

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

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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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1 Superfields

1.1 Vector Superfields

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

1.2 Chiral Superfields

SF	Spin 0	Spin $\frac{1}{2}$	Generations	$(U(1) \otimes SU(2) \otimes SU(3))$
\hat{q}	\tilde{q}	q	3	$(\frac{1}{6}, \mathbf{2}, \mathbf{3})$
\hat{l}	\tilde{l}	l	3	$(-\frac{1}{2}, \mathbf{2}, \mathbf{1})$
\hat{H}_d	H_d	\tilde{H}_d	1	$(-\frac{1}{2}, \mathbf{2}, \mathbf{1})$
\hat{H}_u	H_u	\tilde{H}_u	1	$(\frac{1}{2}, \mathbf{2}, \mathbf{1})$
\hat{d}	\tilde{d}_R^*	d_R^*	3	$(\frac{1}{3}, \mathbf{1}, \bar{\mathbf{3}})$
\hat{u}	\tilde{u}_R^*	u_R^*	3	$(-\frac{2}{3}, \mathbf{1}, \bar{\mathbf{3}})$
\hat{e}	\tilde{e}_R^*	e_R^*	3	$(1, \mathbf{1}, \mathbf{1})$
SF(T)	ST	FT	1	$(0, \mathbf{3}, \mathbf{1})$

2 Superpotential and Lagrangian

2.1 Superpotential

$$W = \mu \hat{H}_u \hat{H}_d + M_T \text{SF}(T) \text{SF}(T) - Y_d \hat{d} \hat{q} \hat{H}_d - Y_e \hat{e} \hat{l} \hat{H}_d + \lambda \hat{H}_d \text{SF}(T) \hat{H}_u + Y_u \hat{u} \hat{q} \hat{H}_u \quad (1)$$

2.2 Softbreaking terms

$$\begin{aligned}
-L_{SB,W} = & + T^{0,2} B_T + 2T^- T^+ B_T - H_d^0 H_u^0 B_\mu + H_d^- H_u^+ B_\mu - \frac{1}{\sqrt{2}} H_d^0 H_u^0 T^0 T_\lambda - \frac{1}{\sqrt{2}} H_d^- H_u^+ T^0 T_\lambda \\
& + H_d^0 H_u^+ T^- T_\lambda - H_d^- H_u^0 T^+ T_\lambda + H_d^0 \tilde{d}_{R,i\alpha}^* \delta_{\alpha\beta} \tilde{d}_{L,j\beta} T_{d,ij} - H_d^- \tilde{d}_{R,i\alpha}^* \delta_{\alpha\beta} \tilde{u}_{L,j\beta} T_{d,ij} \\
& + H_d^0 \tilde{e}_{R,i}^* \tilde{e}_{L,j} T_{e,ij} - H_d^- \tilde{e}_{R,i}^* \tilde{\nu}_{L,j} T_{e,ij} - H_u^+ \tilde{u}_{R,i\alpha}^* \delta_{\alpha\beta} \tilde{d}_{L,j\beta} T_{u,ij} + H_u^0 \tilde{u}_{R,i\alpha}^* \delta_{\alpha\beta} \tilde{u}_{L,j\beta} T_{u,ij} + \text{h.c.} \quad (2)
\end{aligned}$$

$$\begin{aligned}
-L_{SB,\phi} = & + m_{H_d}^2 |H_d^0|^2 + m_{H_d}^2 |H_d^-|^2 + m_{H_u}^2 |H_u^0|^2 + m_{H_u}^2 |H_u^+|^2 + m_t^2 |T^0|^2 + m_t^2 |T^-|^2 + m_t^2 |T^+|^2 \\
& + \tilde{d}_{L,i\alpha}^* \delta_{\alpha\beta} m_{q,ij}^2 \tilde{d}_{L,j\beta} + \tilde{d}_{R,i\alpha}^* \delta_{\alpha\beta} m_{d,ij}^2 \tilde{d}_{R,j\beta} + \tilde{e}_{L,i}^* m_{l,ij}^2 \tilde{e}_{L,j} + \tilde{e}_{R,i}^* m_{e,ij}^2 \tilde{e}_{R,j} \\
& + \tilde{u}_{L,i\alpha}^* \delta_{\alpha\beta} m_{q,ij}^2 \tilde{u}_{L,j\beta} + \tilde{u}_{R,i\alpha}^* \delta_{\alpha\beta} m_{u,ij}^2 \tilde{u}_{R,j\beta} + \tilde{\nu}_{L,i}^* m_{l,ij}^2 \tilde{\nu}_{L,j} \quad (3)
\end{aligned}$$

$$-L_{SB,\lambda} = \frac{1}{2} \left(\lambda_B^2 M_1 \delta_{ij} + M_2 \delta_{ij} \lambda_{\tilde{W},i} \lambda_{\tilde{W},j} + M_3 \delta_{ij} \lambda_{\tilde{g},\alpha} \lambda_{\tilde{g},\beta} + \text{h.c.} \right) \quad (4)$$

2.3 Gauge fixing terms

2.3.1 Gauge fixing terms for eigenstates 'GaugeES'

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

2.3.2 Gauge fixing terms for eigenstates 'EWSB'

$$\begin{aligned} L_{GF} = & -\frac{1}{2}|\partial_\mu g|^2\xi_g^{-1} - \frac{1}{2}|\partial_\mu \gamma|^2\xi_\gamma^{-1} \\ & - \left| \frac{1}{2} \left(2\partial_\mu W^- - ig_2 \left(H_d^- v_d + \sqrt{2}T^- v_T + \sqrt{2}v_T T^{+,*} - v_u H_u^{+,*} \right) \xi_{W^-} \right) \right|^2 \xi_{W^-}^{-1} \\ & - \frac{1}{2} \left| \frac{1}{2} \left(2\partial_\mu Z + (\sigma_d v_d - \sigma_u v_u) \xi_Z (g_1 \sin \Theta_W + g_2 \cos \Theta_W) \right) \right|^2 \xi_Z^{-1} \end{aligned} \quad (6)$$

2.4 Fields integrated out

None

3 Renormalization Group Equations

3.1 Anomalous Dimensions

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

$$\begin{aligned} \gamma_{\hat{q}}^{(2)} = & + \left(8g_2^2 g_3^2 + \frac{1}{90} g_1^2 (16g_3^2 + 9g_2^2) + \frac{199}{900} g_1^4 + \frac{27}{4} g_2^4 - \frac{8}{9} g_3^4 \right) \mathbf{1} + \frac{4}{5} g_1^2 Y_u^\dagger Y_u - \frac{3}{2} |\lambda|^2 Y_u^\dagger Y_u \\ & - 2Y_d^\dagger Y_d Y_d^\dagger Y_d - 2Y_u^\dagger Y_u Y_u^\dagger Y_u + Y_d^\dagger Y_d \left(-3\text{Tr}(Y_d Y_d^\dagger) + \frac{2}{5} g_1^2 - \frac{3}{2} |\lambda|^2 - \text{Tr}(Y_e Y_e^\dagger) \right) \\ & - 3Y_u^\dagger Y_u \text{Tr}(Y_u Y_u^\dagger) \end{aligned} \quad (8)$$

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

$$\begin{aligned} \gamma_{\hat{l}}^{(2)} = & + \frac{9}{100} \left(10g_1^2 g_2^2 + 23g_1^4 + 75g_2^4 \right) \mathbf{1} - 2Y_e^\dagger Y_e Y_e^\dagger Y_e \\ & + Y_e^\dagger Y_e \left(-3\text{Tr}(Y_d Y_d^\dagger) - \frac{3}{2} |\lambda|^2 + \frac{6}{5} g_1^2 - \text{Tr}(Y_e Y_e^\dagger) \right) \end{aligned} \quad (10)$$

$$\gamma_{\hat{H}_d}^{(1)} = 3\text{Tr}(Y_d Y_d^\dagger) - \frac{3}{10} g_1^2 - \frac{3}{2} g_2^2 + \frac{3}{2} |\lambda|^2 + \text{Tr}(Y_e Y_e^\dagger) \quad (11)$$

$$\begin{aligned} \gamma_{\hat{H}_d}^{(2)} = & + \frac{207}{100} g_1^4 + \frac{9}{10} g_1^2 g_2^2 + \frac{27}{4} g_2^4 - \frac{15}{4} \lambda^2 \lambda^{*,2} - \frac{2}{5} \left(-40g_3^2 + g_1^2 \right) \text{Tr}(Y_d Y_d^\dagger) + \frac{6}{5} g_1^2 \text{Tr}(Y_e Y_e^\dagger) \\ & + \lambda^* \left(6g_2^2 \lambda - \frac{9}{2} \lambda \text{Tr}(Y_u Y_u^\dagger) \right) - 9\text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) - 3\text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 3\text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) \end{aligned} \quad (12)$$

$$\gamma_{\hat{H}_u}^{(1)} = -\frac{3}{10} \left(-10\text{Tr}(Y_u Y_u^\dagger) + 5g_2^2 - 5|\lambda|^2 + g_1^2 \right) \quad (13)$$

$$\begin{aligned}\gamma_{\hat{H}_u}^{(2)} = & +\frac{207}{100}g_1^4 + \frac{9}{10}g_1^2g_2^2 + \frac{27}{4}g_2^4 - \frac{15}{4}\lambda^2\lambda^{*,2} + \frac{3}{2}|\lambda|^2 \left(-3\text{Tr}(Y_dY_d^\dagger) + 4g_2^2 - \text{Tr}(Y_eY_e^\dagger) \right) \\ & + \frac{4}{5}(20g_3^2 + g_1^2)\text{Tr}(Y_uY_u^\dagger) - 3\text{Tr}(Y_dY_u^\dagger Y_uY_d^\dagger) - 9\text{Tr}(Y_uY_u^\dagger Y_uY_u^\dagger)\end{aligned}\quad (14)$$

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

$$\begin{aligned}\gamma_{\hat{d}}^{(2)} = & +\frac{2}{225}\left(-100g_3^4 + 101g_1^4 + 80g_1^2g_3^2\right)\mathbf{1} - 2\left(Y_d^*Y_d^TY_d^*Y_d^T + Y_d^*Y_u^TY_u^*Y_d^T\right) \\ & + Y_d^*Y_d^T\left(-2\text{Tr}(Y_eY_e^\dagger) - 3|\lambda|^2 + 6g_2^2 - 6\text{Tr}(Y_dY_d^\dagger) + \frac{2}{5}g_1^2\right)\end{aligned}\quad (16)$$

$$\gamma_{\hat{u}}^{(1)} = 2Y_u^*Y_u^T - \frac{8}{15}(5g_3^2 + g_1^2)\mathbf{1}\quad (17)$$

$$\begin{aligned}\gamma_{\hat{u}}^{(2)} = & +\frac{8}{225}\left(107g_1^4 - 25g_3^4 + 80g_1^2g_3^2\right)\mathbf{1} - 2\left(Y_u^*Y_d^TY_d^*Y_u^T + Y_u^*Y_u^TY_u^*Y_u^T\right) \\ & + Y_u^*Y_u^T\left(-3|\lambda|^2 + 6g_2^2 - 6\text{Tr}(Y_uY_u^\dagger) - \frac{2}{5}g_1^2\right)\end{aligned}\quad (18)$$

$$\gamma_{\hat{e}}^{(1)} = 2Y_e^*Y_e^T - \frac{6}{5}g_1^2\mathbf{1}\quad (19)$$

$$\gamma_{\hat{e}}^{(2)} = -2Y_e^*Y_e^TY_e^*Y_e^T + \frac{234}{25}g_1^4\mathbf{1} + Y_e^*Y_e^T\left(-2\text{Tr}(Y_eY_e^\dagger) - 3|\lambda|^2 + 6g_2^2 - 6\text{Tr}(Y_dY_d^\dagger) - \frac{6}{5}g_1^2\right)\quad (20)$$

$$\gamma_{\text{SF}(T)}^{(1)} = -4g_2^2 + |\lambda|^2\quad (21)$$

$$\gamma_{\text{SF}(T)}^{(2)} = 28g_2^4 - 3\lambda^2\lambda^{*,2} + \frac{1}{5}|\lambda|^2\left(-15\text{Tr}(Y_dY_d^\dagger) - 15\text{Tr}(Y_uY_u^\dagger) + 3g_1^2 - 5g_2^2 - 5\text{Tr}(Y_eY_e^\dagger)\right)\quad (22)$$

3.2 Gauge Couplings

$$\beta_{g_1}^{(1)} = \frac{33}{5}g_1^3\quad (23)$$

$$\beta_{g_1}^{(2)} = \frac{1}{25}g_1^3\left(-130\text{Tr}(Y_uY_u^\dagger) + 135g_2^2 + 199g_1^2 + 440g_3^2 - 45|\lambda|^2 - 70\text{Tr}(Y_dY_d^\dagger) - 90\text{Tr}(Y_eY_e^\dagger)\right)\quad (24)$$

$$\beta_{g_2}^{(1)} = 3g_2^3\quad (25)$$

$$\beta_{g_2}^{(2)} = \frac{1}{5}g_2^3\left(-10\text{Tr}(Y_eY_e^\dagger) + 120g_3^2 + 245g_2^2 - 30\text{Tr}(Y_dY_d^\dagger) - 30\text{Tr}(Y_uY_u^\dagger) - 35|\lambda|^2 + 9g_1^2\right)\quad (26)$$

$$\beta_{g_3}^{(1)} = -3g_3^3\quad (27)$$

$$\beta_{g_3}^{(2)} = \frac{1}{5}g_3^3\left(11g_1^2 - 20\text{Tr}(Y_dY_d^\dagger) - 20\text{Tr}(Y_uY_u^\dagger) + 45g_2^2 + 70g_3^2\right)\quad (28)$$

3.3 Gaugino Mass Parameters

$$\beta_{M_1}^{(1)} = \frac{66}{5}g_1^2M_1\quad (29)$$

$$\beta_{M_1}^{(2)} = \frac{2}{25}g_1^2 \left(398g_1^2M_1 + 135g_2^2M_1 + 440g_3^2M_1 + 440g_3^2M_3 + 135g_2^2M_2 - 45\lambda^* \left(M_1\lambda - T_\lambda \right) - 70M_1\text{Tr}\left(Y_dY_d^\dagger\right) \right. \\ \left. - 90M_1\text{Tr}\left(Y_eY_e^\dagger\right) - 130M_1\text{Tr}\left(Y_uY_u^\dagger\right) + 70\text{Tr}\left(Y_d^\dagger T_d\right) + 90\text{Tr}\left(Y_e^\dagger T_e\right) + 130\text{Tr}\left(Y_u^\dagger T_u\right) \right) \quad (30)$$

$$\beta_{M_2}^{(1)} = 6g_2^2M_2 \quad (31)$$

$$\beta_{M_2}^{(2)} = \frac{2}{5}g_2^2 \left(9g_1^2M_1 + 120g_3^2M_3 + 9g_1^2M_2 + 490g_2^2M_2 + 120g_3^2M_2 - 35\lambda^* \left(M_2\lambda - T_\lambda \right) - 30M_2\text{Tr}\left(Y_dY_d^\dagger\right) \right. \\ \left. - 10M_2\text{Tr}\left(Y_eY_e^\dagger\right) - 30M_2\text{Tr}\left(Y_uY_u^\dagger\right) + 30\text{Tr}\left(Y_d^\dagger T_d\right) + 10\text{Tr}\left(Y_e^\dagger T_e\right) + 30\text{Tr}\left(Y_u^\dagger T_u\right) \right) \quad (32)$$

$$\beta_{M_3}^{(1)} = -6g_3^2M_3 \quad (33)$$

$$\beta_{M_3}^{(2)} = \frac{2}{5}g_3^2 \left(11g_1^2M_1 + 11g_1^2M_3 + 45g_2^2M_3 + 140g_3^2M_3 + 45g_2^2M_2 - 20M_3\text{Tr}\left(Y_dY_d^\dagger\right) - 20M_3\text{Tr}\left(Y_uY_u^\dagger\right) \right. \\ \left. + 20\text{Tr}\left(Y_d^\dagger T_d\right) + 20\text{Tr}\left(Y_u^\dagger T_u\right) \right) \quad (34)$$

3.4 Trilinear Superpotential Parameters

$$\beta_{Y_d}^{(1)} = 3Y_dY_d^\dagger Y_d + Y_d \left(-3g_2^2 + 3\text{Tr}\left(Y_dY_d^\dagger\right) - \frac{16}{3}g_3^2 + \frac{3}{2}|\lambda|^2 - \frac{7}{15}g_1^2 + \text{Tr}\left(Y_eY_e^\dagger\right) \right) + Y_dY_u^\dagger Y_u \quad (35)$$

$$\beta_{Y_d}^{(2)} = +\frac{4}{5}g_1^2Y_dY_u^\dagger Y_u - \frac{3}{2}|\lambda|^2Y_dY_u^\dagger Y_u - 4Y_dY_d^\dagger Y_dY_d^\dagger Y_d - 2Y_dY_u^\dagger Y_uY_d^\dagger Y_d \\ - 2Y_dY_u^\dagger Y_uY_u^\dagger Y_u + Y_dY_d^\dagger Y_d \left(-3\text{Tr}\left(Y_eY_e^\dagger\right) + 6g_2^2 - 9\text{Tr}\left(Y_dY_d^\dagger\right) + \frac{4}{5}g_1^2 - \frac{9}{2}|\lambda|^2 \right) \\ - 3Y_dY_u^\dagger Y_u\text{Tr}\left(Y_uY_u^\dagger\right) \\ + Y_d \left(\frac{287}{90}g_1^4 + g_1^2g_2^2 + \frac{27}{2}g_2^4 + \frac{8}{9}g_1^2g_3^2 + 8g_2^2g_3^2 - \frac{16}{9}g_3^4 - \frac{15}{4}\lambda^2\lambda^{*,2} - \frac{2}{5} \left(-40g_3^2 + g_1^2 \right) \text{Tr}\left(Y_dY_d^\dagger\right) \right. \\ \left. + \frac{6}{5}g_1^2\text{Tr}\left(Y_eY_e^\dagger\right) + \lambda^* \left(6g_2^2\lambda - \frac{9}{2}\lambda\text{Tr}\left(Y_uY_u^\dagger\right) \right) - 9\text{Tr}\left(Y_dY_d^\dagger Y_dY_d^\dagger\right) - 3\text{Tr}\left(Y_dY_u^\dagger Y_uY_d^\dagger\right) \right. \\ \left. - 3\text{Tr}\left(Y_eY_e^\dagger Y_eY_e^\dagger\right) \right) \quad (36)$$

$$\beta_{Y_e}^{(1)} = 3Y_eY_e^\dagger Y_e + Y_e \left(-3g_2^2 + 3\text{Tr}\left(Y_dY_d^\dagger\right) + \frac{3}{2}|\lambda|^2 - \frac{9}{5}g_1^2 + \text{Tr}\left(Y_eY_e^\dagger\right) \right) \quad (37)$$

$$\beta_{Y_e}^{(2)} = -4Y_eY_e^\dagger Y_eY_e^\dagger Y_e + Y_eY_e^\dagger Y_e \left(-3\text{Tr}\left(Y_eY_e^\dagger\right) + 6g_2^2 - 9\text{Tr}\left(Y_dY_d^\dagger\right) - \frac{9}{2}|\lambda|^2 \right) \\ + \frac{1}{20}Y_e \left(-75\lambda^2\lambda^{*,2} - 8 \left(-40g_3^2 + g_1^2 \right) \text{Tr}\left(Y_dY_d^\dagger\right) + 30|\lambda|^2 \left(-3\text{Tr}\left(Y_uY_u^\dagger\right) + 4g_2^2 \right) \right. \\ \left. + 6 \left(45g_1^4 + 6g_1^2g_2^2 + 45g_2^4 + 4g_1^2\text{Tr}\left(Y_eY_e^\dagger\right) - 30\text{Tr}\left(Y_dY_d^\dagger Y_dY_d^\dagger\right) - 10\text{Tr}\left(Y_dY_u^\dagger Y_uY_d^\dagger\right) \right. \right. \\ \left. \left. - 10\text{Tr}\left(Y_eY_e^\dagger Y_eY_e^\dagger\right) \right) \right) \quad (38)$$

$$\beta_\lambda^{(1)} = 3\lambda\text{Tr}\left(Y_dY_d^\dagger\right) + 3\lambda\text{Tr}\left(Y_uY_u^\dagger\right) + 4\lambda^2\lambda^* - 7g_2^2\lambda - \frac{3}{5}g_1^2\lambda + \lambda\text{Tr}\left(Y_eY_e^\dagger\right) \quad (39)$$

$$\beta_\lambda^{(2)} = -\frac{1}{50}\lambda \left(-207g_1^4 - 90g_1^2g_2^2 - 2075g_2^4 + 525\lambda^2\lambda^{*,2} + 20 \left(-40g_3^2 + g_1^2 \right) \text{Tr}\left(Y_dY_d^\dagger\right) - 60g_1^2\text{Tr}\left(Y_eY_e^\dagger\right) \right)$$

$$\begin{aligned}
& -5|\lambda|^2\left(110g_2^2 - 25\text{Tr}\left(Y_e Y_e^\dagger\right) + 6g_1^2 - 75\text{Tr}\left(Y_d Y_d^\dagger\right) - 75\text{Tr}\left(Y_u Y_u^\dagger\right)\right) - 40g_1^2\text{Tr}\left(Y_u Y_u^\dagger\right) \\
& - 800g_3^2\text{Tr}\left(Y_u Y_u^\dagger\right) + 450\text{Tr}\left(Y_d Y_d^\dagger Y_d Y_d^\dagger\right) + 300\text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) + 150\text{Tr}\left(Y_e Y_e^\dagger Y_e Y_e^\dagger\right) \\
& + 450\text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right)
\end{aligned} \tag{40}$$

$$\beta_{Y_u}^{(1)} = 3Y_u Y_u^\dagger Y_u + Y_u \left(-3g_2^2 + 3\text{Tr}\left(Y_u Y_u^\dagger\right) - \frac{13}{15}g_1^2 - \frac{16}{3}g_3^2 + \frac{3}{2}|\lambda|^2 \right) + Y_u Y_d^\dagger Y_d \tag{41}$$

$$\begin{aligned}
\beta_{Y_u}^{(2)} = & +\frac{2}{5}g_1^2 Y_u Y_u^\dagger Y_u + 6g_2^2 Y_u Y_u^\dagger Y_u - \frac{9}{2}|\lambda|^2 Y_u Y_u^\dagger Y_u - 2Y_u Y_d^\dagger Y_d Y_d^\dagger Y_d \\
& - 2Y_u Y_d^\dagger Y_d Y_u^\dagger Y_u - 4Y_u Y_u^\dagger Y_u Y_u^\dagger Y_u \\
& + Y_u Y_d^\dagger Y_d \left(-3\text{Tr}\left(Y_d Y_d^\dagger\right) + \frac{2}{5}g_1^2 - \frac{3}{2}|\lambda|^2 - \text{Tr}\left(Y_e Y_e^\dagger\right) \right) - 9Y_u Y_u^\dagger Y_u \text{Tr}\left(Y_u Y_u^\dagger\right) \\
& + Y_u \left(\frac{2743}{450}g_1^4 + g_1^2 g_2^2 + \frac{27}{2}g_2^4 + \frac{136}{45}g_1^2 g_3^2 + 8g_2^2 g_3^2 - \frac{16}{9}g_3^4 - \frac{15}{4}\lambda^2 \lambda^{*,2} \right) \\
& + \frac{3}{2}|\lambda|^2 \left(-3\text{Tr}\left(Y_d Y_d^\dagger\right) + 4g_2^2 - \text{Tr}\left(Y_e Y_e^\dagger\right) \right) + \frac{4}{5}(20g_3^2 + g_1^2)\text{Tr}\left(Y_u Y_u^\dagger\right) - 3\text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) \\
& - 9\text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right)
\end{aligned} \tag{42}$$

3.5 Bilinear Superpotential Parameters

$$\beta_\mu^{(1)} = -3g_2^2 \mu + 3\mu|\lambda|^2 + 3\mu\text{Tr}\left(Y_d Y_d^\dagger\right) + 3\mu\text{Tr}\left(Y_u Y_u^\dagger\right) - \frac{3}{5}g_1^2 \mu + \mu\text{Tr}\left(Y_e Y_e^\dagger\right) \tag{43}$$

$$\begin{aligned}
\beta_\mu^{(2)} = & \frac{1}{50}\mu \left(207g_1^4 + 90g_1^2 g_2^2 + 675g_2^4 - 375\lambda^2 \lambda^{*,2} - 20 \left(-40g_3^2 + g_1^2 \right) \text{Tr}\left(Y_d Y_d^\dagger\right) + 60g_1^2 \text{Tr}\left(Y_e Y_e^\dagger\right) \right) \\
& + 75|\lambda|^2 \left(-3\text{Tr}\left(Y_d Y_d^\dagger\right) - 3\text{Tr}\left(Y_u Y_u^\dagger\right) + 8g_2^2 - \text{Tr}\left(Y_e Y_e^\dagger\right) \right) + 40g_1^2 \text{Tr}\left(Y_u Y_u^\dagger\right) \\
& + 800g_3^2 \text{Tr}\left(Y_u Y_u^\dagger\right) - 450\text{Tr}\left(Y_d Y_d^\dagger Y_d Y_d^\dagger\right) - 300\text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) - 150\text{Tr}\left(Y_e Y_e^\dagger Y_e Y_e^\dagger\right) \\
& - 450\text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right)
\end{aligned} \tag{44}$$

$$\beta_{M_T}^{(1)} = 2M_T |\lambda|^2 - 8g_2^2 M_T \tag{45}$$

$$\beta_{M_T}^{(2)} = \frac{2}{5}M_T \left(140g_2^4 - 15\lambda^2 \lambda^{*,2} + |\lambda|^2 \left(-15\text{Tr}\left(Y_d Y_d^\dagger\right) - 15\text{Tr}\left(Y_u Y_u^\dagger\right) + 3g_1^2 - 5g_2^2 - 5\text{Tr}\left(Y_e Y_e^\dagger\right) \right) \right) \tag{46}$$

3.6 Trilinear Soft-Breaking Parameters

$$\begin{aligned}
\beta_{T_d}^{(1)} = & +4Y_d Y_d^\dagger T_d + 2Y_d Y_u^\dagger T_u + 5T_d Y_d^\dagger Y_d + T_d Y_u^\dagger Y_u - \frac{7}{15}g_1^2 T_d - 3g_2^2 T_d - \frac{16}{3}g_3^2 T_d \\
& + \frac{3}{2}|\lambda|^2 T_d + 3T_d \text{Tr}\left(Y_d Y_d^\dagger\right) + T_d \text{Tr}\left(Y_e Y_e^\dagger\right)
\end{aligned}$$

$$+ Y_d \left(2\text{Tr} \left(Y_e^\dagger T_e \right) + 3\lambda^* T_\lambda + 6g_2^2 M_2 + 6\text{Tr} \left(Y_d^\dagger T_d \right) + \frac{14}{15} g_1^2 M_1 + \frac{32}{3} g_3^2 M_3 \right) \quad (47)$$

$$\begin{aligned} \beta_{T_d}^{(2)} = & \frac{6}{5} g_1^2 Y_d Y_d^\dagger T_d + 6g_2^2 Y_d Y_d^\dagger T_d - 6|\lambda|^2 Y_d Y_d^\dagger T_d - \frac{8}{5} g_1^2 M_1 Y_d Y_u^\dagger Y_u \\ & + \frac{8}{5} g_1^2 Y_d Y_u^\dagger T_u - 3|\lambda|^2 Y_d Y_u^\dagger T_u + \frac{6}{5} g_1^2 T_d Y_d^\dagger Y_d + 12g_2^2 T_d Y_d^\dagger Y_d \\ & - \frac{15}{2} |\lambda|^2 T_d Y_d^\dagger Y_d + \frac{4}{5} g_1^2 T_d Y_u^\dagger Y_u - \frac{3}{2} |\lambda|^2 T_d Y_u^\dagger Y_u - 6Y_d Y_d^\dagger Y_d Y_d^\dagger T_d \\ & - 8Y_d Y_d^\dagger T_d Y_d^\dagger Y_d - 2Y_d Y_u^\dagger Y_u Y_d^\dagger T_d - 4Y_d Y_u^\dagger Y_u Y_u^\dagger T_u - 4Y_d Y_u^\dagger T_u Y_d^\dagger Y_d \\ & - 4Y_d Y_u^\dagger T_u Y_u^\dagger Y_u - 6T_d Y_d^\dagger Y_d Y_d^\dagger Y_d - 4T_d Y_u^\dagger Y_u Y_d^\dagger Y_d - 2T_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{27}{2} g_2^4 T_d + \frac{8}{9} g_1^2 g_3^2 T_d + 8g_2^2 g_3^2 T_d - \frac{16}{9} g_3^4 T_d + 6g_2^2 |\lambda|^2 T_d \\ & - \frac{15}{4} \lambda^2 \lambda^{*,2} T_d - 3\lambda^* Y_d Y_u^\dagger Y_u T_\lambda - 12Y_d Y_d^\dagger T_d \text{Tr} \left(Y_d Y_d^\dagger \right) \\ & - 15T_d Y_d^\dagger Y_d \text{Tr} \left(Y_d Y_d^\dagger \right) - \frac{2}{5} g_1^2 T_d \text{Tr} \left(Y_d Y_d^\dagger \right) + 16g_2^2 T_d \text{Tr} \left(Y_d Y_d^\dagger \right) \\ & - 4Y_d Y_d^\dagger T_d \text{Tr} \left(Y_e Y_e^\dagger \right) - 5T_d Y_d^\dagger Y_d \text{Tr} \left(Y_e Y_e^\dagger \right) + \frac{6}{5} g_1^2 T_d \text{Tr} \left(Y_e Y_e^\dagger \right) \\ & - 6Y_d Y_u^\dagger T_u \text{Tr} \left(Y_u Y_u^\dagger \right) - 3T_d Y_u^\dagger Y_u \text{Tr} \left(Y_u Y_u^\dagger \right) - \frac{9}{2} |\lambda|^2 T_d \text{Tr} \left(Y_u Y_u^\dagger \right) \\ & - \frac{1}{5} Y_d Y_d^\dagger Y_d \left(30\text{Tr} \left(Y_e^\dagger T_e \right) + 45\lambda^* T_\lambda + 60g_2^2 M_2 + 8g_1^2 M_1 + 90\text{Tr} \left(Y_d^\dagger T_d \right) \right) \\ & - 6Y_d Y_u^\dagger Y_u \text{Tr} \left(Y_u^\dagger T_u \right) - 9T_d \text{Tr} \left(Y_d Y_d^\dagger Y_d Y_d^\dagger \right) - 3T_d \text{Tr} \left(Y_d Y_u^\dagger Y_u Y_d^\dagger \right) \\ & - 3T_d \text{Tr} \left(Y_e Y_e^\dagger Y_e Y_e^\dagger \right) \\ & - \frac{1}{45} Y_d \left(675\lambda\lambda^{*,2} T_\lambda + 135\lambda^* \left(3\lambda \text{Tr} \left(Y_u^\dagger T_u \right) + 3T_\lambda \text{Tr} \left(Y_u Y_u^\dagger \right) + 4g_2^2 M_2 \lambda - 4g_2^2 T_\lambda \right) \right. \\ & + 2 \left(287g_1^4 M_1 + 45g_1^2 g_2^2 M_1 + 40g_1^2 g_3^2 M_1 + 40g_1^2 g_3^2 M_3 + 360g_2^2 g_3^2 M_3 - 160g_3^4 M_3 \right. \\ & + 45g_1^2 g_2^2 M_2 + 1215g_2^4 M_2 + 360g_2^2 g_3^2 M_2 - 18 \left(-40g_3^2 M_3 + g_1^2 M_1 \right) \text{Tr} \left(Y_d Y_d^\dagger \right) \\ & + 54g_1^2 M_1 \text{Tr} \left(Y_e Y_e^\dagger \right) + 18g_1^2 \text{Tr} \left(Y_d^\dagger T_d \right) - 720g_3^2 \text{Tr} \left(Y_d^\dagger T_d \right) - 54g_1^2 \text{Tr} \left(Y_e^\dagger T_e \right) \\ & \left. \left. + 810\text{Tr} \left(Y_d Y_d^\dagger T_d Y_d^\dagger \right) + 135\text{Tr} \left(Y_d Y_u^\dagger T_u Y_d^\dagger \right) + 270\text{Tr} \left(Y_e Y_e^\dagger T_e Y_e^\dagger \right) + 135\text{Tr} \left(Y_u Y_d^\dagger T_d Y_u^\dagger \right) \right) \right) \quad (48) \end{aligned}$$

$$\begin{aligned} \beta_{T_e}^{(1)} = & +4Y_e Y_e^\dagger T_e + 5T_e Y_e^\dagger Y_e - \frac{9}{5} g_1^2 T_e - 3g_2^2 T_e + \frac{3}{2} |\lambda|^2 T_e + 3T_e \text{Tr} \left(Y_d Y_d^\dagger \right) \\ & + T_e \text{Tr} \left(Y_e Y_e^\dagger \right) + Y_e \left(2\text{Tr} \left(Y_e^\dagger T_e \right) + 3\lambda^* T_\lambda + 6g_2^2 M_2 + 6\text{Tr} \left(Y_d^\dagger T_d \right) + \frac{18}{5} g_1^2 M_1 \right) \quad (49) \end{aligned}$$

$$\begin{aligned} \beta_{T_e}^{(2)} = & + \frac{6}{5} g_1^2 Y_e Y_e^\dagger T_e + 6g_2^2 Y_e Y_e^\dagger T_e - 6|\lambda|^2 Y_e Y_e^\dagger T_e - \frac{6}{5} g_1^2 T_e Y_e^\dagger Y_e \\ & + 12g_2^2 T_e Y_e^\dagger Y_e - \frac{15}{2} |\lambda|^2 T_e Y_e^\dagger Y_e - 6Y_e Y_e^\dagger Y_e Y_e^\dagger T_e - 8Y_e Y_e^\dagger T_e Y_e^\dagger Y_e \\ & - 6T_e Y_e^\dagger Y_e Y_e^\dagger Y_e + \frac{27}{2} g_1^4 T_e + \frac{9}{5} g_1^2 g_2^2 T_e + \frac{27}{2} g_2^4 T_e + 6g_2^2 |\lambda|^2 T_e - \frac{15}{4} \lambda^2 \lambda^{*,2} T_e \end{aligned}$$

$$\begin{aligned}
& -12Y_e Y_e^\dagger T_e \text{Tr}(Y_d Y_d^\dagger) - 15T_e Y_e^\dagger Y_e \text{Tr}(Y_d Y_d^\dagger) - \frac{2}{5}g_1^2 T_e \text{Tr}(Y_d Y_d^\dagger) \\
& + 16g_3^2 T_e \text{Tr}(Y_d Y_d^\dagger) - 4Y_e Y_e^\dagger T_e \text{Tr}(Y_e Y_e^\dagger) - 5T_e Y_e^\dagger Y_e \text{Tr}(Y_e Y_e^\dagger) \\
& + \frac{6}{5}g_1^2 T_e \text{Tr}(Y_e Y_e^\dagger) - \frac{9}{2}|\lambda|^2 T_e \text{Tr}(Y_u Y_u^\dagger) \\
& - 3Y_e Y_e^\dagger Y_e (2\text{Tr}(Y_e^\dagger T_e) + 3\lambda^* T_\lambda + 4g_2^2 M_2 + 6\text{Tr}(Y_d^\dagger T_d)) - 9T_e \text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) \\
& - 3T_e \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 3T_e \text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) \\
& - \frac{1}{5}Y_e (75\lambda\lambda^{*,2} T_\lambda + 15\lambda^* (3\lambda \text{Tr}(Y_u^\dagger T_u) + 3T_\lambda \text{Tr}(Y_u Y_u^\dagger) + 4g_2^2 M_2 \lambda - 4g_2^2 T_\lambda) \\
& + 2(135g_1^4 M_1 + 9g_1^2 g_2^2 M_1 + 9g_1^2 g_2^2 M_2 + 135g_1^4 M_2 + (-2g_1^2 M_1 + 80g_3^2 M_3) \text{Tr}(Y_d Y_d^\dagger) \\
& + 6g_1^2 M_1 \text{Tr}(Y_e Y_e^\dagger) + 2g_1^2 \text{Tr}(Y_d^\dagger T_d) - 80g_3^2 \text{Tr}(Y_d^\dagger T_d) - 6g_1^2 \text{Tr}(Y_e^\dagger T_e) \\
& + 90\text{Tr}(Y_d Y_d^\dagger T_d Y_d^\dagger) + 15\text{Tr}(Y_d Y_u^\dagger T_u Y_d^\dagger) + 30\text{Tr}(Y_e Y_e^\dagger T_e Y_e^\dagger) + 15\text{Tr}(Y_u Y_d^\dagger T_d Y_u^\dagger))
\end{aligned} \tag{50}$$

$$\begin{aligned}
\beta_{T_\lambda}^{(1)} & = +T_\lambda (12|\lambda|^2 + 3\text{Tr}(Y_d Y_d^\dagger) + 3\text{Tr}(Y_u Y_u^\dagger) - 7g_2^2 - \frac{3}{5}g_1^2 + \text{Tr}(Y_e Y_e^\dagger)) \\
& + \frac{2}{5}\lambda (15\text{Tr}(Y_d^\dagger T_d) + 15\text{Tr}(Y_u^\dagger T_u) + 35g_2^2 M_2 + 3g_1^2 M_1 + 5\text{Tr}(Y_e^\dagger T_e))
\end{aligned} \tag{51}$$

$$\begin{aligned}
\beta_{T_\lambda}^{(2)} & = -\frac{105}{2}\lambda^2 \lambda^{*,2} T_\lambda \\
& - \frac{1}{10}|\lambda|^2 (-3T_\lambda (110g_2^2 - 25\text{Tr}(Y_e Y_e^\dagger) + 6g_1^2 - 75\text{Tr}(Y_d Y_d^\dagger) - 75\text{Tr}(Y_u Y_u^\dagger)) \\
& + 2\lambda (110g_2^2 M_2 + 25\text{Tr}(Y_e^\dagger T_e) + 6g_1^2 M_1 + 75\text{Tr}(Y_d^\dagger T_d) + 75\text{Tr}(Y_u^\dagger T_u))) \\
& + T_\lambda \left(\frac{207}{50}g_1^4 + \frac{9}{5}g_1^2 g_2^2 + \frac{83}{2}g_2^4 - \frac{2}{5}(-40g_3^2 + g_1^2) \text{Tr}(Y_d Y_d^\dagger) + \frac{6}{5}g_1^2 \text{Tr}(Y_e Y_e^\dagger) + \frac{4}{5}g_1^2 \text{Tr}(Y_u Y_u^\dagger) \right. \\
& + 16g_3^2 \text{Tr}(Y_u Y_u^\dagger) - 9\text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) - 6\text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 3\text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) - 9\text{Tr}(Y_u Y_u^\dagger Y_u Y_u^\dagger) \\
& - \frac{2}{25}\lambda (207g_1^4 M_1 + 45g_1^2 g_2^2 M_1 + 45g_1^2 g_2^2 M_2 + 2075g_2^4 M_2 - 10(-40g_3^2 M_3 + g_1^2 M_1) \text{Tr}(Y_d Y_d^\dagger) \\
& + 30g_1^2 M_1 \text{Tr}(Y_e Y_e^\dagger) + 20g_1^2 M_1 \text{Tr}(Y_u Y_u^\dagger) + 400g_3^2 M_3 \text{Tr}(Y_u Y_u^\dagger) + 10g_1^2 \text{Tr}(Y_d^\dagger T_d) \\
& - 400g_3^2 \text{Tr}(Y_d^\dagger T_d) - 30g_1^2 \text{Tr}(Y_e^\dagger T_e) - 20g_1^2 \text{Tr}(Y_u^\dagger T_u) - 400g_3^2 \text{Tr}(Y_u^\dagger T_u) \\
& + 450\text{Tr}(Y_d Y_d^\dagger T_d Y_d^\dagger) + 150\text{Tr}(Y_d Y_u^\dagger T_u Y_d^\dagger) + 150\text{Tr}(Y_e Y_e^\dagger T_e Y_e^\dagger) + 150\text{Tr}(Y_u Y_d^\dagger T_d Y_u^\dagger) \\
& \left. + 450\text{Tr}(Y_u Y_u^\dagger T_u Y_u^\dagger) \right)
\end{aligned} \tag{52}$$

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

$$\beta_{T_u}^{(2)} = +\frac{4}{5}g_1^2 Y_u Y_d^\dagger T_d - 3|\lambda|^2 Y_u Y_d^\dagger T_d - \frac{4}{5}g_1^2 M_1 Y_u Y_u^\dagger Y_u - 12g_2^2 M_2 Y_u Y_u^\dagger Y_u$$

$$\begin{aligned}
& + \frac{6}{5}g_1^2 Y_u Y_u^\dagger T_u + 6g_2^2 Y_u Y_u^\dagger T_u - 6|\lambda|^2 Y_u Y_u^\dagger T_u + \frac{2}{5}g_1^2 T_u Y_d^\dagger Y_d \\
& - \frac{3}{2}|\lambda|^2 T_u Y_d^\dagger Y_d + 12g_2^2 T_u Y_u^\dagger Y_u - \frac{15}{2}|\lambda|^2 T_u Y_u^\dagger Y_u - 4Y_u Y_d^\dagger Y_d Y_d^\dagger T_d \\
& - 2Y_u Y_d^\dagger Y_d Y_u^\dagger T_u - 4Y_u Y_d^\dagger T_d Y_d^\dagger Y_d - 4Y_u Y_d^\dagger T_d Y_u^\dagger Y_u - 6Y_u Y_u^\dagger Y_u Y_u^\dagger T_u \\
& - 8Y_u Y_u^\dagger T_u Y_u^\dagger Y_u - 2T_u Y_d^\dagger Y_d Y_d^\dagger Y_d - 4T_u Y_d^\dagger Y_d Y_u^\dagger Y_u - 6T_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{27}{2}g_2^4 T_u + \frac{136}{45}g_1^2 g_3^2 T_u + 8g_2^2 g_3^2 T_u - \frac{16}{9}g_3^4 T_u + 6g_2^2 |\lambda|^2 T_u - \frac{15}{4}\lambda^2 \lambda^{*,2} T_u \\
& - 9\lambda^* Y_u Y_u^\dagger Y_u T_\lambda - 6Y_u Y_d^\dagger T_d \text{Tr}(Y_d Y_d^\dagger) - 3T_u Y_d^\dagger Y_d \text{Tr}(Y_d Y_d^\dagger) \\
& - \frac{9}{2}|\lambda|^2 T_u \text{Tr}(Y_d Y_d^\dagger) - 2Y_u Y_d^\dagger T_d \text{Tr}(Y_e Y_e^\dagger) - T_u Y_d^\dagger Y_d \text{Tr}(Y_e Y_e^\dagger) \\
& - \frac{3}{2}|\lambda|^2 T_u \text{Tr}(Y_e Y_e^\dagger) - 12Y_u Y_u^\dagger T_u \text{Tr}(Y_u Y_u^\dagger) - 15T_u Y_u^\dagger Y_u \text{Tr}(Y_u Y_u^\dagger) \\
& + \frac{4}{5}g_1^2 T_u \text{Tr}(Y_u Y_u^\dagger) + 16g_3^2 T_u \text{Tr}(Y_u Y_u^\dagger) \\
& + Y_u Y_d^\dagger Y_d \left(-2\text{Tr}(Y_e^\dagger T_e) - 3\lambda^* T_\lambda - 6\text{Tr}(Y_d^\dagger T_d) - \frac{4}{5}g_1^2 M_1 \right) - 18Y_u Y_u^\dagger Y_u \text{Tr}(Y_u^\dagger T_u) \\
& - 3T_u \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 9T_u \text{Tr}(Y_u Y_u^\dagger Y_u Y_u^\dagger) \\
& - \frac{1}{225}Y_u \left(3375\lambda\lambda^{*,2} T_\lambda + 675\lambda^* \left(\lambda \left(3\text{Tr}(Y_d^\dagger T_d) + 4g_2^2 M_2 + \text{Tr}(Y_e^\dagger T_e) \right) \right) + T_\lambda \left(3\text{Tr}(Y_d Y_d^\dagger) - 4g_2^2 + \text{Tr}(Y_e Y_e^\dagger) \right) \right) \\
& + 2 \left(2743g_1^4 M_1 + 225g_1^2 g_2^2 M_1 + 680g_1^2 g_3^2 M_1 + 680g_1^2 g_3^2 M_3 + 1800g_2^2 g_3^2 M_3 - 800g_3^4 M_3 \right. \\
& + 225g_1^2 g_2^2 M_2 + 6075g_2^4 M_2 + 1800g_2^2 g_3^2 M_2 + 180 \left(20g_3^2 M_3 + g_1^2 M_1 \right) \text{Tr}(Y_u Y_u^\dagger) \\
& \left. - 180 \left(20g_3^2 + g_1^2 \right) \text{Tr}(Y_u^\dagger T_u) + 675\text{Tr}(Y_d Y_u^\dagger T_u Y_d^\dagger) + 675\text{Tr}(Y_u Y_d^\dagger T_d Y_u^\dagger) \right. \\
& \left. + 4050\text{Tr}(Y_u Y_u^\dagger T_u Y_u^\dagger) \right) \tag{54}
\end{aligned}$$

3.7 Bilinear Soft-Breaking Parameters

$$\begin{aligned}
\beta_{B_\mu}^{(1)} & = + \frac{6}{5}g_1^2 M_1 \mu + 6g_2^2 M_2 \mu + 6\mu \lambda^* T_\lambda \\
& + B_\mu \left(-3g_2^2 + 3|\lambda|^2 + 3\text{Tr}(Y_d Y_d^\dagger) + 3\text{Tr}(Y_u Y_u^\dagger) - \frac{3}{5}g_1^2 + \text{Tr}(Y_e Y_e^\dagger) \right) + 6\mu \text{Tr}(Y_d^\dagger T_d) \\
& + 2\mu \text{Tr}(Y_e^\dagger T_e) + 6\mu \text{Tr}(Y_u^\dagger T_u) \tag{55} \\
\beta_{B_\mu}^{(2)} & = \frac{1}{50} \left(B_\mu \left(207g_1^4 + 90g_1^2 g_2^2 + 675g_2^4 - 375\lambda^2 \lambda^{*,2} - 20 \left(-40g_3^2 + g_1^2 \right) \text{Tr}(Y_d Y_d^\dagger) + 60g_1^2 \text{Tr}(Y_e Y_e^\dagger) \right) \right. \\
& + 75|\lambda|^2 \left(-3\text{Tr}(Y_d Y_d^\dagger) - 3\text{Tr}(Y_u Y_u^\dagger) + 8g_2^2 - \text{Tr}(Y_e Y_e^\dagger) \right) + 40g_1^2 \text{Tr}(Y_u Y_u^\dagger) \\
& \left. + 800g_3^2 \text{Tr}(Y_u Y_u^\dagger) - 450\text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) - 300\text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 150\text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) \right)
\end{aligned}$$

$$\begin{aligned}
& -450\text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right) \\
& -2\mu\left(414g_1^4 M_1 + 90g_1^2 g_2^2 M_1 + 90g_1^2 g_2^2 M_2 + 1350g_2^4 M_2 + 750\lambda\lambda^{*,2} T_\lambda\right. \\
& -20\left(-40g_3^2 M_3 + g_1^2 M_1\right)\text{Tr}\left(Y_d Y_d^\dagger\right) + 60g_1^2 M_1 \text{Tr}\left(Y_e Y_e^\dagger\right) + 40g_1^2 M_1 \text{Tr}\left(Y_u Y_u^\dagger\right) \\
& + 800g_3^2 M_3 \text{Tr}\left(Y_u Y_u^\dagger\right) + 20g_1^2 \text{Tr}\left(Y_d^\dagger T_d\right) - 800g_3^2 \text{Tr}\left(Y_d^\dagger T_d\right) - 60g_1^2 \text{Tr}\left(Y_e^\dagger T_e\right) \\
& -40g_1^2 \text{Tr}\left(Y_u^\dagger T_u\right) - 800g_3^2 \text{Tr}\left(Y_u^\dagger T_u\right) \\
& + 75\lambda^*\left(T_\lambda\left(3\text{Tr}\left(Y_d Y_d^\dagger\right) + 3\text{Tr}\left(Y_u Y_u^\dagger\right) - 8g_2^2 + \text{Tr}\left(Y_e Y_e^\dagger\right)\right)\right. \\
& \left. + \lambda\left(3\text{Tr}\left(Y_d^\dagger T_d\right) + 3\text{Tr}\left(Y_u^\dagger T_u\right) + 8g_2^2 M_2 + \text{Tr}\left(Y_e^\dagger T_e\right)\right)\right) \\
& + 900\text{Tr}\left(Y_d Y_d^\dagger T_d Y_d^\dagger\right) + 300\text{Tr}\left(Y_d Y_u^\dagger T_u Y_d^\dagger\right) + 300\text{Tr}\left(Y_e Y_e^\dagger T_e Y_e^\dagger\right) + 300\text{Tr}\left(Y_u Y_d^\dagger T_d Y_u^\dagger\right) \\
& \left. + 900\text{Tr}\left(Y_u Y_u^\dagger T_u Y_u^\dagger\right)\right) \tag{56}
\end{aligned}$$

$$\beta_{B_T}^{(1)} = 2\left(2M_T \lambda^* T_\lambda - 4g_2^2 B_T + 8g_2^2 M_2 M_T + |\lambda|^2 B_T\right) \tag{57}$$

$$\begin{aligned}
\beta_{B_T}^{(2)} = & -\frac{2}{5}\left(B_T\left(-140g_2^4 + 15\lambda^2 \lambda^{*,2} + |\lambda|^2\left(15\text{Tr}\left(Y_d Y_d^\dagger\right) + 15\text{Tr}\left(Y_u Y_u^\dagger\right) - 3g_1^2 + 5g_2^2 + 5\text{Tr}\left(Y_e Y_e^\dagger\right)\right)\right)\right. \\
& + 2M_T\left(280g_2^4 M_2 + 30\lambda\lambda^{*,2} T_\lambda\right. \\
& \left. + \lambda^*\left(T_\lambda\left(15\text{Tr}\left(Y_d Y_d^\dagger\right) + 15\text{Tr}\left(Y_u Y_u^\dagger\right) - 3g_1^2 + 5g_2^2 + 5\text{Tr}\left(Y_e Y_e^\dagger\right)\right)\right)\right. \\
& \left. + \lambda\left(15\text{Tr}\left(Y_d^\dagger T_d\right) + 15\text{Tr}\left(Y_u^\dagger T_u\right) + 3g_1^2 M_1 - 5g_2^2 M_2 + 5\text{Tr}\left(Y_e^\dagger T_e\right)\right)\right)\right) \tag{58}
\end{aligned}$$

3.8 Soft-Breaking Scalar Masses

$$\sigma_{1,1} = \sqrt{\frac{3}{5}}g_1\left(-2\text{Tr}\left(m_u^2\right) - \text{Tr}\left(m_l^2\right) - m_{H_d}^2 + m_{H_u}^2 + \text{Tr}\left(m_d^2\right) + \text{Tr}\left(m_e^2\right) + \text{Tr}\left(m_q^2\right)\right) \tag{59}$$

$$\sigma_{2,11} = \frac{1}{10}g_1^2\left(2\text{Tr}\left(m_d^2\right) + 3\text{Tr}\left(m_l^2\right) + 3m_{H_d}^2 + 3m_{H_u}^2 + 6\text{Tr}\left(m_e^2\right) + 8\text{Tr}\left(m_u^2\right) + \text{Tr}\left(m_q^2\right)\right) \tag{60}$$

$$\begin{aligned}
\sigma_{3,1} = & \frac{1}{20}\frac{1}{\sqrt{15}}g_1\left(-9g_1^2 m_{H_d}^2 - 45g_2^2 m_{H_d}^2 + 9g_1^2 m_{H_u}^2 + 45g_2^2 m_{H_u}^2 + 45\left(-m_{H_u}^2 + m_{H_d}^2\right)|\lambda|^2 + 4\left(20g_3^2 + g_1^2\right)\text{Tr}\left(m_d^2\right)\right. \\
& + 36g_1^2 \text{Tr}\left(m_e^2\right) - 9g_1^2 \text{Tr}\left(m_l^2\right) - 45g_2^2 \text{Tr}\left(m_l^2\right) + g_1^2 \text{Tr}\left(m_q^2\right) + 45g_2^2 \text{Tr}\left(m_q^2\right) + 80g_3^2 \text{Tr}\left(m_q^2\right) \\
& - 32g_1^2 \text{Tr}\left(m_u^2\right) - 160g_3^2 \text{Tr}\left(m_u^2\right) + 90m_{H_d}^2 \text{Tr}\left(Y_d Y_d^\dagger\right) + 30m_{H_d}^2 \text{Tr}\left(Y_e Y_e^\dagger\right) - 90m_{H_u}^2 \text{Tr}\left(Y_u Y_u^\dagger\right) \\
& - 60\text{Tr}\left(Y_d Y_d^\dagger m_d^{2*}\right) - 30\text{Tr}\left(Y_d m_q^{2*} Y_d^\dagger\right) - 60\text{Tr}\left(Y_e Y_e^\dagger m_e^{2*}\right) + 30\text{Tr}\left(Y_e m_l^{2*} Y_e^\dagger\right) \\
& \left. + 120\text{Tr}\left(Y_u Y_u^\dagger m_u^{2*}\right) - 30\text{Tr}\left(Y_u m_q^{2*} Y_u^\dagger\right)\right) \tag{61}
\end{aligned}$$

$$\sigma_{2,2} = \frac{1}{2}\left(3\text{Tr}\left(m_q^2\right) + 4m_l^2 + m_{H_d}^2 + m_{H_u}^2 + \text{Tr}\left(m_l^2\right)\right) \tag{62}$$

$$\sigma_{2,3} = \frac{1}{2} \left(2\text{Tr}(m_q^2) + \text{Tr}(m_d^2) + \text{Tr}(m_u^2) \right) \quad (63)$$

$$\begin{aligned} \beta_{m_q^2}^{(1)} = & -\frac{2}{15}g_1^2\mathbf{1}|M_1|^2 - \frac{32}{3}g_3^2\mathbf{1}|M_3|^2 - 6g_2^2\mathbf{1}|M_2|^2 + 2m_{H_d}^2Y_d^\dagger Y_d + 2m_{H_u}^2Y_u^\dagger Y_u + 2T_d^\dagger T_d \\ & + 2T_u^\dagger T_u + m_q^2Y_d^\dagger Y_d + m_q^2Y_u^\dagger Y_u + 2Y_d^\dagger m_d^2 Y_d + Y_d^\dagger Y_d m_q^2 + 2Y_u^\dagger m_u^2 Y_u \\ & + Y_u^\dagger Y_u m_q^2 + \frac{1}{\sqrt{15}}g_1\mathbf{1}\sigma_{1,1} \end{aligned} \quad (64)$$

$$\begin{aligned} \beta_{m_q^2}^{(2)} = & \frac{2}{5}g_1^2g_2^2\mathbf{1}|M_2|^2 + 69g_2^4\mathbf{1}|M_2|^2 + 32g_2^2g_3^2\mathbf{1}|M_2|^2 \\ & + \frac{16}{45}g_3^2 \left(15 \left(3g_2^2(2M_3 + M_2) - 8g_3^2M_3 \right) + g_1^2(2M_3 + M_1) \right) \mathbf{1}M_3^* + \frac{1}{5}g_1^2g_2^2M_1\mathbf{1}M_2^* + 16g_2^2g_3^2M_3\mathbf{1}M_2^* \\ & + \frac{4}{5}g_1^2m_{H_d}^2Y_d^\dagger Y_d - 6m_{H_d}^2|\lambda|^2Y_d^\dagger Y_d - 3m_{H_u}^2|\lambda|^2Y_d^\dagger Y_d \\ & - 3m_t^2|\lambda|^2Y_d^\dagger Y_d - 3|T_\lambda|^2Y_d^\dagger Y_d - 3\lambda T_\lambda^*Y_d^\dagger T_d + \frac{8}{5}g_1^2m_{H_u}^2Y_u^\dagger Y_u \\ & - 3m_{H_d}^2|\lambda|^2Y_u^\dagger Y_u - 6m_{H_u}^2|\lambda|^2Y_u^\dagger Y_u - 3m_t^2|\lambda|^2Y_u^\dagger Y_u - 3|T_\lambda|^2Y_u^\dagger Y_u \\ & + \frac{1}{225}g_1^2M_1^* \left(\left(5 \left(16g_3^2(2M_1 + M_3) + 9g_2^2(2M_1 + M_2) \right) + 597g_1^2M_1 \right) \mathbf{1} \right. \\ & \left. + 180 \left(2M_1Y_d^\dagger Y_d - 2Y_u^\dagger T_u + 4M_1Y_u^\dagger Y_u - Y_d^\dagger T_d \right) \right) \\ & - 3\lambda T_\lambda^*Y_u^\dagger T_u - \frac{4}{5}g_1^2M_1T_d^\dagger Y_d + \frac{4}{5}g_1^2T_d^\dagger T_d - 3|\lambda|^2T_d^\dagger T_d \\ & - \frac{8}{5}g_1^2M_1T_u^\dagger Y_u + \frac{8}{5}g_1^2T_u^\dagger T_u - 3|\lambda|^2T_u^\dagger T_u + \frac{2}{5}g_1^2m_q^2Y_d^\dagger Y_d \\ & - \frac{3}{2}|\lambda|^2m_q^2Y_d^\dagger Y_d + \frac{4}{5}g_1^2m_q^2Y_u^\dagger Y_u - \frac{3}{2}|\lambda|^2m_q^2Y_u^\dagger Y_u + \frac{4}{5}g_1^2Y_d^\dagger m_d^2 Y_d \\ & - 3|\lambda|^2Y_d^\dagger m_d^2 Y_d + \frac{2}{5}g_1^2Y_d^\dagger Y_d m_q^2 - \frac{3}{2}|\lambda|^2Y_d^\dagger Y_d m_q^2 + \frac{8}{5}g_1^2Y_u^\dagger m_u^2 Y_u \\ & - 3|\lambda|^2Y_u^\dagger m_u^2 Y_u + \frac{4}{5}g_1^2Y_u^\dagger Y_u m_q^2 - \frac{3}{2}|\lambda|^2Y_u^\dagger Y_u m_q^2 - 8m_{H_d}^2Y_d^\dagger Y_d Y_d^\dagger Y_d \\ & - 4Y_d^\dagger Y_d T_d^\dagger T_d - 4Y_d^\dagger T_d T_d^\dagger Y_d - 8m_{H_u}^2Y_u^\dagger Y_u Y_u^\dagger Y_u - 4Y_u^\dagger Y_u T_u^\dagger T_u \\ & - 4Y_u^\dagger T_u T_u^\dagger Y_u - 4T_d^\dagger Y_d Y_d^\dagger T_d - 4T_d^\dagger T_d Y_d^\dagger Y_d - 4T_u^\dagger Y_u Y_u^\dagger T_u \\ & - 4T_u^\dagger T_u Y_u^\dagger Y_u - 2m_q^2Y_d^\dagger Y_d Y_d^\dagger Y_d - 2m_q^2Y_u^\dagger Y_u Y_u^\dagger Y_u - 4Y_d^\dagger m_d^2 Y_d Y_d^\dagger Y_d \\ & - 4Y_d^\dagger Y_d m_q^2 Y_d^\dagger Y_d - 4Y_d^\dagger Y_d Y_d^\dagger m_d^2 Y_d - 2Y_d^\dagger Y_d Y_d^\dagger Y_d m_q^2 - 4Y_u^\dagger m_u^2 Y_u Y_u^\dagger Y_u \\ & - 4Y_u^\dagger Y_u m_q^2 Y_u^\dagger Y_u - 4Y_u^\dagger Y_u Y_u^\dagger m_u^2 Y_u - 2Y_u^\dagger Y_u Y_u^\dagger Y_u m_q^2 - 3\lambda^* T_d^\dagger Y_d T_\lambda \\ & - 3\lambda^* T_u^\dagger Y_u T_\lambda + 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_1\mathbf{1}\sigma_{3,1} \\ & - 12m_{H_d}^2Y_d^\dagger Y_d \text{Tr}(Y_d Y_d^\dagger) - 6T_d^\dagger T_d \text{Tr}(Y_d Y_d^\dagger) - 3m_q^2Y_d^\dagger Y_d \text{Tr}(Y_d Y_d^\dagger) \\ & - 6Y_d^\dagger m_d^2 Y_d \text{Tr}(Y_d Y_d^\dagger) - 3Y_d^\dagger Y_d m_q^2 \text{Tr}(Y_d Y_d^\dagger) - 4m_{H_d}^2Y_d^\dagger Y_d \text{Tr}(Y_e Y_e^\dagger) \\ & - 2T_d^\dagger T_d \text{Tr}(Y_e Y_e^\dagger) - m_q^2Y_d^\dagger Y_d \text{Tr}(Y_e Y_e^\dagger) - 2Y_d^\dagger m_d^2 Y_d \text{Tr}(Y_e Y_e^\dagger) \end{aligned}$$

$$\begin{aligned}
& -Y_d^\dagger Y_d m_q^2 \text{Tr}(Y_e Y_e^\dagger) - 12m_{H_u}^2 Y_u^\dagger Y_u \text{Tr}(Y_u Y_u^\dagger) - 6T_u^\dagger T_u \text{Tr}(Y_u Y_u^\dagger) \\
& - 3m_q^2 Y_u^\dagger Y_u \text{Tr}(Y_u Y_u^\dagger) - 6Y_u^\dagger m_u^2 Y_u \text{Tr}(Y_u Y_u^\dagger) - 3Y_u^\dagger Y_u m_q^2 \text{Tr}(Y_u Y_u^\dagger) \\
& - 6T_d^\dagger Y_d \text{Tr}(Y_d^\dagger T_d) - 2T_d^\dagger Y_d \text{Tr}(Y_e^\dagger T_e) - 6T_u^\dagger Y_u \text{Tr}(Y_u^\dagger T_u) \\
& - 6Y_d^\dagger T_d \text{Tr}(T_d^* Y_d^T) - 6Y_d^\dagger Y_d \text{Tr}(T_d^* T_d^T) - 2Y_d^\dagger T_d \text{Tr}(T_e^* Y_e^T) \\
& - 2Y_d^\dagger Y_d \text{Tr}(T_e^* T_e^T) - 6Y_u^\dagger T_u \text{Tr}(T_u^* Y_u^T) - 6Y_u^\dagger Y_u \text{Tr}(T_u^* T_u^T) \\
& - 6Y_d^\dagger Y_d \text{Tr}(m_d^2 Y_d Y_d^\dagger) - 2Y_d^\dagger Y_d \text{Tr}(m_e^2 Y_e Y_e^\dagger) - 2Y_d^\dagger Y_d \text{Tr}(m_l^2 Y_e^\dagger Y_e) \\
& - 6Y_d^\dagger Y_d \text{Tr}(m_q^2 Y_d^\dagger Y_d) - 6Y_u^\dagger Y_u \text{Tr}(m_q^2 Y_u^\dagger Y_u) - 6Y_u^\dagger Y_u \text{Tr}(m_u^2 Y_u Y_u^\dagger)
\end{aligned} \tag{65}$$

$$\begin{aligned}
\beta_{m_l^2}^{(1)} &= -\frac{6}{5}g_1^2 \mathbf{1}|M_1|^2 - 6g_2^2 \mathbf{1}|M_2|^2 + 2m_{H_d}^2 Y_e^\dagger Y_e + 2T_e^\dagger T_e + m_l^2 Y_e^\dagger Y_e + 2Y_e^\dagger m_e^2 Y_e \\
&+ Y_e^\dagger Y_e m_l^2 - \sqrt{\frac{3}{5}}g_1 \mathbf{1}\sigma_{1,1}
\end{aligned} \tag{66}$$

$$\begin{aligned}
\beta_{m_l^2}^{(2)} &= +\frac{3}{5}g_2^2 \left(115g_2^2 M_2 + 3g_1^2 (2M_2 + M_1) \right) \mathbf{1}M_2^* + \frac{12}{5}g_1^2 m_{H_d}^2 Y_e^\dagger Y_e - 6m_{H_d}^2 |\lambda|^2 Y_e^\dagger Y_e \\
&- 3m_{H_u}^2 |\lambda|^2 Y_e^\dagger Y_e - 3m_t^2 |\lambda|^2 Y_e^\dagger Y_e - 3|T_\lambda|^2 Y_e^\dagger Y_e \\
&+ \frac{3}{25}g_1^2 M_1^* \left(-20Y_e^\dagger T_e + 3 \left(5g_2^2 (2M_1 + M_2) + 69g_1^2 M_1 \right) \mathbf{1} + 40M_1 Y_e^\dagger Y_e \right) - 3\lambda T_\lambda^* Y_e^\dagger T_e \\
&- \frac{12}{5}g_1^2 M_1 T_e^\dagger Y_e + \frac{12}{5}g_1^2 T_e^\dagger T_e - 3|\lambda|^2 T_e^\dagger T_e + \frac{6}{5}g_1^2 m_l^2 Y_e^\dagger Y_e \\
&- \frac{3}{2}|\lambda|^2 m_l^2 Y_e^\dagger Y_e + \frac{12}{5}g_1^2 Y_e^\dagger m_e^2 Y_e - 3|\lambda|^2 Y_e^\dagger m_e^2 Y_e + \frac{6}{5}g_1^2 Y_e^\dagger Y_e m_l^2 \\
&- \frac{3}{2}|\lambda|^2 Y_e^\dagger Y_e m_l^2 - 8m_{H_d}^2 Y_e^\dagger Y_e Y_e^\dagger Y_e - 4Y_e^\dagger Y_e T_e^\dagger T_e - 4Y_e^\dagger T_e T_e^\dagger Y_e \\
&- 4T_e^\dagger Y_e Y_e^\dagger T_e - 4T_e^\dagger T_e Y_e^\dagger Y_e - 2m_l^2 Y_e^\dagger Y_e Y_e^\dagger Y_e - 4Y_e^\dagger m_e^2 Y_e Y_e^\dagger Y_e \\
&- 4Y_e^\dagger Y_e m_l^2 Y_e^\dagger Y_e - 4Y_e^\dagger Y_e Y_e^\dagger m_e^2 Y_e - 2Y_e^\dagger Y_e Y_e^\dagger Y_e m_l^2 - 3\lambda^* T_e^\dagger Y_e T_\lambda + 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 \mathbf{1}\sigma_{3,1} - 12m_{H_d}^2 Y_e^\dagger Y_e \text{Tr}(Y_d Y_d^\dagger) - 6T_e^\dagger T_e \text{Tr}(Y_d Y_d^\dagger) \\
&- 3m_l^2 Y_e^\dagger Y_e \text{Tr}(Y_d Y_d^\dagger) - 6Y_e^\dagger m_e^2 Y_e \text{Tr}(Y_d Y_d^\dagger) - 3Y_e^\dagger Y_e m_l^2 \text{Tr}(Y_d Y_d^\dagger) \\
&- 4m_{H_d}^2 Y_e^\dagger Y_e \text{Tr}(Y_e Y_e^\dagger) - 2T_e^\dagger T_e \text{Tr}(Y_e Y_e^\dagger) - m_l^2 Y_e^\dagger Y_e \text{Tr}(Y_e Y_e^\dagger) \\
&- 2Y_e^\dagger m_e^2 Y_e \text{Tr}(Y_e Y_e^\dagger) - Y_e^\dagger Y_e m_l^2 \text{Tr}(Y_e Y_e^\dagger) - 6T_e^\dagger Y_e \text{Tr}(Y_d^\dagger T_d) \\
&- 2T_e^\dagger Y_e \text{Tr}(Y_e^\dagger T_e) - 6Y_e^\dagger T_e \text{Tr}(T_d^* Y_d^T) - 6Y_e^\dagger Y_e \text{Tr}(T_d^* T_d^T) \\
&- 2Y_e^\dagger T_e \text{Tr}(T_e^* Y_e^T) - 2Y_e^\dagger Y_e \text{Tr}(T_e^* T_e^T) - 6Y_e^\dagger Y_e \text{Tr}(m_d^2 Y_d Y_d^\dagger) \\
&- 2Y_e^\dagger Y_e \text{Tr}(m_e^2 Y_e Y_e^\dagger) - 2Y_e^\dagger Y_e \text{Tr}(m_l^2 Y_e^\dagger Y_e) - 6Y_e^\dagger Y_e \text{Tr}(m_q^2 Y_d^\dagger Y_d)
\end{aligned} \tag{67}$$

$$\begin{aligned}
\beta_{m_{H_d}^2}^{(1)} &= -\frac{6}{5}g_1^2|M_1|^2 - 6g_2^2|M_2|^2 + 3m_{H_d}^2|\lambda|^2 + 3m_{H_u}^2|\lambda|^2 + 3m_t^2|\lambda|^2 + 3|T_\lambda|^2 - \sqrt{\frac{3}{5}}g_1\sigma_{1,1} \\
&+ 6m_{H_d}^2\text{Tr}(Y_d Y_d^\dagger) + 2m_{H_d}^2\text{Tr}(Y_e Y_e^\dagger) + 6\text{Tr}(T_d^* T_d^T) + 2\text{Tr}(T_e^* T_e^T) + 6\text{Tr}(m_d^2 Y_d Y_d^\dagger) \\
&+ 2\text{Tr}(m_e^2 Y_e Y_e^\dagger) + 2\text{Tr}(m_l^2 Y_e^\dagger Y_e) + 6\text{Tr}(m_q^2 Y_d^\dagger Y_d)
\end{aligned} \tag{68}$$

$$\begin{aligned}
\beta_{m_{H_d}^2}^{(2)} &= +12g_2^2 m_{H_d}^2 |\lambda|^2 + 12g_2^2 m_{H_u}^2 |\lambda|^2 + 12g_2^2 m_t^2 |\lambda|^2 + 12g_2^2 |T_\lambda|^2 - 15m_{H_d}^2 \lambda^2 \lambda^{*,2} \\
&- 15m_{H_u}^2 \lambda^2 \lambda^{*,2} - 15m_t^2 \lambda^2 \lambda^{*,2} - 12g_2^2 M_2 \lambda T_\lambda^* \\
&+ \frac{3}{5}g_2^2 M_2^* (115g_2^2 M_2 + 20\lambda^* (2M_2 \lambda - T_\lambda) + 3g_1^2 (2M_2 + M_1)) - 30|\lambda|^2 T_\lambda^* T_\lambda + 6g_2^4 \sigma_{2,2} + \frac{6}{5}g_1^2 \sigma_{2,11} \\
&- 4\sqrt{\frac{3}{5}}g_1\sigma_{3,1} - \frac{4}{5}g_1^2 m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger) + 32g_3^2 m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger) + 64g_3^2 |M_3|^2 \text{Tr}(Y_d Y_d^\dagger) \\
&+ \frac{12}{5}g_1^2 m_{H_d}^2 \text{Tr}(Y_e Y_e^\dagger) - 9m_{H_d}^2 |\lambda|^2 \text{Tr}(Y_u Y_u^\dagger) - 18m_{H_u}^2 |\lambda|^2 \text{Tr}(Y_u Y_u^\dagger) \\
&- 9m_t^2 |\lambda|^2 \text{Tr}(Y_u Y_u^\dagger) - 9|T_\lambda|^2 \text{Tr}(Y_u Y_u^\dagger) - 32g_3^2 M_3^* \text{Tr}(Y_d^\dagger T_d) \\
&+ \frac{1}{25}g_1^2 M_1^* (621g_1^2 M_1 + 90g_2^2 M_1 + 45g_2^2 M_2 - 40M_1 \text{Tr}(Y_d Y_d^\dagger) + 120M_1 \text{Tr}(Y_e Y_e^\dagger) + 20\text{Tr}(Y_d^\dagger T_d) \\
&- 60\text{Tr}(Y_e^\dagger T_e)) \\
&- 9\lambda T_\lambda^* \text{Tr}(Y_u^\dagger T_u) + \frac{4}{5}g_1^2 M_1 \text{Tr}(T_d^* Y_d^T) - 32g_3^2 M_3 \text{Tr}(T_d^* Y_d^T) - \frac{4}{5}g_1^2 \text{Tr}(T_d^* T_d^T) \\
&+ 32g_3^2 \text{Tr}(T_d^* T_d^T) - \frac{12}{5}g_1^2 M_1 \text{Tr}(T_e^* Y_e^T) + \frac{12}{5}g_1^2 \text{Tr}(T_e^* T_e^T) - 9\lambda^* T_\lambda \text{Tr}(T_u^* Y_u^T) \\
&- 9|\lambda|^2 \text{Tr}(T_u^* T_u^T) - \frac{4}{5}g_1^2 \text{Tr}(m_d^2 Y_d Y_d^\dagger) + 32g_3^2 \text{Tr}(m_d^2 Y_d Y_d^\dagger) + \frac{12}{5}g_1^2 \text{Tr}(m_e^2 Y_e Y_e^\dagger) \\
&+ \frac{12}{5}g_1^2 \text{Tr}(m_l^2 Y_e^\dagger Y_e) - \frac{4}{5}g_1^2 \text{Tr}(m_q^2 Y_d^\dagger Y_d) + 32g_3^2 \text{Tr}(m_q^2 Y_d^\dagger Y_d) - 9|\lambda|^2 \text{Tr}(m_q^2 Y_u^\dagger Y_u) \\
&- 9|\lambda|^2 \text{Tr}(m_u^2 Y_u Y_u^\dagger) - 36m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) - 36\text{Tr}(Y_d Y_d^\dagger T_d T_d^\dagger) \\
&- 6m_{H_d}^2 \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 6m_{H_u}^2 \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 6\text{Tr}(Y_d Y_u^\dagger T_u T_u^\dagger) \\
&- 36\text{Tr}(Y_d T_d^\dagger T_d Y_d^\dagger) - 6\text{Tr}(Y_d T_u^\dagger T_u Y_d^\dagger) - 12m_{H_d}^2 \text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) - 12\text{Tr}(Y_e Y_e^\dagger T_e T_e^\dagger) \\
&- 12\text{Tr}(Y_e T_e^\dagger T_e Y_e^\dagger) - 6\text{Tr}(Y_u Y_d^\dagger T_d T_u^\dagger) - 6\text{Tr}(Y_u T_d^\dagger T_d Y_u^\dagger) - 36\text{Tr}(m_d^2 Y_d Y_d^\dagger Y_d Y_d^\dagger) \\
&- 6\text{Tr}(m_d^2 Y_d Y_u^\dagger Y_u Y_d^\dagger) - 12\text{Tr}(m_e^2 Y_e Y_e^\dagger Y_e Y_e^\dagger) - 12\text{Tr}(m_l^2 Y_e^\dagger Y_e Y_e^\dagger Y_e) - 36\text{Tr}(m_q^2 Y_d^\dagger Y_d Y_d^\dagger Y_d) \\
&- 6\text{Tr}(m_q^2 Y_d^\dagger Y_d Y_u^\dagger Y_u) - 6\text{Tr}(m_q^2 Y_u^\dagger Y_u Y_d^\dagger Y_d) - 6\text{Tr}(m_u^2 Y_u Y_d^\dagger Y_d Y_u^\dagger)
\end{aligned} \tag{69}$$

$$\begin{aligned}
\beta_{m_{H_u}^2}^{(1)} &= -\frac{6}{5}g_1^2|M_1|^2 - 6g_2^2|M_2|^2 + 3m_{H_d}^2|\lambda|^2 + 3m_{H_u}^2|\lambda|^2 + 3m_t^2|\lambda|^2 + 3|T_\lambda|^2 + \sqrt{\frac{3}{5}}g_1\sigma_{1,1} \\
&+ 6m_{H_u}^2\text{Tr}(Y_u Y_u^\dagger) + 6\text{Tr}(T_u^* T_u^T) + 6\text{Tr}(m_q^2 Y_u^\dagger Y_u) + 6\text{Tr}(m_u^2 Y_u Y_u^\dagger)
\end{aligned} \tag{70}$$

$$\beta_{m_{H_u}^2}^{(2)} = +12g_2^2 m_{H_d}^2 |\lambda|^2 + 12g_2^2 m_{H_u}^2 |\lambda|^2 + 12g_2^2 m_t^2 |\lambda|^2 + 12g_2^2 |T_\lambda|^2 - 15m_{H_d}^2 \lambda^2 \lambda^{*,2}$$

$$\begin{aligned}
& -15m_{H_u}^2 \lambda^2 \lambda^{*,2} - 15m_t^2 \lambda^2 \lambda^{*,2} - 12g_2^2 M_2 \lambda T_\lambda^* \\
& + \frac{3}{5}g_2^2 M_2^* \left(115g_2^2 M_2 + 20\lambda^* \left(2M_2 \lambda - T_\lambda \right) + 3g_1^2 \left(2M_2 + M_1 \right) \right) - 30|\lambda|^2 T_\lambda^* T_\lambda + 6g_2^4 \sigma_{2,2} + \frac{6}{5}g_1^2 \sigma_{2,11} \\
& + 4\sqrt{\frac{3}{5}}g_1 \sigma_{3,1} - 18m_{H_d}^2 |\lambda|^2 \text{Tr} \left(Y_d Y_d^\dagger \right) - 9m_{H_u}^2 |\lambda|^2 \text{Tr} \left(Y_d Y_d^\dagger \right) - 9m_t^2 |\lambda|^2 \text{Tr} \left(Y_d Y_d^\dagger \right) \\
& - 9|T_\lambda|^2 \text{Tr} \left(Y_d Y_d^\dagger \right) - 6m_{H_d}^2 |\lambda|^2 \text{Tr} \left(Y_e Y_e^\dagger \right) - 3m_{H_u}^2 |\lambda|^2 \text{Tr} \left(Y_e Y_e^\dagger \right) \\
& - 3m_t^2 |\lambda|^2 \text{Tr} \left(Y_e Y_e^\dagger \right) - 3|T_\lambda|^2 \text{Tr} \left(Y_e Y_e^\dagger \right) + \frac{8}{5}g_1^2 m_{H_u}^2 \text{Tr} \left(Y_u Y_u^\dagger \right) + 32g_3^2 m_{H_u}^2 \text{Tr} \left(Y_u Y_u^\dagger \right) \\
& + 64g_3^2 |M_3|^2 \text{Tr} \left(Y_u Y_u^\dagger \right) - 9\lambda T_\lambda^* \text{Tr} \left(Y_d^\dagger T_d \right) - 3\lambda T_\lambda^* \text{Tr} \left(Y_e^\dagger T_e \right) \\
& + \frac{1}{25}g_1^2 M_1^* \left(-40\text{Tr} \left(Y_u^\dagger T_u \right) + 45g_2^2 M_2 + 621g_1^2 M_1 + 80M_1 \text{Tr} \left(Y_u Y_u^\dagger \right) + 90g_2^2 M_1 \right) \\
& - 32g_3^2 M_3^* \text{Tr} \left(Y_u^\dagger T_u \right) - 9\lambda^* T_\lambda \text{Tr} \left(T_d^* Y_d^T \right) - 9|\lambda|^2 \text{Tr} \left(T_d^* T_d^T \right) - 3\lambda^* T_\lambda \text{Tr} \left(T_e^* Y_e^T \right) \\
& - 3|\lambda|^2 \text{Tr} \left(T_e^* T_e^T \right) - \frac{8}{5}g_1^2 M_1 \text{Tr} \left(T_u^* Y_u^T \right) - 32g_3^2 M_3 \text{Tr} \left(T_u^* Y_u^T \right) + \frac{8}{5}g_1^2 \text{Tr} \left(T_u^* T_u^T \right) \\
& + 32g_3^2 \text{Tr} \left(T_u^* T_u^T \right) - 9|\lambda|^2 \text{Tr} \left(m_d^2 Y_d Y_d^\dagger \right) - 3|\lambda|^2 \text{Tr} \left(m_e^2 Y_e Y_e^\dagger \right) - 3|\lambda|^2 \text{Tr} \left(m_l^2 Y_e^\dagger Y_e \right) \\
& - 9|\lambda|^2 \text{Tr} \left(m_q^2 Y_d^\dagger Y_d \right) + \frac{8}{5}g_1^2 \text{Tr} \left(m_q^2 Y_u^\dagger Y_u \right) + 32g_3^2 \text{Tr} \left(m_q^2 Y_u^\dagger Y_u \right) + \frac{8}{5}g_1^2 \text{Tr} \left(m_u^2 Y_u Y_u^\dagger \right) \\
& + 32g_3^2 \text{Tr} \left(m_u^2 Y_u Y_u^\dagger \right) - 6m_{H_d}^2 \text{Tr} \left(Y_d Y_u^\dagger Y_u Y_d^\dagger \right) - 6m_{H_u}^2 \text{Tr} \left(Y_d Y_u^\dagger Y_u Y_d^\dagger \right) \\
& - 6\text{Tr} \left(Y_d Y_u^\dagger T_u T_d^\dagger \right) - 6\text{Tr} \left(Y_d T_u^\dagger T_u Y_d^\dagger \right) - 6\text{Tr} \left(Y_u Y_d^\dagger T_d T_u^\dagger \right) - 36m_{H_u}^2 \text{Tr} \left(Y_u Y_u^\dagger Y_u Y_u^\dagger \right) \\
& - 36\text{Tr} \left(Y_u Y_u^\dagger T_u T_u^\dagger \right) - 6\text{Tr} \left(Y_u T_d^\dagger T_d Y_u^\dagger \right) - 36\text{Tr} \left(Y_u T_u^\dagger T_u Y_u^\dagger \right) \\
& - 6\text{Tr} \left(m_d^2 Y_d Y_u^\dagger Y_u Y_d^\dagger \right) - 6\text{Tr} \left(m_q^2 Y_d^\dagger Y_d Y_u^\dagger Y_u \right) - 6\text{Tr} \left(m_q^2 Y_u^\dagger Y_u Y_d^\dagger Y_d \right) \\
& - 36\text{Tr} \left(m_q^2 Y_u^\dagger Y_u Y_u^\dagger Y_u \right) - 6\text{Tr} \left(m_u^2 Y_u Y_d^\dagger Y_d Y_u^\dagger \right) - 36\text{Tr} \left(m_u^2 Y_u Y_u^\dagger Y_u Y_u^\dagger \right)
\end{aligned} \tag{71}$$

$$\begin{aligned}
\beta_{m_d^2}^{(1)} &= -\frac{8}{15}g_1^2 \mathbf{1} |M_1|^2 - \frac{32}{3}g_3^2 \mathbf{1} |M_3|^2 + 4m_{H_d}^2 Y_d Y_d^\dagger + 4T_d T_d^\dagger + 2m_d^2 Y_d Y_d^\dagger + 4Y_d m_q^2 Y_d^\dagger \\
& + 2Y_d Y_d^\dagger m_d^2 + 2\frac{1}{\sqrt{15}}g_1 \mathbf{1} \sigma_{1,1}
\end{aligned} \tag{72}$$

$$\begin{aligned}
\beta_{m_d^2}^{(2)} &= +\frac{64}{45}g_3^2 \left(-30g_3^2 M_3 + g_1^2 \left(2M_3 + M_1 \right) \right) \mathbf{1} M_3^* + \frac{4}{5}g_1^2 m_{H_d}^2 Y_d Y_d^\dagger + 12g_2^2 m_{H_d}^2 Y_d Y_d^\dagger \\
& + 24g_2^2 |M_2|^2 Y_d Y_d^\dagger - 12m_{H_d}^2 |\lambda|^2 Y_d Y_d^\dagger - 6m_{H_u}^2 |\lambda|^2 Y_d Y_d^\dagger \\
& - 6m_t^2 |\lambda|^2 Y_d Y_d^\dagger - 6|T_\lambda|^2 Y_d Y_d^\dagger - \frac{4}{5}g_1^2 M_1 Y_d T_d^\dagger - 12g_2^2 M_2 Y_d T_d^\dagger \\
& + \frac{4}{225}g_1^2 M_1^* \left(2 \left(303g_1^2 M_1 + 40g_3^2 \left(2M_1 + M_3 \right) \right) \mathbf{1} - 45T_d Y_d^\dagger + 90M_1 Y_d Y_d^\dagger \right) - 12g_2^2 M_2^* T_d Y_d^\dagger \\
& - 6\lambda T_\lambda^* T_d Y_d^\dagger + \frac{4}{5}g_1^2 T_d T_d^\dagger + 12g_2^2 T_d T_d^\dagger - 6|\lambda|^2 T_d T_d^\dagger \\
& + \frac{2}{5}g_1^2 m_d^2 Y_d Y_d^\dagger + 6g_2^2 m_d^2 Y_d Y_d^\dagger - 3|\lambda|^2 m_d^2 Y_d Y_d^\dagger + \frac{4}{5}g_1^2 Y_d m_q^2 Y_d^\dagger
\end{aligned}$$

$$\begin{aligned}
& + 12g_2^2 Y_d m_q^2 Y_d^\dagger - 6|\lambda|^2 Y_d m_q^2 Y_d^\dagger + \frac{2}{5} g_1^2 Y_d Y_d^\dagger m_d^2 + 6g_2^2 Y_d Y_d^\dagger m_d^2 \\
& - 3|\lambda|^2 Y_d Y_d^\dagger m_d^2 - 8m_{H_d}^2 Y_d Y_d^\dagger Y_d Y_d^\dagger - 4Y_d Y_d^\dagger T_d T_d^\dagger - 4m_{H_d}^2 Y_d Y_u^\dagger Y_u Y_d^\dagger \\
& - 4m_{H_u}^2 Y_d Y_u^\dagger Y_u Y_d^\dagger - 4Y_d Y_u^\dagger T_u T_u^\dagger - 4Y_d T_d^\dagger T_d Y_d^\dagger - 4Y_d T_u^\dagger T_u Y_d^\dagger \\
& - 4T_d Y_d^\dagger Y_d T_d^\dagger - 4T_d Y_u^\dagger Y_u T_d^\dagger - 4T_d T_d^\dagger Y_d Y_d^\dagger - 4T_d T_u^\dagger Y_u Y_d^\dagger \\
& - 2m_d^2 Y_d Y_d^\dagger Y_d Y_d^\dagger - 2m_d^2 Y_d Y_u^\dagger Y_u Y_d^\dagger - 4Y_d m_q^2 Y_d^\dagger Y_d Y_d^\dagger - 4Y_d m_q^2 Y_u^\dagger Y_u Y_d^\dagger \\
& - 4Y_d Y_d^\dagger m_d^2 Y_d Y_d^\dagger - 4Y_d Y_d^\dagger Y_d m_q^2 Y_d^\dagger - 2Y_d Y_d^\dagger Y_d Y_d^\dagger m_d^2 - 4Y_d Y_u^\dagger m_u^2 Y_u Y_d^\dagger \\
& - 4Y_d Y_u^\dagger Y_u m_q^2 Y_d^\dagger - 2Y_d Y_u^\dagger Y_u Y_d^\dagger m_d^2 - 6\lambda^* Y_d T_d^\dagger T_\lambda + \frac{32}{3} g_3^4 \mathbf{1}\sigma_{2,3} + \frac{8}{15} g_1^2 \mathbf{1}\sigma_{2,11} \\
& + 8\frac{1}{\sqrt{15}} g_1 \mathbf{1}\sigma_{3,1} - 24m_{H_d}^2 Y_d Y_d^\dagger \text{Tr}(Y_d Y_d^\dagger) - 12T_d T_d^\dagger \text{Tr}(Y_d Y_d^\dagger) \\
& - 6m_d^2 Y_d Y_d^\dagger \text{Tr}(Y_d Y_d^\dagger) - 12Y_d m_q^2 Y_d^\dagger \text{Tr}(Y_d Y_d^\dagger) - 6Y_d Y_d^\dagger m_d^2 \text{Tr}(Y_d Y_d^\dagger) \\
& - 8m_{H_d}^2 Y_d Y_d^\dagger \text{Tr}(Y_e Y_e^\dagger) - 4T_d T_d^\dagger \text{Tr}(Y_e Y_e^\dagger) - 2m_d^2 Y_d Y_d^\dagger \text{Tr}(Y_e Y_e^\dagger) \\
& - 4Y_d m_q^2 Y_d^\dagger \text{Tr}(Y_e Y_e^\dagger) - 2Y_d Y_d^\dagger m_d^2 \text{Tr}(Y_e Y_e^\dagger) - 12Y_d T_d^\dagger \text{Tr}(Y_d^\dagger T_d) \\
& - 4Y_d T_d^\dagger \text{Tr}(Y_e^\dagger T_e) - 12T_d Y_d^\dagger \text{Tr}(T_d^* Y_d^T) - 12Y_d Y_d^\dagger \text{Tr}(T_d^* T_d^T) \\
& - 4T_d Y_d^\dagger \text{Tr}(T_e^* Y_e^T) - 4Y_d Y_d^\dagger \text{Tr}(T_e^* T_e^T) - 12Y_d Y_d^\dagger \text{Tr}(m_d^2 Y_d Y_d^\dagger) \\
& - 4Y_d Y_d^\dagger \text{Tr}(m_e^2 Y_e Y_e^\dagger) - 4Y_d Y_d^\dagger \text{Tr}(m_l^2 Y_l Y_l^\dagger) - 12Y_d Y_d^\dagger \text{Tr}(m_q^2 Y_d^\dagger Y_d)
\end{aligned} \tag{73}$$

$$\begin{aligned}
\beta_{m_u^2}^{(1)} = & -\frac{32}{15} g_1^2 \mathbf{1}|M_1|^2 - \frac{32}{3} g_3^2 \mathbf{1}|M_3|^2 + 4m_{H_u}^2 Y_u Y_u^\dagger + 4T_u T_u^\dagger + 2m_u^2 Y_u Y_u^\dagger + 4Y_u m_q^2 Y_u^\dagger \\
& + 2Y_u Y_u^\dagger m_u^2 - 4\frac{1}{\sqrt{15}} g_1 \mathbf{1}\sigma_{1,1}
\end{aligned} \tag{74}$$

$$\begin{aligned}
\beta_{m_u^2}^{(2)} = & -\frac{128}{45} g_3^2 \left(15g_3^2 M_3 - 2g_1^2 (2M_3 + M_1) \right) \mathbf{1}M_3^* - \frac{4}{5} g_1^2 m_{H_u}^2 Y_u Y_u^\dagger + 12g_2^2 m_{H_u}^2 Y_u Y_u^\dagger \\
& + 24g_2^2 |M_2|^2 Y_u Y_u^\dagger - 6m_{H_d}^2 |\lambda|^2 Y_u Y_u^\dagger - 12m_{H_u}^2 |\lambda|^2 Y_u Y_u^\dagger \\
& - 6m_t^2 |\lambda|^2 Y_u Y_u^\dagger - 6|T_\lambda|^2 Y_u Y_u^\dagger + \frac{4}{5} g_1^2 M_1 Y_u T_u^\dagger - 12g_2^2 M_2 Y_u T_u^\dagger \\
& - 12g_2^2 M_2^* T_u Y_u^\dagger - 6\lambda T_\lambda^* T_u Y_u^\dagger \\
& + \frac{4}{225} g_1^2 M_1^* \left(45 \left(-2M_1 Y_u Y_u^\dagger + T_u Y_u^\dagger \right) + 8 \left(321g_1^2 M_1 + 40g_3^2 (2M_1 + M_3) \right) \right) \mathbf{1} - \frac{4}{5} g_1^2 T_u T_u^\dagger \\
& + 12g_2^2 T_u T_u^\dagger - 6|\lambda|^2 T_u T_u^\dagger - \frac{2}{5} g_1^2 m_u^2 Y_u Y_u^\dagger + 6g_2^2 m_u^2 Y_u Y_u^\dagger \\
& - 3|\lambda|^2 m_u^2 Y_u Y_u^\dagger - \frac{4}{5} g_1^2 Y_u m_q^2 Y_u^\dagger + 12g_2^2 Y_u m_q^2 Y_u^\dagger - 6|\lambda|^2 Y_u m_q^2 Y_u^\dagger \\
& - \frac{2}{5} g_1^2 Y_u Y_u^\dagger m_u^2 + 6g_2^2 Y_u Y_u^\dagger m_u^2 - 3|\lambda|^2 Y_u Y_u^\dagger m_u^2 - 4m_{H_d}^2 Y_u Y_d^\dagger Y_d Y_u^\dagger \\
& - 4m_{H_u}^2 Y_u Y_d^\dagger Y_d Y_u^\dagger - 4Y_u Y_d^\dagger T_d T_u^\dagger - 8m_{H_u}^2 Y_u Y_u^\dagger Y_u Y_u^\dagger - 4Y_u Y_u^\dagger T_u T_u^\dagger
\end{aligned}$$

$$\begin{aligned}
& -4Y_u T_d^\dagger T_d Y_u^\dagger - 4Y_u T_u^\dagger T_u Y_u^\dagger - 4T_u Y_d^\dagger Y_d T_u^\dagger - 4T_u Y_u^\dagger Y_u T_u^\dagger \\
& -4T_u T_d^\dagger Y_d Y_u^\dagger - 4T_u T_u^\dagger Y_u Y_u^\dagger - 2m_u^2 Y_u Y_d^\dagger Y_d Y_u^\dagger - 2m_u^2 Y_u Y_u^\dagger Y_u Y_u^\dagger \\
& -4Y_u m_q^2 Y_d^\dagger Y_d Y_u^\dagger - 4Y_u m_q^2 Y_u^\dagger Y_u Y_u^\dagger - 4Y_u Y_d^\dagger m_d^2 Y_d Y_u^\dagger \\
& -4Y_u Y_d^\dagger Y_d m_q^2 Y_u^\dagger - 2Y_u Y_d^\dagger Y_d Y_u^\dagger m_u^2 - 4Y_u Y_u^\dagger m_u^2 Y_u Y_u^\dagger - 4Y_u Y_u^\dagger Y_u m_q^2 Y_u^\dagger \\
& -2Y_u Y_u^\dagger Y_u Y_u^\dagger m_u^2 - 6\lambda^* Y_u T_u^\dagger T_\lambda + \frac{32}{3} g_3^4 \mathbf{1}\sigma_{2,3} + \frac{32}{15} g_1^2 \mathbf{1}\sigma_{2,11} - 16 \frac{1}{\sqrt{15}} g_1 \mathbf{1}\sigma_{3,1} \\
& -24m_{H_u}^2 Y_u Y_u^\dagger \text{Tr}(Y_u Y_u^\dagger) - 12T_u T_u^\dagger \text{Tr}(Y_u Y_u^\dagger) - 6m_u^2 Y_u Y_u^\dagger \text{Tr}(Y_u Y_u^\dagger) \\
& -12Y_u m_q^2 Y_u^\dagger \text{Tr}(Y_u Y_u^\dagger) - 6Y_u Y_u^\dagger m_u^2 \text{Tr}(Y_u Y_u^\dagger) - 12Y_u T_u^\dagger \text{Tr}(Y_u^\dagger T_u) \\
& -12T_u Y_u^\dagger \text{Tr}(T_u^* Y_u^T) - 12Y_u Y_u^\dagger \text{Tr}(T_u^* T_u^T) - 12Y_u Y_u^\dagger \text{Tr}(m_q^2 Y_u^\dagger Y_u) \\
& -12Y_u Y_u^\dagger \text{Tr}(m_u^2 Y_u Y_u^\dagger)
\end{aligned} \tag{75}$$

$$\begin{aligned}
\beta_{m_e^2}^{(1)} &= -\frac{24}{5} g_1^2 \mathbf{1}|M_1|^2 + 2\left(2m_{H_d}^2 Y_e Y_e^\dagger + 2T_e T_e^\dagger + 2Y_e m_l^2 Y_e^\dagger + m_e^2 Y_e Y_e^\dagger + Y_e Y_e^\dagger m_e^2\right) \\
&+ 2\sqrt{\frac{3}{5}} g_1 \mathbf{1}\sigma_{1,1}
\end{aligned} \tag{76}$$

$$\begin{aligned}
\beta_{m_e^2}^{(2)} &= -\frac{12}{5} g_1^2 m_{H_d}^2 Y_e Y_e^\dagger + 12g_2^2 m_{H_d}^2 Y_e Y_e^\dagger + 24g_2^2 |M_2|^2 Y_e Y_e^\dagger \\
&-12m_{H_d}^2 |\lambda|^2 Y_e Y_e^\dagger - 6m_{H_u}^2 |\lambda|^2 Y_e Y_e^\dagger - 6m_t^2 |\lambda|^2 Y_e Y_e^\dagger - 6|T_\lambda|^2 Y_e Y_e^\dagger \\
&+ \frac{12}{5} g_1^2 M_1 Y_e T_e^\dagger - 12g_2^2 M_2 Y_e T_e^\dagger - 12g_2^2 M_2^* T_e Y_e^\dagger - 6\lambda T_\lambda^* T_e Y_e^\dagger \\
&+ \frac{12}{25} g_1^2 M_1^* \left(234g_1^2 M_1 \mathbf{1} + 5\left(-2M_1 Y_e Y_e^\dagger + T_e Y_e^\dagger\right)\right) - \frac{12}{5} g_1^2 T_e T_e^\dagger + 12g_2^2 T_e T_e^\dagger \\
&-6|\lambda|^2 T_e T_e^\dagger - \frac{6}{5} g_1^2 m_e^2 Y_e Y_e^\dagger + 6g_2^2 m_e^2 Y_e Y_e^\dagger - 3|\lambda|^2 m_e^2 Y_e Y_e^\dagger \\
&- \frac{12}{5} g_1^2 Y_e m_l^2 Y_e^\dagger + 12g_2^2 Y_e m_l^2 Y_e^\dagger - 6|\lambda|^2 Y_e m_l^2 Y_e^\dagger - \frac{6}{5} g_1^2 Y_e Y_e^\dagger m_e^2 \\
&+ 6g_2^2 Y_e Y_e^\dagger m_e^2 - 3|\lambda|^2 Y_e Y_e^\dagger m_e^2 - 8m_{H_d}^2 Y_e Y_e^\dagger Y_e Y_e^\dagger - 4Y_e Y_e^\dagger T_e T_e^\dagger \\
&-4Y_e T_e^\dagger T_e Y_e^\dagger - 4T_e Y_e^\dagger Y_e T_e^\dagger - 4T_e T_e^\dagger Y_e Y_e^\dagger - 2m_e^2 Y_e Y_e^\dagger Y_e Y_e^\dagger \\
&-4Y_e m_l^2 Y_e^\dagger Y_e Y_e^\dagger - 4Y_e Y_e^\dagger m_e^2 Y_e Y_e^\dagger - 4Y_e Y_e^\dagger Y_e m_l^2 Y_e^\dagger - 2Y_e Y_e^\dagger Y_e Y_e^\dagger m_e^2 \\
&-6\lambda^* Y_e T_e^\dagger T_\lambda + \frac{8}{5} g_1 \mathbf{1}\left(3g_1 \sigma_{2,11} + \sqrt{15} \sigma_{3,1}\right) - 24m_{H_d}^2 Y_e Y_e^\dagger \text{Tr}(Y_d Y_d^\dagger) \\
&-12T_e T_e^\dagger \text{Tr}(Y_d Y_d^\dagger) - 6m_e^2 Y_e Y_e^\dagger \text{Tr}(Y_d Y_d^\dagger) - 12Y_e m_l^2 Y_e^\dagger \text{Tr}(Y_d Y_d^\dagger) \\
&-6Y_e Y_e^\dagger m_e^2 \text{Tr}(Y_d Y_d^\dagger) - 8m_{H_d}^2 Y_e Y_e^\dagger \text{Tr}(Y_e Y_e^\dagger) - 4T_e T_e^\dagger \text{Tr}(Y_e Y_e^\dagger) \\
&-2m_e^2 Y_e Y_e^\dagger \text{Tr}(Y_e Y_e^\dagger) - 4Y_e m_l^2 Y_e^\dagger \text{Tr}(Y_e Y_e^\dagger) - 2Y_e Y_e^\dagger m_e^2 \text{Tr}(Y_e Y_e^\dagger) \\
&-12Y_e T_e^\dagger \text{Tr}(Y_d^\dagger T_d) - 4Y_e T_e^\dagger \text{Tr}(Y_e^\dagger T_e) - 12T_e Y_e^\dagger \text{Tr}(T_d^* Y_d^T) \\
&-12Y_e Y_e^\dagger \text{Tr}(T_d^* T_d^T) - 4T_e Y_e^\dagger \text{Tr}(T_e^* Y_e^T) - 4Y_e Y_e^\dagger \text{Tr}(T_e^* T_e^T)
\end{aligned}$$

$$\begin{aligned}
& -12Y_e Y_e^\dagger \text{Tr}(m_d^2 Y_d Y_d^\dagger) - 4Y_e Y_e^\dagger \text{Tr}(m_e^2 Y_e Y_e^\dagger) - 4Y_e Y_e^\dagger \text{Tr}(m_t^2 Y_e^\dagger Y_e) \\
& -12Y_e Y_e^\dagger \text{Tr}(m_q^2 Y_d^\dagger Y_d)
\end{aligned} \tag{77}$$

$$\beta_{m_t^2}^{(1)} = 2 \left(-8g_2^2 |M_2|^2 + (m_{H_d}^2 + m_{H_u}^2 + m_t^2) |\lambda|^2 + |T_\lambda|^2 \right) \tag{78}$$

$$\begin{aligned}
\beta_{m_t^2}^{(2)} = & -12(m_{H_d}^2 + m_{H_u}^2 + m_t^2) \lambda^2 \lambda^{*,2} + 2g_2^2 M_2^* (152g_2^2 M_2 + \lambda^* (-2M_2 \lambda + T_\lambda)) \\
& - \frac{2}{5} (-40g_2^4 \sigma_{2,2} \\
& + T_\lambda^* (T_\lambda (15\text{Tr}(Y_d Y_d^\dagger) + 15\text{Tr}(Y_u Y_u^\dagger) - 3g_1^2 + 5g_2^2 + 5\text{Tr}(Y_e Y_e^\dagger)) \\
& + \lambda (15\text{Tr}(Y_d^\dagger T_d) + 15\text{Tr}(Y_u^\dagger T_u) + 3g_1^2 M_1 - 5g_2^2 M_2 + 5\text{Tr}(Y_e^\dagger T_e))) \\
& + \lambda^* \left(\frac{6}{5} g_1^2 m_{H_d}^2 \lambda - 2g_2^2 m_{H_d}^2 \lambda + \frac{6}{5} g_1^2 m_{H_u}^2 \lambda - 2g_2^2 m_{H_u}^2 \lambda + \frac{6}{5} g_1^2 m_t^2 \lambda - 2g_2^2 m_t^2 \lambda \right. \\
& - 24\lambda |T_\lambda|^2 + \frac{6}{5} g_1^2 M_1^* (2M_1 \lambda - T_\lambda) - 12m_{H_d}^2 \lambda \text{Tr}(Y_d Y_d^\dagger) - 6m_{H_u}^2 \lambda \text{Tr}(Y_d Y_d^\dagger) \\
& - 6m_t^2 \lambda \text{Tr}(Y_d Y_d^\dagger) - 4m_{H_d}^2 \lambda \text{Tr}(Y_e Y_e^\dagger) - 2m_{H_u}^2 \lambda \text{Tr}(Y_e Y_e^\dagger) - 2m_t^2 \lambda \text{Tr}(Y_e Y_e^\dagger) \\
& - 6m_{H_d}^2 \lambda \text{Tr}(Y_u Y_u^\dagger) - 12m_{H_u}^2 \lambda \text{Tr}(Y_u Y_u^\dagger) - 6m_t^2 \lambda \text{Tr}(Y_u Y_u^\dagger) - 6T_\lambda \text{Tr}(T_d^* Y_d^T) \\
& - 6\lambda \text{Tr}(T_d^* T_d^T) - 2T_\lambda \text{Tr}(T_e^* Y_e^T) - 2\lambda \text{Tr}(T_e^* T_e^T) - 6T_\lambda \text{Tr}(T_u^* Y_u^T) - 6\lambda \text{Tr}(T_u^* T_u^T) \\
& - 6\lambda \text{Tr}(m_d^2 Y_d Y_d^\dagger) - 2\lambda \text{Tr}(m_e^2 Y_e Y_e^\dagger) - 2\lambda \text{Tr}(m_t^2 Y_e^\dagger Y_e) - 6\lambda \text{Tr}(m_q^2 Y_d^\dagger Y_d) \\
& \left. - 6\lambda \text{Tr}(m_q^2 Y_u^\dagger Y_u) - 6\lambda \text{Tr}(m_u^2 Y_u Y_u^\dagger) \right)
\end{aligned} \tag{79}$$

3.9 Vacuum expectation values

$$\beta_{v_d}^{(1)} = \frac{1}{20} v_d (15g_2^2 + 15g_2^2 \text{Xi} - 20\text{Tr}(Y_e Y_e^\dagger) - 30|\lambda|^2 + 3g_1^2 + 3g_1^2 \text{Xi} - 60\text{Tr}(Y_d Y_d^\dagger)) \tag{80}$$

$$\begin{aligned}
\beta_{v_d}^{(2)} = & \frac{1}{400} v_d (-414g_1^4 - 180g_1^2 g_2^2 - 1800g_2^4 - 9g_1^4 \text{Xi} - 90g_1^2 g_2^2 \text{Xi} + 875g_2^4 \text{Xi} + 9g_1^4 \text{Xi}^2 + 90g_1^2 g_2^2 \text{Xi}^2 \\
& - 225g_2^4 \text{Xi}^2 + 1500\lambda^2 \lambda^{*,2} - 40(5(32g_3^2 + 9g_2^2 \text{Xi}) + g_1^2(9\text{Xi} - 4)) \text{Tr}(Y_d Y_d^\dagger) - 480g_1^2 \text{Tr}(Y_e Y_e^\dagger) \\
& - 120g_1^2 \text{Xi} \text{Tr}(Y_e Y_e^\dagger) - 600g_2^2 \text{Xi} \text{Tr}(Y_e Y_e^\dagger) - 60|\lambda|^2 (-30\text{Tr}(Y_u Y_u^\dagger) + 3g_1^2 \text{Xi} + 5g_2^2(3\text{Xi} + 8)) \\
& + 3600\text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) + 1200\text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) + 1200\text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger)
\end{aligned} \tag{81}$$

$$\beta_{v_u}^{(1)} = \frac{3}{20} v_u (-10|\lambda|^2 - 20\text{Tr}(Y_u Y_u^\dagger) + (5g_2^2 + g_1^2)(1 + \text{Xi})) \tag{82}$$

$$\begin{aligned}
\beta_{v_u}^{(2)} = & \frac{1}{400} v_u (-414g_1^4 - 180g_1^2 g_2^2 - 1800g_2^4 - 9g_1^4 \text{Xi} - 90g_1^2 g_2^2 \text{Xi} + 875g_2^4 \text{Xi} + 9g_1^4 \text{Xi}^2 + 90g_1^2 g_2^2 \text{Xi}^2 \\
& - 225g_2^4 \text{Xi}^2 + 1500\lambda^2 \lambda^{*,2} - 60|\lambda|^2 (-10\text{Tr}(Y_e Y_e^\dagger) + 15g_2^2 \text{Xi} - 30\text{Tr}(Y_d Y_d^\dagger) + 3g_1^2 \text{Xi} + 40g_2^2)
\end{aligned}$$

$$-40\left(5\left(32g_3^2 + 9g_2^2\text{Xi}\right) + g_1^2\left(9\text{Xi} + 8\right)\right)\text{Tr}\left(Y_u Y_u^\dagger\right) + 1200\text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) + 3600\text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right) \quad (83)$$

$$\beta_{v_T}^{(1)} = v_T\left(2g_2^2\left(1 + \text{Xi}\right) - |\lambda|^2\right) \quad (84)$$

$$\begin{aligned} \beta_{v_T}^{(2)} = & +\frac{1}{3}g_2^4 v_T\left(10\text{Xi} + 3\text{Xi}^2 - 51\right) + 3v_T\lambda^2\lambda^{*,2} \\ & -\frac{1}{5}v_T|\lambda|^2\left(-15\text{Tr}\left(Y_d Y_d^\dagger\right) - 15\text{Tr}\left(Y_u Y_u^\dagger\right) + 20g_2^2\text{Xi} + 3g_1^2 - 5g_2^2 - 5\text{Tr}\left(Y_e Y_e^\dagger\right)\right) \end{aligned} \quad (85)$$

4 Field Rotations

4.1 Rotations in gauge sector for eigenstates 'EWSB'

$$\begin{pmatrix} B_\rho \\ W_{3\rho} \end{pmatrix} = Z^{\gamma Z} \begin{pmatrix} \gamma_\rho \\ Z_\rho \end{pmatrix} \quad (86)$$

$$\begin{pmatrix} W_{1\rho} \\ W_{2\rho} \end{pmatrix} = Z^W \begin{pmatrix} W_\rho^- \\ W_\rho^- \end{pmatrix} \quad (87)$$

$$\begin{pmatrix} \lambda_{\tilde{W},1} \\ \lambda_{\tilde{W},2} \\ \lambda_{\tilde{W},3} \end{pmatrix} = Z^{\tilde{W}} \begin{pmatrix} \tilde{W}^- \\ \tilde{W}^+ \\ \tilde{W}^0 \end{pmatrix} \quad (88)$$

$$(89)$$

The mixing matrices are parametrized by

$$Z^{\gamma Z} = \begin{pmatrix} \cos \Theta_W & -\sin \Theta_W \\ \sin \Theta_W & \cos \Theta_W \end{pmatrix} \quad (90)$$

$$Z^W = \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ -i\frac{1}{\sqrt{2}} & i\frac{1}{\sqrt{2}} \end{pmatrix} \quad (91)$$

$$Z^{\tilde{W}} = \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \\ -i\frac{1}{\sqrt{2}} & i\frac{1}{\sqrt{2}} & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad (92)$$

$$(93)$$

4.2 Rotations in Mass sector for eigenstates 'EWSB'

4.2.1 Mass Matrices for Scalars

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

$$m_{\tilde{d}}^2 = \begin{pmatrix} m_{\tilde{d}_L \tilde{d}_L^*} & -\frac{1}{2} \frac{1}{\sqrt{2}} \left(-2v_d T_d^\dagger + v_u (2\mu + v_T \lambda) Y_d^\dagger \right) \delta_{\alpha_1 \beta_2} \\ \frac{1}{2} \frac{1}{\sqrt{2}} \delta_{\alpha_2 \beta_1} \left(2v_d T_d - v_u Y_d (2\mu^* + v_T \lambda^*) \right) & m_{\tilde{d}_R \tilde{d}_R^*} \end{pmatrix} \quad (94)$$

$$m_{\tilde{d}_L \tilde{d}_L^*} = -\frac{1}{24} \left(3g_2^2 + g_1^2 \right) \mathbf{1} \left(-v_u^2 + v_d^2 \right) \delta_{\alpha_1 \beta_1} + \frac{1}{2} \delta_{\alpha_1 \beta_1} \left(2m_q^2 + v_d^2 Y_d^\dagger Y_d \right) \quad (95)$$

$$m_{\tilde{d}_R \tilde{d}_R^*} = \frac{1}{12} g_1^2 \mathbf{1} \left(-v_d^2 + v_u^2 \right) \delta_{\alpha_2 \beta_2} + \frac{1}{2} \delta_{\alpha_2 \beta_2} \left(2m_d^2 + v_d^2 Y_d Y_d^\dagger \right) \quad (96)$$

This matrix is diagonalized by Z^D :

$$Z^D m_{\tilde{d}}^2 Z^{D,\dagger} = m_{2,\tilde{d}}^{dia} \quad (97)$$

with

$$\tilde{d}_{L,i\alpha} = \sum_j Z_{ji}^{D,*} \tilde{d}_{j\alpha}, \quad \tilde{d}_{R,i\alpha} = \sum_j Z_{ji}^{D,*} \tilde{d}_{j\alpha} \quad (98)$$

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

$$m_{\tilde{\nu}}^2 = \left(\frac{1}{8} \left(g_1^2 + g_2^2 \right) \mathbf{1} \left(-v_u^2 + v_d^2 \right) + m_l^2 \right) \quad (99)$$

This matrix is diagonalized by Z^V :

$$Z^V m_{\tilde{\nu}}^2 Z^{V,\dagger} = m_{2,\tilde{\nu}}^{dia} \quad (100)$$

with

$$\tilde{\nu}_{L,i} = \sum_j Z_{ji}^{V,*} \tilde{\nu}_j \quad (101)$$

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

$$m_{\tilde{u}}^2 = \begin{pmatrix} m_{\tilde{u}_L \tilde{u}_L^*} & -\frac{1}{2} \frac{1}{\sqrt{2}} \left(-2v_u T_u^\dagger + v_d (2\mu + v_T \lambda) Y_u^\dagger \right) \delta_{\alpha_1 \beta_2} \\ \frac{1}{2} \frac{1}{\sqrt{2}} \delta_{\alpha_2 \beta_1} \left(2v_u T_u - v_d Y_u (2\mu^* + v_T \lambda^*) \right) & m_{\tilde{u}_R \tilde{u}_R^*} \end{pmatrix} \quad (102)$$

$$m_{\tilde{u}_L \tilde{u}_L^*} = -\frac{1}{24} \left(-3g_2^2 + g_1^2 \right) \mathbf{1} \left(-v_u^2 + v_d^2 \right) \delta_{\alpha_1 \beta_1} + \frac{1}{2} \delta_{\alpha_1 \beta_1} \left(2m_q^2 + v_u^2 Y_u^\dagger Y_u \right) \quad (103)$$

$$m_{\tilde{u}_R \tilde{u}_R^*} = \frac{1}{2} \delta_{\alpha_2 \beta_2} \left(2m_u^2 + v_u^2 Y_u Y_u^\dagger \right) + \frac{1}{6} g_1^2 \mathbf{1} \left(-v_u^2 + v_d^2 \right) \delta_{\alpha_2 \beta_2} \quad (104)$$

This matrix is diagonalized by Z^U :

$$Z^U m_{\tilde{u}}^2 Z^{U,\dagger} = m_{2,\tilde{u}}^{dia} \quad (105)$$

with

$$\tilde{u}_{L,i\alpha} = \sum_j Z_{ji}^{U,*} \tilde{u}_{j\alpha}, \quad \tilde{u}_{R,i\alpha} = \sum_j Z_{ji}^{U,*} \tilde{u}_{j\alpha} \quad (106)$$

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

$$m_{\tilde{e}}^2 = \begin{pmatrix} m_{\tilde{e}_L \tilde{e}_L^*} & \frac{1}{2} \frac{1}{\sqrt{2}} (2v_d T_e^\dagger - v_u (2\mu + v_T \lambda) Y_e^\dagger) \\ \frac{1}{2} \frac{1}{\sqrt{2}} (2v_d T_e - v_u Y_e (2\mu^* + v_T \lambda^*)) & m_{\tilde{e}_R \tilde{e}_R^*} \end{pmatrix} \quad (107)$$

$$m_{\tilde{e}_L \tilde{e}_L^*} = \frac{1}{2} v_d^2 Y_e^\dagger Y_e + \frac{1}{8} (-g_2^2 + g_1^2) \mathbf{1} (-v_u^2 + v_d^2) + m_l^2 \quad (108)$$

$$m_{\tilde{e}_R \tilde{e}_R^*} = \frac{1}{2} v_d^2 Y_e Y_e^\dagger + \frac{1}{4} g_1^2 \mathbf{1} (-v_d^2 + v_u^2) + m_e^2 \quad (109)$$

This matrix is diagonalized by Z^E :

$$Z^E m_{\tilde{e}}^2 Z^{E,\dagger} = m_{2,\tilde{e}}^{dia} \quad (110)$$

with

$$\tilde{e}_{L,i} = \sum_j Z_{ji}^{E,*} \tilde{e}_j, \quad \tilde{e}_{R,i} = \sum_j Z_{ji}^{E,*} \tilde{e}_j \quad (111)$$

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

$$m_h^2 = \begin{pmatrix} m_{\phi_d \phi_d} & m_{\phi_u \phi_d} & m_{\phi_T \phi_d} \\ m_{\phi_d \phi_u} & m_{\phi_u \phi_u} & m_{\phi_T \phi_u} \\ m_{\phi_d \phi_T} & m_{\phi_u \phi_T} & m_{\phi_T \phi_T} \end{pmatrix} \quad (112)$$

$$m_{\phi_d \phi_d} = \frac{1}{4} (2(2\mu + v_T \lambda) \mu^* + (2v_T \mu + (v_T^2 + v_u^2) \lambda) \lambda^*) + \frac{1}{8} (g_1^2 + g_2^2) (3v_d^2 - v_u^2) + m_{H_d}^2 \quad (113)$$

$$m_{\phi_d \phi_u} = \frac{1}{4} \left((-2M_T v_T + 2v_d v_u \lambda) \lambda^* - 4\Re(B_\mu) + v_T (-2\lambda M_T^* - 2\Re(T_\lambda)) \right) - \frac{1}{4} (g_1^2 + g_2^2) v_d v_u \quad (114)$$

$$m_{\phi_u \phi_u} = \frac{1}{4} (2(2\mu + v_T \lambda) \mu^* + (2v_T \mu + (v_d^2 + v_T^2) \lambda) \lambda^*) - \frac{1}{8} (g_1^2 + g_2^2) (-3v_u^2 + v_d^2) + m_{H_u}^2 \quad (115)$$

$$m_{\phi_d \phi_T} = \frac{1}{2} (\lambda (v_d \mu^* - v_u M_T^*) + (-M_T v_u + v_d (v_T \lambda + \mu)) \lambda^* - v_u \Re(T_\lambda)) \quad (116)$$

$$m_{\phi_u \phi_T} = \frac{1}{2} (\lambda (-v_d M_T^* + v_u \mu^*) + (-M_T v_d + v_u (v_T \lambda + \mu)) \lambda^* - v_d \Re(T_\lambda)) \quad (117)$$

$$m_{\phi_T \phi_T} = 2\Re(B_T) + 4|M_T|^2 + \frac{1}{4} (v_d^2 + v_u^2) |\lambda|^2 + m_t^2 \quad (118)$$

This matrix is diagonalized by Z^H :

$$Z^H m_h^2 Z^{H,\dagger} = m_{2,h}^{dia} \quad (119)$$

with

$$\phi_d = \sum_j Z_{j1}^H h_j, \quad \phi_u = \sum_j Z_{j2}^H h_j, \quad \phi_T = \sum_j Z_{j3}^H h_j \quad (120)$$

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

$$m_{A^0}^2 = \begin{pmatrix} m_{\sigma_d \sigma_d} & m_{\sigma_u \sigma_d} & -\frac{1}{2}v_u \left(2\Re(\lambda M_T^*) - \Re(T_\lambda) \right) \\ m_{\sigma_d \sigma_u} & m_{\sigma_u \sigma_u} & -\frac{1}{2}v_d \left(2\Re(\lambda M_T^*) - \Re(T_\lambda) \right) \\ -\frac{1}{2}v_u \left(2\Re(\lambda M_T^*) - \Re(T_\lambda) \right) & -\frac{1}{2}v_d \left(2\Re(\lambda M_T^*) - \Re(T_\lambda) \right) & m_{\sigma_T \sigma_T} \end{pmatrix} + \xi_Z m^2(Z) \quad (121)$$

$$m_{\sigma_d \sigma_d} = \frac{1}{4} \left(2(2\mu + v_T \lambda) \mu^* + (2v_T \mu + (v_T^2 + v_u^2) \lambda) \lambda^* \right) + \frac{1}{8} (g_1^2 + g_2^2) (-v_u^2 + v_d^2) + m_{H_d}^2 \quad (122)$$

$$m_{\sigma_d \sigma_u} = \frac{1}{4} \left(4\Re(B_\mu) + v_T (2\Re(T_\lambda) + 4\Re(\lambda M_T^*)) \right) \quad (123)$$

$$m_{\sigma_u \sigma_u} = \frac{1}{4} \left(2(2\mu + v_T \lambda) \mu^* + (2v_T \mu + (v_d^2 + v_T^2) \lambda) \lambda^* \right) - \frac{1}{8} (g_1^2 + g_2^2) (-v_u^2 + v_d^2) + m_{H_u}^2 \quad (124)$$

$$m_{\sigma_T \sigma_T} = \frac{1}{4} \left(16|M_T|^2 - 8\Re(B_T) + (v_d^2 + v_u^2) |\lambda|^2 \right) + m_t^2 \quad (125)$$

Gauge fixing contributions:

$$m^2(\xi_Z) = \begin{pmatrix} m_{\sigma_d \sigma_d} & m_{\sigma_u \sigma_d} & 0 \\ m_{\sigma_d \sigma_u} & m_{\sigma_u \sigma_u} & 0 \\ 0 & 0 & 0 \end{pmatrix} \quad (126)$$

$$m_{\sigma_d \sigma_d} = \frac{1}{4} v_d^2 (g_1 \sin \Theta_W + g_2 \cos \Theta_W)^2 \quad (127)$$

$$m_{\sigma_d \sigma_u} = -\frac{1}{4} v_d v_u (g_1 \sin \Theta_W + g_2 \cos \Theta_W)^2 \quad (128)$$

$$m_{\sigma_u \sigma_u} = \frac{1}{4} v_u^2 (g_1 \sin \Theta_W + g_2 \cos \Theta_W)^2 \quad (129)$$

This matrix is diagonalized by Z^A :

$$Z^A m_{A^0}^2 Z^{A,\dagger} = m_{2,A^0}^{dia} \quad (130)$$

with

$$\sigma_d = \sum_j Z_{j1}^A A_j^0, \quad \sigma_u = \sum_j Z_{j2}^A A_j^0, \quad \sigma_T = \sum_j Z_{j3}^A A_j^0 \quad (131)$$

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

$$m_{H^\pm}^2 = \begin{pmatrix} m_{H_d^- H_d^{-,*}} & m_{H_u^{+,*} H_d^{-,*}}^* & m_{T^- H_d^{-,*}}^* & m_{T^{+,*} H_d^{-,*}}^* \\ m_{H_d^- H_u^+} & m_{H_u^{+,*} H_u^+} & m_{T^- H_u^+}^* & m_{T^{+,*} H_u^+}^* \\ m_{H_d^- T^{-,*}} & m_{H_u^{+,*} T^{-,*}} & m_{T^- T^{-,*}} & 2B_T^* - \frac{1}{2} g_2^2 v_T^2 \\ m_{H_d^- T^+} & m_{H_u^{+,*} T^+} & 2B_T - \frac{1}{2} g_2^2 v_T^2 & m_{T^{+,*} T^+} \end{pmatrix} + \xi_{W^-} m^2(W^-) \quad (132)$$

$$m_{H_d^- H_d^{-,*}} = \frac{1}{4} \left(-2 \left(-2\mu + v_T \lambda \right) \mu^* + \left(-2v_T \mu + \left(2v_u^2 + v_T^2 \right) \lambda \right) \lambda^* \right) + \frac{1}{8} \left(g_1^2 \left(-v_u^2 + v_d^2 \right) + g_2^2 \left(v_d^2 + v_u^2 \right) \right) + m_{H_d}^2 \quad (133)$$

$$m_{H_d^- H_u^+} = \frac{1}{4} \left(-2v_T T_\lambda + \lambda \left(-4v_T M_T^* + v_d v_u \lambda^* \right) \right) + \frac{1}{4} g_2^2 v_d v_u + B_\mu \quad (134)$$

$$m_{H_u^{+,*} H_u^+} = \frac{1}{4} \left(-2 \left(-2\mu + v_T \lambda \right) \mu^* + \left(2v_d^2 \lambda + v_T \left(-2\mu + v_T \lambda \right) \right) \lambda^* \right) + \frac{1}{8} \left(g_1^2 \left(-v_d^2 + v_u^2 \right) + g_2^2 \left(v_d^2 + v_u^2 \right) \right) + m_{H_u}^2 \quad (135)$$

$$m_{H_d^- T^{-,*}} = -\frac{1}{2} \frac{1}{\sqrt{2}} \left(4v_u \lambda M_T^* + v_d \left(-2\mu + v_T \lambda \right) \lambda^* \right) + \frac{1}{2} \frac{1}{\sqrt{2}} g_2^2 v_d v_T \quad (136)$$

$$m_{H_u^{+,*} T^{-,*}} = \frac{1}{2} \frac{1}{\sqrt{2}} \left(2v_d T_\lambda^* - v_u \left(2\mu + v_T \lambda \right) \lambda^* \right) + \frac{1}{2} \frac{1}{\sqrt{2}} g_2^2 v_T v_u \quad (137)$$

$$m_{T^- T^{-,*}} = 4|M_T|^2 + \frac{1}{2} v_d^2 |\lambda|^2 + \frac{1}{4} g_2^2 \left(2v_T^2 - v_d^2 + v_u^2 \right) + m_t^2 \quad (138)$$

$$m_{H_d^- T^+} = \frac{1}{2} \frac{1}{\sqrt{2}} \left(-2v_u T_\lambda + v_d \lambda \left(2\mu^* + v_T \lambda^* \right) \right) - \frac{1}{2} \frac{1}{\sqrt{2}} g_2^2 v_d v_T \quad (139)$$

$$m_{H_u^{+,*} T^+} = \frac{1}{2} \frac{1}{\sqrt{2}} \left(-2v_u \lambda \mu^* + \left(4M_T v_d + v_T v_u \lambda \right) \lambda^* \right) - \frac{1}{2} \frac{1}{\sqrt{2}} g_2^2 v_T v_u \quad (140)$$

$$m_{T^+ T^+} = 4|M_T|^2 + \frac{1}{2} v_u^2 |\lambda|^2 + \frac{1}{4} g_2^2 \left(2v_T^2 - v_u^2 + v_d^2 \right) + m_t^2 \quad (141)$$

Gauge fixing contributions:

$$m^2(\xi_{W^-}) = \begin{pmatrix} \frac{1}{4} g_2^2 v_d^2 & -\frac{1}{4} g_2^2 v_d v_u & \frac{1}{2} \frac{1}{\sqrt{2}} g_2^2 v_d v_T & \frac{1}{2} \frac{1}{\sqrt{2}} g_2^2 v_d v_T \\ -\frac{1}{4} g_2^2 v_d v_u & \frac{1}{4} g_2^2 v_u^2 & -\frac{1}{2} \frac{1}{\sqrt{2}} g_2^2 v_T v_u & -\frac{1}{2} \frac{1}{\sqrt{2}} g_2^2 v_T v_u \\ \frac{1}{2} \frac{1}{\sqrt{2}} g_2^2 v_d v_T & -\frac{1}{2} \frac{1}{\sqrt{2}} g_2^2 v_T v_u & \frac{1}{2} g_2^2 v_T^2 & \frac{1}{2} g_2^2 v_T^2 \\ \frac{1}{2} \frac{1}{\sqrt{2}} g_2^2 v_d v_T & -\frac{1}{2} \frac{1}{\sqrt{2}} g_2^2 v_T v_u & \frac{1}{2} g_2^2 v_T^2 & \frac{1}{2} g_2^2 v_T^2 \end{pmatrix} \quad (142)$$

This matrix is diagonalized by Z^+ :

$$Z^+ m_{H^-}^2 Z^{+,\dagger} = m_{2,H^-}^{dia} \quad (143)$$

with

$$H_d^- = \sum_j Z_{j1}^+ H_j^-, \quad H_u^+ = \sum_j Z_{j2}^+ H_j^+, \quad T^- = \sum_j Z_{j3}^+ H_j^- \quad (144)$$

$$T^+ = \sum_j Z_{j4}^+ H_j^+ \quad (145)$$

4.2.2 Mass Matrices for Fermions

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

$$m_{\tilde{\chi}^0} = \begin{pmatrix} M_1 & 0 & -\frac{1}{2}g_1 v_d & \frac{1}{2}g_1 v_u & 0 \\ 0 & M_2 & \frac{1}{2}g_2 v_d & -\frac{1}{2}g_2 v_u & 0 \\ -\frac{1}{2}g_1 v_d & \frac{1}{2}g_2 v_d & 0 & -\frac{1}{2}v_T \lambda - \mu & -\frac{1}{2}v_u \lambda \\ \frac{1}{2}g_1 v_u & -\frac{1}{2}g_2 v_u & -\frac{1}{2}v_T \lambda - \mu & 0 & -\frac{1}{2}v_d \lambda \\ 0 & 0 & -\frac{1}{2}v_u \lambda & -\frac{1}{2}v_d \lambda & 2M_T \end{pmatrix} \quad (146)$$

This matrix is diagonalized by N :

$$N^* m_{\tilde{\chi}^0} N^\dagger = m_{\tilde{\chi}^0}^{dia} \quad (147)$$

with

$$\lambda_{\tilde{B}} = \sum_j N_{j1}^* \lambda_j^0, \quad \tilde{W}^0 = \sum_j N_{j2}^* \lambda_j^0, \quad \tilde{H}_d^0 = \sum_j N_{j3}^* \lambda_j^0 \quad (148)$$

$$\tilde{H}_u^0 = \sum_j N_{j4}^* \lambda_j^0, \quad \lambda_{T^0} = \sum_j N_{j5}^* \lambda_j^0 \quad (149)$$

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

$$m_{\tilde{\chi}^-} = \begin{pmatrix} M_2 & \frac{1}{\sqrt{2}}g_2 v_u & -g_2 v_T \\ \frac{1}{\sqrt{2}}g_2 v_d & -\frac{1}{2}v_T \lambda + \mu & -\frac{1}{\sqrt{2}}v_u \lambda \\ g_2 v_T & \frac{1}{\sqrt{2}}v_d \lambda & 2M_T \end{pmatrix} \quad (150)$$

This matrix is diagonalized by U and V

$$U^* m_{\tilde{\chi}^-} V^\dagger = m_{\tilde{\chi}^-}^{dia} \quad (151)$$

with

$$\tilde{W}^- = \sum_{t_2} U_{j1}^* \lambda_j^-, \quad \tilde{H}_d^- = \sum_{t_2} U_{j2}^* \lambda_j^-, \quad \lambda_{T^-} = \sum_{t_2} U_{j3}^* \lambda_j^- \quad (152)$$

$$\tilde{W}^+ = \sum_{t_2} V_{1j}^* \lambda_j^+, \quad \tilde{H}_u^+ = \sum_{t_2} V_{2j}^* \lambda_j^+, \quad \lambda_{T^+} = \sum_{t_2} V_{3j}^* \lambda_j^+ \quad (153)$$

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

$$m_e = \left(\frac{1}{\sqrt{2}}v_d Y_e^T \right) \quad (154)$$

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

$$U_L^{e,*} m_e U_R^{e,\dagger} = m_e^{dia} \quad (155)$$

with

$$e_{L,i} = \sum_{t_2} U_{L,ji}^{e,*} E_{L,j} \quad (156)$$

$$e_{R,i} = \sum_{t_2} U_{R,ij}^e E_{R,j}^* \quad (157)$$

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

$$m_d = \left(\frac{1}{\sqrt{2}} v_d \delta_{\alpha_1 \beta_1} Y_d^T \right) \quad (158)$$

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

$$U_L^{d,*} m_d U_R^{d,\dagger} = m_d^{dia} \quad (159)$$

with

$$d_{L,i\alpha} = \sum_{t_2} U_{L,ji}^{d,*} D_{L,j\alpha} \quad (160)$$

$$d_{R,i\alpha} = \sum_{t_2} U_{R,ij}^d D_{R,j\alpha}^* \quad (161)$$

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

$$m_u = \left(\frac{1}{\sqrt{2}} v_u \delta_{\alpha_1 \beta_1} Y_u^T \right) \quad (162)$$

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

$$U_L^{u,*} m_u U_R^{u,\dagger} = m_u^{dia} \quad (163)$$

with

$$u_{L,i\alpha} = \sum_{t_2} U_{L,ji}^{u,*} U_{L,j\alpha} \quad (164)$$

$$u_{R,i\alpha} = \sum_{t_2} U_{R,ij}^u U_{R,j\alpha}^* \quad (165)$$

5 Vacuum Expectation Values

$$H_d^0 = \frac{1}{\sqrt{2}} \phi_d + \frac{1}{\sqrt{2}} v_d + i \frac{1}{\sqrt{2}} \sigma_d \quad (166)$$

$$H_u^0 = \frac{1}{\sqrt{2}} \phi_u + \frac{1}{\sqrt{2}} v_u + i \frac{1}{\sqrt{2}} \sigma_u \quad (167)$$

$$T^0 = \frac{1}{\sqrt{2}} \phi_T + \frac{1}{\sqrt{2}} v_T + i \frac{1}{\sqrt{2}} \sigma_T \quad (168)$$

6 Tadpole Equations

$$\frac{\partial V}{\partial \phi_d} = +\frac{1}{8} (g_1^2 + g_2^2) v_d (-v_u + v_d) (v_d + v_u)$$

$$+ \frac{1}{4} \left(v_d \left(2(2\mu + v_T \lambda) \mu^* + 4m_{H_d}^2 \right) + \left(v_d (v_T^2 + v_u^2) \lambda + v_T (-2M_T v_u + 2v_d \mu) \right) \lambda^* + v_u \left(-4\Re(B_\mu) + v_T (-2\lambda M_T^* - 2\Re(T_\lambda)) \right) \right) \quad (169)$$

$$\begin{aligned} \frac{\partial V}{\partial \phi_u} &= + \frac{1}{8} (g_1^2 + g_2^2) v_u (-v_d^2 + v_u^2) \\ &+ \frac{1}{4} \left(\left((v_d^2 + v_T^2) v_u \lambda + v_T (-2M_T v_d + 2v_u \mu) \right) \lambda^* + v_d \left(-4\Re(B_\mu) + v_T (-2\lambda M_T^* - 2\Re(T_\lambda)) \right) \right) + v_u \left(2(2\mu + v_T \lambda) \mu^* + 4m_t^2 \right) \end{aligned} \quad (170)$$

$$\begin{aligned} \frac{\partial V}{\partial \phi_T} &= \frac{1}{4} \left(2(8M_T v_T - v_d v_u \lambda) M_T^* + \left(-2M_T v_d v_u + (v_d^2 + v_u^2) (v_T \lambda + \mu) \right) \lambda^* + (v_d^2 + v_u^2) \lambda \mu^* + v_T (4m_t^2 + 8\Re(B_T)) \right. \\ &\quad \left. - 2v_d v_u \Re(T_\lambda) \right) \end{aligned} \quad (171)$$

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	4	generation, 4
\tilde{g}	Fermion	Majorana	1	color, 8
ν	Fermion	Dirac	3	generation, 3
$\tilde{\chi}^0$	Fermion	Majorana	5	generation, 5
$\tilde{\chi}^-$	Fermion	Dirac	3	generation, 3
e	Fermion	Dirac	3	generation, 3
d	Fermion	Dirac	3	generation, 3, color, 3
u	Fermion	Dirac	3	generation, 3, color, 3
g	Vector	real	1	color, 8, lorentz, 4
γ	Vector	real	1	lorentz, 4
Z	Vector	real	1	lorentz, 4
W^-	Vector	complex	1	lorentz, 4
η^G	Ghost	real	1	color, 8
η^γ	Ghost	real	1	
η^Z	Ghost	real	1	

η^-	Ghost	complex	1
η^+	Ghost	complex	1

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

8.1 One Loop Self-Energy

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

$$\begin{aligned}
\Pi_{i,j}(p^2) = & +4\Gamma_{\tilde{d}_i, \tilde{d}_j^*, W^+, W^-} \left(-\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2\Gamma_{\tilde{d}_i, \tilde{d}_j^*, Z, Z} \left(-\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) \\
& - \frac{1}{2} \sum_{a=1}^3 A_0(m_{A_a^0}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, A_a^0, A_a^0} - \sum_{a=1}^3 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, \tilde{\nu}_a^*, \tilde{\nu}_a} \\
& - \frac{1}{2} \sum_{a=1}^3 A_0(m_{h_a}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, h_a, h_a} \\
& - 2 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^3 B_0(p^2, m_{u_a}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} \left(\Gamma_{\tilde{d}_j^*, u_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{d}_i^*, u_a, \tilde{\chi}_b^-}^R + \Gamma_{\tilde{d}_j^*, u_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{d}_i^*, u_a, \tilde{\chi}_b^-}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{u_a}^2, m_{\tilde{\chi}_b^-}^2) \left(\Gamma_{\tilde{d}_j^*, u_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{d}_i^*, u_a, \tilde{\chi}_b^-}^L + \Gamma_{\tilde{d}_j^*, u_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{d}_i^*, u_a, \tilde{\chi}_b^-}^R \right) \\
& - 2 \sum_{a=1}^3 m_{d_a} \sum_{b=1}^5 B_0(p^2, m_{d_a}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_b^0} \left(\Gamma_{\tilde{d}_j^*, d_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{d}_i^*, d_a, \tilde{\chi}_b^0}^R + \Gamma_{\tilde{d}_j^*, d_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{d}_i^*, d_a, \tilde{\chi}_b^0}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^5 G_0(p^2, m_{d_a}^2, m_{\tilde{\chi}_b^0}^2) \left(\Gamma_{\tilde{d}_j^*, d_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{d}_i^*, d_a, \tilde{\chi}_b^0}^L + \Gamma_{\tilde{d}_j^*, d_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{d}_i^*, d_a, \tilde{\chi}_b^0}^R \right) \\
& - \sum_{a=1}^4 A_0(m_{H_a^-}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, H_a^+, H_a^-} - C \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, \tilde{d}_a^*, \tilde{d}_a} \\
& - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, \tilde{e}_a^*, \tilde{e}_a} - C \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, \tilde{u}_a^*, \tilde{u}_a} \\
& + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{d_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j^*, \tilde{d}_a, A_b^0}^* \Gamma_{\tilde{d}_i^*, \tilde{d}_a, A_b^0} + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{d_a}^2, m_{h_b}^2) \Gamma_{\tilde{d}_j^*, \tilde{d}_a, h_b}^* \Gamma_{\tilde{d}_i^*, \tilde{d}_a, h_b} \\
& + \sum_{a=1}^6 \sum_{b=1}^4 B_0(p^2, m_{u_a}^2, m_{H_b^-}^2) \Gamma_{\tilde{d}_j^*, \tilde{u}_a, H_b^-}^* \Gamma_{\tilde{d}_i^*, \tilde{u}_a, H_b^-} \\
& - \frac{8}{3} m_{\tilde{g}} \sum_{b=1}^3 B_0(p^2, m_{\tilde{g}}^2, m_{d_b}^2) m_{d_b} \left(\Gamma_{\tilde{d}_j^*, \tilde{g}_1, d_b}^{L*} \Gamma_{\tilde{d}_i^*, \tilde{g}_1, d_b}^R + \Gamma_{\tilde{d}_j^*, \tilde{g}_1, d_b}^{R*} \Gamma_{\tilde{d}_i^*, \tilde{g}_1, d_b}^L \right)
\end{aligned}$$

$$\begin{aligned}
& + \frac{4}{3} \sum_{b=1}^3 G_0(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_b}^2) \left(\Gamma_{\tilde{d}_j^*, \tilde{g}_1, d_b}^{L*} \Gamma_{\tilde{d}_i^*, \tilde{g}_1, d_b}^L + \Gamma_{\tilde{d}_j^*, \tilde{g}_1, d_b}^{R*} \Gamma_{\tilde{d}_i^*, \tilde{g}_1, d_b}^R \right) \\
& + \frac{4}{3} \sum_{b=1}^6 \Gamma_{\tilde{d}_j^*, g, \tilde{d}_b}^* \Gamma_{\tilde{d}_i^*, g, \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, 0) + \sum_{b=1}^6 \Gamma_{\tilde{d}_j^*, \gamma, \tilde{d}_b}^* \Gamma_{\tilde{d}_i^*, \gamma, \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, 0) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{d}_j^*, Z, \tilde{d}_b}^* \Gamma_{\tilde{d}_i^*, Z, \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, m_Z^2) + \sum_{b=1}^6 \Gamma_{\tilde{d}_j^*, W^-, \tilde{u}_b}^* \Gamma_{\tilde{d}_i^*, W^-, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, m_{W^-}^2) \quad (172)
\end{aligned}$$

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

$$\begin{aligned}
\Pi_{i,j}(p^2) = & +4\Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, W^+, W^-} \left(-\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2\Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, Z, Z} \left(-\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) \\
& - \frac{1}{2} \sum_{a=1}^3 A_0(m_{A_a}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, A_a^0, A_a^0} - \sum_{a=1}^3 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, \tilde{\nu}_a^*, \tilde{\nu}_a} \\
& - \frac{1}{2} \sum_{a=1}^3 A_0(m_{h_a}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, h_a, h_a} + \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{\tilde{\nu}_a}^2, m_{h_b}^2) \Gamma_{\tilde{\nu}_j^*, \tilde{\nu}_a, h_b}^* \Gamma_{\tilde{\nu}_i^*, \tilde{\nu}_a, h_b} \\
& - 2 \sum_{a=1}^3 m_{\tilde{\chi}_a^-} \sum_{b=1}^3 B_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{e_b}^2) m_{e_b} \left(\Gamma_{\tilde{\nu}_j^*, \tilde{\chi}_a^+, e_b}^{L*} \Gamma_{\tilde{\nu}_i^*, \tilde{\chi}_a^+, e_b}^R + \Gamma_{\tilde{\nu}_j^*, \tilde{\chi}_a^+, e_b}^{R*} \Gamma_{\tilde{\nu}_i^*, \tilde{\chi}_a^+, e_b}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{e_b}^2) \left(\Gamma_{\tilde{\nu}_j^*, \tilde{\chi}_a^+, e_b}^{L*} \Gamma_{\tilde{\nu}_i^*, \tilde{\chi}_a^+, e_b}^L + \Gamma_{\tilde{\nu}_j^*, \tilde{\chi}_a^+, e_b}^{R*} \Gamma_{\tilde{\nu}_i^*, \tilde{\chi}_a^+, e_b}^R \right) \\
& - 2 \sum_{a=1}^3 m_{\nu_a} \sum_{b=1}^5 B_0(p^2, m_{\nu_a}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_b^0} \left(\Gamma_{\tilde{\nu}_j^*, \nu_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\nu}_i^*, \nu_a, \tilde{\chi}_b^0}^R + \Gamma_{\tilde{\nu}_j^*, \nu_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\nu}_i^*, \nu_a, \tilde{\chi}_b^0}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^5 G_0(p^2, m_{\nu_a}^2, m_{\tilde{\chi}_b^0}^2) \left(\Gamma_{\tilde{\nu}_j^*, \nu_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\nu}_i^*, \nu_a, \tilde{\chi}_b^0}^L + \Gamma_{\tilde{\nu}_j^*, \nu_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\nu}_i^*, \nu_a, \tilde{\chi}_b^0}^R \right) \\
& - \sum_{a=1}^4 A_0(m_{H_a^-}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, H_a^+, H_a^-} + \sum_{a=1}^4 \sum_{b=1}^6 B_0(p^2, m_{H_a^-}^2, m_{\tilde{e}_b}^2) \Gamma_{\tilde{\nu}_j^*, H_a^+, \tilde{e}_b}^* \Gamma_{\tilde{\nu}_i^*, H_a^+, \tilde{e}_b} \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, \tilde{d}_a^*, \tilde{d}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, \tilde{e}_a^*, \tilde{e}_a} \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, \tilde{u}_a^*, \tilde{u}_a} + \sum_{b=1}^3 \Gamma_{\tilde{\nu}_j^*, Z, \tilde{\nu}_b}^* \Gamma_{\tilde{\nu}_i^*, Z, \tilde{\nu}_b} F_0(p^2, m_{\tilde{\nu}_b}^2, m_Z^2) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{\nu}_j^*, W^+, \tilde{e}_b}^* \Gamma_{\tilde{\nu}_i^*, W^+, \tilde{e}_b} F_0(p^2, m_{\tilde{e}_b}^2, m_{W^-}^2) \quad (173)
\end{aligned}$$

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

$$\begin{aligned}
\Pi_{i,j}(p^2) = & +4\Gamma_{\tilde{u}_i, \tilde{u}_j^*, W^+, W^-} \left(-\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2\Gamma_{\tilde{u}_i, \tilde{u}_j^*, Z, Z} \left(-\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) \\
& - \frac{1}{2} \sum_{a=1}^3 A_0(m_{A_a^0}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, A_a^0, A_a^0} - \sum_{a=1}^3 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, \tilde{\nu}_a^*, \tilde{\nu}_a} \\
& - \frac{1}{2} \sum_{a=1}^3 A_0(m_{h_a}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, h_a, h_a} \\
& - 2 \sum_{a=1}^3 m_{\tilde{\chi}_a^-} \sum_{b=1}^3 B_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{d_b}^2) m_{d_b} \left(\Gamma_{\tilde{u}_j^*, \tilde{\chi}_a^+, d_b}^{L*} \Gamma_{\tilde{u}_i^*, \tilde{\chi}_a^+, d_b}^R + \Gamma_{\tilde{u}_j^*, \tilde{\chi}_a^+, d_b}^{R*} \Gamma_{\tilde{u}_i^*, \tilde{\chi}_a^+, d_b}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{d_b}^2) \left(\Gamma_{\tilde{u}_j^*, \tilde{\chi}_a^+, d_b}^{L*} \Gamma_{\tilde{u}_i^*, \tilde{\chi}_a^+, d_b}^L + \Gamma_{\tilde{u}_j^*, \tilde{\chi}_a^+, d_b}^{R*} \Gamma_{\tilde{u}_i^*, \tilde{\chi}_a^+, d_b}^R \right) \\
& - 2 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^5 B_0(p^2, m_{u_a}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_b^0} \left(\Gamma_{\tilde{u}_j^*, u_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{u}_i^*, u_a, \tilde{\chi}_b^0}^R + \Gamma_{\tilde{u}_j^*, u_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{u}_i^*, u_a, \tilde{\chi}_b^0}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^5 G_0(p^2, m_{u_a}^2, m_{\tilde{\chi}_b^0}^2) \left(\Gamma_{\tilde{u}_j^*, u_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{u}_i^*, u_a, \tilde{\chi}_b^0}^L + \Gamma_{\tilde{u}_j^*, u_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{u}_i^*, u_a, \tilde{\chi}_b^0}^R \right) \\
& - \sum_{a=1}^4 A_0(m_{H_a^-}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, H_a^+, H_a^-} + \sum_{a=1}^4 \sum_{b=1}^6 B_0(p^2, m_{H_a^-}^2, m_{d_b}^2) \Gamma_{\tilde{u}_j^*, H_a^+, d_b}^* \Gamma_{\tilde{u}_i^*, H_a^+, d_b} \\
& - C \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, \tilde{d}_a^*, \tilde{d}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, \tilde{e}_a^*, \tilde{e}_a} \\
& - C \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, \tilde{u}_a^*, \tilde{u}_a} + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{\tilde{u}_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{u}_j^*, \tilde{u}_a, A_b^0}^* \Gamma_{\tilde{u}_i^*, \tilde{u}_a, A_b^0} \\
& + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{\tilde{u}_a}^2, m_{h_b}^2) \Gamma_{\tilde{u}_j^*, \tilde{u}_a, h_b}^* \Gamma_{\tilde{u}_i^*, \tilde{u}_a, h_b} \\
& - \frac{8}{3} m_{\tilde{g}} \sum_{b=1}^3 B_0(p^2, m_{\tilde{g}}^2, m_{u_b}^2) m_{u_b} \left(\Gamma_{\tilde{u}_j^*, \tilde{g}_1, u_b}^{L*} \Gamma_{\tilde{u}_i^*, \tilde{g}_1, u_b}^R + \Gamma_{\tilde{u}_j^*, \tilde{g}_1, u_b}^{R*} \Gamma_{\tilde{u}_i^*, \tilde{g}_1, u_b}^L \right) \\
& + \frac{4}{3} \sum_{b=1}^3 G_0(p^2, m_{\tilde{g}}^2, m_{u_b}^2) \left(\Gamma_{\tilde{u}_j^*, \tilde{g}_1, u_b}^{L*} \Gamma_{\tilde{u}_i^*, \tilde{g}_1, u_b}^L + \Gamma_{\tilde{u}_j^*, \tilde{g}_1, u_b}^{R*} \Gamma_{\tilde{u}_i^*, \tilde{g}_1, u_b}^R \right) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, W^+, \tilde{d}_b}^* \Gamma_{\tilde{u}_i^*, W^+, \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, m_{W^-}^2) + \frac{4}{3} \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, g, \tilde{u}_b}^* \Gamma_{\tilde{u}_i^*, g, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, 0) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, \gamma, \tilde{u}_b}^* \Gamma_{\tilde{u}_i^*, \gamma, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, 0) + \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, Z, \tilde{u}_b}^* \Gamma_{\tilde{u}_i^*, Z, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, m_Z^2)
\end{aligned} \tag{174}$$

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

$$\begin{aligned}
\Pi_{i,j}(p^2) = & +4\Gamma_{\tilde{e}_i, \tilde{e}_j^*, W^+, W^-} \left(-\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2\Gamma_{\tilde{e}_i, \tilde{e}_j^*, Z, Z} \left(-\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) \\
& - \frac{1}{2} \sum_{a=1}^3 A_0(m_{A_0^0}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, A_0^0, A_0^0} - \sum_{a=1}^3 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, \tilde{\nu}_a^*, \tilde{\nu}_a} \\
& - \frac{1}{2} \sum_{a=1}^3 A_0(m_{h_a}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, h_a, h_a} \\
& - 2 \sum_{a=1}^3 m_{\nu_a} \sum_{b=1}^3 B_0(p^2, m_{\nu_a}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} \left(\Gamma_{\tilde{e}_j^*, \nu_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{e}_i^*, \nu_a, \tilde{\chi}_b^-}^R + \Gamma_{\tilde{e}_j^*, \nu_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{e}_i^*, \nu_a, \tilde{\chi}_b^-}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{\nu_a}^2, m_{\tilde{\chi}_b^-}^2) \left(\Gamma_{\tilde{e}_j^*, \nu_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{e}_i^*, \nu_a, \tilde{\chi}_b^-}^L + \Gamma_{\tilde{e}_j^*, \nu_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{e}_i^*, \nu_a, \tilde{\chi}_b^-}^R \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^4 B_0(p^2, m_{\tilde{\nu}_a}^2, m_{H_b^-}^2) \Gamma_{\tilde{e}_j^*, \tilde{\nu}_a, H_b^-}^* \Gamma_{\tilde{e}_i^*, \tilde{\nu}_a, H_b^-} \\
& - 2 \sum_{a=1}^3 m_{e_a} \sum_{b=1}^5 B_0(p^2, m_{e_a}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_b^0} \left(\Gamma_{\tilde{e}_j^*, e_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{e}_i^*, e_a, \tilde{\chi}_b^0}^R + \Gamma_{\tilde{e}_j^*, e_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{e}_i^*, e_a, \tilde{\chi}_b^0}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^5 G_0(p^2, m_{e_a}^2, m_{\tilde{\chi}_b^0}^2) \left(\Gamma_{\tilde{e}_j^*, e_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{e}_i^*, e_a, \tilde{\chi}_b^0}^L + \Gamma_{\tilde{e}_j^*, e_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{e}_i^*, e_a, \tilde{\chi}_b^0}^R \right) \\
& - \sum_{a=1}^4 A_0(m_{H_a^-}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, H_a^+, H_a^-} - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, \tilde{d}_a^*, \tilde{d}_a} \\
& - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, \tilde{e}_a^*, \tilde{e}_a} - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, \tilde{u}_a^*, \tilde{u}_a} \\
& + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{\tilde{e}_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{e}_j^*, \tilde{e}_a, A_b^0}^* \Gamma_{\tilde{e}_i^*, \tilde{e}_a, A_b^0} + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{\tilde{e}_a}^2, m_{h_b}^2) \Gamma_{\tilde{e}_j^*, \tilde{e}_a, h_b}^* \Gamma_{\tilde{e}_i^*, \tilde{e}_a, h_b} \\
& + \sum_{b=1}^3 \Gamma_{\tilde{e}_j^*, W^-, \tilde{\nu}_b}^* \Gamma_{\tilde{e}_i^*, W^-, \tilde{\nu}_b} F_0(p^2, m_{\tilde{\nu}_b}^2, m_{W^-}^2) + \sum_{b=1}^6 \Gamma_{\tilde{e}_j^*, \gamma, \tilde{e}_b}^* \Gamma_{\tilde{e}_i^*, \gamma, \tilde{e}_b} F_0(p^2, m_{\tilde{e}_b}^2, 0) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{e}_j^*, Z, \tilde{e}_b}^* \Gamma_{\tilde{e}_i^*, Z, \tilde{e}_b} F_0(p^2, m_{\tilde{e}_b}^2, m_Z^2) \tag{175}
\end{aligned}$$

• Self-Energy for Higgs (h)

$$\begin{aligned}
\Pi_{i,j}(p^2) = & +2 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_Z^2, m_Z^2) \right) \Gamma_{\tilde{h}_j, Z, Z}^* \Gamma_{\tilde{h}_i, Z, Z} + 4 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{W^-}^2, m_{W^-}^2) \right) \Gamma_{\tilde{h}_j, W^+, W^-}^* \Gamma_{\tilde{h}_i, W^+, W^-} \\
& - B_0(p^2, m_{\eta^-}^2, m_{\eta^-}^2) \Gamma_{\tilde{h}_i, \eta^-, \eta^-} \Gamma_{\tilde{h}_j, \eta^-, \eta^-} - B_0(p^2, m_{\eta^+}^2, m_{\eta^+}^2) \Gamma_{\tilde{h}_i, \eta^+, \eta^+} \Gamma_{\tilde{h}_j, \eta^+, \eta^+}
\end{aligned}$$

$$\begin{aligned}
& - B_0(p^2, m_{\eta^z}^2, m_{\eta^z}^2) \Gamma_{\check{h}_i, \check{\eta}^z, \eta^z} \Gamma_{\check{h}_j, \check{\eta}^z, \eta^z} + 4\Gamma_{\check{h}_i, \check{h}_j, W^+, W^-} \left(-\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) \\
& + 2\Gamma_{\check{h}_i, \check{h}_j, Z, Z} \left(-\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) - \frac{1}{2} \sum_{a=1}^3 A_0(m_{A_a^0}^2) \Gamma_{\check{h}_i, \check{h}_j, A_a^0, A_a^0} - \sum_{a=1}^3 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\check{h}_i, \check{h}_j, \tilde{\nu}_a^*, \tilde{\nu}_a} \\
& - \frac{1}{2} \sum_{a=1}^3 A_0(m_{h_a}^2) \Gamma_{\check{h}_i, \check{h}_j, h_a, h_a} + \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{A_a^0}^2, m_{A_b^0}^2) \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(p^2, m_{\tilde{\nu}_a}^2, m_{\tilde{\nu}_b}^2) \Gamma_{\check{h}_j, \tilde{\nu}_a^*, \tilde{\nu}_b} \Gamma_{\check{h}_i, \tilde{\nu}_a^*, \tilde{\nu}_b} + \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{h_a}^2, m_{A_b^0}^2) \Gamma_{\check{h}_j, h_a, A_b^0}^* \Gamma_{\check{h}_i, h_a, A_b^0} \\
& + \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{h_a}^2, m_{h_b}^2) \Gamma_{\check{h}_j, h_a, h_b}^* \Gamma_{\check{h}_i, h_a, h_b} \\
& - 2 \sum_{a=1}^3 m_{\tilde{\chi}_a^-} \sum_{b=1}^3 B_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} \left(\Gamma_{\check{h}_j, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{L*} \Gamma_{\check{h}_i, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^R + \Gamma_{\check{h}_j, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{R*} \Gamma_{\check{h}_i, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{\chi}_b^-}^2) \left(\Gamma_{\check{h}_j, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{L*} \Gamma_{\check{h}_i, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^L + \Gamma_{\check{h}_j, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{R*} \Gamma_{\check{h}_i, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^R \right) \\
& - 6 \sum_{a=1}^3 m_{d_a} \sum_{b=1}^3 B_0(p^2, m_{d_a}^2, m_{d_b}^2) m_{d_b} \left(\Gamma_{\check{h}_j, \bar{d}_a, d_b}^{L*} \Gamma_{\check{h}_i, \bar{d}_a, d_b}^R + \Gamma_{\check{h}_j, \bar{d}_a, d_b}^{R*} \Gamma_{\check{h}_i, \bar{d}_a, d_b}^L \right) \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{d_a}^2, m_{d_b}^2) \left(\Gamma_{\check{h}_j, \bar{d}_a, d_b}^{L*} \Gamma_{\check{h}_i, \bar{d}_a, d_b}^L + \Gamma_{\check{h}_j, \bar{d}_a, d_b}^{R*} \Gamma_{\check{h}_i, \bar{d}_a, d_b}^R \right) \\
& - 2 \sum_{a=1}^3 m_{e_a} \sum_{b=1}^3 B_0(p^2, m_{e_a}^2, m_{e_b}^2) m_{e_b} \left(\Gamma_{\check{h}_j, \bar{e}_a, e_b}^{L*} \Gamma_{\check{h}_i, \bar{e}_a, e_b}^R + \Gamma_{\check{h}_j, \bar{e}_a, e_b}^{R*} \Gamma_{\check{h}_i, \bar{e}_a, e_b}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{e_a}^2, m_{e_b}^2) \left(\Gamma_{\check{h}_j, \bar{e}_a, e_b}^{L*} \Gamma_{\check{h}_i, \bar{e}_a, e_b}^L + \Gamma_{\check{h}_j, \bar{e}_a, e_b}^{R*} \Gamma_{\check{h}_i, \bar{e}_a, e_b}^R \right) \\
& - 6 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^3 B_0(p^2, m_{u_a}^2, m_{u_b}^2) m_{u_b} \left(\Gamma_{\check{h}_j, \bar{u}_a, u_b}^{L*} \Gamma_{\check{h}_i, \bar{u}_a, u_b}^R + \Gamma_{\check{h}_j, \bar{u}_a, u_b}^{R*} \Gamma_{\check{h}_i, \bar{u}_a, u_b}^L \right) \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{u_a}^2, m_{u_b}^2) \left(\Gamma_{\check{h}_j, \bar{u}_a, u_b}^{L*} \Gamma_{\check{h}_i, \bar{u}_a, u_b}^L + \Gamma_{\check{h}_j, \bar{u}_a, u_b}^{R*} \Gamma_{\check{h}_i, \bar{u}_a, u_b}^R \right) \\
& - \sum_{a=1}^4 A_0(m_{H_a^-}^2) \Gamma_{\check{h}_i, \check{h}_j, H_a^+, H_a^-} + \sum_{a=1}^4 \sum_{b=1}^4 B_0(p^2, m_{H_a^-}^2, m_{H_b^-}^2) \Gamma_{\check{h}_j, H_a^+, H_b^-}^* \Gamma_{\check{h}_i, H_a^+, H_b^-} \\
& - \sum_{a=1}^5 m_{\tilde{\chi}_a^0} \sum_{b=1}^5 B_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_b^0} \left(\Gamma_{\check{h}_j, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{L*} \Gamma_{\check{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R + \Gamma_{\check{h}_j, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{R*} \Gamma_{\check{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^L \right) \\
& + \frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^5 G_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2) \left(\Gamma_{\check{h}_j, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{L*} \Gamma_{\check{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^L + \Gamma_{\check{h}_j, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{R*} \Gamma_{\check{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R \right)
\end{aligned}$$

$$\begin{aligned}
& -3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{h}_i, \tilde{h}_j, \tilde{d}_a^*, \tilde{d}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{h}_i, \tilde{h}_j, \tilde{e}_a^*, \tilde{e}_a} \\
& -3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{h}_i, \tilde{h}_j, \tilde{u}_a^*, \tilde{u}_a} + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{d}_a}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{h}_j, \tilde{d}_a^*, \tilde{d}_b}^* \Gamma_{\tilde{h}_i, \tilde{d}_a^*, \tilde{d}_b} \\
& + \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{e}_a}^2, m_{\tilde{e}_b}^2) \Gamma_{\tilde{h}_j, \tilde{e}_a^*, \tilde{e}_b}^* \Gamma_{\tilde{h}_i, \tilde{e}_a^*, \tilde{e}_b} + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{u}_a}^2, m_{\tilde{u}_b}^2) \Gamma_{\tilde{h}_j, \tilde{u}_a^*, \tilde{u}_b}^* \Gamma_{\tilde{h}_i, \tilde{u}_a^*, \tilde{u}_b} \\
& + \sum_{b=1}^3 \Gamma_{\tilde{h}_j, Z, A_b^0}^* \Gamma_{\tilde{h}_i, Z, A_b^0} F_0(p^2, m_{A_b^0}^2, m_Z^2) + 2 \sum_{b=1}^4 \Gamma_{\tilde{h}_j, W^+, H_b^-}^* \Gamma_{\tilde{h}_i, W^+, H_b^-} F_0(p^2, m_{H_b^-}^2, m_{W^-}^2) \tag{176}
\end{aligned}$$

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

$$\begin{aligned}
\Pi_{i,j}(p^2) = & -B_0(p^2, m_{\eta^-}^2, m_{\eta^-}^2) \Gamma_{\tilde{A}_i^0, \eta^-, \eta^-} \Gamma_{\tilde{A}_j^0, \eta^-, \eta^-} - B_0(p^2, m_{\eta^+}^2, m_{\eta^+}^2) \Gamma_{\tilde{A}_i^0, \eta^+, \eta^+} \Gamma_{\tilde{A}_j^0, \eta^+, \eta^+} \\
& + 4\Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, W^+, W^-} \left(-\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2\Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, Z, Z} \left(-\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) \\
& - \frac{1}{2} \sum_{a=1}^3 A_0(m_{A_a^0}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, A_a^0, A_a^0} - \sum_{a=1}^3 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, \tilde{\nu}_a^*, \tilde{\nu}_a} \\
& - \frac{1}{2} \sum_{a=1}^3 A_0(m_{h_a}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, h_a, h_a} + \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{A_a^0}^2, m_{A_b^0}^2) \Gamma_{\tilde{A}_j^0, A_a^0, A_b^0}^* \Gamma_{\tilde{A}_i^0, A_a^0, A_b^0} \\
& + \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{h_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{A}_j^0, h_a, A_b^0}^* \Gamma_{\tilde{A}_i^0, h_a, A_b^0} \\
& + \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{h_a}^2, m_{h_b}^2) \Gamma_{\tilde{A}_j^0, h_a, h_b}^* \Gamma_{\tilde{A}_i^0, h_a, h_b} \\
& - 2 \sum_{a=1}^3 m_{\tilde{\chi}_a^-} \sum_{b=1}^3 B_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} \left(\Gamma_{\tilde{A}_j^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^R + \Gamma_{\tilde{A}_j^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{\chi}_b^-}^2) \left(\Gamma_{\tilde{A}_j^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^L + \Gamma_{\tilde{A}_j^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^R \right) \\
& - 6 \sum_{a=1}^3 m_{d_a} \sum_{b=1}^3 B_0(p^2, m_{d_a}^2, m_{d_b}^2) m_{d_b} \left(\Gamma_{\tilde{A}_j^0, \tilde{d}_a, d_b}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{d}_a, d_b}^R + \Gamma_{\tilde{A}_j^0, \tilde{d}_a, d_b}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{d}_a, d_b}^L \right) \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{d_a}^2, m_{d_b}^2) \left(\Gamma_{\tilde{A}_j^0, \tilde{d}_a, d_b}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{d}_a, d_b}^L + \Gamma_{\tilde{A}_j^0, \tilde{d}_a, d_b}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{d}_a, d_b}^R \right) \\
& - 2 \sum_{a=1}^3 m_{e_a} \sum_{b=1}^3 B_0(p^2, m_{e_a}^2, m_{e_b}^2) m_{e_b} \left(\Gamma_{\tilde{A}_j^0, \tilde{e}_a, e_b}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{e}_a, e_b}^R + \Gamma_{\tilde{A}_j^0, \tilde{e}_a, e_b}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{e}_a, e_b}^L \right)
\end{aligned}$$

$$\begin{aligned}
& + \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{e_a}^2, m_{e_b}^2) \left(\Gamma_{\tilde{A}_j^0, \tilde{e}_a, e_b}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{e}_a, e_b}^L + \Gamma_{\tilde{A}_j^0, \tilde{e}_a, e_b}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{e}_a, e_b}^R \right) \\
& - 6 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^3 B_0(p^2, m_{u_a}^2, m_{u_b}^2) m_{u_b} \left(\Gamma_{\tilde{A}_j^0, \tilde{u}_a, u_b}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{u}_a, u_b}^R + \Gamma_{\tilde{A}_j^0, \tilde{u}_a, u_b}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{u}_a, u_b}^L \right) \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{u_a}^2, m_{u_b}^2) \left(\Gamma_{\tilde{A}_j^0, \tilde{u}_a, u_b}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{u}_a, u_b}^L + \Gamma_{\tilde{A}_j^0, \tilde{u}_a, u_b}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{u}_a, u_b}^R \right) \\
& - \sum_{a=1}^4 A_0(m_{H_a^-}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, H_a^+, H_a^-} + \sum_{a=1}^4 \sum_{b=1}^4 B_0(p^2, m_{H_a^-}^2, m_{H_b^-}^2) \Gamma_{\tilde{A}_j^0, H_a^+, H_b^-}^* \Gamma_{\tilde{A}_i^0, H_a^+, H_b^-} \\
& - \sum_{a=1}^5 m_{\tilde{\chi}_a^0} \sum_{b=1}^5 B_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_b^0} \left(\Gamma_{\tilde{A}_j^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R + \Gamma_{\tilde{A}_j^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^L \right) \\
& + \frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^5 G_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2) \left(\Gamma_{\tilde{A}_j^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^L + \Gamma_{\tilde{A}_j^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R \right) \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, \tilde{d}_a^*, \tilde{d}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, \tilde{e}_a^*, \tilde{e}_a} \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, \tilde{u}_a^*, \tilde{u}_a} + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{d}_a}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{A}_j^0, \tilde{d}_a^*, \tilde{d}_b}^* \Gamma_{\tilde{A}_i^0, \tilde{d}_a^*, \tilde{d}_b} \\
& + \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{e}_a}^2, m_{\tilde{e}_b}^2) \Gamma_{\tilde{A}_j^0, \tilde{e}_a^*, \tilde{e}_b}^* \Gamma_{\tilde{A}_i^0, \tilde{e}_a^*, \tilde{e}_b} \\
& + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{u}_a}^2, m_{\tilde{u}_b}^2) \Gamma_{\tilde{A}_j^0, \tilde{u}_a^*, \tilde{u}_b}^* \Gamma_{\tilde{A}_i^0, \tilde{u}_a^*, \tilde{u}_b} + \sum_{b=1}^3 \Gamma_{\tilde{A}_j^0, Z, h_b}^* \Gamma_{\tilde{A}_i^0, Z, h_b} F_0(p^2, m_{h_b}^2, m_Z^2) \\
& + 2 \sum_{b=1}^4 \Gamma_{\tilde{A}_j^0, W^+, H_b^-}^* \Gamma_{\tilde{A}_i^0, W^+, H_b^-} F_0(p^2, m_{H_b^-}^2, m_{W^-}^2) \tag{177}
\end{aligned}$$

• Self-Energy for Charged Higgs (H^-)

$$\begin{aligned}
\Pi_{i,j}(p^2) = & +4 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, 0, m_{W^-}^2) \right) \Gamma_{\tilde{H}_j^+, W^-, \gamma}^* \Gamma_{\tilde{H}_i^+, W^-, \gamma} + 4 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{W^-}^2, m_Z^2) \right) \Gamma_{\tilde{H}_j^+, Z, W^-}^* \Gamma_{\tilde{H}_i^+, Z, W^-} \\
& - B_0(p^2, m_{\eta^Z}^2, m_{\eta^+}^2) \Gamma_{\tilde{H}_i^+, \eta^+, \eta^Z} \Gamma_{\tilde{H}_j^-, \eta^+, \eta^Z} - B_0(p^2, m_{\eta^-}^2, m_{\eta^Z}^2) \Gamma_{\tilde{H}_i^+, \eta^Z, \eta^-} \Gamma_{\tilde{H}_j^-, \eta^Z, \eta^-} \\
& + 4 \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, W^+, W^-} \left(-\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2 \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, Z, Z} \left(-\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) \\
& - \frac{1}{2} \sum_{a=1}^3 A_0(m_{A_a^0}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, A_a^0, A_a^0} - \sum_{a=1}^3 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \tilde{\nu}_a^*, \tilde{\nu}_a} \\
& - \frac{1}{2} \sum_{a=1}^3 A_0(m_{h_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, h_a, h_a}
\end{aligned}$$

$$\begin{aligned}
& -6 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^3 B_0(p^2, m_{u_a}^2, m_{d_b}^2) m_{d_b} \left(\Gamma_{\tilde{H}_j^+, \tilde{u}_a, d_b}^{L*} \Gamma_{\tilde{H}_i^+, \tilde{u}_a, d_b}^R + \Gamma_{\tilde{H}_j^+, \tilde{u}_a, d_b}^{R*} \Gamma_{\tilde{H}_i^+, \tilde{u}_a, d_b}^L \right) \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{u_a}^2, m_{d_b}^2) \left(\Gamma_{\tilde{H}_j^+, \tilde{u}_a, d_b}^{L*} \Gamma_{\tilde{H}_i^+, \tilde{u}_a, d_b}^L + \Gamma_{\tilde{H}_j^+, \tilde{u}_a, d_b}^{R*} \Gamma_{\tilde{H}_i^+, \tilde{u}_a, d_b}^R \right) \\
& - 2 \sum_{a=1}^3 m_{\nu_a} \sum_{b=1}^3 B_0(p^2, m_{\nu_a}^2, m_{e_b}^2) m_{e_b} \left(\Gamma_{\tilde{H}_j^+, \tilde{\nu}_a, e_b}^{L*} \Gamma_{\tilde{H}_i^+, \tilde{\nu}_a, e_b}^R + \Gamma_{\tilde{H}_j^+, \tilde{\nu}_a, e_b}^{R*} \Gamma_{\tilde{H}_i^+, \tilde{\nu}_a, e_b}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{\nu_a}^2, m_{e_b}^2) \left(\Gamma_{\tilde{H}_j^+, \tilde{\nu}_a, e_b}^{L*} \Gamma_{\tilde{H}_i^+, \tilde{\nu}_a, e_b}^L + \Gamma_{\tilde{H}_j^+, \tilde{\nu}_a, e_b}^{R*} \Gamma_{\tilde{H}_i^+, \tilde{\nu}_a, e_b}^R \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^6 B_0(p^2, m_{\nu_a}^2, m_{e_b}^2) \Gamma_{\tilde{H}_j^+, \tilde{\nu}_a^*, \tilde{e}_b}^* \Gamma_{\tilde{H}_i^+, \tilde{\nu}_a^*, \tilde{e}_b} - \sum_{a=1}^4 A_0(m_{H_a^-}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, H_a^+, H_a^-} \\
& + \sum_{a=1}^4 \sum_{b=1}^3 B_0(p^2, m_{H_a^-}^2, m_{A_b^0}^2) \Gamma_{\tilde{H}_j^+, H_a^-, A_b^0}^* \Gamma_{\tilde{H}_i^+, H_a^-, A_b^0} \\
& + \sum_{a=1}^4 \sum_{b=1}^3 B_0(p^2, m_{H_a^-}^2, m_{h_b}^2) \Gamma_{\tilde{H}_j^+, H_a^-, h_b}^* \Gamma_{\tilde{H}_i^+, H_a^-, h_b} \\
& - 2 \sum_{a=1}^5 m_{\tilde{\chi}_a^0} \sum_{b=1}^3 B_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} \left(\Gamma_{\tilde{H}_j^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{H}_i^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^R + \Gamma_{\tilde{H}_j^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{H}_i^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^L \right) \\
& + \sum_{a=1}^5 \sum_{b=1}^3 G_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^-}^2) \left(\Gamma_{\tilde{H}_j^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{H}_i^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^L + \Gamma_{\tilde{H}_j^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{H}_i^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^R \right) \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \tilde{d}_a^*, \tilde{d}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \tilde{e}_a^*, \tilde{e}_a} \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \tilde{u}_a^*, \tilde{u}_a} + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{u}_a}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{H}_j^+, \tilde{u}_a^*, \tilde{d}_b}^* \Gamma_{\tilde{H}_i^+, \tilde{u}_a^*, \tilde{d}_b} \\
& + \sum_{b=1}^3 \Gamma_{\tilde{H}_j^+, W^-, A_b^0}^* \Gamma_{\tilde{H}_i^+, W^-, A_b^0} F_0(p^2, m_{A_b^0}^2, m_{W^-}^2) + \sum_{b=1}^3 \Gamma_{\tilde{H}_j^+, W^-, h_b}^* \Gamma_{\tilde{H}_i^+, W^-, h_b} F_0(p^2, m_{h_b}^2, m_{W^-}^2) \\
& + \sum_{b=1}^4 \Gamma_{\tilde{H}_j^+, \gamma, H_b^-}^* \Gamma_{\tilde{H}_i^+, \gamma, H_b^-} F_0(p^2, m_{H_b^-}^2, 0) + \sum_{b=1}^4 \Gamma_{\tilde{H}_j^+, Z, H_b^-}^* \Gamma_{\tilde{H}_i^+, Z, H_b^-} F_0(p^2, m_{H_b^-}^2, m_Z^2) \tag{178}
\end{aligned}$$

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

$$\Sigma_{i,j}^S(p^2) = +2 \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{\nu_b}^2, m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{\nu}_a^*, \nu_b}^{L*} m_{\nu_b} \Gamma_{\tilde{\chi}_i^0, \tilde{\nu}_a^*, \nu_b}^R$$

$$\begin{aligned}
& + \sum_{a=1}^3 \sum_{b=1}^5 B_0 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{h_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, h_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^0, h_a, \tilde{\chi}_b^0}^R \\
& + 2 \sum_{a=1}^4 \sum_{b=1}^3 B_0 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{H_a^-}^2 \right) \Gamma_{\tilde{\chi}_j^0, H_a^+, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^0, H_a^+, \tilde{\chi}_b^-}^R \\
& + \sum_{a=1}^5 m_{\tilde{\chi}_a^0} \sum_{b=1}^3 B_0 \left(p^2, m_{\tilde{\chi}_a^0}^2, m_{A_b^0}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{\chi}_a^0, A_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{\chi}_a^0, A_b^0}^R \\
& + 6 \sum_{a=1}^6 \sum_{b=1}^3 B_0 \left(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{d}_a^*, d_b}^{L*} m_{d_b} \Gamma_{\tilde{\chi}_i^0, \tilde{d}_a^*, d_b}^R \\
& + 2 \sum_{a=1}^6 \sum_{b=1}^3 B_0 \left(p^2, m_{e_b}^2, m_{\tilde{e}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{e}_a^*, e_b}^{L*} m_{e_b} \Gamma_{\tilde{\chi}_i^0, \tilde{e}_a^*, e_b}^R \\
& + 6 \sum_{a=1}^6 \sum_{b=1}^3 B_0 \left(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{u}_a^*, u_b}^{L*} m_{u_b} \Gamma_{\tilde{\chi}_i^0, \tilde{u}_a^*, u_b}^R \\
& - 8 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{W^-}^2 \right) \right) \Gamma_{\tilde{\chi}_j^0, W^+, \tilde{\chi}_b^-}^{R*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^0, W^+, \tilde{\chi}_b^-}^L \\
& - 4 \sum_{b=1}^5 \left(-\frac{1}{2} \text{rMS} + B_0 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_Z^2 \right) \right) \Gamma_{\tilde{\chi}_j^0, Z, \tilde{\chi}_b^0}^{R*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^0, Z, \tilde{\chi}_b^0}^L \tag{179}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) = & - \sum_{a=1}^3 \sum_{b=1}^3 B_1 \left(p^2, m_{\nu_b}^2, m_{\tilde{\nu}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{\nu}_a^*, \nu_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{\nu}_a^*, \nu_b}^R \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^5 B_1 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{h_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, h_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, h_a, \tilde{\chi}_b^0}^R \\
& - \sum_{a=1}^4 \sum_{b=1}^3 B_1 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{H_a^-}^2 \right) \Gamma_{\tilde{\chi}_j^0, H_a^+, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^0, H_a^+, \tilde{\chi}_b^-}^R \\
& - \frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^3 B_1 \left(p^2, m_{\tilde{\chi}_a^0}^2, m_{A_b^0}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{\chi}_a^0, A_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{\chi}_a^0, A_b^0}^R \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1 \left(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{d}_a^*, d_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{d}_a^*, d_b}^R \\
& - \sum_{a=1}^6 \sum_{b=1}^3 B_1 \left(p^2, m_{e_b}^2, m_{\tilde{e}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{e}_a^*, e_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{e}_a^*, e_b}^R \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1 \left(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{u}_a^*, u_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{u}_a^*, u_b}^R
\end{aligned}$$

$$\begin{aligned}
& -2 \sum_{b=1}^3 B_1 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{W^-}^2 \right) \Gamma_{\tilde{\chi}_j^0, W^+, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^0, W^+, \tilde{\chi}_b^-}^L - \sum_{b=1}^5 B_1 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_Z^2 \right) \Gamma_{\tilde{\chi}_j^0, Z, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, Z, \tilde{\chi}_b^0}^L \quad (180) \\
\Sigma_{i,j}^L(p^2) = & - \sum_{a=1}^3 \sum_{b=1}^3 B_1 \left(p^2, m_{\nu_b}^2, m_{\tilde{\nu}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{\nu}_a^*, \nu_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{\nu}_a^*, \nu_b}^L \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^5 B_1 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{h_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, h_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, h_a, \tilde{\chi}_b^0}^L \\
& - \sum_{a=1}^4 \sum_{b=1}^3 B_1 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{H_a^-}^2 \right) \Gamma_{\tilde{\chi}_j^0, H_a^+, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^0, H_a^+, \tilde{\chi}_b^-}^L \\
& - \frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^3 B_1 \left(p^2, m_{\tilde{\chi}_a^0}^2, m_{A_b^0}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{\chi}_a^0, A_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{\chi}_a^0, A_b^0}^L \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1 \left(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{d}_a^*, d_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{d}_a^*, d_b}^L \\
& - \sum_{a=1}^6 \sum_{b=1}^3 B_1 \left(p^2, m_{e_b}^2, m_{\tilde{e}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{e}_a^*, e_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{e}_a^*, e_b}^L \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1 \left(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{u}_a^*, u_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{u}_a^*, u_b}^L \\
& - 2 \sum_{b=1}^3 B_1 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{W^-}^2 \right) \Gamma_{\tilde{\chi}_j^0, W^+, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^0, W^+, \tilde{\chi}_b^-}^R - \sum_{b=1}^5 B_1 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_Z^2 \right) \Gamma_{\tilde{\chi}_j^0, Z, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, Z, \tilde{\chi}_b^0}^R \quad (181)
\end{aligned}$$

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

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) = & + \sum_{a=1}^3 m_{\tilde{\chi}_a^-} \sum_{b=1}^3 B_0 \left(p^2, m_{\tilde{\chi}_a^-}^2, m_{A_b^0}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{\chi}_a^-, A_b^0}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{\chi}_a^-, A_b^0}^R \\
& + \sum_{a=1}^3 \sum_{b=1}^3 B_0 \left(p^2, m_{e_b}^2, m_{\tilde{\nu}_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{\nu}_a^*, e_b}^{L*} m_{e_b} \Gamma_{\tilde{\chi}_i^+, \tilde{\nu}_a^*, e_b}^R \\
& + \sum_{a=1}^3 \sum_{b=1}^3 B_0 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{h_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, h_a, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^+, h_a, \tilde{\chi}_b^-}^R \\
& + 3 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^6 B_0 \left(p^2, m_{u_a}^2, m_{d_b}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a, \tilde{d}_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a, \tilde{d}_b}^R \\
& + \sum_{a=1}^3 m_{\nu_a} \sum_{b=1}^6 B_0 \left(p^2, m_{\nu_a}^2, m_{\tilde{e}_b}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{\nu}_a, \tilde{e}_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{\nu}_a, \tilde{e}_b}^R
\end{aligned}$$

$$\begin{aligned}
& + \sum_{a=1}^4 \sum_{b=1}^5 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{H_a^-}^2) \Gamma_{\tilde{\chi}_j^+, H_a^-, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^+, H_a^-, \tilde{\chi}_b^0}^R \\
& + 3 \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{d_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a^*, d_b}^{L*} m_{d_b} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a^*, d_b}^R \\
& - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}_b^-}^2, 0) \right) \Gamma_{\tilde{\chi}_j^+, \gamma, \tilde{\chi}_b^-}^{R*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^+, \gamma, \tilde{\chi}_b^-}^L \\
& - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_Z^2) \right) \Gamma_{\tilde{\chi}_j^+, Z, \tilde{\chi}_b^-}^{R*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^+, Z, \tilde{\chi}_b^-}^L \\
& - 4 \sum_{b=1}^5 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{W^-}^2) \right) \Gamma_{\tilde{\chi}_j^+, W^-, \tilde{\chi}_b^0}^{R*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^+, W^-, \tilde{\chi}_b^0}^L \tag{182}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) &= -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{\tilde{\chi}_a^-}^2, m_{A_b^0}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{\chi}_a^-, A_b^0}^{R*} \Gamma_{\tilde{\chi}_i^+, \tilde{\chi}_a^-, A_b^0}^R \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{\nu}_a^*, e_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \tilde{\nu}_a^*, e_b}^R \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{h_a}^2) \Gamma_{\tilde{\chi}_j^+, h_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^+, h_a, \tilde{\chi}_b^-}^R \\
& - \frac{3}{2} \sum_{a=1}^3 \sum_{b=1}^6 B_1(p^2, m_{u_a}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a, \tilde{d}_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a, \tilde{d}_b}^R \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^6 B_1(p^2, m_{\nu_a}^2, m_{\tilde{e}_b}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{\nu}_a, \tilde{e}_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \tilde{\nu}_a, \tilde{e}_b}^R \\
& - \frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{H_a^-}^2) \Gamma_{\tilde{\chi}_j^+, H_a^-, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^+, H_a^-, \tilde{\chi}_b^0}^R \\
& - \frac{3}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a^*, d_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a^*, d_b}^R - \sum_{b=1}^3 B_1(p^2, m_{\tilde{\chi}_b^-}^2, 0) \Gamma_{\tilde{\chi}_j^+, \gamma, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^+, \gamma, \tilde{\chi}_b^-}^L \\
& - \sum_{b=1}^3 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_Z^2) \Gamma_{\tilde{\chi}_j^+, Z, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^+, Z, \tilde{\chi}_b^-}^L - \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{W^-}^2) \Gamma_{\tilde{\chi}_j^+, W^-, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^+, W^-, \tilde{\chi}_b^0}^L \tag{183}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) &= -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{\tilde{\chi}_a^-}^2, m_{A_b^0}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{\chi}_a^-, A_b^0}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{\chi}_a^-, A_b^0}^L \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{\nu}_a^*, e_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{\nu}_a^*, e_b}^L
\end{aligned}$$

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{h}_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, h_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^+, h_a, \tilde{\chi}_b^-}^L \\
& -\frac{3}{2} \sum_{a=1}^3 \sum_{b=1}^6 B_1 \left(p^2, m_{\tilde{u}_a}^2, m_{\tilde{d}_b}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a, \tilde{d}_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a, \tilde{d}_b}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^6 B_1 \left(p^2, m_{\tilde{\nu}_a}^2, m_{\tilde{e}_b}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{\nu}_a, \tilde{e}_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{\nu}_a, \tilde{e}_b}^L \\
& -\frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^5 B_1 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{H_a^-}^2 \right) \Gamma_{\tilde{\chi}_j^+, H_a^-, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^+, H_a^-, \tilde{\chi}_b^0}^L \\
& -\frac{3}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1 \left(p^2, m_{\tilde{d}_b}^2, m_{\tilde{u}_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a, \tilde{d}_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a, \tilde{d}_b}^L - \sum_{b=1}^3 B_1 \left(p^2, m_{\tilde{\chi}_b^-}^2, 0 \right) \Gamma_{\tilde{\chi}_j^+, \gamma, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^+, \gamma, \tilde{\chi}_b^-}^R \\
& - \sum_{b=1}^3 B_1 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_Z^2 \right) \Gamma_{\tilde{\chi}_j^+, Z, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^+, Z, \tilde{\chi}_b^-}^R - \sum_{b=1}^5 B_1 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{W^-}^2 \right) \Gamma_{\tilde{\chi}_j^+, W^-, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^+, W^-, \tilde{\chi}_b^0}^R \quad (184)
\end{aligned}$$

• Self-Energy for Leptons (e)

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) &= + \sum_{a=1}^3 m_{e_a} \sum_{b=1}^3 B_0 \left(p^2, m_{e_a}^2, m_{A_b^0}^2 \right) \Gamma_{\tilde{e}_j, e_a, A_b^0}^{L*} \Gamma_{\tilde{e}_i, e_a, A_b^0}^R \\
& + \sum_{a=1}^3 \sum_{b=1}^3 B_0 \left(p^2, m_{e_b}^2, m_{\tilde{h}_a}^2 \right) \Gamma_{\tilde{e}_j, h_a, e_b}^{L*} m_{e_b} \Gamma_{\tilde{e}_i, h_a, e_b}^R \\
& + \sum_{a=1}^3 \sum_{b=1}^3 B_0 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{\nu}_a}^2 \right) \Gamma_{\tilde{e}_j, \tilde{\nu}_a, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{e}_i, \tilde{\nu}_a, \tilde{\chi}_b^-}^R \\
& + \sum_{a=1}^4 \sum_{b=1}^3 B_0 \left(p^2, m_{\nu_b}^2, m_{H_a^-}^2 \right) \Gamma_{\tilde{e}_j, H_a^-, \nu_b}^{L*} m_{\nu_b} \Gamma_{\tilde{e}_i, H_a^-, \nu_b}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^5 B_0 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2 \right) \Gamma_{\tilde{e}_j, \tilde{e}_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{e}_i, \tilde{e}_a, \tilde{\chi}_b^0}^R \\
& - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0 \left(p^2, m_{e_b}^2, 0 \right) \right) \Gamma_{\tilde{e}_j, \gamma, e_b}^{R*} m_{e_b} \Gamma_{\tilde{e}_i, \gamma, e_b}^L \\
& - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0 \left(p^2, m_{\nu_b}^2, m_{W^-}^2 \right) \right) \Gamma_{\tilde{e}_j, W^-, \nu_b}^{R*} m_{\nu_b} \Gamma_{\tilde{e}_i, W^-, \nu_b}^L \\
& - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0 \left(p^2, m_{e_b}^2, m_Z^2 \right) \right) \Gamma_{\tilde{e}_j, Z, e_b}^{R*} m_{e_b} \Gamma_{\tilde{e}_i, Z, e_b}^L \quad (185)
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) = & -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{e_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{e}_j, e_a, A_b^0}^{R*} \Gamma_{\tilde{e}_i, e_a, A_b^0}^R \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{h_a}^2) \Gamma_{\tilde{e}_j, h_a, e_b}^{R*} \Gamma_{\tilde{e}_i, h_a, e_b}^R \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{e}_j, \tilde{\nu}_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{e}_i, \tilde{\nu}_a, \tilde{\chi}_b^-}^R \\
& -\frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^3 B_1(p^2, m_{\nu_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{e}_j, H_a^-, \nu_b}^{R*} \Gamma_{\tilde{e}_i, H_a^-, \nu_b}^R \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{e}_j, \tilde{e}_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{e}_i, \tilde{e}_a, \tilde{\chi}_b^0}^R - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, 0) \Gamma_{\tilde{e}_j, \gamma, e_b}^{L*} \Gamma_{\tilde{e}_i, \gamma, e_b}^L \\
& - \sum_{b=1}^3 B_1(p^2, m_{\nu_b}^2, m_{W^-}^2) \Gamma_{\tilde{e}_j, W^-, \nu_b}^{L*} \Gamma_{\tilde{e}_i, W^-, \nu_b}^L - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_Z^2) \Gamma_{\tilde{e}_j, Z, e_b}^{L*} \Gamma_{\tilde{e}_i, Z, e_b}^L \quad (186)
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) = & -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{e_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{e}_j, e_a, A_b^0}^{L*} \Gamma_{\tilde{e}_i, e_a, A_b^0}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{h_a}^2) \Gamma_{\tilde{e}_j, h_a, e_b}^{L*} \Gamma_{\tilde{e}_i, h_a, e_b}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{e}_j, \tilde{\nu}_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{e}_i, \tilde{\nu}_a, \tilde{\chi}_b^-}^L \\
& -\frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^3 B_1(p^2, m_{\nu_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{e}_j, H_a^-, \nu_b}^{L*} \Gamma_{\tilde{e}_i, H_a^-, \nu_b}^L \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{e}_j, \tilde{e}_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{e}_i, \tilde{e}_a, \tilde{\chi}_b^0}^L - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, 0) \Gamma_{\tilde{e}_j, \gamma, e_b}^{R*} \Gamma_{\tilde{e}_i, \gamma, e_b}^R \\
& - \sum_{b=1}^3 B_1(p^2, m_{\nu_b}^2, m_{W^-}^2) \Gamma_{\tilde{e}_j, W^-, \nu_b}^{R*} \Gamma_{\tilde{e}_i, W^-, \nu_b}^R - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_Z^2) \Gamma_{\tilde{e}_j, Z, e_b}^{R*} \Gamma_{\tilde{e}_i, Z, e_b}^R \quad (187)
\end{aligned}$$

• Self-Energy for Down-Quarks (d)

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) = & + \sum_{a=1}^3 m_{d_a} \sum_{b=1}^3 B_0(p^2, m_{d_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j, d_a, A_b^0}^{L*} \Gamma_{\tilde{d}_i, d_a, A_b^0}^R \\
& + \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{d_b}^2, m_{h_a}^2) \Gamma_{\tilde{d}_j, h_a, d_b}^{L*} m_{d_b} \Gamma_{\tilde{d}_i, h_a, d_b}^R
\end{aligned}$$

$$\begin{aligned}
& + \sum_{a=1}^4 \sum_{b=1}^3 B_0(p^2, m_{u_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{d}_j, H_a^-, u_b}^{L*} m_{u_b} \Gamma_{\tilde{d}_i, H_a^-, u_b}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_j, \tilde{u}_a, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{d}_i, \tilde{u}_a, \tilde{\chi}_b^-}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^5 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{\chi}_b^0}^R \\
& + \frac{4}{3} m_{\tilde{g}} \sum_{a=1}^6 B_0(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{g}_1}^R - \frac{16}{3} \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, 0) \right) \Gamma_{\tilde{d}_j, g, d_b}^{R*} m_{d_b} \Gamma_{\tilde{d}_i, g, d_b}^L \\
& - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, 0) \right) \Gamma_{\tilde{d}_j, \gamma, d_b}^{R*} m_{d_b} \Gamma_{\tilde{d}_i, \gamma, d_b}^L \\
& - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, m_{W^-}^2) \right) \Gamma_{\tilde{d}_j, W^-, u_b}^{R*} m_{u_b} \Gamma_{\tilde{d}_i, W^-, u_b}^L \\
& - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, m_Z^2) \right) \Gamma_{\tilde{d}_j, Z, d_b}^{R*} m_{d_b} \Gamma_{\tilde{d}_i, Z, d_b}^L \tag{188}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) & = -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{d_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j, d_a, A_b^0}^{R*} \Gamma_{\tilde{d}_i, d_a, A_b^0}^R \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{h_a}^2) \Gamma_{\tilde{d}_j, h_a, d_b}^{R*} \Gamma_{\tilde{d}_i, h_a, d_b}^R \\
& - \frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{d}_j, H_a^-, u_b}^{R*} \Gamma_{\tilde{d}_i, H_a^-, u_b}^R \\
& - \frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_j, \tilde{u}_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{d}_i, \tilde{u}_a, \tilde{\chi}_b^-}^R \\
& - \frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{\chi}_b^0}^R \\
& - \frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{g}_1}^{R*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{g}_1}^R - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, g, d_b}^{L*} \Gamma_{\tilde{d}_i, g, d_b}^L \\
& - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, \gamma, d_b}^{L*} \Gamma_{\tilde{d}_i, \gamma, d_b}^L - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{W^-}^2) \Gamma_{\tilde{d}_j, W^-, u_b}^{L*} \Gamma_{\tilde{d}_i, W^-, u_b}^L \\
& - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_Z^2) \Gamma_{\tilde{d}_j, Z, d_b}^{L*} \Gamma_{\tilde{d}_i, Z, d_b}^L \tag{189}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) = & -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{d_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j, d_a, A_b^0}^{L*} \Gamma_{\tilde{d}_i, d_a, A_b^0}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{h_a}^2) \Gamma_{\tilde{d}_j, h_a, d_b}^{L*} \Gamma_{\tilde{d}_i, h_a, d_b}^L \\
& -\frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{d}_j, H_a^-, u_b}^{L*} \Gamma_{\tilde{d}_i, H_a^-, u_b}^L \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_j, \tilde{u}_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{d}_i, \tilde{u}_a, \tilde{\chi}_b^-}^L \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{\chi}_b^0}^L \\
& -\frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{g}_1}^L - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, g, d_b}^{R*} \Gamma_{\tilde{d}_i, g, d_b}^R \\
& -\sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, \gamma, d_b}^{R*} \Gamma_{\tilde{d}_i, \gamma, d_b}^R - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{W^-}^2) \Gamma_{\tilde{d}_j, W^-, u_b}^{R*} \Gamma_{\tilde{d}_i, W^-, u_b}^R \\
& -\sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_Z^2) \Gamma_{\tilde{d}_j, Z, d_b}^{R*} \Gamma_{\tilde{d}_i, Z, d_b}^R
\end{aligned} \tag{190}$$

• Self-Energy for Up-Quarks (u)

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) = & + \sum_{a=1}^3 m_{u_a} \sum_{b=1}^3 B_0(p^2, m_{u_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{u}_j, u_a, A_b^0}^{L*} \Gamma_{\tilde{u}_i, u_a, A_b^0}^R \\
& + \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{u_b}^2, m_{h_a}^2) \Gamma_{\tilde{u}_j, h_a, u_b}^{L*} m_{u_b} \Gamma_{\tilde{u}_i, h_a, u_b}^R \\
& + \sum_{a=1}^3 m_{\tilde{\chi}_a^-} \sum_{b=1}^6 B_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{u}_j, \tilde{\chi}_a^+, \tilde{d}_b}^{L*} \Gamma_{\tilde{u}_i, \tilde{\chi}_a^+, \tilde{d}_b}^R \\
& + \sum_{a=1}^4 \sum_{b=1}^3 B_0(p^2, m_{d_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{u}_j, H_a^+, d_b}^{L*} m_{d_b} \Gamma_{\tilde{u}_i, H_a^+, d_b}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^5 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{\chi}_b^0}^R \\
& + \frac{4}{3} m_{\tilde{g}} \sum_{a=1}^6 B_0(p^2, m_{\tilde{g}}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{g}_1}^R - \frac{16}{3} \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, 0) \right) \Gamma_{\tilde{u}_j, g, u_b}^{R*} m_{u_b} \Gamma_{\tilde{u}_i, g, u_b}^L
\end{aligned}$$

$$\begin{aligned}
& -4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, 0) \right) \Gamma_{\tilde{u}_j, \gamma, u_b}^{R*} m_{u_b} \Gamma_{\tilde{u}_i, \gamma, u_b}^L - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, m_Z^2) \right) \Gamma_{\tilde{u}_j, Z, u_b}^{R*} m_{u_b} \Gamma_{\tilde{u}_i, Z, u_b}^L \\
& -4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, m_{W^-}^2) \right) \Gamma_{\tilde{u}_j, W^+, d_b}^{R*} m_{d_b} \Gamma_{\tilde{u}_i, W^+, d_b}^L \tag{191}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) &= -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{u_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{u}_j, u_a, A_b^0}^{R*} \Gamma_{\tilde{u}_i, u_a, A_b^0}^R \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{h_a}^2) \Gamma_{\tilde{u}_j, h_a, u_b}^{R*} \Gamma_{\tilde{u}_i, h_a, u_b}^R \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^6 B_1(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{u}_j, \tilde{\chi}_a^+, \tilde{d}_b}^{R*} \Gamma_{\tilde{u}_i, \tilde{\chi}_a^+, \tilde{d}_b}^R \\
& -\frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{u}_j, H_a^+, d_b}^{R*} \Gamma_{\tilde{u}_i, H_a^+, d_b}^R \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{\chi}_b^0}^R \\
& -\frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{g}_1}^{R*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{g}_1}^R - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, g, u_b}^{L*} \Gamma_{\tilde{u}_i, g, u_b}^L \\
& -\sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, \gamma, u_b}^{L*} \Gamma_{\tilde{u}_i, \gamma, u_b}^L - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_Z^2) \Gamma_{\tilde{u}_j, Z, u_b}^{L*} \Gamma_{\tilde{u}_i, Z, u_b}^L \\
& -\sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{W^-}^2) \Gamma_{\tilde{u}_j, W^+, d_b}^{L*} \Gamma_{\tilde{u}_i, W^+, d_b}^L \tag{192}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) &= -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{u_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{u}_j, u_a, A_b^0}^{L*} \Gamma_{\tilde{u}_i, u_a, A_b^0}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{h_a}^2) \Gamma_{\tilde{u}_j, h_a, u_b}^{L*} \Gamma_{\tilde{u}_i, h_a, u_b}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^6 B_1(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{u}_j, \tilde{\chi}_a^+, \tilde{d}_b}^{L*} \Gamma_{\tilde{u}_i, \tilde{\chi}_a^+, \tilde{d}_b}^L \\
& -\frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{u}_j, H_a^+, d_b}^{L*} \Gamma_{\tilde{u}_i, H_a^+, d_b}^L \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{\chi}_b^0}^L
\end{aligned}$$

$$\begin{aligned}
& -\frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{g}_1}^L - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, g, u_b}^{R*} \Gamma_{\tilde{u}_i, g, u_b}^R \\
& - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, \gamma, u_b}^{R*} \Gamma_{\tilde{u}_i, \gamma, u_b}^R - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_Z^2) \Gamma_{\tilde{u}_j, Z, u_b}^{R*} \Gamma_{\tilde{u}_i, Z, u_b}^R \\
& - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{W^-}^2) \Gamma_{\tilde{u}_j, W^+, d_b}^{R*} \Gamma_{\tilde{u}_i, W^+, d_b}^R
\end{aligned} \tag{193}$$

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

$$\begin{aligned}
\Sigma^S(p^2) &= + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{g}_j, \tilde{d}_a^*, d_b}^{L*} m_{d_b} \Gamma_{\tilde{g}_i, \tilde{d}_a^*, d_b}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{g}_j, \tilde{u}_a^*, u_b}^{L*} m_{u_b} \Gamma_{\tilde{g}_i, \tilde{u}_a^*, u_b}^R - 12 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{g}}^2, 0) \right) \Gamma_{\tilde{g}_j, g, \tilde{g}_1}^{R*} m_{\tilde{g}} \Gamma_{\tilde{g}_i, g, \tilde{g}_1}^L
\end{aligned} \tag{194}$$

$$\begin{aligned}
\Sigma^R(p^2) &= -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{g}_j, \tilde{d}_a^*, d_b}^{R*} \Gamma_{\tilde{g}_i, \tilde{d}_a^*, d_b}^R \\
& - \frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{g}_j, \tilde{u}_a^*, u_b}^{R*} \Gamma_{\tilde{g}_i, \tilde{u}_a^*, u_b}^R - 3B_1(p^2, m_{\tilde{g}}^2, 0) \Gamma_{\tilde{g}_j, g, \tilde{g}_1}^{L*} \Gamma_{\tilde{g}_i, g, \tilde{g}_1}^L
\end{aligned} \tag{195}$$

$$\begin{aligned}
\Sigma^L(p^2) &= -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{g}_j, \tilde{d}_a^*, d_b}^{L*} \Gamma_{\tilde{g}_i, \tilde{d}_a^*, d_b}^L \\
& - \frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{g}_j, \tilde{u}_a^*, u_b}^{L*} \Gamma_{\tilde{g}_i, \tilde{u}_a^*, u_b}^L - 3B_1(p^2, m_{\tilde{g}}^2, 0) \Gamma_{\tilde{g}_j, g, \tilde{g}_1}^{R*} \Gamma_{\tilde{g}_i, g, \tilde{g}_1}^R
\end{aligned} \tag{196}$$

• **Self-Energy for Z-Boson** (Z)

$$\begin{aligned}
\Pi(p^2) &= + |\Gamma_{Z, \eta^-, \eta^-}|^2 B_{00}(p^2, m_{\eta^-}^2, m_{\eta^-}^2) + |\Gamma_{Z, \eta^+, \eta^+}|^2 B_{00}(p^2, m_{\eta^+}^2, m_{\eta^+}^2) \\
& - |\Gamma_{Z, W^+, W^-}|^2 \left(10B_{00}(p^2, m_{W^-}^2, m_{W^-}^2) + 2A_0(m_{W^-}^2) - 2\text{rMS} \left(2m_{W^-}^2 - \frac{1}{3}p^2 \right) + B_0(p^2, m_{W^-}^2, m_{W^-}^2) (2m_{W^-}^2 + 4p^2) \right) \\
& + \frac{1}{2} \sum_{a=1}^3 A_0(m_{A_a^0}^2) \Gamma_{Z, Z, A_a^0, A_a^0} + \sum_{a=1}^3 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{Z, Z, \tilde{\nu}_a^*, \tilde{\nu}_a} + \frac{1}{2} \sum_{a=1}^3 A_0(m_{h_a}^2) \Gamma_{Z, Z, h_a, h_a} \\
& - 4 \sum_{a=1}^3 \sum_{b=1}^3 |\Gamma_{Z, h_a, A_b^0}|^2 B_{00}(p^2, m_{A_b^0}^2, m_{h_a}^2) - 4 \sum_{a=1}^3 \sum_{b=1}^3 |\Gamma_{Z, \tilde{\nu}_a^*, \tilde{\nu}_b}|^2 B_{00}(p^2, m_{\tilde{\nu}_a}^2, m_{\tilde{\nu}_b}^2) \\
& + \sum_{a=1}^3 \sum_{b=1}^3 \left[(|\Gamma_{Z, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^L|^2 + |\Gamma_{Z, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^R|^2) H_0(p^2, m_{\tilde{\chi}_a}^2, m_{\tilde{\chi}_b}^2) \right]
\end{aligned}$$

$$\begin{aligned}
& + 4B_0 \left(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{\chi}_b^-}^2 \right) m_{\tilde{\chi}_a^-} m_{\tilde{\chi}_b^-} \Re \left(\Gamma_{Z, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{L*} \Gamma_{Z, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^R \right) \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 \left[\left(|\Gamma_{Z, \tilde{d}_a, d_b}^L|^2 + |\Gamma_{Z, \tilde{d}_a, d_b}^R|^2 \right) H_0 \left(p^2, m_{d_a}^2, m_{d_b}^2 \right) \right. \\
& + 4B_0 \left(p^2, m_{d_a}^2, m_{d_b}^2 \right) m_{d_a} m_{d_b} \Re \left(\Gamma_{Z, \tilde{d}_a, d_b}^{L*} \Gamma_{Z, \tilde{d}_a, d_b}^R \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^3 \left[\left(|\Gamma_{Z, \tilde{e}_a, e_b}^L|^2 + |\Gamma_{Z, \tilde{e}_a, e_b}^R|^2 \right) H_0 \left(p^2, m_{e_a}^2, m_{e_b}^2 \right) \right. \\
& + 4B_0 \left(p^2, m_{e_a}^2, m_{e_b}^2 \right) m_{e_a} m_{e_b} \Re \left(\Gamma_{Z, \tilde{e}_a, e_b}^{L*} \Gamma_{Z, \tilde{e}_a, e_b}^R \right) \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 \left[\left(|\Gamma_{Z, \tilde{u}_a, u_b}^L|^2 + |\Gamma_{Z, \tilde{u}_a, u_b}^R|^2 \right) H_0 \left(p^2, m_{u_a}^2, m_{u_b}^2 \right) \right. \\
& + 4B_0 \left(p^2, m_{u_a}^2, m_{u_b}^2 \right) m_{u_a} m_{u_b} \Re \left(\Gamma_{Z, \tilde{u}_a, u_b}^{L*} \Gamma_{Z, \tilde{u}_a, u_b}^R \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^3 \left[\left(|\Gamma_{Z, \tilde{\nu}_a, \nu_b}^L|^2 + |\Gamma_{Z, \tilde{\nu}_a, \nu_b}^R|^2 \right) H_0 \left(p^2, m_{\nu_a}^2, m_{\nu_b}^2 \right) \right. \\
& + 4B_0 \left(p^2, m_{\nu_a}^2, m_{\nu_b}^2 \right) m_{\nu_a} m_{\nu_b} \Re \left(\Gamma_{Z, \tilde{\nu}_a, \nu_b}^{L*} \Gamma_{Z, \tilde{\nu}_a, \nu_b}^R \right) \\
& + \sum_{a=1}^4 A_0 \left(m_{H_a^-}^2 \right) \Gamma_{Z, Z, H_a^+, H_a^-} - 4 \sum_{a=1}^4 \sum_{b=1}^4 |\Gamma_{Z, H_a^+, H_b^-}|^2 B_{00} \left(p^2, m_{H_a^-}^2, m_{H_b^-}^2 \right) \\
& + \frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^5 \left[\left(|\Gamma_{Z, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^L|^2 + |\Gamma_{Z, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R|^2 \right) H_0 \left(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2 \right) \right. \\
& + 4B_0 \left(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2 \right) m_{\tilde{\chi}_a^0} m_{\tilde{\chi}_b^0} \Re \left(\Gamma_{Z, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{L*} \Gamma_{Z, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R \right) \\
& + 3 \sum_{a=1}^6 A_0 \left(m_{\tilde{d}_a}^2 \right) \Gamma_{Z, Z, \tilde{d}_a^*, \tilde{d}_a} + \sum_{a=1}^6 A_0 \left(m_{\tilde{e}_a}^2 \right) \Gamma_{Z, Z, \tilde{e}_a^*, \tilde{e}_a} + 3 \sum_{a=1}^6 A_0 \left(m_{\tilde{u}_a}^2 \right) \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} \left(p^2, m_{\tilde{d}_a}^2, m_{\tilde{d}_b}^2 \right) - 4 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z, \tilde{e}_a^*, \tilde{e}_b}|^2 B_{00} \left(p^2, m_{\tilde{e}_a}^2, m_{\tilde{e}_b}^2 \right) \\
& - 12 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z, \tilde{u}_a^*, \tilde{u}_b}|^2 B_{00} \left(p^2, m_{\tilde{u}_a}^2, m_{\tilde{u}_b}^2 \right) + \sum_{b=1}^3 |\Gamma_{Z, Z, h_b}|^2 B_0 \left(p^2, m_Z^2, m_{h_b}^2 \right) \\
& + 2 \sum_{b=1}^4 |\Gamma_{Z, W^+, H_b^-}|^2 B_0 \left(p^2, m_{W^-}^2, m_{H_b^-}^2 \right) + 2 \text{rMS} m_{W^-}^2 \Gamma_{Z, Z, W^+, W^-}^1 - A_0 \left(m_{W^-}^2 \right) \left(4\Gamma_{Z, Z, W^+, W^-}^1 + \Gamma_{Z, Z, W^+, W^-}^2 + \Gamma_{Z, Z, W^+, W^-}^3 \right)
\end{aligned} \tag{197}$$

• Self-Energy for W-Boson (W^-)

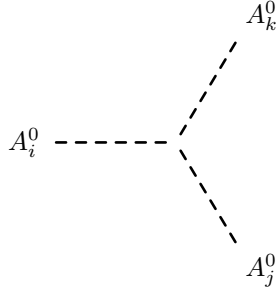
$$\begin{aligned}
\Pi(p^2) = & -12 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{W^+, \tilde{u}_a^*, \tilde{d}_b}|^2 B_{00}(p^2, m_{\tilde{d}_b}^2, m_{\tilde{u}_a}^2) + 2\text{rMS}m_{W^-}^2 \Gamma_{W^-, W^+, W^+, W^-}^1 + 3 \sum_{a=1}^3 \sum_{b=1}^3 \left[(|\Gamma_{W^+, \tilde{u}_a, \tilde{d}_b}^L|^2 + |\Gamma_{W^+, \tilde{u}_a, \tilde{d}_b}^R|^2) \right. \\
& + 4B_0(p^2, m_{\tilde{u}_a}^2, m_{\tilde{d}_b}^2) m_{\tilde{d}_b} m_{\tilde{u}_a} \Re(\Gamma_{W^+, \tilde{u}_a, \tilde{d}_b}^{L*} \Gamma_{W^+, \tilde{u}_a, \tilde{d}_b}^R) \left. \right] + 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{W^-, W^+, \tilde{d}_a^*, \tilde{d}_a} + 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{W^-, W^+, \tilde{u}_a^*, \tilde{u}_a} \\
& + 4B_0(p^2, m_{\tilde{\nu}_a}^2, m_{\tilde{e}_b}^2) m_{\tilde{e}_b} m_{\tilde{\nu}_a} \Re(\Gamma_{W^+, \tilde{\nu}_a, \tilde{e}_b}^{L*} \Gamma_{W^+, \tilde{\nu}_a, \tilde{e}_b}^R) + \sum_{a=1}^4 A_0(m_{H_a^-}^2) \Gamma_{W^-, W^+, H_a^+, H_a^-} + \sum_{a=1}^5 \sum_{b=1}^3 \left[(|\Gamma_{W^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}|^2 + |\Gamma_{W^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^R|^2) \right. \\
& \left. + 4B_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} m_{\tilde{\chi}_a^0} \Re(\Gamma_{W^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^{L*} \Gamma_{W^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^R) \right] + \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{W^-, W^+, \tilde{e}_a^*, \tilde{e}_a} + \sum_{b=1}^3 |\Gamma_{W^+, W^-, \tilde{h}_b}|^2 B_0(p^2, m_{W^-}^2)
\end{aligned} \tag{198}$$

8.2 Tadpoles

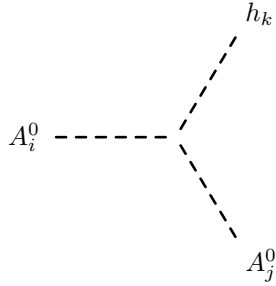
$$\begin{aligned}
\delta t_h^{(1)} = & + A_0(m_{\eta^-}^2) \Gamma_{\tilde{h}_i, \eta^-, \eta^-} + A_0(m_{\eta^+}^2) \Gamma_{\tilde{h}_i, \eta^+, \eta^+} + A_0(m_{\eta^Z}^2) \Gamma_{\tilde{h}_i, \eta^Z, \eta^Z} \\
& + 4\Gamma_{\tilde{h}_i, W^+, W^-} \left(-\frac{1}{2} \text{rMS}m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2\Gamma_{\tilde{h}_i, Z, Z} \left(-\frac{1}{2} \text{rMS}m_Z^2 + A_0(m_Z^2) \right) - \frac{1}{2} \sum_{a=1}^3 A_0(m_{A_a^0}^2) \Gamma_{\tilde{h}_i, A_a^0, A_a^0} \\
& - \sum_{a=1}^3 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{h}_i, \tilde{\nu}_a^*, \tilde{\nu}_a} - \frac{1}{2} \sum_{a=1}^3 A_0(m_{\tilde{h}_a}^2) \Gamma_{\tilde{h}_i, \tilde{h}_a, \tilde{h}_a} \\
& + 2 \sum_{a=1}^3 A_0(m_{\tilde{\chi}_a^-}^2) m_{\tilde{\chi}_a^-} \left(\Gamma_{\tilde{h}_i, \tilde{\chi}_a^+, \tilde{\chi}_a^-}^L + \Gamma_{\tilde{h}_i, \tilde{\chi}_a^+, \tilde{\chi}_a^-}^R \right) \\
& + 6 \sum_{a=1}^3 A_0(m_{\tilde{d}_a}^2) m_{\tilde{d}_a} \left(\Gamma_{\tilde{h}_i, \tilde{d}_a, \tilde{d}_a}^L + \Gamma_{\tilde{h}_i, \tilde{d}_a, \tilde{d}_a}^R \right) \\
& + 2 \sum_{a=1}^3 A_0(m_{\tilde{e}_a}^2) m_{\tilde{e}_a} \left(\Gamma_{\tilde{h}_i, \tilde{e}_a, \tilde{e}_a}^L + \Gamma_{\tilde{h}_i, \tilde{e}_a, \tilde{e}_a}^R \right) \\
& + 6 \sum_{a=1}^3 A_0(m_{\tilde{u}_a}^2) m_{\tilde{u}_a} \left(\Gamma_{\tilde{h}_i, \tilde{u}_a, \tilde{u}_a}^L + \Gamma_{\tilde{h}_i, \tilde{u}_a, \tilde{u}_a}^R \right) - \sum_{a=1}^4 A_0(m_{H_a^-}^2) \Gamma_{\tilde{h}_i, H_a^+, H_a^-} \\
& + \sum_{a=1}^5 A_0(m_{\tilde{\chi}_a^0}^2) m_{\tilde{\chi}_a^0} \left(\Gamma_{\tilde{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_a^0}^L + \Gamma_{\tilde{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_a^0}^R \right) - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{h}_i, \tilde{d}_a^*, \tilde{d}_a} \\
& - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{h}_i, \tilde{e}_a^*, \tilde{e}_a} - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{h}_i, \tilde{u}_a^*, \tilde{u}_a}
\end{aligned} \tag{199}$$

9 Interactions for eigenstates 'EWSB'

9.1 Three Scalar-Interaction

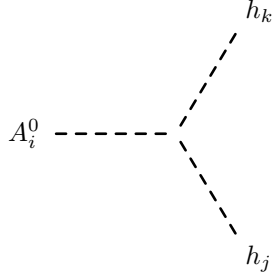


$$\begin{aligned}
& \frac{1}{4} \left(- \left(2\lambda M_T^* - T_\lambda + T_\lambda^* \right) \left(Z_{i1}^A \left(Z_{j2}^A Z_{k3}^A + Z_{j3}^A Z_{k2}^A \right) + Z_{i2}^A \left(Z_{j1}^A Z_{k3}^A + Z_{j3}^A Z_{k1}^A \right) + Z_{i3}^A \left(Z_{j1}^A Z_{k2}^A + Z_{j2}^A Z_{k1}^A \right) \right) \right. \\
& + 2\lambda \mu^* \left(Z_{i1}^A \left(Z_{j1}^A Z_{k3}^A + Z_{j3}^A Z_{k1}^A \right) + Z_{i2}^A \left(Z_{j2}^A Z_{k3}^A + Z_{j3}^A Z_{k2}^A \right) + Z_{i3}^A \left(Z_{j1}^A Z_{k1}^A + Z_{j2}^A Z_{k2}^A \right) \right) \\
& - 2\lambda^* \left(Z_{i3}^A \left(Z_{j1}^A \left(-M_T Z_{k2}^A + \mu Z_{k1}^A \right) + Z_{j2}^A \left(-M_T Z_{k1}^A + \mu Z_{k2}^A \right) \right) \right. \\
& + Z_{i1}^A \left(\left(-M_T Z_{j2}^A + \mu Z_{j1}^A \right) Z_{k3}^A + Z_{j3}^A \left(-M_T Z_{k2}^A + \mu Z_{k1}^A \right) \right) \\
& \left. + Z_{i2}^A \left(\left(-M_T Z_{j1}^A + \mu Z_{j2}^A \right) Z_{k3}^A + Z_{j3}^A \left(-M_T Z_{k1}^A + \mu Z_{k2}^A \right) \right) \right) \right) \quad (200)
\end{aligned}$$

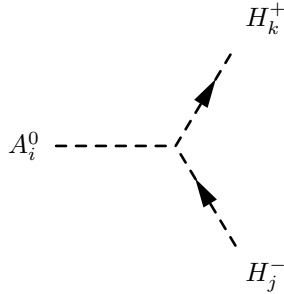


$$\begin{aligned}
& - \frac{i}{4} \left(Z_{i3}^A \left(-2\lambda M_T^* \left(Z_{j1}^A Z_{k2}^H + Z_{j2}^A Z_{k1}^H \right) + \left(T_\lambda^* + T_\lambda \right) \left(Z_{j1}^A Z_{k2}^H + Z_{j2}^A Z_{k1}^H \right) \right) \right. \\
& - 2\lambda^* \left(-\lambda Z_{j3}^A \left(v_d Z_{k1}^H + v_u Z_{k2}^H \right) + M_T Z_{j1}^A Z_{k2}^H + M_T Z_{j2}^A Z_{k1}^H \right) \\
& + Z_{i2}^A \left(-2\lambda M_T^* Z_{j3}^A Z_{k1}^H - 2M_T \lambda^* Z_{j3}^A Z_{k1}^H + T_\lambda^* Z_{j3}^A Z_{k1}^H + T_\lambda Z_{j3}^A Z_{k1}^H + 2\lambda M_T^* Z_{j1}^A Z_{k3}^H \right. \\
& + 2M_T \lambda^* Z_{j1}^A Z_{k3}^H + T_\lambda^* Z_{j1}^A Z_{k3}^H + T_\lambda Z_{j1}^A Z_{k3}^H \\
& + Z_{j2}^A \left(2 \left(\lambda \mu^* + \left(v_T \lambda + \mu \right) \lambda^* \right) Z_{k3}^H + \left(g_1^2 + g_2^2 \right) v_u Z_{k2}^H - v_d \left(-2|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k1}^H \right) \\
& \left. + Z_{i1}^A \left(-2\lambda M_T^* Z_{j3}^A Z_{k2}^H - 2M_T \lambda^* Z_{j3}^A Z_{k2}^H + T_\lambda^* Z_{j3}^A Z_{k2}^H + T_\lambda Z_{j3}^A Z_{k2}^H + 2\lambda M_T^* Z_{j2}^A Z_{k3}^H \right) \right)
\end{aligned}$$

$$\begin{aligned}
& + 2M_T \lambda^* Z_{j2}^A Z_{k3}^H + T_\lambda^* Z_{j2}^A Z_{k3}^H + T_\lambda Z_{j2}^A Z_{k3}^H \\
& + Z_{j1}^A \left(2 \left(\lambda \mu^* + (v_T \lambda + \mu) \lambda^* \right) Z_{k3}^H + (g_1^2 + g_2^2) v_d Z_{k1}^H - v_u \left(-2|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k2}^H \right) \Big) \Big) \quad (201)
\end{aligned}$$

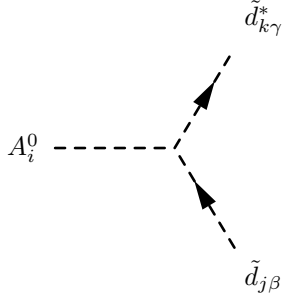


$$\begin{aligned}
& \frac{1}{4} \left(2\lambda M_T^* Z_{i3}^A Z_{j2}^H Z_{k1}^H + T_\lambda^* Z_{i3}^A Z_{j2}^H Z_{k1}^H - T_\lambda Z_{i3}^A Z_{j2}^H Z_{k1}^H - 2\lambda M_T^* Z_{i2}^A Z_{j3}^H Z_{k1}^H \right. \\
& + T_\lambda^* Z_{i2}^A Z_{j3}^H Z_{k1}^H - T_\lambda Z_{i2}^A Z_{j3}^H Z_{k1}^H + 2\lambda M_T^* Z_{i3}^A Z_{j1}^H Z_{k2}^H + T_\lambda^* Z_{i3}^A Z_{j1}^H Z_{k2}^H \\
& - T_\lambda Z_{i3}^A Z_{j1}^H Z_{k2}^H - 2\lambda M_T^* Z_{i1}^A Z_{j3}^H Z_{k2}^H + T_\lambda^* Z_{i1}^A Z_{j3}^H Z_{k2}^H - T_\lambda Z_{i1}^A Z_{j3}^H Z_{k2}^H \\
& + 2\lambda \mu^* Z_{i3}^A \left(Z_{j1}^H Z_{k1}^H + Z_{j2}^H Z_{k2}^H \right) - 2\lambda M_T^* Z_{i2}^A Z_{j1}^H Z_{k3}^H + T_\lambda^* Z_{i2}^A Z_{j1}^H Z_{k3}^H \\
& - T_\lambda Z_{i2}^A Z_{j1}^H Z_{k3}^H - 2\lambda M_T^* Z_{i1}^A Z_{j2}^H Z_{k3}^H + T_\lambda^* Z_{i1}^A Z_{j2}^H Z_{k3}^H - T_\lambda Z_{i1}^A Z_{j2}^H Z_{k3}^H \\
& - 2\lambda^* \left(Z_{i3}^A \left(Z_{j1}^H \left(M_T Z_{k2}^H + \mu Z_{k1}^H \right) + Z_{j2}^H \left(M_T Z_{k1}^H + \mu Z_{k2}^H \right) \right) \right. \\
& \left. - M_T \left(Z_{i1}^A \left(Z_{j2}^H Z_{k3}^H + Z_{j3}^H Z_{k2}^H \right) + Z_{i2}^A \left(Z_{j1}^H Z_{k3}^H + Z_{j3}^H Z_{k1}^H \right) \right) \right) \Big) \Big) \quad (202)
\end{aligned}$$

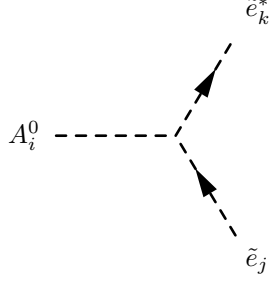


$$\begin{aligned}
& \frac{1}{4} \left(g_2^2 v_u Z_{i1}^A Z_{j2}^+ Z_{k1}^+ + g_2^2 v_d Z_{i2}^A Z_{j2}^+ Z_{k1}^+ + 2T_\lambda^* Z_{i3}^A Z_{j2}^+ Z_{k1}^+ \right. \\
& + \sqrt{2} g_2^2 v_T Z_{i1}^A Z_{j3}^+ Z_{k1}^+ - \sqrt{2} g_2^2 v_d Z_{i3}^A Z_{j3}^+ Z_{k1}^+ - \sqrt{2} g_2^2 v_T Z_{i1}^A Z_{j4}^+ Z_{k1}^+ \\
& + 2\sqrt{2} T_\lambda^* Z_{i2}^A Z_{j4}^+ Z_{k1}^+ - \sqrt{2} g_2^2 v_d Z_{i3}^A Z_{j4}^+ Z_{k1}^+ - g_2^2 v_u Z_{i1}^A Z_{j1}^+ Z_{k2}^+ \\
& \left. - g_2^2 v_d Z_{i2}^A Z_{j1}^+ Z_{k2}^+ + 4\lambda M_T^* Z_{i3}^A Z_{j1}^+ Z_{k2}^+ - 2T_\lambda Z_{i3}^A Z_{j1}^+ Z_{k2}^+ \right)
\end{aligned}$$

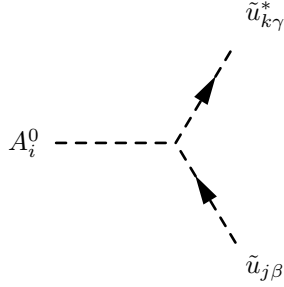
$$\begin{aligned}
& + 2\sqrt{2}T_\lambda Z_{i1}^A Z_{j3}^+ Z_{k2}^+ - \sqrt{2}g_2^2 v_T Z_{i2}^A Z_{j3}^+ Z_{k2}^+ - \sqrt{2}g_2^2 v_u Z_{i3}^A Z_{j3}^+ Z_{k2}^+ \\
& + 4\sqrt{2}\lambda M_T^* Z_{i1}^A Z_{j4}^+ Z_{k2}^+ + \sqrt{2}g_2^2 v_T Z_{i2}^A Z_{j4}^+ Z_{k2}^+ - \sqrt{2}g_2^2 v_u Z_{i3}^A Z_{j4}^+ Z_{k2}^+ \\
& - \sqrt{2}g_2^2 v_T Z_{i1}^A Z_{j1}^+ Z_{k3}^+ - 4\sqrt{2}\lambda M_T^* Z_{i2}^A Z_{j1}^+ Z_{k3}^+ + \sqrt{2}g_2^2 v_d Z_{i3}^A Z_{j1}^+ Z_{k3}^+ \\
& - 2\sqrt{2}T_\lambda^* Z_{i1}^A Z_{j2}^+ Z_{k3}^+ + \sqrt{2}g_2^2 v_T Z_{i2}^A Z_{j2}^+ Z_{k3}^+ + \sqrt{2}g_2^2 v_u Z_{i3}^A Z_{j2}^+ Z_{k3}^+ \\
& - 4g_2^2 v_T Z_{i3}^A Z_{j4}^+ Z_{k3}^+ + \sqrt{2}g_2^2 v_T Z_{i1}^A Z_{j1}^+ Z_{k4}^+ - 2\sqrt{2}T_\lambda Z_{i2}^A Z_{j1}^+ Z_{k4}^+ \\
& + \sqrt{2}g_2^2 v_d Z_{i3}^A Z_{j1}^+ Z_{k4}^+ - \sqrt{2}g_2^2 v_T Z_{i2}^A Z_{j2}^+ Z_{k4}^+ + \sqrt{2}g_2^2 v_u Z_{i3}^A Z_{j2}^+ Z_{k4}^+ \\
& + 4g_2^2 v_T Z_{i3}^A Z_{j3}^+ Z_{k4}^+ \\
& - 2\lambda\mu^* \left(\sqrt{2} \left(Z_{j1}^+ Z_{k4}^+ - Z_{j3}^+ Z_{k1}^+ \right) + Z_{i2}^A \left(Z_{j2}^+ Z_{k4}^+ - Z_{j3}^+ Z_{k2}^+ \right) \right) + Z_{i3}^A \left(Z_{j1}^+ Z_{k1}^+ + Z_{j2}^+ Z_{k2}^+ \right) \\
& + \lambda^* \left(Z_{i1}^A \left(-\sqrt{2}v_T \lambda Z_{j3}^+ Z_{k1}^+ + \sqrt{2}v_T \lambda Z_{j4}^+ Z_{k1}^+ + 2\sqrt{2}\mu Z_{j4}^+ Z_{k1}^+ - v_u \lambda Z_{j1}^+ Z_{k2}^+ \right. \right. \\
& \left. \left. + \sqrt{2}v_T \lambda Z_{j1}^+ Z_{k3}^+ - 2\sqrt{2}\mu Z_{j1}^+ Z_{k3}^+ - \sqrt{2}v_T \lambda Z_{j1}^+ Z_{k4}^+ + Z_{j2}^+ \left(-4\sqrt{2}M_T Z_{k4}^+ + v_u \lambda Z_{k1}^+ \right) \right) \right) \\
& + Z_{i3}^A \left(\sqrt{2}\lambda \left(Z_{j3}^+ + Z_{j4}^+ \right) \left(v_d Z_{k1}^+ + v_u Z_{k2}^+ \right) + Z_{j1}^+ \left(2\mu Z_{k1}^+ - \sqrt{2}v_d \lambda \left(Z_{k3}^+ + Z_{k4}^+ \right) \right) \right) \\
& - Z_{j2}^+ \left(-2\mu Z_{k2}^+ + 4M_T Z_{k1}^+ + \sqrt{2}v_u \lambda \left(Z_{k3}^+ + Z_{k4}^+ \right) \right) \\
& + Z_{i2}^A \left(- \left(\sqrt{2} \left(-2\mu + v_T \lambda \right) Z_{j4}^+ + v_d \lambda Z_{j1}^+ \right) Z_{k2}^+ + \sqrt{2}Z_{j3}^+ \left(4M_T Z_{k1}^+ + v_T \lambda Z_{k2}^+ \right) \right. \\
& \left. + Z_{j2}^+ \left(\sqrt{2} \left(- \left(2\mu + v_T \lambda \right) Z_{k3}^+ + v_T \lambda Z_{k4}^+ \right) + v_d \lambda Z_{k1}^+ \right) \right) \Big) \tag{203}
\end{aligned}$$



$$\begin{aligned}
& \frac{1}{2} \frac{1}{\sqrt{2}} \delta_{\beta\gamma} \left(2 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Z_{k3+a}^D T_{d,ab} Z_{i1}^A - 2 \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{D,*} T_{d,ab}^* Z_{kb}^D Z_{i1}^A \right. \\
& + v_T \lambda^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D Z_{i2}^A + 2\mu^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D Z_{i2}^A \\
& - v_T \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{kb}^D Z_{i2}^A - 2\mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{kb}^D Z_{i2}^A \\
& \left. + v_u \lambda^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D Z_{i3}^A - v_u \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{kb}^D Z_{i3}^A \right) \tag{204}
\end{aligned}$$

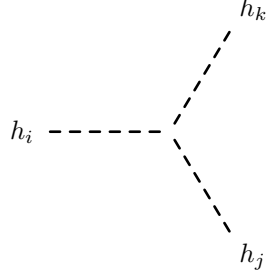


$$\begin{aligned}
& \frac{1}{2} \frac{1}{\sqrt{2}} \left(2 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Z_{k3+a}^E T_{e,ab} Z_{i1}^A - 2 \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{E,*} T_{e,ab}^* Z_{kb}^E Z_{i1}^A \right. \\
& + v_T \lambda^* \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E Z_{i2}^A + 2\mu^* \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E Z_{i2}^A \\
& - v_T \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{kb}^E Z_{i2}^A - 2\mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{kb}^E Z_{i2}^A \\
& \left. + v_u \lambda^* \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E Z_{i3}^A - v_u \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{kb}^E Z_{i3}^A \right) \quad (205)
\end{aligned}$$

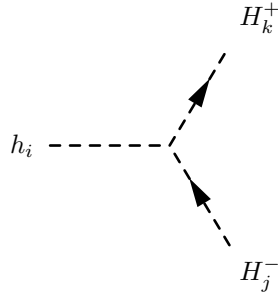


$$\begin{aligned}
& \frac{1}{2} \frac{1}{\sqrt{2}} \delta_{\beta\gamma} \left(2\mu^* \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U Z_{i1}^A - v_T \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{j3+a}^{U,*} Z_{kb}^U Z_{i1}^A \right. \\
& - 2\mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{j3+a}^{U,*}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

$$+ \lambda^* \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U \left(v_d Z_{i3}^A + v_T Z_{i1}^A \right) \quad (206)$$

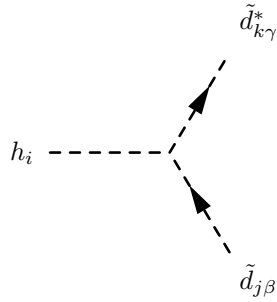


$$\begin{aligned}
& - \frac{i}{4} \left(Z_{i1}^H \left(Z_{j1}^H \left(2 \left(\lambda \mu^* + (v_T \lambda + \mu) \lambda^* \right) Z_{k3}^H + 3 \left(g_1^2 + g_2^2 \right) v_d Z_{k1}^H - v_u \left(-2|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k2}^H \right) \right. \right. \\
& - Z_{j2}^H \left(\left(2\lambda M_T^* + 2M_T \lambda^* + T_\lambda^* + T_\lambda \right) Z_{k3}^H + v_d \left(-2|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k2}^H + v_u \left(-2|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k1}^H \right) \\
& + Z_{j3}^H \left(- \left(2\lambda M_T^* + T_\lambda^* + T_\lambda \right) Z_{k2}^H + 2\lambda^* \left(-M_T Z_{k2}^H + v_d \lambda Z_{k3}^H + (v_T \lambda + \mu) Z_{k1}^H \right) + 2\lambda \mu^* Z_{k1}^H \right) \left. \right) \\
& - Z_{i2}^H \left(Z_{j2}^H \left(-2 \left(\lambda \mu^* + (v_T \lambda + \mu) \lambda^* \right) Z_{k3}^H - 3 \left(g_1^2 + g_2^2 \right) v_u Z_{k2}^H + v_d \left(-2|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k1}^H \right) \right. \\
& + Z_{j1}^H \left(\left(2\lambda M_T^* + 2M_T \lambda^* + T_\lambda^* + T_\lambda \right) Z_{k3}^H + v_d \left(-2|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k2}^H + v_u \left(-2|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k1}^H \right) \\
& + Z_{j3}^H \left(2\lambda M_T^* Z_{k1}^H + 2\lambda^* \left(M_T Z_{k1}^H - (v_T \lambda + \mu) Z_{k2}^H - v_u \lambda Z_{k3}^H \right) - 2\lambda \mu^* Z_{k2}^H + T_\lambda^* Z_{k1}^H + T_\lambda Z_{k1}^H \right) \left. \right) \\
& + Z_{i3}^H \left(- \left(2\lambda M_T^* + T_\lambda^* + T_\lambda \right) \left(Z_{j1}^H Z_{k2}^H + Z_{j2}^H Z_{k1}^H \right) + 2\lambda \mu^* \left(Z_{j1}^H Z_{k1}^H + Z_{j2}^H Z_{k2}^H \right) \right. \\
& + 2\lambda^* \left(\lambda Z_{j3}^H \left(v_d Z_{k1}^H + v_u Z_{k2}^H \right) + Z_{j1}^H \left(-M_T Z_{k2}^H + v_d \lambda Z_{k3}^H + (v_T \lambda + \mu) Z_{k1}^H \right) \right. \\
& \left. \left. + Z_{j2}^H \left(-M_T Z_{k1}^H + (v_T \lambda + \mu) Z_{k2}^H + v_u \lambda Z_{k3}^H \right) \right) \right) \left. \right) \quad (207)
\end{aligned}$$



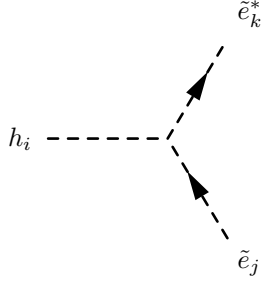
$$- \frac{i}{4} \left(Z_{i1}^H \left(g_2^2 v_u Z_{j2}^+ Z_{k1}^+ + v_u |\lambda|^2 Z_{j2}^+ Z_{k1}^+ + \sqrt{2} g_2^2 v_T Z_{j3}^+ Z_{k1}^+ - \sqrt{2} v_T |\lambda|^2 Z_{j3}^+ Z_{k1}^+ \right. \right.$$

$$\begin{aligned}
& + 2\sqrt{2}\lambda\mu^* Z_{j_3}^+ Z_{k_1}^+ - \sqrt{2}g_2^2 v_T Z_{j_4}^+ Z_{k_1}^+ + \sqrt{2}v_T |\lambda|^2 Z_{j_4}^+ Z_{k_1}^+ + 2\sqrt{2}\mu\lambda^* Z_{j_4}^+ Z_{k_1}^+ \\
& - g_1^2 v_d Z_{j_2}^+ Z_{k_2}^+ + g_2^2 v_d Z_{j_2}^+ Z_{k_2}^+ + 4v_d |\lambda|^2 Z_{j_2}^+ Z_{k_2}^+ + 2\sqrt{2}T_\lambda Z_{j_3}^+ Z_{k_2}^+ \\
& + 4\sqrt{2}\lambda M_T^* Z_{j_4}^+ Z_{k_2}^+ + 2\sqrt{2}T_\lambda^* Z_{j_2}^+ Z_{k_3}^+ - 2g_2^2 v_d Z_{j_3}^+ Z_{k_3}^+ + 4v_d |\lambda|^2 Z_{j_3}^+ Z_{k_3}^+ \\
& + 4\sqrt{2}M_T \lambda^* Z_{j_2}^+ Z_{k_4}^+ + 2g_2^2 v_d Z_{j_4}^+ Z_{k_4}^+ \\
& + Z_{j_1}^+ \left((g_1^2 + g_2^2) v_d Z_{k_1}^+ + v_u (g_2^2 + |\lambda|^2) Z_{k_2}^+ \right. \\
& \left. + \sqrt{2} \left((2\lambda\mu^* - g_2^2 v_T + v_T |\lambda|^2) Z_{k_4}^+ + (2\mu\lambda^* + g_2^2 v_T - v_T |\lambda|^2) Z_{k_3}^+ \right) \right) \\
& + Z_{i_2}^H \left(-4\sqrt{2}M_T \lambda^* Z_{j_3}^+ Z_{k_1}^+ - 2\sqrt{2}T_\lambda^* Z_{j_4}^+ Z_{k_1}^+ + \sqrt{2}g_2^2 v_T Z_{j_3}^+ Z_{k_2}^+ - \sqrt{2}v_T |\lambda|^2 Z_{j_3}^+ Z_{k_2}^+ \right. \\
& - 2\sqrt{2}\lambda\mu^* Z_{j_3}^+ Z_{k_2}^+ - \sqrt{2}g_2^2 v_T Z_{j_4}^+ Z_{k_2}^+ + \sqrt{2}v_T |\lambda|^2 Z_{j_4}^+ Z_{k_2}^+ - 2\sqrt{2}\mu\lambda^* Z_{j_4}^+ Z_{k_2}^+ \\
& + 2g_2^2 v_u Z_{j_3}^+ Z_{k_3}^+ - 2g_2^2 v_u Z_{j_4}^+ Z_{k_4}^+ + 4v_u |\lambda|^2 Z_{j_4}^+ Z_{k_4}^+ \\
& \left. + Z_{j_2}^+ \left(v_d (g_2^2 + |\lambda|^2) Z_{k_1}^+ + (g_1^2 + g_2^2) v_u Z_{k_2}^+ \right) \right. \\
& \left. + \sqrt{2} \left((-2\lambda\mu^* - g_2^2 v_T + v_T |\lambda|^2) Z_{k_4}^+ + (- (2\mu + v_T \lambda) \lambda^* + g_2^2 v_T) Z_{k_3}^+ \right) \right) \\
& + Z_{j_1}^+ \left(-2\sqrt{2} (2\lambda M_T^* Z_{k_3}^+ + T_\lambda Z_{k_4}^+) + v_d (g_2^2 + |\lambda|^2) Z_{k_2}^+ + v_u (4|\lambda|^2 - g_1^2 + g_2^2) Z_{k_1}^+ \right) \\
& + Z_{i_3}^H \left(-2\lambda\mu^* Z_{j_1}^+ Z_{k_1}^+ - 2T_\lambda^* Z_{j_2}^+ Z_{k_1}^+ + \sqrt{2}g_2^2 v_d Z_{j_3}^+ Z_{k_1}^+ - \sqrt{2}g_2^2 v_d Z_{j_4}^+ Z_{k_1}^+ \right. \\
& - 4\lambda M_T^* Z_{j_1}^+ Z_{k_2}^+ - 2T_\lambda Z_{j_1}^+ Z_{k_2}^+ - 2\lambda\mu^* Z_{j_2}^+ Z_{k_2}^+ + \sqrt{2}g_2^2 v_u Z_{j_3}^+ Z_{k_2}^+ \\
& - \sqrt{2}g_2^2 v_u Z_{j_4}^+ Z_{k_2}^+ + \sqrt{2}g_2^2 v_d Z_{j_1}^+ Z_{k_3}^+ + \sqrt{2}g_2^2 v_u Z_{j_2}^+ Z_{k_3}^+ + 4g_2^2 v_T Z_{j_3}^+ Z_{k_3}^+ \\
& - 4g_2^2 v_T Z_{j_4}^+ Z_{k_3}^+ - \sqrt{2}g_2^2 v_d Z_{j_1}^+ Z_{k_4}^+ - \sqrt{2}g_2^2 v_u Z_{j_2}^+ Z_{k_4}^+ - 4g_2^2 v_T Z_{j_3}^+ Z_{k_4}^+ \\
& \left. + 4g_2^2 v_T Z_{j_4}^+ Z_{k_4}^+ \right. \\
& \left. + \lambda^* \left(-\sqrt{2}\lambda \left(-Z_{j_4}^+ + Z_{j_3}^+ \right) \left(v_d Z_{k_1}^+ + v_u Z_{k_2}^+ \right) + Z_{j_1}^+ \left(2(-\mu + v_T \lambda) Z_{k_1}^+ + \sqrt{2}v_d \lambda \left(-Z_{k_3}^+ + Z_{k_4}^+ \right) \right) \right. \right. \\
& \left. \left. + Z_{j_2}^+ \left(2(-\mu + v_T \lambda) Z_{k_2}^+ - 4M_T Z_{k_1}^+ + \sqrt{2}v_u \lambda \left(-Z_{k_3}^+ + Z_{k_4}^+ \right) \right) \right) \right) \tag{208}
\end{aligned}$$

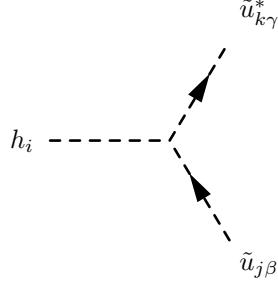


$$\frac{i}{12} \delta_{\beta\gamma} \left((3g_2^2 + g_1^2) \sum_{a=1}^3 Z_{j_a}^{D,*} Z_{k_a}^D (v_d Z_{i_1}^H - v_u Z_{i_2}^H) + 2g_1^2 \sum_{a=1}^3 Z_{j_{3+a}}^{D,*} Z_{k_{3+a}}^D (v_d Z_{i_1}^H - v_u Z_{i_2}^H) \right)$$

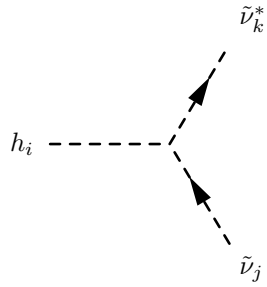
$$\begin{aligned}
& + 3 \left(-2\sqrt{2} \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Z_{k3+a}^D T_{d,ab} Z_{i1}^H - 2\sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{D,*} T_{d,ab}^* Z_{kb}^D Z_{i1}^H \right. \\
& - 4v_d \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{d,ba} Z_{k3+b}^D Z_{i1}^H - 4v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{kc}^D Z_{i1}^H \\
& + \sqrt{2}v_T \lambda^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D Z_{i2}^H + 2\sqrt{2}\mu^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D Z_{i2}^H \\
& + \sqrt{2}v_T \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{kb}^D Z_{i2}^H + 2\sqrt{2}\mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{kb}^D Z_{i2}^H \\
& \left. + \sqrt{2}v_u \lambda^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D Z_{i3}^H + \sqrt{2}v_u \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{kb}^D Z_{i3}^H \right) \quad (209)
\end{aligned}$$



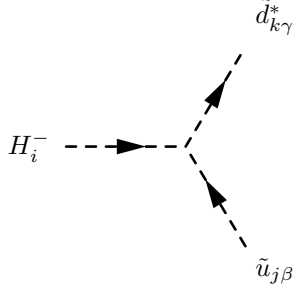
$$\begin{aligned}
& - \frac{i}{4} \left(2\sqrt{2} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Z_{k3+a}^E T_{e,ab} Z_{i1}^H + 2\sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{E,*} T_{e,ab}^* Z_{kb}^E Z_{i1}^H \right. \\
& + 4v_d \sum_{c=1}^3 Z_{j3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{e,ba} Z_{k3+b}^E Z_{i1}^H + 4v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{kc}^E Z_{i1}^H \\
& - \sqrt{2}v_T \lambda^* \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E Z_{i2}^H - 2\sqrt{2}\mu^* \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E Z_{i2}^H \\
& - \sqrt{2}v_T \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{kb}^E Z_{i2}^H - 2\sqrt{2}\mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{kb}^E Z_{i2}^H \\
& + \left(-g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \left(v_d Z_{i1}^H - v_u Z_{i2}^H \right) + 2g_1^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E \left(-v_d Z_{i1}^H + v_u Z_{i2}^H \right) \\
& \left. - \sqrt{2}v_u \lambda^* \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E Z_{i3}^H - \sqrt{2}v_u \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{kb}^E Z_{i3}^H \right) \quad (210)
\end{aligned}$$



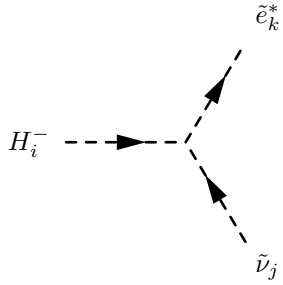
$$\begin{aligned}
& \frac{i}{12} \delta_{\beta\gamma} \left(\left(-3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \left(v_d Z_{i1}^H - v_u Z_{i2}^H \right) + 4g_1^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \left(-v_d Z_{i1}^H + v_u Z_{i2}^H \right) \right. \\
& + 3 \left(2\sqrt{2}\mu^* \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U Z_{i1}^H + \sqrt{2}v_T \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{j3+a}^{U,*} Z_{kb}^U Z_{i1}^H \right. \\
& + 2\sqrt{2}\mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{j3+a}^{U,*} Z_{kb}^U Z_{i1}^H - 2\sqrt{2} \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Z_{k3+a}^U T_{u,ab} Z_{i2}^H \\
& - 2\sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{U,*} T_{u,ab}^* Z_{kb}^U Z_{i2}^H - 4v_u \sum_{c=1}^3 Z_{j3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{u,ba} Z_{k3+b}^U Z_{i2}^H \\
& - 4v_u \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{kc}^U Z_{i2}^H + \sqrt{2}v_d \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{j3+a}^{U,*} Z_{kb}^U Z_{i3}^H \\
& \left. \left. + \sqrt{2}\lambda^* \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U \left(v_d Z_{i3}^H + v_T Z_{i1}^H \right) \right) \right) \tag{211}
\end{aligned}$$



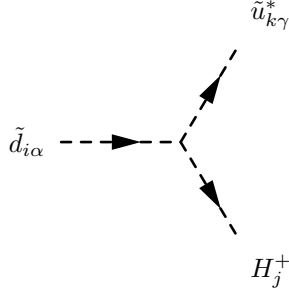
$$-\frac{i}{4} \left(g_1^2 + g_2^2 \right) \delta_{jk} \left(v_d Z_{i1}^H - v_u Z_{i2}^H \right) \tag{212}$$



$$\begin{aligned}
& -\frac{i}{4}\delta_{\beta\gamma}\left(g_2^2\sum_{a=1}^3Z_{ja}^{U,*}Z_{ka}^D\left(2v_T\left(-Z_{i4}^++Z_{i3}^+\right)+\sqrt{2}v_dZ_{i1}^++\sqrt{2}v_uZ_{i2}^+\right)\right. \\
& -2\left(2\sum_{b=1}^3Z_{jb}^{U,*}\sum_{a=1}^3Z_{k3+a}^DT_{d,ab}Z_{i1}^++\sqrt{2}v_u\sum_{c=1}^3Z_{j3+c}^{U,*}\sum_{b=1}^3\sum_{a=1}^3Y_{u,ca}^*Y_{d,ba}Z_{k3+b}^DZ_{i1}^+\right. \\
& +\sqrt{2}v_d\sum_{c=1}^3\sum_{b=1}^3Z_{jb}^{U,*}\sum_{a=1}^3Y_{d,ac}^*Y_{d,ab}Z_{kc}^DZ_{i1}^+-v_T\lambda^*\sum_{b=1}^3Z_{jb}^{U,*}\sum_{a=1}^3Y_{d,ab}Z_{k3+a}^DZ_{i2}^+ \\
& +2\mu^*\sum_{b=1}^3Z_{jb}^{U,*}\sum_{a=1}^3Y_{d,ab}Z_{k3+a}^DZ_{i2}^++2\sum_{b=1}^3\sum_{a=1}^3Z_{j3+a}^{U,*}T_{u,ab}^*Z_{kb}^DZ_{i2}^+ \\
& +\sqrt{2}v_d\sum_{c=1}^3Z_{j3+c}^{U,*}\sum_{b=1}^3\sum_{a=1}^3Y_{u,ca}^*Y_{d,ba}Z_{k3+b}^DZ_{i2}^+ \\
& +\sqrt{2}v_u\sum_{c=1}^3\sum_{b=1}^3Z_{jb}^{U,*}\sum_{a=1}^3Y_{u,ac}^*Y_{u,ab}Z_{kc}^DZ_{i2}^+ \\
& +\sum_{b=1}^3\sum_{a=1}^3Y_{u,ab}^*Z_{j3+a}^{U,*}Z_{kb}^D\left(\left(2\mu-v_T\lambda\right)Z_{i1}^++\sqrt{2}v_d\lambda Z_{i3}^+\right) \\
& \left.-\sqrt{2}v_u\lambda^*\sum_{b=1}^3Z_{jb}^{U,*}\sum_{a=1}^3Y_{d,ab}Z_{k3+a}^DZ_{i4}^+\right) \tag{213}
\end{aligned}$$

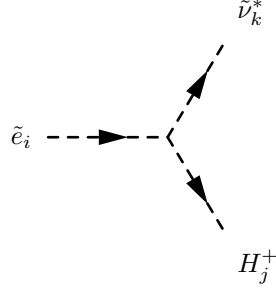


$$\begin{aligned}
& -\frac{i}{4} \left(-4 \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Z_{k3+a}^E T_{e,ab} Z_{i1}^+ - 2\sqrt{2}v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{kc}^E Z_{i1}^+ \right. \\
& + 2v_T \lambda^* \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E Z_{i2}^+ - 4\mu^* \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E Z_{i2}^+ \\
& + 2\sqrt{2}v_u \lambda^* \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E Z_{i4}^+ \\
& \left. + g_2^2 \sum_{a=1}^3 Z_{ja}^{V,*} Z_{ka}^E \left(2v_T Z_{i3}^+ - 2v_T Z_{i4}^+ + \sqrt{2}v_d Z_{i1}^+ + \sqrt{2}v_u Z_{i2}^+ \right) \right) \tag{214}
\end{aligned}$$



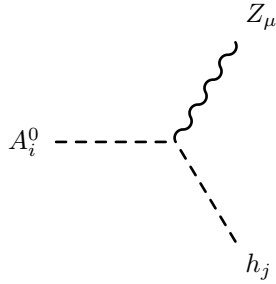
$$\begin{aligned}
& -\frac{i}{4} \delta_{\alpha\gamma} \left(g_2^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^U \left(2v_T Z_{j3}^+ - 2v_T Z_{j4}^+ + \sqrt{2}v_d Z_{j1}^+ + \sqrt{2}v_u Z_{j2}^+ \right) \right. \\
& + 2 \left(-2\mu^* \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U Z_{j1}^+ - 2 \sum_{b=1}^3 \sum_{a=1}^3 Z_{i3+a}^{D,*} T_{d,ab}^* Z_{kb}^U Z_{j1}^+ \right. \\
& - \sqrt{2}v_u \sum_{c=1}^3 Z_{i3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{u,ba} Z_{k3+b}^U Z_{j1}^+ \\
& - \sqrt{2}v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{kc}^U Z_{j1}^+ - 2 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Z_{k3+a}^U T_{u,ab} Z_{j2}^+ \\
& + v_T \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{i3+a}^{D,*} Z_{kb}^U Z_{j2}^+ - 2\mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{i3+a}^{D,*} Z_{kb}^U Z_{j2}^+ \\
& - \sqrt{2}v_d \sum_{c=1}^3 Z_{i3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{u,ba} Z_{k3+b}^U Z_{j2}^+ \\
& - \sqrt{2}v_u \sum_{c=1}^3 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{kc}^U Z_{j2}^+ \\
& \left. + \lambda^* \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U \left(-\sqrt{2}v_d Z_{j3}^+ + v_T Z_{j1}^+ \right) \right)
\end{aligned}$$

$$+ \sqrt{2}v_u\lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{i3+a}^{D,*} Z_{kb}^U Z_{j4}^+ \Big) \Big) \quad (215)$$

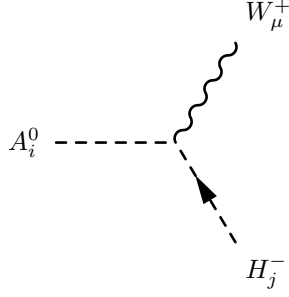


$$\begin{aligned}
& - \frac{i}{4} \left(-4 \sum_{b=1}^3 \sum_{a=1}^3 Z_{i3+a}^{E,*} T_{e,ab}^* Z_{kb}^V Z_{j1}^+ - 2\sqrt{2}v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{kc}^V Z_{j1}^+ \right. \\
& + 2v_T \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{i3+a}^{E,*} Z_{kb}^V Z_{j2}^+ - 4\mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{i3+a}^{E,*} Z_{kb}^V Z_{j2}^+ \\
& + 2\sqrt{2}v_u\lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{i3+a}^{E,*} Z_{kb}^V Z_{j4}^+ \\
& \left. + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^V \left(2v_T Z_{j3}^+ - 2v_T Z_{j4}^+ + \sqrt{2}v_d Z_{j1}^+ + \sqrt{2}v_u Z_{j2}^+ \right) \right) \quad (216)
\end{aligned}$$

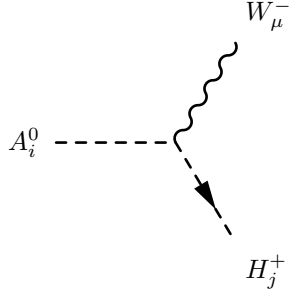
9.2 Two Scalar-One Vector Boson-Interaction



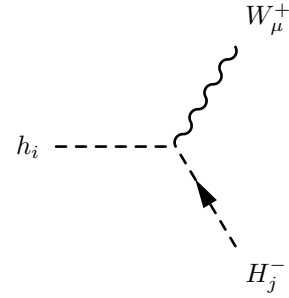
$$\frac{1}{2} \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left(Z_{i1}^A Z_{j1}^H - Z_{i2}^A Z_{j2}^H \right) \left(-p_\mu^{h_j} + p_\mu^{A_i^0} \right) \quad (217)$$



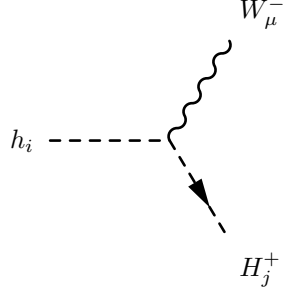
$$\frac{1}{2}g_2\left(\sqrt{2}Z_{i3}^A(-Z_{j4}^+ + Z_{j3}^+) + Z_{i1}^AZ_{j1}^+ + Z_{i2}^AZ_{j2}^+\right)\left(-p_\mu^{H_j^-} + p_\mu^{A_i^0}\right) \quad (218)$$



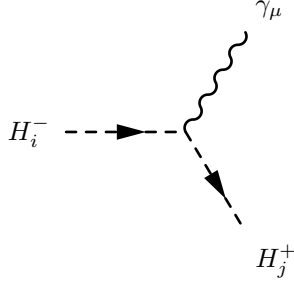
$$\frac{1}{2}g_2\left(\sqrt{2}Z_{i3}^A(-Z_{j4}^+ + Z_{j3}^+) + Z_{i1}^AZ_{j1}^+ + Z_{i2}^AZ_{j2}^+\right)\left(-p_\mu^{H_j^+} + p_\mu^{A_i^0}\right) \quad (219)$$



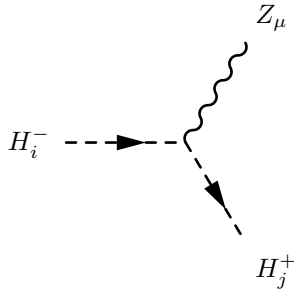
$$\frac{i}{2}g_2\left(\sqrt{2}Z_{i3}^H(Z_{j3}^+ + Z_{j4}^+) + Z_{i1}^HZ_{j1}^+ - Z_{i2}^HZ_{j2}^+\right)\left(-p_\mu^{H_j^-} + p_\mu^{h_i}\right) \quad (220)$$



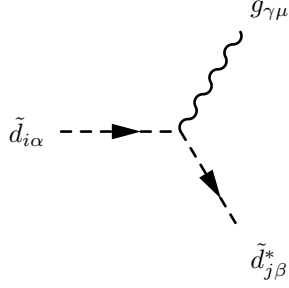
$$-\frac{i}{2}g_2\left(\sqrt{2}Z_{i3}^H\left(Z_{j3}^++Z_{j4}^+\right)+Z_{i1}^HZ_{j1}^+-Z_{i2}^HZ_{j2}^+\right)\left(-p_\mu^{H_j^+}+p_\mu^{h_i}\right) \quad (221)$$



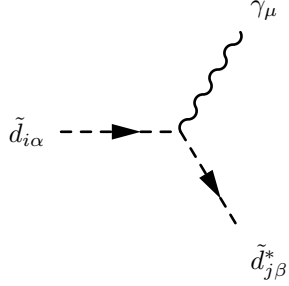
$$\frac{i}{2}\left(\left(g_1\cos\Theta_W+g_2\sin\Theta_W\right)Z_{i1}^+Z_{j1}^++\left(g_1\cos\Theta_W+g_2\sin\Theta_W\right)Z_{i2}^+Z_{j2}^+\right. \\ \left.+2g_2\sin\Theta_W\left(Z_{i3}^+Z_{j3}^++Z_{i4}^+Z_{j4}^+\right)\right)\left(-p_\mu^{H_j^+}+p_\mu^{H_i^-}\right) \quad (222)$$



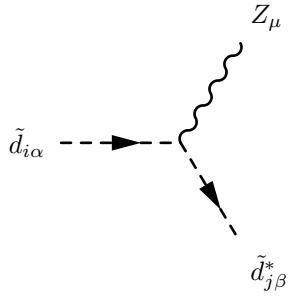
$$\frac{i}{2}\left(\left(-g_1\sin\Theta_W+g_2\cos\Theta_W\right)Z_{i1}^+Z_{j1}^++\left(-g_1\sin\Theta_W+g_2\cos\Theta_W\right)Z_{i2}^+Z_{j2}^+\right. \\ \left.+2g_2\cos\Theta_W\left(Z_{i3}^+Z_{j3}^++Z_{i4}^+Z_{j4}^+\right)\right)\left(-p_\mu^{H_j^+}+p_\mu^{H_i^-}\right) \quad (223)$$



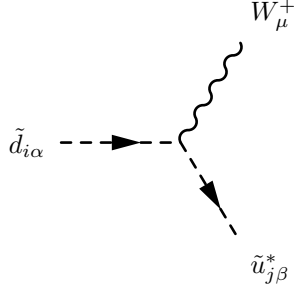
$$-\frac{i}{2}g_3\delta_{ij}\lambda_{\beta,\alpha}^\gamma\left(-p_\mu^{\tilde{d}_{j\beta}^*}+p_\mu^{\tilde{d}_{i\alpha}}\right) \quad (224)$$



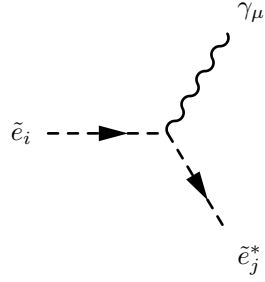
$$-\frac{i}{6}\delta_{\alpha,\beta}\left(-2g_1\cos\Theta_W\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{j3+a}^D+\left(-3g_2\sin\Theta_W+g_1\cos\Theta_W\right)\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^D\right)\left(-p_\mu^{\tilde{d}_{j\beta}^*}+p_\mu^{\tilde{d}_{i\alpha}}\right) \quad (225)$$



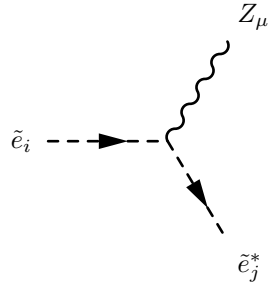
$$\frac{i}{6}\delta_{\alpha,\beta}\left(-2g_1\sin\Theta_W\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{j3+a}^D+\left(3g_2\cos\Theta_W+g_1\sin\Theta_W\right)\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^D\right)\left(-p_\mu^{\tilde{d}_{j\beta}^*}+p_\mu^{\tilde{d}_{i\alpha}}\right) \quad (226)$$



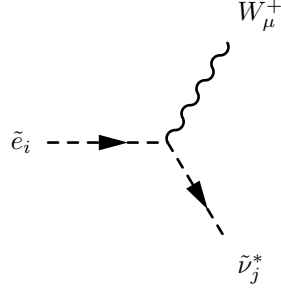
$$-i \frac{1}{\sqrt{2}} g_2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U \left(-p_\mu^{\tilde{u}_{j\beta}^*} + p_\mu^{\tilde{d}_{i\alpha}} \right) \quad (227)$$



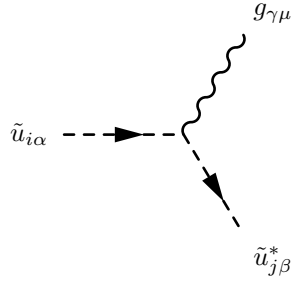
$$\frac{i}{2} \left(2g_1 \cos \Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E + \left(g_1 \cos \Theta_W + g_2 \sin \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right) \left(-p_\mu^{\tilde{e}_j^*} + p_\mu^{\tilde{e}_i} \right) \quad (228)$$



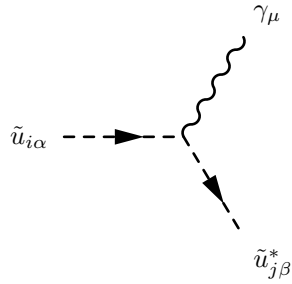
$$\frac{i}{2} \left(-2g_1 \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E + \left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right) \left(-p_\mu^{\tilde{e}_j^*} + p_\mu^{\tilde{e}_i} \right) \quad (229)$$



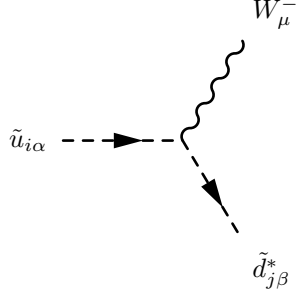
$$-i \frac{1}{\sqrt{2}} g_2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^V \left(-p_\mu^{\tilde{\nu}_j^*} + p_\mu^{\tilde{e}_i} \right) \quad (230)$$



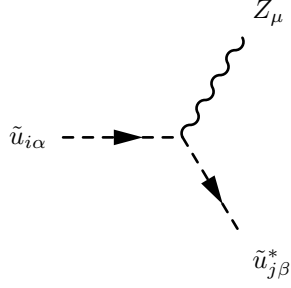
$$- \frac{i}{2} g_3 \delta_{ij} \lambda_{\beta,\alpha}^\gamma \left(-p_\mu^{\tilde{u}_{j\beta}^*} + p_\mu^{\tilde{u}_{i\alpha}} \right) \quad (231)$$



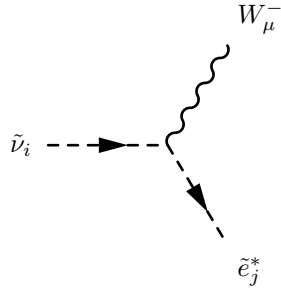
$$- \frac{i}{6} \delta_{\alpha,\beta} \left((3g_2 \sin \Theta_W + g_1 \cos \Theta_W) \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U + 4g_1 \cos \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \right) \left(-p_\mu^{\tilde{u}_{j\beta}^*} + p_\mu^{\tilde{u}_{i\alpha}} \right) \quad (232)$$



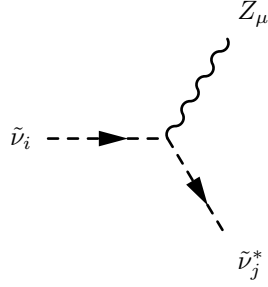
$$-i \frac{1}{\sqrt{2}} g_2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D \left(-p_\mu^{\tilde{d}_{j\beta}^*} + p_\mu^{\tilde{u}_{i\alpha}} \right) \quad (233)$$



$$-\frac{i}{6} \delta_{\alpha\beta} \left((3g_2 \cos \Theta_W - g_1 \sin \Theta_W) \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U - 4g_1 \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \right) \left(-p_\mu^{\tilde{u}_{j\beta}^*} + p_\mu^{\tilde{u}_{i\alpha}} \right) \quad (234)$$

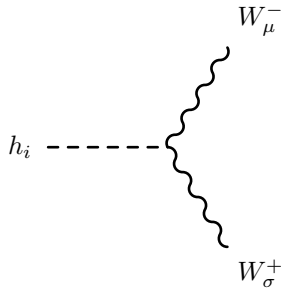


$$-i \frac{1}{\sqrt{2}} g_2 \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ja}^E \left(-p_\mu^{\tilde{e}_j^*} + p_\mu^{\tilde{\nu}_i} \right) \quad (235)$$

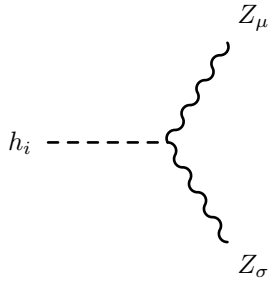


$$-\frac{i}{2}\delta_{ij}\left(g_1\sin\Theta_W+g_2\cos\Theta_W\right)\left(-p_\mu^{\tilde{\nu}_j^*}+p_\mu^{\tilde{\nu}_i}\right) \quad (236)$$

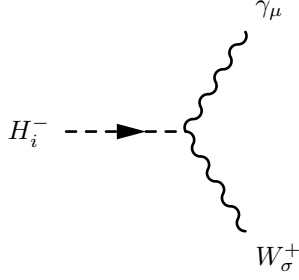
9.3 One Scalar-Two Vector Boson-Interaction



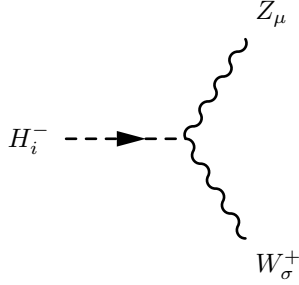
$$\frac{i}{2}g_2^2\left(4v_T Z_{i3}^H+v_d Z_{i1}^H+v_u Z_{i2}^H\right)\left(g_{\sigma\mu}\right) \quad (237)$$



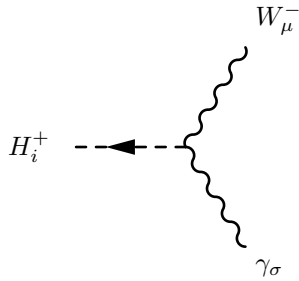
$$\frac{i}{2}\left(g_1\sin\Theta_W+g_2\cos\Theta_W\right)^2\left(v_d Z_{i1}^H+v_u Z_{i2}^H\right)\left(g_{\sigma\mu}\right) \quad (238)$$



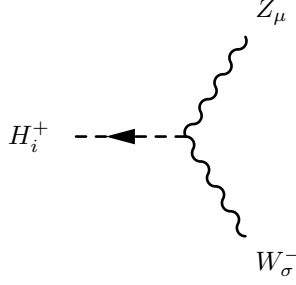
$$-\frac{i}{2}g_2\left(g_1v_d\cos\Theta_W Z_{i1}^+ - g_1v_u\cos\Theta_W Z_{i2}^+ + \sqrt{2}g_2v_T\sin\Theta_W\left(Z_{i3}^+ + Z_{i4}^+\right)\right)\left(g_{\sigma\mu}\right) \quad (239)$$



$$-\frac{i}{2}g_2\left(-g_1v_d\sin\Theta_W Z_{i1}^+ + g_1v_u\sin\Theta_W Z_{i2}^+ + \sqrt{2}g_2v_T\cos\Theta_W\left(Z_{i3}^+ + Z_{i4}^+\right)\right)\left(g_{\sigma\mu}\right) \quad (240)$$

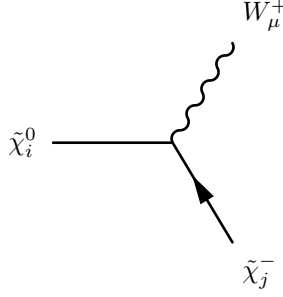


$$-\frac{i}{2}g_2\left(g_1v_d\cos\Theta_W Z_{i1}^+ - g_1v_u\cos\Theta_W Z_{i2}^+ + \sqrt{2}g_2v_T\sin\Theta_W\left(Z_{i3}^+ + Z_{i4}^+\right)\right)\left(g_{\sigma\mu}\right) \quad (241)$$



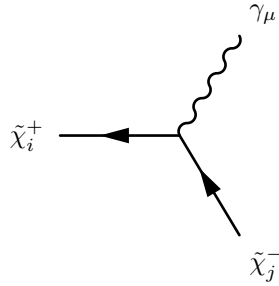
$$-\frac{i}{2}g_2\left(-g_1v_d\sin\Theta_W Z_{i1}^+ + g_1v_u\sin\Theta_W Z_{i2}^+ + \sqrt{2}g_2v_T\cos\Theta_W(Z_{i3}^+ + Z_{i4}^+)\right)(g_{\sigma\mu}) \quad (242)$$

9.4 Two Fermion-One Vector Boson-Interaction



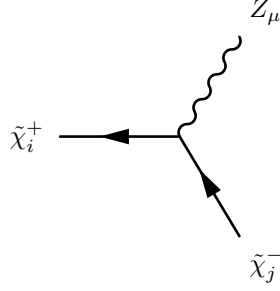
$$-\frac{i}{2}g_2\left(2U_{j1}^*N_{i2} + 2U_{j3}^*N_{i5} + \sqrt{2}U_{j2}^*N_{i3}\right)\left(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\right) \quad (243)$$

$$+\frac{i}{2}g_2\left(2N_{i2}^*V_{j1} + 2N_{i5}^*V_{j3} - \sqrt{2}N_{i4}^*V_{j2}\right)\left(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\right) \quad (244)$$



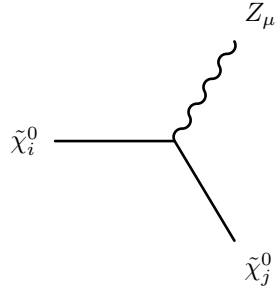
$$\frac{i}{2}\left(2g_2U_{j1}^*\sin\Theta_W U_{i1} + 2g_2U_{j3}^*\sin\Theta_W U_{i3} + U_{j2}^*\left(g_1\cos\Theta_W + g_2\sin\Theta_W\right)U_{i2}\right)\left(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\right) \quad (245)$$

$$+\frac{i}{2}\left(2g_2V_{i1}^*\sin\Theta_W V_{j1} + 2g_2V_{i3}^*\sin\Theta_W V_{j3} + V_{i2}^*\left(g_1\cos\Theta_W + g_2\sin\Theta_W\right)V_{j2}\right)\left(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\right) \quad (246)$$



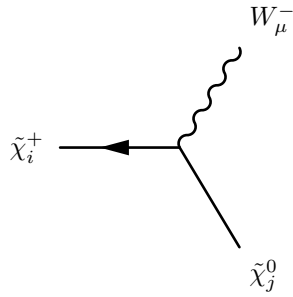
$$\frac{i}{2} \left(2g_2 U_{j1}^* \cos \Theta_W U_{i1} + 2g_2 U_{j3}^* \cos \Theta_W U_{i3} + U_{j2}^* \left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) U_{i2} \right) \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (247)$$

$$+ \frac{i}{2} \left(2g_2 V_{i1}^* \cos \Theta_W V_{j1} + 2g_2 V_{i3}^* \cos \Theta_W V_{j3} + V_{i2}^* \left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) V_{j2} \right) \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (248)$$



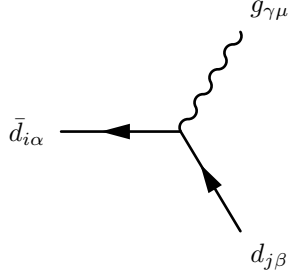
$$- \frac{i}{2} \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left(N_{j3}^* N_{i3} - N_{j4}^* N_{i4} \right) \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (249)$$

$$+ \frac{i}{2} \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left(N_{i3}^* N_{j3} - N_{i4}^* N_{j4} \right) \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (250)$$



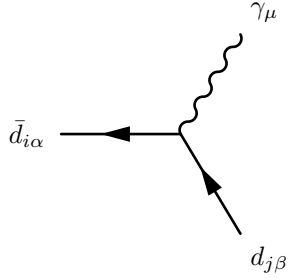
$$- \frac{i}{2} g_2 \left(2N_{j2}^* U_{i1} + 2N_{j5}^* U_{i3} + \sqrt{2} N_{j3}^* U_{i2} \right) \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (251)$$

$$+ - \frac{i}{2} g_2 \left(2V_{i1}^* N_{j2} + 2V_{i3}^* N_{j5} - \sqrt{2} V_{i2}^* N_{j4} \right) \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (252)$$



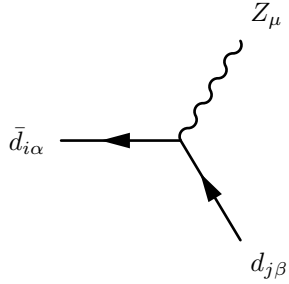
$$-\frac{i}{2}g_3\delta_{ij}\lambda_{\alpha,\beta}^\gamma\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (253)$$

$$+\frac{i}{2}g_3\delta_{ij}\lambda_{\alpha,\beta}^\gamma\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (254)$$



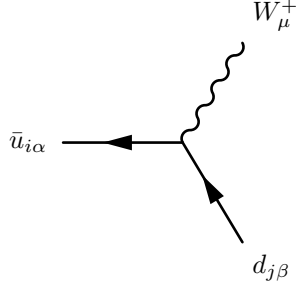
$$-\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(-3g_2\sin\Theta_W+g_1\cos\Theta_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (255)$$

$$+\frac{i}{3}g_1\cos\Theta_W\delta_{\alpha\beta}\delta_{ij}\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (256)$$

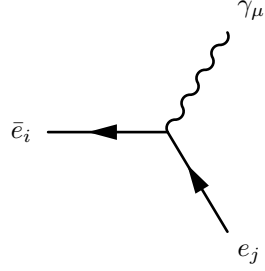


$$\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(3g_2\cos\Theta_W+g_1\sin\Theta_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (257)$$

$$+\frac{i}{3}g_1\delta_{\alpha\beta}\delta_{ij}\sin\Theta_W\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (258)$$

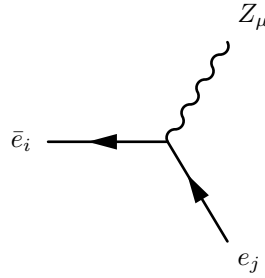


$$-i \frac{1}{\sqrt{2}} g_2 \delta_{\alpha\beta} \sum_{a=1}^3 U_{L,ja}^{d,*} U_{L,ia}^u \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (259)$$



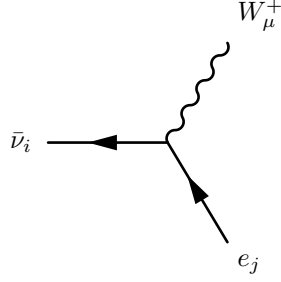
$$\frac{i}{2} \delta_{ij} \left(g_1 \cos \Theta_W + g_2 \sin \Theta_W \right) \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (260)$$

$$+ i g_1 \cos \Theta_W \delta_{ij} \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (261)$$

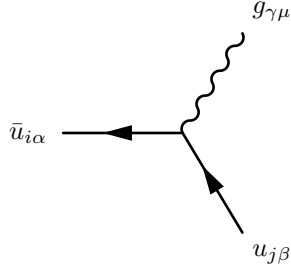


$$\frac{i}{2} \delta_{ij} \left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (262)$$

$$+ -i g_1 \delta_{ij} \sin \Theta_W \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (263)$$

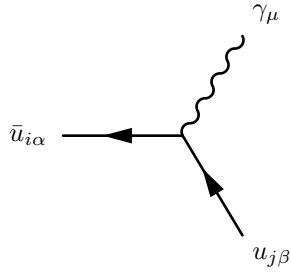


$$-i \frac{1}{\sqrt{2}} g_2 U_{L,ji}^{e,*} \Theta_{i,3} \left(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \right) \quad (264)$$



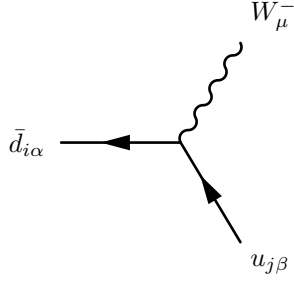
$$-\frac{i}{2} g_3 \delta_{ij} \lambda_{\alpha,\beta}^\gamma \left(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \right) \quad (265)$$

$$+\frac{i}{2} g_3 \delta_{ij} \lambda_{\alpha,\beta}^\gamma \left(\gamma_\mu \cdot \frac{1+\gamma_5}{2} \right) \quad (266)$$

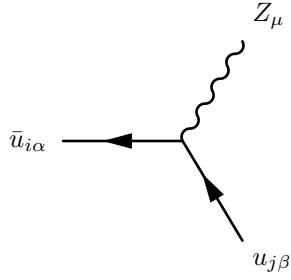


$$-\frac{i}{6} \delta_{\alpha\beta} \delta_{ij} \left(3g_2 \sin \Theta_W + g_1 \cos \Theta_W \right) \left(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \right) \quad (267)$$

$$+\frac{2i}{3} g_1 \cos \Theta_W \delta_{\alpha\beta} \delta_{ij} \left(\gamma_\mu \cdot \frac{1+\gamma_5}{2} \right) \quad (268)$$

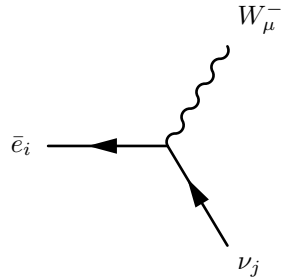


$$-i \frac{1}{\sqrt{2}} g_2 \delta_{\alpha\beta} \sum_{a=1}^3 U_{L,ja}^{u,*} U_{L,ia}^d \left(\gamma_{\mu} \cdot \frac{1 - \gamma_5}{2} \right) \quad (269)$$

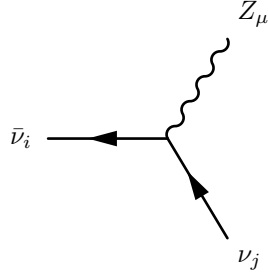


$$- \frac{i}{6} \delta_{\alpha\beta} \delta_{ij} \left(3g_2 \cos \Theta_W - g_1 \sin \Theta_W \right) \left(\gamma_{\mu} \cdot \frac{1 - \gamma_5}{2} \right) \quad (270)$$

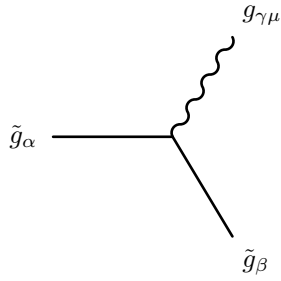
$$+ \frac{2i}{3} g_1 \delta_{\alpha\beta} \delta_{ij} \sin \Theta_W \left(\gamma_{\mu} \cdot \frac{1 + \gamma_5}{2} \right) \quad (271)$$



$$-i \frac{1}{\sqrt{2}} g_2 \Theta_{j,3} U_{L,ij}^e \left(\gamma_{\mu} \cdot \frac{1 - \gamma_5}{2} \right) \quad (272)$$



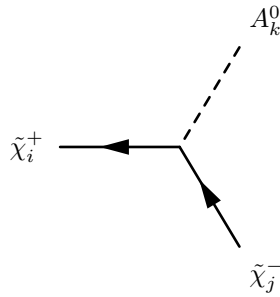
$$-\frac{i}{2}\delta_{ij}\left(g_1\sin\Theta_W+g_2\cos\Theta_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (273)$$



$$-g_3|\phi_{\tilde{g}}|^2f_{\alpha,\beta,\gamma}\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (274)$$

$$+g_3|\phi_{\tilde{g}}|^2f_{\alpha,\beta,\gamma}\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (275)$$

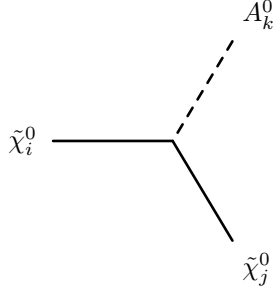
9.5 Two Fermion-One Scalar Boson-Interaction



$$\frac{1}{2}\left(U_{j3}^*\left(-2g_2V_{i1}^*Z_{k3}^A+\sqrt{2}\lambda V_{i2}^*Z_{k1}^A\right)\right)$$

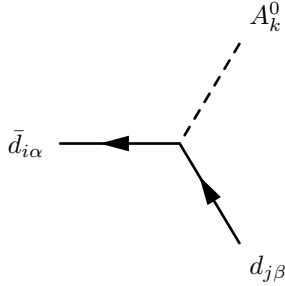
$$-U_{j2}^* \left(\lambda V_{i2}^* Z_{k3}^A + \sqrt{2} g_2 V_{i1}^* Z_{k1}^A + \sqrt{2} \lambda V_{i3}^* Z_{k2}^A \right) + g_2 U_{j1}^* \left(2V_{i3}^* Z_{k3}^A - \sqrt{2} V_{i2}^* Z_{k2}^A \right) \left(\frac{1-\gamma_5}{2} \right) \quad (276)$$

$$+ \frac{1}{2} \left(-\sqrt{2} \lambda^* U_{i3} V_{j2} Z_{k1}^A + U_{i2} \left(\lambda^* \left(\sqrt{2} V_{j3} Z_{k2}^A + V_{j2} Z_{k3}^A \right) + \sqrt{2} g_2 V_{j1} Z_{k1}^A \right) \right. \\ \left. + g_2 \left(2U_{i3} V_{j1} Z_{k3}^A + U_{i1} \left(-2V_{j3} Z_{k3}^A + \sqrt{2} V_{j2} Z_{k2}^A \right) \right) \right) \left(\frac{1+\gamma_5}{2} \right) \quad (277)$$



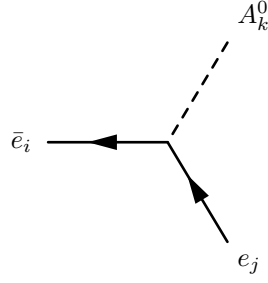
$$\frac{1}{2} \left(-g_2 N_{i2}^* N_{j3}^* Z_{k1}^A - \lambda N_{i5}^* N_{j4}^* Z_{k1}^A - \lambda N_{i4}^* N_{j5}^* Z_{k1}^A - g_1 N_{i4}^* N_{j1}^* Z_{k2}^A \right. \\ \left. + g_2 N_{i4}^* N_{j2}^* Z_{k2}^A - \lambda N_{i5}^* N_{j3}^* Z_{k2}^A + g_2 N_{i2}^* N_{j4}^* Z_{k2}^A + g_1 N_{i1}^* \left(N_{j3}^* Z_{k1}^A - N_{j4}^* Z_{k2}^A \right) \right. \\ \left. - \lambda N_{i4}^* N_{j3}^* Z_{k3}^A + N_{i3}^* \left(g_1 N_{j1}^* Z_{k1}^A - g_2 N_{j2}^* Z_{k1}^A - \lambda \left(N_{j4}^* Z_{k3}^A + N_{j5}^* Z_{k2}^A \right) \right) \right) \left(\frac{1-\gamma_5}{2} \right) \quad (278)$$

$$+ \frac{1}{2} \left(\lambda^* Z_{k3}^A \left(N_{i3} N_{j4} + N_{i4} N_{j3} \right) \right. \\ \left. + Z_{k1}^A \left(-g_1 N_{i1} N_{j3} + g_2 N_{i2} N_{j3} + \lambda^* N_{i4} N_{j5} + \lambda^* N_{i5} N_{j4} + N_{i3} \left(-g_1 N_{j1} + g_2 N_{j2} \right) \right) \right. \\ \left. + Z_{k2}^A \left(\left(g_1 N_{i1} - g_2 N_{i2} \right) N_{j4} + \lambda^* \left(N_{i3} N_{j5} + N_{i5} N_{j3} \right) + N_{i4} \left(g_1 N_{j1} - g_2 N_{j2} \right) \right) \right) \left(\frac{1+\gamma_5}{2} \right) \quad (279)$$



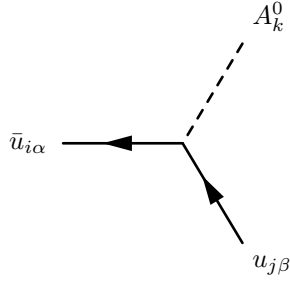
$$\frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{d,*} \sum_{a=1}^3 U_{R,ia}^{d,*} Y_{d,ab} Z_{k1}^A \left(\frac{1-\gamma_5}{2} \right) \quad (280)$$

$$+ -\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^3\sum_{a=1}^3Y_{d,ab}^*U_{R,ja}^dU_{L,ib}^dZ_{k1}^A\left(\frac{1+\gamma_5}{2}\right) \quad (281)$$



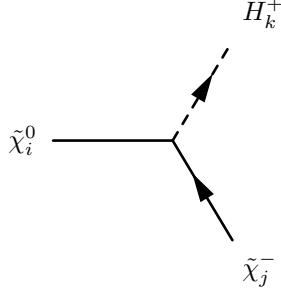
$$\frac{1}{\sqrt{2}}\sum_{b=1}^3U_{L,jb}^{e,*}\sum_{a=1}^3U_{R,ia}^eY_{e,ab}Z_{k1}^A\left(\frac{1-\gamma_5}{2}\right) \quad (282)$$

$$+ -\frac{1}{\sqrt{2}}\sum_{b=1}^3\sum_{a=1}^3Y_{e,ab}^*U_{R,ja}^eU_{L,ib}^eZ_{k1}^A\left(\frac{1+\gamma_5}{2}\right) \quad (283)$$



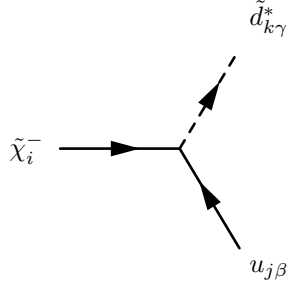
$$\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^3U_{L,jb}^{u,*}\sum_{a=1}^3U_{R,ia}^uY_{u,ab}Z_{k2}^A\left(\frac{1-\gamma_5}{2}\right) \quad (284)$$

$$+ -\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^3\sum_{a=1}^3Y_{u,ab}^*U_{R,ja}^uU_{L,ib}^uZ_{k2}^A\left(\frac{1+\gamma_5}{2}\right) \quad (285)$$



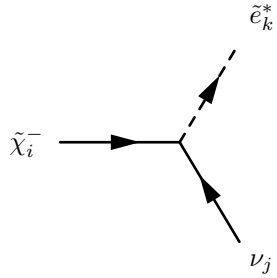
$$\begin{aligned} & \frac{i}{2} \left(-2 \left(g_2 U_{j1}^* \left(N_{i3}^* Z_{k1}^+ + \sqrt{2} N_{i5}^* Z_{k3}^+ \right) + U_{j3}^* \left(\lambda N_{i3}^* Z_{k2}^+ - \sqrt{2} g_2 N_{i2}^* Z_{k3}^+ \right) \right) \right. \\ & \left. + U_{j2}^* \left(2\lambda N_{i4}^* Z_{k4}^+ + \sqrt{2} g_1 N_{i1}^* Z_{k1}^+ + \sqrt{2} g_2 N_{i2}^* Z_{k1}^+ + \sqrt{2} \lambda N_{i5}^* Z_{k2}^+ \right) \right) \left(\frac{1 - \gamma_5}{2} \right) \end{aligned} \quad (286)$$

$$\begin{aligned} & + \frac{i}{2} \left(-\sqrt{2} V_{j2} \left(g_1 N_{i1} + g_2 N_{i2} \right) Z_{k2}^+ + \lambda^* \left(2V_{j3} N_{i4} Z_{k1}^+ + V_{j2} \left(-2N_{i3} Z_{k3}^+ + \sqrt{2} N_{i5} Z_{k1}^+ \right) \right) \right) \\ & - 2g_2 \left(\sqrt{2} V_{j3} N_{i2} Z_{k4}^+ + V_{j1} \left(N_{i4} Z_{k2}^+ - \sqrt{2} N_{i5} Z_{k4}^+ \right) \right) \left(\frac{1 + \gamma_5}{2} \right) \end{aligned} \quad (287)$$

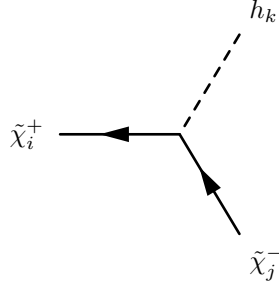


$$-i\delta_{\beta\gamma} \left(g_2 U_{i1}^* \sum_{a=1}^3 U_{L,ja}^{u,*} Z_{ka}^D - U_{i2}^* \sum_{b=1}^3 U_{L,jb}^{u,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \right) \left(\frac{1 - \gamma_5}{2} \right) \quad (288)$$

$$+ i\delta_{\beta\gamma} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* U_{R,ja}^u Z_{kb}^D V_{i2} \left(\frac{1 + \gamma_5}{2} \right) \quad (289)$$

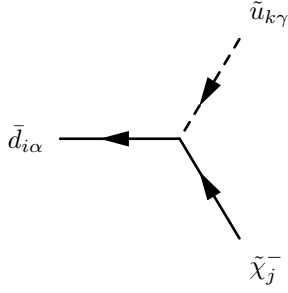


$$i\left(-g_2 U_{i1}^* \Theta_{j,3} Z_{kj}^E + U_{i2}^* \sum_{a=1}^3 Y_{e,aj} Z_{k3+a}^E\right) \left(\frac{1-\gamma_5}{2}\right) \quad (290)$$



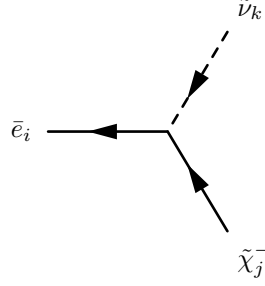
$$-\frac{i}{2} \left(U_{j3}^* \left(2g_2 V_{i1}^* Z_{k3}^H + \sqrt{2} \lambda V_{i2}^* Z_{k1}^H \right) + g_2 U_{j1}^* \left(-2V_{i3}^* Z_{k3}^H + \sqrt{2} V_{i2}^* Z_{k2}^H \right) \right. \\ \left. + U_{j2}^* \left(-\lambda \left(\sqrt{2} V_{i3}^* Z_{k2}^H + V_{i2}^* Z_{k3}^H \right) + \sqrt{2} g_2 V_{i1}^* Z_{k1}^H \right) \right) \left(\frac{1-\gamma_5}{2} \right) \quad (291)$$

$$+ \frac{i}{2} \left(\sqrt{2} \lambda^* U_{i3} V_{j2} Z_{k1}^H + U_{i2} \left(-\lambda^* \left(\sqrt{2} V_{j3} Z_{k2}^H + V_{j2} Z_{k3}^H \right) + \sqrt{2} g_2 V_{j1} Z_{k1}^H \right) \right. \\ \left. + g_2 \left(2U_{i3} V_{j1} Z_{k3}^H + U_{i1} \left(-2V_{j3} Z_{k3}^H + \sqrt{2} V_{j2} Z_{k2}^H \right) \right) \right) \left(\frac{1+\gamma_5}{2} \right) \quad (292)$$



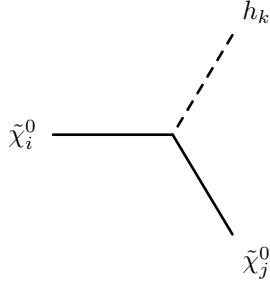
$$i U_{j2}^* \delta_{\alpha\gamma} \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 U_{R,ia}^{d,*} Y_{d,ab} \left(\frac{1-\gamma_5}{2} \right) \quad (293)$$

$$+ -i \delta_{\alpha\gamma} \left(g_2 \sum_{a=1}^3 Z_{ka}^{U,*} U_{L,ia}^d V_{j1} - \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{k3+a}^{U,*} U_{L,ib}^d V_{j2} \right) \left(\frac{1+\gamma_5}{2} \right) \quad (294)$$



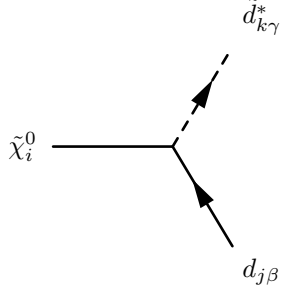
$$iU_{j2}^* \sum_{b=1}^3 Z_{kb}^{V,*} \sum_{a=1}^3 U_{R,ia}^{e,*} Y_{e,ab} \left(\frac{1-\gamma_5}{2} \right) \quad (295)$$

$$+ -ig_2 \sum_{a=1}^3 Z_{ka}^{V,*} U_{L,ia}^e V_{j1} \left(\frac{1+\gamma_5}{2} \right) \quad (296)$$



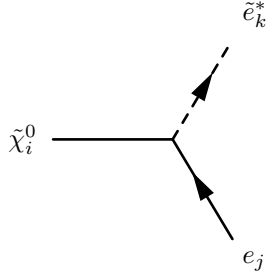
$$\begin{aligned} & \frac{i}{2} \left(-g_2 N_{i2}^* N_{j3}^* Z_{k1}^H + \lambda N_{i5}^* N_{j4}^* Z_{k1}^H + \lambda N_{i4}^* N_{j5}^* Z_{k1}^H - g_1 N_{i4}^* N_{j1}^* Z_{k2}^H \right. \\ & + g_2 N_{i4}^* N_{j2}^* Z_{k2}^H + \lambda N_{i5}^* N_{j3}^* Z_{k2}^H + g_2 N_{i2}^* N_{j4}^* Z_{k2}^H + g_1 N_{i1}^* \left(N_{j3}^* Z_{k1}^H - N_{j4}^* Z_{k2}^H \right) \\ & \left. + \lambda N_{i4}^* N_{j3}^* Z_{k3}^H + N_{i3}^* \left(g_1 N_{j1}^* Z_{k1}^H - g_2 N_{j2}^* Z_{k1}^H + \lambda N_{j4}^* Z_{k3}^H + \lambda N_{j5}^* Z_{k2}^H \right) \right) \left(\frac{1-\gamma_5}{2} \right) \quad (297) \end{aligned}$$

$$\begin{aligned} & + \frac{i}{2} \left(\lambda^* Z_{k3}^H \left(N_{i3} N_{j4} + N_{i4} N_{j3} \right) \right. \\ & + Z_{k1}^H \left(g_1 N_{i1} N_{j3} - g_2 N_{i2} N_{j3} + \lambda^* N_{i4} N_{j5} + \lambda^* N_{i5} N_{j4} + N_{i3} \left(g_1 N_{j1} - g_2 N_{j2} \right) \right) \\ & \left. + Z_{k2}^H \left(\left(-g_1 N_{i1} + g_2 N_{i2} \right) N_{j4} + \lambda^* \left(N_{i3} N_{j5} + N_{i5} N_{j3} \right) + N_{i4} \left(-g_1 N_{j1} + g_2 N_{j2} \right) \right) \right) \left(\frac{1+\gamma_5}{2} \right) \quad (298) \end{aligned}$$



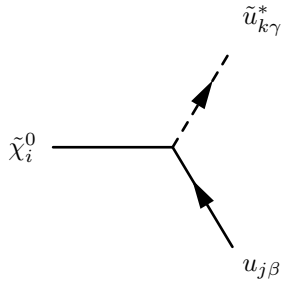
$$-\frac{i}{6}\delta_{\beta\gamma}\left(-3\sqrt{2}g_2N_{i2}^*\sum_{a=1}^3U_{L,ja}^{d,*}Z_{ka}^D+6N_{i3}^*\sum_{b=1}^3U_{L,jb}^{d,*}\sum_{a=1}^3Y_{d,ab}Z_{k3+a}^D+\sqrt{2}g_1N_{i1}^*\sum_{a=1}^3U_{L,ja}^{d,*}Z_{ka}^D\right)\left(\frac{1-\gamma_5}{2}\right) \quad (299)$$

$$+\frac{i}{3}\delta_{\beta\gamma}\left(3\sum_{b=1}^3\sum_{a=1}^3Y_{d,ab}^*U_{R,ja}^dZ_{kb}^DN_{i3}+\sqrt{2}g_1\sum_{a=1}^3Z_{k3+a}^DU_{R,ja}^dN_{i1}\right)\left(\frac{1+\gamma_5}{2}\right) \quad (300)$$



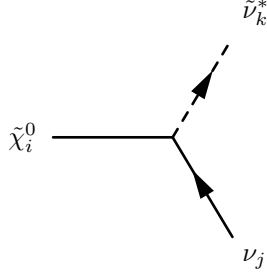
$$\frac{i}{2}\left(-2N_{i3}^*\sum_{b=1}^3U_{L,jb}^{e,*}\sum_{a=1}^3Y_{e,ab}Z_{k3+a}^E+\sqrt{2}g_1N_{i1}^*\sum_{a=1}^3U_{L,ja}^{e,*}Z_{ka}^E+\sqrt{2}g_2N_{i2}^*\sum_{a=1}^3U_{L,ja}^{e,*}Z_{ka}^E\right)\left(\frac{1-\gamma_5}{2}\right) \quad (301)$$

$$+i\left(\sqrt{2}g_1\sum_{a=1}^3Z_{k3+a}^EU_{R,ja}^eN_{i1}+\sum_{b=1}^3\sum_{a=1}^3Y_{e,ab}^*U_{R,ja}^eZ_{kb}^EN_{i3}\right)\left(\frac{1+\gamma_5}{2}\right) \quad (302)$$

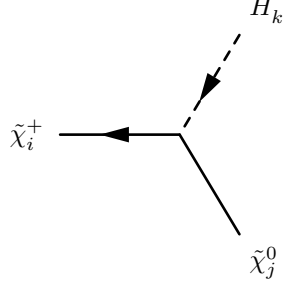


$$-\frac{i}{6}\delta_{\beta\gamma}\left(3\sqrt{2}g_2N_{i2}^*\sum_{a=1}^3U_{L,ja}^{u,*}Z_{ka}^U+6N_{i4}^*\sum_{b=1}^3U_{L,jb}^{u,*}\sum_{a=1}^3Y_{u,ab}Z_{k3+a}^U+\sqrt{2}g_1N_{i1}^*\sum_{a=1}^3U_{L,ja}^{u,*}Z_{ka}^U\right)\left(\frac{1-\gamma_5}{2}\right) \quad (303)$$

$$+\frac{i}{3}\delta_{\beta\gamma}\left(2\sqrt{2}g_1\sum_{a=1}^3Z_{k3+a}^U U_{R,ja}^u N_{i1}-3\sum_{b=1}^3\sum_{a=1}^3Y_{u,ab}^*U_{R,ja}^u Z_{kb}^U N_{i4}\right)\left(\frac{1+\gamma_5}{2}\right) \quad (304)$$

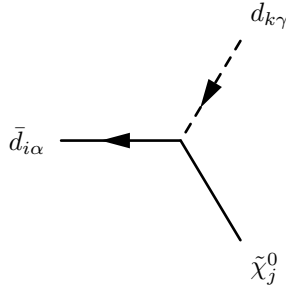


$$i\frac{1}{\sqrt{2}}\left(g_1N_{i1}^*-g_2N_{i2}^*\right)\Theta_{j,3}Z_{kj}^V\left(\frac{1-\gamma_5}{2}\right) \quad (305)$$



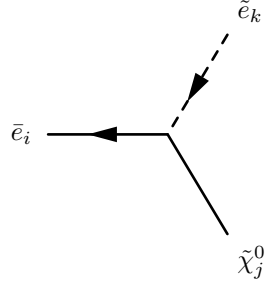
$$\begin{aligned} & \frac{i}{2}\left(V_{i2}^*\left(-2\lambda N_{j3}^*Z_{k3}^+-\sqrt{2}g_1N_{j1}^*Z_{k2}^+-\sqrt{2}g_2N_{j2}^*Z_{k2}^++\sqrt{2}\lambda N_{j5}^*Z_{k1}^+\right)\right. \\ & \left.+2V_{i3}^*\left(\lambda N_{j4}^*Z_{k1}^+-\sqrt{2}g_2N_{j2}^*Z_{k4}^+\right)+2g_2V_{i1}^*\left(-N_{j4}^*Z_{k2}^++\sqrt{2}N_{j5}^*Z_{k4}^+\right)\right)\left(\frac{1-\gamma_5}{2}\right) \end{aligned} \quad (306)$$

$$\begin{aligned} & +\frac{i}{2}\left(-2\left(g_2U_{i1}\left(N_{j3}Z_{k1}^++\sqrt{2}N_{j5}Z_{k3}^+\right)+U_{i3}\left(\lambda^*N_{j3}Z_{k2}^+-\sqrt{2}g_2N_{j2}Z_{k3}^+\right)\right)\right. \\ & \left.+U_{i2}\left(2\lambda^*N_{j4}Z_{k4}^++\sqrt{2}g_1N_{j1}Z_{k1}^++\sqrt{2}g_2N_{j2}Z_{k1}^++\sqrt{2}\lambda^*N_{j5}Z_{k2}^+\right)\right)\left(\frac{1+\gamma_5}{2}\right) \end{aligned} \quad (307)$$



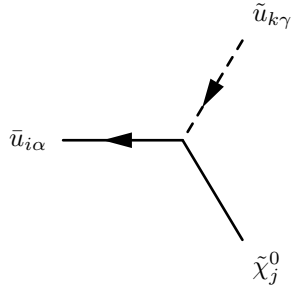
$$- \frac{i}{3} \delta_{\alpha\gamma} \left(3N_{j3}^* \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 U_{R,ia}^{d,*} Y_{d,ab} + \sqrt{2}g_1 N_{j1}^* \sum_{a=1}^3 Z_{k3+a}^{D,*} U_{R,ia}^{d,*} \right) \left(\frac{1-\gamma_5}{2} \right) \quad (308)$$

$$+ -\frac{i}{6} \delta_{\alpha\gamma} \left(6 \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{k3+a}^{D,*} U_{L,ib}^d N_{j3} + \sqrt{2} \sum_{a=1}^3 Z_{ka}^{D,*} U_{L,ia}^d \left(-3g_2 N_{j2} + g_1 N_{j1} \right) \right) \left(\frac{1+\gamma_5}{2} \right) \quad (309)$$



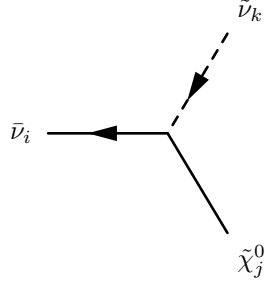
$$- i \left(N_{j3}^* \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 U_{R,ia}^{e,*} Y_{e,ab} + \sqrt{2}g_1 N_{j1}^* \sum_{a=1}^3 Z_{k3+a}^{E,*} U_{R,ia}^{e,*} \right) \left(\frac{1-\gamma_5}{2} \right) \quad (310)$$

$$+ \frac{i}{2} \left(-2 \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{k3+a}^{E,*} U_{L,ib}^e N_{j3} + \sqrt{2} \sum_{a=1}^3 Z_{ka}^{E,*} U_{L,ia}^e \left(g_1 N_{j1} + g_2 N_{j2} \right) \right) \left(\frac{1+\gamma_5}{2} \right) \quad (311)$$



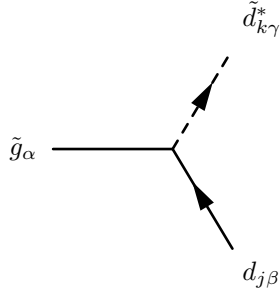
$$\frac{i}{3}\delta_{\alpha\gamma}\left(2\sqrt{2}g_1N_{j1}^*\sum_{a=1}^3Z_{k3+a}^{U,*}U_{R,ia}^{u,*}-3N_{j4}^*\sum_{b=1}^3Z_{kb}^{U,*}\sum_{a=1}^3U_{R,ia}^{u,*}Y_{u,ab}\right)\left(\frac{1-\gamma_5}{2}\right) \quad (312)$$

$$+\frac{i}{6}\delta_{\alpha\gamma}\left(6\sum_{b=1}^3\sum_{a=1}^3Y_{u,ab}^*Z_{k3+a}^{U,*}U_{L,ib}^uN_{j4}+\sqrt{2}\sum_{a=1}^3Z_{ka}^{U,*}U_{L,ia}^u(3g_2N_{j2}+g_1N_{j1})\right)\left(\frac{1+\gamma_5}{2}\right) \quad (313)$$



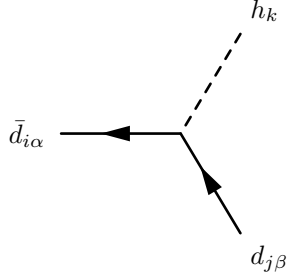
(314)

$$+i\frac{1}{\sqrt{2}}Z_{ki}^{V,*}\Theta_{i,3}(g_1N_{j1}-g_2N_{j2})\left(\frac{1+\gamma_5}{2}\right) \quad (315)$$



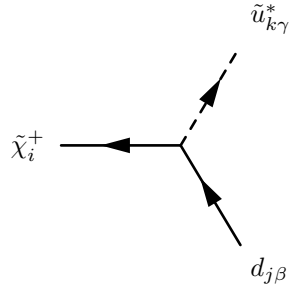
$$-i\frac{1}{\sqrt{2}}g_3\phi_{\tilde{g}}\lambda_{\gamma,\beta}^\alpha\sum_{a=1}^3U_{L,ja}^{d,*}Z_{ka}^D\left(\frac{1-\gamma_5}{2}\right) \quad (316)$$

$$+i\frac{1}{\sqrt{2}}g_3\phi_{\tilde{g}}^*\lambda_{\gamma,\beta}^\alpha\sum_{a=1}^3Z_{k3+a}^D U_{R,ja}^d\left(\frac{1+\gamma_5}{2}\right) \quad (317)$$



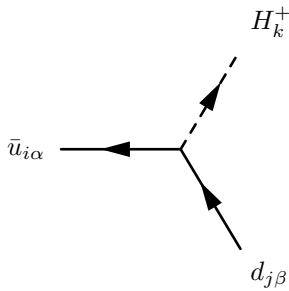
$$-i \frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{d,*} \sum_{a=1}^3 U_{R,ia}^{d,*} Y_{d,ab} Z_{k1}^H \left(\frac{1-\gamma_5}{2} \right) \quad (318)$$

$$+ -i \frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* U_{R,ja}^d U_{L,ib}^d Z_{k1}^H \left(\frac{1+\gamma_5}{2} \right) \quad (319)$$



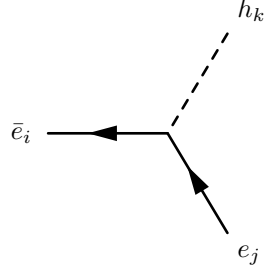
$$-i \delta_{\beta\gamma} \left(g_2 V_{i1}^* \sum_{a=1}^3 U_{L,ja}^{d,*} Z_{ka}^U - V_{i2}^* \sum_{b=1}^3 U_{L,jb}^{d,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U \right) \left(\frac{1-\gamma_5}{2} \right) \quad (320)$$

$$+ i \delta_{\beta\gamma} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* U_{R,ja}^d Z_{kb}^U U_{i2} \left(\frac{1+\gamma_5}{2} \right) \quad (321)$$



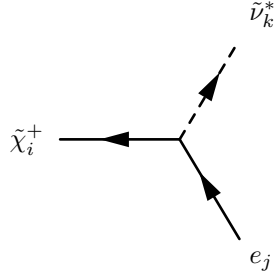
$$i\delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{d,*} \sum_{a=1}^3 U_{R,ia}^{u,*} Y_{u,ab} Z_{k2}^+ \left(\frac{1-\gamma_5}{2} \right) \quad (322)$$

$$+ i\delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* U_{R,ja}^d U_{L,ib}^u Z_{k1}^+ \left(\frac{1+\gamma_5}{2} \right) \quad (323)$$



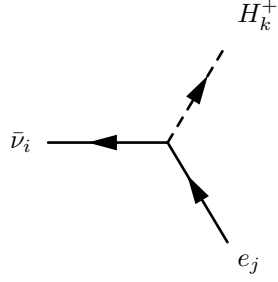
$$-i \frac{1}{\sqrt{2}} \sum_{b=1}^3 U_{L,jb}^{e,*} \sum_{a=1}^3 U_{R,ia}^{e,*} Y_{e,ab} Z_{k1}^H \left(\frac{1-\gamma_5}{2} \right) \quad (324)$$

$$+ -i \frac{1}{\sqrt{2}} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* U_{R,ja}^e U_{L,ib}^e Z_{k1}^H \left(\frac{1+\gamma_5}{2} \right) \quad (325)$$



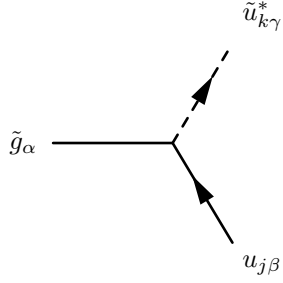
$$-ig_2 V_{i1}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{ka}^V \left(\frac{1-\gamma_5}{2} \right) \quad (326)$$

$$+ i \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* U_{R,ja}^e Z_{kb}^V U_{i2} \left(\frac{1+\gamma_5}{2} \right) \quad (327)$$



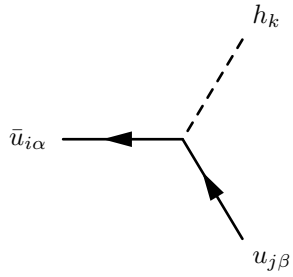
(328)

$$+ i \sum_{a=1}^3 Y_{e,ai}^* U_{R,ja}^e Z_{k1}^+ \left(\frac{1 + \gamma_5}{2} \right) \quad (329)$$



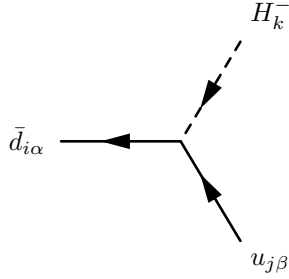
$$- i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}} \lambda_{\gamma,\beta}^\alpha \sum_{a=1}^3 U_{L,ja}^{u,*} Z_{ka}^U \left(\frac{1 - \gamma_5}{2} \right) \quad (330)$$

$$+ i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\gamma,\beta}^\alpha \sum_{a=1}^3 Z_{k3+a}^U U_{R,ja}^u \left(\frac{1 + \gamma_5}{2} \right) \quad (331)$$



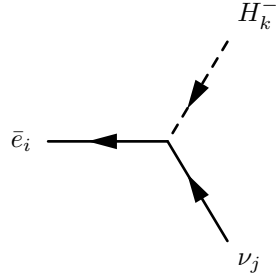
$$-i \frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{u,*} \sum_{a=1}^3 U_{R,ia}^{u,*} Y_{u,ab} Z_{k2}^H \left(\frac{1-\gamma_5}{2} \right) \quad (332)$$

$$+ -i \frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* U_{R,ja}^u U_{L,ib}^u Z_{k2}^H \left(\frac{1+\gamma_5}{2} \right) \quad (333)$$

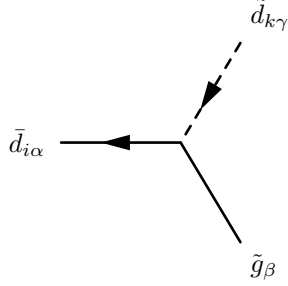


$$i \delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{u,*} \sum_{a=1}^3 U_{R,ia}^{d,*} Y_{d,ab} Z_{k1}^+ \left(\frac{1-\gamma_5}{2} \right) \quad (334)$$

$$+ i \delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* U_{R,ja}^u U_{L,ib}^d Z_{k2}^+ \left(\frac{1+\gamma_5}{2} \right) \quad (335)$$

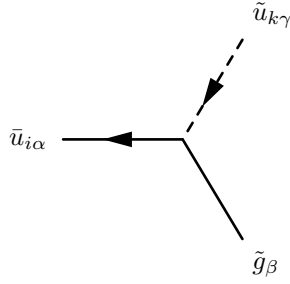


$$i \sum_{a=1}^3 U_{R,ia}^{e,*} Y_{e,aj} Z_{k1}^+ \left(\frac{1-\gamma_5}{2} \right) \quad (336)$$



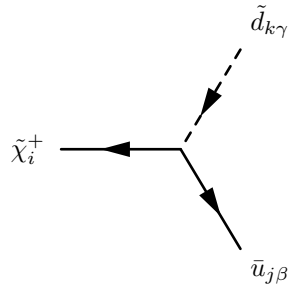
$$i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}} \lambda_{\alpha,\gamma}^\beta \sum_{a=1}^3 Z_{k3+a}^{D,*} U_{R,ia}^{d,*} \left(\frac{1-\gamma_5}{2} \right) \quad (337)$$

$$+ -i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\alpha,\gamma}^\beta \sum_{a=1}^3 Z_{ka}^{D,*} U_{L,ia}^d \left(\frac{1+\gamma_5}{2} \right) \quad (338)$$



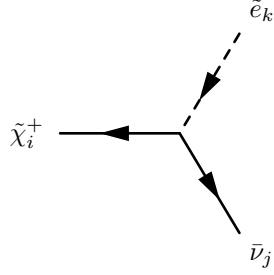
$$i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}} \lambda_{\alpha,\gamma}^\beta \sum_{a=1}^3 Z_{k3+a}^{U,*} U_{R,ia}^{u,*} \left(\frac{1-\gamma_5}{2} \right) \quad (339)$$

$$+ -i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\alpha,\gamma}^\beta \sum_{a=1}^3 Z_{ka}^{U,*} U_{L,ia}^u \left(\frac{1+\gamma_5}{2} \right) \quad (340)$$



$$iV_{i2}^* \delta_{\beta\gamma} \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 U_{R,ja}^{u,*} Y_{u,ab} \left(\frac{1-\gamma_5}{2} \right) \quad (341)$$

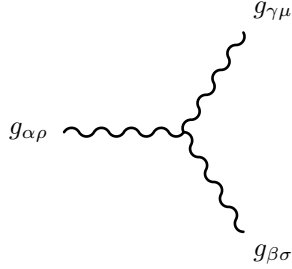
$$+ -i\delta_{\beta\gamma} \left(g_2 \sum_{a=1}^3 Z_{ka}^{D,*} U_{L,ja}^u U_{i1} - \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{k3+a}^{D,*} U_{L,jb}^u U_{i2} \right) \left(\frac{1+\gamma_5}{2} \right) \quad (342)$$



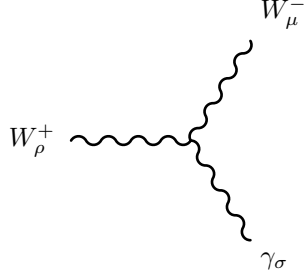
(343)

$$+ -i \left(g_2 Z_{kj}^{E,*} \Theta_{j,3} U_{i1} - \sum_{a=1}^3 Y_{e,aj}^* Z_{k3+a}^{E,*} U_{i2} \right) \left(\frac{1+\gamma_5}{2} \right) \quad (344)$$

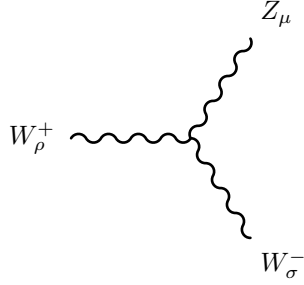
9.6 Three Vector Boson-Interaction



$$g_3 f_{\alpha,\beta,\gamma} \left(g_{\rho\mu} \left(-p_\sigma^{g_{\gamma\mu}} + p_\sigma^{g_{\alpha\rho}} \right) + g_{\rho\sigma} \left(-p_\mu^{g_{\alpha\rho}} + p_\mu^{g_{\beta\sigma}} \right) + g_{\sigma\mu} \left(-p_\rho^{g_{\beta\sigma}} + p_\rho^{g_{\gamma\mu}} \right) \right) \quad (345)$$

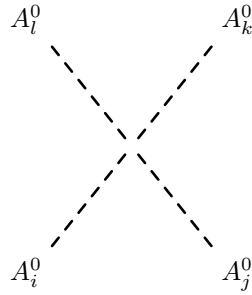


$$ig_2 \sin \Theta_W \left(g_{\rho\mu} \left(-p_\sigma^{W^-} + p_\sigma^{W^+} \right) + g_{\rho\sigma} \left(-p_\mu^{W^+} + p_\mu^{\gamma\sigma} \right) + g_{\sigma\mu} \left(-p_\rho^{\gamma\sigma} + p_\rho^{W^-} \right) \right) \quad (346)$$



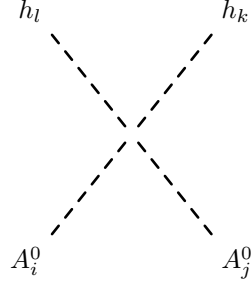
$$-ig_2 \cos \Theta_W \left(g_{\rho\mu} \left(-p_\sigma^{Z^0} + p_\sigma^{W^+} \right) + g_{\rho\sigma} \left(-p_\mu^{W^+} + p_\mu^{W^-} \right) + g_{\sigma\mu} \left(-p_\rho^{W^-} + p_\rho^{Z^0} \right) \right) \quad (347)$$

9.7 Four Scalar-Interaction

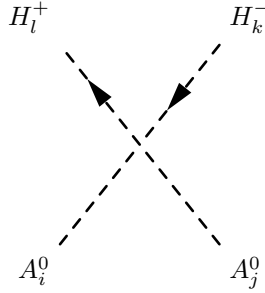


$$-\frac{i}{4} \left(2|\lambda|^2 Z_{i3}^A \left(Z_{j1}^A \left(Z_{k1}^A Z_{l3}^A + Z_{k3}^A Z_{l1}^A \right) + Z_{j2}^A \left(Z_{k2}^A Z_{l3}^A + Z_{k3}^A Z_{l2}^A \right) + Z_{j3}^A \left(Z_{k1}^A Z_{l1}^A + Z_{k2}^A Z_{l2}^A \right) \right) \right. \\ \left. - Z_{i2}^A \left(\left(-2|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{j1}^A \left(Z_{k1}^A Z_{l2}^A + Z_{k2}^A Z_{l1}^A \right) - 2|\lambda|^2 Z_{j3}^A \left(Z_{k2}^A Z_{l3}^A + Z_{k3}^A Z_{l2}^A \right) \right) \right)$$

$$\begin{aligned}
& + Z_{j2}^A \left(\left(-2|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k1}^A Z_{l1}^A - 2|\lambda|^2 Z_{k3}^A Z_{l3}^A - 3 \left(g_1^2 + g_2^2 \right) Z_{k2}^A Z_{l2}^A \right) \\
& + Z_{i1}^A \left(- \left(-2|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{j2}^A \left(Z_{k1}^A Z_{l2}^A + Z_{k2}^A Z_{l1}^A \right) + 2|\lambda|^2 Z_{j3}^A \left(Z_{k1}^A Z_{l3}^A + Z_{k3}^A Z_{l1}^A \right) \right. \\
& \left. + Z_{j1}^A \left(- \left(-2|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k2}^A Z_{l2}^A + 2|\lambda|^2 Z_{k3}^A Z_{l3}^A + 3 \left(g_1^2 + g_2^2 \right) Z_{k1}^A Z_{l1}^A \right) \right)
\end{aligned} \tag{348}$$

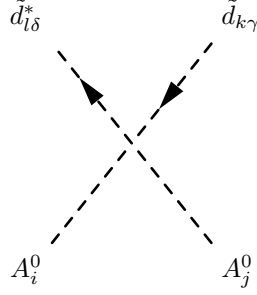


$$\begin{aligned}
& - \frac{i}{4} \left(2|\lambda|^2 Z_{i3}^A Z_{j3}^A \left(Z_{k1}^H Z_{l1}^H + Z_{k2}^H Z_{l2}^H \right) \right. \\
& + Z_{i2}^A Z_{j2}^A \left(- \left(-2|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k1}^H Z_{l1}^H + 2|\lambda|^2 Z_{k3}^H Z_{l3}^H + \left(g_1^2 + g_2^2 \right) Z_{k2}^H Z_{l2}^H \right) \\
& \left. + Z_{i1}^A Z_{j1}^A \left(- \left(-2|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k2}^H Z_{l2}^H + 2|\lambda|^2 Z_{k3}^H Z_{l3}^H + \left(g_1^2 + g_2^2 \right) Z_{k1}^H Z_{l1}^H \right) \right)
\end{aligned} \tag{349}$$

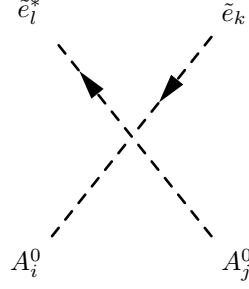


$$\begin{aligned}
& - \frac{i}{4} \left(Z_{i1}^A \left(- \left(g_2^2 + |\lambda|^2 \right) Z_{j2}^A \left(Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) \right. \right. \\
& + Z_{j1}^A \left(\left(g_1^2 + g_2^2 \right) Z_{k1}^+ Z_{l1}^+ + \left(4|\lambda|^2 - g_1^2 + g_2^2 \right) Z_{k2}^+ Z_{l2}^+ - 2g_2^2 Z_{k3}^+ Z_{l3}^+ + 4|\lambda|^2 Z_{k3}^+ Z_{l3}^+ \right. \\
& \left. \left. + 2g_2^2 Z_{k4}^+ Z_{l4}^+ \right) \right. \\
& + \sqrt{2} \left(- |\lambda|^2 + g_2^2 \right) Z_{j3}^A \left(Z_{k1}^+ \left(Z_{l3}^+ + Z_{l4}^+ \right) + Z_{k3}^+ Z_{l1}^+ + Z_{k4}^+ Z_{l1}^+ \right) \\
& \left. - Z_{i2}^A \left(\left(g_2^2 + |\lambda|^2 \right) Z_{j1}^A \left(Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) \right) \right)
\end{aligned}$$

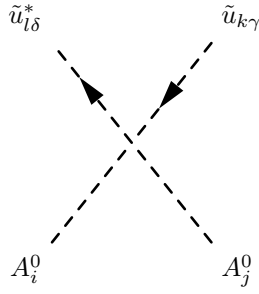
$$\begin{aligned}
& + Z_{j2}^A \left((-4|\lambda|^2 - g_2^2 + g_1^2) Z_{k1}^+ Z_{l1}^+ - (g_1^2 + g_2^2) Z_{k2}^+ Z_{l2}^+ - 2g_2^2 Z_{k3}^+ Z_{l3}^+ + 2g_2^2 Z_{k4}^+ Z_{l4}^+ \right. \\
& - 4|\lambda|^2 Z_{k4}^+ Z_{l4}^+ \left. \right) \\
& + \sqrt{2} \left(-|\lambda|^2 + g_2^2 \right) Z_{j3}^A \left(Z_{k2}^+ (Z_{l3}^+ + Z_{l4}^+) + Z_{k3}^+ Z_{l2}^+ + Z_{k4}^+ Z_{l2}^+ \right) \\
& + Z_{i3}^A \left(g_2^2 \left(4Z_{j3}^A (Z_{k3}^+ + Z_{k4}^+) (Z_{l3}^+ + Z_{l4}^+) + \sqrt{2} Z_{j1}^A (Z_{k1}^+ (Z_{l3}^+ + Z_{l4}^+) + Z_{k3}^+ Z_{l1}^+ + Z_{k4}^+ Z_{l1}^+) \right. \right. \\
& - \left. \left. \sqrt{2} Z_{j2}^A (Z_{k2}^+ (Z_{l3}^+ + Z_{l4}^+) + Z_{k3}^+ Z_{l2}^+ + Z_{k4}^+ Z_{l2}^+) \right) \right) \\
& + |\lambda|^2 \left(2Z_{j3}^A (Z_{k1}^+ Z_{l1}^+ + Z_{k2}^+ Z_{l2}^+) \right) \\
& + \sqrt{2} \left(-Z_{j1}^A (Z_{k1}^+ (Z_{l3}^+ + Z_{l4}^+) + Z_{k3}^+ Z_{l1}^+ + Z_{k4}^+ Z_{l1}^+) + Z_{j2}^A (Z_{k2}^+ (Z_{l3}^+ + Z_{l4}^+) + Z_{k3}^+ Z_{l2}^+ + Z_{k4}^+ Z_{l2}^+) \right) \left. \right) \quad (350)
\end{aligned}$$



$$\begin{aligned}
& \frac{i}{12} \delta_{\gamma\delta} \left((3g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ka}^{D,*} Z_{la}^D (Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A) \right. \\
& + 2g_1^2 \sum_{a=1}^3 Z_{k3+a}^{D,*} Z_{l3+a}^D (Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A) \\
& - 3 \left(4 \sum_{c=1}^3 Z_{k3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{d,ba} Z_{l3+b}^D Z_{i1}^A Z_{j1}^A \right. \\
& + 4 \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^D Z_{i1}^A Z_{j1}^A \\
& \left. + \sqrt{2} \left(\lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{k3+a}^{D,*} Z_{lb}^D + \lambda^* \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D \right) (Z_{i2}^A Z_{j3}^A + Z_{i3}^A Z_{j2}^A) \right) \left. \right) \quad (351)
\end{aligned}$$

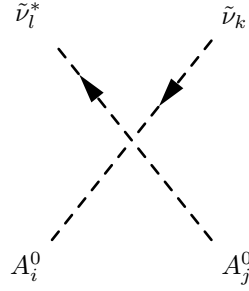


$$\begin{aligned}
& -\frac{i}{4} \left(4 \sum_{c=1}^3 Z_{k3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{e,ba} Z_{l3+b}^E Z_{i1}^A Z_{j1}^A \right. \\
& + 4 \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E Z_{i1}^A Z_{j1}^A + \sqrt{2} \lambda^* \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E Z_{i3}^A Z_{j2}^A \\
& + \sqrt{2} \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{k3+a}^{E,*} Z_{lb}^E Z_{i3}^A Z_{j2}^A \\
& + \left(-g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{E,*} Z_{la}^E \left(Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A \right) \\
& + 2g_1^2 \sum_{a=1}^3 Z_{k3+a}^{E,*} Z_{l3+a}^E \left(-Z_{i1}^A Z_{j1}^A + Z_{i2}^A Z_{j2}^A \right) + \sqrt{2} \lambda^* \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E Z_{i2}^A Z_{j3}^A \\
& \left. + \sqrt{2} \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{k3+a}^{E,*} Z_{lb}^E Z_{i2}^A Z_{j3}^A \right) \tag{352}
\end{aligned}$$

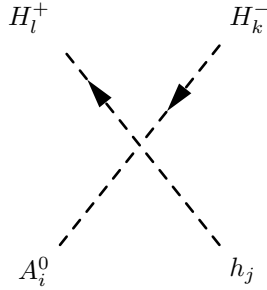


$$\begin{aligned}
& \frac{i}{12} \delta_{\gamma\delta} \left(\left(-3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^U \left(Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A \right) \right. \\
& \left. + 4g_1^2 \sum_{a=1}^3 Z_{k3+a}^{U,*} Z_{l3+a}^U \left(-Z_{i1}^A Z_{j1}^A + Z_{i2}^A Z_{j2}^A \right) \right)
\end{aligned}$$

$$\begin{aligned}
& -3 \left(4 \left(\sum_{c=1}^3 Z_{k3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{u,ba} Z_{l3+b}^U + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^U \right) Z_{i2}^A Z_{j2}^A \right. \\
& + \sqrt{2} \lambda^* \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \left(Z_{i1}^A Z_{j3}^A + Z_{i3}^A Z_{j1}^A \right) \\
& \left. + \sqrt{2} \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{k3+a}^{U,*} Z_{lb}^U \left(Z_{i1}^A Z_{j3}^A + Z_{i3}^A Z_{j1}^A \right) \right) \quad (353)
\end{aligned}$$

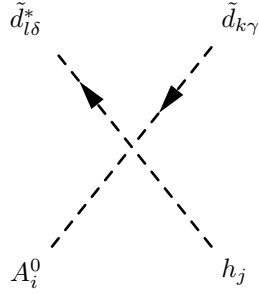


$$-\frac{i}{4} (g_1^2 + g_2^2) \delta_{kl} \left(Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A \right) \quad (354)$$

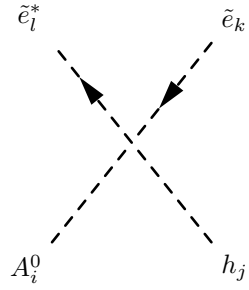


$$\begin{aligned}
& \frac{1}{4} \left(Z_{i1}^A \left((g_2^2 + |\lambda|^2) Z_{j2}^H \left(-Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) \right. \right. \\
& + \sqrt{2} \left(-|\lambda|^2 + g_2^2 \right) Z_{j3}^H \left(Z_{k1}^+ \left(-Z_{l3}^+ + Z_{l4}^+ \right) + Z_{k3}^+ Z_{l1}^+ - Z_{k4}^+ Z_{l1}^+ \right) \left. \right) \\
& + Z_{i2}^A \left((g_2^2 + |\lambda|^2) Z_{j1}^H \left(-Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) \right. \\
& - \sqrt{2} \left(-|\lambda|^2 + g_2^2 \right) Z_{j3}^H \left(Z_{k2}^+ \left(-Z_{l3}^+ + Z_{l4}^+ \right) + Z_{k3}^+ Z_{l2}^+ - Z_{k4}^+ Z_{l2}^+ \right) \left. \right) \\
& + Z_{i3}^A \left(4g_2^2 Z_{j3}^H \left(Z_{k3}^+ Z_{l4}^+ - Z_{k4}^+ Z_{l3}^+ \right) \right. \\
& \left. - \sqrt{2} \left(-|\lambda|^2 + g_2^2 \right) Z_{j1}^H \left(-Z_{k1}^+ \left(Z_{l3}^+ + Z_{l4}^+ \right) + Z_{k3}^+ Z_{l1}^+ + Z_{k4}^+ Z_{l1}^+ \right) \right)
\end{aligned}$$

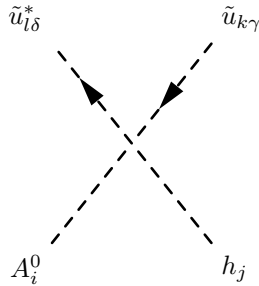
$$-\sqrt{2}\left(-|\lambda|^2 + g_2^2\right)Z_{j2}^H\left(-Z_{k2}^+\left(Z_{l3}^+ + Z_{l4}^+\right) + Z_{k3}^+Z_{l2}^+ + Z_{k4}^+Z_{l2}^+\right)\right) \quad (355)$$



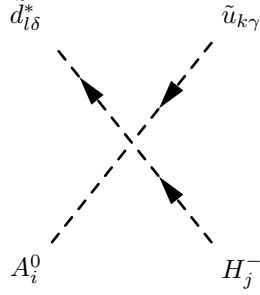
$$\frac{1}{2}\frac{1}{\sqrt{2}}\delta_{\gamma\delta}\left(-\lambda\sum_{b=1}^3\sum_{a=1}^3Y_{d,ab}^*Z_{k3+a}^{D,*}Z_{lb}^D + \lambda^*\sum_{b=1}^3Z_{kb}^{D,*}\sum_{a=1}^3Y_{d,ab}Z_{l3+a}^D\right)\left(Z_{i2}^AZ_{j3}^H + Z_{i3}^AZ_{j2}^H\right) \quad (356)$$



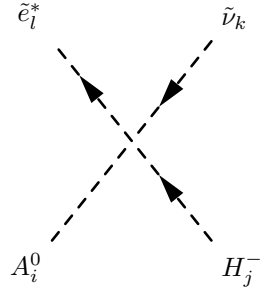
$$\frac{1}{2}\frac{1}{\sqrt{2}}\left(-\lambda\sum_{b=1}^3\sum_{a=1}^3Y_{e,ab}^*Z_{k3+a}^{E,*}Z_{lb}^E + \lambda^*\sum_{b=1}^3Z_{kb}^{E,*}\sum_{a=1}^3Y_{e,ab}Z_{l3+a}^E\right)\left(Z_{i2}^AZ_{j3}^H + Z_{i3}^AZ_{j2}^H\right) \quad (357)$$



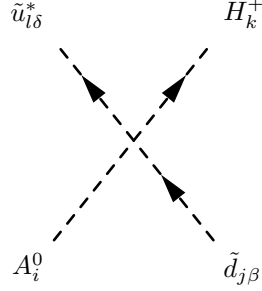
$$\frac{1}{2}\frac{1}{\sqrt{2}}\delta_{\gamma\delta}\left(-\lambda\sum_{b=1}^3\sum_{a=1}^3Y_{u,ab}^*Z_{k3+a}^{U,*}Z_{lb}^U + \lambda^*\sum_{b=1}^3Z_{kb}^{U,*}\sum_{a=1}^3Y_{u,ab}Z_{l3+a}^U\right)\left(Z_{i1}^AZ_{j3}^H + Z_{i3}^AZ_{j1}^H\right) \quad (358)$$



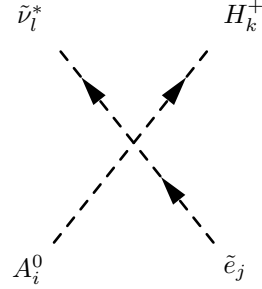
$$\begin{aligned}
& -\frac{1}{4}\delta_{\gamma\delta}\left(2\left(-\sqrt{2}\sum_{c=1}^3\sum_{b=1}^3Z_{kb}^{U,*}\sum_{a=1}^3Y_{d,ac}^*Y_{d,ab}Z_{lc}^DZ_{i1}^AZ_{j1}^+-\lambda\sum_{b=1}^3\sum_{a=1}^3Y_{u,ab}^*Z_{k3+a}^{U,*}Z_{lb}^DZ_{i3}^AZ_{j1}^+\right.\right. \\
& +\sqrt{2}\sum_{c=1}^3\sum_{b=1}^3Z_{kb}^{U,*}\sum_{a=1}^3Y_{u,ac}^*Y_{u,ab}Z_{lc}^DZ_{i2}^AZ_{j2}^++\lambda^*\sum_{b=1}^3Z_{kb}^{U,*}\sum_{a=1}^3Y_{d,ab}Z_{l3+a}^DZ_{i3}^AZ_{j2}^+ \\
& +\sqrt{2}\sum_{c=1}^3Z_{k3+c}^{U,*}\sum_{b=1}^3\sum_{a=1}^3Y_{u,ca}^*Y_{d,ba}Z_{l3+b}^D\left(Z_{i1}^AZ_{j2}^+-Z_{i2}^AZ_{j1}^+\right) \\
& +\sqrt{2}\lambda\sum_{b=1}^3\sum_{a=1}^3Y_{u,ab}^*Z_{k3+a}^{U,*}Z_{lb}^DZ_{i1}^AZ_{j3}^++\sqrt{2}\lambda^*\sum_{b=1}^3Z_{kb}^{U,*}\sum_{a=1}^3Y_{d,ab}Z_{l3+a}^DZ_{i2}^AZ_{j4}^+ \\
& \left.\left.+g_2^2\sum_{a=1}^3Z_{ka}^{U,*}Z_{la}^D\left(2Z_{i3}^A\left(Z_{j3}^++Z_{j4}^+\right)+\sqrt{2}Z_{i1}^AZ_{j1}^+-\sqrt{2}Z_{i2}^AZ_{j2}^+\right)\right)\right) \tag{359}
\end{aligned}$$



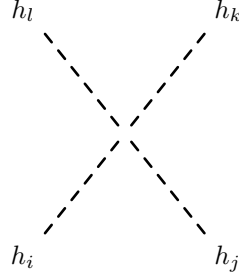
$$\begin{aligned}
& \frac{1}{4}\left(2\sqrt{2}\sum_{c=1}^3\sum_{b=1}^3Z_{kb}^{V,*}\sum_{a=1}^3Y_{e,ac}^*Y_{e,ab}Z_{lc}^EZ_{i1}^AZ_{j1}^+\right. \\
& -2\lambda^*\sum_{b=1}^3Z_{kb}^{V,*}\sum_{a=1}^3Y_{e,ab}Z_{l3+a}^E\left(\sqrt{2}Z_{i2}^AZ_{j4}^++Z_{i3}^AZ_{j2}^+\right) \\
& \left.-g_2^2\sum_{a=1}^3Z_{ka}^{V,*}Z_{la}^E\left(2Z_{i3}^A\left(Z_{j3}^++Z_{j4}^+\right)+\sqrt{2}Z_{i1}^AZ_{j1}^+-\sqrt{2}Z_{i2}^AZ_{j2}^+\right)\right) \tag{360}
\end{aligned}$$



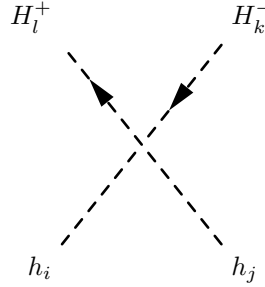
$$\begin{aligned}
& \frac{1}{4} \delta_{\beta\delta} \left(2 \left(-\sqrt{2} \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^U Z_{i1}^A Z_{k1}^+ - \lambda^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U Z_{i3}^A Z_{k1}^+ \right. \right. \\
& + \sqrt{2} \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^U Z_{i2}^A Z_{k2}^+ + \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{lb}^U Z_{i3}^A Z_{k2}^+ \\
& + \sqrt{2} \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{u,ba} Z_{l3+b}^U \left(Z_{i1}^A Z_{k2}^+ - Z_{i2}^A Z_{k1}^+ \right) \\
& + \sqrt{2} \lambda^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U Z_{i1}^A Z_{k3}^+ + \sqrt{2} \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{lb}^U Z_{i2}^A Z_{k4}^+ \left. \right) \\
& + g_2^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^U \left(2Z_{i3}^A \left(Z_{k3}^+ + Z_{k4}^+ \right) + \sqrt{2} Z_{i1}^A Z_{k1}^+ - \sqrt{2} Z_{i2}^A Z_{k2}^+ \right) \tag{361}
\end{aligned}$$



$$\begin{aligned}
& \frac{1}{4} \left(-2\sqrt{2} \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^V Z_{i1}^A Z_{k1}^+ \right. \\
& + 2\lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{lb}^V \left(\sqrt{2} Z_{i2}^A Z_{k4}^+ + Z_{i3}^A Z_{k2}^+ \right) \\
& + g_2^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^V \left(2Z_{i3}^A \left(Z_{k3}^+ + Z_{k4}^+ \right) + \sqrt{2} Z_{i1}^A Z_{k1}^+ - \sqrt{2} Z_{i2}^A Z_{k2}^+ \right) \left. \right) \tag{362}
\end{aligned}$$

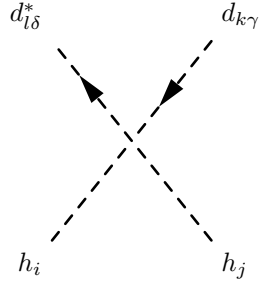


$$\begin{aligned}
& -\frac{i}{4} \left(2|\lambda|^2 Z_{i3}^H \left(Z_{j1}^H \left(Z_{k1}^H Z_{l3}^H + Z_{k3}^H Z_{l1}^H \right) + Z_{j2}^H \left(Z_{k2}^H Z_{l3}^H + Z_{k3}^H Z_{l2}^H \right) + Z_{j3}^H \left(Z_{k1}^H Z_{l1}^H + Z_{k2}^H Z_{l2}^H \right) \right) \right. \\
& - Z_{i2}^H \left(\left(-2|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{j1}^H \left(Z_{k1}^H Z_{l2}^H + Z_{k2}^H Z_{l1}^H \right) - 2|\lambda|^2 Z_{j3}^H \left(Z_{k2}^H Z_{l3}^H + Z_{k3}^H Z_{l2}^H \right) \right. \\
& + Z_{j2}^H \left(\left(-2|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k1}^H Z_{l1}^H - 2|\lambda|^2 Z_{k3}^H Z_{l3}^H - 3 \left(g_1^2 + g_2^2 \right) Z_{k2}^H Z_{l2}^H \right) \\
& + Z_{i1}^H \left(- \left(-2|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{j2}^H \left(Z_{k1}^H Z_{l2}^H + Z_{k2}^H Z_{l1}^H \right) + 2|\lambda|^2 Z_{j3}^H \left(Z_{k1}^H Z_{l3}^H + Z_{k3}^H Z_{l1}^H \right) \right. \\
& \left. \left. + Z_{j1}^H \left(- \left(-2|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k2}^H Z_{l2}^H + 2|\lambda|^2 Z_{k3}^H Z_{l3}^H + 3 \left(g_1^2 + g_2^2 \right) Z_{k1}^H Z_{l1}^H \right) \right) \right) \quad (363)
\end{aligned}$$

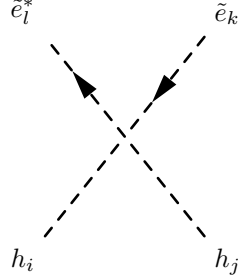


$$\begin{aligned}
& -\frac{i}{4} \left(Z_{i1}^H \left(\left(g_2^2 + |\lambda|^2 \right) Z_{j2}^H \left(Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) \right. \right. \\
& + \sqrt{2} \left(-|\lambda|^2 + g_2^2 \right) Z_{j3}^H \left(Z_{k1}^+ \left(-Z_{l4}^+ + Z_{l3}^+ \right) + Z_{k3}^+ Z_{l1}^+ - Z_{k4}^+ Z_{l1}^+ \right) \\
& + Z_{j1}^H \left(\left(g_1^2 + g_2^2 \right) Z_{k1}^+ Z_{l1}^+ + \left(4|\lambda|^2 - g_1^2 + g_2^2 \right) Z_{k2}^+ Z_{l2}^+ - 2g_2^2 Z_{k3}^+ Z_{l3}^+ + 4|\lambda|^2 Z_{k3}^+ Z_{l3}^+ \right. \\
& \left. \left. + 2g_2^2 Z_{k4}^+ Z_{l4}^+ \right) \right) \\
& + Z_{i2}^H \left(\left(g_2^2 + |\lambda|^2 \right) Z_{j1}^H \left(Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) \right. \\
& + \sqrt{2} \left(-|\lambda|^2 + g_2^2 \right) Z_{j3}^H \left(Z_{k2}^+ \left(-Z_{l4}^+ + Z_{l3}^+ \right) + Z_{k3}^+ Z_{l2}^+ - Z_{k4}^+ Z_{l2}^+ \right) \\
& \left. \left. + Z_{j2}^H \left(\left(4|\lambda|^2 - g_1^2 + g_2^2 \right) Z_{k1}^+ Z_{l1}^+ + \left(g_1^2 + g_2^2 \right) Z_{k2}^+ Z_{l2}^+ + 2g_2^2 Z_{k3}^+ Z_{l3}^+ - 2g_2^2 Z_{k4}^+ Z_{l4}^+ \right) \right) \right)
\end{aligned}$$

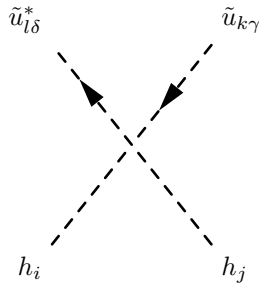
$$\begin{aligned}
& + 4|\lambda|^2 Z_{k_4}^+ Z_{l_4}^+)) \\
& + Z_{i_3}^H \left(g_2^2 \left(\sqrt{2} Z_{j_1}^H \left(Z_{k_1}^+ \left(-Z_{l_4}^+ + Z_{l_3}^+ \right) + Z_{k_3}^+ Z_{l_1}^+ - Z_{k_4}^+ Z_{l_1}^+ \right) \right. \right. \\
& + \sqrt{2} Z_{j_2}^H \left(Z_{k_2}^+ \left(-Z_{l_4}^+ + Z_{l_3}^+ \right) + Z_{k_3}^+ Z_{l_2}^+ - Z_{k_4}^+ Z_{l_2}^+ \right) + 4 Z_{j_3}^H \left(-Z_{k_4}^+ + Z_{k_3}^+ \right) \left(-Z_{l_4}^+ + Z_{l_3}^+ \right) \right) \\
& + |\lambda|^2 \left(2 Z_{j_3}^H \left(Z_{k_1}^+ Z_{l_1}^+ + Z_{k_2}^+ Z_{l_2}^+ \right) \right. \\
& + \sqrt{2} \left(Z_{j_1}^H \left(Z_{k_1}^+ \left(-Z_{l_3}^+ + Z_{l_4}^+ \right) - Z_{k_3}^+ Z_{l_1}^+ + Z_{k_4}^+ Z_{l_1}^+ \right) \right. \\
& \left. \left. + Z_{j_2}^H \left(Z_{k_2}^+ \left(-Z_{l_3}^+ + Z_{l_4}^+ \right) - Z_{k_3}^+ Z_{l_2}^+ + Z_{k_4}^+ Z_{l_2}^+ \right) \right) \right) \right) \right) \tag{364}
\end{aligned}$$



$$\begin{aligned}
& \frac{i}{12} \delta_{\gamma\delta} \left(\left(3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{D,*} Z_{la}^D \left(Z_{i_1}^H Z_{j_1}^H - Z_{i_2}^H Z_{j_2}^H \right) \right. \\
& + 2g_1^2 \sum_{a=1}^3 Z_{k_{3+a}}^{D,*} Z_{l_{3+a}}^D \left(Z_{i_1}^H Z_{j_1}^H - Z_{i_2}^H Z_{j_2}^H \right) \\
& + 3 \left(-4 \sum_{c=1}^3 Z_{k_{3+c}}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{d,ba} Z_{l_{3+b}}^D Z_{i_1}^H Z_{j_1}^H \right. \\
& - 4 \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{l_c}^D Z_{i_1}^H Z_{j_1}^H \\
& \left. \left. + \sqrt{2} \left(\lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{k_{3+a}}^{D,*} Z_{l_b}^D + \lambda^* \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{l_{3+a}}^D \right) \left(Z_{i_2}^H Z_{j_3}^H + Z_{i_3}^H Z_{j_2}^H \right) \right) \right) \tag{365}
\end{aligned}$$

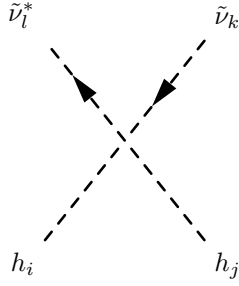


$$\begin{aligned}
& -\frac{i}{4} \left(4 \sum_{c=1}^3 Z_{k3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{e,ba} Z_{l3+b}^E Z_{i1}^H Z_{j1}^H \right. \\
& + 4 \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E Z_{i1}^H Z_{j1}^H - \sqrt{2} \lambda^* \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E Z_{i3}^H Z_{j2}^H \\
& - \sqrt{2} \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{k3+a}^{E,*} Z_{lb}^E Z_{i3}^H Z_{j2}^H \\
& + \left(-g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{E,*} Z_{la}^E \left(Z_{i1}^H Z_{j1}^H - Z_{i2}^H Z_{j2}^H \right) \\
& + 2g_1^2 \sum_{a=1}^3 Z_{k3+a}^{E,*} Z_{l3+a}^E \left(-Z_{i1}^H Z_{j1}^H + Z_{i2}^H Z_{j2}^H \right) - \sqrt{2} \lambda^* \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E Z_{i2}^H Z_{j3}^H \\
& \left. - \sqrt{2} \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{k3+a}^{E,*} Z_{lb}^E Z_{i2}^H Z_{j3}^H \right) \tag{366}
\end{aligned}$$

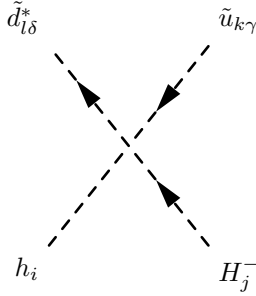


$$\begin{aligned}
& \frac{i}{12} \delta_{\gamma\delta} \left(\left(-3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^U \left(Z_{i1}^H Z_{j1}^H - Z_{i2}^H Z_{j2}^H \right) \right. \\
& \left. + 4g_1^2 \sum_{a=1}^3 Z_{k3+a}^{U,*} Z_{l3+a}^U \left(-Z_{i1}^H Z_{j1}^H + Z_{i2}^H Z_{j2}^H \right) \right)
\end{aligned}$$

$$\begin{aligned}
& + 3 \left(-4 \left(\sum_{c=1}^3 Z_{k3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{u,ba} Z_{l3+b}^U + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^U \right) Z_{i2}^H Z_{j2}^H \right. \\
& + \sqrt{2} \lambda^* \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \left(Z_{i1}^H Z_{j3}^H + Z_{i3}^H Z_{j1}^H \right) \\
& \left. + \sqrt{2} \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{k3+a}^{U,*} Z_{lb}^U \left(Z_{i1}^H Z_{j3}^H + Z_{i3}^H Z_{j1}^H \right) \right) \quad (367)
\end{aligned}$$

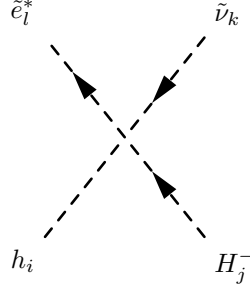


$$-\frac{i}{4} (g_1^2 + g_2^2) \delta_{kl} \left(Z_{i1}^H Z_{j1}^H - Z_{i2}^H Z_{j2}^H \right) \quad (368)$$

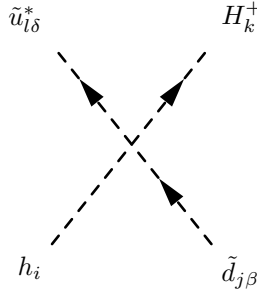


$$\begin{aligned}
& -\frac{i}{4} \delta_{\gamma\delta} \left(g_2^2 \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^D \left(2Z_{i3}^H \left(-Z_{j4}^+ + Z_{j3}^+ \right) + \sqrt{2} Z_{i1}^H Z_{j1}^+ + \sqrt{2} Z_{i2}^H Z_{j2}^+ \right) \right. \\
& - 2 \left(\sqrt{2} \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^D Z_{i1}^H Z_{j1}^+ - \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{k3+a}^{U,*} Z_{lb}^D Z_{i3}^H Z_{j1}^+ \right. \\
& + \sqrt{2} \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^D Z_{i2}^H Z_{j2}^+ - \lambda^* \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D Z_{i3}^H Z_{j2}^+ \\
& \left. \left. + \sqrt{2} \sum_{c=1}^3 Z_{k3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{d,ba} Z_{l3+b}^D \left(Z_{i1}^H Z_{j2}^+ + Z_{i2}^H Z_{j1}^+ \right) \right)
\end{aligned}$$

$$+ \sqrt{2}\lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{k3+a}^{U,*} Z_{lb}^D Z_{i1}^H Z_{j3}^+ - \sqrt{2}\lambda^* \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D Z_{i2}^H Z_{j4}^+ \Big) \quad (369)$$

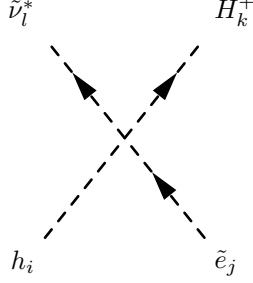


$$- \frac{i}{4} \left(-2\sqrt{2} \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{V,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E Z_{i1}^H Z_{j1}^+ \right. \\ \left. + g_2^2 \sum_{a=1}^3 Z_{ka}^{V,*} Z_{la}^E \left(2Z_{i3}^H \left(-Z_{j4}^+ + Z_{j3}^+ \right) + \sqrt{2}Z_{i1}^H Z_{j1}^+ + \sqrt{2}Z_{i2}^H Z_{j2}^+ \right) \right. \\ \left. + 2\lambda^* \sum_{b=1}^3 Z_{kb}^{V,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \left(\sqrt{2}Z_{i2}^H Z_{j4}^+ + Z_{i3}^H Z_{j2}^+ \right) \right) \quad (370)$$

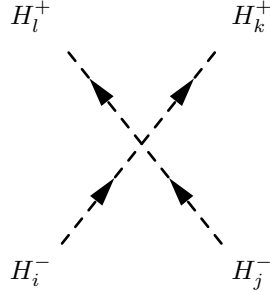


$$- \frac{i}{4} \delta_{\beta\delta} \left(g_2^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^U \left(2Z_{i3}^H \left(-Z_{k4}^+ + Z_{k3}^+ \right) + \sqrt{2}Z_{i1}^H Z_{k1}^+ + \sqrt{2}Z_{i2}^H Z_{k2}^+ \right) \right. \\ \left. - 2 \left(\sqrt{2} \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^U Z_{i1}^H Z_{k1}^+ - \lambda^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U Z_{i3}^H Z_{k1}^+ \right. \right. \\ \left. \left. + \sqrt{2} \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^U Z_{i2}^H Z_{k2}^+ - \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^D Z_{lb}^U Z_{i3}^H Z_{k2}^+ \right) \right)$$

$$\begin{aligned}
& + \sqrt{2} \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{u,ba} Z_{l3+b}^U \left(Z_{i1}^H Z_{k2}^+ + Z_{i2}^H Z_{k1}^+ \right) \\
& + \sqrt{2} \lambda^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U Z_{i1}^H Z_{k3}^+ - \sqrt{2} \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{lb}^U Z_{i2}^H Z_{k4}^+ \Big) \Big) \tag{371}
\end{aligned}$$

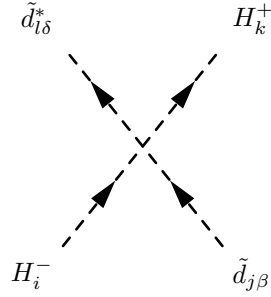


$$\begin{aligned}
& - \frac{i}{4} \left(-2\sqrt{2} \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^V Z_{i1}^H Z_{k1}^+ \right. \\
& + g_2^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^V \left(2Z_{i3}^H \left(-Z_{k4}^+ + Z_{k3}^+ \right) + \sqrt{2} Z_{i1}^H Z_{k1}^+ + \sqrt{2} Z_{i2}^H Z_{k2}^+ \right) \\
& \left. + 2\lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{lb}^V \left(\sqrt{2} Z_{i2}^H Z_{k4}^+ + Z_{i3}^H Z_{k2}^+ \right) \right) \tag{372}
\end{aligned}$$

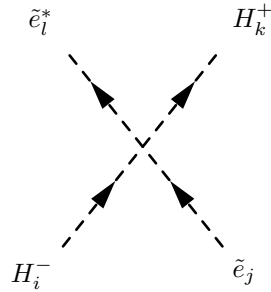


$$\begin{aligned}
& - \frac{i}{4} \left(Z_{i1}^+ \left(2(g_1^2 + g_2^2) Z_{j1}^+ Z_{k1}^+ Z_{l1}^+ - \left(-2|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{j2}^+ \left(Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) \right. \right. \\
& + 2 \left(- \left(-2|\lambda|^2 + g_2^2 \right) Z_{j4}^+ \left(Z_{k1}^+ Z_{l4}^+ + Z_{k4}^+ Z_{l1}^+ \right) + g_2^2 Z_{j3}^+ \left(Z_{k1}^+ Z_{l3}^+ + Z_{k3}^+ Z_{l1}^+ \right) \right) \Big) \\
& - Z_{i2}^+ \left(\left(-2|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{j1}^+ \left(Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) \right. \\
& \left. - 2 \left(\left(g_1^2 + g_2^2 \right) Z_{j2}^+ Z_{k2}^+ Z_{l2}^+ - \left(-2|\lambda|^2 + g_2^2 \right) Z_{j3}^+ \left(Z_{k2}^+ Z_{l3}^+ + Z_{k3}^+ Z_{l2}^+ \right) \right) \right)
\end{aligned}$$

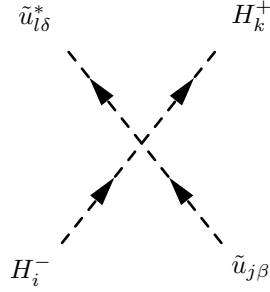
$$\begin{aligned}
& + g_2^2 Z_{j4}^+ \left(Z_{k2}^+ Z_{l4}^+ + Z_{k4}^+ Z_{l2}^+ \right) \Big) \\
& + 2 \left(Z_{i3}^+ \left(g_2^2 Z_{j1}^+ \left(Z_{k1}^+ Z_{l3}^+ + Z_{k3}^+ Z_{l1}^+ \right) - \left(-2|\lambda|^2 + g_2^2 \right) Z_{j2}^+ \left(Z_{k2}^+ Z_{l3}^+ + Z_{k3}^+ Z_{l2}^+ \right) \right. \right. \\
& + 2g_2^2 \left(2Z_{j3}^+ Z_{k3}^+ Z_{l3}^+ - Z_{j4}^+ \left(Z_{k3}^+ Z_{l4}^+ + Z_{k4}^+ Z_{l3}^+ \right) \right) \\
& + Z_{i4}^+ \left(- \left(-2|\lambda|^2 + g_2^2 \right) Z_{j1}^+ \left(Z_{k1}^+ Z_{l4}^+ + Z_{k4}^+ Z_{l1}^+ \right) \right. \\
& \left. \left. + g_2^2 \left(-2 \left(-2Z_{j4}^+ Z_{k4}^+ Z_{l4}^+ + Z_{j3}^+ \left(Z_{k3}^+ Z_{l4}^+ + Z_{k4}^+ Z_{l3}^+ \right) \right) + Z_{j2}^+ \left(Z_{k2}^+ Z_{l4}^+ + Z_{k4}^+ Z_{l2}^+ \right) \right) \right) \right) \Big) \tag{373}
\end{aligned}$$



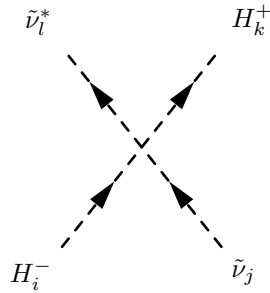
$$\begin{aligned}
& \frac{i}{12} \delta_{\beta\delta} \left(2 \left(g_1^2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{l3+a}^D \left(Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+ \right) \right. \right. \\
& - 6 \left(\sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{d,ba} Z_{l3+b}^D Z_{i1}^+ Z_{k1}^+ + \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^D Z_{i2}^+ Z_{k2}^+ \right. \\
& + \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{lb}^D Z_{i3}^+ Z_{k2}^+ + \lambda^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D Z_{i2}^+ Z_{k3}^+ \Big) \\
& \left. + \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^D \left(\left(-3g_2^2 + g_1^2 \right) Z_{i1}^+ Z_{k1}^+ - \left(-3g_2^2 + g_1^2 \right) Z_{i2}^+ Z_{k2}^+ + 6g_2^2 \left(-Z_{i3}^+ Z_{k3}^+ + Z_{i4}^+ Z_{k4}^+ \right) \right) \right) \tag{374}
\end{aligned}$$



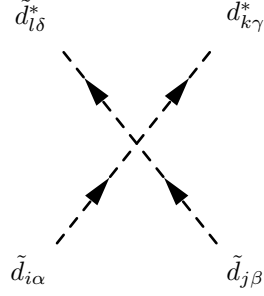
$$\begin{aligned}
& -\frac{i}{4} \left(2g_1^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{l3+a}^E \left(-Z_{i1}^+ Z_{k1}^+ + Z_{i2}^+ Z_{k2}^+ \right) \right. \\
& + 4 \left(\sum_{c=1}^3 Z_{j3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{e,ba} Z_{l3+b}^E Z_{i1}^+ Z_{k1}^+ + \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{lb}^E Z_{i3}^+ Z_{k2}^+ \right. \\
& + \lambda^* \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E Z_{i2}^+ Z_{k3}^+ \left. \right) \\
& + \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^E \left(2g_2^2 \left(Z_{i3}^+ Z_{k3}^+ - Z_{i4}^+ Z_{k4}^+ \right) + \left(g_1^2 + g_2^2 \right) Z_{i1}^+ Z_{k1}^+ - \left(g_1^2 + g_2^2 \right) Z_{i2}^+ Z_{k2}^+ \right) \tag{375}
\end{aligned}$$



$$\begin{aligned}
& \frac{i}{12} \delta_{\beta\delta} \left(-4 \left(g_1^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U \left(Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+ \right) \right. \right. \\
& + 3 \left(\sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^U Z_{i1}^+ Z_{k1}^+ - \lambda^* \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U Z_{i4}^+ Z_{k1}^+ \right. \\
& + \sum_{c=1}^3 Z_{j3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{u,ba} Z_{l3+b}^U Z_{i2}^+ Z_{k2}^+ - \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{j3+a}^{U,*} Z_{lb}^U Z_{i1}^+ Z_{k4}^+ \left. \right) \left. \right) \\
& + \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \left(\left(3g_2^2 + g_1^2 \right) Z_{i1}^+ Z_{k1}^+ - \left(3g_2^2 + g_1^2 \right) Z_{i2}^+ Z_{k2}^+ + 6g_2^2 \left(Z_{i3}^+ Z_{k3}^+ - Z_{i4}^+ Z_{k4}^+ \right) \right) \tag{376}
\end{aligned}$$



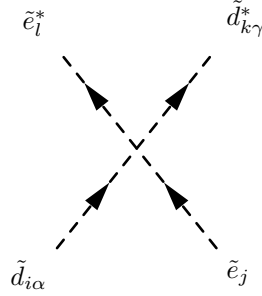
$$\begin{aligned}
& -\frac{i}{4} \left(4 \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^V Z_{i1}^+ Z_{k1}^+ \right. \\
& \left. + \delta_{jl} \left(2g_2^2 \left(-Z_{i3}^+ Z_{k3}^+ + Z_{i4}^+ Z_{k4}^+ \right) + \left(-g_1^2 + g_2^2 \right) Z_{i2}^+ Z_{k2}^+ + \left(-g_2^2 + g_1^2 \right) Z_{i1}^+ Z_{k1}^+ \right) \right) \quad (377)
\end{aligned}$$



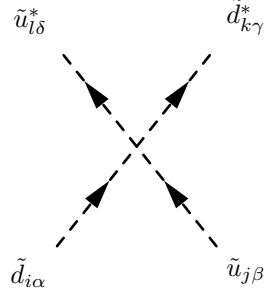
$$\begin{aligned}
& -\frac{i}{72} \left(\delta_{\alpha\delta} \delta_{\beta\gamma} \left(g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D + 9g_2^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D \right. \right. \\
& - 6g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D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

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

$$\begin{aligned}
& + 6g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{l3+b}^D + 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{l3+b}^D \\
& - 6g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{l3+b}^D \\
& + 72 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{i3+c}^{D,*} Z_{kd}^D \\
& + 72 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{j3+c}^{D,*} Z_{ld}^D \Big) \tag{378}
\end{aligned}$$

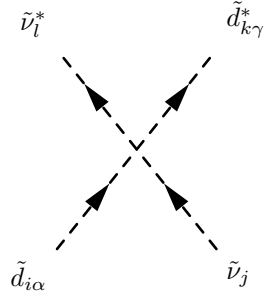


$$\begin{aligned}
& \frac{i}{24} \delta_{\alpha\gamma} \left(-2g_1^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{l3+a}^E \left(2 \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \right. \\
& + \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^E \left(2g_1^2 \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \left(-3g_2^2 + g_1^2 \right) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \\
& + g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E - 3g_2^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E \\
& + 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E - 2g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \\
& - 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \\
& - 24 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{i3+c}^{D,*} Z_{kd}^D \\
& \left. - 24 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{j3+c}^{E,*} Z_{ld}^E \right) \tag{379}
\end{aligned}$$

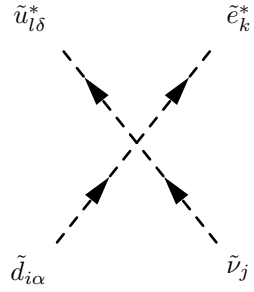


$$\begin{aligned}
& -\frac{i}{72} \left(\delta_{\alpha\gamma} \delta_{\beta\delta} \left(\sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \left(2 \left(3g_3^2 + g_1^2 \right) \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \left(-6g_3^2 - 9g_2^2 + g_1^2 \right) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \right. \right. \\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

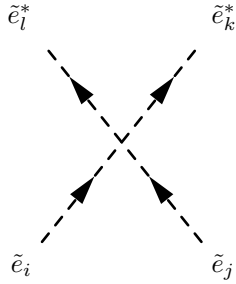
$$+ 4 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{i3+c}^{D,*} Z_{ld}^U \Big) \quad (380)$$



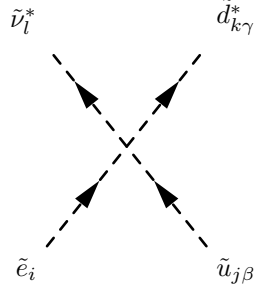
$$\frac{i}{12} \delta_{\alpha\gamma} \delta_{jl} \left(2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D + (3g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \right) \quad (381)$$



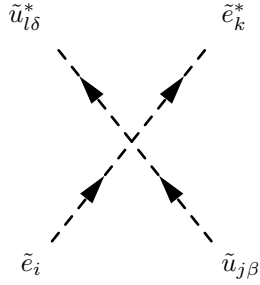
$$- \frac{i}{4} \delta_{\alpha\delta} \left(g_2^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{V,*} Z_{kb}^E + g_2^2 \sum_{a=1}^3 Z_{ja}^{V,*} Z_{ka}^E \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^U \right) \\ + 4 \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{i3+c}^{D,*} Z_{ld}^U \Big) \quad (382)$$



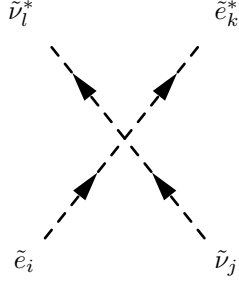
$$\begin{aligned}
& -\frac{i}{8} \left(g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{kb}^E + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{kb}^E \right. \\
& - 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{l3+a}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{kb}^E \\
& - 2g_1^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{l3+a}^E \left(-2 \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{k3+b}^E + \sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^E \right) \\
& + \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^E \left(-2g_1^2 \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{k3+b}^E + (g_1^2 + g_2^2) \sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^E \right) \\
& - 2g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{k3+b}^E + 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{l3+a}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{k3+b}^E \\
& + g_1^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E + g_2^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E \\
& - 2g_1^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E + g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E \\
& + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E - 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E \\
& - 2g_1^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{l3+b}^E + 4g_1^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{l3+b}^E \\
& - 2g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E + 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \\
& + 8 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^{E,*} Z_{kd}^E \\
& + 8 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{j3+c}^{E,*} Z_{kd}^E \\
& + 8 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^{E,*} Z_{ld}^E \\
& + 8 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{j3+c}^{E,*} Z_{ld}^E \Big) \tag{383}
\end{aligned}$$



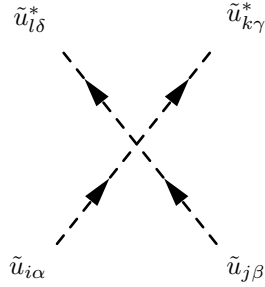
$$\begin{aligned}
& -\frac{i}{4}\delta_{\beta\gamma}\left(g_2^2\sum_{a=1}^3Z_{ia}^{E,*}Z_{la}^V\sum_{b=1}^3Z_{jb}^{U,*}Z_{kb}^D+g_2^2\sum_{a=1}^3Z_{ja}^{U,*}Z_{ka}^D\sum_{b=1}^3Z_{ib}^{E,*}Z_{lb}^V\right. \\
& \left.+4\sum_{b=1}^3Z_{jb}^{U,*}\sum_{a=1}^3Y_{d,ab}Z_{k3+a}^D\sum_{d=1}^3\sum_{c=1}^3Y_{e,cd}^*Z_{i3+c}^{E,*}Z_{ld}^V\right) \tag{384}
\end{aligned}$$



$$\begin{aligned}
& \frac{i}{24}\delta_{\beta\delta}\left(-4g_1^2\sum_{a=1}^3Z_{j3+a}^{U,*}Z_{l3+a}^U\left(-2\sum_{b=1}^3Z_{i3+b}^{E,*}Z_{k3+b}^E+\sum_{b=1}^3Z_{ib}^{E,*}Z_{kb}^E\right)\right. \\
& +\sum_{a=1}^3Z_{ja}^{U,*}Z_{la}^U\left(-2g_1^2\sum_{b=1}^3Z_{i3+b}^{E,*}Z_{k3+b}^E+\left(3g_2^2+g_1^2\right)\sum_{b=1}^3Z_{ib}^{E,*}Z_{kb}^E\right) \\
& +g_1^2\sum_{a=1}^3Z_{ia}^{E,*}Z_{ka}^E\sum_{b=1}^3Z_{jb}^{U,*}Z_{lb}^U+3g_2^2\sum_{a=1}^3Z_{ia}^{E,*}Z_{ka}^E\sum_{b=1}^3Z_{jb}^{U,*}Z_{lb}^U \\
& -2g_1^2\sum_{a=1}^3Z_{i3+a}^{E,*}Z_{k3+a}^E\sum_{b=1}^3Z_{jb}^{U,*}Z_{lb}^U-4g_1^2\sum_{a=1}^3Z_{ia}^{E,*}Z_{ka}^E\sum_{b=1}^3Z_{j3+b}^{U,*}Z_{l3+b}^U \\
& \left.+8g_1^2\sum_{a=1}^3Z_{i3+a}^{E,*}Z_{k3+a}^E\sum_{b=1}^3Z_{j3+b}^{U,*}Z_{l3+b}^U\right) \tag{385}
\end{aligned}$$



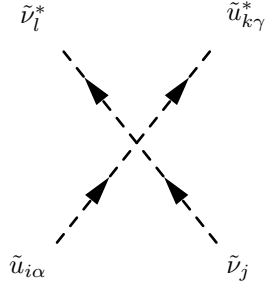
$$\begin{aligned}
& -\frac{i}{4} \left(\delta_{jl} \left(-2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E + \left(-g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \right) \right. \\
& + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^V \sum_{b=1}^3 Z_{jb}^{V,*} Z_{kb}^E + g_2^2 \sum_{a=1}^3 Z_{ja}^{V,*} Z_{ka}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^V \\
& \left. + 4 \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd} Z_{i3+c}^{E,*} Z_{ld}^V \right) \tag{386}
\end{aligned}$$



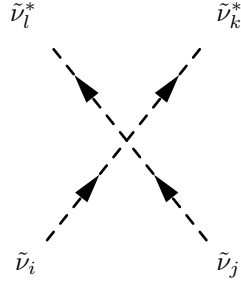
$$\begin{aligned}
& -\frac{i}{72} \left(\delta_{\alpha\delta} \delta_{\beta\gamma} \left(g_1^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U + 9g_2^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U \right) \right. \\
& - 6g_3^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U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

$$\begin{aligned}
& -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 \\
& + 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 \\
& + 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 - 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 + 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 + 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 - 18g_3^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + 18g_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 \\
& + 72 \sum_{b=1}^3 Z_{ib}^{U,*} \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}^U \\
& + 72 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{i3+c}^{U,*} Z_{ld}^U \\
& + \delta_{\alpha\gamma} \delta_{\beta\delta} \left(18g_3^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U - 18g_3^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{l3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U \right. \\
& + \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U \left(2 \left(-3g_3^2 + 8g_1^2 \right) \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{k3+b}^U + \left(-4g_1^2 + 6g_3^2 \right) \sum_{b=1}^3 Z_{ib}^{U,*} Z_{kb}^U \right) \\
& + \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \left(2 \left(-2g_1^2 + 3g_3^2 \right) \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{k3+b}^U + \left(-6g_3^2 + 9g_2^2 + g_1^2 \right) \sum_{b=1}^3 Z_{ib}^{U,*} Z_{kb}^U \right) \\
& \left. - 18g_3^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{k3+b}^U + 18g_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 \right)
\end{aligned}$$

$$\begin{aligned}
& + 18g_3^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U - 18g_3^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U \\
& + g_1^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U + 9g_2^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& - 6g_3^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U - 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& + 6g_3^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U - 18g_3^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U \\
& + 18g_3^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U - 4g_1^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + 6g_3^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U + 16g_1^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& - 6g_3^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + 72 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{i3+c}^{U,*} Z_{kd}^U \\
& + 72 \sum_{b=1}^3 Z_{ib}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{j3+c}^{U,*} Z_{ld}^U \Big) \tag{387}
\end{aligned}$$

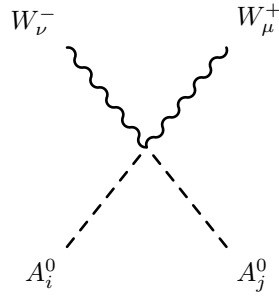


$$\frac{i}{12} \delta_{\alpha\gamma} \delta_{jl} \left(\left(-3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U - 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \right) \tag{388}$$

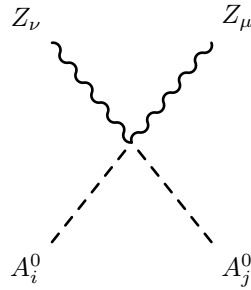


$$-\frac{i}{4}(g_1^2 + g_2^2)(\delta_{ik}\delta_{jl} + \delta_{il}\delta_{jk}) \quad (389)$$

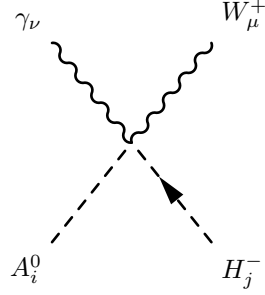
9.8 Two Scalar-Two Vector Boson-Interaction



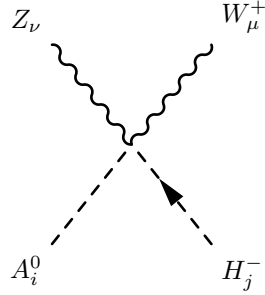
$$\frac{i}{2}g_2^2(4Z_{i3}^AZ_{j3}^A + Z_{i1}^AZ_{j1}^A + Z_{i2}^AZ_{j2}^A)(g_{\mu\nu}) \quad (390)$$



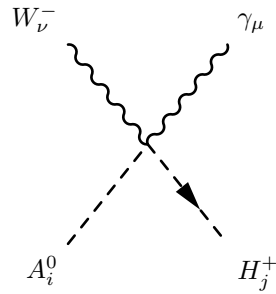
$$\frac{i}{2}(g_1 \sin \Theta_W + g_2 \cos \Theta_W)^2(Z_{i1}^AZ_{j1}^A + Z_{i2}^AZ_{j2}^A)(g_{\mu\nu}) \quad (391)$$



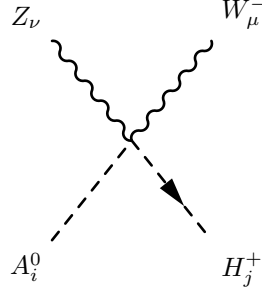
$$-\frac{1}{2}g_2 \left(g_1 \cos \Theta_W Z_{i1}^A Z_{j1}^+ + g_1 \cos \Theta_W Z_{i2}^A Z_{j2}^+ + \sqrt{2}g_2 \sin \Theta_W Z_{i3}^A (-Z_{j4}^+ + Z_{j3}^+) \right) (g_{\mu\nu}) \quad (392)$$



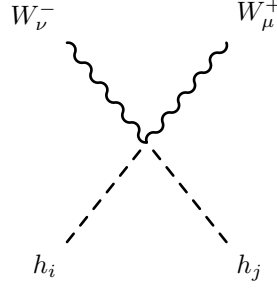
$$\frac{1}{2}g_2 \left(g_1 \sin \Theta_W Z_{i1}^A Z_{j1}^+ + g_1 \sin \Theta_W Z_{i2}^A Z_{j2}^+ + \sqrt{2}g_2 \cos \Theta_W Z_{i3}^A (-Z_{j3}^+ + Z_{j4}^+) \right) (g_{\mu\nu}) \quad (393)$$



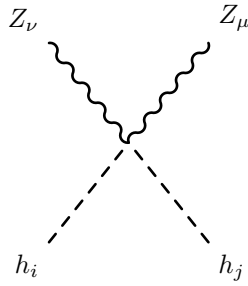
$$\frac{1}{2}g_2 \left(g_1 \cos \Theta_W Z_{i1}^A Z_{j1}^+ + g_1 \cos \Theta_W Z_{i2}^A Z_{j2}^+ + \sqrt{2}g_2 \sin \Theta_W Z_{i3}^A (-Z_{j4}^+ + Z_{j3}^+) \right) (g_{\mu\nu}) \quad (394)$$



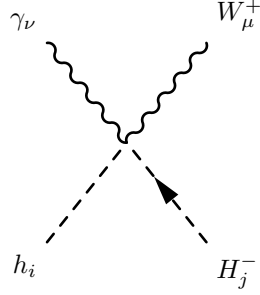
$$\frac{1}{2}g_2 \left(-g_1 \sin \Theta_W Z_{i1}^A Z_{j1}^+ - g_1 \sin \Theta_W Z_{i2}^A Z_{j2}^+ + \sqrt{2}g_2 \cos \Theta_W Z_{i3}^A (-Z_{j4}^+ + Z_{j3}^+) \right) (g_{\mu\nu}) \quad (395)$$



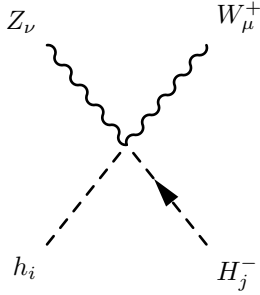
$$\frac{i}{2}g_2^2 \left(4Z_{i3}^H Z_{j3}^H + Z_{i1}^H Z_{j1}^H + Z_{i2}^H Z_{j2}^H \right) (g_{\mu\nu}) \quad (396)$$



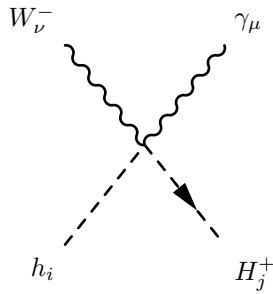
$$\frac{i}{2} \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right)^2 \left(Z_{i1}^H Z_{j1}^H + Z_{i2}^H Z_{j2}^H \right) (g_{\mu\nu}) \quad (397)$$



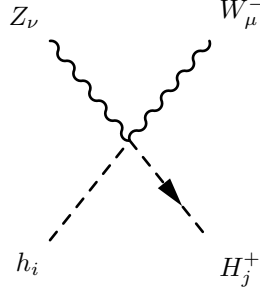
$$-\frac{i}{2}g_2\left(g_1\cos\Theta_W Z_{i1}^H Z_{j1}^+ - g_1\cos\Theta_W Z_{i2}^H Z_{j2}^+ + \sqrt{2}g_2\sin\Theta_W Z_{i3}^H\left(Z_{j3}^+ + Z_{j4}^+\right)\right)\left(g_{\mu\nu}\right) \quad (398)$$



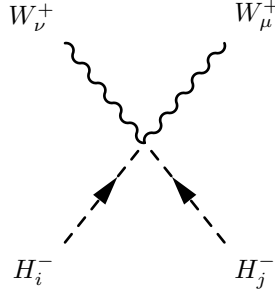
$$-\frac{i}{2}g_2\left(-g_1\sin\Theta_W Z_{i1}^H Z_{j1}^+ + g_1\sin\Theta_W Z_{i2}^H Z_{j2}^+ + \sqrt{2}g_2\cos\Theta_W Z_{i3}^H\left(Z_{j3}^+ + Z_{j4}^+\right)\right)\left(g_{\mu\nu}\right) \quad (399)$$



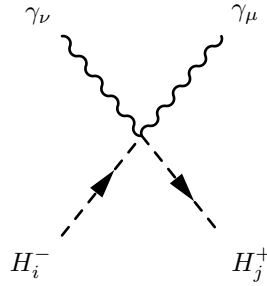
$$-\frac{i}{2}g_2\left(g_1\cos\Theta_W Z_{i1}^H Z_{j1}^+ - g_1\cos\Theta_W Z_{i2}^H Z_{j2}^+ + \sqrt{2}g_2\sin\Theta_W Z_{i3}^H\left(Z_{j3}^+ + Z_{j4}^+\right)\right)\left(g_{\mu\nu}\right) \quad (400)$$



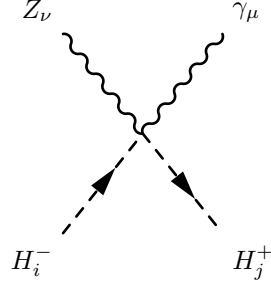
$$-\frac{i}{2}g_2\left(-g_1\sin\Theta_W Z_{i1}^H Z_{j1}^+ + g_1\sin\Theta_W Z_{i2}^H Z_{j2}^+ + \sqrt{2}g_2\cos\Theta_W Z_{i3}^H(Z_{j3}^+ + Z_{j4}^+)\right)(g_{\mu\nu}) \quad (401)$$



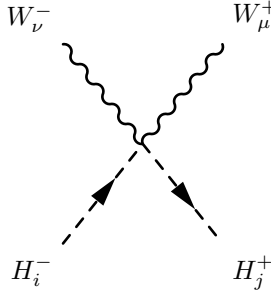
$$-2ig_2^2\left(Z_{i3}^+ Z_{j4}^+ + Z_{i4}^+ Z_{j3}^+\right)(g_{\mu\nu}) \quad (402)$$



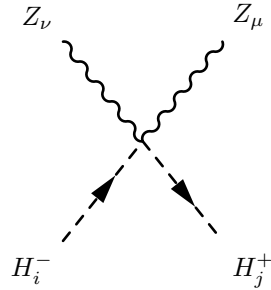
$$\frac{i}{2}\left(\left(g_1\cos\Theta_W + g_2\sin\Theta_W\right)^2 Z_{i1}^+ Z_{j1}^+ + \left(g_1\cos\Theta_W + g_2\sin\Theta_W\right)^2 Z_{i2}^+ Z_{j2}^+ + 4g_2^2\sin^2\Theta_W\left(Z_{i3}^+ Z_{j3}^+ + Z_{i4}^+ Z_{j4}^+\right)\right)(g_{\mu\nu}) \quad (403)$$



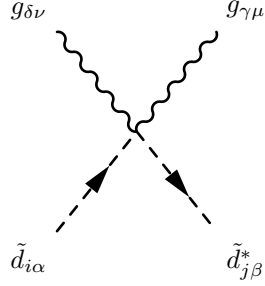
$$\begin{aligned}
& -\frac{i}{4} \left(\left(-2g_1g_2 \cos 2\Theta_W + (-g_2^2 + g_1^2) \sin 2\Theta_W \right) Z_{i1}^+ Z_{j1}^+ \right. \\
& + \left(-2g_1g_2 \cos 2\Theta_W + (-g_2^2 + g_1^2) \sin 2\Theta_W \right) Z_{i2}^+ Z_{j2}^+ \\
& \left. - 4g_2^2 \sin 2\Theta_W (Z_{i3}^+ Z_{j3}^+ + Z_{i4}^+ Z_{j4}^+) \right) (g_{\mu\nu})
\end{aligned} \tag{404}$$



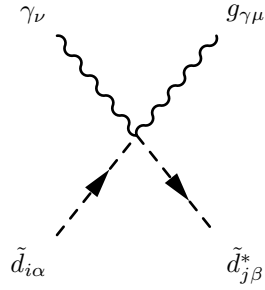
$$\frac{i}{2} g_2^2 \left(2Z_{i3}^+ Z_{j3}^+ + 2Z_{i4}^+ Z_{j4}^+ + Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+ \right) (g_{\mu\nu}) \tag{405}$$



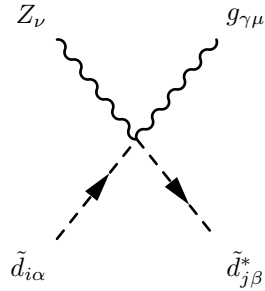
$$\begin{aligned}
& \frac{i}{2} \left(\left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right)^2 Z_{i1}^+ Z_{j1}^+ + \left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right)^2 Z_{i2}^+ Z_{j2}^+ \right. \\
& \left. + 4g_2^2 \cos^2 \Theta_W (Z_{i3}^+ Z_{j3}^+ + Z_{i4}^+ Z_{j4}^+) \right) (g_{\mu\nu})
\end{aligned} \tag{406}$$



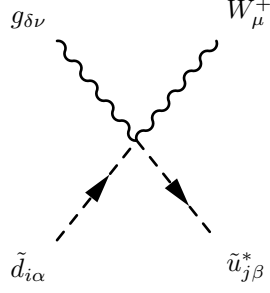
$$\frac{i}{4} g_3^2 \delta_{ij} \left(\sum_{a=1}^3 \lambda_{a,\alpha}^\gamma \lambda_{\beta,a}^\delta + \sum_{a=1}^3 \lambda_{\beta,a}^\gamma \lambda_{a,\alpha}^\delta \right) (g_{\mu\nu}) \quad (407)$$



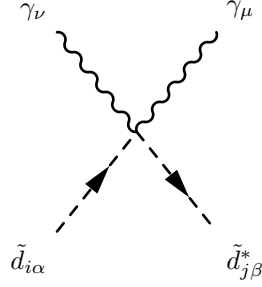
$$\frac{i}{6} g_3 \lambda_{\beta,\alpha}^\gamma \left(-2g_1 \cos \Theta_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D + \left(-3g_2 \sin \Theta_W + g_1 \cos \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \right) (g_{\mu\nu}) \quad (408)$$



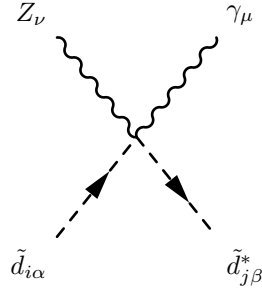
$$-\frac{i}{6} g_3 \lambda_{\beta,\alpha}^\gamma \left(-2g_1 \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D + \left(3g_2 \cos \Theta_W + g_1 \sin \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \right) (g_{\mu\nu}) \quad (409)$$



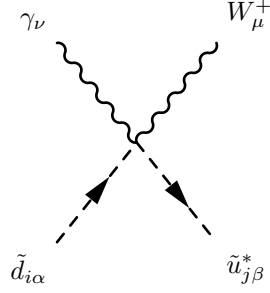
$$i \frac{1}{\sqrt{2}} g_2 g_3 \lambda_{\beta,\alpha}^{\delta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U (g_{\mu\nu}) \quad (410)$$



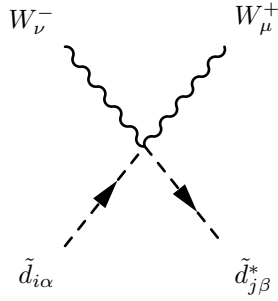
$$\frac{i}{18} \delta_{\alpha\beta} \left((-3g_2 \sin \Theta_W + g_1 \cos \Theta_W)^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D + 4g_1^2 \cos^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \right) (g_{\mu\nu}) \quad (411)$$



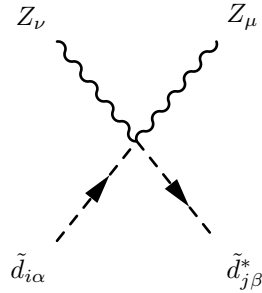
$$- \frac{i}{36} \delta_{\alpha\beta} \left((6g_1 g_2 \cos 2\Theta_W + (-9g_2^2 + g_1^2) \sin 2\Theta_W) \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D + 4g_1^2 \sin 2\Theta_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \right) (g_{\mu\nu}) \quad (412)$$



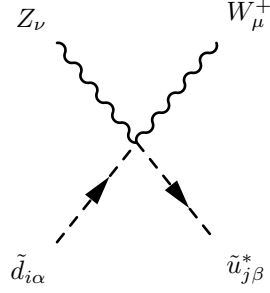
$$\frac{i}{3} \frac{1}{\sqrt{2}} g_1 g_2 \cos \Theta_W \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U (g_{\mu\nu}) \quad (413)$$



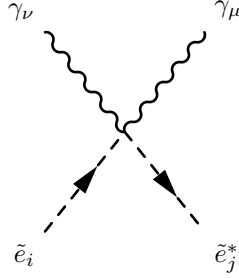
$$\frac{i}{2} g_2^2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D (g_{\mu\nu}) \quad (414)$$



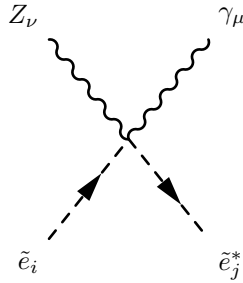
$$\frac{i}{18} \delta_{\alpha\beta} \left((3g_2 \cos \Theta_W + g_1 \sin \Theta_W)^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D + 4g_1^2 \sin^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \right) (g_{\mu\nu}) \quad (415)$$



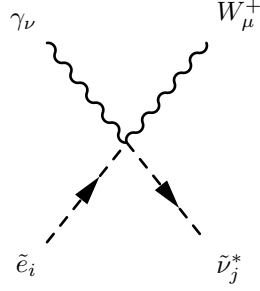
$$-\frac{i}{3} \frac{1}{\sqrt{2}} g_1 g_2 \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U (g_{\mu\nu}) \quad (416)$$



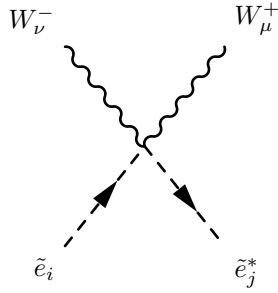
$$\frac{i}{2} \left(4g_1^2 \cos^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E + (g_1 \cos \Theta_W + g_2 \sin \Theta_W)^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right) (g_{\mu\nu}) \quad (417)$$



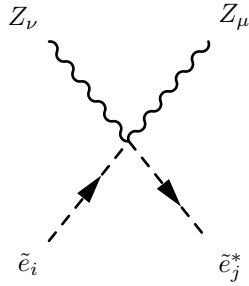
$$-\frac{i}{4} \left((-2g_1 g_2 \cos 2\Theta_W + (-g_2^2 + g_1^2) \sin 2\Theta_W) \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E + 4g_1^2 \sin 2\Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \right) (g_{\mu\nu}) \quad (418)$$



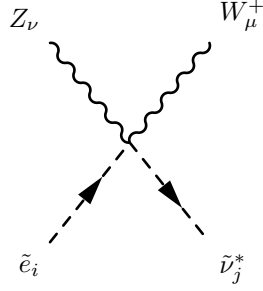
$$-i \frac{1}{\sqrt{2}} g_1 g_2 \cos \Theta_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^V (g_{\mu\nu}) \quad (419)$$



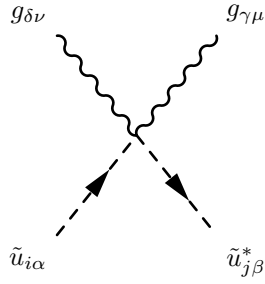
$$\frac{i}{2} g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E (g_{\mu\nu}) \quad (420)$$



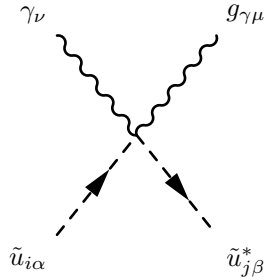
$$\frac{i}{2} \left(4g_1^2 \sin^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E + \left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right)^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right) (g_{\mu\nu}) \quad (421)$$



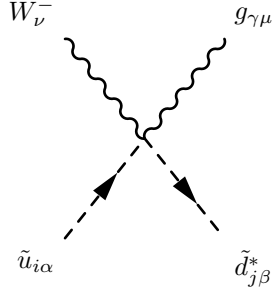
$$i \frac{1}{\sqrt{2}} g_1 g_2 \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^V (g_{\mu\nu}) \quad (422)$$



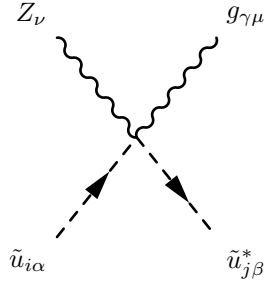
$$\frac{i}{4} g_3^2 \delta_{ij} \left(\sum_{a=1}^3 \lambda_{a,\alpha}^\gamma \lambda_{\beta,a}^\delta + \sum_{a=1}^3 \lambda_{\beta,a}^\gamma \lambda_{a,\alpha}^\delta \right) (g_{\mu\nu}) \quad (423)$$



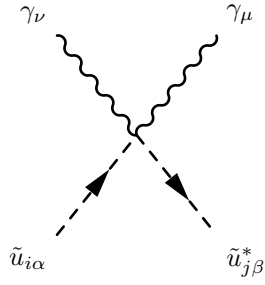
$$\frac{i}{6} g_3 \lambda_{\beta,\alpha}^\gamma \left(\left(3g_2 \sin \Theta_W + g_1 \cos \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U + 4g_1 \cos \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \right) (g_{\mu\nu}) \quad (424)$$



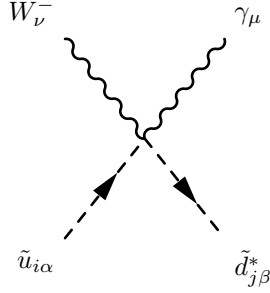
$$i \frac{1}{\sqrt{2}} g_2 g_3 \lambda_{\beta,\alpha}^\gamma \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D (g_{\mu\nu}) \quad (425)$$



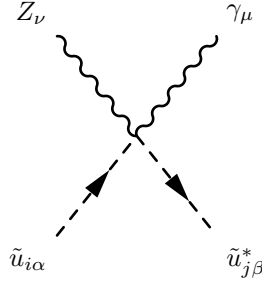
$$\frac{i}{6} g_3 \lambda_{\beta,\alpha}^\gamma \left((3g_2 \cos \Theta_W - g_1 \sin \Theta_W) \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U - 4g_1 \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \right) (g_{\mu\nu}) \quad (426)$$



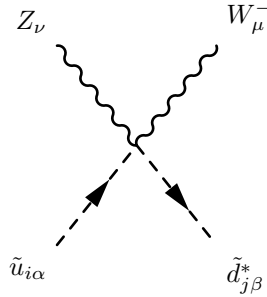
$$\frac{i}{18} \delta_{\alpha\beta} \left(16g_1^2 \cos^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U + (3g_2 \sin \Theta_W + g_1 \cos \Theta_W)^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \right) (g_{\mu\nu}) \quad (427)$$



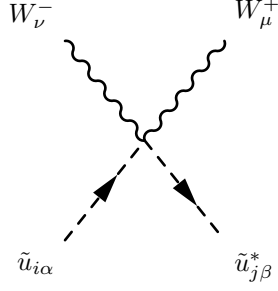
$$\frac{i}{3} \frac{1}{\sqrt{2}} g_1 g_2 \cos \Theta_W \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D (g_{\mu\nu}) \quad (428)$$



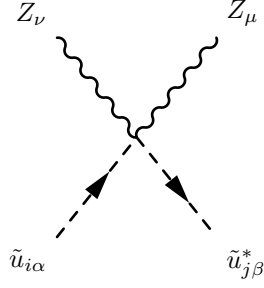
$$\begin{aligned} & - \frac{i}{36} \delta_{\alpha\beta} \left((-6g_1 g_2 \cos 2\Theta_W + (-9g_2^2 + g_1^2) \sin 2\Theta_W) \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \right. \\ & \left. + 16g_1^2 \sin 2\Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \right) (g_{\mu\nu}) \quad (429) \end{aligned}$$



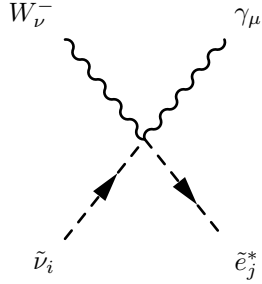
$$- \frac{i}{3} \frac{1}{\sqrt{2}} g_1 g_2 \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D (g_{\mu\nu}) \quad (430)$$



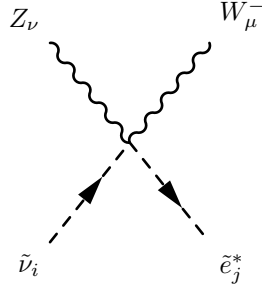
$$\frac{i}{2} g_2^2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U (g_{\mu\nu}) \quad (431)$$



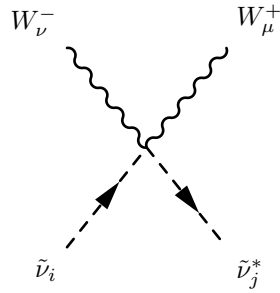
$$\frac{i}{18} \delta_{\alpha\beta} \left(16g_1^2 \sin^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U + \left(-3g_2 \cos \Theta_W + g_1 \sin \Theta_W \right)^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \right) (g_{\mu\nu}) \quad (432)$$



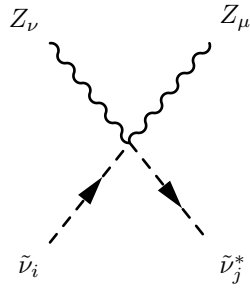
$$-i \frac{1}{\sqrt{2}} g_1 g_2 \cos \Theta_W \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ja}^E (g_{\mu\nu}) \quad (433)$$



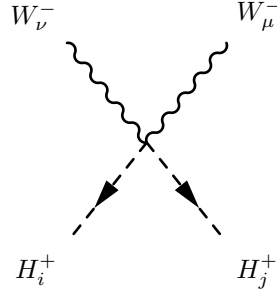
$$i \frac{1}{\sqrt{2}} g_1 g_2 \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ja}^E (g_{\mu\nu}) \quad (434)$$



$$\frac{i}{2} g_2^2 \delta_{ij} (g_{\mu\nu}) \quad (435)$$

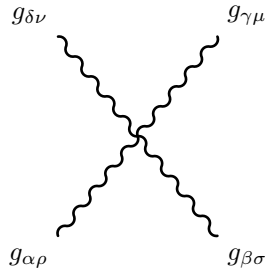


$$\frac{i}{2} \delta_{ij} (g_1 \sin \Theta_W + g_2 \cos \Theta_W)^2 (g_{\mu\nu}) \quad (436)$$



$$-2ig_2^2(Z_{i3}^+Z_{j4}^+ + Z_{i4}^+Z_{j3}^+)(g_{\mu\nu}) \quad (437)$$

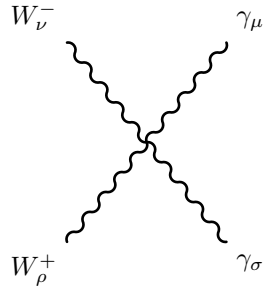
9.9 Four Vector Boson-Interaction



$$-ig_3^2\left(\sum_{a=1}^8 f_{\alpha,\delta,a}f_{\beta,\gamma,a} + \sum_{a=1}^8 f_{\alpha,\gamma,a}f_{\beta,\delta,a}\right)(g_{\rho\sigma}g_{\mu\nu}) \quad (438)$$

$$+ ig_3^2\left(-\sum_{a=1}^8 f_{\alpha,\beta,a}f_{\gamma,\delta,a} + \sum_{a=1}^8 f_{\alpha,\delta,a}f_{\beta,\gamma,a}\right)(g_{\rho\mu}g_{\sigma\nu}) \quad (439)$$

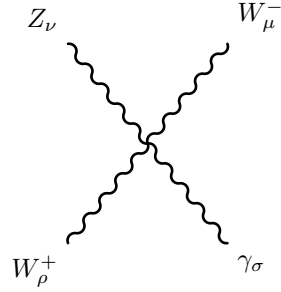
$$+ ig_3^2\left(\sum_{a=1}^8 f_{\alpha,\gamma,a}f_{\beta,\delta,a} + \sum_{a=1}^8 f_{\alpha,\beta,a}f_{\gamma,\delta,a}\right)(g_{\rho\nu}g_{\sigma\mu}) \quad (440)$$



$$ig_2^2 \sin \Theta_W^2 (g_{\rho\sigma} g_{\mu\nu}) \quad (441)$$

$$+ ig_2^2 \sin \Theta_W^2 (g_{\rho\mu} g_{\sigma\nu}) \quad (442)$$

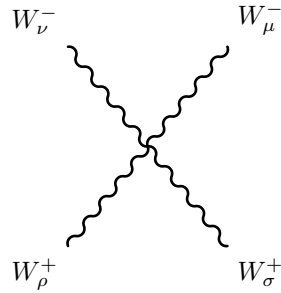
$$+ -2ig_2^2 \sin \Theta_W^2 (g_{\rho\nu} g_{\sigma\mu}) \quad (443)$$



$$ig_2^2 \cos \Theta_W \sin \Theta_W (g_{\rho\sigma} g_{\mu\nu}) \quad (444)$$

$$+ -ig_2^2 \sin 2\Theta_W (g_{\rho\mu} g_{\sigma\nu}) \quad (445)$$

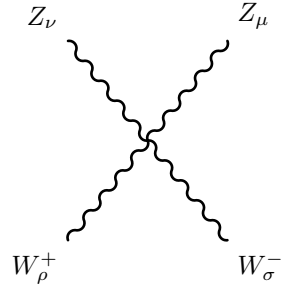
$$+ ig_2^2 \cos \Theta_W \sin \Theta_W (g_{\rho\nu} g_{\sigma\mu}) \quad (446)$$



$$2ig_2^2 (g_{\rho\sigma} g_{\mu\nu}) \quad (447)$$

$$+ -ig_2^2 (g_{\rho\mu} g_{\sigma\nu}) \quad (448)$$

$$+ -ig_2^2 (g_{\rho\nu} g_{\sigma\mu}) \quad (449)$$

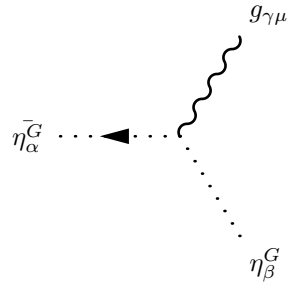


$$- 2ig_2^2 \cos^2 \Theta_W^2 (g_{\rho\sigma} g_{\mu\nu}) \quad (450)$$

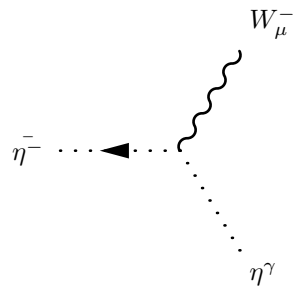
$$+ ig_2^2 \cos^2 \Theta_W^2 (g_{\rho\mu} g_{\sigma\nu}) \quad (451)$$

$$+ ig_2^2 \cos^2 \Theta_W^2 (g_{\rho\nu} g_{\sigma\mu}) \quad (452)$$

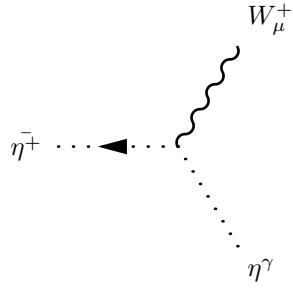
9.10 Two Ghosts-One Vector Boson-Interaction



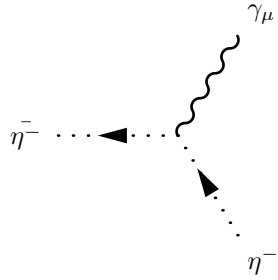
$$g_3 f_{\alpha,\beta,\gamma} (p_\mu^{\eta_\beta^G}) \quad (453)$$



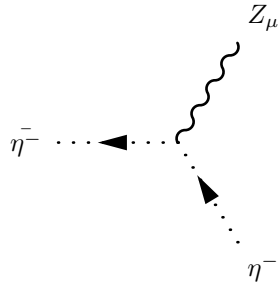
$$ig_2 \sin \Theta_W (p_\mu^{\eta^\gamma}) \quad (454)$$



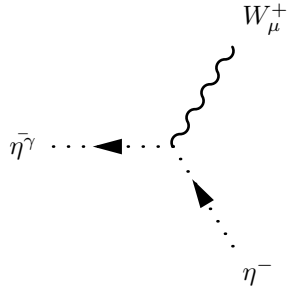
$$-ig_2 \sin \Theta_W (p_\mu^{\eta^\gamma}) \quad (455)$$



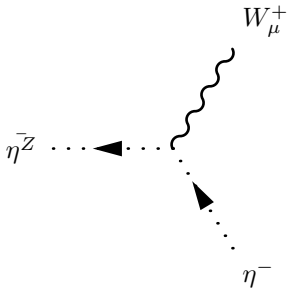
$$-ig_2 \sin \Theta_W (p_\mu^{\eta^-}) \quad (456)$$



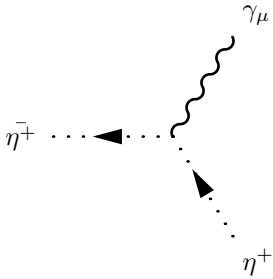
$$-ig_2 \cos \Theta_W (p_\mu^{\eta^-}) \quad (457)$$



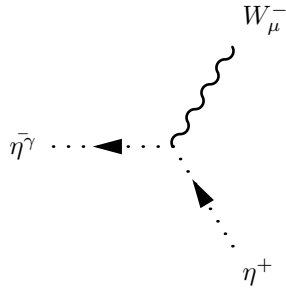
$$ig_2 \sin \Theta_W (p_\mu^{\eta^-}) \tag{458}$$



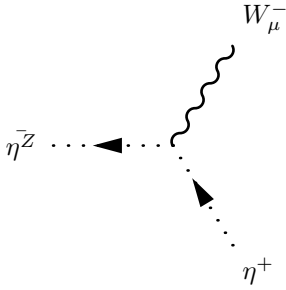
$$ig_2 \cos \Theta_W (p_\mu^{\eta^-}) \tag{459}$$



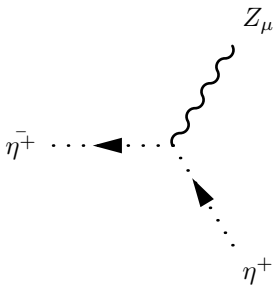
$$ig_2 \sin \Theta_W (p_\mu^{\eta^+}) \tag{460}$$



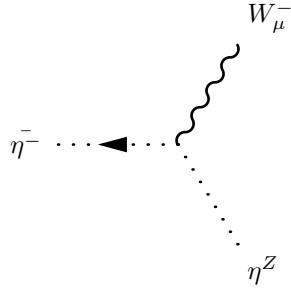
$$-ig_2 \sin \Theta_W (p_\mu^{\eta^+}) \quad (461)$$



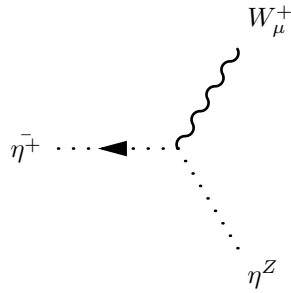
$$-ig_2 \cos \Theta_W (p_\mu^{\eta^+}) \quad (462)$$



$$ig_2 \cos \Theta_W (p_\mu^{\eta^+}) \quad (463)$$

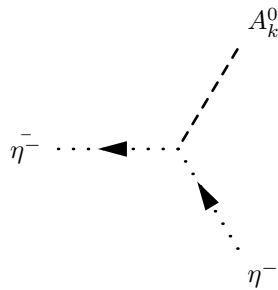


$$ig_2 \cos \Theta_W (p_\mu^{\eta^0}) \quad (464)$$

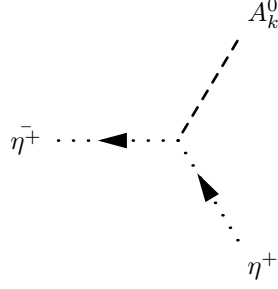


$$-ig_2 \cos \Theta_W (p_\mu^{\eta^0}) \quad (465)$$

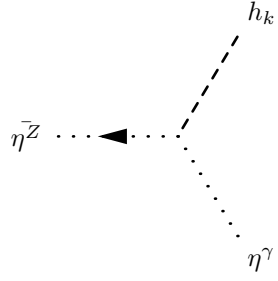
9.11 Two Ghosts-One Scalar-Interaction



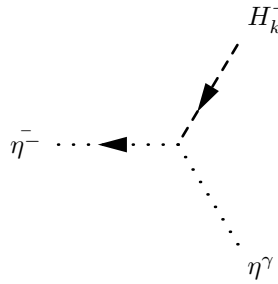
$$\frac{1}{4} g_2^2 \xi_{W^-} (v_d Z_{k1}^A - v_u Z_{k2}^A) \quad (466)$$



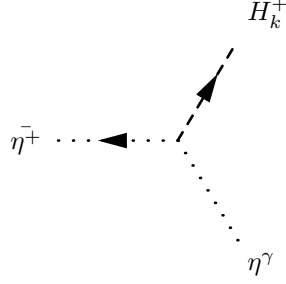
$$\frac{1}{4}g_2^2\xi_{W^-}\left(-v_d Z_{k1}^A + v_u Z_{k2}^A\right) \quad (467)$$



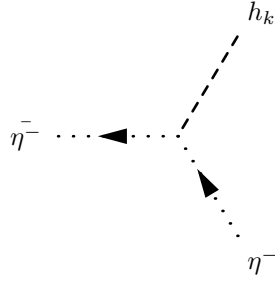
$$\frac{i}{8}\xi_Z\left(2g_1g_2\cos 2\Theta_W + \left(-g_2^2 + g_1^2\right)\sin 2\Theta_W\right)\left(v_d Z_{k1}^H + v_u Z_{k2}^H\right) \quad (468)$$



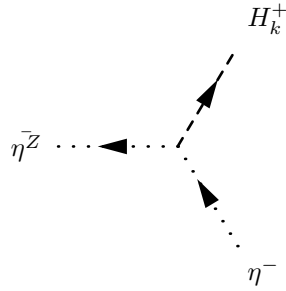
$$\begin{aligned} &\frac{i}{4}g_2\xi_{W^-}\left(v_d\left(g_1\cos\Theta_W + g_2\sin\Theta_W\right)Z_{k1}^+ - v_u\left(g_1\cos\Theta_W + g_2\sin\Theta_W\right)Z_{k2}^+ \right. \\ &\left. + 2\sqrt{2}g_2v_T\sin\Theta_W\left(Z_{k3}^+ + Z_{k4}^+\right)\right) \quad (469) \end{aligned}$$



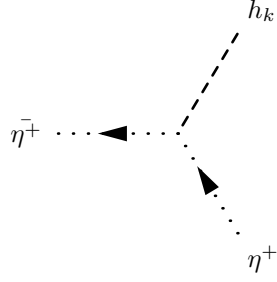
$$\begin{aligned} & \frac{i}{4} g_2 \xi_{W^-} \left(v_d (g_1 \cos \Theta_W + g_2 \sin \Theta_W) Z_{k1}^+ - v_u (g_1 \cos \Theta_W + g_2 \sin \Theta_W) Z_{k2}^+ \right. \\ & \left. + 2\sqrt{2} g_2 v_T \sin \Theta_W (Z_{k3}^+ + Z_{k4}^+) \right) \end{aligned} \quad (470)$$



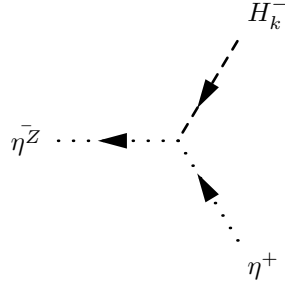
$$- \frac{i}{4} g_2^2 \xi_{W^-} \left(4v_T Z_{k3}^H + v_d Z_{k1}^H + v_u Z_{k2}^H \right) \quad (471)$$



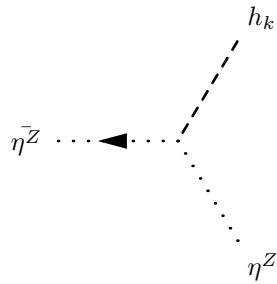
$$- \frac{i}{4} g_2 \xi_Z \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left(v_d Z_{k1}^+ - v_u Z_{k2}^+ \right) \quad (472)$$



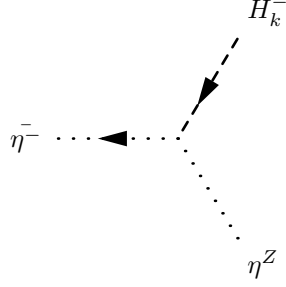
$$-\frac{i}{4}g_2^2\xi_{W^-}\left(4v_T Z_{k3}^H + v_d Z_{k1}^H + v_u Z_{k2}^H\right) \quad (473)$$



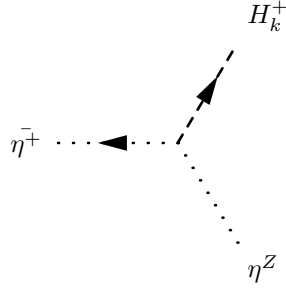
$$-\frac{i}{4}g_2\xi_Z\left(g_1\sin\Theta_W + g_2\cos\Theta_W\right)\left(v_d Z_{k1}^+ - v_u Z_{k2}^+\right) \quad (474)$$



$$-\frac{i}{4}\xi_Z\left(g_1\sin\Theta_W + g_2\cos\Theta_W\right)^2\left(v_d Z_{k1}^H + v_u Z_{k2}^H\right) \quad (475)$$



$$\begin{aligned} & \frac{i}{4} g_2 \xi_{W^-} \left(v_d \left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) Z_{k1}^+ + \left(g_1 v_u \sin \Theta_W - g_2 v_u \cos \Theta_W \right) Z_{k2}^+ \right. \\ & \left. + 2\sqrt{2} g_2 v_T \cos \Theta_W \left(Z_{k3}^+ + Z_{k4}^+ \right) \right) \end{aligned} \quad (476)$$



$$\begin{aligned} & \frac{i}{4} g_2 \xi_{W^-} \left(v_d \left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) Z_{k1}^+ + \left(g_1 v_u \sin \Theta_W - g_2 v_u \cos \Theta_W \right) Z_{k2}^+ \right. \\ & \left. + 2\sqrt{2} g_2 v_T \cos \Theta_W \left(Z_{k3}^+ + Z_{k4}^+ \right) \right) \end{aligned} \quad (477)$$

10 Clebsch-Gordan Coefficients

- : Gauge group:SU[2], Dynkin labels: (-2),(2)

$$K_{a,b}^{SU[2],-1 \times 3} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}_{ab} \quad (478)$$

- : Gauge group:SU[2], Dynkin labels: (2),(2)

$$K_{a,b}^{SU[2],3 \times 3} = \begin{pmatrix} 0 & 0 & 1 \\ 0 & -1 & 0 \\ 1 & 0 & 0 \end{pmatrix}_{ab} \quad (479)$$

- : Gauge group:SU[2], Dynkin labels: (1),(2),(1)

$$K_{1,a,b}^{SU[2],2\times 3\times 2} = \begin{pmatrix} 0 & 0 \\ 0 & \frac{1}{\sqrt{2}} \\ -1 & 0 \end{pmatrix}_{ab} \quad (480)$$

$$K_{2,a,b}^{SU[2],2\times 3\times 2} = \begin{pmatrix} 0 & -1 \\ \frac{1}{\sqrt{2}} & 0 \\ 0 & 0 \end{pmatrix}_{ab} \quad (481)$$

$$(482)$$