

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

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

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# 1 Superfields

## 1.1 Vector Superfields

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

## 1.2 Chiral Superfields

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

# 2 Superpotential and Lagrangian

## 2.1 Superpotential

$$\begin{aligned}
W = & L_1 \hat{s} + \mu \hat{H}_u \hat{H}_d + \frac{1}{2} M_S \hat{s} \hat{s} - Y_d \hat{d} \hat{q} \hat{H}_d - Y_e \hat{e} \hat{l} \hat{H}_d + \lambda \hat{H}_u \hat{H}_d \hat{s} + \frac{1}{3} \kappa \hat{s} \hat{s} \hat{s} \\
& + Y_u \hat{u} \hat{q} \hat{H}_u
\end{aligned} \tag{1}$$

## 2.2 Softbreaking terms

$$\begin{aligned}
-L_{SB,W} = & \frac{1}{2} S^2 B_S - H_d^0 H_u^0 B_\mu + H_d^- H_u^+ B_\mu + S \xi_1 + \frac{1}{3} S^3 T_\kappa - H_d^0 H_u^0 S T_\lambda + H_d^- H_u^+ S T_\lambda \\
& + H_d^0 \tilde{d}_{R,i\alpha}^* \delta_{\alpha\beta} \tilde{d}_{L,j\beta} T_{d,ij} - H_d^- \tilde{d}_{R,i\alpha}^* \delta_{\alpha\beta} \tilde{u}_{L,j\beta} T_{d,ij} + H_d^0 \tilde{e}_{R,i}^* \tilde{e}_{L,j} T_{e,ij} - H_d^- \tilde{e}_{R,i}^* \tilde{\nu}_{L,j} T_{e,ij} \\
& - H_u^+ \tilde{u}_{R,i\alpha}^* \delta_{\alpha\beta} \tilde{d}_{L,j\beta} T_{u,ij} + H_u^0 \tilde{u}_{R,i\alpha}^* \delta_{\alpha\beta} \tilde{u}_{L,j\beta} T_{u,ij} + \text{h.c.}
\end{aligned} \tag{2}$$

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

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

## 2.3 Gauge fixing terms

### 2.3.1 Gauge fixing terms for eigenstates 'GaugeES'

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

### 2.3.2 Gauge fixing terms for eigenstates 'EWSB'

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

## 2.4 Fields integrated out

None

# 3 Renormalization Group Equations

## 3.1 Anomalous Dimensions

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

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

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

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

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

$$\begin{aligned} \gamma_{\hat{H}_d}^{(2)} = & + \frac{207}{100} g_1^4 + \frac{9}{10} g_1^2 g_2^2 + \frac{15}{4} g_2^4 - 2\lambda |\kappa|^2 \lambda^* - 3\lambda^2 \lambda^{*,2} - \frac{2}{5} g_1^2 \text{Tr} \left( Y_d Y_d^\dagger \right) + 16g_3^2 \text{Tr} \left( Y_d Y_d^\dagger \right) \\ & + \frac{6}{5} g_1^2 \text{Tr} \left( Y_e Y_e^\dagger \right) - 3|\lambda|^2 \text{Tr} \left( Y_u Y_u^\dagger \right) - 9\text{Tr} \left( Y_d Y_d^\dagger Y_d Y_d^\dagger \right) - 3\text{Tr} \left( Y_d Y_u^\dagger Y_u Y_d^\dagger \right) \\ & - 3\text{Tr} \left( Y_e Y_e^\dagger Y_e Y_e^\dagger \right) \end{aligned} \quad (12)$$

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

$$\begin{aligned} \gamma_{\hat{H}_u}^{(2)} = & +\frac{207}{100}g_1^4 + \frac{9}{10}g_1^2g_2^2 + \frac{15}{4}g_2^4 - 2\lambda|\kappa|^2\lambda^* - 3\lambda^2\lambda^{*,2} - |\lambda|^2 \left( 3\text{Tr}(Y_d Y_d^\dagger) + \text{Tr}(Y_e Y_e^\dagger) \right) \\ & + \frac{4}{5}g_1^2\text{Tr}(Y_u Y_u^\dagger) + 16g_3^2\text{Tr}(Y_u Y_u^\dagger) - 3\text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 9\text{Tr}(Y_u Y_u^\dagger Y_u Y_u^\dagger) \end{aligned} \quad (14)$$

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

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

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

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

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

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

$$\gamma_{\hat{s}}^{(1)} = 2 \left( |\kappa|^2 + |\lambda|^2 \right) \quad (21)$$

$$\begin{aligned} \gamma_{\hat{s}}^{(2)} = & -8\kappa^2\kappa^{*,2} - 8\lambda|\kappa|^2\lambda^* \\ & - \frac{2}{5}|\lambda|^2 \left( 10\lambda\lambda^* - 15g_2^2 + 15\text{Tr}(Y_d Y_d^\dagger) + 15\text{Tr}(Y_u Y_u^\dagger) - 3g_1^2 + 5\text{Tr}(Y_e Y_e^\dagger) \right) \end{aligned} \quad (22)$$

### 3.2 Gauge Couplings

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

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

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

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

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

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

### 3.3 Gaugino Mass Parameters

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

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

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

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

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

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

### 3.4 Trilinear Superpotential Parameters

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

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

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

$$\begin{aligned} \beta_{Y_e}^{(2)} = & -4Y_e Y_e^\dagger Y_e Y_e^\dagger Y_e + Y_e Y_e^\dagger Y_e \left( -3|\lambda|^2 - 3\text{Tr} \left( Y_e Y_e^\dagger \right) + 6g_2^2 - 9\text{Tr} \left( Y_d Y_d^\dagger \right) \right) \\ & + Y_e \left( \frac{27}{2}g_1^4 + \frac{9}{5}g_1^2 g_2^2 + \frac{15}{2}g_2^4 - 2\lambda|\kappa|^2 \lambda^* - 3\lambda^2 \lambda^{*,2} - \frac{2}{5}g_1^2 \text{Tr} \left( Y_d Y_d^\dagger \right) + 16g_3^2 \text{Tr} \left( Y_d Y_d^\dagger \right) \right. \\ & \left. + \frac{6}{5}g_1^2 \text{Tr} \left( Y_e Y_e^\dagger \right) - 3|\lambda|^2 \text{Tr} \left( Y_u Y_u^\dagger \right) - 9\text{Tr} \left( Y_d Y_d^\dagger Y_d Y_d^\dagger \right) - 3\text{Tr} \left( Y_d Y_u^\dagger Y_u Y_d^\dagger \right) \right. \\ & \left. - 3\text{Tr} \left( Y_e Y_e^\dagger Y_e Y_e^\dagger \right) \right) \end{aligned} \quad (38)$$

$$\beta_\lambda^{(1)} = 2\lambda|\kappa|^2 - 3g_2^2\lambda + 3\lambda\text{Tr}(Y_d Y_d^\dagger) + 3\lambda\text{Tr}(Y_u Y_u^\dagger) + 4\lambda^2\lambda^* - \frac{3}{5}g_1^2\lambda + \lambda\text{Tr}(Y_e Y_e^\dagger) \quad (39)$$

$$\begin{aligned} \beta_\lambda^{(2)} = & -\frac{1}{50}\lambda\left(-207g_1^4 - 90g_1^2g_2^2 - 375g_2^4 + 400\kappa^2\kappa^{*.2} + 600\lambda|\kappa|^2\lambda^* + 500\lambda^2\lambda^{*.2} + 20g_1^2\text{Tr}(Y_d Y_d^\dagger)\right. \\ & - 800g_3^2\text{Tr}(Y_d Y_d^\dagger) - 60g_1^2\text{Tr}(Y_e Y_e^\dagger) \\ & - 30|\lambda|^2\left(10g_2^2 - 15\text{Tr}(Y_d Y_d^\dagger) - 15\text{Tr}(Y_u Y_u^\dagger) + 2g_1^2 - 5\text{Tr}(Y_e Y_e^\dagger)\right) - 40g_1^2\text{Tr}(Y_u Y_u^\dagger) \\ & - 800g_3^2\text{Tr}(Y_u Y_u^\dagger) + 450\text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) + 300\text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) + 150\text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) \\ & \left. + 450\text{Tr}(Y_u Y_u^\dagger Y_u Y_u^\dagger)\right) \end{aligned} \quad (40)$$

$$\beta_\kappa^{(1)} = 6\kappa\left(|\kappa|^2 + |\lambda|^2\right) \quad (41)$$

$$\begin{aligned} \beta_\kappa^{(2)} = & -\frac{6}{5}\kappa\left(20\kappa^2\kappa^{*.2} + 20\lambda|\kappa|^2\lambda^* \right. \\ & \left. + |\lambda|^2\left(10\lambda\lambda^* - 15g_2^2 + 15\text{Tr}(Y_d Y_d^\dagger) + 15\text{Tr}(Y_u Y_u^\dagger) - 3g_1^2 + 5\text{Tr}(Y_e Y_e^\dagger)\right)\right) \end{aligned} \quad (42)$$

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

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

### 3.5 Bilinear Superpotential Parameters

$$\beta_\mu^{(1)} = 2\mu|\lambda|^2 - 3g_2^2\mu + 3\mu\text{Tr}(Y_d Y_d^\dagger) + 3\mu\text{Tr}(Y_u Y_u^\dagger) - \frac{3}{5}g_1^2\mu + \mu\text{Tr}(Y_e Y_e^\dagger) \quad (45)$$

$$\begin{aligned} \beta_\mu^{(2)} = & \frac{1}{50}\mu\left(207g_1^4 + 90g_1^2g_2^2 + 375g_2^4 - 200\lambda|\kappa|^2\lambda^* - 300\lambda^2\lambda^{*.2} - 20g_1^2\text{Tr}(Y_d Y_d^\dagger)\right. \\ & + 800g_3^2\text{Tr}(Y_d Y_d^\dagger) + 60g_1^2\text{Tr}(Y_e Y_e^\dagger) + 40g_1^2\text{Tr}(Y_u Y_u^\dagger) + 800g_3^2\text{Tr}(Y_u Y_u^\dagger) \\ & - 50|\lambda|^2\left(3\text{Tr}(Y_d Y_d^\dagger) + 3\text{Tr}(Y_u Y_u^\dagger) + \text{Tr}(Y_e Y_e^\dagger)\right) - 450\text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) - 300\text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) \\ & \left. - 150\text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) - 450\text{Tr}(Y_u Y_u^\dagger Y_u Y_u^\dagger)\right) \end{aligned} \quad (46)$$

$$\beta_{M_S}^{(1)} = 4M_S\left(|\kappa|^2 + |\lambda|^2\right) \quad (47)$$



$$\begin{aligned}
\beta_{M_S}^{(2)} &= -\frac{4}{5}M_S \left( 20\kappa^2\kappa^{*,2} + 20\lambda|\kappa|^2\lambda^* \right. \\
&\quad \left. + |\lambda|^2 \left( 10\lambda\lambda^* - 15g_2^2 + 15\text{Tr}(Y_d Y_d^\dagger) + 15\text{Tr}(Y_u Y_u^\dagger) - 3g_1^2 + 5\text{Tr}(Y_e Y_e^\dagger) \right) \right)
\end{aligned} \tag{48}$$

### 3.6 Linear Superpotential Parameters

$$\beta_{L_1}^{(1)} = 2L_1 \left( |\kappa|^2 + |\lambda|^2 \right) \tag{49}$$

$$\begin{aligned}
\beta_{L_1}^{(2)} &= -\frac{2}{5}L_1 \left( 20\kappa^2\kappa^{*,2} + 20\lambda|\kappa|^2\lambda^* \right. \\
&\quad \left. + |\lambda|^2 \left( 10\lambda\lambda^* - 15g_2^2 + 15\text{Tr}(Y_d Y_d^\dagger) + 15\text{Tr}(Y_u Y_u^\dagger) - 3g_1^2 + 5\text{Tr}(Y_e Y_e^\dagger) \right) \right)
\end{aligned} \tag{50}$$

### 3.7 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 \\
&\quad + |\lambda|^2 T_d + 3T_d \text{Tr}(Y_d Y_d^\dagger) + T_d \text{Tr}(Y_e Y_e^\dagger) \\
&\quad + Y_d \left( 2\lambda^* T_\lambda + 2\text{Tr}(Y_e^\dagger T_e) \right) + 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 \\
\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 - 4|\lambda|^2 Y_d Y_d^\dagger T_d - \frac{8}{5}g_1^2 M_1 Y_d Y_u^\dagger Y_u \\
&\quad + \frac{8}{5}g_1^2 Y_d Y_u^\dagger T_u - 2|\lambda|^2 Y_d Y_u^\dagger T_u + \frac{6}{5}g_1^2 T_d Y_d^\dagger Y_d + 12g_2^2 T_d Y_d^\dagger Y_d \\
&\quad - 5|\lambda|^2 T_d Y_d^\dagger Y_d + \frac{4}{5}g_1^2 T_d Y_u^\dagger Y_u - |\lambda|^2 T_d Y_u^\dagger Y_u - 6Y_d Y_d^\dagger Y_d Y_d^\dagger T_d \\
&\quad - 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 \\
&\quad - 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 \\
&\quad + \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 - 2\lambda|\kappa|^2\lambda^* T_d \\
&\quad - 3\lambda^2\lambda^{*,2} T_d - 2\lambda^* Y_d Y_u^\dagger Y_u T_\lambda - 12Y_d Y_d^\dagger T_d \text{Tr}(Y_d Y_d^\dagger) \\
&\quad - 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) \\
&\quad - 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) \\
&\quad - 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) - 3|\lambda|^2 T_d \text{Tr}(Y_u Y_u^\dagger) \\
&\quad - \frac{2}{5}Y_d Y_d^\dagger Y_d \left( 15\lambda^* T_\lambda + 15\text{Tr}(Y_e^\dagger T_e) \right) + 30g_2^2 M_2 + 45\text{Tr}(Y_d^\dagger T_d) + 4g_1^2 M_1
\end{aligned} \tag{51}$$

$$\begin{aligned}
& -6Y_d Y_u^\dagger Y_u \text{Tr}(Y_u^\dagger T_u) - 9T_d \text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) - 3T_d \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) \\
& -3T_d \text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) \\
& -\frac{2}{45} Y_d \left( 287g_1^4 M_1 + 45g_1^2 g_2^2 M_1 + 40g_1^2 g_3^2 M_1 + 40g_1^2 g_3^2 M_3 + 360g_2^2 g_3^2 M_3 - 160g_3^4 M_3 \right. \\
& \left. + 45g_1^2 g_2^2 M_2 + 675g_2^4 M_2 + 360g_2^2 g_3^2 M_2 + 270\lambda\lambda^{*2} T_\lambda + 90\kappa^* \lambda^* (\kappa T_\lambda + \lambda T_\kappa) \right) \\
& -18g_1^2 M_1 \text{Tr}(Y_d Y_d^\dagger) + 720g_3^2 M_3 \text{Tr}(Y_d Y_d^\dagger) + 54g_1^2 M_1 \text{Tr}(Y_e Y_e^\dagger) + 18g_1^2 \text{Tr}(Y_d^\dagger T_d) \\
& -720g_3^2 \text{Tr}(Y_d^\dagger T_d) - 54g_1^2 \text{Tr}(Y_e^\dagger T_e) + 135\lambda^* (\lambda \text{Tr}(Y_u^\dagger T_u) + T_\lambda \text{Tr}(Y_u Y_u^\dagger)) \\
& + 810 \text{Tr}(Y_d Y_d^\dagger T_d Y_d^\dagger) + 135 \text{Tr}(Y_d Y_u^\dagger T_u Y_d^\dagger) + 270 \text{Tr}(Y_e Y_e^\dagger T_e Y_e^\dagger) + 135 \text{Tr}(Y_u Y_d^\dagger T_d Y_u^\dagger) \tag{52}
\end{aligned}$$

$$\begin{aligned}
\beta_{T_e}^{(1)} & = +4Y_e Y_e^\dagger T_e + 5T_e Y_e^\dagger Y_e - \frac{9}{5} g_1^2 T_e - 3g_2^2 T_e + |\lambda|^2 T_e + 3T_e \text{Tr}(Y_d Y_d^\dagger) + T_e \text{Tr}(Y_e Y_e^\dagger) \\
& + Y_e (2\lambda^* T_\lambda + 2\text{Tr}(Y_e^\dagger T_e) + 6g_2^2 M_2 + 6\text{Tr}(Y_d^\dagger T_d) + \frac{18}{5} g_1^2 M_1) \tag{53}
\end{aligned}$$

$$\begin{aligned}
\beta_{T_e}^{(2)} & = +\frac{6}{5} g_1^2 Y_e Y_e^\dagger T_e + 6g_2^2 Y_e Y_e^\dagger T_e - 4|\lambda|^2 Y_e Y_e^\dagger T_e - \frac{6}{5} g_1^2 T_e Y_e^\dagger Y_e \\
& + 12g_2^2 T_e Y_e^\dagger Y_e - 5|\lambda|^2 T_e Y_e^\dagger Y_e - 6Y_e Y_e^\dagger Y_e Y_e^\dagger T_e - 8Y_e Y_e^\dagger T_e Y_e^\dagger Y_e \\
& - 6T_e Y_e^\dagger Y_e Y_e^\dagger Y_e + \frac{27}{2} g_1^4 T_e + \frac{9}{5} g_1^2 g_2^2 T_e + \frac{15}{2} g_2^4 T_e - 2\lambda|\kappa|^2 \lambda^* T_e - 3\lambda^2 \lambda^{*2} T_e \\
& - 12Y_e Y_e^\dagger T_e \text{Tr}(Y_d Y_d^\dagger) - 15T_e Y_e^\dagger Y_e \text{Tr}(Y_d Y_d^\dagger) - \frac{2}{5} g_1^2 T_e \text{Tr}(Y_d Y_d^\dagger) \\
& + 16g_3^2 T_e \text{Tr}(Y_d Y_d^\dagger) - 4Y_e Y_e^\dagger T_e \text{Tr}(Y_e Y_e^\dagger) - 5T_e Y_e^\dagger Y_e \text{Tr}(Y_e Y_e^\dagger) \\
& + \frac{6}{5} g_1^2 T_e \text{Tr}(Y_e Y_e^\dagger) - 3|\lambda|^2 T_e \text{Tr}(Y_u Y_u^\dagger) \\
& - 6Y_e Y_e^\dagger Y_e (2g_2^2 M_2 + 3\text{Tr}(Y_d^\dagger T_d) + \lambda^* T_\lambda + \text{Tr}(Y_e^\dagger T_e)) - 9T_e \text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) \\
& - 3T_e \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 3T_e \text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) \\
& - \frac{2}{5} Y_e (135g_1^4 M_1 + 9g_1^2 g_2^2 M_1 + 9g_1^2 g_2^2 M_2 + 75g_2^4 M_2 + 30\lambda\lambda^{*2} T_\lambda + 10\kappa^* \lambda^* (\kappa T_\lambda + \lambda T_\kappa) \\
& - 2g_1^2 M_1 \text{Tr}(Y_d Y_d^\dagger) + 80g_3^2 M_3 \text{Tr}(Y_d Y_d^\dagger) + 6g_1^2 M_1 \text{Tr}(Y_e Y_e^\dagger) + 2g_1^2 \text{Tr}(Y_d^\dagger T_d) \\
& - 80g_3^2 \text{Tr}(Y_d^\dagger T_d) - 6g_1^2 \text{Tr}(Y_e^\dagger T_e) + 15\lambda^* (\lambda \text{Tr}(Y_u^\dagger T_u) + T_\lambda \text{Tr}(Y_u Y_u^\dagger)) + 90 \text{Tr}(Y_d Y_d^\dagger T_d Y_d^\dagger) \\
& + 15 \text{Tr}(Y_d Y_u^\dagger T_u Y_d^\dagger) + 30 \text{Tr}(Y_e Y_e^\dagger T_e Y_e^\dagger) + 15 \text{Tr}(Y_u Y_d^\dagger T_d Y_u^\dagger) \tag{54}
\end{aligned}$$

$$\begin{aligned}
\beta_{T_\lambda}^{(1)} & = +\frac{6}{5} g_1^2 M_1 \lambda + 6g_2^2 M_2 \lambda + 2\kappa^* (2\lambda T_\kappa + \kappa T_\lambda) \\
& + T_\lambda (12|\lambda|^2 - 3g_2^2 + 3\text{Tr}(Y_d Y_d^\dagger) + 3\text{Tr}(Y_u Y_u^\dagger) - \frac{3}{5} g_1^2 + \text{Tr}(Y_e Y_e^\dagger)) + 6\lambda \text{Tr}(Y_d^\dagger T_d) \\
& + 2\lambda \text{Tr}(Y_e^\dagger T_e) + 6\lambda \text{Tr}(Y_u^\dagger T_u) \tag{55}
\end{aligned}$$

$$\begin{aligned}
\beta_{T_\lambda}^{(2)} = & -\frac{414}{25}g_1^4M_1\lambda - \frac{18}{5}g_1^2g_2^2M_1\lambda - \frac{18}{5}g_1^2g_2^2M_2\lambda - 30g_2^4M_2\lambda + \frac{207}{50}g_1^4T_\lambda + \frac{9}{5}g_1^2g_2^2T_\lambda \\
& + \frac{15}{2}g_2^4T_\lambda - 50\lambda^2\lambda^{*,2}T_\lambda - 8\kappa\kappa^{*,2}(4\lambda T_\kappa + \kappa T_\lambda) + \frac{4}{5}g_1^2M_1\lambda\text{Tr}(Y_dY_d^\dagger) \\
& - 32g_3^2M_3\lambda\text{Tr}(Y_dY_d^\dagger) - \frac{2}{5}g_1^2T_\lambda\text{Tr}(Y_dY_d^\dagger) + 16g_3^2T_\lambda\text{Tr}(Y_dY_d^\dagger) - \frac{12}{5}g_1^2M_1\lambda\text{Tr}(Y_eY_e^\dagger) \\
& + \frac{6}{5}g_1^2T_\lambda\text{Tr}(Y_eY_e^\dagger) - \frac{8}{5}g_1^2M_1\lambda\text{Tr}(Y_uY_u^\dagger) - 32g_3^2M_3\lambda\text{Tr}(Y_uY_u^\dagger) + \frac{4}{5}g_1^2T_\lambda\text{Tr}(Y_uY_u^\dagger) \\
& + 16g_3^2T_\lambda\text{Tr}(Y_uY_u^\dagger) - \frac{4}{5}g_1^2\lambda\text{Tr}(Y_d^\dagger T_d) + 32g_3^2\lambda\text{Tr}(Y_d^\dagger T_d) + \frac{12}{5}g_1^2\lambda\text{Tr}(Y_e^\dagger T_e) \\
& + \frac{8}{5}g_1^2\lambda\text{Tr}(Y_u^\dagger T_u) + 32g_3^2\lambda\text{Tr}(Y_u^\dagger T_u) \\
& - \frac{3}{5}|\lambda|^2(20\kappa^*(2\lambda T_\kappa + 3\kappa T_\lambda) + T_\lambda(15\text{Tr}(Y_eY_e^\dagger) - 30g_2^2 + 45\text{Tr}(Y_dY_d^\dagger) + 45\text{Tr}(Y_uY_u^\dagger) - 6g_1^2) \\
& + 2\lambda(10g_2^2M_2 + 15\text{Tr}(Y_d^\dagger T_d) + 15\text{Tr}(Y_u^\dagger T_u) + 2g_1^2M_1 + 5\text{Tr}(Y_e^\dagger T_e))) \\
& - 9T_\lambda\text{Tr}(Y_dY_d^\dagger Y_dY_d^\dagger) - 36\lambda\text{Tr}(Y_dY_d^\dagger T_dY_d^\dagger) - 6T_\lambda\text{Tr}(Y_dY_u^\dagger Y_uY_d^\dagger) - 12\lambda\text{Tr}(Y_dY_u^\dagger T_uY_d^\dagger) \\
& - 3T_\lambda\text{Tr}(Y_eY_e^\dagger Y_eY_e^\dagger) - 12\lambda\text{Tr}(Y_eY_e^\dagger T_eY_e^\dagger) - 12\lambda\text{Tr}(Y_uY_d^\dagger T_dY_u^\dagger) - 9T_\lambda\text{Tr}(Y_uY_u^\dagger Y_uY_u^\dagger) \\
& - 36\lambda\text{Tr}(Y_uY_u^\dagger T_uY_u^\dagger)
\end{aligned} \tag{56}$$

$$\beta_{T_\kappa}^{(1)} = 6(3|\kappa|^2T_\kappa + \lambda^*(2\kappa T_\lambda + \lambda T_\kappa)) \tag{57}$$

$$\begin{aligned}
\beta_{T_\kappa}^{(2)} = & -\frac{6}{5}(100\kappa^2\kappa^{*,2}T_\kappa + 10\lambda\lambda^{*,2}(4\kappa T_\lambda + \lambda T_\kappa) \\
& + \lambda^*(\lambda T_\kappa(-15g_2^2 + 15\text{Tr}(Y_dY_d^\dagger) + 15\text{Tr}(Y_uY_u^\dagger) - 3g_1^2 + 5\text{Tr}(Y_eY_e^\dagger) + 60|\kappa|^2) \\
& + 2\kappa(T_\lambda(-15g_2^2 + 15\text{Tr}(Y_dY_d^\dagger) + 15\text{Tr}(Y_uY_u^\dagger) + 20|\kappa|^2 - 3g_1^2 + 5\text{Tr}(Y_eY_e^\dagger)) \\
& + \lambda(15g_2^2M_2 + 15\text{Tr}(Y_d^\dagger T_d) + 15\text{Tr}(Y_u^\dagger T_u) + 3g_1^2M_1 + 5\text{Tr}(Y_e^\dagger T_e))))))
\end{aligned} \tag{58}$$

$$\begin{aligned}
\beta_{T_u}^{(1)} = & +2Y_uY_d^\dagger T_d + 4Y_uY_u^\dagger T_u + T_uY_d^\dagger Y_d + 5T_uY_u^\dagger Y_u - \frac{13}{15}g_1^2T_u - 3g_2^2T_u - \frac{16}{3}g_3^2T_u \\
& + |\lambda|^2T_u + 3T_u\text{Tr}(Y_uY_u^\dagger) + Y_u(2\lambda^*T_\lambda + 6g_2^2M_2 + 6\text{Tr}(Y_u^\dagger T_u) + \frac{26}{15}g_1^2M_1 + \frac{32}{3}g_3^2M_3)
\end{aligned} \tag{59}$$

$$\begin{aligned}
\beta_{T_u}^{(2)} = & +\frac{4}{5}g_1^2Y_uY_d^\dagger T_d - 2|\lambda|^2Y_uY_d^\dagger T_d - \frac{4}{5}g_1^2M_1Y_uY_u^\dagger Y_u - 12g_2^2M_2Y_uY_u^\dagger Y_u \\
& + \frac{6}{5}g_1^2Y_uY_u^\dagger T_u + 6g_2^2Y_uY_u^\dagger T_u - 4|\lambda|^2Y_uY_u^\dagger T_u + \frac{2}{5}g_1^2T_uY_d^\dagger Y_d \\
& - |\lambda|^2T_uY_d^\dagger Y_d + 12g_2^2T_uY_u^\dagger Y_u - 5|\lambda|^2T_uY_u^\dagger Y_u - 4Y_uY_d^\dagger Y_dY_d^\dagger T_d \\
& - 2Y_uY_d^\dagger Y_dY_u^\dagger T_u - 4Y_uY_d^\dagger T_dY_d^\dagger Y_d - 4Y_uY_d^\dagger T_dY_u^\dagger Y_u - 6Y_uY_u^\dagger Y_uY_u^\dagger T_u \\
& - 8Y_uY_u^\dagger T_uY_u^\dagger Y_u - 2T_uY_d^\dagger Y_dY_d^\dagger Y_d - 4T_uY_d^\dagger Y_dY_u^\dagger Y_u - 6T_uY_u^\dagger Y_uY_u^\dagger Y_u + \frac{2743}{450}g_1^4T_u \\
& + g_1^2g_2^2T_u + \frac{15}{2}g_2^4T_u + \frac{136}{45}g_1^2g_3^2T_u + 8g_2^2g_3^2T_u - \frac{16}{9}g_3^4T_u - 2\lambda|\kappa|^2\lambda^*T_u - 3\lambda^2\lambda^{*,2}T_u
\end{aligned}$$

$$\begin{aligned}
& -6\lambda^* Y_u Y_u^\dagger Y_u T_\lambda - 6Y_u Y_d^\dagger T_d \text{Tr}(Y_d Y_d^\dagger) - 3T_u Y_d^\dagger Y_d \text{Tr}(Y_d Y_d^\dagger) \\
& -3|\lambda|^2 T_u \text{Tr}(Y_d Y_d^\dagger) - 2Y_u Y_d^\dagger T_d \text{Tr}(Y_e Y_e^\dagger) - T_u Y_d^\dagger Y_d \text{Tr}(Y_e Y_e^\dagger) \\
& -|\lambda|^2 T_u \text{Tr}(Y_e Y_e^\dagger) - 12Y_u Y_u^\dagger T_u \text{Tr}(Y_u Y_u^\dagger) - 15T_u Y_u^\dagger Y_u \text{Tr}(Y_u Y_u^\dagger) \\
& + \frac{4}{5} g_1^2 T_u \text{Tr}(Y_u Y_u^\dagger) + 16g_3^2 T_u \text{Tr}(Y_u Y_u^\dagger) \\
& - \frac{2}{5} Y_u Y_d^\dagger Y_d \left( 15 \text{Tr}(Y_d^\dagger T_d) + 2g_1^2 M_1 + 5\lambda^* T_\lambda + 5 \text{Tr}(Y_e^\dagger T_e) \right) - 18Y_u Y_u^\dagger Y_u \text{Tr}(Y_u^\dagger T_u) \\
& - 3T_u \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 9T_u \text{Tr}(Y_u Y_u^\dagger Y_u Y_u^\dagger) \\
& - \frac{2}{225} Y_u \left( 2743g_1^4 M_1 + 225g_1^2 g_2^2 M_1 + 680g_1^2 g_3^2 M_1 + 680g_1^2 g_3^2 M_3 + 1800g_2^2 g_3^2 M_3 - 800g_3^4 M_3 \right. \\
& \left. + 225g_1^2 g_2^2 M_2 + 3375g_2^4 M_2 + 1800g_2^2 g_3^2 M_2 + 1350\lambda\lambda^{*,2} T_\lambda + 450\kappa^* \lambda^* (\kappa T_\lambda + \lambda T_\kappa) \right. \\
& \left. + 180g_1^2 M_1 \text{Tr}(Y_u Y_u^\dagger) + 3600g_3^2 M_3 \text{Tr}(Y_u Y_u^\dagger) \right. \\
& \left. + 225\lambda^* (\lambda (3\text{Tr}(Y_d^\dagger T_d) + \text{Tr}(Y_e^\dagger T_e)) + T_\lambda (3\text{Tr}(Y_d Y_d^\dagger) + \text{Tr}(Y_e Y_e^\dagger))) \right) - 180g_1^2 \text{Tr}(Y_u^\dagger T_u) \\
& - 3600g_3^2 \text{Tr}(Y_u^\dagger T_u) + 675\text{Tr}(Y_d Y_u^\dagger T_u Y_d^\dagger) + 675\text{Tr}(Y_u Y_d^\dagger T_d Y_u^\dagger) + 4050\text{Tr}(Y_u Y_u^\dagger T_u Y_u^\dagger)
\end{aligned} \tag{60}$$

### 3.8 Bilinear Soft-Breaking Parameters

$$\begin{aligned}
\beta_{B_\mu}^{(1)} &= +\frac{6}{5} g_1^2 M_1 \mu + 6g_2^2 M_2 \mu + 2\lambda B_S \kappa^* + 4\mu \lambda^* T_\lambda \\
& + B_\mu \left( -3g_2^2 + 3\text{Tr}(Y_d Y_d^\dagger) + 3\text{Tr}(Y_u Y_u^\dagger) + 6|\lambda|^2 - \frac{3}{5} g_1^2 + \text{Tr}(Y_e Y_e^\dagger) \right) + 6\mu \text{Tr}(Y_d^\dagger T_d) \\
& + 2\mu \text{Tr}(Y_e^\dagger T_e) + 6\mu \text{Tr}(Y_u^\dagger T_u)
\end{aligned} \tag{61}$$

$$\begin{aligned}
\beta_{B_\mu}^{(2)} &= \frac{1}{50} \left( B_\mu \left( 207g_1^4 + 90g_1^2 g_2^2 + 375g_2^4 - 700\lambda^2 \lambda^{*,2} - 20(-40g_3^2 + g_1^2) \text{Tr}(Y_d Y_d^\dagger) + 60g_1^2 \text{Tr}(Y_e Y_e^\dagger) \right. \right. \\
& \left. \left. + 10|\lambda|^2 (180g_2^2 - 20\kappa\kappa^* - 25\text{Tr}(Y_e Y_e^\dagger) + 36g_1^2 - 75\text{Tr}(Y_d Y_d^\dagger) - 75\text{Tr}(Y_u Y_u^\dagger)) \right. \right. \\
& \left. \left. + 40g_1^2 \text{Tr}(Y_u Y_u^\dagger) + 800g_3^2 \text{Tr}(Y_u Y_u^\dagger) - 450\text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) - 300\text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) \right. \right. \\
& \left. \left. - 150\text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) - 450\text{Tr}(Y_u Y_u^\dagger Y_u Y_u^\dagger) \right) \right. \\
& - 4 \left( 207g_1^4 M_1 \mu + 45g_1^2 g_2^2 M_1 \mu + 45g_1^2 g_2^2 M_2 \mu + 375g_2^4 M_2 \mu + 100\lambda (|\kappa|^2 + |\lambda|^2) B_S \kappa^* \right. \\
& \left. + 100M_S \lambda \kappa^{*,2} T_\kappa + 400\lambda \mu \lambda^{*,2} T_\lambda - 10g_1^2 M_1 \mu \text{Tr}(Y_d Y_d^\dagger) + 400g_3^2 M_3 \mu \text{Tr}(Y_d Y_d^\dagger) \right. \\
& \left. + 30g_1^2 M_1 \mu \text{Tr}(Y_e Y_e^\dagger) + 20g_1^2 M_1 \mu \text{Tr}(Y_u Y_u^\dagger) + 400g_3^2 M_3 \mu \text{Tr}(Y_u Y_u^\dagger) \right. \\
& \left. + 10g_1^2 \mu \text{Tr}(Y_d^\dagger T_d) - 400g_3^2 \mu \text{Tr}(Y_d^\dagger T_d) - 30g_1^2 \mu \text{Tr}(Y_e^\dagger T_e) - 20g_1^2 \mu \text{Tr}(Y_u^\dagger T_u) \right)
\end{aligned}$$

$$\begin{aligned}
& -400g_3^2\mu\text{Tr}\left(Y_u^\dagger T_u\right) \\
& +5\lambda^*\left(20\kappa^*\left(\left(\kappa\mu+M_S\lambda\right)T_\lambda+\lambda\mu T_\kappa\right)\right. \\
& +\mu\left(5T_\lambda\left(3\text{Tr}\left(Y_d Y_d^\dagger\right)+3\text{Tr}\left(Y_u Y_u^\dagger\right)+\text{Tr}\left(Y_e Y_e^\dagger\right)\right)\right. \\
& +3\lambda\left(15\text{Tr}\left(Y_d^\dagger T_d\right)+15\text{Tr}\left(Y_u^\dagger T_u\right)+30g_2^2 M_2+5\text{Tr}\left(Y_e^\dagger T_e\right)+6g_1^2 M_1\right)\left.\right) \\
& +450\mu\text{Tr}\left(Y_d Y_d^\dagger T_d Y_d^\dagger\right)+150\mu\text{Tr}\left(Y_d Y_u^\dagger T_u Y_d^\dagger\right)+150\mu\text{Tr}\left(Y_e Y_e^\dagger T_e Y_e^\dagger\right) \\
& +150\mu\text{Tr}\left(Y_u Y_d^\dagger T_d Y_u^\dagger\right)+450\mu\text{Tr}\left(Y_u Y_u^\dagger T_u Y_u^\dagger\right)\left.\right) \tag{62}
\end{aligned}$$

$$\beta_{B_S}^{(1)}=4\left(2|\kappa|^2+|\lambda|^2\right)B_S+8\left(\kappa B_\mu\lambda^*+M_S\kappa^*T_\kappa+M_S\lambda^*T_\lambda\right) \tag{63}$$

$$\begin{aligned}
\beta_{B_S}^{(2)}& =-\frac{4}{5}\left(B_S\left(40\kappa^2\kappa^{*,2}+40\lambda|\kappa|^2\lambda^*\right.\right. \\
& +|\lambda|^2\left(10\lambda\lambda^*-15g_2^2+15\text{Tr}\left(Y_d Y_d^\dagger\right)+15\text{Tr}\left(Y_u Y_u^\dagger\right)-3g_1^2+5\text{Tr}\left(Y_e Y_e^\dagger\right)\right)\left.\right) \\
& +2\left(50M_S\kappa\kappa^{*,2}T_\kappa+10\lambda^{*,2}\left(\left(2M_S\lambda+\kappa\mu\right)T_\lambda+\kappa\lambda B_\mu\right)\right. \\
& +\lambda^*\left(3g_1^2 M_1 M_S\lambda+15g_2^2 M_2 M_S\lambda+9g_1^2 M_1\kappa\mu+45g_2^2 M_2\kappa\mu-3g_1^2 M_S T_\lambda-15g_2^2 M_S T_\lambda\right. \\
& +10M_S\kappa^*\left(2\lambda T_\kappa+3\kappa T_\lambda\right)+15M_S T_\lambda\text{Tr}\left(Y_d Y_d^\dagger\right)+5M_S T_\lambda\text{Tr}\left(Y_e Y_e^\dagger\right)+15M_S T_\lambda\text{Tr}\left(Y_u Y_u^\dagger\right) \\
& +\kappa B_\mu\left(15\text{Tr}\left(Y_d Y_d^\dagger\right)+15\text{Tr}\left(Y_u Y_u^\dagger\right)-45g_2^2+5\text{Tr}\left(Y_e Y_e^\dagger\right)-9g_1^2\right)+15M_S\lambda\text{Tr}\left(Y_d^\dagger T_d\right) \\
& \left.\left.+15\kappa\mu\text{Tr}\left(Y_d^\dagger T_d\right)+5M_S\lambda\text{Tr}\left(Y_e^\dagger T_e\right)+5\kappa\mu\text{Tr}\left(Y_e^\dagger T_e\right)+15M_S\lambda\text{Tr}\left(Y_u^\dagger T_u\right)+15\kappa\mu\text{Tr}\left(Y_u^\dagger T_u\right)\right)\right) \tag{64}
\end{aligned}$$

### 3.9 Linear Soft-Breaking Parameters

$$\begin{aligned}
\beta_{\xi_1}^{(1)}& =2\left(2m_S^2\kappa M_S^*+M_S B_S\kappa^*+2M_S B_\mu\lambda^*+2m_{H_d}^2\lambda\mu^*+2m_{H_u}^2\lambda\mu^*+|\kappa|^2\xi_1+|\lambda|^2\xi_1+2L_1\kappa^*T_\kappa\right. \\
& \left.+B_S^*T_\kappa+2L_1\lambda^*T_\lambda+2B_\mu^*T_\lambda\right) \tag{65}
\end{aligned}$$

$$\begin{aligned}
\beta_{\xi_1}^{(2)}& =-\frac{2}{5}\left(6g_1^2 L_1 M_1|\lambda|^2+30g_2^2 L_1 M_2|\lambda|^2+20M_S\left(|\kappa|^2+|\lambda|^2\right)B_S\kappa^*+6g_1^2 M_1 M_S\mu\lambda^*\right. \\
& +30g_2^2 M_2 M_S\mu\lambda^*-6g_1^2 M_S B_\mu\lambda^*-30g_2^2 M_S B_\mu\lambda^*+20M_S\lambda B_\mu\lambda^{*,2}-6g_1^2 m_{H_d}^2\lambda\mu^* \\
& -30g_2^2 m_{H_d}^2\lambda\mu^*-6g_1^2 m_{H_u}^2\lambda\mu^*-30g_2^2 m_{H_u}^2\lambda\mu^*-12g_1^2\lambda|M_1|^2\mu^*-60g_2^2\lambda|M_2|^2\mu^* \\
& +40\lambda|T_\lambda|^2\mu^*+40m_{H_d}^2\lambda^2\lambda^*\mu^*+40m_{H_u}^2\lambda^2\lambda^*\mu^*+20m_S^2\lambda^2\lambda^*\mu^*+6g_1^2 M_1\lambda B_\mu^* \\
& +30g_2^2 M_2\lambda B_\mu^*-3g_1^2|\lambda|^2\xi_1-15g_2^2|\lambda|^2\xi_1+20\kappa^2\kappa^{*,2}\xi_1+20\lambda|\kappa|^2\lambda^*\xi_1 \\
& +10\lambda^2\lambda^{*,2}\xi_1+40L_1|\lambda|^2\kappa^*T_\kappa+20M_S^2\kappa^{*,2}T_\kappa+80L_1\kappa\kappa^{*,2}T_\kappa+40|\kappa|^2 B_S^*T_\kappa+20|\lambda|^2 B_S^*T_\kappa \\
& +20M_S^*\left(2\kappa|T_\kappa|^2+\left(3m_S^2+m_{H_d}^2+m_{H_u}^2\right)\kappa|\lambda|^2+5m_S^2\kappa^2\kappa^*+\kappa|T_\lambda|^2+\lambda T_\lambda^*T_\kappa\right)-6g_1^2 L_1\lambda^*T_\lambda \\
& \left.-30g_2^2 L_1\lambda^*T_\lambda+40L_1|\kappa|^2\lambda^*T_\lambda+20M_S^2\kappa^*\lambda^*T_\lambda+40L_1\lambda\lambda^{*,2}T_\lambda+20M_S\mu\lambda^{*,2}T_\lambda\right)
\end{aligned}$$

$$\begin{aligned}
& + 6g_1^2 M_1 \mu^* T_\lambda + 30g_2^2 M_2 \mu^* T_\lambda + 20\kappa \lambda^* B_S^* T_\lambda - 6g_1^2 B_\mu^* T_\lambda - 30g_2^2 B_\mu^* T_\lambda + 40|\lambda|^2 B_\mu^* T_\lambda \\
& + 30M_S B_\mu \lambda^* \text{Tr}(Y_d Y_d^\dagger) + 60m_{H_d}^2 \lambda \mu^* \text{Tr}(Y_d Y_d^\dagger) + 30m_{H_u}^2 \lambda \mu^* \text{Tr}(Y_d Y_d^\dagger) \\
& + 15|\lambda|^2 \xi_1 \text{Tr}(Y_d Y_d^\dagger) + 30L_1 \lambda^* T_\lambda \text{Tr}(Y_d Y_d^\dagger) + 30B_\mu^* T_\lambda \text{Tr}(Y_d Y_d^\dagger) + 10M_S B_\mu \lambda^* \text{Tr}(Y_e Y_e^\dagger) \\
& + 20m_{H_d}^2 \lambda \mu^* \text{Tr}(Y_e Y_e^\dagger) + 10m_{H_u}^2 \lambda \mu^* \text{Tr}(Y_e Y_e^\dagger) + 5|\lambda|^2 \xi_1 \text{Tr}(Y_e Y_e^\dagger) \\
& + 10L_1 \lambda^* T_\lambda \text{Tr}(Y_e Y_e^\dagger) + 10B_\mu^* T_\lambda \text{Tr}(Y_e Y_e^\dagger) + 30M_S B_\mu \lambda^* \text{Tr}(Y_u Y_u^\dagger) + 30m_{H_d}^2 \lambda \mu^* \text{Tr}(Y_u Y_u^\dagger) \\
& + 60m_{H_u}^2 \lambda \mu^* \text{Tr}(Y_u Y_u^\dagger) + 15|\lambda|^2 \xi_1 \text{Tr}(Y_u Y_u^\dagger) + 30L_1 \lambda^* T_\lambda \text{Tr}(Y_u Y_u^\dagger) + 30B_\mu^* T_\lambda \text{Tr}(Y_u Y_u^\dagger) \\
& + 30L_1 |\lambda|^2 \text{Tr}(Y_d^\dagger T_d) + 30M_S \mu \lambda^* \text{Tr}(Y_d^\dagger T_d) + 30\lambda B_\mu^* \text{Tr}(Y_d^\dagger T_d) + 10L_1 |\lambda|^2 \text{Tr}(Y_e^\dagger T_e) \\
& + 10M_S \mu \lambda^* \text{Tr}(Y_e^\dagger T_e) + 10\lambda B_\mu^* \text{Tr}(Y_e^\dagger T_e) + 30L_1 |\lambda|^2 \text{Tr}(Y_u^\dagger T_u) + 30M_S \mu \lambda^* \text{Tr}(Y_u^\dagger T_u) \\
& + 30\lambda B_\mu^* \text{Tr}(Y_u^\dagger T_u) + 30\mu^* T_\lambda \text{Tr}(T_d^* Y_d^T) + 30\lambda \mu^* \text{Tr}(T_d^* T_d^T) + 10\mu^* T_\lambda \text{Tr}(T_e^* Y_e^T) \\
& + 10\lambda \mu^* \text{Tr}(T_e^* T_e^T) + 30\mu^* T_\lambda \text{Tr}(T_u^* Y_u^T) + 30\lambda \mu^* \text{Tr}(T_u^* T_u^T) + 30\lambda \mu^* \text{Tr}(Y_d Y_d^\dagger m_d^{2*}) \\
& + 30\lambda \mu^* \text{Tr}(Y_d m_q^{2*} Y_d^\dagger) + 10\lambda \mu^* \text{Tr}(Y_e Y_e^\dagger m_e^{2*}) + 10\lambda \mu^* \text{Tr}(Y_e m_l^{2*} Y_e^\dagger) \\
& + 30\lambda \mu^* \text{Tr}(Y_u Y_u^\dagger m_u^{2*}) + 30\lambda \mu^* \text{Tr}(Y_u m_q^{2*} Y_u^\dagger)
\end{aligned} \tag{66}$$

### 3.10 Soft-Breaking Scalar Masses

$$\sigma_{1,1} = \sqrt{\frac{3}{5}} g_1 \left( -2\text{Tr}(m_u^2) - \text{Tr}(m_l^2) - m_{H_d}^2 + m_{H_u}^2 + \text{Tr}(m_d^2) + \text{Tr}(m_e^2) + \text{Tr}(m_q^2) \right) \tag{67}$$

$$\sigma_{2,11} = \frac{1}{10} g_1^2 \left( 2\text{Tr}(m_d^2) + 3\text{Tr}(m_l^2) + 3m_{H_d}^2 + 3m_{H_u}^2 + 6\text{Tr}(m_e^2) + 8\text{Tr}(m_u^2) + \text{Tr}(m_q^2) \right) \tag{68}$$

$$\begin{aligned}
\sigma_{3,1} &= \frac{1}{20} \frac{1}{\sqrt{15}} g_1 \left( -9g_1^2 m_{H_d}^2 - 45g_2^2 m_{H_d}^2 + 9g_1^2 m_{H_u}^2 + 45g_2^2 m_{H_u}^2 + 30 \left( -m_{H_u}^2 + m_{H_d}^2 \right) |\lambda|^2 + 4 \left( 20g_3^2 + g_1^2 \right) \text{Tr}(m_d^2) \right. \\
& + 36g_1^2 \text{Tr}(m_e^2) - 9g_1^2 \text{Tr}(m_l^2) - 45g_2^2 \text{Tr}(m_l^2) + g_1^2 \text{Tr}(m_q^2) + 45g_2^2 \text{Tr}(m_q^2) + 80g_3^2 \text{Tr}(m_q^2) \\
& - 32g_1^2 \text{Tr}(m_u^2) - 160g_3^2 \text{Tr}(m_u^2) + 90m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger) + 30m_{H_d}^2 \text{Tr}(Y_e Y_e^\dagger) - 90m_{H_u}^2 \text{Tr}(Y_u Y_u^\dagger) \\
& - 60\text{Tr}(Y_d Y_d^\dagger m_d^{2*}) - 30\text{Tr}(Y_d m_q^{2*} Y_d^\dagger) - 60\text{Tr}(Y_e Y_e^\dagger m_e^{2*}) + 30\text{Tr}(Y_e m_l^{2*} Y_e^\dagger) \\
& \left. + 120\text{Tr}(Y_u Y_u^\dagger m_u^{2*}) - 30\text{Tr}(Y_u m_q^{2*} Y_u^\dagger) \right)
\end{aligned} \tag{69}$$

$$\sigma_{2,2} = \frac{1}{2} \left( 3\text{Tr}(m_q^2) + m_{H_d}^2 + m_{H_u}^2 + \text{Tr}(m_l^2) \right) \tag{70}$$

$$\sigma_{2,3} = \frac{1}{2} \left( 2\text{Tr}(m_q^2) + \text{Tr}(m_d^2) + \text{Tr}(m_u^2) \right) \tag{71}$$

$$\beta_{m_q^2}^{(1)} = -\frac{2}{15} g_1^2 \mathbf{1} |M_1|^2 - \frac{32}{3} g_3^2 \mathbf{1} |M_3|^2 - 6g_2^2 \mathbf{1} |M_2|^2 + 2m_{H_d}^2 Y_d^\dagger Y_d + 2m_{H_u}^2 Y_u^\dagger Y_u + 2T_d^\dagger T_d$$

$$\begin{aligned}
& + 2T_u^\dagger T_u + m_q^2 Y_d^\dagger Y_d + m_q^2 Y_u^\dagger Y_u + 2Y_d^\dagger m_d^2 Y_d + Y_d^\dagger Y_d m_q^2 + 2Y_u^\dagger m_u^2 Y_u \\
& + Y_u^\dagger Y_u m_q^2 + \frac{1}{\sqrt{15}} g_1 \mathbf{1} \sigma_{1,1}
\end{aligned} \tag{72}$$

$$\begin{aligned}
\beta_{m_q^2}^{(2)} = & + \frac{2}{5} g_1^2 g_2^2 \mathbf{1} |M_2|^2 + 33 g_2^4 \mathbf{1} |M_2|^2 + 32 g_2^2 g_3^2 \mathbf{1} |M_2|^2 \\
& + \frac{16}{45} g_3^2 \left( 15 \left( 3g_2^2 (2M_3 + M_2) - 8g_3^2 M_3 \right) + g_1^2 (2M_3 + M_1) \right) \mathbf{1} M_3^* + \frac{1}{5} g_1^2 g_2^2 M_1 \mathbf{1} M_2^* + 16 g_2^2 g_3^2 M_3 \mathbf{1} M_2^* \\
& + \frac{4}{5} g_1^2 m_{H_d}^2 Y_d^\dagger Y_d - 4m_{H_d}^2 |\lambda|^2 Y_d^\dagger Y_d - 2m_{H_u}^2 |\lambda|^2 Y_d^\dagger Y_d \\
& - 2m_S^2 |\lambda|^2 Y_d^\dagger Y_d - 2|T_\lambda|^2 Y_d^\dagger Y_d - 2\lambda T_\lambda^* Y_d^\dagger T_d + \frac{8}{5} g_1^2 m_{H_u}^2 Y_u^\dagger Y_u \\
& - 2m_{H_d}^2 |\lambda|^2 Y_u^\dagger Y_u - 4m_{H_u}^2 |\lambda|^2 Y_u^\dagger Y_u - 2m_S^2 |\lambda|^2 Y_u^\dagger Y_u - 2|T_\lambda|^2 Y_u^\dagger Y_u \\
& + \frac{1}{225} g_1^2 M_1^* \left( \left( 5 \left( 16g_3^2 (2M_1 + M_3) + 9g_2^2 (2M_1 + M_2) \right) + 597g_1^2 M_1 \right) \mathbf{1} \right. \\
& \left. + 180 \left( 2M_1 Y_d^\dagger Y_d - 2Y_u^\dagger T_u + 4M_1 Y_u^\dagger Y_u - Y_d^\dagger T_d \right) \right) \\
& - 2\lambda T_\lambda^* Y_u^\dagger T_u - \frac{4}{5} g_1^2 M_1 T_d^\dagger Y_d + \frac{4}{5} g_1^2 T_d^\dagger T_d - 2|\lambda|^2 T_d^\dagger T_d \\
& - \frac{8}{5} g_1^2 M_1 T_u^\dagger Y_u + \frac{8}{5} g_1^2 T_u^\dagger T_u - 2|\lambda|^2 T_u^\dagger T_u + \frac{2}{5} g_1^2 m_q^2 Y_d^\dagger Y_d \\
& - |\lambda|^2 m_q^2 Y_d^\dagger Y_d + \frac{4}{5} g_1^2 m_q^2 Y_u^\dagger Y_u - |\lambda|^2 m_q^2 Y_u^\dagger Y_u + \frac{4}{5} g_1^2 Y_d^\dagger m_d^2 Y_d \\
& - 2|\lambda|^2 Y_d^\dagger m_d^2 Y_d + \frac{2}{5} g_1^2 Y_d^\dagger Y_d m_q^2 - |\lambda|^2 Y_d^\dagger Y_d m_q^2 + \frac{8}{5} g_1^2 Y_u^\dagger m_u^2 Y_u \\
& - 2|\lambda|^2 Y_u^\dagger m_u^2 Y_u + \frac{4}{5} g_1^2 Y_u^\dagger Y_u m_q^2 - |\lambda|^2 Y_u^\dagger Y_u m_q^2 - 8m_{H_d}^2 Y_d^\dagger Y_d Y_d^\dagger Y_d \\
& - 4Y_d^\dagger Y_d T_d^\dagger T_d - 4Y_d^\dagger T_d T_d^\dagger Y_d - 8m_{H_u}^2 Y_u^\dagger Y_u Y_u^\dagger Y_u - 4Y_u^\dagger Y_u T_u^\dagger T_u \\
& - 4Y_u^\dagger T_u T_u^\dagger Y_u - 4T_d^\dagger Y_d Y_d^\dagger T_d - 4T_d^\dagger T_d Y_d^\dagger Y_d - 4T_u^\dagger Y_u Y_u^\dagger T_u \\
& - 4T_u^\dagger T_u Y_u^\dagger Y_u - 2m_q^2 Y_d^\dagger Y_d Y_d^\dagger Y_d - 2m_q^2 Y_u^\dagger Y_u Y_u^\dagger Y_u - 4Y_d^\dagger m_d^2 Y_d Y_d^\dagger Y_d \\
& - 4Y_d^\dagger Y_d m_q^2 Y_d^\dagger Y_d - 4Y_d^\dagger Y_d Y_d^\dagger m_d^2 Y_d - 2Y_d^\dagger Y_d Y_d^\dagger Y_d m_q^2 - 4Y_u^\dagger m_u^2 Y_u Y_u^\dagger Y_u \\
& - 4Y_u^\dagger Y_u m_q^2 Y_u^\dagger Y_u - 4Y_u^\dagger Y_u Y_u^\dagger m_u^2 Y_u - 2Y_u^\dagger Y_u Y_u^\dagger Y_u m_q^2 - 2\lambda^* T_d^\dagger Y_d T_\lambda \\
& - 2\lambda^* T_u^\dagger Y_u T_\lambda + 6g_2^4 \mathbf{1} \sigma_{2,2} + \frac{32}{3} g_3^4 \mathbf{1} \sigma_{2,3} + \frac{2}{15} g_1^2 \mathbf{1} \sigma_{2,11} + 4 \frac{1}{\sqrt{15}} g_1 \mathbf{1} \sigma_{3,1} \\
& - 12m_{H_d}^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}$$

$$\begin{aligned}
& -6T_d^\dagger Y_d \text{Tr}(Y_d^\dagger T_d) - 2T_d^\dagger Y_d \text{Tr}(Y_e^\dagger T_e) - 6T_u^\dagger Y_u \text{Tr}(Y_u^\dagger T_u) \\
& -6Y_d^\dagger T_d \text{Tr}(T_d^* Y_d^T) - 6Y_d^\dagger Y_d \text{Tr}(T_d^* T_d^T) - 2Y_d^\dagger T_d \text{Tr}(T_e^* Y_e^T) \\
& -2Y_d^\dagger Y_d \text{Tr}(T_e^* T_e^T) - 6Y_u^\dagger T_u \text{Tr}(T_u^* Y_u^T) - 6Y_u^\dagger Y_u \text{Tr}(T_u^* T_u^T) \\
& -6Y_d^\dagger Y_d \text{Tr}(m_d^2 Y_d Y_d^\dagger) - 2Y_d^\dagger Y_d \text{Tr}(m_e^2 Y_e Y_e^\dagger) - 2Y_d^\dagger Y_d \text{Tr}(m_l^2 Y_e^\dagger Y_e) \\
& -6Y_d^\dagger Y_d \text{Tr}(m_q^2 Y_d^\dagger Y_d) - 6Y_u^\dagger Y_u \text{Tr}(m_q^2 Y_u^\dagger Y_u) - 6Y_u^\dagger Y_u \text{Tr}(m_u^2 Y_u Y_u^\dagger)
\end{aligned} \tag{73}$$

$$\begin{aligned}
\beta_{m_l^2}^{(1)} &= -\frac{6}{5}g_1^2 \mathbf{1}|M_1|^2 - 6g_2^2 \mathbf{1}|M_2|^2 + 2m_{H_d}^2 Y_e^\dagger Y_e + 2T_e^\dagger T_e + m_l^2 Y_e^\dagger Y_e + 2Y_e^\dagger m_e^2 Y_e \\
&+ Y_e^\dagger Y_e m_l^2 - \sqrt{\frac{3}{5}}g_1 \mathbf{1}\sigma_{1,1}
\end{aligned} \tag{74}$$

$$\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 - 4m_{H_d}^2 |\lambda|^2 Y_e^\dagger Y_e \\
&- 2m_{H_u}^2 |\lambda|^2 Y_e^\dagger Y_e - 2m_S^2 |\lambda|^2 Y_e^\dagger Y_e - 2|T_\lambda|^2 Y_e^\dagger Y_e \\
&+ \frac{3}{25}g_1^2 M_1^* \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) - 2\lambda T_\lambda^* Y_e^\dagger T_e \\
&- \frac{12}{5}g_1^2 M_1 T_e^\dagger Y_e + \frac{12}{5}g_1^2 T_e^\dagger T_e - 2|\lambda|^2 T_e^\dagger T_e + \frac{6}{5}g_1^2 m_l^2 Y_e^\dagger Y_e \\
&- |\lambda|^2 m_l^2 Y_e^\dagger Y_e + \frac{12}{5}g_1^2 Y_e^\dagger m_e^2 Y_e - 2|\lambda|^2 Y_e^\dagger m_e^2 Y_e + \frac{6}{5}g_1^2 Y_e^\dagger Y_e m_l^2 \\
&- |\lambda|^2 Y_e^\dagger Y_e m_l^2 - 8m_{H_d}^2 Y_e^\dagger Y_e Y_e^\dagger Y_e - 4Y_e^\dagger Y_e T_e^\dagger T_e - 4Y_e^\dagger T_e T_e^\dagger Y_e \\
&- 4T_e^\dagger Y_e Y_e^\dagger T_e - 4T_e^\dagger T_e Y_e^\dagger Y_e - 2m_l^2 Y_e^\dagger Y_e Y_e^\dagger Y_e - 4Y_e^\dagger m_e^2 Y_e Y_e^\dagger Y_e \\
&- 4Y_e^\dagger Y_e m_l^2 Y_e^\dagger Y_e - 4Y_e^\dagger Y_e Y_e^\dagger m_e^2 Y_e - 2Y_e^\dagger Y_e Y_e^\dagger Y_e m_l^2 - 2\lambda^* T_e^\dagger Y_e T_\lambda + 6g_2^4 \mathbf{1}\sigma_{2,2} \\
&+ \frac{6}{5}g_1^2 \mathbf{1}\sigma_{2,11} - 4\sqrt{\frac{3}{5}}g_1 \mathbf{1}\sigma_{3,1} - 12m_{H_d}^2 Y_e^\dagger Y_e \text{Tr}(Y_d Y_d^\dagger) - 6T_e^\dagger T_e \text{Tr}(Y_d Y_d^\dagger) \\
&- 3m_l^2 Y_e^\dagger Y_e \text{Tr}(Y_d Y_d^\dagger) - 6Y_e^\dagger m_e^2 Y_e \text{Tr}(Y_d Y_d^\dagger) - 3Y_e^\dagger Y_e m_l^2 \text{Tr}(Y_d Y_d^\dagger) \\
&- 4m_{H_d}^2 Y_e^\dagger Y_e \text{Tr}(Y_e Y_e^\dagger) - 2T_e^\dagger T_e \text{Tr}(Y_e Y_e^\dagger) - m_l^2 Y_e^\dagger Y_e \text{Tr}(Y_e Y_e^\dagger) \\
&- 2Y_e^\dagger m_e^2 Y_e \text{Tr}(Y_e Y_e^\dagger) - Y_e^\dagger Y_e m_l^2 \text{Tr}(Y_e Y_e^\dagger) - 6T_e^\dagger Y_e \text{Tr}(Y_d^\dagger T_d) \\
&- 2T_e^\dagger Y_e \text{Tr}(Y_e^\dagger T_e) - 6Y_e^\dagger T_e \text{Tr}(T_d^* Y_d^T) - 6Y_e^\dagger Y_e \text{Tr}(T_d^* T_d^T) \\
&- 2Y_e^\dagger T_e \text{Tr}(T_e^* Y_e^T) - 2Y_e^\dagger Y_e \text{Tr}(T_e^* T_e^T) - 6Y_e^\dagger Y_e \text{Tr}(m_d^2 Y_d Y_d^\dagger) \\
&- 2Y_e^\dagger Y_e \text{Tr}(m_e^2 Y_e Y_e^\dagger) - 2Y_e^\dagger Y_e \text{Tr}(m_l^2 Y_e^\dagger Y_e) - 6Y_e^\dagger Y_e \text{Tr}(m_q^2 Y_d^\dagger Y_d)
\end{aligned} \tag{75}$$

$$\begin{aligned}
\beta_{m_{H_d}^2}^{(1)} &= -\frac{6}{5}g_1^2 |M_1|^2 - 6g_2^2 |M_2|^2 + 2m_{H_d}^2 |\lambda|^2 + 2m_{H_u}^2 |\lambda|^2 + 2m_S^2 |\lambda|^2 + 2|T_\lambda|^2 - \sqrt{\frac{3}{5}}g_1 \sigma_{1,1} \\
&+ 6m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger) + 2m_{H_d}^2 \text{Tr}(Y_e Y_e^\dagger) + 6\text{Tr}(T_d^* T_d^T) + 2\text{Tr}(T_e^* T_e^T) + 6\text{Tr}(m_d^2 Y_d Y_d^\dagger) \\
&+ 2\text{Tr}(m_e^2 Y_e Y_e^\dagger) + 2\text{Tr}(m_l^2 Y_e^\dagger Y_e) + 6\text{Tr}(m_q^2 Y_d^\dagger Y_d)
\end{aligned} \tag{76}$$



$$\begin{aligned}
\beta_{m_{H_d}^2}^{(2)} &= \frac{1}{25} \left( 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} \left( Y_d Y_d^\dagger \right) + 120M_1 \text{Tr} \left( Y_e Y_e^\dagger \right) + 20 \text{Tr} \left( Y_d^\dagger T_d \right) \right. \right. \\
&\quad \left. \left. - 60 \text{Tr} \left( Y_e^\dagger T_e \right) \right) \right. \\
&\quad + 5 \left( 3g_2^2 \left( 3g_1^2 \left( 2M_2 + M_1 \right) + 55g_2^2 M_2 \right) M_2^* \right. \\
&\quad \left. - 2 \left( 30 \left( m_{H_d}^2 + m_{H_u}^2 + m_S^2 \right) \lambda^2 \lambda^{*,2} + 10\kappa^* \left( \left( 4m_S^2 + m_{H_d}^2 + m_{H_u}^2 \right) \kappa |\lambda|^2 + T_\lambda^* \left( \kappa T_\lambda + \lambda T_\kappa \right) \right) - 15g_2^4 \sigma_{2,2} - 3g_1^2 \sigma_{2,11} \right. \right. \\
&\quad \left. \left. + 2\sqrt{15}g_1 \sigma_{3,1} + 2g_1^2 m_{H_d}^2 \text{Tr} \left( Y_d Y_d^\dagger \right) - 80g_3^2 m_{H_d}^2 \text{Tr} \left( Y_d Y_d^\dagger \right) - 160g_3^2 |M_3|^2 \text{Tr} \left( Y_d Y_d^\dagger \right) \right. \right. \\
&\quad \left. \left. - 6g_1^2 m_{H_d}^2 \text{Tr} \left( Y_e Y_e^\dagger \right) + 15|T_\lambda|^2 \text{Tr} \left( Y_u Y_u^\dagger \right) + 80g_3^2 M_3^* \text{Tr} \left( Y_d^\dagger T_d \right) + 15\lambda T_\lambda^* \text{Tr} \left( Y_u^\dagger T_u \right) \right. \right. \\
&\quad \left. \left. - 2g_1^2 M_1 \text{Tr} \left( T_d^* Y_d^T \right) + 80g_3^2 M_3 \text{Tr} \left( T_d^* Y_d^T \right) + 2g_1^2 \text{Tr} \left( T_d^* T_d^T \right) - 80g_3^2 \text{Tr} \left( T_d^* T_d^T \right) \right. \right. \\
&\quad \left. \left. + 6g_1^2 M_1 \text{Tr} \left( T_e^* Y_e^T \right) - 6g_1^2 \text{Tr} \left( T_e^* T_e^T \right) + 2g_1^2 \text{Tr} \left( m_d^2 Y_d Y_d^\dagger \right) - 80g_3^2 \text{Tr} \left( m_d^2 Y_d Y_d^\dagger \right) \right. \right. \\
&\quad \left. \left. - 6g_1^2 \text{Tr} \left( m_e^2 Y_e Y_e^\dagger \right) - 6g_1^2 \text{Tr} \left( m_l^2 Y_e^\dagger Y_e \right) + 2g_1^2 \text{Tr} \left( m_q^2 Y_d^\dagger Y_d \right) - 80g_3^2 \text{Tr} \left( m_q^2 Y_d^\dagger Y_d \right) \right. \right. \\
&\quad \left. \left. + 5\lambda^* \left( 2T_\kappa^* \left( \kappa T_\lambda + \lambda T_\kappa \right) \right. \right. \right. \\
&\quad \left. \left. + 3 \left( 4\lambda |T_\lambda|^2 + \left( 2m_{H_u}^2 + m_{H_d}^2 + m_S^2 \right) \lambda \text{Tr} \left( Y_u Y_u^\dagger \right) + T_\lambda \text{Tr} \left( T_u^* Y_u^T \right) + \lambda \text{Tr} \left( T_u^* T_u^T \right) + \lambda \text{Tr} \left( m_q^2 Y_u^\dagger Y_u \right) \right. \right. \right. \\
&\quad \left. \left. + \lambda \text{Tr} \left( m_u^2 Y_u Y_u^\dagger \right) \right) \right) \right. \\
&\quad \left. + 90m_{H_d}^2 \text{Tr} \left( Y_d Y_d^\dagger Y_d Y_d^\dagger \right) + 90 \text{Tr} \left( Y_d Y_d^\dagger T_d T_d^\dagger \right) + 15m_{H_d}^2 \text{Tr} \left( Y_d Y_u^\dagger Y_u Y_d^\dagger \right) \right. \\
&\quad \left. + 15m_{H_u}^2 \text{Tr} \left( Y_d Y_u^\dagger Y_u Y_d^\dagger \right) + 15 \text{Tr} \left( Y_d Y_u^\dagger T_u T_d^\dagger \right) + 90 \text{Tr} \left( Y_d T_d^\dagger T_d Y_d^\dagger \right) \right. \\
&\quad \left. + 15 \text{Tr} \left( Y_d T_u^\dagger T_u Y_d^\dagger \right) + 30m_{H_d}^2 \text{Tr} \left( Y_e Y_e^\dagger Y_e Y_e^\dagger \right) + 30 \text{Tr} \left( Y_e Y_e^\dagger T_e T_e^\dagger \right) + 30 \text{Tr} \left( Y_e T_e^\dagger T_e Y_e^\dagger \right) \right. \\
&\quad \left. + 15 \text{Tr} \left( Y_u Y_d^\dagger T_d T_u^\dagger \right) + 15 \text{Tr} \left( Y_u T_d^\dagger T_d Y_u^\dagger \right) + 90 \text{Tr} \left( m_d^2 Y_d Y_d^\dagger Y_d Y_d^\dagger \right) + 15 \text{Tr} \left( m_d^2 Y_d Y_u^\dagger Y_u Y_d^\dagger \right) \right. \\
&\quad \left. + 30 \text{Tr} \left( m_e^2 Y_e Y_e^\dagger Y_e Y_e^\dagger \right) + 30 \text{Tr} \left( m_l^2 Y_e^\dagger Y_e 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) \right. \\
&\quad \left. + 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) \right) \right) \tag{77}
\end{aligned}$$

$$\begin{aligned}
\beta_{m_{H_u}^2}^{(1)} &= -\frac{6}{5} g_1^2 |M_1|^2 - 6g_2^2 |M_2|^2 + 2m_{H_d}^2 |\lambda|^2 + 2m_{H_u}^2 |\lambda|^2 + 2m_S^2 |\lambda|^2 + 2|T_\lambda|^2 + \sqrt{\frac{3}{5}} g_1 \sigma_{1,1} \\
&\quad + 6m_{H_u}^2 \text{Tr} \left( Y_u Y_u^\dagger \right) + 6 \text{Tr} \left( T_u^* T_u^T \right) + 6 \text{Tr} \left( m_q^2 Y_u^\dagger Y_u \right) + 6 \text{Tr} \left( m_u^2 Y_u Y_u^\dagger \right) \tag{78}
\end{aligned}$$

$$\begin{aligned}
\beta_{m_{H_u}^2}^{(2)} &= \frac{1}{25} \left( g_1^2 M_1^* \left( -40 \text{Tr} \left( Y_u^\dagger T_u \right) + 45g_2^2 M_2 + 621g_1^2 M_1 + 80M_1 \text{Tr} \left( Y_u Y_u^\dagger \right) + 90g_2^2 M_1 \right) \right. \\
&\quad \left. + 5 \left( 3g_2^2 \left( 3g_1^2 \left( 2M_2 + M_1 \right) + 55g_2^2 M_2 \right) M_2^* \right. \right. \\
&\quad \left. \left. - 2 \left( 30 \left( m_{H_d}^2 + m_{H_u}^2 + m_S^2 \right) \lambda^2 \lambda^{*,2} + 10\kappa^* \left( \left( 4m_S^2 + m_{H_d}^2 + m_{H_u}^2 \right) \kappa |\lambda|^2 + T_\lambda^* \left( \kappa T_\lambda + \lambda T_\kappa \right) \right) - 15g_2^4 \sigma_{2,2} - 3g_1^2 \sigma_{2,11} \right. \right. \right. \\
&\quad \left. \left. - 2\sqrt{15}g_1 \sigma_{3,1} + 15|T_\lambda|^2 \text{Tr} \left( Y_d Y_d^\dagger \right) + 5|T_\lambda|^2 \text{Tr} \left( Y_e Y_e^\dagger \right) - 4g_1^2 m_{H_u}^2 \text{Tr} \left( Y_u Y_u^\dagger \right) \right. \right.
\end{aligned}$$

$$\begin{aligned}
& -80g_3^2 m_{H_u}^2 \text{Tr}(Y_u Y_u^\dagger) - 160g_3^2 |M_3|^2 \text{Tr}(Y_u Y_u^\dagger) + 15\lambda T_\lambda^* \text{Tr}(Y_d^\dagger T_d) + 5\lambda T_\lambda^* \text{Tr}(Y_e^\dagger T_e) \\
& + 80g_3^2 M_3^* \text{Tr}(Y_u^\dagger T_u) + 4g_1^2 M_1 \text{Tr}(T_u^* Y_u^T) + 80g_3^2 M_3 \text{Tr}(T_u^* Y_u^T) - 4g_1^2 \text{Tr}(T_u^* T_u^T) \\
& - 80g_3^2 \text{Tr}(T_u^* T_u^T) \\
& + 5\lambda^* \left( 12\lambda |T_\lambda|^2 + 2T_\kappa^* (\kappa T_\lambda + \lambda T_\kappa) + 6m_{H_d}^2 \lambda \text{Tr}(Y_d Y_d^\dagger) + 3m_{H_u}^2 \lambda \text{Tr}(Y_d Y_d^\dagger) + 3m_S^2 \lambda \text{Tr}(Y_d Y_d^\dagger) \right. \\
& + 2m_{H_d}^2 \lambda \text{Tr}(Y_e Y_e^\dagger) + m_{H_u}^2 \lambda \text{Tr}(Y_e Y_e^\dagger) + m_S^2 \lambda \text{Tr}(Y_e Y_e^\dagger) + 3T_\lambda \text{Tr}(T_d^* Y_d^T) + 3\lambda \text{Tr}(T_d^* T_d^T) \\
& + T_\lambda \text{Tr}(T_e^* Y_e^T) + \lambda \text{Tr}(T_e^* T_e^T) + 3\lambda \text{Tr}(m_d^2 Y_d Y_d^\dagger) + \lambda \text{Tr}(m_e^2 Y_e Y_e^\dagger) + \lambda \text{Tr}(m_l^2 Y_e^\dagger Y_e) \\
& \left. + 3\lambda \text{Tr}(m_q^2 Y_d^\dagger Y_d) \right) \\
& - 4g_1^2 \text{Tr}(m_q^2 Y_u^\dagger Y_u) - 80g_3^2 \text{Tr}(m_q^2 Y_u^\dagger Y_u) - 4g_1^2 \text{Tr}(m_u^2 Y_u Y_u^\dagger) - 80g_3^2 \text{Tr}(m_u^2 Y_u Y_u^\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) \\
& + 15\text{Tr}(Y_d T_u^\dagger T_u Y_d^\dagger) + 15\text{Tr}(Y_u Y_d^\dagger T_d T_u^\dagger) + 90m_{H_u}^2 \text{Tr}(Y_u Y_u^\dagger Y_u Y_u^\dagger) + 90\text{Tr}(Y_u Y_u^\dagger T_u T_u^\dagger) \\
& + 15\text{Tr}(Y_u T_d^\dagger T_d Y_u^\dagger) + 90\text{Tr}(Y_u T_u^\dagger T_u Y_u^\dagger) + 15\text{Tr}(m_d^2 Y_d Y_u^\dagger Y_u Y_d^\dagger) \\
& + 15\text{Tr}(m_q^2 Y_d^\dagger Y_d Y_u^\dagger Y_u) + 15\text{Tr}(m_q^2 Y_u^\dagger Y_u Y_d^\dagger Y_d) + 90\text{Tr}(m_q^2 Y_u^\dagger Y_u Y_u^\dagger Y_u) \\
& + 15\text{Tr}(m_u^2 Y_u Y_d^\dagger Y_d Y_u^\dagger) + 90\text{Tr}(m_u^2 Y_u Y_u^\dagger Y_u Y_u^\dagger) \Big) \Big) \tag{79}
\end{aligned}$$

$$\begin{aligned}
\beta_{m_d^2}^{(1)} &= -\frac{8}{15} g_1^2 \mathbf{1} |M_1|^2 - \frac{32}{3} g_3^2 \mathbf{1} |M_3|^2 + 4m_{H_d}^2 Y_d Y_d^\dagger + 4T_d T_d^\dagger + 2m_d^2 Y_d Y_d^\dagger + 4Y_d m_q^2 Y_d^\dagger \\
& + 2Y_d Y_d^\dagger m_d^2 + 2\frac{1}{\sqrt{15}} g_1 \mathbf{1} \sigma_{1,1} \tag{80}
\end{aligned}$$

$$\begin{aligned}
\beta_{m_d^2}^{(2)} &= +\frac{64}{45} g_3^2 \left( -30g_3^2 M_3 + g_1^2 (2M_3 + M_1) \right) \mathbf{1} M_3^* + \frac{4}{5} g_1^2 m_{H_d}^2 Y_d Y_d^\dagger + 12g_2^2 m_{H_d}^2 Y_d Y_d^\dagger \\
& + 24g_2^2 |M_2|^2 Y_d Y_d^\dagger - 8m_{H_d}^2 |\lambda|^2 Y_d Y_d^\dagger - 4m_{H_u}^2 |\lambda|^2 Y_d Y_d^\dagger \\
& - 4m_S^2 |\lambda|^2 Y_d Y_d^\dagger - 4|T_\lambda|^2 Y_d Y_d^\dagger - \frac{4}{5} g_1^2 M_1 Y_d T_d^\dagger - 12g_2^2 M_2 Y_d T_d^\dagger \\
& + \frac{4}{225} g_1^2 M_1^* \left( 2 \left( 303g_1^2 M_1 + 40g_3^2 (2M_1 + M_3) \right) \mathbf{1} - 45T_d Y_d^\dagger + 90M_1 Y_d Y_d^\dagger \right) - 12g_2^2 M_2^* T_d Y_d^\dagger \\
& - 4\lambda T_\lambda^* T_d Y_d^\dagger + \frac{4}{5} g_1^2 T_d T_d^\dagger + 12g_2^2 T_d T_d^\dagger - 4|\lambda|^2 T_d T_d^\dagger \\
& + \frac{2}{5} g_1^2 m_d^2 Y_d Y_d^\dagger + 6g_2^2 m_d^2 Y_d Y_d^\dagger - 2|\lambda|^2 m_d^2 Y_d Y_d^\dagger + \frac{4}{5} g_1^2 Y_d m_q^2 Y_d^\dagger \\
& + 12g_2^2 Y_d m_q^2 Y_d^\dagger - 4|\lambda|^2 Y_d m_q^2 Y_d^\dagger + \frac{2}{5} g_1^2 Y_d Y_d^\dagger m_d^2 + 6g_2^2 Y_d Y_d^\dagger m_d^2 \\
& - 2|\lambda|^2 Y_d Y_d^\dagger m_d^2 - 8m_{H_d}^2 Y_d Y_d^\dagger Y_d Y_d^\dagger - 4Y_d Y_d^\dagger T_d T_d^\dagger - 4m_{H_d}^2 Y_d Y_u^\dagger Y_u Y_d^\dagger \\
& - 4m_{H_u}^2 Y_d Y_u^\dagger Y_u Y_d^\dagger - 4Y_d Y_u^\dagger T_u T_d^\dagger - 4Y_d T_d^\dagger T_d Y_d^\dagger - 4Y_d T_u^\dagger T_u Y_d^\dagger \\
& - 4T_d Y_d^\dagger Y_d T_d^\dagger - 4T_d Y_u^\dagger Y_u T_d^\dagger - 4T_d T_d^\dagger Y_d Y_d^\dagger - 4T_d T_u^\dagger Y_u Y_d^\dagger
\end{aligned}$$

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

$$- 4Y_d Y_d^\dagger \text{Tr}(m_e^2 Y_e Y_e^\dagger) - 4Y_d Y_d^\dagger \text{Tr}(m_l^2 Y_e^\dagger Y_e) - 12Y_d Y_d^\dagger \text{Tr}(m_q^2 Y_d^\dagger Y_d) \quad (81)$$

$$\begin{aligned}
\beta_{m_u^2}^{(1)} &= -\frac{32}{15} g_1^2 \mathbf{1}|M_1|^2 - \frac{32}{3} g_3^2 \mathbf{1}|M_3|^2 + 4m_{H_u}^2 Y_u Y_u^\dagger + 4T_u T_u^\dagger + 2m_u^2 Y_u Y_u^\dagger + 4Y_u m_q^2 Y_u^\dagger \\
&+ 2Y_u Y_u^\dagger m_u^2 - 4 \frac{1}{\sqrt{15}} g_1 \mathbf{1}\sigma_{1,1} \quad (82)
\end{aligned}$$

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

$$\begin{aligned}
& -2Y_u Y_u^\dagger Y_u Y_u^\dagger m_u^2 - 4\lambda^* Y_u T_u^\dagger T_\lambda + \frac{32}{3} g_3^4 \mathbf{1}\sigma_{2,3} + \frac{32}{15} g_1^2 \mathbf{1}\sigma_{2,11} - 16 \frac{1}{\sqrt{15}} g_1 \mathbf{1}\sigma_{3,1} \\
& - 24m_{H_u}^2 Y_u Y_u^\dagger \text{Tr}(Y_u Y_u^\dagger) - 12T_u T_u^\dagger \text{Tr}(Y_u Y_u^\dagger) - 6m_u^2 Y_u Y_u^\dagger \text{Tr}(Y_u Y_u^\dagger) \\
& - 12Y_u m_q^2 Y_u^\dagger \text{Tr}(Y_u Y_u^\dagger) - 6Y_u Y_u^\dagger m_u^2 \text{Tr}(Y_u Y_u^\dagger) - 12Y_u T_u^\dagger \text{Tr}(Y_u^\dagger T_u) \\
& - 12T_u Y_u^\dagger \text{Tr}(T_u^* Y_u^T) - 12Y_u Y_u^\dagger \text{Tr}(T_u^* T_u^T) - 12Y_u Y_u^\dagger \text{Tr}(m_q^2 Y_u^\dagger Y_u) \\
& - 12Y_u Y_u^\dagger \text{Tr}(m_u^2 Y_u Y_u^\dagger)
\end{aligned} \tag{83}$$

$$\begin{aligned}
\beta_{m_e^2}^{(1)} &= -\frac{24}{5} g_1^2 \mathbf{1}|M_1|^2 + 2\left(2m_{H_d}^2 Y_e Y_e^\dagger + 2T_e T_e^\dagger + 2Y_e m_l^2 Y_e^\dagger + m_e^2 Y_e Y_e^\dagger + Y_e Y_e^\dagger m_e^2\right) \\
&+ 2\sqrt{\frac{3}{5}} g_1 \mathbf{1}\sigma_{1,1}
\end{aligned} \tag{84}$$

$$\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 + 10\lambda T_\lambda^* T_e Y_e^\dagger + 6g_1^2 T_e T_e^\dagger - 30g_2^2 T_e T_e^\dagger\right. \\
&+ 10|\lambda|^2 T_e T_e^\dagger + 3g_1^2 m_e^2 Y_e Y_e^\dagger - 15g_2^2 m_e^2 Y_e Y_e^\dagger + 5|\lambda|^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 + 10|\lambda|^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 + 5|\lambda|^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 \\
&+ 10Y_e T_e^\dagger T_e Y_e^\dagger + 10T_e Y_e^\dagger Y_e T_e^\dagger + 10T_e T_e^\dagger Y_e Y_e^\dagger + 5m_e^2 Y_e Y_e^\dagger Y_e Y_e^\dagger \\
&+ 10Y_e m_l^2 Y_e^\dagger Y_e 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 \\
&+ 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\lambda^* T_\lambda + 10\text{Tr}(Y_e^\dagger T_e)\right) + 30g_2^2 M_2 + 30\text{Tr}(Y_d^\dagger T_d) - 6g_1^2 M_1) + 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 + 5\left(2m_{H_d}^2 + m_{H_u}^2 + m_S^2\right)|\lambda|^2 + 5|T_\lambda|^2 + 30m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger)\right. \\
&+ 10m_{H_d}^2 \text{Tr}(Y_e Y_e^\dagger) + 15\text{Tr}(T_d^* T_d^T) + 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) \\
&\left. + 5\text{Tr}(m_l^2 Y_e^\dagger Y_e) + 15\text{Tr}(m_q^2 Y_d^\dagger Y_d)\right)
\end{aligned} \tag{85}$$

$$\beta_{m_S^2}^{(1)} = 4\left(3m_S^2 |\kappa|^2 + \left(m_{H_d}^2 + m_{H_u}^2 + m_S^2\right)|\lambda|^2 + |T_\kappa|^2 + |T_\lambda|^2\right) \tag{86}$$

$$\begin{aligned}
\beta_{m_S^2}^{(2)} &= -\frac{4}{5} \left(120m_S^2 \kappa^2 \kappa^{*,2} + 20\left(m_{H_d}^2 + m_{H_u}^2 + m_S^2\right)\lambda^2 \lambda^{*,2}\right. \\
&+ 20\kappa^* \left(4\kappa |T_\kappa|^2 + \left(4m_S^2 + m_{H_d}^2 + m_{H_u}^2\right)\kappa |\lambda|^2 + T_\lambda^* \left(\kappa T_\lambda + \lambda T_\kappa\right)\right)
\end{aligned}$$

$$\begin{aligned}
& + T_\lambda^* \left( T_\lambda \left( 15 \text{Tr} \left( Y_d Y_d^\dagger \right) - 3 \left( 5g_2^2 - 5 \text{Tr} \left( Y_u Y_u^\dagger \right) + g_1^2 \right) + 5 \text{Tr} \left( Y_e Y_e^\dagger \right) \right) \right. \\
& + \lambda \left( 15 \text{Tr} \left( Y_d^\dagger T_d \right) + 3 \left( 5g_2^2 M_2 + 5 \text{Tr} \left( Y_u^\dagger T_u \right) + g_1^2 M_1 \right) + 5 \text{Tr} \left( Y_e^\dagger T_e \right) \right) \\
& + \lambda^* \left( -3g_1^2 m_{H_d}^2 \lambda - 15g_2^2 m_{H_d}^2 \lambda - 3g_1^2 m_{H_u}^2 \lambda - 15g_2^2 m_{H_u}^2 \lambda - 3g_1^2 m_S^2 \lambda - 15g_2^2 m_S^2 \lambda \right. \\
& + 20\lambda |T_\kappa|^2 + 40\lambda |T_\lambda|^2 + 20\kappa T_\kappa^* T_\lambda + 3g_1^2 M_1^* \left( -2M_1 \lambda + T_\lambda \right) + 15g_2^2 M_2^* \left( -2M_2 \lambda + T_\lambda \right) \\
& + 30m_{H_d}^2 \lambda \text{Tr} \left( Y_d Y_d^\dagger \right) + 15m_{H_u}^2 \lambda \text{Tr} \left( Y_d Y_d^\dagger \right) + 15m_S^2 \lambda \text{Tr} \left( Y_d Y_d^\dagger \right) + 10m_{H_d}^2 \lambda \text{Tr} \left( Y_e Y_e^\dagger \right) \\
& + 5m_{H_u}^2 \lambda \text{Tr} \left( Y_e Y_e^\dagger \right) + 5m_S^2 \lambda \text{Tr} \left( Y_e Y_e^\dagger \right) + 15m_{H_d}^2 \lambda \text{Tr} \left( Y_u Y_u^\dagger \right) + 30m_{H_u}^2 \lambda \text{Tr} \left( Y_u Y_u^\dagger \right) \\
& + 15m_S^2 \lambda \text{Tr} \left( Y_u Y_u^\dagger \right) + 15T_\lambda \text{Tr} \left( T_d^* Y_d^T \right) + 15\lambda \text{Tr} \left( T_d^* T_d^T \right) + 5T_\lambda \text{Tr} \left( T_e^* Y_e^T \right) + 5\lambda \text{Tr} \left( T_e^* T_e^T \right) \\
& + 15T_\lambda \text{Tr} \left( T_u^* Y_u^T \right) + 15\lambda \text{Tr} \left( T_u^* T_u^T \right) + 15\lambda \text{Tr} \left( m_d^2 Y_d Y_d^\dagger \right) + 5\lambda \text{Tr} \left( m_e^2 Y_e Y_e^\dagger \right) + 5\lambda \text{Tr} \left( m_l^2 Y_e^\dagger Y_e \right) \\
& \left. + 15\lambda \text{Tr} \left( m_q^2 Y_d^\dagger Y_d \right) + 15\lambda \text{Tr} \left( m_q^2 Y_u^\dagger Y_u \right) + 15\lambda \text{Tr} \left( m_u^2 Y_u Y_u^\dagger \right) \right) \tag{87}
\end{aligned}$$

### 3.11 Vacuum expectation values

$$\beta_{v_d}^{(1)} = \frac{1}{20} v_d \left( 15g_2^2 + 15g_2^2 \text{Xi} - 20|\lambda|^2 - 20 \text{Tr} \left( Y_e Y_e^\dagger \right) + 3g_1^2 + 3g_1^2 \text{Xi} - 60 \text{Tr} \left( Y_d Y_d^\dagger \right) \right) \tag{88}$$

$$\begin{aligned}
\beta_{v_d}^{(2)} = & \frac{1}{400} v_d \left( -414g_1^4 - 180g_1^2 g_2^2 - 1200g_2^4 - 9g_1^4 \text{Xi} - 90g_1^2 g_2^2 \text{Xi} + 875g_2^4 \text{Xi} + 9g_1^4 \text{Xi}^2 + 90g_1^2 g_2^2 \text{Xi}^2 \right. \\
& - 225g_2^4 \text{Xi}^2 + 1200\lambda^2 \lambda^{*,2} - 40 \left( 5 \left( 32g_3^2 + 9g_2^2 \text{Xi} \right) + g_1^2 \left( 9\text{Xi} - 4 \right) \right) \text{Tr} \left( Y_d Y_d^\dagger \right) - 480g_1^2 \text{Tr} \left( Y_e Y_e^\dagger \right) \\
& - 120g_1^2 \text{Xi} \text{Tr} \left( Y_e Y_e^\dagger \right) - 600g_2^2 \text{Xi} \text{Tr} \left( Y_e Y_e^\dagger \right) - 40|\lambda|^2 \left( 15g_2^2 \text{Xi} - 20\kappa\kappa^* - 30 \text{Tr} \left( Y_u Y_u^\dagger \right) + 3g_1^2 \text{Xi} \right) \\
& \left. + 3600 \text{Tr} \left( Y_d Y_d^\dagger Y_d Y_d^\dagger \right) + 1200 \text{Tr} \left( Y_d Y_u^\dagger Y_u Y_d^\dagger \right) + 1200 \text{Tr} \left( Y_e Y_e^\dagger Y_e Y_e^\dagger \right) \right) \tag{89}
\end{aligned}$$

$$\beta_{v_u}^{(1)} = \frac{1}{20} v_u \left( -20|\lambda|^2 + 3 \left( -20 \text{Tr} \left( Y_u Y_u^\dagger \right) + \left( 5g_2^2 + g_1^2 \right) \left( 1 + \text{Xi} \right) \right) \right) \tag{90}$$

$$\begin{aligned}
\beta_{v_u}^{(2)} = & \frac{1}{400} v_u \left( -414g_1^4 - 180g_1^2 g_2^2 - 1200g_2^4 - 9g_1^4 \text{Xi} - 90g_1^2 g_2^2 \text{Xi} + 875g_2^4 \text{Xi} + 9g_1^4 \text{Xi}^2 + 90g_1^2 g_2^2 \text{Xi}^2 \right. \\
& - 225g_2^4 \text{Xi}^2 + 1200\lambda^2 \lambda^{*,2} - 40|\lambda|^2 \left( -10 \text{Tr} \left( Y_e Y_e^\dagger \right) + 15g_2^2 \text{Xi} - 20\kappa\kappa^* - 30 \text{Tr} \left( Y_d Y_d^\dagger \right) + 3g_1^2 \text{Xi} \right) \\
& \left. - 40 \left( 5 \left( 32g_3^2 + 9g_2^2 \text{Xi} \right) + g_1^2 \left( 9\text{Xi} + 8 \right) \right) \text{Tr} \left( Y_u Y_u^\dagger \right) + 1200 \text{Tr} \left( Y_d Y_u^\dagger Y_u Y_d^\dagger \right) + 3600 \text{Tr} \left( Y_u Y_u^\dagger Y_u Y_u^\dagger \right) \right) \tag{91}
\end{aligned}$$

$$\beta_{v_s}^{(1)} = -2v_s \left( |\kappa|^2 + |\lambda|^2 \right) \tag{92}$$

$$\begin{aligned}
\beta_{v_s}^{(2)} = & +8v_s \kappa^2 \kappa^{*,2} + 8v_s \lambda |\kappa|^2 \lambda^* \\
& + \frac{2}{5} v_s |\lambda|^2 \left( 10\lambda\lambda^* - 15g_2^2 + 15 \text{Tr} \left( Y_d Y_d^\dagger \right) + 15 \text{Tr} \left( Y_u Y_u^\dagger \right) - 3g_1^2 + 5 \text{Tr} \left( Y_e Y_e^\dagger \right) \right) \tag{93}
\end{aligned}$$

## 4 Field Rotations

### 4.1 Rotations in gauge sector for eigenstates 'EWSB'

$$\begin{pmatrix} B_\rho \\ W_{3\rho} \end{pmatrix} = Z^{\gamma Z} \begin{pmatrix} \gamma_\rho \\ Z_\rho \end{pmatrix} \quad (94)$$

$$\begin{pmatrix} W_{1\rho} \\ W_{2\rho} \end{pmatrix} = Z^W \begin{pmatrix} W_\rho^- \\ W_\rho^- \end{pmatrix} \quad (95)$$

$$\begin{pmatrix} \lambda_{\tilde{W},1} \\ \lambda_{\tilde{W},2} \\ \lambda_{\tilde{W},3} \end{pmatrix} = Z^{\tilde{W}} \begin{pmatrix} \tilde{W}^- \\ \tilde{W}^+ \\ \tilde{W}^0 \end{pmatrix} \quad (96)$$

$$(97)$$

The mixing matrices are parametrized by

$$Z^{\gamma Z} = \begin{pmatrix} \cos \Theta_W & -\sin \Theta_W \\ \sin \Theta_W & \cos \Theta_W \end{pmatrix} \quad (98)$$

$$Z^W = \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ -i\frac{1}{\sqrt{2}} & i\frac{1}{\sqrt{2}} \end{pmatrix} \quad (99)$$

$$Z^{\tilde{W}} = \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \\ -i\frac{1}{\sqrt{2}} & i\frac{1}{\sqrt{2}} & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad (100)$$

$$(101)$$

### 4.2 Rotations in Mass sector for eigenstates 'EWSB'

#### 4.2.1 Mass Matrices for Scalars

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

$$m_{\tilde{d}}^2 = \begin{pmatrix} m_{\tilde{d}_L \tilde{d}_L^*} & m_{\tilde{d}_R \tilde{d}_L^*}^\dagger \\ m_{\tilde{d}_L \tilde{d}_R^*} & m_{\tilde{d}_R \tilde{d}_R^*} \end{pmatrix} \quad (102)$$

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

$$m_{\tilde{d}_L \tilde{d}_R^*} = -\frac{1}{2} \delta_{\alpha_2 \beta_1} (\sqrt{2} (-v_d T_d + v_u Y_d \mu^*) + v_s v_u Y_d \lambda^*) \quad (104)$$

$$m_{\tilde{d}_R \tilde{d}_R^*} = \frac{1}{12} g_1^2 \mathbf{1} (-v_d^2 + v_u^2) \delta_{\alpha_2 \beta_2} + \frac{1}{2} \delta_{\alpha_2 \beta_2} (2m_d^2 + v_d^2 Y_d Y_d^\dagger) \quad (105)$$

This matrix is diagonalized by  $Z^D$ :

$$Z^D m_d^2 Z^{D,\dagger} = m_{2,d}^{dia} \quad (106)$$

with

$$\tilde{d}_{L,i\alpha} = \sum_j Z_{ji}^{D,*} \tilde{d}_{j\alpha}, \quad \tilde{d}_{R,i\alpha} = \sum_j Z_{ji}^{D,*} \tilde{d}_{j\alpha} \quad (107)$$

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

$$m_{\tilde{\nu}}^2 = \left( \frac{1}{8} (g_1^2 + g_2^2) \mathbf{1} (-v_u^2 + v_d^2) + m_l^2 \right) \quad (108)$$

This matrix is diagonalized by  $Z^V$ :

$$Z^V m_{\tilde{\nu}}^2 Z^{V,\dagger} = m_{2,\tilde{\nu}}^{dia} \quad (109)$$

with

$$\tilde{\nu}_{L,i} = \sum_j Z_{ji}^{V,*} \tilde{\nu}_j \quad (110)$$

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

$$m_{\tilde{u}}^2 = \begin{pmatrix} m_{\tilde{u}_L} \tilde{u}_L^* & m_{\tilde{u}_R}^{\dagger} \tilde{u}_L^* \\ m_{\tilde{u}_L} \tilde{u}_R^* & m_{\tilde{u}_R} \tilde{u}_R^* \end{pmatrix} \quad (111)$$

$$m_{\tilde{u}_L} \tilde{u}_L^* = -\frac{1}{24} (-3g_2^2 + g_1^2) \mathbf{1} (-v_u^2 + v_d^2) \delta_{\alpha_1\beta_1} + \frac{1}{2} \delta_{\alpha_1\beta_1} (2m_q^2 + v_u^2 Y_u^{\dagger} Y_u) \quad (112)$$

$$m_{\tilde{u}_L} \tilde{u}_R^* = -\frac{1}{2} \delta_{\alpha_2\beta_1} (\sqrt{2} (v_d Y_u \mu^* - v_u T_u) + v_d v_s Y_u \lambda^*) \quad (113)$$

$$m_{\tilde{u}_R} \tilde{u}_R^* = \frac{1}{2} \delta_{\alpha_2\beta_2} (2m_u^2 + v_u^2 Y_u Y_u^{\dagger}) + \frac{1}{6} g_1^2 \mathbf{1} (-v_u^2 + v_d^2) \delta_{\alpha_2\beta_2} \quad (114)$$

This matrix is diagonalized by  $Z^U$ :

$$Z^U m_{\tilde{u}}^2 Z^{U,\dagger} = m_{2,\tilde{u}}^{dia} \quad (115)$$

with

$$\tilde{u}_{L,i\alpha} = \sum_j Z_{ji}^{U,*} \tilde{u}_{j\alpha}, \quad \tilde{u}_{R,i\alpha} = \sum_j Z_{ji}^{U,*} \tilde{u}_{j\alpha} \quad (116)$$

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

$$m_{\tilde{e}}^2 = \begin{pmatrix} m_{\tilde{e}_L} \tilde{e}_L^* & \frac{1}{2} (\sqrt{2} v_d T_e^{\dagger} - v_u (\sqrt{2} \mu + v_s \lambda) Y_e^{\dagger}) \\ \frac{1}{2} (\sqrt{2} v_d T_e - v_u Y_e (\sqrt{2} \mu^* + v_s \lambda^*)) & m_{\tilde{e}_R} \tilde{e}_R^* \end{pmatrix} \quad (117)$$

$$m_{\tilde{e}_L} \tilde{e}_L^* = \frac{1}{2} v_d^2 Y_e^{\dagger} Y_e + \frac{1}{8} (-g_2^2 + g_1^2) \mathbf{1} (-v_u^2 + v_d^2) + m_l^2 \quad (118)$$

$$m_{\tilde{e}_R \tilde{e}_R^*} = \frac{1}{2} v_d^2 Y_e Y_e^\dagger + \frac{1}{4} g_1^2 \mathbf{1} \left( -v_d^2 + v_u^2 \right) + m_e^2 \quad (119)$$

This matrix is diagonalized by  $Z^E$ :

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

with

$$\tilde{e}_{L,i} = \sum_j Z_{ji}^{E,*} \tilde{e}_j, \quad \tilde{e}_{R,i} = \sum_j Z_{ji}^{E,*} \tilde{e}_j \quad (121)$$

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

$$m_h^2 = \begin{pmatrix} m_{\phi_d \phi_d} & m_{\phi_u \phi_d} & m_{\phi_s \phi_d} \\ m_{\phi_d \phi_u} & m_{\phi_u \phi_u} & m_{\phi_s \phi_u} \\ m_{\phi_d \phi_s} & m_{\phi_u \phi_s} & m_{\phi_s \phi_s} \end{pmatrix} \quad (122)$$

$$m_{\phi_d \phi_d} = \frac{1}{2} \left( (2\mu + \sqrt{2}v_s \lambda) \mu^* + (\sqrt{2}v_s \mu + (v_s^2 + v_u^2) \lambda) \lambda^* \right) + \frac{1}{8} (g_1^2 + g_2^2) (3v_d^2 - v_u^2) + m_{H_d}^2 \quad (123)$$

$$m_{\phi_d \phi_u} = \frac{1}{4} \left( -2 \left( (-2v_d v_u \lambda + L_1) \lambda^* + \lambda L_1^* \right) - 2v_s^2 \Re(\lambda \kappa^*) - 4\Re(B_\mu) - \sqrt{2}v_s (2\Re(\lambda M_S^*) + 2\Re(T_\lambda)) \right) - \frac{1}{4} (g_1^2 + g_2^2) v_d v_u \quad (124)$$

$$m_{\phi_u \phi_u} = \frac{1}{2} \left( (2\mu + \sqrt{2}v_s \lambda) \mu^* + (\sqrt{2}v_s \mu + (v_d^2 + v_s^2) \lambda) \lambda^* \right) - \frac{1}{8} (g_1^2 + g_2^2) (-3v_u^2 + v_d^2) + m_{H_u}^2 \quad (125)$$

$$m_{\phi_d \phi_s} = -\frac{1}{4} v_u \left( 4v_s \Re(\lambda \kappa^*) + \sqrt{2} (2\Re(\lambda M_S^*) + 2\Re(T_\lambda)) \right) + v_d \left( \frac{1}{\sqrt{2}} \lambda \mu^* + \left( \frac{1}{\sqrt{2}} \mu + v_s \lambda \right) \lambda^* \right) \quad (126)$$

$$m_{\phi_u \phi_s} = -\frac{1}{4} v_d \left( 4v_s \Re(\lambda \kappa^*) + \sqrt{2} (2\Re(\lambda M_S^*) + 2\Re(T_\lambda)) \right) + v_u \left( \frac{1}{\sqrt{2}} \lambda \mu^* + \left( \frac{1}{\sqrt{2}} \mu + v_s \lambda \right) \lambda^* \right) \quad (127)$$

$$m_{\phi_s \phi_s} = +m_S^2 + \frac{1}{2} \left( v_d^2 |\lambda|^2 + v_u^2 |\lambda|^2 + \kappa (2L_1^* + 6v_s^2 \kappa^*) + 2(L_1 \kappa^* + |M_S|^2 + \Re(B_S)) - 2v_d v_u \Re(\lambda \kappa^*) + \sqrt{2}v_s (2\Re(T_\kappa) + 6\Re(\kappa M_S^*)) \right) \quad (128)$$

This matrix is diagonalized by  $Z^H$ :

$$Z^H m_h^2 Z^{H,\dagger} = m_{2,h}^{dia} \quad (129)$$

with

$$\phi_d = \sum_j Z_{j1}^{H,*} h_j, \quad \phi_u = \sum_j Z_{j2}^{H,*} h_j, \quad \phi_s = \sum_j Z_{j3}^{H,*} h_j \quad (130)$$

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

$$m_{A^0}^2 = \begin{pmatrix} m_{\sigma_d \sigma_d} & m_{\sigma_u \sigma_d} & m_{\sigma_s \sigma_d} \\ m_{\sigma_d \sigma_u} & m_{\sigma_u \sigma_u} & m_{\sigma_s \sigma_u} \\ m_{\sigma_d \sigma_s} & m_{\sigma_u \sigma_s} & m_{\sigma_s \sigma_s} \end{pmatrix} + \xi_Z m^2(Z) \quad (131)$$



$$m_{\sigma_d \sigma_d} = \frac{1}{2} \left( (2\mu + \sqrt{2}v_s \lambda) \mu^* + (\sqrt{2}v_s \mu + (v_s^2 + v_u^2) \lambda) \lambda^* \right) + \frac{1}{8} (g_1^2 + g_2^2) (-v_u^2 + v_d^2) + m_{H_d}^2 \quad (132)$$

$$m_{\sigma_d \sigma_u} = \frac{1}{4} \left( 2v_s^2 \Re(\lambda \kappa^*) + 4\Re(B_\mu) + 4\Re(\lambda L_1^*) + \sqrt{2}v_s (2\Re(\lambda M_S^*) + 2\Re(T_\lambda)) \right) \quad (133)$$

$$m_{\sigma_u \sigma_u} = \frac{1}{2} \left( (2\mu + \sqrt{2}v_s \lambda) \mu^* + (\sqrt{2}v_s \mu + (v_d^2 + v_s^2) \lambda) \lambda^* \right) - \frac{1}{8} (g_1^2 + g_2^2) (-v_u^2 + v_d^2) + m_{H_u}^2 \quad (134)$$

$$m_{\sigma_d \sigma_s} = -\frac{1}{4} v_u \left( 4v_s \Re(\lambda \kappa^*) + \sqrt{2} (2\Re(\lambda M_S^*) - 2\Re(T_\lambda)) \right) \quad (135)$$

$$m_{\sigma_u \sigma_s} = -\frac{1}{4} v_d \left( 4v_s \Re(\lambda \kappa^*) + \sqrt{2} (2\Re(\lambda M_S^*) - 2\Re(T_\lambda)) \right) \quad (136)$$

$$\begin{aligned} m_{\sigma_s \sigma_s} &= +m_S^2 \\ &+ \frac{1}{2} \left( 2|M_S|^2 + (v_d^2 + v_u^2) |\lambda|^2 + \kappa \left( -2L_1^* + 2v_s^2 \kappa^* \right) - 2(L_1 \kappa^* + \Re(B_S)) + 2v_d v_u \Re(\lambda \kappa^*) \right. \\ &\left. + \sqrt{2}v_s (2\Re(\kappa M_S^*) - 2\Re(T_\kappa)) \right) \end{aligned} \quad (137)$$

Gauge fixing contributions:

$$m^2(\xi_Z) = \begin{pmatrix} m_{\sigma_d \sigma_d} & m_{\sigma_u \sigma_d} & 0 \\ m_{\sigma_d \sigma_u} & m_{\sigma_u \sigma_u} & 0 \\ 0 & 0 & 0 \end{pmatrix} \quad (138)$$

$$m_{\sigma_d \sigma_d} = \frac{1}{4} v_d^2 (g_1 \sin \Theta_W + g_2 \cos \Theta_W)^2 \quad (139)$$

$$m_{\sigma_d \sigma_u} = -\frac{1}{4} v_d v_u (g_1 \sin \Theta_W + g_2 \cos \Theta_W)^2 \quad (140)$$

$$m_{\sigma_u \sigma_u} = \frac{1}{4} v_u^2 (g_1 \sin \Theta_W + g_2 \cos \Theta_W)^2 \quad (141)$$

This matrix is diagonalized by  $Z^A$ :

$$Z^A m_{A_0}^2 Z^{A,\dagger} = m_{2,A_0}^{dia} \quad (142)$$

with

$$\sigma_d = \sum_j Z_{j1}^{A,*} A_j^0, \quad \sigma_u = \sum_j Z_{j2}^{A,*} A_j^0, \quad \sigma_s = \sum_j Z_{j3}^{A,*} A_j^0 \quad (143)$$

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

$$m_{H^-}^2 = \begin{pmatrix} m_{H_d^- H_d^{-,*}} & m_{H_u^{+,*} H_d^{-,*}} \\ m_{H_d^- H_u^+} & m_{H_u^{+,*} H_u^+} \end{pmatrix} + \xi_{W^-} m^2(W^-) \quad (144)$$

$$m_{H_d^- H_d^{-,*}} = \frac{1}{2} \left( (2\mu + \sqrt{2}v_s \lambda) \mu^* + v_s (\sqrt{2}\mu + v_s \lambda) \lambda^* \right) + \frac{1}{8} (g_1^2 (-v_u^2 + v_d^2) + g_2^2 (v_d^2 + v_u^2)) + m_{H_d}^2 \quad (145)$$

$$m_{H_d^- H_u^+} = \frac{1}{2} \left( 2(\lambda L_1^* + B_\mu) + \lambda (-v_d v_u \lambda^* + v_s^2 \kappa^*) + \sqrt{2}v_s (\lambda M_S^* + T_\lambda) \right) + \frac{1}{4} g_2^2 v_d v_u \quad (146)$$

$$m_{H_u^{+,*} H_u^+} = \frac{1}{2} \left( (2\mu + \sqrt{2}v_s\lambda)\mu^* + v_s(\sqrt{2}\mu + v_s\lambda)\lambda^* \right) + \frac{1}{8} \left( g_1^2(-v_d^2 + v_u^2) + g_2^2(v_d^2 + v_u^2) \right) + m_{H_u}^2 \quad (147)$$

Gauge fixing contributions:

$$m^2(\xi_{W^-}) = \begin{pmatrix} \frac{1}{4}g_2^2v_d^2 & -\frac{1}{4}g_2^2v_dv_u \\ -\frac{1}{4}g_2^2v_dv_u & \frac{1}{4}g_2^2v_u^2 \end{pmatrix} \quad (148)$$

This matrix is diagonalized by  $Z^+$ :

$$Z^+ m_{H^-}^2 Z^{+\dagger} = m_{2,H^-}^{dia} \quad (149)$$

with

$$H_d^- = \sum_j Z_{j1}^+ H_j^-, \quad H_u^+ = \sum_j Z_{j2}^+ H_j^+ \quad (150)$$

#### 4.2.2 Mass Matrices for Fermions

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

$$m_{\tilde{\chi}^0} = \begin{pmatrix} M_1 & 0 & -\frac{1}{2}g_1v_d & \frac{1}{2}g_1v_u & 0 \\ 0 & M_2 & \frac{1}{2}g_2v_d & -\frac{1}{2}g_2v_u & 0 \\ -\frac{1}{2}g_1v_d & \frac{1}{2}g_2v_d & 0 & -\frac{1}{\sqrt{2}}v_s\lambda - \mu & -\frac{1}{\sqrt{2}}v_u\lambda \\ \frac{1}{2}g_1v_u & -\frac{1}{2}g_2v_u & -\frac{1}{\sqrt{2}}v_s\lambda - \mu & 0 & -\frac{1}{\sqrt{2}}v_d\lambda \\ 0 & 0 & -\frac{1}{\sqrt{2}}v_u\lambda & -\frac{1}{\sqrt{2}}v_d\lambda & \sqrt{2}v_s\kappa + M_S \end{pmatrix} \quad (151)$$

This matrix is diagonalized by  $N$ :

$$N^* m_{\tilde{\chi}^0} N^\dagger = m_{\tilde{\chi}^0}^{dia} \quad (152)$$

with

$$\lambda_{\tilde{B}} = \sum_j N_{j1}^* \lambda_j^0, \quad \tilde{W}^0 = \sum_j N_{j2}^* \lambda_j^0, \quad \tilde{H}_d^0 = \sum_j N_{j3}^* \lambda_j^0 \quad (153)$$

$$\tilde{H}_u^0 = \sum_j N_{j4}^* \lambda_j^0, \quad \tilde{S} = \sum_j N_{j5}^* \lambda_j^0 \quad (154)$$

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

$$m_{\tilde{\chi}^-} = \begin{pmatrix} M_2 & \frac{1}{\sqrt{2}}g_2v_u \\ \frac{1}{\sqrt{2}}g_2v_d & \frac{1}{\sqrt{2}}v_s\lambda + \mu \end{pmatrix} \quad (155)$$

This matrix is diagonalized by  $U$  and  $V$

$$U^* m_{\tilde{\chi}^-} V^\dagger = m_{\tilde{\chi}^-}^{dia} \quad (156)$$

with

$$\tilde{W}^- = \sum_{t_2} U_{j1}^* \lambda_j^-, \quad \tilde{H}_d^- = \sum_{t_2} U_{j2}^* \lambda_j^- \quad (157)$$

$$\tilde{W}^+ = \sum_{t_2} V_{1j}^* \lambda_j^+, \quad \tilde{H}_u^+ = \sum_{t_2} V_{2j}^* \lambda_j^+ \quad (158)$$

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

$$m_e = \left( \frac{1}{\sqrt{2}} v_d Y_e^T \right) \quad (159)$$

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

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

with

$$e_{L,i} = \sum_{t_2} U_{L,ji}^{e,*} E_{L,j} \quad (161)$$

$$e_{R,i} = \sum_{t_2} U_{R,ij}^e E_{R,j}^* \quad (162)$$

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

$$m_d = \left( \frac{1}{\sqrt{2}} v_d \delta_{\alpha_1 \beta_1} Y_d^T \right) \quad (163)$$

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

$$U_L^{d,*} m_d U_R^{d,\dagger} = m_d^{dia} \quad (164)$$

with

$$d_{L,i\alpha} = \sum_{t_2} U_{L,ji}^{d,*} D_{L,j\alpha} \quad (165)$$

$$d_{R,i\alpha} = \sum_{t_2} U_{R,ij}^d D_{R,j\alpha}^* \quad (166)$$

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

$$m_u = \left( \frac{1}{\sqrt{2}} v_u \delta_{\alpha_1 \beta_1} Y_u^T \right) \quad (167)$$

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

$$U_L^{u,*} m_u U_R^{u,\dagger} = m_u^{dia} \quad (168)$$

with

$$u_{L,i\alpha} = \sum_{t_2} U_{L,ji}^{u,*} U_{L,j\alpha} \quad (169)$$

$$u_{R,i\alpha} = \sum_{t_2} U_{R,ij}^u U_{R,j\alpha}^* \quad (170)$$

## 5 Vacuum Expectation Values

$$H_d^0 = \frac{1}{\sqrt{2}}\phi_d + \frac{1}{\sqrt{2}}v_d + i\frac{1}{\sqrt{2}}\sigma_d \quad (171)$$

$$H_u^0 = \frac{1}{\sqrt{2}}\phi_u + \frac{1}{\sqrt{2}}v_u + i\frac{1}{\sqrt{2}}\sigma_u \quad (172)$$

$$S = \frac{1}{\sqrt{2}}\phi_s + \frac{1}{\sqrt{2}}v_s + i\frac{1}{\sqrt{2}}\sigma_s \quad (173)$$

## 6 Tadpole Equations

$$\begin{aligned} \frac{\partial V}{\partial \phi_d} = & +\frac{1}{8}(g_1^2 + g_2^2)v_d(-v_u + v_d)(v_d + v_u) \\ & +\frac{1}{4}\left(2v_d\left(2(m_{H_d}^2 + |\mu|^2) + \sqrt{2}v_s\lambda\mu^* + \left(\sqrt{2}v_s\mu + (v_s^2 + v_u^2)\lambda\right)\lambda^*\right)\right. \\ & \left.+ v_u\left(-2(L_1\lambda^* + \lambda L_1^*) - 4\Re(B_\mu) - \sqrt{2}v_s(\lambda M_S^* + M_S\lambda^* + T_\lambda^* + T_\lambda) - v_s^2(\kappa\lambda^* + \lambda\kappa^*)\right)\right) \end{aligned} \quad (174)$$

$$\begin{aligned} \frac{\partial V}{\partial \phi_u} = & +\frac{1}{8}(g_1^2 + g_2^2)v_u(-v_d^2 + v_u^2) \\ & +\frac{1}{4}\left(2v_u\left(2(m_{H_u}^2 + |\mu|^2) + \sqrt{2}v_s\lambda\mu^* + \left(\sqrt{2}v_s\mu + (v_d^2 + v_s^2)\lambda\right)\lambda^*\right)\right. \\ & \left.+ v_d\left(-2(L_1\lambda^* + \lambda L_1^*) - 4\Re(B_\mu) - \sqrt{2}v_s(\lambda M_S^* + M_S\lambda^* + T_\lambda^* + T_\lambda) - v_s^2(\kappa\lambda^* + \lambda\kappa^*)\right)\right) \end{aligned} \quad (175)$$

$$\begin{aligned} \frac{\partial V}{\partial \phi_s} = & \frac{1}{4}\left(4v_s^3|\kappa|^2 + 2v_s\left(2(\kappa L_1^* + m_S^2 + |M_S|^2 + \Re(B_S))\right) + (2L_1 - v_d v_u \lambda)\kappa^* + \left((v_d^2 + v_u^2)\lambda - v_d v_u \kappa\right)\lambda^*\right) \\ & +\sqrt{2}\left(\left(2L_1 - v_d v_u \lambda\right)M_S^* + \left(-M_S v_d v_u + (v_d^2 + v_u^2)\mu\right)\lambda^* + \lambda\left(v_d^2\mu^* + v_u^2\mu^*\right) + 2\left(M_S L_1^* + \xi_1^* + \xi_1\right)\right. \\ & \left.- 2v_d v_u \Re(T_\lambda) + v_s^2\left(3\kappa M_S^* + 3M_S \kappa^* + T_\kappa^* + T_\kappa\right)\right) \end{aligned} \quad (176)$$

## 7 Particle content for eigenstates 'EWSB'

Name	Type	complex/real	Generations	Indices
$\tilde{d}$	Scalar	complex	6	generation, 6, color, 3
$\tilde{\nu}$	Scalar	complex	3	generation, 3
$\tilde{u}$	Scalar	complex	6	generation, 6, color, 3
$\tilde{e}$	Scalar	complex	6	generation, 6
$h$	Scalar	real	3	generation, 3
$A^0$	Scalar	real	3	generation, 3
$H^-$	Scalar	complex	2	generation, 2

$\tilde{g}$	Fermion	Majorana	1	color, 8
$\nu$	Fermion	Dirac	3	generation, 3
$\tilde{\chi}^0$	Fermion	Majorana	5	generation, 5
$\tilde{\chi}^-$	Fermion	Dirac	2	generation, 2
$e$	Fermion	Dirac	3	generation, 3
$d$	Fermion	Dirac	3	generation, 3, color, 3
$u$	Fermion	Dirac	3	generation, 3, color, 3
$g$	Vector	real	1	color, 8, lorentz, 4
$\gamma$	Vector	real	1	lorentz, 4
$Z$	Vector	real	1	lorentz, 4
$W^-$	Vector	complex	1	lorentz, 4
$\eta^G$	Ghost	real	1	color, 8
$\eta^\gamma$	Ghost	real	1	
$\eta^Z$	Ghost	real	1	
$\eta^-$	Ghost	complex	1	
$\eta^+$	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 ( $\tilde{d}$ )

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

$$\begin{aligned}
& - 2 \sum_{a=1}^3 m_{d_a} \sum_{b=1}^5 B_0(p^2, m_{d_a}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_b^0} \left( \Gamma_{\tilde{d}_j^*, d_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{d}_i^*, d_a, \tilde{\chi}_b^0}^R + \Gamma_{\tilde{d}_j^*, d_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{d}_i^*, d_a, \tilde{\chi}_b^0}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^5 G_0(p^2, m_{d_a}^2, m_{\tilde{\chi}_b^0}^2) \left( \Gamma_{\tilde{d}_j^*, d_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{d}_i^*, d_a, \tilde{\chi}_b^0}^L + \Gamma_{\tilde{d}_j^*, d_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{d}_i^*, d_a, \tilde{\chi}_b^0}^R \right) \\
& - C \sum_{a=1}^6 A_0(m_{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{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^-} \\
& + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{d_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j^*, \tilde{d}_a, A_b^0}^* \Gamma_{\tilde{d}_i^*, \tilde{d}_a, A_b^0} + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{d_a}^2, m_{h_b}^2) \Gamma_{\tilde{d}_j^*, \tilde{d}_a, h_b}^* \Gamma_{\tilde{d}_i^*, \tilde{d}_a, h_b} \\
& - \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) \\
& + \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 (177)
\end{aligned}$$

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

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

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

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

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

$$\begin{aligned}
& -C \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, \tilde{u}_a^*, \tilde{u}_a} + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{\tilde{u}_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{u}_j^*, \tilde{u}_a, A_b^0}^* \Gamma_{\tilde{u}_i^*, \tilde{u}_a, A_b^0} \\
& + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{\tilde{u}_a}^2, m_{h_b}^2) \Gamma_{\tilde{u}_j^*, \tilde{u}_a, h_b}^* \Gamma_{\tilde{u}_i^*, \tilde{u}_a, h_b} \\
& - \frac{8}{3} m_{\tilde{g}} \sum_{b=1}^3 B_0(p^2, m_{\tilde{g}}^2, m_{u_b}^2) m_{u_b} \left( \Gamma_{\tilde{u}_j^*, \tilde{g}_1, u_b}^{L*} \Gamma_{\tilde{u}_i^*, \tilde{g}_1, u_b}^R + \Gamma_{\tilde{u}_j^*, \tilde{g}_1, u_b}^{R*} \Gamma_{\tilde{u}_i^*, \tilde{g}_1, u_b}^L \right) \\
& + \frac{4}{3} \sum_{b=1}^3 G_0(p^2, m_{\tilde{g}}^2, m_{u_b}^2) \left( \Gamma_{\tilde{u}_j^*, \tilde{g}_1, u_b}^{L*} \Gamma_{\tilde{u}_i^*, \tilde{g}_1, u_b}^L + \Gamma_{\tilde{u}_j^*, \tilde{g}_1, u_b}^{R*} \Gamma_{\tilde{u}_i^*, \tilde{g}_1, u_b}^R \right) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, W^+, \tilde{d}_b}^* \Gamma_{\tilde{u}_i^*, W^+, \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, m_{W^-}^2) + \frac{4}{3} \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, g, \tilde{u}_b}^* \Gamma_{\tilde{u}_i^*, g, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, 0) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, \gamma, \tilde{u}_b}^* \Gamma_{\tilde{u}_i^*, \gamma, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, 0) + \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, Z, \tilde{u}_b}^* \Gamma_{\tilde{u}_i^*, Z, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, m_Z^2) \tag{179}
\end{aligned}$$

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

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



$$\begin{aligned}
& -3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, \tilde{u}_a^*, \tilde{u}_a} + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{\tilde{e}_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{e}_j^*, \tilde{e}_a, A_b^0} \Gamma_{\tilde{e}_i^*, \tilde{e}_a, A_b^0} \\
& + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{\tilde{e}_a}^2, m_{h_b}^2) \Gamma_{\tilde{e}_j^*, \tilde{e}_a, h_b} \Gamma_{\tilde{e}_i^*, \tilde{e}_a, h_b} + \sum_{b=1}^3 \Gamma_{\tilde{e}_j^*, W^-, \tilde{\nu}_b} \Gamma_{\tilde{e}_i^*, W^-, \tilde{\nu}_b} F_0(p^2, m_{\tilde{\nu}_b}^2, m_{W^-}^2) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{e}_j^*, \gamma, \tilde{e}_b} \Gamma_{\tilde{e}_i^*, \gamma, \tilde{e}_b} F_0(p^2, m_{\tilde{e}_b}^2, 0) + \sum_{b=1}^6 \Gamma_{\tilde{e}_j^*, Z, \tilde{e}_b} \Gamma_{\tilde{e}_i^*, Z, \tilde{e}_b} F_0(p^2, m_{\tilde{e}_b}^2, m_Z^2)
\end{aligned} \tag{180}$$

• **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) - \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_{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) \\
& - \frac{1}{2} \sum_{a=1}^3 A_0(m_{A_a^0}^2) \Gamma_{\tilde{h}_i, \tilde{h}_j, A_a^0, A_a^0} - \sum_{a=1}^3 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{h}_i, \tilde{h}_j, \tilde{\nu}_a^*, \tilde{\nu}_a} \\
& - \frac{1}{2} \sum_{a=1}^3 A_0(m_{h_a}^2) \Gamma_{\tilde{h}_i, \tilde{h}_j, h_a, h_a} + \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{A_a^0}^2, m_{A_b^0}^2) \Gamma_{\tilde{h}_j, A_a^0, A_b^0} \Gamma_{\tilde{h}_i, A_a^0, A_b^0} \\
& + \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{\tilde{\nu}_a}^2, m_{\tilde{\nu}_b}^2) \Gamma_{\tilde{h}_j, \tilde{\nu}_a^*, \tilde{\nu}_b} \Gamma_{\tilde{h}_i, \tilde{\nu}_a^*, \tilde{\nu}_b} + \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{h_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{h}_j, h_a, A_b^0} \Gamma_{\tilde{h}_i, h_a, A_b^0} \\
& + \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{h_a}^2, m_{h_b}^2) \Gamma_{\tilde{h}_j, h_a, h_b} \Gamma_{\tilde{h}_i, h_a, h_b} \\
& - 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, \tilde{d}_a, d_b}^{L*} \Gamma_{\tilde{h}_i, \tilde{d}_a, d_b}^R + \Gamma_{\tilde{h}_j, \tilde{d}_a, d_b}^{R*} \Gamma_{\tilde{h}_i, \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{h}_j, \tilde{d}_a, d_b}^{L*} \Gamma_{\tilde{h}_i, \tilde{d}_a, d_b}^L + \Gamma_{\tilde{h}_j, \tilde{d}_a, d_b}^{R*} \Gamma_{\tilde{h}_i, \tilde{d}_a, d_b}^R \right)
\end{aligned}$$

$$\begin{aligned}
& -2 \sum_{a=1}^3 m_{e_a} \sum_{b=1}^3 B_0(p^2, m_{e_a}^2, m_{e_b}^2) m_{e_b} \left( \Gamma_{\check{h}_j, \bar{e}_a, e_b}^{L*} \Gamma_{\check{h}_i, \bar{e}_a, e_b}^R + \Gamma_{\check{h}_j, \bar{e}_a, e_b}^{R*} \Gamma_{\check{h}_i, \bar{e}_a, e_b}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{e_a}^2, m_{e_b}^2) \left( \Gamma_{\check{h}_j, \bar{e}_a, e_b}^{L*} \Gamma_{\check{h}_i, \bar{e}_a, e_b}^L + \Gamma_{\check{h}_j, \bar{e}_a, e_b}^{R*} \Gamma_{\check{h}_i, \bar{e}_a, e_b}^R \right) \\
& -6 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^3 B_0(p^2, m_{u_a}^2, m_{u_b}^2) m_{u_b} \left( \Gamma_{\check{h}_j, \bar{u}_a, u_b}^{L*} \Gamma_{\check{h}_i, \bar{u}_a, u_b}^R + \Gamma_{\check{h}_j, \bar{u}_a, u_b}^{R*} \Gamma_{\check{h}_i, \bar{u}_a, u_b}^L \right) \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{u_a}^2, m_{u_b}^2) \left( \Gamma_{\check{h}_j, \bar{u}_a, u_b}^{L*} \Gamma_{\check{h}_i, \bar{u}_a, u_b}^L + \Gamma_{\check{h}_j, \bar{u}_a, u_b}^{R*} \Gamma_{\check{h}_i, \bar{u}_a, u_b}^R \right) \\
& - \sum_{a=1}^5 m_{\tilde{\chi}_a^0} \sum_{b=1}^5 B_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_b^0} \left( \Gamma_{\check{h}_j, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{L*} \Gamma_{\check{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R + \Gamma_{\check{h}_j, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{R*} \Gamma_{\check{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^L \right) \\
& + \frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^5 G_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2) \left( \Gamma_{\check{h}_j, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{L*} \Gamma_{\check{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^L + \Gamma_{\check{h}_j, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{R*} \Gamma_{\check{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R \right) \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\check{h}_i, \check{h}_j, \tilde{d}_a^*, \tilde{d}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\check{h}_i, \check{h}_j, \tilde{e}_a^*, \tilde{e}_a} \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\check{h}_i, \check{h}_j, \tilde{u}_a^*, \tilde{u}_a} + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{d}_a}^2, m_{\tilde{d}_b}^2) \Gamma_{\check{h}_j, \tilde{d}_a^*, \tilde{d}_b}^* \Gamma_{\check{h}_i, \tilde{d}_a^*, \tilde{d}_b} \\
& + \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{e}_a}^2, m_{\tilde{e}_b}^2) \Gamma_{\check{h}_j, \tilde{e}_a^*, \tilde{e}_b}^* \Gamma_{\check{h}_i, \tilde{e}_a^*, \tilde{e}_b} + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{u}_a}^2, m_{\tilde{u}_b}^2) \Gamma_{\check{h}_j, \tilde{u}_a^*, \tilde{u}_b}^* \Gamma_{\check{h}_i, \tilde{u}_a^*, \tilde{u}_b} \\
& + 2 \sum_{b=1}^2 \Gamma_{\check{h}_j, W^+, H_b^-}^* \Gamma_{\check{h}_i, W^+, H_b^-} F_0(p^2, m_{H_b^-}^2, m_{W^-}^2) + \sum_{b=1}^3 \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) \tag{181}
\end{aligned}$$

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

$$\begin{aligned}
\Pi_{i,j}(p^2) &= -B_0(p^2, m_{\eta^-}^2, m_{\eta^-}^2) \Gamma_{\check{A}_i^0, \eta^-, \eta^-} \Gamma_{\check{A}_j^0, \eta^-, \eta^-} - B_0(p^2, m_{\eta^+}^2, m_{\eta^+}^2) \Gamma_{\check{A}_i^0, \eta^+, \eta^+} \Gamma_{\check{A}_j^0, \eta^+, \eta^+} \\
& + 4\Gamma_{\check{A}_i^0, \check{A}_j^0, W^+, W^-} \left( -\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2\Gamma_{\check{A}_i^0, \check{A}_j^0, Z, Z} \left( -\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) \\
& - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\check{A}_i^0, \check{A}_j^0, H_a^+, H_a^-} + \sum_{a=1}^2 \sum_{b=1}^2 B_0(p^2, m_{H_a^-}^2, m_{H_b^-}^2) \Gamma_{\check{A}_i^0, H_a^+, H_b^-}^* \Gamma_{\check{A}_j^0, H_a^+, H_b^-} \\
& - 2 \sum_{a=1}^2 m_{\tilde{\chi}_a^-} \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} \left( \Gamma_{\check{A}_j^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{L*} \Gamma_{\check{A}_i^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^R + \Gamma_{\check{A}_j^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{R*} \Gamma_{\check{A}_i^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^L \right) \\
& + \sum_{a=1}^2 \sum_{b=1}^2 G_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{\chi}_b^-}^2) \left( \Gamma_{\check{A}_j^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{L*} \Gamma_{\check{A}_i^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^L + \Gamma_{\check{A}_j^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{R*} \Gamma_{\check{A}_i^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^R \right)
\end{aligned}$$

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^3 A_0(m_{A_a^0}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, A_a^0, A_a^0} - \sum_{a=1}^3 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, \tilde{\nu}_a^*, \tilde{\nu}_a} \\
& -\frac{1}{2} \sum_{a=1}^3 A_0(m_{h_a}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, h_a, h_a} + \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{A_a^0}^2, m_{A_b^0}^2) \Gamma_{\tilde{A}_j^0, A_a^0, A_b^0}^* \Gamma_{\tilde{A}_i^0, A_a^0, A_b^0} \\
& + \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{h_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{A}_j^0, h_a, A_b^0}^* \Gamma_{\tilde{A}_i^0, h_a, A_b^0} \\
& + \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{h_a}^2, m_{h_b}^2) \Gamma_{\tilde{A}_j^0, h_a, h_b}^* \Gamma_{\tilde{A}_i^0, h_a, h_b} \\
& - 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}^5 m_{\tilde{\chi}_a^0} \sum_{b=1}^5 B_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_b^0} \left( \Gamma_{\tilde{A}_j^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R + \Gamma_{\tilde{A}_j^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^L \right) \\
& + \frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^5 G_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2) \left( \Gamma_{\tilde{A}_j^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^L + \Gamma_{\tilde{A}_j^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R \right) \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, \tilde{d}_a^*, \tilde{d}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, \tilde{e}_a^*, \tilde{e}_a} \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, \tilde{u}_a^*, \tilde{u}_a} + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{d_a}^2, m_{d_b}^2) \Gamma_{\tilde{A}_j^0, \tilde{d}_a^*, \tilde{d}_b}^* \Gamma_{\tilde{A}_i^0, \tilde{d}_a^*, \tilde{d}_b} \\
& + \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{e_a}^2, m_{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}
\end{aligned}$$

$$\begin{aligned}
& + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{u}_a}^2, m_{\tilde{u}_b}^2) \Gamma_{\tilde{A}_j^0, \tilde{u}_a^*, \tilde{u}_b}^* \Gamma_{\tilde{A}_i^0, \tilde{u}_a^*, \tilde{u}_b} \\
& + 2 \sum_{b=1}^2 \Gamma_{\tilde{A}_j^0, W^+, H_b^-}^* \Gamma_{\tilde{A}_i^0, W^+, H_b^-} F_0(p^2, m_{H_b^-}^2, m_{W^-}^2) + \sum_{b=1}^3 \Gamma_{\tilde{A}_j^0, Z, h_b}^* \Gamma_{\tilde{A}_i^0, Z, h_b} F_0(p^2, m_{h_b}^2, m_Z^2) \quad (182)
\end{aligned}$$

• 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^+}^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^-} \\
& + 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) \\
& - \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}^3 B_0(p^2, m_{H_a^-}^2, m_{A_b^0}^2) \Gamma_{\tilde{H}_j^+, H_a^-, A_b^0}^* \Gamma_{\tilde{H}_i^+, H_a^-, A_b^0} \\
& + \sum_{a=1}^2 \sum_{b=1}^3 B_0(p^2, m_{H_a^-}^2, m_{h_b}^2) \Gamma_{\tilde{H}_j^+, H_a^-, h_b}^* \Gamma_{\tilde{H}_i^+, H_a^-, h_b} - \frac{1}{2} \sum_{a=1}^3 A_0(m_{A_a^0}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, A_a^0, A_a^0} \\
& - \sum_{a=1}^3 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \tilde{\nu}_a^*, \tilde{\nu}_a} - \frac{1}{2} \sum_{a=1}^3 A_0(m_{h_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, h_a, h_a} \\
& - 6 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^3 B_0(p^2, m_{u_a}^2, m_{d_b}^2) m_{d_b} \left( \Gamma_{\tilde{H}_j^+, \tilde{u}_a, d_b}^{L*} \Gamma_{\tilde{H}_i^+, \tilde{u}_a, d_b}^R + \Gamma_{\tilde{H}_j^+, \tilde{u}_a, d_b}^{R*} \Gamma_{\tilde{H}_i^+, \tilde{u}_a, d_b}^L \right) \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{u_a}^2, m_{d_b}^2) \left( \Gamma_{\tilde{H}_j^+, \tilde{u}_a, d_b}^{L*} \Gamma_{\tilde{H}_i^+, \tilde{u}_a, d_b}^L + \Gamma_{\tilde{H}_j^+, \tilde{u}_a, d_b}^{R*} \Gamma_{\tilde{H}_i^+, \tilde{u}_a, d_b}^R \right) \\
& - 2 \sum_{a=1}^3 m_{\nu_a} \sum_{b=1}^3 B_0(p^2, m_{\nu_a}^2, m_{e_b}^2) m_{e_b} \left( \Gamma_{\tilde{H}_j^+, \tilde{\nu}_a, e_b}^{L*} \Gamma_{\tilde{H}_i^+, \tilde{\nu}_a, e_b}^R + \Gamma_{\tilde{H}_j^+, \tilde{\nu}_a, e_b}^{R*} \Gamma_{\tilde{H}_i^+, \tilde{\nu}_a, e_b}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{\nu_a}^2, m_{e_b}^2) \left( \Gamma_{\tilde{H}_j^+, \tilde{\nu}_a, e_b}^{L*} \Gamma_{\tilde{H}_i^+, \tilde{\nu}_a, e_b}^L + \Gamma_{\tilde{H}_j^+, \tilde{\nu}_a, e_b}^{R*} \Gamma_{\tilde{H}_i^+, \tilde{\nu}_a, e_b}^R \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^6 B_0(p^2, m_{\tilde{\nu}_a}^2, m_{\tilde{e}_b}^2) \Gamma_{\tilde{H}_j^+, \tilde{\nu}_a^*, \tilde{e}_b}^* \Gamma_{\tilde{H}_i^+, \tilde{\nu}_a^*, \tilde{e}_b} \\
& - 2 \sum_{a=1}^5 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^-}^R + \Gamma_{\tilde{H}_j^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{H}_i^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^L \right) \\
& + \sum_{a=1}^5 \sum_{b=1}^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)
\end{aligned}$$

$$\begin{aligned}
& -3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \tilde{d}_a^*, \tilde{d}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \tilde{e}_a^*, \tilde{e}_a} \\
& -3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \tilde{u}_a^*, \tilde{u}_a} + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{u}_a}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{H}_j^+, \tilde{u}_a^*, \tilde{d}_b} \Gamma_{\tilde{H}_i^+, \tilde{u}_a^*, \tilde{d}_b} \\
& + \sum_{b=1}^2 \Gamma_{\tilde{H}_j^+, \gamma, H_b^-}^* \Gamma_{\tilde{H}_i^+, \gamma, H_b^-} F_0(p^2, m_{H_b^-}^2, 0) + \sum_{b=1}^2 \Gamma_{\tilde{H}_j^+, Z, H_b^-}^* \Gamma_{\tilde{H}_i^+, Z, H_b^-} F_0(p^2, m_{H_b^-}^2, m_Z^2) \\
& + \sum_{b=1}^3 \Gamma_{\tilde{H}_j^+, W^-, A_b^0}^* \Gamma_{\tilde{H}_i^+, W^-, A_b^0} F_0(p^2, m_{A_b^0}^2, m_{W^-}^2) + \sum_{b=1}^3 \Gamma_{\tilde{H}_j^+, W^-, h_b}^* \Gamma_{\tilde{H}_i^+, W^-, h_b} F_0(p^2, m_{h_b}^2, m_{W^-}^2) \quad (183)
\end{aligned}$$

• 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 \\
& + 2 \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{\nu_b}^2, m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{\nu}_a^*, \nu_b}^{L*} m_{\nu_b} \Gamma_{\tilde{\chi}_i^0, \tilde{\nu}_a^*, \nu_b}^R \\
& + \sum_{a=1}^3 \sum_{b=1}^5 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 \\
& + \sum_{a=1}^5 m_{\tilde{\chi}_a^0} \sum_{b=1}^3 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_{\tilde{d}_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{d}_a^*, \tilde{d}_b}^{L*} m_{\tilde{d}_b} \Gamma_{\tilde{\chi}_i^0, \tilde{d}_a^*, \tilde{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 \\
& - 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}^5 \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 \quad (184) \\
\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
\end{aligned}$$

$$\begin{aligned}
& - \sum_{a=1}^3 \sum_{b=1}^3 B_1 \left( p^2, m_{\nu_b}^2, m_{\tilde{\nu}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{\nu}_a^*, \nu_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{\nu}_a^*, \nu_b}^R \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^5 B_1 \left( p^2, m_{\tilde{\chi}_b^0}^2, m_{h_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, h_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, h_a, \tilde{\chi}_b^0}^R \\
& - \frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^3 B_1 \left( p^2, m_{\tilde{\chi}_a^0}^2, m_{A_b^0}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{\chi}_a^0, A_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{\chi}_a^0, A_b^0}^R \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1 \left( p^2, m_{d_b}^2, m_{\tilde{d}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{d}_a^*, d_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{d}_a^*, d_b}^R \\
& - \sum_{a=1}^6 \sum_{b=1}^3 B_1 \left( p^2, m_{e_b}^2, m_{\tilde{e}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{e}_a^*, e_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{e}_a^*, e_b}^R \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1 \left( p^2, m_{u_b}^2, m_{\tilde{u}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{u}_a^*, u_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{u}_a^*, u_b}^R \\
& - 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}^5 B_1 \left( p^2, m_{\tilde{\chi}_b^0}^2, m_Z^2 \right) \Gamma_{\tilde{\chi}_j^0, Z, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, Z, \tilde{\chi}_b^0}^L \quad (185) \\
\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 \\
& - \sum_{a=1}^3 \sum_{b=1}^3 B_1 \left( p^2, m_{\nu_b}^2, m_{\tilde{\nu}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{\nu}_a^*, \nu_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{\nu}_a^*, \nu_b}^L \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^5 B_1 \left( p^2, m_{\tilde{\chi}_b^0}^2, m_{h_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, h_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, h_a, \tilde{\chi}_b^0}^L \\
& - \frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^3 B_1 \left( p^2, m_{\tilde{\chi}_a^0}^2, m_{A_b^0}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{\chi}_a^0, A_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{\chi}_a^0, A_b^0}^L \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1 \left( p^2, m_{d_b}^2, m_{\tilde{d}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{d}_a^*, d_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{d}_a^*, d_b}^L \\
& - \sum_{a=1}^6 \sum_{b=1}^3 B_1 \left( p^2, m_{e_b}^2, m_{\tilde{e}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{e}_a^*, e_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{e}_a^*, e_b}^L \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1 \left( p^2, m_{u_b}^2, m_{\tilde{u}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{u}_a^*, u_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{u}_a^*, u_b}^L \\
& - 2 \sum_{b=1}^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}^5 B_1 \left( p^2, m_{\tilde{\chi}_b^0}^2, m_Z^2 \right) \Gamma_{\tilde{\chi}_j^0, Z, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, Z, \tilde{\chi}_b^0}^R \quad (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}^3 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}^5 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{H_a^-}^2) \Gamma_{\tilde{\chi}_j^+, H_a^-, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^+, H_a^-, \tilde{\chi}_b^0}^R \\
& + \sum_{a=1}^3 \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}^3 \sum_{b=1}^3 B_0(p^2, m_{e_b}^2, m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{\nu}_a^*, e_b}^{L*} m_{e_b} \Gamma_{\tilde{\chi}_i^+, \tilde{\nu}_a^*, e_b}^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 \\
& + \sum_{a=1}^3 m_{\nu_a} \sum_{b=1}^6 B_0(p^2, m_{\nu_a}^2, m_{\tilde{e}_b}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{\nu}_a, \tilde{e}_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{\nu}_a, \tilde{e}_b}^R \\
& + 3 \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{d_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a^*, d_b}^{L*} m_{d_b} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a^*, d_b}^R \\
& - 4 \sum_{b=1}^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 \\
& - 4 \sum_{b=1}^5 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{W^-}^2) \right) \Gamma_{\tilde{\chi}_j^+, W^-, \tilde{\chi}_b^0}^{R*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^+, W^-, \tilde{\chi}_b^0}^L \tag{187}
\end{aligned}$$

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

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^6 B_1(p^2, m_{\nu_a}^2, m_{\bar{e}_b}^2) \Gamma_{\tilde{\chi}_j^+, \bar{\nu}_a, \bar{e}_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \bar{\nu}_a, \bar{e}_b}^R \\
& -\frac{3}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{\bar{u}_a}^2) \Gamma_{\tilde{\chi}_j^+, \bar{u}_a^*, d_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \bar{u}_a^*, d_b}^R - \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, 0) \Gamma_{\tilde{\chi}_j^+, \gamma, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^+, \gamma, \tilde{\chi}_b^-}^L \\
& - \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_Z^2) \Gamma_{\tilde{\chi}_j^+, Z, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^+, Z, \tilde{\chi}_b^-}^L - \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{W^-}^2) \Gamma_{\tilde{\chi}_j^+, W^-, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^+, W^-, \tilde{\chi}_b^0}^L \quad (188)
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) &= -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{\tilde{\chi}_a^-}^2, m_{A_b^0}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{\chi}_a^-, A_b^0}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{\chi}_a^-, A_b^0}^L \\
& -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{H_a^-}^2) \Gamma_{\tilde{\chi}_j^+, H_a^-, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^+, H_a^-, \tilde{\chi}_b^0}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{h_a}^2) \Gamma_{\tilde{\chi}_j^+, h_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^+, h_a, \tilde{\chi}_b^-}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{\bar{\nu}_a}^2) \Gamma_{\tilde{\chi}_j^+, \bar{\nu}_a^*, e_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \bar{\nu}_a^*, e_b}^L \\
& -\frac{3}{2} \sum_{a=1}^3 \sum_{b=1}^6 B_1(p^2, m_{u_a}^2, m_{\bar{d}_b}^2) \Gamma_{\tilde{\chi}_j^+, \bar{u}_a, \bar{d}_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \bar{u}_a, \bar{d}_b}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^6 B_1(p^2, m_{\nu_a}^2, m_{\bar{e}_b}^2) \Gamma_{\tilde{\chi}_j^+, \bar{\nu}_a, \bar{e}_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \bar{\nu}_a, \bar{e}_b}^L \\
& -\frac{3}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{\bar{u}_a}^2) \Gamma_{\tilde{\chi}_j^+, \bar{u}_a^*, d_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \bar{u}_a^*, d_b}^L - \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, 0) \Gamma_{\tilde{\chi}_j^+, \gamma, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^+, \gamma, \tilde{\chi}_b^-}^R \\
& - \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_Z^2) \Gamma_{\tilde{\chi}_j^+, Z, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^+, Z, \tilde{\chi}_b^-}^R - \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{W^-}^2) \Gamma_{\tilde{\chi}_j^+, W^-, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^+, W^-, \tilde{\chi}_b^0}^R \quad (189)
\end{aligned}$$

• Self-Energy for Leptons ( $e$ )

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) &= + \sum_{a=1}^2 \sum_{b=1}^3 B_0(p^2, m_{\nu_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{e}_j, H_a^-, \nu_b}^{L*} m_{\nu_b} \Gamma_{\tilde{e}_i, H_a^-, \nu_b}^R \\
& + \sum_{a=1}^3 \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{\bar{\nu}_a}^2) \Gamma_{\tilde{e}_j, \bar{\nu}_a, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{e}_i, \bar{\nu}_a, \tilde{\chi}_b^-}^R \\
& + \sum_{a=1}^3 m_{e_a} \sum_{b=1}^3 B_0(p^2, m_{e_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{e}_j, e_a, A_b^0}^{L*} \Gamma_{\tilde{e}_i, e_a, A_b^0}^R
\end{aligned}$$



$$\begin{aligned}
& + \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{e_b}^2, m_{h_a}^2) \Gamma_{\tilde{e}_j, h_a, e_b}^{L*} m_{e_b} \Gamma_{\tilde{e}_i, h_a, e_b}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^5 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{e}_j, \tilde{e}_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{e}_i, \tilde{e}_a, \tilde{\chi}_b^0}^R \\
& - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{e_b}^2, 0) \right) \Gamma_{\tilde{e}_j, \gamma, e_b}^{R*} m_{e_b} \Gamma_{\tilde{e}_i, \gamma, e_b}^L \\
& - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{\nu_b}^2, m_{W^-}^2) \right) \Gamma_{\tilde{e}_j, W^-, \nu_b}^{R*} m_{\nu_b} \Gamma_{\tilde{e}_i, W^-, \nu_b}^L \\
& - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{e_b}^2, m_Z^2) \right) \Gamma_{\tilde{e}_j, Z, e_b}^{R*} m_{e_b} \Gamma_{\tilde{e}_i, Z, e_b}^L \tag{190}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) &= -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{\nu_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{e}_j, H_a^-, \nu_b}^{R*} \Gamma_{\tilde{e}_i, H_a^-, \nu_b}^R \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{e}_j, \tilde{\nu}_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{e}_i, \tilde{\nu}_a, \tilde{\chi}_b^-}^R \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{e_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{e}_j, e_a, A_b^0}^{R*} \Gamma_{\tilde{e}_i, e_a, A_b^0}^R \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{h_a}^2) \Gamma_{\tilde{e}_j, h_a, e_b}^{R*} \Gamma_{\tilde{e}_i, h_a, e_b}^R \\
& - \frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{e}_j, \tilde{e}_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{e}_i, \tilde{e}_a, \tilde{\chi}_b^0}^R - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, 0) \Gamma_{\tilde{e}_j, \gamma, e_b}^{L*} \Gamma_{\tilde{e}_i, \gamma, e_b}^L \\
& - \sum_{b=1}^3 B_1(p^2, m_{\nu_b}^2, m_{W^-}^2) \Gamma_{\tilde{e}_j, W^-, \nu_b}^{L*} \Gamma_{\tilde{e}_i, W^-, \nu_b}^L - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_Z^2) \Gamma_{\tilde{e}_j, Z, e_b}^{L*} \Gamma_{\tilde{e}_i, Z, e_b}^L \tag{191}
\end{aligned}$$

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

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{e}_j, \tilde{e}_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{e}_i, \tilde{e}_a, \tilde{\chi}_b^0}^L - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, 0) \Gamma_{\tilde{e}_j, \gamma, e_b}^{R*} \Gamma_{\tilde{e}_i, \gamma, e_b}^R \\
& - \sum_{b=1}^3 B_1(p^2, m_{\nu_b}^2, m_{W^-}^2) \Gamma_{\tilde{e}_j, W^-, \nu_b}^{R*} \Gamma_{\tilde{e}_i, W^-, \nu_b}^R - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_Z^2) \Gamma_{\tilde{e}_j, Z, e_b}^{R*} \Gamma_{\tilde{e}_i, Z, e_b}^R \quad (192)
\end{aligned}$$

• Self-Energy for Down-Quarks (d)

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) &= + \sum_{a=1}^2 \sum_{b=1}^3 B_0(p^2, m_{u_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{d}_j, H_a^-, u_b}^{L*} m_{u_b} \Gamma_{\tilde{d}_i, H_a^-, u_b}^R \\
&+ \sum_{a=1}^3 m_{d_a} \sum_{b=1}^3 B_0(p^2, m_{d_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j, d_a, A_b^0}^{L*} \Gamma_{\tilde{d}_i, d_a, A_b^0}^R \\
&+ \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{d_b}^2, m_{h_a}^2) \Gamma_{\tilde{d}_j, h_a, d_b}^{L*} m_{d_b} \Gamma_{\tilde{d}_i, h_a, d_b}^R \\
&+ \sum_{a=1}^6 \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_j, \tilde{u}_a, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{d}_i, \tilde{u}_a, \tilde{\chi}_b^-}^R \\
&+ \sum_{a=1}^6 \sum_{b=1}^5 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{\chi}_b^0}^R \\
&+ \frac{4}{3} m_{\tilde{g}} \sum_{a=1}^6 B_0(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{g}_1}^R - \frac{16}{3} \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, 0) \right) \Gamma_{\tilde{d}_j, g, d_b}^{R*} m_{d_b} \Gamma_{\tilde{d}_i, g, d_b}^L \\
&- 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, 0) \right) \Gamma_{\tilde{d}_j, \gamma, d_b}^{R*} m_{d_b} \Gamma_{\tilde{d}_i, \gamma, d_b}^L \\
&- 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, m_{W^-}^2) \right) \Gamma_{\tilde{d}_j, W^-, u_b}^{R*} m_{u_b} \Gamma_{\tilde{d}_i, W^-, u_b}^L \\
&- 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, m_Z^2) \right) \Gamma_{\tilde{d}_j, Z, d_b}^{R*} m_{d_b} \Gamma_{\tilde{d}_i, Z, d_b}^L \quad (193)
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) &= -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{d}_j, H_a^-, u_b}^{R*} \Gamma_{\tilde{d}_i, H_a^-, u_b}^R \\
&- \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{d_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j, d_a, A_b^0}^{R*} \Gamma_{\tilde{d}_i, d_a, A_b^0}^R \\
&- \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{h_a}^2) \Gamma_{\tilde{d}_j, h_a, d_b}^{R*} \Gamma_{\tilde{d}_i, h_a, d_b}^R
\end{aligned}$$

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_j, \tilde{u}_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{d}_i, \tilde{u}_a, \tilde{\chi}_b^-}^R \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{\chi}_b^0}^R \\
& -\frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{g}_1}^{R*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{g}_1}^R - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, g, d_b}^{L*} \Gamma_{\tilde{d}_i, g, d_b}^L \\
& -\sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, \gamma, d_b}^{L*} \Gamma_{\tilde{d}_i, \gamma, d_b}^L - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{W^-}^2) \Gamma_{\tilde{d}_j, W^-, u_b}^{L*} \Gamma_{\tilde{d}_i, W^-, u_b}^L \\
& -\sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_Z^2) \Gamma_{\tilde{d}_j, Z, d_b}^{L*} \Gamma_{\tilde{d}_i, Z, d_b}^L
\end{aligned} \tag{194}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) &= -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{d}_j, H_a^-, u_b}^{L*} \Gamma_{\tilde{d}_i, H_a^-, u_b}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{d_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j, d_a, A_b^0}^{L*} \Gamma_{\tilde{d}_i, d_a, A_b^0}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{h_a}^2) \Gamma_{\tilde{d}_j, h_a, d_b}^{L*} \Gamma_{\tilde{d}_i, h_a, d_b}^L \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_j, \tilde{u}_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{d}_i, \tilde{u}_a, \tilde{\chi}_b^-}^L \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{\chi}_b^0}^L \\
& -\frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{g}_1}^L - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, g, d_b}^{R*} \Gamma_{\tilde{d}_i, g, d_b}^R \\
& -\sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, \gamma, d_b}^{R*} \Gamma_{\tilde{d}_i, \gamma, d_b}^R - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{W^-}^2) \Gamma_{\tilde{d}_j, W^-, u_b}^{R*} \Gamma_{\tilde{d}_i, W^-, u_b}^R \\
& -\sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_Z^2) \Gamma_{\tilde{d}_j, Z, d_b}^{R*} \Gamma_{\tilde{d}_i, Z, d_b}^R
\end{aligned} \tag{195}$$

• Self-Energy for Up-Quarks ( $u$ )

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

$$\begin{aligned}
& + \sum_{a=1}^2 m_{\tilde{\chi}_a^-} \sum_{b=1}^6 B_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{u}_j, \tilde{\chi}_a^+, \tilde{d}_b}^{L*} \Gamma_{\tilde{u}_i, \tilde{\chi}_a^+, \tilde{d}_b}^R \\
& + \sum_{a=1}^3 m_{u_a} \sum_{b=1}^3 B_0(p^2, m_{u_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{u}_j, u_a, A_b^0}^{L*} \Gamma_{\tilde{u}_i, u_a, A_b^0}^R \\
& + \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{u_b}^2, m_{h_a}^2) \Gamma_{\tilde{u}_j, h_a, u_b}^{L*} m_{u_b} \Gamma_{\tilde{u}_i, h_a, u_b}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^5 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{\chi}_b^0}^R \\
& + \frac{4}{3} m_{\tilde{g}} \sum_{a=1}^6 B_0(p^2, m_{\tilde{g}}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{g}_1}^R - \frac{16}{3} \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, 0) \right) \Gamma_{\tilde{u}_j, g, u_b}^{R*} m_{u_b} \Gamma_{\tilde{u}_i, g, u_b}^L \\
& - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, 0) \right) \Gamma_{\tilde{u}_j, \gamma, u_b}^{R*} m_{u_b} \Gamma_{\tilde{u}_i, \gamma, u_b}^L - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, m_Z^2) \right) \Gamma_{\tilde{u}_j, Z, u_b}^{R*} m_{u_b} \Gamma_{\tilde{u}_i, Z, u_b}^L \\
& - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, m_{W^-}^2) \right) \Gamma_{\tilde{u}_j, W^+, d_b}^{R*} m_{d_b} \Gamma_{\tilde{u}_i, W^+, d_b}^L \tag{196}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) & = -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{u}_j, H_a^+, d_b}^{R*} \Gamma_{\tilde{u}_i, H_a^+, d_b}^R \\
& - \frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^6 B_1(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{u}_j, \tilde{\chi}_a^+, \tilde{d}_b}^{R*} \Gamma_{\tilde{u}_i, \tilde{\chi}_a^+, \tilde{d}_b}^R \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{u_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{u}_j, u_a, A_b^0}^{R*} \Gamma_{\tilde{u}_i, u_a, A_b^0}^R \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{h_a}^2) \Gamma_{\tilde{u}_j, h_a, u_b}^{R*} \Gamma_{\tilde{u}_i, h_a, u_b}^R \\
& - \frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{\chi}_b^0}^R \\
& - \frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{g}_1}^{R*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{g}_1}^R - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, g, u_b}^{L*} \Gamma_{\tilde{u}_i, g, u_b}^L \\
& - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, \gamma, u_b}^{L*} \Gamma_{\tilde{u}_i, \gamma, u_b}^L - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_Z^2) \Gamma_{\tilde{u}_j, Z, u_b}^{L*} \Gamma_{\tilde{u}_i, Z, u_b}^L \\
& - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{W^-}^2) \Gamma_{\tilde{u}_j, W^+, d_b}^{L*} \Gamma_{\tilde{u}_i, W^+, d_b}^L \tag{197}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) = & -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{u}_j, H_a^+, d_b}^{L*} \Gamma_{\tilde{u}_i, H_a^+, d_b}^L \\
& -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^6 B_1(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{u}_j, \tilde{\chi}_a^+, \tilde{d}_b}^{L*} \Gamma_{\tilde{u}_i, \tilde{\chi}_a^+, \tilde{d}_b}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{u_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{u}_j, u_a, A_b^0}^{L*} \Gamma_{\tilde{u}_i, u_a, A_b^0}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{h_a}^2) \Gamma_{\tilde{u}_j, h_a, u_b}^{L*} \Gamma_{\tilde{u}_i, h_a, u_b}^L \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{\chi}_b^0}^L \\
& -\frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{g}_1}^L - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, g, u_b}^{R*} \Gamma_{\tilde{u}_i, g, u_b}^R \\
& -\sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, \gamma, u_b}^{R*} \Gamma_{\tilde{u}_i, \gamma, u_b}^R - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_Z^2) \Gamma_{\tilde{u}_j, Z, u_b}^{R*} \Gamma_{\tilde{u}_i, Z, u_b}^R \\
& -\sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{W^-}^2) \Gamma_{\tilde{u}_j, W^+, d_b}^{R*} \Gamma_{\tilde{u}_i, W^+, d_b}^R
\end{aligned} \tag{198}$$

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

$$\begin{aligned}
& -12 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z, \bar{d}_a^*, \bar{d}_b}|^2 B_{00}(p^2, m_{\bar{d}_a}^2, m_{\bar{d}_b}^2) - 4 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z, \bar{e}_a^*, \bar{e}_b}|^2 B_{00}(p^2, m_{\bar{e}_a}^2, m_{\bar{e}_b}^2) \\
& -12 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z, \bar{u}_a^*, \bar{u}_b}|^2 B_{00}(p^2, m_{\bar{u}_a}^2, m_{\bar{u}_b}^2) + 2 \sum_{b=1}^2 |\Gamma_{Z, W^+, H_b^-}|^2 B_0(p^2, m_{W^-}^2, m_{H_b^-}^2) \\
& + \sum_{b=1}^3 |\Gamma_{Z, Z, h_b}|^2 B_0(p^2, m_Z^2, m_{h_b}^2) + 2\text{rMS}m_{W^-}^2 \Gamma_{Z, Z, W^+, W^-}^1 - A_0(m_{W^-}^2) (4\Gamma_{Z, Z, W^+, W^-}^1 + \Gamma_{Z, Z, W^+, W^-}^2 + \Gamma_{Z, Z, W^+, W^-}^3)
\end{aligned} \tag{202}$$

• Self-Energy for W-Boson ( $W^-$ )

$$\begin{aligned}
\Pi(p^2) = & -12 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{W^+, \bar{u}_a^*, \bar{d}_b}|^2 B_{00}(p^2, m_{\bar{d}_b}^2, m_{\bar{u}_a}^2) + 2\text{rMS}m_{W^-}^2 \Gamma_{W^-, W^+, W^+, W^-}^1 + 3 \sum_{a=1}^3 \sum_{b=1}^3 [ (|\Gamma_{W^+, \bar{u}_a, d_b}^L|^2 + |\Gamma_{W^+, \bar{u}_a, d_b}^R|^2) H_0 \\
& + 4B_0(p^2, m_{u_a}^2, m_{d_b}^2) m_{d_b} m_{u_a} \Re(\Gamma_{W^+, \bar{u}_a, d_b}^{L*} \Gamma_{W^+, \bar{u}_a, d_b}^R) ] + 3 \sum_{a=1}^6 A_0(m_{\bar{d}_a}^2) \Gamma_{W^-, W^+, \bar{d}_a^*, \bar{d}_a} + 3 \sum_{a=1}^6 A_0(m_{\bar{u}_a}^2) \Gamma_{W^-, W^+, \bar{u}_a^*, \bar{u}_a} \\
& + 4B_0(p^2, m_{\nu_a}^2, m_{e_b}^2) m_{e_b} m_{\nu_a} \Re(\Gamma_{W^+, \bar{\nu}_a, e_b}^{L*} \Gamma_{W^+, \bar{\nu}_a, e_b}^R) + \sum_{a=1}^5 \sum_{b=1}^2 [ (|\Gamma_{W^+, \bar{\chi}_a^0, \bar{\chi}_b^-}|^2 + |\Gamma_{W^+, \bar{\chi}_a^0, \bar{\chi}_b^-}|^2) H_0(p^2, m_{\bar{\chi}_a^0}^2, m_{\bar{\chi}_b^-}^2) \\
& + 4B_0(p^2, m_{\bar{\chi}_a^0}^2, m_{\bar{\chi}_b^-}^2) m_{\bar{\chi}_b^-} m_{\bar{\chi}_a^0} \Re(\Gamma_{W^+, \bar{\chi}_a^0, \bar{\chi}_b^-}^{L*} \Gamma_{W^+, \bar{\chi}_a^0, \bar{\chi}_b^-}^R) ] + \sum_{a=1}^6 A_0(m_{\bar{e}_a}^2) \Gamma_{W^-, W^+, \bar{e}_a^*, \bar{e}_a} + \sum_{b=1}^2 |\Gamma_{W^+, \gamma, H_b^-}|^2 B_0(p^2, 0, m_{H_b^-}^2)
\end{aligned} \tag{203}$$

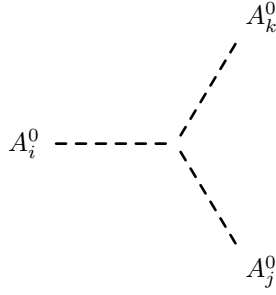
## 8.2 Tadpoles

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

$$\begin{aligned}
& + 6 \sum_{a=1}^3 A_0(m_{u_a}^2) m_{u_a} \left( \Gamma_{\tilde{h}_i, \tilde{u}_a, u_a}^L + \Gamma_{\tilde{h}_i, \tilde{u}_a, u_a}^R \right) + \sum_{a=1}^5 A_0(m_{\tilde{\chi}_a^0}^2) m_{\tilde{\chi}_a^0} \left( \Gamma_{\tilde{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_a^0}^L + \Gamma_{\tilde{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_a^0}^R \right) \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{h}_i, \tilde{d}_a^*, \tilde{d}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{h}_i, \tilde{e}_a^*, \tilde{e}_a} - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{h}_i, \tilde{u}_a^*, \tilde{u}_a}
\end{aligned} \tag{204}$$

## 9 Interactions for eigenstates 'EWSB'

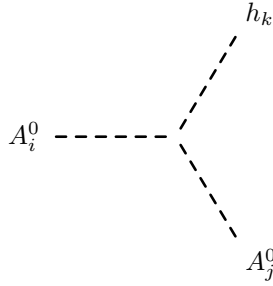
### 9.1 Three Scalar-Interaction



$$\begin{aligned}
& \frac{1}{4} \left( -\sqrt{2} \lambda M_S^* Z_{i3}^{A,*} Z_{j2}^{A,*} Z_{k1}^{A,*} - 2v_s \lambda \kappa^* Z_{i3}^{A,*} Z_{j2}^{A,*} Z_{k1}^{A,*} - \sqrt{2} T_\lambda^* Z_{i3}^{A,*} Z_{j2}^{A,*} Z_{k1}^{A,*} \right. \\
& - \sqrt{2} \lambda M_S^* Z_{i2}^{A,*} Z_{j3}^{A,*} Z_{k1}^{A,*} - 2v_s \lambda \kappa^* Z_{i2}^{A,*} Z_{j3}^{A,*} Z_{k1}^{A,*} - \sqrt{2} T_\lambda^* Z_{i2}^{A,*} Z_{j3}^{A,*} Z_{k1}^{A,*} \\
& + 2v_u \lambda \kappa^* Z_{i3}^{A,*} Z_{j3}^{A,*} Z_{k1}^{A,*} - \sqrt{2} \lambda M_S^* Z_{i3}^{A,*} Z_{j1}^{A,*} Z_{k2}^{A,*} - 2v_s \lambda \kappa^* Z_{i3}^{A,*} Z_{j1}^{A,*} Z_{k2}^{A,*} \\
& - \sqrt{2} T_\lambda^* Z_{i3}^{A,*} Z_{j1}^{A,*} Z_{k2}^{A,*} - \sqrt{2} \lambda M_S^* Z_{i1}^{A,*} Z_{j3}^{A,*} Z_{k2}^{A,*} - 2v_s \lambda \kappa^* Z_{i1}^{A,*} Z_{j3}^{A,*} Z_{k2}^{A,*} \\
& - \sqrt{2} T_\lambda^* Z_{i1}^{A,*} Z_{j3}^{A,*} Z_{k2}^{A,*} + 2v_d \lambda \kappa^* Z_{i3}^{A,*} Z_{j3}^{A,*} Z_{k2}^{A,*} - \sqrt{2} \lambda M_S^* Z_{i2}^{A,*} Z_{j1}^{A,*} Z_{k3}^{A,*} \\
& - 2v_s \lambda \kappa^* Z_{i2}^{A,*} Z_{j1}^{A,*} Z_{k3}^{A,*} - \sqrt{2} T_\lambda^* Z_{i2}^{A,*} Z_{j1}^{A,*} Z_{k3}^{A,*} + 2v_u \lambda \kappa^* Z_{i3}^{A,*} Z_{j1}^{A,*} Z_{k3}^{A,*} \\
& - \sqrt{2} \lambda M_S^* Z_{i1}^{A,*} Z_{j2}^{A,*} Z_{k3}^{A,*} - 2v_s \lambda \kappa^* Z_{i1}^{A,*} Z_{j2}^{A,*} Z_{k3}^{A,*} - \sqrt{2} T_\lambda^* Z_{i1}^{A,*} Z_{j2}^{A,*} Z_{k3}^{A,*} \\
& + 2v_d \lambda \kappa^* Z_{i3}^{A,*} Z_{j2}^{A,*} Z_{k3}^{A,*} + 2v_u \lambda \kappa^* Z_{i1}^{A,*} Z_{j3}^{A,*} Z_{k3}^{A,*} + 2v_d \lambda \kappa^* Z_{i2}^{A,*} Z_{j3}^{A,*} Z_{k3}^{A,*} \\
& + 6\sqrt{2} \kappa M_S^* Z_{i3}^{A,*} Z_{j3}^{A,*} Z_{k3}^{A,*} - 6\sqrt{2} M_S \kappa^* Z_{i3}^{A,*} Z_{j3}^{A,*} Z_{k3}^{A,*} + 2\sqrt{2} T_\kappa^* Z_{i3}^{A,*} Z_{j3}^{A,*} Z_{k3}^{A,*} \\
& + 2\sqrt{2} \lambda \mu^* \left( Z_{i3}^{A,*} \left( Z_{j1}^{A,*} Z_{k1}^{A,*} + Z_{j2}^{A,*} Z_{k2}^{A,*} \right) + Z_{i1}^{A,*} \left( Z_{j1}^{A,*} Z_{k3}^{A,*} + Z_{j3}^{A,*} Z_{k1}^{A,*} \right) \right. \\
& \left. + Z_{i2}^{A,*} \left( Z_{j2}^{A,*} Z_{k3}^{A,*} + Z_{j3}^{A,*} Z_{k2}^{A,*} \right) \right) \\
& + \lambda^* \left( Z_{i1}^{A,*} \left( \left( -2\sqrt{2} \mu Z_{j1}^{A,*} + \left( 2v_s \kappa + \sqrt{2} M_S \right) Z_{j2}^{A,*} \right) Z_{k3}^{A,*} \right. \right. \\
& \left. \left. + Z_{j3}^{A,*} \left( -2\sqrt{2} \mu Z_{k1}^{A,*} + \left( 2v_s \kappa + \sqrt{2} M_S \right) Z_{k2}^{A,*} - 2v_u \kappa Z_{k3}^{A,*} \right) \right) \right) \\
& + Z_{i3}^{A,*} \left( -2\kappa Z_{j3}^{A,*} \left( v_d Z_{k2}^{A,*} + v_u Z_{k1}^{A,*} \right) + Z_{j1}^{A,*} \left( -2\sqrt{2} \mu Z_{k1}^{A,*} + \left( 2v_s \kappa + \sqrt{2} M_S \right) Z_{k2}^{A,*} - 2v_u \kappa Z_{k3}^{A,*} \right) \right. \\
& \left. + Z_{j2}^{A,*} \left( -2 \left( \sqrt{2} \mu Z_{k2}^{A,*} + v_d \kappa Z_{k3}^{A,*} \right) + \left( 2v_s \kappa + \sqrt{2} M_S \right) Z_{k1}^{A,*} \right) \right)
\end{aligned}$$

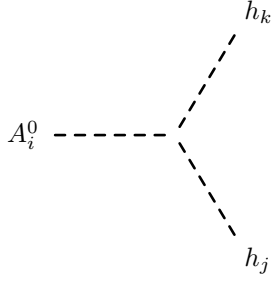


$$\begin{aligned}
& + Z_{i2}^{A,*} \left( \left( -2\sqrt{2}\mu Z_{j2}^{A,*} + \left( 2v_s\kappa + \sqrt{2}M_S \right) Z_{j1}^{A,*} \right) Z_{k3}^{A,*} \right. \\
& + Z_{j3}^{A,*} \left( -2 \left( \sqrt{2}\mu Z_{k2}^{A,*} + v_d\kappa Z_{k3}^{A,*} \right) + \left( 2v_s\kappa + \sqrt{2}M_S \right) Z_{k1}^{A,*} \right) \left. \right) \\
& - 2\sqrt{2}Z_{i3}^{A,*} Z_{j3}^{A,*} Z_{k3}^{A,*} T_\kappa + \sqrt{2}Z_{i3}^{A,*} Z_{j2}^{A,*} Z_{k1}^{A,*} T_\lambda + \sqrt{2}Z_{i2}^{A,*} Z_{j3}^{A,*} Z_{k1}^{A,*} T_\lambda \\
& + \sqrt{2}Z_{i3}^{A,*} Z_{j1}^{A,*} Z_{k2}^{A,*} T_\lambda + \sqrt{2}Z_{i1}^{A,*} Z_{j3}^{A,*} Z_{k2}^{A,*} T_\lambda + \sqrt{2}Z_{i2}^{A,*} Z_{j1}^{A,*} Z_{k3}^{A,*} T_\lambda \\
& + \sqrt{2}Z_{i1}^{A,*} Z_{j2}^{A,*} Z_{k3}^{A,*} T_\lambda \left. \right) \tag{205}
\end{aligned}$$



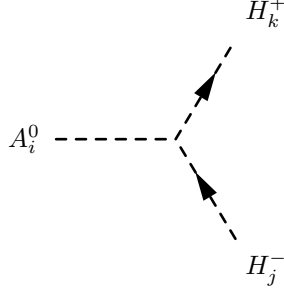
$$\begin{aligned}
& - \frac{i}{4} \left( Z_{i3}^{A,*} \left( -\sqrt{2}M_S\lambda^* Z_{j2}^{A,*} Z_{k1}^{H,*} - 2v_s\kappa\lambda^* Z_{j2}^{A,*} Z_{k1}^{H,*} + \sqrt{2}T_\lambda^* Z_{j2}^{A,*} Z_{k1}^{H,*} + 4v_d|\lambda|^2 Z_{j3}^{A,*} Z_{k1}^{H,*} \right. \right. \\
& + 2v_u\kappa\lambda^* Z_{j3}^{A,*}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

$$\begin{aligned}
& -2v_s\kappa\lambda^*Z_{j_3}^{A,*}Z_{k_2}^{H,*} + \sqrt{2}T_\lambda^*Z_{j_3}^{A,*}Z_{k_2}^{H,*} + \sqrt{2}\lambda M_S^*Z_{j_2}^{A,*}Z_{k_3}^{H,*} + 2v_s\lambda\kappa^*Z_{j_2}^{A,*}Z_{k_3}^{H,*} \\
& + \sqrt{2}M_S\lambda^*Z_{j_2}^{A,*}Z_{k_3}^{H,*} + 2v_s\kappa\lambda^*Z_{j_2}^{A,*}Z_{k_3}^{H,*} + \sqrt{2}T_\lambda^*Z_{j_2}^{A,*}Z_{k_3}^{H,*} - 2v_u\lambda\kappa^*Z_{j_3}^{A,*}Z_{k_3}^{H,*} \\
& - 2v_u\kappa\lambda^*Z_{j_3}^{A,*}Z_{k_3}^{H,*} \\
& + Z_{j_1}^{A,*}\left(2\left(2v_s|\lambda|^2 + \sqrt{2}\lambda\mu^* + \sqrt{2}\mu\lambda^*\right)Z_{k_3}^{H,*} + \left(g_1^2 + g_2^2\right)v_dZ_{k_1}^{H,*} - v_u\left(-4|\lambda|^2 + g_1^2 + g_2^2\right)Z_{k_2}^{H,*}\right) \\
& + \sqrt{2}Z_{j_3}^{A,*}Z_{k_2}^{H,*}T_\lambda + \sqrt{2}Z_{j_2}^{A,*}Z_{k_3}^{H,*}T_\lambda\left)\right)
\end{aligned} \tag{206}$$

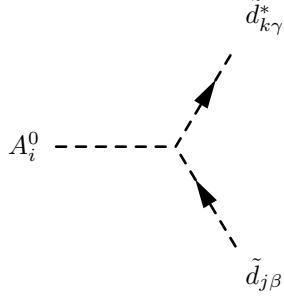


$$\begin{aligned}
& \frac{1}{4}\left(\sqrt{2}\lambda M_S^*Z_{i_3}^{A,*}Z_{j_2}^{H,*}Z_{k_1}^{H,*} + 2v_s\lambda\kappa^*Z_{i_3}^{A,*}Z_{j_2}^{H,*}Z_{k_1}^{H,*} + \sqrt{2}T_\lambda^*Z_{i_3}^{A,*}Z_{j_2}^{H,*}Z_{k_1}^{H,*} \right. \\
& - \sqrt{2}\lambda M_S^*Z_{i_2}^{A,*}Z_{j_3}^{H,*}Z_{k_1}^{H,*} - 2v_s\lambda\kappa^*Z_{i_2}^{A,*}Z_{j_3}^{H,*}Z_{k_1}^{H,*} + \sqrt{2}T_\lambda^*Z_{i_2}^{A,*}Z_{j_3}^{H,*}Z_{k_1}^{H,*} \\
& + 2v_u\lambda\kappa^*Z_{i_3}^{A,*}Z_{j_3}^{H,*}Z_{k_1}^{H,*} + \sqrt{2}\lambda M_S^*Z_{i_3}^{A,*}Z_{j_1}^{H,*}Z_{k_2}^{H,*} + 2v_s\lambda\kappa^*Z_{i_3}^{A,*}Z_{j_1}^{H,*}Z_{k_2}^{H,*} \\
& + \sqrt{2}T_\lambda^*Z_{i_3}^{A,*}Z_{j_1}^{H,*}Z_{k_2}^{H,*} - \sqrt{2}\lambda M_S^*Z_{i_1}^{A,*}Z_{j_3}^{H,*}Z_{k_2}^{H,*} - 2v_s\lambda\kappa^*Z_{i_1}^{A,*}Z_{j_3}^{H,*}Z_{k_2}^{H,*} \\
& + \sqrt{2}T_\lambda^*Z_{i_1}^{A,*}Z_{j_3}^{H,*}Z_{k_2}^{H,*} + 2v_d\lambda\kappa^*Z_{i_3}^{A,*}Z_{j_3}^{H,*}Z_{k_2}^{H,*} \\
& + 2\sqrt{2}\lambda\mu^*Z_{i_3}^{A,*}\left(Z_{j_1}^{H,*}Z_{k_1}^{H,*} + Z_{j_2}^{H,*}Z_{k_2}^{H,*}\right) - \sqrt{2}\lambda M_S^*Z_{i_2}^{A,*}Z_{j_1}^{H,*}Z_{k_3}^{H,*} \\
& - 2v_s\lambda\kappa^*Z_{i_2}^{A,*}Z_{j_1}^{H,*}Z_{k_3}^{H,*} + \sqrt{2}T_\lambda^*Z_{i_2}^{A,*}Z_{j_1}^{H,*}Z_{k_3}^{H,*} + 2v_u\lambda\kappa^*Z_{i_3}^{A,*}Z_{j_1}^{H,*}Z_{k_3}^{H,*} \\
& - \sqrt{2}\lambda M_S^*Z_{i_1}^{A,*}Z_{j_2}^{H,*}Z_{k_3}^{H,*} - 2v_s\lambda\kappa^*Z_{i_1}^{A,*}Z_{j_2}^{H,*}Z_{k_3}^{H,*} + \sqrt{2}T_\lambda^*Z_{i_1}^{A,*}Z_{j_2}^{H,*}Z_{k_3}^{H,*} \\
& + 2v_d\lambda\kappa^*Z_{i_3}^{A,*}Z_{j_2}^{H,*}Z_{k_3}^{H,*} - 2v_u\lambda\kappa^*Z_{i_1}^{A,*}Z_{j_3}^{H,*}Z_{k_3}^{H,*} - 2v_d\lambda\kappa^*Z_{i_2}^{A,*}Z_{j_3}^{H,*}Z_{k_3}^{H,*} \\
& + 2\sqrt{2}\kappa M_S^*Z_{i_3}^{A,*}Z_{j_3}^{H,*}Z_{k_3}^{H,*} - 2\sqrt{2}M_S\kappa^*Z_{i_3}^{A,*}Z_{j_3}^{H,*}Z_{k_3}^{H,*} - 2\sqrt{2}T_\kappa^*Z_{i_3}^{A,*}Z_{j_3}^{H,*}Z_{k_3}^{H,*} \\
& + \lambda^*\left(Z_{i_2}^{A,*}\left(\left(2v_s\kappa + \sqrt{2}M_S\right)Z_{j_1}^{H,*}Z_{k_3}^{H,*} + Z_{j_3}^{H,*}\left(2v_d\kappa Z_{k_3}^{H,*} + \left(2v_s\kappa + \sqrt{2}M_S\right)Z_{k_1}^{H,*}\right)\right)\right) \\
& + Z_{i_1}^{A,*}\left(\left(2v_s\kappa + \sqrt{2}M_S\right)Z_{j_2}^{H,*}Z_{k_3}^{H,*} + Z_{j_3}^{H,*}\left(\left(2v_s\kappa + \sqrt{2}M_S\right)Z_{k_2}^{H,*} + 2v_u\kappa Z_{k_3}^{H,*}\right)\right) \\
& - Z_{i_3}^{A,*}\left(2\kappa Z_{j_3}^{H,*}\left(v_dZ_{k_2}^{H,*} + v_uZ_{k_1}^{H,*}\right) + Z_{j_1}^{H,*}\left(2\sqrt{2}\mu Z_{k_1}^{H,*} + \left(2v_s\kappa + \sqrt{2}M_S\right)Z_{k_2}^{H,*} + 2v_u\kappa Z_{k_3}^{H,*}\right)\right) \\
& + Z_{j_2}^{H,*}\left(2\left(\sqrt{2}\mu Z_{k_2}^{H,*} + v_d\kappa Z_{k_3}^{H,*}\right) + \left(2v_s\kappa + \sqrt{2}M_S\right)Z_{k_1}^{H,*}\right) \\
& + 2\sqrt{2}Z_{i_3}^{A,*}Z_{j_3}^{H,*}Z_{k_3}^{H,*}T_\kappa - \sqrt{2}Z_{i_3}^{A,*}Z_{j_2}^{H,*}Z_{k_1}^{H,*}T_\lambda - \sqrt{2}Z_{i_2}^{A,*}Z_{j_3}^{H,*}Z_{k_1}^{H,*}T_\lambda \\
& - \sqrt{2}Z_{i_3}^{A,*}Z_{j_1}^{H,*}Z_{k_2}^{H,*}T_\lambda - \sqrt{2}Z_{i_1}^{A,*}Z_{j_3}^{H,*}Z_{k_2}^{H,*}T_\lambda - \sqrt{2}Z_{i_2}^{A,*}Z_{j_1}^{H,*}Z_{k_3}^{H,*}T_\lambda
\end{aligned}$$

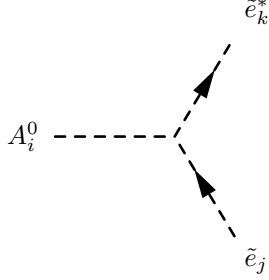
$$- \sqrt{2} Z_{i1}^{A,*} Z_{j2}^{H,*} Z_{k3}^{H,*} T_\lambda \Big) \quad (207)$$



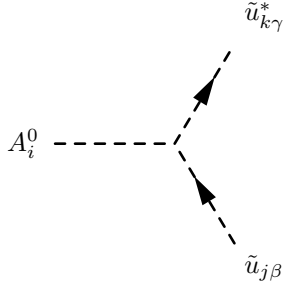
$$\begin{aligned} & \frac{1}{4} \left( g_2^2 v_u Z_{i1}^{A,*} Z_{j2}^+ Z_{k1}^+ + g_2^2 v_d Z_{i2}^{A,*} Z_{j2}^+ Z_{k1}^+ - 2\sqrt{2} T_\lambda^* Z_{i3}^{A,*} Z_{j2}^+ Z_{k1}^+ \right. \\ & - g_2^2 v_u Z_{i1}^{A,*} Z_{j1}^+ Z_{k2}^+ - g_2^2 v_d Z_{i2}^{A,*} Z_{j1}^+ Z_{k2}^+ - 2\sqrt{2} \lambda M_S^* Z_{i3}^{A,*} Z_{j1}^+ Z_{k2}^+ \\ & - 4v_s \lambda \kappa^* Z_{i3}^{A,*} Z_{j1}^+ Z_{k2}^+ + 2\sqrt{2} Z_{i3}^{A,*} T_\lambda Z_{j1}^+ Z_{k2}^+ + 2\sqrt{2} \lambda \mu^* Z_{i3}^{A,*} \left( Z_{j1}^+ Z_{k1}^+ + Z_{j2}^+ Z_{k2}^+ \right) \\ & - 2\lambda^* \left( \lambda \left( v_d Z_{i2}^{A,*} + v_u Z_{i1}^{A,*} \right) \left( -Z_{j1}^+ Z_{k2}^+ + Z_{j2}^+ Z_{k1}^+ \right) \right. \\ & \left. \left. + Z_{i3}^{A,*} \left( \sqrt{2} \mu Z_{j1}^+ Z_{k1}^+ + Z_{j2}^+ \left( - \left( 2v_s \kappa + \sqrt{2} M_S \right) Z_{k1}^+ + \sqrt{2} \mu Z_{k2}^+ \right) \right) \right) \right) \quad (208) \end{aligned}$$



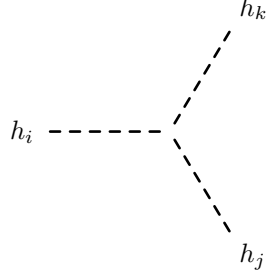
$$\begin{aligned} & \frac{1}{2} \delta_{\beta\gamma} \left( \sqrt{2} \mu^* Z_{i2}^{A,*} \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D + \lambda^* \left( v_s Z_{i2}^{A,*} + v_u Z_{i3}^{A,*} \right) \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \right. \\ & + \sqrt{2} Z_{i1}^{A,*} \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Z_{k3+a}^D T_{d,ab} - v_s \lambda Z_{i2}^{A,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{kb}^D \\ & - \sqrt{2} \mu Z_{i2}^{A,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{kb}^D - v_u \lambda Z_{i3}^{A,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{kb}^D \\ & \left. - \sqrt{2} Z_{i1}^{A,*} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{D,*} T_{d,ab}^* Z_{kb}^D \right) \quad (209) \end{aligned}$$



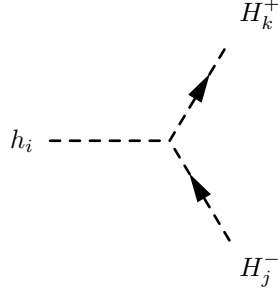
$$\begin{aligned}
& \frac{1}{2} \left( \sqrt{2} \mu^* Z_{i2}^{A,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E + \lambda^* \left( v_s Z_{i2}^{A,*} + v_u Z_{i3}^{A,*} \right) \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \right. \\
& + \sqrt{2} Z_{i1}^{A,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Z_{k3+a}^E T_{e,ab} - v_s \lambda Z_{i2}^{A,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{kb}^E \\
& - \sqrt{2} \mu Z_{i2}^{A,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{kb}^E - v_u \lambda Z_{i3}^{A,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{kb}^E \\
& \left. - \sqrt{2} Z_{i1}^{A,*} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{E,*} T_{e,ab}^* Z_{kb}^E \right) \tag{210}
\end{aligned}$$



$$\begin{aligned}
& \frac{1}{2} \delta_{\beta\gamma} \left( \sqrt{2} \mu^* Z_{i1}^{A,*} \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U + \lambda^* \left( v_d Z_{i3}^{A,*} + v_s Z_{i1}^{A,*} \right) \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U \right. \\
& + \sqrt{2} Z_{i2}^{A,*} \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Z_{k3+a}^U T_{u,ab} - v_s \lambda Z_{i1}^{A,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{j3+a}^{U,*} Z_{kb}^U \\
& - \sqrt{2} \mu Z_{i1}^{A,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{j3+a}^{U,*} Z_{kb}^U - v_d \lambda Z_{i3}^{A,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{j3+a}^{U,*} Z_{kb}^U \\
& \left. - \sqrt{2} Z_{i2}^{A,*} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{U,*} T_{u,ab}^* Z_{kb}^U \right) \tag{211}
\end{aligned}$$

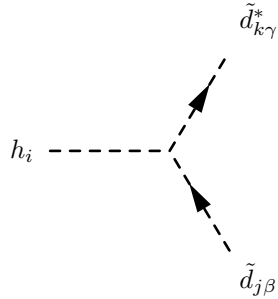


$$\begin{aligned}
& -\frac{i}{4} \left( Z_{i3}^{H,*} \left( 2\sqrt{2}\lambda\mu^* Z_{j1}^{H,*} Z_{k1}^{H,*} - \sqrt{2}\lambda M_S^* Z_{j2}^{H,*} Z_{k1}^{H,*} - 2v_s\lambda\kappa^* Z_{j2}^{H,*} Z_{k1}^{H,*} - \sqrt{2}T_\lambda^* Z_{j2}^{H,*} Z_{k1}^{H,*} \right. \right. \\
& - 2v_u\lambda\kappa^* Z_{j3}^{H,*} Z_{k1}^{H,*} - \sqrt{2}\lambda M_S^* Z_{j1}^{H,*} Z_{k2}^{H,*} - 2v_s\lambda\kappa^* Z_{j1}^{H,*} Z_{k2}^{H,*} - \sqrt{2}T_\lambda^* Z_{j1}^{H,*} Z_{k2}^{H,*} \\
& + 2\sqrt{2}\lambda\mu^* Z_{j2}^{H,*} Z_{k2}^{H,*} - 2v_d\lambda\kappa^* Z_{j3}^{H,*} Z_{k2}^{H,*} - 2v_u\lambda\kappa^* Z_{j1}^{H,*} Z_{k3}^{H,*} \\
& - 2v_d\lambda\kappa^* Z_{j2}^{H,*} Z_{k3}^{H,*} + 24v_s|\kappa|^2 Z_{j3}^{H,*} Z_{k3}^{H,*} + 6\sqrt{2}\kappa M_S^* Z_{j3}^{H,*} Z_{k3}^{H,*} \\
& + 6\sqrt{2}M_S\kappa^* Z_{j3}^{H,*} Z_{k3}^{H,*} + 2\sqrt{2}T_\kappa^* Z_{j3}^{H,*} Z_{k3}^{H,*} \\
& \left. + \lambda^* \left( -2Z_{j3}^{H,*} \left( (-2v_d\lambda + v_u\kappa) Z_{k1}^{H,*} + (-2v_u\lambda + v_d\kappa) Z_{k2}^{H,*} \right) \right. \right. \\
& + Z_{j1}^{H,*} \left( -2 \left( -2v_d\lambda + v_u\kappa \right) Z_{k3}^{H,*} + 2 \left( 2v_s\lambda + \sqrt{2}\mu \right) Z_{k1}^{H,*} - \left( 2v_s\kappa + \sqrt{2}M_S \right) Z_{k2}^{H,*} \right) \\
& + Z_{j2}^{H,*} \left( 2 \left( 2v_s\lambda + \sqrt{2}\mu \right) Z_{k2}^{H,*} - 2 \left( -2v_u\lambda + v_d\kappa \right) Z_{k3}^{H,*} - \left( 2v_s\kappa + \sqrt{2}M_S \right) Z_{k1}^{H,*} \right) \\
& + 2\sqrt{2}Z_{j3}^{H,*} Z_{k3}^{H,*} T_\kappa - \sqrt{2}Z_{j2}^{H,*} Z_{k1}^{H,*} T_\lambda - \sqrt{2}Z_{j1}^{H,*} Z_{k2}^{H,*} T_\lambda \left. \right) \\
& - Z_{i2}^{H,*} \left( Z_{j2}^{H,*} \left( -2 \left( 2v_s|\lambda|^2 + \sqrt{2}\lambda\mu^* + \sqrt{2}\mu\lambda^* \right) Z_{k3}^{H,*} - 3 \left( g_1^2 + g_2^2 \right) v_u Z_{k2}^{H,*} + v_d \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k1}^{H,*} \right) \right. \\
& + Z_{j3}^{H,*} \left( \sqrt{2}\lambda M_S^* Z_{k1}^{H,*} + \sqrt{2}M_S\lambda^* Z_{k1}^{H,*} + 2v_s\kappa\lambda^* Z_{k1}^{H,*} + \sqrt{2}T_\lambda^* Z_{k1}^{H,*} - 4v_s|\lambda|^2 Z_{k2}^{H,*} \right. \\
& - 2\sqrt{2}\mu\lambda^* Z_{k2}^{H,*} - 2\sqrt{2}\lambda\mu^* Z_{k2}^{H,*} - 4v_u|\lambda|^2 Z_{k3}^{H,*} + 2v_d\kappa\lambda^* Z_{k3}^{H,*} \\
& \left. + 2\lambda\kappa^* \left( v_d Z_{k3}^{H,*} + v_s Z_{k1}^{H,*} \right) + \sqrt{2}Z_{k1}^{H,*} T_\lambda \right) \\
& + Z_{j1}^{H,*} \left( v_u \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k1}^{H,*} + v_d \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k2}^{H,*} \right. \\
& \left. + Z_{k3}^{H,*} \left( 2v_s\kappa\lambda^* + 2v_s\lambda\kappa^* + \sqrt{2}\lambda M_S^* + \sqrt{2}M_S\lambda^* + \sqrt{2}T_\lambda + \sqrt{2}T_\lambda^* \right) \right) \\
& + Z_{i1}^{H,*} \left( Z_{j1}^{H,*} \left( 2 \left( 2v_s|\lambda|^2 + \sqrt{2}\lambda\mu^* + \sqrt{2}\mu\lambda^* \right) Z_{k3}^{H,*} + 3 \left( g_1^2 + g_2^2 \right) v_d Z_{k1}^{H,*} - v_u \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k2}^{H,*} \right) \right. \\
& + Z_{j3}^{H,*} \left( 2\sqrt{2}\lambda\mu^* Z_{k1}^{H,*} - \sqrt{2}\lambda M_S^* Z_{k2}^{H,*} - 2v_s\lambda\kappa^* Z_{k2}^{H,*} - \sqrt{2}T_\lambda^* Z_{k2}^{H,*} - 2v_u\lambda\kappa^* Z_{k3}^{H,*} \right. \\
& \left. + \lambda^* \left( -2 \left( -2v_d\lambda + v_u\kappa \right) Z_{k3}^{H,*} + 2 \left( 2v_s\lambda + \sqrt{2}\mu \right) Z_{k1}^{H,*} - \left( 2v_s\kappa + \sqrt{2}M_S \right) Z_{k2}^{H,*} \right) - \sqrt{2}Z_{k2}^{H,*} T_\lambda \right) \\
& - Z_{j2}^{H,*} \left( v_u \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k1}^{H,*} + v_d \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k2}^{H,*} \right. \\
& \left. + Z_{k3}^{H,*} \left( 2v_s\kappa\lambda^* + 2v_s\lambda\kappa^* + \sqrt{2}\lambda M_S^* + \sqrt{2}M_S\lambda^* + \sqrt{2}T_\lambda + \sqrt{2}T_\lambda^* \right) \right) \left. \right) \left. \right) \left. \right) \tag{212}
\end{aligned}$$



$$\begin{aligned}
& -\frac{i}{4} \left( Z_{i2}^{H,*} \left( Z_{j2}^+ \left( (g_1^2 + g_2^2) v_u Z_{k2}^+ + v_d (-2|\lambda|^2 + g_2^2) Z_{k1}^+ \right) \right. \right. \\
& + Z_{j1}^+ \left( (-g_1^2 + g_2^2) v_u Z_{k1}^+ + v_d (-2|\lambda|^2 + g_2^2) Z_{k2}^+ \right) \\
& + Z_{i1}^{H,*} \left( Z_{j2}^+ \left( (-g_1^2 + g_2^2) v_d Z_{k2}^+ + v_u (-2|\lambda|^2 + g_2^2) Z_{k1}^+ \right) \right. \\
& + Z_{j1}^+ \left( (g_1^2 + g_2^2) v_d Z_{k1}^+ + v_u (-2|\lambda|^2 + g_2^2) Z_{k2}^+ \right) \\
& + 2Z_{i3}^{H,*} \left( \sqrt{2} T_\lambda^* Z_{j2}^+ Z_{k1}^+ + \sqrt{2} \lambda M_S^* Z_{j1}^+ Z_{k2}^+ + 2v_s \lambda \kappa^* Z_{j1}^+ Z_{k2}^+ + \sqrt{2} T_\lambda Z_{j1}^+ Z_{k2}^+ \right. \\
& + \sqrt{2} \lambda \mu^* \left( Z_{j1}^+ Z_{k1}^+ + Z_{j2}^+ Z_{k2}^+ \right) \\
& \left. \left. + \lambda^* \left( (2v_s \lambda + \sqrt{2} \mu) Z_{j1}^+ Z_{k1}^+ + Z_{j2}^+ \left( (2v_s \kappa + \sqrt{2} M_S) Z_{k1}^+ + (2v_s \lambda + \sqrt{2} \mu) Z_{k2}^+ \right) \right) \right) \right) \quad (213)
\end{aligned}$$

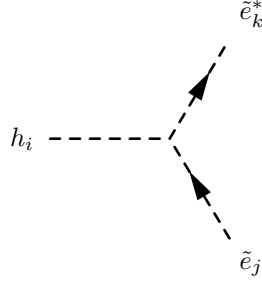

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$$\begin{aligned}
& \frac{i}{12} \delta_{\beta\gamma} \left( 6v_u Z_{i3}^{H,*} \left( \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{kb}^D + \lambda^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \right) \right. \\
& + Z_{i2}^{H,*} \left( - (3g_2^2 + g_1^2) v_u \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D - 2g_1^2 v_u \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{k3+a}^D \right. \\
& \left. + 6 \left( v_s \lambda^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D + \sqrt{2} \mu^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \right) \right)
\end{aligned}$$

$$\begin{aligned}
& + \left( \sqrt{2}\mu + v_s\lambda \right) \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{kb}^D \bigg) \\
& + Z_{i1}^{H,*} \left( \left( 3g_2^2 + g_1^2 \right) v_d \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \right. \\
& + 2 \left( g_1^2 v_d \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{k3+a}^D \right. \\
& - 3 \left( \sqrt{2} \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Z_{k3+a}^D T_{d,ab} + \sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{D,*} T_{d,ab}^* Z_{kb}^D \right. \\
& \left. \left. \left. + 2v_d \left( \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{d,ba} Z_{k3+b}^D + \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{kc}^D \right) \right) \right) \bigg) \bigg) \quad (214)
\end{aligned}$$

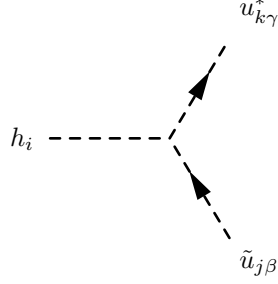

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$$\begin{aligned}
& \frac{i}{4} \left( 2v_u Z_{i3}^{H,*} \left( \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{kb}^E + \lambda^* \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \right) \right. \\
& + Z_{i2}^{H,*} \left( \left(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

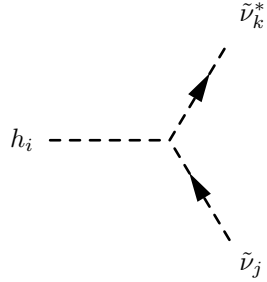
$$+ 4v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{kc}^E \Big) \Big) \quad (215)$$


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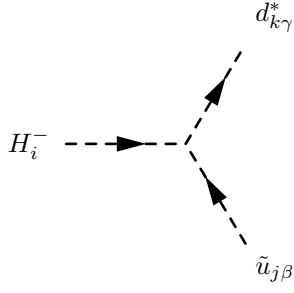
$$\begin{aligned} & \frac{i}{12} \delta_{\beta\gamma} \left( 6v_d Z_{i3}^{H,*} \left( \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{j3+a}^{U,*} Z_{kb}^U + \lambda^* \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U \right) \right. \\ & + Z_{i1}^{H,*} \left( \left( -3g_2^2 + g_1^2 \right) v_d \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U - 4g_1^2 v_d \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \right. \\ & + 6 \left( v_s \lambda^* \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U + \sqrt{2} \mu^* \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U \right. \\ & \left. \left. + \left( \sqrt{2} \mu + v_s \lambda \right) \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{j3+a}^{U,*} Z_{kb}^U \right) \right) \\ & - Z_{i2}^{H,*} \left( \left( -3g_2^2 + g_1^2 \right) v_u \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U - 4g_1^2 v_u \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \right. \\ & + 6 \left( \sqrt{2} \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Z_{k3+a}^U T_{u,ab} + \sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{U,*} T_{u,ab}^* Z_{kb}^U \right. \\ & \left. \left. + 2v_u \left( \sum_{c=1}^3 Z_{j3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{u,ba} Z_{k3+b}^U + \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{kc}^U \right) \right) \right) \Big) \Big) \quad (216) \end{aligned}$$


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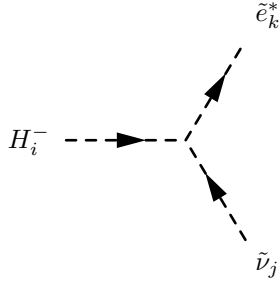




$$-\frac{i}{4}(g_1^2 + g_2^2)(v_d Z_{i1}^{H,*} - v_u Z_{i2}^{H,*})\delta_{jk} \quad (217)$$

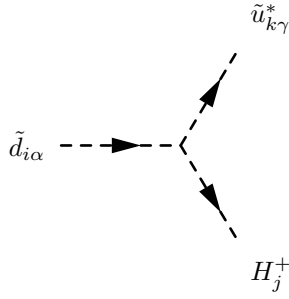


$$\begin{aligned}
& -\frac{i}{4}\delta_{\beta\gamma}\left(\sqrt{2}g_2^2\sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^D(v_d Z_{i1}^+ + v_u Z_{i2}^+)\right. \\
& -2\left(2\sum_{b=1}^3 Z_{jb}^{U,*}\sum_{a=1}^3 Z_{k3+a}^D T_{d,ab} Z_{i1}^+ + (2\mu + \sqrt{2}v_s\lambda)\sum_{b=1}^3\sum_{a=1}^3 Y_{u,ab} Z_{j3+a}^{U,*} Z_{kb}^D Z_{i1}^+\right. \\
& +\sqrt{2}v_u\sum_{c=1}^3 Z_{j3+c}^{U,*}\sum_{b=1}^3\sum_{a=1}^3 Y_{u,ca}^* Y_{d,ba} Z_{k3+b}^D Z_{i1}^+ \\
& +\sqrt{2}v_d\sum_{c=1}^3\sum_{b=1}^3 Z_{jb}^{U,*}\sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{kc}^D Z_{i1}^+ +\sqrt{2}v_s\lambda^*\sum_{b=1}^3 Z_{jb}^{U,*}\sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D Z_{i2}^+ \\
& +2\mu^*\sum_{b=1}^3 Z_{jb}^{U,*}\sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D Z_{i2}^+ +2\sum_{b=1}^3\sum_{a=1}^3 Z_{j3+a}^{U,*} T_{u,ab}^* Z_{kb}^D Z_{i2}^+ \\
& +\sqrt{2}v_d\sum_{c=1}^3 Z_{j3+c}^{U,*}\sum_{b=1}^3\sum_{a=1}^3 Y_{u,ca}^* Y_{d,ba} Z_{k3+b}^D Z_{i2}^+ \\
& \left. +\sqrt{2}v_u\sum_{c=1}^3\sum_{b=1}^3 Z_{jb}^{U,*}\sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{kc}^D Z_{i2}^+\right) \quad (218)
\end{aligned}$$



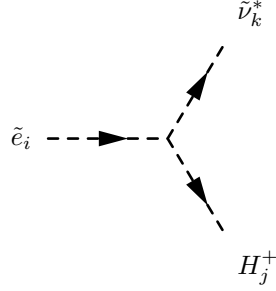
$$\begin{aligned}
& -\frac{i}{4}\left(\sqrt{2}g_2^2\sum_{a=1}^3Z_{ja}^{V,*}Z_{ka}^E\left(v_dZ_{i1}^+ + v_uZ_{i2}^+\right)\right. \\
& - 2\left(2\sum_{b=1}^3Z_{jb}^{V,*}\sum_{a=1}^3Z_{k3+a}^ET_{e,ab}Z_{i1}^+ + \sqrt{2}v_d\sum_{c=1}^3\sum_{b=1}^3Z_{jb}^{V,*}\sum_{a=1}^3Y_{e,ac}^*Y_{e,ab}Z_{kc}^EZ_{i1}^+\right. \\
& \left. + \left(2\mu^* + \sqrt{2}v_s\lambda^*\right)\sum_{b=1}^3Z_{jb}^{V,*}\sum_{a=1}^3Y_{e,ab}Z_{k3+a}^EZ_{i2}^+\right)\left.\right) \tag{219}
\end{aligned}$$


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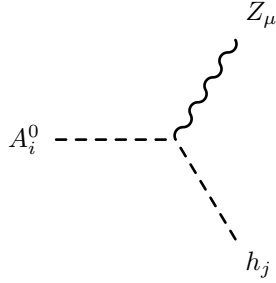
$$\begin{aligned}
& -\frac{i}{4}\delta_{\alpha\gamma}\left(\sqrt{2}g_2^2\sum_{a=1}^3Z_{ia}^{D,*}Z_{ka}^U\left(v_dZ_{j1}^+ + v_uZ_{j2}^+\right)\right. \\
& - 2\left(\sqrt{2}v_s\lambda^*\sum_{b=1}^3Z_{ib}^{D,*}\sum_{a=1}^3Y_{u,ab}Z_{k3+a}^UZ_{j1}^+ + 2\mu^*\sum_{b=1}^3Z_{ib}^{D,*}\sum_{a=1}^3Y_{u,ab}Z_{k3+a}^UZ_{j1}^+\right. \\
& + 2\sum_{b=1}^3\sum_{a=1}^3Z_{i3+a}^{D,*}T_{d,ab}^*Z_{kb}^UZ_{j1}^+ + \sqrt{2}v_u\sum_{c=1}^3Z_{i3+c}^{D,*}\sum_{b=1}^3\sum_{a=1}^3Y_{d,ca}^*Y_{u,ba}Z_{k3+b}^UZ_{j1}^+ \\
& + \sqrt{2}v_d\sum_{c=1}^3\sum_{b=1}^3Z_{ib}^{D,*}\sum_{a=1}^3Y_{d,ac}^*Y_{d,ab}Z_{kc}^UZ_{j1}^+ + 2\sum_{b=1}^3Z_{ib}^{D,*}\sum_{a=1}^3Z_{k3+a}^UT_{u,ab}Z_{j2}^+ \\
& + \sqrt{2}v_s\lambda\sum_{b=1}^3\sum_{a=1}^3Y_{d,ab}^*Z_{i3+a}^{D,*}Z_{kb}^UZ_{j2}^+ + 2\mu\sum_{b=1}^3\sum_{a=1}^3Y_{d,ab}^*Z_{i3+a}^{D,*}Z_{kb}^UZ_{j2}^+ \\
& + \sqrt{2}v_d\sum_{c=1}^3Z_{i3+c}^{D,*}\sum_{b=1}^3\sum_{a=1}^3Y_{d,ca}^*Y_{u,ba}Z_{k3+b}^UZ_{j2}^+ \\
& \left. + \sqrt{2}v_u\sum_{c=1}^3\sum_{b=1}^3Z_{ib}^{D,*}\sum_{a=1}^3Y_{u,ac}^*Y_{u,ab}Z_{kc}^UZ_{j2}^+\right)\left.\right) \tag{220}
\end{aligned}$$


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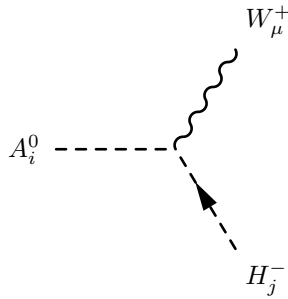


$$\begin{aligned}
& -\frac{i}{4} \left( \sqrt{2} g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^V (v_d Z_{j1}^+ + v_u Z_{j2}^+) \right. \\
& - 2 \left( 2 \sum_{b=1}^3 \sum_{a=1}^3 Z_{i3+a}^{E,*} T_{e,ab}^* Z_{kb}^V Z_{j1}^+ + \sqrt{2} v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{kc}^V Z_{j1}^+ \right. \\
& \left. \left. + (2\mu + \sqrt{2} v_s \lambda) \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{i3+a}^{E,*} Z_{kb}^V Z_{j2}^+ \right) \right) \quad (221)
\end{aligned}$$

## 9.2 Two Scalar-One Vector Boson-Interaction

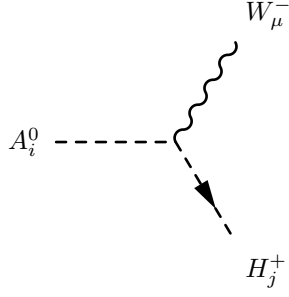


$$\frac{1}{2} \left( Z_{i1}^{A,*} Z_{j1}^{H,*} - Z_{i2}^{A,*} Z_{j2}^{H,*} \right) (g_1 \sin \Theta_W + g_2 \cos \Theta_W) \left( -p_\mu^{h_j} + p_\mu^{A_i^0} \right) \quad (222)$$



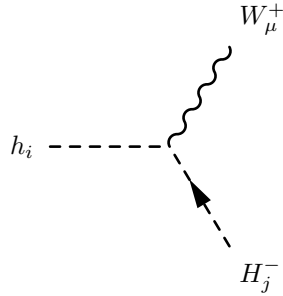
$$\frac{1}{2}g_2\left(Z_{i1}^{A,*}Z_{j1}^+ + Z_{i2}^{A,*}Z_{j2}^+\right)\left(-p_\mu^{H_j^-} + p_\mu^{A_i^0}\right) \quad (223)$$


---



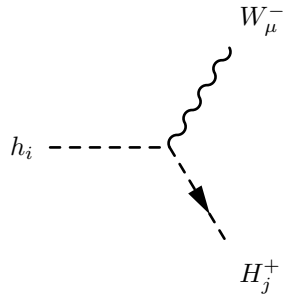
$$\frac{1}{2}g_2\left(Z_{i1}^{A,*}Z_{j1}^+ + Z_{i2}^{A,*}Z_{j2}^+\right)\left(-p_\mu^{H_j^+} + p_\mu^{A_i^0}\right) \quad (224)$$


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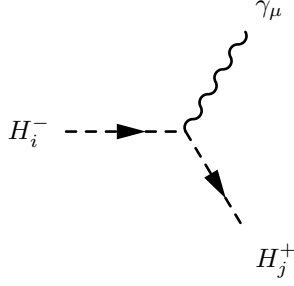
$$\frac{i}{2}g_2\left(Z_{i1}^{H,*}Z_{j1}^+ - Z_{i2}^{H,*}Z_{j2}^+\right)\left(-p_\mu^{H_j^-} + p_\mu^{h_i}\right) \quad (225)$$


---



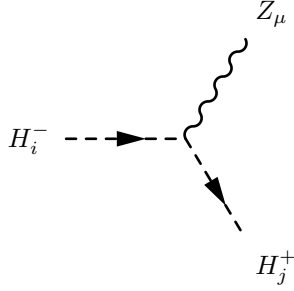
$$-\frac{i}{2}g_2\left(Z_{i1}^{H,*}Z_{j1}^+ - Z_{i2}^{H,*}Z_{j2}^+\right)\left(-p_\mu^{H_j^+} + p_\mu^{h_i}\right) \quad (226)$$


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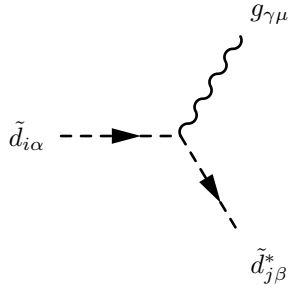
$$\frac{i}{2} \left( g_1 \cos \Theta_W + g_2 \sin \Theta_W \right) \left( Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+ \right) \left( -p_\mu^{H_j^+} + p_\mu^{H_i^-} \right) \quad (227)$$


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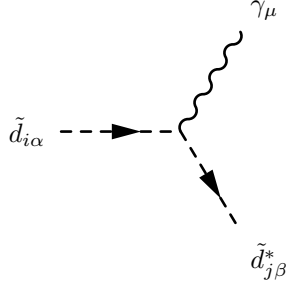
$$\frac{i}{2} \left( -g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left( Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+ \right) \left( -p_\mu^{H_j^+} + p_\mu^{H_i^-} \right) \quad (228)$$


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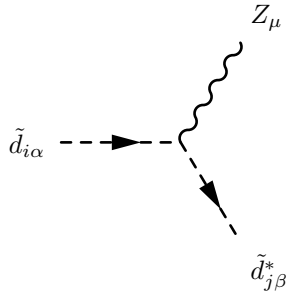
$$-\frac{i}{2} g_3 \delta_{ij} \lambda_{\beta,\alpha}^\gamma \left( -p_\mu^{\tilde{d}_{j\beta}^*} + p_\mu^{\tilde{d}_{i\alpha}} \right) \quad (229)$$


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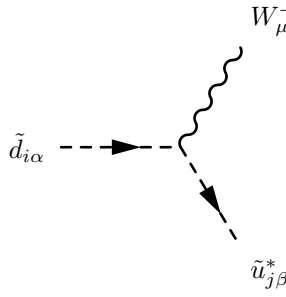
$$-\frac{i}{6}\delta_{\alpha\beta}\left(-2g_1\cos\Theta_W\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{j3+a}^D+\left(-3g_2\sin\Theta_W+g_1\cos\Theta_W\right)\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^D\right)\left(-p_\mu^{\tilde{d}_{j\beta}^*}+p_\mu^{\tilde{d}_{i\alpha}}\right) \quad (230)$$


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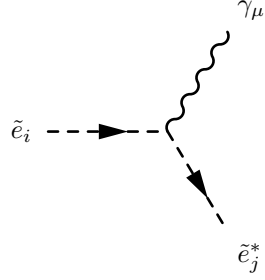
$$\frac{i}{6}\delta_{\alpha\beta}\left(-2g_1\sin\Theta_W\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{j3+a}^D+\left(3g_2\cos\Theta_W+g_1\sin\Theta_W\right)\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^D\right)\left(-p_\mu^{\tilde{d}_{j\beta}^*}+p_\mu^{\tilde{d}_{i\alpha}}\right) \quad (231)$$


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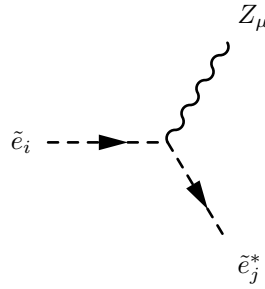
$$-i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^U\left(-p_\mu^{\tilde{u}_{j\beta}^*}+p_\mu^{\tilde{d}_{i\alpha}}\right) \quad (232)$$


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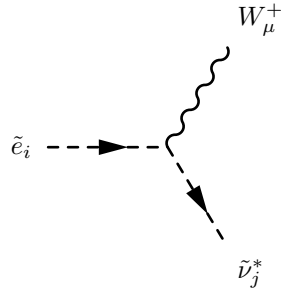
$$\frac{i}{2} \left( 2g_1 \cos \Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E + \left( g_1 \cos \Theta_W + g_2 \sin \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right) \left( -p_\mu^{\tilde{e}_j^*} + p_\mu^{\tilde{e}_i} \right) \quad (233)$$


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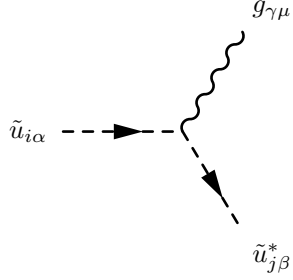
$$\frac{i}{2} \left( -2g_1 \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E + \left( -g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right) \left( -p_\mu^{\tilde{e}_j^*} + p_\mu^{\tilde{e}_i} \right) \quad (234)$$


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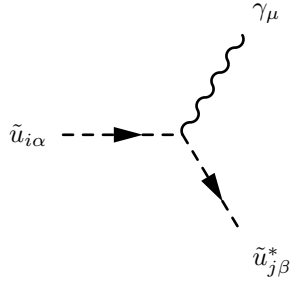
$$-i \frac{1}{\sqrt{2}} g_2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^V \left( -p_\mu^{\tilde{\nu}_j^*} + p_\mu^{\tilde{e}_i} \right) \quad (235)$$


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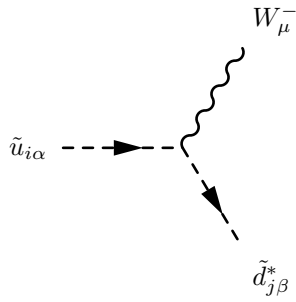
$$-\frac{i}{2}g_3\delta_{ij}\lambda_{\beta,\alpha}^{\gamma}\left(-p_{\mu}^{\tilde{u}_{j\beta}^*}+p_{\mu}^{\tilde{u}_{i\alpha}}\right) \quad (236)$$


---



$$-\frac{i}{6}\delta_{\alpha,\beta}\left(\left(3g_2\sin\Theta_W+g_1\cos\Theta_W\right)\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^U+4g_1\cos\Theta_W\sum_{a=1}^3Z_{i3+a}^{U,*}Z_{j3+a}^U\right)\left(-p_{\mu}^{\tilde{u}_{j\beta}^*}+p_{\mu}^{\tilde{u}_{i\alpha}}\right) \quad (237)$$

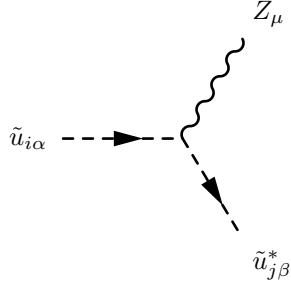

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$$-i\frac{1}{\sqrt{2}}g_2\delta_{\alpha,\beta}\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^D\left(-p_{\mu}^{\tilde{d}_{j\beta}^*}+p_{\mu}^{\tilde{u}_{i\alpha}}\right) \quad (238)$$

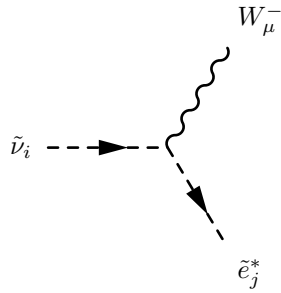

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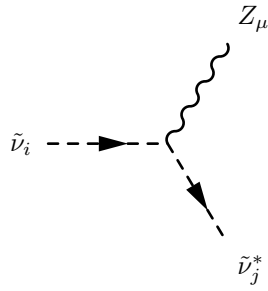
$$-\frac{i}{6}\delta_{\alpha\beta}\left(\left(3g_2\cos\Theta_W-g_1\sin\Theta_W\right)\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^U-4g_1\sin\Theta_W\sum_{a=1}^3Z_{i3+a}^{U,*}Z_{j3+a}^U\right)\left(-p_\mu^{\tilde{u}_{j\beta}^*}+p_\mu^{\tilde{u}_{i\alpha}}\right) \quad (239)$$


---



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

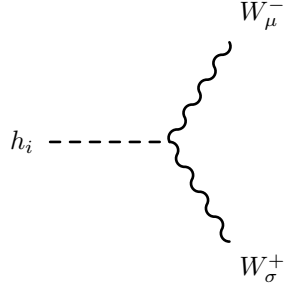

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$$-\frac{i}{2}\delta_{ij}\left(g_1\sin\Theta_W+g_2\cos\Theta_W\right)\left(-p_\mu^{\tilde{\nu}_j^*}+p_\mu^{\tilde{\nu}_i}\right) \quad (241)$$

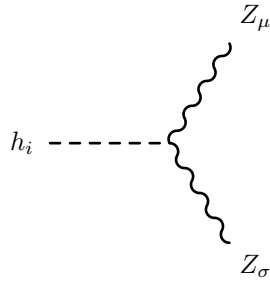

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### 9.3 One Scalar-Two Vector Boson-Interaction



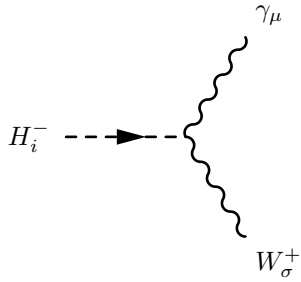
$$\frac{i}{2}g_2^2(v_d Z_{i1}^{H,*} + v_u Z_{i2}^{H,*})(g_{\sigma\mu}) \quad (242)$$


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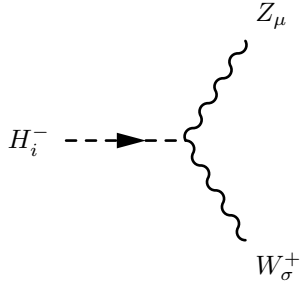
$$\frac{i}{2}(v_d Z_{i1}^{H,*} + v_u Z_{i2}^{H,*})(g_1 \sin \Theta_W + g_2 \cos \Theta_W)^2 (g_{\sigma\mu}) \quad (243)$$


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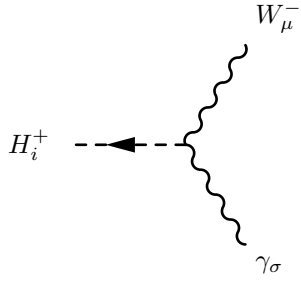
$$-\frac{i}{2}g_1 g_2 \cos \Theta_W (v_d Z_{i1}^+ - v_u Z_{i2}^+)(g_{\sigma\mu}) \quad (244)$$


---



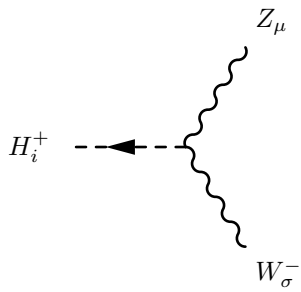
$$\frac{i}{2} g_1 g_2 \sin \Theta_W (v_d Z_{i1}^+ - v_u Z_{i2}^+) (g_{\sigma\mu}) \quad (245)$$


---



$$-\frac{i}{2} g_1 g_2 \cos \Theta_W (v_d Z_{i1}^+ - v_u Z_{i2}^+) (g_{\sigma\mu}) \quad (246)$$

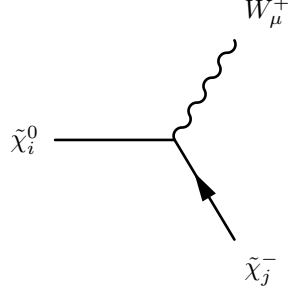

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$$\frac{i}{2} g_1 g_2 \sin \Theta_W (v_d Z_{i1}^+ - v_u Z_{i2}^+) (g_{\sigma\mu}) \quad (247)$$


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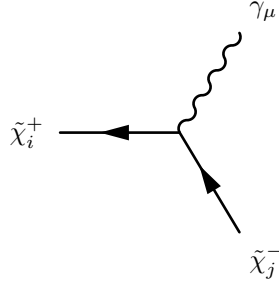
## 9.4 Two Fermion-One Vector Boson-Interaction



$$-\frac{i}{2}g_2\left(2U_{j1}^*N_{i2} + \sqrt{2}U_{j2}^*N_{i3}\right)\left(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\right) \quad (248)$$

$$+ \left(i\frac{1}{\sqrt{2}}g_2N_{i4}^*V_{j2} - ig_2N_{i2}^*V_{j1}\right)\left(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\right) \quad (249)$$

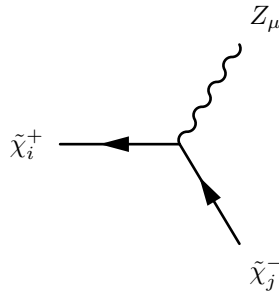

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$$\frac{i}{2}\left(2g_2U_{j1}^*\sin\Theta_W U_{i1} + U_{j2}^*\left(g_1\cos\Theta_W + g_2\sin\Theta_W\right)U_{i2}\right)\left(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\right) \quad (250)$$

$$+ \frac{i}{2}\left(2g_2V_{i1}^*\sin\Theta_W V_{j1} + V_{i2}^*\left(g_1\cos\Theta_W + g_2\sin\Theta_W\right)V_{j2}\right)\left(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\right) \quad (251)$$

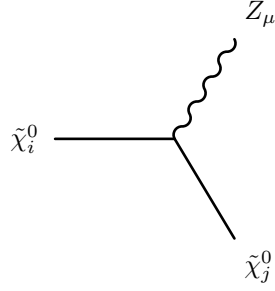

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$$\frac{i}{2} \left( 2g_2 U_{j1}^* \cos \Theta_W U_{i1} + U_{j2}^* \left( -g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) U_{i2} \right) \left( \gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (252)$$

$$+ \frac{i}{2} \left( 2g_2 V_{i1}^* \cos \Theta_W V_{j1} + V_{i2}^* \left( -g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) V_{j2} \right) \left( \gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (253)$$

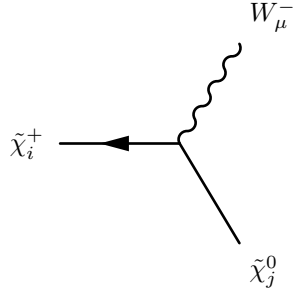

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$$- \frac{i}{2} \left( g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left( N_{j3}^* N_{i3} - N_{j4}^* N_{i4} \right) \left( \gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (254)$$

$$+ \frac{i}{2} \left( g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left( N_{i3}^* N_{j3} - N_{i4}^* N_{j4} \right) \left( \gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (255)$$

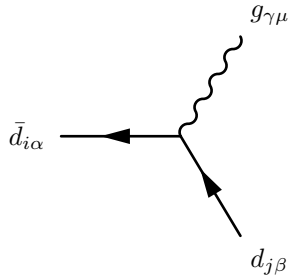

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$$- \frac{i}{2} g_2 \left( 2N_{j2}^* U_{i1} + \sqrt{2} N_{j3}^* U_{i2} \right) \left( \gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (256)$$

$$+ \left( i \frac{1}{\sqrt{2}} g_2 V_{i2}^* N_{j4} - i g_2 V_{i1}^* N_{j2} \right) \left( \gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (257)$$

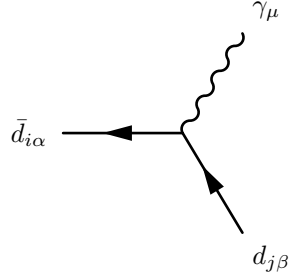

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$$-\frac{i}{2}g_3\delta_{ij}\lambda_{\alpha,\beta}^\gamma\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (258)$$

$$+\frac{i}{2}g_3\delta_{ij}\lambda_{\alpha,\beta}^\gamma\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (259)$$

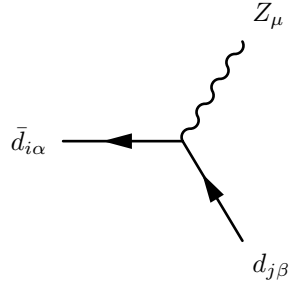

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$$-\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(-3g_2\sin\Theta_W+g_1\cos\Theta_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (260)$$

$$+\frac{i}{3}g_1\cos\Theta_W\delta_{\alpha\beta}\delta_{ij}\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (261)$$

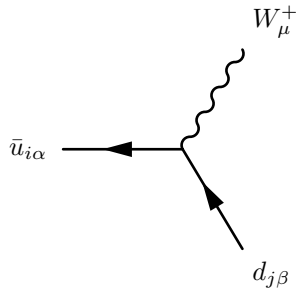

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$$\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(3g_2\cos\Theta_W+g_1\sin\Theta_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (262)$$

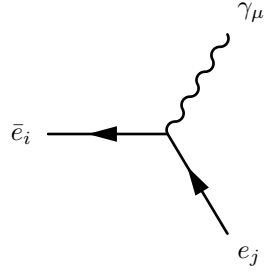
$$+\frac{i}{3}g_1\delta_{\alpha\beta}\delta_{ij}\sin\Theta_W\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (263)$$


---



$$-i \frac{1}{\sqrt{2}} g_2 \delta_{\alpha\beta} \sum_{a=1}^3 U_{L,ja}^{d,*} U_{L,ia}^u \left( \gamma_\mu \cdot \frac{1-\gamma_5}{2} \right) \quad (264)$$

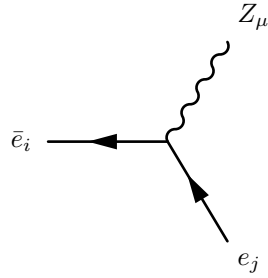

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$$\frac{i}{2} \delta_{ij} \left( g_1 \cos \Theta_W + g_2 \sin \Theta_W \right) \left( \gamma_\mu \cdot \frac{1-\gamma_5}{2} \right) \quad (265)$$

$$+ i g_1 \cos \Theta_W \delta_{ij} \left( \gamma_\mu \cdot \frac{1+\gamma_5}{2} \right) \quad (266)$$

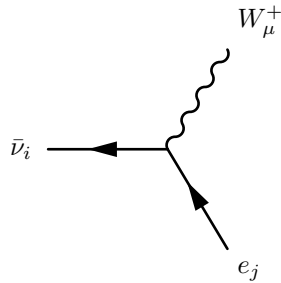

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$$\frac{i}{2} \delta_{ij} \left( -g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left( \gamma_\mu \cdot \frac{1-\gamma_5}{2} \right) \quad (267)$$

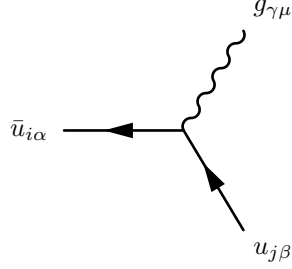
$$+ -i g_1 \delta_{ij} \sin \Theta_W \left( \gamma_\mu \cdot \frac{1+\gamma_5}{2} \right) \quad (268)$$


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$$-i \frac{1}{\sqrt{2}} g_2 U_{L,ji}^{e,*} \Theta_{i,3} \left( \gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (269)$$

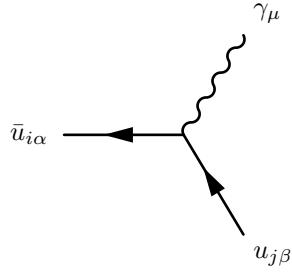

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$$- \frac{i}{2} g_3 \delta_{ij} \lambda_{\alpha,\beta}^\gamma \left( \gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (270)$$

$$+ - \frac{i}{2} g_3 \delta_{ij} \lambda_{\alpha,\beta}^\gamma \left( \gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (271)$$

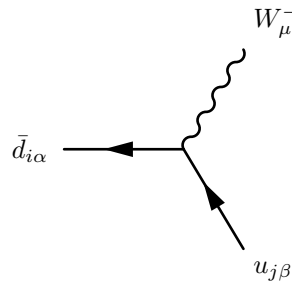

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$$- \frac{i}{6} \delta_{\alpha\beta} \delta_{ij} \left( 3g_2 \sin \Theta_W + g_1 \cos \Theta_W \right) \left( \gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (272)$$

$$+ - \frac{2i}{3} g_1 \cos \Theta_W \delta_{\alpha\beta} \delta_{ij} \left( \gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (273)$$

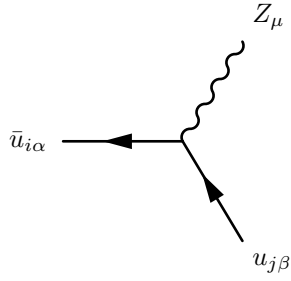

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$$-i \frac{1}{\sqrt{2}} g_2 \delta_{\alpha\beta} \sum_{a=1}^3 U_{L,ja}^{u,*} U_{L,ia}^d \left( \gamma_\mu \cdot \frac{1-\gamma_5}{2} \right) \quad (274)$$

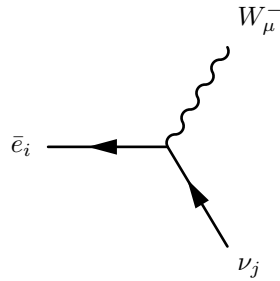

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$$-\frac{i}{6} \delta_{\alpha\beta} \delta_{ij} \left( 3g_2 \cos \Theta_W - g_1 \sin \Theta_W \right) \left( \gamma_\mu \cdot \frac{1-\gamma_5}{2} \right) \quad (275)$$

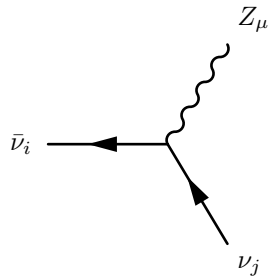
$$+\frac{2i}{3} g_1 \delta_{\alpha\beta} \delta_{ij} \sin \Theta_W \left( \gamma_\mu \cdot \frac{1+\gamma_5}{2} \right) \quad (276)$$


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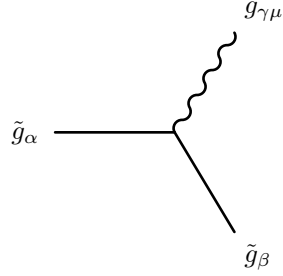
$$-i \frac{1}{\sqrt{2}} g_2 \Theta_{j,3} U_{L,ij}^e \left( \gamma_\mu \cdot \frac{1-\gamma_5}{2} \right) \quad (277)$$


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$$-\frac{i}{2}\delta_{ij}\left(g_1\sin\Theta_W+g_2\cos\Theta_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (278)$$


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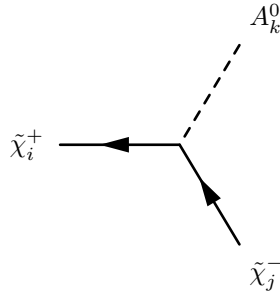


$$-g_3|\phi_{\tilde{g}}|^2 f_{\alpha,\beta,\gamma}\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (279)$$

$$+g_3|\phi_{\tilde{g}}|^2 f_{\alpha,\beta,\gamma}\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (280)$$


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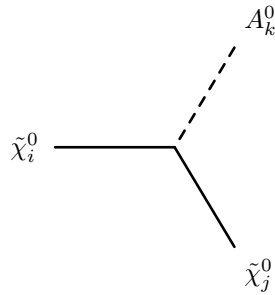
## 9.5 Two Fermion-One Scalar Boson-Interaction



$$\frac{1}{\sqrt{2}}\left(-g_2U_{j1}^*V_{i2}Z_{k2}^{A,*}+U_{j2}^*\left(-g_2V_{i1}^*Z_{k1}^{A,*}+\lambda V_{i2}^*Z_{k3}^{A,*}\right)\right)\left(\frac{1-\gamma_5}{2}\right) \quad (281)$$

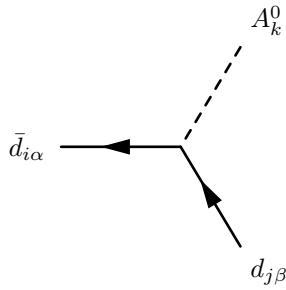
$$+\frac{1}{\sqrt{2}}\left(g_2Z_{k1}^{A,*}U_{i2}V_{j1}+\left(g_2Z_{k2}^{A,*}U_{i1}-\lambda^*Z_{k3}^{A,*}U_{i2}\right)V_{j2}\right)\left(\frac{1+\gamma_5}{2}\right) \quad (282)$$


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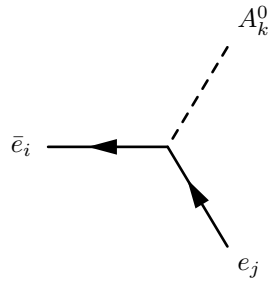
$$\begin{aligned}
& \frac{1}{2} \left( -Z_{k2}^{A,*} \left( g_1 N_{i1}^* N_{j4}^* - g_2 N_{i2}^* N_{j4}^* + N_{i4}^* \left( g_1 N_{j1}^* - g_2 N_{j2}^* \right) + \sqrt{2} \lambda N_{i3}^* N_{j5}^* + \sqrt{2} \lambda N_{i5}^* N_{j3}^* \right) \right. \\
& + Z_{k1}^{A,*} \left( g_1 N_{i1}^* N_{j3}^* - g_2 N_{i2}^* N_{j3}^* + N_{i3}^* \left( g_1 N_{j1}^* - g_2 N_{j2}^* \right) - \sqrt{2} \lambda N_{i4}^* N_{j5}^* - \sqrt{2} \lambda N_{i5}^* N_{j4}^* \right) \\
& \left. - \sqrt{2} Z_{k3}^{A,*} \left( -2\kappa N_{i5}^* N_{j5}^* + \lambda N_{i3}^* N_{j4}^* + \lambda N_{i4}^* N_{j3}^* \right) \right) \left( \frac{1-\gamma_5}{2} \right) \tag{283}
\end{aligned}$$

$$\begin{aligned}
& + \frac{1}{2} \left( Z_{k1}^{A,*} \left( -g_1 N_{i1} N_{j3} + g_2 N_{i2} N_{j3} + N_{i3} \left( -g_1 N_{j1} + g_2 N_{j2} \right) + \sqrt{2} \lambda^* N_{i4} N_{j5} + \sqrt{2} \lambda^* N_{i5} N_{j4} \right) \right. \\
& + \sqrt{2} Z_{k3}^{A,*} \left( -2\kappa^* N_{i5} N_{j5} + \lambda^* \left( N_{i3} N_{j4} + N_{i4} N_{j3} \right) \right) \\
& \left. + Z_{k2}^{A,*} \left( \left( g_1 N_{i1} - g_2 N_{i2} \right) N_{j4} + N_{i4} \left( g_1 N_{j1} - g_2 N_{j2} \right) + \sqrt{2} \lambda^* \left( N_{i3} N_{j5} + N_{i5} N_{j3} \right) \right) \right) \left( \frac{1+\gamma_5}{2} \right) \tag{284}
\end{aligned}$$



$$\frac{1}{\sqrt{2}} Z_{k1}^{A,*} \delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{d,*} \sum_{a=1}^3 U_{R,ia}^{d,*} Y_{d,ab} \left( \frac{1-\gamma_5}{2} \right) \tag{285}$$

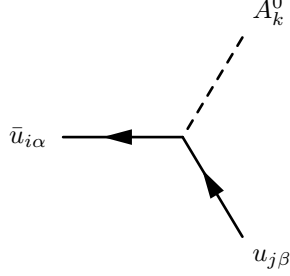
$$+ -\frac{1}{\sqrt{2}} Z_{k1}^{A,*} \delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* U_{R,ja}^d U_{L,ib}^d \left( \frac{1+\gamma_5}{2} \right) \tag{286}$$



$$\frac{1}{\sqrt{2}} Z_{k1}^{A,*} \sum_{b=1}^3 U_{L,jb}^{e,*} \sum_{a=1}^3 U_{R,ia}^{e,*} Y_{e,ab} \left( \frac{1-\gamma_5}{2} \right) \tag{287}$$

$$+ -\frac{1}{\sqrt{2}}Z_{k1}^{A,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* U_{R,ja}^e U_{L,ib}^e \left(\frac{1+\gamma_5}{2}\right) \quad (288)$$

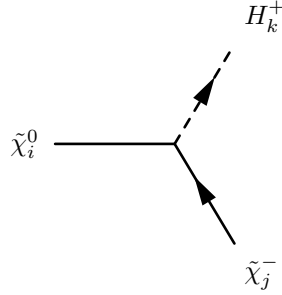

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$$\frac{1}{\sqrt{2}}Z_{k2}^{A,*} \delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{u,*} \sum_{a=1}^3 U_{R,ia}^{u,*} Y_{u,ab} \left(\frac{1-\gamma_5}{2}\right) \quad (289)$$

$$+ -\frac{1}{\sqrt{2}}Z_{k2}^{A,*} \delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* U_{R,ja}^u U_{L,ib}^u \left(\frac{1+\gamma_5}{2}\right) \quad (290)$$

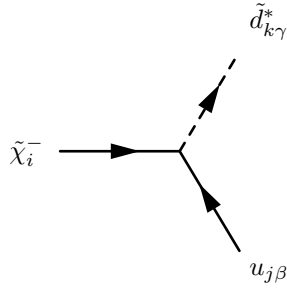

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$$\frac{i}{2} \left( -2g_2 U_{j1}^* N_{i3}^* Z_{k1}^+ + U_{j2}^* \left( -2\lambda N_{i5}^* Z_{k2}^+ + \sqrt{2}g_1 N_{i1}^* Z_{k1}^+ + \sqrt{2}g_2 N_{i2}^* Z_{k1}^+ \right) \right) \left(\frac{1-\gamma_5}{2}\right) \quad (291)$$

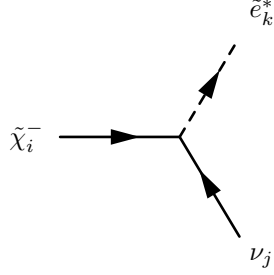
$$+ -\frac{i}{2} \left( \left( 2g_2 V_{j1} N_{i4} + \sqrt{2}V_{j2} \left( g_1 N_{i1} + g_2 N_{i2} \right) \right) Z_{k2}^+ + 2\lambda^* V_{j2} N_{i5} Z_{k1}^+ \right) \left(\frac{1+\gamma_5}{2}\right) \quad (292)$$


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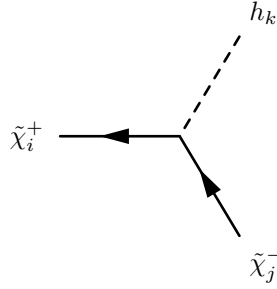


$$-i\delta_{\beta\gamma}\left(g_2U_{i1}^*\sum_{a=1}^3U_{L,ja}^{u,*}Z_{ka}^D-U_{i2}^*\sum_{b=1}^3U_{L,jb}^{u,*}\sum_{a=1}^3Y_{d,ab}Z_{k3+a}^D\right)\left(\frac{1-\gamma_5}{2}\right) \quad (293)$$

$$+i\delta_{\beta\gamma}\sum_{b=1}^3\sum_{a=1}^3Y_{u,ab}^*U_{R,ja}^uZ_{kb}^DV_{i2}\left(\frac{1+\gamma_5}{2}\right) \quad (294)$$

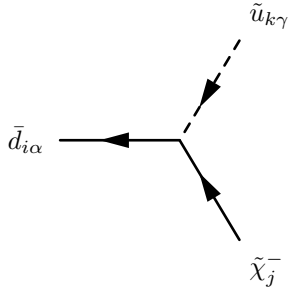


$$i\left(-g_2U_{i1}^*\Theta_{j,3}Z_{kj}^E+U_{i2}^*\sum_{a=1}^3Y_{e,aj}Z_{k3+a}^E\right)\left(\frac{1-\gamma_5}{2}\right) \quad (295)$$



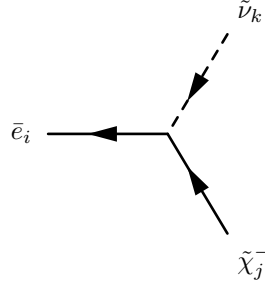
$$-i\frac{1}{\sqrt{2}}\left(g_2U_{j1}^*V_{i2}^*Z_{k2}^{H,*}+U_{j2}^*\left(g_2V_{i1}^*Z_{k1}^{H,*}+\lambda V_{i2}^*Z_{k3}^{H,*}\right)\right)\left(\frac{1-\gamma_5}{2}\right) \quad (296)$$

$$+i\frac{1}{\sqrt{2}}\left(g_2Z_{k1}^{H,*}U_{i2}V_{j1}+\left(g_2Z_{k2}^{H,*}U_{i1}+\lambda^*Z_{k3}^{H,*}U_{i2}\right)V_{j2}\right)\left(\frac{1+\gamma_5}{2}\right) \quad (297)$$



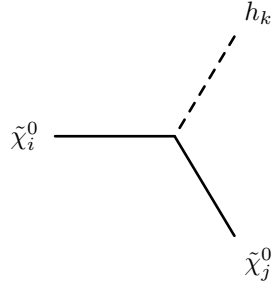
$$iU_{j2}^* \delta_{\alpha\gamma} \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 U_{R,ia}^{d,*} Y_{d,ab} \left( \frac{1-\gamma_5}{2} \right) \quad (298)$$

$$+ -i\delta_{\alpha\gamma} \left( g_2 \sum_{a=1}^3 Z_{ka}^{U,*} U_{L,ia}^d V_{j1} - \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{k3+a}^{U,*} U_{L,ib}^d V_{j2} \right) \left( \frac{1+\gamma_5}{2} \right) \quad (299)$$



$$iU_{j2}^* \sum_{b=1}^3 Z_{kb}^{V,*} \sum_{a=1}^3 U_{R,ia}^{e,*} Y_{e,ab} \left( \frac{1-\gamma_5}{2} \right) \quad (300)$$

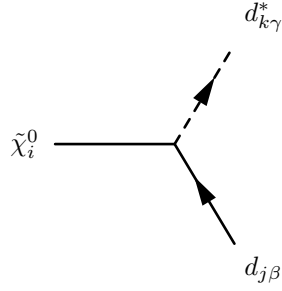
$$+ -ig_2 \sum_{a=1}^3 Z_{ka}^{V,*} U_{L,ia}^e V_{j1} \left( \frac{1+\gamma_5}{2} \right) \quad (301)$$



$$\begin{aligned} & \frac{i}{2} \left( Z_{k2}^{H,*} \left( -g_1 N_{i1}^* N_{j4}^* + g_2 N_{i2}^* N_{j4}^* + N_{i4}^* \left( -g_1 N_{j1}^* + g_2 N_{j2}^* \right) + \sqrt{2} \lambda N_{i3}^* N_{j5}^* + \sqrt{2} \lambda N_{i5}^* N_{j3}^* \right) \right. \\ & + Z_{k1}^{H,*} \left( g_1 N_{i1}^* N_{j3}^* - g_2 N_{i2}^* N_{j3}^* + N_{i3}^* \left( g_1 N_{j1}^* - g_2 N_{j2}^* \right) + \sqrt{2} \lambda N_{i4}^* N_{j5}^* + \sqrt{2} \lambda N_{i5}^* N_{j4}^* \right) \\ & + \sqrt{2} Z_{k3}^{H,*} \left( -2\kappa N_{i5}^* N_{j5}^* + \lambda N_{i3}^* N_{j4}^* + \lambda N_{i4}^* N_{j3}^* \right) \left. \right) \left( \frac{1-\gamma_5}{2} \right) \quad (302) \\ & + \frac{i}{2} \left( Z_{k1}^{H,*} \left( g_1 N_{i1} N_{j3} - g_2 N_{i2} N_{j3} + N_{i3} \left( g_1 N_{j1} - g_2 N_{j2} \right) + \sqrt{2} \lambda^* N_{i4} N_{j5} + \sqrt{2} \lambda^* N_{i5} N_{j4} \right) \right. \\ & + \sqrt{2} Z_{k3}^{H,*} \left( -2\kappa^* N_{i5} N_{j5} + \lambda^* \left( N_{i3} N_{j4} + N_{i4} N_{j3} \right) \right) \end{aligned}$$

$$+ Z_{k2}^{H,*} \left( \left( -g_1 N_{i1} + g_2 N_{i2} \right) N_{j4} + N_{i4} \left( -g_1 N_{j1} + g_2 N_{j2} \right) + \sqrt{2} \lambda^* \left( N_{i3} N_{j5} + N_{i5} N_{j3} \right) \right) \left( \frac{1 + \gamma_5}{2} \right) \quad (303)$$

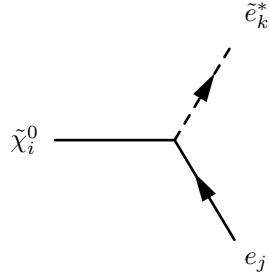

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$$- \frac{i}{6} \delta_{\beta\gamma} \left( -3\sqrt{2} g_2 N_{i2}^* \sum_{a=1}^3 U_{L,ja}^{d,*} Z_{ka}^D + 6N_{i3}^* \sum_{b=1}^3 U_{L,jb}^{d,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D + \sqrt{2} g_1 N_{i1}^* \sum_{a=1}^3 U_{L,ja}^{d,*} Z_{ka}^D \right) \left( \frac{1 - \gamma_5}{2} \right) \quad (304)$$

$$+ -\frac{i}{3} \delta_{\beta\gamma} \left( 3 \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* U_{R,ja}^d Z_{kb}^D N_{i3} + \sqrt{2} g_1 \sum_{a=1}^3 Z_{k3+a}^D U_{R,ja}^d N_{i1} \right) \left( \frac{1 + \gamma_5}{2} \right) \quad (305)$$

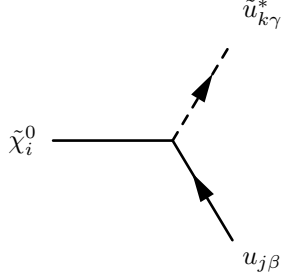

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$$\frac{i}{2} \left( -2N_{i3}^* \sum_{b=1}^3 U_{L,jb}^{e,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E + \sqrt{2} g_1 N_{i1}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{ka}^E + \sqrt{2} g_2 N_{i2}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{ka}^E \right) \left( \frac{1 - \gamma_5}{2} \right) \quad (306)$$

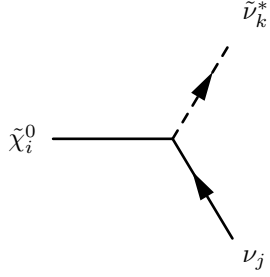
$$+ -i \left( \sqrt{2} g_1 \sum_{a=1}^3 Z_{k3+a}^E U_{R,ja}^e N_{i1} + \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* U_{R,ja}^e Z_{kb}^E N_{i3} \right) \left( \frac{1 + \gamma_5}{2} \right) \quad (307)$$


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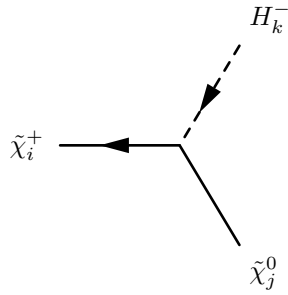


$$-\frac{i}{6}\delta_{\beta\gamma}\left(3\sqrt{2}g_2N_{i2}^*\sum_{a=1}^3U_{L,ja}^{u,*}Z_{ka}^U+6N_{i4}^*\sum_{b=1}^3U_{L,jb}^{u,*}\sum_{a=1}^3Y_{u,ab}Z_{k3+a}^U+\sqrt{2}g_1N_{i1}^*\sum_{a=1}^3U_{L,ja}^{u,*}Z_{ka}^U\right)\left(\frac{1-\gamma_5}{2}\right) \quad (308)$$

$$+\frac{i}{3}\delta_{\beta\gamma}\left(2\sqrt{2}g_1\sum_{a=1}^3Z_{k3+a}^U U_{R,ja}^u N_{i1}-3\sum_{b=1}^3\sum_{a=1}^3Y_{u,ab}^*U_{R,ja}^u Z_{kb}^U N_{i4}\right)\left(\frac{1+\gamma_5}{2}\right) \quad (309)$$



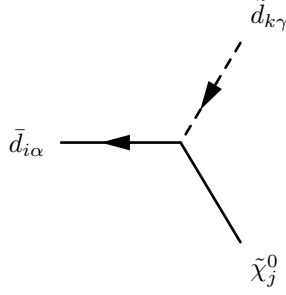
$$i\frac{1}{\sqrt{2}}\left(g_1N_{i1}^*-g_2N_{i2}^*\right)\Theta_{j,3}Z_{kj}^V\left(\frac{1-\gamma_5}{2}\right) \quad (310)$$



$$-\frac{i}{2}\left(2g_2V_{i1}^*N_{j4}^*Z_{k2}^++V_{i2}^*\left(2\lambda N_{j5}^*Z_{k1}^++\sqrt{2}\left(g_1N_{j1}^*+g_2N_{j2}^*\right)Z_{k2}^+\right)\right)\left(\frac{1-\gamma_5}{2}\right) \quad (311)$$

$$+\frac{i}{2}\left(-2g_2U_{i1}N_{j3}Z_{k1}^++U_{i2}\left(-2\lambda^*N_{j5}Z_{k2}^++\sqrt{2}g_1N_{j1}Z_{k1}^++\sqrt{2}g_2N_{j2}Z_{k1}^+\right)\right)\left(\frac{1+\gamma_5}{2}\right) \quad (312)$$

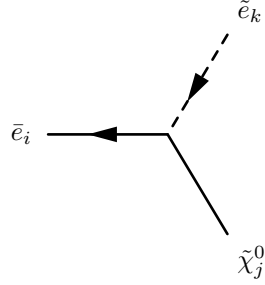




$$-\frac{i}{3}\delta_{\alpha\gamma}\left(3N_{j3}^*\sum_{b=1}^3Z_{kb}^{D,*}\sum_{a=1}^3U_{R,ia}^{d,*}Y_{d,ab}+\sqrt{2}g_1N_{j1}^*\sum_{a=1}^3Z_{k3+a}^{D,*}U_{R,ia}^{d,*}\right)\left(\frac{1-\gamma_5}{2}\right) \quad (313)$$

$$+\frac{i}{6}\delta_{\alpha\gamma}\left(6\sum_{b=1}^3\sum_{a=1}^3Y_{d,ab}^*Z_{k3+a}^{D,*}U_{L,ib}^dN_{j3}+\sqrt{2}\sum_{a=1}^3Z_{ka}^{D,*}U_{L,ia}^d(-3g_2N_{j2}+g_1N_{j1})\right)\left(\frac{1+\gamma_5}{2}\right) \quad (314)$$

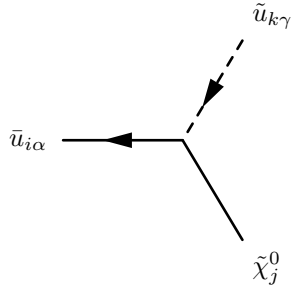

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$$-i\left(N_{j3}^*\sum_{b=1}^3Z_{kb}^{E,*}\sum_{a=1}^3U_{R,ia}^{e,*}Y_{e,ab}+\sqrt{2}g_1N_{j1}^*\sum_{a=1}^3Z_{k3+a}^{E,*}U_{R,ia}^{e,*}\right)\left(\frac{1-\gamma_5}{2}\right) \quad (315)$$

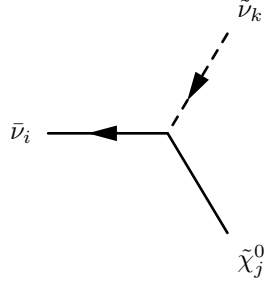
$$+\frac{i}{2}\left(-2\sum_{b=1}^3\sum_{a=1}^3Y_{e,ab}^*Z_{k3+a}^{E,*}U_{L,ib}^eN_{j3}+\sqrt{2}\sum_{a=1}^3Z_{ka}^{E,*}U_{L,ia}^e(g_1N_{j1}+g_2N_{j2})\right)\left(\frac{1+\gamma_5}{2}\right) \quad (316)$$


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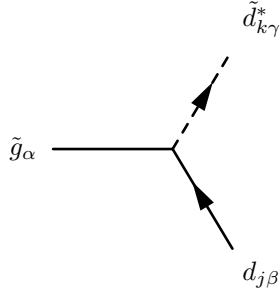
$$\frac{i}{3}\delta_{\alpha\gamma}\left(2\sqrt{2}g_1N_{j1}^*\sum_{a=1}^3Z_{k3+a}^{U,*}U_{R,ia}^{u,*}-3N_{j4}^*\sum_{b=1}^3Z_{kb}^{U,*}\sum_{a=1}^3U_{R,ia}^{u,*}Y_{u,ab}\right)\left(\frac{1-\gamma_5}{2}\right) \quad (317)$$

$$+\frac{i}{6}\delta_{\alpha\gamma}\left(6\sum_{b=1}^3\sum_{a=1}^3Y_{u,ab}^*Z_{k3+a}^{U,*}U_{L,ib}^uN_{j4}+\sqrt{2}\sum_{a=1}^3Z_{ka}^{U,*}U_{L,ia}^u(3g_2N_{j2}+g_1N_{j1})\right)\left(\frac{1+\gamma_5}{2}\right) \quad (318)$$



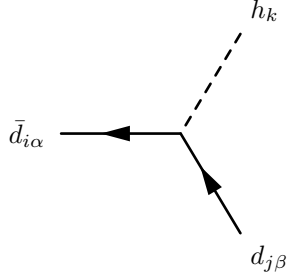
(319)

$$+i\frac{1}{\sqrt{2}}Z_{ki}^{V,*}\Theta_{i,3}(g_1N_{j1}-g_2N_{j2})\left(\frac{1+\gamma_5}{2}\right) \quad (320)$$



$$-i\frac{1}{\sqrt{2}}g_3\phi_{\tilde{g}}\lambda_{\gamma,\beta}^\alpha\sum_{a=1}^3U_{L,ja}^{d,*}Z_{ka}^D\left(\frac{1-\gamma_5}{2}\right) \quad (321)$$

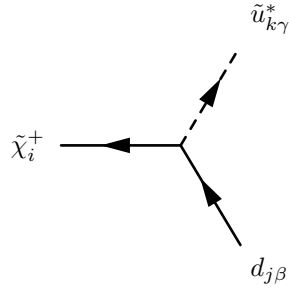
$$+i\frac{1}{\sqrt{2}}g_3\phi_{\tilde{g}}^*\lambda_{\gamma,\beta}^\alpha\sum_{a=1}^3Z_{k3+a}^D U_{R,ja}^d\left(\frac{1+\gamma_5}{2}\right) \quad (322)$$



$$-i \frac{1}{\sqrt{2}} Z_{k1}^{H,*} \delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{d,*} \sum_{a=1}^3 U_{R,ia}^{d,*} Y_{d,ab} \left( \frac{1-\gamma_5}{2} \right) \quad (323)$$

$$+ -i \frac{1}{\sqrt{2}} Z_{k1}^{H,*} \delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* U_{R,ja}^d U_{L,ib}^d \left( \frac{1+\gamma_5}{2} \right) \quad (324)$$

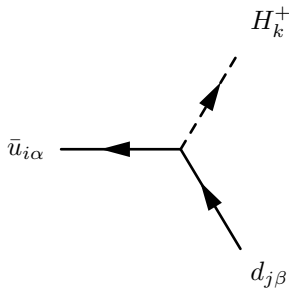

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$$-i \delta_{\beta\gamma} \left( g_2 V_{i1}^* \sum_{a=1}^3 U_{L,ja}^{d,*} Z_{ka}^U - V_{i2}^* \sum_{b=1}^3 U_{L,jb}^{d,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U \right) \left( \frac{1-\gamma_5}{2} \right) \quad (325)$$

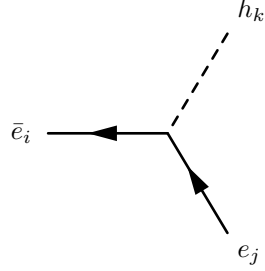
$$+ i \delta_{\beta\gamma} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* U_{R,ja}^d Z_{kb}^U U_{i2} \left( \frac{1+\gamma_5}{2} \right) \quad (326)$$


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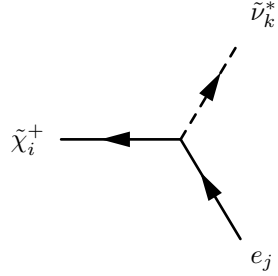
$$i\delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{d,*} \sum_{a=1}^3 U_{R,ia}^{u,*} Y_{u,ab} Z_{k2}^+ \left( \frac{1-\gamma_5}{2} \right) \quad (327)$$

$$+ i\delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* U_{R,ja}^d U_{L,ib}^u Z_{k1}^+ \left( \frac{1+\gamma_5}{2} \right) \quad (328)$$



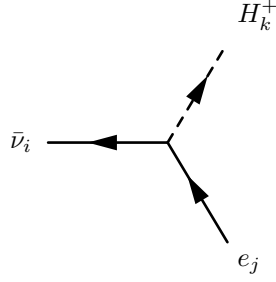
$$-i \frac{1}{\sqrt{2}} Z_{k1}^{H,*} \sum_{b=1}^3 U_{L,jb}^{e,*} \sum_{a=1}^3 U_{R,ia}^{e,*} Y_{e,ab} \left( \frac{1-\gamma_5}{2} \right) \quad (329)$$

$$+ -i \frac{1}{\sqrt{2}} Z_{k1}^{H,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* U_{R,ja}^e U_{L,ib}^e \left( \frac{1+\gamma_5}{2} \right) \quad (330)$$



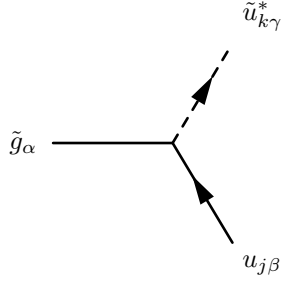
$$-ig_2 V_{i1}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{ka}^V \left( \frac{1-\gamma_5}{2} \right) \quad (331)$$

$$+ i \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* U_{R,ja}^e Z_{kb}^V U_{i2} \left( \frac{1+\gamma_5}{2} \right) \quad (332)$$



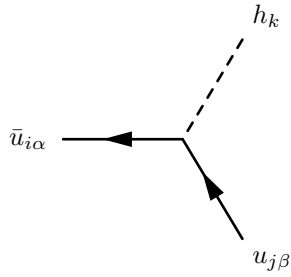
(333)

$$+ i \sum_{a=1}^3 Y_{e,ai}^* U_{R,ja}^e Z_{k1}^+ \left( \frac{1 + \gamma_5}{2} \right) \quad (334)$$



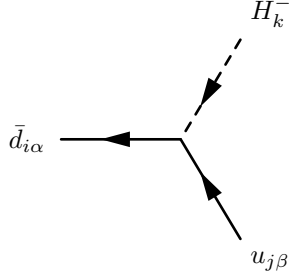
$$- i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}} \lambda_{\gamma,\beta}^\alpha \sum_{a=1}^3 U_{L,ja}^{u,*} Z_{ka}^U \left( \frac{1 - \gamma_5}{2} \right) \quad (335)$$

$$+ i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\gamma,\beta}^\alpha \sum_{a=1}^3 Z_{k3+a}^U U_{R,ja}^u \left( \frac{1 + \gamma_5}{2} \right) \quad (336)$$



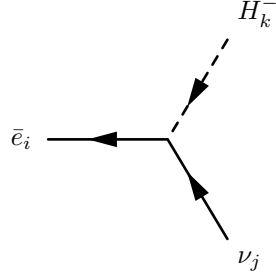
$$-i \frac{1}{\sqrt{2}} Z_{k2}^{H,*} \delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{u,*} \sum_{a=1}^3 U_{R,ia}^{u,*} Y_{u,ab} \left( \frac{1-\gamma_5}{2} \right) \quad (337)$$

$$+ -i \frac{1}{\sqrt{2}} Z_{k2}^{H,*} \delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* U_{R,ja}^u U_{L,ib}^u \left( \frac{1+\gamma_5}{2} \right) \quad (338)$$

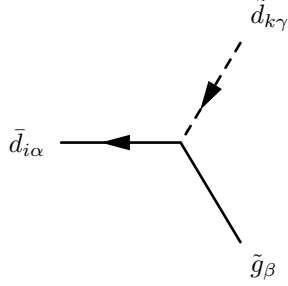


$$i \delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{u,*} \sum_{a=1}^3 U_{R,ia}^{d,*} Y_{d,ab} Z_{k1}^+ \left( \frac{1-\gamma_5}{2} \right) \quad (339)$$

$$+ i \delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* U_{R,ja}^u U_{L,ib}^d Z_{k2}^+ \left( \frac{1+\gamma_5}{2} \right) \quad (340)$$



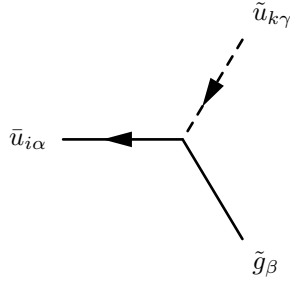
$$i \sum_{a=1}^3 U_{R,ia}^{e,*} Y_{e,aj} Z_{k1}^+ \left( \frac{1-\gamma_5}{2} \right) \quad (341)$$



$$i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}} \lambda_{\alpha,\gamma}^\beta \sum_{a=1}^3 Z_{k3+a}^{D,*} U_{R,ia}^{d,*} \left( \frac{1-\gamma_5}{2} \right) \quad (342)$$

$$+ -i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\alpha,\gamma}^\beta \sum_{a=1}^3 Z_{ka}^{D,*} U_{L,ia}^d \left( \frac{1+\gamma_5}{2} \right) \quad (343)$$

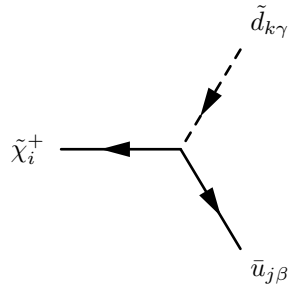

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$$i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}} \lambda_{\alpha,\gamma}^\beta \sum_{a=1}^3 Z_{k3+a}^{U,*} U_{R,ia}^{u,*} \left( \frac{1-\gamma_5}{2} \right) \quad (344)$$

$$+ -i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\alpha,\gamma}^\beta \sum_{a=1}^3 Z_{ka}^{U,*} U_{L,ia}^u \left( \frac{1+\gamma_5}{2} \right) \quad (345)$$

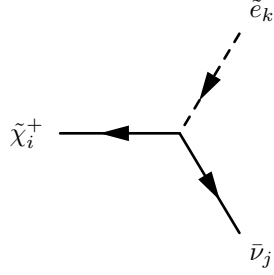

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$$iV_{i2}^* \delta_{\beta\gamma} \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 U_{R,ja}^{u,*} Y_{u,ab} \left( \frac{1-\gamma_5}{2} \right) \quad (346)$$

$$+ -i\delta_{\beta\gamma} \left( g_2 \sum_{a=1}^3 Z_{ka}^{D,*} U_{L,ja}^u U_{i1} - \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{k3+a}^{D,*} U_{L,jb}^u U_{i2} \right) \left( \frac{1+\gamma_5}{2} \right) \quad (347)$$


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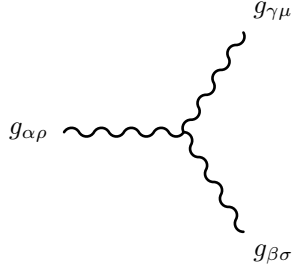


(348)

$$+ -i \left( g_2 Z_{kj}^{E,*} \Theta_{j,3} U_{i1} - \sum_{a=1}^3 Y_{e,aj}^* Z_{k3+a}^{E,*} U_{i2} \right) \left( \frac{1+\gamma_5}{2} \right) \quad (349)$$


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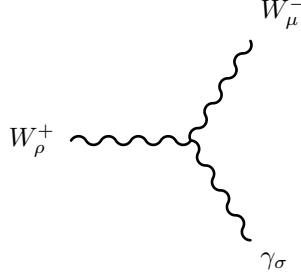
## 9.6 Three Vector Boson-Interaction



$$g_3 f_{\alpha,\beta,\gamma} \left( g_{\rho\mu} \left( -p_\sigma^{g_{\gamma\mu}} + p_\sigma^{g_{\alpha\rho}} \right) + g_{\rho\sigma} \left( -p_\mu^{g_{\alpha\rho}} + p_\mu^{g_{\beta\sigma}} \right) + g_{\sigma\mu} \left( -p_\rho^{g_{\beta\sigma}} + p_\rho^{g_{\gamma\mu}} \right) \right) \quad (350)$$

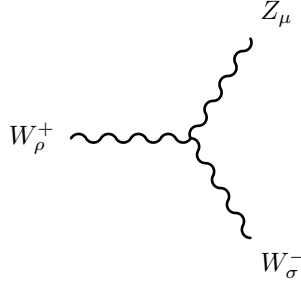

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$$ig_2 \sin \Theta_W \left( g_{\rho\mu} \left( -p_\sigma^{W^-} + p_\sigma^{W^+} \right) + g_{\rho\sigma} \left( -p_\mu^{W^+} + p_\mu^{\gamma\sigma} \right) + g_{\sigma\mu} \left( -p_\rho^{\gamma\sigma} + p_\rho^{W^-} \right) \right) \quad (351)$$

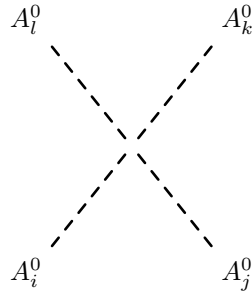

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$$-ig_2 \cos \Theta_W \left( g_{\rho\mu} \left( -p_\sigma^{Z_\mu} + p_\sigma^{W^+} \right) + g_{\rho\sigma} \left( -p_\mu^{W^+} + p_\mu^{W^-} \right) + g_{\sigma\mu} \left( -p_\rho^{W^-} + p_\rho^{Z_\mu} \right) \right) \quad (352)$$

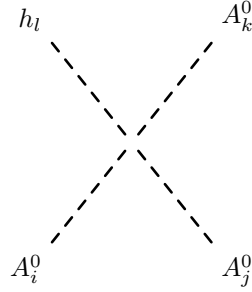

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## 9.7 Four Scalar-Interaction

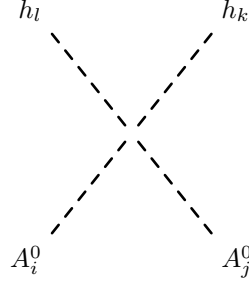


$$\begin{aligned} & -\frac{i}{4} \left( Z_{i1}^{A,*} \left( Z_{j1}^{A,*} \left( 3(g_1^2 + g_2^2) Z_{k1}^{A,*} Z_{l1}^{A,*} - \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k2}^{A,*} Z_{l2}^{A,*} + 4|\lambda|^2 Z_{k3}^{A,*} Z_{l3}^{A,*} \right) \right. \right. \\ & \left. \left. - Z_{j2}^{A,*} \left( 2(\kappa\lambda^* + \lambda\kappa^*) Z_{k3}^{A,*} Z_{l3}^{A,*} + \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k1}^{A,*} Z_{l2}^{A,*} + \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k2}^{A,*} Z_{l1}^{A,*} \right) \right) \end{aligned}$$

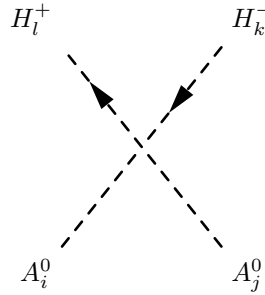
$$\begin{aligned}
& + 2Z_{j3}^{A,*} \left( -\lambda\kappa^* \left( Z_{k2}^{A,*} Z_{l3}^{A,*} + Z_{k3}^{A,*} Z_{l2}^{A,*} \right) \right. \\
& + \lambda^* \left( \left( 2\lambda Z_{k1}^{A,*} - \kappa Z_{k2}^{A,*} \right) Z_{l3}^{A,*} + Z_{k3}^{A,*} \left( 2\lambda Z_{l1}^{A,*} - \kappa Z_{l2}^{A,*} \right) \right) \left. \right) \\
& - Z_{i2}^{A,*} \left( Z_{j2}^{A,*} \left( -3 \left( g_1^2 + g_2^2 \right) Z_{k2}^{A,*} Z_{l2}^{A,*} + \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k1}^{A,*} Z_{l1}^{A,*} - 4|\lambda|^2 Z_{k3}^{A,*} Z_{l3}^{A,*} \right) \right. \\
& + Z_{j1}^{A,*} \left( 2 \left( \kappa\lambda^* + \lambda\kappa^* \right) Z_{k3}^{A,*} Z_{l3}^{A,*} + \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k1}^{A,*} Z_{l2}^{A,*} + \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k2}^{A,*} Z_{l1}^{A,*} \right) \\
& + 2Z_{j3}^{A,*} \left( \lambda^* \left( \left( -2\lambda Z_{k2}^{A,*} + \kappa Z_{k1}^{A,*} \right) Z_{l3}^{A,*} + Z_{k3}^{A,*} \left( -2\lambda Z_{l2}^{A,*} + \kappa Z_{l1}^{A,*} \right) \right) + \lambda\kappa^* \left( Z_{k1}^{A,*} Z_{l3}^{A,*} + Z_{k3}^{A,*} Z_{l1}^{A,*} \right) \right) \left. \right) \\
& + 2Z_{i3}^{A,*} \left( \lambda^* \left( Z_{j3}^{A,*} \left( Z_{k1}^{A,*} \left( 2\lambda Z_{l1}^{A,*} - \kappa Z_{l2}^{A,*} \right) + Z_{k2}^{A,*} \left( 2\lambda Z_{l2}^{A,*} - \kappa Z_{l1}^{A,*} \right) \right) \right. \right. \\
& + Z_{j1}^{A,*} \left( \left( 2\lambda Z_{k1}^{A,*} - \kappa Z_{k2}^{A,*} \right) Z_{l3}^{A,*} + Z_{k3}^{A,*} \left( 2\lambda Z_{l1}^{A,*} - \kappa Z_{l2}^{A,*} \right) \right) \left. \right) \\
& - Z_{j2}^{A,*} \left( \left( -2\lambda Z_{k2}^{A,*} + \kappa Z_{k1}^{A,*} \right) Z_{l3}^{A,*} + Z_{k3}^{A,*} \left( -2\lambda Z_{l2}^{A,*} + \kappa Z_{l1}^{A,*} \right) \right) \left. \right) \\
& - \kappa^* \left( Z_{j3}^{A,*} \left( -12\kappa Z_{k3}^{A,*} Z_{l3}^{A,*} + \lambda Z_{k1}^{A,*} Z_{l2}^{A,*} + \lambda Z_{k2}^{A,*} Z_{l1}^{A,*} \right) \right. \\
& + \lambda \left( Z_{j1}^{A,*} \left( Z_{k2}^{A,*} Z_{l3}^{A,*} + Z_{k3}^{A,*} Z_{l2}^{A,*} \right) + Z_{j2}^{A,*} \left( Z_{k1}^{A,*} Z_{l3}^{A,*} + Z_{k3}^{A,*} Z_{l1}^{A,*} \right) \right) \left. \right) \left. \right) \tag{353}
\end{aligned}$$



$$\begin{aligned}
& \frac{1}{2} \left( -\kappa\lambda^* + \lambda\kappa^* \right) \left( Z_{i2}^{A,*} \left( -Z_{j1}^{A,*} Z_{k3}^{A,*} Z_{l3}^{H,*} + Z_{j3}^{A,*} \left( -Z_{k1}^{A,*} Z_{l3}^{H,*} + Z_{k3}^{A,*} Z_{l1}^{H,*} \right) \right) \right. \\
& + Z_{i3}^{A,*} \left( Z_{j3}^{A,*} \left( Z_{k1}^{A,*} Z_{l2}^{H,*} + Z_{k2}^{A,*} Z_{l1}^{H,*} \right) + Z_{j2}^{A,*} \left( -Z_{k1}^{A,*} Z_{l3}^{H,*} + Z_{k3}^{A,*} Z_{l1}^{H,*} \right) \right) \\
& + Z_{j1}^{A,*} \left( -Z_{k2}^{A,*} Z_{l3}^{H,*} + Z_{k3}^{A,*} Z_{l2}^{H,*} \right) \\
& + Z_{i1}^{A,*} \left( -Z_{j2}^{A,*} Z_{k3}^{A,*} Z_{l3}^{H,*} + Z_{j3}^{A,*} \left( -Z_{k2}^{A,*} Z_{l3}^{H,*} + Z_{k3}^{A,*} Z_{l2}^{H,*} \right) \right) \left. \right) \tag{354}
\end{aligned}$$

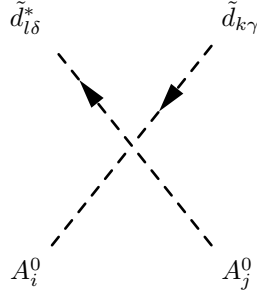


$$\begin{aligned}
& -\frac{i}{4} \left( Z_{i2}^{A,*} \left( Z_{j2}^{A,*} \left( - \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k1}^{H,*} Z_{l1}^{H,*} + 4|\lambda|^2 Z_{k3}^{H,*} Z_{l3}^{H,*} + \left( g_1^2 + g_2^2 \right) Z_{k2}^{H,*} Z_{l2}^{H,*} \right) \right. \right. \\
& - 2 \left( \kappa \lambda^* + \lambda \kappa^* \right) \left( - Z_{j1}^{A,*} Z_{k3}^{H,*} Z_{l3}^{H,*} + Z_{j3}^{A,*} \left( Z_{k1}^{H,*} Z_{l3}^{H,*} + Z_{k3}^{H,*} Z_{l1}^{H,*} \right) \right) \left. \right) \\
& + Z_{i1}^{A,*} \left( Z_{j1}^{A,*} \left( - \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k2}^{H,*} Z_{l2}^{H,*} + 4|\lambda|^2 Z_{k3}^{H,*} Z_{l3}^{H,*} + \left( g_1^2 + g_2^2 \right) Z_{k1}^{H,*} Z_{l1}^{H,*} \right) \right. \\
& - 2 \left( \kappa \lambda^* + \lambda \kappa^* \right) \left( - Z_{j2}^{A,*} Z_{k3}^{H,*} Z_{l3}^{H,*} + Z_{j3}^{A,*} \left( Z_{k2}^{H,*} Z_{l3}^{H,*} + Z_{k3}^{H,*} Z_{l2}^{H,*} \right) \right) \left. \right) \\
& + 2 Z_{i3}^{A,*} \left( \lambda^* \left( Z_{j3}^{A,*} \left( Z_{k1}^{H,*} \left( 2\lambda Z_{l1}^{H,*} + \kappa Z_{l2}^{H,*} \right) + Z_{k2}^{H,*} \left( 2\lambda Z_{l2}^{H,*} + \kappa Z_{l1}^{H,*} \right) \right) \right. \right. \\
& - \kappa \left( Z_{j1}^{A,*} \left( Z_{k2}^{H,*} Z_{l3}^{H,*} + Z_{k3}^{H,*} Z_{l2}^{H,*} \right) + Z_{j2}^{A,*} \left( Z_{k1}^{H,*} Z_{l3}^{H,*} + Z_{k3}^{H,*} Z_{l1}^{H,*} \right) \right) \left. \right) \\
& + \kappa^* \left( Z_{j3}^{A,*} \left( 4\kappa Z_{k3}^{H,*} Z_{l3}^{H,*} + \lambda Z_{k1}^{H,*} Z_{l2}^{H,*} + \lambda Z_{k2}^{H,*} Z_{l1}^{H,*} \right) \right. \\
& \left. \left. - \lambda \left( Z_{j1}^{A,*} \left( Z_{k2}^{H,*} Z_{l3}^{H,*} + Z_{k3}^{H,*} Z_{l2}^{H,*} \right) + Z_{j2}^{A,*} \left( Z_{k1}^{H,*} Z_{l3}^{H,*} + Z_{k3}^{H,*} Z_{l1}^{H,*} \right) \right) \right) \right) \right) \quad (355)
\end{aligned}$$

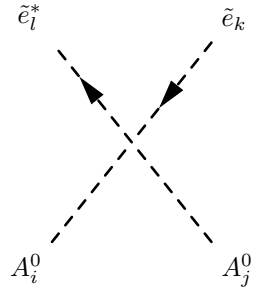


$$\begin{aligned}
& -\frac{i}{4} \left( Z_{i1}^{A,*} \left( - \left( -2|\lambda|^2 + g_2^2 \right) Z_{j2}^{A,*} \left( Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) \right. \right. \\
& + Z_{j1}^{A,*} \left( \left( g_1^2 + g_2^2 \right) Z_{k1}^+ Z_{l1}^+ + \left( -g_1^2 + g_2^2 \right) Z_{k2}^+ Z_{l2}^+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

$$+ 4Z_{i3}^{A,*} Z_{j3}^{A,*} \left( -\lambda \kappa^* Z_{k1}^+ Z_{l2}^+ + \lambda^* \left( \lambda Z_{k1}^+ Z_{l1}^+ + Z_{k2}^+ \left( -\kappa Z_{l1}^+ + \lambda Z_{l2}^+ \right) \right) \right) \quad (356)$$



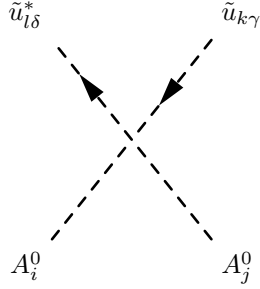
$$\begin{aligned} & \frac{i}{12} \delta_{\gamma\delta} \left( -6Z_{i3}^{A,*} Z_{j2}^{A,*} \left( \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{k3+a}^{D,*} Z_{lb}^D + \lambda^* \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D \right) \right. \\ & - Z_{i2}^{A,*} \left( Z_{j2}^{A,*} \left( 2g_1^2 \sum_{a=1}^3 Z_{k3+a}^{D,*} Z_{l3+a}^D + (3g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ka}^{D,*} Z_{la}^D \right) \right. \\ & + 6Z_{j3}^{A,*} \left( \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{k3+a}^{D,*} Z_{lb}^D + \lambda^* \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D \right) \\ & + Z_{i1}^{A,*} Z_{j1}^{A,*} \left( (3g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ka}^{D,*} Z_{la}^D \right. \\ & + 2 \left( g_1^2 \sum_{a=1}^3 Z_{k3+a}^{D,*} Z_{l3+a}^D \right. \\ & \left. \left. - 6 \left( \sum_{c=1}^3 Z_{k3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{d,ba} Z_{l3+b}^D + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 Y_{d,ac} Y_{d,ab} Z_{lc}^D \right) \right) \right) \quad (357) \end{aligned}$$



$$- \frac{i}{4} \left( 2Z_{i3}^{A,*} Z_{j2}^{A,*} \left( \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{k3+a}^{E,*} Z_{lb}^E + \lambda^* \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \right) \right)$$

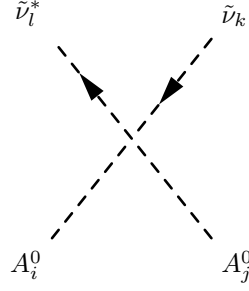
$$\begin{aligned}
& + Z_{i2}^{A,*} \left( Z_{j2}^{A,*} \left( 2g_1^2 \sum_{a=1}^3 Z_{k3+a}^{E,*} Z_{l3+a}^E + \left( -g_1^2 + g_2^2 \right) \sum_{a=1}^3 Z_{ka}^{E,*} Z_{la}^E \right) \right. \\
& + 2Z_{j3}^{A,*} \left( \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{k3+a}^{E,*} Z_{lb}^E + \lambda^* \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \right) \\
& + Z_{i1}^{A,*} Z_{j1}^{A,*} \left( \left( -g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{E,*} Z_{la}^E - 2g_1^2 \sum_{a=1}^3 Z_{k3+a}^{E,*} Z_{l3+a}^E \right. \\
& \left. \left. + 4 \left( \sum_{c=1}^3 Z_{k3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{e,ba} Z_{l3+b}^E + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E \right) \right) \right) \quad (358)
\end{aligned}$$


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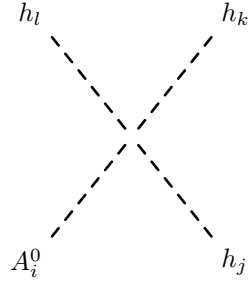
$$\begin{aligned}
& - \frac{i}{12} \delta_{\gamma\delta} \left( 6Z_{i3}^{A,*} Z_{j1}^{A,*} \left( \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{k3+a}^{U,*} Z_{lb}^U + \lambda^* \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \right) \right. \\
& + Z_{i1}^{A,*} \left( Z_{j1}^{A,*} \left(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


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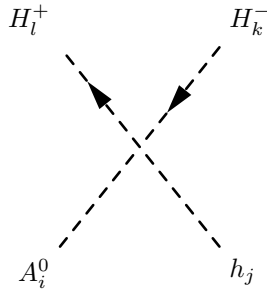
$$-\frac{i}{4}(g_1^2 + g_2^2)(Z_{i1}^{A,*} Z_{j1}^{A,*} - Z_{i2}^{A,*} Z_{j2}^{A,*})\delta_{kl} \quad (360)$$


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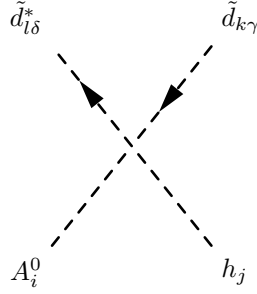
$$\begin{aligned} & \frac{1}{2}(-\kappa\lambda^* + \lambda\kappa^*)\left(-Z_{i2}^{A,*}\left(Z_{j1}^{H,*}Z_{k3}^{H,*}Z_{l3}^{H,*} + Z_{j3}^{H,*}\left(Z_{k1}^{H,*}Z_{l3}^{H,*} + Z_{k3}^{H,*}Z_{l1}^{H,*}\right)\right)\right) \\ & + Z_{i3}^{A,*}\left(Z_{j3}^{H,*}\left(Z_{k1}^{H,*}Z_{l2}^{H,*} + Z_{k2}^{H,*}Z_{l1}^{H,*}\right) + Z_{j2}^{H,*}\left(Z_{k1}^{H,*}Z_{l3}^{H,*} + Z_{k3}^{H,*}Z_{l1}^{H,*}\right)\right) \\ & + Z_{j1}^{H,*}\left(Z_{k2}^{H,*}Z_{l3}^{H,*} + Z_{k3}^{H,*}Z_{l2}^{H,*}\right) \\ & - Z_{i1}^{A,*}\left(Z_{j2}^{H,*}Z_{k3}^{H,*}Z_{l3}^{H,*} + Z_{j3}^{H,*}\left(Z_{k2}^{H,*}Z_{l3}^{H,*} + Z_{k3}^{H,*}Z_{l2}^{H,*}\right)\right) \end{aligned} \quad (361)$$


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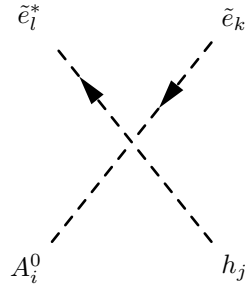
$$\begin{aligned}
& \frac{1}{4} \left( (-2|\lambda|^2 + g_2^2) Z_{i2}^{A,*} Z_{j1}^{H,*} \left( -Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) \right. \\
& + \left( -2|\lambda|^2 + g_2^2 \right) Z_{i1}^{A,*} Z_{j2}^{H,*} \left( -Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) \\
& \left. + 4Z_{i3}^{A,*} Z_{j3}^{H,*} \left( \kappa \lambda^* Z_{k2}^+ Z_{l1}^+ - \lambda \kappa^* Z_{k1}^+ Z_{l2}^+ \right) \right) \quad (362)
\end{aligned}$$


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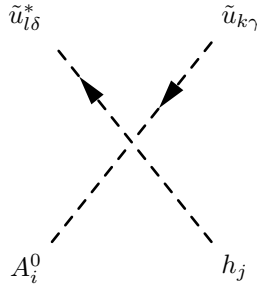
$$\frac{1}{2} \left( Z_{i2}^{A,*} Z_{j3}^{H,*} + Z_{i3}^{A,*} Z_{j2}^{H,*} \right) \delta_{\gamma\delta} \left( -\lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{k3+a}^{D,*} Z_{lb}^D + \lambda^* \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D \right) \quad (363)$$


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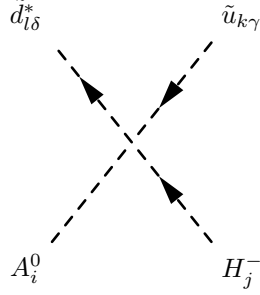
$$\frac{1}{2} \left( Z_{i2}^{A,*} Z_{j3}^{H,*} + Z_{i3}^{A,*} Z_{j2}^{H,*} \right) \left( -\lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{k3+a}^{E,*} Z_{lb}^E + \lambda^* \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \right) \quad (364)$$


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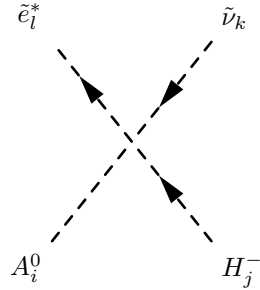
$$\frac{1}{2} \left( Z_{i1}^{A,*} Z_{j3}^{H,*} + Z_{i3}^{A,*} Z_{j1}^{H,*} \right) \delta_{\gamma\delta} \left( -\lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{k3+a}^{U,*} Z_{lb}^U + \lambda^* \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \right) \quad (365)$$


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$$\begin{aligned} & \frac{1}{2} \frac{1}{\sqrt{2}} \delta_{\gamma\delta} \left( Z_{i3}^{A,*} \left( -2\lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{k3+a}^{U,*} Z_{lb}^D Z_{j1}^+ + 2\lambda^* \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D Z_{j2}^+ \right) \right. \\ & - Z_{i1}^{A,*} \left( g_2^2 \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^D Z_{j1}^+ - 2 \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^D Z_{j1}^+ \right. \\ & + 2 \sum_{c=1}^3 Z_{k3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{d,ba} Z_{l3+b}^D Z_{j2}^+ \left. \right) \\ & + Z_{i2}^{A,*} \left( 2 \sum_{c=1}^3 Z_{k3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{d,ba} Z_{l3+b}^D Z_{j1}^+ \right. \\ & \left. \left. + \left( -2 \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^D + g_2^2 \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^D \right) Z_{j2}^+ \right) \right) \quad (366) \end{aligned}$$


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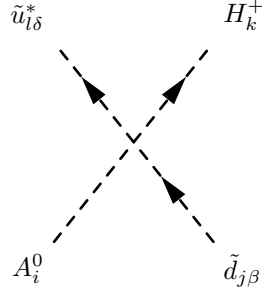


$$\frac{1}{2} \frac{1}{\sqrt{2}} \left( Z_{i1}^{A,*} \left( 2 \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{V,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E - g_2^2 \sum_{a=1}^3 Z_{ka}^{V,*} Z_{la}^E \right) Z_{j1}^+ \right.$$



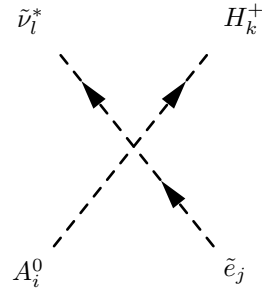
$$+ \left( 2\lambda^* Z_{i3}^{A,*} \sum_{b=1}^3 Z_{kb}^{V,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E + g_2^2 Z_{i2}^{A,*} \sum_{a=1}^3 Z_{ka}^{V,*} Z_{la}^E \right) Z_{j2}^+ \quad (367)$$


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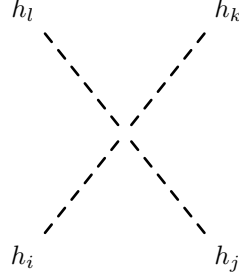
$$\begin{aligned} & \frac{1}{2} \frac{1}{\sqrt{2}} \delta_{\beta\delta} \left( 2\lambda^* Z_{i3}^{A,*} \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U Z_{k1}^+ - 2Z_{i2}^{A,*} \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{u,ba} Z_{l3+b}^U Z_{k1}^+ \right. \\ & - g_2^2 Z_{i2}^{A,*} \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^U Z_{k2}^+ - 2\lambda Z_{i3}^{A,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{lb}^U Z_{k2}^+ \\ & + 2Z_{i2}^{A,*} \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^U Z_{k2}^+ \\ & + Z_{i1}^{A,*} \left( g_2^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^U Z_{k1}^+ - 2 \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^U Z_{k1}^+ \right. \\ & \left. \left. + 2 \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{u,ba} Z_{l3+b}^U Z_{k2}^+ \right) \right) \quad (368) \end{aligned}$$


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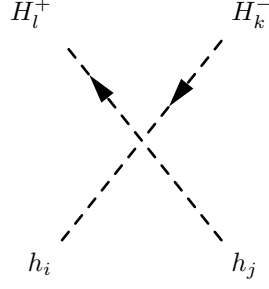


$$\frac{1}{2} \frac{1}{\sqrt{2}} \left( Z_{i1}^{A,*} \left( -2 \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^V + g_2^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^V \right) Z_{k1}^+ \right)$$

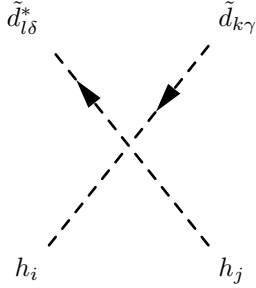
$$- \left( 2\lambda Z_{i3}^{A,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{lb}^V + g_2^2 Z_{i2}^{A,*} \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^V \right) Z_{k2}^+ \quad (369)$$



$$\begin{aligned}
& - \frac{i}{4} \left( Z_{i1}^{H,*} \left( Z_{j1}^{H,*} \left( 3(g_1^2 + g_2^2) Z_{k1}^{H,*} Z_{l1}^{H,*} - \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k2}^{H,*} Z_{l2}^{H,*} + 4|\lambda|^2 Z_{k3}^{H,*} Z_{l3}^{H,*} \right) \right. \right. \\
& - Z_{j2}^{H,*} \left( 2(\kappa\lambda^* + \lambda\kappa^*) Z_{k3}^{H,*} Z_{l3}^{H,*} + \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k1}^{H,*} Z_{l2}^{H,*} + \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k2}^{H,*} Z_{l1}^{H,*} \right) \\
& + 2Z_{j3}^{H,*} \left( -\lambda\kappa^* \left( Z_{k2}^{H,*} Z_{l3}^{H,*} + Z_{k3}^{H,*} Z_{l2}^{H,*} \right) \right. \\
& \left. \left. + \lambda^* \left( \left( 2\lambda Z_{k1}^{H,*} - \kappa Z_{k2}^{H,*} \right) Z_{l3}^{H,*} + Z_{k3}^{H,*} \left( 2\lambda Z_{l1}^{H,*} - \kappa Z_{l2}^{H,*} \right) \right) \right) \right) \\
& - Z_{i2}^{H,*} \left( Z_{j2}^{H,*} \left( -3(g_1^2 + g_2^2) Z_{k2}^{H,*} Z_{l2}^{H,*} + \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k1}^{H,*} Z_{l1}^{H,*} - 4|\lambda|^2 Z_{k3}^{H,*} Z_{l3}^{H,*} \right) \right. \\
& + Z_{j1}^{H,*} \left( 2(\kappa\lambda^* + \lambda\kappa^*) Z_{k3}^{H,*} Z_{l3}^{H,*} + \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k1}^{H,*} Z_{l2}^{H,*} + \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k2}^{H,*} Z_{l1}^{H,*} \right) \\
& + 2Z_{j3}^{H,*} \left( \lambda^* \left( \left( -2\lambda Z_{k2}^{H,*} + \kappa Z_{k1}^{H,*} \right) Z_{l3}^{H,*} + Z_{k3}^{H,*} \left( -2\lambda Z_{l2}^{H,*} + \kappa Z_{l1}^{H,*} \right) \right) + \lambda\kappa^* \left( Z_{k1}^{H,*} Z_{l3}^{H,*} + Z_{k3}^{H,*} Z_{l1}^{H,*} \right) \right) \\
& + 2Z_{i3}^{H,*} \left( \lambda^* \left( Z_{j3}^{H,*} \left( Z_{k1}^{H,*} \left( 2\lambda Z_{l1}^{H,*} - \kappa Z_{l2}^{H,*} \right) + Z_{k2}^{H,*} \left( 2\lambda Z_{l2}^{H,*} - \kappa Z_{l1}^{H,*} \right) \right) \right. \right. \\
& \left. \left. + Z_{j1}^{H,*} \left( \left( 2\lambda Z_{k1}^{H,*} - \kappa Z_{k2}^{H,*} \right) Z_{l3}^{H,*} + Z_{k3}^{H,*} \left( 2\lambda Z_{l1}^{H,*} - \kappa Z_{l2}^{H,*} \right) \right) \right) \right. \\
& \left. - Z_{j2}^{H,*} \left( \left( -2\lambda Z_{k2}^{H,*} + \kappa Z_{k1}^{H,*} \right) Z_{l3}^{H,*} + Z_{k3}^{H,*} \left( -2\lambda Z_{l2}^{H,*} + \kappa Z_{l1}^{H,*} \right) \right) \right) \\
& - \kappa^* \left( Z_{j3}^{H,*} \left( -12\kappa Z_{k3}^{H,*} Z_{l3}^{H,*} + \lambda Z_{k1}^{H,*} Z_{l2}^{H,*} + \lambda Z_{k2}^{H,*} Z_{l1}^{H,*} \right) \right. \\
& \left. + \lambda \left( Z_{j1}^{H,*} \left( Z_{k2}^{H,*} Z_{l3}^{H,*} + Z_{k3}^{H,*} Z_{l2}^{H,*} \right) + Z_{j2}^{H,*} \left( Z_{k1}^{H,*} Z_{l3}^{H,*} + Z_{k3}^{H,*} Z_{l1}^{H,*} \right) \right) \right) \right) \quad (370)
\end{aligned}$$



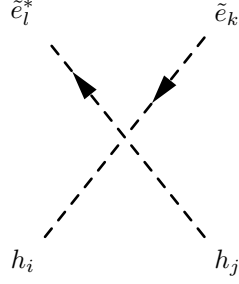
$$\begin{aligned}
& -\frac{i}{4} \left( Z_{i1}^{H,*} \left( (-2|\lambda|^2 + g_2^2) Z_{j2}^{H,*} (Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+) \right. \right. \\
& + Z_{j1}^{H,*} \left( (g_1^2 + g_2^2) Z_{k1}^+ Z_{l1}^+ + (-g_1^2 + g_2^2) Z_{k2}^+ Z_{l2}^+ \right) \\
& + Z_{i2}^{H,*} \left( (-2|\lambda|^2 + g_2^2) Z_{j1}^{H,*} (Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+) \right. \\
& + Z_{j2}^{H,*} \left( (-g_1^2 + g_2^2) Z_{k1}^+ Z_{l1}^+ + (g_1^2 + g_2^2) Z_{k2}^+ Z_{l2}^+ \right) \\
& \left. \left. + 4Z_{i3}^{H,*} Z_{j3}^{H,*} (\lambda \kappa^* Z_{k1}^+ Z_{l2}^+ + \lambda^* (\lambda Z_{k1}^+ Z_{l1}^+ + Z_{k2}^+ (\kappa Z_{l1}^+ + \lambda Z_{l2}^+))) \right) \right) \quad (371)
\end{aligned}$$



$$\begin{aligned}
& \frac{i}{12} \delta_{\gamma\delta} \left( 6Z_{i3}^{H,*} Z_{j2}^{H,*} \left( \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{k3+a}^{D,*} Z_{lb}^D + \lambda^* \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D \right) \right. \\
& - Z_{i2}^{H,*} \left( Z_{j2}^{H,*} \left( 2g_1^2 \sum_{a=1}^3 Z_{k3+a}^{D,*} Z_{l3+a}^D + (3g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ka}^{D,*} Z_{la}^D \right) \right. \\
& \left. - 6Z_{j3}^{H,*} \left( \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{k3+a}^{D,*} Z_{lb}^D + \lambda^* \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D \right) \right) \\
& + Z_{i1}^{H,*} Z_{j1}^{H,*} \left( (3g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ka}^{D,*} Z_{la}^D \right. \\
& \left. + 2 \left( g_1^2 \sum_{a=1}^3 Z_{k3+a}^{D,*} Z_{l3+a}^D \right) \right)
\end{aligned}$$

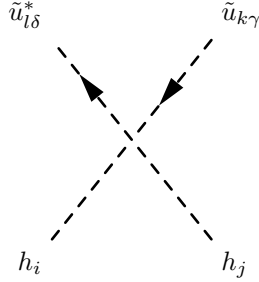
$$-6 \left( \sum_{c=1}^3 Z_{k3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{d,ba} Z_{l3+b}^D + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^D \right) \quad (372)$$


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$$\begin{aligned} & \frac{i}{4} \left( 2Z_{i3}^{H,*} Z_{j2}^{H,*} \left( \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{k3+a}^{E,*} Z_{lb}^E + \lambda^* \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \right) \right. \\ & + Z_{i2}^{H,*} \left( Z_{j2}^{H,*} \left( -2g_1^2 \sum_{a=1}^3 Z_{k3+a}^{E,*} Z_{l3+a}^E + \left( -g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{E,*} Z_{la}^E \right) \right. \\ & + 2Z_{j3}^{H,*} \left( \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{k3+a}^{E,*} Z_{lb}^E + \lambda^* \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \right) \left. \right) \\ & + Z_{i1}^{H,*} Z_{j1}^{H,*} \left( \left( -g_1^2 + g_2^2 \right) \sum_{a=1}^3 Z_{ka}^{E,*} Z_{la}^E + 2g_1^2 \sum_{a=1}^3 Z_{k3+a}^{E,*} Z_{l3+a}^E \right. \\ & \left. \left. - 4 \left( \sum_{c=1}^3 Z_{k3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{e,ba} Z_{l3+b}^E + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E \right) \right) \right) \quad (373) \end{aligned}$$

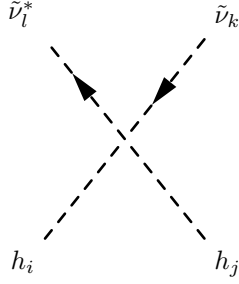

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$$\frac{i}{12} \delta_{\gamma\delta} \left( 6Z_{i3}^{H,*} Z_{j1}^{H,*} \left( \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{k3+a}^{U,*} Z_{lb}^U + \lambda^* \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \right) \right)$$

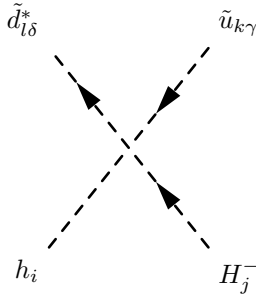
$$\begin{aligned}
& + Z_{i1}^{H,*} \left( Z_{j1}^{H,*} \left( \left( -3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^U - 4g_1^2 \sum_{a=1}^3 Z_{k3+a}^{U,*} Z_{l3+a}^U \right) \right. \\
& + 6Z_{j3}^{H,*} \left( \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{k3+a}^{U,*} Z_{lb}^U + \lambda^* \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \right) \\
& - Z_{i2}^{H,*} Z_{j2}^{H,*} \left( \left( -3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^U - 4g_1^2 \sum_{a=1}^3 Z_{k3+a}^{U,*} Z_{l3+a}^U \right. \\
& \left. \left. + 12 \left( \sum_{c=1}^3 Z_{k3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{u,ba} Z_{l3+b}^U + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^U \right) \right) \right) \quad (374)
\end{aligned}$$


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$$- \frac{i}{4} (g_1^2 + g_2^2) \left( Z_{i1}^{H,*} Z_{j1}^{H,*} - Z_{i2}^{H,*} Z_{j2}^{H,*} \right) \delta_{kl} \quad (375)$$

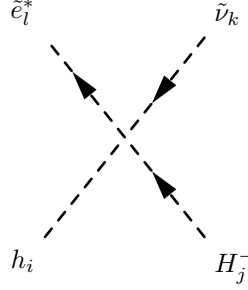

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$$\begin{aligned}
& \frac{i}{2} \frac{1}{\sqrt{2}} \delta_{\gamma\delta} \left( 2Z_{i3}^{H,*} \left( \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{k3+a}^{U,*} Z_{lb}^D Z_{j1}^+ + \lambda^* \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D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

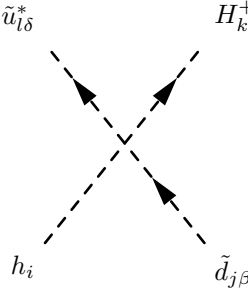
$$\begin{aligned}
& + Z_{i2}^{H,*} \left( 2 \sum_{c=1}^3 Z_{k3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{d,ba} Z_{l3+b}^D Z_{j1}^+ \right. \\
& \left. + \left( 2 \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^D - g_2^2 \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^D \right) Z_{j2}^+ \right)
\end{aligned} \tag{376}$$


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$$\begin{aligned}
& - \frac{i}{2} \frac{1}{\sqrt{2}} \left( Z_{i1}^{H,*} \left( -2 \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{V,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E + g_2^2 \sum_{a=1}^3 Z_{ka}^{V,*} Z_{la}^E \right) Z_{j1}^+ \right. \\
& \left. + \left( -2\lambda^* Z_{i3}^{H,*} \sum_{b=1}^3 Z_{kb}^{V,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E + g_2^2 Z_{i2}^{H,*} \sum_{a=1}^3 Z_{ka}^{V,*} Z_{la}^E \right) Z_{j2}^+ \right)
\end{aligned} \tag{377}$$

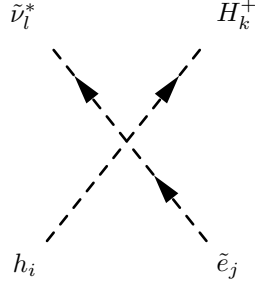

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$$\begin{aligned}
& \frac{i}{2} \frac{1}{\sqrt{2}} \delta_{\beta\delta} \left( 2\lambda^* Z_{i3}^{H,*} \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U Z_{k1}^+ + 2Z_{i2}^{H,*} \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^*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

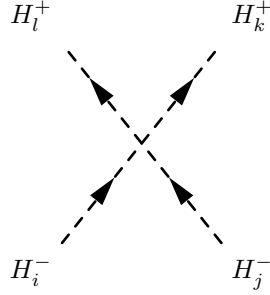
$$\begin{aligned}
& + Z_{i1}^{H,*} \left( -g_2^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^U Z_{k1}^+ + 2 \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^U Z_{k1}^+ \right. \\
& \left. + 2 \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{u,ba} Z_{l3+b}^U Z_{k2}^+ \right)
\end{aligned} \tag{378}$$


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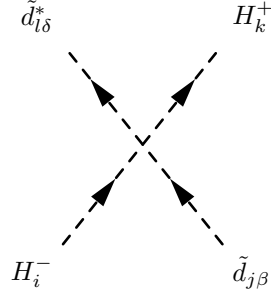
$$\begin{aligned}
& - \frac{i}{2} \frac{1}{\sqrt{2}} \left( Z_{i1}^{H,*} \left( -2 \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^V + g_2^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^V \right) Z_{k1}^+ \right. \\
& \left. + \left( -2\lambda Z_{i3}^{H,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{lb}^V + g_2^2 Z_{i2}^{H,*} \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^V \right) Z_{k2}^+ \right)
\end{aligned} \tag{379}$$


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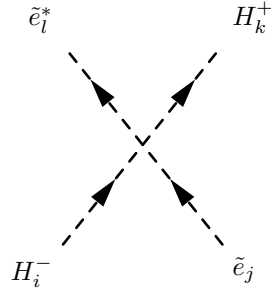
$$\begin{aligned}
& - \frac{i}{4} \left( -Z_{i2}^+ \left( -2(g_1^2 + g_2^2) Z_{j2}^+ Z_{k2}^+ Z_{l2}^+ + (-4|\lambda|^2 + g_1^2 + g_2^2) Z_{j1}^+ (Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+) \right) \right. \\
& \left. + Z_{i1}^+ \left( 2(g_1^2 + g_2^2) Z_{j1}^+ Z_{k1}^+ Z_{l1}^+ - (-4|\lambda|^2 + g_1^2 + g_2^2) Z_{j2}^+ (Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+) \right) \right)
\end{aligned} \tag{380}$$


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$$\begin{aligned}
& \frac{i}{12} \delta_{\beta\delta} \left( \left( -3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^D \left( Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+ \right) \right. \\
& + 2 \left( g_1^2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{l3+a}^D \left( Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+ \right) \right. \\
& \left. \left. - 6 \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^D Z_{i2}^+ Z_{k2}^+ + \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{d,ba} Z_{l3+b}^D Z_{i1}^+ Z_{k1}^+ \right) \right) \right) \quad (381)
\end{aligned}$$

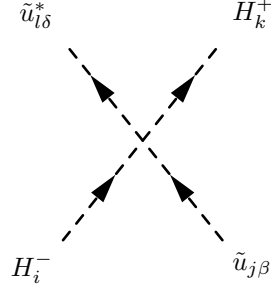

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$$\begin{aligned}
& - \frac{i}{4} \left( 4 \sum_{c=1}^3 Z_{j3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{e,ba} Z_{l3+b}^E Z_{i1}^+ Z_{k1}^+ \right. \\
& + \left( g_1^2 + g_2^2 \right) \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^E \left( Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+ \right) \\
& \left. + 2g_1^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{l3+a}^E \left( -Z_{i1}^+ Z_{k1}^+ + Z_{i2}^+ Z_{k2}^+ \right) \right) \quad (382)
\end{aligned}$$

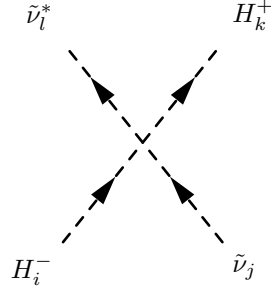

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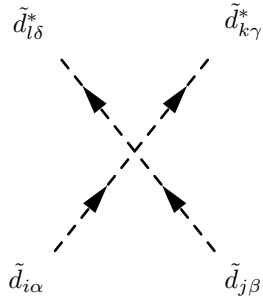
$$\begin{aligned}
& \frac{i}{12} \delta_{\beta\delta} \left( (3g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U (Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+) \right. \\
& - 4 \left( g_1^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U (Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+) \right. \\
& \left. \left. + 3 \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^U Z_{i1}^+ Z_{k1}^+ + \sum_{c=1}^3 Z_{j3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{u,ba} Z_{l3+b}^U Z_{i2}^+ Z_{k2}^+ \right) \right) \right) \quad (383)
\end{aligned}$$


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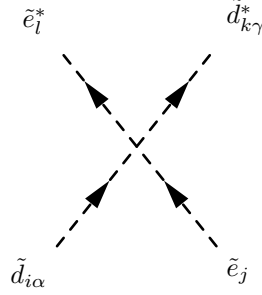
$$- \frac{i}{4} \left( 4 \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^V Z_{i1}^+ Z_{k1}^+ + (-g_2^2 + g_1^2) \delta_{jl} (Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+) \right) \quad (384)$$


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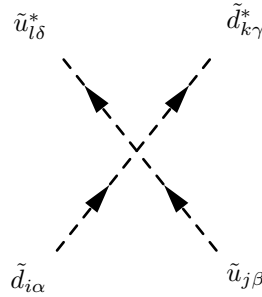


$$\begin{aligned}
& -\frac{i}{72} \left( \delta_{\alpha\delta} \delta_{\beta\gamma} \left( g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D + 9g_2^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D \right. \right. \\
& - 6g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*}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

$$\begin{aligned}
& + 72 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{i3+c}^{D,*} Z_{ld}^D \\
& + \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 \\
& - 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 \\
& \left. + 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 \right)
\end{aligned} \tag{385}$$

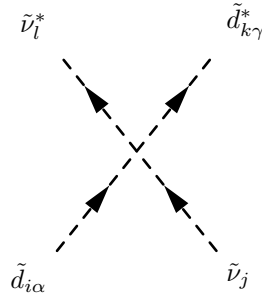


$$\begin{aligned}
& \frac{i}{24} \delta_{\alpha\gamma} \left( -2g_1^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{l3+a}^E \left( 2 \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \right. \\
& + \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^E \left( 2g_1^2 \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \left( -3g_2^2 + g_1^2 \right) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \\
& + g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E - 3g_2^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E \\
& + 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E - 2g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \\
& - 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \\
& - 24 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{i3+c}^{D,*} Z_{kd}^D \\
& \left. - 24 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{j3+c}^{E,*} Z_{ld}^E \right) \tag{386}
\end{aligned}$$



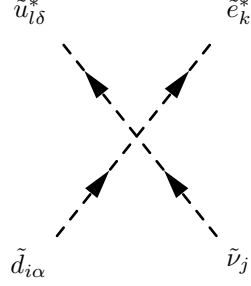
$$- \frac{i}{72} \left( \delta_{\alpha\gamma} \delta_{\beta\delta} \left( \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \left( 2 \left( 3g_3^2 + g_1^2 \right) \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \left( -6g_3^2 - 9g_2^2 + g_1^2 \right) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \right) \right.$$

$$\begin{aligned}
& -2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U \left( (2g_1^2 - 3g_3^2) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D + (3g_3^2 + 4g_1^2) \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 \\
& - 6g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \Big) \\
& + 18\delta_{\alpha\delta}\delta_{\beta\gamma} \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 \\
& + 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 \\
& \left. + 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 \right) \tag{387}
\end{aligned}$$



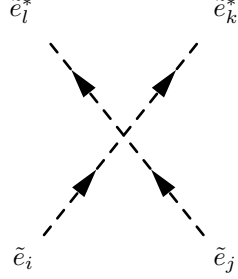
$$\frac{i}{12} \delta_{\alpha\gamma} \delta_{jl} \left( 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D + (3g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \right) \quad (388)$$


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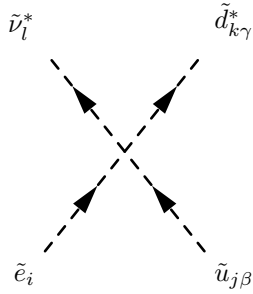
$$\begin{aligned} & -\frac{i}{4} \delta_{\alpha\delta} \left( g_2^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{V,*} Z_{kb}^E + g_2^2 \sum_{a=1}^3 Z_{ja}^{V,*} Z_{ka}^E \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^U \right. \\ & \left. + 4 \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd} Z_{i3+c}^{D,*} Z_{ld}^U \right) \quad (389) \end{aligned}$$


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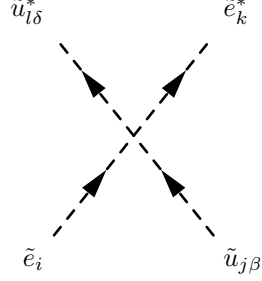


$$\begin{aligned} & -\frac{i}{8} \left( g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{kb}^E + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{kb}^E \right. \\ & - 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{l3+a}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{kb}^E \\ & - 2g_1^2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

$$\begin{aligned}
& -2g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{k3+b}^E + 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{l3+a}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{k3+b}^E \\
& + g_1^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E + g_2^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E \\
& - 2g_1^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E + g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E \\
& + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E - 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E \\
& - 2g_1^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{l3+b}^E + 4g_1^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{l3+b}^E \\
& - 2g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E + 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \\
& + 8 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^{E,*} Z_{kd}^E \\
& + 8 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{j3+c}^{E,*} Z_{kd}^E \\
& + 8 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^{E,*} Z_{ld}^E \\
& + 8 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{j3+c}^{E,*} Z_{ld}^E \Big) \tag{390}
\end{aligned}$$

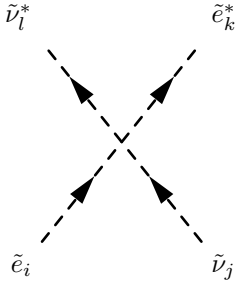


$$\begin{aligned}
& -\frac{i}{4} \delta_{\beta\gamma} \left( g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^V \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^D + g_2^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^D \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^V \right. \\
& \left. + 4 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^{E,*} Z_{ld}^V \right) \tag{391}
\end{aligned}$$



$$\begin{aligned}
& \frac{i}{24} \delta_{\beta\delta} \left( -4g_1^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U \left( -2 \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{k3+b}^E + \sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^E \right) \right. \\
& + \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \left( -2g_1^2 \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{k3+b}^E + (3g_2^2 + g_1^2) \sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^E \right) \\
& + g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U + 3g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& - 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U - 4g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& \left. + 8g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \right) \tag{392}
\end{aligned}$$

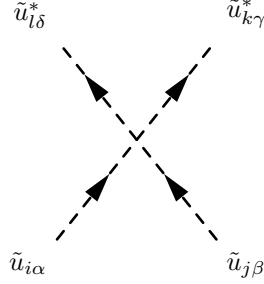

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$$\begin{aligned}
& -\frac{i}{4} \left( \delta_{jl} \left( -2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E + (-g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \right) \right. \\
& \left. + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^V \sum_{b=1}^3 Z_{jb}^{V,*}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



$$+ 4 \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E + \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^E Z_{ld}^V \Big) \quad (393)$$

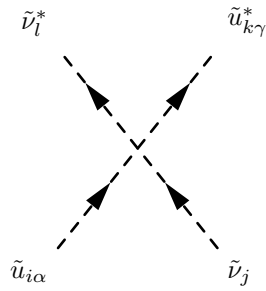


$$\begin{aligned}
& - \frac{i}{72} \left( \delta_{\alpha\delta} \delta_{\beta\gamma} \left( g_1^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U + 9g_2^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U \right. \right. \\
& - 6g_3^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U - 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{l3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U \\
& + 6g_3^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{l3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U \\
& + 18g_3^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \left( - \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{k3+b}^U + \sum_{b=1}^3 Z_{ib}^{U,*} Z_{kb}^U \right) \\
& - 18g_3^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U \left( - \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{k3+b}^U + \sum_{b=1}^3 Z_{ib}^{U,*} Z_{kb}^U \right) \\
& - 4g_1^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{k3+b}^U + 6g_3^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{k3+b}^U \\
& + 16g_1^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{l3+a}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{k3+b}^U - 6g_3^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{l3+a}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{k3+b}^U \\
& + g_1^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U + 9g_2^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U \\
& - 6g_3^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U - 4g_1^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U \\
& + 6g_3^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U + 18g_3^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& - 18g_3^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U - 4g_1^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U
\end{aligned}$$

$$\begin{aligned}
& + 6g_3^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U + 16g_1^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U \\
& - 6g_3^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U - 18g_3^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + 18g_3^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + 72 \sum_{b=1}^3 Z_{ib}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{j3+c}^{U,*} Z_{kd}^U \\
& + 72 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{i3+c}^{U,*} Z_{ld}^U \\
& + \delta_{\alpha\gamma} \delta_{\beta\delta} \left( 18g_3^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U - 18g_3^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{l3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U \right. \\
& + \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U \left( 2 \left( -3g_3^2 + 8g_1^2 \right) \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{k3+b}^U + \left( -4g_1^2 + 6g_3^2 \right) \sum_{b=1}^3 Z_{ib}^{U,*} Z_{kb}^U \right) \\
& + \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \left( 2 \left( -2g_1^2 + 3g_3^2 \right) \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{k3+b}^U + \left( -6g_3^2 + 9g_2^2 + g_1^2 \right) \sum_{b=1}^3 Z_{ib}^{U,*} Z_{kb}^U \right) \\
& - 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
\end{aligned}$$

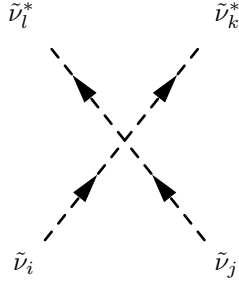
$$\begin{aligned}
& -6g_3^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + 72 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd} Z_{i3+c}^{U,*} Z_{kd}^U \\
& + 72 \sum_{b=1}^3 Z_{ib}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd} Z_{j3+c}^{U,*} Z_{ld}^U \Big)
\end{aligned} \tag{394}$$


---



$$\frac{i}{12} \delta_{\alpha\gamma} \delta_{jl} \left( \left( -3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U - 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \right) \tag{395}$$

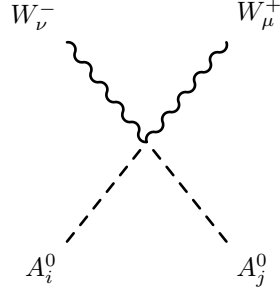

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$$-\frac{i}{4} (g_1^2 + g_2^2) (\delta_{ik} \delta_{jl} + \delta_{il} \delta_{jk}) \tag{396}$$

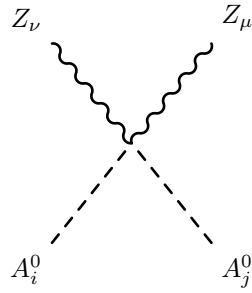

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## 9.8 Two Scalar-Two Vector Boson-Interaction



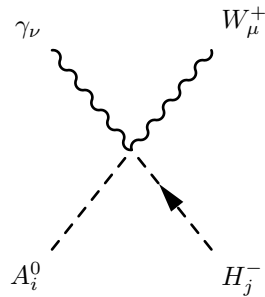
$$\frac{i}{2}g_2^2 \left( Z_{i1}^{A,*} Z_{j1}^{A,*} + Z_{i2}^{A,*} Z_{j2}^{A,*} \right) (g_{\mu\nu}) \quad (397)$$


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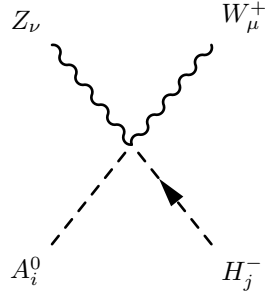
$$\frac{i}{2} \left( Z_{i1}^{A,*} Z_{j1}^{A,*} + Z_{i2}^{A,*} Z_{j2}^{A,*} \right) (g_1 \sin \Theta_W + g_2 \cos \Theta_W)^2 (g_{\mu\nu}) \quad (398)$$


---



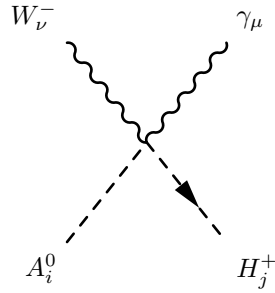
$$-\frac{1}{2}g_1g_2 \cos \Theta_W \left( Z_{i1}^{A,*} Z_{j1}^+ + Z_{i2}^{A,*} Z_{j2}^+ \right) (g_{\mu\nu}) \quad (399)$$


---



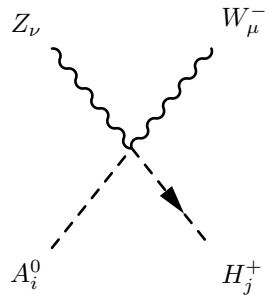
$$\frac{1}{2}g_1g_2 \sin \Theta_W \left( Z_{i1}^{A,*} Z_{j1}^+ + Z_{i2}^{A,*} Z_{j2}^+ \right) \left( g_{\mu\nu} \right) \quad (400)$$


---



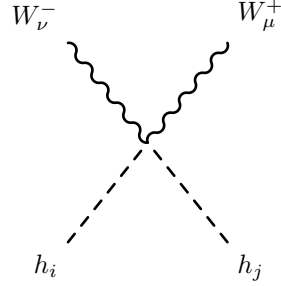
$$\frac{1}{2}g_1g_2 \cos \Theta_W \left( Z_{i1}^{A,*} Z_{j1}^+ + Z_{i2}^{A,*} Z_{j2}^+ \right) \left( g_{\mu\nu} \right) \quad (401)$$


---



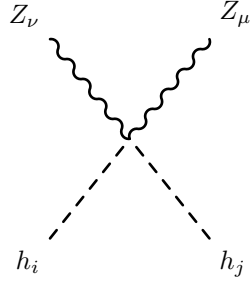
$$-\frac{1}{2}g_1g_2 \sin \Theta_W \left( Z_{i1}^{A,*} Z_{j1}^+ + Z_{i2}^{A,*} Z_{j2}^+ \right) \left( g_{\mu\nu} \right) \quad (402)$$


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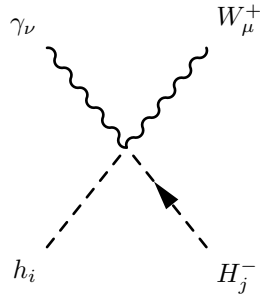
$$\frac{i}{2}g_2^2 \left( Z_{i1}^{H,*} Z_{j1}^{H,*} + Z_{i2}^{H,*} Z_{j2}^{H,*} \right) (g_{\mu\nu}) \quad (403)$$


---



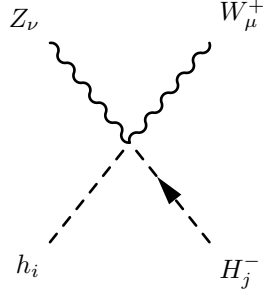
$$\frac{i}{2} \left( Z_{i1}^{H,*} Z_{j1}^{H,*} + Z_{i2}^{H,*} Z_{j2}^{H,*} \right) (g_1 \sin \Theta_W + g_2 \cos \Theta_W)^2 (g_{\mu\nu}) \quad (404)$$


---



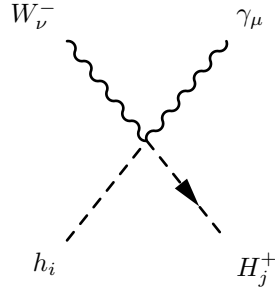
$$-\frac{i}{2}g_1g_2 \cos \Theta_W \left( Z_{i1}^{H,*} Z_{j1}^+ - Z_{i2}^{H,*} Z_{j2}^+ \right) (g_{\mu\nu}) \quad (405)$$


---



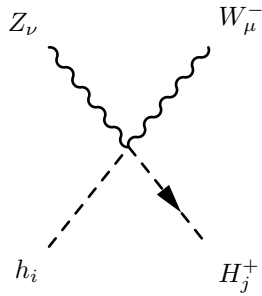
$$\frac{i}{2}g_1g_2 \sin \Theta_W \left( Z_{i1}^{H,*} Z_{j1}^+ - Z_{i2}^{H,*} Z_{j2}^+ \right) \left( g_{\mu\nu} \right) \quad (406)$$


---



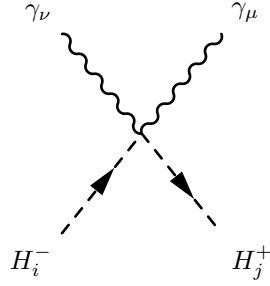
$$-\frac{i}{2}g_1g_2 \cos \Theta_W \left( Z_{i1}^{H,*} Z_{j1}^+ - Z_{i2}^{H,*} Z_{j2}^+ \right) \left( g_{\mu\nu} \right) \quad (407)$$


---



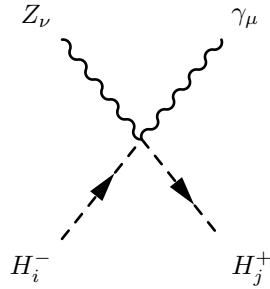
$$\frac{i}{2}g_1g_2 \sin \Theta_W \left( Z_{i1}^{H,*} Z_{j1}^+ - Z_{i2}^{H,*} Z_{j2}^+ \right) \left( g_{\mu\nu} \right) \quad (408)$$


---



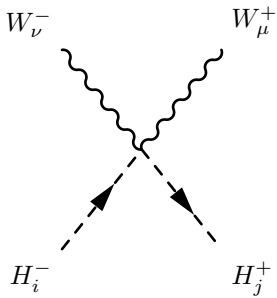
$$\frac{i}{2} (g_1 \cos \Theta_W + g_2 \sin \Theta_W)^2 (Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+) (g_{\mu\nu}) \quad (409)$$


---



$$-\frac{i}{4} \left( -2g_1 g_2 \cos 2\Theta_W + (-g_2^2 + g_1^2) \sin 2\Theta_W \right) (Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+) (g_{\mu\nu}) \quad (410)$$

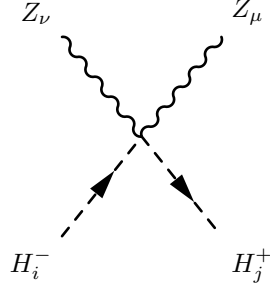

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$$\frac{i}{2} g_2^2 (Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+) (g_{\mu\nu}) \quad (411)$$

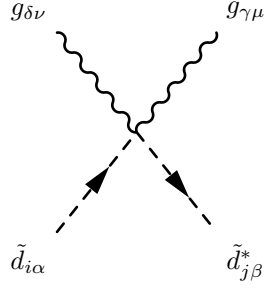

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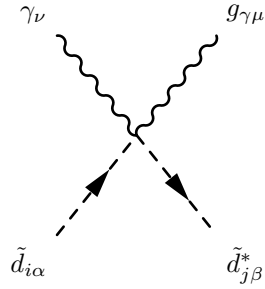
$$\frac{i}{2} \left( -g_1 \sin \Theta_W + g_2 \cos \Theta_W \right)^2 \left( Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+ \right) (g_{\mu\nu}) \quad (412)$$


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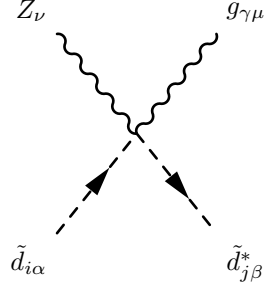
$$\frac{i}{4} g_3^2 \delta_{ij} \left( \sum_{a=1}^3 \lambda_{a,\alpha}^\gamma \lambda_{\beta,a}^\delta + \sum_{a=1}^3 \lambda_{\beta,a}^\gamma \lambda_{a,\alpha}^\delta \right) (g_{\mu\nu}) \quad (413)$$


---



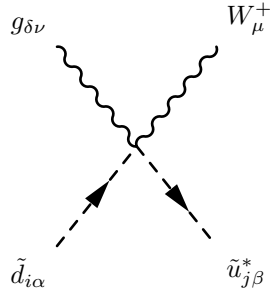
$$\frac{i}{6} g_3 \lambda_{\beta,\alpha}^\gamma \left( -2g_1 \cos \Theta_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D + \left( -3g_2 \sin \Theta_W + g_1 \cos \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \right) (g_{\mu\nu}) \quad (414)$$


---



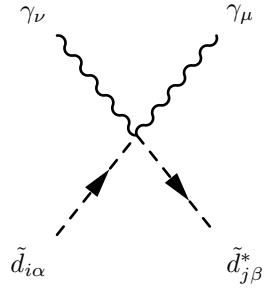
$$-\frac{i}{6}g_3\lambda_{\beta,\alpha}^\gamma\left(-2g_1\sin\Theta_W\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{j3+a}^D+(3g_2\cos\Theta_W+g_1\sin\Theta_W)\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^D\right)(g_{\mu\nu}) \quad (415)$$


---



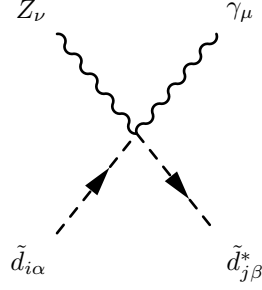
$$i\frac{1}{\sqrt{2}}g_2g_3\lambda_{\beta,\alpha}^\delta\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^U(g_{\mu\nu}) \quad (416)$$


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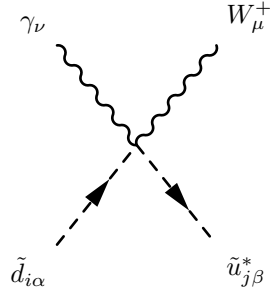
$$\frac{i}{18}\delta_{\alpha\beta}\left(\left(-3g_2\sin\Theta_W+g_1\cos\Theta_W\right)^2\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^D+4g_1^2\cos^2\Theta_W\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{j3+a}^D\right)(g_{\mu\nu}) \quad (417)$$


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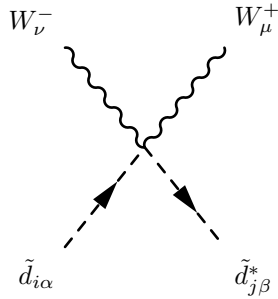
$$\begin{aligned}
& -\frac{i}{36}\delta_{\alpha\beta}\left(\left(6g_1g_2\cos 2\Theta_W + \left(-9g_2^2 + g_1^2\right)\sin 2\Theta_W\right)\sum_{a=1}^3 Z_{ia}^{D,*}Z_{ja}^D\right. \\
& \left.+ 4g_1^2\sin 2\Theta_W\sum_{a=1}^3 Z_{i3+a}^{D,*}Z_{j3+a}^D\right)\left(g_{\mu\nu}\right)
\end{aligned} \tag{418}$$


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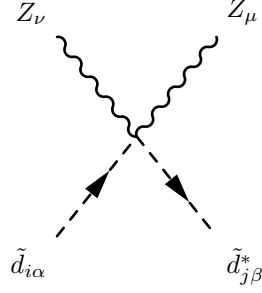
$$\frac{i}{3}\frac{1}{\sqrt{2}}g_1g_2\cos\Theta_W\delta_{\alpha\beta}\sum_{a=1}^3 Z_{ia}^{D,*}Z_{ja}^U\left(g_{\mu\nu}\right) \tag{419}$$


---



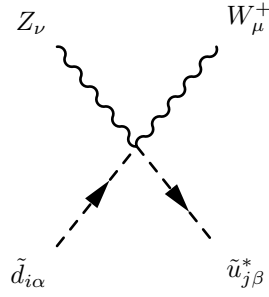
$$\frac{i}{2}g_2^2\delta_{\alpha\beta}\sum_{a=1}^3 Z_{ia}^{D,*}Z_{ja}^D\left(g_{\mu\nu}\right) \tag{420}$$


---



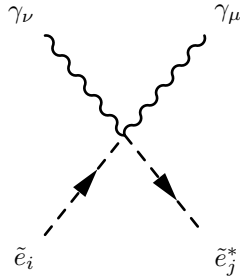
$$\frac{i}{18} \delta_{\alpha\beta} \left( (3g_2 \cos \Theta_W + g_1 \sin \Theta_W)^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D + 4g_1^2 \sin^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^D Z_{j3+a}^D \right) (g_{\mu\nu}) \quad (421)$$


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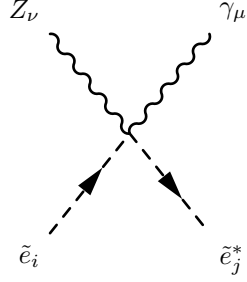
$$-\frac{i}{3} \frac{1}{\sqrt{2}} g_1 g_2 \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U (g_{\mu\nu}) \quad (422)$$


---



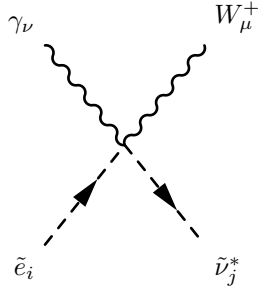
$$\frac{i}{2} \left( 4g_1^2 \cos^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E + (g_1 \cos \Theta_W + g_2 \sin \Theta_W)^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right) (g_{\mu\nu}) \quad (423)$$


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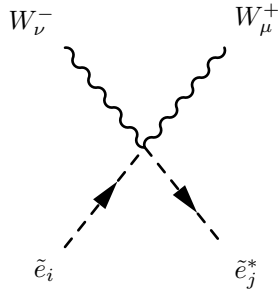
$$\begin{aligned}
& -\frac{i}{4} \left( (-2g_1 g_2 \cos 2\Theta_W + (-g_2^2 + g_1^2) \sin 2\Theta_W) \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right. \\
& \left. + 4g_1^2 \sin 2\Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \right) (g_{\mu\nu})
\end{aligned} \tag{424}$$


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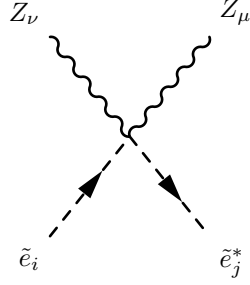
$$-i \frac{1}{\sqrt{2}} g_1 g_2 \cos \Theta_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^V (g_{\mu\nu}) \tag{425}$$


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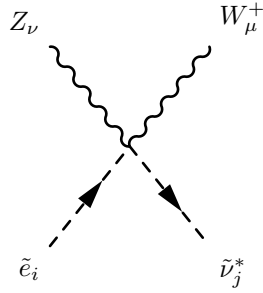
$$\frac{i}{2} g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E (g_{\mu\nu}) \tag{426}$$


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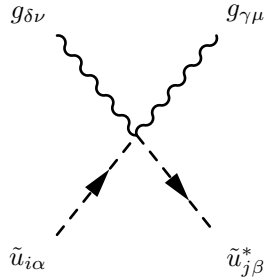
$$\frac{i}{2} \left( 4g_1^2 \sin^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E + \left( -g_1 \sin \Theta_W + g_2 \cos \Theta_W \right)^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right) (g_{\mu\nu}) \quad (427)$$


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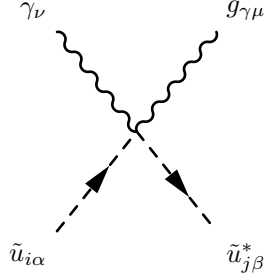
$$i \frac{1}{\sqrt{2}} g_1 g_2 \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^V (g_{\mu\nu}) \quad (428)$$


---



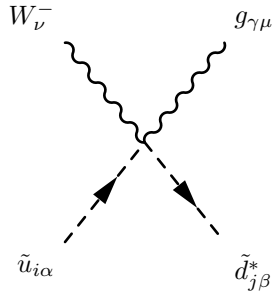
$$\frac{i}{4} g_3^2 \delta_{ij} \left( \sum_{a=1}^3 \lambda_{a,\alpha}^\gamma \lambda_{\beta,a}^\delta + \sum_{a=1}^3 \lambda_{\beta,a}^\gamma \lambda_{a,\alpha}^\delta \right) (g_{\mu\nu}) \quad (429)$$


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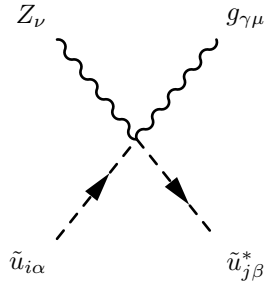
$$\frac{i}{6} g_3 \lambda_{\beta,\alpha}^\gamma \left( (3g_2 \sin \Theta_W + g_1 \cos \Theta_W) \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U + 4g_1 \cos \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \right) (g_{\mu\nu}) \quad (430)$$


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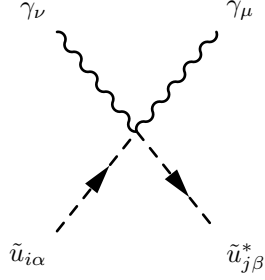
$$i \frac{1}{\sqrt{2}} g_2 g_3 \lambda_{\beta,\alpha}^\gamma \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D (g_{\mu\nu}) \quad (431)$$


---



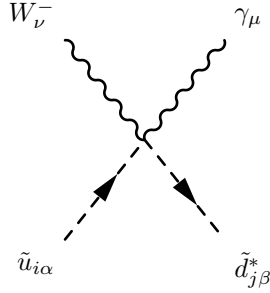
$$\frac{i}{6} g_3 \lambda_{\beta,\alpha}^\gamma \left( (3g_2 \cos \Theta_W - g_1 \sin \Theta_W) \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U - 4g_1 \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \right) (g_{\mu\nu}) \quad (432)$$


---



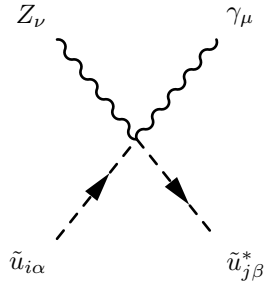
$$\frac{i}{18} \delta_{\alpha\beta} \left( 16g_1^2 \cos^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U + \left( 3g_2 \sin \Theta_W + g_1 \cos \Theta_W \right)^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \right) (g_{\mu\nu}) \quad (433)$$


---



$$\frac{i}{3} \frac{1}{\sqrt{2}} g_1 g_2 \cos \Theta_W \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D (g_{\mu\nu}) \quad (434)$$

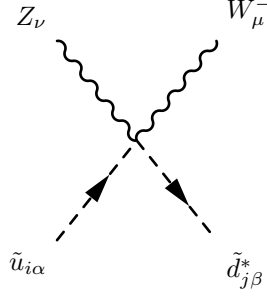

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$$\begin{aligned} & - \frac{i}{36} \delta_{\alpha\beta} \left( -6g_1 g_2 \cos 2\Theta_W + \left( -9g_2^2 + g_1^2 \right) \sin 2\Theta_W \right) \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\ & + 16g_1^2 \sin 2\Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U (g_{\mu\nu}) \end{aligned} \quad (435)$$

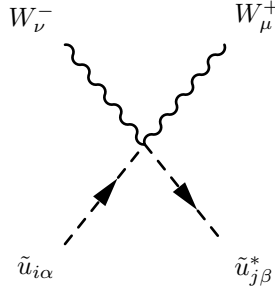

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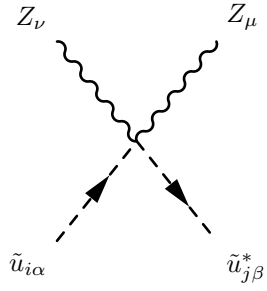
$$-\frac{i}{3} \frac{1}{\sqrt{2}} g_1 g_2 \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D (g_{\mu\nu}) \quad (436)$$


---



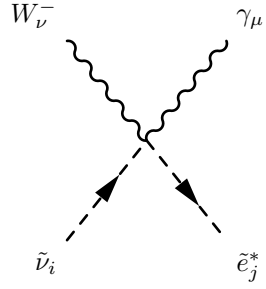
$$\frac{i}{2} g_2^2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U (g_{\mu\nu}) \quad (437)$$


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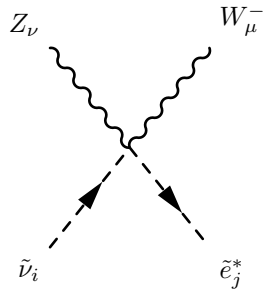
$$\frac{i}{18} \delta_{\alpha\beta} \left( 16g_1^2 \sin^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U + \left( -3g_2 \cos \Theta_W + g_1 \sin \Theta_W \right)^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \right) (g_{\mu\nu}) \quad (438)$$


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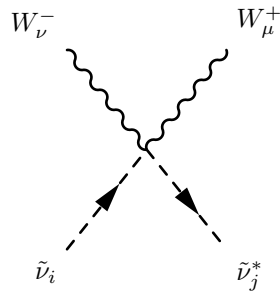
$$-i \frac{1}{\sqrt{2}} g_1 g_2 \cos \Theta_W \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ja}^E (g_{\mu\nu}) \quad (439)$$


---



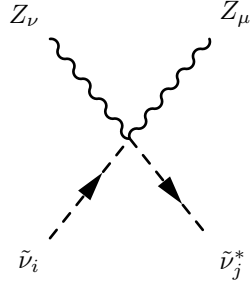
$$i \frac{1}{\sqrt{2}} g_1 g_2 \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ja}^E (g_{\mu\nu}) \quad (440)$$


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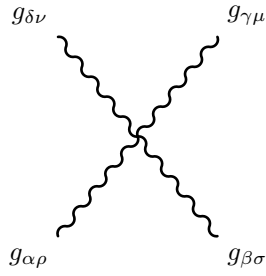
$$\frac{i}{2} g_2^2 \delta_{ij} (g_{\mu\nu}) \quad (441)$$


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$$\frac{i}{2} \delta_{ij} (g_1 \sin \Theta_W + g_2 \cos \Theta_W)^2 (g_{\mu\nu}) \quad (442)$$

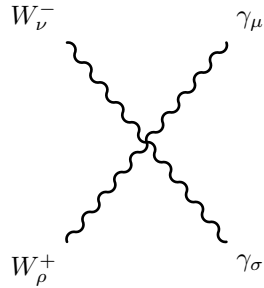
## 9.9 Four Vector Boson-Interaction



$$-ig_3^2 \left( \sum_{a=1}^8 f_{\alpha,\delta,a} f_{\beta,\gamma,a} + \sum_{a=1}^8 f_{\alpha,\gamma,a} f_{\beta,\delta,a} \right) (g_{\rho\sigma} g_{\mu\nu}) \quad (443)$$

$$+ ig_3^2 \left( - \sum_{a=1}^8 f_{\alpha,\beta,a} f_{\gamma,\delta,a} + \sum_{a=1}^8 f_{\alpha,\delta,a} f_{\beta,\gamma,a} \right) (g_{\rho\mu} g_{\sigma\nu}) \quad (444)$$

$$+ ig_3^2 \left( \sum_{a=1}^8 f_{\alpha,\gamma,a} f_{\beta,\delta,a} + \sum_{a=1}^8 f_{\alpha,\beta,a} f_{\gamma,\delta,a} \right) (g_{\rho\nu} g_{\sigma\mu}) \quad (445)$$

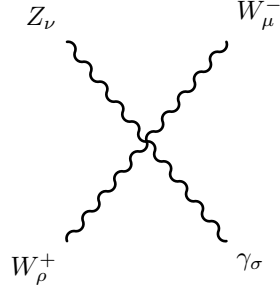


$$ig_2^2 \sin \Theta_W^2 (g_{\rho\sigma} g_{\mu\nu}) \quad (446)$$

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

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


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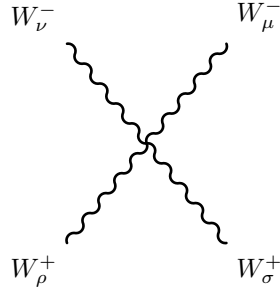


$$ig_2^2 \cos \Theta_W \sin \Theta_W (g_{\rho\sigma} g_{\mu\nu}) \quad (449)$$

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

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


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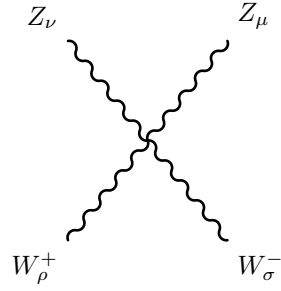


$$2ig_2^2 (g_{\rho\sigma} g_{\mu\nu}) \quad (452)$$

$$+ -ig_2^2 (g_{\rho\mu} g_{\sigma\nu}) \quad (453)$$

$$+ -ig_2^2 (g_{\rho\nu} g_{\sigma\mu}) \quad (454)$$


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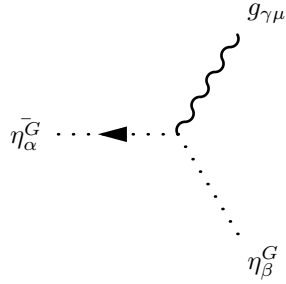


$$- 2ig_2^2 \cos \Theta_W^2 (g_{\rho\sigma} g_{\mu\nu}) \quad (455)$$

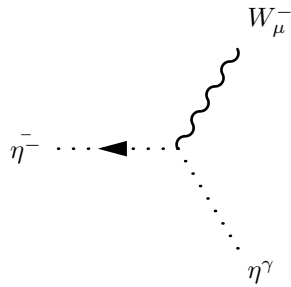
$$+ ig_2^2 \cos \Theta_W^2 (g_{\rho\mu} g_{\sigma\nu}) \quad (456)$$

$$+ ig_2^2 \cos \Theta_W^2 (g_{\rho\nu} g_{\sigma\mu}) \quad (457)$$

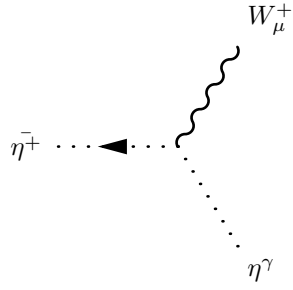
### 9.10 Two Ghosts-One Vector Boson-Interaction



$$g_3 f_{\alpha,\beta,\gamma} (p_\mu^{\eta_\beta^G}) \quad (458)$$

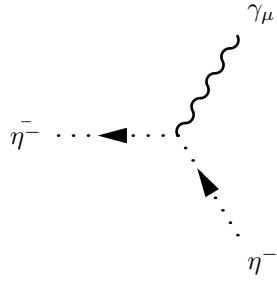


$$ig_2 \sin \Theta_W (p_\mu^{\eta^\gamma}) \quad (459)$$



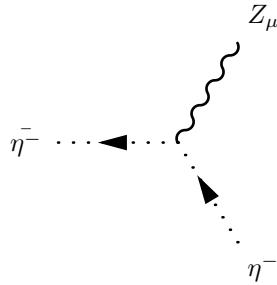
$$-ig_2 \sin \Theta_W (p_\mu^{\eta^+}) \quad (460)$$


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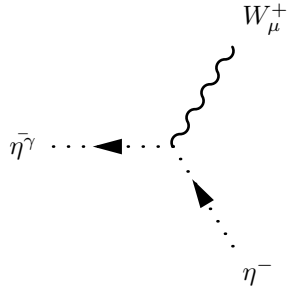
$$-ig_2 \sin \Theta_W (p_\mu^{\eta^-}) \quad (461)$$


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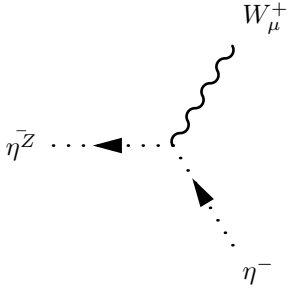
$$-ig_2 \cos \Theta_W (p_\mu^{\eta^-}) \quad (462)$$


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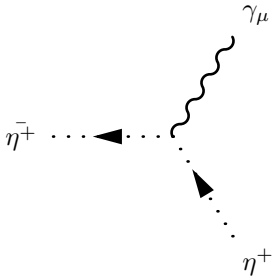
$$ig_2 \sin \Theta_W (p_\mu^{\eta^-}) \quad (463)$$


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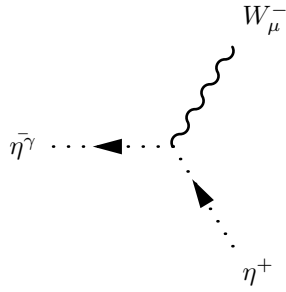
$$ig_2 \cos \Theta_W (p_\mu^{\eta^-}) \quad (464)$$


---



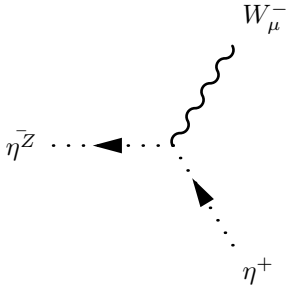
$$ig_2 \sin \Theta_W (p_\mu^{\eta^+}) \quad (465)$$


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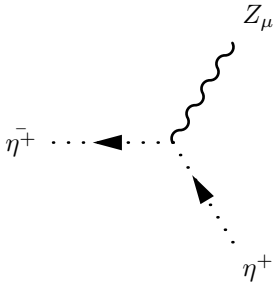
$$-ig_2 \sin \Theta_W (p_\mu^{\eta^+}) \quad (466)$$


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$$-ig_2 \cos \Theta_W (p_\mu^{\eta^+}) \quad (467)$$

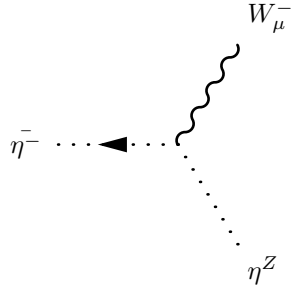

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$$ig_2 \cos \Theta_W (p_\mu^{\eta^+}) \quad (468)$$

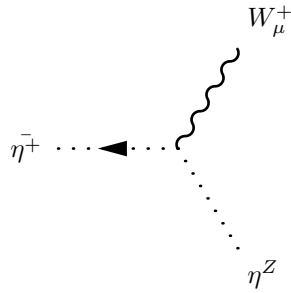

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$$ig_2 \cos \Theta_W (p_\mu^{\eta^Z}) \quad (469)$$

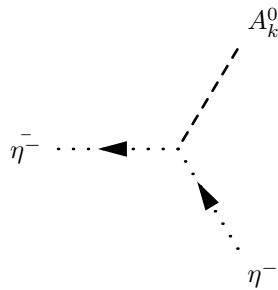

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$$-ig_2 \cos \Theta_W (p_\mu^{\eta^Z}) \quad (470)$$

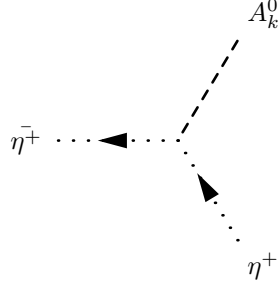

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### 9.11 Two Ghosts-One Scalar-Interaction



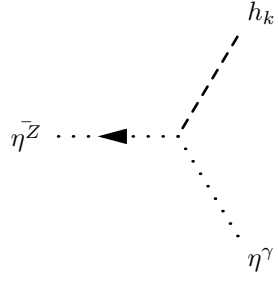
$$\frac{1}{4} g_2^2 (v_d Z_{k1}^{A,*} - v_u Z_{k2}^{A,*}) \xi_{W^-} \quad (471)$$


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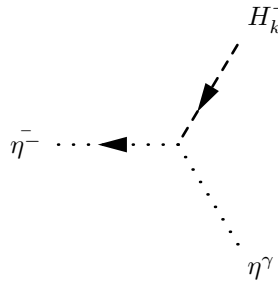
$$\frac{1}{4}g_2^2 \left( -v_d Z_{k1}^{A,*} + v_u Z_{k2}^{A,*} \right) \xi_{W^-} \quad (472)$$


---



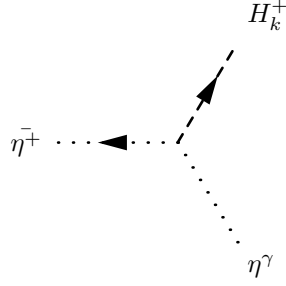
$$\frac{i}{8} \left( v_d Z_{k1}^{H,*} + v_u Z_{k2}^{H,*} \right) \xi_Z \left( 2g_1 g_2 \cos 2\Theta_W + \left( -g_2^2 + g_1^2 \right) \sin 2\Theta_W \right) \quad (473)$$


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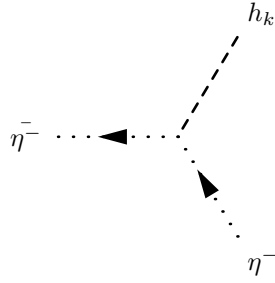
$$\frac{i}{4}g_2 \xi_{W^-} \left( g_1 \cos \Theta_W + g_2 \sin \Theta_W \right) \left( v_d Z_{k1}^+ - v_u Z_{k2}^+ \right) \quad (474)$$


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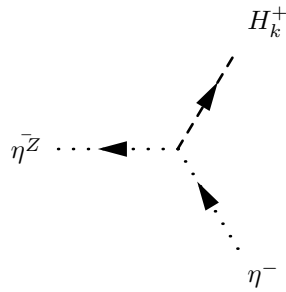
$$\frac{i}{4} g_2 \xi_{W^-} \left( g_1 \cos \Theta_W + g_2 \sin \Theta_W \right) \left( v_d Z_{k1}^+ - v_u Z_{k2}^+ \right) \quad (475)$$


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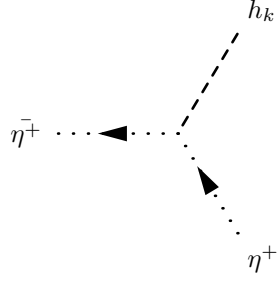
$$-\frac{i}{4} g_2^2 \left( v_d Z_{k1}^{H,*} + v_u Z_{k2}^{H,*} \right) \xi_{W^-} \quad (476)$$


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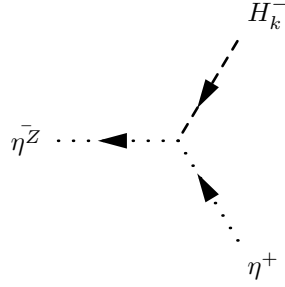
$$-\frac{i}{4} g_2 \xi_Z \left( g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left( v_d Z_{k1}^+ - v_u Z_{k2}^+ \right) \quad (477)$$


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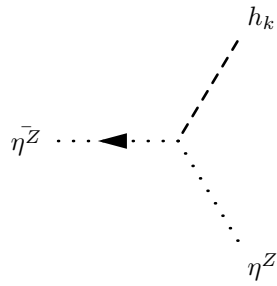
$$-\frac{i}{4}g_2^2(v_d Z_{k1}^{H,*} + v_u Z_{k2}^{H,*})\xi_{W^-} \quad (478)$$


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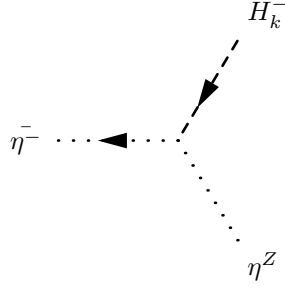
$$-\frac{i}{4}g_2\xi_Z(g_1 \sin \Theta_W + g_2 \cos \Theta_W)(v_d Z_{k1}^+ - v_u Z_{k2}^+) \quad (479)$$


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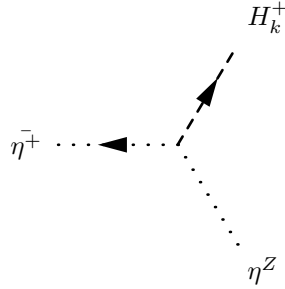
$$-\frac{i}{4}(v_d Z_{k1}^{H,*} + v_u Z_{k2}^{H,*})\xi_Z(g_1 \sin \Theta_W + g_2 \cos \Theta_W)^2 \quad (480)$$


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$$\frac{i}{4} g_2 \xi_{W^-} \left( -g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left( v_d Z_{k1}^+ - v_u Z_{k2}^+ \right) \quad (481)$$


---



$$\frac{i}{4} g_2 \xi_{W^-} \left( -g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left( v_d Z_{k1}^+ - v_u Z_{k2}^+ \right) \quad (482)$$


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## 10 Clebsch-Gordan Coefficients