} Q_u - \frac{32}{5} g_1^2 g_p^2 M_1 Q_{l_9} Q_u
\end{aligned}
$$

$$
\begin{aligned}
&- \frac{32}{5} g_1^2 g_p^2 M_Z Q_{l_9} Q_u + \frac{72}{5} g_1^2 g_p^2 M_1 Q_q Q_u + \frac{72}{5} g_1^2 g_p^2 M_Z Q_q Q_u - \frac{352}{15} g_1^2 g_p^2 M_1 Q_u^2 \\
&- \frac{64}{3} g_3^2 g_p^2 M_3 Q_u^2 - \frac{352}{15} g_1^2 g_p^2 M_Z Q_u^2 - \frac{64}{3} g_3^2 g_p^2 M_Z Q_u^2 - 72 g_p^4 M_Z Q_d^2 Q_u^2 \\
&- 8 g_p^4 M_Z Q_{e_4}^2 Q_u^2 - 16 g_p^4 M_Z Q_{e_9}^2 Q_u^2 - 16 g_p^4 M_Z Q_{H_d}^2 Q_u^2 - 88 g_p^4 M_Z Q_{H_u}^2 Q_u^2 \\
&- 16 g_p^4 M_Z Q_{l_4}^2 Q_u^2 - 32 g_p^4 M_Z Q_{l_9}^2 Q_u^2 - 216 g_p^4 M_Z Q_q^2 Q_u^2 - 8 g_p^4 M_Z Q_s^2 Q_u^2 \\
&- 88 g_p^4 M_Z Q_u^4 - 4 g_p^2 M_Z Q_{H_d}^2 \lambda^2 + 4 g_p^2 M_Z Q_{H_u}^2 \lambda^2 - 4 g_p^2 M_Z Q_s^2 \lambda^2 - 2\lambda Y1^* \Big(\lambda T Y1 + Y1 T_\lambda \Big) \\
&- 2\lambda T_\lambda \Big(- 2 g_p^2 Q_{H_d}^2 + 2 g_p^2 Q_{H_u}^2 - 2 g_p^2 Q_s^2 + 3 \mathrm{Tr}\Big(Y_d Y_d^\dagger \Big) + 6\lambda^2 + \mathrm{Tr}\Big(Y 2 Y 2^\dagger \Big) \Big) \\
&- \frac{8}{5} g_1^2 M_1 \mathrm{Tr}\Big(Y_u Y_u^\dagger \Big) - 32 g_3^2 M_3 \mathrm{Tr}\Big(Y_u Y_u^\dagger \Big) + 12 g_p^2 M_Z Q_{H_u}^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger \Big) \\
&- 12 g_p^2 M_Z Q_q^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger \Big) - 12 g_p^2 M_Z Q_u^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger \Big) - 2\lambda^2 \mathrm{Tr}\Big(Y 2^\dagger T Y 2 \Big) - 6\lambda^2 \mathrm{Tr}\Big(Y_d^\dagger T_d \Big) \\
&+ \frac{8}{5} g_1^2 \mathrm{Tr}\Big(Y_u^\dagger T_u \Big) + 32 g_3^2 \mathrm{Tr}\Big(Y_u^\dagger T_u \Big) - 12 g_p^2 Q_{H_u}^2 \mathrm{Tr}\Big(Y_u^\dagger T_u \Big) + 12 g_p^2 Q_q^2 \mathrm{Tr}\Big(Y_u^\dagger T_u \Big) \\
&+ 12 g_p^2 Q_u^2 \mathrm{Tr}\Big(Y_u^\dagger T_u \Big) - 6 \mathrm{Tr}\Big(Y_d Y_u^\dagger T_u Y_d^\dagger \Big) - 6 \mathrm{Tr}\Big(Y_u Y_d^\dagger T_d Y_u^\dagger \Big) - 36 \mathrm{Tr}\Big(Y_u Y_u^\dagger T_u Y_u^\dagger \Big) \Big)
\end{aligned} \tag{63}
$$

3.6 Non-holomorphic trilinear soft-terms

$$
\begin{aligned}
\beta_{T_d'}^{(1)} &= + T_d' Y_d^\dagger Y_d + 3 T_d' Y_u^\dagger Y_u + 2 Y_d Y_d^\dagger T_d' + 6 Y_d \mathrm{Tr}\Big(T_d' Y_d^\dagger \Big) + 2 Y_d \mathrm{Tr}\Big(T_e' Y 2^\dagger \Big) \\
&\quad + \frac{1}{15} T_d' \Big(15\lambda^2 + 2 g_1^2 - 30 g_p^2 \Big(- Q_{H_u}^2 + Q_d^2 + Q_q^2 \Big) + 45 \mathrm{Tr}\Big(Y_u Y_u^\dagger \Big) - 80 g_3^2 \Big)
\end{aligned} \tag{64}
$$

$$
\beta_{T_d'}^{(2)} = 0 \tag{65}
$$

$$
\begin{aligned}
\beta_{T_e'}^{(1)} &= + T_e' Y 2^\dagger Y 2 + 2 Y 2 Y 2^\dagger T_e' + 6 Y 2 \mathrm{Tr}\Big(T_d' Y_d^\dagger \Big) + 2 Y 2 \mathrm{Tr}\Big(T_e' Y 2^\dagger \Big) \\
&\quad + T_e' \Big(- 2 g_p^2 Q_{e_9}^2 + 2 g_p^2 Q_{H_u}^2 - 2 g_p^2 Q_{l_9}^2 + 3 \mathrm{Tr}\Big(Y_u Y_u^\dagger \Big) - \frac{6}{5} g_1^2 + \lambda^2 \Big)
\end{aligned} \tag{66}
$$

$$
\beta_{T_e'}^{(2)} = 0 \tag{67}
$$

3.7 Soft-Breaking Scalar Masses

$$
\sigma_{1,1} = \sqrt{\frac{3}{5}} g_1 \Big(- 2 \mathrm{Tr}\Big(m_u^2 \Big) - m_{l_4}^2 - \mathrm{Tr}\Big(m_{l_9}^2 \Big) - m_{H_d}^2 + m_{e_4}^2 + m_{H_u}^2 + \mathrm{Tr}\Big(m_d^2 \Big) + \mathrm{Tr}\Big(m_{e_9}^2 \Big) + \mathrm{Tr}\Big(m_q^2 \Big) \Big) \tag{68}
$$

$$
\begin{aligned}
\sigma_{1,4} &= g_p \Big(m_{e_4}^2 Q_{e_4} + 2 m_{H_d}^2 Q_{H_d} + 2 m_{H_u}^2 Q_{H_u} + 2 m_{l_4}^2 Q_{l_4} + m_s^2 Q_s + 3 Q_d \mathrm{Tr}\Big(m_d^2 \Big) + Q_{e_9} \mathrm{Tr}\Big(m_{e_9}^2 \Big) + 2 Q_{l_9} \mathrm{Tr}\Big(m_{l_9}^2 \Big) \\
&\quad + 6 Q_q \mathrm{Tr}\Big(m_q^2 \Big) + 3 Q_u \mathrm{Tr}\Big(m_u^2 \Big) \Big)
\end{aligned} \tag{69}
$$

$$
\sigma_{2,11} = \frac{1}{10} g_1^2 \Big(2 \mathrm{Tr}\Big(m_d^2 \Big) + 3 m_{l_4}^2 + 3 \mathrm{Tr}\Big(m_{l_9}^2 \Big) + 3 m_{H_d}^2 + 3 m_{H_u}^2 + 6 m_{e_4}^2 + 6 \mathrm{Tr}\Big(m_{e_9}^2 \Big) + 8 \mathrm{Tr}\Big(m_u^2 \Big) + \mathrm{Tr}\Big(m_q^2 \Big) \Big) \tag{70}
$$

$$\sigma_{2,14} = \sqrt{\frac{3}{5}} g_1 g_p \Big(m_{e_4}^2 Q_{e_4} - m_{H_d}^2 Q_{H_d} + m_{H_u}^2 Q_{H_u} - m_{l_4}^2 Q_{l_4} + Q_d \mathrm{Tr}\Big(m_d^2\Big) + Q_{e_9} \mathrm{Tr}\Big(m_{e_9}^2\Big) - Q_{l_9} \mathrm{Tr}\Big(m_{l_9}^2\Big) + Q_q \mathrm{Tr}\Big(m_q^2\Big) - 2 Q_u \mathrm{Tr}\Big(m_u^2\Big)\Big) \tag{71}$$

$$\begin{aligned}\sigma_{3,1} = {} & \frac{1}{20}\frac{1}{\sqrt{15}} g_1 \Big(36 g_1^2 m_{e_4}^2 - 9 g_1^2 m_{H_d}^2 - 45 g_2^2 m_{H_d}^2 + 9 g_1^2 m_{H_u}^2 + 45 g_2^2 m_{H_u}^2 - 9 g_1^2 m_{l_4}^2 - 45 g_2^2 m_{l_4}^2 \\ & + 60 g_p^2 m_{e_4}^2 Q_{e_4}^2 - 60 g_p^2 m_{H_d}^2 Q_{H_d}^2 + 60 g_p^2 m_{H_u}^2 Q_{H_u}^2 - 60 g_p^2 m_{l_4}^2 Q_{l_4}^2 + 30 m_{H_d}^2 \lambda^2 - 30 m_{H_u}^2 \lambda^2 \\ & + 30 \Big(- 2 m_{e_4}^2 + m_{H_d}^2 + m_{l_4}^2 \Big) |Y1|^2 + 4 \Big(15 g_p^2 Q_d^2 + 20 g_3^2 + g_1^2 \Big) \mathrm{Tr}\Big(m_d^2\Big) + 36 g_1^2 \mathrm{Tr}\Big(m_{e_9}^2\Big) + 60 g_p^2 Q_{e_9}^2 \mathrm{Tr}\Big(m_{e_9}^2\Big) \\ & - 9 g_1^2 \mathrm{Tr}\Big(m_{l_9}^2\Big) - 45 g_2^2 \mathrm{Tr}\Big(m_{l_9}^2\Big) - 60 g_p^2 Q_{l_9}^2 \mathrm{Tr}\Big(m_{l_9}^2\Big) + g_1^2 \mathrm{Tr}\Big(m_q^2\Big) + 45 g_2^2 \mathrm{Tr}\Big(m_q^2\Big) + 80 g_3^2 \mathrm{Tr}\Big(m_q^2\Big) \\ & + 60 g_p^2 Q_q^2 \mathrm{Tr}\Big(m_q^2\Big) - 32 g_1^2 \mathrm{Tr}\Big(m_u^2\Big) - 160 g_3^2 \mathrm{Tr}\Big(m_u^2\Big) - 120 g_p^2 Q_u^2 \mathrm{Tr}\Big(m_u^2\Big) + 30 m_{H_d}^2 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) \\ & + 90 m_{H_d}^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 90 m_{H_u}^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 60 \mathrm{Tr}\Big(Y2Y2^\dagger m_{e9^*}^2\Big) + 30 \mathrm{Tr}\Big(Y2 m_{l9^*}^2 Y2^\dagger\Big) \\ & - 60 \mathrm{Tr}\Big(Y_d Y_d^\dagger m_d^{2*}\Big) - 30 \mathrm{Tr}\Big(Y_d m_q^{2*} Y_d^\dagger\Big) + 120 \mathrm{Tr}\Big(Y_u Y_u^\dagger m_u^{2*}\Big) - 30 \mathrm{Tr}\Big(Y_u m_q^{2*} Y_u^\dagger\Big)\Big)\end{aligned} \tag{72}$$

$$\sigma_{2,2} = \frac{1}{2}\Big(3\mathrm{Tr}\Big(m_q^2\Big) + m_{H_d}^2 + m_{H_u}^2 + m_{l_4}^2 + \mathrm{Tr}\Big(m_{l_9}^2\Big)\Big) \tag{73}$$

$$\sigma_{2,3} = \frac{1}{2}\Big(2\mathrm{Tr}\Big(m_q^2\Big) + \mathrm{Tr}\Big(m_d^2\Big) + \mathrm{Tr}\Big(m_u^2\Big)\Big) \tag{74}$$

$$\sigma_{2,41} = \sqrt{\frac{3}{5}} g_1 g_p \Big(m_{e_4}^2 Q_{e_4} - m_{H_d}^2 Q_{H_d} + m_{H_u}^2 Q_{H_u} - m_{l_4}^2 Q_{l_4} + Q_d \mathrm{Tr}\Big(m_d^2\Big) + Q_{e_9} \mathrm{Tr}\Big(m_{e_9}^2\Big) - Q_{l_9} \mathrm{Tr}\Big(m_{l_9}^2\Big) + Q_q \mathrm{Tr}\Big(m_q^2\Big) - 2 Q_u \mathrm{Tr}\Big(m_u^2\Big)\Big) \tag{75}$$

$$\begin{aligned}\sigma_{2,44} = {} & g_p^2 \Big(m_{e_4}^2 Q_{e_4}^2 + 2 m_{H_d}^2 Q_{H_d}^2 + 2 m_{H_u}^2 Q_{H_u}^2 + 2 m_{l_4}^2 Q_{l_4}^2 + m_s^2 Q_s^2 + 3 Q_d^2 \mathrm{Tr}\Big(m_d^2\Big) + Q_{e_9}^2 \mathrm{Tr}\Big(m_{e_9}^2\Big) \\ & + 2 Q_{l_9}^2 \mathrm{Tr}\Big(m_{l_9}^2\Big) + 6 Q_q^2 \mathrm{Tr}\Big(m_q^2\Big) + 3 Q_u^2 \mathrm{Tr}\Big(m_u^2\Big)\Big)\end{aligned} \tag{76}$$

$$\begin{aligned}\sigma_{3,4} = {} & \frac{1}{10} g_p \Big(6 g_1^2 m_{e_4}^2 Q_{e_4} + 10 g_p^2 m_{e_4}^2 Q_{e_4}^3 + 3 g_1^2 m_{H_d}^2 Q_{H_d} + 15 g_2^2 m_{H_d}^2 Q_{H_d} + 20 g_p^2 m_{H_d}^2 Q_{H_d}^3 \\ & + 3 g_1^2 m_{H_u}^2 Q_{H_u} + 15 g_2^2 m_{H_u}^2 Q_{H_u} + 20 g_p^2 m_{H_u}^2 Q_{H_u}^3 + 3 g_1^2 m_{l_4}^2 Q_{l_4} + 15 g_2^2 m_{l_4}^2 Q_{l_4} \\ & + 20 g_p^2 m_{l_4}^2 Q_{l_4}^3 + 10 g_p^2 m_s^2 Q_s^3 - 10 m_{H_d}^2 Q_{H_d} \lambda^2 - 10 m_{H_u}^2 Q_{H_u} \lambda^2 - 10 m_s^2 Q_s \lambda^2 \\ & - 10 \Big(m_{e_4}^2 Q_{e_4} + m_{l_4}^2 Q_{l_4} + m_{H_d}^2 Q_{H_d} \Big) |Y1|^2 + 2 Q_d \Big(15 g_p^2 Q_d^2 + 20 g_3^2 + g_1^2 \Big) \mathrm{Tr}\Big(m_d^2\Big) + 6 g_1^2 Q_{e_9} \mathrm{Tr}\Big(m_{e_9}^2\Big) \\ & + 10 g_p^2 Q_{e_9}^3 \mathrm{Tr}\Big(m_{e_9}^2\Big) + 3 g_1^2 Q_{l_9} \mathrm{Tr}\Big(m_{l_9}^2\Big) + 15 g_2^2 Q_{l_9} \mathrm{Tr}\Big(m_{l_9}^2\Big) + 20 g_p^2 Q_{l_9}^3 \mathrm{Tr}\Big(m_{l_9}^2\Big) + g_1^2 Q_q \mathrm{Tr}\Big(m_q^2\Big) \\ & + 45 g_2^2 Q_q \mathrm{Tr}\Big(m_q^2\Big) + 80 g_3^2 Q_q \mathrm{Tr}\Big(m_q^2\Big) + 60 g_p^2 Q_q^3 \mathrm{Tr}\Big(m_q^2\Big) + 8 g_1^2 Q_u \mathrm{Tr}\Big(m_u^2\Big) + 40 g_3^2 Q_u \mathrm{Tr}\Big(m_u^2\Big) \\ & + 30 g_p^2 Q_u^3 \mathrm{Tr}\Big(m_u^2\Big) - 10 m_{H_d}^2 Q_{H_d} \mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 30 m_{H_d}^2 Q_{H_d} \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 30 m_{H_u}^2 Q_{H_u} \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) \\ & - 10 Q_{e_9} \mathrm{Tr}\Big(Y2Y2^\dagger m_{e9^*}^2\Big) - 10 Q_{l_9} \mathrm{Tr}\Big(Y2 m_{l9^*}^2 Y2^\dagger\Big) - 30 Q_d \mathrm{Tr}\Big(Y_d Y_d^\dagger m_d^{2*}\Big) - 30 Q_q \mathrm{Tr}\Big(Y_d m_q^{2*} Y_d^\dagger\Big) \\ & - 30 Q_u \mathrm{Tr}\Big(Y_u Y_u^\dagger m_u^{2*}\Big) - 30 Q_q \mathrm{Tr}\Big(Y_u m_q^{2*} Y_u^\dagger\Big)\Big)\end{aligned} \tag{77}$$

$$
\begin{aligned}
\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 - 8g_p^2Q_q^2\mathbf{1}|M_Z|^2 - 6g_2^2\mathbf{1}|M_2|^2 + 2m_{H_d}^2Y_d^\dagger Y_d \\
&+ 2m_{H_u}^2Y_u^\dagger Y_u + 2T_d^\dagger T_d + 2T_u^\dagger T_u + 2T_d'^T T_d'^* + m_q^2Y_d^\dagger Y_d + m_q^2Y_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} + 2g_pQ_q\mathbf{1}\sigma_{1,4} \qquad (78)\\
\beta^{(2)}_{m_q^2} =& +\frac{24}{5}g_1^2g_p^2Q_dQ_q\mathbf{1}|M_Z|^2 + \frac{8}{5}g_1^2g_p^2Q_{e_4}Q_q\mathbf{1}|M_Z|^2 + \frac{16}{5}g_1^2g_p^2Q_{e_9}Q_q\mathbf{1}|M_Z|^2 \\
&- \frac{8}{5}g_1^2g_p^2Q_{H_d}Q_q\mathbf{1}|M_Z|^2 + \frac{8}{5}g_1^2g_p^2Q_{H_u}Q_q\mathbf{1}|M_Z|^2 - \frac{8}{5}g_1^2g_p^2Q_{l_4}Q_q\mathbf{1}|M_Z|^2 \\
&- \frac{16}{5}g_1^2g_p^2Q_{l_9}Q_q\mathbf{1}|M_Z|^2 + \frac{16}{3}g_1^2g_p^2Q_q^2\mathbf{1}|M_Z|^2 + 24g_2^2g_p^2Q_q^2\mathbf{1}|M_Z|^2 \\
&+ \frac{128}{3}g_3^2g_p^2Q_q^2\mathbf{1}|M_Z|^2 + 216g_p^4Q_d^2Q_q^2\mathbf{1}|M_Z|^2 + 24g_p^4Q_{e_4}^2Q_q^2\mathbf{1}|M_Z|^2 \\
&+ 48g_p^4Q_{e_9}^2Q_q^2\mathbf{1}|M_Z|^2 + 48g_p^4Q_{H_d}^2Q_q^2\mathbf{1}|M_Z|^2 + 48g_p^4Q_{H_u}^2Q_q^2\mathbf{1}|M_Z|^2 \\
&+ 48g_p^4Q_{l_4}^2Q_q^2\mathbf{1}|M_Z|^2 + 96g_p^4Q_{l_9}^2Q_q^2\mathbf{1}|M_Z|^2 + 480g_p^4Q_q^4\mathbf{1}|M_Z|^2 \\
&+ 24g_p^4Q_q^2Q_s^2\mathbf{1}|M_Z|^2 - \frac{48}{5}g_1^2g_p^2Q_qQ_u\mathbf{1}|M_Z|^2 + 216g_p^4Q_q^2Q_u^2\mathbf{1}|M_Z|^2 \\
&+ \frac{2}{5}g_1^2g_2^2\mathbf{1}|M_2|^2 + 33g_2^4\mathbf{1}|M_2|^2 + 32g_2^2g_3^2\mathbf{1}|M_2|^2 + 24g_2^2g_p^2Q_q^2\mathbf{1}|M_2|^2 \\
&- \frac{16}{45}g_3^2\Big(-15\Big(3g_2^2\Big(2M_3+M_2\Big) + 4g_p^2\Big(2M_3+M_Z\Big)Q_q^2 - 8g_3^2M_3\Big) - g_1^2\Big(2M_3+M_1\Big)\Big)\mathbf{1}M_3^* \\
&+ \frac{12}{5}g_1^2g_p^2M_1Q_dQ_q\mathbf{1}M_Z^* + \frac{4}{5}g_1^2g_p^2M_1Q_{e_4}Q_q\mathbf{1}M_Z^* + \frac{8}{5}g_1^2g_p^2M_1Q_{e_9}Q_q\mathbf{1}M_Z^* \\
&- \frac{4}{5}g_1^2g_p^2M_1Q_{H_d}Q_q\mathbf{1}M_Z^* + \frac{4}{5}g_1^2g_p^2M_1Q_{H_u}Q_q\mathbf{1}M_Z^* - \frac{4}{5}g_1^2g_p^2M_1Q_{l_4}Q_q\mathbf{1}M_Z^* \\
&- \frac{8}{5}g_1^2g_p^2M_1Q_{l_9}Q_q\mathbf{1}M_Z^* + \frac{8}{3}g_1^2g_p^2M_1Q_q^2\mathbf{1}M_Z^* + \frac{64}{3}g_3^2g_p^2M_3Q_q^2\mathbf{1}M_Z^* \\
&+ 12g_2^2g_p^2M_2Q_q^2\mathbf{1}M_Z^* - \frac{24}{5}g_1^2g_p^2M_1Q_qQ_u\mathbf{1}M_Z^* + \frac{1}{5}g_1^2g_2^2M_1\mathbf{1}M_2^* + 16g_2^2g_3^2M_3\mathbf{1}M_2^* \\
&+ 12g_2^2g_p^2M_ZQ_q^2\mathbf{1}M_2^* + \frac{4}{5}g_1^2m_{H_d}^2Y_d^\dagger Y_d + 4g_p^2m_{H_d}^2Q_d^2Y_d^\dagger Y_d \\
&+ 4g_p^2m_{H_d}^2Q_{H_d}^2Y_d^\dagger Y_d - 4g_p^2m_{H_d}^2Q_q^2Y_d^\dagger Y_d - 4m_{H_d}^2\lambda^2Y_d^\dagger Y_d \\
&- 2m_{H_u}^2\lambda^2Y_d^\dagger Y_d - 2m_s^2\lambda^2Y_d^\dagger Y_d + 8g_p^2Q_d^2|M_Z|^2Y_d^\dagger Y_d \\
&+ 8g_p^2Q_{H_d}^2|M_Z|^2Y_d^\dagger Y_d - 8g_p^2Q_q^2|M_Z|^2Y_d^\dagger Y_d - 2m_{e_4}^2|Y1|^2Y_d^\dagger Y_d \\
&- 4m_{H_d}^2|Y1|^2Y_d^\dagger Y_d - 2m_{l_4}^2|Y1|^2Y_d^\dagger Y_d - 2|TY1|^2Y_d^\dagger Y_d \\
&- 4g_p^2Q_d^2M_Z^*Y_d^\dagger T_d - 4g_p^2Q_{H_d}^2M_Z^*Y_d^\dagger T_d + 4g_p^2Q_q^2M_Z^*Y_d^\dagger T_d \\
&- 2Y1TY1^*Y_d^\dagger T_d + \frac{8}{5}g_1^2m_{H_u}^2Y_u^\dagger Y_u + 4g_p^2m_{H_u}^2Q_{H_u}^2Y_u^\dagger Y_u \\
&- 4g_p^2m_{H_u}^2Q_q^2Y_u^\dagger Y_u + 4g_p^2m_{H_u}^2Q_u^2Y_u^\dagger Y_u - 2m_{H_d}^2\lambda^2Y_u^\dagger Y_u \\
&- 4m_{H_u}^2\lambda^2Y_u^\dagger Y_u - 2m_s^2\lambda^2Y_u^\dagger Y_u + 8g_p^2Q_{H_u}^2|M_Z|^2Y_u^\dagger Y_u \\
&- 8g_p^2Q_q^2|M_Z|^2Y_u^\dagger Y_u + 8g_p^2Q_u^2|M_Z|^2Y_u^\dagger Y_u
\end{aligned}
$$

$$
\begin{aligned}
&+ \frac{1}{225} g_1^2 M_1^* \Big(\Big(597 g_1^2 M_1 + 80 g_3^2 \Big(2M_1 + M_3 \Big) + 45 g_2^2 \Big(2M_1 + M_2 \Big) \\
&+ 60 g_p^2 \Big(2M_1 + M_Z \Big) Q_q \Big(10 Q_q - 18 Q_u + 3 Q_{e_4} - 3 Q_{H_d} + 3 Q_{H_u} - 3 Q_{l_4} + 6 Q_{e_9} - 6 Q_{l_9} + 9 Q_d \Big) \Big) \mathbf{1} \\
&+ 180 \Big(2 M_1 Y_d^\dagger Y_d - 2 Y_u^\dagger T_u + 4 M_1 Y_u^\dagger Y_u - Y_d^\dagger T_d \Big) \Big) \\
&- 4 g_p^2 Q_{H_u}^2 M_Z^* Y_u^\dagger T_u + 4 g_p^2 Q_q^2 M_Z^* Y_u^\dagger T_u - 4 g_p^2 Q_u^2 M_Z^* Y_u^\dagger T_u \\
&- \frac{4}{5} g_1^2 M_1 T_d^\dagger Y_d - 4 g_p^2 M_Z Q_d^2 T_d^\dagger Y_d - 4 g_p^2 M_Z Q_{H_d}^2 T_d^\dagger Y_d \\
&+ 4 g_p^2 M_Z Q_q^2 T_d^\dagger Y_d + \frac{4}{5} g_1^2 T_d^\dagger T_d + 4 g_p^2 Q_d^2 T_d^\dagger T_d + 4 g_p^2 Q_{H_d}^2 T_d^\dagger T_d \\
&- 4 g_p^2 Q_q^2 T_d^\dagger T_d - 2 \lambda^2 T_d^\dagger T_d - 2 |Y1|^2 T_d^\dagger T_d - \frac{8}{5} g_1^2 M_1 T_u^\dagger Y_u \\
&- 4 g_p^2 M_Z Q_{H_u}^2 T_u^\dagger Y_u + 4 g_p^2 M_Z Q_q^2 T_u^\dagger Y_u - 4 g_p^2 M_Z Q_u^2 T_u^\dagger Y_u \\
&+ \frac{8}{5} g_1^2 T_u^\dagger T_u + 4 g_p^2 Q_{H_u}^2 T_u^\dagger T_u - 4 g_p^2 Q_q^2 T_u^\dagger T_u + 4 g_p^2 Q_u^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 + 2 g_p^2 Q_d^2 m_q^2 Y_d^\dagger Y_d + 2 g_p^2 Q_{H_d}^2 m_q^2 Y_d^\dagger Y_d \\
&- 2 g_p^2 Q_q^2 m_q^2 Y_d^\dagger Y_d - \lambda^2 m_q^2 Y_d^\dagger Y_d - |Y1|^2 m_q^2 Y_d^\dagger Y_d + \frac{4}{5} g_1^2 m_q^2 Y_u^\dagger Y_u \\
&+ 2 g_p^2 Q_{H_u}^2 m_q^2 Y_u^\dagger Y_u - 2 g_p^2 Q_q^2 m_q^2 Y_u^\dagger Y_u + 2 g_p^2 Q_u^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 + 4 g_p^2 Q_d^2 Y_d^\dagger m_d^2 Y_d \\
&+ 4 g_p^2 Q_{H_d}^2 Y_d^\dagger m_d^2 Y_d - 4 g_p^2 Q_q^2 Y_d^\dagger m_d^2 Y_d - 2 \lambda^2 Y_d^\dagger m_d^2 Y_d \\
&- 2 |Y1|^2 Y_d^\dagger m_d^2 Y_d + \frac{2}{5} g_1^2 Y_d^\dagger Y_d m_q^2 + 2 g_p^2 Q_d^2 Y_d^\dagger Y_d m_q^2 \\
&+ 2 g_p^2 Q_{H_d}^2 Y_d^\dagger Y_d m_q^2 - 2 g_p^2 Q_q^2 Y_d^\dagger Y_d m_q^2 - \lambda^2 Y_d^\dagger Y_d m_q^2 \\
&- |Y1|^2 Y_d^\dagger Y_d m_q^2 + \frac{8}{5} g_1^2 Y_u^\dagger m_u^2 Y_u + 4 g_p^2 Q_{H_u}^2 Y_u^\dagger m_u^2 Y_u \\
&- 4 g_p^2 Q_q^2 Y_u^\dagger m_u^2 Y_u + 4 g_p^2 Q_u^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 + 2 g_p^2 Q_{H_u}^2 Y_u^\dagger Y_u m_q^2 - 2 g_p^2 Q_q^2 Y_u^\dagger Y_u m_q^2 \\
&+ 2 g_p^2 Q_u^2 Y_u^\dagger Y_u m_q^2 - \lambda^2 Y_u^\dagger Y_u m_q^2 - 8 m_{H_d}^2 Y_d^\dagger Y_d Y_d^\dagger Y_d - 4 Y_d^\dagger Y_d T_d^\dagger T_d \\
&- 4 Y_d^\dagger T_d T_d^\dagger Y_d - 8 m_{H_u}^2 Y_u^\dagger Y_u Y_u^\dagger Y_u - 4 Y_u^\dagger Y_u T_u^\dagger T_u - 4 Y_u^\dagger T_u T_u^\dagger Y_u \\
&- 4 T_d^\dagger Y_d Y_d^\dagger T_d - 4 T_d^\dagger T_d Y_d^\dagger Y_d - 4 T_u^\dagger Y_u Y_u^\dagger T_u - 4 T_u^\dagger T_u Y_u^\dagger Y_u \\
&- 2 m_q^2 Y_d^\dagger Y_d Y_d^\dagger Y_d - 2 m_q^2 Y_u^\dagger Y_u Y_u^\dagger Y_u - 4 Y_d^\dagger m_d^2 Y_d Y_d^\dagger Y_d - 4 Y_d^\dagger Y_d m_q^2 Y_d^\dagger Y_d \\
&- 4 Y_d^\dagger Y_d Y_d^\dagger m_d^2 Y_d - 2 Y_d^\dagger Y_d Y_d^\dagger Y_d m_q^2 - 4 Y_u^\dagger m_u^2 Y_u Y_u^\dagger Y_u - 4 Y_u^\dagger Y_u m_q^2 Y_u^\dagger Y_u \\
&- 4 Y_u^\dagger Y_u Y_u^\dagger m_u^2 Y_u - 2 Y_u^\dagger Y_u Y_u^\dagger Y_u m_q^2 - 2 Y 1^* T_d^\dagger Y_d T Y 1 - 2 \lambda Y_d^\dagger T_d T_\lambda \\
&- 2 \lambda Y_u^\dagger T_u T_\lambda - 2 \lambda T_d^\dagger Y_d T_\lambda - 2 \lambda T_u^\dagger Y_u T_\lambda - 2 Y_d^\dagger Y_d T_\lambda^2 - 2 Y_u^\dagger Y_u T_\lambda^2
\end{aligned}
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\begin{aligned}
&+ 6g_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_1g_pQ_q\mathbf{1}\sigma_{2,14} + 4\frac{1}{\sqrt{15}}g_1g_pQ_q\mathbf{1}\sigma_{2,41} + 8g_p^2Q_q^2\mathbf{1}\sigma_{2,44}\\
&+ 4\frac{1}{\sqrt{15}}g_1\mathbf{1}\sigma_{3,1} + 8g_pQ_q\mathbf{1}\sigma_{3,4} - 4m_{H_d}^2Y_d^\dagger Y_d\mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 2T_d^\dagger T_d\mathrm{Tr}\Big(Y2Y2^\dagger\Big)\\
&- m_q^2Y_d^\dagger Y_d\mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 2Y_d^\dagger m_d^2Y_d\mathrm{Tr}\Big(Y2Y2^\dagger\Big) - Y_d^\dagger Y_d m_q^2\mathrm{Tr}\Big(Y2Y2^\dagger\Big)\\
&- 12m_{H_d}^2Y_d^\dagger Y_d\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 6T_d^\dagger T_d\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 3m_q^2Y_d^\dagger Y_d\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)\\
&- 6Y_d^\dagger m_d^2Y_d\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 3Y_d^\dagger Y_d m_q^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 12m_{H_u}^2Y_u^\dagger Y_u\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)\\
&- 6T_u^\dagger T_u\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - 3m_q^2Y_u^\dagger Y_u\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - 6Y_u^\dagger m_u^2Y_u\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)\\
&- 3Y_u^\dagger Y_u m_q^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - 2T_d^\dagger Y_d\mathrm{Tr}\Big(Y2^\dagger TY2\Big) - 6T_d^\dagger Y_d\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)\\
&- 6T_u^\dagger Y_u\mathrm{Tr}\Big(Y_u^\dagger T_u\Big) - 2Y_d^\dagger T_d\mathrm{Tr}\Big(TY2^*Y2^T\Big) - 2Y_d^\dagger Y_d\mathrm{Tr}\Big(TY2^*TY2^T\Big)\\
&- 6Y_d^\dagger T_d\mathrm{Tr}\Big(T_d^*Y_d^T\Big) - 6Y_d^\dagger Y_d\mathrm{Tr}\Big(T_d^*T_d^T\Big) - 6Y_u^\dagger T_u\mathrm{Tr}\Big(T_u^*Y_u^T\Big)\\
&- 6Y_u^\dagger Y_u\mathrm{Tr}\Big(T_u^*T_u^T\Big) - 6Y_d^\dagger Y_d\mathrm{Tr}\Big(m_d^2Y_dY_d^\dagger\Big) - 2Y_d^\dagger Y_d\mathrm{Tr}\Big(m_{e_9}^2Y2Y2^\dagger\Big)\\
&- 2Y_d^\dagger Y_d\mathrm{Tr}\Big(m_{l_9}^2Y2^\dagger Y2\Big) - 6Y_d^\dagger Y_d\mathrm{Tr}\Big(m_q^2Y_d^\dagger Y_d\Big) - 6Y_u^\dagger Y_u\mathrm{Tr}\Big(m_q^2Y_u^\dagger Y_u\Big)\\
&- 6Y_u^\dagger Y_u\mathrm{Tr}\Big(m_u^2Y_uY_u^\dagger\Big)
\end{aligned}
\tag{79}
$$

$$
\begin{aligned}
\beta^{(1)}_{m_{l_4}^2} &= -\frac{6}{5}g_1^2|M_1|^2 - 8g_p^2Q_{l_4}^2|M_Z|^2 - 6g_2^2|M_2|^2 + 2m_{e_4}^2|Y1|^2 + 2m_{H_d}^2|Y1|^2 + 2m_{l_4}^2|Y1|^2 + 2|TY1|^2\\
&- \sqrt{\frac{3}{5}}g_1\sigma_{1,1} + 2g_pQ_{l_4}\sigma_{1,4}
\end{aligned}
\tag{80}
$$

$$
\begin{aligned}
\beta^{(2)}_{m_{l_4}^2} &= +\frac{18}{5}g_1^2g_2^2|M_2|^2 + 33g_2^4|M_2|^2 + 24g_2^2g_p^2Q_{l_4}^2|M_2|^2 + \frac{12}{5}g_1^2m_{e_4}^2|Y1|^2 + \frac{12}{5}g_1^2m_{H_d}^2|Y1|^2\\
&+ \frac{12}{5}g_1^2m_{l_4}^2|Y1|^2 + 4g_p^2m_{e_4}^2Q_{e_4}^2|Y1|^2 + 4g_p^2m_{H_d}^2Q_{e_4}^2|Y1|^2 + 4g_p^2m_{l_4}^2Q_{e_4}^2|Y1|^2\\
&+ 4g_p^2m_{e_4}^2Q_{H_d}^2|Y1|^2 + 4g_p^2m_{H_d}^2Q_{H_d}^2|Y1|^2 + 4g_p^2m_{l_4}^2Q_{H_d}^2|Y1|^2 - 4g_p^2m_{e_4}^2Q_{l_4}^2|Y1|^2\\
&- 4g_p^2m_{H_d}^2Q_{l_4}^2|Y1|^2 - 4g_p^2m_{l_4}^2Q_{l_4}^2|Y1|^2 - 2m_{e_4}^2\lambda^2|Y1|^2 - 4m_{H_d}^2\lambda^2|Y1|^2\\
&- 2m_{H_u}^2\lambda^2|Y1|^2 - 2m_{l_4}^2\lambda^2|Y1|^2 - 2m_s^2\lambda^2|Y1|^2 + \frac{12}{5}g_1^2|TY1|^2 + 4g_p^2Q_{e_4}^2|TY1|^2\\
&+ 4g_p^2Q_{H_d}^2|TY1|^2 - 4g_p^2Q_{l_4}^2|TY1|^2 - 2\lambda^2|TY1|^2 - 12m_{e_4}^2|Y1|^4 - 12m_{H_d}^2|Y1|^4 - 12m_{l_4}^2|Y1|^4\\
&+ \frac{9}{5}g_1^2g_2^2M_1M_2^* + 12g_2^2g_p^2M_ZQ_{l_4}^2M_2^* - \frac{12}{5}g_1^2M_1Y1TY1^* - 4g_p^2M_ZQ_{e_4}^2Y1TY1^*\\
&- 4g_p^2M_ZQ_{H_d}^2Y1TY1^* + 4g_p^2M_ZQ_{l_4}^2Y1TY1^*\\
&+ \frac{3}{25}g_1^2M_1^*\Big(207g_1^2M_1 + 15g_2^2\Big(2M_1 + M_2\Big) - 20g_p^2\Big(2M_1 + M_Z\Big)Q_{l_4}\Big(2Q_{e_9} - 2Q_{l_4} - 2Q_{l_9} + 3Q_d + 3Q_q - 6Q_u - Q_{H_d} + Q_{e_4} + Q\\
&+ 20Y1^*\Big(2M_1Y1 - TY1\Big)\Big)
\end{aligned}
$$

$$
\begin{aligned}
&+\frac{4}{5}g_p^2M_Z^*\Big(3Q_{l_4}\Big(-g_1^2\Big(2M_Z+M_1\Big)\Big(2Q_{e_9}-2Q_{l_4}-2Q_{l_9}+3Q_d+3Q_q-6Q_u-Q_{H_d}+Q_{e_4}+Q_{H_u}\Big)\\
&+5Q_{l_4}\Big(2g_p^2M_Z\Big(18Q_q^2+2Q_{e_9}^2+2Q_{H_d}^2+2Q_{H_u}^2+4Q_{l_4}^2+4Q_{l_9}^2+9Q_d^2+9Q_u^2+Q_{e_4}^2+Q_s^2\Big)+g_2^2\Big(2M_Z+M_2\Big)\Big)\Big)\\
&+5\Big(-Q_{l_4}^2+Q_{e_4}^2+Q_{H_d}^2\Big)Y1^*\Big(2M_ZY1-TY1\Big)\Big)\\
&-24|Y1|^2TY1^*TY1-2Y1\lambda TY1^*T_\lambda-2\lambda Y1^*TY1T_\lambda-2|Y1|^2T_\lambda^2+6g_2^4\sigma_{2,2}+\frac{6}{5}g_1^2\sigma_{2,11}-4\sqrt{\frac{3}{5}}g_1g_pQ_{l_4}\sigma_{2,14}\\
&-4\sqrt{\frac{3}{5}}g_1g_pQ_{l_4}\sigma_{2,41}+8g_p^2Q_{l_4}^2\sigma_{2,44}-4\sqrt{\frac{3}{5}}g_1\sigma_{3,1}+8g_pQ_{l_4}\sigma_{3,4}-2m_{e_4}^2|Y1|^2\mathrm{Tr}\Big(Y2Y2^\dagger\Big)\\
&-4m_{H_d}^2|Y1|^2\mathrm{Tr}\Big(Y2Y2^\dagger\Big)-2m_{l_4}^2|Y1|^2\mathrm{Tr}\Big(Y2Y2^\dagger\Big)-2|TY1|^2\mathrm{Tr}\Big(Y2Y2^\dagger\Big)-6m_{e_4}^2|Y1|^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)\\
&-12m_{H_d}^2|Y1|^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)-6m_{l_4}^2|Y1|^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)-6|TY1|^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)-2Y1TY1^*\mathrm{Tr}\Big(Y2^\dagger TY2\Big)\\
&-6Y1TY1^*\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)-2Y1^*TY1\mathrm{Tr}\Big(TY2^*Y2^T\Big)-2|Y1|^2\mathrm{Tr}\Big(TY2^*TY2^T\Big)-6Y1^*TY1\mathrm{Tr}\Big(T_d^*Y_d^T\Big)\\
&-6|Y1|^2\mathrm{Tr}\Big(T_d^*T_d^T\Big)-6|Y1|^2\mathrm{Tr}\Big(m_d^2Y_dY_d^\dagger\Big)-2|Y1|^2\mathrm{Tr}\Big(m_{e_9}^2Y2Y2^\dagger\Big)-2|Y1|^2\mathrm{Tr}\Big(m_{l_9}^2Y2^\dagger Y2\Big)\\
&-6|Y1|^2\mathrm{Tr}\Big(m_q^2Y_d^\dagger Y_d\Big)
\end{aligned}
\tag{81}
$$

$$
\begin{aligned}
\beta^{(1)}_{m_{l_9}^2}=&-\frac{6}{5}g_1^2\mathbf{1}|M_1|^2-8g_p^2Q_{l_9}^2\mathbf{1}|M_Z|^2-6g_2^2\mathbf{1}|M_2|^2+2m_{H_d}^2Y2^\dagger Y2+2TY2^\dagger TY2+2T_e'^TT_e'^*\\
&+m_{l_9}^2Y2^\dagger Y2+2Y2^\dagger m_{e_9}^2Y2+Y2^\dagger Y2m_{l_9}^2-\sqrt{\frac{3}{5}}g_1\mathbf{1}\sigma_{1,1}+2g_pQ_{l_9}\mathbf{1}\sigma_{1,4}
\end{aligned}
\tag{82}
$$

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\begin{aligned}
\beta^{(2)}_{m_{l_9}^2}=&+\frac{18}{5}g_1^2g_2^2\mathbf{1}|M_2|^2+33g_2^4\mathbf{1}|M_2|^2+24g_2^2g_p^2Q_{l_9}^2\mathbf{1}|M_2|^2+\frac{9}{5}g_1^2g_2^2M_1\mathbf{1}M_2^*\\
&+12g_2^2g_p^2M_ZQ_{l_9}^2\mathbf{1}M_2^*+\frac{12}{5}g_1^2m_{H_d}^2Y2^\dagger Y2+4g_p^2m_{H_d}^2Q_{e_9}^2Y2^\dagger Y2\\
&+4g_p^2m_{H_d}^2Q_{H_d}^2Y2^\dagger Y2-4g_p^2m_{H_d}^2Q_{l_9}^2Y2^\dagger Y2-4m_{H_d}^2\lambda^2Y2^\dagger Y2-2m_{H_u}^2\lambda^2Y2^\dagger Y2\\
&-2m_s^2\lambda^2Y2^\dagger Y2-2m_{e_4}^2|Y1|^2Y2^\dagger Y2-4m_{H_d}^2|Y1|^2Y2^\dagger Y2-2m_{l_4}^2|Y1|^2Y2^\dagger Y2\\
&-2|TY1|^2Y2^\dagger Y2\\
&+\frac{4}{5}g_p^2M_Z^*\Big(3Q_{l_9}\Big(-g_1^2\Big(2M_Z+M_1\Big)\Big(2Q_{e_9}+3Q_d-3Q_{l_9}+3Q_q-6Q_u-Q_{H_d}-Q_{l_4}+Q_{e_4}+Q_{H_u}\Big)\\
&+5Q_{l_9}\Big(2g_p^2M_Z\Big(18Q_q^2+2Q_{e_9}^2+2Q_{H_d}^2+2Q_{H_u}^2+2Q_{l_4}^2+6Q_{l_9}^2+9Q_d^2+9Q_u^2+Q_{e_4}^2+Q_s^2\Big)+g_2^2\Big(2M_Z+M_2\Big)\Big)\Big)\mathbf{1}\\
&+5\Big(-Q_{l_9}^2+Q_{e_9}^2+Q_{H_d}^2\Big)\Big(2M_ZY2^\dagger Y2-Y2^\dagger TY2\Big)\Big)\\
&+\frac{3}{25}g_1^2M_1^*\Big(\Big(15g_2^2\Big(2M_1+M_2\Big)+207g_1^2M_1+20g_p^2\Big(2M_1+M_Z\Big)Q_{l_9}\Big(-2Q_{e_9}-3Q_d+3Q_{l_9}-3Q_q+6Q_u-Q_{e_4}-Q_{H_u}+Q_{H_d}\\
&+40M_1Y2^\dagger Y2-20Y2^\dagger TY2\Big)\\
&-2Y1TY1^*Y2^\dagger TY2-\frac{12}{5}g_1^2M_1TY2^\dagger Y2-4g_p^2M_ZQ_{e_9}^2TY2^\dagger Y2-4g_p^2M_ZQ_{H_d}^2TY2^\dagger Y2\\
&+4g_p^2M_ZQ_{l_9}^2TY2^\dagger Y2+\frac{12}{5}g_1^2TY2^\dagger TY2+4g_p^2Q_{e_9}^2TY2^\dagger TY2+4g_p^2Q_{H_d}^2TY2^\dagger TY2
\end{aligned}
$$

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\begin{aligned}
&- 4g_p^2 Q_{l_9}^2 TY2^\dagger TY2 - 2\lambda^2 TY2^\dagger TY2 - 2|Y1|^2 TY2^\dagger TY2 + \frac{6}{5}g_1^2 m_{l_9}^2 Y2^\dagger Y2 \\
&+ 2g_p^2 Q_{e_9}^2 m_{l_9}^2 Y2^\dagger Y2 + 2g_p^2 Q_{H_d}^2 m_{l_9}^2 Y2^\dagger Y2 - 2g_p^2 Q_{l_9}^2 m_{l_9}^2 Y2^\dagger Y2 \\
&- \lambda^2 m_{l_9}^2 Y2^\dagger Y2 - |Y1|^2 m_{l_9}^2 Y2^\dagger Y2 + \frac{12}{5}g_1^2 Y2^\dagger m_{e_9}^2 Y2 + 4g_p^2 Q_{e_9}^2 Y2^\dagger m_{e_9}^2 Y2 \\
&+ 4g_p^2 Q_{H_d}^2 Y2^\dagger m_{e_9}^2 Y2 - 4g_p^2 Q_{l_9}^2 Y2^\dagger m_{e_9}^2 Y2 - 2\lambda^2 Y2^\dagger m_{e_9}^2 Y2 \\
&- 2|Y1|^2 Y2^\dagger m_{e_9}^2 Y2 + \frac{6}{5}g_1^2 Y2^\dagger Y2 m_{l_9}^2 + 2g_p^2 Q_{e_9}^2 Y2^\dagger Y2 m_{l_9}^2
\end{aligned}
$$

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\begin{aligned}
&+ 2g_p^2 Q_{H_d}^2 Y2^\dagger Y2 m_{l_9}^2 - 2g_p^2 Q_{l_9}^2 Y2^\dagger Y2 m_{l_9}^2 - \lambda^2 Y2^\dagger Y2 m_{l_9}^2 \\
&- |Y1|^2 Y2^\dagger Y2 m_{l_9}^2 - 8m_{H_d}^2 Y2^\dagger Y2 Y2^\dagger Y2 - 4Y2^\dagger Y2 TY2^\dagger TY2 - 4Y2^\dagger TY2 TY2^\dagger Y2 \\
&- 4TY2^\dagger Y2 Y2^\dagger TY2 - 4TY2^\dagger TY2 Y2^\dagger Y2 - 2m_{l_9}^2 Y2^\dagger Y2 Y2^\dagger Y2 - 4Y2^\dagger m_{e_9}^2 Y2 Y2^\dagger Y2 \\
&- 4Y2^\dagger Y2 m_{l_9}^2 Y2^\dagger Y2 - 4Y2^\dagger Y2 Y2^\dagger m_{e_9}^2 Y2 - 2Y2^\dagger Y2 Y2^\dagger Y2 m_{l_9}^2 - 2Y1^* TY2^\dagger Y2 TY1 - 2\lambda Y2^\dagger TY2 T_\lambda \\
&- 2\lambda TY2^\dagger Y2 T_\lambda - 2Y2^\dagger Y2 T_\lambda^2 + 6g_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 g_p Q_{l_9} \mathbf{1}\sigma_{2,14} - 4\sqrt{\frac{3}{5}}g_1 g_p Q_{l_9} \mathbf{1}\sigma_{2,41} \\
&+ 8g_p^2 Q_{l_9}^2 \mathbf{1}\sigma_{2,44} - 4\sqrt{\frac{3}{5}}g_1 \mathbf{1}\sigma_{3,1} + 8g_p Q_{l_9} \mathbf{1}\sigma_{3,4} - 4m_{H_d}^2 Y2^\dagger Y2 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 2TY2^\dagger TY2 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) \\
&- m_{l_9}^2 Y2^\dagger Y2 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 2Y2^\dagger m_{e_9}^2 Y2 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) - Y2^\dagger Y2 m_{l_9}^2 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) \\
&- 12m_{H_d}^2 Y2^\dagger Y2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 6TY2^\dagger TY2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 3m_{l_9}^2 Y2^\dagger Y2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) \\
&- 6Y2^\dagger m_{e_9}^2 Y2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 3Y2^\dagger Y2 m_{l_9}^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 2TY2^\dagger Y2 \mathrm{Tr}\Big(Y2^\dagger TY2\Big) \\
&- 6TY2^\dagger Y2 \mathrm{Tr}\Big(Y_d^\dagger T_d\Big) - 2Y2^\dagger TY2 \mathrm{Tr}\Big(TY2^* Y2^T\Big) - 2Y2^\dagger Y2 \mathrm{Tr}\Big(TY2^* TY2^T\Big) - 6Y2^\dagger TY2 \mathrm{Tr}\Big(T_d^* Y_d^T\Big) \\
&- 6Y2^\dagger Y2 \mathrm{Tr}\Big(T_d^* T_d^T\Big) - 6Y2^\dagger Y2 \mathrm{Tr}\Big(m_d^2 Y_d Y_d^\dagger\Big) - 2Y2^\dagger Y2 \mathrm{Tr}\Big(m_{e_9}^2 Y2Y2^\dagger\Big) \\
&- 2Y2^\dagger Y2 \mathrm{Tr}\Big(m_{l_9}^2 Y2^\dagger Y2\Big) - 6Y2^\dagger Y2 \mathrm{Tr}\Big(m_q^2 Y_d^\dagger Y_d\Big)
\end{aligned} \tag{83}
$$

$$
\begin{aligned}
\beta^{(1)}_{m_{H_d}^2} &= +2m_{H_d}^2\lambda^2 + 2m_{H_u}^2\lambda^2 + 2m_s^2\lambda^2 - \frac{6}{5}g_1^2|M_1|^2 - 8g_p^2 Q_{H_d}^2|M_Z|^2 - 6g_2^2|M_2|^2 + 2m_{e_4}^2|Y1|^2 \\
&+ 2m_{H_d}^2|Y1|^2 + 2m_{l_4}^2|Y1|^2 + 2|TY1|^2 + 2T_\lambda^2 - \sqrt{\frac{3}{5}}g_1\sigma_{1,1} + 2g_p Q_{H_d}\sigma_{1,4} + 2m_{H_d}^2 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) + 6m_{H_d}^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) \\
&+ 2\mathrm{Tr}\Big(TY2^* TY2^T\Big) + 6\mathrm{Tr}\Big(T_d^* T_d^T\Big) + 6\mathrm{Tr}\Big(m_d^2 Y_d Y_d^\dagger\Big) + 2\mathrm{Tr}\Big(m_{e_9}^2 Y2Y2^\dagger\Big) + 2\mathrm{Tr}\Big(m_{l_9}^2 Y2^\dagger Y2\Big) + 6\mathrm{Tr}\Big(m_q^2 Y_d^\dagger Y_d\Big)
\end{aligned} \tag{84}
$$

$$
\begin{aligned}
\beta^{(2)}_{m_{H_d}^2} &= -4g_p^2 m_{H_d}^2 Q_{H_d}^2\lambda^2 - 4g_p^2 m_{H_u}^2 Q_{H_d}^2\lambda^2 - 4g_p^2 m_s^2 Q_{H_d}^2\lambda^2 + 4g_p^2 m_{H_d}^2 Q_{H_u}^2\lambda^2 \\
&+ 4g_p^2 m_{H_u}^2 Q_{H_u}^2\lambda^2 + 4g_p^2 m_s^2 Q_{H_u}^2\lambda^2 + 4g_p^2 m_{H_d}^2 Q_s^2\lambda^2 + 4g_p^2 m_{H_u}^2 Q_s^2\lambda^2 \\
&+ 4g_p^2 m_s^2 Q_s^2\lambda^2 - 12m_{H_d}^2\lambda^4 - 12m_{H_u}^2\lambda^4 - 12m_s^2\lambda^4 + \frac{18}{5}g_1^2 g_2^2|M_2|^2 + 33g_2^4|M_2|^2 \\
&+ 24g_2^2 g_p^2 Q_{H_d}^2|M_2|^2 + \frac{12}{5}g_1^2 m_{e_4}^2|Y1|^2 + \frac{12}{5}g_1^2 m_{H_d}^2|Y1|^2 + \frac{12}{5}g_1^2 m_{l_4}^2|Y1|^2
\end{aligned}
$$

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\begin{aligned}
&+ 4g_p^2 m_{e_4}^2 Q_{e_4}^2 |Y1|^2 + 4g_p^2 m_{H_d}^2 Q_{e_4}^2 |Y1|^2 + 4g_p^2 m_{l_4}^2 Q_{e_4}^2 |Y1|^2 - 4g_p^2 m_{e_4}^2 Q_{H_d}^2 |Y1|^2 \\
&- 4g_p^2 m_{H_d}^2 Q_{H_d}^2 |Y1|^2 - 4g_p^2 m_{l_4}^2 Q_{H_d}^2 |Y1|^2 + 4g_p^2 m_{e_4}^2 Q_{l_4}^2 |Y1|^2 + 4g_p^2 m_{H_d}^2 Q_{l_4}^2 |Y1|^2 \\
&+ 4g_p^2 m_{l_4}^2 Q_{l_4}^2 |Y1|^2 + \frac{12}{5} g_1^2 |TY1|^2 + 4g_p^2 Q_{e_4}^2 |TY1|^2 - 4g_p^2 Q_{H_d}^2 |TY1|^2 + 4g_p^2 Q_{l_4}^2 |TY1|^2 \\
&- 12 m_{e_4}^2 |Y1|^4 - 12 m_{H_d}^2 |Y1|^4 - 12 m_{l_4}^2 |Y1|^4 + \frac{9}{5} g_1^2 g_2^2 M_1 M_2^* + 12 g_2^2 g_p^2 M_Z Q_{H_d}^2 M_2^* - \frac{12}{5} g_1^2 M_1 Y1 TY1^* \\
&- 4g_p^2 M_Z Q_{e_4}^2 Y1 TY1^* + 4g_p^2 M_Z Q_{H_d}^2 Y1 TY1^* - 4g_p^2 M_Z Q_{l_4}^2 Y1 TY1^* - 24 |Y1|^2 TY1^* TY1 \\
&+ 4g_p^2 M_Z Q_{H_d}^2 \lambda T_\lambda - 4g_p^2 M_Z Q_{H_u}^2 \lambda T_\lambda - 4g_p^2 M_Z Q_s^2 \lambda T_\lambda - 4g_p^2 Q_{H_d}^2 T_\lambda^2 \\
&+ 4g_p^2 Q_{H_u}^2 T_\lambda^2 + 4g_p^2 Q_s^2 T_\lambda^2 - 24 \lambda^2 T_\lambda^2 + 6 g_2^4 \sigma_{2,2} + \frac{6}{5} g_1^2 \sigma_{2,11} - 4\sqrt{\frac{3}{5}} g_1 g_p Q_{H_d} \sigma_{2,14} - 4\sqrt{\frac{3}{5}} g_1 g_p Q_{H_d} \sigma_{2,41} \\
&+ 8 g_p^2 Q_{H_d}^2 \sigma_{2,44} - 4\sqrt{\frac{3}{5}} g_1 \sigma_{3,1} + 8 g_p Q_{H_d} \sigma_{3,4} + \frac{12}{5} g_1^2 m_{H_d}^2 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) + 4g_p^2 m_{H_d}^2 Q_{e_9}^2 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) \\
&- 4g_p^2 m_{H_d}^2 Q_{H_d}^2 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) + 4g_p^2 m_{H_d}^2 Q_{l_9}^2 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) - \frac{4}{5} g_1^2 m_{H_d}^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) \\
&+ 32 g_3^2 m_{H_d}^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + 12 g_p^2 m_{H_d}^2 Q_d^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 12 g_p^2 m_{H_d}^2 Q_{H_d}^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) \\
&+ 12 g_p^2 m_{H_d}^2 Q_q^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) + 64 g_3^2 |M_3|^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 6 m_{H_d}^2 \lambda^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) \\
&- 12 m_{H_u}^2 \lambda^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 6 m_s^2 \lambda^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 6 T_\lambda^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 32 g_3^2 M_3^* \mathrm{Tr}\Big(Y_d^\dagger T_d\Big) \\
&+ \frac{1}{25} g_1^2 M_1^* \Big(621 g_1^2 M_1 + 90 g_2^2 M_1 + 45 g_2^2 M_2 - 360 g_p^2 M_1 Q_d Q_{H_d} - 180 g_p^2 M_Z Q_d Q_{H_d} - 120 g_p^2 M_1 Q_{e_4} Q_{H_d} \\
&- 60 g_p^2 M_Z Q_{e_4} Q_{H_d} - 240 g_p^2 M_1 Q_{e_9} Q_{H_d} - 120 g_p^2 M_Z Q_{e_9} Q_{H_d} + 240 g_p^2 M_1 Q_{H_d}^2 + 120 g_p^2 M_Z Q_{H_d}^2 \\
&- 120 g_p^2 M_1 Q_{H_d} Q_{H_u} - 60 g_p^2 M_Z Q_{H_d} Q_{H_u} + 120 g_p^2 M_1 Q_{H_d} Q_{l_4} + 60 g_p^2 M_Z Q_{H_d} Q_{l_4} + 240 g_p^2 M_1 Q_{H_d} Q_{l_9} \\
&+ 120 g_p^2 M_Z Q_{H_d} Q_{l_9} - 360 g_p^2 M_1 Q_{H_d} Q_q - 180 g_p^2 M_Z Q_{H_d} Q_q + 720 g_p^2 M_1 Q_{H_d} Q_u + 360 g_p^2 M_Z Q_{H_d} Q_u \\
&+ 60 Y1^* \Big(2 M_1 Y1 - TY1\Big) + 120 M_1 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 40 M_1 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 60 \mathrm{Tr}\Big(Y2^\dagger TY2\Big) + 20 \mathrm{Tr}\Big(Y_d^\dagger T_d\Big)\Big) \\
&+ \frac{4}{5} g_p^2 M_Z^* \Big(- 9 g_1^2 M_1 Q_d Q_{H_d} - 18 g_1^2 M_Z Q_d Q_{H_d} - 3 g_1^2 M_1 Q_{e_4} Q_{H_d} - 6 g_1^2 M_Z Q_{e_4} Q_{H_d} - 6 g_1^2 M_1 Q_{e_9} Q_{H_d} \\
&- 12 g_1^2 M_Z Q_{e_9} Q_{H_d} + 6 g_1^2 M_1 Q_{H_d}^2 + 12 g_1^2 M_Z Q_{H_d}^2 + 30 g_2^2 M_Z Q_{H_d}^2 + 15 g_2^2 M_2 Q_{H_d}^2 \\
&+ 270 g_p^2 M_Z Q_d^2 Q_{H_d}^2 + 30 g_p^2 M_Z Q_{e_4}^2 Q_{H_d}^2 + 60 g_p^2 M_Z Q_{e_9}^2 Q_{H_d}^2 + 120 g_p^2 M_Z Q_{H_d}^4 \\
&- 3 g_1^2 M_1 Q_{H_d} Q_{H_u} - 6 g_1^2 M_Z Q_{H_d} Q_{H_u} + 60 g_p^2 M_Z Q_{H_d}^2 Q_{H_u}^2 + 3 g_1^2 M_1 Q_{H_d} Q_{l_4} + 6 g_1^2 M_Z Q_{H_d} Q_{l_4} \\
&+ 60 g_p^2 M_Z Q_{H_d}^2 Q_{l_4}^2 + 6 g_1^2 M_1 Q_{H_d} Q_{l_9} + 12 g_1^2 M_Z Q_{H_d} Q_{l_9} + 120 g_p^2 M_Z Q_{H_d}^2 Q_{l_9}^2 \\
&- 9 g_1^2 M_1 Q_{H_d} Q_q - 18 g_1^2 M_Z Q_{H_d} Q_q + 540 g_p^2 M_Z Q_{H_d}^2 Q_q^2 + 30 g_p^2 M_Z Q_{H_d}^2 Q_s^2 + 18 g_1^2 M_1 Q_{H_d} Q_u \\
&+ 36 g_1^2 M_Z Q_{H_d} Q_u + 270 g_p^2 M_Z Q_{H_d}^2 Q_u^2 - 10 M_Z Q_{H_d}^2 \lambda^2 + 10 M_Z Q_{H_u}^2 \lambda^2 + 10 M_Z Q_s^2 \lambda^2 \\
&+ 5\Big(- Q_{H_d}^2 + Q_{e_4}^2 + Q_{l_4}^2 \Big) Y1^* \Big(2 M_Z Y1 - TY1\Big) + 5\Big(- Q_{H_u}^2 - Q_s^2 + Q_{H_d}^2 \Big) \lambda T_\lambda + 10 M_Z Q_{e_9}^2 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) \\
&- 10 M_Z Q_{H_d}^2 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) + 10 M_Z Q_{l_9}^2 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) + 30 M_Z Q_d^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 30 M_Z Q_{H_d}^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) \\
&+ 30 M_Z Q_q^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 5 Q_{e_9}^2 \mathrm{Tr}\Big(Y2^\dagger TY2\Big) + 5 Q_{H_d}^2 \mathrm{Tr}\Big(Y2^\dagger TY2\Big) - 5 Q_{l_9}^2 \mathrm{Tr}\Big(Y2^\dagger TY2\Big)
\end{aligned}
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\begin{aligned}
&- 15Q_d^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big) + 15Q_{H_d}^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big) - 15Q_q^2\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)\Big) \\
&- 6\lambda T_\lambda\mathrm{Tr}\Big(Y_u^\dagger T_u\Big) - \frac{12}{5}g_1^2M_1\mathrm{Tr}\Big(TY2^*Y2^T\Big) - 4g_p^2M_ZQ_{e_9}^2\mathrm{Tr}\Big(TY2^*Y2^T\Big) + 4g_p^2M_ZQ_{H_d}^2\mathrm{Tr}\Big(TY2^*Y2^T\Big) \\
&- 4g_p^2M_ZQ_{l_9}^2\mathrm{Tr}\Big(TY2^*Y2^T\Big) + \frac{12}{5}g_1^2\mathrm{Tr}\Big(TY2^*TY2^T\Big) + 4g_p^2Q_{e_9}^2\mathrm{Tr}\Big(TY2^*TY2^T\Big) - 4g_p^2Q_{H_d}^2\mathrm{Tr}\Big(TY2^*TY2^T\Big) \\
&+ 4g_p^2Q_{l_9}^2\mathrm{Tr}\Big(TY2^*TY2^T\Big) + \frac{4}{5}g_1^2M_1\mathrm{Tr}\Big(T_d^*Y_d^T\Big) - 32g_3^2M_3\mathrm{Tr}\Big(T_d^*Y_d^T\Big) - 12g_p^2M_ZQ_d^2\mathrm{Tr}\Big(T_d^*Y_d^T\Big) \\
&+ 12g_p^2M_ZQ_{H_d}^2\mathrm{Tr}\Big(T_d^*Y_d^T\Big) - 12g_p^2M_ZQ_q^2\mathrm{Tr}\Big(T_d^*Y_d^T\Big) - \frac{4}{5}g_1^2\mathrm{Tr}\Big(T_d^*T_d^T\Big) + 32g_3^2\mathrm{Tr}\Big(T_d^*T_d^T\Big) \\
&+ 12g_p^2Q_d^2\mathrm{Tr}\Big(T_d^*T_d^T\Big) - 12g_p^2Q_{H_d}^2\mathrm{Tr}\Big(T_d^*T_d^T\Big) + 12g_p^2Q_q^2\mathrm{Tr}\Big(T_d^*T_d^T\Big) - 6\lambda T_\lambda\mathrm{Tr}\Big(T_u^*Y_u^T\Big) \\
&- 6\lambda^2\mathrm{Tr}\Big(T_u^*T_u^T\Big) - \frac{4}{5}g_1^2\mathrm{Tr}\Big(m_d^2Y_dY_d^\dagger\Big) + 32g_3^2\mathrm{Tr}\Big(m_d^2Y_dY_d^\dagger\Big) + 12g_p^2Q_d^2\mathrm{Tr}\Big(m_d^2Y_dY_d^\dagger\Big) \\
&- 12g_p^2Q_{H_d}^2\mathrm{Tr}\Big(m_d^2Y_dY_d^\dagger\Big) + 12g_p^2Q_q^2\mathrm{Tr}\Big(m_d^2Y_dY_d^\dagger\Big) + \frac{12}{5}g_1^2\mathrm{Tr}\Big(m_{e_9}^2Y2Y2^\dagger\Big) \\
&+ 4g_p^2Q_{e_9}^2\mathrm{Tr}\Big(m_{e_9}^2Y2Y2^\dagger\Big) - 4g_p^2Q_{H_d}^2\mathrm{Tr}\Big(m_{e_9}^2Y2Y2^\dagger\Big) + 4g_p^2Q_{l_9}^2\mathrm{Tr}\Big(m_{e_9}^2Y2Y2^\dagger\Big) \\
&+ \frac{12}{5}g_1^2\mathrm{Tr}\Big(m_{l_9}^2Y2^\dagger Y2\Big) + 4g_p^2Q_{e_9}^2\mathrm{Tr}\Big(m_{l_9}^2Y2^\dagger Y2\Big) - 4g_p^2Q_{H_d}^2\mathrm{Tr}\Big(m_{l_9}^2Y2^\dagger Y2\Big) \\
&+ 4g_p^2Q_{l_9}^2\mathrm{Tr}\Big(m_{l_9}^2Y2^\dagger Y2\Big) - \frac{4}{5}g_1^2\mathrm{Tr}\Big(m_q^2Y_d^\dagger Y_d\Big) + 32g_3^2\mathrm{Tr}\Big(m_q^2Y_d^\dagger Y_d\Big) \\
&+ 12g_p^2Q_d^2\mathrm{Tr}\Big(m_q^2Y_d^\dagger Y_d\Big) - 12g_p^2Q_{H_d}^2\mathrm{Tr}\Big(m_q^2Y_d^\dagger Y_d\Big) + 12g_p^2Q_q^2\mathrm{Tr}\Big(m_q^2Y_d^\dagger Y_d\Big) \\
&- 6\lambda^2\mathrm{Tr}\Big(m_q^2Y_u^\dagger Y_u\Big) - 6\lambda^2\mathrm{Tr}\Big(m_u^2Y_uY_u^\dagger\Big) - 12m_{H_d}^2\mathrm{Tr}\Big(Y2Y2^\dagger Y2Y2^\dagger\Big) - 12\mathrm{Tr}\Big(Y2Y2^\dagger TY2TY2^\dagger\Big) \\
&- 12\mathrm{Tr}\Big(Y2TY2^\dagger TY2Y2^\dagger\Big) - 36m_{H_d}^2\mathrm{Tr}\Big(Y_dY_d^\dagger Y_dY_d^\dagger\Big) - 36\mathrm{Tr}\Big(Y_dY_d^\dagger T_dT_d^\dagger\Big) - 6m_{H_d}^2\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big) \\
&- 6m_{H_u}^2\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big) - 6\mathrm{Tr}\Big(Y_dY_u^\dagger T_uT_d^\dagger\Big) - 36\mathrm{Tr}\Big(Y_dT_d^\dagger T_dY_d^\dagger\Big) \\
&- 6\mathrm{Tr}\Big(Y_dT_u^\dagger T_uY_d^\dagger\Big) - 6\mathrm{Tr}\Big(Y_uY_d^\dagger T_dT_u^\dagger\Big) - 6\mathrm{Tr}\Big(Y_uT_d^\dagger T_dY_u^\dagger\Big) - 36\mathrm{Tr}\Big(m_d^2Y_dY_d^\dagger Y_dY_d^\dagger\Big) \\
&- 6\mathrm{Tr}\Big(m_d^2Y_dY_u^\dagger Y_uY_d^\dagger\Big) - 12\mathrm{Tr}\Big(m_{e_9}^2Y2Y2^\dagger Y2Y2^\dagger\Big) - 12\mathrm{Tr}\Big(m_{l_9}^2Y2^\dagger Y2Y2^\dagger Y2\Big) - 36\mathrm{Tr}\Big(m_q^2Y_d^\dagger Y_dY_d^\dagger Y_d\Big) \\
&- 6\mathrm{Tr}\Big(m_q^2Y_d^\dagger Y_dY_u^\dagger Y_u\Big) - 6\mathrm{Tr}\Big(m_q^2Y_u^\dagger Y_uY_d^\dagger Y_d\Big) - 6\mathrm{Tr}\Big(m_u^2Y_uY_d^\dagger Y_dY_u^\dagger\Big) \qquad (85)
\end{aligned}
$$

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\begin{aligned}
\beta^{(1)}_{m_{H_u}^2} &= +2m_{H_d}^2\lambda^2 + 2m_{H_u}^2\lambda^2 + 2m_s^2\lambda^2 - \frac{6}{5}g_1^2|M_1|^2 - 8g_p^2Q_{H_u}^2|M_Z|^2 - 6g_2^2|M_2|^2 + 2T_\lambda^2 + \sqrt{\frac{3}{5}}g_1\sigma_{1,1} \\
&+ 2g_pQ_{H_u}\sigma_{1,4} + 6\mathrm{Tr}\Big(T_d'T_d'^\dagger\Big) + 2\mathrm{Tr}\Big(T_e'T_e'^\dagger\Big) + 6m_{H_u}^2\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) \qquad (86) \\
\beta^{(2)}_{m_{H_u}^2} &= +4g_p^2m_{H_d}^2Q_{H_d}^2\lambda^2 + 4g_p^2m_{H_u}^2Q_{H_d}^2\lambda^2 + 4g_p^2m_s^2Q_{H_d}^2\lambda^2 - 4g_p^2m_{H_d}^2Q_{H_u}^2\lambda^2 \\
&- 4g_p^2m_{H_u}^2Q_{H_u}^2\lambda^2 - 4g_p^2m_s^2Q_{H_u}^2\lambda^2 + 4g_p^2m_{H_d}^2Q_s^2\lambda^2 + 4g_p^2m_{H_u}^2Q_s^2\lambda^2 \\
&+ 4g_p^2m_s^2Q_s^2\lambda^2 - 12m_{H_d}^2\lambda^4 - 12m_{H_u}^2\lambda^4 - 12m_s^2\lambda^4 + \frac{18}{5}g_1^2g_2^2|M_2|^2 + 33g_2^4|M_2|^2
\end{aligned}
$$

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\begin{aligned}
&+ 24g_2^2g_p^2Q_{H_u}^2|M_2|^2 - 2m_{e_4}^2\lambda^2|Y1|^2 - 4m_{H_d}^2\lambda^2|Y1|^2 - 2m_{H_u}^2\lambda^2|Y1|^2 - 2m_{l_4}^2\lambda^2|Y1|^2 \\
&- 2m_s^2\lambda^2|Y1|^2 - 2\lambda^2|TY1|^2 + \frac{9}{5}g_1^2g_2^2M_1M_2^* + 12g_2^2g_p^2M_ZQ_{H_u}^2M_2^* - 4g_p^2M_ZQ_{H_d}^2\lambda T_\lambda \\
&+ 4g_p^2M_ZQ_{H_u}^2\lambda T_\lambda - 4g_p^2M_ZQ_s^2\lambda T_\lambda - 2Y1\lambda TY1^*T_\lambda - 2\lambda Y1^*TY1T_\lambda + 4g_p^2Q_{H_d}^2T_\lambda^2 \\
&- 4g_p^2Q_{H_u}^2T_\lambda^2 + 4g_p^2Q_s^2T_\lambda^2 - 24\lambda^2T_\lambda^2 - 2|Y1|^2T_\lambda^2 + 6g_2^4\sigma_{2,2} + \frac{6}{5}g_1^2\sigma_{2,11} + 4\sqrt{\frac{3}{5}}g_1g_pQ_{H_u}\sigma_{2,14} \\
&+ 4\sqrt{\frac{3}{5}}g_1g_pQ_{H_u}\sigma_{2,41} + 8g_p^2Q_{H_u}^2\sigma_{2,44} + 4\sqrt{\frac{3}{5}}g_1\sigma_{3,1} + 8g_pQ_{H_u}\sigma_{3,4} - 4m_{H_d}^2\lambda^2\mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 2m_{H_u}^2\lambda^2\mathrm{Tr}\Big(Y2Y2^\dagger\Big) \\
&- 2m_s^2\lambda^2\mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 2T_\lambda^2\mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 12m_{H_d}^2\lambda^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 6m_{H_u}^2\lambda^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) \\
&- 6m_s^2\lambda^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 6T_\lambda^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + \frac{8}{5}g_1^2m_{H_u}^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 32g_3^2m_{H_u}^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) \\
&- 12g_p^2m_{H_u}^2Q_{H_u}^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 12g_p^2m_{H_u}^2Q_q^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 12g_p^2m_{H_u}^2Q_u^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) \\
&+ 64g_3^2|M_3|^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - 2\lambda T_\lambda\mathrm{Tr}\Big(Y2^\dagger TY2\Big) - 6\lambda T_\lambda\mathrm{Tr}\Big(Y_d^\dagger T_d\Big) \\
&+ \frac{1}{25}g_1^2M_1^*\Big(621g_1^2M_1 + 45g_2^2\Big(2M_1 + M_2\Big) + 60g_p^2\Big(2M_1 + M_Z\Big)Q_{H_u}\Big(2Q_{e_9} + 2Q_{H_u} - 2Q_{l_9} + 3Q_d + 3Q_q - 6Q_u - Q_{H_d} - Q_{l_4} + \\
&+ 80M_1\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - 40\mathrm{Tr}\Big(Y_u^\dagger T_u\Big)\Big) \\
&- 32g_3^2M_3^*\mathrm{Tr}\Big(Y_u^\dagger T_u\Big) \\
&+ \frac{4}{5}g_p^2M_Z^*\Big(9g_1^2M_1Q_dQ_{H_u} + 18g_1^2M_ZQ_dQ_{H_u} + 3g_1^2M_1Q_{e_4}Q_{H_u} + 6g_1^2M_ZQ_{e_4}Q_{H_u} + 6g_1^2M_1Q_{e_9}Q_{H_u} \\
&+ 12g_1^2M_ZQ_{e_9}Q_{H_u} - 3g_1^2M_1Q_{H_d}Q_{H_u} - 6g_1^2M_ZQ_{H_d}Q_{H_u} + 6g_1^2M_1Q_{H_u}^2 + 12g_1^2M_ZQ_{H_u}^2 \\
&+ 30g_2^2M_ZQ_{H_u}^2 + 15g_2^2M_2Q_{H_u}^2 + 270g_p^2M_ZQ_d^2Q_{H_u}^2 + 30g_p^2M_ZQ_{e_4}^2Q_{H_u}^2 \\
&+ 60g_p^2M_ZQ_{e_9}^2Q_{H_u}^2 + 60g_p^2M_ZQ_{H_d}^2Q_{H_u}^2 + 120g_p^2M_ZQ_{H_u}^4 - 3g_1^2M_1Q_{H_u}Q_{l_4} \\
&- 6g_1^2M_ZQ_{H_u}Q_{l_4} + 60g_p^2M_ZQ_{H_u}^2Q_{l_4}^2 - 6g_1^2M_1Q_{H_u}Q_{l_9} - 12g_1^2M_ZQ_{H_u}Q_{l_9} \\
&+ 120g_p^2M_ZQ_{H_u}^2Q_{l_9}^2 + 9g_1^2M_1Q_{H_u}Q_q + 18g_1^2M_ZQ_{H_u}Q_q + 540g_p^2M_ZQ_{H_u}^2Q_q^2 \\
&+ 30g_p^2M_ZQ_{H_u}^2Q_s^2 - 18g_1^2M_1Q_{H_u}Q_u - 36g_1^2M_ZQ_{H_u}Q_u + 270g_p^2M_ZQ_{H_u}^2Q_u^2 + 10M_ZQ_{H_d}^2\lambda^2 \\
&- 10M_ZQ_{H_u}^2\lambda^2 + 10M_ZQ_s^2\lambda^2 - 5\Big(-Q_{H_u}^2 + Q_{H_d}^2 + Q_s^2\Big)\lambda T_\lambda - 30M_Z\Big(-Q_q^2 - Q_u^2 + Q_{H_u}^2\Big)\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) \\
&+ 15Q_{H_u}^2\mathrm{Tr}\Big(Y_u^\dagger T_u\Big) - 15Q_q^2\mathrm{Tr}\Big(Y_u^\dagger T_u\Big) - 15Q_u^2\mathrm{Tr}\Big(Y_u^\dagger T_u\Big)\Big) \\
&- 2\lambda T_\lambda\mathrm{Tr}\Big(TY2^*Y2^T\Big) - 2\lambda^2\mathrm{Tr}\Big(TY2^*TY2^T\Big) - 6\lambda T_\lambda\mathrm{Tr}\Big(T_d^*Y_d^T\Big) - 6\lambda^2\mathrm{Tr}\Big(T_d^*T_d^T\Big) - \frac{8}{5}g_1^2M_1\mathrm{Tr}\Big(T_u^*Y_u^T\Big) \\
&- 32g_3^2M_3\mathrm{Tr}\Big(T_u^*Y_u^T\Big) + 12g_p^2M_ZQ_{H_u}^2\mathrm{Tr}\Big(T_u^*Y_u^T\Big) - 12g_p^2M_ZQ_q^2\mathrm{Tr}\Big(T_u^*Y_u^T\Big) \\
&- 12g_p^2M_ZQ_u^2\mathrm{Tr}\Big(T_u^*Y_u^T\Big) + \frac{8}{5}g_1^2\mathrm{Tr}\Big(T_u^*T_u^T\Big) + 32g_3^2\mathrm{Tr}\Big(T_u^*T_u^T\Big) - 12g_p^2Q_{H_u}^2\mathrm{Tr}\Big(T_u^*T_u^T\Big) \\
&+ 12g_p^2Q_q^2\mathrm{Tr}\Big(T_u^*T_u^T\Big) + 12g_p^2Q_u^2\mathrm{Tr}\Big(T_u^*T_u^T\Big) - 6\lambda^2\mathrm{Tr}\Big(m_d^2Y_dY_d^\dagger\Big) - 2\lambda^2\mathrm{Tr}\Big(m_{e_9}^2Y2Y2^\dagger\Big) \\
&- 2\lambda^2\mathrm{Tr}\Big(m_{l_9}^2Y2^\dagger Y2\Big) - 6\lambda^2\mathrm{Tr}\Big(m_q^2Y_d^\dagger Y_d\Big) + \frac{8}{5}g_1^2\mathrm{Tr}\Big(m_q^2Y_u^\dagger Y_u\Big) + 32g_3^2\mathrm{Tr}\Big(m_q^2Y_u^\dagger Y_u\Big)
\end{aligned}
$$

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\begin{aligned}
&- 12g_p^2Q_{H_u}^2\mathrm{Tr}\Big(m_q^2Y_u^\dagger Y_u\Big) + 12g_p^2Q_q^2\mathrm{Tr}\Big(m_q^2Y_u^\dagger Y_u\Big) + 12g_p^2Q_u^2\mathrm{Tr}\Big(m_q^2Y_u^\dagger Y_u\Big) \\
&+ \frac{8}{5}g_1^2\mathrm{Tr}\Big(m_u^2Y_uY_u^\dagger\Big) + 32g_3^2\mathrm{Tr}\Big(m_u^2Y_uY_u^\dagger\Big) - 12g_p^2Q_{H_u}^2\mathrm{Tr}\Big(m_u^2Y_uY_u^\dagger\Big) \\
&+ 12g_p^2Q_q^2\mathrm{Tr}\Big(m_u^2Y_uY_u^\dagger\Big) + 12g_p^2Q_u^2\mathrm{Tr}\Big(m_u^2Y_uY_u^\dagger\Big) - 6m_{H_d}^2\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big) \\
&- 6m_{H_u}^2\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big) - 6\mathrm{Tr}\Big(Y_dY_u^\dagger T_uT_d^\dagger\Big) - 6\mathrm{Tr}\Big(Y_dT_u^\dagger T_uY_d^\dagger\Big) \\
&- 6\mathrm{Tr}\Big(Y_uY_d^\dagger T_dT_u^\dagger\Big) - 36m_{H_u}^2\mathrm{Tr}\Big(Y_uY_u^\dagger Y_uY_u^\dagger\Big) - 36\mathrm{Tr}\Big(Y_uY_u^\dagger T_uT_u^\dagger\Big) - 6\mathrm{Tr}\Big(Y_uT_d^\dagger T_dY_u^\dagger\Big) \\
&- 36\mathrm{Tr}\Big(Y_uT_u^\dagger T_uY_u^\dagger\Big) - 6\mathrm{Tr}\Big(m_d^2Y_dY_u^\dagger Y_uY_d^\dagger\Big) - 6\mathrm{Tr}\Big(m_q^2Y_d^\dagger Y_dY_u^\dagger Y_u\Big) \\
&- 6\mathrm{Tr}\Big(m_q^2Y_u^\dagger Y_uY_d^\dagger Y_d\Big) - 36\mathrm{Tr}\Big(m_q^2Y_u^\dagger Y_uY_u^\dagger Y_u\Big) - 6\mathrm{Tr}\Big(m_u^2Y_uY_d^\dagger Y_dY_u^\dagger\Big) \\
&- 36\mathrm{Tr}\Big(m_u^2Y_uY_u^\dagger Y_uY_u^\dagger\Big)
\end{aligned} \tag{87}
$$

$$
\begin{aligned}
\beta_{m_d^2}^{(1)} = &-\frac{8}{15}g_1^2\mathbf{1}|M_1|^2 - \frac{32}{3}g_3^2\mathbf{1}|M_3|^2 - 8g_p^2Q_d^2\mathbf{1}|M_Z|^2 + 4m_{H_d}^2Y_dY_d^\dagger + 4T_d'^*T_d'^T + 4T_dT_d^\dagger \\
&+ 2m_d^2Y_dY_d^\dagger + 4Y_dm_q^2Y_d^\dagger + 2Y_dY_d^\dagger m_d^2 + 2\frac{1}{\sqrt{15}}g_1\mathbf{1}\sigma_{1,1} + 2g_pQ_d\mathbf{1}\sigma_{1,4}
\end{aligned} \tag{88}
$$

$$
\begin{aligned}
\beta_{m_d^2}^{(2)} = &+\frac{176}{15}g_1^2g_p^2Q_d^2\mathbf{1}|M_Z|^2 + \frac{128}{3}g_3^2g_p^2Q_d^2\mathbf{1}|M_Z|^2 + 264g_p^4Q_d^4\mathbf{1}|M_Z|^2 \\
&+ \frac{16}{5}g_1^2g_p^2Q_dQ_{e_4}\mathbf{1}|M_Z|^2 + 24g_p^4Q_d^2Q_{e_4}^2\mathbf{1}|M_Z|^2 + \frac{32}{5}g_1^2g_p^2Q_dQ_{e_9}\mathbf{1}|M_Z|^2 \\
&+ 48g_p^4Q_d^2Q_{e_9}^2\mathbf{1}|M_Z|^2 - \frac{16}{5}g_1^2g_p^2Q_dQ_{H_d}\mathbf{1}|M_Z|^2 + 48g_p^4Q_d^2Q_{H_d}^2\mathbf{1}|M_Z|^2 \\
&+ \frac{16}{5}g_1^2g_p^2Q_dQ_{H_u}\mathbf{1}|M_Z|^2 + 48g_p^4Q_d^2Q_{H_u}^2\mathbf{1}|M_Z|^2 - \frac{16}{5}g_1^2g_p^2Q_dQ_{l_4}\mathbf{1}|M_Z|^2 \\
&+ 48g_p^4Q_d^2Q_{l_4}^2\mathbf{1}|M_Z|^2 - \frac{32}{5}g_1^2g_p^2Q_dQ_{l_9}\mathbf{1}|M_Z|^2 + 96g_p^4Q_d^2Q_{l_9}^2\mathbf{1}|M_Z|^2 \\
&+ \frac{48}{5}g_1^2g_p^2Q_dQ_q\mathbf{1}|M_Z|^2 + 432g_p^4Q_d^2Q_q^2\mathbf{1}|M_Z|^2 + 24g_p^4Q_d^2Q_s^2\mathbf{1}|M_Z|^2 \\
&- \frac{96}{5}g_1^2g_p^2Q_dQ_u\mathbf{1}|M_Z|^2 + 216g_p^4Q_d^2Q_u^2\mathbf{1}|M_Z|^2 \\
&- \frac{64}{45}g_3^2\Big(-15g_p^2\Big(2M_3+M_Z\Big)Q_d^2 + 30g_3^2M_3 - g_1^2\Big(2M_3+M_1\Big)\Big)\mathbf{1}M_3^* + \frac{88}{15}g_1^2g_p^2M_1Q_d^2\mathbf{1}M_Z^* \\
&+ \frac{64}{3}g_3^2g_p^2M_3Q_d^2\mathbf{1}M_Z^* + \frac{8}{5}g_1^2g_p^2M_1Q_dQ_{e_4}\mathbf{1}M_Z^* + \frac{16}{5}g_1^2g_p^2M_1Q_dQ_{e_9}\mathbf{1}M_Z^* \\
&- \frac{8}{5}g_1^2g_p^2M_1Q_dQ_{H_d}\mathbf{1}M_Z^* + \frac{8}{5}g_1^2g_p^2M_1Q_dQ_{H_u}\mathbf{1}M_Z^* - \frac{8}{5}g_1^2g_p^2M_1Q_dQ_{l_4}\mathbf{1}M_Z^* \\
&- \frac{16}{5}g_1^2g_p^2M_1Q_dQ_{l_9}\mathbf{1}M_Z^* + \frac{24}{5}g_1^2g_p^2M_1Q_dQ_q\mathbf{1}M_Z^* - \frac{48}{5}g_1^2g_p^2M_1Q_dQ_u\mathbf{1}M_Z^* \\
&+ \frac{4}{5}g_1^2m_{H_d}^2Y_dY_d^\dagger + 12g_2^2m_{H_d}^2Y_dY_d^\dagger - 8g_p^2m_{H_d}^2Q_d^2Y_dY_d^\dagger \\
&+ 8g_p^2m_{H_d}^2Q_{H_d}^2Y_dY_d^\dagger + 8g_p^2m_{H_d}^2Q_q^2Y_dY_d^\dagger - 8m_{H_d}^2\lambda^2Y_dY_d^\dagger
\end{aligned}
$$

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\begin{aligned}
&- 4m_{H_u}^2\lambda^2 Y_d Y_d^\dagger - 4m_s^2\lambda^2 Y_d Y_d^\dagger - 16g_p^2 Q_d^2 |M_Z|^2 Y_d Y_d^\dagger \\
&+ 16g_p^2 Q_{H_d}^2 |M_Z|^2 Y_d Y_d^\dagger + 16g_p^2 Q_q^2 |M_Z|^2 Y_d Y_d^\dagger + 24g_2^2 |M_2|^2 Y_d Y_d^\dagger \\
&- 4m_{e_4}^2 |Y1|^2 Y_d Y_d^\dagger - 8m_{H_d}^2 |Y1|^2 Y_d Y_d^\dagger - 4m_{l_4}^2 |Y1|^2 Y_d Y_d^\dagger - 4|TY1|^2 Y_d Y_d^\dagger \\
&- \frac{4}{5} g_1^2 M_1 Y_d T_d^\dagger - 12 g_2^2 M_2 Y_d T_d^\dagger + 8 g_p^2 M_Z Q_d^2 Y_d T_d^\dagger \\
&- 8 g_p^2 M_Z Q_{H_d}^2 Y_d T_d^\dagger - 8 g_p^2 M_Z Q_q^2 Y_d T_d^\dagger \\
&+ \frac{4}{225} g_1^2 M_1^* \Big(2\Big(15 g_p^2 \Big(2M_1 + M_Z \Big) Q_d \Big(11 Q_d + 3\Big(2Q_{e_9} - 2Q_{l_9} + 3Q_q - 6Q_u - Q_{H_d} - Q_{l_4} + Q_{e_4} + Q_{H_u} \Big) \Big) + 303 g_1^2 M_1 + 40 g_3^2 \Big(2 \\
&+ 90 M_1 Y_d Y_d^\dagger - 45 T_d Y_d^\dagger \Big) \\
&+ 8 g_p^2 Q_d^2 M_Z^* T_d Y_d^\dagger - 8 g_p^2 Q_{H_d}^2 M_Z^* T_d Y_d^\dagger - 8 g_p^2 Q_q^2 M_Z^* T_d Y_d^\dagger \\
&- 12 g_2^2 M_2^* T_d Y_d^\dagger - 4 Y1 TY1^* T_d Y_d^\dagger + \frac{4}{5} g_1^2 T_d T_d^\dagger + 12 g_2^2 T_d T_d^\dagger \\
&- 8 g_p^2 Q_d^2 T_d T_d^\dagger + 8 g_p^2 Q_{H_d}^2 T_d T_d^\dagger + 8 g_p^2 Q_q^2 T_d T_d^\dagger - 4\lambda^2 T_d T_d^\dagger \\
&- 4|Y1|^2 T_d T_d^\dagger + \frac{2}{5} g_1^2 m_d^2 Y_d Y_d^\dagger + 6 g_2^2 m_d^2 Y_d Y_d^\dagger - 4 g_p^2 Q_d^2 m_d^2 Y_d Y_d^\dagger \\
&+ 4 g_p^2 Q_{H_d}^2 m_d^2 Y_d Y_d^\dagger + 4 g_p^2 Q_q^2 m_d^2 Y_d Y_d^\dagger - 2\lambda^2 m_d^2 Y_d Y_d^\dagger \\
&- 2|Y1|^2 m_d^2 Y_d Y_d^\dagger + \frac{4}{5} g_1^2 Y_d m_q^2 Y_d^\dagger + 12 g_2^2 Y_d m_q^2 Y_d^\dagger - 8 g_p^2 Q_d^2 Y_d m_q^2 Y_d^\dagger \\
&+ 8 g_p^2 Q_{H_d}^2 Y_d m_q^2 Y_d^\dagger + 8 g_p^2 Q_q^2 Y_d m_q^2 Y_d^\dagger - 4\lambda^2 Y_d m_q^2 Y_d^\dagger \\
&- 4|Y1|^2 Y_d m_q^2 Y_d^\dagger + \frac{2}{5} g_1^2 Y_d Y_d^\dagger m_d^2 + 6 g_2^2 Y_d Y_d^\dagger m_d^2 - 4 g_p^2 Q_d^2 Y_d Y_d^\dagger m_d^2 \\
&+ 4 g_p^2 Q_{H_d}^2 Y_d Y_d^\dagger m_d^2 + 4 g_p^2 Q_q^2 Y_d Y_d^\dagger m_d^2 - 2\lambda^2 Y_d Y_d^\dagger m_d^2 \\
&- 2|Y1|^2 Y_d Y_d^\dagger m_d^2 - 8 m_{H_d}^2 Y_d Y_d^\dagger Y_d Y_d^\dagger - 4 Y_d Y_d^\dagger T_d T_d^\dagger - 4 m_{H_d}^2 Y_d Y_u^\dagger Y_u Y_d^\dagger \\
&- 4 m_{H_u}^2 Y_d Y_u^\dagger Y_u Y_d^\dagger - 4 Y_d Y_u^\dagger T_u T_d^\dagger - 4 Y_d T_d^\dagger T_d Y_d^\dagger - 4 Y_d T_u^\dagger T_u Y_d^\dagger \\
&- 4 T_d Y_d^\dagger Y_d T_d^\dagger - 4 T_d Y_u^\dagger Y_u T_d^\dagger - 4 T_d T_d^\dagger Y_d Y_d^\dagger - 4 T_d T_u^\dagger Y_u Y_d^\dagger \\
&- 2 m_d^2 Y_d Y_d^\dagger Y_d Y_d^\dagger - 2 m_d^2 Y_d Y_u^\dagger Y_u Y_d^\dagger - 4 Y_d m_q^2 Y_d^\dagger Y_d Y_d^\dagger - 4 Y_d m_q^2 Y_u^\dagger Y_u Y_d^\dagger \\
&- 4 Y_d Y_d^\dagger m_d^2 Y_d Y_d^\dagger - 4 Y_d Y_d^\dagger Y_d m_q^2 Y_d^\dagger - 2 Y_d Y_d^\dagger Y_d Y_d^\dagger m_d^2 - 4 Y_d Y_u^\dagger m_u^2 Y_u Y_d^\dagger \\
&- 4 Y_d Y_u^\dagger Y_u m_q^2 Y_d^\dagger - 2 Y_d Y_u^\dagger Y_u Y_d^\dagger m_d^2 - 4 Y1^* Y_d T_d^\dagger TY1 - 4\lambda Y_d T_d^\dagger T_\lambda \\
&- 4\lambda T_d Y_d^\dagger T_\lambda - 4 Y_d Y_d^\dagger T_\lambda^2 + \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 g_p Q_d \mathbf{1}\sigma_{2,14} \\
&+ 8\frac{1}{\sqrt{15}} g_1 g_p Q_d \mathbf{1}\sigma_{2,41} + 8 g_p^2 Q_d^2 \mathbf{1}\sigma_{2,44} + 8\frac{1}{\sqrt{15}} g_1 \mathbf{1}\sigma_{3,1} + 8 g_p Q_d \mathbf{1}\sigma_{3,4} \\
&- 8 m_{H_d}^2 Y_d Y_d^\dagger \mathrm{Tr}\Big(Y2Y2^\dagger \Big) - 4 T_d T_d^\dagger \mathrm{Tr}\Big(Y2Y2^\dagger \Big) - 2 m_d^2 Y_d Y_d^\dagger \mathrm{Tr}\Big(Y2Y2^\dagger \Big) \\
&- 4 Y_d m_q^2 Y_d^\dagger \mathrm{Tr}\Big(Y2Y2^\dagger \Big) - 2 Y_d Y_d^\dagger m_d^2 \mathrm{Tr}\Big(Y2Y2^\dagger \Big) - 24 m_{H_d}^2 Y_d Y_d^\dagger \mathrm{Tr}\Big(Y_d Y_d^\dagger \Big) \\
&- 12 T_d T_d^\dagger \mathrm{Tr}\Big(Y_d Y_d^\dagger \Big) - 6 m_d^2 Y_d Y_d^\dagger \mathrm{Tr}\Big(Y_d Y_d^\dagger \Big) - 12 Y_d m_q^2 Y_d^\dagger \mathrm{Tr}\Big(Y_d Y_d^\dagger \Big)
\end{aligned}
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\begin{aligned}
&- 6Y_dY_d^\dagger m_d^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 4Y_dT_d^\dagger\mathrm{Tr}\Big(Y2^\dagger TY2\Big) - 12Y_dT_d^\dagger\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)\\
&- 4T_dY_d^\dagger\mathrm{Tr}\Big(TY2^*Y2^T\Big) - 4Y_dY_d^\dagger\mathrm{Tr}\Big(TY2^*TY2^T\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) - 12Y_dY_d^\dagger\mathrm{Tr}\Big(m_d^2Y_dY_d^\dagger\Big) - 4Y_dY_d^\dagger\mathrm{Tr}\Big(m_{e_9}^2Y2Y2^\dagger\Big)\\
&- 4Y_dY_d^\dagger\mathrm{Tr}\Big(m_{l_9}^2Y2^\dagger Y2\Big) - 12Y_dY_d^\dagger\mathrm{Tr}\Big(m_q^2Y_d^\dagger Y_d\Big) \qquad (89)\\
\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 - 8g_p^2Q_u^2\mathbf{1}|M_Z|^2 + 4m_{H_u}^2Y_uY_u^\dagger + 4T_uT_u^\dagger\\
&+ 2m_u^2Y_uY_u^\dagger + 4Y_um_q^2Y_u^\dagger + 2Y_uY_u^\dagger m_u^2 - 4\frac{1}{\sqrt{15}}g_1\mathbf{1}\sigma_{1,1} + 2g_pQ_u\mathbf{1}\sigma_{1,4} \qquad (90)\\
\beta_{m_u^2}^{(2)} &= \frac{1}{225}\Big(4g_1^2M_1^*\Big(4\Big(-15g_p^2\Big(2M_1+M_Z\Big)\Big(-22Q_u+3Q_{e_4}-3Q_{H_d}+3Q_{H_u}-3Q_{l_4}+6Q_{e_9}-6Q_{l_9}+9Q_d+9Q_q\Big)Q_u + 642g_1^2M_1\\
&+ 45\Big(-2M_1Y_uY_u^\dagger + T_uY_u^\dagger\Big)\Big)\\
&+ 10\Big(32g_3^2\Big(15g_p^2\Big(2M_3+M_Z\Big)Q_u^2 - 30g_3^2M_3 + 4g_1^2\Big(2M_3+M_1\Big)\Big)\mathbf{1}M_3^*\\
&+ 12g_p^2M_Z^*\Big(Q_u\Big(-2g_1^2\Big(2M_Z+M_1\Big)\Big(-22Q_u+3Q_{e_4}-3Q_{H_d}+3Q_{H_u}-3Q_{l_4}+6Q_{e_9}-6Q_{l_9}+9Q_d+9Q_q\Big)\\
&+ 5Q_u\Big(8g_3^2\Big(2M_Z+M_3\Big) + 9g_p^2M_Z\Big(11Q_u^2+18Q_q^2+2Q_{e_9}^2+2Q_{H_d}^2+2Q_{H_u}^2+2Q_{l_4}^2+4Q_{l_9}^2+9Q_d^2+Q_{e_4}^2+Q_s^2\Big)\Big)\Big)\mathbf{1}\\
&+ 15\Big(-Q_u^2+Q_{H_u}^2+Q_q^2\Big)\Big(2M_ZY_uY_u^\dagger - T_uY_u^\dagger\Big)\Big)\\
&+ 12\mathbf{1}\Big(15g_pQ_u\Big(g_pQ_u\sigma_{2,44}+\sigma_{3,4}\Big) + 20g_3^4\sigma_{2,3} - 2\sqrt{15}g_1\Big(g_pQ_u\Big(\sigma_{2,14}+\sigma_{2,41}\Big)+\sigma_{3,1}\Big) + 4g_1^2\sigma_{2,11}\Big)\\
&- 9\Big(30g_2^2M_2^*T_uY_u^\dagger + 2g_1^2T_uT_u^\dagger - 30g_2^2T_uT_u^\dagger - 20g_p^2Q_{H_u}^2T_uT_u^\dagger\\
&- 20g_p^2Q_q^2T_uT_u^\dagger + 20g_p^2Q_u^2T_uT_u^\dagger + 10\lambda^2T_uT_u^\dagger + g_1^2m_u^2Y_uY_u^\dagger\\
&- 15g_2^2m_u^2Y_uY_u^\dagger - 10g_p^2Q_{H_u}^2m_u^2Y_uY_u^\dagger - 10g_p^2Q_q^2m_u^2Y_uY_u^\dagger\\
&+ 10g_p^2Q_u^2m_u^2Y_uY_u^\dagger + 5\lambda^2m_u^2Y_uY_u^\dagger + 2g_1^2Y_um_q^2Y_u^\dagger - 30g_2^2Y_um_q^2Y_u^\dagger\\
&- 20g_p^2Q_{H_u}^2Y_um_q^2Y_u^\dagger - 20g_p^2Q_q^2Y_um_q^2Y_u^\dagger + 20g_p^2Q_u^2Y_um_q^2Y_u^\dagger\\
&+ 10\lambda^2Y_um_q^2Y_u^\dagger + g_1^2Y_uY_u^\dagger m_u^2 - 15g_2^2Y_uY_u^\dagger m_u^2 - 10g_p^2Q_{H_u}^2Y_uY_u^\dagger m_u^2\\
&- 10g_p^2Q_q^2Y_uY_u^\dagger m_u^2 + 10g_p^2Q_u^2Y_uY_u^\dagger m_u^2 + 5\lambda^2Y_uY_u^\dagger m_u^2\\
&+ 10m_{H_d}^2Y_uY_d^\dagger Y_dY_u^\dagger + 10m_{H_u}^2Y_uY_d^\dagger Y_dY_u^\dagger + 10Y_uY_d^\dagger T_dT_u^\dagger\\
&+ 20m_{H_u}^2Y_uY_u^\dagger Y_uY_u^\dagger + 10Y_uY_u^\dagger T_uT_u^\dagger + 10Y_uT_d^\dagger T_dY_u^\dagger + 10Y_uT_u^\dagger T_uY_u^\dagger\\
&+ 10T_uY_d^\dagger Y_dT_u^\dagger + 10T_uY_u^\dagger Y_uT_u^\dagger + 10T_uT_d^\dagger Y_dY_u^\dagger + 10T_uT_u^\dagger Y_uY_u^\dagger\\
&+ 5m_u^2Y_uY_d^\dagger Y_dY_u^\dagger + 5m_u^2Y_uY_u^\dagger Y_uY_u^\dagger + 10Y_um_q^2Y_d^\dagger Y_dY_u^\dagger + 10Y_um_q^2Y_u^\dagger Y_uY_u^\dagger\\
&+ 10Y_uY_d^\dagger m_d^2Y_dY_u^\dagger + 10Y_uY_d^\dagger Y_dm_q^2Y_u^\dagger + 5Y_uY_d^\dagger Y_dY_u^\dagger m_u^2\\
&+ 10Y_uY_u^\dagger m_u^2Y_uY_u^\dagger + 10Y_uY_u^\dagger Y_um_q^2Y_u^\dagger + 5Y_uY_u^\dagger Y_uY_u^\dagger m_u^2 + 10\lambda T_uY_u^\dagger T_\lambda\\
&+ 30T_uT_u^\dagger\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 15m_u^2Y_uY_u^\dagger\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 30Y_um_q^2Y_u^\dagger\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)
\end{aligned}
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\begin{aligned}
&+ 15Y_uY_u^\dagger m_u^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)\\
&+ Y_uT_u^\dagger\Big(10\lambda T_\lambda + 20g_p^2M_ZQ_{H_u}^2 + 20g_p^2M_ZQ_q^2 - 20g_p^2M_ZQ_u^2 - 2g_1^2M_1 + 30g_2^2M_2 + 30\mathrm{Tr}\Big(Y_u^\dagger T_u\Big)\Big)\\
&+ 30T_uY_u^\dagger\mathrm{Tr}\Big(T_u^*Y_u^T\Big)\\
&+ 2Y_uY_u^\dagger\Big(g_1^2m_{H_u}^2 - 15g_2^2m_{H_u}^2 - 10g_p^2m_{H_u}^2Q_{H_u}^2 - 10g_p^2m_{H_u}^2Q_q^2 + 10g_p^2m_{H_u}^2Q_u^2 + 5m_{H_d}^2\lambda^2\\
&+ 10m_{H_u}^2\lambda^2 + 5m_s^2\lambda^2 - 30g_2^2|M_2|^2 + 5T_\lambda^2 + 30m_{H_u}^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 15\mathrm{Tr}\Big(T_u^*T_u^T\Big) + 15\mathrm{Tr}\Big(m_q^2Y_u^\dagger Y_u\Big)\\
&+ 15\mathrm{Tr}\Big(m_u^2Y_uY_u^\dagger\Big)\Big)\Big)\Big)\Big) \qquad (91)\\
\beta^{(1)}_{m_{e_4}^2} &= -\frac{24}{5}g_1^2|M_1|^2 - 8g_p^2Q_{e_4}^2|M_Z|^2 + 4m_{e_4}^2|Y1|^2 + 4m_{H_d}^2|Y1|^2 + 4m_{l_4}^2|Y1|^2 + 4|TY1|^2 + 2\sqrt{\frac{3}{5}}g_1\sigma_{1,1}\\
&+ 2g_pQ_{e_4}\sigma_{1,4} \qquad (92)\\
\beta^{(2)}_{m_{e_4}^2} &= \frac{4}{25}\Big(3g_1^2M_1^*\Big(10g_p^2\Big(2M_1 + M_Z\Big)Q_{e_4}\Big(2Q_{e_9} - 2Q_{l_9} + 3Q_d + 3Q_{e_4} + 3Q_q - 6Q_u - Q_{H_d} - Q_{l_4} + Q_{H_u}\Big) + 234g_1^2M_1 + 5Y1^*\Big(- 2\\
&+ 5\Big(- 3g_1^2|TY1|^2 + 15g_2^2|TY1|^2 - 10g_p^2Q_{e_4}^2|TY1|^2 + 10g_p^2Q_{H_d}^2|TY1|^2 + 10g_p^2Q_{l_4}^2|TY1|^2\\
&- 5\lambda^2|TY1|^2 - 20\Big(m_{e_4}^2 + m_{H_d}^2 + m_{l_4}^2\Big)|Y1|^4 + 3g_1^2M_1Y1TY1^* - 15g_2^2M_2Y1TY1^* + 10g_p^2M_ZQ_{e_4}^2Y1TY1^*\\
&- 10g_p^2M_ZQ_{H_d}^2Y1TY1^* - 10g_p^2M_ZQ_{l_4}^2Y1TY1^*\\
&+ 2g_p^2M_Z^*\Big(3Q_{e_4}\Big(g_1^2\Big(2M_Z + M_1\Big)\Big(2Q_{e_9} - 2Q_{l_9} + 3Q_d + 3Q_{e_4} + 3Q_q - 6Q_u - Q_{H_d} - Q_{l_4} + Q_{H_u}\Big)\\
&+ 5g_p^2M_ZQ_{e_4}\Big(18Q_q^2 + 2Q_{e_9}^2 + 2Q_{H_d}^2 + 2Q_{H_u}^2 + 2Q_{l_4}^2 + 3Q_{e_4}^2 + 4Q_{l_9}^2 + 9Q_d^2 + 9Q_u^2 + Q_s^2\Big)\Big)\\
&- 5\Big(- Q_{H_d}^2 - Q_{l_4}^2 + Q_{e_4}^2\Big)Y1^*\Big(2M_ZY1 - TY1\Big)\Big)\\
&- 5Y1\lambda TY1^*T_\lambda + 6g_1^2\sigma_{2,11} + 2\sqrt{15}g_1g_pQ_{e_4}\sigma_{2,14} + 2\sqrt{15}g_1g_pQ_{e_4}\sigma_{2,41} + 10g_p^2Q_{e_4}^2\sigma_{2,44}\\
&+ 2\sqrt{15}g_1\sigma_{3,1} + 10g_pQ_{e_4}\sigma_{3,4} - 5|TY1|^2\mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 15|TY1|^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 5Y1TY1^*\mathrm{Tr}\Big(Y2^\dagger TY2\Big)\\
&- 15Y1TY1^*\mathrm{Tr}\Big(Y_d^\dagger T_d\Big)\\
&- Y1^*\Big(3g_1^2m_{e_4}^2Y1 - 15g_2^2m_{e_4}^2Y1 + 3g_1^2m_{H_d}^2Y1 - 15g_2^2m_{H_d}^2Y1 + 3g_1^2m_{l_4}^2Y1 - 15g_2^2m_{l_4}^2Y1\\
&+ 10g_p^2m_{e_4}^2Q_{e_4}^2Y1 + 10g_p^2m_{H_d}^2Q_{e_4}^2Y1 + 10g_p^2m_{l_4}^2Q_{e_4}^2Y1 - 10g_p^2m_{e_4}^2Q_{H_d}^2Y1\\
&- 10g_p^2m_{H_d}^2Q_{H_d}^2Y1 - 10g_p^2m_{l_4}^2Q_{H_d}^2Y1 - 10g_p^2m_{e_4}^2Q_{l_4}^2Y1 - 10g_p^2m_{H_d}^2Q_{l_4}^2Y1\\
&- 10g_p^2m_{l_4}^2Q_{l_4}^2Y1 + 5m_{e_4}^2Y1\lambda^2 + 10m_{H_d}^2Y1\lambda^2 + 5m_{H_u}^2Y1\lambda^2 + 5m_{l_4}^2Y1\lambda^2 + 5m_s^2Y1\lambda^2 + 40Y1|TY1|^2\\
&+ 15g_2^2M_2^*\Big(- 2M_2Y1 + TY1\Big) + 5\lambda TY1T_\lambda + 5Y1T_\lambda^2 + 5m_{e_4}^2Y1\mathrm{Tr}\Big(Y2Y2^\dagger\Big) + 10m_{H_d}^2Y1\mathrm{Tr}\Big(Y2Y2^\dagger\Big)\\
&+ 5m_{l_4}^2Y1\mathrm{Tr}\Big(Y2Y2^\dagger\Big) + 15m_{e_4}^2Y1\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + 30m_{H_d}^2Y1\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + 15m_{l_4}^2Y1\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)\\
&+ 5TY1\mathrm{Tr}\Big(TY2^*Y2^T\Big) + 5Y1\mathrm{Tr}\Big(TY2^*TY2^T\Big) + 15TY1\mathrm{Tr}\Big(T_d^*Y_d^T\Big) + 15Y1\mathrm{Tr}\Big(T_d^*T_d^T\Big) + 15Y1\mathrm{Tr}\Big(m_d^2Y_dY_d^\dagger\Big)\\
&+ 5Y1\mathrm{Tr}\Big(m_{e_9}^2Y2Y2^\dagger\Big) + 5Y1\mathrm{Tr}\Big(m_{l_9}^2Y2^\dagger Y2\Big) + 15Y1\mathrm{Tr}\Big(m_q^2Y_d^\dagger Y_d\Big)\Big)\Big)\Big) \qquad (93)
\end{aligned}
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\begin{aligned}
\beta^{(1)}_{m^2_{e_9}} =& -\frac{24}{5}g_1^2\mathbf{1}|M_1|^2 - 8g_p^2Q^2_{e_9}\mathbf{1}|M_Z|^2 + 4m^2_{H_d}Y2Y2^\dagger + 4T'^*_e T'^T_e + 4TY2TY2^\dagger + 2m^2_{e_9}Y2Y2^\dagger \\
&+ 4Y2m^2_{l_9}Y2^\dagger + 2Y2Y2^\dagger m^2_{e_9} + 2\sqrt{\frac{3}{5}}g_1\mathbf{1}\sigma_{1,1} + 2g_pQ_{e_9}\mathbf{1}\sigma_{1,4} \qquad (94)\\
\beta^{(2)}_{m^2_{e_9}} =& -\frac{12}{5}g_1^2m^2_{H_d}Y2Y2^\dagger + 12g_2^2m^2_{H_d}Y2Y2^\dagger - 8g_p^2m^2_{H_d}Q^2_{e_9}Y2Y2^\dagger \\
&+ 8g_p^2m^2_{H_d}Q^2_{H_d}Y2Y2^\dagger + 8g_p^2m^2_{H_d}Q^2_{l_9}Y2Y2^\dagger - 8m^2_{H_d}\lambda^2Y2Y2^\dagger - 4m^2_{H_u}\lambda^2Y2Y2^\dagger \\
&- 4m_s^2\lambda^2Y2Y2^\dagger + 24g_2^2|M_2|^2Y2Y2^\dagger - 4m^2_{e_4}|Y1|^2Y2Y2^\dagger - 8m^2_{H_d}|Y1|^2Y2Y2^\dagger \\
&- 4m^2_{l_4}|Y1|^2Y2Y2^\dagger - 4|TY1|^2Y2Y2^\dagger + \frac{12}{5}g_1^2M_1Y2TY2^\dagger - 12g_2^2M_2Y2TY2^\dagger \\
&+ 8g_p^2M_ZQ^2_{e_9}Y2TY2^\dagger - 8g_p^2M_ZQ^2_{H_d}Y2TY2^\dagger - 8g_p^2M_ZQ^2_{l_9}Y2TY2^\dagger \\
&+ \frac{8}{5}g_p^2M_Z^*\Big(3Q_{e_9}\Big(g_1^2\Big(2M_Z + M_1\Big)\Big(-2Q_{l_9} + 3Q_d + 3Q_q + 4Q_{e_9} - 6Q_u - Q_{H_d} - Q_{l_4} + Q_{e_4} + Q_{H_u}\Big) \\
&+ 5g_p^2M_ZQ_{e_9}\Big(18Q_q^2 + 2Q^2_{H_d} + 2Q^2_{H_u} + 2Q^2_{l_4} + 4Q^2_{e_9} + 4Q^2_{l_9} + 9Q_d^2 + 9Q_u^2 + Q^2_{e_4} + Q_s^2\Big)\Big)\mathbf{1} \\
&- 5\Big(-Q^2_{H_d} - Q^2_{l_9} + Q^2_{e_9}\Big)\Big(2M_ZY2Y2^\dagger - TY2Y2^\dagger\Big)\Big) \\
&- 12g_2^2M_2^*TY2Y2^\dagger - 4Y1TY1^*TY2Y2^\dagger \\
&+ \frac{12}{25}g_1^2M_1^*\Big(2\Big(117g_1^2M_1 + 5g_p^2\Big(2M_1 + M_Z\Big)Q_{e_9}\Big(-2Q_{l_9} + 3Q_d + 3Q_q + 4Q_{e_9} - 6Q_u - Q_{H_d} - Q_{l_4} + Q_{e_4} + Q_{H_u}\Big)\Big)\mathbf{1} \\
&+ 5\Big(-2M_1Y2Y2^\dagger + TY2Y2^\dagger\Big)\Big) \\
&- \frac{12}{5}g_1^2TY2TY2^\dagger + 12g_2^2TY2TY2^\dagger - 8g_p^2Q^2_{e_9}TY2TY2^\dagger + 8g_p^2Q^2_{H_d}TY2TY2^\dagger \\
&+ 8g_p^2Q^2_{l_9}TY2TY2^\dagger - 4\lambda^2TY2TY2^\dagger - 4|Y1|^2TY2TY2^\dagger - \frac{6}{5}g_1^2m^2_{e_9}Y2Y2^\dagger \\
&+ 6g_2^2m^2_{e_9}Y2Y2^\dagger - 4g_p^2Q^2_{e_9}m^2_{e_9}Y2Y2^\dagger + 4g_p^2Q^2_{H_d}m^2_{e_9}Y2Y2^\dagger \\
&+ 4g_p^2Q^2_{l_9}m^2_{e_9}Y2Y2^\dagger - 2\lambda^2m^2_{e_9}Y2Y2^\dagger - 2|Y1|^2m^2_{e_9}Y2Y2^\dagger - \frac{12}{5}g_1^2Y2m^2_{l_9}Y2^\dagger \\
&+ 12g_2^2Y2m^2_{l_9}Y2^\dagger - 8g_p^2Q^2_{e_9}Y2m^2_{l_9}Y2^\dagger + 8g_p^2Q^2_{H_d}Y2m^2_{l_9}Y2^\dagger \\
&+ 8g_p^2Q^2_{l_9}Y2m^2_{l_9}Y2^\dagger - 4\lambda^2Y2m^2_{l_9}Y2^\dagger - 4|Y1|^2Y2m^2_{l_9}Y2^\dagger - \frac{6}{5}g_1^2Y2Y2^\dagger m^2_{e_9} \\
&+ 6g_2^2Y2Y2^\dagger m^2_{e_9} - 4g_p^2Q^2_{e_9}Y2Y2^\dagger m^2_{e_9} + 4g_p^2Q^2_{H_d}Y2Y2^\dagger m^2_{e_9} \\
&+ 4g_p^2Q^2_{l_9}Y2Y2^\dagger m^2_{e_9} - 2\lambda^2Y2Y2^\dagger m^2_{e_9} - 2|Y1|^2Y2Y2^\dagger m^2_{e_9} - 8m^2_{H_d}Y2Y2^\dagger Y2Y2^\dagger \\
&- 4Y2Y2^\dagger TY2TY2^\dagger - 4Y2TY2^\dagger TY2Y2^\dagger - 4TY2Y2^\dagger Y2TY2^\dagger - 4TY2TY2^\dagger Y2Y2^\dagger \\
&- 2m^2_{e_9}Y2Y2^\dagger Y2Y2^\dagger - 4Y2m^2_{l_9}Y2^\dagger Y2Y2^\dagger - 4Y2Y2^\dagger m^2_{e_9}Y2Y2^\dagger - 4Y2Y2^\dagger Y2m^2_{l_9}Y2^\dagger \\
&- 2Y2Y2^\dagger Y2Y2^\dagger m^2_{e_9} - 4Y1^*Y2TY2^\dagger TY1 - 4\lambda Y2TY2^\dagger T_\lambda - 4\lambda TY2Y2^\dagger T_\lambda - 4Y2Y2^\dagger T_\lambda^2 \\
&+ \frac{24}{5}g_1^2\mathbf{1}\sigma_{2,11} + 8\sqrt{\frac{3}{5}}g_1g_pQ_{e_9}\mathbf{1}\sigma_{2,14} + 8\sqrt{\frac{3}{5}}g_1g_pQ_{e_9}\mathbf{1}\sigma_{2,41} + 8g_p^2Q^2_{e_9}\mathbf{1}\sigma_{2,44} + 8\sqrt{\frac{3}{5}}g_1\mathbf{1}\sigma_{3,1} + 8g_pQ_{e_9}\mathbf{1}\sigma_{3,4} \\
&- 8m^2_{H_d}Y2Y2^\dagger\mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 4TY2TY2^\dagger\mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 2m^2_{e_9}Y2Y2^\dagger\mathrm{Tr}\Big(Y2Y2^\dagger\Big)
\end{aligned}
$$

$$
\begin{aligned}
&- 4Y2m_{l_9}^2 Y2^\dagger \mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 2Y2Y2^\dagger m_{e_9}^2 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 24m_{H_d}^2 Y2Y2^\dagger \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) \\
&- 12TY2TY2^\dagger \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 6m_{e_9}^2 Y2Y2^\dagger \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 12Y2m_{l_9}^2 Y2^\dagger \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) \\
&- 6Y2Y2^\dagger m_{e_9}^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 4Y2TY2^\dagger \mathrm{Tr}\Big(Y2^\dagger TY2\Big) - 12Y2TY2^\dagger \mathrm{Tr}\Big(Y_d^\dagger T_d\Big) \\
&- 4TY2Y2^\dagger \mathrm{Tr}\Big(TY2^*Y2^T\Big) - 4Y2Y2^\dagger \mathrm{Tr}\Big(TY2^*TY2^T\Big) - 12TY2Y2^\dagger \mathrm{Tr}\Big(T_d^* Y_d^T\Big) - 12Y2Y2^\dagger \mathrm{Tr}\Big(T_d^* T_d^T\Big) \\
&- 12Y2Y2^\dagger \mathrm{Tr}\Big(m_d^2 Y_d Y_d^\dagger\Big) - 4Y2Y2^\dagger \mathrm{Tr}\Big(m_{e_9}^2 Y2Y2^\dagger\Big) - 4Y2Y2^\dagger \mathrm{Tr}\Big(m_{l_9}^2 Y2^\dagger Y2\Big) \\
&- 12Y2Y2^\dagger \mathrm{Tr}\Big(m_q^2 Y_d^\dagger Y_d\Big)
\end{aligned} \tag{95}
$$

$$
\beta_{m_s^2}^{(1)} = 2g_p Q_s \sigma_{1,4} + 4m_s^2\lambda^2 + 4m_{H_d}^2\lambda^2 + 4m_{H_u}^2\lambda^2 + 4T_\lambda^2 - 8g_p^2 Q_s^2 |M_Z|^2 \tag{96}
$$

$$
\begin{aligned}
\beta_{m_s^2}^{(2)} = &+\frac{12}{5}g_1^2 m_{H_d}^2\lambda^2 + 12g_2^2 m_{H_d}^2\lambda^2 + \frac{12}{5}g_1^2 m_{H_u}^2\lambda^2 + 12g_2^2 m_{H_u}^2\lambda^2 + \frac{12}{5}g_1^2 m_s^2\lambda^2 + 12g_2^2 m_s^2\lambda^2 \\
&+ 8g_p^2 m_{H_d}^2 Q_{H_d}^2\lambda^2 + 8g_p^2 m_{H_u}^2 Q_{H_d}^2\lambda^2 + 8g_p^2 m_s^2 Q_{H_d}^2\lambda^2 + 8g_p^2 m_{H_d}^2 Q_{H_u}^2\lambda^2 \\
&+ 8g_p^2 m_{H_u}^2 Q_{H_u}^2\lambda^2 + 8g_p^2 m_s^2 Q_{H_u}^2\lambda^2 - 8g_p^2 m_{H_d}^2 Q_s^2\lambda^2 - 8g_p^2 m_{H_u}^2 Q_s^2\lambda^2 \\
&- 8g_p^2 m_s^2 Q_s^2\lambda^2 - 16m_{H_d}^2\lambda^4 - 16m_{H_u}^2\lambda^4 - 16m_s^2\lambda^4 + 24g_2^2\lambda^2|M_2|^2 - 4m_{e_4}^2\lambda^2|Y1|^2 \\
&- 8m_{H_d}^2\lambda^2|Y1|^2 - 4m_{H_u}^2\lambda^2|Y1|^2 - 4m_{l_4}^2\lambda^2|Y1|^2 - 4m_s^2\lambda^2|Y1|^2 - 4\lambda^2|TY1|^2 \\
&+ \frac{12}{5}g_1^2\lambda M_1^*\Big(2M_1\lambda - T_\lambda\Big) - \frac{12}{5}g_1^2 M_1\lambda T_\lambda - 12g_2^2 M_2\lambda T_\lambda - 8g_p^2 M_Z Q_{H_d}^2\lambda T_\lambda \\
&- 8g_p^2 M_Z Q_{H_u}^2\lambda T_\lambda + 8g_p^2 M_Z Q_s^2\lambda T_\lambda - 12g_2^2\lambda M_2^* T_\lambda - 4Y1\lambda TY1^* T_\lambda - 4\lambda Y1^* TY1 T_\lambda \\
&+ \frac{12}{5}g_1^2 T_\lambda^2 + 12g_2^2 T_\lambda^2 + 8g_p^2 Q_{H_d}^2 T_\lambda^2 + 8g_p^2 Q_{H_u}^2 T_\lambda^2 - 8g_p^2 Q_s^2 T_\lambda^2 - 32\lambda^2 T_\lambda^2 \\
&- 4|Y1|^2 T_\lambda^2 \\
&+ 8g_p^2 M_Z^*\Big(3g_p^2 M_Z Q_s^2\Big(18Q_q^2 + 2Q_{e_9}^2 + 2Q_{H_d}^2 + 2Q_{H_u}^2 + 2Q_{l_4}^2 + 3Q_s^2 + 4Q_{l_9}^2 + 9Q_d^2 + 9Q_u^2 + Q_{e_4}^2\Big) \\
&+ 2M_Z\Big(-Q_s^2 + Q_{H_d}^2 + Q_{H_u}^2\Big)\lambda^2 - \Big(-Q_s^2 + Q_{H_d}^2 + Q_{H_u}^2\Big)\lambda T_\lambda\Big) \\
&+ 8g_p^2 Q_s^2\sigma_{2,44} + 8g_p Q_s\sigma_{3,4} - 8m_{H_d}^2\lambda^2 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 4m_{H_u}^2\lambda^2 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 4m_s^2\lambda^2 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) \\
&- 4T_\lambda^2 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 24m_{H_d}^2\lambda^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 12m_{H_u}^2\lambda^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 12m_s^2\lambda^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) \\
&- 12T_\lambda^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 12m_{H_d}^2\lambda^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 24m_{H_u}^2\lambda^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 12m_s^2\lambda^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) \\
&- 12T_\lambda^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 4\lambda T_\lambda \mathrm{Tr}\Big(Y2^\dagger TY2\Big) - 12\lambda T_\lambda \mathrm{Tr}\Big(Y_d^\dagger T_d\Big) - 12\lambda T_\lambda \mathrm{Tr}\Big(Y_u^\dagger T_u\Big) \\
&- 4\lambda T_\lambda \mathrm{Tr}\Big(TY2^*Y2^T\Big) - 4\lambda^2 \mathrm{Tr}\Big(TY2^*TY2^T\Big) - 12\lambda T_\lambda \mathrm{Tr}\Big(T_d^* Y_d^T\Big) - 12\lambda^2 \mathrm{Tr}\Big(T_d^* T_d^T\Big) - 12\lambda T_\lambda \mathrm{Tr}\Big(T_u^* Y_u^T\Big) \\
&- 12\lambda^2 \mathrm{Tr}\Big(T_u^* T_u^T\Big) - 12\lambda^2 \mathrm{Tr}\Big(m_d^2 Y_d Y_d^\dagger\Big) - 4\lambda^2 \mathrm{Tr}\Big(m_{e_9}^2 Y2Y2^\dagger\Big) - 4\lambda^2 \mathrm{Tr}\Big(m_{l_9}^2 Y2^\dagger Y2\Big) \\
&- 12\lambda^2 \mathrm{Tr}\Big(m_q^2 Y_d^\dagger Y_d\Big) - 12\lambda^2 \mathrm{Tr}\Big(m_q^2 Y_u^\dagger Y_u\Big) - 12\lambda^2 \mathrm{Tr}\Big(m_u^2 Y_u Y_u^\dagger\Big)
\end{aligned} \tag{97}
$$

3.8 Vacuum expectation values

$$\beta_{v_d}^{(1)} = \frac{1}{20}v_d\Big(3g_1^2 + 15g_2^2 + 20g_p^2Q_{H_d}^2 + 3g_1^2\mathrm{Xi} + 15g_2^2\mathrm{Xi} + 20g_p^2Q_{H_d}^2\mathrm{Xi} - 20\lambda^2 - 20|Y1|^2 - 20\mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 60\mathrm{Tr}\Big(Y_dY_d^\dagger\Big)\Big) \tag{98}$$

$$\begin{aligned}\beta_{v_d}^{(2)} = \frac{1}{200}v_d\Big(&- 207g_1^4 - 90g_1^2g_2^2 - 600g_2^4 + 360g_1^2g_p^2Q_dQ_{H_d} + 120g_1^2g_p^2Q_{e_4}Q_{H_d} + 240g_1^2g_p^2Q_{e_9}Q_{H_d} \\ &- 240g_1^2g_p^2Q_{H_d}^2 - 600g_2^2g_p^2Q_{H_d}^2 - 1800g_p^4Q_d^2Q_{H_d}^2 - 200g_p^4Q_{e_4}^2Q_{H_d}^2 \\ &- 400g_p^4Q_{e_9}^2Q_{H_d}^2 - 800g_p^4Q_{H_d}^4 + 120g_1^2g_p^2Q_{H_d}Q_{H_u} - 400g_p^4Q_{H_d}^2Q_{H_u}^2 \\ &- 120g_1^2g_p^2Q_{H_d}Q_{l_4} - 400g_p^4Q_{H_d}^2Q_{l_4}^2 - 240g_1^2g_p^2Q_{H_d}Q_{l_9} - 800g_p^4Q_{H_d}^2Q_{l_9}^2 \\ &+ 360g_1^2g_p^2Q_{H_d}Q_q - 3600g_p^4Q_{H_d}^2Q_q^2 - 200g_p^4Q_{H_d}^2Q_s^2 - 720g_1^2g_p^2Q_{H_d}Q_u \\ &- 1800g_p^4Q_{H_d}^2Q_u^2 - 9g_1^4\mathrm{Xi} - 90g_1^2g_2^2\mathrm{Xi} + 325g_2^4\mathrm{Xi} - 120g_1^2g_p^2Q_{H_d}^2\mathrm{Xi} - 600g_2^2g_p^2Q_{H_d}^2\mathrm{Xi} \\ &- 400g_p^4Q_{H_d}^4\mathrm{Xi} + 9g_1^4\mathrm{Xi}^2 + 90g_1^2g_2^2\mathrm{Xi}^2 + 120g_1^2g_p^2Q_{H_d}^2\mathrm{Xi}^2 + 600g_2^2g_p^2Q_{H_d}^2\mathrm{Xi}^2 + 400g_p^4Q_{H_d}^4\mathrm{Xi}^2 \\ &+ 400g_p^2Q_{H_d}^2\lambda^2 - 400g_p^2Q_{H_u}^2\lambda^2 - 400g_p^2Q_s^2\lambda^2 - 60g_1^2\mathrm{Xi}\lambda^2 - 300g_2^2\mathrm{Xi}\lambda^2 \\ &- 400g_p^2Q_{H_d}^2\mathrm{Xi}\lambda^2 + 600\lambda^4 - 20\Big(15g_2^2\mathrm{Xi} + 20g_p^2\Big(Q_{H_d}^2\Big(-1+\mathrm{Xi}\Big) + Q_{e_4}^2 + Q_{l_4}^2\Big) + 3g_1^2\Big(4+\mathrm{Xi}\Big)\Big)|Y1|^2 + 600|Y1|^4 \\ &- 20\Big(15g_2^2\mathrm{Xi} + 20g_p^2\Big(Q_{H_d}^2\Big(-1+\mathrm{Xi}\Big) + Q_{e_9}^2 + Q_{l_9}^2\Big) + 3g_1^2\Big(4+\mathrm{Xi}\Big)\Big)\mathrm{Tr}\Big(Y2Y2^\dagger\Big) + 80g_1^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) \\ &- 3200g_3^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 1200g_p^2Q_d^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + 1200g_p^2Q_{H_d}^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) \\ &- 1200g_p^2Q_q^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 180g_1^2\mathrm{Xi}\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 900g_2^2\mathrm{Xi}\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) \\ &- 1200g_p^2Q_{H_d}^2\mathrm{Xi}\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) + 600\lambda^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) + 600\mathrm{Tr}\Big(Y2Y2^\dagger Y2Y2^\dagger\Big) + 1800\mathrm{Tr}\Big(Y_dY_d^\dagger Y_dY_d^\dagger\Big) \\ &+ 600\mathrm{Tr}\Big(Y_dY_u^\dagger Y_uY_d^\dagger\Big)\Big)\end{aligned} \tag{99}$$

$$\beta_{v_u}^{(1)} = \frac{1}{20}v_u\Big(3g_1^2\Big(1+\mathrm{Xi}\Big) + 5\Big(3g_2^2\Big(1+\mathrm{Xi}\Big) + 4g_p^2Q_{H_u}^2\Big(1+\mathrm{Xi}\Big) - 4\lambda^2\Big) - 60\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)\Big) \tag{100}$$

$$\begin{aligned}\beta_{v_u}^{(2)} = &+ v_u\lambda^2|Y1|^2 \\ &+ \frac{1}{200}v_u\Big(- 207g_1^4 - 90g_1^2g_2^2 - 600g_2^4 - 360g_1^2g_p^2Q_dQ_{H_u} - 120g_1^2g_p^2Q_{e_4}Q_{H_u} - 240g_1^2g_p^2Q_{e_9}Q_{H_u} \\ &+ 120g_1^2g_p^2Q_{H_d}Q_{H_u} - 240g_1^2g_p^2Q_{H_u}^2 - 600g_2^2g_p^2Q_{H_u}^2 - 1800g_p^4Q_d^2Q_{H_u}^2 \\ &- 200g_p^4Q_{e_4}^2Q_{H_u}^2 - 400g_p^4Q_{e_9}^2Q_{H_u}^2 - 400g_p^4Q_{H_d}^2Q_{H_u}^2 - 800g_p^4Q_{H_u}^4 + 120g_1^2g_p^2Q_{H_u}Q_{l_4} \\ &- 400g_p^4Q_{H_u}^2Q_{l_4}^2 + 240g_1^2g_p^2Q_{H_u}Q_{l_9} - 800g_p^4Q_{H_u}^2Q_{l_9}^2 - 360g_1^2g_p^2Q_{H_u}Q_q \\ &- 3600g_p^4Q_{H_u}^2Q_q^2 - 200g_p^4Q_{H_u}^2Q_s^2 + 720g_1^2g_p^2Q_{H_u}Q_u - 1800g_p^4Q_{H_u}^2Q_u^2 - 9g_1^4\mathrm{Xi} \\ &- 90g_1^2g_2^2\mathrm{Xi} + 325g_2^4\mathrm{Xi} - 120g_1^2g_p^2Q_{H_u}^2\mathrm{Xi} - 600g_2^2g_p^2Q_{H_u}^2\mathrm{Xi} - 400g_p^4Q_{H_u}^4\mathrm{Xi} + 9g_1^4\mathrm{Xi}^2 \\ &+ 90g_1^2g_2^2\mathrm{Xi}^2 + 120g_1^2g_p^2Q_{H_u}^2\mathrm{Xi}^2 + 600g_2^2g_p^2Q_{H_u}^2\mathrm{Xi}^2 + 400g_p^4Q_{H_u}^4\mathrm{Xi}^2 - 400g_p^2Q_{H_d}^2\lambda^2 \\ &+ 400g_p^2Q_{H_u}^2\lambda^2 - 400g_p^2Q_s^2\lambda^2 - 60g_1^2\mathrm{Xi}\lambda^2 - 300g_2^2\mathrm{Xi}\lambda^2 - 400g_p^2Q_{H_u}^2\mathrm{Xi}\lambda^2 + 600\lambda^4 \\ &+ 200\lambda^2\mathrm{Tr}\Big(Y2Y2^\dagger\Big) + 600\lambda^2\mathrm{Tr}\Big(Y_dY_d^\dagger\Big) - 160g_1^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big) - 3200g_3^2\mathrm{Tr}\Big(Y_uY_u^\dagger\Big)\end{aligned}$$

$$+ 1200 g_p^2 Q_{H_u}^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 1200 g_p^2 Q_q^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 1200 g_p^2 Q_u^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big)$$
$$- 180 g_1^2 \mathrm{Xi}\mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 900 g_2^2 \mathrm{Xi}\mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) - 1200 g_p^2 Q_{H_u}^2 \mathrm{Xi}\mathrm{Tr}\Big(Y_u Y_u^\dagger\Big) + 600 \mathrm{Tr}\Big(Y_d Y_u^\dagger Y_u Y_d^\dagger\Big)$$
$$+ 1800 \mathrm{Tr}\Big(Y_u Y_u^\dagger Y_u Y_u^\dagger\Big)\Big) \tag{101}$$

$$\beta_{v_S}^{(1)} = v_S\Big(-2\lambda^2 + g_p^2 Q_s^2\Big(1 + \mathrm{Xi}\Big)\Big) \tag{102}$$

$$\beta_{v_S}^{(2)} = -\frac{1}{5} v_S\Big(45 g_p^4 Q_d^2 Q_s^2 + 5 g_p^4 Q_{e_4}^2 Q_s^2 + 10 g_p^4 Q_{e_9}^2 Q_s^2 + 10 g_p^4 Q_{H_d}^2 Q_s^2 + 10 g_p^4 Q_{H_u}^2 Q_s^2$$
$$+ 10 g_p^4 Q_{l_4}^2 Q_s^2 + 20 g_p^4 Q_{l_9}^2 Q_s^2 + 90 g_p^4 Q_q^2 Q_s^2 + 15 g_p^4 Q_s^4 + 45 g_p^4 Q_s^2 Q_u^2 + 10 g_p^4 Q_s^4 \mathrm{Xi}$$
$$- 10 g_p^4 Q_s^4 \mathrm{Xi}^2 + 6 g_1^2 \lambda^2 + 30 g_2^2 \lambda^2 + 20 g_p^2 Q_{H_d}^2 \lambda^2 + 20 g_p^2 Q_{H_u}^2 \lambda^2 - 20 g_p^2 Q_s^2 \lambda^2$$
$$+ 20 g_p^2 Q_s^2 \mathrm{Xi}\lambda^2 - 20\lambda^4 - 10\lambda^2 |Y1|^2 - 10\lambda^2 \mathrm{Tr}\Big(Y2Y2^\dagger\Big) - 30\lambda^2 \mathrm{Tr}\Big(Y_d Y_d^\dagger\Big) - 30\lambda^2 \mathrm{Tr}\Big(Y_u Y_u^\dagger\Big)\Big) \tag{103}$$

4 Field Rotations

4.1 Rotations in gauge sector for eigenstates 'EWSB'

$$\begin{pmatrix} B_\rho \\ W_{3\rho} \\ U_\rho \end{pmatrix} = Z^{\gamma Z Z'} \begin{pmatrix} \gamma_\rho \\ Z_\rho \\ Z'_\rho \end{pmatrix} \tag{104}$$

$$\begin{pmatrix} W_{1\rho} \\ W_{2\rho} \end{pmatrix} = Z^W \begin{pmatrix} W_\rho^- \\ W_\rho^- \end{pmatrix} \tag{105}$$

$$\begin{pmatrix} \lambda_{\tilde{W},1} \\ \lambda_{\tilde{W},2} \\ \lambda_{\tilde{W},3} \end{pmatrix} = Z^{\tilde{W}} \begin{pmatrix} \tilde{W}^- \\ \tilde{W}^+ \\ \tilde{W}^0 \end{pmatrix} \tag{106}$$

$$\tag{107}$$

The mixing matrices are parametrized by

$$Z^{\gamma Z Z'} = \begin{pmatrix} \cos\Theta_W & -\cos\Theta'_W \sin\Theta_W & \sin\Theta_W \sin\Theta'_W \\ \sin\Theta_W & \cos\Theta_W \cos\Theta'_W & -\cos\Theta_W \sin\Theta'_W \\ 0 & \sin\Theta'_W & \cos\Theta'_W \end{pmatrix} \tag{108}$$

$$Z^W = \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ -i\frac{1}{\sqrt{2}} & i\frac{1}{\sqrt{2}} \end{pmatrix} \tag{109}$$

$$Z^{\tilde{W}} = \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \\ -i\frac{1}{\sqrt{2}} & i\frac{1}{\sqrt{2}} & 0 \\ 0 & 0 & 1 \end{pmatrix} \tag{110}$$

$$\tag{111}$$

4.2 Rotations in Mass sector for eigenstates 'EWSB'

4.2.1 Mass Matrices for Scalars

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

$$m^2_{\tilde{d}} = \begin{pmatrix} m_{\tilde{d}_L \tilde{d}^*_L} & m^\dagger_{\tilde{d}_R \tilde{d}^*_L} \\ -\frac{1}{2}\delta_{\alpha_2\beta_1}\Big(-\sqrt{2}v_d T_d + v_u\Big(\sqrt{2}T'_d + v_S Y_d \lambda\Big)\Big) & m_{\tilde{d}_R \tilde{d}^*_R} \end{pmatrix} \tag{112}$$

$$\begin{aligned} m_{\tilde{d}_L \tilde{d}^*_L} &= +\frac{1}{24}\mathbf{1}\Big(12 g_p^2 Q_q\Big(Q_{H_d} v_d^2 + Q_{H_u} v_u^2 + Q_s v_S^2\Big) + \Big(3g_2^2 + g_1^2\Big)\Big(-v_d^2 + v_u^2\Big)\Big)\delta_{\alpha_1\beta_1} \\ &\quad + \frac{1}{2}\delta_{\alpha_1\beta_1}\Big(2m_q^2 + v_d^2 Y_d^\dagger Y_d\Big) \end{aligned} \tag{113}$$

$$m_{\tilde{d}_R \tilde{d}^*_R} = \frac{1}{12}\mathbf{1}\Big(6 g_p^2 Q_d\Big(Q_{H_d} v_d^2 + Q_{H_u} v_u^2 + Q_s v_S^2\Big) + g_1^2\Big(-v_d^2 + v_u^2\Big)\Big)\delta_{\alpha_2\beta_2} + \frac{1}{2}\delta_{\alpha_2\beta_2}\Big(2m_d^2 + v_d^2 Y_d Y_d^\dagger\Big) \tag{114}$$

This matrix is diagonalized by Z^D:

$$Z^D m^2_{\tilde{d}} Z^{D,\dagger} = m^{dia}_{2,\tilde{d}} \tag{115}$$

with

$$\tilde{d}_{L,i\alpha} = \sum_j Z^{D,*}_{ji} \tilde{d}_{j\alpha}\,, \qquad \tilde{d}_{R,i\alpha} = \sum_j Z^{D,*}_{ji} \tilde{d}_{j\alpha} \tag{116}$$

- **Mass matrix for Sneutrinos**, Basis: $(Sv4L, Sv9L), (Sv4L^*, Sv9L^*)$

$$m^2_{\tilde{\nu}} = \begin{pmatrix} m_{Sv4LSv4L^*} & 0 \\ 0 & m_{Sv9LSv9L^*} \end{pmatrix} \tag{117}$$

$$m_{Sv4LSv4L^*} = \frac{1}{8}\Big(4 g_p^2 Q_{l_4}\Big(Q_{H_d} v_d^2 + Q_{H_u} v_u^2 + Q_s v_S^2\Big) + \Big(g_1^2 + g_2^2\Big)\Big(-v_u^2 + v_d^2\Big)\Big) + m^2_{l_4} \tag{118}$$

$$m_{Sv9LSv9L^*} = \frac{1}{8}\mathbf{1}\Big(4 g_p^2 Q_{l_9}\Big(Q_{H_d} v_d^2 + Q_{H_u} v_u^2 + Q_s v_S^2\Big) + \Big(g_1^2 + g_2^2\Big)\Big(-v_u^2 + v_d^2\Big)\Big) + m^2_{l_9} \tag{119}$$

This matrix is diagonalized by Z^V:

$$Z^V m^2_{\tilde{\nu}} Z^{V,\dagger} = m^{dia}_{2,\tilde{\nu}} \tag{120}$$

with

$$Sv4L = \sum_j Z^{V,*}_{j1} \tilde{\nu}_j\,, \qquad Sv9L_i = \sum_j Z^{V,*}_{ji} \tilde{\nu}_j \tag{121}$$

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

$$m^2_{\tilde{u}} = \begin{pmatrix} m_{\tilde{u}_L \tilde{u}^*_L} & \frac{1}{2}\Big(\sqrt{2} v_u T^\dagger_u - v_d v_S \lambda Y^\dagger_u\Big)\delta_{\alpha_1\beta_2} \\ \frac{1}{2}\delta_{\alpha_2\beta_1}\Big(\sqrt{2} v_u T_u - v_d v_S Y_u \lambda\Big) & m_{\tilde{u}_R \tilde{u}^*_R} \end{pmatrix} \tag{122}$$

$$\begin{aligned} m_{\tilde{u}_L \tilde{u}^*_L} =& +\frac{1}{24}\mathbf{1}\Big(12 g_p^2 Q_q \Big(Q_{H_d} v_d^2 + Q_{H_u} v_u^2 + Q_s v_S^2\Big) + 3 g_2^2 \Big(-v_u^2 + v_d^2\Big) + g_1^2 \Big(-v_d^2 + v_u^2\Big)\Big)\delta_{\alpha_1\beta_1} \\ &+ \frac{1}{2}\delta_{\alpha_1\beta_1}\Big(2 m_q^2 + v_u^2 Y^\dagger_u Y_u\Big) \end{aligned} \tag{123}$$

$$m_{\tilde{u}_R \tilde{u}^*_R} = \frac{1}{2}\delta_{\alpha_2\beta_2}\Big(2 m_u^2 + v_u^2 Y_u Y^\dagger_u\Big) + \frac{1}{6}\mathbf{1}\Big(3 g_p^2 Q_u \Big(Q_{H_d} v_d^2 + Q_{H_u} v_u^2 + Q_s v_S^2\Big) + g_1^2 \Big(-v_u^2 + v_d^2\Big)\Big)\delta_{\alpha_2\beta_2} \tag{124}$$

This matrix is diagonalized by Z^U:

$$Z^U m^2_{\tilde{u}} Z^{U,\dagger} = m^{dia}_{2,\tilde{u}} \tag{125}$$

with

$$\tilde{u}_{L,i\alpha} = \sum_j Z^{U,*}_{ji} \tilde{u}_{j\alpha}\,, \qquad \tilde{u}_{R,i\alpha} = \sum_j Z^{U,*}_{ji} \tilde{u}_{j\alpha} \tag{126}$$

- **Mass matrix for Sleptons**, Basis: $(Se4L, Se9L, Se4R, Se9R), (Se4L^*, Se9L^*, Se4R^*, Se9R^*)$

$$m^2_{\tilde{e}} = \begin{pmatrix} m_{Se4LSe4L^*} & 0 & m^*_{Se4RSe4L^*} & 0 \\ 0 & m_{Se9LSe9L^*} & 0 & m^*_{Se9RSe9L^*} \\ m_{Se4LSe4R^*} & 0 & m_{Se4RSe4R^*} & 0 \\ 0 & m_{Se9LSe9R^*} & 0 & m_{Se9RSe9R^*} \end{pmatrix} \tag{127}$$

$$m_{Se4LSe4L^*} = \frac{1}{2} v_d^2 |Y1|^2 + \frac{1}{8}\Big(4 g_p^2 Q_{l_4}\Big(Q_{H_d} v_d^2 + Q_{H_u} v_u^2 + Q_s v_S^2\Big) + g_1^2\Big(-v_u^2 + v_d^2\Big) + g_2^2\Big(-v_d^2 + v_u^2\Big)\Big) + m^2_{l_4} \tag{128}$$

$$\begin{aligned} m_{Se9LSe9L^*} =& +m^2_{l_9} + \frac{1}{8}\mathbf{1}\Big(4 g_p^2 Q_{l_9}\Big(Q_{H_d} v_d^2 + Q_{H_u} v_u^2 + Q_s v_S^2\Big) + g_1^2\Big(-v_u^2 + v_d^2\Big) + g_2^2\Big(-v_d^2 + v_u^2\Big)\Big) \\ &+ \frac{1}{2} v_d^2 Y2^\dagger Y2 \end{aligned} \tag{129}$$

$$m_{Se4LSe4R^*} = -\frac{1}{2} v_S v_u Y1\lambda + \frac{1}{\sqrt{2}} v_d T Y1 \tag{130}$$

$$m_{Se4RSe4R^*} = \frac{1}{2} v_d^2 |Y1|^2 + \frac{1}{4}\Big(2 g_p^2 Q_{e_4}\Big(Q_{H_d} v_d^2 + Q_{H_u} v_u^2 + Q_s v_S^2\Big) + g_1^2\Big(-v_d^2 + v_u^2\Big)\Big) + m^2_{e_4} \tag{131}$$

$$m_{Se9LSe9R^*} = -\frac{1}{2} v_u\Big(\sqrt{2} T'_e + v_S Y2\lambda\Big) + \frac{1}{\sqrt{2}} v_d T Y2 \tag{132}$$

$$m_{Se9RSe9R^*} = \frac{1}{2} v_d^2 Y2 Y2^\dagger + \frac{1}{4}\mathbf{1}\Big(2 g_p^2 Q_{e_9}\Big(Q_{H_d} v_d^2 + Q_{H_u} v_u^2 + Q_s v_S^2\Big) + g_1^2\Big(-v_d^2 + v_u^2\Big)\Big) + m^2_{e_9} \tag{133}$$

This matrix is diagonalized by Z^E:

$$Z^E m^2_{\tilde{e}} Z^{E,\dagger} = m^{dia}_{2,\tilde{e}} \tag{134}$$

with

$$Se4L = \sum_j Z^{E,*}_{j1} \tilde{e}_j \,, \qquad Se9L_i = \sum_j Z^{E,*}_{ji} \tilde{e}_j \,, \qquad Se4R = \sum_j Z^{E,*}_{j4} \tilde{e}_j \tag{135}$$

$$Se9R_i = \sum_j Z^{E,*}_{ji} \tilde{e}_j \tag{136}$$

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

$$m^2_h = \begin{pmatrix} m_{\phi_d\phi_d} & m_{\phi_u\phi_d} & m_{\sigma_s\phi_d} \\ m_{\phi_d\phi_u} & m_{\phi_u\phi_u} & m_{\sigma_s\phi_u} \\ m_{\phi_d\sigma_s} & m_{\phi_u\sigma_s} & m_{\sigma_s\sigma_s} \end{pmatrix} \tag{137}$$

$$m_{\phi_d\phi_d} = \frac{1}{2}\Big(v_S^2 + v_u^2\Big)\lambda^2 + \frac{1}{8}\Big(4g_p^2 Q_{H_d}\Big(3Q_{H_d}v_d^2 + Q_{H_u}v_u^2 + Q_s v_S^2\Big) + \Big(g_1^2 + g_2^2\Big)\Big(3v_d^2 - v_u^2\Big)\Big) + m^2_{H_d} \tag{138}$$

$$m_{\phi_d\phi_u} = -\frac{1}{4}\Big(-4g_p^2 Q_{H_d}Q_{H_u} + g_1^2 + g_2^2\Big)v_d v_u - \frac{1}{\sqrt{2}}v_S T_\lambda + v_d v_u \lambda^2 \tag{139}$$

$$m_{\phi_u\phi_u} = \frac{1}{2}\Big(v_d^2 + v_S^2\Big)\lambda^2 + \frac{1}{8}\Big(4g_p^2 Q_{H_u}\Big(3Q_{H_u}v_u^2 + Q_{H_d}v_d^2 + Q_s v_S^2\Big) + \Big(-g_1^2 - g_2^2\Big)\Big(-3v_u^2 + v_d^2\Big)\Big) + m^2_{H_u} \tag{140}$$

$$m_{\phi_d\sigma_s} = -\frac{1}{\sqrt{2}}v_u T_\lambda + g_p^2 Q_{H_d}Q_s v_d v_S + v_d v_S \lambda^2 \tag{141}$$

$$m_{\phi_u\sigma_s} = -\frac{1}{\sqrt{2}}v_d T_\lambda + g_p^2 Q_{H_u}Q_s v_S v_u + v_S v_u \lambda^2 \tag{142}$$

$$m_{\sigma_s\sigma_s} = \frac{1}{2}g_p^2 Q_s\Big(3Q_s v_S^2 + Q_{H_d}v_d^2 + Q_{H_u}v_u^2\Big) + \frac{1}{2}\Big(v_d^2 + v_u^2\Big)\lambda^2 + m_s^2 \tag{143}$$

This matrix is diagonalized by Z^H:

$$Z^H m^2_h Z^{H,\dagger} = m^{dia}_{2,h} \tag{144}$$

with

$$\phi_d = \sum_j Z^{H,*}_{j1} h_j \,, \qquad \phi_u = \sum_j Z^{H,*}_{j2} h_j \,, \qquad \sigma_s = \sum_j Z^{H,*}_{j3} h_j \tag{145}$$

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

$$m^2_{A^0} = \begin{pmatrix} m_{\sigma_d\sigma_d} & \frac{1}{\sqrt{2}}v_S T_\lambda & \frac{1}{\sqrt{2}}v_u T_\lambda \\ \frac{1}{\sqrt{2}}v_S T_\lambda & m_{\sigma_u\sigma_u} & \frac{1}{\sqrt{2}}v_d T_\lambda \\ \frac{1}{\sqrt{2}}v_u T_\lambda & \frac{1}{\sqrt{2}}v_d T_\lambda & m_{\phi_s\phi_s} \end{pmatrix} + \xi_Z m^2(Z) + \xi_{Z'} m^2(Z') \tag{146}$$

$$m_{\sigma_d\sigma_d} = \frac{1}{2}\Big(v_S^2 + v_u^2\Big)\lambda^2 + \frac{1}{8}\Big(4g_p^2 Q_{H_d}\Big(Q_{H_d}v_d^2 + Q_{H_u}v_u^2 + Q_s v_S^2\Big) + \Big(g_1^2 + g_2^2\Big)\Big(-v_u^2 + v_d^2\Big)\Big) + m^2_{H_d} \tag{147}$$

$$m_{\sigma_u\sigma_u} = \frac{1}{2}\Big(v_d^2 + v_S^2\Big)\lambda^2 + \frac{1}{8}\Big(4g_p^2 Q_{H_u}\Big(Q_{H_d}v_d^2 + Q_{H_u}v_u^2 + Q_s v_S^2\Big) + \Big(g_1^2 + g_2^2\Big)\Big(-v_d^2 + v_u^2\Big)\Big) + m_{H_u}^2 \tag{148}$$

$$m_{\phi_s\phi_s} = \frac{1}{2}g_p^2 Q_s\Big(Q_{H_d}v_d^2 + Q_{H_u}v_u^2 + Q_s v_S^2\Big) + \frac{1}{2}\Big(v_d^2 + v_u^2\Big)\lambda^2 + m_s^2 \tag{149}$$

Gauge fixing contributions:

$$m^2(\xi_Z) = \begin{pmatrix} m_{\sigma_d\sigma_d} & m_{\sigma_u\sigma_d} & m_{\phi_s\sigma_d} \\ m_{\sigma_d\sigma_u} & m_{\sigma_u\sigma_u} & m_{\phi_s\sigma_u} \\ m_{\sigma_d\phi_s} & m_{\sigma_u\phi_s} & g_p^2 Q_s^2 v_S^2 \sin\Theta_W'^{,2} \end{pmatrix} \tag{150}$$

$$m_{\sigma_d\sigma_d} = \frac{1}{4}v_d^2\Big(2g_p Q_{H_d}\sin\Theta_W' + \cos\Theta_W'\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\Big)^2 \tag{151}$$

$$m_{\sigma_d\sigma_u} = -\frac{1}{4}v_d v_u\Big(2g_p Q_{H_d}\sin\Theta_W' + \cos\Theta_W'\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\Big)\Big(-2g_p Q_{H_u}\sin\Theta_W' + \cos\Theta_W'\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\Big) \tag{152}$$

$$m_{\sigma_u\sigma_u} = \frac{1}{4}v_u^2\Big(-2g_p Q_{H_u}\sin\Theta_W' + \cos\Theta_W'\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\Big)^2 \tag{153}$$

$$m_{\sigma_d\phi_s} = \frac{1}{2}g_p Q_s v_d v_S \sin\Theta_W'\Big(2g_p Q_{H_d}\sin\Theta_W' + \cos\Theta_W'\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\Big) \tag{154}$$

$$m_{\sigma_u\phi_s} = \frac{1}{2}g_p Q_s v_S v_u \sin\Theta_W'\Big(2g_p Q_{H_u}\sin\Theta_W' - \cos\Theta_W'\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\Big) \tag{155}$$

$$m^2(\xi_{Z'}) = \begin{pmatrix} m_{\sigma_d\sigma_d} & m_{\sigma_u\sigma_d} & m_{\phi_s\sigma_d} \\ m_{\sigma_d\sigma_u} & m_{\sigma_u\sigma_u} & m_{\phi_s\sigma_u} \\ m_{\sigma_d\phi_s} & m_{\sigma_u\phi_s} & g_p^2 Q_s^2 v_S^2 \cos\Theta_W'^{,2} \end{pmatrix} \tag{156}$$

$$m_{\sigma_d\sigma_d} = \frac{1}{4}v_d^2\Big(-2g_p Q_{H_d}\cos\Theta_W' + \Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta_W'\Big)^2 \tag{157}$$

$$m_{\sigma_d\sigma_u} = \frac{1}{8}v_d v_u\Big(-2\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta_W' + 4g_p Q_{H_d}\cos\Theta_W'\Big)\Big(2g_p Q_{H_u}\cos\Theta_W' + \Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta_W' \tag{158}$$

$$m_{\sigma_u\sigma_u} = \frac{1}{4}v_u^2\Big(2g_p Q_{H_u}\cos\Theta_W' + \Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta_W'\Big)^2 \tag{159}$$

$$m_{\sigma_d\phi_s} = \frac{1}{2}g_p Q_s v_d v_S \cos\Theta_W'\Big(2g_p Q_{H_d}\cos\Theta_W' - \Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta_W'\Big) \tag{160}$$

$$m_{\sigma_u\phi_s} = \frac{1}{2}g_p Q_s v_S v_u \cos\Theta_W'\Big(2g_p Q_{H_u}\cos\Theta_W' + \Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta_W'\Big) \tag{161}$$

This matrix is diagonalized by Z^A:

$$Z^A m_{A^0}^2 Z^{A,\dagger} = m_{2,A^0}^{dia} \tag{162}$$

with

$$\sigma_d = \sum_j Z_{j1}^{A,*}A_j^0\,, \qquad \sigma_u = \sum_j Z_{j2}^{A,*}A_j^0\,, \qquad \phi_s = \sum_j Z_{j3}^{A,*}A_j^0 \tag{163}$$

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

$$m^2_{H^-} = \begin{pmatrix} m_{H_d^- H_d^{-,*}} & -\frac{1}{2}v_d v_u \lambda^2 + \frac{1}{4}g_2^2 v_d v_u + \frac{1}{\sqrt{2}} v_S T_\lambda \\ -\frac{1}{2}v_d v_u \lambda^2 + \frac{1}{4}g_2^2 v_d v_u + \frac{1}{\sqrt{2}} v_S T_\lambda & m_{H_u^{+,*} H_u^+} \end{pmatrix} + \xi_{W^-} m^2(W^-) \tag{164}$$

$$m_{H_d^- H_d^{-,*}} = \frac{1}{2}v_S^2\lambda^2 + \frac{1}{8}\Big(4g_p^2 Q_{H_d}\Big(Q_{H_d}v_d^2 + Q_{H_u}v_u^2 + Q_s v_S^2\Big) + g_1^2\Big(-v_u^2 + v_d^2\Big) + g_2^2\Big(v_d^2 + v_u^2\Big)\Big) + m_{H_d}^2 \tag{165}$$

$$m_{H_u^{+,*} H_u^+} = \frac{1}{2}v_S^2\lambda^2 + \frac{1}{8}\Big(4g_p^2 Q_{H_u}\Big(Q_{H_d}v_d^2 + Q_{H_u}v_u^2 + Q_s v_S^2\Big) + g_1^2\Big(-v_d^2 + v_u^2\Big) + g_2^2\Big(v_d^2 + v_u^2\Big)\Big) + m_{H_u}^2 \tag{166}$$

Gauge fixing contributions:

$$m^2(\xi_{W^-}) = \begin{pmatrix} \frac{1}{4}g_2^2 v_d^2 & -\frac{1}{4}g_2^2 v_d v_u \\ -\frac{1}{4}g_2^2 v_d v_u & \frac{1}{4}g_2^2 v_u^2 \end{pmatrix} \tag{167}$$

This matrix is diagonalized by Z^+:

$$Z^+ m^2_{H^-} Z^{+,\dagger} = m^{dia}_{2,H^-} \tag{168}$$

with

$$H_d^- = \sum_j Z^+_{j1} H_j^- \,, \qquad H_u^+ = \sum_j Z^+_{j2} H_j^+ \tag{169}$$

4.2.2 Mass Matrices for Fermions

- **Mass matrix for Neutrinos**, Basis: $(Fv4L, Fv9L), (Fv4L, Fv9L)$

$$m_\nu = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix} \tag{170}$$

This matrix is diagonalized by ZVL:

$$ZVL^* m_\nu ZVL^\dagger = m_\nu^{dia} \tag{171}$$

with

$$Fv4L = \sum_j ZVL^*_{j1}\mathrm{FvL}\Big(\{\mathrm{gt2}\}\Big), \qquad Fv9L_i = \sum_j ZVL^*_{ji}\mathrm{FvL}\Big(\{\mathrm{gt2}\}\Big) \tag{172}$$

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

$$m_{\tilde{\chi}^0} = \begin{pmatrix} M_Z & 0 & 0 & g_p Q_{H_d} v_d & g_p Q_{H_u} v_u & g_p Q_s v_S \\ 0 & M_1 & 0 & -\frac{1}{2}g_1 v_d & \frac{1}{2}g_1 v_u & 0 \\ 0 & 0 & M_2 & \frac{1}{2}g_2 v_d & -\frac{1}{2}g_2 v_u & 0 \\ g_p Q_{H_d} v_d & -\frac{1}{2}g_1 v_d & \frac{1}{2}g_2 v_d & 0 & -\frac{1}{\sqrt{2}}v_S\lambda & -\frac{1}{\sqrt{2}}v_u\lambda \\ g_p Q_{H_u} v_u & \frac{1}{2}g_1 v_u & -\frac{1}{2}g_2 v_u & -\frac{1}{\sqrt{2}}v_S\lambda & 0 & -\frac{1}{\sqrt{2}}v_d\lambda \\ g_p Q_s v_S & 0 & 0 & -\frac{1}{\sqrt{2}}v_u\lambda & -\frac{1}{\sqrt{2}}v_d\lambda & 0 \end{pmatrix} \tag{173}$$

This matrix is diagonalized by N:

$$N^* m_{\tilde{\chi}^0} N^\dagger = m_{\tilde{\chi}^0}^{dia} \tag{174}$$

with

$$\lambda_U = \sum_j N_{j1}^* \lambda_j^0 \,, \qquad \lambda_{\tilde{B}} = \sum_j N_{j2}^* \lambda_j^0 \,, \qquad \tilde{W}^0 = \sum_j N_{j3}^* \lambda_j^0 \tag{175}$$

$$\tilde{H}_d^0 = \sum_j N_{j4}^* \lambda_j^0 \,, \qquad \tilde{H}_u^0 = \sum_j N_{j5}^* \lambda_j^0 \,, \qquad \tilde{S} = \sum_j N_{j6}^* \lambda_j^0 \tag{176}$$

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

$$m_{\tilde{\chi}^-} = \begin{pmatrix} M_2 & \frac{1}{\sqrt{2}} g_2 v_u \\ \frac{1}{\sqrt{2}} g_2 v_d & \frac{1}{\sqrt{2}} v_S \lambda \end{pmatrix} \tag{177}$$

This matrix is diagonalized by U and V

$$U^* m_{\tilde{\chi}^-} V^\dagger = m_{\tilde{\chi}^-}^{dia} \tag{178}$$

with

$$\tilde{W}^- = \sum_{t_2} U_{j1}^* \lambda_j^- \,, \qquad \tilde{H}_d^- = \sum_{t_2} U_{j2}^* \lambda_j^- \tag{179}$$

$$\tilde{W}^+ = \sum_{t_2} V_{1j}^* \lambda_j^+ \,, \qquad \tilde{H}_u^+ = \sum_{t_2} V_{2j}^* \lambda_j^+ \tag{180}$$

- **Mass matrix for Leptons**, Basis: $(Fe4L, Fe9L), (Fe4R^*, Fe9R^*)$

$$m_e = \begin{pmatrix} \frac{1}{\sqrt{2}} v_d Y1 & 0 \\ 0 & \frac{1}{\sqrt{2}} v_d Y2^T \end{pmatrix} \tag{181}$$

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

$$U_L^{e,*} m_e U_R^{e,\dagger} = m_e^{dia} \tag{182}$$

with

$$Fe4L = \sum_{t_2} U_{L,j1}^{e,*} E_{L,j} \,, \qquad Fe9L_i = \sum_{t_2} U_{L,ji}^{e,*} E_{L,j} \tag{183}$$

$$Fe4R = \sum_{t_2} U_{R,1j}^{e} E_{R,j}^* \,, \qquad Fe9R_i = \sum_{t_2} U_{R,ij}^{e} E_{R,j}^* \tag{184}$$

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

$$m_d = \begin{pmatrix} \frac{1}{\sqrt{2}} v_d \delta_{\alpha_1 \beta_1} Y_d^T \end{pmatrix} \tag{185}$$

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

$$U_L^{d,*} m_d U_R^{d,\dagger} = m_d^{dia} \tag{186}$$

with

$$d_{L,i\alpha} = \sum_{t_2} U_{L,ji}^{d,*} D_{L,j\alpha} \tag{187}$$

$$d_{R,i\alpha} = \sum_{t_2} U_{R,ij}^{d} D_{R,j\alpha}^{*} \tag{188}$$

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

$$m_u = \left(\begin{array}{c} \frac{1}{\sqrt{2}} v_u \delta_{\alpha_1 \beta_1} Y_u^T \end{array} \right) \tag{189}$$

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

$$U_L^{u,*} m_u U_R^{u,\dagger} = m_u^{dia} \tag{190}$$

with

$$u_{L,i\alpha} = \sum_{t_2} U_{L,ji}^{u,*} \mathrm{FUL}\Big(\{\mathrm{gt2}, \mathrm{ct1}\}\Big) \tag{191}$$

$$u_{R,i\alpha} = \sum_{t_2} U_{R,ij}^{u} U_{R,j\alpha}^{*} \tag{192}$$

5 Vacuum Expectation Values

$$H_d^0 = \frac{1}{\sqrt{2}}\phi_d + \frac{1}{\sqrt{2}} v_d + i\frac{1}{\sqrt{2}}\sigma_d \tag{193}$$

$$H_u^0 = \frac{1}{\sqrt{2}}\phi_u + \frac{1}{\sqrt{2}} v_u + i\frac{1}{\sqrt{2}}\sigma_u \tag{194}$$

$$S = \frac{1}{\sqrt{2}}\sigma_s + \frac{1}{\sqrt{2}} v_S + i\frac{1}{\sqrt{2}}\phi_s \tag{195}$$

6 Tadpole Equations

$$\begin{aligned} \frac{\partial V}{\partial \phi_d} = &+\frac{1}{8} v_d \Big(4 g_p^2 Q_{H_d} \Big(Q_{H_d} v_d^2 + Q_{H_u} v_u^2 + Q_s v_S^2\Big) + \Big(g_1^2 + g_2^2\Big)\Big(-v_u + v_d\Big)\Big(v_d + v_u\Big)\Big) + v_d \Big(\frac{1}{2}\Big(v_S^2 + v_u^2\Big)\lambda^2 + m_{H_d}^2\Big) \\ &- \frac{1}{\sqrt{2}} v_S v_u T_\lambda \end{aligned} \tag{196}$$

$$\frac{\partial V}{\partial \phi_u} = +\frac{1}{8} v_u \Big(4 g_p^2 Q_{H_u} \Big(Q_{H_d} v_d^2 + Q_{H_u} v_u^2 + Q_s v_S^2\Big) + \Big(g_1^2 + g_2^2\Big)\Big(-v_d^2 + v_u^2\Big)\Big) + v_u \Big(\frac{1}{2}\Big(v_d^2 + v_S^2\Big)\lambda^2 + m_{H_u}^2\Big)$$

$$- \frac{1}{\sqrt{2}} v_d v_S T_\lambda \tag{197}$$

$$\frac{\partial V}{\partial \sigma_s} = \frac{1}{2} g_p^2 Q_s v_S \Big(Q_{H_d} v_d^2 + Q_{H_u} v_u^2 + Q_s v_S^2 \Big) - \frac{1}{\sqrt{2}} v_d v_u T_\lambda + v_S \Big(\frac{1}{2} \Big(v_d^2 + v_u^2 \Big) \lambda^2 + m_s^2 \Big) \tag{198}$$

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	6	generation, 6
$\tilde{\chi}^-$	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
Z'	Vector	real	1	lorentz, 4
W^-	Vector	complex	1	lorentz, 4
η^G	Ghost	real	1	color, 8
η^γ	Ghost	real	1	
η^Z	Ghost	real	1	
$\eta^{Z'}$	Ghost	real	1	
η^-	Ghost	complex	1	
η^+	Ghost	complex	1	

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}
16\pi^2\,\Pi_{i,j}(p^2) = {} & +4\Gamma_{\tilde{\tilde{d}}_i,\tilde{\tilde{d}}_j^*,W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{W^-}+A_0\Big(m^2_{W^-}\Big)\Big)+2\Gamma_{\tilde{\tilde{d}}_i,\tilde{\tilde{d}}_j^*,Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{Z}+A_0\Big(m^2_{Z}\Big)\Big)\\
& +2\Gamma_{\tilde{\tilde{d}}_i,\tilde{\tilde{d}}_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_{\tilde{\tilde{d}}_i,\tilde{\tilde{d}}_j^*,H_a^+,H_a^-}\\
& -\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{A_a^0}\Big)\Gamma_{\tilde{\tilde{d}}_i,\tilde{\tilde{d}}_j^*,A_a^0,A_a^0}-\sum_{a=1}^{3}A_0\Big(m^2_{\tilde{\nu}_a}\Big)\Gamma_{\tilde{\tilde{d}}_i,\tilde{\tilde{d}}_j^*,\tilde{\nu}_a^*,\tilde{\nu}_a}\\
& -\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{h_a}\Big)\Gamma_{\tilde{\tilde{d}}_i,\tilde{\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^2_{u_a},m^2_{\tilde{\chi}_b^-}\Big)m_{\tilde{\chi}_b^-}\Big(\Gamma^{L*}_{\tilde{\tilde{d}}_j^*,u_a,\tilde{\chi}_b^-}\Gamma^{R}_{\tilde{\tilde{d}}_i^*,u_a,\tilde{\chi}_b^-}+\Gamma^{R*}_{\tilde{\tilde{d}}_j^*,u_a,\tilde{\chi}_b^-}\Gamma^{L}_{\tilde{\tilde{d}}_i^*,u_a,\tilde{\chi}_b^-}\Big)\\
& +\sum_{a=1}^{3}\sum_{b=1}^{2}G_0\Big(p^2,m^2_{u_a},m^2_{\tilde{\chi}_b^-}\Big)\Big(\Gamma^{L*}_{\tilde{\tilde{d}}_j^*,u_a,\tilde{\chi}_b^-}\Gamma^{L}_{\tilde{\tilde{d}}_i^*,u_a,\tilde{\chi}_b^-}+\Gamma^{R*}_{\tilde{\tilde{d}}_j^*,u_a,\tilde{\chi}_b^-}\Gamma^{R}_{\tilde{\tilde{d}}_i^*,u_a,\tilde{\chi}_b^-}\Big)\\
& -2\sum_{a=1}^{3}m_{d_a}\sum_{b=1}^{6}B_0\Big(p^2,m^2_{d_a},m^2_{\tilde{\chi}_b^0}\Big)m_{\tilde{\chi}_b^0}\Big(\Gamma^{L*}_{\tilde{\tilde{d}}_j^*,d_a,\tilde{\chi}_b^0}\Gamma^{R}_{\tilde{\tilde{d}}_i^*,d_a,\tilde{\chi}_b^0}+\Gamma^{R*}_{\tilde{\tilde{d}}_j^*,d_a,\tilde{\chi}_b^0}\Gamma^{L}_{\tilde{\tilde{d}}_i^*,d_a,\tilde{\chi}_b^0}\Big)\\
& +\sum_{a=1}^{3}\sum_{b=1}^{6}G_0\Big(p^2,m^2_{d_a},m^2_{\tilde{\chi}_b^0}\Big)\Big(\Gamma^{L*}_{\tilde{\tilde{d}}_j^*,d_a,\tilde{\chi}_b^0}\Gamma^{L}_{\tilde{\tilde{d}}_i^*,d_a,\tilde{\chi}_b^0}+\Gamma^{R*}_{\tilde{\tilde{d}}_j^*,d_a,\tilde{\chi}_b^0}\Gamma^{R}_{\tilde{\tilde{d}}_i^*,d_a,\tilde{\chi}_b^0}\Big)\\
& -C\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{d}_a}\Big)\Gamma_{\tilde{\tilde{d}}_i,\tilde{\tilde{d}}_j^*,\tilde{d}_a^*,\tilde{d}_a}-\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{e}_a}\Big)\Gamma_{\tilde{\tilde{d}}_i,\tilde{\tilde{d}}_j^*,\tilde{e}_a^*,\tilde{e}_a}\\
& -C\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{u}_a}\Big)\Gamma_{\tilde{\tilde{d}}_i,\tilde{\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^{*}_{\tilde{\tilde{d}}_j^*,\tilde{u}_a,H_b^-}\Gamma_{\tilde{\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_b^0}\Big)\Gamma^{*}_{\tilde{\tilde{d}}_j^*,\tilde{d}_a,A_b^0}\Gamma_{\tilde{\tilde{d}}_i^*,\tilde{d}_a,A_b^0}+\sum_{a=1}^{6}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{d}_a},m^2_{h_b}\Big)\Gamma^{*}_{\tilde{\tilde{d}}_j^*,\tilde{d}_a,h_b}\Gamma_{\tilde{\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*}_{\tilde{\tilde{d}}_j^*,\tilde{g}_1,d_b}\Gamma^{R}_{\tilde{\tilde{d}}_i^*,\tilde{g}_1,d_b}+\Gamma^{R*}_{\tilde{\tilde{d}}_j^*,\tilde{g}_1,d_b}\Gamma^{L}_{\tilde{\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*}_{\tilde{\tilde{d}}_j^*,\tilde{g}_1,d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i^*,\tilde{g}_1,d_b}+\Gamma^{R*}_{\tilde{\tilde{d}}_j^*,\tilde{g}_1,d_b}\Gamma^{R}_{\tilde{\tilde{d}}_i^*,\tilde{g}_1,d_b}\Big)\\
& +\frac{4}{3}\sum_{b=1}^{6}\Gamma^{*}_{\tilde{\tilde{d}}_j^*,g,\tilde{d}_b}\Gamma_{\tilde{\tilde{d}}_i^*,g,\tilde{d}_b}F_0\Big(p^2,m^2_{\tilde{d}_b},0\Big)+\sum_{b=1}^{6}\Gamma^{*}_{\tilde{\tilde{d}}_j^*,\gamma,\tilde{d}_b}\Gamma_{\tilde{\tilde{d}}_i^*,\gamma,\tilde{d}_b}F_0\Big(p^2,m^2_{\tilde{d}_b},0\Big)
\end{aligned}
$$

$$+\sum_{b=1}^{6}\Gamma^{*}_{\check{\tilde{d}}^{*}_{j},Z,\tilde{d}_b}\Gamma_{\check{\tilde{d}}^{*}_{i},Z,\tilde{d}_b}F_0\Big(p^2,m^2_{\tilde{d}_b},m^2_{Z}\Big)+\sum_{b=1}^{6}\Gamma^{*}_{\check{\tilde{d}}^{*}_{j},Z',\tilde{d}_b}\Gamma_{\check{\tilde{d}}^{*}_{i},Z',\tilde{d}_b}F_0\Big(p^2,m^2_{\tilde{d}_b},m^2_{Z'}\Big)$$
$$+\sum_{b=1}^{6}\Gamma^{*}_{\check{\tilde{d}}^{*}_{j},W^-,\tilde{u}_b}\Gamma_{\check{\tilde{d}}^{*}_{i},W^-,\tilde{u}_b}F_0\Big(p^2,m^2_{\tilde{u}_b},m^2_{W^-}\Big) \tag{199}$$

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

$$\begin{aligned}
16\pi^2\ \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)\\
&+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}^{6}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}^{6}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)\\
&-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}^{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{200}$$

- **Self-Energy for Neutrinos** (ν)

$$
\begin{aligned}
16\pi^2\ \Sigma^S_{i,j}(p^2) = &+\sum_{a=1}^{2}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{e_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\check{\nu}_j,H^+_a,e_b} m_{e_b}\Gamma^{R}_{\check{\nu}_i,H^+_a,e_b}\\
&+\sum_{a=1}^{2} m_{\tilde{\chi}^-_a}\sum_{b=1}^{6} B_0\Big(p^2, m^2_{\tilde{\chi}^-_a}, m^2_{\tilde{e}_b}\Big)\Gamma^{L*}_{\check{\nu}_j,\tilde{\chi}^+_a,\tilde{e}_b}\Gamma^{R}_{\check{\nu}_i,\tilde{\chi}^+_a,\tilde{e}_b}\\
&+\sum_{a=1}^{3}\sum_{b=1}^{6} B_0\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{\tilde{\nu}_a}\Big)\Gamma^{L*}_{\check{\nu}_j,\tilde{\nu}_a,\tilde{\chi}^0_b} m_{\tilde{\chi}^0_b}\Gamma^{R}_{\check{\nu}_i,\tilde{\nu}_a,\tilde{\chi}^0_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\nu_b}, m^2_Z\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,Z,\nu_b} m_{\nu_b}\Gamma^{L}_{\check{\nu}_i,Z,\nu_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\nu_b}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,Z',\nu_b} m_{\nu_b}\Gamma^{L}_{\check{\nu}_i,Z',\nu_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{e_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,W^+,e_b} m_{e_b}\Gamma^{L}_{\check{\nu}_i,W^+,e_b}
\end{aligned}
\tag{201}
$$

$$
\begin{aligned}
16\pi^2\ \Sigma^R_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{H^-_a}\Big)\Gamma^{R*}_{\check{\nu}_j,H^+_a,e_b}\Gamma^{R}_{\check{\nu}_i,H^+_a,e_b}\\
&-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{\tilde{\chi}^-_a}, m^2_{\tilde{e}_b}\Big)\Gamma^{R*}_{\check{\nu}_j,\tilde{\chi}^+_a,\tilde{e}_b}\Gamma^{R}_{\check{\nu}_i,\tilde{\chi}^+_a,\tilde{e}_b}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{\tilde{\nu}_a}\Big)\Gamma^{R*}_{\check{\nu}_j,\tilde{\nu}_a,\tilde{\chi}^0_b}\Gamma^{R}_{\check{\nu}_i,\tilde{\nu}_a,\tilde{\chi}^0_b}\\
&-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu_b}, m^2_Z\Big)\Big)\Gamma^{L*}_{\check{\nu}_j,Z,\nu_b}\Gamma^{L}_{\check{\nu}_i,Z,\nu_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu_b}, m^2_{Z'}\Big)\Big)\Gamma^{L*}_{\check{\nu}_j,Z',\nu_b}\Gamma^{L}_{\check{\nu}_i,Z',\nu_b}\\
&-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{e_b}, m^2_{W^-}\Big)\Big)\Gamma^{L*}_{\check{\nu}_j,W^+,e_b}\Gamma^{L}_{\check{\nu}_i,W^+,e_b}
\end{aligned}
\tag{202}
$$

$$
\begin{aligned}
16\pi^2\ \Sigma^L_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\check{\nu}_j,H^+_a,e_b}\Gamma^{L}_{\check{\nu}_i,H^+_a,e_b}\\
&-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{\tilde{\chi}^-_a}, m^2_{\tilde{e}_b}\Big)\Gamma^{L*}_{\check{\nu}_j,\tilde{\chi}^+_a,\tilde{e}_b}\Gamma^{L}_{\check{\nu}_i,\tilde{\chi}^+_a,\tilde{e}_b}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{\tilde{\nu}_a}\Big)\Gamma^{L*}_{\check{\nu}_j,\tilde{\nu}_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{\nu}_i,\tilde{\nu}_a,\tilde{\chi}^0_b}\\
&-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu_b}, m^2_Z\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,Z,\nu_b}\Gamma^{R}_{\check{\nu}_i,Z,\nu_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu_b}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,Z',\nu_b}\Gamma^{R}_{\check{\nu}_i,Z',\nu_b}
\end{aligned}
$$

$$- \sum_{b=1}^{3} \Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{e_b}^2, m_{W^-}^2\Big)\Big) \Gamma^{R*}_{\check{\tilde{\nu}}_j, W^+, e_b} \Gamma^{R}_{\check{\tilde{\nu}}_i, W^+, e_b} \tag{203}$$

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

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

$$+\sum_{b=1}^{6}\Gamma^{*}_{\check{\tilde{u}}_j^*,\gamma,\tilde{u}_b}\Gamma_{\check{\tilde{u}}_i^*,\gamma,\tilde{u}_b}F_0\Big(p^2,m^2_{\tilde{u}_b},0\Big)+\sum_{b=1}^{6}\Gamma^{*}_{\check{\tilde{u}}_j^*,Z,\tilde{u}_b}\Gamma_{\check{\tilde{u}}_i^*,Z,\tilde{u}_b}F_0\Big(p^2,m^2_{\tilde{u}_b},m^2_Z\Big)$$
$$+\sum_{b=1}^{6}\Gamma^{*}_{\check{\tilde{u}}_j^*,Z',\tilde{u}_b}\Gamma_{\check{\tilde{u}}_i^*,Z',\tilde{u}_b}F_0\Big(p^2,m^2_{\tilde{u}_b},m^2_{Z'}\Big) \tag{204}$$

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

$$\begin{aligned}
16\pi^2\,\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)\\
&+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_a^0}\Big)\Gamma_{\check{\tilde{e}}_i,\check{\tilde{e}}_j^*,A_a^0,A_a^0}-\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}^{6}B_0\Big(p^2,m^2_{e_a},m^2_{\tilde{\chi}_b^0}\Big)m_{\tilde{\chi}_b^0}\Big(\Gamma^{L*}_{\check{\tilde{e}}_j^*,e_a,\tilde{\chi}_b^0}\Gamma^{R}_{\check{\tilde{e}}_i^*,e_a,\tilde{\chi}_b^0}+\Gamma^{R*}_{\check{\tilde{e}}_j^*,e_a,\tilde{\chi}_b^0}\Gamma^{L}_{\check{\tilde{e}}_i^*,e_a,\tilde{\chi}_b^0}\Big)\\
&+\sum_{a=1}^{3}\sum_{b=1}^{6}G_0\Big(p^2,m^2_{e_a},m^2_{\tilde{\chi}_b^0}\Big)\Big(\Gamma^{L*}_{\check{\tilde{e}}_j^*,e_a,\tilde{\chi}_b^0}\Gamma^{L}_{\check{\tilde{e}}_i^*,e_a,\tilde{\chi}_b^0}+\Gamma^{R*}_{\check{\tilde{e}}_j^*,e_a,\tilde{\chi}_b^0}\Gamma^{R}_{\check{\tilde{e}}_i^*,e_a,\tilde{\chi}_b^0}\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_b^0}\Big)\Gamma^{*}_{\check{\tilde{e}}_j^*,\tilde{e}_a,A_b^0}\Gamma_{\check{\tilde{e}}_i^*,\tilde{e}_a,A_b^0}\\
&+\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)\\
&+\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{205}$$

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

$$
\begin{aligned}
16\pi^2\,\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_Z^2,m_{Z'}^2\Big)\Big)\Gamma^*_{\check{h}_j,Z',Z}\Gamma_{\check{h}_i,Z',Z}+2\Big(-\frac{1}{2}\\
& +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}\\
& -2B_0\Big(p^2,m_{\eta^Z}^2,m_{\eta^{Z'}}^2\Big)\Gamma_{\check{h}_i,\eta^{\bar{Z}'},\eta^Z}\Gamma_{\check{h}_j,\eta^{\bar{Z}'},\eta^Z}-B_0\Big(p^2,m_{\eta^{Z'}}^2,m_{\eta^{Z'}}^2\Big)\Gamma_{\check{h}_i,\eta^{\bar{Z}'},\eta^{Z'}}\Gamma_{\check{h}_j,\eta^{\bar{Z}'},\eta^{Z'}}\\
& +4\Gamma_{\check{h}_i,\check{h}_j,W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m_{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)+2\Gamma_{\check{h}_i,\check{h}_j,Z',Z'}\Big(-\frac{1}{2}\mathrm{rM}\\
& -\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_{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}+\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{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)\\
&-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}\\
&-\sum_{a=1}^{6}m_{\tilde{\chi}^0_a}\sum_{b=1}^{6}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}^{6}\sum_{b=1}^{6}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)\\
&+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)\\
&+\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{206}
$$

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

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

$$
\begin{aligned}
&- \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} + \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}\\
&- 6\sum_{a=1}^{3} m_{d_a}\sum_{b=1}^{3} B_0\Big(p^2,m^2_{d_a},m^2_{d_b}\Big)m_{d_b}\Big(\Gamma^{L*}_{\check{A}^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^2_{d_a},m^2_{d_b}\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^2_{e_a},m^2_{e_b}\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^2_{e_a},m^2_{e_b}\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^2_{u_a},m^2_{u_b}\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^2_{u_a},m^2_{u_b}\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)\\
&- 3\sum_{a=1}^{6} A_0\Big(m^2_{\tilde{d}_a}\Big)\Gamma_{\check{A}^0_i,\check{A}^0_j,\tilde{d}^*_a,\tilde{d}_a} - \sum_{a=1}^{6} A_0\Big(m^2_{\tilde{e}_a}\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^2_{\tilde{u}_a}\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^2_{\tilde{d}_a},m^2_{\tilde{d}_b}\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^2_{\tilde{e}_a},m^2_{\tilde{e}_b}\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^2_{\tilde{u}_a},m^2_{\tilde{u}_b}\Big)\Gamma^*_{\check{A}^0_j,\tilde{u}^*_a,\tilde{u}_b}\Gamma_{\check{A}^0_i,\tilde{u}^*_a,\tilde{u}_b}\\
&- \sum_{a=1}^{6} m_{\tilde{\chi}^0_a}\sum_{b=1}^{6} 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{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}^{6}\sum_{b=1}^{6} G_0\Big(p^2,m^2_{\tilde{\chi}^0_a},m^2_{\tilde{\chi}^0_b}\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)\\
&+ 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^2_{H^-_b},m^2_{W^-}\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^2_{h_b},m^2_{Z}\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^2_{h_b},m^2_{Z'}\Big) \qquad (207)
\end{aligned}
$$

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

$$
\begin{aligned}
16\pi^2\ \Pi_{i,j}(p^2) = {} & +4\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,0,m^2_{W^-}\Big)\Big)\Gamma^*_{\check{H}^+_j,W^-,\gamma}\Gamma_{\check{H}^+_i,W^-,\gamma}+4\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m^2_{W^-},m^2_Z\Big)\Big)\Gamma^*_{\check{H}^+_j,Z,W^-}\Gamma_{\check{H}^+_i,Z,W^-}\\
& +4\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m^2_{W^-},m^2_{Z'}\Big)\Big)\Gamma^*_{\check{H}^+_j,Z',W^-}\Gamma_{\check{H}^+_i,Z',W^-}-B_0\Big(p^2,m^2_{\eta^Z},m^2_{\eta^+}\Big)\Gamma_{\check{H}^+_i,\bar{\eta^+},\eta^Z}\Gamma_{\check{H}^-_j,\eta^+,\bar{\eta^Z}}\\
& -B_0\Big(p^2,m^2_{\eta^{Z'}},m^2_{\eta^+}\Big)\Gamma_{\check{H}^+_i,\bar{\eta^+},\eta^{Z'}}\Gamma_{\check{H}^-_j,\eta^+,\bar{\eta^{Z'}}}-B_0\Big(p^2,m^2_{\eta^-},m^2_{\eta^Z}\Big)\Gamma_{\check{H}^+_i,\bar{\eta^Z},\eta^-}\Gamma_{\check{H}^-_j,\eta^Z,\bar{\eta^-}}\\
& -B_0\Big(p^2,m^2_{\eta^-},m^2_{\eta^{Z'}}\Big)\Gamma_{\check{H}^+_i,\bar{\eta^{Z'}},\eta^-}\Gamma_{\check{H}^-_j,\eta^{Z'},\bar{\eta^-}}+4\Gamma_{\check{H}^-_i,\check{H}^+_j,W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{W^-}+A_0\Big(m^2_{W^-}\Big)\Big)\\
& +2\Gamma_{\check{H}^-_i,\check{H}^+_j,Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m^2_Z+A_0\Big(m^2_Z\Big)\Big)+2\Gamma_{\check{H}^-_i,\check{H}^+_j,Z',Z'}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{Z'}+A_0\Big(m^2_{Z'}\Big)\Big)\\
& -\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^0_b}\Big)\Gamma^*_{\check{H}^+_j,H^-_a,A^0_b}\Gamma_{\check{H}^+_i,H^-_a,A^0_b}\\
& +\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^0_a}\Big)\Gamma_{\check{H}^-_i,\check{H}^+_j,A^0_a,A^0_a}\\
& -\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}-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}\\
& -2\sum_{a=1}^{6}m_{\tilde{\chi}^0_a}\sum_{b=1}^{2}B_0\Big(p^2,m^2_{\tilde{\chi}^0_a},m^2_{\tilde{\chi}^-_b}\Big)m_{\tilde{\chi}^-_b}\Big(\Gamma^{L*}_{\check{H}^+_j,\tilde{\chi}^0_a,\tilde{\chi}^-_b}\Gamma^{R}_{\check{H}^+_i,\tilde{\chi}^0_a,\tilde{\chi}^-_b}+\Gamma^{R*}_{\check{H}^+_j,\tilde{\chi}^0_a,\tilde{\chi}^-_b}\Gamma^{L}_{\check{H}^+_i,\tilde{\chi}^0_a,\tilde{\chi}^-_b}\Big)\\
& +\sum_{a=1}^{6}\sum_{b=1}^{2}G_0\Big(p^2,m^2_{\tilde{\chi}^0_a},m^2_{\tilde{\chi}^-_b}\Big)\Big(\Gamma^{L*}_{\check{H}^+_j,\tilde{\chi}^0_a,\tilde{\chi}^-_b}\Gamma^{L}_{\check{H}^+_i,\tilde{\chi}^0_a,\tilde{\chi}^-_b}+\Gamma^{R*}_{\check{H}^+_j,\tilde{\chi}^0_a,\tilde{\chi}^-_b}\Gamma^{R}_{\check{H}^+_i,\tilde{\chi}^0_a,\tilde{\chi}^-_b}\Big)\\
& +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)
\end{aligned}
$$

$$+\sum_{b=1}^{2}\Gamma^{*}_{\check{H}_j^+,Z,H_b^-}\Gamma_{\check{H}_i^+,Z,H_b^-}F_0\Big(p^2,m^2_{H_b^-},m^2_Z\Big)+\sum_{b=1}^{2}\Gamma^{*}_{\check{H}_j^+,Z',H_b^-}\Gamma_{\check{H}_i^+,Z',H_b^-}F_0\Big(p^2,m^2_{H_b^-},m^2_{Z'}\Big)$$
$$+\sum_{b=1}^{3}\Gamma^{*}_{\check{H}_j^+,W^-,A_b^0}\Gamma_{\check{H}_i^+,W^-,A_b^0}F_0\Big(p^2,m^2_{A_b^0},m^2_{W^-}\Big)+\sum_{b=1}^{3}\Gamma^{*}_{\check{H}_j^+,W^-,h_b}\Gamma_{\check{H}_i^+,W^-,h_b}F_0\Big(p^2,m^2_{h_b},m^2_{W^-}\Big) \tag{208}$$

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

$$\begin{aligned}
16\pi^2\ \Sigma^S_{i,j}(p^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_{H_b^-}\Big)\Gamma^{L*}_{\check{\tilde{\chi}}_j^0,\tilde{\chi}_a^+,H_b^-}\Gamma^{R}_{\check{\tilde{\chi}}_i^0,\tilde{\chi}_a^+,H_b^-}\\
&+\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*}_{\check{\tilde{\chi}}_j^0,H_a^+,\tilde{\chi}_b^-}m_{\tilde{\chi}_b^-}\Gamma^{R}_{\check{\tilde{\chi}}_i^0,H_a^+,\tilde{\chi}_b^-}\\
&-4\sum_{a=1}^{2}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m^2_{\tilde{\chi}_a^-},m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\check{\tilde{\chi}}_j^0,\tilde{\chi}_a^+,W^-}m_{\tilde{\chi}_a^-}\Gamma^{L}_{\check{\tilde{\chi}}_i^0,\tilde{\chi}_a^+,W^-}\\
&+\sum_{a=1}^{3}m_{\nu_a}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\nu_a},m^2_{\tilde{\nu}_b}\Big)\Gamma^{L*}_{\check{\tilde{\chi}}_j^0,\bar{\nu}_a,\tilde{\nu}_b}\Gamma^{R}_{\check{\tilde{\chi}}_i^0,\bar{\nu}_a,\tilde{\nu}_b}\\
&+\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*}_{\check{\tilde{\chi}}_j^0,\tilde{\nu}_a^*,\nu_b}m_{\nu_b}\Gamma^{R}_{\check{\tilde{\chi}}_i^0,\tilde{\nu}_a^*,\nu_b}\\
&+3\sum_{a=1}^{3}m_{d_a}\sum_{b=1}^{6}B_0\Big(p^2,m^2_{d_a},m^2_{\tilde{d}_b}\Big)\Gamma^{L*}_{\check{\tilde{\chi}}_j^0,\bar{d}_a,\tilde{d}_b}\Gamma^{R}_{\check{\tilde{\chi}}_i^0,\bar{d}_a,\tilde{d}_b}\\
&+\sum_{a=1}^{3}m_{e_a}\sum_{b=1}^{6}B_0\Big(p^2,m^2_{e_a},m^2_{\tilde{e}_b}\Big)\Gamma^{L*}_{\check{\tilde{\chi}}_j^0,\bar{e}_a,\tilde{e}_b}\Gamma^{R}_{\check{\tilde{\chi}}_i^0,\bar{e}_a,\tilde{e}_b}\\
&+3\sum_{a=1}^{3}m_{u_a}\sum_{b=1}^{6}B_0\Big(p^2,m^2_{u_a},m^2_{\tilde{u}_b}\Big)\Gamma^{L*}_{\check{\tilde{\chi}}_j^0,\bar{u}_a,\tilde{u}_b}\Gamma^{R}_{\check{\tilde{\chi}}_i^0,\bar{u}_a,\tilde{u}_b}\\
&+\sum_{a=1}^{3}\sum_{b=1}^{6}B_0\Big(p^2,m^2_{\tilde{\chi}_b^0},m^2_{h_a}\Big)\Gamma^{L*}_{\check{\tilde{\chi}}_j^0,h_a,\tilde{\chi}_b^0}m_{\tilde{\chi}_b^0}\Gamma^{R}_{\check{\tilde{\chi}}_i^0,h_a,\tilde{\chi}_b^0}\\
&+\sum_{a=1}^{6}m_{\tilde{\chi}_a^0}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{\chi}_a^0},m^2_{A_b^0}\Big)\Gamma^{L*}_{\check{\tilde{\chi}}_j^0,\tilde{\chi}_a^0,A_b^0}\Gamma^{R}_{\check{\tilde{\chi}}_i^0,\tilde{\chi}_a^0,A_b^0}\\
&+3\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*}_{\check{\tilde{\chi}}_j^0,\tilde{d}_a^*,d_b}m_{d_b}\Gamma^{R}_{\check{\tilde{\chi}}_i^0,\tilde{d}_a^*,d_b}\\
&+\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*}_{\check{\tilde{\chi}}_j^0,\tilde{e}_a^*,e_b}m_{e_b}\Gamma^{R}_{\check{\tilde{\chi}}_i^0,\tilde{e}_a^*,e_b}
\end{aligned}$$

$$
\begin{aligned}
&+ 3\sum_{a=1}^{6}\sum_{b=1}^{3} B_0\Big(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2\Big)\Gamma^{L*}_{\tilde{\chi}_j^0,\tilde{u}_a^*,u_b} m_{u_b} \Gamma^{R}_{\tilde{\chi}_i^0,\tilde{u}_a^*,u_b} \\
&- 4\sum_{b=1}^{2}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{\tilde{\chi}_b^-}^2, m_{W^-}^2\Big)\Big)\Gamma^{R*}_{\tilde{\chi}_j^0,W^+,\tilde{\chi}_b^-} m_{\tilde{\chi}_b^-} \Gamma^{L}_{\tilde{\chi}_i^0,W^+,\tilde{\chi}_b^-} \\
&- 4\sum_{b=1}^{6}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{Z}^2\Big)\Big)\Gamma^{R*}_{\tilde{\chi}_j^0,Z,\tilde{\chi}_b^0} m_{\tilde{\chi}_b^0} \Gamma^{L}_{\tilde{\chi}_i^0,Z,\tilde{\chi}_b^0} \\
&- 4\sum_{b=1}^{6}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{Z'}^2\Big)\Big)\Gamma^{R*}_{\tilde{\chi}_j^0,Z',\tilde{\chi}_b^0} m_{\tilde{\chi}_b^0} \Gamma^{L}_{\tilde{\chi}_i^0,Z',\tilde{\chi}_b^0} \qquad (209)
\end{aligned}
$$

$$
\begin{aligned}
16\pi^2\ \Sigma^R_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{2} B_1\Big(p^2, m_{\tilde{\chi}_a^-}^2, m_{H_b^-}^2\Big)\Gamma^{R*}_{\tilde{\chi}_j^0,\tilde{\chi}_a^+,H_b^-}\Gamma^{R}_{\tilde{\chi}_i^0,\tilde{\chi}_a^+,H_b^-} \\
&- \frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{2} B_1\Big(p^2, m_{\tilde{\chi}_b^-}^2, m_{H_a^-}^2\Big)\Gamma^{R*}_{\tilde{\chi}_j^0,H_a^+,\tilde{\chi}_b^-}\Gamma^{R}_{\tilde{\chi}_i^0,H_a^+,\tilde{\chi}_b^-} \\
&- \sum_{a=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{\tilde{\chi}_a^-}^2, m_{W^-}^2\Big)\Big)\Gamma^{L*}_{\tilde{\chi}_j^0,\tilde{\chi}_a^+,W^-}\Gamma^{L}_{\tilde{\chi}_i^0,\tilde{\chi}_a^+,W^-} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{\nu_a}^2, m_{\tilde{\nu}_b}^2\Big)\Gamma^{R*}_{\tilde{\chi}_j^0,\bar{\nu}_a,\tilde{\nu}_b}\Gamma^{R}_{\tilde{\chi}_i^0,\bar{\nu}_a,\tilde{\nu}_b} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{\nu_b}^2, m_{\tilde{\nu}_a}^2\Big)\Gamma^{R*}_{\tilde{\chi}_j^0,\tilde{\nu}_a^*,\nu_b}\Gamma^{R}_{\tilde{\chi}_i^0,\tilde{\nu}_a^*,\nu_b} \\
&- \frac{3}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m_{d_a}^2, m_{\tilde{d}_b}^2\Big)\Gamma^{R*}_{\tilde{\chi}_j^0,\bar{d}_a,\tilde{d}_b}\Gamma^{R}_{\tilde{\chi}_i^0,\bar{d}_a,\tilde{d}_b} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m_{e_a}^2, m_{\tilde{e}_b}^2\Big)\Gamma^{R*}_{\tilde{\chi}_j^0,\bar{e}_a,\tilde{e}_b}\Gamma^{R}_{\tilde{\chi}_i^0,\bar{e}_a,\tilde{e}_b} \\
&- \frac{3}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m_{u_a}^2, m_{\tilde{u}_b}^2\Big)\Gamma^{R*}_{\tilde{\chi}_j^0,\bar{u}_a,\tilde{u}_b}\Gamma^{R}_{\tilde{\chi}_i^0,\bar{u}_a,\tilde{u}_b} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{h_a}^2\Big)\Gamma^{R*}_{\tilde{\chi}_j^0,h_a,\tilde{\chi}_b^0}\Gamma^{R}_{\tilde{\chi}_i^0,h_a,\tilde{\chi}_b^0} \\
&- \frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m_{\tilde{\chi}_a^0}^2, m_{A_b^0}^2\Big)\Gamma^{R*}_{\tilde{\chi}_j^0,\tilde{\chi}_a^0,A_b^0}\Gamma^{R}_{\tilde{\chi}_i^0,\tilde{\chi}_a^0,A_b^0} \\
&- \frac{3}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2\Big)\Gamma^{R*}_{\tilde{\chi}_j^0,\tilde{d}_a^*,d_b}\Gamma^{R}_{\tilde{\chi}_i^0,\tilde{d}_a^*,d_b}
\end{aligned}
$$

$$
\begin{aligned}
&- \frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{\tilde{e}_a}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,\tilde{e}^*_a,e_b}\Gamma^{R}_{\tilde{\chi}^0_i,\tilde{e}^*_a,e_b}\\
&- \frac{3}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,\tilde{u}^*_a,u_b}\Gamma^{R}_{\tilde{\chi}^0_i,\tilde{u}^*_a,u_b}\\
&- \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{W^-}\Big)\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,W^+,\tilde{\chi}^-_b}\Gamma^{L}_{\tilde{\chi}^0_i,W^+,\tilde{\chi}^-_b}\\
&- \sum_{b=1}^{6}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{Z}\Big)\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,Z,\tilde{\chi}^0_b}\Gamma^{L}_{\tilde{\chi}^0_i,Z,\tilde{\chi}^0_b} - \sum_{b=1}^{6}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{Z'}\Big)\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,Z',\tilde{\chi}^0_b}\Gamma^{L}_{\tilde{\chi}^0_i,Z',\tilde{\chi}^0_b}
\end{aligned}
\tag{210}
$$

$$
\begin{aligned}
16\pi^2\ \Sigma^L_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\tilde{\chi}^-_a}, m^2_{H^-_b}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{\chi}^+_a,H^-_b}\Gamma^{L}_{\tilde{\chi}^0_i,\tilde{\chi}^+_a,H^-_b}\\
&- \frac{1}{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}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^-_a}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,\tilde{\chi}^+_a,W^-}\Gamma^{R}_{\tilde{\chi}^0_i,\tilde{\chi}^+_a,W^-}\\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{\nu_a}, m^2_{\tilde{\nu}_b}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\bar{\nu}_a,\tilde{\nu}_b}\Gamma^{L}_{\tilde{\chi}^0_i,\bar{\nu}_a,\tilde{\nu}_b}\\
&- \frac{1}{2}\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{3}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{d_a}, m^2_{\tilde{d}_b}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\bar{d}_a,\tilde{d}_b}\Gamma^{L}_{\tilde{\chi}^0_i,\bar{d}_a,\tilde{d}_b}\\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{e_a}, m^2_{\tilde{e}_b}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\bar{e}_a,\tilde{e}_b}\Gamma^{L}_{\tilde{\chi}^0_i,\bar{e}_a,\tilde{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{u}_b}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\bar{u}_a,\tilde{u}_b}\Gamma^{L}_{\tilde{\chi}^0_i,\bar{u}_a,\tilde{u}_b}\\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} 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}^{6}\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}\\
&- \frac{3}{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{\chi}^0_j,\tilde{d}^*_a,d_b}\Gamma^{L}_{\tilde{\chi}^0_i,\tilde{d}^*_a,d_b}
\end{aligned}
$$

$$
\begin{aligned}
&- \frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{\tilde{e}_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{e}^*_a,e_b}\Gamma^{L}_{\tilde{\chi}^0_i,\tilde{e}^*_a,e_b}\\
&- \frac{3}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{u}^*_a,u_b}\Gamma^{L}_{\tilde{\chi}^0_i,\tilde{u}^*_a,u_b}\\
&- \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,W^+,\tilde{\chi}^-_b}\Gamma^{R}_{\tilde{\chi}^0_i,W^+,\tilde{\chi}^-_b}\\
&- \sum_{b=1}^{6}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,Z,\tilde{\chi}^0_b}\Gamma^{R}_{\tilde{\chi}^0_i,Z,\tilde{\chi}^0_b} - \sum_{b=1}^{6}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,Z',\tilde{\chi}^0_b}\Gamma^{R}_{\tilde{\chi}^0_i,Z',\tilde{\chi}^0_b}
\end{aligned}
\tag{211}
$$

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

$$
\begin{aligned}
16\pi^2\ \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}^{6} 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}\\
&+3\sum_{a=1}^{3} m_{u_a}\sum_{b=1}^{6} B_0\Big(p^2, m^2_{u_a}, m^2_{\tilde{d}_b}\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^2_{\nu_a}, m^2_{\tilde{e}_b}\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^2_{d_b}, m^2_{\tilde{u}_a}\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^2_{\tilde{\chi}^-_b}, 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^2_{\tilde{\chi}^-_b}, m^2_{Z}\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}^{2}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^+_j,Z',\tilde{\chi}^-_b} m_{\tilde{\chi}^-_b}\Gamma^{L}_{\tilde{\chi}^+_i,Z',\tilde{\chi}^-_b}
\end{aligned}
$$

$$- 4\sum_{b=1}^{6}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^+_j,W^-,\tilde{\chi}^0_b} m_{\tilde{\chi}^0_b}\Gamma^{L}_{\tilde{\chi}^+_i,W^-,\tilde{\chi}^0_b} \tag{212}$$

$$\begin{aligned}
16\pi^2\ \Sigma^R_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{\tilde{\chi}^-_a}, m^2_{A^0_b}\Big)\Gamma^{R*}_{\tilde{\chi}^+_j,\tilde{\chi}^-_a,A^0_b}\Gamma^{R}_{\tilde{\chi}^+_i,\tilde{\chi}^-_a,A^0_b}\\
&-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{H^-_a}\Big)\Gamma^{R*}_{\tilde{\chi}^+_j,H^-_a,\tilde{\chi}^0_b}\Gamma^{R}_{\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^{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^2_{e_b}, m^2_{\tilde{\nu}_a}\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^2_{u_a}, m^2_{\tilde{d}_b}\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^2_{\nu_a}, m^2_{\tilde{e}_b}\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^2_{d_b}, m^2_{\tilde{u}_a}\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}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, 0\Big)\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,\gamma,\tilde{\chi}^-_b}\Gamma^{L}_{\tilde{\chi}^+_i,\gamma,\tilde{\chi}^-_b} - \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{Z}\Big)\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,Z,\tilde{\chi}^-_b}\Gamma^{L}_{\tilde{\chi}^+_i,Z,\tilde{\chi}^-_b}\\
&-\sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{Z'}\Big)\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,Z',\tilde{\chi}^-_b}\Gamma^{L}_{\tilde{\chi}^+_i,Z',\tilde{\chi}^-_b}\\
&-\sum_{b=1}^{6}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{W^-}\Big)\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,W^-,\tilde{\chi}^0_b}\Gamma^{L}_{\tilde{\chi}^+_i,W^-,\tilde{\chi}^0_b}
\end{aligned} \tag{213}$$

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

$$
\begin{aligned}
&- \frac{3}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{u_a}, m^2_{\tilde{d}_b}\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,\bar{u}_a,\tilde{d}_b}\Gamma^{L}_{\tilde{\chi}^+_i,\bar{u}_a,\tilde{d}_b}\\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{\nu_a}, m^2_{\tilde{e}_b}\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,\bar{\nu}_a,\tilde{e}_b}\Gamma^{L}_{\tilde{\chi}^+_i,\bar{\nu}_a,\tilde{e}_b}\\
&- \frac{3}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{d_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,\tilde{u}^*_a,d_b}\Gamma^{L}_{\tilde{\chi}^+_i,\tilde{u}^*_a,d_b}\\
&- \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, 0\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^+_j,\gamma,\tilde{\chi}^-_b}\Gamma^{R}_{\tilde{\chi}^+_i,\gamma,\tilde{\chi}^-_b} - \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^+_j,Z,\tilde{\chi}^-_b}\Gamma^{R}_{\tilde{\chi}^+_i,Z,\tilde{\chi}^-_b}\\
&- \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^+_j,Z',\tilde{\chi}^-_b}\Gamma^{R}_{\tilde{\chi}^+_i,Z',\tilde{\chi}^-_b}\\
&- \sum_{b=1}^{6}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^+_j,W^-,\tilde{\chi}^0_b}\Gamma^{R}_{\tilde{\chi}^+_i,W^-,\tilde{\chi}^0_b}
\end{aligned}
\tag{214}
$$

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

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

$$- 4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{e_b}^2, m_{Z'}^2\Big)\Big)\Gamma^{R*}_{\check{\bar{e}}_j,Z',e_b} m_{e_b} \Gamma^{L}_{\check{\bar{e}}_i,Z',e_b} \tag{215}$$

$$\begin{aligned}
16\pi^2\ \Sigma^R_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m_{\nu_b}^2, m_{H_a^-}^2\Big)\Gamma^{R*}_{\check{\bar{e}}_j,H_a^-,\nu_b}\Gamma^{R}_{\check{\bar{e}}_i,H_a^-,\nu_b} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{2} B_1\Big(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{\nu}_a}^2\Big)\Gamma^{R*}_{\check{\bar{e}}_j,\tilde{\nu}_a,\tilde{\chi}_b^-}\Gamma^{R}_{\check{\bar{e}}_i,\tilde{\nu}_a,\tilde{\chi}_b^-} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{e_a}^2, m_{A_b^0}^2\Big)\Gamma^{R*}_{\check{\bar{e}}_j,e_a,A_b^0}\Gamma^{R}_{\check{\bar{e}}_i,e_a,A_b^0} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{e_b}^2, m_{h_a}^2\Big)\Gamma^{R*}_{\check{\bar{e}}_j,h_a,e_b}\Gamma^{R}_{\check{\bar{e}}_i,h_a,e_b} \\
&- \frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{6} B_1\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2\Big)\Gamma^{R*}_{\check{\bar{e}}_j,\tilde{e}_a,\tilde{\chi}_b^0}\Gamma^{R}_{\check{\bar{e}}_i,\tilde{e}_a,\tilde{\chi}_b^0} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{e_b}^2, 0\Big)\Big)\Gamma^{L*}_{\check{\bar{e}}_j,\gamma,e_b}\Gamma^{L}_{\check{\bar{e}}_i,\gamma,e_b} \\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{\nu_b}^2, m_{W^-}^2\Big)\Big)\Gamma^{L*}_{\check{\bar{e}}_j,W^-,\nu_b}\Gamma^{L}_{\check{\bar{e}}_i,W^-,\nu_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{e_b}^2, m_Z^2\Big)\Big)\Gamma^{L*}_{\check{\bar{e}}_j,Z,e_b}\Gamma^{L}_{\check{\bar{e}}_i,Z,e_b} \\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{e_b}^2, m_{Z'}^2\Big)\Big)\Gamma^{L*}_{\check{\bar{e}}_j,Z',e_b}\Gamma^{L}_{\check{\bar{e}}_i,Z',e_b}
\end{aligned} \tag{216}$$

$$\begin{aligned}
16\pi^2\ \Sigma^L_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m_{\nu_b}^2, m_{H_a^-}^2\Big)\Gamma^{L*}_{\check{\bar{e}}_j,H_a^-,\nu_b}\Gamma^{L}_{\check{\bar{e}}_i,H_a^-,\nu_b} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{2} B_1\Big(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{\nu}_a}^2\Big)\Gamma^{L*}_{\check{\bar{e}}_j,\tilde{\nu}_a,\tilde{\chi}_b^-}\Gamma^{L}_{\check{\bar{e}}_i,\tilde{\nu}_a,\tilde{\chi}_b^-} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{e_a}^2, m_{A_b^0}^2\Big)\Gamma^{L*}_{\check{\bar{e}}_j,e_a,A_b^0}\Gamma^{L}_{\check{\bar{e}}_i,e_a,A_b^0} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{e_b}^2, m_{h_a}^2\Big)\Gamma^{L*}_{\check{\bar{e}}_j,h_a,e_b}\Gamma^{L}_{\check{\bar{e}}_i,h_a,e_b} \\
&- \frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{6} B_1\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2\Big)\Gamma^{L*}_{\check{\bar{e}}_j,\tilde{e}_a,\tilde{\chi}_b^0}\Gamma^{L}_{\check{\bar{e}}_i,\tilde{e}_a,\tilde{\chi}_b^0} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{e_b}^2, 0\Big)\Big)\Gamma^{R*}_{\check{\bar{e}}_j,\gamma,e_b}\Gamma^{R}_{\check{\bar{e}}_i,\gamma,e_b} \\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{\nu_b}^2, m_{W^-}^2\Big)\Big)\Gamma^{R*}_{\check{\bar{e}}_j,W^-,\nu_b}\Gamma^{R}_{\check{\bar{e}}_i,W^-,\nu_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{e_b}^2, m_Z^2\Big)\Big)\Gamma^{R*}_{\check{\bar{e}}_j,Z,e_b}\Gamma^{R}_{\check{\bar{e}}_i,Z,e_b} \\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{e_b}^2, m_{Z'}^2\Big)\Big)\Gamma^{R*}_{\check{\bar{e}}_j,Z',e_b}\Gamma^{R}_{\check{\bar{e}}_i,Z',e_b}
\end{aligned} \tag{217}$$

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

$$
\begin{aligned}
16\pi^2\ \Sigma^S_{i,j}(p^2) = &+\sum_{a=1}^{2}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{u_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,H^-_a,u_b} m_{u_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,H^-_a,u_b}\\
&+\sum_{a=1}^{3} m_{d_a}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{d_a}, m^2_{A^0_b}\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,d_a,A^0_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,d_a,A^0_b}\\
&+\sum_{a=1}^{3}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{d_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\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^2_{\tilde{\chi}^-_b}, m^2_{\tilde{u}_a}\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}^{6} B_0\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{\tilde{d}_a}\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,\tilde{d}_a,\tilde{\chi}^0_b} m_{\tilde{\chi}^0_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,\tilde{d}_a,\tilde{\chi}^0_b}\\
&+\frac{4}{3} m_{\tilde{g}}\sum_{a=1}^{6} B_0\Big(p^2, m^2_{\tilde{g}}, m^2_{\tilde{d}_a}\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^2_{d_b}, 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^2_{d_b}, 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^2_{u_b}, m^2_{W^-}\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^2_{d_b}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,Z,d_b} m_{d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,Z,d_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{d_b}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,Z',d_b} m_{d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,Z',d_b} \qquad (218)\\
16\pi^2\ \Sigma^R_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_b}, m^2_{H^-_a}\Big)\Gamma^{R*}_{\tilde{\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^2_{d_a}, m^2_{A^0_b}\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,d_a,A^0_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,d_a,A^0_b}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{d_b}, m^2_{h_a}\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^2_{\tilde{\chi}^-_b}, m^2_{\tilde{u}_a}\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}^{6} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{\tilde{d}_a}\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,\tilde{d}_a,\tilde{\chi}^0_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,\tilde{d}_a,\tilde{\chi}^0_b}
\end{aligned}
$$

$$
\begin{aligned}
&- \frac{2}{3}\sum_{a=1}^{6} B_1\Big(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2\Big)\Gamma^{R*}_{\check{\tilde{d}}_j,\tilde{d}_a,\tilde{g}_1}\Gamma^{R}_{\check{\tilde{d}}_i,\tilde{d}_a,\tilde{g}_1} - \frac{4}{3}\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, 0\Big)\Big)\Gamma^{L*}_{\check{\tilde{d}}_j,g,d_b}\Gamma^{L}_{\check{\tilde{d}}_i,g,d_b}\\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, 0\Big)\Big)\Gamma^{L*}_{\check{\tilde{d}}_j,\gamma,d_b}\Gamma^{L}_{\check{\tilde{d}}_i,\gamma,d_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{u_b}^2, m_{W^-}^2\Big)\Big)\Gamma^{L*}_{\check{\tilde{d}}_j,W^-,u_b}\Gamma^{L}_{\check{\tilde{d}}_i,W^-,u_b}\\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, m_Z^2\Big)\Big)\Gamma^{L*}_{\check{\tilde{d}}_j,Z,d_b}\Gamma^{L}_{\check{\tilde{d}}_i,Z,d_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, m_{Z'}^2\Big)\Big)\Gamma^{L*}_{\check{\tilde{d}}_j,Z',d_b}\Gamma^{L}_{\check{\tilde{d}}_i,Z',d_b}
\end{aligned}
\tag{219}
$$

$$
\begin{aligned}
16\pi^2\ \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*}_{\check{\tilde{d}}_j,H_a^-,u_b}\Gamma^{L}_{\check{\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*}_{\check{\tilde{d}}_j,d_a,A_b^0}\Gamma^{L}_{\check{\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*}_{\check{\tilde{d}}_j,h_a,d_b}\Gamma^{L}_{\check{\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*}_{\check{\tilde{d}}_j,\tilde{u}_a,\tilde{\chi}_b^-}\Gamma^{L}_{\check{\tilde{d}}_i,\tilde{u}_a,\tilde{\chi}_b^-}\\
&- \frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{6} B_1\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2\Big)\Gamma^{L*}_{\check{\tilde{d}}_j,\tilde{d}_a,\tilde{\chi}_b^0}\Gamma^{L}_{\check{\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*}_{\check{\tilde{d}}_j,\tilde{d}_a,\tilde{g}_1}\Gamma^{L}_{\check{\tilde{d}}_i,\tilde{d}_a,\tilde{g}_1} - \frac{4}{3}\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, 0\Big)\Big)\Gamma^{R*}_{\check{\tilde{d}}_j,g,d_b}\Gamma^{R}_{\check{\tilde{d}}_i,g,d_b}\\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, 0\Big)\Big)\Gamma^{R*}_{\check{\tilde{d}}_j,\gamma,d_b}\Gamma^{R}_{\check{\tilde{d}}_i,\gamma,d_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{u_b}^2, m_{W^-}^2\Big)\Big)\Gamma^{R*}_{\check{\tilde{d}}_j,W^-,u_b}\Gamma^{R}_{\check{\tilde{d}}_i,W^-,u_b}\\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, m_Z^2\Big)\Big)\Gamma^{R*}_{\check{\tilde{d}}_j,Z,d_b}\Gamma^{R}_{\check{\tilde{d}}_i,Z,d_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, m_{Z'}^2\Big)\Big)\Gamma^{R*}_{\check{\tilde{d}}_j,Z',d_b}\Gamma^{R}_{\check{\tilde{d}}_i,Z',d_b}
\end{aligned}
\tag{220}
$$

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

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

$$
\begin{aligned}
&+\sum_{a=1}^{3}\sum_{b=1}^{3} B_0\Big(p^2, m_{u_b}^2, m_{h_a}^2\Big)\Gamma^{L*}_{\tilde{\breve{u}}_j,h_a,u_b} m_{u_b}\Gamma^{R}_{\tilde{\breve{u}}_i,h_a,u_b}\\
&+\sum_{a=1}^{6}\sum_{b=1}^{6} B_0\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{u}_a}^2\Big)\Gamma^{L*}_{\tilde{\breve{u}}_j,\tilde{u}_a,\tilde{\chi}_b^0} m_{\tilde{\chi}_b^0}\Gamma^{R}_{\tilde{\breve{u}}_i,\tilde{u}_a,\tilde{\chi}_b^0}\\
&+\frac{4}{3}m_{\tilde{g}}\sum_{a=1}^{6} B_0\Big(p^2, m_{\tilde{g}}^2, m_{\tilde{u}_a}^2\Big)\Gamma^{L*}_{\tilde{\breve{u}}_j,\tilde{u}_a,\tilde{g}_1}\Gamma^{R}_{\tilde{\breve{u}}_i,\tilde{u}_a,\tilde{g}_1} - \frac{16}{3}\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{u_b}^2, 0\Big)\Big)\Gamma^{R*}_{\tilde{\breve{u}}_j,g,u_b} m_{u_b}\Gamma^{L}_{\tilde{\breve{u}}_i,g,u_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{u_b}^2, 0\Big)\Big)\Gamma^{R*}_{\tilde{\breve{u}}_j,\gamma,u_b} m_{u_b}\Gamma^{L}_{\tilde{\breve{u}}_i,\gamma,u_b} - 4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{u_b}^2, m_Z^2\Big)\Big)\Gamma^{R*}_{\tilde{\breve{u}}_j,Z,u_b} m_{u_b}\Gamma^{L}_{\tilde{\breve{u}}_i,}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{u_b}^2, m_{Z'}^2\Big)\Big)\Gamma^{R*}_{\tilde{\breve{u}}_j,Z',u_b} m_{u_b}\Gamma^{L}_{\tilde{\breve{u}}_i,Z',u_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{d_b}^2, m_{W^-}^2\Big)\Big)\Gamma^{R*}_{\tilde{\breve{u}}_j,W^+,d_b} m_{d_b}\Gamma^{L}_{\tilde{\breve{u}}_i,W^+,d_b}
\end{aligned}
\tag{221}
$$

$$
\begin{aligned}
16\pi^2\ \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*}_{\tilde{\breve{u}}_j,H_a^+,d_b}\Gamma^{R}_{\tilde{\breve{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*}_{\tilde{\breve{u}}_j,\tilde{\chi}_a^+,\tilde{d}_b}\Gamma^{R}_{\tilde{\breve{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*}_{\tilde{\breve{u}}_j,u_a,A_b^0}\Gamma^{R}_{\tilde{\breve{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*}_{\tilde{\breve{u}}_j,h_a,u_b}\Gamma^{R}_{\tilde{\breve{u}}_i,h_a,u_b}\\
&-\frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{6} B_1\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{u}_a}^2\Big)\Gamma^{R*}_{\tilde{\breve{u}}_j,\tilde{u}_a,\tilde{\chi}_b^0}\Gamma^{R}_{\tilde{\breve{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*}_{\tilde{\breve{u}}_j,\tilde{u}_a,\tilde{g}_1}\Gamma^{R}_{\tilde{\breve{u}}_i,\tilde{u}_a,\tilde{g}_1} - \frac{4}{3}\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{u_b}^2, 0\Big)\Big)\Gamma^{L*}_{\tilde{\breve{u}}_j,g,u_b}\Gamma^{L}_{\tilde{\breve{u}}_i,g,u_b}\\
&-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{u_b}^2, 0\Big)\Big)\Gamma^{L*}_{\tilde{\breve{u}}_j,\gamma,u_b}\Gamma^{L}_{\tilde{\breve{u}}_i,\gamma,u_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{u_b}^2, m_Z^2\Big)\Big)\Gamma^{L*}_{\tilde{\breve{u}}_j,Z,u_b}\Gamma^{L}_{\tilde{\breve{u}}_i,Z,u_b}\\
&-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{u_b}^2, m_{Z'}^2\Big)\Big)\Gamma^{L*}_{\tilde{\breve{u}}_j,Z',u_b}\Gamma^{L}_{\tilde{\breve{u}}_i,Z',u_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, m_{W^-}^2\Big)\Big)\Gamma^{L*}_{\tilde{\breve{u}}_j,W^+,d_b}\Gamma^{L}_{\tilde{\breve{u}}_i,W^+,d_b}
\end{aligned}
\tag{222}
$$

$$
16\pi^2\ \Sigma^L_{i,j}(p^2) = -\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, m_{H_a^-}^2\Big)\Gamma^{L*}_{\tilde{\breve{u}}_j,H_a^+,d_b}\Gamma^{L}_{\tilde{\breve{u}}_i,H_a^+,d_b}
$$

$$
\begin{aligned}
&- \frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{\tilde{\chi}^-_a}, m^2_{\tilde{d}_b}\Big)\Gamma^{L*}_{\check{\tilde{u}}_j,\tilde{\chi}^+_a,\tilde{d}_b}\Gamma^{L}_{\check{\tilde{u}}_i,\tilde{\chi}^+_a,\tilde{d}_b}\\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_a}, m^2_{A^0_b}\Big)\Gamma^{L*}_{\check{\tilde{u}}_j,u_a,A^0_b}\Gamma^{L}_{\check{\tilde{u}}_i,u_a,A^0_b}\\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\check{\tilde{u}}_j,h_a,u_b}\Gamma^{L}_{\check{\tilde{u}}_i,h_a,u_b}\\
&- \frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{L*}_{\check{\tilde{u}}_j,\tilde{u}_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{\tilde{u}}_i,\tilde{u}_a,\tilde{\chi}^0_b}\\
&- \frac{2}{3}\sum_{a=1}^{6} B_1\Big(p^2, m^2_{\tilde{g}}, m^2_{\tilde{u}_a}\Big)\Gamma^{L*}_{\check{\tilde{u}}_j,\tilde{u}_a,\tilde{g}_1}\Gamma^{L}_{\check{\tilde{u}}_i,\tilde{u}_a,\tilde{g}_1} - \frac{4}{3}\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{u_b}, 0\Big)\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,g,u_b}\Gamma^{R}_{\check{\tilde{u}}_i,g,u_b}\\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{u_b}, 0\Big)\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,\gamma,u_b}\Gamma^{R}_{\check{\tilde{u}}_i,\gamma,u_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{u_b}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,Z,u_b}\Gamma^{R}_{\check{\tilde{u}}_i,Z,u_b}\\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{u_b}, m^2_{Z'}\Big)\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,Z',u_b}\Gamma^{R}_{\check{\tilde{u}}_i,Z',u_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{d_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,W^+,d_b}\Gamma^{R}_{\check{\tilde{u}}_i,W^+,d_b}
\end{aligned}
\tag{223}
$$

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

$$
\begin{aligned}
16\pi^2\ \Sigma^S(p^2) = &+\frac{1}{2}\sum_{a=1}^{3} m_{d_a}\sum_{b=1}^{6} B_0\Big(p^2, m^2_{d_a}, m^2_{\tilde{d}_b}\Big)\Gamma^{L*}_{\tilde{g}_j,\bar{d}_a,\tilde{d}_b}\Gamma^{R}_{\tilde{g}_i,\bar{d}_a,\tilde{d}_b}\\
&+ \frac{1}{2}\sum_{a=1}^{3} m_{u_a}\sum_{b=1}^{6} B_0\Big(p^2, m^2_{u_a}, m^2_{\tilde{u}_b}\Big)\Gamma^{L*}_{\tilde{g}_j,\bar{u}_a,\tilde{u}_b}\Gamma^{R}_{\tilde{g}_i,\bar{u}_a,\tilde{u}_b}\\
&+ \frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{d_b}, m^2_{\tilde{d}_a}\Big)\Gamma^{L*}_{\tilde{g}_j,\tilde{d}^*_a,d_b} m_{d_b}\Gamma^{R}_{\tilde{g}_i,\tilde{d}^*_a,d_b}\\
&+ \frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{u_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{L*}_{\tilde{g}_j,\tilde{u}^*_a,u_b} m_{u_b}\Gamma^{R}_{\tilde{g}_i,\tilde{u}^*_a,u_b}\\
&- 12\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\tilde{g}}, 0\Big)\Big)\Gamma^{R*}_{\tilde{g}_j,g,\tilde{g}_1} m_{\tilde{g}}\Gamma^{L}_{\tilde{g}_i,g,\tilde{g}_1}
\end{aligned}
\tag{224}
$$

$$
\begin{aligned}
16\pi^2\ \Sigma^R(p^2) = &-\frac{1}{4}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{d_a}, m^2_{\tilde{d}_b}\Big)\Gamma^{R*}_{\tilde{g}_j,\bar{d}_a,\tilde{d}_b}\Gamma^{R}_{\tilde{g}_i,\bar{d}_a,\tilde{d}_b}\\
&- \frac{1}{4}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{u_a}, m^2_{\tilde{u}_b}\Big)\Gamma^{R*}_{\tilde{g}_j,\bar{u}_a,\tilde{u}_b}\Gamma^{R}_{\tilde{g}_i,\bar{u}_a,\tilde{u}_b}
\end{aligned}
$$

$$
\begin{aligned}
&- \frac{1}{4}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{d_b}, m^2_{\tilde{d}_a}\Big)\Gamma^{R*}_{\tilde{g}_j,\tilde{d}^*_a,d_b}\Gamma^{R}_{\tilde{g}_i,\tilde{d}^*_a,d_b} \\
&- \frac{1}{4}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{R*}_{\tilde{g}_j,\tilde{u}^*_a,u_b}\Gamma^{R}_{\tilde{g}_i,\tilde{u}^*_a,u_b} - 3\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{g}}, 0\Big)\Big)\Gamma^{L*}_{\tilde{g}_j,g,\tilde{g}_1}\Gamma^{L}_{\tilde{g}_i,g,\tilde{g}_1} \quad (225)
\end{aligned}
$$

$$
\begin{aligned}
16\pi^2\ \Sigma^L(p^2) = &-\frac{1}{4}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{d_a}, m^2_{\tilde{d}_b}\Big)\Gamma^{L*}_{\tilde{g}_j,\bar{d}_a,\tilde{d}_b}\Gamma^{L}_{\tilde{g}_i,\bar{d}_a,\tilde{d}_b} \\
&- \frac{1}{4}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{u_a}, m^2_{\tilde{u}_b}\Big)\Gamma^{L*}_{\tilde{g}_j,\bar{u}_a,\tilde{u}_b}\Gamma^{L}_{\tilde{g}_i,\bar{u}_a,\tilde{u}_b} \\
&- \frac{1}{4}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{d_b}, m^2_{\tilde{d}_a}\Big)\Gamma^{L*}_{\tilde{g}_j,\tilde{d}^*_a,d_b}\Gamma^{L}_{\tilde{g}_i,\tilde{d}^*_a,d_b} \\
&- \frac{1}{4}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{L*}_{\tilde{g}_j,\tilde{u}^*_a,u_b}\Gamma^{L}_{\tilde{g}_i,\tilde{u}^*_a,u_b} - 3\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{g}}, 0\Big)\Big)\Gamma^{R*}_{\tilde{g}_j,g,\tilde{g}_1}\Gamma^{R}_{\tilde{g}_i,g,\tilde{g}_1} \quad (226)
\end{aligned}
$$

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

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

$$
\begin{aligned}
&+ 4B_0\Big(p^2, m_{e_a}^2, m_{e_b}^2\Big) m_{e_a} m_{e_b} \Re\Big(\Gamma^{L*}_{Z,\bar{e}_a,e_b} \Gamma^{R}_{Z,\bar{e}_a,e_b}\Big)\Big] \\
&+ 3\sum_{a=1}^{3}\sum_{b=1}^{3}\Big[\Big(|\Gamma^{L}_{Z,\bar{u}_a,u_b}|^2 + |\Gamma^{R}_{Z,\bar{u}_a,u_b}|^2\Big) H_0\Big(p^2, m_{u_a}^2, m_{u_b}^2\Big) \\
&+ 4B_0\Big(p^2, m_{u_a}^2, m_{u_b}^2\Big) m_{u_a} m_{u_b} \Re\Big(\Gamma^{L*}_{Z,\bar{u}_a,u_b} \Gamma^{R}_{Z,\bar{u}_a,u_b}\Big)\Big] \\
&+ \sum_{a=1}^{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_{\nu_a}^2, m_{\nu_b}^2\Big) \\
&+ 4B_0\Big(p^2, m_{\nu_a}^2, m_{\nu_b}^2\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] \\
&+ 3\sum_{a=1}^{6} A_0\Big(m_{\tilde{d}_a}^2\Big) \Gamma_{Z,Z,\tilde{d}_a^*,\tilde{d}_a} + \sum_{a=1}^{6} A_0\Big(m_{\tilde{e}_a}^2\Big) \Gamma_{Z,Z,\tilde{e}_a^*,\tilde{e}_a} + 3\sum_{a=1}^{6} A_0\Big(m_{\tilde{u}_a}^2\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_{\tilde{d}_a}^2, m_{\tilde{d}_b}^2\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_{\tilde{e}_a}^2, m_{\tilde{e}_b}^2\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_{\tilde{u}_a}^2, m_{\tilde{u}_b}^2\Big) \\
&+ \frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{6}\Big[\Big(|\Gamma^{L}_{Z,\tilde{\chi}_a^0,\tilde{\chi}_b^0}|^2 + |\Gamma^{R}_{Z,\tilde{\chi}_a^0,\tilde{\chi}_b^0}|^2\Big) H_0\Big(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2\Big) \\
&+ 4B_0\Big(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2\Big) m_{\tilde{\chi}_a^0} m_{\tilde{\chi}_b^0} \Re\Big(\Gamma^{L*}_{Z,\tilde{\chi}_a^0,\tilde{\chi}_b^0} \Gamma^{R}_{Z,\tilde{\chi}_a^0,\tilde{\chi}_b^0}\Big)\Big] \\
&+ 2\sum_{b=1}^{2} |\Gamma_{Z,W^+,H_b^-}|^2 B_0\Big(p^2, m_{W^-}^2, m_{H_b^-}^2\Big) + \sum_{b=1}^{3} |\Gamma_{Z,Z,h_b}|^2 B_0\Big(p^2, m_Z^2, m_{h_b}^2\Big) \\
&+ \sum_{b=1}^{3} |\Gamma_{Z,Z',h_b}|^2 B_0\Big(p^2, m_{Z'}^2, m_{h_b}^2\Big) + 2\mathrm{rMS} m_{W^-}^2 \Gamma^1_{Z,Z,W^+,W^-} - A_0\Big(m_{W^-}^2\Big)\Big(4\Gamma^1_{Z,Z,W^+,W^-} + \Gamma^2_{Z,Z,W^+,W^-} + \Gamma^3_{Z,Z,W}
\end{aligned}
\tag{227}
$$

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

$$
\begin{aligned}
16\pi^2\ \Pi(p^2) = &+|\Gamma_{Z',\bar{\eta^-},\eta^-}|^2 B_{00}\Big(p^2, m_{\eta^-}^2, m_{\eta^-}^2\Big) + |\Gamma_{Z',\bar{\eta^+},\eta^+}|^2 B_{00}\Big(p^2, m_{\eta^+}^2, m_{\eta^+}^2\Big) \\
&- |\Gamma_{Z',W^+,W^-}|^2\Big(10B_{00}\Big(p^2, m_{W^-}^2, m_{W^-}^2\Big) + 2A_0\Big(m_{W^-}^2\Big) - 2\mathrm{rMS}\Big(2m_{W^-}^2 - \frac{1}{3}p^2\Big) + B_0\Big(p^2, m_{W^-}^2, m_{W^-}^2\Big)\Big(2m_{W^-}^2 + \\
&+ \sum_{a=1}^{2} A_0\Big(m_{H_a^-}^2\Big) \Gamma_{Z',Z',H_a^+,H_a^-} - 4\sum_{a=1}^{2}\sum_{b=1}^{2} |\Gamma_{Z',H_a^+,H_b^-}|^2 B_{00}\Big(p^2, m_{H_a^-}^2, m_{H_b^-}^2\Big) \\
&+ \sum_{a=1}^{2}\sum_{b=1}^{2}\Big[\Big(|\Gamma^{L}_{Z',\tilde{\chi}_a^+,\tilde{\chi}_b^-}|^2 + |\Gamma^{R}_{Z',\tilde{\chi}_a^+,\tilde{\chi}_b^-}|^2\Big) H_0\Big(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{\chi}_b^-}^2\Big) \\
&+ 4B_0\Big(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{\chi}_b^-}^2\Big) m_{\tilde{\chi}_a^-} m_{\tilde{\chi}_b^-} \Re\Big(\Gamma^{L*}_{Z',\tilde{\chi}_a^+,\tilde{\chi}_b^-} \Gamma^{R}_{Z',\tilde{\chi}_a^+,\tilde{\chi}_b^-}\Big)\Big]
\end{aligned}
$$

$$
\begin{aligned}
&+\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}|^2B_{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}|^2B_{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]\\
&+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}|^2B_{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}|^2B_{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}|^2B_{00}\Big(p^2,m^2_{\tilde{u}_a},m^2_{\tilde{u}_b}\Big)\\
&+\frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{6}\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]\\
&+2\sum_{b=1}^{2}|\Gamma_{Z',W^+,H^-_b}|^2B_0\Big(p^2,m^2_{W^-},m^2_{H^-_b}\Big)+\sum_{b=1}^{3}|\Gamma_{Z',Z,h_b}|^2B_0\Big(p^2,m^2_Z,m^2_{h_b}\Big)\\
&+\sum_{b=1}^{3}|\Gamma_{Z',Z',h_b}|^2B_0\Big(p^2,m^2_{Z'},m^2_{h_b}\Big)+2\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'}
\end{aligned}
\tag{228}
$$

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

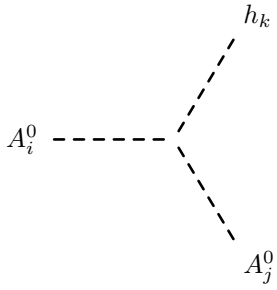
$$
\begin{aligned}
16\pi^2\ \Pi(p^2) = &-12\sum_{a=1}^{6}\sum_{b=1}^{6}|\Gamma_{W^+,\tilde{u}_a^*,\tilde{d}_b}|^2 B_{00}\Big(p^2,m_{\tilde{d}_b}^2,m_{\tilde{u}_a}^2\Big) + 2\mathrm{rMS}m_{W^-}^2\Gamma^1_{W^-,W^+,W^+,W^-} + 3\sum_{a=1}^{3}\sum_{b=1}^{3}\Big[\Big(|\Gamma^L_{W^+,\bar{u}_a,d_b}|^2 + |\Gamma^R_{W^+,\bar{u}_a,d}\\
&+ 4B_0\Big(p^2,m_{u_a}^2,m_{d_b}^2\Big)m_{d_b}m_{u_a}\Re\Big(\Gamma^{L*}_{W^+,\bar{u}_a,d_b}\Gamma^R_{W^+,\bar{u}_a,d_b}\Big)\Big] + 3\sum_{a=1}^{6}A_0\Big(m_{\tilde{d}_a}^2\Big)\Gamma_{W^-,W^+,\tilde{d}_a^*,\tilde{d}_a} + 3\sum_{a=1}^{6}A_0\Big(m_{\tilde{u}_a}^2\Big)\Gamma_{W^-,W^+,\tilde{u}}\\
&+ 4B_0\Big(p^2,m_{\nu_a}^2,m_{e_b}^2\Big)m_{e_b}m_{\nu_a}\Re\Big(\Gamma^{L*}_{W^+,\bar{\nu}_a,e_b}\Gamma^R_{W^+,\bar{\nu}_a,e_b}\Big)\Big] + \sum_{a=1}^{6}A_0\Big(m_{\tilde{e}_a}^2\Big)\Gamma_{W^-,W^+,\tilde{e}_a^*,\tilde{e}_a} + \sum_{a=1}^{6}\sum_{b=1}^{2}\Big[\Big(|\Gamma^L_{W^+,\tilde{\chi}_a^0,\tilde{\chi}_b^-}|^2 + |\Gamma\\
&+ 4B_0\Big(p^2,m_{\tilde{\chi}_a^0}^2,m_{\tilde{\chi}_b^-}^2\Big)m_{\tilde{\chi}_b^-}m_{\tilde{\chi}_a^0}\Re\Big(\Gamma^{L*}_{W^+,\tilde{\chi}_a^0,\tilde{\chi}_b^-}\Gamma^R_{W^+,\tilde{\chi}_a^0,\tilde{\chi}_b^-}\Big)\Big] + \sum_{b=1}^{2}|\Gamma_{W^+,\gamma,H_b^-}|^2 B_0\Big(p^2,0,m_{H_b^-}^2\Big) + \sum_{b=1}^{2}|\Gamma_{W^+,Z,H_b^-}|^2 B_0
\end{aligned}
\tag{229}
$$

8.2 Tadpoles

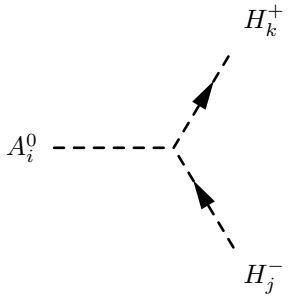
$$
\begin{aligned}
16\pi^2\ \delta t_h^{(1)} = &+ A_0\Big(m_{\eta^-}^2\Big)\Gamma_{\check{h}_i,\eta^-,\eta^-} + A_0\Big(m_{\eta^+}^2\Big)\Gamma_{\check{h}_i,\eta^+,\eta^+} + A_0\Big(m_{\eta^Z}^2\Big)\Gamma_{\check{h}_i,\eta^Z,\eta^Z}\\
&+ A_0\Big(m_{\eta^{Z'}}^2\Big)\Gamma_{\check{h}_i,\eta^{Z'},\eta^{Z'}} + 4\Gamma_{\check{h}_i,W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m_{W^-}^2 + A_0\Big(m_{W^-}^2\Big)\Big) + 2\Gamma_{\check{h}_i,Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m_Z^2 + A_0\Big(m_Z^2\Big)\Big)\\
&+ 2\Gamma_{\check{h}_i,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,H_a^+,H_a^-}\\
&+ 2\sum_{a=1}^{2}A_0\Big(m_{\tilde{\chi}_a^-}^2\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_{A_a^0}^2\Big)\Gamma_{\check{h}_i,A_a^0,A_a^0}\\
&- \sum_{a=1}^{3}A_0\Big(m_{\tilde{\nu}_a}^2\Big)\Gamma_{\check{h}_i,\tilde{\nu}_a^*,\tilde{\nu}_a} - \frac{1}{2}\sum_{a=1}^{3}A_0\Big(m_{h_a}^2\Big)\Gamma_{\check{h}_i,h_a,h_a}\\
&+ 6\sum_{a=1}^{3}A_0\Big(m_{d_a}^2\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_{e_a}^2\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_{u_a}^2\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) - 3\sum_{a=1}^{6}A_0\Big(m_{\tilde{d}_a}^2\Big)\Gamma_{\check{h}_i,\tilde{d}_a^*,\tilde{d}_a}\\
&- \sum_{a=1}^{6}A_0\Big(m_{\tilde{e}_a}^2\Big)\Gamma_{\check{h}_i,\tilde{e}_a^*,\tilde{e}_a} - 3\sum_{a=1}^{6}A_0\Big(m_{\tilde{u}_a}^2\Big)\Gamma_{\check{h}_i,\tilde{u}_a^*,\tilde{u}_a}\\
&+ \sum_{a=1}^{6}A_0\Big(m_{\tilde{\chi}_a^0}^2\Big)m_{\tilde{\chi}_a^0}\Big(\Gamma^L_{\check{h}_i,\tilde{\chi}_a^0,\tilde{\chi}_a^0} + \Gamma^R_{\check{h}_i,\tilde{\chi}_a^0,\tilde{\chi}_a^0}\Big)
\end{aligned}
\tag{230}
$$

9 Interactions for eigenstates 'EWSB'

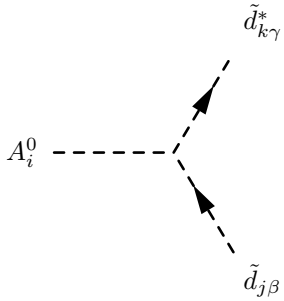
9.1 Three Scalar-Interaction



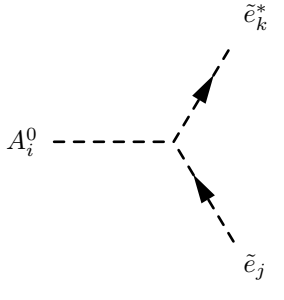
$$
\begin{aligned}
&-\frac{i}{4}\Big(2Z_{i3}^{A,*}\Big(2Z_{j3}^{A,*}\Big(g_p^2Q_s^2v_SZ_{k3}^{H,*}+v_d\Big(g_p^2Q_{H_d}Q_s+\lambda^2\Big)Z_{k1}^{H,*}+v_u\Big(g_p^2Q_{H_u}Q_s+\lambda^2\Big)Z_{k2}^{H,*}\Big)\\
&+\sqrt{2}\Big(Z_{j1}^{A,*}Z_{k2}^{H,*}+Z_{j2}^{A,*}Z_{k1}^{H,*}\Big)T_\lambda\Big)\\
&+Z_{i2}^{A,*}\Big(Z_{j2}^{A,*}\Big(-v_d\Big(-4\Big(g_p^2Q_{H_d}Q_{H_u}+\lambda^2\Big)+g_1^2+g_2^2\Big)Z_{k1}^{H,*}+\Big(4g_p^2Q_{H_u}^2+g_1^2+g_2^2\Big)v_uZ_{k2}^{H,*}\\
&+4v_S\Big(g_p^2Q_{H_u}Q_s+\lambda^2\Big)Z_{k3}^{H,*}\Big)\\
&+2\sqrt{2}\Big(Z_{j1}^{A,*}Z_{k3}^{H,*}+Z_{j3}^{A,*}Z_{k1}^{H,*}\Big)T_\lambda\Big)\\
&+Z_{i1}^{A,*}\Big(Z_{j1}^{A,*}\Big(\Big(4g_p^2Q_{H_d}^2+g_1^2+g_2^2\Big)v_dZ_{k1}^{H,*}-v_u\Big(-4\Big(g_p^2Q_{H_d}Q_{H_u}+\lambda^2\Big)+g_1^2+g_2^2\Big)Z_{k2}^{H,*}\\
&+4v_S\Big(g_p^2Q_{H_d}Q_s+\lambda^2\Big)Z_{k3}^{H,*}\Big)\\
&+2\sqrt{2}\Big(Z_{j2}^{A,*}Z_{k3}^{H,*}+Z_{j3}^{A,*}Z_{k2}^{H,*}\Big)T_\lambda\Big)\Big)
\end{aligned}
\tag{231}
$$



$$
\frac{1}{4}\Big(-2\sqrt{2}Z_{i3}^{A,*}T_\lambda+v_d\Big(-2\lambda^2+g_2^2\Big)Z_{i2}^{A,*}+v_u\Big(-2\lambda^2+g_2^2\Big)Z_{i1}^{A,*}\Big)\Big(-Z_{j1}^{+}Z_{k2}^{+}+Z_{j2}^{+}Z_{k1}^{+}\Big) \tag{232}
$$

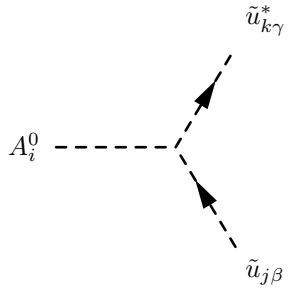


$$\frac{1}{2}\delta_{\beta\gamma}\Big(v_u\lambda Z^{A,*}_{i3}\Big(-\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{d,ab}Z^{D,*}_{j3+a}Z^D_{kb}+\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}Y_{d,ab}Z^D_{k3+a}\Big)$$
$$+Z^{A,*}_{i2}\Big(\sqrt{2}\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}T'_{d,ab}Z^D_{k3+a}+v_S\lambda\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}Y_{d,ab}Z^D_{k3+a}$$
$$-\sqrt{2}\sum_{b=1}^{3}\sum_{a=1}^{3}T'^{,*}_{d,ab}Z^{D,*}_{j3+a}Z^D_{kb}-v_S\lambda\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{d,ab}Z^{D,*}_{j3+a}Z^D_{kb}\Big)$$
$$+\sqrt{2}Z^{A,*}_{i1}\Big(-\sum_{b=1}^{3}\sum_{a=1}^{3}Z^{D,*}_{j3+a}T^*_{d,ab}Z^D_{kb}+\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}Z^D_{k3+a}T_{d,ab}\Big)\Big) \tag{233}$$

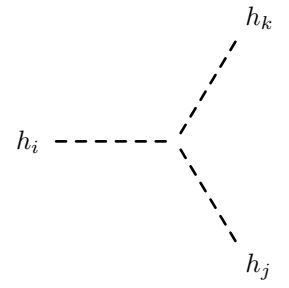


$$\frac{1}{2}\Big(v_u\lambda Z^{A,*}_{i3}\Big(-\sum_{b=1}^{2}\sum_{a=1}^{2}Y2^*_{ab}Z^{E,*}_{j4+a}Z^E_{k1+b}+Y1Z^{E,*}_{j1}Z^E_{k4}-Y1^*Z^{E,*}_{j4}Z^E_{k1}+\sum_{b=1}^{2}Z^{E,*}_{j1+b}\sum_{a=1}^{2}Y2_{ab}Z^E_{k4+a}\Big)$$
$$+Z^{A,*}_{i2}\Big(\sqrt{2}\sum_{b=1}^{2}Z^{E,*}_{j1+b}\sum_{a=1}^{2}T'_{e,ab}Z^E_{k4+a}+v_S\lambda\sum_{b=1}^{2}Z^{E,*}_{j1+b}\sum_{a=1}^{2}Y2_{ab}Z^E_{k4+a}$$
$$-\sqrt{2}\sum_{b=1}^{2}\sum_{a=1}^{2}T'^{,*}_{e,ab}Z^{E,*}_{j4+a}Z^E_{k1+b}-v_S\lambda\sum_{b=1}^{2}\sum_{a=1}^{2}Y2^*_{ab}Z^{E,*}_{j4+a}Z^E_{k1+b}-v_S\lambda Y1^*Z^{E,*}_{j4}Z^E_{k1}$$
$$+v_SY1\lambda Z^{E,*}_{j1}Z^E_{k4}\Big)$$

$$+\sqrt{2}Z_{i1}^{A,*}\Big(-\sum_{b=1}^{2}\sum_{a=1}^{2}Z_{j4+a}^{E,*}TY2_{ab}^{*}Z_{k1+b}^{E}-TY1^{*}Z_{j4}^{E,*}Z_{k1}^{E}+Z_{j1}^{E,*}TY1Z_{k4}^{E}+\sum_{b=1}^{2}Z_{j1+b}^{E,*}\sum_{a=1}^{2}Z_{k4+a}^{E}TY2_{ab}\Big)\Big) \tag{234}$$

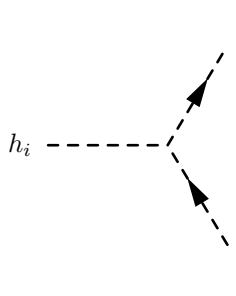


$$\begin{aligned}
&\frac{1}{2}\delta_{\beta\gamma}\Big(v_S\lambda Z_{i1}^{A,*}\Big(-\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{u,ab}^{*}Z_{j3+a}^{U,*}Z_{kb}^{U}+\sum_{b=1}^{3}Z_{jb}^{U,*}\sum_{a=1}^{3}Y_{u,ab}Z_{k3+a}^{U}\Big)\\
&+v_d\lambda Z_{i3}^{A,*}\Big(-\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{u,ab}^{*}Z_{j3+a}^{U,*}Z_{kb}^{U}+\sum_{b=1}^{3}Z_{jb}^{U,*}\sum_{a=1}^{3}Y_{u,ab}Z_{k3+a}^{U}\Big)\\
&+\sqrt{2}Z_{i2}^{A,*}\Big(-\sum_{b=1}^{3}\sum_{a=1}^{3}Z_{j3+a}^{U,*}T_{u,ab}^{*}Z_{kb}^{U}+\sum_{b=1}^{3}Z_{jb}^{U,*}\sum_{a=1}^{3}Z_{k3+a}^{U}T_{u,ab}\Big)\Big)
\end{aligned} \tag{235}$$

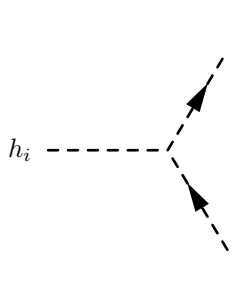


$$\begin{aligned}
&-\frac{i}{4}\Big(2Z_{i3}^{H,*}\Big(2Z_{j3}^{H,*}\Big(3g_p^2Q_s^2v_SZ_{k3}^{H,*}+v_d\Big(g_p^2Q_{H_d}Q_s+\lambda^2\Big)Z_{k1}^{H,*}+v_u\Big(g_p^2Q_{H_u}Q_s+\lambda^2\Big)Z_{k2}^{H,*}\Big)\\
&+Z_{j2}^{H,*}\Big(2v_S\Big(g_p^2Q_{H_u}Q_s+\lambda^2\Big)Z_{k2}^{H,*}+2v_u\Big(g_p^2Q_{H_u}Q_s+\lambda^2\Big)Z_{k3}^{H,*}-\sqrt{2}Z_{k1}^{H,*}T_\lambda\Big)\\
&+Z_{j1}^{H,*}\Big(2v_d\Big(g_p^2Q_{H_d}Q_s+\lambda^2\Big)Z_{k3}^{H,*}+2v_S\Big(g_p^2Q_{H_d}Q_s+\lambda^2\Big)Z_{k1}^{H,*}-\sqrt{2}Z_{k2}^{H,*}T_\lambda\Big)\Big)\\
&+Z_{i2}^{H,*}\Big(Z_{j2}^{H,*}\Big(-v_d\Big(-4\Big(g_p^2Q_{H_d}Q_{H_u}+\lambda^2\Big)+g_1^2+g_2^2\Big)Z_{k1}^{H,*}+3\Big(4g_p^2Q_{H_u}^2+g_1^2+g_2^2\Big)v_uZ_{k2}^{H,*}\\
&+4v_S\Big(g_p^2Q_{H_u}Q_s+\lambda^2\Big)Z_{k3}^{H,*}\Big)
\end{aligned}$$

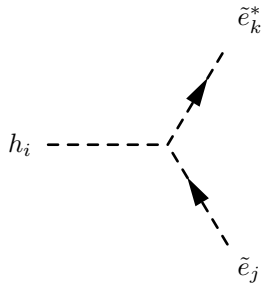
$$
\begin{aligned}
&+ 2Z_{j3}^{H,*}\Big(2v_S\Big(g_p^2Q_{H_u}Q_s+\lambda^2\Big)Z_{k2}^{H,*}+2v_u\Big(g_p^2Q_{H_u}Q_s+\lambda^2\Big)Z_{k3}^{H,*}-\sqrt{2}Z_{k1}^{H,*}T_\lambda\Big)\\
&- Z_{j1}^{H,*}\Big(v_u\Big(-4\Big(g_p^2Q_{H_d}Q_{H_u}+\lambda^2\Big)+g_1^2+g_2^2\Big)Z_{k1}^{H,*}+v_d\Big(-4\Big(g_p^2Q_{H_d}Q_{H_u}+\lambda^2\Big)+g_1^2+g_2^2\Big)Z_{k2}^{H,*}\\
&+2\sqrt{2}Z_{k3}^{H,*}T_\lambda\Big)\Big)\\
&+ Z_{i1}^{H,*}\Big(Z_{j1}^{H,*}\Big(3\Big(4g_p^2Q_{H_d}^2+g_1^2+g_2^2\Big)v_dZ_{k1}^{H,*}-v_u\Big(-4\Big(g_p^2Q_{H_d}Q_{H_u}+\lambda^2\Big)+g_1^2+g_2^2\Big)Z_{k2}^{H,*}\\
&+4v_S\Big(g_p^2Q_{H_d}Q_s+\lambda^2\Big)Z_{k3}^{H,*}\Big)\\
&+2Z_{j3}^{H,*}\Big(2v_d\Big(g_p^2Q_{H_d}Q_s+\lambda^2\Big)Z_{k3}^{H,*}+2v_S\Big(g_p^2Q_{H_d}Q_s+\lambda^2\Big)Z_{k1}^{H,*}-\sqrt{2}Z_{k2}^{H,*}T_\lambda\Big)\\
&- Z_{j2}^{H,*}\Big(v_u\Big(-4\Big(g_p^2Q_{H_d}Q_{H_u}+\lambda^2\Big)+g_1^2+g_2^2\Big)Z_{k1}^{H,*}+v_d\Big(-4\Big(g_p^2Q_{H_d}Q_{H_u}+\lambda^2\Big)+g_1^2+g_2^2\Big)Z_{k2}^{H,*}\\
&+2\sqrt{2}Z_{k3}^{H,*}T_\lambda\Big)\Big)\Big)
\end{aligned}
\tag{236}
$$



$$
\begin{aligned}
&-\frac{i}{4}\Big(Z_{i2}^{H,*}\Big(Z_{j2}^+\Big(\Big(4g_p^2Q_{H_u}^2+g_1^2+g_2^2\Big)v_uZ_{k2}^++v_d\Big(-2\lambda^2+g_2^2\Big)Z_{k1}^+\Big)\\
&+Z_{j1}^+\Big(\Big(4g_p^2Q_{H_d}Q_{H_u}-g_1^2+g_2^2\Big)v_uZ_{k1}^++v_d\Big(-2\lambda^2+g_2^2\Big)Z_{k2}^+\Big)\Big)\\
&+Z_{i1}^{H,*}\Big(Z_{j2}^+\Big(\Big(4g_p^2Q_{H_d}Q_{H_u}-g_1^2+g_2^2\Big)v_dZ_{k2}^++v_u\Big(-2\lambda^2+g_2^2\Big)Z_{k1}^+\Big)\\
&+Z_{j1}^+\Big(\Big(4g_p^2Q_{H_d}^2+g_1^2+g_2^2\Big)v_dZ_{k1}^++v_u\Big(-2\lambda^2+g_2^2\Big)Z_{k2}^+\Big)\Big)\\
&+2Z_{i3}^{H,*}\Big(Z_{j1}^+\Big(2v_S\Big(g_p^2Q_{H_d}Q_s+\lambda^2\Big)Z_{k1}^++\sqrt{2}T_\lambda Z_{k2}^+\Big)+Z_{j2}^+\Big(2v_S\Big(g_p^2Q_{H_u}Q_s+\lambda^2\Big)Z_{k2}^++\sqrt{2}T_\lambda Z_{k1}^+\Big)\Big)\Big)
\end{aligned}
\tag{237}
$$

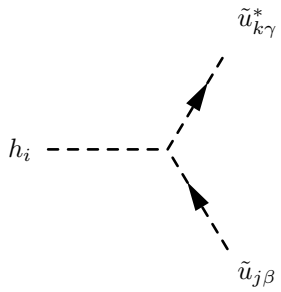


$$
\begin{aligned}
&\frac{i}{12}\delta_{\beta\gamma}\Big(6Z^{H,*}_{i3}\Big(-2g_p^2Q_qQ_sv_S\sum_{a=1}^{3}Z^{D,*}_{ja}Z^{D}_{ka}-2g_p^2Q_dQ_sv_S\sum_{a=1}^{3}Z^{D,*}_{j3+a}Z^{D}_{k3+a}\\
&+v_u\lambda\Big(\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}Y_{d,ab}Z^{D}_{k3+a}+\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{d,ab}Z^{D,*}_{j3+a}Z^{D}_{kb}\Big)\Big)\\
&-Z^{H,*}_{i2}\Big(\Big(3\Big(4g_p^2Q_{H_u}Q_q+g_2^2\Big)+g_1^2\Big)v_u\sum_{a=1}^{3}Z^{D,*}_{ja}Z^{D}_{ka}+2\Big(6g_p^2Q_dQ_{H_u}+g_1^2\Big)v_u\sum_{a=1}^{3}Z^{D,*}_{j3+a}Z^{D}_{k3+a}\\
&-6\Big(\sqrt{2}\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}T'_{d,ab}Z^{D}_{k3+a}+v_S\lambda\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}Y_{d,ab}Z^{D}_{k3+a}+\sqrt{2}\sum_{b=1}^{3}\sum_{a=1}^{3}T'^{,*}_{d,ab}Z^{D,*}_{j3+a}Z^{D}_{kb}\\
&+v_S\lambda\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{d,ab}Z^{D,*}_{j3+a}Z^{D}_{kb}\Big)\Big)\\
&+Z^{H,*}_{i1}\Big(\Big(3\Big(-4g_p^2Q_{H_d}Q_q+g_2^2\Big)+g_1^2\Big)v_d\sum_{a=1}^{3}Z^{D,*}_{ja}Z^{D}_{ka}+2\Big(-6g_p^2Q_dQ_{H_d}+g_1^2\Big)v_d\sum_{a=1}^{3}Z^{D,*}_{j3+a}Z^{D}_{k3+a}\\
&-6\Big(\sqrt{2}\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}Z^{D}_{k3+a}T_{d,ab}+\sqrt{2}\sum_{b=1}^{3}\sum_{a=1}^{3}Z^{D,*}_{j3+a}T^{*}_{d,ab}Z^{D}_{kb}\\
&+2v_d\Big(\sum_{c=1}^{3}Z^{D,*}_{j3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{d,ca}Y_{d,ba}Z^{D}_{k3+b}+\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}Y^{*}_{d,ac}Y_{d,ab}Z^{D}_{kc}\Big)\Big)\Big)\Big)
\end{aligned}
\tag{238}
$$



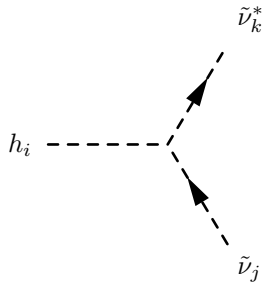
$$
\begin{aligned}
&-\frac{i}{4}\Big(2Z^{H,*}_{i3}\Big(2g_p^2Q_{l_9}Q_sv_S\sum_{a=1}^{2}Z^{E,*}_{j1+a}Z^{E}_{k1+a}+2g_p^2Q_{e_9}Q_sv_S\sum_{a=1}^{2}Z^{E,*}_{j4+a}Z^{E}_{k4+a}\\
&-v_u\lambda\sum_{b=1}^{2}Z^{E,*}_{j1+b}\sum_{a=1}^{2}Y2_{ab}Z^{E}_{k4+a}-v_u\lambda\sum_{b=1}^{2}\sum_{a=1}^{2}Y2^{*}_{ab}Z^{E,*}_{j4+a}Z^{E}_{k1+b}\\
&+2g_p^2Q_{l_4}Q_sv_SZ^{E,*}_{j1}Z^{E}_{k1}-v_u\lambda Y1^{*}Z^{E,*}_{j4}Z^{E}_{k1}-v_uY1\lambda Z^{E,*}_{j1}Z^{E}_{k4}\\
&+2g_p^2Q_{e_4}Q_sv_SZ^{E,*}_{j4}Z^{E}_{k4}\Big)\\
&+Z^{H,*}_{i2}\Big(\Big(4g_p^2Q_{H_u}Q_{l_9}-g_1^2+g_2^2\Big)v_u\sum_{a=1}^{2}Z^{E,*}_{j1+a}Z^{E}_{k1+a}+2\Big(2g_p^2Q_{e_9}Q_{H_u}+g_1^2\Big)v_u\sum_{a=1}^{2}Z^{E,*}_{j4+a}Z^{E}_{k4+a}
\end{aligned}
$$

$$
\begin{aligned}
&- 2\sqrt{2}\sum_{b=1}^{2} Z^{E,*}_{j1+b}\sum_{a=1}^{2} T'_{e,ab} Z^{E}_{k4+a} - 2v_S\lambda\sum_{b=1}^{2} Z^{E,*}_{j1+b}\sum_{a=1}^{2} Y2_{ab} Z^{E}_{k4+a} \\
&- 2\sqrt{2}\sum_{b=1}^{2}\sum_{a=1}^{2} T'^{,*}_{e,ab} Z^{E,*}_{j4+a} Z^{E}_{k1+b} - 2v_S\lambda\sum_{b=1}^{2}\sum_{a=1}^{2} Y2^{*}_{ab} Z^{E,*}_{j4+a} Z^{E}_{k1+b} - g_1^2 v_u Z^{E,*}_{j1} Z^{E}_{k1} \\
&+ g_2^2 v_u Z^{E,*}_{j1} Z^{E}_{k1} + 4g_p^2 Q_{H_u} Q_{l_4} v_u Z^{E,*}_{j1} Z^{E}_{k1} - 2v_S\lambda Y1^{*} Z^{E,*}_{j4} Z^{E}_{k1} \\
&- 2v_S Y1\lambda Z^{E,*}_{j1} Z^{E}_{k4} + 2g_1^2 v_u Z^{E,*}_{j4} Z^{E}_{k4} + 4g_p^2 Q_{e_4} Q_{H_u} v_u Z^{E,*}_{j4} Z^{E}_{k4}\Big) \\
&+ Z^{H,*}_{i1}\Big(\Big(4g_p^2 Q_{H_d} Q_{l_9} - g_2^2 + g_1^2\Big) v_d \sum_{a=1}^{2} Z^{E,*}_{j1+a} Z^{E}_{k1+a} - 2\Big(-2g_p^2 Q_{e_9} Q_{H_d} + g_1^2\Big) v_d \sum_{a=1}^{2} Z^{E,*}_{j4+a} Z^{E}_{k4+a} \\
&+ 2\sqrt{2}\sum_{b=1}^{2} Z^{E,*}_{j1+b}\sum_{a=1}^{2} Z^{E}_{k4+a} TY2_{ab} + 2\sqrt{2}\sum_{b=1}^{2}\sum_{a=1}^{2} Z^{E,*}_{j4+a} TY2^{*}_{ab} Z^{E}_{k1+b} \\
&+ 4v_d\sum_{c=1}^{2} Z^{E,*}_{j4+c}\sum_{b=1}^{2}\sum_{a=1}^{2} Y2^{*}_{ca} Y2_{ba} Z^{E}_{k4+b} + 4v_d\sum_{c=1}^{2}\sum_{b=1}^{2} Z^{E,*}_{j1+b}\sum_{a=1}^{2} Y2^{*}_{ac} Y2_{ab} Z^{E}_{k1+c} \\
&+ g_1^2 v_d Z^{E,*}_{j1} Z^{E}_{k1} - g_2^2 v_d Z^{E,*}_{j1} Z^{E}_{k1} + 4g_p^2 Q_{H_d} Q_{l_4} v_d Z^{E,*}_{j1} Z^{E}_{k1} \\
&+ 4v_d |Y1|^2 Z^{E,*}_{j1} Z^{E}_{k1} + 2\sqrt{2} TY1^{*} Z^{E,*}_{j4} Z^{E}_{k1} - 2g_1^2 v_d Z^{E,*}_{j4} Z^{E}_{k4} \\
&+ 4g_p^2 Q_{e_4} Q_{H_d} v_d Z^{E,*}_{j4} Z^{E}_{k4} + 4v_d |Y1|^2 Z^{E,*}_{j4} Z^{E}_{k4} + 2\sqrt{2} Z^{E,*}_{j1} TY1 Z^{E}_{k4}\Big)\Big)
\end{aligned}
\tag{239}
$$

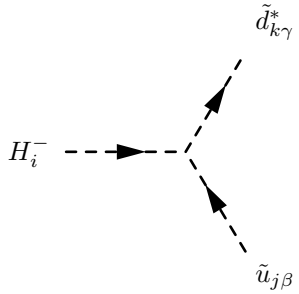


$$
\begin{aligned}
&\frac{i}{12}\delta_{\beta\gamma}\Big(6Z^{H,*}_{i3}\Big(-2g_p^2 Q_q Q_s v_S\sum_{a=1}^{3} Z^{U,*}_{ja} Z^{U}_{ka} - 2g_p^2 Q_s Q_u v_S\sum_{a=1}^{3} Z^{U,*}_{j3+a} Z^{U}_{k3+a} \\
&+ v_d\lambda\Big(\sum_{b=1}^{3} Z^{U,*}_{jb}\sum_{a=1}^{3} Y_{u,ab} Z^{U}_{k3+a} + \sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{u,ab} Z^{U,*}_{j3+a} Z^{U}_{kb}\Big)\Big) \\
&+ Z^{H,*}_{i1}\Big(\Big(-3\Big(4g_p^2 Q_{H_d} Q_q + g_2^2\Big) + g_1^2\Big) v_d\sum_{a=1}^{3} Z^{U,*}_{ja} Z^{U}_{ka} - 4\Big(3g_p^2 Q_{H_d} Q_u + g_1^2\Big) v_d\sum_{a=1}^{3} Z^{U,*}_{j3+a} Z^{U}_{k3+a} \\
&+ 6v_S\lambda\Big(\sum_{b=1}^{3} Z^{U,*}_{jb}\sum_{a=1}^{3} Y_{u,ab} Z^{U}_{k3+a} + \sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{u,ab} Z^{U,*}_{j3+a} Z^{U}_{kb}\Big)\Big)
\end{aligned}
$$

$$
\begin{aligned}
&- Z_{i2}^{H,*}\Big(\Big(12g_p^2Q_{H_u}Q_q - 3g_2^2 + g_1^2\Big)v_u\sum_{a=1}^{3}Z_{ja}^{U,*}Z_{ka}^{U} - 4\Big(-3g_p^2Q_{H_u}Q_u + g_1^2\Big)v_u\sum_{a=1}^{3}Z_{j3+a}^{U,*}Z_{k3+a}^{U}\\
&+ 6\Big(\sqrt{2}\sum_{b=1}^{3}Z_{jb}^{U,*}\sum_{a=1}^{3}Z_{k3+a}^{U}T_{u,ab} + \sqrt{2}\sum_{b=1}^{3}\sum_{a=1}^{3}Z_{j3+a}^{U,*}T_{u,ab}^{*}Z_{kb}^{U}\\
&+ 2v_u\Big(\sum_{c=1}^{3}Z_{j3+c}^{U,*}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{u,ca}^{*}Y_{u,ba}Z_{k3+b}^{U} + \sum_{c=1}^{3}\sum_{b=1}^{3}Z_{jb}^{U,*}\sum_{a=1}^{3}Y_{u,ac}^{*}Y_{u,ab}Z_{kc}^{U}\Big)\Big)\Big)\Big)
\end{aligned}
\tag{240}
$$

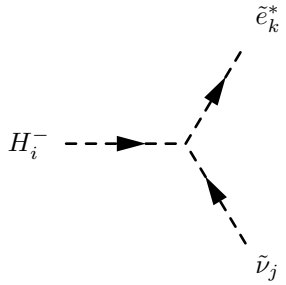


$$
\begin{aligned}
&- \frac{i}{4}\Big(4g_p^2Q_sv_SZ_{i3}^{H,*}\Big(Q_{l_4}Z_{j1}^{V,*}Z_{k1}^{V} + Q_{l_9}\sum_{a=1}^{2}Z_{j1+a}^{V,*}Z_{k1+a}^{V}\Big)\\
&+ v_dZ_{i1}^{H,*}\Big(\Big(4g_p^2Q_{H_d}Q_{l_4} + g_1^2 + g_2^2\Big)Z_{j1}^{V,*}Z_{k1}^{V} + \Big(4g_p^2Q_{H_d}Q_{l_9} + g_1^2 + g_2^2\Big)\sum_{a=1}^{2}Z_{j1+a}^{V,*}Z_{k1+a}^{V}\Big)\\
&- v_uZ_{i2}^{H,*}\Big(\Big(-4g_p^2Q_{H_u}Q_{l_4} + g_1^2 + g_2^2\Big)Z_{j1}^{V,*}Z_{k1}^{V} + \Big(-4g_p^2Q_{H_u}Q_{l_9} + g_1^2 + g_2^2\Big)\sum_{a=1}^{2}Z_{j1+a}^{V,*}Z_{k1+a}^{V}\Big)\Big)
\end{aligned}
\tag{241}
$$

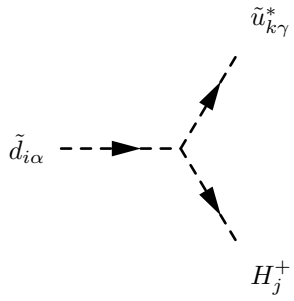


$$
- \frac{i}{4}\delta_{\beta\gamma}\Big(\sqrt{2}g_2^2\sum_{a=1}^{3}Z_{ja}^{U,*}Z_{ka}^{D}\Big(v_dZ_{i1}^{+} + v_uZ_{i2}^{+}\Big)
$$

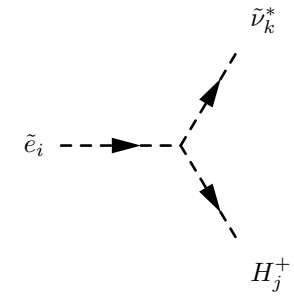
$$
\begin{aligned}
&- 2\Big(2\sum_{b=1}^{3} Z_{jb}^{U,*}\sum_{a=1}^{3} Z_{k3+a}^{D} T_{d,ab} Z_{i1}^{+} + \sqrt{2}v_S\lambda\sum_{b=1}^{3}\sum_{a=1}^{3} Y_{u,ab}^{*} Z_{j3+a}^{U,*} Z_{kb}^{D} Z_{i1}^{+} \\
&+ \sqrt{2}v_u\sum_{c=1}^{3} Z_{j3+c}^{U,*}\sum_{b=1}^{3}\sum_{a=1}^{3} Y_{u,ca}^{*} Y_{d,ba} Z_{k3+b}^{D} Z_{i1}^{+} \\
&+ \sqrt{2}v_d\sum_{c=1}^{3}\sum_{b=1}^{3} Z_{jb}^{U,*}\sum_{a=1}^{3} Y_{d,ac}^{*} Y_{d,ab} Z_{kc}^{D} Z_{i1}^{+} + 2\sum_{b=1}^{3} Z_{jb}^{U,*}\sum_{a=1}^{3} T_{d,ab}^{\prime} Z_{k3+a}^{D} Z_{i2}^{+} \\
&+ \sqrt{2}v_S\lambda\sum_{b=1}^{3} Z_{jb}^{U,*}\sum_{a=1}^{3} Y_{d,ab} Z_{k3+a}^{D} Z_{i2}^{+} + 2\sum_{b=1}^{3}\sum_{a=1}^{3} Z_{j3+a}^{U,*} T_{u,ab}^{*} Z_{kb}^{D} Z_{i2}^{+} \\
&+ \sqrt{2}v_d\sum_{c=1}^{3} Z_{j3+c}^{U,*}\sum_{b=1}^{3}\sum_{a=1}^{3} Y_{u,ca}^{*} Y_{d,ba} Z_{k3+b}^{D} Z_{i2}^{+} \\
&+ \sqrt{2}v_u\sum_{c=1}^{3}\sum_{b=1}^{3} Z_{jb}^{U,*}\sum_{a=1}^{3} Y_{u,ac}^{*} Y_{u,ab} Z_{kc}^{D} Z_{i2}^{+}\Big)\Big)
\end{aligned}
\tag{242}
$$



$$
\begin{aligned}
&- \frac{i}{4}\Big(-4\sum_{b=1}^{2} Z_{j1+b}^{V,*}\sum_{a=1}^{2} Z_{k4+a}^{E} TY2_{ab} Z_{i1}^{+} - 2\sqrt{2}v_d\sum_{c=1}^{2}\sum_{b=1}^{2} Z_{j1+b}^{V,*}\sum_{a=1}^{2} Y2_{ac}^{*} Y2_{ab} Z_{k1+c}^{E} Z_{i1}^{+} \\
&+ \sqrt{2}g_2^2 v_d Z_{j1}^{V,*} Z_{k1}^{E} Z_{i1}^{+} - 2\sqrt{2}v_d|Y1|^2 Z_{j1}^{V,*} Z_{k1}^{E} Z_{i1}^{+} - 4Z_{j1}^{V,*} TY1 Z_{k4}^{E} Z_{i1}^{+} \\
&- 4\sum_{b=1}^{2} Z_{j1+b}^{V,*}\sum_{a=1}^{2} T_{e,ab}^{\prime} Z_{k4+a}^{E} Z_{i2}^{+} - 2\sqrt{2}v_S\lambda\sum_{b=1}^{2} Z_{j1+b}^{V,*}\sum_{a=1}^{2} Y2_{ab} Z_{k4+a}^{E} Z_{i2}^{+} \\
&+ \sqrt{2}g_2^2 v_u Z_{j1}^{V,*} Z_{k1}^{E} Z_{i2}^{+} - 2\sqrt{2}v_S Y1\lambda Z_{j1}^{V,*} Z_{k4}^{E} Z_{i2}^{+} \\
&+ \sqrt{2}g_2^2\sum_{a=1}^{2} Z_{j1+a}^{V,*} Z_{k1+a}^{E}\Big(v_d Z_{i1}^{+} + v_u Z_{i2}^{+}\Big)\Big)
\end{aligned}
\tag{243}
$$



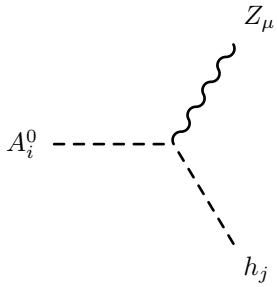
$$
\begin{aligned}
&-\frac{i}{4}\delta_{\alpha\gamma}\Big(\sqrt{2}g_2^2\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{U}_{ka}\Big(v_dZ^+_{j1}+v_uZ^+_{j2}\Big)\\
&-2\Big(\sqrt{2}v_S\lambda\sum_{b=1}^{3}Z^{D,*}_{ib}\sum_{a=1}^{3}Y_{u,ab}Z^U_{k3+a}Z^+_{j1}+2\sum_{b=1}^{3}\sum_{a=1}^{3}Z^{D,*}_{i3+a}T^*_{d,ab}Z^U_{kb}Z^+_{j1}\\
&+\sqrt{2}v_u\sum_{c=1}^{3}Z^{D,*}_{i3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{d,ca}Y_{u,ba}Z^U_{k3+b}Z^+_{j1}\\
&+\sqrt{2}v_d\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{D,*}_{ib}\sum_{a=1}^{3}Y^*_{d,ac}Y_{d,ab}Z^U_{kc}Z^+_{j1}+2\sum_{b=1}^{3}Z^{D,*}_{ib}\sum_{a=1}^{3}Z^U_{k3+a}T_{u,ab}Z^+_{j2}\\
&+2\sum_{b=1}^{3}\sum_{a=1}^{3}T'^{,*}_{d,ab}Z^{D,*}_{i3+a}Z^U_{kb}Z^+_{j2}+\sqrt{2}v_S\lambda\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{d,ab}Z^{D,*}_{i3+a}Z^U_{kb}Z^+_{j2}\\
&+\sqrt{2}v_d\sum_{c=1}^{3}Z^{D,*}_{i3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{d,ca}Y_{u,ba}Z^U_{k3+b}Z^+_{j2}\\
&+\sqrt{2}v_u\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{D,*}_{ib}\sum_{a=1}^{3}Y^*_{u,ac}Y_{u,ab}Z^U_{kc}Z^+_{j2}\Big)\Big)
\end{aligned}
\tag{244}
$$



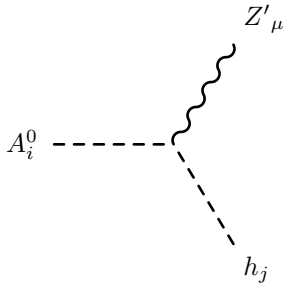
$$
-\frac{i}{4}\Big(-4\sum_{b=1}^{2}\sum_{a=1}^{2}Z^{E,*}_{i4+a}TY2^*_{ab}Z^V_{k1+b}Z^+_{j1}-2\sqrt{2}v_d\sum_{c=1}^{2}\sum_{b=1}^{2}Z^{E,*}_{i1+b}\sum_{a=1}^{2}Y2^*_{ac}Y2_{ab}Z^V_{k1+c}Z^+_{j1}
$$

$$
\begin{aligned}
&- 4\sum_{b=1}^{2}\sum_{a=1}^{2} T'^{,*}_{e,ab} Z^{E,*}_{i4+a} Z^{V}_{k1+b} Z^{+}_{j2} - 2\sqrt{2} v_S \lambda \sum_{b=1}^{2}\sum_{a=1}^{2} Y2^{*}_{ab} Z^{E,*}_{i4+a} Z^{V}_{k1+b} Z^{+}_{j2} \\
&+ \sqrt{2} g_2^2 \sum_{a=1}^{2} Z^{E,*}_{i1+a} Z^{V}_{k1+a} \Big(v_d Z^{+}_{j1} + v_u Z^{+}_{j2} \Big) + \sqrt{2} g_2^2 v_d Z^{E,*}_{i1} Z^{+}_{j1} Z^{V}_{k1} \\
&- 2\sqrt{2} v_d |Y1|^2 Z^{E,*}_{i1} Z^{+}_{j1} Z^{V}_{k1} - 4 T Y1^{*} Z^{E,*}_{i4} Z^{+}_{j1} Z^{V}_{k1} + \sqrt{2} g_2^2 v_u Z^{E,*}_{i1} Z^{+}_{j2} Z^{V}_{k1} \\
&- 2\sqrt{2} v_S \lambda Y1^{*} Z^{E,*}_{i4} Z^{+}_{j2} Z^{V}_{k1} \Big)
\end{aligned} \tag{245}
$$

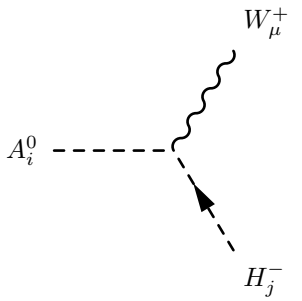
9.2 Two Scalar-One Vector Boson-Interaction



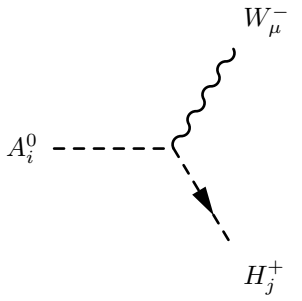
$$
\begin{aligned}
&\frac{1}{2}\Big(2 g_p Q_s Z^{A,*}_{i3} Z^{H,*}_{j3} \sin\Theta'_W \\
&+ Z^{A,*}_{i1} Z^{H,*}_{j1} \Big(2 g_p Q_{H_d} \sin\Theta'_W + g_1 \cos\Theta'_W \sin\Theta_W + g_2 \cos\Theta_W \cos\Theta'_W \Big) \\
&- Z^{A,*}_{i2} Z^{H,*}_{j2} \Big(- 2 g_p Q_{H_u} \sin\Theta'_W + g_1 \cos\Theta'_W \sin\Theta_W + g_2 \cos\Theta_W \cos\Theta'_W \Big) \Big) \Big(- p_\mu^{h_j} + p_\mu^{A_i^0} \Big)
\end{aligned} \tag{246}
$$



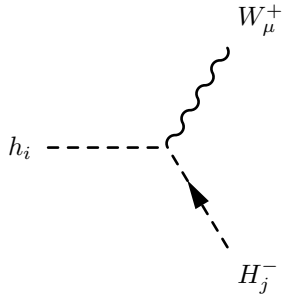
$$
\begin{aligned}
&\frac{1}{2}\Big(2 g_p Q_s Z^{A,*}_{i3} Z^{H,*}_{j3} \cos\Theta'_W \\
&+ Z^{A,*}_{i2} Z^{H,*}_{j2} \Big(2 g_p Q_{H_u} \cos\Theta'_W + g_1 \sin\Theta_W \sin\Theta'_W + g_2 \cos\Theta_W \sin\Theta'_W \Big) \\
&+ Z^{A,*}_{i1} Z^{H,*}_{j1} \Big(2 g_p Q_{H_d} \cos\Theta'_W - \Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) \sin\Theta'_W \Big) \Big) \Big(- p_\mu^{h_j} + p_\mu^{A_i^0} \Big)
\end{aligned} \tag{247}
$$



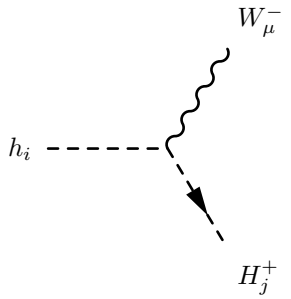
$$\frac{1}{2}g_2\Big(Z_{i1}^{A,*}Z_{j1}^{+} + Z_{i2}^{A,*}Z_{j2}^{+}\Big)\Big(-p_\mu^{H_j^-} + p_\mu^{A_i^0}\Big) \tag{248}$$



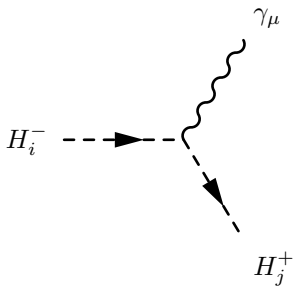
$$\frac{1}{2}g_2\Big(Z_{i1}^{A,*}Z_{j1}^{+} + Z_{i2}^{A,*}Z_{j2}^{+}\Big)\Big(-p_\mu^{H_j^+} + p_\mu^{A_i^0}\Big) \tag{249}$$



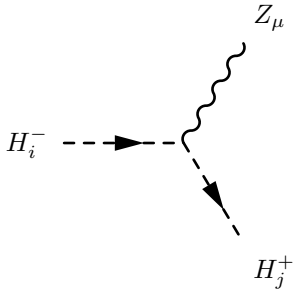
$$\frac{i}{2}g_2\Big(Z_{i1}^{H,*}Z_{j1}^{+} - Z_{i2}^{H,*}Z_{j2}^{+}\Big)\Big(-p_\mu^{H_j^-} + p_\mu^{h_i}\Big) \tag{250}$$



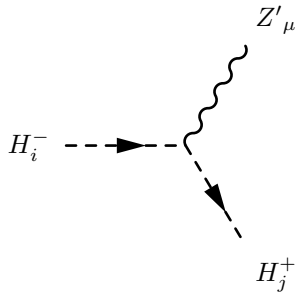
$$-\frac{i}{2}g_2\Big(Z_{i1}^{H,*}Z_{j1}^{+}-Z_{i2}^{H,*}Z_{j2}^{+}\Big)\Big(-p_\mu^{H_j^+}+p_\mu^{h_i}\Big) \tag{251}$$



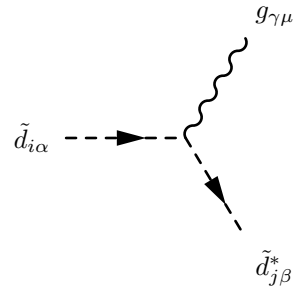
$$\frac{i}{2}\Big(g_1\cos\Theta_W+g_2\sin\Theta_W\Big)\Big(Z_{i1}^{+}Z_{j1}^{+}+Z_{i2}^{+}Z_{j2}^{+}\Big)\Big(-p_\mu^{H_j^+}+p_\mu^{H_i^-}\Big) \tag{252}$$



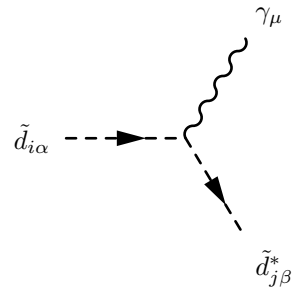
$$\begin{aligned}&\frac{i}{2}\Big(\Big(-2g_pQ_{H_d}\sin\Theta'_W-g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)Z_{i1}^{+}Z_{j1}^{+}\\&+\Big(2g_pQ_{H_u}\sin\Theta'_W-g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)Z_{i2}^{+}Z_{j2}^{+}\Big)\Big(-p_\mu^{H_j^+}+p_\mu^{H_i^-}\Big)\end{aligned} \tag{253}$$



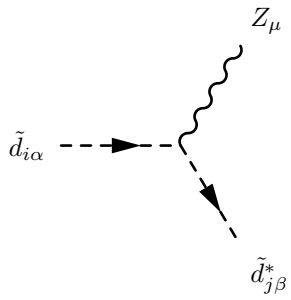
$$-\frac{i}{2}\Big(\Big(2g_pQ_{H_d}\cos\Theta'_W+\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)Z^+_{i1}Z^+_{j1}$$
$$+\Big(-2g_pQ_{H_u}\cos\Theta'_W+\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)Z^+_{i2}Z^+_{j2}\Big)\Big(-p_\mu^{H_j^+}+p_\mu^{H_i^-}\Big) \tag{254}$$



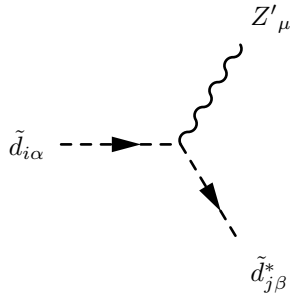
$$-\frac{i}{2}g_3\delta_{ij}\lambda^\gamma_{\beta,\alpha}\Big(-p_\mu^{\tilde{d}^*_{j\beta}}+p_\mu^{\tilde{d}_{i\alpha}}\Big) \tag{255}$$



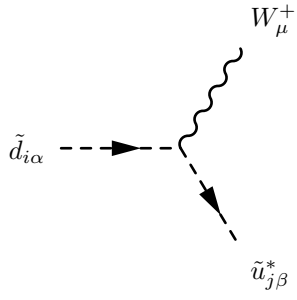
$$-\frac{i}{6}\delta_{\alpha\beta}\Big(-2g_1\cos\Theta_W\sum_{a=1}^{3}Z^{D,*}_{i3+a}Z^D_{j3+a}+\Big(-3g_2\sin\Theta_W+g_1\cos\Theta_W\Big)\sum_{a=1}^{3}Z^{D,*}_{ia}Z^D_{ja}\Big)\Big(-p_\mu^{\tilde{d}^*_{j\beta}}+p_\mu^{\tilde{d}_{i\alpha}}\Big) \tag{256}$$



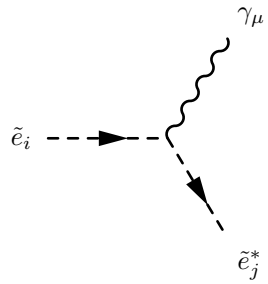
$$\frac{i}{6}\delta_{\alpha\beta}\Big(\Big(3g_2\cos\Theta_W\cos\Theta'_W - 6g_pQ_q\sin\Theta'_W + g_1\cos\Theta'_W\sin\Theta_W\Big)\sum_{a=1}^{3} Z^{D,*}_{ia}Z^{D}_{ja}$$
$$- 2\Big(-3g_pQ_d\sin\Theta'_W + g_1\cos\Theta'_W\sin\Theta_W\Big)\sum_{a=1}^{3} Z^{D,*}_{i3+a}Z^{D}_{j3+a}\Big)\Big(-p_\mu^{\tilde{d}^*_{j\beta}} + p_\mu^{\tilde{d}_{i\alpha}}\Big) \tag{257}$$



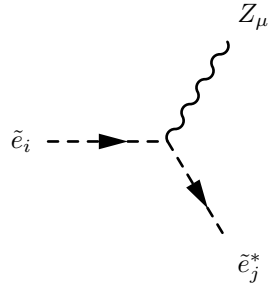
$$-\frac{i}{6}\delta_{\alpha\beta}\Big(\Big(\Big(3g_2\cos\Theta_W + g_1\sin\Theta_W\Big)\sin\Theta'_W + 6g_pQ_q\cos\Theta'_W\Big)\sum_{a=1}^{3} Z^{D,*}_{ia}Z^{D}_{ja}$$
$$- 2\Big(3g_pQ_d\cos\Theta'_W + g_1\sin\Theta_W\sin\Theta'_W\Big)\sum_{a=1}^{3} Z^{D,*}_{i3+a}Z^{D}_{j3+a}\Big)\Big(-p_\mu^{\tilde{d}^*_{j\beta}} + p_\mu^{\tilde{d}_{i\alpha}}\Big) \tag{258}$$



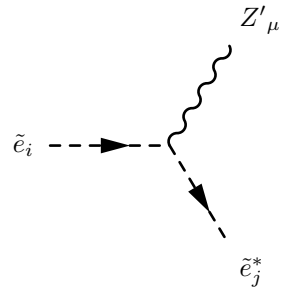
$$- i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^{3} Z^{D,*}_{ia} Z^{U}_{ja}\Big(- p_\mu^{\tilde{u}^*_{j\beta}} + p_\mu^{\tilde{d}_{i\alpha}}\Big) \tag{259}$$



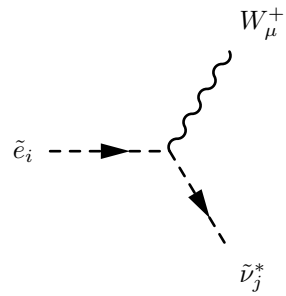
$$\begin{aligned}&\frac{i}{2}\Big(\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)\sum_{a=1}^{2} Z^{E,*}_{i1+a}Z^{E}_{j1+a} + 2g_1\cos\Theta_W\sum_{a=1}^{2} Z^{E,*}_{i4+a}Z^{E}_{j4+a}\\&+ g_1 Z^{E,*}_{i1}\cos\Theta_W Z^{E}_{j1} + g_2 Z^{E,*}_{i1}\sin\Theta_W Z^{E}_{j1} + 2g_1 Z^{E,*}_{i4}\cos\Theta_W Z^{E}_{j4}\Big)\Big(- p_\mu^{\tilde{e}^*_j} + p_\mu^{\tilde{e}_i}\Big)\end{aligned} \tag{260}$$



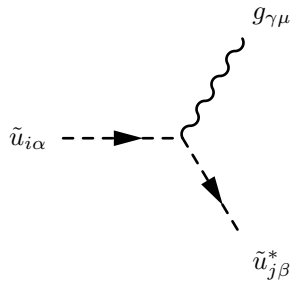
$$\begin{aligned}&\frac{i}{2}\Big(\Big(- 2g_pQ_{l_9}\sin\Theta'_W - g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W\Big)\sum_{a=1}^{2} Z^{E,*}_{i1+a}Z^{E}_{j1+a}\\&+ \Big(- 2g_1\cos\Theta'_W\sin\Theta_W + 2g_pQ_{e_9}\sin\Theta'_W\Big)\sum_{a=1}^{2} Z^{E,*}_{i4+a}Z^{E}_{j4+a}\\&+ g_2 Z^{E,*}_{i1}\cos\Theta_W\cos\Theta'_W Z^{E}_{j1} - g_1 Z^{E,*}_{i1}\cos\Theta'_W\sin\Theta_W Z^{E}_{j1}\\&- 2g_pQ_{l_4}Z^{E,*}_{i1}\sin\Theta'_W Z^{E}_{j1} - 2g_1 Z^{E,*}_{i4}\cos\Theta'_W\sin\Theta_W Z^{E}_{j4}\\&+ 2g_pQ_{e_4}Z^{E,*}_{i4}\sin\Theta'_W Z^{E}_{j4}\Big)\Big(- p_\mu^{\tilde{e}^*_j} + p_\mu^{\tilde{e}_i}\Big)\end{aligned} \tag{261}$$



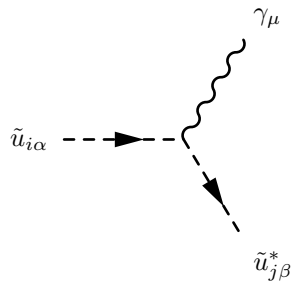
$$
\begin{aligned}
&-\frac{i}{2}\Big(\Big(2g_pQ_{l_9}\cos\Theta'_W+\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)\sum_{a=1}^{2}Z^{E,*}_{i1+a}Z^E_{j1+a}\\
&-2\Big(g_1\sin\Theta_W\sin\Theta'_W+g_pQ_{e_9}\cos\Theta'_W\Big)\sum_{a=1}^{2}Z^{E,*}_{i4+a}Z^E_{j4+a}+2g_pQ_{l_4}Z^{E,*}_{i1}\cos\Theta'_WZ^E_{j1}\\
&+g_2Z^{E,*}_{i1}\cos\Theta_W\sin\Theta'_WZ^E_{j1}-g_1Z^{E,*}_{i1}\sin\Theta_W\sin\Theta'_WZ^E_{j1}\\
&-2g_pQ_{e_4}Z^{E,*}_{i4}\cos\Theta'_WZ^E_{j4}-2g_1Z^{E,*}_{i4}\sin\Theta_W\sin\Theta'_WZ^E_{j4}\Big)\Big(-p_\mu^{\tilde{e}^*_j}+p_\mu^{\tilde{e}_i}\Big)
\end{aligned}
\tag{262}
$$



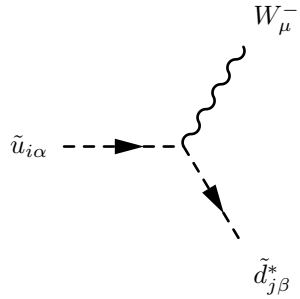
$$
-i\frac{1}{\sqrt{2}}g_2\Big(Z^{E,*}_{i1}Z^V_{j1}+\sum_{a=1}^{2}Z^{E,*}_{i1+a}Z^V_{j1+a}\Big)\Big(-p_\mu^{\tilde{\nu}^*_j}+p_\mu^{\tilde{e}_i}\Big)
\tag{263}
$$



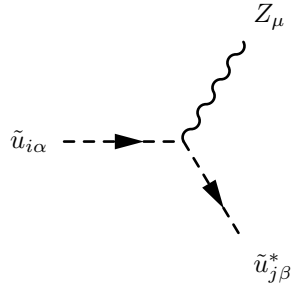
$$-\frac{i}{2}g_3\delta_{ij}\lambda^{\gamma}_{\beta,\alpha}\Big(-p_\mu^{\tilde{u}^*_{j\beta}}+p_\mu^{\tilde{u}_{i\alpha}}\Big) \tag{264}$$



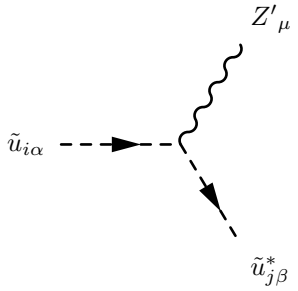
$$-\frac{i}{6}\delta_{\alpha\beta}\Big(\Big(3g_2\sin\Theta_W+g_1\cos\Theta_W\Big)\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{U}_{ja}+4g_1\cos\Theta_W\sum_{a=1}^{3}Z^{U,*}_{i3+a}Z^{U}_{j3+a}\Big)\Big(-p_\mu^{\tilde{u}^*_{j\beta}}+p_\mu^{\tilde{u}_{i\alpha}}\Big) \tag{265}$$



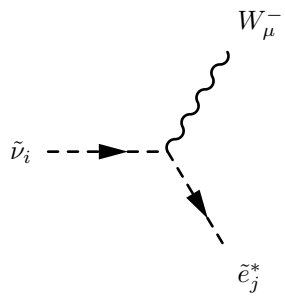
$$-i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{D}_{ja}\Big(-p_\mu^{\tilde{d}^*_{j\beta}}+p_\mu^{\tilde{u}_{i\alpha}}\Big) \tag{266}$$



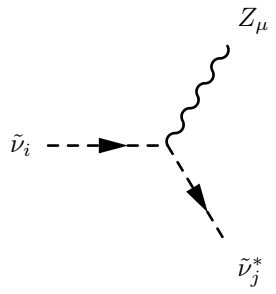
$$- \frac{i}{6}\delta_{\alpha\beta}\Big(\Big(3g_2\cos\Theta_W\cos\Theta'_W + 6g_pQ_q\sin\Theta'_W - g_1\cos\Theta'_W\sin\Theta_W\Big)\sum_{a=1}^{3} Z^{U,*}_{ia}Z^{U}_{ja}$$
$$- 2\Big(2g_1\cos\Theta'_W\sin\Theta_W + 3g_pQ_u\sin\Theta'_W\Big)\sum_{a=1}^{3} Z^{U,*}_{i3+a}Z^{U}_{j3+a}\Big)\Big(- p_\mu^{\tilde{u}^*_{j\beta}} + p_\mu^{\tilde{u}_{i\alpha}}\Big) \tag{267}$$



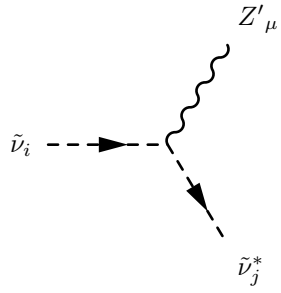
$$- \frac{i}{6}\delta_{\alpha\beta}\Big(\Big(\Big(- 3g_2\cos\Theta_W + g_1\sin\Theta_W\Big)\sin\Theta'_W + 6g_pQ_q\cos\Theta'_W\Big)\sum_{a=1}^{3} Z^{U,*}_{ia}Z^{U}_{ja}$$
$$+ 2\Big(2g_1\sin\Theta_W\sin\Theta'_W - 3g_pQ_u\cos\Theta'_W\Big)\sum_{a=1}^{3} Z^{U,*}_{i3+a}Z^{U}_{j3+a}\Big)\Big(- p_\mu^{\tilde{u}^*_{j\beta}} + p_\mu^{\tilde{u}_{i\alpha}}\Big) \tag{268}$$



$$- i\frac{1}{\sqrt{2}}g_2\Big(Z^{V,*}_{i1}Z^{E}_{j1} + \sum_{a=1}^{2} Z^{V,*}_{i1+a}Z^{E}_{j1+a}\Big)\Big(- p_\mu^{\tilde{e}^*_j} + p_\mu^{\tilde{\nu}_i}\Big) \tag{269}$$

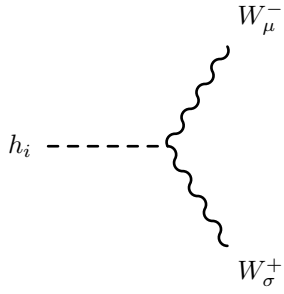


$$
\begin{aligned}
&-\frac{i}{2}\Big(\Big(2g_pQ_{l_9}\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)\sum_{a=1}^{2}Z^{V,*}_{i1+a}Z^{V}_{j1+a}\\
&+Z^{V,*}_{i1}\Big(2g_pQ_{l_4}\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)Z^{V}_{j1}\Big)\Big(-p_\mu^{\tilde{\nu}_j^*}+p_\mu^{\tilde{\nu}_i}\Big)
\end{aligned}
\tag{270}
$$

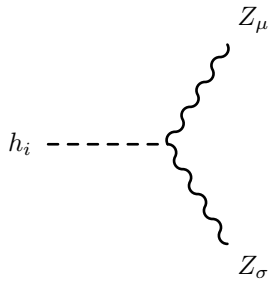


$$
\begin{aligned}
&-\frac{i}{2}\Big(\Big(2g_pQ_{l_9}\cos\Theta'_W-\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)\sum_{a=1}^{2}Z^{V,*}_{i1+a}Z^{V}_{j1+a}\\
&+Z^{V,*}_{i1}\Big(2g_pQ_{l_4}\cos\Theta'_W-\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)Z^{V}_{j1}\Big)\Big(-p_\mu^{\tilde{\nu}_j^*}+p_\mu^{\tilde{\nu}_i}\Big)
\end{aligned}
\tag{271}
$$

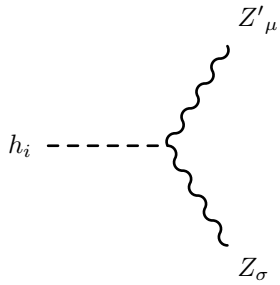
9.3 One Scalar-Two Vector Boson-Interaction



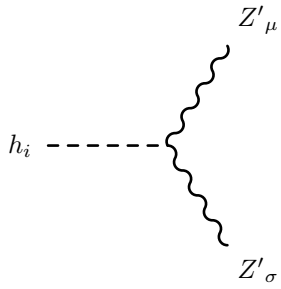
$$\frac{i}{2}g_2^2\Big(v_d Z_{i1}^{H,*} + v_u Z_{i2}^{H,*}\Big)\Big(g_{\sigma\mu}\Big) \tag{272}$$



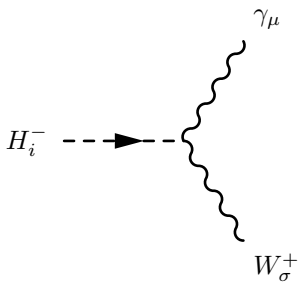
$$\begin{aligned}
&\frac{i}{2}\Big(4g_p^2Q_s^2v_S Z_{i3}^{H,*}\sin\Theta_W^{\prime,2} \\
&+ v_d Z_{i1}^{H,*}\Big(2g_pQ_{H_d}\sin\Theta_W' + g_1\cos\Theta_W'\sin\Theta_W + g_2\cos\Theta_W\cos\Theta_W'\Big)^2 \\
&+ v_u Z_{i2}^{H,*}\Big(-2g_pQ_{H_u}\sin\Theta_W' + g_1\cos\Theta_W'\sin\Theta_W + g_2\cos\Theta_W\cos\Theta_W'\Big)^2\Big)\Big(g_{\sigma\mu}\Big)
\end{aligned} \tag{273}$$



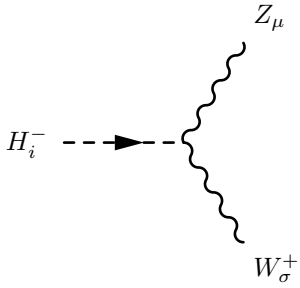
$$\begin{aligned}
&-\frac{i}{2}\Big(-4g_p^2Q_s^2v_S Z_{i3}^{H,*}\cos\Theta_W'\sin\Theta_W' \\
&+ v_d Z_{i1}^{H,*}\Big(-2g_1g_pQ_{H_d}\cos\Theta_W^{\prime,2}\sin\Theta_W + g_2^2\cos\Theta_W^2\cos\Theta_W'\sin\Theta_W' \\
&+ \cos\Theta_W'\Big(-4g_p^2Q_{H_d}^2 + g_1^2\sin\Theta_W^2\Big)\sin\Theta_W' + 2g_1g_pQ_{H_d}\sin\Theta_W\sin\Theta_W^{\prime,2} \\
&+ 2g_2\cos\Theta_W\Big(g_1\cos\Theta_W'\sin\Theta_W\sin\Theta_W' - g_pQ_{H_d}\cos\Theta_W^{\prime,2} + g_pQ_{H_d}\sin\Theta_W^{\prime,2}\Big)\Big) \\
&+ v_u Z_{i2}^{H,*}\Big(2g_1g_pQ_{H_u}\cos\Theta_W^{\prime,2}\sin\Theta_W + g_2^2\cos\Theta_W^2\cos\Theta_W'\sin\Theta_W' \\
&+ \cos\Theta_W'\Big(-4g_p^2Q_{H_u}^2 + g_1^2\sin\Theta_W^2\Big)\sin\Theta_W' - 2g_1g_pQ_{H_u}\sin\Theta_W\sin\Theta_W^{\prime,2} \\
&+ 2g_2\cos\Theta_W\Big(g_1\cos\Theta_W'\sin\Theta_W\sin\Theta_W' + g_pQ_{H_u}\cos\Theta_W^{\prime,2} - g_pQ_{H_u}\sin\Theta_W^{\prime,2}\Big)\Big)\Big)\Big(g_{\sigma\mu}\Big)
\end{aligned} \tag{274}$$



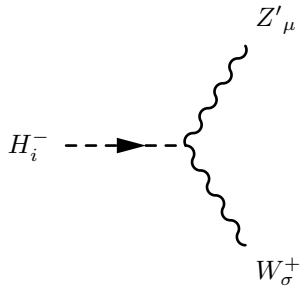
$$\frac{i}{2}\Big(4g_p^2Q_s^2v_S Z_{i3}^{H,*}\cos\Theta_W'^{,2}$$
$$+ v_d Z_{i1}^{H,*}\Big(-2g_pQ_{H_d}\cos\Theta_W' + \Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta_W'\Big)^2$$
$$+ v_u Z_{i2}^{H,*}\Big(2g_pQ_{H_u}\cos\Theta_W' + \Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta_W'\Big)^2\Big)\Big(g_{\sigma\mu}\Big) \tag{275}$$



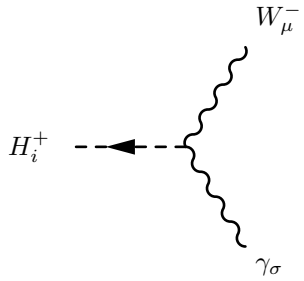
$$-\frac{i}{2}g_1g_2\cos\Theta_W\Big(v_dZ_{i1}^+ - v_uZ_{i2}^+\Big)\Big(g_{\sigma\mu}\Big) \tag{276}$$



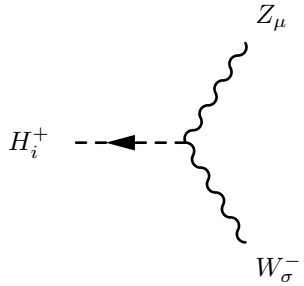
$$\frac{i}{2}g_2\Big(v_d\Big(2g_pQ_{H_d}\sin\Theta_W' + g_1\cos\Theta_W'\sin\Theta_W\Big)Z_{i1}^+$$
$$+ v_u\Big(2g_pQ_{H_u}\sin\Theta_W' - g_1\cos\Theta_W'\sin\Theta_W\Big)Z_{i2}^+\Big)\Big(g_{\sigma\mu}\Big) \tag{277}$$



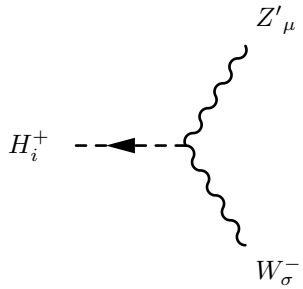
$$\frac{i}{2}g_2\Big(v_d\Big(2g_pQ_{H_d}\cos\Theta'_W - g_1\sin\Theta_W\sin\Theta'_W\Big)Z^+_{i1} + v_u\Big(2g_pQ_{H_u}\cos\Theta'_W + g_1\sin\Theta_W\sin\Theta'_W\Big)Z^+_{i2}\Big)\Big(g_{\sigma\mu}\Big) \tag{278}$$



$$-\frac{i}{2}g_1g_2\cos\Theta_W\Big(v_dZ^+_{i1} - v_uZ^+_{i2}\Big)\Big(g_{\sigma\mu}\Big) \tag{279}$$

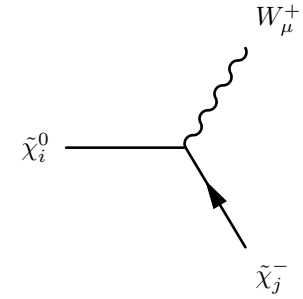


$$\frac{i}{2}g_2\Big(v_d\Big(2g_pQ_{H_d}\sin\Theta'_W + g_1\cos\Theta'_W\sin\Theta_W\Big)Z^+_{i1} + v_u\Big(2g_pQ_{H_u}\sin\Theta'_W - g_1\cos\Theta'_W\sin\Theta_W\Big)Z^+_{i2}\Big)\Big(g_{\sigma\mu}\Big) \tag{280}$$



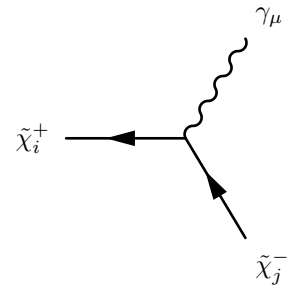
$$\frac{i}{2}g_2\Big(v_d\Big(2g_pQ_{H_d}\cos\Theta'_W - g_1\sin\Theta_W\sin\Theta'_W\Big)Z^+_{i1} + v_u\Big(2g_pQ_{H_u}\cos\Theta'_W + g_1\sin\Theta_W\sin\Theta'_W\Big)Z^+_{i2}\Big)\Big(g_{\sigma\mu}\Big) \tag{281}$$

9.4 Two Fermion-One Vector Boson-Interaction



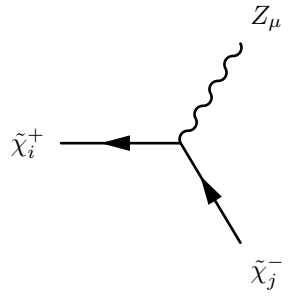
$$-\frac{i}{2}g_2\Big(2U^*_{j1}N_{i3} + \sqrt{2}U^*_{j2}N_{i4}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{282}$$

$$+\Big(i\frac{1}{\sqrt{2}}g_2N^*_{i5}V_{j2} - ig_2N^*_{i3}V_{j1}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{283}$$



$$\frac{i}{2}\Big(2g_2U^*_{j1}\sin\Theta_W U_{i1} + U^*_{j2}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)U_{i2}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{284}$$

$$+\ \frac{i}{2}\Big(2g_2V^*_{i1}\sin\Theta_W V_{j1} + V^*_{i2}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)V_{j2}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{285}$$

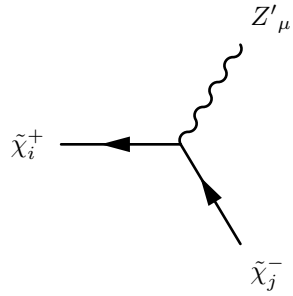


$$\frac{i}{2}\Big(2g_2U^*_{j1}\cos\Theta_W\cos\Theta'_W U_{i1}$$

$$+ U^*_{j2}\Big(-2g_pQ_{H_d}\sin\Theta'_W - g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W\Big)U_{i2}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{286}$$

$$+\ \frac{i}{2}\Big(2g_2V^*_{i1}\cos\Theta_W\cos\Theta'_W V_{j1}$$

$$+ V^*_{i2}\Big(2g_pQ_{H_u}\sin\Theta'_W - g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W\Big)V_{j2}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{287}$$

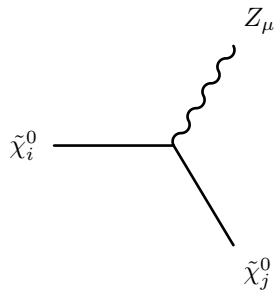


$$-\frac{i}{2}\Big(2g_2U^*_{j1}\cos\Theta_W\sin\Theta'_W U_{i1}$$

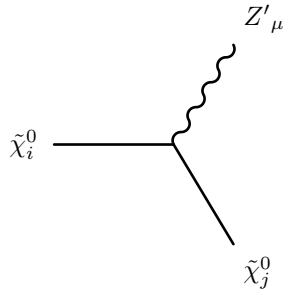
$$+ U^*_{j2}\Big(2g_pQ_{H_d}\cos\Theta'_W + \Big(-g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)U_{i2}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{288}$$

$$+\ -\frac{i}{2}\Big(2g_2V^*_{i1}\cos\Theta_W\sin\Theta'_W V_{j1}$$

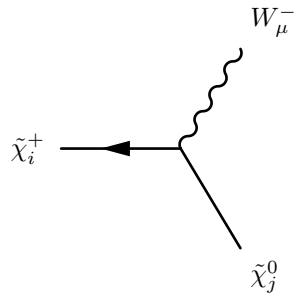
$$+ V^*_{i2}\Big(-2g_pQ_{H_u}\cos\Theta'_W + \Big(-g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)V_{j2}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{289}$$



$$
\begin{aligned}
&-\frac{i}{2}\Big(N_{j4}^*\Big(2g_pQ_{H_d}\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)N_{i4}\\
&-N_{j5}^*\Big(-2g_pQ_{H_u}\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)N_{i5}\\
&+2g_pQ_sN_{j6}^*\sin\Theta'_WN_{i6}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \qquad (290)\\
&+\frac{i}{2}\Big(N_{i4}^*\Big(2g_pQ_{H_d}\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)N_{j4}\\
&-N_{i5}^*\Big(-2g_pQ_{H_u}\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)N_{j5}\\
&+2g_pQ_sN_{i6}^*\sin\Theta'_WN_{j6}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \qquad (291)
\end{aligned}
$$

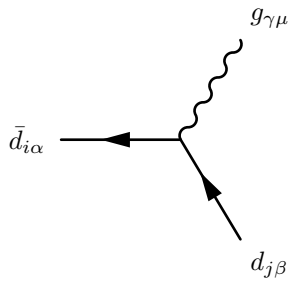


$$
\begin{aligned}
&-\frac{i}{2}\Big(N_{j4}^*\Big(2g_pQ_{H_d}\cos\Theta'_W-\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)N_{i4}\\
&+N_{j5}^*\Big(2g_pQ_{H_u}\cos\Theta'_W+g_1\sin\Theta_W\sin\Theta'_W+g_2\cos\Theta_W\sin\Theta'_W\Big)N_{i5}\\
&+2g_pQ_sN_{j6}^*\cos\Theta'_WN_{i6}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \qquad (292)\\
&+\frac{i}{2}\Big(N_{i4}^*\Big(2g_pQ_{H_d}\cos\Theta'_W-\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)N_{j4}\\
&+N_{i5}^*\Big(2g_pQ_{H_u}\cos\Theta'_W+g_1\sin\Theta_W\sin\Theta'_W+g_2\cos\Theta_W\sin\Theta'_W\Big)N_{j5}\\
&+2g_pQ_sN_{i6}^*\cos\Theta'_WN_{j6}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \qquad (293)
\end{aligned}
$$



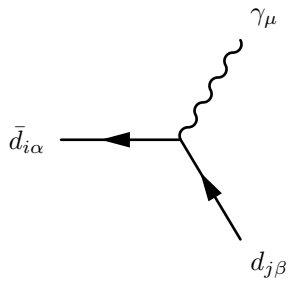
$$-\frac{i}{2}g_2\Big(2N_{j3}^*U_{i1}+\sqrt{2}N_{j4}^*U_{i2}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{294}$$

$$+\Big(i\frac{1}{\sqrt{2}}g_2V_{i2}^*N_{j5}-ig_2V_{i1}^*N_{j3}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{295}$$



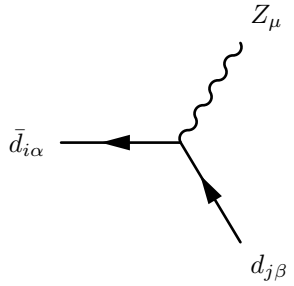
$$-\frac{i}{2}g_3\delta_{ij}\lambda^\gamma_{\alpha,\beta}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{296}$$

$$+\ -\frac{i}{2}g_3\delta_{ij}\lambda^\gamma_{\alpha,\beta}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{297}$$



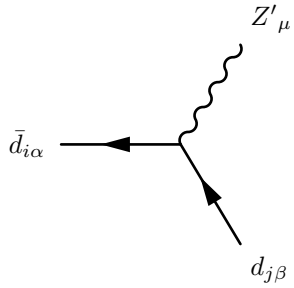
$$-\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\Big(-3g_2\sin\Theta_W+g_1\cos\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{298}$$

$$+\ \frac{i}{3}g_1\cos\Theta_W\delta_{\alpha\beta}\delta_{ij}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{299}$$



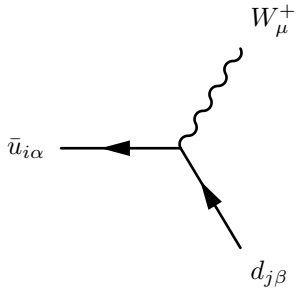
$$\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\Big(3g_2\cos\Theta_W\cos\Theta'_W-6g_pQ_q\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{300}$$

$$+\ -\frac{i}{3}\delta_{\alpha\beta}\delta_{ij}\Big(-3g_pQ_d\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{301}$$

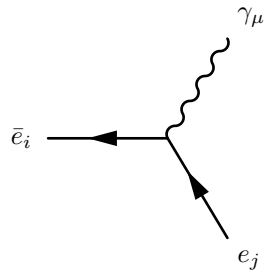


$$-\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(3g_2\cos\Theta_W+g_1\sin\Theta_W\Big)\sin\Theta'_W+6g_pQ_q\cos\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{302}$$

$$+\ \frac{i}{3}\delta_{\alpha\beta}\delta_{ij}\Big(3g_pQ_d\cos\Theta'_W+g_1\sin\Theta_W\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{303}$$

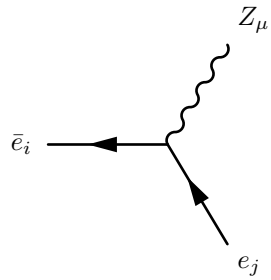


$$- i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^{3}U^{d,*}_{L,ja}U^{u}_{L,ia}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{304}$$



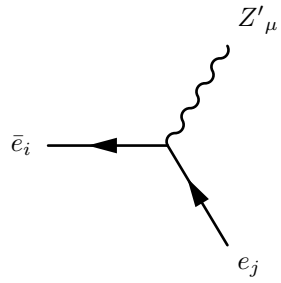
$$\frac{i}{2}\Big(g_1\cos\Theta_W+g_2\sin\Theta_W\Big)\Big(U^{e,*}_{L,j1}U^{e}_{L,i1}+\sum_{a=1}^{2}U^{e,*}_{L,j1+a}U^{e}_{L,i1+a}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{305}$$

$$+\ ig_1\cos\Theta_W\Big(U^{e,*}_{R,i1}U^{e}_{R,j1}+\sum_{a=1}^{2}U^{e,*}_{R,i1+a}U^{e}_{R,j1+a}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{306}$$

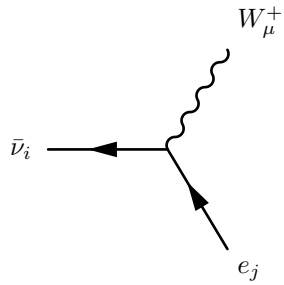


$$\begin{aligned}&\frac{i}{2}\Big(\Big(-2g_pQ_{l_9}\sin\Theta'_W-g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)\sum_{a=1}^{2}U^{e,*}_{L,j1+a}U^{e}_{L,i1+a}\\&+U^{e,*}_{L,j1}\Big(-2g_pQ_{l_4}\sin\Theta'_W-g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)U^{e}_{L,i1}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big)\end{aligned} \tag{307}$$

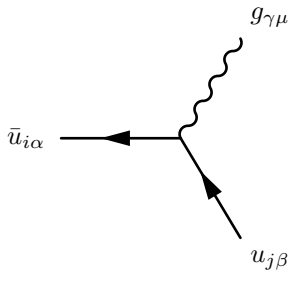
$$\begin{aligned}&+\ -i\Big(\Big(g_1\cos\Theta'_W\sin\Theta_W-g_pQ_{e_9}\sin\Theta'_W\Big)\sum_{a=1}^{2}U^{e,*}_{R,i1+a}U^{e}_{R,j1+a}\\&+U^{e,*}_{R,i1}\Big(g_1\cos\Theta'_W\sin\Theta_W-g_pQ_{e_4}\sin\Theta'_W\Big)U^{e}_{R,j1}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big)\end{aligned} \tag{308}$$



$$
\begin{aligned}
&-\frac{i}{2}\Big(\Big(2g_pQ_{l_9}\cos\Theta'_W+\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)\sum_{a=1}^{2}U^{e,*}_{L,j1+a}U^{e}_{L,i1+a}\\
&+U^{e,*}_{L,j1}\Big(2g_pQ_{l_4}\cos\Theta'_W+\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)U^{e}_{L,i1}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \qquad (309)\\
&+i\Big(\Big(g_1\sin\Theta_W\sin\Theta'_W+g_pQ_{e_9}\cos\Theta'_W\Big)\sum_{a=1}^{2}U^{e,*}_{R,i1+a}U^{e}_{R,j1+a}\\
&+U^{e,*}_{R,i1}\Big(g_1\sin\Theta_W\sin\Theta'_W+g_pQ_{e_4}\cos\Theta'_W\Big)U^{e}_{R,j1}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \qquad (310)
\end{aligned}
$$

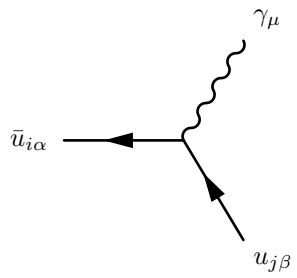


$$
-i\frac{1}{\sqrt{2}}g_2\Big(U^{e,*}_{L,j1}ZVL_{i1}+\sum_{a=1}^{2}U^{e,*}_{L,j1+a}ZVL_{i1+a}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \qquad (311)
$$



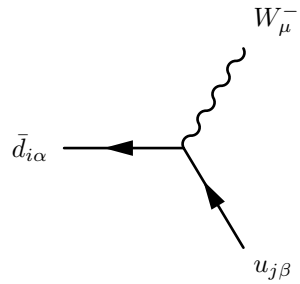
$$- \frac{i}{2} g_3 \delta_{ij} \lambda^{\gamma}_{\alpha,\beta} \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{312}$$

$$+ \; - \frac{i}{2} g_3 \delta_{ij} \lambda^{\gamma}_{\alpha,\beta} \Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2} \Big) \tag{313}$$

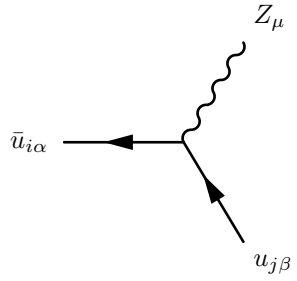


$$- \frac{i}{6} \delta_{\alpha\beta} \delta_{ij} \Big(3 g_2 \sin\Theta_W + g_1 \cos\Theta_W \Big) \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{314}$$

$$+ \; - \frac{2i}{3} g_1 \cos\Theta_W \delta_{\alpha\beta} \delta_{ij} \Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2} \Big) \tag{315}$$

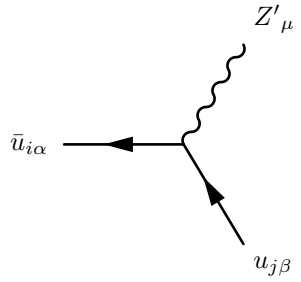


$$- i \frac{1}{\sqrt{2}} g_2 \delta_{\alpha\beta} \sum_{a=1}^{3} U^{u,*}_{L,ja} U^{d}_{L,ia} \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{316}$$



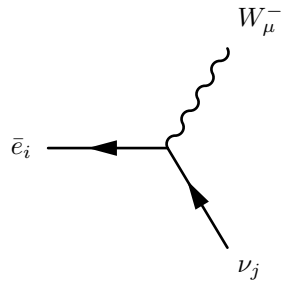
$$- \frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\Big(3g_2\cos\Theta_W\cos\Theta'_W + 6g_pQ_q\sin\Theta'_W - g_1\cos\Theta'_W\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{317}$$

$$+ \frac{i}{3}\delta_{\alpha\beta}\delta_{ij}\Big(2g_1\cos\Theta'_W\sin\Theta_W + 3g_pQ_u\sin\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{318}$$

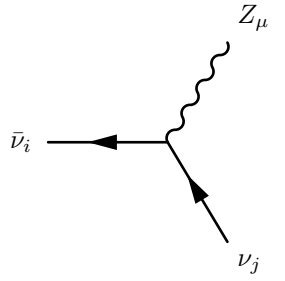


$$- \frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\Big(\Big(-3g_2\cos\Theta_W + g_1\sin\Theta_W\Big)\sin\Theta'_W + 6g_pQ_q\cos\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{319}$$

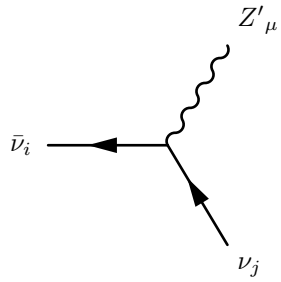
$$+ \frac{i}{3}\delta_{\alpha\beta}\delta_{ij}\Big(-2g_1\sin\Theta_W\sin\Theta'_W + 3g_pQ_u\cos\Theta'_W\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{320}$$



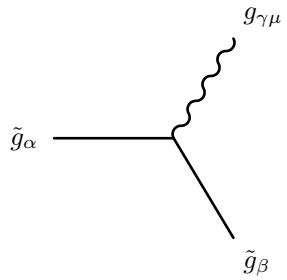
$$- i\frac{1}{\sqrt{2}}g_2\Big(ZVL^*_{j1}U^e_{L,i1} + \sum_{a=1}^{2} ZVL^*_{j1+a}U^e_{L,i1+a}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{321}$$



$$- \frac{i}{2}\Big(\Big(2g_pQ_{l_9}\sin\Theta'_W + g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W\Big)\sum_{a=1}^{2} ZVL^*_{j1+a}ZVL_{i1+a}$$
$$+ ZVL^*_{j1}\Big(2g_pQ_{l_4}\sin\Theta'_W + g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W\Big)ZVL_{i1}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{322}$$

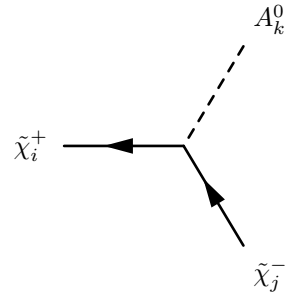


$$- \frac{i}{2}\Big(\Big(2g_pQ_{l_9}\cos\Theta'_W - \Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)\sum_{a=1}^{2} ZVL^*_{j1+a}ZVL_{i1+a}$$
$$+ ZVL^*_{j1}\Big(2g_pQ_{l_4}\cos\Theta'_W - \Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)ZVL_{i1}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{323}$$



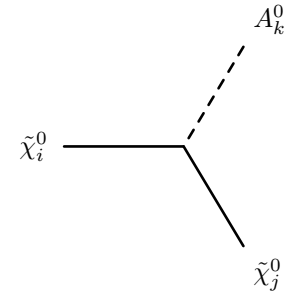
$$- g_3|\phi_{\tilde{g}}|^2 f_{\alpha,\beta,\gamma}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{324}$$
$$+ \ -g_3|\phi_{\tilde{g}}|^2 f_{\alpha,\beta,\gamma}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{325}$$

9.5 Two Fermion-One Scalar Boson-Interaction



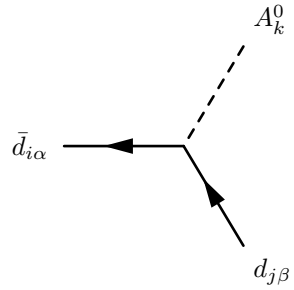
$$\frac{1}{\sqrt{2}}\Big(- g_2 U_{j1}^* V_{i2}^* Z_{k2}^{A,*} + U_{j2}^* \Big(- g_2 V_{i1}^* Z_{k1}^{A,*} + \lambda V_{i2}^* Z_{k3}^{A,*} \Big) \Big) \Big(\frac{1-\gamma_5}{2} \Big) \tag{326}$$

$$+ \frac{1}{\sqrt{2}} \Big(g_2 Z_{k1}^{A,*} U_{i2} V_{j1} + \Big(g_2 Z_{k2}^{A,*} U_{i1} - \lambda Z_{k3}^{A,*} U_{i2} \Big) V_{j2} \Big) \Big(\frac{1+\gamma_5}{2} \Big) \tag{327}$$



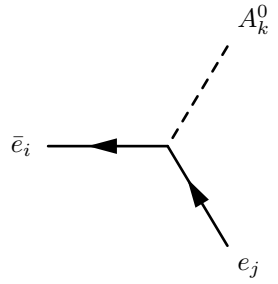
$$\begin{aligned}
&\frac{1}{2}\Big(- Z_{k3}^{A,*} \Big(2 g_p Q_s N_{i1}^* N_{j6}^* + 2 g_p Q_s N_{i6}^* N_{j1}^* + \sqrt{2} \lambda N_{i4}^* N_{j5}^* + \sqrt{2} \lambda N_{i5}^* N_{j4}^* \Big) \\
&- Z_{k2}^{A,*} \Big(N_{i5}^* \Big(2 g_p Q_{H_u} N_{j1}^* + g_1 N_{j2}^* - g_2 N_{j3}^* \Big) + \sqrt{2} \lambda N_{i6}^* N_{j4}^* + 2 g_p Q_{H_u} N_{i1}^* N_{j5}^* + g_1 N_{i2}^* N_{j5}^* \\
&- g_2 N_{i3}^* N_{j5}^* + \sqrt{2} \lambda N_{i4}^* N_{j6}^* \Big) \\
&- Z_{k1}^{A,*} \Big(N_{i4}^* \Big(2 g_p Q_{H_d} N_{j1}^* - g_1 N_{j2}^* + g_2 N_{j3}^* \Big) + 2 g_p Q_{H_d} N_{i1}^* N_{j4}^* - g_1 N_{i2}^* N_{j4}^* + g_2 N_{i3}^* N_{j4}^* \\
&+ \sqrt{2} \lambda N_{i6}^* N_{j5}^* + \sqrt{2} \lambda N_{i5}^* N_{j6}^* \Big) \Big) \Big(\frac{1-\gamma_5}{2} \Big) \\
&+ \frac{1}{2} \Big(Z_{k3}^{A,*} \Big(2 g_p Q_s N_{i1} N_{j6} + 2 g_p Q_s N_{i6} N_{j1} + \sqrt{2} \lambda N_{i4} N_{j5} + \sqrt{2} \lambda N_{i5} N_{j4} \Big) \\
&+ Z_{k2}^{A,*} \Big(N_{i5} \Big(2 g_p Q_{H_u} N_{j1} + g_1 N_{j2} - g_2 N_{j3} \Big) + \sqrt{2} \lambda N_{i6} N_{j4} + 2 g_p Q_{H_u} N_{i1} N_{j5} + g_1 N_{i2} N_{j5} \\
&- g_2 N_{i3} N_{j5} + \sqrt{2} \lambda N_{i4} N_{j6} \Big) \\
&+ Z_{k1}^{A,*} \Big(N_{i4} \Big(2 g_p Q_{H_d} N_{j1} - g_1 N_{j2} + g_2 N_{j3} \Big) + 2 g_p Q_{H_d} N_{i1} N_{j4} - g_1 N_{i2} N_{j4} + g_2 N_{i3} N_{j4}
\end{aligned} \tag{328}$$

$$+ \sqrt{2}\lambda N_{i6}N_{j5} + \sqrt{2}\lambda N_{i5}N_{j6}\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{329}$$



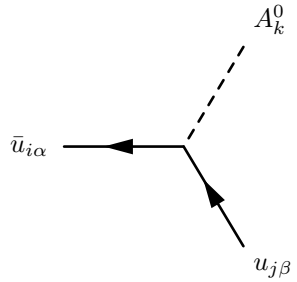
$$\frac{1}{\sqrt{2}}Z_{k1}^{A,*}\delta_{\alpha\beta}\sum_{b=1}^{3}U_{L,jb}^{d,*}\sum_{a=1}^{3}U_{R,ia}^{d,*}Y_{d,ab}\Big(\frac{1-\gamma_5}{2}\Big) \tag{330}$$

$$+ -\frac{1}{\sqrt{2}}Z_{k1}^{A,*}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{d,ab}^{*}U_{R,ja}^{d}U_{L,ib}^{d}\Big(\frac{1+\gamma_5}{2}\Big) \tag{331}$$



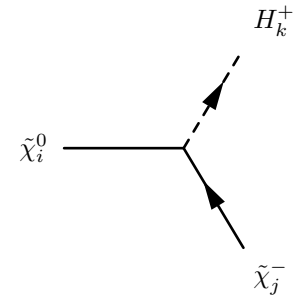
$$\frac{1}{\sqrt{2}}Z_{k1}^{A,*}\Big(Y1U_{L,j1}^{e,*}U_{R,i1}^{e,*} + \sum_{b=1}^{2}U_{L,j1+b}^{e,*}\sum_{a=1}^{2}U_{R,i1+a}^{e,*}Y2_{ab}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{332}$$

$$+ -\frac{1}{\sqrt{2}}Z_{k1}^{A,*}\Big(Y1^{*}U_{L,i1}^{e}U_{R,j1}^{e} + \sum_{b=1}^{2}\sum_{a=1}^{2}Y2_{ab}^{*}U_{R,j1+a}^{e}U_{L,i1+b}^{e}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{333}$$



$$\frac{1}{\sqrt{2}} Z_{k2}^{A,*} \delta_{\alpha\beta} \sum_{b=1}^{3} U_{L,jb}^{u,*} \sum_{a=1}^{3} U_{R,ia}^{u,*} Y_{u,ab} \Big(\frac{1-\gamma_5}{2} \Big) \tag{334}$$

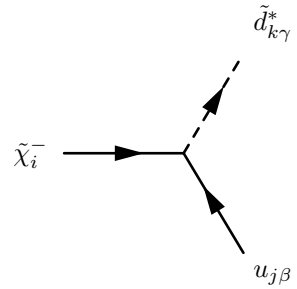
$$+ -\frac{1}{\sqrt{2}} Z_{k2}^{A,*} \delta_{\alpha\beta} \sum_{b=1}^{3} \sum_{a=1}^{3} Y_{u,ab}^{*} U_{R,ja}^{u} U_{L,ib}^{u} \Big(\frac{1+\gamma_5}{2} \Big) \tag{335}$$



$$- \frac{i}{2} \Big(2 g_2 U_{j1}^{*} N_{i4}^{*} Z_{k1}^{+}$$

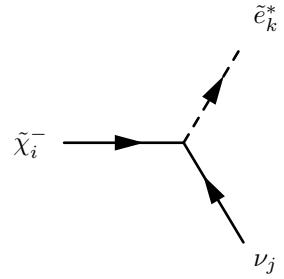
$$+ U_{j2}^{*} \Big(2\lambda N_{i6}^{*} Z_{k2}^{+} + 2\sqrt{2} g_p Q_{H_d} N_{i1}^{*} Z_{k1}^{+} - \sqrt{2} g_1 N_{i2}^{*} Z_{k1}^{+} - \sqrt{2} g_2 N_{i3}^{*} Z_{k1}^{+} \Big) \Big) \Big(\frac{1-\gamma_5}{2} \Big) \tag{336}$$

$$+ -\frac{i}{2} \Big(2 g_2 V_{j1} N_{i5} Z_{k2}^{+} + V_{j2} \Big(2\lambda N_{i6} Z_{k1}^{+} + \sqrt{2} \Big(2 g_p Q_{H_u} N_{i1} + g_1 N_{i2} + g_2 N_{i3} \Big) Z_{k2}^{+} \Big) \Big) \Big(\frac{1+\gamma_5}{2} \Big) \tag{337}$$

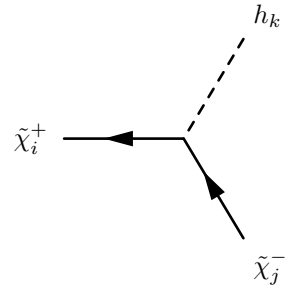


$$- i\delta_{\beta\gamma}\Big(g_2 U^*_{i1}\sum_{a=1}^{3} U^{u,*}_{L,ja} Z^D_{ka} - U^*_{i2}\sum_{b=1}^{3} U^{u,*}_{L,jb}\sum_{a=1}^{3} Y_{d,ab} Z^D_{k3+a}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{338}$$

$$+\ i\delta_{\beta\gamma}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^*_{u,ab} U^u_{R,ja} Z^D_{kb} V_{i2}\Big(\frac{1+\gamma_5}{2}\Big) \tag{339}$$

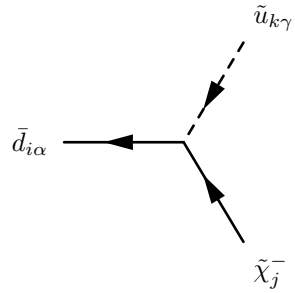


$$- i\Big(g_2 U^*_{i1}\Big(ZVL^*_{j1} Z^E_{k1} + \sum_{a=1}^{2} ZVL^*_{j1+a} Z^E_{k1+a}\Big) - U^*_{i2}\Big(Y1ZVL^*_{j1} Z^E_{k4} + \sum_{b=1}^{2} ZVL^*_{j1+b}\sum_{a=1}^{2} Y2_{ab} Z^E_{k4+a}\Big)\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{340}$$



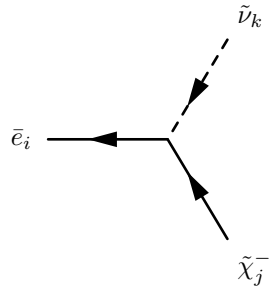
$$- i\frac{1}{\sqrt{2}}\Big(g_2 U^*_{j1} V^*_{i2} Z^{H,*}_{k2} + U^*_{j2}\Big(g_2 V^*_{i1} Z^{H,*}_{k1} + \lambda V^*_{i2} Z^{H,*}_{k3}\Big)\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{341}$$

$$+\ -i\frac{1}{\sqrt{2}}\Big(g_2 Z^{H,*}_{k1} U_{i2} V_{j1} + \Big(g_2 Z^{H,*}_{k2} U_{i1} + \lambda Z^{H,*}_{k3} U_{i2}\Big) V_{j2}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{342}$$



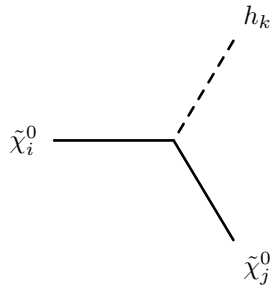
$$iU^*_{j2}\delta_{\alpha\gamma}\sum_{b=1}^{3}Z^{U,*}_{kb}\sum_{a=1}^{3}U^{d,*}_{R,ia}Y_{d,ab}\Big(\frac{1-\gamma_5}{2}\Big) \tag{343}$$

$$+\ -i\delta_{\alpha\gamma}\Big(g_2\sum_{a=1}^{3}Z^{U,*}_{ka}U^{d}_{L,ia}V_{j1}-\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{u,ab}Z^{U,*}_{k3+a}U^{d}_{L,ib}V_{j2}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{344}$$



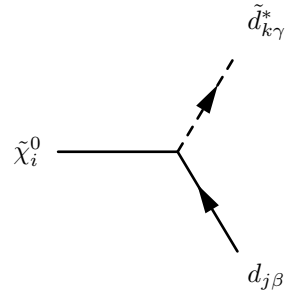
$$iU^*_{j2}\Big(Y1U^{e,*}_{R,i1}Z^{V,*}_{k1}+\sum_{b=1}^{2}Z^{V,*}_{k1+b}\sum_{a=1}^{2}U^{e,*}_{R,i1+a}Y2_{ab}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{345}$$

$$+\ -ig_2V_{j1}\Big(Z^{V,*}_{k1}U^{e}_{L,i1}+\sum_{a=1}^{2}Z^{V,*}_{k1+a}U^{e}_{L,i1+a}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{346}$$

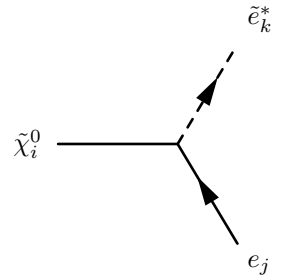


$$\begin{aligned}
&-\frac{i}{2}\Big(Z^{H,*}_{k3}\Big(2g_pQ_sN^*_{i1}N^*_{j6}+2g_pQ_sN^*_{i6}N^*_{j1}-\sqrt{2}\lambda N^*_{i4}N^*_{j5}-\sqrt{2}\lambda N^*_{i5}N^*_{j4}\Big)\\
&+Z^{H,*}_{k2}\Big(N^*_{i5}\Big(2g_pQ_{H_u}N^*_{j1}+g_1N^*_{j2}-g_2N^*_{j3}\Big)-\sqrt{2}\lambda N^*_{i6}N^*_{j4}+2g_pQ_{H_u}N^*_{i1}N^*_{j5}+g_1N^*_{i2}N^*_{j5}\\
&-g_2N^*_{i3}N^*_{j5}-\sqrt{2}\lambda N^*_{i4}N^*_{j6}\Big)\\
&+Z^{H,*}_{k1}\Big(N^*_{i4}\Big(2g_pQ_{H_d}N^*_{j1}-g_1N^*_{j2}+g_2N^*_{j3}\Big)+2g_pQ_{H_d}N^*_{i1}N^*_{j4}-g_1N^*_{i2}N^*_{j4}+g_2N^*_{i3}N^*_{j4}\\
&-\sqrt{2}\lambda N^*_{i6}N^*_{j5}-\sqrt{2}\lambda N^*_{i5}N^*_{j6}\Big)\Big)\Big(\frac{1-\gamma_5}{2}\Big)
\end{aligned} \tag{347}$$

$$+ -\frac{i}{2}\Big(Z^{H,*}_{k3}\Big(2g_pQ_sN_{i1}N_{j6} + 2g_pQ_sN_{i6}N_{j1} - \sqrt{2}\lambda N_{i4}N_{j5} - \sqrt{2}\lambda N_{i5}N_{j4}\Big)$$
$$+ Z^{H,*}_{k2}\Big(N_{i5}\Big(2g_pQ_{H_u}N_{j1} + g_1N_{j2} - g_2N_{j3}\Big) - \sqrt{2}\lambda N_{i6}N_{j4} + 2g_pQ_{H_u}N_{i1}N_{j5} + g_1N_{i2}N_{j5}$$
$$- g_2N_{i3}N_{j5} - \sqrt{2}\lambda N_{i4}N_{j6}\Big)$$
$$+ Z^{H,*}_{k1}\Big(N_{i4}\Big(2g_pQ_{H_d}N_{j1} - g_1N_{j2} + g_2N_{j3}\Big) + 2g_pQ_{H_d}N_{i1}N_{j4} - g_1N_{i2}N_{j4} + g_2N_{i3}N_{j4}$$
$$- \sqrt{2}\lambda N_{i6}N_{j5} - \sqrt{2}\lambda N_{i5}N_{j6}\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{348}$$



$$- \frac{i}{6}\delta_{\beta\gamma}\Big(6\sqrt{2}g_pQ_qN^*_{i1}\sum_{a=1}^{3}U^{d,*}_{L,ja}Z^D_{ka} + \sqrt{2}g_1N^*_{i2}\sum_{a=1}^{3}U^{d,*}_{L,ja}Z^D_{ka} - 3\sqrt{2}g_2N^*_{i3}\sum_{a=1}^{3}U^{d,*}_{L,ja}Z^D_{ka}$$
$$+ 6N^*_{i4}\sum_{b=1}^{3}U^{d,*}_{L,jb}\sum_{a=1}^{3}Y_{d,ab}Z^D_{k3+a}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{349}$$
$$+ -\frac{i}{3}\delta_{\beta\gamma}\Big(3\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{d,ab}U^d_{R,ja}Z^D_{kb}N_{i4} + \sqrt{2}\sum_{a=1}^{3}Z^D_{k3+a}U^d_{R,ja}\Big(3g_pQ_dN_{i1} + g_1N_{i2}\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{350}$$



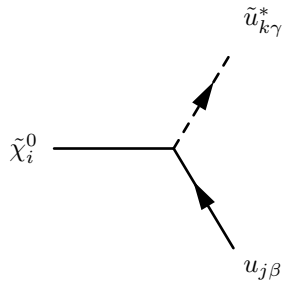
$$\frac{i}{2}\Big(\sqrt{2}g_2N^*_{i3}\sum_{a=1}^{2}U^{e,*}_{L,j1+a}Z^E_{k1+a} - 2N^*_{i4}\sum_{b=1}^{2}U^{e,*}_{L,j1+b}\sum_{a=1}^{2}Y2_{ab}Z^E_{k4+a} + \sqrt{2}g_2U^{e,*}_{L,j1}N^*_{i3}Z^E_{k1}$$

$$+\sqrt{2}g_1N^*_{i2}\Big(U^{e,*}_{L,j1}Z^E_{k1}+\sum_{a=1}^{2}U^{e,*}_{L,j1+a}Z^E_{k1+a}\Big)$$

$$-2\sqrt{2}g_pN^*_{i1}\Big(Q_{l_4}U^{e,*}_{L,j1}Z^E_{k1}+Q_{l_9}\sum_{a=1}^{2}U^{e,*}_{L,j1+a}Z^E_{k1+a}\Big)-2Y1U^{e,*}_{L,j1}N^*_{i4}Z^E_{k4}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{351}$$

$$+\ -i\Big(\sqrt{2}Z^E_{k4}U^e_{R,j1}\Big(g_1N_{i2}+g_pQ_{e_4}N_{i1}\Big)+\sqrt{2}\sum_{a=1}^{2}Z^E_{k4+a}U^e_{R,j1+a}\Big(g_1N_{i2}+g_pQ_{e_9}N_{i1}\Big)$$

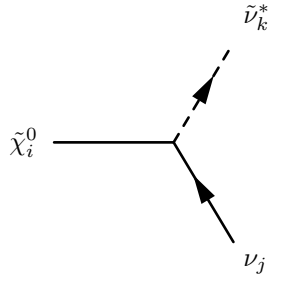
$$+\Big(Y1^*Z^E_{k1}U^e_{R,j1}+\sum_{b=1}^{2}\sum_{a=1}^{2}Y2^*_{ab}U^e_{R,j1+a}Z^E_{k1+b}\Big)N_{i4}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{352}$$



$$-\frac{i}{6}\delta_{\beta\gamma}\Big(6\sqrt{2}g_pQ_qN^*_{i1}\sum_{a=1}^{3}U^{u,*}_{L,ja}Z^U_{ka}+\sqrt{2}g_1N^*_{i2}\sum_{a=1}^{3}U^{u,*}_{L,ja}Z^U_{ka}+3\sqrt{2}g_2N^*_{i3}\sum_{a=1}^{3}U^{u,*}_{L,ja}Z^U_{ka}$$

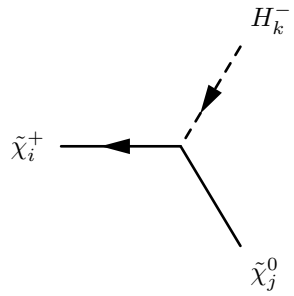
$$+6N^*_{i5}\sum_{b=1}^{3}U^{u,*}_{L,jb}\sum_{a=1}^{3}Y_{u,ab}Z^U_{k3+a}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{353}$$

$$+\ -\frac{i}{3}\delta_{\beta\gamma}\Big(3\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{u,ab}U^u_{R,ja}Z^U_{kb}N_{i5}+\sqrt{2}\sum_{a=1}^{3}Z^U_{k3+a}U^u_{R,ja}\Big(-2g_1N_{i2}+3g_pQ_uN_{i1}\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{354}$$



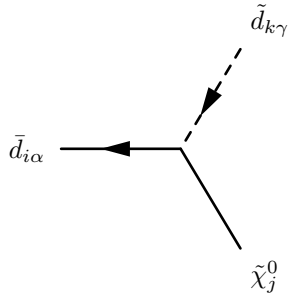
$$i\frac{1}{\sqrt{2}}\Big(\Big(g_1N^*_{i2}-g_2N^*_{i3}\Big)\Big(ZVL^*_{j1}Z^V_{k1}+\sum_{a=1}^{2}ZVL^*_{j1+a}Z^V_{k1+a}\Big)$$

$$- 2g_p N^*_{i1}\Big(Q_{l_4} ZVL^*_{j1} Z^V_{k1} + Q_{l_9}\sum_{a=1}^{2} ZVL^*_{j1+a} Z^V_{k1+a}\Big)\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{355}$$



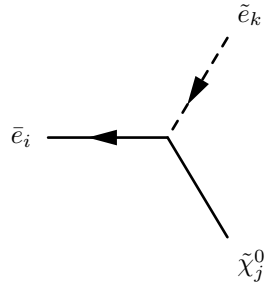
$$- \frac{i}{2}\Big(2g_2 V^*_{i1} N^*_{j5} Z^+_{k2} + V^*_{i2}\Big(2\lambda N^*_{j6} Z^+_{k1} + \sqrt{2}\Big(2g_p Q_{H_u} N^*_{j1} + g_1 N^*_{j2} + g_2 N^*_{j3}\Big) Z^+_{k2}\Big)\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{356}$$

$$\begin{aligned} &+ -\frac{i}{2}\Big(2g_2 U_{i1} N_{j4} Z^+_{k1} \\ &+ U_{i2}\Big(2\lambda N_{j6} Z^+_{k2} + 2\sqrt{2} g_p Q_{H_d} N_{j1} Z^+_{k1} - \sqrt{2} g_1 N_{j2} Z^+_{k1} - \sqrt{2} g_2 N_{j3} Z^+_{k1}\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \end{aligned} \tag{357}$$

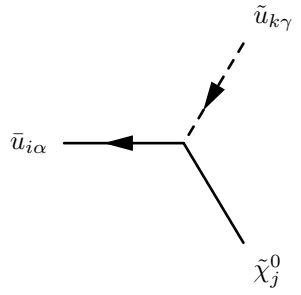


$$\begin{aligned} &- \frac{i}{3}\delta_{\alpha\gamma}\Big(3\sqrt{2} g_p Q_d N^*_{j1}\sum_{a=1}^{3} Z^{D,*}_{k3+a} U^{d,*}_{R,ia} + \sqrt{2} g_1 N^*_{j2}\sum_{a=1}^{3} Z^{D,*}_{k3+a} U^{d,*}_{R,ia} \\ &+ 3N^*_{j4}\sum_{b=1}^{3} Z^{D,*}_{kb}\sum_{a=1}^{3} U^{d,*}_{R,ia} Y_{d,ab}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \end{aligned} \tag{358}$$

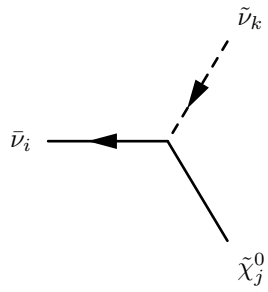
$$+ -\frac{i}{6}\delta_{\alpha\gamma}\Big(6\sum_{b=1}^{3}\sum_{a=1}^{3} Y^*_{d,ab} Z^{D,*}_{k3+a} U^d_{L,ib} N_{j4} + \sqrt{2}\sum_{a=1}^{3} Z^{D,*}_{ka} U^d_{L,ia}\Big(-3g_2 N_{j3} + 6g_p Q_q N_{j1} + g_1 N_{j2}\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{359}$$



$$
\begin{aligned}
&- i\Big(\sqrt{2}Z_{k4}^{E,*}U_{R,i1}^{e,*}\Big(g_1N_{j2}^* + g_pQ_{e_4}N_{j1}^*\Big) + Y1Z_{k1}^{E,*}U_{R,i1}^{e,*}N_{j4}^* \\
&+ \sqrt{2}g_pQ_{e_9}N_{j1}^*\sum_{a=1}^{2}Z_{k4+a}^{E,*}U_{R,i1+a}^{e,*} + \sqrt{2}g_1N_{j2}^*\sum_{a=1}^{2}Z_{k4+a}^{E,*}U_{R,i1+a}^{e,*} \\
&+ N_{j4}^*\sum_{b=1}^{2}Z_{k1+b}^{E,*}\sum_{a=1}^{2}U_{R,i1+a}^{e,*}Y2_{ab}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \qquad (360)\\
&+ -\frac{i}{2}\Big(\sqrt{2}Z_{k1}^{E,*}U_{L,i1}^{e}\Big(2g_pQ_{l_4}N_{j1} - g_1N_{j2} - g_2N_{j3}\Big) \\
&+ \sqrt{2}\sum_{a=1}^{2}Z_{k1+a}^{E,*}U_{L,i1+a}^{e}\Big(2g_pQ_{l_9}N_{j1} - g_1N_{j2} - g_2N_{j3}\Big) \\
&+ 2\Big(Y1^*Z_{k4}^{E,*}U_{L,i1}^{e} + \sum_{b=1}^{2}\sum_{a=1}^{2}Y2_{ab}^*Z_{k4+a}^{E,*}U_{L,i1+b}^{e}\Big)N_{j4}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \qquad (361)
\end{aligned}
$$

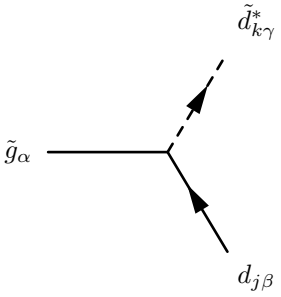


$$
\begin{aligned}
&- \frac{i}{3}\delta_{\alpha\gamma}\Big(3\sqrt{2}g_pQ_uN_{j1}^*\sum_{a=1}^{3}Z_{k3+a}^{U,*}U_{R,ia}^{u,*} - 2\sqrt{2}g_1N_{j2}^*\sum_{a=1}^{3}Z_{k3+a}^{U,*}U_{R,ia}^{u,*} \\
&+ 3N_{j5}^*\sum_{b=1}^{3}Z_{kb}^{U,*}\sum_{a=1}^{3}U_{R,ia}^{u,*}Y_{u,ab}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \qquad (362)\\
&+ -\frac{i}{6}\delta_{\alpha\gamma}\Big(6\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{u,ab}^*Z_{k3+a}^{U,*}U_{L,ib}^{u}N_{j5} + \sqrt{2}\sum_{a=1}^{3}Z_{ka}^{U,*}U_{L,ia}^{u}\Big(3g_2N_{j3} + 6g_pQ_qN_{j1} + g_1N_{j2}\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \qquad (363)
\end{aligned}
$$



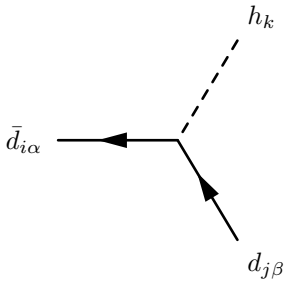
(364)

$$+ \; -i\frac{1}{\sqrt{2}}\Big(\sum_{a=1}^{2} Z^{V,*}_{k1+a} ZVL_{i1+a}\Big(2g_p Q_{l_9} N_{j1} - g_1 N_{j2} + g_2 N_{j3}\Big) + Z^{V,*}_{k1}\Big(2g_p Q_{l_4} N_{j1} - g_1 N_{j2} + g_2 N_{j3}\Big) ZVL_{i1}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{365}$$



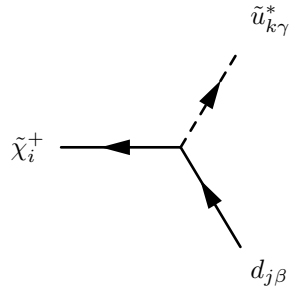
$$- \; i\frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}} \lambda^{\alpha}_{\gamma,\beta} \sum_{a=1}^{3} U^{d,*}_{L,ja} Z^{D}_{ka}\Big(\frac{1-\gamma_5}{2}\Big) \tag{366}$$

$$+ \; i\frac{1}{\sqrt{2}} g_3 \phi^*_{\tilde{g}} \lambda^{\alpha}_{\gamma,\beta} \sum_{a=1}^{3} Z^{D}_{k3+a} U^{d}_{R,ja}\Big(\frac{1+\gamma_5}{2}\Big) \tag{367}$$



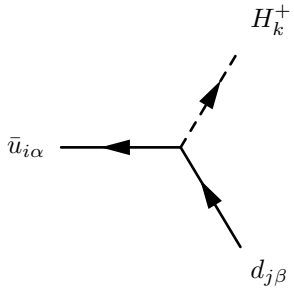
$$- i\frac{1}{\sqrt{2}} Z_{k1}^{H,*} \delta_{\alpha\beta} \sum_{b=1}^{3} U_{L,jb}^{d,*} \sum_{a=1}^{3} U_{R,ia}^{d,*} Y_{d,ab} \Big(\frac{1-\gamma_5}{2} \Big) \tag{368}$$

$$+ \; -i\frac{1}{\sqrt{2}} Z_{k1}^{H,*} \delta_{\alpha\beta} \sum_{b=1}^{3} \sum_{a=1}^{3} Y_{d,ab}^{*} U_{R,ja}^{d} U_{L,ib}^{d} \Big(\frac{1+\gamma_5}{2} \Big) \tag{369}$$



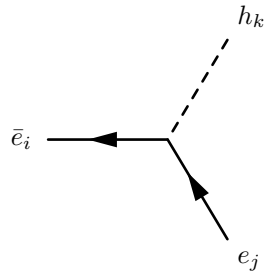
$$- i\delta_{\beta\gamma} \Big(g_2 V_{i1}^{*} \sum_{a=1}^{3} U_{L,ja}^{d,*} Z_{ka}^{U} - V_{i2}^{*} \sum_{b=1}^{3} U_{L,jb}^{d,*} \sum_{a=1}^{3} Y_{u,ab} Z_{k3+a}^{U} \Big) \Big(\frac{1-\gamma_5}{2} \Big) \tag{370}$$

$$+ \; i\delta_{\beta\gamma} \sum_{b=1}^{3} \sum_{a=1}^{3} Y_{d,ab}^{*} U_{R,ja}^{d} Z_{kb}^{U} U_{i2} \Big(\frac{1+\gamma_5}{2} \Big) \tag{371}$$



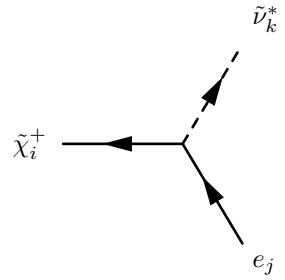
$$i\delta_{\alpha\beta} \sum_{b=1}^{3} U_{L,jb}^{d,*} \sum_{a=1}^{3} U_{R,ia}^{u,*} Y_{u,ab} Z_{k2}^{+} \Big(\frac{1-\gamma_5}{2} \Big) \tag{372}$$

$$+ \; i\delta_{\alpha\beta} \sum_{b=1}^{3} \sum_{a=1}^{3} Y_{d,ab}^{*} U_{R,ja}^{d} U_{L,ib}^{u} Z_{k1}^{+} \Big(\frac{1+\gamma_5}{2} \Big) \tag{373}$$



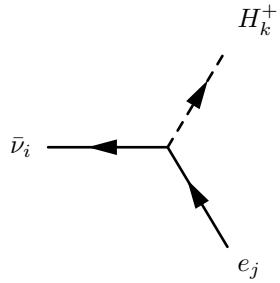
$$- i\frac{1}{\sqrt{2}}Z^{H,*}_{k1}\Big(Y1U^{e,*}_{L,j1}U^{e,*}_{R,i1} + \sum_{b=1}^{2}U^{e,*}_{L,j1+b}\sum_{a=1}^{2}U^{e,*}_{R,i1+a}Y2_{ab}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{374}$$

$$+ \; -i\frac{1}{\sqrt{2}}Z^{H,*}_{k1}\Big(Y1^{*}U^{e}_{L,i1}U^{e}_{R,j1} + \sum_{b=1}^{2}\sum_{a=1}^{2}Y2^{*}_{ab}U^{e}_{R,j1+a}U^{e}_{L,i1+b}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{375}$$

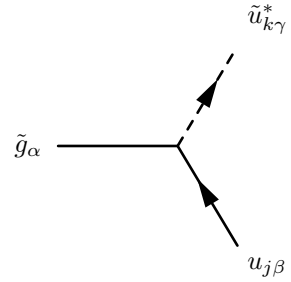


$$- ig_2V^{*}_{i1}\Big(U^{e,*}_{L,j1}Z^{V}_{k1} + \sum_{a=1}^{2}U^{e,*}_{L,j1+a}Z^{V}_{k1+a}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{376}$$

$$+ \; iU_{i2}\Big(Y1^{*}U^{e}_{R,j1}Z^{V}_{k1} + \sum_{b=1}^{2}\sum_{a=1}^{2}Y2^{*}_{ab}U^{e}_{R,j1+a}Z^{V}_{k1+b}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{377}$$

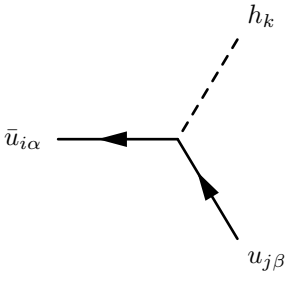


$$+ \; iZ^{+}_{k1}\Big(Y1^{*}U^{e}_{R,j1}ZVL_{i1} + \sum_{b=1}^{2}\sum_{a=1}^{2}Y2^{*}_{ab}U^{e}_{R,j1+a}ZVL_{i1+b}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{379}$$



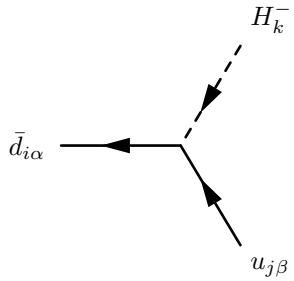
$$- \; i\frac{1}{\sqrt{2}}g_3\phi_{\tilde{g}}\lambda^{\alpha}_{\gamma,\beta}\sum_{a=1}^{3}U^{u,*}_{L,ja}Z^{U}_{ka}\Big(\frac{1-\gamma_5}{2}\Big) \tag{380}$$

$$+ \; i\frac{1}{\sqrt{2}}g_3\phi^{*}_{\tilde{g}}\lambda^{\alpha}_{\gamma,\beta}\sum_{a=1}^{3}Z^{U}_{k3+a}U^{u}_{R,ja}\Big(\frac{1+\gamma_5}{2}\Big) \tag{381}$$



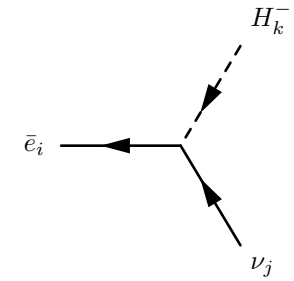
$$- \; i\frac{1}{\sqrt{2}}Z^{H,*}_{k2}\delta_{\alpha\beta}\sum_{b=1}^{3}U^{u,*}_{L,jb}\sum_{a=1}^{3}U^{u,*}_{R,ia}Y_{u,ab}\Big(\frac{1-\gamma_5}{2}\Big) \tag{382}$$

$$+ \; -i\frac{1}{\sqrt{2}}Z^{H,*}_{k2}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{u,ab}U^{u}_{R,ja}U^{u}_{L,ib}\Big(\frac{1+\gamma_5}{2}\Big) \tag{383}$$

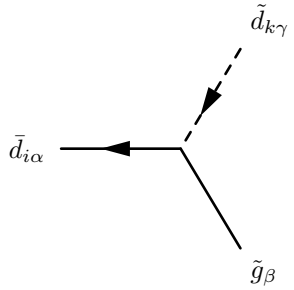


$$i\delta_{\alpha\beta}\sum_{b=1}^{3}U_{L,jb}^{u,*}\sum_{a=1}^{3}U_{R,ia}^{d,*}Y_{d,ab}Z_{k1}^{+}\Big(\frac{1-\gamma_5}{2}\Big) \tag{384}$$

$$+\ i\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{u,ab}^{*}U_{R,ja}^{u}U_{L,ib}^{d}Z_{k2}^{+}\Big(\frac{1+\gamma_5}{2}\Big) \tag{385}$$

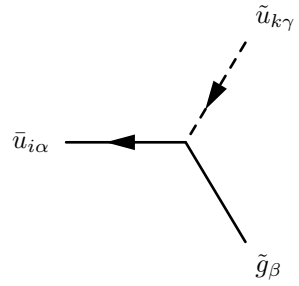


$$i\Big(Y1U_{R,i1}^{e,*}ZVL_{j1}^{*}+\sum_{b=1}^{2}ZVL_{j1+b}^{*}\sum_{a=1}^{2}U_{R,i1+a}^{e,*}Y2_{ab}\Big)Z_{k1}^{+}\Big(\frac{1-\gamma_5}{2}\Big) \tag{386}$$



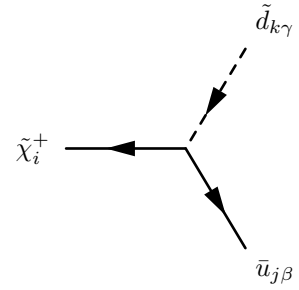
$$i\frac{1}{\sqrt{2}}g_3\phi_{\tilde{g}}\lambda_{\alpha,\gamma}^{\beta}\sum_{a=1}^{3}Z_{k3+a}^{D,*}U_{R,ia}^{d,*}\Big(\frac{1-\gamma_5}{2}\Big) \tag{387}$$

$$+\ -i\frac{1}{\sqrt{2}}g_3\phi_{\tilde{g}}^*\lambda_{\alpha,\gamma}^{\beta}\sum_{a=1}^{3}Z_{ka}^{D,*}U_{L,ia}^{d}\Big(\frac{1+\gamma_5}{2}\Big) \tag{388}$$



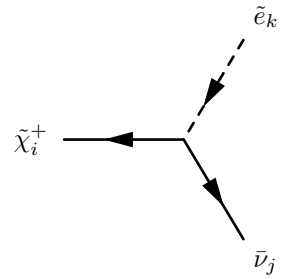
$$i\frac{1}{\sqrt{2}}g_3\phi_{\tilde{g}}\lambda_{\alpha,\gamma}^{\beta}\sum_{a=1}^{3}Z_{k3+a}^{U,*}U_{R,ia}^{u,*}\Big(\frac{1-\gamma_5}{2}\Big) \tag{389}$$

$$+\ -i\frac{1}{\sqrt{2}}g_3\phi_{\tilde{g}}^*\lambda_{\alpha,\gamma}^{\beta}\sum_{a=1}^{3}Z_{ka}^{U,*}U_{L,ia}^{u}\Big(\frac{1+\gamma_5}{2}\Big) \tag{390}$$



$$iV_{i2}^*\delta_{\beta\gamma}\sum_{b=1}^{3}Z_{kb}^{D,*}\sum_{a=1}^{3}U_{R,ja}^{u,*}Y_{u,ab}\Big(\frac{1-\gamma_5}{2}\Big) \tag{391}$$

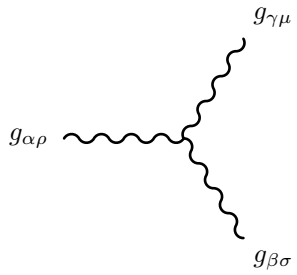
$$+\ -i\delta_{\beta\gamma}\Big(g_2\sum_{a=1}^{3}Z_{ka}^{D,*}U_{L,ja}^{u}U_{i1}-\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{d,ab}^{*}Z_{k3+a}^{D,*}U_{L,jb}^{u}U_{i2}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{392}$$



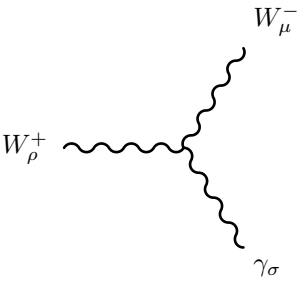
(393)

$$+ \; -i\Big(g_2 \sum_{a=1}^{2} Z_{k1+a}^{E,*} ZVL_{j1+a} U_{i1} + \Big(g_2 Z_{k1}^{E,*} U_{i1} - Y1^* Z_{k4}^{E,*} U_{i2}\Big) ZVL_{j1} - \sum_{b=1}^{2}\sum_{a=1}^{2} Y2_{ab}^* Z_{k4+a}^{E,*} ZVL_{j1+b} U_{i2}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{394}$$

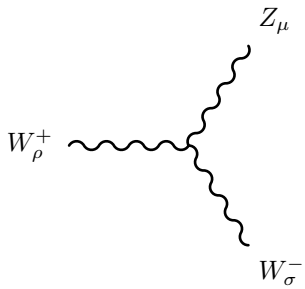
9.6 Three Vector Boson-Interaction



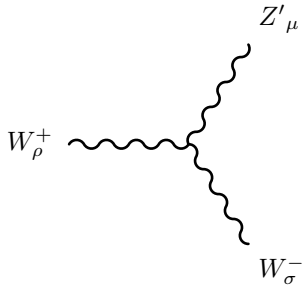
$$g_3 f_{\alpha,\beta,\gamma}\Big(g_{\rho\mu}\Big(-p_\sigma^{g_{\gamma\mu}} + p_\sigma^{g_{\alpha\rho}}\Big) + g_{\rho\sigma}\Big(-p_\mu^{g_{\alpha\rho}} + p_\mu^{g_{\beta\sigma}}\Big) + g_{\sigma\mu}\Big(-p_\rho^{g_{\beta\sigma}} + p_\rho^{g_{\gamma\mu}}\Big)\Big) \tag{395}$$



$$ig_2 \sin\Theta_W\Big(g_{\rho\mu}\Big(-p_\sigma^{W_\mu^-} + p_\sigma^{W_\rho^+}\Big) + g_{\rho\sigma}\Big(-p_\mu^{W_\rho^+} + p_\mu^{\gamma_\sigma}\Big) + g_{\sigma\mu}\Big(-p_\rho^{\gamma_\sigma} + p_\rho^{W_\mu^-}\Big)\Big) \tag{396}$$

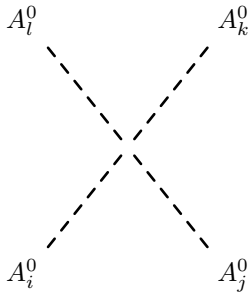


$$-ig_2\cos\Theta_W\cos\Theta'_W\Big(g_{\rho\mu}\Big(-p_\sigma^{Z_\mu}+p_\sigma^{W_\rho^+}\Big)+g_{\rho\sigma}\Big(-p_\mu^{W_\rho^+}+p_\mu^{W_\sigma^-}\Big)+g_{\sigma\mu}\Big(-p_\rho^{W_\sigma^-}+p_\rho^{Z_\mu}\Big)\Big) \tag{397}$$



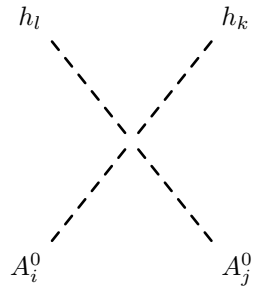
$$ig_2\cos\Theta_W\sin\Theta'_W\Big(g_{\rho\mu}\Big(-p_\sigma^{Z'_\mu}+p_\sigma^{W_\rho^+}\Big)+g_{\rho\sigma}\Big(-p_\mu^{W_\rho^+}+p_\mu^{W_\sigma^-}\Big)+g_{\sigma\mu}\Big(-p_\rho^{W_\sigma^-}+p_\rho^{Z'_\mu}\Big)\Big) \tag{398}$$

9.7 Four Scalar-Interaction

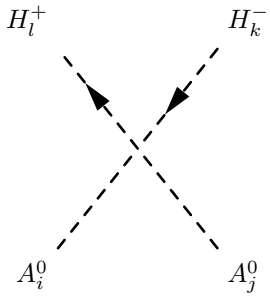


$$-\frac{i}{4}\Big(4Z_{i3}^{A,*}\Big(\Big(g_p^2Q_{H_d}Q_s+\lambda^2\Big)Z_{j1}^{A,*}\Big(Z_{k1}^{A,*}Z_{l3}^{A,*}+Z_{k3}^{A,*}Z_{l1}^{A,*}\Big)$$
$$+\Big(g_p^2Q_{H_u}Q_s+\lambda^2\Big)Z_{j2}^{A,*}\Big(Z_{k2}^{A,*}Z_{l3}^{A,*}+Z_{k3}^{A,*}Z_{l2}^{A,*}\Big)$$

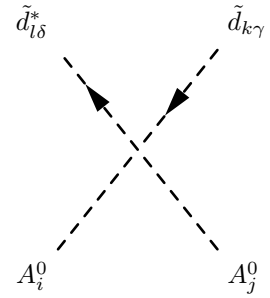
$$
\begin{aligned}
&+ Z_{j3}^{A,*}\Big(3g_p^2Q_s^2Z_{k3}^{A,*}Z_{l3}^{A,*} + \Big(g_p^2Q_{H_d}Q_s + \lambda^2\Big)Z_{k1}^{A,*}Z_{l1}^{A,*} + \Big(g_p^2Q_{H_u}Q_s + \lambda^2\Big)Z_{k2}^{A,*}Z_{l2}^{A,*}\Big)\Big)\\
&+ Z_{i1}^{A,*}\Big(-\Big(-4\Big(g_p^2Q_{H_d}Q_{H_u} + \lambda^2\Big) + g_1^2 + g_2^2\Big)Z_{j2}^{A,*}\Big(Z_{k1}^{A,*}Z_{l2}^{A,*} + Z_{k2}^{A,*}Z_{l1}^{A,*}\Big)\\
&+ 4\Big(g_p^2Q_{H_d}Q_s + \lambda^2\Big)Z_{j3}^{A,*}\Big(Z_{k1}^{A,*}Z_{l3}^{A,*} + Z_{k3}^{A,*}Z_{l1}^{A,*}\Big)\\
&+ Z_{j1}^{A,*}\Big(3\Big(4g_p^2Q_{H_d}^2 + g_1^2 + g_2^2\Big)Z_{k1}^{A,*}Z_{l1}^{A,*} - \Big(-4\Big(g_p^2Q_{H_d}Q_{H_u} + \lambda^2\Big) + g_1^2 + g_2^2\Big)Z_{k2}^{A,*}Z_{l2}^{A,*}\\
&+ 4\Big(g_p^2Q_{H_d}Q_s + \lambda^2\Big)Z_{k3}^{A,*}Z_{l3}^{A,*}\Big)\Big)\\
&+ Z_{i2}^{A,*}\Big(-\Big(-4\Big(g_p^2Q_{H_d}Q_{H_u} + \lambda^2\Big) + g_1^2 + g_2^2\Big)Z_{j1}^{A,*}\Big(Z_{k1}^{A,*}Z_{l2}^{A,*} + Z_{k2}^{A,*}Z_{l1}^{A,*}\Big)\\
&+ 4\Big(g_p^2Q_{H_u}Q_s + \lambda^2\Big)Z_{j3}^{A,*}\Big(Z_{k2}^{A,*}Z_{l3}^{A,*} + Z_{k3}^{A,*}Z_{l2}^{A,*}\Big)\\
&+ Z_{j2}^{A,*}\Big(-\Big(-4\Big(g_p^2Q_{H_d}Q_{H_u} + \lambda^2\Big) + g_1^2 + g_2^2\Big)Z_{k1}^{A,*}Z_{l1}^{A,*} + 3\Big(4g_p^2Q_{H_u}^2 + g_1^2 + g_2^2\Big)Z_{k2}^{A,*}Z_{l2}^{A,*}\\
&+ 4\Big(g_p^2Q_{H_u}Q_s + \lambda^2\Big)Z_{k3}^{A,*}Z_{l3}^{A,*}\Big)\Big)\Big)
\end{aligned}
\tag{399}
$$



$$
\begin{aligned}
&-\frac{i}{4}\Big(4Z_{i3}^{A,*}Z_{j3}^{A,*}\Big(\Big(g_p^2Q_{H_d}Q_s + \lambda^2\Big)Z_{k1}^{H,*}Z_{l1}^{H,*} + \Big(g_p^2Q_{H_u}Q_s + \lambda^2\Big)Z_{k2}^{H,*}Z_{l2}^{H,*} + g_p^2Q_s^2Z_{k3}^{H,*}Z_{l3}^{H,*}\Big)\\
&+ Z_{i1}^{A,*}Z_{j1}^{A,*}\Big(\Big(4g_p^2Q_{H_d}^2 + g_1^2 + g_2^2\Big)Z_{k1}^{H,*}Z_{l1}^{H,*} - \Big(-4\Big(g_p^2Q_{H_d}Q_{H_u} + \lambda^2\Big) + g_1^2 + g_2^2\Big)Z_{k2}^{H,*}Z_{l2}^{H,*}\\
&+ 4\Big(g_p^2Q_{H_d}Q_s + \lambda^2\Big)Z_{k3}^{H,*}Z_{l3}^{H,*}\Big)\\
&+ Z_{i2}^{A,*}Z_{j2}^{A,*}\Big(-\Big(-4\Big(g_p^2Q_{H_d}Q_{H_u} + \lambda^2\Big) + g_1^2 + g_2^2\Big)Z_{k1}^{H,*}Z_{l1}^{H,*} + \Big(4g_p^2Q_{H_u}^2 + g_1^2 + g_2^2\Big)Z_{k2}^{H,*}Z_{l2}^{H,*}\\
&+ 4\Big(g_p^2Q_{H_u}Q_s + \lambda^2\Big)Z_{k3}^{H,*}Z_{l3}^{H,*}\Big)\Big)
\end{aligned}
\tag{400}
$$

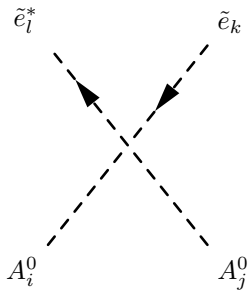


$$
\begin{aligned}
&-\frac{i}{4}\Big(4Z_{i3}^{A,*}Z_{j3}^{A,*}\Big(\Big(g_p^2Q_{H_d}Q_s+\lambda^2\Big)Z_{k1}^{+}Z_{l1}^{+}+\Big(g_p^2Q_{H_u}Q_s+\lambda^2\Big)Z_{k2}^{+}Z_{l2}^{+}\Big)\\
&+Z_{i1}^{A,*}\Big(-\Big(-2\lambda^2+g_2^2\Big)Z_{j2}^{A,*}\Big(Z_{k1}^{+}Z_{l2}^{+}+Z_{k2}^{+}Z_{l1}^{+}\Big)\\
&+Z_{j1}^{A,*}\Big(\Big(4g_p^2Q_{H_d}^2+g_1^2+g_2^2\Big)Z_{k1}^{+}Z_{l1}^{+}+\Big(4g_p^2Q_{H_d}Q_{H_u}-g_1^2+g_2^2\Big)Z_{k2}^{+}Z_{l2}^{+}\Big)\Big)\\
&+Z_{i2}^{A,*}\Big(-\Big(-2\lambda^2+g_2^2\Big)Z_{j1}^{A,*}\Big(Z_{k1}^{+}Z_{l2}^{+}+Z_{k2}^{+}Z_{l1}^{+}\Big)\\
&+Z_{j2}^{A,*}\Big(\Big(4g_p^2Q_{H_d}Q_{H_u}-g_1^2+g_2^2\Big)Z_{k1}^{+}Z_{l1}^{+}+\Big(4g_p^2Q_{H_u}^2+g_1^2+g_2^2\Big)Z_{k2}^{+}Z_{l2}^{+}\Big)\Big)\Big)
\end{aligned}
\tag{401}
$$

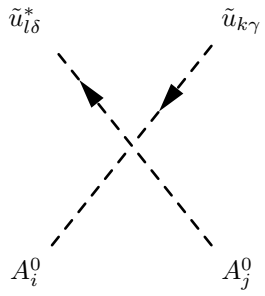


$$
\begin{aligned}
&-\frac{i}{12}\delta_{\gamma\delta}\Big(6Z_{i3}^{A,*}\Big(2g_p^2Q_sZ_{j3}^{A,*}\Big(Q_d\sum_{a=1}^{3}Z_{k3+a}^{D,*}Z_{l3+a}^{D}+Q_q\sum_{a=1}^{3}Z_{ka}^{D,*}Z_{la}^{D}\Big)\\
&+\lambda Z_{j2}^{A,*}\Big(\sum_{b=1}^{3}Z_{kb}^{D,*}\sum_{a=1}^{3}Y_{d,ab}Z_{l3+a}^{D}+\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{d,ab}^{*}Z_{k3+a}^{D,*}Z_{lb}^{D}\Big)\Big)\\
&+Z_{i2}^{A,*}\Big(Z_{j2}^{A,*}\Big(\Big(12g_p^2Q_{H_u}Q_q+3g_2^2+g_1^2\Big)\sum_{a=1}^{3}Z_{ka}^{D,*}Z_{la}^{D}+2\Big(6g_p^2Q_dQ_{H_u}+g_1^2\Big)\sum_{a=1}^{3}Z_{k3+a}^{D,*}Z_{l3+a}^{D}\Big)\\
&+6\lambda Z_{j3}^{A,*}\Big(\sum_{b=1}^{3}Z_{kb}^{D,*}\sum_{a=1}^{3}Y_{d,ab}Z_{l3+a}^{D}+\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{d,ab}^{*}Z_{k3+a}^{D,*}Z_{lb}^{D}\Big)\Big)\\
&+Z_{i1}^{A,*}Z_{j1}^{A,*}\Big(-\Big(3\Big(-4g_p^2Q_{H_d}Q_q+g_2^2\Big)+g_1^2\Big)\sum_{a=1}^{3}Z_{ka}^{D,*}Z_{la}^{D}-2\Big(-6g_p^2Q_dQ_{H_d}+g_1^2\Big)\sum_{a=1}^{3}Z_{k3+a}^{D,*}Z_{l3+a}^{D}
\end{aligned}
$$

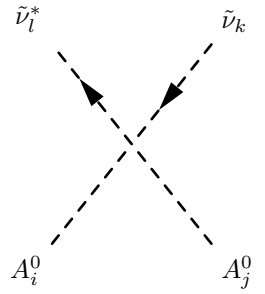
$$+ 12\Big(\sum_{c=1}^{3} Z^{D,*}_{k3+c}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{d,ca}Y_{d,ba}Z^{D}_{l3+b} + \sum_{c=1}^{3}\sum_{b=1}^{3} Z^{D,*}_{kb}\sum_{a=1}^{3} Y^{*}_{d,ac}Y_{d,ab}Z^{D}_{lc}\Big)\Big)\Big) \tag{402}$$



$$\begin{aligned}
&- \frac{i}{4}\Big(Z^{A,*}_{i1}Z^{A,*}_{j1}\Big(\Big(4g_p^2Q_{H_d}Q_{l_9} - g_2^2 + g_1^2\Big)\sum_{a=1}^{2} Z^{E,*}_{k1+a}Z^{E}_{l1+a} - 2\Big(-2g_p^2Q_{e_9}Q_{H_d} + g_1^2\Big)\sum_{a=1}^{2} Z^{E,*}_{k4+a}Z^{E}_{l4+a}\\
&+ 4\sum_{c=1}^{2} Z^{E,*}_{k4+c}\sum_{b=1}^{2}\sum_{a=1}^{2} Y2^{*}_{ca}Y2_{ba}Z^{E}_{l4+b} + 4\sum_{c=1}^{2}\sum_{b=1}^{2} Z^{E,*}_{k1+b}\sum_{a=1}^{2} Y2^{*}_{ac}Y2_{ab}Z^{E}_{l1+c} + g_1^2Z^{E,*}_{k1}Z^{E}_{l1}\\
&- g_2^2Z^{E,*}_{k1}Z^{E}_{l1} + 4g_p^2Q_{H_d}Q_{l_4}Z^{E,*}_{k1}Z^{E}_{l1} + 4|Y1|^2Z^{E,*}_{k1}Z^{E}_{l1} - 2g_1^2Z^{E,*}_{k4}Z^{E}_{l4}\\
&+ 4g_p^2Q_{e_4}Q_{H_d}Z^{E,*}_{k4}Z^{E}_{l4} + 4|Y1|^2Z^{E,*}_{k4}Z^{E}_{l4}\Big)\\
&+ 2Z^{A,*}_{i3}\Big(\lambda Z^{A,*}_{j2}\Big(Y1Z^{E,*}_{k1}Z^{E}_{l4} + Y1^{*}Z^{E,*}_{k4}Z^{E}_{l1} + \sum_{b=1}^{2} Z^{E,*}_{k1+b}\sum_{a=1}^{2} Y2_{ab}Z^{E}_{l4+a} + \sum_{b=1}^{2}\sum_{a=1}^{2} Y2^{*}_{ab}Z^{E,*}_{k4+a}Z^{E}_{l1+b}\Big)\\
&+ 2g_p^2Q_sZ^{A,*}_{j3}\Big(Q_{e_4}Z^{E,*}_{k4}Z^{E}_{l4} + Q_{e_9}\sum_{a=1}^{2} Z^{E,*}_{k4+a}Z^{E}_{l4+a} + Q_{l_4}Z^{E,*}_{k1}Z^{E}_{l1} + Q_{l_9}\sum_{a=1}^{2} Z^{E,*}_{k1+a}Z^{E}_{l1+a}\Big)\Big)\\
&+ Z^{A,*}_{i2}\Big(2\lambda Z^{A,*}_{j3}\Big(Y1Z^{E,*}_{k1}Z^{E}_{l4} + Y1^{*}Z^{E,*}_{k4}Z^{E}_{l1} + \sum_{b=1}^{2} Z^{E,*}_{k1+b}\sum_{a=1}^{2} Y2_{ab}Z^{E}_{l4+a} + \sum_{b=1}^{2}\sum_{a=1}^{2} Y2^{*}_{ab}Z^{E,*}_{k4+a}Z^{E}_{l1+b}\Big)\\
&+ Z^{A,*}_{j2}\Big(\Big(4g_p^2Q_{H_u}Q_{l_9} - g_1^2 + g_2^2\Big)\sum_{a=1}^{2} Z^{E,*}_{k1+a}Z^{E}_{l1+a} + 2\Big(2g_p^2Q_{e_9}Q_{H_u} + g_1^2\Big)\sum_{a=1}^{2} Z^{E,*}_{k4+a}Z^{E}_{l4+a}\\
&- g_1^2Z^{E,*}_{k1}Z^{E}_{l1} + g_2^2Z^{E,*}_{k1}Z^{E}_{l1} + 4g_p^2Q_{H_u}Q_{l_4}Z^{E,*}_{k1}Z^{E}_{l1} + 2g_1^2Z^{E,*}_{k4}Z^{E}_{l4}\\
&+ 4g_p^2Q_{e_4}Q_{H_u}Z^{E,*}_{k4}Z^{E}_{l4}\Big)\Big)\Big)
\end{aligned} \tag{403}$$

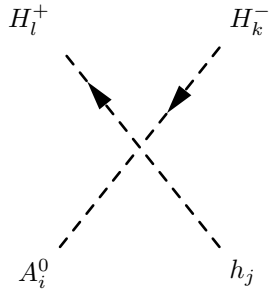


$$
\begin{aligned}
&-\frac{i}{12}\delta_{\gamma\delta}\Big(6Z^{A,*}_{i3}\Big(2g_p^2Q_sZ^{A,*}_{j3}\Big(Q_q\sum_{a=1}^{3}Z^{U,*}_{ka}Z^{U}_{la}+Q_u\sum_{a=1}^{3}Z^{U,*}_{k3+a}Z^{U}_{l3+a}\Big)\\
&+\lambda Z^{A,*}_{j1}\Big(\sum_{b=1}^{3}Z^{U,*}_{kb}\sum_{a=1}^{3}Y_{u,ab}Z^{U}_{l3+a}+\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{u,ab}Z^{U,*}_{k3+a}Z^{U}_{lb}\Big)\Big)\\
&+Z^{A,*}_{i1}\Big(Z^{A,*}_{j1}\Big(\Big(12g_p^2Q_{H_d}Q_q+3g_2^2-g_1^2\Big)\sum_{a=1}^{3}Z^{U,*}_{ka}Z^{U}_{la}+4\Big(3g_p^2Q_{H_d}Q_u+g_1^2\Big)\sum_{a=1}^{3}Z^{U,*}_{k3+a}Z^{U}_{l3+a}\Big)\\
&+6\lambda Z^{A,*}_{j3}\Big(\sum_{b=1}^{3}Z^{U,*}_{kb}\sum_{a=1}^{3}Y_{u,ab}Z^{U}_{l3+a}+\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{u,ab}Z^{U,*}_{k3+a}Z^{U}_{lb}\Big)\Big)\\
&+Z^{A,*}_{i2}Z^{A,*}_{j2}\Big(\Big(12g_p^2Q_{H_u}Q_q-3g_2^2+g_1^2\Big)\sum_{a=1}^{3}Z^{U,*}_{ka}Z^{U}_{la}-4\Big(-3g_p^2Q_{H_u}Q_u+g_1^2\Big)\sum_{a=1}^{3}Z^{U,*}_{k3+a}Z^{U}_{l3+a}\\
&+12\Big(\sum_{c=1}^{3}Z^{U,*}_{k3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{u,ca}Y_{u,ba}Z^{U}_{l3+b}+\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{U,*}_{kb}\sum_{a=1}^{3}Y^*_{u,ac}Y_{u,ab}Z^{U}_{lc}\Big)\Big)\Big)
\end{aligned}
\tag{404}
$$

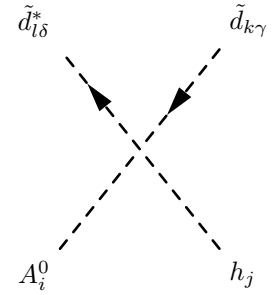


$$
\begin{aligned}
&-\frac{i}{4}\Big(4g_p^2Q_sZ^{A,*}_{i3}Z^{A,*}_{j3}\Big(Q_{l_4}Z^{V,*}_{k1}Z^{V}_{l1}+Q_{l_9}\sum_{a=1}^{2}Z^{V,*}_{k1+a}Z^{V}_{l1+a}\Big)\\
&+Z^{A,*}_{i1}Z^{A,*}_{j1}\Big(\Big(4g_p^2Q_{H_d}Q_{l_4}+g_1^2+g_2^2\Big)Z^{V,*}_{k1}Z^{V}_{l1}+\Big(4g_p^2Q_{H_d}Q_{l_9}+g_1^2+g_2^2\Big)\sum_{a=1}^{2}Z^{V,*}_{k1+a}Z^{V}_{l1+a}\Big)
\end{aligned}
$$

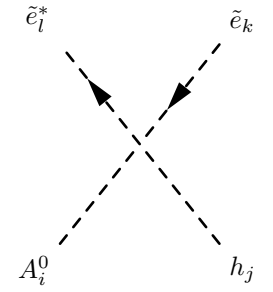
$$- Z_{i2}^{A,*} Z_{j2}^{A,*} \Big(\Big(- 4 g_p^2 Q_{H_u} Q_{l_4} + g_1^2 + g_2^2 \Big) Z_{k1}^{V,*} Z_{l1}^{V} + \Big(- 4 g_p^2 Q_{H_u} Q_{l_9} + g_1^2 + g_2^2 \Big) \sum_{a=1}^{2} Z_{k1+a}^{V,*} Z_{l1+a}^{V} \Big) \Big) \tag{405}$$



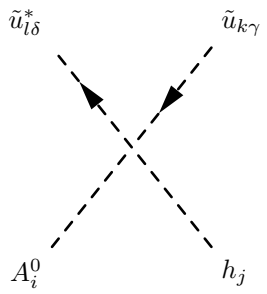
$$\frac{1}{4} \Big(- 2\lambda^2 + g_2^2 \Big) \Big(Z_{i1}^{A,*} Z_{j2}^{H,*} + Z_{i2}^{A,*} Z_{j1}^{H,*} \Big) \Big(- Z_{k1}^{+} Z_{l2}^{+} + Z_{k2}^{+} Z_{l1}^{+} \Big) \tag{406}$$



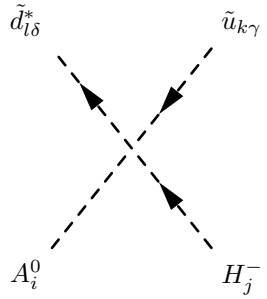
$$\frac{1}{2} \lambda \Big(Z_{i2}^{A,*} Z_{j3}^{H,*} + Z_{i3}^{A,*} Z_{j2}^{H,*} \Big) \delta_{\gamma\delta} \Big(- \sum_{b=1}^{3} \sum_{a=1}^{3} Y_{d,ab}^{*} Z_{k3+a}^{D,*} Z_{lb}^{D} + \sum_{b=1}^{3} Z_{kb}^{D,*} \sum_{a=1}^{3} Y_{d,ab} Z_{l3+a}^{D} \Big) \tag{407}$$



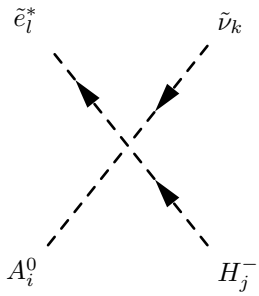
$$\frac{1}{2}\lambda\Big(Z^{A,*}_{i2}Z^{H,*}_{j3}+Z^{A,*}_{i3}Z^{H,*}_{j2}\Big)\Big(-\sum_{b=1}^{2}\sum_{a=1}^{2}Y2^{*}_{ab}Z^{E,*}_{k4+a}Z^{E}_{l1+b}+Y1Z^{E,*}_{k1}Z^{E}_{l4}-Y1^{*}Z^{E,*}_{k4}Z^{E}_{l1}+\sum_{b=1}^{2}Z^{E,*}_{k1+b}\sum_{a=1}^{2}Y2_{ab}Z^{E}_{l4+a}\Big) \tag{408}$$



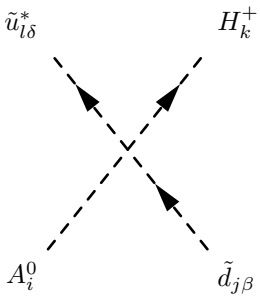
$$\frac{1}{2}\lambda\Big(Z^{A,*}_{i1}Z^{H,*}_{j3}+Z^{A,*}_{i3}Z^{H,*}_{j1}\Big)\delta_{\gamma\delta}\Big(-\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{u,ab}Z^{U,*}_{k3+a}Z^{U}_{lb}+\sum_{b=1}^{3}Z^{U,*}_{kb}\sum_{a=1}^{3}Y_{u,ab}Z^{U}_{l3+a}\Big) \tag{409}$$



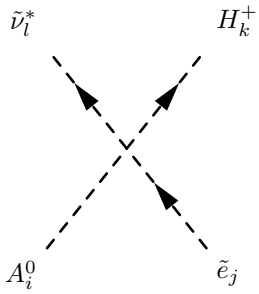
$$\begin{aligned}
&\frac{1}{2}\frac{1}{\sqrt{2}}\delta_{\gamma\delta}\Big(Z^{A,*}_{i3}\Big(-2\lambda\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{u,ab}Z^{U,*}_{k3+a}Z^{D}_{lb}Z^{+}_{j1}+2\lambda\sum_{b=1}^{3}Z^{U,*}_{kb}\sum_{a=1}^{3}Y_{d,ab}Z^{D}_{l3+a}Z^{+}_{j2}\Big)\\
&-Z^{A,*}_{i1}\Big(g_2^2\sum_{a=1}^{3}Z^{U,*}_{ka}Z^{D}_{la}Z^{+}_{j1}-2\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{U,*}_{kb}\sum_{a=1}^{3}Y^{*}_{d,ac}Y_{d,ab}Z^{D}_{lc}Z^{+}_{j1}\\
&+2\sum_{c=1}^{3}Z^{U,*}_{k3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{u,ca}Y_{d,ba}Z^{D}_{l3+b}Z^{+}_{j2}\Big)\\
&+Z^{A,*}_{i2}\Big(2\sum_{c=1}^{3}Z^{U,*}_{k3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{u,ca}Y_{d,ba}Z^{D}_{l3+b}Z^{+}_{j1}\\
&+\Big(-2\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{U,*}_{kb}\sum_{a=1}^{3}Y^{*}_{u,ac}Y_{u,ab}Z^{D}_{lc}+g_2^2\sum_{a=1}^{3}Z^{U,*}_{ka}Z^{D}_{la}\Big)Z^{+}_{j2}\Big)\Big)
\end{aligned} \tag{410}$$



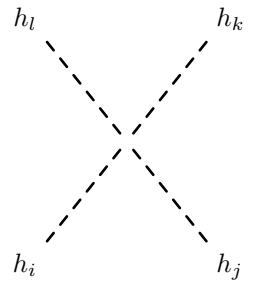
$$\frac{1}{2}\frac{1}{\sqrt{2}}\Big(-Z_{i1}^{A,*}\Big(-2\sum_{c=1}^{2}\sum_{b=1}^{2}Z_{k1+b}^{V,*}\sum_{a=1}^{2}Y2_{ac}^{*}Y2_{ab}Z_{l1+c}^{E}+\Big(-2|Y1|^2+g_2^2\Big)Z_{k1}^{V,*}Z_{l1}^{E}+g_2^2\sum_{a=1}^{2}Z_{k1+a}^{V,*}Z_{l1+a}^{E}\Big)Z_{j1}^{+}$$
$$+\Big(2\lambda Z_{i3}^{A,*}\Big(Y1Z_{k1}^{V,*}Z_{l4}^{E}+\sum_{b=1}^{2}Z_{k1+b}^{V,*}\sum_{a=1}^{2}Y2_{ab}Z_{l4+a}^{E}\Big)+g_2^2Z_{i2}^{A,*}\Big(Z_{k1}^{V,*}Z_{l1}^{E}+\sum_{a=1}^{2}Z_{k1+a}^{V,*}Z_{l1+a}^{E}\Big)\Big)Z_{j2}^{+}\Big) \tag{411}$$



$$\frac{1}{2}\frac{1}{\sqrt{2}}\delta_{\beta\delta}\Big(2\lambda Z_{i3}^{A,*}\Big(-\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{d,ab}^{*}Z_{j3+a}^{D,*}Z_{lb}^{U}Z_{k2}^{+}+\sum_{b=1}^{3}Z_{jb}^{D,*}\sum_{a=1}^{3}Y_{u,ab}Z_{l3+a}^{U}Z_{k1}^{+}\Big)$$
$$+Z_{i1}^{A,*}\Big(g_2^2\sum_{a=1}^{3}Z_{ja}^{D,*}Z_{la}^{U}Z_{k1}^{+}-2\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{jb}^{D,*}\sum_{a=1}^{3}Y_{d,ac}^{*}Y_{d,ab}Z_{lc}^{U}Z_{k1}^{+}$$
$$+2\sum_{c=1}^{3}Z_{j3+c}^{D,*}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{d,ca}^{*}Y_{u,ba}Z_{l3+b}^{U}Z_{k2}^{+}\Big)$$
$$-Z_{i2}^{A,*}\Big(2\sum_{c=1}^{3}Z_{j3+c}^{D,*}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{d,ca}^{*}Y_{u,ba}Z_{l3+b}^{U}Z_{k1}^{+}$$
$$+\Big(-2\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{jb}^{D,*}\sum_{a=1}^{3}Y_{u,ac}^{*}Y_{u,ab}Z_{lc}^{U}+g_2^2\sum_{a=1}^{3}Z_{ja}^{D,*}Z_{la}^{U}\Big)Z_{k2}^{+}\Big)\Big) \tag{412}$$

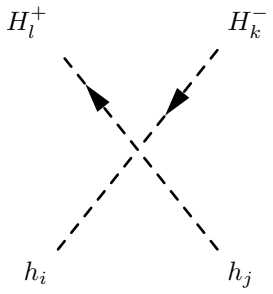


$$\frac{1}{2}\frac{1}{\sqrt{2}}\Big(Z_{i1}^{A,*}Z_{k1}^{+}\Big(-2\sum_{c=1}^{2}\sum_{b=1}^{2}Z_{j1+b}^{E,*}\sum_{a=1}^{2}Y2_{ac}^{*}Y2_{ab}Z_{l1+c}^{V}+\Big(-2|Y1|^2+g_2^2\Big)Z_{j1}^{E,*}Z_{l1}^{V}+g_2^2\sum_{a=1}^{2}Z_{j1+a}^{E,*}Z_{l1+a}^{V}\Big)$$
$$-Z_{k2}^{+}\Big(2\lambda Z_{i3}^{A,*}\Big(Y1^{*}Z_{j4}^{E,*}Z_{l1}^{V}+\sum_{b=1}^{2}\sum_{a=1}^{2}Y2_{ab}^{*}Z_{j4+a}^{E,*}Z_{l1+b}^{V}\Big)+g_2^2Z_{i2}^{A,*}\Big(Z_{j1}^{E,*}Z_{l1}^{V}+\sum_{a=1}^{2}Z_{j1+a}^{E,*}Z_{l1+a}^{V}\Big)\Big)\Big) \tag{413}$$

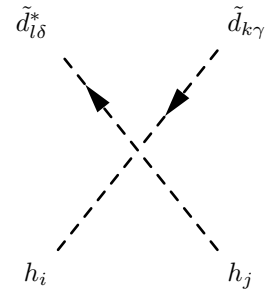


$$-\frac{i}{4}\Big(4Z_{i3}^{H,*}\Big(\Big(g_p^2Q_{H_d}Q_s+\lambda^2\Big)Z_{j1}^{H,*}\Big(Z_{k1}^{H,*}Z_{l3}^{H,*}+Z_{k3}^{H,*}Z_{l1}^{H,*}\Big)$$
$$+\Big(g_p^2Q_{H_u}Q_s+\lambda^2\Big)Z_{j2}^{H,*}\Big(Z_{k2}^{H,*}Z_{l3}^{H,*}+Z_{k3}^{H,*}Z_{l2}^{H,*}\Big)$$
$$+Z_{j3}^{H,*}\Big(3g_p^2Q_s^2Z_{k3}^{H,*}Z_{l3}^{H,*}+\Big(g_p^2Q_{H_d}Q_s+\lambda^2\Big)Z_{k1}^{H,*}Z_{l1}^{H,*}+\Big(g_p^2Q_{H_u}Q_s+\lambda^2\Big)Z_{k2}^{H,*}Z_{l2}^{H,*}\Big)\Big)$$
$$+Z_{i1}^{H,*}\Big(-\Big(-4\Big(g_p^2Q_{H_d}Q_{H_u}+\lambda^2\Big)+g_1^2+g_2^2\Big)Z_{j2}^{H,*}\Big(Z_{k1}^{H,*}Z_{l2}^{H,*}+Z_{k2}^{H,*}Z_{l1}^{H,*}\Big)$$
$$+4\Big(g_p^2Q_{H_d}Q_s+\lambda^2\Big)Z_{j3}^{H,*}\Big(Z_{k1}^{H,*}Z_{l3}^{H,*}+Z_{k3}^{H,*}Z_{l1}^{H,*}\Big)$$
$$+Z_{j1}^{H,*}\Big(3\Big(4g_p^2Q_{H_d}^2+g_1^2+g_2^2\Big)Z_{k1}^{H,*}Z_{l1}^{H,*}-\Big(-4\Big(g_p^2Q_{H_d}Q_{H_u}+\lambda^2\Big)+g_1^2+g_2^2\Big)Z_{k2}^{H,*}Z_{l2}^{H,*}$$
$$+4\Big(g_p^2Q_{H_d}Q_s+\lambda^2\Big)Z_{k3}^{H,*}Z_{l3}^{H,*}\Big)\Big)$$
$$+Z_{i2}^{H,*}\Big(-\Big(-4\Big(g_p^2Q_{H_d}Q_{H_u}+\lambda^2\Big)+g_1^2+g_2^2\Big)Z_{j1}^{H,*}\Big(Z_{k1}^{H,*}Z_{l2}^{H,*}+Z_{k2}^{H,*}Z_{l1}^{H,*}\Big)$$
$$+4\Big(g_p^2Q_{H_u}Q_s+\lambda^2\Big)Z_{j3}^{H,*}\Big(Z_{k2}^{H,*}Z_{l3}^{H,*}+Z_{k3}^{H,*}Z_{l2}^{H,*}\Big)$$

$$+ Z_{j2}^{H,*}\Big(- \Big(- 4\Big(g_p^2 Q_{H_d} Q_{H_u} + \lambda^2\Big) + g_1^2 + g_2^2\Big) Z_{k1}^{H,*} Z_{l1}^{H,*} + 3\Big(4 g_p^2 Q_{H_u}^2 + g_1^2 + g_2^2\Big) Z_{k2}^{H,*} Z_{l2}^{H,*}$$
$$+ 4\Big(g_p^2 Q_{H_u} Q_s + \lambda^2\Big) Z_{k3}^{H,*} Z_{l3}^{H,*}\Big)\Big) \tag{414}$$

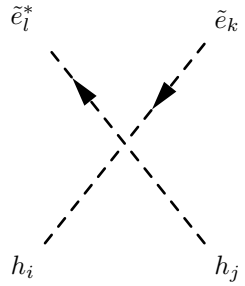


$$- \frac{i}{4}\Big(4 Z_{i3}^{H,*} Z_{j3}^{H,*}\Big(\Big(g_p^2 Q_{H_d} Q_s + \lambda^2\Big) Z_{k1}^{+} Z_{l1}^{+} + \Big(g_p^2 Q_{H_u} Q_s + \lambda^2\Big) Z_{k2}^{+} Z_{l2}^{+}\Big)$$
$$+ Z_{i1}^{H,*}\Big(\Big(- 2\lambda^2 + g_2^2\Big) Z_{j2}^{H,*}\Big(Z_{k1}^{+} Z_{l2}^{+} + Z_{k2}^{+} Z_{l1}^{+}\Big)$$
$$+ Z_{j1}^{H,*}\Big(\Big(4 g_p^2 Q_{H_d}^2 + g_1^2 + g_2^2\Big) Z_{k1}^{+} Z_{l1}^{+} + \Big(4 g_p^2 Q_{H_d} Q_{H_u} - g_1^2 + g_2^2\Big) Z_{k2}^{+} Z_{l2}^{+}\Big)\Big)$$
$$+ Z_{i2}^{H,*}\Big(\Big(- 2\lambda^2 + g_2^2\Big) Z_{j1}^{H,*}\Big(Z_{k1}^{+} Z_{l2}^{+} + Z_{k2}^{+} Z_{l1}^{+}\Big)$$
$$+ Z_{j2}^{H,*}\Big(\Big(4 g_p^2 Q_{H_d} Q_{H_u} - g_1^2 + g_2^2\Big) Z_{k1}^{+} Z_{l1}^{+} + \Big(4 g_p^2 Q_{H_u}^2 + g_1^2 + g_2^2\Big) Z_{k2}^{+} Z_{l2}^{+}\Big)\Big)\Big) \tag{415}$$



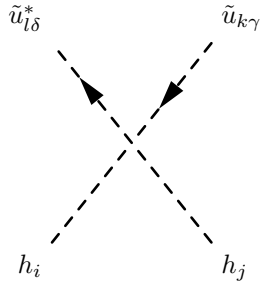
$$\frac{i}{12}\delta_{\gamma\delta}\Big(6 Z_{i3}^{H,*}\Big(- 2 g_p^2 Q_s Z_{j3}^{H,*}\Big(Q_d \sum_{a=1}^{3} Z_{k3+a}^{D,*} Z_{l3+a}^{D} + Q_q \sum_{a=1}^{3} Z_{ka}^{D,*} Z_{la}^{D}\Big)$$
$$+ \lambda Z_{j2}^{H,*}\Big(\sum_{b=1}^{3} Z_{kb}^{D,*} \sum_{a=1}^{3} Y_{d,ab} Z_{l3+a}^{D} + \sum_{b=1}^{3}\sum_{a=1}^{3} Y_{d,ab}^{*} Z_{k3+a}^{D,*} Z_{lb}^{D}\Big)\Big)$$
$$- Z_{i2}^{H,*}\Big(Z_{j2}^{H,*}\Big(\Big(12 g_p^2 Q_{H_u} Q_q + 3 g_2^2 + g_1^2\Big) \sum_{a=1}^{3} Z_{ka}^{D,*} Z_{la}^{D} + 2\Big(6 g_p^2 Q_d Q_{H_u} + g_1^2\Big) \sum_{a=1}^{3} Z_{k3+a}^{D,*} Z_{l3+a}^{D}\Big)$$

$$
\begin{aligned}
&- 6\lambda Z_{j3}^{H,*}\Big(\sum_{b=1}^{3} Z_{kb}^{D,*}\sum_{a=1}^{3} Y_{d,ab} Z_{l3+a}^{D} + \sum_{b=1}^{3}\sum_{a=1}^{3} Y_{d,ab}^{*} Z_{k3+a}^{D,*} Z_{lb}^{D}\Big)\Big)\\
&+ Z_{i1}^{H,*} Z_{j1}^{H,*}\Big(\Big(3\Big(-4g_p^2 Q_{H_d} Q_q + g_2^2\Big) + g_1^2\Big)\sum_{a=1}^{3} Z_{ka}^{D,*} Z_{la}^{D}\\
&+ 2\Big(\Big(-6g_p^2 Q_d Q_{H_d} + g_1^2\Big)\sum_{a=1}^{3} Z_{k3+a}^{D,*} Z_{l3+a}^{D}\\
&- 6\Big(\sum_{c=1}^{3} Z_{k3+c}^{D,*}\sum_{b=1}^{3}\sum_{a=1}^{3} Y_{d,ca}^{*} Y_{d,ba} Z_{l3+b}^{D} + \sum_{c=1}^{3}\sum_{b=1}^{3} Z_{kb}^{D,*}\sum_{a=1}^{3} Y_{d,ac}^{*} Y_{d,ab} Z_{lc}^{D}\Big)\Big)\Big)\Big)
\end{aligned}
\tag{416}
$$

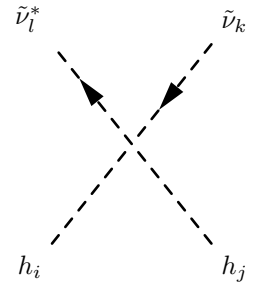


$$
\begin{aligned}
&- \frac{i}{4}\Big(Z_{i1}^{H,*} Z_{j1}^{H,*}\Big(\Big(4g_p^2 Q_{H_d} Q_{l_9} - g_2^2 + g_1^2\Big)\sum_{a=1}^{2} Z_{k1+a}^{E,*} Z_{l1+a}^{E} - 2\Big(-2g_p^2 Q_{e_9} Q_{H_d} + g_1^2\Big)\sum_{a=1}^{2} Z_{k4+a}^{E,*} Z_{l4+a}^{E}\\
&+ 4\sum_{c=1}^{2} Z_{k4+c}^{E,*}\sum_{b=1}^{2}\sum_{a=1}^{2} Y2_{ca}^{*} Y2_{ba} Z_{l4+b}^{E} + 4\sum_{c=1}^{2}\sum_{b=1}^{2} Z_{k1+b}^{E,*}\sum_{a=1}^{2} Y2_{ac}^{*} Y2_{ab} Z_{l1+c}^{E} + g_1^2 Z_{k1}^{E,*} Z_{l1}^{E}\\
&- g_2^2 Z_{k1}^{E,*} Z_{l1}^{E} + 4g_p^2 Q_{H_d} Q_{l_4} Z_{k1}^{E,*} Z_{l1}^{E} + 4|Y1|^2 Z_{k1}^{E,*} Z_{l1}^{E} - 2g_1^2 Z_{k4}^{E,*} Z_{l4}^{E}\\
&+ 4g_p^2 Q_{e_4} Q_{H_d} Z_{k4}^{E,*} Z_{l4}^{E} + 4|Y1|^2 Z_{k4}^{E,*} Z_{l4}^{E}\Big)\\
&+ 2Z_{i3}^{H,*}\Big(-\lambda Z_{j2}^{H,*}\Big(Y1 Z_{k1}^{E,*} Z_{l4}^{E} + Y1^{*} Z_{k4}^{E,*} Z_{l1}^{E} + \sum_{b=1}^{2} Z_{k1+b}^{E,*}\sum_{a=1}^{2} Y2_{ab} Z_{l4+a}^{E} + \sum_{b=1}^{2}\sum_{a=1}^{2} Y2_{ab}^{*} Z_{k4+a}^{E,*} Z_{l1+b}^{E}\Big)\\
&+ 2g_p^2 Q_s Z_{j3}^{H,*}\Big(Q_{e_4} Z_{k4}^{E,*} Z_{l4}^{E} + Q_{e_9}\sum_{a=1}^{2} Z_{k4+a}^{E,*} Z_{l4+a}^{E} + Q_{l_4} Z_{k1}^{E,*} Z_{l1}^{E} + Q_{l_9}\sum_{a=1}^{2} Z_{k1+a}^{E,*} Z_{l1+a}^{E}\Big)\Big)\\
&+ Z_{i2}^{H,*}\Big(-2\lambda Z_{j3}^{H,*}\Big(Y1 Z_{k1}^{E,*} Z_{l4}^{E} + Y1^{*} Z_{k4}^{E,*} Z_{l1}^{E} + \sum_{b=1}^{2} Z_{k1+b}^{E,*}\sum_{a=1}^{2} Y2_{ab} Z_{l4+a}^{E} + \sum_{b=1}^{2}\sum_{a=1}^{2} Y2_{ab}^{*} Z_{k4+a}^{E,*} Z_{l1+b}^{E}\Big)\\
&+ Z_{j2}^{H,*}\Big(\Big(4g_p^2 Q_{H_u} Q_{l_9} - g_1^2 + g_2^2\Big)\sum_{a=1}^{2} Z_{k1+a}^{E,*} Z_{l1+a}^{E} + 2\Big(2g_p^2 Q_{e_9} Q_{H_u} + g_1^2\Big)\sum_{a=1}^{2} Z_{k4+a}^{E,*} Z_{l4+a}^{E}\\
&- g_1^2 Z_{k1}^{E,*} Z_{l1}^{E} + g_2^2 Z_{k1}^{E,*} Z_{l1}^{E} + 4g_p^2 Q_{H_u} Q_{l_4} Z_{k1}^{E,*} Z_{l1}^{E} + 2g_1^2 Z_{k4}^{E,*} Z_{l4}^{E}
\end{aligned}
$$

$$+ 4g_p^2 Q_{e_4} Q_{H_u} Z_{k4}^{E,*} Z_{l4}^{E}\Big)\Big)\Big) \tag{417}$$



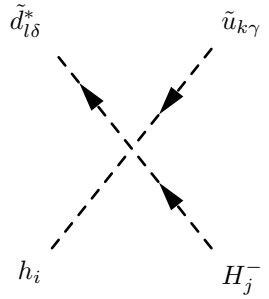
$$\begin{aligned}
&\frac{i}{12}\delta_{\gamma\delta}\Big(6Z_{i3}^{H,*}\Big(-2g_p^2 Q_s Z_{j3}^{H,*}\Big(Q_q\sum_{a=1}^{3} Z_{ka}^{U,*} Z_{la}^{U} + Q_u\sum_{a=1}^{3} Z_{k3+a}^{U,*} Z_{l3+a}^{U}\Big)\\
&+\lambda Z_{j1}^{H,*}\Big(\sum_{b=1}^{3} Z_{kb}^{U,*}\sum_{a=1}^{3} Y_{u,ab} Z_{l3+a}^{U} + \sum_{b=1}^{3}\sum_{a=1}^{3} Y_{u,ab}^{*} Z_{k3+a}^{U,*} Z_{lb}^{U}\Big)\Big)\\
&+ Z_{i1}^{H,*}\Big(Z_{j1}^{H,*}\Big(\Big(-3\Big(4g_p^2 Q_{H_d} Q_q + g_2^2\Big) + g_1^2\Big)\sum_{a=1}^{3} Z_{ka}^{U,*} Z_{la}^{U} - 4\Big(3g_p^2 Q_{H_d} Q_u + g_1^2\Big)\sum_{a=1}^{3} Z_{k3+a}^{U,*} Z_{l3+a}^{U}\Big)\\
&+ 6\lambda Z_{j3}^{H,*}\Big(\sum_{b=1}^{3} Z_{kb}^{U,*}\sum_{a=1}^{3} Y_{u,ab} Z_{l3+a}^{U} + \sum_{b=1}^{3}\sum_{a=1}^{3} Y_{u,ab}^{*} Z_{k3+a}^{U,*} Z_{lb}^{U}\Big)\Big)\\
&- Z_{i2}^{H,*} Z_{j2}^{H,*}\Big(\Big(12g_p^2 Q_{H_u} Q_q - 3g_2^2 + g_1^2\Big)\sum_{a=1}^{3} Z_{ka}^{U,*} Z_{la}^{U} - 4\Big(-3g_p^2 Q_{H_u} Q_u + g_1^2\Big)\sum_{a=1}^{3} Z_{k3+a}^{U,*} Z_{l3+a}^{U}\\
&+ 12\Big(\sum_{c=1}^{3} Z_{k3+c}^{U,*}\sum_{b=1}^{3}\sum_{a=1}^{3} Y_{u,ca}^{*} Y_{u,ba} Z_{l3+b}^{U} + \sum_{c=1}^{3}\sum_{b=1}^{3} Z_{kb}^{U,*}\sum_{a=1}^{3} Y_{u,ac}^{*} Y_{u,ab} Z_{lc}^{U}\Big)\Big)\Big)
\end{aligned} \tag{418}$$



$$-\frac{i}{4}\Big(4g_p^2 Q_s Z_{i3}^{H,*} Z_{j3}^{H,*}\Big(Q_{l_4} Z_{k1}^{V,*} Z_{l1}^{V} + Q_{l_9}\sum_{a=1}^{2} Z_{k1+a}^{V,*} Z_{l1+a}^{V}\Big)$$

$$+ Z_{i1}^{H,*} Z_{j1}^{H,*} \Big(\Big(4 g_p^2 Q_{H_d} Q_{l_4} + g_1^2 + g_2^2 \Big) Z_{k1}^{V,*} Z_{l1}^{V} + \Big(4 g_p^2 Q_{H_d} Q_{l_9} + g_1^2 + g_2^2 \Big) \sum_{a=1}^{2} Z_{k1+a}^{V,*} Z_{l1+a}^{V} \Big)$$

$$- Z_{i2}^{H,*} Z_{j2}^{H,*} \Big(\Big(- 4 g_p^2 Q_{H_u} Q_{l_4} + g_1^2 + g_2^2 \Big) Z_{k1}^{V,*} Z_{l1}^{V} + \Big(- 4 g_p^2 Q_{H_u} Q_{l_9} + g_1^2 + g_2^2 \Big) \sum_{a=1}^{2} Z_{k1+a}^{V,*} Z_{l1+a}^{V} \Big) \Big) \tag{419}$$



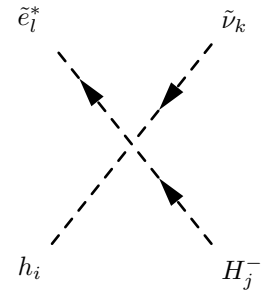
$$\frac{i}{2} \frac{1}{\sqrt{2}} \delta_{\gamma\delta} \Big(2 \lambda Z_{i3}^{H,*} \Big(\sum_{b=1}^{3} \sum_{a=1}^{3} Y_{u,ab}^{*} Z_{k3+a}^{U,*} Z_{lb}^{D} Z_{j1}^{+} + \sum_{b=1}^{3} Z_{kb}^{U,*} \sum_{a=1}^{3} Y_{d,ab} Z_{l3+a}^{D} Z_{j2}^{+} \Big)$$

$$+ Z_{i1}^{H,*} \Big(- g_2^2 \sum_{a=1}^{3} Z_{ka}^{U,*} Z_{la}^{D} Z_{j1}^{+} + 2 \sum_{c=1}^{3} \sum_{b=1}^{3} Z_{kb}^{U,*} \sum_{a=1}^{3} Y_{d,ac}^{*} Y_{d,ab} Z_{lc}^{D} Z_{j1}^{+}$$

$$+ 2 \sum_{c=1}^{3} Z_{k3+c}^{U,*} \sum_{b=1}^{3} \sum_{a=1}^{3} Y_{u,ca}^{*} Y_{d,ba} Z_{l3+b}^{D} Z_{j2}^{+} \Big)$$

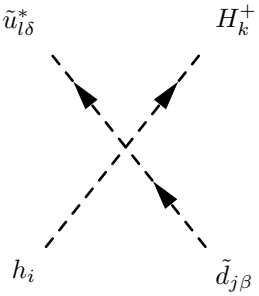
$$+ Z_{i2}^{H,*} \Big(2 \sum_{c=1}^{3} Z_{k3+c}^{U,*} \sum_{b=1}^{3} \sum_{a=1}^{3} Y_{u,ca}^{*} Y_{d,ba} Z_{l3+b}^{D} Z_{j1}^{+}$$

$$+ \Big(2 \sum_{c=1}^{3} \sum_{b=1}^{3} Z_{kb}^{U,*} \sum_{a=1}^{3} Y_{u,ac}^{*} Y_{u,ab} Z_{lc}^{D} - g_2^2 \sum_{a=1}^{3} Z_{ka}^{U,*} Z_{la}^{D} \Big) Z_{j2}^{+} \Big) \Big) \tag{420}$$

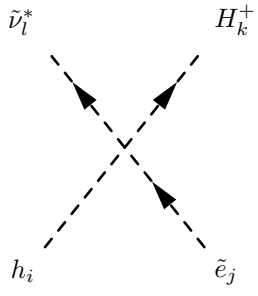


$$- \frac{i}{2} \frac{1}{\sqrt{2}} \Big(Z_{i1}^{H,*} \Big(- 2 \sum_{c=1}^{2} \sum_{b=1}^{2} Z_{k1+b}^{V,*} \sum_{a=1}^{2} Y2_{ac}^{*} Y2_{ab} Z_{l1+c}^{E} + \Big(- 2 |Y1|^2 + g_2^2 \Big) Z_{k1}^{V,*} Z_{l1}^{E} + g_2^2 \sum_{a=1}^{2} Z_{k1+a}^{V,*} Z_{l1+a}^{E} \Big) Z_{j1}^{+}$$

$$+\Big(-2\lambda Z^{H,*}_{i3}\Big(Y1Z^{V,*}_{k1}Z^{E}_{l4}+\sum_{b=1}^{2}Z^{V,*}_{k1+b}\sum_{a=1}^{2}Y2_{ab}Z^{E}_{l4+a}\Big)+g_2^2Z^{H,*}_{i2}\Big(Z^{V,*}_{k1}Z^{E}_{l1}+\sum_{a=1}^{2}Z^{V,*}_{k1+a}Z^{E}_{l1+a}\Big)\Big)Z^{+}_{j2}\Big) \tag{421}$$

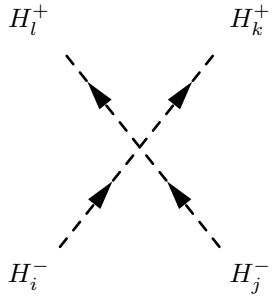


$$\begin{aligned}
&\frac{i}{2}\frac{1}{\sqrt{2}}\delta_{\beta\delta}\Big(2\lambda Z^{H,*}_{i3}\Big(\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{d,ab}Z^{D,*}_{j3+a}Z^{U}_{lb}Z^{+}_{k2}+\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}Y_{u,ab}Z^{U}_{l3+a}Z^{+}_{k1}\Big)\\
&+Z^{H,*}_{i1}\Big(-g_2^2\sum_{a=1}^{3}Z^{D,*}_{ja}Z^{U}_{la}Z^{+}_{k1}+2\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}Y^*_{d,ac}Y_{d,ab}Z^{U}_{lc}Z^{+}_{k1}\\
&+2\sum_{c=1}^{3}Z^{D,*}_{j3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{d,ca}Y_{u,ba}Z^{U}_{l3+b}Z^{+}_{k2}\Big)\\
&+Z^{H,*}_{i2}\Big(2\sum_{c=1}^{3}Z^{D,*}_{j3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^*_{d,ca}Y_{u,ba}Z^{U}_{l3+b}Z^{+}_{k1}\\
&+\Big(2\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}Y^*_{u,ac}Y_{u,ab}Z^{U}_{lc}-g_2^2\sum_{a=1}^{3}Z^{D,*}_{ja}Z^{U}_{la}\Big)Z^{+}_{k2}\Big)\Big)
\end{aligned} \tag{422}$$

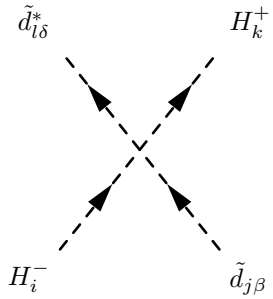


$$-\frac{i}{2}\frac{1}{\sqrt{2}}\Big(Z^{H,*}_{i1}Z^{+}_{k1}\Big(-2\sum_{c=1}^{2}\sum_{b=1}^{2}Z^{E,*}_{j1+b}\sum_{a=1}^{2}Y2^*_{ac}Y2_{ab}Z^{V}_{l1+c}+\Big(-2|Y1|^2+g_2^2\Big)Z^{E,*}_{j1}Z^{V}_{l1}+g_2^2\sum_{a=1}^{2}Z^{E,*}_{j1+a}Z^{V}_{l1+a}\Big)$$

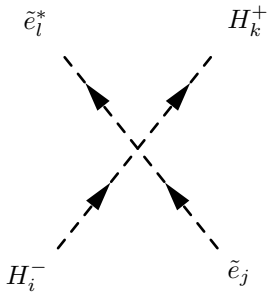
$$+ Z^{+}_{k2}\Big(- 2\lambda Z^{H,*}_{i3}\Big(Y1^{*} Z^{E,*}_{j4} Z^{V}_{l1} + \sum_{b=1}^{2}\sum_{a=1}^{2} Y2^{*}_{ab} Z^{E,*}_{j4+a} Z^{V}_{l1+b}\Big) + g_2^2 Z^{H,*}_{i2}\Big(Z^{E,*}_{j1} Z^{V}_{l1} + \sum_{a=1}^{2} Z^{E,*}_{j1+a} Z^{V}_{l1+a}\Big)\Big)\Big) \tag{423}$$



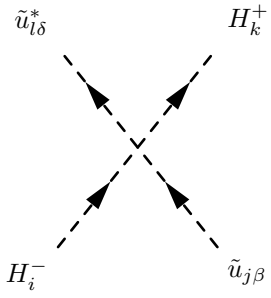
$$\begin{aligned}
&- \frac{i}{4}\Big(Z^{+}_{i2}\Big(2\Big(4g_p^2 Q_{H_u}^2 + g_1^2 + g_2^2\Big) Z^{+}_{j2} Z^{+}_{k2} Z^{+}_{l2} \\
&- \Big(- 4\Big(g_p^2 Q_{H_d} Q_{H_u} + \lambda^2\Big) + g_1^2 + g_2^2\Big) Z^{+}_{j1}\Big(Z^{+}_{k1} Z^{+}_{l2} + Z^{+}_{k2} Z^{+}_{l1}\Big)\Big) \\
&+ Z^{+}_{i1}\Big(2\Big(4g_p^2 Q_{H_d}^2 + g_1^2 + g_2^2\Big) Z^{+}_{j1} Z^{+}_{k1} Z^{+}_{l1} \\
&- \Big(- 4\Big(g_p^2 Q_{H_d} Q_{H_u} + \lambda^2\Big) + g_1^2 + g_2^2\Big) Z^{+}_{j2}\Big(Z^{+}_{k1} Z^{+}_{l2} + Z^{+}_{k2} Z^{+}_{l1}\Big)\Big)\Big)
\end{aligned} \tag{424}$$



$$\begin{aligned}
&\frac{i}{12}\delta_{\beta\delta}\Big(\sum_{a=1}^{3} Z^{D,*}_{ja} Z^{D}_{la}\Big(- \Big(12g_p^2 Q_{H_u} Q_q - 3g_2^2 + g_1^2\Big) Z^{+}_{i2} Z^{+}_{k2} + \Big(- 3\Big(4g_p^2 Q_{H_d} Q_q + g_2^2\Big) + g_1^2\Big) Z^{+}_{i1} Z^{+}_{k1}\Big) \\
&+ 2\Big(\sum_{a=1}^{3} Z^{D,*}_{j3+a} Z^{D}_{l3+a}\Big(\Big(- 6g_p^2 Q_d Q_{H_d} + g_1^2\Big) Z^{+}_{i1} Z^{+}_{k1} - \Big(6g_p^2 Q_d Q_{H_u} + g_1^2\Big) Z^{+}_{i2} Z^{+}_{k2}\Big) \\
&- 6\Big(\sum_{c=1}^{3}\sum_{b=1}^{3} Z^{D,*}_{jb} \sum_{a=1}^{3} Y^{*}_{u,ac} Y_{u,ab} Z^{D}_{lc} Z^{+}_{i2} Z^{+}_{k2} + \sum_{c=1}^{3} Z^{D,*}_{j3+c} \sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{d,ca} Y_{d,ba} Z^{D}_{l3+b} Z^{+}_{i1} Z^{+}_{k1}\Big)\Big)\Big)
\end{aligned} \tag{425}$$

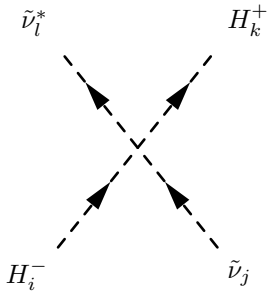


$$
\begin{aligned}
&-\frac{i}{4}\Big(4\sum_{c=1}^{2} Z^{E,*}_{j4+c}\sum_{b=1}^{2}\sum_{a=1}^{2} Y2^*_{ca} Y2_{ba} Z^E_{l4+b} Z^+_{i1} Z^+_{k1} + g_1^2 Z^{E,*}_{j1} Z^E_{l1} Z^+_{i1} Z^+_{k1} \\
&+ g_2^2 Z^{E,*}_{j1} Z^E_{l1} Z^+_{i1} Z^+_{k1} + 4g_p^2 Q_{H_d} Q_{l_4} Z^{E,*}_{j1} Z^E_{l1} Z^+_{i1} Z^+_{k1} - 2g_1^2 Z^{E,*}_{j4} Z^E_{l4} Z^+_{i1} Z^+_{k1} \\
&+ 4g_p^2 Q_{e_4} Q_{H_d} Z^{E,*}_{j4} Z^E_{l4} Z^+_{i1} Z^+_{k1} + 4|Y1|^2 Z^{E,*}_{j4} Z^E_{l4} Z^+_{i1} Z^+_{k1} \\
&- g_1^2 Z^{E,*}_{j1} Z^E_{l1} Z^+_{i2} Z^+_{k2} - g_2^2 Z^{E,*}_{j1} Z^E_{l1} Z^+_{i2} Z^+_{k2} \\
&+ 4g_p^2 Q_{H_u} Q_{l_4} Z^{E,*}_{j1} Z^E_{l1} Z^+_{i2} Z^+_{k2} + 2g_1^2 Z^{E,*}_{j4} Z^E_{l4} Z^+_{i2} Z^+_{k2} \\
&+ 4g_p^2 Q_{e_4} Q_{H_u} Z^{E,*}_{j4} Z^E_{l4} Z^+_{i2} Z^+_{k2} \\
&+ \sum_{a=1}^{2} Z^{E,*}_{j4+a} Z^E_{l4+a}\Big(-2\Big(-2g_p^2 Q_{e_9} Q_{H_d} + g_1^2\Big) Z^+_{i1} Z^+_{k1} + 2\Big(2g_p^2 Q_{e_9} Q_{H_u} + g_1^2\Big) Z^+_{i2} Z^+_{k2}\Big) \\
&+ \sum_{a=1}^{2} Z^{E,*}_{j1+a} Z^E_{l1+a}\Big(\Big(4g_p^2 Q_{H_d} Q_{l_9} + g_1^2 + g_2^2\Big) Z^+_{i1} Z^+_{k1} - \Big(-4g_p^2 Q_{H_u} Q_{l_9} + g_1^2 + g_2^2\Big) Z^+_{i2} Z^+_{k2}\Big)\Big)
\end{aligned}
\tag{426}
$$

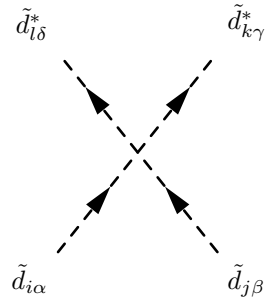


$$
\begin{aligned}
&\frac{i}{12}\delta_{\beta\delta}\Big(\sum_{a=1}^{3} Z^{U,*}_{ja} Z^U_{la}\Big(\Big(-12g_p^2 Q_{H_d} Q_q + 3g_2^2 + g_1^2\Big) Z^+_{i1} Z^+_{k1} - \Big(12g_p^2 Q_{H_u} Q_q + 3g_2^2 + g_1^2\Big) Z^+_{i2} Z^+_{k2}\Big) \\
&- 4\Big(\sum_{a=1}^{3} Z^{U,*}_{j3+a} Z^U_{l3+a}\Big(\Big(3g_p^2 Q_{H_d} Q_u + g_1^2\Big) Z^+_{i1} Z^+_{k1} - \Big(-3g_p^2 Q_{H_u} Q_u + g_1^2\Big) Z^+_{i2} Z^+_{k2}\Big)
\end{aligned}
$$

$$+ 3\Big(\sum_{c=1}^{3}\sum_{b=1}^{3} Z^{U,*}_{jb}\sum_{a=1}^{3} Y^{*}_{d,ac}Y_{d,ab}Z^{U}_{lc}Z^{+}_{i1}Z^{+}_{k1} + \sum_{c=1}^{3} Z^{U,*}_{j3+c}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{u,ca}Y_{u,ba}Z^{U}_{l3+b}Z^{+}_{i2}Z^{+}_{k2}\Big)\Big)\Big) \tag{427}$$



$$\begin{aligned}
&- \frac{i}{4}\Big(4\sum_{c=1}^{2}\sum_{b=1}^{2} Z^{V,*}_{j1+b}\sum_{a=1}^{2} Y2^{*}_{ac}Y2_{ab}Z^{V}_{l1+c}Z^{+}_{i1}Z^{+}_{k1} \\
&+ \sum_{a=1}^{2} Z^{V,*}_{j1+a}Z^{V}_{l1+a}\Big(\Big(4g_p^2Q_{H_d}Q_{l_9} - g_2^2 + g_1^2\Big)Z^{+}_{i1}Z^{+}_{k1} + \Big(4g_p^2Q_{H_u}Q_{l_9} - g_1^2 + g_2^2\Big)Z^{+}_{i2}Z^{+}_{k2}\Big) \\
&+ Z^{V,*}_{j1}\Big(\Big(4g_p^2Q_{H_d}Q_{l_4} + 4|Y1|^2 - g_2^2 + g_1^2\Big)Z^{+}_{i1}Z^{+}_{k1} + \Big(4g_p^2Q_{H_u}Q_{l_4} - g_1^2 + g_2^2\Big)Z^{+}_{i2}Z^{+}_{k2}\Big)Z^{V}_{l1}\Big)
\end{aligned} \tag{428}$$



$$\begin{aligned}
&- \frac{i}{72}\Big(\delta_{\alpha\delta}\delta_{\beta\gamma}\Big(g_1^2\sum_{a=1}^{3} Z^{D,*}_{ia}Z^{D}_{la}\sum_{b=1}^{3} Z^{D,*}_{jb}Z^{D}_{kb} + 9g_2^2\sum_{a=1}^{3} Z^{D,*}_{ia}Z^{D}_{la}\sum_{b=1}^{3} Z^{D,*}_{jb}Z^{D}_{kb} \\
&- 6g_3^2\sum_{a=1}^{3} Z^{D,*}_{ia}Z^{D}_{la}\sum_{b=1}^{3} Z^{D,*}_{jb}Z^{D}_{kb} + 36g_p^2Q_q^2\sum_{a=1}^{3} Z^{D,*}_{ia}Z^{D}_{la}\sum_{b=1}^{3} Z^{D,*}_{jb}Z^{D}_{kb} \\
&+ 2g_1^2\sum_{a=1}^{3} Z^{D,*}_{i3+a}Z^{D}_{l3+a}\sum_{b=1}^{3} Z^{D,*}_{jb}Z^{D}_{kb} + 6g_3^2\sum_{a=1}^{3} Z^{D,*}_{i3+a}Z^{D}_{l3+a}\sum_{b=1}^{3} Z^{D,*}_{jb}Z^{D}_{kb} \\
&+ 36g_p^2Q_dQ_q\sum_{a=1}^{3} Z^{D,*}_{i3+a}Z^{D}_{l3+a}\sum_{b=1}^{3} Z^{D,*}_{jb}Z^{D}_{kb}
\end{aligned}$$

$$
+ 18 g_3^2 \sum_{a=1}^{3} Z_{ja}^{D,*} Z_{la}^{D} \Big(- \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{k3+b}^{D} + \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{kb}^{D} \Big)
$$

$$
- 18 g_3^2 \sum_{a=1}^{3} Z_{j3+a}^{D,*} Z_{l3+a}^{D} \Big(- \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{k3+b}^{D} + \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{kb}^{D} \Big)
$$

$$
+ 2 g_1^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{la}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{k3+b}^{D} + 6 g_3^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{la}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{k3+b}^{D}
$$

$$
+ 36 g_p^2 Q_d Q_q \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{la}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{k3+b}^{D} + 4 g_1^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{l3+a}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{k3+b}^{D}
$$

$$
- 6 g_3^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{l3+a}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{k3+b}^{D} + 36 g_p^2 Q_d^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{l3+a}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{k3+b}^{D}
$$

$$
+ g_1^2 \sum_{a=1}^{3} Z_{ja}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{lb}^{D} + 9 g_2^2 \sum_{a=1}^{3} Z_{ja}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{lb}^{D}
$$

$$
- 6 g_3^2 \sum_{a=1}^{3} Z_{ja}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{lb}^{D} + 36 g_p^2 Q_q^2 \sum_{a=1}^{3} Z_{ja}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{lb}^{D}
$$

$$
+ 2 g_1^2 \sum_{a=1}^{3} Z_{j3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{lb}^{D} + 6 g_3^2 \sum_{a=1}^{3} Z_{j3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{lb}^{D}
$$

$$
+ 36 g_p^2 Q_d Q_q \sum_{a=1}^{3} Z_{j3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{lb}^{D} + 18 g_3^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{jb}^{D,*} Z_{lb}^{D}
$$

$$
- 18 g_3^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{jb}^{D,*} Z_{lb}^{D} + 2 g_1^2 \sum_{a=1}^{3} Z_{ja}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{l3+b}^{D}
$$

$$
+ 6 g_3^2 \sum_{a=1}^{3} Z_{ja}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{l3+b}^{D} + 36 g_p^2 Q_d Q_q \sum_{a=1}^{3} Z_{ja}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{l3+b}^{D}
$$

$$
+ 4 g_1^2 \sum_{a=1}^{3} Z_{j3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{l3+b}^{D} - 6 g_3^2 \sum_{a=1}^{3} Z_{j3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{l3+b}^{D}
$$

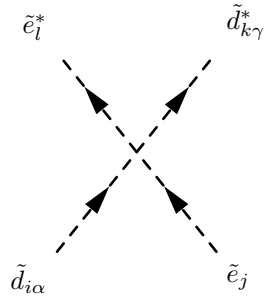
$$
+ 36 g_p^2 Q_d^2 \sum_{a=1}^{3} Z_{j3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{l3+b}^{D} - 18 g_3^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{l3+b}^{D}
$$

$$
+ 18 g_3^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{l3+b}^{D}
$$

$$
+ 72 \sum_{b=1}^{3} Z_{ib}^{D,*} \sum_{a=1}^{3} Y_{d,ab} Z_{l3+a}^{D} \sum_{d=1}^{3} \sum_{c=1}^{3} Y_{d,cd}^{*} Z_{j3+c}^{D,*} Z_{kd}^{D}
$$

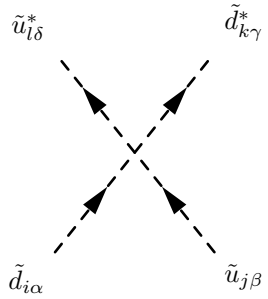
$$
\begin{aligned}
&+ 72 \sum_{b=1}^{3} Z_{jb}^{D,*} \sum_{a=1}^{3} Y_{d,ab} Z_{k3+a}^{D} \sum_{d=1}^{3} \sum_{c=1}^{3} Y_{d,cd}^{*} Z_{i3+c}^{D,*} Z_{ld}^{D} \Big) \\
&+ \delta_{\alpha\gamma} \delta_{\beta\delta} \Big(18 g_3^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{la}^{D} \sum_{b=1}^{3} Z_{jb}^{D,*} Z_{kb}^{D} - 18 g_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(18 g_p^2 Q_d^2 + 2 g_1^2 - 3 g_3^2 \Big) \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{k3+b}^{D} + \Big(18 g_p^2 Q_d Q_q + 3 g_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(18 g_p^2 Q_d Q_q + 3 g_3^2 + g_1^2 \Big) \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{k3+b}^{D} + \Big(36 g_p^2 Q_q^2 - 6 g_3^2 + 9 g_2^2 + g_1^2 \Big) \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{kb}^{D} \Big) \\
&- 18 g_3^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{la}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{k3+b}^{D} + 18 g_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} \\
&+ 18 g_3^2 \sum_{a=1}^{3} Z_{ja}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{lb}^{D} - 18 g_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} + 9 g_2^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{jb}^{D,*} Z_{lb}^{D} \\
&- 6 g_3^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{jb}^{D,*} Z_{lb}^{D} + 36 g_p^2 Q_q^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{jb}^{D,*} Z_{lb}^{D} \\
&+ 2 g_1^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{jb}^{D,*} Z_{lb}^{D} + 6 g_3^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{jb}^{D,*} Z_{lb}^{D} \\
&+ 36 g_p^2 Q_d Q_q \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{jb}^{D,*} Z_{lb}^{D} - 18 g_3^2 \sum_{a=1}^{3} Z_{ja}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{l3+b}^{D} \\
&+ 18 g_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} + 2 g_1^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{l3+b}^{D} \\
&+ 6 g_3^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{l3+b}^{D} + 36 g_p^2 Q_d Q_q \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{l3+b}^{D} \\
&+ 4 g_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} - 6 g_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} \\
&+ 36 g_p^2 Q_d^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}
\end{aligned}
$$

$$+ 72\sum_{b=1}^{3} Z_{ib}^{D,*}\sum_{a=1}^{3} Y_{d,ab} Z_{k3+a}^{D}\sum_{d=1}^{3}\sum_{c=1}^{3} Y_{d,cd}^{*} Z_{j3+c}^{D,*} Z_{ld}^{D}\Big)\Big) \tag{429}$$



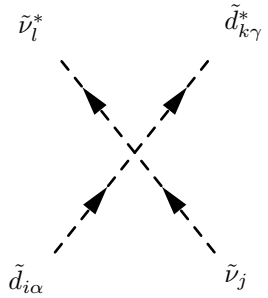
$$\frac{i}{24}\delta_{\alpha\gamma}\Big(g_1^2\sum_{a=1}^{2} Z_{j1+a}^{E,*} Z_{l1+a}^{E}\sum_{b=1}^{3} Z_{ib}^{D,*} Z_{kb}^{D} - 3g_2^2\sum_{a=1}^{2} Z_{j1+a}^{E,*} Z_{l1+a}^{E}\sum_{b=1}^{3} Z_{ib}^{D,*} Z_{kb}^{D}$$
$$- 12g_p^2 Q_{l_9} Q_q\sum_{a=1}^{2} Z_{j1+a}^{E,*} Z_{l1+a}^{E}\sum_{b=1}^{3} Z_{ib}^{D,*} Z_{kb}^{D} - 2g_1^2\sum_{a=1}^{2} Z_{j4+a}^{E,*} Z_{l4+a}^{E}\sum_{b=1}^{3} Z_{ib}^{D,*} Z_{kb}^{D}$$
$$- 12g_p^2 Q_{e_9} Q_q\sum_{a=1}^{2} Z_{j4+a}^{E,*} Z_{l4+a}^{E}\sum_{b=1}^{3} Z_{ib}^{D,*} Z_{kb}^{D} + 2g_1^2\sum_{a=1}^{2} Z_{j1+a}^{E,*} Z_{l1+a}^{E}\sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{k3+b}^{D}$$
$$- 12g_p^2 Q_d Q_{l_9}\sum_{a=1}^{2} Z_{j1+a}^{E,*} Z_{l1+a}^{E}\sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{k3+b}^{D} - 4g_1^2\sum_{a=1}^{2} Z_{j4+a}^{E,*} Z_{l4+a}^{E}\sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{k3+b}^{D}$$
$$- 12g_p^2 Q_d Q_{e_9}\sum_{a=1}^{2} Z_{j4+a}^{E,*} Z_{l4+a}^{E}\sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{k3+b}^{D}$$
$$- 24\sum_{b=1}^{3} Z_{ib}^{D,*}\sum_{a=1}^{3} Y_{d,ab} Z_{k3+a}^{D}\sum_{d=1}^{2}\sum_{c=1}^{2} Y2_{cd}^{*} Z_{j4+c}^{E,*} Z_{l1+d}^{E}$$
$$- 24\sum_{b=1}^{2} Z_{j1+b}^{E,*}\sum_{a=1}^{2} Y2_{ab} Z_{l4+a}^{E}\sum_{d=1}^{3}\sum_{c=1}^{3} Y_{d,cd}^{*} Z_{i3+c}^{D,*} Z_{kd}^{D}$$
$$- 24Y1^{*} Z_{j4}^{E,*}\sum_{b=1}^{3} Z_{ib}^{D,*}\sum_{a=1}^{3} Y_{d,ab} Z_{k3+a}^{D} Z_{l1}^{E} - 24Y1 Z_{j1}^{E,*}\sum_{b=1}^{3}\sum_{a=1}^{3} Y_{d,ab}^{*} Z_{i3+a}^{D,*} Z_{kb}^{D} Z_{l4}^{E}$$
$$+ 2\sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D}\Big(\Big(-6g_p^2 Q_d Q_{l_9} + g_1^2\Big)\sum_{b=1}^{2} Z_{j1+b}^{E,*} Z_{l1+b}^{E} - 2\Big(3g_p^2 Q_d Q_{e_9} + g_1^2\Big)\sum_{b=1}^{2} Z_{j4+b}^{E,*} Z_{l4+b}^{E}$$
$$+ 2\Big(-6g_p^2 Q_d Q_{l_4} + g_1^2\Big) Z_{j1}^{E,*} Z_{l1}^{E} - 4\Big(3g_p^2 Q_d Q_{e_4} + g_1^2\Big) Z_{j4}^{E,*} Z_{l4}^{E}\Big)$$
$$+\sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D}\Big(\Big(-3\Big(4g_p^2 Q_{l_9} Q_q + g_2^2\Big) + g_1^2\Big)\sum_{b=1}^{2} Z_{j1+b}^{E,*} Z_{l1+b}^{E}$$

$$- 2\Big(\Big(6g_p^2Q_{e_9}Q_q + g_1^2\Big)\sum_{b=1}^{2} Z_{j4+b}^{E,*}Z_{l4+b}^{E} + \Big(12g_p^2Q_{l_4}Q_q + 3g_2^2 - g_1^2\Big)Z_{j1}^{E,*}Z_{l1}^{E}$$
$$+ 2\Big(6g_p^2Q_{e_4}Q_q + g_1^2\Big)Z_{j4}^{E,*}Z_{l4}^{E}\Big)\Big) \tag{430}$$

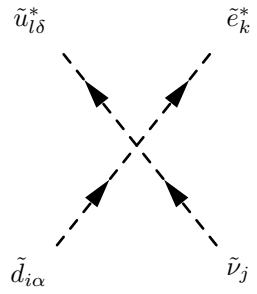


$$- \frac{i}{72}\Big(\delta_{\alpha\gamma}\delta_{\beta\delta}\Big(\sum_{a=1}^{3} Z_{ja}^{U,*}Z_{la}^{U}\Big(\Big(36g_p^2Q_q^2 - 6g_3^2 - 9g_2^2 + g_1^2\Big)\sum_{b=1}^{3} Z_{ib}^{D,*}Z_{kb}^{D}$$
$$+ 2\Big(18g_p^2Q_dQ_q + 3g_3^2 + g_1^2\Big)\sum_{b=1}^{3} Z_{i3+b}^{D,*}Z_{k3+b}^{D}\Big)$$
$$+ \sum_{a=1}^{3} Z_{j3+a}^{U,*}Z_{l3+a}^{U}\Big(-2\Big(-18g_p^2Q_dQ_u + 3g_3^2 + 4g_1^2\Big)\sum_{b=1}^{3} Z_{i3+b}^{D,*}Z_{k3+b}^{D} + \Big(36g_p^2Q_qQ_u - 4g_1^2 + 6g_3^2\Big)\sum_{b=1}^{3} Z_{ib}^{D,*}Z_{kb}^{D}\Big)$$
$$+ g_1^2\sum_{a=1}^{3} Z_{ia}^{D,*}Z_{ka}^{D}\sum_{b=1}^{3} Z_{jb}^{U,*}Z_{lb}^{U} - 9g_2^2\sum_{a=1}^{3} Z_{ia}^{D,*}Z_{ka}^{D}\sum_{b=1}^{3} Z_{jb}^{U,*}Z_{lb}^{U}$$
$$- 6g_3^2\sum_{a=1}^{3} Z_{ia}^{D,*}Z_{ka}^{D}\sum_{b=1}^{3} Z_{jb}^{U,*}Z_{lb}^{U} + 36g_p^2Q_q^2\sum_{a=1}^{3} Z_{ia}^{D,*}Z_{ka}^{D}\sum_{b=1}^{3} Z_{jb}^{U,*}Z_{lb}^{U}$$
$$+ 2g_1^2\sum_{a=1}^{3} Z_{i3+a}^{D,*}Z_{k3+a}^{D}\sum_{b=1}^{3} Z_{jb}^{U,*}Z_{lb}^{U} + 6g_3^2\sum_{a=1}^{3} Z_{i3+a}^{D,*}Z_{k3+a}^{D}\sum_{b=1}^{3} Z_{jb}^{U,*}Z_{lb}^{U}$$
$$+ 36g_p^2Q_dQ_q\sum_{a=1}^{3} Z_{i3+a}^{D,*}Z_{k3+a}^{D}\sum_{b=1}^{3} Z_{jb}^{U,*}Z_{lb}^{U} - 4g_1^2\sum_{a=1}^{3} Z_{ia}^{D,*}Z_{ka}^{D}\sum_{b=1}^{3} Z_{j3+b}^{U,*}Z_{l3+b}^{U}$$
$$+ 6g_3^2\sum_{a=1}^{3} Z_{ia}^{D,*}Z_{ka}^{D}\sum_{b=1}^{3} Z_{j3+b}^{U,*}Z_{l3+b}^{U} + 36g_p^2Q_qQ_u\sum_{a=1}^{3} Z_{ia}^{D,*}Z_{ka}^{D}\sum_{b=1}^{3} Z_{j3+b}^{U,*}Z_{l3+b}^{U}$$
$$- 8g_1^2\sum_{a=1}^{3} Z_{i3+a}^{D,*}Z_{k3+a}^{D}\sum_{b=1}^{3} Z_{j3+b}^{U,*}Z_{l3+b}^{U} - 6g_3^2\sum_{a=1}^{3} Z_{i3+a}^{D,*}Z_{k3+a}^{D}\sum_{b=1}^{3} Z_{j3+b}^{U,*}Z_{l3+b}^{U}$$
$$+ 36g_p^2Q_dQ_u\sum_{a=1}^{3} Z_{i3+a}^{D,*}Z_{k3+a}^{D}\sum_{b=1}^{3} Z_{j3+b}^{U,*}Z_{l3+b}^{U}\Big)$$

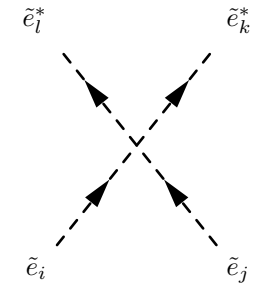
$$
\begin{aligned}
&+ 18\delta_{\alpha\delta}\delta_{\beta\gamma}\Big(g_2^2\sum_{a=1}^{3}Z_{ia}^{D,*}Z_{la}^{U}\sum_{b=1}^{3}Z_{jb}^{U,*}Z_{kb}^{D} + g_3^2\sum_{a=1}^{3}Z_{ja}^{U,*}Z_{la}^{U}\Big(-\sum_{b=1}^{3}Z_{i3+b}^{D,*}Z_{k3+b}^{D} + \sum_{b=1}^{3}Z_{ib}^{D,*}Z_{kb}^{D}\Big)\\
&+ g_3^2\sum_{a=1}^{3}Z_{j3+a}^{U,*}Z_{l3+a}^{U}\Big(-\sum_{b=1}^{3}Z_{ib}^{D,*}Z_{kb}^{D} + \sum_{b=1}^{3}Z_{i3+b}^{D,*}Z_{k3+b}^{D}\Big)\\
&+ g_2^2\sum_{a=1}^{3}Z_{ja}^{U,*}Z_{ka}^{D}\sum_{b=1}^{3}Z_{ib}^{D,*}Z_{lb}^{U} + g_3^2\sum_{a=1}^{3}Z_{ia}^{D,*}Z_{ka}^{D}\sum_{b=1}^{3}Z_{jb}^{U,*}Z_{lb}^{U}\\
&- g_3^2\sum_{a=1}^{3}Z_{i3+a}^{D,*}Z_{k3+a}^{D}\sum_{b=1}^{3}Z_{jb}^{U,*}Z_{lb}^{U} - g_3^2\sum_{a=1}^{3}Z_{ia}^{D,*}Z_{ka}^{D}\sum_{b=1}^{3}Z_{j3+b}^{U,*}Z_{l3+b}^{U}\\
&+ g_3^2\sum_{a=1}^{3}Z_{i3+a}^{D,*}Z_{k3+a}^{D}\sum_{b=1}^{3}Z_{j3+b}^{U,*}Z_{l3+b}^{U} + 4\sum_{b=1}^{3}Z_{ib}^{D,*}\sum_{a=1}^{3}Y_{u,ab}Z_{l3+a}^{U}\sum_{d=1}^{3}\sum_{c=1}^{3}Y_{u,cd}^{*}Z_{j3+c}^{U,*}Z_{kd}^{D}\\
&+ 4\sum_{b=1}^{3}Z_{jb}^{U,*}\sum_{a=1}^{3}Y_{d,ab}Z_{k3+a}^{D}\sum_{d=1}^{3}\sum_{c=1}^{3}Y_{d,cd}^{*}Z_{i3+c}^{D,*}Z_{ld}^{U}\Big)\Big)
\end{aligned}
\tag{431}
$$



$$
\begin{aligned}
&\frac{i}{24}\delta_{\alpha\gamma}\Big(\sum_{a=1}^{2}Z_{j1+a}^{V,*}Z_{l1+a}^{V}\Big(2\Big(-6g_p^2Q_dQ_{l_9}+g_1^2\Big)\sum_{b=1}^{3}Z_{i3+b}^{D,*}Z_{k3+b}^{D} + \Big(3\Big(-4g_p^2Q_{l_9}Q_q+g_2^2\Big)+g_1^2\Big)\sum_{b=1}^{3}Z_{ib}^{D,*}Z_{kb}^{D}\Big)\\
&+ 2\sum_{a=1}^{3}Z_{i3+a}^{D,*}Z_{k3+a}^{D}\Big(2\Big(-6g_p^2Q_dQ_{l_4}+g_1^2\Big)Z_{j1}^{V,*}Z_{l1}^{V} + \Big(-6g_p^2Q_dQ_{l_9}+g_1^2\Big)\sum_{b=1}^{2}Z_{j1+b}^{V,*}Z_{l1+b}^{V}\Big)\\
&+ \sum_{a=1}^{3}Z_{ia}^{D,*}Z_{ka}^{D}\Big(2\Big(3\Big(-4g_p^2Q_{l_4}Q_q+g_2^2\Big)+g_1^2\Big)Z_{j1}^{V,*}Z_{l1}^{V} + \Big(3\Big(-4g_p^2Q_{l_9}Q_q+g_2^2\Big)+g_1^2\Big)\sum_{b=1}^{2}Z_{j1+b}^{V,*}Z_{l1+b}^{V}\Big)\Big)
\end{aligned}
\tag{432}
$$



$$
\begin{aligned}
&-\frac{i}{4}\delta_{\alpha\delta}\Big(g_2^2\sum_{a=1}^{2}Z^{V,*}_{j1+a}Z^{E}_{k1+a}\sum_{b=1}^{3}Z^{D,*}_{ib}Z^{U}_{lb}+4\sum_{b=1}^{2}Z^{V,*}_{j1+b}\sum_{a=1}^{2}Y2_{ab}Z^{E}_{k4+a}\sum_{d=1}^{3}\sum_{c=1}^{3}Y^{*}_{d,cd}Z^{D,*}_{i3+c}Z^{U}_{ld}\\
&+g_2^2\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{U}_{la}\Big(2Z^{V,*}_{j1}Z^{E}_{k1}+\sum_{b=1}^{2}Z^{V,*}_{j1+b}Z^{E}_{k1+b}\Big)+4Y1Z^{V,*}_{j1}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{d,ab}Z^{D,*}_{i3+a}Z^{U}_{lb}Z^{E}_{k4}\Big)
\end{aligned}
\tag{433}
$$

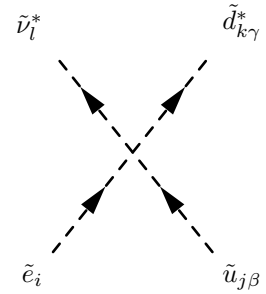


$$
\begin{aligned}
&-\frac{i}{8}\Big(g_1^2\sum_{a=1}^{2}Z^{E,*}_{i1+a}Z^{E}_{l1+a}\sum_{b=1}^{2}Z^{E,*}_{j1+b}Z^{E}_{k1+b}+g_2^2\sum_{a=1}^{2}Z^{E,*}_{i1+a}Z^{E}_{l1+a}\sum_{b=1}^{2}Z^{E,*}_{j1+b}Z^{E}_{k1+b}\\
&+4g_p^2Q_{l_9}^2\sum_{a=1}^{2}Z^{E,*}_{i1+a}Z^{E}_{l1+a}\sum_{b=1}^{2}Z^{E,*}_{j1+b}Z^{E}_{k1+b}-2g_1^2\sum_{a=1}^{2}Z^{E,*}_{i4+a}Z^{E}_{l4+a}\sum_{b=1}^{2}Z^{E,*}_{j1+b}Z^{E}_{k1+b}\\
&+4g_p^2Q_{e_9}Q_{l_9}\sum_{a=1}^{2}Z^{E,*}_{i4+a}Z^{E}_{l4+a}\sum_{b=1}^{2}Z^{E,*}_{j1+b}Z^{E}_{k1+b}-2g_1^2\sum_{a=1}^{2}Z^{E,*}_{i1+a}Z^{E}_{l1+a}\sum_{b=1}^{2}Z^{E,*}_{j4+b}Z^{E}_{k4+b}\\
&+4g_p^2Q_{e_9}Q_{l_9}\sum_{a=1}^{2}Z^{E,*}_{i1+a}Z^{E}_{l1+a}\sum_{b=1}^{2}Z^{E,*}_{j4+b}Z^{E}_{k4+b}+4g_1^2\sum_{a=1}^{2}Z^{E,*}_{i4+a}Z^{E}_{l4+a}\sum_{b=1}^{2}Z^{E,*}_{j4+b}Z^{E}_{k4+b}\\
&+4g_p^2Q_{e_9}^2\sum_{a=1}^{2}Z^{E,*}_{i4+a}Z^{E}_{l4+a}\sum_{b=1}^{2}Z^{E,*}_{j4+b}Z^{E}_{k4+b}+g_1^2\sum_{a=1}^{2}Z^{E,*}_{j1+a}Z^{E}_{k1+a}\sum_{b=1}^{2}Z^{E,*}_{i1+b}Z^{E}_{l1+b}\\
&+g_2^2\sum_{a=1}^{2}Z^{E,*}_{j1+a}Z^{E}_{k1+a}\sum_{b=1}^{2}Z^{E,*}_{i1+b}Z^{E}_{l1+b}+4g_p^2Q_{l_9}^2\sum_{a=1}^{2}Z^{E,*}_{j1+a}Z^{E}_{k1+a}\sum_{b=1}^{2}Z^{E,*}_{i1+b}Z^{E}_{l1+b}
\end{aligned}
$$

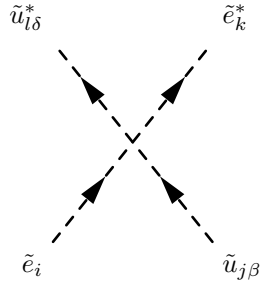
$$
\begin{aligned}
&- 2g_1^2 \sum_{a=1}^{2} Z_{j4+a}^{E,*} Z_{k4+a}^{E} \sum_{b=1}^{2} Z_{i1+b}^{E,*} Z_{l1+b}^{E} + 4g_p^2 Q_{e_9} Q_{l_9} \sum_{a=1}^{2} Z_{j4+a}^{E,*} Z_{k4+a}^{E} \sum_{b=1}^{2} Z_{i1+b}^{E,*} Z_{l1+b}^{E} \\
&+ g_1^2 \sum_{a=1}^{2} Z_{i1+a}^{E,*} Z_{k1+a}^{E} \sum_{b=1}^{2} Z_{j1+b}^{E,*} Z_{l1+b}^{E} + g_2^2 \sum_{a=1}^{2} Z_{i1+a}^{E,*} Z_{k1+a}^{E} \sum_{b=1}^{2} Z_{j1+b}^{E,*} Z_{l1+b}^{E} \\
&+ 4g_p^2 Q_{l_9}^2 \sum_{a=1}^{2} Z_{i1+a}^{E,*} Z_{k1+a}^{E} \sum_{b=1}^{2} Z_{j1+b}^{E,*} Z_{l1+b}^{E} - 2g_1^2 \sum_{a=1}^{2} Z_{i4+a}^{E,*} Z_{k4+a}^{E} \sum_{b=1}^{2} Z_{j1+b}^{E,*} Z_{l1+b}^{E} \\
&+ 4g_p^2 Q_{e_9} Q_{l_9} \sum_{a=1}^{2} Z_{i4+a}^{E,*} Z_{k4+a}^{E} \sum_{b=1}^{2} Z_{j1+b}^{E,*} Z_{l1+b}^{E} - 2g_1^2 \sum_{a=1}^{2} Z_{j1+a}^{E,*} Z_{k1+a}^{E} \sum_{b=1}^{2} Z_{i4+b}^{E,*} Z_{l4+b}^{E} \\
&+ 4g_p^2 Q_{e_9} Q_{l_9} \sum_{a=1}^{2} Z_{j1+a}^{E,*} Z_{k1+a}^{E} \sum_{b=1}^{2} Z_{i4+b}^{E,*} Z_{l4+b}^{E} + 4g_1^2 \sum_{a=1}^{2} Z_{j4+a}^{E,*} Z_{k4+a}^{E} \sum_{b=1}^{2} Z_{i4+b}^{E,*} Z_{l4+b}^{E} \\
&+ 4g_p^2 Q_{e_9}^2 \sum_{a=1}^{2} Z_{j4+a}^{E,*} Z_{k4+a}^{E} \sum_{b=1}^{2} Z_{i4+b}^{E,*} Z_{l4+b}^{E} - 2g_1^2 \sum_{a=1}^{2} Z_{i1+a}^{E,*} Z_{k1+a}^{E} \sum_{b=1}^{2} Z_{j4+b}^{E,*} Z_{l4+b}^{E} \\
&+ 4g_p^2 Q_{e_9} Q_{l_9} \sum_{a=1}^{2} Z_{i1+a}^{E,*} Z_{k1+a}^{E} \sum_{b=1}^{2} Z_{j4+b}^{E,*} Z_{l4+b}^{E} + 4g_1^2 \sum_{a=1}^{2} Z_{i4+a}^{E,*} Z_{k4+a}^{E} \sum_{b=1}^{2} Z_{j4+b}^{E,*} Z_{l4+b}^{E} \\
&+ 4g_p^2 Q_{e_9}^2 \sum_{a=1}^{2} Z_{i4+a}^{E,*} Z_{k4+a}^{E} \sum_{b=1}^{2} Z_{j4+b}^{E,*} Z_{l4+b}^{E} \\
&+ 8 \sum_{b=1}^{2} Z_{j1+b}^{E,*} \sum_{a=1}^{2} Y2_{ab} Z_{l4+a}^{E} \sum_{d=1}^{2} \sum_{c=1}^{2} Y2_{cd}^{*} Z_{i4+c}^{E,*} Z_{k1+d}^{E} \\
&+ 8 \sum_{b=1}^{2} Z_{i1+b}^{E,*} \sum_{a=1}^{2} Y2_{ab} Z_{l4+a}^{E} \sum_{d=1}^{2} \sum_{c=1}^{2} Y2_{cd}^{*} Z_{j4+c}^{E,*} Z_{k1+d}^{E} \\
&+ 8 \sum_{b=1}^{2} Z_{j1+b}^{E,*} \sum_{a=1}^{2} Y2_{ab} Z_{k4+a}^{E} \sum_{d=1}^{2} \sum_{c=1}^{2} Y2_{cd}^{*} Z_{i4+c}^{E,*} Z_{l1+d}^{E} \\
&+ 8 \sum_{b=1}^{2} Z_{i1+b}^{E,*} \sum_{a=1}^{2} Y2_{ab} Z_{k4+a}^{E} \sum_{d=1}^{2} \sum_{c=1}^{2} Y2_{cd}^{*} Z_{j4+c}^{E,*} Z_{l1+d}^{E} + 2g_1^2 Z_{j1}^{E,*} \sum_{a=1}^{2} Z_{i1+a}^{E,*} Z_{l1+a}^{E} Z_{k1}^{E} \\
&+ 2g_2^2 Z_{j1}^{E,*} \sum_{a=1}^{2} Z_{i1+a}^{E,*} Z_{l1+a}^{E} Z_{k1}^{E} + 8g_p^2 Q_{l_4} Q_{l_9} Z_{j1}^{E,*} \sum_{a=1}^{2} Z_{i1+a}^{E,*} Z_{l1+a}^{E} Z_{k1}^{E} \\
&- 4g_1^2 Z_{j1}^{E,*} \sum_{a=1}^{2} Z_{i4+a}^{E,*} Z_{l4+a}^{E} Z_{k1}^{E} + 8g_p^2 Q_{e_9} Q_{l_4} Z_{j1}^{E,*} \sum_{a=1}^{2} Z_{i4+a}^{E,*} Z_{l4+a}^{E} Z_{k1}^{E} \\
&+ 8Y1^{*} Z_{j4}^{E,*} \sum_{b=1}^{2} Z_{i1+b}^{E,*} \sum_{a=1}^{2} Y2_{ab} Z_{l4+a}^{E} Z_{k1}^{E} + 8Y1^{*} Z_{i4}^{E,*} \sum_{b=1}^{2} Z_{j1+b}^{E,*} \sum_{a=1}^{2} Y2_{ab} Z_{l4+a}^{E} Z_{k1}^{E}
\end{aligned}
$$

$$
\begin{aligned}
&- 4g_1^2 Z_{j4}^{E,*} \sum_{a=1}^{2} Z_{i1+a}^{E,*} Z_{l1+a}^{E} Z_{k4}^{E} + 8g_p^2 Q_{e_4} Q_{l_9} Z_{j4}^{E,*} \sum_{a=1}^{2} Z_{i1+a}^{E,*} Z_{l1+a}^{E} Z_{k4}^{E} \\
&+ 8g_1^2 Z_{j4}^{E,*} \sum_{a=1}^{2} Z_{i4+a}^{E,*} Z_{l4+a}^{E} Z_{k4}^{E} + 8g_p^2 Q_{e_4} Q_{e_9} Z_{j4}^{E,*} \sum_{a=1}^{2} Z_{i4+a}^{E,*} Z_{l4+a}^{E} Z_{k4}^{E} \\
&+ 8Y1 Z_{j1}^{E,*} \sum_{b=1}^{2} \sum_{a=1}^{2} Y2_{ab}^{*} Z_{i4+a}^{E,*} Z_{l1+b}^{E} Z_{k4}^{E} + 8Y1 Z_{i1}^{E,*} \sum_{b=1}^{2} \sum_{a=1}^{2} Y2_{ab}^{*} Z_{j4+a}^{E,*} Z_{l1+b}^{E} Z_{k4}^{E} \\
&+ \sum_{a=1}^{2} Z_{j4+a}^{E,*} Z_{l4+a}^{E} \Big(- 2\Big(- 2g_p^2 Q_{e_9} Q_{l_9} + g_1^2 \Big) \sum_{b=1}^{2} Z_{i1+b}^{E,*} Z_{k1+b}^{E} + 4\Big(g_p^2 Q_{e_9}^2 + g_1^2 \Big) \sum_{b=1}^{2} Z_{i4+b}^{E,*} Z_{k4+b}^{E} \\
&- 4g_1^2 Z_{i1}^{E,*} Z_{k1}^{E} + 8g_p^2 Q_{e_9} Q_{l_4} Z_{i1}^{E,*} Z_{k1}^{E} + 8g_1^2 Z_{i4}^{E,*} Z_{k4}^{E} + 8g_p^2 Q_{e_4} Q_{e_9} Z_{i4}^{E,*} Z_{k4}^{E} \Big) \\
&+ \sum_{a=1}^{2} Z_{j1+a}^{E,*} Z_{l1+a}^{E} \Big(\Big(4g_p^2 Q_{l_9}^2 + g_1^2 + g_2^2 \Big) \sum_{b=1}^{2} Z_{i1+b}^{E,*} Z_{k1+b}^{E} - 2\Big(- 2g_p^2 Q_{e_9} Q_{l_9} + g_1^2 \Big) \sum_{b=1}^{2} Z_{i4+b}^{E,*} Z_{k4+b}^{E} \\
&+ 2g_1^2 Z_{i1}^{E,*} Z_{k1}^{E} + 2g_2^2 Z_{i1}^{E,*} Z_{k1}^{E} + 8g_p^2 Q_{l_4} Q_{l_9} Z_{i1}^{E,*} Z_{k1}^{E} - 4g_1^2 Z_{i4}^{E,*} Z_{k4}^{E} \\
&+ 8g_p^2 Q_{e_4} Q_{l_9} Z_{i4}^{E,*} Z_{k4}^{E} \Big) \\
&+ 2g_1^2 Z_{j1}^{E,*} \sum_{a=1}^{2} Z_{i1+a}^{E,*} Z_{k1+a}^{E} Z_{l1}^{E} + 2g_2^2 Z_{j1}^{E,*} \sum_{a=1}^{2} Z_{i1+a}^{E,*} Z_{k1+a}^{E} Z_{l1}^{E} \\
&+ 8g_p^2 Q_{l_4} Q_{l_9} Z_{j1}^{E,*} \sum_{a=1}^{2} Z_{i1+a}^{E,*} Z_{k1+a}^{E} Z_{l1}^{E} + 2g_1^2 Z_{i1}^{E,*} \sum_{a=1}^{2} Z_{j1+a}^{E,*} Z_{k1+a}^{E} Z_{l1}^{E} \\
&+ 2g_2^2 Z_{i1}^{E,*} \sum_{a=1}^{2} Z_{j1+a}^{E,*} Z_{k1+a}^{E} Z_{l1}^{E} + 8g_p^2 Q_{l_4} Q_{l_9} Z_{i1}^{E,*} \sum_{a=1}^{2} Z_{j1+a}^{E,*} Z_{k1+a}^{E} Z_{l1}^{E} \\
&- 4g_1^2 Z_{j1}^{E,*} \sum_{a=1}^{2} Z_{i4+a}^{E,*} Z_{k4+a}^{E} Z_{l1}^{E} + 8g_p^2 Q_{e_9} Q_{l_4} Z_{j1}^{E,*} \sum_{a=1}^{2} Z_{i4+a}^{E,*} Z_{k4+a}^{E} Z_{l1}^{E} \\
&- 4g_1^2 Z_{i1}^{E,*} \sum_{a=1}^{2} Z_{j4+a}^{E,*} Z_{k4+a}^{E} Z_{l1}^{E} + 8g_p^2 Q_{e_9} Q_{l_4} Z_{i1}^{E,*} \sum_{a=1}^{2} Z_{j4+a}^{E,*} Z_{k4+a}^{E} Z_{l1}^{E} \\
&+ 8Y1^{*} Z_{j4}^{E,*} \sum_{b=1}^{2} Z_{i1+b}^{E,*} \sum_{a=1}^{2} Y2_{ab} Z_{k4+a}^{E} Z_{l1}^{E} + 8Y1^{*} Z_{i4}^{E,*} \sum_{b=1}^{2} Z_{j1+b}^{E,*} \sum_{a=1}^{2} Y2_{ab} Z_{k4+a}^{E} Z_{l1}^{E} \\
&+ 4g_1^2 Z_{i1}^{E,*} Z_{j1}^{E,*} Z_{k1}^{E} Z_{l1}^{E} + 4g_2^2 Z_{i1}^{E,*} Z_{j1}^{E,*} Z_{k1}^{E} Z_{l1}^{E} + 16g_p^2 Q_{l_4}^2 Z_{i1}^{E,*} Z_{j1}^{E,*} Z_{k1}^{E} Z_{l1}^{E} \\
&- 4g_1^2 Z_{i4}^{E,*} Z_{j1}^{E,*} Z_{k4}^{E} Z_{l1}^{E} + 8g_p^2 Q_{e_4} Q_{l_4} Z_{i4}^{E,*} Z_{j1}^{E,*} Z_{k4}^{E} Z_{l1}^{E} \\
&+ 8|Y1|^2 Z_{i4}^{E,*} Z_{j1}^{E,*} Z_{k4}^{E} Z_{l1}^{E} - 4g_1^2 Z_{i1}^{E,*} Z_{j4}^{E,*} Z_{k4}^{E} Z_{l1}^{E} \\
&+ 8g_p^2 Q_{e_4} Q_{l_4} Z_{i1}^{E,*} Z_{j4}^{E,*} Z_{k4}^{E} Z_{l1}^{E} + 8|Y1|^2 Z_{i1}^{E,*} Z_{j4}^{E,*} Z_{k4}^{E} Z_{l1}^{E} \\
&- 4g_1^2 Z_{j4}^{E,*} \sum_{a=1}^{2} Z_{i1+a}^{E,*} Z_{k1+a}^{E} Z_{l4}^{E} + 8g_p^2 Q_{e_4} Q_{l_9} Z_{j4}^{E,*} \sum_{a=1}^{2} Z_{i1+a}^{E,*} Z_{k1+a}^{E} Z_{l4}^{E}
\end{aligned}
$$

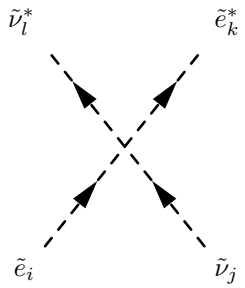
$$
\begin{aligned}
&- 4g_1^2 Z_{i4}^{E,*} \sum_{a=1}^{2} Z_{j1+a}^{E,*} Z_{k1+a}^{E} Z_{l4}^{E} + 8g_p^2 Q_{e_4} Q_{l_9} Z_{i4}^{E,*} \sum_{a=1}^{2} Z_{j1+a}^{E,*} Z_{k1+a}^{E} Z_{l4}^{E} \\
&+ 8g_1^2 Z_{j4}^{E,*} \sum_{a=1}^{2} Z_{i4+a}^{E,*} Z_{k4+a}^{E} Z_{l4}^{E} + 8g_p^2 Q_{e_4} Q_{e_9} Z_{j4}^{E,*} \sum_{a=1}^{2} Z_{i4+a}^{E,*} Z_{k4+a}^{E} Z_{l4}^{E} \\
&+ 8g_1^2 Z_{i4}^{E,*} \sum_{a=1}^{2} Z_{j4+a}^{E,*} Z_{k4+a}^{E} Z_{l4}^{E} + 8g_p^2 Q_{e_4} Q_{e_9} Z_{i4}^{E,*} \sum_{a=1}^{2} Z_{j4+a}^{E,*} Z_{k4+a}^{E} Z_{l4}^{E} \\
&+ 8Y1 Z_{j1}^{E,*} \sum_{b=1}^{2} \sum_{a=1}^{2} Y2_{ab}^{*} Z_{i4+a}^{E,*} Z_{k1+b}^{E} Z_{l4}^{E} + 8Y1 Z_{i1}^{E,*} \sum_{b=1}^{2} \sum_{a=1}^{2} Y2_{ab}^{*} Z_{j4+a}^{E,*} Z_{k1+b}^{E} Z_{l4}^{E} \\
&- 4g_1^2 Z_{i4}^{E,*} Z_{j1}^{E,*} Z_{k1}^{E} Z_{l4}^{E} + 8g_p^2 Q_{e_4} Q_{l_4} Z_{i4}^{E,*} Z_{j1}^{E,*} Z_{k1}^{E} Z_{l4}^{E} \\
&+ 8|Y1|^2 Z_{i4}^{E,*} Z_{j1}^{E,*} Z_{k1}^{E} Z_{l4}^{E} - 4g_1^2 Z_{i1}^{E,*} Z_{j4}^{E,*} Z_{k1}^{E} Z_{l4}^{E} \\
&+ 8g_p^2 Q_{e_4} Q_{l_4} Z_{i1}^{E,*} Z_{j4}^{E,*} Z_{k1}^{E} Z_{l4}^{E} + 8|Y1|^2 Z_{i1}^{E,*} Z_{j4}^{E,*} Z_{k1}^{E} Z_{l4}^{E} \\
&+ 16g_1^2 Z_{i4}^{E,*} Z_{j4}^{E,*} Z_{k4}^{E} Z_{l4}^{E} + 16g_p^2 Q_{e_4}^2 Z_{i4}^{E,*} Z_{j4}^{E,*} Z_{k4}^{E} Z_{l4}^{E} \Big)
\end{aligned} \tag{434}
$$



$$
\begin{aligned}
&- \frac{i}{4} \delta_{\beta\gamma} \Big(g_2^2 \sum_{a=1}^{2} Z_{i1+a}^{E,*} Z_{l1+a}^{V} \sum_{b=1}^{3} Z_{jb}^{U,*} Z_{kb}^{D} + g_2^2 \sum_{a=1}^{3} Z_{ja}^{U,*} Z_{ka}^{D} \Big(2 Z_{i1}^{E,*} Z_{l1}^{V} + \sum_{b=1}^{2} Z_{i1+b}^{E,*} Z_{l1+b}^{V} \Big) \\
&+ 4 \sum_{b=1}^{3} Z_{jb}^{U,*} \sum_{a=1}^{3} Y_{d,ab} Z_{k3+a}^{D} \Big(Y1^{*} Z_{i4}^{E,*} Z_{l1}^{V} + \sum_{d=1}^{2} \sum_{c=1}^{2} Y2_{cd}^{*} Z_{i4+c}^{E,*} Z_{l1+d}^{V} \Big) \Big)
\end{aligned} \tag{435}
$$

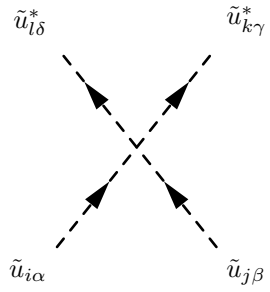


$$\frac{i}{24}\delta_{\beta\delta}\Big(g_1^2\sum_{a=1}^{2}Z_{i1+a}^{E,*}Z_{k1+a}^{E}\sum_{b=1}^{3}Z_{jb}^{U,*}Z_{lb}^{U}+3g_2^2\sum_{a=1}^{2}Z_{i1+a}^{E,*}Z_{k1+a}^{E}\sum_{b=1}^{3}Z_{jb}^{U,*}Z_{lb}^{U}$$
$$-12g_p^2Q_{l_9}Q_q\sum_{a=1}^{2}Z_{i1+a}^{E,*}Z_{k1+a}^{E}\sum_{b=1}^{3}Z_{jb}^{U,*}Z_{lb}^{U}-2g_1^2\sum_{a=1}^{2}Z_{i4+a}^{E,*}Z_{k4+a}^{E}\sum_{b=1}^{3}Z_{jb}^{U,*}Z_{lb}^{U}$$
$$-12g_p^2Q_{e_9}Q_q\sum_{a=1}^{2}Z_{i4+a}^{E,*}Z_{k4+a}^{E}\sum_{b=1}^{3}Z_{jb}^{U,*}Z_{lb}^{U}-4g_1^2\sum_{a=1}^{2}Z_{i1+a}^{E,*}Z_{k1+a}^{E}\sum_{b=1}^{3}Z_{j3+b}^{U,*}Z_{l3+b}^{U}$$
$$-12g_p^2Q_{l_9}Q_u\sum_{a=1}^{2}Z_{i1+a}^{E,*}Z_{k1+a}^{E}\sum_{b=1}^{3}Z_{j3+b}^{U,*}Z_{l3+b}^{U}+8g_1^2\sum_{a=1}^{2}Z_{i4+a}^{E,*}Z_{k4+a}^{E}\sum_{b=1}^{3}Z_{j3+b}^{U,*}Z_{l3+b}^{U}$$
$$-12g_p^2Q_{e_9}Q_u\sum_{a=1}^{2}Z_{i4+a}^{E,*}Z_{k4+a}^{E}\sum_{b=1}^{3}Z_{j3+b}^{U,*}Z_{l3+b}^{U}$$
$$+\sum_{a=1}^{3}Z_{ja}^{U,*}Z_{la}^{U}\Big(\Big(3\Big(-4g_p^2Q_{l_9}Q_q+g_2^2\Big)+g_1^2\Big)\sum_{b=1}^{2}Z_{i1+b}^{E,*}Z_{k1+b}^{E}-2\Big(6g_p^2Q_{e_9}Q_q+g_1^2\Big)\sum_{b=1}^{2}Z_{i4+b}^{E,*}Z_{k4+b}^{E}$$
$$+2\Big(3\Big(-4g_p^2Q_{l_4}Q_q+g_2^2\Big)+g_1^2\Big)Z_{i1}^{E,*}Z_{k1}^{E}-4\Big(6g_p^2Q_{e_4}Q_q+g_1^2\Big)Z_{i4}^{E,*}Z_{k4}^{E}\Big)$$
$$-4\sum_{a=1}^{3}Z_{j3+a}^{U,*}Z_{l3+a}^{U}\Big(\Big(3g_p^2Q_{l_9}Q_u+g_1^2\Big)\sum_{b=1}^{2}Z_{i1+b}^{E,*}Z_{k1+b}^{E}+\Big(-2g_1^2+3g_p^2Q_{e_9}Q_u\Big)\sum_{b=1}^{2}Z_{i4+b}^{E,*}Z_{k4+b}^{E}$$
$$+2g_1^2Z_{i1}^{E,*}Z_{k1}^{E}+6g_p^2Q_{l_4}Q_uZ_{i1}^{E,*}Z_{k1}^{E}-4g_1^2Z_{i4}^{E,*}Z_{k4}^{E}+6g_p^2Q_{e_4}Q_uZ_{i4}^{E,*}Z_{k4}^{E}\Big)\Big) \tag{436}$$



$$-\frac{i}{8}\Big(2g_2^2\sum_{a=1}^{2}Z_{j1+a}^{V,*}Z_{k1+a}^{E}\sum_{b=1}^{2}Z_{i1+b}^{E,*}Z_{l1+b}^{V}+g_1^2\sum_{a=1}^{2}Z_{i1+a}^{E,*}Z_{k1+a}^{E}\sum_{b=1}^{2}Z_{j1+b}^{V,*}Z_{l1+b}^{V}$$
$$-g_2^2\sum_{a=1}^{2}Z_{i1+a}^{E,*}Z_{k1+a}^{E}\sum_{b=1}^{2}Z_{j1+b}^{V,*}Z_{l1+b}^{V}+4g_p^2Q_{l_9}^2\sum_{a=1}^{2}Z_{i1+a}^{E,*}Z_{k1+a}^{E}\sum_{b=1}^{2}Z_{j1+b}^{V,*}Z_{l1+b}^{V}$$
$$-2g_1^2\sum_{a=1}^{2}Z_{i4+a}^{E,*}Z_{k4+a}^{E}\sum_{b=1}^{2}Z_{j1+b}^{V,*}Z_{l1+b}^{V}+4g_p^2Q_{e_9}Q_{l_9}\sum_{a=1}^{2}Z_{i4+a}^{E,*}Z_{k4+a}^{E}\sum_{b=1}^{2}Z_{j1+b}^{V,*}Z_{l1+b}^{V}$$

$$
\begin{aligned}
&+ 8\sum_{b=1}^{2} Z^{V,*}_{j1+b}\sum_{a=1}^{2} Y2_{ab} Z^{E}_{k4+a}\sum_{d=1}^{2}\sum_{c=1}^{2} Y2^{*}_{cd} Z^{E,*}_{i4+c} Z^{V}_{l1+d}\\
&+ 2g_2^2\sum_{a=1}^{2} Z^{E,*}_{i1+a} Z^{V}_{l1+a}\Big(2Z^{V,*}_{j1} Z^{E}_{k1} + \sum_{b=1}^{2} Z^{V,*}_{j1+b} Z^{E}_{k1+b}\Big)\\
&+ 8Y1 Z^{V,*}_{j1}\sum_{b=1}^{2}\sum_{a=1}^{2} Y2^{*}_{ab} Z^{E,*}_{i4+a} Z^{V}_{l1+b} Z^{E}_{k4}\\
&+ \sum_{a=1}^{2} Z^{V,*}_{j1+a} Z^{V}_{l1+a}\Big(\Big(4g_p^2 Q^2_{l_9} - g_2^2 + g_1^2\Big)\sum_{b=1}^{2} Z^{E,*}_{i1+b} Z^{E}_{k1+b} - 2\Big(-2g_p^2 Q_{e_9} Q_{l_9} + g_1^2\Big)\sum_{b=1}^{2} Z^{E,*}_{i4+b} Z^{E}_{k4+b}\\
&+ 2g_1^2 Z^{E,*}_{i1} Z^{E}_{k1} - 2g_2^2 Z^{E,*}_{i1} Z^{E}_{k1} + 8g_p^2 Q_{l_4} Q_{l_9} Z^{E,*}_{i1} Z^{E}_{k1} - 4g_1^2 Z^{E,*}_{i4} Z^{E}_{k4}\\
&+ 8g_p^2 Q_{e_4} Q_{l_9} Z^{E,*}_{i4} Z^{E}_{k4}\Big)\\
&+ 2g_1^2 Z^{V,*}_{j1}\sum_{a=1}^{2} Z^{E,*}_{i1+a} Z^{E}_{k1+a} Z^{V}_{l1} - 2g_2^2 Z^{V,*}_{j1}\sum_{a=1}^{2} Z^{E,*}_{i1+a} Z^{E}_{k1+a} Z^{V}_{l1}\\
&+ 8g_p^2 Q_{l_4} Q_{l_9} Z^{V,*}_{j1}\sum_{a=1}^{2} Z^{E,*}_{i1+a} Z^{E}_{k1+a} Z^{V}_{l1} + 4g_2^2 Z^{E,*}_{i1}\sum_{a=1}^{2} Z^{V,*}_{j1+a} Z^{E}_{k1+a} Z^{V}_{l1}\\
&- 4g_1^2 Z^{V,*}_{j1}\sum_{a=1}^{2} Z^{E,*}_{i4+a} Z^{E}_{k4+a} Z^{V}_{l1} + 8g_p^2 Q_{e_9} Q_{l_4} Z^{V,*}_{j1}\sum_{a=1}^{2} Z^{E,*}_{i4+a} Z^{E}_{k4+a} Z^{V}_{l1}\\
&+ 8Y1^{*} Z^{E,*}_{i4}\sum_{b=1}^{2} Z^{V,*}_{j1+b}\sum_{a=1}^{2} Y2_{ab} Z^{E}_{k4+a} Z^{V}_{l1} + 2g_1^2 Z^{E,*}_{i1} Z^{V,*}_{j1} Z^{E}_{k1} Z^{V}_{l1}\\
&+ 2g_2^2 Z^{E,*}_{i1} Z^{V,*}_{j1} Z^{E}_{k1} Z^{V}_{l1} + 8g_p^2 Q^2_{l_4} Z^{E,*}_{i1} Z^{V,*}_{j1} Z^{E}_{k1} Z^{V}_{l1} - 4g_1^2 Z^{E,*}_{i4} Z^{V,*}_{j1} Z^{E}_{k4} Z^{V}_{l1}\\
&+ 8g_p^2 Q_{e_4} Q_{l_4} Z^{E,*}_{i4} Z^{V,*}_{j1} Z^{E}_{k4} Z^{V}_{l1} + 8|Y1|^2 Z^{E,*}_{i4} Z^{V,*}_{j1} Z^{E}_{k4} Z^{V}_{l1}\Big)
\end{aligned}
\tag{437}
$$

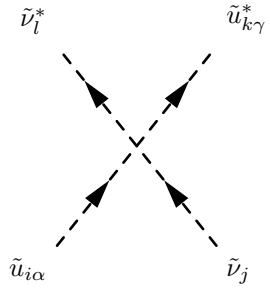


$$
-\frac{i}{72}\Big(\delta_{\alpha\delta}\delta_{\beta\gamma}\Big(g_1^2\sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{la}\sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{kb} + 9g_2^2\sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{la}\sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{kb}
$$

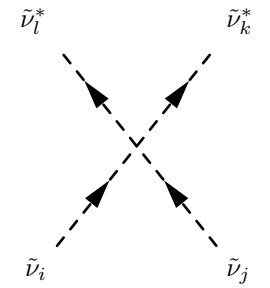
$$
\begin{aligned}
&- 6g_3^2 \sum_{a=1}^{3} Z_{ia}^{U,*} Z_{la}^{U} \sum_{b=1}^{3} Z_{jb}^{U,*} Z_{kb}^{U} + 36g_p^2 Q_q^2 \sum_{a=1}^{3} Z_{ia}^{U,*} Z_{la}^{U} \sum_{b=1}^{3} Z_{jb}^{U,*} Z_{kb}^{U} \\
&- 4g_1^2 \sum_{a=1}^{3} Z_{i3+a}^{U,*} Z_{l3+a}^{U} \sum_{b=1}^{3} Z_{jb}^{U,*} Z_{kb}^{U} + 6g_3^2 \sum_{a=1}^{3} Z_{i3+a}^{U,*} Z_{l3+a}^{U} \sum_{b=1}^{3} Z_{jb}^{U,*} Z_{kb}^{U} \\
&+ 36g_p^2 Q_q Q_u \sum_{a=1}^{3} Z_{i3+a}^{U,*} Z_{l3+a}^{U} \sum_{b=1}^{3} Z_{jb}^{U,*} Z_{kb}^{U} \\
&+ 18g_3^2 \sum_{a=1}^{3} Z_{ja}^{U,*} Z_{la}^{U} \Big(- \sum_{b=1}^{3} Z_{i3+b}^{U,*} Z_{k3+b}^{U} + \sum_{b=1}^{3} Z_{ib}^{U,*} Z_{kb}^{U} \Big) \\
&- 18g_3^2 \sum_{a=1}^{3} Z_{j3+a}^{U,*} Z_{l3+a}^{U} \Big(- \sum_{b=1}^{3} Z_{i3+b}^{U,*} Z_{k3+b}^{U} + \sum_{b=1}^{3} Z_{ib}^{U,*} Z_{kb}^{U} \Big) \\
&- 4g_1^2 \sum_{a=1}^{3} Z_{ia}^{U,*} Z_{la}^{U} \sum_{b=1}^{3} Z_{j3+b}^{U,*} Z_{k3+b}^{U} + 6g_3^2 \sum_{a=1}^{3} Z_{ia}^{U,*} Z_{la}^{U} \sum_{b=1}^{3} Z_{j3+b}^{U,*} Z_{k3+b}^{U} \\
&+ 36g_p^2 Q_q Q_u \sum_{a=1}^{3} Z_{ia}^{U,*} Z_{la}^{U} \sum_{b=1}^{3} Z_{j3+b}^{U,*} Z_{k3+b}^{U} + 16g_1^2 \sum_{a=1}^{3} Z_{i3+a}^{U,*} Z_{l3+a}^{U} \sum_{b=1}^{3} Z_{j3+b}^{U,*} Z_{k3+b}^{U} \\
&- 6g_3^2 \sum_{a=1}^{3} Z_{i3+a}^{U,*} Z_{l3+a}^{U} \sum_{b=1}^{3} Z_{j3+b}^{U,*} Z_{k3+b}^{U} + 36g_p^2 Q_u^2 \sum_{a=1}^{3} Z_{i3+a}^{U,*} Z_{l3+a}^{U} \sum_{b=1}^{3} Z_{j3+b}^{U,*} Z_{k3+b}^{U} \\
&+ g_1^2 \sum_{a=1}^{3} Z_{ja}^{U,*} Z_{ka}^{U} \sum_{b=1}^{3} Z_{ib}^{U,*} Z_{lb}^{U} + 9g_2^2 \sum_{a=1}^{3} Z_{ja}^{U,*} Z_{ka}^{U} \sum_{b=1}^{3} Z_{ib}^{U,*} Z_{lb}^{U} \\
&- 6g_3^2 \sum_{a=1}^{3} Z_{ja}^{U,*} Z_{ka}^{U} \sum_{b=1}^{3} Z_{ib}^{U,*} Z_{lb}^{U} + 36g_p^2 Q_q^2 \sum_{a=1}^{3} Z_{ja}^{U,*} Z_{ka}^{U} \sum_{b=1}^{3} Z_{ib}^{U,*} Z_{lb}^{U} \\
&- 4g_1^2 \sum_{a=1}^{3} Z_{j3+a}^{U,*} Z_{k3+a}^{U} \sum_{b=1}^{3} Z_{ib}^{U,*} Z_{lb}^{U} + 6g_3^2 \sum_{a=1}^{3} Z_{j3+a}^{U,*} Z_{k3+a}^{U} \sum_{b=1}^{3} Z_{ib}^{U,*} Z_{lb}^{U} \\
&+ 36g_p^2 Q_q Q_u \sum_{a=1}^{3} Z_{j3+a}^{U,*} Z_{k3+a}^{U} \sum_{b=1}^{3} Z_{ib}^{U,*} Z_{lb}^{U} + 18g_3^2 \sum_{a=1}^{3} Z_{ia}^{U,*} Z_{ka}^{U} \sum_{b=1}^{3} Z_{jb}^{U,*} Z_{lb}^{U} \\
&- 18g_3^2 \sum_{a=1}^{3} Z_{i3+a}^{U,*} Z_{k3+a}^{U} \sum_{b=1}^{3} Z_{jb}^{U,*} Z_{lb}^{U} - 4g_1^2 \sum_{a=1}^{3} Z_{ja}^{U,*} Z_{ka}^{U} \sum_{b=1}^{3} Z_{i3+b}^{U,*} Z_{l3+b}^{U} \\
&+ 6g_3^2 \sum_{a=1}^{3} Z_{ja}^{U,*} Z_{ka}^{U} \sum_{b=1}^{3} Z_{i3+b}^{U,*} Z_{l3+b}^{U} + 36g_p^2 Q_q Q_u \sum_{a=1}^{3} Z_{ja}^{U,*} Z_{ka}^{U} \sum_{b=1}^{3} Z_{i3+b}^{U,*} Z_{l3+b}^{U} \\
&+ 16g_1^2 \sum_{a=1}^{3} Z_{j3+a}^{U,*} Z_{k3+a}^{U} \sum_{b=1}^{3} Z_{i3+b}^{U,*} Z_{l3+b}^{U} - 6g_3^2 \sum_{a=1}^{3} Z_{j3+a}^{U,*} Z_{k3+a}^{U} \sum_{b=1}^{3} Z_{i3+b}^{U,*} Z_{l3+b}^{U}
\end{aligned}
$$

$$
\begin{aligned}
&+ 36 g_p^2 Q_u^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} - 18 g_3^2 \sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{ka} \sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{l3+b} \\
&+ 18 g_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(18 g_3^2 \sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{la} \sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{kb} - 18 g_3^2 \sum_{a=1}^{3} Z^{U,*}_{i3+a} Z^{U}_{l3+a} \sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{kb} \\
&+ \sum_{a=1}^{3} Z^{U,*}_{ja} Z^{U}_{la} \Big(\Big(36 g_p^2 Q_q^2 - 6 g_3^2 + 9 g_2^2 + g_1^2 \Big) \sum_{b=1}^{3} Z^{U,*}_{ib} Z^{U}_{kb} \\
&+ 2 \Big(18 g_p^2 Q_q Q_u - 2 g_1^2 + 3 g_3^2 \Big) \sum_{b=1}^{3} Z^{U,*}_{i3+b} Z^{U}_{k3+b} \Big) \\
&+ \sum_{a=1}^{3} Z^{U,*}_{j3+a} Z^{U}_{l3+a} \Big(2 \Big(18 g_p^2 Q_u^2 - 3 g_3^2 + 8 g_1^2 \Big) \sum_{b=1}^{3} Z^{U,*}_{i3+b} Z^{U}_{k3+b} + \Big(36 g_p^2 Q_q Q_u - 4 g_1^2 + 6 g_3^2 \Big) \sum_{b=1}^{3} Z^{U,*}_{ib} Z^{U}_{kb} \Big) \\
&- 18 g_3^2 \sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{la} \sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{k3+b} + 18 g_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} \\
&+ 18 g_3^2 \sum_{a=1}^{3} Z^{U,*}_{ja} Z^{U}_{ka} \sum_{b=1}^{3} Z^{U,*}_{ib} Z^{U}_{lb} - 18 g_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} + 9 g_2^2 \sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{ka} \sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb} \\
&- 6 g_3^2 \sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{ka} \sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb} + 36 g_p^2 Q_q^2 \sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{ka} \sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb} \\
&- 4 g_1^2 \sum_{a=1}^{3} Z^{U,*}_{i3+a} Z^{U}_{k3+a} \sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb} + 6 g_3^2 \sum_{a=1}^{3} Z^{U,*}_{i3+a} Z^{U}_{k3+a} \sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb} \\
&+ 36 g_p^2 Q_q Q_u \sum_{a=1}^{3} Z^{U,*}_{i3+a} Z^{U}_{k3+a} \sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb} - 18 g_3^2 \sum_{a=1}^{3} Z^{U,*}_{ja} Z^{U}_{ka} \sum_{b=1}^{3} Z^{U,*}_{i3+b} Z^{U}_{l3+b} \\
&+ 18 g_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} - 4 g_1^2 \sum_{a=1}^{3} Z^{U,*}_{ia} Z^{U}_{ka} \sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{l3+b}
\end{aligned}
$$

$$
\begin{aligned}
&+ 6g_3^2 \sum_{a=1}^{3} Z_{ia}^{U,*} Z_{ka}^{U} \sum_{b=1}^{3} Z_{j3+b}^{U,*} Z_{l3+b}^{U} + 36 g_p^2 Q_q Q_u \sum_{a=1}^{3} Z_{ia}^{U,*} Z_{ka}^{U} \sum_{b=1}^{3} Z_{j3+b}^{U,*} Z_{l3+b}^{U} \\
&+ 16 g_1^2 \sum_{a=1}^{3} Z_{i3+a}^{U,*} Z_{k3+a}^{U} \sum_{b=1}^{3} Z_{j3+b}^{U,*} Z_{l3+b}^{U} - 6 g_3^2 \sum_{a=1}^{3} Z_{i3+a}^{U,*} Z_{k3+a}^{U} \sum_{b=1}^{3} Z_{j3+b}^{U,*} Z_{l3+b}^{U} \\
&+ 36 g_p^2 Q_u^2 \sum_{a=1}^{3} Z_{i3+a}^{U,*} Z_{k3+a}^{U} \sum_{b=1}^{3} Z_{j3+b}^{U,*} Z_{l3+b}^{U} \\
&+ 72 \sum_{b=1}^{3} Z_{jb}^{U,*} \sum_{a=1}^{3} Y_{u,ab} Z_{l3+a}^{U} \sum_{d=1}^{3} \sum_{c=1}^{3} Y_{u,cd}^{*} Z_{i3+c}^{U,*} Z_{kd}^{U} \\
&+ 72 \sum_{b=1}^{3} Z_{ib}^{U,*} \sum_{a=1}^{3} Y_{u,ab} Z_{k3+a}^{U} \sum_{d=1}^{3} \sum_{c=1}^{3} Y_{u,cd}^{*} Z_{j3+c}^{U,*} Z_{ld}^{U} \Big) \Big)
\end{aligned} \tag{438}
$$

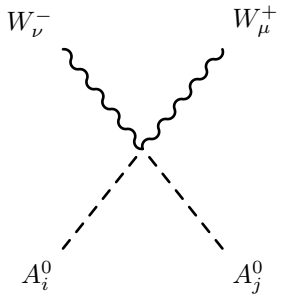


$$
\begin{aligned}
&\frac{i}{24} \delta_{\alpha\gamma} \Big(\sum_{a=1}^{2} Z_{j1+a}^{V,*} Z_{l1+a}^{V} \Big(\Big(-3 \Big(4 g_p^2 Q_{l_9} Q_q + g_2^2 \Big) + g_1^2 \Big) \sum_{b=1}^{3} Z_{ib}^{U,*} Z_{kb}^{U} - 4 \Big(3 g_p^2 Q_{l_9} Q_u + g_1^2 \Big) \sum_{b=1}^{3} Z_{i3+b}^{U,*} Z_{k3+b}^{U} \Big) \\
&+ \sum_{a=1}^{3} Z_{ia}^{U,*} Z_{ka}^{U} \Big(2 \Big(-3 \Big(4 g_p^2 Q_{l_4} Q_q + g_2^2 \Big) + g_1^2 \Big) Z_{j1}^{V,*} Z_{l1}^{V} + \Big(-3 \Big(4 g_p^2 Q_{l_9} Q_q + g_2^2 \Big) + g_1^2 \Big) \sum_{b=1}^{2} Z_{j1+b}^{V,*} Z_{l1+b}^{V} \Big) \\
&- 4 \sum_{a=1}^{3} Z_{i3+a}^{U,*} Z_{k3+a}^{U} \Big(2 \Big(3 g_p^2 Q_{l_4} Q_u + g_1^2 \Big) Z_{j1}^{V,*} Z_{l1}^{V} + \Big(3 g_p^2 Q_{l_9} Q_u + g_1^2 \Big) \sum_{b=1}^{2} Z_{j1+b}^{V,*} Z_{l1+b}^{V} \Big) \Big)
\end{aligned} \tag{439}
$$

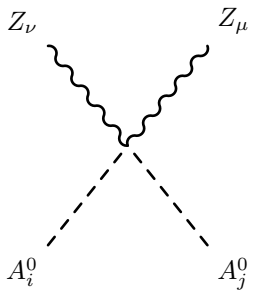


$$
\begin{aligned}
&-\frac{i}{8}\Big(g_1^2\sum_{a=1}^{2}Z_{j1+a}^{V,*}Z_{k1+a}^{V}\sum_{b=1}^{2}Z_{i1+b}^{V,*}Z_{l1+b}^{V}+g_2^2\sum_{a=1}^{2}Z_{j1+a}^{V,*}Z_{k1+a}^{V}\sum_{b=1}^{2}Z_{i1+b}^{V,*}Z_{l1+b}^{V}\\
&+4g_p^2Q_{l_9}^2\sum_{a=1}^{2}Z_{j1+a}^{V,*}Z_{k1+a}^{V}\sum_{b=1}^{2}Z_{i1+b}^{V,*}Z_{l1+b}^{V}+g_1^2\sum_{a=1}^{2}Z_{i1+a}^{V,*}Z_{k1+a}^{V}\sum_{b=1}^{2}Z_{j1+b}^{V,*}Z_{l1+b}^{V}\\
&+g_2^2\sum_{a=1}^{2}Z_{i1+a}^{V,*}Z_{k1+a}^{V}\sum_{b=1}^{2}Z_{j1+b}^{V,*}Z_{l1+b}^{V}+4g_p^2Q_{l_9}^2\sum_{a=1}^{2}Z_{i1+a}^{V,*}Z_{k1+a}^{V}\sum_{b=1}^{2}Z_{j1+b}^{V,*}Z_{l1+b}^{V}\\
&+\sum_{a=1}^{2}Z_{j1+a}^{V,*}Z_{l1+a}^{V}\Big(2\Big(4g_p^2Q_{l_4}Q_{l_9}+g_1^2+g_2^2\Big)Z_{i1}^{V,*}Z_{k1}^{V}+\Big(4g_p^2Q_{l_9}^2+g_1^2+g_2^2\Big)\sum_{b=1}^{2}Z_{i1+b}^{V,*}Z_{k1+b}^{V}\Big)\\
&+\sum_{a=1}^{2}Z_{i1+a}^{V,*}Z_{l1+a}^{V}\Big(2\Big(4g_p^2Q_{l_4}Q_{l_9}+g_1^2+g_2^2\Big)Z_{j1}^{V,*}Z_{k1}^{V}+\Big(4g_p^2Q_{l_9}^2+g_1^2+g_2^2\Big)\sum_{b=1}^{2}Z_{j1+b}^{V,*}Z_{k1+b}^{V}\Big)\\
&+2g_1^2Z_{j1}^{V,*}\sum_{a=1}^{2}Z_{i1+a}^{V,*}Z_{k1+a}^{V}Z_{l1}^{V}+2g_2^2Z_{j1}^{V,*}\sum_{a=1}^{2}Z_{i1+a}^{V,*}Z_{k1+a}^{V}Z_{l1}^{V}\\
&+8g_p^2Q_{l_4}Q_{l_9}Z_{j1}^{V,*}\sum_{a=1}^{2}Z_{i1+a}^{V,*}Z_{k1+a}^{V}Z_{l1}^{V}+2g_1^2Z_{i1}^{V,*}\sum_{a=1}^{2}Z_{j1+a}^{V,*}Z_{k1+a}^{V}Z_{l1}^{V}\\
&+2g_2^2Z_{i1}^{V,*}\sum_{a=1}^{2}Z_{j1+a}^{V,*}Z_{k1+a}^{V}Z_{l1}^{V}+8g_p^2Q_{l_4}Q_{l_9}Z_{i1}^{V,*}\sum_{a=1}^{2}Z_{j1+a}^{V,*}Z_{k1+a}^{V}Z_{l1}^{V}\\
&+4g_1^2Z_{i1}^{V,*}Z_{j1}^{V,*}Z_{k1}^{V}Z_{l1}^{V}+4g_2^2Z_{i1}^{V,*}Z_{j1}^{V,*}Z_{k1}^{V}Z_{l1}^{V}+16g_p^2Q_{l_4}^2Z_{i1}^{V,*}Z_{j1}^{V,*}Z_{k1}^{V}Z_{l1}^{V}\Big)
\end{aligned}
\tag{440}
$$

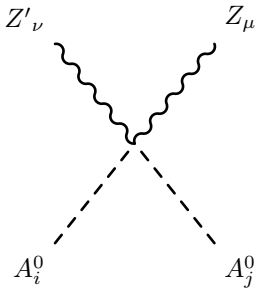
9.8 Two Scalar-Two Vector Boson-Interaction



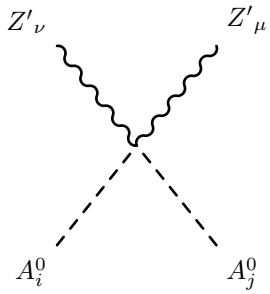
$$
\frac{i}{2}g_2^2\Big(Z_{i1}^{A,*}Z_{j1}^{A,*}+Z_{i2}^{A,*}Z_{j2}^{A,*}\Big)\Big(g_{\mu\nu}\Big)
\tag{441}
$$



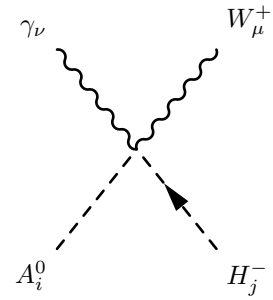
$$\frac{i}{2}\Big(4g_p^2Q_s^2Z_{i3}^{A,*}Z_{j3}^{A,*}\sin\Theta_W^{\prime,2}$$
$$+ Z_{i1}^{A,*}Z_{j1}^{A,*}\Big(2g_pQ_{H_d}\sin\Theta_W^{\prime} + g_1\cos\Theta_W^{\prime}\sin\Theta_W + g_2\cos\Theta_W\cos\Theta_W^{\prime}\Big)^2$$
$$+ Z_{i2}^{A,*}Z_{j2}^{A,*}\Big(-2g_pQ_{H_u}\sin\Theta_W^{\prime} + g_1\cos\Theta_W^{\prime}\sin\Theta_W + g_2\cos\Theta_W\cos\Theta_W^{\prime}\Big)^2\Big)\Big(g_{\mu\nu}\Big) \tag{442}$$



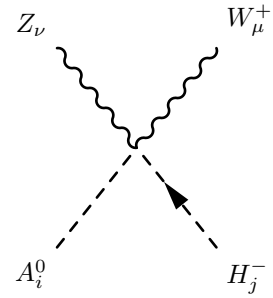
$$-\frac{i}{2}\Big(-4g_p^2Q_s^2Z_{i3}^{A,*}Z_{j3}^{A,*}\cos\Theta_W^{\prime}\sin\Theta_W^{\prime}$$
$$+ Z_{i1}^{A,*}Z_{j1}^{A,*}\Big(-2g_1g_pQ_{H_d}\cos\Theta_W^{\prime,2}\sin\Theta_W + g_2^2\cos\Theta_W^2\cos\Theta_W^{\prime}\sin\Theta_W^{\prime}$$
$$+ \cos\Theta_W^{\prime}\Big(-4g_p^2Q_{H_d}^2 + g_1^2\sin\Theta_W^2\Big)\sin\Theta_W^{\prime} + 2g_1g_pQ_{H_d}\sin\Theta_W\sin\Theta_W^{\prime,2}$$
$$+ 2g_2\cos\Theta_W\Big(g_1\cos\Theta_W^{\prime}\sin\Theta_W\sin\Theta_W^{\prime} - g_pQ_{H_d}\cos\Theta_W^{\prime,2} + g_pQ_{H_d}\sin\Theta_W^{\prime,2}\Big)\Big)$$
$$+ Z_{i2}^{A,*}Z_{j2}^{A,*}\Big(2g_1g_pQ_{H_u}\cos\Theta_W^{\prime,2}\sin\Theta_W + g_2^2\cos\Theta_W^2\cos\Theta_W^{\prime}\sin\Theta_W^{\prime}$$
$$+ \cos\Theta_W^{\prime}\Big(-4g_p^2Q_{H_u}^2 + g_1^2\sin\Theta_W^2\Big)\sin\Theta_W^{\prime} - 2g_1g_pQ_{H_u}\sin\Theta_W\sin\Theta_W^{\prime,2}$$
$$+ 2g_2\cos\Theta_W\Big(g_1\cos\Theta_W^{\prime}\sin\Theta_W\sin\Theta_W^{\prime} + g_pQ_{H_u}\cos\Theta_W^{\prime,2} - g_pQ_{H_u}\sin\Theta_W^{\prime,2}\Big)\Big)\Big)\Big(g_{\mu\nu}\Big) \tag{443}$$



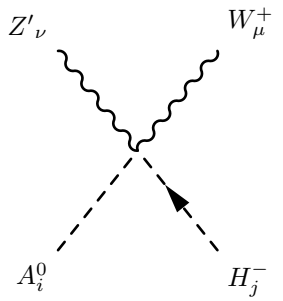
$$\frac{i}{2}\Big(4g_p^2Q_s^2Z_{i3}^{A,*}Z_{j3}^{A,*}\cos\Theta_W'^{,2}$$
$$+ Z_{i1}^{A,*}Z_{j1}^{A,*}\Big(-2g_pQ_{H_d}\cos\Theta_W' + \Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta_W'\Big)^2$$
$$+ Z_{i2}^{A,*}Z_{j2}^{A,*}\Big(2g_pQ_{H_u}\cos\Theta_W' + \Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta_W'\Big)^2\Big)\Big(g_{\mu\nu}\Big) \tag{444}$$



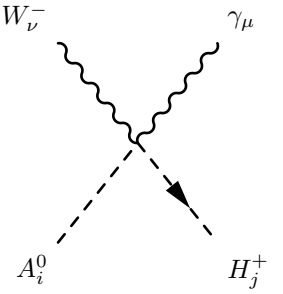
$$-\frac{1}{2}g_1g_2\cos\Theta_W\Big(Z_{i1}^{A,*}Z_{j1}^{+} + Z_{i2}^{A,*}Z_{j2}^{+}\Big)\Big(g_{\mu\nu}\Big) \tag{445}$$



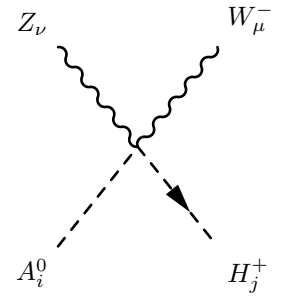
$$\frac{1}{2}g_2\Big(Z_{i1}^{A,*}\Big(2g_pQ_{H_d}\sin\Theta_W' + g_1\cos\Theta_W'\sin\Theta_W\Big)Z_{j1}^{+}$$
$$+ Z_{i2}^{A,*}\Big(-2g_pQ_{H_u}\sin\Theta_W' + g_1\cos\Theta_W'\sin\Theta_W\Big)Z_{j2}^{+}\Big)\Big(g_{\mu\nu}\Big) \tag{446}$$



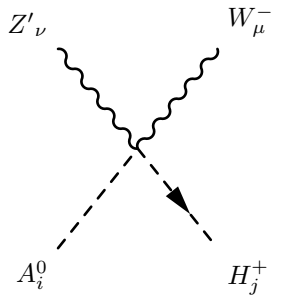
$$\frac{1}{2}g_2\Big(Z^{A,*}_{i1}\Big(2g_pQ_{H_d}\cos\Theta'_W - g_1\sin\Theta_W\sin\Theta'_W\Big)Z^+_{j1} - Z^{A,*}_{i2}\Big(2g_pQ_{H_u}\cos\Theta'_W + g_1\sin\Theta_W\sin\Theta'_W\Big)Z^+_{j2}\Big)\Big(g_{\mu\nu}\Big) \tag{447}$$



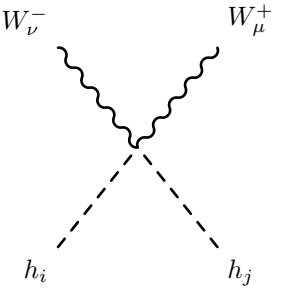
$$\frac{1}{2}g_1g_2\cos\Theta_W\Big(Z^{A,*}_{i1}Z^+_{j1} + Z^{A,*}_{i2}Z^+_{j2}\Big)\Big(g_{\mu\nu}\Big) \tag{448}$$



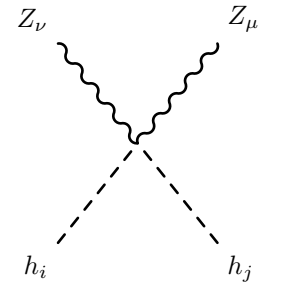
$$-\frac{1}{2}g_2\Big(Z^{A,*}_{i1}\Big(2g_pQ_{H_d}\sin\Theta'_W + g_1\cos\Theta'_W\sin\Theta_W\Big)Z^+_{j1} + Z^{A,*}_{i2}\Big(-2g_pQ_{H_u}\sin\Theta'_W + g_1\cos\Theta'_W\sin\Theta_W\Big)Z^+_{j2}\Big)\Big(g_{\mu\nu}\Big) \tag{449}$$



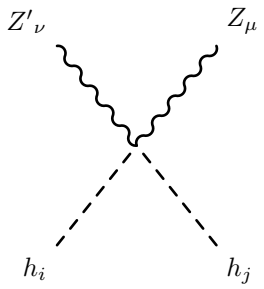
$$\frac{1}{2}g_2\Big(Z^{A,*}_{i1}\Big(-2g_pQ_{H_d}\cos\Theta'_W+g_1\sin\Theta_W\sin\Theta'_W\Big)Z^+_{j1}$$
$$+Z^{A,*}_{i2}\Big(2g_pQ_{H_u}\cos\Theta'_W+g_1\sin\Theta_W\sin\Theta'_W\Big)Z^+_{j2}\Big)\Big(g_{\mu\nu}\Big) \tag{450}$$



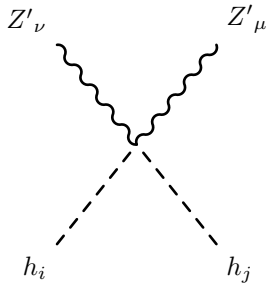
$$\frac{i}{2}g_2^2\Big(Z^{H,*}_{i1}Z^{H,*}_{j1}+Z^{H,*}_{i2}Z^{H,*}_{j2}\Big)\Big(g_{\mu\nu}\Big) \tag{451}$$



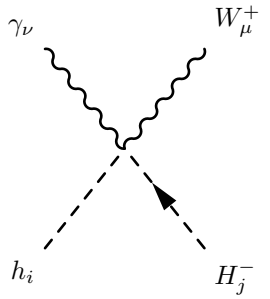
$$\frac{i}{2}\Big(4g_p^2Q_s^2Z^{H,*}_{i3}Z^{H,*}_{j3}\sin\Theta'^{,2}_W$$
$$+Z^{H,*}_{i1}Z^{H,*}_{j1}\Big(2g_pQ_{H_d}\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)^2$$
$$+Z^{H,*}_{i2}Z^{H,*}_{j2}\Big(-2g_pQ_{H_u}\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)^2\Big)\Big(g_{\mu\nu}\Big) \tag{452}$$



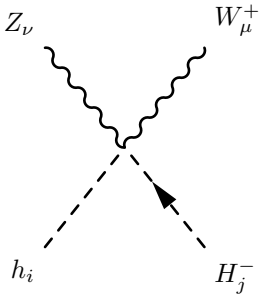
$$
\begin{aligned}
&-\frac{i}{2}\Big(-4g_p^2Q_s^2Z_{i3}^{H,*}Z_{j3}^{H,*}\cos\Theta'_W\sin\Theta'_W \\
&+Z_{i1}^{H,*}Z_{j1}^{H,*}\Big(-2g_1g_pQ_{H_d}\cos\Theta'^{,2}_W\sin\Theta_W+g_2^2\cos\Theta_W^2\cos\Theta'_W\sin\Theta'_W \\
&+\cos\Theta'_W\Big(-4g_p^2Q_{H_d}^2+g_1^2\sin\Theta_W^2\Big)\sin\Theta'_W+2g_1g_pQ_{H_d}\sin\Theta_W\sin\Theta'^{,2}_W \\
&+2g_2\cos\Theta_W\Big(g_1\cos\Theta'_W\sin\Theta_W\sin\Theta'_W-g_pQ_{H_d}\cos\Theta'^{,2}_W+g_pQ_{H_d}\sin\Theta'^{,2}_W\Big)\Big) \\
&+Z_{i2}^{H,*}Z_{j2}^{H,*}\Big(2g_1g_pQ_{H_u}\cos\Theta'^{,2}_W\sin\Theta_W+g_2^2\cos\Theta_W^2\cos\Theta'_W\sin\Theta'_W \\
&+\cos\Theta'_W\Big(-4g_p^2Q_{H_u}^2+g_1^2\sin\Theta_W^2\Big)\sin\Theta'_W-2g_1g_pQ_{H_u}\sin\Theta_W\sin\Theta'^{,2}_W \\
&+2g_2\cos\Theta_W\Big(g_1\cos\Theta'_W\sin\Theta_W\sin\Theta'_W+g_pQ_{H_u}\cos\Theta'^{,2}_W-g_pQ_{H_u}\sin\Theta'^{,2}_W\Big)\Big)\Big)\Big(g_{\mu\nu}\Big)
\end{aligned}
\tag{453}
$$



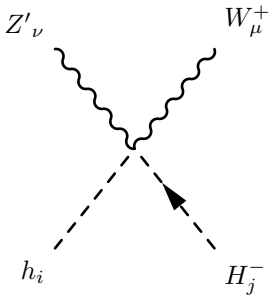
$$
\begin{aligned}
&\frac{i}{2}\Big(4g_p^2Q_s^2Z_{i3}^{H,*}Z_{j3}^{H,*}\cos\Theta'^{,2}_W \\
&+Z_{i1}^{H,*}Z_{j1}^{H,*}\Big(-2g_pQ_{H_d}\cos\Theta'_W+\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)^2 \\
&+Z_{i2}^{H,*}Z_{j2}^{H,*}\Big(2g_pQ_{H_u}\cos\Theta'_W+\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)^2\Big)\Big(g_{\mu\nu}\Big)
\end{aligned}
\tag{454}
$$



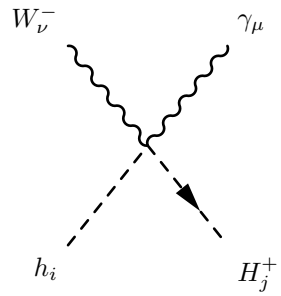
$$-\frac{i}{2}g_1 g_2 \cos\Theta_W \Big(Z_{i1}^{H,*} Z_{j1}^{+} - Z_{i2}^{H,*} Z_{j2}^{+}\Big)\Big(g_{\mu\nu}\Big) \tag{455}$$



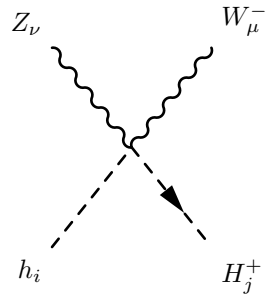
$$\begin{aligned}&\frac{i}{2}g_2\Big(Z_{i1}^{H,*}\Big(2g_p Q_{H_d}\sin\Theta'_W + g_1\cos\Theta'_W\sin\Theta_W\Big)Z_{j1}^{+}\\&+ Z_{i2}^{H,*}\Big(2g_p Q_{H_u}\sin\Theta'_W - g_1\cos\Theta'_W\sin\Theta_W\Big)Z_{j2}^{+}\Big)\Big(g_{\mu\nu}\Big)\end{aligned} \tag{456}$$



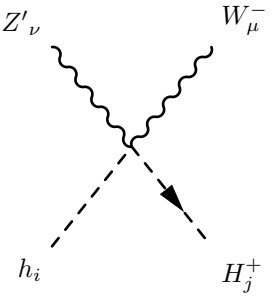
$$\begin{aligned}&\frac{i}{2}g_2\Big(Z_{i1}^{H,*}\Big(2g_p Q_{H_d}\cos\Theta'_W - g_1\sin\Theta_W\sin\Theta'_W\Big)Z_{j1}^{+}\\&+ Z_{i2}^{H,*}\Big(2g_p Q_{H_u}\cos\Theta'_W + g_1\sin\Theta_W\sin\Theta'_W\Big)Z_{j2}^{+}\Big)\Big(g_{\mu\nu}\Big)\end{aligned} \tag{457}$$



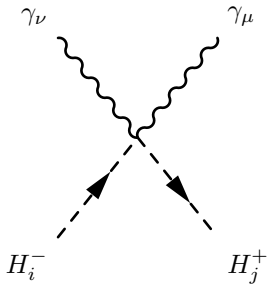
$$-\frac{i}{2}g_1 g_2 \cos\Theta_W \Big(Z_{i1}^{H,*} Z_{j1}^{+} - Z_{i2}^{H,*} Z_{j2}^{+}\Big)\Big(g_{\mu\nu}\Big) \tag{458}$$



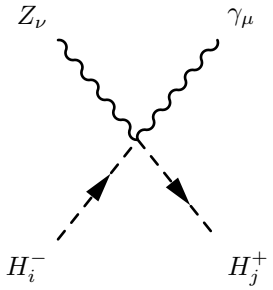
$$\begin{aligned}&\frac{i}{2}g_2\Big(Z_{i1}^{H,*}\Big(2g_p Q_{H_d}\sin\Theta'_W + g_1\cos\Theta'_W\sin\Theta_W\Big)Z_{j1}^{+}\\&+ Z_{i2}^{H,*}\Big(2g_p Q_{H_u}\sin\Theta'_W - g_1\cos\Theta'_W\sin\Theta_W\Big)Z_{j2}^{+}\Big)\Big(g_{\mu\nu}\Big)\end{aligned} \tag{459}$$



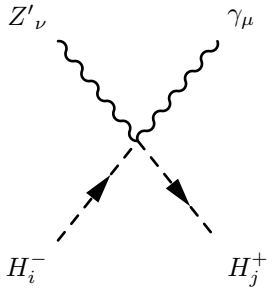
$$\begin{aligned}&\frac{i}{2}g_2\Big(Z_{i1}^{H,*}\Big(2g_p Q_{H_d}\cos\Theta'_W - g_1\sin\Theta_W\sin\Theta'_W\Big)Z_{j1}^{+}\\&+ Z_{i2}^{H,*}\Big(2g_p Q_{H_u}\cos\Theta'_W + g_1\sin\Theta_W\sin\Theta'_W\Big)Z_{j2}^{+}\Big)\Big(g_{\mu\nu}\Big)\end{aligned} \tag{460}$$



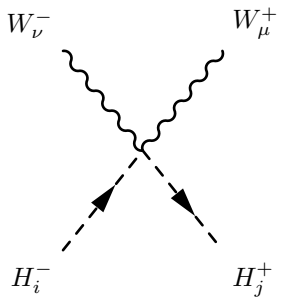
$$\frac{i}{2}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)^2\Big(Z^+_{i1}Z^+_{j1} + Z^+_{i2}Z^+_{j2}\Big)\Big(g_{\mu\nu}\Big) \tag{461}$$



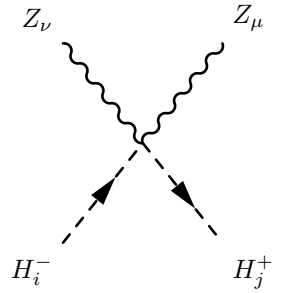
$$\begin{aligned}&-\frac{i}{2}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)\Big(\Big(2g_pQ_{H_d}\sin\Theta'_W + g_1\cos\Theta'_W\sin\Theta_W - g_2\cos\Theta_W\cos\Theta'_W\Big)Z^+_{i1}Z^+_{j1}\\&+\Big(-2g_pQ_{H_u}\sin\Theta'_W + g_1\cos\Theta'_W\sin\Theta_W - g_2\cos\Theta_W\cos\Theta'_W\Big)Z^+_{i2}Z^+_{j2}\Big)\Big(g_{\mu\nu}\Big)\end{aligned} \tag{462}$$



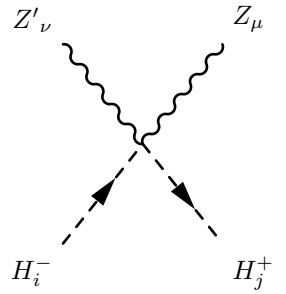
$$\begin{aligned}&\frac{i}{2}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)\Big(\Big(-2g_pQ_{H_d}\cos\Theta'_W + \Big(g_1\sin\Theta_W - g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)Z^+_{i1}Z^+_{j1}\\&+\Big(2g_pQ_{H_u}\cos\Theta'_W + \Big(g_1\sin\Theta_W - g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)Z^+_{i2}Z^+_{j2}\Big)\Big(g_{\mu\nu}\Big)\end{aligned} \tag{463}$$



$$\frac{i}{2}g_2^2\Big(Z_{i1}^+Z_{j1}^+ + Z_{i2}^+Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big) \tag{464}$$

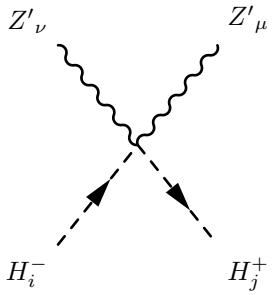


$$\begin{aligned}&\frac{i}{2}\Big(\Big(2g_pQ_{H_d}\sin\Theta'_W + g_1\cos\Theta'_W\sin\Theta_W - g_2\cos\Theta_W\cos\Theta'_W\Big)^2 Z_{i1}^+Z_{j1}^+\\&+\Big(2g_pQ_{H_u}\sin\Theta'_W - g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W\Big)^2 Z_{i2}^+Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big)\end{aligned} \tag{465}$$

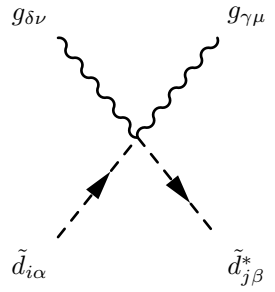


$$\begin{aligned}&-\frac{i}{2}\Big(\Big(-2g_1g_pQ_{H_d}\cos\Theta'^{,2}_W\sin\Theta_W + g_2^2\cos\Theta_W^2\cos\Theta'_W\sin\Theta'_W\\&+\cos\Theta'_W\Big(-4g_p^2Q_{H_d}^2 + g_1^2\sin\Theta_W^2\Big)\sin\Theta'_W + 2g_1g_pQ_{H_d}\sin\Theta_W\sin\Theta'^{,2}_W\end{aligned}$$

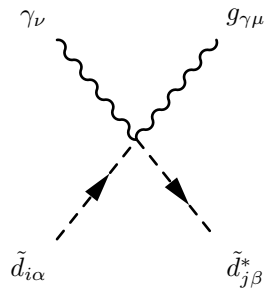
$$+ 2g_2 \cos\Theta_W \Big(- g_1 \cos\Theta'_W \sin\Theta_W \sin\Theta'_W + g_p Q_{H_d} \cos\Theta'^{,2}_W - g_p Q_{H_d} \sin\Theta'^{,2}_W \Big) \Big) Z^+_{i1} Z^+_{j1}$$
$$+ \Big(2g_1 g_p Q_{H_u} \cos\Theta'^{,2}_W \sin\Theta_W + g_2^2 \cos\Theta^2_W \cos\Theta'_W \sin\Theta'_W$$
$$+ \cos\Theta'_W \Big(- 4g_p^2 Q^2_{H_u} + g_1^2 \sin\Theta^2_W \Big) \sin\Theta'_W - 2g_1 g_p Q_{H_u} \sin\Theta_W \sin\Theta'^{,2}_W$$
$$- 2g_2 \cos\Theta_W \Big(g_1 \cos\Theta'_W \sin\Theta_W \sin\Theta'_W + g_p Q_{H_u} \cos\Theta'^{,2}_W - g_p Q_{H_u} \sin\Theta'^{,2}_W \Big) \Big) Z^+_{i2} Z^+_{j2} \Big) \Big(g_{\mu\nu} \Big) \tag{466}$$



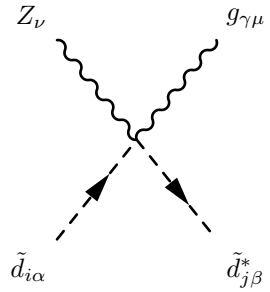
$$\frac{i}{2} \Big(\Big(2g_p Q_{H_d} \cos\Theta'_W + \Big(- g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) \sin\Theta'_W \Big)^2 Z^+_{i1} Z^+_{j1}$$
$$+ \Big(2g_p Q_{H_u} \cos\Theta'_W + \Big(g_1 \sin\Theta_W - g_2 \cos\Theta_W \Big) \sin\Theta'_W \Big)^2 Z^+_{i2} Z^+_{j2} \Big) \Big(g_{\mu\nu} \Big) \tag{467}$$



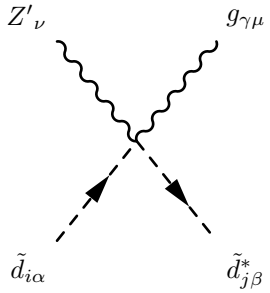
$$\frac{i}{4} g_3^2 \delta_{ij} \Big(\sum_{a=1}^{3} \lambda^\gamma_{a,\alpha} \lambda^\delta_{\beta,a} + \sum_{a=1}^{3} \lambda^\gamma_{\beta,a} \lambda^\delta_{a,\alpha} \Big) \Big(g_{\mu\nu} \Big) \tag{468}$$



$$\frac{i}{6}g_3\lambda^{\gamma}_{\beta,\alpha}\Big(-2g_1\cos\Theta_W\sum_{a=1}^{3}Z^{D,*}_{i3+a}Z^{D}_{j3+a}+\Big(-3g_2\sin\Theta_W+g_1\cos\Theta_W\Big)\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{D}_{ja}\Big)\Big(g_{\mu\nu}\Big) \tag{469}$$

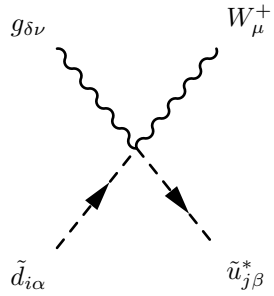


$$-\frac{i}{6}g_3\lambda^{\gamma}_{\beta,\alpha}\Big(\Big(3g_2\cos\Theta_W\cos\Theta'_W-6g_pQ_q\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\Big)\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{D}_{ja}$$
$$-2\Big(-3g_pQ_d\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\Big)\sum_{a=1}^{3}Z^{D,*}_{i3+a}Z^{D}_{j3+a}\Big)\Big(g_{\mu\nu}\Big) \tag{470}$$

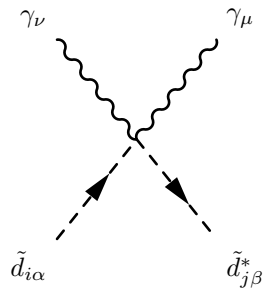


$$\frac{i}{6}g_3\lambda^{\gamma}_{\beta,\alpha}\Big(\Big(\Big(3g_2\cos\Theta_W+g_1\sin\Theta_W\Big)\sin\Theta'_W+6g_pQ_q\cos\Theta'_W\Big)\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{D}_{ja}$$

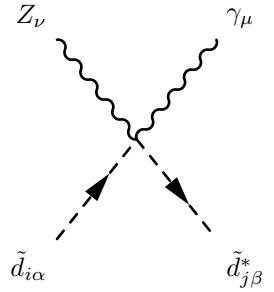
$$- 2\Big(3g_pQ_d\cos\Theta'_W + g_1\sin\Theta_W\sin\Theta'_W\Big)\sum_{a=1}^{3} Z^{D,*}_{i3+a}Z^{D}_{j3+a}\Big)\Big(g_{\mu\nu}\Big) \tag{471}$$



$$i\frac{1}{\sqrt{2}}g_2g_3\lambda^{\delta}_{\beta,\alpha}\sum_{a=1}^{3} Z^{D,*}_{ia}Z^{U}_{ja}\Big(g_{\mu\nu}\Big) \tag{472}$$

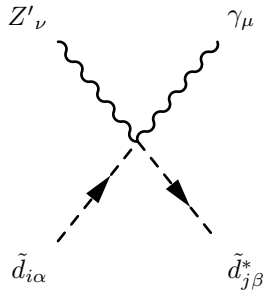


$$\frac{i}{18}\delta_{\alpha\beta}\Big(\Big(-3g_2\sin\Theta_W + g_1\cos\Theta_W\Big)^2\sum_{a=1}^{3} Z^{D,*}_{ia}Z^{D}_{ja} + 4g_1^2\cos\Theta_W^2\sum_{a=1}^{3} Z^{D,*}_{i3+a}Z^{D}_{j3+a}\Big)\Big(g_{\mu\nu}\Big) \tag{473}$$



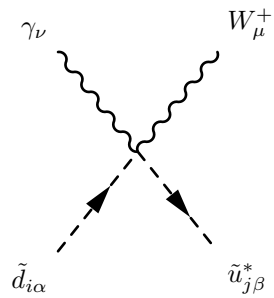
$$- \frac{i}{18}\delta_{\alpha\beta}\Big(\Big(- 3g_2 \sin\Theta_W + g_1 \cos\Theta_W\Big)\Big(3g_2 \cos\Theta_W \cos\Theta'_W - 6g_p Q_q \sin\Theta'_W + g_1 \cos\Theta'_W \sin\Theta_W\Big)\sum_{a=1}^{3} Z^{D,*}_{ia} Z^{D}_{ja}$$

$$+ 4g_1 \cos\Theta_W\Big(- 3g_p Q_d \sin\Theta'_W + g_1 \cos\Theta'_W \sin\Theta_W\Big)\sum_{a=1}^{3} Z^{D,*}_{i3+a} Z^{D}_{j3+a}\Big)\Big(g_{\mu\nu}\Big) \tag{474}$$

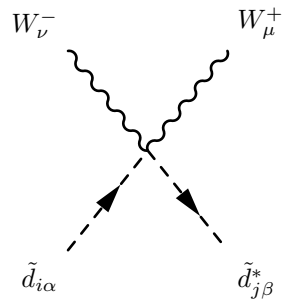


$$\frac{i}{18}\delta_{\alpha\beta}\Big(\Big(- 3g_2 \sin\Theta_W + g_1 \cos\Theta_W\Big)\Big(\Big(3g_2 \cos\Theta_W + g_1 \sin\Theta_W\Big)\sin\Theta'_W + 6g_p Q_q \cos\Theta'_W\Big)\sum_{a=1}^{3} Z^{D,*}_{ia} Z^{D}_{ja}$$

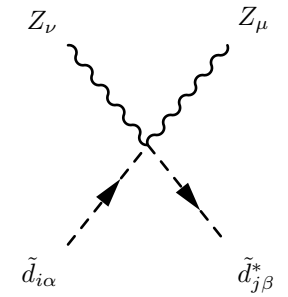
$$+ 4g_1 \cos\Theta_W\Big(3g_p Q_d \cos\Theta'_W + g_1 \sin\Theta_W \sin\Theta'_W\Big)\sum_{a=1}^{3} Z^{D,*}_{i3+a} Z^{D}_{j3+a}\Big)\Big(g_{\mu\nu}\Big) \tag{475}$$



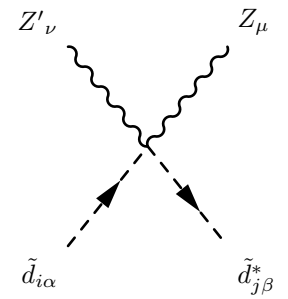
$$\frac{i}{3}\frac{1}{\sqrt{2}} g_1 g_2 \cos\Theta_W \delta_{\alpha\beta} \sum_{a=1}^{3} Z^{D,*}_{ia} Z^{U}_{ja}\Big(g_{\mu\nu}\Big) \tag{476}$$



$$\frac{i}{2}g_2^2\delta_{\alpha\beta}\sum_{a=1}^{3}Z_{ia}^{D,*}Z_{ja}^{D}\Big(g_{\mu\nu}\Big) \tag{477}$$

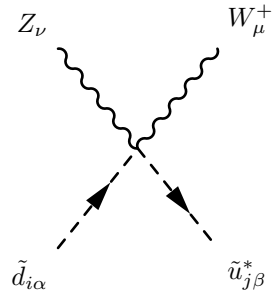


$$\frac{i}{18}\delta_{\alpha\beta}\Big(\Big(3g_2\cos\Theta_W\cos\Theta'_W-6g_pQ_q\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\Big)^2\sum_{a=1}^{3}Z_{ia}^{D,*}Z_{ja}^{D}$$
$$+4\Big(-3g_pQ_d\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\Big)^2\sum_{a=1}^{3}Z_{i3+a}^{D,*}Z_{j3+a}^{D}\Big)\Big(g_{\mu\nu}\Big) \tag{478}$$

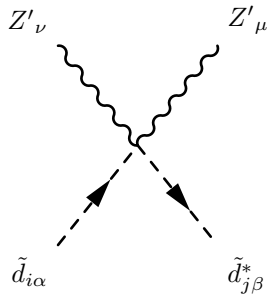


$$-\frac{i}{18}\delta_{\alpha\beta}\Big(\Big(6g_1g_pQ_q\cos\Theta'^{,2}_W\sin\Theta_W+9g_2^2\cos\Theta_W^2\cos\Theta'_W\sin\Theta'_W$$

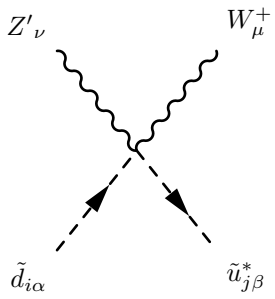
$$+ \cos\Theta'_W \Big(- 36 g_p^2 Q_q^2 + g_1^2 \sin\Theta_W^2 \Big) \sin\Theta'_W - 6 g_1 g_p Q_q \sin\Theta_W \sin\Theta'^{,2}_W$$
$$+ 6 g_2 \cos\Theta_W \Big(3 g_p Q_q \cos\Theta'^{,2}_W - 3 g_p Q_q \sin\Theta'^{,2}_W + g_1 \cos\Theta'_W \sin\Theta_W \sin\Theta'_W \Big) \Big) \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ja}^{D}$$
$$+ 2 \Big(6 g_1 g_p Q_d \cos\Theta'^{,2}_W \sin\Theta_W + g_1^2 \sin\Theta_W^2 \sin 2\Theta'_W$$
$$- 3 g_p Q_d \Big(2 g_1 \sin\Theta_W \sin\Theta'^{,2}_W + 3 g_p Q_d \sin 2\Theta'_W \Big) \Big) \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{j3+a}^{D} \Big) \Big(g_{\mu\nu} \Big) \tag{479}$$



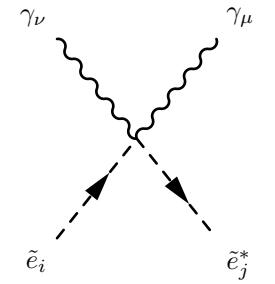
$$- \frac{i}{3} \frac{1}{\sqrt{2}} g_2 \delta_{\alpha\beta} \Big(- 6 g_p Q_q \sin\Theta'_W + g_1 \cos\Theta'_W \sin\Theta_W \Big) \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ja}^{U} \Big(g_{\mu\nu} \Big) \tag{480}$$



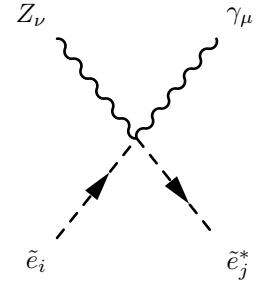
$$\frac{i}{18} \delta_{\alpha\beta} \Big(\Big(\Big(3 g_2 \cos\Theta_W + g_1 \sin\Theta_W \Big) \sin\Theta'_W + 6 g_p Q_q \cos\Theta'_W \Big)^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ja}^{D}$$
$$+ 4 \Big(3 g_p Q_d \cos\Theta'_W + g_1 \sin\Theta_W \sin\Theta'_W \Big)^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{j3+a}^{D} \Big) \Big(g_{\mu\nu} \Big) \tag{481}$$



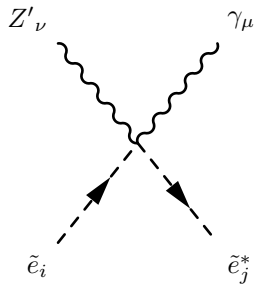
$$\frac{i}{3}\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\Big(6g_pQ_q\cos\Theta'_W+g_1\sin\Theta_W\sin\Theta'_W\Big)\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{U}_{ja}\Big(g_{\mu\nu}\Big) \tag{482}$$



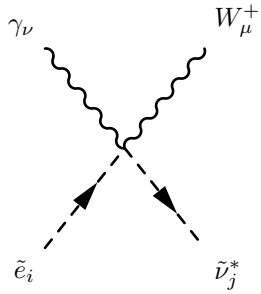
$$\begin{aligned}&\frac{i}{2}\Big(\Big(g_1\cos\Theta_W+g_2\sin\Theta_W\Big)^2\sum_{a=1}^{2}Z^{E,*}_{i1+a}Z^{E}_{j1+a}+4g_1^2\cos\Theta_W^2\sum_{a=1}^{2}Z^{E,*}_{i4+a}Z^{E}_{j4+a}\\&+g_1^2Z^{E,*}_{i1}\cos\Theta_W^2Z^{E}_{j1}+g_2^2Z^{E,*}_{i1}\sin\Theta_W^2Z^{E}_{j1}+g_1g_2Z^{E,*}_{i1}\sin 2\Theta_WZ^{E}_{j1}\\&+4g_1^2Z^{E,*}_{i4}\cos\Theta_W^2Z^{E}_{j4}\Big)\Big(g_{\mu\nu}\Big)\end{aligned} \tag{483}$$



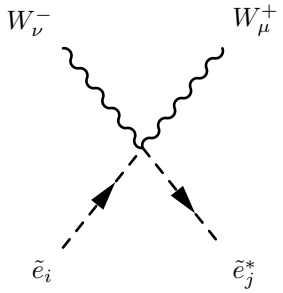
$$
\begin{aligned}
&-\frac{i}{2}\Big(\Big(g_1\cos\Theta_W+g_2\sin\Theta_W\Big)\Big(2g_pQ_{l_9}\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W-g_2\cos\Theta_W\cos\Theta'_W\Big)\sum_{a=1}^{2}Z^{E,*}_{i1+a}Z^{E}_{j1+a}\\
&+4g_1\cos\Theta_W\Big(g_1\cos\Theta'_W\sin\Theta_W-g_pQ_{e_9}\sin\Theta'_W\Big)\sum_{a=1}^{2}Z^{E,*}_{i4+a}Z^{E}_{j4+a}\\
&-g_1g_2Z^{E,*}_{i1}\cos\Theta^2_W\cos\Theta'_WZ^{E}_{j1}+g_1^2Z^{E,*}_{i1}\cos\Theta_W\cos\Theta'_W\sin\Theta_WZ^{E}_{j1}\\
&-g_2^2Z^{E,*}_{i1}\cos\Theta_W\cos\Theta'_W\sin\Theta_WZ^{E}_{j1}+g_1g_2Z^{E,*}_{i1}\cos\Theta'_W\sin\Theta^2_WZ^{E}_{j1}\\
&+2g_1g_pQ_{l_4}Z^{E,*}_{i1}\cos\Theta_W\sin\Theta'_WZ^{E}_{j1}+2g_2g_pQ_{l_4}Z^{E,*}_{i1}\sin\Theta_W\sin\Theta'_WZ^{E}_{j1}\\
&+4g_1^2Z^{E,*}_{i4}\cos\Theta_W\cos\Theta'_W\sin\Theta_WZ^{E}_{j4}-4g_1g_pQ_{e_4}Z^{E,*}_{i4}\cos\Theta_W\sin\Theta'_WZ^{E}_{j4}\Big)\Big(g_{\mu\nu}\Big)
\end{aligned}
\tag{484}
$$



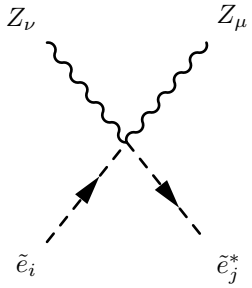
$$
\begin{aligned}
&\frac{i}{2}\Big(\Big(g_1\cos\Theta_W+g_2\sin\Theta_W\Big)\Big(-2g_pQ_{l_9}\cos\Theta'_W+\Big(g_1\sin\Theta_W-g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)\sum_{a=1}^{2}Z^{E,*}_{i1+a}Z^{E}_{j1+a}\\
&+4g_1\cos\Theta_W\Big(g_1\sin\Theta_W\sin\Theta'_W+g_pQ_{e_9}\cos\Theta'_W\Big)\sum_{a=1}^{2}Z^{E,*}_{i4+a}Z^{E}_{j4+a}\\
&-2g_1g_pQ_{l_4}Z^{E,*}_{i1}\cos\Theta_W\cos\Theta'_WZ^{E}_{j1}-2g_2g_pQ_{l_4}Z^{E,*}_{i1}\cos\Theta'_W\sin\Theta_WZ^{E}_{j1}\\
&-g_1g_2Z^{E,*}_{i1}\cos\Theta^2_W\sin\Theta'_WZ^{E}_{j1}+g_1^2Z^{E,*}_{i1}\cos\Theta_W\sin\Theta_W\sin\Theta'_WZ^{E}_{j1}\\
&-g_2^2Z^{E,*}_{i1}\cos\Theta_W\sin\Theta_W\sin\Theta'_WZ^{E}_{j1}+g_1g_2Z^{E,*}_{i1}\sin\Theta^2_W\sin\Theta'_WZ^{E}_{j1}\\
&+4g_1g_pQ_{e_4}Z^{E,*}_{i4}\cos\Theta_W\cos\Theta'_WZ^{E}_{j4}+4g_1^2Z^{E,*}_{i4}\cos\Theta_W\sin\Theta_W\sin\Theta'_WZ^{E}_{j4}\Big)\Big(g_{\mu\nu}\Big)
\end{aligned}
\tag{485}
$$



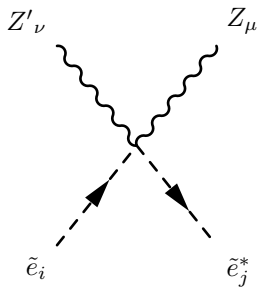
$$- i\frac{1}{\sqrt{2}} g_1 g_2 \cos\Theta_W \Big(Z^{E,*}_{i1} Z^V_{j1} + \sum_{a=1}^{2} Z^{E,*}_{i1+a} Z^V_{j1+a} \Big) \Big(g_{\mu\nu} \Big) \tag{486}$$



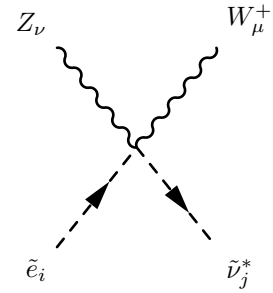
$$\frac{i}{2} g_2^2 \Big(Z^{E,*}_{i1} Z^E_{j1} + \sum_{a=1}^{2} Z^{E,*}_{i1+a} Z^E_{j1+a} \Big) \Big(g_{\mu\nu} \Big) \tag{487}$$



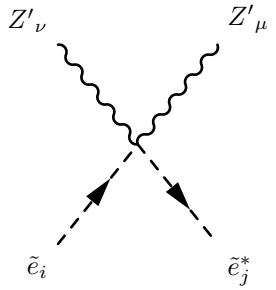
$$\begin{aligned}
&\frac{i}{2} \Big(\Big(2 g_p Q_{l_9} \sin\Theta'_W + g_1 \cos\Theta'_W \sin\Theta_W - g_2 \cos\Theta_W \cos\Theta'_W \Big)^2 \sum_{a=1}^{2} Z^{E,*}_{i1+a} Z^E_{j1+a} \\
&+ 4 \Big(g_1 \cos\Theta'_W \sin\Theta_W - g_p Q_{e_9} \sin\Theta'_W \Big)^2 \sum_{a=1}^{2} Z^{E,*}_{i4+a} Z^E_{j4+a} \\
&+ g_2^2 Z^{E,*}_{i1} \cos\Theta^2_W \cos\Theta'^{,2}_W Z^E_{j1} - 2 g_1 g_2 Z^{E,*}_{i1} \cos\Theta_W \cos\Theta'^{,2}_W \sin\Theta_W Z^E_{j1} \\
&+ g_1^2 Z^{E,*}_{i1} \cos\Theta'^{,2}_W \sin\Theta^2_W Z^E_{j1} \\
&- 4 g_2 g_p Q_{l_4} Z^{E,*}_{i1} \cos\Theta_W \cos\Theta'_W \sin\Theta'_W Z^E_{j1} \\
&+ 4 g_1 g_p Q_{l_4} Z^{E,*}_{i1} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^E_{j1} + 4 g_p^2 Q^2_{l_4} Z^{E,*}_{i1} \sin\Theta'^{,2}_W Z^E_{j1} \\
&+ 4 g_1^2 Z^{E,*}_{i4} \cos\Theta'^{,2}_W \sin\Theta^2_W Z^E_{j4} \\
&- 8 g_1 g_p Q_{e_4} Z^{E,*}_{i4} \cos\Theta'_W \sin\Theta_W \sin\Theta'_W Z^E_{j4} + 4 g_p^2 Q^2_{e_4} Z^{E,*}_{i4} \sin\Theta'^{,2}_W Z^E_{j4} \Big) \Big(g_{\mu\nu} \Big)
\end{aligned} \tag{488}$$



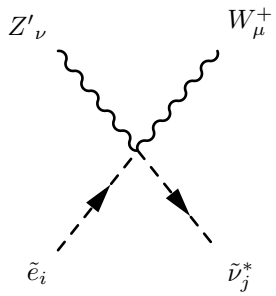
$$
\begin{aligned}
&-\frac{i}{2}\Big(\Big(-2g_1g_pQ_{l_9}\cos\Theta_W^{\prime,2}\sin\Theta_W+g_2^2\cos\Theta_W^2\cos\Theta'_W\sin\Theta'_W\\
&+\cos\Theta'_W\Big(-4g_p^2Q_{l_9}^2+g_1^2\sin\Theta_W^2\Big)\sin\Theta'_W+2g_1g_pQ_{l_9}\sin\Theta_W\sin\Theta_W^{\prime,2}\\
&+2g_2\cos\Theta_W\Big(-g_1\cos\Theta'_W\sin\Theta_W\sin\Theta'_W+g_pQ_{l_9}\cos\Theta_W^{\prime,2}-g_pQ_{l_9}\sin\Theta_W^{\prime,2}\Big)\Big)\sum_{a=1}^{2}Z_{i1+a}^{E,*}Z_{j1+a}^{E}\\
&+4\Big(g_1g_pQ_{e_9}\cos\Theta_W^{\prime,2}\sin\Theta_W+\cos\Theta'_W\Big(g_1^2\sin\Theta_W^2-g_p^2Q_{e_9}^2\Big)\sin\Theta'_W\\
&-g_1g_pQ_{e_9}\sin\Theta_W\sin\Theta_W^{\prime,2}\Big)\sum_{a=1}^{2}Z_{i4+a}^{E,*}Z_{j4+a}^{E}\\
&+2g_2g_pQ_{l_4}Z_{i1}^{E,*}\cos\Theta_W\cos\Theta_W^{\prime,2}Z_{j1}^{E}-2g_1g_pQ_{l_4}Z_{i1}^{E,*}\cos\Theta_W^{\prime,2}\sin\Theta_WZ_{j1}^{E}\\
&-4g_p^2Q_{l_4}^2Z_{i1}^{E,*}\cos\Theta'_W\sin\Theta'_WZ_{j1}^{E}+g_2^2Z_{i1}^{E,*}\cos\Theta_W^2\cos\Theta'_W\sin\Theta'_WZ_{j1}^{E}\\
&-2g_1g_2Z_{i1}^{E,*}\cos\Theta_W\cos\Theta'_W\sin\Theta_W\sin\Theta'_WZ_{j1}^{E}\\
&+g_1^2Z_{i1}^{E,*}\cos\Theta'_W\sin\Theta_W^2\sin\Theta'_WZ_{j1}^{E}\\
&-2g_2g_pQ_{l_4}Z_{i1}^{E,*}\cos\Theta_W\sin\Theta_W^{\prime,2}Z_{j1}^{E}+2g_1g_pQ_{l_4}Z_{i1}^{E,*}\sin\Theta_W\sin\Theta_W^{\prime,2}Z_{j1}^{E}\\
&+4g_1g_pQ_{e_4}Z_{i4}^{E,*}\cos\Theta_W^{\prime,2}\sin\Theta_WZ_{j4}^{E}-4g_p^2Q_{e_4}^2Z_{i4}^{E,*}\cos\Theta'_W\sin\Theta'_WZ_{j4}^{E}\\
&+4g_1^2Z_{i4}^{E,*}\cos\Theta'_W\sin\Theta_W^2\sin\Theta'_WZ_{j4}^{E}\\
&-4g_1g_pQ_{e_4}Z_{i4}^{E,*}\sin\Theta_W\sin\Theta_W^{\prime,2}Z_{j4}^{E}\Big)\Big(g_{\mu\nu}\Big)
\end{aligned}
\tag{489}
$$



$$i\frac{1}{\sqrt{2}}g_2\Big(\Big(2g_pQ_{l_9}\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\Big)\sum_{a=1}^{2}Z^{E,*}_{i1+a}Z^{V}_{j1+a}$$
$$+Z^{E,*}_{i1}\Big(2g_pQ_{l_4}\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\Big)Z^{V}_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{490}$$

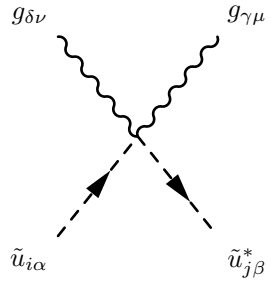


$$\frac{i}{2}\Big(\Big(2g_pQ_{l_9}\cos\Theta'_W+\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)^2\sum_{a=1}^{2}Z^{E,*}_{i1+a}Z^{E}_{j1+a}$$
$$+4\Big(g_1\sin\Theta_W\sin\Theta'_W+g_pQ_{e_9}\cos\Theta'_W\Big)^2\sum_{a=1}^{2}Z^{E,*}_{i4+a}Z^{E}_{j4+a}$$
$$+4g_p^2Q_{l_4}^2Z^{E,*}_{i1}\cos\Theta'^{,2}_WZ^{E}_{j1}+4g_2g_pQ_{l_4}Z^{E,*}_{i1}\cos\Theta_W\cos\Theta'_W\sin\Theta'_WZ^{E}_{j1}$$
$$-4g_1g_pQ_{l_4}Z^{E,*}_{i1}\cos\Theta'_W\sin\Theta_W\sin\Theta'_WZ^{E}_{j1}$$
$$+g_2^2Z^{E,*}_{i1}\cos\Theta^2_W\sin\Theta'^{,2}_WZ^{E}_{j1}-2g_1g_2Z^{E,*}_{i1}\cos\Theta_W\sin\Theta_W\sin\Theta'^{,2}_WZ^{E}_{j1}$$
$$+g_1^2Z^{E,*}_{i1}\sin\Theta^2_W\sin\Theta'^{,2}_WZ^{E}_{j1}+4g_p^2Q_{e_4}^2Z^{E,*}_{i4}\cos\Theta'^{,2}_WZ^{E}_{j4}$$
$$+8g_1g_pQ_{e_4}Z^{E,*}_{i4}\cos\Theta'_W\sin\Theta_W\sin\Theta'_WZ^{E}_{j4}$$
$$+4g_1^2Z^{E,*}_{i4}\sin\Theta^2_W\sin\Theta'^{,2}_WZ^{E}_{j4}\Big)\Big(g_{\mu\nu}\Big) \tag{491}$$

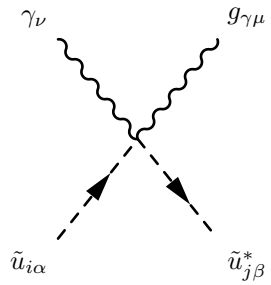


$$i\frac{1}{\sqrt{2}}g_2\Big(\Big(2g_pQ_{l_9}\cos\Theta'_W-g_1\sin\Theta_W\sin\Theta'_W\Big)\sum_{a=1}^{2}Z^{E,*}_{i1+a}Z^{V}_{j1+a}$$

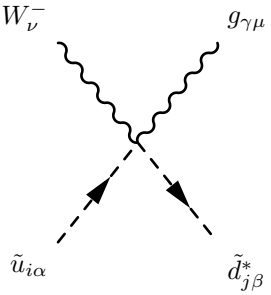
$$+ Z_{i1}^{E,*}\Big(2g_p Q_{l_4}\cos\Theta'_W - g_1\sin\Theta_W\sin\Theta'_W\Big)Z_{j1}^{V}\Big)\Big(g_{\mu\nu}\Big) \tag{492}$$



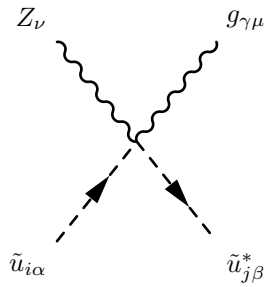
$$\frac{i}{4}g_3^2\delta_{ij}\Big(\sum_{a=1}^{3}\lambda^{\gamma}_{a,\alpha}\lambda^{\delta}_{\beta,a} + \sum_{a=1}^{3}\lambda^{\gamma}_{\beta,a}\lambda^{\delta}_{a,\alpha}\Big)\Big(g_{\mu\nu}\Big) \tag{493}$$



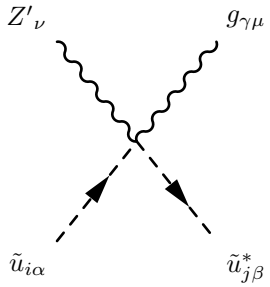
$$\frac{i}{6}g_3\lambda^{\gamma}_{\beta,\alpha}\Big(\Big(3g_2\sin\Theta_W + g_1\cos\Theta_W\Big)\sum_{a=1}^{3}Z_{ia}^{U,*}Z_{ja}^{U} + 4g_1\cos\Theta_W\sum_{a=1}^{3}Z_{i3+a}^{U,*}Z_{j3+a}^{U}\Big)\Big(g_{\mu\nu}\Big) \tag{494}$$



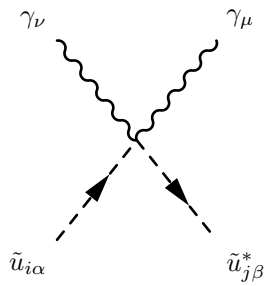
$$i\frac{1}{\sqrt{2}}g_2g_3\lambda^{\gamma}_{\beta,\alpha}\sum_{a=1}^{3}Z_{ia}^{U,*}Z_{ja}^{D}\Big(g_{\mu\nu}\Big) \tag{495}$$



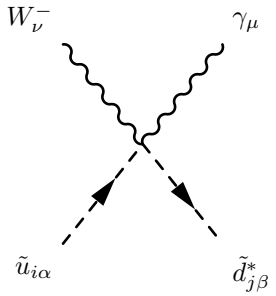
$$\frac{i}{6}g_3\lambda^{\gamma}_{\beta,\alpha}\Big(\Big(3g_2\cos\Theta_W\cos\Theta'_W+6g_pQ_q\sin\Theta'_W-g_1\cos\Theta'_W\sin\Theta_W\Big)\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{U}_{ja}$$
$$-2\Big(2g_1\cos\Theta'_W\sin\Theta_W+3g_pQ_u\sin\Theta'_W\Big)\sum_{a=1}^{3}Z^{U,*}_{i3+a}Z^{U}_{j3+a}\Big)\Big(g_{\mu\nu}\Big) \tag{496}$$



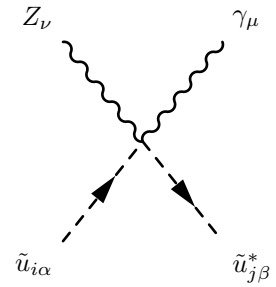
$$\frac{i}{6}g_3\lambda^{\gamma}_{\beta,\alpha}\Big(\Big(\Big(-3g_2\cos\Theta_W+g_1\sin\Theta_W\Big)\sin\Theta'_W+6g_pQ_q\cos\Theta'_W\Big)\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{U}_{ja}$$
$$+2\Big(2g_1\sin\Theta_W\sin\Theta'_W-3g_pQ_u\cos\Theta'_W\Big)\sum_{a=1}^{3}Z^{U,*}_{i3+a}Z^{U}_{j3+a}\Big)\Big(g_{\mu\nu}\Big) \tag{497}$$



$$\frac{i}{18}\delta_{\alpha\beta}\Big(16g_1^2\cos\Theta_W^2\sum_{a=1}^{3}Z^{U,*}_{i3+a}Z^{U}_{j3+a}+\Big(3g_2\sin\Theta_W+g_1\cos\Theta_W\Big)^2\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{U}_{ja}\Big)\Big(g_{\mu\nu}\Big) \tag{498}$$

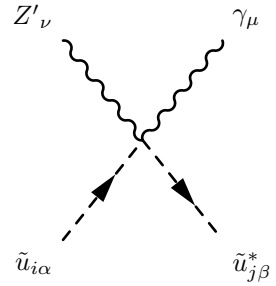


$$\frac{i}{3}\frac{1}{\sqrt{2}}g_1g_2\cos\Theta_W\delta_{\alpha\beta}\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{D}_{ja}\Big(g_{\mu\nu}\Big) \tag{499}$$



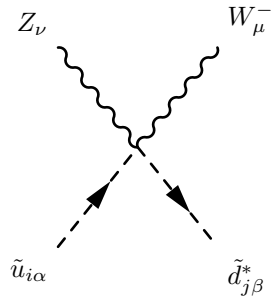
$$-\frac{i}{18}\delta_{\alpha\beta}\Big(\Big(3g_2\sin\Theta_W+g_1\cos\Theta_W\Big)\Big(-3g_2\cos\Theta_W\cos\Theta'_W-6g_pQ_q\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\Big)\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{U}_{ja}$$

$$+8g_1\Big(3g_pQ_u\cos\Theta_W\sin\Theta'_W+g_1\cos\Theta'_W\sin 2\Theta_W\Big)\sum_{a=1}^{3}Z^{U,*}_{i3+a}Z^{U}_{j3+a}\Big)\Big(g_{\mu\nu}\Big) \tag{500}$$

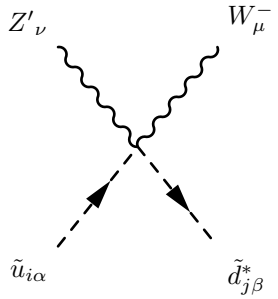


$$\frac{i}{18}\delta_{\alpha\beta}\Big(\Big(3g_2\sin\Theta_W+g_1\cos\Theta_W\Big)\Big(\Big(-3g_2\cos\Theta_W+g_1\sin\Theta_W\Big)\sin\Theta'_W+6g_pQ_q\cos\Theta'_W\Big)\sum_{a=1}^{3}Z_{ia}^{U,*}Z_{ja}^{U}$$

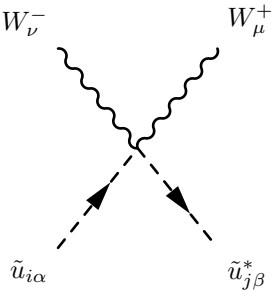
$$+8g_1\Big(-3g_pQ_u\cos\Theta_W\cos\Theta'_W+g_1\sin 2\Theta_W\sin\Theta'_W\Big)\sum_{a=1}^{3}Z_{i3+a}^{U,*}Z_{j3+a}^{U}\Big)\Big(g_{\mu\nu}\Big) \tag{501}$$



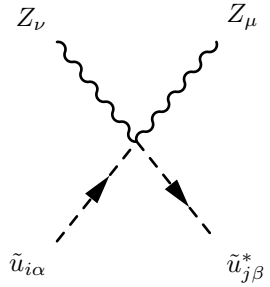
$$-\frac{i}{3}\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\Big(-6g_pQ_q\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\Big)\sum_{a=1}^{3}Z_{ia}^{U,*}Z_{ja}^{D}\Big(g_{\mu\nu}\Big) \tag{502}$$



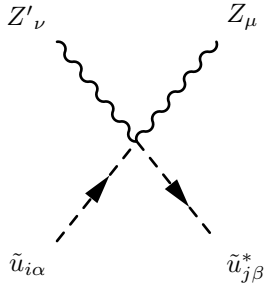
$$\frac{i}{3}\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\Big(6g_pQ_q\cos\Theta'_W+g_1\sin\Theta_W\sin\Theta'_W\Big)\sum_{a=1}^{3}Z_{ia}^{U,*}Z_{ja}^{D}\Big(g_{\mu\nu}\Big) \tag{503}$$



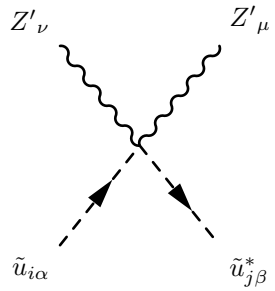
$$\frac{i}{2}g_2^2\delta_{\alpha\beta}\sum_{a=1}^{3}Z_{ia}^{U,*}Z_{ja}^{U}\Big(g_{\mu\nu}\Big) \tag{504}$$



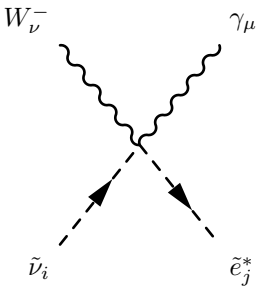
$$\frac{i}{18}\delta_{\alpha\beta}\Big(\Big(3g_2\cos\Theta_W\cos\Theta'_W+6g_pQ_q\sin\Theta'_W-g_1\cos\Theta'_W\sin\Theta_W\Big)^2\sum_{a=1}^{3}Z_{ia}^{U,*}Z_{ja}^{U}$$
$$+4\Big(2g_1\cos\Theta'_W\sin\Theta_W+3g_pQ_u\sin\Theta'_W\Big)^2\sum_{a=1}^{3}Z_{i3+a}^{U,*}Z_{j3+a}^{U}\Big)\Big(g_{\mu\nu}\Big) \tag{505}$$



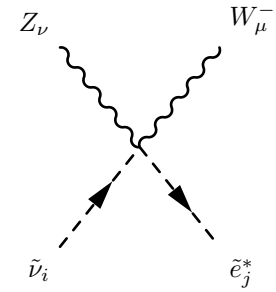
$$-\frac{i}{18}\delta_{\alpha\beta}\Big(\Big(6g_1g_pQ_q\cos\Theta'^{,2}_W\sin\Theta_W+9g_2^2\cos\Theta^2_W\cos\Theta'_W\sin\Theta'_W$$
$$+\cos\Theta'_W\Big(-36g_p^2Q_q^2+g_1^2\sin\Theta^2_W\Big)\sin\Theta'_W-6g_1g_pQ_q\sin\Theta_W\sin\Theta'^{,2}_W$$
$$-6g_2\cos\Theta_W\Big(3g_pQ_q\cos\Theta'^{,2}_W-3g_pQ_q\sin\Theta'^{,2}_W+g_1\cos\Theta'_W\sin\Theta_W\sin\Theta'_W\Big)\Big)\sum_{a=1}^{3}Z_{ia}^{U,*}Z_{ja}^{U}$$
$$-2\Big(6g_1g_pQ_u\sin-2\Theta'_W+\Theta_W-g_1^2\sin 2\Big(-\Theta'_W+\Theta_W\Big)-2g_1^2\sin 2\Theta'_W$$
$$+9g_p^2Q_u^2\sin 2\Theta'_W+g_1^2\sin 2\Big(\Theta_W+\Theta'_W\Big)+6g_1g_pQ_u\sin 2\Theta'_W+\Theta_W\Big)\sum_{a=1}^{3}Z_{i3+a}^{U,*}Z_{j3+a}^{U}\Big)\Big(g_{\mu\nu}\Big) \tag{506}$$



$$\frac{i}{18}\delta_{\alpha\beta}\Big(\Big(\Big(-3g_2\cos\Theta_W+g_1\sin\Theta_W\Big)\sin\Theta'_W+6g_pQ_q\cos\Theta'_W\Big)^2\sum_{a=1}^{3}Z^{U,*}_{ia}Z^U_{ja}$$
$$+4\Big(-2g_1\sin\Theta_W\sin\Theta'_W+3g_pQ_u\cos\Theta'_W\Big)^2\sum_{a=1}^{3}Z^{U,*}_{i3+a}Z^U_{j3+a}\Big)\Big(g_{\mu\nu}\Big) \tag{507}$$

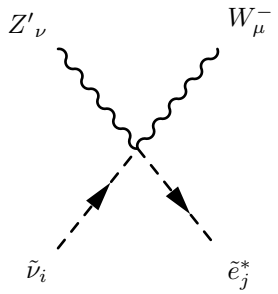


$$-i\frac{1}{\sqrt{2}}g_1g_2\cos\Theta_W\Big(Z^{V,*}_{i1}Z^E_{j1}+\sum_{a=1}^{2}Z^{V,*}_{i1+a}Z^E_{j1+a}\Big)\Big(g_{\mu\nu}\Big) \tag{508}$$

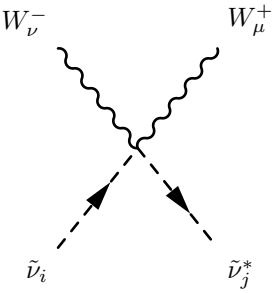


$$i\frac{1}{\sqrt{2}}g_2\Big(\Big(2g_pQ_{l_9}\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\Big)\sum_{a=1}^{2}Z^{V,*}_{i1+a}Z^E_{j1+a}$$

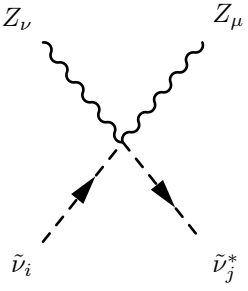
$$+ Z^{V,*}_{i1}\Big(2g_pQ_{l_4}\sin\Theta'_W + g_1\cos\Theta'_W\sin\Theta_W\Big)Z^E_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{509}$$



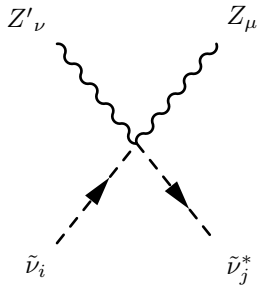
$$i\frac{1}{\sqrt{2}}g_2\Big(\Big(2g_pQ_{l_9}\cos\Theta'_W - g_1\sin\Theta_W\sin\Theta'_W\Big)\sum_{a=1}^{2}Z^{V,*}_{i1+a}Z^E_{j1+a}$$
$$+ Z^{V,*}_{i1}\Big(2g_pQ_{l_4}\cos\Theta'_W - g_1\sin\Theta_W\sin\Theta'_W\Big)Z^E_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{510}$$



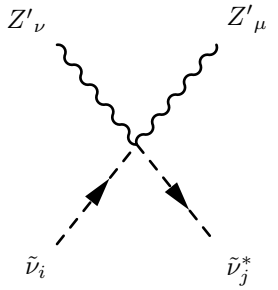
$$\frac{i}{2}g_2^2\Big(Z^{V,*}_{i1}Z^V_{j1} + \sum_{a=1}^{2}Z^{V,*}_{i1+a}Z^V_{j1+a}\Big)\Big(g_{\mu\nu}\Big) \tag{511}$$



$$\frac{i}{2}\Big(\Big(2g_pQ_{l_9}\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)^2\sum_{a=1}^{2}Z^{V,*}_{i1+a}Z^V_{j1+a}$$
$$+Z^{V,*}_{i1}\Big(2g_pQ_{l_4}\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)^2Z^V_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{512}$$

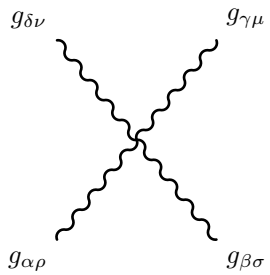


$$-\frac{i}{2}\Big(\Big(-2g_1g_pQ_{l_9}\cos\Theta'^{,2}_W\sin\Theta_W+g_2^2\cos\Theta^2_W\cos\Theta'_W\sin\Theta'_W$$
$$+\cos\Theta'_W\Big(-4g_p^2Q^2_{l_9}+g_1^2\sin\Theta^2_W\Big)\sin\Theta'_W+2g_1g_pQ_{l_9}\sin\Theta_W\sin\Theta'^{,2}_W$$
$$+2g_2\cos\Theta_W\Big(g_1\cos\Theta'_W\sin\Theta_W\sin\Theta'_W-g_pQ_{l_9}\cos\Theta'^{,2}_W+g_pQ_{l_9}\sin\Theta'^{,2}_W\Big)\Big)\sum_{a=1}^{2}Z^{V,*}_{i1+a}Z^V_{j1+a}$$
$$+Z^{V,*}_{i1}\Big(-2g_1g_pQ_{l_4}\cos\Theta'^{,2}_W\sin\Theta_W+g_2^2\cos\Theta^2_W\cos\Theta'_W\sin\Theta'_W$$
$$+g_1^2\cos\Theta'_W\sin\Theta^2_W\sin\Theta'_W$$
$$+2g_2\cos\Theta_W\Big(g_1\cos\Theta'_W\sin\Theta_W\sin\Theta'_W-g_pQ_{l_4}\cos\Theta'^{,2}_W+g_pQ_{l_4}\sin\Theta'^{,2}_W\Big)$$
$$+2g_pQ_{l_4}\Big(g_1\sin\Theta_W\sin\Theta'^{,2}_W-g_pQ_{l_4}\sin 2\Theta'_W\Big)\Big)Z^V_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{513}$$



$$\frac{i}{2}\Big(\Big(-2g_pQ_{l_9}\cos\Theta'_W+\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)^2\sum_{a=1}^{2}Z^{V,*}_{i1+a}Z^V_{j1+a}$$
$$+Z^{V,*}_{i1}\Big(-2g_pQ_{l_4}\cos\Theta'_W+\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)^2Z^V_{j1}\Big)\Big(g_{\mu\nu}\Big) \tag{514}$$

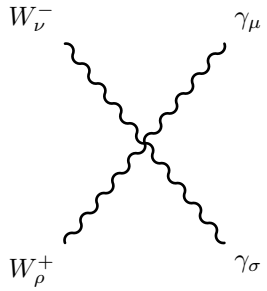
9.9 Four Vector Boson-Interaction



$$- ig_3^2\Big(\sum_{a=1}^{8} f_{\alpha,\delta,a}f_{\beta,\gamma,a} + \sum_{a=1}^{8} f_{\alpha,\gamma,a}f_{\beta,\delta,a}\Big)\Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{515}$$

$$+ ig_3^2\Big(-\sum_{a=1}^{8} f_{\alpha,\beta,a}f_{\gamma,\delta,a} + \sum_{a=1}^{8} f_{\alpha,\delta,a}f_{\beta,\gamma,a}\Big)\Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{516}$$

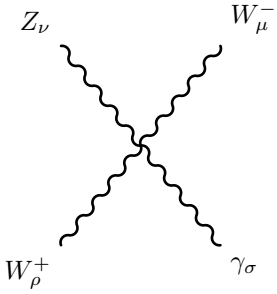
$$+ ig_3^2\Big(\sum_{a=1}^{8} f_{\alpha,\gamma,a}f_{\beta,\delta,a} + \sum_{a=1}^{8} f_{\alpha,\beta,a}f_{\gamma,\delta,a}\Big)\Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{517}$$



$$ig_2^2 \sin\Theta_W^2\Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{518}$$

$$+ ig_2^2 \sin\Theta_W^2\Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{519}$$

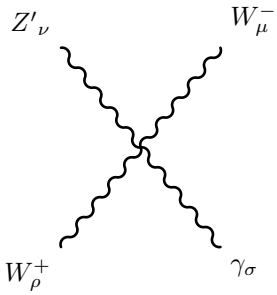
$$+ -2ig_2^2 \sin\Theta_W^2\Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{520}$$



$$ig_2^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W \left(g_{\rho\sigma} g_{\mu\nu}\right) \tag{521}$$

$$+\ -ig_2^2 \cos\Theta'_W \sin 2\Theta_W \left(g_{\rho\mu} g_{\sigma\nu}\right) \tag{522}$$

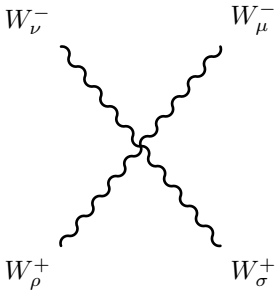
$$+\ ig_2^2 \cos\Theta_W \cos\Theta'_W \sin\Theta_W \left(g_{\rho\nu} g_{\sigma\mu}\right) \tag{523}$$



$$-\ ig_2^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W \left(g_{\rho\sigma} g_{\mu\nu}\right) \tag{524}$$

$$+\ ig_2^2 \sin 2\Theta_W \sin\Theta'_W \left(g_{\rho\mu} g_{\sigma\nu}\right) \tag{525}$$

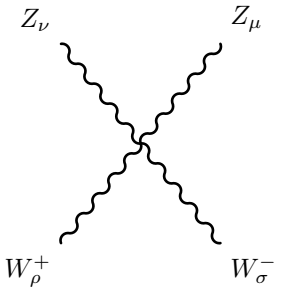
$$+\ -ig_2^2 \cos\Theta_W \sin\Theta_W \sin\Theta'_W \left(g_{\rho\nu} g_{\sigma\mu}\right) \tag{526}$$



$$2ig_2^2\Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{527}$$

$$+\ -ig_2^2\Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{528}$$

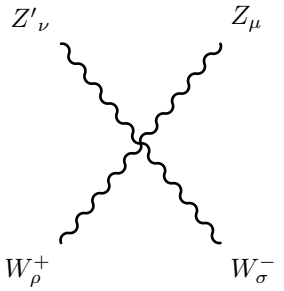
$$+\ -ig_2^2\Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{529}$$



$$-\ 2ig_2^2\cos\Theta_W^2\cos\Theta_W^{\prime,2}\Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{530}$$

$$+\ ig_2^2\cos\Theta_W^2\cos\Theta_W^{\prime,2}\Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{531}$$

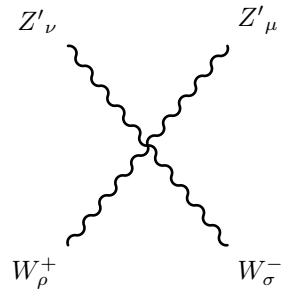
$$+\ ig_2^2\cos\Theta_W^2\cos\Theta_W^{\prime,2}\Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{532}$$



$$ig_2^2\cos\Theta_W^2\sin 2\Theta_W^{\prime}\Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{533}$$

$$+\ -ig_2^2\cos\Theta_W^2\cos\Theta_W^{\prime}\sin\Theta_W^{\prime}\Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{534}$$

$$+\ -ig_2^2\cos\Theta_W^2\cos\Theta_W^{\prime}\sin\Theta_W^{\prime}\Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{535}$$

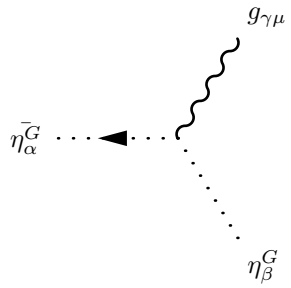


$$- 2ig_2^2 \cos\Theta_W^2 \sin\Theta_W'^{,2} \left(g_{\rho\sigma} g_{\mu\nu}\right) \tag{536}$$

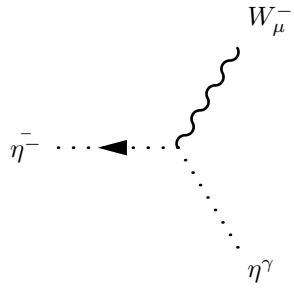
$$+ ig_2^2 \cos\Theta_W^2 \sin\Theta_W'^{,2} \left(g_{\rho\mu} g_{\sigma\nu}\right) \tag{537}$$

$$+ ig_2^2 \cos\Theta_W^2 \sin\Theta_W'^{,2} \left(g_{\rho\nu} g_{\sigma\mu}\right) \tag{538}$$

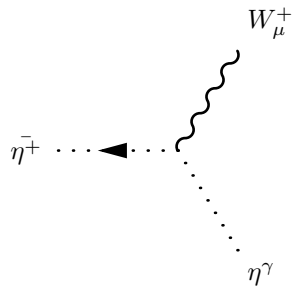
9.10 Two Ghosts-One Vector Boson-Interaction



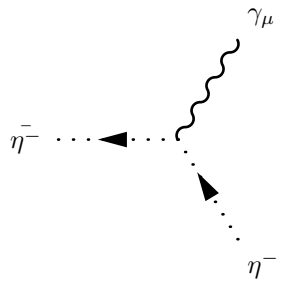
$$g_3 f_{\alpha,\beta,\gamma} \left(p_\mu^{\eta_\beta^G}\right) \tag{539}$$



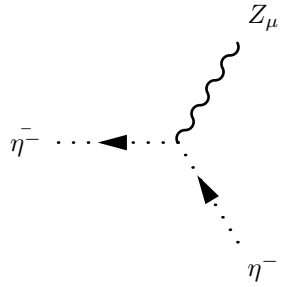
$$ig_2 \sin\Theta_W \left(p_\mu^{\eta^\gamma}\right) \tag{540}$$



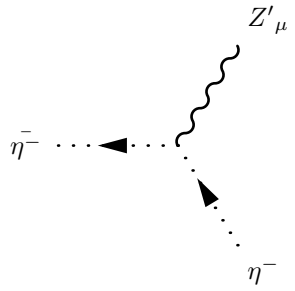
$$-ig_2 \sin\Theta_W \left(p_\mu^{\eta^\gamma}\right) \tag{541}$$



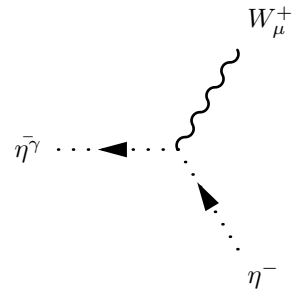
$$-ig_2 \sin\Theta_W \left(p_\mu^{\eta^-}\right) \tag{542}$$



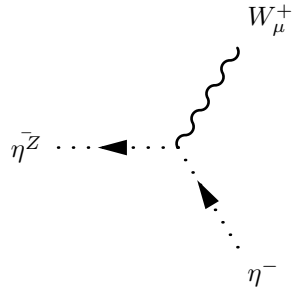
$$-ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^-}\right) \tag{543}$$



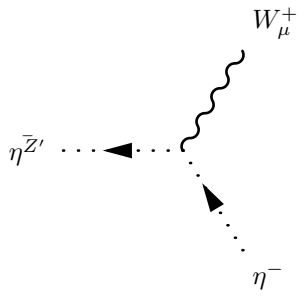
$$ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^-}\right) \tag{544}$$



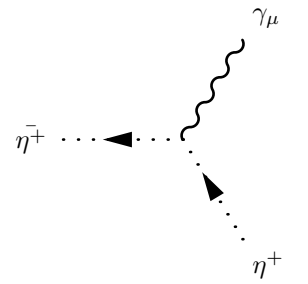
$$ig_2 \sin\Theta_W \left(p_\mu^{\eta^-}\right) \tag{545}$$



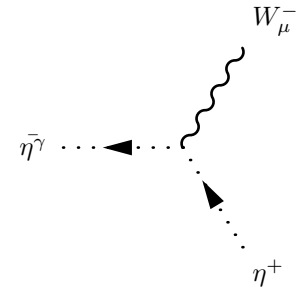
$$ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^-}\right) \tag{546}$$



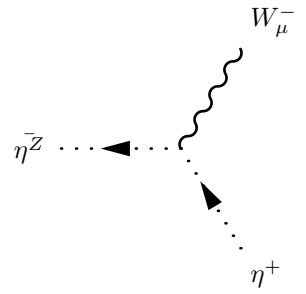
$$-ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^-}\right) \tag{547}$$



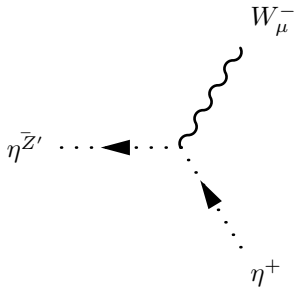
$$ig_2 \sin\Theta_W \left(p_\mu^{\eta^+}\right) \tag{548}$$



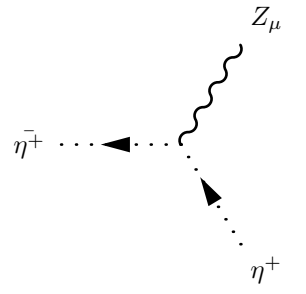
$$-ig_2 \sin\Theta_W \left(p_\mu^{\eta^+}\right) \tag{549}$$



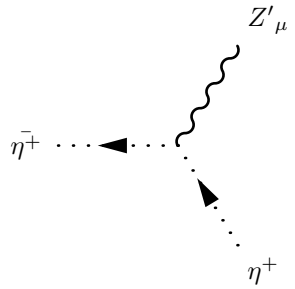
$$-ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^+}\right) \tag{550}$$



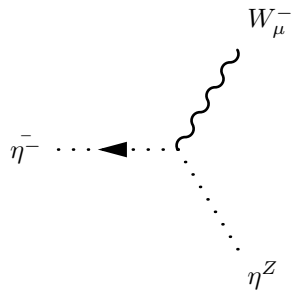
$$ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^+}\right) \tag{551}$$



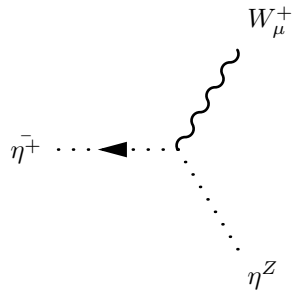
$$ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^+}\right) \tag{552}$$



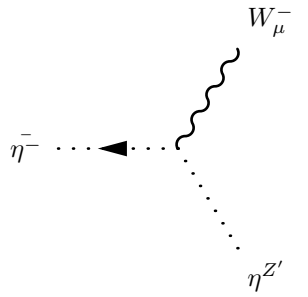
$$-ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^+}\right) \tag{553}$$



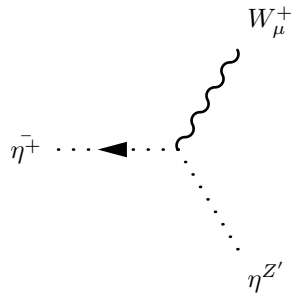
$$ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^Z}\right) \tag{554}$$



$$-ig_2 \cos\Theta_W \cos\Theta'_W \left(p_\mu^{\eta^Z}\right) \tag{555}$$

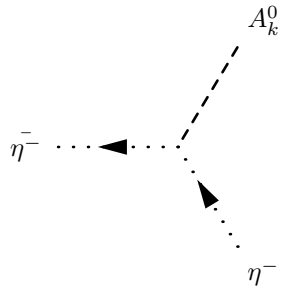


$$-ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^{Z'}}\right) \tag{556}$$

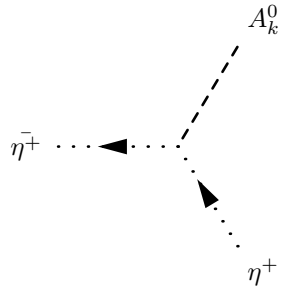


$$ig_2 \cos\Theta_W \sin\Theta'_W \left(p_\mu^{\eta^{Z'}}\right) \tag{557}$$

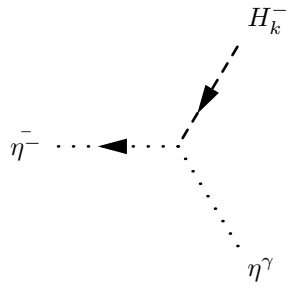
9.11 Two Ghosts-One Scalar-Interaction



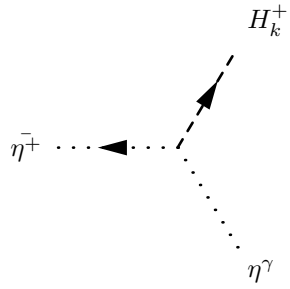
$$\frac{1}{4} g_2^2 \left(v_d Z_{k1}^{A,*} - v_u Z_{k2}^{A,*}\right) \xi_{W^-} \tag{558}$$



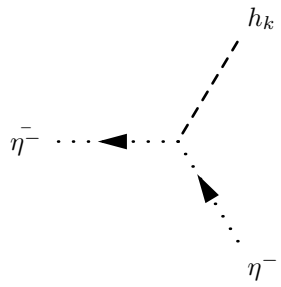
$$\frac{1}{4}g_2^2\Big(-v_d Z_{k1}^{A,*} + v_u Z_{k2}^{A,*}\Big)\xi_{W^-} \tag{559}$$



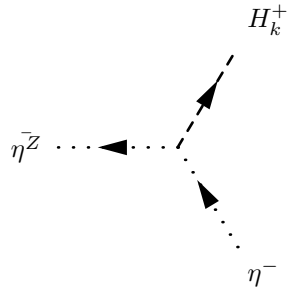
$$\frac{i}{4}g_2\xi_{W^-}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)\Big(v_d Z_{k1}^{+} - v_u Z_{k2}^{+}\Big) \tag{560}$$



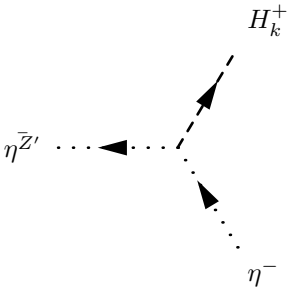
$$\frac{i}{4}g_2\xi_{W^-}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)\Big(v_d Z_{k1}^{+} - v_u Z_{k2}^{+}\Big) \tag{561}$$



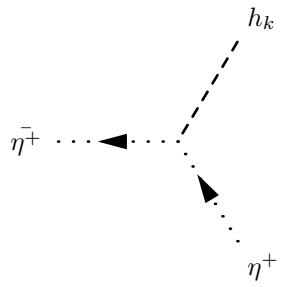
$$-\frac{i}{4}g_2^2\Big(v_d Z_{k1}^{H,*}+v_u Z_{k2}^{H,*}\Big)\xi_{W^-} \tag{562}$$



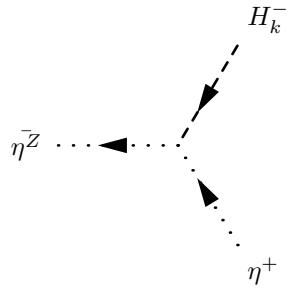
$$\begin{aligned}&-\frac{i}{4}g_2\xi_Z\Big(v_d\Big(2g_pQ_{H_d}\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)Z_{k1}^+\\&-v_u\Big(-2g_pQ_{H_u}\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\Big)Z_{k2}^+\Big)\end{aligned} \tag{563}$$



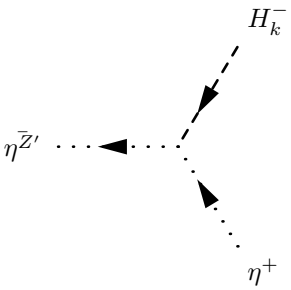
$$\begin{aligned}&\frac{i}{4}g_2\xi_{Z'}\Big(v_d\Big(-2g_pQ_{H_d}\cos\Theta'_W+\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)Z_{k1}^+\\&-v_u\Big(2g_pQ_{H_u}\cos\Theta'_W+\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)Z_{k2}^+\Big)\end{aligned} \tag{564}$$



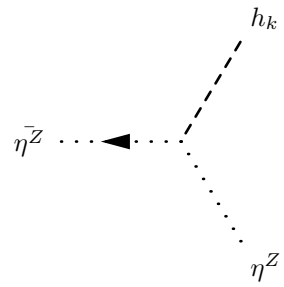
$$-\frac{i}{4}g_2^2\Big(v_d Z_{k1}^{H,*} + v_u Z_{k2}^{H,*}\Big)\xi_{W^-} \tag{565}$$



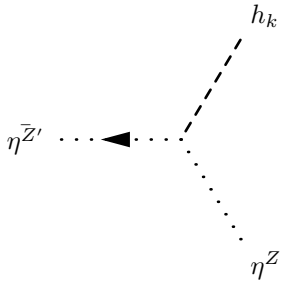
$$\begin{aligned}&-\frac{i}{4}g_2\xi_Z\Big(v_d\Big(2g_pQ_{H_d}\sin\Theta'_W + g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W\Big)Z_{k1}^+\\&-v_u\Big(-2g_pQ_{H_u}\sin\Theta'_W + g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W\Big)Z_{k2}^+\Big)\end{aligned} \tag{566}$$



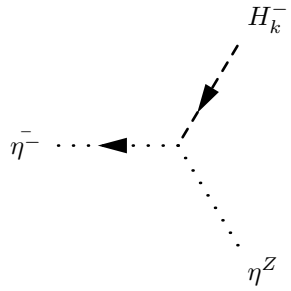
$$\begin{aligned}&\frac{i}{4}g_2\xi_{Z'}\Big(v_d\Big(-2g_pQ_{H_d}\cos\Theta'_W + \Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)Z_{k1}^+\\&-v_u\Big(2g_pQ_{H_u}\cos\Theta'_W + \Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)Z_{k2}^+\Big)\end{aligned} \tag{567}$$



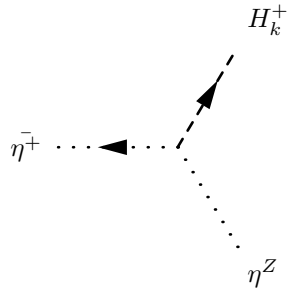
$$
\begin{aligned}
&-\frac{i}{4}\xi_Z\Big(4g_p^2Q_s^2v_SZ_{k3}^{H,*}\sin\Theta_W^{\prime,2}\\
&+v_dZ_{k1}^{H,*}\Big(2g_pQ_{H_d}\sin\Theta_W^{\prime}+g_1\cos\Theta_W^{\prime}\sin\Theta_W+g_2\cos\Theta_W\cos\Theta_W^{\prime}\Big)^2\\
&+v_uZ_{k2}^{H,*}\Big(-2g_pQ_{H_u}\sin\Theta_W^{\prime}+g_1\cos\Theta_W^{\prime}\sin\Theta_W+g_2\cos\Theta_W\cos\Theta_W^{\prime}\Big)^2\Big)
\end{aligned}
\tag{568}
$$



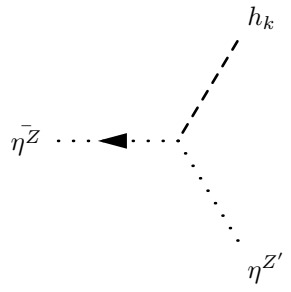
$$
\begin{aligned}
&\frac{i}{4}\xi_{Z'}\Big(-4g_p^2Q_s^2v_SZ_{k3}^{H,*}\cos\Theta_W^{\prime}\sin\Theta_W^{\prime}\\
&+v_dZ_{k1}^{H,*}\Big(-2g_1g_pQ_{H_d}\cos\Theta_W^{\prime,2}\sin\Theta_W+g_2^2\cos\Theta_W^2\cos\Theta_W^{\prime}\sin\Theta_W^{\prime}\\
&+\cos\Theta_W^{\prime}\Big(-4g_p^2Q_{H_d}^2+g_1^2\sin\Theta_W^2\Big)\sin\Theta_W^{\prime}+2g_1g_pQ_{H_d}\sin\Theta_W\sin\Theta_W^{\prime,2}\\
&+2g_2\cos\Theta_W\Big(g_1\cos\Theta_W^{\prime}\sin\Theta_W\sin\Theta_W^{\prime}-g_pQ_{H_d}\cos\Theta_W^{\prime,2}+g_pQ_{H_d}\sin\Theta_W^{\prime,2}\Big)\Big)\\
&+v_uZ_{k2}^{H,*}\Big(2g_1g_pQ_{H_u}\cos\Theta_W^{\prime,2}\sin\Theta_W+g_2^2\cos\Theta_W^2\cos\Theta_W^{\prime}\sin\Theta_W^{\prime}\\
&+\cos\Theta_W^{\prime}\Big(-4g_p^2Q_{H_u}^2+g_1^2\sin\Theta_W^2\Big)\sin\Theta_W^{\prime}-2g_1g_pQ_{H_u}\sin\Theta_W\sin\Theta_W^{\prime,2}\\
&+2g_2\cos\Theta_W\Big(g_1\cos\Theta_W^{\prime}\sin\Theta_W\sin\Theta_W^{\prime}+g_pQ_{H_u}\cos\Theta_W^{\prime,2}-g_pQ_{H_u}\sin\Theta_W^{\prime,2}\Big)\Big)\Big)
\end{aligned}
\tag{569}
$$



$$\frac{i}{4}g_2\xi_{W^-}\Big(v_d\Big(-2g_pQ_{H_d}\sin\Theta'_W - g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W\Big)Z^+_{k1} + v_u\Big(-2g_pQ_{H_u}\sin\Theta'_W + g_1\cos\Theta'_W\sin\Theta_W - g_2\cos\Theta_W\cos\Theta'_W\Big)Z^+_{k2}\Big) \tag{570}$$

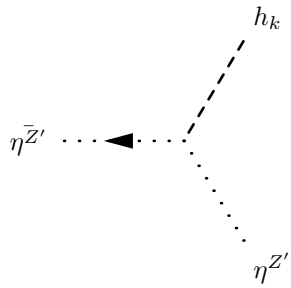


$$\frac{i}{4}g_2\xi_{W^-}\Big(v_d\Big(-2g_pQ_{H_d}\sin\Theta'_W - g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W\Big)Z^+_{k1} + v_u\Big(-2g_pQ_{H_u}\sin\Theta'_W + g_1\cos\Theta'_W\sin\Theta_W - g_2\cos\Theta_W\cos\Theta'_W\Big)Z^+_{k2}\Big) \tag{571}$$

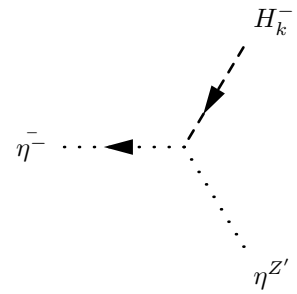


$$\frac{i}{4}\xi_Z\Big(-4g_p^2Q_s^2v_S Z^{H,*}_{k3}\cos\Theta'_W\sin\Theta'_W$$

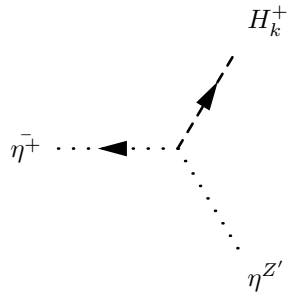
$$
\begin{aligned}
&+ v_d Z_{k1}^{H,*}\Big(- 2 g_1 g_p Q_{H_d} \cos\Theta_W'^{,2} \sin\Theta_W + g_2^2 \cos\Theta_W^2 \cos\Theta_W' \sin\Theta_W' \\
&+ \cos\Theta_W' \Big(- 4 g_p^2 Q_{H_d}^2 + g_1^2 \sin\Theta_W^2 \Big) \sin\Theta_W' + 2 g_1 g_p Q_{H_d} \sin\Theta_W \sin\Theta_W'^{,2} \\
&+ 2 g_2 \cos\Theta_W \Big(g_1 \cos\Theta_W' \sin\Theta_W \sin\Theta_W' - g_p Q_{H_d} \cos\Theta_W'^{,2} + g_p Q_{H_d} \sin\Theta_W'^{,2} \Big) \Big) \\
&+ v_u Z_{k2}^{H,*}\Big(2 g_1 g_p Q_{H_u} \cos\Theta_W'^{,2} \sin\Theta_W + g_2^2 \cos\Theta_W^2 \cos\Theta_W' \sin\Theta_W' \\
&+ \cos\Theta_W' \Big(- 4 g_p^2 Q_{H_u}^2 + g_1^2 \sin\Theta_W^2 \Big) \sin\Theta_W' - 2 g_1 g_p Q_{H_u} \sin\Theta_W \sin\Theta_W'^{,2} \\
&+ 2 g_2 \cos\Theta_W \Big(g_1 \cos\Theta_W' \sin\Theta_W \sin\Theta_W' + g_p Q_{H_u} \cos\Theta_W'^{,2} - g_p Q_{H_u} \sin\Theta_W'^{,2} \Big) \Big) \Big)
\end{aligned} \tag{572}
$$



$$
\begin{aligned}
&- \frac{i}{4} \xi_{Z'} \Big(4 g_p^2 Q_s^2 v_S Z_{k3}^{H,*} \cos\Theta_W'^{,2} \\
&+ v_d Z_{k1}^{H,*}\Big(- 2 g_p Q_{H_d} \cos\Theta_W' + \Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) \sin\Theta_W' \Big)^2 \\
&+ v_u Z_{k2}^{H,*}\Big(2 g_p Q_{H_u} \cos\Theta_W' + \Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) \sin\Theta_W' \Big)^2 \Big)
\end{aligned} \tag{573}
$$



$$
\begin{aligned}
&- \frac{i}{4} g_2 \xi_{W^-} \Big(v_d \Big(2 g_p Q_{H_d} \cos\Theta_W' + \Big(- g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) \sin\Theta_W' \Big) Z_{k1}^{+} \\
&+ v_u \Big(2 g_p Q_{H_u} \cos\Theta_W' + \Big(g_1 \sin\Theta_W - g_2 \cos\Theta_W \Big) \sin\Theta_W' \Big) Z_{k2}^{+} \Big)
\end{aligned} \tag{574}
$$



$$
\begin{aligned}
&-\frac{i}{4}g_2\xi_{W^-}\Big(v_d\Big(2g_pQ_{H_d}\cos\Theta'_W+\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)Z^+_{k1}\\
&+v_u\Big(2g_pQ_{H_u}\cos\Theta'_W+\Big(g_1\sin\Theta_W-g_2\cos\Theta_W\Big)\sin\Theta'_W\Big)Z^+_{k2}\Big)
\end{aligned}
\tag{575}
$$

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10 Clebsch-Gordan Coefficients