

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

SARAH 4.6.0

November 18, 2015

This file was automatically generated by SARAH version 4.6.0.

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**

Package Homepage: [projects.hepforge.org/sarah/](http://projects.hepforge.org/sarah/)  
by **Florian Staub**, [florian.staub@cern.ch](mailto:florian.staub@cern.ch)

# Contents

<b>1</b>	<b>Superfields</b>	<b>3</b>
1.1	Vector Superfields . . . . .	3
1.2	Chiral Superfields . . . . .	3
<b>2</b>	<b>Superpotential and Lagrangian</b>	<b>3</b>
2.1	Superpotential . . . . .	3
2.2	Softbreaking terms . . . . .	3
2.3	Gauge fixing terms . . . . .	4
2.3.1	Gauge fixing terms for eigenstates 'GaugeES' . . . . .	4
2.3.2	Gauge fixing terms for eigenstates 'EWSB' . . . . .	4
2.4	Fields integrated out . . . . .	4
<b>3</b>	<b>Renormalization Group Equations</b>	<b>4</b>
3.1	Anomalous Dimensions . . . . .	4
3.2	Gauge Couplings . . . . .	6
3.3	Gaugino Mass Parameters . . . . .	6
3.4	Trilinear Superpotential Parameters . . . . .	7
3.5	Bilinear Superpotential Parameters . . . . .	9
3.6	Trilinear Soft-Breaking Parameters . . . . .	9
3.7	Bilinear Soft-Breaking Parameters . . . . .	15
3.8	Soft-Breaking Scalar Masses . . . . .	15
3.9	Vacuum expectation values . . . . .	26
<b>4</b>	<b>Field Rotations</b>	<b>27</b>
4.1	Rotations in gauge sector for eigenstates 'EWSB' . . . . .	27
4.2	Rotations in Mass sector for eigenstates 'EWSB' . . . . .	28
4.2.1	Mass Matrices for Scalars . . . . .	28
4.2.2	Mass Matrices for Fermions . . . . .	32
<b>5</b>	<b>Vacuum Expectation Values</b>	<b>34</b>
<b>6</b>	<b>Tadpole Equations</b>	<b>34</b>
<b>7</b>	<b>Particle content for eigenstates 'EWSB'</b>	<b>35</b>
<b>8</b>	<b>One Loop Self-Energy and One Loop Tadpoles for eigenstates 'EWSB'</b>	<b>36</b>
8.1	One Loop Self-Energy . . . . .	36
8.2	Tadpoles . . . . .	57
<b>9</b>	<b>Interactions for eigenstates 'EWSB'</b>	<b>58</b>
9.1	Three Scalar-Interaction . . . . .	58
9.2	Two Scalar-One Vector Boson-Interaction . . . . .	82
9.3	One Scalar-Two Vector Boson-Interaction . . . . .	89
9.4	Two Fermion-One Vector Boson-Interaction . . . . .	91
9.5	Two Fermion-One Scalar Boson-Interaction . . . . .	98

9.6	Three Vector Boson-Interaction . . . . .	113
9.7	Four Scalar-Interaction . . . . .	114
9.8	Two Scalar-Two Vector Boson-Interaction . . . . .	180
9.9	Four Vector Boson-Interaction . . . . .	198
9.10	Two Ghosts-One Vector Boson-Interaction . . . . .	200
9.11	Two Ghosts-One Scalar-Interaction . . . . .	204
<b>10</b>	<b>Clebsch-Gordan Coefficients</b>	<b>208</b>

# 1 Superfields

## 1.1 Vector Superfields

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

## 1.2 Chiral Superfields

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

# 2 Superpotential and Lagrangian

## 2.1 Superpotential

$$W = \frac{1}{2} \mu_X \hat{X} \hat{X} - Y_d \hat{d} \hat{q} \hat{H}_d - Y_e \hat{e} \hat{l} \hat{H}_d + \lambda \hat{s} \hat{H}_u \hat{H}_d + \frac{1}{3} \kappa \hat{s} \hat{s} \hat{s} + \lambda_N \hat{s} \hat{\nu} \hat{X} + Y_u \hat{u} \hat{q} \hat{H}_u + Y_\nu \hat{\nu} \hat{l} \hat{H}_u \quad (1)$$

## 2.2 Softbreaking terms

$$\begin{aligned} -L_{SB,W} = & + \frac{1}{3} S^3 T_\kappa - H_d^0 H_u^0 S T_\lambda + H_d^- H_u^+ S T_\lambda + \frac{1}{2} \tilde{x}_i \tilde{x}_j B_{\mu_X, ij} + H_d^0 \tilde{d}_{R, i\alpha}^* \delta_{\alpha\beta} \tilde{d}_{L, j\beta} T_{d, ij} \\ & - H_d^- \tilde{d}_{R, i\alpha}^* \delta_{\alpha\beta} \tilde{u}_{L, j\beta} T_{d, ij} + H_d^0 \tilde{e}_{R, i}^* \tilde{e}_{L, j} T_{e, ij} - H_d^- \tilde{e}_{R, i}^* \tilde{\nu}_{L, j} T_{e, ij} - H_u^+ \tilde{u}_{R, i\alpha}^* \delta_{\alpha\beta} \tilde{d}_{L, j\beta} T_{u, ij} \\ & + H_u^0 \tilde{u}_{R, i\alpha}^* \delta_{\alpha\beta} \tilde{u}_{L, j\beta} T_{u, ij} - H_u^+ \tilde{\nu}_{R, i}^* \tilde{e}_{L, j} T_{Y_\nu, ij} + H_u^0 \tilde{\nu}_{R, i}^* \tilde{\nu}_{L, j} T_{Y_\nu, ij} + S \tilde{\nu}_{R, j}^* \tilde{x}_k T_{\lambda_N, jk} + \text{h.c.} \\ -L_{SB,\phi} = & + m_{H_d}^2 |H_d^0|^2 + m_{H_d}^2 |H_d^-|^2 + m_{H_u}^2 |H_u^0|^2 + m_{H_u}^2 |H_u^+|^2 + m_S^2 |S|^2 + \tilde{d}_{L, i\alpha}^* \delta_{\alpha\beta} m_{q, ij}^2 \tilde{d}_{L, j\beta} \end{aligned} \quad (2)$$

$$\begin{aligned}
& + \tilde{d}_{R,i\alpha}^* \delta_{\alpha\beta} m_{d,ij}^2 \tilde{d}_{R,j\beta} + \tilde{e}_{L,i}^* m_{l,ij}^2 \tilde{e}_{L,j} + \tilde{e}_{R,i}^* m_{e,ij}^2 \tilde{e}_{R,j} + \tilde{u}_{L,i\alpha}^* \delta_{\alpha\beta} m_{q,ij}^2 \tilde{u}_{L,j\beta} \\
& + \tilde{u}_{R,i\alpha}^* \delta_{\alpha\beta} m_{u,ij}^2 \tilde{u}_{R,j\beta} + \tilde{\nu}_{L,i}^* m_{l,ij}^2 \tilde{\nu}_{L,j} + \tilde{\nu}_{R,i}^* m_{\nu,ij}^2 \tilde{\nu}_{R,j} + \tilde{x}_i^* m_{x,ij}^2 \tilde{x}_j
\end{aligned} \tag{3}$$

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

## 2.3 Gauge fixing terms

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

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

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

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

## 2.4 Fields integrated out

None

# 3 Renormalization Group Equations

## 3.1 Anomalous Dimensions

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\begin{aligned}\gamma_{\hat{e}}^{(2)} = & +\frac{234}{25}g_1^4\mathbf{1} \\ & - \frac{2}{5}\left(5\left(Y_e^*Y_e^TY_e^*Y_e^T + Y_e^*Y_\nu^TY_\nu^*Y_e^T\right) \right. \\ & \left. + Y_e^*Y_e^T\left(-15g_2^2 + 15\text{Tr}(Y_dY_d^\dagger) + 3g_1^2 + 5|\lambda|^2 + 5\text{Tr}(Y_eY_e^\dagger)\right)\right)\end{aligned}\quad (20)$$

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

$$\begin{aligned}\gamma_{\hat{\nu}}^{(2)} = & -2|\kappa|^2\lambda_N^*\lambda_N^T - 2|\lambda|^2\lambda_N^*\lambda_N^T - 2Y_\nu^*Y_e^TY_e^*Y_\nu^T - 2Y_\nu^*Y_\nu^TY_\nu^*Y_\nu^T - \lambda_N^*\lambda_N^T\lambda_N^*\lambda_N^T \\ & + Y_\nu^*Y_\nu^T\left(-2|\lambda|^2 - 2\text{Tr}(Y_\nu Y_\nu^\dagger) + 6g_2^2 - 6\text{Tr}(Y_uY_u^\dagger) + \frac{6}{5}g_1^2\right) - \lambda_N^*\lambda_N^T\text{Tr}(\lambda_N\lambda_N^\dagger)\end{aligned}\quad (22)$$

$$\gamma_{\hat{s}}^{(1)} = 2|\kappa|^2 + 2|\lambda|^2 + \text{Tr}(\lambda_N\lambda_N^\dagger)\quad (23)$$

$$\begin{aligned}\gamma_{\hat{s}}^{(2)} = & -8\kappa^2\kappa^{*,2} - 4\lambda^2\lambda^{*,2} \\ & + \frac{2}{5}|\lambda|^2\left(15g_2^2 - 15\text{Tr}(Y_dY_d^\dagger) - 15\text{Tr}(Y_uY_u^\dagger) + 3g_1^2 - 5\text{Tr}(Y_eY_e^\dagger) - 5\text{Tr}(Y_\nu Y_\nu^\dagger)\right)\end{aligned}$$

$$-4|\kappa|^2\left(2\lambda\lambda^* + \text{Tr}\left(\lambda_N\lambda_N^\dagger\right)\right) - 2\left(\text{Tr}\left(Y_\nu Y_\nu^\dagger\lambda_N\lambda_N^\dagger\right) + \text{Tr}\left(\lambda_N\lambda_N^\dagger\lambda_N\lambda_N^\dagger\right)\right) \quad (24)$$

$$\gamma_{\widehat{X}}^{(1)} = \lambda_N^\dagger\lambda_N \quad (25)$$

$$\begin{aligned} \gamma_{\widehat{X}}^{(2)} = & -2|\kappa|^2\lambda_N^\dagger\lambda_N - 2|\lambda|^2\lambda_N^\dagger\lambda_N - 2\lambda_N^\dagger Y_\nu Y_\nu^\dagger\lambda_N - \lambda_N^\dagger\lambda_N\lambda_N^\dagger\lambda_N \\ & - \lambda_N^\dagger\lambda_N\text{Tr}\left(\lambda_N\lambda_N^\dagger\right) \end{aligned} \quad (26)$$

### 3.2 Gauge Couplings

$$\beta_{g_1}^{(1)} = \frac{33}{5}g_1^3 \quad (27)$$

$$\beta_{g_1}^{(2)} = \frac{1}{25}g_1^3\left(-130\text{Tr}\left(Y_u Y_u^\dagger\right) + 135g_2^2 + 199g_1^2 - 30|\lambda|^2 - 30\text{Tr}\left(Y_\nu Y_\nu^\dagger\right) + 440g_3^2 - 70\text{Tr}\left(Y_d Y_d^\dagger\right) - 90\text{Tr}\left(Y_e Y_e^\dagger\right)\right) \quad (28)$$

$$\beta_{g_2}^{(1)} = g_2^3 \quad (29)$$

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

$$\beta_{g_3}^{(1)} = -3g_3^3 \quad (31)$$

$$\beta_{g_3}^{(2)} = \frac{1}{5}g_3^3\left(11g_1^2 - 20\text{Tr}\left(Y_d Y_d^\dagger\right) - 20\text{Tr}\left(Y_u Y_u^\dagger\right) + 45g_2^2 + 70g_3^2\right) \quad (32)$$

### 3.3 Gaugino Mass Parameters

$$\beta_{M_1}^{(1)} = \frac{66}{5}g_1^2 M_1 \quad (33)$$

$$\begin{aligned} \beta_{M_1}^{(2)} = & \frac{2}{25}g_1^2\left(398g_1^2 M_1 + 135g_2^2 M_1 + 440g_3^2 M_1 + 440g_3^2 M_3 + 135g_2^2 M_2 - 30\lambda^*\left(M_1\lambda - T_\lambda\right) - 70M_1\text{Tr}\left(Y_d Y_d^\dagger\right) \right. \\ & - 90M_1\text{Tr}\left(Y_e Y_e^\dagger\right) - 130M_1\text{Tr}\left(Y_u Y_u^\dagger\right) - 30M_1\text{Tr}\left(Y_\nu Y_\nu^\dagger\right) + 70\text{Tr}\left(Y_d^\dagger T_d\right) + 90\text{Tr}\left(Y_e^\dagger T_e\right) \\ & \left. + 130\text{Tr}\left(Y_u^\dagger T_u\right) + 30\text{Tr}\left(Y_\nu^\dagger T_{Y_\nu}\right)\right) \end{aligned} \quad (34)$$

$$\beta_{M_2}^{(1)} = 2g_2^2 M_2 \quad (35)$$

$$\begin{aligned} \beta_{M_2}^{(2)} = & \frac{2}{5}g_2^2\left(9g_1^2 M_1 + 120g_3^2 M_3 + 9g_1^2 M_2 + 250g_2^2 M_2 + 120g_3^2 M_2 - 10\lambda^*\left(M_2\lambda - T_\lambda\right) - 30M_2\text{Tr}\left(Y_d Y_d^\dagger\right) \right. \\ & - 10M_2\text{Tr}\left(Y_e Y_e^\dagger\right) - 30M_2\text{Tr}\left(Y_u Y_u^\dagger\right) - 10M_2\text{Tr}\left(Y_\nu Y_\nu^\dagger\right) + 30\text{Tr}\left(Y_d^\dagger T_d\right) + 10\text{Tr}\left(Y_e^\dagger T_e\right) \\ & \left. + 30\text{Tr}\left(Y_u^\dagger T_u\right) + 10\text{Tr}\left(Y_\nu^\dagger T_{Y_\nu}\right)\right) \end{aligned} \quad (36)$$

$$\beta_{M_3}^{(1)} = -6g_3^2 M_3 \quad (37)$$

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

$$+ 20\text{Tr}(Y_d^\dagger T_d) + 20\text{Tr}(Y_u^\dagger T_u)) \quad (38)$$

### 3.4 Trilinear Superpotential Parameters

$$\beta_{Y_d}^{(1)} = 3Y_d Y_d^\dagger Y_d + Y_d \left( -3g_2^2 + 3\text{Tr}(Y_d Y_d^\dagger) - \frac{16}{3}g_3^2 - \frac{7}{15}g_1^2 + |\lambda|^2 + \text{Tr}(Y_e Y_e^\dagger) \right) + Y_d Y_u^\dagger Y_u \quad (39)$$

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

$$\beta_{Y_e}^{(1)} = 3Y_e Y_e^\dagger Y_e + Y_e \left( -3g_2^2 + 3\text{Tr}(Y_d Y_d^\dagger) - \frac{9}{5}g_1^2 + |\lambda|^2 + \text{Tr}(Y_e Y_e^\dagger) \right) + Y_e Y_\nu^\dagger Y_\nu \quad (41)$$

$$\begin{aligned} \beta_{Y_e}^{(2)} = & -|\lambda|^2 Y_e Y_\nu^\dagger Y_\nu - 4Y_e Y_e^\dagger Y_e Y_e^\dagger Y_e - 2Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger Y_e - 2Y_e Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu \\ & - Y_e Y_\nu^\dagger \lambda_N \lambda_N^\dagger Y_\nu + Y_e Y_e^\dagger Y_e \left( -3|\lambda|^2 - 3\text{Tr}(Y_e Y_e^\dagger) + 6g_2^2 - 9\text{Tr}(Y_d Y_d^\dagger) \right) \\ & - 3Y_e Y_\nu^\dagger Y_\nu \text{Tr}(Y_u Y_u^\dagger) - Y_e Y_\nu^\dagger Y_\nu \text{Tr}(Y_\nu Y_\nu^\dagger) \\ & + \frac{1}{10}Y_e \left( 135g_1^4 + 18g_1^2 g_2^2 + 75g_2^4 - 20\lambda|\kappa|^2 \lambda^* - 30\lambda^2 \lambda^{*,2} - 4g_1^2 \text{Tr}(Y_d Y_d^\dagger) + 160g_3^2 \text{Tr}(Y_d Y_d^\dagger) \right. \\ & + 12g_1^2 \text{Tr}(Y_e Y_e^\dagger) - 10|\lambda|^2 \left( 3\text{Tr}(Y_u Y_u^\dagger) + \text{Tr}(Y_\nu Y_\nu^\dagger) + \text{Tr}(\lambda_N \lambda_N^\dagger) \right) - 90\text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) \\ & \left. - 30\text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 30\text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) - 10\text{Tr}(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger) \right) \end{aligned} \quad (42)$$

$$\begin{aligned} \beta_\lambda^{(1)} = & -\frac{3}{5}g_1^2 \lambda - 3g_2^2 \lambda + 2\lambda|\kappa|^2 + 4\lambda^2 \lambda^* + 3\lambda \text{Tr}(Y_d Y_d^\dagger) + \lambda \text{Tr}(Y_e Y_e^\dagger) + 3\lambda \text{Tr}(Y_u Y_u^\dagger) \\ & + \lambda \text{Tr}(Y_\nu Y_\nu^\dagger) + \lambda \text{Tr}(\lambda_N \lambda_N^\dagger) \end{aligned} \quad (43)$$

$$\begin{aligned} \beta_\lambda^{(2)} = & -\frac{1}{50}\lambda \left( -207g_1^4 - 90g_1^2 g_2^2 - 375g_2^4 + 400\kappa^2 \kappa^{*,2} + 500\lambda^2 \lambda^{*,2} + 20g_1^2 \text{Tr}(Y_d Y_d^\dagger) - 800g_3^2 \text{Tr}(Y_d Y_d^\dagger) \right. \\ & - 60g_1^2 \text{Tr}(Y_e Y_e^\dagger) - 40g_1^2 \text{Tr}(Y_u Y_u^\dagger) - 800g_3^2 \text{Tr}(Y_u Y_u^\dagger) \\ & - 10|\lambda|^2 \left( -10\text{Tr}(\lambda_N \lambda_N^\dagger) - 15\text{Tr}(Y_e Y_e^\dagger) - 15\text{Tr}(Y_\nu Y_\nu^\dagger) + 30g_2^2 - 45\text{Tr}(Y_d Y_d^\dagger) - 45\text{Tr}(Y_u Y_u^\dagger) + 6g_1^2 \right) \\ & \left. + 200|\kappa|^2 \left( 3\lambda \lambda^* + \text{Tr}(\lambda_N \lambda_N^\dagger) \right) + 450\text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) + 300\text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) + 150\text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) \right) \end{aligned}$$



$$\begin{aligned}
& + 100\text{Tr}\left(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger\right) + 450\text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right) + 150\text{Tr}\left(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\right) + 150\text{Tr}\left(Y_\nu Y_\nu^\dagger \lambda_N \lambda_N^\dagger\right) \\
& + 100\text{Tr}\left(\lambda_N \lambda_N^\dagger \lambda_N \lambda_N^\dagger\right)
\end{aligned} \tag{44}$$

$$\beta_\kappa^{(1)} = 3\kappa\left(2|\kappa|^2 + 2|\lambda|^2 + \text{Tr}\left(\lambda_N \lambda_N^\dagger\right)\right) \tag{45}$$

$$\begin{aligned}
\beta_\kappa^{(2)} = & -\frac{6}{5}\kappa\left(20\kappa^2\kappa^{*,2} + 10\lambda^2\lambda^{*,2} \right. \\
& + |\lambda|^2\left(-15g_2^2 + 15\text{Tr}\left(Y_d Y_d^\dagger\right) + 15\text{Tr}\left(Y_u Y_u^\dagger\right) - 3g_1^2 + 5\text{Tr}\left(Y_e Y_e^\dagger\right) + 5\text{Tr}\left(Y_\nu Y_\nu^\dagger\right)\right) \\
& \left. + 10|\kappa|^2\left(2\lambda\lambda^* + \text{Tr}\left(\lambda_N \lambda_N^\dagger\right)\right) + 5\left(\text{Tr}\left(Y_\nu Y_\nu^\dagger \lambda_N \lambda_N^\dagger\right) + \text{Tr}\left(\lambda_N \lambda_N^\dagger \lambda_N \lambda_N^\dagger\right)\right)\right)
\end{aligned} \tag{46}$$

$$\beta_{\lambda_N}^{(1)} = 2\lambda_N|\kappa|^2 + 2\lambda_N|\lambda|^2 + 2\lambda_N\lambda_N^\dagger\lambda_N + 2Y_\nu Y_\nu^\dagger\lambda_N + \lambda_N\text{Tr}\left(\lambda_N \lambda_N^\dagger\right) \tag{47}$$

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

$$\beta_{Y_u}^{(1)} = 3Y_u Y_u^\dagger Y_u + Y_u\left(-3g_2^2 + 3\text{Tr}\left(Y_u Y_u^\dagger\right) - \frac{13}{15}g_1^2 - \frac{16}{3}g_3^2 + |\lambda|^2 + \text{Tr}\left(Y_\nu Y_\nu^\dagger\right)\right) + Y_u Y_d^\dagger Y_d \tag{49}$$

$$\begin{aligned}
\beta_{Y_u}^{(2)} = & +\frac{2}{5}g_1^2Y_u Y_u^\dagger Y_u + 6g_2^2Y_u Y_u^\dagger Y_u - 3|\lambda|^2Y_u Y_u^\dagger Y_u - 2Y_u Y_d^\dagger Y_d Y_d^\dagger Y_d \\
& - 2Y_u Y_d^\dagger Y_d Y_u^\dagger Y_u - 4Y_u Y_u^\dagger Y_u Y_u^\dagger Y_u \\
& + Y_u Y_d^\dagger Y_d\left(-3\text{Tr}\left(Y_d Y_d^\dagger\right) + \frac{2}{5}g_1^2 - |\lambda|^2 - \text{Tr}\left(Y_e Y_e^\dagger\right)\right) - 9Y_u Y_u^\dagger Y_u\text{Tr}\left(Y_u Y_u^\dagger\right) \\
& - 3Y_u Y_u^\dagger Y_u\text{Tr}\left(Y_\nu Y_\nu^\dagger\right) \\
& + Y_u\left(\frac{2743}{450}g_1^4 + g_1^2g_2^2 + \frac{15}{2}g_2^4 + \frac{136}{45}g_1^2g_3^2 + 8g_2^2g_3^2 - \frac{16}{9}g_3^4 - 2\lambda|\kappa|^2\lambda^* - 3\lambda^2\lambda^{*,2} \right. \\
& + \frac{4}{5}g_1^2\text{Tr}\left(Y_u Y_u^\dagger\right) + 16g_3^2\text{Tr}\left(Y_u Y_u^\dagger\right) - |\lambda|^2\left(3\text{Tr}\left(Y_d Y_d^\dagger\right) + \text{Tr}\left(Y_e Y_e^\dagger\right) + \text{Tr}\left(\lambda_N \lambda_N^\dagger\right)\right) \\
& - 3\text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) - \text{Tr}\left(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger\right) - 9\text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right) - 3\text{Tr}\left(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\right) \\
& \left. - \text{Tr}\left(Y_\nu Y_\nu^\dagger \lambda_N \lambda_N^\dagger\right)\right)
\end{aligned} \tag{50}$$

$$\beta_{Y_\nu}^{(1)} = 3Y_\nu Y_\nu^\dagger Y_\nu + Y_\nu\left(-3g_2^2 + 3\text{Tr}\left(Y_u Y_u^\dagger\right) - \frac{3}{5}g_1^2 + |\lambda|^2 + \text{Tr}\left(Y_\nu Y_\nu^\dagger\right)\right) + Y_\nu Y_e^\dagger Y_e + \lambda_N\lambda_N^\dagger Y_\nu \tag{51}$$

$$\begin{aligned}
\beta_{Y_\nu}^{(2)} = & +\frac{6}{5}g_1^2 Y_\nu Y_\nu^\dagger Y_\nu + 6g_2^2 Y_\nu Y_\nu^\dagger Y_\nu - 3|\lambda|^2 Y_\nu Y_\nu^\dagger Y_\nu - 2|\kappa|^2 \lambda_N \lambda_N^\dagger Y_\nu \\
& - 2|\lambda|^2 \lambda_N \lambda_N^\dagger Y_\nu - 2Y_\nu Y_e^\dagger Y_e Y_e^\dagger Y_e - 2Y_\nu Y_e^\dagger Y_e Y_\nu^\dagger Y_\nu - 4Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu \\
& - Y_\nu Y_\nu^\dagger \lambda_N \lambda_N^\dagger Y_\nu - \lambda_N \lambda_N^\dagger \lambda_N \lambda_N^\dagger Y_\nu \\
& + Y_\nu Y_e^\dagger Y_e \left( -3\text{Tr}(Y_d Y_d^\dagger) + \frac{6}{5}g_1^2 - |\lambda|^2 - \text{Tr}(Y_e Y_e^\dagger) \right) - 9Y_\nu Y_\nu^\dagger Y_\nu \text{Tr}(Y_u Y_u^\dagger) \\
& - 3Y_\nu Y_\nu^\dagger Y_\nu \text{Tr}(Y_\nu Y_\nu^\dagger) - \lambda_N \lambda_N^\dagger Y_\nu \text{Tr}(\lambda_N \lambda_N^\dagger) \\
& + Y_\nu \left( \frac{207}{50}g_1^4 + \frac{9}{5}g_1^2 g_2^2 + \frac{15}{2}g_2^4 - 2\lambda|\kappa|^2 \lambda^* - 3\lambda^2 \lambda^{*,2} + \frac{4}{5}g_1^2 \text{Tr}(Y_u Y_u^\dagger) + 16g_3^2 \text{Tr}(Y_u Y_u^\dagger) \right. \\
& - |\lambda|^2 \left( 3\text{Tr}(Y_d Y_d^\dagger) + \text{Tr}(Y_e Y_e^\dagger) + \text{Tr}(\lambda_N \lambda_N^\dagger) \right) - 3\text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - \text{Tr}(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger) \\
& \left. - 9\text{Tr}(Y_u Y_u^\dagger Y_u Y_u^\dagger) - 3\text{Tr}(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger) - \text{Tr}(Y_\nu Y_\nu^\dagger \lambda_N \lambda_N^\dagger) \right)
\end{aligned} \tag{52}$$

### 3.5 Bilinear Superpotential Parameters

$$\beta_{\mu_X}^{(1)} = \mu_X \lambda_N^\dagger \lambda_N + \lambda_N^T \lambda_N^* \mu_X \tag{53}$$

$$\begin{aligned}
\beta_{\mu_X}^{(2)} = & -2|\kappa|^2 \left( \mu_X \lambda_N^\dagger \lambda_N + \lambda_N^T \lambda_N^* \mu_X \right) - 2|\lambda|^2 \left( \mu_X \lambda_N^\dagger \lambda_N + \lambda_N^T \lambda_N^* \mu_X \right) \\
& - 2\mu_X \lambda_N^\dagger Y_\nu Y_\nu^\dagger \lambda_N - \mu_X \lambda_N^\dagger \lambda_N \lambda_N^\dagger \lambda_N - 2\lambda_N^T Y_\nu^* Y_\nu^T \lambda_N^* \mu_X - \lambda_N^T \lambda_N^* \lambda_N^T \lambda_N^* \mu_X \\
& - \mu_X \lambda_N^\dagger \lambda_N \text{Tr}(\lambda_N \lambda_N^\dagger) - \lambda_N^T \lambda_N^* \mu_X \text{Tr}(\lambda_N \lambda_N^\dagger)
\end{aligned} \tag{54}$$

### 3.6 Trilinear Soft-Breaking Parameters

$$\begin{aligned}
\beta_{T_d}^{(1)} = & +4Y_d Y_d^\dagger T_d + 2Y_d Y_u^\dagger T_u + 5T_d Y_d^\dagger Y_d + T_d Y_u^\dagger Y_u - \frac{7}{15}g_1^2 T_d - 3g_2^2 T_d - \frac{16}{3}g_3^2 T_d \\
& + |\lambda|^2 T_d + 3T_d \text{Tr}(Y_d Y_d^\dagger) + T_d \text{Tr}(Y_e Y_e^\dagger) \\
& + Y_d \left( 2\lambda^* T_\lambda + 2\text{Tr}(Y_e^\dagger T_e) + 6g_2^2 M_2 + 6\text{Tr}(Y_d^\dagger T_d) + \frac{14}{15}g_1^2 M_1 + \frac{32}{3}g_3^2 M_3 \right) \\
\beta_{T_d}^{(2)} = & +\frac{6}{5}g_1^2 Y_d Y_d^\dagger T_d + 6g_2^2 Y_d Y_d^\dagger T_d - 4|\lambda|^2 Y_d Y_d^\dagger T_d - \frac{8}{5}g_1^2 M_1 Y_d Y_u^\dagger Y_u \\
& + \frac{8}{5}g_1^2 Y_d Y_u^\dagger T_u - 2|\lambda|^2 Y_d Y_u^\dagger T_u + \frac{6}{5}g_1^2 T_d Y_d^\dagger Y_d + 12g_2^2 T_d Y_d^\dagger Y_d \\
& - 5|\lambda|^2 T_d Y_d^\dagger Y_d + \frac{4}{5}g_1^2 T_d Y_u^\dagger Y_u - |\lambda|^2 T_d Y_u^\dagger Y_u - 6Y_d Y_d^\dagger Y_d Y_d^\dagger T_d \\
& - 8Y_d Y_d^\dagger T_d Y_d^\dagger Y_d - 2Y_d Y_u^\dagger Y_u Y_d^\dagger T_d - 4Y_d Y_u^\dagger Y_u Y_u^\dagger T_u - 4Y_d Y_u^\dagger T_u Y_d^\dagger Y_d \\
& - 4Y_d Y_u^\dagger T_u Y_u^\dagger Y_u - 6T_d Y_d^\dagger Y_d Y_d^\dagger Y_d - 4T_d Y_u^\dagger Y_u Y_d^\dagger Y_d - 2T_d Y_u^\dagger Y_u Y_u^\dagger Y_u \\
& + \frac{287}{90}g_1^4 T_d + g_1^2 g_2^2 T_d + \frac{15}{2}g_2^4 T_d + \frac{8}{9}g_1^2 g_3^2 T_d + 8g_2^2 g_3^2 T_d - \frac{16}{9}g_3^4 T_d - 2\lambda|\kappa|^2 \lambda^* T_d
\end{aligned} \tag{55}$$

$$\begin{aligned}
& -3\lambda^2\lambda^{*,2}T_d - 2\lambda^*Y_dY_u^\dagger Y_uT_\lambda - 12Y_dY_d^\dagger T_d\text{Tr}(Y_dY_d^\dagger) \\
& -15T_dY_d^\dagger Y_d\text{Tr}(Y_dY_d^\dagger) - \frac{2}{5}g_1^2T_d\text{Tr}(Y_dY_d^\dagger) + 16g_3^2T_d\text{Tr}(Y_dY_d^\dagger) \\
& -4Y_dY_d^\dagger T_d\text{Tr}(Y_eY_e^\dagger) - 5T_dY_d^\dagger Y_d\text{Tr}(Y_eY_e^\dagger) + \frac{6}{5}g_1^2T_d\text{Tr}(Y_eY_e^\dagger) \\
& -6Y_dY_u^\dagger T_u\text{Tr}(Y_uY_u^\dagger) - 3T_dY_u^\dagger Y_u\text{Tr}(Y_uY_u^\dagger) - 3|\lambda|^2T_d\text{Tr}(Y_uY_u^\dagger) \\
& -2Y_dY_u^\dagger T_u\text{Tr}(Y_\nu Y_\nu^\dagger) - T_dY_u^\dagger Y_u\text{Tr}(Y_\nu Y_\nu^\dagger) - |\lambda|^2T_d\text{Tr}(Y_\nu Y_\nu^\dagger) \\
& -|\lambda|^2T_d\text{Tr}(\lambda_N\lambda_N^\dagger) \\
& -\frac{2}{5}Y_dY_d^\dagger Y_d(15\lambda^*T_\lambda + 15\text{Tr}(Y_e^\dagger T_e) + 30g_2^2M_2 + 45\text{Tr}(Y_d^\dagger T_d) + 4g_1^2M_1) \\
& -6Y_dY_u^\dagger Y_u\text{Tr}(Y_u^\dagger T_u) - 2Y_dY_u^\dagger Y_u\text{Tr}(Y_\nu^\dagger T_{Y_\nu}) - 9T_d\text{Tr}(Y_dY_d^\dagger Y_dY_d^\dagger) \\
& -3T_d\text{Tr}(Y_dY_u^\dagger Y_uY_d^\dagger) - 3T_d\text{Tr}(Y_eY_e^\dagger Y_eY_e^\dagger) - T_d\text{Tr}(Y_eY_\nu^\dagger Y_\nu Y_e^\dagger) \\
& -\frac{2}{45}Y_d(287g_1^4M_1 + 45g_1^2g_2^2M_1 + 40g_1^2g_3^2M_1 + 40g_1^2g_3^2M_3 + 360g_2^2g_3^2M_3 - 160g_3^4M_3 \\
& + 45g_1^2g_2^2M_2 + 675g_2^4M_2 + 360g_2^2g_3^2M_2 + 270\lambda\lambda^{*,2}T_\lambda + 90\kappa^*\lambda^*(\kappa T_\lambda + \lambda T_\kappa) \\
& -18g_1^2M_1\text{Tr}(Y_dY_d^\dagger) + 720g_3^2M_3\text{Tr}(Y_dY_d^\dagger) + 54g_1^2M_1\text{Tr}(Y_eY_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) \\
& + 45\lambda^*(\lambda(3\text{Tr}(Y_u^\dagger T_u) + \text{Tr}(Y_\nu^\dagger T_{Y_\nu}) + \text{Tr}(\lambda_N^\dagger T_{\lambda_N})) + T_\lambda(3\text{Tr}(Y_uY_u^\dagger) + \text{Tr}(Y_\nu Y_\nu^\dagger) + \text{Tr}(\lambda_N\lambda_N^\dagger))) \\
& + 810\text{Tr}(Y_dY_d^\dagger T_dY_d^\dagger) + 135\text{Tr}(Y_dY_u^\dagger T_uY_d^\dagger) + 270\text{Tr}(Y_eY_e^\dagger T_eY_e^\dagger) + 45\text{Tr}(Y_eY_\nu^\dagger T_{Y_\nu}Y_e^\dagger) \\
& + 135\text{Tr}(Y_uY_d^\dagger T_dY_u^\dagger) + 45\text{Tr}(Y_\nu Y_e^\dagger T_eY_\nu^\dagger)
\end{aligned} \tag{56}$$

$$\begin{aligned}
\beta_{T_e}^{(1)} = & +4Y_eY_e^\dagger T_e + 2Y_eY_\nu^\dagger T_{Y_\nu} + 5T_eY_e^\dagger Y_e + T_eY_\nu^\dagger Y_\nu - \frac{9}{5}g_1^2T_e - 3g_2^2T_e + |\lambda|^2T_e \\
& + 3T_e\text{Tr}(Y_dY_d^\dagger) + T_e\text{Tr}(Y_eY_e^\dagger) + Y_e(2\lambda^*T_\lambda + 2\text{Tr}(Y_e^\dagger T_e) + 6g_2^2M_2 + 6\text{Tr}(Y_d^\dagger T_d) + \frac{18}{5}g_1^2M_1)
\end{aligned} \tag{57}$$

$$\begin{aligned}
\beta_{T_e}^{(2)} = & +\frac{6}{5}g_1^2Y_eY_e^\dagger T_e + 6g_2^2Y_eY_e^\dagger T_e - 4|\lambda|^2Y_eY_e^\dagger T_e - 2|\lambda|^2Y_eY_\nu^\dagger T_{Y_\nu} \\
& -\frac{6}{5}g_1^2T_eY_e^\dagger Y_e + 12g_2^2T_eY_e^\dagger Y_e - 5|\lambda|^2T_eY_e^\dagger Y_e - |\lambda|^2T_eY_\nu^\dagger Y_\nu \\
& -6Y_eY_e^\dagger Y_eY_e^\dagger T_e - 8Y_eY_e^\dagger T_eY_e^\dagger Y_e - 2Y_eY_\nu^\dagger Y_\nu Y_e^\dagger T_e - 4Y_eY_\nu^\dagger Y_\nu Y_\nu^\dagger T_{Y_\nu} \\
& -2Y_eY_\nu^\dagger \lambda_N\lambda_N^\dagger T_{Y_\nu} - 4Y_eY_\nu^\dagger T_{Y_\nu}Y_e^\dagger Y_e - 4Y_eY_\nu^\dagger T_{Y_\nu}Y_\nu^\dagger Y_\nu \\
& -2Y_eY_\nu^\dagger T_{\lambda_N}\lambda_N^\dagger Y_\nu - 6T_eY_e^\dagger Y_eY_e^\dagger Y_e - 4T_eY_\nu^\dagger Y_\nu Y_e^\dagger Y_e - 2T_eY_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu \\
& -T_eY_\nu^\dagger \lambda_N\lambda_N^\dagger Y_\nu + \frac{27}{2}g_1^4T_e + \frac{9}{5}g_1^2g_2^2T_e + \frac{15}{2}g_2^4T_e - 2\lambda|\kappa|^2\lambda^*T_e - 3\lambda^2\lambda^{*,2}T_e \\
& -2\lambda^*Y_eY_\nu^\dagger Y_\nu T_\lambda - 12Y_eY_e^\dagger T_e\text{Tr}(Y_dY_d^\dagger) - 15T_eY_e^\dagger Y_e\text{Tr}(Y_dY_d^\dagger)
\end{aligned}$$

$$\begin{aligned}
& -\frac{2}{5}g_1^2T_e\text{Tr}\left(Y_dY_d^\dagger\right)+16g_3^2T_e\text{Tr}\left(Y_dY_d^\dagger\right)-4Y_eY_e^\dagger T_e\text{Tr}\left(Y_eY_e^\dagger\right) \\
& -5T_eY_e^\dagger Y_e\text{Tr}\left(Y_eY_e^\dagger\right)+\frac{6}{5}g_1^2T_e\text{Tr}\left(Y_eY_e^\dagger\right)-6Y_eY_\nu^\dagger T_{Y_\nu}\text{Tr}\left(Y_uY_u^\dagger\right) \\
& -3T_eY_\nu^\dagger Y_\nu\text{Tr}\left(Y_uY_u^\dagger\right)-3|\lambda|^2T_e\text{Tr}\left(Y_uY_u^\dagger\right)-2Y_eY_\nu^\dagger T_{Y_\nu}\text{Tr}\left(Y_\nu Y_\nu^\dagger\right) \\
& -T_eY_\nu^\dagger Y_\nu\text{Tr}\left(Y_\nu Y_\nu^\dagger\right)-|\lambda|^2T_e\text{Tr}\left(Y_\nu Y_\nu^\dagger\right)-|\lambda|^2T_e\text{Tr}\left(\lambda_N\lambda_N^\dagger\right) \\
& -6Y_eY_e^\dagger Y_e\left(2g_2^2M_2+3\text{Tr}\left(Y_d^\dagger T_d\right)+\lambda^*T_\lambda+\text{Tr}\left(Y_e^\dagger T_e\right)\right)-6Y_eY_\nu^\dagger Y_\nu\text{Tr}\left(Y_u^\dagger T_u\right) \\
& -2Y_eY_\nu^\dagger Y_\nu\text{Tr}\left(Y_\nu^\dagger T_{Y_\nu}\right)-9T_e\text{Tr}\left(Y_dY_d^\dagger Y_dY_d^\dagger\right)-3T_e\text{Tr}\left(Y_dY_u^\dagger Y_uY_d^\dagger\right) \\
& -3T_e\text{Tr}\left(Y_eY_e^\dagger Y_eY_e^\dagger\right)-T_e\text{Tr}\left(Y_eY_\nu^\dagger Y_\nu Y_e^\dagger\right) \\
& -\frac{2}{5}Y_e\left(135g_1^4M_1+9g_1^2g_2^2M_1+9g_1^2g_2^2M_2+75g_2^4M_2+30\lambda\lambda^{*,2}T_\lambda+10\kappa^*\lambda^*\left(\kappa T_\lambda+\lambda T_\kappa\right)\right. \\
& -2g_1^2M_1\text{Tr}\left(Y_dY_d^\dagger\right)+80g_3^2M_3\text{Tr}\left(Y_dY_d^\dagger\right)+6g_1^2M_1\text{Tr}\left(Y_eY_e^\dagger\right)+2g_1^2\text{Tr}\left(Y_d^\dagger T_d\right) \\
& -80g_3^2\text{Tr}\left(Y_d^\dagger T_d\right)-6g_1^2\text{Tr}\left(Y_e^\dagger T_e\right) \\
& \left.+5\lambda^*\left(\lambda\left(3\text{Tr}\left(Y_u^\dagger T_u\right)+\text{Tr}\left(Y_\nu^\dagger T_{Y_\nu}\right)+\text{Tr}\left(\lambda_N^\dagger T_{\lambda_N}\right)\right)+T_\lambda\left(3\text{Tr}\left(Y_uY_u^\dagger\right)+\text{Tr}\left(Y_\nu Y_\nu^\dagger\right)+\text{Tr}\left(\lambda_N\lambda_N^\dagger\right)\right)\right) \\
& +90\text{Tr}\left(Y_dY_d^\dagger T_dY_d^\dagger\right)+15\text{Tr}\left(Y_dY_u^\dagger T_uY_d^\dagger\right)+30\text{Tr}\left(Y_eY_e^\dagger T_eY_e^\dagger\right)+5\text{Tr}\left(Y_eY_\nu^\dagger T_{Y_\nu}Y_e^\dagger\right) \\
& +15\text{Tr}\left(Y_uY_d^\dagger T_dY_u^\dagger\right)+5\text{Tr}\left(Y_\nu Y_e^\dagger T_eY_\nu^\dagger\right)
\end{aligned} \tag{58}$$

$$\begin{aligned}
\beta_{T_\lambda}^{(1)} & = +2\kappa^*\left(2\lambda T_\kappa+\kappa T_\lambda\right) \\
& +T_\lambda\left(12|\lambda|^2-3g_2^2+3\text{Tr}\left(Y_dY_d^\dagger\right)+3\text{Tr}\left(Y_uY_u^\dagger\right)-\frac{3}{5}g_1^2+\text{Tr}\left(Y_eY_e^\dagger\right)+\text{Tr}\left(Y_\nu Y_\nu^\dagger\right)+\text{Tr}\left(\lambda_N\lambda_N^\dagger\right)\right) \\
& +\frac{2}{5}\lambda\left(15g_2^2M_2+15\text{Tr}\left(Y_d^\dagger T_d\right)+15\text{Tr}\left(Y_u^\dagger T_u\right)+3g_1^2M_1+5\text{Tr}\left(\lambda_N^\dagger T_{\lambda_N}\right)+5\text{Tr}\left(Y_e^\dagger T_e\right)+5\text{Tr}\left(Y_\nu^\dagger T_{Y_\nu}\right)\right)
\end{aligned} \tag{59}$$

$$\begin{aligned}
\beta_{T_\lambda}^{(2)} & = -\frac{414}{25}g_1^4M_1\lambda-\frac{18}{5}g_1^2g_2^2M_1\lambda-\frac{18}{5}g_1^2g_2^2M_2\lambda-30g_2^4M_2\lambda+\frac{207}{50}g_1^4T_\lambda+\frac{9}{5}g_1^2g_2^2T_\lambda \\
& +\frac{15}{2}g_2^4T_\lambda-50\lambda^2\lambda^{*,2}T_\lambda-8\kappa\kappa^{*,2}\left(4\lambda T_\kappa+\kappa T_\lambda\right)+\frac{4}{5}g_1^2M_1\lambda\text{Tr}\left(Y_dY_d^\dagger\right) \\
& -32g_3^2M_3\lambda\text{Tr}\left(Y_dY_d^\dagger\right)-\frac{2}{5}g_1^2T_\lambda\text{Tr}\left(Y_dY_d^\dagger\right)+16g_3^2T_\lambda\text{Tr}\left(Y_dY_d^\dagger\right)-\frac{12}{5}g_1^2M_1\lambda\text{Tr}\left(Y_eY_e^\dagger\right) \\
& +\frac{6}{5}g_1^2T_\lambda\text{Tr}\left(Y_eY_e^\dagger\right)-\frac{8}{5}g_1^2M_1\lambda\text{Tr}\left(Y_uY_u^\dagger\right)-32g_3^2M_3\lambda\text{Tr}\left(Y_uY_u^\dagger\right)+\frac{4}{5}g_1^2T_\lambda\text{Tr}\left(Y_uY_u^\dagger\right) \\
& +16g_3^2T_\lambda\text{Tr}\left(Y_uY_u^\dagger\right)-\frac{4}{5}g_1^2\lambda\text{Tr}\left(Y_d^\dagger T_d\right)+32g_3^2\lambda\text{Tr}\left(Y_d^\dagger T_d\right)+\frac{12}{5}g_1^2\lambda\text{Tr}\left(Y_e^\dagger T_e\right) \\
& +\frac{8}{5}g_1^2\lambda\text{Tr}\left(Y_u^\dagger T_u\right)+32g_3^2\lambda\text{Tr}\left(Y_u^\dagger T_u\right) \\
& -4\kappa^*\left(2\kappa\lambda\text{Tr}\left(\lambda_N^\dagger T_{\lambda_N}\right)+2\lambda T_\kappa\text{Tr}\left(\lambda_N\lambda_N^\dagger\right)+\kappa T_\lambda\text{Tr}\left(\lambda_N\lambda_N^\dagger\right)\right) \\
& -\frac{1}{5}|\lambda|^2\left(60\kappa^*\left(2\lambda T_\kappa+3\kappa T_\lambda\right)\right)
\end{aligned}$$

$$\begin{aligned}
& + 3T_\lambda \left( 10\text{Tr}(\lambda_N \lambda_N^\dagger) + 15\text{Tr}(Y_e Y_e^\dagger) + 15\text{Tr}(Y_\nu Y_\nu^\dagger) - 30g_2^2 + 45\text{Tr}(Y_d Y_d^\dagger) + 45\text{Tr}(Y_u Y_u^\dagger) - 6g_1^2 \right) \\
& + 2\lambda \left( 10\text{Tr}(\lambda_N^\dagger T_{\lambda_N}) + 15\text{Tr}(Y_e^\dagger T_e) + 15\text{Tr}(Y_\nu^\dagger T_{Y_\nu}) + 30g_2^2 M_2 + 45\text{Tr}(Y_d^\dagger T_d) + 45\text{Tr}(Y_u^\dagger T_u) + 6g_1^2 M_1 \right) \\
& - 9T_\lambda \text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) - 36\lambda \text{Tr}(Y_d Y_d^\dagger T_d Y_d^\dagger) - 6T_\lambda \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 12\lambda \text{Tr}(Y_d Y_u^\dagger T_u Y_d^\dagger) \\
& - 3T_\lambda \text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) - 12\lambda \text{Tr}(Y_e Y_e^\dagger T_e Y_e^\dagger) - 2T_\lambda \text{Tr}(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger) - 4\lambda \text{Tr}(Y_e Y_\nu^\dagger T_{Y_\nu} Y_e^\dagger) \\
& - 12\lambda \text{Tr}(Y_u Y_d^\dagger T_d Y_u^\dagger) - 9T_\lambda \text{Tr}(Y_u Y_u^\dagger Y_u Y_u^\dagger) - 36\lambda \text{Tr}(Y_u Y_u^\dagger T_u Y_u^\dagger) - 4\lambda \text{Tr}(Y_\nu Y_e^\dagger T_e Y_\nu^\dagger) \\
& - 3T_\lambda \text{Tr}(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger) - 3T_\lambda \text{Tr}(Y_\nu Y_\nu^\dagger \lambda_N \lambda_N^\dagger) - 12\lambda \text{Tr}(Y_\nu Y_\nu^\dagger T_{Y_\nu} Y_\nu^\dagger) \\
& - 6\lambda \text{Tr}(Y_\nu Y_\nu^\dagger T_{\lambda_N} \lambda_N^\dagger) - 2T_\lambda \text{Tr}(\lambda_N \lambda_N^\dagger \lambda_N \lambda_N^\dagger) - 6\lambda \text{Tr}(\lambda_N \lambda_N^\dagger T_{Y_\nu} Y_\nu^\dagger) - 8\lambda \text{Tr}(\lambda_N \lambda_N^\dagger T_{\lambda_N} \lambda_N^\dagger) \tag{60}
\end{aligned}$$

$$\beta_{T_\kappa}^{(1)} = 3 \left( 2\kappa \text{Tr}(\lambda_N^\dagger T_{\lambda_N}) + 2\lambda^* (2\kappa T_\lambda + \lambda T_\kappa) + 6|\kappa|^2 T_\kappa + T_\kappa \text{Tr}(\lambda_N \lambda_N^\dagger) \right) \tag{61}$$

$$\begin{aligned}
\beta_{T_\kappa}^{(2)} = & -\frac{6}{5} \left( 10\lambda \lambda^{*,2} (4\kappa T_\lambda + \lambda T_\kappa) \right. \\
& + \lambda^* \left( \lambda T_\kappa (-15g_2^2 + 15\text{Tr}(Y_d Y_d^\dagger) + 15\text{Tr}(Y_u Y_u^\dagger) - 3g_1^2 + 5\text{Tr}(Y_e Y_e^\dagger) + 5\text{Tr}(Y_\nu Y_\nu^\dagger) + 60|\kappa|^2) \right. \\
& + 2\kappa \left( T_\lambda (-15g_2^2 + 15\text{Tr}(Y_d Y_d^\dagger) + 15\text{Tr}(Y_u Y_u^\dagger) + 20|\kappa|^2 - 3g_1^2 + 5\text{Tr}(Y_e Y_e^\dagger) + 5\text{Tr}(Y_\nu Y_\nu^\dagger)) \right. \\
& + \lambda (15g_2^2 M_2 + 15\text{Tr}(Y_d^\dagger T_d) + 15\text{Tr}(Y_u^\dagger T_u) + 3g_1^2 M_1 + 5\text{Tr}(Y_e^\dagger T_e) + 5\text{Tr}(Y_\nu^\dagger T_{Y_\nu})) \Big) \\
& + 5 \left( 20\kappa^2 \kappa^{*,2} T_\kappa + 2|\kappa|^2 (2\kappa \text{Tr}(\lambda_N^\dagger T_{\lambda_N}) + 3T_\kappa \text{Tr}(\lambda_N \lambda_N^\dagger)) + T_\kappa (\text{Tr}(Y_\nu Y_\nu^\dagger \lambda_N \lambda_N^\dagger) + \text{Tr}(\lambda_N \lambda_N^\dagger \lambda_N \lambda_N^\dagger)) \right. \\
& \left. \left. + 2\kappa (2\text{Tr}(\lambda_N \lambda_N^\dagger T_{\lambda_N} \lambda_N^\dagger) + \text{Tr}(Y_\nu Y_\nu^\dagger T_{\lambda_N} \lambda_N^\dagger) + \text{Tr}(\lambda_N \lambda_N^\dagger T_{Y_\nu} Y_\nu^\dagger)) \right) \right) \tag{62}
\end{aligned}$$

$$\begin{aligned}
\beta_{T_{\lambda_N}}^{(1)} = & + 2Y_\nu Y_\nu^\dagger T_{\lambda_N} + 3\lambda_N \lambda_N^\dagger T_{\lambda_N} + 4T_{Y_\nu} Y_\nu^\dagger \lambda_N + 3T_{\lambda_N} \lambda_N^\dagger \lambda_N + 2\kappa^* (2\lambda_N T_\kappa + \kappa T_{\lambda_N}) \\
& + 2\lambda^* (2\lambda_N T_\lambda + \lambda T_{\lambda_N}) + T_{\lambda_N} \text{Tr}(\lambda_N \lambda_N^\dagger) + 2\lambda_N \text{Tr}(\lambda_N^\dagger T_{\lambda_N}) \tag{63}
\end{aligned}$$

$$\begin{aligned}
\beta_{T_{\lambda_N}}^{(2)} = & -\frac{12}{5} g_1^2 M_1 Y_\nu Y_\nu^\dagger \lambda_N - 12g_2^2 M_2 Y_\nu Y_\nu^\dagger \lambda_N + \frac{6}{5} g_1^2 Y_\nu Y_\nu^\dagger T_{\lambda_N} + 6g_2^2 Y_\nu Y_\nu^\dagger T_{\lambda_N} \\
& + \frac{12}{5} g_1^2 T_{Y_\nu} Y_\nu^\dagger \lambda_N + 12g_2^2 T_{Y_\nu} Y_\nu^\dagger \lambda_N - 2Y_\nu Y_e^\dagger Y_e Y_\nu^\dagger T_{\lambda_N} \\
& - 4Y_\nu Y_e^\dagger T_e Y_\nu^\dagger \lambda_N - 2Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger T_{\lambda_N} - 4Y_\nu Y_\nu^\dagger T_{Y_\nu} Y_\nu^\dagger \lambda_N - 4\lambda_N \lambda_N^\dagger Y_\nu Y_\nu^\dagger T_{\lambda_N} \\
& - 3\lambda_N \lambda_N^\dagger \lambda_N \lambda_N^\dagger T_{\lambda_N} - 4\lambda_N \lambda_N^\dagger T_{Y_\nu} Y_\nu^\dagger \lambda_N - 4\lambda_N \lambda_N^\dagger T_{\lambda_N} \lambda_N^\dagger \lambda_N - 4T_{Y_\nu} Y_e^\dagger Y_e Y_\nu^\dagger \lambda_N \\
& - 4T_{Y_\nu} Y_\nu^\dagger Y_\nu Y_\nu^\dagger \lambda_N - 2T_{\lambda_N} \lambda_N^\dagger Y_\nu Y_\nu^\dagger \lambda_N - 3T_{\lambda_N} \lambda_N^\dagger \lambda_N \lambda_N^\dagger \lambda_N - 8\kappa \kappa^{*,2} (4\lambda_N T_\kappa + \kappa T_{\lambda_N}) \\
& - 4\lambda \lambda^{*,2} (4\lambda_N T_\lambda + \lambda T_{\lambda_N}) - 6Y_\nu Y_\nu^\dagger T_{\lambda_N} \text{Tr}(Y_u Y_u^\dagger) - 12T_{Y_\nu} Y_\nu^\dagger \lambda_N \text{Tr}(Y_u Y_u^\dagger) \\
& - 2Y_\nu Y_\nu^\dagger T_{\lambda_N} \text{Tr}(Y_\nu Y_\nu^\dagger) - 4T_{Y_\nu} Y_\nu^\dagger \lambda_N \text{Tr}(Y_\nu Y_\nu^\dagger) - 3\lambda_N \lambda_N^\dagger T_{\lambda_N} \text{Tr}(\lambda_N \lambda_N^\dagger) \\
& - 3T_{\lambda_N} \lambda_N^\dagger \lambda_N \text{Tr}(\lambda_N \lambda_N^\dagger) - 12Y_\nu Y_\nu^\dagger \lambda_N \text{Tr}(Y_u^\dagger T_u) - 4Y_\nu Y_\nu^\dagger \lambda_N \text{Tr}(Y_\nu^\dagger T_{Y_\nu}) \\
& - \frac{2}{5} \lambda^* \left( 10 (2\lambda_N \lambda_N^\dagger \lambda_N + Y_\nu Y_\nu^\dagger \lambda_N) T_\lambda \right)
\end{aligned}$$

$$\begin{aligned}
& + \lambda \left( 5Y_\nu Y_\nu^\dagger T_{\lambda_N} + 15\lambda_N \lambda_N^\dagger T_{\lambda_N} + 10T_{Y_\nu} Y_\nu^\dagger \lambda_N + 15T_{\lambda_N} \lambda_N^\dagger \lambda_N - 3g_1^2 T_{\lambda_N} - 15g_2^2 T_{\lambda_N} \right. \\
& + 20|\kappa|^2 T_{\lambda_N} + 15T_{\lambda_N} \text{Tr} \left( Y_d Y_d^\dagger \right) + 5T_{\lambda_N} \text{Tr} \left( Y_e Y_e^\dagger \right) + 15T_{\lambda_N} \text{Tr} \left( Y_u Y_u^\dagger \right) + 5T_{\lambda_N} \text{Tr} \left( Y_\nu Y_\nu^\dagger \right) \\
& + 2\lambda_N \left( 20\kappa^* \left( \kappa T_\lambda + \lambda T_\kappa \right) + T_\lambda \left( -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) + 5\text{Tr} \left( Y_\nu Y_\nu^\dagger \right) \right) \right. \\
& + \lambda \left( 15g_2^2 M_2 + 15\text{Tr} \left( Y_d^\dagger T_d \right) + 15\text{Tr} \left( Y_u^\dagger T_u \right) + 3g_1^2 M_1 + 5\text{Tr} \left( Y_e^\dagger T_e \right) + 5\text{Tr} \left( Y_\nu^\dagger T_{Y_\nu} \right) \right) \\
& - 4\lambda_N \lambda_N^\dagger \lambda_N \text{Tr} \left( \lambda_N^\dagger T_{\lambda_N} \right) \\
& - 2\kappa^* \left( 4T_\kappa \left( \lambda_N \text{Tr} \left( \lambda_N \lambda_N^\dagger \right) + \lambda_N \lambda_N^\dagger \lambda_N \right) \right. \\
& + \kappa \left( 2T_{\lambda_N} \text{Tr} \left( \lambda_N \lambda_N^\dagger \right) + 3\lambda_N \lambda_N^\dagger T_{\lambda_N} + 3T_{\lambda_N} \lambda_N^\dagger \lambda_N + 4\lambda_N \text{Tr} \left( \lambda_N^\dagger T_{\lambda_N} \right) \right) \\
& - 2T_{\lambda_N} \text{Tr} \left( Y_\nu Y_\nu^\dagger \lambda_N \lambda_N^\dagger \right) - 4\lambda_N \text{Tr} \left( Y_\nu Y_\nu^\dagger T_{\lambda_N} \lambda_N^\dagger \right) - 2T_{\lambda_N} \text{Tr} \left( \lambda_N \lambda_N^\dagger \lambda_N \lambda_N^\dagger \right) \\
& \left. - 4\lambda_N \text{Tr} \left( \lambda_N \lambda_N^\dagger T_{Y_\nu} Y_\nu^\dagger \right) - 8\lambda_N \text{Tr} \left( \lambda_N \lambda_N^\dagger T_{\lambda_N} \lambda_N^\dagger \right) \right) \tag{64}
\end{aligned}$$

$$\begin{aligned}
\beta_{T_u}^{(1)} = & + 2Y_u Y_d^\dagger T_d + 4Y_u Y_u^\dagger T_u + T_u Y_d^\dagger Y_d + 5T_u Y_u^\dagger Y_u - \frac{13}{15}g_1^2 T_u - 3g_2^2 T_u - \frac{16}{3}g_3^2 T_u \\
& + |\lambda|^2 T_u + 3T_u \text{Tr} \left( Y_u Y_u^\dagger \right) + T_u \text{Tr} \left( Y_\nu Y_\nu^\dagger \right) \\
& + Y_u \left( 2\lambda^* T_\lambda + 2\text{Tr} \left( Y_\nu^\dagger T_{Y_\nu} \right) + 6g_2^2 M_2 + 6\text{Tr} \left( Y_u^\dagger T_u \right) + \frac{26}{15}g_1^2 M_1 + \frac{32}{3}g_3^2 M_3 \right) \tag{65}
\end{aligned}$$

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

$$\begin{aligned}
& -9T_u \text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right) - 3T_u \text{Tr}\left(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\right) - T_u \text{Tr}\left(Y_\nu Y_\nu^\dagger \lambda_N \lambda_N^\dagger\right) \\
& - \frac{2}{225} Y_u \left( 2743g_1^4 M_1 + 225g_1^2 g_2^2 M_1 + 680g_1^2 g_3^2 M_1 + 680g_1^2 g_3^2 M_3 + 1800g_2^2 g_3^2 M_3 - 800g_3^4 M_3 \right. \\
& \left. + 225g_1^2 g_2^2 M_2 + 3375g_2^4 M_2 + 1800g_2^2 g_3^2 M_2 + 1350\lambda\lambda^{*,2} T_\lambda + 450\kappa^* \lambda^* \left( \kappa T_\lambda + \lambda T_\kappa \right) \right. \\
& \left. + 180g_1^2 M_1 \text{Tr}\left(Y_u Y_u^\dagger\right) + 3600g_3^2 M_3 \text{Tr}\left(Y_u Y_u^\dagger\right) - 180g_1^2 \text{Tr}\left(Y_u^\dagger T_u\right) - 3600g_3^2 \text{Tr}\left(Y_u^\dagger T_u\right) \right. \\
& \left. + 225\lambda^* \left( \lambda \left( 3\text{Tr}\left(Y_d^\dagger T_d\right) + \text{Tr}\left(Y_e^\dagger T_e\right) + \text{Tr}\left(\lambda_N^\dagger T_{\lambda_N}\right) \right) + T_\lambda \left( 3\text{Tr}\left(Y_d Y_d^\dagger\right) + \text{Tr}\left(Y_e Y_e^\dagger\right) + \text{Tr}\left(\lambda_N \lambda_N^\dagger\right) \right) \right) \right. \\
& \left. + 675\text{Tr}\left(Y_d Y_u^\dagger T_u Y_d^\dagger\right) + 225\text{Tr}\left(Y_e Y_\nu^\dagger T_{Y_\nu} Y_e^\dagger\right) + 675\text{Tr}\left(Y_u Y_d^\dagger T_d Y_u^\dagger\right) + 4050\text{Tr}\left(Y_u Y_u^\dagger T_u Y_u^\dagger\right) \right. \\
& \left. + 225\text{Tr}\left(Y_\nu Y_e^\dagger T_e Y_\nu^\dagger\right) + 1350\text{Tr}\left(Y_\nu Y_\nu^\dagger T_{Y_\nu} Y_\nu^\dagger\right) + 225\text{Tr}\left(Y_\nu Y_\nu^\dagger T_{\lambda_N} \lambda_N^\dagger\right) + 225\text{Tr}\left(\lambda_N \lambda_N^\dagger T_{Y_\nu} Y_\nu^\dagger\right) \right) \quad (66)
\end{aligned}$$

$$\begin{aligned}
\beta_{T_{Y_\nu}}^{(1)} & = +2Y_\nu Y_e^\dagger T_e + 4Y_\nu Y_\nu^\dagger T_{Y_\nu} + \lambda_N \lambda_N^\dagger T_{Y_\nu} + T_{Y_\nu} Y_e^\dagger Y_e + 5T_{Y_\nu} Y_\nu^\dagger Y_\nu \\
& + 2T_{\lambda_N} \lambda_N^\dagger Y_\nu - \frac{3}{5} g_1^2 T_{Y_\nu} - 3g_2^2 T_{Y_\nu} + |\lambda|^2 T_{Y_\nu} + 3T_{Y_\nu} \text{Tr}\left(Y_u Y_u^\dagger\right) + T_{Y_\nu} \text{Tr}\left(Y_\nu Y_\nu^\dagger\right) \\
& + Y_\nu \left( 2\lambda^* T_\lambda + 2\text{Tr}\left(Y_\nu^\dagger T_{Y_\nu}\right) + 6g_2^2 M_2 + 6\text{Tr}\left(Y_u^\dagger T_u\right) + \frac{6}{5} g_1^2 M_1 \right) \quad (67)
\end{aligned}$$

$$\begin{aligned}
\beta_{T_{Y_\nu}}^{(2)} & = +\frac{12}{5} g_1^2 Y_\nu Y_e^\dagger T_e - 2|\lambda|^2 Y_\nu Y_e^\dagger T_e - \frac{12}{5} g_1^2 M_1 Y_\nu Y_\nu^\dagger Y_\nu - 12g_2^2 M_2 Y_\nu Y_\nu^\dagger Y_\nu \\
& + \frac{6}{5} g_1^2 Y_\nu Y_\nu^\dagger T_{Y_\nu} + 6g_2^2 Y_\nu Y_\nu^\dagger T_{Y_\nu} - 4|\lambda|^2 Y_\nu Y_\nu^\dagger T_{Y_\nu} - 2|\kappa|^2 \lambda_N \lambda_N^\dagger T_{Y_\nu} \\
& - 2|\lambda|^2 \lambda_N \lambda_N^\dagger T_{Y_\nu} + \frac{6}{5} g_1^2 T_{Y_\nu} Y_e^\dagger Y_e - |\lambda|^2 T_{Y_\nu} Y_e^\dagger Y_e + \frac{12}{5} g_1^2 T_{Y_\nu} Y_\nu^\dagger Y_\nu \\
& + 12g_2^2 T_{Y_\nu} Y_\nu^\dagger Y_\nu - 5|\lambda|^2 T_{Y_\nu} Y_\nu^\dagger Y_\nu - 4|\kappa|^2 T_{\lambda_N} \lambda_N^\dagger Y_\nu - 4|\lambda|^2 T_{\lambda_N} \lambda_N^\dagger Y_\nu \\
& - 4Y_\nu Y_e^\dagger Y_e Y_e^\dagger T_e - 2Y_\nu Y_e^\dagger Y_e Y_\nu^\dagger T_{Y_\nu} - 4Y_\nu Y_e^\dagger T_e Y_e^\dagger Y_e - 4Y_\nu Y_e^\dagger T_e Y_\nu^\dagger Y_\nu \\
& - 6Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger T_{Y_\nu} - 2Y_\nu Y_\nu^\dagger \lambda_N \lambda_N^\dagger T_{Y_\nu} - 8Y_\nu Y_\nu^\dagger T_{Y_\nu} Y_\nu^\dagger Y_\nu - 2Y_\nu Y_\nu^\dagger T_{\lambda_N} \lambda_N^\dagger Y_\nu \\
& - \lambda_N \lambda_N^\dagger \lambda_N \lambda_N^\dagger T_{Y_\nu} - 2\lambda_N \lambda_N^\dagger T_{\lambda_N} \lambda_N^\dagger Y_\nu - 2T_{Y_\nu} Y_e^\dagger Y_e Y_e^\dagger Y_e - 4T_{Y_\nu} Y_e^\dagger Y_e Y_\nu^\dagger Y_\nu \\
& - 6T_{Y_\nu} Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu - T_{Y_\nu} Y_\nu^\dagger \lambda_N \lambda_N^\dagger Y_\nu - 2T_{\lambda_N} \lambda_N^\dagger \lambda_N \lambda_N^\dagger Y_\nu + \frac{207}{50} g_1^4 T_{Y_\nu} \\
& + \frac{9}{5} g_1^2 g_2^2 T_{Y_\nu} + \frac{15}{2} g_2^4 T_{Y_\nu} - 2\lambda|\kappa|^2 \lambda^* T_{Y_\nu} - 3\lambda^2 \lambda^{*,2} T_{Y_\nu} - 4\kappa^* \lambda_N \lambda_N^\dagger Y_\nu T_\kappa \\
& - 6\lambda^* Y_\nu Y_\nu^\dagger T_\lambda - 4\lambda^* \lambda_N \lambda_N^\dagger Y_\nu T_\lambda - 6Y_\nu Y_e^\dagger T_e \text{Tr}\left(Y_d Y_d^\dagger\right) \\
& - 3T_{Y_\nu} Y_e^\dagger Y_e \text{Tr}\left(Y_d Y_d^\dagger\right) - 3|\lambda|^2 T_{Y_\nu} \text{Tr}\left(Y_d Y_d^\dagger\right) - 2Y_\nu Y_e^\dagger T_e \text{Tr}\left(Y_e Y_e^\dagger\right) \\
& - T_{Y_\nu} Y_e^\dagger Y_e \text{Tr}\left(Y_e Y_e^\dagger\right) - |\lambda|^2 T_{Y_\nu} \text{Tr}\left(Y_e Y_e^\dagger\right) - 12Y_\nu Y_\nu^\dagger T_{Y_\nu} \text{Tr}\left(Y_u Y_u^\dagger\right) \\
& - 15T_{Y_\nu} Y_\nu^\dagger Y_\nu \text{Tr}\left(Y_u Y_u^\dagger\right) + \frac{4}{5} g_1^2 T_{Y_\nu} \text{Tr}\left(Y_u Y_u^\dagger\right) + 16g_3^2 T_{Y_\nu} \text{Tr}\left(Y_u Y_u^\dagger\right) \\
& - 4Y_\nu Y_\nu^\dagger T_{Y_\nu} \text{Tr}\left(Y_\nu Y_\nu^\dagger\right) - 5T_{Y_\nu} Y_\nu^\dagger Y_\nu \text{Tr}\left(Y_\nu Y_\nu^\dagger\right) - \lambda_N \lambda_N^\dagger T_{Y_\nu} \text{Tr}\left(\lambda_N \lambda_N^\dagger\right) \\
& - 2T_{\lambda_N} \lambda_N^\dagger Y_\nu \text{Tr}\left(\lambda_N \lambda_N^\dagger\right) - |\lambda|^2 T_{Y_\nu} \text{Tr}\left(\lambda_N \lambda_N^\dagger\right)
\end{aligned}$$

$$\begin{aligned}
& -\frac{2}{5}Y_\nu Y_e^\dagger Y_e \left( 15\text{Tr}\left(Y_d^\dagger T_d\right) + 5\lambda^* T_\lambda + 5\text{Tr}\left(Y_e^\dagger T_e\right) + 6g_1^2 M_1 \right) - 18Y_\nu Y_\nu^\dagger Y_\nu \text{Tr}\left(Y_u^\dagger T_u\right) \\
& - 6Y_\nu Y_\nu^\dagger Y_\nu \text{Tr}\left(Y_\nu^\dagger T_{Y_\nu}\right) - 2\lambda_N \lambda_N^\dagger Y_\nu \text{Tr}\left(\lambda_N^\dagger T_{\lambda_N}\right) - 3T_{Y_\nu} \text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) \\
& - T_{Y_\nu} \text{Tr}\left(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger\right) - 9T_{Y_\nu} \text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right) - 3T_{Y_\nu} \text{Tr}\left(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\right) \\
& - T_{Y_\nu} \text{Tr}\left(Y_\nu Y_\nu^\dagger \lambda_N \lambda_N^\dagger\right) \\
& - \frac{2}{25}Y_\nu \left( 207g_1^4 M_1 + 45g_1^2 g_2^2 M_1 + 45g_1^2 g_2^2 M_2 + 375g_2^4 M_2 + 150\lambda\lambda^{*,2} T_\lambda + 50\kappa^* \lambda^* \left( \kappa T_\lambda + \lambda T_\kappa \right) \right. \\
& + 20g_1^2 M_1 \text{Tr}\left(Y_u Y_u^\dagger\right) + 400g_3^2 M_3 \text{Tr}\left(Y_u Y_u^\dagger\right) - 20g_1^2 \text{Tr}\left(Y_u^\dagger T_u\right) - 400g_3^2 \text{Tr}\left(Y_u^\dagger T_u\right) \\
& + 25\lambda^* \left( \lambda \left( 3\text{Tr}\left(Y_d^\dagger T_d\right) + \text{Tr}\left(Y_e^\dagger T_e\right) + \text{Tr}\left(\lambda_N^\dagger T_{\lambda_N}\right) \right) + T_\lambda \left( 3\text{Tr}\left(Y_d Y_d^\dagger\right) + \text{Tr}\left(Y_e Y_e^\dagger\right) + \text{Tr}\left(\lambda_N \lambda_N^\dagger\right) \right) \Big) \\
& + 75\text{Tr}\left(Y_d Y_u^\dagger T_u Y_d^\dagger\right) + 25\text{Tr}\left(Y_e Y_\nu^\dagger T_{Y_\nu} Y_e^\dagger\right) + 75\text{Tr}\left(Y_u Y_d^\dagger T_d Y_u^\dagger\right) + 450\text{Tr}\left(Y_u Y_u^\dagger T_u Y_u^\dagger\right) \\
& + 25\text{Tr}\left(Y_\nu Y_e^\dagger T_e Y_\nu^\dagger\right) + 150\text{Tr}\left(Y_\nu Y_\nu^\dagger T_{Y_\nu} Y_\nu^\dagger\right) + 25\text{Tr}\left(Y_\nu Y_\nu^\dagger T_{\lambda_N} \lambda_N^\dagger\right) + 25\text{Tr}\left(\lambda_N \lambda_N^\dagger T_{Y_\nu} Y_\nu^\dagger\right) \Big) \tag{68}
\end{aligned}$$

### 3.7 Bilinear Soft-Breaking Parameters

$$\begin{aligned}
\beta_{B_{\mu_X}}^{(1)} &= 2\mu_X \lambda_N^\dagger T_{\lambda_N} + 2T_{\lambda_N}^T \lambda_N^* \mu_X + B_{\mu_X} \lambda_N^\dagger \lambda_N + \lambda_N^T \lambda_N^* B_{\mu_X} \\
\beta_{B_{\mu_X}}^{(2)} &= -4\mu_X \lambda_N^\dagger Y_\nu Y_\nu^\dagger T_{\lambda_N} - 2\mu_X \lambda_N^\dagger \lambda_N \lambda_N^\dagger T_{\lambda_N} - 4\mu_X \lambda_N^\dagger T_{Y_\nu} Y_\nu^\dagger \lambda_N \\
& - 2\mu_X \lambda_N^\dagger T_{\lambda_N} \lambda_N^\dagger \lambda_N - 2B_{\mu_X} \lambda_N^\dagger Y_\nu Y_\nu^\dagger \lambda_N - B_{\mu_X} \lambda_N^\dagger \lambda_N \lambda_N^\dagger \lambda_N - 2\lambda_N^T Y_\nu^* Y_\nu^T \lambda_N^* B_{\mu_X} \\
& - 4\lambda_N^T Y_\nu^* T_{Y_\nu}^T \lambda_N^* \mu_X - \lambda_N^T \lambda_N^* \lambda_N^T \lambda_N^* B_{\mu_X} - 2\lambda_N^T \lambda_N^* T_{\lambda_N}^T \lambda_N^* \mu_X \\
& - 4T_{\lambda_N}^T Y_\nu^* Y_\nu^T \lambda_N^* \mu_X - 2T_{\lambda_N}^T \lambda_N^* \lambda_N^T \lambda_N^* \mu_X \\
& - 2\kappa^* \left( \kappa \left( 2\mu_X \lambda_N^\dagger T_{\lambda_N} + 2T_{\lambda_N}^T \lambda_N^* \mu_X + B_{\mu_X} \lambda_N^\dagger \lambda_N + \lambda_N^T \lambda_N^* B_{\mu_X} \right) \right. \\
& + 2 \left( \mu_X \lambda_N^\dagger \lambda_N + \lambda_N^T \lambda_N^* \mu_X \right) T_\kappa \Big) \\
& - 2\lambda^* \left( \lambda \left( 2\mu_X \lambda_N^\dagger T_{\lambda_N} + 2T_{\lambda_N}^T \lambda_N^* \mu_X + B_{\mu_X} \lambda_N^\dagger \lambda_N + \lambda_N^T \lambda_N^* B_{\mu_X} \right) \right. \\
& + 2 \left( \mu_X \lambda_N^\dagger \lambda_N + \lambda_N^T \lambda_N^* \mu_X \right) T_\lambda \Big) \\
& - 2\mu_X \lambda_N^\dagger T_{\lambda_N} \text{Tr}\left(\lambda_N \lambda_N^\dagger\right) - B_{\mu_X} \lambda_N^\dagger \lambda_N \text{Tr}\left(\lambda_N \lambda_N^\dagger\right) - \lambda_N^T \lambda_N^* B_{\mu_X} \text{Tr}\left(\lambda_N \lambda_N^\dagger\right) \\
& - 2T_{\lambda_N}^T \lambda_N^* \mu_X \text{Tr}\left(\lambda_N \lambda_N^\dagger\right) - 2\mu_X \lambda_N^\dagger \lambda_N \text{Tr}\left(\lambda_N^\dagger T_{\lambda_N}\right) - 2\lambda_N^T \lambda_N^* \mu_X \text{Tr}\left(\lambda_N^\dagger T_{\lambda_N}\right) \tag{70}
\end{aligned}$$

### 3.8 Soft-Breaking Scalar Masses

$$\sigma_{1,1} = \sqrt{\frac{3}{5}}g_1 \left( -2\text{Tr}\left(m_u^2\right) - \text{Tr}\left(m_l^2\right) - m_{H_d}^2 + m_{H_u}^2 + \text{Tr}\left(m_d^2\right) + \text{Tr}\left(m_e^2\right) + \text{Tr}\left(m_q^2\right) \right) \tag{71}$$



$$\sigma_{2,11} = \frac{1}{10}g_1^2 \left( 2\text{Tr}(m_d^2) + 3\text{Tr}(m_l^2) + 3m_{H_d}^2 + 3m_{H_u}^2 + 6\text{Tr}(m_e^2) + 8\text{Tr}(m_u^2) + \text{Tr}(m_q^2) \right) \quad (72)$$

$$\begin{aligned} \sigma_{3,1} = & \frac{1}{20} \frac{1}{\sqrt{15}} g_1 \left( -9g_1^2 m_{H_d}^2 - 45g_2^2 m_{H_d}^2 + 9g_1^2 m_{H_u}^2 + 45g_2^2 m_{H_u}^2 + 30 \left( -m_{H_u}^2 + m_{H_d}^2 \right) |\lambda|^2 + 4 \left( 20g_3^2 + g_1^2 \right) \text{Tr}(m_d^2) \right. \\ & + 36g_1^2 \text{Tr}(m_e^2) - 9g_1^2 \text{Tr}(m_l^2) - 45g_2^2 \text{Tr}(m_l^2) + g_1^2 \text{Tr}(m_q^2) + 45g_2^2 \text{Tr}(m_q^2) + 80g_3^2 \text{Tr}(m_q^2) \\ & - 32g_1^2 \text{Tr}(m_u^2) - 160g_3^2 \text{Tr}(m_u^2) + 90m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger) + 30m_{H_d}^2 \text{Tr}(Y_e Y_e^\dagger) - 90m_{H_u}^2 \text{Tr}(Y_u Y_u^\dagger) \\ & - 30m_{H_u}^2 \text{Tr}(Y_\nu Y_\nu^\dagger) - 60\text{Tr}(Y_d Y_d^\dagger m_d^{2*}) - 30\text{Tr}(Y_d m_q^{2*} Y_d^\dagger) - 60\text{Tr}(Y_e Y_e^\dagger m_e^{2*}) \\ & \left. + 30\text{Tr}(Y_e m_l^{2*} Y_e^\dagger) + 120\text{Tr}(Y_u Y_u^\dagger m_u^{2*}) - 30\text{Tr}(Y_u m_q^{2*} Y_u^\dagger) + 30\text{Tr}(Y_\nu m_l^{2*} Y_\nu^\dagger) \right) \end{aligned} \quad (73)$$

$$\sigma_{2,2} = \frac{1}{2} \left( 3\text{Tr}(m_q^2) + m_{H_d}^2 + m_{H_u}^2 + \text{Tr}(m_l^2) \right) \quad (74)$$

$$\sigma_{2,3} = \frac{1}{2} \left( 2\text{Tr}(m_q^2) + \text{Tr}(m_d^2) + \text{Tr}(m_u^2) \right) \quad (75)$$

$$\begin{aligned} \beta_{m_q}^{(1)} = & -\frac{2}{15}g_1^2 \mathbf{1}|M_1|^2 - \frac{32}{3}g_2^2 \mathbf{1}|M_3|^2 - 6g_2^2 \mathbf{1}|M_2|^2 + 2m_{H_d}^2 Y_d^\dagger Y_d + 2m_{H_u}^2 Y_u^\dagger Y_u + 2T_d^\dagger T_d \\ & + 2T_u^\dagger T_u + m_q^2 Y_d^\dagger Y_d + m_q^2 Y_u^\dagger Y_u + 2Y_d^\dagger m_d^2 Y_d + Y_d^\dagger Y_d m_q^2 + 2Y_u^\dagger m_u^2 Y_u \\ & + Y_u^\dagger Y_u m_q^2 + \frac{1}{\sqrt{15}} g_1 \mathbf{1} \sigma_{1,1} \end{aligned} \quad (76)$$

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

$$\begin{aligned}
& -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}(Y_d Y_d^\dagger) - 6T_d^\dagger T_d \text{Tr}(Y_d Y_d^\dagger) - 3m_q^2 Y_d^\dagger Y_d \text{Tr}(Y_d Y_d^\dagger) \\
& -6Y_d^\dagger m_d^2 Y_d \text{Tr}(Y_d Y_d^\dagger) - 3Y_d^\dagger Y_d m_q^2 \text{Tr}(Y_d Y_d^\dagger) - 4m_{H_d}^2 Y_d^\dagger Y_d \text{Tr}(Y_e Y_e^\dagger) \\
& -2T_d^\dagger T_d \text{Tr}(Y_e Y_e^\dagger) - m_q^2 Y_d^\dagger Y_d \text{Tr}(Y_e Y_e^\dagger) - 2Y_d^\dagger m_d^2 Y_d \text{Tr}(Y_e Y_e^\dagger) \\
& -Y_d^\dagger Y_d m_q^2 \text{Tr}(Y_e Y_e^\dagger) - 12m_{H_u}^2 Y_u^\dagger Y_u \text{Tr}(Y_u Y_u^\dagger) - 6T_u^\dagger T_u \text{Tr}(Y_u Y_u^\dagger) \\
& -3m_q^2 Y_u^\dagger Y_u \text{Tr}(Y_u Y_u^\dagger) - 6Y_u^\dagger m_u^2 Y_u \text{Tr}(Y_u Y_u^\dagger) - 3Y_u^\dagger Y_u m_q^2 \text{Tr}(Y_u Y_u^\dagger) \\
& -4m_{H_u}^2 Y_u^\dagger Y_u \text{Tr}(Y_\nu Y_\nu^\dagger) - 2T_u^\dagger T_u \text{Tr}(Y_\nu Y_\nu^\dagger) - m_q^2 Y_u^\dagger Y_u \text{Tr}(Y_\nu Y_\nu^\dagger) \\
& -2Y_u^\dagger m_u^2 Y_u \text{Tr}(Y_\nu Y_\nu^\dagger) - Y_u^\dagger Y_u m_q^2 \text{Tr}(Y_\nu Y_\nu^\dagger) - 6T_d^\dagger Y_d \text{Tr}(Y_d^\dagger T_d) \\
& -2T_d^\dagger Y_d \text{Tr}(Y_e^\dagger T_e) - 6T_u^\dagger Y_u \text{Tr}(Y_u^\dagger T_u) - 2T_u^\dagger Y_u \text{Tr}(Y_\nu^\dagger T_\nu) \\
& -6Y_d^\dagger T_d \text{Tr}(T_d^* Y_d^T) - 6Y_d^\dagger Y_d \text{Tr}(T_d^* T_d^T) - 2Y_d^\dagger T_d \text{Tr}(T_e^* Y_e^T) \\
& -2Y_d^\dagger Y_d \text{Tr}(T_e^* T_e^T) - 6Y_u^\dagger T_u \text{Tr}(T_u^* Y_u^T) - 6Y_u^\dagger Y_u \text{Tr}(T_u^* T_u^T) \\
& -2Y_u^\dagger T_u \text{Tr}(T_{Y_\nu^*} Y_\nu^T) - 2Y_u^\dagger Y_u \text{Tr}(T_{Y_\nu^*} T_{Y_\nu}^T) - 6Y_d^\dagger Y_d \text{Tr}(m_d^2 Y_d Y_d^\dagger) \\
& -2Y_d^\dagger Y_d \text{Tr}(m_e^2 Y_e Y_e^\dagger) - 2Y_d^\dagger Y_d \text{Tr}(m_l^2 Y_e^\dagger Y_e) - 2Y_u^\dagger Y_u \text{Tr}(m_l^2 Y_\nu^\dagger Y_\nu) \\
& -6Y_d^\dagger Y_d \text{Tr}(m_q^2 Y_d^\dagger Y_d) - 6Y_u^\dagger Y_u \text{Tr}(m_q^2 Y_u^\dagger Y_u) - 6Y_u^\dagger Y_u \text{Tr}(m_u^2 Y_u Y_u^\dagger) \\
& -2Y_u^\dagger Y_u \text{Tr}(m_\nu^2 Y_\nu Y_\nu^\dagger)
\end{aligned} \tag{77}$$

$$\begin{aligned}
\beta_{m_l^2}^{(1)} &= -\frac{6}{5} g_1^2 \mathbf{1}|M_1|^2 - 6g_2^2 \mathbf{1}|M_2|^2 + 2m_{H_d}^2 Y_e^\dagger Y_e + 2m_{H_u}^2 Y_\nu^\dagger Y_\nu + 2T_e^\dagger T_e + 2T_{Y_\nu}^\dagger T_{Y_\nu} \\
&+ m_l^2 Y_e^\dagger Y_e + m_l^2 Y_\nu^\dagger Y_\nu + 2Y_e^\dagger m_e^2 Y_e + Y_e^\dagger Y_e m_l^2 + 2Y_\nu^\dagger m_\nu^2 Y_\nu + Y_\nu^\dagger Y_\nu m_l^2 \\
&- \sqrt{\frac{3}{5}} g_1 \mathbf{1}\sigma_{1,1}
\end{aligned} \tag{78}$$

$$\begin{aligned}
\beta_{m_l^2}^{(2)} &= +\frac{3}{5} g_2^2 \left( 3g_2^2 (2M_2 + M_1) + 55g_2^2 M_2 \right) \mathbf{1}M_2^* + \frac{12}{5} g_1^2 m_{H_d}^2 Y_e^\dagger Y_e - 4m_{H_d}^2 |\lambda|^2 Y_e^\dagger Y_e \\
&- 2m_{H_u}^2 |\lambda|^2 Y_e^\dagger Y_e - 2m_S^2 |\lambda|^2 Y_e^\dagger Y_e - 2|T_\lambda|^2 Y_e^\dagger Y_e \\
&+ \frac{3}{25} g_1^2 M_1^* \left( -20Y_e^\dagger T_e + 3 \left( 5g_2^2 (2M_1 + M_2) + 69g_1^2 M_1 \right) \mathbf{1} + 40M_1 Y_e^\dagger Y_e \right) - 2\lambda T_\lambda^* Y_e^\dagger T_e
\end{aligned}$$

$$\begin{aligned}
& -2m_{H_d}^2|\lambda|^2Y_\nu^\dagger Y_\nu - 4m_{H_u}^2|\lambda|^2Y_\nu^\dagger Y_\nu - 2m_S^2|\lambda|^2Y_\nu^\dagger Y_\nu - 2|T_\lambda|^2Y_\nu^\dagger Y_\nu \\
& - 2\lambda T_\lambda^* Y_\nu^\dagger T_{Y_\nu} - \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 \\
& - 2|\lambda|^2 T_{Y_\nu}^\dagger T_{Y_\nu} + \frac{6}{5}g_1^2 m_l^2 Y_e^\dagger Y_e - |\lambda|^2 m_l^2 Y_e^\dagger Y_e - |\lambda|^2 m_l^2 Y_\nu^\dagger Y_\nu \\
& + \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 \\
& - 2|\lambda|^2 Y_\nu^\dagger m_\nu^2 Y_\nu - |\lambda|^2 Y_\nu^\dagger Y_\nu m_l^2 - 8m_{H_d}^2 Y_e^\dagger Y_e Y_e^\dagger Y_e - 4Y_e^\dagger Y_e T_e^\dagger T_e \\
& - 4Y_e^\dagger T_e T_e^\dagger Y_e - 8m_{H_u}^2 Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu - 4Y_\nu^\dagger Y_\nu T_{Y_\nu}^\dagger T_{Y_\nu} - 2m_{H_u}^2 Y_\nu^\dagger \lambda_N \lambda_N^\dagger Y_\nu \\
& - 2m_S^2 Y_\nu^\dagger \lambda_N \lambda_N^\dagger Y_\nu - 2Y_\nu^\dagger \lambda_N T_{\lambda_N}^\dagger T_{Y_\nu} - 4Y_\nu^\dagger T_{Y_\nu} T_{Y_\nu}^\dagger Y_\nu \\
& - 2Y_\nu^\dagger T_{\lambda_N} T_{\lambda_N}^\dagger Y_\nu - 4T_e^\dagger Y_e Y_e^\dagger T_e - 4T_e^\dagger T_e Y_e^\dagger Y_e - 4T_{Y_\nu}^\dagger Y_\nu Y_\nu^\dagger T_{Y_\nu} \\
& - 2T_{Y_\nu}^\dagger \lambda_N \lambda_N^\dagger T_{Y_\nu} - 4T_{Y_\nu}^\dagger T_{Y_\nu} Y_\nu^\dagger Y_\nu - 2T_{Y_\nu}^\dagger T_{\lambda_N} \lambda_N^\dagger Y_\nu - 2m_l^2 Y_e^\dagger Y_e Y_e^\dagger Y_e \\
& - 2m_l^2 Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu - m_l^2 Y_\nu^\dagger \lambda_N \lambda_N^\dagger Y_\nu - 4Y_e^\dagger m_e^2 Y_e Y_e^\dagger Y_e - 4Y_e^\dagger Y_e m_l^2 Y_e^\dagger Y_e \\
& - 4Y_e^\dagger Y_e Y_e^\dagger m_e^2 Y_e - 2Y_e^\dagger Y_e Y_e^\dagger Y_e m_l^2 - 4Y_\nu^\dagger m_\nu^2 Y_\nu Y_\nu^\dagger Y_\nu - 2Y_\nu^\dagger m_\nu^2 \lambda_N \lambda_N^\dagger Y_\nu \\
& - 4Y_\nu^\dagger Y_\nu m_l^2 Y_\nu^\dagger Y_\nu - 4Y_\nu^\dagger Y_\nu Y_\nu^\dagger m_\nu^2 Y_\nu - 2Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu m_l^2 - 2Y_\nu^\dagger \lambda_N m_x^2 \lambda_N^\dagger Y_\nu \\
& - 2Y_\nu^\dagger \lambda_N \lambda_N^\dagger m_\nu^2 Y_\nu - Y_\nu^\dagger \lambda_N \lambda_N^\dagger Y_\nu m_l^2 - 2\lambda^* T_e^\dagger Y_e T_\lambda - 2\lambda^* T_{Y_\nu}^\dagger Y_\nu 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) - 12m_{H_u}^2 Y_\nu^\dagger Y_\nu \text{Tr}(Y_u Y_u^\dagger) \\
& - 6T_{Y_\nu}^\dagger T_{Y_\nu} \text{Tr}(Y_u Y_u^\dagger) - 3m_l^2 Y_\nu^\dagger Y_\nu \text{Tr}(Y_u Y_u^\dagger) - 6Y_\nu^\dagger m_\nu^2 Y_\nu \text{Tr}(Y_u Y_u^\dagger) \\
& - 3Y_\nu^\dagger Y_\nu m_l^2 \text{Tr}(Y_u Y_u^\dagger) - 4m_{H_u}^2 Y_\nu^\dagger Y_\nu \text{Tr}(Y_\nu Y_\nu^\dagger) - 2T_{Y_\nu}^\dagger T_{Y_\nu} \text{Tr}(Y_\nu Y_\nu^\dagger) \\
& - m_l^2 Y_\nu^\dagger Y_\nu \text{Tr}(Y_\nu Y_\nu^\dagger) - 2Y_\nu^\dagger m_\nu^2 Y_\nu \text{Tr}(Y_\nu Y_\nu^\dagger) - Y_\nu^\dagger Y_\nu m_l^2 \text{Tr}(Y_\nu Y_\nu^\dagger) \\
& - 6T_e^\dagger Y_e \text{Tr}(Y_d^\dagger T_d) - 2T_e^\dagger Y_e \text{Tr}(Y_e^\dagger T_e) - 6T_{Y_\nu}^\dagger Y_\nu \text{Tr}(Y_u^\dagger T_u) \\
& - 2T_{Y_\nu}^\dagger Y_\nu \text{Tr}(Y_\nu^\dagger T_{Y_\nu}) - 6Y_e^\dagger T_e \text{Tr}(T_d^* Y_d^T) - 6Y_e^\dagger Y_e \text{Tr}(T_d^* T_d^T) \\
& - 2Y_e^\dagger T_e \text{Tr}(T_e^* Y_e^T) - 2Y_e^\dagger Y_e \text{Tr}(T_e^* T_e^T) - 6Y_\nu^\dagger T_{Y_\nu} \text{Tr}(T_u^* Y_u^T) \\
& - 6Y_\nu^\dagger Y_\nu \text{Tr}(T_u^* T_u^T) - 2Y_\nu^\dagger T_{Y_\nu} \text{Tr}(T_{Y_\nu}^* Y_\nu^T) - 2Y_\nu^\dagger Y_\nu \text{Tr}(T_{Y_\nu}^* T_{Y_\nu}^T) \\
& - 6Y_e^\dagger Y_e \text{Tr}(m_d^2 Y_d Y_d^\dagger) - 2Y_e^\dagger Y_e \text{Tr}(m_e^2 Y_e Y_e^\dagger) - 2Y_e^\dagger Y_e \text{Tr}(m_l^2 Y_e^\dagger Y_e) \\
& - 2Y_\nu^\dagger Y_\nu \text{Tr}(m_l^2 Y_\nu^\dagger Y_\nu) - 6Y_e^\dagger Y_e \text{Tr}(m_q^2 Y_d^\dagger Y_d) - 6Y_\nu^\dagger Y_\nu \text{Tr}(m_q^2 Y_u^\dagger Y_u)
\end{aligned}$$

$$- 6Y_\nu^\dagger Y_\nu \text{Tr}(m_u^2 Y_u Y_u^\dagger) - 2Y_\nu^\dagger Y_\nu \text{Tr}(m_\nu^2 Y_\nu Y_\nu^\dagger) \quad (79)$$

$$\begin{aligned} \beta_{m_{H_d}^2}^{(1)} = & -\frac{6}{5}g_1^2|M_1|^2 - 6g_2^2|M_2|^2 + 2m_{H_d}^2|\lambda|^2 + 2m_{H_u}^2|\lambda|^2 + 2m_S^2|\lambda|^2 + 2|T_\lambda|^2 - \sqrt{\frac{3}{5}}g_1\sigma_{1,1} \\ & + 6m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger) + 2m_{H_d}^2 \text{Tr}(Y_e Y_e^\dagger) + 6\text{Tr}(T_d^* T_d^T) + 2\text{Tr}(T_e^* T_e^T) + 6\text{Tr}(m_d^2 Y_d Y_d^\dagger) \\ & + 2\text{Tr}(m_e^2 Y_e Y_e^\dagger) + 2\text{Tr}(m_l^2 Y_e^\dagger Y_e) + 6\text{Tr}(m_q^2 Y_d^\dagger Y_d) \end{aligned} \quad (80)$$

$$\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}(Y_d Y_d^\dagger) + 120M_1 \text{Tr}(Y_e Y_e^\dagger) + 20\text{Tr}(Y_d^\dagger T_d) \right. \right. \\ & \left. \left. - 60\text{Tr}(Y_e^\dagger T_e) \right) \right) \\ & + 5 \left( 3g_2^2 \left( 3g_1^2 (2M_2 + M_1) + 55g_2^2 M_2 \right) M_2^* \right. \\ & \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. \\ & \left. \left. + 2\sqrt{15}g_1\sigma_{3,1} + 2g_1^2 m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger) - 80g_3^2 m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger) - 160g_3^2 |M_3|^2 \text{Tr}(Y_d Y_d^\dagger) \right. \right. \\ & \left. \left. - 6g_1^2 m_{H_d}^2 \text{Tr}(Y_e Y_e^\dagger) + 15|T_\lambda|^2 \text{Tr}(Y_u Y_u^\dagger) + 5|T_\lambda|^2 \text{Tr}(Y_\nu Y_\nu^\dagger) + 5|T_\lambda|^2 \text{Tr}(\lambda_N \lambda_N^\dagger) \right. \right. \\ & \left. \left. + 80g_3^2 M_3^* \text{Tr}(Y_d^\dagger T_d) + 15\lambda T_\lambda^* \text{Tr}(Y_u^\dagger T_u) + 5\lambda T_\lambda^* \text{Tr}(Y_\nu^\dagger T_{Y_\nu}) + 5\lambda T_\lambda^* \text{Tr}(\lambda_N^\dagger T_{\lambda_N}) \right. \right. \\ & \left. \left. - 2g_1^2 M_1 \text{Tr}(T_d^* Y_d^T) + 80g_3^2 M_3 \text{Tr}(T_d^* Y_d^T) + 2g_1^2 \text{Tr}(T_d^* T_d^T) - 80g_3^2 \text{Tr}(T_d^* T_d^T) \right. \right. \\ & \left. \left. + 6g_1^2 M_1 \text{Tr}(T_e^* Y_e^T) - 6g_1^2 \text{Tr}(T_e^* T_e^T) + 2g_1^2 \text{Tr}(m_d^2 Y_d Y_d^\dagger) - 80g_3^2 \text{Tr}(m_d^2 Y_d Y_d^\dagger) \right. \right. \\ & \left. \left. - 6g_1^2 \text{Tr}(m_e^2 Y_e Y_e^\dagger) - 6g_1^2 \text{Tr}(m_l^2 Y_e^\dagger Y_e) + 2g_1^2 \text{Tr}(m_q^2 Y_d^\dagger Y_d) - 80g_3^2 \text{Tr}(m_q^2 Y_d^\dagger Y_d) \right. \right. \\ & \left. \left. + 5\lambda^* \left( 12\lambda |T_\lambda|^2 + 2T_\kappa^* \left( \kappa T_\lambda + \lambda T_\kappa \right) + 3m_{H_d}^2 \lambda \text{Tr}(Y_u Y_u^\dagger) + 6m_{H_u}^2 \lambda \text{Tr}(Y_u Y_u^\dagger) + 3m_S^2 \lambda \text{Tr}(Y_u Y_u^\dagger) \right. \right. \\ & \left. \left. + m_{H_d}^2 \lambda \text{Tr}(Y_\nu Y_\nu^\dagger) + 2m_{H_u}^2 \lambda \text{Tr}(Y_\nu Y_\nu^\dagger) + m_S^2 \lambda \text{Tr}(Y_\nu Y_\nu^\dagger) + m_{H_d}^2 \lambda \text{Tr}(\lambda_N \lambda_N^\dagger) \right. \right. \\ & \left. \left. + m_{H_u}^2 \lambda \text{Tr}(\lambda_N \lambda_N^\dagger) + 2m_S^2 \lambda \text{Tr}(\lambda_N \lambda_N^\dagger) + 3T_\lambda \text{Tr}(T_u^* Y_u^T) + 3\lambda \text{Tr}(T_u^* T_u^T) + T_\lambda \text{Tr}(T_{Y_\nu}^* Y_\nu^T) \right. \right. \\ & \left. \left. + \lambda \text{Tr}(T_{Y_\nu}^* T_{Y_\nu}^T) + T_\lambda \text{Tr}(T_{\lambda_N}^* \lambda_N^T) + \lambda \text{Tr}(T_{\lambda_N}^* T_{\lambda_N}^T) + \lambda \text{Tr}(m_l^2 Y_\nu^\dagger Y_\nu) + 3\lambda \text{Tr}(m_q^2 Y_u^\dagger Y_u) \right. \right. \\ & \left. \left. + 3\lambda \text{Tr}(m_u^2 Y_u Y_u^\dagger) + \lambda \text{Tr}(m_\nu^2 Y_\nu Y_\nu^\dagger) + \lambda \text{Tr}(m_\nu^2 \lambda_N \lambda_N^\dagger) + \lambda \text{Tr}(m_x^2 \lambda_N^\dagger \lambda_N) \right) \right) \\ & + 90m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) + 90\text{Tr}(Y_d Y_d^\dagger T_d T_d^\dagger) + 15m_{H_d}^2 \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) \\ & + 15m_{H_u}^2 \text{Tr}(Y_d Y_u^\dagger T_u Y_d^\dagger) + 15\text{Tr}(Y_d Y_u^\dagger T_u T_d^\dagger) + 90\text{Tr}(Y_d T_d^\dagger T_d Y_d^\dagger) \\ & + 15\text{Tr}(Y_d T_u^\dagger T_u Y_d^\dagger) + 30m_{H_d}^2 \text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) + 30\text{Tr}(Y_e Y_e^\dagger T_e T_e^\dagger) + 5m_{H_d}^2 \text{Tr}(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger) \\ & + 5m_{H_u}^2 \text{Tr}(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger) + 5\text{Tr}(Y_e Y_\nu^\dagger T_{Y_\nu} T_e^\dagger) + 30\text{Tr}(Y_e T_e^\dagger T_e Y_e^\dagger) \\ & + 5\text{Tr}(Y_e T_{Y_\nu}^\dagger T_{Y_\nu} Y_e^\dagger) + 15\text{Tr}(Y_u Y_d^\dagger T_d T_u^\dagger) + 15\text{Tr}(Y_u T_d^\dagger T_d Y_u^\dagger) + 5\text{Tr}(Y_\nu Y_e^\dagger T_e T_{Y_\nu}^\dagger) \end{aligned}$$

$$\begin{aligned}
& + 5\text{Tr}\left(Y_\nu T_e^\dagger T_e Y_\nu^\dagger\right) + 90\text{Tr}\left(m_d^2 Y_d Y_d^\dagger Y_d Y_d^\dagger\right) + 15\text{Tr}\left(m_d^2 Y_d Y_u^\dagger Y_u Y_d^\dagger\right) + 30\text{Tr}\left(m_e^2 Y_e Y_e^\dagger Y_e Y_e^\dagger\right) \\
& + 5\text{Tr}\left(m_e^2 Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger\right) + 30\text{Tr}\left(m_l^2 Y_e^\dagger Y_e Y_e^\dagger Y_e\right) + 5\text{Tr}\left(m_l^2 Y_e^\dagger Y_e Y_\nu^\dagger Y_\nu\right) \\
& + 5\text{Tr}\left(m_l^2 Y_\nu^\dagger Y_\nu Y_e^\dagger Y_e\right) + 90\text{Tr}\left(m_q^2 Y_d^\dagger Y_d Y_d^\dagger Y_d\right) + 15\text{Tr}\left(m_q^2 Y_d^\dagger Y_d Y_u^\dagger Y_u\right) \\
& + 15\text{Tr}\left(m_q^2 Y_u^\dagger Y_u Y_d^\dagger Y_d\right) + 15\text{Tr}\left(m_u^2 Y_u Y_d^\dagger Y_d Y_u^\dagger\right) + 5\text{Tr}\left(m_\nu^2 Y_\nu Y_e^\dagger Y_e Y_\nu^\dagger\right) \Big) \Big) \Big) \Big) \Big) \quad (81)
\end{aligned}$$

$$\begin{aligned} \beta_{m_{H_u}}^{(1)} = & -\frac{6}{5}g_1^2|M_1|^2 - 6g_2^2|M_2|^2 + 2m_{H_d}^2|\lambda|^2 + 2m_{H_u}^2|\lambda|^2 + 2m_S^2|\lambda|^2 + 2|T_\lambda|^2 + \sqrt{\frac{3}{5}}g_1\sigma_{1,1} \\ & + 6m_{H_u}^2\text{Tr}(Y_u Y_u^\dagger) + 2m_{H_u}^2\text{Tr}(Y_\nu Y_\nu^\dagger) + 6\text{Tr}(T_u^* T_u^T) + 2\text{Tr}(T_{Y_\nu}^* T_{Y_\nu}^T) + 2\text{Tr}(m_l^2 Y_\nu^\dagger Y_\nu) \\ & + 6\text{Tr}(m_q^2 Y_u^\dagger Y_u) + 6\text{Tr}(m_u^2 Y_u Y_u^\dagger) + 2\text{Tr}(m_\nu^2 Y_\nu Y_\nu^\dagger) \end{aligned} \quad (82)$$

$$\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) + 45 g_2^2 M_2 + 621 g_1^2 M_1 + 80 M_1 \text{Tr} \left( Y_u Y_u^\dagger \right) + 90 g_2^2 M_1 \right) \right. \\
& + 5 \left( 3 g_2^2 \left( 3 g_1^2 \left( 2 M_2 + M_1 \right) + 55 g_2^2 M_2 \right) M_2^* \right. \\
& - 2 \left( 30 \left( m_{H_d}^2 + m_{H_u}^2 + m_S^2 \right) \lambda^2 \lambda^{*,2} + 10 \kappa^* \left( \left( 4 m_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) - 15 g_2^4 \sigma_{2,2} - 3 g_1^2 \sigma_{2,11} \right. \\
& - 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) - 4 g_1^2 m_{H_u}^2 \text{Tr} \left( Y_u Y_u^\dagger \right) \\
& - 80 g_3^2 m_{H_u}^2 \text{Tr} \left( Y_u Y_u^\dagger \right) - 160 g_3^2 |M_3|^2 \text{Tr} \left( Y_u Y_u^\dagger \right) + 5 |T_\lambda|^2 \text{Tr} \left( \lambda_N \lambda_N^\dagger \right) + 15 \lambda T_\lambda^* \text{Tr} \left( Y_d^\dagger T_d \right) \\
& + 5 \lambda T_\lambda^* \text{Tr} \left( Y_e^\dagger T_e \right) + 80 g_3^2 M_3^* \text{Tr} \left( Y_u^\dagger T_u \right) + 5 \lambda T_\lambda^* \text{Tr} \left( \lambda_N^\dagger T_{\lambda_N} \right) + 4 g_1^2 M_1 \text{Tr} \left( T_u^* Y_u^T \right) \\
& + 80 g_3^2 M_3 \text{Tr} \left( T_u^* Y_u^T \right) - 4 g_1^2 \text{Tr} \left( T_u^* T_u^T \right) - 80 g_3^2 \text{Tr} \left( T_u^* T_u^T \right) - 4 g_1^2 \text{Tr} \left( m_q^2 Y_u^\dagger Y_u \right) \\
& - 80 g_3^2 \text{Tr} \left( m_q^2 Y_u^\dagger Y_u \right) - 4 g_1^2 \text{Tr} \left( m_u^2 Y_u Y_u^\dagger \right) - 80 g_3^2 \text{Tr} \left( m_u^2 Y_u Y_u^\dagger \right) \\
& \left. + 5 \lambda^* \left( 12 \lambda |T_\lambda|^2 + 2 T_\kappa^* \left( \kappa T_\lambda + \lambda T_\kappa \right) + 6 m_{H_d}^2 \lambda \text{Tr} \left( Y_d Y_d^\dagger \right) + 3 m_{H_u}^2 \lambda \text{Tr} \left( Y_d Y_d^\dagger \right) + 3 m_S^2 \lambda \text{Tr} \left( Y_d Y_d^\dagger \right) \right) \right)
\end{aligned}$$

$$\begin{aligned}
& + 2m_{H_d}^2 \lambda \text{Tr} \left( Y_e Y_e^\dagger \right) + m_{H_u}^2 \lambda \text{Tr} \left( Y_e Y_e^\dagger \right) + m_S^2 \lambda \text{Tr} \left( Y_e Y_e^\dagger \right) + m_{H_d}^2 \lambda \text{Tr} \left( \lambda_N \lambda_N^\dagger \right) \\
& + m_{H_u}^2 \lambda \text{Tr} \left( \lambda_N \lambda_N^\dagger \right) + 2m_S^2 \lambda \text{Tr} \left( \lambda_N \lambda_N^\dagger \right) + 3T_\lambda \text{Tr} \left( T_d^* Y_d^T \right) + 3\lambda \text{Tr} \left( T_d^* T_d^T \right) + T_\lambda \text{Tr} \left( T_e^* Y_e^T \right) \\
& + \lambda \text{Tr} \left( T_e^* T_e^T \right) + T_\lambda \text{Tr} \left( T_{\lambda N^*} T_{\lambda N}^T \right) + \lambda \text{Tr} \left( T_{\lambda N^*} T_{\lambda N}^T \right) + 3\lambda \text{Tr} \left( m_d^2 Y_d Y_d^\dagger \right) + \lambda \text{Tr} \left( m_e^2 Y_e Y_e^\dagger \right) \\
& + \lambda \text{Tr} \left( m_l^2 Y_e^\dagger Y_e \right) + 3\lambda \text{Tr} \left( m_q^2 Y_d^\dagger Y_d \right) + \lambda \text{Tr} \left( m_\nu^2 \lambda_N \lambda_N^\dagger \right) + \lambda \text{Tr} \left( m_x^2 \lambda_N^\dagger \lambda_N \right) \\
& + 15m_{H_d}^2 \text{Tr} \left( Y_d Y_u^\dagger Y_u Y_d^\dagger \right) + 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) \\
& + 15\text{Tr} \left( Y_d T_u^\dagger T_u Y_d^\dagger \right) + 5m_{H_d}^2 \text{Tr} \left( Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger \right) + 5m_{H_u}^2 \text{Tr} \left( Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger \right) \\
& + 5\text{Tr} \left( Y_e Y_\nu^\dagger T_{Y_\nu} T_e^\dagger \right) + 5\text{Tr} \left( Y_e T_{Y_\nu}^\dagger T_{Y_\nu} Y_e^\dagger \right) + 15\text{Tr} \left( Y_u Y_d^\dagger T_d T_u^\dagger \right) + 90m_{H_u}^2 \text{Tr} \left( Y_u Y_u^\dagger Y_u Y_u^\dagger \right) \\
& + 90\text{Tr} \left( Y_u Y_u^\dagger T_u T_u^\dagger \right) + 15\text{Tr} \left( Y_u T_d^\dagger T_d Y_u^\dagger \right) + 90\text{Tr} \left( Y_u T_u^\dagger T_u Y_u^\dagger \right) + 5\text{Tr} \left( Y_\nu Y_e^\dagger T_e T_{Y_\nu}^\dagger \right)
\end{aligned}$$

$$\begin{aligned}
& + 30m_{H_u}^2 \text{Tr}\left(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\right) + 5m_{H_u}^2 \text{Tr}\left(Y_\nu Y_\nu^\dagger \lambda_N \lambda_N^\dagger\right) + 5m_S^2 \text{Tr}\left(Y_\nu Y_\nu^\dagger \lambda_N \lambda_N^\dagger\right) \\
& + 30\text{Tr}\left(Y_\nu Y_\nu^\dagger T_{Y_\nu} T_{Y_\nu}^\dagger\right) + 5\text{Tr}\left(Y_\nu Y_\nu^\dagger T_{\lambda_N} T_{\lambda_N}^\dagger\right) + 5\text{Tr}\left(Y_\nu T_e^\dagger T_e Y_\nu^\dagger\right) + 30\text{Tr}\left(Y_\nu T_{Y_\nu}^\dagger T_{Y_\nu} Y_\nu^\dagger\right) \\
& + 5\text{Tr}\left(Y_\nu T_{Y_\nu}^\dagger T_{\lambda_N} \lambda_N^\dagger\right) + 5\text{Tr}\left(\lambda_N \lambda_N^\dagger T_{Y_\nu} T_{Y_\nu}^\dagger\right) + 5\text{Tr}\left(\lambda_N T_{\lambda_N}^\dagger T_{Y_\nu} Y_\nu^\dagger\right) \\
& + 15\text{Tr}\left(m_d^2 Y_d Y_u^\dagger Y_u Y_d^\dagger\right) + 5\text{Tr}\left(m_e^2 Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger\right) + 5\text{Tr}\left(m_l^2 Y_e^\dagger Y_e Y_\nu^\dagger Y_\nu\right) \\
& + 5\text{Tr}\left(m_l^2 Y_\nu^\dagger Y_\nu Y_e^\dagger Y_e\right) + 30\text{Tr}\left(m_l^2 Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu\right) + 5\text{Tr}\left(m_l^2 Y_\nu^\dagger \lambda_N \lambda_N^\dagger Y_\nu\right) \\
& + 15\text{Tr}\left(m_q^2 Y_d^\dagger Y_d Y_u^\dagger Y_u\right) + 15\text{Tr}\left(m_q^2 Y_u^\dagger Y_u Y_d^\dagger Y_d\right) + 90\text{Tr}\left(m_q^2 Y_u^\dagger Y_u Y_u^\dagger Y_u\right) \\
& + 15\text{Tr}\left(m_u^2 Y_u Y_d^\dagger Y_d Y_u^\dagger\right) + 90\text{Tr}\left(m_u^2 Y_u Y_u^\dagger Y_u Y_u^\dagger\right) + 5\text{Tr}\left(m_\nu^2 Y_\nu Y_e^\dagger Y_e Y_\nu^\dagger\right) \\
& + 30\text{Tr}\left(m_\nu^2 Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\right) + 5\text{Tr}\left(m_\nu^2 Y_\nu Y_\nu^\dagger \lambda_N \lambda_N^\dagger\right) + 5\text{Tr}\left(m_\nu^2 \lambda_N \lambda_N^\dagger Y_\nu Y_\nu^\dagger\right) \\
& + 5\text{Tr}\left(m_x^2 \lambda_N^\dagger Y_\nu Y_\nu^\dagger \lambda_N\right)\Bigg)
\end{aligned} \tag{83}$$

$$\begin{aligned} \beta_{m_d^2}^{(1)} = & -\frac{8}{15}g_1^2\mathbf{1}|M_1|^2 - \frac{32}{3}g_1^2\mathbf{1}|M_3|^2 + 4m_{H_d}^2Y_dY_d^\dagger + 4T_dT_d^\dagger + 2m_d^2Y_dY_d^\dagger + 4Y_dm_q^2Y_d^\dagger \\ & + 2Y_dY_d^\dagger m_d^2 + 2\frac{1}{\sqrt{15}}g_1\mathbf{1}\sigma_{1,1} \end{aligned} \quad (84)$$

$$\begin{aligned}\beta_{m_d^2} = & \frac{64}{45}g_3^2\left(-30g_3^2M_3 + g_1^2\left(2M_3 + M_1\right)\right)\mathbf{1}M_3^* + \frac{4}{5}g_1^2m_{H_d}^2Y_dY_d^\dagger + 12g_2^2m_{H_d}^2Y_dY_d^\dagger \\ & + 24g_2^2|M_2|^2Y_dY_d^\dagger - 8m_{H_d}^2|\lambda|^2Y_dY_d^\dagger - 4m_{H_u}^2|\lambda|^2Y_dY_d^\dagger \\ & - 4m_S^2|\lambda|^2Y_dY_d^\dagger - 4|T_\lambda|^2Y_dY_d^\dagger - \frac{4}{5}g_1^2M_1Y_dT_d^\dagger - 12g_2^2M_2Y_dT_d^\dagger \\ & + \frac{4}{225}g_1^2M_1^*\left(2\left(303g_1^2M_1 + 40g_3^2\left(2M_1 + M_3\right)\right)\mathbf{1} - 45T_dY_d^\dagger + 90M_1Y_dY_d^\dagger\right) - 12g_2^2M_2^*T_dY_d^\dagger \\ & - 4\lambda T_\lambda^*T_dY_d^\dagger + \frac{4}{5}g_1^2T_dT_d^\dagger + 12g_2^2T_dT_d^\dagger - 4|\lambda|^2T_dT_d^\dagger \\ & + \frac{2}{5}g_1^2m_d^2Y_dY_d^\dagger + 6g_2^2m_d^2Y_dY_d^\dagger - 2|\lambda|^2m_d^2Y_dY_d^\dagger + \frac{4}{5}g_1^2Y_dm_q^2Y_d^\dagger \\ & + 12g_2^2Y_dm_q^2Y_d^\dagger - 4|\lambda|^2Y_dm_q^2Y_d^\dagger + \frac{2}{5}g_1^2Y_dY_d^\dagger m_d^2 + 6g_2^2Y_dY_d^\dagger m_d^2 \\ & - 2|\lambda|^2Y_dY_d^\dagger m_d^2 - 8m_{H_d}^2Y_dY_d^\dagger Y_dY_d^\dagger - 4Y_dY_d^\dagger T_dT_d^\dagger - 4m_{H_d}^2Y_dY_u^\dagger Y_uY_d^\dagger \\ & - 4m_{H_u}^2Y_dY_u^\dagger Y_uY_d^\dagger - 4Y_dY_u^\dagger T_uT_d^\dagger - 4Y_dT_d^\dagger T_dY_d^\dagger - 4Y_dT_u^\dagger T_uY_d^\dagger \\ & - 4T_dY_d^\dagger Y_dT_d^\dagger - 4T_dY_u^\dagger Y_uT_d^\dagger - 4T_dT_d^\dagger Y_dY_d^\dagger - 4T_dT_u^\dagger Y_uY_d^\dagger \\ & - 2m_d^2Y_dY_d^\dagger Y_dY_d^\dagger - 2m_d^2Y_dY_u^\dagger Y_uY_d^\dagger - 4Y_dm_q^2Y_d^\dagger Y_dY_d^\dagger - 4Y_dm_q^2Y_u^\dagger Y_uY_d^\dagger \\ & - 4Y_dY_d^\dagger m_d^2Y_dY_d^\dagger - 4Y_dY_d^\dagger Y_dm_q^2Y_d^\dagger - 2Y_dY_d^\dagger Y_dY_d^\dagger m_d^2 - 4Y_dY_u^\dagger m_u^2Y_uY_d^\dagger \\ & - 4Y_dY_u^\dagger Y_uY_d^\dagger m_q^2Y_d^\dagger - 2Y_dY_u^\dagger Y_uY_d^\dagger m_d^2 - 4\lambda^*Y_dT_d^\dagger T_\lambda + \frac{32}{3}g_3^4\mathbf{1}\sigma_{2,3} + \frac{8}{15}g_1^2\mathbf{1}\sigma_{2,11} \\ & + 8\frac{1}{\sqrt{15}}g_1\mathbf{1}\sigma_{3,1} - 24m_{H_d}^2Y_dY_d^\dagger \text{Tr}\left(Y_dY_d^\dagger\right) - 12T_dT_d^\dagger \text{Tr}\left(Y_dY_d^\dagger\right)\end{aligned}$$

$$\begin{aligned}
& -6m_d^2 Y_d Y_d^\dagger \text{Tr}(Y_d Y_d^\dagger) - 12Y_d m_q^2 Y_d^\dagger \text{Tr}(Y_d Y_d^\dagger) - 6Y_d Y_d^\dagger m_d^2 \text{Tr}(Y_d Y_d^\dagger) \\
& -8m_{H_d}^2 Y_d Y_d^\dagger \text{Tr}(Y_e Y_e^\dagger) - 4T_d T_d^\dagger \text{Tr}(Y_e Y_e^\dagger) - 2m_d^2 Y_d Y_d^\dagger \text{Tr}(Y_e Y_e^\dagger) \\
& -4Y_d m_q^2 Y_d^\dagger \text{Tr}(Y_e Y_e^\dagger) - 2Y_d Y_d^\dagger m_d^2 \text{Tr}(Y_e Y_e^\dagger) - 12Y_d T_d^\dagger \text{Tr}(Y_d^\dagger T_d) \\
& -4Y_d T_d^\dagger \text{Tr}(Y_e^\dagger T_e) - 12T_d Y_d^\dagger \text{Tr}(T_d^* Y_d^T) - 12Y_d Y_d^\dagger \text{Tr}(T_d^* T_d^T) \\
& -4T_d Y_d^\dagger \text{Tr}(T_e^* Y_e^T) - 4Y_d Y_d^\dagger \text{Tr}(T_e^* T_e^T) - 12Y_d Y_d^\dagger \text{Tr}(m_d^2 Y_d Y_d^\dagger) \\
& -4Y_d Y_d^\dagger \text{Tr}(m_e^2 Y_e Y_e^\dagger) - 4Y_d Y_d^\dagger \text{Tr}(m_l^2 Y_e^\dagger Y_e) - 12Y_d Y_d^\dagger \text{Tr}(m_q^2 Y_d^\dagger Y_d)
\end{aligned} \tag{85}$$

$$\begin{aligned}
\beta_{m_u^2}^{(1)} = & -\frac{32}{15} g_1^2 \mathbf{1} |M_1|^2 - \frac{32}{3} g_3^2 \mathbf{1} |M_3|^2 + 4m_{H_u}^2 Y_u Y_u^\dagger + 4T_u T_u^\dagger + 2m_u^2 Y_u Y_u^\dagger + 4Y_u m_q^2 Y_u^\dagger \\
& + 2Y_u Y_u^\dagger m_u^2 - 4 \frac{1}{\sqrt{15}} g_1 \mathbf{1} \sigma_{1,1}
\end{aligned} \tag{86}$$

$$\begin{aligned}
\beta_{m_u^2}^{(2)} = & -\frac{128}{45} g_3^2 \left( 15g_3^2 M_3 - 2g_1^2 (2M_3 + M_1) \right) \mathbf{1} M_3^* - \frac{4}{5} g_1^2 m_{H_u}^2 Y_u Y_u^\dagger + 12g_2^2 m_{H_u}^2 Y_u Y_u^\dagger \\
& + 24g_2^2 |M_2|^2 Y_u Y_u^\dagger - 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^* \left( 45 \left( -2M_1 Y_u Y_u^\dagger + T_u Y_u^\dagger \right) + 8 \left( 321g_1^2 M_1 + 40g_3^2 (2M_1 + M_3) \right) \mathbf{1} \right) - \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 \\
& - 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) - 8m_{H_u}^2 Y_u Y_u^\dagger \text{Tr}(Y_\nu Y_\nu^\dagger) \\
& - 4T_u T_u^\dagger \text{Tr}(Y_\nu Y_\nu^\dagger) - 2m_u^2 Y_u Y_u^\dagger \text{Tr}(Y_\nu Y_\nu^\dagger) - 4Y_u m_q^2 Y_u^\dagger \text{Tr}(Y_\nu Y_\nu^\dagger)
\end{aligned}$$

$$\begin{aligned}
& -2Y_u Y_u^\dagger m_u^2 \text{Tr}(Y_\nu Y_\nu^\dagger) - 12Y_u T_u^\dagger \text{Tr}(Y_u^\dagger T_u) - 4Y_u T_u^\dagger \text{Tr}(Y_\nu^\dagger T_{Y_\nu}) \\
& -12T_u Y_u^\dagger \text{Tr}(T_u^* Y_u^T) - 12Y_u Y_u^\dagger \text{Tr}(T_u^* T_u^T) - 4T_u Y_u^\dagger \text{Tr}(T_{Y_\nu^*} Y_\nu^T) \\
& -4Y_u Y_u^\dagger \text{Tr}(T_{Y_\nu^*} T_{Y_\nu}^T) - 4Y_u Y_u^\dagger \text{Tr}(m_l^2 Y_\nu^\dagger Y_\nu) - 12Y_u Y_u^\dagger \text{Tr}(m_q^2 Y_u^\dagger Y_u) \\
& -12Y_u Y_u^\dagger \text{Tr}(m_u^2 Y_u Y_u^\dagger) - 4Y_u Y_u^\dagger \text{Tr}(m_\nu^2 Y_\nu Y_\nu^\dagger)
\end{aligned} \tag{87}$$

$$\begin{aligned}
\beta_{m_e^2}^{(1)} &= -\frac{24}{5} g_1^2 \mathbf{1} |M_1|^2 + 2 \left( 2m_{H_d}^2 Y_e Y_e^\dagger + 2T_e T_e^\dagger + 2Y_e m_l^2 Y_e^\dagger + m_e^2 Y_e Y_e^\dagger + Y_e Y_e^\dagger m_e^2 \right) \\
&+ 2\sqrt{\frac{3}{5}} g_1 \mathbf{1} \sigma_{1,1}
\end{aligned} \tag{88}$$

$$\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 \\
&+ 10m_{H_d}^2 Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger + 10m_{H_u}^2 Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger + 10Y_e Y_\nu^\dagger T_{Y_\nu} T_e^\dagger \\
&+ 10Y_e T_e^\dagger T_e Y_e^\dagger + 10Y_e T_{Y_\nu}^\dagger T_{Y_\nu} Y_e^\dagger + 10T_e Y_e^\dagger Y_e T_e^\dagger + 10T_e Y_\nu^\dagger Y_\nu T_e^\dagger \\
&+ 10T_e T_e^\dagger Y_e Y_e^\dagger + 10T_e T_{Y_\nu}^\dagger Y_\nu Y_e^\dagger + 5m_e^2 Y_e Y_e^\dagger Y_e Y_e^\dagger + 5m_e^2 Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger \\
&+ 10Y_e m_l^2 Y_e^\dagger Y_e Y_e^\dagger + 10Y_e m_l^2 Y_\nu^\dagger Y_\nu Y_e^\dagger + 10Y_e Y_e^\dagger m_e^2 Y_e Y_e^\dagger + 10Y_e Y_e^\dagger Y_e m_l^2 Y_e^\dagger \\
&+ 5Y_e Y_e^\dagger Y_e Y_e^\dagger m_e^2 + 10Y_e Y_\nu^\dagger m_\nu^2 Y_\nu Y_e^\dagger + 10Y_e Y_\nu^\dagger Y_\nu m_l^2 Y_e^\dagger \\
&+ 5Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger m_e^2 + 30T_e T_e^\dagger \text{Tr}(Y_d Y_d^\dagger) + 15m_e^2 Y_e Y_e^\dagger \text{Tr}(Y_d Y_d^\dagger) \\
&+ 30Y_e m_l^2 Y_e^\dagger \text{Tr}(Y_d Y_d^\dagger) + 15Y_e Y_e^\dagger m_e^2 \text{Tr}(Y_d Y_d^\dagger) + 10T_e T_e^\dagger \text{Tr}(Y_e Y_e^\dagger) \\
&+ 5m_e^2 Y_e Y_e^\dagger \text{Tr}(Y_e Y_e^\dagger) + 10Y_e m_l^2 Y_e^\dagger \text{Tr}(Y_e Y_e^\dagger) + 5Y_e Y_e^\dagger m_e^2 \text{Tr}(Y_e Y_e^\dagger) \\
&+ Y_e T_e^\dagger (10\lambda^* T_\lambda + 10\text{Tr}(Y_e^\dagger T_e)) + 30g_2^2 M_2 + 30\text{Tr}(Y_d^\dagger T_d) - 6g_1^2 M_1) + 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 (3g_1^2 m_{H_d}^2 - 15g_2^2 m_{H_d}^2 - 30g_2^2 |M_2|^2 + 5(2m_{H_d}^2 + m_{H_u}^2 + m_S^2)|\lambda|^2 + 5|T_\lambda|^2 + 30m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger) \\
&+ 10m_{H_d}^2 \text{Tr}(Y_e Y_e^\dagger) + 15\text{Tr}(T_d^* T_d^T) + 5\text{Tr}(T_e^* T_e^T) + 15\text{Tr}(m_d^2 Y_d Y_d^\dagger) + 5\text{Tr}(m_e^2 Y_e Y_e^\dagger) \\
&+ 5\text{Tr}(m_l^2 Y_e^\dagger Y_e) + 15\text{Tr}(m_q^2 Y_d^\dagger Y_d)) \Big) \Big)
\end{aligned} \tag{89}$$

$$\begin{aligned}
\beta_{m_\nu^2}^{(1)} &= +4m_{H_u}^2 Y_\nu Y_\nu^\dagger + 2m_S^2 \lambda_N \lambda_N^\dagger + 4T_{Y_\nu} T_{Y_\nu}^\dagger + 2T_{\lambda_N} T_{\lambda_N}^\dagger + 2m_\nu^2 Y_\nu Y_\nu^\dagger + m_\nu^2 \lambda_N \lambda_N^\dagger \\
&+ 4Y_\nu m_l^2 Y_\nu^\dagger + 2Y_\nu Y_\nu^\dagger m_\nu^2 + 2\lambda_N m_x^2 \lambda_N^\dagger + \lambda_N \lambda_N^\dagger m_\nu^2
\end{aligned} \tag{90}$$

$$\beta_{m_\nu^2}^{(2)} = -16m_S^2 |\kappa|^2 \lambda_N \lambda_N^\dagger - 4m_{H_d}^2 |\lambda|^2 \lambda_N \lambda_N^\dagger - 4m_{H_u}^2 |\lambda|^2 \lambda_N \lambda_N^\dagger$$



$$\begin{aligned}
& -8m_S^2|\lambda|^2\lambda_N\lambda_N^\dagger - 4|T_\kappa|^2\lambda_N\lambda_N^\dagger - 4|T_\lambda|^2\lambda_N\lambda_N^\dagger - \frac{12}{5}g_1^2M_1^*T_{Y_\nu}Y_\nu^\dagger \\
& -12g_2^2M_2^*T_{Y_\nu}Y_\nu^\dagger - 4\lambda T_\lambda^*T_{Y_\nu}Y_\nu^\dagger + \frac{12}{5}g_1^2T_{Y_\nu}T_{Y_\nu}^\dagger + 12g_2^2T_{Y_\nu}T_{Y_\nu}^\dagger \\
& -4|\lambda|^2T_{Y_\nu}T_{Y_\nu}^\dagger - 4\kappa T_\kappa^*T_{\lambda_N}\lambda_N^\dagger - 4\lambda T_\lambda^*T_{\lambda_N}\lambda_N^\dagger - 4|\kappa|^2T_{\lambda_N}T_{\lambda_N}^\dagger \\
& -4|\lambda|^2T_{\lambda_N}T_{\lambda_N}^\dagger + \frac{6}{5}g_1^2m_\nu^2Y_\nu Y_\nu^\dagger + 6g_2^2m_\nu^2Y_\nu Y_\nu^\dagger - 2|\lambda|^2m_\nu^2Y_\nu Y_\nu^\dagger \\
& -2|\kappa|^2m_\nu^2\lambda_N\lambda_N^\dagger - 2|\lambda|^2m_\nu^2\lambda_N\lambda_N^\dagger + \frac{12}{5}g_1^2Y_\nu m_l^2Y_\nu^\dagger + 12g_2^2Y_\nu m_l^2Y_\nu^\dagger \\
& -4|\lambda|^2Y_\nu m_l^2Y_\nu^\dagger + \frac{6}{5}g_1^2Y_\nu Y_\nu^\dagger m_\nu^2 + 6g_2^2Y_\nu Y_\nu^\dagger m_\nu^2 - 2|\lambda|^2Y_\nu Y_\nu^\dagger m_\nu^2 \\
& -4|\kappa|^2\lambda_N m_x^2\lambda_N^\dagger - 4|\lambda|^2\lambda_N m_x^2\lambda_N^\dagger - 2|\kappa|^2\lambda_N\lambda_N^\dagger m_\nu^2 - 2|\lambda|^2\lambda_N\lambda_N^\dagger m_\nu^2 \\
& -4m_{H_d}^2Y_\nu Y_e^\dagger Y_e Y_\nu^\dagger - 4m_{H_u}^2Y_\nu Y_e^\dagger Y_e Y_\nu^\dagger - 4Y_\nu Y_e^\dagger T_e T_{Y_\nu}^\dagger \\
& -8m_{H_u}^2Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger - 4Y_\nu Y_\nu^\dagger T_{Y_\nu}T_{Y_\nu}^\dagger - 4Y_\nu T_e^\dagger T_e Y_\nu^\dagger - 4Y_\nu T_{Y_\nu}^\dagger T_{Y_\nu}Y_\nu^\dagger \\
& -4m_S^2\lambda_N\lambda_N^\dagger\lambda_N\lambda_N^\dagger - 2\lambda_N\lambda_N^\dagger T_{\lambda_N}T_{\lambda_N}^\dagger - 2\lambda_N T_{\lambda_N}^\dagger T_{\lambda_N}\lambda_N^\dagger - 4T_{Y_\nu}Y_e^\dagger Y_e T_{Y_\nu}^\dagger \\
& -4T_{Y_\nu}Y_\nu^\dagger Y_\nu T_{Y_\nu}^\dagger - 4T_{Y_\nu}T_e^\dagger Y_e Y_\nu^\dagger - 4T_{Y_\nu}T_{Y_\nu}^\dagger Y_\nu Y_\nu^\dagger - 2T_{\lambda_N}\lambda_N^\dagger\lambda_N T_{\lambda_N}^\dagger \\
& -2T_{\lambda_N}T_{\lambda_N}^\dagger\lambda_N\lambda_N^\dagger - 2m_\nu^2Y_\nu Y_e^\dagger Y_e Y_\nu^\dagger - 2m_\nu^2Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger - m_\nu^2\lambda_N\lambda_N^\dagger\lambda_N\lambda_N^\dagger \\
& -4Y_\nu m_l^2Y_e^\dagger Y_e Y_\nu^\dagger - 4Y_\nu m_l^2Y_\nu^\dagger Y_\nu Y_\nu^\dagger - 4Y_\nu Y_e^\dagger m_e^2Y_e Y_\nu^\dagger \\
& -4Y_\nu Y_e^\dagger Y_e m_l^2Y_\nu^\dagger - 2Y_\nu Y_e^\dagger Y_e Y_\nu^\dagger m_\nu^2 - 4Y_\nu Y_\nu^\dagger m_\nu^2Y_\nu Y_\nu^\dagger - 4Y_\nu Y_\nu^\dagger Y_\nu m_l^2Y_\nu^\dagger \\
& -2Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger m_\nu^2 - 2\lambda_N m_x^2\lambda_N^\dagger\lambda_N\lambda_N^\dagger - 2\lambda_N\lambda_N^\dagger m_\nu^2\lambda_N\lambda_N^\dagger - 2\lambda_N\lambda_N^\dagger\lambda_N m_x^2\lambda_N^\dagger \\
& -\lambda_N\lambda_N^\dagger\lambda_N\lambda_N^\dagger m_\nu^2 - 4\kappa^*\lambda_N T_{\lambda_N}^\dagger T_\kappa - 4\lambda^*\lambda_N T_{\lambda_N}^\dagger T_\lambda - 12T_{Y_\nu}T_{Y_\nu}^\dagger \text{Tr}(Y_u Y_u^\dagger) \\
& -6m_\nu^2Y_\nu Y_\nu^\dagger \text{Tr}(Y_u Y_u^\dagger) - 12Y_\nu m_l^2Y_\nu^\dagger \text{Tr}(Y_u Y_u^\dagger) - 6Y_\nu Y_\nu^\dagger m_\nu^2 \text{Tr}(Y_u Y_u^\dagger) \\
& -4T_{Y_\nu}T_{Y_\nu}^\dagger \text{Tr}(Y_\nu Y_\nu^\dagger) - 2m_\nu^2Y_\nu Y_\nu^\dagger \text{Tr}(Y_\nu Y_\nu^\dagger) - 4Y_\nu m_l^2Y_\nu^\dagger \text{Tr}(Y_\nu Y_\nu^\dagger) \\
& -2Y_\nu Y_\nu^\dagger m_\nu^2 \text{Tr}(Y_\nu Y_\nu^\dagger) - 4m_S^2\lambda_N\lambda_N^\dagger \text{Tr}(\lambda_N\lambda_N^\dagger) - 2T_{\lambda_N}T_{\lambda_N}^\dagger \text{Tr}(\lambda_N\lambda_N^\dagger) \\
& -m_\nu^2\lambda_N\lambda_N^\dagger \text{Tr}(\lambda_N\lambda_N^\dagger) - 2\lambda_N m_x^2\lambda_N^\dagger \text{Tr}(\lambda_N\lambda_N^\dagger) - \lambda_N\lambda_N^\dagger m_\nu^2 \text{Tr}(\lambda_N\lambda_N^\dagger) \\
& -\frac{4}{5}Y_\nu T_{Y_\nu}^\dagger (15g_2^2M_2 + 15\text{Tr}(Y_u^\dagger T_u) + 3g_1^2M_1 + 5\lambda^*T_\lambda + 5\text{Tr}(Y_\nu^\dagger T_{Y_\nu})) \\
& -2\lambda_N T_{\lambda_N}^\dagger \text{Tr}(\lambda_N^\dagger T_{\lambda_N}) - 12T_{Y_\nu}Y_\nu^\dagger \text{Tr}(T_u^* Y_u^T) - 4T_{Y_\nu}Y_\nu^\dagger \text{Tr}(T_{Y_\nu} Y_\nu^T) \\
& -2T_{\lambda_N}\lambda_N^\dagger \text{Tr}(T_{\lambda_N}^* \lambda_N^T) - 2\lambda_N\lambda_N^\dagger \text{Tr}(T_{\lambda_N}^* T_{\lambda_N}^T) \\
& + \frac{4}{5}Y_\nu Y_\nu^\dagger (3g_1^2m_{H_u}^2 + 15g_2^2m_{H_u}^2 + 6g_1^2|M_1|^2 + 30g_2^2|M_2|^2 - 5m_{H_d}^2|\lambda|^2 - 10m_{H_u}^2|\lambda|^2 - 5m_S^2|\lambda|^2 \\
& -5|T_\lambda|^2 - 30m_{H_u}^2 \text{Tr}(Y_u Y_u^\dagger) - 10m_{H_u}^2 \text{Tr}(Y_\nu Y_\nu^\dagger) - 15\text{Tr}(T_u^* T_u^T) - 5\text{Tr}(T_{Y_\nu} Y_\nu^T) \\
& -5\text{Tr}(m_l^2 Y_\nu^\dagger Y_\nu) - 15\text{Tr}(m_q^2 Y_u^\dagger Y_u) - 15\text{Tr}(m_u^2 Y_u Y_u^\dagger) - 5\text{Tr}(m_\nu^2 Y_\nu Y_\nu^\dagger)
\end{aligned}$$

$$-2\lambda_N\lambda_N^\dagger\text{Tr}\left(m_\nu^2\lambda_N\lambda_N^\dagger\right)-2\lambda_N\lambda_N^\dagger\text{Tr}\left(m_x^2\lambda_N^\dagger\lambda_N\right) \quad (91)$$

$$\begin{aligned} \beta_{m_S^2}^{(1)} &= 2\left(6m_S^2|\kappa|^2+2\left(m_{H_d}^2+m_{H_u}^2+m_S^2\right)|\lambda|^2+2|T_\kappa|^2+2|T_\lambda|^2+m_S^2\text{Tr}\left(\lambda_N\lambda_N^\dagger\right)+\text{Tr}\left(T_{\lambda N^*}T_{\lambda N}^T\right)\right. \\ &\quad \left.+\text{Tr}\left(m_\nu^2\lambda_N\lambda_N^\dagger\right)+\text{Tr}\left(m_x^2\lambda_N^\dagger\lambda_N\right)\right) \end{aligned} \quad (92)$$

$$\begin{aligned} \beta_{m_S^2}^{(2)} &= -\frac{4}{5}\left(-3g_1^2|T_\lambda|^2-15g_2^2|T_\lambda|^2+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}+3g_1^2M_1\lambda T_\lambda^* \right. \\ &\quad +15g_2^2M_2\lambda T_\lambda^*+15|T_\lambda|^2\text{Tr}\left(Y_dY_d^\dagger\right)+5|T_\lambda|^2\text{Tr}\left(Y_eY_e^\dagger\right)+15|T_\lambda|^2\text{Tr}\left(Y_uY_u^\dagger\right) \\ &\quad +5|T_\lambda|^2\text{Tr}\left(Y_\nu Y_\nu^\dagger\right)+10|T_\kappa|^2\text{Tr}\left(\lambda_N\lambda_N^\dagger\right)+15\lambda T_\lambda^*\text{Tr}\left(Y_d^\dagger T_d\right)+5\lambda T_\lambda^*\text{Tr}\left(Y_e^\dagger T_e\right) \\ &\quad +15\lambda T_\lambda^*\text{Tr}\left(Y_u^\dagger T_u\right)+5\lambda T_\lambda^*\text{Tr}\left(Y_\nu^\dagger T_\nu\right)+10\kappa T_\kappa^*\text{Tr}\left(\lambda_N^\dagger T_{\lambda N}\right) \\ &\quad +\lambda^*\left(-3g_1^2m_{H_d}^2\lambda-15g_2^2m_{H_d}^2\lambda-3g_1^2m_{H_u}^2\lambda-15g_2^2m_{H_u}^2\lambda-3g_1^2m_S^2\lambda-15g_2^2m_S^2\lambda\right. \\ &\quad +20\lambda|T_\kappa|^2+40\lambda|T_\lambda|^2+20\kappa T_\kappa^*T_\lambda+3g_1^2M_1^*\left(-2M_1\lambda+T_\lambda\right)+15g_2^2M_2^*\left(-2M_2\lambda+T_\lambda\right) \\ &\quad +30m_{H_d}^2\lambda\text{Tr}\left(Y_dY_d^\dagger\right)+15m_{H_u}^2\lambda\text{Tr}\left(Y_dY_d^\dagger\right)+15m_S^2\lambda\text{Tr}\left(Y_dY_d^\dagger\right)+10m_{H_d}^2\lambda\text{Tr}\left(Y_eY_e^\dagger\right) \\ &\quad +5m_{H_u}^2\lambda\text{Tr}\left(Y_eY_e^\dagger\right)+5m_S^2\lambda\text{Tr}\left(Y_eY_e^\dagger\right)+15m_{H_d}^2\lambda\text{Tr}\left(Y_uY_u^\dagger\right)+30m_{H_u}^2\lambda\text{Tr}\left(Y_uY_u^\dagger\right) \\ &\quad +15m_S^2\lambda\text{Tr}\left(Y_uY_u^\dagger\right)+5m_{H_d}^2\lambda\text{Tr}\left(Y_\nu Y_\nu^\dagger\right)+10m_{H_u}^2\lambda\text{Tr}\left(Y_\nu Y_\nu^\dagger\right)+5m_S^2\lambda\text{Tr}\left(Y_\nu Y_\nu^\dagger\right) \\ &\quad +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) \\ &\quad +15\lambda\text{Tr}\left(T_u^*T_u^T\right)+5T_\lambda\text{Tr}\left(T_{Y_\nu^*}Y_\nu^T\right)+5\lambda\text{Tr}\left(T_{Y_\nu^*}T_{Y_\nu}^T\right)+15\lambda\text{Tr}\left(m_d^2Y_dY_d^\dagger\right)+5\lambda\text{Tr}\left(m_e^2Y_eY_e^\dagger\right) \\ &\quad +5\lambda\text{Tr}\left(m_l^2Y_e^\dagger Y_e\right)+5\lambda\text{Tr}\left(m_l^2Y_\nu^\dagger Y_\nu\right)+15\lambda\text{Tr}\left(m_q^2Y_d^\dagger Y_d\right)+15\lambda\text{Tr}\left(m_q^2Y_u^\dagger Y_u\right) \\ &\quad +15\lambda\text{Tr}\left(m_u^2Y_uY_u^\dagger\right)+5\lambda\text{Tr}\left(m_\nu^2Y_\nu Y_\nu^\dagger\right) \\ &\quad +10\kappa^*\left(2\left(4m_S^2+m_{H_d}^2+m_{H_u}^2\right)\kappa|\lambda|^2+8\kappa|T_\kappa|^2+2\kappa|T_\lambda|^2+2\lambda T_\lambda^*T_\kappa+4m_S^2\kappa\text{Tr}\left(\lambda_N\lambda_N^\dagger\right)+T_\kappa\text{Tr}\left(T_{\lambda N^*}\lambda_{\lambda N}^T\right)\right. \\ &\quad \left.+\kappa\text{Tr}\left(T_{\lambda N^*}T_{\lambda N}^T\right)+\kappa\text{Tr}\left(m_\nu^2\lambda_N\lambda_N^\dagger\right)+\kappa\text{Tr}\left(m_x^2\lambda_N^\dagger\lambda_N\right)\right) \\ &\quad +5m_{H_u}^2\text{Tr}\left(Y_\nu Y_\nu^\dagger\lambda_N\lambda_N^\dagger\right)+5m_S^2\text{Tr}\left(Y_\nu Y_\nu^\dagger\lambda_N\lambda_N^\dagger\right)+5\text{Tr}\left(Y_\nu Y_\nu^\dagger T_{\lambda N}T_{\lambda N}^\dagger\right) \\ &\quad +5\text{Tr}\left(Y_\nu T_{Y_\nu}^\dagger T_{\lambda N}\lambda_N^\dagger\right)+10m_S^2\text{Tr}\left(\lambda_N\lambda_N^\dagger\lambda_N\lambda_N^\dagger\right)+5\text{Tr}\left(\lambda_N\lambda_N^\dagger T_{Y_\nu}T_{Y_\nu}^\dagger\right)+10\text{Tr}\left(\lambda_N\lambda_N^\dagger T_{\lambda N}T_{\lambda N}^\dagger\right) \\ &\quad +5\text{Tr}\left(\lambda_N T_{\lambda N}^\dagger T_{Y_\nu}Y_\nu^\dagger\right)+10\text{Tr}\left(\lambda_N T_{\lambda N}^\dagger T_{\lambda N}\lambda_N^\dagger\right)+5\text{Tr}\left(m_l^2Y_\nu^\dagger\lambda_N\lambda_N^\dagger Y_\nu\right) \\ &\quad +5\text{Tr}\left(m_\nu^2Y_\nu Y_\nu^\dagger\lambda_N\lambda_N^\dagger\right)+5\text{Tr}\left(m_\nu^2\lambda_N\lambda_N^\dagger Y_\nu Y_\nu^\dagger\right)+10\text{Tr}\left(m_\nu^2\lambda_N\lambda_N^\dagger\lambda_N\lambda_N^\dagger\right) \\ &\quad \left.+5\text{Tr}\left(m_x^2\lambda_N^\dagger Y_\nu Y_\nu^\dagger\lambda_N\right)+10\text{Tr}\left(m_x^2\lambda_N^\dagger\lambda_N\lambda_N^\dagger\lambda_N\right)\right) \end{aligned} \quad (93)$$

$$\beta_{m_x^2}^{(1)}=2\lambda_N^\dagger m_\nu^2\lambda_N+2m_S^2\lambda_N^\dagger\lambda_N+2T_{\lambda N}^\dagger T_{\lambda N}+m_x^2\lambda_N^\dagger\lambda_N+\lambda_N^\dagger\lambda_N m_x^2 \quad (94)$$

$$\beta_{m_x^2}^{(2)}=-4|T_\kappa|^2\lambda_N^\dagger\lambda_N-4|T_\lambda|^2\lambda_N^\dagger\lambda_N-4\kappa T_\kappa^*\lambda_N^\dagger T_{\lambda N}-4\lambda T_\lambda^*\lambda_N^\dagger T_{\lambda N}$$

$$\begin{aligned}
& -4m_{H_u}^2 \lambda_N^\dagger Y_\nu Y_\nu^\dagger \lambda_N - 4m_S^2 \lambda_N^\dagger Y_\nu Y_\nu^\dagger \lambda_N - 4\lambda_N^\dagger Y_\nu T_{Y_\nu}^\dagger T_{\lambda_N} \\
& -4m_S^2 \lambda_N^\dagger \lambda_N \lambda_N^\dagger \lambda_N - 2\lambda_N^\dagger \lambda_N T_{\lambda_N}^\dagger T_{\lambda_N} - 4\lambda_N^\dagger T_{Y_\nu} T_{Y_\nu}^\dagger \lambda_N - 2\lambda_N^\dagger T_{\lambda_N} T_{\lambda_N}^\dagger \lambda_N \\
& -4T_{\lambda_N}^\dagger Y_\nu Y_\nu^\dagger T_{\lambda_N} - 2T_{\lambda_N}^\dagger \lambda_N \lambda_N^\dagger T_{\lambda_N} - 4T_{\lambda_N}^\dagger T_{Y_\nu} Y_\nu^\dagger \lambda_N - 2T_{\lambda_N}^\dagger T_{\lambda_N} \lambda_N^\dagger \lambda_N \\
& -2m_x^2 \lambda_N^\dagger Y_\nu Y_\nu^\dagger \lambda_N - m_x^2 \lambda_N^\dagger \lambda_N \lambda_N^\dagger \lambda_N - 4\lambda_N^\dagger m_\nu^2 Y_\nu Y_\nu^\dagger \lambda_N - 2\lambda_N^\dagger m_\nu^2 \lambda_N \lambda_N^\dagger \lambda_N \\
& -4\lambda_N^\dagger Y_\nu m_l^2 Y_\nu^\dagger \lambda_N - 4\lambda_N^\dagger Y_\nu Y_\nu^\dagger m_\nu^2 \lambda_N - 2\lambda_N^\dagger Y_\nu Y_\nu^\dagger \lambda_N m_x^2 \\
& -2\lambda_N^\dagger \lambda_N m_x^2 \lambda_N^\dagger \lambda_N - 2\lambda_N^\dagger \lambda_N \lambda_N^\dagger m_\nu^2 \lambda_N - \lambda_N^\dagger \lambda_N \lambda_N^\dagger \lambda_N m_x^2 \\
& -2\kappa^* \left( 8m_S^2 \kappa \lambda_N^\dagger \lambda_N + \kappa \left( 2\lambda_N^\dagger m_\nu^2 \lambda_N + 2T_{\lambda_N}^\dagger T_{\lambda_N} + m_x^2 \lambda_N^\dagger \lambda_N + \lambda_N^\dagger \lambda_N m_x^2 \right) \right. \\
& \left. + 2T_{\lambda_N}^\dagger \lambda_N T_\kappa \right) \\
& -2\lambda^* \left( 2 \left( 2m_S^2 + m_{H_d}^2 + m_{H_u}^2 \right) \lambda \lambda_N^\dagger \lambda_N + \lambda \left( 2\lambda_N^\dagger m_\nu^2 \lambda_N + 2T_{\lambda_N}^\dagger T_{\lambda_N} + m_x^2 \lambda_N^\dagger \lambda_N + \lambda_N^\dagger \lambda_N m_x^2 \right) \right. \\
& \left. + 2T_{\lambda_N}^\dagger \lambda_N T_\lambda \right) \\
& -4m_S^2 \lambda_N^\dagger \lambda_N \text{Tr} \left( \lambda_N \lambda_N^\dagger \right) - 2T_{\lambda_N}^\dagger T_{\lambda_N} \text{Tr} \left( \lambda_N \lambda_N^\dagger \right) - m_x^2 \lambda_N^\dagger \lambda_N \text{Tr} \left( \lambda_N \lambda_N^\dagger \right) \\
& -2\lambda_N^\dagger m_\nu^2 \lambda_N \text{Tr} \left( \lambda_N \lambda_N^\dagger \right) - \lambda_N^\dagger \lambda_N m_x^2 \text{Tr} \left( \lambda_N \lambda_N^\dagger \right) - 2T_{\lambda_N}^\dagger \lambda_N \text{Tr} \left( \lambda_N^\dagger T_{\lambda_N} \right) \\
& -2\lambda_N^\dagger T_{\lambda_N} \text{Tr} \left( T_{\lambda_N}^* \lambda_N^T \right) - 2\lambda_N^\dagger \lambda_N \text{Tr} \left( T_{\lambda_N}^* T_{\lambda_N}^T \right) - 2\lambda_N^\dagger \lambda_N \text{Tr} \left( m_\nu^2 \lambda_N \lambda_N^\dagger \right) \\
& -2\lambda_N^\dagger \lambda_N \text{Tr} \left( m_x^2 \lambda_N^\dagger \lambda_N \right)
\end{aligned} \tag{95}$$

### 3.9 Vacuum expectation values

$$\beta_{v_d}^{(1)} = \frac{1}{20} v_d \left( 15g_2^2 + 15g_2^2 \text{Xi} - 20|\lambda|^2 - 20\text{Tr} \left( Y_e Y_e^\dagger \right) + 3g_1^2 + 3g_1^2 \text{Xi} - 60\text{Tr} \left( Y_d Y_d^\dagger \right) \right) \tag{96}$$

$$\begin{aligned}
\beta_{v_d}^{(2)} = \frac{1}{400} v_d \Big( & -414g_1^4 - 180g_1^2 g_2^2 - 1200g_2^4 - 9g_1^4 \text{Xi} - 90g_1^2 g_2^2 \text{Xi} + 875g_2^4 \text{Xi} + 9g_1^4 \text{Xi}^2 + 90g_1^2 g_2^2 \text{Xi}^2 \\
& -225g_2^4 \text{Xi}^2 + 1200\lambda^2 \lambda^{*,2} - 40 \left( 5 \left( 32g_3^2 + 9g_2^2 \text{Xi} \right) + g_1^2 \left( 9\text{Xi} - 4 \right) \right) \text{Tr} \left( Y_d Y_d^\dagger \right) - 480g_1^2 \text{Tr} \left( Y_e Y_e^\dagger \right) \\
& -120g_1^2 \text{Xi} \text{Tr} \left( Y_e Y_e^\dagger \right) - 600g_2^2 \text{Xi} \text{Tr} \left( Y_e Y_e^\dagger \right) \\
& -40|\lambda|^2 \left( -10\text{Tr} \left( \lambda_N \lambda_N^\dagger \right) - 10\text{Tr} \left( Y_\nu Y_\nu^\dagger \right) + 15g_2^2 \text{Xi} - 20\kappa\kappa^* - 30\text{Tr} \left( Y_u Y_u^\dagger \right) + 3g_1^2 \text{Xi} \right) \\
& + 3600\text{Tr} \left( Y_d Y_d^\dagger Y_d Y_d^\dagger \right) + 1200\text{Tr} \left( Y_d Y_u^\dagger Y_u Y_d^\dagger \right) + 1200\text{Tr} \left( Y_e Y_e^\dagger Y_e Y_e^\dagger \right) + 400\text{Tr} \left( Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger \right) \Big)
\end{aligned} \tag{97}$$

$$\beta_{v_u}^{(1)} = \frac{1}{20} v_u \left( 15g_2^2 + 15g_2^2 \text{Xi} - 20|\lambda|^2 - 20\text{Tr} \left( Y_\nu Y_\nu^\dagger \right) + 3g_1^2 + 3g_1^2 \text{Xi} - 60\text{Tr} \left( Y_u Y_u^\dagger \right) \right) \tag{98}$$

$$\begin{aligned}
\beta_{v_u}^{(2)} = \frac{1}{400} v_u \Big( & -414g_1^4 - 180g_1^2 g_2^2 - 1200g_2^4 - 9g_1^4 \text{Xi} - 90g_1^2 g_2^2 \text{Xi} + 875g_2^4 \text{Xi} + 9g_1^4 \text{Xi}^2 + 90g_1^2 g_2^2 \text{Xi}^2 \\
& -225g_2^4 \text{Xi}^2 + 1200\lambda^2 \lambda^{*,2} - 40 \left( 5 \left( 32g_3^2 + 9g_2^2 \text{Xi} \right) + g_1^2 \left( 9\text{Xi} + 8 \right) \right) \text{Tr} \left( Y_u Y_u^\dagger \right) - 120g_1^2 \text{Xi} \text{Tr} \left( Y_\nu Y_\nu^\dagger \right) \\
& -600g_2^2 \text{Xi} \text{Tr} \left( Y_\nu Y_\nu^\dagger \right) \Big)
\end{aligned}$$

$$\begin{aligned}
& -40|\lambda|^2 \left( -10\text{Tr}(\lambda_N \lambda_N^\dagger) - 10\text{Tr}(Y_e Y_e^\dagger) + 15g_2^2 \text{Xi} - 20\kappa\kappa^* - 30\text{Tr}(Y_d Y_d^\dagger) + 3g_1^2 \text{Xi} \right) \\
& + 1200\text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) + 400\text{Tr}(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger) + 3600\text{Tr}(Y_u Y_u^\dagger Y_u Y_u^\dagger) + 1200\text{Tr}(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger) \\
& + 400\text{Tr}(Y_\nu Y_\nu^\dagger \lambda_N \lambda_N^\dagger) \Big) \tag{99}
\end{aligned}$$

$$\beta_{v_s}^{(1)} = -v_s \left( 2|\kappa|^2 + 2|\lambda|^2 + \text{Tr}(\lambda_N \lambda_N^\dagger) \right) \tag{100}$$

$$\begin{aligned}
\beta_{v_s}^{(2)} = & \frac{2}{5}v_s \left( 20\kappa^2 \kappa^{*,2} + 10\lambda^2 \lambda^{*,2} \right. \\
& + |\lambda|^2 \left( -15g_2^2 + 15\text{Tr}(Y_d Y_d^\dagger) + 15\text{Tr}(Y_u Y_u^\dagger) - 3g_1^2 + 5\text{Tr}(Y_e Y_e^\dagger) + 5\text{Tr}(Y_\nu Y_\nu^\dagger) \right) \\
& \left. + 10|\kappa|^2 \left( 2\lambda\lambda^* + \text{Tr}(\lambda_N \lambda_N^\dagger) \right) + 5 \left( \text{Tr}(Y_\nu Y_\nu^\dagger \lambda_N \lambda_N^\dagger) + \text{Tr}(\lambda_N \lambda_N^\dagger \lambda_N \lambda_N^\dagger) \right) \right) \tag{101}
\end{aligned}$$

## 4 Field Rotations

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

$$\begin{pmatrix} B_\rho \\ W_{3\rho} \end{pmatrix} = Z^{\gamma Z} \begin{pmatrix} \gamma_\rho \\ Z_\rho \end{pmatrix} \tag{102}$$

$$\begin{pmatrix} W_{1\rho} \\ W_{2\rho} \end{pmatrix} = Z^W \begin{pmatrix} W_\rho^- \\ W_\rho^- \end{pmatrix} \tag{103}$$

$$\begin{pmatrix} \lambda_{\tilde{W},1} \\ \lambda_{\tilde{W},2} \\ \lambda_{\tilde{W},3} \end{pmatrix} = Z^{\tilde{W}} \begin{pmatrix} \tilde{W}^- \\ \tilde{W}^+ \\ \tilde{W}^0 \end{pmatrix} \tag{104}$$

$$\tag{105}$$

The mixing matrices are parametrized by

$$Z^{\gamma Z} = \begin{pmatrix} \cos \Theta_W & -\sin \Theta_W \\ \sin \Theta_W & \cos \Theta_W \end{pmatrix} \tag{106}$$

$$Z^W = \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ -i\frac{1}{\sqrt{2}} & i\frac{1}{\sqrt{2}} \end{pmatrix} \tag{107}$$

$$Z^{\tilde{W}} = \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \\ -i\frac{1}{\sqrt{2}} & i\frac{1}{\sqrt{2}} & 0 \\ 0 & 0 & 1 \end{pmatrix} \tag{108}$$

$$\tag{109}$$

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

### 4.2.1 Mass Matrices for Scalars

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

$$m_{\tilde{d}}^2 = \begin{pmatrix} m_{\tilde{d}_L \tilde{d}_L^*} & \frac{1}{2}(\sqrt{2}v_d T_d^\dagger - v_s v_u \lambda Y_d^\dagger) \delta_{\alpha_1 \beta_2} \\ \frac{1}{2}\delta_{\alpha_2 \beta_1}(\sqrt{2}v_d T_d - v_s v_u Y_d \lambda^*) & m_{\tilde{d}_R \tilde{d}_R^*} \end{pmatrix} \quad (110)$$

$$m_{\tilde{d}_L \tilde{d}_L^*} = -\frac{1}{24}(3g_2^2 + g_1^2)\mathbf{1}(-v_u^2 + v_d^2)\delta_{\alpha_1 \beta_1} + \frac{1}{2}\delta_{\alpha_1 \beta_1}(2m_q^2 + v_d^2 Y_d^\dagger Y_d) \quad (111)$$

$$m_{\tilde{d}_R \tilde{d}_R^*} = \frac{1}{12}g_1^2\mathbf{1}(-v_d^2 + v_u^2)\delta_{\alpha_2 \beta_2} + \frac{1}{2}\delta_{\alpha_2 \beta_2}(2m_d^2 + v_d^2 Y_d Y_d^\dagger) \quad (112)$$

This matrix is diagonalized by  $Z^D$ :

$$Z^D m_{\tilde{d}}^2 Z^{D,\dagger} = m_{2,\tilde{d}}^{dia} \quad (113)$$

with

$$\tilde{d}_{L,i\alpha} = \sum_j Z_{ji}^{D,*} \tilde{d}_{j\alpha}, \quad \tilde{d}_{R,i\alpha} = \sum_j Z_{ji}^{D,*} \tilde{d}_{j\alpha} \quad (114)$$

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

$$m_{\nu^i}^2 = \begin{pmatrix} m_{\sigma_L \sigma_L} & m_{\sigma_R \sigma_L}^T & \frac{1}{2}v_s v_u \Re(Y_\nu^T \lambda_N^*) \\ m_{\sigma_L \sigma_R} & m_{\sigma_R \sigma_R}^T & m_{\sigma_X \sigma_R}^T \\ \frac{1}{2}v_s v_u \Re(\lambda_N^T Y_\nu^*) & m_{\sigma_R \sigma_X} & m_{\sigma_X \sigma_X} \end{pmatrix} \quad (115)$$

$$m_{\sigma_L \sigma_L} = \frac{1}{4}(2v_u^2 \Re(Y_\nu^T Y_\nu^*) + 4\Re(m_l^2)) + \frac{1}{8}(g_1^2 + g_2^2)\mathbf{1}(-v_u^2 + v_d^2) \quad (116)$$

$$m_{\sigma_L \sigma_R} = -\frac{1}{2}v_d v_s \Re(\lambda Y_\nu^*) + \frac{1}{\sqrt{2}}v_u \Re(T_{Y_\nu}) \quad (117)$$

$$m_{\sigma_R \sigma_R} = \frac{1}{4}(2v_s^2 \Re(\lambda_N \lambda_N^\dagger) + 2v_u^2 \Re(Y_\nu Y_\nu^\dagger) + 4\Re(m_\nu^2)) \quad (118)$$

$$m_{\sigma_R \sigma_X} = \frac{1}{8}(-2v_d v_u \lambda^* \lambda_N^T + 2((-v_d v_u \lambda + v_s^2 \kappa)\lambda_N^\dagger + v_s^2 \kappa^* \lambda_N^T) + \sqrt{2}v_s(-4\Re(\mu_X \lambda_N^\dagger) + 4\Re(T_{\lambda_N}^T))) \quad (119)$$

$$m_{\sigma_X \sigma_X} = \frac{1}{8}(4v_s^2 \Re(\lambda_N^T \lambda_N^*) - 8\Re(B_{\mu_X}) + 8\Re(\mu_X \mu_X^*) + 8\Re(m_x^2)) \quad (120)$$

This matrix is diagonalized by  $Z^i$ :

$$Z^i m_{\nu^i}^2 Z^{i,\dagger} = m_{2,\nu^i}^{dia} \quad (121)$$

with

$$\sigma_{L,i} = \sum_j Z_{ji}^{i,*} \nu_j^i, \quad \sigma_{R,i} = \sum_j Z_{ji}^{i,*} \nu_j^i, \quad \sigma_{X,i} = \sum_j Z_{ji}^{i,*} \nu_j^i \quad (122)$$

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

$$m_{\nu R}^2 = \begin{pmatrix} m_{\phi_L \phi_L} & m_{\phi_R \phi_L}^T & \frac{1}{2} v_s v_u \Re(Y_\nu^T \lambda_N^*) \\ m_{\phi_L \phi_R} & m_{\phi_R \phi_R} & m_{\phi_X \phi_R}^T \\ \frac{1}{2} v_s v_u \Re(\lambda_N^T Y_\nu^*) & m_{\phi_R \phi_X} & m_{\phi_X \phi_X} \end{pmatrix} \quad (123)$$

$$m_{\phi_L \phi_L} = \frac{1}{4} \left( 2v_u^2 \Re(Y_\nu^T Y_\nu^*) + 4\Re(m_l^2) \right) + \frac{1}{8} (g_1^2 + g_2^2) \mathbf{1} (-v_u^2 + v_d^2) \quad (124)$$

$$m_{\phi_L \phi_R} = -\frac{1}{2} v_d v_s \Re(\lambda Y_\nu^*) + \frac{1}{\sqrt{2}} v_u \Re(T_{Y_\nu}) \quad (125)$$

$$m_{\phi_R \phi_R} = \frac{1}{4} \left( 2v_s^2 \Re(\lambda_N \lambda_N^\dagger) + 2v_u^2 \Re(Y_\nu Y_\nu^\dagger) + 4\Re(m_\nu^2) \right) \quad (126)$$

$$m_{\phi_R \phi_X} = \frac{1}{8} \left( -2v_d v_u \lambda^* \lambda_N^T + 2 \left( (-v_d v_u \lambda + v_s^2 \kappa) \lambda_N^\dagger + v_s^2 \kappa^* \lambda_N^T \right) + \sqrt{2} v_s \left( 4\Re(\mu_X \lambda_N^\dagger) + 4\Re(T_{\lambda_N}^T) \right) \right) \quad (127)$$

$$m_{\phi_X \phi_X} = \frac{1}{8} \left( 2 \left( 2\Re(B_{\mu_X}) + 2v_s^2 \Re(\lambda_N^T \lambda_N^*) \right) + 4 \left( 2\Re(m_x^2) + \Re(B_{\mu_X}) \right) + 8\Re(\mu_X \mu_X^*) \right) \quad (128)$$

This matrix is diagonalized by  $Z^R$ :

$$Z^R m_{\nu R}^2 Z^{R,\dagger} = m_{2,\nu R}^{dia} \quad (129)$$

with

$$\phi_{L,i} = \sum_j Z_{ji}^{R,*} \nu_j^R, \quad \phi_{R,i} = \sum_j Z_{ji}^{R,*} \nu_j^R, \quad \phi_{X,i} = \sum_j Z_{ji}^{R,*} \nu_j^R \quad (130)$$

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

$$m_{\tilde{u}}^2 = \begin{pmatrix} m_{\tilde{u}_L \tilde{u}_L^*} & \frac{1}{2} \left( \sqrt{2} v_u T_u^\dagger - v_d v_s \lambda Y_u^\dagger \right) \delta_{\alpha_1 \beta_2} \\ \frac{1}{2} \delta_{\alpha_2 \beta_1} \left( \sqrt{2} v_u T_u - v_d v_s Y_u \lambda^* \right) & m_{\tilde{u}_R \tilde{u}_R^*} \end{pmatrix} \quad (131)$$

$$m_{\tilde{u}_L \tilde{u}_L^*} = -\frac{1}{24} \left( -3g_2^2 + g_1^2 \right) \mathbf{1} (-v_u^2 + v_d^2) \delta_{\alpha_1 \beta_1} + \frac{1}{2} \delta_{\alpha_1 \beta_1} \left( 2m_q^2 + v_u^2 Y_u^\dagger Y_u \right) \quad (132)$$

$$m_{\tilde{u}_R \tilde{u}_R^*} = \frac{1}{2} \delta_{\alpha_2 \beta_2} \left( 2m_u^2 + v_u^2 Y_u Y_u^\dagger \right) + \frac{1}{6} g_1^2 \mathbf{1} (-v_u^2 + v_d^2) \delta_{\alpha_2 \beta_2} \quad (133)$$

This matrix is diagonalized by  $Z^U$ :

$$Z^U m_{\tilde{u}}^2 Z^{U,\dagger} = m_{2,\tilde{u}}^{dia} \quad (134)$$

with

$$\tilde{u}_{L,i\alpha} = \sum_j Z_{ji}^{U,*} \tilde{u}_{j\alpha}, \quad \tilde{u}_{R,i\alpha} = \sum_j Z_{ji}^{U,*} \tilde{u}_{j\alpha} \quad (135)$$

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

$$m_{\tilde{e}}^2 = \begin{pmatrix} m_{\tilde{e}_L \tilde{e}_L^*} & -\frac{1}{2}v_s v_u \lambda Y_e^\dagger + \frac{1}{\sqrt{2}}v_d T_e^\dagger \\ -\frac{1}{2}v_s v_u Y_e \lambda^* + \frac{1}{\sqrt{2}}v_d T_e & m_{\tilde{e}_R \tilde{e}_R^*} \end{pmatrix} \quad (136)$$

$$m_{\tilde{e}_L \tilde{e}_L^*} = \frac{1}{2}v_d^2 Y_e^\dagger Y_e + \frac{1}{8}(-g_2^2 + g_1^2)\mathbf{1}(-v_u^2 + v_d^2) + m_l^2 \quad (137)$$

$$m_{\tilde{e}_R \tilde{e}_R^*} = \frac{1}{2}v_d^2 Y_e Y_e^\dagger + \frac{1}{4}g_1^2\mathbf{1}(-v_d^2 + v_u^2) + m_e^2 \quad (138)$$

This matrix is diagonalized by  $Z^E$ :

$$Z^E m_{\tilde{e}}^2 Z^{E,\dagger} = m_{2,\tilde{e}}^{dia} \quad (139)$$

with

$$\tilde{e}_{L,i} = \sum_j Z_{ji}^{E,*} \tilde{e}_j, \quad \tilde{e}_{R,i} = \sum_j Z_{ji}^{E,*} \tilde{e}_j \quad (140)$$

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

$$m_h^2 = \begin{pmatrix} m_{\phi_d \phi_d} & m_{\phi_u \phi_d} & m_{\phi_s \phi_d} \\ m_{\phi_d \phi_u} & m_{\phi_u \phi_u} & m_{\phi_s \phi_u} \\ m_{\phi_d \phi_s} & m_{\phi_u \phi_s} & m_{\phi_s \phi_s} \end{pmatrix} \quad (141)$$

$$m_{\phi_d \phi_d} = \frac{1}{2}(v_s^2 + v_u^2)|\lambda|^2 + \frac{1}{8}(g_1^2 + g_2^2)(3v_d^2 - v_u^2) + m_{H_d}^2 \quad (142)$$

$$m_{\phi_d \phi_u} = \frac{1}{4}(-2\sqrt{2}v_s \Re(T_\lambda) + (4v_d v_u \lambda - v_s^2 \kappa)\lambda^* - v_s^2 \lambda \kappa^*) - \frac{1}{4}(g_1^2 + g_2^2)v_d v_u \quad (143)$$

$$m_{\phi_u \phi_u} = \frac{1}{2}(v_d^2 + v_s^2)|\lambda|^2 - \frac{1}{8}(g_1^2 + g_2^2)(-3v_u^2 + v_d^2) + m_{H_u}^2 \quad (144)$$

$$m_{\phi_d \phi_s} = -\frac{1}{\sqrt{2}}v_u \Re(T_\lambda) + v_s \left( \left( -\frac{1}{2}v_u \kappa + v_d \lambda \right) \lambda^* - \frac{1}{2}v_u \lambda \kappa^* \right) \quad (145)$$

$$m_{\phi_u \phi_s} = \frac{1}{2} \left( -v_d \left( \sqrt{2} \Re(T_\lambda) + v_s \lambda \kappa^* \right) - v_s \left( -2v_u \lambda + v_d \kappa \right) \lambda^* \right) \quad (146)$$

$$m_{\phi_s \phi_s} = \frac{1}{2} \left( 2\sqrt{2}v_s \Re(T_\kappa) + (6v_s^2 \kappa - v_d v_u \lambda) \kappa^* + \left( (v_d^2 + v_u^2) \lambda - v_d v_u \kappa \right) \lambda^* \right) + m_S^2 \quad (147)$$

This matrix is diagonalized by  $Z^H$ :

$$Z^H m_h^2 Z^{H,\dagger} = m_{2,h}^{dia} \quad (148)$$

with

$$\phi_d = \sum_j Z_{j1}^H h_j, \quad \phi_u = \sum_j Z_{j2}^H h_j, \quad \phi_s = \sum_j Z_{j3}^H h_j \quad (149)$$

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

$$m_{A^0}^2 = \begin{pmatrix} m_{\sigma_d \sigma_d} & \frac{1}{4} v_s \left( 2\sqrt{2} \Re(T_\lambda) + 2v_s \Re(\lambda \kappa^*) \right) & m_{\sigma_s \sigma_d} \\ \frac{1}{4} v_s \left( 2\sqrt{2} \Re(T_\lambda) + 2v_s \Re(\lambda \kappa^*) \right) & m_{\sigma_u \sigma_u} & m_{\sigma_s \sigma_u} \\ m_{\sigma_d \sigma_s} & m_{\sigma_u \sigma_s} & m_{\sigma_s \sigma_s} \end{pmatrix} + \xi_Z m^2(Z) \quad (150)$$

$$m_{\sigma_d \sigma_d} = \frac{1}{2} (v_s^2 + v_u^2) |\lambda|^2 + \frac{1}{8} (g_1^2 + g_2^2) (-v_u^2 + v_d^2) + m_{H_d}^2 \quad (151)$$

$$m_{\sigma_u \sigma_u} = \frac{1}{2} (v_d^2 + v_s^2) |\lambda|^2 - \frac{1}{8} (g_1^2 + g_2^2) (-v_u^2 + v_d^2) + m_{H_u}^2 \quad (152)$$

$$m_{\sigma_d \sigma_s} = -\frac{1}{2} v_u \left( 2v_s \Re(\lambda \kappa^*) - \sqrt{2} \Re(T_\lambda) \right) \quad (153)$$

$$m_{\sigma_u \sigma_s} = -\frac{1}{2} v_d \left( 2v_s \Re(\lambda \kappa^*) - \sqrt{2} \Re(T_\lambda) \right) \quad (154)$$

$$m_{\sigma_s \sigma_s} = \frac{1}{2} \left( -2\sqrt{2} v_s \Re(T_\kappa) + (2v_s^2 \kappa + v_d v_u \lambda) \kappa^* + ((v_d^2 + v_u^2) \lambda + v_d v_u \kappa) \lambda^* \right) + m_S^2 \quad (155)$$

Gauge fixing contributions:

$$m^2(\xi_Z) = \begin{pmatrix} m_{\sigma_d \sigma_d} & m_{\sigma_u \sigma_d} & 0 \\ m_{\sigma_d \sigma_u} & m_{\sigma_u \sigma_u} & 0 \\ 0 & 0 & 0 \end{pmatrix} \quad (156)$$

$$m_{\sigma_d \sigma_d} = \frac{1}{4} v_d^2 \left( g_1 \sin \Theta_W + g_2 \cos \Theta_W \right)^2 \quad (157)$$

$$m_{\sigma_d \sigma_u} = -\frac{1}{4} v_d v_u \left( g_1 \sin \Theta_W + g_2 \cos \Theta_W \right)^2 \quad (158)$$

$$m_{\sigma_u \sigma_u} = \frac{1}{4} v_u^2 \left( g_1 \sin \Theta_W + g_2 \cos \Theta_W \right)^2 \quad (159)$$

This matrix is diagonalized by  $Z^A$ :

$$Z^A m_{A^0}^2 Z^{A,\dagger} = m_{2,A^0}^{dia} \quad (160)$$

with

$$\sigma_d = \sum_j Z_{j1}^A A_j^0, \quad \sigma_u = \sum_j Z_{j2}^A A_j^0, \quad \sigma_s = \sum_j Z_{j3}^A A_j^0 \quad (161)$$

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

$$m_{H^-}^2 = \begin{pmatrix} m_{H_d^- H_d^{-,*}} & m_{H_u^{+,*} H_d^{-,*}}^* \\ m_{H_d^- H_u^+} & m_{H_u^{+,*} H_u^+} \end{pmatrix} + \xi_{W^-} m^2(W^-) \quad (162)$$



$$m_{H_d^- H_d^{+,*}} = \frac{1}{2} v_s^2 |\lambda|^2 + \frac{1}{8} \left( g_1^2 \left( -v_u^2 + v_d^2 \right) + g_2^2 \left( v_d^2 + v_u^2 \right) \right) + m_{H_d}^2 \quad (163)$$

$$m_{H_d^- H_u^+} = \frac{1}{2} \left( \lambda \left( -v_d v_u \lambda^* + v_s^2 \kappa^* \right) + \sqrt{2} v_s T_\lambda \right) + \frac{1}{4} g_2^2 v_d v_u \quad (164)$$

$$m_{H_u^{+,*} H_u^+} = \frac{1}{2} v_s^2 |\lambda|^2 + \frac{1}{8} \left( g_1^2 \left( -v_d^2 + v_u^2 \right) + g_2^2 \left( v_d^2 + v_u^2 \right) \right) + m_{H_u}^2 \quad (165)$$

Gauge fixing contributions:

$$m^2(\xi_{W^-}) = \begin{pmatrix} \frac{1}{4} g_2^2 v_d^2 & -\frac{1}{4} g_2^2 v_d v_u \\ -\frac{1}{4} g_2^2 v_d v_u & \frac{1}{4} g_2^2 v_u^2 \end{pmatrix} \quad (166)$$

This matrix is diagonalized by  $Z^+$ :

$$Z^+ m_{H^-}^2 Z^{+, \dagger} = m_{2,H^-}^{dia} \quad (167)$$

with

$$H_d^- = \sum_j Z_{j1}^+ H_j^-, \quad H_u^+ = \sum_j Z_{j2}^+ H_j^+ \quad (168)$$

#### 4.2.2 Mass Matrices for Fermions

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

$$m_{\tilde{\chi}^0} = \begin{pmatrix} M_1 & 0 & -\frac{1}{2} g_1 v_d & \frac{1}{2} g_1 v_u & 0 \\ 0 & M_2 & \frac{1}{2} g_2 v_d & -\frac{1}{2} g_2 v_u & 0 \\ -\frac{1}{2} g_1 v_d & \frac{1}{2} g_2 v_d & 0 & -\frac{1}{\sqrt{2}} v_s \lambda & -\frac{1}{\sqrt{2}} v_u \lambda \\ \frac{1}{2} g_1 v_u & -\frac{1}{2} g_2 v_u & -\frac{1}{\sqrt{2}} v_s \lambda & 0 & -\frac{1}{\sqrt{2}} v_d \lambda \\ 0 & 0 & -\frac{1}{\sqrt{2}} v_u \lambda & -\frac{1}{\sqrt{2}} v_d \lambda & \sqrt{2} v_s \kappa \end{pmatrix} \quad (169)$$

This matrix is diagonalized by  $N$ :

$$N^* m_{\tilde{\chi}^0} N^\dagger = m_{\tilde{\chi}^0}^{dia} \quad (170)$$

with

$$\lambda_{\tilde{B}} = \sum_j N_{j1}^* \lambda_j^0, \quad \tilde{W}^0 = \sum_j N_{j2}^* \lambda_j^0, \quad \tilde{H}_d^0 = \sum_j N_{j3}^* \lambda_j^0 \quad (171)$$

$$\tilde{H}_u^0 = \sum_j N_{j4}^* \lambda_j^0, \quad \tilde{S} = \sum_j N_{j5}^* \lambda_j^0 \quad (172)$$

- **Mass matrix for Neutrinos**, Basis:  $(\nu_L, \nu_R, x)$ ,  $(\nu_L, \nu_R, x)$

$$m_\nu = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & \mu_X \end{pmatrix} \quad (173)$$

This matrix is diagonalized by  $U^V$ :

$$U^{V,*} m_\nu U^{V,\dagger} = m_\nu^{dia} \quad (174)$$

with

$$\nu_{L,i} = \sum_j U_{ji}^{V,*} \nu_{M,j}, \quad \nu_{R,i} = \sum_j U_{ji}^{V,*} \nu_{M,j}, \quad x_i = \sum_j U_{ji}^{V,*} \nu_{M,j} \quad (175)$$

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

$$m_{\tilde{\chi}^-} = \begin{pmatrix} M_2 & \frac{1}{\sqrt{2}} g_2 v_u \\ \frac{1}{\sqrt{2}} g_2 v_d & \frac{1}{\sqrt{2}} v_s \lambda \end{pmatrix} \quad (176)$$

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

$$U^* m_{\tilde{\chi}^-} V^\dagger = m_{\tilde{\chi}}^{dia} \quad (177)$$

with

$$\tilde{W}^- = \sum_{t_2} U_{j1}^* \lambda_j^-, \quad \tilde{H}_d^- = \sum_{t_2} U_{j2}^* \lambda_j^- \quad (178)$$

$$\tilde{W}^+ = \sum_{t_2} V_{1j}^* \lambda_j^+, \quad \tilde{H}_u^+ = \sum_{t_2} V_{2j}^* \lambda_j^+ \quad (179)$$

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

$$m_e = \begin{pmatrix} \frac{1}{\sqrt{2}} v_d Y_e^T \end{pmatrix} \quad (180)$$

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

$$U_L^{e,*} m_e U_R^{e,\dagger} = m_e^{dia} \quad (181)$$

with

$$e_{L,i} = \sum_{t_2} U_{L,ji}^{e,*} E_{L,j} \quad (182)$$

$$e_{R,i} = \sum_{t_2} U_{R,ij}^e E_{R,j}^* \quad (183)$$

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

$$m_d = \begin{pmatrix} \frac{1}{\sqrt{2}} v_d \delta_{\alpha_1 \beta_1} Y_d^T \end{pmatrix} \quad (184)$$

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

$$U_L^{d,*} m_d U_R^{d,\dagger} = m_d^{dia} \quad (185)$$

with

$$d_{L,i\alpha} = \sum_{t_2} U_{L,ji}^{d,*} D_{L,j\alpha} \quad (186)$$

$$d_{R,i\alpha} = \sum_{t_2} U_{R,ij}^d D_{R,j\alpha}^* \quad (187)$$

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

$$m_u = \left( \frac{1}{\sqrt{2}} v_u \delta_{\alpha_1 \beta_1} Y_u^T \right) \quad (188)$$

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

$$U_L^{u,*} m_u U_R^{u,\dagger} = m_u^{dia} \quad (189)$$

with

$$u_{L,i\alpha} = \sum_{t_2} U_{L,ji}^{u,*} U_{L,j\alpha} \quad (190)$$

$$u_{R,i\alpha} = \sum_{t_2} U_{R,ij}^u U_{R,j\alpha}^* \quad (191)$$

## 5 Vacuum Expectation Values

$$H_d^0 = \frac{1}{\sqrt{2}} \phi_d + \frac{1}{\sqrt{2}} v_d + i \frac{1}{\sqrt{2}} \sigma_d \quad (192)$$

$$H_u^0 = \frac{1}{\sqrt{2}} \phi_u + \frac{1}{\sqrt{2}} v_u + i \frac{1}{\sqrt{2}} \sigma_u \quad (193)$$

$$S = \frac{1}{\sqrt{2}} \phi_s + \frac{1}{\sqrt{2}} v_s + i \frac{1}{\sqrt{2}} \sigma_s \quad (194)$$

$$\tilde{\nu}_L = \frac{1}{\sqrt{2}} \phi_L + i \frac{1}{\sqrt{2}} \sigma_L \quad (195)$$

$$\tilde{\nu}_R = \frac{1}{\sqrt{2}} \phi_R + i \frac{1}{\sqrt{2}} \sigma_R \quad (196)$$

$$\tilde{x} = \frac{1}{\sqrt{2}} \phi_X + i \frac{1}{\sqrt{2}} \sigma_X \quad (197)$$

## 6 Tadpole Equations

$$\frac{\partial V}{\partial \phi_d} = \frac{1}{4} \left( \left( 2v_d (v_s^2 + v_u^2) \lambda - v_s^2 v_u \kappa \right) \lambda^* + 4m_{H_d}^2 v_d - v_s v_u \left( 2\sqrt{2} \Re(T_\lambda) + v_s \lambda \kappa^* \right) \right) + \frac{1}{8} (g_1^2 + g_2^2) v_d (-v_u + v_d) (v_d + v_u) \quad (198)$$

$$\begin{aligned} \frac{\partial V}{\partial \phi_u} = & + \frac{1}{8} (g_1^2 + g_2^2) v_u (-v_d^2 + v_u^2) \\ & + \frac{1}{4} \left( \left( 2(v_d^2 + v_s^2) v_u \lambda - v_d v_s^2 \kappa \right) \lambda^* + 4m_{H_u}^2 v_u - v_d v_s \left( 2\sqrt{2} \Re(T_\lambda) + v_s \lambda \kappa^* \right) \right) \end{aligned} \quad (199)$$

$$\begin{aligned} \frac{\partial V}{\partial \phi_s} = & \frac{1}{4} \left( \left( -2v_d v_s v_u \lambda + 4v_s^3 \kappa \right) \kappa^* + v_s \left( 2 \left( (v_d^2 + v_u^2) \lambda - v_d v_u \kappa \right) \lambda^* + 4m_S^2 \right) \right. \\ & \left. + \sqrt{2} \left( -v_d v_u (T_\lambda^* + T_\lambda) + v_s^2 (T_\kappa^* + T_\kappa) \right) \right) \end{aligned} \quad (200)$$

$$\frac{\partial V}{\partial \phi_{L_i}} = 0 \quad (201)$$

$$\frac{\partial V}{\partial \phi_{R_i}} = 0 \quad (202)$$

$$\frac{\partial V}{\partial \phi_{X_i}} = 0 \quad (203)$$

## 7 Particle content for eigenstates 'EWSB'

Name	Type	complex/real	Generations	Indices
$\tilde{d}$	Scalar	complex	6	generation, 6, color, 3
$\nu^I$	Scalar	real	9	generation, 9
$\nu^R$	Scalar	real	9	generation, 9
$\tilde{u}$	Scalar	complex	6	generation, 6, color, 3
$\tilde{e}$	Scalar	complex	6	generation, 6
$h$	Scalar	real	3	generation, 3
$A^0$	Scalar	real	3	generation, 3
$H^-$	Scalar	complex	2	generation, 2
$\tilde{g}$	Fermion	Majorana	1	color, 8
$\tilde{\chi}^0$	Fermion	Majorana	5	generation, 5
$\nu$	Fermion	Majorana	9	generation, 9
$\tilde{\chi}^-$	Fermion	Dirac	2	generation, 2
$e$	Fermion	Dirac	3	generation, 3
$d$	Fermion	Dirac	3	generation, 3, color, 3
$u$	Fermion	Dirac	3	generation, 3, color, 3
$g$	Vector	real	1	color, 8, lorentz, 4
$\gamma$	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} \\
& - \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) \\
& - 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_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, \tilde{d}_a^*, \tilde{d}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, \tilde{e}_a^*, \tilde{e}_a} \\
& - C \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, \tilde{u}_a^*, \tilde{u}_a} + \sum_{a=1}^6 \sum_{b=1}^2 B_0(p^2, m_{\tilde{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_{\tilde{d}_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j^*, \tilde{d}_a, A_b^0}^* \Gamma_{\tilde{d}_i^*, \tilde{d}_a, A_b^0} + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{\tilde{d}_a}^2, m_{h_b}^2) \Gamma_{\tilde{d}_j^*, \tilde{d}_a, h_b}^* \Gamma_{\tilde{d}_i^*, \tilde{d}_a, h_b} \\
& - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^i}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, \nu_a^i, \nu_a^i} - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^R}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, \nu_a^R, \nu_a^R} \\
& - \frac{8}{3} m_{\tilde{g}} \sum_{b=1}^3 B_0(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_b}^2) m_{\tilde{d}_b} \left( \Gamma_{\tilde{d}_j^*, \tilde{g}_1, \tilde{d}_b}^{L*} \Gamma_{\tilde{d}_i^*, \tilde{g}_1, \tilde{d}_b}^R + \Gamma_{\tilde{d}_j^*, \tilde{g}_1, \tilde{d}_b}^{R*} \Gamma_{\tilde{d}_i^*, \tilde{g}_1, \tilde{d}_b}^L \right) \\
& + \frac{4}{3} \sum_{b=1}^3 G_0(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_b}^2) \left( \Gamma_{\tilde{d}_j^*, \tilde{g}_1, \tilde{d}_b}^{L*} \Gamma_{\tilde{d}_i^*, \tilde{g}_1, \tilde{d}_b}^L + \Gamma_{\tilde{d}_j^*, \tilde{g}_1, \tilde{d}_b}^{R*} \Gamma_{\tilde{d}_i^*, \tilde{g}_1, \tilde{d}_b}^R \right) \\
& + \frac{4}{3} \sum_{b=1}^6 \Gamma_{\tilde{d}_j^*, g, \tilde{d}_b}^* \Gamma_{\tilde{d}_i^*, g, \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, 0) + \sum_{b=1}^6 \Gamma_{\tilde{d}_j^*, \gamma, \tilde{d}_b}^* \Gamma_{\tilde{d}_i^*, \gamma, \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, 0)
\end{aligned}$$

$$+ \sum_{b=1}^6 \Gamma_{\tilde{d}_j^*, Z, \tilde{d}_b}^* \Gamma_{\tilde{d}_i^*, Z, \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, m_Z^2) + \sum_{b=1}^6 \Gamma_{\tilde{d}_j^*, W^-, \tilde{u}_b}^* \Gamma_{\tilde{d}_i^*, W^-, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, m_{W^-}^2) \quad (204)$$

• **Self-Energy for CP-odd Sneutrino ( $\nu^i$ )**

$$\begin{aligned} \Pi_{i,j}(p^2) = & +4\Gamma_{\tilde{\nu}_i^i, \tilde{\nu}_j^i, W^+, W^-} \left( -\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2\Gamma_{\tilde{\nu}_i^i, \tilde{\nu}_j^i, Z, Z} \left( -\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) \\ & - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\tilde{\nu}_i^i, \tilde{\nu}_j^i, H_a^+, H_a^-} - \frac{1}{2} \sum_{a=1}^3 A_0(m_{A_a^0}^2) \Gamma_{\tilde{\nu}_i^i, \tilde{\nu}_j^i, A_a^0, A_a^0} \\ & - \frac{1}{2} \sum_{a=1}^3 A_0(m_{h_a}^2) \Gamma_{\tilde{\nu}_i^i, \tilde{\nu}_j^i, h_a, h_a} \\ & - 4 \sum_{a=1}^3 m_{e_a} \sum_{b=1}^2 B_0(p^2, m_{e_a}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} \left( \Gamma_{\tilde{\nu}_j^i, \tilde{e}_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\nu}_i^i, \tilde{e}_a, \tilde{\chi}_b^-}^R + \Gamma_{\tilde{\nu}_j^i, \tilde{e}_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\nu}_i^i, \tilde{e}_a, \tilde{\chi}_b^-}^L \right) \\ & + 2 \sum_{a=1}^3 \sum_{b=1}^2 G_0(p^2, m_{e_a}^2, m_{\tilde{\chi}_b^-}^2) \left( \Gamma_{\tilde{\nu}_j^i, \tilde{e}_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\nu}_i^i, \tilde{e}_a, \tilde{\chi}_b^-}^L + \Gamma_{\tilde{\nu}_j^i, \tilde{e}_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\nu}_i^i, \tilde{e}_a, \tilde{\chi}_b^-}^R \right) \\ & - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{\nu}_i^i, \tilde{\nu}_j^i, \tilde{d}_a^*, \tilde{d}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{\nu}_i^i, \tilde{\nu}_j^i, \tilde{e}_a^*, \tilde{e}_a} \\ & - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{\nu}_i^i, \tilde{\nu}_j^i, \tilde{u}_a^*, \tilde{u}_a} + 2 \sum_{a=1}^6 \sum_{b=1}^2 B_0(p^2, m_{\tilde{e}_a}^2, m_{H_b^-}^2) \Gamma_{\tilde{\nu}_j^i, \tilde{e}_a^*, H_b^-}^* \Gamma_{\tilde{\nu}_i^i, \tilde{e}_a^*, H_b^-} \\ & - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^i}^2) \Gamma_{\tilde{\nu}_i^i, \tilde{\nu}_j^i, \nu_a^i, \nu_a^i} - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^R}^2) \Gamma_{\tilde{\nu}_i^i, \tilde{\nu}_j^i, \nu_a^R, \nu_a^R} \\ & + \sum_{a=1}^9 \sum_{b=1}^3 B_0(p^2, m_{\nu_a^i}^2, m_{A_b^0}^2) \Gamma_{\tilde{\nu}_j^i, \nu_a^i, A_b^0}^* \Gamma_{\tilde{\nu}_i^i, \nu_a^i, A_b^0} \\ & + \sum_{a=1}^9 \sum_{b=1}^3 B_0(p^2, m_{\nu_a^i}^2, m_{h_b}^2) \Gamma_{\tilde{\nu}_j^i, \nu_a^i, h_b}^* \Gamma_{\tilde{\nu}_i^i, \nu_a^i, h_b} \\ & + \sum_{a=1}^9 \sum_{b=1}^3 B_0(p^2, m_{\nu_a^R}^2, m_{A_b^0}^2) \Gamma_{\tilde{\nu}_j^i, \nu_a^R, A_b^0}^* \Gamma_{\tilde{\nu}_i^i, \nu_a^R, A_b^0} \\ & + \sum_{a=1}^9 \sum_{b=1}^3 B_0(p^2, m_{\nu_a^R}^2, m_{h_b}^2) \Gamma_{\tilde{\nu}_j^i, \nu_a^R, h_b}^* \Gamma_{\tilde{\nu}_i^i, \nu_a^R, h_b} \\ & - 2 \sum_{a=1}^9 m_{\nu_a} \sum_{b=1}^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^i, \nu_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\nu}_i^i, \nu_a, \tilde{\chi}_b^0}^R + \Gamma_{\tilde{\nu}_j^i, \nu_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\nu}_i^i, \nu_a, \tilde{\chi}_b^0}^L \right) \\ & + \sum_{a=1}^9 \sum_{b=1}^5 G_0(p^2, m_{\nu_a}^2, m_{\tilde{\chi}_b^0}^2) \left( \Gamma_{\tilde{\nu}_j^i, \nu_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\nu}_i^i, \nu_a, \tilde{\chi}_b^0}^L + \Gamma_{\tilde{\nu}_j^i, \nu_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\nu}_i^i, \nu_a, \tilde{\chi}_b^0}^R \right) \end{aligned}$$

$$+ 2 \sum_{b=1}^6 \Gamma_{\tilde{\nu}_j^i, W^+, \tilde{e}_b}^* \Gamma_{\tilde{\nu}_i^i, W^+, \tilde{e}_b} F_0(p^2, m_{\tilde{e}_b}^2, m_{W^-}^2) + \sum_{b=1}^9 \Gamma_{\tilde{\nu}_j^i, Z, \nu_b^R}^* \Gamma_{\tilde{\nu}_i^i, Z, \nu_b^R} F_0(p^2, m_{\nu_b^R}^2, m_Z^2) \quad (205)$$

• **Self-Energy for CP-even Sneutrino ( $\nu^R$ )**

$$\begin{aligned} \Pi_{i,j}(p^2) = & +4\Gamma_{\tilde{\nu}_i^R, \tilde{\nu}_j^R, W^+, W^-} \left( -\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2\Gamma_{\tilde{\nu}_i^R, \tilde{\nu}_j^R, Z, Z} \left( -\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) \\ & - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\tilde{\nu}_i^R, \tilde{\nu}_j^R, H_a^+, H_a^-} - \frac{1}{2} \sum_{a=1}^3 A_0(m_{A_a^0}^2) \Gamma_{\tilde{\nu}_i^R, \tilde{\nu}_j^R, A_a^0, A_a^0} \\ & - \frac{1}{2} \sum_{a=1}^3 A_0(m_{h_a}^2) \Gamma_{\tilde{\nu}_i^R, \tilde{\nu}_j^R, h_a, h_a} \\ & - 4 \sum_{a=1}^3 m_{e_a} \sum_{b=1}^2 B_0(p^2, m_{e_a}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} \left( \Gamma_{\tilde{\nu}_j^R, \tilde{e}_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\nu}_i^R, \tilde{e}_a, \tilde{\chi}_b^-}^R + \Gamma_{\tilde{\nu}_j^R, \tilde{e}_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\nu}_i^R, \tilde{e}_a, \tilde{\chi}_b^-}^L \right) \\ & + 2 \sum_{a=1}^3 \sum_{b=1}^2 G_0(p^2, m_{e_a}^2, m_{\tilde{\chi}_b^-}^2) \left( \Gamma_{\tilde{\nu}_j^R, \tilde{e}_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\nu}_i^R, \tilde{e}_a, \tilde{\chi}_b^-}^L + \Gamma_{\tilde{\nu}_j^R, \tilde{e}_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\nu}_i^R, \tilde{e}_a, \tilde{\chi}_b^-}^R \right) \\ & - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{\nu}_i^R, \tilde{\nu}_j^R, \tilde{d}_a^*, \tilde{d}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{\nu}_i^R, \tilde{\nu}_j^R, \tilde{e}_a^*, \tilde{e}_a} \\ & - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{\nu}_i^R, \tilde{\nu}_j^R, \tilde{u}_a^*, \tilde{u}_a} + 2 \sum_{a=1}^6 \sum_{b=1}^2 B_0(p^2, m_{\tilde{e}_a}^2, m_{H_b^-}^2) \Gamma_{\tilde{\nu}_j^R, \tilde{e}_a^*, H_b^-}^* \Gamma_{\tilde{\nu}_i^R, \tilde{e}_a^*, H_b^-} \\ & - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^i}^2) \Gamma_{\tilde{\nu}_i^R, \tilde{\nu}_j^R, \nu_a^i, \nu_a^i} - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^R}^2) \Gamma_{\tilde{\nu}_i^R, \tilde{\nu}_j^R, \nu_a^R, \nu_a^R} \\ & + \sum_{a=1}^9 \sum_{b=1}^3 B_0(p^2, m_{\nu_a^i}^2, m_{A_b^0}^2) \Gamma_{\tilde{\nu}_j^R, \nu_a^i, A_b^0}^* \Gamma_{\tilde{\nu}_i^R, \nu_a^i, A_b^0} \\ & + \sum_{a=1}^9 \sum_{b=1}^3 B_0(p^2, m_{\nu_a^i}^2, m_{h_b}^2) \Gamma_{\tilde{\nu}_j^R, \nu_a^i, h_b}^* \Gamma_{\tilde{\nu}_i^R, \nu_a^i, h_b} \\ & + \sum_{a=1}^9 \sum_{b=1}^3 B_0(p^2, m_{\nu_a^R}^2, m_{A_b^0}^2) \Gamma_{\tilde{\nu}_j^R, \nu_a^R, A_b^0}^* \Gamma_{\tilde{\nu}_i^R, \nu_a^R, A_b^0} \\ & + \sum_{a=1}^9 \sum_{b=1}^3 B_0(p^2, m_{\nu_a^R}^2, m_{h_b}^2) \Gamma_{\tilde{\nu}_j^R, \nu_a^R, h_b}^* \Gamma_{\tilde{\nu}_i^R, \nu_a^R, h_b} \\ & - 2 \sum_{a=1}^9 m_{\nu_a} \sum_{b=1}^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^R, \nu_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\nu}_i^R, \nu_a, \tilde{\chi}_b^0}^R + \Gamma_{\tilde{\nu}_j^R, \nu_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\nu}_i^R, \nu_a, \tilde{\chi}_b^0}^L \right) \\ & + \sum_{a=1}^9 \sum_{b=1}^5 G_0(p^2, m_{\nu_a}^2, m_{\tilde{\chi}_b^0}^2) \left( \Gamma_{\tilde{\nu}_j^R, \nu_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\nu}_i^R, \nu_a, \tilde{\chi}_b^0}^L + \Gamma_{\tilde{\nu}_j^R, \nu_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\nu}_i^R, \nu_a, \tilde{\chi}_b^0}^R \right) \end{aligned}$$

$$+ 2 \sum_{b=1}^6 \Gamma_{\tilde{\nu}_j^R, W^+, \tilde{e}_b}^* \Gamma_{\tilde{\nu}_i^R, W^+, \tilde{e}_b} F_0(p^2, m_{\tilde{e}_b}^2, m_{W^-}^2) + \sum_{b=1}^9 \Gamma_{\tilde{\nu}_j^R, Z, \nu_b^i}^* \Gamma_{\tilde{\nu}_i^R, Z, \nu_b^i} F_0(p^2, m_{\nu_b^i}^2, m_Z^2) \quad (206)$$

• 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} \\ & - \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} \\ & - 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{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^i}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, \nu_a^i, \nu_a^i} \\ & - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^R}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, \nu_a^R, \nu_a^R} \\ & - \frac{8}{3} m_{\tilde{g}} \sum_{b=1}^3 B_0(p^2, m_{\tilde{g}}^2, m_{u_b}^2) m_{u_b} \left( \Gamma_{\tilde{u}_j^*, \tilde{g}_1, u_b}^{L*} \Gamma_{\tilde{u}_i^*, \tilde{g}_1, u_b}^R + \Gamma_{\tilde{u}_j^*, \tilde{g}_1, u_b}^{R*} \Gamma_{\tilde{u}_i^*, \tilde{g}_1, u_b}^L \right) \\ & + \frac{4}{3} \sum_{b=1}^3 G_0(p^2, m_{\tilde{g}}^2, m_{u_b}^2) \left( \Gamma_{\tilde{u}_j^*, \tilde{g}_1, u_b}^{L*} \Gamma_{\tilde{u}_i^*, \tilde{g}_1, u_b}^L + \Gamma_{\tilde{u}_j^*, \tilde{g}_1, u_b}^{R*} \Gamma_{\tilde{u}_i^*, \tilde{g}_1, u_b}^R \right) \end{aligned}$$



$$\begin{aligned}
& + \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, W^+, \tilde{d}_b}^* \Gamma_{\tilde{u}_i^*, W^+, \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, m_{W^-}^2) + \frac{4}{3} \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, g, \tilde{u}_b}^* \Gamma_{\tilde{u}_i^*, g, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, 0) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, \gamma, \tilde{u}_b}^* \Gamma_{\tilde{u}_i^*, \gamma, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, 0) + \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, Z, \tilde{u}_b}^* \Gamma_{\tilde{u}_i^*, Z, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, m_Z^2)
\end{aligned} \tag{207}$$

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

$$\begin{aligned}
\Pi_{i,j}(p^2) = & +4\Gamma_{\tilde{e}_i, \tilde{e}_j^*, W^+, W^-} \left( -\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2\Gamma_{\tilde{e}_i, \tilde{e}_j^*, Z, Z} \left( -\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) \\
& - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, H_a^+, H_a^-} - \frac{1}{2} \sum_{a=1}^3 A_0(m_{A_a^0}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, A_a^0, A_a^0} \\
& - \frac{1}{2} \sum_{a=1}^3 A_0(m_{h_a}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, h_a, h_a} \\
& - 2 \sum_{a=1}^3 m_{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} \\
& - 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} - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^i}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, \nu_a^i, \nu_a^i} \\
& - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^R}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, \nu_a^R, \nu_a^R} + \sum_{a=1}^9 \sum_{b=1}^2 B_0(p^2, m_{\nu_a^i}^2, m_{H_b^-}^2) \Gamma_{\tilde{e}_j^*, \nu_a^i, H_b^-}^* \Gamma_{\tilde{e}_i^*, \nu_a^i, H_b^-} \\
& + \sum_{a=1}^9 \sum_{b=1}^2 B_0(p^2, m_{\nu_a^R}^2, m_{H_b^-}^2) \Gamma_{\tilde{e}_j^*, \nu_a^R, H_b^-}^* \Gamma_{\tilde{e}_i^*, \nu_a^R, H_b^-} \\
& - 2 \sum_{a=1}^9 m_{\nu_a} \sum_{b=1}^2 B_0(p^2, m_{\nu_a}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} \left( \Gamma_{\tilde{e}_j^*, \nu_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{e}_i^*, \nu_a, \tilde{\chi}_b^-}^R + \Gamma_{\tilde{e}_j^*, \nu_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{e}_i^*, \nu_a, \tilde{\chi}_b^-}^L \right) \\
& + \sum_{a=1}^9 \sum_{b=1}^2 G_0(p^2, m_{\nu_a}^2, m_{\tilde{\chi}_b^-}^2) \left( \Gamma_{\tilde{e}_j^*, \nu_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{e}_i^*, \nu_a, \tilde{\chi}_b^-}^L + \Gamma_{\tilde{e}_j^*, \nu_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{e}_i^*, \nu_a, \tilde{\chi}_b^-}^R \right) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{e}_j^*, \gamma, \tilde{e}_b}^* \Gamma_{\tilde{e}_i^*, \gamma, \tilde{e}_b} F_0(p^2, m_{\tilde{e}_b}^2, 0) + \sum_{b=1}^6 \Gamma_{\tilde{e}_j^*, Z, \tilde{e}_b}^* \Gamma_{\tilde{e}_i^*, Z, \tilde{e}_b} F_0(p^2, m_{\tilde{e}_b}^2, m_Z^2)
\end{aligned}$$

$$+ \sum_{b=1}^9 \Gamma_{\tilde{e}_j^*, W^-, \nu_b^i}^* \Gamma_{\tilde{e}_i^*, W^-, \nu_b^i} F_0(p^2, m_{\nu_b^i}^2, m_{W^-}^2) + \sum_{b=1}^9 \Gamma_{\tilde{e}_j^*, W^-, \nu_b^R}^* \Gamma_{\tilde{e}_i^*, W^-, \nu_b^R} F_0(p^2, m_{\nu_b^R}^2, m_{W^-}^2) \quad (208)$$

• **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} - \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_{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, \bar{d}_a, d_b}^{L*} \Gamma_{\tilde{h}_i, \bar{d}_a, d_b}^R + \Gamma_{\tilde{h}_j, \bar{d}_a, d_b}^{R*} \Gamma_{\tilde{h}_i, \bar{d}_a, d_b}^L \right) \\ & + 3 \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{d_a}^2, m_{d_b}^2) \left( \Gamma_{\tilde{h}_j, \bar{d}_a, d_b}^{L*} \Gamma_{\tilde{h}_i, \bar{d}_a, d_b}^L + \Gamma_{\tilde{h}_j, \bar{d}_a, d_b}^{R*} \Gamma_{\tilde{h}_i, \bar{d}_a, d_b}^R \right) \\ & - 2 \sum_{a=1}^3 m_{e_a} \sum_{b=1}^3 B_0(p^2, m_{e_a}^2, m_{e_b}^2) m_{e_b} \left( \Gamma_{\tilde{h}_j, \bar{e}_a, e_b}^{L*} \Gamma_{\tilde{h}_i, \bar{e}_a, e_b}^R + \Gamma_{\tilde{h}_j, \bar{e}_a, e_b}^{R*} \Gamma_{\tilde{h}_i, \bar{e}_a, e_b}^L \right) \\ & + \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{e_a}^2, m_{e_b}^2) \left( \Gamma_{\tilde{h}_j, \bar{e}_a, e_b}^{L*} \Gamma_{\tilde{h}_i, \bar{e}_a, e_b}^L + \Gamma_{\tilde{h}_j, \bar{e}_a, e_b}^{R*} \Gamma_{\tilde{h}_i, \bar{e}_a, e_b}^R \right) \\ & - 6 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^3 B_0(p^2, m_{u_a}^2, m_{u_b}^2) m_{u_b} \left( \Gamma_{\tilde{h}_j, \bar{u}_a, u_b}^{L*} \Gamma_{\tilde{h}_i, \bar{u}_a, u_b}^R + \Gamma_{\tilde{h}_j, \bar{u}_a, u_b}^{R*} \Gamma_{\tilde{h}_i, \bar{u}_a, u_b}^L \right) \end{aligned}$$

$$\begin{aligned}
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{u_a}^2, m_{u_b}^2) \left( \Gamma_{\tilde{h}_j, \tilde{u}_a, u_b}^{L*} \Gamma_{\tilde{h}_i, \tilde{u}_a, u_b}^L + \Gamma_{\tilde{h}_j, \tilde{u}_a, u_b}^{R*} \Gamma_{\tilde{h}_i, \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{h}_j, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R + \Gamma_{\tilde{h}_j, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{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_{\tilde{h}_j, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^L + \Gamma_{\tilde{h}_j, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{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_{\tilde{h}_i, \tilde{h}_j, \tilde{d}_a^*, \tilde{d}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{h}_i, \tilde{h}_j, \tilde{e}_a^*, \tilde{e}_a} \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{h}_i, \tilde{h}_j, \tilde{u}_a^*, \tilde{u}_a} + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{d}_a}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{h}_j, \tilde{d}_a^*, \tilde{d}_b}^* \Gamma_{\tilde{h}_i, \tilde{d}_a^*, \tilde{d}_b} \\
& + \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{e}_a}^2, m_{\tilde{e}_b}^2) \Gamma_{\tilde{h}_j, \tilde{e}_a^*, \tilde{e}_b}^* \Gamma_{\tilde{h}_i, \tilde{e}_a^*, \tilde{e}_b} + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{u}_a}^2, m_{\tilde{u}_b}^2) \Gamma_{\tilde{h}_j, \tilde{u}_a^*, \tilde{u}_b}^* \Gamma_{\tilde{h}_i, \tilde{u}_a^*, \tilde{u}_b} \\
& - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^i}^2) \Gamma_{\tilde{h}_i, \tilde{h}_j, \nu_a^i, \nu_a^i} - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^R}^2) \Gamma_{\tilde{h}_i, \tilde{h}_j, \nu_a^R, \nu_a^R} \\
& + \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 B_0(p^2, m_{\nu_a^i}^2, m_{\nu_b^i}^2) \Gamma_{\tilde{h}_j, \nu_a^i, \nu_b^i}^* \Gamma_{\tilde{h}_i, \nu_a^i, \nu_b^i} \\
& + \sum_{a=1}^9 \sum_{b=1}^9 B_0(p^2, m_{\nu_a^R}^2, m_{\nu_b^i}^2) \Gamma_{\tilde{h}_j, \nu_a^R, \nu_b^i}^* \Gamma_{\tilde{h}_i, \nu_a^R, \nu_b^i} \\
& + \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 B_0(p^2, m_{\nu_a^R}^2, m_{\nu_b^R}^2) \Gamma_{\tilde{h}_j, \nu_a^R, \nu_b^R}^* \Gamma_{\tilde{h}_i, \nu_a^R, \nu_b^R} \\
& + 2 \sum_{b=1}^2 \Gamma_{\tilde{h}_j, W^+, H_b^-}^* \Gamma_{\tilde{h}_i, W^+, H_b^-} F_0(p^2, m_{H_b^-}^2, m_{W^-}^2) + \sum_{b=1}^3 \Gamma_{\tilde{h}_j, Z, A_b^0}^* \Gamma_{\tilde{h}_i, Z, A_b^0} F_0(p^2, m_{A_b^0}^2, m_Z^2) \quad (209)
\end{aligned}$$

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

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

$$\begin{aligned}
& + \sum_{a=1}^2 \sum_{b=1}^2 G_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{\chi}_b^-}^2) \left( \Gamma_{\tilde{A}_j^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^L + \Gamma_{\tilde{A}_j^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^R \right) \\
& - \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} - \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_{\tilde{d}_a}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{A}_j^0, \tilde{d}_a^*, \tilde{d}_b}^* \Gamma_{\tilde{A}_i^0, \tilde{d}_a^*, \tilde{d}_b}
\end{aligned}$$

$$\begin{aligned}
& + \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{e}_a}^2, m_{\tilde{e}_b}^2) \Gamma_{\tilde{A}_j^0, \tilde{e}_a^*, \tilde{e}_b}^* \Gamma_{\tilde{A}_i^0, \tilde{e}_a^*, \tilde{e}_b} \\
& + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{u}_a}^2, m_{\tilde{u}_b}^2) \Gamma_{\tilde{A}_j^0, \tilde{u}_a^*, \tilde{u}_b}^* \Gamma_{\tilde{A}_i^0, \tilde{u}_a^*, \tilde{u}_b} - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^i}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, \nu_a^i, \nu_a^i} \\
& - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^R}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, \nu_a^R, \nu_a^R} + \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 B_0(p^2, m_{\nu_a^i}^2, m_{\nu_b^i}^2) \Gamma_{\tilde{A}_j^0, \nu_a^i, \nu_b^i}^* \Gamma_{\tilde{A}_i^0, \nu_a^i, \nu_b^i} \\
& + \sum_{a=1}^9 \sum_{b=1}^9 B_0(p^2, m_{\nu_a^R}^2, m_{\nu_b^i}^2) \Gamma_{\tilde{A}_j^0, \nu_a^R, \nu_b^i}^* \Gamma_{\tilde{A}_i^0, \nu_a^R, \nu_b^i} \\
& + \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 B_0(p^2, m_{\nu_a^R}^2, m_{\nu_b^R}^2) \Gamma_{\tilde{A}_j^0, \nu_a^R, \nu_b^R}^* \Gamma_{\tilde{A}_i^0, \nu_a^R, \nu_b^R} \\
& + 2 \sum_{b=1}^2 \Gamma_{\tilde{A}_j^0, W^+, H_b^-}^* \Gamma_{\tilde{A}_i^0, W^+, H_b^-} F_0(p^2, m_{H_b^-}^2, m_{W^-}^2) + \sum_{b=1}^3 \Gamma_{\tilde{A}_j^0, Z, h_b}^* \Gamma_{\tilde{A}_i^0, Z, h_b} F_0(p^2, m_{h_b}^2, m_Z^2) \quad (210)
\end{aligned}$$

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

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

$$\begin{aligned}
& + \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) \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \tilde{d}_a^*, \tilde{d}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \tilde{e}_a^*, \tilde{e}_a} \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \tilde{u}_a^*, \tilde{u}_a} + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{u}_a}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{H}_j^+, \tilde{u}_a^*, \tilde{d}_b}^* \Gamma_{\tilde{H}_i^+, \tilde{u}_a^*, \tilde{d}_b} \\
& - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^i}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \nu_a^i, \nu_a^i} - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^R}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \nu_a^R, \nu_a^R} \\
& - 2 \sum_{a=1}^9 m_{\nu_a} \sum_{b=1}^3 B_0(p^2, m_{\nu_a}^2, m_{e_b}^2) m_{e_b} \left( \Gamma_{\tilde{H}_j^+, \nu_a, e_b}^{L*} \Gamma_{\tilde{H}_i^+, \nu_a, e_b}^R + \Gamma_{\tilde{H}_j^+, \nu_a, e_b}^{R*} \Gamma_{\tilde{H}_i^+, \nu_a, e_b}^L \right) \\
& + \sum_{a=1}^9 \sum_{b=1}^3 G_0(p^2, m_{\nu_a}^2, m_{e_b}^2) \left( \Gamma_{\tilde{H}_j^+, \nu_a, e_b}^{L*} \Gamma_{\tilde{H}_i^+, \nu_a, e_b}^L + \Gamma_{\tilde{H}_j^+, \nu_a, e_b}^{R*} \Gamma_{\tilde{H}_i^+, \nu_a, e_b}^R \right) \\
& + \sum_{a=1}^9 \sum_{b=1}^6 B_0(p^2, m_{\nu_a^i}^2, m_{\tilde{e}_b}^2) \Gamma_{\tilde{H}_j^+, \nu_a^i, \tilde{e}_b}^* \Gamma_{\tilde{H}_i^+, \nu_a^i, \tilde{e}_b} \\
& + \sum_{a=1}^9 \sum_{b=1}^6 B_0(p^2, m_{\nu_a^R}^2, m_{\tilde{e}_b}^2) \Gamma_{\tilde{H}_j^+, \nu_a^R, \tilde{e}_b}^* \Gamma_{\tilde{H}_i^+, \nu_a^R, \tilde{e}_b} + \sum_{b=1}^2 \Gamma_{\tilde{H}_j^+, \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)
\end{aligned} \tag{211}$$

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

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) = & + 2 \sum_{a=1}^2 \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{H_a^-}^2) \Gamma_{\tilde{\chi}_j^0, H_a^+, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^0, H_a^+, \tilde{\chi}_b^-}^R \\
& + \sum_{a=1}^3 \sum_{b=1}^5 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{h_a}^2) \Gamma_{\tilde{\chi}_j^0, h_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^0, h_a, \tilde{\chi}_b^0}^R \\
& + \sum_{a=1}^5 m_{\tilde{\chi}_a^0} \sum_{b=1}^3 B_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{A_b^0}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{\chi}_a^0, A_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{\chi}_a^0, A_b^0}^R \\
& + 6 \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{\tilde{d}_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{d}_a^*, \tilde{d}_b}^{L*} m_{\tilde{d}_b} \Gamma_{\tilde{\chi}_i^0, \tilde{d}_a^*, \tilde{d}_b}^R
\end{aligned}$$

$$\begin{aligned}
& + 2 \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{e_b}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{e}_a^*, e_b}^{L*} m_{e_b} \Gamma_{\tilde{\chi}_i^0, \tilde{e}_a^*, e_b}^R \\
& + 6 \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{u}_a^*, u_b}^{L*} m_{u_b} \Gamma_{\tilde{\chi}_i^0, \tilde{u}_a^*, u_b}^R \\
& + \sum_{a=1}^9 \sum_{b=1}^9 B_0(p^2, m_{\nu_b}^2, m_{\nu_a^i}^2) \Gamma_{\tilde{\chi}_j^0, \nu_a^i, \nu_b}^{L*} m_{\nu_b} \Gamma_{\tilde{\chi}_i^0, \nu_a^i, \nu_b}^R \\
& + \sum_{a=1}^9 \sum_{b=1}^9 B_0(p^2, m_{\nu_b}^2, m_{\nu_a^R}^2) \Gamma_{\tilde{\chi}_j^0, \nu_a^R, \nu_b}^{L*} m_{\nu_b} \Gamma_{\tilde{\chi}_i^0, \nu_a^R, \nu_b}^R \\
& - 8 \sum_{b=1}^2 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{W^-}^2) \right) \Gamma_{\tilde{\chi}_j^0, W^+, \tilde{\chi}_b^-}^{R*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^0, W^+, \tilde{\chi}_b^-}^L \\
& - 4 \sum_{b=1}^5 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_Z^2) \right) \Gamma_{\tilde{\chi}_j^0, Z, \tilde{\chi}_b^0}^{R*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^0, Z, \tilde{\chi}_b^0}^L \tag{212}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) = & - \sum_{a=1}^2 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{H_a^-}^2) \Gamma_{\tilde{\chi}_j^0, H_a^+, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^0, H_a^+, \tilde{\chi}_b^-}^R \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{h_a}^2) \Gamma_{\tilde{\chi}_j^0, h_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, h_a, \tilde{\chi}_b^0}^R \\
& - \frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^3 B_1(p^2, m_{\tilde{\chi}_a^0}^2, m_{A_b^0}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{\chi}_a^0, A_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{\chi}_a^0, A_b^0}^R \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{d}_a^*, d_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{d}_a^*, d_b}^R \\
& - \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{e}_a^*, e_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{e}_a^*, e_b}^R \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{u}_a^*, u_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{u}_a^*, u_b}^R \\
& - \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{\nu_a^i}^2) \Gamma_{\tilde{\chi}_j^0, \nu_a^i, \nu_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \nu_a^i, \nu_b}^R \\
& - \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{\nu_a^R}^2) \Gamma_{\tilde{\chi}_j^0, \nu_a^R, \nu_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \nu_a^R, \nu_b}^R \\
& - 2 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{W^-}^2) \Gamma_{\tilde{\chi}_j^0, W^+, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^0, W^+, \tilde{\chi}_b^-}^L - \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_Z^2) \Gamma_{\tilde{\chi}_j^0, Z, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, Z, \tilde{\chi}_b^0}^L \tag{213}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) = & - \sum_{a=1}^2 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{H_a^-}^2) \Gamma_{\tilde{\chi}_j^0, H_a^+, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^0, H_a^+, \tilde{\chi}_b^-}^L \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{h_a}^2) \Gamma_{\tilde{\chi}_j^0, h_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, h_a, \tilde{\chi}_b^0}^L \\
& - \frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^3 B_1(p^2, m_{\tilde{\chi}_a^0}^2, m_{A_b^0}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{\chi}_a^0, A_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{\chi}_a^0, A_b^0}^L \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{d}_a^*, d_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{d}_a^*, d_b}^L \\
& - \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{e}_a^*, e_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{e}_a^*, e_b}^L \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{u}_a^*, u_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{u}_a^*, u_b}^L \\
& - \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{\nu_a^i}^2) \Gamma_{\tilde{\chi}_j^0, \nu_a^i, \nu_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \nu_a^i, \nu_b}^L \\
& - \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{\nu_a^R}^2) \Gamma_{\tilde{\chi}_j^0, \nu_a^R, \nu_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \nu_a^R, \nu_b}^L \\
& - 2 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{W^-}^2) \Gamma_{\tilde{\chi}_j^0, W^+, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^0, W^+, \tilde{\chi}_b^-}^R - \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_Z^2) \Gamma_{\tilde{\chi}_j^0, Z, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, Z, \tilde{\chi}_b^0}^R \quad (214)
\end{aligned}$$

• Self-Energy for Neutrinos ( $\nu$ )

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) = & + 2 \sum_{a=1}^2 \sum_{b=1}^3 B_0(p^2, m_{e_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{\nu}_j, H_a^+, e_b}^{L*} m_{e_b} \Gamma_{\tilde{\nu}_i, H_a^+, e_b}^R \\
& + 2 \sum_{a=1}^6 \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{\nu}_j, \tilde{e}_a^*, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\nu}_i, \tilde{e}_a^*, \tilde{\chi}_b^-}^R \\
& + \sum_{a=1}^9 \sum_{b=1}^5 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{\nu_a^i}^2) \Gamma_{\tilde{\nu}_j, \nu_a^i, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\nu}_i, \nu_a^i, \tilde{\chi}_b^0}^R \\
& + \sum_{a=1}^9 \sum_{b=1}^5 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{\nu_a^R}^2) \Gamma_{\tilde{\nu}_j, \nu_a^R, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\nu}_i, \nu_a^R, \tilde{\chi}_b^0}^R \\
& - 8 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{e_b}^2, m_{W^-}^2) \right) \Gamma_{\tilde{\nu}_j, W^+, e_b}^{R*} m_{e_b} \Gamma_{\tilde{\nu}_i, W^+, e_b}^L
\end{aligned}$$



$$-4 \sum_{b=1}^9 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{\nu_b}^2, m_Z^2) \right) \Gamma_{\tilde{\nu}_j, Z, \nu_b}^{R*} m_{\nu_b} \Gamma_{\tilde{\nu}_i, Z, \nu_b}^L \quad (215)$$

$$\begin{aligned} \Sigma_{i,j}^R(p^2) = & - \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{\nu}_j, H_a^+, e_b}^{R*} \Gamma_{\tilde{\nu}_i, H_a^+, e_b}^R \\ & - \sum_{a=1}^6 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{\nu}_j, \tilde{e}_a^*, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\nu}_i, \tilde{e}_a^*, \tilde{\chi}_b^-}^R \\ & - \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\nu_a^i}^2) \Gamma_{\tilde{\nu}_j, \nu_a^i, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\nu}_i, \nu_a^i, \tilde{\chi}_b^0}^R \\ & - \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\nu_a^R}^2) \Gamma_{\tilde{\nu}_j, \nu_a^R, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\nu}_i, \nu_a^R, \tilde{\chi}_b^0}^R - 2 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{W^-}^2) \Gamma_{\tilde{\nu}_j, W^+, e_b}^{L*} \Gamma_{\tilde{\nu}_i, W^+, e_b}^L \\ & - \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_Z^2) \Gamma_{\tilde{\nu}_j, Z, \nu_b}^{L*} \Gamma_{\tilde{\nu}_i, Z, \nu_b}^L \end{aligned} \quad (216)$$

$$\begin{aligned} \Sigma_{i,j}^L(p^2) = & - \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{\nu}_j, H_a^+, e_b}^{L*} \Gamma_{\tilde{\nu}_i, H_a^+, e_b}^L \\ & - \sum_{a=1}^6 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{\nu}_j, \tilde{e}_a^*, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\nu}_i, \tilde{e}_a^*, \tilde{\chi}_b^-}^L \\ & - \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\nu_a^i}^2) \Gamma_{\tilde{\nu}_j, \nu_a^i, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\nu}_i, \nu_a^i, \tilde{\chi}_b^0}^L \\ & - \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\nu_a^R}^2) \Gamma_{\tilde{\nu}_j, \nu_a^R, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\nu}_i, \nu_a^R, \tilde{\chi}_b^0}^L - 2 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{W^-}^2) \Gamma_{\tilde{\nu}_j, W^+, e_b}^{R*} \Gamma_{\tilde{\nu}_i, W^+, e_b}^R \\ & - \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_Z^2) \Gamma_{\tilde{\nu}_j, Z, \nu_b}^{R*} \Gamma_{\tilde{\nu}_i, Z, \nu_b}^R \end{aligned} \quad (217)$$

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

$$\begin{aligned} \Sigma_{i,j}^S(p^2) = & + \sum_{a=1}^2 m_{\tilde{\chi}_a^-} \sum_{b=1}^3 B_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{A_b^0}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{\chi}_a^-, A_b^0}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{\chi}_a^-, A_b^0}^R \\ & + \sum_{a=1}^2 \sum_{b=1}^5 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{H_a^-}^2) \Gamma_{\tilde{\chi}_j^+, H_a^-, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^+, H_a^-, \tilde{\chi}_b^0}^R \\ & + \sum_{a=1}^3 \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{h_a}^2) \Gamma_{\tilde{\chi}_j^+, h_a, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^+, h_a, \tilde{\chi}_b^-}^R \end{aligned}$$

$$\begin{aligned}
& + 3 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^6 B_0(p^2, m_{u_a}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a, \tilde{d}_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a, \tilde{d}_b}^R \\
& + 3 \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{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 \\
& + \sum_{a=1}^6 \sum_{b=1}^9 B_0(p^2, m_{\nu_b}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{e}_a, \nu_b}^{L*} m_{\nu_b} \Gamma_{\tilde{\chi}_i^+, \tilde{e}_a, \nu_b}^R \\
& + \sum_{a=1}^9 \sum_{b=1}^3 B_0(p^2, m_{e_b}^2, m_{\nu_a^i}^2) \Gamma_{\tilde{\chi}_j^+, \nu_a^i, e_b}^{L*} m_{e_b} \Gamma_{\tilde{\chi}_i^+, \nu_a^i, e_b}^R \\
& + \sum_{a=1}^9 \sum_{b=1}^3 B_0(p^2, m_{e_b}^2, m_{\nu_a^R}^2) \Gamma_{\tilde{\chi}_j^+, \nu_a^R, e_b}^{L*} m_{e_b} \Gamma_{\tilde{\chi}_i^+, \nu_a^R, e_b}^R \\
& - 4 \sum_{b=1}^2 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}_b^-}^2, 0) \right) \Gamma_{\tilde{\chi}_j^+, \gamma, \tilde{\chi}_b^-}^{R*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^+, \gamma, \tilde{\chi}_b^-}^L \\
& - 4 \sum_{b=1}^2 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_Z^2) \right) \Gamma_{\tilde{\chi}_j^+, Z, \tilde{\chi}_b^-}^{R*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^+, Z, \tilde{\chi}_b^-}^L \\
& - 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{218} \\
\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{3}{2} \sum_{a=1}^3 \sum_{b=1}^6 B_1(p^2, m_{u_a}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a, \tilde{d}_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a, \tilde{d}_b}^R \\
& - \frac{3}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a^*, d_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a^*, d_b}^R \\
& - \frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{e}_a, \nu_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \tilde{e}_a, \nu_b}^R \\
& - \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{\nu_a^i}^2) \Gamma_{\tilde{\chi}_j^+, \nu_a^i, e_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \nu_a^i, e_b}^R
\end{aligned}$$

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{\nu_a^R}^2) \Gamma_{\tilde{\chi}_j^+, \nu_a^R, e_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \nu_a^R, e_b}^R - \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, 0) \Gamma_{\tilde{\chi}_j^+, \gamma, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^+, \gamma, \tilde{\chi}_b^-}^L \\
& - \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_Z^2) \Gamma_{\tilde{\chi}_j^+, Z, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^+, Z, \tilde{\chi}_b^-}^L - \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{W^-}^2) \Gamma_{\tilde{\chi}_j^+, W^-, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^+, W^-, \tilde{\chi}_b^0}^L \quad (219)
\end{aligned}$$

$$\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{3}{2} \sum_{a=1}^3 \sum_{b=1}^6 B_1(p^2, m_{u_a}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a, \tilde{d}_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a, \tilde{d}_b}^L \\
& -\frac{3}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a^*, d_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a^*, d_b}^L \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{e}_a, \nu_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{e}_a, \nu_b}^L \\
& -\frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{\nu_a^i}^2) \Gamma_{\tilde{\chi}_j^+, \nu_a^i, e_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \nu_a^i, e_b}^L \\
& -\frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{\nu_a^R}^2) \Gamma_{\tilde{\chi}_j^+, \nu_a^R, e_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \nu_a^R, e_b}^R - \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, 0) \Gamma_{\tilde{\chi}_j^+, \gamma, \tilde{\chi}_b^-}^{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 (220)
\end{aligned}$$

• Self-Energy for Leptons ( $e$ )

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) = & + \sum_{a=1}^2 \sum_{b=1}^9 B_0(p^2, m_{\nu_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{e}_j, H_a^-, \nu_b}^{L*} m_{\nu_b} \Gamma_{\tilde{e}_i, H_a^-, \nu_b}^R \\
& + \sum_{a=1}^3 m_{e_a} \sum_{b=1}^3 B_0(p^2, m_{e_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{e}_j, e_a, A_b^0}^{L*} \Gamma_{\tilde{e}_i, e_a, A_b^0}^R \\
& + \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{e_b}^2, m_{h_a}^2) \Gamma_{\tilde{e}_j, h_a, e_b}^{L*} m_{e_b} \Gamma_{\tilde{e}_i, h_a, e_b}^R
\end{aligned}$$

$$\begin{aligned}
& + \sum_{a=1}^6 \sum_{b=1}^5 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{e}_j, \tilde{e}_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{e}_i, \tilde{e}_a, \tilde{\chi}_b^0}^R \\
& + \sum_{a=1}^9 \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{\nu_a^i}^2) \Gamma_{\tilde{e}_j, \nu_a^i, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{e}_i, \nu_a^i, \tilde{\chi}_b^-}^R \\
& + \sum_{a=1}^9 \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{\nu_a^R}^2) \Gamma_{\tilde{e}_j, \nu_a^R, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{e}_i, \nu_a^R, \tilde{\chi}_b^-}^R \\
& - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{e_b}^2, 0) \right) \Gamma_{\tilde{e}_j, \gamma, e_b}^{R*} m_{e_b} \Gamma_{\tilde{e}_i, \gamma, e_b}^L - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{e_b}^2, m_Z^2) \right) \Gamma_{\tilde{e}_j, Z, e_b}^{R*} m_{e_b} \Gamma_{\tilde{e}_i, Z, e_b}^L \\
& - 4 \sum_{b=1}^9 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{\nu_b}^2, m_{W^-}^2) \right) \Gamma_{\tilde{e}_j, W^-, \nu_b}^{R*} m_{\nu_b} \Gamma_{\tilde{e}_i, W^-, \nu_b}^L \tag{221}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) &= -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{e}_j, H_a^-, \nu_b}^{R*} \Gamma_{\tilde{e}_i, H_a^-, \nu_b}^R \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{e_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{e}_j, e_a, A_b^0}^{R*} \Gamma_{\tilde{e}_i, e_a, A_b^0}^R \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{h_a}^2) \Gamma_{\tilde{e}_j, h_a, e_b}^{R*} \Gamma_{\tilde{e}_i, h_a, e_b}^R \\
& - \frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{e}_j, \tilde{e}_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{e}_i, \tilde{e}_a, \tilde{\chi}_b^0}^R \\
& - \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\nu_a^i}^2) \Gamma_{\tilde{e}_j, \nu_a^i, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{e}_i, \nu_a^i, \tilde{\chi}_b^-}^R \\
& - \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\nu_a^R}^2) \Gamma_{\tilde{e}_j, \nu_a^R, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{e}_i, \nu_a^R, \tilde{\chi}_b^-}^R - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, 0) \Gamma_{\tilde{e}_j, \gamma, e_b}^{L*} \Gamma_{\tilde{e}_i, \gamma, e_b}^L \\
& - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_Z^2) \Gamma_{\tilde{e}_j, Z, e_b}^{L*} \Gamma_{\tilde{e}_i, Z, e_b}^L - \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{W^-}^2) \Gamma_{\tilde{e}_j, W^-, \nu_b}^{L*} \Gamma_{\tilde{e}_i, W^-, \nu_b}^L \tag{222}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) &= -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{e}_j, H_a^-, \nu_b}^{L*} \Gamma_{\tilde{e}_i, H_a^-, \nu_b}^L \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{e_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{e}_j, e_a, A_b^0}^{L*} \Gamma_{\tilde{e}_i, e_a, A_b^0}^L \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{h_a}^2) \Gamma_{\tilde{e}_j, h_a, e_b}^{L*} \Gamma_{\tilde{e}_i, h_a, e_b}^L
\end{aligned}$$

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{e}_j, \tilde{e}_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{e}_i, \tilde{e}_a, \tilde{\chi}_b^0}^L \\
& -\frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\nu_a^i}^2) \Gamma_{\tilde{e}_j, \nu_a^i, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{e}_i, \nu_a^i, \tilde{\chi}_b^-}^L \\
& -\frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\nu_a^R}^2) \Gamma_{\tilde{e}_j, \nu_a^R, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{e}_i, \nu_a^R, \tilde{\chi}_b^-}^L - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, 0) \Gamma_{\tilde{e}_j, \gamma, e_b}^{R*} \Gamma_{\tilde{e}_i, \gamma, e_b}^R \\
& - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_Z^2) \Gamma_{\tilde{e}_j, Z, e_b}^{R*} \Gamma_{\tilde{e}_i, Z, e_b}^R - \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{W^-}^2) \Gamma_{\tilde{e}_j, W^-, \nu_b}^{R*} \Gamma_{\tilde{e}_i, W^-, \nu_b}^R
\end{aligned} \tag{223}$$

• Self-Energy for Down-Quarks (d)

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) = & + \sum_{a=1}^2 \sum_{b=1}^3 B_0(p^2, m_{u_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{d}_j, H_a^-, u_b}^{L*} m_{u_b} \Gamma_{\tilde{d}_i, H_a^-, u_b}^R \\
& + \sum_{a=1}^3 m_{d_a} \sum_{b=1}^3 B_0(p^2, m_{d_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j, d_a, A_b^0}^{L*} \Gamma_{\tilde{d}_i, d_a, A_b^0}^R \\
& + \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{d_b}^2, m_{h_a}^2) \Gamma_{\tilde{d}_j, h_a, d_b}^{L*} m_{d_b} \Gamma_{\tilde{d}_i, h_a, d_b}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_j, \tilde{u}_a, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{d}_i, \tilde{u}_a, \tilde{\chi}_b^-}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^5 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{\chi}_b^0}^R \\
& + \frac{4}{3} m_{\tilde{g}} \sum_{a=1}^6 B_0(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{g}_1}^R - \frac{16}{3} \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, 0) \right) \Gamma_{\tilde{d}_j, g, d_b}^{R*} m_{d_b} \Gamma_{\tilde{d}_i, g, d_b}^L \\
& - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, 0) \right) \Gamma_{\tilde{d}_j, \gamma, d_b}^{R*} m_{d_b} \Gamma_{\tilde{d}_i, \gamma, d_b}^L \\
& - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, m_{W^-}^2) \right) \Gamma_{\tilde{d}_j, W^-, u_b}^{R*} m_{u_b} \Gamma_{\tilde{d}_i, W^-, u_b}^L \\
& - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, m_Z^2) \right) \Gamma_{\tilde{d}_j, Z, d_b}^{R*} m_{d_b} \Gamma_{\tilde{d}_i, Z, d_b}^L
\end{aligned} \tag{224}$$

$$\Sigma_{i,j}^R(p^2) = -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{d}_j, H_a^-, u_b}^{R*} \Gamma_{\tilde{d}_i, H_a^-, u_b}^R$$

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{\tilde{d}_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j, d_a, A_b^0}^{R*} \Gamma_{\tilde{d}_i, d_a, A_b^0}^R \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{\tilde{d}_b}^2, m_{h_a}^2) \Gamma_{\tilde{d}_j, h_a, d_b}^{R*} \Gamma_{\tilde{d}_i, h_a, d_b}^R \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_j, \tilde{u}_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{d}_i, \tilde{u}_a, \tilde{\chi}_b^-}^R \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{\chi}_b^0}^R \\
& -\frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{g}_1}^{R*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{g}_1}^R - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, g, d_b}^{L*} \Gamma_{\tilde{d}_i, g, d_b}^L \\
& -\sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, \gamma, d_b}^{L*} \Gamma_{\tilde{d}_i, \gamma, d_b}^L - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{W^-}^2) \Gamma_{\tilde{d}_j, W^-, u_b}^{L*} \Gamma_{\tilde{d}_i, W^-, u_b}^L \\
& -\sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_Z^2) \Gamma_{\tilde{d}_j, Z, d_b}^{L*} \Gamma_{\tilde{d}_i, Z, d_b}^L
\end{aligned} \tag{225}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) = & -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{d}_j, H_a^-, u_b}^{L*} \Gamma_{\tilde{d}_i, H_a^-, u_b}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{\tilde{d}_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j, d_a, A_b^0}^{L*} \Gamma_{\tilde{d}_i, d_a, A_b^0}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{\tilde{d}_b}^2, m_{h_a}^2) \Gamma_{\tilde{d}_j, h_a, d_b}^{L*} \Gamma_{\tilde{d}_i, h_a, d_b}^L \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_j, \tilde{u}_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{d}_i, \tilde{u}_a, \tilde{\chi}_b^-}^L \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{\chi}_b^0}^L \\
& -\frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{g}_1}^L - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, g, d_b}^{R*} \Gamma_{\tilde{d}_i, g, d_b}^R \\
& -\sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, \gamma, d_b}^{R*} \Gamma_{\tilde{d}_i, \gamma, d_b}^R - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{W^-}^2) \Gamma_{\tilde{d}_j, W^-, u_b}^{R*} \Gamma_{\tilde{d}_i, W^-, u_b}^R \\
& -\sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_Z^2) \Gamma_{\tilde{d}_j, Z, d_b}^{R*} \Gamma_{\tilde{d}_i, Z, d_b}^R
\end{aligned} \tag{226}$$

• Self-Energy for Up-Quarks ( $u$ )

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) = & + \sum_{a=1}^2 \sum_{b=1}^3 B_0(p^2, m_{d_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{u}_j, H_a^+, d_b}^{L*} m_{d_b} \Gamma_{\tilde{u}_i, H_a^+, d_b}^R \\
& + \sum_{a=1}^2 m_{\tilde{\chi}_a^-} \sum_{b=1}^6 B_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{u}_j, \tilde{\chi}_a^+, \tilde{d}_b}^{L*} \Gamma_{\tilde{u}_i, \tilde{\chi}_a^+, \tilde{d}_b}^R \\
& + \sum_{a=1}^3 m_{u_a} \sum_{b=1}^3 B_0(p^2, m_{u_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{u}_j, u_a, A_b^0}^{L*} \Gamma_{\tilde{u}_i, u_a, A_b^0}^R \\
& + \sum_{a=1}^3 \sum_{b=1}^3 B_0(p^2, m_{u_b}^2, m_{h_a}^2) \Gamma_{\tilde{u}_j, h_a, u_b}^{L*} m_{u_b} \Gamma_{\tilde{u}_i, h_a, u_b}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^5 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{\chi}_b^0}^R \\
& + \frac{4}{3} m_{\tilde{g}} \sum_{a=1}^6 B_0(p^2, m_{\tilde{g}}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{g}_1}^R - \frac{16}{3} \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, 0) \right) \Gamma_{\tilde{u}_j, g, u_b}^{R*} m_{u_b} \Gamma_{\tilde{u}_i, g, u_b}^L \\
& - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, 0) \right) \Gamma_{\tilde{u}_j, \gamma, u_b}^{R*} m_{u_b} \Gamma_{\tilde{u}_i, \gamma, u_b}^L - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, m_Z^2) \right) \Gamma_{\tilde{u}_j, Z, u_b}^{R*} m_{u_b} \Gamma_{\tilde{u}_i, Z, u_b}^L \\
& - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, m_{W^-}^2) \right) \Gamma_{\tilde{u}_j, W^+, d_b}^{R*} m_{d_b} \Gamma_{\tilde{u}_i, W^+, d_b}^L \tag{227}
\end{aligned}$$

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

$$- \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{W^-}^2) \Gamma_{\tilde{u}_j, W^+, d_b}^{L*} \Gamma_{\tilde{u}_i, W^+, d_b}^L \quad (228)$$

$$\begin{aligned} \Sigma_{i,j}^L(p^2) = & -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{u}_j, H_a^+, d_b}^{L*} \Gamma_{\tilde{u}_i, H_a^+, d_b}^L \\ & -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^6 B_1(p^2, m_{\tilde{\chi}_a^-}^2, m_{d_b}^2) \Gamma_{\tilde{u}_j, \tilde{\chi}_a^+, \tilde{d}_b}^{L*} \Gamma_{\tilde{u}_i, \tilde{\chi}_a^+, \tilde{d}_b}^L \\ & -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{u_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{u}_j, u_a, A_b^0}^{L*} \Gamma_{\tilde{u}_i, u_a, A_b^0}^L \\ & -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{h_a}^2) \Gamma_{\tilde{u}_j, h_a, u_b}^{L*} \Gamma_{\tilde{u}_i, h_a, u_b}^L \\ & -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{\chi}_b^0}^L \\ & -\frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{g}_1}^L - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, g, u_b}^{R*} \Gamma_{\tilde{u}_i, g, u_b}^R \\ & - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, \gamma, u_b}^{R*} \Gamma_{\tilde{u}_i, \gamma, u_b}^R - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_Z^2) \Gamma_{\tilde{u}_j, Z, u_b}^{R*} \Gamma_{\tilde{u}_i, Z, u_b}^R \\ & - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{W^-}^2) \Gamma_{\tilde{u}_j, W^+, d_b}^{R*} \Gamma_{\tilde{u}_i, W^+, d_b}^R \end{aligned} \quad (229)$$

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

$$\begin{aligned} \Sigma^S(p^2) = & + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{g}_j, \tilde{d}_a^*, d_b}^{L*} m_{d_b} \Gamma_{\tilde{g}_i, \tilde{d}_a^*, d_b}^R \\ & + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{g}_j, \tilde{u}_a^*, u_b}^{L*} m_{u_b} \Gamma_{\tilde{g}_i, \tilde{u}_a^*, u_b}^R - 12 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{g}}^2, 0) \right) \Gamma_{\tilde{g}_j, g, \tilde{g}_1}^{R*} m_{\tilde{g}} \Gamma_{\tilde{g}_i, g, \tilde{g}_1}^L \end{aligned} \quad (230)$$

$$\begin{aligned} \Sigma^R(p^2) = & -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{g}_j, \tilde{d}_a^*, d_b}^{R*} \Gamma_{\tilde{g}_i, \tilde{d}_a^*, d_b}^R \\ & -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{g}_j, \tilde{u}_a^*, u_b}^{R*} \Gamma_{\tilde{g}_i, \tilde{u}_a^*, u_b}^R - 3 B_1(p^2, m_{\tilde{g}}^2, 0) \Gamma_{\tilde{g}_j, g, \tilde{g}_1}^{L*} \Gamma_{\tilde{g}_i, g, \tilde{g}_1}^L \\ \Sigma^L(p^2) = & -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{g}_j, \tilde{d}_a^*, d_b}^{L*} \Gamma_{\tilde{g}_i, \tilde{d}_a^*, d_b}^L \end{aligned} \quad (231)$$



$$-\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{g}_j, \tilde{u}_a^*, u_b}^{L*} \Gamma_{\tilde{g}_i, \tilde{u}_a^*, u_b}^L - 3B_1(p^2, m_{\tilde{g}}^2, 0) \Gamma_{\tilde{g}_j, g, \tilde{g}_1}^{R*} \Gamma_{\tilde{g}_i, g, \tilde{g}_1}^R \quad (232)$$

• **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} + \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) \\ & + 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_{\tilde{d}_a}^2, m_{d_b}^2) \right. \\ & \left. + 4B_0(p^2, m_{\tilde{d}_a}^2, m_{d_b}^2) m_{\tilde{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_{\tilde{e}_a}^2, m_{e_b}^2) \right. \\ & \left. + 4B_0(p^2, m_{\tilde{e}_a}^2, m_{e_b}^2) m_{\tilde{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_{\tilde{u}_a}^2, m_{u_b}^2) \right. \\ & \left. + 4B_0(p^2, m_{\tilde{u}_a}^2, m_{u_b}^2) m_{\tilde{u}_a} m_{u_b} \Re(\Gamma_{Z, \tilde{u}_a, u_b}^{L*} \Gamma_{Z, \tilde{u}_a, u_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}$$

$$\begin{aligned}
& -12 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z, \tilde{d}_a^*, \tilde{d}_b}|^2 B_{00}(p^2, m_{\tilde{d}_a}^2, m_{\tilde{d}_b}^2) - 4 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z, \tilde{e}_a^*, \tilde{e}_b}|^2 B_{00}(p^2, m_{\tilde{e}_a}^2, m_{\tilde{e}_b}^2) \\
& -12 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z, \tilde{u}_a^*, \tilde{u}_b}|^2 B_{00}(p^2, m_{\tilde{u}_a}^2, m_{\tilde{u}_b}^2) + \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^i}^2) \Gamma_{Z, Z, \nu_a^i, \nu_a^i} \\
& + \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^R}^2) \Gamma_{Z, Z, \nu_a^R, \nu_a^R} - 4 \sum_{a=1}^9 \sum_{b=1}^9 |\Gamma_{Z, \nu_a^R, \nu_b^i}|^2 B_{00}(p^2, m_{\nu_b^i}^2, m_{\nu_a^R}^2) \\
& + \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 \left[ \left( |\Gamma_{Z, \nu_a, \nu_b}^L|^2 + |\Gamma_{Z, \nu_a, \nu_b}^R|^2 \right) H_0(p^2, m_{\nu_a}^2, m_{\nu_b}^2) \right. \\
& \left. + 4B_0(p^2, m_{\nu_a}^2, m_{\nu_b}^2) m_{\nu_a} m_{\nu_b} \Re(\Gamma_{Z, \nu_a, \nu_b}^{L*} \Gamma_{Z, \nu_a, \nu_b}^R) \right] \\
& + 2 \sum_{b=1}^2 |\Gamma_{Z, W^+, H_b^-}|^2 B_0(p^2, m_{W^-}^2, m_{H_b^-}^2) + \sum_{b=1}^3 |\Gamma_{Z, Z, h_b}|^2 B_0(p^2, m_Z^2, m_{h_b}^2) + 2\text{rMS} m_{W^-}^2 \Gamma_{Z, Z, W^+, W^-}^1 \\
& - A_0(m_{W^-}^2) \left( 4\Gamma_{Z, Z, W^+, W^-}^1 + \Gamma_{Z, Z, W^+, W^-}^2 + \Gamma_{Z, Z, W^+, W^-}^3 \right) \tag{233}
\end{aligned}$$

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

$$\begin{aligned}
\Pi(p^2) = & -12 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{W^+, \tilde{u}_a^*, \tilde{d}_b}|^2 B_{00}(p^2, m_{\tilde{d}_b}^2, m_{\tilde{u}_a}^2) + 2\text{rMS} m_{W^-}^2 \Gamma_{W^-, W^+, W^+, W^-}^1 + 3 \sum_{a=1}^3 \sum_{b=1}^3 \left[ \left( |\Gamma_{W^+, \tilde{u}_a, d_b}^L|^2 + |\Gamma_{W^+, \tilde{u}_a, d_b}^R|^2 \right) H_0(p^2, m_{\tilde{u}_a}^2, m_{d_b}^2) \right. \\
& \left. + 4B_0(p^2, m_{\tilde{u}_a}^2, m_{d_b}^2) m_{d_b} m_{\tilde{u}_a} \Re(\Gamma_{W^+, \tilde{u}_a, d_b}^{L*} \Gamma_{W^+, \tilde{u}_a, d_b}^R) \right] + 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{W^-, W^+, \tilde{d}_a^*, \tilde{d}_a} + 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{W^-, W^+, \tilde{u}_a^*, \tilde{u}_a} \\
& + 4B_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} m_{\tilde{\chi}_a^0} \Re(\Gamma_{W^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^{L*} \Gamma_{W^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^R) + \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{W^-, W^+, \tilde{e}_a^*, \tilde{e}_a} + \sum_{a=1}^9 \sum_{b=1}^3 \left[ \left( |\Gamma_{W^+, \nu_a, e_b}^L|^2 + |\Gamma_{W^+, \nu_a, e_b}^R|^2 \right) H_0(p^2, m_{\nu_a}^2, m_{e_b}^2) \right. \\
& \left. + 4B_0(p^2, m_{\nu_a}^2, m_{e_b}^2) m_{e_b} m_{\nu_a} \Re(\Gamma_{W^+, \nu_a, e_b}^{L*} \Gamma_{W^+, \nu_a, e_b}^R) \right] + \sum_{b=1}^2 |\Gamma_{W^+, \gamma, H_b^-}|^2 B_0(p^2, 0, m_{H_b^-}^2) + \sum_{b=1}^2 |\Gamma_{W^+, Z, H_b^-}|^2 B_0(p^2, m_Z^2, m_{H_b^-}^2) \tag{234}
\end{aligned}$$

## 8.2 Tadpoles

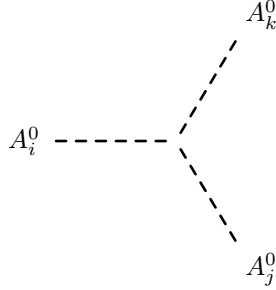
$$\begin{aligned}
\delta t_h^{(1)} = & + A_0(m_{\eta^-}^2) \Gamma_{\tilde{h}_i, \eta^-, \eta^-} + A_0(m_{\eta^+}^2) \Gamma_{\tilde{h}_i, \eta^+, \eta^+} + A_0(m_{\eta^Z}^2) \Gamma_{\tilde{h}_i, \eta^Z, \eta^Z} \\
& + 4\Gamma_{\tilde{h}_i, W^+, W^-} \left( -\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2)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

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^3 A_0(m_{h_a}^2) \Gamma_{\tilde{h}_i, h_a, h_a} + 6 \sum_{a=1}^3 A_0(m_{\tilde{d}_a}^2) m_{d_a} \left( \Gamma_{\tilde{h}_i, \tilde{d}_a, d_a}^L + \Gamma_{\tilde{h}_i, \tilde{d}_a, d_a}^R \right) \\
& + 2 \sum_{a=1}^3 A_0(m_{e_a}^2) m_{e_a} \left( \Gamma_{\tilde{h}_i, \tilde{e}_a, e_a}^L + \Gamma_{\tilde{h}_i, \tilde{e}_a, e_a}^R \right) \\
& + 6 \sum_{a=1}^3 A_0(m_{u_a}^2) m_{u_a} \left( \Gamma_{\tilde{h}_i, \tilde{u}_a, u_a}^L + \Gamma_{\tilde{h}_i, \tilde{u}_a, u_a}^R \right) + \sum_{a=1}^5 A_0(m_{\tilde{\chi}_a^0}^2) m_{\tilde{\chi}_a^0} \left( \Gamma_{\tilde{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_a^0}^L + \Gamma_{\tilde{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_a^0}^R \right) \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{h}_i, \tilde{d}_a^*, \tilde{d}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{h}_i, \tilde{e}_a^*, \tilde{e}_a} - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{h}_i, \tilde{u}_a^*, \tilde{u}_a} \\
& - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^i}^2) \Gamma_{\tilde{h}_i, \nu_a^i, \nu_a^i} - \frac{1}{2} \sum_{a=1}^9 A_0(m_{\nu_a^R}^2) \Gamma_{\tilde{h}_i, \nu_a^R, \nu_a^R}
\end{aligned} \tag{235}$$

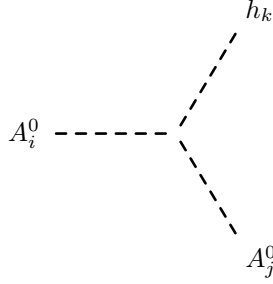
$$\delta t_{\nu^R}^{(1)} = 0 \tag{236}$$

## 9 Interactions for eigenstates 'EWSB'

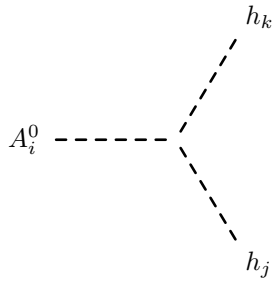
### 9.1 Three Scalar-Interaction



$$\begin{aligned}
& \frac{1}{4} \left( -2\lambda\kappa^* \left( Z_{i2}^A \left( v_s Z_{j1}^A Z_{k3}^A + Z_{j3}^A \left( -v_d Z_{k3}^A + v_s Z_{k1}^A \right) \right) + Z_{i1}^A \left( v_s Z_{j2}^A Z_{k3}^A + Z_{j3}^A \left( v_s Z_{k2}^A - v_u Z_{k3}^A \right) \right) \right. \right. \\
& \left. \left. - Z_{i3}^A \left( Z_{j1}^A \left( -v_s Z_{k2}^A + v_u Z_{k3}^A \right) + Z_{j2}^A \left( v_d Z_{k3}^A - v_s Z_{k1}^A \right) + Z_{j3}^A \left( v_d Z_{k2}^A + v_u Z_{k1}^A \right) \right) \right) \right. \\
& \left. + 2\kappa\lambda^* \left( Z_{i2}^A \left( v_s Z_{j1}^A Z_{k3}^A + Z_{j3}^A \left( -v_d Z_{k3}^A + v_s Z_{k1}^A \right) \right) + Z_{i1}^A \left( v_s Z_{j2}^A Z_{k3}^A + Z_{j3}^A \left( v_s Z_{k2}^A - v_u Z_{k3}^A \right) \right) \right. \right. \\
& \left. \left. - Z_{i3}^A \left( Z_{j1}^A \left( -v_s Z_{k2}^A + v_u Z_{k3}^A \right) + Z_{j2}^A \left( v_d Z_{k3}^A - v_s Z_{k1}^A \right) + Z_{j3}^A \left( v_d Z_{k2}^A + v_u Z_{k1}^A \right) \right) \right) \right) \\
& + \sqrt{2} \left( 2 \left( -T_\kappa + T_\kappa^* \right) Z_{i3}^A Z_{j3}^A Z_{k3}^A \right. \\
& \left. - T_\lambda^* \left( Z_{i1}^A \left( Z_{j2}^A Z_{k3}^A + Z_{j3}^A Z_{k2}^A \right) + Z_{i2}^A \left( Z_{j1}^A Z_{k3}^A + Z_{j3}^A Z_{k1}^A \right) + Z_{i3}^A \left( Z_{j1}^A Z_{k2}^A + Z_{j2}^A Z_{k1}^A \right) \right) \right. \\
& \left. + T_\lambda \left( Z_{i1}^A \left( Z_{j2}^A Z_{k3}^A + Z_{j3}^A Z_{k2}^A \right) + Z_{i2}^A \left( Z_{j1}^A Z_{k3}^A + Z_{j3}^A Z_{k1}^A \right) + Z_{i3}^A \left( Z_{j1}^A Z_{k2}^A + Z_{j2}^A Z_{k1}^A \right) \right) \right) \Big)
\end{aligned} \tag{237}$$

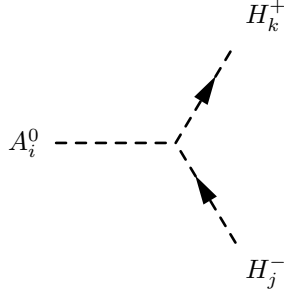


$$\begin{aligned}
& -\frac{i}{4} \left( Z_{i1}^A \left( -2v_s \lambda \kappa^* Z_{j3}^A Z_{k2}^H - 2v_s \kappa \lambda^* Z_{j3}^A Z_{k2}^H + \sqrt{2} T_\lambda^* Z_{j3}^A Z_{k2}^H + \sqrt{2} T_\lambda Z_{j3}^A Z_{k2}^H \right. \right. \\
& + 2v_s \lambda \kappa^* Z_{j2}^A Z_{k3}^H + 2v_s \kappa \lambda^* Z_{j2}^A Z_{k3}^H + \sqrt{2} T_\lambda^* Z_{j2}^A Z_{k3}^H + \sqrt{2} T_\lambda Z_{j2}^A Z_{k3}^H \\
& - 2v_u \lambda \kappa^* Z_{j3}^A Z_{k3}^H - 2v_u \kappa \lambda^* Z_{j3}^A Z_{k3}^H \\
& + Z_{j1}^A \left( 4v_s |\lambda|^2 Z_{k3}^H + (g_1^2 + g_2^2) v_d Z_{k1}^H - v_u (-4|\lambda|^2 + g_1^2 + g_2^2) Z_{k2}^H \right) \\
& + Z_{i2}^A \left( -2v_s \kappa \lambda^* Z_{j3}^A Z_{k1}^H + \sqrt{2} T_\lambda^* Z_{j3}^A Z_{k1}^H + \sqrt{2} T_\lambda Z_{j3}^A Z_{k1}^H + 2v_s \kappa \lambda^* Z_{j1}^A Z_{k3}^H \right. \\
& + \sqrt{2} T_\lambda^* Z_{j1}^A Z_{k3}^H + \sqrt{2} T_\lambda Z_{j1}^A Z_{k3}^H - 2v_d \kappa \lambda^* Z_{j3}^A Z_{k3}^H \\
& + Z_{j2}^A \left( 4v_s |\lambda|^2 Z_{k3}^H + (g_1^2 + g_2^2) v_u Z_{k2}^H - v_d (-4|\lambda|^2 + g_1^2 + g_2^2) Z_{k1}^H \right) \\
& - 2\lambda \kappa^* \left( -v_s Z_{j1}^A Z_{k3}^H + Z_{j3}^A (v_d Z_{k3}^H + v_s Z_{k1}^H) \right) \\
& + Z_{i3}^A \left( \sqrt{2} \left( -2(T_\kappa^* + T_\kappa) Z_{j3}^A Z_{k3}^H + T_\lambda^* (Z_{j1}^A Z_{k2}^H + Z_{j2}^A Z_{k1}^H) + T_\lambda (Z_{j1}^A Z_{k2}^H + Z_{j2}^A Z_{k1}^H) \right) \right. \\
& - 2\lambda^* \left( -Z_{j3}^A \left( (2v_d \lambda + v_u \kappa) Z_{k1}^H + (2v_u \lambda + v_d \kappa) Z_{k2}^H \right) + \kappa Z_{j2}^A (v_d Z_{k3}^H + v_s Z_{k1}^H) \right. \\
& + \kappa Z_{j1}^A (v_s Z_{k2}^H + v_u Z_{k3}^H) \left. \right) \\
& - 2\kappa^* \left( \lambda Z_{j2}^A (v_d Z_{k3}^H + v_s Z_{k1}^H) + \lambda Z_{j1}^A (v_s Z_{k2}^H + v_u Z_{k3}^H) \right. \\
& \left. \left. - Z_{j3}^A (4v_s \kappa Z_{k3}^H + v_d \lambda Z_{k2}^H + v_u \lambda Z_{k1}^H) \right) \right) \right) \quad (238)
\end{aligned}$$



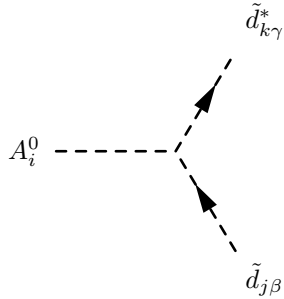
$$\begin{aligned}
& \frac{1}{4} \left( 2\lambda\kappa^* \left( -Z_{i2}^A \left( v_s Z_{j1}^H Z_{k3}^H + Z_{j3}^H \left( v_d Z_{k3}^H + v_s Z_{k1}^H \right) \right) \right. \right. \\
& + Z_{i3}^A \left( Z_{j1}^H \left( v_s Z_{k2}^H + v_u Z_{k3}^H \right) + Z_{j2}^H \left( v_d Z_{k3}^H + v_s Z_{k1}^H \right) + Z_{j3}^H \left( v_d Z_{k2}^H + v_u Z_{k1}^H \right) \right) \\
& \left. \left. - Z_{i1}^A \left( v_s Z_{j2}^H Z_{k3}^H + Z_{j3}^H \left( v_s Z_{k2}^H + v_u Z_{k3}^H \right) \right) \right) \right) \\
& - 2\kappa\lambda^* \left( -Z_{i2}^A \left( v_s Z_{j1}^H Z_{k3}^H + Z_{j3}^H \left( v_d Z_{k3}^H + v_s Z_{k1}^H \right) \right) \right. \\
& + Z_{i3}^A \left( Z_{j1}^H \left( v_s Z_{k2}^H + v_u Z_{k3}^H \right) + Z_{j2}^H \left( v_d Z_{k3}^H + v_s Z_{k1}^H \right) + Z_{j3}^H \left( v_d Z_{k2}^H + v_u Z_{k1}^H \right) \right) \\
& \left. \left. - Z_{i1}^A \left( v_s Z_{j2}^H Z_{k3}^H + Z_{j3}^H \left( v_s Z_{k2}^H + v_u Z_{k3}^H \right) \right) \right) \right) \\
& + \sqrt{2} \left( 2 \left( -T_\kappa^* + T_\kappa \right) Z_{i3}^A Z_{j3}^H Z_{k3}^H \right. \\
& + T_\lambda^* \left( Z_{i1}^A \left( Z_{j2}^H Z_{k3}^H + Z_{j3}^H Z_{k2}^H \right) + Z_{i2}^A \left( Z_{j1}^H Z_{k3}^H + Z_{j3}^H Z_{k1}^H \right) + Z_{i3}^A \left( Z_{j1}^H Z_{k2}^H + Z_{j2}^H Z_{k1}^H \right) \right) \\
& \left. \left. - T_\lambda \left( Z_{i1}^A \left( Z_{j2}^H Z_{k3}^H + Z_{j3}^H Z_{k2}^H \right) + Z_{i2}^A \left( Z_{j1}^H Z_{k3}^H + Z_{j3}^H Z_{k1}^H \right) + Z_{i3}^A \left( Z_{j1}^H Z_{k2}^H + Z_{j2}^H Z_{k1}^H \right) \right) \right) \right) \quad (239)
\end{aligned}$$


---



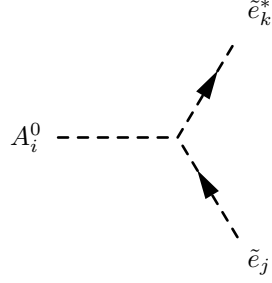
$$\begin{aligned}
& \frac{1}{4} \left( v_u \left( -2|\lambda|^2 + g_2^2 \right) Z_{i1}^A \left( -Z_{j1}^+ Z_{k2}^+ + Z_{j2}^+ Z_{k1}^+ \right) \right. \\
& + v_d \left( -2|\lambda|^2 + g_2^2 \right) Z_{i2}^A \left( -Z_{j1}^+ Z_{k2}^+ + Z_{j2}^+ Z_{k1}^+ \right) \\
& \left. + 2Z_{i3}^A \left( 2v_s \kappa \lambda^* Z_{j2}^+ Z_{k1}^+ + \left( -2v_s \lambda \kappa^* + \sqrt{2} T_\lambda \right) Z_{j1}^+ Z_{k2}^+ - \sqrt{2} T_\lambda^* Z_{j2}^+ Z_{k1}^+ \right) \right) \quad (240)
\end{aligned}$$


---



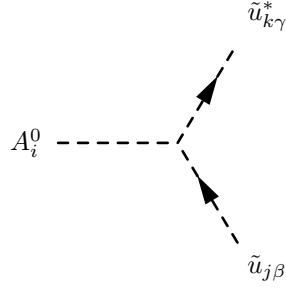
$$\begin{aligned}
& \frac{1}{2} \delta_{\beta\gamma} \left( \sqrt{2} \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Z_{k3+a}^D T_{d,ab} Z_{i1}^A - \sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{D,*} T_{d,ab}^* Z_{kb}^D Z_{i1}^A \right. \\
& \left. + \left( -\lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{kb}^D + \lambda^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \right) \left( v_s Z_{i2}^A + v_u Z_{i3}^A \right) \right) \quad (241)
\end{aligned}$$


---



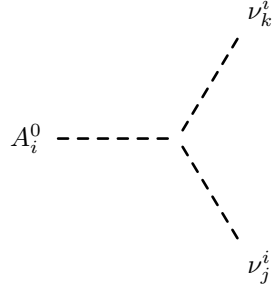
$$\begin{aligned}
& \frac{1}{2} \left( \sqrt{2} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Z_{k3+a}^E T_{e,ab} Z_{i1}^A - \sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{E,*} T_{e,ab}^* Z_{kb}^E Z_{i1}^A \right. \\
& \left. + \left( -\lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{kb}^E + \lambda^* \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \right) \left( v_s Z_{i2}^A + v_u Z_{i3}^A \right) \right) \quad (242)
\end{aligned}$$


---



$$\begin{aligned}
& \frac{1}{2} \delta_{\beta\gamma} \left( \sqrt{2} \left( -\sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{U,*} T_{u,ab}^* Z_{kb}^U + \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Z_{k3+a}^U T_{u,ab} \right) Z_{i2}^A \right. \\
& + \lambda^* \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U \left( v_d Z_{i3}^A + v_s Z_{i1}^A \right) \\
& \left. - \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{j3+a}^{U,*} Z_{kb}^U \left( v_d Z_{i3}^A + v_s Z_{i1}^A \right) \right) \quad (243)
\end{aligned}$$

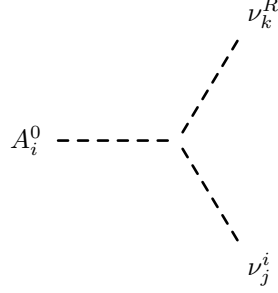

---



$$\begin{aligned}
& \frac{1}{8} \left( -2v_u \lambda \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba}^* Z_{i1}^A - 2v_u \lambda \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba}^* Z_{i1}^A \right. \\
& + 2v_s \lambda^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} Z_{i1}^A + 2v_s \lambda^* \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} Z_{i1}^A \\
& + 2v_u \lambda^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} Z_{i1}^A + 2v_u \lambda^* \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i1}^A \\
& - 2v_d \lambda \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba}^* Z_{i2}^A - 2v_d \lambda \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba}^* Z_{i2}^A \\
& - 2\sqrt{2} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{Y,\nu_{ab}^*} Z_{i2}^A - 2\sqrt{2} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} T_{Y,\nu_{ab}^*} Z_{i2}^A \\
& + 2v_d \lambda^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} Z_{i2}^A + 2v_d \lambda^* \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i2}^A \\
& + 2\sqrt{2} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{Y_\nu,ab} Z_{i2}^A + 2\sqrt{2} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} T_{Y_\nu,ab} Z_{i2}^A \\
& + 2v_s \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^A + 2v_s \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^A \\
& - 2v_s \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^A \\
& - 2v_s \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^A + 4v_s \kappa \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba}^* Z_{i3}^A \\
& + 4v_s \kappa \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba}^* Z_{i3}^A - 2\sqrt{2} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{\lambda,N_{ab}^*} Z_{i3}^A \\
& - 2\sqrt{2} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} T_{\lambda,N_{ab}^*} Z_{i3}^A + 2v_d \lambda^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} Z_{i3}^A
\end{aligned}$$

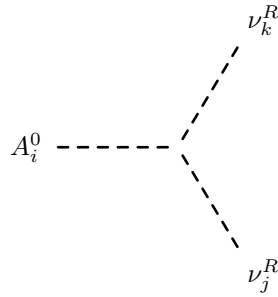
$$\begin{aligned}
& + 2v_d \lambda^* \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} Z_{i3}^A - 4v_s \kappa^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} Z_{i3}^A \\
& - 4v_s \kappa^* \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i3}^A + 2\sqrt{2} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{\lambda_{N,ab}} Z_{i3}^A \\
& + 2\sqrt{2} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} T_{\lambda_{N,ab}} Z_{i3}^A + \sqrt{2} \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ab} Z_{i3}^A \\
& + \sqrt{2} \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ab} Z_{i3}^A + \sqrt{2} \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ba} Z_{i3}^A \\
& + \sqrt{2} \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ba} Z_{i3}^A \\
& - 2v_u \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^A \\
& - 2v_u \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^A \\
& + 2v_u \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^A + 2v_u \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^A \\
& - \sqrt{2} \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 \mu_{X,ac}^* \lambda_{N,ba} Z_{i3}^A \\
& - \sqrt{2} \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 \mu_{X,ac}^* \lambda_{N,ba} Z_{i3}^A \\
& - \sqrt{2} \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 \mu_{X,ca}^* \lambda_{N,ba} Z_{i3}^A \\
& - \sqrt{2} \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 \mu_{X,ca}^* \lambda_{N,ba} Z_{i3}^A \\
& - 2\lambda \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{j3+a}^{i,*} \left( v_d Z_{i3}^A + v_s Z_{i1}^A \right) \\
& - 2\lambda \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} \left( v_d Z_{i3}^A + v_s Z_{i1}^A \right)
\end{aligned} \tag{244}$$





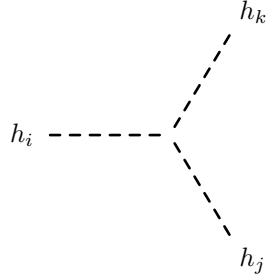
$$\begin{aligned}
& -\frac{i}{8} \left( -2v_u \lambda \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba}^* Z_{i1}^A + 2v_u \lambda \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba}^* Z_{i1}^A \right. \\
& + 2v_s \lambda^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} Z_{i1}^A - 2v_s \lambda^* \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i1}^A \\
& - 2v_u \lambda^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} Z_{i1}^A + 2v_u \lambda^* \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i1}^A \\
& - 2v_d \lambda \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba}^* Z_{i2}^A + 2v_d \lambda \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba}^* Z_{i2}^A \\
& + 2\sqrt{2} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{Y,\nu_{ab}^*} Z_{i2}^A - 2\sqrt{2} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{Y,\nu_{ab}^*} Z_{i2}^A \\
& - 2v_d \lambda^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} Z_{i2}^A + 2v_d \lambda^* \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i2}^A \\
& + 2\sqrt{2} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{Y_{\nu,ab}} Z_{i2}^A - 2\sqrt{2} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{Y_{\nu,ab}} Z_{i2}^A \\
& - 2v_s \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^A \\
& + 2v_s \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^A + 2v_s \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^A \\
& - 2v_s \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^A + 4v_s \kappa \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba}^* Z_{i3}^A \\
& - 4v_s \kappa \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba}^* Z_{i3}^A + 2\sqrt{2} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{\lambda, N_{ab}^*} Z_{i3}^A \\
& - 2\sqrt{2} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{\lambda, N_{ab}^*} Z_{i3}^A + 2v_d \lambda^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} Z_{i3}^A
\end{aligned}$$

$$\begin{aligned}
& -2v_d\lambda^* \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i3}^A + 4v_s\kappa^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} Z_{i3}^A \\
& -4v_s\kappa^* \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i3}^A + 2\sqrt{2} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{\lambda_{N,ab}} Z_{i3}^A \\
& -2\sqrt{2} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{\lambda_{N,ab}} Z_{i3}^A + \sqrt{2} \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ab} Z_{i3}^A \\
& + \sqrt{2} \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ab} Z_{i3}^A + \sqrt{2} \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ba} Z_{i3}^A \\
& + \sqrt{2} \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ba} Z_{i3}^A + 2v_u \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^A \\
& -2v_u \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^A \\
& -2v_u \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^A \\
& + 2v_u \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^A + \sqrt{2} \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 \mu_{X,ac}^* \lambda_{N,ba} Z_{i3}^A \\
& + \sqrt{2} \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 \mu_{X,ac}^* \lambda_{N,ba} Z_{i3}^A + \sqrt{2} \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 \mu_{X,ca}^* \lambda_{N,ba} Z_{i3}^A \\
& + \sqrt{2} \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 \mu_{X,ca}^* \lambda_{N,ba} Z_{i3}^A \\
& + 2\lambda \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{j3+a}^{i,*} \left( v_d Z_{i3}^A + v_s Z_{i1}^A \right) \\
& - 2\lambda \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} \left( v_d Z_{i3}^A + v_s Z_{i1}^A \right)
\end{aligned} \tag{245}$$



$$\begin{aligned}
& \frac{1}{8} \left( -2v_u \lambda \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba}^* Z_{i1}^A - 2v_u \lambda \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba}^* Z_{i1}^A \right. \\
& + 2v_s \lambda^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} Z_{i1}^A + 2v_s \lambda^* \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i1}^A \\
& + 2v_u \lambda^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba} Z_{i1}^A + 2v_u \lambda^* \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i1}^A \\
& - 2v_d \lambda \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba}^* Z_{i2}^A - 2v_d \lambda \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba}^* Z_{i2}^A \\
& - 2\sqrt{2} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} T_{Y,\nu_{ab}^*} Z_{i2}^A - 2\sqrt{2} \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{Y,\nu_{ab}^*} Z_{i2}^A \\
& + 2v_d \lambda^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba} Z_{i2}^A + 2v_d \lambda^* \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i2}^A \\
& + 2\sqrt{2} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} T_{Y_\nu,ab} Z_{i2}^A + 2\sqrt{2} \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{Y_\nu,ab} Z_{i2}^A \\
& + 2v_s \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^A + 2v_s \sum_{c=1}^3 Z_{j6+c}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^A \\
& - 2v_s \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^A \\
& - 2v_s \sum_{c=1}^3 Z_{jc}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^A + 4v_s \kappa \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba}^* Z_{i3}^A \\
& + 4v_s \kappa \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba}^* Z_{i3}^A - 2\sqrt{2} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} T_{\lambda,N_{ab}^*} Z_{i3}^A \\
& - 2\sqrt{2} \sum_{b=1}^3 Z_{j6+b}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{\lambda,N_{ab}^*} Z_{i3}^A + 2v_d \lambda^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} Z_{i3}^A \\
& + 2v_d \lambda^* \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i3}^A - 4v_s \kappa^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba} Z_{i3}^A \\
& - 4v_s \kappa^* \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i3}^A + 2\sqrt{2} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} T_{\lambda_N,ab} Z_{i3}^A \\
& + 2\sqrt{2} \sum_{b=1}^3 Z_{j6+b}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{\lambda_N,ab} Z_{i3}^A - \sqrt{2} \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ab} Z_{i3}^A
\end{aligned}$$

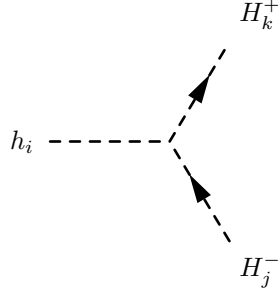
$$\begin{aligned}
& -\sqrt{2} \sum_{c=1}^3 Z_{j3+c}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ab} Z_{i3}^A \\
& -\sqrt{2} \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ba} Z_{i3}^A \\
& -\sqrt{2} \sum_{c=1}^3 Z_{j3+c}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ba} Z_{i3}^A \\
& -2v_u \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^A \\
& -2v_u \sum_{c=1}^3 Z_{j6+c}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^A \\
& +2v_u \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^A + 2v_u \sum_{c=1}^3 Z_{jc}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^A \\
& +\sqrt{2} \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 \mu_{X,ac}^* \lambda_{N,ba} Z_{i3}^A + \sqrt{2} \sum_{c=1}^3 Z_{j6+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 \mu_{X,ac}^* \lambda_{N,ba} Z_{i3}^A \\
& +\sqrt{2} \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 \mu_{X,ca}^* \lambda_{N,ba} Z_{i3}^A + \sqrt{2} \sum_{c=1}^3 Z_{j6+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 \mu_{X,ca}^* \lambda_{N,ba} Z_{i3}^A \\
& -2\lambda \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{j3+a}^{R,*} \left( v_d Z_{i3}^A + v_s Z_{i1}^A \right) \\
& -2\lambda \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} \left( v_d Z_{i3}^A + v_s Z_{i1}^A \right)
\end{aligned} \tag{246}$$



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

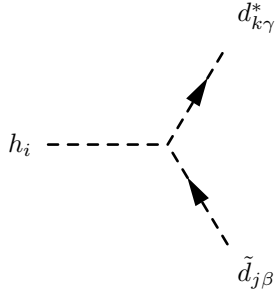
$$\begin{aligned}
& -Z_{j3}^H \left( \sqrt{2} (T_\lambda^* + T_\lambda) Z_{k2}^H + 2\lambda\kappa^* (v_s Z_{k2}^H + v_u Z_{k3}^H) \right. \\
& + 2\lambda^* \left( \left( -2v_d\lambda + v_u\kappa \right) Z_{k3}^H - 2v_s\lambda Z_{k1}^H + v_s\kappa Z_{k2}^H \right) \left. \right) \\
& - Z_{i2}^H \left( Z_{j2}^H \left( -3(g_1^2 + g_2^2) v_u Z_{k2}^H - 4v_s|\lambda|^2 Z_{k3}^H + v_d \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k1}^H \right) \right. \\
& + Z_{j1}^H \left( v_u \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k1}^H + v_d \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k2}^H \right. \\
& + \left( 2v_s\kappa\lambda^* + 2v_s\lambda\kappa^* + \sqrt{2} (T_\lambda^* + T_\lambda) \right) Z_{k3}^H \left. \right) \\
& + Z_{j3}^H \left( \sqrt{2} (T_\lambda^* + T_\lambda) Z_{k1}^H + 2\lambda\kappa^* (v_d Z_{k3}^H + v_s Z_{k1}^H) \right. \\
& + 2\lambda^* \left( -2v_s\lambda Z_{k2}^H + \left( -2v_u\lambda + v_d\kappa \right) Z_{k3}^H + v_s\kappa Z_{k1}^H \right) \left. \right) \\
& + Z_{i3}^H \left( -\sqrt{2} \left( -2(T_\kappa^* + T_\kappa) Z_{j3}^H Z_{k3}^H + T_\lambda^* (Z_{j1}^H Z_{k2}^H + Z_{j2}^H Z_{k1}^H) + T_\lambda (Z_{j1}^H Z_{k2}^H + Z_{j2}^H Z_{k1}^H) \right) \right. \\
& - 2\kappa^* \left( \lambda Z_{j2}^H (v_d Z_{k3}^H + v_s Z_{k1}^H) + \lambda Z_{j1}^H (v_s Z_{k2}^H + v_u Z_{k3}^H) \right. \\
& + Z_{j3}^H \left( -12v_s\kappa Z_{k3}^H + v_d\lambda Z_{k2}^H + v_u\lambda Z_{k1}^H \right) \left. \right) \\
& - 2\lambda^* \left( Z_{j3}^H \left( \left( -2v_d\lambda + v_u\kappa \right) Z_{k1}^H + \left( -2v_u\lambda + v_d\kappa \right) Z_{k2}^H \right) \right. \\
& + Z_{j1}^H \left( \left( -2v_d\lambda + v_u\kappa \right) Z_{k3}^H - 2v_s\lambda Z_{k1}^H + v_s\kappa Z_{k2}^H \right) \\
& + Z_{j2}^H \left( -2v_s\lambda Z_{k2}^H + \left( -2v_u\lambda + v_d\kappa \right) Z_{k3}^H + v_s\kappa Z_{k1}^H \right) \left. \right) \left. \right) \quad (247)
\end{aligned}$$


---



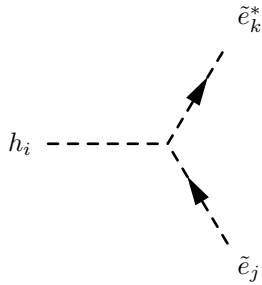
$$\begin{aligned}
& -\frac{i}{4} \left( Z_{i2}^H \left( Z_{j2}^+ \left( (g_1^2 + g_2^2) v_u Z_{k2}^+ + v_d \left( -2|\lambda|^2 + g_2^2 \right) Z_{k1}^+ \right) \right. \right. \\
& + Z_{j1}^+ \left( \left( -g_1^2 + g_2^2 \right) v_u Z_{k1}^+ + v_d \left( -2|\lambda|^2 + g_2^2 \right) Z_{k2}^+ \right) \left. \right) \\
& + Z_{i1}^H \left( Z_{j2}^+ \left( \left( -g_1^2 + g_2^2 \right) v_d Z_{k2}^+ + v_u \left( -2|\lambda|^2 + g_2^2 \right) Z_{k1}^+ \right) \right. \\
& + Z_{j1}^+ \left( \left( g_1^2 + g_2^2 \right) v_d Z_{k1}^+ + v_u \left( -2|\lambda|^2 + g_2^2 \right) Z_{k2}^+ \right) \left. \right) \\
& + 2Z_{i3}^H \left( \left( 2v_s\lambda\kappa^* + \sqrt{2}T_\lambda \right) Z_{j1}^+ Z_{k2}^+ + 2v_s\lambda^* \left( \lambda Z_{j1}^+ Z_{k1}^+ + Z_{j2}^+ \left( \kappa Z_{k1}^+ + \lambda Z_{k2}^+ \right) \right) + \sqrt{2}T_\lambda^* Z_{j2}^+ Z_{k1}^+ \right) \left. \right) \quad (248)
\end{aligned}$$


---



$$\begin{aligned}
& \frac{i}{12} \delta_{\beta\gamma} \left( \left( 3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \left( v_d Z_{i1}^H - v_u Z_{i2}^H \right) \right. \\
& + 2 \left( g_1^2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{k3+a}^D \left( v_d Z_{i1}^H - v_u Z_{i2}^H \right) \right. \\
& + 3 \left( -\sqrt{2} \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Z_{k3+a}^D T_{d,ab} Z_{i1}^H - \sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{D,*} T_{d,ab}^* Z_{kb}^D Z_{i1}^H \right. \\
& - 2v_d \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{d,ba} Z_{k3+b}^D Z_{i1}^H - 2v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{kc}^D Z_{i1}^H \\
& + v_s \lambda^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D Z_{i2}^H + v_s \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{kb}^D Z_{i2}^H \\
& \left. \left. + v_u \lambda^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D Z_{i3}^H + v_u \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{kb}^D Z_{i3}^H \right) \right) \quad (249)
\end{aligned}$$

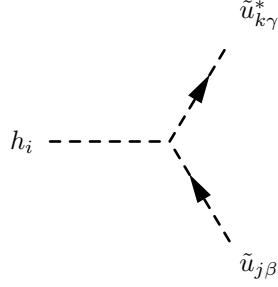

---



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

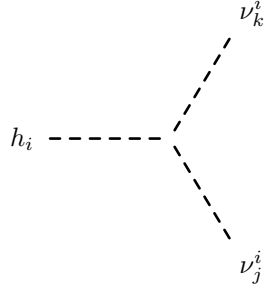
$$\begin{aligned}
& -2v_d \sum_{c=1}^3 Z_{j3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{e,ba} Z_{k3+b}^E Z_{i1}^H - 2v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{kc}^E Z_{i1}^H \\
& + v_s \lambda^* \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E Z_{i2}^H + v_s \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{kb}^E Z_{i2}^H \\
& + g_1^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E \left( v_d Z_{i1}^H - v_u Z_{i2}^H \right) + v_u \lambda^* \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E Z_{i3}^H \\
& + v_u \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{kb}^E Z_{i3}^H \Big) \Big) \tag{250}
\end{aligned}$$


---



$$\begin{aligned}
& \frac{i}{12} \delta_{\beta\gamma} \Big( \left( -3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \left( v_d Z_{i1}^H - v_u Z_{i2}^H \right) + 4g_1^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \left( -v_d Z_{i1}^H + v_u Z_{i2}^H \right) \\
& + 6 \Big( - \left( \sqrt{2} \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Z_{k3+a}^U T_{u,ab} + \sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{U,*} T_{u,ab}^* Z_{kb}^U \right. \\
& + 2v_u \left( \sum_{c=1}^3 Z_{j3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{u,ba} Z_{k3+b}^U + \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{kc}^U \right) \Big) Z_{i2}^H \\
& + \lambda^* \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U \left( v_d Z_{i3}^H + v_s Z_{i1}^H \right) \\
& + \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{j3+a}^{U,*} Z_{kb}^U \left( v_d Z_{i3}^H + v_s Z_{i1}^H \right) \Big) \Big) \tag{251}
\end{aligned}$$


---



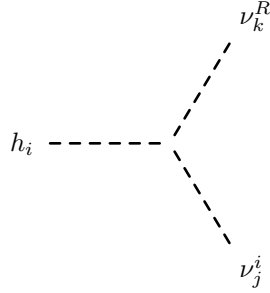
$$\begin{aligned}
& \frac{i}{8} \left( 2v_s \lambda \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} Z_{i1}^H + 2v_u \lambda \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba}^* Z_{i1}^H \right. \\
& + 2v_u \lambda \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba}^* Z_{i1}^H + 2v_s \lambda^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} Z_{i1}^H \\
& + 2v_s \lambda^* \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} Z_{i1}^H + 2v_u \lambda^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} Z_{i1}^H \\
& + 2v_u \lambda^* \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i1}^H + 2v_d \lambda \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba}^* Z_{i2}^H \\
& + 2v_d \lambda \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba}^* Z_{i2}^H - 2\sqrt{2} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{Y,\nu_{ab}^*} Z_{i2}^H \\
& - 2\sqrt{2} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} T_{Y,\nu_{ab}^*} Z_{i2}^H + 2v_d \lambda^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} Z_{i2}^H \\
& + 2v_d \lambda^* \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i2}^H - 2\sqrt{2} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{Y,\nu_{ab}} Z_{i2}^H \\
& - 2\sqrt{2} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} T_{Y,\nu_{ab}} Z_{i2}^H - 4v_u \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H \\
& - 4v_u \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H \\
& - 2v_s \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^H \\
& - 2v_s \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^H \\
& \left. - 4v_u \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^H \right)
\end{aligned}$$



$$\begin{aligned}
& -4v_u \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^H \\
& -2v_s \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^H \\
& -2v_s \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^H \\
& -2(g_1^2 + g_2^2) \sum_{a=1}^3 Z_{ja}^{i,*} Z_{ka}^{i,*} (v_d Z_{i1}^H - v_u Z_{i2}^H) + 2v_d \lambda \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} Z_{i3}^H \\
& -4v_s \kappa \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba}^* Z_{i3}^H - 4v_s \kappa \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba}^* Z_{i3}^H \\
& -2\sqrt{2} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{\lambda, N_{ab}^*} Z_{i3}^H - 2\sqrt{2} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} T_{\lambda, N_{ab}^*} Z_{i3}^H \\
& + 2v_d \lambda^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} Z_{i3}^H + 2v_d \lambda^* \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} Z_{i3}^H \\
& -4v_s \kappa^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} Z_{i3}^H - 4v_s \kappa^* \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i3}^H \\
& -2\sqrt{2} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{\lambda_N, ab} Z_{i3}^H - 2\sqrt{2} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} T_{\lambda_N, ab} Z_{i3}^H \\
& + \sqrt{2} \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ab} Z_{i3}^H + \sqrt{2} \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ab} Z_{i3}^H \\
& + \sqrt{2} \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ba} Z_{i3}^H + \sqrt{2} \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ba} Z_{i3}^H \\
& -2v_u \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^H \\
& -2v_u \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^H \\
& -2v_u \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^H \\
& -2v_u \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^H
\end{aligned}$$

$$\begin{aligned}
& -4v_s \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* \lambda_{N,ab} Z_{i3}^H \\
& -4v_s \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* \lambda_{N,ab} Z_{i3}^H \\
& +\sqrt{2} \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 \mu_{X,ac}^* \lambda_{N,ba} Z_{i3}^H + \sqrt{2} \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 \mu_{X,ac}^* \lambda_{N,ba} Z_{i3}^H \\
& +\sqrt{2} \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 \mu_{X,ca}^* \lambda_{N,ba} Z_{i3}^H + \sqrt{2} \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 \mu_{X,ca}^* \lambda_{N,ba} Z_{i3}^H \\
& -4v_s \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \lambda_{N,ba} Z_{i3}^H \\
& -4v_s \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \lambda_{N,ba} Z_{i3}^H \\
& +2\lambda \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{j3+a}^{i,*} \left( v_d Z_{i3}^H + v_s Z_{i1}^H \right)
\end{aligned} \tag{252}$$


---

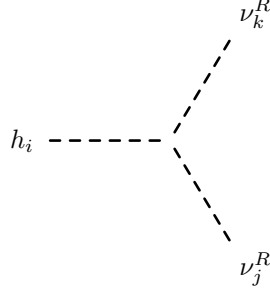


$$\begin{aligned}
& \frac{1}{8} \left( 2v_u \lambda \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba}^* Z_{i1}^H - 2v_u \lambda \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba}^* Z_{i1}^H \right. \\
& + 2v_s \lambda^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} Z_{i1}^H - 2v_s \lambda^* \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i1}^H \\
& - 2v_u \lambda^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} Z_{i1}^H + 2v_u \lambda^* \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i1}^H \\
& + 2v_d \lambda \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba}^* Z_{i2}^H - 2v_d \lambda \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba}^* Z_{i2}^H \\
& \left. + 2\sqrt{2} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{Y,\nu_{ab}^*} Z_{i2}^H - 2\sqrt{2} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{Y,\nu_{ab}^*} Z_{i2}^H \right)
\end{aligned}$$

$$\begin{aligned}
& -2v_d\lambda^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} Z_{i2}^H + 2v_d\lambda^* \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i2}^H \\
& -2\sqrt{2} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{Y\nu,ab} Z_{i2}^H + 2\sqrt{2} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{Y\nu,ab} Z_{i2}^H \\
& +4v_u \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H - 4v_u \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H \\
& +2v_s \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^H \\
& -2v_s \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^H \\
& -4v_u \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^H \\
& +4v_u \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^H \\
& +2v_s \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^H \\
& -2v_s \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^H - 4v_s\kappa \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba}^* Z_{i3}^H \\
& +4v_s\kappa \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba}^* Z_{i3}^H + 2\sqrt{2} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{\lambda,N_{ab}^*} Z_{i3}^H \\
& -2\sqrt{2} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{\lambda,N_{ab}^*} Z_{i3}^H + 2v_d\lambda^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} Z_{i3}^H \\
& -2v_d\lambda^* \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i3}^H + 4v_s\kappa^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} Z_{i3}^H \\
& -4v_s\kappa^* \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i3}^H - 2\sqrt{2} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{\lambda_{N,ab}} Z_{i3}^H \\
& +2\sqrt{2} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{\lambda_{N,ab}} Z_{i3}^H + \sqrt{2} \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ab} Z_{i3}^H \\
& +\sqrt{2} \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ab} Z_{i3}^H + \sqrt{2} \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ba} Z_{i3}^H
\end{aligned}$$

$$\begin{aligned}
& + \sqrt{2} \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ba} Z_{i3}^H + 2v_u \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^H \\
& - 2v_u \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^H \\
& + 2v_u \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^H \\
& - 2v_u \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^H \\
& + 4v_s \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* \lambda_{N,ab} Z_{i3}^H \\
& - 4v_s \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* \lambda_{N,ab} Z_{i3}^H \\
& - \sqrt{2} \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 \mu_{X,ac}^* \lambda_{N,ba} Z_{i3}^H \\
& - \sqrt{2} \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 \mu_{X,ac}^* \lambda_{N,ba} Z_{i3}^H \\
& - \sqrt{2} \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 \mu_{X,ca}^* \lambda_{N,ba} Z_{i3}^H \\
& - \sqrt{2} \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 \mu_{X,ca}^* \lambda_{N,ba} Z_{i3}^H \\
& - 4v_s \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \lambda_{N,ba} Z_{i3}^H \\
& + 4v_s \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \lambda_{N,ba} Z_{i3}^H \\
& - 2\lambda \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{j3+a}^{i,*} \left( v_d Z_{i3}^H + v_s Z_{i1}^H \right) \\
& + 2\lambda \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} \left( v_d Z_{i3}^H + v_s Z_{i1}^H \right)
\end{aligned} \tag{253}$$


---

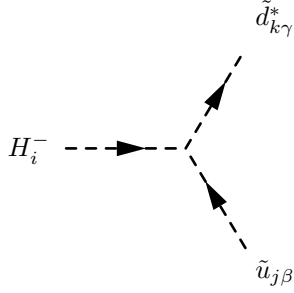


$$\begin{aligned}
& -\frac{i}{8} \left( -2v_s \lambda \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} Z_{i1}^H - 2v_u \lambda \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba}^* Z_{i1}^H \right. \\
& - 2v_u \lambda \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba}^* Z_{i1}^H - 2v_s \lambda^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} Z_{i1}^H \\
& - 2v_s \lambda^* \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i1}^H - 2v_u \lambda^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba} Z_{i1}^H \\
& - 2v_u \lambda^* \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i1}^H - 2v_d \lambda \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba}^* Z_{i2}^H \\
& - 2v_d \lambda \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba}^* Z_{i2}^H + 2\sqrt{2} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} T_{Y,\nu_{ab}^*} Z_{i2}^H \\
& + 2\sqrt{2} \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{Y,\nu_{ab}^*} Z_{i2}^H - 2v_d \lambda^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba} Z_{i2}^H \\
& - 2v_d \lambda^* \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i2}^H + 2\sqrt{2} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} T_{Y,\nu_{ab}} Z_{i2}^H \\
& + 2\sqrt{2} \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{Y,\nu_{ab}} Z_{i2}^H + 4v_u \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H \\
& + 4v_u \sum_{c=1}^3 Z_{jc}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H + 2v_s \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^H \\
& + 2v_s \sum_{c=1}^3 Z_{j6+c}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^H \\
& + 4v_u \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^H \\
& + 4v_u \sum_{c=1}^3 Z_{j3+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^H
\end{aligned}$$

$$\begin{aligned}
& + 2v_s \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^H + 2v_s \sum_{c=1}^3 Z_{jc}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^H \\
& + 2(g_1^2 + g_2^2) \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^{R,*} (v_d Z_{i1}^H - v_u Z_{i2}^H) - 2v_d \lambda \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} Z_{i3}^H \\
& + 4v_s \kappa \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba}^* Z_{i3}^H + 4v_s \kappa \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba}^* Z_{i3}^H \\
& + 2\sqrt{2} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} T_{\lambda, N_{ab}^*} Z_{i3}^H + 2\sqrt{2} \sum_{b=1}^3 Z_{j6+b}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{\lambda, N_{ab}^*} Z_{i3}^H \\
& - 2v_d \lambda^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} Z_{i3}^H - 2v_d \lambda^* \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i3}^H \\
& + 4v_s \kappa^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba} Z_{i3}^H + 4v_s \kappa^* \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i3}^H \\
& + 2\sqrt{2} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} T_{\lambda_N, ab} Z_{i3}^H + 2\sqrt{2} \sum_{b=1}^3 Z_{j6+b}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} T_{\lambda_N, ab} Z_{i3}^H \\
& + \sqrt{2} \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ab} Z_{i3}^H + \sqrt{2} \sum_{c=1}^3 Z_{j3+c}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ab} Z_{i3}^H \\
& + \sqrt{2} \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ba} Z_{i3}^H + \sqrt{2} \sum_{c=1}^3 Z_{j3+c}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \mu_{X,ba} Z_{i3}^H \\
& + 2v_u \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^H + 2v_u \sum_{c=1}^3 Z_{j6+c}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^H \\
& + 2v_u \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^H + 2v_u \sum_{c=1}^3 Z_{jc}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^H \\
& + 4v_s \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{j6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* \lambda_{N,ab} Z_{i3}^H \\
& + 4v_s \sum_{c=1}^3 Z_{j6+c}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* \lambda_{N,ab} Z_{i3}^H \\
& + \sqrt{2} \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 \mu_{X,ac}^* \lambda_{N,ba} Z_{i3}^H + \sqrt{2} \sum_{c=1}^3 Z_{j6+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 \mu_{X,ac}^* \lambda_{N,ba} Z_{i3}^H \\
& + \sqrt{2} \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 \mu_{X,ca}^* \lambda_{N,ba} Z_{i3}^H + \sqrt{2} \sum_{c=1}^3 Z_{j6+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 \mu_{X,ca}^* \lambda_{N,ba} Z_{i3}^H
\end{aligned}$$

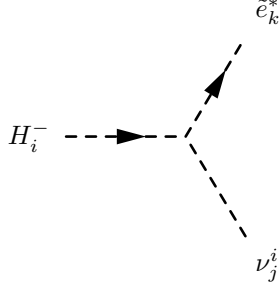
$$\begin{aligned}
& + 4v_s \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \lambda_{N,ba} Z_{i3}^H \\
& + 4v_s \sum_{c=1}^3 Z_{j3+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \lambda_{N,ba} Z_{i3}^H \\
& - 2\lambda \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{j3+a}^{R,*} \left( v_d Z_{i3}^H + v_s Z_{i1}^H \right)
\end{aligned} \tag{254}$$


---



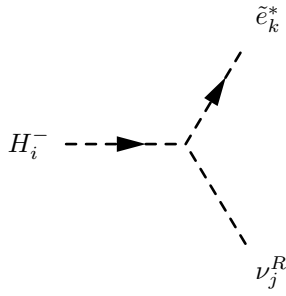
$$\begin{aligned}
& - \frac{i}{4} \delta_{\beta\gamma} \left( \sqrt{2} g_2^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^D \left( v_d Z_{i1}^+ + v_u Z_{i2}^+ \right) \right. \\
& - 2 \left( 2 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Z_{k3+a}^D T_{d,ab} Z_{i1}^+ + \sqrt{2} v_s \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{j3+a}^{U,*} Z_{kb}^D Z_{i1}^+ \right. \\
& + \sqrt{2} v_u \sum_{c=1}^3 Z_{j3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{d,ba} Z_{k3+b}^D Z_{i1}^+ \\
& + \sqrt{2} v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{kc}^D Z_{i1}^+ + \sqrt{2} v_s \lambda^* \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D Z_{i2}^+ \\
& + 2 \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{U,*} T_{u,ab}^* Z_{kb}^D Z_{i2}^+ + \sqrt{2} v_d \sum_{c=1}^3 Z_{j3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{d,ba} Z_{k3+b}^D Z_{i2}^+ \\
& \left. \left. + \sqrt{2} v_u \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{kc}^D Z_{i2}^+ \right) \right)
\end{aligned} \tag{255}$$


---



$$\begin{aligned}
& \frac{1}{4} \left( g_2^2 \sum_{a=1}^3 Z_{ja}^{i,*} Z_{ka}^E \left( v_d Z_{i1}^+ + v_u Z_{i2}^+ \right) \right. \\
& - 2 \left( \sqrt{2} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^E T_{e,ab} Z_{i1}^+ + v_s \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* Z_{j3+a}^{i,*} Z_{kb}^E Z_{i1}^+ \right. \\
& + v_u \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ca}^* Y_{e,ba} Z_{k3+b}^E Z_{i1}^+ + v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{kc}^E Z_{i1}^+ \\
& + v_s \lambda^* \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E Z_{i2}^+ + \sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{Y,\nu_{ab}^*} Z_{kb}^E Z_{i2}^+ \\
& + v_d \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ca}^* Y_{e,ba} Z_{k3+b}^E Z_{i2}^+ + v_u \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{kc}^E Z_{i2}^+ \\
& \left. \left. + v_s \sum_{c=1}^3 \sum_{b=1}^3 Z_{j6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{kc}^E Z_{i2}^+ \right) \right) \quad (256)
\end{aligned}$$


---

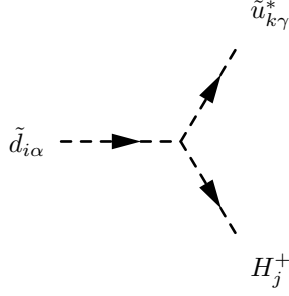


$$\begin{aligned}
& - \frac{i}{4} \left( g_2^2 \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^E \left( v_d Z_{i1}^+ + v_u Z_{i2}^+ \right) \right. \\
& - 2 \left( \sqrt{2} \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^E T_{e,ab} Z_{i1}^+ + v_s \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* Z_{j3+a}^{R,*} Z_{kb}^E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



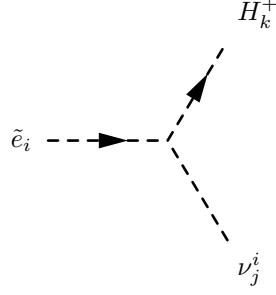
$$\begin{aligned}
& + v_u \sum_{c=1}^3 Z_{j3+c}^{R,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ca}^* Y_{e,ba} Z_{k3+b}^E Z_{i1}^+ + v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{kc}^E Z_{i1}^+ \\
& + v_s \lambda^* \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E Z_{i2}^+ + \sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{R,*} T_{Y,\nu_{ab}^*} Z_{kb}^E Z_{i2}^+ \\
& + v_d \sum_{c=1}^3 Z_{j3+c}^{R,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ca}^* Y_{e,ba} Z_{k3+b}^E Z_{i2}^+ + v_u \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{kc}^E Z_{i2}^+ \\
& + v_s \sum_{c=1}^3 \sum_{b=1}^3 Z_{j6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{kc}^E Z_{i2}^+ \Big) \Big) \quad (257)
\end{aligned}$$


---



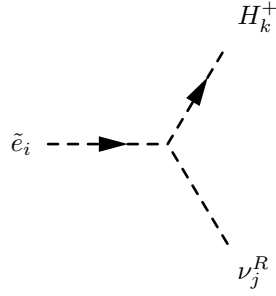
$$\begin{aligned}
& - \frac{i}{4} \delta_{\alpha\gamma} \left( \sqrt{2} g_2^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^U \left( v_d Z_{j1}^+ + v_u Z_{j2}^+ \right) \right. \\
& - 2 \left( \sqrt{2} v_s \lambda^* \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U Z_{j1}^+ + 2 \sum_{b=1}^3 \sum_{a=1}^3 Z_{i3+a}^{D,*} T_{d,ab}^* Z_{kb}^U Z_{j1}^+ \right. \\
& + \sqrt{2} v_u \sum_{c=1}^3 Z_{i3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{u,ba} Z_{k3+b}^U Z_{j1}^+ \\
& + \sqrt{2} v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{kc}^U Z_{j1}^+ + 2 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Z_{k3+a}^U T_{u,ab} Z_{j2}^+ \\
& + \sqrt{2} v_s \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{i3+a}^{D,*} Z_{kb}^U Z_{j2}^+ + \sqrt{2} v_d \sum_{c=1}^3 Z_{i3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{u,ba} Z_{k3+b}^U Z_{j2}^+ \\
& \left. \left. + \sqrt{2} v_u \sum_{c=1}^3 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{kc}^U Z_{j2}^+ \right) \right) \quad (258)
\end{aligned}$$


---



$$\begin{aligned}
& \frac{1}{4} \left( -g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^{i,*} \left( v_d Z_{k1}^+ + v_u Z_{k2}^+ \right) \right. \\
& + 2 \left( \sqrt{2} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{E,*} T_{e,ab}^* Z_{k1}^+ + v_s \lambda^* \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} Z_{k1}^+ \right. \\
& + v_d \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{k1}^+ + v_u \sum_{c=1}^3 Z_{i3+c}^{E,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Y_{e,ca}^* Y_{\nu,ba} Z_{k1}^+ \\
& + v_s \lambda \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{e,ab}^* Z_{i3+a}^{E,*} Z_{k2}^+ + \sqrt{2} \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} T_{Y_\nu,ab} Z_{k2}^+ \\
& + v_u \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{k2}^+ + v_s \sum_{c=1}^3 Z_{j6+c}^{i,*} \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{k2}^+ \\
& \left. \left. + v_d \sum_{c=1}^3 Z_{i3+c}^{E,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Y_{e,ca}^* Y_{\nu,ba} Z_{k2}^+ \right) \right) \quad (259)
\end{aligned}$$


---

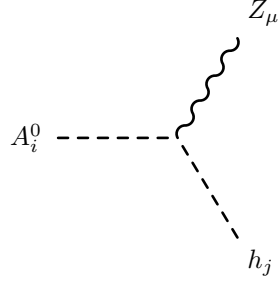


$$\begin{aligned}
& -\frac{i}{4} \left( g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^{R,*} \left( v_d Z_{k1}^+ + v_u Z_{k2}^+ \right) \right. \\
& - 2 \left( \sqrt{2} \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{E,*} T_{e,ab}^* Z_{k1}^+ + v_s \lambda^* \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{j3+a}^{R,*}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

$$\begin{aligned}
& + v_d \sum_{c=1}^3 Z_{jc}^{R,*} \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{k1}^+ + v_u \sum_{c=1}^3 Z_{i3+c}^{E,*} \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Y_{e,ca}^* Y_{\nu,ba} Z_{k1}^+ \\
& + v_s \lambda \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Y_{e,ab}^* Z_{i3+a}^{E,*} Z_{k2}^+ + \sqrt{2} \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} T_{Y\nu,ab} Z_{k2}^+ \\
& + v_u \sum_{c=1}^3 Z_{jc}^{R,*} \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{k2}^+ + v_s \sum_{c=1}^3 Z_{j6+c}^{R,*} \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{k2}^+ \\
& + v_d \sum_{c=1}^3 Z_{i3+c}^{E,*} \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Y_{e,ca}^* Y_{\nu,ba} Z_{k2}^+ \Big) \Big) \tag{260}
\end{aligned}$$

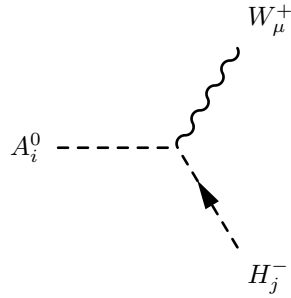

---

## 9.2 Two Scalar-One Vector Boson-Interaction



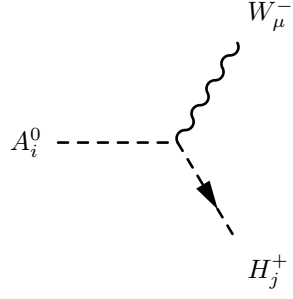
$$\frac{1}{2} \left( g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left( Z_{i1}^A Z_{j1}^H - Z_{i2}^A Z_{j2}^H \right) \left( -p_\mu^{h_j} + p_\mu^{A_i^0} \right) \tag{261}$$


---



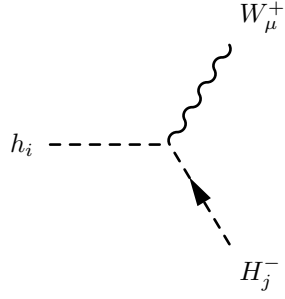
$$\frac{1}{2} g_2 \left( Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+ \right) \left( -p_\mu^{H_j^-} + p_\mu^{A_i^0} \right) \tag{262}$$


---



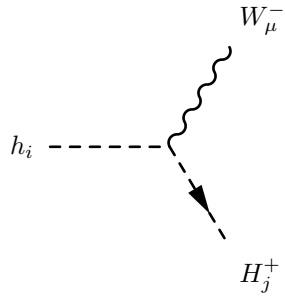
$$\frac{1}{2}g_2\left(Z_{i1}^AZ_{j1}^++Z_{i2}^AZ_{j2}^+\right)\left(-p_\mu^{H_j^+}+p_\mu^{A_i^0}\right) \quad (263)$$


---



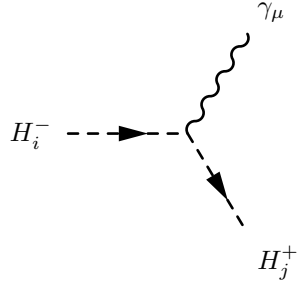
$$\frac{i}{2}g_2\left(Z_{i1}^HZ_{j1}^+-Z_{i2}^HZ_{j2}^+\right)\left(-p_\mu^{H_j^-}+p_\mu^{h_i}\right) \quad (264)$$


---



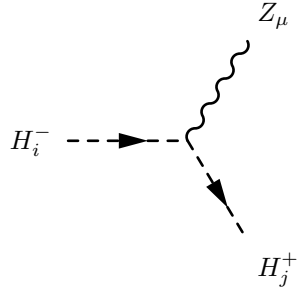
$$-\frac{i}{2}g_2\left(Z_{i1}^HZ_{j1}^+-Z_{i2}^HZ_{j2}^+\right)\left(-p_\mu^{H_j^+}+p_\mu^{h_i}\right) \quad (265)$$


---



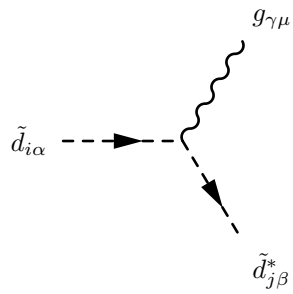
$$\frac{i}{2} \left( g_1 \cos \Theta_W + g_2 \sin \Theta_W \right) \left( Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+ \right) \left( -p_\mu^{H_j^+} + p_\mu^{H_i^-} \right) \quad (266)$$


---



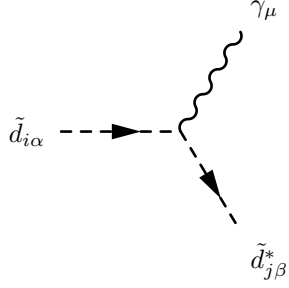
$$\frac{i}{2} \left( -g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left( Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+ \right) \left( -p_\mu^{H_j^+} + p_\mu^{H_i^-} \right) \quad (267)$$


---



$$-\frac{i}{2} g_3 \delta_{ij} \lambda_{\beta,\alpha}^\gamma \left( -p_\mu^{\tilde{d}_{j\beta}^*} + p_\mu^{\tilde{d}_{i\alpha}} \right) \quad (268)$$

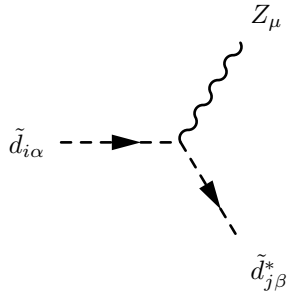

---



---


$$-\frac{i}{6}\delta_{\alpha\beta}\left(-2g_1\cos\Theta_W\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{j3+a}^D+\left(-3g_2\sin\Theta_W+g_1\cos\Theta_W\right)\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^D\right)\left(-p_\mu^{\tilde{d}_{j\beta}^*}+p_\mu^{\tilde{d}_{i\alpha}}\right) \quad (269)$$

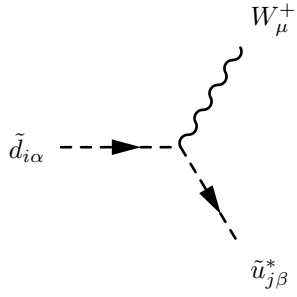

---



---


$$\frac{i}{6}\delta_{\alpha\beta}\left(-2g_1\sin\Theta_W\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{j3+a}^D+\left(3g_2\cos\Theta_W+g_1\sin\Theta_W\right)\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^D\right)\left(-p_\mu^{\tilde{d}_{j\beta}^*}+p_\mu^{\tilde{d}_{i\alpha}}\right) \quad (270)$$

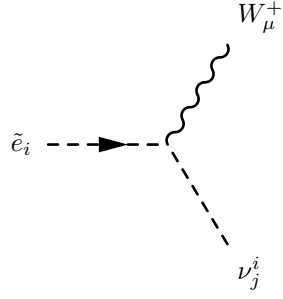

---



---

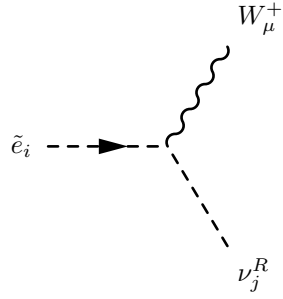

$$-i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^U\left(-p_\mu^{\tilde{u}_{j\beta}^*}+p_\mu^{\tilde{d}_{i\alpha}}\right) \quad (271)$$


---



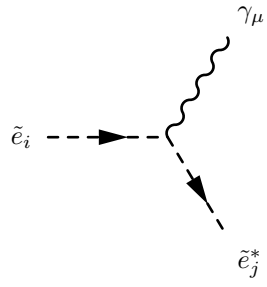
$$-\frac{1}{2}g_2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^{i,*} \left( -p_\mu^{\nu_j^i} + p_\mu^{\tilde{e}_i} \right) \quad (272)$$


---



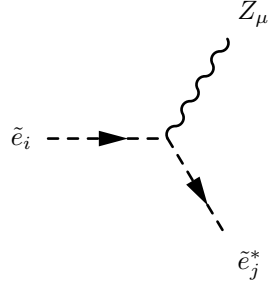
$$-\frac{i}{2}g_2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^{R,*} \left( -p_\mu^{\nu_j^R} + p_\mu^{\tilde{e}_i} \right) \quad (273)$$


---



$$\frac{i}{2} \left( 2g_1 \cos \Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E + \left( g_1 \cos \Theta_W + g_2 \sin \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right) \left( -p_\mu^{\tilde{e}_j^*} + p_\mu^{\tilde{e}_i} \right) \quad (274)$$

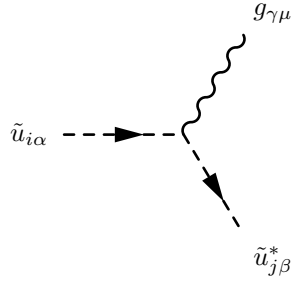

---



---


$$\frac{i}{2} \left( -2g_1 \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E + \left( -g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right) \left( -p_\mu^{\tilde{e}_j^*} + p_\mu^{\tilde{e}_i} \right) \quad (275)$$

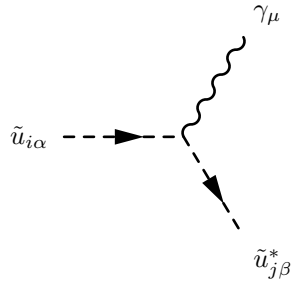

---



---


$$-\frac{i}{2} g_3 \delta_{ij} \lambda_{\beta,\alpha}^\gamma \left( -p_\mu^{\tilde{u}_{j\beta}^*} + p_\mu^{\tilde{u}_{i\alpha}} \right) \quad (276)$$


---

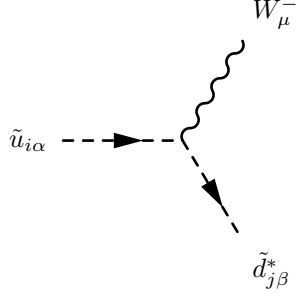


---


$$-\frac{i}{6} \delta_{\alpha,\beta} \left( \left( 3g_2 \sin \Theta_W + g_1 \cos \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U + 4g_1 \cos \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \right) \left( -p_\mu^{\tilde{u}_{j\beta}^*} + p_\mu^{\tilde{u}_{i\alpha}} \right) \quad (277)$$

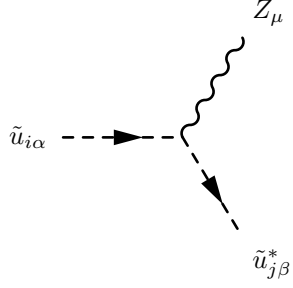

---





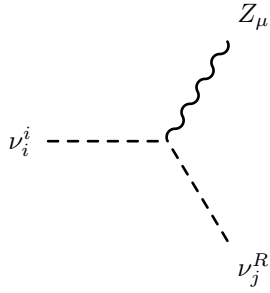
$$-i \frac{1}{\sqrt{2}} g_2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D \left( -p_\mu^{\tilde{d}_{j\beta}^*} + p_\mu^{\tilde{u}_{i\alpha}} \right) \quad (278)$$


---



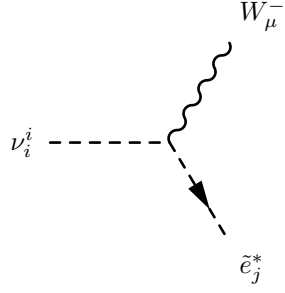
$$-\frac{i}{6} \delta_{\alpha\beta} \left( \left( 3g_2 \cos \Theta_W - g_1 \sin \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U - 4g_1 \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \right) \left( -p_\mu^{\tilde{u}_{j\beta}^*} + p_\mu^{\tilde{u}_{i\alpha}} \right) \quad (279)$$


---



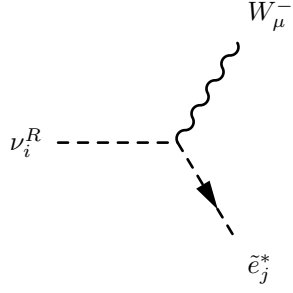
$$\frac{1}{2} \left( g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{i,*} Z_{ja}^{R,*} \left( -p_\mu^{\nu_j^R} + p_\mu^{\nu_i^i} \right) \quad (280)$$


---



$$\frac{1}{2}g_2 \sum_{a=1}^3 Z_{ia}^{i,*} Z_{ja}^E \left( -p_\mu^{\tilde{e}_j^*} + p_\mu^{\nu_i^i} \right) \quad (281)$$

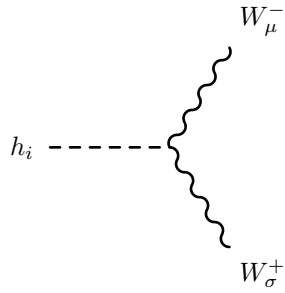

---



$$-\frac{i}{2}g_2 \sum_{a=1}^3 Z_{ia}^{R,*} Z_{ja}^E \left( -p_\mu^{\tilde{e}_j^*} + p_\mu^{\nu_i^R} \right) \quad (282)$$

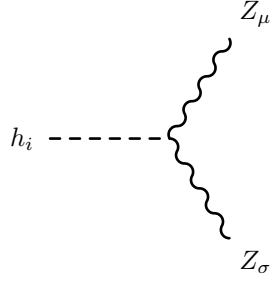

---

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



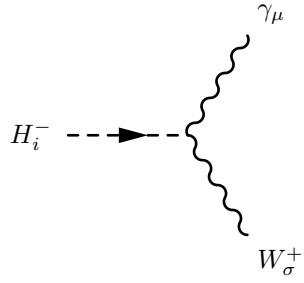
$$\frac{i}{2}g_2^2 \left( v_d Z_{i1}^H + v_u Z_{i2}^H \right) \left( g_{\sigma\mu} \right) \quad (283)$$


---



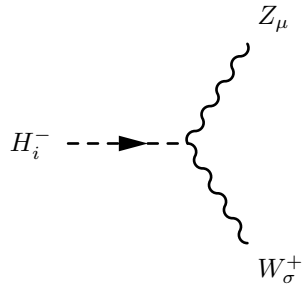
$$\frac{i}{2} \left( g_1 \sin \Theta_W + g_2 \cos \Theta_W \right)^2 \left( v_d Z_{i1}^H + v_u Z_{i2}^H \right) \left( g_{\sigma\mu} \right) \quad (284)$$


---



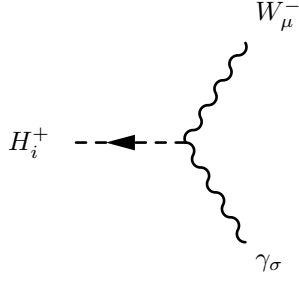
$$-\frac{i}{2} g_1 g_2 \cos \Theta_W \left( v_d Z_{i1}^+ - v_u Z_{i2}^+ \right) \left( g_{\sigma\mu} \right) \quad (285)$$


---



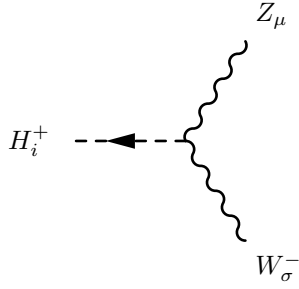
$$\frac{i}{2} g_1 g_2 \sin \Theta_W \left( v_d Z_{i1}^+ - v_u Z_{i2}^+ \right) \left( g_{\sigma\mu} \right) \quad (286)$$


---



$$-\frac{i}{2}g_1g_2\cos\Theta_W\left(v_dZ_{i1}^+-v_uZ_{i2}^+\right)\left(g_{\sigma\mu}\right) \quad (287)$$

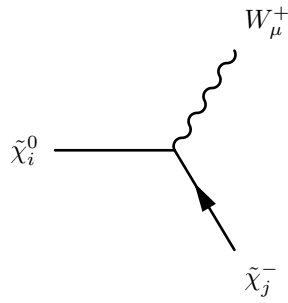

---



$$\frac{i}{2}g_1g_2\sin\Theta_W\left(v_dZ_{i1}^+-v_uZ_{i2}^+\right)\left(g_{\sigma\mu}\right) \quad (288)$$


---

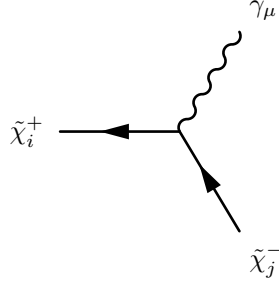
#### 9.4 Two Fermion-One Vector Boson-Interaction



$$-\frac{i}{2}g_2\left(2U_{j1}^*N_{i2}+\sqrt{2}U_{j2}^*N_{i3}\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (289)$$

$$+\left(i\frac{1}{\sqrt{2}}g_2N_{i4}^*V_{j2}-ig_2N_{i2}^*V_{j1}\right)\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (290)$$

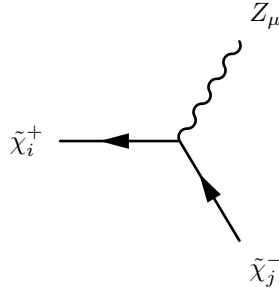

---



$$\frac{i}{2} \left( 2g_2 U_{j1}^* \sin \Theta_W U_{i1} + U_{j2}^* \left( g_1 \cos \Theta_W + g_2 \sin \Theta_W \right) U_{i2} \right) \left( \gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (291)$$

$$+ \frac{i}{2} \left( 2g_2 V_{i1}^* \sin \Theta_W V_{j1} + V_{i2}^* \left( g_1 \cos \Theta_W + g_2 \sin \Theta_W \right) V_{j2} \right) \left( \gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (292)$$

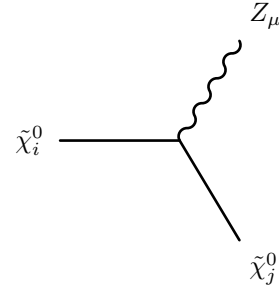

---



$$\frac{i}{2} \left( 2g_2 U_{j1}^* \cos \Theta_W U_{i1} + U_{j2}^* \left( -g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) U_{i2} \right) \left( \gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (293)$$

$$+ \frac{i}{2} \left( 2g_2 V_{i1}^* \cos \Theta_W V_{j1} + V_{i2}^* \left( -g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) V_{j2} \right) \left( \gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (294)$$

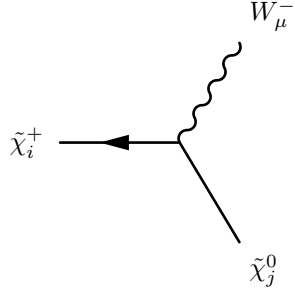

---



$$- \frac{i}{2} \left( g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left( N_{j3}^* N_{i3} - N_{j4}^* N_{i4} \right) \left( \gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (295)$$

$$+ \frac{i}{2} \left( g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left( N_{i3}^* N_{j3} - N_{i4}^* N_{j4} \right) \left( \gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (296)$$

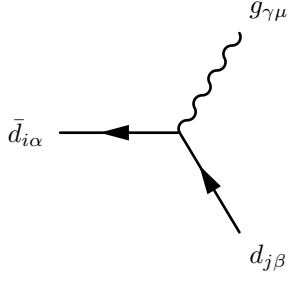

---



$$-\frac{i}{2}g_2\left(2N_{j2}^*U_{i1}+\sqrt{2}N_{j3}^*U_{i2}\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (297)$$

$$+\left(i\frac{1}{\sqrt{2}}g_2V_{i2}^*N_{j4}-ig_2V_{i1}^*N_{j2}\right)\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (298)$$

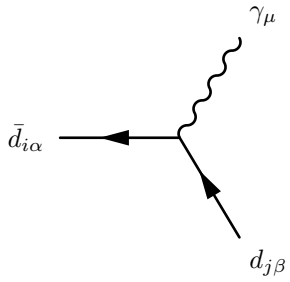

---



$$-\frac{i}{2}g_3\delta_{ij}\lambda_{\alpha,\beta}^\gamma\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (299)$$

$$+ -\frac{i}{2}g_3\delta_{ij}\lambda_{\alpha,\beta}^\gamma\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (300)$$

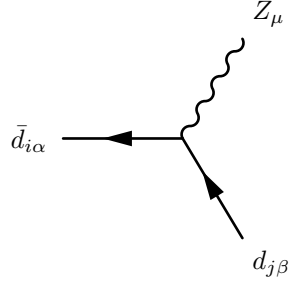

---



$$-\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(-3g_2\sin\Theta_W+g_1\cos\Theta_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (301)$$

$$+ \frac{i}{3} g_1 \cos \Theta_W \delta_{\alpha\beta} \delta_{ij} \left( \gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (302)$$

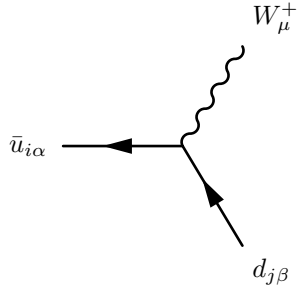

---



$$\frac{i}{6} \delta_{\alpha\beta} \delta_{ij} \left( 3g_2 \cos \Theta_W + g_1 \sin \Theta_W \right) \left( \gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (303)$$

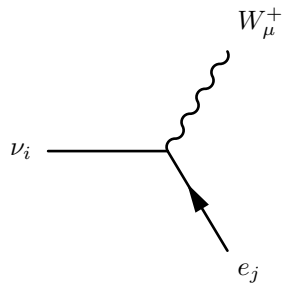
$$+ -\frac{i}{3} g_1 \delta_{\alpha\beta} \delta_{ij} \sin \Theta_W \left( \gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (304)$$


---



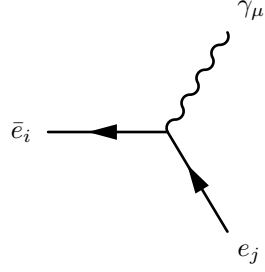
$$- i \frac{1}{\sqrt{2}} g_2 \delta_{\alpha\beta} \sum_{a=1}^3 U_{L,ja}^{d,*} U_{L,ia}^u \left( \gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (305)$$


---



$$-i \frac{1}{\sqrt{2}} g_2 \sum_{a=1}^3 U_{L,ja}^{e,*} U_{ia}^V \left( \gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (306)$$

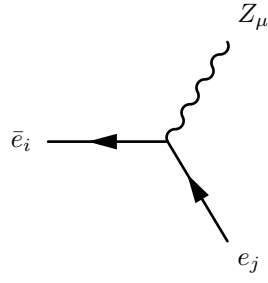

---



$$\frac{i}{2} \delta_{ij} \left( g_1 \cos \Theta_W + g_2 \sin \Theta_W \right) \left( \gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (307)$$

$$+ i g_1 \cos \Theta_W \delta_{ij} \left( \gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (308)$$

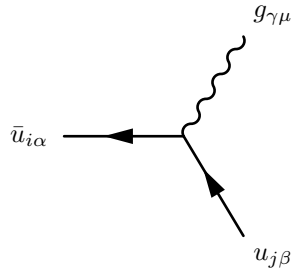

---



$$\frac{i}{2} \delta_{ij} \left( -g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left( \gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (309)$$

$$+ -i g_1 \delta_{ij} \sin \Theta_W \left( \gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (310)$$


---

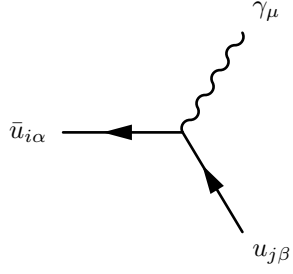




$$-\frac{i}{2}g_3\delta_{ij}\lambda_{\alpha,\beta}^\gamma\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (311)$$

$$+\frac{i}{2}g_3\delta_{ij}\lambda_{\alpha,\beta}^\gamma\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (312)$$

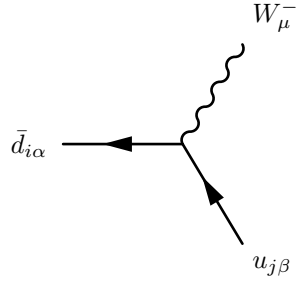

---



$$-\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(3g_2\sin\Theta_W+g_1\cos\Theta_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (313)$$

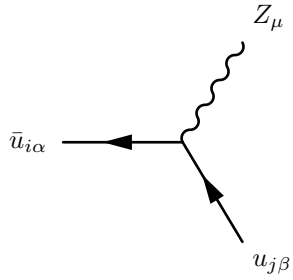
$$+\frac{2i}{3}g_1\cos\Theta_W\delta_{\alpha\beta}\delta_{ij}\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (314)$$


---



$$-i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^3U_{L,ja}^{u,*}U_{L,ia}^d\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (315)$$

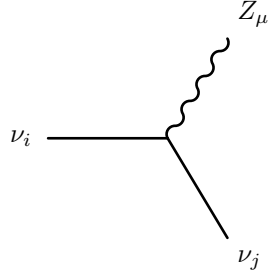

---



$$-\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(3g_2\cos\Theta_W-g_1\sin\Theta_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (316)$$

$$+\frac{2i}{3}g_1\delta_{\alpha\beta}\delta_{ij}\sin\Theta_W\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (317)$$

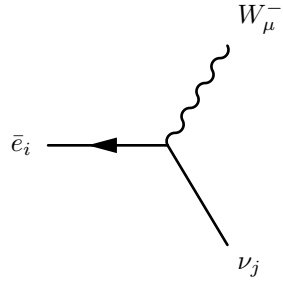

---



$$-\frac{i}{2}\left(g_1\sin\Theta_W+g_2\cos\Theta_W\right)\sum_{a=1}^3U_{ja}^{V,*}U_{ia}^V\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (318)$$

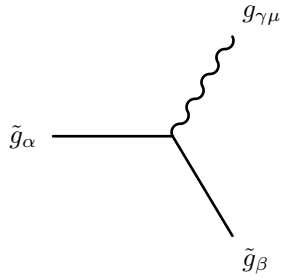
$$+\frac{i}{2}\left(g_1\sin\Theta_W+g_2\cos\Theta_W\right)\sum_{a=1}^3U_{ia}^{V,*}U_{ja}^V\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (319)$$


---



$$-i\frac{1}{\sqrt{2}}g_2\sum_{a=1}^3U_{ja}^{V,*}U_{L,ia}^e\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (320)$$

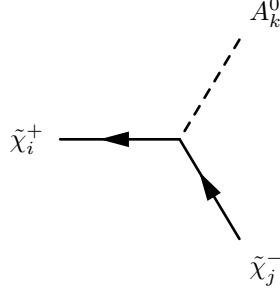

---



$$-g_3|\phi_{\tilde{g}}|^2 f_{\alpha,\beta,\gamma}\left(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\right) \quad (321)$$

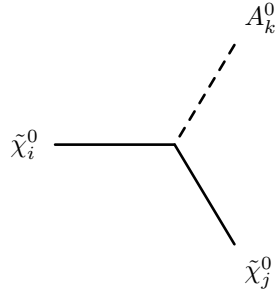
$$+ -g_3|\phi_{\tilde{g}}|^2 f_{\alpha,\beta,\gamma}\left(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\right) \quad (322)$$

## 9.5 Two Fermion-One Scalar Boson-Interaction



$$\frac{1}{\sqrt{2}}\left(-g_2 U_{j1}^* V_{i2}^* Z_{k2}^A + U_{j2}^*\left(-g_2 V_{i1}^* Z_{k1}^A + \lambda V_{i2}^* Z_{k3}^A\right)\right)\left(\frac{1-\gamma_5}{2}\right) \quad (323)$$

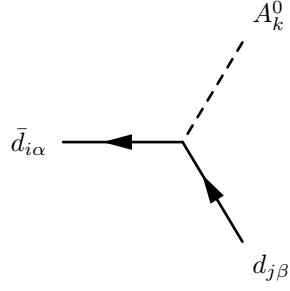
$$+ \frac{1}{\sqrt{2}}\left(g_2 U_{i1} V_{j2} Z_{k2}^A + U_{i2}\left(g_2 V_{j1} Z_{k1}^A - \lambda^* V_{j2} Z_{k3}^A\right)\right)\left(\frac{1+\gamma_5}{2}\right) \quad (324)$$



$$\begin{aligned} & \frac{1}{2}\left(-g_2 N_{i2}^* N_{j3}^* Z_{k1}^A - \sqrt{2}\lambda N_{i5}^* N_{j4}^* Z_{k1}^A - \sqrt{2}\lambda N_{i4}^* N_{j5}^* Z_{k1}^A - g_1 N_{i4}^* N_{j1}^* Z_{k2}^A \right. \\ & + g_2 N_{i4}^* N_{j2}^* Z_{k2}^A - \sqrt{2}\lambda N_{i5}^* N_{j3}^* Z_{k2}^A + g_2 N_{i2}^* N_{j4}^* Z_{k2}^A \\ & + g_1 N_{i1}^* \left(N_{j3}^* Z_{k1}^A - N_{j4}^* Z_{k2}^A\right) - \sqrt{2}\lambda N_{i4}^* N_{j3}^* Z_{k3}^A + 2\sqrt{2}\kappa N_{i5}^* N_{j5}^* Z_{k3}^A \\ & + N_{i3}^* \left(g_1 N_{j1}^* Z_{k1}^A - g_2 N_{j2}^* Z_{k1}^A - \sqrt{2}\lambda \left(N_{j4}^* Z_{k3}^A + N_{j5}^* Z_{k2}^A\right)\right)\left.\right)\left(\frac{1-\gamma_5}{2}\right) \\ & + \frac{1}{2}\left(Z_{k1}^A \left(-g_1 N_{i1} N_{j3} + g_2 N_{i2} N_{j3} + N_{i3} \left(-g_1 N_{j1} + g_2 N_{j2}\right) + \sqrt{2}\lambda^* N_{i4} N_{j5} + \sqrt{2}\lambda^* N_{i5} N_{j4}\right) \right. \\ & \left. + \sqrt{2} Z_{k3}^A \left(-2\kappa^* N_{i5} N_{j5} + \lambda^* \left(N_{i3} N_{j4} + N_{i4} N_{j3}\right)\right)\right) \end{aligned} \quad (325)$$

$$+ Z_{k2}^A \left( \left( g_1 N_{i1} - g_2 N_{i2} \right) N_{j4} + N_{i4} \left( g_1 N_{j1} - g_2 N_{j2} \right) + \sqrt{2} \lambda^* \left( N_{i3} N_{j5} + N_{i5} N_{j3} \right) \right) \left( \frac{1 + \gamma_5}{2} \right) \quad (326)$$

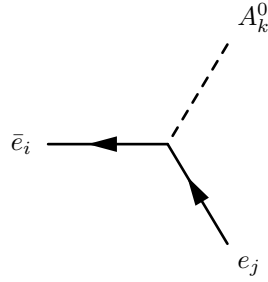

---



$$\frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{d,*} \sum_{a=1}^3 U_{R,ia}^{d,*} Y_{d,ab} Z_{k1}^A \left( \frac{1 - \gamma_5}{2} \right) \quad (327)$$

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

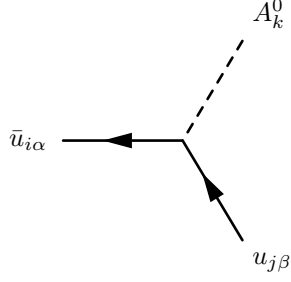

---



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

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

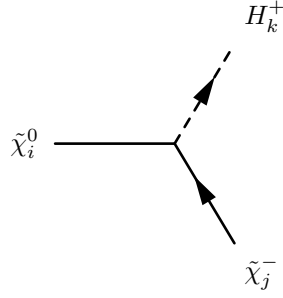

---



$$\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^3U_{L,jb}^{u,*}\sum_{a=1}^3U_{R,ia}^{u,*}Y_{u,ab}Z_{k2}^A\left(\frac{1-\gamma_5}{2}\right) \quad (331)$$

$$+ -\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^3\sum_{a=1}^3Y_{u,ab}^*U_{R,ja}^uU_{L,ib}^uZ_{k2}^A\left(\frac{1+\gamma_5}{2}\right) \quad (332)$$

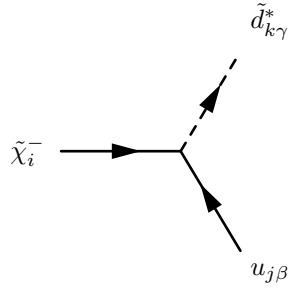

---



$$\frac{i}{2}\left(-2g_2U_{j1}^*N_{i3}^*Z_{k1}^+ + U_{j2}^*\left(-2\lambda N_{i5}^*Z_{k2}^+ + \sqrt{2}g_1N_{i1}^*Z_{k1}^+ + \sqrt{2}g_2N_{i2}^*Z_{k1}^+\right)\right)\left(\frac{1-\gamma_5}{2}\right) \quad (333)$$

$$+ -\frac{i}{2}\left(\left(2g_2V_{j1}N_{i4} + \sqrt{2}V_{j2}\left(g_1N_{i1} + g_2N_{i2}\right)\right)Z_{k2}^+ + 2\lambda^*V_{j2}N_{i5}Z_{k1}^+\right)\left(\frac{1+\gamma_5}{2}\right) \quad (334)$$

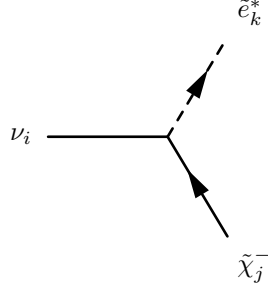

---



$$-i\delta_{\beta\gamma}\left(g_2U_{i1}^*\sum_{a=1}^3U_{L,ja}^{u,*}Z_{ka}^D-U_{i2}^*\sum_{b=1}^3U_{L,jb}^{u,*}\sum_{a=1}^3Y_{d,ab}Z_{k3+a}^D\right)\left(\frac{1-\gamma_5}{2}\right) \quad (335)$$

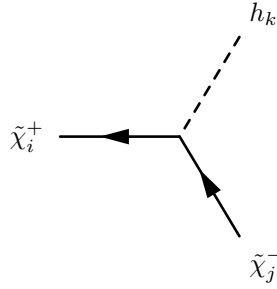
$$+i\delta_{\beta\gamma}\sum_{b=1}^3\sum_{a=1}^3Y_{u,ab}^*U_{R,ja}^uZ_{kb}^DV_{i2}\left(\frac{1+\gamma_5}{2}\right) \quad (336)$$


---



$$-i\left(g_2U_{j1}^*\sum_{a=1}^3U_{ia}^{V,*}Z_{ka}^E-U_{j2}^*\sum_{b=1}^3U_{ib}^{V,*}\sum_{a=1}^3Y_{e,ab}Z_{k3+a}^E\right)\left(\frac{1-\gamma_5}{2}\right) \quad (337)$$

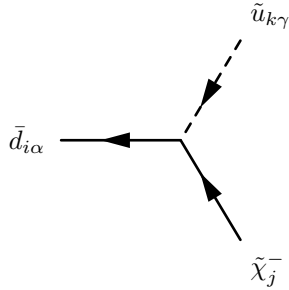

---



$$-i\frac{1}{\sqrt{2}}\left(g_2U_{j1}^*V_{i2}^*Z_{k2}^H+U_{j2}^*\left(g_2V_{i1}^*Z_{k1}^H+\lambda V_{i2}^*Z_{k3}^H\right)\right)\left(\frac{1-\gamma_5}{2}\right) \quad (338)$$

$$+ -i\frac{1}{\sqrt{2}}\left(g_2U_{i1}V_{j2}Z_{k2}^H+U_{i2}\left(g_2V_{j1}Z_{k1}^H+\lambda^*V_{j2}Z_{k3}^H\right)\right)\left(\frac{1+\gamma_5}{2}\right) \quad (339)$$

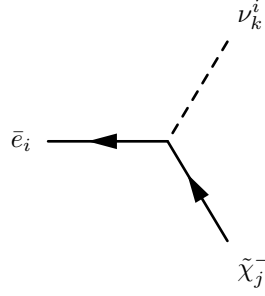

---



$$iU_{j2}^* \delta_{\alpha\gamma} \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 U_{R,ia}^{d,*} Y_{d,ab} \left( \frac{1-\gamma_5}{2} \right) \quad (340)$$

$$+ -i\delta_{\alpha\gamma} \left( g_2 \sum_{a=1}^3 Z_{ka}^{U,*} U_{L,ia}^d V_{j1} - \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{k3+a}^{U,*} U_{L,ib}^d V_{j2} \right) \left( \frac{1+\gamma_5}{2} \right) \quad (341)$$

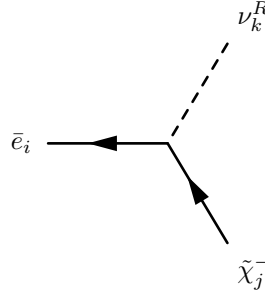

---



$$- \frac{1}{\sqrt{2}} U_{j2}^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 U_{R,ia}^{e,*} Y_{e,ab} \left( \frac{1-\gamma_5}{2} \right) \quad (342)$$

$$+ \frac{1}{\sqrt{2}} \left( g_2 \sum_{a=1}^3 Z_{ka}^{i,*} U_{L,ia}^e V_{j1} - \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} U_{L,ib}^e V_{j2} \right) \left( \frac{1+\gamma_5}{2} \right) \quad (343)$$

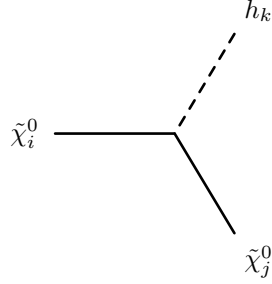

---



$$i \frac{1}{\sqrt{2}} U_{j2}^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 U_{R,ia}^{e,*} Y_{e,ab} \left( \frac{1-\gamma_5}{2} \right) \quad (344)$$

$$+ -i \frac{1}{\sqrt{2}} \left( g_2 \sum_{a=1}^3 Z_{ka}^{R,*} U_{L,ia}^e V_{j1} - \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} U_{L,ib}^e V_{j2} \right) \left( \frac{1+\gamma_5}{2} \right) \quad (345)$$

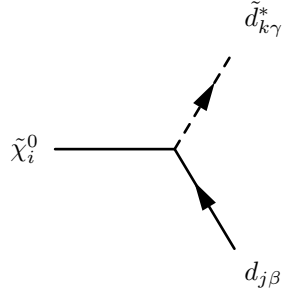

---



$$\begin{aligned}
& \frac{i}{2} \left( -g_2 N_{i2}^* N_{j3}^* Z_{k1}^H + \sqrt{2} \lambda N_{i5}^* N_{j4}^* Z_{k1}^H + \sqrt{2} \lambda N_{i4}^* N_{j5}^* Z_{k1}^H - g_1 N_{i4}^* N_{j1}^* Z_{k2}^H \right. \\
& + g_2 N_{i4}^* N_{j2}^* Z_{k2}^H + \sqrt{2} \lambda N_{i5}^* N_{j3}^* Z_{k2}^H + g_2 N_{i2}^* N_{j4}^* Z_{k2}^H \\
& + g_1 N_{i1}^* \left( N_{j3}^* Z_{k1}^H - N_{j4}^* Z_{k2}^H \right) + \sqrt{2} \lambda N_{i4}^* N_{j3}^* Z_{k3}^H - 2\sqrt{2} \kappa N_{i5}^* N_{j5}^* Z_{k3}^H \\
& \left. + N_{i3}^* \left( g_1 N_{j1}^* Z_{k1}^H - g_2 N_{j2}^* Z_{k1}^H + \sqrt{2} \lambda \left( N_{j4}^* Z_{k3}^H + N_{j5}^* Z_{k2}^H \right) \right) \right) \left( \frac{1-\gamma_5}{2} \right) \quad (346)
\end{aligned}$$

$$\begin{aligned}
& + \frac{i}{2} \left( Z_{k1}^H \left( g_1 N_{i1} N_{j3} - g_2 N_{i2} N_{j3} + N_{i3} \left( g_1 N_{j1} - g_2 N_{j2} \right) + \sqrt{2} \lambda^* N_{i4} N_{j5} + \sqrt{2} \lambda^* N_{i5} N_{j4} \right) \right. \\
& + \sqrt{2} Z_{k3}^H \left( -2\kappa^* N_{i5} N_{j5} + \lambda^* \left( N_{i3} N_{j4} + N_{i4} N_{j3} \right) \right) \\
& \left. + Z_{k2}^H \left( \left( -g_1 N_{i1} + g_2 N_{i2} \right) N_{j4} + N_{i4} \left( -g_1 N_{j1} + g_2 N_{j2} \right) + \sqrt{2} \lambda^* \left( N_{i3} N_{j5} + N_{i5} N_{j3} \right) \right) \right) \left( \frac{1+\gamma_5}{2} \right) \quad (347)
\end{aligned}$$


---

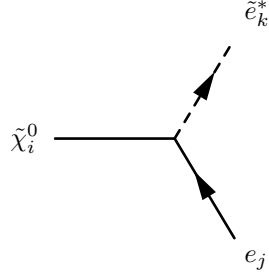


$$-\frac{i}{6} \delta_{\beta\gamma} \left( -3\sqrt{2} g_2 N_{i2}^* \sum_{a=1}^3 U_{L,ja}^{d,*} Z_{ka}^D + 6N_{i3}^* \sum_{b=1}^3 U_{L,jb}^{d,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D + \sqrt{2} g_1 N_{i1}^* \sum_{a=1}^3 U_{L,ja}^{d,*} Z_{ka}^D \right) \left( \frac{1-\gamma_5}{2} \right) \quad (348)$$

$$+ -\frac{i}{3} \delta_{\beta\gamma} \left( 3 \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* U_{R,ja}^d Z_{kb}^D N_{i3} + \sqrt{2} g_1 \sum_{a=1}^3 Z_{k3+a}^D U_{R,ja}^d N_{i1} \right) \left( \frac{1+\gamma_5}{2} \right) \quad (349)$$


---

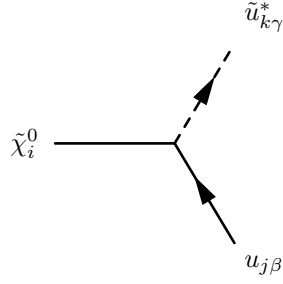




$$\frac{i}{2} \left( -2N_{i3}^* \sum_{b=1}^3 U_{L,jb}^{e,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E + \sqrt{2}g_1 N_{i1}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{ka}^E + \sqrt{2}g_2 N_{i2}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{ka}^E \right) \left( \frac{1-\gamma_5}{2} \right) \quad (350)$$

$$+ -i \left( \sqrt{2}g_1 \sum_{a=1}^3 Z_{k3+a}^E U_{R,ja}^e N_{i1} + \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* U_{R,ja}^e Z_{kb}^E N_{i3} \right) \left( \frac{1+\gamma_5}{2} \right) \quad (351)$$

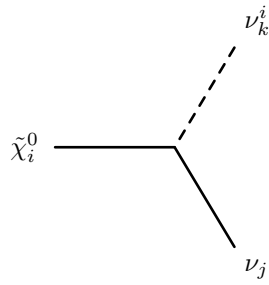

---



$$- \frac{i}{6} \delta_{\beta\gamma} \left( 3\sqrt{2}g_2 N_{i2}^* \sum_{a=1}^3 U_{L,ja}^{u,*} Z_{ka}^U + 6N_{i4}^* \sum_{b=1}^3 U_{L,jb}^{u,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U + \sqrt{2}g_1 N_{i1}^* \sum_{a=1}^3 U_{L,ja}^{u,*} Z_{ka}^U \right) \left( \frac{1-\gamma_5}{2} \right) \quad (352)$$

$$+ \frac{i}{3} \delta_{\beta\gamma} \left( 2\sqrt{2}g_1 \sum_{a=1}^3 Z_{k3+a}^U U_{R,ja}^u N_{i1} - 3 \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* U_{R,ja}^u Z_{kb}^U N_{i4} \right) \left( \frac{1+\gamma_5}{2} \right) \quad (353)$$

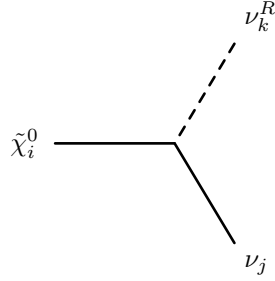

---



$$\begin{aligned}
& \frac{1}{2} \left( g_1 N_{i1}^* \sum_{a=1}^3 U_{ja}^{V,*} Z_{ka}^{i,*} - g_2 N_{i2}^* \sum_{a=1}^3 U_{ja}^{V,*} Z_{ka}^{i,*} \right. \\
& \left. - \sqrt{2} \left( N_{i4}^* \sum_{b=1}^3 U_{jb}^{V,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} + N_{i5}^* \sum_{b=1}^3 U_{j6+b}^{V,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} \lambda_{N,ab} \right) \right) \left( \frac{1-\gamma_5}{2} \right) \quad (354)
\end{aligned}$$

$$\begin{aligned}
& + \frac{1}{2} \left( \sum_{a=1}^3 Z_{ka}^{i,*} U_{ja}^V \left( -g_1 N_{i1} + g_2 N_{i2} \right) \right. \\
& \left. + \sqrt{2} \left( \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} U_{jb}^V N_{i4} + \sum_{b=1}^3 \sum_{a=1}^3 Z_{k3+a}^{i,*} \lambda_{N,ab}^* U_{j6+b}^V N_{i5} \right) \right) \left( \frac{1+\gamma_5}{2} \right) \quad (355)
\end{aligned}$$

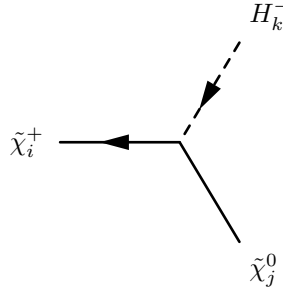

---



$$\begin{aligned}
& \frac{i}{2} \left( g_1 N_{i1}^* \sum_{a=1}^3 U_{ja}^{V,*} Z_{ka}^{R,*} - g_2 N_{i2}^* \sum_{a=1}^3 U_{ja}^{V,*} Z_{ka}^{R,*} \right. \\
& \left. - \sqrt{2} \left( N_{i4}^* \sum_{b=1}^3 U_{jb}^{V,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} + N_{i5}^* \sum_{b=1}^3 U_{j6+b}^{V,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} \lambda_{N,ab} \right) \right) \left( \frac{1-\gamma_5}{2} \right) \quad (356)
\end{aligned}$$

$$\begin{aligned}
& + \frac{i}{2} \left( \sum_{a=1}^3 Z_{ka}^{R,*} U_{ja}^V \left( g_1 N_{i1} - g_2 N_{i2} \right) \right. \\
& \left. - \sqrt{2} \left( \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} U_{jb}^V N_{i4} + \sum_{b=1}^3 \sum_{a=1}^3 Z_{k3+a}^{R,*} \lambda_{N,ab}^* U_{j6+b}^V N_{i5} \right) \right) \left( \frac{1+\gamma_5}{2} \right) \quad (357)
\end{aligned}$$

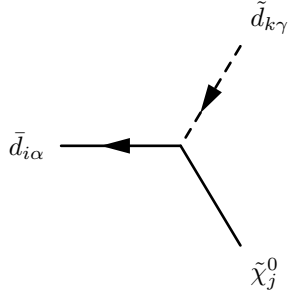

---



$$-\frac{i}{2}\left(2g_2V_{i1}^*N_{j4}^*Z_{k2}^++V_{i2}^*\left(2\lambda N_{j5}^*Z_{k1}^++\sqrt{2}\left(g_1N_{j1}^++g_2N_{j2}^*\right)Z_{k2}^+\right)\right)\left(\frac{1-\gamma_5}{2}\right) \quad (358)$$

$$+\frac{i}{2}\left(-2g_2U_{i1}N_{j3}Z_{k1}^++U_{i2}\left(-2\lambda^*N_{j5}Z_{k2}^++\sqrt{2}g_1N_{j1}Z_{k1}^++\sqrt{2}g_2N_{j2}Z_{k1}^+\right)\right)\left(\frac{1+\gamma_5}{2}\right) \quad (359)$$

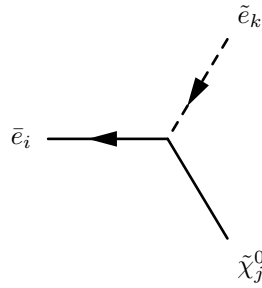

---



$$-\frac{i}{3}\delta_{\alpha\gamma}\left(3N_{j3}^*\sum_{b=1}^3Z_{kb}^{D,*}\sum_{a=1}^3U_{R,ia}^{d,*}Y_{d,ab}+\sqrt{2}g_1N_{j1}^*\sum_{a=1}^3Z_{k3+a}^{D,*}U_{R,ia}^{d,*}\right)\left(\frac{1-\gamma_5}{2}\right) \quad (360)$$

$$+\frac{i}{6}\delta_{\alpha\gamma}\left(6\sum_{b=1}^3\sum_{a=1}^3Y_{d,ab}^*Z_{k3+a}^{D,*}U_{L,ib}^dN_{j3}+\sqrt{2}\sum_{a=1}^3Z_{ka}^{D,*}U_{L,ia}^d\left(-3g_2N_{j2}+g_1N_{j1}\right)\right)\left(\frac{1+\gamma_5}{2}\right) \quad (361)$$

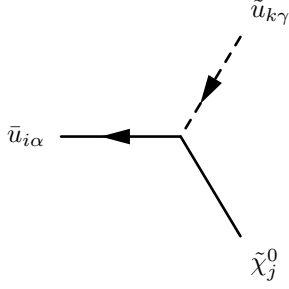

---



$$-i\left(N_{j3}^*\sum_{b=1}^3Z_{kb}^{E,*}\sum_{a=1}^3U_{R,ia}^{e,*}Y_{e,ab}+\sqrt{2}g_1N_{j1}^*\sum_{a=1}^3Z_{k3+a}^{E,*}U_{R,ia}^{e,*}\right)\left(\frac{1-\gamma_5}{2}\right) \quad (362)$$

$$+\frac{i}{2}\left(-2\sum_{b=1}^3\sum_{a=1}^3Y_{e,ab}^*Z_{k3+a}^{E,*}U_{L,ib}^eN_{j3}+\sqrt{2}\sum_{a=1}^3Z_{ka}^{E,*}U_{L,ia}^e\left(g_1N_{j1}+g_2N_{j2}\right)\right)\left(\frac{1+\gamma_5}{2}\right) \quad (363)$$

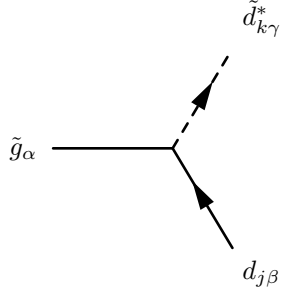

---



$$\frac{i}{3}\delta_{\alpha\gamma}\left(2\sqrt{2}g_1N_{j1}^*\sum_{a=1}^3Z_{k3+a}^{U,*}U_{R,ia}^{u,*}-3N_{j4}^*\sum_{b=1}^3Z_{kb}^{U,*}\sum_{a=1}^3U_{R,ia}^{u,*}Y_{u,ab}\right)\left(\frac{1-\gamma_5}{2}\right) \quad (364)$$

$$+ -\frac{i}{6}\delta_{\alpha\gamma}\left(6\sum_{b=1}^3\sum_{a=1}^3Y_{u,ab}^*Z_{k3+a}^{U,*}U_{L,ib}^uN_{j4}+\sqrt{2}\sum_{a=1}^3Z_{ka}^{U,*}U_{L,ia}^u\left(3g_2N_{j2}+g_1N_{j1}\right)\right)\left(\frac{1+\gamma_5}{2}\right) \quad (365)$$

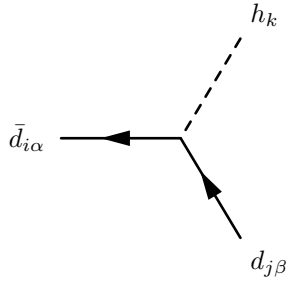

---



$$-i\frac{1}{\sqrt{2}}g_3\phi_{\tilde{g}}^*\lambda_{\gamma,\beta}^\alpha\sum_{a=1}^3U_{L,ja}^{d,*}Z_{ka}^D\left(\frac{1-\gamma_5}{2}\right) \quad (366)$$

$$+i\frac{1}{\sqrt{2}}g_3\phi_{\tilde{g}}^*\lambda_{\gamma,\beta}^\alpha\sum_{a=1}^3Z_{k3+a}^DU_{R,ja}^d\left(\frac{1+\gamma_5}{2}\right) \quad (367)$$

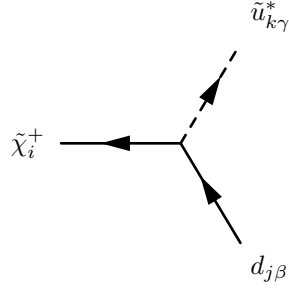

---



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

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

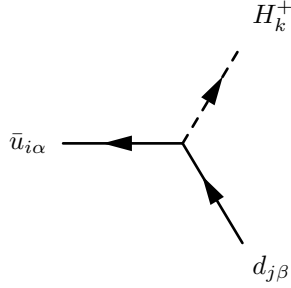

---



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

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

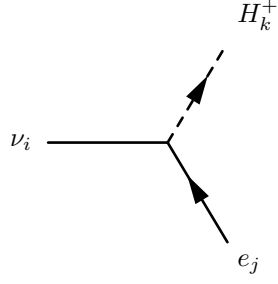

---



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

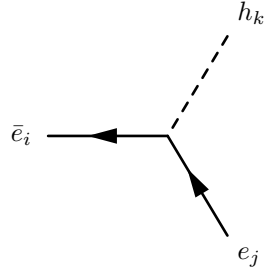
$$+ i \delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* U_{R,ja}^d U_{L,ib}^u Z_{k1}^+ \left( \frac{1+\gamma_5}{2} \right) \quad (373)$$


---



(374)

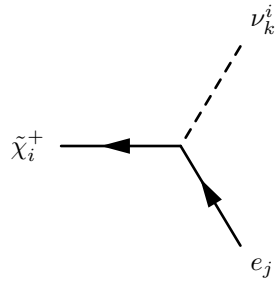
$$+ i \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* U_{R,ja}^e U_{ib}^V Z_{k1}^+ \left( \frac{1 + \gamma_5}{2} \right) \quad (375)$$



(376)

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

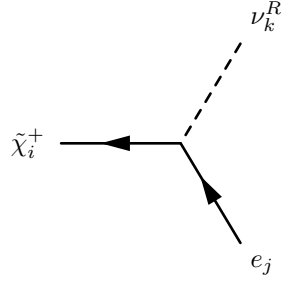
$$+ -i \frac{1}{\sqrt{2}} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* U_{R,ja}^e U_{L,ib}^e Z_{k1}^H \left( \frac{1 + \gamma_5}{2} \right) \quad (377)$$



$$\frac{1}{\sqrt{2}} \left( -g_2 V_{i1}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{ka}^{i,*} + V_{i2}^* \sum_{b=1}^3 U_{L,jb}^{e,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \right) \left( \frac{1-\gamma_5}{2} \right) \quad (378)$$

$$+ \frac{1}{\sqrt{2}} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{e,ab}^* U_{R,ja}^e U_{i2} \left( \frac{1+\gamma_5}{2} \right) \quad (379)$$

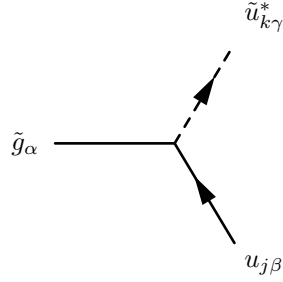

---



$$-i \frac{1}{\sqrt{2}} \left( g_2 V_{i1}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{ka}^{R,*} - V_{i2}^* \sum_{b=1}^3 U_{L,jb}^{e,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \right) \left( \frac{1-\gamma_5}{2} \right) \quad (380)$$

$$+ i \frac{1}{\sqrt{2}} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{e,ab}^* U_{R,ja}^e U_{i2} \left( \frac{1+\gamma_5}{2} \right) \quad (381)$$

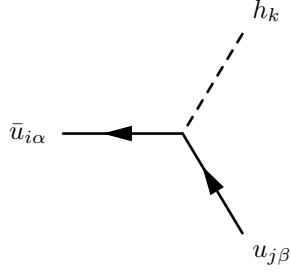

---



$$-i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\gamma,\beta}^\alpha \sum_{a=1}^3 U_{L,ja}^{u,*} Z_{ka}^U \left( \frac{1-\gamma_5}{2} \right) \quad (382)$$

$$+ i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\gamma,\beta}^\alpha \sum_{a=1}^3 Z_{k3+a}^U U_{R,ja}^u \left( \frac{1+\gamma_5}{2} \right) \quad (383)$$

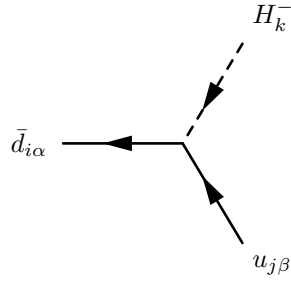

---



$$-i \frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{u,*} \sum_{a=1}^3 U_{R,ia}^{u,*} Y_{u,ab} Z_{k2}^H \left( \frac{1-\gamma_5}{2} \right) \quad (384)$$

$$+ -i \frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* U_{R,ja}^u U_{L,ib}^u Z_{k2}^H \left( \frac{1+\gamma_5}{2} \right) \quad (385)$$

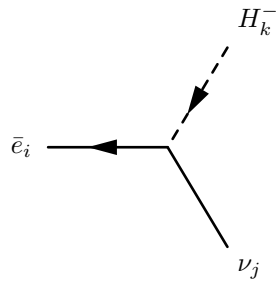

---



$$i \delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{u,*} \sum_{a=1}^3 U_{R,ia}^{d,*} Y_{d,ab} Z_{k1}^+ \left( \frac{1-\gamma_5}{2} \right) \quad (386)$$

$$+ i \delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* U_{R,ja}^u U_{L,ib}^d Z_{k2}^+ \left( \frac{1+\gamma_5}{2} \right) \quad (387)$$

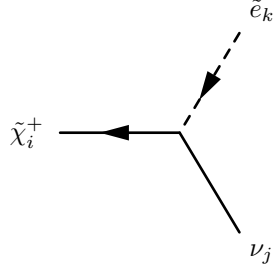

---





$$i \sum_{b=1}^3 U_{jb}^{V,*} \sum_{a=1}^3 U_{R,ia}^{e,*} Y_{e,ab} Z_{k1}^+ \left( \frac{1-\gamma_5}{2} \right) \quad (388)$$

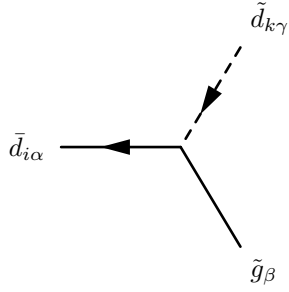

---



(389)

$$+ -i \left( g_2 \sum_{a=1}^3 Z_{ka}^{E,*} U_{ja}^V U_{i1} - \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{k3+a}^{E,*} U_{jb}^V U_{i2} \right) \left( \frac{1+\gamma_5}{2} \right) \quad (390)$$

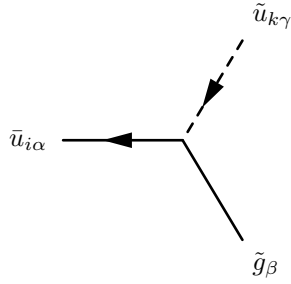

---



$$i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}} \lambda_{\alpha,\gamma}^\beta \sum_{a=1}^3 Z_{k3+a}^{D,*} U_{R,ia}^{d,*} \left( \frac{1-\gamma_5}{2} \right) \quad (391)$$

$$+ -i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\alpha,\gamma}^\beta \sum_{a=1}^3 Z_{ka}^{D,*} U_{L,ia}^d \left( \frac{1+\gamma_5}{2} \right) \quad (392)$$

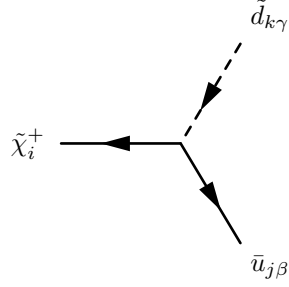

---



$$i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}} \lambda_{\alpha, \gamma}^{\beta} \sum_{a=1}^3 Z_{k3+a}^{U,*} U_{R,ia}^{u,*} \left( \frac{1-\gamma_5}{2} \right) \quad (393)$$

$$+ -i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\alpha, \gamma}^{\beta} \sum_{a=1}^3 Z_{ka}^{U,*} U_{L,ia}^u \left( \frac{1+\gamma_5}{2} \right) \quad (394)$$


---

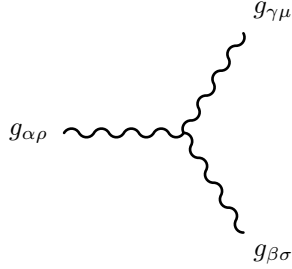


$$i V_{i2}^* \delta_{\beta\gamma} \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 U_{R,ja}^{u,*} Y_{u,ab} \left( \frac{1-\gamma_5}{2} \right) \quad (395)$$

$$+ -i \delta_{\beta\gamma} \left( g_2 \sum_{a=1}^3 Z_{ka}^{D,*} U_{L,ja}^u U_{i1} - \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{k3+a}^{D,*} U_{L,jb}^u U_{i2} \right) \left( \frac{1+\gamma_5}{2} \right) \quad (396)$$

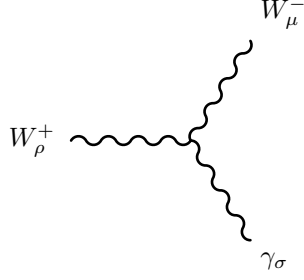

---

## 9.6 Three Vector Boson-Interaction



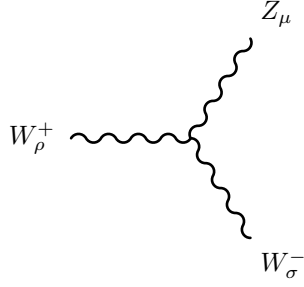
$$g_3 f_{\alpha, \beta, \gamma} \left( g_{\rho\mu} \left( -p_{\sigma}^{g\gamma\mu} + p_{\sigma}^{g\alpha\rho} \right) + g_{\rho\sigma} \left( -p_{\mu}^{g\alpha\rho} + p_{\mu}^{g\beta\sigma} \right) + g_{\sigma\mu} \left( -p_{\rho}^{g\beta\sigma} + p_{\rho}^{g\gamma\mu} \right) \right) \quad (397)$$


---



$$ig_2 \sin \Theta_W \left( g_{\rho\mu} \left( -p_\sigma^{W_\mu^-} + p_\sigma^{W_\rho^+} \right) + g_{\rho\sigma} \left( -p_\mu^{W_\rho^+} + p_\mu^{\gamma_\sigma} \right) + g_{\sigma\mu} \left( -p_\rho^{\gamma_\sigma} + p_\rho^{W_\mu^-} \right) \right) \quad (398)$$

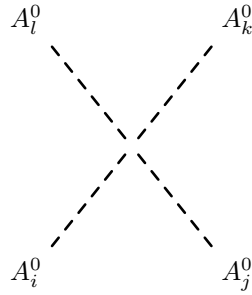

---



$$-ig_2 \cos \Theta_W \left( g_{\rho\mu} \left( -p_\sigma^{Z_\mu} + p_\sigma^{W_\rho^+} \right) + g_{\rho\sigma} \left( -p_\mu^{W_\rho^+} + p_\mu^{W_\sigma^-} \right) + g_{\sigma\mu} \left( -p_\rho^{W_\sigma^-} + p_\rho^{Z_\mu} \right) \right) \quad (399)$$


---

## 9.7 Four Scalar-Interaction

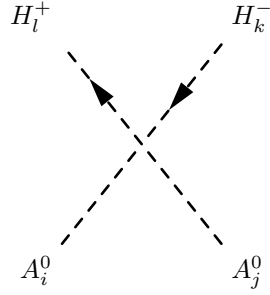


$$\begin{aligned} & -\frac{i}{4} \left( Z_{i1}^A \left( Z_{j1}^A \left( 3(g_1^2 + g_2^2) Z_{k1}^A Z_{l1}^A - \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k2}^A Z_{l2}^A + 4|\lambda|^2 Z_{k3}^A Z_{l3}^A \right) \right. \right. \\ & \left. \left. - Z_{j2}^A \left( 2(\kappa\lambda^* + \lambda\kappa^*)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



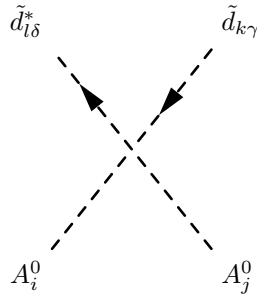
$$\begin{aligned}
& -\frac{i}{4}\left(Z_{i2}^A\left(Z_{j2}^A\left(-\left(-4|\lambda|^2+g_1^2+g_2^2\right)Z_{k1}^HZ_{l1}^H+4|\lambda|^2Z_{k3}^HZ_{l3}^H+\left(g_1^2+g_2^2\right)Z_{k2}^HZ_{l2}^H\right)\right.\right. \\
& \left.-2\left(\kappa\lambda^*+\lambda\kappa^*\right)\left(-Z_{j1}^AZ_{k3}^HZ_{l3}^H+Z_{j3}^A\left(Z_{k1}^HZ_{l3}^H+Z_{k3}^HZ_{l1}^H\right)\right)\right) \\
& +Z_{i1}^A\left(Z_{j1}^A\left(-\left(-4|\lambda|^2+g_1^2+g_2^2\right)Z_{k2}^HZ_{l2}^H+4|\lambda|^2Z_{k3}^HZ_{l3}^H+\left(g_1^2+g_2^2\right)Z_{k1}^HZ_{l1}^H\right)\right. \\
& \left.-2\left(\kappa\lambda^*+\lambda\kappa^*\right)\left(-Z_{j2}^AZ_{k3}^HZ_{l3}^H+Z_{j3}^A\left(Z_{k2}^HZ_{l3}^H+Z_{k3}^HZ_{l2}^H\right)\right)\right) \\
& +2Z_{i3}^A\left(\lambda^*\left(Z_{j3}^A\left(Z_{k1}^H\left(2\lambda Z_{l1}^H+\kappa Z_{l2}^H\right)+Z_{k2}^H\left(2\lambda Z_{l2}^H+\kappa Z_{l1}^H\right)\right)\right.\right. \\
& \left.-\kappa\left(Z_{j1}^A\left(Z_{k2}^HZ_{l3}^H+Z_{k3}^HZ_{l2}^H\right)+Z_{j2}^A\left(Z_{k1}^HZ_{l3}^H+Z_{k3}^HZ_{l1}^H\right)\right)\right) \\
& \left.+\kappa^*\left(Z_{j3}^A\left(4\kappa Z_{k3}^HZ_{l3}^H+\lambda Z_{k1}^HZ_{l2}^H+\lambda Z_{k2}^HZ_{l1}^H\right)\right.\right. \\
& \left.-\lambda\left(Z_{j1}^A\left(Z_{k2}^HZ_{l3}^H+Z_{k3}^HZ_{l2}^H\right)+Z_{j2}^A\left(Z_{k1}^HZ_{l3}^H+Z_{k3}^HZ_{l1}^H\right)\right)\right)\left.\right) \tag{402}
\end{aligned}$$


---



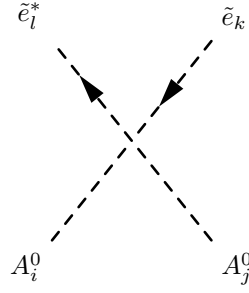
$$\begin{aligned}
& -\frac{i}{4}\left(Z_{i1}^A\left(-\left(-2|\lambda|^2+g_2^2\right)Z_{j2}^A\left(Z_{k1}^+Z_{l2}^++Z_{k2}^+Z_{l1}^+\right)\right.\right. \\
& +Z_{j1}^A\left(\left(g_1^2+g_2^2\right)Z_{k1}^+Z_{l1}^++\left(-g_1^2+g_2^2\right)Z_{k2}^+Z_{l2}^+\right) \\
& +Z_{i2}^A\left(-\left(-2|\lambda|^2+g_2^2\right)Z_{j1}^A\left(Z_{k1}^+Z_{l2}^++Z_{k2}^+Z_{l1}^+\right)\right. \\
& +Z_{j2}^A\left(\left(-g_1^2+g_2^2\right)Z_{k1}^+Z_{l1}^++\left(g_1^2+g_2^2\right)Z_{k2}^+Z_{l2}^+\right) \\
& \left.\left.+4Z_{i3}^AZ_{j3}^A\left(-\lambda\kappa^*Z_{k1}^+Z_{l2}^++\lambda^*\left(\lambda Z_{k1}^+Z_{l1}^++Z_{k2}^+\left(-\kappa Z_{l1}^++\lambda Z_{l2}^+\right)\right)\right)\right)\right) \tag{403}
\end{aligned}$$


---



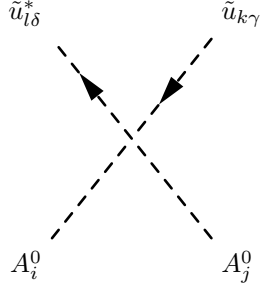
$$\begin{aligned}
& \frac{i}{12} \delta_{\gamma\delta} \left( \left( 3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{D,*} Z_{la}^D \left( Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A \right) \right. \\
& + 2 \left( g_1^2 \sum_{a=1}^3 Z_{k3+a}^{D,*} Z_{l3+a}^D \left( Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A \right) \right. \\
& - 3 \left( 2 \sum_{c=1}^3 Z_{k3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{d,ba} Z_{l3+b}^D Z_{i1}^A Z_{j1}^A \right. \\
& + 2 \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^D Z_{i1}^A Z_{j1}^A \\
& \left. \left. \left. + \left( \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{k3+a}^{D,*} Z_{lb}^D + \lambda^* \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D \right) \left( Z_{i2}^A Z_{j3}^A + Z_{i3}^A Z_{j2}^A \right) \right) \right) \right) \quad (404)
\end{aligned}$$


---



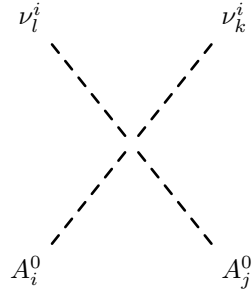
$$\begin{aligned}
& - \frac{i}{4} \left( \left( -g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{E,*} Z_{la}^E \left( Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A \right) \right. \\
& + 2 \left( 2 \sum_{c=1}^3 Z_{k3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{e,ba} Z_{l3+b}^E Z_{i1}^A Z_{j1}^A \right. \\
& + 2 \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E Z_{i1}^A Z_{j1}^A + \lambda^* \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E Z_{i3}^A Z_{j2}^A \\
& + \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{k3+a}^{E,*} Z_{lb}^E Z_{i3}^A Z_{j2}^A + g_1^2 \sum_{a=1}^3 Z_{k3+a}^{E,*} Z_{l3+a}^E \left( -Z_{i1}^A Z_{j1}^A + Z_{i2}^A Z_{j2}^A \right) \\
& \left. \left. \left. + \lambda^* \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E Z_{i2}^A Z_{j3}^A + \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{k3+a}^{E,*} Z_{lb}^E Z_{i2}^A Z_{j3}^A \right) \right) \right) \quad (405)
\end{aligned}$$


---



$$\begin{aligned}
& \frac{i}{12} \delta_{\gamma\delta} \left( \left( -3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^U \left( Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A \right) \right. \\
& - 2 \left( 2g_1^2 \sum_{a=1}^3 Z_{k3+a}^{U,*} Z_{l3+a}^U \left( Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A \right) \right. \\
& + 3 \left( 2 \left( \sum_{c=1}^3 Z_{k3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{u,ba} Z_{l3+b}^U + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^U \right) Z_{i2}^A Z_{j2}^A \right. \\
& + \lambda^* \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \left( Z_{i1}^A Z_{j3}^A + Z_{i3}^A Z_{j1}^A \right) \\
& \left. \left. + \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{k3+a}^{U,*} Z_{lb}^U \left( Z_{i1}^A Z_{j3}^A + Z_{i3}^A Z_{j1}^A \right) \right) \right) \quad (406)
\end{aligned}$$


---



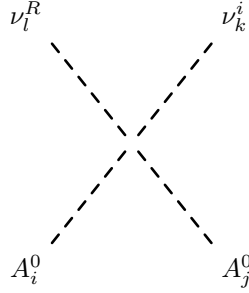
$$\begin{aligned}
& - \frac{i}{4} \left( \lambda \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba}^* Z_{i2}^A Z_{j1}^A + \lambda^* \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i2}^A Z_{j1}^A \right. \\
& + \lambda^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba} Z_{i2}^A Z_{j1}^A + \lambda \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} Z_{i3}^A Z_{j1}^A \\
& \left. + \lambda \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{l3+a}^{i,*} Z_{i3}^A Z_{j1}^A + \lambda^* \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} Z_{i3}^A Z_{j1}^A \right)
\end{aligned}$$

$$\begin{aligned}
& + \lambda^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{i,*} Y_{\nu,ab} Z_{i3}^A Z_{j1}^A + \lambda \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba}^* Z_{i1}^A Z_{j2}^A \\
& + \lambda^* \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba}^* Z_{i1}^A Z_{j2}^A + \lambda^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba}^* Z_{i1}^A Z_{j2}^A \\
& + 2 \sum_{c=1}^3 Z_{lc}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{j2}^A \\
& + 2 \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{j2}^A \\
& + 2 \sum_{c=1}^3 Z_{l3+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^A Z_{j2}^A \\
& + 2 \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^A Z_{j2}^A \\
& + \sum_{c=1}^3 Z_{l6+c}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^A Z_{j2}^A \\
& + \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^A Z_{j2}^A \\
& + \sum_{c=1}^3 Z_{lc}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^A Z_{j2}^A \\
& + \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{l6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^A Z_{j2}^A \\
& + \left( g_1^2 + g_2^2 \right) \sum_{a=1}^3 Z_{ka}^{i,*} Z_{la}^{i,*} \left( Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A \right) + \lambda \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} Z_{i1}^A Z_{j3}^A \\
& + \lambda \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{l3+a}^{i,*} Z_{i1}^A Z_{j3}^A + \lambda^* \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} Z_{i1}^A Z_{j3}^A \\
& + \lambda^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{i,*} Y_{\nu,ab} Z_{i1}^A Z_{j3}^A + \sum_{c=1}^3 Z_{l6+c}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{j3}^A \\
& + \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{j3}^A \\
& + \sum_{c=1}^3 Z_{lc}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^A Z_{j3}^A
\end{aligned}$$



$$\begin{aligned}
& + \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{l6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^A Z_{j3}^A - 2\kappa \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba}^* Z_{i3}^A Z_{j3}^A \\
& - 2\kappa^* \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i3}^A Z_{j3}^A - 2\kappa^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba} Z_{i3}^A Z_{j3}^A \\
& + 2 \sum_{c=1}^3 Z_{l6+c}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* \lambda_{N,ab} Z_{i3}^A Z_{j3}^A \\
& + 2 \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{l6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* \lambda_{N,ab} Z_{i3}^A Z_{j3}^A \\
& + 2 \sum_{c=1}^3 Z_{l3+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \lambda_{N,ba} Z_{i3}^A Z_{j3}^A \\
& + 2 \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \lambda_{N,ba} Z_{i3}^A Z_{j3}^A \\
& + \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba}^* \left( -2\kappa Z_{i3}^A Z_{j3}^A + \lambda Z_{i1}^A Z_{j2}^A + \lambda Z_{i2}^A Z_{j1}^A \right)
\end{aligned} \tag{407}$$


---

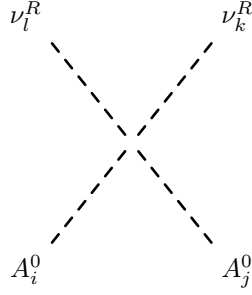


$$\begin{aligned}
& \frac{1}{4} \left( \lambda^* \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i2}^A Z_{j1}^A - \lambda^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} Z_{i2}^A Z_{j1}^A \right. \\
& + \lambda \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} Z_{i3}^A Z_{j1}^A - \lambda \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{l3+a}^{R,*} Z_{i3}^A Z_{j1}^A \\
& - \lambda^* \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} Z_{i3}^A Z_{j1}^A + \lambda^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} Z_{i3}^A Z_{j1}^A \\
& + \lambda^* \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i1}^A Z_{j2}^A - \lambda^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} Z_{i1}^A Z_{j2}^A \\
& \left. + 2 \sum_{c=1}^3 Z_{lc}^{R,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{j2}^A \right)
\end{aligned}$$

$$\begin{aligned}
& -2 \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{j2}^A \\
& -2 \sum_{c=1}^3 Z_{l3+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^A Z_{j2}^A \\
& +2 \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^A Z_{j2}^A \\
& + \sum_{c=1}^3 Z_{l6+c}^{R,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^A Z_{j2}^A \\
& - \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^A Z_{j2}^A \\
& + \sum_{c=1}^3 Z_{lc}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^A Z_{j2}^A \\
& - \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{l6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^A Z_{j2}^A + \lambda \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} Z_{i1}^A Z_{j3}^A \\
& - \lambda \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{l3+a}^{R,*} Z_{i1}^A Z_{j3}^A - \lambda^* \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} Z_{i1}^A Z_{j3}^A \\
& + \lambda^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} Z_{i1}^A Z_{j3}^A + \sum_{c=1}^3 Z_{l6+c}^{R,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{j3}^A \\
& - \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{j3}^A \\
& + \sum_{c=1}^3 Z_{lc}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^A Z_{j3}^A \\
& - \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{l6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^A Z_{j3}^A - 2\kappa^* \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i3}^A Z_{j3}^A \\
& + 2\kappa^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} Z_{i3}^A Z_{j3}^A + 2 \sum_{c=1}^3 Z_{l6+c}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* \lambda_{N,ab} Z_{i3}^A Z_{j3}^A \\
& - 2 \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{l6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* \lambda_{N,ab} Z_{i3}^A Z_{j3}^A \\
& - 2 \sum_{c=1}^3 Z_{l3+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \lambda_{N,ba} Z_{i3}^A Z_{j3}^A
\end{aligned}$$

$$\begin{aligned}
& + 2 \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \lambda_{N,ba} Z_{i3}^A Z_{j3}^A \\
& - \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba}^* \left( -2\kappa Z_{i3}^A Z_{j3}^A + \lambda Z_{i1}^A Z_{j2}^A + \lambda Z_{i2}^A Z_{j1}^A \right) \\
& + \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba}^* \left( -2\kappa Z_{i3}^A Z_{j3}^A + \lambda Z_{i1}^A Z_{j2}^A + \lambda Z_{i2}^A Z_{j1}^A \right)
\end{aligned} \tag{408}$$


---

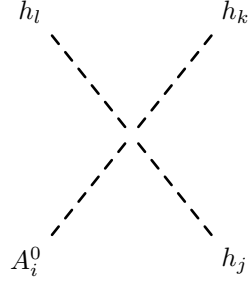


$$\begin{aligned}
& - \frac{i}{4} \left( \lambda \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba}^* Z_{i2}^A Z_{j1}^A + \lambda^* \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i2}^A Z_{j1}^A \right. \\
& + \lambda^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} Z_{i2}^A Z_{j1}^A + \lambda \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} Z_{i3}^A Z_{j1}^A \\
& + \lambda \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{l3+a}^{R,*} Z_{i3}^A Z_{j1}^A + \lambda^* \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i3}^A Z_{j1}^A \\
& + \lambda^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} Z_{i3}^A Z_{j1}^A + \lambda \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba}^* Z_{i1}^A Z_{j2}^A \\
& + \lambda^* \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i1}^A Z_{j2}^A + \lambda^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} Z_{i1}^A Z_{j2}^A \\
& + 2 \sum_{c=1}^3 Z_{lc}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{j2}^A \\
& + 2 \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{j2}^A \\
& + 2 \sum_{c=1}^3 Z_{l3+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^A Z_{j2}^A \\
& + 2 \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^A Z_{j2}^A
\end{aligned}$$

$$\begin{aligned}
& + \sum_{c=1}^3 Z_{l6+c}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^A Z_{j2}^A \\
& + \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^A Z_{j2}^A \\
& + \sum_{c=1}^3 Z_{lc}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^A Z_{j2}^A \\
& + \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{l6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^A Z_{j2}^A \\
& + \left( g_1^2 + g_2^2 \right) \sum_{a=1}^3 Z_{ka}^{R,*} Z_{la}^{R,*} \left( Z_{i1}^A Z_{j1}^A - Z_{i2}^A Z_{j2}^A \right) + \lambda \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} Z_{i1}^A Z_{j3}^A \\
& + \lambda \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{l3+a}^{R,*} Z_{i1}^A Z_{j3}^A + \lambda^* \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i1}^A Z_{j3}^A \\
& + \lambda^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} Z_{i1}^A Z_{j3}^A + \sum_{c=1}^3 Z_{l6+c}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{j3}^A \\
& + \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{j3}^A \\
& + \sum_{c=1}^3 Z_{lc}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^A Z_{j3}^A \\
& + \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{l6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^A Z_{j3}^A - 2\kappa \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba}^* Z_{i3}^A Z_{j3}^A \\
& - 2\kappa^* \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i3}^A Z_{j3}^A - 2\kappa^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} Z_{i3}^A Z_{j3}^A \\
& + 2 \sum_{c=1}^3 Z_{l6+c}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* \lambda_{N,ab} Z_{i3}^A Z_{j3}^A \\
& + 2 \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{l6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* \lambda_{N,ab} Z_{i3}^A Z_{j3}^A \\
& + 2 \sum_{c=1}^3 Z_{l3+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \lambda_{N,ba} Z_{i3}^A Z_{j3}^A \\
& + 2 \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \lambda_{N,ba} Z_{i3}^A Z_{j3}^A
\end{aligned}$$

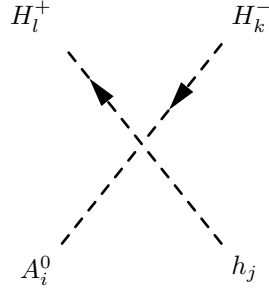
$$+ \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba}^* \left( -2\kappa Z_{i3}^A Z_{j3}^A + \lambda Z_{i1}^A Z_{j2}^A + \lambda Z_{i2}^A Z_{j1}^A \right) \quad (409)$$


---



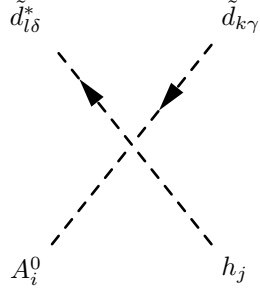
$$\begin{aligned} & \frac{1}{2} \left( -\kappa \lambda^* + \lambda \kappa^* \right) \left( -Z_{i2}^A \left( Z_{j1}^H Z_{k3}^H Z_{l3}^H + Z_{j3}^H \left( Z_{k1}^H Z_{l3}^H + Z_{k3}^H Z_{l1}^H \right) \right) \right. \\ & + Z_{i3}^A \left( Z_{j1}^H \left( Z_{k2}^H Z_{l3}^H + Z_{k3}^H Z_{l2}^H \right) + Z_{j2}^H \left( Z_{k1}^H Z_{l3}^H + Z_{k3}^H Z_{l1}^H \right) + Z_{j3}^H \left( Z_{k1}^H Z_{l2}^H + Z_{k2}^H Z_{l1}^H \right) \right) \\ & \left. - Z_{i1}^A \left( Z_{j2}^H Z_{k3}^H Z_{l3}^H + Z_{j3}^H \left( Z_{k2}^H Z_{l3}^H + Z_{k3}^H Z_{l2}^H \right) \right) \right) \quad (410) \end{aligned}$$


---



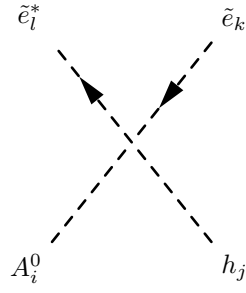
$$\begin{aligned} & \frac{1}{4} \left( \left( -2|\lambda|^2 + g_2^2 \right) Z_{i2}^A Z_{j1}^H \left( -Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) \right. \\ & + \left( -2|\lambda|^2 + g_2^2 \right) Z_{i1}^A Z_{j2}^H \left( -Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) \\ & \left. + 4Z_{i3}^A Z_{j3}^H \left( \kappa \lambda^* Z_{k2}^+ Z_{l1}^+ - \lambda \kappa^* Z_{k1}^+ Z_{l2}^+ \right) \right) \quad (411) \end{aligned}$$


---



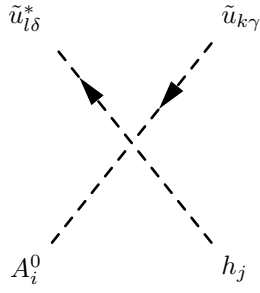
$$\frac{1}{2}\delta_{\gamma\delta}\left(-\lambda\sum_{b=1}^3\sum_{a=1}^3Y_{d,ab}^*Z_{k3+a}^{D,*}Z_{lb}^D+\lambda^*\sum_{b=1}^3Z_{kb}^{D,*}\sum_{a=1}^3Y_{d,ab}Z_{l3+a}^D\right)\left(Z_{i2}^AZ_{j3}^H+Z_{i3}^AZ_{j2}^H\right) \quad (412)$$


---



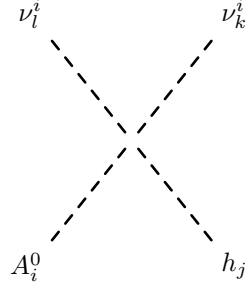
$$\frac{1}{2}\left(-\lambda\sum_{b=1}^3\sum_{a=1}^3Y_{e,ab}^*Z_{k3+a}^{E,*}Z_{lb}^E+\lambda^*\sum_{b=1}^3Z_{kb}^{E,*}\sum_{a=1}^3Y_{e,ab}Z_{l3+a}^E\right)\left(Z_{i2}^AZ_{j3}^H+Z_{i3}^AZ_{j2}^H\right) \quad (413)$$


---



$$\frac{1}{2}\delta_{\gamma\delta}\left(-\lambda\sum_{b=1}^3\sum_{a=1}^3Y_{u,ab}^*Z_{k3+a}^{U,*}Z_{lb}^U+\lambda^*\sum_{b=1}^3Z_{kb}^{U,*}\sum_{a=1}^3Y_{u,ab}Z_{l3+a}^U\right)\left(Z_{i1}^AZ_{j3}^H+Z_{i3}^AZ_{j1}^H\right) \quad (414)$$

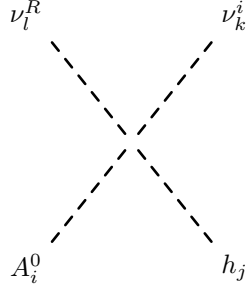

---



$$\begin{aligned}
& \frac{1}{4} \left( \lambda^* \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i2}^A Z_{j1}^H + \lambda^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba} Z_{i2}^A Z_{j1}^H \right. \\
& - \lambda \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} Z_{i3}^A Z_{j1}^H - \lambda \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{l3+a}^{i,*} Z_{i3}^A Z_{j1}^H \\
& + \lambda^* \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} Z_{i3}^A Z_{j1}^H + \lambda^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{i,*} Y_{\nu,ab} Z_{i3}^A Z_{j1}^H \\
& + \lambda^* \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i1}^A Z_{j2}^H + \lambda^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba} Z_{i1}^A Z_{j2}^H \\
& - \sum_{c=1}^3 Z_{l6+c}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^A Z_{j2}^H \\
& - \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^A Z_{j2}^H \\
& + \sum_{c=1}^3 Z_{lc}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^A Z_{j2}^H \\
& + \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{l6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^A Z_{j2}^H - \lambda \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} Z_{i1}^A Z_{j3}^H \\
& - \lambda \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{l3+a}^{i,*} Z_{i1}^A Z_{j3}^H + \lambda^* \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} Z_{i1}^A Z_{j3}^H \\
& + \lambda^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{i,*} Y_{\nu,ab} Z_{i1}^A Z_{j3}^H + \sum_{c=1}^3 Z_{l6+c}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{j3}^H \\
& + \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{j3}^H \\
& - \sum_{c=1}^3 Z_{lc}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^A Z_{j3}^H
\end{aligned}$$

$$\begin{aligned}
& - \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{l6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^A Z_{j3}^H - 2\kappa^* \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i3}^A Z_{j3}^H \\
& - 2\kappa^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba} Z_{i3}^A Z_{j3}^H \\
& - \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba}^* \left( -2\kappa Z_{i3}^A Z_{j3}^H + \lambda Z_{i1}^A Z_{j2}^H + \lambda Z_{i2}^A Z_{j1}^H \right) \\
& - \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba}^* \left( -2\kappa Z_{i3}^A Z_{j3}^H + \lambda Z_{i1}^A Z_{j2}^H + \lambda Z_{i2}^A Z_{j1}^H \right) \tag{415}
\end{aligned}$$


---

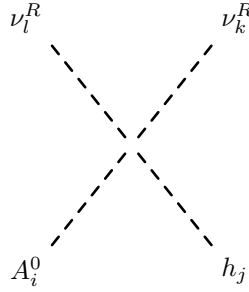


$$\begin{aligned}
& \frac{i}{4} \left( \lambda^* \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i2}^A Z_{j1}^H - \lambda^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} Z_{i2}^A Z_{j1}^H \right. \\
& - \lambda \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} Z_{i3}^A Z_{j1}^H + \lambda \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{l3+a}^{R,*} Z_{i3}^A Z_{j1}^H \\
& - \lambda^* \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} Z_{i3}^A Z_{j1}^H + \lambda^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} Z_{i3}^A Z_{j1}^H \\
& + \lambda^* \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i1}^A Z_{j2}^H - \lambda^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} Z_{i1}^A Z_{j2}^H \\
& - \sum_{c=1}^3 Z_{l6+c}^{R,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^A Z_{j2}^H \\
& + \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^A Z_{j2}^H \\
& + \sum_{c=1}^3 Z_{lc}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^A Z_{j2}^H \\
& \left. - \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{l6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^A Z_{j2}^H - \lambda \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} Z_{i1}^A Z_{j3}^H \right)
\end{aligned}$$



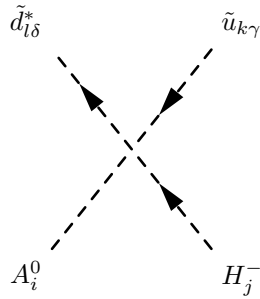
$$\begin{aligned}
& + \lambda \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{l3+a}^{R,*} Z_{i1}^A Z_{j3}^H - \lambda^* \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} Z_{i1}^A Z_{j3}^H \\
& + \lambda^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} Z_{i1}^A Z_{j3}^H + \sum_{c=1}^3 Z_{l6+c}^{R,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{j3}^H \\
& - \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{j3}^H \\
& - \sum_{c=1}^3 Z_{lc}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^A Z_{j3}^H \\
& + \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{l6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^A Z_{j3}^H - 2\kappa^* \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i3}^A Z_{j3}^H \\
& + 2\kappa^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} Z_{i3}^A Z_{j3}^H \\
& + \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba}^* \left( -2\kappa Z_{i3}^A Z_{j3}^H + \lambda Z_{i1}^A Z_{j2}^H + \lambda Z_{i2}^A Z_{j1}^H \right) \\
& - \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba}^* \left( -2\kappa Z_{i3}^A Z_{j3}^H + \lambda Z_{i1}^A Z_{j2}^H + \lambda Z_{i2}^A Z_{j1}^H \right)
\end{aligned} \tag{416}$$


---



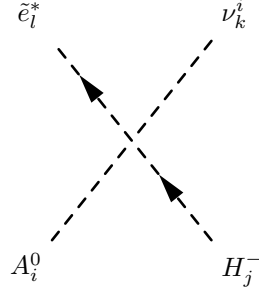
$$\begin{aligned}
& \frac{1}{4} \left( \lambda^* \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i2}^A Z_{j1}^H + \lambda^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} Z_{i2}^A Z_{j1}^H \right. \\
& - \lambda \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} Z_{i3}^A Z_{j1}^H - \lambda \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{l3+a}^{R,*} Z_{i3}^A Z_{j1}^H \\
& + \lambda^* \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i3}^A Z_{j1}^H + \lambda^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} Z_{i3}^A Z_{j1}^H \\
& \left. + \lambda^* \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i1}^A Z_{j2}^H + \lambda^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} Z_{i1}^A Z_{j2}^H \right)
\end{aligned}$$

$$\begin{aligned}
& - \sum_{c=1}^3 Z_{l6+c}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^A Z_{j2}^H \\
& - \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^A Z_{j2}^H \\
& + \sum_{c=1}^3 Z_{lc}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^A Z_{j2}^H \\
& + \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{l6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^A Z_{j2}^H - \lambda \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} Z_{i1}^A Z_{j3}^H \\
& - \lambda \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{l3+a}^{R,*} Z_{i1}^A Z_{j3}^H + \lambda^* \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i1}^A Z_{j3}^H \\
& + \lambda^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} Z_{i1}^A Z_{j3}^H + \sum_{c=1}^3 Z_{l6+c}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{j3}^H \\
& + \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{j3}^H \\
& - \sum_{c=1}^3 Z_{lc}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^A Z_{j3}^H \\
& - \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{l6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^A Z_{j3}^H - 2\kappa^* \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i3}^A Z_{j3}^H \\
& - 2\kappa^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} Z_{i3}^A Z_{j3}^H \\
& - \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba}^* \left( -2\kappa Z_{i3}^A Z_{j3}^H + \lambda Z_{i1}^A Z_{j2}^H + \lambda Z_{i2}^A Z_{j1}^H \right) \\
& - \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba}^* \left( -2\kappa Z_{i3}^A Z_{j3}^H + \lambda Z_{i1}^A Z_{j2}^H + \lambda Z_{i2}^A Z_{j1}^H \right)
\end{aligned} \tag{417}$$



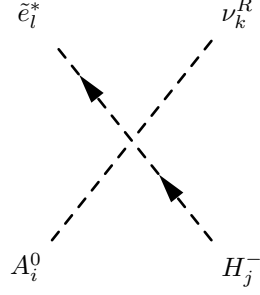
$$\begin{aligned}
& \frac{1}{2} \frac{1}{\sqrt{2}} \delta_{\gamma\delta} \left( g_2^2 \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^D \left( -Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+ \right) \right. \\
& + 2 \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^D Z_{i1}^A Z_{j1}^+ - \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{k3+a}^{U,*} Z_{lb}^D Z_{i3}^A Z_{j1}^+ \right. \\
& - \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^D Z_{i2}^A Z_{j2}^+ + \lambda^* \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D Z_{i3}^A Z_{j2}^+ \\
& \left. \left. + \sum_{c=1}^3 Z_{k3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{d,ba} Z_{l3+b}^D \left( -Z_{i1}^A Z_{j2}^+ + Z_{i2}^A Z_{j1}^+ \right) \right) \right) \quad (418)
\end{aligned}$$


---



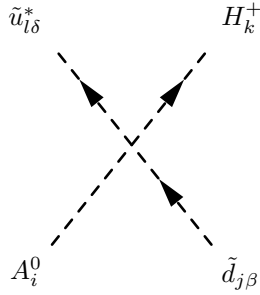
$$\begin{aligned}
& - \frac{i}{4} \left( g_2^2 \sum_{a=1}^3 Z_{ka}^{i,*} Z_{la}^E \left( Z_{i1}^A Z_{j1}^+ - Z_{i2}^A Z_{j2}^+ \right) \right. \\
& + 2 \left( - \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E Z_{i1}^A Z_{j1}^+ + \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} Z_{lb}^E Z_{i3}^A Z_{j1}^+ \right. \\
& + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{lc}^E Z_{i2}^A Z_{j2}^+ - \lambda^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E Z_{i3}^A Z_{j2}^+ \\
& + \sum_{c=1}^3 \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{lc}^E Z_{i3}^A Z_{j2}^+ \\
& \left. \left. + \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ca}^* Y_{e,ba} Z_{l3+b}^E \left( Z_{i1}^A Z_{j2}^+ - Z_{i2}^A Z_{j1}^+ \right) \right) \right) \quad (419)
\end{aligned}$$


---



$$\begin{aligned}
& \frac{1}{4} \left( g_2^2 \sum_{a=1}^3 Z_{ka}^{R,*} Z_{la}^E \left( -Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+ \right) \right. \\
& + 2 \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E Z_{i1}^A Z_{j1}^+ - \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} Z_{lb}^E Z_{i3}^A Z_{j1}^+ \right. \\
& - \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{lc}^E Z_{i2}^A Z_{j2}^+ + \lambda^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E Z_{i3}^A Z_{j2}^+ \\
& - \sum_{c=1}^3 \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{lc}^E Z_{i3}^A Z_{j2}^+ \\
& \left. \left. + \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ca}^* Y_{e,ba} Z_{l3+b}^E \left( -Z_{i1}^A Z_{j2}^+ + Z_{i2}^A Z_{j1}^+ \right) \right) \right) \quad (420)
\end{aligned}$$

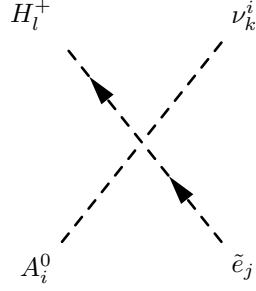

---



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

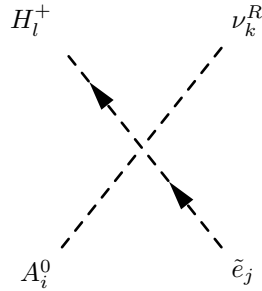
$$+ \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{u,ba} Z_{l3+b}^U \left( Z_{i1}^A Z_{k2}^+ - Z_{i2}^A Z_{k1}^+ \right) \right) \quad (421)$$


---



$$\begin{aligned} & - \frac{i}{4} \left( g_2^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^{i,*} \left( Z_{i1}^A Z_{l1}^+ - Z_{i2}^A Z_{l2}^+ \right) \right. \\ & + 2 \left( - \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{i1}^A Z_{l1}^+ + \lambda^* \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} Z_{i3}^A Z_{l1}^+ \right. \\ & + \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{l2}^+ - \lambda \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{i3}^A Z_{l2}^+ \\ & + \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^A Z_{l2}^+ \\ & \left. \left. + \sum_{c=1}^3 Z_{j3+c}^{E,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Y_{e,ca}^* Y_{\nu,ba} \left( Z_{i1}^A Z_{l2}^+ - Z_{i2}^A Z_{l1}^+ \right) \right) \right) \quad (422) \end{aligned}$$

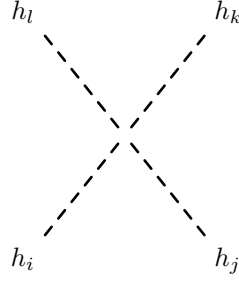

---



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

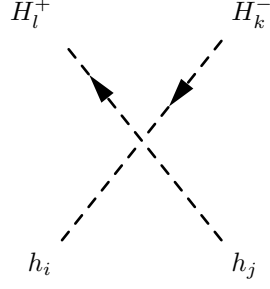
$$\begin{aligned}
& + 2 \left( - \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{i1}^A Z_{l1}^+ + \lambda^* \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i3}^A Z_{l1}^+ \right. \\
& + \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^A Z_{l2}^+ - \lambda \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{i3}^A Z_{l2}^+ \\
& + \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^A Z_{l2}^+ \\
& \left. + \sum_{c=1}^3 Z_{j3+c}^{E,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Y_{e,ca}^* Y_{\nu,ba} \left( Z_{i1}^A Z_{l2}^+ - Z_{i2}^A Z_{l1}^+ \right) \right) \quad (423)
\end{aligned}$$


---



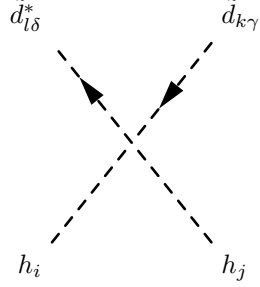
$$\begin{aligned}
& - \frac{i}{4} \left( Z_{i1}^H \left( Z_{j1}^H \left( 3(g_1^2 + g_2^2) Z_{k1}^H Z_{l1}^H - \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{k2}^H Z_{l2}^H + 4|\lambda|^2 Z_{k3}^H Z_{l3}^H \right) \right. \right. \\
& - Z_{j2}^H \left( 2(\kappa\lambda^* + \lambda\kappa^*) Z_{k3}^H Z_{l3}^H + \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^* \left( (2\lambda Z_{k1}^H - \kappa Z_{k2}^H) Z_{l3}^H + Z_{k3}^H (2\lambda Z_{l1}^H - \kappa Z_{l2}^H) \right) - \lambda\kappa^* \left( Z_{k2}^H Z_{l3}^H + Z_{k3}^H Z_{l2}^H \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( (-2\lambda Z_{k2}^H + \kappa Z_{k1}^H) Z_{l3}^H + Z_{k3}^H (-2\lambda Z_{l2}^H + \kappa Z_{l1}^H) \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 (2\lambda Z_{l1}^H - \kappa Z_{l2}^H) + Z_{k2}^H (2\lambda Z_{l2}^H - \kappa Z_{l1}^H) \right) \right. \right. \\
& + Z_{j1}^H \left( (2\lambda Z_{k1}^H - \kappa Z_{k2}^H) Z_{l3}^H + Z_{k3}^H (2\lambda Z_{l1}^H - \kappa Z_{l2}^H) \right) \\
& - Z_{j2}^H \left( (-2\lambda Z_{k2}^H + \kappa Z_{k1}^H) Z_{l3}^H + Z_{k3}^H (-2\lambda Z_{l2}^H + \kappa Z_{l1}^H) \right) \\
& \left. \left. - \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. \right. \right. \\
& \left. \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 (424)
\end{aligned}$$


---



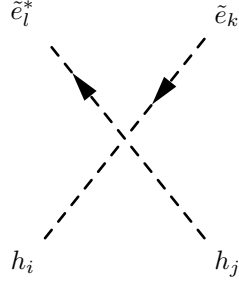
$$\begin{aligned}
& -\frac{i}{4} \left( Z_{i1}^H \left( (-2|\lambda|^2 + g_2^2) Z_{j2}^H (Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+) + Z_{j1}^H \left( (g_1^2 + g_2^2) Z_{k1}^+ Z_{l1}^+ + (-g_1^2 + g_2^2) Z_{k2}^+ Z_{l2}^+ \right) \right) \right. \\
& + Z_{i2}^H \left( (-2|\lambda|^2 + g_2^2) Z_{j1}^H (Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+) + Z_{j2}^H \left( (-g_1^2 + g_2^2) Z_{k1}^+ Z_{l1}^+ + (g_1^2 + g_2^2) Z_{k2}^+ Z_{l2}^+ \right) \right) \\
& \left. + 4Z_{i3}^H Z_{j3}^H \left( \lambda \kappa^* Z_{k1}^+ Z_{l2}^+ + \lambda^* \left( \lambda Z_{k1}^+ Z_{l1}^+ + Z_{k2}^+ \left( \kappa Z_{l1}^+ + \lambda Z_{l2}^+ \right) \right) \right) \right) \quad (425)
\end{aligned}$$


---



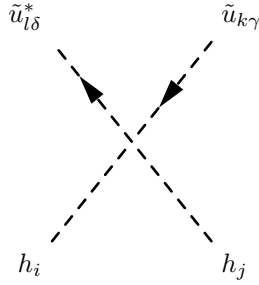
$$\begin{aligned}
& \frac{i}{12} \delta_{\gamma\delta} \left( (3g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ka}^{D,*} Z_{la}^D (Z_{i1}^H Z_{j1}^H - Z_{i2}^H Z_{j2}^H) \right. \\
& + 2 \left( g_1^2 \sum_{a=1}^3 Z_{k3+a}^{D,*} Z_{l3+a}^D (Z_{i1}^H Z_{j1}^H - Z_{i2}^H Z_{j2}^H) \right. \\
& + 3 \left( -2 \sum_{c=1}^3 Z_{k3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{d,ba} Z_{l3+b}^D Z_{i1}^H Z_{j1}^H \right. \\
& - 2 \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^D Z_{i1}^H Z_{j1}^H \\
& \left. \left. + \left( \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{k3+a}^{D,*} Z_{lb}^D + \lambda^* \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D \right) (Z_{i2}^H Z_{j3}^H + Z_{i3}^H Z_{j2}^H) \right) \right) \quad (426)
\end{aligned}$$


---



$$\begin{aligned}
& -\frac{i}{4} \left( (-g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ka}^{E,*} Z_{la}^E (Z_{i1}^H Z_{j1}^H - Z_{i2}^H Z_{j2}^H) \right. \\
& - 2 \left( -2 \sum_{c=1}^3 Z_{k3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{e,ba} Z_{l3+b}^E Z_{i1}^H Z_{j1}^H \right. \\
& - 2 \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E Z_{i1}^H Z_{j1}^H + \lambda^* \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E Z_{i3}^H Z_{j2}^H \\
& + \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{k3+a}^{E,*} Z_{lb}^E Z_{i3}^H Z_{j2}^H + g_1^2 \sum_{a=1}^3 Z_{k3+a}^{E,*} Z_{l3+a}^E (Z_{i1}^H Z_{j1}^H - Z_{i2}^H Z_{j2}^H) \\
& \left. \left. + \lambda^* \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E Z_{i2}^H Z_{j3}^H + \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{k3+a}^{E,*} Z_{lb}^E Z_{i2}^H Z_{j3}^H \right) \right) \quad (427)
\end{aligned}$$


---

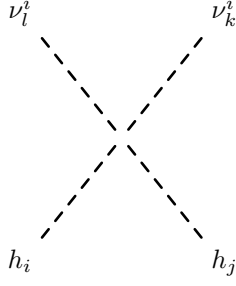


$$\begin{aligned}
& \frac{i}{12} \delta_{\gamma\delta} \left( (-3g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^U (Z_{i1}^H Z_{j1}^H - Z_{i2}^H Z_{j2}^H) \right. \\
& + 4g_1^2 \sum_{a=1}^3 Z_{k3+a}^{U,*} Z_{l3+a}^U (-Z_{i1}^H Z_{j1}^H + Z_{i2}^H Z_{j2}^H) \\
& \left. + 6 \left( -2 \left( \sum_{c=1}^3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



$$\begin{aligned}
& + \lambda^* \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \left( Z_{i1}^H Z_{j3}^H + Z_{i3}^H Z_{j1}^H \right) \\
& + \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{k3+a}^{U,*} Z_{lb}^U \left( Z_{i1}^H Z_{j3}^H + Z_{i3}^H Z_{j1}^H \right) \Big) \Big) \quad (428)
\end{aligned}$$

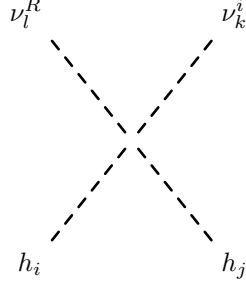

---



$$\begin{aligned}
& \frac{i}{4} \Big( \lambda \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba}^* Z_{i2}^H Z_{j1}^H + \lambda^* \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i2}^H Z_{j1}^H \\
& + \lambda^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba} Z_{i2}^H Z_{j1}^H + \lambda \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} Z_{i3}^H Z_{j1}^H \\
& + \lambda \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{l3+a}^{i,*} Z_{i3}^H Z_{j1}^H + \lambda^* \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} Z_{i3}^H Z_{j1}^H \\
& + \lambda^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{i,*} Y_{\nu,ab} Z_{i3}^H Z_{j1}^H + \lambda \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba}^* Z_{i1}^H Z_{j2}^H \\
& + \lambda^* \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i1}^H Z_{j2}^H + \lambda^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba} Z_{i1}^H Z_{j2}^H \\
& - 2 \sum_{c=1}^3 Z_{lc}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H Z_{j2}^H \\
& - 2 \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H Z_{j2}^H \\
& - 2 \sum_{c=1}^3 Z_{l3+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^H Z_{j2}^H \\
& - 2 \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^H Z_{j2}^H \\
& - \sum_{c=1}^3 Z_{l6+c}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^H Z_{j2}^H
\end{aligned}$$

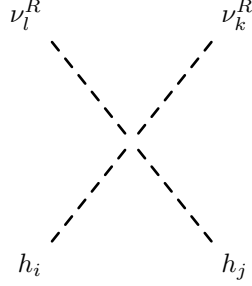
$$\begin{aligned}
& - \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^H Z_{j2}^H \\
& - \sum_{c=1}^3 Z_{lc}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^H Z_{j2}^H \\
& - \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{l6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^H Z_{j2}^H \\
& - \left( g_1^2 + g_2^2 \right) \sum_{a=1}^3 Z_{ka}^{i,*} Z_{la}^{i,*} \left( Z_{i1}^H Z_{j1}^H - Z_{i2}^H Z_{j2}^H \right) + \lambda \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} Z_{i1}^H Z_{j3}^H \\
& + \lambda \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{l3+a}^{i,*} Z_{i1}^H Z_{j3}^H + \lambda^* \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} Z_{i1}^H Z_{j3}^H \\
& + \lambda^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{i,*} Y_{\nu,ab} Z_{i1}^H Z_{j3}^H - \sum_{c=1}^3 Z_{l6+c}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^H Z_{j3}^H \\
& - \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^H Z_{j3}^H \\
& - \sum_{c=1}^3 Z_{lc}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^H Z_{j3}^H \\
& - \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{l6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^H Z_{j3}^H - 2\kappa \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba}^* Z_{i3}^H Z_{j3}^H \\
& - 2\kappa^* \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba}^* Z_{i3}^H Z_{j3}^H - 2\kappa^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba}^* Z_{i3}^H Z_{j3}^H \\
& - 2 \sum_{c=1}^3 Z_{l6+c}^{i,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* \lambda_{N,ab} Z_{i3}^H Z_{j3}^H \\
& - 2 \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{l6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* \lambda_{N,ab} Z_{i3}^H Z_{j3}^H \\
& - 2 \sum_{c=1}^3 Z_{l3+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \lambda_{N,ba} Z_{i3}^H Z_{j3}^H \\
& - 2 \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \lambda_{N,ba} Z_{i3}^H Z_{j3}^H \\
& + \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba}^* \left( -2\kappa Z_{i3}^H Z_{j3}^H + \lambda Z_{i1}^H Z_{j2}^H + \lambda Z_{i2}^H Z_{j1}^H \right)
\end{aligned} \tag{429}$$


---



$$\begin{aligned}
& \frac{1}{4} \left( -\lambda^* \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i2}^H Z_{j1}^H + \lambda^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} Z_{i2}^H Z_{j1}^H \right. \\
& - \lambda \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} Z_{i3}^H Z_{j1}^H + \lambda \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{l3+a}^{R,*} Z_{i3}^H Z_{j1}^H \\
& + \lambda^* \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} Z_{i3}^H Z_{j1}^H - \lambda^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} Z_{i3}^H Z_{j1}^H \\
& - \lambda^* \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i1}^H Z_{j2}^H + \lambda^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} Z_{i1}^H Z_{j2}^H \\
& + 2 \sum_{c=1}^3 Z_{lc}^{R,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H Z_{j2}^H \\
& - 2 \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H Z_{j2}^H \\
& - 2 \sum_{c=1}^3 Z_{l3+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^H Z_{j2}^H \\
& + 2 \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^H Z_{j2}^H \\
& + \sum_{c=1}^3 Z_{l6+c}^{R,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^H Z_{j2}^H \\
& - \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^H Z_{j2}^H \\
& + \sum_{c=1}^3 Z_{lc}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^H Z_{j2}^H \\
& - \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{l6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^H Z_{j2}^H - \lambda \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} Z_{i1}^H Z_{j3}^H \\
& \left. - \lambda \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} Z_{i1}^H Z_{j3}^H \right)
\end{aligned}$$

$$\begin{aligned}
& + \lambda \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{l3+a}^{R,*} Z_{i1}^H Z_{j3}^H + \lambda^* \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} Z_{i1}^H Z_{j3}^H \\
& - \lambda^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} Z_{i1}^H Z_{j3}^H + \sum_{c=1}^3 Z_{l6+c}^{R,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^H Z_{j3}^H \\
& - \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^H Z_{j3}^H \\
& + \sum_{c=1}^3 Z_{lc}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^H Z_{j3}^H \\
& - \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{l6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^H Z_{j3}^H + 2\kappa^* \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i3}^H Z_{j3}^H \\
& - 2\kappa^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} Z_{i3}^H Z_{j3}^H + 2 \sum_{c=1}^3 Z_{l6+c}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ac}^* \lambda_{N,ab} Z_{i3}^H Z_{j3}^H \\
& - 2 \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{l6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* \lambda_{N,ab} Z_{i3}^H Z_{j3}^H \\
& - 2 \sum_{c=1}^3 Z_{l3+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 \lambda_{N,ca}^* \lambda_{N,ba} Z_{i3}^H Z_{j3}^H \\
& + 2 \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \lambda_{N,ba} Z_{i3}^H Z_{j3}^H \\
& + \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba}^* \left( -2\kappa Z_{i3}^H Z_{j3}^H + \lambda Z_{i1}^H Z_{j2}^H + \lambda Z_{i2}^H Z_{j1}^H \right) \\
& - \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba}^* \left( -2\kappa Z_{i3}^H Z_{j3}^H + \lambda Z_{i1}^H Z_{j2}^H + \lambda Z_{i2}^H Z_{j1}^H \right)
\end{aligned} \tag{430}$$

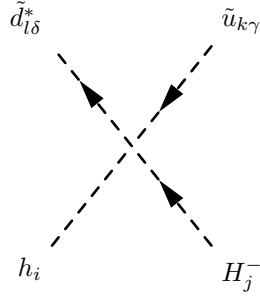


$$\frac{i}{4} \left( \lambda \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba}^* Z_{i2}^H Z_{j1}^H + \lambda^* \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i2}^H Z_{j1}^H \right)$$

$$\begin{aligned}
& + \lambda^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} Z_{i2}^H Z_{j1}^H + \lambda \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} Z_{i3}^H Z_{j1}^H \\
& + \lambda \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{l3+a}^{R,*} Z_{i3}^H Z_{j1}^H + \lambda^* \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i3}^H Z_{j1}^H \\
& + \lambda^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} Z_{i3}^H Z_{j1}^H + \lambda \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba}^* Z_{i1}^H Z_{j2}^H \\
& + \lambda^* \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i1}^H Z_{j2}^H + \lambda^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} Z_{i1}^H Z_{j2}^H \\
& - 2 \sum_{c=1}^3 Z_{lc}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H Z_{j2}^H \\
& - 2 \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H Z_{j2}^H \\
& - 2 \sum_{c=1}^3 Z_{l3+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^H Z_{j2}^H \\
& - 2 \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^H Z_{j2}^H \\
& - \sum_{c=1}^3 Z_{l6+c}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^H Z_{j2}^H \\
& - \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^H Z_{j2}^H \\
& - \sum_{c=1}^3 Z_{lc}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^H Z_{j2}^H \\
& - \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{l6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i3}^H Z_{j2}^H \\
& - \left( g_1^2 + g_2^2 \right) \sum_{a=1}^3 Z_{ka}^{R,*} Z_{la}^{R,*} \left( Z_{i1}^H Z_{j1}^H - Z_{i2}^H Z_{j2}^H \right) + \lambda \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} Z_{i1}^H Z_{j3}^H \\
& + \lambda \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ab}^* Z_{l3+a}^{R,*} Z_{i1}^H Z_{j3}^H + \lambda^* \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i1}^H Z_{j3}^H \\
& + \lambda^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} Z_{i1}^H Z_{j3}^H - \sum_{c=1}^3 Z_{l6+c}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^H Z_{j3}^H
\end{aligned}$$

$$\begin{aligned}
& - \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i2}^H Z_{j3}^H \\
& - \sum_{c=1}^3 Z_{lc}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^H Z_{j3}^H \\
& - \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{l6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{i2}^H Z_{j3}^H - 2\kappa \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba}^* Z_{i3}^H Z_{j3}^H \\
& - 2\kappa^* \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i3}^H Z_{j3}^H - 2\kappa^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} Z_{i3}^H Z_{j3}^H \\
& - 2 \sum_{c=1}^3 Z_{l6+c}^{R,*} \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* \lambda_{N,ab} Z_{i3}^H Z_{j3}^H \\
& - 2 \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{l6+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ac}^* \lambda_{N,ab} Z_{i3}^H Z_{j3}^H \\
& - 2 \sum_{c=1}^3 Z_{l3+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \lambda_{N,ba} Z_{i3}^H Z_{j3}^H \\
& - 2 \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 \lambda_{N,ca}^* \lambda_{N,ba} Z_{i3}^H Z_{j3}^H \\
& + \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba}^* \left( -2\kappa Z_{i3}^H Z_{j3}^H + \lambda Z_{i1}^H Z_{j2}^H + \lambda Z_{i2}^H Z_{j1}^H \right)
\end{aligned} \tag{431}$$

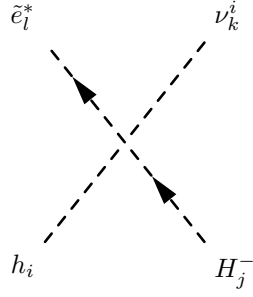

---



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

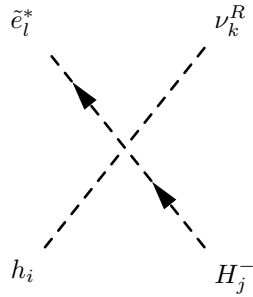
$$+ \sum_{c=1}^3 Z_{k3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{d,ba} Z_{l3+b}^D \left( Z_{i1}^H Z_{j2}^+ + Z_{i2}^H Z_{j1}^+ \right) \right) \quad (432)$$


---



$$\begin{aligned} & \frac{1}{4} \left( g_2^2 \sum_{a=1}^3 Z_{ka}^{i,*} Z_{la}^E \left( Z_{i1}^H Z_{j1}^+ + Z_{i2}^H Z_{j2}^+ \right) \right. \\ & - 2 \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E Z_{i1}^H Z_{j1}^+ + \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{i,*} Z_{lb}^E Z_{i3}^H Z_{j1}^+ \right. \\ & + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{lc}^E Z_{i2}^H Z_{j2}^+ + \lambda^* \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E Z_{i3}^H Z_{j2}^+ \\ & + \sum_{c=1}^3 \sum_{b=1}^3 Z_{k6+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{lc}^E Z_{i3}^H Z_{j2}^+ \\ & \left. \left. + \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ca}^* Y_{e,ba} Z_{l3+b}^E \left( Z_{i1}^H Z_{j2}^+ + Z_{i2}^H Z_{j1}^+ \right) \right) \right) \quad (433) \end{aligned}$$

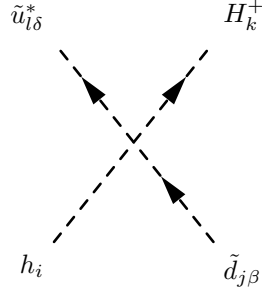

---



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

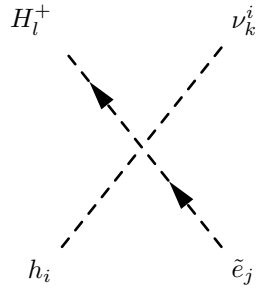
$$\begin{aligned}
& -2 \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E Z_{i1}^H Z_{j1}^+ + \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ab}^* Z_{k3+a}^{R,*} Z_{lb}^E Z_{i3}^H Z_{j1}^+ \right. \\
& + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{lc}^E Z_{i2}^H Z_{j2}^+ + \lambda^* \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E Z_{i3}^H Z_{j2}^+ \\
& + \sum_{c=1}^3 \sum_{b=1}^3 Z_{k6+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ac}^* \lambda_{N,ab} Z_{lc}^E Z_{i3}^H Z_{j2}^+ \\
& \left. + \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{\nu,ca}^* Y_{e,ba} Z_{l3+b}^E \left( Z_{i1}^H Z_{j2}^+ + Z_{i2}^H Z_{j1}^+ \right) \right) \quad (434)
\end{aligned}$$


---



$$\begin{aligned}
& -\frac{i}{2} \frac{1}{\sqrt{2}} \delta_{\beta\delta} \left( g_2^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^U \left( Z_{i1}^H Z_{k1}^+ + Z_{i2}^H Z_{k2}^+ \right) \right. \\
& -2 \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^U Z_{i1}^H Z_{k1}^+ + \lambda^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U Z_{i3}^H Z_{k1}^+ \right. \\
& + \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^U Z_{i2}^H Z_{k2}^+ + \lambda \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{lb}^U Z_{i3}^H Z_{k2}^+ \\
& \left. \left. + \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{u,ba} Z_{l3+b}^U \left( Z_{i1}^H Z_{k2}^+ + Z_{i2}^H Z_{k1}^+ \right) \right) \right) \quad (435)
\end{aligned}$$

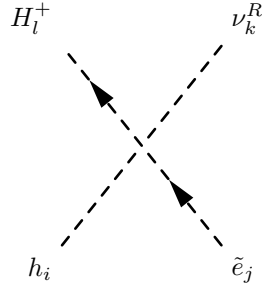

---





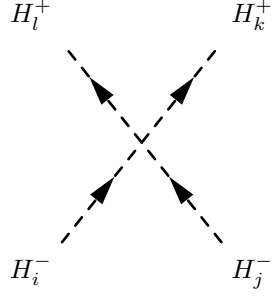
$$\begin{aligned}
& \frac{1}{4} \left( -g_2^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^{i,*} \left( Z_{i1}^H Z_{l1}^+ + Z_{i2}^H Z_{l2}^+ \right) \right. \\
& + 2 \left( \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{i1}^H Z_{l1}^+ + \lambda^* \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} Z_{i3}^H Z_{l1}^+ \right. \\
& + \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H Z_{l2}^+ + \lambda \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{i3}^H Z_{l2}^+ \\
& + \sum_{c=1}^3 Z_{k6+c}^{i,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^H Z_{l2}^+ \\
& \left. \left. + \sum_{c=1}^3 Z_{j3+c}^{E,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Y_{e,ca}^* Y_{\nu,ba} \left( Z_{i1}^H Z_{l2}^+ + Z_{i2}^H Z_{l1}^+ \right) \right) \right) \quad (436)
\end{aligned}$$


---



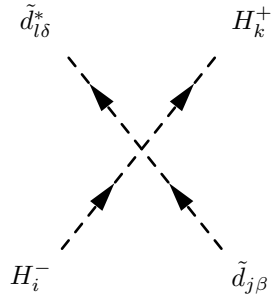
$$\begin{aligned}
& -\frac{i}{4} \left( g_2^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^{R,*} \left( Z_{i1}^H Z_{l1}^+ + Z_{i2}^H Z_{l2}^+ \right) \right. \\
& - 2 \left( \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{i1}^H Z_{l1}^+ + \lambda^* \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i3}^H Z_{l1}^+ \right. \\
& + \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H Z_{l2}^+ + \lambda \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{i3}^H Z_{l2}^+ \\
& + \sum_{c=1}^3 Z_{k6+c}^{R,*} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 \lambda_{N,ac}^* Y_{\nu,ab} Z_{i3}^H Z_{l2}^+ \\
& \left. \left. + \sum_{c=1}^3 Z_{j3+c}^{E,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Y_{e,ca}^* Y_{\nu,ba} \left( Z_{i1}^H Z_{l2}^+ + Z_{i2}^H Z_{l1}^+ \right) \right) \right) \quad (437)
\end{aligned}$$


---



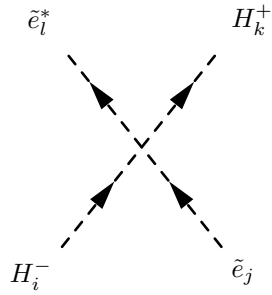
$$\begin{aligned}
& -\frac{i}{4} \left( -Z_{i2}^+ \left( -2(g_1^2 + g_2^2) Z_{j2}^+ Z_{k2}^+ Z_{l2}^+ + \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{j1}^+ \left( Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) \right) \right. \\
& \left. + Z_{i1}^+ \left( 2(g_1^2 + g_2^2) Z_{j1}^+ Z_{k1}^+ Z_{l1}^+ - \left( -4|\lambda|^2 + g_1^2 + g_2^2 \right) Z_{j2}^+ \left( Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) \right) \right) \quad (438)
\end{aligned}$$


---



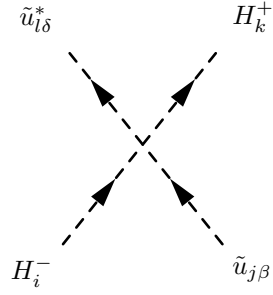
$$\begin{aligned}
& \frac{i}{12} \delta_{\beta\delta} \left( \left( -3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^D \left( Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+ \right) \right. \\
& + 2 \left( g_1^2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{l3+a}^D \left( Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+ \right) \right. \\
& \left. \left. - 6 \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^D Z_{i2}^+ Z_{k2}^+ + \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{d,ba} Z_{l3+b}^D Z_{i1}^+ Z_{k1}^+ \right) \right) \right) \quad (439)
\end{aligned}$$


---



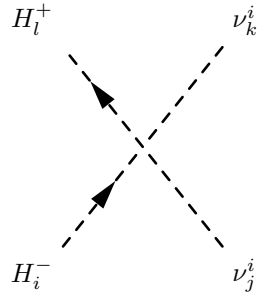
$$\begin{aligned}
& -\frac{i}{4} \left( (g_1^2 + g_2^2) \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^E (Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+) \right. \\
& + 2g_1^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{l3+a}^E (-Z_{i1}^+ Z_{k1}^+ + Z_{i2}^+ Z_{k2}^+) \\
& \left. + 4 \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{\nu,ac}^* Y_{\nu,ab} Z_{lc}^E Z_{i2}^+ Z_{k2}^+ + \sum_{c=1}^3 Z_{j3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{e,ba} Z_{l3+b}^E Z_{i1}^+ Z_{k1}^+ \right) \right) \quad (440)
\end{aligned}$$


---



$$\begin{aligned}
& \frac{i}{12} \delta_{\beta\delta} \left( (3g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U (Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+) \right. \\
& - 4 \left( g_1^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U (Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+) \right. \\
& \left. \left. + 3 \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^U Z_{i1}^+ Z_{k1}^+ + \sum_{c=1}^3 Z_{j3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{u,ba} Z_{l3+b}^U Z_{i2}^+ Z_{k2}^+ \right) \right) \right) \quad (441)
\end{aligned}$$

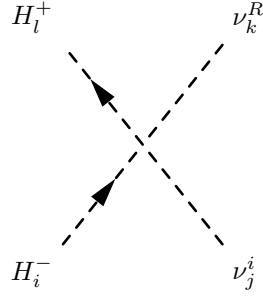

---



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

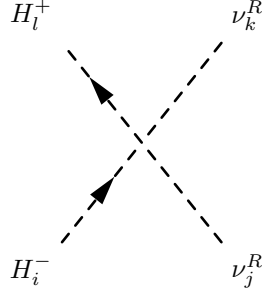
$$\begin{aligned}
& + 2 \left( \sum_{c=1}^3 Z_{kc}^{i,*} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{i1}^+ Z_{l1}^+ + \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{i1}^+ Z_{l1}^+ \right. \\
& + \lambda^* \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} Z_{i2}^+ Z_{l1}^+ + \lambda^* \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} Z_{i2}^+ Z_{l1}^+ \\
& + \lambda \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba}^* Z_{i1}^+ Z_{l2}^+ + \lambda \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba}^* Z_{i1}^+ Z_{l2}^+ \\
& + \sum_{c=1}^3 Z_{k3+c}^{i,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^+ Z_{l2}^+ \\
& \left. + \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^+ Z_{l2}^+ \right) \quad (442)
\end{aligned}$$


---

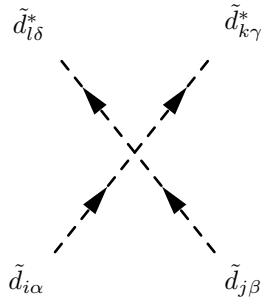


$$\begin{aligned}
& \frac{1}{2} \left( \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{i1}^+ Z_{l1}^+ \right. \\
& - \sum_{c=1}^3 Z_{jc}^{i,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{i1}^+ Z_{l1}^+ + \lambda^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} Z_{i2}^+ Z_{l1}^+ \\
& - \lambda^* \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i2}^+ Z_{l1}^+ - \lambda \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba}^* Z_{i1}^+ Z_{l2}^+ \\
& + \lambda \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba}^* Z_{i1}^+ Z_{l2}^+ - \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^+ Z_{l2}^+ \\
& \left. + \sum_{c=1}^3 Z_{j3+c}^{i,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^+ Z_{l2}^+ \right) \quad (443)
\end{aligned}$$


---



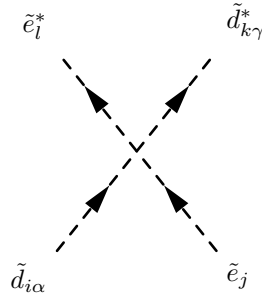
$$\begin{aligned}
& -\frac{i}{4} \left( \left( -g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^{R,*} \left( Z_{i1}^+ Z_{l1}^+ - Z_{i2}^+ Z_{l2}^+ \right) \right. \\
& + 2 \left( \sum_{c=1}^3 Z_{kc}^{R,*} \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{i1}^+ Z_{l1}^+ + \sum_{c=1}^3 Z_{jc}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{i1}^+ Z_{l1}^+ \right. \\
& + \lambda^* \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba} Z_{i2}^+ Z_{l1}^+ + \lambda^* \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} Z_{i2}^+ Z_{l1}^+ \\
& + \lambda \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba}^* Z_{i1}^+ Z_{l2}^+ + \lambda \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba}^* Z_{i1}^+ Z_{l2}^+ \\
& + \sum_{c=1}^3 Z_{k3+c}^{R,*} \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^+ Z_{l2}^+ \\
& \left. \left. + \sum_{c=1}^3 Z_{j3+c}^{R,*} \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Y_{\nu,ca}^* Y_{\nu,ba} Z_{i2}^+ Z_{l2}^+ \right) \right) \quad (444)
\end{aligned}$$



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

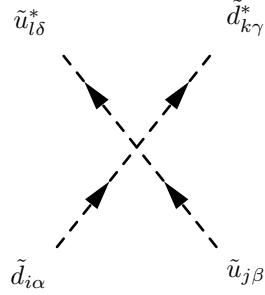
$$\begin{aligned}
& + 6g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D \\
& + 18g_3^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^D \left( - \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \\
& - 18g_3^2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{l3+a}^D \left(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

$$\begin{aligned}
& + 2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{l3+a}^D \left( (2g_1^2 - 3g_3^2) \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + (3g_3^2 + g_1^2) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \\
& + \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^D \left( 2(3g_3^2 + g_1^2) \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + (-6g_3^2 + 9g_2^2 + g_1^2) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \\
& - 18g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{k3+b}^D + 18g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{k3+b}^D \\
& + 18g_3^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D - 18g_3^2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D \\
& + g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{lb}^D + 9g_2^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{lb}^D \\
& - 6g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{lb}^D + 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{lb}^D \\
& + 6g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{lb}^D - 18g_3^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{l3+b}^D \\
& + 18g_3^2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{l3+b}^D + 2g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{l3+b}^D \\
& + 6g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{l3+b}^D + 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{l3+b}^D \\
& - 6g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{l3+b}^D \\
& + 72 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{i3+c}^{D,*} Z_{kd}^D \\
& + 72 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{j3+c}^{D,*} Z_{ld}^D \Big) \Big)
\end{aligned} \tag{445}$$



$$\begin{aligned}
& \frac{i}{24} \delta_{\alpha\gamma} \left( -2g_1^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{l3+a}^E \left( 2 \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \right. \\
& + \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^E \left( 2g_1^2 \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \left( -3g_2^2 + g_1^2 \right) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \\
& + g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E - 3g_2^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E \\
& + 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E - 2g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \\
& - 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \\
& - 24 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{i3+c}^{D,*} Z_{kd}^D \\
& \left. - 24 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{j3+c}^{E,*} Z_{ld}^E \right) \tag{446}
\end{aligned}$$


---

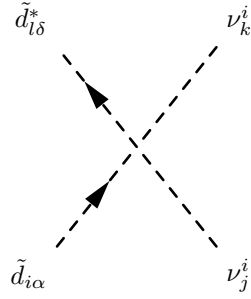


$$\begin{aligned}
& -\frac{i}{72} \left( \delta_{\alpha\gamma} \delta_{\beta\delta} \left( \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \left( 2 \left( 3g_3^2 + g_1^2 \right) \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \left( -6g_3^2 - 9g_2^2 + g_1^2 \right) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \right. \right.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



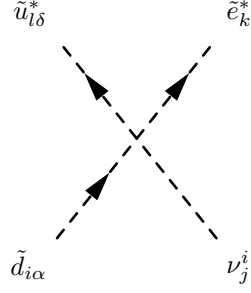
$$\begin{aligned}
& + 6g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U - 8g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& - 6g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \Big) \\
& + 18\delta_{\alpha\delta}\delta_{\beta\gamma} \Big( g_2^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^D + g_3^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \Big( - \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \Big) \\
& + g_3^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U \Big( - \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D + \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D \Big) \\
& + g_2^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^D \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^U + g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& - g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U - g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U + 4 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{j3+c}^{U,*} Z_{kd}^D \\
& + 4 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{i3+c}^{D,*} Z_{ld}^U \Big) \Big) \quad (447)
\end{aligned}$$


---



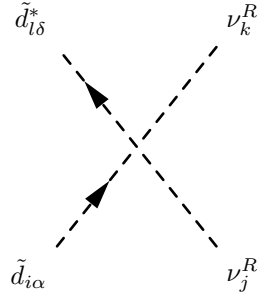
$$\begin{aligned}
& \frac{i}{24} \delta_{\alpha\delta} \Big( \Big( 3g_2^2 + g_1^2 \Big) \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{jb}^{i,*} Z_{kb}^{i,*} + 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{jb}^{i,*} Z_{kb}^{i,*} \\
& + \sum_{a=1}^3 Z_{ja}^{i,*} Z_{ka}^{i,*} \Big( 2g_1^2 \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{l3+b}^D + \Big( 3g_2^2 + g_1^2 \Big) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D \Big) \Big) \quad (448)
\end{aligned}$$


---



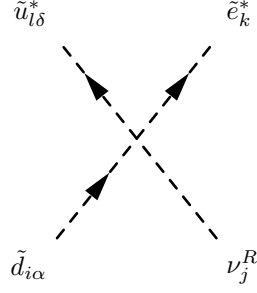
$$\begin{aligned}
& \frac{1}{4} \frac{1}{\sqrt{2}} \delta_{\alpha\delta} \left( g_2^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{i,*} Z_{kb}^E + g_2^2 \sum_{a=1}^3 Z_{ja}^{i,*} Z_{ka}^E \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^U \right. \\
& + 4 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \sum_{d=1}^3 \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{i,*} Z_{kd}^E \\
& \left. + 4 \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{i3+c}^{D,*} Z_{ld}^U \right) \quad (449)
\end{aligned}$$


---



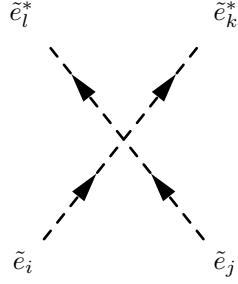
$$\begin{aligned}
& \frac{i}{24} \delta_{\alpha\delta} \left( (3g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{jb}^{R,*} Z_{kb}^{R,*} + 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{jb}^{R,*} Z_{kb}^{R,*} \right. \\
& \left. + \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^{R,*} \left( 2g_1^2 \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{l3+b}^D + (3g_2^2 + g_1^2) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D \right) \right) \quad (450)
\end{aligned}$$


---



$$\begin{aligned}
& -\frac{i}{4}\frac{1}{\sqrt{2}}\delta_{\alpha\delta}\left(g_2^2\sum_{a=1}^3Z_{ia}^{D,*}Z_{la}^U\sum_{b=1}^3Z_{jb}^{R,*}Z_{kb}^E+g_2^2\sum_{a=1}^3Z_{ja}^{R,*}Z_{ka}^E\sum_{b=1}^3Z_{ib}^{D,*}Z_{lb}^U\right. \\
& +4\sum_{b=1}^3Z_{ib}^{D,*}\sum_{a=1}^3Y_{u,ab}Z_{l3+a}^U\sum_{d=1}^3\sum_{c=1}^3Y_{\nu,cd}^*Z_{j3+c}^{R,*}Z_{kd}^E \\
& \left.+4\sum_{b=1}^3Z_{jb}^{R,*}\sum_{a=1}^3Y_{e,ab}Z_{k3+a}^E\sum_{d=1}^3\sum_{c=1}^3Y_{d,cd}^*Z_{i3+c}^{D,*}Z_{ld}^U\right) \tag{451}
\end{aligned}$$

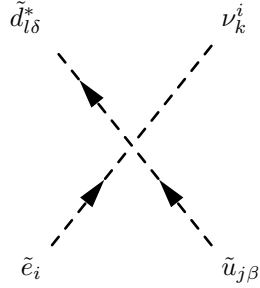

---



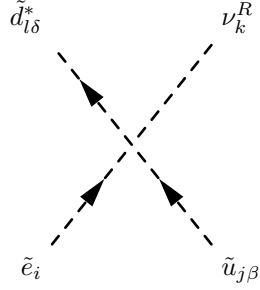
$$\begin{aligned}
& -\frac{i}{8}\left(g_1^2\sum_{a=1}^3Z_{ia}^{E,*}Z_{la}^E\sum_{b=1}^3Z_{jb}^{E,*}Z_{kb}^E+g_2^2\sum_{a=1}^3Z_{ia}^{E,*}Z_{la}^E\sum_{b=1}^3Z_{jb}^{E,*}Z_{kb}^E\right. \\
& -2g_1^2\sum_{a=1}^3Z_{i3+a}^{E,*}Z_{l3+a}^E\sum_{b=1}^3Z_{jb}^{E,*}Z_{kb}^E \\
& -2g_1^2\sum_{a=1}^3Z_{j3+a}^{E,*}Z_{l3+a}^E\left(-2\sum_{b=1}^3Z_{i3+b}^{E,*}Z_{k3+b}^E+\sum_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

$$\begin{aligned}
& + g_1^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E + g_2^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E \\
& - 2g_1^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E + g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E \\
& + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E - 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E \\
& - 2g_1^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{l3+b}^E + 4g_1^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{l3+b}^E \\
& - 2g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E + 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \\
& + 8 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^{E,*} Z_{kd}^E \\
& + 8 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{j3+c}^{E,*} Z_{kd}^E \\
& + 8 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^{E,*} Z_{ld}^E \\
& + 8 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{j3+c}^{E,*} Z_{ld}^E \Big) \tag{452}
\end{aligned}$$


---

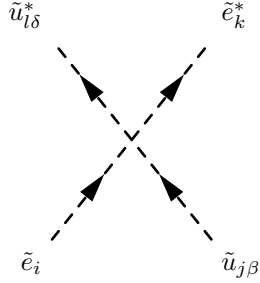


$$\begin{aligned}
& - \frac{1}{4} \frac{1}{\sqrt{2}} \delta_{\beta\delta} \Big( g_2^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^D \sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^{i,*} + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^{i,*} \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^D \\
& + 4 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^{E,*} \\
& + 4 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{j3+c}^{U,*} Z_{ld}^D \Big) \tag{453}
\end{aligned}$$



$$\begin{aligned}
& -\frac{i}{4}\frac{1}{\sqrt{2}}\delta_{\beta\delta}\left(g_2^2\sum_{a=1}^3Z_{ja}^{U,*}Z_{la}^D\sum_{b=1}^3Z_{ib}^{E,*}Z_{kb}^{R,*}+g_2^2\sum_{a=1}^3Z_{ia}^{E,*}Z_{ka}^{R,*}\sum_{b=1}^3Z_{jb}^{U,*}Z_{lb}^D\right. \\
& +4\sum_{b=1}^3Z_{jb}^{U,*}\sum_{a=1}^3Y_{d,ab}Z_{l3+a}^D\sum_{d=1}^3Z_{kd}^{R,*}\sum_{c=1}^3Y_{e,cd}^*Z_{i3+c}^{E,*} \\
& \left.+4\sum_{b=1}^3Z_{ib}^{E,*}\sum_{a=1}^3Z_{k3+a}^{R,*}Y_{\nu,ab}\sum_{d=1}^3\sum_{c=1}^3Y_{u,cd}^*Z_{j3+c}^{U,*}Z_{ld}^D\right) \tag{454}
\end{aligned}$$

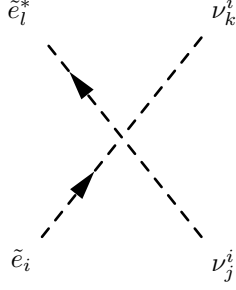

---



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

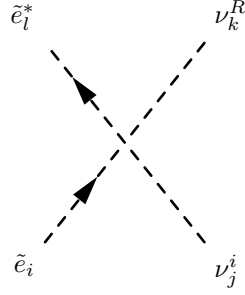
$$+ 8g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \Big) \quad (455)$$


---



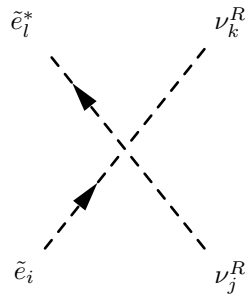
$$\begin{aligned}
& -\frac{i}{8} \left( g_2^2 \sum_{a=1}^3 Z_{ka}^{i,*} Z_{la}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{jb}^{i,*} + g_2^2 \sum_{a=1}^3 Z_{ja}^{i,*} Z_{la}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^{i,*} \right. \\
& + g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{jb}^{i,*} Z_{kb}^{i,*} - g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{jb}^{i,*} Z_{kb}^{i,*} \\
& - 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{l3+a}^E \sum_{b=1}^3 Z_{jb}^{i,*} Z_{kb}^{i,*} + g_1^2 \sum_{a=1}^3 Z_{ja}^{i,*} Z_{ka}^{i,*} \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E \\
& - g_2^2 \sum_{a=1}^3 Z_{ja}^{i,*} Z_{ka}^{i,*} \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^{i,*} \sum_{b=1}^3 Z_{jb}^{i,*} Z_{lb}^E \\
& + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^{i,*} \sum_{b=1}^3 Z_{kb}^{i,*} Z_{lb}^E - 2g_1^2 \sum_{a=1}^3 Z_{ja}^{i,*} Z_{ka}^{i,*} \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{l3+b}^E \\
& + 4 \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^{E,*} \\
& + 4 \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^{E,*} \\
& + 4 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{i,*} Z_{ld}^E \\
& \left. + 4 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} Z_{ld}^E \right) \quad (456)
\end{aligned}$$


---



$$\begin{aligned}
& \frac{1}{8} \left( -g_2^2 \sum_{a=1}^3 Z_{ka}^{R,*} Z_{la}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{jb}^{i,*} + g_2^2 \sum_{a=1}^3 Z_{ja}^{i,*} Z_{la}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^{R,*} \right. \\
& + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{jb}^{i,*} Z_{lb}^E - g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^{i,*} \sum_{b=1}^3 Z_{kb}^{R,*} Z_{lb}^E \\
& - 4 \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^{E,*} \\
& + 4 \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^{E,*} \\
& + 4 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{i,*} Z_{ld}^E \\
& \left. - 4 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*} Z_{ld}^E \right) \quad (457)
\end{aligned}$$

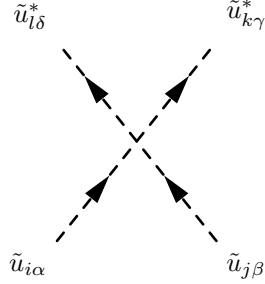

---



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

$$\begin{aligned}
& -2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{l3+a}^E \sum_{b=1}^3 Z_{jb}^{R,*} Z_{kb}^{R,*} + g_1^2 \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E \\
& -g_2^2 \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{jb}^{R,*} Z_{lb}^E \\
& + g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^{R,*} \sum_{b=1}^3 Z_{kb}^{R,*} Z_{lb}^E - 2g_1^2 \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{l3+b}^E \\
& + 4 \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 Z_{jd}^{R,*} \sum_{c=1}^3 Y_{e,cd} Z_{i3+c}^{E,*} \\
& + 4 \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{e,cd} Z_{i3+c}^{E,*} \\
& + 4 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{R,*} Z_{ld}^E \\
& + 4 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*} Z_{ld}^E \Big) \tag{458}
\end{aligned}$$


---



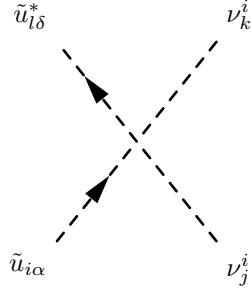
$$\begin{aligned}
& -\frac{i}{72} \left( \delta_{\alpha\delta} \delta_{\beta\gamma} \left( g_1^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U + 9g_2^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U \right. \right. \\
& - 6g_3^2 \sum_{a=1}^3 Z_{ia}^{U,*}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



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

$$\begin{aligned}
& + 18g_3^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U - 18g_3^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U \\
& + g_1^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U + 9g_2^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& - 6g_3^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U - 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& + 6g_3^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U - 18g_3^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U \\
& + 18g_3^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U - 4g_1^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + 6g_3^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U + 16g_1^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& - 6g_3^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + 72 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{i3+c}^{U,*} Z_{kd}^U \\
& + 72 \sum_{b=1}^3 Z_{ib}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{j3+c}^{U,*} Z_{ld}^U \Big) \tag{459}
\end{aligned}$$

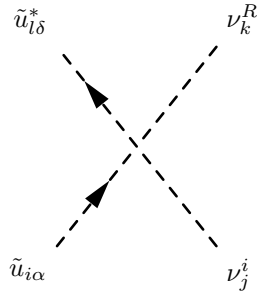

---



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

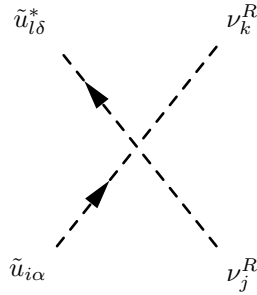
$$\begin{aligned}
& -12 \sum_{b=1}^3 Z_{ib}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{i,*} \\
& -12 \sum_{b=1}^3 Z_{ib}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& -12 \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{i3+c}^{U,*} Z_{ld}^U \\
& -12 \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{i3+c}^{U,*} Z_{ld}^U \Big) \tag{460}
\end{aligned}$$


---



$$\begin{aligned}
& \frac{1}{2} \delta_{\alpha\delta} \Big( \sum_{b=1}^3 Z_{ib}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \Big( - \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*} + \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{i,*} \Big) \\
& + \Big( - \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} + \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \Big) \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{i3+c}^{U,*} Z_{ld}^U \Big) \tag{461}
\end{aligned}$$

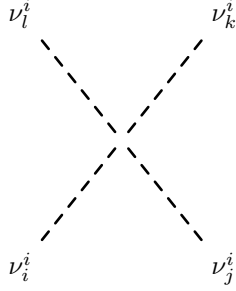

---



$$\frac{i}{24} \delta_{\alpha\delta} \Big( \Big( -3g_2^2 + g_1^2 \Big) \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{R,*} Z_{kb}^{R,*} - 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{l3+a}^U \sum_{b=1}^3 Z_{jb}^{R,*} Z_{kb}^{R,*}$$

$$\begin{aligned}
& + g_1^2 \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U - 3g_2^2 \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U \\
& - 4g_1^2 \sum_{a=1}^3 Z_{ja}^{R,*} Z_{ka}^{R,*} \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U \\
& - 12 \sum_{b=1}^3 Z_{ib}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{j3+c}^{R,*} \\
& - 12 \sum_{b=1}^3 Z_{ib}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \sum_{d=1}^3 Z_{jd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{R,*} \\
& - 12 \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{i3+c}^{U,*} Z_{ld}^U \\
& - 12 \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{i3+c}^{U,*} Z_{ld}^U \Big) \tag{462}
\end{aligned}$$


---



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

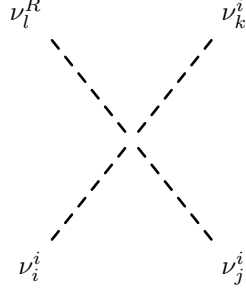
$$\begin{aligned}
& + 2 \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{lb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{i,*} \\
&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

$$\begin{aligned}
& + 2 \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{i,*} \\
& + 2 \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{i,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{i,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{i,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{i,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{i,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{i,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{j6+c}^{i,*} \lambda_{N,dc}^*
\end{aligned}$$

$$\begin{aligned}
& + 2 \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{j6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{i,*} \sum_{c=1}^3 Z_{j6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{i,*} \sum_{c=1}^3 Z_{j6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{i,*} \sum_{c=1}^3 Z_{j6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{i,*} \sum_{c=1}^3 Z_{j6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{k6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{k6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{l3+b}^{i,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{i,*} \sum_{c=1}^3 Z_{k6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{i,*} \sum_{c=1}^3 Z_{k6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{i,*} \sum_{c=1}^3 Z_{k6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{i,*} \sum_{c=1}^3 Z_{k6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{l6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{l6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{i,*} \sum_{c=1}^3 Z_{l6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{i,*} \sum_{c=1}^3 Z_{l6+c}^{i,*} \lambda_{N,dc}^*
\end{aligned}$$

$$\begin{aligned}
& + 2 \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{i,*} \sum_{c=1}^3 Z_{l6+c}^{i,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{i,*} \sum_{c=1}^3 Z_{l6+c}^{i,*} \lambda_{N,dc}^* \Big)
\end{aligned} \tag{463}$$


---



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

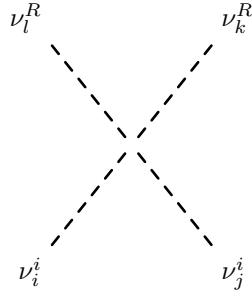


$$\begin{aligned}
& - \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& + \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& - \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& + \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& + \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& + \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{ld}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{k3+c}^{i,*} \\
& - \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{kb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& + \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{i,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{i,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{i,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^*
\end{aligned}$$

$$\begin{aligned}
& - \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{i,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{j6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{j6+c}^{i,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{i,*} \sum_{c=1}^3 Z_{j6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{i,*} \sum_{c=1}^3 Z_{j6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{j6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{j6+c}^{i,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{k6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{k6+c}^{i,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{i,*} \sum_{c=1}^3 Z_{k6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{i,*} \sum_{c=1}^3 Z_{k6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{k6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{k6+c}^{i,*} \lambda_{N,dc}^*
\end{aligned}$$

$$\begin{aligned}
& + \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{k3+b}^{i,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{i,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{i,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{i,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{i,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \Big) \tag{464}
\end{aligned}$$


---



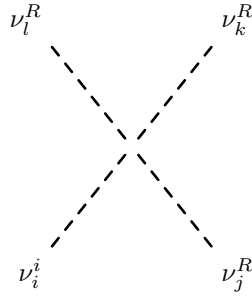
$$\begin{aligned}
& - \frac{i}{8} \left( (g_1^2 + g_2^2) \sum_{a=1}^3 Z_{ka}^{R,*} Z_{la}^{R,*} \sum_{b=1}^3 Z_{ib}^{i,*} Z_{jb}^{i,*} + (g_1^2 + g_2^2) \sum_{a=1}^3 Z_{ia}^{i,*} Z_{ja}^{i,*} \sum_{b=1}^3 Z_{kb}^{R,*} Z_{lb}^{R,*} \right. \\
& + 2 \left( \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{i,*}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

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

$$\begin{aligned}
& + \sum_{b=1}^3 Z_{jb}^{i,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& + \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& + \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{i,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{i,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{R,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{R,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{j6+c}^{i,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{j6+c}^{i,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{R,*} \sum_{c=1}^3 Z_{j6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{R,*} \sum_{c=1}^3 Z_{j6+c}^{i,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{j6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{j6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{k6+c}^{R,*} \lambda_{N,dc}^*
\end{aligned}$$

$$\begin{aligned}
& + \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{k6+c}^{R,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{i,*} \sum_{c=1}^3 Z_{k6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{i,*} \sum_{c=1}^3 Z_{k6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{k6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{k6+c}^{R,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{i,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{i,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{j3+b}^{i,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{R,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{R,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \Big) \Big) \quad (465)
\end{aligned}$$


---



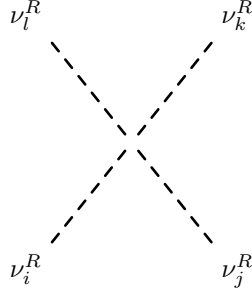
$$\frac{1}{4} \left( \sum_{b=1}^3 Z_{lb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{i3+c}^{i,*} \right)$$

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

$$\begin{aligned}
& - \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{id}^{i,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{kb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& + \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{jd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{i,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& + \sum_{b=1}^3 Z_{ib}^{i,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& - \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{R,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{R,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{R,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{R,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{i6+c}^{i,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{j6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{j6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{R,*} \sum_{c=1}^3 Z_{j6+c}^{R,*} \lambda_{N,dc}^*
\end{aligned}$$



$$\begin{aligned}
& - \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{R,*} \sum_{c=1}^3 Z_{j6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{j6+c}^{R,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{j6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{k6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{k6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{R,*} \sum_{c=1}^3 Z_{k6+c}^{R,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{R,*} \sum_{c=1}^3 Z_{k6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{k6+c}^{R,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{k6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{i,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{R,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{R,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \\
& + \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{i6+a}^{i,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{R,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \\
& - \sum_{b=1}^3 Z_{i3+b}^{i,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{R,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \Big)
\end{aligned} \tag{466}$$



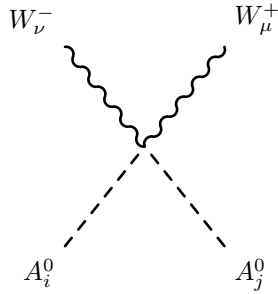
$$\begin{aligned}
& -\frac{i}{8} \left( (g_1^2 + g_2^2) \sum_{a=1}^3 Z_{ka}^{R,*} Z_{la}^{R,*} \sum_{b=1}^3 Z_{ib}^{R,*} Z_{jb}^{R,*} + (g_1^2 + g_2^2) \sum_{a=1}^3 Z_{ja}^{R,*} Z_{la}^{R,*} \sum_{b=1}^3 Z_{ib}^{R,*} Z_{kb}^{R,*} \right. \\
& + g_1^2 \sum_{a=1}^3 Z_{ia}^{R,*} Z_{la}^{R,*} \sum_{b=1}^3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

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

$$\begin{aligned}
& + 2 \sum_{b=1}^3 Z_{jb}^{R,*} \sum_{a=1}^3 Z_{i3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{ib}^{R,*} \sum_{a=1}^3 Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^3 Z_{kd}^{R,*} \sum_{c=1}^3 Y_{\nu,cd}^* Z_{l3+c}^{R,*} \\
& + 2 \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{R,*} \sum_{c=1}^3 Z_{i6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{R,*} \sum_{c=1}^3 Z_{i6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{R,*} \sum_{c=1}^3 Z_{i6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{R,*} \sum_{c=1}^3 Z_{i6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{i6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{i6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{R,*} \sum_{c=1}^3 Z_{j6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{R,*} \sum_{c=1}^3 Z_{j6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{i6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{R,*} \sum_{c=1}^3 Z_{j6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{i3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{R,*} \sum_{c=1}^3 Z_{j6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{i6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{j6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{i3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{j6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{R,*} \sum_{c=1}^3 Z_{k6+c}^{R,*} \lambda_{N,dc}^*
\end{aligned}$$

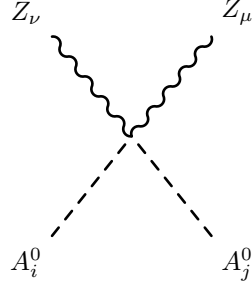
$$\begin{aligned}
& + 2 \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{R,*} \sum_{c=1}^3 Z_{k6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{l3+b}^{R,*} \sum_{a=1}^3 Z_{i6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{R,*} \sum_{c=1}^3 Z_{k6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{i3+b}^{R,*} \sum_{a=1}^3 Z_{l6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{R,*} \sum_{c=1}^3 Z_{k6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{i6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{k6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{i3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{l3+d}^{R,*} \sum_{c=1}^3 Z_{k6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{R,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{i3+d}^{R,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{k3+b}^{R,*} \sum_{a=1}^3 Z_{i6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{R,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{i3+b}^{R,*} \sum_{a=1}^3 Z_{k6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{j3+d}^{R,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{j3+b}^{R,*} \sum_{a=1}^3 Z_{i6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{R,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \\
& + 2 \sum_{b=1}^3 Z_{i3+b}^{R,*} \sum_{a=1}^3 Z_{j6+a}^{R,*} \lambda_{N,ba} \sum_{d=1}^3 Z_{k3+d}^{R,*} \sum_{c=1}^3 Z_{l6+c}^{R,*} \lambda_{N,dc}^* \Big) \tag{467}
\end{aligned}$$

## 9.8 Two Scalar-Two Vector Boson-Interaction



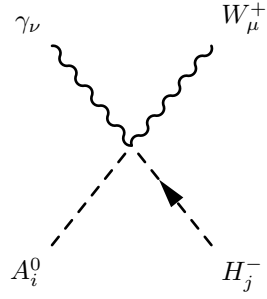
$$\frac{i}{2}g_2^2\left(Z_{i1}^AZ_{j1}^A+Z_{i2}^AZ_{j2}^A\right)\left(g_{\mu\nu}\right) \quad (468)$$


---



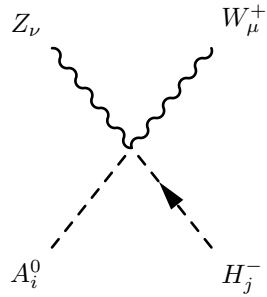
$$\frac{i}{2}\left(g_1\sin\Theta_W+g_2\cos\Theta_W\right)^2\left(Z_{i1}^AZ_{j1}^A+Z_{i2}^AZ_{j2}^A\right)\left(g_{\mu\nu}\right) \quad (469)$$


---



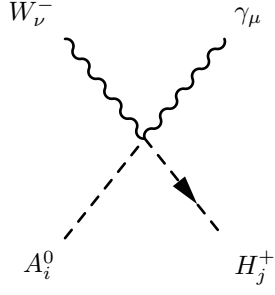
$$-\frac{1}{2}g_1g_2\cos\Theta_W\left(Z_{i1}^AZ_{j1}^++Z_{i2}^AZ_{j2}^+\right)\left(g_{\mu\nu}\right) \quad (470)$$


---



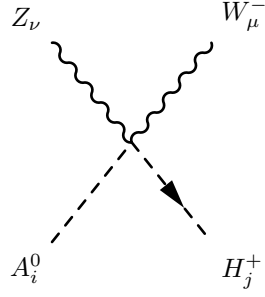
$$\frac{1}{2}g_1g_2\sin\Theta_W\left(Z_{i1}^AZ_{j1}^++Z_{i2}^AZ_{j2}^+\right)\left(g_{\mu\nu}\right) \quad (471)$$


---



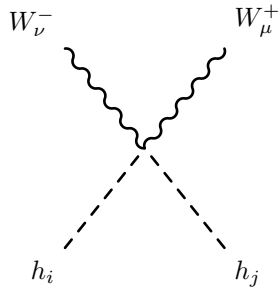
$$\frac{1}{2}g_1g_2\cos\Theta_W\left(Z_{i1}^AZ_{j1}^++Z_{i2}^AZ_{j2}^+\right)\left(g_{\mu\nu}\right) \quad (472)$$


---



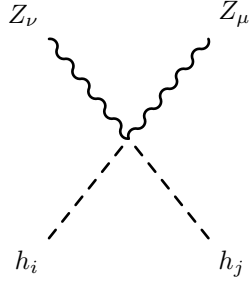
$$-\frac{1}{2}g_1g_2\sin\Theta_W\left(Z_{i1}^AZ_{j1}^++Z_{i2}^AZ_{j2}^+\right)\left(g_{\mu\nu}\right) \quad (473)$$


---



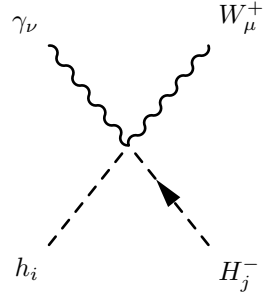
$$\frac{i}{2}g_2^2\left(Z_{i1}^HZ_{j1}^H+Z_{i2}^HZ_{j2}^H\right)\left(g_{\mu\nu}\right) \quad (474)$$


---



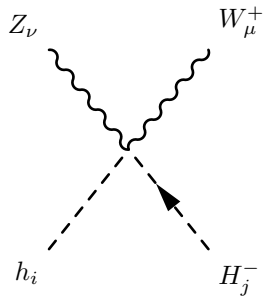
$$\frac{i}{2} \left( g_1 \sin \Theta_W + g_2 \cos \Theta_W \right)^2 \left( Z_{i1}^H Z_{j1}^H + Z_{i2}^H Z_{j2}^H \right) (g_{\mu\nu}) \quad (475)$$


---



$$- \frac{i}{2} g_1 g_2 \cos \Theta_W \left( Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+ \right) (g_{\mu\nu}) \quad (476)$$

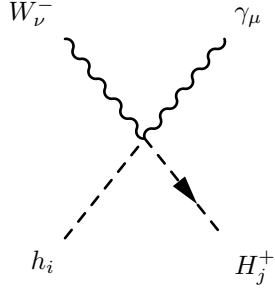

---



$$\frac{i}{2} g_1 g_2 \sin \Theta_W \left( Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+ \right) (g_{\mu\nu}) \quad (477)$$

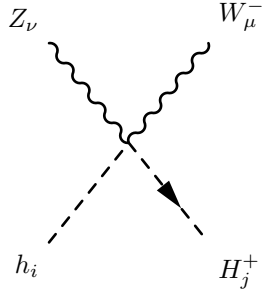

---





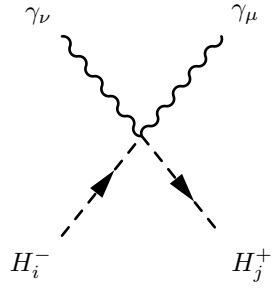
$$-\frac{i}{2}g_1g_2\cos\Theta_W\left(Z_{i1}^HZ_{j1}^+-Z_{i2}^HZ_{j2}^+\right)\left(g_{\mu\nu}\right) \quad (478)$$


---



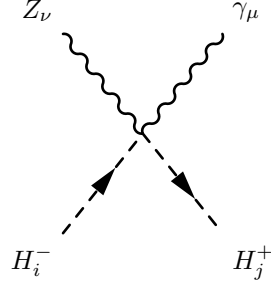
$$\frac{i}{2}g_1g_2\sin\Theta_W\left(Z_{i1}^HZ_{j1}^+-Z_{i2}^HZ_{j2}^+\right)\left(g_{\mu\nu}\right) \quad (479)$$


---



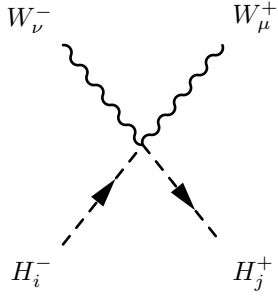
$$\frac{i}{2}\left(g_1\cos\Theta_W+g_2\sin\Theta_W\right)^2\left(Z_{i1}^+Z_{j1}^++Z_{i2}^+Z_{j2}^+\right)\left(g_{\mu\nu}\right) \quad (480)$$


---



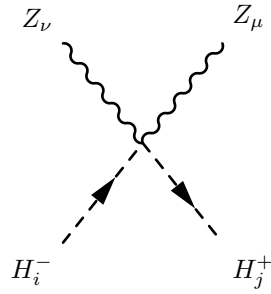
$$-\frac{i}{4}\left(-2g_1g_2\cos 2\Theta_W+\left(-g_2^2+g_1^2\right)\sin 2\Theta_W\right)\left(Z_{i1}^+Z_{j1}^++Z_{i2}^+Z_{j2}^+\right)\left(g_{\mu\nu}\right) \quad (481)$$


---



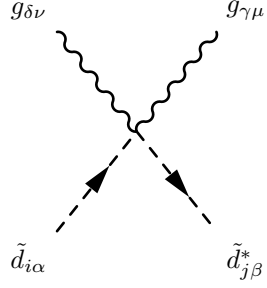
$$\frac{i}{2}g_2^2\left(Z_{i1}^+Z_{j1}^++Z_{i2}^+Z_{j2}^+\right)\left(g_{\mu\nu}\right) \quad (482)$$


---



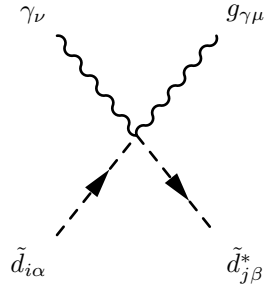
$$\frac{i}{2}\left(-g_1\sin \Theta_W+g_2\cos \Theta_W\right)^2\left(Z_{i1}^+Z_{j1}^++Z_{i2}^+Z_{j2}^+\right)\left(g_{\mu\nu}\right) \quad (483)$$


---



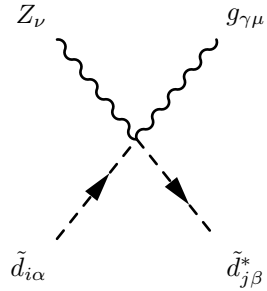
$$\frac{i}{4}g_3^2\delta_{ij}\left(\sum_{a=1}^3\lambda_{a,\alpha}^\gamma\lambda_{\beta,a}^\delta+\sum_{a=1}^3\lambda_{\beta,a}^\gamma\lambda_{a,\alpha}^\delta\right)(g_{\mu\nu}) \quad (484)$$


---



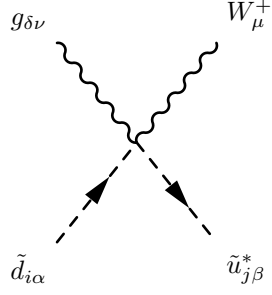
$$\frac{i}{6}g_3\lambda_{\beta,\alpha}^\gamma\left(-2g_1\cos\Theta_W\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{j3+a}^D+\left(-3g_2\sin\Theta_W+g_1\cos\Theta_W\right)\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^D\right)(g_{\mu\nu}) \quad (485)$$


---



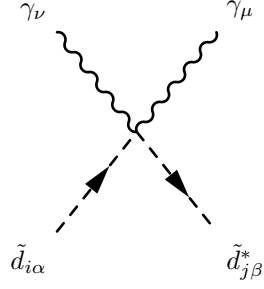
$$-\frac{i}{6}g_3\lambda_{\beta,\alpha}^\gamma\left(-2g_1\sin\Theta_W\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{j3+a}^D+\left(3g_2\cos\Theta_W+g_1\sin\Theta_W\right)\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^D\right)(g_{\mu\nu}) \quad (486)$$


---



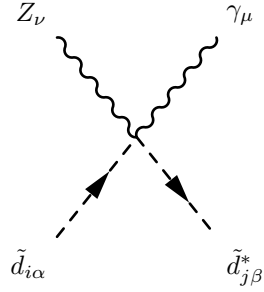
$$i \frac{1}{\sqrt{2}} g_2 g_3 \lambda_{\beta,\alpha}^\delta \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U (g_{\mu\nu}) \quad (487)$$


---



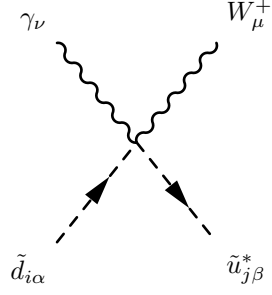
$$\frac{i}{18} \delta_{\alpha\beta} \left( \left( -3g_2 \sin \Theta_W + g_1 \cos \Theta_W \right)^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D + 4g_1^2 \cos^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \right) (g_{\mu\nu}) \quad (488)$$


---



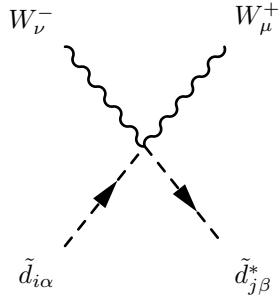
$$\begin{aligned} & - \frac{i}{36} \delta_{\alpha\beta} \left( \left( 6g_1 g_2 \cos 2\Theta_W + \left( -9g_2^2 + g_1^2 \right) \sin 2\Theta_W \right) \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \right. \\ & \left. + 4g_1^2 \sin 2\Theta_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \right) (g_{\mu\nu}) \end{aligned} \quad (489)$$


---



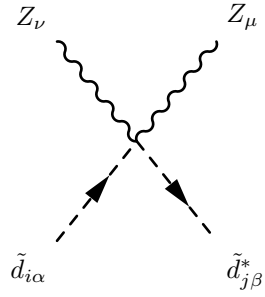
$$\frac{i}{3} \frac{1}{\sqrt{2}} g_1 g_2 \cos \Theta_W \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U (g_{\mu\nu}) \quad (490)$$


---



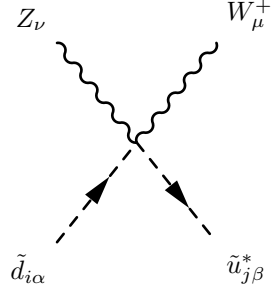
$$\frac{i}{2} g_2^2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D (g_{\mu\nu}) \quad (491)$$


---



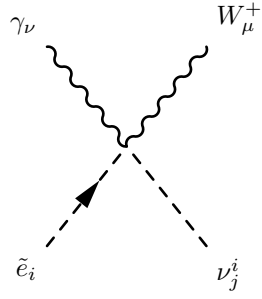
$$\frac{i}{18} \delta_{\alpha\beta} \left( \left( 3g_2 \cos \Theta_W + g_1 \sin \Theta_W \right)^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D + 4g_1^2 \sin^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \right) (g_{\mu\nu}) \quad (492)$$


---



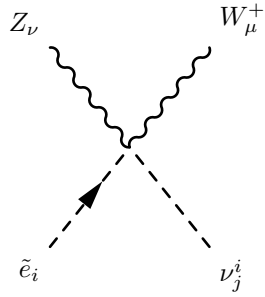
$$-\frac{i}{3}\frac{1}{\sqrt{2}}g_1g_2\delta_{\alpha\beta}\sin\Theta_W\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^U(g_{\mu\nu}) \quad (493)$$


---



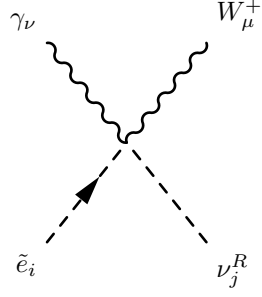
$$-\frac{1}{2}g_1g_2\cos\Theta_W\sum_{a=1}^3Z_{ia}^{E,*}Z_{ja}^{i,*}(g_{\mu\nu}) \quad (494)$$


---



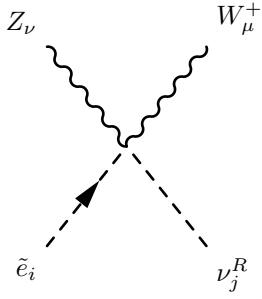
$$\frac{1}{2}g_1g_2\sin\Theta_W\sum_{a=1}^3Z_{ia}^{E,*}Z_{ja}^{i,*}(g_{\mu\nu}) \quad (495)$$


---



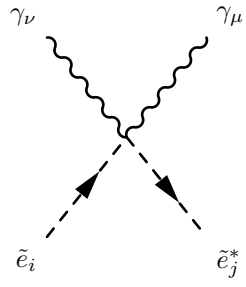
$$-\frac{i}{2}g_1g_2\cos\Theta_W\sum_{a=1}^3Z_{ia}^{E,*}Z_{ja}^{R,*}\left(g_{\mu\nu}\right) \quad (496)$$


---



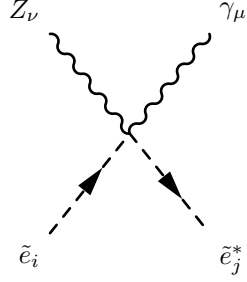
$$\frac{i}{2}g_1g_2\sin\Theta_W\sum_{a=1}^3Z_{ia}^{E,*}Z_{ja}^{R,*}\left(g_{\mu\nu}\right) \quad (497)$$


---



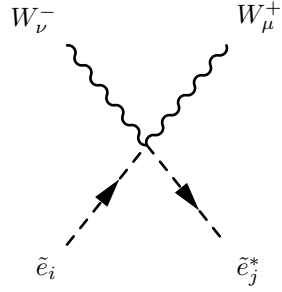
$$\frac{i}{2}\left(4g_1^2\cos^2\Theta_W\sum_{a=1}^3Z_{i3+a}^{E,*}Z_{j3+a}^E+\left(g_1\cos\Theta_W+g_2\sin\Theta_W\right)^2\sum_{a=1}^3Z_{ia}^{E,*}Z_{ja}^E\right)\left(g_{\mu\nu}\right) \quad (498)$$


---



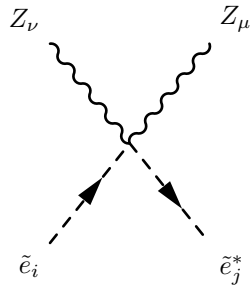
$$\begin{aligned}
& -\frac{i}{4} \left( \left( -2g_1 g_2 \cos 2\Theta_W + \left( -g_2^2 + g_1^2 \right) \sin 2\Theta_W \right) \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right. \\
& \left. + 4g_1^2 \sin 2\Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \right) (g_{\mu\nu})
\end{aligned} \tag{499}$$


---



$$\frac{i}{2} g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E (g_{\mu\nu}) \tag{500}$$

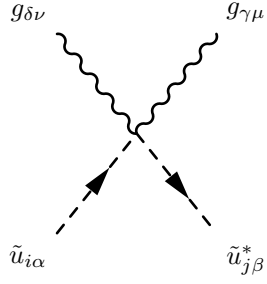

---



$$\frac{i}{2} \left( 4g_1^2 \sin^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E + \left( -g_1 \sin \Theta_W + g_2 \cos \Theta_W \right)^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right) (g_{\mu\nu}) \tag{501}$$

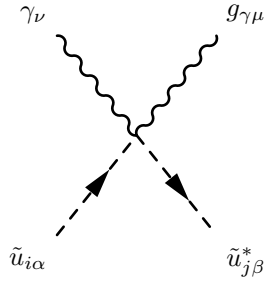

---





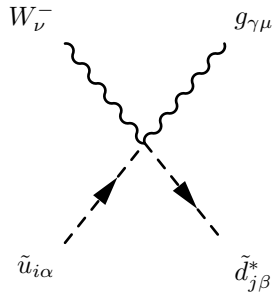
$$\frac{i}{4}g_3^2\delta_{ij}\left(\sum_{a=1}^3\lambda_{a,\alpha}^\gamma\lambda_{\beta,a}^\delta+\sum_{a=1}^3\lambda_{\beta,a}^\gamma\lambda_{a,\alpha}^\delta\right)\left(g_{\mu\nu}\right) \quad (502)$$


---



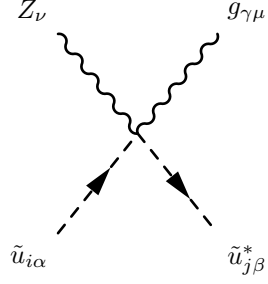
$$\frac{i}{6}g_3\lambda_{\beta,\alpha}^\gamma\left(\left(3g_2\sin\Theta_W+g_1\cos\Theta_W\right)\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^U+4g_1\cos\Theta_W\sum_{a=1}^3Z_{i3+a}^{U,*}Z_{j3+a}^U\right)\left(g_{\mu\nu}\right) \quad (503)$$


---



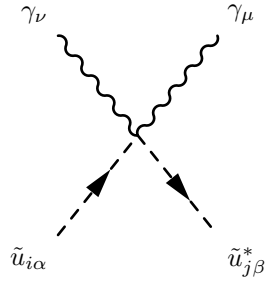
$$i\frac{1}{\sqrt{2}}g_2g_3\lambda_{\beta,\alpha}^\gamma\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^D\left(g_{\mu\nu}\right) \quad (504)$$


---



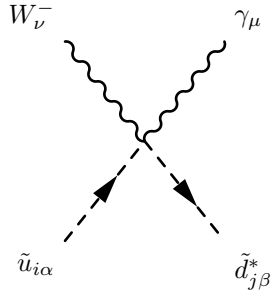
$$\frac{i}{6} g_3 \lambda_{\beta, \alpha}^{\gamma} \left( \left( 3g_2 \cos \Theta_W - g_1 \sin \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U - 4g_1 \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \right) (g_{\mu\nu}) \quad (505)$$


---



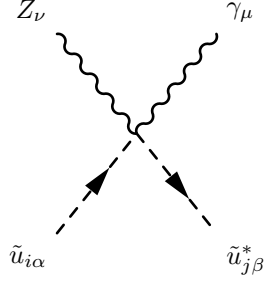
$$\frac{i}{18} \delta_{\alpha\beta} \left( 16g_1^2 \cos^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U + \left( 3g_2 \sin \Theta_W + g_1 \cos \Theta_W \right)^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \right) (g_{\mu\nu}) \quad (506)$$


---



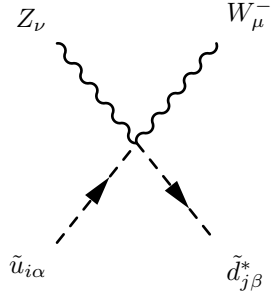
$$\frac{i}{3} \frac{1}{\sqrt{2}} g_1 g_2 \cos \Theta_W \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D (g_{\mu\nu}) \quad (507)$$


---



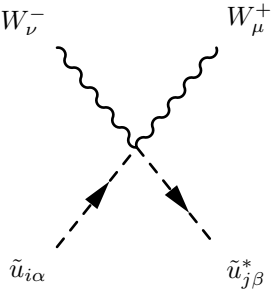
$$\begin{aligned}
& -\frac{i}{36}\delta_{\alpha\beta}\left(\left(-6g_1g_2\cos 2\Theta_W+\left(-9g_2^2+g_1^2\right)\sin 2\Theta_W\right)\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^U\right. \\
& \left.+16g_1^2\sin 2\Theta_W\sum_{a=1}^3Z_{i3+a}^{U,*}Z_{j3+a}^U\right)\left(g_{\mu\nu}\right)
\end{aligned} \tag{508}$$


---



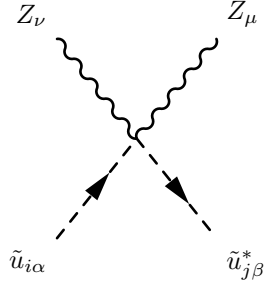
$$-\frac{i}{3}\frac{1}{\sqrt{2}}g_1g_2\delta_{\alpha\beta}\sin\Theta_W\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^D\left(g_{\mu\nu}\right) \tag{509}$$


---



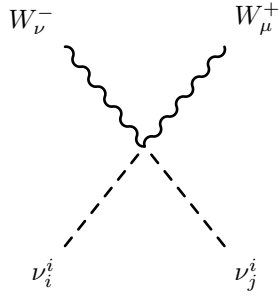
$$\frac{i}{2}g_2^2\delta_{\alpha\beta}\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^U\left(g_{\mu\nu}\right) \tag{510}$$


---



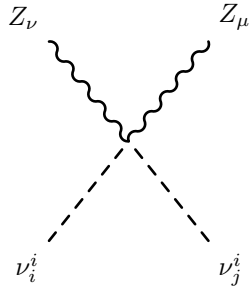
$$\frac{i}{18} \delta_{\alpha\beta} \left( 16g_1^2 \sin^2 \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U + \left( -3g_2 \cos \Theta_W + g_1 \sin \Theta_W \right)^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \right) (g_{\mu\nu}) \quad (511)$$


---



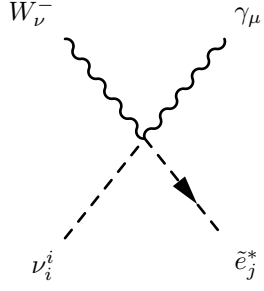
$$\frac{i}{2} g_2^2 \sum_{a=1}^3 Z_{ia}^{i,*} Z_{ja}^{i,*} (g_{\mu\nu}) \quad (512)$$


---



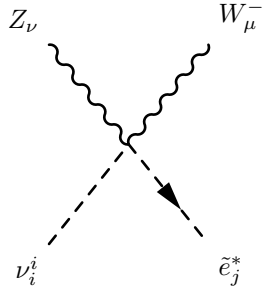
$$\frac{i}{2} \left( g_1 \sin \Theta_W + g_2 \cos \Theta_W \right)^2 \sum_{a=1}^3 Z_{ia}^{i,*} Z_{ja}^{i,*} (g_{\mu\nu}) \quad (513)$$


---



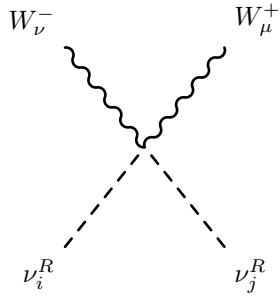
$$\frac{1}{2}g_1g_2\cos\Theta_W\sum_{a=1}^3Z_{ia}^{i,*}Z_{ja}^E(g_{\mu\nu}) \quad (514)$$


---



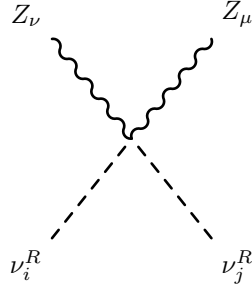
$$-\frac{1}{2}g_1g_2\sin\Theta_W\sum_{a=1}^3Z_{ia}^{i,*}Z_{ja}^E(g_{\mu\nu}) \quad (515)$$


---



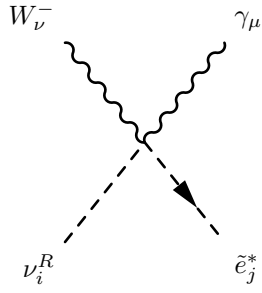
$$\frac{i}{2}g_2^2\sum_{a=1}^3Z_{ia}^{R,*}Z_{ja}^{R,*}(g_{\mu\nu}) \quad (516)$$


---



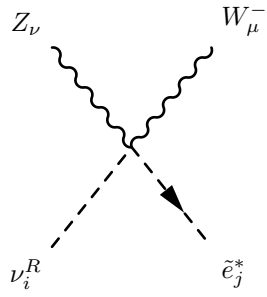
$$\frac{i}{2} \left( g_1 \sin \Theta_W + g_2 \cos \Theta_W \right)^2 \sum_{a=1}^3 Z_{ia}^{R,*} Z_{ja}^{R,*} \left( g_{\mu\nu} \right) \quad (517)$$


---



$$-\frac{i}{2} g_1 g_2 \cos \Theta_W \sum_{a=1}^3 Z_{ia}^{R,*} Z_{ja}^E \left( g_{\mu\nu} \right) \quad (518)$$

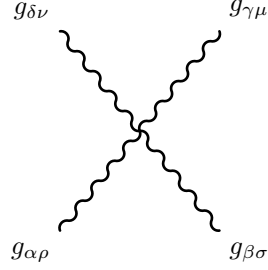

---



$$\frac{i}{2} g_1 g_2 \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{R,*} Z_{ja}^E \left( g_{\mu\nu} \right) \quad (519)$$


---

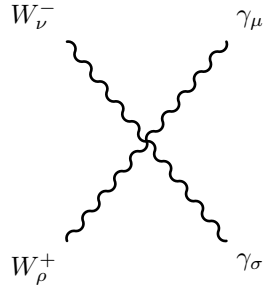
## 9.9 Four Vector Boson-Interaction



$$-ig_3^2 \left( \sum_{a=1}^8 f_{\alpha,\delta,a} f_{\beta,\gamma,a} + \sum_{a=1}^8 f_{\alpha,\gamma,a} f_{\beta,\delta,a} \right) (g_{\rho\sigma} g_{\mu\nu}) \quad (520)$$

$$+ ig_3^2 \left( - \sum_{a=1}^8 f_{\alpha,\beta,a} f_{\gamma,\delta,a} + \sum_{a=1}^8 f_{\alpha,\delta,a} f_{\beta,\gamma,a} \right) (g_{\rho\mu} g_{\sigma\nu}) \quad (521)$$

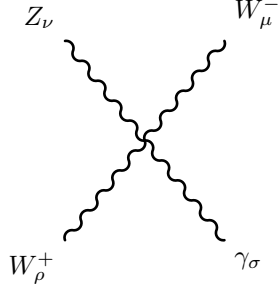
$$+ ig_3^2 \left( \sum_{a=1}^8 f_{\alpha,\gamma,a} f_{\beta,\delta,a} + \sum_{a=1}^8 f_{\alpha,\beta,a} f_{\gamma,\delta,a} \right) (g_{\rho\nu} g_{\sigma\mu}) \quad (522)$$



$$ig_2^2 \sin \Theta_W^2 (g_{\rho\sigma} g_{\mu\nu}) \quad (523)$$

$$+ ig_2^2 \sin \Theta_W^2 (g_{\rho\mu} g_{\sigma\nu}) \quad (524)$$

$$+ -2ig_2^2 \sin \Theta_W^2 (g_{\rho\nu} g_{\sigma\mu}) \quad (525)$$

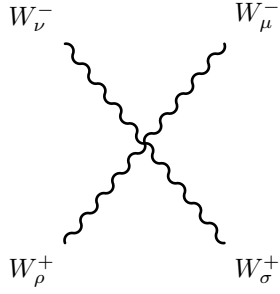


$$ig_2^2 \cos \Theta_W \sin \Theta_W (g_{\rho\sigma} g_{\mu\nu}) \quad (526)$$

$$+ -ig_2^2 \sin 2\Theta_W (g_{\rho\mu} g_{\sigma\nu}) \quad (527)$$

$$+ ig_2^2 \cos \Theta_W \sin \Theta_W (g_{\rho\nu} g_{\sigma\mu}) \quad (528)$$


---

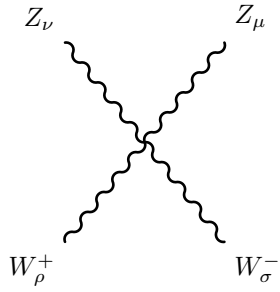


$$2ig_2^2 (g_{\rho\sigma} g_{\mu\nu}) \quad (529)$$

$$+ -ig_2^2 (g_{\rho\mu} g_{\sigma\nu}) \quad (530)$$

$$+ -ig_2^2 (g_{\rho\nu} g_{\sigma\mu}) \quad (531)$$


---



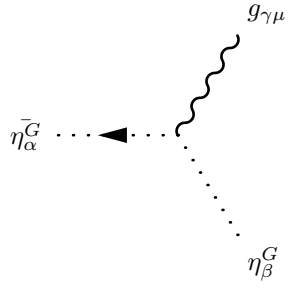


$$- 2ig_2^2 \cos \Theta_W^2 (g_{\rho\sigma} g_{\mu\nu}) \quad (532)$$

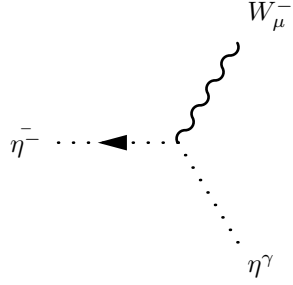
$$+ ig_2^2 \cos \Theta_W^2 (g_{\rho\mu} g_{\sigma\nu}) \quad (533)$$

$$+ ig_2^2 \cos \Theta_W^2 (g_{\rho\nu} g_{\sigma\mu}) \quad (534)$$

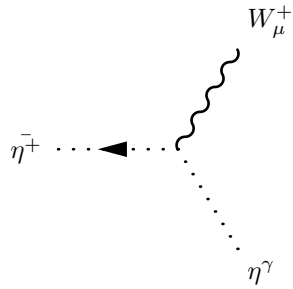
## 9.10 Two Ghosts-One Vector Boson-Interaction



$$g_3 f_{\alpha,\beta,\gamma} (p_\mu^{\eta_\beta^G}) \quad (535)$$

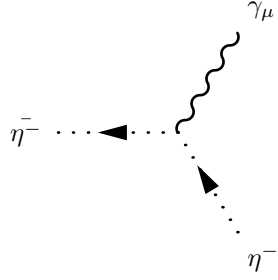


$$ig_2 \sin \Theta_W (p_\mu^{\eta^\gamma}) \quad (536)$$



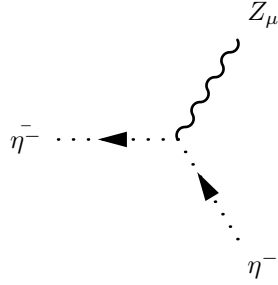
$$-ig_2 \sin \Theta_W \left( p_\mu^{\eta^\gamma} \right) \quad (537)$$


---



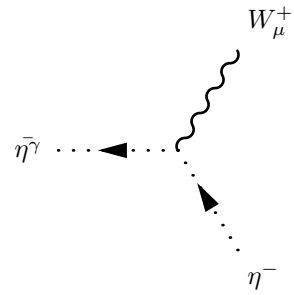
$$-ig_2 \sin \Theta_W \left( p_\mu^{\eta^-} \right) \quad (538)$$


---



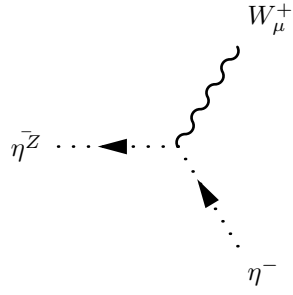
$$-ig_2 \cos \Theta_W \left( p_\mu^{\eta^-} \right) \quad (539)$$


---



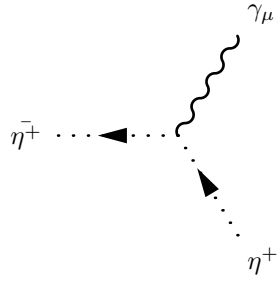
$$ig_2 \sin \Theta_W \left( p_\mu^{\eta^-} \right) \quad (540)$$


---



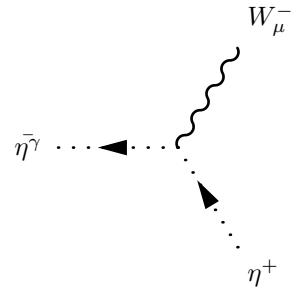
$$ig_2 \cos \Theta_W \left( p_\mu^{\eta^-} \right) \quad (541)$$


---



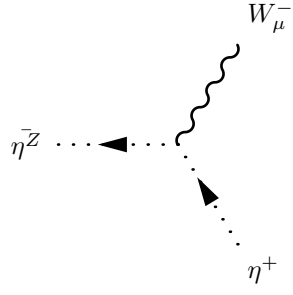
$$ig_2 \sin \Theta_W \left( p_\mu^{\eta^+} \right) \quad (542)$$


---



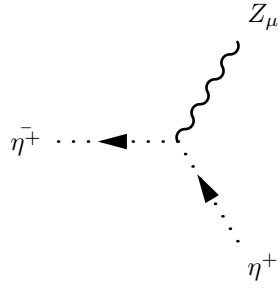
$$-ig_2 \sin \Theta_W \left( p_\mu^{\eta^+} \right) \quad (543)$$


---



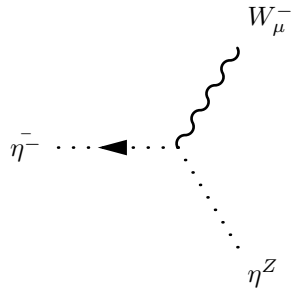
$$-ig_2 \cos \Theta_W (p_\mu^{\eta^+}) \quad (544)$$


---



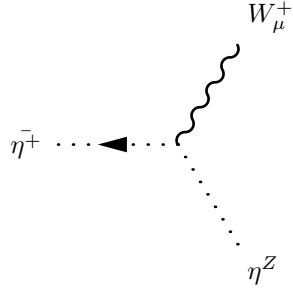
$$ig_2 \cos \Theta_W (p_\mu^{\eta^+}) \quad (545)$$


---



$$ig_2 \cos \Theta_W (p_\mu^{\eta^Z}) \quad (546)$$

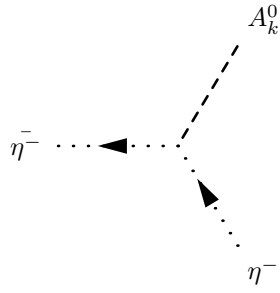

---



$$-ig_2 \cos \Theta_W \left( p_\mu^{\eta^Z} \right) \quad (547)$$

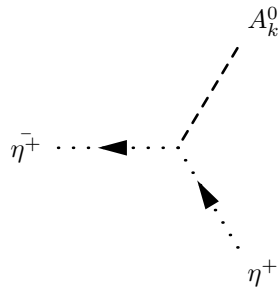

---

### 9.11 Two Ghosts-One Scalar-Interaction



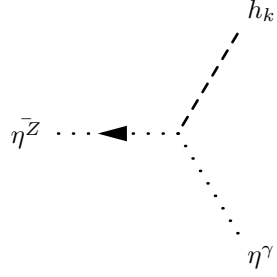
$$\frac{1}{4} g_2^2 \xi_{W^-} \left( v_d Z_{k1}^A - v_u Z_{k2}^A \right) \quad (548)$$


---



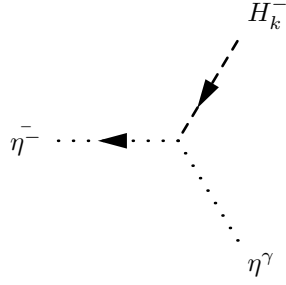
$$\frac{1}{4} g_2^2 \xi_{W^-} \left( -v_d Z_{k1}^A + v_u Z_{k2}^A \right) \quad (549)$$


---



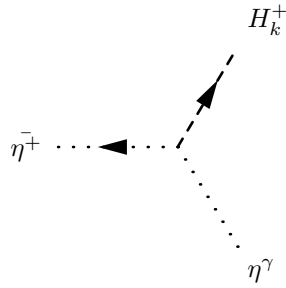
$$\frac{i}{8}\xi_Z\left(2g_1g_2\cos 2\Theta_W+\left(-g_2^2+g_1^2\right)\sin 2\Theta_W\right)\left(v_dZ_{k1}^H+v_uZ_{k2}^H\right) \quad (550)$$


---



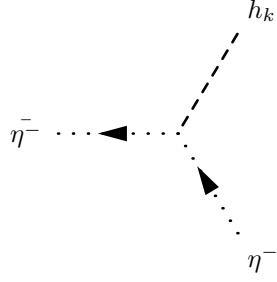
$$\frac{i}{4}g_2\xi_{W-}\left(g_1\cos \Theta_W+g_2\sin \Theta_W\right)\left(v_dZ_{k1}^+-v_uZ_{k2}^+\right) \quad (551)$$


---



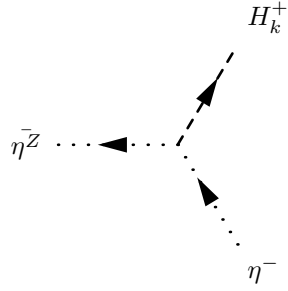
$$\frac{i}{4}g_2\xi_{W-}\left(g_1\cos \Theta_W+g_2\sin \Theta_W\right)\left(v_dZ_{k1}^+-v_uZ_{k2}^+\right) \quad (552)$$


---



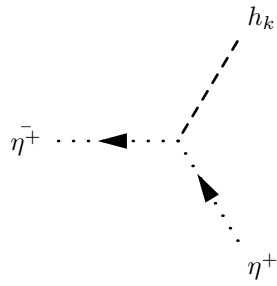
$$-\frac{i}{4}g_2^2\xi_{W^-}\left(v_dZ_{k1}^H+v_uZ_{k2}^H\right) \quad (553)$$


---



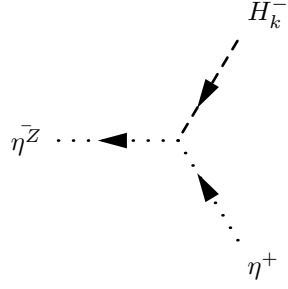
$$-\frac{i}{4}g_2\xi_Z\left(g_1\sin\Theta_W+g_2\cos\Theta_W\right)\left(v_dZ_{k1}^+-v_uZ_{k2}^+\right) \quad (554)$$


---



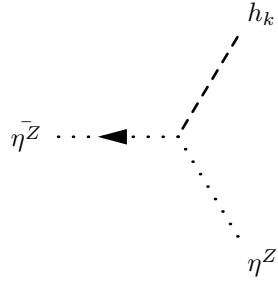
$$-\frac{i}{4}g_2^2\xi_{W^-}\left(v_dZ_{k1}^H+v_uZ_{k2}^H\right) \quad (555)$$


---



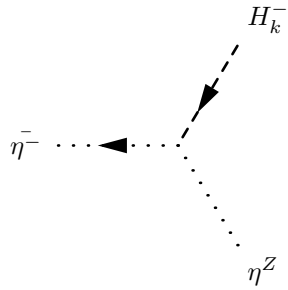
$$-\frac{i}{4}g_2\xi_Z\left(g_1\sin\Theta_W+g_2\cos\Theta_W\right)\left(v_dZ_{k1}^+-v_uZ_{k2}^+\right) \quad (556)$$


---



$$-\frac{i}{4}\xi_Z\left(g_1\sin\Theta_W+g_2\cos\Theta_W\right)^2\left(v_dZ_{k1}^H+v_uZ_{k2}^H\right) \quad (557)$$

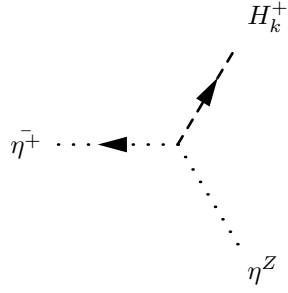

---



$$\frac{i}{4}g_2\xi_{W-}\left(-g_1\sin\Theta_W+g_2\cos\Theta_W\right)\left(v_dZ_{k1}^+-v_uZ_{k2}^+\right) \quad (558)$$


---





$$\frac{i}{4}g_2\xi_{W-}\left(-g_1\sin\Theta_W+g_2\cos\Theta_W\right)\left(v_dZ_{k1}^+-v_uZ_{k2}^+\right) \tag{559}$$

---

## 10 Clebsch-Gordan Coefficients