

Inverse Seesaw
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	$(1, \mathbf{1}, \mathbf{1})$
$\hat{\nu}$	$\tilde{\nu}_R^*$	ν_R^*	3	$(0, \mathbf{1}, \mathbf{1})$
\hat{s}	S	\tilde{S}	3	$(0, \mathbf{1}, \mathbf{1})$

2 Superpotential and Lagrangian

2.1 Superpotential

$$W = \mu \hat{H}_u \hat{H}_d + \frac{1}{2} \mu_S \hat{s} \hat{s} + M_\nu \hat{\nu} \hat{s} - Y_d \hat{d} \hat{q} \hat{H}_d - Y_e \hat{e} \hat{l} \hat{H}_d + Y_u \hat{u} \hat{q} \hat{H}_u + Y_\nu \hat{\nu} \hat{l} \hat{H}_u \quad (1)$$

2.2 Softbreaking terms

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

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

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

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'

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

2.4 Fields integrated out

None

3 Renormalization Group Equations

3.1 Anomalous Dimensions

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

$$\begin{aligned} \gamma_{\hat{q}}^{(2)} = & + \left(8g_2^2 g_3^2 + \frac{15}{4} g_2^4 + \frac{1}{90} g_1^2 \left(16g_3^2 + 9g_2^2 \right) + \frac{199}{900} g_1^4 - \frac{8}{9} g_3^4 \right) \mathbf{1} + \frac{4}{5} g_1^2 Y_u^\dagger Y_u - 2Y_d^\dagger Y_d Y_d^\dagger Y_d \\ & - 2Y_u^\dagger Y_u Y_u^\dagger Y_u + Y_d^\dagger Y_d \left(-3\text{Tr} \left(Y_d Y_d^\dagger \right) + \frac{2}{5} g_1^2 - \text{Tr} \left(Y_e Y_e^\dagger \right) \right) - 3Y_u^\dagger Y_u \text{Tr} \left(Y_u Y_u^\dagger \right) \\ & - Y_u^\dagger Y_u \text{Tr} \left(Y_\nu Y_\nu^\dagger \right) \end{aligned} \quad (8)$$

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

$$\begin{aligned} \gamma_{\hat{i}}^{(2)} = & + \frac{3}{100} \left(125g_2^4 + 30g_1^2 g_2^2 + 69g_1^4 \right) \mathbf{1} - 2Y_e^\dagger Y_e Y_e^\dagger Y_e - 2Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu \\ & + Y_e^\dagger Y_e \left(-3\text{Tr} \left(Y_d Y_d^\dagger \right) + \frac{6}{5} g_1^2 - \text{Tr} \left(Y_e Y_e^\dagger \right) \right) - 3Y_\nu^\dagger Y_\nu \text{Tr} \left(Y_u Y_u^\dagger \right) \\ & - Y_\nu^\dagger Y_\nu \text{Tr} \left(Y_\nu Y_\nu^\dagger \right) \end{aligned} \quad (10)$$

$$\gamma_{\hat{H}_d}^{(1)} = 3\text{Tr} \left(Y_d Y_d^\dagger \right) - \frac{3}{10} \left(5g_2^2 + g_1^2 \right) + \text{Tr} \left(Y_e Y_e^\dagger \right) \quad (11)$$

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

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

$$\begin{aligned} \gamma_{\hat{H}_u}^{(2)} = & +\frac{207}{100}g_1^4 + \frac{9}{10}g_1^2g_2^2 + \frac{15}{4}g_2^4 + \frac{4}{5}\left(20g_3^2 + g_1^2\right)\text{Tr}\left(Y_u Y_u^\dagger\right) - 3\text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) \\ & - \text{Tr}\left(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger\right) - 9\text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right) - 3\text{Tr}\left(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\right) \end{aligned} \quad (14)$$

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

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

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

$$\begin{aligned} \gamma_{\hat{u}}^{(2)} = & +\frac{8}{225}\left(107g_1^4 - 25g_3^4 + 80g_1^2g_3^2\right)\mathbf{1} \\ & - \frac{2}{5}\left(5\left(Y_u^* Y_d^T Y_d^* Y_u^T + Y_u^* Y_u^T Y_u^* Y_u^T\right) + Y_u^* Y_u^T\left(-15g_2^2 + 15\text{Tr}\left(Y_u Y_u^\dagger\right) + 5\text{Tr}\left(Y_\nu Y_\nu^\dagger\right) + g_1^2\right)\right) \end{aligned} \quad (18)$$

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

$$\begin{aligned} \gamma_{\hat{e}}^{(2)} = & +\frac{234}{25}g_1^4\mathbf{1} - 2\left(Y_e^* Y_e^T Y_e^* Y_e^T + Y_e^* Y_\nu^T Y_\nu^* Y_e^T\right) \\ & + Y_e^* Y_e^T\left(-2\text{Tr}\left(Y_e Y_e^\dagger\right) + 6g_2^2 - 6\text{Tr}\left(Y_d Y_d^\dagger\right) - \frac{6}{5}g_1^2\right) \end{aligned} \quad (20)$$

$$\gamma_{\hat{\nu}}^{(1)} = 2Y_\nu^* Y_\nu^T \quad (21)$$

$$\gamma_{\hat{\nu}}^{(2)} = -2\left(Y_\nu^* Y_e^T Y_e^* Y_\nu^T + Y_\nu^* Y_\nu^T Y_\nu^* Y_\nu^T\right) + Y_\nu^* Y_\nu^T\left(-2\text{Tr}\left(Y_\nu Y_\nu^\dagger\right) + 6g_2^2 - 6\text{Tr}\left(Y_u Y_u^\dagger\right) + \frac{6}{5}g_1^2\right) \quad (22)$$

3.2 Gauge Couplings

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

$$\beta_{g_1}^{(2)} = \frac{1}{25}g_1^3\left(-130\text{Tr}\left(Y_u Y_u^\dagger\right) + 135g_2^2 + 199g_1^2 - 30\text{Tr}\left(Y_\nu Y_\nu^\dagger\right) + 440g_3^2 - 70\text{Tr}\left(Y_d Y_d^\dagger\right) - 90\text{Tr}\left(Y_e Y_e^\dagger\right)\right) \quad (24)$$

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

$$\beta_{g_2}^{(2)} = \frac{1}{5}g_2^3\left(-10\text{Tr}\left(Y_e Y_e^\dagger\right) - 10\text{Tr}\left(Y_\nu Y_\nu^\dagger\right) + 120g_3^2 + 125g_2^2 - 30\text{Tr}\left(Y_d Y_d^\dagger\right) - 30\text{Tr}\left(Y_u Y_u^\dagger\right) + 9g_1^2\right) \quad (26)$$

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

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

3.3 Gaugino Mass Parameters

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

$$\begin{aligned} \beta_{M_1}^{(2)} = & \frac{2}{25}g_1^2 \left(398g_1^2 M_1 + 135g_2^2 M_1 + 440g_3^2 M_1 + 440g_3^2 M_3 + 135g_2^2 M_2 - 70M_1 \text{Tr}(Y_d Y_d^\dagger) - 90M_1 \text{Tr}(Y_e Y_e^\dagger) \right. \\ & \left. - 130M_1 \text{Tr}(Y_u Y_u^\dagger) - 30M_1 \text{Tr}(Y_\nu Y_\nu^\dagger) + 70\text{Tr}(Y_d^\dagger T_d) + 90\text{Tr}(Y_e^\dagger T_e) + 130\text{Tr}(Y_u^\dagger T_u) + 30\text{Tr}(Y_\nu^\dagger T_\nu) \right) \end{aligned} \quad (30)$$

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

$$\begin{aligned} \beta_{M_2}^{(2)} = & \frac{2}{5}g_2^2 \left(9g_1^2 M_1 + 120g_3^2 M_3 + 9g_1^2 M_2 + 250g_2^2 M_2 + 120g_3^2 M_2 - 30M_2 \text{Tr}(Y_d Y_d^\dagger) - 10M_2 \text{Tr}(Y_e Y_e^\dagger) \right. \\ & \left. - 30M_2 \text{Tr}(Y_u Y_u^\dagger) - 10M_2 \text{Tr}(Y_\nu Y_\nu^\dagger) + 30\text{Tr}(Y_d^\dagger T_d) + 10\text{Tr}(Y_e^\dagger T_e) + 30\text{Tr}(Y_u^\dagger T_u) + 10\text{Tr}(Y_\nu^\dagger T_\nu) \right) \end{aligned} \quad (32)$$

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

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

3.4 Trilinear Superpotential Parameters

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

$$\begin{aligned} \beta_{Y_d}^{(2)} = & + \frac{4}{5}g_1^2 Y_d Y_u^\dagger Y_u - 4Y_d Y_d^\dagger Y_d Y_d^\dagger Y_d - 2Y_d Y_u^\dagger Y_u Y_d^\dagger Y_d - 2Y_d Y_u^\dagger Y_u Y_u^\dagger Y_u \\ & + Y_d Y_d^\dagger Y_d \left(-3\text{Tr}(Y_e Y_e^\dagger) + 6g_2^2 - 9\text{Tr}(Y_d Y_d^\dagger) + \frac{4}{5}g_1^2 \right) - 3Y_d Y_u^\dagger Y_u \text{Tr}(Y_u Y_u^\dagger) \\ & - Y_d Y_u^\dagger Y_u \text{Tr}(Y_\nu Y_\nu^\dagger) \\ & + Y_d \left(\frac{287}{90}g_1^4 + g_1^2 g_2^2 + \frac{15}{2}g_2^4 + \frac{8}{9}g_1^2 g_3^2 + 8g_2^2 g_3^2 - \frac{16}{9}g_3^4 - \frac{2}{5}(-40g_3^2 + g_1^2) \text{Tr}(Y_d Y_d^\dagger) \right. \\ & \left. + \frac{6}{5}g_1^2 \text{Tr}(Y_e Y_e^\dagger) - 9\text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) - 3\text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 3\text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) \right. \\ & \left. - \text{Tr}(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger) \right) \end{aligned} \quad (36)$$

$$\beta_{Y_e}^{(1)} = 3Y_e Y_e^\dagger Y_e + Y_e \left(-3g_2^2 + 3\text{Tr}(Y_d Y_d^\dagger) - \frac{9}{5}g_1^2 + \text{Tr}(Y_e Y_e^\dagger) \right) + Y_e Y_\nu^\dagger Y_\nu \quad (37)$$

$$\begin{aligned} \beta_{Y_e}^{(2)} = & -4Y_e Y_e^\dagger Y_e Y_e^\dagger Y_e - 2Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger Y_e - 2Y_e Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu \\ & + Y_e Y_e^\dagger Y_e \left(-3\text{Tr}(Y_e Y_e^\dagger) + 6g_2^2 - 9\text{Tr}(Y_d Y_d^\dagger) \right) - 3Y_e Y_\nu^\dagger Y_\nu \text{Tr}(Y_u Y_u^\dagger) \\ & - Y_e Y_\nu^\dagger Y_\nu \text{Tr}(Y_\nu Y_\nu^\dagger) \\ & + \frac{1}{10}Y_e \left(135g_1^4 + 18g_1^2 g_2^2 + 75g_2^4 - 4(-40g_3^2 + g_1^2) \text{Tr}(Y_d Y_d^\dagger) + 12g_1^2 \text{Tr}(Y_e Y_e^\dagger) - 90\text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) \right) \end{aligned}$$

$$-30\text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) - 30\text{Tr}\left(Y_e Y_e^\dagger Y_e Y_e^\dagger\right) - 10\text{Tr}\left(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger\right) \quad (38)$$

$$\beta_{Y_u}^{(1)} = 3Y_u Y_u^\dagger Y_u + Y_u \left(-3g_2^2 + 3\text{Tr}\left(Y_u Y_u^\dagger\right) - \frac{13}{15}g_1^2 - \frac{16}{3}g_3^2 + \text{Tr}\left(Y_\nu Y_\nu^\dagger\right) \right) + Y_u Y_d^\dagger Y_d \quad (39)$$

$$\begin{aligned} \beta_{Y_u}^{(2)} = & + \frac{2}{5}g_1^2 Y_u Y_u^\dagger Y_u + 6g_2^2 Y_u Y_u^\dagger Y_u - 2Y_u Y_d^\dagger Y_d Y_d^\dagger Y_d - 2Y_u Y_d^\dagger Y_d Y_u^\dagger Y_u \\ & - 4Y_u Y_u^\dagger Y_u Y_u^\dagger Y_u + Y_u Y_d^\dagger Y_d \left(-3\text{Tr}\left(Y_d Y_d^\dagger\right) + \frac{2}{5}g_1^2 - \text{Tr}\left(Y_e Y_e^\dagger\right) \right) - 9Y_u Y_u^\dagger Y_u \text{Tr}\left(Y_u Y_u^\dagger\right) \\ & - 3Y_u Y_u^\dagger Y_u \text{Tr}\left(Y_\nu Y_\nu^\dagger\right) \\ & + Y_u \left(\frac{2743}{450}g_1^4 + g_1^2 g_2^2 + \frac{15}{2}g_2^4 + \frac{136}{45}g_1^2 g_3^2 + 8g_2^2 g_3^2 - \frac{16}{9}g_3^4 + \frac{4}{5}(20g_3^2 + g_1^2) \text{Tr}\left(Y_u Y_u^\dagger\right) \right. \\ & \left. - 3\text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) - \text{Tr}\left(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger\right) - 9\text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right) - 3\text{Tr}\left(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\right) \right) \end{aligned} \quad (40)$$

$$\beta_{Y_\nu}^{(1)} = 3Y_\nu Y_\nu^\dagger Y_\nu + Y_\nu \left(-3g_2^2 + 3\text{Tr}\left(Y_u Y_u^\dagger\right) - \frac{3}{5}g_1^2 + \text{Tr}\left(Y_\nu Y_\nu^\dagger\right) \right) + Y_\nu Y_e^\dagger Y_e \quad (41)$$

$$\begin{aligned} \beta_{Y_\nu}^{(2)} = & + \frac{6}{5}g_1^2 Y_\nu Y_\nu^\dagger Y_\nu + 6g_2^2 Y_\nu Y_\nu^\dagger Y_\nu - 2Y_\nu Y_e^\dagger Y_e Y_e^\dagger Y_e - 2Y_\nu Y_e^\dagger Y_e Y_\nu^\dagger Y_\nu \\ & - 4Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu + Y_\nu Y_e^\dagger Y_e \left(-3\text{Tr}\left(Y_d Y_d^\dagger\right) + \frac{6}{5}g_1^2 - \text{Tr}\left(Y_e Y_e^\dagger\right) \right) - 9Y_\nu Y_\nu^\dagger Y_\nu \text{Tr}\left(Y_u Y_u^\dagger\right) \\ & - 3Y_\nu Y_\nu^\dagger Y_\nu \text{Tr}\left(Y_\nu Y_\nu^\dagger\right) \\ & + Y_\nu \left(\frac{207}{50}g_1^4 + \frac{9}{5}g_1^2 g_2^2 + \frac{15}{2}g_2^4 + \frac{4}{5}(20g_3^2 + g_1^2) \text{Tr}\left(Y_u Y_u^\dagger\right) - 3\text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) \right. \\ & \left. - \text{Tr}\left(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger\right) - 9\text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right) - 3\text{Tr}\left(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\right) \right) \end{aligned} \quad (42)$$

3.5 Bilinear Superpotential Parameters

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

$$\begin{aligned} \beta_{\mu}^{(2)} = & \frac{1}{50}\mu \left(207g_1^4 + 90g_1^2 g_2^2 + 375g_2^4 - 20 \left(-40g_3^2 + g_1^2 \right) \text{Tr}\left(Y_d Y_d^\dagger\right) + 60g_1^2 \text{Tr}\left(Y_e Y_e^\dagger\right) + 40g_1^2 \text{Tr}\left(Y_u Y_u^\dagger\right) \right. \\ & + 800g_3^2 \text{Tr}\left(Y_u Y_u^\dagger\right) - 450\text{Tr}\left(Y_d Y_d^\dagger Y_d Y_d^\dagger\right) - 300\text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) - 150\text{Tr}\left(Y_e Y_e^\dagger Y_e Y_e^\dagger\right) \\ & \left. - 100\text{Tr}\left(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger\right) - 450\text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right) - 150\text{Tr}\left(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\right) \right) \end{aligned} \quad (44)$$

$$\beta_{\mu_S}^{(1)} = 0 \quad (45)$$

$$\beta_{\mu_S}^{(2)} = 0 \quad (46)$$

$$\beta_{M_\nu}^{(1)} = 2Y_\nu Y_\nu^\dagger M_\nu \quad (47)$$

$$\begin{aligned} \beta_{M_\nu}^{(2)} = & -2 \left(Y_\nu Y_e^\dagger Y_e Y_\nu^\dagger M_\nu + Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger M_\nu \right) \\ & + Y_\nu Y_\nu^\dagger M_\nu \left(-2\text{Tr}\left(Y_\nu Y_\nu^\dagger\right) + 6g_2^2 - 6\text{Tr}\left(Y_u Y_u^\dagger\right) + \frac{6}{5}g_1^2 \right) \end{aligned} \quad (48)$$

3.6 Trilinear Soft-Breaking Parameters

$$\begin{aligned} \beta_{T_d}^{(1)} = & +4Y_d Y_d^\dagger T_d + 2Y_d Y_u^\dagger T_u + 5T_d Y_d^\dagger Y_d + T_d Y_u^\dagger Y_u - \frac{7}{15}g_1^2 T_d - 3g_2^2 T_d - \frac{16}{3}g_3^2 T_d \\ & + 3T_d \text{Tr}(Y_d Y_d^\dagger) + T_d \text{Tr}(Y_e Y_e^\dagger) + Y_d (2\text{Tr}(Y_e^\dagger T_e) + 6g_2^2 M_2 + 6\text{Tr}(Y_d^\dagger T_d)) + \frac{14}{15}g_1^2 M_1 + \frac{32}{3}g_3^2 M_3 \end{aligned} \quad (49)$$

$$\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 - \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 \\ & + \frac{6}{5}g_1^2 T_d Y_d^\dagger Y_d + 12g_2^2 T_d Y_d^\dagger Y_d + \frac{4}{5}g_1^2 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{15}{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 \\ & - 12Y_d Y_d^\dagger T_d \text{Tr}(Y_d Y_d^\dagger) - 15T_d Y_d^\dagger Y_d \text{Tr}(Y_d Y_d^\dagger) - \frac{2}{5}g_1^2 T_d \text{Tr}(Y_d Y_d^\dagger) \\ & + 16g_3^2 T_d \text{Tr}(Y_d Y_d^\dagger) - 4Y_d Y_d^\dagger T_d \text{Tr}(Y_e Y_e^\dagger) - 5T_d Y_d^\dagger Y_d \text{Tr}(Y_e Y_e^\dagger) \\ & + \frac{6}{5}g_1^2 T_d \text{Tr}(Y_e Y_e^\dagger) - 6Y_d Y_u^\dagger T_u \text{Tr}(Y_u Y_u^\dagger) - 3T_d Y_u^\dagger Y_u \text{Tr}(Y_u Y_u^\dagger) \\ & - 2Y_d Y_u^\dagger T_u \text{Tr}(Y_\nu Y_\nu^\dagger) - T_d Y_u^\dagger Y_u \text{Tr}(Y_\nu Y_\nu^\dagger) \\ & - \frac{2}{5}Y_d Y_d^\dagger Y_d (15\text{Tr}(Y_e^\dagger T_e) + 30g_2^2 M_2 + 45\text{Tr}(Y_d^\dagger T_d) + 4g_1^2 M_1) - 6Y_d Y_u^\dagger Y_u \text{Tr}(Y_u^\dagger T_u) \\ & - 2Y_d Y_u^\dagger Y_u \text{Tr}(Y_\nu^\dagger T_\nu) - 9T_d \text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) - 3T_d \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) \\ & - 3T_d \text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) - T_d \text{Tr}(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger) \\ & - \frac{2}{45}Y_d (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 \\ & + 45g_1^2 g_2^2 M_2 + 675g_2^4 M_2 + 360g_2^2 g_3^2 M_2 - 18(-40g_3^2 M_3 + g_1^2 M_1)) \text{Tr}(Y_d Y_d^\dagger) \\ & + 54g_1^2 M_1 \text{Tr}(Y_e Y_e^\dagger) + 18g_1^2 \text{Tr}(Y_d^\dagger T_d) - 720g_3^2 \text{Tr}(Y_d^\dagger T_d) - 54g_1^2 \text{Tr}(Y_e^\dagger T_e) \\ & + 810\text{Tr}(Y_d Y_d^\dagger T_d Y_d^\dagger) + 135\text{Tr}(Y_d Y_u^\dagger T_u Y_d^\dagger) + 270\text{Tr}(Y_e Y_e^\dagger T_e Y_e^\dagger) + 45\text{Tr}(Y_e Y_\nu^\dagger T_\nu Y_e^\dagger) \\ & + 135\text{Tr}(Y_u Y_d^\dagger T_d Y_u^\dagger) + 45\text{Tr}(Y_\nu Y_e^\dagger T_e Y_\nu^\dagger) \end{aligned} \quad (50)$$

$$\begin{aligned} \beta_{T_e}^{(1)} = & +4Y_e Y_e^\dagger T_e + 2Y_e Y_\nu^\dagger T_\nu + 5T_e Y_e^\dagger Y_e + T_e Y_\nu^\dagger Y_\nu - \frac{9}{5}g_1^2 T_e - 3g_2^2 T_e \\ & + 3T_e \text{Tr}(Y_d Y_d^\dagger) + T_e \text{Tr}(Y_e Y_e^\dagger) + Y_e (2\text{Tr}(Y_e^\dagger T_e) + 6g_2^2 M_2 + 6\text{Tr}(Y_d^\dagger T_d) + \frac{18}{5}g_1^2 M_1) \end{aligned} \quad (51)$$

$$\begin{aligned} \beta_{T_e}^{(2)} = & +\frac{6}{5}g_1^2 Y_e Y_e^\dagger T_e + 6g_2^2 Y_e Y_e^\dagger T_e - \frac{6}{5}g_1^2 T_e Y_e^\dagger Y_e + 12g_2^2 T_e Y_e^\dagger Y_e \\ & - 6Y_e Y_e^\dagger Y_e Y_e^\dagger T_e - 8Y_e Y_e^\dagger T_e Y_e^\dagger Y_e - 2Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger T_e - 4Y_e Y_\nu^\dagger Y_\nu Y_\nu^\dagger T_\nu \\ & - 4Y_e Y_\nu^\dagger T_\nu Y_e^\dagger Y_e - 4Y_e Y_\nu^\dagger T_\nu Y_\nu^\dagger Y_\nu - 6T_e Y_e^\dagger Y_e Y_e^\dagger Y_e - 4T_e Y_\nu^\dagger Y_\nu Y_e^\dagger Y_e \end{aligned}$$

$$\begin{aligned}
& -2T_e Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu + \frac{27}{2} g_1^4 T_e + \frac{9}{5} g_1^2 g_2^2 T_e + \frac{15}{2} g_2^4 T_e - 12Y_e Y_e^\dagger T_e \text{Tr}(Y_d Y_d^\dagger) \\
& - 15T_e Y_e^\dagger Y_e \text{Tr}(Y_d Y_d^\dagger) - \frac{2}{5} g_1^2 T_e \text{Tr}(Y_d Y_d^\dagger) + 16g_3^2 T_e \text{Tr}(Y_d Y_d^\dagger) \\
& - 4Y_e Y_e^\dagger T_e \text{Tr}(Y_e Y_e^\dagger) - 5T_e Y_e^\dagger Y_e \text{Tr}(Y_e Y_e^\dagger) + \frac{6}{5} g_1^2 T_e \text{Tr}(Y_e Y_e^\dagger) \\
& - 6Y_e Y_\nu^\dagger T_\nu \text{Tr}(Y_u Y_u^\dagger) - 3T_e Y_\nu^\dagger Y_\nu \text{Tr}(Y_u Y_u^\dagger) - 2Y_e Y_\nu^\dagger T_\nu \text{Tr}(Y_\nu Y_\nu^\dagger) \\
& - T_e Y_\nu^\dagger Y_\nu \text{Tr}(Y_\nu Y_\nu^\dagger) - 6Y_e Y_e^\dagger Y_e (2g_2^2 M_2 + 3\text{Tr}(Y_d^\dagger T_d) + \text{Tr}(Y_e^\dagger T_e)) \\
& - 6Y_e Y_\nu^\dagger Y_\nu \text{Tr}(Y_u^\dagger T_u) - 2Y_e Y_\nu^\dagger Y_\nu \text{Tr}(Y_\nu^\dagger T_\nu) - 9T_e \text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) \\
& - 3T_e \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 3T_e \text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) - T_e \text{Tr}(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger) \\
& - \frac{2}{5} Y_e (135g_1^4 M_1 + 9g_1^2 g_2^2 M_1 + 9g_1^2 g_2^2 M_2 + 75g_2^4 M_2 + (-2g_1^2 M_1 + 80g_3^2 M_3) \text{Tr}(Y_d Y_d^\dagger) \\
& + 6g_1^2 M_1 \text{Tr}(Y_e Y_e^\dagger) + 2g_1^2 \text{Tr}(Y_d^\dagger T_d) - 80g_3^2 \text{Tr}(Y_d^\dagger T_d) - 6g_1^2 \text{Tr}(Y_e^\dagger T_e) \\
& + 90\text{Tr}(Y_d Y_d^\dagger T_d Y_d^\dagger) + 15\text{Tr}(Y_d Y_u^\dagger T_u Y_d^\dagger) + 30\text{Tr}(Y_e Y_e^\dagger T_e Y_e^\dagger) + 5\text{Tr}(Y_e Y_\nu^\dagger T_\nu Y_e^\dagger) \\
& + 15\text{Tr}(Y_u Y_d^\dagger T_d Y_u^\dagger) + 5\text{Tr}(Y_\nu Y_e^\dagger T_e Y_\nu^\dagger)) \tag{52}
\end{aligned}$$

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

$$\begin{aligned}
\beta_{T_u}^{(2)} = & +\frac{4}{5} g_1^2 Y_u Y_d^\dagger T_d - \frac{4}{5} g_1^2 M_1 Y_u Y_u^\dagger Y_u - 12g_2^2 M_2 Y_u Y_u^\dagger Y_u + \frac{6}{5} g_1^2 Y_u Y_u^\dagger T_u \\
& + 6g_2^2 Y_u Y_u^\dagger T_u + \frac{2}{5} g_1^2 T_u Y_d^\dagger Y_d + 12g_2^2 T_u Y_u^\dagger Y_u - 4Y_u Y_d^\dagger Y_d Y_d^\dagger T_d \\
& - 2Y_u Y_d^\dagger Y_d Y_u^\dagger T_u - 4Y_u Y_d^\dagger T_d Y_d^\dagger Y_d - 4Y_u Y_d^\dagger T_d Y_u^\dagger Y_u - 6Y_u Y_u^\dagger Y_u Y_u^\dagger T_u \\
& - 8Y_u Y_u^\dagger T_u Y_u^\dagger Y_u - 2T_u Y_d^\dagger Y_d Y_d^\dagger Y_d - 4T_u Y_d^\dagger Y_d Y_u^\dagger Y_u - 6T_u Y_u^\dagger Y_u Y_u^\dagger Y_u + \frac{2743}{450} g_1^4 T_u \\
& + g_1^2 g_2^2 T_u + \frac{15}{2} g_2^4 T_u + \frac{136}{45} g_1^2 g_3^2 T_u + 8g_2^2 g_3^2 T_u - \frac{16}{9} g_3^4 T_u - 6Y_u Y_d^\dagger T_d \text{Tr}(Y_d Y_d^\dagger) \\
& - 3T_u Y_d^\dagger Y_d \text{Tr}(Y_d Y_d^\dagger) - 2Y_u Y_d^\dagger T_d \text{Tr}(Y_e Y_e^\dagger) - T_u Y_d^\dagger Y_d \text{Tr}(Y_e Y_e^\dagger) \\
& - 12Y_u Y_u^\dagger T_u \text{Tr}(Y_u Y_u^\dagger) - 15T_u Y_u^\dagger Y_u \text{Tr}(Y_u Y_u^\dagger) + \frac{4}{5} g_1^2 T_u \text{Tr}(Y_u Y_u^\dagger) \\
& + 16g_3^2 T_u \text{Tr}(Y_u Y_u^\dagger) - 4Y_u Y_u^\dagger T_u \text{Tr}(Y_\nu Y_\nu^\dagger) - 5T_u Y_u^\dagger Y_u \text{Tr}(Y_\nu Y_\nu^\dagger) \\
& - \frac{2}{5} Y_u Y_d^\dagger Y_d (15\text{Tr}(Y_d^\dagger T_d) + 2g_1^2 M_1 + 5\text{Tr}(Y_e^\dagger T_e)) - 18Y_u Y_u^\dagger Y_u \text{Tr}(Y_u^\dagger T_u) \\
& - 6Y_u Y_u^\dagger Y_u \text{Tr}(Y_\nu^\dagger T_\nu) - 3T_u \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - T_u \text{Tr}(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger) \\
& - 9T_u \text{Tr}(Y_u Y_u^\dagger Y_u Y_u^\dagger) - 3T_u \text{Tr}(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger)
\end{aligned}$$

$$\begin{aligned}
& + Y_u \left(-\frac{5486}{225} g_1^4 M_1 - 2g_1^2 g_2^2 M_1 - \frac{272}{45} g_1^2 g_3^2 M_1 - \frac{272}{45} g_1^2 g_3^2 M_3 - 16g_2^2 g_3^2 M_3 + \frac{64}{9} g_3^4 M_3 \right. \\
& - 2g_1^2 g_2^2 M_2 - 30g_2^4 M_2 - 16g_2^2 g_3^2 M_2 - \frac{8}{5} (20g_3^2 M_3 + g_1^2 M_1) \text{Tr}(Y_u Y_u^\dagger) \\
& + \frac{8}{5} (20g_3^2 + g_1^2) \text{Tr}(Y_u^\dagger T_u) - 6\text{Tr}(Y_d Y_u^\dagger T_u Y_d^\dagger) - 2\text{Tr}(Y_e Y_\nu^\dagger T_\nu Y_e^\dagger) - 6\text{Tr}(Y_u Y_d^\dagger T_d Y_u^\dagger) \\
& \left. - 36\text{Tr}(Y_u Y_u^\dagger T_u Y_u^\dagger) - 2\text{Tr}(Y_\nu Y_e^\dagger T_e Y_\nu^\dagger) - 12\text{Tr}(Y_\nu Y_\nu^\dagger T_\nu Y_\nu^\dagger) \right) \quad (54)
\end{aligned}$$

$$\begin{aligned}
\beta_{T_\nu}^{(1)} & = +2Y_\nu Y_e^\dagger T_e + 4Y_\nu Y_\nu^\dagger T_\nu + T_\nu Y_e^\dagger Y_e + 5T_\nu Y_\nu^\dagger Y_\nu - \frac{3}{5} g_1^2 T_\nu - 3g_2^2 T_\nu \\
& + 3T_\nu \text{Tr}(Y_u Y_u^\dagger) + T_\nu \text{Tr}(Y_\nu Y_\nu^\dagger) + Y_\nu \left(2\text{Tr}(Y_\nu^\dagger T_\nu) + 6g_2^2 M_2 + 6\text{Tr}(Y_u^\dagger T_u) + \frac{6}{5} g_1^2 M_1 \right) \quad (55)
\end{aligned}$$

$$\begin{aligned}
\beta_{T_\nu}^{(2)} & = +\frac{12}{5} g_1^2 Y_\nu Y_e^\dagger T_e - \frac{12}{5} g_1^2 M_1 Y_\nu Y_\nu^\dagger Y_\nu - 12g_2^2 M_2 Y_\nu Y_\nu^\dagger Y_\nu + \frac{6}{5} g_1^2 Y_\nu Y_\nu^\dagger T_\nu \\
& + 6g_2^2 Y_\nu Y_\nu^\dagger T_\nu + \frac{6}{5} g_1^2 T_\nu Y_e^\dagger Y_e + \frac{12}{5} g_1^2 T_\nu Y_\nu^\dagger Y_\nu + 12g_2^2 T_\nu Y_\nu^\dagger Y_\nu \\
& - 4Y_\nu Y_e^\dagger Y_e Y_e^\dagger T_e - 2Y_\nu Y_e^\dagger Y_e Y_\nu^\dagger T_\nu - 4Y_\nu Y_e^\dagger T_e Y_e^\dagger Y_e - 4Y_\nu Y_e^\dagger T_e Y_\nu^\dagger Y_\nu \\
& - 6Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger T_\nu - 8Y_\nu Y_\nu^\dagger T_\nu Y_\nu^\dagger Y_\nu - 2T_\nu Y_e^\dagger Y_e Y_e^\dagger Y_e - 4T_\nu Y_e^\dagger Y_e Y_\nu^\dagger Y_\nu \\
& - 6T_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu + \frac{207}{50} g_1^4 T_\nu + \frac{9}{5} g_1^2 g_2^2 T_\nu + \frac{15}{2} g_2^4 T_\nu - 6Y_\nu Y_e^\dagger T_e \text{Tr}(Y_d Y_d^\dagger) \\
& - 3T_\nu Y_e^\dagger Y_e \text{Tr}(Y_d Y_d^\dagger) - 2Y_\nu Y_e^\dagger T_e \text{Tr}(Y_e Y_e^\dagger) - T_\nu Y_e^\dagger Y_e \text{Tr}(Y_e Y_e^\dagger) \\
& - 12Y_\nu Y_\nu^\dagger T_\nu \text{Tr}(Y_u Y_u^\dagger) - 15T_\nu Y_\nu^\dagger Y_\nu \text{Tr}(Y_u Y_u^\dagger) + \frac{4}{5} g_1^2 T_\nu \text{Tr}(Y_u Y_u^\dagger) \\
& + 16g_3^2 T_\nu \text{Tr}(Y_u Y_u^\dagger) - 4Y_\nu Y_\nu^\dagger T_\nu \text{Tr}(Y_\nu Y_\nu^\dagger) - 5T_\nu Y_\nu^\dagger Y_\nu \text{Tr}(Y_\nu Y_\nu^\dagger) \\
& - \frac{2}{5} Y_\nu Y_e^\dagger Y_e \left(15\text{Tr}(Y_d^\dagger T_d) + 5\text{Tr}(Y_e^\dagger T_e) + 6g_1^2 M_1 \right) - 18Y_\nu Y_\nu^\dagger Y_\nu \text{Tr}(Y_u^\dagger T_u) \\
& - 6Y_\nu Y_\nu^\dagger Y_\nu \text{Tr}(Y_\nu^\dagger T_\nu) - 3T_\nu \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - T_\nu \text{Tr}(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger) \\
& - 9T_\nu \text{Tr}(Y_u Y_u^\dagger Y_u Y_u^\dagger) - 3T_\nu \text{Tr}(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger) \\
& - \frac{2}{25} Y_\nu \left(207g_1^4 M_1 + 45g_1^2 g_2^2 M_1 + 45g_1^2 g_2^2 M_2 + 375g_2^4 M_2 + 20(20g_3^2 M_3 + g_1^2 M_1) \text{Tr}(Y_u Y_u^\dagger) \right. \\
& - 20(20g_3^2 + g_1^2) \text{Tr}(Y_u^\dagger T_u) + 75\text{Tr}(Y_d Y_u^\dagger T_u Y_d^\dagger) + 25\text{Tr}(Y_e Y_\nu^\dagger T_\nu Y_e^\dagger) \\
& \left. + 75\text{Tr}(Y_u Y_d^\dagger T_d Y_u^\dagger) + 450\text{Tr}(Y_u Y_u^\dagger T_u Y_u^\dagger) + 25\text{Tr}(Y_\nu Y_e^\dagger T_e Y_\nu^\dagger) + 150\text{Tr}(Y_\nu Y_\nu^\dagger T_\nu Y_\nu^\dagger) \right) \quad (56)
\end{aligned}$$

3.7 Bilinear Soft-Breaking Parameters

$$\begin{aligned}
\beta_{B_\mu}^{(1)} & = +B_\mu \left(-3g_2^2 + 3\text{Tr}(Y_d Y_d^\dagger) + 3\text{Tr}(Y_u Y_u^\dagger) - \frac{3}{5} g_1^2 + \text{Tr}(Y_e Y_e^\dagger) + \text{Tr}(Y_\nu Y_\nu^\dagger) \right) \\
& + \frac{2}{5} \mu \left(15g_2^2 M_2 + 15\text{Tr}(Y_d^\dagger T_d) + 15\text{Tr}(Y_u^\dagger T_u) + 3g_1^2 M_1 + 5\text{Tr}(Y_e^\dagger T_e) + 5\text{Tr}(Y_\nu^\dagger T_\nu) \right) \quad (57)
\end{aligned}$$

$$\begin{aligned}
\beta_{B_\mu}^{(2)} = & +B_\mu \left(\frac{207}{50} g_1^4 + \frac{9}{5} g_1^2 g_2^2 + \frac{15}{2} g_2^4 - \frac{2}{5} \left(-40g_3^2 + g_1^2 \right) \text{Tr} \left(Y_d Y_d^\dagger \right) + \frac{6}{5} g_1^2 \text{Tr} \left(Y_e Y_e^\dagger \right) + \frac{4}{5} g_1^2 \text{Tr} \left(Y_u Y_u^\dagger \right) \right. \\
& + 16g_3^2 \text{Tr} \left(Y_u Y_u^\dagger \right) - 9 \text{Tr} \left(Y_d Y_d^\dagger Y_d Y_d^\dagger \right) - 6 \text{Tr} \left(Y_d Y_u^\dagger Y_u Y_d^\dagger \right) - 3 \text{Tr} \left(Y_e Y_e^\dagger Y_e Y_e^\dagger \right) \\
& - 2 \text{Tr} \left(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger \right) - 9 \text{Tr} \left(Y_u Y_u^\dagger Y_u Y_u^\dagger \right) - 3 \text{Tr} \left(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger \right) \\
& - \frac{2}{25} \mu \left(207g_1^4 M_1 + 45g_1^2 g_2^2 M_1 + 45g_1^2 g_2^2 M_2 + 375g_2^4 M_2 - 10 \left(-40g_3^2 M_3 + g_1^2 M_1 \right) \text{Tr} \left(Y_d Y_d^\dagger \right) \right. \\
& + 30g_1^2 M_1 \text{Tr} \left(Y_e Y_e^\dagger \right) + 20g_1^2 M_1 \text{Tr} \left(Y_u Y_u^\dagger \right) + 400g_3^2 M_3 \text{Tr} \left(Y_u Y_u^\dagger \right) + 10g_1^2 \text{Tr} \left(Y_d^\dagger T_d \right) \\
& - 400g_3^2 \text{Tr} \left(Y_d^\dagger T_d \right) - 30g_1^2 \text{Tr} \left(Y_e^\dagger T_e \right) - 20g_1^2 \text{Tr} \left(Y_u^\dagger T_u \right) - 400g_3^2 \text{Tr} \left(Y_u^\dagger T_u \right) \\
& + 450 \text{Tr} \left(Y_d Y_d^\dagger T_d Y_d^\dagger \right) + 150 \text{Tr} \left(Y_d Y_u^\dagger T_u Y_d^\dagger \right) + 150 \text{Tr} \left(Y_e Y_e^\dagger T_e Y_e^\dagger \right) + 50 \text{Tr} \left(Y_e Y_\nu^\dagger T_\nu Y_e^\dagger \right) \\
& \left. + 150 \text{Tr} \left(Y_u Y_d^\dagger T_d Y_u^\dagger \right) + 450 \text{Tr} \left(Y_u Y_u^\dagger T_u Y_u^\dagger \right) + 50 \text{Tr} \left(Y_\nu Y_e^\dagger T_e Y_\nu^\dagger \right) + 150 \text{Tr} \left(Y_\nu Y_\nu^\dagger T_\nu Y_\nu^\dagger \right) \right) \quad (58)
\end{aligned}$$

$$\beta_{B_S}^{(1)} = 0 \quad (59)$$

$$\beta_{B_S}^{(2)} = 0 \quad (60)$$

$$\beta_{B_\nu}^{(1)} = 2 \left(2T_\nu Y_\nu^\dagger M_\nu + Y_\nu Y_\nu^\dagger B_\nu \right) \quad (61)$$

$$\begin{aligned}
\beta_{B_\nu}^{(2)} = & -\frac{2}{5} \left(-6g_1^2 T_\nu Y_\nu^\dagger M_\nu - 30g_2^2 T_\nu Y_\nu^\dagger M_\nu + 5Y_\nu Y_e^\dagger Y_e Y_\nu^\dagger B_\nu + 10Y_\nu Y_e^\dagger T_e Y_\nu^\dagger M_\nu \right. \\
& + 5Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger B_\nu + 10Y_\nu Y_\nu^\dagger T_\nu Y_\nu^\dagger M_\nu + 10T_\nu Y_e^\dagger Y_e Y_\nu^\dagger M_\nu + 10T_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger M_\nu \\
& + 30T_\nu Y_\nu^\dagger M_\nu \text{Tr} \left(Y_u Y_u^\dagger \right) + 10T_\nu Y_\nu^\dagger M_\nu \text{Tr} \left(Y_\nu Y_\nu^\dagger \right) \\
& + Y_\nu Y_\nu^\dagger B_\nu \left(15 \text{Tr} \left(Y_u Y_u^\dagger \right) - 3 \left(5g_2^2 + g_1^2 \right) + 5 \text{Tr} \left(Y_\nu Y_\nu^\dagger \right) \right) \\
& \left. + 2Y_\nu Y_\nu^\dagger M_\nu \left(15g_2^2 M_2 + 15 \text{Tr} \left(Y_u^\dagger T_u \right) + 3g_1^2 M_1 + 5 \text{Tr} \left(Y_\nu^\dagger T_\nu \right) \right) \right) \quad (62)
\end{aligned}$$

3.8 Soft-Breaking Scalar Masses

$$\sigma_{1,1} = \sqrt{\frac{3}{5}} g_1 \left(-2 \text{Tr} \left(m_u^2 \right) - \text{Tr} \left(m_l^2 \right) - m_{H_d}^2 + m_{H_u}^2 + \text{Tr} \left(m_d^2 \right) + \text{Tr} \left(m_e^2 \right) + \text{Tr} \left(m_q^2 \right) \right) \quad (63)$$

$$\sigma_{2,11} = \frac{1}{10} g_1^2 \left(2 \text{Tr} \left(m_d^2 \right) + 3 \text{Tr} \left(m_l^2 \right) + 3m_{H_d}^2 + 3m_{H_u}^2 + 6 \text{Tr} \left(m_e^2 \right) + 8 \text{Tr} \left(m_u^2 \right) + \text{Tr} \left(m_q^2 \right) \right) \quad (64)$$

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

$$+ 120\text{Tr}\left(Y_u Y_u^\dagger m_u^{2*}\right) - 30\text{Tr}\left(Y_u m_q^{2*} Y_u^\dagger\right) + 30\text{Tr}\left(Y_\nu m_l^{2*} Y_\nu^\dagger\right) \quad (65)$$

$$\sigma_{2,2} = \frac{1}{2}\left(3\text{Tr}\left(m_q^2\right) + m_{H_d}^2 + m_{H_u}^2 + \text{Tr}\left(m_t^2\right)\right) \quad (66)$$

$$\sigma_{2,3} = \frac{1}{2}\left(2\text{Tr}\left(m_q^2\right) + \text{Tr}\left(m_d^2\right) + \text{Tr}\left(m_u^2\right)\right) \quad (67)$$

$$\begin{aligned} \beta_{m_q^2}^{(1)} = & -\frac{2}{15}g_1^2\mathbf{1}|M_1|^2 - \frac{32}{3}g_3^2\mathbf{1}|M_3|^2 - 6g_2^2\mathbf{1}|M_2|^2 + 2m_{H_d}^2 Y_d^\dagger Y_d + 2m_{H_u}^2 Y_u^\dagger Y_u + 2T_d^\dagger T_d \\ & + 2T_u^\dagger T_u + m_q^2 Y_d^\dagger Y_d + m_q^2 Y_u^\dagger Y_u + 2Y_d^\dagger m_d^2 Y_d + Y_d^\dagger Y_d m_q^2 + 2Y_u^\dagger m_u^2 Y_u \\ & + Y_u^\dagger Y_u m_q^2 + \frac{1}{\sqrt{15}}g_1\mathbf{1}\sigma_{1,1} \end{aligned} \quad (68)$$

$$\begin{aligned} \beta_{m_q^2}^{(2)} = & \frac{2}{5}g_1^2g_2^2\mathbf{1}|M_2|^2 + 33g_2^4\mathbf{1}|M_2|^2 + 32g_2^2g_3^2\mathbf{1}|M_2|^2 \\ & + \frac{16}{45}g_3^2\left(15\left(3g_2^2\left(2M_3 + M_2\right) - 8g_3^2M_3\right) + g_1^2\left(2M_3 + M_1\right)\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 + \frac{8}{5}g_1^2m_{H_u}^2Y_u^\dagger Y_u \\ & + \frac{1}{225}g_1^2M_1^*\left(\left(5\left(16g_3^2\left(2M_1 + M_3\right) + 9g_2^2\left(2M_1 + M_2\right)\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) \\ & - \frac{4}{5}g_1^2M_1T_d^\dagger Y_d + \frac{4}{5}g_1^2T_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 \\ & + \frac{2}{5}g_1^2m_q^2Y_d^\dagger Y_d + \frac{4}{5}g_1^2m_q^2Y_u^\dagger Y_u + \frac{4}{5}g_1^2Y_d^\dagger m_d^2 Y_d + \frac{2}{5}g_1^2Y_d^\dagger Y_d m_q^2 \\ & + \frac{8}{5}g_1^2Y_u^\dagger m_u^2 Y_u + \frac{4}{5}g_1^2Y_u^\dagger Y_u m_q^2 - 8m_{H_d}^2 Y_d^\dagger Y_d Y_d^\dagger Y_d - 4Y_d^\dagger Y_d T_d^\dagger T_d \\ & - 4Y_d^\dagger T_d T_d^\dagger Y_d - 8m_{H_u}^2 Y_u^\dagger Y_u Y_u^\dagger Y_u - 4Y_u^\dagger Y_u T_u^\dagger T_u - 4Y_u^\dagger T_u T_u^\dagger Y_u \\ & - 4T_d^\dagger Y_d Y_d^\dagger T_d - 4T_d^\dagger T_d Y_d^\dagger Y_d - 4T_u^\dagger Y_u Y_u^\dagger T_u - 4T_u^\dagger T_u Y_u^\dagger Y_u \\ & - 2m_q^2 Y_d^\dagger Y_d Y_d^\dagger Y_d - 2m_q^2 Y_u^\dagger Y_u Y_u^\dagger Y_u - 4Y_d^\dagger m_d^2 Y_d Y_d^\dagger Y_d - 4Y_d^\dagger Y_d m_q^2 Y_d^\dagger Y_d \\ & - 4Y_d^\dagger Y_d Y_d^\dagger m_d^2 Y_d - 2Y_d^\dagger Y_d Y_d^\dagger Y_d m_q^2 - 4Y_u^\dagger m_u^2 Y_u Y_u^\dagger Y_u - 4Y_u^\dagger Y_u m_q^2 Y_u^\dagger Y_u \\ & - 4Y_u^\dagger Y_u Y_u^\dagger m_u^2 Y_u - 2Y_u^\dagger Y_u Y_u^\dagger Y_u m_q^2 + 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}^2 Y_d^\dagger Y_d \text{Tr}\left(Y_d Y_d^\dagger\right) - 6T_d^\dagger T_d \text{Tr}\left(Y_d Y_d^\dagger\right) - 3m_q^2 Y_d^\dagger Y_d \text{Tr}\left(Y_d Y_d^\dagger\right) \\ & - 6Y_d^\dagger m_d^2 Y_d \text{Tr}\left(Y_d Y_d^\dagger\right) - 3Y_d^\dagger Y_d m_q^2 \text{Tr}\left(Y_d Y_d^\dagger\right) - 4m_{H_d}^2 Y_d^\dagger Y_d \text{Tr}\left(Y_e Y_e^\dagger\right) \\ & - 2T_d^\dagger T_d \text{Tr}\left(Y_e Y_e^\dagger\right) - m_q^2 Y_d^\dagger Y_d \text{Tr}\left(Y_e Y_e^\dagger\right) - 2Y_d^\dagger m_d^2 Y_d \text{Tr}\left(Y_e Y_e^\dagger\right) \\ & - Y_d^\dagger Y_d m_q^2 \text{Tr}\left(Y_e Y_e^\dagger\right) - 12m_{H_u}^2 Y_u^\dagger Y_u \text{Tr}\left(Y_u Y_u^\dagger\right) - 6T_u^\dagger T_u \text{Tr}\left(Y_u Y_u^\dagger\right) \\ & - 3m_q^2 Y_u^\dagger Y_u \text{Tr}\left(Y_u Y_u^\dagger\right) - 6Y_u^\dagger m_u^2 Y_u \text{Tr}\left(Y_u Y_u^\dagger\right) - 3Y_u^\dagger Y_u m_q^2 \text{Tr}\left(Y_u Y_u^\dagger\right) \end{aligned}$$

$$\begin{aligned}
& -4m_{H_u}^2 Y_u^\dagger Y_u \text{Tr}(Y_\nu Y_\nu^\dagger) - 2T_u^\dagger T_u \text{Tr}(Y_\nu Y_\nu^\dagger) - m_q^2 Y_u^\dagger Y_u \text{Tr}(Y_\nu Y_\nu^\dagger) \\
& -2Y_u^\dagger m_u^2 Y_u \text{Tr}(Y_\nu Y_\nu^\dagger) - Y_u^\dagger Y_u m_q^2 \text{Tr}(Y_\nu Y_\nu^\dagger) - 6T_d^\dagger Y_d \text{Tr}(Y_d^\dagger T_d) \\
& -2T_d^\dagger Y_d \text{Tr}(Y_e^\dagger T_e) - 6T_u^\dagger Y_u \text{Tr}(Y_u^\dagger T_u) - 2T_u^\dagger Y_u \text{Tr}(Y_\nu^\dagger T_\nu) \\
& -6Y_d^\dagger T_d \text{Tr}(T_d^* Y_d^T) - 6Y_d^\dagger Y_d \text{Tr}(T_d^* T_d^T) - 2Y_d^\dagger T_d \text{Tr}(T_e^* Y_e^T) \\
& -2Y_d^\dagger Y_d \text{Tr}(T_e^* T_e^T) - 6Y_u^\dagger T_u \text{Tr}(T_u^* Y_u^T) - 6Y_u^\dagger Y_u \text{Tr}(T_u^* T_u^T) \\
& -2Y_u^\dagger T_u \text{Tr}(T_\nu^* Y_\nu^T) - 2Y_u^\dagger Y_u \text{Tr}(T_\nu^* T_\nu^T) - 6Y_d^\dagger Y_d \text{Tr}(m_d^2 Y_d Y_d^\dagger) \\
& -2Y_d^\dagger Y_d \text{Tr}(m_e^2 Y_e Y_e^\dagger) - 2Y_d^\dagger Y_d \text{Tr}(m_l^2 Y_e^\dagger Y_e) - 2Y_u^\dagger Y_u \text{Tr}(m_l^2 Y_\nu^\dagger Y_\nu) \\
& -6Y_d^\dagger Y_d \text{Tr}(m_q^2 Y_d^\dagger Y_d) - 6Y_u^\dagger Y_u \text{Tr}(m_q^2 Y_u^\dagger Y_u) - 6Y_u^\dagger Y_u \text{Tr}(m_u^2 Y_u Y_u^\dagger) \\
& -2Y_u^\dagger Y_u \text{Tr}(m_\nu^2 Y_\nu Y_\nu^\dagger)
\end{aligned} \tag{69}$$

$$\begin{aligned}
\beta_{m_l^2}^{(1)} &= -\frac{6}{5} g_1^2 \mathbf{1} |M_1|^2 - 6g_2^2 \mathbf{1} |M_2|^2 + 2m_{H_d}^2 Y_e^\dagger Y_e + 2m_{H_u}^2 Y_\nu^\dagger Y_\nu + 2T_e^\dagger T_e + 2T_\nu^\dagger T_\nu \\
&+ m_l^2 Y_e^\dagger Y_e + m_l^2 Y_\nu^\dagger Y_\nu + 2Y_e^\dagger m_e^2 Y_e + Y_e^\dagger Y_e m_l^2 + 2Y_\nu^\dagger m_\nu^2 Y_\nu + Y_\nu^\dagger Y_\nu m_l^2 \\
&- \sqrt{\frac{3}{5}} g_1 \mathbf{1} \sigma_{1,1}
\end{aligned} \tag{70}$$

$$\begin{aligned}
\beta_{m_l^2}^{(2)} &= +\frac{3}{5} g_2^2 \left(3g_1^2 (2M_2 + M_1) + 55g_2^2 M_2 \right) \mathbf{1} M_2^* + \frac{12}{5} g_1^2 m_{H_d}^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) - \frac{12}{5} g_1^2 M_1 T_e^\dagger Y_e \\
&+ \frac{12}{5} g_1^2 T_e^\dagger T_e + \frac{6}{5} g_1^2 m_l^2 Y_e^\dagger Y_e + \frac{12}{5} g_1^2 Y_e^\dagger m_e^2 Y_e + \frac{6}{5} g_1^2 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 - 8m_{H_u}^2 Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu \\
&- 4Y_\nu^\dagger Y_\nu T_\nu^\dagger T_\nu - 4Y_\nu^\dagger T_\nu T_\nu^\dagger Y_\nu - 4T_e^\dagger Y_e Y_e^\dagger T_e - 4T_e^\dagger T_e Y_e^\dagger Y_e \\
&- 4T_\nu^\dagger Y_\nu Y_\nu^\dagger T_\nu - 4T_\nu^\dagger T_\nu Y_\nu^\dagger Y_\nu - 2m_l^2 Y_e^\dagger Y_e Y_e^\dagger Y_e - 2m_l^2 Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu \\
&- 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 \\
&- 4Y_\nu^\dagger m_\nu^2 Y_\nu Y_\nu^\dagger Y_\nu - 4Y_\nu^\dagger Y_\nu m_l^2 Y_\nu^\dagger Y_\nu - 4Y_\nu^\dagger Y_\nu Y_\nu^\dagger m_\nu^2 Y_\nu - 2Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu m_l^2 + 6g_2^4 \mathbf{1} \sigma_{2,2} \\
&+ \frac{6}{5} g_1^2 \mathbf{1} \sigma_{2,11} - 4\sqrt{\frac{3}{5}} g_1 \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) - 12m_{H_u}^2 Y_\nu^\dagger Y_\nu \text{Tr}(Y_u Y_u^\dagger) \\
&- 6T_\nu^\dagger T_\nu \text{Tr}(Y_u Y_u^\dagger) - 3m_l^2 Y_\nu^\dagger Y_\nu \text{Tr}(Y_u Y_u^\dagger) - 6Y_\nu^\dagger m_\nu^2 Y_\nu \text{Tr}(Y_u Y_u^\dagger)
\end{aligned}$$

$$\begin{aligned}
& -3Y_\nu^\dagger Y_\nu m_l^2 \text{Tr}(Y_u Y_u^\dagger) - 4m_{H_u}^2 Y_\nu^\dagger Y_\nu \text{Tr}(Y_\nu Y_\nu^\dagger) - 2T_\nu^\dagger T_\nu \text{Tr}(Y_\nu Y_\nu^\dagger) \\
& - m_l^2 Y_\nu^\dagger Y_\nu \text{Tr}(Y_\nu Y_\nu^\dagger) - 2Y_\nu^\dagger m_\nu^2 Y_\nu \text{Tr}(Y_\nu Y_\nu^\dagger) - Y_\nu^\dagger Y_\nu m_l^2 \text{Tr}(Y_\nu Y_\nu^\dagger) \\
& - 6T_e^\dagger Y_e \text{Tr}(Y_d^\dagger T_d) - 2T_e^\dagger Y_e \text{Tr}(Y_e^\dagger T_e) - 6T_\nu^\dagger Y_\nu \text{Tr}(Y_u^\dagger T_u) \\
& - 2T_\nu^\dagger Y_\nu \text{Tr}(Y_\nu^\dagger T_\nu) - 6Y_e^\dagger T_e \text{Tr}(T_d^* Y_d^T) - 6Y_e^\dagger Y_e \text{Tr}(T_d^* T_d^T) \\
& - 2Y_e^\dagger T_e \text{Tr}(T_e^* Y_e^T) - 2Y_e^\dagger Y_e \text{Tr}(T_e^* T_e^T) - 6Y_\nu^\dagger T_\nu \text{Tr}(T_u^* Y_u^T) \\
& - 6Y_\nu^\dagger Y_\nu \text{Tr}(T_u^* T_u^T) - 2Y_\nu^\dagger T_\nu \text{Tr}(T_\nu^* Y_\nu^T) - 2Y_\nu^\dagger Y_\nu \text{Tr}(T_\nu^* T_\nu^T) \\
& - 6Y_e^\dagger Y_e \text{Tr}(m_d^2 Y_d Y_d^\dagger) - 2Y_e^\dagger Y_e \text{Tr}(m_e^2 Y_e Y_e^\dagger) - 2Y_e^\dagger Y_e \text{Tr}(m_l^2 Y_e^\dagger Y_e) \\
& - 2Y_\nu^\dagger Y_\nu \text{Tr}(m_l^2 Y_\nu^\dagger Y_\nu) - 6Y_e^\dagger Y_e \text{Tr}(m_q^2 Y_d^\dagger Y_d) - 6Y_\nu^\dagger Y_\nu \text{Tr}(m_q^2 Y_u^\dagger Y_u) \\
& - 6Y_\nu^\dagger Y_\nu \text{Tr}(m_u^2 Y_u Y_u^\dagger) - 2Y_\nu^\dagger Y_\nu \text{Tr}(m_\nu^2 Y_\nu Y_\nu^\dagger)
\end{aligned} \tag{71}$$

$$\begin{aligned}
\beta_{m_{H_d}^2}^{(1)} &= -\frac{6}{5}g_1^2|M_1|^2 - 6g_2^2|M_2|^2 - \sqrt{\frac{3}{5}}g_1\sigma_{1,1} + 6m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger) + 2m_{H_d}^2 \text{Tr}(Y_e Y_e^\dagger) + 6\text{Tr}(T_d^* T_d^T) \\
&+ 2\text{Tr}(T_e^* T_e^T) + 6\text{Tr}(m_d^2 Y_d Y_d^\dagger) + 2\text{Tr}(m_e^2 Y_e Y_e^\dagger) + 2\text{Tr}(m_l^2 Y_e^\dagger Y_e) + 6\text{Tr}(m_q^2 Y_d^\dagger Y_d)
\end{aligned} \tag{72}$$

$$\begin{aligned}
\beta_{m_{H_d}^2}^{(2)} &= \frac{1}{25} \left(15g_2^2 \left(3g_1^2 (2M_2 + M_1) + 55g_2^2 M_2 \right) M_2^* \right. \\
&+ g_1^2 M_1^* \left(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) \right. \\
&- \left. 60\text{Tr}(Y_e^\dagger T_e) \right) \\
&+ 10 \left(15g_2^4 \sigma_{2,2} + 3g_2^2 \sigma_{2,11} - 2\sqrt{15}g_1 \sigma_{3,1} + \left(160g_3^2 |M_3|^2 - 2g_1^2 m_{H_d}^2 + 80g_3^2 m_{H_d}^2 \right) \text{Tr}(Y_d Y_d^\dagger) \right. \\
&+ 6g_1^2 m_{H_d}^2 \text{Tr}(Y_e Y_e^\dagger) - 80g_3^2 M_3^* \text{Tr}(Y_d^\dagger T_d) + 2g_1^2 M_1 \text{Tr}(T_d^* Y_d^T) - 80g_3^2 M_3 \text{Tr}(T_d^* Y_d^T) \\
&- 2g_1^2 \text{Tr}(T_d^* T_d^T) + 80g_3^2 \text{Tr}(T_d^* T_d^T) - 6g_1^2 M_1 \text{Tr}(T_e^* Y_e^T) + 6g_1^2 \text{Tr}(T_e^* T_e^T) \\
&- 2g_1^2 \text{Tr}(m_d^2 Y_d Y_d^\dagger) + 80g_3^2 \text{Tr}(m_d^2 Y_d Y_d^\dagger) + 6g_1^2 \text{Tr}(m_e^2 Y_e Y_e^\dagger) + 6g_1^2 \text{Tr}(m_l^2 Y_e^\dagger Y_e) \\
&- 2g_1^2 \text{Tr}(m_q^2 Y_d^\dagger Y_d) + 80g_3^2 \text{Tr}(m_q^2 Y_d^\dagger Y_d) - 90m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) - 90\text{Tr}(Y_d Y_d^\dagger T_d T_d^\dagger) \\
&- 15m_{H_d}^2 \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 15m_{H_u}^2 \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 15\text{Tr}(Y_d Y_u^\dagger T_u T_d^\dagger) \\
&- 90\text{Tr}(Y_d T_d^\dagger T_d Y_d^\dagger) - 15\text{Tr}(Y_d T_u^\dagger T_u Y_d^\dagger) - 30m_{H_d}^2 \text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) - 30\text{Tr}(Y_e Y_e^\dagger T_e T_e^\dagger) \\
&- 5m_{H_d}^2 \text{Tr}(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger) - 5m_{H_u}^2 \text{Tr}(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger) - 5\text{Tr}(Y_e Y_\nu^\dagger T_\nu T_e^\dagger) \\
&- 30\text{Tr}(Y_e T_e^\dagger T_e Y_e^\dagger) - 5\text{Tr}(Y_e T_\nu^\dagger T_\nu Y_e^\dagger) - 15\text{Tr}(Y_u Y_d^\dagger T_d T_u^\dagger) - 15\text{Tr}(Y_u T_d^\dagger T_d Y_u^\dagger) \\
&- 5\text{Tr}(Y_\nu Y_e^\dagger T_e T_\nu^\dagger) - 5\text{Tr}(Y_\nu T_e^\dagger T_e Y_\nu^\dagger) - 90\text{Tr}(m_d^2 Y_d Y_d^\dagger Y_d Y_d^\dagger)
\end{aligned}$$

$$\begin{aligned}
& -15\text{Tr}\left(m_d^2 Y_d Y_u^\dagger Y_u Y_d^\dagger\right) - 30\text{Tr}\left(m_e^2 Y_e Y_e^\dagger Y_e Y_e^\dagger\right) - 5\text{Tr}\left(m_e^2 Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger\right) \\
& - 30\text{Tr}\left(m_l^2 Y_e^\dagger Y_e Y_e^\dagger Y_e\right) - 5\text{Tr}\left(m_l^2 Y_e^\dagger Y_e Y_\nu^\dagger Y_\nu\right) - 5\text{Tr}\left(m_l^2 Y_\nu^\dagger Y_\nu Y_e^\dagger Y_e\right) \\
& - 90\text{Tr}\left(m_q^2 Y_d^\dagger Y_d Y_d^\dagger Y_d\right) - 15\text{Tr}\left(m_q^2 Y_d^\dagger Y_d Y_u^\dagger Y_u\right) - 15\text{Tr}\left(m_q^2 Y_u^\dagger Y_u Y_d^\dagger Y_d\right) \\
& - 15\text{Tr}\left(m_u^2 Y_u Y_d^\dagger Y_d Y_u^\dagger\right) - 5\text{Tr}\left(m_\nu^2 Y_\nu Y_e^\dagger Y_e Y_\nu^\dagger\right)
\end{aligned} \tag{73}$$

$$\begin{aligned}
\beta_{m_{H_u}^2}^{(1)} &= -\frac{6}{5}g_1^2|M_1|^2 - 6g_2^2|M_2|^2 + \sqrt{\frac{3}{5}}g_1\sigma_{1,1} + 6m_{H_u}^2\text{Tr}\left(Y_u Y_u^\dagger\right) + 2m_{H_u}^2\text{Tr}\left(Y_\nu Y_\nu^\dagger\right) + 6\text{Tr}\left(T_u^* T_u^T\right) \\
& + 2\text{Tr}\left(T_\nu^* T_\nu^T\right) + 2\text{Tr}\left(m_l^2 Y_\nu^\dagger Y_\nu\right) + 6\text{Tr}\left(m_q^2 Y_u^\dagger Y_u\right) + 6\text{Tr}\left(m_u^2 Y_u Y_u^\dagger\right) + 2\text{Tr}\left(m_\nu^2 Y_\nu Y_\nu^\dagger\right)
\end{aligned} \tag{74}$$

$$\begin{aligned}
\beta_{m_{H_u}^2}^{(2)} &= +\frac{3}{5}g_2^2\left(3g_1^2\left(2M_2 + M_1\right) + 55g_2^2M_2\right)M_2^* + 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{8}{5}g_1^2m_{H_u}^2\text{Tr}\left(Y_u Y_u^\dagger\right) \\
& + 32g_3^2m_{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) \\
& + \frac{1}{25}g_1^2M_1^*\left(-40\text{Tr}\left(Y_u^\dagger T_u\right) + 45g_2^2M_2 + 621g_1^2M_1 + 80M_1\text{Tr}\left(Y_u Y_u^\dagger\right) + 90g_2^2M_1\right) \\
& - 32g_3^2M_3^*\text{Tr}\left(Y_u^\dagger T_u\right) - \frac{8}{5}g_1^2M_1\text{Tr}\left(T_u^* Y_u^T\right) - 32g_3^2M_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) + \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) - 2m_{H_d}^2\text{Tr}\left(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger\right) \\
& - 2m_{H_u}^2\text{Tr}\left(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger\right) - 2\text{Tr}\left(Y_e Y_\nu^\dagger T_\nu T_e^\dagger\right) - 2\text{Tr}\left(Y_e T_\nu^\dagger T_\nu Y_e^\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) - 2\text{Tr}\left(Y_\nu Y_e^\dagger T_e T_\nu^\dagger\right) - 12m_{H_u}^2\text{Tr}\left(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\right) - 12\text{Tr}\left(Y_\nu Y_\nu^\dagger T_\nu T_\nu^\dagger\right) \\
& - 2\text{Tr}\left(Y_\nu T_e^\dagger T_e Y_\nu^\dagger\right) - 12\text{Tr}\left(Y_\nu T_\nu^\dagger T_\nu Y_\nu^\dagger\right) - 6\text{Tr}\left(m_d^2 Y_d Y_u^\dagger Y_u Y_d^\dagger\right) \\
& - 2\text{Tr}\left(m_e^2 Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger\right) - 2\text{Tr}\left(m_l^2 Y_e^\dagger Y_e Y_\nu^\dagger Y_\nu\right) - 2\text{Tr}\left(m_l^2 Y_\nu^\dagger Y_\nu Y_e^\dagger Y_e\right) \\
& - 12\text{Tr}\left(m_l^2 Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu\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) \\
& - 2\text{Tr}\left(m_\nu^2 Y_\nu Y_e^\dagger Y_e Y_\nu^\dagger\right) - 12\text{Tr}\left(m_\nu^2 Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\right)
\end{aligned} \tag{75}$$

$$\begin{aligned}
\beta_{m_d^2}^{(1)} &= -\frac{8}{15}g_1^2\mathbf{1}|M_1|^2 - \frac{32}{3}g_3^2\mathbf{1}|M_3|^2 + 4m_{H_d}^2 Y_d Y_d^\dagger + 4T_d T_d^\dagger + 2m_d^2 Y_d Y_d^\dagger + 4Y_d m_q^2 Y_d^\dagger \\
& + 2Y_d Y_d^\dagger m_d^2 + 2\frac{1}{\sqrt{15}}g_1\mathbf{1}\sigma_{1,1}
\end{aligned} \tag{76}$$

$$\beta_{m_d^2}^{(2)} = +\frac{64}{45}g_3^2\left(-30g_3^2M_3 + g_1^2\left(2M_3 + M_1\right)\right)\mathbf{1}M_3^* + \frac{4}{5}g_1^2m_{H_d}^2 Y_d Y_d^\dagger + 12g_2^2m_{H_d}^2 Y_d Y_d^\dagger$$

$$\begin{aligned}
& + 24g_2^2|M_2|^2Y_dY_d^\dagger - \frac{4}{5}g_1^2M_1Y_dT_d^\dagger - 12g_2^2M_2Y_dT_d^\dagger \\
& + \frac{4}{225}g_1^2M_1^*\left(2\left(303g_1^2M_1 + 40g_3^2\left(2M_1 + M_3\right)\right)\mathbf{1} - 45T_dY_d^\dagger + 90M_1Y_dY_d^\dagger\right) - 12g_2^2M_2^*T_dY_d^\dagger \\
& + \frac{4}{5}g_1^2T_dT_d^\dagger + 12g_2^2T_dT_d^\dagger + \frac{2}{5}g_1^2m_d^2Y_dY_d^\dagger + 6g_2^2m_d^2Y_dY_d^\dagger \\
& + \frac{4}{5}g_1^2Y_dm_q^2Y_d^\dagger + 12g_2^2Y_dm_q^2Y_d^\dagger + \frac{2}{5}g_1^2Y_dY_d^\dagger m_d^2 + 6g_2^2Y_dY_d^\dagger m_d^2 \\
& - 8m_{H_d}^2Y_dY_d^\dagger Y_dY_d^\dagger - 4Y_dY_d^\dagger T_dT_d^\dagger - 4m_{H_d}^2Y_dY_u^\dagger Y_uY_d^\dagger \\
& - 4m_{H_u}^2Y_dY_u^\dagger Y_uY_d^\dagger - 4Y_dY_u^\dagger T_uT_d^\dagger - 4Y_dT_d^\dagger T_dY_d^\dagger - 4Y_dT_u^\dagger T_uY_d^\dagger \\
& - 4T_dY_d^\dagger Y_dT_d^\dagger - 4T_dY_u^\dagger Y_uT_d^\dagger - 4T_dT_d^\dagger Y_dY_d^\dagger - 4T_dT_u^\dagger Y_uY_d^\dagger \\
& - 2m_d^2Y_dY_d^\dagger Y_dY_d^\dagger - 2m_d^2Y_dY_u^\dagger Y_uY_d^\dagger - 4Y_dm_q^2Y_d^\dagger Y_dY_d^\dagger - 4Y_dm_q^2Y_u^\dagger Y_uY_d^\dagger \\
& - 4Y_dY_d^\dagger m_d^2Y_dY_d^\dagger - 4Y_dY_d^\dagger Y_dm_q^2Y_d^\dagger - 2Y_dY_d^\dagger Y_dY_d^\dagger m_d^2 - 4Y_dY_u^\dagger m_u^2Y_uY_d^\dagger \\
& - 4Y_dY_u^\dagger Y_u m_q^2Y_d^\dagger - 2Y_dY_u^\dagger Y_uY_d^\dagger m_d^2 + \frac{32}{3}g_3^4\mathbf{1}\sigma_{2,3} + \frac{8}{15}g_1^2\mathbf{1}\sigma_{2,11} + 8\frac{1}{\sqrt{15}}g_1\mathbf{1}\sigma_{3,1} \\
& - 24m_{H_d}^2Y_dY_d^\dagger \text{Tr}\left(Y_dY_d^\dagger\right) - 12T_dT_d^\dagger \text{Tr}\left(Y_dY_d^\dagger\right) - 6m_d^2Y_dY_d^\dagger \text{Tr}\left(Y_dY_d^\dagger\right) \\
& - 12Y_dm_q^2Y_d^\dagger \text{Tr}\left(Y_dY_d^\dagger\right) - 6Y_dY_d^\dagger m_d^2 \text{Tr}\left(Y_dY_d^\dagger\right) - 8m_{H_d}^2Y_dY_d^\dagger \text{Tr}\left(Y_eY_e^\dagger\right) \\
& - 4T_dT_d^\dagger \text{Tr}\left(Y_eY_e^\dagger\right) - 2m_d^2Y_dY_d^\dagger \text{Tr}\left(Y_eY_e^\dagger\right) - 4Y_dm_q^2Y_d^\dagger \text{Tr}\left(Y_eY_e^\dagger\right) \\
& - 2Y_dY_d^\dagger m_d^2 \text{Tr}\left(Y_eY_e^\dagger\right) - 12Y_dT_d^\dagger \text{Tr}\left(Y_d^\dagger T_d\right) - 4Y_dT_d^\dagger \text{Tr}\left(Y_e^\dagger T_e\right) \\
& - 12T_dY_d^\dagger \text{Tr}\left(T_d^*Y_d^T\right) - 12Y_dY_d^\dagger \text{Tr}\left(T_d^*T_d^T\right) - 4T_dY_d^\dagger \text{Tr}\left(T_e^*Y_e^T\right) \\
& - 4Y_dY_d^\dagger \text{Tr}\left(T_e^*T_e^T\right) - 12Y_dY_d^\dagger \text{Tr}\left(m_d^2Y_dY_d^\dagger\right) - 4Y_dY_d^\dagger \text{Tr}\left(m_e^2Y_eY_e^\dagger\right) \\
& - 4Y_dY_d^\dagger \text{Tr}\left(m_l^2Y_e^\dagger Y_e\right) - 12Y_dY_d^\dagger \text{Tr}\left(m_q^2Y_d^\dagger Y_d\right)
\end{aligned} \tag{77}$$

$$\begin{aligned}
\beta_{m_2^2}^{(1)} &= -\frac{32}{15}g_1^2\mathbf{1}|M_1|^2 - \frac{32}{3}g_3^2\mathbf{1}|M_3|^2 + 4m_{H_u}^2Y_uY_u^\dagger + 4T_uT_u^\dagger + 2m_u^2Y_uY_u^\dagger + 4Y_um_q^2Y_u^\dagger \\
& + 2Y_uY_u^\dagger m_u^2 - 4\frac{1}{\sqrt{15}}g_1\mathbf{1}\sigma_{1,1}
\end{aligned} \tag{78}$$

$$\begin{aligned}
\beta_{m_2^2}^{(2)} &= -\frac{128}{45}g_3^2\left(15g_3^2M_3 - 2g_1^2\left(2M_3 + M_1\right)\right)\mathbf{1}M_3^* - \frac{4}{5}g_1^2m_{H_u}^2Y_uY_u^\dagger + 12g_2^2m_{H_u}^2Y_uY_u^\dagger \\
& + 24g_2^2|M_2|^2Y_uY_u^\dagger + \frac{4}{5}g_1^2M_1Y_uT_u^\dagger - 12g_2^2M_2Y_uT_u^\dagger - 12g_2^2M_2^*T_uY_u^\dagger \\
& + \frac{4}{225}g_1^2M_1^*\left(45\left(-2M_1Y_uY_u^\dagger + T_uY_u^\dagger\right) + 8\left(321g_1^2M_1 + 40g_3^2\left(2M_1 + M_3\right)\right)\mathbf{1}\right) - \frac{4}{5}g_1^2T_uT_u^\dagger \\
& + 12g_2^2T_uT_u^\dagger - \frac{2}{5}g_1^2m_u^2Y_uY_u^\dagger + 6g_2^2m_u^2Y_uY_u^\dagger - \frac{4}{5}g_1^2Y_um_q^2Y_u^\dagger \\
& + 12g_2^2Y_um_q^2Y_u^\dagger - \frac{2}{5}g_1^2Y_uY_u^\dagger m_u^2 + 6g_2^2Y_uY_u^\dagger m_u^2 - 4m_{H_d}^2Y_uY_d^\dagger Y_dY_u^\dagger
\end{aligned}$$

$$\begin{aligned}
& -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 \\
& -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 + \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) - 8m_{H_u}^2 Y_u Y_u^\dagger \text{Tr}(Y_\nu Y_\nu^\dagger) - 4T_u T_u^\dagger \text{Tr}(Y_\nu Y_\nu^\dagger) \\
& -2m_u^2 Y_u Y_u^\dagger \text{Tr}(Y_\nu Y_\nu^\dagger) - 4Y_u m_q^2 Y_u^\dagger \text{Tr}(Y_\nu Y_\nu^\dagger) - 2Y_u Y_u^\dagger m_u^2 \text{Tr}(Y_\nu Y_\nu^\dagger) \\
& -12Y_u T_u^\dagger \text{Tr}(Y_u^\dagger T_u) - 4Y_u T_u^\dagger \text{Tr}(Y_\nu^\dagger T_\nu) - 12T_u Y_u^\dagger \text{Tr}(T_u^* Y_u^T) \\
& -12Y_u Y_u^\dagger \text{Tr}(T_u^* T_u^T) - 4T_u Y_u^\dagger \text{Tr}(T_\nu^* Y_\nu^T) - 4Y_u Y_u^\dagger \text{Tr}(T_\nu^* T_\nu^T) \\
& -4Y_u Y_u^\dagger \text{Tr}(m_l^2 Y_\nu^\dagger Y_\nu) - 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) \\
& -4Y_u Y_u^\dagger \text{Tr}(m_\nu^2 Y_\nu Y_\nu^\dagger)
\end{aligned} \tag{79}$$

$$\begin{aligned}
\beta_{m_e^2}^{(1)} &= -\frac{24}{5} g_1^2 \mathbf{1} |M_1|^2 + 2 \left(2m_{H_d}^2 Y_e Y_e^\dagger + 2T_e T_e^\dagger + 2Y_e m_l^2 Y_e^\dagger + m_e^2 Y_e Y_e^\dagger + Y_e Y_e^\dagger m_e^2 \right) \\
&+ 2\sqrt{\frac{3}{5}} g_1 \mathbf{1}_{\sigma_{1,1}}
\end{aligned} \tag{80}$$

$$\begin{aligned}
\beta_{m_e^2}^{(2)} &= \frac{2}{25} \left(6g_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) + 20g_1 \mathbf{1} \left(3g_1 \sigma_{2,11} + \sqrt{15} \sigma_{3,1} \right) \right. \\
&- 5 \left(30g_2^2 M_2^* T_e Y_e^\dagger + 6g_1^2 T_e T_e^\dagger - 30g_2^2 T_e T_e^\dagger + 3g_1^2 m_e^2 Y_e Y_e^\dagger \right. \\
&- 15g_2^2 m_e^2 Y_e Y_e^\dagger + 6g_1^2 Y_e m_l^2 Y_e^\dagger - 30g_2^2 Y_e m_l^2 Y_e^\dagger + 3g_1^2 Y_e Y_e^\dagger m_e^2 \\
&- 15g_2^2 Y_e Y_e^\dagger m_e^2 + 20m_{H_d}^2 Y_e Y_e^\dagger Y_e Y_e^\dagger + 10Y_e Y_e^\dagger T_e T_e^\dagger + 10m_{H_d}^2 Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger \\
&+ 10m_{H_u}^2 Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger + 10Y_e Y_\nu^\dagger T_\nu T_e^\dagger + 10Y_e T_e^\dagger T_e Y_e^\dagger + 10Y_e T_\nu^\dagger T_\nu Y_e^\dagger \\
&+ 10T_e Y_e^\dagger Y_e T_e^\dagger + 10T_e Y_\nu^\dagger Y_\nu T_e^\dagger + 10T_e T_e^\dagger Y_e Y_e^\dagger + 10T_e T_\nu^\dagger Y_\nu Y_e^\dagger \\
&+ 5m_e^2 Y_e Y_e^\dagger Y_e Y_e^\dagger + 5m_e^2 Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger + 10Y_e m_l^2 Y_e^\dagger Y_e Y_e^\dagger + 10Y_e m_l^2 Y_\nu^\dagger Y_\nu Y_e^\dagger \\
&+ 10Y_e Y_e^\dagger m_e^2 Y_e Y_e^\dagger + 10Y_e Y_e^\dagger Y_e m_l^2 Y_e^\dagger + 5Y_e Y_e^\dagger Y_e Y_e^\dagger m_e^2 + 10Y_e Y_\nu^\dagger m_\nu^2 Y_\nu Y_e^\dagger \\
&+ 10Y_e Y_\nu^\dagger Y_\nu m_l^2 Y_e^\dagger + 5Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger m_e^2 + 30T_e T_e^\dagger \text{Tr}(Y_d Y_d^\dagger) \\
&+ 15m_e^2 Y_e Y_e^\dagger \text{Tr}(Y_d Y_d^\dagger) + 30Y_e m_l^2 Y_e^\dagger \text{Tr}(Y_d Y_d^\dagger) + 15Y_e Y_e^\dagger m_e^2 \text{Tr}(Y_d Y_d^\dagger) \\
&+ 10T_e T_e^\dagger \text{Tr}(Y_e Y_e^\dagger) + 5m_e^2 Y_e Y_e^\dagger \text{Tr}(Y_e Y_e^\dagger) + 10Y_e m_l^2 Y_e^\dagger \text{Tr}(Y_e Y_e^\dagger) \\
&+ 5Y_e Y_e^\dagger m_e^2 \text{Tr}(Y_e Y_e^\dagger) + Y_e T_e^\dagger \left(10\text{Tr}(Y_e^\dagger T_e) + 30g_2^2 M_2 + 30\text{Tr}(Y_d^\dagger T_d) - 6g_1^2 M_1 \right)
\end{aligned}$$

$$\begin{aligned}
& + 30T_e Y_e^\dagger \text{Tr}(T_d^* Y_d^T) + 10T_e Y_e^\dagger \text{Tr}(T_e^* Y_e^T) \\
& + 2Y_e Y_e^\dagger \left(3g_1^2 m_{H_d}^2 - 15g_2^2 m_{H_d}^2 - 30g_2^2 |M_2|^2 + 30m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger) + 10m_{H_d}^2 \text{Tr}(Y_e Y_e^\dagger) + 15\text{Tr}(T_d^* T_d^T) \right. \\
& \left. + 5\text{Tr}(T_e^* T_e^T) + 15\text{Tr}(m_d^2 Y_d Y_d^\dagger) + 5\text{Tr}(m_e^2 Y_e Y_e^\dagger) + 5\text{Tr}(m_l^2 Y_l Y_l^\dagger) + 15\text{Tr}(m_q^2 Y_d^\dagger Y_d) \right) \quad (81)
\end{aligned}$$

$$\beta_{m_z^2}^{(1)} = 2 \left(2m_{H_u}^2 Y_\nu Y_\nu^\dagger + 2T_\nu T_\nu^\dagger + 2Y_\nu m_l^2 Y_\nu^\dagger + m_\nu^2 Y_\nu Y_\nu^\dagger + Y_\nu Y_\nu^\dagger m_\nu^2 \right) \quad (82)$$

$$\begin{aligned}
\beta_{m_z^2}^{(2)} = & -\frac{2}{5} \left(6g_1^2 M_1^* T_\nu Y_\nu^\dagger + 30g_2^2 M_2^* T_\nu Y_\nu^\dagger - 6g_1^2 T_\nu T_\nu^\dagger - 30g_2^2 T_\nu T_\nu^\dagger \right. \\
& - 3g_1^2 m_\nu^2 Y_\nu Y_\nu^\dagger - 15g_2^2 m_\nu^2 Y_\nu Y_\nu^\dagger - 6g_1^2 Y_\nu m_l^2 Y_\nu^\dagger - 30g_2^2 Y_\nu m_l^2 Y_\nu^\dagger \\
& - 3g_1^2 Y_\nu Y_\nu^\dagger m_\nu^2 - 15g_2^2 Y_\nu Y_\nu^\dagger m_\nu^2 + 10m_{H_d}^2 Y_\nu Y_e^\dagger Y_e Y_\nu^\dagger \\
& + 10m_{H_u}^2 Y_\nu Y_e^\dagger Y_e Y_\nu^\dagger + 10Y_\nu Y_e^\dagger T_e T_\nu^\dagger + 20m_{H_u}^2 Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger + 10Y_\nu Y_\nu^\dagger T_\nu T_\nu^\dagger \\
& + 10Y_\nu T_e^\dagger T_e Y_\nu^\dagger + 10Y_\nu T_\nu^\dagger T_\nu Y_\nu^\dagger + 10T_\nu Y_e^\dagger Y_e T_\nu^\dagger + 10T_\nu Y_\nu^\dagger Y_\nu T_\nu^\dagger \\
& + 10T_\nu T_e^\dagger Y_e Y_\nu^\dagger + 10T_\nu T_\nu^\dagger Y_\nu Y_\nu^\dagger + 5m_\nu^2 Y_\nu Y_e^\dagger Y_e Y_\nu^\dagger + 5m_\nu^2 Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger \\
& + 10Y_\nu m_l^2 Y_e^\dagger Y_e Y_\nu^\dagger + 10Y_\nu m_l^2 Y_\nu^\dagger Y_\nu Y_\nu^\dagger + 10Y_\nu Y_e^\dagger m_e^2 Y_e Y_\nu^\dagger \\
& + 10Y_\nu Y_e^\dagger Y_e m_l^2 Y_\nu^\dagger + 5Y_\nu Y_e^\dagger Y_e Y_\nu^\dagger m_\nu^2 + 10Y_\nu Y_\nu^\dagger m_\nu^2 Y_\nu Y_\nu^\dagger + 10Y_\nu Y_\nu^\dagger Y_\nu m_l^2 Y_\nu^\dagger \\
& + 5Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger m_\nu^2 + 30T_\nu T_\nu^\dagger \text{Tr}(Y_u Y_u^\dagger) + 15m_\nu^2 Y_\nu Y_\nu^\dagger \text{Tr}(Y_u Y_u^\dagger) \\
& + 30Y_\nu m_l^2 Y_\nu^\dagger \text{Tr}(Y_u Y_u^\dagger) + 15Y_\nu Y_\nu^\dagger m_\nu^2 \text{Tr}(Y_u Y_u^\dagger) + 10T_\nu T_\nu^\dagger \text{Tr}(Y_\nu Y_\nu^\dagger) \\
& + 5m_\nu^2 Y_\nu Y_\nu^\dagger \text{Tr}(Y_\nu Y_\nu^\dagger) + 10Y_\nu m_l^2 Y_\nu^\dagger \text{Tr}(Y_\nu Y_\nu^\dagger) + 5Y_\nu Y_\nu^\dagger m_\nu^2 \text{Tr}(Y_\nu Y_\nu^\dagger) \\
& + 2Y_\nu T_\nu^\dagger \left(15g_2^2 M_2 + 15\text{Tr}(Y_u^\dagger T_u) + 3g_1^2 M_1 + 5\text{Tr}(Y_\nu^\dagger T_\nu) \right) + 30T_\nu Y_\nu^\dagger \text{Tr}(T_u^* Y_u^T) \\
& + 10T_\nu Y_\nu^\dagger \text{Tr}(T_\nu^* Y_\nu^T) \\
& + \frac{4}{5} Y_\nu Y_\nu^\dagger \left(3g_1^2 m_{H_u}^2 + 15g_2^2 m_{H_u}^2 + 6g_1^2 |M_1|^2 + 30g_2^2 |M_2|^2 - 30m_{H_u}^2 \text{Tr}(Y_u Y_u^\dagger) - 10m_{H_u}^2 \text{Tr}(Y_\nu Y_\nu^\dagger) \right. \\
& - 15\text{Tr}(T_u^* T_u^T) - 5\text{Tr}(T_\nu^* T_\nu^T) - 5\text{Tr}(m_l^2 Y_\nu^\dagger Y_\nu) - 15\text{Tr}(m_q^2 Y_u^\dagger Y_u) - 15\text{Tr}(m_u^2 Y_u Y_u^\dagger) \\
& \left. - 5\text{Tr}(m_\nu^2 Y_\nu Y_\nu^\dagger) \right) \quad (83)
\end{aligned}$$

$$\beta_{m_z^2}^{(1)} = 0 \quad (84)$$

$$\beta_{m_z^2}^{(2)} = 0 \quad (85)$$

3.9 Vacuum expectation values

$$\beta_{v_d}^{(1)} = \frac{1}{20} v_d \left(-20\text{Tr}(Y_e Y_e^\dagger) + 3(5g_2^2 + g_1^2)(1 + \text{Xi}) - 60\text{Tr}(Y_d Y_d^\dagger) \right) \quad (86)$$

$$\beta_{v_d}^{(2)} = \frac{1}{400} v_d \left(-414g_1^4 - 180g_1^2 g_2^2 - 1200g_2^4 - 9g_1^4 \text{Xi} - 90g_1^2 g_2^2 \text{Xi} + 875g_2^4 \text{Xi} + 9g_1^4 \text{Xi}^2 + 90g_1^2 g_2^2 \text{Xi}^2 \right)$$

$$\begin{aligned}
& -225g_2^4\text{Xi}^2 - 40\left(5\left(32g_3^2 + 9g_2^2\text{Xi}\right) + g_1^2\left(9\text{Xi} - 4\right)\right)\text{Tr}\left(Y_d Y_d^\dagger\right) - 120\left(5g_2^2\text{Xi} + g_1^2\left(4 + \text{Xi}\right)\right)\text{Tr}\left(Y_e Y_e^\dagger\right) \\
& + 3600\text{Tr}\left(Y_d Y_d^\dagger Y_d Y_d^\dagger\right) + 1200\text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) + 1200\text{Tr}\left(Y_e Y_e^\dagger Y_e Y_e^\dagger\right) + 400\text{Tr}\left(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger\right)
\end{aligned} \tag{87}$$

$$\beta_{v_u}^{(1)} = \frac{1}{20}v_u\left(-20\text{Tr}\left(Y_\nu Y_\nu^\dagger\right) + 3\left(5g_2^2 + g_1^2\right)\left(1 + \text{Xi}\right) - 60\text{Tr}\left(Y_u Y_u^\dagger\right)\right) \tag{88}$$

$$\begin{aligned}
\beta_{v_u}^{(2)} = & \frac{1}{400}v_u\left(-414g_1^4 - 180g_1^2g_2^2 - 1200g_2^4 - 9g_1^4\text{Xi} - 90g_1^2g_2^2\text{Xi} + 875g_2^4\text{Xi} + 9g_1^4\text{Xi}^2 + 90g_1^2g_2^2\text{Xi}^2\right. \\
& - 225g_2^4\text{Xi}^2 - 40\left(5\left(32g_3^2 + 9g_2^2\text{Xi}\right) + g_1^2\left(9\text{Xi} + 8\right)\right)\text{Tr}\left(Y_u Y_u^\dagger\right) - 120\left(5g_2^2 + g_1^2\right)\text{Xi}\text{Tr}\left(Y_\nu Y_\nu^\dagger\right) \\
& \left. + 1200\text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) + 400\text{Tr}\left(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger\right) + 3600\text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right) + 1200\text{Tr}\left(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\right)\right)
\end{aligned} \tag{89}$$

4 Field Rotations

4.1 Rotations in gauge sector for eigenstates 'EWSB'

$$\begin{pmatrix} B_\rho \\ W_{3\rho} \end{pmatrix} = Z^{\gamma Z} \begin{pmatrix} \gamma_\rho \\ Z_\rho \end{pmatrix} \tag{90}$$

$$\begin{pmatrix} W_{1\rho} \\ W_{2\rho} \end{pmatrix} = Z^W \begin{pmatrix} W_\rho^- \\ W_\rho^- \end{pmatrix} \tag{91}$$

$$\begin{pmatrix} \lambda_{\tilde{W},1} \\ \lambda_{\tilde{W},2} \\ \lambda_{\tilde{W},3} \end{pmatrix} = Z^{\tilde{W}} \begin{pmatrix} \tilde{W}^- \\ \tilde{W}^+ \\ \tilde{W}^0 \end{pmatrix} \tag{92}$$

$$\tag{93}$$

The mixing matrices are parametrized by

$$Z^{\gamma Z} = \begin{pmatrix} \cos \Theta_W & -\sin \Theta_W \\ \sin \Theta_W & \cos \Theta_W \end{pmatrix} \tag{94}$$

$$Z^W = \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ -i\frac{1}{\sqrt{2}} & i\frac{1}{\sqrt{2}} \end{pmatrix} \tag{95}$$

$$Z^{\tilde{W}} = \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \\ -i\frac{1}{\sqrt{2}} & i\frac{1}{\sqrt{2}} & 0 \\ 0 & 0 & 1 \end{pmatrix} \tag{96}$$

$$\tag{97}$$

4.2 Rotations in Mass sector for eigenstates 'EWSB'

4.2.1 Mass Matrices for Scalars

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

$$m_{\tilde{d}}^2 = \begin{pmatrix} m_{\tilde{d}_L \tilde{d}_L^*} & \frac{1}{\sqrt{2}}(v_d T_d^\dagger - v_u \mu Y_d^\dagger) \delta_{\alpha_1 \beta_2} \\ \frac{1}{\sqrt{2}} \delta_{\alpha_2 \beta_1} (v_d T_d - v_u Y_d \mu^*) & m_{\tilde{d}_R \tilde{d}_R^*} \end{pmatrix} \quad (98)$$

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

$$m_{\tilde{d}_R \tilde{d}_R^*} = \frac{1}{12} g_1^2 \mathbf{1}(-v_d^2 + v_u^2) \delta_{\alpha_2 \beta_2} + \frac{1}{2} \delta_{\alpha_2 \beta_2} (2m_d^2 + v_d^2 Y_d Y_d^\dagger) \quad (100)$$

This matrix is diagonalized by Z^D :

$$Z^D m_{\tilde{d}}^2 Z^{D,\dagger} = m_{2,\tilde{d}}^{dia} \quad (101)$$

with

$$\tilde{d}_{L,i\alpha} = \sum_j Z_{ji}^{D,*} \tilde{d}_{j\alpha}, \quad \tilde{d}_{R,i\alpha} = \sum_j Z_{ji}^{D,*} \tilde{d}_{j\alpha} \quad (102)$$

- **Mass matrix for CP-odd Sneutrino**, Basis: $(\sigma_L, \sigma_R, \sigma_S), (\sigma_L, \sigma_R, \sigma_S)$

$$m_{\nu^i}^2 = \begin{pmatrix} m_{\sigma_L \sigma_L} & m_{\sigma_R \sigma_L}^T & \frac{1}{\sqrt{2}} v_u \Re(Y_\nu^T M_\nu^*) \\ m_{\sigma_L \sigma_R} & m_{\sigma_R \sigma_R} & \frac{1}{4} (4\Re(B_\nu) - 4\Re(M_\nu \mu_S^*)) \\ \frac{1}{\sqrt{2}} v_u \Re(M_\nu^T Y_\nu^*) & \frac{1}{4} (4\Re(B_\nu^T) - 4\Re(\mu_S M_\nu^\dagger)) & m_{\sigma_S \sigma_S} \end{pmatrix} \quad (103)$$

$$m_{\sigma_L \sigma_L} = \frac{1}{4} (2v_u^2 \Re(Y_\nu^T Y_\nu^*) + 4\Re(m_l^2)) + \frac{1}{8} (g_1^2 + g_2^2) \mathbf{1}(-v_u^2 + v_d^2) \quad (104)$$

$$m_{\sigma_L \sigma_R} = -\frac{1}{2} \frac{1}{\sqrt{2}} (2v_d \Re(\mu Y_\nu^*) - 2v_u \Re(T_\nu)) \quad (105)$$

$$m_{\sigma_R \sigma_R} = \frac{1}{4} (2(2\Re(m_\nu^2) + 2\Re(M_\nu M_\nu^\dagger)) + 2v_u^2 \Re(Y_\nu Y_\nu^\dagger)) \quad (106)$$

$$m_{\sigma_S \sigma_S} = \frac{1}{8} (4(2\Re(M_\nu^T M_\nu^*) + 2\Re(m_S^2)) - 8\Re(B_S) + 8\Re(\mu_S \mu_S^*)) \quad (107)$$

This matrix is diagonalized by Z^i :

$$Z^i m_{\nu^i}^2 Z^{i,\dagger} = m_{2,\nu^i}^{dia} \quad (108)$$

with

$$\sigma_{L,i} = \sum_j Z_{ji}^{i,*} \nu_j^i, \quad \sigma_{R,i} = \sum_j Z_{ji}^{i,*} \nu_j^i, \quad \sigma_{S,i} = \sum_j Z_{ji}^{i,*} \nu_j^i \quad (109)$$

- **Mass matrix for CP-even Sneutrino**, Basis: $(\phi_L, \phi_R, \phi_S), (\phi_L, \phi_R, \phi_S)$

$$m_{\nu R}^2 = \begin{pmatrix} m_{\phi_L \phi_L} & m_{\phi_R \phi_L}^T & \frac{1}{\sqrt{2}} v_u \Re(Y_\nu^T M_\nu^*) \\ m_{\phi_L \phi_R} & m_{\phi_R \phi_R} & \frac{1}{4} (4\Re(B_\nu) + 4\Re(M_\nu \mu_S^*)) \\ \frac{1}{\sqrt{2}} v_u \Re(M_\nu^T Y_\nu^*) & \frac{1}{4} (4\Re(B_\nu^T) + 4\Re(\mu_S M_\nu^\dagger)) & m_{\phi_S \phi_S} \end{pmatrix} \quad (110)$$

$$m_{\phi_L \phi_L} = \frac{1}{4} (2v_u^2 \Re(Y_\nu^T Y_\nu^*) + 4\Re(m_t^2)) + \frac{1}{8} (g_1^2 + g_2^2) \mathbf{1} (-v_u^2 + v_d^2) \quad (111)$$

$$m_{\phi_L \phi_R} = -\frac{1}{2} \frac{1}{\sqrt{2}} (2v_d \Re(\mu Y_\nu^*) - 2v_u \Re(T_\nu)) \quad (112)$$

$$m_{\phi_R \phi_R} = \frac{1}{4} (2(2\Re(m_\nu^2) + 2\Re(M_\nu M_\nu^\dagger)) + 2v_u^2 \Re(Y_\nu Y_\nu^\dagger)) \quad (113)$$

$$m_{\phi_S \phi_S} = \frac{1}{8} (4(2\Re(M_\nu^T M_\nu^*) + 2\Re(m_S^2) + \Re(B_S)) + 4\Re(B_S) + 8\Re(\mu_S \mu_S^*)) \quad (114)$$

This matrix is diagonalized by Z^R :

$$Z^R m_{\nu R}^2 Z^{R,\dagger} = m_{2,\nu R}^{dia} \quad (115)$$

with

$$\phi_{L,i} = \sum_j Z_{ji}^{R,*} \nu_j^R, \quad \phi_{R,i} = \sum_j Z_{ji}^{R,*} \nu_j^R, \quad \phi_{S,i} = \sum_j Z_{ji}^{R,*} \nu_j^R \quad (116)$$

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

$$m_{\tilde{u}}^2 = \begin{pmatrix} m_{\tilde{u}_L \tilde{u}_L^*} & \frac{1}{\sqrt{2}} (-v_d \mu Y_u^\dagger + v_u T_u^\dagger) \delta_{\alpha_1 \beta_2} \\ \frac{1}{\sqrt{2}} \delta_{\alpha_2 \beta_1} (-v_d Y_u \mu^* + v_u T_u) & m_{\tilde{u}_R \tilde{u}_R^*} \end{pmatrix} \quad (117)$$

$$m_{\tilde{u}_L \tilde{u}_L^*} = -\frac{1}{24} (-3g_2^2 + g_1^2) \mathbf{1} (-v_u^2 + v_d^2) \delta_{\alpha_1 \beta_1} + \frac{1}{2} \delta_{\alpha_1 \beta_1} (2m_q^2 + v_u^2 Y_u^\dagger Y_u) \quad (118)$$

$$m_{\tilde{u}_R \tilde{u}_R^*} = \frac{1}{2} \delta_{\alpha_2 \beta_2} (2m_u^2 + v_u^2 Y_u Y_u^\dagger) + \frac{1}{6} g_1^2 \mathbf{1} (-v_u^2 + v_d^2) \delta_{\alpha_2 \beta_2} \quad (119)$$

This matrix is diagonalized by Z^U :

$$Z^U m_{\tilde{u}}^2 Z^{U,\dagger} = m_{2,\tilde{u}}^{dia} \quad (120)$$

with

$$\tilde{u}_{L,i\alpha} = \sum_j Z_{ji}^{U,*} \tilde{u}_{j\alpha}, \quad \tilde{u}_{R,i\alpha} = \sum_j Z_{ji}^{U,*} \tilde{u}_{j\alpha} \quad (121)$$

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

$$m_{\tilde{e}}^2 = \begin{pmatrix} m_{\tilde{e}_L \tilde{e}_L^*} & \frac{1}{\sqrt{2}} (v_d T_e^\dagger - v_u \mu Y_e^\dagger) \\ \frac{1}{\sqrt{2}} (v_d T_e - v_u Y_e \mu^*) & m_{\tilde{e}_R \tilde{e}_R^*} \end{pmatrix} \quad (122)$$

$$m_{\tilde{e}_L \tilde{e}_L^*} = \frac{1}{2} v_d^2 Y_e^\dagger Y_e + \frac{1}{8} (-g_2^2 + g_1^2) \mathbf{1} (-v_u^2 + v_d^2) + m_l^2 \quad (123)$$

$$m_{\tilde{e}_R \tilde{e}_R^*} = \frac{1}{2} v_d^2 Y_e Y_e^\dagger + \frac{1}{4} g_1^2 \mathbf{1} (-v_d^2 + v_u^2) + m_e^2 \quad (124)$$

This matrix is diagonalized by Z^E :

$$Z^E m_{\tilde{e}}^2 Z^{E,\dagger} = m_{2,\tilde{e}}^{dia} \quad (125)$$

with

$$\tilde{e}_{L,i} = \sum_j Z_{ji}^{E,*} \tilde{e}_j, \quad \tilde{e}_{R,i} = \sum_j Z_{ji}^{E,*} \tilde{e}_j \quad (126)$$

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

$$m_h^2 = \begin{pmatrix} \frac{1}{8} (g_1^2 + g_2^2) (3v_d^2 - v_u^2) + m_{H_d}^2 + |\mu|^2 & -\frac{1}{4} (g_1^2 + g_2^2) v_d v_u - \Re(B_\mu) \\ -\frac{1}{4} (g_1^2 + g_2^2) v_d v_u - \Re(B_\mu) & -\frac{1}{8} (g_1^2 + g_2^2) (-3v_u^2 + v_d^2) + m_{H_u}^2 + |\mu|^2 \end{pmatrix} \quad (127)$$

This matrix is diagonalized by Z^H :

$$Z^H m_h^2 Z^{H,\dagger} = m_{2,h}^{dia} \quad (128)$$

with

$$\phi_d = \sum_j Z_{j1}^H h_j, \quad \phi_u = \sum_j Z_{j2}^H h_j \quad (129)$$

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

$$m_{A^0}^2 = \begin{pmatrix} \frac{1}{8} (g_1^2 + g_2^2) (-v_u^2 + v_d^2) + m_{H_d}^2 + |\mu|^2 & \Re(B_\mu) \\ \Re(B_\mu) & -\frac{1}{8} (g_1^2 + g_2^2) (-v_u^2 + v_d^2) + m_{H_u}^2 + |\mu|^2 \end{pmatrix} + \xi_Z m^2(Z) \quad (130)$$

Gauge fixing contributions:

$$m^2(\xi_Z) = \begin{pmatrix} \frac{1}{4} v_d^2 (g_1 \sin \Theta_W + g_2 \cos \Theta_W)^2 & -\frac{1}{4} v_d v_u (g_1 \sin \Theta_W + g_2 \cos \Theta_W)^2 \\ -\frac{1}{4} v_d v_u (g_1 \sin \Theta_W + g_2 \cos \Theta_W)^2 & \frac{1}{4} v_u^2 (g_1 \sin \Theta_W + g_2 \cos \Theta_W)^2 \end{pmatrix} \quad (131)$$

This matrix is diagonalized by Z^A :

$$Z^A m_{A^0}^2 Z^{A,\dagger} = m_{2,A^0}^{dia} \quad (132)$$

with

$$\sigma_d = \sum_j Z_{j1}^A A_j^0, \quad \sigma_u = \sum_j Z_{j2}^A A_j^0 \quad (133)$$

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

$$m_{H^-}^2 = \begin{pmatrix} m_{H_d^- H_d^{-,*}} & \frac{1}{4}g_2^2 v_d v_u + B_\mu^* \\ \frac{1}{4}g_2^2 v_d v_u + B_\mu & m_{H_u^{+,*} H_u^+} \end{pmatrix} + \xi_{W^-} m^2(W^-) \quad (134)$$

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

$$m_{H_u^{+,*} H_u^+} = \frac{1}{8} \left(g_1^2 (-v_d^2 + v_u^2) + g_2^2 (v_d^2 + v_u^2) \right) + m_{H_u}^2 + |\mu|^2 \quad (136)$$

Gauge fixing contributions:

$$m^2(\xi_{W^-}) = \begin{pmatrix} \frac{1}{4}g_2^2 v_d^2 & -\frac{1}{4}g_2^2 v_d v_u \\ -\frac{1}{4}g_2^2 v_d v_u & \frac{1}{4}g_2^2 v_u^2 \end{pmatrix} \quad (137)$$

This matrix is diagonalized by Z^+ :

$$Z^+ m_{H^-}^2 Z^{+,\dagger} = m_{2,H^-}^{dia} \quad (138)$$

with

$$H_d^- = \sum_j Z_{j1}^+ H_j^-, \quad H_u^+ = \sum_j Z_{j2}^+ H_j^+ \quad (139)$$

4.2.2 Mass Matrices for Fermions

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

$$m_{\tilde{\chi}^0} = \begin{pmatrix} M_1 & 0 & -\frac{1}{2}g_1 v_d & \frac{1}{2}g_1 v_u \\ 0 & M_2 & \frac{1}{2}g_2 v_d & -\frac{1}{2}g_2 v_u \\ -\frac{1}{2}g_1 v_d & \frac{1}{2}g_2 v_d & 0 & -\mu \\ \frac{1}{2}g_1 v_u & -\frac{1}{2}g_2 v_u & -\mu & 0 \end{pmatrix} \quad (140)$$

This matrix is diagonalized by N :

$$N^* m_{\tilde{\chi}^0} N^\dagger = m_{\tilde{\chi}^0}^{dia} \quad (141)$$

with

$$\lambda_{\tilde{B}} = \sum_j N_{j1}^* \lambda_j^0, \quad \tilde{W}^0 = \sum_j N_{j2}^* \lambda_j^0, \quad \tilde{H}_d^0 = \sum_j N_{j3}^* \lambda_j^0 \quad (142)$$

$$\tilde{H}_u^0 = \sum_j N_{j4}^* \lambda_j^0 \quad (143)$$

- **Mass matrix for Neutrinos**, Basis: $(\nu_L, \nu_R^*, \tilde{S}), (\nu_L, \nu_R^*, \tilde{S})$

$$m_\nu = \begin{pmatrix} 0 & \frac{1}{\sqrt{2}}v_u Y_\nu^T & 0 \\ \frac{1}{\sqrt{2}}v_u Y_\nu & 0 & M_\nu \\ 0 & M_\nu^T & \mu_S \end{pmatrix} \quad (144)$$

This matrix is diagonalized by U^V :

$$U^{V,*} m_\nu U^{V,\dagger} = m_\nu^{dia} \quad (145)$$

with

$$\nu_{L,i} = \sum_j U_{ji}^{V,*} \nu_{M,j}, \quad \nu_{R,i} = \sum_j U_{ji}^V \nu_{M,j}^*, \quad \tilde{S}_i = \sum_j U_{ji}^{V,*} \nu_{M,j} \quad (146)$$

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

$$m_{\tilde{\chi}^-} = \begin{pmatrix} M_2 & \frac{1}{\sqrt{2}} g_2 v_u \\ \frac{1}{\sqrt{2}} g_2 v_d & \mu \end{pmatrix} \quad (147)$$

This matrix is diagonalized by U and V

$$U^* m_{\tilde{\chi}^-} V^\dagger = m_{\tilde{\chi}^-}^{dia} \quad (148)$$

with

$$\tilde{W}^- = \sum_{t_2} U_{j1}^* \lambda_j^-, \quad \tilde{H}_d^- = \sum_{t_2} U_{j2}^* \lambda_j^- \quad (149)$$

$$\tilde{W}^+ = \sum_{t_2} V_{1j}^* \lambda_j^+, \quad \tilde{H}_u^+ = \sum_{t_2} V_{2j}^* \lambda_j^+ \quad (150)$$

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

$$m_e = \begin{pmatrix} \frac{1}{\sqrt{2}} v_d Y_e^T \end{pmatrix} \quad (151)$$

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

$$U_L^{e,*} m_e U_R^{e,\dagger} = m_e^{dia} \quad (152)$$

with

$$e_{L,i} = \sum_{t_2} U_{L,ji}^{e,*} E_{L,j} \quad (153)$$

$$e_{R,i} = \sum_{t_2} U_{R,ij}^e E_{R,j}^* \quad (154)$$

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

$$m_d = \begin{pmatrix} \frac{1}{\sqrt{2}} v_d \delta_{\alpha_1 \beta_1} Y_d^T \end{pmatrix} \quad (155)$$

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

$$U_L^{d,*} m_d U_R^{d,\dagger} = m_d^{dia} \quad (156)$$

with

$$d_{L,i\alpha} = \sum_{t_2} U_{L,ji}^{d,*} D_{L,j\alpha} \quad (157)$$

$$d_{R,i\alpha} = \sum_{t_2} U_{R,ij}^d D_{R,j\alpha}^* \quad (158)$$

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

$$m_u = \left(\frac{1}{\sqrt{2}} v_u \delta_{\alpha_1\beta_1} Y_u^T \right) \quad (159)$$

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

$$U_L^{u,*} m_u U_R^{u,\dagger} = m_u^{dia} \quad (160)$$

with

$$u_{L,i\alpha} = \sum_{t_2} U_{L,ji}^{u,*} U_{L,j\alpha} \quad (161)$$

$$u_{R,i\alpha} = \sum_{t_2} U_{R,ij}^u U_{R,j\alpha}^* \quad (162)$$

5 Vacuum Expectation Values

$$H_d^0 = \frac{1}{\sqrt{2}} \phi_d + \frac{1}{\sqrt{2}} v_d + i \frac{1}{\sqrt{2}} \sigma_d \quad (163)$$

$$H_u^0 = \frac{1}{\sqrt{2}} \phi_u + \frac{1}{\sqrt{2}} v_u + i \frac{1}{\sqrt{2}} \sigma_u \quad (164)$$

$$\tilde{\nu}_L = \frac{1}{\sqrt{2}} \phi_L + i \frac{1}{\sqrt{2}} \sigma_L \quad (165)$$

$$\tilde{\nu}_R = \frac{1}{\sqrt{2}} \phi_R + i \frac{1}{\sqrt{2}} \sigma_R \quad (166)$$

$$S = \frac{1}{\sqrt{2}} \phi_S + i \frac{1}{\sqrt{2}} \sigma_S \quad (167)$$

6 Tadpole Equations

$$\frac{\partial V}{\partial \phi_d} = -\frac{1}{2} v_u (B_\mu + B_\mu^*) + \frac{1}{8} (g_1^2 + g_2^2) v_d (-v_u + v_d) (v_d + v_u) + v_d (m_{H_d}^2 + |\mu|^2) \quad (168)$$

$$\frac{\partial V}{\partial \phi_u} = \frac{1}{8} (g_1^2 + g_2^2) v_u (-v_d^2 + v_u^2) - v_d \Re(B_\mu) + v_u (m_{H_u}^2 + |\mu|^2) \quad (169)$$

$$\frac{\partial V}{\partial \phi_{L_i}} = 0 \quad (170)$$

$$\frac{\partial V}{\partial \phi_{R_i}} = 0 \tag{171}$$

$$\frac{\partial V}{\partial \phi_{S_i}} = 0 \tag{172}$$

7 Particle content for eigenstates 'EWSB'

Name	Type	complex/real	Generations	Indices
\tilde{d}	Scalar	complex	6	generation, 6, color, 3
ν^I	Scalar	real	9	generation, 9
ν^R	Scalar	real	9	generation, 9
\tilde{u}	Scalar	complex	6	generation, 6, color, 3
\tilde{e}	Scalar	complex	6	generation, 6
h	Scalar	real	2	generation, 2
A^0	Scalar	real	2	generation, 2
H^-	Scalar	complex	2	generation, 2
\tilde{g}	Fermion	Majorana	1	color, 8
$\tilde{\chi}^0$	Fermion	Majorana	4	generation, 4
ν	Fermion	Majorana	9	generation, 9
$\tilde{\chi}^-$	Fermion	Dirac	2	generation, 2
e	Fermion	Dirac	3	generation, 3
d	Fermion	Dirac	3	generation, 3, color, 3
u	Fermion	Dirac	3	generation, 3, color, 3
g	Vector	real	1	color, 8, lorentz, 4
γ	Vector	real	1	lorentz, 4
Z	Vector	real	1	lorentz, 4
W^-	Vector	complex	1	lorentz, 4
η^G	Ghost	real	1	color, 8
η^γ	Ghost	real	1	
η^Z	Ghost	real	1	
η^-	Ghost	complex	1	
η^+	Ghost	complex	1	

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

8.1 One Loop Self-Energy

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

$$\begin{aligned}
\Pi_{i,j}(p^2) = & +4\Gamma_{\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}^2 A_0(m_{A_a^0}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, A_a^0, A_a^0} - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, H_a^+, H_a^-} \\
& - \frac{1}{2} \sum_{a=1}^2 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}^2 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}^2 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}^4 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}^4 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) \\
& - 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}^2 B_0(p^2, m_{\tilde{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}^2 B_0(p^2, m_{\tilde{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}^2 B_0(p^2, m_{\tilde{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{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^i}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, \nu_a^i, \nu_a^i} - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^R}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, \nu_a^R, \nu_a^R} \\
& - \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) \\
& + \frac{4}{3} \sum_{b=1}^3 G_0(p^2, m_{\tilde{g}}^2, m_{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)
\end{aligned}$$

$$+ \sum_{b=1}^6 \Gamma_{\tilde{d}_j^*, Z, \tilde{d}_b}^* \Gamma_{\tilde{d}_i^*, Z, \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, m_Z^2) + \sum_{b=1}^6 \Gamma_{\tilde{d}_j^*, W^-, \tilde{u}_b}^* \Gamma_{\tilde{d}_i^*, W^-, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, m_{W^-}^2) \quad (173)$$

• Self-Energy for CP-odd Sneutrino (ν^i)

$$\begin{aligned} \Pi_{i,j}(p^2) = & +4\Gamma_{\tilde{\nu}_i^i, \tilde{\nu}_j^i, W^+, W^-} \left(-\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2\Gamma_{\tilde{\nu}_i^i, \tilde{\nu}_j^i, Z, Z} \left(-\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) \\ & - \frac{1}{2} \sum_{a=1}^2 A_0(m_{A_0^a}^2) \Gamma_{\tilde{\nu}_i^i, \tilde{\nu}_j^i, A_0^a, A_0^a} - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\tilde{\nu}_i^i, \tilde{\nu}_j^i, H_a^+, H_a^-} \\ & - \frac{1}{2} \sum_{a=1}^2 A_0(m_{h_a}^2) \Gamma_{\tilde{\nu}_i^i, \tilde{\nu}_j^i, h_a, h_a} \\ & - 4 \sum_{a=1}^3 m_{e_a} \sum_{b=1}^2 B_0(p^2, m_{e_a}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} \left(\Gamma_{\tilde{\nu}_j^i, \tilde{e}_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\nu}_i^i, \tilde{e}_a, \tilde{\chi}_b^-}^R + \Gamma_{\tilde{\nu}_j^i, \tilde{e}_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\nu}_i^i, \tilde{e}_a, \tilde{\chi}_b^-}^L \right) \\ & + 2 \sum_{a=1}^3 \sum_{b=1}^2 G_0(p^2, m_{e_a}^2, m_{\tilde{\chi}_b^-}^2) \left(\Gamma_{\tilde{\nu}_j^i, \tilde{e}_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\nu}_i^i, \tilde{e}_a, \tilde{\chi}_b^-}^L + \Gamma_{\tilde{\nu}_j^i, \tilde{e}_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\nu}_i^i, \tilde{e}_a, \tilde{\chi}_b^-}^R \right) \\ & - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{\nu}_i^i, \tilde{\nu}_j^i, \tilde{d}_a^*, \tilde{d}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{\nu}_i^i, \tilde{\nu}_j^i, \tilde{e}_a^*, \tilde{e}_a} \\ & - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{\nu}_i^i, \tilde{\nu}_j^i, \tilde{u}_a^*, \tilde{u}_a} + 2 \sum_{a=1}^6 \sum_{b=1}^2 B_0(p^2, m_{\tilde{e}_a}^2, m_{H_b^-}^2) \Gamma_{\tilde{\nu}_j^i, \tilde{e}_a^*, H_b^-}^* \Gamma_{\tilde{\nu}_i^i, \tilde{e}_a^*, H_b^-} \\ & - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^i}^2) \Gamma_{\tilde{\nu}_i^i, \tilde{\nu}_j^i, \nu_a^i, \nu_a^i} - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^R}^2) \Gamma_{\tilde{\nu}_i^i, \tilde{\nu}_j^i, \nu_a^R, \nu_a^R} \\ & + \sum_{a=1}^9 \sum_{b=1}^2 B_0(p^2, m_{\nu_a^i}^2, m_{A_b^0}^2) \Gamma_{\tilde{\nu}_j^i, \nu_a^i, A_b^0}^* \Gamma_{\tilde{\nu}_i^i, \nu_a^i, A_b^0} \\ & + \sum_{a=1}^9 \sum_{b=1}^2 B_0(p^2, m_{\nu_a^i}^2, m_{h_b}^2) \Gamma_{\tilde{\nu}_j^i, \nu_a^i, h_b}^* \Gamma_{\tilde{\nu}_i^i, \nu_a^i, h_b} \\ & + \sum_{a=1}^9 \sum_{b=1}^2 B_0(p^2, m_{\nu_a^R}^2, m_{A_b^0}^2) \Gamma_{\tilde{\nu}_j^i, \nu_a^R, A_b^0}^* \Gamma_{\tilde{\nu}_i^i, \nu_a^R, A_b^0} \\ & + \sum_{a=1}^9 \sum_{b=1}^2 B_0(p^2, m_{\nu_a^R}^2, m_{h_b}^2) \Gamma_{\tilde{\nu}_j^i, \nu_a^R, h_b}^* \Gamma_{\tilde{\nu}_i^i, \nu_a^R, h_b} \\ & - 2 \sum_{a=1}^9 m_{\nu_a} \sum_{b=1}^4 B_0(p^2, m_{\nu_a}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_b^0} \left(\Gamma_{\tilde{\nu}_j^i, \nu_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\nu}_i^i, \nu_a, \tilde{\chi}_b^0}^R + \Gamma_{\tilde{\nu}_j^i, \nu_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\nu}_i^i, \nu_a, \tilde{\chi}_b^0}^L \right) \\ & + \sum_{a=1}^9 \sum_{b=1}^4 G_0(p^2, m_{\nu_a}^2, m_{\tilde{\chi}_b^0}^2) \left(\Gamma_{\tilde{\nu}_j^i, \nu_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\nu}_i^i, \nu_a, \tilde{\chi}_b^0}^L + \Gamma_{\tilde{\nu}_j^i, \nu_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\nu}_i^i, \nu_a, \tilde{\chi}_b^0}^R \right) \end{aligned}$$

$$+ 2 \sum_{b=1}^6 \Gamma_{\tilde{\nu}_j^i, W^+, \tilde{e}_b}^* \Gamma_{\tilde{\nu}_i^i, W^+, \tilde{e}_b} F_0(p^2, m_{\tilde{e}_b}^2, m_{W^-}^2) + \sum_{b=1}^9 \Gamma_{\tilde{\nu}_j^i, Z, \nu_b^R}^* \Gamma_{\tilde{\nu}_i^i, Z, \nu_b^R} F_0(p^2, m_{\nu_b^R}^2, m_Z^2) \quad (174)$$

• **Self-Energy for CP-even Sneutrino (ν^R)**

$$\begin{aligned} \Pi_{i,j}(p^2) = & +4\Gamma_{\tilde{\nu}_i^R, \tilde{\nu}_j^R, W^+, W^-} \left(-\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2\Gamma_{\tilde{\nu}_i^R, \tilde{\nu}_j^R, Z, Z} \left(-\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) \\ & - \frac{1}{2} \sum_{a=1}^2 A_0(m_{A_a^0}^2) \Gamma_{\tilde{\nu}_i^R, \tilde{\nu}_j^R, A_a^0, A_a^0} - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\tilde{\nu}_i^R, \tilde{\nu}_j^R, H_a^+, H_a^-} \\ & - \frac{1}{2} \sum_{a=1}^2 A_0(m_{h_a}^2) \Gamma_{\tilde{\nu}_i^R, \tilde{\nu}_j^R, h_a, h_a} \\ & - 4 \sum_{a=1}^3 m_{e_a} \sum_{b=1}^2 B_0(p^2, m_{e_a}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} \left(\Gamma_{\tilde{\nu}_j^R, \tilde{e}_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\nu}_i^R, \tilde{e}_a, \tilde{\chi}_b^-}^R + \Gamma_{\tilde{\nu}_j^R, \tilde{e}_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\nu}_i^R, \tilde{e}_a, \tilde{\chi}_b^-}^L \right) \\ & + 2 \sum_{a=1}^3 \sum_{b=1}^2 G_0(p^2, m_{e_a}^2, m_{\tilde{\chi}_b^-}^2) \left(\Gamma_{\tilde{\nu}_j^R, \tilde{e}_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\nu}_i^R, \tilde{e}_a, \tilde{\chi}_b^-}^L + \Gamma_{\tilde{\nu}_j^R, \tilde{e}_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\nu}_i^R, \tilde{e}_a, \tilde{\chi}_b^-}^R \right) \\ & - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{\nu}_i^R, \tilde{\nu}_j^R, \tilde{d}_a^*, \tilde{d}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{\nu}_i^R, \tilde{\nu}_j^R, \tilde{e}_a^*, \tilde{e}_a} \\ & - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{\nu}_i^R, \tilde{\nu}_j^R, \tilde{u}_a^*, \tilde{u}_a} + 2 \sum_{a=1}^6 \sum_{b=1}^2 B_0(p^2, m_{\tilde{e}_a}^2, m_{H_b^-}^2) \Gamma_{\tilde{\nu}_j^R, \tilde{e}_a^*, H_b^-}^* \Gamma_{\tilde{\nu}_i^R, \tilde{e}_a^*, H_b^-} \\ & - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^i}^2) \Gamma_{\tilde{\nu}_i^R, \tilde{\nu}_j^R, \nu_a^i, \nu_a^i} - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^R}^2) \Gamma_{\tilde{\nu}_i^R, \tilde{\nu}_j^R, \nu_a^R, \nu_a^R} \\ & + \sum_{a=1}^9 \sum_{b=1}^2 B_0(p^2, m_{\nu_a^i}^2, m_{A_b^0}^2) \Gamma_{\tilde{\nu}_j^R, \nu_a^i, A_b^0}^* \Gamma_{\tilde{\nu}_i^R, \nu_a^i, A_b^0} \\ & + \sum_{a=1}^9 \sum_{b=1}^2 B_0(p^2, m_{\nu_a^i}^2, m_{h_b}^2) \Gamma_{\tilde{\nu}_j^R, \nu_a^i, h_b}^* \Gamma_{\tilde{\nu}_i^R, \nu_a^i, h_b} \\ & + \sum_{a=1}^9 \sum_{b=1}^2 B_0(p^2, m_{\nu_a^R}^2, m_{A_b^0}^2) \Gamma_{\tilde{\nu}_j^R, \nu_a^R, A_b^0}^* \Gamma_{\tilde{\nu}_i^R, \nu_a^R, A_b^0} \\ & + \sum_{a=1}^9 \sum_{b=1}^2 B_0(p^2, m_{\nu_a^R}^2, m_{h_b}^2) \Gamma_{\tilde{\nu}_j^R, \nu_a^R, h_b}^* \Gamma_{\tilde{\nu}_i^R, \nu_a^R, h_b} \\ & - 2 \sum_{a=1}^9 m_{\nu_a} \sum_{b=1}^4 B_0(p^2, m_{\nu_a}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_b^0} \left(\Gamma_{\tilde{\nu}_j^R, \nu_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\nu}_i^R, \nu_a, \tilde{\chi}_b^0}^R + \Gamma_{\tilde{\nu}_j^R, \nu_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\nu}_i^R, \nu_a, \tilde{\chi}_b^0}^L \right) \\ & + \sum_{a=1}^9 \sum_{b=1}^4 G_0(p^2, m_{\nu_a}^2, m_{\tilde{\chi}_b^0}^2) \left(\Gamma_{\tilde{\nu}_j^R, \nu_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\nu}_i^R, \nu_a, \tilde{\chi}_b^0}^L + \Gamma_{\tilde{\nu}_j^R, \nu_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\nu}_i^R, \nu_a, \tilde{\chi}_b^0}^R \right) \end{aligned}$$

$$+ 2 \sum_{b=1}^6 \Gamma_{\tilde{\nu}_j^R, W^+, \tilde{e}_b}^* \Gamma_{\tilde{\nu}_i^R, W^+, \tilde{e}_b} F_0(p^2, m_{\tilde{e}_b}^2, m_{W^-}^2) + \sum_{b=1}^9 \Gamma_{\tilde{\nu}_j^R, Z, \nu_b^i}^* \Gamma_{\tilde{\nu}_i^R, Z, \nu_b^i} F_0(p^2, m_{\nu_b^i}^2, m_Z^2) \quad (175)$$

• 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}^2 A_0(m_{A_a^0}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, A_a^0, A_a^0} - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, H_a^+, H_a^-} \\ & - \frac{1}{2} \sum_{a=1}^2 A_0(m_{h_a}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, h_a, h_a} \\ & - 2 \sum_{a=1}^2 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}^2 \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) \\ & + \sum_{a=1}^2 \sum_{b=1}^6 B_0(p^2, m_{H_a^-}^2, m_{d_b}^2) \Gamma_{\tilde{u}_j^*, H_a^+, \tilde{d}_b}^* \Gamma_{\tilde{u}_i^*, H_a^+, \tilde{d}_b} \\ & - 2 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^4 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}^4 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) \\ & - 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}^2 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}^2 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{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^i}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, \nu_a^i, \nu_a^i} \\ & - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^R}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, \nu_a^R, \nu_a^R} \\ & - \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) \end{aligned}$$

$$\begin{aligned}
& + \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, W^+, \tilde{d}_b}^* \Gamma_{\tilde{u}_i^*, W^+, \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, m_{W^-}^2) + \frac{4}{3} \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, g, \tilde{u}_b} \Gamma_{\tilde{u}_i^*, g, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, 0) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, \gamma, \tilde{u}_b} \Gamma_{\tilde{u}_i^*, \gamma, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, 0) + \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, Z, \tilde{u}_b}^* \Gamma_{\tilde{u}_i^*, Z, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, m_Z^2)
\end{aligned} \tag{176}$$

• 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}^2 A_0(m_{A_a^0}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, A_a^0, A_a^0} - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, H_a^+, H_a^-} \\
& - \frac{1}{2} \sum_{a=1}^2 A_0(m_{h_a}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, h_a, h_a} \\
& - 2 \sum_{a=1}^3 m_{e_a} \sum_{b=1}^4 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}^4 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) \\
& - 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}^2 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}^2 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} - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^i}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, \nu_a^i, \nu_a^i} \\
& - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^R}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, \nu_a^R, \nu_a^R} + \sum_{a=1}^9 \sum_{b=1}^2 B_0(p^2, m_{\nu_a^i}^2, m_{H_b^-}^2) \Gamma_{\tilde{e}_j^*, \nu_a^i, H_b^-}^* \Gamma_{\tilde{e}_i^*, \nu_a^i, H_b^-} \\
& + \sum_{a=1}^9 \sum_{b=1}^2 B_0(p^2, m_{\nu_a^R}^2, m_{H_b^-}^2) \Gamma_{\tilde{e}_j^*, \nu_a^R, H_b^-}^* \Gamma_{\tilde{e}_i^*, \nu_a^R, H_b^-} \\
& - 2 \sum_{a=1}^9 m_{\nu_a} \sum_{b=1}^2 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}^9 \sum_{b=1}^2 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_{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)
\end{aligned}$$

$$+ \sum_{b=1}^9 \Gamma_{\tilde{e}_j^*, W^-, \nu_b^i}^* \Gamma_{\tilde{e}_i^*, W^-, \nu_b^i} F_0(p^2, m_{\nu_b^i}^2, m_{W^-}^2) + \sum_{b=1}^9 \Gamma_{\tilde{e}_j^*, W^-, \nu_b^R} \Gamma_{\tilde{e}_i^*, W^-, \nu_b^R} F_0(p^2, m_{\nu_b^R}^2, m_{W^-}^2) \quad (177)$$

• **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^+} \\ & - B_0(p^2, m_{\eta^Z}^2, m_{\eta^Z}^2) \Gamma_{\tilde{h}_i, \eta^Z, \eta^Z} \Gamma_{\tilde{h}_j, \eta^Z, \eta^Z} + 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}^2 A_0(m_{A_a^0}^2) \Gamma_{\tilde{h}_i, \tilde{h}_j, A_a^0, A_a^0} \\ & - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\tilde{h}_i, \tilde{h}_j, H_a^+, H_a^-} - \frac{1}{2} \sum_{a=1}^2 A_0(m_{h_a}^2) \Gamma_{\tilde{h}_i, \tilde{h}_j, h_a, h_a} \\ & + \frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^2 B_0(p^2, m_{A_a^0}^2, m_{A_b^0}^2) \Gamma_{\tilde{h}_j, A_a^0, A_b^0}^* \Gamma_{\tilde{h}_i, A_a^0, A_b^0} \\ & + \sum_{a=1}^2 \sum_{b=1}^2 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^-} \\ & + \frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^2 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}^2 m_{\tilde{\chi}_a^-} \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} \left(\Gamma_{\tilde{h}_j, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{h}_i, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^R + \Gamma_{\tilde{h}_j, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{h}_i, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^L \right) \\ & + \sum_{a=1}^2 \sum_{b=1}^2 G_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{\chi}_b^-}^2) \left(\Gamma_{\tilde{h}_j, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{h}_i, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^L + \Gamma_{\tilde{h}_j, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{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_{\tilde{h}_j, \bar{d}_a, d_b}^{L*} \Gamma_{\tilde{h}_i, \bar{d}_a, d_b}^R + \Gamma_{\tilde{h}_j, \bar{d}_a, d_b}^{R*} \Gamma_{\tilde{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_{\tilde{h}_j, \bar{d}_a, d_b}^{L*} \Gamma_{\tilde{h}_i, \bar{d}_a, d_b}^L + \Gamma_{\tilde{h}_j, \bar{d}_a, d_b}^{R*} \Gamma_{\tilde{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_{\tilde{h}_j, \bar{e}_a, e_b}^{L*} \Gamma_{\tilde{h}_i, \bar{e}_a, e_b}^R + \Gamma_{\tilde{h}_j, \bar{e}_a, e_b}^{R*} \Gamma_{\tilde{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_{\tilde{h}_j, \bar{e}_a, e_b}^{L*} \Gamma_{\tilde{h}_i, \bar{e}_a, e_b}^L + \Gamma_{\tilde{h}_j, \bar{e}_a, e_b}^{R*} \Gamma_{\tilde{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_{\tilde{h}_j, \bar{u}_a, u_b}^{L*} \Gamma_{\tilde{h}_i, \bar{u}_a, u_b}^R + \Gamma_{\tilde{h}_j, \bar{u}_a, u_b}^{R*} \Gamma_{\tilde{h}_i, \bar{u}_a, u_b}^L \right) \end{aligned}$$

$$\begin{aligned}
& + 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, \check{u}_a, u_b}^{L*} \Gamma_{\check{h}_i, \check{u}_a, u_b}^L + \Gamma_{\check{h}_j, \check{u}_a, u_b}^{R*} \Gamma_{\check{h}_i, \check{u}_a, u_b}^R \right) \\
& - \sum_{a=1}^4 m_{\check{\chi}_a^0} \sum_{b=1}^4 B_0(p^2, m_{\check{\chi}_a^0}^2, m_{\check{\chi}_b^0}^2) m_{\check{\chi}_b^0} \left(\Gamma_{\check{h}_j, \check{\chi}_a^0, \check{\chi}_b^0}^{L*} \Gamma_{\check{h}_i, \check{\chi}_a^0, \check{\chi}_b^0}^R + \Gamma_{\check{h}_j, \check{\chi}_a^0, \check{\chi}_b^0}^{R*} \Gamma_{\check{h}_i, \check{\chi}_a^0, \check{\chi}_b^0}^L \right) \\
& + \frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^4 G_0(p^2, m_{\check{\chi}_a^0}^2, m_{\check{\chi}_b^0}^2) \left(\Gamma_{\check{h}_j, \check{\chi}_a^0, \check{\chi}_b^0}^{L*} \Gamma_{\check{h}_i, \check{\chi}_a^0, \check{\chi}_b^0}^L + \Gamma_{\check{h}_j, \check{\chi}_a^0, \check{\chi}_b^0}^{R*} \Gamma_{\check{h}_i, \check{\chi}_a^0, \check{\chi}_b^0}^R \right) \\
& - 3 \sum_{a=1}^6 A_0(m_{\check{d}_a}^2) \Gamma_{\check{h}_i, \check{h}_j, \check{d}_a^*, \check{d}_a} - \sum_{a=1}^6 A_0(m_{\check{e}_a}^2) \Gamma_{\check{h}_i, \check{h}_j, \check{e}_a^*, \check{e}_a} \\
& - 3 \sum_{a=1}^6 A_0(m_{\check{u}_a}^2) \Gamma_{\check{h}_i, \check{h}_j, \check{u}_a^*, \check{u}_a} + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\check{d}_a}^2, m_{\check{d}_b}^2) \Gamma_{\check{h}_j, \check{d}_a^*, \check{d}_b}^* \Gamma_{\check{h}_i, \check{d}_a^*, \check{d}_b} \\
& + \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\check{e}_a}^2, m_{\check{e}_b}^2) \Gamma_{\check{h}_j, \check{e}_a^*, \check{e}_b}^* \Gamma_{\check{h}_i, \check{e}_a^*, \check{e}_b} + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\check{u}_a}^2, m_{\check{u}_b}^2) \Gamma_{\check{h}_j, \check{u}_a^*, \check{u}_b}^* \Gamma_{\check{h}_i, \check{u}_a^*, \check{u}_b} \\
& - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^i}^2) \Gamma_{\check{h}_i, \check{h}_j, \nu_a^i, \nu_a^i} - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^R}^2) \Gamma_{\check{h}_i, \check{h}_j, \nu_a^R, \nu_a^R} \\
& + \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 B_0(p^2, m_{\nu_a^i}^2, m_{\nu_b^i}^2) \Gamma_{\check{h}_j, \nu_a^i, \nu_b^i}^* \Gamma_{\check{h}_i, \nu_a^i, \nu_b^i} \\
& + \sum_{a=1}^9 \sum_{b=1}^9 B_0(p^2, m_{\nu_a^R}^2, m_{\nu_b^i}^2) \Gamma_{\check{h}_j, \nu_a^R, \nu_b^i}^* \Gamma_{\check{h}_i, \nu_a^R, \nu_b^i} \\
& + \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 B_0(p^2, m_{\nu_a^R}^2, m_{\nu_b^R}^2) \Gamma_{\check{h}_j, \nu_a^R, \nu_b^R}^* \Gamma_{\check{h}_i, \nu_a^R, \nu_b^R} \\
& - \sum_{a=1}^9 m_{\nu_a} \sum_{b=1}^9 B_0(p^2, m_{\nu_a}^2, m_{\nu_b}^2) m_{\nu_b} \left(\Gamma_{\check{h}_j, \nu_a, \nu_b}^{L*} \Gamma_{\check{h}_i, \nu_a, \nu_b}^R + \Gamma_{\check{h}_j, \nu_a, \nu_b}^{R*} \Gamma_{\check{h}_i, \nu_a, \nu_b}^L \right) \\
& + \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 G_0(p^2, m_{\nu_a}^2, m_{\nu_b}^2) \left(\Gamma_{\check{h}_j, \nu_a, \nu_b}^{L*} \Gamma_{\check{h}_i, \nu_a, \nu_b}^L + \Gamma_{\check{h}_j, \nu_a, \nu_b}^{R*} \Gamma_{\check{h}_i, \nu_a, \nu_b}^R \right) \\
& + \sum_{b=1}^2 \Gamma_{\check{h}_j, Z, A_b^0}^* \Gamma_{\check{h}_i, Z, A_b^0} F_0(p^2, m_{A_b^0}^2, m_Z^2) + 2 \sum_{b=1}^2 \Gamma_{\check{h}_j, W^+, H_b^-}^* \Gamma_{\check{h}_i, W^+, H_b^-} F_0(p^2, m_{H_b^-}^2, m_{W^-}^2) \tag{178}
\end{aligned}$$

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

$$\begin{aligned}
\Pi_{i,j}(p^2) = & -B_0(p^2, m_{\eta^-}^2, m_{\eta^-}^2) \Gamma_{\check{A}_i^0, \eta^-, \eta^-} \Gamma_{\check{A}_j^0, \eta^-, \eta^-} - B_0(p^2, m_{\eta^+}^2, m_{\eta^+}^2) \Gamma_{\check{A}_i^0, \eta^+, \eta^+} \Gamma_{\check{A}_j^0, \eta^+, \eta^+} \\
& + 4\Gamma_{\check{A}_i^0, \check{A}_j^0, W^+, W^-} \left(-\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2\Gamma_{\check{A}_i^0, \check{A}_j^0, Z, Z} \left(-\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right)
\end{aligned}$$

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^2 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}^2 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}^2 A_0(m_{h_a}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, h_a, h_a} + \sum_{a=1}^2 \sum_{b=1}^2 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}^2 \sum_{b=1}^2 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} \\
& - 2 \sum_{a=1}^2 m_{\tilde{\chi}_a^-} \sum_{b=1}^2 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}^2 \sum_{b=1}^2 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) \\
& + \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 m_{\tilde{\chi}_a^0} \sum_{b=1}^4 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}^4 \sum_{b=1}^4 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}
\end{aligned}$$

$$\begin{aligned}
& + \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{e}_a}^2, m_{\tilde{e}_b}^2) \Gamma_{\tilde{A}_j^0, \tilde{e}_a^*, \tilde{e}_b}^* \Gamma_{\tilde{A}_i^0, \tilde{e}_a^*, \tilde{e}_b} \\
& + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{u}_a}^2, m_{\tilde{u}_b}^2) \Gamma_{\tilde{A}_j^0, \tilde{u}_a^*, \tilde{u}_b}^* \Gamma_{\tilde{A}_i^0, \tilde{u}_a^*, \tilde{u}_b} - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^i}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, \nu_a^i, \nu_a^i} \\
& - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^R}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, \nu_a^R, \nu_a^R} + \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 B_0(p^2, m_{\nu_a^i}^2, m_{\nu_b^i}^2) \Gamma_{\tilde{A}_j^0, \nu_a^i, \nu_b^i}^* \Gamma_{\tilde{A}_i^0, \nu_a^i, \nu_b^i} \\
& + \sum_{a=1}^9 \sum_{b=1}^9 B_0(p^2, m_{\nu_a^R}^2, m_{\nu_b^i}^2) \Gamma_{\tilde{A}_j^0, \nu_a^R, \nu_b^i}^* \Gamma_{\tilde{A}_i^0, \nu_a^R, \nu_b^i} \\
& + \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 B_0(p^2, m_{\nu_a^R}^2, m_{\nu_b^R}^2) \Gamma_{\tilde{A}_j^0, \nu_a^R, \nu_b^R}^* \Gamma_{\tilde{A}_i^0, \nu_a^R, \nu_b^R} \\
& - \sum_{a=1}^9 m_{\nu_a} \sum_{b=1}^9 B_0(p^2, m_{\nu_a}^2, m_{\nu_b}^2) m_{\nu_b} \left(\Gamma_{\tilde{A}_j^0, \nu_a, \nu_b}^{L*} \Gamma_{\tilde{A}_i^0, \nu_a, \nu_b}^R + \Gamma_{\tilde{A}_j^0, \nu_a, \nu_b}^{R*} \Gamma_{\tilde{A}_i^0, \nu_a, \nu_b}^L \right) \\
& + \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 G_0(p^2, m_{\nu_a}^2, m_{\nu_b}^2) \left(\Gamma_{\tilde{A}_j^0, \nu_a, \nu_b}^{L*} \Gamma_{\tilde{A}_i^0, \nu_a, \nu_b}^L + \Gamma_{\tilde{A}_j^0, \nu_a, \nu_b}^{R*} \Gamma_{\tilde{A}_i^0, \nu_a, \nu_b}^R \right) \\
& + \sum_{b=1}^2 \Gamma_{\tilde{A}_j^0, Z, h_b}^* \Gamma_{\tilde{A}_i^0, Z, h_b} F_0(p^2, m_{h_b}^2, m_Z^2) + 2 \sum_{b=1}^2 \Gamma_{\tilde{A}_j^0, W^+, H_b^-}^* \Gamma_{\tilde{A}_i^0, W^+, H_b^-} F_0(p^2, m_{H_b^-}^2, m_{W^-}^2) \quad (179)
\end{aligned}$$

• Self-Energy for Charged Higgs (H^-)

$$\begin{aligned}
\Pi_{i,j}(p^2) = & +4 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, 0, m_{W^-}^2) \right) \Gamma_{\tilde{H}_j^+, W^-, \gamma}^* \Gamma_{\tilde{H}_i^+, W^-, \gamma} + 4 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{W^-}^2, m_Z^2) \right) \Gamma_{\tilde{H}_j^+, Z, W^-}^* \Gamma_{\tilde{H}_i^+, Z, W^-} \\
& - B_0(p^2, m_{\eta^Z}^2, m_{\eta^+}^2) \Gamma_{\tilde{H}_i^+, \eta^+, \eta^Z} \Gamma_{\tilde{H}_j^-, \eta^+, \eta^Z} - B_0(p^2, m_{\eta^-}^2, m_{\eta^Z}^2) \Gamma_{\tilde{H}_i^+, \eta^Z, \eta^-} \Gamma_{\tilde{H}_j^-, \eta^Z, \eta^-} \\
& + 4 \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, W^+, W^-} \left(-\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2 \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, Z, Z} \left(-\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) \\
& - \frac{1}{2} \sum_{a=1}^2 A_0(m_{A_a^0}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, A_a^0, A_a^0} - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, H_a^-, H_a^-} \\
& - \frac{1}{2} \sum_{a=1}^2 A_0(m_{h_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, h_a, h_a} + \sum_{a=1}^2 \sum_{b=1}^2 B_0(p^2, m_{H_a^-}^2, m_{A_b^0}^2) \Gamma_{\tilde{H}_j^+, H_a^-, A_b^0}^* \Gamma_{\tilde{H}_i^+, H_a^-, A_b^0} \\
& + \sum_{a=1}^2 \sum_{b=1}^2 B_0(p^2, m_{H_a^-}^2, m_{h_b}^2) \Gamma_{\tilde{H}_j^+, H_a^-, h_b}^* \Gamma_{\tilde{H}_i^+, H_a^-, h_b} \\
& - 6 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^3 B_0(p^2, m_{u_a}^2, m_{d_b}^2) m_{d_b} \left(\Gamma_{\tilde{H}_j^+, \tilde{u}_a, d_b}^{L*} \Gamma_{\tilde{H}_i^+, \tilde{u}_a, d_b}^R + \Gamma_{\tilde{H}_j^+, \tilde{u}_a, d_b}^{R*} \Gamma_{\tilde{H}_i^+, \tilde{u}_a, d_b}^L \right)
\end{aligned}$$

$$\begin{aligned}
& + 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}^4 m_{\tilde{\chi}_a^0} \sum_{b=1}^2 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^-}^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) \\
& + \sum_{a=1}^4 \sum_{b=1}^2 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} \\
& - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^i}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \nu_a^i, \nu_a^i} - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^R}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \nu_a^R, \nu_a^R} \\
& - 2 \sum_{a=1}^9 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^+, \nu_a, e_b}^{L*} \Gamma_{\tilde{H}_i^+, \nu_a, e_b}^L + \Gamma_{\tilde{H}_j^+, \nu_a, e_b}^{R*} \Gamma_{\tilde{H}_i^+, \nu_a, e_b}^R \right) \\
& + \sum_{a=1}^9 \sum_{b=1}^3 G_0(p^2, m_{\nu_a}^2, m_{e_b}^2) \left(\Gamma_{\tilde{H}_j^+, \nu_a, e_b}^{L*} \Gamma_{\tilde{H}_i^+, \nu_a, e_b}^L + \Gamma_{\tilde{H}_j^+, \nu_a, e_b}^{R*} \Gamma_{\tilde{H}_i^+, \nu_a, e_b}^R \right) \\
& + \sum_{a=1}^9 \sum_{b=1}^6 B_0(p^2, m_{\nu_a^i}^2, m_{\tilde{e}_b}^2) \Gamma_{\tilde{H}_j^+, \nu_a^i, \tilde{e}_b}^* \Gamma_{\tilde{H}_i^+, \nu_a^i, \tilde{e}_b} \\
& + \sum_{a=1}^9 \sum_{b=1}^6 B_0(p^2, m_{\nu_a^R}^2, m_{\tilde{e}_b}^2) \Gamma_{\tilde{H}_j^+, \nu_a^R, \tilde{e}_b}^* \Gamma_{\tilde{H}_i^+, \nu_a^R, \tilde{e}_b} + \sum_{b=1}^2 \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}^2 \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}^2 \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}^2 \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)
\end{aligned} \tag{180}$$

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

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) & = +2 \sum_{a=1}^2 \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{H_a^-}^2) \Gamma_{\tilde{\chi}_j^0, H_a^-, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^0, H_a^-, \tilde{\chi}_b^-}^R \\
& + \sum_{a=1}^2 \sum_{b=1}^4 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{h_a}^2) \Gamma_{\tilde{\chi}_j^0, h_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^0, h_a, \tilde{\chi}_b^0}^R
\end{aligned}$$

$$\begin{aligned}
& + \sum_{a=1}^4 m_{\tilde{\chi}_a^0} \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{A_b^0}^2) \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(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \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(p^2, m_{e_b}^2, m_{\tilde{e}_a}^2) \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(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \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 \\
& + \sum_{a=1}^9 \sum_{b=1}^9 B_0(p^2, m_{\nu_b}^2, m_{\nu_a^i}^2) \Gamma_{\tilde{\chi}_j^0, \nu_a^i, \nu_b}^{L*} m_{\nu_b} \Gamma_{\tilde{\chi}_i^0, \nu_a^i, \nu_b}^R \\
& + \sum_{a=1}^9 \sum_{b=1}^9 B_0(p^2, m_{\nu_b}^2, m_{\nu_a^R}^2) \Gamma_{\tilde{\chi}_j^0, \nu_a^R, \nu_b}^{L*} m_{\nu_b} \Gamma_{\tilde{\chi}_i^0, \nu_a^R, \nu_b}^R \\
& - 8 \sum_{b=1}^2 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{W^-}^2) \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}^4 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_Z^2) \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{181} \\
\Sigma_{i,j}^R(p^2) = & - \sum_{a=1}^2 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{H_a^-}^2) \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}^2 \sum_{b=1}^4 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{h_a}^2) \Gamma_{\tilde{\chi}_j^0, h_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, h_a, \tilde{\chi}_b^0}^R \\
& - \frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_a^0}^2, m_{A_b^0}^2) \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(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \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(p^2, m_{e_b}^2, m_{\tilde{e}_a}^2) \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(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{u}_a^*, u_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{u}_a^*, u_b}^R \\
& - \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{\nu_a^i}^2) \Gamma_{\tilde{\chi}_j^0, \nu_a^i, \nu_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \nu_a^i, \nu_b}^R
\end{aligned}$$

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 B_1 \left(p^2, m_{\nu_b}^2, m_{\nu_a^R}^2 \right) \Gamma_{\tilde{\chi}_j^0, \nu_a^R, \nu_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \nu_a^R, \nu_b}^R \\
& - 2 \sum_{b=1}^2 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}^4 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 (182) \\
\Sigma_{i,j}^L(p^2) = & - \sum_{a=1}^2 \sum_{b=1}^2 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}^2 \sum_{b=1}^4 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 \\
& - \frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^2 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 \\
& - \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 B_1 \left(p^2, m_{\nu_b}^2, m_{\nu_a^i}^2 \right) \Gamma_{\tilde{\chi}_j^0, \nu_a^i, \nu_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \nu_a^i, \nu_b}^L \\
& - \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 B_1 \left(p^2, m_{\nu_b}^2, m_{\nu_a^R}^2 \right) \Gamma_{\tilde{\chi}_j^0, \nu_a^R, \nu_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \nu_a^R, \nu_b}^L \\
& - 2 \sum_{b=1}^2 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}^4 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 (183)
\end{aligned}$$

• Self-Energy for Neutrinos (ν)

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) = & + 2 \sum_{a=1}^2 \sum_{b=1}^3 B_0 \left(p^2, m_{e_b}^2, m_{H_a^-}^2 \right) \Gamma_{\tilde{\nu}_j, H_a^+, e_b}^{L*} m_{e_b} \Gamma_{\tilde{\nu}_i, H_a^+, e_b}^R \\
& + \sum_{a=1}^2 \sum_{b=1}^9 B_0 \left(p^2, m_{\nu_b}^2, m_{h_a}^2 \right) \Gamma_{\tilde{\nu}_j, h_a, \nu_b}^{L*} m_{\nu_b} \Gamma_{\tilde{\nu}_i, h_a, \nu_b}^R \\
& + 2 \sum_{a=1}^6 \sum_{b=1}^2 B_0 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{e}_a}^2 \right) \Gamma_{\tilde{\nu}_j, \tilde{e}_a^*, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\nu}_i, \tilde{e}_a^*, \tilde{\chi}_b^-}^R
\end{aligned}$$

$$\begin{aligned}
& + \sum_{a=1}^9 m_{\nu_a} \sum_{b=1}^2 B_0 \left(p^2, m_{\nu_a}^2, m_{A_b^0}^2 \right) \Gamma_{\tilde{\nu}_j, \nu_a, A_b^0}^{L*} \Gamma_{\tilde{\nu}_i, \nu_a, A_b^0}^R \\
& + \sum_{a=1}^9 \sum_{b=1}^4 B_0 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{\nu_a^i}^2 \right) \Gamma_{\tilde{\nu}_j, \nu_a^i, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\nu}_i, \nu_a^i, \tilde{\chi}_b^0}^R \\
& + \sum_{a=1}^9 \sum_{b=1}^4 B_0 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{\nu_a^R}^2 \right) \Gamma_{\tilde{\nu}_j, \nu_a^R, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\nu}_i, \nu_a^R, \tilde{\chi}_b^0}^R \\
& - 8 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0 \left(p^2, m_{e_b}^2, m_{W^-}^2 \right) \right) \Gamma_{\tilde{\nu}_j, W^+, e_b}^{R*} m_{e_b} \Gamma_{\tilde{\nu}_i, W^+, e_b}^L \\
& - 4 \sum_{b=1}^9 \left(-\frac{1}{2} \text{rMS} + B_0 \left(p^2, m_{\nu_b}^2, m_Z^2 \right) \right) \Gamma_{\tilde{\nu}_j, Z, \nu_b}^{R*} m_{\nu_b} \Gamma_{\tilde{\nu}_i, Z, \nu_b}^L \tag{184}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) &= - \sum_{a=1}^2 \sum_{b=1}^3 B_1 \left(p^2, m_{e_b}^2, m_{H_a^-}^2 \right) \Gamma_{\tilde{\nu}_j, H_a^+, e_b}^{R*} \Gamma_{\tilde{\nu}_i, H_a^+, e_b}^R \\
& - \frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^9 B_1 \left(p^2, m_{\nu_b}^2, m_{h_a}^2 \right) \Gamma_{\tilde{\nu}_j, h_a, \nu_b}^{R*} \Gamma_{\tilde{\nu}_i, h_a, \nu_b}^R \\
& - \sum_{a=1}^6 \sum_{b=1}^2 B_1 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{e}_a}^2 \right) \Gamma_{\tilde{\nu}_j, \tilde{e}_a^*, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\nu}_i, \tilde{e}_a^*, \tilde{\chi}_b^-}^R \\
& - \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^2 B_1 \left(p^2, m_{\nu_a}^2, m_{A_b^0}^2 \right) \Gamma_{\tilde{\nu}_j, \nu_a, A_b^0}^{R*} \Gamma_{\tilde{\nu}_i, \nu_a, A_b^0}^R \\
& - \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^4 B_1 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{\nu_a^i}^2 \right) \Gamma_{\tilde{\nu}_j, \nu_a^i, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\nu}_i, \nu_a^i, \tilde{\chi}_b^0}^R \\
& - \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^4 B_1 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{\nu_a^R}^2 \right) \Gamma_{\tilde{\nu}_j, \nu_a^R, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\nu}_i, \nu_a^R, \tilde{\chi}_b^0}^R - 2 \sum_{b=1}^3 B_1 \left(p^2, m_{e_b}^2, m_{W^-}^2 \right) \Gamma_{\tilde{\nu}_j, W^+, e_b}^{L*} \Gamma_{\tilde{\nu}_i, W^+, e_b}^L \\
& - \sum_{b=1}^9 B_1 \left(p^2, m_{\nu_b}^2, m_Z^2 \right) \Gamma_{\tilde{\nu}_j, Z, \nu_b}^{L*} \Gamma_{\tilde{\nu}_i, Z, \nu_b}^L \tag{185}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) &= - \sum_{a=1}^2 \sum_{b=1}^3 B_1 \left(p^2, m_{e_b}^2, m_{H_a^-}^2 \right) \Gamma_{\tilde{\nu}_j, H_a^+, e_b}^{L*} \Gamma_{\tilde{\nu}_i, H_a^+, e_b}^L \\
& - \frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^9 B_1 \left(p^2, m_{\nu_b}^2, m_{h_a}^2 \right) \Gamma_{\tilde{\nu}_j, h_a, \nu_b}^{L*} \Gamma_{\tilde{\nu}_i, h_a, \nu_b}^L \\
& - \sum_{a=1}^6 \sum_{b=1}^2 B_1 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{e}_a}^2 \right) \Gamma_{\tilde{\nu}_j, \tilde{e}_a^*, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\nu}_i, \tilde{e}_a^*, \tilde{\chi}_b^-}^L
\end{aligned}$$

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^2 B_1(p^2, m_{\nu_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{\nu}_j, \nu_a, A_b^0}^{L*} \Gamma_{\tilde{\nu}_i, \nu_a, A_b^0}^L \\
& -\frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^4 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\nu_a^i}^2) \Gamma_{\tilde{\nu}_j, \nu_a^i, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\nu}_i, \nu_a^i, \tilde{\chi}_b^0}^L \\
& -\frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^4 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\nu_a^R}^2) \Gamma_{\tilde{\nu}_j, \nu_a^R, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\nu}_i, \nu_a^R, \tilde{\chi}_b^0}^L - 2 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{W^-}^2) \Gamma_{\tilde{\nu}_j, W^+, e_b}^{R*} \Gamma_{\tilde{\nu}_i, W^+, e_b}^R \\
& - \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_Z^2) \Gamma_{\tilde{\nu}_j, Z, \nu_b}^{R*} \Gamma_{\tilde{\nu}_i, Z, \nu_b}^R \tag{186}
\end{aligned}$$

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

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) = & + \sum_{a=1}^2 m_{\tilde{\chi}_a^-} \sum_{b=1}^2 B_0(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}^R \\
& + \sum_{a=1}^2 \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{h_a}^2) \Gamma_{\tilde{\chi}_j^+, h_a, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^+, h_a, \tilde{\chi}_b^-}^R \\
& + \sum_{a=1}^2 \sum_{b=1}^4 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}^3 m_{u_a} \sum_{b=1}^6 B_0(p^2, m_{u_a}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a, \tilde{d}_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a, \tilde{d}_b}^R \\
& + 3 \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{\tilde{d}_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a, \tilde{d}_b}^{L*} m_{\tilde{d}_b} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a, \tilde{d}_b}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^9 B_0(p^2, m_{\nu_b}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{e}_a, \nu_b}^{L*} m_{\nu_b} \Gamma_{\tilde{\chi}_i^+, \tilde{e}_a, \nu_b}^R \\
& + \sum_{a=1}^9 \sum_{b=1}^3 B_0(p^2, m_{e_b}^2, m_{\nu_a^i}^2) \Gamma_{\tilde{\chi}_j^+, \nu_a^i, e_b}^{L*} m_{e_b} \Gamma_{\tilde{\chi}_i^+, \nu_a^i, e_b}^R \\
& + \sum_{a=1}^9 \sum_{b=1}^3 B_0(p^2, m_{e_b}^2, m_{\nu_a^R}^2) \Gamma_{\tilde{\chi}_j^+, \nu_a^R, e_b}^{L*} m_{e_b} \Gamma_{\tilde{\chi}_i^+, \nu_a^R, e_b}^R \\
& - 4 \sum_{b=1}^2 \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}^2 \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
\end{aligned}$$

$$-4 \sum_{b=1}^4 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{W^-}^2) \right) \Gamma_{\tilde{\chi}_j^+, W^-, \tilde{\chi}_b^0}^{R*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^+, W^-, \tilde{\chi}_b^0}^L \quad (187)$$

$$\begin{aligned} \Sigma_{i,j}^R(p^2) = & -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^2 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}^2 \sum_{b=1}^2 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{1}{2} \sum_{a=1}^2 \sum_{b=1}^4 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}^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{3}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{\tilde{d}_b}^2, m_{\tilde{u}_a}^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}^6 \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{e}_a, \nu_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \tilde{e}_a, \nu_b}^R \\ & -\frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{\nu_a^i}^2) \Gamma_{\tilde{\chi}_j^+, \nu_a^i, e_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \nu_a^i, e_b}^R \\ & -\frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{\nu_a^R}^2) \Gamma_{\tilde{\chi}_j^+, \nu_a^R, e_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \nu_a^R, e_b}^R - \sum_{b=1}^2 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}^2 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}^4 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 \quad (188) \end{aligned}$$

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

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^9 B_1 \left(p^2, m_{\nu_b}^2, m_{\tilde{e}_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{e}_a, \nu_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{e}_a, \nu_b}^L \\
& -\frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^3 B_1 \left(p^2, m_{e_b}^2, m_{\nu_a^i}^2 \right) \Gamma_{\tilde{\chi}_j^+, \nu_a^i, e_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \nu_a^i, e_b}^L \\
& -\frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^3 B_1 \left(p^2, m_{e_b}^2, m_{\nu_a^R}^2 \right) \Gamma_{\tilde{\chi}_j^+, \nu_a^R, e_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \nu_a^R, e_b}^L - \sum_{b=1}^2 B_1 \left(p^2, m_{\tilde{\chi}_b^-}^2, 0 \right) \Gamma_{\tilde{\chi}_j^+, \gamma, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^+, \gamma, \tilde{\chi}_b^-}^R \\
& - \sum_{b=1}^2 B_1 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_Z^2 \right) \Gamma_{\tilde{\chi}_j^+, Z, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^+, Z, \tilde{\chi}_b^-}^R - \sum_{b=1}^4 B_1 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{W^-}^2 \right) \Gamma_{\tilde{\chi}_j^+, W^-, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^+, W^-, \tilde{\chi}_b^0}^R \quad (189)
\end{aligned}$$

• Self-Energy for Leptons (e)

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) &= + \sum_{a=1}^2 \sum_{b=1}^3 B_0 \left(p^2, m_{e_b}^2, m_{h_a}^2 \right) \Gamma_{\tilde{e}_j, h_a, e_b}^{L*} m_{e_b} \Gamma_{\tilde{e}_i, h_a, e_b}^R \\
& + \sum_{a=1}^2 \sum_{b=1}^9 B_0 \left(p^2, m_{\nu_b}^2, m_{H_a^-}^2 \right) \Gamma_{\tilde{e}_j, H_a^-, \nu_b}^{L*} m_{\nu_b} \Gamma_{\tilde{e}_i, H_a^-, \nu_b}^R \\
& + \sum_{a=1}^3 m_{e_a} \sum_{b=1}^2 B_0 \left(p^2, m_{e_a}^2, m_{A_b^0}^2 \right) \Gamma_{\tilde{e}_j, e_a, A_b^0}^{L*} \Gamma_{\tilde{e}_i, e_a, A_b^0}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^4 B_0 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2 \right) \Gamma_{\tilde{e}_j, \tilde{e}_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{e}_i, \tilde{e}_a, \tilde{\chi}_b^0}^R \\
& + \sum_{a=1}^9 \sum_{b=1}^2 B_0 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{\nu_a^i}^2 \right) \Gamma_{\tilde{e}_j, \nu_a^i, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{e}_i, \nu_a^i, \tilde{\chi}_b^-}^R \\
& + \sum_{a=1}^9 \sum_{b=1}^2 B_0 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{\nu_a^R}^2 \right) \Gamma_{\tilde{e}_j, \nu_a^R, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{e}_i, \nu_a^R, \tilde{\chi}_b^-}^R \\
& - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0 \left(p^2, m_{e_b}^2, 0 \right) \right) \Gamma_{\tilde{e}_j, \gamma, e_b}^{R*} m_{e_b} \Gamma_{\tilde{e}_i, \gamma, e_b}^L - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0 \left(p^2, m_{e_b}^2, m_Z^2 \right) \right) \Gamma_{\tilde{e}_j, Z, e_b}^{R*} m_{e_b} \Gamma_{\tilde{e}_i, Z, e_b}^L \\
& - 4 \sum_{b=1}^9 \left(-\frac{1}{2} \text{rMS} + B_0 \left(p^2, m_{\nu_b}^2, m_{W^-}^2 \right) \right) \Gamma_{\tilde{e}_j, W^-, \nu_b}^{R*} m_{\nu_b} \Gamma_{\tilde{e}_i, W^-, \nu_b}^L \quad (190)
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) &= -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1 \left(p^2, m_{e_b}^2, m_{h_a}^2 \right) \Gamma_{\tilde{e}_j, h_a, e_b}^{R*} \Gamma_{\tilde{e}_i, h_a, e_b}^R \\
& - \frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^9 B_1 \left(p^2, m_{\nu_b}^2, m_{H_a^-}^2 \right) \Gamma_{\tilde{e}_j, H_a^-, \nu_b}^{R*} \Gamma_{\tilde{e}_i, H_a^-, \nu_b}^R
\end{aligned}$$

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^2 B_1(p^2, m_{e_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{e}_j, e_a, A_b^0}^{R*} \Gamma_{\tilde{e}_i, e_a, A_b^0}^R \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^4 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{e}_j, \tilde{e}_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{e}_i, \tilde{e}_a, \tilde{\chi}_b^0}^R \\
& -\frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\nu_a^i}^2) \Gamma_{\tilde{e}_j, \nu_a^i, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{e}_i, \nu_a^i, \tilde{\chi}_b^-}^R \\
& -\frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\nu_a^R}^2) \Gamma_{\tilde{e}_j, \nu_a^R, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{e}_i, \nu_a^R, \tilde{\chi}_b^-}^R - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, 0) \Gamma_{\tilde{e}_j, \gamma, e_b}^{L*} \Gamma_{\tilde{e}_i, \gamma, e_b}^L \\
& - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_Z^2) \Gamma_{\tilde{e}_j, Z, e_b}^{L*} \Gamma_{\tilde{e}_i, Z, e_b}^L - \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{W^-}^2) \Gamma_{\tilde{e}_j, W^-, \nu_b}^{L*} \Gamma_{\tilde{e}_i, W^-, \nu_b}^L
\end{aligned} \tag{191}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) &= -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{h_a}^2) \Gamma_{\tilde{e}_j, h_a, e_b}^{L*} \Gamma_{\tilde{e}_i, h_a, e_b}^L \\
& -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{e}_j, H_a^-, \nu_b}^{L*} \Gamma_{\tilde{e}_i, H_a^-, \nu_b}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^2 B_1(p^2, m_{e_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{e}_j, e_a, A_b^0}^{L*} \Gamma_{\tilde{e}_i, e_a, A_b^0}^L \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^4 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{e}_j, \tilde{e}_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{e}_i, \tilde{e}_a, \tilde{\chi}_b^0}^L \\
& -\frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\nu_a^i}^2) \Gamma_{\tilde{e}_j, \nu_a^i, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{e}_i, \nu_a^i, \tilde{\chi}_b^-}^L \\
& -\frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\nu_a^R}^2) \Gamma_{\tilde{e}_j, \nu_a^R, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{e}_i, \nu_a^R, \tilde{\chi}_b^-}^L - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, 0) \Gamma_{\tilde{e}_j, \gamma, e_b}^{R*} \Gamma_{\tilde{e}_i, \gamma, e_b}^R \\
& - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_Z^2) \Gamma_{\tilde{e}_j, Z, e_b}^{R*} \Gamma_{\tilde{e}_i, Z, e_b}^R - \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{W^-}^2) \Gamma_{\tilde{e}_j, W^-, \nu_b}^{R*} \Gamma_{\tilde{e}_i, W^-, \nu_b}^R
\end{aligned} \tag{192}$$

• Self-Energy for Down-Quarks (d)

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

$$\begin{aligned}
& + \sum_{a=1}^3 m_{d_a} \sum_{b=1}^2 B_0(p^2, m_{d_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j, d_a, A_b^0}^{L*} \Gamma_{\tilde{d}_i, d_a, A_b^0}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_j, \tilde{u}_a, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{d}_i, \tilde{u}_a, \tilde{\chi}_b^-}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^4 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{\chi}_b^0}^R \\
& + \frac{4}{3} m_{\tilde{g}} \sum_{a=1}^6 B_0(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{g}_1}^R - \frac{16}{3} \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, 0) \right) \Gamma_{\tilde{d}_j, g, d_b}^{R*} m_{d_b} \Gamma_{\tilde{d}_i, g, d_b}^L \\
& - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, 0) \right) \Gamma_{\tilde{d}_j, \gamma, d_b}^{R*} m_{d_b} \Gamma_{\tilde{d}_i, \gamma, d_b}^L \\
& - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, m_{W^-}^2) \right) \Gamma_{\tilde{d}_j, W^-, u_b}^{R*} m_{u_b} \Gamma_{\tilde{d}_i, W^-, u_b}^L \\
& - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, m_Z^2) \right) \Gamma_{\tilde{d}_j, Z, d_b}^{R*} m_{d_b} \Gamma_{\tilde{d}_i, Z, d_b}^L \tag{193}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) & = -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{h_a}^2) \Gamma_{\tilde{d}_j, h_a, d_b}^{R*} \Gamma_{\tilde{d}_i, h_a, d_b}^R \\
& - \frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{d}_j, H_a^-, u_b}^{R*} \Gamma_{\tilde{d}_i, H_a^-, u_b}^R \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^2 B_1(p^2, m_{d_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j, d_a, A_b^0}^{R*} \Gamma_{\tilde{d}_i, d_a, A_b^0}^R \\
& - \frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_j, \tilde{u}_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{d}_i, \tilde{u}_a, \tilde{\chi}_b^-}^R \\
& - \frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^4 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{\chi}_b^0}^R \\
& - \frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{g}_1}^{R*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{g}_1}^R - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, g, d_b}^{L*} \Gamma_{\tilde{d}_i, g, d_b}^L \\
& - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, \gamma, d_b}^{L*} \Gamma_{\tilde{d}_i, \gamma, d_b}^L - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{W^-}^2) \Gamma_{\tilde{d}_j, W^-, u_b}^{L*} \Gamma_{\tilde{d}_i, W^-, u_b}^L \\
& - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_Z^2) \Gamma_{\tilde{d}_j, Z, d_b}^{L*} \Gamma_{\tilde{d}_i, Z, d_b}^L \tag{194}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) = & -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{h_a}^2) \Gamma_{\tilde{d}_j, h_a, d_b}^{L*} \Gamma_{\tilde{d}_i, h_a, d_b}^L \\
& -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{d}_j, H_a^-, u_b}^{L*} \Gamma_{\tilde{d}_i, H_a^-, u_b}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^2 B_1(p^2, m_{d_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j, d_a, A_b^0}^{L*} \Gamma_{\tilde{d}_i, d_a, A_b^0}^L \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_j, \tilde{u}_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{d}_i, \tilde{u}_a, \tilde{\chi}_b^-}^L \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^4 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{d_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{\chi}_b^0}^L \\
& -\frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{g}_1}^L - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, g, d_b}^{R*} \Gamma_{\tilde{d}_i, g, d_b}^R \\
& - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, \gamma, d_b}^{R*} \Gamma_{\tilde{d}_i, \gamma, d_b}^R - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{W^-}^2) \Gamma_{\tilde{d}_j, W^-, u_b}^{R*} \Gamma_{\tilde{d}_i, W^-, u_b}^R \\
& - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_Z^2) \Gamma_{\tilde{d}_j, Z, d_b}^{R*} \Gamma_{\tilde{d}_i, Z, d_b}^R
\end{aligned} \tag{195}$$

• **Self-Energy for Up-Quarks** (u)

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

$$\begin{aligned}
& -4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, 0) \right) \Gamma_{\tilde{u}_j, \gamma, u_b}^{R*} m_{u_b} \Gamma_{\tilde{u}_i, \gamma, u_b}^L - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, m_Z^2) \right) \Gamma_{\tilde{u}_j, Z, u_b}^{R*} m_{u_b} \Gamma_{\tilde{u}_i, Z, u_b}^L \\
& -4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, m_{W^-}^2) \right) \Gamma_{\tilde{u}_j, W^+, d_b}^{R*} m_{d_b} \Gamma_{\tilde{u}_i, W^+, d_b}^L \tag{196}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) &= -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{u}_j, H_a^+, d_b}^{R*} \Gamma_{\tilde{u}_i, H_a^+, d_b}^R \\
& -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{h_a}^2) \Gamma_{\tilde{u}_j, h_a, u_b}^{R*} \Gamma_{\tilde{u}_i, h_a, u_b}^R \\
& -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^6 B_1(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{u}_j, \tilde{\chi}_a^+, \tilde{d}_b}^{R*} \Gamma_{\tilde{u}_i, \tilde{\chi}_a^+, \tilde{d}_b}^R \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^2 B_1(p^2, m_{u_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{u}_j, u_a, A_b^0}^{R*} \Gamma_{\tilde{u}_i, u_a, A_b^0}^R \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^4 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{\chi}_b^0}^R \\
& -\frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{g}_1}^{R*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{g}_1}^R - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, g, u_b}^{L*} \Gamma_{\tilde{u}_i, g, u_b}^L \\
& -\sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, \gamma, u_b}^{L*} \Gamma_{\tilde{u}_i, \gamma, u_b}^L - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_Z^2) \Gamma_{\tilde{u}_j, Z, u_b}^{L*} \Gamma_{\tilde{u}_i, Z, u_b}^L \\
& -\sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{W^-}^2) \Gamma_{\tilde{u}_j, W^+, d_b}^{L*} \Gamma_{\tilde{u}_i, W^+, d_b}^L \tag{197}
\end{aligned}$$

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

$$\begin{aligned}
& -\frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{g}_1}^L - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, g, u_b}^{R*} \Gamma_{\tilde{u}_i, g, u_b}^R \\
& - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, \gamma, u_b}^{R*} \Gamma_{\tilde{u}_i, \gamma, u_b}^R - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_Z^2) \Gamma_{\tilde{u}_j, Z, u_b}^{R*} \Gamma_{\tilde{u}_i, Z, u_b}^R \\
& - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{W^-}^2) \Gamma_{\tilde{u}_j, W^+, d_b}^{R*} \Gamma_{\tilde{u}_i, W^+, d_b}^R
\end{aligned} \tag{198}$$

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

$$\begin{aligned}
\Sigma^S(p^2) &= + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{g}_j, \tilde{d}_a^*, d_b}^{L*} m_{d_b} \Gamma_{\tilde{g}_i, \tilde{d}_a^*, d_b}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{g}_j, \tilde{u}_a^*, u_b}^{L*} m_{u_b} \Gamma_{\tilde{g}_i, \tilde{u}_a^*, u_b}^R - 12 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{g}}^2, 0) \right) \Gamma_{\tilde{g}_j, g, \tilde{g}_1}^{R*} m_{\tilde{g}} \Gamma_{\tilde{g}_i, g, \tilde{g}_1}^L
\end{aligned} \tag{199}$$

$$\begin{aligned}
\Sigma^R(p^2) &= -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{g}_j, \tilde{d}_a^*, d_b}^{R*} \Gamma_{\tilde{g}_i, \tilde{d}_a^*, d_b}^R \\
& - \frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{g}_j, \tilde{u}_a^*, u_b}^{R*} \Gamma_{\tilde{g}_i, \tilde{u}_a^*, u_b}^R - 3B_1(p^2, m_{\tilde{g}}^2, 0) \Gamma_{\tilde{g}_j, g, \tilde{g}_1}^{L*} \Gamma_{\tilde{g}_i, g, \tilde{g}_1}^L
\end{aligned} \tag{200}$$

$$\begin{aligned}
\Sigma^L(p^2) &= -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{g}_j, \tilde{d}_a^*, d_b}^{L*} \Gamma_{\tilde{g}_i, \tilde{d}_a^*, d_b}^L \\
& - \frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{g}_j, \tilde{u}_a^*, u_b}^{L*} \Gamma_{\tilde{g}_i, \tilde{u}_a^*, u_b}^L - 3B_1(p^2, m_{\tilde{g}}^2, 0) \Gamma_{\tilde{g}_j, g, \tilde{g}_1}^{R*} \Gamma_{\tilde{g}_i, g, \tilde{g}_1}^R
\end{aligned} \tag{201}$$

• **Self-Energy for Z-Boson (Z)**

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

$$\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) \left. \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) \left. \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) \left. \right] \\
& + \frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^4 \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) \left. \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) + \frac{1}{2} \sum_{a=1}^9 A_0 \left(m_{\nu_a^i}^2 \right) \Gamma_{Z, Z, \nu_a^i, \nu_a^i} \\
& + \frac{1}{2} \sum_{a=1}^9 A_0 \left(m_{\nu_a^R}^2 \right) \Gamma_{Z, Z, \nu_a^R, \nu_a^R} - 4 \sum_{a=1}^9 \sum_{b=1}^9 |\Gamma_{Z, \nu_a^R, \nu_b^i}|^2 B_{00} \left(p^2, m_{\nu_b^i}^2, m_{\nu_a^R}^2 \right) \\
& + \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 \left[\left(|\Gamma_{Z, \nu_a, \nu_b}^L|^2 + |\Gamma_{Z, \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, \nu_a, \nu_b}^{L*} \Gamma_{Z, \nu_a, \nu_b}^R \right) \left. \right] \\
& + 2 \sum_{b=1}^2 |\Gamma_{Z, W^+, H_b^-}|^2 B_0 \left(p^2, m_{W^-}^2, m_{H_b^-}^2 \right) + \sum_{b=1}^2 |\Gamma_{Z, Z, h_b}|^2 B_0 \left(p^2, m_Z^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) \tag{202}
\end{aligned}$$

• Self-Energy for W-Boson (W^-)

$$\begin{aligned}
\Pi(p^2) = & -12 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{W^+, \tilde{u}_a^*, \tilde{d}_b}|^2 B_{00}(p^2, m_{\tilde{d}_b}^2, m_{\tilde{u}_a}^2) + 2\text{rMS}m_{W^-}^2 \Gamma_{W^-, W^+, W^+, W^-}^1 + 3 \sum_{a=1}^3 \sum_{b=1}^3 \left[(|\Gamma_{W^+, \tilde{u}_a, \tilde{d}_b}^L|^2 + |\Gamma_{W^+, \tilde{u}_a, \tilde{d}_b}^R|^2) \right. \\
& + 4B_0(p^2, m_{\tilde{u}_a}^2, m_{\tilde{d}_b}^2) m_{\tilde{d}_b} m_{\tilde{u}_a} \Re(\Gamma_{W^+, \tilde{u}_a, \tilde{d}_b}^{L*} \Gamma_{W^+, \tilde{u}_a, \tilde{d}_b}^R) \left. \right] + 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{W^-, W^+, \tilde{d}_a^*, \tilde{d}_a} + 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{W^-, W^+, \tilde{u}_a^*, \tilde{u}_a} \\
& + 4B_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} m_{\tilde{\chi}_a^0} \Re(\Gamma_{W^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^{L*} \Gamma_{W^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^R) \left. \right] + \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{W^-, W^+, \tilde{e}_a^*, \tilde{e}_a} + \sum_{a=1}^9 \sum_{b=1}^3 \left[(|\Gamma_{W^+, \nu_a, e_b}^L|^2 + |\Gamma_{W^+, \nu_a, e_b}^R|^2) \right. \\
& + 4B_0(p^2, m_{\nu_a}^2, m_{e_b}^2) m_{e_b} m_{\nu_a} \Re(\Gamma_{W^+, \nu_a, e_b}^{L*} \Gamma_{W^+, \nu_a, e_b}^R) \left. \right] + \sum_{b=1}^2 |\Gamma_{W^+, \gamma, H_b^-}|^2 B_0(p^2, 0, m_{H_b^-}^2) + \sum_{b=1}^2 |\Gamma_{W^+, W^-, h_b}|^2 B_0(p^2, m_{h_b}^2)
\end{aligned} \tag{203}$$

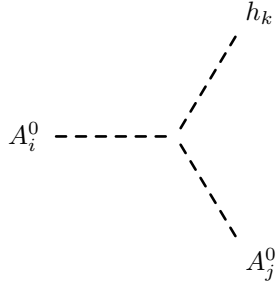
8.2 Tadpoles

$$\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}^2 A_0(m_{A_a^0}^2) \Gamma_{\tilde{h}_i, A_a^0, A_a^0} \\
& - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\tilde{h}_i, H_a^+, H_a^-} - \frac{1}{2} \sum_{a=1}^2 A_0(m_{h_a}^2) \Gamma_{\tilde{h}_i, h_a, h_a} \\
& + 2 \sum_{a=1}^2 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_{e_a}^2) m_{e_a} \left(\Gamma_{\tilde{h}_i, \tilde{e}_a, e_a}^L + \Gamma_{\tilde{h}_i, \tilde{e}_a, 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, u_a}^L + \Gamma_{\tilde{h}_i, \tilde{u}_a, u_a}^R \right) + \sum_{a=1}^4 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} \\
& - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^i}^2) \Gamma_{\tilde{h}_i, \nu_a^i, \nu_a^i} - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^R}^2) \Gamma_{\tilde{h}_i, \nu_a^R, \nu_a^R} \\
& + \sum_{a=1}^9 A_0(m_{\nu_a}^2) m_{\nu_a} \left(\Gamma_{\tilde{h}_i, \nu_a, \nu_a}^L + \Gamma_{\tilde{h}_i, \nu_a, \nu_a}^R \right)
\end{aligned} \tag{204}$$

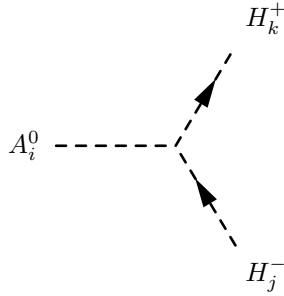
$$\delta t_{\nu^R}^{(1)} = 0 \tag{205}$$

9 Interactions for eigenstates 'EWSB'

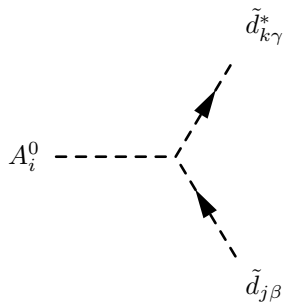
9.1 Three Scalar-Interaction



$$-\frac{i}{4}(g_1^2 + g_2^2)(Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A)(v_d Z_{k1}^H - v_u Z_{k2}^H) \quad (206)$$

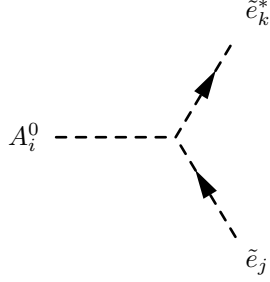


$$\frac{1}{4}g_2^2(v_d Z_{i2}^A + v_u Z_{i1}^A)(-Z_{j1}^+ Z_{k2}^+ + Z_{j2}^+ Z_{k1}^+) \quad (207)$$

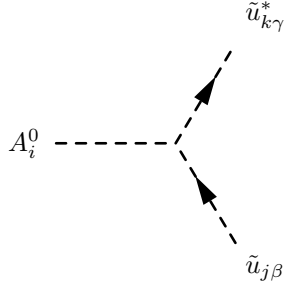


$$\frac{1}{\sqrt{2}}\delta_{\beta\gamma}\left(\sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Z_{k3+a}^D T_{d,ab} Z_{i1}^A - \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{D,*} T_{d,ab}^* Z_{kb}^D Z_{i1}^A\right)$$

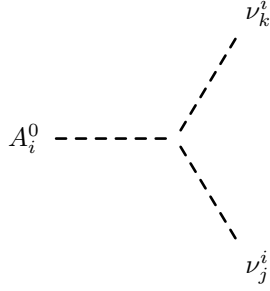
$$+ \left(-\mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^D Z_{kb}^D + \mu^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \right) Z_{i2}^A \quad (208)$$



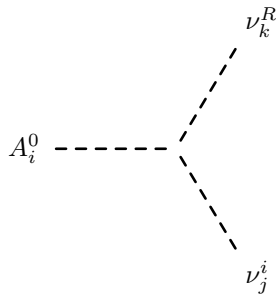
$$\frac{1}{\sqrt{2}} \left(\sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Z_{k3+a}^E T_{e,ab} Z_{i1}^A - \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{E,*} T_{e,ab}^* Z_{kb}^E Z_{i1}^A \right) \\ + \left(-\mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^E Z_{kb}^E + \mu^* \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \right) Z_{i2}^A \quad (209)$$



$$\frac{1}{\sqrt{2}} \delta_{\beta\gamma} \left(\mu^* \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U Z_{i1}^A - \mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{j3+a}^{U,*} Z_{kb}^U Z_{i1}^A \right) \\ + \left(-\sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{U,*} T_{u,ab}^* Z_{kb}^U + \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Z_{k3+a}^U T_{u,ab} \right) Z_{i2}^A \quad (210)$$

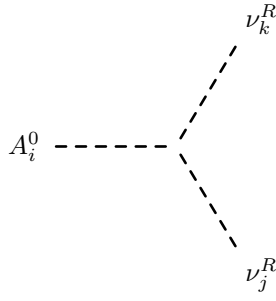


$$\begin{aligned}
& \frac{1}{2} \frac{1}{\sqrt{2}} \left(-\mu \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{j3+a}^{i,*} Z_{i1}^A - \mu \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} Z_{i1}^A \right. \\
& + \mu^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} Z_{i1}^A + \mu^* \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} Z_{i1}^A \\
& - \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{\nu,ab}^* Z_{i2}^A - \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} T_{\nu,ab}^* Z_{i2}^A \\
& + \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{\nu,ab} Z_{i2}^A + \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} T_{\nu,ab} Z_{i2}^A \\
& - \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* M_{\nu,ab} Z_{i2}^A - \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* M_{\nu,ab} Z_{i2}^A \\
& \left. + \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 M_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^A + \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 M_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^A \right) \quad (211)
\end{aligned}$$

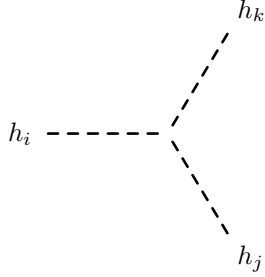


$$\begin{aligned}
& -\frac{i}{2} \frac{1}{\sqrt{2}} \left(\mu \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{j3+a}^{i,*} Z_{i1}^A - \mu \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} Z_{i1}^A \right. \\
& \left. + \mu^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} Z_{i1}^A - \mu^* \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i1}^A \right)
\end{aligned}$$

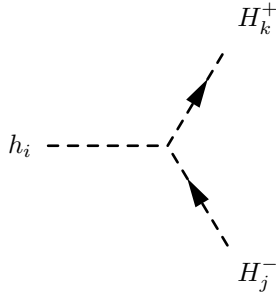
$$\begin{aligned}
& + \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{\nu,ab}^* Z_{i2}^A - \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{\nu,ab}^* Z_{i2}^A \\
& + \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{\nu,ab} Z_{i2}^A - \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{\nu,ab} Z_{i2}^A \\
& + \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* M_{\nu,ab} Z_{i2}^A - \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* M_{\nu,ab} Z_{i2}^A \\
& - \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 M_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^A + \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 M_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^A
\end{aligned} \tag{212}$$



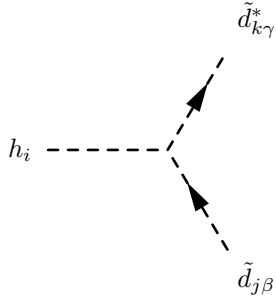
$$\begin{aligned}
& \frac{1}{2} \frac{1}{\sqrt{2}} \left(-\mu \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{j3+a}^{R,*} Z_{i1}^A - \mu \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} Z_{i1}^A \right. \\
& + \mu^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} Z_{i1}^A + \mu^* \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i1}^A \\
& - \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} T_{\nu,ab}^* Z_{i2}^A - \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{\nu,ab}^* Z_{i2}^A \\
& + \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} T_{\nu,ab} Z_{i2}^A + \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{\nu,ab} Z_{i2}^A \\
& - \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* M_{\nu,ab} Z_{i2}^A - \sum_{c=1}^3 Z_{jc}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* M_{\nu,ab} Z_{i2}^A \\
& \left. + \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 M_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^A + \sum_{c=1}^3 Z_{j6+c}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 M_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^A \right)
\end{aligned} \tag{213}$$



$$\begin{aligned}
& \frac{i}{4} (g_1^2 + g_2^2) \left(Z_{i2}^H \left(Z_{j1}^H (v_d Z_{k2}^H + v_u Z_{k1}^H) + Z_{j2}^H (-3v_u Z_{k2}^H + v_d Z_{k1}^H) \right) \right. \\
& \left. + Z_{i1}^H \left(Z_{j1}^H (-3v_d Z_{k1}^H + v_u Z_{k2}^H) + Z_{j2}^H (v_d Z_{k2}^H + v_u Z_{k1}^H) \right) \right)
\end{aligned} \tag{214}$$

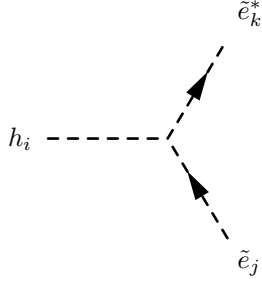


$$\begin{aligned}
& -\frac{i}{4} \left(Z_{i1}^H \left(Z_{j1}^+ \left((g_1^2 + g_2^2) v_d Z_{k1}^+ + g_2^2 v_u Z_{k2}^+ \right) + Z_{j2}^+ \left((-g_1^2 + g_2^2) v_d Z_{k2}^+ + g_2^2 v_u Z_{k1}^+ \right) \right) \right. \\
& \left. + Z_{i2}^H \left(Z_{j1}^+ \left((-g_1^2 + g_2^2) v_u Z_{k1}^+ + g_2^2 v_d Z_{k2}^+ \right) + Z_{j2}^+ \left((g_1^2 + g_2^2) v_u Z_{k2}^+ + g_2^2 v_d Z_{k1}^+ \right) \right) \right)
\end{aligned} \tag{215}$$

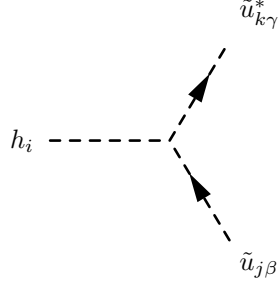


$$\frac{i}{12} \delta_{\beta\gamma} \left((3g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D (v_d Z_{i1}^H - v_u Z_{i2}^H) \right)$$

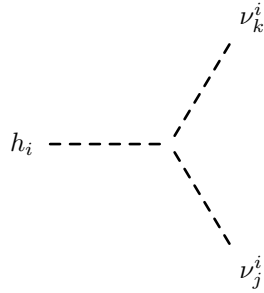
$$\begin{aligned}
& + 2 \left(g_1^2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{k3+a}^D \left(v_d Z_{i1}^H - v_u Z_{i2}^H \right) \right. \\
& - 3 \left(\sqrt{2} \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Z_{k3+a}^D T_{d,ab} Z_{i1}^H + \sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{D,*} T_{d,ab}^* Z_{kb}^D Z_{i1}^H \right. \\
& + 2v_d \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{d,ba} Z_{k3+b}^D Z_{i1}^H + 2v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{kc}^D Z_{i1}^H \\
& \left. \left. - \sqrt{2} \mu^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D Z_{i2}^H - \sqrt{2} \mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{kb}^D Z_{i2}^H \right) \right) \quad (216)
\end{aligned}$$



$$\begin{aligned}
& - \frac{i}{4} \left(\left(-g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \left(v_d Z_{i1}^H - v_u Z_{i2}^H \right) \right. \\
& + 2 \left(\sqrt{2} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Z_{k3+a}^E T_{e,ab} Z_{i1}^H + \sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{E,*} T_{e,ab}^* Z_{kb}^E Z_{i1}^H \right. \\
& + 2v_d \sum_{c=1}^3 Z_{j3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{e,ba} Z_{k3+b}^E Z_{i1}^H + 2v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{kc}^E Z_{i1}^H \\
& \left. - \sqrt{2} \mu^* \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E Z_{i2}^H - \sqrt{2} \mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{kb}^E Z_{i2}^H \right) \\
& \left. + g_1^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E \left(-v_d Z_{i1}^H + v_u Z_{i2}^H \right) \right) \quad (217)
\end{aligned}$$

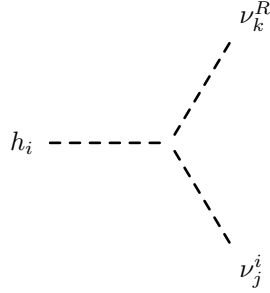


$$\begin{aligned}
& \frac{i}{12} \delta_{\beta\gamma} \left(\left(-3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \left(v_d Z_{i1}^H - v_u Z_{i2}^H \right) \right. \\
& - 2 \left(-3\sqrt{2}\mu^* \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U Z_{i1}^H - 3\sqrt{2}\mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{j3+a}^{U,*} Z_{kb}^U Z_{i1}^H \right. \\
& + 3\sqrt{2} \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Z_{k3+a}^U T_{u,ab} Z_{i2}^H + 3\sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{U,*} T_{u,ab}^* Z_{kb}^U Z_{i2}^H \\
& + 6v_u \sum_{c=1}^3 Z_{j3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{u,ba} Z_{k3+b}^U Z_{i2}^H + 6v_u \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{kc}^U Z_{i2}^H \\
& \left. \left. + 2g_1^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \left(v_d Z_{i1}^H - v_u Z_{i2}^H \right) \right) \right) \tag{218}
\end{aligned}$$



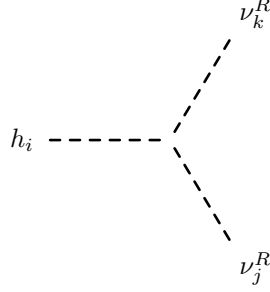
$$\begin{aligned}
& - \frac{i}{4} \left(-\sqrt{2}\mu \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{j3+a}^{i,*} Z_{i1}^H - \sqrt{2}\mu \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} Z_{i1}^H \right. \\
& - \sqrt{2}\mu^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} Z_{i1}^H - \sqrt{2}\mu^* \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} Z_{i1}^H \\
& \left. + \sqrt{2} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{\nu,ab}^* Z_{i2}^H + \sqrt{2} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} T_{\nu,ab}^* Z_{i2}^H \right)
\end{aligned}$$

$$\begin{aligned}
& + \sqrt{2} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{\nu,ab} Z_{i2}^H + \sqrt{2} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} T_{\nu,ab} Z_{i2}^H \\
& + \sqrt{2} \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* M_{\nu,ab} Z_{i2}^H + \sqrt{2} \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* M_{\nu,ab} Z_{i2}^H \\
& + \sqrt{2} \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 M_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H + \sqrt{2} \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 M_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H \\
& + 2v_u \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H + 2v_u \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H \\
& + 2v_u \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^H \\
& + 2v_u \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^H \\
& + \left(g_1^2 + g_2^2 \right) \sum_{a=1}^3 Z_{ja}^{i,*} Z_{ka}^{i,*} \left(v_d Z_{i1}^H - v_u Z_{i2}^H \right)
\end{aligned} \tag{219}$$



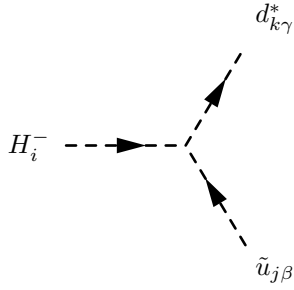
$$\begin{aligned}
& \frac{1}{4} \left(-\sqrt{2}\mu \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{j3+a}^{i,*} Z_{i1}^H + \sqrt{2}\mu \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} Z_{i1}^H \right. \\
& + \sqrt{2}\mu^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} Z_{i1}^H - \sqrt{2}\mu^* \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i1}^H \\
& + \sqrt{2} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{\nu,ab}^* Z_{i2}^H - \sqrt{2} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{\nu,ab}^* Z_{i2}^H \\
& - \sqrt{2} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{\nu,ab} Z_{i2}^H + \sqrt{2} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{\nu,ab} Z_{i2}^H \\
& \left. + \sqrt{2} \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* M_{\nu,ab} Z_{i2}^H - \sqrt{2} \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* M_{\nu,ab} Z_{i2}^H \right)
\end{aligned}$$

$$\begin{aligned}
& + \sqrt{2} \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 M_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H - \sqrt{2} \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 M_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H \\
& + 2v_u \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H - 2v_u \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H \\
& - 2v_u \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^H \\
& + 2v_u \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^H \Big) \tag{220}
\end{aligned}$$

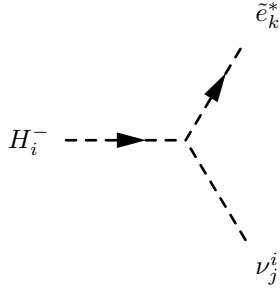


$$\begin{aligned}
& - \frac{i}{4} \left(-\sqrt{2}\mu \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{j3+a}^{R,*} Z_{i1}^H - \sqrt{2}\mu \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} Z_{i1}^H \right. \\
& - \sqrt{2}\mu^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} Z_{i1}^H - \sqrt{2}\mu^* \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i1}^H \\
& + \sqrt{2} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} T_{\nu,ab}^* Z_{i2}^H + \sqrt{2} \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{\nu,ab}^* Z_{i2}^H \\
& + \sqrt{2} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} T_{\nu,ab} Z_{i2}^H + \sqrt{2} \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{\nu,ab} Z_{i2}^H \\
& + \sqrt{2} \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* M_{\nu,ab} Z_{i2}^H + \sqrt{2} \sum_{c=1}^3 Z_{jc}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* M_{\nu,ab} Z_{i2}^H \\
& + \sqrt{2} \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 M_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H + \sqrt{2} \sum_{c=1}^3 Z_{j6+c}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 M_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H \\
& + 2v_u \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H + 2v_u \sum_{c=1}^3 Z_{jc}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H \\
& + 2v_u \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^H
\end{aligned}$$

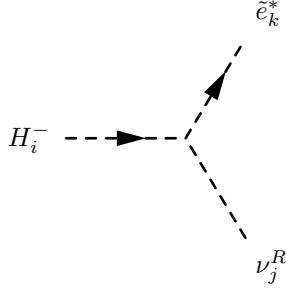
$$\begin{aligned}
& + 2v_u \sum_{c=1}^3 Z_{j3+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^H \\
& + \left(g_1^2 + g_2^2 \right) \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^{R,*} \left(v_d Z_{i1}^H - v_u Z_{i2}^H \right)
\end{aligned} \tag{221}$$



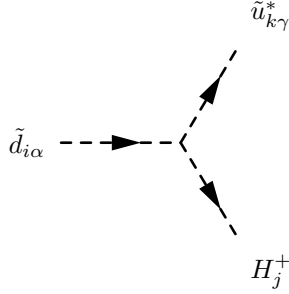
$$\begin{aligned}
& - \frac{i}{4} \delta_{\beta\gamma} \left(\sqrt{2} g_2^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^D \left(v_d Z_{i1}^+ + v_u Z_{i2}^+ \right) \right. \\
& - 2 \left(2 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Z_{k3+a}^D T_{d,ab} Z_{i1}^+ + 2\mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{j3+a}^{U,*} Z_{kb}^D Z_{i1}^+ \right. \\
& + \sqrt{2} v_u \sum_{c=1}^3 Z_{j3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{d,ba} Z_{k3+b}^D Z_{i1}^+ \\
& + \sqrt{2} v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{kc}^D Z_{i1}^+ + 2\mu^* \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D Z_{i2}^+ \\
& + 2 \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{U,*} T_{u,ab}^* Z_{kb}^D Z_{i2}^+ + \sqrt{2} v_d \sum_{c=1}^3 Z_{j3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{d,ba} Z_{k3+b}^D Z_{i2}^+ \\
& \left. \left. + \sqrt{2} v_u \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{kc}^D Z_{i2}^+ \right) \right)
\end{aligned} \tag{222}$$



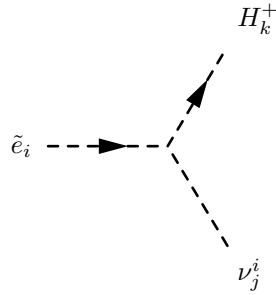
$$\begin{aligned}
& \frac{1}{4} \left(g_2^2 \sum_{a=1}^3 Z_{ja}^{i,*} Z_{ka}^E \left(v_d Z_{i1}^+ + v_u Z_{i2}^+ \right) \right. \\
& - 2 \left(\sqrt{2} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^E T_{e,ab} Z_{i1}^+ + \sqrt{2} \mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* Z_{j3+a}^{i,*} Z_{kb}^E Z_{i1}^+ \right. \\
& + v_u \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ca}^* Y_{e,ba} Z_{k3+b}^E Z_{i1}^+ + v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{kc}^E Z_{i1}^+ \\
& + \sqrt{2} \mu^* \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E Z_{i2}^+ + \sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{\nu,ab}^* Z_{kb}^E Z_{i2}^+ \\
& + v_d \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ca}^* Y_{e,ba} Z_{k3+b}^E Z_{i2}^+ + \sqrt{2} \sum_{c=1}^3 \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* M_{\nu,ab} Z_{kc}^E Z_{i2}^+ \\
& \left. \left. + v_u \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{kc}^E Z_{i2}^+ \right) \right) \tag{223}
\end{aligned}$$



$$\begin{aligned}
& - \frac{i}{4} \left(g_2^2 \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^E \left(v_d Z_{i1}^+ + v_u Z_{i2}^+ \right) \right. \\
& - 2 \left(\sqrt{2} \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^E T_{e,ab} Z_{i1}^+ + \sqrt{2} \mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* Z_{j3+a}^{R,*} Z_{kb}^E Z_{i1}^+ \right. \\
& + v_u \sum_{c=1}^3 Z_{j3+c}^{R,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ca}^* Y_{e,ba} Z_{k3+b}^E Z_{i1}^+ + v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{kc}^E Z_{i1}^+ \\
& + \sqrt{2} \mu^* \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E Z_{i2}^+ + \sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{R,*} T_{\nu,ab}^* Z_{kb}^E Z_{i2}^+ \\
& + v_d \sum_{c=1}^3 Z_{j3+c}^{R,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ca}^* Y_{e,ba} Z_{k3+b}^E Z_{i2}^+ + \sqrt{2} \sum_{c=1}^3 \sum_{b=1}^3 Z_{j6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* M_{\nu,ab} Z_{kc}^E Z_{i2}^+ \\
& \left. \left. + v_u \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{kc}^E Z_{i2}^+ \right) \right) \tag{224}
\end{aligned}$$

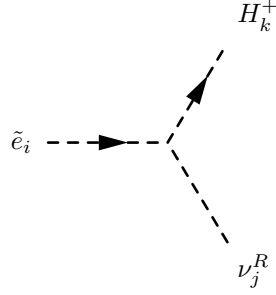


$$\begin{aligned}
& -\frac{i}{4}\delta_{\alpha\gamma}\left(\sqrt{2}g_2^2\sum_{a=1}^3Z_{ia}^{D,*}Z_{ka}^U\left(v_dZ_{j1}^++v_uZ_{j2}^+\right)\right. \\
& -2\left(2\mu^*\sum_{b=1}^3Z_{ib}^{D,*}\sum_{a=1}^3Y_{u,ab}Z_{k3+a}^UZ_{j1}^++2\sum_{b=1}^3\sum_{a=1}^3Z_{i3+a}^{D,*}T_{d,ab}^*Z_{kb}^UZ_{j1}^+\right. \\
& +\sqrt{2}v_u\sum_{c=1}^3Z_{i3+c}^{D,*}\sum_{b=1}^3\sum_{a=1}^3Y_{d,ca}^*Y_{u,ba}Z_{k3+b}^UZ_{j1}^+ \\
& +\sqrt{2}v_d\sum_{c=1}^3\sum_{b=1}^3Z_{ib}^{D,*}\sum_{a=1}^3Y_{d,ac}^*Y_{d,ab}Z_{kc}^UZ_{j1}^++2\sum_{b=1}^3Z_{ib}^{D,*}\sum_{a=1}^3Z_{k3+a}^UT_{u,ab}Z_{j2}^+ \\
& +2\mu\sum_{b=1}^3\sum_{a=1}^3Y_{d,ab}^*Z_{i3+a}^{D,*}Z_{kb}^UZ_{j2}^++\sqrt{2}v_d\sum_{c=1}^3Z_{i3+c}^{D,*}\sum_{b=1}^3\sum_{a=1}^3Y_{d,ca}^*Y_{u,ba}Z_{k3+b}^UZ_{j2}^+ \\
& \left.+\sqrt{2}v_u\sum_{c=1}^3\sum_{b=1}^3Z_{ib}^{D,*}\sum_{a=1}^3Y_{u,ac}^*Y_{u,ab}Z_{kc}^UZ_{j2}^+\right) \tag{225}
\end{aligned}$$



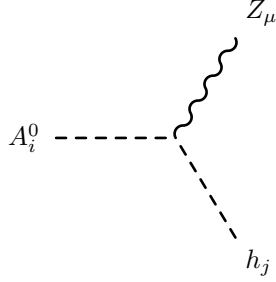
$$\frac{1}{4}\left(-g_2^2\sum_{a=1}^3Z_{ia}^{E,*}Z_{ja}^{i,*}\left(v_dZ_{k1}^++v_uZ_{k2}^+\right)\right)$$

$$\begin{aligned}
& + 2 \left(\sqrt{2} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{E,*} T_{e,ab}^* Z_{k1}^+ + \sqrt{2} \mu^* \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} Z_{k1}^+ \right. \\
& + v_d \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{k1}^+ + v_u \sum_{c=1}^3 Z_{i3+c}^{E,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Y_{e,ca}^* Y_{\nu,ba} Z_{k1}^+ \\
& + \sqrt{2} \mu \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{e,ab}^* Z_{i3+a}^{E,*} Z_{k2}^+ + \sqrt{2} \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{\nu,ab} Z_{k2}^+ \\
& + \sqrt{2} \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 M_{\nu,ac}^* Y_{\nu,ab} Z_{k2}^+ + v_u \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{k2}^+ \\
& \left. + v_d \sum_{c=1}^3 Z_{i3+c}^{E,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Y_{e,ca}^* Y_{\nu,ba} Z_{k2}^+ \right) \tag{226}
\end{aligned}$$

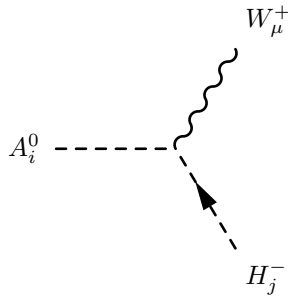


$$\begin{aligned}
& - \frac{i}{4} \left(g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^{R,*} \left(v_d Z_{k1}^+ + v_u Z_{k2}^+ \right) \right. \\
& - 2 \left(\sqrt{2} \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{E,*} T_{e,ab}^* Z_{k1}^+ + \sqrt{2} \mu^* \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} Z_{k1}^+ \right. \\
& + v_d \sum_{c=1}^3 Z_{jc}^{R,*} \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{k1}^+ + v_u \sum_{c=1}^3 Z_{i3+c}^{E,*} \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Y_{e,ca}^* Y_{\nu,ba} Z_{k1}^+ \\
& + \sqrt{2} \mu \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Y_{e,ab}^* Z_{i3+a}^{E,*} Z_{k2}^+ + \sqrt{2} \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} T_{\nu,ab} Z_{k2}^+ \\
& + \sqrt{2} \sum_{c=1}^3 Z_{j6+c}^{R,*} \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 M_{\nu,ac}^* Y_{\nu,ab} Z_{k2}^+ + v_u \sum_{c=1}^3 Z_{jc}^{R,*} \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{k2}^+ \\
& \left. + v_d \sum_{c=1}^3 Z_{i3+c}^{E,*} \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Y_{e,ca}^* Y_{\nu,ba} Z_{k2}^+ \right) \tag{227}
\end{aligned}$$

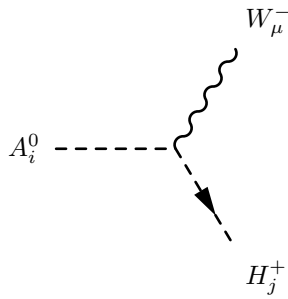
9.2 Two Scalar-One Vector Boson-Interaction



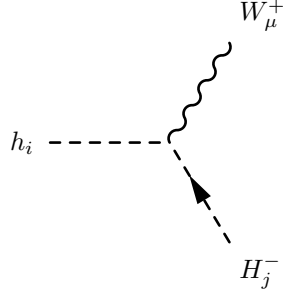
$$\frac{1}{2} \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left(Z_{i1}^A Z_{j1}^H - Z_{i2}^A Z_{j2}^H \right) \left(-p_\mu^{h_j} + p_\mu^{A_i^0} \right) \quad (228)$$



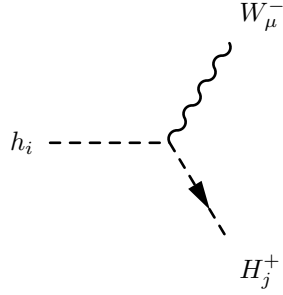
$$\frac{1}{2} g_2 \left(Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+ \right) \left(-p_\mu^{H_j^-} + p_\mu^{A_i^0} \right) \quad (229)$$



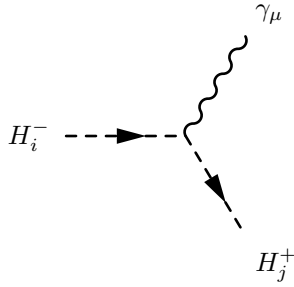
$$\frac{1}{2} g_2 \left(Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+ \right) \left(-p_\mu^{H_j^+} + p_\mu^{A_i^0} \right) \quad (230)$$



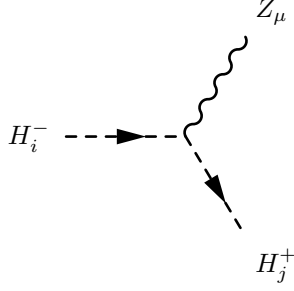
$$\frac{i}{2}g_2\left(Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+\right)\left(-p_\mu^{H_j^-} + p_\mu^{h_i}\right) \quad (231)$$



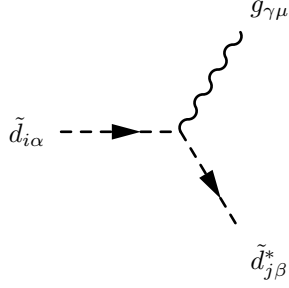
$$-\frac{i}{2}g_2\left(Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+\right)\left(-p_\mu^{H_j^+} + p_\mu^{h_i}\right) \quad (232)$$



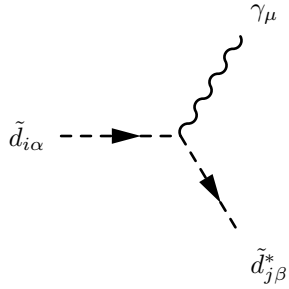
$$\frac{i}{2}\left(g_1 \cos \Theta_W + g_2 \sin \Theta_W\right)\left(Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+\right)\left(-p_\mu^{H_j^+} + p_\mu^{H_i^-}\right) \quad (233)$$



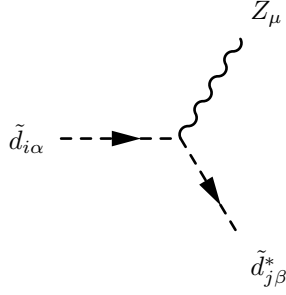
$$\frac{i}{2} \left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left(Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+ \right) \left(-p_\mu^{H_j^+} + p_\mu^{H_i^-} \right) \quad (234)$$



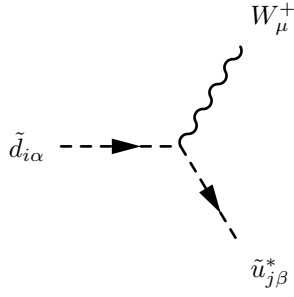
$$-\frac{i}{2} g_3 \delta_{ij} \lambda_{\beta, \alpha}^\gamma \left(-p_\mu^{\tilde{d}_{j\beta}^*} + p_\mu^{\tilde{d}_{i\alpha}} \right) \quad (235)$$



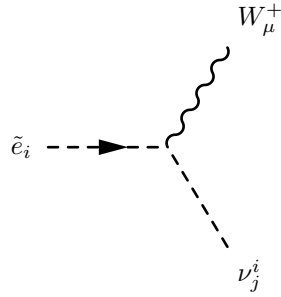
$$-\frac{i}{6} \delta_{\alpha\beta} \left(-2g_1 \cos \Theta_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D + \left(-3g_2 \sin \Theta_W + g_1 \cos \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \right) \left(-p_\mu^{\tilde{d}_{j\beta}^*} + p_\mu^{\tilde{d}_{i\alpha}} \right) \quad (236)$$



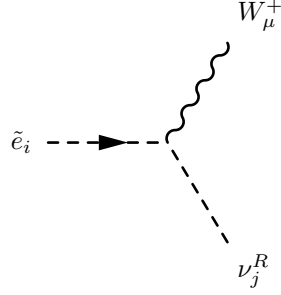
$$\frac{i}{6} \delta_{\alpha\beta} \left(-2g_1 \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D + (3g_2 \cos \Theta_W + g_1 \sin \Theta_W) \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \right) \left(-p_\mu^{\tilde{d}_{j\beta}^*} + p_\mu^{\tilde{d}_{i\alpha}} \right) \quad (237)$$



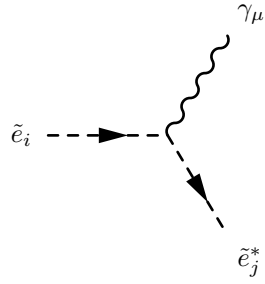
$$-i \frac{1}{\sqrt{2}} g_2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U \left(-p_\mu^{\tilde{u}_{j\beta}^*} + p_\mu^{\tilde{d}_{i\alpha}} \right) \quad (238)$$



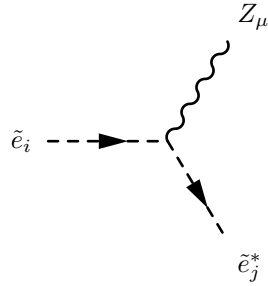
$$-\frac{1}{2} g_2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^{i,*} \left(-p_\mu^{\nu_j^i} + p_\mu^{\tilde{e}_i} \right) \quad (239)$$



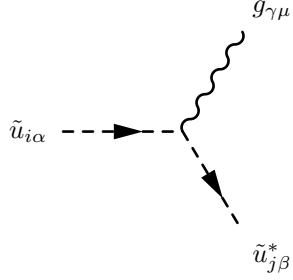
$$-\frac{i}{2}g_2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^{R,*} \left(-p_\mu^{\nu_j^R} + p_\mu^{\tilde{e}_i} \right) \quad (240)$$



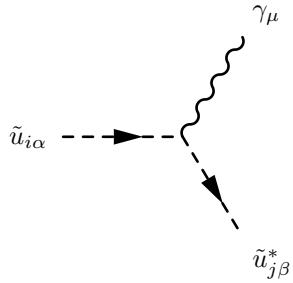
$$\frac{i}{2} \left(2g_1 \cos \Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E + \left(g_1 \cos \Theta_W + g_2 \sin \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right) \left(-p_\mu^{\tilde{e}_j^*} + p_\mu^{\tilde{e}_i} \right) \quad (241)$$



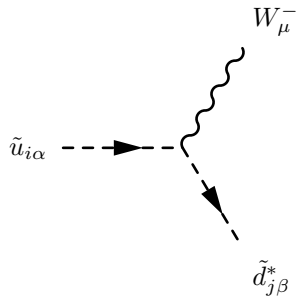
$$\frac{i}{2} \left(-2g_1 \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E + \left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right) \left(-p_\mu^{\tilde{e}_j^*} + p_\mu^{\tilde{e}_i} \right) \quad (242)$$



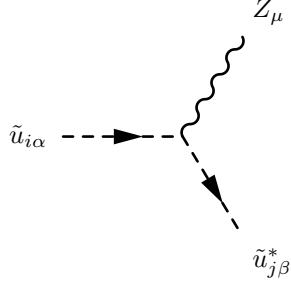
$$-\frac{i}{2}g_3\delta_{ij}\lambda_{\beta,\alpha}^{\gamma}\left(-p_{\mu}^{\tilde{u}_{j\beta}^*}+p_{\mu}^{\tilde{u}_{i\alpha}}\right) \quad (243)$$



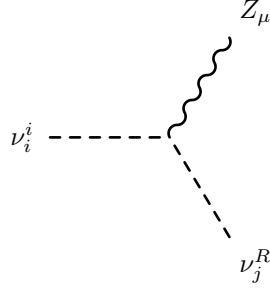
$$-\frac{i}{6}\delta_{\alpha,\beta}\left(\left(3g_2\sin\Theta_W+g_1\cos\Theta_W\right)\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^U+4g_1\cos\Theta_W\sum_{a=1}^3Z_{i3+a}^{U,*}Z_{j3+a}^U\right)\left(-p_{\mu}^{\tilde{u}_{j\beta}^*}+p_{\mu}^{\tilde{u}_{i\alpha}}\right) \quad (244)$$



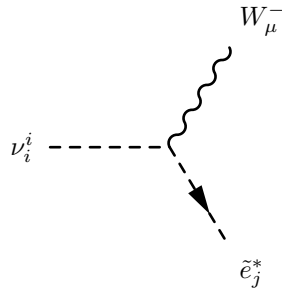
$$-i\frac{1}{\sqrt{2}}g_2\delta_{\alpha,\beta}\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^D\left(-p_{\mu}^{\tilde{d}_{j\beta}^*}+p_{\mu}^{\tilde{u}_{i\alpha}}\right) \quad (245)$$



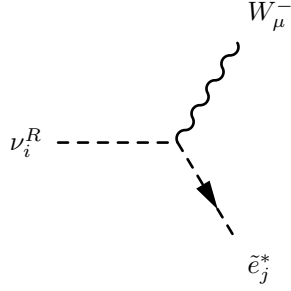
$$-\frac{i}{6}\delta_{\alpha\beta}\left(\left(3g_2\cos\Theta_W-g_1\sin\Theta_W\right)\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^U-4g_1\sin\Theta_W\sum_{a=1}^3Z_{i3+a}^{U,*}Z_{j3+a}^U\right)\left(-p_\mu^{\tilde{u}_{j\beta}^*}+p_\mu^{\tilde{u}_{i\alpha}}\right) \quad (246)$$



$$\frac{1}{2}\left(g_1\sin\Theta_W+g_2\cos\Theta_W\right)\sum_{a=1}^3Z_{ia}^{i,*}Z_{ja}^{R,*}\left(-p_\mu^{\nu_j^R}+p_\mu^{\nu_i^i}\right) \quad (247)$$

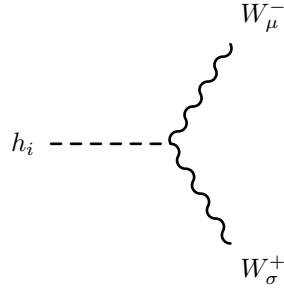


$$\frac{1}{2}g_2\sum_{a=1}^3Z_{ia}^{i,*}Z_{ja}^E\left(-p_\mu^{\tilde{e}_j^*}+p_\mu^{\nu_i^i}\right) \quad (248)$$

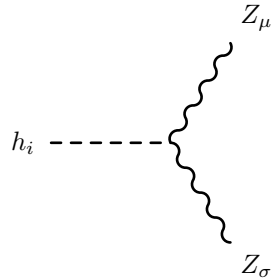


$$-\frac{i}{2}g_2 \sum_{a=1}^3 Z_{ia}^{R,*} Z_{ja}^E \left(-p_\mu^{\tilde{e}_j^*} + p_\mu^{\nu_i^R} \right) \quad (249)$$

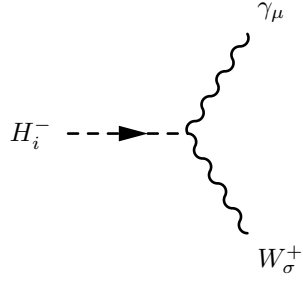
9.3 One Scalar-Two Vector Boson-Interaction



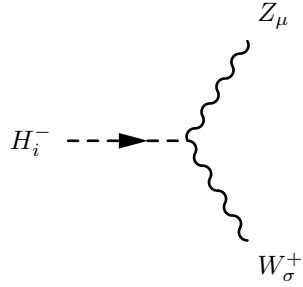
$$\frac{i}{2}g_2^2 \left(v_d Z_{i1}^H + v_u Z_{i2}^H \right) \left(g_{\sigma\mu} \right) \quad (250)$$



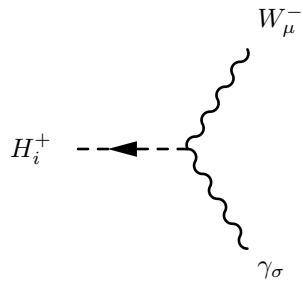
$$\frac{i}{2} \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right)^2 \left(v_d Z_{i1}^H + v_u Z_{i2}^H \right) \left(g_{\sigma\mu} \right) \quad (251)$$



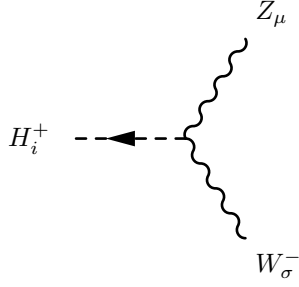
$$-\frac{i}{2}g_1g_2\cos\Theta_W\left(v_dZ_{i1}^+ - v_uZ_{i2}^+\right)\left(g_{\sigma\mu}\right) \quad (252)$$



$$\frac{i}{2}g_1g_2\sin\Theta_W\left(v_dZ_{i1}^+ - v_uZ_{i2}^+\right)\left(g_{\sigma\mu}\right) \quad (253)$$

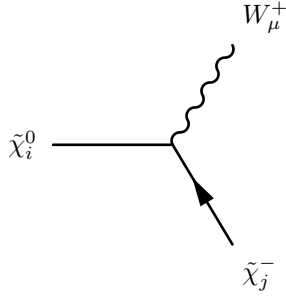


$$-\frac{i}{2}g_1g_2\cos\Theta_W\left(v_dZ_{i1}^+ - v_uZ_{i2}^+\right)\left(g_{\sigma\mu}\right) \quad (254)$$



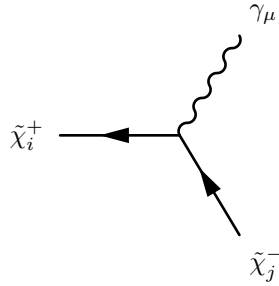
$$\frac{i}{2}g_1g_2\sin\Theta_W\left(v_dZ_{i1}^+ - v_uZ_{i2}^+\right)\left(g_{\sigma\mu}\right) \quad (255)$$

9.4 Two Fermion-One Vector Boson-Interaction



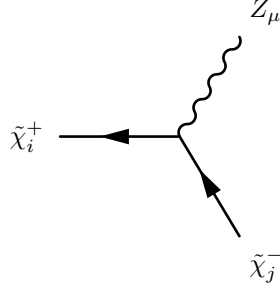
$$-\frac{i}{2}g_2\left(2U_{j1}^*N_{i2} + \sqrt{2}U_{j2}^*N_{i3}\right)\left(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\right) \quad (256)$$

$$+ \left(i\frac{1}{\sqrt{2}}g_2N_{i4}^*V_{j2} - ig_2N_{i2}^*V_{j1}\right)\left(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\right) \quad (257)$$



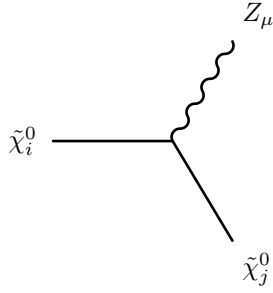
$$\frac{i}{2}\left(2g_2U_{j1}^*\sin\Theta_WU_{i1} + U_{j2}^*\left(g_1\cos\Theta_W + g_2\sin\Theta_W\right)U_{i2}\right)\left(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\right) \quad (258)$$

$$+ \frac{i}{2}\left(2g_2V_{i1}^*\sin\Theta_WV_{j1} + V_{i2}^*\left(g_1\cos\Theta_W + g_2\sin\Theta_W\right)V_{j2}\right)\left(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\right) \quad (259)$$



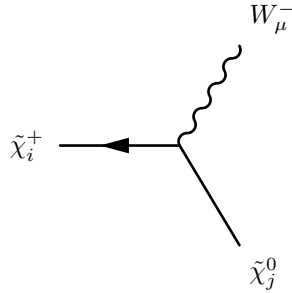
$$\frac{i}{2} \left(2g_2 U_{j1}^* \cos \Theta_W U_{i1} + U_{j2}^* \left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) U_{i2} \right) \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (260)$$

$$+ \frac{i}{2} \left(2g_2 V_{i1}^* \cos \Theta_W V_{j1} + V_{i2}^* \left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) V_{j2} \right) \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (261)$$



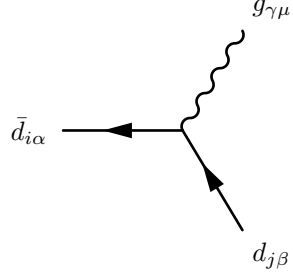
$$- \frac{i}{2} \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left(N_{j3}^* N_{i3} - N_{j4}^* N_{i4} \right) \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (262)$$

$$+ \frac{i}{2} \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left(N_{i3}^* N_{j3} - N_{i4}^* N_{j4} \right) \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (263)$$



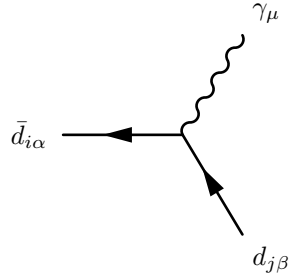
$$- \frac{i}{2} g_2 \left(2N_{j2}^* U_{i1} + \sqrt{2} N_{j3}^* U_{i2} \right) \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (264)$$

$$+ \left(i \frac{1}{\sqrt{2}} g_2 V_{i2}^* N_{j4} - i g_2 V_{i1}^* N_{j2} \right) \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (265)$$



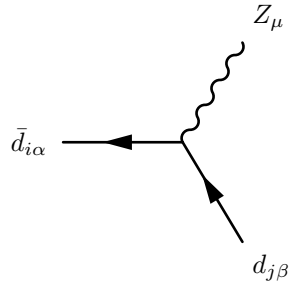
$$- \frac{i}{2} g_3 \delta_{ij} \lambda_{\alpha,\beta}^\gamma \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (266)$$

$$+ - \frac{i}{2} g_3 \delta_{ij} \lambda_{\alpha,\beta}^\gamma \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (267)$$



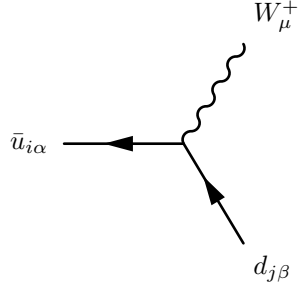
$$- \frac{i}{6} \delta_{\alpha\beta} \delta_{ij} \left(-3g_2 \sin \Theta_W + g_1 \cos \Theta_W \right) \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (268)$$

$$+ \frac{i}{3} g_1 \cos \Theta_W \delta_{\alpha\beta} \delta_{ij} \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (269)$$

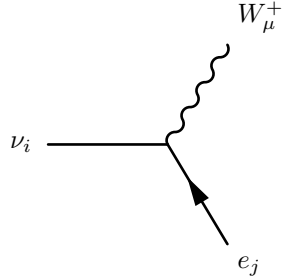


$$\frac{i}{6} \delta_{\alpha\beta} \delta_{ij} \left(3g_2 \cos \Theta_W + g_1 \sin \Theta_W \right) \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (270)$$

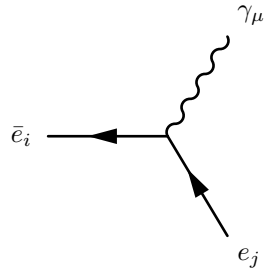
$$+ -\frac{i}{3} g_1 \delta_{\alpha\beta} \delta_{ij} \sin \Theta_W \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (271)$$



$$-i \frac{1}{\sqrt{2}} g_2 \delta_{\alpha\beta} \sum_{a=1}^3 U_{L,ja}^{d,*} U_{L,ia}^u \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (272)$$

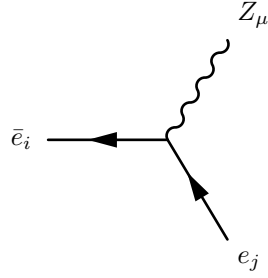


$$-i \frac{1}{\sqrt{2}} g_2 \sum_{a=1}^3 U_{L,ja}^{e,*} U_{ia}^V \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (273)$$



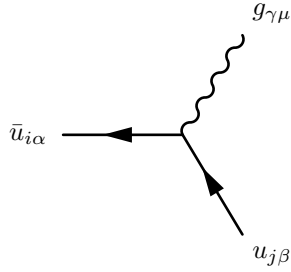
$$\frac{i}{2}\delta_{ij}\left(g_1\cos\Theta_W+g_2\sin\Theta_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (274)$$

$$+ig_1\cos\Theta_W\delta_{ij}\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (275)$$



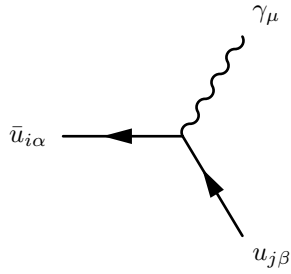
$$\frac{i}{2}\delta_{ij}\left(-g_1\sin\Theta_W+g_2\cos\Theta_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (276)$$

$$-ig_1\delta_{ij}\sin\Theta_W\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (277)$$



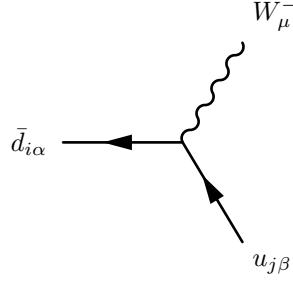
$$-\frac{i}{2}g_3\delta_{ij}\lambda_{\alpha,\beta}^\gamma\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (278)$$

$$+\frac{i}{2}g_3\delta_{ij}\lambda_{\alpha,\beta}^\gamma\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (279)$$

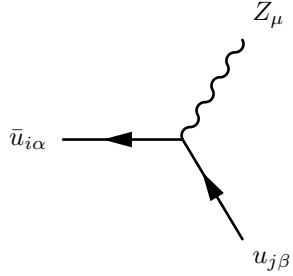


$$-\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(3g_2\sin\Theta_W+g_1\cos\Theta_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (280)$$

$$+\frac{2i}{3}g_1\cos\Theta_W\delta_{\alpha\beta}\delta_{ij}\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (281)$$

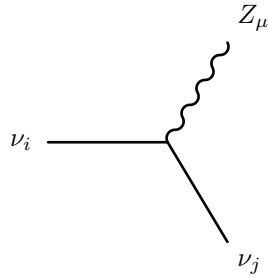


$$-i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^3U_{L,ja}^{u,*}U_{L,ia}^d\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (282)$$



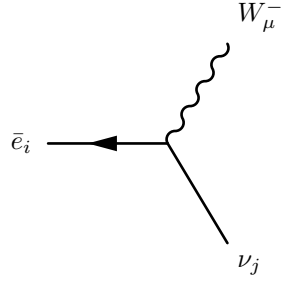
$$-\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(3g_2\cos\Theta_W-g_1\sin\Theta_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (283)$$

$$+\frac{2i}{3}g_1\delta_{\alpha\beta}\delta_{ij}\sin\Theta_W\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (284)$$

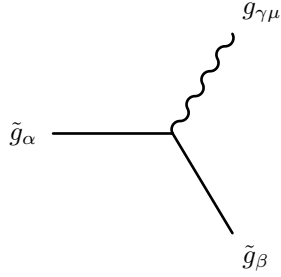


$$- \frac{i}{2} (g_1 \sin \Theta_W + g_2 \cos \Theta_W) \sum_{a=1}^3 U_{ja}^{V_i^*} U_{ia}^V \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (285)$$

$$+ \frac{i}{2} (g_1 \sin \Theta_W + g_2 \cos \Theta_W) \sum_{a=1}^3 U_{ia}^{V_i^*} U_{ja}^V \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (286)$$



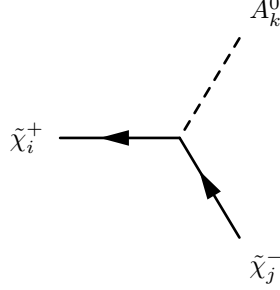
$$- i \frac{1}{\sqrt{2}} g_2 \sum_{a=1}^3 U_{ja}^{V_i^*} U_{L,ia}^e \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (287)$$



$$- g_3 |\phi_{\tilde{g}}|^2 f_{\alpha,\beta,\gamma} \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (288)$$

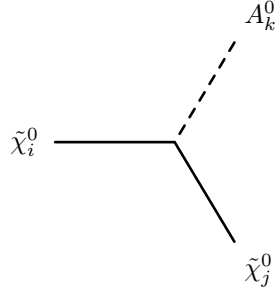
$$+ -g_3 |\phi_{\tilde{g}}|^2 f_{\alpha,\beta,\gamma} \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (289)$$

9.5 Two Fermion-One Scalar Boson-Interaction



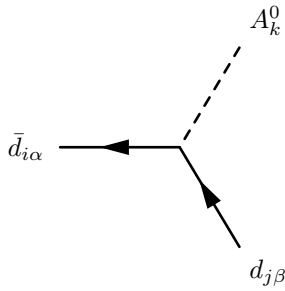
$$-\frac{1}{\sqrt{2}}g_2\left(U_{j1}^*V_{i2}^*Z_{k2}^A+U_{j2}^*V_{i1}^*Z_{k1}^A\right)\left(\frac{1-\gamma_5}{2}\right) \quad (290)$$

$$+\frac{1}{\sqrt{2}}g_2\left(U_{i1}V_{j2}Z_{k2}^A+U_{i2}V_{j1}Z_{k1}^A\right)\left(\frac{1+\gamma_5}{2}\right) \quad (291)$$



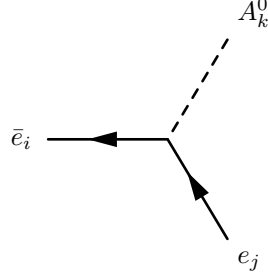
$$\begin{aligned} &\frac{1}{2}\left(N_{i3}^*\left(g_1N_{j1}^*-g_2N_{j2}^*\right)Z_{k1}^A-g_2N_{i2}^*N_{j3}^*Z_{k1}^A-g_1N_{i4}^*N_{j1}^*Z_{k2}^A+g_2N_{i4}^*N_{j2}^*Z_{k2}^A\right. \\ &\left.+g_2N_{i2}^*N_{j4}^*Z_{k2}^A+g_1N_{i1}^*\left(N_{j3}^*Z_{k1}^A-N_{j4}^*Z_{k2}^A\right)\right)\left(\frac{1-\gamma_5}{2}\right) \end{aligned} \quad (292)$$

$$\begin{aligned} &+\frac{1}{2}\left(Z_{k1}^A\left(\left(-g_1N_{i1}+g_2N_{i2}\right)N_{j3}+N_{i3}\left(-g_1N_{j1}+g_2N_{j2}\right)\right)\right. \\ &\left.+Z_{k2}^A\left(\left(g_1N_{i1}-g_2N_{i2}\right)N_{j4}+N_{i4}\left(g_1N_{j1}-g_2N_{j2}\right)\right)\right)\left(\frac{1+\gamma_5}{2}\right) \end{aligned} \quad (293)$$



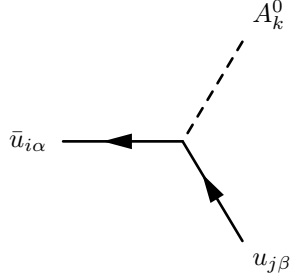
$$\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^3U_{L,jb}^{d,*}\sum_{a=1}^3U_{R,ia}^{d,*}Y_{d,ab}Z_{k1}^A\left(\frac{1-\gamma_5}{2}\right) \quad (294)$$

$$+ -\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^3\sum_{a=1}^3Y_{d,ab}^*U_{R,ja}^dU_{L,ib}^dZ_{k1}^A\left(\frac{1+\gamma_5}{2}\right) \quad (295)$$



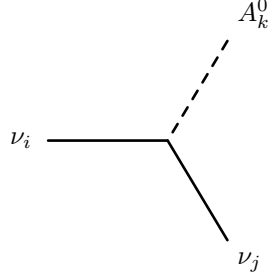
$$\frac{1}{\sqrt{2}}\sum_{b=1}^3U_{L,jb}^{e,*}\sum_{a=1}^3U_{R,ia}^{e,*}Y_{e,ab}Z_{k1}^A\left(\frac{1-\gamma_5}{2}\right) \quad (296)$$

$$+ -\frac{1}{\sqrt{2}}\sum_{b=1}^3\sum_{a=1}^3Y_{e,ab}^*U_{R,ja}^eU_{L,ib}^eZ_{k1}^A\left(\frac{1+\gamma_5}{2}\right) \quad (297)$$



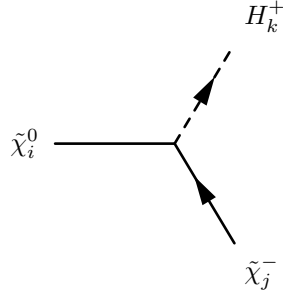
$$\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^3U_{L,jb}^{u,*}\sum_{a=1}^3U_{R,ia}^{u,*}Y_{u,ab}Z_{k2}^A\left(\frac{1-\gamma_5}{2}\right) \quad (298)$$

$$+ -\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^3\sum_{a=1}^3Y_{u,ab}^*U_{R,ja}^uU_{L,ib}^uZ_{k2}^A\left(\frac{1+\gamma_5}{2}\right) \quad (299)$$



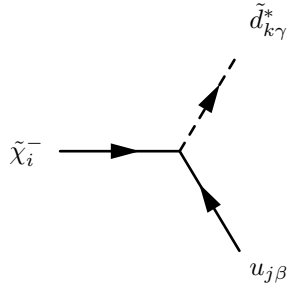
$$\frac{1}{\sqrt{2}} \left(\sum_{b=1}^3 U_{jb}^{V,*} \sum_{a=1}^3 U_{i3+a}^{V,*} Y_{\nu,ab} + \sum_{b=1}^3 U_{ib}^{V,*} \sum_{a=1}^3 U_{j3+a}^{V,*} Y_{\nu,ab} \right) Z_{k2}^A \left(\frac{1-\gamma_5}{2} \right) \quad (300)$$

$$+ -\frac{1}{\sqrt{2}} \left(\sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* U_{j3+a}^V U_{ib}^V + \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* U_{i3+a}^V U_{jb}^V \right) Z_{k2}^A \left(\frac{1+\gamma_5}{2} \right) \quad (301)$$



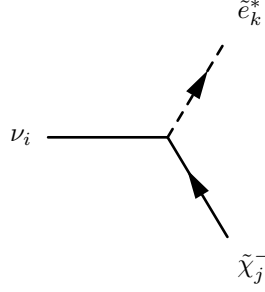
$$\frac{i}{2} \left(-2g_2 U_{j1}^* N_{i3}^* + \sqrt{2} U_{j2}^* (g_1 N_{i1}^* + g_2 N_{i2}^*) \right) Z_{k1}^+ \left(\frac{1-\gamma_5}{2} \right) \quad (302)$$

$$+ -\frac{i}{2} \left(2g_2 V_{j1} N_{i4} + \sqrt{2} V_{j2} (g_1 N_{i1} + g_2 N_{i2}) \right) Z_{k2}^+ \left(\frac{1+\gamma_5}{2} \right) \quad (303)$$



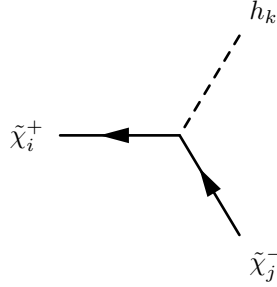
$$-i\delta_{\beta\gamma}\left(g_2U_{i1}^*\sum_{a=1}^3U_{L,ja}^{u,*}Z_{ka}^D-U_{i2}^*\sum_{b=1}^3U_{L,jb}^{u,*}\sum_{a=1}^3Y_{d,ab}Z_{k3+a}^D\right)\left(\frac{1-\gamma_5}{2}\right) \quad (304)$$

$$+i\delta_{\beta\gamma}\sum_{b=1}^3\sum_{a=1}^3Y_{u,ab}^*U_{R,ja}^uZ_{kb}^DV_{i2}\left(\frac{1+\gamma_5}{2}\right) \quad (305)$$



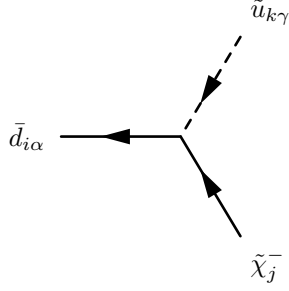
$$-i\left(g_2U_{j1}^*\sum_{a=1}^3U_{ia}^{V,*}Z_{ka}^E-U_{j2}^*\sum_{b=1}^3U_{ib}^{V,*}\sum_{a=1}^3Y_{e,ab}Z_{k3+a}^E\right)\left(\frac{1-\gamma_5}{2}\right) \quad (306)$$

$$+i\sum_{b=1}^3\sum_{a=1}^3Y_{\nu,ab}^*U_{i3+a}^VZ_{kb}^EV_{j2}\left(\frac{1+\gamma_5}{2}\right) \quad (307)$$



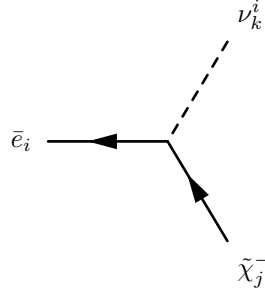
$$-i\frac{1}{\sqrt{2}}g_2\left(U_{j1}^*V_{i2}^*Z_{k2}^H+U_{j2}^*V_{i1}^*Z_{k1}^H\right)\left(\frac{1-\gamma_5}{2}\right) \quad (308)$$

$$+i\frac{1}{\sqrt{2}}g_2\left(U_{i1}V_{j2}Z_{k2}^H+U_{i2}V_{j1}Z_{k1}^H\right)\left(\frac{1+\gamma_5}{2}\right) \quad (309)$$



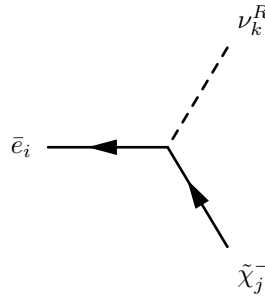
$$iU_{j2}^* \delta_{\alpha\gamma} \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 U_{R,ia}^{d,*} Y_{d,ab} \left(\frac{1-\gamma_5}{2} \right) \quad (310)$$

$$+ -i\delta_{\alpha\gamma} \left(g_2 \sum_{a=1}^3 Z_{ka}^{U,*} U_{L,ia}^d V_{j1} - \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{k3+a}^{U,*} U_{L,ib}^d V_{j2} \right) \left(\frac{1+\gamma_5}{2} \right) \quad (311)$$



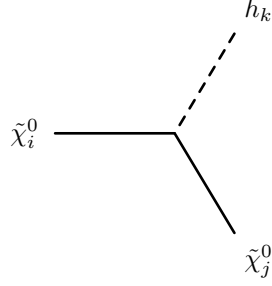
$$- \frac{1}{\sqrt{2}} U_{j2}^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 U_{R,ia}^{e,*} Y_{e,ab} \left(\frac{1-\gamma_5}{2} \right) \quad (312)$$

$$+ \frac{1}{\sqrt{2}} \left(g_2 \sum_{a=1}^3 Z_{ka}^{i,*} U_{L,ia}^e V_{j1} - \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} U_{L,ib}^e V_{j2} \right) \left(\frac{1+\gamma_5}{2} \right) \quad (313)$$



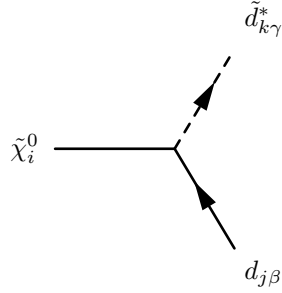
$$i \frac{1}{\sqrt{2}} U_{j2}^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 U_{R,ia}^{e,*} Y_{e,ab} \left(\frac{1-\gamma_5}{2} \right) \quad (314)$$

$$+ -i \frac{1}{\sqrt{2}} \left(g_2 \sum_{a=1}^3 Z_{ka}^{R,*} U_{L,ia}^e V_{j1} - \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} U_{L,ib}^e V_{j2} \right) \left(\frac{1+\gamma_5}{2} \right) \quad (315)$$



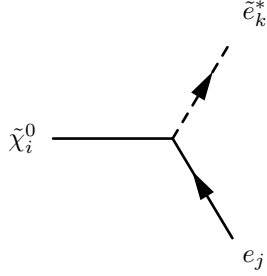
$$\begin{aligned} & \frac{i}{2} \left(N_{i3}^* \left(g_1 N_{j1}^* - g_2 N_{j2}^* \right) Z_{k1}^H - g_2 N_{i2}^* N_{j3}^* Z_{k1}^H - g_1 N_{i4}^* N_{j1}^* Z_{k2}^H + g_2 N_{i4}^* N_{j2}^* Z_{k2}^H \right. \\ & \left. + g_2 N_{i2}^* N_{j4}^* Z_{k2}^H + g_1 N_{i1}^* \left(N_{j3}^* Z_{k1}^H - N_{j4}^* Z_{k2}^H \right) \right) \left(\frac{1-\gamma_5}{2} \right) \end{aligned} \quad (316)$$

$$\begin{aligned} & + \frac{i}{2} \left(Z_{k1}^H \left(\left(g_1 N_{i1} - g_2 N_{i2} \right) N_{j3} + N_{i3} \left(g_1 N_{j1} - g_2 N_{j2} \right) \right) \right. \\ & \left. + Z_{k2}^H \left(\left(-g_1 N_{i1} + g_2 N_{i2} \right) N_{j4} + N_{i4} \left(-g_1 N_{j1} + g_2 N_{j2} \right) \right) \right) \left(\frac{1+\gamma_5}{2} \right) \end{aligned} \quad (317)$$



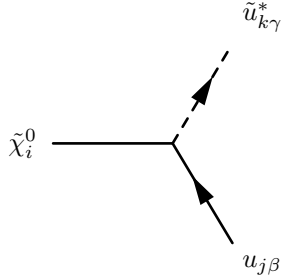
$$- \frac{i}{6} \delta_{\beta\gamma} \left(-3\sqrt{2} g_2 N_{i2}^* \sum_{a=1}^3 U_{L,ja}^{d,*} Z_{ka}^D + 6N_{i3}^* \sum_{b=1}^3 U_{L,jb}^{d,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D + \sqrt{2} g_1 N_{i1}^* \sum_{a=1}^3 U_{L,ja}^{d,*} Z_{ka}^D \right) \left(\frac{1-\gamma_5}{2} \right) \quad (318)$$

$$+ -\frac{i}{3} \delta_{\beta\gamma} \left(3 \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* U_{R,ja}^d Z_{kb}^D N_{i3} + \sqrt{2} g_1 \sum_{a=1}^3 Z_{k3+a}^D U_{R,ja}^d N_{i1} \right) \left(\frac{1+\gamma_5}{2} \right) \quad (319)$$



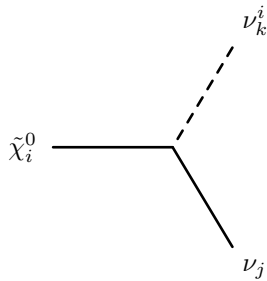
$$\frac{i}{2} \left(-2N_{i3}^* \sum_{b=1}^3 U_{L,jb}^{e,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E + \sqrt{2}g_1 N_{i1}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{ka}^E + \sqrt{2}g_2 N_{i2}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{ka}^E \right) \left(\frac{1-\gamma_5}{2} \right) \quad (320)$$

$$+ -i \left(\sqrt{2}g_1 \sum_{a=1}^3 Z_{k3+a}^E U_{R,ja}^e N_{i1} + \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* U_{R,ja}^e Z_{kb}^E N_{i3} \right) \left(\frac{1+\gamma_5}{2} \right) \quad (321)$$



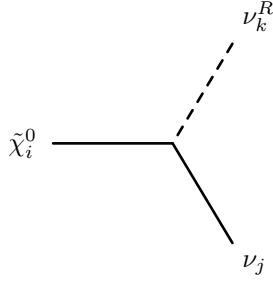
$$- \frac{i}{6} \delta_{\beta\gamma} \left(3\sqrt{2}g_2 N_{i2}^* \sum_{a=1}^3 U_{L,ja}^{u,*} Z_{ka}^U + 6N_{i4}^* \sum_{b=1}^3 U_{L,jb}^{u,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U + \sqrt{2}g_1 N_{i1}^* \sum_{a=1}^3 U_{L,ja}^{u,*} Z_{ka}^U \right) \left(\frac{1-\gamma_5}{2} \right) \quad (322)$$

$$+ \frac{i}{3} \delta_{\beta\gamma} \left(2\sqrt{2}g_1 \sum_{a=1}^3 Z_{k3+a}^U U_{R,ja}^u N_{i1} - 3 \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* U_{R,ja}^u Z_{kb}^U N_{i4} \right) \left(\frac{1+\gamma_5}{2} \right) \quad (323)$$



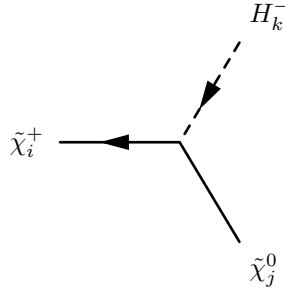
$$\begin{aligned} & \frac{1}{2} \left(g_1 N_{i1}^* \sum_{a=1}^3 U_{ja}^{V,*} Z_{ka}^{i,*} - g_2 N_{i2}^* \sum_{a=1}^3 U_{ja}^{V,*} Z_{ka}^{i,*} \right. \\ & \left. + \sqrt{2} N_{i4}^* \left(- \sum_{b=1}^3 U_{jb}^{V,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} + \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 U_{j3+a}^{V,*} Y_{\nu,ab} \right) \right) \left(\frac{1-\gamma_5}{2} \right) \end{aligned} \quad (324)$$

$$\begin{aligned} & + \frac{1}{2} \left(\sum_{a=1}^3 Z_{ka}^{i,*} U_{ja}^V \left(-g_1 N_{i1} + g_2 N_{i2} \right) \right. \\ & \left. + \sqrt{2} \left(- \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* U_{j3+a}^V + \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} U_{jb}^V \right) N_{i4} \right) \left(\frac{1+\gamma_5}{2} \right) \end{aligned} \quad (325)$$



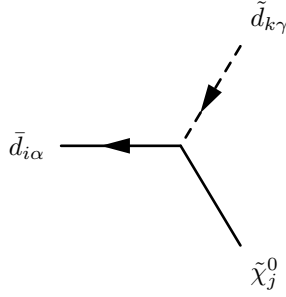
$$\begin{aligned} & \frac{i}{2} \left(g_1 N_{i1}^* \sum_{a=1}^3 U_{ja}^{V,*} Z_{ka}^{R,*} - g_2 N_{i2}^* \sum_{a=1}^3 U_{ja}^{V,*} Z_{ka}^{R,*} \right. \\ & \left. - \sqrt{2} N_{i4}^* \left(\sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 U_{j3+a}^{V,*} Y_{\nu,ab} + \sum_{b=1}^3 U_{jb}^{V,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \right) \right) \left(\frac{1-\gamma_5}{2} \right) \end{aligned} \quad (326)$$

$$\begin{aligned} & + \frac{i}{2} \left(\sum_{a=1}^3 Z_{ka}^{R,*} U_{ja}^V \left(g_1 N_{i1} - g_2 N_{i2} \right) \right. \\ & \left. - \sqrt{2} \left(\sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* U_{j3+a}^V + \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} U_{jb}^V \right) N_{i4} \right) \left(\frac{1+\gamma_5}{2} \right) \end{aligned} \quad (327)$$



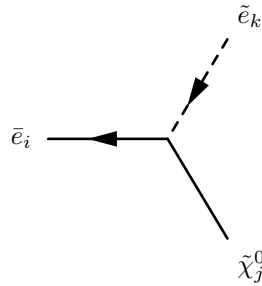
$$-\frac{i}{2}\left(2g_2V_{i1}^*N_{j4}^*+\sqrt{2}V_{i2}^*(g_1N_{j1}^*+g_2N_{j2}^*)\right)Z_{k2}^+\left(\frac{1-\gamma_5}{2}\right) \quad (328)$$

$$+\frac{i}{2}\left(-2g_2U_{i1}N_{j3}+\sqrt{2}U_{i2}(g_1N_{j1}+g_2N_{j2})\right)Z_{k1}^+\left(\frac{1+\gamma_5}{2}\right) \quad (329)$$



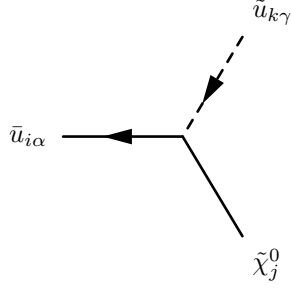
$$-\frac{i}{3}\delta_{\alpha\gamma}\left(3N_{j3}^*\sum_{b=1}^3Z_{kb}^{D,*}\sum_{a=1}^3U_{R,ia}^{d,*}Y_{d,ab}+\sqrt{2}g_1N_{j1}^*\sum_{a=1}^3Z_{k3+a}^{D,*}U_{R,ia}^{d,*}\right)\left(\frac{1-\gamma_5}{2}\right) \quad (330)$$

$$+\frac{i}{6}\delta_{\alpha\gamma}\left(6\sum_{b=1}^3\sum_{a=1}^3Y_{d,ab}^*Z_{k3+a}^{D,*}U_{L,ib}^dN_{j3}+\sqrt{2}\sum_{a=1}^3Z_{ka}^{D,*}U_{L,ia}^d(-3g_2N_{j2}+g_1N_{j1})\right)\left(\frac{1+\gamma_5}{2}\right) \quad (331)$$



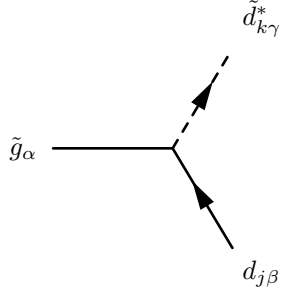
$$-i\left(N_{j3}^*\sum_{b=1}^3Z_{kb}^{E,*}\sum_{a=1}^3U_{R,ia}^{e,*}Y_{e,ab}+\sqrt{2}g_1N_{j1}^*\sum_{a=1}^3Z_{k3+a}^{E,*}U_{R,ia}^{e,*}\right)\left(\frac{1-\gamma_5}{2}\right) \quad (332)$$

$$+\frac{i}{2}\left(-2\sum_{b=1}^3\sum_{a=1}^3Y_{e,ab}^*Z_{k3+a}^{E,*}U_{L,ib}^eN_{j3}+\sqrt{2}\sum_{a=1}^3Z_{ka}^{E,*}U_{L,ia}^e(g_1N_{j1}+g_2N_{j2})\right)\left(\frac{1+\gamma_5}{2}\right) \quad (333)$$



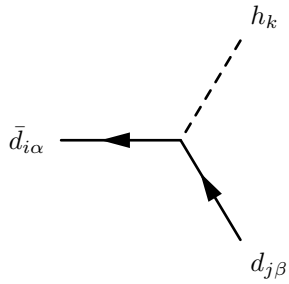
$$\frac{i}{3}\delta_{\alpha\gamma}\left(2\sqrt{2}g_1N_{j1}^*\sum_{a=1}^3Z_{k3+a}^{U,*}U_{R,ia}^{u,*}-3N_{j4}^*\sum_{b=1}^3Z_{kb}^{U,*}\sum_{a=1}^3U_{R,ia}^{u,*}Y_{u,ab}\right)\left(\frac{1-\gamma_5}{2}\right) \quad (334)$$

$$+\frac{i}{6}\delta_{\alpha\gamma}\left(6\sum_{b=1}^3\sum_{a=1}^3Y_{u,ab}^*Z_{k3+a}^{U,*}U_{L,ib}^uN_{j4}+\sqrt{2}\sum_{a=1}^3Z_{ka}^{U,*}U_{L,ia}^u(3g_2N_{j2}+g_1N_{j1})\right)\left(\frac{1+\gamma_5}{2}\right) \quad (335)$$



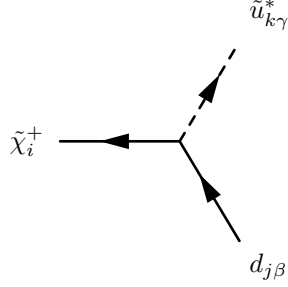
$$-i\frac{1}{\sqrt{2}}g_3\phi_{\tilde{g}}^*\lambda_{\gamma,\beta}^\alpha\sum_{a=1}^3U_{L,ja}^{d,*}Z_{ka}^D\left(\frac{1-\gamma_5}{2}\right) \quad (336)$$

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



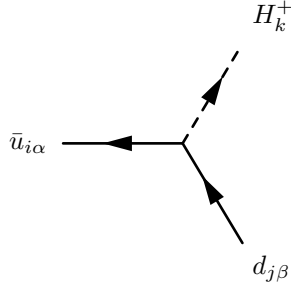
$$-i \frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{d,*} \sum_{a=1}^3 U_{R,ia}^{d,*} Y_{d,ab} Z_{k1}^H \left(\frac{1-\gamma_5}{2} \right) \quad (338)$$

$$+ -i \frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* U_{R,ja}^d U_{L,ib}^d Z_{k1}^H \left(\frac{1+\gamma_5}{2} \right) \quad (339)$$



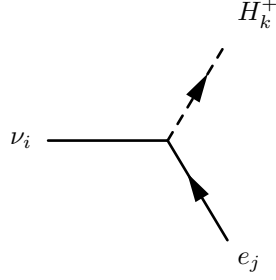
$$-i \delta_{\beta\gamma} \left(g_2 V_{i1}^* \sum_{a=1}^3 U_{L,ja}^{d,*} Z_{ka}^U - V_{i2}^* \sum_{b=1}^3 U_{L,jb}^{d,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U \right) \left(\frac{1-\gamma_5}{2} \right) \quad (340)$$

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



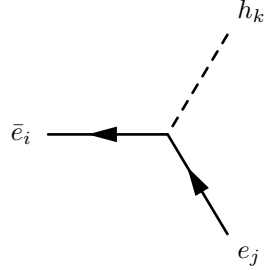
$$i \delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{d,*} \sum_{a=1}^3 U_{R,ia}^{u,*} Y_{u,ab} Z_{k2}^+ \left(\frac{1-\gamma_5}{2} \right) \quad (342)$$

$$+ i \delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* U_{R,ja}^d U_{L,ib}^u Z_{k1}^+ \left(\frac{1+\gamma_5}{2} \right) \quad (343)$$



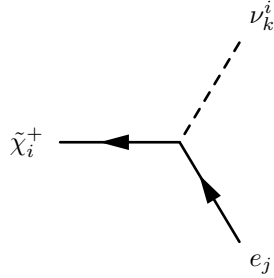
$$i \sum_{b=1}^3 U_{L,jb}^{e,*} \sum_{a=1}^3 U_{i3+a}^{V,*} Y_{\nu,ab} Z_{k2}^+ \left(\frac{1-\gamma_5}{2} \right) \quad (344)$$

$$+ i \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* U_{R,ja}^e U_{ib}^V Z_{k1}^+ \left(\frac{1+\gamma_5}{2} \right) \quad (345)$$



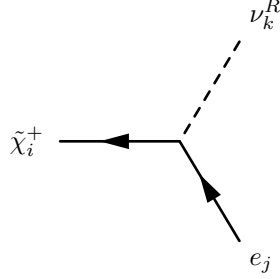
$$-i \frac{1}{\sqrt{2}} \sum_{b=1}^3 U_{L,jb}^{e,*} \sum_{a=1}^3 U_{R,ia}^{e,*} Y_{e,ab} Z_{k1}^H \left(\frac{1-\gamma_5}{2} \right) \quad (346)$$

$$+ -i \frac{1}{\sqrt{2}} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* U_{R,ja}^e U_{L,ib}^e Z_{k1}^H \left(\frac{1+\gamma_5}{2} \right) \quad (347)$$



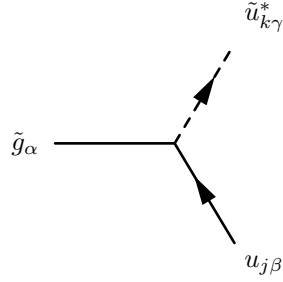
$$\frac{1}{\sqrt{2}} \left(-g_2 V_{i1}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{ka}^{i,*} + V_{i2}^* \sum_{b=1}^3 U_{L,jb}^{e,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \right) \left(\frac{1-\gamma_5}{2} \right) \quad (348)$$

$$+ \frac{1}{\sqrt{2}} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{e,ab}^* U_{R,ja}^e U_{i2} \left(\frac{1+\gamma_5}{2} \right) \quad (349)$$



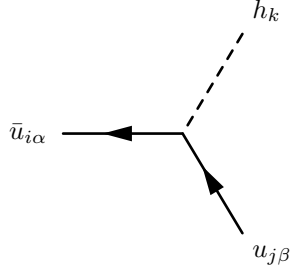
$$-i \frac{1}{\sqrt{2}} \left(g_2 V_{i1}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{ka}^{R,*} - V_{i2}^* \sum_{b=1}^3 U_{L,jb}^{e,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \right) \left(\frac{1-\gamma_5}{2} \right) \quad (350)$$

$$+ i \frac{1}{\sqrt{2}} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{e,ab}^* U_{R,ja}^e U_{i2} \left(\frac{1+\gamma_5}{2} \right) \quad (351)$$



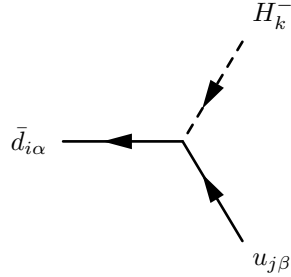
$$-i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\gamma,\beta}^\alpha \sum_{a=1}^3 U_{L,ja}^{u,*} Z_{ka}^U \left(\frac{1-\gamma_5}{2} \right) \quad (352)$$

$$+ i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\gamma,\beta}^\alpha \sum_{a=1}^3 Z_{k3+a}^U U_{R,ja}^u \left(\frac{1+\gamma_5}{2} \right) \quad (353)$$



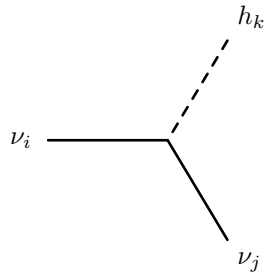
$$-i \frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{u,*} \sum_{a=1}^3 U_{R,ia}^{u,*} Y_{u,ab} Z_{k2}^H \left(\frac{1-\gamma_5}{2} \right) \quad (354)$$

$$+ -i \frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* U_{R,ja}^u U_{L,ib}^u Z_{k2}^H \left(\frac{1+\gamma_5}{2} \right) \quad (355)$$



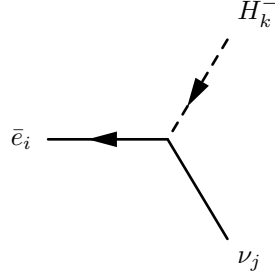
$$i \delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{u,*} \sum_{a=1}^3 U_{R,ia}^{d,*} Y_{d,ab} Z_{k1}^+ \left(\frac{1-\gamma_5}{2} \right) \quad (356)$$

$$+ i \delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* U_{R,ja}^u U_{L,ib}^d Z_{k2}^+ \left(\frac{1+\gamma_5}{2} \right) \quad (357)$$



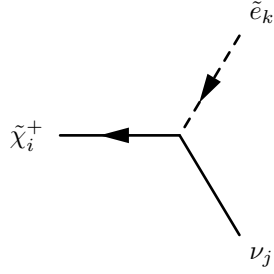
$$-i \frac{1}{\sqrt{2}} \left(\sum_{b=1}^3 U_{jb}^{V,*} \sum_{a=1}^3 U_{i3+a}^{V,*} Y_{\nu,ab} + \sum_{b=1}^3 U_{ib}^{V,*} \sum_{a=1}^3 U_{j3+a}^{V,*} Y_{\nu,ab} \right) Z_{k2}^H \left(\frac{1-\gamma_5}{2} \right) \quad (358)$$

$$+ -i \frac{1}{\sqrt{2}} \left(\sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* U_{j3+a}^V U_{ib}^V + \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* U_{i3+a}^V U_{jb}^V \right) Z_{k2}^H \left(\frac{1+\gamma_5}{2} \right) \quad (359)$$



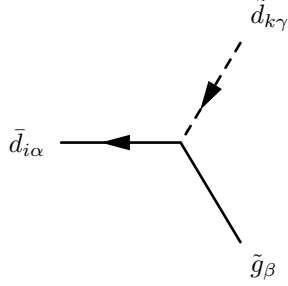
$$i \sum_{b=1}^3 U_{jb}^{V,*} \sum_{a=1}^3 U_{R,ia}^{e,*} Y_{e,ab} Z_{k1}^+ \left(\frac{1-\gamma_5}{2} \right) \quad (360)$$

$$+ i \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* U_{j3+a}^V U_{L,ib}^e Z_{k2}^+ \left(\frac{1+\gamma_5}{2} \right) \quad (361)$$



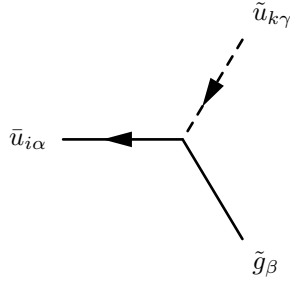
$$i V_{i2}^* \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 U_{j3+a}^{V,*} Y_{\nu,ab} \left(\frac{1-\gamma_5}{2} \right) \quad (362)$$

$$+ -i \left(g_2 \sum_{a=1}^3 Z_{ka}^{E,*} U_{ja}^V U_{i1} - \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{k3+a}^{E,*} U_{jb}^V U_{i2} \right) \left(\frac{1+\gamma_5}{2} \right) \quad (363)$$



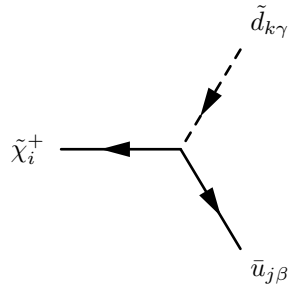
$$i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}} \lambda_{\alpha,\gamma}^\beta \sum_{a=1}^3 Z_{k3+a}^{D,*} U_{R,ia}^{d,*} \left(\frac{1-\gamma_5}{2} \right) \quad (364)$$

$$+ -i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\alpha,\gamma}^\beta \sum_{a=1}^3 Z_{ka}^{D,*} U_{L,ia}^d \left(\frac{1+\gamma_5}{2} \right) \quad (365)$$



$$i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}} \lambda_{\alpha,\gamma}^\beta \sum_{a=1}^3 Z_{k3+a}^{U,*} U_{R,ia}^{u,*} \left(\frac{1-\gamma_5}{2} \right) \quad (366)$$

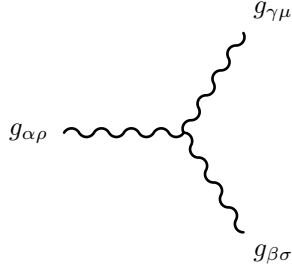
$$+ -i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\alpha,\gamma}^\beta \sum_{a=1}^3 Z_{ka}^{U,*} U_{L,ia}^u \left(\frac{1+\gamma_5}{2} \right) \quad (367)$$



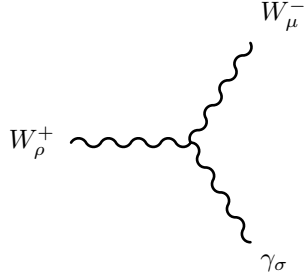
$$iV_{i2}^* \delta_{\beta\gamma} \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 U_{R,ja}^{u,*} Y_{u,ab} \left(\frac{1-\gamma_5}{2} \right) \quad (368)$$

$$+ -i\delta_{\beta\gamma} \left(g_2 \sum_{a=1}^3 Z_{ka}^{D,*} U_{L,ja}^u U_{i1} - \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{k3+a}^{D,*} U_{L,jb}^u U_{i2} \right) \left(\frac{1+\gamma_5}{2} \right) \quad (369)$$

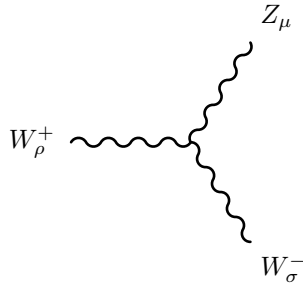
9.6 Three Vector Boson-Interaction



$$g_3 f_{\alpha,\beta,\gamma} \left(g_{\rho\mu} \left(-p_\sigma^{g\gamma\mu} + p_\sigma^{g\alpha\rho} \right) + g_{\rho\sigma} \left(-p_\mu^{g\alpha\rho} + p_\mu^{g\beta\sigma} \right) + g_{\sigma\mu} \left(-p_\rho^{g\beta\sigma} + p_\rho^{g\gamma\mu} \right) \right) \quad (370)$$

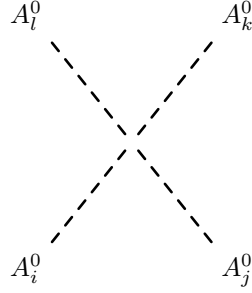


$$ig_2 \sin \Theta_W \left(g_{\rho\mu} \left(-p_\sigma^{W_\mu^-} + p_\sigma^{W_\rho^+} \right) + g_{\rho\sigma} \left(-p_\mu^{W_\rho^+} + p_\mu^{\gamma_\sigma} \right) + g_{\sigma\mu} \left(-p_\rho^{\gamma_\sigma} + p_\rho^{W_\mu^-} \right) \right) \quad (371)$$

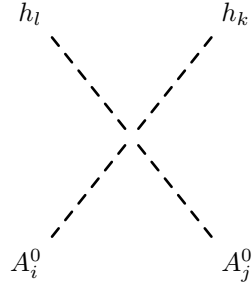


$$-ig_2 \cos \Theta_W \left(g_{\rho\mu} \left(-p_\sigma^{Z^\mu} + p_\sigma^{W_\rho^+} \right) + g_{\rho\sigma} \left(-p_\mu^{W_\rho^+} + p_\mu^{W_\sigma^-} \right) + g_{\sigma\mu} \left(-p_\rho^{W_\sigma^-} + p_\rho^{Z^\mu} \right) \right) \quad (372)$$

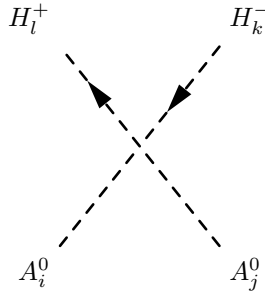
9.7 Four Scalar-Interaction



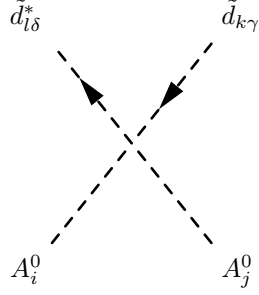
$$\begin{aligned} & \frac{i}{4} \left(g_1^2 + g_2^2 \right) \left(Z_{i2}^A \left(Z_{j1}^A \left(Z_{k1}^A Z_{l2}^A + Z_{k2}^A Z_{l1}^A \right) + Z_{j2}^A \left(-3Z_{k2}^A Z_{l2}^A + Z_{k1}^A Z_{l1}^A \right) \right) \right. \\ & \left. + Z_{i1}^A \left(Z_{j1}^A \left(-3Z_{k1}^A Z_{l1}^A + Z_{k2}^A Z_{l2}^A \right) + Z_{j2}^A \left(Z_{k1}^A Z_{l2}^A + Z_{k2}^A Z_{l1}^A \right) \right) \right) \end{aligned} \quad (373)$$



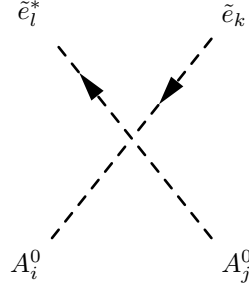
$$-\frac{i}{4} \left(g_1^2 + g_2^2 \right) \left(Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A \right) \left(Z_{k1}^H Z_{l1}^H - Z_{k2}^H Z_{l2}^H \right) \quad (374)$$



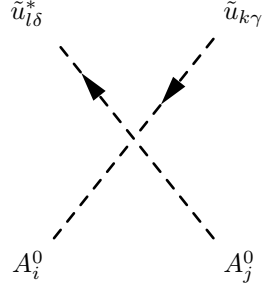
$$\begin{aligned}
& \frac{i}{4} \left(Z_{i1}^A \left(g_2^2 Z_{j2}^A \left(Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) - Z_{j1}^A \left(\left(g_1^2 + g_2^2 \right) Z_{k1}^+ Z_{l1}^+ + \left(-g_1^2 + g_2^2 \right) Z_{k2}^+ Z_{l2}^+ \right) \right) \right. \\
& \left. + Z_{i2}^A \left(g_2^2 Z_{j1}^A \left(Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) + Z_{j2}^A \left(- \left(g_1^2 + g_2^2 \right) Z_{k2}^+ Z_{l2}^+ + \left(-g_2^2 + g_1^2 \right) Z_{k1}^+ Z_{l1}^+ \right) \right) \right) \quad (375)
\end{aligned}$$



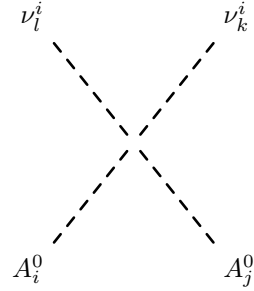
$$\begin{aligned}
& \frac{i}{12} \delta_{\gamma\delta} \left(\left(3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{D,*} Z_{la}^D \left(Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A \right) \right. \\
& + 2 \left(-6 \left(\sum_{c=1}^3 Z_{k3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{d,ba} Z_{l3+b}^D + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^D \right) Z_{i1}^A Z_{j1}^A \right. \\
& \left. \left. + g_1^2 \sum_{a=1}^3 Z_{k3+a}^{D,*} Z_{l3+a}^D \left(Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A \right) \right) \right) \quad (376)
\end{aligned}$$



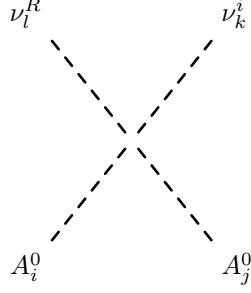
$$\begin{aligned}
& - \frac{i}{4} \left(4 \left(\sum_{c=1}^3 Z_{k3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{e,ba} Z_{l3+b}^E + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E \right) Z_{i1}^A Z_{j1}^A \right. \\
& + \left(-g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{E,*} Z_{la}^E \left(Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A \right) \\
& \left. + 2g_1^2 \sum_{a=1}^3 Z_{k3+a}^{E,*} Z_{l3+a}^E \left(-Z_{i1}^A Z_{j1}^A + Z_{i2}^A Z_{j2}^A \right) \right) \quad (377)
\end{aligned}$$



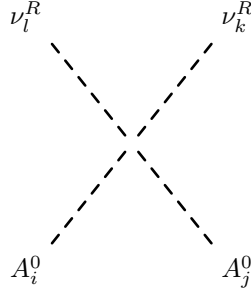
$$\begin{aligned}
& \frac{i}{12} \delta_{\gamma\delta} \left(\left(-3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^U \left(Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A \right) \right. \\
& - 4 \left(3 \left(\sum_{c=1}^3 Z_{k3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{u,ba} Z_{l3+b}^U + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^U \right) Z_{i2}^A Z_{j2}^A \right. \\
& \left. \left. + g_1^2 \sum_{a=1}^3 Z_{k3+a}^{U,*} Z_{l3+a}^U \left(Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A \right) \right) \right) \quad (378)
\end{aligned}$$



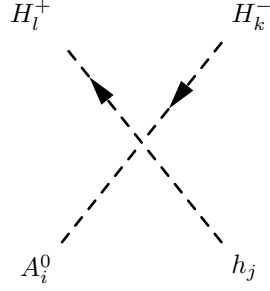
$$\begin{aligned}
& - \frac{i}{4} \left(2 \left(\sum_{c=1}^3 Z_{lc}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} + \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} \right) \right. \\
& + \sum_{c=1}^3 Z_{l3+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} + \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} \left. \right) Z_{i2}^A Z_{j2}^A \\
& + \left(g_1^2 + g_2^2 \right) \sum_{a=1}^3 Z_{ka}^{i,*} Z_{la}^{i,*} \left(Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A \right) \quad (379)
\end{aligned}$$



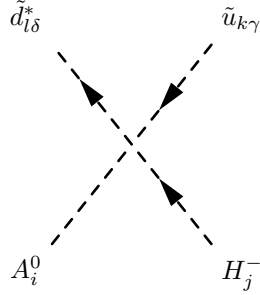
$$\begin{aligned}
& \frac{1}{2} \left(\sum_{c=1}^3 Z_{lc}^{R,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} - \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} \right. \\
& \left. - \sum_{c=1}^3 Z_{l3+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} + \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} \right) Z_{i2}^A Z_{j2}^A \quad (380)
\end{aligned}$$



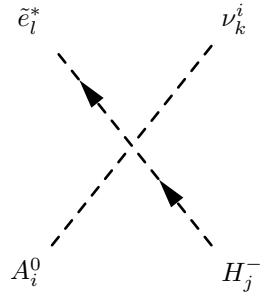
$$\begin{aligned}
& -\frac{i}{4} \left(2 \left(\sum_{c=1}^3 Z_{lc}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} + \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} \right. \right. \\
& \left. \left. + \sum_{c=1}^3 Z_{l3+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} + \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} \right) Z_{i2}^A Z_{j2}^A \right. \\
& \left. + \left(g_1^2 + g_2^2 \right) \sum_{a=1}^3 Z_{ka}^{R,*} Z_{la}^{R,*} \left(Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A \right) \right) \quad (381)
\end{aligned}$$



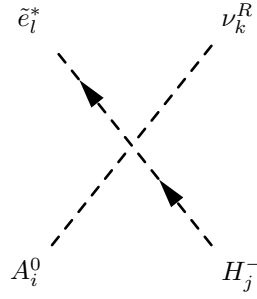
$$\frac{1}{4} g_2^2 \left(Z_{i1}^A Z_{j2}^H + Z_{i2}^A Z_{j1}^H \right) \left(-Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) \quad (382)$$



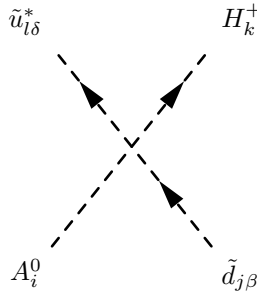
$$\begin{aligned} & \frac{1}{2} \frac{1}{\sqrt{2}} \delta_{\gamma\delta} \left(g_2^2 \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^D \left(-Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+ \right) \right. \\ & + 2 \left(\sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^D Z_{i1}^A Z_{j1}^+ - \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^D Z_{i2}^A Z_{j2}^+ \right. \\ & \left. \left. + \sum_{c=1}^3 Z_{k3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{d,ba} Z_{l3+b}^D \left(-Z_{i1}^A Z_{j2}^+ + Z_{i2}^A Z_{j1}^+ \right) \right) \right) \quad (383) \end{aligned}$$



$$\begin{aligned}
& \frac{i}{4} \left(g_2^2 \sum_{a=1}^3 Z_{ka}^{i,*} Z_{la}^E \left(-Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+ \right) \right. \\
& + 2 \left(\sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E Z_{i1}^A Z_{j1}^+ - \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{lc}^E Z_{i2}^A Z_{j2}^+ \right. \\
& \left. \left. + \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ca}^* Y_{e,ba} Z_{l3+b}^E \left(-Z_{i1}^A Z_{j2}^+ + Z_{i2}^A Z_{j1}^+ \right) \right) \right) \quad (384)
\end{aligned}$$

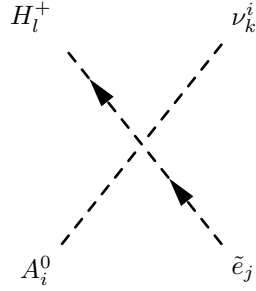


$$\begin{aligned}
& \frac{1}{4} \left(g_2^2 \sum_{a=1}^3 Z_{ka}^{R,*} Z_{la}^E \left(-Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+ \right) \right. \\
& + 2 \left(\sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E Z_{i1}^A Z_{j1}^+ - \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{lc}^E Z_{i2}^A Z_{j2}^+ \right. \\
& \left. \left. + \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ca}^* Y_{e,ba} Z_{l3+b}^E \left(-Z_{i1}^A Z_{j2}^+ + Z_{i2}^A Z_{j1}^+ \right) \right) \right) \quad (385)
\end{aligned}$$

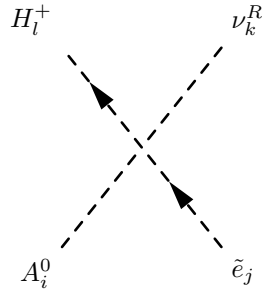


$$\frac{1}{2} \frac{1}{\sqrt{2}} \delta_{\beta\delta} \left(-2 \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^U Z_{i1}^A Z_{k1}^+ \right)$$

$$\begin{aligned}
& -2 \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{u,ba} Z_{l3+b}^U Z_{i2}^A Z_{k1}^+ \\
& + 2 \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{u,ba} Z_{l3+b}^U Z_{i1}^A Z_{k2}^+ \\
& + 2 \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^U Z_{i2}^A Z_{k2}^+ + g_2^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^U \left(Z_{i1}^A Z_{k1}^+ - Z_{i2}^A Z_{k2}^+ \right)
\end{aligned} \tag{386}$$

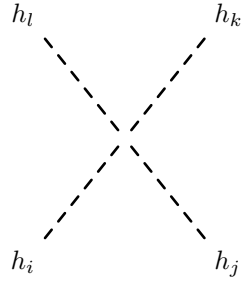


$$\begin{aligned}
& \frac{i}{4} \left(g_2^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^{i,*} \left(-Z_{i1}^A Z_{l1}^+ + Z_{i2}^A Z_{l2}^+ \right) \right. \\
& + 2 \left(\sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{i1}^A Z_{l1}^+ \right. \\
& - \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{l2}^+ \\
& \left. \left. + \sum_{c=1}^3 Z_{j3+c}^{E,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Y_{e,ca}^* Y_{\nu,ba} \left(-Z_{i1}^A Z_{l2}^+ + Z_{i2}^A Z_{l1}^+ \right) \right) \right)
\end{aligned} \tag{387}$$

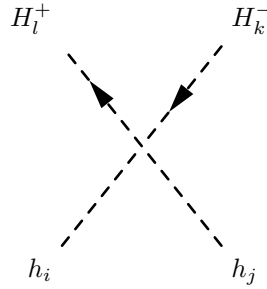


$$\frac{1}{4} \left(-2 \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{i1}^A Z_{l1}^+ \right)$$

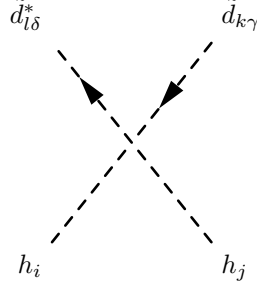
$$\begin{aligned}
& - 2 \sum_{c=1}^3 Z_{j3+c}^{E,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Y_{e,ca}^* Y_{\nu,ba} Z_{i2}^A Z_{l1}^+ \\
& + 2 \sum_{c=1}^3 Z_{j3+c}^{E,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Y_{e,ca}^* Y_{\nu,ba} Z_{i1}^A Z_{l2}^+ \\
& + 2 \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{l2}^+ + g_2^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^{R,*} \left(Z_{i1}^A Z_{l1}^+ - Z_{i2}^A Z_{l2}^+ \right)
\end{aligned} \tag{388}$$



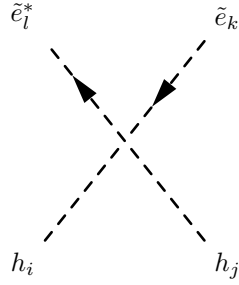
$$\begin{aligned}
& \frac{i}{4} \left(g_1^2 + g_2^2 \right) \left(Z_{i2}^H \left(Z_{j1}^H \left(Z_{k1}^H Z_{l2}^H + Z_{k2}^H Z_{l1}^H \right) + Z_{j2}^H \left(-3Z_{k2}^H Z_{l2}^H + Z_{k1}^H Z_{l1}^H \right) \right) \right. \\
& \left. + Z_{i1}^H \left(Z_{j1}^H \left(-3Z_{k1}^H Z_{l1}^H + Z_{k2}^H Z_{l2}^H \right) + Z_{j2}^H \left(Z_{k1}^H Z_{l2}^H + Z_{k2}^H Z_{l1}^H \right) \right) \right)
\end{aligned} \tag{389}$$



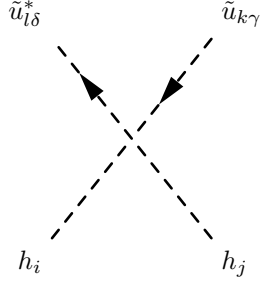
$$\begin{aligned}
& - \frac{i}{4} \left(Z_{i1}^H \left(g_2^2 Z_{j2}^H \left(Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) + Z_{j1}^H \left(\left(g_1^2 + g_2^2 \right) Z_{k1}^+ Z_{l1}^+ + \left(-g_1^2 + g_2^2 \right) Z_{k2}^+ Z_{l2}^+ \right) \right) \right. \\
& \left. + Z_{i2}^H \left(g_2^2 Z_{j1}^H \left(Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) + Z_{j2}^H \left(\left(-g_1^2 + g_2^2 \right) Z_{k1}^+ Z_{l1}^+ + \left(g_1^2 + g_2^2 \right) Z_{k2}^+ Z_{l2}^+ \right) \right) \right)
\end{aligned} \tag{390}$$



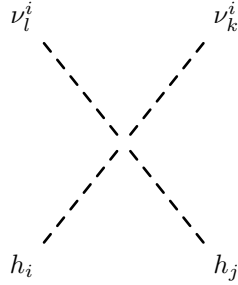
$$\begin{aligned}
& \frac{i}{12} \delta_{\gamma\delta} \left((3g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ka}^{D,*} Z_{la}^D (Z_{i1}^H Z_{j1}^H - Z_{i2}^H Z_{j2}^H) \right. \\
& + 2 \left(-6 \left(\sum_{c=1}^3 Z_{k3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{d,ba} Z_{l3+b}^D + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^D \right) Z_{i1}^H Z_{j1}^H \right. \\
& \left. \left. + g_1^2 \sum_{a=1}^3 Z_{k3+a}^{D,*} Z_{l3+a}^D (Z_{i1}^H Z_{j1}^H - Z_{i2}^H Z_{j2}^H) \right) \right) \tag{391}
\end{aligned}$$



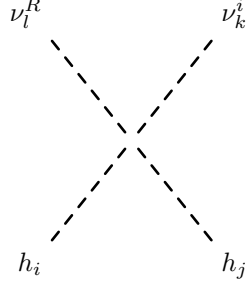
$$\begin{aligned}
& -\frac{i}{4} \left(4 \left(\sum_{c=1}^3 Z_{k3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{e,ba} Z_{l3+b}^E + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E \right) Z_{i1}^H Z_{j1}^H \right. \\
& + \left(-g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{E,*} Z_{la}^E (Z_{i1}^H Z_{j1}^H - Z_{i2}^H Z_{j2}^H) \\
& \left. + 2g_1^2 \sum_{a=1}^3 Z_{k3+a}^{E,*} Z_{l3+a}^E (-Z_{i1}^H Z_{j1}^H + Z_{i2}^H Z_{j2}^H) \right) \tag{392}
\end{aligned}$$



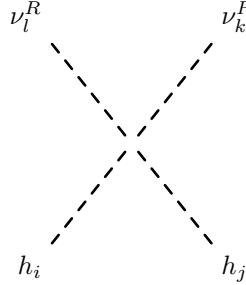
$$\begin{aligned}
& \frac{i}{12} \delta_{\gamma\delta} \left(\left(-3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^U \left(Z_{i1}^H Z_{j1}^H - Z_{i2}^H Z_{j2}^H \right) \right. \\
& - 4 \left(3 \left(\sum_{c=1}^3 Z_{k3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{u,ba} Z_{l3+b}^U + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^U \right) Z_{i2}^H Z_{j2}^H \right. \\
& \left. \left. + g_1^2 \sum_{a=1}^3 Z_{k3+a}^{U,*} Z_{l3+a}^U \left(Z_{i1}^H Z_{j1}^H - Z_{i2}^H Z_{j2}^H \right) \right) \right) \tag{393}
\end{aligned}$$



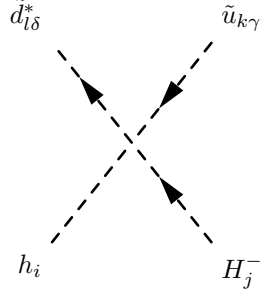
$$\begin{aligned}
& - \frac{i}{4} \left(2 \left(\sum_{c=1}^3 Z_{lc}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} + \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} \right. \right. \\
& \left. \left. + \sum_{c=1}^3 Z_{l3+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} + \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} \right) Z_{i2}^H Z_{j2}^H \right. \\
& \left. + \left(g_1^2 + g_2^2 \right) \sum_{a=1}^3 Z_{ka}^{i,*} Z_{la}^{i,*} \left(Z_{i1}^H Z_{j1}^H - Z_{i2}^H Z_{j2}^H \right) \right) \tag{394}
\end{aligned}$$



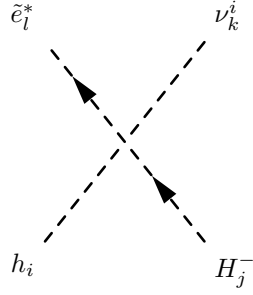
$$\begin{aligned}
& \frac{1}{2} \left(\sum_{c=1}^3 Z_{lc}^{R,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} - \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} \right. \\
& \left. - \sum_{c=1}^3 Z_{l3+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} + \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} \right) Z_{i2}^H Z_{j2}^H \quad (395)
\end{aligned}$$



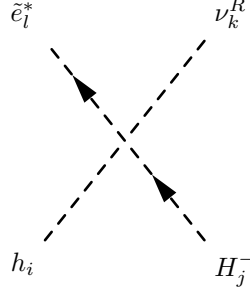
$$\begin{aligned}
& -\frac{i}{4} \left(2 \left(\sum_{c=1}^3 Z_{lc}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} + \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} \right) \right. \\
& \left. + \sum_{c=1}^3 Z_{l3+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} + \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} \right) Z_{i2}^H Z_{j2}^H \\
& + \left(g_1^2 + g_2^2 \right) \sum_{a=1}^3 Z_{ka}^{R,*} Z_{la}^{R,*} \left(Z_{i1}^H Z_{j1}^H - Z_{i2}^H Z_{j2}^H \right) \quad (396)
\end{aligned}$$



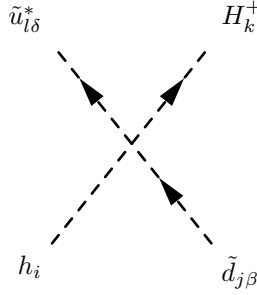
$$\begin{aligned}
& -\frac{i}{2} \frac{1}{\sqrt{2}} \delta_{\gamma\delta} \left(g_2^2 \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^D \left(Z_{i1}^H Z_{j1}^+ + Z_{i2}^H Z_{j2}^+ \right) \right. \\
& - 2 \left(\sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^D Z_{i1}^H Z_{j1}^+ + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^D Z_{i2}^H Z_{j2}^+ \right. \\
& \left. \left. + \sum_{c=1}^3 Z_{k3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{d,ba} Z_{l3+b}^D \left(Z_{i1}^H Z_{j2}^+ + Z_{i2}^H Z_{j1}^+ \right) \right) \right) \quad (397)
\end{aligned}$$



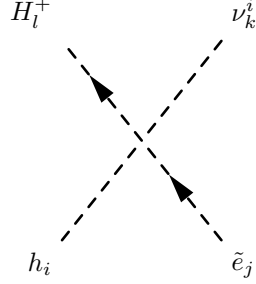
$$\begin{aligned}
& \frac{1}{4} \left(g_2^2 \sum_{a=1}^3 Z_{ka}^{i,*} Z_{la}^E \left(Z_{i1}^H Z_{j1}^+ + Z_{i2}^H Z_{j2}^+ \right) \right. \\
& - 2 \left(\sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E Z_{i1}^H Z_{j1}^+ + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{lc}^E Z_{i2}^H Z_{j2}^+ \right. \\
& \left. \left. + \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ca}^* Y_{e,ba} Z_{l3+b}^E \left(Z_{i1}^H Z_{j2}^+ + Z_{i2}^H Z_{j1}^+ \right) \right) \right) \quad (398)
\end{aligned}$$



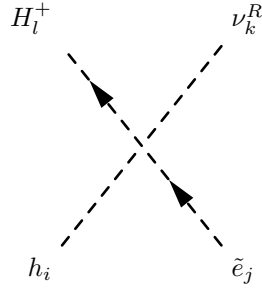
$$\begin{aligned}
& -\frac{i}{4} \left(g_2^2 \sum_{a=1}^3 Z_{ka}^{R,*} Z_{la}^E \left(Z_{i1}^H Z_{j1}^+ + Z_{i2}^H Z_{j2}^+ \right) \right. \\
& - 2 \left(\sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E Z_{i1}^H Z_{j1}^+ + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{lc}^E Z_{i2}^H Z_{j2}^+ \right. \\
& \left. \left. + \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ca}^* Y_{e,ba} Z_{l3+b}^E \left(Z_{i1}^H Z_{j2}^+ + Z_{i2}^H Z_{j1}^+ \right) \right) \right) \quad (399)
\end{aligned}$$



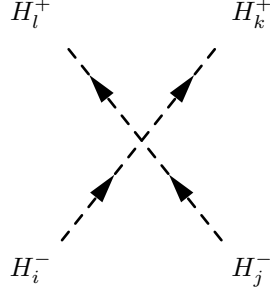
$$\begin{aligned}
& -\frac{i}{2} \frac{1}{\sqrt{2}} \delta_{\beta\delta} \left(g_2^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^U \left(Z_{i1}^H Z_{k1}^+ + Z_{i2}^H Z_{k2}^+ \right) \right. \\
& - 2 \left(\sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^U Z_{i1}^H Z_{k1}^+ + \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^U Z_{i2}^H Z_{k2}^+ \right. \\
& \left. \left. + \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{u,ba} Z_{l3+b}^U \left(Z_{i1}^H Z_{k2}^+ + Z_{i2}^H Z_{k1}^+ \right) \right) \right) \quad (400)
\end{aligned}$$



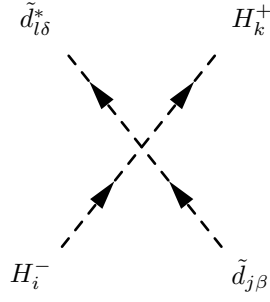
$$\begin{aligned}
& \frac{1}{4} \left(-g_2^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^{i,*} \left(Z_{i1}^H Z_{l1}^+ + Z_{i2}^H Z_{l2}^+ \right) \right. \\
& + 2 \left(\sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{i1}^H Z_{l1}^+ + \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H Z_{l2}^+ \right. \\
& \left. \left. + \sum_{c=1}^3 Z_{j3+c}^{E,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Y_{e,ca}^* Y_{\nu,ba} \left(Z_{i1}^H Z_{l2}^+ + Z_{i2}^H Z_{l1}^+ \right) \right) \right) \quad (401)
\end{aligned}$$



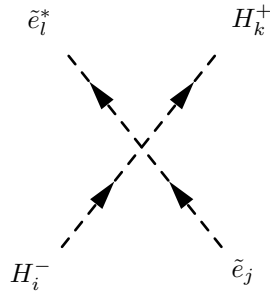
$$\begin{aligned}
& -\frac{i}{4} \left(g_2^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^{R,*} \left(Z_{i1}^H Z_{l1}^+ + Z_{i2}^H Z_{l2}^+ \right) \right. \\
& - 2 \left(\sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{i1}^H Z_{l1}^+ + \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H Z_{l2}^+ \right. \\
& \left. \left. + \sum_{c=1}^3 Z_{j3+c}^{E,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Y_{e,ca}^* Y_{\nu,ba} \left(Z_{i1}^H Z_{l2}^+ + Z_{i2}^H Z_{l1}^+ \right) \right) \right) \quad (402)
\end{aligned}$$



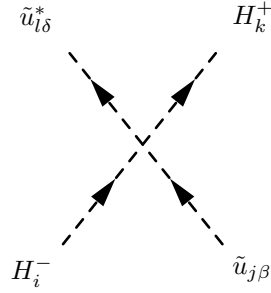
$$\begin{aligned}
& -\frac{i}{4}(g_1^2 + g_2^2) \left(-Z_{i2}^+ \left(-2Z_{j2}^+ Z_{k2}^+ Z_{l2}^+ + Z_{j1}^+ \left(Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) \right) \right. \\
& \left. + Z_{i1}^+ \left(2Z_{j1}^+ Z_{k1}^+ Z_{l1}^+ - Z_{j2}^+ \left(Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) \right) \right) \quad (403)
\end{aligned}$$



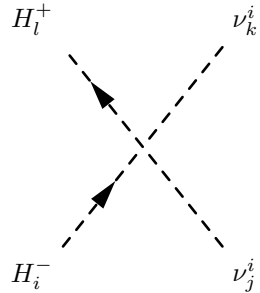
$$\begin{aligned}
& \frac{i}{12} \delta_{\beta\delta} \left(\left(-3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ja^*}^D Z_{la}^D \left(Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+ \right) \right. \\
& + 2 \left(g_1^2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{l3+a}^D \left(Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+ \right) \right. \\
& \left. \left. - 6 \left(\sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^D Z_{i2}^+ Z_{k2}^+ + \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{d,ba} Z_{l3+b}^D Z_{i1}^+ Z_{k1}^+ \right) \right) \right) \quad (404)
\end{aligned}$$



$$\begin{aligned}
& -\frac{i}{4} \left((g_1^2 + g_2^2) \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^E (Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+) \right. \\
& + 2g_1^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{l3+a}^E (-Z_{i1}^+ Z_{k1}^+ + Z_{i2}^+ Z_{k2}^+) \\
& \left. + 4 \left(\sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{lc}^E Z_{i2}^+ Z_{k2}^+ + \sum_{c=1}^3 Z_{j3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{e,ba} Z_{l3+b}^E Z_{i1}^+ Z_{k1}^+ \right) \right) \quad (405)
\end{aligned}$$

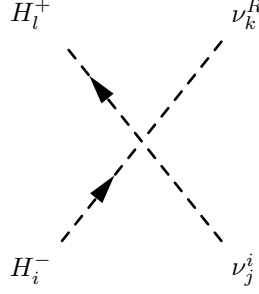


$$\begin{aligned}
& \frac{i}{12} \delta_{\beta\delta} \left((3g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U (Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+) \right. \\
& - 4 \left(g_1^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U (Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+) \right. \\
& \left. \left. + 3 \left(\sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^U Z_{i1}^+ Z_{k1}^+ + \sum_{c=1}^3 Z_{j3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{u,ba} Z_{l3+b}^U Z_{i2}^+ Z_{k2}^+ \right) \right) \right) \quad (406)
\end{aligned}$$

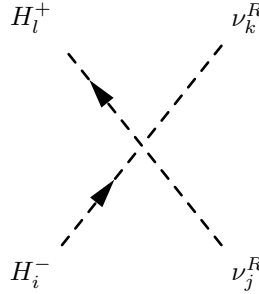


$$-\frac{i}{4} \left((-g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ja}^{i,*} Z_{ka}^{i,*} (Z_{i1}^+ Z_{l1}^+ - Z_{i2}^+ Z_{l2}^+) \right)$$

$$\begin{aligned}
& + 2 \left(\sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{i1}^+ Z_{l1}^+ + \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{i1}^+ Z_{l1}^+ \right. \\
& \left. + \left(\sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} + \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} \right) Z_{i2}^+ Z_{l2}^+ \right) \quad (407)
\end{aligned}$$

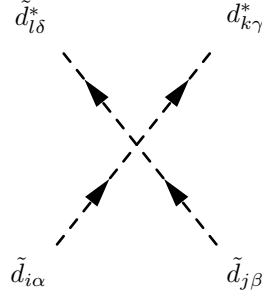


$$\begin{aligned}
& \frac{1}{2} \left(\sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{i1}^+ Z_{l1}^+ \right. \\
& \left. - \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{i1}^+ Z_{l1}^+ \right. \\
& \left. + \left(- \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} + \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} \right) Z_{i2}^+ Z_{l2}^+ \right) \quad (408)
\end{aligned}$$



$$\begin{aligned}
& - \frac{i}{4} \left((-g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^{R,*} (Z_{i1}^+ Z_{l1}^+ - Z_{i2}^+ Z_{l2}^+) \right. \\
& \left. + 2 \left(\sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{i1}^+ Z_{l1}^+ + \sum_{c=1}^3 Z_{jc}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{i1}^+ Z_{l1}^+ \right) \right)
\end{aligned}$$

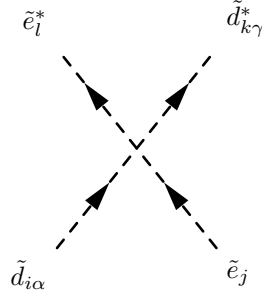
$$+ \left(\sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} + \sum_{c=1}^3 Z_{j3+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} \right) Z_{i2}^+ Z_{l2}^+ \Big) \quad (409)$$



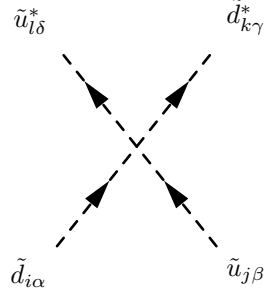
$$\begin{aligned}
& - \frac{i}{72} \left(\delta_{\alpha\delta} \delta_{\beta\gamma} \left(g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D + 9g_2^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D \right. \right. \\
& - 6g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*}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

$$\begin{aligned}
& + 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 \\
& + 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
\end{aligned}$$

$$\begin{aligned}
& -6g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{l3+b}^D \\
& + 72 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{i3+c}^{D,*} Z_{kd}^D \\
& + 72 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{j3+c}^{D,*} Z_{ld}^D \Big) \tag{410}
\end{aligned}$$

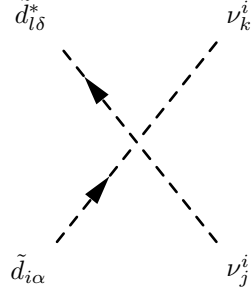


$$\begin{aligned}
& \frac{i}{24} \delta_{\alpha\gamma} \left(-2g_1^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{l3+a}^E \left(2 \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \right. \\
& + \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^E \left(2g_1^2 \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \left(-3g_2^2 + g_1^2 \right) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \\
& + g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E - 3g_2^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E \\
& + 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E - 2g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \\
& - 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \\
& - 24 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{i3+c}^{D,*} Z_{kd}^D \\
& \left. - 24 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{j3+c}^{E,*} Z_{ld}^E \right) \tag{411}
\end{aligned}$$

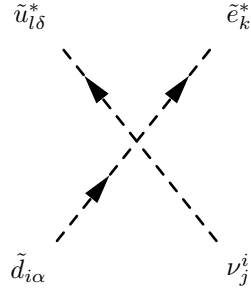


$$\begin{aligned}
& -\frac{i}{72} \left(\delta_{\alpha\gamma} \delta_{\beta\delta} \left(\sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \left(2 \left(3g_3^2 + g_1^2 \right) \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \left(-6g_3^2 - 9g_2^2 + g_1^2 \right) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \right. \right. \\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

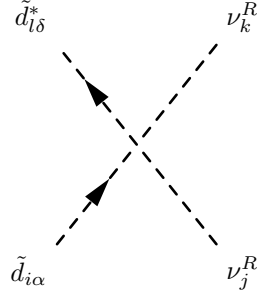
$$+ 4 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{i3+c}^{D,*} Z_{ld}^U \Big) \quad (412)$$



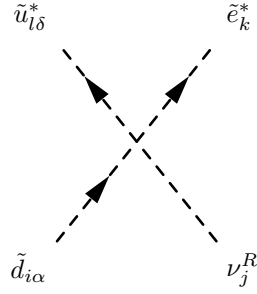
$$\begin{aligned} & \frac{i}{24} \delta_{\alpha\delta} \left((3g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{jb}^{i,*} Z_{kb}^{i,*} + 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{jb}^{i,*} Z_{kb}^{i,*} \right. \\ & \left. + \sum_{a=1}^3 Z_{ja}^{i,*} Z_{ka}^{i,*} \left(2g_1^2 \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{l3+b}^D + (3g_2^2 + g_1^2) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D \right) \right) \quad (413) \end{aligned}$$



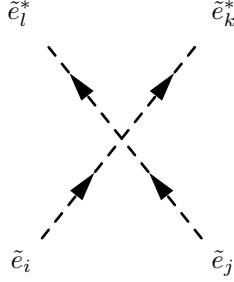
$$\begin{aligned} & \frac{1}{4} \frac{1}{\sqrt{2}} \delta_{\alpha\delta} \left(g_2^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{i,*} Z_{kb}^E + g_2^2 \sum_{a=1}^3 Z_{ja}^{i,*} Z_{ka}^E \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^U \right. \\ & + 4 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \sum_{d=1}^3 \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{i,*} Z_{kd}^E \\ & \left. + 4 \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{i3+c}^{D,*} Z_{ld}^U \right) \quad (414) \end{aligned}$$



$$\begin{aligned}
& \frac{i}{24} \delta_{\alpha\delta} \left((3g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{jb}^{R,*} Z_{kb}^{R,*} + 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{jb}^{R,*} Z_{kb}^{R,*} \right. \\
& \left. + \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^{R,*} \left(2g_1^2 \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{l3+b}^D + (3g_2^2 + g_1^2) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D \right) \right) \quad (415)
\end{aligned}$$

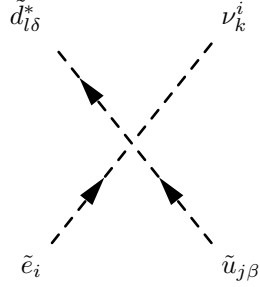


$$\begin{aligned}
& - \frac{i}{4\sqrt{2}} \delta_{\alpha\delta} \left(g_2^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{R,*} Z_{kb}^E + g_2^2 \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^E \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^U \right. \\
& + 4 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \sum_{d=1}^3 \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{R,*} Z_{kd}^E \\
& \left. + 4 \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{i3+c}^{D,*} Z_{ld}^U \right) \quad (416)
\end{aligned}$$

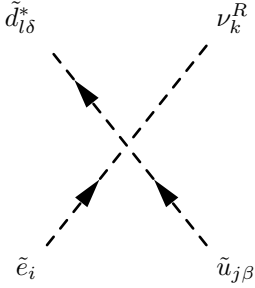


$$\begin{aligned}
& -\frac{i}{8} \left(g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{kb}^E + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{kb}^E \right. \\
& - 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{l3+a}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{kb}^E \\
& - 2g_1^2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

$$\begin{aligned}
& + 8 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^{E,*} Z_{ld}^E \\
& + 8 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{j3+c}^{E,*} Z_{ld}^E
\end{aligned} \tag{417}$$

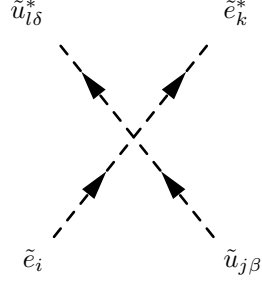


$$\begin{aligned}
& - \frac{1}{4} \frac{1}{\sqrt{2}} \delta_{\beta\delta} \left(g_2^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^D \sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^{i,*} + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^{i,*} \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^D \right. \\
& + 4 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^{E,*} \\
& \left. + 4 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{j3+c}^{U,*} Z_{ld}^D \right)
\end{aligned} \tag{418}$$

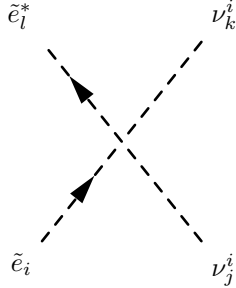


$$\begin{aligned}
& - \frac{i}{4} \frac{1}{\sqrt{2}} \delta_{\beta\delta} \left(g_2^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^D \sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^{R,*} + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^D \right. \\
& + 4 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^{E,*}
\end{aligned}$$

$$+ 4 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{j3+c}^{U,*} Z_{ld}^D \quad (419)$$

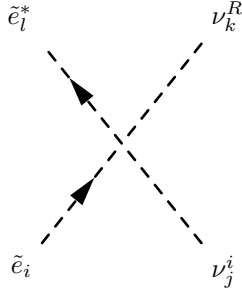


$$\begin{aligned} & \frac{i}{24} \delta_{\beta\delta} \left(-4g_1^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U \left(-2 \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{k3+b}^E + \sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^E \right) \right. \\ & + \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \left(-2g_1^2 \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{k3+b}^E + (3g_2^2 + g_1^2) \sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^E \right) \\ & + g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U + 3g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\ & - 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U - 4g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\ & \left. + 8g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \right) \quad (420) \end{aligned}$$



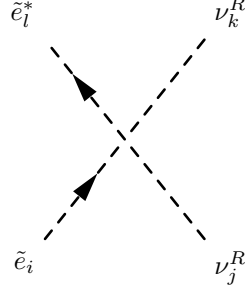
$$- \frac{i}{8} \left(g_2^2 \sum_{a=1}^3 Z_{ka}^{i,*} Z_{la}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{jb}^{i,*} + g_2^2 \sum_{a=1}^3 Z_{ja}^{i,*} Z_{la}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^{i,*} \right)$$

$$\begin{aligned}
& + g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{jb}^{i,*} Z_{kb}^{i,*} - g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{jb}^{i,*} Z_{kb}^{i,*} \\
& - 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{l3+a}^E \sum_{b=1}^3 Z_{jb}^{i,*} Z_{kb}^{i,*} + g_1^2 \sum_{a=1}^3 Z_{ja}^{i,*} Z_{ka}^{i,*} \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E \\
& - g_2^2 \sum_{a=1}^3 Z_{ja}^{i,*} Z_{ka}^{i,*} \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^{i,*} \sum_{b=1}^3 Z_{jb}^{i,*} Z_{lb}^E \\
& + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} Z_{lb}^E - 2g_1^2 \sum_{a=1}^3 Z_{ja}^{i,*} Z_{ka}^{i,*} \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{l3+b}^E \\
& + 4 \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^{E,*} \\
& + 4 \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^{E,*} \\
& + 4 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{i,*} Z_{ld}^E \\
& + 4 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} Z_{ld}^E \Big) \tag{421}
\end{aligned}$$

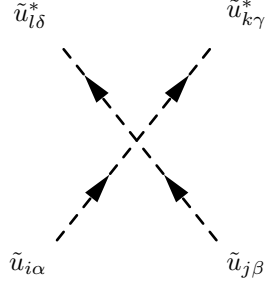


$$\begin{aligned}
& \frac{1}{8} \left(-g_2^2 \sum_{a=1}^3 Z_{ka}^{R,*} Z_{la}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{jb}^{i,*} + g_2^2 \sum_{a=1}^3 Z_{ja}^{i,*} Z_{la}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^{R,*} \right. \\
& + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{jb}^{i,*} Z_{lb}^E - g_2^2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

$$\begin{aligned}
& + 4 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{\nu,cd} Z_{j3+c}^{i,*} Z_{ld}^E \\
& - 4 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{\nu,cd} Z_{k3+c}^{R,*} Z_{ld}^E
\end{aligned} \tag{422}$$



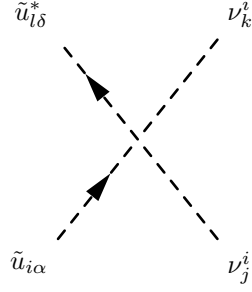
$$\begin{aligned}
& - \frac{i}{8} \left(g_2^2 \sum_{a=1}^3 Z_{ka}^{R,*} Z_{la}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{jb}^{R,*} + g_2^2 \sum_{a=1}^3 Z_{ja}^{R,*} Z_{la}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^{R,*} \right. \\
& + g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{jb}^{R,*} Z_{kb}^{R,*} - g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{jb}^{R,*} Z_{kb}^{R,*} \\
& - 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{l3+a}^E \sum_{b=1}^3 Z_{jb}^{R,*} Z_{kb}^{R,*} + g_1^2 \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E \\
& - g_2^2 \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{jb}^{R,*} Z_{lb}^E \\
& + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} Z_{lb}^E - 2g_1^2 \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{l3+b}^E \\
& + 4 \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 Z_{jd}^{R,*} \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^{E,*} \\
& + 4 \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^{E,*} \\
& + 4 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{R,*} Z_{ld}^E \\
& + 4 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*} Z_{ld}^E
\end{aligned} \tag{423}$$



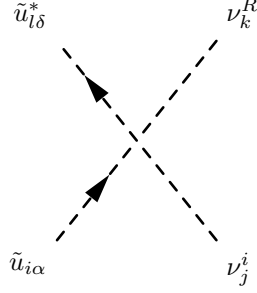
$$\begin{aligned}
& -\frac{i}{72} \left(\delta_{\alpha\delta} \delta_{\beta\gamma} \left(g_1^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U + 9g_2^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U \right. \right. \\
& - 6g_3^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U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

$$\begin{aligned}
& -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) \\
& - 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 \\
& + 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
\end{aligned}$$

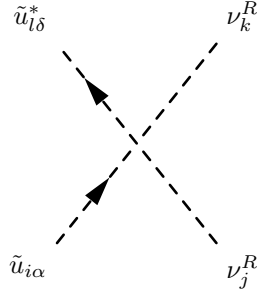
$$\begin{aligned}
& + 72 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{i3+c}^{U,*} Z_{kd}^U \\
& + 72 \sum_{b=1}^3 Z_{ib}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{j3+c}^{U,*} Z_{ld}^U \Big) \tag{424}
\end{aligned}$$



$$\begin{aligned}
& \frac{i}{24} \delta_{\alpha\delta} \left(\left(-3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{i,*} Z_{kb}^{i,*} - 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{l3+a}^U \sum_{b=1}^3 Z_{jb}^{i,*} Z_{kb}^{i,*} \right. \\
& + g_1^2 \sum_{a=1}^3 Z_{ja}^{i,*} Z_{ka}^{i,*} \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U - 3g_2^2 \sum_{a=1}^3 Z_{ja}^{i,*} Z_{ka}^{i,*} \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U \\
& - 4g_1^2 \sum_{a=1}^3 Z_{ja}^{i,*} Z_{ka}^{i,*} \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U \\
& - 12 \sum_{b=1}^3 Z_{ib}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{i,*} \\
& - 12 \sum_{b=1}^3 Z_{ib}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& - 12 \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{i3+c}^{U,*} Z_{ld}^U \\
& \left. - 12 \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{i3+c}^{U,*} Z_{ld}^U \right) \tag{425}
\end{aligned}$$

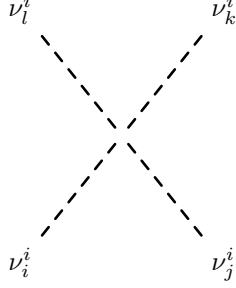


$$\begin{aligned}
& \frac{1}{2} \delta_{\alpha\delta} \left(\sum_{b=1}^3 Z_{ib}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \left(- \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd} Z_{k3+c}^{R,*} + \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd} Z_{j3+c}^{i,*} \right) \right. \\
& \left. + \left(- \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} + \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \right) \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd} Z_{i3+c}^{U,*} Z_{ld}^U \right) \quad (426)
\end{aligned}$$



$$\begin{aligned}
& \frac{i}{24} \delta_{\alpha\delta} \left(\left(-3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{R,*} Z_{kb}^{R,*} - 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{l3+a}^U \sum_{b=1}^3 Z_{jb}^{R,*} Z_{kb}^{R,*} \right. \\
& + g_1^2 \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U - 3g_2^2 \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U \\
& - 4g_1^2 \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U \\
& - 12 \sum_{b=1}^3 Z_{ib}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd} Z_{j3+c}^{R,*} \\
& - 12 \sum_{b=1}^3 Z_{ib}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \sum_{d=1}^3 Z_{jd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd} Z_{k3+c}^{R,*} \\
& \left. - 12 \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd} Z_{i3+c}^{U,*} Z_{ld}^U \right)
\end{aligned}$$

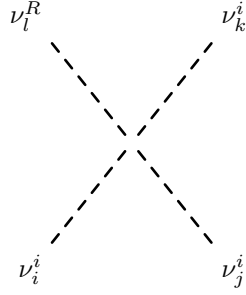
$$- 12 \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{i3+c}^{U,*} Z_{ld}^U \quad (427)$$



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

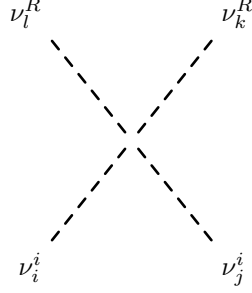
$$\begin{aligned}
& + 2 \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{i,*}
\end{aligned}$$

$$\begin{aligned}
& + 2 \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{i,*} \Big) \tag{428}
\end{aligned}$$



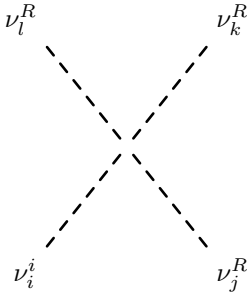
$$\begin{aligned}
& \frac{1}{4} \left(- \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{i,*} \right. \\
& + \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{i,*} \\
& + \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{i,*} \\
& + \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{i,*} \\
& - \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \left(\sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{i,*} + \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{i,*} \right) \\
& + \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} \left(\sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{i,*} + \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{i,*} \right) \\
& - \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{i,*} \\
& + \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{i,*} \\
& + \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{i,*} \Big)
\end{aligned}$$

$$\begin{aligned}
& + \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{i,*} \\
& - \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& + \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& - \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& + \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& + \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& + \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& - \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*}
\end{aligned} \tag{429}$$



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

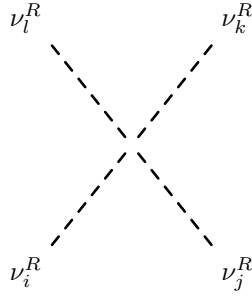
$$\begin{aligned}
& + \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*} \\
& + \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*} \\
& + \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*} \\
& + \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& + \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& + \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& + \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& + \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \Big) \tag{430}
\end{aligned}$$



$$\frac{1}{4} \left(\sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{i,*} \right)$$

$$\begin{aligned}
& + \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{i,*} \\
& + \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{i,*} \\
& + \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{i,*} \\
& + \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \left(- \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{R,*} + \sum_{d=1}^3 Z_{jd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{i,*} \right) \\
& + \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} \left(- \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{R,*} + \sum_{d=1}^3 Z_{jd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{i,*} \right) \\
& - \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{R,*} \\
& + \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{R,*} \\
& + \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*} \\
& + \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*} \\
& + \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*}
\end{aligned}$$

$$\begin{aligned}
& - \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& + \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& + \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*}
\end{aligned} \tag{431}$$

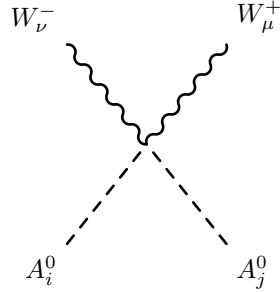


$$\begin{aligned}
& - \frac{i}{8} \left((g_1^2 + g_2^2) \sum_{a=1}^3 Z_{ka}^{R,*} Z_{la}^{R,*} \sum_{b=1}^3 Z_{ib}^{R,*} Z_{jb}^{R,*} + (g_1^2 + g_2^2) \sum_{a=1}^3 Z_{ja}^{R,*} Z_{la}^{R,*} \sum_{b=1}^3 Z_{ib}^{R,*} Z_{kb}^{R,*} \right. \\
& + g_1^2 \sum_{a=1}^3 Z_{ia}^{R,*} Z_{la}^{R,*} \sum_{b=1}^3 Z_{jb}^{R,*} Z_{kb}^{R,*} + g_2^2 \sum_{a=1}^3 Z_{ia}^{R,*} Z_{la}^{R,*} \sum_{b=1}^3 Z_{jb}^{R,*} Z_{kb}^{R,*} \\
& + g_1^2 \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{ib}^{R,*} Z_{lb}^{R,*} + g_2^2 \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{ib}^{R,*} Z_{lb}^{R,*} \\
& + g_1^2 \sum_{a=1}^3 Z_{ia}^{R,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{jb}^{R,*} Z_{lb}^{R,*} + g_2^2 \sum_{a=1}^3 Z_{ia}^{R,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{jb}^{R,*} Z_{lb}^{R,*} \\
& + g_1^2 \sum_{a=1}^3 Z_{ia}^{R,*} Z_{ja}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} Z_{lb}^{R,*} + g_2^2 \sum_{a=1}^3 Z_{ia}^{R,*} Z_{ja}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} Z_{lb}^{R,*} \\
& \left. + 2 \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{R,*} \right)
\end{aligned}$$

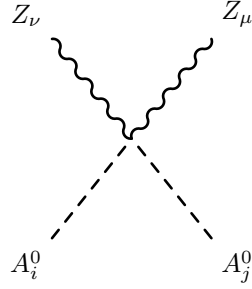
$$\begin{aligned}
& + 2 \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{ib}^{R,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{ib}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{ib}^{R,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*}
\end{aligned}$$

$$\begin{aligned}
& + 2 \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{ib}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{ib}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{ib}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \Big) \tag{432}
\end{aligned}$$

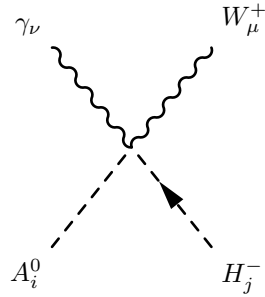
9.8 Two Scalar-Two Vector Boson-Interaction



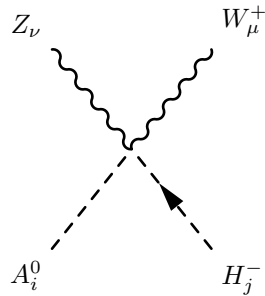
$$\frac{i}{2} g_2^2 \left(Z_{i1}^A Z_{j1}^A + Z_{i2}^A Z_{j2}^A \right) (g_{\mu\nu}) \tag{433}$$



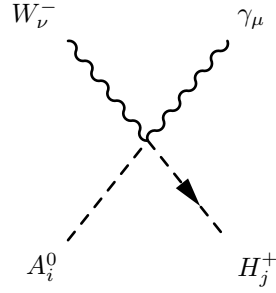
$$\frac{i}{2} (g_1 \sin \Theta_W + g_2 \cos \Theta_W)^2 (Z_{i1}^A Z_{j1}^A + Z_{i2}^A Z_{j2}^A) (g_{\mu\nu}) \quad (434)$$



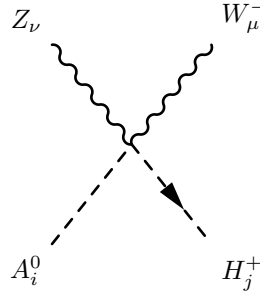
$$-\frac{1}{2} g_1 g_2 \cos \Theta_W (Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+) (g_{\mu\nu}) \quad (435)$$



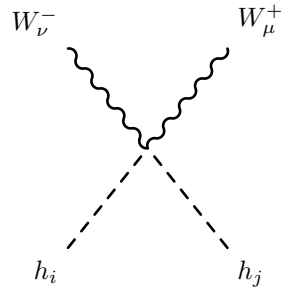
$$\frac{1}{2} g_1 g_2 \sin \Theta_W (Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+) (g_{\mu\nu}) \quad (436)$$



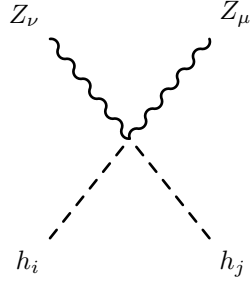
$$\frac{1}{2}g_1g_2 \cos \Theta_W \left(Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+ \right) \left(g_{\mu\nu} \right) \quad (437)$$



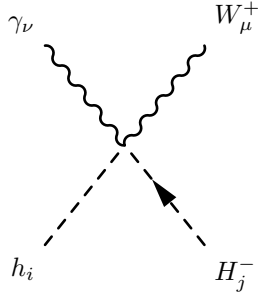
$$- \frac{1}{2}g_1g_2 \sin \Theta_W \left(Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+ \right) \left(g_{\mu\nu} \right) \quad (438)$$



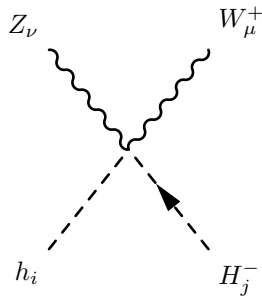
$$\frac{i}{2}g_2^2 \left(Z_{i1}^H Z_{j1}^H + Z_{i2}^H Z_{j2}^H \right) \left(g_{\mu\nu} \right) \quad (439)$$



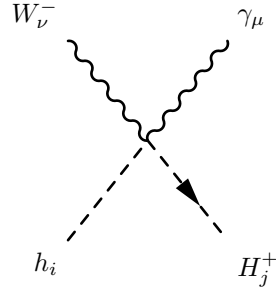
$$\frac{i}{2} (g_1 \sin \Theta_W + g_2 \cos \Theta_W)^2 (Z_{i1}^H Z_{j1}^H + Z_{i2}^H Z_{j2}^H) (g_{\mu\nu}) \quad (440)$$



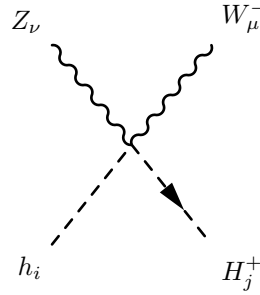
$$-\frac{i}{2} g_1 g_2 \cos \Theta_W (Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+) (g_{\mu\nu}) \quad (441)$$



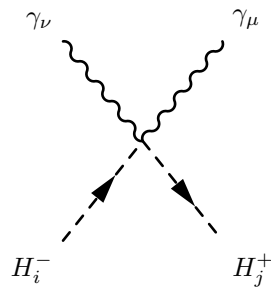
$$\frac{i}{2} g_1 g_2 \sin \Theta_W (Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+) (g_{\mu\nu}) \quad (442)$$



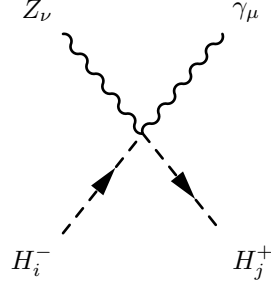
$$-\frac{i}{2}g_1g_2\cos\Theta_W\left(Z_{i1}^HZ_{j1}^+-Z_{i2}^HZ_{j2}^+\right)\left(g_{\mu\nu}\right) \quad (443)$$



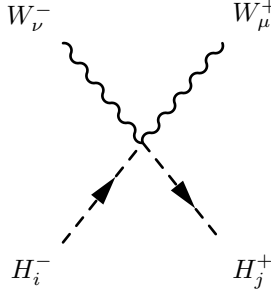
$$\frac{i}{2}g_1g_2\sin\Theta_W\left(Z_{i1}^HZ_{j1}^+-Z_{i2}^HZ_{j2}^+\right)\left(g_{\mu\nu}\right) \quad (444)$$



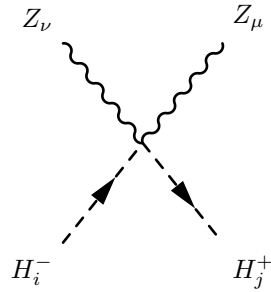
$$\frac{i}{2}\left(g_1\cos\Theta_W+g_2\sin\Theta_W\right)^2\left(Z_{i1}^+Z_{j1}^++Z_{i2}^+Z_{j2}^+\right)\left(g_{\mu\nu}\right) \quad (445)$$



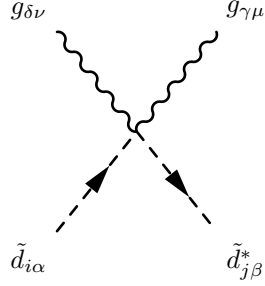
$$-\frac{i}{4} \left(-2g_1g_2 \cos 2\Theta_W + (-g_2^2 + g_1^2) \sin 2\Theta_W \right) (Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+) (g_{\mu\nu}) \quad (446)$$



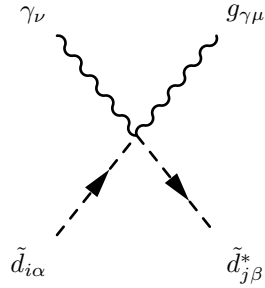
$$\frac{i}{2} g_2^2 (Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+) (g_{\mu\nu}) \quad (447)$$



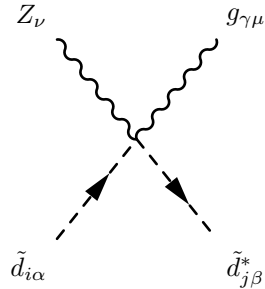
$$\frac{i}{2} \left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right)^2 (Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+) (g_{\mu\nu}) \quad (448)$$



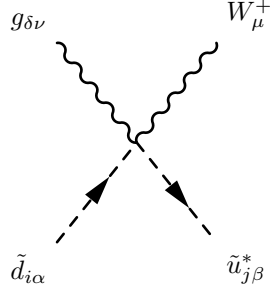
$$\frac{i}{4} g_3^2 \delta_{ij} \left(\sum_{a=1}^3 \lambda_{a,\alpha}^\gamma \lambda_{\beta,a}^\delta + \sum_{a=1}^3 \lambda_{\beta,a}^\gamma \lambda_{a,\alpha}^\delta \right) (g_{\mu\nu}) \quad (449)$$



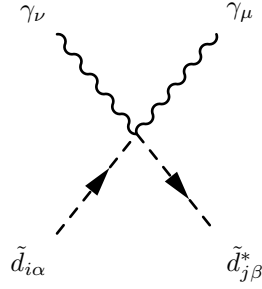
$$\frac{i}{6} g_3 \lambda_{\beta,\alpha}^\gamma \left(-2g_1 \cos \Theta_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D + \left(-3g_2 \sin \Theta_W + g_1 \cos \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \right) (g_{\mu\nu}) \quad (450)$$



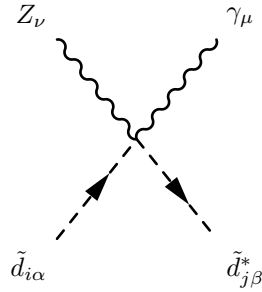
$$-\frac{i}{6} g_3 \lambda_{\beta,\alpha}^\gamma \left(-2g_1 \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D + \left(3g_2 \cos \Theta_W + g_1 \sin \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \right) (g_{\mu\nu}) \quad (451)$$



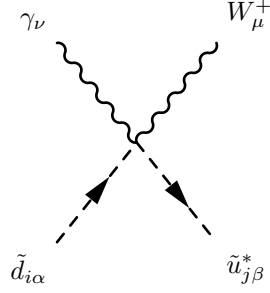
$$i \frac{1}{\sqrt{2}} g_2 g_3 \lambda_{\beta,\alpha}^{\delta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U (g_{\mu\nu}) \quad (452)$$



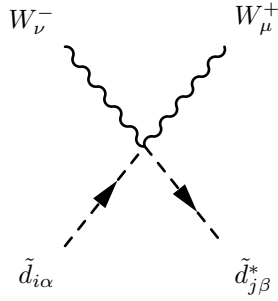
$$\frac{i}{18} \delta_{\alpha\beta} \left((-3g_2 \sin \Theta_W + g_1 \cos \Theta_W)^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D + 4g_1^2 \cos^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \right) (g_{\mu\nu}) \quad (453)$$



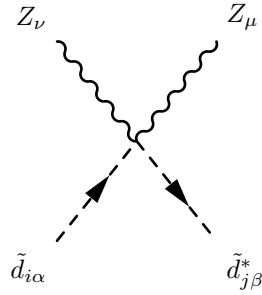
$$-\frac{i}{36} \delta_{\alpha\beta} \left((6g_1 g_2 \cos 2\Theta_W + (-9g_2^2 + g_1^2) \sin 2\Theta_W) \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D + 4g_1^2 \sin 2\Theta_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \right) (g_{\mu\nu}) \quad (454)$$



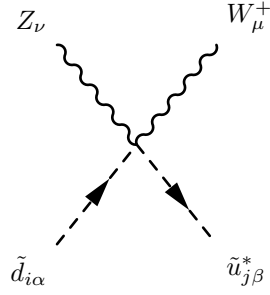
$$\frac{i}{3} \frac{1}{\sqrt{2}} g_1 g_2 \cos \Theta_W \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U (g_{\mu\nu}) \quad (455)$$



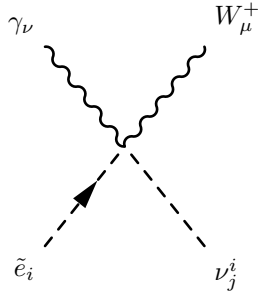
$$\frac{i}{2} g_2^2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D (g_{\mu\nu}) \quad (456)$$



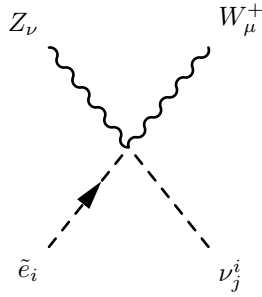
$$\frac{i}{18} \delta_{\alpha\beta} \left((3g_2 \cos \Theta_W + g_1 \sin \Theta_W)^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D + 4g_1^2 \sin^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \right) (g_{\mu\nu}) \quad (457)$$



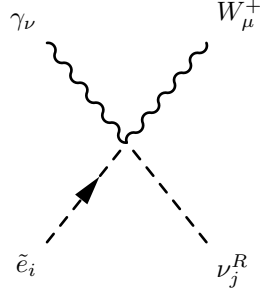
$$-\frac{i}{3} \frac{1}{\sqrt{2}} g_1 g_2 \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U (g_{\mu\nu}) \quad (458)$$



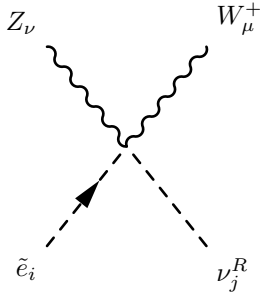
$$-\frac{1}{2} g_1 g_2 \cos \Theta_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^{i,*} (g_{\mu\nu}) \quad (459)$$



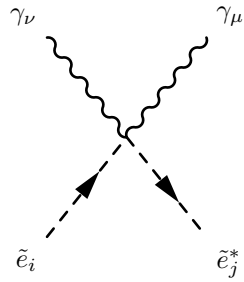
$$\frac{1}{2} g_1 g_2 \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^{i,*} (g_{\mu\nu}) \quad (460)$$



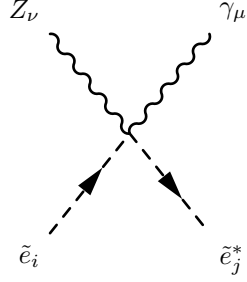
$$-\frac{i}{2}g_1g_2\cos\Theta_W\sum_{a=1}^3Z_{ia}^{E,*}Z_{ja}^{R,*}(g_{\mu\nu}) \quad (461)$$



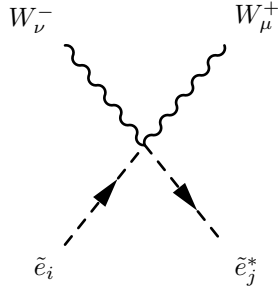
$$\frac{i}{2}g_1g_2\sin\Theta_W\sum_{a=1}^3Z_{ia}^{E,*}Z_{ja}^{R,*}(g_{\mu\nu}) \quad (462)$$



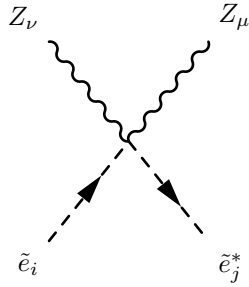
$$\frac{i}{2}\left(4g_1^2\cos^2\Theta_W\sum_{a=1}^3Z_{i3+a}^{E,*}Z_{j3+a}^E+(g_1\cos\Theta_W+g_2\sin\Theta_W)^2\sum_{a=1}^3Z_{ia}^{E,*}Z_{ja}^E\right)(g_{\mu\nu}) \quad (463)$$



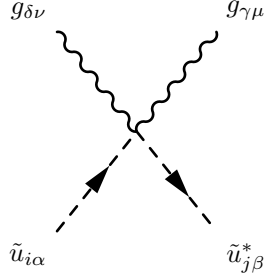
$$\begin{aligned}
& -\frac{i}{4} \left((-2g_1g_2 \cos 2\Theta_W + (-g_2^2 + g_1^2) \sin 2\Theta_W) \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right. \\
& \left. + 4g_1^2 \sin 2\Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \right) (g_{\mu\nu}) \tag{464}
\end{aligned}$$



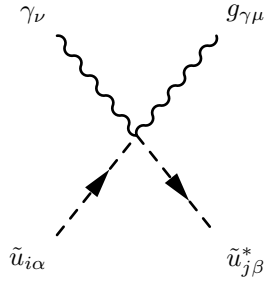
$$\frac{i}{2} g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E (g_{\mu\nu}) \tag{465}$$



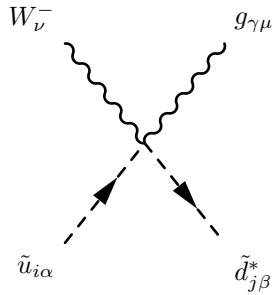
$$\frac{i}{2} \left(4g_1^2 \sin^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E + (-g_1 \sin \Theta_W + g_2 \cos \Theta_W)^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right) (g_{\mu\nu}) \tag{466}$$



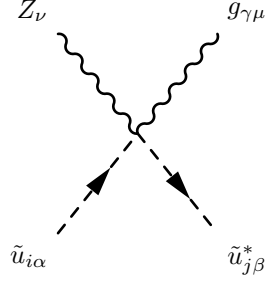
$$\frac{i}{4} g_3^2 \delta_{ij} \left(\sum_{a=1}^3 \lambda_{a,\alpha}^\gamma \lambda_{\beta,a}^\delta + \sum_{a=1}^3 \lambda_{\beta,a}^\gamma \lambda_{a,\alpha}^\delta \right) (g_{\mu\nu}) \quad (467)$$



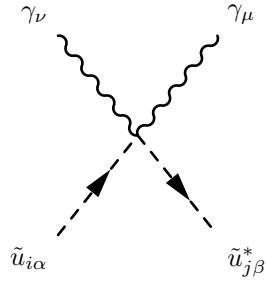
$$\frac{i}{6} g_3 \lambda_{\beta,\alpha}^\gamma \left((3g_2 \sin \Theta_W + g_1 \cos \Theta_W) \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U + 4g_1 \cos \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \right) (g_{\mu\nu}) \quad (468)$$



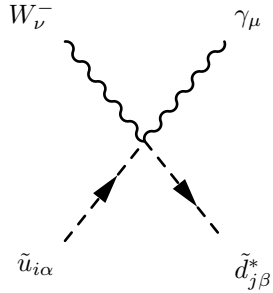
$$i \frac{1}{\sqrt{2}} g_2 g_3 \lambda_{\beta,\alpha}^\gamma \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D (g_{\mu\nu}) \quad (469)$$



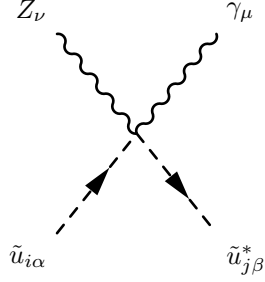
$$\frac{i}{6} g_3 \lambda_{\beta, \alpha}^{\gamma} \left(\left(3g_2 \cos \Theta_W - g_1 \sin \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U - 4g_1 \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \right) (g_{\mu\nu}) \quad (470)$$



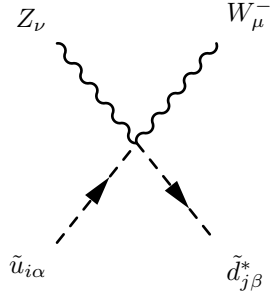
$$\frac{i}{18} \delta_{\alpha\beta} \left(16g_1^2 \cos^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U + \left(3g_2 \sin \Theta_W + g_1 \cos \Theta_W \right)^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \right) (g_{\mu\nu}) \quad (471)$$



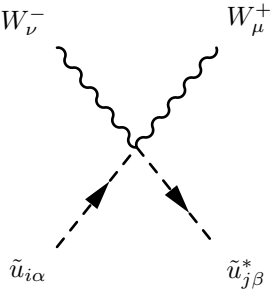
$$\frac{i}{3} \frac{1}{\sqrt{2}} g_1 g_2 \cos \Theta_W \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D (g_{\mu\nu}) \quad (472)$$



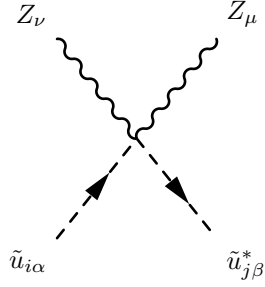
$$\begin{aligned}
& -\frac{i}{36}\delta_{\alpha\beta}\left(\left(-6g_1g_2\cos 2\Theta_W + \left(-9g_2^2 + g_1^2\right)\sin 2\Theta_W\right)\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^U\right. \\
& \left.+ 16g_1^2\sin 2\Theta_W\sum_{a=1}^3Z_{i3+a}^{U,*}Z_{j3+a}^U\right)(g_{\mu\nu})
\end{aligned} \tag{473}$$



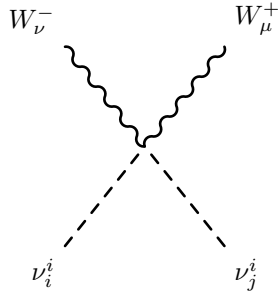
$$-\frac{i}{3}\frac{1}{\sqrt{2}}g_1g_2\delta_{\alpha\beta}\sin\Theta_W\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^D(g_{\mu\nu}) \tag{474}$$



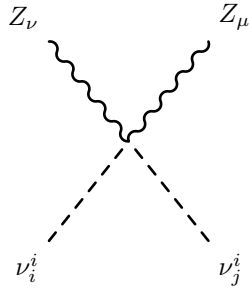
$$\frac{i}{2}g_2^2\delta_{\alpha\beta}\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^U(g_{\mu\nu}) \tag{475}$$



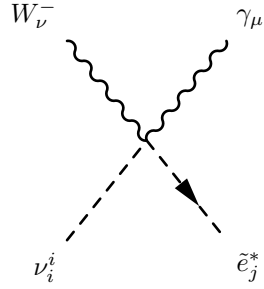
$$\frac{i}{18} \delta_{\alpha\beta} \left(16g_1^2 \sin^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U + \left(-3g_2 \cos \Theta_W + g_1 \sin \Theta_W \right)^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \right) (g_{\mu\nu}) \quad (476)$$



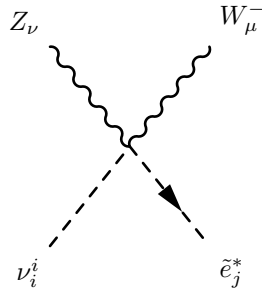
$$\frac{i}{2} g_2^2 \sum_{a=1}^3 Z_{ia}^{i,*} Z_{ja}^{i,*} (g_{\mu\nu}) \quad (477)$$



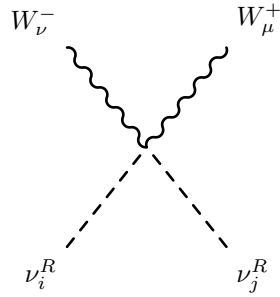
$$\frac{i}{2} \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right)^2 \sum_{a=1}^3 Z_{ia}^{i,*} Z_{ja}^{i,*} (g_{\mu\nu}) \quad (478)$$



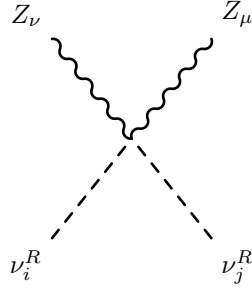
$$\frac{1}{2} g_1 g_2 \cos \Theta_W \sum_{a=1}^3 Z_{ia}^{i,*} Z_{ja}^E (g_{\mu\nu}) \quad (479)$$



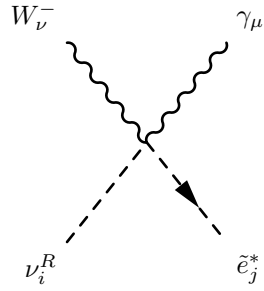
$$-\frac{1}{2} g_1 g_2 \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{i,*} Z_{ja}^E (g_{\mu\nu}) \quad (480)$$



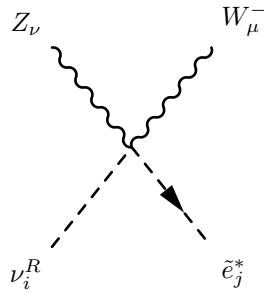
$$\frac{i}{2} g_2^2 \sum_{a=1}^3 Z_{ia}^{R,*} Z_{ja}^{R,*} (g_{\mu\nu}) \quad (481)$$



$$\frac{i}{2} \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right)^2 \sum_{a=1}^3 Z_{ia}^{R,*} Z_{ja}^{R,*} (g_{\mu\nu}) \quad (482)$$

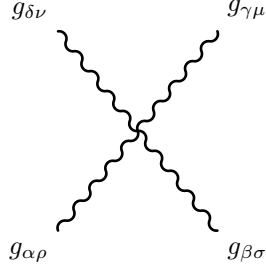


$$-\frac{i}{2} g_1 g_2 \cos \Theta_W \sum_{a=1}^3 Z_{ia}^{R,*} Z_{ja}^E (g_{\mu\nu}) \quad (483)$$



$$\frac{i}{2} g_1 g_2 \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{R,*} Z_{ja}^E (g_{\mu\nu}) \quad (484)$$

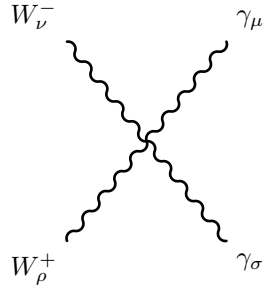
9.9 Four Vector Boson-Interaction



$$-ig_3^2 \left(\sum_{a=1}^8 f_{\alpha,\delta,a} f_{\beta,\gamma,a} + \sum_{a=1}^8 f_{\alpha,\gamma,a} f_{\beta,\delta,a} \right) (g_{\rho\sigma} g_{\mu\nu}) \quad (485)$$

$$+ ig_3^2 \left(- \sum_{a=1}^8 f_{\alpha,\beta,a} f_{\gamma,\delta,a} + \sum_{a=1}^8 f_{\alpha,\delta,a} f_{\beta,\gamma,a} \right) (g_{\rho\mu} g_{\sigma\nu}) \quad (486)$$

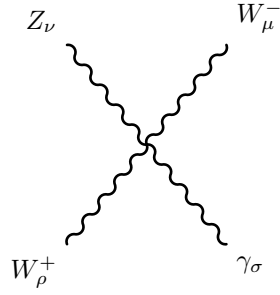
$$+ ig_3^2 \left(\sum_{a=1}^8 f_{\alpha,\gamma,a} f_{\beta,\delta,a} + \sum_{a=1}^8 f_{\alpha,\beta,a} f_{\gamma,\delta,a} \right) (g_{\rho\nu} g_{\sigma\mu}) \quad (487)$$



$$ig_2^2 \sin^2 \Theta_W (g_{\rho\sigma} g_{\mu\nu}) \quad (488)$$

$$+ ig_2^2 \sin^2 \Theta_W (g_{\rho\mu} g_{\sigma\nu}) \quad (489)$$

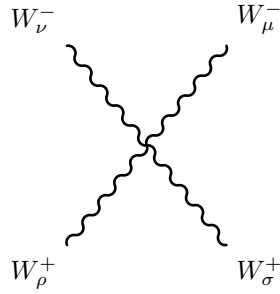
$$+ -2ig_2^2 \sin^2 \Theta_W (g_{\rho\nu} g_{\sigma\mu}) \quad (490)$$



$$ig_2^2 \cos \Theta_W \sin \Theta_W (g_{\rho\sigma} g_{\mu\nu}) \quad (491)$$

$$+ -ig_2^2 \sin 2\Theta_W (g_{\rho\mu} g_{\sigma\nu}) \quad (492)$$

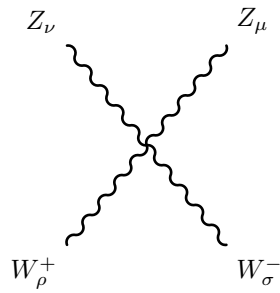
$$+ ig_2^2 \cos \Theta_W \sin \Theta_W (g_{\rho\nu} g_{\sigma\mu}) \quad (493)$$



$$2ig_2^2 (g_{\rho\sigma} g_{\mu\nu}) \quad (494)$$

$$+ -ig_2^2 (g_{\rho\mu} g_{\sigma\nu}) \quad (495)$$

$$+ -ig_2^2 (g_{\rho\nu} g_{\sigma\mu}) \quad (496)$$

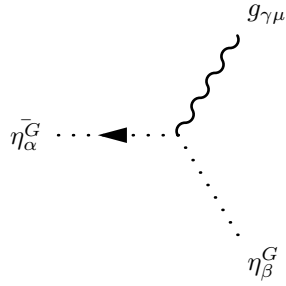


$$- 2ig_2^2 \cos^2 \Theta_W^2 (g_{\rho\sigma} g_{\mu\nu}) \quad (497)$$

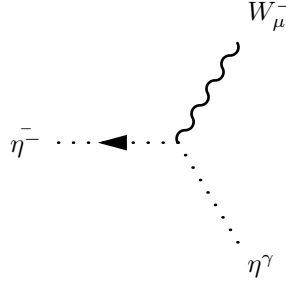
$$+ ig_2^2 \cos^2 \Theta_W^2 (g_{\rho\mu} g_{\sigma\nu}) \quad (498)$$

$$+ ig_2^2 \cos^2 \Theta_W^2 (g_{\rho\nu} g_{\sigma\mu}) \quad (499)$$

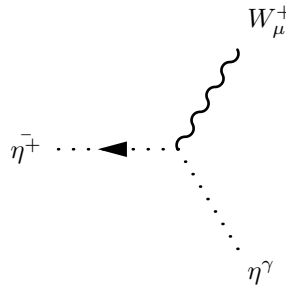
9.10 Two Ghosts-One Vector Boson-Interaction



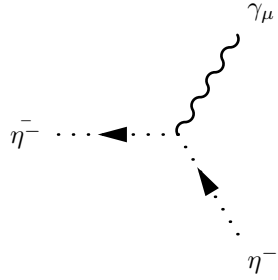
$$g_3 f_{\alpha,\beta,\gamma} (p_\mu^{\eta_\beta^G}) \quad (500)$$



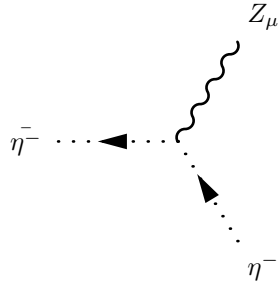
$$ig_2 \sin \Theta_W (p_\mu^{\eta^\gamma}) \quad (501)$$



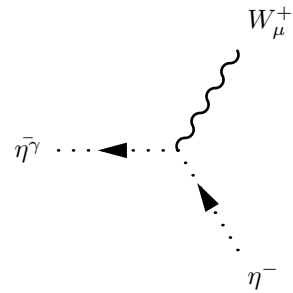
$$-ig_2 \sin \Theta_W (p_\mu^{\eta^\gamma}) \quad (502)$$



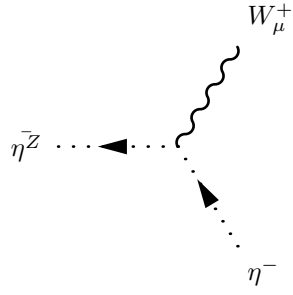
$$-ig_2 \sin \Theta_W (p_\mu^{\eta^-}) \quad (503)$$



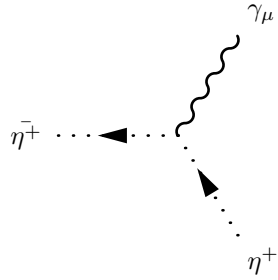
$$-ig_2 \cos \Theta_W (p_\mu^{\eta^-}) \quad (504)$$



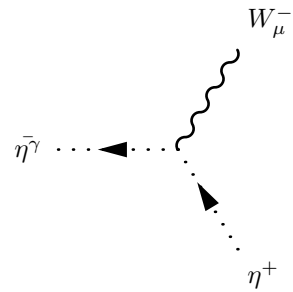
$$ig_2 \sin \Theta_W (p_\mu^{\eta^-}) \quad (505)$$



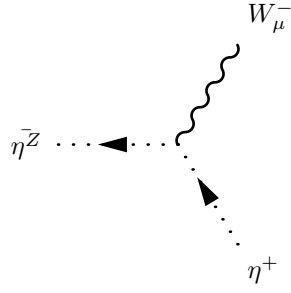
$$ig_2 \cos \Theta_W (p_\mu^{\eta^-}) \quad (506)$$



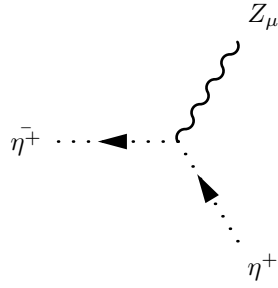
$$ig_2 \sin \Theta_W (p_\mu^{\eta^+}) \quad (507)$$



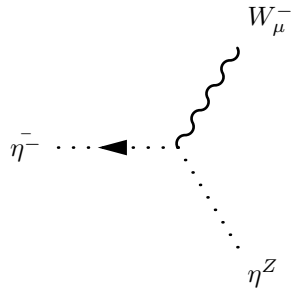
$$-ig_2 \sin \Theta_W (p_\mu^{\eta^+}) \quad (508)$$



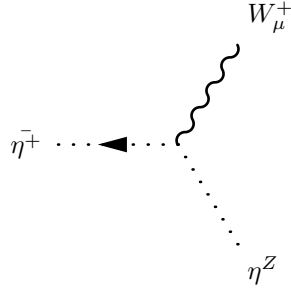
$$-ig_2 \cos \Theta_W (p_\mu^{\eta^+}) \quad (509)$$



$$ig_2 \cos \Theta_W (p_\mu^{\eta^+}) \quad (510)$$

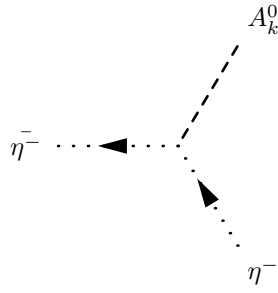


$$ig_2 \cos \Theta_W (p_\mu^{\eta^Z}) \quad (511)$$

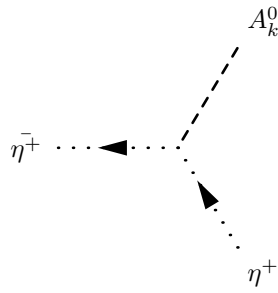


$$-ig_2 \cos \Theta_W (p_\mu^{\eta^Z}) \quad (512)$$

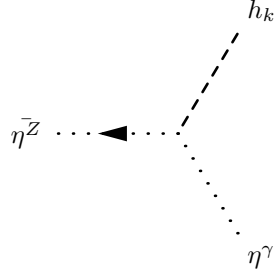
9.11 Two Ghosts-One Scalar-Interaction



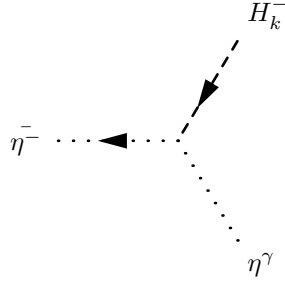
$$\frac{1}{4} g_2^2 \xi_{W^-} (v_d Z_{k1}^A - v_u Z_{k2}^A) \quad (513)$$



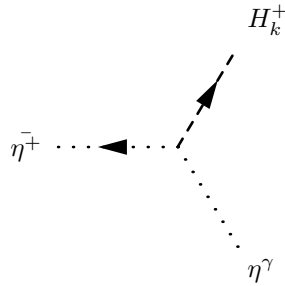
$$\frac{1}{4} g_2^2 \xi_{W^-} (-v_d Z_{k1}^A + v_u Z_{k2}^A) \quad (514)$$



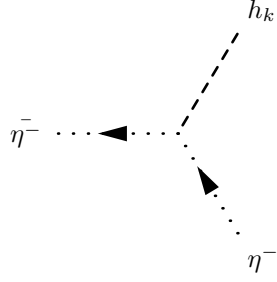
$$\frac{i}{8}\xi_Z \left(2g_1 g_2 \cos 2\Theta_W + (-g_2^2 + g_1^2) \sin 2\Theta_W \right) (v_d Z_{k1}^H + v_u Z_{k2}^H) \quad (515)$$



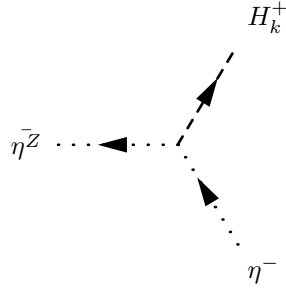
$$\frac{i}{4}g_2\xi_{W^-} \left(g_1 \cos \Theta_W + g_2 \sin \Theta_W \right) (v_d Z_{k1}^+ - v_u Z_{k2}^+) \quad (516)$$



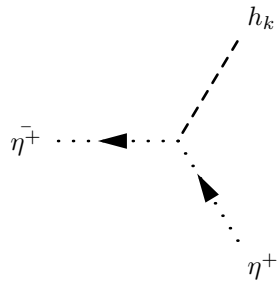
$$\frac{i}{4}g_2\xi_{W^-} \left(g_1 \cos \Theta_W + g_2 \sin \Theta_W \right) (v_d Z_{k1}^+ - v_u Z_{k2}^+) \quad (517)$$



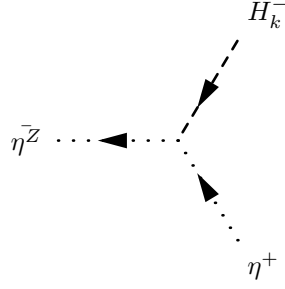
$$-\frac{i}{4}g_2^2\xi_{W^-}\left(v_d Z_{k1}^H + v_u Z_{k2}^H\right) \quad (518)$$



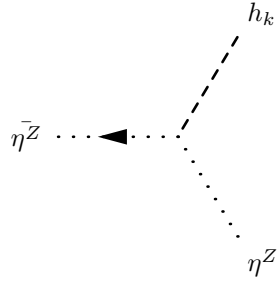
$$-\frac{i}{4}g_2\xi_Z\left(g_1\sin\Theta_W + g_2\cos\Theta_W\right)\left(v_d Z_{k1}^+ - v_u Z_{k2}^+\right) \quad (519)$$



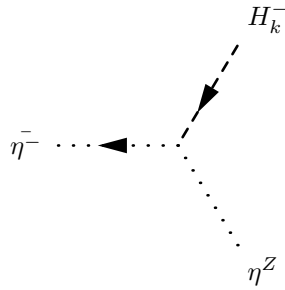
$$-\frac{i}{4}g_2^2\xi_{W^-}\left(v_d Z_{k1}^H + v_u Z_{k2}^H\right) \quad (520)$$



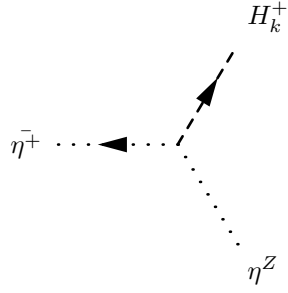
$$-\frac{i}{4}g_2\xi_Z(g_1\sin\Theta_W+g_2\cos\Theta_W)(v_dZ_{k1}^+-v_uZ_{k2}^+) \quad (521)$$



$$-\frac{i}{4}\xi_Z(g_1\sin\Theta_W+g_2\cos\Theta_W)^2(v_dZ_{k1}^H+v_uZ_{k2}^H) \quad (522)$$



$$\frac{i}{4}g_2\xi_{W^-}(-g_1\sin\Theta_W+g_2\cos\Theta_W)(v_dZ_{k1}^+-v_uZ_{k2}^+) \quad (523)$$



$$\frac{i}{4} g_2 \xi_{W^-} \left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left(v_d Z_{k1}^+ - v_u Z_{k2}^+ \right) \quad (524)$$

10 Clebsch-Gordan Coefficients