

$U(1)_R \times U(1)_{B-L}$  with inverse seesaw  
Superpotential, Rotations and Interactions for eigenstates 'EWSB'  
including Renormalization Group Equations  
including one-loop Self-Energies

SARAH 4.6.0

November 19, 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 Superfields</b>	<b>3</b>
1.1 Vector Superfields . . . . .	3
1.2 Chiral Superfields . . . . .	3
<b>2 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 Renormalization Group Equations</b>	<b>4</b>
3.1 Anomalous Dimensions . . . . .	4
3.2 Gauge Couplings . . . . .	7
3.3 Gaugino Mass Parameters . . . . .	10
3.4 Trilinear Superpotential Parameters . . . . .	13
3.5 Bilinear Superpotential Parameters . . . . .	16
3.6 Trilinear Soft-Breaking Parameters . . . . .	16
3.7 Bilinear Soft-Breaking Parameters . . . . .	26
3.8 Soft-Breaking Scalar Masses . . . . .	27
3.9 Vacuum expectation values . . . . .	55
<b>4 Field Rotations</b>	<b>56</b>
4.1 Rotations in gauge sector for eigenstates 'EWSB'	56
4.2 Rotations in Mass sector for eigenstates 'EWSB'	57
4.2.1 Mass Matrices for Scalars . . . . .	57
4.2.2 Mass Matrices for Fermions . . . . .	64
<b>5 Vacuum Expectation Values</b>	<b>66</b>
<b>6 Tadpole Equations</b>	<b>66</b>
<b>7 Particle content for eigenstates 'EWSB'</b>	<b>67</b>
<b>8 One Loop Self-Energy and One Loop Tadpoles for eigenstates 'EWSB'</b>	<b>68</b>
8.1 One Loop Self-Energy . . . . .	68
8.2 Tadpoles . . . . .	90
<b>9 Interactions for eigenstates 'EWSB'</b>	<b>91</b>
9.1 Three Scalar-Interaction . . . . .	91
9.2 Two Scalar-One Vector Boson-Interaction . . . . .	99
9.3 One Scalar-Two Vector Boson-Interaction . . . . .	109
9.4 Two Fermion-One Vector Boson-Interaction . . . . .	113
9.5 Two Fermion-One Scalar Boson-Interaction . . . . .	123

9.6	Three Vector Boson-Interaction . . . . .	140
9.7	Four Scalar-Interaction . . . . .	141
9.8	Two Scalar-Two Vector Boson-Interaction . . . . .	174
9.9	Four Vector Boson-Interaction . . . . .	203
9.10	Two Ghosts-One Vector Boson-Interaction . . . . .	206
9.11	Two Ghosts-One Scalar-Interaction . . . . .	213
<b>10</b>	<b>Clebsch-Gordan Coefficients</b>	<b>222</b>

# 1 Superfields

## 1.1 Vector Superfields

SF	Spin $\frac{1}{2}$	Spin 1	$SU(N)$	Coupling	Name
$\hat{B}$	$\lambda_{\hat{B}}$	$B$	$U(1)$	$g_{BL}$	bminl
$\hat{W}$	$\lambda_{\hat{W}}$	$W$	$SU(2)$	$g_L$	left
$\hat{B}_R$	$\lambda_R$	$B_R$	$U(1)$	$g_R$	right
$\hat{g}$	$\lambda_{\hat{g}}$	$g$	$SU(3)$	$g_s$	color

## 1.2 Chiral Superfields

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

# 2 Superpotential and Lagrangian

## 2.1 Superpotential

$$W = -\mu_R \hat{\chi}_R \hat{\chi}_R + \mu \hat{H}_u \hat{H}_d - Y_d \hat{d} \hat{q} \hat{H}_d - Y_e \hat{e} \hat{l} \hat{H}_d + Y_u \hat{u} \hat{q} \hat{H}_u + Y_s \hat{\nu} \hat{\chi}_R \hat{S} + Y_\nu \hat{\nu} \hat{l} \hat{H}_u \quad (1)$$

## 2.2 Softbreaking terms

$$\begin{aligned}
-L_{SB,W} = & -\chi_R^0 \bar{\chi}_R^0 B_{\mu_R} - H_d^0 H_u^0 B_\mu + H_d^- H_u^+ B_\mu + H_d^0 \tilde{d}_{R,i\alpha}^* \delta_{\alpha\beta} \tilde{d}_{L,j\beta} T_{d,ij} - H_d^- \tilde{d}_{R,i\alpha}^* \delta_{\alpha\beta} \tilde{u}_{L,j\beta} T_{d,ij} \\
& + H_d^0 \tilde{e}_{R,i}^* \tilde{e}_{L,j} T_{e,ij} - H_d^- \tilde{e}_{R,i}^* \tilde{\nu}_{L,j} T_{e,ij} + \chi_R^0 \tilde{\nu}_{R,i}^* \tilde{S}_k T_{s,ik} - H_u^+ \tilde{u}_{R,i\alpha}^* \delta_{\alpha\beta} \tilde{d}_{L,j\beta} T_{u,ij} \\
& + H_u^0 \tilde{u}_{R,i\alpha}^* \delta_{\alpha\beta} \tilde{u}_{L,j\beta} T_{u,ij} - H_u^+ \tilde{\nu}_{R,i}^* \tilde{e}_{L,j} T_{\nu,ij} + H_u^0 \tilde{\nu}_{R,i}^* \tilde{\nu}_{L,j} T_{\nu,ij} + \text{h.c.} \quad (2) \\
-L_{SB,\phi} = & + m_\chi^2 |\chi_R^0|^2 + m_{\tilde{\chi}}^2 |\tilde{\chi}_R^0|^2 + m_{H_d}^2 |H_d^0|^2 + m_{H_d}^2 |H_d^-|^2 + m_{H_u}^2 |H_u^0|^2 + m_{H_u}^2 |H_u^+|^2 \\
& + \tilde{d}_{L,i\alpha}^* \delta_{\alpha\beta} m_{q,ij}^2 \tilde{d}_{L,j\beta} + \tilde{d}_{R,i\alpha}^* \delta_{\alpha\beta} m_{d,ij}^2 \tilde{d}_{R,j\beta} + \tilde{e}_{L,i}^* m_{l,ij}^2 \tilde{e}_{L,j} + \tilde{e}_{R,i}^* m_{e,ij}^2 \tilde{e}_{R,j} + \tilde{S}_i^* m_{S,ij}^2 \tilde{S}_j
\end{aligned}$$

$$+ \tilde{u}_{L,i\alpha}^* \delta_{\alpha\beta} m_{q,ij}^2 \tilde{u}_{L,j\beta} + \tilde{u}_{R,i\alpha}^* \delta_{\alpha\beta} m_{u,ij}^2 \tilde{u}_{R,j\beta} + \tilde{\nu}_{L,i}^* m_{l,ij}^2 \tilde{\nu}_{L,j} + \tilde{\nu}_{R,i}^* m_{\nu,ij}^2 \tilde{\nu}_{R,j} \quad (3)$$

$$-L_{SB,\lambda} = \frac{1}{2} \left( 2\lambda_{\tilde{B}} \lambda_R M_{BR} + \lambda_R^2 M_4 \delta_{ij} + \lambda_{\tilde{B}}^2 M_1 \delta_{ij} + M_2 \delta_{ij} \lambda_{\tilde{W},i} \lambda_{\tilde{W},j} + M_3 \delta_{ij} \lambda_{\tilde{g},\alpha} \lambda_{\tilde{g},\beta} + \text{h.c.} \right) \quad (4)$$

## 2.3 Gauge fixing terms

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

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

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

$$\begin{aligned} L_{GF} = & -\frac{1}{2} |\partial_\mu g|^2 \xi_g^{-1} - \frac{1}{2} |\partial_\mu \gamma|^2 \xi_\gamma^{-1} - \frac{i}{2} g_L \left( H_d^- v_d - v_u H_u^{+,*} \right) \xi_{W^-} + |\partial_\mu W^-|^2 \xi_{W^-}^{-1} \\ & - \frac{1}{2} \frac{1}{2} \left( 2\partial_\mu Z \right. \\ & + \xi_Z \left( g_L \left( \sigma_d v_d - \sigma_u v_u \right) Z Z_{12} + g_{RB} \sigma_R v_{\chi_R} Z Z_{22} - g_{RB} \bar{\sigma}_R v_{\bar{\chi}_R} Z Z_{22} + g_{BL} \left( \bar{\sigma}_R v_{\bar{\chi}_R} - \sigma_R v_{\chi_R} \right) Z Z_{22} - g_{RB} \sigma_d v_d Z Z_{22} \right. \\ & + g_{RB} \sigma_u v_u Z Z_{22} - g_{BR} \sigma_R v_{\chi_R} Z Z_{32} + g_R \sigma_R v_{\chi_R} Z Z_{32} + g_{BR} \bar{\sigma}_R v_{\bar{\chi}_R} Z Z_{32} - g_R \bar{\sigma}_R v_{\bar{\chi}_R} Z Z_{32} - g_R \sigma_d v_d Z Z_{32} + g_R \sigma_u v_u Z Z_{32} \left. \right) \Big|^2 \\ & - \frac{1}{2} \frac{1}{2} \left( 2\partial_\mu Z_R \right. \\ & + \xi_{Z_R} \left( g_L \left( \sigma_d v_d - \sigma_u v_u \right) Z Z_{13} + g_{RB} \sigma_R v_{\chi_R} Z Z_{23} - g_{RB} \bar{\sigma}_R v_{\bar{\chi}_R} Z Z_{23} + g_{BL} \left( \bar{\sigma}_R v_{\bar{\chi}_R} - \sigma_R v_{\chi_R} \right) Z Z_{23} - g_{RB} \sigma_d v_d Z Z_{23} \right. \\ & + g_{RB} \sigma_u v_u Z Z_{23} - g_{BR} \sigma_R v_{\chi_R} Z Z_{33} + g_R \sigma_R v_{\chi_R} Z Z_{33} + g_{BR} \bar{\sigma}_R v_{\bar{\chi}_R} Z Z_{33} - g_R \bar{\sigma}_R v_{\bar{\chi}_R} Z Z_{33} - g_R \sigma_d v_d Z Z_{33} + g_R \sigma_u v_u Z Z_{33} \left. \right) \Big|^2 \end{aligned} \quad (6)$$

## 2.4 Fields integrated out

None

## 3 Renormalization Group Equations

### 3.1 Anomalous Dimensions

$$\gamma_{\hat{q}}^{(1)} = -\frac{1}{12} \left( 18g_L^2 + 32g_s^2 + g_{BL}^2 + g_{BR}^2 \right) \mathbf{1} + Y_d^\dagger Y_d + Y_u^\dagger Y_u \quad (7)$$

$$\begin{aligned} \gamma_{\hat{q}}^{(2)} = & \frac{1}{72} \left( \left( -64g_s^4 + 41g_{BL}^4 + 41g_{BR}^4 + 18g_{BR}^2 g_L^2 + 270g_L^4 + 32g_s^2 \left( 18g_L^2 + g_{BL}^2 + g_{BR}^2 \right) - 3\sqrt{6}g_{BR}^3 g_R + 45g_{BR}^2 g_R^2 \right. \right. \\ & - 3\sqrt{6}g_{BL}^3 g_{RB} - 3g_{BL} g_{BR} \left( -30g_R + \sqrt{6}g_{BR} \right) g_{RB} + g_{BL}^2 \left( 18g_L^2 - 3\sqrt{6}g_{BR} g_R + 45g_{RB}^2 + 82g_{BR}^2 \right) \Big) \mathbf{1} \\ & - 12 \left( 12 \left( Y_d^\dagger Y_d Y_d^\dagger Y_d + Y_u^\dagger Y_u Y_u^\dagger Y_u \right) \right. \\ & \left. + Y_d^\dagger Y_d \left( 18\text{Tr} \left( Y_d Y_d^\dagger \right) - 6g_R^2 - 6g_{RB}^2 + 6\text{Tr} \left( Y_e Y_e^\dagger \right) + \sqrt{6}g_{BL} g_{RB} + \sqrt{6}g_{BR} g_R \right) \right) \end{aligned}$$

$$- Y_u^\dagger Y_u \left( -18 \text{Tr} \left( Y_u Y_u^\dagger \right) + 6g_R^2 + 6g_{RB}^2 - 6 \text{Tr} \left( Y_v Y_v^\dagger \right) + \sqrt{6} g_{BL} g_{RB} + \sqrt{6} g_{BR} g_R \right) \right) \quad (8)$$

$$\gamma_i^{(1)} = -\frac{3}{4} \left( 2g_L^2 + g_{BL}^2 + g_{BR}^2 \right) \mathbf{1} + Y_e^\dagger Y_e + Y_v^\dagger Y_v \quad (9)$$

$$\begin{aligned} \gamma_i^{(2)} = & \frac{1}{8} \left( 3 \left( 15g_{BL}^4 + 15g_{BR}^4 + 10g_L^4 - \sqrt{6} g_{BR}^3 g_R + 3g_{BR}^2 \left( 2g_L^2 + 5g_R^2 \right) - \sqrt{6} g_{BL}^3 g_{RB} \right. \right. \\ & + g_{BL} g_{BR} \left( 30g_R - \sqrt{6} g_{BR} \right) g_{RB} + g_{BL}^2 \left( 15g_{RB}^2 + 30g_{BR}^2 + 6g_L^2 - \sqrt{6} g_{BR} g_R \right) \left. \right) \mathbf{1} \\ & + 4 \left( -2 \left( 2Y_e^\dagger Y_e Y_e^\dagger Y_e + 2Y_v^\dagger Y_v Y_v^\dagger Y_v + Y_v^\dagger Y_s Y_s^\dagger Y_v \right) \right. \\ & + Y_e^\dagger Y_e \left( 2g_R^2 + 2g_{RB}^2 - 2 \text{Tr} \left( Y_e Y_e^\dagger \right) - 6 \text{Tr} \left( Y_d Y_d^\dagger \right) + \sqrt{6} g_{BL} g_{RB} + \sqrt{6} g_{BR} g_R \right) \\ & \left. - Y_v^\dagger Y_v \left( -2g_R^2 - 2g_{RB}^2 + 2 \text{Tr} \left( Y_v Y_v^\dagger \right) + 6 \text{Tr} \left( Y_u Y_u^\dagger \right) + \sqrt{6} g_{BL} g_{RB} + \sqrt{6} g_{BR} g_R \right) \right) \end{aligned} \quad (10)$$

$$\gamma_{\hat{H}_d}^{(1)} = \frac{1}{2} \left( 2 \text{Tr} \left( Y_e Y_e^\dagger \right) - 3g_L^2 + 6 \text{Tr} \left( Y_d Y_d^\dagger \right) - g_R^2 - g_{RB}^2 \right) \quad (11)$$

$$\begin{aligned} \gamma_{\hat{H}_d}^{(2)} = & \frac{1}{8} \left( 30g_L^4 + 27g_{BR}^2 g_R^2 + 12g_L^2 g_R^2 - 2\sqrt{6} g_{BR} g_R^3 + 32g_R^4 + 54g_{BL} g_{BR} g_R g_{RB} - 2\sqrt{6} g_{BL} g_R^2 g_{RB} \right. \\ & + 27g_{BL}^2 g_{RB}^2 + 12g_L^2 g_{RB}^2 - 2\sqrt{6} g_{BR} g_R g_{RB}^2 + 64g_R^2 g_{RB}^2 - 2\sqrt{6} g_{BL} g_{RB}^3 + 32g_{RB}^4 \\ & + 4 \left( 32g_s^2 - \sqrt{6} g_{BL} g_{RB} - \sqrt{6} g_{BR} g_R + g_{BL}^2 + g_{BR}^2 \right) \text{Tr} \left( Y_d Y_d^\dagger \right) \\ & + 4 \left( 3g_{BL}^2 + 3g_{BR}^2 + \sqrt{6} g_{BL} g_{RB} + \sqrt{6} g_{BR} g_R \right) \text{Tr} \left( Y_e Y_e^\dagger \right) - 72 \text{Tr} \left( Y_d Y_d^\dagger Y_d Y_d^\dagger \right) - 24 \text{Tr} \left( Y_d Y_u^\dagger Y_u Y_d^\dagger \right) \\ & \left. - 24 \text{Tr} \left( Y_e Y_e^\dagger Y_e Y_e^\dagger \right) - 8 \text{Tr} \left( Y_e Y_v^\dagger Y_v Y_e^\dagger \right) \right) \end{aligned} \quad (12)$$

$$\gamma_{\hat{H}_u}^{(1)} = \frac{1}{2} \left( 2 \text{Tr} \left( Y_v Y_v^\dagger \right) - 3g_L^2 + 6 \text{Tr} \left( Y_u Y_u^\dagger \right) - g_R^2 - g_{RB}^2 \right) \quad (13)$$

$$\begin{aligned} \gamma_{\hat{H}_u}^{(2)} = & \frac{1}{8} \left( 30g_L^4 + 27g_{BR}^2 g_R^2 + 12g_L^2 g_R^2 - 2\sqrt{6} g_{BR} g_R^3 + 32g_R^4 + 54g_{BL} g_{BR} g_R g_{RB} - 2\sqrt{6} g_{BL} g_R^2 g_{RB} \right. \\ & + 27g_{BL}^2 g_{RB}^2 + 12g_L^2 g_{RB}^2 - 2\sqrt{6} g_{BR} g_R g_{RB}^2 + 64g_R^2 g_{RB}^2 - 2\sqrt{6} g_{BL} g_{RB}^3 + 32g_{RB}^4 \\ & + 4 \left( 32g_s^2 + \sqrt{6} g_{BL} g_{RB} + \sqrt{6} g_{BR} g_R + g_{BL}^2 + g_{BR}^2 \right) \text{Tr} \left( Y_u Y_u^\dagger \right) \\ & + 4 \left( 3g_{BL}^2 + 3g_{BR}^2 - \sqrt{6} g_{BL} g_{RB} - \sqrt{6} g_{BR} g_R \right) \text{Tr} \left( Y_v Y_v^\dagger \right) - 24 \text{Tr} \left( Y_d Y_u^\dagger Y_u Y_d^\dagger \right) \\ & \left. - 8 \text{Tr} \left( Y_e Y_v^\dagger Y_v Y_e^\dagger \right) - 8 \text{Tr} \left( Y_s Y_s^\dagger Y_v Y_v^\dagger \right) - 72 \text{Tr} \left( Y_u Y_u^\dagger Y_u Y_u^\dagger \right) - 24 \text{Tr} \left( Y_v Y_v^\dagger Y_v Y_v^\dagger \right) \right) \end{aligned} \quad (14)$$

$$\gamma_{\hat{\chi}_R}^{(1)} = \frac{1}{4} \left( -2g_R^2 - 2g_{RB}^2 + 2\sqrt{6} g_{BL} g_{RB} + 2\sqrt{6} g_{BR} g_R - 3g_{BL}^2 - 3g_{BR}^2 + 4 \text{Tr} \left( Y_s Y_s^\dagger \right) \right) \quad (15)$$

$$\begin{aligned} \gamma_{\hat{\chi}_R}^{(2)} = & \frac{1}{8} \left( 45g_{BL}^4 + 90g_{BL}^2 g_{BR}^2 + 45g_{BR}^4 - 36\sqrt{6} g_{BL}^2 g_{BR} g_R - 36\sqrt{6} g_{BR}^3 g_R + 12g_{BL}^2 g_R^2 + 102g_{BR}^2 g_R^2 \right. \\ & - 36\sqrt{6} g_{BR} g_R^3 + 32g_R^4 - 36\sqrt{6} g_{BL}^3 g_{RB} - 36\sqrt{6} g_{BL} g_{BR}^2 g_{RB} + 180g_{BL} g_{BR} g_R g_{RB} \\ & - 36\sqrt{6} g_{BL} g_R^2 g_{RB} + 102g_{BL}^2 g_{RB}^2 + 12g_{BR}^2 g_{RB}^2 - 36\sqrt{6} g_{BR} g_R g_{RB}^2 + 64g_R^2 g_{RB}^2 - 36\sqrt{6} g_{BL} g_{RB}^3 \\ & \left. + 32g_{RB}^4 - 16 \text{Tr} \left( Y_s Y_s^\dagger Y_s Y_s^\dagger \right) - 16 \text{Tr} \left( Y_s Y_s^\dagger Y_v Y_v^\dagger \right) \right) \end{aligned} \quad (16)$$

$$\gamma_{\hat{\chi}_R}^{(1)} = \frac{1}{4} \left( -2 \left( g_R^2 + g_{RB}^2 \right) + 2\sqrt{6} g_{BL} g_{RB} + 2\sqrt{6} g_{BR} g_R - 3g_{BL}^2 - 3g_{BR}^2 \right) \quad (17)$$

$$\begin{aligned}\gamma_{\tilde{\chi}_R}^{(2)} = & \frac{1}{8} \left( 45g_{BL}^4 + 45g_{BR}^4 - 36\sqrt{6}g_{BR}^3g_R - 36\sqrt{6}g_{BL}^3g_{RB} - 36\sqrt{6}g_{BR}g_R(g_R^2 + g_{RB}^2) + 32(g_R^2 + g_{RB}^2)^2 \right. \\ & + 6g_{BR}^2(17g_R^2 + 2g_{RB}^2) + 6g_{BL}^2(15g_{BR}^2 + 17g_{RB}^2 + 2g_R^2 - 6\sqrt{6}g_{BR}g_R) \\ & \left. - 36g_{BL}g_{RB}(-5g_{BR}g_R + \sqrt{6}g_{BR}^2 + \sqrt{6}(g_R^2 + g_{RB}^2)) \right) \end{aligned} \quad (18)$$

$$\gamma_{\tilde{S}}^{(1)} = Y_s^\dagger Y_s \quad (19)$$

$$\begin{aligned}\gamma_{\tilde{S}}^{(2)} = & -Y_s^\dagger Y_s Y_s^\dagger Y_s - 2Y_s^\dagger Y_v Y_v^\dagger Y_s \\ & + Y_s^\dagger Y_s \left( \frac{3}{2}g_{BL}^2 + \frac{3}{2}g_{BR}^2 - \text{Tr}(Y_s Y_s^\dagger) - \sqrt{6}g_{BL}g_{RB} - \sqrt{6}g_{BR}g_R + g_R^2 + g_{RB}^2 \right) \end{aligned} \quad (20)$$

$$\gamma_{\tilde{u}}^{(1)} = \frac{1}{12} \left( 24Y_u^* Y_u^T - \left( 2\sqrt{6}g_{BL}g_{RB} + 2\sqrt{6}g_{BR}g_R + 32g_s^2 + 6g_R^2 + 6g_{RB}^2 + g_{BL}^2 + g_{BR}^2 \right) \mathbf{1} \right) \quad (21)$$

$$\begin{aligned}\gamma_{\tilde{u}}^{(2)} = & \frac{1}{72} \left( \left( -64g_s^4 + 41g_{BL}^4 + 41g_{BR}^4 + 80\sqrt{6}g_{BR}^3g_R + 270g_{BR}^2g_R^2 + 84\sqrt{6}g_{BR}g_R^3 + 288g_R^4 + 80\sqrt{6}g_{BL}^3g_{RB} \right. \right. \\ & - 12g_{BR}^2g_{RB}^2 + 84\sqrt{6}g_{BR}g_Rg_{RB}^2 + 576g_R^2g_{RB}^2 + 288g_{BR}^4 \\ & + 2g_{BL}^2(135g_{RB}^2 + 40\sqrt{6}g_{BR}g_R + 41g_{BR}^2 - 6g_R^2) \\ & + 32g_s^2(2\sqrt{6}g_{BL}g_{RB} + 2\sqrt{6}g_{BR}g_R + 6(g_R^2 + g_{RB}^2) + g_{BL}^2 + g_{BR}^2) \\ & + 4g_{BL}g_{RB}(141g_{BR}g_R + 20\sqrt{6}g_{BR}^2 + 21\sqrt{6}(g_R^2 + g_{RB}^2)) \left. \right) \mathbf{1} \\ & + 24 \left( -6(Y_u^* Y_d^T Y_d^* Y_u^T + Y_u^* Y_u^T Y_u^* Y_u^T) \right. \\ & \left. + Y_u^* Y_u^T (18g_L^2 - 18\text{Tr}(Y_u Y_u^\dagger) - 6\text{Tr}(Y_v Y_v^\dagger) - \sqrt{6}g_{BL}g_{RB} - \sqrt{6}g_{BR}g_R) \right) \end{aligned} \quad (22)$$

$$\gamma_{\tilde{d}}^{(1)} = \frac{1}{12} \left( 24Y_d^* Y_d^T - \left( -2\sqrt{6}g_{BL}g_{RB} - 2\sqrt{6}g_{BR}g_R + 32g_s^2 + 6g_R^2 + 6g_{RB}^2 + g_{BL}^2 + g_{BR}^2 \right) \mathbf{1} \right) \quad (23)$$

$$\begin{aligned}\gamma_{\tilde{d}}^{(2)} = & \frac{1}{72} \left( \left( -64g_s^4 + 41g_{BL}^4 + 41g_{BR}^4 - 86\sqrt{6}g_{BR}^3g_R + 342g_{BR}^2g_R^2 - 120\sqrt{6}g_{BR}g_R^3 + 288g_R^4 - 86\sqrt{6}g_{BL}^3g_{RB} \right. \right. \\ & + 24g_{BR}^2g_{RB}^2 - 120\sqrt{6}g_{BR}g_Rg_{RB}^2 + 576g_R^2g_{RB}^2 + 288g_{BR}^4 \\ & + g_{BL}^2(24g_R^2 + 342g_{RB}^2 + 82g_{BR}^2 - 86\sqrt{6}g_{BR}g_R) \\ & + 32g_s^2(-2\sqrt{6}g_{BL}g_{RB} - 2\sqrt{6}g_{BR}g_R + 6(g_R^2 + g_{RB}^2) + g_{BL}^2 + g_{BR}^2) \\ & - 2g_{BL}g_{RB}(-318g_{BR}g_R + 43\sqrt{6}g_{BR}^2 + 60\sqrt{6}(g_R^2 + g_{RB}^2)) \left. \right) \mathbf{1} \\ & + 24 \left( -6(Y_d^* Y_d^T Y_d^* Y_d^T + Y_d^* Y_u^T Y_u^* Y_d^T) \right. \\ & \left. + Y_d^* Y_d^T (18g_L^2 - 18\text{Tr}(Y_d Y_d^\dagger) - 6\text{Tr}(Y_e Y_e^\dagger) + \sqrt{6}g_{BL}g_{RB} + \sqrt{6}g_{BR}g_R) \right) \end{aligned} \quad (24)$$

$$\gamma_{\tilde{\nu}}^{(1)} = \frac{1}{4} \left( - \left( 2(g_R^2 + g_{RB}^2) - 2\sqrt{6}g_{BL}g_{RB} - 2\sqrt{6}g_{BR}g_R + 3g_{BL}^2 + 3g_{BR}^2 \right) \mathbf{1} + 4(2Y_v^* Y_v^T + Y_s^* Y_s^T) \right) \quad (25)$$

$$\begin{aligned}\gamma_{\tilde{\nu}}^{(2)} = & \frac{1}{8} \left( \left( 45g_{BL}^4 + 45g_{BR}^4 - 36\sqrt{6}g_{BR}^3g_R - 36\sqrt{6}g_{BL}^3g_{RB} - 36\sqrt{6}g_{BR}g_R(g_R^2 + g_{RB}^2) + 32(g_R^2 + g_{RB}^2)^2 \right. \right. \\ & \left. \left. + 6g_{BR}^2(17g_R^2 + 2g_{RB}^2) + 6g_{BL}^2(15g_{BR}^2 + 17g_{RB}^2 + 2g_R^2 - 6\sqrt{6}g_{BR}g_R) \right) \right) \end{aligned}$$

$$\begin{aligned}
& -36g_{BL}g_{RB} \left( -5g_{BR}g_R + \sqrt{6}g_{BR}^2 + \sqrt{6}(g_R^2 + g_{RB}^2) \right) \mathbf{1} \\
& -8 \left( Y_s^* Y_s^T Y_s^* Y_s^T + 2Y_v^* Y_e^T Y_e^* Y_v^T + 2Y_v^* Y_v^T Y_v^* Y_v^T + Y_s^* Y_s^T \text{Tr}(Y_s Y_s^\dagger) \right. \\
& \left. - Y_v^* Y_v^T \left( -2\text{Tr}(Y_v Y_v^\dagger) + 6g_L^2 - 6\text{Tr}(Y_u Y_u^\dagger) + \sqrt{6}g_{BL}g_{RB} + \sqrt{6}g_{BR}g_R \right) \right) \quad (26)
\end{aligned}$$

$$\gamma_e^{(1)} = \frac{1}{4} \left( - \left( 2(g_R^2 + g_{RB}^2) + 2\sqrt{6}g_{BL}g_{RB} + 2\sqrt{6}g_{BR}g_R + 3g_{BL}^2 + 3g_{BR}^2 \right) \mathbf{1} + 8Y_e^* Y_e^T \right) \quad (27)$$

$$\begin{aligned}
\gamma_e^{(2)} = & \frac{1}{8} \left( \left( 45g_{BL}^4 + 45g_{BR}^4 + 30\sqrt{6}g_{BR}^3g_R + 78g_{BR}^2g_R^2 + 30\sqrt{6}g_{BL}^3g_{RB} + 32\sqrt{6}g_{BR}g_R(g_R^2 + g_{RB}^2) \right. \right. \\
& + 32(g_R^2 + g_{RB}^2)^2 + 6g_{BL}^2(13g_{RB}^2 + 15g_{BR}^2 + 5\sqrt{6}g_{BR}g_R) \\
& + 2g_{BL}g_{RB}(15\sqrt{6}g_{BR}^2 + 16\sqrt{6}(g_R^2 + g_{RB}^2) + 78g_{BR}g_R) \left. \right) \mathbf{1} \\
& + 8 \left( -2(Y_e^* Y_e^T Y_e^* Y_e^T + Y_e^* Y_v^T Y_v^* Y_e^T) \right. \\
& \left. + Y_e^* Y_e^T \left( -2\text{Tr}(Y_e Y_e^\dagger) + 6g_L^2 - 6\text{Tr}(Y_d Y_d^\dagger) - \sqrt{6}g_{BL}g_{RB} - \sqrt{6}g_{BR}g_R \right) \right) \quad (28)
\end{aligned}$$

### 3.2 Gauge Couplings

$$\beta_{g_{BL}}^{(1)} = \frac{1}{4} \left( 27g_{BL}^3 - 2\sqrt{6}g_{BL}^2g_{RB} + g_{BL}(27g_{BR}^2 + 30g_{RB}^2 - \sqrt{6}g_{BR}g_R) + g_{BR}(30g_R - \sqrt{6}g_{BR})g_{RB} \right) \quad (29)$$

$$\begin{aligned}
\beta_{g_{BL}}^{(2)} = & \frac{1}{8} \left( 64g_s^2g_{BL}^3 + 65g_{BL}^5 + 64g_s^2g_{BL}g_{BR}^2 + 130g_{BL}^3g_{BR}^2 + 65g_{BL}g_{BR}^4 + 72g_{BL}^3g_L^2 + 72g_{BL}g_{BR}^2g_L^2 \right. \\
& - 9\sqrt{6}g_{BL}^3g_{BR}g_R - 9\sqrt{6}g_{BL}g_{BR}^3g_R + 30g_{BL}^3g_R^2 + 90g_{BL}g_{BR}^2g_R^2 - 2\sqrt{6}g_{BL}g_{BR}g_R^3 \\
& - 12\sqrt{6}g_{BL}^4g_{RB} - 15\sqrt{6}g_{BL}^2g_{BR}^2g_{RB} - 3\sqrt{6}g_{BR}^4g_{RB} + 192g_s^2g_{BR}g_Rg_{RB} + 210g_{BL}^2g_{BR}g_Rg_{RB} \\
& + 90g_{BR}^3g_Rg_{RB} + 24g_{BR}g_L^2g_Rg_{RB} - 4\sqrt{6}g_{BL}^2g_R^2g_{RB} - 6\sqrt{6}g_{BR}^2g_R^2g_{RB} + 60g_{BR}g_R^3g_{RB} \\
& + 192g_s^2g_{BL}g_{RB}^2 + 180g_{BL}^3g_{RB}^2 + 120g_{BL}g_{BR}^2g_{RB}^2 + 24g_{BL}g_L^2g_{RB}^2 - 10\sqrt{6}g_{BL}g_{BR}g_Rg_{RB}^2 \\
& + 60g_{BL}g_R^2g_{RB}^2 - 8\sqrt{6}g_{BL}^3g_{RB}^2 - 2\sqrt{6}g_{BR}^2g_{RB}^3 + 60g_{BR}g_Rg_{RB}^3 + 60g_{BL}g_{RB}^4 \\
& + \left( 4g_{BR}(-12g_R + \sqrt{6}g_{BR})g_{RB} - 8g_{BL}^3 + 8\sqrt{6}g_{BL}^2g_{RB} + g_{BL}(-48g_{RB}^2 + 4\sqrt{6}g_{BR}g_R - 8g_{BR}^2) \right) \text{Tr}(Y_d Y_d^\dagger) \\
& - 4 \left( 2\sqrt{6}g_{BL}^2g_{RB} + 6g_{BL}^3 + g_{BL}(4g_{RB}^2 + 6g_{BR}^2 + \sqrt{6}g_{BR}g_R) + g_{BR}(4g_R + \sqrt{6}g_{BR})g_{RB} \right) \text{Tr}(Y_e Y_e^\dagger) \\
& - 12g_{BL}^3 \text{Tr}(Y_s Y_s^\dagger) - 12g_{BL}g_{BR}^2 \text{Tr}(Y_s Y_s^\dagger) + 4\sqrt{6}g_{BL}g_{BR}g_R \text{Tr}(Y_s Y_s^\dagger) \\
& + 8\sqrt{6}g_{BL}^2g_{RB} \text{Tr}(Y_s Y_s^\dagger) + 4\sqrt{6}g_{BR}^2g_{RB} \text{Tr}(Y_s Y_s^\dagger) - 8g_{BR}g_Rg_{RB} \text{Tr}(Y_s Y_s^\dagger) \\
& - 8g_{BL}g_{RB}^2 \text{Tr}(Y_s Y_s^\dagger) - 8g_{BL}^3 \text{Tr}(Y_u Y_u^\dagger) - 8g_{BL}g_{BR}^2 \text{Tr}(Y_u Y_u^\dagger) - 4\sqrt{6}g_{BL}g_{BR}g_R \text{Tr}(Y_u Y_u^\dagger) \\
& - 8\sqrt{6}g_{BL}^2g_{RB} \text{Tr}(Y_u Y_u^\dagger) - 4\sqrt{6}g_{BR}^2g_{RB} \text{Tr}(Y_u Y_u^\dagger) - 48g_{BR}g_Rg_{RB} \text{Tr}(Y_u Y_u^\dagger) \\
& - 48g_{BL}g_{RB}^2 \text{Tr}(Y_u Y_u^\dagger) - 24g_{BL}^3 \text{Tr}(Y_v Y_v^\dagger) - 24g_{BL}g_{BR}^2 \text{Tr}(Y_v Y_v^\dagger) + 4\sqrt{6}g_{BL}g_{BR}g_R \text{Tr}(Y_v Y_v^\dagger)
\end{aligned}$$



$$\begin{aligned}
& + 8\sqrt{6}g_{BL}^2g_{RB}\text{Tr}(Y_vY_v^\dagger) + 4\sqrt{6}g_{BR}^2g_{RB}\text{Tr}(Y_vY_v^\dagger) - 16g_{BR}g_{RB}g_{RB}\text{Tr}(Y_vY_v^\dagger) \\
& - 16g_{BL}g_{RB}^2\text{Tr}(Y_vY_v^\dagger)
\end{aligned} \tag{30}$$

$$\beta_{g_L}^{(1)} = g_L^3 \tag{31}$$

$$\beta_{g_L}^{(2)} = g_L^3(24g_s^2 + 25g_L^2 - 2\text{Tr}(Y_eY_e^\dagger) - 2\text{Tr}(Y_vY_v^\dagger) + 3g_{BL}^2 - 6\text{Tr}(Y_dY_d^\dagger) - 6\text{Tr}(Y_uY_u^\dagger) + g_R^2) \tag{32}$$

$$\beta_{g_R}^{(1)} = \frac{1}{4}(27g_{BL}g_{BR}g_{RB} + 27g_{BR}^2g_R - 2\sqrt{6}g_{BR}g_R^2 + 30g_R^3 + 30g_Rg_{RB}^2 - \sqrt{6}g_{BL}g_Rg_{RB} - \sqrt{6}g_{BR}g_{RB}^2) \tag{33}$$

$$\begin{aligned}
\beta_{g_R}^{(2)} = & \frac{1}{8}(64g_s^2g_{BR}^2g_R + 65g_{BL}^2g_{BR}^2g_R + 65g_{BR}^4g_R + 72g_{BR}^2g_L^2g_R - 6\sqrt{6}g_{BL}^2g_{BR}g_R^2 - 12\sqrt{6}g_{BR}^3g_R^2 \\
& + 192g_s^2g_R^3 + 30g_{BL}^2g_R^3 + 180g_{BR}^2g_R^3 + 24g_L^2g_R^3 - 8\sqrt{6}g_{BR}g_R^4 + 60g_R^5 + 64g_s^2g_{BL}g_{BR}g_{RB} \\
& + 65g_{BL}^3g_{BR}g_{RB} + 65g_{BL}g_{BR}^3g_{RB} + 72g_{BL}g_{BR}g_L^2g_{RB} - 3\sqrt{6}g_{BL}^3g_Rg_{RB} - 15\sqrt{6}g_{BL}g_{BR}^2g_Rg_{RB} \\
& + 210g_{BL}g_{BR}g_R^2g_{RB} - 6\sqrt{6}g_{BL}g_R^3g_{RB} - 9\sqrt{6}g_{BL}g_{BR}g_R^2g_{RB} - 3\sqrt{6}g_{BR}^3g_R^2g_{RB} + 192g_s^2g_Rg_{RB}^2 \\
& + 90g_{BL}^2g_Rg_{RB}^2 + 120g_{BR}^2g_Rg_{RB}^2 + 24g_L^2g_Rg_{RB}^2 - 10\sqrt{6}g_{BR}g_R^2g_{RB}^2 + 120g_R^3g_{RB}^2 + 90g_{BL}g_{BR}g_{RB}^3 \\
& - 6\sqrt{6}g_{BL}g_Rg_{RB}^3 - 2\sqrt{6}g_{BR}g_R^4 + 60g_Rg_{RB}^4 \\
& + (-48g_R^3 + 4g_{BR}(2\sqrt{6}g_R^2 + g_{RB}(-2g_{BL} + \sqrt{6}g_{RB}))) + 4g_R(-12g_{RB} + \sqrt{6}g_{BL})g_{RB} - 8g_{BR}^2g_R)\text{Tr}(Y_dY_d^\dagger) \\
& - 4(2\sqrt{6}g_{BR}g_R^2 + 4g_R^3 + 4g_Rg_{RB}^2 + 6g_{BL}g_{BR}g_{RB} + 6g_{BR}^2g_R + \sqrt{6}g_{BL}g_Rg_{RB} + \sqrt{6}g_{BR}g_{RB}^2)\text{Tr}(Y_eY_e^\dagger) \\
& - 12g_{BR}^2g_R\text{Tr}(Y_sY_s^\dagger) + 8\sqrt{6}g_{BR}g_R^2\text{Tr}(Y_sY_s^\dagger) - 8g_R^3\text{Tr}(Y_sY_s^\dagger) - 12g_{BL}g_{BR}g_{RB}\text{Tr}(Y_sY_s^\dagger) \\
& + 4\sqrt{6}g_{BL}g_Rg_{RB}\text{Tr}(Y_sY_s^\dagger) + 4\sqrt{6}g_{BR}g_{RB}^2\text{Tr}(Y_sY_s^\dagger) - 8g_Rg_{RB}^2\text{Tr}(Y_sY_s^\dagger) \\
& - 8g_{BR}^2g_R\text{Tr}(Y_uY_u^\dagger) - 8\sqrt{6}g_{BR}g_R^2\text{Tr}(Y_uY_u^\dagger) - 48g_R^3\text{Tr}(Y_uY_u^\dagger) - 8g_{BL}g_{BR}g_{RB}\text{Tr}(Y_uY_u^\dagger) \\
& - 4\sqrt{6}g_{BL}g_Rg_{RB}\text{Tr}(Y_uY_u^\dagger) - 4\sqrt{6}g_{BR}g_{RB}^2\text{Tr}(Y_uY_u^\dagger) - 48g_Rg_{RB}^2\text{Tr}(Y_uY_u^\dagger) \\
& - 24g_{BR}^2g_R\text{Tr}(Y_vY_v^\dagger) + 8\sqrt{6}g_{BR}g_R^2\text{Tr}(Y_vY_v^\dagger) - 16g_R^3\text{Tr}(Y_vY_v^\dagger) - 24g_{BL}g_{BR}g_{RB}\text{Tr}(Y_vY_v^\dagger) \\
& + 4\sqrt{6}g_{BL}g_Rg_{RB}\text{Tr}(Y_vY_v^\dagger) + 4\sqrt{6}g_{BR}g_{RB}^2\text{Tr}(Y_vY_v^\dagger) - 16g_Rg_{RB}^2\text{Tr}(Y_vY_v^\dagger)
\end{aligned} \tag{34}$$

$$\beta_{g_s}^{(1)} = -3g_s^3 \tag{35}$$

$$\beta_{g_s}^{(2)} = g_s^3(14g_s^2 + 3g_R^2 - 4\text{Tr}(Y_dY_d^\dagger) - 4\text{Tr}(Y_uY_u^\dagger) + 9g_L^2 + g_{BL}^2) \tag{36}$$

$$\beta_{g_{BR}}^{(1)} = \frac{1}{4}(g_{BL}^2(27g_{BR} - \sqrt{6}g_R) + g_{BL}(30g_Rg_{RB} - \sqrt{6}g_{BR}g_{RB}) + g_{BR}(27g_{BR}^2 - 2\sqrt{6}g_{BR}g_R + 30g_R^2)) \tag{37}$$

$$\begin{aligned}
\beta_{g_{BR}}^{(2)} = & \frac{1}{8}(64g_s^2g_{BL}^2g_{BR} + 65g_{BL}^4g_{BR} + 64g_s^2g_{BR}^3 + 130g_{BL}^2g_{BR}^3 + 65g_{BR}^5 + 72g_{BL}^2g_{BR}g_L^2 + 72g_{BR}^3g_L^2 \\
& - 3\sqrt{6}g_{BL}^4g_R - 15\sqrt{6}g_{BL}^2g_{BR}^2g_R - 12\sqrt{6}g_{BR}^4g_R + 192g_s^2g_{BR}g_R^2 + 120g_{BL}^2g_{BR}g_R^2 \\
& + 180g_{BR}^3g_R^2 + 24g_{BR}g_L^2g_R^2 - 2\sqrt{6}g_{BL}^2g_R^3 - 8\sqrt{6}g_{BR}^2g_R^3 + 60g_{BR}g_R^4 - 9\sqrt{6}g_{BL}^3g_{BR}g_{RB} \\
& - 9\sqrt{6}g_{BL}g_{BR}^3g_{RB} + 192g_s^2g_{BL}g_{BR}g_{RB} + 90g_{BL}^3g_{BR}g_{RB} + 210g_{BL}g_{BR}^2g_{RB}g_{RB} + 24g_{BL}g_L^2g_{RB}g_{RB} \\
& - 10\sqrt{6}g_{BL}g_{BR}g_R^2g_{RB} + 60g_{BL}g_R^3g_{RB} + 90g_{BL}g_{BR}g_R^2g_{RB} + 30g_{BR}^3g_{RB}^2 - 6\sqrt{6}g_{BL}^2g_Rg_{RB}^2
\end{aligned}$$

$$\begin{aligned}
& -4\sqrt{6}g_{BR}^2g_Rg_{RB}^2 + 60g_{BR}g_R^2g_{RB}^2 - 2\sqrt{6}g_{BL}g_{BR}g_{RB}^3 + 60g_{BL}g_Rg_{RB}^3 \\
& + \left(4g_{BL}\left(-12g_R + \sqrt{6}g_{BR}\right)g_{RB} - 8g_{BR}\left(6g_R^2 - \sqrt{6}g_{BR}g_R + g_{BR}^2\right) + g_{BL}^2\left(4\sqrt{6}g_R - 8g_{BR}\right)\right)\text{Tr}\left(Y_dY_d^\dagger\right) \\
& - 4\left(2g_{BR}\left(2g_R^2 + 3g_{BR}^2 + \sqrt{6}g_{BR}g_R\right) + g_{BL}^2\left(6g_{BR} + \sqrt{6}g_R\right) + g_{BL}\left(4g_R + \sqrt{6}g_{BR}\right)g_{RB}\right)\text{Tr}\left(Y_eY_e^\dagger\right) \\
& - 12g_{BL}^2g_{BR}\text{Tr}\left(Y_sY_s^\dagger\right) - 12g_{BR}^3\text{Tr}\left(Y_sY_s^\dagger\right) + 4\sqrt{6}g_{BL}^2g_R\text{Tr}\left(Y_sY_s^\dagger\right) \\
& + 8\sqrt{6}g_{BR}^2g_R\text{Tr}\left(Y_sY_s^\dagger\right) - 8g_{BR}g_R^2\text{Tr}\left(Y_sY_s^\dagger\right) + 4\sqrt{6}g_{BL}g_{BR}g_{RB}\text{Tr}\left(Y_sY_s^\dagger\right) \\
& - 8g_{BL}g_Rg_{RB}\text{Tr}\left(Y_sY_s^\dagger\right) - 8g_{BL}^2g_{BR}\text{Tr}\left(Y_uY_u^\dagger\right) - 8g_{BR}^3\text{Tr}\left(Y_uY_u^\dagger\right) - 4\sqrt{6}g_{BL}^2g_R\text{Tr}\left(Y_uY_u^\dagger\right) \\
& - 8\sqrt{6}g_{BR}^2g_R\text{Tr}\left(Y_uY_u^\dagger\right) - 48g_{BR}g_R^2\text{Tr}\left(Y_uY_u^\dagger\right) - 4\sqrt{6}g_{BL}g_{BR}g_{RB}\text{Tr}\left(Y_uY_u^\dagger\right) \\
& - 48g_{BL}g_Rg_{RB}\text{Tr}\left(Y_uY_u^\dagger\right) - 24g_{BL}^2g_{BR}\text{Tr}\left(Y_vY_v^\dagger\right) - 24g_{BR}^3\text{Tr}\left(Y_vY_v^\dagger\right) + 4\sqrt{6}g_{BL}^2g_R\text{Tr}\left(Y_vY_v^\dagger\right) \\
& + 8\sqrt{6}g_{BR}^2g_R\text{Tr}\left(Y_vY_v^\dagger\right) - 16g_{BR}g_R^2\text{Tr}\left(Y_vY_v^\dagger\right) + 4\sqrt{6}g_{BL}g_{BR}g_{RB}\text{Tr}\left(Y_vY_v^\dagger\right) \\
& - 16g_{BL}g_Rg_{RB}\text{Tr}\left(Y_vY_v^\dagger\right)
\end{aligned} \tag{38}$$

$$\beta_{g_{RB}}^{(1)} = \frac{1}{4}\left(27g_{BL}^2g_{RB} + 30g_{RB}\left(g_R^2 + g_{RB}^2\right) + g_{BL}\left(27g_{BR}g_R - \sqrt{6}\left(2g_{RB}^2 + g_R^2\right)\right) - \sqrt{6}g_{BR}g_Rg_{RB}\right) \tag{39}$$

$$\begin{aligned}
\beta_{g_{RB}}^{(2)} = & \frac{1}{8}\left(64g_s^2g_{BL}g_{BR}g_R + 65g_{BL}^3g_{BR}g_R + 65g_{BL}g_{BR}^3g_R + 72g_{BL}g_{BR}g_L^2g_R - 3\sqrt{6}g_{BL}^3g_R^2\right. \\
& - 9\sqrt{6}g_{BL}g_{BR}^2g_R^2 + 90g_{BL}g_{BR}g_R^3 - 2\sqrt{6}g_{BL}g_R^4 + 64g_s^2g_{BL}g_{RB} + 65g_{BL}^4g_{RB} + 65g_{BL}^2g_{BR}^2g_{RB} \\
& + 72g_{BL}^2g_L^2g_{RB} - 15\sqrt{6}g_{BL}^2g_{BR}g_Rg_{RB} - 3\sqrt{6}g_{BR}^3g_Rg_{RB} + 192g_s^2g_R^2g_{RB} + 120g_{BL}^2g_R^2g_{RB} \\
& + 90g_{BR}^2g_R^2g_{RB} + 24g_L^2g_R^2g_{RB} - 6\sqrt{6}g_{BR}g_R^3g_{RB} + 60g_R^4g_{RB} - 12\sqrt{6}g_{BL}^3g_{RB}^2 \\
& - 6\sqrt{6}g_{BL}g_{BR}^2g_{RB}^2 + 210g_{BL}g_{BR}g_Rg_{RB}^2 - 10\sqrt{6}g_{BL}g_R^2g_{RB}^2 + 192g_s^2g_{RB}^3 + 180g_{BL}^2g_{RB}^3 \\
& + 30g_{BR}^3g_{RB} + 24g_L^2g_{RB}^3 - 6\sqrt{6}g_{BR}g_Rg_{RB}^3 + 120g_R^2g_{RB}^3 - 8\sqrt{6}g_{BL}g_{RB}^4 + 60g_{RB}^5 \\
& + \left(4g_{RB}\left(-12\left(g_R^2 + g_{RB}^2\right) + \sqrt{6}g_{BR}g_R\right) - 8g_{BL}^2g_{RB} + g_{BL}\left(4\sqrt{6}\left(2g_{RB}^2 + g_R^2\right) - 8g_{BR}g_R\right)\right)\text{Tr}\left(Y_dY_d^\dagger\right) \\
& - 4\left(6g_{BL}^2g_{RB} + g_{BL}\left(6g_{BR}g_R + \sqrt{6}\left(2g_{RB}^2 + g_R^2\right)\right) + g_{RB}\left(4\left(g_R^2 + g_{RB}^2\right) + \sqrt{6}g_{BR}g_R\right)\right)\text{Tr}\left(Y_eY_e^\dagger\right) \\
& - 12g_{BL}g_{BR}g_R\text{Tr}\left(Y_sY_s^\dagger\right) + 4\sqrt{6}g_{BL}g_R^2\text{Tr}\left(Y_sY_s^\dagger\right) - 12g_{BL}^2g_{RB}\text{Tr}\left(Y_sY_s^\dagger\right) \\
& + 4\sqrt{6}g_{BR}g_Rg_{RB}\text{Tr}\left(Y_sY_s^\dagger\right) - 8g_R^2g_{RB}\text{Tr}\left(Y_sY_s^\dagger\right) + 8\sqrt{6}g_{BL}g_{RB}^2\text{Tr}\left(Y_sY_s^\dagger\right) \\
& - 8g_{RB}^3\text{Tr}\left(Y_sY_s^\dagger\right) - 8g_{BL}g_{BR}g_R\text{Tr}\left(Y_uY_u^\dagger\right) - 4\sqrt{6}g_{BL}g_R^2\text{Tr}\left(Y_uY_u^\dagger\right) - 8g_{BL}^2g_{RB}\text{Tr}\left(Y_uY_u^\dagger\right) \\
& - 4\sqrt{6}g_{BR}g_Rg_{RB}\text{Tr}\left(Y_uY_u^\dagger\right) - 48g_R^2g_{RB}\text{Tr}\left(Y_uY_u^\dagger\right) - 8\sqrt{6}g_{BL}g_{RB}^2\text{Tr}\left(Y_uY_u^\dagger\right) \\
& - 48g_{RB}^3\text{Tr}\left(Y_uY_u^\dagger\right) - 24g_{BL}g_{BR}g_R\text{Tr}\left(Y_vY_v^\dagger\right) + 4\sqrt{6}g_{BL}g_R^2\text{Tr}\left(Y_vY_v^\dagger\right) - 24g_{BL}^2g_{RB}\text{Tr}\left(Y_vY_v^\dagger\right) \\
& + 4\sqrt{6}g_{BR}g_Rg_{RB}\text{Tr}\left(Y_vY_v^\dagger\right) - 16g_R^2g_{RB}\text{Tr}\left(Y_vY_v^\dagger\right) + 8\sqrt{6}g_{BL}g_{RB}^2\text{Tr}\left(Y_vY_v^\dagger\right) \\
& \left. - 16g_{RB}^3\text{Tr}\left(Y_vY_v^\dagger\right)\right)
\end{aligned} \tag{40}$$

### 3.3 Gaugino Mass Parameters

$$\beta_{M_1}^{(1)} = \frac{1}{2} \left( 27g_{BL}^2 M_1 - g_{BL} \left( -27g_{BR} M_{BR} + 2\sqrt{6}g_{RB} M_1 + \sqrt{6}g_R M_{BR} \right) + g_{RB} \left( 30g_{RB} M_1 + 30g_R M_{BR} - \sqrt{6}g_{BR} M_{BR} \right) \right) \quad (41)$$

$$\begin{aligned} \beta_{M_1}^{(2)} = & \frac{1}{4} \left( 64g_s^2 g_{BL}^2 M_1 + 130g_{BL}^4 M_1 + 65g_{BL}^2 g_{BR}^2 M_1 + 72g_{BL}^2 g_L^2 M_1 - 6\sqrt{6}g_{BL}^2 g_{BR} g_R M_1 + 30g_{BL}^2 g_R^2 M_1 \right. \\ & - 24\sqrt{6}g_{BL}^3 g_{RB} M_1 - 6\sqrt{6}g_{BL} g_{BR}^2 g_{RB} M_1 + 120g_{BL} g_{BR} g_R g_{RB} M_1 - 4\sqrt{6}g_{BL} g_R^2 g_{RB} M_1 \\ & + 192g_s^2 g_{RB}^2 M_1 + 360g_{BL}^2 g_{RB}^2 M_1 + 30g_{BR}^2 g_{RB}^2 M_1 + 24g_L^2 g_{RB}^2 M_1 - 4\sqrt{6}g_{BR} g_R g_{RB}^2 M_1 \\ & + 60g_R^2 g_{RB}^2 M_1 - 16\sqrt{6}g_{BL} g_{RB}^3 M_1 + 120g_{RB}^4 M_1 + 64g_s^2 g_{BL} g_{BR} M_{BR} + 195g_{BL}^3 g_{BR} M_{BR} + 65g_{BL} g_{BR}^3 M_{BR} \\ & + 72g_{BL} g_{BR} g_L^2 M_{BR} - 9\sqrt{6}g_{BL}^3 g_R M_{BR} - 9\sqrt{6}g_{BL} g_{BR}^2 g_R M_{BR} + 90g_{BL} g_{BR} g_R^2 M_{BR} - 2\sqrt{6}g_{BL} g_R^3 M_{BR} \\ & - 27\sqrt{6}g_{BL}^2 g_{BR} g_{RB} M_{BR} - 3\sqrt{6}g_{BR}^3 g_{RB} M_{BR} + 192g_s^2 g_R g_{RB} M_{BR} + 270g_{BL}^2 g_R g_{RB} M_{BR} + 90g_{BR}^2 g_R g_{RB} M_{BR} \\ & + 24g_L^2 g_R g_{RB} M_{BR} - 6\sqrt{6}g_{BR} g_R^2 g_{RB} M_{BR} + 60g_R^3 g_{RB} M_{BR} + 270g_{BL} g_{BR} g_{RB}^2 M_{BR} - 18\sqrt{6}g_{BL} g_R g_{RB}^2 M_{BR} \\ & - 6\sqrt{6}g_{BR} g_{RB}^3 M_{BR} + 180g_R g_{RB}^3 M_{BR} + 65g_{BL}^2 g_{BR}^2 M_4 - 6\sqrt{6}g_{BL}^2 g_{BR} g_R M_4 + 30g_{BL}^2 g_R^2 M_4 \\ & - 6\sqrt{6}g_{BL} g_{BR}^2 g_{RB} M_4 + 120g_{BL} g_{BR} g_R g_{RB} M_4 - 4\sqrt{6}g_{BL} g_R^2 g_{RB} M_4 + 30g_{BR}^2 g_{RB}^2 M_4 \\ & - 4\sqrt{6}g_{BR} g_R g_{RB}^2 M_4 + 60g_R^2 g_{RB}^2 M_4 + 64g_s^2 g_{BL}^2 M_3 + 192g_s^2 g_{RB}^2 M_3 + 72g_{BL}^2 g_L^2 M_2 \\ & + 24g_L^2 g_{RB}^2 M_2 \\ & + \left( 4g_{BL} \left( -2g_{BR} M_{BR} + 2\sqrt{6}g_{RB} M_1 + \sqrt{6}g_R M_{BR} \right) + 4g_{RB} \left( -12g_{RB} M_1 - 12g_R M_{BR} + \sqrt{6}g_{BR} M_{BR} \right) - 8g_{BL}^2 M_1 \right) \text{Tr} \left( Y_d Y_d^\dagger \right) \\ & - 4 \left( 6g_{BL}^2 M_1 + g_{BL} \left( 2\sqrt{6}g_{RB} M_1 + 6g_{BR} M_{BR} + \sqrt{6}g_R M_{BR} \right) + g_{RB} \left( 4g_{RB} M_1 + 4g_R M_{BR} + \sqrt{6}g_{BR} M_{BR} \right) \right) \text{Tr} \left( Y_e Y_e^\dagger \right) \\ & - 12g_{BL}^2 M_1 \text{Tr} \left( Y_s Y_s^\dagger \right) + 8\sqrt{6}g_{BL} g_{RB} M_1 \text{Tr} \left( Y_s Y_s^\dagger \right) - 8g_{RB}^2 M_1 \text{Tr} \left( Y_s Y_s^\dagger \right) \\ & - 12g_{BL} g_{BR} M_{BR} \text{Tr} \left( Y_s Y_s^\dagger \right) + 4\sqrt{6}g_{BL} g_R M_{BR} \text{Tr} \left( Y_s Y_s^\dagger \right) + 4\sqrt{6}g_{BR} g_{RB} M_{BR} \text{Tr} \left( Y_s Y_s^\dagger \right) \\ & - 8g_R g_{RB} M_{BR} \text{Tr} \left( Y_s Y_s^\dagger \right) - 8g_{BL}^2 M_1 \text{Tr} \left( Y_u Y_u^\dagger \right) - 8\sqrt{6}g_{BL} g_{RB} M_1 \text{Tr} \left( Y_u Y_u^\dagger \right) \\ & - 48g_{RB}^2 M_1 \text{Tr} \left( Y_u Y_u^\dagger \right) - 8g_{BL} g_{BR} M_{BR} \text{Tr} \left( Y_u Y_u^\dagger \right) - 4\sqrt{6}g_{BL} g_R M_{BR} \text{Tr} \left( Y_u Y_u^\dagger \right) \\ & - 4\sqrt{6}g_{BR} g_{RB} M_{BR} \text{Tr} \left( Y_u Y_u^\dagger \right) - 48g_R g_{RB} M_{BR} \text{Tr} \left( Y_u Y_u^\dagger \right) - 24g_{BL}^2 M_1 \text{Tr} \left( Y_v Y_v^\dagger \right) \\ & + 8\sqrt{6}g_{BL} g_{RB} M_1 \text{Tr} \left( Y_v Y_v^\dagger \right) - 16g_{RB}^2 M_1 \text{Tr} \left( Y_v Y_v^\dagger \right) - 24g_{BL} g_{BR} M_{BR} \text{Tr} \left( Y_v Y_v^\dagger \right) \\ & + 4\sqrt{6}g_{BL} g_R M_{BR} \text{Tr} \left( Y_v Y_v^\dagger \right) + 4\sqrt{6}g_{BR} g_{RB} M_{BR} \text{Tr} \left( Y_v Y_v^\dagger \right) - 16g_R g_{RB} M_{BR} \text{Tr} \left( Y_v Y_v^\dagger \right) \\ & + 8g_{BL}^2 \text{Tr} \left( Y_d^\dagger T_d \right) - 8\sqrt{6}g_{BL} g_{RB} \text{Tr} \left( Y_d^\dagger T_d \right) + 48g_{RB}^2 \text{Tr} \left( Y_d^\dagger T_d \right) + 24g_{BL}^2 \text{Tr} \left( Y_e^\dagger T_e \right) \\ & + 8\sqrt{6}g_{BL} g_{RB} \text{Tr} \left( Y_e^\dagger T_e \right) + 16g_{RB}^2 \text{Tr} \left( Y_e^\dagger T_e \right) + 12g_{BL}^2 \text{Tr} \left( Y_s^\dagger T_s \right) - 8\sqrt{6}g_{BL} g_{RB} \text{Tr} \left( Y_s^\dagger T_s \right) \\ & + 8g_{RB}^2 \text{Tr} \left( Y_s^\dagger T_s \right) + 8g_{BL}^2 \text{Tr} \left( Y_u^\dagger T_u \right) + 8\sqrt{6}g_{BL} g_{RB} \text{Tr} \left( Y_u^\dagger T_u \right) + 48g_{RB}^2 \text{Tr} \left( Y_u^\dagger T_u \right) \end{aligned}$$

$$+ 24g_{BL}^2 \text{Tr}(Y_v^\dagger T_\nu) - 8\sqrt{6}g_{BL}g_{RB} \text{Tr}(Y_v^\dagger T_\nu) + 16g_{RB}^2 \text{Tr}(Y_v^\dagger T_\nu) \quad (42)$$

$$\beta_{M_2}^{(1)} = 2g_L^2 M_2 \quad (43)$$

$$\begin{aligned} \beta_{M_2}^{(2)} = & 2g_L^2 \left( 3g_{BL}^2 M_1 + g_R^2 M_4 + 24g_s^2 M_3 + 24g_s^2 M_2 + 3g_{BL}^2 M_2 + 50g_L^2 M_2 + g_R^2 M_2 - 6M_2 \text{Tr}(Y_d Y_d^\dagger) \right. \\ & - 2M_2 \text{Tr}(Y_e Y_e^\dagger) - 6M_2 \text{Tr}(Y_u Y_u^\dagger) - 2M_2 \text{Tr}(Y_v Y_v^\dagger) + 6\text{Tr}(Y_d^\dagger T_d) + 2\text{Tr}(Y_e^\dagger T_e) + 6\text{Tr}(Y_u^\dagger T_u) \\ & \left. + 2\text{Tr}(Y_v^\dagger T_\nu) \right) \quad (44) \end{aligned}$$

$$\beta_{M_4}^{(1)} = \frac{1}{2} \left( 27g_{BR}^2 M_4 + 30g_R \left( g_{RB} M_{BR} + g_R M_4 \right) + g_{BL} \left( 27g_{BR} - \sqrt{6}g_R \right) M_{BR} - \sqrt{6}g_{BR} \left( 2g_R M_4 + g_{RB} M_{BR} \right) \right) \quad (45)$$

$$\begin{aligned} \beta_{M_4}^{(2)} = & \frac{1}{4} \left( 65g_{BL}^2 g_{BR}^2 M_1 - 6\sqrt{6}g_{BL}^2 g_{BR} g_R M_1 + 30g_{BL}^2 g_R^2 M_1 - 6\sqrt{6}g_{BL} g_{BR}^2 g_R M_1 + 120g_{BL} g_{BR} g_R g_{RB} M_1 \right. \\ & - 4\sqrt{6}g_{BL} g_R^2 g_{RB} M_1 + 30g_{BR}^2 g_{RB}^2 M_1 - 4\sqrt{6}g_{BR} g_R g_{RB}^2 M_1 + 60g_R^2 g_{RB}^2 M_1 + 64g_s^2 g_{BL} g_{BR} M_{BR} \\ & + 65g_{BL}^3 g_{BR} M_{BR} + 195g_{BL} g_{BR}^3 M_{BR} + 72g_{BL} g_{BR} g_L^3 M_{BR} - 3\sqrt{6}g_{BL}^3 g_R M_{BR} - 27\sqrt{6}g_{BL} g_{BR}^2 g_R M_{BR} \\ & + 270g_{BL} g_{BR} g_R^2 M_{BR} - 6\sqrt{6}g_{BL} g_R^3 M_{BR} - 9\sqrt{6}g_{BL}^2 g_{BR} g_{RB} M_{BR} - 9\sqrt{6}g_{BR}^3 g_{RB} M_{BR} \\ & + 192g_s^2 g_R g_{RB} M_{BR} + 90g_{BL}^2 g_R g_{RB} M_{BR} + 270g_{BR}^2 g_R g_{RB} M_{BR} + 24g_L^2 g_R g_{RB} M_{BR} - 18\sqrt{6}g_{BR} g_R^2 g_{RB} M_{BR} \\ & + 180g_R^3 g_{RB} M_{BR} + 90g_{BL} g_{BR} g_{RB}^2 M_{BR} - 6\sqrt{6}g_{BL} g_R g_{RB}^2 M_{BR} - 2\sqrt{6}g_{BR} g_{RB}^3 M_{BR} + 60g_R g_{RB}^3 M_{BR} \\ & + 64g_s^2 g_{BR}^2 M_4 + 65g_{BL}^2 g_{BR}^2 M_4 + 130g_{BR}^4 M_4 + 72g_{BR}^2 g_L^2 M_4 - 6\sqrt{6}g_{BL}^2 g_{BR} g_R M_4 \\ & - 24\sqrt{6}g_{BR}^3 g_R M_4 + 192g_s^2 g_R^2 M_4 + 30g_{BL}^2 g_R^2 M_4 + 360g_{BR}^2 g_R^2 M_4 + 24g_L^2 g_R^2 M_4 \\ & - 16\sqrt{6}g_{BR} g_R^3 M_4 + 120g_R^4 M_4 - 6\sqrt{6}g_{BL} g_{BR}^2 g_{RB} M_4 + 120g_{BL} g_{BR} g_R g_{RB} M_4 \\ & - 4\sqrt{6}g_{BL} g_R^2 g_{RB} M_4 + 30g_{BR}^2 g_{RB}^2 M_4 - 4\sqrt{6}g_{BR} g_R g_{RB}^2 M_4 + 60g_R^2 g_{RB}^2 M_4 + 64g_s^2 g_{BR}^2 M_3 \\ & + 192g_s^2 g_R^2 M_3 + 72g_{BR}^2 g_L^2 M_2 + 24g_L^2 g_R^2 M_2 \\ & + \left( -48g_R \left( g_{RB} M_{BR} + g_R M_4 \right) + 4\sqrt{6}g_{BR} \left( 2g_R M_4 + g_{RB} M_{BR} \right) - 8g_{BR}^2 M_4 + g_{BL} \left( 4\sqrt{6}g_R M_{BR} - 8g_{BR} M_{BR} \right) \right) \text{Tr}(Y_d Y_d^\dagger) \\ & - 4 \left( 4g_R \left( g_{RB} M_{BR} + g_R M_4 \right) + 6g_{BR}^2 M_4 + g_{BL} \left( 6g_{BR} + \sqrt{6}g_R \right) M_{BR} + \sqrt{6}g_{BR} \left( 2g_R M_4 + g_{RB} M_{BR} \right) \right) \text{Tr}(Y_e Y_e^\dagger) \\ & - 12g_{BL} g_{BR} M_{BR} \text{Tr}(Y_s Y_s^\dagger) + 4\sqrt{6}g_{BL} g_R M_{BR} \text{Tr}(Y_s Y_s^\dagger) + 4\sqrt{6}g_{BR} g_{RB} M_{BR} \text{Tr}(Y_s Y_s^\dagger) \\ & - 8g_R g_{RB} M_{BR} \text{Tr}(Y_s Y_s^\dagger) - 12g_{BR}^2 M_4 \text{Tr}(Y_s Y_s^\dagger) + 8\sqrt{6}g_{BR} g_R M_4 \text{Tr}(Y_s Y_s^\dagger) \\ & - 8g_R^2 M_4 \text{Tr}(Y_s Y_s^\dagger) - 8g_{BL} g_{BR} M_{BR} \text{Tr}(Y_u Y_u^\dagger) - 4\sqrt{6}g_{BL} g_R M_{BR} \text{Tr}(Y_u Y_u^\dagger) \\ & - 4\sqrt{6}g_{BR} g_{RB} M_{BR} \text{Tr}(Y_u Y_u^\dagger) - 48g_R g_{RB} M_{BR} \text{Tr}(Y_u Y_u^\dagger) - 8g_{BR}^2 M_4 \text{Tr}(Y_u Y_u^\dagger) \\ & - 8\sqrt{6}g_{BR} g_R M_4 \text{Tr}(Y_u Y_u^\dagger) - 48g_R^2 M_4 \text{Tr}(Y_u Y_u^\dagger) - 24g_{BL} g_{BR} M_{BR} \text{Tr}(Y_v Y_v^\dagger) \\ & + 4\sqrt{6}g_{BL} g_R M_{BR} \text{Tr}(Y_v Y_v^\dagger) + 4\sqrt{6}g_{BR} g_{RB} M_{BR} \text{Tr}(Y_v Y_v^\dagger) - 16g_R g_{RB} M_{BR} \text{Tr}(Y_v Y_v^\dagger) \\ & - 24g_{BR}^2 M_4 \text{Tr}(Y_v Y_v^\dagger) + 8\sqrt{6}g_{BR} g_R M_4 \text{Tr}(Y_v Y_v^\dagger) - 16g_R^2 M_4 \text{Tr}(Y_v Y_v^\dagger) + 8g_{BR}^2 \text{Tr}(Y_d^\dagger T_d) \\ & - 8\sqrt{6}g_{BR} g_R \text{Tr}(Y_d^\dagger T_d) + 48g_R^2 \text{Tr}(Y_d^\dagger T_d) + 24g_{BR}^2 \text{Tr}(Y_e^\dagger T_e) + 8\sqrt{6}g_{BR} g_R \text{Tr}(Y_e^\dagger T_e) \end{aligned}$$

$$\begin{aligned}
& + 16g_R^2 \text{Tr}(Y_e^\dagger T_e) + 12g_{BR}^2 \text{Tr}(Y_s^\dagger T_s) - 8\sqrt{6}g_{BR}g_R \text{Tr}(Y_s^\dagger T_s) + 8g_R^2 \text{Tr}(Y_s^\dagger T_s) \\
& + 8g_{BR}^2 \text{Tr}(Y_u^\dagger T_u) + 8\sqrt{6}g_{BR}g_R \text{Tr}(Y_u^\dagger T_u) + 48g_R^2 \text{Tr}(Y_u^\dagger T_u) + 24g_{BR}^2 \text{Tr}(Y_v^\dagger T_v) \\
& - 8\sqrt{6}g_{BR}g_R \text{Tr}(Y_v^\dagger T_v) + 16g_R^2 \text{Tr}(Y_v^\dagger T_v)
\end{aligned} \tag{46}$$

$$\beta_{M_3}^{(1)} = -6g_s^2 M_3 \tag{47}$$

$$\begin{aligned}
\beta_{M_3}^{(2)} &= 2g_s^2 (g_{BL}^2 M_1 + 3g_R^2 M_4 + 28g_s^2 M_3 + g_{BL}^2 M_3 + 9g_L^2 M_3 + 3g_R^2 M_3 + 9g_L^2 M_2 - 4M_3 \text{Tr}(Y_d Y_d^\dagger) \\
& - 4M_3 \text{Tr}(Y_u Y_u^\dagger) + 4\text{Tr}(Y_d^\dagger T_d) + 4\text{Tr}(Y_u^\dagger T_u))
\end{aligned} \tag{48}$$

$$\begin{aligned}
\beta_{M_{BR}}^{(1)} &= \frac{1}{4} (27g_{BL}^2 M_{BR} + 27g_{BR}^2 M_{BR} - \sqrt{6}g_{BR} (2g_R M_{BR} + g_{RB} (M_1 + M_4))) + 30 (g_R^2 M_{BR} + g_{RB}^2 M_{BR} + g_R g_{RB} (M_1 + M_4)) \\
& + g_{BL} (27g_{BR} (M_1 + M_4) - \sqrt{6} (2g_{RB} M_{BR} + g_R (M_1 + M_4)))
\end{aligned} \tag{49}$$

$$\begin{aligned}
\beta_{M_{BR}}^{(2)} &= \frac{1}{8} (64g_s^2 g_{BL} g_{BR} M_1 + 195g_{BL}^3 g_{BR} M_1 + 65g_{BL} g_{BR}^3 M_1 + 72g_{BL} g_{BR} g_L^2 M_1 - 9\sqrt{6}g_{BL}^3 g_R M_1 \\
& - 9\sqrt{6}g_{BL} g_{BR}^2 g_R M_1 + 90g_{BL} g_{BR} g_R^2 M_1 - 2\sqrt{6}g_{BL} g_R^3 M_1 - 27\sqrt{6}g_{BL}^2 g_{BR} g_{RB} M_1 \\
& - 3\sqrt{6}g_{BR}^3 g_{RB} M_1 + 192g_s^2 g_R g_{RB} M_1 + 270g_{BL}^2 g_R g_{RB} M_1 + 90g_{BR}^2 g_R g_{RB} M_1 + 24g_L^2 g_R g_{RB} M_1 \\
& - 6\sqrt{6}g_{BR} g_R^2 g_{RB} M_1 + 60g_R^3 g_{RB} M_1 + 270g_{BL} g_{BR} g_{RB}^2 M_1 - 18\sqrt{6}g_{BL} g_R g_{RB}^2 M_1 \\
& - 6\sqrt{6}g_{BR} g_{RB}^3 M_1 + 180g_R g_{RB}^3 M_1 + 64g_s^2 g_{BL}^2 M_{BR} + 65g_{BL}^4 M_{BR} + 64g_s^2 g_{BR}^2 M_{BR} + 390g_{BL}^2 g_{BR}^2 M_{BR} \\
& + 65g_{BR}^4 M_{BR} + 72g_{BL}^2 g_L^2 M_{BR} + 72g_{BR}^2 g_L^2 M_{BR} - 36\sqrt{6}g_{BL}^2 g_{BR} g_R M_{BR} - 12\sqrt{6}g_{BR}^3 g_R M_{BR} \\
& + 192g_s^2 g_R^2 M_{BR} + 180g_{BL}^2 g_R^2 M_{BR} + 180g_{BR}^2 g_R^2 M_{BR} + 24g_L^2 g_R^2 M_{BR} - 8\sqrt{6}g_{BR} g_R^3 M_{BR} + 60g_R^4 M_{BR} \\
& - 12\sqrt{6}g_{BL}^3 g_{RB} M_{BR} - 36\sqrt{6}g_{BL} g_{BR}^2 g_{RB} M_{BR} + 720g_{BL} g_{BR} g_R g_{RB} M_{BR} - 24\sqrt{6}g_{BL} g_R^2 g_{RB} M_{BR} \\
& + 192g_s^2 g_{RB}^2 M_{BR} + 180g_{BL}^2 g_{RB}^2 M_{BR} + 180g_{BR}^2 g_{RB}^2 M_{BR} + 24g_L^2 g_{RB}^2 M_{BR} - 24\sqrt{6}g_{BR} g_R g_{RB}^2 M_{BR} \\
& + 360g_R^2 g_{RB}^2 M_{BR} - 8\sqrt{6}g_{BL} g_{RB}^3 M_{BR} + 60g_R^4 M_{BR} + 64g_s^2 g_{BL} g_{BR} M_4 + 65g_{BL}^3 g_{BR} M_4 + 195g_{BL} g_{BR}^3 M_4 \\
& + 72g_{BL} g_{BR} g_L^2 M_4 - 3\sqrt{6}g_{BL}^3 g_R M_4 - 27\sqrt{6}g_{BL} g_{BR}^2 g_R M_4 + 270g_{BL} g_{BR} g_R^2 M_4 \\
& - 6\sqrt{6}g_{BL} g_R^3 M_4 - 9\sqrt{6}g_{BL}^2 g_{BR} g_{RB} M_4 - 9\sqrt{6}g_{BR}^3 g_{RB} M_4 + 192g_s^2 g_R g_{RB} M_4 \\
& + 90g_{BL}^2 g_R g_{RB} M_4 + 270g_{BR}^2 g_R g_{RB} M_4 + 24g_L^2 g_R g_{RB} M_4 - 18\sqrt{6}g_{BR} g_R^2 g_{RB} M_4 + 180g_R^3 g_{RB} M_4 \\
& + 90g_{BL} g_{BR} g_{RB}^2 M_4 - 6\sqrt{6}g_{BL} g_R g_{RB}^2 M_4 - 2\sqrt{6}g_{BR} g_R^3 M_4 + 60g_R g_{RB}^3 M_4 + 128g_s^2 g_{BL} g_{BR} M_3 \\
& + 384g_s^2 g_R g_{RB} M_3 + 144g_{BL} g_{BR} g_L^2 M_2 + 48g_L^2 g_R g_{RB} M_2 \\
& - 4 (2g_{BL}^2 M_{BR} + 2g_{BR}^2 M_{BR} - \sqrt{6}g_{BR} (2g_R M_{BR} + g_{RB} (M_1 + M_4))) + 12 (g_R^2 M_{BR} + g_{RB}^2 M_{BR} + g_R g_{RB} (M_1 + M_4)) \\
& + g_{BL} (2g_{BR} (M_1 + M_4) - \sqrt{6} (2g_{RB} M_{BR} + g_R (M_1 + M_4))) \text{Tr}(Y_d Y_d^\dagger) \\
& - 4 (6g_{BL}^2 M_{BR} + 6g_{BR}^2 M_{BR} + \sqrt{6}g_{BR} (2g_R M_{BR} + g_{RB} (M_1 + M_4))) + 4 (g_R^2 M_{BR} + g_{RB}^2 M_{BR} + g_R g_{RB} (M_1 + M_4)) \\
& + g_{BL} (6g_{BR} (M_1 + M_4) + \sqrt{6} (2g_{RB} M_{BR} + g_R (M_1 + M_4))) \text{Tr}(Y_e Y_e^\dagger) \\
& - 12g_{BL} g_{BR} M_1 \text{Tr}(Y_s Y_s^\dagger) + 4\sqrt{6}g_{BL} g_R M_1 \text{Tr}(Y_s Y_s^\dagger) + 4\sqrt{6}g_{BR} g_{RB} M_1 \text{Tr}(Y_s Y_s^\dagger)
\end{aligned}$$

$$\begin{aligned}
& -8g_R g_{RB} M_1 \text{Tr}(Y_s Y_s^\dagger) - 12g_{BL}^2 M_{BR} \text{Tr}(Y_s Y_s^\dagger) - 12g_{BR}^2 M_{BR} \text{Tr}(Y_s Y_s^\dagger) \\
& + 8\sqrt{6}g_{BR} g_R M_{BR} \text{Tr}(Y_s Y_s^\dagger) - 8g_R^2 M_{BR} \text{Tr}(Y_s Y_s^\dagger) + 8\sqrt{6}g_{BL} g_{RB} M_{BR} \text{Tr}(Y_s Y_s^\dagger) \\
& - 8g_{RB}^2 M_{BR} \text{Tr}(Y_s Y_s^\dagger) - 12g_{BL} g_{BR} M_4 \text{Tr}(Y_s Y_s^\dagger) + 4\sqrt{6}g_{BL} g_R M_4 \text{Tr}(Y_s Y_s^\dagger) \\
& + 4\sqrt{6}g_{BR} g_{RB} M_4 \text{Tr}(Y_s Y_s^\dagger) - 8g_R g_{RB} M_4 \text{Tr}(Y_s Y_s^\dagger) - 8g_{BL} g_{BR} M_1 \text{Tr}(Y_u Y_u^\dagger) \\
& - 4\sqrt{6}g_{BL} g_R M_1 \text{Tr}(Y_u Y_u^\dagger) - 4\sqrt{6}g_{BR} g_{RB} M_1 \text{Tr}(Y_u Y_u^\dagger) - 48g_R g_{RB} M_1 \text{Tr}(Y_u Y_u^\dagger) \\
& - 8g_{BL}^2 M_{BR} \text{Tr}(Y_u Y_u^\dagger) - 8g_{BR}^2 M_{BR} \text{Tr}(Y_u Y_u^\dagger) - 8\sqrt{6}g_{BR} g_R M_{BR} \text{Tr}(Y_u Y_u^\dagger) \\
& - 48g_R^2 M_{BR} \text{Tr}(Y_u Y_u^\dagger) - 8\sqrt{6}g_{BL} g_{RB} M_{BR} \text{Tr}(Y_u Y_u^\dagger) - 48g_{RB}^2 M_{BR} \text{Tr}(Y_u Y_u^\dagger) \\
& - 8g_{BL} g_{BR} M_4 \text{Tr}(Y_u Y_u^\dagger) - 4\sqrt{6}g_{BL} g_R M_4 \text{Tr}(Y_u Y_u^\dagger) - 4\sqrt{6}g_{BR} g_{RB} M_4 \text{Tr}(Y_u Y_u^\dagger) \\
& - 48g_R g_{RB} M_4 \text{Tr}(Y_u Y_u^\dagger) - 24g_{BL} g_{BR} M_1 \text{Tr}(Y_v Y_v^\dagger) + 4\sqrt{6}g_{BL} g_R M_1 \text{Tr}(Y_v Y_v^\dagger) \\
& + 4\sqrt{6}g_{BR} g_{RB} M_1 \text{Tr}(Y_v Y_v^\dagger) - 16g_R g_{RB} M_1 \text{Tr}(Y_v Y_v^\dagger) - 24g_{BL}^2 M_{BR} \text{Tr}(Y_v Y_v^\dagger) \\
& - 24g_{BR}^2 M_{BR} \text{Tr}(Y_v Y_v^\dagger) + 8\sqrt{6}g_{BR} g_R M_{BR} \text{Tr}(Y_v Y_v^\dagger) - 16g_R^2 M_{BR} \text{Tr}(Y_v Y_v^\dagger) \\
& + 8\sqrt{6}g_{BL} g_{RB} M_{BR} \text{Tr}(Y_v Y_v^\dagger) - 16g_{RB}^2 M_{BR} \text{Tr}(Y_v Y_v^\dagger) - 24g_{BL} g_{BR} M_4 \text{Tr}(Y_v Y_v^\dagger) \\
& + 4\sqrt{6}g_{BL} g_R M_4 \text{Tr}(Y_v Y_v^\dagger) + 4\sqrt{6}g_{BR} g_{RB} M_4 \text{Tr}(Y_v Y_v^\dagger) - 16g_R g_{RB} M_4 \text{Tr}(Y_v Y_v^\dagger) \\
& + 16g_{BL} g_{BR} \text{Tr}(Y_d^\dagger T_d) - 8\sqrt{6}g_{BL} g_R \text{Tr}(Y_d^\dagger T_d) - 8\sqrt{6}g_{BR} g_{RB} \text{Tr}(Y_d^\dagger T_d) + 96g_R g_{RB} \text{Tr}(Y_d^\dagger T_d) \\
& + 48g_{BL} g_{BR} \text{Tr}(Y_e^\dagger T_e) + 8\sqrt{6}g_{BL} g_R \text{Tr}(Y_e^\dagger T_e) + 8\sqrt{6}g_{BR} g_{RB} \text{Tr}(Y_e^\dagger T_e) + 32g_R g_{RB} \text{Tr}(Y_e^\dagger T_e) \\
& + 24g_{BL} g_{BR} \text{Tr}(Y_s^\dagger T_s) - 8\sqrt{6}g_{BL} g_R \text{Tr}(Y_s^\dagger T_s) - 8\sqrt{6}g_{BR} g_{RB} \text{Tr}(Y_s^\dagger T_s) + 16g_R g_{RB} \text{Tr}(Y_s^\dagger T_s) \\
& + 16g_{BL} g_{BR} \text{Tr}(Y_u^\dagger T_u) + 8\sqrt{6}g_{BL} g_R \text{Tr}(Y_u^\dagger T_u) + 8\sqrt{6}g_{BR} g_{RB} \text{Tr}(Y_u^\dagger T_u) + 96g_R g_{RB} \text{Tr}(Y_u^\dagger T_u) \\
& + 48g_{BL} g_{BR} \text{Tr}(Y_v^\dagger T_\nu) - 8\sqrt{6}g_{BL} g_R \text{Tr}(Y_v^\dagger T_\nu) - 8\sqrt{6}g_{BR} g_{RB} \text{Tr}(Y_v^\dagger T_\nu) + 32g_R g_{RB} \text{Tr}(Y_v^\dagger T_\nu)
\end{aligned} \tag{50}$$

### 3.4 Trilinear Superpotential Parameters

$$\begin{aligned}
\beta_{Y_d}^{(1)} &= +3Y_d Y_d^\dagger Y_d + Y_d Y_u^\dagger Y_u \\
& - \frac{1}{6}Y_d \left( 18g_L^2 - 18\text{Tr}(Y_d Y_d^\dagger) + 32g_s^2 + 6g_R^2 + 6g_{RB}^2 - 6\text{Tr}(Y_e Y_e^\dagger) - \sqrt{6}g_{BL} g_{RB} - \sqrt{6}g_{BR} g_R + g_{BL}^2 + g_{BR}^2 \right) \\
\beta_{Y_d}^{(2)} &= \frac{1}{72} \left( 12 \left( -12 \left( 2Y_d Y_d^\dagger Y_d Y_d^\dagger Y_d + Y_d Y_u^\dagger Y_u Y_d^\dagger Y_d + Y_d Y_u^\dagger Y_u Y_u^\dagger Y_u \right) \right. \right. \\
& + Y_d Y_d^\dagger Y_d \left( -18\text{Tr}(Y_e Y_e^\dagger) + 36g_L^2 - 54\text{Tr}(Y_d Y_d^\dagger) + 6g_R^2 + 6g_{RB}^2 + \sqrt{6}g_{BL} g_{RB} + \sqrt{6}g_{BR} g_R \right) \\
& \left. \left. + Y_d Y_u^\dagger Y_u \left( -18\text{Tr}(Y_u Y_u^\dagger) + 6g_R^2 + 6g_{RB}^2 - 6\text{Tr}(Y_v Y_v^\dagger) + \sqrt{6}g_{BL} g_{RB} + \sqrt{6}g_{BR} g_R \right) \right)
\end{aligned} \tag{51}$$

$$\begin{aligned}
& + Y_d \left( -128g_s^4 + 64g_s^2g_{BL}^2 + 82g_{BL}^4 + 64g_s^2g_{BR}^2 + 164g_{BL}^2g_{BR}^2 + 82g_{BR}^4 + 576g_s^2g_L^2 + 18g_{BL}^2g_L^2 \right. \\
& + 18g_{BR}^2g_L^2 + 540g_L^4 - 64\sqrt{6}g_s^2g_{BR}g_R - 89\sqrt{6}g_{BL}^2g_{BR}g_R - 89\sqrt{6}g_{BR}^3g_R + 192g_s^2g_R^2 \\
& + 24g_{BL}^2g_R^2 + 630g_{BR}^2g_R^2 + 108g_L^2g_R^2 - 138\sqrt{6}g_{BR}g_R^3 + 576g_R^4 - 64\sqrt{6}g_s^2g_{BL}g_{RB} \\
& - 89\sqrt{6}g_{BL}^3g_{RB} - 89\sqrt{6}g_{BL}g_{BR}^2g_{RB} + 1212g_{BL}g_{BR}g_{RB} - 138\sqrt{6}g_{BL}g_R^2g_{RB} + 192g_s^2g_{RB}^2 \\
& + 630g_{BL}^2g_{RB}^2 + 24g_{BR}^2g_{RB}^2 + 108g_L^2g_{RB}^2 - 138\sqrt{6}g_{BR}g_{RB}^2 + 1152g_R^2g_{RB}^2 - 138\sqrt{6}g_{BL}g_{RB}^3 \\
& + 576g_{RB}^4 + 36 \left( 32g_s^2 - \sqrt{6}g_{BL}g_{RB} - \sqrt{6}g_{BR}g_R + g_{BL}^2 + g_{BR}^2 \right) \text{Tr} \left( Y_d Y_d^\dagger \right) \\
& + 36 \left( 3g_{BL}^2 + 3g_{BR}^2 + \sqrt{6}g_{BL}g_{RB} + \sqrt{6}g_{BR}g_R \right) \text{Tr} \left( Y_e Y_e^\dagger \right) - 648 \text{Tr} \left( Y_d Y_d^\dagger Y_d Y_d^\dagger \right) \\
& - 216 \text{Tr} \left( Y_d Y_u^\dagger Y_u Y_d^\dagger \right) - 216 \text{Tr} \left( Y_e Y_e^\dagger Y_e Y_e^\dagger \right) - 72 \text{Tr} \left( Y_e Y_v^\dagger Y_v Y_e^\dagger \right) \left. \right) \quad (52)
\end{aligned}$$

$$\begin{aligned}
\beta_{Y_e}^{(1)} & = \frac{1}{2} \left( 2 \left( 3Y_e Y_e^\dagger Y_e + Y_e Y_v^\dagger Y_v \right) \right. \\
& \left. - Y_e \left( 2g_R^2 + 2g_{RB}^2 - 2 \text{Tr} \left( Y_e Y_e^\dagger \right) + 3g_{BL}^2 + 3g_{BR}^2 + 6g_L^2 - 6 \text{Tr} \left( Y_d Y_d^\dagger \right) + \sqrt{6}g_{BL}g_{RB} + \sqrt{6}g_{BR}g_R \right) \right) \quad (53)
\end{aligned}$$

$$\begin{aligned}
\beta_{Y_e}^{(2)} & = \frac{1}{8} \left( 4 \left( -2 \left( 2 \left( Y_e Y_v^\dagger Y_v Y_e^\dagger Y_e + Y_e Y_v^\dagger Y_v Y_v^\dagger Y_v \right) + 4Y_e Y_e^\dagger Y_e Y_e^\dagger Y_e + Y_e Y_v^\dagger Y_s Y_s^\dagger Y_v \right) \right. \right. \\
& + Y_e Y_e^\dagger Y_e \left( 12g_L^2 - 18 \text{Tr} \left( Y_d Y_d^\dagger \right) + 2g_R^2 + 2g_{RB}^2 - 6 \text{Tr} \left( Y_e Y_e^\dagger \right) - \sqrt{6}g_{BL}g_{RB} - \sqrt{6}g_{BR}g_R \right) \\
& - Y_e Y_v^\dagger Y_v \left( -2g_R^2 - 2g_{RB}^2 + 2 \text{Tr} \left( Y_v Y_v^\dagger \right) + 6 \text{Tr} \left( Y_u Y_u^\dagger \right) + \sqrt{6}g_{BL}g_{RB} + \sqrt{6}g_{BR}g_R \right) \left. \right) \\
& + Y_e \left( 90g_{BL}^4 + 180g_{BL}^2g_{BR}^2 + 90g_{BR}^4 + 18g_{BL}^2g_L^2 + 18g_{BR}^2g_L^2 + 60g_L^4 + 27\sqrt{6}g_{BL}^2g_{BR}g_R + 27\sqrt{6}g_{BR}^3g_R \right. \\
& + 150g_{BR}^2g_R^2 + 12g_L^2g_R^2 + 30\sqrt{6}g_{BR}g_R^3 + 64g_R^4 + 27\sqrt{6}g_{BL}^3g_{RB} + 27\sqrt{6}g_{BL}g_{BR}^2g_{RB} \\
& + 300g_{BL}g_{BR}g_{RB} + 30\sqrt{6}g_{BL}g_R^2g_{RB} + 150g_{BL}^2g_{RB}^2 + 12g_L^2g_{RB}^2 + 30\sqrt{6}g_{BR}g_{RB}^2 + 128g_R^2g_{RB}^2 \\
& + 30\sqrt{6}g_{BL}g_{RB}^3 + 64g_{RB}^4 + 4 \left( 32g_s^2 - \sqrt{6}g_{BL}g_{RB} - \sqrt{6}g_{BR}g_R + g_{BL}^2 + g_{BR}^2 \right) \text{Tr} \left( Y_d Y_d^\dagger \right) \\
& + 4 \left( 3g_{BL}^2 + 3g_{BR}^2 + \sqrt{6}g_{BL}g_{RB} + \sqrt{6}g_{BR}g_R \right) \text{Tr} \left( Y_e Y_e^\dagger \right) - 72 \text{Tr} \left( Y_d Y_d^\dagger Y_d Y_d^\dagger \right) - 24 \text{Tr} \left( Y_d Y_u^\dagger Y_u Y_d^\dagger \right) \\
& \left. - 24 \text{Tr} \left( Y_e Y_e^\dagger Y_e Y_e^\dagger \right) - 8 \text{Tr} \left( Y_e Y_v^\dagger Y_v Y_e^\dagger \right) \right) \quad (54)
\end{aligned}$$

$$\begin{aligned}
\beta_{Y_u}^{(1)} & = +Y_u Y_d^\dagger Y_d + 3Y_u Y_u^\dagger Y_u \\
& - \frac{1}{6} Y_u \left( 18g_L^2 - 18 \text{Tr} \left( Y_u Y_u^\dagger \right) + 32g_s^2 + 6g_R^2 + 6g_{RB}^2 - 6 \text{Tr} \left( Y_v Y_v^\dagger \right) + \sqrt{6}g_{BL}g_{RB} + \sqrt{6}g_{BR}g_R + g_{BL}^2 + g_{BR}^2 \right) \quad (55)
\end{aligned}$$

$$\begin{aligned}
\beta_{Y_u}^{(2)} & = \frac{1}{72} \left( -12 \left( 12 \left( 2Y_u Y_u^\dagger Y_u Y_u^\dagger Y_u + Y_u Y_d^\dagger Y_d Y_d^\dagger Y_d + Y_u Y_d^\dagger Y_d Y_u^\dagger Y_u \right) \right. \right. \\
& + Y_u Y_d^\dagger Y_d \left( 18 \text{Tr} \left( Y_d Y_d^\dagger \right) - 6g_R^2 - 6g_{RB}^2 + 6 \text{Tr} \left( Y_e Y_e^\dagger \right) + \sqrt{6}g_{BL}g_{RB} + \sqrt{6}g_{BR}g_R \right) \\
& + Y_u Y_u^\dagger Y_u \left( 18 \text{Tr} \left( Y_v Y_v^\dagger \right) - 36g_L^2 + 54 \text{Tr} \left( Y_u Y_u^\dagger \right) - 6g_R^2 - 6g_{RB}^2 + \sqrt{6}g_{BL}g_{RB} + \sqrt{6}g_{BR}g_R \right) \left. \right) \\
& + Y_u \left( -128g_s^4 + 64g_s^2g_{BL}^2 + 82g_{BL}^4 + 64g_s^2g_{BR}^2 + 164g_{BL}^2g_{BR}^2 + 82g_{BR}^4 + 576g_s^2g_L^2 + 18g_{BL}^2g_L^2 \right. \\
& + 18g_{BR}^2g_L^2 + 540g_L^4 + 64\sqrt{6}g_s^2g_{BR}g_R + 77\sqrt{6}g_{BL}^2g_{BR}g_R + 77\sqrt{6}g_{BR}^3g_R + 192g_s^2g_R^2
\end{aligned}$$

$$\begin{aligned}
& -12g_{BL}^2g_R^2 + 558g_{BR}^2g_R^2 + 108g_L^2g_R^2 + 66\sqrt{6}g_{BR}g_R^3 + 576g_R^4 + 64\sqrt{6}g_s^2g_{BL}g_{RB} \\
& + 77\sqrt{6}g_{BL}^3g_{RB} + 77\sqrt{6}g_{BL}g_{BR}^2g_{RB} + 1140g_{BL}g_{BR}g_{RB} + 66\sqrt{6}g_{BL}g_R^2g_{RB} + 192g_s^2g_{RB}^2 \\
& + 558g_{BL}^2g_{RB}^2 - 12g_{BR}^2g_{RB}^2 + 108g_L^2g_{RB}^2 + 66\sqrt{6}g_{BR}g_Rg_{RB}^2 + 1152g_R^2g_{RB}^2 + 66\sqrt{6}g_{BL}g_{RB}^3 + 576g_{RB}^4 \\
& + 36\left(32g_s^2 + \sqrt{6}g_{BL}g_{RB} + \sqrt{6}g_{BR}g_R + g_{BL}^2 + g_{BR}^2\right)\text{Tr}\left(Y_u Y_u^\dagger\right) \\
& + 36\left(3g_{BL}^2 + 3g_{BR}^2 - \sqrt{6}g_{BL}g_{RB} - \sqrt{6}g_{BR}g_R\right)\text{Tr}\left(Y_v Y_v^\dagger\right) - 216\text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) \\
& - 72\text{Tr}\left(Y_e Y_v^\dagger Y_v Y_e^\dagger\right) - 72\text{Tr}\left(Y_s Y_s^\dagger Y_v Y_v^\dagger\right) - 648\text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right) - 216\text{Tr}\left(Y_v Y_v^\dagger Y_v Y_v^\dagger\right)
\end{aligned} \tag{56}$$

$$\begin{aligned}
\beta_{Y_s}^{(1)} & = +2\left(Y_s Y_s^\dagger Y_s + Y_v Y_v^\dagger Y_s\right) \\
& + Y_s\left(-\frac{3}{2}g_{BL}^2 - \frac{3}{2}g_{BR}^2 - g_R^2 - g_{RB}^2 + \sqrt{6}g_{BL}g_{RB} + \sqrt{6}g_{BR}g_R + \text{Tr}\left(Y_s Y_s^\dagger\right)\right)
\end{aligned} \tag{57}$$

$$\begin{aligned}
\beta_{Y_s}^{(2)} & = +6g_L^2 Y_v Y_v^\dagger Y_s + \sqrt{6}g_{BR}g_R Y_v Y_v^\dagger Y_s + \sqrt{6}g_{BL}g_{RB} Y_v Y_v^\dagger Y_s - 2Y_s Y_s^\dagger Y_s Y_s^\dagger Y_s \\
& - 2Y_s Y_s^\dagger Y_v Y_v^\dagger Y_s - 2Y_v Y_e^\dagger Y_e Y_v^\dagger Y_s - 2Y_v Y_v^\dagger Y_v Y_v^\dagger Y_s \\
& + Y_s Y_s^\dagger Y_s\left(-2\text{Tr}\left(Y_s Y_s^\dagger\right) + \frac{3}{2}g_{BL}^2 + \frac{3}{2}g_{BR}^2 - \sqrt{6}g_{BL}g_{RB} - \sqrt{6}g_{BR}g_R + g_R^2 + g_{RB}^2\right) \\
& - 6Y_v Y_v^\dagger Y_s \text{Tr}\left(Y_u Y_u^\dagger\right) - 2Y_v Y_v^\dagger Y_s \text{Tr}\left(Y_v Y_v^\dagger\right) \\
& + Y_s\left(\frac{45}{4}g_{BL}^4 + \frac{45}{2}g_{BL}^2g_{BR}^2 + \frac{45}{4}g_{BR}^4 - 9\sqrt{6}g_{BL}^2g_{BR}g_R - 9\sqrt{6}g_{BR}^3g_R + 3g_{BL}^2g_R^2 + \frac{51}{2}g_{BR}^2g_R^2\right. \\
& - 9\sqrt{6}g_{BR}g_R^3 + 8g_R^4 - 9\sqrt{6}g_{BL}^3g_{RB} - 9\sqrt{6}g_{BL}g_{BR}^2g_{RB} + 45g_{BL}g_{BR}g_Rg_{RB} - 9\sqrt{6}g_{BL}g_R^2g_{RB} \\
& \left. + \frac{51}{2}g_{BL}^2g_{RB}^2 + 3g_{BR}^2g_{RB}^2 - 9\sqrt{6}g_{BR}g_Rg_{RB}^2 + 16g_R^2g_{RB}^2 - 9\sqrt{6}g_{BL}g_{RB}^3 + 8g_{RB}^4 - 2\text{Tr}\left(Y_s Y_s^\dagger Y_s Y_s^\dagger\right)\right. \\
& \left. - 2\text{Tr}\left(Y_s Y_s^\dagger Y_v Y_v^\dagger\right)\right)
\end{aligned} \tag{58}$$

$$\begin{aligned}
\beta_{Y_v}^{(1)} & = +Y_s Y_s^\dagger Y_v + Y_v Y_e^\dagger Y_e + 3Y_v Y_v^\dagger Y_v \\
& - \frac{1}{2}Y_v\left(2g_R^2 + 2g_{RB}^2 - 2\text{Tr}\left(Y_v Y_v^\dagger\right) + 3g_{BL}^2 + 3g_{BR}^2 + 6g_L^2 - 6\text{Tr}\left(Y_u Y_u^\dagger\right) - \sqrt{6}g_{BL}g_{RB} - \sqrt{6}g_{BR}g_R\right)
\end{aligned} \tag{59}$$

$$\begin{aligned}
\beta_{Y_v}^{(2)} & = \frac{1}{8}\left(-4\left(-12g_L^2 Y_v Y_v^\dagger Y_v - \sqrt{6}g_{BR}g_R Y_v Y_v^\dagger Y_v - 2g_R^2 Y_v Y_v^\dagger Y_v - \sqrt{6}g_{BL}g_{RB} Y_v Y_v^\dagger Y_v\right.\right. \\
& - 2g_{RB}^2 Y_v Y_v^\dagger Y_v + 2Y_s Y_s^\dagger Y_s Y_s^\dagger Y_v + 4Y_v Y_e^\dagger Y_e Y_e^\dagger Y_e + 4Y_v Y_e^\dagger Y_e Y_v^\dagger Y_v \\
& + 2Y_v Y_v^\dagger Y_s Y_s^\dagger Y_v + 8Y_v Y_v^\dagger Y_v Y_v^\dagger Y_v \\
& \left. - Y_v Y_e^\dagger Y_e\left(2g_R^2 + 2g_{RB}^2 - 2\text{Tr}\left(Y_e Y_e^\dagger\right) - 6\text{Tr}\left(Y_d Y_d^\dagger\right) + \sqrt{6}g_{BL}g_{RB} + \sqrt{6}g_{BR}g_R\right)\right. \\
& \left. + 2Y_s Y_s^\dagger Y_v \text{Tr}\left(Y_s Y_s^\dagger\right) + 18Y_v Y_v^\dagger Y_v \text{Tr}\left(Y_u Y_u^\dagger\right) + 6Y_v Y_v^\dagger Y_v \text{Tr}\left(Y_v Y_v^\dagger\right)\right) \\
& + Y_v\left(90g_{BL}^4 + 180g_{BL}^2g_{BR}^2 + 90g_{BR}^4 + 18g_{BL}^2g_L^2 + 18g_{BR}^2g_L^2 + 60g_L^4 - 39\sqrt{6}g_{BL}^2g_{BR}g_R - 39\sqrt{6}g_{BR}^3g_R\right. \\
& + 12g_{BL}^2g_R^2 + 174g_{BR}^2g_R^2 + 12g_L^2g_R^2 - 38\sqrt{6}g_{BR}g_R^3 + 64g_R^4 - 39\sqrt{6}g_{BL}^3g_{RB} \\
& - 39\sqrt{6}g_{BL}g_{BR}^2g_{RB} + 324g_{BL}g_{BR}g_Rg_{RB} - 38\sqrt{6}g_{BL}g_R^2g_{RB} + 174g_{BL}^2g_{RB}^2 + 12g_{BR}^2g_{RB}^2 + 12g_L^2g_{RB}^2 \\
& \left. - 38\sqrt{6}g_{BR}g_Rg_{RB}^2 + 128g_R^2g_{RB}^2 - 38\sqrt{6}g_{BL}g_{RB}^3 + 64g_{RB}^4\right)
\end{aligned}$$



$$\begin{aligned}
& + 4\left(32g_s^2 + \sqrt{6}g_{BL}g_{RB} + \sqrt{6}g_{BR}g_R + g_{BL}^2 + g_{BR}^2\right)\text{Tr}\left(Y_u Y_u^\dagger\right) \\
& + 4\left(3g_{BL}^2 + 3g_{BR}^2 - \sqrt{6}g_{BL}g_{RB} - \sqrt{6}g_{BR}g_R\right)\text{Tr}\left(Y_v Y_v^\dagger\right) - 24\text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) \\
& - 8\text{Tr}\left(Y_e Y_v^\dagger Y_v Y_e^\dagger\right) - 8\text{Tr}\left(Y_s Y_s^\dagger Y_v Y_v^\dagger\right) - 72\text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right) - 24\text{Tr}\left(Y_v Y_v^\dagger Y_v Y_v^\dagger\right)
\end{aligned} \tag{60}$$

### 3.5 Bilinear Superpotential Parameters

$$\beta_{\mu_R}^{(1)} = -\frac{1}{2}\mu_R\left(2g_R^2 + 2g_{RB}^2 - 2\text{Tr}\left(Y_s Y_s^\dagger\right) - 2\sqrt{6}g_{BL}g_{RB} - 2\sqrt{6}g_{BR}g_R + 3g_{BL}^2 + 3g_{BR}^2\right) \tag{61}$$

$$\begin{aligned}
\beta_{\mu_R}^{(2)} = & \frac{1}{4}\mu_R\left(45g_{BL}^4 + 90g_{BL}^2 g_{BR}^2 + 45g_{BR}^4 - 36\sqrt{6}g_{BL}^2 g_{BR}g_R - 36\sqrt{6}g_{BR}^3 g_R + 12g_{BL}^2 g_R^2 + 102g_{BR}^2 g_R^2 \right. \\
& - 36\sqrt{6}g_{BR}g_R^3 + 32g_R^4 - 36\sqrt{6}g_{BL}^3 g_{RB} - 36\sqrt{6}g_{BL}g_{BR}^2 g_{RB} + 180g_{BL}g_{BR}g_R g_{RB} \\
& - 36\sqrt{6}g_{BL}g_R^2 g_{RB} + 102g_{BL}^2 g_{RB}^2 + 12g_{BR}^2 g_{RB}^2 - 36\sqrt{6}g_{BR}g_R g_{RB}^2 + 64g_R^2 g_{RB}^2 - 36\sqrt{6}g_{BL}g_{RB}^3 \\
& \left. + 32g_{RB}^4 - 8\text{Tr}\left(Y_s Y_s^\dagger Y_s Y_s^\dagger\right) - 8\text{Tr}\left(Y_s Y_s^\dagger Y_v Y_v^\dagger\right)\right)
\end{aligned} \tag{62}$$

$$\beta_{\mu}^{(1)} = \mu\left(-3g_L^2 + 3\text{Tr}\left(Y_d Y_d^\dagger\right) + 3\text{Tr}\left(Y_u Y_u^\dagger\right) - g_R^2 - g_{RB}^2 + \text{Tr}\left(Y_e Y_e^\dagger\right) + \text{Tr}\left(Y_v Y_v^\dagger\right)\right) \tag{63}$$

$$\begin{aligned}
\beta_{\mu}^{(2)} = & \frac{1}{4}\mu\left(30g_L^4 + 27g_{BR}^2 g_R^2 + 12g_L^2 g_R^2 - 2\sqrt{6}g_{BR}g_R^3 + 32g_R^4 + 54g_{BL}g_{BR}g_R g_{RB} - 2\sqrt{6}g_{BL}g_R^2 g_{RB} \right. \\
& + 27g_{BL}^2 g_{RB}^2 + 12g_L^2 g_{RB}^2 - 2\sqrt{6}g_{BR}g_R g_{RB}^2 + 64g_R^2 g_{RB}^2 - 2\sqrt{6}g_{BL}g_{RB}^3 + 32g_R^4 \\
& + 2\left(32g_s^2 - \sqrt{6}g_{BL}g_{RB} - \sqrt{6}g_{BR}g_R + g_{BL}^2 + g_{BR}^2\right)\text{Tr}\left(Y_d Y_d^\dagger\right) \\
& + 2\left(3g_{BL}^2 + 3g_{BR}^2 + \sqrt{6}g_{BL}g_{RB} + \sqrt{6}g_{BR}g_R\right)\text{Tr}\left(Y_e Y_e^\dagger\right) + 64g_s^2\text{Tr}\left(Y_u Y_u^\dagger\right) + 2g_{BL}^2\text{Tr}\left(Y_u Y_u^\dagger\right) \\
& + 2g_{BR}^2\text{Tr}\left(Y_u Y_u^\dagger\right) + 2\sqrt{6}g_{BR}g_R\text{Tr}\left(Y_u Y_u^\dagger\right) + 2\sqrt{6}g_{BL}g_{RB}\text{Tr}\left(Y_u Y_u^\dagger\right) + 6g_{BL}^2\text{Tr}\left(Y_v Y_v^\dagger\right) \\
& + 6g_{BR}^2\text{Tr}\left(Y_v Y_v^\dagger\right) - 2\sqrt{6}g_{BR}g_R\text{Tr}\left(Y_v Y_v^\dagger\right) - 2\sqrt{6}g_{BL}g_{RB}\text{Tr}\left(Y_v Y_v^\dagger\right) - 36\text{Tr}\left(Y_d Y_d^\dagger Y_d Y_d^\dagger\right) \\
& - 24\text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) - 12\text{Tr}\left(Y_e Y_e^\dagger Y_e Y_e^\dagger\right) - 8\text{Tr}\left(Y_e Y_v^\dagger Y_v Y_e^\dagger\right) - 4\text{Tr}\left(Y_s Y_s^\dagger Y_v Y_v^\dagger\right) \\
& \left. - 36\text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right) - 12\text{Tr}\left(Y_v Y_v^\dagger Y_v Y_v^\dagger\right)\right)
\end{aligned} \tag{64}$$

### 3.6 Trilinear Soft-Breaking Parameters

$$\begin{aligned}
\beta_{T_d}^{(1)} = & \frac{1}{6}\left(24Y_d Y_d^\dagger T_d + 12Y_d Y_u^\dagger T_u + 30T_d Y_d^\dagger Y_d + 6T_d Y_u^\dagger Y_u - 32g_s^2 T_d - g_{BL}^2 T_d \right. \\
& - g_{BR}^2 T_d - 18g_L^2 T_d + \sqrt{6}g_{BR}g_R T_d - 6g_R^2 T_d + \sqrt{6}g_{BL}g_{RB} T_d - 6g_{RB}^2 T_d + 18T_d\text{Tr}\left(Y_d Y_d^\dagger\right) \\
& \left. + 6T_d\text{Tr}\left(Y_e Y_e^\dagger\right)\right)
\end{aligned}$$

$$\begin{aligned}
& + 2Y_d \left( g_{BL}^2 M_1 - \sqrt{6} g_{BL} g_{RB} M_1 + 6g_{RB}^2 M_1 + 2g_{BL} g_{BR} M_{BR} - \sqrt{6} g_{BL} g_R M_{BR} - \sqrt{6} g_{BR} g_{RB} M_{BR} + 12g_R g_{RB} M_{BR} \right. \\
& \left. + g_{BR}^2 M_4 - \sqrt{6} g_{BR} g_R M_4 + 6g_R^2 M_4 + 32g_s^2 M_3 + 18g_L^2 M_2 + 18\text{Tr} \left( Y_d^\dagger T_d \right) + 6\text{Tr} \left( Y_e^\dagger T_e \right) \right) \quad (65)
\end{aligned}$$

$$\begin{aligned}
\beta_{T_d}^{(2)} = & + 6g_L^2 Y_d Y_d^\dagger T_d + 2g_R^2 Y_d Y_d^\dagger T_d + 2g_{RB}^2 Y_d Y_d^\dagger T_d - \sqrt{\frac{2}{3}} g_{BL} g_{RB} M_1 Y_d Y_u^\dagger Y_u \\
& - 2g_{RB}^2 M_1 Y_d Y_u^\dagger Y_u - \sqrt{\frac{2}{3}} g_{BL} g_R M_{BR} Y_d Y_u^\dagger Y_u - \sqrt{\frac{2}{3}} g_{BR} g_{RB} M_{BR} Y_d Y_u^\dagger Y_u \\
& - 4g_R g_{RB} M_{BR} Y_d Y_u^\dagger Y_u - \sqrt{\frac{2}{3}} g_{BR} g_R M_4 Y_d Y_u^\dagger Y_u - 2g_R^2 M_4 Y_d Y_u^\dagger Y_u \\
& + \sqrt{\frac{2}{3}} g_{BR} g_R Y_d Y_u^\dagger T_u + 2g_R^2 Y_d Y_u^\dagger T_u + \sqrt{\frac{2}{3}} g_{BL} g_{RB} Y_d Y_u^\dagger T_u + 2g_{RB}^2 Y_d Y_u^\dagger T_u \\
& + 12g_L^2 T_d Y_d^\dagger Y_d + \sqrt{\frac{3}{2}} g_{BR} g_R T_d Y_d^\dagger Y_d + g_R^2 T_d Y_d^\dagger Y_d + \sqrt{\frac{3}{2}} g_{BL} g_{RB} T_d Y_d^\dagger Y_d \\
& + g_{RB}^2 T_d Y_d^\dagger Y_d + \frac{1}{\sqrt{6}} g_{BR} g_R T_d Y_u^\dagger Y_u + g_R^2 T_d Y_u^\dagger Y_u + \frac{1}{\sqrt{6}} g_{BL} g_{RB} T_d Y_u^\dagger Y_u \\
& + g_{RB}^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{16}{9} g_s^4 T_d + \frac{8}{9} g_s^2 g_{BL}^2 T_d + \frac{41}{36} g_{BL}^4 T_d \\
& + \frac{8}{9} g_s^2 g_{BR}^2 T_d + \frac{41}{18} g_{BL}^2 g_{BR}^2 T_d + \frac{41}{36} g_{BR}^4 T_d + 8g_s^2 g_L^2 T_d + \frac{1}{4} g_{BL}^2 g_L^2 T_d + \frac{1}{4} g_{BR}^2 g_L^2 T_d + \frac{15}{2} g_L^4 T_d \\
& - \frac{8}{3} \sqrt{\frac{2}{3}} g_s^2 g_{BR} g_R T_d - \frac{89}{12} \frac{1}{\sqrt{6}} g_{BL}^2 g_{BR} g_R T_d - \frac{89}{12} \frac{1}{\sqrt{6}} g_{BR}^3 g_R T_d + \frac{8}{3} g_s^2 g_R^2 T_d + \frac{1}{3} g_{BL}^2 g_R^2 T_d \\
& + \frac{35}{4} g_{BR} g_R^2 T_d + \frac{3}{2} g_L^2 g_R^2 T_d - \frac{23}{2} \frac{1}{\sqrt{6}} g_{BR} g_R^3 T_d + 8g_R^4 T_d - \frac{8}{3} \sqrt{\frac{2}{3}} g_s^2 g_{BL} g_{RB} T_d \\
& - \frac{89}{12} \frac{1}{\sqrt{6}} g_{BL}^3 g_{RB} T_d - \frac{89}{12} \frac{1}{\sqrt{6}} g_{BL} g_{BR}^2 g_{RB} T_d + \frac{101}{6} g_{BL} g_{BR} g_R g_{RB} T_d - \frac{23}{2} \frac{1}{\sqrt{6}} g_{BL} g_R^2 g_{RB} T_d \\
& + \frac{8}{3} g_s^2 g_{RB}^2 T_d + \frac{35}{4} g_{BL}^2 g_{RB}^2 T_d + \frac{1}{3} g_{BR}^2 g_{RB}^2 T_d + \frac{3}{2} g_L^2 g_{RB}^2 T_d - \frac{23}{2} \frac{1}{\sqrt{6}} g_{BR} g_R g_{RB}^2 T_d \\
& + 16g_R^2 g_{RB}^2 T_d - \frac{23}{2} \frac{1}{\sqrt{6}} g_{BL} g_{RB}^3 T_d + 8g_{RB}^4 T_d - 12Y_d Y_d^\dagger T_d \text{Tr} \left( Y_d Y_d^\dagger \right) \\
& - 15T_d Y_d^\dagger Y_d \text{Tr} \left( Y_d Y_d^\dagger \right) + 16g_s^2 T_d \text{Tr} \left( Y_d Y_d^\dagger \right) + \frac{1}{2} g_{BL}^2 T_d \text{Tr} \left( Y_d Y_d^\dagger \right) \\
& + \frac{1}{2} g_{BR}^2 T_d \text{Tr} \left( Y_d Y_d^\dagger \right) - \sqrt{\frac{3}{2}} g_{BR} g_R T_d \text{Tr} \left( Y_d Y_d^\dagger \right) - \sqrt{\frac{3}{2}} g_{BL} g_{RB} T_d \text{Tr} \left( Y_d Y_d^\dagger \right) \\
& - 4Y_d Y_d^\dagger T_d \text{Tr} \left( Y_e Y_e^\dagger \right) - 5T_d Y_d^\dagger Y_d \text{Tr} \left( Y_e Y_e^\dagger \right) + \frac{3}{2} g_{BL}^2 T_d \text{Tr} \left( Y_e Y_e^\dagger \right) \\
& + \frac{3}{2} g_{BR}^2 T_d \text{Tr} \left( Y_e Y_e^\dagger \right) + \sqrt{\frac{3}{2}} g_{BR} g_R T_d \text{Tr} \left( Y_e Y_e^\dagger \right) + \sqrt{\frac{3}{2}} g_{BL} g_{RB} T_d \text{Tr} \left( Y_e Y_e^\dagger \right)
\end{aligned}$$

$$\begin{aligned}
& -6Y_d Y_u^\dagger T_u \text{Tr}(Y_u Y_u^\dagger) - 3T_d Y_u^\dagger Y_u \text{Tr}(Y_u Y_u^\dagger) - 2Y_d Y_u^\dagger T_u \text{Tr}(Y_v Y_v^\dagger) \\
& - T_d Y_u^\dagger Y_u \text{Tr}(Y_v Y_v^\dagger) \\
& - \frac{1}{3} Y_d Y_d^\dagger Y_d \left( \sqrt{6} g_{BL} g_{RB} M_1 + 6g_{RB}^2 M_1 + \sqrt{6} g_{BL} g_R M_{BR} + \sqrt{6} g_{BR} g_{RB} M_{BR} + 12g_R g_{RB} M_{BR} + \sqrt{6} g_{BR} g_R M_4 \right. \\
& + 6g_R^2 M_4 + 36g_L^2 M_2 + 54\text{Tr}(Y_d^\dagger T_d) + 18\text{Tr}(Y_e^\dagger T_e) \left. \right) \\
& - 6Y_d Y_u^\dagger Y_u \text{Tr}(Y_u^\dagger T_u) - 2Y_d Y_u^\dagger Y_u \text{Tr}(Y_v^\dagger T_\nu) - 9T_d \text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) \\
& - 3T_d \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 3T_d \text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) - T_d \text{Tr}(Y_e Y_v^\dagger Y_v Y_e^\dagger) \\
& + \frac{1}{36} Y_d \left( -64g_s^2 g_{BL}^2 M_1 - 164g_{BL}^4 M_1 - 164g_{BL}^2 g_{BR}^2 M_1 - 18g_{BL}^2 g_L^2 M_1 + 89\sqrt{6} g_{BL}^2 g_{BR} g_R M_1 \right. \\
& - 24g_{BL}^2 g_R^2 M_1 + 64\sqrt{6} g_s^2 g_{BL} g_{RB} M_1 + 178\sqrt{6} g_{BL}^3 g_{RB} M_1 + 89\sqrt{6} g_{BL} g_{BR}^2 g_{RB} M_1 \\
& - 1212g_{BL} g_{BR} g_R g_{RB} M_1 + 138\sqrt{6} g_{BL} g_{RB}^2 M_1 - 192g_s^2 g_{RB}^2 M_1 - 1260g_{BL}^2 g_{RB}^2 M_1 - 24g_{BR}^2 g_{RB}^2 M_1 \\
& - 108g_L^2 g_{RB}^2 M_1 + 138\sqrt{6} g_{BR} g_R g_{RB}^2 M_1 - 1152g_R^2 g_{RB}^2 M_1 + 276\sqrt{6} g_{BL} g_{RB}^3 M_1 - 1152g_{RB}^4 M_1 \\
& - 128g_s^2 g_{BL} g_{BR} M_{BR} - 328g_{BL}^3 g_{BR} M_{BR} - 328g_{BL} g_{BR}^3 M_{BR} - 36g_{BL} g_{BR} g_L^2 M_{BR} + 64\sqrt{6} g_s^2 g_{BL} g_R M_{BR} \\
& + 89\sqrt{6} g_{BL}^3 g_R M_{BR} + 267\sqrt{6} g_{BL} g_{BR}^2 g_R M_{BR} - 1260g_{BL} g_{BR} g_R^2 M_{BR} + 138\sqrt{6} g_{BL} g_{RB}^3 M_{BR} \\
& + 64\sqrt{6} g_s^2 g_{BR} g_{RB} M_{BR} + 267\sqrt{6} g_{BL}^2 g_{BR} g_{RB} M_{BR} + 89\sqrt{6} g_{BR}^3 g_{RB} M_{BR} - 384g_s^2 g_R g_{RB} M_{BR} \\
& - 1260g_{BL}^2 g_R g_{RB} M_{BR} - 1260g_{BR}^2 g_R g_{RB} M_{BR} - 216g_L^2 g_R g_{RB} M_{BR} + 414\sqrt{6} g_{BR} g_{RB}^2 g_{RB} M_{BR} \\
& - 2304g_R^3 g_{RB} M_{BR} - 1260g_{BL} g_{BR} g_{RB}^2 M_{BR} + 414\sqrt{6} g_{BL} g_R g_{RB}^2 M_{BR} + 138\sqrt{6} g_{BR} g_{RB}^3 M_{BR} - 2304g_R g_{RB}^3 M_{BR} \\
& - 64g_s^2 g_{BR}^2 M_4 - 164g_{BL}^2 g_{BR}^2 M_4 - 164g_{BR}^4 M_4 - 18g_{BR}^2 g_L^2 M_4 + 64\sqrt{6} g_s^2 g_{BR} g_R M_4 \\
& + 89\sqrt{6} g_{BL}^2 g_{BR} g_R M_4 + 178\sqrt{6} g_{BR}^3 g_R M_4 - 192g_s^2 g_R^2 M_4 - 24g_{BL}^2 g_R^2 M_4 - 1260g_{BR}^2 g_R^2 M_4 \\
& - 108g_L^2 g_R^2 M_4 + 276\sqrt{6} g_{BR} g_R^3 M_4 - 1152g_R^4 M_4 + 89\sqrt{6} g_{BL} g_{BR}^2 g_{RB} M_4 - 1212g_{BL} g_{BR} g_R g_{RB} M_4 \\
& + 138\sqrt{6} g_{BL} g_{RB}^2 g_{RB} M_4 - 24g_{BR}^2 g_{RB}^2 M_4 + 138\sqrt{6} g_{BR} g_R g_{RB}^2 M_4 - 1152g_R^2 g_{RB}^2 M_4 + 256g_s^4 M_3 \\
& - 64g_s^2 g_{BL}^2 M_3 - 64g_s^2 g_{BR}^2 M_3 - 576g_s^2 g_L^2 M_3 + 64\sqrt{6} g_s^2 g_{BR} g_R M_3 - 192g_s^2 g_R^2 M_3 \\
& + 64\sqrt{6} g_s^2 g_{BL} g_{RB} M_3 - 192g_s^2 g_{RB}^2 M_3 - 576g_s^2 g_L^2 M_2 - 18g_{BL}^2 g_L^2 M_2 - 18g_{BR}^2 g_L^2 M_2 \\
& - 1080g_L^4 M_2 - 108g_L^2 g_R^2 M_2 - 108g_L^2 g_{RB}^2 M_2 \\
& - 36 \left( 32g_s^2 M_3 - g_{BL} \left( -2g_{BR} M_{BR} + \sqrt{6} g_{RB} M_1 + \sqrt{6} g_R M_{BR} \right) + g_{BL}^2 M_1 + g_{BR}^2 M_4 - \sqrt{6} g_{BR} \left( g_{RB} M_{BR} + g_R M_4 \right) \right) \text{Tr}(Y_d Y_d^\dagger) \\
& - 36 \left( 3g_{BL}^2 M_1 + g_{BL} \left( 6g_{BR} M_{BR} + \sqrt{6} g_{RB} M_1 + \sqrt{6} g_R M_{BR} \right) + g_{BR} \left( 3g_{BR} M_4 + \sqrt{6} g_{RB} M_{BR} + \sqrt{6} g_R M_4 \right) \right) \text{Tr}(Y_e Y_e^\dagger) \\
& + 1152g_s^2 \text{Tr}(Y_d^\dagger T_d) + 36g_{BL}^2 \text{Tr}(Y_d^\dagger T_d) + 36g_{BR}^2 \text{Tr}(Y_d^\dagger T_d) - 36\sqrt{6} g_{BR} g_R \text{Tr}(Y_d^\dagger T_d) \\
& - 36\sqrt{6} g_{BL} g_{RB} \text{Tr}(Y_d^\dagger T_d) + 108g_{BL}^2 \text{Tr}(Y_e^\dagger T_e) + 108g_{BR}^2 \text{Tr}(Y_e^\dagger T_e) + 36\sqrt{6} g_{BR} g_R \text{Tr}(Y_e^\dagger T_e) \\
& + 36\sqrt{6} g_{BL} g_{RB} \text{Tr}(Y_e^\dagger T_e) - 1296\text{Tr}(Y_d Y_d^\dagger T_d Y_d^\dagger) - 216\text{Tr}(Y_d Y_u^\dagger T_u Y_d^\dagger) - 432\text{Tr}(Y_e Y_e^\dagger T_e Y_e^\dagger) \\
& - 72\text{Tr}(Y_e Y_v^\dagger T_\nu Y_e^\dagger) - 216\text{Tr}(Y_u Y_d^\dagger T_d Y_u^\dagger) - 72\text{Tr}(Y_v Y_e^\dagger T_e Y_v^\dagger) \tag{66}
\end{aligned}$$

$$\begin{aligned}
\beta_{T_e}^{(1)} = & +\frac{1}{2}\left(8Y_e Y_e^\dagger T_e + 4Y_e Y_v^\dagger T_\nu + 10T_e Y_e^\dagger Y_e + 2T_e Y_v^\dagger Y_v - 3g_{BL}^2 T_e - 3g_{BR}^2 T_e - 6g_L^2 T_e \right. \\
& - \sqrt{6}g_{BR}g_R T_e - 2g_R^2 T_e - \sqrt{6}g_{BL}g_{RB} T_e - 2g_{RB}^2 T_e + 6T_e \text{Tr}\left(Y_d Y_d^\dagger\right) + 2T_e \text{Tr}\left(Y_e Y_e^\dagger\right)\left. \right) \\
& + Y_e \left(3g_{BL}^2 M_1 + \sqrt{6}g_{BL}g_{RB} M_1 + 2g_{RB}^2 M_1 + 6g_{BL}g_{BR} M_{BR} + \sqrt{6}g_{BL}g_R M_{BR} + \sqrt{6}g_{BR}g_{RB} M_{BR} + 4g_R g_{RB} M_{BR} \right. \\
& \left. + 3g_{BR}^2 M_4 + \sqrt{6}g_{BR}g_R M_4 + 2g_R^2 M_4 + 6g_L^2 M_2 + 6\text{Tr}\left(Y_d^\dagger T_d\right) + 2\text{Tr}\left(Y_e^\dagger T_e\right)\right) \tag{67}
\end{aligned}$$

$$\begin{aligned}
\beta_{T_e}^{(2)} = & \frac{1}{8}\left(48g_L^2 Y_e Y_e^\dagger T_e + 16g_R^2 Y_e Y_e^\dagger T_e + 16g_{RB}^2 Y_e Y_e^\dagger T_e \right. \\
& + 8\sqrt{6}g_{BL}g_{RB} M_1 Y_e Y_v^\dagger Y_v - 16g_{RB}^2 M_1 Y_e Y_v^\dagger Y_v + 8\sqrt{6}g_{BL}g_R M_{BR} Y_e Y_v^\dagger Y_v \\
& + 8\sqrt{6}g_{BR}g_{RB} M_{BR} Y_e Y_v^\dagger Y_v - 32g_R g_{RB} M_{BR} Y_e Y_v^\dagger Y_v + 8\sqrt{6}g_{BR}g_R M_4 Y_e Y_v^\dagger Y_v \\
& - 16g_R^2 M_4 Y_e Y_v^\dagger Y_v - 8\sqrt{6}g_{BR}g_R Y_e Y_v^\dagger T_\nu + 16g_R^2 Y_e Y_v^\dagger T_\nu \\
& - 8\sqrt{6}g_{BL}g_{RB} Y_e Y_v^\dagger T_\nu + 16g_{RB}^2 Y_e Y_v^\dagger T_\nu + 96g_L^2 T_e Y_e^\dagger Y_e \\
& - 12\sqrt{6}g_{BR}g_R T_e Y_e^\dagger Y_e + 8g_R^2 T_e Y_e^\dagger Y_e - 12\sqrt{6}g_{BL}g_{RB} T_e Y_e^\dagger Y_e \\
& + 8g_{RB}^2 T_e Y_e^\dagger Y_e - 4\sqrt{6}g_{BR}g_R T_e Y_v^\dagger Y_v + 8g_R^2 T_e Y_v^\dagger Y_v \\
& - 4\sqrt{6}g_{BL}g_{RB} T_e Y_v^\dagger Y_v + 8g_{RB}^2 T_e Y_v^\dagger Y_v - 48Y_e Y_e^\dagger Y_e Y_e^\dagger T_e - 64Y_e Y_e^\dagger T_e Y_e^\dagger Y_e \\
& - 16Y_e Y_v^\dagger Y_s Y_s^\dagger T_\nu - 16Y_e Y_v^\dagger Y_v Y_e^\dagger T_e - 32Y_e Y_v^\dagger Y_v Y_v^\dagger T_\nu \\
& - 16Y_e Y_v^\dagger T_s Y_s^\dagger Y_v - 32Y_e Y_v^\dagger T_\nu Y_e^\dagger Y_e - 32Y_e Y_v^\dagger T_\nu Y_v^\dagger Y_v - 48T_e Y_e^\dagger Y_e Y_e^\dagger Y_e \\
& - 8T_e Y_v^\dagger Y_s Y_s^\dagger Y_v - 32T_e Y_v^\dagger Y_v Y_e^\dagger Y_e - 16T_e Y_v^\dagger Y_v Y_v^\dagger Y_v + 90g_{BL}^4 T_e \\
& + 180g_{BL}^2 g_{BR}^2 T_e + 90g_{BR}^4 T_e + 18g_{BL}^2 g_L^2 T_e + 18g_{BR}^2 g_L^2 T_e + 60g_L^4 T_e + 27\sqrt{6}g_{BL}^2 g_{BR}g_R T_e \\
& + 27\sqrt{6}g_{BR}^3 g_R T_e + 150g_{BR}^2 g_R^2 T_e + 12g_L^2 g_R^2 T_e + 30\sqrt{6}g_{BR}g_R^3 T_e + 64g_R^4 T_e \\
& + 27\sqrt{6}g_{BL}^3 g_{RB} T_e + 27\sqrt{6}g_{BL}g_{BR}^2 g_{RB} T_e + 300g_{BL}g_{BR}g_R g_{RB} T_e + 30\sqrt{6}g_{BL}g_R^2 g_{RB} T_e \\
& + 150g_{BL}^2 g_{RB}^2 T_e + 12g_L^2 g_{RB}^2 T_e + 30\sqrt{6}g_{BR}g_R g_{RB}^2 T_e + 128g_R^2 g_{RB}^2 T_e + 30\sqrt{6}g_{BL}g_{RB}^3 T_e \\
& + 64g_{RB}^4 T_e - 96Y_e Y_e^\dagger T_e \text{Tr}\left(Y_d Y_d^\dagger\right) - 120T_e Y_e^\dagger Y_e \text{Tr}\left(Y_d Y_d^\dagger\right) + 128g_s^2 T_e \text{Tr}\left(Y_d Y_d^\dagger\right) \\
& + 4g_{BL}^2 T_e \text{Tr}\left(Y_d Y_d^\dagger\right) + 4g_{BR}^2 T_e \text{Tr}\left(Y_d Y_d^\dagger\right) - 4\sqrt{6}g_{BR}g_R T_e \text{Tr}\left(Y_d Y_d^\dagger\right) \\
& - 4\sqrt{6}g_{BL}g_{RB} T_e \text{Tr}\left(Y_d Y_d^\dagger\right) - 32Y_e Y_e^\dagger T_e \text{Tr}\left(Y_e Y_e^\dagger\right) - 40T_e Y_e^\dagger Y_e \text{Tr}\left(Y_e Y_e^\dagger\right) \\
& + 12g_{BL}^2 T_e \text{Tr}\left(Y_e Y_e^\dagger\right) + 12g_{BR}^2 T_e \text{Tr}\left(Y_e Y_e^\dagger\right) + 4\sqrt{6}g_{BR}g_R T_e \text{Tr}\left(Y_e Y_e^\dagger\right) \\
& + 4\sqrt{6}g_{BL}g_{RB} T_e \text{Tr}\left(Y_e Y_e^\dagger\right) - 48Y_e Y_v^\dagger T_\nu \text{Tr}\left(Y_u Y_u^\dagger\right) - 24T_e Y_v^\dagger Y_v \text{Tr}\left(Y_u Y_u^\dagger\right) \\
& - 16Y_e Y_v^\dagger T_\nu \text{Tr}\left(Y_v Y_v^\dagger\right) - 8T_e Y_v^\dagger Y_v \text{Tr}\left(Y_v Y_v^\dagger\right) \\
& + 8Y_e Y_e^\dagger Y_e \left(\sqrt{6}g_{BL}g_{RB} M_1 - 2g_{RB}^2 M_1 + \sqrt{6}g_{BL}g_R M_{BR} + \sqrt{6}g_{BR}g_{RB} M_{BR} - 4g_R g_{RB} M_{BR} + \sqrt{6}g_{BR}g_R M_4 \right. \\
& \left. - 2g_R^2 M_4 - 12g_L^2 M_2 - 18\text{Tr}\left(Y_d^\dagger T_d\right) - 6\text{Tr}\left(Y_e^\dagger T_e\right)\right) \\
& - 48Y_e Y_v^\dagger Y_v \text{Tr}\left(Y_u^\dagger T_u\right) - 16Y_e Y_v^\dagger Y_v \text{Tr}\left(Y_v^\dagger T_\nu\right) - 72T_e \text{Tr}\left(Y_d Y_d^\dagger Y_d Y_d^\dagger\right)
\end{aligned}$$

$$\begin{aligned}
& -24T_e \text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) - 24T_e \text{Tr}\left(Y_e Y_e^\dagger Y_e Y_e^\dagger\right) - 8T_e \text{Tr}\left(Y_e Y_v^\dagger Y_v Y_e^\dagger\right) \\
& - 2Y_e \left(180g_{BL}^4 M_1 + 180g_{BL}^2 g_{BR}^2 M_1 + 18g_{BL}^2 g_L^2 M_1 + 27\sqrt{6}g_{BL}^2 g_{BR} g_R M_1 + 54\sqrt{6}g_{BL}^3 g_{RB} M_1 \right. \\
& + 27\sqrt{6}g_{BL} g_{BR}^2 g_{RB} M_1 + 300g_{BL} g_{BR} g_R g_{RB} M_1 + 30\sqrt{6}g_{BL} g_R^2 g_{RB} M_1 + 300g_{BL}^2 g_{RB}^2 M_1 + 12g_L^2 g_{RB}^2 M_1 \\
& + 30\sqrt{6}g_{BR} g_R^2 g_{RB} M_1 + 128g_R^2 g_{RB}^2 M_1 + 60\sqrt{6}g_{BL} g_{RB}^3 M_1 + 128g_{RB}^4 M_1 + 360g_{BL}^3 g_{BR} M_{BR} \\
& + 360g_{BL} g_{BR}^3 M_{BR} + 36g_{BL} g_{BR} g_L^2 M_{BR} + 27\sqrt{6}g_{BL}^3 g_R M_{BR} + 81\sqrt{6}g_{BL} g_{BR}^2 g_R M_{BR} + 300g_{BL} g_{BR} g_R^2 M_{BR} \\
& + 30\sqrt{6}g_{BL} g_R^3 M_{BR} + 81\sqrt{6}g_{BL}^2 g_{BR} g_{RB} M_{BR} + 27\sqrt{6}g_{BR}^3 g_{RB} M_{BR} + 300g_{BL}^2 g_R g_{RB} M_{BR} \\
& + 300g_{BR}^2 g_R g_{RB} M_{BR} + 24g_L^2 g_R g_{RB} M_{BR} + 90\sqrt{6}g_{BR} g_R^2 g_{RB} M_{BR} + 256g_R^3 g_{RB} M_{BR} + 300g_{BL} g_{BR} g_{RB}^2 M_{BR} \\
& + 90\sqrt{6}g_{BL} g_R g_{RB}^2 M_{BR} + 30\sqrt{6}g_{BR} g_{RB}^3 M_{BR} + 256g_R g_{RB}^3 M_{BR} + 180g_{BL}^2 g_{BR}^2 M_4 + 180g_{BR}^4 M_4 \\
& + 18g_{BR}^2 g_L^2 M_4 + 27\sqrt{6}g_{BL}^2 g_{BR} g_R M_4 + 54\sqrt{6}g_{BR}^3 g_R M_4 + 300g_{BR}^2 g_R^2 M_4 + 12g_L^2 g_R^2 M_4 \\
& + 60\sqrt{6}g_{BR} g_R^3 M_4 + 128g_R^4 M_4 + 27\sqrt{6}g_{BL} g_{BR}^2 g_{RB} M_4 + 300g_{BL} g_{BR} g_R g_{RB} M_4 + 30\sqrt{6}g_{BL} g_R^2 g_{RB} M_4 \\
& + 30\sqrt{6}g_{BR} g_R^2 g_{RB} M_4 + 128g_R^2 g_{RB}^2 M_4 + 18g_{BL}^2 g_L^2 M_2 + 18g_{BR}^2 g_L^2 M_2 + 120g_L^4 M_2 + 12g_L^2 g_R^2 M_2 \\
& + 12g_L^2 g_{RB}^2 M_2 \\
& + 4\left(32g_s^2 M_3 - g_{BL}\left(-2g_{BR} M_{BR} + \sqrt{6}g_{RB} M_1 + \sqrt{6}g_R M_{BR}\right) + g_{BL}^2 M_1 + g_{BR}^2 M_4 - \sqrt{6}g_{BR}\left(g_{RB} M_{BR} + g_R M_4\right)\right) \text{Tr}\left(Y_d Y_d^\dagger\right) \\
& + 4\left(3g_{BL}^2 M_1 + g_{BL}\left(6g_{BR} M_{BR} + \sqrt{6}g_{RB} M_1 + \sqrt{6}g_R M_{BR}\right) + g_{BR}\left(3g_{BR} M_4 + \sqrt{6}g_{RB} M_{BR} + \sqrt{6}g_R M_4\right)\right) \text{Tr}\left(Y_e Y_e^\dagger\right) \\
& - 128g_s^2 \text{Tr}\left(Y_d^\dagger T_d\right) - 4g_{BL}^2 \text{Tr}\left(Y_d^\dagger T_d\right) - 4g_{BR}^2 \text{Tr}\left(Y_d^\dagger T_d\right) + 4\sqrt{6}g_{BR} g_R \text{Tr}\left(Y_d^\dagger T_d\right) \\
& + 4\sqrt{6}g_{BL} g_{RB} \text{Tr}\left(Y_d^\dagger T_d\right) - 12g_{BL}^2 \text{Tr}\left(Y_e^\dagger T_e\right) - 12g_{BR}^2 \text{Tr}\left(Y_e^\dagger T_e\right) - 4\sqrt{6}g_{BR} g_R \text{Tr}\left(Y_e^\dagger T_e\right) \\
& - 4\sqrt{6}g_{BL} g_{RB} \text{Tr}\left(Y_e^\dagger T_e\right) + 144\text{Tr}\left(Y_d Y_d^\dagger T_d Y_d^\dagger\right) + 24\text{Tr}\left(Y_d Y_u^\dagger T_u Y_d^\dagger\right) + 48\text{Tr}\left(Y_e Y_e^\dagger T_e Y_e^\dagger\right) \\
& + 8\text{Tr}\left(Y_e Y_v^\dagger T_\nu Y_e^\dagger\right) + 24\text{Tr}\left(Y_u Y_d^\dagger T_d Y_u^\dagger\right) + 8\text{Tr}\left(Y_v Y_e^\dagger T_e Y_v^\dagger\right) \Big) \tag{68}
\end{aligned}$$

$$\begin{aligned}
\beta_{T_u}^{(1)} &= \frac{1}{6} \left(12Y_u Y_d^\dagger T_d + 24Y_u Y_u^\dagger T_u + 6T_u Y_d^\dagger Y_d + 30T_u Y_u^\dagger Y_u - 32g_s^2 T_u - g_{BL}^2 T_u \right. \\
& - g_{BR}^2 T_u - 18g_L^2 T_u - \sqrt{6}g_{BR} g_R T_u - 6g_R^2 T_u - \sqrt{6}g_{BL} g_{RB} T_u - 6g_{RB}^2 T_u + 18T_u \text{Tr}\left(Y_u Y_u^\dagger\right) \\
& + 6T_u \text{Tr}\left(Y_v Y_v^\dagger\right) \\
& + 2Y_u \left(g_{BL}^2 M_1 + \sqrt{6}g_{BL} g_{RB} M_1 + 6g_{RB}^2 M_1 + 2g_{BL} g_{BR} M_{BR} + \sqrt{6}g_{BL} g_R M_{BR} + \sqrt{6}g_{BR} g_{RB} M_{BR} + 12g_R g_{RB} M_{BR} \right. \\
& \left. + g_{BR}^2 M_4 + \sqrt{6}g_{BR} g_R M_4 + 6g_R^2 M_4 + 32g_s^2 M_3 + 18g_L^2 M_2 + 18\text{Tr}\left(Y_u^\dagger T_u\right) + 6\text{Tr}\left(Y_v^\dagger T_\nu\right)\right) \Big) \tag{69}
\end{aligned}$$

$$\begin{aligned}
\beta_{T_u}^{(2)} &= -\sqrt{\frac{2}{3}}g_{BR} g_R Y_u Y_d^\dagger T_d + 2g_R^2 Y_u Y_d^\dagger T_d - \sqrt{\frac{2}{3}}g_{BL} g_{RB} Y_u Y_d^\dagger T_d + 2g_{RB}^2 Y_u Y_d^\dagger T_d \\
& + \sqrt{\frac{2}{3}}g_{BL} g_{RB} M_1 Y_u Y_u^\dagger Y_u - 2g_{RB}^2 M_1 Y_u Y_u^\dagger Y_u + \sqrt{\frac{2}{3}}g_{BL} g_R M_{BR} Y_u Y_u^\dagger Y_u \\
& + \sqrt{\frac{2}{3}}g_{BR} g_{RB} M_{BR} Y_u Y_u^\dagger Y_u - 4g_R g_{RB} M_{BR} Y_u Y_u^\dagger Y_u + \sqrt{\frac{2}{3}}g_{BR} g_R M_4 Y_u Y_u^\dagger Y_u
\end{aligned}$$

$$\begin{aligned}
& -2g_R^2 M_4 Y_u Y_u^\dagger Y_u - 12g_L^2 M_2 Y_u Y_u^\dagger Y_u + 6g_L^2 Y_u Y_u^\dagger T_u + 2g_R^2 Y_u Y_u^\dagger T_u \\
& + 2g_{RB}^2 Y_u Y_u^\dagger T_u - \frac{1}{\sqrt{6}} g_{BR} g_R T_u Y_d^\dagger Y_d + g_R^2 T_u Y_d^\dagger Y_d \\
& - \frac{1}{\sqrt{6}} g_{BL} g_{RB} T_u Y_d^\dagger Y_d + g_{RB}^2 T_u Y_d^\dagger Y_d + 12g_L^2 T_u Y_u^\dagger Y_u - \sqrt{\frac{3}{2}} g_{BR} g_R T_u Y_u^\dagger Y_u \\
& + g_R^2 T_u Y_u^\dagger Y_u - \sqrt{\frac{3}{2}} g_{BL} g_{RB} T_u Y_u^\dagger Y_u + g_{RB}^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{16}{9} g_s^4 T_u \\
& + \frac{8}{9} g_s^2 g_{BL}^2 T_u + \frac{41}{36} g_{BL}^4 T_u + \frac{8}{9} g_s^2 g_{BR}^2 T_u + \frac{41}{18} g_{BL}^2 g_{BR}^2 T_u + \frac{41}{36} g_{BR}^4 T_u + 8g_s^2 g_L^2 T_u + \frac{1}{4} g_{BL}^2 g_L^2 T_u \\
& + \frac{1}{4} g_{BR}^2 g_L^2 T_u + \frac{15}{2} g_L^4 T_u + \frac{8}{3} \sqrt{\frac{2}{3}} g_s^2 g_{BR} g_R T_u + \frac{77}{12} \frac{1}{\sqrt{6}} g_{BL}^2 g_{BR} g_R T_u + \frac{77}{12} \frac{1}{\sqrt{6}} g_{BR}^3 g_R T_u \\
& + \frac{8}{3} g_s^2 g_R^2 T_u - \frac{1}{6} g_{BL}^2 g_R^2 T_u + \frac{31}{4} g_{BR}^2 g_R^2 T_u + \frac{3}{2} g_L^2 g_R^2 T_u + \frac{11}{2} \frac{1}{\sqrt{6}} g_{BR} g_R^3 T_u + 8g_R^4 T_u \\
& + \frac{8}{3} \sqrt{\frac{2}{3}} g_s^2 g_{BL} g_{RB} T_u + \frac{77}{12} \frac{1}{\sqrt{6}} g_{BL}^3 g_{RB} T_u + \frac{77}{12} \frac{1}{\sqrt{6}} g_{BL} g_{BR}^2 g_{RB} T_u + \frac{95}{6} g_{BL} g_{BR} g_R g_{RB} T_u \\
& + \frac{11}{2} \frac{1}{\sqrt{6}} g_{BL} g_R^2 g_{RB} T_u + \frac{8}{3} g_s^2 g_{RB}^2 T_u + \frac{31}{4} g_{BL}^2 g_{RB}^2 T_u - \frac{1}{6} g_{BR}^2 g_{RB}^2 T_u + \frac{3}{2} g_L^2 g_{RB}^2 T_u \\
& + \frac{11}{2} \frac{1}{\sqrt{6}} g_{BR} g_R g_{RB}^2 T_u + 16g_R^2 g_{RB}^2 T_u + \frac{11}{2} \frac{1}{\sqrt{6}} g_{BL} g_{RB}^3 T_u + 8g_R^4 T_u - 6Y_u Y_d^\dagger T_d \text{Tr}(Y_d Y_d^\dagger) \\
& - 3T_u Y_d^\dagger Y_d \text{Tr}(Y_d Y_d^\dagger) - 2Y_u Y_d^\dagger T_d \text{Tr}(Y_e Y_e^\dagger) - T_u Y_d^\dagger Y_d \text{Tr}(Y_e Y_e^\dagger) \\
& - 12Y_u Y_u^\dagger T_u \text{Tr}(Y_u Y_u^\dagger) - 15T_u Y_u^\dagger Y_u \text{Tr}(Y_u Y_u^\dagger) + 16g_s^2 T_u \text{Tr}(Y_u Y_u^\dagger) \\
& + \frac{1}{2} g_{BL}^2 T_u \text{Tr}(Y_u Y_u^\dagger) + \frac{1}{2} g_{BR}^2 T_u \text{Tr}(Y_u Y_u^\dagger) + \sqrt{\frac{3}{2}} g_{BR} g_R T_u \text{Tr}(Y_u Y_u^\dagger) + \sqrt{\frac{3}{2}} g_{BL} g_{RB} T_u \text{Tr}(Y_u Y_u^\dagger) \\
& - 4Y_u Y_u^\dagger T_u \text{Tr}(Y_v Y_v^\dagger) - 5T_u Y_u^\dagger Y_u \text{Tr}(Y_v Y_v^\dagger) + \frac{3}{2} g_{BL}^2 T_u \text{Tr}(Y_v Y_v^\dagger) \\
& + \frac{3}{2} g_{BR}^2 T_u \text{Tr}(Y_v Y_v^\dagger) - \sqrt{\frac{3}{2}} g_{BR} g_R T_u \text{Tr}(Y_v Y_v^\dagger) - \sqrt{\frac{3}{2}} g_{BL} g_{RB} T_u \text{Tr}(Y_v Y_v^\dagger) \\
& + \frac{1}{3} Y_u Y_d^\dagger Y_d (\sqrt{6} g_{BL} g_{RB} M_1 - 6g_{RB}^2 M_1 + \sqrt{6} g_{BL} g_R M_{BR} + \sqrt{6} g_{BR} g_{RB} M_{BR} - 12g_R g_{RB} M_{BR} + \sqrt{6} g_{BR} g_R M_4 \\
& - 6g_R^2 M_4 - 18\text{Tr}(Y_d^\dagger T_d) - 6\text{Tr}(Y_e^\dagger T_e)) \\
& - 18Y_u Y_u^\dagger Y_u \text{Tr}(Y_u^\dagger T_u) - 6Y_u Y_u^\dagger Y_u \text{Tr}(Y_v^\dagger T_v) - 3T_u \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) \\
& - T_u \text{Tr}(Y_e Y_v^\dagger Y_v Y_e^\dagger) - T_u \text{Tr}(Y_s Y_s^\dagger Y_v Y_v^\dagger) - 9T_u \text{Tr}(Y_u Y_u^\dagger Y_u Y_u^\dagger) - 3T_u \text{Tr}(Y_v Y_v^\dagger Y_v Y_v^\dagger) \\
& + \frac{1}{36} Y_u \left( -64g_s^2 g_{BL}^2 M_1 - 164g_{BL}^4 M_1 - 164g_{BL}^2 g_{BR}^2 M_1 - 18g_{BL}^2 g_L^2 M_1 - 77\sqrt{6} g_{BL}^2 g_{BR} g_R M_1 \right.
\end{aligned}$$

$$\begin{aligned}
& + 12g_{BL}^2g_R^2M_1 - 64\sqrt{6}g_s^2g_{BL}g_{RB}M_1 - 154\sqrt{6}g_{BL}^3g_{RB}M_1 - 77\sqrt{6}g_{BL}g_{BR}^2g_{RB}M_1 \\
& - 1140g_{BL}g_{BR}g_{RB}M_1 - 66\sqrt{6}g_{BL}g_{RB}^2g_{RB}M_1 - 192g_s^2g_{RB}^2M_1 - 1116g_{BL}^2g_{RB}^2M_1 + 12g_{BR}^2g_{RB}^2M_1 \\
& - 108g_L^2g_{RB}^2M_1 - 66\sqrt{6}g_{BR}g_{RB}g_{RB}^2M_1 - 1152g_R^2g_{RB}^2M_1 - 132\sqrt{6}g_{BL}g_{RB}^3M_1 - 1152g_{RB}^4M_1 \\
& - 128g_s^2g_{BL}g_{BR}M_{BR} - 328g_{BL}^3g_{BR}M_{BR} - 328g_{BL}g_{BR}^3M_{BR} - 36g_{BL}g_{BR}g_L^2M_{BR} - 64\sqrt{6}g_s^2g_{BL}g_{RB}M_{BR} \\
& - 77\sqrt{6}g_{BL}^3g_{RB}M_{BR} - 231\sqrt{6}g_{BL}g_{BR}^2g_{RB}M_{BR} - 1116g_{BL}g_{BR}g_R^2M_{BR} - 66\sqrt{6}g_{BL}g_{RB}^3M_{BR} \\
& - 64\sqrt{6}g_s^2g_{BR}g_{RB}M_{BR} - 231\sqrt{6}g_{BL}^2g_{BR}g_{RB}M_{BR} - 77\sqrt{6}g_{BR}^3g_{RB}M_{BR} - 384g_s^2g_{RB}M_{BR} \\
& - 1116g_{BL}^2g_{RB}g_{RB}M_{BR} - 1116g_{BR}^2g_{RB}g_{RB}M_{BR} - 216g_L^2g_{RB}g_{RB}M_{BR} - 198\sqrt{6}g_{BR}g_{RB}^2g_{RB}M_{BR} \\
& - 2304g_R^3g_{RB}M_{BR} - 1116g_{BL}g_{BR}g_{RB}^2M_{BR} - 198\sqrt{6}g_{BL}g_{RB}g_{RB}^2M_{BR} - 66\sqrt{6}g_{BR}g_{RB}^3M_{BR} - 2304g_{RB}^3M_{BR} \\
& - 64g_s^2g_{BR}^2M_4 - 164g_{BL}^2g_{BR}^2M_4 - 164g_{BR}^4M_4 - 18g_{BR}^2g_L^2M_4 - 64\sqrt{6}g_s^2g_{BR}g_{RB}M_4 \\
& - 77\sqrt{6}g_{BL}^2g_{BR}g_{RB}M_4 - 154\sqrt{6}g_{BR}^3g_{RB}M_4 - 192g_s^2g_R^2M_4 + 12g_{BL}^2g_R^2M_4 - 1116g_{BR}^2g_R^2M_4 \\
& - 108g_L^2g_R^2M_4 - 132\sqrt{6}g_{BR}g_R^3M_4 - 1152g_R^4M_4 - 77\sqrt{6}g_{BL}g_{BR}^2g_{RB}M_4 - 1140g_{BL}g_{BR}g_{RB}M_4 \\
& - 66\sqrt{6}g_{BL}g_{RB}^2g_{RB}M_4 + 12g_{BR}^2g_{RB}^2M_4 - 66\sqrt{6}g_{BR}g_{RB}g_{RB}^2M_4 - 1152g_R^2g_{RB}^2M_4 + 256g_s^4M_3 \\
& - 64g_s^2g_{BL}^2M_3 - 64g_s^2g_{BR}^2M_3 - 576g_s^2g_L^2M_3 - 64\sqrt{6}g_s^2g_{BR}g_{RB}M_3 - 192g_s^2g_R^2M_3 \\
& - 64\sqrt{6}g_s^2g_{BL}g_{RB}M_3 - 192g_s^2g_{RB}^2M_3 - 576g_s^2g_L^2M_2 - 18g_{BL}^2g_L^2M_2 - 18g_{BR}^2g_L^2M_2 \\
& - 1080g_L^4M_2 - 108g_L^2g_R^2M_2 - 108g_L^2g_{RB}^2M_2 \\
& - 36\left(32g_s^2M_3 + g_{BL}\left(2g_{BR}M_{BR} + \sqrt{6}g_{RB}M_1 + \sqrt{6}g_{RB}M_{BR}\right) + g_{BL}^2M_1 + g_{BR}^2M_4 + \sqrt{6}g_{BR}\left(g_{RB}M_{BR} + g_{RB}M_4\right)\right)\text{Tr}\left(Y_u Y_u^\dagger\right) \\
& - 36\left(3g_{BL}^2M_1 - g_{BL}\left(-6g_{BR}M_{BR} + \sqrt{6}g_{RB}M_1 + \sqrt{6}g_{RB}M_{BR}\right) + g_{BR}\left(3g_{BR}M_4 - \sqrt{6}g_{RB}M_{BR} - \sqrt{6}g_{RB}M_4\right)\right)\text{Tr}\left(Y_v Y_v^\dagger\right) \\
& + 1152g_s^2\text{Tr}\left(Y_u^\dagger T_u\right) + 36g_{BL}^2\text{Tr}\left(Y_u^\dagger T_u\right) + 36g_{BR}^2\text{Tr}\left(Y_u^\dagger T_u\right) + 36\sqrt{6}g_{BR}g_{RB}\text{Tr}\left(Y_u^\dagger T_u\right) \\
& + 36\sqrt{6}g_{BL}g_{RB}\text{Tr}\left(Y_u^\dagger T_u\right) + 108g_{BL}^2\text{Tr}\left(Y_v^\dagger T_\nu\right) + 108g_{BR}^2\text{Tr}\left(Y_v^\dagger T_\nu\right) - 36\sqrt{6}g_{BR}g_{RB}\text{Tr}\left(Y_v^\dagger T_\nu\right) \\
& - 36\sqrt{6}g_{BL}g_{RB}\text{Tr}\left(Y_v^\dagger T_\nu\right) - 216\text{Tr}\left(Y_d Y_u^\dagger T_u Y_d^\dagger\right) - 72\text{Tr}\left(Y_e Y_v^\dagger T_\nu Y_e^\dagger\right) \\
& - 72\text{Tr}\left(Y_s Y_s^\dagger T_\nu Y_v^\dagger\right) - 216\text{Tr}\left(Y_u Y_d^\dagger T_d Y_u^\dagger\right) - 1296\text{Tr}\left(Y_u Y_u^\dagger T_u Y_u^\dagger\right) - 72\text{Tr}\left(Y_v Y_e^\dagger T_e Y_v^\dagger\right) \\
& - 72\text{Tr}\left(Y_v Y_v^\dagger T_s Y_s^\dagger\right) - 432\text{Tr}\left(Y_v Y_v^\dagger T_\nu Y_v^\dagger\right)
\end{aligned} \tag{70}$$

$$\begin{aligned}
\beta_{T_s}^{(1)} & = +3Y_s Y_s^\dagger T_s + 2Y_v Y_v^\dagger T_s + 3T_s Y_s^\dagger Y_s + 4T_\nu Y_v^\dagger Y_s - \frac{3}{2}g_{BL}^2 T_s - \frac{3}{2}g_{BR}^2 T_s \\
& + \sqrt{6}g_{BR}g_{RB}T_s - g_R^2 T_s + \sqrt{6}g_{BL}g_{RB}T_s - g_{RB}^2 T_s + T_s \text{Tr}\left(Y_s Y_s^\dagger\right) \\
& + Y_s \left(3g_{BL}^2 M_1 + 2g_{RB}^2 M_1 - 2\sqrt{6}g_{BR}g_{RB}M_{BR} + 4g_{RB}g_{RB}M_{BR} - 2g_{BL}\left(-3g_{BR}M_{BR} + \sqrt{6}g_{RB}M_1 + \sqrt{6}g_{RB}M_{BR}\right)\right) \\
& + 3g_{BR}^2 M_4 - 2\sqrt{6}g_{BR}g_{RB}M_4 + 2g_R^2 M_4 + 2\text{Tr}\left(Y_s^\dagger T_s\right)
\end{aligned} \tag{71}$$

$$\begin{aligned}
\beta_{T_s}^{(2)} & = +3g_{BL}^2 Y_s Y_s^\dagger T_s + 3g_{BR}^2 Y_s Y_s^\dagger T_s - 2\sqrt{6}g_{BR}g_{RB} Y_s Y_s^\dagger T_s + 2g_R^2 Y_s Y_s^\dagger T_s \\
& - 2\sqrt{6}g_{BL}g_{RB} Y_s Y_s^\dagger T_s + 2g_{RB}^2 Y_s Y_s^\dagger T_s - 2\sqrt{6}g_{BL}g_{RB} M_1 Y_v Y_v^\dagger Y_s \\
& - 2\sqrt{6}g_{BL}g_{RB} M_{BR} Y_v Y_v^\dagger Y_s - 2\sqrt{6}g_{BR}g_{RB} M_{BR} Y_v Y_v^\dagger Y_s
\end{aligned}$$

$$\begin{aligned}
& -2\sqrt{6}g_{BRGR}M_4Y_vY_v^\dagger Y_s - 12g_L^2M_2Y_vY_v^\dagger Y_s + 6g_L^2Y_vY_v^\dagger T_s \\
& + \sqrt{6}g_{BRGR}Y_vY_v^\dagger T_s + \sqrt{6}g_{BLGRB}Y_vY_v^\dagger T_s + \frac{3}{2}g_{BL}^2T_sY_s^\dagger Y_s \\
& + \frac{3}{2}g_{BR}^2T_sY_s^\dagger Y_s - \sqrt{6}g_{BRGR}T_sY_s^\dagger Y_s + g_R^2T_sY_s^\dagger Y_s \\
& - \sqrt{6}g_{BLGRB}T_sY_s^\dagger Y_s + g_{RB}^2T_sY_s^\dagger Y_s + 12g_L^2T_\nu Y_\nu^\dagger Y_s \\
& + 2\sqrt{6}g_{BRGR}T_\nu Y_\nu^\dagger Y_s + 2\sqrt{6}g_{BLGRB}T_\nu Y_\nu^\dagger Y_s - 3Y_sY_s^\dagger Y_sY_s^\dagger T_s \\
& - 4Y_sY_s^\dagger Y_vY_v^\dagger T_s - 4Y_sY_s^\dagger T_sY_s^\dagger Y_s - 4Y_sY_s^\dagger T_\nu Y_\nu^\dagger Y_s - 2Y_vY_e^\dagger Y_eY_v^\dagger T_s \\
& - 4Y_vY_e^\dagger T_eY_v^\dagger Y_s - 2Y_vY_v^\dagger Y_vY_v^\dagger T_s - 4Y_vY_v^\dagger T_\nu Y_\nu^\dagger Y_s - 3T_sY_s^\dagger Y_sY_s^\dagger Y_s \\
& - 2T_sY_s^\dagger Y_vY_v^\dagger Y_s - 4T_\nu Y_e^\dagger Y_eY_v^\dagger Y_s - 4T_\nu Y_v^\dagger Y_vY_v^\dagger Y_s + \frac{45}{4}g_{BL}^4T_s \\
& + \frac{45}{2}g_{BL}^2g_{BR}^2T_s + \frac{45}{4}g_{BR}^4T_s - 9\sqrt{6}g_{BL}^2g_{BRGR}T_s - 9\sqrt{6}g_{BR}^3g_RT_s + 3g_{BL}^2g_R^2T_s \\
& + \frac{51}{2}g_{BR}^2g_R^2T_s - 9\sqrt{6}g_{BRGR}^3T_s + 8g_R^4T_s - 9\sqrt{6}g_{BLGRB}^3T_s - 9\sqrt{6}g_{BLGRB}^2g_{RBR}T_s \\
& + 45g_{BLGRB}g_{RGRB}T_s - 9\sqrt{6}g_{BLGRB}^2g_{RBR}T_s + \frac{51}{2}g_{BLGRB}^2g_R^2T_s + 3g_{BR}^2g_{RB}^2T_s - 9\sqrt{6}g_{BRGR}g_{RB}^2T_s \\
& + 16g_R^2g_{RB}^2T_s - 9\sqrt{6}g_{BLGRB}^3T_s + 8g_{RB}^4T_s - 3Y_sY_s^\dagger T_s \text{Tr}(Y_sY_s^\dagger) \\
& - 3T_sY_s^\dagger Y_s \text{Tr}(Y_sY_s^\dagger) - 6Y_vY_v^\dagger T_s \text{Tr}(Y_uY_u^\dagger) - 12T_\nu Y_\nu^\dagger Y_s \text{Tr}(Y_uY_u^\dagger) \\
& - 2Y_vY_v^\dagger T_s \text{Tr}(Y_vY_v^\dagger) - 4T_\nu Y_\nu^\dagger Y_s \text{Tr}(Y_vY_v^\dagger) \\
& - Y_sY_s^\dagger Y_s \left( 3g_{BL}^2M_1 + 2g_{RB}^2M_1 - 2\sqrt{6}g_{BRGRB}M_{BR} + 4g_{RGRB}M_{BR} - 2g_{BL} \left( -3g_{BR}M_{BR} + \sqrt{6}g_{RB}M_1 + \sqrt{6}g_RM_{BR} \right) \right. \\
& \left. + 3g_{BR}^2M_4 - 2\sqrt{6}g_{BRGR}M_4 + 2g_R^2M_4 + 4\text{Tr}(Y_s^\dagger T_s) \right) \\
& - 12Y_vY_v^\dagger Y_s \text{Tr}(Y_u^\dagger T_u) - 4Y_vY_v^\dagger Y_s \text{Tr}(Y_v^\dagger T_\nu) - 2T_s \text{Tr}(Y_sY_s^\dagger Y_sY_s^\dagger) \\
& - 2T_s \text{Tr}(Y_sY_s^\dagger Y_vY_v^\dagger) \\
& - Y_s \left( 45g_{BL}^4M_1 + 45g_{BL}^2g_{BR}^2M_1 - 18\sqrt{6}g_{BL}^2g_{BRGR}M_1 + 6g_{BL}^2g_R^2M_1 - 36\sqrt{6}g_{BL}^3g_{RBR}M_1 \right. \\
& - 18\sqrt{6}g_{BL}g_{BR}^2g_{RBR}M_1 + 90g_{BLGRB}g_{RGRB}M_1 - 18\sqrt{6}g_{BL}g_{RB}^2g_{RBR}M_1 + 102g_{BL}^2g_{RB}^2M_1 + 6g_{BR}^2g_{RB}^2M_1 \\
& - 18\sqrt{6}g_{BRGR}g_{RB}^2M_1 + 32g_R^2g_{RB}^2M_1 - 36\sqrt{6}g_{BL}g_{RB}^3M_1 + 32g_{RB}^4M_1 + 90g_{BL}^3g_{BR}M_{BR} \\
& + 90g_{BL}g_{BR}^3M_{BR} - 18\sqrt{6}g_{BL}^3g_{RBR}M_{BR} - 54\sqrt{6}g_{BL}g_{BR}^2g_{RBR}M_{BR} + 102g_{BL}g_{BR}g_{RB}^2M_{BR} - 18\sqrt{6}g_{BL}g_{RB}^3M_{BR} \\
& - 54\sqrt{6}g_{BL}g_{BR}g_{RBR}M_{BR} - 18\sqrt{6}g_{BR}^3g_{RBR}M_{BR} + 102g_{BL}g_{RGRB}M_{BR} + 102g_{BR}^2g_{RGRB}M_{BR} \\
& - 54\sqrt{6}g_{BR}g_{RB}^2g_{RBR}M_{BR} + 64g_R^3g_{RBR}M_{BR} + 102g_{BL}g_{BR}g_{RB}^2M_{BR} - 54\sqrt{6}g_{BL}g_{RB}g_{RB}^2M_{BR} \\
& - 18\sqrt{6}g_{BR}g_{RB}^3M_{BR} + 64g_Rg_{RB}^3M_{BR} + 45g_{BL}^2g_{BR}^2M_4 + 45g_{BR}^4M_4 - 18\sqrt{6}g_{BL}^2g_{BRGR}M_4 \\
& - 36\sqrt{6}g_{BR}^3g_RM_4 + 6g_{BL}^2g_R^2M_4 + 102g_{BR}^2g_R^2M_4 - 36\sqrt{6}g_{BR}g_R^3M_4 + 32g_R^4M_4 \\
& \left. - 18\sqrt{6}g_{BL}g_{BR}^2g_{RBR}M_4 + 90g_{BLGRB}g_{RGRB}M_4 - 18\sqrt{6}g_{BL}g_{RB}^2g_{RBR}M_4 + 6g_{BR}^2g_{RB}^2M_4 \right)
\end{aligned}$$



$$\begin{aligned}
& -18\sqrt{6}g_{BR}g_{RB}g_{RB}^2M_4 + 32g_{RB}^2g_{RB}^2M_4 + 8\text{Tr}\left(Y_sY_s^\dagger T_sY_s^\dagger\right) + 4\text{Tr}\left(Y_sY_s^\dagger T_\nu Y_\nu^\dagger\right) \\
& + 4\text{Tr}\left(Y_\nu Y_\nu^\dagger T_sY_s^\dagger\right)
\end{aligned} \tag{72}$$

$$\begin{aligned}
\beta_{T_\nu}^{(1)} = & +Y_sY_s^\dagger T_\nu + 2Y_\nu Y_\nu^\dagger T_e + 4Y_\nu Y_\nu^\dagger T_\nu + 2T_sY_s^\dagger Y_\nu + T_\nu Y_\nu^\dagger Y_e + 5T_\nu Y_\nu^\dagger Y_\nu \\
& - \frac{3}{2}g_{BL}^2T_\nu - \frac{3}{2}g_{BR}^2T_\nu - 3g_L^2T_\nu + \sqrt{\frac{3}{2}}g_{BR}g_{RB}T_\nu - g_R^2T_\nu + \sqrt{\frac{3}{2}}g_{BL}g_{RB}T_\nu - g_{RB}^2T_\nu + 3T_\nu\text{Tr}\left(Y_uY_u^\dagger\right) \\
& + T_\nu\text{Tr}\left(Y_\nu Y_\nu^\dagger\right) \\
& + Y_\nu\left(3g_{BL}^2M_1 - \sqrt{6}g_{BL}g_{RB}M_1 + 2g_{RB}^2M_1 + 6g_{BL}g_{BR}M_{BR} - \sqrt{6}g_{BL}g_{RB}M_{BR} - \sqrt{6}g_{BR}g_{RB}M_{BR} + 4g_{RB}g_{RB}M_{BR}\right. \\
& \left. + 3g_{BR}^2M_4 - \sqrt{6}g_{BR}g_{RB}M_4 + 2g_R^2M_4 + 6g_L^2M_2 + 6\text{Tr}\left(Y_u^\dagger T_u\right) + 2\text{Tr}\left(Y_\nu^\dagger T_\nu\right)\right)
\end{aligned} \tag{73}$$

$$\begin{aligned}
\beta_{T_\nu}^{(2)} = & \frac{1}{8}\left(-8\sqrt{6}g_{BL}g_{RB}M_1Y_\nu Y_\nu^\dagger Y_e - 16g_{RB}^2M_1Y_\nu Y_\nu^\dagger Y_e - 8\sqrt{6}g_{BL}g_{RB}M_{BR}Y_\nu Y_\nu^\dagger Y_e\right. \\
& - 8\sqrt{6}g_{BR}g_{RB}M_{BR}Y_\nu Y_\nu^\dagger Y_e - 32g_{RB}g_{RB}M_{BR}Y_\nu Y_\nu^\dagger Y_e - 8\sqrt{6}g_{BR}g_{RB}M_4Y_\nu Y_\nu^\dagger Y_e \\
& - 16g_R^2M_4Y_\nu Y_\nu^\dagger Y_e + 8\sqrt{6}g_{BR}g_{RB}Y_\nu Y_\nu^\dagger T_e + 16g_R^2Y_\nu Y_\nu^\dagger T_e \\
& + 8\sqrt{6}g_{BL}g_{RB}Y_\nu Y_\nu^\dagger T_e + 16g_{RB}^2Y_\nu Y_\nu^\dagger T_e - 8\sqrt{6}g_{BL}g_{RB}M_1Y_\nu Y_\nu^\dagger Y_\nu \\
& - 16g_{RB}^2M_1Y_\nu Y_\nu^\dagger Y_\nu - 8\sqrt{6}g_{BL}g_{RB}M_{BR}Y_\nu Y_\nu^\dagger Y_\nu - 8\sqrt{6}g_{BR}g_{RB}M_{BR}Y_\nu Y_\nu^\dagger Y_\nu \\
& - 32g_{RB}g_{RB}M_{BR}Y_\nu Y_\nu^\dagger Y_\nu - 8\sqrt{6}g_{BR}g_{RB}M_4Y_\nu Y_\nu^\dagger Y_\nu - 16g_R^2M_4Y_\nu Y_\nu^\dagger Y_\nu \\
& - 96g_L^2M_2Y_\nu Y_\nu^\dagger Y_\nu + 48g_L^2Y_\nu Y_\nu^\dagger T_\nu + 16g_R^2Y_\nu Y_\nu^\dagger T_\nu + 16g_{RB}^2Y_\nu Y_\nu^\dagger T_\nu \\
& + 4\sqrt{6}g_{BR}g_{RB}T_\nu Y_\nu^\dagger Y_e + 8g_R^2T_\nu Y_\nu^\dagger Y_e + 4\sqrt{6}g_{BL}g_{RB}T_\nu Y_\nu^\dagger Y_e \\
& + 8g_{RB}^2T_\nu Y_\nu^\dagger Y_e + 96g_L^2T_\nu Y_\nu^\dagger Y_\nu + 12\sqrt{6}g_{BR}g_{RB}T_\nu Y_\nu^\dagger Y_\nu + 8g_R^2T_\nu Y_\nu^\dagger Y_\nu \\
& + 12\sqrt{6}g_{BL}g_{RB}T_\nu Y_\nu^\dagger Y_\nu + 8g_{RB}^2T_\nu Y_\nu^\dagger Y_\nu - 8Y_sY_s^\dagger Y_sY_s^\dagger T_\nu - 16Y_sY_s^\dagger T_sY_s^\dagger Y_\nu \\
& - 32Y_\nu Y_\nu^\dagger Y_eY_e^\dagger T_e - 16Y_\nu Y_\nu^\dagger Y_eY_e^\dagger T_\nu - 32Y_\nu Y_\nu^\dagger T_eY_e^\dagger Y_e - 32Y_\nu Y_\nu^\dagger T_eY_e^\dagger Y_\nu \\
& - 16Y_\nu Y_\nu^\dagger Y_sY_s^\dagger T_\nu - 48Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger T_\nu - 16Y_\nu Y_\nu^\dagger T_sY_s^\dagger Y_\nu - 64Y_\nu Y_\nu^\dagger T_\nu Y_\nu^\dagger Y_\nu \\
& - 16T_sY_s^\dagger Y_sY_s^\dagger Y_\nu - 16T_\nu Y_\nu^\dagger Y_eY_e^\dagger Y_e - 32T_\nu Y_\nu^\dagger Y_eY_e^\dagger Y_\nu - 8T_\nu Y_\nu^\dagger Y_sY_s^\dagger Y_\nu \\
& - 48T_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu + 90g_{BL}^4T_\nu + 180g_{BL}^2g_{BR}^2T_\nu + 90g_{BR}^4T_\nu + 18g_{BL}^2g_L^2T_\nu + 18g_{BR}^2g_L^2T_\nu \\
& + 60g_L^4T_\nu - 39\sqrt{6}g_{BL}^2g_{BR}g_{RB}T_\nu - 39\sqrt{6}g_{BR}^3g_{RB}T_\nu + 12g_{BL}^2g_R^2T_\nu + 174g_{BR}^2g_R^2T_\nu \\
& + 12g_L^2g_R^2T_\nu - 38\sqrt{6}g_{BR}g_{RB}^3T_\nu + 64g_R^4T_\nu - 39\sqrt{6}g_{BL}^3g_{RB}T_\nu - 39\sqrt{6}g_{BL}g_{BR}^2g_{RB}T_\nu \\
& + 324g_{BL}g_{BR}g_{RB}g_{RB}T_\nu - 38\sqrt{6}g_{BL}g_R^2g_{RB}T_\nu + 174g_{BL}^2g_{RB}^2T_\nu + 12g_{BR}^2g_{RB}^2T_\nu + 12g_L^2g_{RB}^2T_\nu \\
& - 38\sqrt{6}g_{BR}g_{RB}g_{RB}^2T_\nu + 128g_R^2g_{RB}^2T_\nu - 38\sqrt{6}g_{BL}g_{RB}^3T_\nu + 64g_{RB}^4T_\nu \\
& - 48Y_\nu Y_\nu^\dagger T_e\text{Tr}\left(Y_dY_d^\dagger\right) - 24T_\nu Y_\nu^\dagger Y_e\text{Tr}\left(Y_dY_d^\dagger\right) - 16Y_\nu Y_\nu^\dagger T_e\text{Tr}\left(Y_eY_e^\dagger\right)
\end{aligned}$$

$$\begin{aligned}
& - 8T_\nu Y_\nu^\dagger Y_e\text{Tr}\left(Y_eY_e^\dagger\right) - 8Y_sY_s^\dagger T_\nu\text{Tr}\left(Y_sY_s^\dagger\right) - 16T_sY_s^\dagger Y_\nu\text{Tr}\left(Y_sY_s^\dagger\right) \\
& - 96Y_\nu Y_\nu^\dagger T_\nu\text{Tr}\left(Y_uY_u^\dagger\right) - 120T_\nu Y_\nu^\dagger Y_\nu\text{Tr}\left(Y_uY_u^\dagger\right) + 128g_s^2T_\nu\text{Tr}\left(Y_uY_u^\dagger\right)
\end{aligned}$$

$$\begin{aligned}
& + 4g_{BL}^2 T_\nu \text{Tr}(Y_u Y_u^\dagger) + 4g_{BR}^2 T_\nu \text{Tr}(Y_u Y_u^\dagger) + 4\sqrt{6} g_{BR} g_R T_\nu \text{Tr}(Y_u Y_u^\dagger) \\
& + 4\sqrt{6} g_{BL} g_{RB} T_\nu \text{Tr}(Y_u Y_u^\dagger) - 32Y_v Y_v^\dagger T_\nu \text{Tr}(Y_v Y_v^\dagger) - 40T_\nu Y_v^\dagger Y_v \text{Tr}(Y_v Y_v^\dagger) \\
& + 12g_{BL}^2 T_\nu \text{Tr}(Y_v Y_v^\dagger) + 12g_{BR}^2 T_\nu \text{Tr}(Y_v Y_v^\dagger) - 4\sqrt{6} g_{BR} g_R T_\nu \text{Tr}(Y_v Y_v^\dagger) \\
& - 4\sqrt{6} g_{BL} g_{RB} T_\nu \text{Tr}(Y_v Y_v^\dagger) - 48Y_v Y_e^\dagger Y_e \text{Tr}(Y_d^\dagger T_d) - 16Y_v Y_e^\dagger Y_e \text{Tr}(Y_e^\dagger T_e) \\
& - 16Y_s Y_s^\dagger Y_v \text{Tr}(Y_s^\dagger T_s) - 144Y_v Y_v^\dagger Y_v \text{Tr}(Y_u^\dagger T_u) - 48Y_v Y_v^\dagger Y_v \text{Tr}(Y_v^\dagger T_\nu) \\
& - 24T_\nu \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 8T_\nu \text{Tr}(Y_e Y_v^\dagger Y_v Y_e^\dagger) - 8T_\nu \text{Tr}(Y_s Y_s^\dagger Y_v Y_v^\dagger) \\
& - 72T_\nu \text{Tr}(Y_u Y_u^\dagger Y_u Y_u^\dagger) - 24T_\nu \text{Tr}(Y_v Y_v^\dagger Y_v Y_v^\dagger) \\
& - 2Y_v \left( 180g_{BL}^4 M_1 + 180g_{BL}^2 g_{BR}^2 M_1 + 18g_{BL}^2 g_L^2 M_1 - 39\sqrt{6} g_{BL}^2 g_{BR} g_R M_1 + 12g_{BL}^2 g_R^2 M_1 \right. \\
& - 78\sqrt{6} g_{BL}^3 g_{RB} M_1 - 39\sqrt{6} g_{BL} g_{BR}^2 g_{RB} M_1 + 324g_{BL} g_{BR} g_R g_{RB} M_1 - 38\sqrt{6} g_{BL} g_R^2 g_{RB} M_1 \\
& + 348g_{BL}^2 g_{RB}^2 M_1 + 12g_{BR}^2 g_{RB}^2 M_1 + 12g_L^2 g_{RB}^2 M_1 - 38\sqrt{6} g_{BR} g_R g_{RB}^2 M_1 + 128g_R^2 g_{RB}^2 M_1 \\
& - 76\sqrt{6} g_{BL} g_{RB}^3 M_1 + 128g_{RB}^4 M_1 + 360g_{BL}^3 g_{BR} M_{BR} + 360g_{BL} g_{BR}^3 M_{BR} + 36g_{BL} g_{BR} g_L^2 M_{BR} \\
& - 39\sqrt{6} g_{BL}^3 g_R M_{BR} - 117\sqrt{6} g_{BL} g_{BR}^2 g_R M_{BR} + 348g_{BL} g_{BR} g_R^2 M_{BR} - 38\sqrt{6} g_{BL} g_R^3 M_{BR} \\
& - 117\sqrt{6} g_{BL}^2 g_{BR} g_{RB} M_{BR} - 39\sqrt{6} g_{BR}^3 g_{RB} M_{BR} + 348g_{BL}^2 g_R g_{RB} M_{BR} + 348g_{BR}^2 g_R g_{RB} M_{BR} \\
& + 24g_L^2 g_R g_{RB} M_{BR} - 114\sqrt{6} g_{BR} g_R^2 g_{RB} M_{BR} + 256g_R^3 g_{RB} M_{BR} + 348g_{BL} g_{BR} g_{RB}^2 M_{BR} \\
& - 114\sqrt{6} g_{BL} g_R g_{RB}^2 M_{BR} - 38\sqrt{6} g_{BR} g_{RB}^3 M_{BR} + 256g_R g_{RB}^3 M_{BR} + 180g_{BL}^2 g_{BR}^2 M_4 + 180g_{BR}^4 M_4 \\
& + 18g_{BR}^2 g_L^2 M_4 - 39\sqrt{6} g_{BL}^2 g_{BR} g_R M_4 - 78\sqrt{6} g_{BR}^3 g_R M_4 + 12g_{BL}^2 g_R^2 M_4 + 348g_{BR}^2 g_R^2 M_4 \\
& + 12g_L^2 g_R^2 M_4 - 76\sqrt{6} g_{BR} g_R^3 M_4 + 128g_R^4 M_4 - 39\sqrt{6} g_{BL} g_{BR}^2 g_{RB} M_4 + 324g_{BL} g_{BR} g_R g_{RB} M_4 \\
& - 38\sqrt{6} g_{BL} g_R^2 g_{RB} M_4 + 12g_{BR}^2 g_{RB}^2 M_4 - 38\sqrt{6} g_{BR} g_R g_{RB}^2 M_4 + 128g_R^2 g_{RB}^2 M_4 + 18g_{BL}^2 g_L^2 M_2 \\
& + 18g_{BR}^2 g_L^2 M_2 + 120g_L^4 M_2 + 12g_L^2 g_R^2 M_2 + 12g_L^2 g_{RB}^2 M_2 \\
& + 4 \left( 32g_s^2 M_3 + g_{BL} (2g_{BR} M_{BR} + \sqrt{6} g_{RB} M_1 + \sqrt{6} g_R M_{BR}) + g_{BL}^2 M_1 + g_{BR}^2 M_4 + \sqrt{6} g_{BR} (g_{RB} M_{BR} + g_R M_4) \right) \text{Tr}(Y_u Y_u^\dagger) \\
& + 4 \left( 3g_{BL}^2 M_1 - g_{BL} (-g_{BR} M_{BR} + \sqrt{6} g_{RB} M_1 + \sqrt{6} g_R M_{BR}) + g_{BR} (3g_{BR} M_4 - \sqrt{6} g_{RB} M_{BR} - \sqrt{6} g_R M_4) \right) \text{Tr}(Y_v Y_v^\dagger) \\
& - 128g_s^2 \text{Tr}(Y_u^\dagger T_u) - 4g_{BL}^2 \text{Tr}(Y_u^\dagger T_u) - 4g_{BR}^2 \text{Tr}(Y_u^\dagger T_u) - 4\sqrt{6} g_{BR} g_R \text{Tr}(Y_u^\dagger T_u) \\
& - 4\sqrt{6} g_{BL} g_{RB} \text{Tr}(Y_u^\dagger T_u) - 12g_{BL}^2 \text{Tr}(Y_v^\dagger T_\nu) - 12g_{BR}^2 \text{Tr}(Y_v^\dagger T_\nu) + 4\sqrt{6} g_{BR} g_R \text{Tr}(Y_v^\dagger T_\nu) \\
& + 4\sqrt{6} g_{BL} g_{RB} \text{Tr}(Y_v^\dagger T_\nu) + 24\text{Tr}(Y_d Y_u^\dagger T_u Y_d^\dagger) + 8\text{Tr}(Y_e Y_v^\dagger T_\nu Y_e^\dagger) + 8\text{Tr}(Y_s Y_s^\dagger T_\nu Y_v^\dagger) \\
& + 24\text{Tr}(Y_u Y_d^\dagger T_d Y_u^\dagger) + 144\text{Tr}(Y_u Y_u^\dagger T_u Y_u^\dagger) + 8\text{Tr}(Y_v Y_e^\dagger T_e Y_v^\dagger) + 8\text{Tr}(Y_v Y_v^\dagger T_s Y_s^\dagger) \\
& + 48\text{Tr}(Y_v Y_v^\dagger T_\nu Y_v^\dagger) \Big) \Big) \tag{74}
\end{aligned}$$

### 3.7 Bilinear Soft-Breaking Parameters

$$\begin{aligned}
\beta_{B_{\mu_R}}^{(1)} = & +B_{\mu_R} \left( -\frac{3}{2}g_{BL}^2 - \frac{3}{2}g_{BR}^2 - g_R^2 - g_{RB}^2 + \sqrt{6}g_{BL}g_{RB} + \sqrt{6}g_{BR}g_R + \text{Tr}(Y_s Y_s^\dagger) \right) \\
& + \mu_R \left( 3g_{BL}^2 M_1 + 2g_{RB}^2 M_1 - 2\sqrt{6}g_{BR}g_{RB}M_{BR} + 4g_R g_{RB} M_{BR} - 2g_{BL} \left( -3g_{BR}M_{BR} + \sqrt{6}g_{RB}M_1 + \sqrt{6}g_R M_{BR} \right) \right. \\
& \left. + 3g_{BR}^2 M_4 - 2\sqrt{6}g_{BR}g_R M_4 + 2g_R^2 M_4 + 2\text{Tr}(Y_s^\dagger T_s) \right) \tag{75}
\end{aligned}$$

$$\begin{aligned}
\beta_{B_{\mu_R}}^{(2)} = & +B_{\mu_R} \left( \frac{45}{4}g_{BL}^4 + \frac{45}{2}g_{BL}^2 g_{BR}^2 + \frac{45}{4}g_{BR}^4 - 9\sqrt{6}g_{BL}^2 g_{BR}g_R - 9\sqrt{6}g_{BR}^3 g_R + 3g_{BL}^2 g_R^2 + \frac{51}{2}g_{BR}^2 g_R^2 \right. \\
& - 9\sqrt{6}g_{BR}g_R^3 + 8g_R^4 - 9\sqrt{6}g_{BL}^3 g_{RB} - 9\sqrt{6}g_{BL}g_{BR}^2 g_{RB} + 45g_{BL}g_{BR}g_R g_{RB} - 9\sqrt{6}g_{BL}g_{RB}^2 g_{RB} \\
& \left. + \frac{51}{2}g_{BL}^2 g_{RB}^2 + 3g_{BR}^2 g_{RB}^2 - 9\sqrt{6}g_{BR}g_R g_{RB}^2 + 16g_R^2 g_{RB}^2 - 9\sqrt{6}g_{BL}g_{RB}^3 + 8g_{RB}^4 - 2\text{Tr}(Y_s Y_s^\dagger Y_s Y_s^\dagger) \right. \\
& \left. - 2\text{Tr}(Y_s Y_s^\dagger Y_v Y_v^\dagger) \right) \\
& - \mu_R \left( 45g_{BL}^4 M_1 + 45g_{BL}^2 g_{BR}^2 M_1 - 18\sqrt{6}g_{BL}^2 g_{BR}g_R M_1 + 6g_{BL}^2 g_R^2 M_1 - 36\sqrt{6}g_{BL}^3 g_{RB} M_1 \right. \\
& - 18\sqrt{6}g_{BL}g_{BR}^2 g_{RB} M_1 + 90g_{BL}g_{BR}g_R g_{RB} M_1 - 18\sqrt{6}g_{BL}g_{RB}^2 g_{RB} M_1 + 102g_{BL}^2 g_{RB}^2 M_1 + 6g_{BR}^2 g_{RB}^2 M_1 \\
& - 18\sqrt{6}g_{BR}g_R g_{RB}^2 M_1 + 32g_R^2 g_{RB}^2 M_1 - 36\sqrt{6}g_{BL}g_{RB}^3 M_1 + 32g_{RB}^4 M_1 + 90g_{BL}^3 g_{BR} M_{BR} \\
& + 90g_{BL}g_{BR}^3 M_{BR} - 18\sqrt{6}g_{BL}^3 g_R M_{BR} - 54\sqrt{6}g_{BL}g_{BR}^2 g_R M_{BR} + 102g_{BL}g_{BR}g_R^2 M_{BR} - 18\sqrt{6}g_{BL}g_{RB}^3 M_{BR} \\
& - 54\sqrt{6}g_{BL}g_{BR}g_{RB} M_{BR} - 18\sqrt{6}g_{BR}^3 g_{RB} M_{BR} + 102g_{BL}^2 g_R g_{RB} M_{BR} + 102g_{BR}^2 g_R g_{RB} M_{BR} \\
& - 54\sqrt{6}g_{BR}g_R^2 g_{RB} M_{BR} + 64g_R^3 g_{RB} M_{BR} + 102g_{BL}g_{BR}g_{RB}^2 M_{BR} - 54\sqrt{6}g_{BL}g_R g_{RB}^2 M_{BR} \\
& - 18\sqrt{6}g_{BR}g_{RB}^3 M_{BR} + 64g_R g_{RB}^3 M_{BR} + 45g_{BL}^2 g_{BR}^2 M_4 + 45g_{BR}^4 M_4 - 18\sqrt{6}g_{BL}^2 g_{BR}g_R M_4 \\
& - 36\sqrt{6}g_{BR}^3 g_R M_4 + 6g_{BL}^2 g_R^2 M_4 + 102g_{BR}^2 g_R^2 M_4 - 36\sqrt{6}g_{BR}g_R^3 M_4 + 32g_R^4 M_4 \\
& - 18\sqrt{6}g_{BL}g_{BR}^2 g_{RB} M_4 + 90g_{BL}g_{BR}g_R g_{RB} M_4 - 18\sqrt{6}g_{BL}g_{RB}^2 g_{RB} M_4 + 6g_{BR}^2 g_{RB}^2 M_4 \\
& - 18\sqrt{6}g_{BR}g_R g_{RB}^2 M_4 + 32g_R^2 g_{RB}^2 M_4 + 8\text{Tr}(Y_s Y_s^\dagger T_s Y_s^\dagger) + 4\text{Tr}(Y_s Y_s^\dagger T_\nu Y_\nu^\dagger) \\
& \left. + 4\text{Tr}(Y_v Y_v^\dagger T_s Y_s^\dagger) \right) \tag{76}
\end{aligned}$$

$$\begin{aligned}
\beta_{B_\mu}^{(1)} = & +B_\mu \left( -3g_L^2 + 3\text{Tr}(Y_d Y_d^\dagger) + 3\text{Tr}(Y_u Y_u^\dagger) - g_R^2 - g_{RB}^2 + \text{Tr}(Y_e Y_e^\dagger) + \text{Tr}(Y_v Y_v^\dagger) \right) \\
& + 2\mu \left( 2g_R g_{RB} M_{BR} + 3g_L^2 M_2 + 3\text{Tr}(Y_d^\dagger T_d) + 3\text{Tr}(Y_u^\dagger T_u) + g_R^2 M_4 + g_{RB}^2 M_1 + \text{Tr}(Y_e^\dagger T_e) + \text{Tr}(Y_v^\dagger T_\nu) \right) \tag{77}
\end{aligned}$$

$$\begin{aligned}
\beta_{B_\mu}^{(2)} = & +\frac{1}{4}B_\mu \left( 30g_L^4 + 27g_{BR}^2 g_R^2 + 12g_L^2 g_R^2 - 2\sqrt{6}g_{BR}g_R^3 + 32g_R^4 + 54g_{BL}g_{BR}g_R g_{RB} - 2\sqrt{6}g_{BL}g_{RB}^2 g_{RB} \right. \\
& + 27g_{BL}^2 g_{RB}^2 + 12g_L^2 g_{RB}^2 - 2\sqrt{6}g_{BR}g_R g_{RB}^2 + 64g_R^2 g_{RB}^2 - 2\sqrt{6}g_{BL}g_{RB}^3 + 32g_{RB}^4 \\
& \left. + 2(32g_s^2 - \sqrt{6}g_{BL}g_{RB} - \sqrt{6}g_{BR}g_R + g_{BL}^2 + g_{BR}^2) \text{Tr}(Y_d Y_d^\dagger) \right. \\
& + 2(3g_{BL}^2 + 3g_{BR}^2 + \sqrt{6}g_{BL}g_{RB} + \sqrt{6}g_{BR}g_R) \text{Tr}(Y_e Y_e^\dagger) + 64g_s^2 \text{Tr}(Y_u Y_u^\dagger) + 2g_{BL}^2 \text{Tr}(Y_u Y_u^\dagger) \\
& + 2g_{BR}^2 \text{Tr}(Y_u Y_u^\dagger) + 2\sqrt{6}g_{BR}g_R \text{Tr}(Y_u Y_u^\dagger) + 2\sqrt{6}g_{BL}g_{RB} \text{Tr}(Y_u Y_u^\dagger) + 6g_{BL}^2 \text{Tr}(Y_v Y_v^\dagger) \\
& \left. + 6g_{BR}^2 \text{Tr}(Y_v Y_v^\dagger) - 2\sqrt{6}g_{BR}g_R \text{Tr}(Y_v Y_v^\dagger) - 2\sqrt{6}g_{BL}g_{RB} \text{Tr}(Y_v Y_v^\dagger) - 36\text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) \right)
\end{aligned}$$

$$\begin{aligned}
& -24\text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) - 12\text{Tr}\left(Y_e Y_e^\dagger Y_e Y_e^\dagger\right) - 8\text{Tr}\left(Y_e Y_v^\dagger Y_v Y_e^\dagger\right) - 4\text{Tr}\left(Y_s Y_s^\dagger Y_v Y_v^\dagger\right) \\
& - 36\text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right) - 12\text{Tr}\left(Y_v Y_v^\dagger Y_v Y_v^\dagger\right) \\
& - \mu\left(27g_{BL}g_{BR}g_{R}g_{RB}M_1 - \sqrt{6}g_{BL}g_R^2g_{RB}M_1 + 27g_{BL}^2g_{RB}^2M_1 + 6g_L^2g_{RB}^2M_1 - \sqrt{6}g_{BR}g_{R}g_{RB}^2M_1\right. \\
& + 32g_R^2g_{RB}^2M_1 - 2\sqrt{6}g_{BL}g_{RB}^3M_1 + 32g_R^4M_1 + 27g_{BL}g_{BR}g_R^2M_{BR} - \sqrt{6}g_{BL}g_R^3M_{BR} \\
& + 27g_{BL}^2g_{R}g_{RB}M_{BR} + 27g_{BR}^2g_{R}g_{RB}M_{BR} + 12g_L^2g_{R}g_{RB}M_{BR} - 3\sqrt{6}g_{BR}g_R^2g_{RB}M_{BR} + 64g_R^3g_{RB}M_{BR} \\
& + 27g_{BL}g_{BR}g_{RB}^2M_{BR} - 3\sqrt{6}g_{BL}g_{R}g_{RB}^2M_{BR} - \sqrt{6}g_{BR}g_{RB}^3M_{BR} + 64g_Rg_{RB}^3M_{BR} + 27g_{BR}^2g_{RB}^2M_4 \\
& + 6g_L^2g_{RB}^2M_4 - 2\sqrt{6}g_{BR}g_R^3M_4 + 32g_R^4M_4 + 27g_{BL}g_{BR}g_{R}g_{RB}M_4 - \sqrt{6}g_{BL}g_R^2g_{RB}M_4 \\
& - \sqrt{6}g_{BR}g_{R}g_{RB}^2M_4 + 32g_R^2g_{RB}^2M_4 + 30g_L^4M_2 + 6g_L^2g_R^2M_2 + 6g_L^2g_{RB}^2M_2 \\
& + \left(32g_s^2M_3 - g_{BL}\left(-2g_{BR}M_{BR} + \sqrt{6}g_{RB}M_1 + \sqrt{6}g_{R}M_{BR}\right) + g_{BL}^2M_1 + g_{BR}^2M_4 - \sqrt{6}g_{BR}\left(g_{RB}M_{BR} + g_{R}M_4\right)\right)\text{Tr}\left(Y_d Y_d^\dagger\right) \\
& + \left(3g_{BL}^2M_1 + g_{BL}\left(6g_{BR}M_{BR} + \sqrt{6}g_{RB}M_1 + \sqrt{6}g_{R}M_{BR}\right) + g_{BR}\left(3g_{R}M_4 + \sqrt{6}g_{RB}M_{BR} + \sqrt{6}g_{R}M_4\right)\right)\text{Tr}\left(Y_e Y_e^\dagger\right) \\
& + g_{BL}^2M_1\text{Tr}\left(Y_u Y_u^\dagger\right) + \sqrt{6}g_{BL}g_{RB}M_1\text{Tr}\left(Y_u Y_u^\dagger\right) + 2g_{BL}g_{BR}M_{BR}\text{Tr}\left(Y_u Y_u^\dagger\right) \\
& + \sqrt{6}g_{BL}g_{R}M_{BR}\text{Tr}\left(Y_u Y_u^\dagger\right) + \sqrt{6}g_{BR}g_{RB}M_{BR}\text{Tr}\left(Y_u Y_u^\dagger\right) + g_{BR}^2M_4\text{Tr}\left(Y_u Y_u^\dagger\right) \\
& + \sqrt{6}g_{BR}g_{R}M_4\text{Tr}\left(Y_u Y_u^\dagger\right) + 32g_s^2M_3\text{Tr}\left(Y_u Y_u^\dagger\right) + 3g_{BL}^2M_1\text{Tr}\left(Y_v Y_v^\dagger\right) \\
& - \sqrt{6}g_{BL}g_{RB}M_1\text{Tr}\left(Y_v Y_v^\dagger\right) + 6g_{BL}g_{BR}M_{BR}\text{Tr}\left(Y_v Y_v^\dagger\right) - \sqrt{6}g_{BL}g_{R}M_{BR}\text{Tr}\left(Y_v Y_v^\dagger\right) \\
& - \sqrt{6}g_{BR}g_{RB}M_{BR}\text{Tr}\left(Y_v Y_v^\dagger\right) + 3g_{BR}^2M_4\text{Tr}\left(Y_v Y_v^\dagger\right) - \sqrt{6}g_{BR}g_{R}M_4\text{Tr}\left(Y_v Y_v^\dagger\right) \\
& - 32g_s^2\text{Tr}\left(Y_d^\dagger T_d\right) - g_{BL}^2\text{Tr}\left(Y_d^\dagger T_d\right) - g_{BR}^2\text{Tr}\left(Y_d^\dagger T_d\right) + \sqrt{6}g_{BR}g_{R}\text{Tr}\left(Y_d^\dagger T_d\right) \\
& + \sqrt{6}g_{BL}g_{RB}\text{Tr}\left(Y_d^\dagger T_d\right) - 3g_{BL}^2\text{Tr}\left(Y_e^\dagger T_e\right) - 3g_{BR}^2\text{Tr}\left(Y_e^\dagger T_e\right) - \sqrt{6}g_{BR}g_{R}\text{Tr}\left(Y_e^\dagger T_e\right) \\
& - \sqrt{6}g_{BL}g_{RB}\text{Tr}\left(Y_e^\dagger T_e\right) - 32g_s^2\text{Tr}\left(Y_u^\dagger T_u\right) - g_{BL}^2\text{Tr}\left(Y_u^\dagger T_u\right) - g_{BR}^2\text{Tr}\left(Y_u^\dagger T_u\right) \\
& - \sqrt{6}g_{BR}g_{R}\text{Tr}\left(Y_u^\dagger T_u\right) - \sqrt{6}g_{BL}g_{RB}\text{Tr}\left(Y_u^\dagger T_u\right) - 3g_{BL}^2\text{Tr}\left(Y_v^\dagger T_\nu\right) - 3g_{BR}^2\text{Tr}\left(Y_v^\dagger T_\nu\right) \\
& + \sqrt{6}g_{BR}g_{R}\text{Tr}\left(Y_v^\dagger T_\nu\right) + \sqrt{6}g_{BL}g_{RB}\text{Tr}\left(Y_v^\dagger T_\nu\right) + 36\text{Tr}\left(Y_d Y_d^\dagger T_d Y_d^\dagger\right) + 12\text{Tr}\left(Y_d Y_u^\dagger T_u Y_u^\dagger\right) \\
& + 12\text{Tr}\left(Y_e Y_e^\dagger T_e Y_e^\dagger\right) + 4\text{Tr}\left(Y_e Y_v^\dagger T_\nu Y_e^\dagger\right) + 2\text{Tr}\left(Y_s Y_s^\dagger T_\nu Y_v^\dagger\right) + 12\text{Tr}\left(Y_u Y_d^\dagger T_d Y_u^\dagger\right) \\
& + 36\text{Tr}\left(Y_u Y_u^\dagger T_u Y_u^\dagger\right) + 4\text{Tr}\left(Y_v Y_e^\dagger T_e Y_v^\dagger\right) + 2\text{Tr}\left(Y_v Y_v^\dagger T_s Y_s^\dagger\right) + 12\text{Tr}\left(Y_v Y_v^\dagger T_\nu Y_v^\dagger\right)
\end{aligned} \tag{78}$$

### 3.8 Soft-Breaking Scalar Masses

$$\begin{aligned}
\sigma_{1,1} = & \frac{1}{4}\left(-\sqrt{6}g_{BL}m_\chi^2 + 2g_{RB}m_\chi^2 + \sqrt{6}g_{BL}m_\chi^2 - 2g_{RB}m_\chi^2 - 4g_{RB}m_{H_d}^2 + 4g_{RB}m_{H_u}^2 + (6g_{RB} - \sqrt{6}g_{BL})\text{Tr}\left(m_d^2\right)\right. \\
& \left.+ (2g_{RB} + \sqrt{6}g_{BL})\text{Tr}\left(m_e^2\right) - 2\sqrt{6}g_{BL}\text{Tr}\left(m_l^2\right) + 2\sqrt{6}g_{BL}\text{Tr}\left(m_q^2\right) - \sqrt{6}g_{BL}\text{Tr}\left(m_u^2\right) - 6g_{RB}\text{Tr}\left(m_u^2\right)\right)
\end{aligned}$$

$$+ \sqrt{6}g_{BL}\text{Tr}(m_\nu^2) - 2g_{RB}\text{Tr}(m_\nu^2)) \quad (79)$$

$$\begin{aligned} \sigma_{1,3} = & \frac{1}{4} \left( -\sqrt{6}g_{BR}m_\chi^2 + 2g_{RR}m_\chi^2 + \sqrt{6}g_{BR}m_\chi^2 - 2g_{RR}m_\chi^2 - 4g_{RR}m_{H_d}^2 + 4g_{RR}m_{H_u}^2 + (6g_R - \sqrt{6}g_{BR})\text{Tr}(m_d^2) \right. \\ & + (2g_R + \sqrt{6}g_{BR})\text{Tr}(m_e^2) - 2\sqrt{6}g_{BR}\text{Tr}(m_l^2) + 2\sqrt{6}g_{BR}\text{Tr}(m_q^2) - \sqrt{6}g_{BR}\text{Tr}(m_u^2) - 6g_R\text{Tr}(m_u^2) \\ & \left. + \sqrt{6}g_{BR}\text{Tr}(m_\nu^2) - 2g_R\text{Tr}(m_\nu^2) \right) \quad (80) \end{aligned}$$

$$\begin{aligned} \sigma_{2,11} = & \frac{1}{8} \left( 3g_{BL}^2m_\chi^2 - 2\sqrt{6}g_{BL}g_{RB}m_\chi^2 + 2g_{RB}^2m_\chi^2 + 3g_{BL}^2m_\chi^2 - 2\sqrt{6}g_{BL}g_{RB}m_\chi^2 + 2g_{RB}^2m_\chi^2 + 4g_{RB}^2m_{H_d}^2 \right. \\ & + 4g_{RB}^2m_{H_u}^2 + \left( -2\sqrt{6}g_{BL}g_{RB} + 6g_{RB}^2 + g_{BL}^2 \right)\text{Tr}(m_d^2) + \left( 2g_{RB}^2 + 2\sqrt{6}g_{BL}g_{RB} + 3g_{BL}^2 \right)\text{Tr}(m_e^2) + 6g_{BL}^2\text{Tr}(m_l^2) \\ & + 2g_{BL}^2\text{Tr}(m_q^2) + g_{BL}^2\text{Tr}(m_u^2) + 2\sqrt{6}g_{BL}g_{RB}\text{Tr}(m_u^2) + 6g_{RB}^2\text{Tr}(m_u^2) + 3g_{BL}^2\text{Tr}(m_\nu^2) \\ & \left. - 2\sqrt{6}g_{BL}g_{RB}\text{Tr}(m_\nu^2) + 2g_{RB}^2\text{Tr}(m_\nu^2) \right) \quad (81) \end{aligned}$$

$$\begin{aligned} \sigma_{2,13} = & \frac{1}{8} \left( 3g_{BL}g_{BR}m_\chi^2 - \sqrt{6}g_{BL}g_{RB}m_\chi^2 - \sqrt{6}g_{BR}g_{RB}m_\chi^2 + 2g_{RR}g_{RB}m_\chi^2 + 3g_{BL}g_{BR}m_\chi^2 - \sqrt{6}g_{BL}g_{RB}m_\chi^2 \right. \\ & - \sqrt{6}g_{BR}g_{RB}m_\chi^2 + 2g_{RR}g_{RB}m_\chi^2 + 4g_{RR}g_{RB}m_{H_d}^2 + 4g_{RR}g_{RB}m_{H_u}^2 \\ & + \left( 6g_{RR}g_{RB} + g_{BL}(-\sqrt{6}g_R + g_{BR}) - \sqrt{6}g_{BR}g_{RB} \right)\text{Tr}(m_d^2) \\ & + \left( 2g_{RR}g_{RB} + 3g_{BL}g_{BR} + \sqrt{6}g_{BL}g_R + \sqrt{6}g_{BR}g_{RB} \right)\text{Tr}(m_e^2) + 6g_{BL}g_{BR}\text{Tr}(m_l^2) + 2g_{BL}g_{BR}\text{Tr}(m_q^2) + g_{BL}g_{BR}\text{Tr}(m_u^2) \\ & + \sqrt{6}g_{BL}g_R\text{Tr}(m_u^2) + \sqrt{6}g_{BR}g_{RB}\text{Tr}(m_u^2) + 6g_{RR}g_{RB}\text{Tr}(m_u^2) + 3g_{BL}g_{BR}\text{Tr}(m_\nu^2) - \sqrt{6}g_{BL}g_R\text{Tr}(m_\nu^2) \\ & \left. - \sqrt{6}g_{BR}g_{RB}\text{Tr}(m_\nu^2) + 2g_{RR}g_{RB}\text{Tr}(m_\nu^2) \right) \quad (82) \end{aligned}$$

$$\begin{aligned} \sigma_{3,1} = & \frac{1}{96} \left( -9\sqrt{6}g_{BL}^3m_\chi^2 - 9\sqrt{6}g_{BL}g_{BR}^2m_\chi^2 + 36g_{BL}g_{BR}g_{RR}m_\chi^2 - 6\sqrt{6}g_{BL}g_R^2m_\chi^2 + 54g_{BL}g_{RB}m_\chi^2 \right. \\ & + 18g_{BR}^2g_{RB}m_\chi^2 - 12\sqrt{6}g_{BR}g_{RR}g_{RB}m_\chi^2 + 12g_{RR}^2g_{RB}m_\chi^2 - 18\sqrt{6}g_{BL}g_{RB}^2m_\chi^2 + 12g_{RB}^3m_\chi^2 \\ & + 9\sqrt{6}g_{BL}^3m_\chi^2 + 9\sqrt{6}g_{BL}g_{BR}^2m_\chi^2 - 36g_{BL}g_{BR}g_{RR}m_\chi^2 + 6\sqrt{6}g_{BL}g_R^2m_\chi^2 - 54g_{BL}g_{RB}m_\chi^2 \\ & - 18g_{BR}^2g_{RB}m_\chi^2 + 12\sqrt{6}g_{BR}g_{RR}g_{RB}m_\chi^2 - 12g_{RR}^2g_{RB}m_\chi^2 + 18\sqrt{6}g_{BL}g_{RB}^2m_\chi^2 - 12g_{RB}^3m_\chi^2 \\ & - 72g_L^2g_{RB}m_{H_d}^2 - 24g_R^2g_{RB}m_{H_d}^2 - 24g_{RB}^3m_{H_d}^2 + 72g_L^2g_{RB}m_{H_u}^2 + 24g_R^2g_{RB}m_{H_u}^2 + 24g_{RB}^3m_{H_u}^2 \\ & - \left( \sqrt{6}g_{BL}^3 + 32g_s^2(-6g_{RB} + \sqrt{6}g_{BL}) - 18g_{BL}^2g_{RB} - 6g_{RB}(-2\sqrt{6}g_{BR}g_R + 6(g_R^2 + g_{RB}^2) + g_{BR}^2) \right. \\ & \left. + g_{BL}(-12g_{BR}g_R + 6\sqrt{6}(3g_{RB}^2 + g_R^2) + \sqrt{6}g_{BR}^2) \right)\text{Tr}(m_d^2) \\ & + 3 \left( 3\sqrt{6}g_{BL}^3 + 18g_{BL}^2g_{RB} + 2g_{RB} \left( 2(g_R^2 + g_{RB}^2) + 2\sqrt{6}g_{BR}g_R + 3g_{BR}^2 \right) \right. \\ & \left. + g_{BL} \left( 12g_{BR}g_R + 2\sqrt{6}(3g_{RB}^2 + g_R^2) + 3\sqrt{6}g_{BR}^2 \right) \right)\text{Tr}(m_e^2) \\ & - 18\sqrt{6}g_{BL}^3\text{Tr}(m_l^2) - 18\sqrt{6}g_{BL}g_{BR}^2\text{Tr}(m_l^2) - 36\sqrt{6}g_{BL}g_L^2\text{Tr}(m_l^2) + 64\sqrt{6}g_s^2g_{BL}\text{Tr}(m_q^2) \\ & + 2\sqrt{6}g_{BL}^3\text{Tr}(m_q^2) + 2\sqrt{6}g_{BL}g_{BR}^2\text{Tr}(m_q^2) + 36\sqrt{6}g_{BL}g_L^2\text{Tr}(m_q^2) - 32\sqrt{6}g_s^2g_{BL}\text{Tr}(m_u^2) \\ & \left. - \sqrt{6}g_{BL}^3\text{Tr}(m_u^2) - \sqrt{6}g_{BL}g_{BR}^2\text{Tr}(m_u^2) - 12g_{BL}g_{BR}g_R\text{Tr}(m_u^2) - 6\sqrt{6}g_{BL}g_R^2\text{Tr}(m_u^2) \right) \end{aligned}$$

$$\begin{aligned}
& -192g_s^2g_{RB}\text{Tr}(m_u^2) - 18g_{BL}^2g_{RB}\text{Tr}(m_u^2) - 6g_{BR}^2g_{RB}\text{Tr}(m_u^2) - 12\sqrt{6}g_{BR}g_{RB}\text{Tr}(m_u^2) \\
& - 36g_R^2g_{RB}\text{Tr}(m_u^2) - 18\sqrt{6}g_{BL}g_{RB}^2\text{Tr}(m_u^2) - 36g_{RB}^3\text{Tr}(m_u^2) + 9\sqrt{6}g_{BL}^3\text{Tr}(m_\nu^2) \\
& + 9\sqrt{6}g_{BL}g_{BR}^2\text{Tr}(m_\nu^2) - 36g_{BL}g_{BR}g_R\text{Tr}(m_\nu^2) + 6\sqrt{6}g_{BL}g_R^2\text{Tr}(m_\nu^2) - 54g_{BL}^2g_{RB}\text{Tr}(m_\nu^2) \\
& - 18g_{BR}^2g_{RB}\text{Tr}(m_\nu^2) + 12\sqrt{6}g_{BR}g_{RB}\text{Tr}(m_\nu^2) - 12g_R^2g_{RB}\text{Tr}(m_\nu^2) + 18\sqrt{6}g_{BL}g_{RB}^2\text{Tr}(m_\nu^2) \\
& - 12g_{RB}^3\text{Tr}(m_\nu^2) + 144g_{RB}m_{H_d}^2\text{Tr}(Y_dY_d^\dagger) + 48g_{RB}m_{H_d}^2\text{Tr}(Y_eY_e^\dagger) + 12\sqrt{6}g_{BL}m_\chi^2\text{Tr}(Y_sY_s^\dagger) \\
& - 24g_{RB}m_\chi^2\text{Tr}(Y_sY_s^\dagger) - 144g_{RB}m_{H_u}^2\text{Tr}(Y_uY_u^\dagger) - 48g_{RB}m_{H_u}^2\text{Tr}(Y_vY_v^\dagger) \\
& + 24\sqrt{6}g_{BL}\text{Tr}(Y_dY_d^\dagger m_d^{2*}) - 144g_{RB}\text{Tr}(Y_dY_d^\dagger m_d^{2*}) - 24\sqrt{6}g_{BL}\text{Tr}(Y_d m_q^{2*} Y_d^\dagger) \\
& - 24\sqrt{6}g_{BL}\text{Tr}(Y_eY_e^\dagger m_e^{2*}) - 48g_{RB}\text{Tr}(Y_eY_e^\dagger m_e^{2*}) + 24\sqrt{6}g_{BL}\text{Tr}(Y_e m_l^{2*} Y_e^\dagger) \\
& - 12\sqrt{6}g_{BL}\text{Tr}(Y_sY_s^\dagger m_\nu^{2*}) + 24g_{RB}\text{Tr}(Y_sY_s^\dagger m_\nu^{2*}) + 24\sqrt{6}g_{BL}\text{Tr}(Y_uY_u^\dagger m_u^{2*}) \\
& + 144g_{RB}\text{Tr}(Y_uY_u^\dagger m_u^{2*}) - 24\sqrt{6}g_{BL}\text{Tr}(Y_u m_q^{2*} Y_u^\dagger) - 24\sqrt{6}g_{BL}\text{Tr}(Y_vY_v^\dagger m_\nu^{2*}) \\
& + 48g_{RB}\text{Tr}(Y_vY_v^\dagger m_\nu^{2*}) + 24\sqrt{6}g_{BL}\text{Tr}(Y_v m_l^{2*} Y_v^\dagger)
\end{aligned} \tag{83}$$

$$\sigma_{2,2} = \frac{1}{2} \left( 3\text{Tr}(m_q^2) + m_{H_d}^2 + m_{H_u}^2 + \text{Tr}(m_l^2) \right) \tag{84}$$

$$\begin{aligned}
\sigma_{2,31} = & \frac{1}{8} \left( 3g_{BL}g_{BR}m_\chi^2 - \sqrt{6}g_{BL}g_Rm_\chi^2 - \sqrt{6}g_{BR}g_{RB}m_\chi^2 + 2g_Rg_{RB}m_\chi^2 + 3g_{BL}g_{BR}m_\chi^2 - \sqrt{6}g_{BL}g_Rm_\chi^2 \right. \\
& - \sqrt{6}g_{BR}g_{RB}m_\chi^2 + 2g_Rg_{RB}m_\chi^2 + 4g_Rg_{RB}m_{H_d}^2 + 4g_Rg_{RB}m_{H_u}^2 \\
& + \left( 6g_Rg_{RB} + g_{BL}(-\sqrt{6}g_R + g_{BR}) - \sqrt{6}g_{BR}g_{RB} \right) \text{Tr}(m_d^2) \\
& + \left( 2g_Rg_{RB} + 3g_{BL}g_{BR} + \sqrt{6}g_{BL}g_R + \sqrt{6}g_{BR}g_{RB} \right) \text{Tr}(m_e^2) + 6g_{BL}g_{BR}\text{Tr}(m_l^2) + 2g_{BL}g_{BR}\text{Tr}(m_q^2) + g_{BL}g_{BR}\text{Tr}(m_u^2) \\
& + \sqrt{6}g_{BL}g_R\text{Tr}(m_u^2) + \sqrt{6}g_{BR}g_{RB}\text{Tr}(m_u^2) + 6g_Rg_{RB}\text{Tr}(m_u^2) + 3g_{BL}g_{BR}\text{Tr}(m_\nu^2) - \sqrt{6}g_{BL}g_R\text{Tr}(m_\nu^2) \\
& \left. - \sqrt{6}g_{BR}g_{RB}\text{Tr}(m_\nu^2) + 2g_Rg_{RB}\text{Tr}(m_\nu^2) \right)
\end{aligned} \tag{85}$$

$$\begin{aligned}
\sigma_{2,33} = & \frac{1}{8} \left( 3g_{BR}^2m_\chi^2 - 2\sqrt{6}g_{BR}g_Rm_\chi^2 + 2g_R^2m_\chi^2 + 3g_{BR}^2m_\chi^2 - 2\sqrt{6}g_{BR}g_Rm_\chi^2 + 2g_R^2m_\chi^2 + 4g_R^2m_{H_d}^2 \right. \\
& + 4g_R^2m_{H_u}^2 + \left( -2\sqrt{6}g_{BR}g_R + 6g_R^2 + g_{BR}^2 \right) \text{Tr}(m_d^2) + \left( 2g_R^2 + 2\sqrt{6}g_{BR}g_R + 3g_{BR}^2 \right) \text{Tr}(m_e^2) + 6g_{BR}^2\text{Tr}(m_l^2) \\
& + 2g_{BR}^2\text{Tr}(m_q^2) + g_{BR}^2\text{Tr}(m_u^2) + 2\sqrt{6}g_{BR}g_R\text{Tr}(m_u^2) + 6g_R^2\text{Tr}(m_u^2) + 3g_{BR}^2\text{Tr}(m_\nu^2) \\
& \left. - 2\sqrt{6}g_{BR}g_R\text{Tr}(m_\nu^2) + 2g_R^2\text{Tr}(m_\nu^2) \right)
\end{aligned} \tag{86}$$

$$\begin{aligned}
\sigma_{3,3} = & \frac{1}{96} \left( -9\sqrt{6}g_{BL}g_{BR}m_\chi^2 - 9\sqrt{6}g_{BR}^3m_\chi^2 + 18g_{BL}g_Rm_\chi^2 + 54g_{BR}^2g_Rm_\chi^2 - 18\sqrt{6}g_{BR}g_R^2m_\chi^2 \right. \\
& + 12g_R^3m_\chi^2 + 36g_{BL}g_{BR}g_{RB}m_\chi^2 - 12\sqrt{6}g_{BL}g_Rg_{RB}m_\chi^2 - 6\sqrt{6}g_{BR}g_{RB}^2m_\chi^2 + 12g_Rg_{RB}^2m_\chi^2 \\
& \left. + 9\sqrt{6}g_{BL}g_{BR}m_\chi^2 + 9\sqrt{6}g_{BR}^3m_\chi^2 - 18g_{BL}g_Rm_\chi^2 - 54g_{BR}^2g_Rm_\chi^2 + 18\sqrt{6}g_{BR}g_R^2m_\chi^2 \right)
\end{aligned}$$

$$\begin{aligned}
& -12g_R^3 m_\chi^2 - 36g_{BL}g_{BR}g_{RB}m_\chi^2 + 12\sqrt{6}g_{BL}g_{R}g_{RB}m_\chi^2 + 6\sqrt{6}g_{BR}g_{RB}^2 m_\chi^2 - 12g_R g_{RB}^2 m_\chi^2 \\
& - 72g_L^2 g_R m_{H_d}^2 - 24g_R^3 m_{H_d}^2 - 24g_R g_{RB}^2 m_{H_d}^2 + 72g_L^2 g_R m_{H_u}^2 + 24g_R^3 m_{H_u}^2 + 24g_R g_{RB}^2 m_{H_u}^2 \\
& - \left(\sqrt{6}g_{BR}^3 + 32g_s^2(-6g_R + \sqrt{6}g_{BR}) + g_{BL}^2(-6g_R + \sqrt{6}g_{BR}) - 18g_{BR}^2 g_R + 18\sqrt{6}g_{BR}g_R^2 - 36g_R^3\right) \\
& - 12g_{BL}(-\sqrt{6}g_R + g_{BR})g_{RB} + 6\sqrt{6}g_{BR}g_{RB}^2 - 36g_R g_{RB}^2) \text{Tr}(m_d^2) \\
& + 3\left(3\sqrt{6}g_{BR}^3 + 18g_{BR}^2 g_R + 3g_{BL}^2(2g_R + \sqrt{6}g_{BR}) + 4g_{BL}(3g_{BR} + \sqrt{6}g_R)g_{RB} + 4g_R(g_R^2 + g_{RB}^2)\right) \\
& + 2\sqrt{6}g_{BR}(3g_R^2 + g_{RB}^2) \text{Tr}(m_e^2) \\
& - 18\sqrt{6}g_{BL}g_{BR} \text{Tr}(m_l^2) - 18\sqrt{6}g_{BR}^3 \text{Tr}(m_l^2) - 36\sqrt{6}g_{BR}g_L^2 \text{Tr}(m_l^2) + 64\sqrt{6}g_s^2 g_{BR} \text{Tr}(m_q^2) \\
& + 2\sqrt{6}g_{BL}g_{BR} \text{Tr}(m_q^2) + 2\sqrt{6}g_{BR}^3 \text{Tr}(m_q^2) + 36\sqrt{6}g_{BR}g_L^2 \text{Tr}(m_q^2) - 32\sqrt{6}g_s^2 g_{BR} \text{Tr}(m_u^2) \\
& - \sqrt{6}g_{BL}g_{BR} \text{Tr}(m_u^2) - \sqrt{6}g_{BR}^3 \text{Tr}(m_u^2) - 192g_s^2 g_R \text{Tr}(m_u^2) - 6g_{BL}^2 g_R \text{Tr}(m_u^2) \\
& - 18g_{BR}^2 g_R \text{Tr}(m_u^2) - 18\sqrt{6}g_{BR}g_R^2 \text{Tr}(m_u^2) - 36g_R^3 \text{Tr}(m_u^2) - 12g_{BL}g_{BR}g_{RB} \text{Tr}(m_u^2) \\
& - 12\sqrt{6}g_{BL}g_{R}g_{RB} \text{Tr}(m_u^2) - 6\sqrt{6}g_{BR}g_{RB}^2 \text{Tr}(m_u^2) - 36g_R g_{RB}^2 \text{Tr}(m_u^2) + 9\sqrt{6}g_{BL}g_{BR} \text{Tr}(m_\nu^2) \\
& + 9\sqrt{6}g_{BR}^3 \text{Tr}(m_\nu^2) - 18g_{BL}^2 g_R \text{Tr}(m_\nu^2) - 54g_{BR}^2 g_R \text{Tr}(m_\nu^2) + 18\sqrt{6}g_{BR}g_R^2 \text{Tr}(m_\nu^2) - 12g_R^3 \text{Tr}(m_\nu^2) \\
& - 36g_{BL}g_{BR}g_{RB} \text{Tr}(m_\nu^2) + 12\sqrt{6}g_{BL}g_{R}g_{RB} \text{Tr}(m_\nu^2) + 6\sqrt{6}g_{BR}g_{RB}^2 \text{Tr}(m_\nu^2) - 12g_R g_{RB}^2 \text{Tr}(m_\nu^2) \\
& + 144g_R m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger) + 48g_R m_{H_d}^2 \text{Tr}(Y_e Y_e^\dagger) + 12\sqrt{6}g_{BR} m_\chi^2 \text{Tr}(Y_s Y_s^\dagger) - 24g_R m_\chi^2 \text{Tr}(Y_s Y_s^\dagger) \\
& - 144g_R m_{H_u}^2 \text{Tr}(Y_u Y_u^\dagger) - 48g_R m_{H_u}^2 \text{Tr}(Y_v Y_v^\dagger) + 24\sqrt{6}g_{BR} \text{Tr}(Y_d Y_d^\dagger m_d^{2*}) \\
& - 144g_R \text{Tr}(Y_d Y_d^\dagger m_d^{2*}) - 24\sqrt{6}g_{BR} \text{Tr}(Y_d m_q^{2*} Y_d^\dagger) - 24\sqrt{6}g_{BR} \text{Tr}(Y_e Y_e^\dagger m_e^{2*}) \\
& - 48g_R \text{Tr}(Y_e Y_e^\dagger m_e^{2*}) + 24\sqrt{6}g_{BR} \text{Tr}(Y_e m_l^{2*} Y_e^\dagger) - 12\sqrt{6}g_{BR} \text{Tr}(Y_s Y_s^\dagger m_\nu^{2*}) \\
& + 24g_R \text{Tr}(Y_s Y_s^\dagger m_\nu^{2*}) + 24\sqrt{6}g_{BR} \text{Tr}(Y_u Y_u^\dagger m_u^{2*}) + 144g_R \text{Tr}(Y_u Y_u^\dagger m_u^{2*}) \\
& - 24\sqrt{6}g_{BR} \text{Tr}(Y_u m_q^{2*} Y_u^\dagger) - 24\sqrt{6}g_{BR} \text{Tr}(Y_v Y_v^\dagger m_\nu^{2*}) + 48g_R \text{Tr}(Y_v Y_v^\dagger m_\nu^{2*}) \\
& + 24\sqrt{6}g_{BR} \text{Tr}(Y_v m_l^{2*} Y_v^\dagger) \tag{87}
\end{aligned}$$

$$\sigma_{2,4} = \frac{1}{2} \left( 2\text{Tr}(m_q^2) + \text{Tr}(m_d^2) + \text{Tr}(m_u^2) \right) \tag{88}$$

$$\begin{aligned}
\beta_{m_q^2}^{(1)} &= \frac{1}{6} \left( -2g_{BR}^2 \mathbf{1}|M_4|^2 - 64g_s^2 \mathbf{1}|M_3|^2 - 36g_L^2 \mathbf{1}|M_2|^2 - 2g_{BL}(g_{BL}M_1 + g_{BR}M_{BR}) \mathbf{1}M_1^* \right. \\
& - 2(g_{BL}^2 M_{BR} + g_{BL}g_{BR}(M_1 + M_4) + g_{BR}^2 M_{BR}) \mathbf{1}M_{BR}^* - 2g_{BL}g_{BR}M_{BR} \mathbf{1}M_4^* + 12m_{H_d}^2 Y_d^\dagger Y_d + 12m_{H_u}^2 Y_u^\dagger Y_u \\
& + 12T_d^\dagger T_d + 12T_u^\dagger T_u + 6m_q^2 Y_d^\dagger Y_d + 6m_q^2 Y_u^\dagger Y_u + 12Y_d^\dagger m_d^2 Y_d + 6Y_d^\dagger Y_d m_q^2 \\
& \left. + 12Y_u^\dagger m_u^2 Y_u + 6Y_u^\dagger Y_u m_q^2 + \sqrt{6}g_{BL} \mathbf{1}\sigma_{1,1} + \sqrt{6}g_{BR} \mathbf{1}\sigma_{1,3} \right) \tag{89}
\end{aligned}$$

$$\begin{aligned}
\beta_{m_d^2}^{(2)} = & + \frac{16}{9} g_s^2 g_{BR}^2 \mathbf{1} |M_4|^2 + \frac{41}{9} g_{BL}^2 g_{BR}^2 \mathbf{1} |M_4|^2 + \frac{41}{6} g_{BR}^4 \mathbf{1} |M_4|^2 + g_{BR}^2 g_L^2 \mathbf{1} |M_4|^2 \\
& - \frac{1}{\sqrt{6}} g_{BL}^2 g_{BR} g_R \mathbf{1} |M_4|^2 - \sqrt{\frac{3}{2}} g_{BR}^3 g_R \mathbf{1} |M_4|^2 + \frac{15}{2} g_{BR}^2 g_R^2 \mathbf{1} |M_4|^2 - \frac{1}{\sqrt{6}} g_{BL} g_{BR}^2 g_{RB} \mathbf{1} |M_4|^2 \\
& + 5 g_{BL} g_{BR} g_R g_{RB} \mathbf{1} |M_4|^2 - \frac{128}{3} g_s^4 \mathbf{1} |M_3|^2 + \frac{16}{9} g_s^2 g_{BL}^2 \mathbf{1} |M_3|^2 + \frac{16}{9} g_s^2 g_{BR}^2 \mathbf{1} |M_3|^2 \\
& + 32 g_s^2 g_L^2 \mathbf{1} |M_3|^2 + 32 g_s^2 g_L^2 \mathbf{1} |M_2|^2 + g_{BL}^2 g_L^2 \mathbf{1} |M_2|^2 + g_{BR}^2 g_L^2 \mathbf{1} |M_2|^2 + 33 g_L^4 \mathbf{1} |M_2|^2 \\
& + \frac{41}{18} g_{BL}^2 g_{BR}^2 M_1 \mathbf{1} M_4^* - \frac{1}{2} \frac{1}{\sqrt{6}} g_{BL}^2 g_{BR} g_R M_1 \mathbf{1} M_4^* - \frac{1}{2} \frac{1}{\sqrt{6}} g_{BL} g_{BR}^2 g_{RB} M_1 \mathbf{1} M_4^* \\
& + \frac{5}{2} g_{BL} g_{BR} g_R g_{RB} M_1 \mathbf{1} M_4^* + \frac{16}{9} g_s^2 g_{BL} g_{BR} M_{BR} \mathbf{1} M_4^* + \frac{41}{9} g_{BL}^3 g_{BR} M_{BR} \mathbf{1} M_4^* + \frac{82}{9} g_{BL} g_{BR}^3 M_{BR} \mathbf{1} M_4^* \\
& + g_{BL} g_{BR} g_L^2 M_{BR} \mathbf{1} M_4^* - \frac{1}{2} \frac{1}{\sqrt{6}} g_{BL}^3 g_R M_{BR} \mathbf{1} M_4^* - \sqrt{\frac{3}{2}} g_{BL} g_{BR}^2 g_R M_{BR} \mathbf{1} M_4^* + 5 g_{BL} g_{BR} g_R^2 M_{BR} \mathbf{1} M_4^* \\
& - \frac{1}{2} \sqrt{\frac{3}{2}} g_{BL}^2 g_{BR} g_{RB} M_{BR} \mathbf{1} M_4^* - \frac{1}{\sqrt{6}} g_{BR}^3 g_{RB} M_{BR} \mathbf{1} M_4^* + \frac{5}{2} g_{BL}^2 g_R g_{RB} M_{BR} \mathbf{1} M_4^* + 5 g_{BR}^2 g_R g_{RB} M_{BR} \mathbf{1} M_4^* \\
& + \frac{5}{2} g_{BL} g_{BR} g_{RB}^2 M_{BR} \mathbf{1} M_4^* + \frac{8}{9} g_s^2 g_{BR}^2 M_3 \mathbf{1} M_4^* + \frac{1}{2} g_{BR}^2 g_L^2 M_2 \mathbf{1} M_4^* + \frac{8}{9} g_s^2 g_{BL}^2 M_1 \mathbf{1} M_3^* \\
& + \frac{16}{9} g_s^2 g_{BL} g_{BR} M_{BR} \mathbf{1} M_3^* + \frac{8}{9} g_s^2 g_{BR}^2 M_4 \mathbf{1} M_3^* + 16 g_s^2 g_L^2 M_2 \mathbf{1} M_3^* + \frac{1}{2} g_{BL}^2 g_L^2 M_1 \mathbf{1} M_2^* \\
& + g_{BL} g_{BR} g_L^2 M_{BR} \mathbf{1} M_2^* + \frac{1}{2} g_{BR}^2 g_L^2 M_4 \mathbf{1} M_2^* + 16 g_s^2 g_L^2 M_3 \mathbf{1} M_2^* - \sqrt{\frac{2}{3}} g_{BR} g_R m_{H_d}^2 Y_d^\dagger Y_d \\
& + 2 g_R^2 m_{H_d}^2 Y_d^\dagger Y_d - \sqrt{\frac{2}{3}} g_{BL} g_{RB} m_{H_d}^2 Y_d^\dagger Y_d + 2 g_{RB}^2 m_{H_d}^2 Y_d^\dagger Y_d \\
& - 2 \sqrt{\frac{2}{3}} g_{BR} g_R |M_4|^2 Y_d^\dagger Y_d + 4 g_R^2 |M_4|^2 Y_d^\dagger Y_d - \sqrt{\frac{2}{3}} g_{BL} g_R M_{BR} M_4^* Y_d^\dagger Y_d \\
& - \sqrt{\frac{2}{3}} g_{BR} g_{RB} M_{BR} M_4^* Y_d^\dagger Y_d + 4 g_R g_{RB} M_{BR} M_4^* Y_d^\dagger Y_d + \sqrt{\frac{2}{3}} g_{BR} g_R M_4^* Y_d^\dagger T_d \\
& - 2 g_R^2 M_4^* Y_d^\dagger T_d + \sqrt{\frac{2}{3}} g_{BR} g_R m_{H_u}^2 Y_u^\dagger Y_u + 2 g_R^2 m_{H_u}^2 Y_u^\dagger Y_u + \sqrt{\frac{2}{3}} g_{BL} g_{RB} m_{H_u}^2 Y_u^\dagger Y_u \\
& + 2 g_{RB}^2 m_{H_u}^2 Y_u^\dagger Y_u + 2 \sqrt{\frac{2}{3}} g_{BR} g_R |M_4|^2 Y_u^\dagger Y_u + 4 g_R^2 |M_4|^2 Y_u^\dagger Y_u \\
& + \sqrt{\frac{2}{3}} g_{BL} g_R M_{BR} M_4^* Y_u^\dagger Y_u + \sqrt{\frac{2}{3}} g_{BR} g_{RB} M_{BR} M_4^* Y_u^\dagger Y_u + 4 g_R g_{RB} M_{BR} M_4^* Y_u^\dagger Y_u \\
& - \sqrt{\frac{2}{3}} g_{BR} g_R M_4^* Y_u^\dagger T_u - 2 g_R^2 M_4^* Y_u^\dagger T_u \\
& + \frac{1}{36} M_{BR}^* \left( (164 g_{BL}^4 M_{BR} + g_{BL}^3 (164 g_{BR} (2M_1 + M_4) - 3\sqrt{6} (2g_R M_1 + 4g_{RB} M_{BR} + g_R M_4))) \right) \\
& + g_{BL}^2 \left( 18 \left( 2 \left( 5g_{RB}^2 + g_L^2 \right) M_{BR} + 5g_R^2 M_{BR} + 5g_R g_{RB} (2M_1 + M_4) \right) - 3\sqrt{6} g_{BR} \left( 3g_{RB} (2M_1 + M_4) + 8g_R M_{BR} \right) + 656 g_{BR}^2 M_{BR} \right) \\
& + g_{BR}^2 \left( 164 g_{BR}^2 M_{BR} + 18 \left( 10g_R^2 M_{BR} + \left( 2g_L^2 + 5g_{RB}^2 \right) M_{BR} + 5g_R g_{RB} (2M_4 + M_1) \right) - 3\sqrt{6} g_{BR} \left( 4g_R M_{BR} + g_{RB} (2M_4 + M_1) \right) \right)
\end{aligned}$$



$$\begin{aligned}
& + 64g_s^2 \left( g_{BL}^2 M_{BR} + g_{BL} g_{BR} (M_1 + M_4 + M_3) + g_{BR}^2 M_{BR} \right) \\
& + g_{BL} g_{BR} \left( 164g_{BR}^2 (2M_4 + M_1) - 3\sqrt{6}g_{BR} \left( 3g_R (2M_4 + M_1) + 8g_{RB} M_{BR} \right) \right. \\
& + 18 \left( 2g_L^2 (M_1 + M_4 + M_2) + 5 \left( 6g_R g_{RB} M_{BR} + g_R^2 (2M_4 + M_1) + g_{RB}^2 (2M_1 + M_4) \right) \right) \left. \right) \mathbf{1} \\
& - 12 \left( \left( -12 \left( g_R^2 M_{BR} + g_{RB}^2 M_{BR} + g_R g_{RB} (M_1 + M_4) \right) + \sqrt{6}g_{BL} (2g_{RB} M_{BR} + g_R (M_1 + M_4)) + \sqrt{6}g_{BR} (2g_R M_{BR} + g_{RB} (M_1 + M_4)) \right. \right. \\
& - \sqrt{6}g_{BL} g_R Y_d^\dagger T_d - \sqrt{6}g_{BR} g_{RB} Y_d^\dagger T_d + 12g_R g_{RB} Y_d^\dagger T_d \\
& - \sqrt{6}g_{BL} g_R M_1 Y_u^\dagger Y_u - \sqrt{6}g_{BR} g_{RB} M_1 Y_u^\dagger Y_u - 12g_R g_{RB} M_1 Y_u^\dagger Y_u \\
& - 2\sqrt{6}g_{BR} g_R M_{BR} Y_u^\dagger Y_u - 12g_R^2 M_{BR} Y_u^\dagger Y_u - 2\sqrt{6}g_{BL} g_{RB} M_{BR} Y_u^\dagger Y_u \\
& - 12g_{RB}^2 M_{BR} Y_u^\dagger Y_u - \sqrt{6}g_{BL} g_R M_4 Y_u^\dagger Y_u - \sqrt{6}g_{BR} g_{RB} M_4 Y_u^\dagger Y_u \\
& \left. \left. - 12g_R g_{RB} M_4 Y_u^\dagger Y_u + \sqrt{6}g_{BL} g_R Y_u^\dagger T_u + \sqrt{6}g_{BR} g_{RB} Y_u^\dagger T_u + 12g_R g_{RB} Y_u^\dagger T_u \right) \right) \\
& + \frac{1}{36} M_1^* \left( \left( 246g_{BL}^4 M_1 - 3g_{BR}^2 \left( -30g_R + \sqrt{6}g_{BR} \right) g_{RB} M_{BR} - 2g_{BL}^3 \left( -164g_{BR} M_{BR} + 3\sqrt{6}g_R M_{BR} + 9\sqrt{6}g_{RB} M_1 \right) \right. \right. \\
& + g_{BL} g_{BR} \left( 164g_{BR}^2 M_{BR} + 18 \left( 2 \left( 5g_{RB}^2 + g_L^2 \right) M_{BR} + 5g_R^2 M_{BR} + 5g_R g_{RB} (2M_1 + M_4) \right) - 3\sqrt{6}g_{BR} \left( 3g_R M_{BR} + g_{RB} (2M_1 + M_4) \right) \right. \\
& + 32g_s^2 g_{BL} \left( 2g_{BR} M_{BR} + g_{BL} (2M_1 + M_3) \right) \\
& + g_{BL}^2 \left( 18 \left( 5g_{RB} (2g_R M_{BR} + 3g_{RB} M_1) + g_L^2 (2M_1 + M_2) \right) - 3\sqrt{6}g_{BR} \left( 6g_{RB} M_{BR} + g_R (2M_1 + M_4) \right) + 82g_{BR}^2 (2M_1 + M_4) \right) \left. \right) \\
& - 12 \left( \left( g_{RB} \left( -12g_{RB} M_1 - 12g_R M_{BR} + \sqrt{6}g_{BR} M_{BR} \right) + \sqrt{6}g_{BL} (2g_{RB} M_1 + g_R M_{BR}) \right) Y_d^\dagger Y_d \right. \\
& + g_{RB} \left( 6g_{RB} - \sqrt{6}g_{BL} \right) Y_d^\dagger T_d - 2\sqrt{6}g_{BL} g_{RB} M_1 Y_u^\dagger Y_u - 12g_{RB}^2 M_1 Y_u^\dagger Y_u \\
& - \sqrt{6}g_{BL} g_R M_{BR} Y_u^\dagger Y_u - \sqrt{6}g_{BR} g_{RB} M_{BR} Y_u^\dagger Y_u - 12g_R g_{RB} M_{BR} Y_u^\dagger Y_u \\
& \left. \left. + \sqrt{6}g_{BL} g_{RB} Y_u^\dagger T_u + 6g_{RB}^2 Y_u^\dagger T_u \right) \right) \\
& + \sqrt{\frac{2}{3}} g_{BL} g_{RB} M_1 T_d^\dagger Y_d - 2g_{RB}^2 M_1 T_d^\dagger Y_d + \sqrt{\frac{2}{3}} g_{BL} g_R M_{BR} T_d^\dagger Y_d + \sqrt{\frac{2}{3}} g_{BR} g_{RB} M_{BR} T_d^\dagger Y_d \\
& - 4g_R g_{RB} M_{BR} T_d^\dagger Y_d + \sqrt{\frac{2}{3}} g_{BR} g_R M_4 T_d^\dagger Y_d - 2g_R^2 M_4 T_d^\dagger Y_d - \sqrt{\frac{2}{3}} g_{BR} g_R T_d^\dagger T_d \\
& + 2g_R^2 T_d^\dagger T_d - \sqrt{\frac{2}{3}} g_{BL} g_{RB} T_d^\dagger T_d + 2g_{RB}^2 T_d^\dagger T_d - \sqrt{\frac{2}{3}} g_{BL} g_{RB} M_1 T_u^\dagger Y_u \\
& - 2g_{RB}^2 M_1 T_u^\dagger Y_u - \sqrt{\frac{2}{3}} g_{BL} g_R M_{BR} T_u^\dagger Y_u - \sqrt{\frac{2}{3}} g_{BR} g_{RB} M_{BR} T_u^\dagger Y_u - 4g_R g_{RB} M_{BR} T_u^\dagger Y_u \\
& - \sqrt{\frac{2}{3}} g_{BR} g_R M_4 T_u^\dagger Y_u - 2g_R^2 M_4 T_u^\dagger Y_u + \sqrt{\frac{2}{3}} g_{BR} g_R T_u^\dagger T_u + 2g_R^2 T_u^\dagger T_u \\
& + \sqrt{\frac{2}{3}} g_{BL} g_{RB} T_u^\dagger T_u + 2g_{RB}^2 T_u^\dagger T_u - \frac{1}{\sqrt{6}} g_{BR} g_R m_q^2 Y_d^\dagger Y_d + g_R^2 m_q^2 Y_d^\dagger Y_d \\
& - \frac{1}{\sqrt{6}} g_{BL} g_{RB} m_q^2 Y_d^\dagger Y_d + g_{RB}^2 m_q^2 Y_d^\dagger Y_d + \frac{1}{\sqrt{6}} g_{BR} g_R m_q^2 Y_u^\dagger Y_u
\end{aligned}$$

$$\begin{aligned}
& + g_R^2 m_q^2 Y_u^\dagger Y_u + \frac{1}{\sqrt{6}} g_{BL} g_{RB} m_q^2 Y_u^\dagger Y_u + g_{RB}^2 m_q^2 Y_u^\dagger Y_u - \sqrt{\frac{2}{3}} g_{BR} g_R Y_d^\dagger m_d^2 Y_d \\
& + 2g_R^2 Y_d^\dagger m_d^2 Y_d - \sqrt{\frac{2}{3}} g_{BL} g_{RB} Y_d^\dagger m_d^2 Y_d + 2g_{RB}^2 Y_d^\dagger m_d^2 Y_d \\
& - \frac{1}{\sqrt{6}} g_{BR} g_R Y_d^\dagger Y_d m_q^2 + g_R^2 Y_d^\dagger Y_d m_q^2 - \frac{1}{\sqrt{6}} g_{BL} g_{RB} Y_d^\dagger Y_d m_q^2 \\
& + g_{RB}^2 Y_d^\dagger Y_d m_q^2 + \sqrt{\frac{2}{3}} g_{BR} g_R Y_u^\dagger m_u^2 Y_u + 2g_R^2 Y_u^\dagger m_u^2 Y_u + \sqrt{\frac{2}{3}} g_{BL} g_{RB} Y_u^\dagger m_u^2 Y_u \\
& + 2g_{RB}^2 Y_u^\dagger m_u^2 Y_u + \frac{1}{\sqrt{6}} g_{BR} g_R Y_u^\dagger Y_u m_q^2 + g_R^2 Y_u^\dagger Y_u m_q^2 \\
& + \frac{1}{\sqrt{6}} g_{BL} g_{RB} Y_u^\dagger Y_u m_q^2 + g_{RB}^2 Y_u^\dagger Y_u m_q^2 - 8m_{H_d}^2 Y_d^\dagger Y_d Y_d^\dagger Y_d - 4Y_d^\dagger Y_d T_d^\dagger T_d \\
& - 4Y_d^\dagger T_d T_d^\dagger Y_d - 8m_{H_u}^2 Y_u^\dagger Y_u Y_u^\dagger Y_u - 4Y_u^\dagger Y_u T_u^\dagger T_u - 4Y_u^\dagger T_u T_u^\dagger Y_u \\
& - 4T_d^\dagger Y_d Y_d^\dagger T_d - 4T_d^\dagger T_d Y_d^\dagger Y_d - 4T_u^\dagger Y_u Y_u^\dagger T_u - 4T_u^\dagger T_u Y_u^\dagger Y_u \\
& - 2m_q^2 Y_d^\dagger Y_d Y_d^\dagger Y_d - 2m_q^2 Y_u^\dagger Y_u Y_u^\dagger Y_u - 4Y_d^\dagger m_d^2 Y_d Y_d^\dagger Y_d - 4Y_d^\dagger Y_d m_q^2 Y_d^\dagger Y_d \\
& - 4Y_d^\dagger Y_d Y_d^\dagger m_d^2 Y_d - 2Y_d^\dagger Y_d Y_d^\dagger Y_d m_q^2 - 4Y_u^\dagger m_u^2 Y_u Y_u^\dagger Y_u - 4Y_u^\dagger Y_u m_q^2 Y_u^\dagger Y_u \\
& - 4Y_u^\dagger Y_u Y_u^\dagger m_u^2 Y_u - 2Y_u^\dagger Y_u Y_u^\dagger Y_u m_q^2 + 6g_L^4 \mathbf{1}\sigma_{2,2} + \frac{32}{3} g_s^4 \mathbf{1}\sigma_{2,4} + \frac{1}{3} g_{BL}^2 \mathbf{1}\sigma_{2,11} + \frac{1}{3} g_{BL} g_{BR} \mathbf{1}\sigma_{2,13} + \frac{1}{3} g_{BL} g_{BR} \mathbf{1}\sigma_{2,31} \\
& + \frac{1}{3} g_{BR}^2 \mathbf{1}\sigma_{2,33} + 2\sqrt{\frac{2}{3}} g_{BL} \mathbf{1}\sigma_{3,1} + 2\sqrt{\frac{2}{3}} g_{BR} \mathbf{1}\sigma_{3,3} - 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_v Y_v^\dagger) - 2T_u^\dagger T_u \text{Tr}(Y_v Y_v^\dagger) \\
& - m_q^2 Y_u^\dagger Y_u \text{Tr}(Y_v Y_v^\dagger) - 2Y_u^\dagger m_u^2 Y_u \text{Tr}(Y_v Y_v^\dagger) - Y_u^\dagger Y_u m_q^2 \text{Tr}(Y_v Y_v^\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_v^\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_\nu^* T_\nu^T) - 2Y_u^\dagger T_u \text{Tr}(T_\nu^* Y_\nu^T) - 2Y_u^\dagger Y_u \text{Tr}(T_\nu^* T_\nu^T) \\
& - 6Y_d^\dagger Y_d \text{Tr}(m_d^2 Y_d Y_d^\dagger) - 2Y_d^\dagger Y_d \text{Tr}(m_e^2 Y_e Y_e^\dagger) - 2Y_d^\dagger Y_d \text{Tr}(m_l^2 Y_e^\dagger Y_e) \\
& - 2Y_u^\dagger Y_u \text{Tr}(m_l^2 Y_\nu^\dagger Y_\nu) - 6Y_d^\dagger Y_d \text{Tr}(m_q^2 Y_d^\dagger Y_d) - 6Y_u^\dagger Y_u \text{Tr}(m_q^2 Y_u^\dagger Y_u)
\end{aligned}$$

$$-6Y_u^\dagger Y_u \text{Tr}(m_u^2 Y_u Y_u^\dagger) - 2Y_u^\dagger Y_u \text{Tr}(m_\nu^2 Y_\nu Y_\nu^\dagger) \quad (90)$$

$$\begin{aligned} \beta_{m_l^2}^{(1)} = & -3g_{BR}^2 \mathbf{1}|M_4|^2 - 6g_L^2 \mathbf{1}|M_2|^2 - 3g_{BL} \left( g_{BL}M_1 + g_{BR}M_{BR} \right) \mathbf{1}M_1^* - 3 \left( g_{BL}^2 M_{BR} + g_{BL}g_{BR} \left( M_1 + M_4 \right) + g_{BR}^2 M_{BR} \right) \mathbf{1}M_{BR}^* \\ & - 3g_{BL}g_{BR}M_{BR} \mathbf{1}M_4^* + 2m_{H_d}^2 Y_e^\dagger Y_e + 2m_{H_u}^2 Y_\nu^\dagger Y_\nu + 2T_e^\dagger T_e + 2T_\nu^\dagger T_\nu + m_l^2 Y_e^\dagger Y_e \\ & + m_l^2 Y_\nu^\dagger Y_\nu + 2Y_e^\dagger m_e^2 Y_e + Y_e^\dagger Y_e m_l^2 + 2Y_\nu^\dagger m_\nu^2 Y_\nu + Y_\nu^\dagger Y_\nu m_l^2 - \sqrt{\frac{3}{2}} g_{BL} \mathbf{1}\sigma_{1,1} \\ & - \sqrt{\frac{3}{2}} g_{BR} \mathbf{1}\sigma_{1,3} \end{aligned} \quad (91)$$

$$\begin{aligned} \beta_{m_l^2}^{(2)} = & +45g_{BL}^2 g_{BR}^2 \mathbf{1}|M_4|^2 + \frac{135}{2} g_{BR}^4 \mathbf{1}|M_4|^2 + 9g_{BR}^2 g_L^2 \mathbf{1}|M_4|^2 - 3\sqrt{\frac{3}{2}} g_{BL}^2 g_{BR} g_R \mathbf{1}|M_4|^2 \\ & - 9\sqrt{\frac{3}{2}} g_{BR}^3 g_R \mathbf{1}|M_4|^2 + \frac{135}{2} g_{BR}^2 g_R^2 \mathbf{1}|M_4|^2 - 3\sqrt{\frac{3}{2}} g_{BL} g_{BR}^2 g_{RB} \mathbf{1}|M_4|^2 + 45g_{BL} g_{BR} g_R g_{RB} \mathbf{1}|M_4|^2 \\ & + 9g_{BL}^2 g_L^2 \mathbf{1}|M_2|^2 + 9g_{BR}^2 g_L^2 \mathbf{1}|M_2|^2 + 33g_L^4 \mathbf{1}|M_2|^2 + \frac{45}{2} g_{BL}^2 g_{BR}^2 M_1 \mathbf{1}M_4^* \\ & - \frac{3}{2} \sqrt{\frac{3}{2}} g_{BL}^2 g_{BR} g_R M_1 \mathbf{1}M_4^* - \frac{3}{2} \sqrt{\frac{3}{2}} g_{BL} g_{BR}^2 g_{RB} M_1 \mathbf{1}M_4^* + \frac{45}{2} g_{BL} g_{BR} g_R g_{RB} M_1 \mathbf{1}M_4^* + 45g_{BL}^3 g_{BR} M_{BR} \mathbf{1}M_4^* \\ & + 90g_{BL} g_{BR}^3 M_{BR} \mathbf{1}M_4^* + 9g_{BL} g_{BR} g_L^2 M_{BR} \mathbf{1}M_4^* - \frac{3}{2} \sqrt{\frac{3}{2}} g_{BL}^3 g_R M_{BR} \mathbf{1}M_4^* - 9\sqrt{\frac{3}{2}} g_{BL} g_{BR}^2 g_R M_{BR} \mathbf{1}M_4^* \\ & + 45g_{BL} g_{BR} g_R^2 M_{BR} \mathbf{1}M_4^* - \frac{9}{2} \sqrt{\frac{3}{2}} g_{BL}^2 g_{BR} g_{RB} M_{BR} \mathbf{1}M_4^* - 3\sqrt{\frac{3}{2}} g_{BR}^3 g_{RB} M_{BR} \mathbf{1}M_4^* + \frac{45}{2} g_{BL}^2 g_R g_{RB} M_{BR} \mathbf{1}M_4^* \\ & + 45g_{BR}^2 g_R g_{RB} M_{BR} \mathbf{1}M_4^* + \frac{45}{2} g_{BL} g_{BR} g_{RB}^2 M_{BR} \mathbf{1}M_4^* + \frac{9}{2} g_{BR}^2 g_L^2 M_2 \mathbf{1}M_4^* + \frac{9}{2} g_{BL}^2 g_L^2 M_1 \mathbf{1}M_2^* \\ & + 9g_{BL} g_{BR} g_L^2 M_{BR} \mathbf{1}M_2^* + \frac{9}{2} g_{BR}^2 g_L^2 M_4 \mathbf{1}M_2^* + \sqrt{6} g_{BR} g_R m_{H_d}^2 Y_e^\dagger Y_e + 2g_R^2 m_{H_d}^2 Y_e^\dagger Y_e \\ & + \sqrt{6} g_{BL} g_{RB} m_{H_d}^2 Y_e^\dagger Y_e + 2g_{RB}^2 m_{H_d}^2 Y_e^\dagger Y_e + 2\sqrt{6} g_{BR} g_R |M_4|^2 Y_e^\dagger Y_e \\ & + 4g_R^2 |M_4|^2 Y_e^\dagger Y_e + \sqrt{6} g_{BL} g_R M_{BR} M_4^* Y_e^\dagger Y_e + \sqrt{6} g_{BR} g_{RB} M_{BR} M_4^* Y_e^\dagger Y_e \\ & + 4g_R g_{RB} M_{BR} M_4^* Y_e^\dagger Y_e - \sqrt{6} g_{BR} g_R M_4^* Y_e^\dagger T_e - 2g_R^2 M_4^* Y_e^\dagger T_e \\ & - \sqrt{6} g_{BR} g_R m_{H_u}^2 Y_\nu^\dagger Y_\nu + 2g_R^2 m_{H_u}^2 Y_\nu^\dagger Y_\nu - \sqrt{6} g_{BL} g_{RB} m_{H_u}^2 Y_\nu^\dagger Y_\nu \\ & + 2g_{RB}^2 m_{H_u}^2 Y_\nu^\dagger Y_\nu - 2\sqrt{6} g_{BR} g_R |M_4|^2 Y_\nu^\dagger Y_\nu + 4g_R^2 |M_4|^2 Y_\nu^\dagger Y_\nu \\ & - \sqrt{6} g_{BL} g_R M_{BR} M_4^* Y_\nu^\dagger Y_\nu - \sqrt{6} g_{BR} g_{RB} M_{BR} M_4^* Y_\nu^\dagger Y_\nu + 4g_R g_{RB} M_{BR} M_4^* Y_\nu^\dagger Y_\nu \\ & + \sqrt{6} g_{BR} g_R M_4^* Y_\nu^\dagger T_\nu - 2g_R^2 M_4^* Y_\nu^\dagger T_\nu \\ & + \frac{1}{4} M_{BR}^* \left( 3 \left( 60g_{BL}^4 M_{BR} + g_{BL}^3 \left( 60g_{BR} \left( 2M_1 + M_4 \right) - \sqrt{6} \left( 2g_R M_1 + 4g_{RB} M_{BR} + g_R M_4 \right) \right) \right) \right. \\ & + g_{BL}^2 \left( 240g_{BR}^2 M_{BR} + 6 \left( 2 \left( 5g_{RB}^2 + g_L^2 \right) M_{BR} + 5g_R^2 M_{BR} + 5g_R g_{RB} \left( 2M_1 + M_4 \right) \right) - \sqrt{6} g_{BR} \left( 3g_{RB} \left( 2M_1 + M_4 \right) + 8g_R M_{BR} \right) \right) \\ & + g_{BR}^2 \left( 60g_{BR}^2 M_{BR} + 6 \left( 10g_R^2 M_{BR} + \left( 2g_L^2 + 5g_{RB}^2 \right) M_{BR} + 5g_R g_{RB} \left( 2M_4 + M_1 \right) \right) - \sqrt{6} g_{BR} \left( 4g_R M_{BR} + g_{RB} \left( 2M_4 + M_1 \right) \right) \right) \\ & \left. + g_{BL} g_{BR} \left( 60g_{BR}^2 \left( 2M_4 + M_1 \right) - \sqrt{6} g_{BR} \left( 3g_R \left( 2M_4 + M_1 \right) + 8g_{RB} M_{BR} \right) \right) \right) \end{aligned}$$

$$\begin{aligned}
& + 6\left(2g_L^2\left(M_1 + M_4 + M_2\right) + 5\left(6g_Rg_{RB}M_{BR} + g_R^2\left(2M_4 + M_1\right) + g_{RB}^2\left(2M_1 + M_4\right)\right)\right)\mathbf{1} \\
& + 4\left(\left(4\left(g_R^2M_{BR} + g_{RB}^2M_{BR} + g_Rg_{RB}\left(M_1 + M_4\right)\right) + \sqrt{6}g_{BL}\left(2g_{RB}M_{BR} + g_R\left(M_1 + M_4\right)\right) + \sqrt{6}g_{BR}\left(2g_RM_{BR} + g_{RB}\left(M_1 + \right.\right.\right. \\
& - \left.\left.\left.4g_Rg_{RB} + \sqrt{6}g_{BL}g_R + \sqrt{6}g_{BR}g_{RB}\right)Y_e^\dagger T_e - \sqrt{6}g_{BL}g_RM_1Y_v^\dagger Y_v \right. \right. \\
& - \left.\left. \sqrt{6}g_{BR}g_{RB}M_1Y_v^\dagger Y_v + 4g_Rg_{RB}M_1Y_v^\dagger Y_v - 2\sqrt{6}g_{BR}g_RM_{BR}Y_v^\dagger Y_v \right. \right. \\
& + \left.\left. 4g_R^2M_{BR}Y_v^\dagger Y_v - 2\sqrt{6}g_{BL}g_{RB}M_{BR}Y_v^\dagger Y_v + 4g_{RB}^2M_{BR}Y_v^\dagger Y_v \right. \right. \\
& - \left.\left. \sqrt{6}g_{BL}g_RM_4Y_v^\dagger Y_v - \sqrt{6}g_{BR}g_{RB}M_4Y_v^\dagger Y_v + 4g_Rg_{RB}M_4Y_v^\dagger Y_v \right. \right. \\
& \left. \left. + \sqrt{6}g_{BL}g_RY_v^\dagger T_\nu + \sqrt{6}g_{BR}g_{RB}Y_v^\dagger T_\nu - 4g_Rg_{RB}Y_v^\dagger T_\nu\right)\right) \\
& + \frac{1}{4}M_1^*\left(3\left(90g_{BL}^4M_1 + g_{BR}^2\left(30g_R - \sqrt{6}g_{BR}\right)g_{RB}M_{BR} - 2g_{BL}^3\left(3\sqrt{6}g_{RB}M_1 - 60g_{BR}M_{BR} + \sqrt{6}g_RM_{BR}\right) \right. \right. \\
& + \left.\left. g_{BL}g_{BR}\left(60g_{BR}^2M_{BR} + 6\left(2\left(5g_{RB}^2 + g_L^2\right)M_{BR} + 5g_R^2M_{BR} + 5g_Rg_{RB}\left(2M_1 + M_4\right)\right) - \sqrt{6}g_{BR}\left(3g_RM_{BR} + g_{RB}\left(2M_1 + M_4\right)\right) \right. \right. \\
& + \left.\left. g_{BL}^2\left(30g_{BR}^2\left(2M_1 + M_4\right) + 6\left(5g_{RB}\left(2g_RM_{BR} + 3g_{RB}M_1\right) + g_L^2\left(2M_1 + M_2\right)\right) - \sqrt{6}g_{BR}\left(6g_{RB}M_{BR} + g_R\left(2M_1 + M_4\right)\right)\right)\right) \\
& + 4\left(\left(g_{RB}\left(4g_{RB}M_1 + 4g_RM_{BR} + \sqrt{6}g_{BR}M_{BR}\right) + \sqrt{6}g_{BL}\left(2g_{RB}M_1 + g_RM_{BR}\right)\right)Y_e^\dagger Y_e \right. \\
& - \left.\left. g_{RB}\left(2g_{RB} + \sqrt{6}g_{BL}\right)Y_e^\dagger T_e - 2\sqrt{6}g_{BL}g_{RB}M_1Y_v^\dagger Y_v + 4g_{RB}^2M_1Y_v^\dagger Y_v \right. \right. \\
& - \left.\left. \sqrt{6}g_{BL}g_RM_{BR}Y_v^\dagger Y_v - \sqrt{6}g_{BR}g_{RB}M_{BR}Y_v^\dagger Y_v + 4g_Rg_{RB}M_{BR}Y_v^\dagger Y_v \right. \right. \\
& \left. \left. + \sqrt{6}g_{BL}g_{RB}Y_v^\dagger T_\nu - 2g_{RB}^2Y_v^\dagger T_\nu\right)\right) \\
& - \sqrt{6}g_{BL}g_{RB}M_1T_e^\dagger Y_e - 2g_{RB}^2M_1T_e^\dagger Y_e - \sqrt{6}g_{BL}g_RM_{BR}T_e^\dagger Y_e \\
& - \sqrt{6}g_{BR}g_{RB}M_{BR}T_e^\dagger Y_e - 4g_Rg_{RB}M_{BR}T_e^\dagger Y_e - \sqrt{6}g_{BR}g_RM_4T_e^\dagger Y_e \\
& - 2g_R^2M_4T_e^\dagger Y_e + \sqrt{6}g_{BR}g_RT_e^\dagger T_e + 2g_R^2T_e^\dagger T_e + \sqrt{6}g_{BL}g_{RB}T_e^\dagger T_e \\
& + 2g_{RB}^2T_e^\dagger T_e + \sqrt{6}g_{BL}g_{RB}M_1T_\nu^\dagger Y_v - 2g_{RB}^2M_1T_\nu^\dagger Y_v + \sqrt{6}g_{BL}g_RM_{BR}T_\nu^\dagger Y_v \\
& + \sqrt{6}g_{BR}g_{RB}M_{BR}T_\nu^\dagger Y_v - 4g_Rg_{RB}M_{BR}T_\nu^\dagger Y_v + \sqrt{6}g_{BR}g_RM_4T_\nu^\dagger Y_v \\
& - 2g_R^2M_4T_\nu^\dagger Y_v - \sqrt{6}g_{BR}g_RT_\nu^\dagger T_\nu + 2g_R^2T_\nu^\dagger T_\nu - \sqrt{6}g_{BL}g_{RB}T_\nu^\dagger T_\nu \\
& + 2g_{RB}^2T_\nu^\dagger T_\nu + \sqrt{\frac{3}{2}}g_{BR}g_Rm_l^2Y_e^\dagger Y_e + g_R^2m_l^2Y_e^\dagger Y_e + \sqrt{\frac{3}{2}}g_{BL}g_{RB}m_l^2Y_e^\dagger Y_e \\
& + g_{RB}^2m_l^2Y_e^\dagger Y_e - \sqrt{\frac{3}{2}}g_{BR}g_Rm_l^2Y_v^\dagger Y_v + g_R^2m_l^2Y_v^\dagger Y_v - \sqrt{\frac{3}{2}}g_{BL}g_{RB}m_l^2Y_v^\dagger Y_v \\
& + g_{RB}^2m_l^2Y_v^\dagger Y_v + \sqrt{6}g_{BR}g_RY_e^\dagger m_e^2Y_e + 2g_R^2Y_e^\dagger m_e^2Y_e \\
& + \sqrt{6}g_{BL}g_{RB}Y_e^\dagger m_e^2Y_e + 2g_{RB}^2Y_e^\dagger m_e^2Y_e + \sqrt{\frac{3}{2}}g_{BR}g_RY_e^\dagger Y_e m_l^2 + g_R^2Y_e^\dagger Y_e m_l^2 \\
& + \sqrt{\frac{3}{2}}g_{BL}g_{RB}Y_e^\dagger Y_e m_l^2 + g_{RB}^2Y_e^\dagger Y_e m_l^2 - \sqrt{6}g_{BR}g_RY_v^\dagger m_\nu^2Y_v \\
& + 2g_R^2Y_v^\dagger m_\nu^2Y_v - \sqrt{6}g_{BL}g_{RB}Y_v^\dagger m_\nu^2Y_v + 2g_{RB}^2Y_v^\dagger m_\nu^2Y_v
\end{aligned}$$

$$\begin{aligned}
& -\sqrt{\frac{3}{2}}g_{BR}g_{R}Y_v^\dagger Y_v m_l^2 + g_R^2 Y_v^\dagger Y_v m_l^2 - \sqrt{\frac{3}{2}}g_{BL}g_{RB}Y_v^\dagger Y_v m_l^2 + g_{RB}^2 Y_v^\dagger Y_v 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 - 2m_\chi^2 Y_v^\dagger Y_s Y_s^\dagger Y_v \\
& - 2m_{H_u}^2 Y_v^\dagger Y_s Y_s^\dagger Y_v - 2Y_v^\dagger Y_s T_s^\dagger T_s - 8m_{H_u}^2 Y_v^\dagger Y_v Y_v^\dagger Y_v - 4Y_v^\dagger Y_v T_\nu^\dagger T_\nu \\
& - 2Y_v^\dagger T_s T_s^\dagger Y_v - 4Y_v^\dagger T_\nu T_\nu^\dagger Y_v - 4T_e^\dagger Y_e Y_e^\dagger T_e - 4T_e^\dagger T_e Y_e^\dagger Y_e \\
& - 2T_\nu^\dagger Y_s Y_s^\dagger T_\nu - 4T_\nu^\dagger Y_v Y_v^\dagger T_\nu - 2T_\nu^\dagger T_s Y_s^\dagger Y_v - 4T_\nu^\dagger T_\nu Y_v^\dagger Y_v \\
& - 2m_l^2 Y_e^\dagger Y_e Y_e^\dagger Y_e - m_l^2 Y_v^\dagger Y_s Y_s^\dagger Y_v - 2m_l^2 Y_v^\dagger Y_v Y_v^\dagger Y_v - 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 - 2Y_v^\dagger m_\nu^2 Y_s Y_s^\dagger Y_v \\
& - 4Y_v^\dagger m_\nu^2 Y_v Y_v^\dagger Y_v - 2Y_v^\dagger Y_s m_s^2 Y_s^\dagger Y_v - 2Y_v^\dagger Y_s Y_s^\dagger m_\nu^2 Y_v \\
& - Y_v^\dagger Y_s Y_s^\dagger Y_v m_l^2 - 4Y_v^\dagger Y_v m_l^2 Y_v^\dagger Y_v - 4Y_v^\dagger Y_v Y_v^\dagger m_\nu^2 Y_v - 2Y_v^\dagger Y_v Y_v^\dagger Y_v m_l^2 \\
& + 6g_L^4 \mathbf{1}\sigma_{2,2} + 3g_{BL}^2 \mathbf{1}\sigma_{2,11} + 3g_{BL}g_{BR} \mathbf{1}\sigma_{2,13} + 3g_{BL}g_{BR} \mathbf{1}\sigma_{2,31} + 3g_{BR}^2 \mathbf{1}\sigma_{2,33} - 2\sqrt{6}g_{BL} \mathbf{1}\sigma_{3,1} - 2\sqrt{6}g_{BR} \mathbf{1}\sigma_{3,3} \\
& - 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_v^\dagger Y_v \text{Tr}(Y_u Y_u^\dagger) - 6T_\nu^\dagger T_\nu \text{Tr}(Y_u Y_u^\dagger) \\
& - 3m_l^2 Y_v^\dagger Y_v \text{Tr}(Y_u Y_u^\dagger) - 6Y_v^\dagger m_\nu^2 Y_v \text{Tr}(Y_u Y_u^\dagger) - 3Y_v^\dagger Y_v m_l^2 \text{Tr}(Y_u Y_u^\dagger) \\
& - 4m_{H_u}^2 Y_v^\dagger Y_v \text{Tr}(Y_v Y_v^\dagger) - 2T_\nu^\dagger T_\nu \text{Tr}(Y_v Y_v^\dagger) - m_l^2 Y_v^\dagger Y_v \text{Tr}(Y_v Y_v^\dagger) \\
& - 2Y_v^\dagger m_\nu^2 Y_v \text{Tr}(Y_v Y_v^\dagger) - Y_v^\dagger Y_v m_l^2 \text{Tr}(Y_v Y_v^\dagger) - 6T_e^\dagger Y_e \text{Tr}(Y_d^\dagger T_d) \\
& - 2T_e^\dagger Y_e \text{Tr}(Y_e^\dagger T_e) - 6T_\nu^\dagger Y_v \text{Tr}(Y_u^\dagger T_u) - 2T_\nu^\dagger Y_v \text{Tr}(Y_v^\dagger T_\nu) \\
& - 6Y_e^\dagger T_e \text{Tr}(T_d^* Y_d^T) - 6Y_e^\dagger Y_e \text{Tr}(T_d^* T_d^T) - 2Y_e^\dagger T_e \text{Tr}(T_e^* Y_e^T) \\
& - 2Y_e^\dagger Y_e \text{Tr}(T_e^* T_e^T) - 6Y_v^\dagger T_\nu \text{Tr}(T_u^* Y_u^T) - 6Y_v^\dagger Y_v \text{Tr}(T_u^* T_u^T) \\
& - 2Y_v^\dagger T_\nu \text{Tr}(T_\nu^* Y_\nu^T) - 2Y_v^\dagger Y_v \text{Tr}(T_\nu^* T_\nu^T) - 6Y_e^\dagger Y_e \text{Tr}(m_d^2 Y_d Y_d^\dagger) \\
& - 2Y_e^\dagger Y_e \text{Tr}(m_e^2 Y_e Y_e^\dagger) - 2Y_e^\dagger Y_e \text{Tr}(m_l^2 Y_e^\dagger Y_e) - 2Y_v^\dagger Y_v \text{Tr}(m_l^2 Y_v^\dagger Y_v) \\
& - 6Y_e^\dagger Y_e \text{Tr}(m_q^2 Y_d^\dagger Y_d) - 6Y_v^\dagger Y_v \text{Tr}(m_q^2 Y_u^\dagger Y_u) - 6Y_v^\dagger Y_v \text{Tr}(m_u^2 Y_u Y_u^\dagger) \\
& - 2Y_v^\dagger Y_v \text{Tr}(m_\nu^2 Y_v Y_v^\dagger) \tag{92}
\end{aligned}$$

$$\begin{aligned}
\beta_{m_{H_d}^2}^{(1)} & = -2g_R^2 |M_4|^2 - 6g_L^2 |M_2|^2 - 2g_{RB} (g_{RB} M_1 + g_R M_{BR}) M_1^* - 2(g_R^2 M_{BR} + g_{RB}^2 M_{BR} + g_R g_{RB} (M_1 + M_4)) M_{BR}^* \\
& - 2g_R g_{RB} M_{BR} M_4^* - g_{RB} \sigma_{1,1} - g_R \sigma_{1,3} + 6m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger) + 2m_{H_d}^2 \text{Tr}(Y_e Y_e^\dagger) + 6\text{Tr}(T_d^* T_d^T) + 2\text{Tr}(T_e^* T_e^T) \\
& + 6\text{Tr}(m_d^2 Y_d Y_d^\dagger) + 2\text{Tr}(m_e^2 Y_e Y_e^\dagger) + 2\text{Tr}(m_l^2 Y_e^\dagger Y_e) + 6\text{Tr}(m_q^2 Y_d^\dagger Y_d) \tag{93}
\end{aligned}$$

$$\begin{aligned}
\beta_{m_{H_d}^2}^{(2)} = & + \frac{81}{2} g_{BR}^2 g_R^2 |M_4|^2 + 6g_L^2 g_R^2 |M_4|^2 - 3\sqrt{6} g_{BR} g_R^3 |M_4|^2 + 48g_R^4 |M_4|^2 \\
& + 27g_{BL} g_{BR} g_R g_{RB} |M_4|^2 - \sqrt{6} g_{BL} g_R^2 g_{RB} |M_4|^2 - \sqrt{6} g_{BR} g_R g_{RB}^2 |M_4|^2 + 32g_R^2 g_{RB}^2 |M_4|^2 \\
& + 33g_L^4 |M_2|^2 + 6g_L^2 g_R^2 |M_2|^2 + 6g_L^2 g_{RB}^2 |M_2|^2 + \frac{27}{2} g_{BL} g_{BR} g_R g_{RB} M_1 M_4^* \\
& - \sqrt{\frac{3}{2}} g_{BL} g_R^2 g_{RB} M_1 M_4^* - \sqrt{\frac{3}{2}} g_{BR} g_R g_{RB}^2 M_1 M_4^* + 16g_R^2 g_{RB}^2 M_1 M_4^* + 27g_{BL} g_{BR} g_R^2 M_{BR} M_4^* \\
& - \sqrt{6} g_{BL} g_R^3 M_{BR} M_4^* + \frac{27}{2} g_{BL} g_R g_{RB} M_{BR} M_4^* + 27g_{BR}^2 g_R g_{RB} M_{BR} M_4^* + 6g_L^2 g_R g_{RB} M_{BR} M_4^* \\
& - 3\sqrt{6} g_{BR} g_R^2 g_{RB} M_{BR} M_4^* + 64g_R^3 g_{RB} M_{BR} M_4^* + \frac{27}{2} g_{BL} g_{BR} g_{RB}^2 M_{BR} M_4^* - 3\sqrt{\frac{3}{2}} g_{BL} g_R g_{RB}^2 M_{BR} M_4^* \\
& - \sqrt{\frac{3}{2}} g_{BR} g_{RB}^3 M_{BR} M_4^* + 32g_R g_{RB}^3 M_{BR} M_4^* + 3g_L^2 g_R^2 M_2 M_4^* + 3g_L^2 g_{RB}^2 M_1 M_2^* + 6g_L^2 g_R g_{RB} M_{BR} M_2^* \\
& + 3g_L^2 g_R^2 M_4 M_2^* + 6g_L^4 \sigma_{2,2} + 2g_{RB}^2 \sigma_{2,11} + 2g_R g_{RB} \sigma_{2,13} + 2g_R g_{RB} \sigma_{2,31} + 2g_R^2 \sigma_{2,33} - 4g_{RB} \sigma_{3,1} - 4g_R \sigma_{3,3} \\
& + 32g_s^2 m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger) + g_{BL}^2 m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger) + g_{BR}^2 m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger) \\
& - \sqrt{6} g_{BR} g_R m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger) - \sqrt{6} g_{BL} g_{RB} m_{H_d}^2 \text{Tr}(Y_d Y_d^\dagger) + 2g_{BR}^2 |M_4|^2 \text{Tr}(Y_d Y_d^\dagger) \\
& - 2\sqrt{6} g_{BR} g_R |M_4|^2 \text{Tr}(Y_d Y_d^\dagger) + 64g_s^2 |M_3|^2 \text{Tr}(Y_d Y_d^\dagger) + 2g_{BL} g_{BR} M_{BR} M_4^* \text{Tr}(Y_d Y_d^\dagger) \\
& - \sqrt{6} g_{BL} g_R M_{BR} M_4^* \text{Tr}(Y_d Y_d^\dagger) - \sqrt{6} g_{BR} g_{RB} M_{BR} M_4^* \text{Tr}(Y_d Y_d^\dagger) + 3g_{BL}^2 m_{H_d}^2 \text{Tr}(Y_e Y_e^\dagger) \\
& + 3g_{BR}^2 m_{H_d}^2 \text{Tr}(Y_e Y_e^\dagger) + \sqrt{6} g_{BR} g_R m_{H_d}^2 \text{Tr}(Y_e Y_e^\dagger) + \sqrt{6} g_{BL} g_{RB} m_{H_d}^2 \text{Tr}(Y_e Y_e^\dagger) \\
& + 6g_{BR}^2 |M_4|^2 \text{Tr}(Y_e Y_e^\dagger) + 2\sqrt{6} g_{BR} g_R |M_4|^2 \text{Tr}(Y_e Y_e^\dagger) + 6g_{BL} g_{BR} M_{BR} M_4^* \text{Tr}(Y_e Y_e^\dagger) \\
& + \sqrt{6} g_{BL} g_R M_{BR} M_4^* \text{Tr}(Y_e Y_e^\dagger) + \sqrt{6} g_{BR} g_{RB} M_{BR} M_4^* \text{Tr}(Y_e Y_e^\dagger) - g_{BR}^2 M_4^* \text{Tr}(Y_d^\dagger T_d) \\
& + \sqrt{6} g_{BR} g_R M_4^* \text{Tr}(Y_d^\dagger T_d) - 32g_s^2 M_3^* \text{Tr}(Y_d^\dagger T_d) - 3g_{BR}^2 M_4^* \text{Tr}(Y_e^\dagger T_e) \\
& - \sqrt{6} g_{BR} g_R M_4^* \text{Tr}(Y_e^\dagger T_e) \\
& + \frac{1}{2} M_1^* \left( 54g_{BL} g_{BR} g_R g_{RB} M_1 - 2\sqrt{6} g_{BL} g_R^2 g_{RB} M_1 + 81g_{BL}^2 g_{RB}^2 M_1 + 12g_L^2 g_{RB}^2 M_1 - 2\sqrt{6} g_{BR} g_R g_{RB}^2 M_1 \right. \\
& + 64g_R^2 g_{RB}^2 M_1 - 6\sqrt{6} g_{BL} g_{RB}^3 M_1 + 96g_{RB}^4 M_1 + 27g_{BL} g_{BR} g_R^2 M_{BR} - \sqrt{6} g_{BL} g_R^3 M_{BR} \\
& + 54g_{BL}^2 g_R g_{RB} M_{BR} + 27g_{BR}^2 g_R g_{RB} M_{BR} + 12g_L^2 g_R g_{RB} M_{BR} - 3\sqrt{6} g_{BR} g_R^2 g_{RB} M_{BR} + 64g_R^3 g_{RB} M_{BR} \\
& + 54g_{BL} g_{BR} g_{RB}^2 M_{BR} - 6\sqrt{6} g_{BL} g_R g_{RB}^2 M_{BR} - 2\sqrt{6} g_{BR} g_{RB}^3 M_{BR} + 128g_R g_{RB}^3 M_{BR} + 27g_{BL} g_{BR} g_R g_{RB} M_4 \\
& \left. - \sqrt{6} g_{BL} g_R^2 g_{RB} M_4 - \sqrt{6} g_{BR} g_R g_{RB}^2 M_4 + 32g_R^2 g_{RB}^2 M_4 + 6g_L^2 g_{RB}^2 M_2 \right) \\
& + \left( -2g_{BL} \left( -2g_{BR} M_{BR} + 2\sqrt{6} g_{RB} M_1 + \sqrt{6} g_R M_{BR} \right) - 2\sqrt{6} g_{BR} g_{RB} M_{BR} + 4g_{BL}^2 M_1 \right) \text{Tr}(Y_d Y_d^\dagger) \\
& + 2 \left( 2\sqrt{6} g_{BL} g_{RB} M_1 + 6g_{BL}^2 M_1 + 6g_{BL} g_{BR} M_{BR} + \sqrt{6} g_{BL} g_R M_{BR} + \sqrt{6} g_{BR} g_{RB} M_{BR} \right) \text{Tr}(Y_e Y_e^\dagger) \\
& - 2g_{BL}^2 \text{Tr}(Y_d^\dagger T_d) + 2\sqrt{6} g_{BL} g_{RB} \text{Tr}(Y_d^\dagger T_d) - 6g_{BL}^2 \text{Tr}(Y_e^\dagger T_e) - 2\sqrt{6} g_{BL} g_{RB} \text{Tr}(Y_e^\dagger T_e)
\end{aligned}$$

$$\begin{aligned}
& + \frac{1}{2} M_{BR}^* \left( 27 g_{BL} g_{BR} g_R^2 M_1 - \sqrt{6} g_{BL} g_R^3 M_1 + 54 g_{BL}^2 g_{RB} M_1 + 27 g_{BR}^2 g_{RB} M_1 + 12 g_L^2 g_{RB} M_1 \right. \\
& - 3 \sqrt{6} g_{BR} g_{RB}^2 M_1 + 64 g_{RB}^3 M_1 + 54 g_{BL} g_{BR} g_{RB}^2 M_1 - 6 \sqrt{6} g_{BL} g_{RB}^2 M_1 - 2 \sqrt{6} g_{BR} g_{RB}^3 M_1 \\
& + 128 g_{RB}^3 M_1 + 27 g_{BL}^2 g_{RB}^2 M_{BR} + 54 g_{BR}^2 g_{RB}^2 M_{BR} + 12 g_L^2 g_{RB}^2 M_{BR} - 4 \sqrt{6} g_{BR} g_{RB}^3 M_{BR} + 64 g_{RB}^4 M_{BR} \\
& + 162 g_{BL} g_{BR} g_{RB} M_{BR} - 8 \sqrt{6} g_{BL} g_{RB}^2 M_{BR} + 54 g_{BL}^2 g_{RB}^2 M_{BR} + 27 g_{BR}^2 g_{RB}^2 M_{BR} + 12 g_L^2 g_{RB}^2 M_{BR} \\
& - 8 \sqrt{6} g_{BR} g_{RB}^2 M_{BR} + 256 g_{RB}^2 M_{BR} - 4 \sqrt{6} g_{BL} g_{RB}^3 M_{BR} + 64 g_{RB}^4 M_{BR} + 54 g_{BL} g_{BR} g_{RB}^2 M_4 \\
& - 2 \sqrt{6} g_{BL} g_{RB}^3 M_4 + 27 g_{BL}^2 g_{RB} M_4 + 54 g_{BR}^2 g_{RB} M_4 + 12 g_L^2 g_{RB} M_4 - 6 \sqrt{6} g_{BR} g_{RB}^2 M_4 \\
& + 128 g_{RB}^3 M_4 + 27 g_{BL} g_{BR} g_{RB}^2 M_4 - 3 \sqrt{6} g_{BL} g_{RB}^2 M_4 - \sqrt{6} g_{BR} g_{RB}^3 M_4 + 64 g_{RB}^3 M_4 \\
& \left. + 12 g_L^2 g_{RB} M_2 \right) \\
& + \left( -2 g_{BR} \left( -2 \left( -\sqrt{6} g_R + g_{BR} \right) M_{BR} + \sqrt{6} g_{RB} \left( M_1 + M_4 \right) \right) + 4 g_{BL}^2 M_{BR} + g_{BL} \left( -2 \sqrt{6} \left( 2 g_{RB} M_{BR} + g_R \left( M_1 + M_4 \right) \right) \right) \right. \\
& + 2 \left( 6 g_{BL}^2 M_{BR} + g_{BL} \left( 6 g_{BR} \left( M_1 + M_4 \right) + \sqrt{6} \left( 2 g_{RB} M_{BR} + g_R \left( M_1 + M_4 \right) \right) \right) \right) + g_{BR} \left( 2 \left( 3 g_{BR} + \sqrt{6} g_R \right) M_{BR} + \sqrt{6} g_{RB} \left( M_1 + M_4 \right) \right) \\
& - 4 g_{BL} g_{BR} \text{Tr} \left( Y_d^\dagger T_d \right) + 2 \sqrt{6} g_{BL} g_R \text{Tr} \left( Y_d^\dagger T_d \right) + 2 \sqrt{6} g_{BR} g_{RB} \text{Tr} \left( Y_d^\dagger T_d \right) - 12 g_{BL} g_{BR} \text{Tr} \left( Y_e^\dagger T_e \right) \\
& - 2 \sqrt{6} g_{BL} g_R \text{Tr} \left( Y_e^\dagger T_e \right) - 2 \sqrt{6} g_{BR} g_{RB} \text{Tr} \left( Y_e^\dagger T_e \right) \\
& - g_{BL}^2 M_1 \text{Tr} \left( T_d^* Y_d^T \right) + \sqrt{6} g_{BL} g_{RB} M_1 \text{Tr} \left( T_d^* Y_d^T \right) - 2 g_{BL} g_{BR} M_{BR} \text{Tr} \left( T_d^* Y_d^T \right) \\
& + \sqrt{6} g_{BL} g_R M_{BR} \text{Tr} \left( T_d^* Y_d^T \right) + \sqrt{6} g_{BR} g_{RB} M_{BR} \text{Tr} \left( T_d^* Y_d^T \right) - g_{BR}^2 M_4 \text{Tr} \left( T_d^* Y_d^T \right) \\
& + \sqrt{6} g_{BR} g_R M_4 \text{Tr} \left( T_d^* Y_d^T \right) - 32 g_s^2 M_3 \text{Tr} \left( T_d^* Y_d^T \right) + 32 g_s^2 \text{Tr} \left( T_d^* T_d^T \right) + g_{BL}^2 \text{Tr} \left( T_d^* T_d^T \right) \\
& + g_{BR}^2 \text{Tr} \left( T_d^* T_d^T \right) - \sqrt{6} g_{BR} g_R \text{Tr} \left( T_d^* T_d^T \right) - \sqrt{6} g_{BL} g_{RB} \text{Tr} \left( T_d^* T_d^T \right) - 3 g_{BL}^2 M_1 \text{Tr} \left( T_e^* Y_e^T \right) \\
& - \sqrt{6} g_{BL} g_{RB} M_1 \text{Tr} \left( T_e^* Y_e^T \right) - 6 g_{BL} g_{BR} M_{BR} \text{Tr} \left( T_e^* Y_e^T \right) - \sqrt{6} g_{BL} g_R M_{BR} \text{Tr} \left( T_e^* Y_e^T \right) \\
& - \sqrt{6} g_{BR} g_{RB} M_{BR} \text{Tr} \left( T_e^* Y_e^T \right) - 3 g_{BR}^2 M_4 \text{Tr} \left( T_e^* Y_e^T \right) - \sqrt{6} g_{BR} g_R M_4 \text{Tr} \left( T_e^* Y_e^T \right) \\
& + 3 g_{BL}^2 \text{Tr} \left( T_e^* T_e^T \right) + 3 g_{BR}^2 \text{Tr} \left( T_e^* T_e^T \right) + \sqrt{6} g_{BR} g_R \text{Tr} \left( T_e^* T_e^T \right) + \sqrt{6} g_{BL} g_{RB} \text{Tr} \left( T_e^* T_e^T \right) \\
& + 32 g_s^2 \text{Tr} \left( m_d^2 Y_d Y_d^\dagger \right) + g_{BL}^2 \text{Tr} \left( m_d^2 Y_d Y_d^\dagger \right) + g_{BR}^2 \text{Tr} \left( m_d^2 Y_d Y_d^\dagger \right) \\
& - \sqrt{6} g_{BR} g_R \text{Tr} \left( m_d^2 Y_d Y_d^\dagger \right) - \sqrt{6} g_{BL} g_{RB} \text{Tr} \left( m_d^2 Y_d Y_d^\dagger \right) + 3 g_{BL}^2 \text{Tr} \left( m_e^2 Y_e Y_e^\dagger \right) \\
& + 3 g_{BR}^2 \text{Tr} \left( m_e^2 Y_e Y_e^\dagger \right) + \sqrt{6} g_{BR} g_R \text{Tr} \left( m_e^2 Y_e Y_e^\dagger \right) + \sqrt{6} g_{BL} g_{RB} \text{Tr} \left( m_e^2 Y_e Y_e^\dagger \right) \\
& + 3 g_{BL}^2 \text{Tr} \left( m_l^2 Y_e^\dagger Y_e \right) + 3 g_{BR}^2 \text{Tr} \left( m_l^2 Y_e^\dagger Y_e \right) + \sqrt{6} g_{BR} g_R \text{Tr} \left( m_l^2 Y_e^\dagger Y_e \right) \\
& + \sqrt{6} g_{BL} g_{RB} \text{Tr} \left( m_l^2 Y_e^\dagger Y_e \right) + 32 g_s^2 \text{Tr} \left( m_q^2 Y_d^\dagger Y_d \right) + g_{BL}^2 \text{Tr} \left( m_q^2 Y_d^\dagger Y_d \right) + g_{BR}^2 \text{Tr} \left( m_q^2 Y_d^\dagger Y_d \right) \\
& - \sqrt{6} g_{BR} g_R \text{Tr} \left( m_q^2 Y_d^\dagger Y_d \right) - \sqrt{6} g_{BL} g_{RB} \text{Tr} \left( m_q^2 Y_d^\dagger Y_d \right) - 36 m_{H_d}^2 \text{Tr} \left( Y_d Y_d^\dagger Y_d Y_d^\dagger \right) \\
& - 36 \text{Tr} \left( Y_d Y_d^\dagger T_d T_d^\dagger \right) - 6 m_{H_d}^2 \text{Tr} \left( Y_d Y_u^\dagger Y_u Y_d^\dagger \right) - 6 m_{H_u}^2 \text{Tr} \left( Y_d Y_u^\dagger Y_u Y_d^\dagger \right)
\end{aligned}$$

$$\begin{aligned}
& -6\text{Tr}\left(Y_d Y_u^\dagger T_u T_d^\dagger\right) - 36\text{Tr}\left(Y_d T_d^\dagger T_d Y_d^\dagger\right) - 6\text{Tr}\left(Y_d T_u^\dagger T_u Y_d^\dagger\right) - 12m_{H_d}^2 \text{Tr}\left(Y_e Y_e^\dagger Y_e Y_e^\dagger\right) \\
& - 12\text{Tr}\left(Y_e Y_e^\dagger T_e T_e^\dagger\right) - 2m_{H_d}^2 \text{Tr}\left(Y_e Y_v^\dagger Y_v Y_e^\dagger\right) - 2m_{H_u}^2 \text{Tr}\left(Y_e Y_v^\dagger Y_v Y_e^\dagger\right) \\
& - 2\text{Tr}\left(Y_e Y_v^\dagger T_\nu T_\nu^\dagger\right) - 12\text{Tr}\left(Y_e T_e^\dagger T_e Y_e^\dagger\right) - 2\text{Tr}\left(Y_e T_\nu^\dagger T_\nu Y_e^\dagger\right) - 6\text{Tr}\left(Y_u Y_d^\dagger T_d T_u^\dagger\right) \\
& - 6\text{Tr}\left(Y_u T_d^\dagger T_d Y_u^\dagger\right) - 2\text{Tr}\left(Y_v Y_e^\dagger T_e T_\nu^\dagger\right) - 2\text{Tr}\left(Y_v T_e^\dagger T_e Y_v^\dagger\right) - 36\text{Tr}\left(m_d^2 Y_d Y_d^\dagger Y_d Y_d^\dagger\right) \\
& - 6\text{Tr}\left(m_d^2 Y_d Y_u^\dagger Y_u Y_d^\dagger\right) - 12\text{Tr}\left(m_e^2 Y_e Y_e^\dagger Y_e Y_e^\dagger\right) - 2\text{Tr}\left(m_e^2 Y_e Y_v^\dagger Y_v Y_e^\dagger\right) \\
& - 12\text{Tr}\left(m_l^2 Y_e^\dagger Y_e Y_e^\dagger Y_e\right) - 2\text{Tr}\left(m_l^2 Y_e^\dagger Y_e Y_v^\dagger Y_v\right) - 2\text{Tr}\left(m_l^2 Y_v^\dagger Y_v Y_e^\dagger Y_e\right) \\
& - 36\text{Tr}\left(m_q^2 Y_d^\dagger Y_d Y_d^\dagger Y_d\right) - 6\text{Tr}\left(m_q^2 Y_d^\dagger Y_d Y_u^\dagger Y_u\right) - 6\text{Tr}\left(m_q^2 Y_u^\dagger Y_u Y_d^\dagger Y_d\right) \\
& - 6\text{Tr}\left(m_u^2 Y_u Y_d^\dagger Y_d Y_u^\dagger\right) - 2\text{Tr}\left(m_\nu^2 Y_v Y_e^\dagger Y_e Y_\nu^\dagger\right)
\end{aligned} \tag{94}$$

$$\begin{aligned}
\beta_{m_{H_u}^2}^{(1)} &= -2g_R^2 |M_4|^2 - 6g_L^2 |M_2|^2 - 2g_{RB} \left(g_{RB} M_1 + g_R M_{BR}\right) M_1^* - 2 \left(g_R^2 M_{BR} + g_{RB}^2 M_{BR} + g_R g_{RB} \left(M_1 + M_4\right)\right) M_{BR}^* \\
& - 2g_R g_{RB} M_{BR} M_4^* + g_{RB} \sigma_{1,1} + g_R \sigma_{1,3} + 6m_{H_u}^2 \text{Tr}\left(Y_u Y_u^\dagger\right) + 2m_{H_u}^2 \text{Tr}\left(Y_v Y_v^\dagger\right) + 6\text{Tr}\left(T_u^* T_u^T\right) + 2\text{Tr}\left(T_\nu^* T_\nu^T\right) \\
& + 2\text{Tr}\left(m_l^2 Y_v^\dagger Y_v\right) + 6\text{Tr}\left(m_q^2 Y_u^\dagger Y_u\right) + 6\text{Tr}\left(m_u^2 Y_u Y_u^\dagger\right) + 2\text{Tr}\left(m_\nu^2 Y_v Y_v^\dagger\right)
\end{aligned} \tag{95}$$

$$\begin{aligned}
\beta_{m_{H_u}^2}^{(2)} &= +\frac{81}{2} g_{BR}^2 g_R^2 |M_4|^2 + 6g_L^2 g_R^2 |M_4|^2 - 3\sqrt{6} g_{BR} g_R^3 |M_4|^2 + 48g_R^4 |M_4|^2 \\
& + 27g_{BL} g_{BR} g_R g_{RB} |M_4|^2 - \sqrt{6} g_{BL} g_R^2 g_{RB} |M_4|^2 - \sqrt{6} g_{BR} g_R g_{RB}^2 |M_4|^2 + 32g_R^2 g_{RB}^2 |M_4|^2 \\
& + 33g_L^4 |M_2|^2 + 6g_L^2 g_R^2 |M_2|^2 + 6g_L^2 g_{RB}^2 |M_2|^2 + \frac{27}{2} g_{BL} g_{BR} g_R g_{RB} M_1 M_4^* \\
& - \sqrt{\frac{3}{2}} g_{BL} g_R^2 g_{RB} M_1 M_4^* - \sqrt{\frac{3}{2}} g_{BR} g_R g_{RB}^2 M_1 M_4^* + 16g_R^2 g_{RB}^2 M_1 M_4^* + 27g_{BL} g_{BR} g_R^2 M_{BR} M_4^* \\
& - \sqrt{6} g_{BL} g_R^3 M_{BR} M_4^* + \frac{27}{2} g_{BL} g_R g_{RB} M_{BR} M_4^* + 27g_{BR}^2 g_R g_{RB} M_{BR} M_4^* + 6g_L^2 g_R g_{RB} M_{BR} M_4^* \\
& - 3\sqrt{6} g_{BR} g_R^2 g_{RB} M_{BR} M_4^* + 64g_R^3 g_{RB} M_{BR} M_4^* + \frac{27}{2} g_{BL} g_{BR} g_{RB}^2 M_{BR} M_4^* - 3\sqrt{\frac{3}{2}} g_{BL} g_R g_{RB}^2 M_{BR} M_4^* \\
& - \sqrt{\frac{3}{2}} g_{BR} g_{RB}^3 M_{BR} M_4^* + 32g_R g_{RB}^3 M_{BR} M_4^* + 3g_L^2 g_R^2 M_2 M_4^* + 3g_L^2 g_{RB}^2 M_1 M_2^* + 6g_L^2 g_R g_{RB} M_{BR} M_2^* \\
& + 3g_L^2 g_R^2 M_4 M_2^* + 6g_L^4 \sigma_{2,2} + 2g_{RB}^2 \sigma_{2,11} + 2g_R g_{RB} \sigma_{2,13} + 2g_R g_{RB} \sigma_{2,31} + 2g_R^2 \sigma_{2,33} + 4g_{RB} \sigma_{3,1} + 4g_R \sigma_{3,3} \\
& + 32g_s^2 m_{H_u}^2 \text{Tr}\left(Y_u Y_u^\dagger\right) + g_{BL}^2 m_{H_u}^2 \text{Tr}\left(Y_u Y_u^\dagger\right) + g_{BR}^2 m_{H_u}^2 \text{Tr}\left(Y_u Y_u^\dagger\right) \\
& + \sqrt{6} g_{BR} g_R m_{H_u}^2 \text{Tr}\left(Y_u Y_u^\dagger\right) + \sqrt{6} g_{BL} g_{RB} m_{H_u}^2 \text{Tr}\left(Y_u Y_u^\dagger\right) + 2g_{BR}^2 |M_4|^2 \text{Tr}\left(Y_u Y_u^\dagger\right) \\
& + 2\sqrt{6} g_{BR} g_R |M_4|^2 \text{Tr}\left(Y_u Y_u^\dagger\right) + 64g_s^2 |M_3|^2 \text{Tr}\left(Y_u Y_u^\dagger\right) + 2g_{BL} g_{BR} M_{BR} M_4^* \text{Tr}\left(Y_u Y_u^\dagger\right) \\
& + \sqrt{6} g_{BL} g_R M_{BR} M_4^* \text{Tr}\left(Y_u Y_u^\dagger\right) + \sqrt{6} g_{BR} g_{RB} M_{BR} M_4^* \text{Tr}\left(Y_u Y_u^\dagger\right) + 3g_{BL}^2 m_{H_u}^2 \text{Tr}\left(Y_v Y_v^\dagger\right) \\
& + 3g_{BR}^2 m_{H_u}^2 \text{Tr}\left(Y_v Y_v^\dagger\right) - \sqrt{6} g_{BR} g_R m_{H_u}^2 \text{Tr}\left(Y_v Y_v^\dagger\right) - \sqrt{6} g_{BL} g_{RB} m_{H_u}^2 \text{Tr}\left(Y_v Y_v^\dagger\right)
\end{aligned}$$



$$\begin{aligned}
& + 6g_{BR}^2|M_4|^2\text{Tr}\left(Y_v Y_v^\dagger\right) - 2\sqrt{6}g_{BR}g_R|M_4|^2\text{Tr}\left(Y_v Y_v^\dagger\right) + 6g_{BL}g_{BR}M_{BR}M_4^*\text{Tr}\left(Y_v Y_v^\dagger\right) \\
& - \sqrt{6}g_{BL}g_R M_{BR}M_4^*\text{Tr}\left(Y_v Y_v^\dagger\right) - \sqrt{6}g_{BR}g_{RB}M_{BR}M_4^*\text{Tr}\left(Y_v Y_v^\dagger\right) - g_{BR}^2M_4^*\text{Tr}\left(Y_u^\dagger T_u\right) \\
& - \sqrt{6}g_{BR}g_R M_4^*\text{Tr}\left(Y_u^\dagger T_u\right) - 32g_s^2M_3^*\text{Tr}\left(Y_u^\dagger T_u\right) - 3g_{BR}^2M_4^*\text{Tr}\left(Y_v^\dagger T_\nu\right) \\
& + \sqrt{6}g_{BR}g_R M_4^*\text{Tr}\left(Y_v^\dagger T_\nu\right) \\
& + \frac{1}{2}M_1^*\left(54g_{BL}g_{BR}g_Rg_{RB}M_1 - 2\sqrt{6}g_{BL}g_R^2g_{RB}M_1 + 81g_{BL}^2g_{RB}^2M_1 + 12g_L^2g_{RB}^2M_1 - 2\sqrt{6}g_{BR}g_Rg_{RB}^2M_1\right. \\
& + 64g_R^2g_{RB}^2M_1 - 6\sqrt{6}g_{BL}g_R^3M_1 + 96g_{RB}^4M_1 + 27g_{BL}g_{BR}g_R^2M_{BR} - \sqrt{6}g_{BL}g_R^3M_{BR} \\
& + 54g_{BL}g_Rg_{RB}M_{BR} + 27g_{BR}^2g_Rg_{RB}M_{BR} + 12g_L^2g_Rg_{RB}M_{BR} - 3\sqrt{6}g_{BR}g_R^2g_{RB}M_{BR} + 64g_R^3g_{RB}M_{BR} \\
& + 54g_{BL}g_{BR}g_{RB}^2M_{BR} - 6\sqrt{6}g_{BL}g_Rg_{RB}^2M_{BR} - 2\sqrt{6}g_{BR}g_R^3M_{BR} + 128g_Rg_{RB}^3M_{BR} + 27g_{BL}g_{BR}g_Rg_{RB}M_4 \\
& - \sqrt{6}g_{BL}g_R^2g_{RB}M_4 - \sqrt{6}g_{BR}g_Rg_{RB}^2M_4 + 32g_R^2g_{RB}^2M_4 + 6g_L^2g_{RB}^2M_2 \\
& + 2\left(2g_{BL}^2M_1 + g_{BL}\left(2g_{BR}M_{BR} + 2\sqrt{6}g_{RB}M_1 + \sqrt{6}g_{RB}M_{BR}\right) + \sqrt{6}g_{BR}g_{RB}M_{BR}\right)\text{Tr}\left(Y_u Y_u^\dagger\right) \\
& + 2\left(-2\sqrt{6}g_{BL}g_{RB}M_1 + 6g_{BL}^2M_1 + 6g_{BL}g_{BR}M_{BR} - \sqrt{6}g_{BL}g_RM_{BR} - \sqrt{6}g_{BR}g_{RB}M_{BR}\right)\text{Tr}\left(Y_v Y_v^\dagger\right) \\
& - 2g_{BL}^2\text{Tr}\left(Y_u^\dagger T_u\right) - 2\sqrt{6}g_{BL}g_{RB}\text{Tr}\left(Y_u^\dagger T_u\right) - 6g_{BL}^2\text{Tr}\left(Y_v^\dagger T_\nu\right) + 2\sqrt{6}g_{BL}g_{RB}\text{Tr}\left(Y_v^\dagger T_\nu\right) \\
& + \frac{1}{2}M_{BR}^*\left(27g_{BL}g_{BR}g_R^2M_1 - \sqrt{6}g_{BL}g_R^3M_1 + 54g_{BL}^2g_Rg_{RB}M_1 + 27g_{BR}^2g_Rg_{RB}M_1 + 12g_L^2g_Rg_{RB}M_1\right. \\
& - 3\sqrt{6}g_{BR}g_R^2g_{RB}M_1 + 64g_R^3g_{RB}M_1 + 54g_{BL}g_{BR}g_{RB}^2M_1 - 6\sqrt{6}g_{BL}g_Rg_{RB}^2M_1 - 2\sqrt{6}g_{BR}g_R^3M_1 \\
& + 128g_Rg_{RB}^3M_1 + 27g_{BL}^2g_R^2M_{BR} + 54g_{BR}^2g_R^2M_{BR} + 12g_L^2g_R^2M_{BR} - 4\sqrt{6}g_{BR}g_R^3M_{BR} + 64g_R^4M_{BR} \\
& + 162g_{BL}g_{BR}g_Rg_{RB}M_{BR} - 8\sqrt{6}g_{BL}g_R^2g_{RB}M_{BR} + 54g_{BL}^2g_{RB}^2M_{BR} + 27g_{BR}^2g_{RB}^2M_{BR} + 12g_L^2g_{RB}^2M_{BR} \\
& - 8\sqrt{6}g_{BR}g_Rg_{RB}^2M_{BR} + 256g_R^2g_{RB}^2M_{BR} - 4\sqrt{6}g_{BL}g_R^3M_{BR} + 64g_{RB}^4M_{BR} + 54g_{BL}g_{BR}g_{RB}^2M_4 \\
& - 2\sqrt{6}g_{BL}g_R^3M_4 + 27g_{BL}^2g_Rg_{RB}M_4 + 54g_{BR}^2g_Rg_{RB}M_4 + 12g_L^2g_Rg_{RB}M_4 - 6\sqrt{6}g_{BR}g_R^2g_{RB}M_4 \\
& + 128g_R^3g_{RB}M_4 + 27g_{BL}g_{BR}g_{RB}^2M_4 - 3\sqrt{6}g_{BL}g_Rg_{RB}^2M_4 - \sqrt{6}g_{BR}g_{RB}^3M_4 + 64g_Rg_{RB}^3M_4 \\
& + 12g_L^2g_Rg_{RB}M_2 \\
& + 2\left(2g_{BL}^2M_{BR} + g_{BL}\left(2g_{BR}\left(M_1 + M_4\right) + \sqrt{6}\left(2g_{RB}M_{BR} + g_R\left(M_1 + M_4\right)\right)\right) + g_{BR}\left(2\left(\sqrt{6}g_R + g_{BR}\right)M_{BR} + \sqrt{6}g_{RB}\left(M_1 +\right.\right. \\
& + 2\left(6g_{BL}^2M_{BR} + g_{BR}\left(-2\sqrt{6}g_RM_{BR} + 6g_{BR}M_{BR} - \sqrt{6}g_{RB}\left(M_1 + M_4\right)\right)\right) \\
& \left.\left. + g_{BL}\left(6g_{BR}\left(M_1 + M_4\right) - \sqrt{6}\left(2g_{RB}M_{BR} + g_R\left(M_1 + M_4\right)\right)\right)\right)\right)\text{Tr}\left(Y_v Y_v^\dagger\right) \\
& - 4g_{BL}g_{BR}\text{Tr}\left(Y_u^\dagger T_u\right) - 2\sqrt{6}g_{BL}g_R\text{Tr}\left(Y_u^\dagger T_u\right) - 2\sqrt{6}g_{BR}g_{RB}\text{Tr}\left(Y_u^\dagger T_u\right) - 12g_{BL}g_{BR}\text{Tr}\left(Y_v^\dagger T_\nu\right) \\
& + 2\sqrt{6}g_{BL}g_R\text{Tr}\left(Y_v^\dagger T_\nu\right) + 2\sqrt{6}g_{BR}g_{RB}\text{Tr}\left(Y_v^\dagger T_\nu\right) \\
& - g_{BL}^2M_1\text{Tr}\left(T_u^* Y_u^T\right) - \sqrt{6}g_{BL}g_{RB}M_1\text{Tr}\left(T_u^* Y_u^T\right) - 2g_{BL}g_{BR}M_{BR}\text{Tr}\left(T_u^* Y_u^T\right) \\
& - \sqrt{6}g_{BL}g_R M_{BR}\text{Tr}\left(T_u^* Y_u^T\right) - \sqrt{6}g_{BR}g_{RB}M_{BR}\text{Tr}\left(T_u^* Y_u^T\right) - g_{BR}^2M_4\text{Tr}\left(T_u^* Y_u^T\right)
\end{aligned}$$

$$\begin{aligned}
& -\sqrt{6}g_{BR}g_R M_4 \text{Tr}(T_u^* Y_u^T) - 32g_s^2 M_3 \text{Tr}(T_u^* Y_u^T) + 32g_s^2 \text{Tr}(T_u^* T_u^T) + g_{BL}^2 \text{Tr}(T_u^* T_u^T) \\
& + g_{BR}^2 \text{Tr}(T_u^* T_u^T) + \sqrt{6}g_{BR}g_R \text{Tr}(T_u^* T_u^T) + \sqrt{6}g_{BL}g_{RB} \text{Tr}(T_u^* T_u^T) - 3g_{BL}^2 M_1 \text{Tr}(T_\nu^* Y_\nu^T) \\
& + \sqrt{6}g_{BL}g_{RB} M_1 \text{Tr}(T_\nu^* Y_\nu^T) - 6g_{BL}g_{BR} M_{BR} \text{Tr}(T_\nu^* Y_\nu^T) + \sqrt{6}g_{BL}g_R M_{BR} \text{Tr}(T_\nu^* Y_\nu^T) \\
& + \sqrt{6}g_{BR}g_{RB} M_{BR} \text{Tr}(T_\nu^* Y_\nu^T) - 3g_{BR}^2 M_4 \text{Tr}(T_\nu^* Y_\nu^T) + \sqrt{6}g_{BR}g_R M_4 \text{Tr}(T_\nu^* Y_\nu^T) \\
& + 3g_{BL}^2 \text{Tr}(T_\nu^* T_\nu^T) + 3g_{BR}^2 \text{Tr}(T_\nu^* T_\nu^T) - \sqrt{6}g_{BR}g_R \text{Tr}(T_\nu^* T_\nu^T) - \sqrt{6}g_{BL}g_{RB} \text{Tr}(T_\nu^* T_\nu^T) \\
& + 3g_{BL}^2 \text{Tr}(m_l^2 Y_\nu^\dagger Y_\nu) + 3g_{BR}^2 \text{Tr}(m_l^2 Y_\nu^\dagger Y_\nu) - \sqrt{6}g_{BR}g_R \text{Tr}(m_l^2 Y_\nu^\dagger Y_\nu) \\
& - \sqrt{6}g_{BL}g_{RB} \text{Tr}(m_l^2 Y_\nu^\dagger Y_\nu) + 32g_s^2 \text{Tr}(m_q^2 Y_u^\dagger Y_u) + g_{BL}^2 \text{Tr}(m_q^2 Y_u^\dagger Y_u) \\
& + g_{BR}^2 \text{Tr}(m_q^2 Y_u^\dagger Y_u) + \sqrt{6}g_{BR}g_R \text{Tr}(m_q^2 Y_u^\dagger Y_u) + \sqrt{6}g_{BL}g_{RB} \text{Tr}(m_q^2 Y_u^\dagger Y_u) \\
& + 32g_s^2 \text{Tr}(m_u^2 Y_u Y_u^\dagger) + g_{BL}^2 \text{Tr}(m_u^2 Y_u Y_u^\dagger) + g_{BR}^2 \text{Tr}(m_u^2 Y_u Y_u^\dagger) + \sqrt{6}g_{BR}g_R \text{Tr}(m_u^2 Y_u Y_u^\dagger) \\
& + \sqrt{6}g_{BL}g_{RB} \text{Tr}(m_u^2 Y_u Y_u^\dagger) + 3g_{BL}^2 \text{Tr}(m_\nu^2 Y_\nu Y_\nu^\dagger) + 3g_{BR}^2 \text{Tr}(m_\nu^2 Y_\nu Y_\nu^\dagger) \\
& - \sqrt{6}g_{BR}g_R \text{Tr}(m_\nu^2 Y_\nu Y_\nu^\dagger) - \sqrt{6}g_{BL}g_{RB} \text{Tr}(m_\nu^2 Y_\nu Y_\nu^\dagger) - 6m_{H_d}^2 \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) \\
& - 6m_{H_u}^2 \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 6\text{Tr}(Y_d Y_u^\dagger T_u T_d^\dagger) - 6\text{Tr}(Y_d T_u^\dagger T_u Y_d^\dagger) \\
& - 2m_{H_d}^2 \text{Tr}(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger) - 2m_{H_u}^2 \text{Tr}(Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger) - 2\text{Tr}(Y_e Y_\nu^\dagger T_\nu T_e^\dagger) \\
& - 2\text{Tr}(Y_e T_\nu^\dagger T_\nu Y_e^\dagger) - 2m_\chi^2 \text{Tr}(Y_s Y_s^\dagger Y_\nu Y_\nu^\dagger) - 2m_{H_u}^2 \text{Tr}(Y_s Y_s^\dagger Y_\nu Y_\nu^\dagger) \\
& - 2\text{Tr}(Y_s Y_s^\dagger T_\nu T_\nu^\dagger) - 2\text{Tr}(Y_s T_\nu^\dagger T_\nu Y_s^\dagger) - 6\text{Tr}(Y_u Y_d^\dagger T_d T_u^\dagger) - 36m_{H_u}^2 \text{Tr}(Y_u Y_u^\dagger Y_u Y_u^\dagger) \\
& - 36\text{Tr}(Y_u Y_u^\dagger T_u T_u^\dagger) - 6\text{Tr}(Y_u T_d^\dagger T_d Y_u^\dagger) - 36\text{Tr}(Y_u T_u^\dagger T_u Y_u^\dagger) - 2\text{Tr}(Y_\nu Y_e^\dagger T_e T_\nu^\dagger) \\
& - 12m_{H_u}^2 \text{Tr}(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger) - 2\text{Tr}(Y_\nu Y_\nu^\dagger T_s T_s^\dagger) - 12\text{Tr}(Y_\nu Y_\nu^\dagger T_\nu T_\nu^\dagger) - 2\text{Tr}(Y_\nu T_e^\dagger T_e Y_\nu^\dagger) \\
& - 2\text{Tr}(Y_\nu T_\nu^\dagger T_s Y_\nu^\dagger) - 12\text{Tr}(Y_\nu T_\nu^\dagger T_\nu Y_\nu^\dagger) - 6\text{Tr}(m_d^2 Y_d Y_u^\dagger Y_u Y_d^\dagger) \\
& - 2\text{Tr}(m_e^2 Y_e Y_\nu^\dagger Y_\nu Y_e^\dagger) - 2\text{Tr}(m_l^2 Y_e^\dagger Y_e Y_\nu^\dagger Y_\nu) - 2\text{Tr}(m_l^2 Y_\nu^\dagger Y_s Y_s^\dagger Y_\nu) \\
& - 2\text{Tr}(m_l^2 Y_\nu^\dagger Y_\nu Y_e^\dagger Y_e) - 12\text{Tr}(m_l^2 Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu) - 6\text{Tr}(m_q^2 Y_d^\dagger Y_d Y_u^\dagger Y_u) \\
& - 6\text{Tr}(m_q^2 Y_u^\dagger Y_u Y_d^\dagger Y_d) - 36\text{Tr}(m_q^2 Y_u^\dagger Y_u Y_u^\dagger Y_u) - 2\text{Tr}(m_s^2 Y_s^\dagger Y_\nu Y_\nu^\dagger Y_s) \\
& - 6\text{Tr}(m_u^2 Y_u Y_d^\dagger Y_d Y_u^\dagger) - 36\text{Tr}(m_u^2 Y_u Y_u^\dagger Y_u Y_u^\dagger) - 2\text{Tr}(m_\nu^2 Y_s Y_s^\dagger Y_\nu Y_\nu^\dagger) \\
& - 2\text{Tr}(m_\nu^2 Y_\nu Y_e^\dagger Y_e Y_\nu^\dagger) - 2\text{Tr}(m_\nu^2 Y_\nu Y_\nu^\dagger Y_s Y_s^\dagger) - 12\text{Tr}(m_\nu^2 Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger)
\end{aligned} \tag{96}$$

$$\begin{aligned}
\beta_{m_\chi^2}^{(1)} &= -3g_{BR}^2 |M_4|^2 + 2\sqrt{6}g_{BR}g_R |M_4|^2 - 2g_R^2 |M_4|^2 \\
&+ \left( -3g_{BL}^2 M_1 + g_{BL} \left( 2\sqrt{6}g_{RB} M_1 - 3g_{BR} M_{BR} + \sqrt{6}g_R M_{BR} \right) + g_{RB} \left( -2g_{RB} M_1 - 2g_R M_{BR} + \sqrt{6}g_{BR} M_{BR} \right) \right) M_1^*
\end{aligned}$$

$$\begin{aligned}
& + \left( -3g_{BL}^2 M_{BR} - 3g_{BR}^2 M_{BR} + \sqrt{6}g_{BR} \left( 2g_R M_{BR} + g_{RB} \left( M_1 + M_4 \right) \right) - 2 \left( g_R^2 M_{BR} + g_{RB}^2 M_{BR} + g_R g_{RB} \left( M_1 + M_4 \right) \right) \right. \\
& + g_{BL} \left( -3g_{BR} \left( M_1 + M_4 \right) + \sqrt{6} \left( 2g_{RB} M_{BR} + g_R \left( M_1 + M_4 \right) \right) \right) \left. \right) M_{BR}^* \\
& - 3g_{BL} g_{BR} M_{BR} M_4^* + \sqrt{6} g_{BL} g_R M_{BR} M_4^* + \sqrt{6} g_{BR} g_{RB} M_{BR} M_4^* - 2g_R g_{RB} M_{BR} M_4^* - \sqrt{\frac{3}{2}} g_{BL} \sigma_{1,1} + g_{RB} \sigma_{1,1} \\
& - \sqrt{\frac{3}{2}} g_{BR} \sigma_{1,3} + g_R \sigma_{1,3} + 2m_\chi^2 \text{Tr} \left( Y_s Y_s^\dagger \right) + 2\text{Tr} \left( T_s^* T_s^T \right) + 2\text{Tr} \left( m_S^2 Y_s^\dagger Y_s \right) + 2\text{Tr} \left( m_L^2 Y_s Y_s^\dagger \right) \tag{97}
\end{aligned}$$

$$\begin{aligned}
\beta_{m_\chi^2}^{(2)} = & + 45g_{BL}^2 g_{BR}^2 |M_4|^2 + \frac{135}{2} g_{BR}^4 |M_4|^2 - 18\sqrt{6} g_{BL}^2 g_{BR} g_R |M_4|^2 - 54\sqrt{6} g_{BR}^3 g_R |M_4|^2 \\
& + 6g_{BL}^2 g_R^2 |M_4|^2 + 153g_{BR}^2 g_R^2 |M_4|^2 - 54\sqrt{6} g_{BR} g_R^3 |M_4|^2 + 48g_R^4 |M_4|^2 \\
& - 18\sqrt{6} g_{BL} g_{BR}^2 g_{RB} |M_4|^2 + 90g_{BL} g_{BR} g_R g_{RB} |M_4|^2 - 18\sqrt{6} g_{BL} g_R^2 g_{RB} |M_4|^2 + 6g_{BR}^2 g_{RB}^2 |M_4|^2 \\
& - 18\sqrt{6} g_{BR} g_R g_{RB}^2 |M_4|^2 + 32g_R^2 g_{RB}^2 |M_4|^2 \\
& + \frac{1}{2} \left( 135g_{BL}^4 M_1 - 36g_{BL}^3 \left( 3\sqrt{6} g_{RB} M_1 - 5g_{BR} M_{BR} + \sqrt{6} g_R M_{BR} \right) \right. \\
& + 3g_{BL}^2 \left( 15g_{BR}^2 \left( 2M_1 + M_4 \right) + 2 \left( 34g_R g_{RB} M_{BR} + 51g_{RB}^2 M_1 + g_R^2 \left( 2M_1 + M_4 \right) \right) - 6\sqrt{6} g_{BR} \left( 6g_{RB} M_{BR} + g_R \left( 2M_1 + M_4 \right) \right) \right) \\
& + 2g_{RB} \left( -9\sqrt{6} g_{BR}^3 M_{BR} + 3g_{BR}^2 \left( 17g_R M_{BR} + g_{RB} \left( 2M_1 + M_4 \right) \right) - 9\sqrt{6} g_{BR} \left( 2g_{RB}^2 M_{BR} + 3g_R^2 M_{BR} + g_R g_{RB} \left( 2M_1 + M_4 \right) \right) \right. \\
& \left. + 16 \left( 2g_R^3 M_{BR} + 3g_{RB}^3 M_1 + 4g_R g_{RB}^2 M_{BR} + g_R^2 g_{RB} \left( 2M_1 + M_4 \right) \right) \right) \\
& - 6g_{BL} \left( -15g_{BR}^3 M_{BR} + 3\sqrt{6} g_{BR}^2 \left( 3g_R M_{BR} + g_{RB} \left( 2M_1 + M_4 \right) \right) - g_{BR} \left( 15g_R g_{RB} \left( 2M_1 + M_4 \right) + 17g_R^2 M_{BR} + 34g_{RB}^2 M_{BR} \right) \right. \\
& \left. + 3\sqrt{6} \left( 6g_{RB}^3 M_1 + 6g_R g_{RB}^2 M_{BR} + g_R^2 g_{RB} \left( 2M_1 + M_4 \right) + g_R^3 M_{BR} \right) \right) \left. \right) M_1^* \\
& + \left( 45g_{BL}^4 M_{BR} + 45g_{BR}^4 M_{BR} - 9\sqrt{6} g_{BR}^3 \left( 4g_R M_{BR} + g_{RB} \left( 2M_4 + M_1 \right) \right) \right. \\
& + 3g_{BR}^2 \left( 17g_R g_{RB} \left( 2M_4 + M_1 \right) + 19g_{RB}^2 M_{BR} + 34g_R^2 M_{BR} \right) \\
& - 9\sqrt{6} g_{BR} \left( 3g_R^2 g_{RB} \left( 2M_4 + M_1 \right) + 4g_R^3 M_{BR} + 8g_R g_{RB}^2 M_{BR} + g_{RB}^3 \left( 2M_1 + M_4 \right) \right) \\
& + 32 \left( 4g_R^2 g_{RB}^2 M_{BR} + g_R^3 g_{RB} \left( 2M_4 + M_1 \right) + g_R^4 M_{BR} + g_{RB}^4 M_{BR} + g_R g_{RB}^3 \left( 2M_1 + M_4 \right) \right) \\
& + 9g_{BL}^3 \left( 5g_{BR} \left( 2M_1 + M_4 \right) - \sqrt{6} \left( 4g_{RB} M_{BR} + g_R \left( 2M_1 + M_4 \right) \right) \right) \\
& - 3g_{BL}^2 \left( -17g_R g_{RB} \left( 2M_1 + M_4 \right) - 19g_R^2 M_{BR} - 34g_{RB}^2 M_{BR} + 3\sqrt{6} g_{BR} \left( 3g_{RB} \left( 2M_1 + M_4 \right) + 8g_R M_{BR} \right) - 60g_{BR}^2 M_{BR} \right) \\
& + 3g_{BL} \left( 15g_{BR}^3 \left( 2M_4 + M_1 \right) - 3\sqrt{6} g_{BR}^2 \left( 3g_R \left( 2M_4 + M_1 \right) + 8g_{RB} M_{BR} \right) + g_{BR} \left( 17g_R^2 \left( 2M_4 + M_1 \right) + 17g_{RB}^2 \left( 2M_1 + M_4 \right) + 9 \right. \right. \\
& \left. \left. - 3\sqrt{6} \left( 3g_R g_{RB}^2 \left( 2M_1 + M_4 \right) + 4g_{RB}^3 M_{BR} + 8g_R^2 g_{RB} M_{BR} + g_R^3 \left( 2M_4 + M_1 \right) \right) \right) \right) \left. \right) M_{BR}^* \\
& + \frac{45}{2} g_{BL}^2 g_{BR}^2 M_1 M_4^* - 9\sqrt{6} g_{BL} g_{BR} g_R M_1 M_4^* + 3g_{BL}^2 g_R^2 M_1 M_4^* - 9\sqrt{6} g_{BL} g_{BR}^2 g_{RB} M_1 M_4^* \\
& + 45g_{BL} g_{BR} g_R g_{RB} M_1 M_4^* - 9\sqrt{6} g_{BL} g_R^2 g_{RB} M_1 M_4^* + 3g_{BR}^2 g_{RB}^2 M_1 M_4^* - 9\sqrt{6} g_{BR} g_R g_{RB}^2 M_1 M_4^* \\
& + 16g_R^2 g_{RB}^2 M_1 M_4^* + 45g_{BL}^3 g_{BR} M_{BR} M_4^* + 90g_{BL} g_{BR}^3 M_{BR} M_4^* - 9\sqrt{6} g_{BL}^3 g_R M_{BR} M_4^*
\end{aligned}$$

$$\begin{aligned}
& -54\sqrt{6}g_{BL}g_{BR}^2M_{BR}M_4^* + 102g_{BL}g_{BR}g_R^2M_{BR}M_4^* - 18\sqrt{6}g_{BL}g_R^3M_{BR}M_4^* \\
& -27\sqrt{6}g_{BL}^2g_{BR}g_{RB}M_{BR}M_4^* - 18\sqrt{6}g_{BR}^3g_{RB}M_{BR}M_4^* + 51g_{BL}^2g_{RB}M_{BR}M_4^* + 102g_{BR}^2g_{RB}M_{BR}M_4^* \\
& -54\sqrt{6}g_{BR}g_{RB}^2M_{BR}M_4^* + 64g_{RB}^3M_{BR}M_4^* + 51g_{BL}g_{BR}g_{RB}^2M_{BR}M_4^* - 27\sqrt{6}g_{BL}g_{RB}^2M_{BR}M_4^* \\
& -9\sqrt{6}g_{BR}g_{RB}^3M_{BR}M_4^* + 32g_{RB}^3M_{BR}M_4^* + 3g_{BL}^2\sigma_{2,11} - 2\sqrt{6}g_{BL}g_{RB}\sigma_{2,11} + 2g_{RB}^2\sigma_{2,11} + 3g_{BL}g_{BR}\sigma_{2,13} \\
& -\sqrt{6}g_{BL}g_{RB}\sigma_{2,13} - \sqrt{6}g_{BR}g_{RB}\sigma_{2,13} + 2g_{RB}g_{RB}\sigma_{2,13} + 3g_{BL}g_{BR}\sigma_{2,31} - \sqrt{6}g_{BL}g_{RB}\sigma_{2,31} - \sqrt{6}g_{BR}g_{RB}\sigma_{2,31} \\
& + 2g_{RB}g_{RB}\sigma_{2,31} + 3g_{BR}^2\sigma_{2,33} - 2\sqrt{6}g_{BR}g_{RB}\sigma_{2,33} + 2g_{RB}^2\sigma_{2,33} - 2\sqrt{6}g_{BL}\sigma_{3,1} + 4g_{RB}\sigma_{3,1} - 2\sqrt{6}g_{BR}\sigma_{3,3} + 4g_{RB}\sigma_{3,3} \\
& -8m_\chi^2\text{Tr}\left(Y_sY_s^\dagger Y_sY_s^\dagger\right) - 4m_\chi^2\text{Tr}\left(Y_sY_s^\dagger Y_\nu Y_\nu^\dagger\right) - 4m_{H_u}^2\text{Tr}\left(Y_sY_s^\dagger Y_\nu Y_\nu^\dagger\right) \\
& -8\text{Tr}\left(Y_sY_s^\dagger T_sT_s^\dagger\right) - 4\text{Tr}\left(Y_sY_s^\dagger T_\nu T_\nu^\dagger\right) - 8\text{Tr}\left(Y_sT_s^\dagger T_sY_s^\dagger\right) - 4\text{Tr}\left(Y_sT_s^\dagger T_\nu Y_\nu^\dagger\right) \\
& -4\text{Tr}\left(Y_\nu Y_\nu^\dagger T_sT_s^\dagger\right) - 4\text{Tr}\left(Y_\nu T_\nu^\dagger T_sY_s^\dagger\right) - 4\text{Tr}\left(m_l^2Y_\nu^\dagger Y_sY_s^\dagger Y_\nu\right) - 8\text{Tr}\left(m_S^2Y_s^\dagger Y_sY_s^\dagger Y_s\right) \\
& -4\text{Tr}\left(m_S^2Y_s^\dagger Y_\nu Y_\nu^\dagger Y_s\right) - 8\text{Tr}\left(m_\nu^2Y_sY_s^\dagger Y_sY_s^\dagger\right) - 4\text{Tr}\left(m_\nu^2Y_sY_s^\dagger Y_\nu Y_\nu^\dagger\right) \\
& -4\text{Tr}\left(m_\nu^2Y_\nu Y_\nu^\dagger Y_sY_s^\dagger\right)
\end{aligned} \tag{98}$$

$$\begin{aligned}
\beta_{m_\chi^2}^{(1)} &= -3g_{BR}^2|M_4|^2 + 2\sqrt{6}g_{BR}g_R|M_4|^2 - 2g_R^2|M_4|^2 \\
& + \left(-3g_{BL}^2M_1 + g_{BL}\left(2\sqrt{6}g_{RB}M_1 - 3g_{BR}M_{BR} + \sqrt{6}g_RM_{BR}\right) + g_{RB}\left(-2g_{RB}M_1 - 2g_RM_{BR} + \sqrt{6}g_{BR}M_{BR}\right)\right)M_1^* \\
& + \left(-3g_{BL}^2M_{BR} - 3g_{BR}^2M_{BR} + \sqrt{6}g_{BR}\left(2g_RM_{BR} + g_{RB}\left(M_1 + M_4\right)\right) - 2\left(g_R^2M_{BR} + g_{RB}^2M_{BR} + g_Rg_{RB}\left(M_1 + M_4\right)\right)\right) \\
& + g_{BL}\left(-3g_{BR}\left(M_1 + M_4\right) + \sqrt{6}\left(2g_{RB}M_{BR} + g_R\left(M_1 + M_4\right)\right)\right)M_{BR}^* \\
& -3g_{BL}g_{BR}M_{BR}M_4^* + \sqrt{6}g_{BL}g_RM_{BR}M_4^* + \sqrt{6}g_{BR}g_{RB}M_{BR}M_4^* - 2g_Rg_{RB}M_{BR}M_4^* + \sqrt{\frac{3}{2}}g_{BL}\sigma_{1,1} - g_{RB}\sigma_{1,1} \\
& + \sqrt{\frac{3}{2}}g_{BR}\sigma_{1,3} - g_R\sigma_{1,3}
\end{aligned} \tag{99}$$

$$\begin{aligned}
\beta_{m_\chi^2}^{(2)} &= +45g_{BL}^2g_{BR}^2|M_4|^2 + \frac{135}{2}g_{BR}^4|M_4|^2 - 18\sqrt{6}g_{BL}^2g_{BR}g_R|M_4|^2 - 54\sqrt{6}g_{BR}^3g_R|M_4|^2 \\
& + 6g_{BL}^2g_R^2|M_4|^2 + 153g_{BR}^2g_R^2|M_4|^2 - 54\sqrt{6}g_{BR}g_R^3|M_4|^2 + 48g_R^4|M_4|^2 \\
& - 18\sqrt{6}g_{BL}g_{BR}^2g_{RB}|M_4|^2 + 90g_{BL}g_{BR}g_Rg_{RB}|M_4|^2 - 18\sqrt{6}g_{BL}g_R^2g_{RB}|M_4|^2 + 6g_{BR}^2g_{RB}^2|M_4|^2 \\
& - 18\sqrt{6}g_{BR}g_Rg_{RB}^2|M_4|^2 + 32g_R^2g_{RB}^2|M_4|^2 \\
& + \frac{1}{2}\left(135g_{BL}^4M_1 - 36g_{BL}^3\left(3\sqrt{6}g_{RB}M_1 - 5g_{BR}M_{BR} + \sqrt{6}g_RM_{BR}\right)\right) \\
& + 3g_{BL}^2\left(15g_{BR}^2\left(2M_1 + M_4\right) + 2\left(34g_Rg_{RB}M_{BR} + 51g_{RB}^2M_1 + g_R^2\left(2M_1 + M_4\right)\right) - 6\sqrt{6}g_{BR}\left(6g_{RB}M_{BR} + g_R\left(2M_1 + M_4\right)\right)\right) \\
& + 2g_{RB}\left(-9\sqrt{6}g_{BR}^3M_{BR} + 3g_{BR}^2\left(17g_RM_{BR} + g_{RB}\left(2M_1 + M_4\right)\right) - 9\sqrt{6}g_{BR}\left(2g_{RB}^2M_{BR} + 3g_R^2M_{BR} + g_Rg_{RB}\left(2M_1 + M_4\right)\right)\right) \\
& + 16\left(2g_R^3M_{BR} + 3g_{RB}^3M_1 + 4g_Rg_{RB}^2M_{BR} + g_R^2g_{RB}\left(2M_1 + M_4\right)\right) \\
& - 6g_{BL}\left(-15g_{BR}^3M_{BR} + 3\sqrt{6}g_{BR}^2\left(3g_RM_{BR} + g_{RB}\left(2M_1 + M_4\right)\right) - g_{BR}\left(15g_Rg_{RB}\left(2M_1 + M_4\right) + 17g_R^2M_{BR} + 34g_{RB}^2M_{BR}\right)\right)
\end{aligned}$$

$$\begin{aligned}
& + 3\sqrt{6}\left(6g_{RB}^3M_1 + 6g_{Rg_{RB}^2}M_{BR} + g_{R^2g_{RB}}(2M_1 + M_4) + g_R^3M_{BR}\right)M_1^* \\
& + \left(45g_{BL}^4M_{BR} + 45g_{BR}^4M_{BR} - 9\sqrt{6}g_{BR}^3(4g_RM_{BR} + g_{RB}(2M_4 + M_1))\right) \\
& + 3g_{BR}^2\left(17g_{Rg_{RB}}(2M_4 + M_1) + 19g_{RB}^2M_{BR} + 34g_R^2M_{BR}\right) \\
& - 9\sqrt{6}g_{BR}\left(3g_{R^2g_{RB}}(2M_4 + M_1) + 4g_R^3M_{BR} + 8g_{Rg_{RB}^2}M_{BR} + g_{RB}^3(2M_1 + M_4)\right) \\
& + 32\left(4g_{R^2g_{RB}^2}M_{BR} + g_{R^3g_{RB}}(2M_4 + M_1) + g_R^4M_{BR} + g_{RB}^4M_{BR} + g_{Rg_{RB}^3}(2M_1 + M_4)\right) \\
& + 9g_{BL}^3\left(5g_{BR}(2M_1 + M_4) - \sqrt{6}\left(4g_{RB}M_{BR} + g_R(2M_1 + M_4)\right)\right) \\
& - 3g_{BL}^2\left(-17g_{Rg_{RB}}(2M_1 + M_4) - 19g_R^2M_{BR} - 34g_{RB}^2M_{BR} + 3\sqrt{6}g_{BR}\left(3g_{RB}(2M_1 + M_4) + 8g_RM_{BR}\right) - 60g_{BR}^2M_{BR}\right) \\
& + 3g_{BL}\left(15g_{BR}^3(2M_4 + M_1) - 3\sqrt{6}g_{BR}^2\left(3g_R(2M_4 + M_1) + 8g_{RB}M_{BR}\right) + g_{BR}\left(17g_R^2(2M_4 + M_1) + 17g_{RB}^2(2M_1 + M_4) + 98\right) \right. \\
& \left. - 3\sqrt{6}\left(3g_{Rg_{RB}^2}(2M_1 + M_4) + 4g_{RB}^3M_{BR} + 8g_{R^2g_{RB}}M_{BR} + g_R^3(2M_4 + M_1)\right)\right)M_{BR}^* \\
& + \frac{45}{2}g_{BL}^2g_{BR}^2M_1M_4^* - 9\sqrt{6}g_{BL}^2g_{BRg_R}M_1M_4^* + 3g_{BL}^2g_R^2M_1M_4^* - 9\sqrt{6}g_{BL}g_{BR}^2g_{RB}M_1M_4^* \\
& + 45g_{BLg_{BRg_Rg_{RB}}}M_1M_4^* - 9\sqrt{6}g_{BLg_R^2g_{RB}}M_1M_4^* + 3g_{BR}^2g_{RB}^2M_1M_4^* - 9\sqrt{6}g_{BRg_Rg_{RB}^2}M_1M_4^* \\
& + 16g_{R^2g_{RB}^2}M_1M_4^* + 45g_{BL}^3g_{BR}M_{BR}M_4^* + 90g_{BL}g_{BR}^3M_{BR}M_4^* - 9\sqrt{6}g_{BL}^3g_RM_{BR}M_4^* \\
& - 54\sqrt{6}g_{BL}g_{BR}^2g_RM_{BR}M_4^* + 102g_{BLg_{BR}g_R^2}M_{BR}M_4^* - 18\sqrt{6}g_{BL}g_R^3M_{BR}M_4^* \\
& - 27\sqrt{6}g_{BL}^2g_{BRg_{RB}}M_{BR}M_4^* - 18\sqrt{6}g_{BR}^3g_{RB}M_{BR}M_4^* + 51g_{BL}^2g_{Rg_{RB}}M_{BR}M_4^* + 102g_{BR}^2g_{Rg_{RB}}M_{BR}M_4^* \\
& - 54\sqrt{6}g_{BRg_R^2g_{RB}}M_{BR}M_4^* + 64g_{R^3g_{RB}}M_{BR}M_4^* + 51g_{BLg_{RB}g_{RB}^2}M_{BR}M_4^* - 27\sqrt{6}g_{BLg_Rg_{RB}^2}M_{BR}M_4^* \\
& - 9\sqrt{6}g_{BRg_{RB}^3}M_{BR}M_4^* + 32g_{Rg_{RB}^3}M_{BR}M_4^* + 3g_{BL}^2\sigma_{2,11} - 2\sqrt{6}g_{BLg_{RB}}\sigma_{2,11} + 2g_{RB}^2\sigma_{2,11} + 3g_{BLg_{BR}}\sigma_{2,13} \\
& - \sqrt{6}g_{BLg_R}\sigma_{2,13} - \sqrt{6}g_{BRg_{RB}}\sigma_{2,13} + 2g_{Rg_{RB}}\sigma_{2,13} + 3g_{BLg_{BR}}\sigma_{2,31} - \sqrt{6}g_{BLg_R}\sigma_{2,31} - \sqrt{6}g_{BRg_{RB}}\sigma_{2,31} \\
& + 2g_{Rg_{RB}}\sigma_{2,31} + 3g_{BR}^2\sigma_{2,33} - 2\sqrt{6}g_{BRg_R}\sigma_{2,33} + 2g_R^2\sigma_{2,33} + 2\sqrt{6}g_{BL}\sigma_{3,1} - 4g_{RB}\sigma_{3,1} + 2\sqrt{6}g_{BR}\sigma_{3,3} - 4g_R\sigma_{3,3}
\end{aligned} \tag{100}$$

$$\beta_{m_s^2}^{(1)} = 2m_\chi^2 Y_s^\dagger Y_s + 2T_s^\dagger T_s + 2Y_s^\dagger m_\nu^2 Y_s + m_S^2 Y_s^\dagger Y_s + Y_s^\dagger Y_s m_S^2 \tag{101}$$

$$\begin{aligned}
\beta_{m_s^2}^{(2)} = & + \left(-2g_{RB}^2 + 2\sqrt{6}g_{BLg_{RB}} - 3g_{BL}^2\right)M_1^* Y_s^\dagger T_s - 6g_{BLg_{BR}}M_{BR}^* Y_s^\dagger T_s \\
& + 2\sqrt{6}g_{BLg_R}M_{BR}^* Y_s^\dagger T_s + 2\sqrt{6}g_{BRg_{RB}}M_{BR}^* Y_s^\dagger T_s - 4g_{Rg_{RB}}M_{BR}^* Y_s^\dagger T_s \\
& - 3g_{BR}^2M_4^* Y_s^\dagger T_s + 2\sqrt{6}g_{BRg_R}M_4^* Y_s^\dagger T_s - 2g_R^2M_4^* Y_s^\dagger T_s - 3g_{BL}^2M_1 T_s^\dagger Y_s \\
& + 2\sqrt{6}g_{BLg_{RB}}M_1 T_s^\dagger Y_s - 2g_{RB}^2M_1 T_s^\dagger Y_s - 6g_{BLg_{BR}}M_{BR} T_s^\dagger Y_s \\
& + 2\sqrt{6}g_{BLg_R}M_{BR} T_s^\dagger Y_s + 2\sqrt{6}g_{BRg_{RB}}M_{BR} T_s^\dagger Y_s - 4g_{Rg_{RB}}M_{BR} T_s^\dagger Y_s \\
& - 3g_{BR}^2M_4 T_s^\dagger Y_s + 2\sqrt{6}g_{BRg_R}M_4 T_s^\dagger Y_s - 2g_R^2M_4 T_s^\dagger Y_s + 3g_{BL}^2 T_s^\dagger T_s \\
& + 3g_{BR}^2 T_s^\dagger T_s - 2\sqrt{6}g_{BRg_R} T_s^\dagger T_s + 2g_R^2 T_s^\dagger T_s - 2\sqrt{6}g_{BLg_{RB}} T_s^\dagger T_s \\
& + 2g_{RB}^2 T_s^\dagger T_s + \frac{3}{2}g_{BL}^2 m_S^2 Y_s^\dagger Y_s + \frac{3}{2}g_{BR}^2 m_S^2 Y_s^\dagger Y_s - \sqrt{6}g_{BRg_R} m_S^2 Y_s^\dagger Y_s
\end{aligned}$$

$$\begin{aligned}
& + g_R^2 m_S^2 Y_s^\dagger Y_s - \sqrt{6} g_{BL} g_{RB} m_S^2 Y_s^\dagger Y_s + g_{RB}^2 m_S^2 Y_s^\dagger Y_s + 3g_{BL}^2 Y_s^\dagger m_\nu^2 Y_s \\
& + 3g_{BR}^2 Y_s^\dagger m_\nu^2 Y_s - 2\sqrt{6} g_{BR} g_R Y_s^\dagger m_\nu^2 Y_s + 2g_R^2 Y_s^\dagger m_\nu^2 Y_s \\
& - 2\sqrt{6} g_{BL} g_{RB} Y_s^\dagger m_\nu^2 Y_s + 2g_{RB}^2 Y_s^\dagger m_\nu^2 Y_s + \frac{3}{2} g_{BL}^2 Y_s^\dagger Y_s m_S^2 \\
& + \frac{3}{2} g_{BR}^2 Y_s^\dagger Y_s m_S^2 - \sqrt{6} g_{BR} g_R Y_s^\dagger Y_s m_S^2 + g_R^2 Y_s^\dagger Y_s m_S^2 \\
& - \sqrt{6} g_{BL} g_{RB} Y_s^\dagger Y_s m_S^2 + g_{RB}^2 Y_s^\dagger Y_s m_S^2 - 4m_\chi^2 Y_s^\dagger Y_s Y_s^\dagger Y_s - 2Y_s^\dagger Y_s T_s^\dagger T_s \\
& - 4m_\chi^2 Y_s^\dagger Y_v Y_v^\dagger Y_s - 4m_{H_u}^2 Y_s^\dagger Y_v Y_v^\dagger Y_s - 4Y_s^\dagger Y_v T_\nu^\dagger T_\nu \\
& - 2Y_s^\dagger T_s T_s^\dagger Y_s - 4Y_s^\dagger T_\nu T_\nu^\dagger Y_s - 2T_s^\dagger Y_s Y_s^\dagger T_s - 4T_s^\dagger Y_v Y_v^\dagger T_s \\
& - 2T_s^\dagger T_s Y_s^\dagger Y_s - 4T_s^\dagger T_\nu Y_v^\dagger Y_s - m_S^2 Y_s^\dagger Y_s Y_s^\dagger Y_s - 2m_S^2 Y_s^\dagger Y_v Y_v^\dagger Y_s \\
& - 2Y_s^\dagger m_\nu^2 Y_s Y_s^\dagger Y_s - 4Y_s^\dagger m_\nu^2 Y_v Y_v^\dagger Y_s - 2Y_s^\dagger Y_s m_S^2 Y_s^\dagger Y_s - 2Y_s^\dagger Y_s Y_s^\dagger m_\nu^2 Y_s \\
& - Y_s^\dagger Y_s Y_s^\dagger Y_s m_S^2 - 4Y_s^\dagger Y_v m_l^2 Y_v^\dagger Y_s - 4Y_s^\dagger Y_v Y_v^\dagger m_\nu^2 Y_s \\
& - 2Y_s^\dagger Y_v Y_v^\dagger Y_s m_S^2 - 2T_s^\dagger T_s \text{Tr}(Y_s Y_s^\dagger) - m_S^2 Y_s^\dagger Y_s \text{Tr}(Y_s Y_s^\dagger) \\
& - 2Y_s^\dagger m_\nu^2 Y_s \text{Tr}(Y_s Y_s^\dagger) - Y_s^\dagger Y_s m_S^2 \text{Tr}(Y_s Y_s^\dagger) - 2T_s^\dagger Y_s \text{Tr}(Y_s^\dagger T_s) \\
& - 2Y_s^\dagger T_s \text{Tr}(T_s^* Y_s^T) \\
& + Y_s^\dagger Y_s \left( 3g_{BL}^2 m_\chi^2 + 3g_{BR}^2 m_\chi^2 - 2\sqrt{6} g_{BR} g_R m_\chi^2 + 2g_R^2 m_\chi^2 - 2\sqrt{6} g_{BL} g_{RB} m_\chi^2 + 2g_{RB}^2 m_\chi^2 + 6g_{BR}^2 |M_4|^2 \right. \\
& \left. - 4\sqrt{6} g_{BR} g_R |M_4|^2 + 4g_R^2 |M_4|^2 \right) \\
& + \left( -2g_{BL} \left( 2\sqrt{6} g_{RB} M_1 - 3g_{BR} M_{BR} + \sqrt{6} g_R M_{BR} \right) + 2g_{RB} \left( 2g_{RB} M_1 + 2g_R M_{BR} - \sqrt{6} g_{BR} M_{BR} \right) + 6g_{BL}^2 M_1 \right) M_1^* \\
& + \left( 6g_{BL}^2 M_{BR} + 6g_{BR}^2 M_{BR} - 2\sqrt{6} g_{BR} \left( 2g_R M_{BR} + g_{RB} (M_1 + M_4) \right) + 4 \left( g_R^2 M_{BR} + g_{RB}^2 M_{BR} + g_R g_{RB} (M_1 + M_4) \right) \right. \\
& \left. + g_{BL} \left( -2\sqrt{6} \left( 2g_{RB} M_{BR} + g_R (M_1 + M_4) \right) + 6g_{BR} (M_1 + M_4) \right) \right) M_{BR}^* \\
& + 6g_{BL} g_{RB} M_{BR} M_4^* - 2\sqrt{6} g_{BL} g_R M_{BR} M_4^* - 2\sqrt{6} g_{BR} g_{RB} M_{BR} M_4^* + 4g_R g_{RB} M_{BR} M_4^* - 4m_\chi^2 \text{Tr}(Y_s Y_s^\dagger) \\
& - 2\text{Tr}(T_s^* T_s^T) - 2\text{Tr}(m_S^2 Y_s^\dagger Y_s) - 2\text{Tr}(m_\nu^2 Y_s Y_s^\dagger) \tag{102}
\end{aligned}$$

$$\begin{aligned}
\beta_{m_u^2}^{(1)} & = \frac{1}{6} \left( -2g_{BR}^2 \mathbf{1} |M_4|^2 - 4\sqrt{6} g_{BR} g_R \mathbf{1} |M_4|^2 - 12g_R^2 \mathbf{1} |M_4|^2 - 64g_S^2 \mathbf{1} |M_3|^2 \right. \\
& - 2 \left( g_{BL}^2 M_1 + g_{BL} \left( 2\sqrt{6} g_{RB} M_1 + \left( \sqrt{6} g_R + g_{BR} \right) M_{BR} \right) + g_{RB} \left( 6g_{RB} M_1 + 6g_R M_{BR} + \sqrt{6} g_{BR} M_{BR} \right) \right) \mathbf{1} M_1^* \\
& - 2 \left( g_{BL}^2 M_{BR} + g_{BR}^2 M_{BR} + \sqrt{6} g_{BR} \left( 2g_R M_{BR} + g_{RB} (M_1 + M_4) \right) + 6 \left( g_R^2 M_{BR} + g_{RB}^2 M_{BR} + g_R g_{RB} (M_1 + M_4) \right) \right. \\
& \left. + g_{BL} \left( g_{BR} (M_1 + M_4) + \sqrt{6} \left( 2g_{RB} M_{BR} + g_R (M_1 + M_4) \right) \right) \right) \mathbf{1} M_{BR}^* \\
& - 2g_{BL} g_{RB} M_{BR} \mathbf{1} M_4^* - 2\sqrt{6} g_{BL} g_R M_{BR} \mathbf{1} M_4^* - 2\sqrt{6} g_{BR} g_{RB} M_{BR} \mathbf{1} M_4^* - 12g_R g_{RB} M_{BR} \mathbf{1} M_4^* \\
& + 24m_{H_u}^2 Y_u Y_u^\dagger + 24T_u T_u^\dagger + 12m_u^2 Y_u Y_u^\dagger + 24Y_u m_q^2 Y_u^\dagger + 12Y_u Y_u^\dagger m_u^2 \\
& \left. - \sqrt{6} g_{BL} \mathbf{1} \sigma_{1,1} - 6g_{RB} \mathbf{1} \sigma_{1,1} - \sqrt{6} g_{BR} \mathbf{1} \sigma_{1,3} - 6g_R \mathbf{1} \sigma_{1,3} \right) \tag{103}
\end{aligned}$$

$$\begin{aligned}
\beta_{m_u^2}^{(2)} = & \frac{1}{18} \left( 32g_s^2 g_{BR}^2 \mathbf{1}|M_4|^2 + 82g_{BL}^2 g_{BR}^2 \mathbf{1}|M_4|^2 + 123g_{BR}^4 \mathbf{1}|M_4|^2 + 64\sqrt{6}g_s^2 g_{BR} g_R \mathbf{1}|M_4|^2 \right. \\
& + 80\sqrt{6}g_{BL}^2 g_{BR} g_R \mathbf{1}|M_4|^2 + 240\sqrt{6}g_{BR}^3 g_R \mathbf{1}|M_4|^2 + 192g_s^2 g_R^2 \mathbf{1}|M_4|^2 - 12g_{BL}^2 g_R^2 \mathbf{1}|M_4|^2 \\
& + 810g_{BR}^2 g_R^2 \mathbf{1}|M_4|^2 + 252\sqrt{6}g_{BR} g_R^3 \mathbf{1}|M_4|^2 + 864g_R^4 \mathbf{1}|M_4|^2 + 80\sqrt{6}g_{BL} g_{BR}^2 g_{RB} \mathbf{1}|M_4|^2 \\
& + 564g_{BL} g_{BR} g_R g_{RB} \mathbf{1}|M_4|^2 + 84\sqrt{6}g_{BL} g_R^2 g_{RB} \mathbf{1}|M_4|^2 - 12g_{BR}^2 g_{RB}^2 \mathbf{1}|M_4|^2 \\
& + 84\sqrt{6}g_{BR} g_R g_{RB}^2 \mathbf{1}|M_4|^2 + 576g_R^2 g_{RB}^2 \mathbf{1}|M_4|^2 - 768g_s^4 \mathbf{1}|M_3|^2 + 32g_s^2 g_{BL}^2 \mathbf{1}|M_3|^2 \\
& + 32g_s^2 g_{BR}^2 \mathbf{1}|M_3|^2 + 64\sqrt{6}g_s^2 g_{BR} g_R \mathbf{1}|M_3|^2 + 192g_s^2 g_R^2 \mathbf{1}|M_3|^2 + 64\sqrt{6}g_s^2 g_{BL} g_{RB} \mathbf{1}|M_3|^2 \\
& + 192g_s^2 g_{RB}^2 \mathbf{1}|M_3|^2 + 41g_{BL}^2 g_{BR}^2 M_1 \mathbf{1}M_4^* + 40\sqrt{6}g_{BL}^2 g_{BR} g_R M_1 \mathbf{1}M_4^* - 6g_{BL}^2 g_R^2 M_1 \mathbf{1}M_4^* \\
& + 40\sqrt{6}g_{BL} g_{BR}^2 g_{RB} M_1 \mathbf{1}M_4^* + 282g_{BL} g_{BR} g_R g_{RB} M_1 \mathbf{1}M_4^* + 42\sqrt{6}g_{BL} g_R^2 g_{RB} M_1 \mathbf{1}M_4^* \\
& - 6g_{BR}^2 g_{RB}^2 M_1 \mathbf{1}M_4^* + 42\sqrt{6}g_{BR} g_R g_{RB}^2 M_1 \mathbf{1}M_4^* + 288g_R^2 g_{RB}^2 M_1 \mathbf{1}M_4^* + 32g_s^2 g_{BL} g_{BR} M_{BR} \mathbf{1}M_4^* \\
& + 82g_{BL}^3 g_{BR} M_{BR} \mathbf{1}M_4^* + 164g_{BL} g_{BR}^3 M_{BR} \mathbf{1}M_4^* + 32\sqrt{6}g_s^2 g_{BL} g_R M_{BR} \mathbf{1}M_4^* + 40\sqrt{6}g_{BL}^3 g_R M_{BR} \mathbf{1}M_4^* \\
& + 240\sqrt{6}g_{BL} g_{BR}^2 g_R M_{BR} \mathbf{1}M_4^* + 540g_{BL} g_{BR} g_R^2 M_{BR} \mathbf{1}M_4^* + 84\sqrt{6}g_{BL} g_R^3 M_{BR} \mathbf{1}M_4^* \\
& + 32\sqrt{6}g_s^2 g_{BR} g_{RB} M_{BR} \mathbf{1}M_4^* + 120\sqrt{6}g_{BL}^2 g_{BR} g_{RB} M_{BR} \mathbf{1}M_4^* + 80\sqrt{6}g_{BR}^3 g_{RB} M_{BR} \mathbf{1}M_4^* \\
& + 192g_s^2 g_R g_{RB} M_{BR} \mathbf{1}M_4^* + 270g_{BL}^2 g_R g_{RB} M_{BR} \mathbf{1}M_4^* + 540g_{BR}^2 g_R g_{RB} M_{BR} \mathbf{1}M_4^* + 252\sqrt{6}g_{BR} g_R^2 g_{RB} M_{BR} \mathbf{1}M_4^* \\
& + 1152g_R^3 g_{RB} M_{BR} \mathbf{1}M_4^* + 270g_{BL} g_{BR} g_{RB}^2 M_{BR} \mathbf{1}M_4^* + 126\sqrt{6}g_{BL} g_R g_{RB}^2 M_{BR} \mathbf{1}M_4^* + 42\sqrt{6}g_{BR} g_{RB}^3 M_{BR} \mathbf{1}M_4^* \\
& + 576g_{BR} g_{RB}^3 M_{BR} \mathbf{1}M_4^* + 16g_s^2 g_{BR}^2 M_3 \mathbf{1}M_4^* + 32\sqrt{6}g_s^2 g_{BR} g_R M_3 \mathbf{1}M_4^* + 96g_s^2 g_R^2 M_3 \mathbf{1}M_4^* \\
& + 16g_s^2 g_{BL}^2 M_1 \mathbf{1}M_3^* + 32\sqrt{6}g_s^2 g_{BL} g_{RB} M_1 \mathbf{1}M_3^* + 96g_s^2 g_{RB}^2 M_1 \mathbf{1}M_3^* + 32g_s^2 g_{BL} g_{BR} M_{BR} \mathbf{1}M_3^* \\
& + 32\sqrt{6}g_s^2 g_{BL} g_R M_{BR} \mathbf{1}M_3^* + 32\sqrt{6}g_s^2 g_{BR} g_{RB} M_{BR} \mathbf{1}M_3^* + 192g_s^2 g_R g_{RB} M_{BR} \mathbf{1}M_3^* \\
& + 16g_s^2 g_{BR}^2 M_4 \mathbf{1}M_3^* + 32\sqrt{6}g_s^2 g_{BR} g_R M_4 \mathbf{1}M_3^* + 96g_s^2 g_R^2 M_4 \mathbf{1}M_3^* + 216g_L^2 m_{H_u}^2 Y_u Y_u^\dagger \\
& - 12\sqrt{6}g_{BR} g_R m_{H_u}^2 Y_u Y_u^\dagger - 12\sqrt{6}g_{BL} g_{RB} m_{H_u}^2 Y_u Y_u^\dagger \\
& - 24\sqrt{6}g_{BR} g_R |M_4|^2 Y_u Y_u^\dagger + 432g_L^2 |M_2|^2 Y_u Y_u^\dagger - 12\sqrt{6}g_{BL} g_R M_{BR} M_4^* Y_u Y_u^\dagger \\
& - 12\sqrt{6}g_{BR} g_{RB} M_{BR} M_4^* Y_u Y_u^\dagger + 12\sqrt{6}g_{BL} g_{RB} M_1 Y_u T_u^\dagger + 12\sqrt{6}g_{BL} g_R M_{BR} Y_u T_u^\dagger \\
& + 12\sqrt{6}g_{BR} g_{RB} M_{BR} Y_u T_u^\dagger + 12\sqrt{6}g_{BR} g_R M_4 Y_u T_u^\dagger - 216g_L^2 M_2 Y_u T_u^\dagger \\
& + 12\sqrt{6}g_{BR} g_R M_4^* T_u Y_u^\dagger - 216g_L^2 M_2^* T_u Y_u^\dagger \\
& + M_1^* \left( \left( 123g_{BL}^4 M_1 + 4g_{BL}^3 \left( 20\sqrt{6}g_R M_{BR} + 41g_{BR} M_{BR} + 60\sqrt{6}g_{RB} M_1 \right) \right. \right. \\
& + g_{BL}^2 \left( 40\sqrt{6}g_{BR} \left( 6g_{RB} M_{BR} + g_R \left( 2M_1 + M_4 \right) \right) + 41g_{BR}^2 \left( 2M_1 + M_4 \right) - 6 \left( -135g_{RB}^2 M_1 - 90g_R g_{RB} M_{BR} + g_R^2 \left( 2M_1 + M_4 \right) \right) \right. \\
& + 2g_{RB} \left( 20\sqrt{6}g_{BR}^3 M_{BR} - 3g_{BR}^2 \left( -45g_R M_{BR} + g_{RB} \left( 2M_1 + M_4 \right) \right) + 21\sqrt{6}g_{BR} \left( 2g_{RB}^2 M_{BR} + 3g_R^2 M_{BR} + g_R g_{RB} \left( 2M_1 + M_4 \right) \right) \right. \\
& \left. \left. + 144 \left( 2g_R^3 M_{BR} + 3g_{RB}^3 M_1 + 4g_R g_{RB}^2 M_{BR} + g_R^2 g_{RB} \left( 2M_1 + M_4 \right) \right) \right) \right) \\
& + 2g_{BL} \left( 41g_{BR}^3 M_{BR} + 20\sqrt{6}g_{BR}^2 \left( 3g_R M_{BR} + g_{RB} \left( 2M_1 + M_4 \right) \right) + 3g_{BR} \left( 45g_R^2 M_{BR} + 47g_R g_{RB} \left( 2M_1 + M_4 \right) + 90g_{RB}^2 M_{BR} \right) \right. \\
& \left. + 21\sqrt{6} \left( 6g_{RB}^3 M_1 + 6g_R g_{RB}^2 M_{BR} + g_R^2 g_{RB} \left( 2M_1 + M_4 \right) + g_R^3 M_{BR} \right) \right) \\
& + 16g_s^2 \left( 2g_{BL} \left( \sqrt{6}g_{RB} \left( 2M_1 + M_3 \right) + \left( \sqrt{6}g_R + g_{BR} \right) M_{BR} \right) + 2g_{RB} \left( 3g_{RB} M_3 + 6g_{RB} M_1 + 6g_R M_{BR} + \sqrt{6}g_{BR} M_{BR} \right) + g_{BL}^2 \left( 2 \right. \right.
\end{aligned}$$

$$\begin{aligned}
& -12\sqrt{6}\left(\left(2g_{BL}g_{RB}M_1 + g_{BL}g_R M_{BR} + g_{BR}g_{RB}M_{BR}\right)Y_u Y_u^\dagger - g_{BL}g_{RB}T_u Y_u^\dagger\right) \\
& + 2M_{BR}^*\left(\left(20\sqrt{6}g_{BR}^3g_{RB}M_1 + 135g_{BR}^2g_Rg_{RB}M_1 + 63\sqrt{6}g_{BR}g_R^2g_{RB}M_1 + 288g_R^3g_{RB}M_1 + 42\sqrt{6}g_{BR}g_{RB}^3M_1\right.\right. \\
& + 576g_Rg_{RB}^3M_1 + 41g_{BL}^4M_{BR} + 41g_{BR}^4M_{BR} + 80\sqrt{6}g_{BR}^3g_RM_{BR} + 270g_{BR}^2g_R^2M_{BR} + 84\sqrt{6}g_{BR}g_R^3M_{BR} \\
& + 288g_R^4M_{BR} + 129g_{BR}^2g_{RB}^2M_{BR} + 168\sqrt{6}g_{BR}g_Rg_{RB}^2M_{BR} + 1152g_R^2g_{RB}^2M_{BR} + 288g_{RB}^4M_{BR} \\
& + 40\sqrt{6}g_{BR}^3g_{RB}M_4 + 270g_{BR}^2g_Rg_{RB}M_4 + 126\sqrt{6}g_{BR}g_R^2g_{RB}M_4 + 576g_R^3g_{RB}M_4 + 21\sqrt{6}g_{BR}g_{RB}^3M_4 \\
& \left.\left.+ 288g_Rg_{RB}^3M_4 + g_{BL}^3\left(20\sqrt{6}\left(4g_{RB}M_{BR} + g_R\left(2M_1 + M_4\right)\right) + 41g_{BR}\left(2M_1 + M_4\right)\right)\right)\right) \\
& + g_{BL}^2\left(164g_{BR}^2M_{BR} + 20\sqrt{6}g_{BR}\left(3g_{RB}\left(2M_1 + M_4\right) + 8g_RM_{BR}\right) + 3\left(43g_R^2M_{BR} + 45g_Rg_{RB}\left(2M_1 + M_4\right) + 90g_{RB}^2M_{BR}\right)\right) \\
& + g_{BL}\left(41g_{BR}^3\left(2M_4 + M_1\right) + 20\sqrt{6}g_{BR}^2\left(3g_R\left(2M_4 + M_1\right) + 8g_{RB}M_{BR}\right)\right) \\
& + 3g_{BR}\left(274g_Rg_{RB}M_{BR} + 45g_R^2\left(2M_4 + M_1\right) + 45g_{RB}^2\left(2M_1 + M_4\right)\right) \\
& + 21\sqrt{6}\left(3g_Rg_{RB}^2\left(2M_1 + M_4\right) + 4g_{RB}^3M_{BR} + 8g_R^2g_{RB}M_{BR} + g_R^3\left(2M_4 + M_1\right)\right) \\
& + 16g_s^2\left(g_{BL}^2M_{BR} + g_{BR}^2M_{BR} + \sqrt{6}g_{BR}\left(2g_RM_{BR} + g_{RB}\left(M_1 + M_4 + M_3\right)\right) + 6\left(g_R^2M_{BR} + g_{RB}^2M_{BR} + g_Rg_{RB}\left(M_1 + M_4 + M_3\right)\right)\right) \\
& + g_{BL}\left(g_{BR}\left(M_1 + M_4 + M_3\right) + \sqrt{6}\left(2g_{RB}M_{BR} + g_R\left(M_1 + M_4 + M_3\right)\right)\right)\mathbf{1} \\
& - 6\sqrt{6}\left(\left(g_{BL}\left(2g_{RB}M_{BR} + g_R\left(M_1 + M_4\right)\right) + g_{BR}\left(2g_RM_{BR} + g_{RB}\left(M_1 + M_4\right)\right)\right)Y_u Y_u^\dagger - \left(g_{BL}g_R + g_{BR}g_{RB}\right)T_u Y_u^\dagger\right) \\
& + 216g_L^2T_u T_u^\dagger - 12\sqrt{6}g_{BR}g_RT_u T_u^\dagger - 12\sqrt{6}g_{BL}g_{RB}T_u T_u^\dagger + 108g_L^2m_u^2Y_u Y_u^\dagger \\
& - 6\sqrt{6}g_{BR}g_Rm_u^2Y_u Y_u^\dagger - 6\sqrt{6}g_{BL}g_{RB}m_u^2Y_u Y_u^\dagger + 216g_L^2Y_u m_q^2Y_u^\dagger \\
& - 12\sqrt{6}g_{BR}g_RY_u m_q^2Y_u^\dagger - 12\sqrt{6}g_{BL}g_{RB}Y_u m_q^2Y_u^\dagger + 108g_L^2Y_u Y_u^\dagger m_u^2 \\
& - 6\sqrt{6}g_{BR}g_RY_u Y_u^\dagger m_u^2 - 6\sqrt{6}g_{BL}g_{RB}Y_u Y_u^\dagger m_u^2 - 72m_{H_d}^2Y_u Y_d^\dagger Y_d Y_u^\dagger \\
& - 72m_{H_u}^2Y_u Y_d^\dagger Y_d Y_u^\dagger - 72Y_u Y_d^\dagger T_d T_u^\dagger - 144m_{H_u}^2Y_u Y_u^\dagger Y_u Y_u^\dagger \\
& - 72Y_u Y_u^\dagger T_u T_u^\dagger - 72Y_u T_d^\dagger T_d Y_u^\dagger - 72Y_u T_u^\dagger T_u Y_u^\dagger - 72T_u Y_d^\dagger Y_d T_u^\dagger \\
& - 72T_u Y_u^\dagger Y_u T_u^\dagger - 72T_u T_d^\dagger Y_d Y_u^\dagger - 72T_u T_u^\dagger Y_u Y_u^\dagger \\
& - 36m_u^2Y_u Y_d^\dagger Y_d Y_u^\dagger - 36m_u^2Y_u Y_u^\dagger Y_u Y_u^\dagger - 72Y_u m_q^2Y_d^\dagger Y_d Y_u^\dagger \\
& - 72Y_u m_q^2Y_u^\dagger Y_u Y_u^\dagger - 72Y_u Y_d^\dagger m_d^2Y_d Y_u^\dagger - 72Y_u Y_d^\dagger Y_d m_q^2Y_u^\dagger \\
& - 36Y_u Y_d^\dagger Y_d Y_u^\dagger m_u^2 - 72Y_u Y_u^\dagger m_u^2 Y_u Y_u^\dagger - 72Y_u Y_u^\dagger Y_u m_q^2Y_u^\dagger - 36Y_u Y_u^\dagger Y_u Y_u^\dagger m_u^2 \\
& + 192g_s^4\mathbf{1}\sigma_{2,4} + 6g_{BL}^2\mathbf{1}\sigma_{2,11} + 12\sqrt{6}g_{BL}g_{RB}\mathbf{1}\sigma_{2,11} + 36g_{RB}^2\mathbf{1}\sigma_{2,11} + 6g_{BL}g_{BR}\mathbf{1}\sigma_{2,13} + 6\sqrt{6}g_{BL}g_R\mathbf{1}\sigma_{2,13} + 6\sqrt{6}g_{BR}g_{RB}\mathbf{1}\sigma_{2,13} \\
& + 36g_Rg_{RB}\mathbf{1}\sigma_{2,13} + 6g_{BL}g_{BR}\mathbf{1}\sigma_{2,31} + 6\sqrt{6}g_{BL}g_R\mathbf{1}\sigma_{2,31} + 6\sqrt{6}g_{BR}g_{RB}\mathbf{1}\sigma_{2,31} + 36g_Rg_{RB}\mathbf{1}\sigma_{2,31} + 6g_{BR}^2\mathbf{1}\sigma_{2,33} + 12\sqrt{6}g_{BR}g_R\mathbf{1}\sigma_{2,33} \\
& + 36g_R^2\mathbf{1}\sigma_{2,33} - 12\sqrt{6}g_{BL}\mathbf{1}\sigma_{3,1} - 72g_{RB}\mathbf{1}\sigma_{3,1} - 12\sqrt{6}g_{BR}\mathbf{1}\sigma_{3,3} - 72g_R\mathbf{1}\sigma_{3,3} - 432m_{H_u}^2Y_u Y_u^\dagger \text{Tr}\left(Y_u Y_u^\dagger\right) \\
& - 216T_u T_u^\dagger \text{Tr}\left(Y_u Y_u^\dagger\right) - 108m_u^2Y_u Y_u^\dagger \text{Tr}\left(Y_u Y_u^\dagger\right) - 216Y_u m_q^2Y_u^\dagger \text{Tr}\left(Y_u Y_u^\dagger\right) \\
& - 108Y_u Y_u^\dagger m_u^2 \text{Tr}\left(Y_u Y_u^\dagger\right) - 144m_{H_u}^2Y_u Y_u^\dagger \text{Tr}\left(Y_u Y_u^\dagger\right) - 72T_u T_u^\dagger \text{Tr}\left(Y_u Y_u^\dagger\right)
\end{aligned}$$



$$\begin{aligned}
& -36m_u^2 Y_u Y_u^\dagger \text{Tr}(Y_v Y_v^\dagger) - 72Y_u m_q^2 Y_u^\dagger \text{Tr}(Y_v Y_v^\dagger) - 36Y_u Y_u^\dagger m_u^2 \text{Tr}(Y_v Y_v^\dagger) \\
& -216Y_u T_u^\dagger \text{Tr}(Y_u^\dagger T_u) - 72Y_u T_u^\dagger \text{Tr}(Y_v^\dagger T_\nu) - 216T_u Y_u^\dagger \text{Tr}(T_u^* Y_u^T) \\
& -216Y_u Y_u^\dagger \text{Tr}(T_u^* T_u^T) - 72T_u Y_u^\dagger \text{Tr}(T_\nu^* Y_\nu^T) - 72Y_u Y_u^\dagger \text{Tr}(T_\nu^* T_\nu^T) \\
& -72Y_u Y_u^\dagger \text{Tr}(m_l^2 Y_v^\dagger Y_v) - 216Y_u Y_u^\dagger \text{Tr}(m_q^2 Y_u^\dagger Y_u) - 216Y_u Y_u^\dagger \text{Tr}(m_u^2 Y_u Y_u^\dagger) \\
& -72Y_u Y_u^\dagger \text{Tr}(m_\nu^2 Y_v Y_v^\dagger)
\end{aligned} \tag{104}$$

$$\begin{aligned}
\beta_{m_d^2}^{(1)} &= \frac{1}{6} \left( -2g_{BR}^2 \mathbf{1}|M_4|^2 + 4\sqrt{6}g_{BR}g_R \mathbf{1}|M_4|^2 - 12g_R^2 \mathbf{1}|M_4|^2 - 64g_s^2 \mathbf{1}|M_3|^2 \right. \\
& -2(g_{BL}^2 M_1 + g_{BL}(-2\sqrt{6}g_{RB}M_1 + (-\sqrt{6}g_R + g_{BR})M_{BR}) + g_{RB}(6g_{RB}M_1 + 6g_R M_{BR} - \sqrt{6}g_{BR}M_{BR})) \mathbf{1}M_1^* \\
& -2(g_{BL}^2 M_{BR} + g_{BR}^2 M_{BR} - \sqrt{6}g_{BR}(2g_R M_{BR} + g_{RB}(M_1 + M_4))) + 6(g_R^2 M_{BR} + g_{RB}^2 M_{BR} + g_R g_{RB}(M_1 + M_4)) \\
& + g_{BL}(g_{BR}(M_1 + M_4) - \sqrt{6}(2g_{RB}M_{BR} + g_R(M_1 + M_4))) \mathbf{1}M_{BR}^* \\
& -2g_{BL}g_{BR}M_{BR} \mathbf{1}M_4^* + 2\sqrt{6}g_{BL}g_R M_{BR} \mathbf{1}M_4^* + 2\sqrt{6}g_{BR}g_{RB}M_{BR} \mathbf{1}M_4^* - 12g_R g_{RB}M_{BR} \mathbf{1}M_4^* \\
& + 24m_{H_d}^2 Y_d Y_d^\dagger + 24T_d T_d^\dagger + 12m_d^2 Y_d Y_d^\dagger + 24Y_d m_q^2 Y_d^\dagger + 12Y_d Y_d^\dagger m_d^2 \\
& \left. - \sqrt{6}g_{BL} \mathbf{1}\sigma_{1,1} + 6g_{RB} \mathbf{1}\sigma_{1,1} - \sqrt{6}g_{BR} \mathbf{1}\sigma_{1,3} + 6g_R \mathbf{1}\sigma_{1,3} \right)
\end{aligned} \tag{105}$$

$$\begin{aligned}
\beta_{m_d^2}^{(2)} &= \frac{1}{18} \left( 32g_s^2 g_{BR}^2 \mathbf{1}|M_4|^2 + 82g_{BL}^2 g_{BR}^2 \mathbf{1}|M_4|^2 + 123g_{BR}^4 \mathbf{1}|M_4|^2 - 64\sqrt{6}g_s^2 g_{BR}g_R \mathbf{1}|M_4|^2 \right. \\
& -86\sqrt{6}g_{BL}g_{BR}g_R \mathbf{1}|M_4|^2 - 258\sqrt{6}g_{BR}^3 g_R \mathbf{1}|M_4|^2 + 192g_s^2 g_R^2 \mathbf{1}|M_4|^2 + 24g_{BL}^2 g_R^2 \mathbf{1}|M_4|^2 \\
& + 1026g_{BR}^2 g_R^2 \mathbf{1}|M_4|^2 - 360\sqrt{6}g_{BR}g_R^3 \mathbf{1}|M_4|^2 + 864g_R^4 \mathbf{1}|M_4|^2 - 86\sqrt{6}g_{BL}g_{BR}^2 g_{RB} \mathbf{1}|M_4|^2 \\
& + 636g_{BL}g_{BR}g_R g_{RB} \mathbf{1}|M_4|^2 - 120\sqrt{6}g_{BL}g_R^2 g_{RB} \mathbf{1}|M_4|^2 + 24g_{BR}^2 g_{RB}^2 \mathbf{1}|M_4|^2 \\
& - 120\sqrt{6}g_{BR}g_R g_{RB} \mathbf{1}|M_4|^2 + 576g_R^2 g_{RB}^2 \mathbf{1}|M_4|^2 - 768g_s^4 \mathbf{1}|M_3|^2 + 32g_s^2 g_{BL}^2 \mathbf{1}|M_3|^2 \\
& + 32g_s^2 g_{BR}^2 \mathbf{1}|M_3|^2 - 64\sqrt{6}g_s^2 g_{BR}g_R \mathbf{1}|M_3|^2 + 192g_s^2 g_R^2 \mathbf{1}|M_3|^2 \\
& - 64\sqrt{6}g_s^2 g_{BL}g_{RB} \mathbf{1}|M_3|^2 + 192g_s^2 g_{RB}^2 \mathbf{1}|M_3|^2 + 41g_{BL}^2 g_{BR}^2 M_1 \mathbf{1}M_4^* \\
& - 43\sqrt{6}g_{BL}g_{BR}g_R M_1 \mathbf{1}M_4^* + 12g_{BL}^2 g_R^2 M_1 \mathbf{1}M_4^* - 43\sqrt{6}g_{BL}g_{BR}^2 g_{RB} M_1 \mathbf{1}M_4^* \\
& + 318g_{BL}g_{BR}g_R g_{RB} M_1 \mathbf{1}M_4^* - 60\sqrt{6}g_{BL}g_R^2 g_{RB} M_1 \mathbf{1}M_4^* + 12g_{BR}^2 g_{RB}^2 M_1 \mathbf{1}M_4^* \\
& - 60\sqrt{6}g_{BR}g_R g_{RB}^2 M_1 \mathbf{1}M_4^* + 288g_R^2 g_{RB}^2 M_1 \mathbf{1}M_4^* + 32g_s^2 g_{BL}g_{BR}M_{BR} \mathbf{1}M_4^* + 82g_{BL}^3 g_{BR}M_{BR} \mathbf{1}M_4^* \\
& + 164g_{BL}g_{BR}^3 M_{BR} \mathbf{1}M_4^* - 32\sqrt{6}g_s^2 g_{BL}g_R M_{BR} \mathbf{1}M_4^* - 43\sqrt{6}g_{BL}^3 g_{RB} M_{BR} \mathbf{1}M_4^* \\
& - 258\sqrt{6}g_{BL}g_{BR}^2 g_R M_{BR} \mathbf{1}M_4^* + 684g_{BL}g_{BR}g_R^2 M_{BR} \mathbf{1}M_4^* - 120\sqrt{6}g_{BL}g_R^3 M_{BR} \mathbf{1}M_4^* \\
& - 32\sqrt{6}g_s^2 g_{BR}g_{RB} M_{BR} \mathbf{1}M_4^* - 129\sqrt{6}g_{BL}g_{BR}g_{RB} M_{BR} \mathbf{1}M_4^* - 86\sqrt{6}g_{BR}^3 g_{RB} M_{BR} \mathbf{1}M_4^* \\
& + 192g_s^2 g_R g_{RB} M_{BR} \mathbf{1}M_4^* + 342g_{BL}g_R g_{RB} M_{BR} \mathbf{1}M_4^* + 684g_{BR}^2 g_R g_{RB} M_{BR} \mathbf{1}M_4^* \\
& - 360\sqrt{6}g_{BR}g_R^2 g_{RB} M_{BR} \mathbf{1}M_4^* + 1152g_R^3 g_{RB} M_{BR} \mathbf{1}M_4^* + 342g_{BL}g_{BR}g_{RB}^2 M_{BR} \mathbf{1}M_4^* \\
& - 180\sqrt{6}g_{BL}g_R g_{RB}^2 M_{BR} \mathbf{1}M_4^* - 60\sqrt{6}g_{BR}g_{RB}^3 M_{BR} \mathbf{1}M_4^* + 576g_R g_{RB}^3 M_{BR} \mathbf{1}M_4^* + 16g_s^2 g_{BR}^2 M_3 \mathbf{1}M_4^* \\
& \left. - 32\sqrt{6}g_s^2 g_{BR}g_R M_3 \mathbf{1}M_4^* + 96g_s^2 g_R^2 M_3 \mathbf{1}M_4^* + 16g_s^2 g_{BL}^2 M_1 \mathbf{1}M_3 \right)
\end{aligned}$$

$$\begin{aligned}
& - 32\sqrt{6}g_s^2g_{BL}g_{RB}M_1\mathbf{1}M_3^* + 96g_s^2g_{RB}^2M_1\mathbf{1}M_3^* + 32g_s^2g_{BL}g_{BR}M_{BR}\mathbf{1}M_3^* \\
& - 32\sqrt{6}g_s^2g_{BL}g_{RB}M_{BR}\mathbf{1}M_3^* - 32\sqrt{6}g_s^2g_{BR}g_{RB}M_{BR}\mathbf{1}M_3^* + 192g_s^2g_{RB}g_{RB}M_{BR}\mathbf{1}M_3^* \\
& + 16g_s^2g_{BR}^2M_4\mathbf{1}M_3^* - 32\sqrt{6}g_s^2g_{BR}g_{RB}M_4\mathbf{1}M_3^* + 96g_s^2g_{RB}^2M_4\mathbf{1}M_3^* + 216g_L^2m_{H_d}^2Y_dY_d^\dagger \\
& + 12\sqrt{6}g_{BR}g_{RB}m_{H_d}^2Y_dY_d^\dagger + 12\sqrt{6}g_{BL}g_{RB}m_{H_d}^2Y_dY_d^\dagger + 24\sqrt{6}g_{BR}g_{RB}|M_4|^2Y_dY_d^\dagger \\
& + 432g_L^2|M_2|^2Y_dY_d^\dagger + 12\sqrt{6}g_{BL}g_{RB}M_{BR}M_4^*Y_dY_d^\dagger + 12\sqrt{6}g_{BR}g_{RB}M_{BR}M_4^*Y_dY_d^\dagger \\
& - 12\sqrt{6}g_{BL}g_{RB}M_1Y_dT_d^\dagger - 12\sqrt{6}g_{BL}g_{RB}M_{BR}Y_dT_d^\dagger - 12\sqrt{6}g_{BR}g_{RB}M_{BR}Y_dT_d^\dagger \\
& - 12\sqrt{6}g_{BR}g_{RB}M_4Y_dT_d^\dagger - 216g_L^2M_2Y_dT_d^\dagger - 12\sqrt{6}g_{BR}g_{RB}M_4^*T_dY_d^\dagger \\
& - 216g_L^2M_2^*T_dY_d^\dagger \\
& + M_1^* \left( \left( 123g_{BL}^4M_1 - 2g_{BL}^3 \left( 129\sqrt{6}g_{RB}M_1 + 43\sqrt{6}g_{RB}M_{BR} - 82g_{BR}M_{BR} \right) \right. \right. \\
& + g_{BL}^2 \left( 41g_{BR}^2(2M_1 + M_4) - 43\sqrt{6}g_{BR} \left( 6g_{RB}M_{BR} + g_{RB}(2M_1 + M_4) \right) \right) + 6 \left( 114g_{RB}g_{RB}M_{BR} + 171g_{RB}^2M_1 + 2g_{RB}^2(2M_1 + M_4) \right) \\
& + g_{RB} \left( - 43\sqrt{6}g_{BR}^3M_{BR} + 6g_{BR}^2 \left( 2g_{RB}(2M_1 + M_4) + 57g_{RB}M_{BR} \right) - 60\sqrt{6}g_{BR} \left( 2g_{RB}^2M_{BR} + 3g_{RB}^2M_{BR} + g_{RB}g_{RB}(2M_1 + M_4) \right) \\
& + 288 \left( 2g_{RB}^3M_{BR} + 3g_{RB}^3M_1 + 4g_{RB}g_{RB}^2M_{BR} + g_{RB}^2g_{RB}(2M_1 + M_4) \right) \left. \right) \\
& - g_{BL} \left( - 82g_{BR}^3M_{BR} + 43\sqrt{6}g_{BR}^2 \left( 3g_{RB}M_{BR} + g_{RB}(2M_1 + M_4) \right) - 6g_{BR} \left( 114g_{RB}^2M_{BR} + 53g_{RB}g_{RB}(2M_1 + M_4) + 57g_{RB}^2M_{BR} \right) \right. \\
& + 60\sqrt{6} \left( 6g_{RB}^3M_1 + 6g_{RB}g_{RB}^2M_{BR} + g_{RB}^2g_{RB}(2M_1 + M_4) + g_{RB}^3M_{BR} \right) \\
& + 16g_s^2 \left( g_{BL}^2(2M_1 + M_3) + 2g_{RB} \left( 3g_{RB}(2M_1 + M_3) + 6g_{RB}M_{BR} - \sqrt{6}g_{BR}M_{BR} \right) \right. \\
& \left. \left. - 2g_{BL} \left( - g_{BR}M_{BR} + \sqrt{6}g_{RB}(2M_1 + M_3) + \sqrt{6}g_{RB}M_{BR} \right) \right) \right) \mathbf{1} \\
& + 12\sqrt{6} \left( \left( 2g_{BL}g_{RB}M_1 + g_{BL}g_{RB}M_{BR} + g_{BR}g_{RB}M_{BR} \right) Y_dY_d^\dagger - g_{BL}g_{RB}T_dY_d^\dagger \right) \\
& + M_{BR}^* \left( \left( - 43\sqrt{6}g_{BR}^3g_{RB}M_1 + 342g_{BR}^2g_{RB}g_{RB}M_1 - 180\sqrt{6}g_{BR}g_{RB}^2g_{RB}M_1 + 576g_{RB}^3g_{RB}M_1 \right. \right. \\
& - 120\sqrt{6}g_{BR}g_{RB}^3M_1 + 1152g_{RB}g_{RB}^3M_1 + 82g_{BL}^4M_{BR} + 82g_{BR}^4M_{BR} - 172\sqrt{6}g_{BR}^3g_{RB}M_{BR} + 684g_{BR}^2g_{RB}^2M_{BR} \\
& - 240\sqrt{6}g_{BR}g_{RB}^3M_{BR} + 576g_{RB}^4M_{BR} + 366g_{BR}^2g_{RB}^2M_{BR} - 480\sqrt{6}g_{BR}g_{RB}g_{RB}^2M_{BR} + 2304g_{RB}^2g_{RB}^2M_{BR} \\
& + 576g_{RB}^4M_{BR} - 86\sqrt{6}g_{BR}^3g_{RB}M_4 + 684g_{BR}^2g_{RB}g_{RB}M_4 - 360\sqrt{6}g_{BR}g_{RB}^2g_{RB}M_4 + 1152g_{RB}^3g_{RB}M_4 \\
& - 60\sqrt{6}g_{BR}g_{RB}^3M_4 + 576g_{RB}g_{RB}^3M_4 + g_{BL}^3 \left( - 43\sqrt{6} \left( 4g_{RB}M_{BR} + g_{RB}(2M_1 + M_4) \right) + 82g_{BR}(2M_1 + M_4) \right) \\
& + g_{BL}^2 \left( 328g_{BR}^2M_{BR} - 43\sqrt{6}g_{BR} \left( 3g_{RB}(2M_1 + M_4) + 8g_{RB}M_{BR} \right) + 6 \left( 114g_{RB}^2M_{BR} + 57g_{RB}g_{RB}(2M_1 + M_4) + 61g_{RB}^2M_{BR} \right) \right. \\
& + g_{BL} \left( 82g_{BR}^3(2M_4 + M_1) - 43\sqrt{6}g_{BR}^2 \left( 3g_{RB}(2M_4 + M_1) + 8g_{RB}M_{BR} \right) \right. \\
& + 6g_{BR} \left( 334g_{RB}g_{RB}M_{BR} + 57g_{RB}^2(2M_4 + M_1) + 57g_{RB}^2(2M_1 + M_4) \right) \\
& \left. \left. - 60\sqrt{6} \left( 3g_{RB}g_{RB}^2(2M_1 + M_4) + 4g_{RB}^3M_{BR} + 8g_{RB}^2g_{RB}M_{BR} + g_{RB}^3(2M_4 + M_1) \right) \right) \right) \\
& + 32g_s^2 \left( g_{BL}^2M_{BR} + g_{BR}^2M_{BR} - \sqrt{6}g_{BR} \left( 2g_{RB}M_{BR} + g_{RB}(M_1 + M_4 + M_3) \right) \right) + 6 \left( g_{RB}^2M_{BR} + g_{RB}^2M_{BR} + g_{RB}g_{RB}(M_1 + M_4 + M_3) \right)
\end{aligned}$$

$$\begin{aligned}
& + g_{BL} \left( g_{BR} \left( M_1 + M_4 + M_3 \right) - \sqrt{6} \left( 2g_{RB}M_{BR} + g_R \left( M_1 + M_4 + M_3 \right) \right) \right) \mathbf{1} \\
& + 12\sqrt{6} \left( \left( g_{BL} \left( 2g_{RB}M_{BR} + g_R \left( M_1 + M_4 \right) \right) + g_{BR} \left( 2g_RM_{BR} + g_{RB} \left( M_1 + M_4 \right) \right) \right) Y_d Y_d^\dagger - \left( g_{BL}g_R + g_{BR}g_{RB} \right) T_d Y_d^\dagger \right) \\
& + 216g_L^2 T_d T_d^\dagger + 12\sqrt{6}g_{BR}g_R T_d T_d^\dagger + 12\sqrt{6}g_{BL}g_{RB} T_d T_d^\dagger + 108g_L^2 m_d^2 Y_d Y_d^\dagger \\
& + 6\sqrt{6}g_{BR}g_R m_d^2 Y_d Y_d^\dagger + 6\sqrt{6}g_{BL}g_{RB} m_d^2 Y_d Y_d^\dagger + 216g_L^2 Y_d m_q^2 Y_d^\dagger \\
& + 12\sqrt{6}g_{BR}g_R Y_d m_q^2 Y_d^\dagger + 12\sqrt{6}g_{BL}g_{RB} Y_d m_q^2 Y_d^\dagger + 108g_L^2 Y_d Y_d^\dagger m_d^2 \\
& + 6\sqrt{6}g_{BR}g_R Y_d Y_d^\dagger m_d^2 + 6\sqrt{6}g_{BL}g_{RB} Y_d Y_d^\dagger m_d^2 - 144m_{H_d}^2 Y_d Y_d^\dagger Y_d Y_d^\dagger \\
& - 72Y_d Y_d^\dagger T_d T_d^\dagger - 72m_{H_d}^2 Y_d Y_u^\dagger Y_u Y_d^\dagger - 72m_{H_u}^2 Y_d Y_u^\dagger Y_u Y_d^\dagger \\
& - 72Y_d Y_u^\dagger T_u T_u^\dagger - 72Y_d T_d^\dagger T_d Y_d^\dagger - 72Y_d T_u^\dagger T_u Y_d^\dagger - 72T_d Y_d^\dagger Y_d T_d^\dagger \\
& - 72T_d Y_u^\dagger Y_u T_d^\dagger - 72T_d T_d^\dagger Y_d Y_d^\dagger - 72T_d T_u^\dagger Y_u Y_d^\dagger - 36m_d^2 Y_d Y_d^\dagger Y_d Y_d^\dagger \\
& - 36m_d^2 Y_d Y_u^\dagger Y_u Y_d^\dagger - 72Y_d m_q^2 Y_d^\dagger Y_d Y_d^\dagger - 72Y_d m_q^2 Y_u^\dagger Y_u Y_d^\dagger \\
& - 72Y_d Y_d^\dagger m_d^2 Y_d Y_d^\dagger - 72Y_d Y_d^\dagger Y_d m_q^2 Y_d^\dagger - 36Y_d Y_d^\dagger Y_d Y_d^\dagger m_d^2 - 72Y_d Y_u^\dagger m_u^2 Y_u Y_d^\dagger \\
& - 72Y_d Y_u^\dagger Y_u m_q^2 Y_d^\dagger - 36Y_d Y_u^\dagger Y_u Y_d^\dagger m_d^2 + 192g_s^4 \mathbf{1}\sigma_{2,4} + 6g_{BL}^2 \mathbf{1}\sigma_{2,11} - 12\sqrt{6}g_{BL}g_{RB} \mathbf{1}\sigma_{2,11} \\
& + 36g_{RB}^2 \mathbf{1}\sigma_{2,11} + 6g_{BL}g_{BR} \mathbf{1}\sigma_{2,13} - 6\sqrt{6}g_{BL}g_R \mathbf{1}\sigma_{2,13} - 6\sqrt{6}g_{BR}g_{RB} \mathbf{1}\sigma_{2,13} + 36g_R g_{RB} \mathbf{1}\sigma_{2,13} + 6g_{BL}g_{BR} \mathbf{1}\sigma_{2,31} - 6\sqrt{6}g_{BL}g_R \mathbf{1}\sigma_{2,31} \\
& - 6\sqrt{6}g_{BR}g_{RB} \mathbf{1}\sigma_{2,31} + 36g_R g_{RB} \mathbf{1}\sigma_{2,31} + 6g_{BR}^2 \mathbf{1}\sigma_{2,33} - 12\sqrt{6}g_{BR}g_R \mathbf{1}\sigma_{2,33} + 36g_R^2 \mathbf{1}\sigma_{2,33} - 12\sqrt{6}g_{BL} \mathbf{1}\sigma_{3,1} + 72g_{RB} \mathbf{1}\sigma_{3,1} \\
& - 12\sqrt{6}g_{BR} \mathbf{1}\sigma_{3,3} + 72g_R \mathbf{1}\sigma_{3,3} - 432m_{H_d}^2 Y_d Y_d^\dagger \text{Tr} \left( Y_d Y_d^\dagger \right) - 216T_d T_d^\dagger \text{Tr} \left( Y_d Y_d^\dagger \right) \\
& - 108m_d^2 Y_d Y_d^\dagger \text{Tr} \left( Y_d Y_d^\dagger \right) - 216Y_d m_q^2 Y_d^\dagger \text{Tr} \left( Y_d Y_d^\dagger \right) - 108Y_d Y_d^\dagger m_d^2 \text{Tr} \left( Y_d Y_d^\dagger \right) \\
& - 144m_{H_d}^2 Y_d Y_d^\dagger \text{Tr} \left( Y_e Y_e^\dagger \right) - 72T_d T_d^\dagger \text{Tr} \left( Y_e Y_e^\dagger \right) - 36m_d^2 Y_d Y_d^\dagger \text{Tr} \left( Y_e Y_e^\dagger \right) \\
& - 72Y_d m_q^2 Y_d^\dagger \text{Tr} \left( Y_e Y_e^\dagger \right) - 36Y_d Y_d^\dagger m_d^2 \text{Tr} \left( Y_e Y_e^\dagger \right) - 216Y_d T_d^\dagger \text{Tr} \left( Y_d^\dagger T_d \right) \\
& - 72Y_d T_d^\dagger \text{Tr} \left( Y_e^\dagger T_e \right) - 216T_d Y_d^\dagger \text{Tr} \left( T_d^* Y_d^T \right) - 216Y_d Y_d^\dagger \text{Tr} \left( T_d^* T_d^T \right) \\
& - 72T_d Y_d^\dagger \text{Tr} \left( T_e^* Y_e^T \right) - 72Y_d Y_d^\dagger \text{Tr} \left( T_e^* T_e^T \right) - 216Y_d Y_d^\dagger \text{Tr} \left( m_d^2 Y_d Y_d^\dagger \right) \\
& - 72Y_d Y_d^\dagger \text{Tr} \left( m_e^2 Y_e Y_e^\dagger \right) - 72Y_d Y_d^\dagger \text{Tr} \left( m_l^2 Y_e^\dagger Y_e \right) - 216Y_d Y_d^\dagger \text{Tr} \left( m_q^2 Y_d^\dagger Y_d \right) \tag{106}
\end{aligned}$$

$$\begin{aligned}
\beta_{m_\tau^2}^{(1)} & = -3g_{BR}^2 \mathbf{1}|M_4|^2 + 2\sqrt{6}g_{BR}g_R \mathbf{1}|M_4|^2 - 2g_R^2 \mathbf{1}|M_4|^2 \\
& + \left( -3g_{BL}^2 M_1 + g_{BL} \left( 2\sqrt{6}g_{RB}M_1 - 3g_{BR}M_{BR} + \sqrt{6}g_R M_{BR} \right) + g_{RB} \left( -2g_{RB}M_1 - 2g_RM_{BR} + \sqrt{6}g_{BR}M_{BR} \right) \right) \mathbf{1}M_1^* \\
& + \left( -3g_{BL}^2 M_{BR} - 3g_{BR}^2 M_{BR} + \sqrt{6}g_{BR} \left( 2g_RM_{BR} + g_{RB} \left( M_1 + M_4 \right) \right) - 2 \left( g_R^2 M_{BR} + g_{RB}^2 M_{BR} + g_R g_{RB} \left( M_1 + M_4 \right) \right) \right) \\
& + g_{BL} \left( -3g_{BR} \left( M_1 + M_4 \right) + \sqrt{6} \left( 2g_{RB}M_{BR} + g_R \left( M_1 + M_4 \right) \right) \right) \mathbf{1}M_{BR}^* \\
& - 3g_{BL}g_{BR}M_{BR} \mathbf{1}M_4^* + \sqrt{6}g_{BL}g_R M_{BR} \mathbf{1}M_4^* + \sqrt{6}g_{BR}g_{RB}M_{BR} \mathbf{1}M_4^* - 2g_R g_{RB} M_{BR} \mathbf{1}M_4^* + 2m_\chi^2 Y_s Y_s^\dagger \\
& + 4m_{H_u}^2 Y_\nu Y_\nu^\dagger + 2T_s T_s^\dagger + 4T_\nu T_\nu^\dagger + m_\nu^2 Y_s Y_s^\dagger + 2m_\nu^2 Y_\nu Y_\nu^\dagger + 2Y_s m_S^2 Y_s^\dagger
\end{aligned}$$

$$\begin{aligned}
& + Y_s Y_s^\dagger m_\nu^2 + 4Y_v m_l^2 Y_v^\dagger + 2Y_v Y_v^\dagger m_\nu^2 + \sqrt{\frac{3}{2}} g_{BL} \mathbf{1} \sigma_{1,1} - g_{RB} \mathbf{1} \sigma_{1,1} + \sqrt{\frac{3}{2}} g_{BR} \mathbf{1} \sigma_{1,3} - g_R \mathbf{1} \sigma_{1,3} \tag{107} \\
\beta_{m_\nu^2}^{(2)} = & + 45g_{BL}^2 g_{BR}^2 \mathbf{1} |M_4|^2 + \frac{135}{2} g_{BR}^4 \mathbf{1} |M_4|^2 - 18\sqrt{6} g_{BL}^2 g_{BR} g_R \mathbf{1} |M_4|^2 - 54\sqrt{6} g_{BR}^3 g_R \mathbf{1} |M_4|^2 \\
& + 6g_{BL}^2 g_R^2 \mathbf{1} |M_4|^2 + 153g_{BR}^2 g_R^2 \mathbf{1} |M_4|^2 - 54\sqrt{6} g_{BR} g_R^3 \mathbf{1} |M_4|^2 + 48g_R^4 \mathbf{1} |M_4|^2 \\
& - 18\sqrt{6} g_{BL} g_{BR}^2 g_{RB} \mathbf{1} |M_4|^2 + 90g_{BL} g_{BR} g_R g_{RB} \mathbf{1} |M_4|^2 - 18\sqrt{6} g_{BL} g_R^2 g_{RB} \mathbf{1} |M_4|^2 \\
& + 6g_{BR}^2 g_{RB}^2 \mathbf{1} |M_4|^2 - 18\sqrt{6} g_{BR} g_R g_{RB}^2 \mathbf{1} |M_4|^2 + 32g_R^2 g_{RB}^2 \mathbf{1} |M_4|^2 + \frac{45}{2} g_{BL}^2 g_{BR}^2 M_1 \mathbf{1} M_4^* \\
& - 9\sqrt{6} g_{BL}^2 g_{BR} g_R M_1 \mathbf{1} M_4^* + 3g_{BL}^2 g_R^2 M_1 \mathbf{1} M_4^* - 9\sqrt{6} g_{BL} g_{BR}^2 g_{RB} M_1 \mathbf{1} M_4^* \\
& + 45g_{BL} g_{BR} g_R g_{RB} M_1 \mathbf{1} M_4^* - 9\sqrt{6} g_{BL} g_R^2 g_{RB} M_1 \mathbf{1} M_4^* + 3g_{BR}^2 g_{RB}^2 M_1 \mathbf{1} M_4^* \\
& - 9\sqrt{6} g_{BR} g_R g_{RB}^2 M_1 \mathbf{1} M_4^* + 16g_R^2 g_{RB}^2 M_1 \mathbf{1} M_4^* + 45g_{BL}^3 g_{BR} M_{BR} \mathbf{1} M_4^* + 90g_{BL} g_{BR}^3 M_{BR} \mathbf{1} M_4^* \\
& - 9\sqrt{6} g_{BL}^2 g_R M_{BR} \mathbf{1} M_4^* - 54\sqrt{6} g_{BL} g_{BR}^2 g_R M_{BR} \mathbf{1} M_4^* + 102g_{BL} g_{BR} g_R^2 M_{BR} \mathbf{1} M_4^* \\
& - 18\sqrt{6} g_{BL} g_R^3 M_{BR} \mathbf{1} M_4^* - 27\sqrt{6} g_{BL}^2 g_{BR} g_{RB} M_{BR} \mathbf{1} M_4^* - 18\sqrt{6} g_{BR}^3 g_{RB} M_{BR} \mathbf{1} M_4^* \\
& + 51g_{BL}^2 g_R g_{RB} M_{BR} \mathbf{1} M_4^* + 102g_{BR}^2 g_R g_{RB} M_{BR} \mathbf{1} M_4^* - 54\sqrt{6} g_{BR} g_R^2 g_{RB} M_{BR} \mathbf{1} M_4^* + 64g_R^3 g_{RB} M_{BR} \mathbf{1} M_4^* \\
& + 51g_{BL} g_{BR} g_{RB}^2 M_{BR} \mathbf{1} M_4^* - 27\sqrt{6} g_{BL} g_R g_{RB}^2 M_{BR} \mathbf{1} M_4^* - 9\sqrt{6} g_{BR} g_{RB}^3 M_{BR} \mathbf{1} M_4^* + 32g_R g_{RB}^3 M_{BR} \mathbf{1} M_4^* \\
& + 12g_L^2 m_{H_u}^2 Y_v Y_v^\dagger + 2\sqrt{6} g_{BR} g_R m_{H_u}^2 Y_v Y_v^\dagger + 2\sqrt{6} g_{BL} g_{RB} m_{H_u}^2 Y_v Y_v^\dagger \\
& + 4\sqrt{6} g_{BR} g_R |M_4|^2 Y_v Y_v^\dagger + 24g_L^2 |M_2|^2 Y_v Y_v^\dagger + 2\sqrt{6} g_{BL} g_R M_{BR} M_4^* Y_v Y_v^\dagger \\
& + 2\sqrt{6} g_{BR} g_{RB} M_{BR} M_4^* Y_v Y_v^\dagger - 2\sqrt{6} g_{BL} g_{RB} M_1 Y_v T_\nu^\dagger - 2\sqrt{6} g_{BL} g_R M_{BR} Y_v T_\nu^\dagger \\
& - 2\sqrt{6} g_{BR} g_{RB} M_{BR} Y_v T_\nu^\dagger - 2\sqrt{6} g_{BR} g_R M_4 Y_v T_\nu^\dagger - 12g_L^2 M_2 Y_v T_\nu^\dagger \\
& - 2\sqrt{6} g_{BR} g_R M_4^* T_\nu Y_v^\dagger - 12g_L^2 M_2^* T_\nu Y_v^\dagger \\
& + \frac{1}{2} M_1^* \left( \left( 135g_{BL}^4 M_1 - 36g_{BL}^3 \left( 3\sqrt{6} g_{RB} M_1 - 5g_{BR} M_{BR} + \sqrt{6} g_R M_{BR} \right) \right. \right. \\
& + 3g_{BL}^2 \left( 15g_{BR}^2 \left( 2M_1 + M_4 \right) + 2 \left( 34g_R g_{RB} M_{BR} + 51g_{RB}^2 M_1 + g_R^2 \left( 2M_1 + M_4 \right) \right) - 6\sqrt{6} g_{BR} \left( 6g_{RB} M_{BR} + g_R \left( 2M_1 + M_4 \right) \right) \right) \\
& + 2g_{RB} \left( -9\sqrt{6} g_{BR}^3 M_{BR} + 3g_{BR}^2 \left( 17g_R M_{BR} + g_{RB} \left( 2M_1 + M_4 \right) \right) - 9\sqrt{6} g_{BR} \left( 2g_{RB}^2 M_{BR} + 3g_R^2 M_{BR} + g_R g_{RB} \left( 2M_1 + M_4 \right) \right) \right) \\
& + 16 \left( 2g_R^3 M_{BR} + 3g_{RB}^3 M_1 + 4g_R g_{RB}^2 M_{BR} + g_R^2 g_{RB} \left( 2M_1 + M_4 \right) \right) \left. \right) \\
& - 6g_{BL} \left( -15g_{BR}^3 M_{BR} + 3\sqrt{6} g_{BR}^2 \left( 3g_R M_{BR} + g_{RB} \left( 2M_1 + M_4 \right) \right) - g_{BR} \left( 15g_R g_{RB} \left( 2M_1 + M_4 \right) + 17g_R^2 M_{BR} + 34g_{RB}^2 M_{BR} \right) \right. \\
& + 3\sqrt{6} \left( 6g_{RB}^3 M_1 + 6g_R g_{RB}^2 M_{BR} + g_R^2 g_{RB} \left( 2M_1 + M_4 \right) + g_R^3 M_{BR} \right) \left. \right) \mathbf{1} \\
& + 4\sqrt{6} \left( \left( 2g_{BL} g_{RB} M_1 + g_{BL} g_R M_{BR} + g_{BR} g_{RB} M_{BR} \right) Y_v Y_v^\dagger - g_{BL} g_{RB} T_\nu Y_v^\dagger \right) \\
& + M_{BR}^* \left( \left( 45g_{BL}^4 M_{BR} + 45g_{BR}^4 M_{BR} - 9\sqrt{6} g_{BR}^3 \left( 4g_R M_{BR} + g_{RB} \left( 2M_4 + M_1 \right) \right) \right. \right. \\
& + 3g_{BR}^2 \left( 17g_R g_{RB} \left( 2M_4 + M_1 \right) + 19g_{RB}^2 M_{BR} + 34g_R^2 M_{BR} \right) \\
& \left. \left. - 9\sqrt{6} g_{BR} \left( 3g_R^2 g_{RB} \left( 2M_4 + M_1 \right) + 4g_R^3 M_{BR} + 8g_R g_{RB}^2 M_{BR} + g_{RB}^3 \left( 2M_1 + M_4 \right) \right) \right) \right)
\end{aligned}$$

$$\begin{aligned}
& + 32\left(4g_R^2g_{RB}^2M_{BR} + g_R^3g_{RB}\left(2M_4 + M_1\right) + g_R^4M_{BR} + g_{RB}^4M_{BR} + g_Rg_{RB}^3\left(2M_1 + M_4\right)\right) \\
& + 9g_{BL}^3\left(5g_{BR}\left(2M_1 + M_4\right) - \sqrt{6}\left(4g_{RB}M_{BR} + g_R\left(2M_1 + M_4\right)\right)\right) \\
& - 3g_{BL}^2\left(-17g_Rg_{RB}\left(2M_1 + M_4\right) - 19g_R^2M_{BR} - 34g_{RB}^2M_{BR} + 3\sqrt{6}g_{BR}\left(3g_{RB}\left(2M_1 + M_4\right) + 8g_{RB}M_{BR}\right) - 60g_{BR}^2M_{BR}\right) \\
& + 3g_{BL}\left(15g_{BR}^3\left(2M_4 + M_1\right) - 3\sqrt{6}g_{BR}^2\left(3g_R\left(2M_4 + M_1\right) + 8g_{RB}M_{BR}\right) + g_{BR}\left(17g_R^2\left(2M_4 + M_1\right) + 17g_{RB}^2\left(2M_1 + M_4\right) + 98\right) \right. \\
& \left. - 3\sqrt{6}\left(3g_Rg_{RB}^2\left(2M_1 + M_4\right) + 4g_{RB}^3M_{BR} + 8g_R^2g_{RB}M_{BR} + g_R^3\left(2M_4 + M_1\right)\right)\right)\mathbf{1} \\
& + 2\sqrt{6}\left(\left(g_{BL}\left(2g_{RB}M_{BR} + g_R\left(M_1 + M_4\right)\right) + g_{BR}\left(2g_RM_{BR} + g_{RB}\left(M_1 + M_4\right)\right)\right)Y_vY_v^\dagger - \left(g_{BL}g_R + g_{BR}g_{RB}\right)T_\nu Y_v^\dagger\right) \\
& + 12g_L^2T_\nu T_\nu^\dagger + 2\sqrt{6}g_{BR}g_RT_\nu T_\nu^\dagger + 2\sqrt{6}g_{BL}g_{RB}T_\nu T_\nu^\dagger + 6g_L^2m_\nu^2Y_vY_v^\dagger \\
& + \sqrt{6}g_{BR}g_Rm_\nu^2Y_vY_v^\dagger + \sqrt{6}g_{BL}g_{RB}m_\nu^2Y_vY_v^\dagger + 12g_L^2Y_vm_l^2Y_v^\dagger \\
& + 2\sqrt{6}g_{BR}g_RY_vm_l^2Y_v^\dagger + 2\sqrt{6}g_{BL}g_{RB}Y_vm_l^2Y_v^\dagger + 6g_L^2Y_vY_v^\dagger m_\nu^2 \\
& + \sqrt{6}g_{BR}g_RY_vY_v^\dagger m_\nu^2 + \sqrt{6}g_{BL}g_{RB}Y_vY_v^\dagger m_\nu^2 - 4m_\chi^2Y_sY_s^\dagger Y_sY_s^\dagger \\
& - 2Y_sY_s^\dagger T_sT_s^\dagger - 2Y_sT_s^\dagger T_sY_s^\dagger - 4m_{H_d}^2Y_vY_e^\dagger Y_eY_v^\dagger \\
& - 4m_{H_u}^2Y_vY_e^\dagger Y_eY_v^\dagger - 4Y_vY_e^\dagger T_eT_\nu^\dagger - 8m_{H_u}^2Y_vY_v^\dagger Y_vY_v^\dagger - 4Y_vY_v^\dagger T_\nu T_\nu^\dagger \\
& - 4Y_vT_e^\dagger T_eY_v^\dagger - 4Y_vT_\nu^\dagger T_\nu Y_v^\dagger - 2T_sY_s^\dagger Y_sT_s^\dagger - 2T_sT_s^\dagger Y_sY_s^\dagger \\
& - 4T_\nu Y_e^\dagger Y_eT_\nu^\dagger - 4T_\nu Y_v^\dagger Y_vT_\nu^\dagger - 4T_\nu T_e^\dagger Y_eY_v^\dagger - 4T_\nu T_\nu^\dagger Y_vY_v^\dagger \\
& - m_\nu^2Y_sY_s^\dagger Y_sY_s^\dagger - 2m_\nu^2Y_vY_e^\dagger Y_eY_v^\dagger - 2m_\nu^2Y_vY_v^\dagger Y_vY_v^\dagger - 2Y_sm_S^2Y_s^\dagger Y_sY_s^\dagger \\
& - 2Y_sY_s^\dagger m_\nu^2Y_sY_s^\dagger - 2Y_sY_s^\dagger Y_sm_S^2Y_s^\dagger - Y_sY_s^\dagger Y_sY_s^\dagger m_\nu^2 - 4Y_vm_l^2Y_e^\dagger Y_eY_v^\dagger \\
& - 4Y_vm_l^2Y_v^\dagger Y_vY_v^\dagger - 4Y_vY_e^\dagger m_e^2Y_eY_v^\dagger - 4Y_vY_e^\dagger Y_em_l^2Y_v^\dagger \\
& - 2Y_vY_e^\dagger Y_eY_v^\dagger m_\nu^2 - 4Y_vY_v^\dagger m_\nu^2Y_vY_v^\dagger - 4Y_vY_v^\dagger Y_vm_l^2Y_v^\dagger - 2Y_vY_v^\dagger Y_vY_v^\dagger m_\nu^2 \\
& + 3g_{BL}^2\mathbf{1}\sigma_{2,11} - 2\sqrt{6}g_{BL}g_{RB}\mathbf{1}\sigma_{2,11} + 2g_{RB}^2\mathbf{1}\sigma_{2,11} + 3g_{BL}g_{BR}\mathbf{1}\sigma_{2,13} - \sqrt{6}g_{BL}g_R\mathbf{1}\sigma_{2,13} - \sqrt{6}g_{BR}g_{RB}\mathbf{1}\sigma_{2,13} + 2g_Rg_{RB}\mathbf{1}\sigma_{2,13} \\
& + 3g_{BL}g_{BR}\mathbf{1}\sigma_{2,31} - \sqrt{6}g_{BL}g_R\mathbf{1}\sigma_{2,31} - \sqrt{6}g_{BR}g_{RB}\mathbf{1}\sigma_{2,31} + 2g_Rg_{RB}\mathbf{1}\sigma_{2,31} + 3g_{BR}^2\mathbf{1}\sigma_{2,33} - 2\sqrt{6}g_{BR}g_R\mathbf{1}\sigma_{2,33} + 2g_R^2\mathbf{1}\sigma_{2,33} \\
& + 2\sqrt{6}g_{BL}\mathbf{1}\sigma_{3,1} - 4g_{RB}\mathbf{1}\sigma_{3,1} + 2\sqrt{6}g_{BR}\mathbf{1}\sigma_{3,3} - 4g_R\mathbf{1}\sigma_{3,3} - 4m_\chi^2Y_sY_s^\dagger\text{Tr}\left(Y_sY_s^\dagger\right) \\
& - 2T_sT_s^\dagger\text{Tr}\left(Y_sY_s^\dagger\right) - m_\nu^2Y_sY_s^\dagger\text{Tr}\left(Y_sY_s^\dagger\right) - 2Y_sm_S^2Y_s^\dagger\text{Tr}\left(Y_sY_s^\dagger\right) \\
& - Y_sY_s^\dagger m_\nu^2\text{Tr}\left(Y_sY_s^\dagger\right) - 24m_{H_u}^2Y_vY_v^\dagger\text{Tr}\left(Y_uY_u^\dagger\right) - 12T_\nu T_\nu^\dagger\text{Tr}\left(Y_uY_u^\dagger\right) \\
& - 6m_\nu^2Y_vY_v^\dagger\text{Tr}\left(Y_uY_u^\dagger\right) - 12Y_vm_l^2Y_v^\dagger\text{Tr}\left(Y_uY_u^\dagger\right) - 6Y_vY_v^\dagger m_\nu^2\text{Tr}\left(Y_uY_u^\dagger\right) \\
& - 8m_{H_u}^2Y_vY_v^\dagger\text{Tr}\left(Y_vY_v^\dagger\right) - 4T_\nu T_\nu^\dagger\text{Tr}\left(Y_vY_v^\dagger\right) - 2m_\nu^2Y_vY_v^\dagger\text{Tr}\left(Y_vY_v^\dagger\right) \\
& - 4Y_vm_l^2Y_v^\dagger\text{Tr}\left(Y_vY_v^\dagger\right) - 2Y_vY_v^\dagger m_\nu^2\text{Tr}\left(Y_vY_v^\dagger\right) - 2Y_sT_s^\dagger\text{Tr}\left(Y_s^\dagger T_s\right) \\
& - 12Y_vT_\nu^\dagger\text{Tr}\left(Y_u^\dagger T_u\right) - 4Y_vT_\nu^\dagger\text{Tr}\left(Y_v^\dagger T_\nu\right) - 2T_sY_s^\dagger\text{Tr}\left(T_s^*Y_s^T\right) \\
& - 2Y_sY_s^\dagger\text{Tr}\left(T_s^*T_s^T\right) - 12T_\nu Y_v^\dagger\text{Tr}\left(T_u^*Y_u^T\right) - 12Y_vY_v^\dagger\text{Tr}\left(T_u^*T_u^T\right)
\end{aligned}$$

$$\begin{aligned}
& -4T_\nu Y_v^\dagger \text{Tr}(T_\nu^* Y_\nu^T) - 4Y_v Y_v^\dagger \text{Tr}(T_\nu^* T_\nu^T) - 4Y_v Y_v^\dagger \text{Tr}(m_l^2 Y_v^\dagger Y_v) \\
& -12Y_v Y_v^\dagger \text{Tr}(m_q^2 Y_u^\dagger Y_u) - 2Y_s Y_s^\dagger \text{Tr}(m_S^2 Y_s^\dagger Y_s) - 12Y_v Y_v^\dagger \text{Tr}(m_u^2 Y_u Y_u^\dagger) \\
& -2Y_s Y_s^\dagger \text{Tr}(m_\nu^2 Y_s Y_s^\dagger) - 4Y_v Y_v^\dagger \text{Tr}(m_\nu^2 Y_v Y_v^\dagger)
\end{aligned} \tag{108}$$

$$\begin{aligned}
\beta_{m_e^2}^{(1)} &= -3g_{BR}^2 \mathbf{1}|M_4|^2 - 2\sqrt{6}g_{BR}g_R \mathbf{1}|M_4|^2 - 2g_R^2 \mathbf{1}|M_4|^2 \\
& - \left(3g_{BL}^2 M_1 + g_{BL} \left(2\sqrt{6}g_{RB}M_1 + 3g_{BR}M_{BR} + \sqrt{6}g_R M_{BR}\right) + g_{RB} \left(2g_{RB}M_1 + 2g_R M_{BR} + \sqrt{6}g_{BR}M_{BR}\right)\right) \mathbf{1}M_1^* \\
& - \left(3g_{BL}^2 M_{BR} + 3g_{BR}^2 M_{BR} + \sqrt{6}g_{BR} \left(2g_R M_{BR} + g_{RB} \left(M_1 + M_4\right)\right) + 2 \left(g_R^2 M_{BR} + g_{RB}^2 M_{BR} + g_R g_{RB} \left(M_1 + M_4\right)\right)\right) \\
& + g_{BL} \left(3g_{BR} \left(M_1 + M_4\right) + \sqrt{6} \left(2g_{RB} M_{BR} + g_R \left(M_1 + M_4\right)\right)\right) \mathbf{1}M_{BR}^* \\
& - 3g_{BL}g_{BR}M_{BR} \mathbf{1}M_4^* - \sqrt{6}g_{BL}g_R M_{BR} \mathbf{1}M_4^* - \sqrt{6}g_{BR}g_{RB}M_{BR} \mathbf{1}M_4^* - 2g_R g_{RB} M_{BR} \mathbf{1}M_4^* \\
& + 4m_{H_d}^2 Y_e Y_e^\dagger + 4T_e T_e^\dagger + 2m_e^2 Y_e Y_e^\dagger + 4Y_e m_l^2 Y_e^\dagger + 2Y_e Y_e^\dagger m_e^2 + \sqrt{\frac{3}{2}}g_{BL} \mathbf{1}\sigma_{1,1} \\
& + g_{RB} \mathbf{1}\sigma_{1,1} + \sqrt{\frac{3}{2}}g_{BR} \mathbf{1}\sigma_{1,3} + g_R \mathbf{1}\sigma_{1,3}
\end{aligned} \tag{109}$$

$$\begin{aligned}
\beta_{m_e^2}^{(2)} &= +45g_{BL}^2 g_{BR}^2 \mathbf{1}|M_4|^2 + \frac{135}{2}g_{BR}^4 \mathbf{1}|M_4|^2 + 15\sqrt{6}g_{BL}^2 g_{BR}g_R \mathbf{1}|M_4|^2 + 45\sqrt{6}g_{BR}^3 g_R \mathbf{1}|M_4|^2 \\
& + 117g_{BR}^2 g_R^2 \mathbf{1}|M_4|^2 + 48\sqrt{6}g_{BR}g_R^3 \mathbf{1}|M_4|^2 + 48g_R^4 \mathbf{1}|M_4|^2 + 15\sqrt{6}g_{BL}g_{BR}^2 g_{RB} \mathbf{1}|M_4|^2 \\
& + 78g_{BL}g_{BR}g_R g_{RB} \mathbf{1}|M_4|^2 + 16\sqrt{6}g_{BL}g_R^2 g_{RB} \mathbf{1}|M_4|^2 + 16\sqrt{6}g_{BR}g_R g_{RB}^2 \mathbf{1}|M_4|^2 \\
& + 32g_R^2 g_{RB}^2 \mathbf{1}|M_4|^2 + \frac{45}{2}g_{BL}^2 g_{BR}^2 M_1 \mathbf{1}M_4^* + 15\sqrt{\frac{3}{2}}g_{BL}^2 g_{BR}g_R M_1 \mathbf{1}M_4^* + 15\sqrt{\frac{3}{2}}g_{BL}g_{BR}^2 g_{RB} M_1 \mathbf{1}M_4^* \\
& + 39g_{BL}g_{BR}g_R g_{RB} M_1 \mathbf{1}M_4^* + 8\sqrt{6}g_{BL}g_R^2 g_{RB} M_1 \mathbf{1}M_4^* + 8\sqrt{6}g_{BR}g_R g_{RB}^2 M_1 \mathbf{1}M_4^* \\
& + 16g_R^2 g_{RB}^2 M_1 \mathbf{1}M_4^* + 45g_{BL}^3 g_{BR} M_{BR} \mathbf{1}M_4^* + 90g_{BL}g_{BR}^3 M_{BR} \mathbf{1}M_4^* + 15\sqrt{\frac{3}{2}}g_{BL}^3 g_R M_{BR} \mathbf{1}M_4^* \\
& + 45\sqrt{6}g_{BL}g_{BR}^2 g_R M_{BR} \mathbf{1}M_4^* + 78g_{BL}g_{BR}g_R^2 M_{BR} \mathbf{1}M_4^* + 16\sqrt{6}g_{BL}g_R^3 M_{BR} \mathbf{1}M_4^* \\
& + 45\sqrt{\frac{3}{2}}g_{BL}^2 g_{BR}g_{RB} M_{BR} \mathbf{1}M_4^* + 15\sqrt{6}g_{BR}^3 g_{RB} M_{BR} \mathbf{1}M_4^* + 39g_{BL}^2 g_R g_{RB} M_{BR} \mathbf{1}M_4^* + 78g_{BR}^2 g_R g_{RB} M_{BR} \mathbf{1}M_4^* \\
& + 48\sqrt{6}g_{BR}g_R^2 g_{RB} M_{BR} \mathbf{1}M_4^* + 64g_R^3 g_{RB} M_{BR} \mathbf{1}M_4^* + 39g_{BL}g_{BR}g_{RB}^2 M_{BR} \mathbf{1}M_4^* + 24\sqrt{6}g_{BL}g_R g_{RB}^2 M_{BR} \mathbf{1}M_4^* \\
& + 8\sqrt{6}g_{BR}g_{RB}^3 M_{BR} \mathbf{1}M_4^* + 32g_R g_{RB}^3 M_{BR} \mathbf{1}M_4^* + 12g_L^2 m_{H_d}^2 Y_e Y_e^\dagger - 2\sqrt{6}g_{BR}g_R m_{H_d}^2 Y_e Y_e^\dagger \\
& - 2\sqrt{6}g_{BL}g_{RB} m_{H_d}^2 Y_e Y_e^\dagger - 4\sqrt{6}g_{BR}g_R |M_4|^2 Y_e Y_e^\dagger + 24g_L^2 |M_2|^2 Y_e Y_e^\dagger \\
& - 2\sqrt{6}g_{BL}g_R M_{BR} M_4^* Y_e Y_e^\dagger - 2\sqrt{6}g_{BR}g_{RB} M_{BR} M_4^* Y_e Y_e^\dagger + 2\sqrt{6}g_{BL}g_{RB} M_1 Y_e T_e^\dagger \\
& + 2\sqrt{6}g_{BL}g_R M_{BR} Y_e T_e^\dagger + 2\sqrt{6}g_{BR}g_{RB} M_{BR} Y_e T_e^\dagger + 2\sqrt{6}g_{BR}g_R M_4 Y_e T_e^\dagger \\
& - 12g_L^2 M_2 Y_e T_e^\dagger + 2\sqrt{6}g_{BR}g_R M_4^* T_e Y_e^\dagger - 12g_L^2 M_2^* T_e Y_e^\dagger \\
& + \frac{1}{2}M_1^* \left( \left(135g_{BL}^4 M_1 + 30g_{BL}^3 \left(3\sqrt{6}g_{RB}M_1 + 6g_{BR}M_{BR} + \sqrt{6}g_R M_{BR}\right)\right) \right. \\
& \left. + 3g_{BL}^2 \left(15g_{BR}^2 \left(2M_1 + M_4\right) + 26g_{RB} \left(2g_R M_{BR} + 3g_{RB}M_1\right) + 5\sqrt{6}g_{BR} \left(2g_R M_1 + 6g_{RB}M_{BR} + g_R M_4\right)\right) \right)
\end{aligned}$$

$$\begin{aligned}
& + g_{RB} \left( 15\sqrt{6}g_{BR}^3 M_{BR} + 78g_{BR}^2 g_R M_{BR} + 16\sqrt{6}g_{BR} \left( 2g_{RB}^2 M_{BR} + 3g_R^2 M_{BR} + g_R g_{RB} (2M_1 + M_4) \right) \right. \\
& + 32 \left( 2g_R^3 M_{BR} + 3g_{RB}^3 M_1 + 4g_R g_{RB}^2 M_{BR} + g_R^2 g_{RB} (2M_1 + M_4) \right) \left. \right) \\
& + g_{BL} \left( 90g_{BR}^3 M_{BR} + 15\sqrt{6}g_{BR}^2 \left( 3g_R M_{BR} + g_{RB} (2M_1 + M_4) \right) + 78g_{BR} \left( 2g_{RB}^2 M_{BR} + g_R^2 M_{BR} + g_R g_{RB} (2M_1 + M_4) \right) \right. \\
& + 16\sqrt{6} \left( 6g_{RB}^3 M_1 + 6g_R g_{RB}^2 M_{BR} + g_R^2 g_{RB} (2M_1 + M_4) + g_R^3 M_{BR} \right) \left. \right) \mathbf{1} \\
& - 4\sqrt{6} \left( \left( 2g_{BL} g_{RB} M_1 + g_{BL} g_R M_{BR} + g_{BR} g_{RB} M_{BR} \right) Y_e Y_e^\dagger - g_{BL} g_{RB} T_e Y_e^\dagger \right) \\
& + \frac{1}{2} M_{BR}^* \left( \left( 90g_{BL}^4 M_{BR} + 90g_{BR}^4 M_{BR} + 15\sqrt{6}g_{BR}^3 \left( 4g_R M_{BR} + g_{RB} (2M_4 + M_1) \right) + 78g_{BR}^2 \left( 2g_R^2 M_{BR} + g_{RB}^2 M_{BR} + g_R g_{RB} (2M_1 + M_4) \right) \right. \right. \\
& + 16\sqrt{6}g_{BR} \left( 3g_R^2 g_{RB} (2M_4 + M_1) + 4g_R^3 M_{BR} + 8g_R g_{RB}^2 M_{BR} + g_{RB}^3 (2M_1 + M_4) \right) \\
& + 64 \left( 4g_R^2 g_{RB}^2 M_{BR} + g_R^3 g_{RB} (2M_4 + M_1) + g_R^4 M_{BR} + g_{RB}^4 M_{BR} + g_R g_{RB}^3 (2M_1 + M_4) \right) \\
& + 15g_{BL}^3 \left( 6g_{BR} (2M_1 + M_4) + \sqrt{6} \left( 2g_R M_1 + 4g_{RB} M_{BR} + g_R M_4 \right) \right) \\
& + 3g_{BL}^2 \left( 120g_{BR}^2 M_{BR} + 26 \left( 2g_{RB}^2 M_{BR} + g_R^2 M_{BR} + g_R g_{RB} (2M_1 + M_4) \right) + 5\sqrt{6}g_{BR} \left( 3g_{RB} (2M_1 + M_4) + 8g_R M_{BR} \right) \right) \\
& + g_{BL} \left( 90g_{BR}^3 (2M_4 + M_1) + 15\sqrt{6}g_{BR}^2 \left( 3g_R (2M_4 + M_1) + 8g_{RB} M_{BR} \right) + 78g_{BR} \left( 6g_R g_{RB} M_{BR} + g_R^2 (2M_4 + M_1) + g_{RB}^2 (2M_1 + M_4) \right) \right. \\
& + 16\sqrt{6} \left( 3g_R g_{RB}^2 (2M_1 + M_4) + 4g_{RB}^3 M_{BR} + 8g_R^2 g_{RB} M_{BR} + g_R^3 (2M_4 + M_1) \right) \left. \right) \mathbf{1} \\
& - 4\sqrt{6} \left( \left( g_{BL} \left( 2g_{RB} M_{BR} + g_R (M_1 + M_4) \right) + g_{BR} \left( 2g_R M_{BR} + g_{RB} (M_1 + M_4) \right) \right) Y_e Y_e^\dagger - \left( g_{BL} g_R + g_{BR} g_{RB} \right) T_e Y_e^\dagger \right) \\
& + 12g_L^2 T_e T_e^\dagger - 2\sqrt{6}g_{BR} g_R T_e T_e^\dagger - 2\sqrt{6}g_{BL} g_{RB} T_e T_e^\dagger + 6g_L^2 m_e^2 Y_e Y_e^\dagger \\
& - \sqrt{6}g_{BR} g_R m_e^2 Y_e Y_e^\dagger - \sqrt{6}g_{BL} g_{RB} m_e^2 Y_e Y_e^\dagger + 12g_L^2 Y_e m_l^2 Y_e^\dagger \\
& - 2\sqrt{6}g_{BR} g_R Y_e m_l^2 Y_e^\dagger - 2\sqrt{6}g_{BL} g_{RB} Y_e m_l^2 Y_e^\dagger + 6g_L^2 Y_e Y_e^\dagger m_e^2 \\
& - \sqrt{6}g_{BR} g_R Y_e Y_e^\dagger m_e^2 - \sqrt{6}g_{BL} g_{RB} Y_e Y_e^\dagger m_e^2 - 8m_{H_d}^2 Y_e Y_e^\dagger Y_e Y_e^\dagger \\
& - 4Y_e Y_e^\dagger T_e T_e^\dagger - 4m_{H_d}^2 Y_e Y_v^\dagger Y_v Y_e^\dagger - 4m_{H_u}^2 Y_e Y_v^\dagger Y_v Y_e^\dagger \\
& - 4Y_e Y_v^\dagger T_\nu T_\nu^\dagger - 4Y_e T_e^\dagger T_e Y_e^\dagger - 4Y_e T_\nu^\dagger T_\nu Y_e^\dagger - 4T_e Y_e^\dagger Y_e T_e^\dagger \\
& - 4T_e Y_v^\dagger Y_v T_e^\dagger - 4T_e T_e^\dagger Y_e Y_e^\dagger - 4T_e T_\nu^\dagger Y_v Y_e^\dagger - 2m_e^2 Y_e Y_e^\dagger Y_e Y_e^\dagger \\
& - 2m_e^2 Y_e Y_v^\dagger Y_v Y_e^\dagger - 4Y_e m_l^2 Y_e^\dagger Y_e Y_e^\dagger - 4Y_e m_l^2 Y_v^\dagger Y_v Y_e^\dagger - 4Y_e Y_e^\dagger m_e^2 Y_e Y_e^\dagger \\
& - 4Y_e Y_e^\dagger Y_e m_l^2 Y_e^\dagger - 2Y_e Y_e^\dagger Y_e Y_e^\dagger m_e^2 - 4Y_e Y_v^\dagger m_\nu^2 Y_v Y_e^\dagger - 4Y_e Y_v^\dagger Y_v m_l^2 Y_e^\dagger \\
& - 2Y_e Y_v^\dagger Y_v Y_e^\dagger m_e^2 + 3g_{BL}^2 \mathbf{1}\sigma_{2,11} + 2\sqrt{6}g_{BL} g_{RB} \mathbf{1}\sigma_{2,11} + 2g_{RB}^2 \mathbf{1}\sigma_{2,11} + 3g_{BL} g_{BR} \mathbf{1}\sigma_{2,13} + \sqrt{6}g_{BL} g_R \mathbf{1}\sigma_{2,13} \\
& + \sqrt{6}g_{BR} g_{RB} \mathbf{1}\sigma_{2,13} + 2g_R g_{RB} \mathbf{1}\sigma_{2,13} + 3g_{BL} g_{BR} \mathbf{1}\sigma_{2,31} + \sqrt{6}g_{BL} g_R \mathbf{1}\sigma_{2,31} + \sqrt{6}g_{BR} g_{RB} \mathbf{1}\sigma_{2,31} + 2g_R g_{RB} \mathbf{1}\sigma_{2,31} + 3g_{BR}^2 \mathbf{1}\sigma_{2,33} \\
& + 2\sqrt{6}g_{BR} g_R \mathbf{1}\sigma_{2,33} + 2g_R^2 \mathbf{1}\sigma_{2,33} + 2\sqrt{6}g_{BL} \mathbf{1}\sigma_{3,1} + 4g_{RB} \mathbf{1}\sigma_{3,1} + 2\sqrt{6}g_{BR} \mathbf{1}\sigma_{3,3} + 4g_R \mathbf{1}\sigma_{3,3} \\
& - 24m_{H_d}^2 Y_e Y_e^\dagger \text{Tr} \left( Y_d Y_d^\dagger \right) - 12T_e T_e^\dagger \text{Tr} \left( Y_d Y_d^\dagger \right) - 6m_e^2 Y_e Y_e^\dagger \text{Tr} \left( Y_d Y_d^\dagger \right) \\
& - 12Y_e m_l^2 Y_e^\dagger \text{Tr} \left( Y_d Y_d^\dagger \right) - 6Y_e Y_e^\dagger m_e^2 \text{Tr} \left( Y_d Y_d^\dagger \right) - 8m_{H_d}^2 Y_e Y_e^\dagger \text{Tr} \left( Y_e Y_e^\dagger \right)
\end{aligned}$$

$$\begin{aligned}
& -4T_e T_e^\dagger \text{Tr}(Y_e Y_e^\dagger) - 2m_e^2 Y_e Y_e^\dagger \text{Tr}(Y_e Y_e^\dagger) - 4Y_e m_l^2 Y_e^\dagger \text{Tr}(Y_e Y_e^\dagger) \\
& -2Y_e Y_e^\dagger m_e^2 \text{Tr}(Y_e Y_e^\dagger) - 12Y_e T_e^\dagger \text{Tr}(Y_d^\dagger T_d) - 4Y_e T_e^\dagger \text{Tr}(Y_e^\dagger T_e) \\
& -12T_e Y_e^\dagger \text{Tr}(T_d^* Y_d^T) - 12Y_e Y_e^\dagger \text{Tr}(T_d^* T_d^T) - 4T_e Y_e^\dagger \text{Tr}(T_e^* Y_e^T) \\
& -4Y_e Y_e^\dagger \text{Tr}(T_e^* T_e^T) - 12Y_e Y_e^\dagger \text{Tr}(m_d^2 Y_d Y_d^\dagger) - 4Y_e Y_e^\dagger \text{Tr}(m_e^2 Y_e Y_e^\dagger) \\
& -4Y_e Y_e^\dagger \text{Tr}(m_l^2 Y_e^\dagger Y_e) - 12Y_e Y_e^\dagger \text{Tr}(m_q^2 Y_d^\dagger Y_d)
\end{aligned} \tag{110}$$

### 3.9 Vacuum expectation values

$$\beta_{v_{\chi R}}^{(1)} = \frac{1}{8} v_{\chi R} \left( \left( 2(g_R^2 + g_{RB}^2) - 2\sqrt{6}g_{BL}g_{RB} - 2\sqrt{6}g_{BR}g_R + 3g_{BL}^2 + 3g_{BR}^2 \right) (1 + \text{Xi}) - 8\text{Tr}(Y_s Y_s^\dagger) \right) \tag{111}$$

$$\begin{aligned}
\beta_{v_{\chi R}}^{(2)} = & \frac{1}{64} v_{\chi R} \left( -180g_{BL}^4 - 360g_{BL}^2 g_{BR}^2 - 180g_{BR}^4 + 144\sqrt{6}g_{BL}^2 g_{BR}g_R + 144\sqrt{6}g_{BR}^3 g_R - 48g_{BL}^2 g_R^2 - 408g_{BR}^2 g_R^2 \right. \\
& + 144\sqrt{6}g_{BR}g_R^3 - 128g_R^4 + 144\sqrt{6}g_{BL}^3 g_{RB} + 144\sqrt{6}g_{BL}g_{BR}^2 g_{RB} - 720g_{BL}g_{BR}g_R g_{RB} \\
& + 144\sqrt{6}g_{BL}g_R^2 g_{RB} - 408g_{BL}^2 g_{RB}^2 - 48g_{BR}^2 g_{RB}^2 + 144\sqrt{6}g_{BR}g_R g_{RB}^2 - 256g_R^2 g_{RB}^2 \\
& + 144\sqrt{6}g_{BL}g_{RB}^3 - 128g_{RB}^4 - 9g_{BL}^4 \text{Xi} - 18g_{BL}^2 g_{BR}^2 \text{Xi} - 9g_{BR}^4 \text{Xi} + 12\sqrt{6}g_{BL}^2 g_{BR}g_R \text{Xi} + 12\sqrt{6}g_{BR}^3 g_R \text{Xi} \\
& - 12g_{BL}^2 g_R^2 \text{Xi} - 36g_{BR}^2 g_R^2 \text{Xi} + 8\sqrt{6}g_{BR}g_R^3 \text{Xi} - 4g_R^4 \text{Xi} + 12\sqrt{6}g_{BL}^3 g_{RB} \text{Xi} + 12\sqrt{6}g_{BL}g_{BR}^2 g_{RB} \text{Xi} \\
& - 48g_{BL}g_{BR}g_R g_{RB} \text{Xi} + 8\sqrt{6}g_{BL}g_R^2 g_{RB} \text{Xi} - 36g_{BL}^2 g_{RB}^2 \text{Xi} - 12g_{BR}^2 g_{RB}^2 \text{Xi} + 8\sqrt{6}g_{BR}g_R g_{RB}^2 \text{Xi} - 8g_R^2 g_{RB}^2 \text{Xi} \\
& + 8\sqrt{6}g_{BL}g_{RB}^3 \text{Xi} - 4g_{RB}^4 \text{Xi} + 9g_{BL}^4 \text{Xi}^2 + 18g_{BL}^2 g_{BR}^2 \text{Xi}^2 + 9g_{BR}^4 \text{Xi}^2 - 12\sqrt{6}g_{BL}^2 g_{BR}g_R \text{Xi}^2 \\
& - 12\sqrt{6}g_{BR}^3 g_R \text{Xi}^2 + 12g_{BL}^2 g_R^2 \text{Xi}^2 + 36g_{BR}^2 g_R^2 \text{Xi}^2 - 8\sqrt{6}g_{BR}g_R^3 \text{Xi}^2 + 4g_R^4 \text{Xi}^2 - 12\sqrt{6}g_{BL}^3 g_{RB} \text{Xi}^2 \\
& - 12\sqrt{6}g_{BL}g_{BR}^2 g_{RB} \text{Xi}^2 + 48g_{BL}g_{BR}g_R g_{RB} \text{Xi}^2 - 8\sqrt{6}g_{BL}g_R^2 g_{RB} \text{Xi}^2 + 36g_{BL}^2 g_{RB}^2 \text{Xi}^2 + 12g_{BR}^2 g_{RB}^2 \text{Xi}^2 \\
& - 8\sqrt{6}g_{BR}g_R g_{RB}^2 \text{Xi}^2 + 8g_R^2 g_{RB}^2 \text{Xi}^2 - 8\sqrt{6}g_{BL}^3 g_{RB} \text{Xi}^2 + 4g_{RB}^4 \text{Xi}^2 \\
& - 16 \left( 2(g_R^2 + g_{RB}^2) - 2\sqrt{6}g_{BL}g_{RB} - 2\sqrt{6}g_{BR}g_R + 3g_{BL}^2 + 3g_{BR}^2 \right) \text{Xi} \text{Tr}(Y_s Y_s^\dagger) + 128\text{Tr}(Y_s Y_s^\dagger Y_s Y_s^\dagger) \\
& \left. + 128\text{Tr}(Y_s Y_s^\dagger Y_v Y_v^\dagger) \right) \tag{112}
\end{aligned}$$

$$\beta_{v_{\bar{\chi} R}}^{(1)} = \frac{1}{8} \left( 2(g_R^2 + g_{RB}^2) - 2\sqrt{6}g_{BL}g_{RB} - 2\sqrt{6}g_{BR}g_R + 3g_{BL}^2 + 3g_{BR}^2 \right) v_{\bar{\chi} R} (1 + \text{Xi}) \tag{113}$$

$$\begin{aligned}
\beta_{v_{\bar{\chi} R}}^{(2)} = & \frac{1}{64} v_{\bar{\chi} R} \left( 4(g_R^2 + g_{RB}^2)^2 \left( -\text{Xi} - 32 + \text{Xi}^2 \right) + 9g_{BL}^4 \left( -\text{Xi} - 20 + \text{Xi}^2 \right) + 9g_{BR}^4 \left( -\text{Xi} - 20 + \text{Xi}^2 \right) - 8\sqrt{6}g_{BR}g_R \left( g_R^2 + g_{RB}^2 \right) \right. \\
& - 12\sqrt{6}g_{BR}^3 g_R \left( -\text{Xi} - 12 + \text{Xi}^2 \right) - 12\sqrt{6}g_{BL}^3 g_{RB} \left( -\text{Xi} - 12 + \text{Xi}^2 \right) \\
& - 4g_{BL}g_{RB} \left( -12g_{BR}g_R \left( -\text{Xi} - 15 + \text{Xi}^2 \right) + 2\sqrt{6} \left( g_R^2 + g_{RB}^2 \right) \left( -\text{Xi} - 18 + \text{Xi}^2 \right) + 3\sqrt{6}g_{BR}^2 \left( -\text{Xi} - 12 + \text{Xi}^2 \right) \right) \\
& + 12g_{BR}^2 \left( g_R^2 \left( -3\text{Xi} + 3\text{Xi}^2 - 34 \right) + g_{RB}^2 \left( -\text{Xi} - 4 + \text{Xi}^2 \right) \right) \\
& \left. + 6g_{BL}^2 \left( 2g_R^2 \left( -\text{Xi} - 4 + \text{Xi}^2 \right) + 2g_{RB}^2 \left( -3\text{Xi} + 3\text{Xi}^2 - 34 \right) + 2\sqrt{6}g_{BR}g_R \left( -\text{Xi}^2 + 12 + \text{Xi} \right) + 3g_{BR}^2 \left( -\text{Xi} - 20 + \text{Xi}^2 \right) \right) \right) \tag{114}
\end{aligned}$$



$$\beta_{v_d}^{(1)} = \frac{1}{4}v_d \left( -12\text{Tr}(Y_d Y_d^\dagger) + (3g_L^2 + g_R^2 + g_{RB}^2)(1 + \text{Xi}) - 4\text{Tr}(Y_e Y_e^\dagger) \right) \quad (115)$$

$$\begin{aligned} \beta_{v_d}^{(2)} = & -\frac{1}{16}v_d \left( 48g_L^4 + 27g_{BR}^2 g_R^2 + 12g_L^2 g_R^2 - 2\sqrt{6}g_{BR}g_R^3 + 32g_R^4 + 54g_{BL}g_{BR}g_R g_{RB} - 2\sqrt{6}g_{BL}g_R^2 g_{RB} \right. \\ & + 27g_{BL}^2 g_{RB}^2 + 12g_L^2 g_{RB}^2 - 2\sqrt{6}g_{BR}g_R g_{RB}^2 + 64g_R^2 g_{RB}^2 - 2\sqrt{6}g_{BL}g_{RB}^3 + 32g_{RB}^4 - 35g_L^4 \text{Xi} \\ & + 6g_L^2 g_R^2 \text{Xi} + g_R^4 \text{Xi} + 6g_L^2 g_{RB}^2 \text{Xi} + 2g_R^2 g_{RB}^2 \text{Xi} + g_{RB}^4 \text{Xi} + 9g_L^4 \text{Xi}^2 - 6g_L^2 g_R^2 \text{Xi}^2 - g_R^4 \text{Xi}^2 - 6g_L^2 g_{RB}^2 \text{Xi}^2 \\ & \left. - 2g_R^2 g_{RB}^2 \text{Xi}^2 - g_{RB}^4 \text{Xi}^2 \right) \\ & + 8 \left( 32g_s^2 + 3g_R^2 \text{Xi} + 3g_{RB}^2 \text{Xi} + 9g_L^2 \text{Xi} - \sqrt{6}g_{BL}g_{RB} - \sqrt{6}g_{BR}g_R + g_{BL}^2 + g_{BR}^2 \right) \text{Tr}(Y_d Y_d^\dagger) \\ & + 8 \left( 3g_{BL}^2 + 3g_{BR}^2 + (3g_L^2 + g_R^2 + g_{RB}^2) \text{Xi} + \sqrt{6}g_{BL}g_{RB} + \sqrt{6}g_{BR}g_R \right) \text{Tr}(Y_e Y_e^\dagger) - 144\text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) \\ & - 48\text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 48\text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) - 16\text{Tr}(Y_e Y_v^\dagger Y_v Y_e^\dagger) \end{aligned} \quad (116)$$

$$\beta_{v_u}^{(1)} = \frac{1}{4}v_u \left( -12\text{Tr}(Y_u Y_u^\dagger) + (3g_L^2 + g_R^2 + g_{RB}^2)(1 + \text{Xi}) - 4\text{Tr}(Y_v Y_v^\dagger) \right) \quad (117)$$

$$\begin{aligned} \beta_{v_u}^{(2)} = & -\frac{1}{16}v_u \left( 48g_L^4 + 27g_{BR}^2 g_R^2 + 12g_L^2 g_R^2 - 2\sqrt{6}g_{BR}g_R^3 + 32g_R^4 + 54g_{BL}g_{BR}g_R g_{RB} - 2\sqrt{6}g_{BL}g_R^2 g_{RB} \right. \\ & + 27g_{BL}^2 g_{RB}^2 + 12g_L^2 g_{RB}^2 - 2\sqrt{6}g_{BR}g_R g_{RB}^2 + 64g_R^2 g_{RB}^2 - 2\sqrt{6}g_{BL}g_{RB}^3 + 32g_{RB}^4 - 35g_L^4 \text{Xi} \\ & + 6g_L^2 g_R^2 \text{Xi} + g_R^4 \text{Xi} + 6g_L^2 g_{RB}^2 \text{Xi} + 2g_R^2 g_{RB}^2 \text{Xi} + g_{RB}^4 \text{Xi} + 9g_L^4 \text{Xi}^2 - 6g_L^2 g_R^2 \text{Xi}^2 - g_R^4 \text{Xi}^2 - 6g_L^2 g_{RB}^2 \text{Xi}^2 \\ & \left. - 2g_R^2 g_{RB}^2 \text{Xi}^2 - g_{RB}^4 \text{Xi}^2 \right) \\ & + 8 \left( 32g_s^2 + 3g_R^2 \text{Xi} + 3g_{RB}^2 \text{Xi} + 9g_L^2 \text{Xi} + \sqrt{6}g_{BL}g_{RB} + \sqrt{6}g_{BR}g_R + g_{BL}^2 + g_{BR}^2 \right) \text{Tr}(Y_u Y_u^\dagger) \\ & + 8 \left( 3g_{BL}^2 + 3g_{BR}^2 + (3g_L^2 + g_R^2 + g_{RB}^2) \text{Xi} - \sqrt{6}g_{BL}g_{RB} - \sqrt{6}g_{BR}g_R \right) \text{Tr}(Y_v Y_v^\dagger) \\ & - 48\text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 16\text{Tr}(Y_e Y_v^\dagger Y_v Y_e^\dagger) - 16\text{Tr}(Y_s Y_s^\dagger Y_v Y_v^\dagger) - 144\text{Tr}(Y_u Y_u^\dagger Y_u Y_u^\dagger) \\ & - 48\text{Tr}(Y_v Y_v^\dagger Y_v Y_v^\dagger) \end{aligned} \quad (118)$$

## 4 Field Rotations

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

$$\begin{pmatrix} W_{3\rho} \\ B_\rho \\ B_{R,\rho} \end{pmatrix} = ZZ \begin{pmatrix} \gamma_\rho \\ Z_\rho \\ Z_{R,\rho} \end{pmatrix} \quad (119)$$

$$\begin{pmatrix} W_{1\rho} \\ W_{2\rho} \end{pmatrix} = ZW \begin{pmatrix} W_\rho^- \\ W_\rho^- \end{pmatrix} \quad (120)$$

$$\begin{pmatrix} \lambda_{\tilde{W},1} \\ \lambda_{\tilde{W},2} \\ \lambda_{\tilde{W},3} \end{pmatrix} = ZfW \begin{pmatrix} \tilde{W}^- \\ \tilde{W}^+ \\ \tilde{W}^0 \end{pmatrix} \quad (121)$$

$$(122)$$

The mixing matrices are parametrized by

$$ZW = \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ -i\frac{1}{\sqrt{2}} & i\frac{1}{\sqrt{2}} \end{pmatrix} \quad (123)$$

$$ZfW = \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \\ -i\frac{1}{\sqrt{2}} & i\frac{1}{\sqrt{2}} & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad (124)$$

$$(125)$$

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

### 4.2.1 Mass Matrices for Scalars

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

$$m_{\tilde{d}}^2 = \begin{pmatrix} m_{\tilde{d}_L \tilde{d}_L^*} & \frac{1}{\sqrt{2}}(v_d T_d^\dagger - v_u \mu Y_d^\dagger) \delta_{\alpha_1 \beta_2} \\ \frac{1}{\sqrt{2}} \delta_{\alpha_2 \beta_1} (v_d T_d - v_u Y_d \mu^*) & m_{\tilde{d}_R \tilde{d}_R^*} \end{pmatrix} \quad (126)$$

$$m_{\tilde{d}_L \tilde{d}_L^*} = +\frac{1}{24} \mathbf{1} \left( 3g_L^2 (-v_d^2 + v_u^2) + (g_{BL}^2 + g_{BR}^2) (-v_{\chi_R}^2 + v_{\chi_R}^2) + (g_{BL}g_{RB} + g_{BR}g_R) (-v_{\chi_R}^2 - v_d^2 + v_{\chi_R}^2 + v_u^2) \right) \delta_{\alpha_1 \beta_1} \\ + \frac{1}{2} \delta_{\alpha_1 \beta_1} (2m_q^2 + v_d^2 Y_d^\dagger Y_d) \quad (127)$$

$$m_{\tilde{d}_R \tilde{d}_R^*} = +\frac{1}{24} \mathbf{1} \left( (g_{BL}^2 + g_{BR}^2) (-v_{\chi_R}^2 + v_{\chi_R}^2) + (g_{BL}g_{RB} + g_{BR}g_R) (4v_{\chi_R}^2 - 4v_{\chi_R}^2 - v_u^2 + v_d^2) \right. \\ \left. + 3(g_R^2 + g_{RB}^2) (-v_{\chi_R}^2 - v_d^2 + v_{\chi_R}^2 + v_u^2) \right) \delta_{\alpha_2 \beta_2} \\ + \frac{1}{2} \delta_{\alpha_2 \beta_2} (2m_d^2 + v_d^2 Y_d Y_d^\dagger) \quad (128)$$

This matrix is diagonalized by  $Z^D$ :

$$Z^D m_{\tilde{d}}^2 Z^{D,\dagger} = m_{2,d}^{dia} \quad (129)$$

with

$$\tilde{d}_{L,i\alpha} = \sum_j Z_{ji}^{D,*} \tilde{d}_{j\alpha}, \quad \tilde{d}_{R,i\alpha} = \sum_j Z_{ji}^{D,*} \tilde{d}_{j\alpha} \quad (130)$$

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

$$m_{\tilde{\nu}}^2 = \begin{pmatrix} m_{\tilde{\nu}_L \tilde{\nu}_L^*} & \frac{1}{\sqrt{2}}(-v_d \mu Y_v^\dagger + v_u T_\nu^\dagger) & \frac{1}{2} v_{\chi_R} v_u Y_v^\dagger Y_s \\ \frac{1}{\sqrt{2}}(-v_d Y_v \mu^* + v_u T_\nu) & m_{\tilde{\nu}_R \tilde{\nu}_R^*} & \frac{1}{\sqrt{2}}(-v_{\bar{\chi}_R} Y_s \mu_R^* + v_{\chi_R} T_s) \\ \frac{1}{2} v_{\chi_R} v_u Y_s^\dagger Y_v & m_{\tilde{\nu}_R \tilde{S}^*} & \frac{1}{2} v_{\chi_R}^2 Y_s^\dagger Y_s + m_S^2 \end{pmatrix} \quad (131)$$

$$m_{\tilde{\nu}_L \tilde{\nu}_L^*} = +m_l^2 + \frac{1}{8} \mathbf{1} \left( (g_{BL}^2 + g_{BR}^2) (-v_{\bar{\chi}_R}^2 + v_{\chi_R}^2) + (g_{BL} g_{RB} + g_{BR} g_R) (-v_{\chi_R}^2 - v_u^2 + v_{\bar{\chi}_R}^2 + v_d^2) + g_L^2 (-v_u^2 + v_d^2) \right) + \frac{1}{2} v_u^2 Y_v^\dagger Y_v \quad (132)$$

$$m_{\tilde{\nu}_R \tilde{\nu}_R^*} = -\frac{1}{8} \mathbf{1} \left( (g_{BL}^2 + g_{BR}^2) (-v_{\bar{\chi}_R}^2 + v_{\chi_R}^2) + (g_{BL} g_{RB} + g_{BR} g_R) (2v_{\bar{\chi}_R}^2 - 2v_{\chi_R}^2 - v_u^2 + v_d^2) + (g_R^2 + g_{RB}^2) (-v_{\bar{\chi}_R}^2 - v_d^2 + v_{\chi_R}^2 + v_u^2) \right) + \frac{1}{2} (2m_\nu^2 + v_{\chi_R}^2 Y_s Y_s^\dagger + v_u^2 Y_v Y_v^\dagger) \quad (133)$$

$$m_{\tilde{\nu}_R \tilde{S}^*} = \frac{1}{\sqrt{2}} (-\mu_R v_{\bar{\chi}_R} Y_s^\dagger + v_{\chi_R} T_s^\dagger) \quad (134)$$

This matrix is diagonalized by  $Z^V$ :

$$Z^V m_{\tilde{\nu}}^2 Z^{V,\dagger} = m_{2,\tilde{\nu}}^{dia} \quad (135)$$

with

$$\tilde{\nu}_{L,i} = \sum_j Z_{ji}^{V,*} \tilde{\nu}_j, \quad \tilde{\nu}_{R,i} = \sum_j Z_{ji}^{V,*} \tilde{\nu}_j, \quad \tilde{S}_i = \sum_j Z_{ji}^{V,*} \tilde{\nu}_j \quad (136)$$

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

$$m_{\tilde{u}}^2 = \begin{pmatrix} m_{\tilde{u}_L \tilde{u}_L^*} & \frac{1}{\sqrt{2}}(-v_d \mu Y_u^\dagger + v_u T_u^\dagger) \delta_{\alpha_1 \beta_2} \\ \frac{1}{\sqrt{2}} \delta_{\alpha_2 \beta_1} (-v_d Y_u \mu^* + v_u T_u) & m_{\tilde{u}_R \tilde{u}_R^*} \end{pmatrix} \quad (137)$$

$$m_{\tilde{u}_L \tilde{u}_L^*} = +\frac{1}{24} \mathbf{1} \left( 3g_L^2 (-v_u^2 + v_d^2) + (g_{BL}^2 + g_{BR}^2) (-v_{\chi_R}^2 + v_{\bar{\chi}_R}^2) + (g_{BL} g_{RB} + g_{BR} g_R) (-v_{\bar{\chi}_R}^2 - v_d^2 + v_{\chi_R}^2 + v_u^2) \right) \delta_{\alpha_1 \beta_1} + \frac{1}{2} \delta_{\alpha_1 \beta_1} (2m_q^2 + v_u^2 Y_u^\dagger Y_u) \quad (138)$$

$$m_{\tilde{u}_R \tilde{u}_R^*} = +\frac{1}{24} \mathbf{1} \left( (g_{BL}^2 + g_{BR}^2) (-v_{\bar{\chi}_R}^2 + v_{\chi_R}^2) + (g_{BL} g_{RB} + g_{BR} g_R) (-2v_{\bar{\chi}_R}^2 + 2v_{\chi_R}^2 - v_u^2 + v_d^2) + 3(g_R^2 + g_{RB}^2) (-v_{\chi_R}^2 - v_u^2 + v_{\bar{\chi}_R}^2 + v_d^2) \right) \delta_{\alpha_2 \beta_2} + \frac{1}{2} \delta_{\alpha_2 \beta_2} (2m_u^2 + v_u^2 Y_u Y_u^\dagger) \quad (139)$$

This matrix is diagonalized by  $Z^U$ :

$$Z^U m_{\tilde{u}}^2 Z^{U,\dagger} = m_{2,\tilde{u}}^{dia} \quad (140)$$

with

$$\tilde{u}_{L,i\alpha} = \sum_j Z_{ji}^{U,*} \tilde{u}_{j\alpha}, \quad \tilde{u}_{R,i\alpha} = \sum_j Z_{ji}^{U,*} \tilde{u}_{j\alpha} \quad (141)$$

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

$$m_{\tilde{e}}^2 = \begin{pmatrix} m_{\tilde{e}_L \tilde{e}_L^*} & \frac{1}{\sqrt{2}}(v_d T_e^\dagger - v_u \mu Y_e^\dagger) \\ \frac{1}{\sqrt{2}}(v_d T_e - v_u Y_e \mu^*) & m_{\tilde{e}_R \tilde{e}_R^*} \end{pmatrix} \quad (142)$$

$$m_{\tilde{e}_L \tilde{e}_L^*} = +m_l^2 + \frac{1}{8} \mathbf{1} \left( (g_{BL}^2 + g_{BR}^2) (-v_{\chi_R}^2 + v_{\chi_R}^2) + (g_{BL} g_{RB} + g_{BR} g_{RL}) (-v_{\chi_R}^2 - v_u^2 + v_{\chi_R}^2 + v_d^2) + g_L^2 (-v_d^2 + v_u^2) \right) + \frac{1}{2} v_d^2 Y_e^\dagger Y_e \quad (143)$$

$$m_{\tilde{e}_R \tilde{e}_R^*} = +m_e^2 + \frac{1}{8} \mathbf{1} \left( (g_{BL}^2 + g_{BR}^2) (-v_{\chi_R}^2 + v_{\chi_R}^2) + (g_{BL} g_{RB} + g_{BR} g_{RL}) (-v_d^2 + v_u^2) + (g_R^2 + g_{RB}^2) (-v_{\chi_R}^2 - v_d^2 + v_{\chi_R}^2 + v_u^2) \right) + \frac{1}{2} v_d^2 Y_e Y_e^\dagger \quad (144)$$

This matrix is diagonalized by  $Z^E$ :

$$Z^E m_{\tilde{e}}^2 Z^{E,\dagger} = m_{2,\tilde{e}}^{dia} \quad (145)$$

with

$$\tilde{e}_{L,i} = \sum_j Z_{ji}^{E,*} \tilde{e}_j, \quad \tilde{e}_{R,i} = \sum_j Z_{ji}^{E,*} \tilde{e}_j \quad (146)$$

- **Mass matrix for Higgs**, Basis:  $(\phi_d, \phi_u, \bar{\phi}_R, \phi_R), (\phi_d, \phi_u, \bar{\phi}_R, \phi_R)$

$$m_h^2 = \begin{pmatrix} m_{\phi_d \phi_d} & m_{\phi_u \phi_d} & m_{\bar{\phi}_R \phi_d} & \\ m_{\phi_d \phi_u} & m_{\phi_u \phi_u} & & m_{\phi_R \phi_u} \\ m_{\phi_d \bar{\phi}_R} & & m_{\bar{\phi}_R \bar{\phi}_R} & m_{\phi_R \bar{\phi}_R} \\ & m_{\phi_u \phi_R} & m_{\bar{\phi}_R \phi_R} & m_{\phi_R \phi_R} \end{pmatrix} \quad (147)$$

$$m_{\phi_d \phi_d} = +m_{H_d}^2 + \frac{1}{8} \left( g_{BR} g_{RL} (-v_{\chi_R}^2 + v_{\chi_R}^2) + g_L^2 (3v_d^2 - v_u^2) - g_R^2 (-3v_d^2 - v_{\chi_R}^2 + v_{\chi_R}^2 + v_u^2) + g_{RB} (g_{BL} (-v_{\chi_R}^2 + v_{\chi_R}^2) - g_{RB} (-3v_d^2 - v_{\chi_R}^2 + v_{\chi_R}^2 + v_u^2)) \right) + |\mu|^2 \quad (148)$$

$$m_{\phi_d \phi_u} = -\frac{1}{4} (g_L^2 + g_R^2 + g_{RB}^2) v_d v_u - \Re(B_\mu) \quad (149)$$

$$m_{\phi_u \phi_u} = +m_{H_u}^2$$

$$\begin{aligned}
& + \frac{1}{8} \left( g_{BRGR} \left( -v_{\chi_R}^2 + v_{\bar{\chi}_R}^2 \right) - g_L^2 \left( -3v_u^2 + v_d^2 \right) + g_R^2 \left( 3v_u^2 - v_{\chi_R}^2 - v_d^2 + v_{\chi_R}^2 \right) \right. \\
& + g_{RB} \left( g_{BL} \left( -v_{\chi_R}^2 + v_{\bar{\chi}_R}^2 \right) + g_{RB} \left( 3v_u^2 - v_{\chi_R}^2 - v_d^2 + v_{\chi_R}^2 \right) \right) \\
& \left. + |\mu|^2 \right) \tag{150}
\end{aligned}$$

$$m_{\phi_d \bar{\phi}_R} = \frac{1}{4} \left( -g_{BRGR} + g_{RB} \left( -g_{BL} + g_{RB} \right) + g_R^2 \right) v_{\bar{\chi}_R} v_d \tag{151}$$

$$\begin{aligned}
m_{\bar{\phi}_R \bar{\phi}_R} & = +m_{\bar{\chi}}^2 \\
& + \frac{1}{8} \left( \left( -g_{BL}^2 - g_{BR}^2 \right) \left( -3v_{\bar{\chi}_R}^2 + v_{\chi_R}^2 \right) + g_{BRGR} \left( 2v_{\chi_R}^2 - 6v_{\bar{\chi}_R}^2 - v_d^2 + v_u^2 \right) \right. \\
& + g_{BLGRB} \left( 2v_{\chi_R}^2 - 6v_{\bar{\chi}_R}^2 - v_d^2 + v_u^2 \right) - \left( g_R^2 + g_{RB}^2 \right) \left( -3v_{\bar{\chi}_R}^2 - v_d^2 + v_{\chi_R}^2 + v_u^2 \right) \\
& \left. + |\mu_R|^2 \right) \tag{152}
\end{aligned}$$

$$m_{\phi_u \phi_R} = \frac{1}{4} \left( -g_{BRGR} + g_{RB} \left( -g_{BL} + g_{RB} \right) + g_R^2 \right) v_{\chi_R} v_u \tag{153}$$

$$m_{\bar{\phi}_R \phi_R} = -\frac{1}{4} \left( \left( -g_R + g_{BR} \right)^2 + \left( -g_{RB} + g_{BL} \right)^2 \right) v_{\chi_R} v_{\bar{\chi}_R} - \Re \left( B_{\mu_R} \right) \tag{154}$$

$$\begin{aligned}
m_{\phi_R \phi_R} & = +m_{\chi}^2 \\
& + \frac{1}{8} \left( \left( g_{BL}^2 + g_{BR}^2 \right) \left( 3v_{\chi_R}^2 - v_{\bar{\chi}_R}^2 \right) + \left( g_{BLGRB} + g_{BRGR} \right) \left( 2v_{\bar{\chi}_R}^2 - 6v_{\chi_R}^2 - v_u^2 + v_d^2 \right) \right. \\
& + \left( g_R^2 + g_{RB}^2 \right) \left( 3v_{\chi_R}^2 - v_{\bar{\chi}_R}^2 - v_d^2 + v_u^2 \right) \\
& \left. + |\mu_R|^2 \right) \tag{155}
\end{aligned}$$

This matrix is diagonalized by  $Z^H$ :

$$Z^H m_h^2 Z^{H,\dagger} = m_{2,h}^{dia} \tag{156}$$

with

$$\phi_d = \sum_j Z_{j1}^H h_j, \quad \phi_u = \sum_j Z_{j2}^H h_j, \quad \bar{\phi}_R = \sum_j Z_{j3}^H h_j \tag{157}$$

$$\phi_R = \sum_j Z_{j4}^H h_j \tag{158}$$

- **Mass matrix for Pseudo-Scalar Higgs, Basis:**  $(\sigma_d, \sigma_u, \bar{\sigma}_R, \sigma_R), (\sigma_d, \sigma_u, \bar{\sigma}_R, \sigma_R)$

$$m_{A^0}^2 = \begin{pmatrix} m_{\sigma_d \sigma_d} & \Re(B_{\mu}) & 0 & 0 \\ \Re(B_{\mu}) & m_{\sigma_u \sigma_u} & 0 & 0 \\ 0 & 0 & m_{\bar{\sigma}_R \bar{\sigma}_R} & \Re(B_{\mu_R}) \\ 0 & 0 & \Re(B_{\mu_R}) & m_{\sigma_R \sigma_R} \end{pmatrix} + \xi_Z m^2(Z) + \xi_{Z_R} m^2(Z_R) \tag{159}$$

$$m_{\sigma_d \sigma_d} = +m_{H_d}^2$$

$$\begin{aligned}
& + \frac{1}{8} \left( \left( -g_{BL}g_{RB} - g_{BR}g_R + g_R^2 + g_{RB}^2 \right) v_{\tilde{\chi}_R}^2 + \left( g_{BL}g_{RB} + g_{BR}g_R - g_R^2 - g_{RB}^2 \right) v_{\chi_R}^2 + \left( g_L^2 + g_R^2 + g_{RB}^2 \right) \left( -v_u^2 + v_d^2 \right) \right) \\
& + |\mu|^2 \tag{160}
\end{aligned}$$

$$\begin{aligned}
m_{\sigma_u \sigma_u} & = +m_{H_u}^2 \\
& + \frac{1}{8} \left( \left( -g_{BL}g_{RB} - g_{BR}g_R + g_R^2 + g_{RB}^2 \right) v_{\tilde{\chi}_R}^2 + \left( g_{BL}g_{RB} + g_{BR}g_R - g_R^2 - g_{RB}^2 \right) v_{\chi_R}^2 + \left( -g_L^2 - g_R^2 - g_{RB}^2 \right) v_d^2 \right) \\
& + \left( g_L^2 + g_R^2 + g_{RB}^2 \right) v_u^2 \\
& + |\mu|^2 \tag{161}
\end{aligned}$$

$$\begin{aligned}
m_{\bar{\sigma}_R \bar{\sigma}_R} & = +m_{\tilde{\chi}}^2 \\
& + \frac{1}{8} \left( \left( g_{BL}^2 + g_{BR}^2 \right) \left( -v_{\tilde{\chi}_R}^2 + v_{\chi_R}^2 \right) + \left( g_{BL}g_{RB} + g_{BR}g_R \right) \left( -2v_{\tilde{\chi}_R}^2 + 2v_{\chi_R}^2 - v_d^2 + v_u^2 \right) \right) \\
& - \left( g_R^2 + g_{RB}^2 \right) \left( -v_{\tilde{\chi}_R}^2 - v_d^2 + v_{\chi_R}^2 + v_u^2 \right) \\
& + |\mu_R|^2 \tag{162}
\end{aligned}$$

$$\begin{aligned}
m_{\sigma_R \sigma_R} & = +m_{\chi}^2 \\
& + \frac{1}{8} \left( \left( g_{BL}^2 + g_{BR}^2 \right) \left( -v_{\tilde{\chi}_R}^2 + v_{\chi_R}^2 \right) + \left( g_{BL}g_{RB} + g_{BR}g_R \right) \left( 2v_{\tilde{\chi}_R}^2 - 2v_{\chi_R}^2 - v_u^2 + v_d^2 \right) \right) \\
& + \left( g_R^2 + g_{RB}^2 \right) \left( -v_{\tilde{\chi}_R}^2 - v_d^2 + v_{\chi_R}^2 + v_u^2 \right) \\
& + |\mu_R|^2 \tag{163}
\end{aligned}$$

Gauge fixing contributions:

$$m^2(\xi_Z) = \begin{pmatrix} m_{\sigma_d \sigma_d} & m_{\sigma_u \sigma_d} & m_{\bar{\sigma}_R \sigma_d} & m_{\sigma_R \sigma_d} \\ m_{\sigma_d \sigma_u} & m_{\sigma_u \sigma_u} & m_{\bar{\sigma}_R \sigma_u} & m_{\sigma_R \sigma_u} \\ m_{\sigma_d \bar{\sigma}_R} & m_{\sigma_u \bar{\sigma}_R} & m_{\bar{\sigma}_R \bar{\sigma}_R} & m_{\sigma_R \bar{\sigma}_R} \\ m_{\sigma_d \sigma_R} & m_{\sigma_u \sigma_R} & m_{\bar{\sigma}_R \sigma_R} & m_{\sigma_R \sigma_R} \end{pmatrix} \tag{164}$$

$$m_{\sigma_d \sigma_d} = \frac{1}{4} v_d^2 \left( g_L Z Z_{12}^* - g_{RB} Z Z_{22}^* - g_R Z Z_{32}^* \right) \left( g_L Z Z_{12} - g_{RB} Z Z_{22} - g_R Z Z_{32} \right) \tag{165}$$

$$m_{\sigma_d \sigma_u} = -\frac{1}{4} v_d v_u \left( g_L Z Z_{12}^* - g_{RB} Z Z_{22}^* - g_R Z Z_{32}^* \right) \left( g_L Z Z_{12} - g_{RB} Z Z_{22} - g_R Z Z_{32} \right) \tag{166}$$

$$m_{\sigma_u \sigma_u} = \frac{1}{4} v_u^2 \left( g_L Z Z_{12}^* - g_{RB} Z Z_{22}^* - g_R Z Z_{32}^* \right) \left( g_L Z Z_{12} - g_{RB} Z Z_{22} - g_R Z Z_{32} \right) \tag{167}$$

$$\begin{aligned}
m_{\sigma_d \bar{\sigma}_R} & = \frac{1}{8} v_{\tilde{\chi}_R} v_d \left( g_L Z Z_{12}^* \left( \left( -g_{RB} + g_{BL} \right) Z Z_{22} + \left( -g_R + g_{BR} \right) Z Z_{32} \right) + Z Z_{32}^* \left( 2g_R \left( -g_{BR} + g_R \right) Z Z_{32} + 2g_R g_{RB} Z Z_{22} + \right. \right. \\
& \left. \left. + Z Z_{22}^* \left( - \left( \left( -2g_R + g_{BR} \right) g_{RB} + g_{BL} g_R \right) Z Z_{32} + \left( -g_{RB} + g_{BL} \right) \left( -2g_{RB} Z Z_{22} + g_L Z Z_{12} \right) \right) \right) \right) \tag{168}
\end{aligned}$$

$$\begin{aligned}
m_{\sigma_u \bar{\sigma}_R} & = \frac{1}{8} v_{\tilde{\chi}_R} v_u \left( Z Z_{32}^* \left( 2 \left( -g_R + g_{BR} \right) g_R Z Z_{32} + \left( g_{BR} g_{RB} + g_R \left( -2g_{RB} + g_{BL} \right) \right) Z Z_{22} + g_L \left( -g_{BR} + g_R \right) Z Z_{12} \right) + g_L Z \right. \\
& \left. + Z Z_{22}^* \left( \left( \left( -2g_R + g_{BR} \right) g_{RB} + g_{BL} g_R \right) Z Z_{32} + \left( -g_{RB} + g_{BL} \right) \left( 2g_{RB} Z Z_{22} - g_L Z Z_{12} \right) \right) \right) \tag{169}
\end{aligned}$$

$$m_{\bar{\sigma}_R \bar{\sigma}_R} = \frac{1}{4} v_{\bar{\chi}_R}^2 \left( \left( -g_{RB} + g_{BL} \right) Z Z_{22}^* + \left( -g_R + g_{BR} \right) Z Z_{32}^* \right) \left( \left( -g_{RB} + g_{BL} \right) Z Z_{22} + \left( -g_R + g_{BR} \right) Z Z_{32} \right) \quad (170)$$

$$m_{\sigma_d \sigma_R} = \frac{1}{8} v_{\chi_R} v_d \left( Z Z_{32}^* \left( 2 \left( -g_R + g_{BR} \right) g_R Z Z_{32} + \left( g_{BR} g_{RB} + g_R \left( -2g_{RB} + g_{BL} \right) \right) Z Z_{22} + g_L \left( -g_{BR} + g_R \right) Z Z_{12} \right) + g_L Z \right. \\ \left. + Z Z_{22}^* \left( \left( \left( -2g_R + g_{BR} \right) g_{RB} + g_{BL} g_R \right) Z Z_{32} + \left( -g_{RB} + g_{BL} \right) \left( 2g_{RB} Z Z_{22} - g_L Z Z_{12} \right) \right) \right) \quad (171)$$

$$m_{\sigma_u \sigma_R} = \frac{1}{8} v_{\chi_R} v_u \left( g_L Z Z_{12}^* \left( \left( -g_{RB} + g_{BL} \right) Z Z_{22} + \left( -g_R + g_{BR} \right) Z Z_{32} \right) + Z Z_{32}^* \left( 2g_R \left( -g_{BR} + g_R \right) Z Z_{32} + 2g_R g_{RB} Z Z_{22} + \right. \right. \\ \left. \left. + Z Z_{22}^* \left( - \left( \left( -2g_R + g_{BR} \right) g_{RB} + g_{BL} g_R \right) Z Z_{32} + \left( -g_{RB} + g_{BL} \right) \left( -2g_{RB} Z Z_{22} + g_L Z Z_{12} \right) \right) \right) \right) \quad (172)$$

$$m_{\bar{\sigma}_R \sigma_R} = -\frac{1}{4} v_{\chi_R} v_{\bar{\chi}_R} \left( \left( -g_{RB} + g_{BL} \right) Z Z_{22}^* + \left( -g_R + g_{BR} \right) Z Z_{32}^* \right) \left( \left( -g_{RB} + g_{BL} \right) Z Z_{22} + \left( -g_R + g_{BR} \right) Z Z_{32} \right) \quad (173)$$

$$m_{\sigma_R \sigma_R} = \frac{1}{4} v_{\chi_R}^2 \left( \left( -g_{RB} + g_{BL} \right) Z Z_{22}^* + \left( -g_R + g_{BR} \right) Z Z_{32}^* \right) \left( \left( -g_{RB} + g_{BL} \right) Z Z_{22} + \left( -g_R + g_{BR} \right) Z Z_{32} \right) \quad (174)$$

$$m^2(\xi_{Z_R}) = \begin{pmatrix} m_{\sigma_d \sigma_d} & m_{\sigma_u \sigma_d} & m_{\bar{\sigma}_R \sigma_d} & m_{\sigma_R \sigma_d} \\ m_{\sigma_d \sigma_u} & m_{\sigma_u \sigma_u} & m_{\bar{\sigma}_R \sigma_u} & m_{\sigma_R \sigma_u} \\ m_{\sigma_d \bar{\sigma}_R} & m_{\sigma_u \bar{\sigma}_R} & m_{\bar{\sigma}_R \bar{\sigma}_R} & m_{\sigma_R \bar{\sigma}_R} \\ m_{\sigma_d \sigma_R} & m_{\sigma_u \sigma_R} & m_{\bar{\sigma}_R \sigma_R} & m_{\sigma_R \sigma_R} \end{pmatrix} \quad (175)$$

$$m_{\sigma_d \sigma_d} = \frac{1}{4} v_d^2 \left( g_L Z Z_{13}^* - g_{RB} Z Z_{23}^* - g_R Z Z_{33}^* \right) \left( g_L Z Z_{13} - g_{RB} Z Z_{23} - g_R Z Z_{33} \right) \quad (176)$$

$$m_{\sigma_d \sigma_u} = -\frac{1}{4} v_d v_u \left( g_L Z Z_{13}^* - g_{RB} Z Z_{23}^* - g_R Z Z_{33}^* \right) \left( g_L Z Z_{13} - g_{RB} Z Z_{23} - g_R Z Z_{33} \right) \quad (177)$$

$$m_{\sigma_u \sigma_u} = \frac{1}{4} v_u^2 \left( g_L Z Z_{13}^* - g_{RB} Z Z_{23}^* - g_R Z Z_{33}^* \right) \left( g_L Z Z_{13} - g_{RB} Z Z_{23} - g_R Z Z_{33} \right) \quad (178)$$

$$m_{\sigma_d \bar{\sigma}_R} = \frac{1}{8} v_{\bar{\chi}_R} v_d \left( g_L Z Z_{13}^* \left( \left( -g_{RB} + g_{BL} \right) Z Z_{23} + \left( -g_R + g_{BR} \right) Z Z_{33} \right) + Z Z_{33}^* \left( 2g_R \left( -g_{BR} + g_R \right) Z Z_{33} + 2g_R g_{RB} Z Z_{23} + \right. \right. \\ \left. \left. + Z Z_{23}^* \left( - \left( \left( -2g_R + g_{BR} \right) g_{RB} + g_{BL} g_R \right) Z Z_{33} + \left( -g_{RB} + g_{BL} \right) \left( -2g_{RB} Z Z_{23} + g_L Z Z_{13} \right) \right) \right) \right) \quad (179)$$

$$m_{\sigma_u \bar{\sigma}_R} = \frac{1}{8} v_{\bar{\chi}_R} v_u \left( Z Z_{33}^* \left( 2 \left( -g_R + g_{BR} \right) g_R Z Z_{33} + \left( g_{BR} g_{RB} + g_R \left( -2g_{RB} + g_{BL} \right) \right) Z Z_{23} + g_L \left( -g_{BR} + g_R \right) Z Z_{13} \right) + g_L Z \right. \\ \left. + Z Z_{23}^* \left( \left( \left( -2g_R + g_{BR} \right) g_{RB} + g_{BL} g_R \right) Z Z_{33} + \left( -g_{RB} + g_{BL} \right) \left( 2g_{RB} Z Z_{23} - g_L Z Z_{13} \right) \right) \right) \quad (180)$$

$$m_{\bar{\sigma}_R \bar{\sigma}_R} = \frac{1}{4} v_{\bar{\chi}_R}^2 \left( \left( -g_{RB} + g_{BL} \right) Z Z_{23}^* + \left( -g_R + g_{BR} \right) Z Z_{33}^* \right) \left( \left( -g_{RB} + g_{BL} \right) Z Z_{23} + \left( -g_R + g_{BR} \right) Z Z_{33} \right) \quad (181)$$

$$m_{\sigma_d \sigma_R} = \frac{1}{8} v_{\chi_R} v_d \left( Z Z_{33}^* \left( 2 \left( -g_R + g_{BR} \right) g_R Z Z_{33} + \left( g_{BR} g_{RB} + g_R \left( -2g_{RB} + g_{BL} \right) \right) Z Z_{23} + g_L \left( -g_{BR} + g_R \right) Z Z_{13} \right) + g_L Z \right. \\ \left. + Z Z_{23}^* \left( \left( \left( -2g_R + g_{BR} \right) g_{RB} + g_{BL} g_R \right) Z Z_{33} + \left( -g_{RB} + g_{BL} \right) \left( 2g_{RB} Z Z_{23} - g_L Z Z_{13} \right) \right) \right) \quad (182)$$

$$\begin{aligned}
m_{\sigma_u \sigma_R} &= \frac{1}{8} v_{\chi_R} v_u \left( g_L Z Z_{13}^* \left( \left( -g_{RB} + g_{BL} \right) Z Z_{23} + \left( -g_R + g_{BR} \right) Z Z_{33} \right) + Z Z_{33}^* \left( 2g_R \left( -g_{BR} + g_R \right) Z Z_{33} + 2g_R g_{RB} Z Z_{23} + \right. \right. \\
&\quad \left. \left. + Z Z_{23}^* \left( - \left( \left( -2g_R + g_{BR} \right) g_{RB} + g_{BL} g_R \right) Z Z_{33} + \left( -g_{RB} + g_{BL} \right) \left( -2g_{RB} Z Z_{23} + g_L Z Z_{13} \right) \right) \right) \right) \quad (183)
\end{aligned}$$

$$m_{\bar{\sigma}_R \sigma_R} = -\frac{1}{4} v_{\chi_R} v_{\bar{\chi}_R} \left( \left( -g_{RB} + g_{BL} \right) Z Z_{23}^* + \left( -g_R + g_{BR} \right) Z Z_{33}^* \right) \left( \left( -g_{RB} + g_{BL} \right) Z Z_{23} + \left( -g_R + g_{BR} \right) Z Z_{33} \right) \quad (184)$$

$$m_{\sigma_R \sigma_R} = \frac{1}{4} v_{\chi_R}^2 \left( \left( -g_{RB} + g_{BL} \right) Z Z_{23}^* + \left( -g_R + g_{BR} \right) Z Z_{33}^* \right) \left( \left( -g_{RB} + g_{BL} \right) Z Z_{23} + \left( -g_R + g_{BR} \right) Z Z_{33} \right) \quad (185)$$

This matrix is diagonalized by  $Z^A$ :

$$Z^A m_{A^0}^2 Z^{A,\dagger} = m_{2,A^0}^{dia} \quad (186)$$

with

$$\sigma_d = \sum_j Z_{j1}^A A_j^0, \quad \sigma_u = \sum_j Z_{j2}^A A_j^0, \quad \bar{\sigma}_R = \sum_j Z_{j3}^A A_j^0 \quad (187)$$

$$\sigma_R = \sum_j Z_{j4}^A A_j^0 \quad (188)$$

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

$$m_{H^-}^2 = \begin{pmatrix} m_{H_d^- H_d^{-,*}} & \frac{1}{4} g_L^2 v_d v_u + B_\mu^* \\ \frac{1}{4} g_L^2 v_d v_u + B_\mu & m_{H_u^{+,*} H_u^+} \end{pmatrix} + \xi_{W^-} m^2(W^-) \quad (189)$$

$$\begin{aligned}
m_{H_d^- H_d^{-,*}} &= +m_{H_d}^2 \\
&+ \frac{1}{8} \left( g_{BR} g_R \left( -v_{\bar{\chi}_R}^2 + v_{\chi_R}^2 \right) + g_R^2 \left( -v_{\chi_R}^2 - v_u^2 + v_{\bar{\chi}_R}^2 + v_d^2 \right) + g_L^2 \left( v_d^2 + v_u^2 \right) \right. \\
&+ g_{RB} \left( g_{BL} \left( -v_{\bar{\chi}_R}^2 + v_{\chi_R}^2 \right) + g_{RB} \left( -v_{\chi_R}^2 - v_u^2 + v_{\bar{\chi}_R}^2 + v_d^2 \right) \right) \\
&+ |\mu|^2 \quad (190)
\end{aligned}$$

$$\begin{aligned}
m_{H_u^{+,*} H_u^+} &= +m_{H_u}^2 \\
&+ \frac{1}{8} \left( g_{BR} g_R \left( -v_{\chi_R}^2 + v_{\bar{\chi}_R}^2 \right) + g_R^2 \left( -v_{\bar{\chi}_R}^2 - v_d^2 + v_{\chi_R}^2 + v_u^2 \right) + g_L^2 \left( v_d^2 + v_u^2 \right) \right. \\
&+ g_{RB} \left( g_{BL} \left( -v_{\chi_R}^2 + v_{\bar{\chi}_R}^2 \right) + g_{RB} \left( -v_{\bar{\chi}_R}^2 - v_d^2 + v_{\chi_R}^2 + v_u^2 \right) \right) \\
&+ |\mu|^2 \quad (191)
\end{aligned}$$

Gauge fixing contributions:

$$m^2(\xi_{W^-}) = \begin{pmatrix} \frac{1}{4} g_L^2 v_d^2 & -\frac{1}{4} g_L^2 v_d v_u \\ -\frac{1}{4} g_L^2 v_d v_u & \frac{1}{4} g_L^2 v_u^2 \end{pmatrix} \quad (192)$$



This matrix is diagonalized by  $Z^+$ :

$$Z^+ m_{H^-}^2 Z^{+\dagger} = m_{2,H^-}^{dia} \quad (193)$$

with

$$H_d^- = \sum_j Z_{j1}^+ H_j^-, \quad H_u^+ = \sum_j Z_{j2}^+ H_j^+ \quad (194)$$

#### 4.2.2 Mass Matrices for Fermions

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

$$m_{\tilde{\chi}^0} = \begin{pmatrix} M_1 & 0 & -\frac{1}{2}g_{RB}v_d & \frac{1}{2}g_{RB}v_u & M_{BR} & m_{\tilde{\chi}_R^0\lambda_{\tilde{B}}} & m_{\tilde{\chi}_R^0\lambda_{\tilde{B}}} \\ 0 & M_2 & \frac{1}{2}g_Lv_d & -\frac{1}{2}g_Lv_u & 0 & 0 & 0 \\ -\frac{1}{2}g_{RB}v_d & \frac{1}{2}g_Lv_d & 0 & -\mu & -\frac{1}{2}g_Rv_d & 0 & 0 \\ \frac{1}{2}g_{RB}v_u & -\frac{1}{2}g_Lv_u & -\mu & 0 & \frac{1}{2}g_Rv_u & 0 & 0 \\ M_{BR} & 0 & -\frac{1}{2}g_Rv_d & \frac{1}{2}g_Rv_u & M_4 & m_{\tilde{\chi}_R^0\lambda_R} & m_{\tilde{\chi}_R^0\lambda_R} \\ m_{\lambda_{\tilde{B}}\tilde{\chi}_R^0} & 0 & 0 & 0 & m_{\lambda_R\tilde{\chi}_R^0} & 0 & -\mu_R \\ m_{\lambda_{\tilde{B}}\tilde{\chi}_R^0} & 0 & 0 & 0 & m_{\lambda_R\tilde{\chi}_R^0} & -\mu_R & 0 \end{pmatrix} \quad (195)$$

$$m_{\lambda_{\tilde{B}}\tilde{\chi}_R^0} = \frac{1}{2}(-g_{RB} + g_{BL})v_{\tilde{\chi}_R} \quad (196)$$

$$m_{\lambda_R\tilde{\chi}_R^0} = \frac{1}{2}(-g_R + g_{BR})v_{\tilde{\chi}_R} \quad (197)$$

$$m_{\lambda_{\tilde{B}}\tilde{\chi}_R^0} = \frac{1}{2}(-g_{BL} + g_{RB})v_{\tilde{\chi}_R} \quad (198)$$

$$m_{\lambda_R\tilde{\chi}_R^0} = \frac{1}{2}(-g_{BR} + g_R)v_{\tilde{\chi}_R} \quad (199)$$

This matrix is diagonalized by  $N$ :

$$N^* m_{\tilde{\chi}^0} N^\dagger = m_{\tilde{\chi}^0}^{dia} \quad (200)$$

with

$$\lambda_{\tilde{B}} = \sum_j N_{j1}^* \lambda_j^0, \quad \tilde{W}^0 = \sum_j N_{j2}^* \lambda_j^0, \quad \tilde{H}_d^0 = \sum_j N_{j3}^* \lambda_j^0 \quad (201)$$

$$\tilde{H}_u^0 = \sum_j N_{j4}^* \lambda_j^0, \quad \lambda_R = \sum_j N_{j5}^* \lambda_j^0, \quad \tilde{\chi}_R^0 = \sum_j N_{j6}^* \lambda_j^0 \quad (202)$$

$$\tilde{\chi}_R^0 = \sum_j N_{j7}^* \lambda_j^0 \quad (203)$$

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

$$m_{\tilde{\chi}^\pm} = \begin{pmatrix} M_2 & \frac{1}{\sqrt{2}}g_Lv_u \\ \frac{1}{\sqrt{2}}g_Lv_d & \mu \end{pmatrix} \quad (204)$$

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

$$U^* m_{\tilde{\chi}^-} V^\dagger = m_{\tilde{\chi}^-}^{dia} \quad (205)$$

with

$$\tilde{W}^- = \sum_{t_2} U_{j_1}^* \lambda_j^-, \quad \tilde{H}_d^- = \sum_{t_2} U_{j_2}^* \lambda_j^- \quad (206)$$

$$\tilde{W}^+ = \sum_{t_2} V_{1j}^* \lambda_j^+, \quad \tilde{H}_u^+ = \sum_{t_2} V_{2j}^* \lambda_j^+ \quad (207)$$

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

$$m_\nu = \begin{pmatrix} 0 & \frac{1}{\sqrt{2}} v_u Y_v^T & 0 \\ \frac{1}{\sqrt{2}} v_u Y_v & 0 & \frac{1}{\sqrt{2}} v_{\chi_R} Y_s \\ 0 & \frac{1}{\sqrt{2}} v_{\chi_R} Y_s^T & 0 \end{pmatrix} \quad (208)$$

This matrix is diagonalized by  $Z_\nu^V$ :

$$Z_\nu^{V,*} m_\nu Z_\nu^{V,\dagger} = m_\nu^{dia} \quad (209)$$

with

$$\nu_{L,i} = \sum_j Z_{\nu,ji}^{V,*} \nu_{0,j}, \quad \nu_{R,i} = \sum_j Z_{\nu,ji}^V \nu_{0,j}^*, \quad S_i = \sum_j Z_{\nu,ji}^{V,*} \nu_{0,j} \quad (210)$$

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

$$m_e = \begin{pmatrix} \frac{1}{\sqrt{2}} v_d Y_e^T \end{pmatrix} \quad (211)$$

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

$$U_L^{e,*} m_e U_R^{e,\dagger} = m_e^{dia} \quad (212)$$

with

$$e_{L,i} = \sum_{t_2} U_{L,ji}^{e,*} E_{L,j} \quad (213)$$

$$e_{R,i} = \sum_{t_2} U_{R,ij}^e E_{R,j}^* \quad (214)$$

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

$$m_d = \begin{pmatrix} \frac{1}{\sqrt{2}} v_d \delta_{\alpha_1 \beta_1} Y_d^T \end{pmatrix} \quad (215)$$

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

$$U_L^{d,*} m_d U_R^{d,\dagger} = m_d^{dia} \quad (216)$$

with

$$d_{L,i\alpha} = \sum_{t_2} U_{L,ji}^{d,*} D_{L,j\alpha} \quad (217)$$

$$d_{R,i\alpha} = \sum_{t_2} U_{R,ij}^d D_{R,j\alpha}^* \quad (218)$$

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

$$m_u = \left( \frac{1}{\sqrt{2}} v_u \delta_{\alpha_1\beta_1} Y_u^T \right) \quad (219)$$

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

$$U_L^{u,*} m_u U_R^{u,\dagger} = m_u^{dia} \quad (220)$$

with

$$u_{L,i\alpha} = \sum_{t_2} U_{L,ji}^{u,*} U_{L,j\alpha} \quad (221)$$

$$u_{R,i\alpha} = \sum_{t_2} U_{R,ij}^u U_{R,j\alpha}^* \quad (222)$$

## 5 Vacuum Expectation Values

$$\chi_R^0 = \frac{1}{\sqrt{2}} \phi_R + \frac{1}{\sqrt{2}} v_{\chi_R} + i \frac{1}{\sqrt{2}} \sigma_R \quad (223)$$

$$\bar{\chi}_R^0 = \frac{1}{\sqrt{2}} \bar{\phi}_R + \frac{1}{\sqrt{2}} v_{\bar{\chi}_R} + i \frac{1}{\sqrt{2}} \bar{\sigma}_R \quad (224)$$

$$H_d^0 = \frac{1}{\sqrt{2}} \phi_d + \frac{1}{\sqrt{2}} v_d + i \frac{1}{\sqrt{2}} \sigma_d \quad (225)$$

$$H_u^0 = \frac{1}{\sqrt{2}} \phi_u + \frac{1}{\sqrt{2}} v_u + i \frac{1}{\sqrt{2}} \sigma_u \quad (226)$$

## 6 Tadpole Equations

$$\begin{aligned} \frac{\partial V}{\partial \phi_R} = & + \frac{1}{8} v_{\chi_R} \left( (g_{BL}^2 + g_{BR}^2) (-v_{\bar{\chi}_R} + v_{\chi_R}) (v_{\chi_R} + v_{\bar{\chi}_R}) + (g_{BL} g_{RB} + g_{BR} g_R) (2v_{\bar{\chi}_R}^2 - 2v_{\chi_R}^2 - v_u^2 + v_d^2) + (g_R^2 + g_{RB}^2) (-v_{\bar{\chi}_R}^2 - v_{\chi_R}^2) \right) \\ & + v_{\chi_R} (m_\chi^2 + |\mu_R|^2) - \frac{1}{2} v_{\bar{\chi}_R} (B_{\mu_R} + B_{\mu,R^*}) \end{aligned} \quad (227)$$

$$\begin{aligned} \frac{\partial V}{\partial \bar{\phi}_R} = & + \frac{1}{8} v_{\bar{\chi}_R} \left( (g_{BL}^2 + g_{BR}^2) (-v_{\chi_R}^2 + v_{\bar{\chi}_R}^2) + (g_{BL} g_{RB} + g_{BR} g_R) (-2v_{\bar{\chi}_R}^2 + 2v_{\chi_R}^2 - v_d^2 + v_u^2) \right) \\ & - (g_R^2 + g_{RB}^2) (-v_{\bar{\chi}_R}^2 - v_d^2 + v_{\chi_R}^2 + v_u^2) \end{aligned}$$

$$+ v_{\bar{\chi}_R} \left( m_{\bar{\chi}}^2 + |\mu_R|^2 \right) - v_{\chi_R} \Re \left( B_{\mu_R} \right) \quad (228)$$

$$\begin{aligned} \frac{\partial V}{\partial \phi_d} = & + \frac{1}{8} v_d \left( g_{BRGR} \left( -v_{\bar{\chi}_R} + v_{\chi_R} \right) \left( v_{\chi_R} + v_{\bar{\chi}_R} \right) + g_L^2 \left( -v_u + v_d \right) \left( v_d + v_u \right) + g_R^2 \left( -v_{\chi_R}^2 - v_u^2 + v_{\bar{\chi}_R}^2 + v_d^2 \right) \right. \\ & + g_{RB} \left( g_{BL} \left( -v_{\bar{\chi}_R} + v_{\chi_R} \right) \left( v_{\chi_R} + v_{\bar{\chi}_R} \right) + g_{RB} \left( -v_{\chi_R}^2 - v_u^2 + v_{\bar{\chi}_R}^2 + v_d^2 \right) \right) \\ & + v_d \left( m_{H_d}^2 + |\mu|^2 \right) - \frac{1}{2} v_u \left( B_\mu + B_\mu^* \right) \end{aligned} \quad (229)$$

$$\frac{\partial V}{\partial \phi_u} = tempString \quad (230)$$

## 7 Particle content for eigenstates 'EWSB'

Name	Type	complex/real	Generations	Indices
$\tilde{d}$	Scalar	complex	6	generation, 6, color, 3
$\tilde{\nu}$	Scalar	complex	9	generation, 9
$\tilde{u}$	Scalar	complex	6	generation, 6, color, 3
$\tilde{e}$	Scalar	complex	6	generation, 6
$h$	Scalar	real	4	generation, 4
$A^0$	Scalar	real	4	generation, 4
$H^-$	Scalar	complex	2	generation, 2
$\tilde{g}$	Fermion	Majorana	1	color, 8
$\tilde{\chi}^0$	Fermion	Majorana	7	generation, 7
$\tilde{\chi}^-$	Fermion	Dirac	2	generation, 2
$\nu$	Fermion	Majorana	9	generation, 9
$e$	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
$Z_R$	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	
$\eta^{Z_R}$	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) \\
& + 2\Gamma_{\tilde{d}_i, \tilde{d}_j^*, Z_R, Z_R} \left( -\frac{1}{2} \text{rMS} m_{Z_R}^2 + A_0(m_{Z_R}^2) \right) - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, H_a^+, H_a^-} \\
& - 2 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^2 B_0(p^2, m_{u_a}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} \left( \Gamma_{\tilde{d}_j^*, u_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{d}_i^*, u_a, \tilde{\chi}_b^-}^R + \Gamma_{\tilde{d}_j^*, u_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{d}_i^*, u_a, \tilde{\chi}_b^-}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^2 G_0(p^2, m_{u_a}^2, m_{\tilde{\chi}_b^-}^2) \left( \Gamma_{\tilde{d}_j^*, u_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{d}_i^*, u_a, \tilde{\chi}_b^-}^L + \Gamma_{\tilde{d}_j^*, u_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{d}_i^*, u_a, \tilde{\chi}_b^-}^R \right) \\
& - 2 \sum_{a=1}^3 m_{d_a} \sum_{b=1}^7 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}^7 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) \\
& - \frac{1}{2} \sum_{a=1}^4 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}^4 A_0(m_{h_a}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, h_a, h_a} \\
& - C \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, \tilde{d}_a^*, \tilde{d}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, \tilde{e}_a^*, \tilde{e}_a} \\
& - C \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, \tilde{u}_a^*, \tilde{u}_a} + \sum_{a=1}^6 \sum_{b=1}^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}^4 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}^4 B_0(p^2, m_{\tilde{d}_a}^2, m_{h_b}^2) \Gamma_{\tilde{d}_j^*, \tilde{d}_a, h_b}^* \Gamma_{\tilde{d}_i^*, \tilde{d}_a, h_b} \\
& - \sum_{a=1}^9 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, \tilde{\nu}_a^*, \tilde{\nu}_a} \\
& - \frac{8}{3} m_{\tilde{g}} \sum_{b=1}^3 B_0(p^2, m_{\tilde{g}}^2, m_{d_b}^2) m_{d_b} \left( \Gamma_{\tilde{d}_j^*, \tilde{g}_1, d_b}^{L*} \Gamma_{\tilde{d}_i^*, \tilde{g}_1, d_b}^R + \Gamma_{\tilde{d}_j^*, \tilde{g}_1, d_b}^{R*} \Gamma_{\tilde{d}_i^*, \tilde{g}_1, d_b}^L \right)
\end{aligned}$$

$$\begin{aligned}
& + \frac{4}{3} \sum_{b=1}^3 G_0(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_b}^2) \left( \Gamma_{\tilde{d}_j^*, \tilde{g}_1, \tilde{d}_b}^{L*} \Gamma_{\tilde{d}_i^*, \tilde{g}_1, \tilde{d}_b}^L + \Gamma_{\tilde{d}_j^*, \tilde{g}_1, \tilde{d}_b}^{R*} \Gamma_{\tilde{d}_i^*, \tilde{g}_1, \tilde{d}_b}^R \right) \\
& + \frac{4}{3} \sum_{b=1}^6 \Gamma_{\tilde{d}_j^*, g, \tilde{d}_b}^* \Gamma_{\tilde{d}_i^*, g, \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, 0) + \sum_{b=1}^6 \Gamma_{\tilde{d}_j^*, \gamma, \tilde{d}_b}^* \Gamma_{\tilde{d}_i^*, \gamma, \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, 0) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{d}_j^*, Z, \tilde{d}_b}^* \Gamma_{\tilde{d}_i^*, Z, \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, m_Z^2) + \sum_{b=1}^6 \Gamma_{\tilde{d}_j^*, Z_R, \tilde{d}_b}^* \Gamma_{\tilde{d}_i^*, Z_R, \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, m_{Z_R}^2) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{d}_j^*, W^-, \tilde{u}_b}^* \Gamma_{\tilde{d}_i^*, W^-, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, m_{W^-}^2) \tag{231}
\end{aligned}$$

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

$$\begin{aligned}
\Pi_{i,j}(p^2) = & + 4\Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, W^+, W^-} \left( -\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2\Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, Z, Z} \left( -\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) \\
& + 2\Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, Z_R, Z_R} \left( -\frac{1}{2} \text{rMS} m_{Z_R}^2 + A_0(m_{Z_R}^2) \right) - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, H_a^+, H_a^-} \\
& - 2 \sum_{a=1}^2 m_{\tilde{\chi}_a^-} \sum_{b=1}^3 B_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{e_b}^2) m_{e_b} \left( \Gamma_{\tilde{\nu}_j^*, \tilde{\chi}_a^+, e_b}^{L*} \Gamma_{\tilde{\nu}_i^*, \tilde{\chi}_a^+, e_b}^R + \Gamma_{\tilde{\nu}_j^*, \tilde{\chi}_a^+, e_b}^{R*} \Gamma_{\tilde{\nu}_i^*, \tilde{\chi}_a^+, e_b}^L \right) \\
& + \sum_{a=1}^2 \sum_{b=1}^3 G_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{e_b}^2) \left( \Gamma_{\tilde{\nu}_j^*, \tilde{\chi}_a^+, e_b}^{L*} \Gamma_{\tilde{\nu}_i^*, \tilde{\chi}_a^+, e_b}^L + \Gamma_{\tilde{\nu}_j^*, \tilde{\chi}_a^+, e_b}^{R*} \Gamma_{\tilde{\nu}_i^*, \tilde{\chi}_a^+, e_b}^R \right) \\
& + \sum_{a=1}^2 \sum_{b=1}^6 B_0(p^2, m_{H_a^-}^2, m_{\tilde{e}_b}^2) \Gamma_{\tilde{\nu}_j^*, H_a^+, \tilde{e}_b}^* \Gamma_{\tilde{\nu}_i^*, H_a^+, \tilde{e}_b} - \frac{1}{2} \sum_{a=1}^4 A_0(m_{A_a^0}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, A_a^0, A_a^0} \\
& - \frac{1}{2} \sum_{a=1}^4 A_0(m_{h_a}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, h_a, h_a} - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, \tilde{d}_a^*, \tilde{d}_a} \\
& - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, \tilde{e}_a^*, \tilde{e}_a} - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, \tilde{u}_a^*, \tilde{u}_a} \\
& - \sum_{a=1}^9 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, \tilde{\nu}_a^*, \tilde{\nu}_a} + \sum_{a=1}^9 \sum_{b=1}^4 B_0(p^2, m_{\tilde{\nu}_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{\nu}_j^*, \tilde{\nu}_a, A_b^0}^* \Gamma_{\tilde{\nu}_i^*, \tilde{\nu}_a, A_b^0} \\
& + \sum_{a=1}^9 \sum_{b=1}^4 B_0(p^2, m_{\tilde{\nu}_a}^2, m_{h_b}^2) \Gamma_{\tilde{\nu}_j^*, \tilde{\nu}_a, h_b}^* \Gamma_{\tilde{\nu}_i^*, \tilde{\nu}_a, h_b} \\
& - \sum_{a=1}^9 m_{\nu_a} \sum_{b=1}^7 B_0(p^2, m_{\nu_a}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_b^0} \left( \Gamma_{\tilde{\nu}_j^*, \nu_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\nu}_i^*, \nu_a, \tilde{\chi}_b^0}^R + \Gamma_{\tilde{\nu}_j^*, \nu_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\nu}_i^*, \nu_a, \tilde{\chi}_b^0}^L \right) \\
& + \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^7 G_0(p^2, m_{\nu_a}^2, m_{\tilde{\chi}_b^0}^2) \left( \Gamma_{\tilde{\nu}_j^*, \nu_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\nu}_i^*, \nu_a, \tilde{\chi}_b^0}^L + \Gamma_{\tilde{\nu}_j^*, \nu_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\nu}_i^*, \nu_a, \tilde{\chi}_b^0}^R \right)
\end{aligned}$$

$$\begin{aligned}
& + \sum_{b=1}^6 \Gamma_{\tilde{\nu}_j^*, W^+, \tilde{e}_b}^* \Gamma_{\tilde{\nu}_i^*, W^+, \tilde{e}_b} F_0(p^2, m_{\tilde{e}_b}^2, m_{W^-}^2) + \sum_{b=1}^9 \Gamma_{\tilde{\nu}_j^*, \gamma, \tilde{\nu}_b}^* \Gamma_{\tilde{\nu}_i^*, \gamma, \tilde{\nu}_b} F_0(p^2, m_{\tilde{\nu}_b}^2, 0) \\
& + \sum_{b=1}^9 \Gamma_{\tilde{\nu}_j^*, Z, \tilde{\nu}_b}^* \Gamma_{\tilde{\nu}_i^*, Z, \tilde{\nu}_b} F_0(p^2, m_{\tilde{\nu}_b}^2, m_Z^2) + \sum_{b=1}^9 \Gamma_{\tilde{\nu}_j^*, Z_R, \tilde{\nu}_b}^* \Gamma_{\tilde{\nu}_i^*, Z_R, \tilde{\nu}_b} F_0(p^2, m_{\tilde{\nu}_b}^2, m_{Z_R}^2)
\end{aligned} \tag{232}$$

• 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) \\
& + 2\Gamma_{\tilde{u}_i, \tilde{u}_j^*, Z_R, Z_R} \left( -\frac{1}{2} \text{rMS} m_{Z_R}^2 + A_0(m_{Z_R}^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_{d_b}^2) \Gamma_{\tilde{u}_j^*, H_a^+, \tilde{d}_b}^* \Gamma_{\tilde{u}_i^*, H_a^+, \tilde{d}_b} \\
& - 2 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^7 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}^7 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) \\
& - \frac{1}{2} \sum_{a=1}^4 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}^4 A_0(m_{h_a}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, h_a, h_a} \\
& - C \sum_{a=1}^6 A_0(m_{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_{u_a}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, \tilde{u}_a^*, \tilde{u}_a} + \sum_{a=1}^6 \sum_{b=1}^4 B_0(p^2, m_{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}^4 B_0(p^2, m_{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} - \sum_{a=1}^9 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, \tilde{\nu}_a^*, \tilde{\nu}_a} \\
& - \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}$$

$$\begin{aligned}
& + \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, W^+, \tilde{d}_b}^* \Gamma_{\tilde{u}_i^*, W^+, \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, m_{W^-}^2) + \frac{4}{3} \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, g, \tilde{u}_b} \Gamma_{\tilde{u}_i^*, g, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, 0) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, \gamma, \tilde{u}_b} \Gamma_{\tilde{u}_i^*, \gamma, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, 0) + \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, Z, \tilde{u}_b}^* \Gamma_{\tilde{u}_i^*, Z, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, m_Z^2) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, Z_R, \tilde{u}_b}^* \Gamma_{\tilde{u}_i^*, Z_R, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, m_{Z_R}^2)
\end{aligned} \tag{233}$$

• 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) \\
& + 2\Gamma_{\tilde{e}_i, \tilde{e}_j^*, Z_R, Z_R} \left( -\frac{1}{2} \text{rMS} m_{Z_R}^2 + A_0(m_{Z_R}^2) \right) - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, H_a^+, H_a^-} \\
& - 2 \sum_{a=1}^3 m_{e_a} \sum_{b=1}^7 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}^7 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) \\
& - \frac{1}{2} \sum_{a=1}^4 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}^4 A_0(m_{h_a}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, h_a, h_a} \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, \tilde{d}_a^*, \tilde{d}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, \tilde{e}_a^*, \tilde{e}_a} \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, \tilde{u}_a^*, \tilde{u}_a} + \sum_{a=1}^6 \sum_{b=1}^4 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}^4 B_0(p^2, m_{\tilde{e}_a}^2, m_{h_b}^2) \Gamma_{\tilde{e}_j^*, \tilde{e}_a, h_b}^* \Gamma_{\tilde{e}_i, \tilde{e}_a, h_b} - \sum_{a=1}^9 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, \tilde{\nu}_a^*, \tilde{\nu}_a} \\
& + \sum_{a=1}^9 \sum_{b=1}^2 B_0(p^2, m_{\tilde{\nu}_a}^2, m_{H_b^-}^2) \Gamma_{\tilde{e}_j^*, \tilde{\nu}_a, H_b^-}^* \Gamma_{\tilde{e}_i, \tilde{\nu}_a, H_b^-} \\
& - 2 \sum_{a=1}^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}$$



$$+ \sum_{b=1}^6 \Gamma_{\tilde{e}_j^*, Z_R, \tilde{e}_b}^* \Gamma_{\tilde{e}_i^*, Z_R, \tilde{e}_b} F_0(p^2, m_{\tilde{e}_b}^2, m_{Z_R}^2) + \sum_{b=1}^9 \Gamma_{\tilde{e}_j^*, W^-, \tilde{\nu}_b}^* \Gamma_{\tilde{e}_i^*, W^-, \tilde{\nu}_b} F_0(p^2, m_{\tilde{\nu}_b}^2, m_{W^-}^2) \quad (234)$$

• Self-Energy for Higgs ( $h$ )

$$\begin{aligned} \Pi_{i,j}(p^2) = & +2\left(-\frac{1}{2}\text{rMS} + B_0(p^2, 0, 0)\right) \Gamma_{\tilde{h}_j, \gamma, \gamma}^* \Gamma_{\tilde{h}_i, \gamma, \gamma} + 4\left(-\frac{1}{2}\text{rMS} + B_0(p^2, 0, m_Z^2)\right) \Gamma_{\tilde{h}_j, Z, \gamma}^* \Gamma_{\tilde{h}_i, Z, \gamma} + 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, 0, m_{Z_R}^2)\right) \Gamma_{\tilde{h}_j, Z_R, \gamma}^* \Gamma_{\tilde{h}_i, Z_R, \gamma} + 4\left(-\frac{1}{2}\text{rMS} + B_0(p^2, m_Z^2, m_{Z_R}^2)\right) \Gamma_{\tilde{h}_j, Z_R, Z}^* \Gamma_{\tilde{h}_i, Z_R, Z} \\ & + 2\left(-\frac{1}{2}\text{rMS} + B_0(p^2, m_{Z_R}^2, m_{Z_R}^2)\right) \Gamma_{\tilde{h}_j, Z_R, Z_R}^* \Gamma_{\tilde{h}_i, Z_R, Z_R} + 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} - 2B_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} \\ & - 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) + 2\Gamma_{\tilde{h}_i, \tilde{h}_j, Z_R, Z_R} \left(-\frac{1}{2}\text{rMS} m_{Z_R}^2 + A_0(m_{Z_R}^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) \\ & - 6 \sum_{a=1}^3 m_{d_a} \sum_{b=1}^3 B_0(p^2, m_{d_a}^2, m_{d_b}^2) m_{d_b} \left(\Gamma_{\tilde{h}_j, \tilde{d}_a, d_b}^{L*} \Gamma_{\tilde{h}_i, \tilde{d}_a, d_b}^R + \Gamma_{\tilde{h}_j, \tilde{d}_a, d_b}^{R*} \Gamma_{\tilde{h}_i, \tilde{d}_a, d_b}^L\right) \\ & + 3 \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{d_a}^2, m_{d_b}^2) \left(\Gamma_{\tilde{h}_j, \tilde{d}_a, d_b}^{L*} \Gamma_{\tilde{h}_i, \tilde{d}_a, d_b}^L + \Gamma_{\tilde{h}_j, \tilde{d}_a, d_b}^{R*} \Gamma_{\tilde{h}_i, \tilde{d}_a, d_b}^R\right) \\ & - 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, \tilde{e}_a, e_b}^{L*} \Gamma_{\tilde{h}_i, \tilde{e}_a, e_b}^R + \Gamma_{\tilde{h}_j, \tilde{e}_a, e_b}^{R*} \Gamma_{\tilde{h}_i, \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{h}_j, \tilde{e}_a, e_b}^{L*} \Gamma_{\tilde{h}_i, \tilde{e}_a, e_b}^L + \Gamma_{\tilde{h}_j, \tilde{e}_a, e_b}^{R*} \Gamma_{\tilde{h}_i, \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{h}_j, \tilde{u}_a, u_b}^{L*} \Gamma_{\tilde{h}_i, \tilde{u}_a, u_b}^R + \Gamma_{\tilde{h}_j, \tilde{u}_a, u_b}^{R*} \Gamma_{\tilde{h}_i, \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{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) \end{aligned}$$

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^4 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}^4 A_0(m_{h_a}^2) \Gamma_{\tilde{h}_i, \tilde{h}_j, h_a, h_a} \\
& + \frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^4 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} \\
& + \frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^4 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} - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{h}_i, \tilde{h}_j, \tilde{d}_a^*, \tilde{d}_a} \\
& - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{h}_i, \tilde{h}_j, \tilde{e}_a^*, \tilde{e}_a} - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{h}_i, \tilde{h}_j, \tilde{u}_a^*, \tilde{u}_a} \\
& + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{d}_a}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{h}_j, \tilde{d}_a^*, \tilde{d}_b}^* \Gamma_{\tilde{h}_i, \tilde{d}_a^*, \tilde{d}_b} + \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{e}_a}^2, m_{\tilde{e}_b}^2) \Gamma_{\tilde{h}_j, \tilde{e}_a^*, \tilde{e}_b}^* \Gamma_{\tilde{h}_i, \tilde{e}_a^*, \tilde{e}_b} \\
& + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{u}_a}^2, m_{\tilde{u}_b}^2) \Gamma_{\tilde{h}_j, \tilde{u}_a^*, \tilde{u}_b}^* \Gamma_{\tilde{h}_i, \tilde{u}_a^*, \tilde{u}_b} \\
& - \sum_{a=1}^7 m_{\tilde{\chi}_a^0} \sum_{b=1}^7 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}^7 \sum_{b=1}^7 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) \\
& - \sum_{a=1}^9 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{h}_i, \tilde{h}_j, \tilde{\nu}_a^*, \tilde{\nu}_a} + \sum_{a=1}^9 \sum_{b=1}^9 B_0(p^2, m_{\tilde{\nu}_a}^2, m_{\tilde{\nu}_b}^2) \Gamma_{\tilde{h}_j, \tilde{\nu}_a^*, \tilde{\nu}_b}^* \Gamma_{\tilde{h}_i, \tilde{\nu}_a^*, \tilde{\nu}_b} \\
& - \sum_{a=1}^9 m_{\nu_a} \sum_{b=1}^9 B_0(p^2, m_{\nu_a}^2, m_{\nu_b}^2) m_{\nu_b} \left( \Gamma_{\tilde{h}_j, \nu_a, \nu_b}^{L*} \Gamma_{\tilde{h}_i, \nu_a, \nu_b}^R + \Gamma_{\tilde{h}_j, \nu_a, \nu_b}^{R*} \Gamma_{\tilde{h}_i, \nu_a, \nu_b}^L \right) \\
& + \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 G_0(p^2, m_{\nu_a}^2, m_{\nu_b}^2) \left( \Gamma_{\tilde{h}_j, \nu_a, \nu_b}^{L*} \Gamma_{\tilde{h}_i, \nu_a, \nu_b}^L + \Gamma_{\tilde{h}_j, \nu_a, \nu_b}^{R*} \Gamma_{\tilde{h}_i, \nu_a, \nu_b}^R \right) \\
& + 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}^4 \Gamma_{\tilde{h}_j, \gamma, A_b^0}^* \Gamma_{\tilde{h}_i, \gamma, A_b^0} F_0(p^2, m_{A_b^0}^2, 0) \\
& + \sum_{b=1}^4 \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) + \sum_{b=1}^4 \Gamma_{\tilde{h}_j, Z_R, A_b^0}^* \Gamma_{\tilde{h}_i, Z_R, A_b^0} F_0(p^2, m_{A_b^0}^2, m_{Z_R}^2) \tag{235}
\end{aligned}$$

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

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

$$\begin{aligned}
& + 2\Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, Z_R, Z_R} \left( -\frac{1}{2} \text{rMS} m_{Z_R}^2 + A_0(m_{Z_R}^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) \\
& + \sum_{a=1}^2 \sum_{b=1}^2 G_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{\chi}_b^-}^2) \left( \Gamma_{\tilde{A}_j^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^L + \Gamma_{\tilde{A}_j^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^R \right) \\
& - 6 \sum_{a=1}^3 m_{d_a} \sum_{b=1}^3 B_0(p^2, m_{d_a}^2, m_{d_b}^2) m_{d_b} \left( \Gamma_{\tilde{A}_j^0, \tilde{d}_a, d_b}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{d}_a, d_b}^R + \Gamma_{\tilde{A}_j^0, \tilde{d}_a, d_b}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{d}_a, d_b}^L \right) \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{d_a}^2, m_{d_b}^2) \left( \Gamma_{\tilde{A}_j^0, \tilde{d}_a, d_b}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{d}_a, d_b}^L + \Gamma_{\tilde{A}_j^0, \tilde{d}_a, d_b}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{d}_a, d_b}^R \right) \\
& - 2 \sum_{a=1}^3 m_{e_a} \sum_{b=1}^3 B_0(p^2, m_{e_a}^2, m_{e_b}^2) m_{e_b} \left( \Gamma_{\tilde{A}_j^0, \tilde{e}_a, e_b}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{e}_a, e_b}^R + \Gamma_{\tilde{A}_j^0, \tilde{e}_a, e_b}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{e}_a, e_b}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{e_a}^2, m_{e_b}^2) \left( \Gamma_{\tilde{A}_j^0, \tilde{e}_a, e_b}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{e}_a, e_b}^L + \Gamma_{\tilde{A}_j^0, \tilde{e}_a, e_b}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{e}_a, e_b}^R \right) \\
& - 6 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^3 B_0(p^2, m_{u_a}^2, m_{u_b}^2) m_{u_b} \left( \Gamma_{\tilde{A}_j^0, \tilde{u}_a, u_b}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{u}_a, u_b}^R + \Gamma_{\tilde{A}_j^0, \tilde{u}_a, u_b}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{u}_a, u_b}^L \right) \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{u_a}^2, m_{u_b}^2) \left( \Gamma_{\tilde{A}_j^0, \tilde{u}_a, u_b}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{u}_a, u_b}^L + \Gamma_{\tilde{A}_j^0, \tilde{u}_a, u_b}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{u}_a, u_b}^R \right) \\
& - \frac{1}{2} \sum_{a=1}^4 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}^4 A_0(m_{h_a}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, h_a, h_a} \\
& + \sum_{a=1}^4 \sum_{b=1}^4 B_0(p^2, m_{h_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{A}_j^0, h_a, A_b^0}^* \Gamma_{\tilde{A}_i^0, h_a, A_b^0} - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, \tilde{d}_a^*, \tilde{d}_a} \\
& - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, \tilde{e}_a^*, \tilde{e}_a} - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{A}_i^0, \tilde{A}_j^0, \tilde{u}_a^*, \tilde{u}_a} \\
& + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{d}_a}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{A}_j^0, \tilde{d}_a^*, \tilde{d}_b}^* \Gamma_{\tilde{A}_i^0, \tilde{d}_a^*, \tilde{d}_b} \\
& + \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{e}_a}^2, m_{\tilde{e}_b}^2) \Gamma_{\tilde{A}_j^0, \tilde{e}_a^*, \tilde{e}_b}^* \Gamma_{\tilde{A}_i^0, \tilde{e}_a^*, \tilde{e}_b}
\end{aligned}$$

$$\begin{aligned}
& + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{u}_a}^2, m_{\tilde{u}_b}^2) \Gamma_{\tilde{A}_j^*, \tilde{u}_a^*, \tilde{u}_b} \Gamma_{\tilde{A}_i^0, \tilde{u}_a^*, \tilde{u}_b} \\
& - \sum_{a=1}^7 m_{\tilde{\chi}_a^0} \sum_{b=1}^7 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^*, \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^*, \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}^7 \sum_{b=1}^7 G_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2) \left( \Gamma_{\tilde{A}_j^*, \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^*, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R \right) \\
& - \sum_{a=1}^9 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{A}_j^0, \tilde{\nu}_a^0, \tilde{\nu}_a} + \sum_{a=1}^9 \sum_{b=1}^9 B_0(p^2, m_{\tilde{\nu}_a}^2, m_{\tilde{\nu}_b}^2) \Gamma_{\tilde{A}_j^*, \tilde{\nu}_a^*, \tilde{\nu}_b} \Gamma_{\tilde{A}_i^0, \tilde{\nu}_a^*, \tilde{\nu}_b} \\
& - \sum_{a=1}^9 m_{\nu_a} \sum_{b=1}^9 B_0(p^2, m_{\nu_a}^2, m_{\nu_b}^2) m_{\nu_b} \left( \Gamma_{\tilde{A}_j^*, \nu_a, \nu_b}^{L*} \Gamma_{\tilde{A}_i^0, \nu_a, \nu_b}^R + \Gamma_{\tilde{A}_j^*, \nu_a, \nu_b}^{R*} \Gamma_{\tilde{A}_i^0, \nu_a, \nu_b}^L \right) \\
& + \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 G_0(p^2, m_{\nu_a}^2, m_{\nu_b}^2) \left( \Gamma_{\tilde{A}_j^*, \nu_a, \nu_b}^{L*} \Gamma_{\tilde{A}_i^0, \nu_a, \nu_b}^L + \Gamma_{\tilde{A}_j^*, \nu_a, \nu_b}^{R*} \Gamma_{\tilde{A}_i^0, \nu_a, \nu_b}^R \right) \\
& + 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}^4 \Gamma_{\tilde{A}_j^0, \gamma, h_b} \Gamma_{\tilde{A}_i^0, \gamma, h_b} F_0(p^2, m_{h_b}^2, 0) \\
& + \sum_{b=1}^4 \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) + \sum_{b=1}^4 \Gamma_{\tilde{A}_j^*, Z_R, h_b} \Gamma_{\tilde{A}_i^0, Z_R, h_b} F_0(p^2, m_{h_b}^2, m_{Z_R}^2) \quad (236)
\end{aligned}$$

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

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

$$\begin{aligned}
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{u_a}^2, m_{d_b}^2) \left( \Gamma_{\tilde{H}_j^+, \bar{u}_a, d_b}^{L*} \Gamma_{\tilde{H}_i^+, \bar{u}_a, d_b}^L + \Gamma_{\tilde{H}_j^+, \bar{u}_a, d_b}^{R*} \Gamma_{\tilde{H}_i^+, \bar{u}_a, d_b}^R \right) \\
& - \frac{1}{2} \sum_{a=1}^4 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}^4 A_0(m_{h_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, h_a, h_a} \\
& - 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} \\
& - 2 \sum_{a=1}^7 m_{\tilde{\chi}_a^0} \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} \left( \Gamma_{\tilde{H}_j^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{H}_i^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^R + \Gamma_{\tilde{H}_j^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{H}_i^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^L \right) \\
& + \sum_{a=1}^7 \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) \\
& - \sum_{a=1}^9 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \tilde{\nu}_a^*, \tilde{\nu}_a} \\
& - 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_{\tilde{\nu}_a}^2, m_{\tilde{e}_b}^2) \Gamma_{\tilde{H}_j^+, \tilde{\nu}_a^*, \tilde{e}_b} \Gamma_{\tilde{H}_i^+, \tilde{\nu}_a^*, \tilde{e}_b} + \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}^2 \Gamma_{\tilde{H}_j^+, Z_R, H_b^-}^* \Gamma_{\tilde{H}_i^+, Z_R, H_b^-} F_0(p^2, m_{H_b^-}^2, m_{Z_R}^2) \\
& + \sum_{b=1}^4 \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}^4 \Gamma_{\tilde{H}_j^+, W^-, h_b}^* \Gamma_{\tilde{H}_i^+, W^-, h_b} F_0(p^2, m_{h_b}^2, m_{W^-}^2) \quad (237)
\end{aligned}$$

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

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) & = +2 \sum_{a=1}^2 \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{H_a^-}^2) \Gamma_{\tilde{\chi}_j^0, H_a^+, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^0, H_a^+, \tilde{\chi}_b^-}^R \\
& + \sum_{a=1}^4 \sum_{b=1}^7 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{h_a}^2) \Gamma_{\tilde{\chi}_j^0, h_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^0, h_a, \tilde{\chi}_b^0}^R \\
& + 6 \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{\tilde{d}_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{d}_a^*, d_b}^{L*} m_{d_b} \Gamma_{\tilde{\chi}_i^0, \tilde{d}_a^*, d_b}^R
\end{aligned}$$

$$\begin{aligned}
& + 2 \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{e_b}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{e}_a^*, e_b}^{L*} m_{e_b} \Gamma_{\tilde{\chi}_i^0, \tilde{e}_a^*, e_b}^R \\
& + 6 \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{u}_a^*, u_b}^{L*} m_{u_b} \Gamma_{\tilde{\chi}_i^0, \tilde{u}_a^*, u_b}^R \\
& + \sum_{a=1}^7 m_{\tilde{\chi}_a^0} \sum_{b=1}^4 B_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{A_b^0}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{\chi}_a^0, A_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{\chi}_a^0, A_b^0}^R \\
& + 2 \sum_{a=1}^9 \sum_{b=1}^9 B_0(p^2, m_{\nu_b}^2, m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{\nu}_a^*, \nu_b}^{L*} m_{\nu_b} \Gamma_{\tilde{\chi}_i^0, \tilde{\nu}_a^*, \nu_b}^R \\
& - 8 \sum_{b=1}^2 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{W^-}^2) \right) \Gamma_{\tilde{\chi}_j^0, W^+, \tilde{\chi}_b^-}^{R*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^0, W^+, \tilde{\chi}_b^-}^L \\
& - 4 \sum_{b=1}^7 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}_b^0}^2, 0) \right) \Gamma_{\tilde{\chi}_j^0, \gamma, \tilde{\chi}_b^0}^{R*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^0, \gamma, \tilde{\chi}_b^0}^L \\
& - 4 \sum_{b=1}^7 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_Z^2) \right) \Gamma_{\tilde{\chi}_j^0, Z, \tilde{\chi}_b^0}^{R*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^0, Z, \tilde{\chi}_b^0}^L \\
& - 4 \sum_{b=1}^7 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{Z_R}^2) \right) \Gamma_{\tilde{\chi}_j^0, Z_R, \tilde{\chi}_b^0}^{R*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^0, Z_R, \tilde{\chi}_b^0}^L \tag{238}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) &= - \sum_{a=1}^2 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{H_a^-}^2) \Gamma_{\tilde{\chi}_j^0, H_a^+, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^0, H_a^+, \tilde{\chi}_b^-}^R \\
& - \frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^7 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{h_a}^2) \Gamma_{\tilde{\chi}_j^0, h_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, h_a, \tilde{\chi}_b^0}^R \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{\tilde{d}_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{d}_a^*, d_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{d}_a^*, d_b}^R \\
& - \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{e}_a^*, e_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{e}_a^*, e_b}^R \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{u}_a^*, u_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{u}_a^*, u_b}^R \\
& - \frac{1}{2} \sum_{a=1}^7 \sum_{b=1}^4 B_1(p^2, m_{\tilde{\chi}_a^0}^2, m_{A_b^0}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{\chi}_a^0, A_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{\chi}_a^0, A_b^0}^R \\
& - \sum_{a=1}^9 \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{\nu}_a^*, \nu_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{\nu}_a^*, \nu_b}^R
\end{aligned}$$

$$\begin{aligned}
& -2 \sum_{b=1}^2 B_1 \left( p^2, m_{\tilde{\chi}_b^-}^2, m_{W^-}^2 \right) \Gamma_{\tilde{\chi}_j^0, W^+, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^0, W^+, \tilde{\chi}_b^-}^L - \sum_{b=1}^7 B_1 \left( p^2, m_{\tilde{\chi}_b^0}^2, 0 \right) \Gamma_{\tilde{\chi}_j^0, \gamma, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, \gamma, \tilde{\chi}_b^0}^L \\
& - \sum_{b=1}^7 B_1 \left( p^2, m_{\tilde{\chi}_b^0}^2, m_Z^2 \right) \Gamma_{\tilde{\chi}_j^0, Z, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, Z, \tilde{\chi}_b^0}^L - \sum_{b=1}^7 B_1 \left( p^2, m_{\tilde{\chi}_b^0}^2, m_{Z_R}^2 \right) \Gamma_{\tilde{\chi}_j^0, Z_R, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, Z_R, \tilde{\chi}_b^0}^L \quad (239)
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) = & - \sum_{a=1}^2 \sum_{b=1}^2 B_1 \left( p^2, m_{\tilde{\chi}_b^-}^2, m_{H_a^-}^2 \right) \Gamma_{\tilde{\chi}_j^0, H_a^+, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^0, H_a^+, \tilde{\chi}_b^-}^L \\
& - \frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^7 B_1 \left( p^2, m_{\tilde{\chi}_b^0}^2, m_{h_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, h_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, h_a, \tilde{\chi}_b^0}^L \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1 \left( p^2, m_{\tilde{d}_b}^2, m_{\tilde{d}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{d}_a^*, d_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{d}_a^*, d_b}^L \\
& - \sum_{a=1}^6 \sum_{b=1}^3 B_1 \left( p^2, m_{\tilde{e}_b}^2, m_{\tilde{e}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{e}_a^*, e_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{e}_a^*, e_b}^L \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1 \left( p^2, m_{\tilde{u}_b}^2, m_{\tilde{u}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{u}_a^*, u_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{u}_a^*, u_b}^L \\
& - \frac{1}{2} \sum_{a=1}^7 \sum_{b=1}^4 B_1 \left( p^2, m_{\tilde{\chi}_a^0}^2, m_{A_b^0}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{\chi}_a^0, A_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{\chi}_a^0, A_b^0}^L \\
& - \sum_{a=1}^9 \sum_{b=1}^9 B_1 \left( p^2, m_{\nu_b}^2, m_{\tilde{\nu}_a}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{\nu}_a^*, \nu_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{\nu}_a^*, \nu_b}^L \\
& - 2 \sum_{b=1}^2 B_1 \left( p^2, m_{\tilde{\chi}_b^-}^2, m_{W^-}^2 \right) \Gamma_{\tilde{\chi}_j^0, W^+, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^0, W^+, \tilde{\chi}_b^-}^R - \sum_{b=1}^7 B_1 \left( p^2, m_{\tilde{\chi}_b^0}^2, 0 \right) \Gamma_{\tilde{\chi}_j^0, \gamma, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, \gamma, \tilde{\chi}_b^0}^R \\
& - \sum_{b=1}^7 B_1 \left( p^2, m_{\tilde{\chi}_b^0}^2, m_Z^2 \right) \Gamma_{\tilde{\chi}_j^0, Z, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, Z, \tilde{\chi}_b^0}^R - \sum_{b=1}^7 B_1 \left( p^2, m_{\tilde{\chi}_b^0}^2, m_{Z_R}^2 \right) \Gamma_{\tilde{\chi}_j^0, Z_R, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, Z_R, \tilde{\chi}_b^0}^R \quad (240)
\end{aligned}$$

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

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) = & + \sum_{a=1}^2 m_{\tilde{\chi}_a^-} \sum_{b=1}^4 B_0 \left( p^2, m_{\tilde{\chi}_a^-}^2, m_{A_b^0}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{\chi}_a^-, A_b^0}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{\chi}_a^-, A_b^0}^R \\
& + \sum_{a=1}^2 \sum_{b=1}^7 B_0 \left( p^2, m_{\tilde{\chi}_b^0}^2, m_{H_a^-}^2 \right) \Gamma_{\tilde{\chi}_j^+, H_a^-, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^+, H_a^-, \tilde{\chi}_b^0}^R \\
& + 3 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^6 B_0 \left( p^2, m_{\tilde{u}_a}^2, m_{\tilde{d}_b}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a, \tilde{d}_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a, \tilde{d}_b}^R
\end{aligned}$$

$$\begin{aligned}
& + \sum_{a=1}^4 \sum_{b=1}^2 B_0 \left( p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{h}_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, h_a, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^+, h_a, \tilde{\chi}_b^-}^R \\
& + 3 \sum_{a=1}^6 \sum_{b=1}^3 B_0 \left( p^2, m_{\tilde{d}_b}^2, m_{\tilde{u}_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a^*, \tilde{d}_b}^{L*} m_{\tilde{d}_b} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a^*, \tilde{d}_b}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^9 B_0 \left( p^2, m_{\nu_b}^2, m_{\tilde{e}_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{e}_a, \nu_b}^{L*} m_{\nu_b} \Gamma_{\tilde{\chi}_i^+, \tilde{e}_a, \nu_b}^R \\
& + \sum_{a=1}^9 \sum_{b=1}^3 B_0 \left( p^2, m_{e_b}^2, m_{\tilde{\nu}_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{\nu}_a^*, e_b}^{L*} m_{e_b} \Gamma_{\tilde{\chi}_i^+, \tilde{\nu}_a^*, e_b}^R \\
& - 4 \sum_{b=1}^2 \left( -\frac{1}{2} \text{rMS} + B_0 \left( p^2, m_{\tilde{\chi}_b^-}^2, 0 \right) \right) \Gamma_{\tilde{\chi}_j^+, \gamma, \tilde{\chi}_b^-}^{R*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^+, \gamma, \tilde{\chi}_b^-}^L \\
& - 4 \sum_{b=1}^2 \left( -\frac{1}{2} \text{rMS} + B_0 \left( p^2, m_{\tilde{\chi}_b^-}^2, m_Z^2 \right) \right) \Gamma_{\tilde{\chi}_j^+, Z, \tilde{\chi}_b^-}^{R*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^+, Z, \tilde{\chi}_b^-}^L \\
& - 4 \sum_{b=1}^2 \left( -\frac{1}{2} \text{rMS} + B_0 \left( p^2, m_{\tilde{\chi}_b^-}^2, m_{Z_R}^2 \right) \right) \Gamma_{\tilde{\chi}_j^+, Z_R, \tilde{\chi}_b^-}^{R*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^+, Z_R, \tilde{\chi}_b^-}^L \\
& - 4 \sum_{b=1}^7 \left( -\frac{1}{2} \text{rMS} + B_0 \left( p^2, m_{\tilde{\chi}_b^-}^2, m_{W^-}^2 \right) \right) \Gamma_{\tilde{\chi}_j^+, W^-, \tilde{\chi}_b^-}^{R*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^+, W^-, \tilde{\chi}_b^-}^L \tag{241}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) & = -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^4 B_1 \left( p^2, m_{\tilde{\chi}_a^-}^2, m_{A_b^0}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{\chi}_a^-, A_b^0}^{R*} \Gamma_{\tilde{\chi}_i^+, \tilde{\chi}_a^-, A_b^0}^R \\
& - \frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^7 B_1 \left( p^2, m_{\tilde{\chi}_b^0}^2, m_{H_a^-}^2 \right) \Gamma_{\tilde{\chi}_j^+, H_a^-, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^+, H_a^-, \tilde{\chi}_b^0}^R \\
& - \frac{3}{2} \sum_{a=1}^3 \sum_{b=1}^6 B_1 \left( p^2, m_{\tilde{u}_a}^2, m_{\tilde{d}_b}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a, \tilde{d}_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a, \tilde{d}_b}^R \\
& - \frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^2 B_1 \left( p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{h}_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, h_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^+, h_a, \tilde{\chi}_b^-}^R \\
& - \frac{3}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1 \left( p^2, m_{\tilde{d}_b}^2, m_{\tilde{u}_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a^*, \tilde{d}_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a^*, \tilde{d}_b}^R \\
& - \frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^9 B_1 \left( p^2, m_{\nu_b}^2, m_{\tilde{e}_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{e}_a, \nu_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \tilde{e}_a, \nu_b}^R \\
& - \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^3 B_1 \left( p^2, m_{e_b}^2, m_{\tilde{\nu}_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{\nu}_a^*, e_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \tilde{\nu}_a^*, e_b}^R - \sum_{b=1}^2 B_1 \left( p^2, m_{\tilde{\chi}_b^-}^2, 0 \right) \Gamma_{\tilde{\chi}_j^+, \gamma, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^+, \gamma, \tilde{\chi}_b^-}^L
\end{aligned}$$



$$\begin{aligned}
& - \sum_{b=1}^2 B_1 \left( p^2, m_{\tilde{\chi}_b^-}^2, m_Z^2 \right) \Gamma_{\tilde{\chi}_j^+, Z, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^+, Z, \tilde{\chi}_b^-}^L - \sum_{b=1}^2 B_1 \left( p^2, m_{\tilde{\chi}_b^-}^2, m_{Z_R}^2 \right) \Gamma_{\tilde{\chi}_j^+, Z_R, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^+, Z_R, \tilde{\chi}_b^-}^L \\
& - \sum_{b=1}^7 B_1 \left( p^2, m_{\tilde{\chi}_b^0}^2, m_{W^-}^2 \right) \Gamma_{\tilde{\chi}_j^+, W^-, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^+, W^-, \tilde{\chi}_b^0}^L
\end{aligned} \tag{242}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) &= -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^4 B_1 \left( p^2, m_{\tilde{\chi}_a^-}^2, m_{A_b^0}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{\chi}_a^-, A_b^0}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{\chi}_a^-, A_b^0}^L \\
& - \frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^7 B_1 \left( p^2, m_{\tilde{\chi}_b^0}^2, m_{H_a^-}^2 \right) \Gamma_{\tilde{\chi}_j^+, H_a^-, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^+, H_a^-, \tilde{\chi}_b^0}^L \\
& - \frac{3}{2} \sum_{a=1}^3 \sum_{b=1}^6 B_1 \left( p^2, m_{\tilde{u}_a}^2, m_{\tilde{d}_b}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a, \tilde{d}_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a, \tilde{d}_b}^L \\
& - \frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^2 B_1 \left( p^2, m_{\tilde{\chi}_b^-}^2, m_{h_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, h_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^+, h_a, \tilde{\chi}_b^-}^L \\
& - \frac{3}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1 \left( p^2, m_{\tilde{d}_b}^2, m_{\tilde{u}_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a^*, \tilde{d}_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a^*, \tilde{d}_b}^L \\
& - \frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^9 B_1 \left( p^2, m_{\nu_b}^2, m_{\tilde{e}_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{e}_a, \nu_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{e}_a, \nu_b}^L \\
& - \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^3 B_1 \left( p^2, m_{e_b}^2, m_{\tilde{\nu}_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{\nu}_a^*, e_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{\nu}_a^*, e_b}^L - \sum_{b=1}^2 B_1 \left( p^2, m_{\tilde{\chi}_b^-}^2, 0 \right) \Gamma_{\tilde{\chi}_j^+, \gamma, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^+, \gamma, \tilde{\chi}_b^-}^R \\
& - \sum_{b=1}^2 B_1 \left( p^2, m_{\tilde{\chi}_b^-}^2, m_Z^2 \right) \Gamma_{\tilde{\chi}_j^+, Z, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^+, Z, \tilde{\chi}_b^-}^R - \sum_{b=1}^2 B_1 \left( p^2, m_{\tilde{\chi}_b^-}^2, m_{Z_R}^2 \right) \Gamma_{\tilde{\chi}_j^+, Z_R, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^+, Z_R, \tilde{\chi}_b^-}^R \\
& - \sum_{b=1}^7 B_1 \left( p^2, m_{\tilde{\chi}_b^0}^2, m_{W^-}^2 \right) \Gamma_{\tilde{\chi}_j^+, W^-, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^+, W^-, \tilde{\chi}_b^0}^R
\end{aligned} \tag{243}$$

• Self-Energy for Neutrinos ( $\nu$ )

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

$$\begin{aligned}
& + \sum_{a=1}^9 m_{\nu_a} \sum_{b=1}^4 B_0(p^2, m_{\nu_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{\nu}_j, \nu_a, A_b^0}^{L*} \Gamma_{\tilde{\nu}_i, \nu_a, A_b^0}^R \\
& + 2 \sum_{a=1}^9 \sum_{b=1}^7 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{\nu}_j, \tilde{\nu}_a^*, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\nu}_i, \tilde{\nu}_a^*, \tilde{\chi}_b^0}^R \\
& - 8 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{e_b}^2, m_{W^-}^2) \right) \Gamma_{\tilde{\nu}_j, W^+, e_b}^{R*} m_{e_b} \Gamma_{\tilde{\nu}_i, W^+, e_b}^L - 4 \sum_{b=1}^9 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{\nu_b}^2, 0) \right) \Gamma_{\tilde{\nu}_j, \gamma, \nu_b}^{R*} m_{\nu_b} \Gamma_{\tilde{\nu}_i, \gamma}^L \\
& - 4 \sum_{b=1}^9 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{\nu_b}^2, m_Z^2) \right) \Gamma_{\tilde{\nu}_j, Z, \nu_b}^{R*} m_{\nu_b} \Gamma_{\tilde{\nu}_i, Z, \nu_b}^L \\
& - 4 \sum_{b=1}^9 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{\nu_b}^2, m_{Z_R}^2) \right) \Gamma_{\tilde{\nu}_j, Z_R, \nu_b}^{R*} m_{\nu_b} \Gamma_{\tilde{\nu}_i, Z_R, \nu_b}^L \tag{244}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) & = - \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{\nu}_j, H_a^+, e_b}^{R*} \Gamma_{\tilde{\nu}_i, H_a^+, e_b}^R \\
& - \frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{h_a}^2) \Gamma_{\tilde{\nu}_j, h_a, \nu_b}^{R*} \Gamma_{\tilde{\nu}_i, h_a, \nu_b}^R \\
& - \sum_{a=1}^6 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{\nu}_j, \tilde{e}_a^*, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\nu}_i, \tilde{e}_a^*, \tilde{\chi}_b^-}^R \\
& - \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^4 B_1(p^2, m_{\nu_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{\nu}_j, \nu_a, A_b^0}^{R*} \Gamma_{\tilde{\nu}_i, \nu_a, A_b^0}^R \\
& - \sum_{a=1}^9 \sum_{b=1}^7 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{\nu}_j, \tilde{\nu}_a^*, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\nu}_i, \tilde{\nu}_a^*, \tilde{\chi}_b^0}^R - 2 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{W^-}^2) \Gamma_{\tilde{\nu}_j, W^+, e_b}^{L*} \Gamma_{\tilde{\nu}_i, W^+, e_b}^L \\
& - \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, 0) \Gamma_{\tilde{\nu}_j, \gamma, \nu_b}^{L*} \Gamma_{\tilde{\nu}_i, \gamma, \nu_b}^L - \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_Z^2) \Gamma_{\tilde{\nu}_j, Z, \nu_b}^{L*} \Gamma_{\tilde{\nu}_i, Z, \nu_b}^L \\
& - \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{Z_R}^2) \Gamma_{\tilde{\nu}_j, Z_R, \nu_b}^{L*} \Gamma_{\tilde{\nu}_i, Z_R, \nu_b}^L \tag{245}
\end{aligned}$$

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

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^4 B_1(p^2, m_{\nu_a}^2, m_{A_b^0}^2) \Gamma_{\check{\nu}_j, \nu_a, A_b^0}^{L*} \Gamma_{\check{\nu}_i, \nu_a, A_b^0}^L \\
& - \sum_{a=1}^9 \sum_{b=1}^7 B_1(p^2, m_{\check{\chi}_b^0}^2, m_{\check{\nu}_a}^2) \Gamma_{\check{\nu}_j, \check{\nu}_a^*, \check{\chi}_b^0}^{L*} \Gamma_{\check{\nu}_i, \check{\nu}_a^*, \check{\chi}_b^0}^L - 2 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{W^-}^2) \Gamma_{\check{\nu}_j, W^+, e_b}^{R*} \Gamma_{\check{\nu}_i, W^+, e_b}^R \\
& - \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, 0) \Gamma_{\check{\nu}_j, \gamma, \nu_b}^{R*} \Gamma_{\check{\nu}_i, \gamma, \nu_b}^R - \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_Z^2) \Gamma_{\check{\nu}_j, Z, \nu_b}^{R*} \Gamma_{\check{\nu}_i, Z, \nu_b}^R \\
& - \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{Z_R}^2) \Gamma_{\check{\nu}_j, Z_R, \nu_b}^{R*} \Gamma_{\check{\nu}_i, Z_R, \nu_b}^R
\end{aligned} \tag{246}$$

• Self-Energy for Leptons ( $e$ )

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) &= + \sum_{a=1}^2 \sum_{b=1}^9 B_0(p^2, m_{\nu_b}^2, m_{H_a^-}^2) \Gamma_{\check{e}_j, H_a^-, \nu_b}^{L*} m_{\nu_b} \Gamma_{\check{e}_i, H_a^-, \nu_b}^R \\
& + \sum_{a=1}^3 m_{e_a} \sum_{b=1}^4 B_0(p^2, m_{e_a}^2, m_{A_b^0}^2) \Gamma_{\check{e}_j, e_a, A_b^0}^{L*} \Gamma_{\check{e}_i, e_a, A_b^0}^R \\
& + \sum_{a=1}^4 \sum_{b=1}^3 B_0(p^2, m_{e_b}^2, m_{h_a}^2) \Gamma_{\check{e}_j, h_a, e_b}^{L*} m_{e_b} \Gamma_{\check{e}_i, h_a, e_b}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^7 B_0(p^2, m_{\check{\chi}_b^0}^2, m_{\check{e}_a}^2) \Gamma_{\check{e}_j, \check{e}_a, \check{\chi}_b^0}^{L*} m_{\check{\chi}_b^0} \Gamma_{\check{e}_i, \check{e}_a, \check{\chi}_b^0}^R \\
& + \sum_{a=1}^9 \sum_{b=1}^2 B_0(p^2, m_{\check{\chi}_b^-}^2, m_{\check{\nu}_a}^2) \Gamma_{\check{e}_j, \check{\nu}_a, \check{\chi}_b^-}^{L*} m_{\check{\chi}_b^-} \Gamma_{\check{e}_i, \check{\nu}_a, \check{\chi}_b^-}^R \\
& - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{e_b}^2, 0) \right) \Gamma_{\check{e}_j, \gamma, e_b}^{R*} m_{e_b} \Gamma_{\check{e}_i, \gamma, e_b}^L - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{e_b}^2, m_Z^2) \right) \Gamma_{\check{e}_j, Z, e_b}^{R*} m_{e_b} \Gamma_{\check{e}_i, Z, e_b}^L \\
& - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{e_b}^2, m_{Z_R}^2) \right) \Gamma_{\check{e}_j, Z_R, e_b}^{R*} m_{e_b} \Gamma_{\check{e}_i, Z_R, e_b}^L \\
& - 4 \sum_{b=1}^9 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{\nu_b}^2, m_{W^-}^2) \right) \Gamma_{\check{e}_j, W^-, \nu_b}^{R*} m_{\nu_b} \Gamma_{\check{e}_i, W^-, \nu_b}^L
\end{aligned} \tag{247}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) &= -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{H_a^-}^2) \Gamma_{\check{e}_j, H_a^-, \nu_b}^{R*} \Gamma_{\check{e}_i, H_a^-, \nu_b}^R \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^4 B_1(p^2, m_{e_a}^2, m_{A_b^0}^2) \Gamma_{\check{e}_j, e_a, A_b^0}^{R*} \Gamma_{\check{e}_i, e_a, A_b^0}^R
\end{aligned}$$

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{h_a}^2) \Gamma_{\tilde{e}_j, h_a, e_b}^{R*} \Gamma_{\tilde{e}_i, h_a, e_b}^R \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^7 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{e}_j, \tilde{e}_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{e}_i, \tilde{e}_a, \tilde{\chi}_b^0}^R \\
& -\frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{e}_j, \tilde{\nu}_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{e}_i, \tilde{\nu}_a, \tilde{\chi}_b^-}^R - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, 0) \Gamma_{\tilde{e}_j, \gamma, e_b}^{L*} \Gamma_{\tilde{e}_i, \gamma, e_b}^L \\
& -\sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_Z^2) \Gamma_{\tilde{e}_j, Z, e_b}^{L*} \Gamma_{\tilde{e}_i, Z, e_b}^L - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{Z_R}^2) \Gamma_{\tilde{e}_j, Z_R, e_b}^{L*} \Gamma_{\tilde{e}_i, Z_R, e_b}^L \\
& -\sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{W^-}^2) \Gamma_{\tilde{e}_j, W^-, \nu_b}^{L*} \Gamma_{\tilde{e}_i, W^-, \nu_b}^L
\end{aligned} \tag{248}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) &= -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{e}_j, H_a^-, \nu_b}^{L*} \Gamma_{\tilde{e}_i, H_a^-, \nu_b}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^4 B_1(p^2, m_{e_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{e}_j, e_a, A_b^0}^{L*} \Gamma_{\tilde{e}_i, e_a, A_b^0}^L \\
& -\frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{h_a}^2) \Gamma_{\tilde{e}_j, h_a, e_b}^{L*} \Gamma_{\tilde{e}_i, h_a, e_b}^L \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^7 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{e}_j, \tilde{e}_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{e}_i, \tilde{e}_a, \tilde{\chi}_b^0}^L \\
& -\frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{e}_j, \tilde{\nu}_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{e}_i, \tilde{\nu}_a, \tilde{\chi}_b^-}^L - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, 0) \Gamma_{\tilde{e}_j, \gamma, e_b}^{R*} \Gamma_{\tilde{e}_i, \gamma, e_b}^R \\
& -\sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_Z^2) \Gamma_{\tilde{e}_j, Z, e_b}^{R*} \Gamma_{\tilde{e}_i, Z, e_b}^R - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{Z_R}^2) \Gamma_{\tilde{e}_j, Z_R, e_b}^{R*} \Gamma_{\tilde{e}_i, Z_R, e_b}^R \\
& -\sum_{b=1}^9 B_1(p^2, m_{\nu_b}^2, m_{W^-}^2) \Gamma_{\tilde{e}_j, W^-, \nu_b}^{R*} \Gamma_{\tilde{e}_i, W^-, \nu_b}^R
\end{aligned} \tag{249}$$

• Self-Energy for Down-Quarks (d)

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) &= + \sum_{a=1}^2 \sum_{b=1}^3 B_0(p^2, m_{u_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{d}_j, H_a^-, u_b}^{L*} m_{u_b} \Gamma_{\tilde{d}_i, H_a^-, u_b}^R \\
& + \sum_{a=1}^3 m_{d_a} \sum_{b=1}^4 B_0(p^2, m_{d_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j, d_a, A_b^0}^{L*} \Gamma_{\tilde{d}_i, d_a, A_b^0}^R
\end{aligned}$$

$$\begin{aligned}
& + \sum_{a=1}^4 \sum_{b=1}^3 B_0(p^2, m_{d_b}^2, m_{h_a}^2) \Gamma_{\tilde{d}_j, h_a, d_b}^{L*} m_{d_b} \Gamma_{\tilde{d}_i, h_a, d_b}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_j, \tilde{u}_a, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{d}_i, \tilde{u}_a, \tilde{\chi}_b^-}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^7 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{\chi}_b^0}^R \\
& + \frac{4}{3} m_{\tilde{g}} \sum_{a=1}^6 B_0(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{g}_1}^R - \frac{16}{3} \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, 0) \right) \Gamma_{\tilde{d}_j, g, d_b}^{R*} m_{d_b} \Gamma_{\tilde{d}_i, g, d_b}^L \\
& - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, 0) \right) \Gamma_{\tilde{d}_j, \gamma, d_b}^{R*} m_{d_b} \Gamma_{\tilde{d}_i, \gamma, d_b}^L \\
& - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, m_{W^-}^2) \right) \Gamma_{\tilde{d}_j, W^-, u_b}^{R*} m_{u_b} \Gamma_{\tilde{d}_i, W^-, u_b}^L \\
& - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, m_Z^2) \right) \Gamma_{\tilde{d}_j, Z, d_b}^{R*} m_{d_b} \Gamma_{\tilde{d}_i, Z, d_b}^L \\
& - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, m_{Z_R}^2) \right) \Gamma_{\tilde{d}_j, Z_R, d_b}^{R*} m_{d_b} \Gamma_{\tilde{d}_i, Z_R, d_b}^L \tag{250}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) &= -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{d}_j, H_a^-, u_b}^{R*} \Gamma_{\tilde{d}_i, H_a^-, u_b}^R \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^4 B_1(p^2, m_{d_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j, d_a, A_b^0}^{R*} \Gamma_{\tilde{d}_i, d_a, A_b^0}^R \\
& - \frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{h_a}^2) \Gamma_{\tilde{d}_j, h_a, d_b}^{R*} \Gamma_{\tilde{d}_i, h_a, d_b}^R \\
& - \frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_j, \tilde{u}_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{d}_i, \tilde{u}_a, \tilde{\chi}_b^-}^R \\
& - \frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^7 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{\chi}_b^0}^R \\
& - \frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{g}_1}^{R*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{g}_1}^R - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, g, d_b}^{L*} \Gamma_{\tilde{d}_i, g, d_b}^L \\
& - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, \gamma, d_b}^{L*} \Gamma_{\tilde{d}_i, \gamma, d_b}^L - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{W^-}^2) \Gamma_{\tilde{d}_j, W^-, u_b}^{L*} \Gamma_{\tilde{d}_i, W^-, u_b}^L
\end{aligned}$$

$$- \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_Z^2) \Gamma_{\check{d}_j, Z, d_b}^{L*} \Gamma_{\check{d}_i, Z, d_b}^L - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{Z_R}^2) \Gamma_{\check{d}_j, Z_R, d_b}^{L*} \Gamma_{\check{d}_i, Z_R, d_b}^L \quad (251)$$

$$\begin{aligned} \Sigma_{i,j}^L(p^2) = & -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{H_a^-}^2) \Gamma_{\check{d}_j, H_a^-, u_b}^{L*} \Gamma_{\check{d}_i, H_a^-, u_b}^L \\ & -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^4 B_1(p^2, m_{d_a}^2, m_{A_b^0}^2) \Gamma_{\check{d}_j, d_a, A_b^0}^{L*} \Gamma_{\check{d}_i, d_a, A_b^0}^L \\ & -\frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{h_a}^2) \Gamma_{\check{d}_j, h_a, d_b}^{L*} \Gamma_{\check{d}_i, h_a, d_b}^L \\ & -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^2 B_1(p^2, m_{\check{\chi}_b^-}^2, m_{\check{u}_a}^2) \Gamma_{\check{d}_j, \check{u}_a, \check{\chi}_b^-}^{L*} \Gamma_{\check{d}_i, \check{u}_a, \check{\chi}_b^-}^L \\ & -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^7 B_1(p^2, m_{\check{\chi}_b^0}^2, m_{\check{d}_a}^2) \Gamma_{\check{d}_j, \check{d}_a, \check{\chi}_b^0}^{L*} \Gamma_{\check{d}_i, \check{d}_a, \check{\chi}_b^0}^L \\ & -\frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\check{g}}^2, m_{\check{d}_a}^2) \Gamma_{\check{d}_j, \check{d}_a, \check{g}_1}^{L*} \Gamma_{\check{d}_i, \check{d}_a, \check{g}_1}^L - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\check{d}_j, g, d_b}^{R*} \Gamma_{\check{d}_i, g, d_b}^R \\ & - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\check{d}_j, \gamma, d_b}^{R*} \Gamma_{\check{d}_i, \gamma, d_b}^R - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{W^-}^2) \Gamma_{\check{d}_j, W^-, u_b}^{R*} \Gamma_{\check{d}_i, W^-, u_b}^R \\ & - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_Z^2) \Gamma_{\check{d}_j, Z, d_b}^{R*} \Gamma_{\check{d}_i, Z, d_b}^R - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{Z_R}^2) \Gamma_{\check{d}_j, Z_R, d_b}^{R*} \Gamma_{\check{d}_i, Z_R, d_b}^R \end{aligned} \quad (252)$$

• Self-Energy for Up-Quarks ( $u$ )

$$\begin{aligned} \Sigma_{i,j}^S(p^2) = & + \sum_{a=1}^2 \sum_{b=1}^3 B_0(p^2, m_{d_b}^2, m_{H_a^-}^2) \Gamma_{\check{u}_j, H_a^+, d_b}^{L*} m_{d_b} \Gamma_{\check{u}_i, H_a^+, d_b}^R \\ & + \sum_{a=1}^2 m_{\check{\chi}_a^-} \sum_{b=1}^6 B_0(p^2, m_{\check{\chi}_a^-}^2, m_{d_b}^2) \Gamma_{\check{u}_j, \check{\chi}_a^+, \check{d}_b}^{L*} \Gamma_{\check{u}_i, \check{\chi}_a^+, \check{d}_b}^R \\ & + \sum_{a=1}^3 m_{u_a} \sum_{b=1}^4 B_0(p^2, m_{u_a}^2, m_{A_b^0}^2) \Gamma_{\check{u}_j, u_a, A_b^0}^{L*} \Gamma_{\check{u}_i, u_a, A_b^0}^R \\ & + \sum_{a=1}^4 \sum_{b=1}^3 B_0(p^2, m_{u_b}^2, m_{h_a}^2) \Gamma_{\check{u}_j, h_a, u_b}^{L*} m_{u_b} \Gamma_{\check{u}_i, h_a, u_b}^R \\ & + \sum_{a=1}^6 \sum_{b=1}^7 B_0(p^2, m_{\check{\chi}_b^0}^2, m_{\check{u}_a}^2) \Gamma_{\check{u}_j, \check{u}_a, \check{\chi}_b^0}^{L*} m_{\check{\chi}_b^0} \Gamma_{\check{u}_i, \check{u}_a, \check{\chi}_b^0}^R \end{aligned}$$

$$\begin{aligned}
& + \frac{4}{3} m_{\tilde{g}} \sum_{a=1}^6 B_0(p^2, m_{\tilde{g}}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{g}_1}^R - \frac{16}{3} \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, 0) \right) \Gamma_{\tilde{u}_j, g, u_b}^{R*} m_{u_b} \Gamma_{\tilde{u}_i, g, u_b}^L \\
& - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, 0) \right) \Gamma_{\tilde{u}_j, \gamma, u_b}^{R*} m_{u_b} \Gamma_{\tilde{u}_i, \gamma, u_b}^L - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, m_Z^2) \right) \Gamma_{\tilde{u}_j, Z, u_b}^{R*} m_{u_b} \Gamma_{\tilde{u}_i, Z, u_b}^L \\
& - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, m_{Z_R}^2) \right) \Gamma_{\tilde{u}_j, Z_R, u_b}^{R*} m_{u_b} \Gamma_{\tilde{u}_i, Z_R, u_b}^L \\
& - 4 \sum_{b=1}^3 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, m_{W^-}^2) \right) \Gamma_{\tilde{u}_j, W^+, d_b}^{R*} m_{d_b} \Gamma_{\tilde{u}_i, W^+, d_b}^L \tag{253}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) &= -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{u}_j, H_a^+, d_b}^{R*} \Gamma_{\tilde{u}_i, H_a^+, d_b}^R \\
& - \frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^6 B_1(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{u}_j, \tilde{\chi}_a^+, \tilde{d}_b}^{R*} \Gamma_{\tilde{u}_i, \tilde{\chi}_a^+, \tilde{d}_b}^R \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^4 B_1(p^2, m_{u_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{u}_j, u_a, A_b^0}^{R*} \Gamma_{\tilde{u}_i, u_a, A_b^0}^R \\
& - \frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{h_a}^2) \Gamma_{\tilde{u}_j, h_a, u_b}^{R*} \Gamma_{\tilde{u}_i, h_a, u_b}^R \\
& - \frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^7 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{\chi}_b^0}^R \\
& - \frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{g}_1}^{R*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{g}_1}^R - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, g, u_b}^{L*} \Gamma_{\tilde{u}_i, g, u_b}^L \\
& - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, \gamma, u_b}^{L*} \Gamma_{\tilde{u}_i, \gamma, u_b}^L - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_Z^2) \Gamma_{\tilde{u}_j, Z, u_b}^{L*} \Gamma_{\tilde{u}_i, Z, u_b}^L \\
& - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{Z_R}^2) \Gamma_{\tilde{u}_j, Z_R, u_b}^{L*} \Gamma_{\tilde{u}_i, Z_R, u_b}^L - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{W^-}^2) \Gamma_{\tilde{u}_j, W^+, d_b}^{L*} \Gamma_{\tilde{u}_i, W^+, d_b}^L \tag{254}
\end{aligned}$$

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

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^4 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{h_a}^2) \Gamma_{\tilde{u}_j, h_a, u_b}^{L*} \Gamma_{\tilde{u}_i, h_a, u_b}^L \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^7 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{\chi}_b^0}^L \\
& -\frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{g}_1}^L - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, g, u_b}^{R*} \Gamma_{\tilde{u}_i, g, u_b}^R \\
& -\sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, \gamma, u_b}^{R*} \Gamma_{\tilde{u}_i, \gamma, u_b}^R - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_Z^2) \Gamma_{\tilde{u}_j, Z, u_b}^{R*} \Gamma_{\tilde{u}_i, Z, u_b}^R \\
& -\sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{Z_R}^2) \Gamma_{\tilde{u}_j, Z_R, u_b}^{R*} \Gamma_{\tilde{u}_i, Z_R, u_b}^R - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{W^-}^2) \Gamma_{\tilde{u}_j, W^+, d_b}^{R*} \Gamma_{\tilde{u}_i, W^+, d_b}^R
\end{aligned} \tag{255}$$

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

$$\begin{aligned}
\Sigma^S(p^2) &= + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{g}_j, \tilde{d}_a^*, d_b}^{L*} m_{d_b} \Gamma_{\tilde{g}_i, \tilde{d}_a^*, d_b}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{g}_j, \tilde{u}_a^*, u_b}^{L*} m_{u_b} \Gamma_{\tilde{g}_i, \tilde{u}_a^*, u_b}^R - 12 \left( -\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{g}}^2, 0) \right) \Gamma_{\tilde{g}_j, g, \tilde{g}_1}^{R*} m_{\tilde{g}} \Gamma_{\tilde{g}_i, g, \tilde{g}_1}^L
\end{aligned} \tag{256}$$

$$\begin{aligned}
\Sigma^R(p^2) &= -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{g}_j, \tilde{d}_a^*, d_b}^{R*} \Gamma_{\tilde{g}_i, \tilde{d}_a^*, d_b}^R \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{g}_j, \tilde{u}_a^*, u_b}^{R*} \Gamma_{\tilde{g}_i, \tilde{u}_a^*, u_b}^R - 3B_1(p^2, m_{\tilde{g}}^2, 0) \Gamma_{\tilde{g}_j, g, \tilde{g}_1}^{L*} \Gamma_{\tilde{g}_i, g, \tilde{g}_1}^L
\end{aligned} \tag{257}$$

$$\begin{aligned}
\Sigma^L(p^2) &= -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{g}_j, \tilde{d}_a^*, d_b}^{L*} \Gamma_{\tilde{g}_i, \tilde{d}_a^*, d_b}^L \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{g}_j, \tilde{u}_a^*, u_b}^{L*} \Gamma_{\tilde{g}_i, \tilde{u}_a^*, u_b}^L - 3B_1(p^2, m_{\tilde{g}}^2, 0) \Gamma_{\tilde{g}_j, g, \tilde{g}_1}^{R*} \Gamma_{\tilde{g}_i, g, \tilde{g}_1}^R
\end{aligned} \tag{258}$$

• **Self-Energy for Z-Boson ( $Z$ )**

$$\begin{aligned}
\Pi(p^2) &= +|\Gamma_{Z, \eta^-, \eta^-}|^2 B_{00}(p^2, m_{\eta^-}^2, m_{\eta^-}^2) + |\Gamma_{Z, \eta^+, \eta^+}|^2 B_{00}(p^2, m_{\eta^+}^2, m_{\eta^+}^2) \\
& -|\Gamma_{Z, W^+, W^-}|^2 \left( 10B_{00}(p^2, m_{W^-}^2, m_{W^-}^2) + 2A_0(m_{W^-}^2) - 2\text{rMS} \left( 2m_{W^-}^2 - \frac{1}{3}p^2 \right) + B_0(p^2, m_{W^-}^2, m_{W^-}^2) \left( 2m_{W^-}^2 + 4p^2 \right) \right) \\
& + \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{Z, Z, H_a^+, H_a^-} - 4 \sum_{a=1}^2 \sum_{b=1}^2 |\Gamma_{Z, H_a^+, H_b^-}|^2 B_{00}(p^2, m_{H_a^-}^2, m_{H_b^-}^2)
\end{aligned}$$



$$\begin{aligned}
& + \sum_{a=1}^2 \sum_{b=1}^2 \left[ \left( |\Gamma_{Z, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^L|^2 + |\Gamma_{Z, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^R|^2 \right) H_0 \left( p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{\chi}_b^-}^2 \right) \right. \\
& + 4B_0 \left( p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{\chi}_b^-}^2 \right) m_{\tilde{\chi}_a^-} m_{\tilde{\chi}_b^-} \Re \left( \Gamma_{Z, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{L*} \Gamma_{Z, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^R \right) \left. \right] \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 \left[ \left( |\Gamma_{Z, \tilde{d}_a, d_b}^L|^2 + |\Gamma_{Z, \tilde{d}_a, d_b}^R|^2 \right) H_0 \left( p^2, m_{d_a}^2, m_{d_b}^2 \right) \right. \\
& + 4B_0 \left( p^2, m_{d_a}^2, m_{d_b}^2 \right) m_{d_a} m_{d_b} \Re \left( \Gamma_{Z, \tilde{d}_a, d_b}^{L*} \Gamma_{Z, \tilde{d}_a, d_b}^R \right) \left. \right] \\
& + \sum_{a=1}^3 \sum_{b=1}^3 \left[ \left( |\Gamma_{Z, \tilde{e}_a, e_b}^L|^2 + |\Gamma_{Z, \tilde{e}_a, e_b}^R|^2 \right) H_0 \left( p^2, m_{e_a}^2, m_{e_b}^2 \right) \right. \\
& + 4B_0 \left( p^2, m_{e_a}^2, m_{e_b}^2 \right) m_{e_a} m_{e_b} \Re \left( \Gamma_{Z, \tilde{e}_a, e_b}^{L*} \Gamma_{Z, \tilde{e}_a, e_b}^R \right) \left. \right] \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 \left[ \left( |\Gamma_{Z, \tilde{u}_a, u_b}^L|^2 + |\Gamma_{Z, \tilde{u}_a, u_b}^R|^2 \right) H_0 \left( p^2, m_{u_a}^2, m_{u_b}^2 \right) \right. \\
& + 4B_0 \left( p^2, m_{u_a}^2, m_{u_b}^2 \right) m_{u_a} m_{u_b} \Re \left( \Gamma_{Z, \tilde{u}_a, u_b}^{L*} \Gamma_{Z, \tilde{u}_a, u_b}^R \right) \left. \right] \\
& + \frac{1}{2} \sum_{a=1}^4 A_0 \left( m_{A_a^0}^2 \right) \Gamma_{Z, Z, A_a^0, A_a^0} + \frac{1}{2} \sum_{a=1}^4 A_0 \left( m_{h_a}^2 \right) \Gamma_{Z, Z, h_a, h_a} \\
& - 4 \sum_{a=1}^4 \sum_{b=1}^4 |\Gamma_{Z, h_a, A_b^0}|^2 B_{00} \left( p^2, m_{A_b^0}^2, m_{h_a}^2 \right) + 3 \sum_{a=1}^6 A_0 \left( m_{\tilde{d}_a}^2 \right) \Gamma_{Z, Z, \tilde{d}_a^*, \tilde{d}_a} \\
& + \sum_{a=1}^6 A_0 \left( m_{\tilde{e}_a}^2 \right) \Gamma_{Z, Z, \tilde{e}_a^*, \tilde{e}_a} + 3 \sum_{a=1}^6 A_0 \left( m_{\tilde{u}_a}^2 \right) \Gamma_{Z, Z, \tilde{u}_a^*, \tilde{u}_a} \\
& - 12 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z, \tilde{d}_a^*, \tilde{d}_b}|^2 B_{00} \left( p^2, m_{\tilde{d}_a}^2, m_{\tilde{d}_b}^2 \right) - 4 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z, \tilde{e}_a^*, \tilde{e}_b}|^2 B_{00} \left( p^2, m_{\tilde{e}_a}^2, m_{\tilde{e}_b}^2 \right) \\
& - 12 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z, \tilde{u}_a^*, \tilde{u}_b}|^2 B_{00} \left( p^2, m_{\tilde{u}_a}^2, m_{\tilde{u}_b}^2 \right) \\
& + \frac{1}{2} \sum_{a=1}^7 \sum_{b=1}^7 \left[ \left( |\Gamma_{Z, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^L|^2 + |\Gamma_{Z, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R|^2 \right) H_0 \left( p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2 \right) \right. \\
& + 4B_0 \left( p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2 \right) m_{\tilde{\chi}_a^0} m_{\tilde{\chi}_b^0} \Re \left( \Gamma_{Z, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{L*} \Gamma_{Z, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R \right) \left. \right] \\
& + \sum_{a=1}^9 A_0 \left( m_{\tilde{\nu}_a}^2 \right) \Gamma_{Z, Z, \tilde{\nu}_a^*, \tilde{\nu}_a} - 4 \sum_{a=1}^9 \sum_{b=1}^9 |\Gamma_{Z, \tilde{\nu}_a^*, \tilde{\nu}_b}|^2 B_{00} \left( p^2, m_{\tilde{\nu}_a}^2, m_{\tilde{\nu}_b}^2 \right) \\
& + \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 \left[ \left( |\Gamma_{Z, \nu_a, \nu_b}^L|^2 + |\Gamma_{Z, \nu_a, \nu_b}^R|^2 \right) H_0 \left( p^2, m_{\nu_a}^2, m_{\nu_b}^2 \right) \right. \\
& + 4B_0 \left( p^2, m_{\nu_a}^2, m_{\nu_b}^2 \right) m_{\nu_a} m_{\nu_b} \Re \left( \Gamma_{Z, \nu_a, \nu_b}^{L*} \Gamma_{Z, \nu_a, \nu_b}^R \right) \left. \right]
\end{aligned}$$

$$\begin{aligned}
& + 2 \sum_{b=1}^2 |\Gamma_{Z,W^+,H_b^-}|^2 B_0(p^2, m_{W^-}^2, m_{H_b^-}^2) + \sum_{b=1}^4 |\Gamma_{Z,\gamma,h_b}|^2 B_0(p^2, 0, m_{h_b}^2) + \sum_{b=1}^4 |\Gamma_{Z,Z,h_b}|^2 B_0(p^2, m_Z^2, m_{h_b}^2) \\
& + \sum_{b=1}^4 |\Gamma_{Z,Z_R,h_b}|^2 B_0(p^2, m_{Z_R}^2, m_{h_b}^2) + 2\text{rMS} m_{W^-}^2 \Gamma_{Z,Z,W^+,W^-}^1 - A_0(m_{W^-}^2) \left( 4\Gamma_{Z,Z,W^+,W^-}^1 + \Gamma_{Z,Z,W^+,W^-}^2 + \Gamma_{Z,Z,W^+,W^-}^3 \right)
\end{aligned} \tag{259}$$

• **Self-Energy for VZR** ( $Z_R$ )

$$\begin{aligned}
\Pi(p^2) = & + |\Gamma_{Z_R,\eta^-, \eta^-}|^2 B_{00}(p^2, m_{\eta^-}^2, m_{\eta^-}^2) + |\Gamma_{Z_R,\eta^+, \eta^+}|^2 B_{00}(p^2, m_{\eta^+}^2, m_{\eta^+}^2) \\
& - |\Gamma_{Z_R,W^+,W^-}|^2 \left( 10B_{00}(p^2, m_{W^-}^2, m_{W^-}^2) + 2A_0(m_{W^-}^2) - 2\text{rMS} \left( 2m_{W^-}^2 - \frac{1}{3}p^2 \right) + B_0(p^2, m_{W^-}^2, m_{W^-}^2) \right) (2m_{W^-}^2 + 4p^2) \\
& + \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{Z_R,Z_R,H_a^+,H_a^-} - 4 \sum_{a=1}^2 \sum_{b=1}^2 |\Gamma_{Z_R,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[ \left( |\Gamma_{Z_R,\tilde{\chi}_a^+, \tilde{\chi}_b^-}^L|^2 + |\Gamma_{Z_R,\tilde{\chi}_a^+, \tilde{\chi}_b^-}^R|^2 \right) 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 \left( \Gamma_{Z_R,\tilde{\chi}_a^+, \tilde{\chi}_b^-}^{L*} \Gamma_{Z_R,\tilde{\chi}_a^+, \tilde{\chi}_b^-}^R \right) \right] \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 \left[ \left( |\Gamma_{Z_R,\bar{d}_a,d_b}^L|^2 + |\Gamma_{Z_R,\bar{d}_a,d_b}^R|^2 \right) H_0(p^2, m_{d_a}^2, m_{d_b}^2) \right. \\
& \left. + 4B_0(p^2, m_{d_a}^2, m_{d_b}^2) m_{d_a} m_{d_b} \Re \left( \Gamma_{Z_R,\bar{d}_a,d_b}^{L*} \Gamma_{Z_R,\bar{d}_a,d_b}^R \right) \right] \\
& + \sum_{a=1}^3 \sum_{b=1}^3 \left[ \left( |\Gamma_{Z_R,\bar{e}_a,e_b}^L|^2 + |\Gamma_{Z_R,\bar{e}_a,e_b}^R|^2 \right) H_0(p^2, m_{e_a}^2, m_{e_b}^2) \right. \\
& \left. + 4B_0(p^2, m_{e_a}^2, m_{e_b}^2) m_{e_a} m_{e_b} \Re \left( \Gamma_{Z_R,\bar{e}_a,e_b}^{L*} \Gamma_{Z_R,\bar{e}_a,e_b}^R \right) \right] \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 \left[ \left( |\Gamma_{Z_R,\bar{u}_a,u_b}^L|^2 + |\Gamma_{Z_R,\bar{u}_a,u_b}^R|^2 \right) H_0(p^2, m_{u_a}^2, m_{u_b}^2) \right. \\
& \left. + 4B_0(p^2, m_{u_a}^2, m_{u_b}^2) m_{u_a} m_{u_b} \Re \left( \Gamma_{Z_R,\bar{u}_a,u_b}^{L*} \Gamma_{Z_R,\bar{u}_a,u_b}^R \right) \right] \\
& + \frac{1}{2} \sum_{a=1}^4 A_0(m_{A_a^0}^2) \Gamma_{Z_R,Z_R,A_a^0,A_a^0} + \frac{1}{2} \sum_{a=1}^4 A_0(m_{h_a}^2) \Gamma_{Z_R,Z_R,h_a,h_a} \\
& - 4 \sum_{a=1}^4 \sum_{b=1}^4 |\Gamma_{Z_R,h_a,A_b^0}|^2 B_{00}(p^2, m_{A_b^0}^2, m_{h_a}^2) + 3 \sum_{a=1}^6 A_0(m_{\bar{d}_a}^2) \Gamma_{Z_R,Z_R,\bar{d}_a,\bar{d}_a} \\
& + \sum_{a=1}^6 A_0(m_{\bar{e}_a}^2) \Gamma_{Z_R,Z_R,\bar{e}_a,\bar{e}_a} + 3 \sum_{a=1}^6 A_0(m_{\bar{u}_a}^2) \Gamma_{Z_R,Z_R,\bar{u}_a,\bar{u}_a}
\end{aligned}$$

$$\begin{aligned}
& -12 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z_R, \tilde{d}_a^*, \tilde{d}_b}|^2 B_{00}(p^2, m_{\tilde{d}_a}^2, m_{\tilde{d}_b}^2) - 4 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z_R, \tilde{e}_a^*, \tilde{e}_b}|^2 B_{00}(p^2, m_{\tilde{e}_a}^2, m_{\tilde{e}_b}^2) \\
& -12 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z_R, \tilde{u}_a^*, \tilde{u}_b}|^2 B_{00}(p^2, m_{\tilde{u}_a}^2, m_{\tilde{u}_b}^2) \\
& + \frac{1}{2} \sum_{a=1}^7 \sum_{b=1}^7 \left[ (|\Gamma_{Z_R, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^L|^2 + |\Gamma_{Z_R, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R|^2) H_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2) \right. \\
& \left. + 4B_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_a^0} m_{\tilde{\chi}_b^0} \Re(\Gamma_{Z_R, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{L*} \Gamma_{Z_R, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R) \right] \\
& + \sum_{a=1}^9 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{Z_R, Z_R, \tilde{\nu}_a^*, \tilde{\nu}_a} - 4 \sum_{a=1}^9 \sum_{b=1}^9 |\Gamma_{Z_R, \tilde{\nu}_a^*, \tilde{\nu}_b}|^2 B_{00}(p^2, m_{\tilde{\nu}_a}^2, m_{\tilde{\nu}_b}^2) \\
& + \frac{1}{2} \sum_{a=1}^9 \sum_{b=1}^9 \left[ (|\Gamma_{Z_R, \nu_a, \nu_b}^L|^2 + |\Gamma_{Z_R, \nu_a, \nu_b}^R|^2) H_0(p^2, m_{\nu_a}^2, m_{\nu_b}^2) \right. \\
& \left. + 4B_0(p^2, m_{\nu_a}^2, m_{\nu_b}^2) m_{\nu_a} m_{\nu_b} \Re(\Gamma_{Z_R, \nu_a, \nu_b}^{L*} \Gamma_{Z_R, \nu_a, \nu_b}^R) \right] \\
& + 2 \sum_{b=1}^2 |\Gamma_{Z_R, W^+, H_b^-}|^2 B_0(p^2, m_{W^-}^2, m_{H_b^-}^2) + \sum_{b=1}^4 |\Gamma_{Z_R, \gamma, h_b}|^2 B_0(p^2, 0, m_{h_b}^2) + \sum_{b=1}^4 |\Gamma_{Z_R, Z, h_b}|^2 B_0(p^2, m_Z^2, m_{h_b}^2) \\
& + \sum_{b=1}^4 |\Gamma_{Z_R, Z_R, h_b}|^2 B_0(p^2, m_{Z_R}^2, m_{h_b}^2) + 2\text{rMS} m_{W^-}^2 \Gamma_{Z_R, Z_R, W^+, W^-}^1 - A_0(m_{W^-}^2) (4\Gamma_{Z_R, Z_R, W^+, W^-}^1 + \Gamma_{Z_R, Z_R, W^+, W^-}^2 + \Gamma_{Z_R, Z_R, W^+, W^-}^3)
\end{aligned} \tag{260}$$

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

$$\begin{aligned}
\Pi(p^2) &= -12 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{W^+, \tilde{u}_a^*, \tilde{d}_b}|^2 B_{00}(p^2, m_{\tilde{d}_b}^2, m_{\tilde{u}_a}^2) + 2\text{rMS} m_{W^-}^2 \Gamma_{W^-, W^+, W^+, W^-}^1 + 3 \sum_{a=1}^3 \sum_{b=1}^3 \left[ (|\Gamma_{W^+, \tilde{u}_a, d_b}^L|^2 + |\Gamma_{W^+, \tilde{u}_a, d_b}^R|^2) H_0(p^2, m_{\tilde{u}_a}^2, m_{d_b}^2) \right. \\
& \left. + 4B_0(p^2, m_{\tilde{u}_a}^2, m_{d_b}^2) m_{d_b} m_{\tilde{u}_a} \Re(\Gamma_{W^+, \tilde{u}_a, d_b}^{L*} \Gamma_{W^+, \tilde{u}_a, d_b}^R) \right] + 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{W^-, W^+, \tilde{d}_a^*, \tilde{d}_a} + 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{W^-, W^+, \tilde{u}_a^*, \tilde{u}_a} \\
& + 4B_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} m_{\tilde{\chi}_a^0} \Re(\Gamma_{W^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^{L*} \Gamma_{W^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^R) + \sum_{a=1}^9 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{W^-, W^+, \tilde{\nu}_a^*, \tilde{\nu}_a} + \sum_{a=1}^9 \sum_{b=1}^3 \left[ (|\Gamma_{W^+, \nu_a, e_b}^L|^2 + |\Gamma_{W^+, \nu_a, e_b}^R|^2) H_0(p^2, m_{\nu_a}^2, m_{e_b}^2) \right. \\
& \left. + 4B_0(p^2, m_{\nu_a}^2, m_{e_b}^2) m_{e_b} m_{\nu_a} \Re(\Gamma_{W^+, \nu_a, e_b}^{L*} \Gamma_{W^+, \nu_a, e_b}^R) \right] + \sum_{b=1}^2 |\Gamma_{W^+, \gamma, H_b^-}|^2 B_0(p^2, 0, m_{H_b^-}^2) + \sum_{b=1}^2 |\Gamma_{W^+, Z, H_b^-}|^2 B_0(p^2, m_Z^2, m_{H_b^-}^2)
\end{aligned} \tag{261}$$

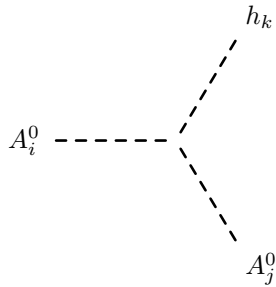
## 8.2 Tadpoles

$$\delta t_h^{(1)} = +A_0(m_{\eta^-}^2) \Gamma_{\tilde{h}_i, \eta^-, \eta^-} + A_0(m_{\eta^+}^2) \Gamma_{\tilde{h}_i, \eta^+, \eta^+} + A_0(m_{\eta^Z}^2) \Gamma_{\tilde{h}_i, \eta^Z, \eta^Z}$$

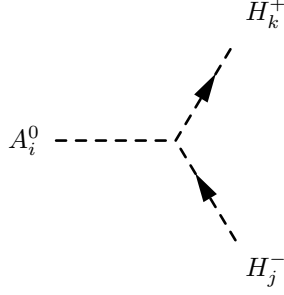
$$\begin{aligned}
& + A_0 \left( m_{\eta^{Z_R}}^2 \right) \Gamma_{\tilde{h}_i, \eta^{\bar{Z}_R}, \eta^{Z_R}} + 4 \Gamma_{\tilde{h}_i, W^+, W^-} \left( -\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0 \left( m_{W^-}^2 \right) \right) + 2 \Gamma_{\tilde{h}_i, Z, Z} \left( -\frac{1}{2} \text{rMS} m_Z^2 + A_0 \left( m_Z^2 \right) \right) \\
& + 2 \Gamma_{\tilde{h}_i, Z_R, Z_R} \left( -\frac{1}{2} \text{rMS} m_{Z_R}^2 + A_0 \left( m_{Z_R}^2 \right) \right) - \sum_{a=1}^2 A_0 \left( m_{H_a^-}^2 \right) \Gamma_{\tilde{h}_i, H_a^+, H_a^-} \\
& + 2 \sum_{a=1}^2 A_0 \left( m_{\tilde{\chi}_a^-}^2 \right) m_{\tilde{\chi}_a^-} \left( \Gamma_{\tilde{h}_i, \tilde{\chi}_a^+, \tilde{\chi}_a^-}^L + \Gamma_{\tilde{h}_i, \tilde{\chi}_a^+, \tilde{\chi}_a^-}^R \right) \\
& + 6 \sum_{a=1}^3 A_0 \left( m_{d_a}^2 \right) m_{d_a} \left( \Gamma_{\tilde{h}_i, \bar{d}_a, d_a}^L + \Gamma_{\tilde{h}_i, \bar{d}_a, d_a}^R \right) \\
& + 2 \sum_{a=1}^3 A_0 \left( m_{e_a}^2 \right) m_{e_a} \left( \Gamma_{\tilde{h}_i, \bar{e}_a, e_a}^L + \Gamma_{\tilde{h}_i, \bar{e}_a, e_a}^R \right) \\
& + 6 \sum_{a=1}^3 A_0 \left( m_{u_a}^2 \right) m_{u_a} \left( \Gamma_{\tilde{h}_i, \bar{u}_a, u_a}^L + \Gamma_{\tilde{h}_i, \bar{u}_a, u_a}^R \right) - \frac{1}{2} \sum_{a=1}^4 A_0 \left( m_{A_a^0}^2 \right) \Gamma_{\tilde{h}_i, A_a^0, A_a^0} \\
& - \frac{1}{2} \sum_{a=1}^4 A_0 \left( m_{h_a}^2 \right) \Gamma_{\tilde{h}_i, h_a, h_a} - 3 \sum_{a=1}^6 A_0 \left( m_{\bar{d}_a}^2 \right) \Gamma_{\tilde{h}_i, \bar{d}_a^*, \bar{d}_a} - \sum_{a=1}^6 A_0 \left( m_{\bar{e}_a}^2 \right) \Gamma_{\tilde{h}_i, \bar{e}_a^*, \bar{e}_a} \\
& - 3 \sum_{a=1}^6 A_0 \left( m_{\bar{u}_a}^2 \right) \Gamma_{\tilde{h}_i, \bar{u}_a^*, \bar{u}_a} + \sum_{a=1}^7 A_0 \left( m_{\tilde{\chi}_a^0}^2 \right) 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) \\
& - \sum_{a=1}^9 A_0 \left( m_{\tilde{\nu}_a}^2 \right) \Gamma_{\tilde{h}_i, \tilde{\nu}_a^*, \tilde{\nu}_a} + \sum_{a=1}^9 A_0 \left( m_{\nu_a}^2 \right) m_{\nu_a} \left( \Gamma_{\tilde{h}_i, \nu_a, \nu_a}^L + \Gamma_{\tilde{h}_i, \nu_a, \nu_a}^R \right)
\end{aligned} \tag{262}$$

## 9 Interactions for eigenstates 'EWSB'

### 9.1 Three Scalar-Interaction

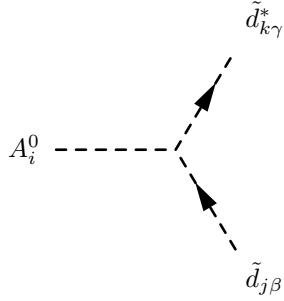


$$\frac{i}{4} (\text{tempString}) \tag{263}$$



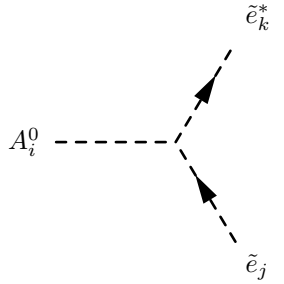
$$\frac{1}{4}g_L^2 \left( v_d Z_{i2}^A + v_u Z_{i1}^A \right) \left( -Z_{j1}^+ Z_{k2}^+ + Z_{j2}^+ Z_{k1}^+ \right) \quad (264)$$


---



$$\begin{aligned} & \frac{1}{\sqrt{2}} \delta_{\beta\gamma} \left( \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Z_{k3+a}^D T_{d,ab} Z_{i1}^A - \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{D,*} T_{d,ab}^* Z_{kb}^D Z_{i1}^A \right. \\ & \left. + \left( -\mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{kb}^D + \mu^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \right) Z_{i2}^A \right) \quad (265) \end{aligned}$$

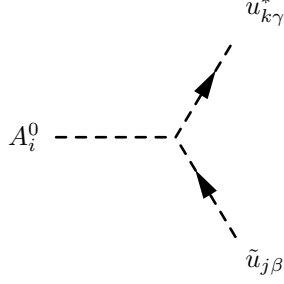

---



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

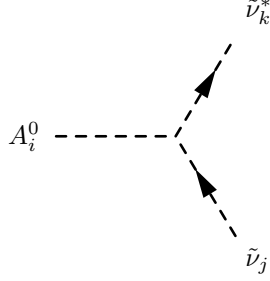
$$+ \left( -\mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{kb}^E + \mu^* \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \right) Z_{i2}^A \quad (266)$$


---



$$\begin{aligned} & \frac{1}{\sqrt{2}} \delta_{\beta\gamma} \left( \mu^* \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U Z_{i1}^A - \mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{j3+a}^{U,*} Z_{kb}^U Z_{i1}^A \right. \\ & \left. + \left( -\sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{U,*} T_{u,ab}^* Z_{kb}^U + \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Z_{k3+a}^U T_{u,ab} \right) Z_{i2}^A \right) \quad (267) \end{aligned}$$

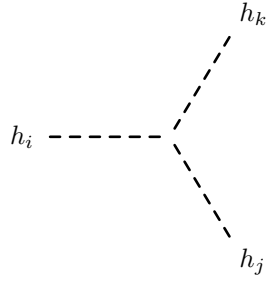

---



$$\begin{aligned} & \frac{1}{2} \left( \sqrt{2} \mu^* \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Y_{v,ab} Z_{k3+a}^V Z_{i1}^A - \sqrt{2} \mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{v,ab}^* Z_{j3+a}^{V,*} Z_{kb}^V Z_{i1}^A \right. \\ & + \sqrt{2} \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Z_{k3+a}^V T_{\nu,ab} Z_{i2}^A - \sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{V,*} T_{\nu,ab}^* Z_{kb}^V Z_{i2}^A \\ & - v_{\chi R} \sum_{c=1}^3 \sum_{b=1}^3 Z_{j6+b}^{V,*} \sum_{a=1}^3 Y_{s,ac}^* Y_{s,ab} Z_{kc}^V Z_{i2}^A + v_{\chi R} \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Y_{s,ac}^* Y_{v,ab} Z_{k6+c}^V Z_{i2}^A \\ & \left. + \sqrt{2} \mu_R^* \sum_{b=1}^3 Z_{j6+b}^{V,*} \sum_{a=1}^3 Y_{s,ab} Z_{k3+a}^V Z_{i3}^A - \sqrt{2} \mu_R \sum_{b=1}^3 \sum_{a=1}^3 Y_{s,ab}^* Z_{j3+a}^{V,*} Z_{k6+b}^V Z_{i3}^A \right) \end{aligned}$$

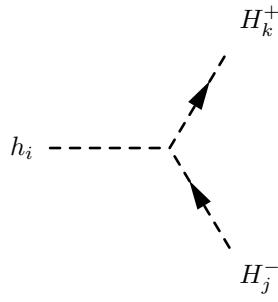
$$\begin{aligned}
& + \sqrt{2} \sum_{b=1}^3 Z_{j6+b}^{V,*} \sum_{a=1}^3 Z_{k3+a}^V T_{s,ab} Z_{i4}^A - \sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{V,*} T_{s,ab}^* Z_{k6+b}^V Z_{i4}^A \\
& + v_u \sum_{c=1}^3 \sum_{b=1}^3 Z_{j6+b}^{V,*} \sum_{a=1}^3 Y_{v,ac}^* Y_{s,ab} Z_{kc}^V Z_{i4}^A - v_u \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Y_{s,ac}^* Y_{v,ab} Z_{k6+c}^V Z_{i4}^A
\end{aligned} \tag{268}$$


---



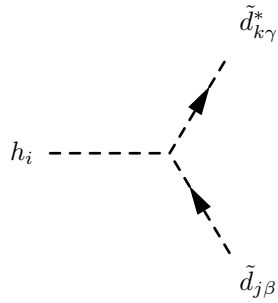
$$\frac{i}{4}(\text{tempString}) \tag{269}$$


---

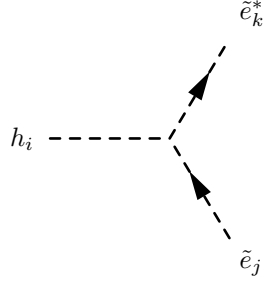


$$-\frac{i}{4}(\text{tempString}) \tag{270}$$


---



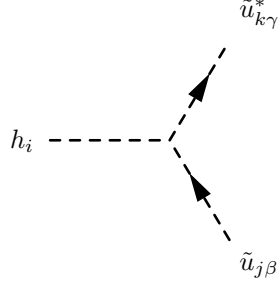
$$\begin{aligned}
& \frac{i}{12} \delta_{\beta\gamma} \left( -6 \left( \sqrt{2} \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Z_{k3+a}^D T_{d,ab} Z_{i1}^H + \sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{D,*} T_{d,ab}^* Z_{kb}^D Z_{i1}^H \right. \right. \\
& + 2v_d \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{d,ba} Z_{k3+b}^D Z_{i1}^H + 2v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{kc}^D Z_{i1}^H \\
& - \sqrt{2} \mu^* \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D Z_{i2}^H - \sqrt{2} \mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{j3+a}^{D,*} Z_{kb}^D Z_{i2}^H \left. \right) \\
& + \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \left( (3g_L^2 + g_{BL}g_{RB} + g_{BR}g_R) v_d Z_{i1}^H - (3g_L^2 + g_{BL}g_{RB} + g_{BR}g_R) v_u Z_{i2}^H \right. \\
& - \left. \left( -g_{BL}g_{RB} - g_{BR}g_R + g_{BL}^2 + g_{BR}^2 \right) (v_{\bar{\chi}_R} Z_{i3}^H - v_{\chi_R} Z_{i4}^H) \right) \\
& + \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{k3+a}^D \left( - \left( -3g_R^2 + \left( -3g_{RB} + g_{BL} \right) g_{RB} + g_{BR}g_R \right) v_d Z_{i1}^H + \left( -3g_R^2 + \left( -3g_{RB} + g_{BL} \right) g_{RB} + g_{BR}g_R \right) v_u Z_{i2}^H \right. \\
& \left. + \left( 3(g_R^2 + g_{RB}^2) - 4g_{BL}g_{RB} - 4g_{BR}g_R + g_{BL}^2 + g_{BR}^2 \right) (v_{\bar{\chi}_R} Z_{i3}^H - v_{\chi_R} Z_{i4}^H) \right) \tag{271}
\end{aligned}$$



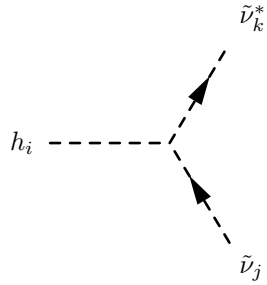
$$\begin{aligned}
& \frac{i}{4} \left( -2 \left( \sqrt{2} \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Z_{k3+a}^E T_{e,ab} Z_{i1}^H + \sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{E,*} T_{e,ab}^* Z_{kb}^E Z_{i1}^H \right. \right. \\
& + 2v_d \sum_{c=1}^3 Z_{j3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{e,ba} Z_{k3+b}^E Z_{i1}^H + 2v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{kc}^E Z_{i1}^H \\
& - \sqrt{2} \mu^* \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E Z_{i2}^H - \sqrt{2} \mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{j3+a}^{E,*} Z_{kb}^E Z_{i2}^H \left. \right) \\
& + \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \left( \left( -g_{BL}g_{RB} - g_{BR}g_R + g_L^2 \right) v_d Z_{i1}^H + \left( g_{BL}g_{RB} + g_{BR}g_R - g_L^2 \right) v_u Z_{i2}^H \right. \\
& + \left. \left( -g_{BL}g_{RB} - g_{BR}g_R + g_{BL}^2 + g_{BR}^2 \right) (v_{\bar{\chi}_R} Z_{i3}^H - v_{\chi_R} Z_{i4}^H) \right) \\
& + \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E \left( \left( g_{BR}g_R + g_{RB} (g_{BL} + g_{RB}) + g_R^2 \right) v_d Z_{i1}^H - \left( g_{BR}g_R + g_{RB} (g_{BL} + g_{RB}) + g_R^2 \right) v_u Z_{i2}^H \right)
\end{aligned}$$



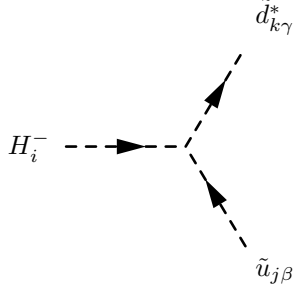
$$- \left( -g_R^2 - g_{RB}^2 + g_{BL}^2 + g_{BR}^2 \right) \left( v_{\bar{\chi}_R} Z_{i3}^H - v_{\chi_R} Z_{i4}^H \right) \quad (272)$$



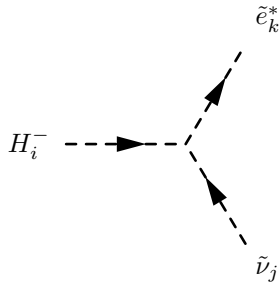
$$\begin{aligned}
& - \frac{i}{12} \delta_{\beta\gamma} \left( 6 \left( -\sqrt{2} \mu^* \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U Z_{i1}^H - \sqrt{2} \mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{j3+a}^{U,*} Z_{kb}^U Z_{i1}^H \right. \right. \\
& + \left( \sqrt{2} \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Z_{k3+a}^U T_{u,ab} + \sqrt{2} \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{U,*} T_{u,ab}^* Z_{kb}^U \right. \\
& + \left. 2v_u \left( \sum_{c=1}^3 Z_{j3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{u,ba} Z_{k3+b}^U + \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{kc}^U \right) \right) Z_{i2}^H \Big) \\
& + \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \left( \left( 3g_L^2 - g_{BL}g_{RB} - g_{BR}g_R \right) v_d Z_{i1}^H + \left( -3g_L^2 + g_{BL}g_{RB} + g_{BR}g_R \right) v_u Z_{i2}^H \right. \\
& + \left. \left( -g_{BL}g_{RB} - g_{BR}g_R + g_{BL}^2 + g_{BR}^2 \right) \left( v_{\bar{\chi}_R} Z_{i3}^H - v_{\chi_R} Z_{i4}^H \right) \right) \\
& + \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \left( \left( 3g_R^2 + g_{BR}g_R + g_{RB} \left( 3g_{RB} + g_{BL} \right) \right) v_d Z_{i1}^H - \left( 3g_R^2 + g_{BR}g_R + g_{RB} \left( 3g_{RB} + g_{BL} \right) \right) v_u Z_{i2}^H \right. \\
& \left. - \left( 2g_{BL}g_{RB} + 2g_{BR}g_R - 3 \left( g_R^2 + g_{RB}^2 \right) + g_{BL}^2 + g_{BR}^2 \right) \left( v_{\bar{\chi}_R} Z_{i3}^H - v_{\chi_R} Z_{i4}^H \right) \right) \Big) \quad (273)
\end{aligned}$$



$$- \frac{i}{4} \left( tempString \right) \quad (274)$$

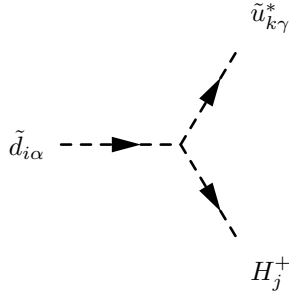


$$\begin{aligned}
& -\frac{i}{4}\delta_{\beta\gamma}\left(\sqrt{2}g_L^2\sum_{a=1}^3Z_{ja}^{U,*}Z_{ka}^D\left(v_dZ_{i1}^++v_uZ_{i2}^+\right)\right. \\
& -2\left(2\sum_{b=1}^3Z_{jb}^{U,*}\sum_{a=1}^3Z_{k3+a}^DT_{d,ab}Z_{i1}^++2\mu\sum_{b=1}^3\sum_{a=1}^3Y_{u,ab}^*Z_{j3+a}^{U,*}Z_{kb}^DZ_{i1}^+\right. \\
& +\sqrt{2}v_u\sum_{c=1}^3Z_{j3+c}^{U,*}\sum_{b=1}^3\sum_{a=1}^3Y_{u,ca}^*Y_{d,ba}Z_{k3+b}^DZ_{i1}^+ \\
& +\sqrt{2}v_d\sum_{c=1}^3\sum_{b=1}^3Z_{jb}^{U,*}\sum_{a=1}^3Y_{d,ac}^*Y_{d,ab}Z_{kc}^DZ_{i1}^++2\mu^*\sum_{b=1}^3Z_{jb}^{U,*}\sum_{a=1}^3Y_{d,ab}Z_{k3+a}^DZ_{i2}^+ \\
& +2\sum_{b=1}^3\sum_{a=1}^3Z_{j3+a}^{U,*}T_{u,ab}^*Z_{kb}^DZ_{i2}^++\sqrt{2}v_d\sum_{c=1}^3Z_{j3+c}^{U,*}\sum_{b=1}^3\sum_{a=1}^3Y_{u,ca}^*Y_{d,ba}Z_{k3+b}^DZ_{i2}^+ \\
& \left.\left.+\sqrt{2}v_u\sum_{c=1}^3\sum_{b=1}^3Z_{jb}^{U,*}\sum_{a=1}^3Y_{u,ac}^*Y_{u,ab}Z_{kc}^DZ_{i2}^+\right)\right) \tag{275}
\end{aligned}$$

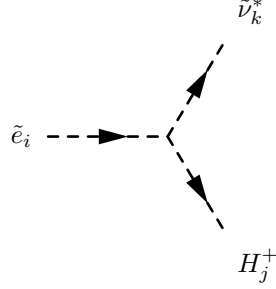


$$\begin{aligned}
& -\frac{i}{4}\left(\sqrt{2}g_L^2\sum_{a=1}^3Z_{ja}^{V,*}Z_{ka}^E\left(v_dZ_{i1}^++v_uZ_{i2}^+\right)\right. \\
& -2\left(2\sum_{b=1}^3Z_{jb}^{V,*}\sum_{a=1}^3Z_{k3+a}^ET_{e,ab}Z_{i1}^++2\mu\sum_{b=1}^3\sum_{a=1}^3Y_{v,ab}^*Z_{j3+a}^{V,*}Z_{kb}^EZ_{i1}^+\right.
\end{aligned}$$

$$\begin{aligned}
& + \sqrt{2}v_u \sum_{c=1}^3 Z_{j3+c}^{V,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{v,ca}^* Y_{e,ba} Z_{k3+b}^E Z_{i1}^+ \\
& + \sqrt{2}v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{kc}^E Z_{i1}^+ + 2\mu^* \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E Z_{i2}^+ \\
& + 2 \sum_{b=1}^3 \sum_{a=1}^3 Z_{j3+a}^{V,*} T_{v,ab}^* Z_{kb}^E Z_{i2}^+ + \sqrt{2}v_d \sum_{c=1}^3 Z_{j3+c}^{V,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{v,ca}^* Y_{e,ba} Z_{k3+b}^E Z_{i2}^+ \\
& + \sqrt{2}v_{\chi_R} \sum_{c=1}^3 \sum_{b=1}^3 Z_{j6+b}^{V,*} \sum_{a=1}^3 Y_{v,ac}^* Y_{s,ab} Z_{kc}^E Z_{i2}^+ \\
& + \sqrt{2}v_u \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Y_{v,ac}^* Y_{v,ab} Z_{kc}^E Z_{i2}^+ \Big) \tag{276}
\end{aligned}$$

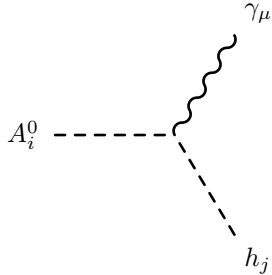


$$\begin{aligned}
& - \frac{i}{4} \delta_{\alpha\gamma} \left( \sqrt{2}g_L^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^U \left( v_d Z_{j1}^+ + v_u Z_{j2}^+ \right) \right. \\
& - 2 \left( 2\mu^* \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U Z_{j1}^+ + 2 \sum_{b=1}^3 \sum_{a=1}^3 Z_{i3+a}^{D,*} T_{d,ab}^* Z_{kb}^U Z_{j1}^+ \right. \\
& + \sqrt{2}v_u \sum_{c=1}^3 Z_{i3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{u,ba} Z_{k3+b}^U Z_{j1}^+ \\
& + \sqrt{2}v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{kc}^U Z_{j1}^+ + 2 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Z_{k3+a}^U T_{u,ab} Z_{j2}^+ \\
& + 2\mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{i3+a}^{D,*} Z_{kb}^U Z_{j2}^+ + \sqrt{2}v_d \sum_{c=1}^3 Z_{i3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{u,ba} Z_{k3+b}^U Z_{j2}^+ \\
& \left. + \sqrt{2}v_u \sum_{c=1}^3 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{kc}^U Z_{j2}^+ \right) \tag{277}
\end{aligned}$$



$$\begin{aligned}
& -\frac{i}{4} \left( \sqrt{2} g_L^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^V (v_d Z_{j1}^+ + v_u Z_{j2}^+) \right. \\
& - 2 \left( 2\mu^* \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{v,ab} Z_{k3+a}^V Z_{j1}^+ + 2 \sum_{b=1}^3 \sum_{a=1}^3 Z_{i3+a}^{E,*} T_{e,ab}^* Z_{kb}^V Z_{j1}^+ \right. \\
& + \sqrt{2} v_u \sum_{c=1}^3 Z_{i3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{v,ba} Z_{k3+b}^V Z_{j1}^+ \\
& + \sqrt{2} v_d \sum_{c=1}^3 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{kc}^V Z_{j1}^+ + 2 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Z_{k3+a}^V T_{v,ab} Z_{j2}^+ \\
& + 2\mu \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{i3+a}^{E,*} Z_{kb}^V Z_{j2}^+ + \sqrt{2} v_d \sum_{c=1}^3 Z_{i3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{v,ba} Z_{k3+b}^V Z_{j2}^+ \\
& + \sqrt{2} v_u \sum_{c=1}^3 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{v,ac}^* Y_{v,ab} Z_{kc}^V Z_{j2}^+ \\
& \left. + \sqrt{2} v_{\chi_R} \sum_{c=1}^3 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{s,ac}^* Y_{v,ab} Z_{k6+c}^V Z_{j2}^+ \right) \quad (278)
\end{aligned}$$

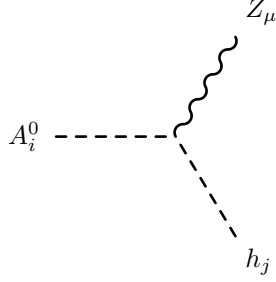
## 9.2 Two Scalar-One Vector Boson-Interaction



$$\frac{1}{2} \left( \left( Z_{i3}^A Z_{j3}^H - Z_{i4}^A Z_{j4}^H \right) \left( g_{BL} Z Z_{21} - g_{RB} Z Z_{21} + \left( -g_R + g_{BR} \right) Z Z_{31} \right) + Z_{i1}^A Z_{j1}^H \left( g_L Z Z_{11} - g_{RB} Z Z_{21} - g_R Z Z_{31} \right) \right)$$

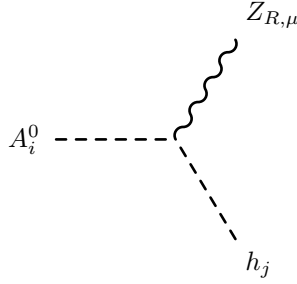
$$+ Z_{i2}^A Z_{j2}^H \left( -g_L Z Z_{11} + g_{RB} Z Z_{21} + g_R Z Z_{31} \right) \left( -p_\mu^{h_j} + p_\mu^{A_i^0} \right) \quad (279)$$


---



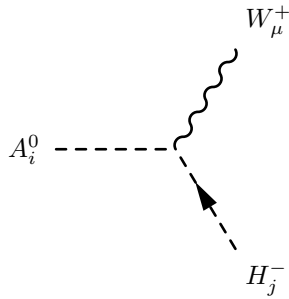
$$\begin{aligned} & \frac{1}{2} \left( \left( Z_{i3}^A Z_{j3}^H - Z_{i4}^A Z_{j4}^H \right) \left( g_{BL} Z Z_{22} - g_{RB} Z Z_{22} + \left( -g_R + g_{BR} \right) Z Z_{32} \right) + Z_{i1}^A Z_{j1}^H \left( g_L Z Z_{12} - g_{RB} Z Z_{22} - g_R Z Z_{32} \right) \right. \\ & \left. + Z_{i2}^A Z_{j2}^H \left( -g_L Z Z_{12} + g_{RB} Z Z_{22} + g_R Z Z_{32} \right) \right) \left( -p_\mu^{h_j} + p_\mu^{A_i^0} \right) \quad (280) \end{aligned}$$


---



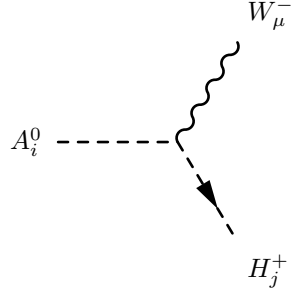
$$\begin{aligned} & \frac{1}{2} \left( \left( Z_{i3}^A Z_{j3}^H - Z_{i4}^A Z_{j4}^H \right) \left( g_{BL} Z Z_{23} - g_{RB} Z Z_{23} + \left( -g_R + g_{BR} \right) Z Z_{33} \right) + Z_{i1}^A Z_{j1}^H \left( g_L Z Z_{13} - g_{RB} Z Z_{23} - g_R Z Z_{33} \right) \right. \\ & \left. + Z_{i2}^A Z_{j2}^H \left( -g_L Z Z_{13} + g_{RB} Z Z_{23} + g_R Z Z_{33} \right) \right) \left( -p_\mu^{h_j} + p_\mu^{A_i^0} \right) \quad (281) \end{aligned}$$


---



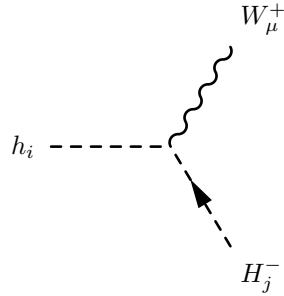
$$\frac{1}{2}g_L \left( Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+ \right) \left( -p_\mu^{H_j^-} + p_\mu^{A_i^0} \right) \quad (282)$$


---



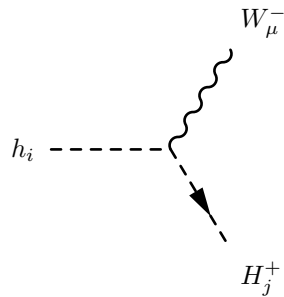
$$\frac{1}{2}g_L \left( Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+ \right) \left( -p_\mu^{H_j^+} + p_\mu^{A_i^0} \right) \quad (283)$$


---



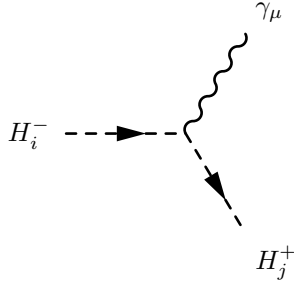
$$\frac{i}{2}g_L \left( Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+ \right) \left( -p_\mu^{H_j^-} + p_\mu^{h_i} \right) \quad (284)$$


---



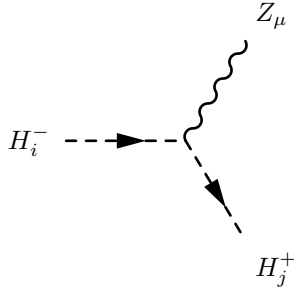
$$-\frac{i}{2}g_L \left( Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+ \right) \left( -p_\mu^{H_j^+} + p_\mu^{h_i} \right) \quad (285)$$


---



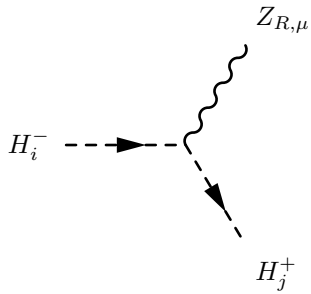
$$\frac{i}{2} \left( Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+ \right) \left( g_L Z Z_{11} + g_{RB} Z Z_{21} + g_R Z Z_{31} \right) \left( -p_\mu^{H_j^+} + p_\mu^{H_i^-} \right) \quad (286)$$


---



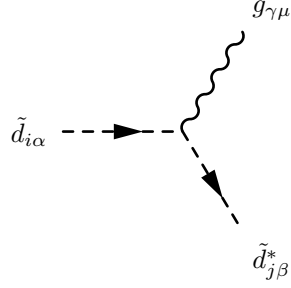
$$\frac{i}{2} \left( Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+ \right) \left( g_L Z Z_{12} + g_{RB} Z Z_{22} + g_R Z Z_{32} \right) \left( -p_\mu^{H_j^+} + p_\mu^{H_i^-} \right) \quad (287)$$


---



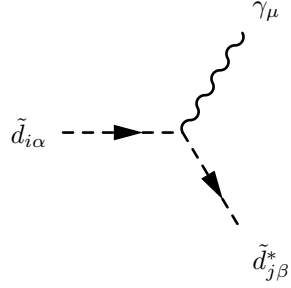
$$\frac{i}{2} \left( Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+ \right) \left( g_L Z Z_{13} + g_{RB} Z Z_{23} + g_R Z Z_{33} \right) \left( -p_\mu^{H_j^+} + p_\mu^{H_i^-} \right) \quad (288)$$


---



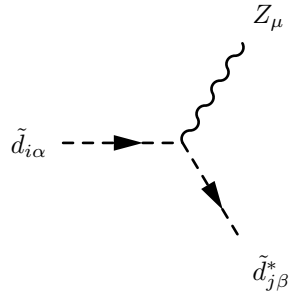
$$-\frac{i}{2}g_s\delta_{ij}\lambda_{\beta,\alpha}^\gamma\left(-p_\mu^{\tilde{d}_{j\beta}^*}+p_\mu^{\tilde{d}_{i\alpha}}\right) \quad (289)$$


---



$$\frac{i}{6}\delta_{\alpha\beta}\left(-\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{j3+a}^D\left(-3g_{RB}ZZ_{21}+\left(-3g_R+g_{BR}\right)ZZ_{31}+g_{BL}ZZ_{21}\right)+\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^D\left(3g_LZZ_{11}-g_{BL}ZZ_{21}-g_{BR}ZZ_{31}\right)\right) \quad (290)$$

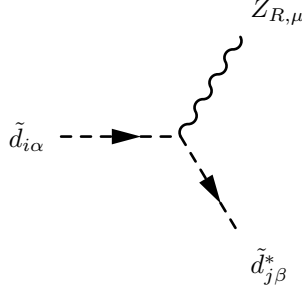

---



$$\frac{i}{6}\delta_{\alpha\beta}\left(-\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{j3+a}^D\left(-3g_{RB}ZZ_{22}+\left(-3g_R+g_{BR}\right)ZZ_{32}+g_{BL}ZZ_{22}\right)+\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^D\left(3g_LZZ_{12}-g_{BL}ZZ_{22}-g_{BR}ZZ_{32}\right)\right) \quad (291)$$

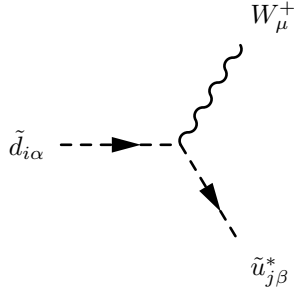

---





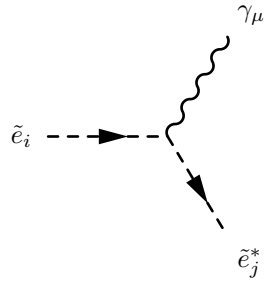
$$\frac{i}{6}\delta_{\alpha\beta}\left(-\sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \left(-3g_{RB}ZZ_{23} + (-3g_R + g_{BR})ZZ_{33} + g_{BL}ZZ_{23}\right) + \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \left(3g_LZZ_{13} - g_{BL}ZZ_{23} - g_{BR}ZZ_{33}\right)\right) \quad (292)$$


---



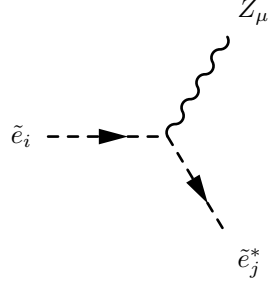
$$-i\frac{1}{\sqrt{2}}g_L\delta_{\alpha\beta}\sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U \left(-p_{\mu}^{\tilde{u}_{j\beta}^*} + p_{\mu}^{\tilde{d}_{i\alpha}}\right) \quad (293)$$


---



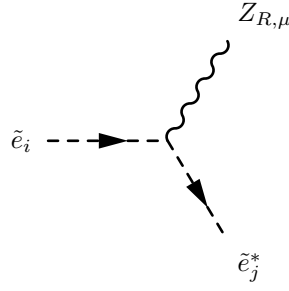
$$\frac{i}{2}\left(\sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \left(g_{BL}ZZ_{21} + (g_{BR} + g_R)ZZ_{31} + g_{RB}ZZ_{21}\right) + \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \left(g_{BL}ZZ_{21} + g_{BR}ZZ_{31} + g_LZZ_{11}\right)\right) \left(-p_{\mu}^{\tilde{e}_j^*} + p_{\mu}^{\tilde{e}_i}\right) \quad (294)$$


---



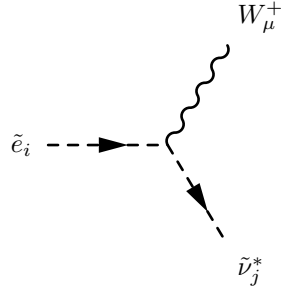
$$\frac{i}{2} \left( \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \left( g_{BL} Z Z_{22} + (g_{BR} + g_R) Z Z_{32} + g_{RB} Z Z_{22} \right) + \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \left( g_{BL} Z Z_{22} + g_{BR} Z Z_{32} + g_L Z Z_{12} \right) \right) \left( -p_\mu^{\tilde{e}_j^*} + p_\mu^{\tilde{e}_i} \right) \quad (295)$$


---



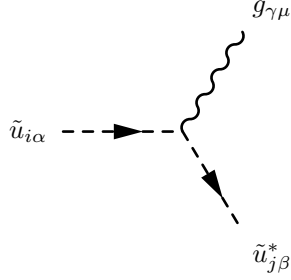
$$\frac{i}{2} \left( \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \left( g_{BL} Z Z_{23} + (g_{BR} + g_R) Z Z_{33} + g_{RB} Z Z_{23} \right) + \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \left( g_{BL} Z Z_{23} + g_{BR} Z Z_{33} + g_L Z Z_{13} \right) \right) \left( -p_\mu^{\tilde{e}_j^*} + p_\mu^{\tilde{e}_i} \right) \quad (296)$$


---



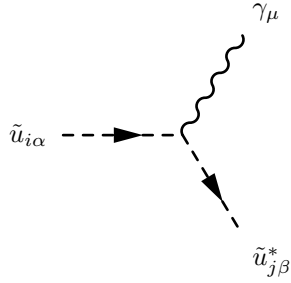
$$-i \frac{1}{\sqrt{2}} g_L \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^V \left( -p_\mu^{\tilde{\nu}_j^*} + p_\mu^{\tilde{e}_i} \right) \quad (297)$$


---



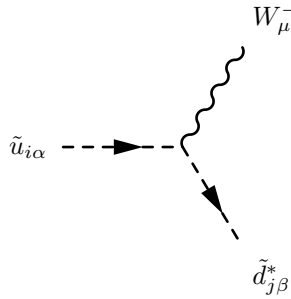
$$-\frac{i}{2}g_s\delta_{ij}\lambda_{\beta,\alpha}^\gamma\left(-p_\mu^{\tilde{u}_{j\beta}^*}+p_\mu^{\tilde{u}_{i\alpha}}\right) \quad (298)$$


---



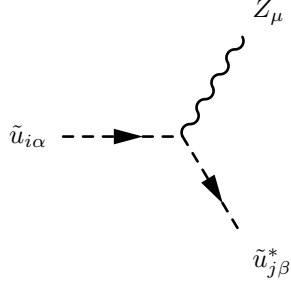
$$-\frac{i}{6}\delta_{\alpha\beta}\left(\sum_{a=1}^3Z_{i3+a}^{U,*}Z_{j3+a}^U\left(3g_{RB}ZZ_{21}+\left(3g_R+g_{BR}\right)ZZ_{31}+g_{BL}ZZ_{21}\right)+\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^U\left(3g_LZZ_{11}+g_{BL}ZZ_{21}+g_{BR}ZZ_{31}\right)\right)\left(-p_\mu^{\tilde{u}_{j\beta}^*}\right) \quad (299)$$


---



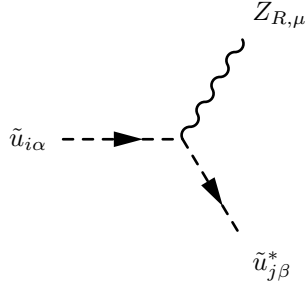
$$-i\frac{1}{\sqrt{2}}g_L\delta_{\alpha\beta}\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^D\left(-p_\mu^{\tilde{d}_{j\beta}^*}+p_\mu^{\tilde{u}_{i\alpha}}\right) \quad (300)$$


---



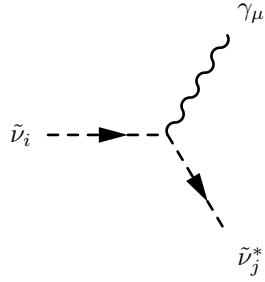
$$-\frac{i}{6}\delta_{\alpha\beta}\left(\sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \left(3g_{RB}ZZ_{22} + (3g_R + g_{BR})ZZ_{32} + g_{BL}ZZ_{22}\right) + \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \left(3g_LZZ_{12} + g_{BL}ZZ_{22} + g_{BR}ZZ_{32}\right)\right) \left(-p_\mu^{\tilde{u}_j^*}\right) \quad (301)$$


---



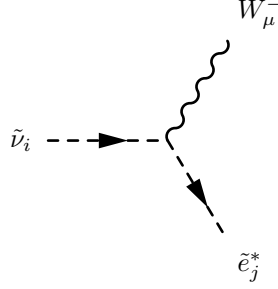
$$-\frac{i}{6}\delta_{\alpha\beta}\left(\sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \left(3g_{RB}ZZ_{23} + (3g_R + g_{BR})ZZ_{33} + g_{BL}ZZ_{23}\right) + \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \left(3g_LZZ_{13} + g_{BL}ZZ_{23} + g_{BR}ZZ_{33}\right)\right) \left(-p_\mu^{\tilde{u}_j^*}\right) \quad (302)$$


---



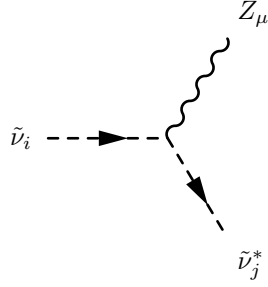
$$-\frac{i}{2}\left(\sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{j3+a}^V \left(-g_{BL}ZZ_{21} + (-g_{BR} + g_R)ZZ_{31} + g_{RB}ZZ_{21}\right) + \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ja}^V \left(-g_{BL}ZZ_{21} - g_{BR}ZZ_{31} + g_LZZ_{11}\right)\right) \left(-p_\mu^{\tilde{\nu}_j^*}\right) \quad (303)$$


---



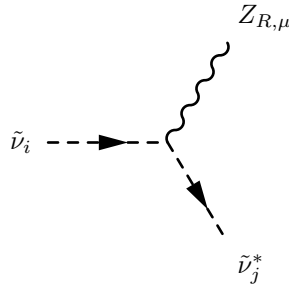
$$-i \frac{1}{\sqrt{2}} g_L \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ja}^E (-p_\mu^{\tilde{e}_j^*} + p_\mu^{\tilde{\nu}_i}) \quad (304)$$


---



$$-\frac{i}{2} \left( \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{j3+a}^V \left( -g_{BL} Z Z_{22} + \left( -g_{BR} + g_R \right) Z Z_{32} + g_{RB} Z Z_{22} \right) + \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ja}^V \left( -g_{BL} Z Z_{22} - g_{BR} Z Z_{32} + g_L Z Z_{12} \right) \right) (-p_\mu^{\tilde{\nu}_j^*}) \quad (305)$$

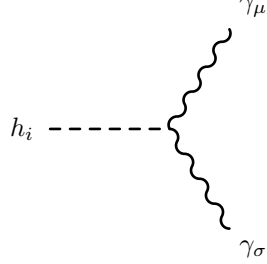

---



$$-\frac{i}{2} \left( \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{j3+a}^V \left( -g_{BL} Z Z_{23} + \left( -g_{BR} + g_R \right) Z Z_{33} + g_{RB} Z Z_{23} \right) + \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ja}^V \left( -g_{BL} Z Z_{23} - g_{BR} Z Z_{33} + g_L Z Z_{13} \right) \right) (-p_\mu^{\tilde{\nu}_j^*}) \quad (306)$$

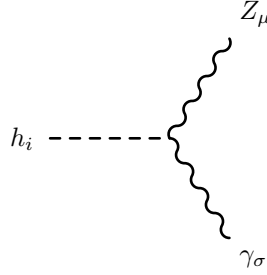

---

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



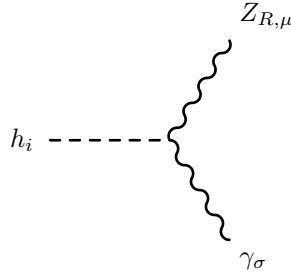
$$\begin{aligned} & \frac{i}{2} \left( (v_{\bar{\chi}_R} Z_{i3}^H + v_{\chi_R} Z_{i4}^H) (g_{BL} Z Z_{21} - g_{RB} Z Z_{21} + (-g_R + g_{BR}) Z Z_{31})^2 + v_d Z_{i1}^H (-g_L Z Z_{11} + g_{RB} Z Z_{21} + g_R Z Z_{31})^2 \right. \\ & \left. + v_u Z_{i2}^H (-g_L Z Z_{11} + g_{RB} Z Z_{21} + g_R Z Z_{31})^2 \right) (g_{\sigma\mu}) \end{aligned} \quad (307)$$


---



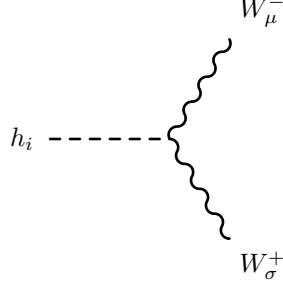
$$\begin{aligned} & \frac{i}{2} \left( (v_{\bar{\chi}_R} Z_{i3}^H + v_{\chi_R} Z_{i4}^H) (g_{BL} Z Z_{21} - g_{RB} Z Z_{21} + (-g_R + g_{BR}) Z Z_{31}) (g_{BL} Z Z_{22} - g_{RB} Z Z_{22} + (-g_R + g_{BR}) Z Z_{32}) \right. \\ & \left. + v_d Z_{i1}^H (g_L Z Z_{11} - g_{RB} Z Z_{21} - g_R Z Z_{31}) (g_L Z Z_{12} - g_{RB} Z Z_{22} - g_R Z Z_{32}) \right. \\ & \left. + v_u Z_{i2}^H (g_L Z Z_{11} - g_{RB} Z Z_{21} - g_R Z Z_{31}) (g_L Z Z_{12} - g_{RB} Z Z_{22} - g_R Z Z_{32}) \right) (g_{\sigma\mu}) \end{aligned} \quad (308)$$


---



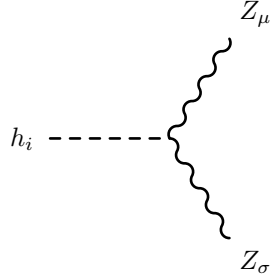
$$\begin{aligned}
& \frac{i}{2} \left( (v_{\bar{\chi}_R} Z_{i3}^H + v_{\chi_R} Z_{i4}^H) (g_{BL} Z Z_{21} - g_{RB} Z Z_{21} + (-g_R + g_{BR}) Z Z_{31}) (g_{BL} Z Z_{23} - g_{RB} Z Z_{23} + (-g_R + g_{BR}) Z Z_{33}) \right. \\
& + v_d Z_{i1}^H (g_L Z Z_{11} - g_{RB} Z Z_{21} - g_R Z Z_{31}) (g_L Z Z_{13} - g_{RB} Z Z_{23} - g_R Z Z_{33}) \\
& \left. + v_u Z_{i2}^H (g_L Z Z_{11} - g_{RB} Z Z_{21} - g_R Z Z_{31}) (g_L Z Z_{13} - g_{RB} Z Z_{23} - g_R Z Z_{33}) \right) (g_{\sigma\mu})
\end{aligned} \tag{309}$$


---



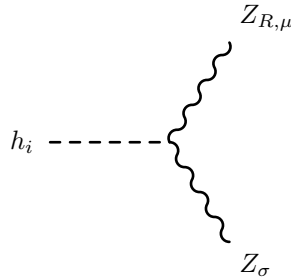
$$\frac{i}{2} g_L^2 (v_d Z_{i1}^H + v_u Z_{i2}^H) (g_{\sigma\mu}) \tag{310}$$


---



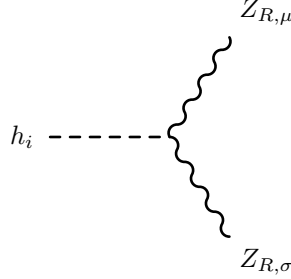
$$\begin{aligned}
& \frac{i}{2} \left( (v_{\bar{\chi}_R} Z_{i3}^H + v_{\chi_R} Z_{i4}^H) (g_{BL} Z Z_{22} - g_{RB} Z Z_{22} + (-g_R + g_{BR}) Z Z_{32})^2 + v_d Z_{i1}^H (-g_L Z Z_{12} + g_{RB} Z Z_{22} + g_R Z Z_{32})^2 \right. \\
& \left. + v_u Z_{i2}^H (-g_L Z Z_{12} + g_{RB} Z Z_{22} + g_R Z Z_{32})^2 \right) (g_{\sigma\mu})
\end{aligned} \tag{311}$$


---



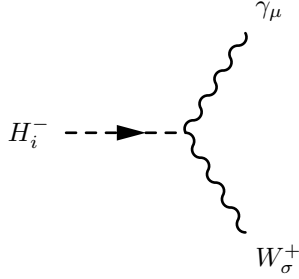
$$\begin{aligned}
& \frac{i}{2} \left( (v_{\bar{\chi}_R} Z_{i3}^H + v_{\chi_R} Z_{i4}^H) (g_{BL} Z Z_{22} - g_{RB} Z Z_{22} + (-g_R + g_{BR}) Z Z_{32}) (g_{BL} Z Z_{23} - g_{RB} Z Z_{23} + (-g_R + g_{BR}) Z Z_{33}) \right. \\
& + v_d Z_{i1}^H (g_L Z Z_{12} - g_{RB} Z Z_{22} - g_R Z Z_{32}) (g_L Z Z_{13} - g_{RB} Z Z_{23} - g_R Z Z_{33}) \\
& \left. + v_u Z_{i2}^H (g_L Z Z_{12} - g_{RB} Z Z_{22} - g_R Z Z_{32}) (g_L Z Z_{13} - g_{RB} Z Z_{23} - g_R Z Z_{33}) \right) (g_{\sigma\mu})
\end{aligned} \tag{312}$$


---



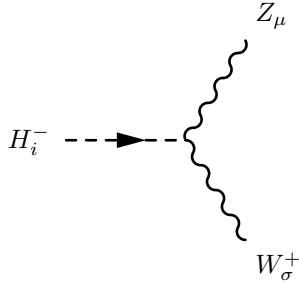
$$\begin{aligned}
& \frac{i}{2} \left( (v_{\bar{\chi}_R} Z_{i3}^H + v_{\chi_R} Z_{i4}^H) (g_{BL} Z Z_{23} - g_{RB} Z Z_{23} + (-g_R + g_{BR}) Z Z_{33})^2 + v_d Z_{i1}^H (-g_L Z Z_{13} + g_{RB} Z Z_{23} + g_R Z Z_{33})^2 \right. \\
& \left. + v_u Z_{i2}^H (-g_L Z Z_{13} + g_{RB} Z Z_{23} + g_R Z Z_{33})^2 \right) (g_{\sigma\mu})
\end{aligned} \tag{313}$$


---



$$-\frac{i}{2} g_L (v_d Z_{i1}^+ - v_u Z_{i2}^+) (g_{RB} Z Z_{21} + g_R Z Z_{31}) (g_{\sigma\mu}) \tag{314}$$

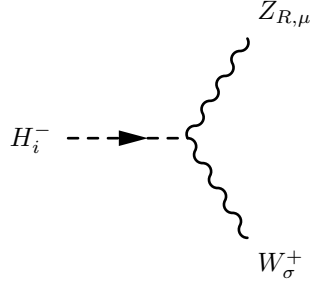

---





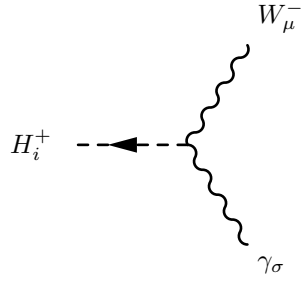
$$-\frac{i}{2}g_L(v_d Z_{i1}^+ - v_u Z_{i2}^+)(g_{RB}ZZ_{22} + g_RZZ_{32})(g_{\sigma\mu}) \quad (315)$$


---



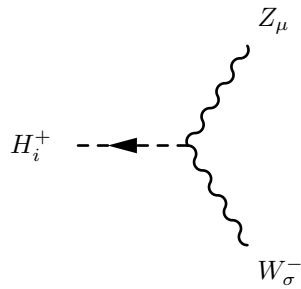
$$-\frac{i}{2}g_L(v_d Z_{i1}^+ - v_u Z_{i2}^+)(g_{RB}ZZ_{23} + g_RZZ_{33})(g_{\sigma\mu}) \quad (316)$$


---



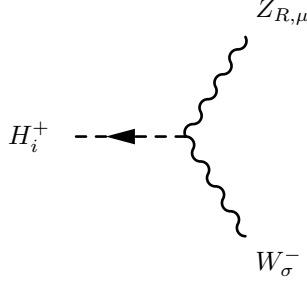
$$-\frac{i}{2}g_L(v_d Z_{i1}^+ - v_u Z_{i2}^+)(g_{RB}ZZ_{21} + g_RZZ_{31})(g_{\sigma\mu}) \quad (317)$$


---



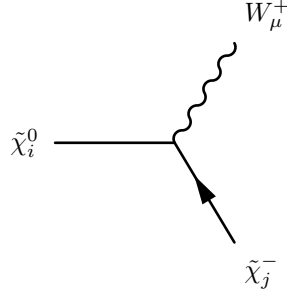
$$-\frac{i}{2}g_L(v_d Z_{i1}^+ - v_u Z_{i2}^+)(g_{RB}ZZ_{22} + g_RZZ_{32})(g_{\sigma\mu}) \quad (318)$$


---



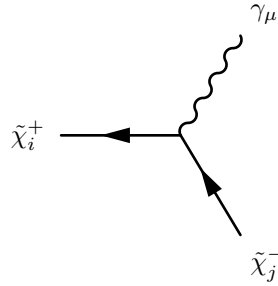
$$-\frac{i}{2}g_L(v_d Z_{i1}^+ - v_u Z_{i2}^+)(g_{RB}ZZ_{23} + g_RZZ_{33})(g_{\sigma\mu}) \quad (319)$$

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



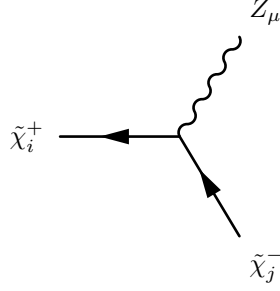
$$-\frac{i}{2}g_L(2U_{j1}^*N_{i2} + \sqrt{2}U_{j2}^*N_{i3})\left(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\right) \quad (320)$$

$$+ \left(i\frac{1}{\sqrt{2}}g_LN_{i4}^*V_{j2} - ig_LN_{i2}^*V_{j1}\right)\left(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\right) \quad (321)$$



$$\frac{i}{2}\left(2g_LU_{j1}^*U_{i1}ZZ_{11} + U_{j2}^*U_{i2}(g_LZZ_{11} + g_{RB}ZZ_{21} + g_RZZ_{31})\right)\left(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\right) \quad (322)$$

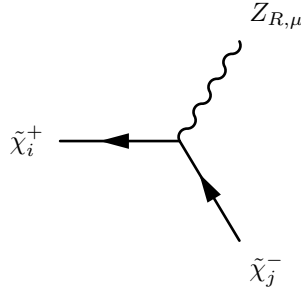
$$+ \frac{i}{2}\left(2g_LV_{i1}^*V_{j1}ZZ_{11} + V_{i2}^*V_{j2}(g_LZZ_{11} + g_{RB}ZZ_{21} + g_RZZ_{31})\right)\left(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\right) \quad (323)$$



$$\frac{i}{2} \left( 2g_L U_{j1}^* U_{i1} Z Z_{12} + U_{j2}^* U_{i2} \left( g_L Z Z_{12} + g_{RB} Z Z_{22} + g_R Z Z_{32} \right) \right) \left( \gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (324)$$

$$+ \frac{i}{2} \left( 2g_L V_{i1}^* V_{j1} Z Z_{12} + V_{i2}^* V_{j2} \left( g_L Z Z_{12} + g_{RB} Z Z_{22} + g_R Z Z_{32} \right) \right) \left( \gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (325)$$

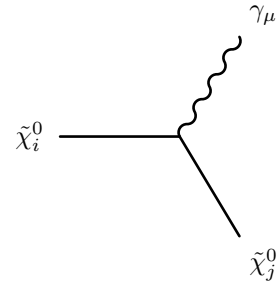

---



$$\frac{i}{2} \left( 2g_L U_{j1}^* U_{i1} Z Z_{13} + U_{j2}^* U_{i2} \left( g_L Z Z_{13} + g_{RB} Z Z_{23} + g_R Z Z_{33} \right) \right) \left( \gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (326)$$

$$+ \frac{i}{2} \left( 2g_L V_{i1}^* V_{j1} Z Z_{13} + V_{i2}^* V_{j2} \left( g_L Z Z_{13} + g_{RB} Z Z_{23} + g_R Z Z_{33} \right) \right) \left( \gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (327)$$


---

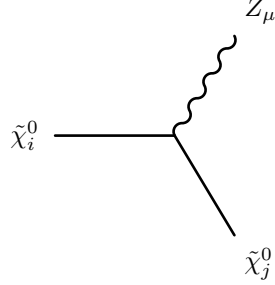


$$- \frac{i}{2} \left( \left( N_{j6}^* N_{i6} - N_{j7}^* N_{i7} \right) \left( g_{BL} Z Z_{21} - g_{RB} Z Z_{21} + \left( -g_R + g_{BR} \right) Z Z_{31} \right) + N_{j3}^* N_{i3} \left( g_L Z Z_{11} - g_{RB} Z Z_{21} - g_R Z Z_{31} \right) \right)$$

$$+ N_{j4}^* N_{i4} \left( -g_L Z Z_{11} + g_{RB} Z Z_{21} + g_R Z Z_{31} \right) \left( \gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (328)$$

$$+ \frac{i}{2} \left( \left( N_{i6}^* N_{j6} - N_{i7}^* N_{j7} \right) \left( g_{BL} Z Z_{21} - g_{RB} Z Z_{21} + \left( -g_R + g_{BR} \right) Z Z_{31} \right) + N_{i3}^* N_{j3} \left( g_L Z Z_{11} - g_{RB} Z Z_{21} - g_R Z Z_{31} \right) \right) \\ + N_{i4}^* N_{j4} \left( -g_L Z Z_{11} + g_{RB} Z Z_{21} + g_R Z Z_{31} \right) \left( \gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (329)$$

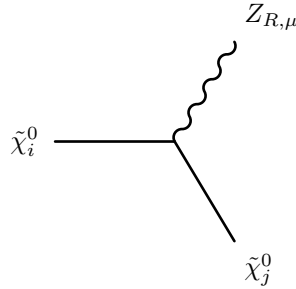

---



$$- \frac{i}{2} \left( \left( N_{j6}^* N_{i6} - N_{j7}^* N_{i7} \right) \left( g_{BL} Z Z_{22} - g_{RB} Z Z_{22} + \left( -g_R + g_{BR} \right) Z Z_{32} \right) + N_{j3}^* N_{i3} \left( g_L Z Z_{12} - g_{RB} Z Z_{22} - g_R Z Z_{32} \right) \right) \\ + N_{j4}^* N_{i4} \left( -g_L Z Z_{12} + g_{RB} Z Z_{22} + g_R Z Z_{32} \right) \left( \gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (330)$$

$$+ \frac{i}{2} \left( \left( N_{i6}^* N_{j6} - N_{i7}^* N_{j7} \right) \left( g_{BL} Z Z_{22} - g_{RB} Z Z_{22} + \left( -g_R + g_{BR} \right) Z Z_{32} \right) + N_{i3}^* N_{j3} \left( g_L Z Z_{12} - g_{RB} Z Z_{22} - g_R Z Z_{32} \right) \right) \\ + N_{i4}^* N_{j4} \left( -g_L Z Z_{12} + g_{RB} Z Z_{22} + g_R Z Z_{32} \right) \left( \gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (331)$$

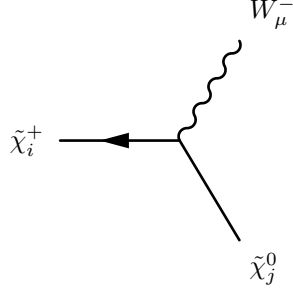

---



$$- \frac{i}{2} \left( \left( N_{j6}^* N_{i6} - N_{j7}^* N_{i7} \right) \left( g_{BL} Z Z_{23} - g_{RB} Z Z_{23} + \left( -g_R + g_{BR} \right) Z Z_{33} \right) + N_{j3}^* N_{i3} \left( g_L Z Z_{13} - g_{RB} Z Z_{23} - g_R Z Z_{33} \right) \right) \\ + N_{j4}^* N_{i4} \left( -g_L Z Z_{13} + g_{RB} Z Z_{23} + g_R Z Z_{33} \right) \left( \gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (332)$$

$$+ \frac{i}{2} \left( \left( N_{i6}^* N_{j6} - N_{i7}^* N_{j7} \right) \left( g_{BL} Z Z_{23} - g_{RB} Z Z_{23} + \left( -g_R + g_{BR} \right) Z Z_{33} \right) + N_{i3}^* N_{j3} \left( g_L Z Z_{13} - g_{RB} Z Z_{23} - g_R Z Z_{33} \right) \right) \\ + N_{i4}^* N_{j4} \left( -g_L Z Z_{13} + g_{RB} Z Z_{23} + g_R Z Z_{33} \right) \left( \gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (333)$$

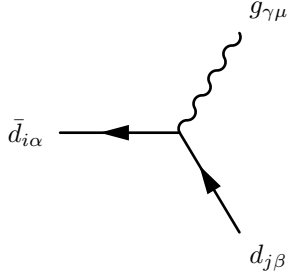

---



$$-\frac{i}{2}g_L\left(2N_{j2}^*U_{i1} + \sqrt{2}N_{j3}^*U_{i2}\right)\left(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\right) \quad (334)$$

$$+ \left(i\frac{1}{\sqrt{2}}g_LV_{i2}^*N_{j4} - ig_LV_{i1}^*N_{j2}\right)\left(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\right) \quad (335)$$

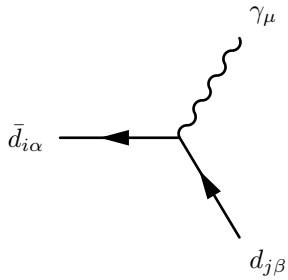

---



$$-\frac{i}{2}g_s\delta_{ij}\lambda_{\alpha,\beta}^\gamma\left(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\right) \quad (336)$$

$$+ -\frac{i}{2}g_s\delta_{ij}\lambda_{\alpha,\beta}^\gamma\left(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\right) \quad (337)$$

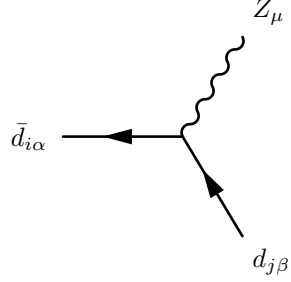

---



$$-\frac{i}{6}\delta_{\alpha,\beta}\delta_{ij}\left(-3g_LZZ_{11} + g_{BL}ZZ_{21} + g_{BR}ZZ_{31}\right)\left(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\right) \quad (338)$$

$$+ -\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(-3g_{RB}ZZ_{21} + \left(-3g_R + g_{BR}\right)ZZ_{31} + g_{BL}ZZ_{21}\right)\left(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\right) \quad (339)$$

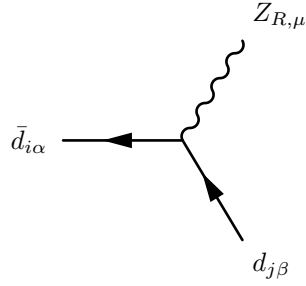

---



$$-\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(-3g_LZZ_{12} + g_{BL}ZZ_{22} + g_{BR}ZZ_{32}\right)\left(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\right) \quad (340)$$

$$+ -\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(-3g_{RB}ZZ_{22} + \left(-3g_R + g_{BR}\right)ZZ_{32} + g_{BL}ZZ_{22}\right)\left(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\right) \quad (341)$$

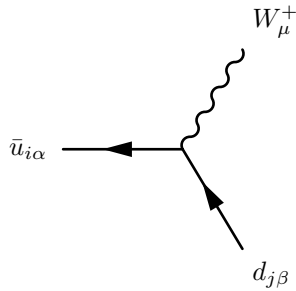

---



$$-\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(-3g_LZZ_{13} + g_{BL}ZZ_{23} + g_{BR}ZZ_{33}\right)\left(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\right) \quad (342)$$

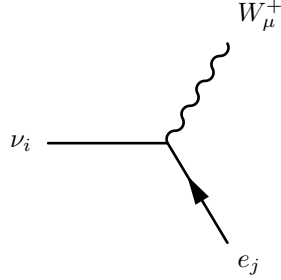
$$+ -\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(-3g_{RB}ZZ_{23} + \left(-3g_R + g_{BR}\right)ZZ_{33} + g_{BL}ZZ_{23}\right)\left(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\right) \quad (343)$$


---



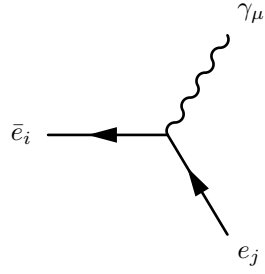
$$-i \frac{1}{\sqrt{2}} g_L \delta_{\alpha\beta} \sum_{a=1}^3 U_{L,ja}^{d,*} U_{L,ia}^u \left( \gamma_\mu \cdot \frac{1-\gamma_5}{2} \right) \quad (344)$$


---



$$-i \frac{1}{\sqrt{2}} g_L \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{\nu,ia}^V \left( \gamma_\mu \cdot \frac{1-\gamma_5}{2} \right) \quad (345)$$

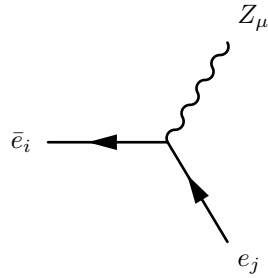

---



$$\frac{i}{2} \delta_{ij} \left( g_{BL} Z Z_{21} + g_{BR} Z Z_{31} + g_L Z Z_{11} \right) \left( \gamma_\mu \cdot \frac{1-\gamma_5}{2} \right) \quad (346)$$

$$+ \frac{i}{2} \delta_{ij} \left( g_{BL} Z Z_{21} + (g_{BR} + g_R) Z Z_{31} + g_{RB} Z Z_{21} \right) \left( \gamma_\mu \cdot \frac{1+\gamma_5}{2} \right) \quad (347)$$

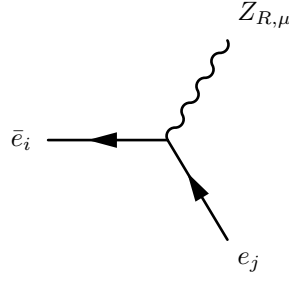

---



$$\frac{i}{2}\delta_{ij}\left(g_{BL}ZZ_{22} + g_{BR}ZZ_{32} + g_LZZ_{12}\right)\left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2}\right) \quad (348)$$

$$+ \frac{i}{2}\delta_{ij}\left(g_{BL}ZZ_{22} + (g_{BR} + g_R)ZZ_{32} + g_{RB}ZZ_{22}\right)\left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2}\right) \quad (349)$$

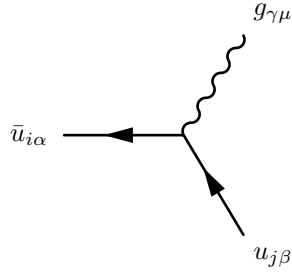

---



$$\frac{i}{2}\delta_{ij}\left(g_{BL}ZZ_{23} + g_{BR}ZZ_{33} + g_LZZ_{13}\right)\left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2}\right) \quad (350)$$

$$+ \frac{i}{2}\delta_{ij}\left(g_{BL}ZZ_{23} + (g_{BR} + g_R)ZZ_{33} + g_{RB}ZZ_{23}\right)\left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2}\right) \quad (351)$$

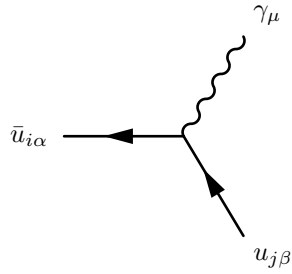

---



$$- \frac{i}{2}g_s\delta_{ij}\lambda_{\alpha,\beta}^\gamma\left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2}\right) \quad (352)$$

$$+ \frac{i}{2}g_s\delta_{ij}\lambda_{\alpha,\beta}^\gamma\left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2}\right) \quad (353)$$


---

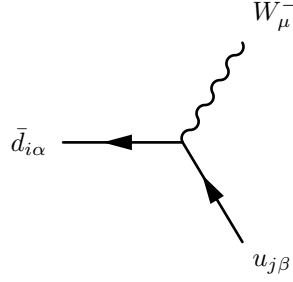




$$-\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(3g_LZZ_{11}+g_{BL}ZZ_{21}+g_{BR}ZZ_{31}\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (354)$$

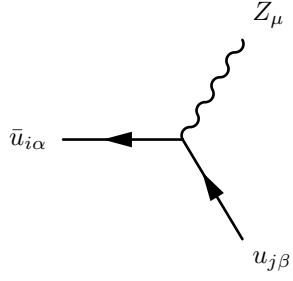
$$+\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(3g_{RB}ZZ_{21}+\left(3g_R+g_{BR}\right)ZZ_{31}+g_{BL}ZZ_{21}\right)\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (355)$$


---



$$-i\frac{1}{\sqrt{2}}g_L\delta_{\alpha\beta}\sum_{a=1}^3U_{L,ja}^{u,*}U_{L,ia}^d\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (356)$$

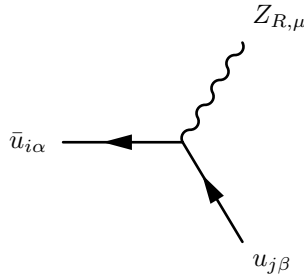

---



$$-\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(3g_LZZ_{12}+g_{BL}ZZ_{22}+g_{BR}ZZ_{32}\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (357)$$

$$+\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(3g_{RB}ZZ_{22}+\left(3g_R+g_{BR}\right)ZZ_{32}+g_{BL}ZZ_{22}\right)\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (358)$$

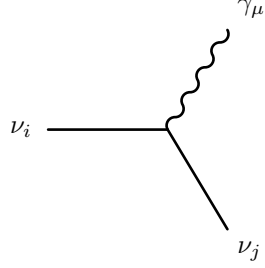

---



$$-\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(3g_LZZ_{13}+g_{BL}ZZ_{23}+g_{BR}ZZ_{33}\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (359)$$

$$+\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(3g_{RB}ZZ_{23}+\left(3g_R+g_{BR}\right)ZZ_{33}+g_{BL}ZZ_{23}\right)\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (360)$$

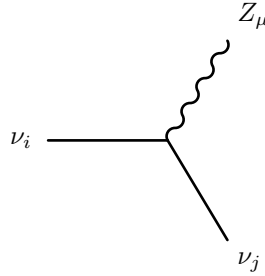

---



$$-\frac{i}{2}\left(\sum_{a=1}^3Z_{\nu,j3+a}^{V,*}Z_{\nu,i3+a}^V\left(g_{BL}ZZ_{21}-g_{RB}ZZ_{21}+\left(-g_R+g_{BR}\right)ZZ_{31}\right)+\sum_{a=1}^3Z_{\nu,ja}^{V,*}Z_{\nu,ia}^V\left(-g_{BL}ZZ_{21}-g_{BR}ZZ_{31}+g_LZZ_{11}\right)\right)\left(\gamma_\mu\right) \quad (361)$$

$$+\frac{i}{2}\left(\sum_{a=1}^3Z_{\nu,i3+a}^{V,*}Z_{\nu,j3+a}^V\left(g_{BL}ZZ_{21}-g_{RB}ZZ_{21}+\left(-g_R+g_{BR}\right)ZZ_{31}\right)+\sum_{a=1}^3Z_{\nu,ia}^{V,*}Z_{\nu,ja}^V\left(-g_{BL}ZZ_{21}-g_{BR}ZZ_{31}+g_LZZ_{11}\right)\right)\left(\gamma_\mu\right) \quad (362)$$

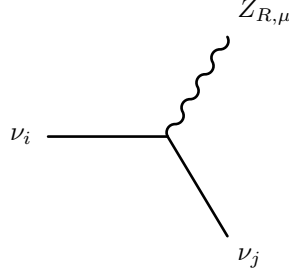

---



$$-\frac{i}{2}\left(\sum_{a=1}^3Z_{\nu,j3+a}^{V,*}Z_{\nu,i3+a}^V\left(g_{BL}ZZ_{22}-g_{RB}ZZ_{22}+\left(-g_R+g_{BR}\right)ZZ_{32}\right)+\sum_{a=1}^3Z_{\nu,ja}^{V,*}Z_{\nu,ia}^V\left(-g_{BL}ZZ_{22}-g_{BR}ZZ_{32}+g_LZZ_{12}\right)\right)\left(\gamma_\mu\right) \quad (363)$$

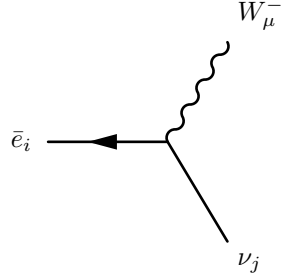
$$+\frac{i}{2}\left(\sum_{a=1}^3Z_{\nu,i3+a}^{V,*}Z_{\nu,j3+a}^V\left(g_{BL}ZZ_{22}-g_{RB}ZZ_{22}+\left(-g_R+g_{BR}\right)ZZ_{32}\right)+\sum_{a=1}^3Z_{\nu,ia}^{V,*}Z_{\nu,ja}^V\left(-g_{BL}ZZ_{22}-g_{BR}ZZ_{32}+g_LZZ_{12}\right)\right)\left(\gamma_\mu\right) \quad (364)$$


---

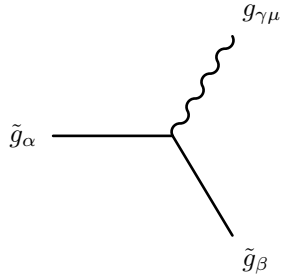


$$-\frac{i}{2} \left( \sum_{a=1}^3 Z_{\nu, j3+a}^{V,*} Z_{\nu, i3+a}^V \left( g_{BL} Z Z_{23} - g_{RB} Z Z_{23} + (-g_R + g_{BR}) Z Z_{33} \right) + \sum_{a=1}^3 Z_{\nu, ja}^{V,*} Z_{\nu, ia}^V \left( -g_{BL} Z Z_{23} - g_{BR} Z Z_{33} + g_L Z Z_{13} \right) \right) (\gamma_\mu) \quad (365)$$

$$+\frac{i}{2} \left( \sum_{a=1}^3 Z_{\nu, i3+a}^{V,*} Z_{\nu, j3+a}^V \left( g_{BL} Z Z_{23} - g_{RB} Z Z_{23} + (-g_R + g_{BR}) Z Z_{33} \right) + \sum_{a=1}^3 Z_{\nu, ia}^{V,*} Z_{\nu, ja}^V \left( -g_{BL} Z Z_{23} - g_{BR} Z Z_{33} + g_L Z Z_{13} \right) \right) (\gamma_\mu) \quad (366)$$



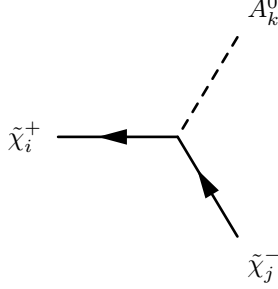
$$-i \frac{1}{\sqrt{2}} g_L \sum_{a=1}^3 Z_{\nu, ja}^{V,*} U_{L, ia}^e \left( \gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (367)$$



$$-g_s f_{\alpha,\beta,\gamma} \left( \gamma_\mu \cdot \frac{1-\gamma_5}{2} \right) \quad (368)$$

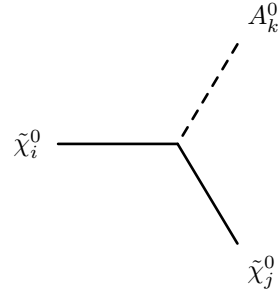
$$+ -g_s f_{\alpha,\beta,\gamma} \left( \gamma_\mu \cdot \frac{1+\gamma_5}{2} \right) \quad (369)$$

## 9.5 Two Fermion-One Scalar Boson-Interaction



$$- \frac{1}{\sqrt{2}} g_L \left( U_{j1}^* V_{i2}^* Z_{k2}^A + U_{j2}^* V_{i1}^* Z_{k1}^A \right) \left( \frac{1-\gamma_5}{2} \right) \quad (370)$$

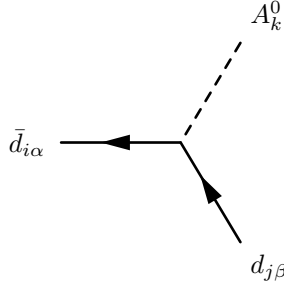
$$+ \frac{1}{\sqrt{2}} g_L \left( U_{i1} V_{j2} Z_{k2}^A + U_{i2} V_{j1} Z_{k1}^A \right) \left( \frac{1+\gamma_5}{2} \right) \quad (371)$$



$$\begin{aligned} & \frac{1}{2} \left( -g_L N_{i2}^* N_{j3}^* Z_{k1}^A + g_R N_{i5}^* N_{j3}^* Z_{k1}^A + N_{i3}^* \left( -g_L N_{j2}^* + g_{RB} N_{j1}^* + g_R N_{j5}^* \right) Z_{k1}^A \right. \\ & - g_{RB} N_{i4}^* N_{j1}^* Z_{k2}^A + g_L N_{i4}^* N_{j2}^* Z_{k2}^A + g_L N_{i2}^* N_{j4}^* Z_{k2}^A - g_R N_{i5}^* N_{j4}^* Z_{k2}^A \\ & - g_R N_{i4}^* N_{j5}^* Z_{k2}^A - g_{BL} N_{i6}^* N_{j1}^* Z_{k3}^A + g_{RB} N_{i6}^* N_{j1}^* Z_{k3}^A - g_{BR} N_{i6}^* N_{j5}^* Z_{k3}^A \\ & + g_R N_{i6}^* N_{j5}^* Z_{k3}^A - g_{BR} N_{i5}^* N_{j6}^* Z_{k3}^A + g_R N_{i5}^* N_{j6}^* Z_{k3}^A + g_{BL} N_{i7}^* N_{j1}^* Z_{k4}^A \\ & - g_{RB} N_{i7}^* N_{j1}^* Z_{k4}^A + g_{BR} N_{i7}^* N_{j5}^* Z_{k4}^A - g_R N_{i7}^* N_{j5}^* Z_{k4}^A + g_{BR} N_{i5}^* N_{j7}^* Z_{k4}^A \\ & \left. - g_R N_{i5}^* N_{j7}^* Z_{k4}^A + N_{i1}^* \left( - \left( -g_{RB} + g_{BL} \right) \left( N_{j6}^* Z_{k3}^A - N_{j7}^* Z_{k4}^A \right) + g_{RB} N_{j3}^* Z_{k1}^A - g_{RB} N_{j4}^* Z_{k2}^A \right) \right) \left( \frac{1-\gamma_5}{2} \right) \quad (372) \\ & + \frac{1}{2} \left( g_{BL} Z_{k3}^A N_{i6} N_{j1} - g_{RB} Z_{k3}^A N_{i6} N_{j1} - g_{BL} Z_{k4}^A N_{i7} N_{j1} + g_{RB} Z_{k4}^A N_{i7} N_{j1} + g_{BR} Z_{k3}^A N_{i6} N_{j5} \right. \end{aligned}$$

$$\begin{aligned}
& -g_R Z_{k3}^A N_{i6} N_{j5} - g_{BR} Z_{k4}^A N_{i7} N_{j5} + g_R Z_{k4}^A N_{i7} N_{j5} \\
& - Z_{k1}^A \left( (-g_L N_{i2} + g_{RB} N_{i1} + g_R N_{i5}) N_{j3} + N_{i3} (-g_L N_{j2} + g_{RB} N_{j1} + g_R N_{j5}) \right) \\
& + Z_{k2}^A \left( (-g_L N_{i2} + g_{RB} N_{i1} + g_R N_{i5}) N_{j4} + N_{i4} (-g_L N_{j2} + g_{RB} N_{j1} + g_R N_{j5}) \right) + g_{BL} Z_{k3}^A N_{i1} N_{j6} \\
& - g_{RB} Z_{k3}^A N_{i1} N_{j6} + g_{BR} Z_{k3}^A N_{i5} N_{j6} - g_R Z_{k3}^A N_{i5} N_{j6} - g_{BL} Z_{k4}^A N_{i1} N_{j7} \\
& + g_{RB} Z_{k4}^A N_{i1} N_{j7} - g_{BR} Z_{k4}^A N_{i5} N_{j7} + g_R Z_{k4}^A N_{i5} N_{j7} \left( \frac{1 + \gamma_5}{2} \right)
\end{aligned} \tag{373}$$

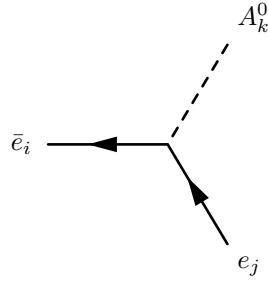

---



$$\frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{d,*} \sum_{a=1}^3 U_{R,ia}^{d,*} Y_{d,ab} Z_{k1}^A \left( \frac{1 - \gamma_5}{2} \right) \tag{374}$$

$$+ -\frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* U_{R,ja}^d U_{L,ib}^d Z_{k1}^A \left( \frac{1 + \gamma_5}{2} \right) \tag{375}$$

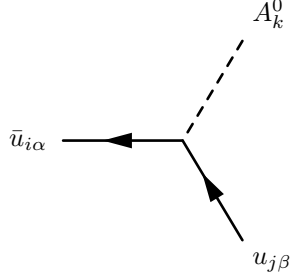

---



$$\frac{1}{\sqrt{2}} \sum_{b=1}^3 U_{L,jb}^{e,*} \sum_{a=1}^3 U_{R,ia}^{e,*} Y_{e,ab} Z_{k1}^A \left( \frac{1 - \gamma_5}{2} \right) \tag{376}$$

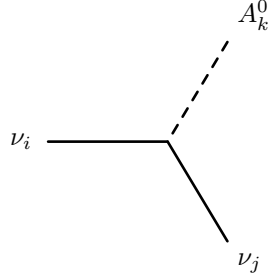
$$+ -\frac{1}{\sqrt{2}} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* U_{R,ja}^e U_{L,ib}^e Z_{k1}^A \left( \frac{1 + \gamma_5}{2} \right) \tag{377}$$


---



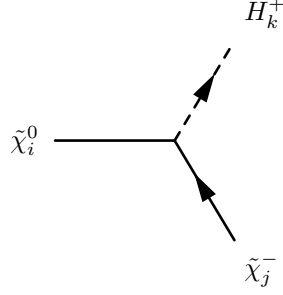
$$\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^3U_{L,jb}^{u,*}\sum_{a=1}^3U_{R,ia}^{u,*}Y_{u,ab}Z_{k2}^A\left(\frac{1-\gamma_5}{2}\right) \quad (378)$$

$$+ -\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^3\sum_{a=1}^3Y_{u,ab}^*U_{R,ja}^uU_{L,ib}^uZ_{k2}^A\left(\frac{1+\gamma_5}{2}\right) \quad (379)$$



$$\frac{1}{\sqrt{2}}\left(\sum_{b=1}^3Z_{\nu,jb}^{V,*}\sum_{a=1}^3Z_{\nu,i3+a}^{V,*}Y_{v,ab}Z_{k2}^A + \sum_{b=1}^3Z_{\nu,ib}^{V,*}\sum_{a=1}^3Z_{\nu,j3+a}^{V,*}Y_{v,ab}Z_{k2}^A\right. \\ \left.+ \left(\sum_{b=1}^3Z_{\nu,j6+b}^{V,*}\sum_{a=1}^3Z_{\nu,i3+a}^{V,*}Y_{s,ab} + \sum_{b=1}^3Z_{\nu,i6+b}^{V,*}\sum_{a=1}^3Z_{\nu,j3+a}^{V,*}Y_{s,ab}\right)Z_{k4}^A\right)\left(\frac{1-\gamma_5}{2}\right) \quad (380)$$

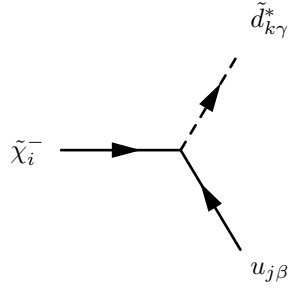
$$+ -\frac{1}{\sqrt{2}}\left(\sum_{b=1}^3\sum_{a=1}^3Y_{v,ab}^*Z_{\nu,j3+a}^VZ_{\nu,ib}^VZ_{k2}^A + \sum_{b=1}^3\sum_{a=1}^3Y_{v,ab}^*Z_{\nu,i3+a}^VZ_{\nu,jb}^VZ_{k2}^A\right. \\ \left.+ \left(\sum_{b=1}^3\sum_{a=1}^3Y_{s,ab}^*Z_{\nu,j3+a}^VZ_{\nu,i6+b}^V + \sum_{b=1}^3\sum_{a=1}^3Y_{s,ab}^*Z_{\nu,i3+a}^VZ_{\nu,j6+b}^V\right)Z_{k4}^A\right)\left(\frac{1+\gamma_5}{2}\right) \quad (381)$$



$$\frac{i}{2} \left( -2g_L U_{j1}^* N_{i3}^* + \sqrt{2} U_{j2}^* (g_L N_{i2}^* + g_{RB} N_{i1}^* + g_R N_{i5}^*) \right) Z_{k1}^+ \left( \frac{1 - \gamma_5}{2} \right) \quad (382)$$

$$+ -\frac{i}{2} \left( 2g_L V_{j1} N_{i4} + \sqrt{2} V_{j2} (g_L N_{i2} + g_{RB} N_{i1} + g_R N_{i5}) \right) Z_{k2}^+ \left( \frac{1 + \gamma_5}{2} \right) \quad (383)$$

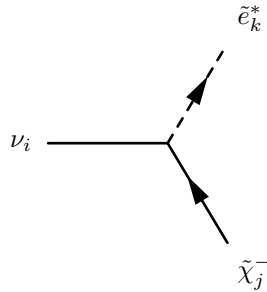

---



$$-i\delta_{\beta\gamma} \left( g_L U_{i1}^* \sum_{a=1}^3 U_{L,ja}^{u,*} Z_{ka}^D - U_{i2}^* \sum_{b=1}^3 U_{L,jb}^{u,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \right) \left( \frac{1 - \gamma_5}{2} \right) \quad (384)$$

$$+ i\delta_{\beta\gamma} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* U_{R,ja}^u Z_{kb}^D V_{i2} \left( \frac{1 + \gamma_5}{2} \right) \quad (385)$$

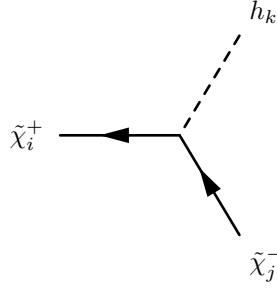

---



$$-i \left( g_L U_{j1}^* \sum_{a=1}^3 Z_{\nu,ia}^{V,*} Z_{ka}^E - U_{j2}^* \sum_{b=1}^3 Z_{\nu,ib}^{V,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \right) \left( \frac{1-\gamma_5}{2} \right) \quad (386)$$

$$+ i \sum_{b=1}^3 \sum_{a=1}^3 Y_{v,ab}^* Z_{\nu,i3+a}^V Z_{kb}^E V_{j2} \left( \frac{1+\gamma_5}{2} \right) \quad (387)$$

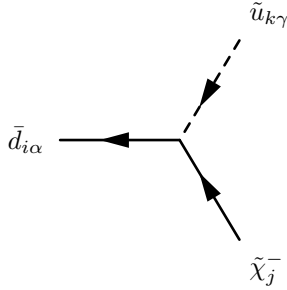

---



$$-i \frac{1}{\sqrt{2}} g_L \left( U_{j1}^* V_{i2}^* Z_{k2}^H + U_{j2}^* V_{i1}^* Z_{k1}^H \right) \left( \frac{1-\gamma_5}{2} \right) \quad (388)$$

$$+ -i \frac{1}{\sqrt{2}} g_L \left( U_{i1} V_{j2} Z_{k2}^H + U_{i2} V_{j1} Z_{k1}^H \right) \left( \frac{1+\gamma_5}{2} \right) \quad (389)$$


---

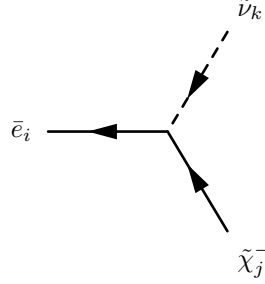


$$i U_{j2}^* \delta_{\alpha\gamma} \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 U_{R,ia}^{d,*} Y_{d,ab} \left( \frac{1-\gamma_5}{2} \right) \quad (390)$$

$$+ -i \delta_{\alpha\gamma} \left( g_L \sum_{a=1}^3 Z_{ka}^{U,*} U_{L,ia}^d V_{j1} - \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{k3+a}^{U,*} U_{L,ib}^d V_{j2} \right) \left( \frac{1+\gamma_5}{2} \right) \quad (391)$$

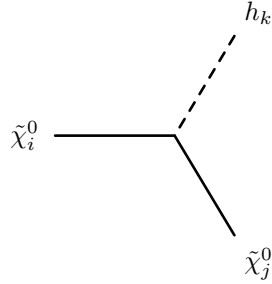

---





$$iU_{j2}^* \sum_{b=1}^3 Z_{kb}^{V,*} \sum_{a=1}^3 U_{R,ia}^{e,*} Y_{e,ab} \left( \frac{1-\gamma_5}{2} \right) \quad (392)$$

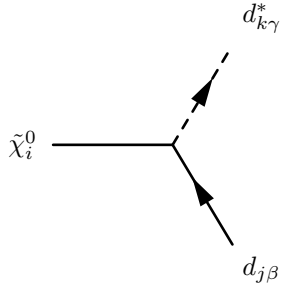
$$+ -i \left( g_L \sum_{a=1}^3 Z_{ka}^{V,*} U_{L,ia}^e V_{j1} - \sum_{b=1}^3 \sum_{a=1}^3 Y_{v,ab}^* Z_{k3+a}^{V,*} U_{L,ib}^e V_{j2} \right) \left( \frac{1+\gamma_5}{2} \right) \quad (393)$$



$$\begin{aligned} & \frac{i}{2} \left( -g_L N_{i2}^* N_{j3}^* Z_{k1}^H + g_R N_{i5}^* N_{j3}^* Z_{k1}^H + N_{i3}^* \left( -g_L N_{j2}^* + g_{RB} N_{j1}^* + g_R N_{j5}^* \right) Z_{k1}^H \right. \\ & - g_{RB} N_{i4}^* N_{j1}^* Z_{k2}^H + g_L N_{i4}^* N_{j2}^* Z_{k2}^H + g_L N_{i2}^* N_{j4}^* Z_{k2}^H - g_R N_{i5}^* N_{j4}^* Z_{k2}^H \\ & - g_R N_{i4}^* N_{j5}^* Z_{k2}^H - g_{BL} N_{i6}^* N_{j1}^* Z_{k3}^H + g_{RB} N_{i6}^* N_{j1}^* Z_{k3}^H - g_{BR} N_{i6}^* N_{j5}^* Z_{k3}^H \\ & + g_R N_{i6}^* N_{j5}^* Z_{k3}^H - g_{BR} N_{i5}^* N_{j6}^* Z_{k3}^H + g_R N_{i5}^* N_{j6}^* Z_{k3}^H + g_{BL} N_{i7}^* N_{j1}^* Z_{k4}^H \\ & - g_{RB} N_{i7}^* N_{j1}^* Z_{k4}^H + g_{BR} N_{i7}^* N_{j5}^* Z_{k4}^H - g_R N_{i7}^* N_{j5}^* Z_{k4}^H + g_{BR} N_{i5}^* N_{j7}^* Z_{k4}^H \\ & \left. - g_R N_{i5}^* N_{j7}^* Z_{k4}^H + N_{i1}^* \left( - \left( -g_{RB} + g_{BL} \right) \left( N_{j6}^* Z_{k3}^H - N_{j7}^* Z_{k4}^H \right) + g_{RB} N_{j3}^* Z_{k1}^H - g_{RB} N_{j4}^* Z_{k2}^H \right) \right) \left( \frac{1-\gamma_5}{2} \right) \quad (394) \\ & + -\frac{i}{2} \left( g_{BL} Z_{k3}^H N_{i6} N_{j1} - g_{RB} Z_{k3}^H N_{i6} N_{j1} - g_{BL} Z_{k4}^H N_{i7} N_{j1} + g_{RB} Z_{k4}^H N_{i7} N_{j1} + g_{BR} Z_{k3}^H N_{i6} N_{j5} \right. \\ & - g_R Z_{k3}^H N_{i6} N_{j5} - g_{BR} Z_{k4}^H N_{i7} N_{j5} + g_R Z_{k4}^H N_{i7} N_{j5} \\ & - Z_{k1}^H \left( \left( -g_L N_{i2} + g_{RB} N_{i1} + g_R N_{i5} \right) N_{j3} + N_{i3} \left( -g_L N_{j2} + g_{RB} N_{j1} + g_R N_{j5} \right) \right) \\ & \left. + Z_{k2}^H \left( \left( -g_L N_{i2} + g_{RB} N_{i1} + g_R N_{i5} \right) N_{j4} + N_{i4} \left( -g_L N_{j2} + g_{RB} N_{j1} + g_R N_{j5} \right) \right) + g_{BL} Z_{k3}^H N_{i1} N_{j6} \right) \end{aligned}$$

$$\begin{aligned}
& -g_{RB}Z_{k3}^HN_{i1}N_{j6} + g_{BR}Z_{k3}^HN_{i5}N_{j6} - g_RZ_{k3}^HN_{i5}N_{j6} - g_{BL}Z_{k4}^HN_{i1}N_{j7} \\
& + g_{RB}Z_{k4}^HN_{i1}N_{j7} - g_{BR}Z_{k4}^HN_{i5}N_{j7} + g_RZ_{k4}^HN_{i5}N_{j7} \left( \frac{1+\gamma_5}{2} \right)
\end{aligned} \tag{395}$$

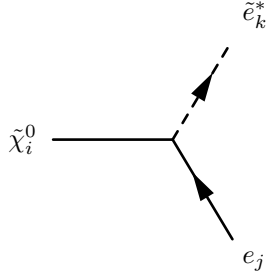

---



$$\begin{aligned}
& -\frac{i}{6}\delta_{\beta\gamma} \left( \sqrt{2}g_{BL}N_{i1}^* \sum_{a=1}^3 U_{L,ja}^{d,*} Z_{ka}^D - 3\sqrt{2}g_L N_{i2}^* \sum_{a=1}^3 U_{L,ja}^{d,*} Z_{ka}^D + \sqrt{2}g_{BR}N_{i5}^* \sum_{a=1}^3 U_{L,ja}^{d,*} Z_{ka}^D \right. \\
& \left. + 6N_{i3}^* \sum_{b=1}^3 U_{L,jb}^{d,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \right) \left( \frac{1-\gamma_5}{2} \right)
\end{aligned} \tag{396}$$

$$\begin{aligned}
& + \frac{i}{6}\delta_{\beta\gamma} \left( -6 \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab} U_{R,ja}^d Z_{kb}^D N_{i3} + \sqrt{2} \sum_{a=1}^3 Z_{k3+a}^D U_{R,ja}^d \left( (-3g_{RB} + g_{BL})N_{i1} + (-3g_R + g_{BR})N_{i5} \right) \right) \left( \frac{1+\gamma_5}{2} \right)
\end{aligned} \tag{397}$$

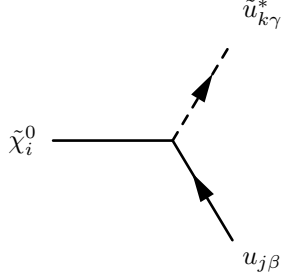

---



$$\begin{aligned}
& \frac{i}{2} \left( \sqrt{2}g_{BL}N_{i1}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{ka}^E + \sqrt{2}g_L N_{i2}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{ka}^E + \sqrt{2}g_{BR}N_{i5}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{ka}^E \right. \\
& \left. - 2N_{i3}^* \sum_{b=1}^3 U_{L,jb}^{e,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \right) \left( \frac{1-\gamma_5}{2} \right)
\end{aligned} \tag{398}$$

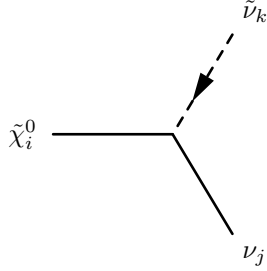
$$\begin{aligned}
& + -\frac{i}{2} \left( 2 \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab} U_{R,ja}^e Z_{kb}^E N_{i3} + \sqrt{2} \sum_{a=1}^3 Z_{k3+a}^E U_{R,ja}^e \left( (g_{BL} + g_{RB})N_{i1} + (g_{BR} + g_R)N_{i5} \right) \right) \left( \frac{1+\gamma_5}{2} \right)
\end{aligned} \tag{399}$$


---



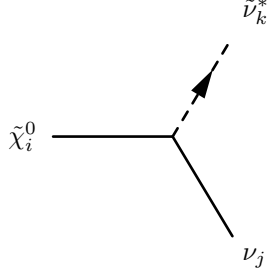
$$\begin{aligned}
& -\frac{i}{6}\delta_{\beta\gamma}\left(\sqrt{2}g_{BL}N_{i1}^*\sum_{a=1}^3U_{L,ja}^{u,*}Z_{ka}^U+3\sqrt{2}g_LN_{i2}^*\sum_{a=1}^3U_{L,ja}^{u,*}Z_{ka}^U+\sqrt{2}g_{BR}N_{i5}^*\sum_{a=1}^3U_{L,ja}^{u,*}Z_{ka}^U\right. \\
& \left.+6N_{i4}^*\sum_{b=1}^3U_{L,jb}^{u,*}\sum_{a=1}^3Y_{u,ab}Z_{k3+a}^U\right)\left(\frac{1-\gamma_5}{2}\right) \tag{400}
\end{aligned}$$

$$\begin{aligned}
& +\frac{i}{6}\delta_{\beta\gamma}\left(-6\sum_{b=1}^3\sum_{a=1}^3Y_{u,ab}^*U_{R,ja}^uZ_{kb}^UN_{i4}+\sqrt{2}\sum_{a=1}^3Z_{k3+a}^U U_{R,ja}^u\left(\left(3g_{RB}+g_{BL}\right)N_{i1}+\left(3g_R+g_{BR}\right)N_{i5}\right)\right)\left(\frac{1+\gamma_5}{2}\right) \tag{401}
\end{aligned}$$



$$\begin{aligned}
& -\frac{i}{2}\left(\sqrt{2}\left(-g_{RB}+g_{BL}\right)N_{i1}^*\sum_{a=1}^3Z_{\nu,j3+a}^{V,*}Z_{k3+a}^{V,*}+\sqrt{2}\left(-g_R+g_{BR}\right)N_{i5}^*\sum_{a=1}^3Z_{\nu,j3+a}^{V,*}Z_{k3+a}^{V,*}\right. \\
& \left.+2\left(N_{i4}^*\sum_{b=1}^3Z_{kb}^{V,*}\sum_{a=1}^3Z_{\nu,j3+a}^{V,*}Y_{v,ab}+N_{i7}^*\sum_{b=1}^3Z_{k6+b}^{V,*}\sum_{a=1}^3Z_{\nu,j3+a}^{V,*}Y_{s,ab}\right)\right)\left(\frac{1-\gamma_5}{2}\right) \tag{402}
\end{aligned}$$

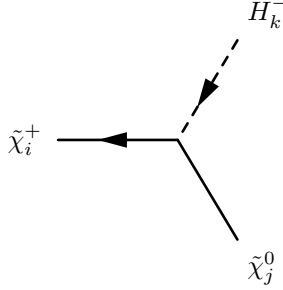
$$\begin{aligned}
& +\frac{i}{2}\left(\sqrt{2}\sum_{a=1}^3Z_{ka}^{V,*}Z_{\nu,ja}^V\left(g_{BL}N_{i1}+g_{BR}N_{i5}-g_LN_{i2}\right)\right. \\
& \left.-2\left(\sum_{b=1}^3\sum_{a=1}^3Y_{s,ab}^*Z_{k3+a}^{V,*}Z_{\nu,j6+b}^VN_{i7}+\sum_{b=1}^3\sum_{a=1}^3Y_{v,ab}^*Z_{k3+a}^{V,*}Z_{\nu,jb}^VN_{i4}\right)\right)\left(\frac{1+\gamma_5}{2}\right) \tag{403}
\end{aligned}$$



$$\begin{aligned}
& \frac{i}{2} \left( \sqrt{2} g_{BL} N_{i1}^* \sum_{a=1}^3 Z_{\nu,ja}^{V,*} Z_{ka}^V - \sqrt{2} g_L N_{i2}^* \sum_{a=1}^3 Z_{\nu,ja}^{V,*} Z_{ka}^V + \sqrt{2} g_{BR} N_{i5}^* \sum_{a=1}^3 Z_{\nu,ja}^{V,*} Z_{ka}^V \right. \\
& \left. - 2N_{i7}^* \sum_{b=1}^3 Z_{\nu,j6+b}^{V,*} \sum_{a=1}^3 Y_{s,ab} Z_{k3+a}^V - 2N_{i4}^* \sum_{b=1}^3 Z_{\nu,jb}^{V,*} \sum_{a=1}^3 Y_{v,ab} Z_{k3+a}^V \right) \left( \frac{1-\gamma_5}{2} \right) \quad (404)
\end{aligned}$$

$$\begin{aligned}
& + \frac{i}{2} \left( \sqrt{2} \sum_{a=1}^3 Z_{\nu,j3+a}^V Z_{k3+a}^V \left( (-g_{RB} + g_{BL}) N_{i1} + (-g_R + g_{BR}) N_{i5} \right) \right. \\
& \left. + 2 \left( \sum_{b=1}^3 \sum_{a=1}^3 Y_{s,ab}^* Z_{\nu,j3+a}^V Z_{k6+b}^V N_{i7} + \sum_{b=1}^3 \sum_{a=1}^3 Y_{v,ab}^* Z_{\nu,j3+a}^V Z_{kb}^V N_{i4} \right) \right) \left( \frac{1+\gamma_5}{2} \right) \quad (405)
\end{aligned}$$

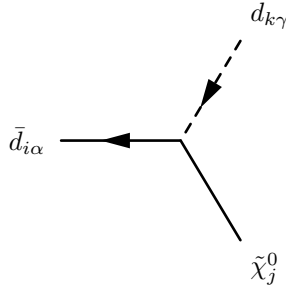

---



$$- \frac{i}{2} \left( 2g_L V_{i1}^* N_{j4}^* + \sqrt{2} V_{i2}^* \left( g_L N_{j2}^* + g_{RB} N_{j1}^* + g_R N_{j5}^* \right) \right) Z_{k2}^+ \left( \frac{1-\gamma_5}{2} \right) \quad (406)$$

$$+ \frac{i}{2} \left( -2g_L U_{i1} N_{j3} + \sqrt{2} U_{i2} \left( g_L N_{j2} + g_{RB} N_{j1} + g_R N_{j5} \right) \right) Z_{k1}^+ \left( \frac{1+\gamma_5}{2} \right) \quad (407)$$

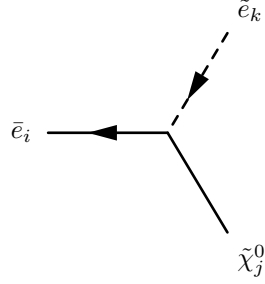

---



$$\begin{aligned} & \frac{i}{6} \delta_{\alpha\gamma} \left( \sqrt{2} \left( -3g_{RB} + g_{BL} \right) N_{j1}^* \sum_{a=1}^3 Z_{k3+a}^{D,*} U_{R,ia}^{d,*} + \sqrt{2} \left( -3g_R + g_{BR} \right) N_{j5}^* \sum_{a=1}^3 Z_{k3+a}^{D,*} U_{R,ia}^{d,*} \right. \\ & \left. - 6N_{j3}^* \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 U_{R,ia}^{d,*} Y_{d,ab} \right) \left( \frac{1-\gamma_5}{2} \right) \end{aligned} \quad (408)$$

$$+ \frac{i}{6} \delta_{\alpha\gamma} \left( 6 \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{k3+a}^{D,*} U_{L,ib}^d N_{j3} + \sqrt{2} \sum_{a=1}^3 Z_{ka}^{D,*} U_{L,ia}^d \left( -3g_L N_{j2} + g_{BL} N_{j1} + g_{BR} N_{j5} \right) \right) \left( \frac{1+\gamma_5}{2} \right) \quad (409)$$

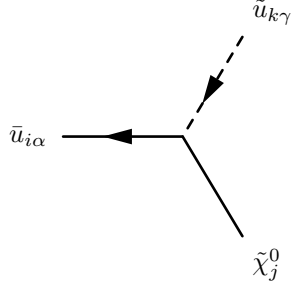

---



$$\begin{aligned} & -\frac{i}{2} \left( \sqrt{2} \left( g_{BL} + g_{RB} \right) N_{j1}^* \sum_{a=1}^3 Z_{k3+a}^{E,*} U_{R,ia}^{e,*} + \sqrt{2} \left( g_{BR} + g_R \right) N_{j5}^* \sum_{a=1}^3 Z_{k3+a}^{E,*} U_{R,ia}^{e,*} \right. \\ & \left. + 2N_{j3}^* \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 U_{R,ia}^{e,*} Y_{e,ab} \right) \left( \frac{1-\gamma_5}{2} \right) \end{aligned} \quad (410)$$

$$+ \frac{i}{2} \left( -2 \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{k3+a}^{E,*} U_{L,ib}^e N_{j3} + \sqrt{2} \sum_{a=1}^3 Z_{ka}^{E,*} U_{L,ia}^e \left( g_{BL} N_{j1} + g_{BR} N_{j5} + g_L N_{j2} \right) \right) \left( \frac{1+\gamma_5}{2} \right) \quad (411)$$

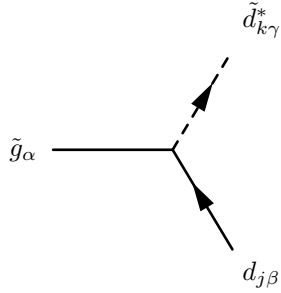

---



$$\begin{aligned} & \frac{i}{6} \delta_{\alpha\gamma} \left( \sqrt{2} (3g_{RB} + g_{BL}) N_{j1}^* \sum_{a=1}^3 Z_{k3+a}^{U,*} U_{R,ia}^{u,*} + \sqrt{2} (3g_R + g_{BR}) N_{j5}^* \sum_{a=1}^3 Z_{k3+a}^{U,*} U_{R,ia}^{u,*} \right. \\ & \left. - 6N_{j4}^* \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 U_{R,ia}^{u,*} Y_{u,ab} \right) \left( \frac{1 - \gamma_5}{2} \right) \end{aligned} \quad (412)$$

$$+ -\frac{i}{6} \delta_{\alpha\gamma} \left( 6 \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* Z_{k3+a}^{U,*} U_{L,ib}^u N_{j4} + \sqrt{2} \sum_{a=1}^3 Z_{ka}^{U,*} U_{L,ia}^u (3g_L N_{j2} + g_{BL} N_{j1} + g_{BR} N_{j5}) \right) \left( \frac{1 + \gamma_5}{2} \right) \quad (413)$$

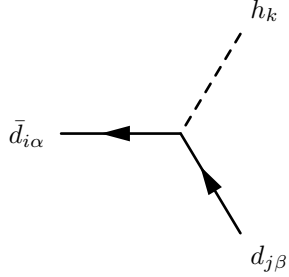

---



$$- i \frac{1}{\sqrt{2}} g_s \lambda_{\gamma,\beta}^\alpha \sum_{a=1}^3 U_{L,ja}^{d,*} Z_{ka}^D \left( \frac{1 - \gamma_5}{2} \right) \quad (414)$$

$$+ i \frac{1}{\sqrt{2}} g_s \lambda_{\gamma,\beta}^\alpha \sum_{a=1}^3 Z_{k3+a}^D U_{R,ja}^d \left( \frac{1 + \gamma_5}{2} \right) \quad (415)$$

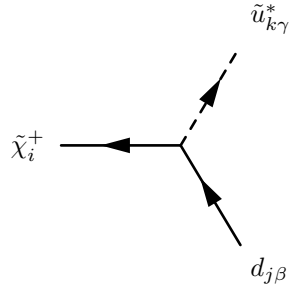

---



$$-i \frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{d,*} \sum_{a=1}^3 U_{R,ia}^{d,*} Y_{d,ab} Z_{k1}^H \left( \frac{1-\gamma_5}{2} \right) \quad (416)$$

$$+ -i \frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* U_{R,ja}^d U_{L,ib}^d Z_{k1}^H \left( \frac{1+\gamma_5}{2} \right) \quad (417)$$

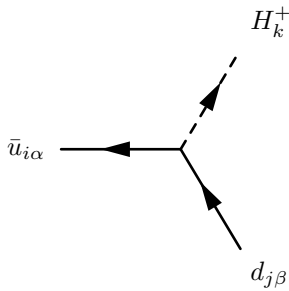

---



$$-i \delta_{\beta\gamma} \left( g_L V_{i1}^* \sum_{a=1}^3 U_{L,ja}^{d,*} Z_{ka}^U - V_{i2}^* \sum_{b=1}^3 U_{L,jb}^{d,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U \right) \left( \frac{1-\gamma_5}{2} \right) \quad (418)$$

$$+ i \delta_{\beta\gamma} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* U_{R,ja}^d Z_{kb}^U U_{i2} \left( \frac{1+\gamma_5}{2} \right) \quad (419)$$

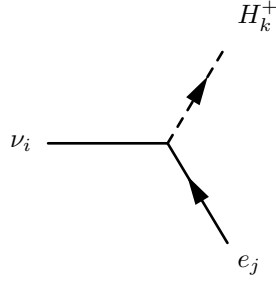

---



$$i\delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{d,*} \sum_{a=1}^3 U_{R,ia}^{u,*} Y_{u,ab} Z_{k2}^+ \left( \frac{1-\gamma_5}{2} \right) \quad (420)$$

$$+ i\delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* U_{R,ja}^d U_{L,ib}^u Z_{k1}^+ \left( \frac{1+\gamma_5}{2} \right) \quad (421)$$

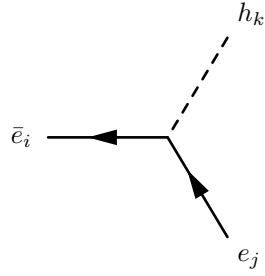

---



$$i \sum_{b=1}^3 U_{L,jb}^{e,*} \sum_{a=1}^3 Z_{\nu,i3+a}^{V,*} Y_{v,ab} Z_{k2}^+ \left( \frac{1-\gamma_5}{2} \right) \quad (422)$$

$$+ i \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* U_{R,ja}^e Z_{\nu,ib}^V Z_{k1}^+ \left( \frac{1+\gamma_5}{2} \right) \quad (423)$$


---

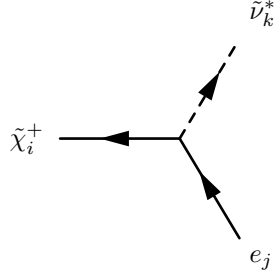


$$-i \frac{1}{\sqrt{2}} \sum_{b=1}^3 U_{L,jb}^{e,*} \sum_{a=1}^3 U_{R,ia}^{e,*} Y_{e,ab} Z_{k1}^H \left( \frac{1-\gamma_5}{2} \right) \quad (424)$$

$$+ -i \frac{1}{\sqrt{2}} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* U_{R,ja}^e U_{L,ib}^e Z_{k1}^H \left( \frac{1+\gamma_5}{2} \right) \quad (425)$$


---

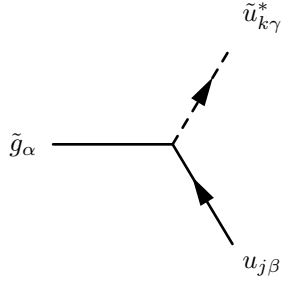




$$-i \left( g_L V_{i1}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{ka}^V - V_{i2}^* \sum_{b=1}^3 U_{L,jb}^{e,*} \sum_{a=1}^3 Y_{v,ab} Z_{k3+a}^V \right) \left( \frac{1 - \gamma_5}{2} \right) \quad (426)$$

$$+ i \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* U_{R,ja}^e Z_{kb}^V U_{i2} \left( \frac{1 + \gamma_5}{2} \right) \quad (427)$$

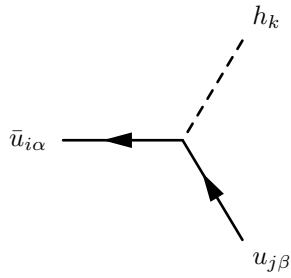

---



$$-i \frac{1}{\sqrt{2}} g_s \lambda_{\gamma,\beta}^\alpha \sum_{a=1}^3 U_{L,ja}^{u,*} Z_{ka}^U \left( \frac{1 - \gamma_5}{2} \right) \quad (428)$$

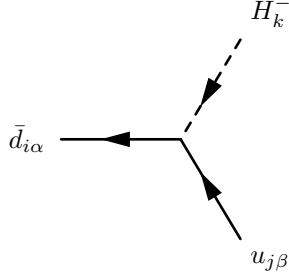
$$+ i \frac{1}{\sqrt{2}} g_s \lambda_{\gamma,\beta}^\alpha \sum_{a=1}^3 Z_{k3+a}^U U_{R,ja}^u \left( \frac{1 + \gamma_5}{2} \right) \quad (429)$$


---



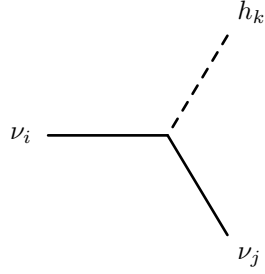
$$-i \frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{u,*} \sum_{a=1}^3 U_{R,ia}^{u,*} Y_{u,ab} Z_{k2}^H \left( \frac{1-\gamma_5}{2} \right) \quad (430)$$

$$+ -i \frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* U_{R,ja}^u U_{L,ib}^u Z_{k2}^H \left( \frac{1+\gamma_5}{2} \right) \quad (431)$$



$$i \delta_{\alpha\beta} \sum_{b=1}^3 U_{L,jb}^{u,*} \sum_{a=1}^3 U_{R,ia}^{d,*} Y_{d,ab} Z_{k1}^+ \left( \frac{1-\gamma_5}{2} \right) \quad (432)$$

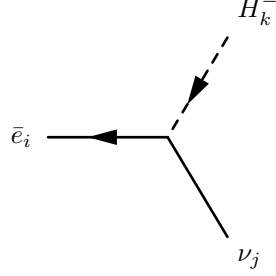
$$+ i \delta_{\alpha\beta} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ab}^* U_{R,ja}^u U_{L,ib}^d Z_{k2}^+ \left( \frac{1+\gamma_5}{2} \right) \quad (433)$$



$$-i \frac{1}{\sqrt{2}} \left( \sum_{b=1}^3 Z_{\nu,jb}^{V,*} \sum_{a=1}^3 Z_{\nu,i3+a}^{V,*} Y_{v,ab} Z_{k2}^H + \sum_{b=1}^3 Z_{\nu,ib}^{V,*} \sum_{a=1}^3 Z_{\nu,j3+a}^{V,*} Y_{v,ab} Z_{k2}^H \right. \\ \left. + \left( \sum_{b=1}^3 Z_{\nu,j6+b}^{V,*} \sum_{a=1}^3 Z_{\nu,i3+a}^{V,*} Y_{s,ab} + \sum_{b=1}^3 Z_{\nu,i6+b}^{V,*} \sum_{a=1}^3 Z_{\nu,j3+a}^{V,*} Y_{s,ab} \right) Z_{k4}^H \right) \left( \frac{1-\gamma_5}{2} \right) \quad (434) \\ + -i \frac{1}{\sqrt{2}} \left( \sum_{b=1}^3 \sum_{a=1}^3 Y_{v,ab}^* Z_{\nu,j3+a}^V Z_{\nu,ib}^V Z_{k2}^H + \sum_{b=1}^3 \sum_{a=1}^3 Y_{v,ab}^* Z_{\nu,i3+a}^V Z_{\nu,jb}^V Z_{k2}^H \right)$$

$$+ \left( \sum_{b=1}^3 \sum_{a=1}^3 Y_{s,ab}^* Z_{\nu,j3+a}^V Z_{\nu,i6+b}^V + \sum_{b=1}^3 \sum_{a=1}^3 Y_{s,ab}^* Z_{\nu,i3+a}^V Z_{\nu,j6+b}^V \right) Z_{k4}^H \left( \frac{1+\gamma_5}{2} \right) \quad (435)$$

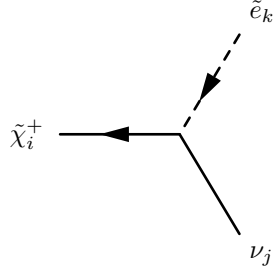

---



$$i \sum_{b=1}^3 Z_{\nu,jb}^{V,*} \sum_{a=1}^3 U_{R,ia}^{e,*} Y_{e,ab} Z_{k1}^+ \left( \frac{1-\gamma_5}{2} \right) \quad (436)$$

$$+ i \sum_{b=1}^3 \sum_{a=1}^3 Y_{v,ab}^* Z_{\nu,j3+a}^V U_{L,ib}^e Z_{k2}^+ \left( \frac{1+\gamma_5}{2} \right) \quad (437)$$

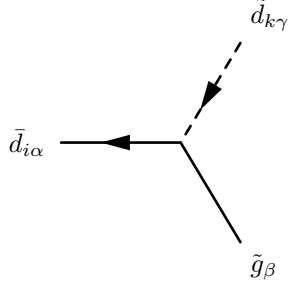

---



$$i V_{i2}^* \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Z_{\nu,j3+a}^{V,*} Y_{v,ab} \left( \frac{1-\gamma_5}{2} \right) \quad (438)$$

$$+ -i \left( g_L \sum_{a=1}^3 Z_{ka}^{E,*} Z_{\nu,ja}^V U_{i1} - \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ab}^* Z_{k3+a}^{E,*} Z_{\nu,jb}^V U_{i2} \right) \left( \frac{1+\gamma_5}{2} \right) \quad (439)$$

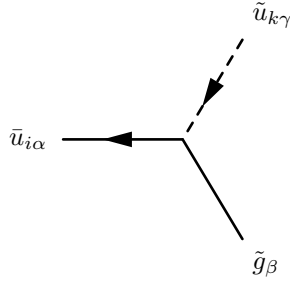

---



$$i \frac{1}{\sqrt{2}} g_s \lambda_{\alpha,\gamma}^\beta \sum_{a=1}^3 Z_{k3+a}^{D,*} U_{R,ia}^{d,*} \left( \frac{1-\gamma_5}{2} \right) \quad (440)$$

$$+ -i \frac{1}{\sqrt{2}} g_s \lambda_{\alpha,\gamma}^\beta \sum_{a=1}^3 Z_{ka}^{D,*} U_{L,ia}^d \left( \frac{1+\gamma_5}{2} \right) \quad (441)$$

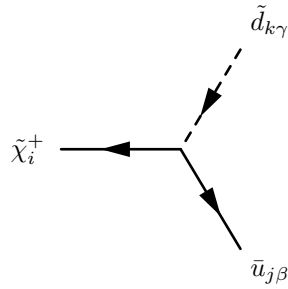

---



$$i \frac{1}{\sqrt{2}} g_s \lambda_{\alpha,\gamma}^\beta \sum_{a=1}^3 Z_{k3+a}^{U,*} U_{R,ia}^{u,*} \left( \frac{1-\gamma_5}{2} \right) \quad (442)$$

$$+ -i \frac{1}{\sqrt{2}} g_s \lambda_{\alpha,\gamma}^\beta \sum_{a=1}^3 Z_{ka}^{U,*} U_{L,ia}^u \left( \frac{1+\gamma_5}{2} \right) \quad (443)$$

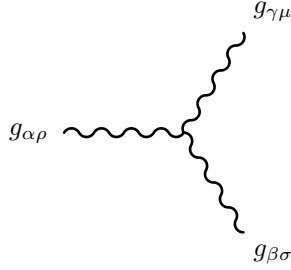

---



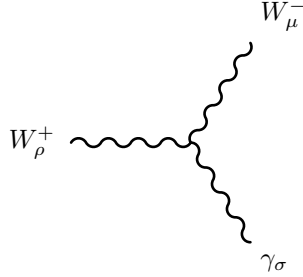
$$iV_{i2}^* \delta_{\beta\gamma} \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 U_{R,ja}^{u,*} Y_{u,ab} \left( \frac{1-\gamma_5}{2} \right) \quad (444)$$

$$+ -i\delta_{\beta\gamma} \left( g_L \sum_{a=1}^3 Z_{ka}^{D,*} U_{L,ja}^u U_{i1} - \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ab}^* Z_{k3+a}^{D,*} U_{L,jb}^u U_{i2} \right) \left( \frac{1+\gamma_5}{2} \right) \quad (445)$$

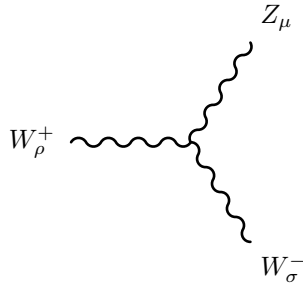
## 9.6 Three Vector Boson-Interaction



$$g_s f_{\alpha,\beta,\gamma} \left( g_{\rho\mu} \left( -p_\sigma^{g\gamma\mu} + p_\sigma^{g\alpha\rho} \right) + g_{\rho\sigma} \left( -p_\mu^{g\alpha\rho} + p_\mu^{g\beta\sigma} \right) + g_{\sigma\mu} \left( -p_\rho^{g\beta\sigma} + p_\rho^{g\gamma\mu} \right) \right) \quad (446)$$

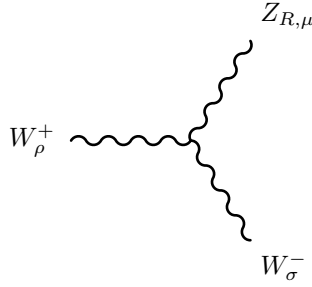


$$i g_L Z Z_{11} \left( g_{\rho\mu} \left( -p_\sigma^{W_\mu^-} + p_\sigma^{W_\rho^+} \right) + g_{\rho\sigma} \left( -p_\mu^{W_\rho^+} + p_\mu^{\gamma_\sigma} \right) + g_{\sigma\mu} \left( -p_\rho^{\gamma_\sigma} + p_\rho^{W_\mu^-} \right) \right) \quad (447)$$



$$-ig_L Z Z_{12} \left( g_{\rho\mu} \left( -p_{\sigma}^{Z_\mu} + p_{\sigma}^{W_\rho^+} \right) + g_{\rho\sigma} \left( -p_{\mu}^{W_\rho^+} + p_{\mu}^{W_\sigma^-} \right) + g_{\sigma\mu} \left( -p_{\rho}^{W_\sigma^-} + p_{\rho}^{Z_\mu} \right) \right) \quad (448)$$

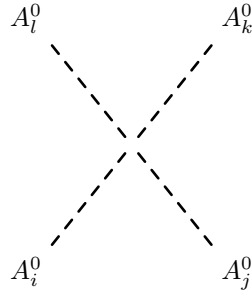

---



$$-ig_L Z Z_{13} \left( g_{\rho\mu} \left( -p_{\sigma}^{Z_{R,\mu}} + p_{\sigma}^{W_\rho^+} \right) + g_{\rho\sigma} \left( -p_{\mu}^{W_\rho^+} + p_{\mu}^{W_\sigma^-} \right) + g_{\sigma\mu} \left( -p_{\rho}^{W_\sigma^-} + p_{\rho}^{Z_{R,\mu}} \right) \right) \quad (449)$$

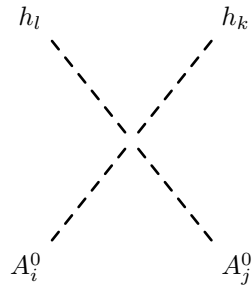

---

## 9.7 Four Scalar-Interaction



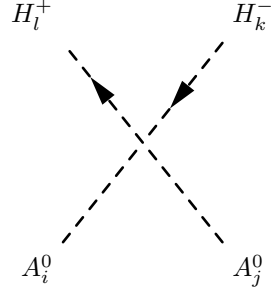
$$-\frac{i}{4} (\text{tempString}) \quad (450)$$


---

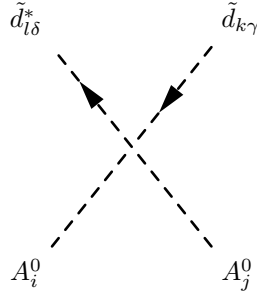


$$-\frac{i}{4} (\text{tempString}) \quad (451)$$

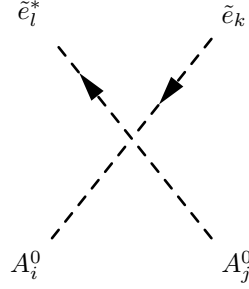

---



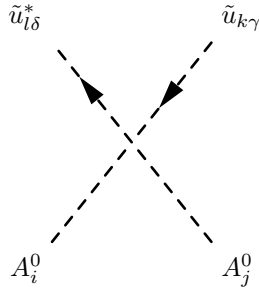
$$\frac{i}{4}(\text{tempString}) \quad (452)$$



$$\begin{aligned}
& \frac{i}{12} \delta_{\gamma\delta} \left( -12 \left( \sum_{c=1}^3 Z_{k3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{d,ba} Z_{l3+b}^D + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^D \right) Z_{i1}^A Z_{j1}^A \right. \\
& + \sum_{a=1}^3 Z_{ka}^{D,*} Z_{la}^D \left( (3g_L^2 + g_{BL}g_{RB} + g_{BR}g_R) Z_{i1}^A Z_{j1}^A - (3g_L^2 + g_{BL}g_{RB} + g_{BR}g_R) Z_{i2}^A Z_{j2}^A \right. \\
& - \left. \left( -g_{BL}g_{RB} + g_{BR}(-g_R + g_{BR}) + g_{BL}^2 \right) (Z_{i3}^A Z_{j3}^A - Z_{i4}^A Z_{j4}^A) \right) \\
& + \sum_{a=1}^3 Z_{k3+a}^{D,*} Z_{l3+a}^D \left( - \left( -3g_R^2 + (-3g_{RB} + g_{BL})g_{RB} + g_{BR}g_R \right) Z_{i1}^A Z_{j1}^A + \left( -3g_R^2 + (-3g_{RB} + g_{BL})g_{RB} + g_{BR}g_R \right) Z_{i2}^A Z_{j2}^A \right. \\
& \left. + \left( 3(g_R^2 + g_{RB}^2) - 4g_{BL}g_{RB} - 4g_{BR}g_R + g_{BL}^2 + g_{BR}^2 \right) (Z_{i3}^A Z_{j3}^A - Z_{i4}^A Z_{j4}^A) \right) \quad (453)
\end{aligned}$$



$$\begin{aligned}
& \frac{i}{4} \left( -4 \left( \sum_{c=1}^3 Z_{k3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{e,ba} Z_{l3+b}^E + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E \right) Z_{i1}^A Z_{j1}^A \right. \\
& + \sum_{a=1}^3 Z_{ka}^{E,*} Z_{la}^E \left( \left( -g_{BL}g_{RB} - g_{BR}g_R + g_L^2 \right) Z_{i1}^A Z_{j1}^A + \left( g_{BL}g_{RB} + g_{BR}g_R - g_L^2 \right) Z_{i2}^A Z_{j2}^A \right. \\
& + \left. \left( -g_{BL}g_{RB} + g_{BR} \left( -g_R + g_{BR} \right) + g_{BL}^2 \right) \left( Z_{i3}^A Z_{j3}^A - Z_{i4}^A Z_{j4}^A \right) \right) \\
& + \sum_{a=1}^3 Z_{k3+a}^{E,*} Z_{l3+a}^E \left( \left( g_{BR}g_R + g_{RB} \left( g_{BL} + g_{RB} \right) + g_R^2 \right) Z_{i1}^A Z_{j1}^A - \left( g_{BR}g_R + g_{RB} \left( g_{BL} + g_{RB} \right) + g_R^2 \right) Z_{i2}^A Z_{j2}^A \right. \\
& \left. \left. - \left( -g_R^2 - g_{RB}^2 + g_{BL}^2 + g_{BR}^2 \right) \left( Z_{i3}^A Z_{j3}^A - Z_{i4}^A Z_{j4}^A \right) \right) \right) \quad (454)
\end{aligned}$$

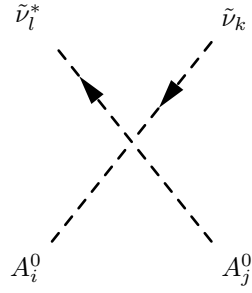


$$\begin{aligned}
& -\frac{i}{12} \delta_{\gamma\delta} \left( 12 \left( \sum_{c=1}^3 Z_{k3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{u,ba} Z_{l3+b}^U + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^U \right) Z_{i2}^A Z_{j2}^A \right. \\
& + \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^U \left( \left( 3g_L^2 - g_{BL}g_{RB} - g_{BR}g_R \right) Z_{i1}^A Z_{j1}^A + \left( -3g_L^2 + g_{BL}g_{RB} + g_{BR}g_R \right) Z_{i2}^A Z_{j2}^A \right. \\
& + \left. \left( -g_{BL}g_{RB} + g_{BR} \left( -g_R + g_{BR} \right) + g_{BL}^2 \right) \left( Z_{i3}^A Z_{j3}^A - Z_{i4}^A Z_{j4}^A \right) \right) \\
& + \sum_{a=1}^3 Z_{k3+a}^{U,*} Z_{l3+a}^U \left( \left( 3g_R^2 + g_{BR}g_R + g_{RB} \left( 3g_{RB} + g_{BL} \right) \right) Z_{i1}^A Z_{j1}^A - \left( 3g_R^2 + g_{BR}g_R + g_{RB} \left( 3g_{RB} + g_{BL} \right) \right) Z_{i2}^A Z_{j2}^A \right.
\end{aligned}$$



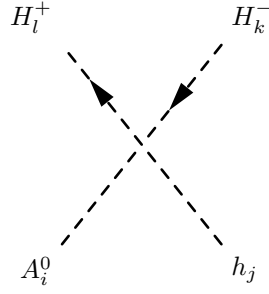
$$- \left( 2g_{BL}g_{RB} + 2g_{BR}g_{RL} - 3(g_R^2 + g_{RB}^2) + g_{BL}^2 + g_{BR}^2 \right) (Z_{i3}^A Z_{j3}^A - Z_{i4}^A Z_{j4}^A) \quad (455)$$


---



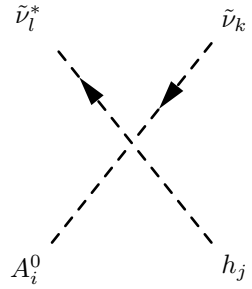
$$- \frac{i}{4} (\text{tempString}) \quad (456)$$


---



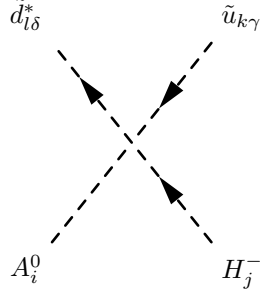
$$\frac{1}{4} g_L^2 (Z_{i1}^A Z_{j2}^H + Z_{i2}^A Z_{j1}^H) (-Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+) \quad (457)$$


---



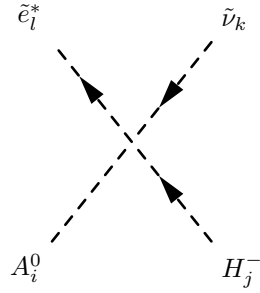
$$\frac{1}{2} \left( - \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{V,*} \sum_{a=1}^3 Y_{s,ac}^* Y_{v,ab} Z_{l6+c}^V + \sum_{c=1}^3 \sum_{b=1}^3 Z_{k6+b}^{V,*} \sum_{a=1}^3 Y_{v,ac}^* Y_{s,ab} Z_{lc}^V \right) (-Z_{i2}^A Z_{j4}^H + Z_{i4}^A Z_{j2}^H) \quad (458)$$


---



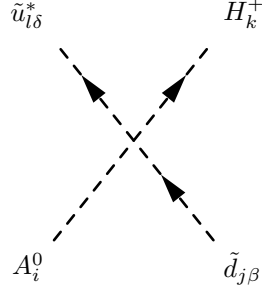
$$\begin{aligned}
& \frac{1}{2} \frac{1}{\sqrt{2}} \delta_{\gamma\delta} \left( g_L^2 \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^D \left( -Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+ \right) \right. \\
& + 2 \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^D Z_{i1}^A Z_{j1}^+ - \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^D Z_{i2}^A Z_{j2}^+ \right. \\
& \left. \left. + \sum_{c=1}^3 Z_{k3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{d,ba} Z_{l3+b}^D \left( -Z_{i1}^A Z_{j2}^+ + Z_{i2}^A Z_{j1}^+ \right) \right) \right) \quad (459)
\end{aligned}$$


---

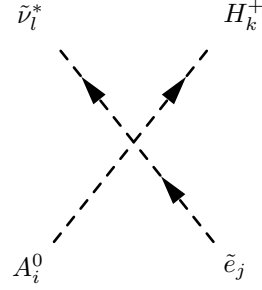


$$\begin{aligned}
& \frac{1}{2} \frac{1}{\sqrt{2}} \left( g_L^2 \sum_{a=1}^3 Z_{ka}^{V,*} Z_{la}^E \left( -Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+ \right) \right. \\
& + 2 \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{V,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E Z_{i1}^A Z_{j1}^+ \right. \\
& - \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{k6+b}^{V,*} \sum_{a=1}^3 Y_{v,ac}^* Y_{s,ab} Z_{lc}^E Z_{i4}^A + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{V,*} \sum_{a=1}^3 Y_{v,ac}^* Y_{v,ab} Z_{lc}^E Z_{i2}^A \right) Z_{j2}^+ \\
& \left. \left. + \sum_{c=1}^3 Z_{k3+c}^{V,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{v,ca}^* Y_{e,ba} Z_{l3+b}^E \left( -Z_{i1}^A Z_{j2}^+ + Z_{i2}^A Z_{j1}^+ \right) \right) \right) \quad (460)
\end{aligned}$$

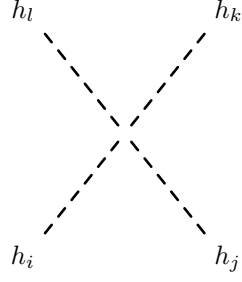

---



$$\begin{aligned}
& \frac{1}{2} \frac{1}{\sqrt{2}} \delta_{\beta\delta} \left( -2 \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^U Z_{i1}^A Z_{k1}^+ \right. \\
& - 2 \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{u,ba} Z_{l3+b}^U Z_{i2}^A Z_{k1}^+ \\
& + 2 \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{u,ba} Z_{l3+b}^U Z_{i1}^A Z_{k2}^+ \\
& \left. + 2 \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^U Z_{i2}^A Z_{k2}^+ + g_L^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^U \left( Z_{i1}^A Z_{k1}^+ - Z_{i2}^A Z_{k2}^+ \right) \right) \quad (461)
\end{aligned}$$

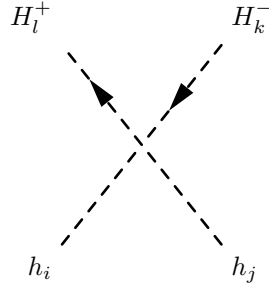


$$\begin{aligned}
& \frac{1}{2} \frac{1}{\sqrt{2}} \left( g_L^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^V \left( Z_{i1}^A Z_{k1}^+ - Z_{i2}^A Z_{k2}^+ \right) \right. \\
& + 2 \left( - \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^V Z_{i1}^A Z_{k1}^+ \right. \\
& + \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{s,ac}^* Y_{v,ab} Z_{l6+c}^V Z_{i4}^A + \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{v,ac}^* Y_{v,ab} Z_{lc}^V Z_{i2}^A \right) Z_{k2}^+ \\
& \left. \left. + \sum_{c=1}^3 Z_{j3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{v,ba} Z_{l3+b}^V \left( Z_{i1}^A Z_{k2}^+ - Z_{i2}^A Z_{k1}^+ \right) \right) \right) \quad (462)
\end{aligned}$$



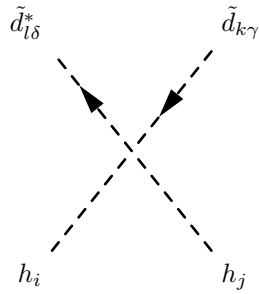
$$-\frac{i}{4}(\text{tempString}) \quad (463)$$


---



$$\frac{i}{4}(\text{tempString}) \quad (464)$$

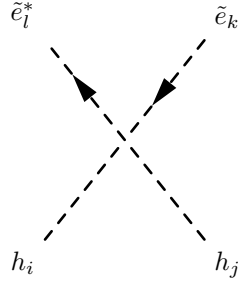

---



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

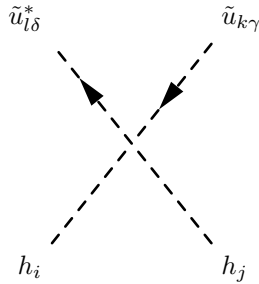
$$\begin{aligned}
& - \left( -g_{BL}g_{RB} + g_{BR}(-g_R + g_{BR}) + g_{BL}^2 \right) \left( Z_{i3}^H Z_{j3}^H - Z_{i4}^H Z_{j4}^H \right) \\
& + \sum_{a=1}^3 Z_{k3+a}^{D,*} Z_{l3+a}^D \left( - \left( -3g_R^2 + \left( -3g_{RB} + g_{BL} \right) g_{RB} + g_{BR}g_R \right) Z_{i1}^H Z_{j1}^H + \left( -3g_R^2 + \left( -3g_{RB} + g_{BL} \right) g_{RB} + g_{BR}g_R \right) Z_{i2}^H Z_{j2}^H \right. \\
& \left. + \left( 3 \left( g_R^2 + g_{RB}^2 \right) - 4g_{BL}g_{RB} - 4g_{BR}g_R + g_{BL}^2 + g_{BR}^2 \right) \left( Z_{i3}^H Z_{j3}^H - Z_{i4}^H Z_{j4}^H \right) \right) \quad (465)
\end{aligned}$$


---



$$\begin{aligned}
& \frac{i}{4} \left( -4 \left( \sum_{c=1}^3 Z_{k3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{e,ba} Z_{l3+b}^E + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E \right) Z_{i1}^H Z_{j1}^H \right. \\
& + \sum_{a=1}^3 Z_{ka}^{E,*} Z_{la}^E \left( \left( -g_{BL}g_{RB} - g_{BR}g_R + g_L^2 \right) Z_{i1}^H Z_{j1}^H + \left( g_{BL}g_{RB} + g_{BR}g_R - g_L^2 \right) Z_{i2}^H Z_{j2}^H \right. \\
& + \left. \left. \left( -g_{BL}g_{RB} + g_{BR}(-g_R + g_{BR}) + g_{BL}^2 \right) \left( Z_{i3}^H Z_{j3}^H - Z_{i4}^H Z_{j4}^H \right) \right) \right. \\
& + \sum_{a=1}^3 Z_{k3+a}^{E,*} Z_{l3+a}^E \left( \left( g_{BR}g_R + g_{RB}(g_{BL} + g_{RB}) + g_R^2 \right) Z_{i1}^H Z_{j1}^H - \left( g_{BR}g_R + g_{RB}(g_{BL} + g_{RB}) + g_R^2 \right) Z_{i2}^H Z_{j2}^H \right. \\
& \left. \left. - \left( -g_R^2 - g_{RB}^2 + g_{BL}^2 + g_{BR}^2 \right) \left( Z_{i3}^H Z_{j3}^H - Z_{i4}^H Z_{j4}^H \right) \right) \right) \quad (466)
\end{aligned}$$

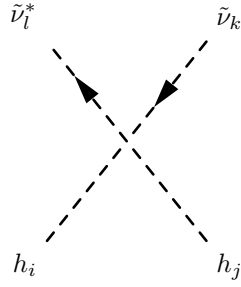

---



$$- \frac{i}{12} \delta_{\gamma\delta} \left( 12 \left( \sum_{c=1}^3 Z_{k3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{u,ba} Z_{l3+b}^U + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^U \right) Z_{i2}^H Z_{j2}^H \right)$$

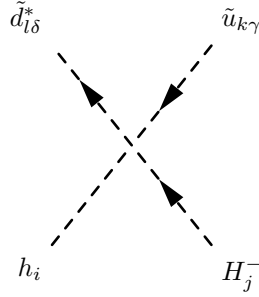
$$\begin{aligned}
& + \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^U \left( (3g_L^2 - g_{BL}g_{RB} - g_{BR}g_R) Z_{i1}^H Z_{j1}^H + (-3g_L^2 + g_{BL}g_{RB} + g_{BR}g_R) Z_{i2}^H Z_{j2}^H \right. \\
& + \left. (-g_{BL}g_{RB} + g_{BR}(-g_R + g_{BR}) + g_{BL}^2) (Z_{i3}^H Z_{j3}^H - Z_{i4}^H Z_{j4}^H) \right) \\
& + \sum_{a=1}^3 Z_{k3+a}^{U,*} Z_{l3+a}^U \left( (3g_R^2 + g_{BR}g_R + g_{RB}(3g_{RB} + g_{BL})) Z_{i1}^H Z_{j1}^H - (3g_R^2 + g_{BR}g_R + g_{RB}(3g_{RB} + g_{BL})) Z_{i2}^H Z_{j2}^H \right. \\
& \left. - (2g_{BL}g_{RB} + 2g_{BR}g_R - 3(g_R^2 + g_{RB}^2) + g_{BL}^2 + g_{BR}^2) (Z_{i3}^H Z_{j3}^H - Z_{i4}^H Z_{j4}^H) \right) \tag{467}
\end{aligned}$$


---



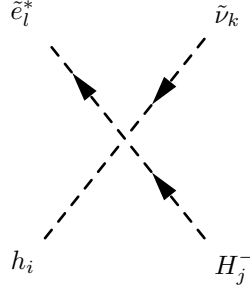
$$- \frac{i}{4} (\text{tempString}) \tag{468}$$


---

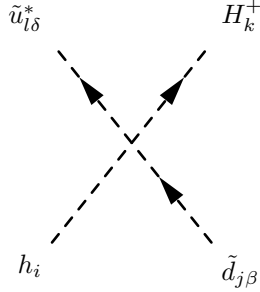


$$\begin{aligned}
& - \frac{i}{2} \frac{1}{\sqrt{2}} \delta_{\gamma\delta} \left( g_L^2 \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^D (Z_{i1}^H Z_{j1}^+ + Z_{i2}^H Z_{j2}^+) \right. \\
& - 2 \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^D Z_{i1}^H Z_{j1}^+ + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{U,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^D Z_{i2}^H Z_{j2}^+ \right. \\
& \left. \left. + \sum_{c=1}^3 Z_{k3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{d,ba} Z_{l3+b}^D (Z_{i1}^H Z_{j2}^+ + Z_{i2}^H Z_{j1}^+) \right) \right) \tag{469}
\end{aligned}$$

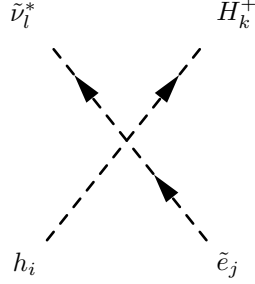

---



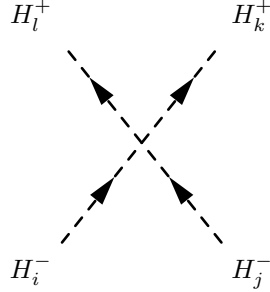
$$\begin{aligned}
& -\frac{i}{2} \frac{1}{\sqrt{2}} \left( g_L^2 \sum_{a=1}^3 Z_{ka}^{V,*} Z_{la}^E \left( Z_{i1}^H Z_{j1}^+ + Z_{i2}^H Z_{j2}^+ \right) \right. \\
& - 2 \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{V,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^E Z_{i1}^H Z_{j1}^+ \right. \\
& + \left. \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{k6+b}^{V,*} \sum_{a=1}^3 Y_{v,ac}^* Y_{s,ab} Z_{lc}^E Z_{i4}^H + \sum_{c=1}^3 \sum_{b=1}^3 Z_{kb}^{V,*} \sum_{a=1}^3 Y_{v,ac}^* Y_{v,ab} Z_{lc}^E Z_{i2}^H \right) Z_{j2}^+ \right. \\
& \left. \left. + \sum_{c=1}^3 Z_{k3+c}^{V,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{v,ca}^* Y_{e,ba} Z_{l3+b}^E \left( Z_{i1}^H Z_{j2}^+ + Z_{i2}^H Z_{j1}^+ \right) \right) \right) \quad (470)
\end{aligned}$$



$$\begin{aligned}
& -\frac{i}{2} \frac{1}{\sqrt{2}} \delta_{\beta\delta} \left( g_L^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^U \left( Z_{i1}^H Z_{k1}^+ + Z_{i2}^H Z_{k2}^+ \right) \right. \\
& - 2 \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^U Z_{i1}^H Z_{k1}^+ + \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^U Z_{i2}^H Z_{k2}^+ \right. \\
& \left. \left. + \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{u,ba} Z_{l3+b}^U \left( Z_{i1}^H Z_{k2}^+ + Z_{i2}^H Z_{k1}^+ \right) \right) \right) \quad (471)
\end{aligned}$$

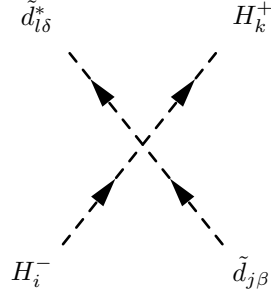


$$\begin{aligned}
& -\frac{i}{2} \frac{1}{\sqrt{2}} \left( g_L^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^V \left( Z_{i1}^H Z_{k1}^+ + Z_{i2}^H Z_{k2}^+ \right) \right. \\
& - 2 \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ac}^* Y_{e,ab} Z_{lc}^V Z_{i1}^H Z_{k1}^+ \right. \\
& + \left. \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{s,ac}^* Y_{v,ab} Z_{l6+c}^V Z_{i4}^H + \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{v,ac}^* Y_{v,ab} Z_{lc}^V Z_{i2}^H \right) Z_{k2}^+ \right. \\
& \left. \left. + \sum_{c=1}^3 Z_{j3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{v,ba} Z_{l3+b}^V \left( Z_{i1}^H Z_{k2}^+ + Z_{i2}^H Z_{k1}^+ \right) \right) \right) \quad (472)
\end{aligned}$$



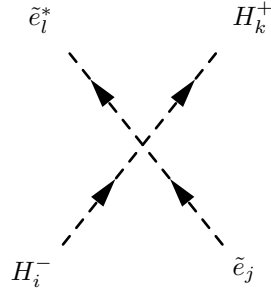
$$\begin{aligned}
& -\frac{i}{4} \left( g_L^2 + g_R^2 + g_{RB}^2 \right) \left( -Z_{i2}^+ \left( -2Z_{j2}^+ Z_{k2}^+ Z_{l2}^+ + Z_{j1}^+ \left( Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) \right) \right. \\
& \left. + Z_{i1}^+ \left( 2Z_{j1}^+ Z_{k1}^+ Z_{l1}^+ - Z_{j2}^+ \left( Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+ \right) \right) \right) \quad (473)
\end{aligned}$$





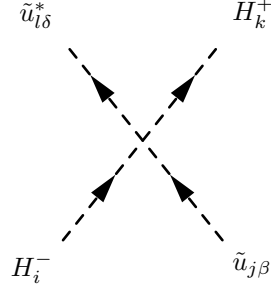
$$\begin{aligned}
& -\frac{i}{12}\delta_{\beta\delta}\left(\left(3g_L^2 - g_{BL}g_{RB} - g_{BR}g_R\right)\sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^D \left(Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+\right)\right. \\
& + \left(-3g_R^2 + \left(-3g_{RB} + g_{BL}\right)g_{RB} + g_{BR}g_R\right)\sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{l3+a}^D \left(Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+\right) \\
& \left. + 12\left(\sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{u,ac}^* Y_{u,ab} Z_{lc}^D Z_{i2}^+ Z_{k2}^+ + \sum_{c=1}^3 Z_{j3+c}^{D,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{d,ca}^* Y_{d,ba} Z_{l3+b}^D Z_{i1}^+ Z_{k1}^+\right)\right) \quad (474)
\end{aligned}$$


---



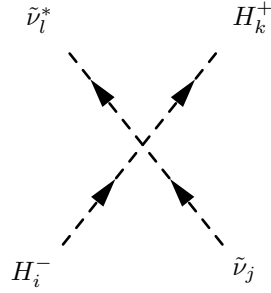
$$\begin{aligned}
& -\frac{i}{4}\left(\left(g_{BL}g_{RB} + g_{BR}g_R + g_L^2\right)\sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^E \left(Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+\right)\right. \\
& - \left(g_{BR}g_R + g_{RB}\left(g_{BL} + g_{RB}\right) + g_R^2\right)\sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{l3+a}^E \left(Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+\right) \\
& \left. + 4\left(\sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{v,ac}^* Y_{v,ab} Z_{lc}^E Z_{i2}^+ Z_{k2}^+ + \sum_{c=1}^3 Z_{j3+c}^{E,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{e,ca}^* Y_{e,ba} Z_{l3+b}^E Z_{i1}^+ Z_{k1}^+\right)\right) \quad (475)
\end{aligned}$$


---



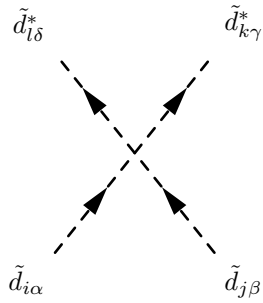
$$\begin{aligned}
& \frac{i}{12} \delta_{\beta\delta} \left( \left( 3g_L^2 + g_{BL}g_{RB} + g_{BR}g_R \right) \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \left( Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+ \right) \right. \\
& - \left( 3g_R^2 + g_{BR}g_R + g_{RB} \left( 3g_{RB} + g_{BL} \right) \right) \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U \left( Z_{i1}^+ Z_{k1}^+ - Z_{i2}^+ Z_{k2}^+ \right) \\
& \left. - 12 \left( \sum_{c=1}^3 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{d,ac}^* Y_{d,ab} Z_{lc}^U Z_{i1}^+ Z_{k1}^+ + \sum_{c=1}^3 Z_{j3+c}^{U,*} \sum_{b=1}^3 \sum_{a=1}^3 Y_{u,ca}^* Y_{u,ba} Z_{l3+b}^U Z_{i2}^+ Z_{k2}^+ \right) \right) \quad (476)
\end{aligned}$$


---



$$\frac{i}{4} (\text{tempString}) \quad (477)$$


---

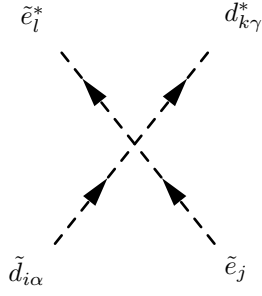


$$\begin{aligned}
& -\frac{i}{72} \left( \delta_{\alpha\delta} \delta_{\beta\gamma} \left( -6g_s^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D + g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D \right. \right. \\
& + g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D + 9g_L^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D \\
& + 6g_s^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D - g_{BL}^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D \\
& - g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D + 3g_{BR}g_R \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D \\
& + 3g_{BL}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D \\
& + 18g_s^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_s^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) \\
& + 6g_s^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{k3+b}^D - g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{k3+b}^D \\
& - g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{k3+b}^D + 3g_{BR}g_R \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{k3+b}^D \\
& + 3g_{BL}g_{RB} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{k3+b}^D - 6g_s^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_{BL}^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_{BR}^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_{BR}g_R \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{k3+b}^D + 9g_R^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_{BL}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{k3+b}^D + 9g_{RB}^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_s^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D + g_{BL}^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D \\
& + g_{BR}^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D + 9g_L^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D
\end{aligned}$$

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

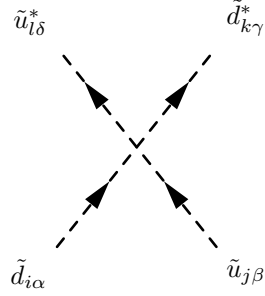
$$\begin{aligned}
& + \left( 3g_{BL}g_{RB} + 3g_{BR}g_R + 6g_s^2 - g_{BL}^2 - g_{BR}^2 \right) \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D \\
& + \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{l3+a}^D \left( \left( 3g_{BL}g_{RB} + 3g_{BR}g_R + 6g_s^2 - g_{BL}^2 - g_{BR}^2 \right) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right. \\
& + \left. \left( -6g_{BL}g_{RB} - 6g_{BR}g_R - 6g_s^2 + 9g_R^2 + 9g_{RB}^2 + g_{BL}^2 + g_{BR}^2 \right) \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D \right) \\
& - 18g_s^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{k3+b}^D + 18g_s^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_s^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D - 18g_s^2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D \\
& - 6g_s^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{lb}^D + g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{lb}^D \\
& + g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{lb}^D + 9g_L^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{lb}^D \\
& + 6g_s^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{lb}^D - g_{BL}^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{lb}^D \\
& - g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{lb}^D + 3g_{BR}g_R \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{lb}^D \\
& + 3g_{BL}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{lb}^D - 18g_s^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{l3+b}^D \\
& + 18g_s^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_s^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{l3+b}^D \\
& - g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{l3+b}^D - g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{l3+b}^D \\
& + 3g_{BR}g_R \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{l3+b}^D + 3g_{BL}g_{RB} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{l3+b}^D \\
& - 6g_s^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 + g_{BL}^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 \\
& + g_{BR}^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_{BR}g_R \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{l3+b}^D
\end{aligned}$$

$$\begin{aligned}
& + 9g_R^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{l3+b}^D - 6g_{BL}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{l3+b}^D \\
& + 9g_{RB}^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{l3+b}^D \\
& + 72 \sum_{b=1}^3 Z_{jb}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{l3+a}^D \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{i3+c}^{D,*} Z_{kd}^D \\
& + 72 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{j3+c}^{D,*} Z_{ld}^D \Big) \tag{478}
\end{aligned}$$



$$\begin{aligned}
& \frac{i}{24} \delta_{\alpha\gamma} \left( \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^E \left( - \left( -3g_{BL}g_{RB} + g_{BR} \left( -3g_R + g_{BR} \right) + g_{BL}^2 \right) \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \left( -3g_L^2 + g_{BL}^2 + g_{BR}^2 \right) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \right. \\
& - \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{l3+a}^E \left( \left( g_{BL}g_{RB} + g_{BR} \left( g_{BR} + g_R \right) + g_{BL}^2 \right) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right. \\
& - \left. \left( -2g_{BL}g_{RB} - 2g_{BR}g_R - 3 \left( g_R^2 + g_{RB}^2 \right) + g_{BL}^2 + g_{BR}^2 \right) \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D \right) \\
& + g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E + g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E \\
& - 3g_L^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E - g_{BL}^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E \\
& - g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E + 3g_{BR}g_R \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E \\
& + 3g_{BL}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E - g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \\
& - g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E - g_{BR}g_R \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E
\end{aligned}$$

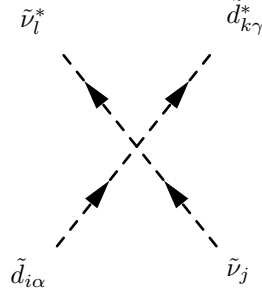
$$\begin{aligned}
& -g_{BL}g_{RB} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E + g_{BL}^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \\
& + g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E - 2g_{BR}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \\
& - 3g_R^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E - 2g_{BL}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \\
& - 3g_{RB}^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \\
& - 24 \sum_{b=1}^3 Z_{jb}^{E,*} \sum_{a=1}^3 Y_{e,ab} Z_{l3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd}^* Z_{i3+c}^{D,*} Z_{kd}^D \\
& - 24 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{j3+c}^{E,*} Z_{ld}^E \tag{479}
\end{aligned}$$



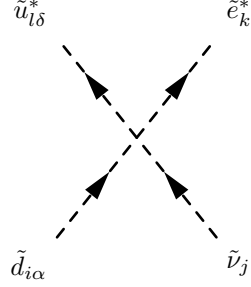
$$\begin{aligned}
& \frac{i}{72} \left( \delta_{\alpha\gamma} \delta_{\beta\delta} \left( \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \left( (6g_s^2 + 9g_L^2 - g_{BL}^2 - g_{BR}^2) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right. \right. \right. \\
& + \left. \left. \left( -3g_{BL}g_{RB} - 3g_{BR}g_{RB} - 6g_s^2 +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

$$\begin{aligned}
& -6g_s^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U + g_{BL}^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& + g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U - 3g_{BR}g_R \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& - 3g_{BL}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U - 6g_s^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U + g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + 3g_{BR}g_R \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U + 3g_{BL}g_{RB} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + 6g_s^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 - g_{BL}^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 \\
& - g_{BR}^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 + 9g_R^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 \\
& + 9g_{RB}^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \Big) \\
& - 18\delta_{\alpha\delta}\delta_{\beta\gamma} \left( g_L^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^D + g_s^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \left( - \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \right. \\
& + g_s^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U \left( - \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D + \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D \right) \\
& + g_L^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^D \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^U + g_s^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& - g_s^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U - g_s^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + g_s^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U + 4 \sum_{b=1}^3 Z_{ib}^{D,*} \sum_{a=1}^3 Y_{u,ab} Z_{l3+a}^U \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd} Z_{j3+c}^{U,*} Z_{kd}^D \\
& \left. + 4 \sum_{b=1}^3 Z_{jb}^{U,*} \sum_{a=1}^3 Y_{d,ab} Z_{k3+a}^D \sum_{d=1}^3 \sum_{c=1}^3 Y_{d,cd} Z_{i3+c}^{D,*} Z_{ld}^U \right) \Big) \tag{480}
\end{aligned}$$



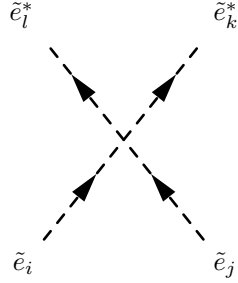


$$\begin{aligned}
& \frac{i}{24} \delta_{\alpha\gamma} \left( \sum_{a=1}^3 Z_{ja}^{V,*} Z_{la}^V \left( - \left( -3g_{BL}g_{RB} + g_{BR} \left( -3g_R + g_{BR} \right) + g_{BL}^2 \right) \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \left( 3g_L^2 + g_{BL}^2 + g_{BR}^2 \right) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \right. \\
& + \sum_{a=1}^3 Z_{j3+a}^{V,*} Z_{l3+a}^V \left( - \left( -g_{BL}g_{RB} + g_{BR} \left( -g_R + g_{BR} \right) + g_{BL}^2 \right) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right. \\
& + \left. \left( 3 \left( g_R^2 + g_{RB}^2 \right) - 4g_{BL}g_{RB} - 4g_{BR}g_R + g_{BL}^2 + g_{BR}^2 \right) \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D \right) \\
& + g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V + g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V \\
& + 3g_L^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V - g_{BL}^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V \\
& - g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V + 3g_{BR}g_R \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V \\
& + 3g_{BL}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V - g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V \\
& - g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V + g_{BR}g_R \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V \\
& + g_{BL}g_{RB} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V + g_{BL}^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V \\
& + g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V - 4g_{BR}g_R \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V \\
& + 3g_R^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V - 4g_{BL}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V \\
& + 3g_{RB}^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V \left. \right) \tag{481}
\end{aligned}$$



$$\begin{aligned}
& -\frac{i}{4}\delta_{\alpha\delta}\left(g_L^2\sum_{a=1}^3Z_{ia}^{D,*}Z_{la}^U\sum_{b=1}^3Z_{jb}^{V,*}Z_{kb}^E+g_L^2\sum_{a=1}^3Z_{ja}^{V,*}Z_{ka}^E\sum_{b=1}^3Z_{ib}^{D,*}Z_{lb}^U\right. \\
& +4\sum_{b=1}^3Z_{ib}^{D,*}\sum_{a=1}^3Y_{u,ab}Z_{l3+a}^U\sum_{d=1}^3\sum_{c=1}^3Y_{v,cd}^*Z_{j3+c}^{V,*}Z_{kd}^E \\
& \left.+4\sum_{b=1}^3Z_{jb}^{V,*}\sum_{a=1}^3Y_{e,ab}Z_{k3+a}^E\sum_{d=1}^3\sum_{c=1}^3Y_{d,cd}^*Z_{i3+c}^{D,*}Z_{ld}^U\right) \tag{482}
\end{aligned}$$

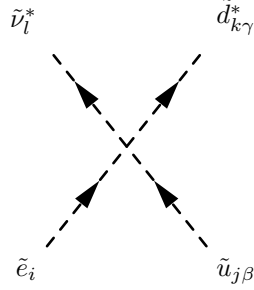

---



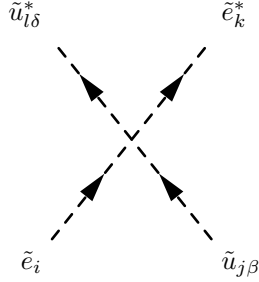
$$\begin{aligned}
& -\frac{i}{8}\left(g_{BL}^2\sum_{a=1}^3Z_{ia}^{E,*}Z_{la}^E\sum_{b=1}^3Z_{jb}^{E,*}Z_{kb}^E+g_{BR}^2\sum_{a=1}^3Z_{ia}^{E,*}Z_{la}^E\sum_{b=1}^3Z_{jb}^{E,*}Z_{kb}^E\right. \\
& +g_L^2\sum_{a=1}^3Z_{ia}^{E,*}Z_{la}^E\sum_{b=1}^3Z_{jb}^{E,*}Z_{kb}^E-g_{BL}^2\sum_{a=1}^3Z_{i3+a}^{E,*}Z_{l3+a}^E\sum_{b=1}^3Z_{jb}^{E,*}Z_{kb}^E \\
& -g_{BR}^2\sum_{a=1}^3Z_{i3+a}^{E,*}Z_{l3+a}^E\sum_{b=1}^3Z_{jb}^{E,*}Z_{kb}^E-g_{BR}g_R\sum_{a=1}^3Z_{i3+a}^{E,*}Z_{l3+a}^E\sum_{b=1}^3Z_{jb}^{E,*}Z_{kb}^E \\
& \left.-g_{BL}g_{RB}\sum_{a=1}^3Z_{i3+a}^{E,*}Z_{l3+a}^E\sum_{b=1}^3Z_{jb}^{E,*}Z_{kb}^E\right)
\end{aligned}$$

$$\begin{aligned}
& + \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^E \left( (g_{BL}^2 + g_{BR}^2 + g_L^2) \sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^E - (g_{BL}g_{RB} + g_{BR}(g_{BR} + g_R) + g_{BL}^2) \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{k3+b}^E \right) \\
& + \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{l3+a}^E \left( - (g_{BL}g_{RB} + g_{BR}(g_{BR} + g_R) + g_{BL}^2) \sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^E \right. \\
& + \left. (2g_{BL}g_{RB} + 2g_{BR}g_R + g_{BL}^2 + g_{BR}^2 + g_R^2 + g_{RB}^2) \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{k3+b}^E \right) \\
& - g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{k3+b}^E - g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{k3+b}^E \\
& - g_{BR}g_R \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{k3+b}^E - g_{BL}g_{RB} \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{k3+b}^E \\
& + g_{BL}^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{l3+a}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{k3+b}^E + g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{l3+a}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{k3+b}^E \\
& + 2g_{BR}g_R \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{l3+a}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{k3+b}^E + g_R^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{l3+a}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{k3+b}^E \\
& + 2g_{BL}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{l3+a}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{k3+b}^E + g_{RB}^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{l3+a}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{k3+b}^E \\
& + g_{BL}^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E + g_{BR}^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E \\
& + g_L^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E - g_{BL}^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E \\
& - g_{BR}^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E - g_{BR}g_R \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E \\
& - g_{BL}g_{RB} \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E + g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E \\
& + g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E + g_L^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E \\
& - g_{BL}^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E - g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E \\
& - g_{BR}g_R \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E - g_{BL}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E
\end{aligned}$$

$$\begin{aligned}
& -g_{BL}^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{l3+b}^E - g_{BR}^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{l3+b}^E \\
& -g_{BR}g_R \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{l3+b}^E - g_{BL}g_{RB} \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{l3+b}^E \\
& + g_{BL}^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 + g_{BR}^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_{BR}g_R \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{l3+b}^E + g_R^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_{BL}g_{RB} \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{l3+b}^E + g_{RB}^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 \\
& - g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E - g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \\
& - g_{BR}g_R \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E - g_{BL}g_{RB} \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \\
& + g_{BL}^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 + g_{BR}^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 \\
& + 2g_{BR}g_R \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E + g_R^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 \\
& + 2g_{BL}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E + g_{RB}^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
\end{aligned} \tag{483}$$

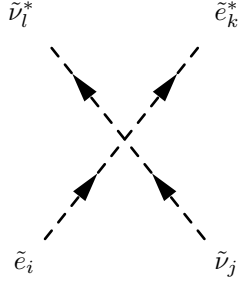


$$\begin{aligned}
& -\frac{i}{4}\delta_{\beta\gamma}\left(g_L^2\sum_{a=1}^3Z_{ia}^{E,*}Z_{la}^V\sum_{b=1}^3Z_{jb}^{U,*}Z_{kb}^D+g_L^2\sum_{a=1}^3Z_{ja}^{U,*}Z_{ka}^D\sum_{b=1}^3Z_{ib}^{E,*}Z_{lb}^V\right. \\
& +4\sum_{b=1}^3Z_{ib}^{E,*}\sum_{a=1}^3Y_{v,ab}Z_{l3+a}^V\sum_{d=1}^3\sum_{c=1}^3Y_{u,cd}^*Z_{j3+c}^{U,*}Z_{kd}^D \\
& \left.+4\sum_{b=1}^3Z_{jb}^{U,*}\sum_{a=1}^3Y_{d,ab}Z_{k3+a}^D\sum_{d=1}^3\sum_{c=1}^3Y_{e,cd}^*Z_{i3+c}^{E,*}Z_{ld}^V\right) \tag{484}
\end{aligned}$$



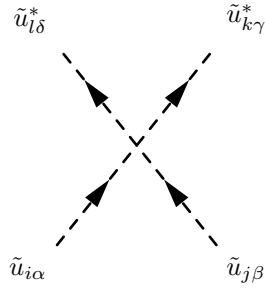
$$\begin{aligned}
& \frac{i}{24}\delta_{\beta\delta}\left(\sum_{a=1}^3Z_{ja}^{U,*}Z_{la}^U\left(\left(3g_L^2+g_{BL}^2+g_{BR}^2\right)\sum_{b=1}^3Z_{ib}^{E,*}Z_{kb}^E-\left(g_{BL}g_{RB}+g_{BR}\left(g_{BR}+g_R\right)+g_{BL}^2\right)\sum_{b=1}^3Z_{i3+b}^{E,*}Z_{k3+b}^E\right)\right. \\
& +\sum_{a=1}^3Z_{j3+a}^{U,*}Z_{l3+a}^U\left(-\left(3g_{BL}g_{RB}+g_{BR}\left(3g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

$$\begin{aligned}
& -g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U - g_{BR} g_R \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& -g_{BL} g_{RB} \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U - g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& -g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U - 3g_{BR} g_R \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& -3g_{BL} g_{RB} \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U + g_{BL}^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U + 4g_{BR} g_R \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + 3g_R^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U + 4g_{BL} g_{RB} \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + 3g_{RB}^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \Big) \tag{485}
\end{aligned}$$



$$\begin{aligned}
& -\frac{i}{8} \left( 2g_L^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^V \sum_{b=1}^3 Z_{jb}^{V,*} Z_{kb}^E \right. \\
& + \sum_{a=1}^3 Z_{ja}^{V,*} Z_{la}^V \left( - \left( g_{BL} g_{RB} + g_{BR} (g_{BR} + g_R) + g_{BL}^2 \right) \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{k3+b}^E + \left( -g_L^2 + g_{BL}^2 + g_{BR}^2 \right) \sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^E \right) \\
& + \sum_{a=1}^3 Z_{j3+a}^{V,*} Z_{l3+a}^V \left( - \left( -g_{BL} g_{RB} + g_{BR} (-g_R + g_{BR}) + g_{BL}^2 \right) \sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^E + \left( -g_R^2 - g_{RB}^2 + g_{BL}^2 + g_{BR}^2 \right) \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{k3+b}^E \right) \\
& + 2g_L^2 \sum_{a=1}^3 Z_{ja}^{V,*} Z_{ka}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^V + g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V \\
& \left. + g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V - g_L^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V \right)
\end{aligned}$$

$$\begin{aligned}
& -g_{BL}^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V - g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V \\
& -g_{BR}g_R \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V - g_{BL}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V \\
& -g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V - g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V \\
& +g_{BR}g_R \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V + g_{BL}g_{RB} \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V \\
& +g_{BL}^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V + g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V \\
& -g_R^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V - g_{RB}^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V \\
& +8 \sum_{b=1}^3 Z_{ib}^{E,*} \sum_{a=1}^3 Y_{v,ab} Z_{l3+a}^V \sum_{d=1}^3 \sum_{c=1}^3 Y_{v,cd}^* Z_{j3+c}^{V,*} Z_{kd}^E \\
& +8 \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Y_{e,ab} Z_{k3+a}^E \sum_{d=1}^3 \sum_{c=1}^3 Y_{e,cd}^* Z_{i3+c}^{E,*} Z_{ld}^V \Big) \tag{486}
\end{aligned}$$



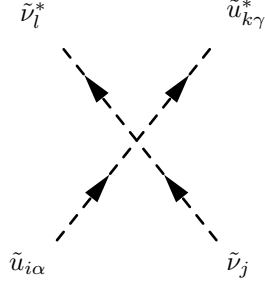
$$\begin{aligned}
& -\frac{i}{72} \left( \delta_{\alpha\delta} \delta_{\beta\gamma} \left( -6g_s^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U + g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U \right. \right. \\
& +g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U + 9g_L^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U \\
& +6g_s^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{l3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U - g_{BL}^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{l3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U \\
& \left. \left. -g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{l3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U - 3g_{BR}g_R \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{l3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U \right) \right)
\end{aligned}$$

$$\begin{aligned}
& -3g_{BLGRB} \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{l3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U \\
& + 18g_s^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \left( - \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{k3+b}^U + \sum_{b=1}^3 Z_{ib}^{U,*} Z_{kb}^U \right) \\
& - 18g_s^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) \\
& + 6g_s^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{k3+b}^U - g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{k3+b}^U \\
& - g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{k3+b}^U - 3g_{BRGR} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{k3+b}^U \\
& - 3g_{BLGRB} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{k3+b}^U - 6g_s^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_{BL}^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_{BR}^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_{BRGR} \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{l3+a}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{k3+b}^U + 9g_R^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_{BLGRB} \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{l3+a}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{k3+b}^U + 9g_{RB}^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_s^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U + g_{BL}^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U \\
& + g_{BR}^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U + 9g_L^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U \\
& + 6g_s^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U - g_{BL}^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U \\
& - g_{BR}^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U - 3g_{BRGR} \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U \\
& - 3g_{BLGRB} \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U + 18g_s^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& - 18g_s^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U + 6g_s^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U
\end{aligned}$$



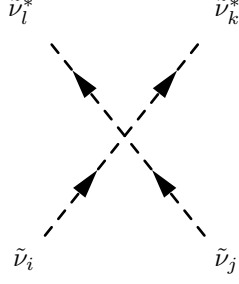
$$\begin{aligned}
& -g_{BL}^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U - g_{BR}^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U \\
& -3g_{BR}g_R \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U - 3g_{BL}g_{RB} \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U \\
& -6g_s^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 + g_{BL}^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 \\
& + g_{BR}^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_{BR}g_R \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U \\
& + 9g_R^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_{BL}g_{RB} \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U \\
& + 9g_{RB}^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_s^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + 18g_s^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_s^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U - 18g_s^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_{ja}^{U,*} Z_{la}^U \left( (-6g_s^2 + 9g_L^2 + g_{BL}^2 + g_{BR}^2) \sum_{b=1}^3 Z_{ib}^{U,*} Z_{kb}^U \right. \\
& + \left. \left. \left( -3g_{BL}g_{RB} + 6g_s^2 - g_{BL}^2 - g_{BR} (3g_R + g_{BR}) \right) \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{k3+b}^U \right) \right. \\
& + \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U \left( \left( -3g_{BL}g_{RB} + 6g_s^2 - g_{BL}^2 - g_{BR} (3g_R + g_{BR}) \right) \sum_{b=1}^3 Z_{ib}^{U,*} Z_{kb}^U \right. \\
& + \left. \left. \left( 6g_{BL}g_{RB} + 6g_{BR}g_R - 6g_s^2 + 9g_R^2 + 9g_{RB}^2 + g_{BL}^2 + g_{BR}^2 \right) \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{k3+b}^U \right) \right. \\
& \left. - 18g_s^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{k3+b}^U + 18g_s^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_s^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U - 18g_s^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U \\
& - 6g_s^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U + g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& + g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U + 9g_L^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& + 6g_s^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U - g_{BL}^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& - g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U - 3g_{BR}g_R \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& - 3g_{BL}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U - 18g_s^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U \\
& + 18g_s^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_s^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& - g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U - g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& - 3g_{BR}g_R \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U - 3g_{BL}g_{RB} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& - 6g_s^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 + g_{BL}^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 \\
& + g_{BR}^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_{BR}g_R \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + 9g_R^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_{BL}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + 9g_{RB}^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{487}
\end{aligned}$$



$$\begin{aligned}
& \frac{i}{24} \delta_{\alpha\gamma} \left( \sum_{a=1}^3 Z_{ja}^{V,*} Z_{la}^V \left( - \left( 3g_{BL}g_{RB} + g_{BR} \left( 3g_R + g_{BR} \right) + g_{BL}^2 \right) \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{k3+b}^U + \left( -3g_L^2 + g_{BL}^2 + g_{BR}^2 \right) \sum_{b=1}^3 Z_{ib}^{U,*} Z_{kb}^U \right) \right. \\
& + \sum_{a=1}^3 Z_{j3+a}^{V,*} Z_{l3+a}^V \left( - \left( -g_{BL}g_{RB} + g_{BR} \left( -g_R + g_{BR} \right) + g_{BL}^2 \right) \sum_{b=1}^3 Z_{ib}^{U,*} Z_{kb}^U \right. \\
& + \left. \left. \left( 2g_{BL}g_{RB} + 2g_{BR}g_R - 3 \left( g_R^2 + g_{RB}^2 \right) + g_{BL}^2 + g_{BR}^2 \right) \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{k3+b}^U \right) \right. \\
& + g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V + g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V \\
& - 3g_L^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V - g_{BL}^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V \\
& - g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V - 3g_{BR}g_R \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V \\
& - 3g_{BL}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V - g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V \\
& - g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V + g_{BR}g_R \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V \\
& + g_{BL}g_{RB} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V + g_{BL}^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V \\
& + g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V + 2g_{BR}g_R \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V \\
& - 3g_R^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V + 2g_{BL}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V \\
& - 3g_{RB}^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V
\end{aligned}$$

$$\begin{aligned}
& -24 \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Y_{v,ab} Z_{l3+a}^V \sum_{d=1}^3 \sum_{c=1}^3 Y_{u,cd}^* Z_{i3+c}^{U,*} Z_{kd}^U \\
& -24 \sum_{b=1}^3 Z_{ib}^{U,*} \sum_{a=1}^3 Y_{u,ab} Z_{k3+a}^U \sum_{d=1}^3 \sum_{c=1}^3 Y_{v,cd}^* Z_{j3+c}^{V,*} Z_{ld}^V
\end{aligned} \tag{488}$$



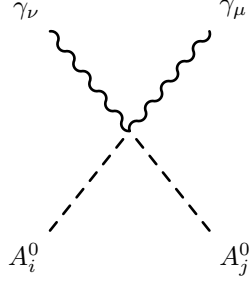
$$\begin{aligned}
& -\frac{i}{8} \left( g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{V,*} Z_{la}^V \sum_{b=1}^3 Z_{jb}^{V,*} Z_{kb}^V + g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{V,*} Z_{la}^V \sum_{b=1}^3 Z_{jb}^{V,*} Z_{kb}^V \right. \\
& + g_L^2 \sum_{a=1}^3 Z_{ia}^{V,*} Z_{la}^V \sum_{b=1}^3 Z_{jb}^{V,*} Z_{kb}^V - g_{BL}^2 \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{l3+a}^V \sum_{b=1}^3 Z_{jb}^{V,*} Z_{kb}^V \\
& - g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{l3+a}^V \sum_{b=1}^3 Z_{jb}^{V,*} Z_{kb}^V + g_{BR} g_R \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{l3+a}^V \sum_{b=1}^3 Z_{jb}^{V,*} Z_{kb}^V \\
& + g_{BL} g_{RB} \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{l3+a}^V \sum_{b=1}^3 Z_{jb}^{V,*} Z_{kb}^V \\
& + \sum_{a=1}^3 Z_{ja}^{V,*} Z_{la}^V \left( (g_{BL}^2 + g_{BR}^2 + g_L^2) \sum_{b=1}^3 Z_{ib}^{V,*} Z_{kb}^V - (-g_{BL} g_{RB} + g_{BR}(-g_R + g_{BR}) + g_{BL}^2) \sum_{b=1}^3 Z_{i3+b}^{V,*} Z_{k3+b}^V \right) \\
& + \sum_{a=1}^3 Z_{j3+a}^{V,*} Z_{l3+a}^V \left( -(-g_{BL} g_{RB} + g_{BR}(-g_R + g_{BR}) + g_{BL}^2) \sum_{b=1}^3 Z_{ib}^{V,*} Z_{kb}^V \right. \\
& \left. + (-2g_{BL} g_{RB} - 2g_{BR} g_R + g_{BL}^2 + g_{BR}^2 + g_R^2 + g_{RB}^2) \sum_{b=1}^3 Z_{i3+b}^{V,*} Z_{k3+b}^V \right) \\
& - g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{V,*} Z_{la}^V \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{k3+b}^V - g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{V,*} Z_{la}^V \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{k3+b}^V \\
& + g_{BR} g_R \sum_{a=1}^3 Z_{ia}^{V,*} Z_{la}^V \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{k3+b}^V + g_{BL} g_{RB} \sum_{a=1}^3 Z_{ia}^{V,*} Z_{la}^V \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{k3+b}^V \\
& + g_{BL}^2 \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{l3+a}^V \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{k3+b}^V + g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{l3+a}^V \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{k3+b}^V
\end{aligned}$$

$$\begin{aligned}
& -2g_{BR}g_R \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{l3+a}^V \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{k3+b}^V + g_R^2 \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{l3+a}^V \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{k3+b}^V \\
& -2g_{BL}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{l3+a}^V \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{k3+b}^V + g_{RB}^2 \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{l3+a}^V \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{k3+b}^V \\
& + g_{BL}^2 \sum_{a=1}^3 Z_{ja}^{V,*} Z_{ka}^V \sum_{b=1}^3 Z_{ib}^{V,*} Z_{lb}^V + g_{BR}^2 \sum_{a=1}^3 Z_{ja}^{V,*} Z_{ka}^V \sum_{b=1}^3 Z_{ib}^{V,*} Z_{lb}^V \\
& + g_L^2 \sum_{a=1}^3 Z_{ja}^{V,*} Z_{ka}^V \sum_{b=1}^3 Z_{ib}^{V,*} Z_{lb}^V - g_{BL}^2 \sum_{a=1}^3 Z_{j3+a}^{V,*} Z_{k3+a}^V \sum_{b=1}^3 Z_{ib}^{V,*} Z_{lb}^V \\
& - g_{BR}^2 \sum_{a=1}^3 Z_{j3+a}^{V,*} Z_{k3+a}^V \sum_{b=1}^3 Z_{ib}^{V,*} Z_{lb}^V + g_{BR}g_R \sum_{a=1}^3 Z_{j3+a}^{V,*} Z_{k3+a}^V \sum_{b=1}^3 Z_{ib}^{V,*} Z_{lb}^V \\
& + g_{BL}g_{RB} \sum_{a=1}^3 Z_{j3+a}^{V,*} Z_{k3+a}^V \sum_{b=1}^3 Z_{ib}^{V,*} Z_{lb}^V + g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ka}^V \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V \\
& + g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ka}^V \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V + g_L^2 \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ka}^V \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V \\
& - g_{BL}^2 \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{k3+a}^V \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V - g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{k3+a}^V \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V \\
& + g_{BR}g_R \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{k3+a}^V \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V + g_{BL}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{k3+a}^V \sum_{b=1}^3 Z_{jb}^{V,*} Z_{lb}^V \\
& - g_{BL}^2 \sum_{a=1}^3 Z_{ja}^{V,*} Z_{ka}^V \sum_{b=1}^3 Z_{i3+b}^{V,*} Z_{l3+b}^V - g_{BR}^2 \sum_{a=1}^3 Z_{ja}^{V,*} Z_{ka}^V \sum_{b=1}^3 Z_{i3+b}^{V,*} Z_{l3+b}^V \\
& + g_{BR}g_R \sum_{a=1}^3 Z_{ja}^{V,*} Z_{ka}^V \sum_{b=1}^3 Z_{i3+b}^{V,*} Z_{l3+b}^V + g_{BL}g_{RB} \sum_{a=1}^3 Z_{ja}^{V,*} Z_{ka}^V \sum_{b=1}^3 Z_{i3+b}^{V,*} Z_{l3+b}^V \\
& + g_{BL}^2 \sum_{a=1}^3 Z_{j3+a}^{V,*} Z_{k3+a}^V \sum_{b=1}^3 Z_{i3+b}^{V,*} Z_{l3+b}^V + g_{BR}^2 \sum_{a=1}^3 Z_{j3+a}^{V,*} Z_{k3+a}^V \sum_{b=1}^3 Z_{i3+b}^{V,*} Z_{l3+b}^V \\
& - 2g_{BR}g_R \sum_{a=1}^3 Z_{j3+a}^{V,*} Z_{k3+a}^V \sum_{b=1}^3 Z_{i3+b}^{V,*} Z_{l3+b}^V + g_R^2 \sum_{a=1}^3 Z_{j3+a}^{V,*} Z_{k3+a}^V \sum_{b=1}^3 Z_{i3+b}^{V,*} Z_{l3+b}^V \\
& - 2g_{BL}g_{RB} \sum_{a=1}^3 Z_{j3+a}^{V,*} Z_{k3+a}^V \sum_{b=1}^3 Z_{i3+b}^{V,*} Z_{l3+b}^V + g_{RB}^2 \sum_{a=1}^3 Z_{j3+a}^{V,*} Z_{k3+a}^V \sum_{b=1}^3 Z_{i3+b}^{V,*} Z_{l3+b}^V \\
& - g_{BL}^2 \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ka}^V \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V - g_{BR}^2 \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ka}^V \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V
\end{aligned}$$

$$\begin{aligned}
& + g_{BR}g_R \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ka}^V \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V + g_{BL}g_{RB} \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ka}^V \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V \\
& + g_{BL}^2 \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{k3+a}^V \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V + g_{BR}^2 \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{k3+a}^V \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V \\
& - 2g_{BR}g_R \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{k3+a}^V \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V + g_R^2 \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{k3+a}^V \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V \\
& - 2g_{BL}g_{RB} \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{k3+a}^V \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V + g_{RB}^2 \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{k3+a}^V \sum_{b=1}^3 Z_{j3+b}^{V,*} Z_{l3+b}^V \\
& + 8 \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Y_{v,ab} Z_{l3+a}^V \sum_{d=1}^3 \sum_{c=1}^3 Y_{v,cd}^* Z_{i3+c}^{V,*} Z_{kd}^V \\
& + 8 \sum_{b=1}^3 Z_{ib}^{V,*} \sum_{a=1}^3 Y_{v,ab} Z_{l3+a}^V \sum_{d=1}^3 \sum_{c=1}^3 Y_{v,cd}^* Z_{j3+c}^{V,*} Z_{kd}^V \\
& + 8 \sum_{b=1}^3 Z_{j6+b}^{V,*} \sum_{a=1}^3 Y_{s,ab} Z_{l3+a}^V \sum_{d=1}^3 \sum_{c=1}^3 Y_{s,cd}^* Z_{i3+c}^{V,*} Z_{k6+d}^V \\
& + 8 \sum_{b=1}^3 Z_{i6+b}^{V,*} \sum_{a=1}^3 Y_{s,ab} Z_{l3+a}^V \sum_{d=1}^3 \sum_{c=1}^3 Y_{s,cd}^* Z_{j3+c}^{V,*} Z_{k6+d}^V \\
& + 8 \sum_{b=1}^3 Z_{jb}^{V,*} \sum_{a=1}^3 Y_{v,ab} Z_{k3+a}^V \sum_{d=1}^3 \sum_{c=1}^3 Y_{v,cd}^* Z_{i3+c}^{V,*} Z_{ld}^V \\
& + 8 \sum_{b=1}^3 Z_{ib}^{V,*} \sum_{a=1}^3 Y_{v,ab} Z_{k3+a}^V \sum_{d=1}^3 \sum_{c=1}^3 Y_{v,cd}^* Z_{j3+c}^{V,*} Z_{ld}^V \\
& + 8 \sum_{b=1}^3 Z_{j6+b}^{V,*} \sum_{a=1}^3 Y_{s,ab} Z_{k3+a}^V \sum_{d=1}^3 \sum_{c=1}^3 Y_{s,cd}^* Z_{i3+c}^{V,*} Z_{l6+d}^V \\
& + 8 \sum_{b=1}^3 Z_{i6+b}^{V,*} \sum_{a=1}^3 Y_{s,ab} Z_{k3+a}^V \sum_{d=1}^3 \sum_{c=1}^3 Y_{s,cd}^* Z_{j3+c}^{V,*} Z_{l6+d}^V
\end{aligned} \tag{489}$$

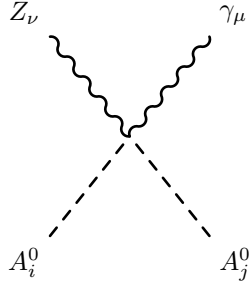

---

## 9.8 Two Scalar-Two Vector Boson-Interaction



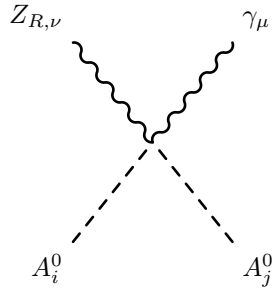
$$\begin{aligned} & \frac{i}{2} \left( (Z_{i3}^A Z_{j3}^A + Z_{i4}^A Z_{j4}^A) (g_{BL} Z Z_{21} - g_{RB} Z Z_{21} + (-g_R + g_{BR}) Z Z_{31})^2 + Z_{i1}^A Z_{j1}^A (-g_L Z Z_{11} + g_{RB} Z Z_{21} + g_R Z Z_{31})^2 \right. \\ & \left. + Z_{i2}^A Z_{j2}^A (-g_L Z Z_{11} + g_{RB} Z Z_{21} + g_R Z Z_{31})^2 \right) (g_{\mu\nu}) \end{aligned} \quad (490)$$


---



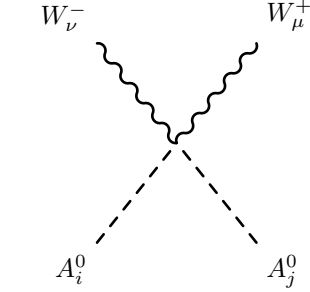
$$\begin{aligned} & \frac{i}{2} \left( (Z_{i3}^A Z_{j3}^A + Z_{i4}^A Z_{j4}^A) (g_{BL} Z Z_{21} - g_{RB} Z Z_{21} + (-g_R + g_{BR}) Z Z_{31}) (g_{BL} Z Z_{22} - g_{RB} Z Z_{22} + (-g_R + g_{BR}) Z Z_{32}) \right. \\ & \left. + Z_{i1}^A Z_{j1}^A (g_L Z Z_{11} - g_{RB} Z Z_{21} - g_R Z Z_{31}) (g_L Z Z_{12} - g_{RB} Z Z_{22} - g_R Z Z_{32}) \right. \\ & \left. + Z_{i2}^A Z_{j2}^A (g_L Z Z_{11} - g_{RB} Z Z_{21} - g_R Z Z_{31}) (g_L Z Z_{12} - g_{RB} Z Z_{22} - g_R Z Z_{32}) \right) (g_{\mu\nu}) \end{aligned} \quad (491)$$


---



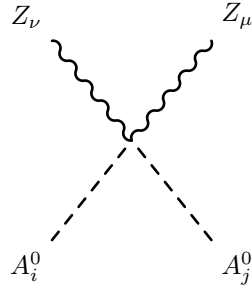
$$\begin{aligned}
& \frac{i}{2} \left( (Z_{i3}^A Z_{j3}^A + Z_{i4}^A Z_{j4}^A) (g_{BL} Z Z_{21} - g_{RB} Z Z_{21} + (-g_R + g_{BR}) Z Z_{31}) (g_{BL} Z Z_{23} - g_{RB} Z Z_{23} + (-g_R + g_{BR}) Z Z_{33}) \right. \\
& + Z_{i1}^A Z_{j1}^A (g_L Z Z_{11} - g_{RB} Z Z_{21} - g_R Z Z_{31}) (g_L Z Z_{13} - g_{RB} Z Z_{23} - g_R Z Z_{33}) \\
& \left. + Z_{i2}^A Z_{j2}^A (g_L Z Z_{11} - g_{RB} Z Z_{21} - g_R Z Z_{31}) (g_L Z Z_{13} - g_{RB} Z Z_{23} - g_R Z Z_{33}) \right) (g_{\mu\nu})
\end{aligned} \tag{492}$$


---



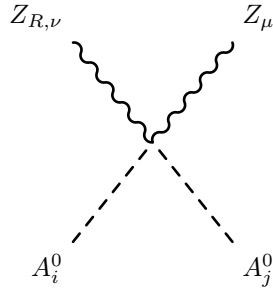
$$\frac{i}{2} g_L^2 (Z_{i1}^A Z_{j1}^A + Z_{i2}^A Z_{j2}^A) (g_{\mu\nu}) \tag{493}$$


---



$$\begin{aligned}
& \frac{i}{2} \left( (Z_{i3}^A Z_{j3}^A + Z_{i4}^A Z_{j4}^A) (g_{BL} Z Z_{22} - g_{RB} Z Z_{22} + (-g_R + g_{BR}) Z Z_{32})^2 + Z_{i1}^A Z_{j1}^A (-g_L Z Z_{12} + g_{RB} Z Z_{22} + g_R Z Z_{32})^2 \right. \\
& \left. + Z_{i2}^A Z_{j2}^A (-g_L Z Z_{12} + g_{RB} Z Z_{22} + g_R Z Z_{32})^2 \right) (g_{\mu\nu})
\end{aligned} \tag{494}$$

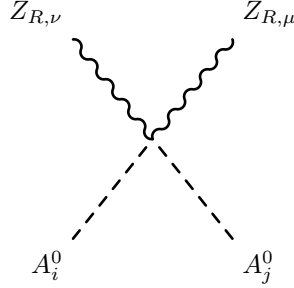

---





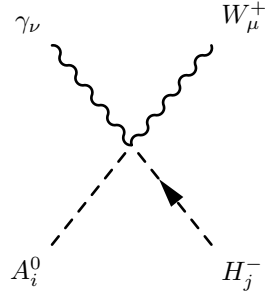
$$\begin{aligned}
& \frac{i}{2} \left( (Z_{i3}^A Z_{j3}^A + Z_{i4}^A Z_{j4}^A) (g_{BL} Z Z_{22} - g_{RB} Z Z_{22} + (-g_R + g_{BR}) Z Z_{32}) (g_{BL} Z Z_{23} - g_{RB} Z Z_{23} + (-g_R + g_{BR}) Z Z_{33}) \right. \\
& + Z_{i1}^A Z_{j1}^A (g_L Z Z_{12} - g_{RB} Z Z_{22} - g_R Z Z_{32}) (g_L Z Z_{13} - g_{RB} Z Z_{23} - g_R Z Z_{33}) \\
& \left. + Z_{i2}^A Z_{j2}^A (g_L Z Z_{12} - g_{RB} Z Z_{22} - g_R Z Z_{32}) (g_L Z Z_{13} - g_{RB} Z Z_{23} - g_R Z Z_{33}) \right) (g_{\mu\nu})
\end{aligned} \tag{495}$$


---



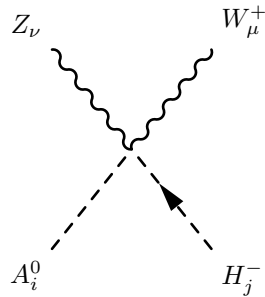
$$\begin{aligned}
& \frac{i}{2} \left( (Z_{i3}^A Z_{j3}^A + Z_{i4}^A Z_{j4}^A) (g_{BL} Z Z_{23} - g_{RB} Z Z_{23} + (-g_R + g_{BR}) Z Z_{33})^2 + Z_{i1}^A Z_{j1}^A (-g_L Z Z_{13} + g_{RB} Z Z_{23} + g_R Z Z_{33})^2 \right. \\
& \left. + Z_{i2}^A Z_{j2}^A (-g_L Z Z_{13} + g_{RB} Z Z_{23} + g_R Z Z_{33})^2 \right) (g_{\mu\nu})
\end{aligned} \tag{496}$$


---



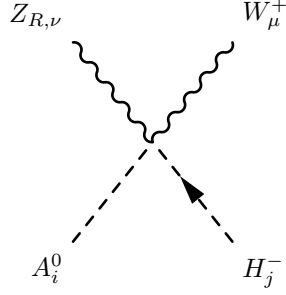
$$-\frac{1}{2} g_L (Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+) (g_{RB} Z Z_{21} + g_R Z Z_{31}) (g_{\mu\nu}) \tag{497}$$


---



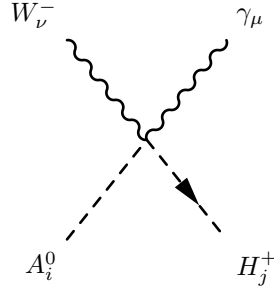
$$-\frac{1}{2}g_L\left(Z_{i1}^AZ_{j1}^+ + Z_{i2}^AZ_{j2}^+\right)\left(g_{RB}ZZ_{22} + g_RZZ_{32}\right)\left(g_{\mu\nu}\right) \quad (498)$$


---



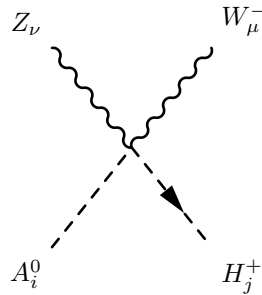
$$-\frac{1}{2}g_L\left(Z_{i1}^AZ_{j1}^+ + Z_{i2}^AZ_{j2}^+\right)\left(g_{RB}ZZ_{23} + g_RZZ_{33}\right)\left(g_{\mu\nu}\right) \quad (499)$$


---



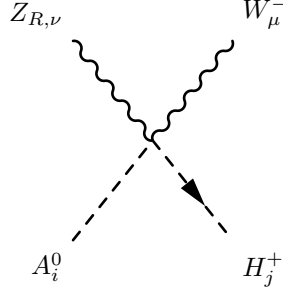
$$\frac{1}{2}g_L\left(Z_{i1}^AZ_{j1}^+ + Z_{i2}^AZ_{j2}^+\right)\left(g_{RB}ZZ_{21} + g_RZZ_{31}\right)\left(g_{\mu\nu}\right) \quad (500)$$


---



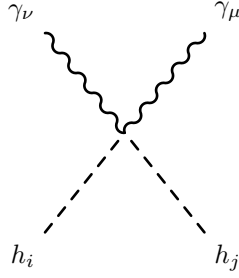
$$\frac{1}{2}g_L\left(Z_{i1}^AZ_{j1}^+ + Z_{i2}^AZ_{j2}^+\right)\left(g_{RB}ZZ_{22} + g_RZZ_{32}\right)\left(g_{\mu\nu}\right) \quad (501)$$


---



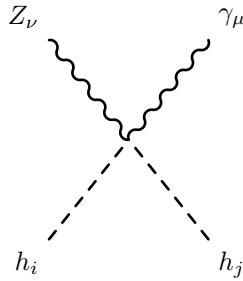
$$\frac{1}{2}g_L \left( Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+ \right) \left( g_{RB} Z Z_{23} + g_R Z Z_{33} \right) \left( g_{\mu\nu} \right) \quad (502)$$


---



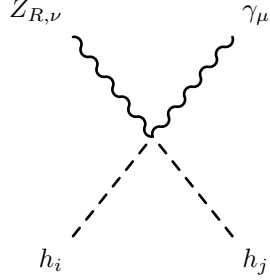
$$\frac{i}{2} \left( \left( Z_{i3}^H Z_{j3}^H + Z_{i4}^H Z_{j4}^H \right) \left( g_{BL} Z Z_{21} - g_{RB} Z Z_{21} + \left( -g_R + g_{BR} \right) Z Z_{31} \right)^2 + Z_{i1}^H Z_{j1}^H \left( -g_L Z Z_{11} + g_{RB} Z Z_{21} + g_R Z Z_{31} \right)^2 \right. \\ \left. + Z_{i2}^H Z_{j2}^H \left( -g_L Z Z_{11} + g_{RB} Z Z_{21} + g_R Z Z_{31} \right)^2 \right) \left( g_{\mu\nu} \right) \quad (503)$$


---

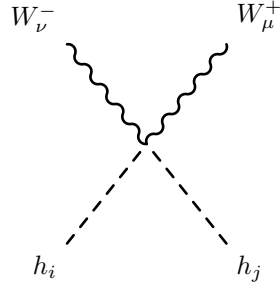


$$\frac{i}{2} \left( \left( Z_{i3}^H Z_{j3}^H + Z_{i4}^H Z_{j4}^H \right) \left( g_{BL} Z Z_{21} - g_{RB} Z Z_{21} + \left( -g_R + g_{BR} \right) Z Z_{31} \right) \left( g_{BL} Z Z_{22} - g_{RB} Z Z_{22} + \left( -g_R + g_{BR} \right) Z Z_{32} \right) \right. \\ \left. + Z_{i1}^H Z_{j1}^H \left( g_L Z Z_{11} - g_{RB} Z Z_{21} - g_R Z Z_{31} \right) \left( g_L Z Z_{12} - g_{RB} Z Z_{22} - g_R Z Z_{32} \right) \right. \\ \left. + Z_{i2}^H Z_{j2}^H \left( g_L Z Z_{11} - g_{RB} Z Z_{21} - g_R Z Z_{31} \right) \left( g_L Z Z_{12} - g_{RB} Z Z_{22} - g_R Z Z_{32} \right) \right) \left( g_{\mu\nu} \right) \quad (504)$$

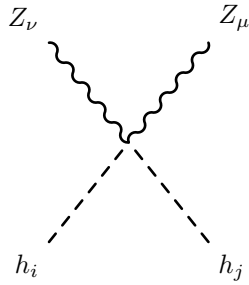

---



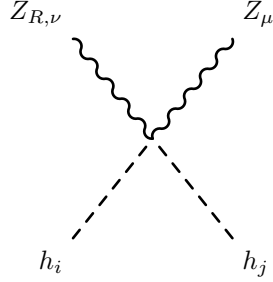
$$\begin{aligned}
& \frac{i}{2} \left( (Z_{i3}^H Z_{j3}^H + Z_{i4}^H Z_{j4}^H) (g_{BL} Z Z_{21} - g_{RB} Z Z_{21} + (-g_R + g_{BR}) Z Z_{31}) (g_{BL} Z Z_{23} - g_{RB} Z Z_{23} + (-g_R + g_{BR}) Z Z_{33}) \right. \\
& + Z_{i1}^H Z_{j1}^H (g_L Z Z_{11} - g_{RB} Z Z_{21} - g_R Z Z_{31}) (g_L Z Z_{13} - g_{RB} Z Z_{23} - g_R Z Z_{33}) \\
& \left. + Z_{i2}^H Z_{j2}^H (g_L Z Z_{11} - g_{RB} Z Z_{21} - g_R Z Z_{31}) (g_L Z Z_{13} - g_{RB} Z Z_{23} - g_R Z Z_{33}) \right) (g_{\mu\nu})
\end{aligned} \tag{505}$$



$$\frac{i}{2} g_L^2 (Z_{i1}^H Z_{j1}^H + Z_{i2}^H Z_{j2}^H) (g_{\mu\nu}) \tag{506}$$

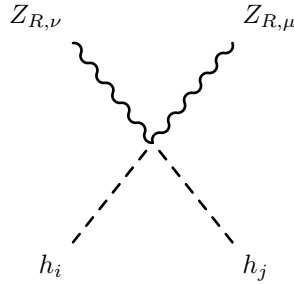


$$\begin{aligned}
& \frac{i}{2} \left( (Z_{i3}^H Z_{j3}^H + Z_{i4}^H Z_{j4}^H) (g_{BL} Z Z_{22} - g_{RB} Z Z_{22} + (-g_R + g_{BR}) Z Z_{32})^2 + Z_{i1}^H Z_{j1}^H (-g_L Z Z_{12} + g_{RB} Z Z_{22} + g_R Z Z_{32})^2 \right. \\
& \left. + Z_{i2}^H Z_{j2}^H (-g_L Z Z_{12} + g_{RB} Z Z_{22} + g_R Z Z_{32})^2 \right) (g_{\mu\nu})
\end{aligned} \tag{507}$$



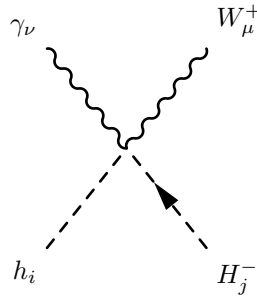
$$\begin{aligned}
& \frac{i}{2} \left( (Z_{i3}^H Z_{j3}^H + Z_{i4}^H Z_{j4}^H) (g_{BL} Z Z_{22} - g_{RB} Z Z_{22} + (-g_R + g_{BR}) Z Z_{32}) (g_{BL} Z Z_{23} - g_{RB} Z Z_{23} + (-g_R + g_{BR}) Z Z_{33}) \right. \\
& + Z_{i1}^H Z_{j1}^H (g_L Z Z_{12} - g_{RB} Z Z_{22} - g_R Z Z_{32}) (g_L Z Z_{13} - g_{RB} Z Z_{23} - g_R Z Z_{33}) \\
& \left. + Z_{i2}^H Z_{j2}^H (g_L Z Z_{12} - g_{RB} Z Z_{22} - g_R Z Z_{32}) (g_L Z Z_{13} - g_{RB} Z Z_{23} - g_R Z Z_{33}) \right) (g_{\mu\nu})
\end{aligned} \tag{508}$$


---



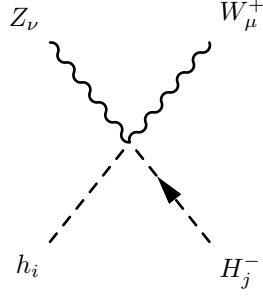
$$\begin{aligned}
& \frac{i}{2} \left( (Z_{i3}^H Z_{j3}^H + Z_{i4}^H Z_{j4}^H) (g_{BL} Z Z_{23} - g_{RB} Z Z_{23} + (-g_R + g_{BR}) Z Z_{33})^2 + Z_{i1}^H Z_{j1}^H (-g_L Z Z_{13} + g_{RB} Z Z_{23} + g_R Z Z_{33})^2 \right. \\
& \left. + Z_{i2}^H Z_{j2}^H (-g_L Z Z_{13} + g_{RB} Z Z_{23} + g_R Z Z_{33})^2 \right) (g_{\mu\nu})
\end{aligned} \tag{509}$$


---



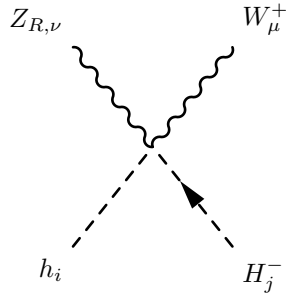
$$-\frac{i}{2}g_L\left(Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+\right)\left(g_{RB}ZZ_{21} + g_RZZ_{31}\right)\left(g_{\mu\nu}\right) \quad (510)$$


---



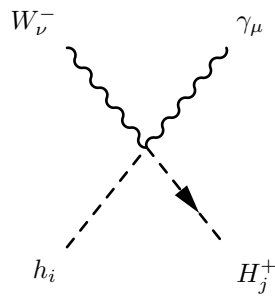
$$-\frac{i}{2}g_L\left(Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+\right)\left(g_{RB}ZZ_{22} + g_RZZ_{32}\right)\left(g_{\mu\nu}\right) \quad (511)$$


---



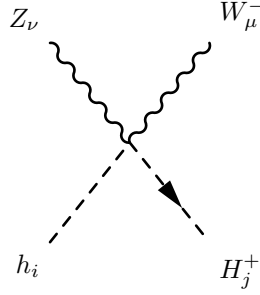
$$-\frac{i}{2}g_L\left(Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+\right)\left(g_{RB}ZZ_{23} + g_RZZ_{33}\right)\left(g_{\mu\nu}\right) \quad (512)$$


---



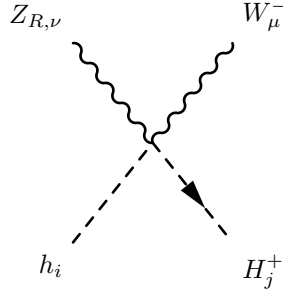
$$-\frac{i}{2}g_L\left(Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+\right)\left(g_{RB}ZZ_{21} + g_RZZ_{31}\right)\left(g_{\mu\nu}\right) \quad (513)$$


---



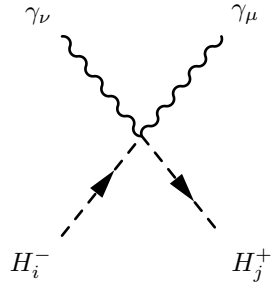
$$-\frac{i}{2}g_L\left(Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+\right)\left(g_{RB}ZZ_{22} + g_RZZ_{32}\right)\left(g_{\mu\nu}\right) \quad (514)$$


---



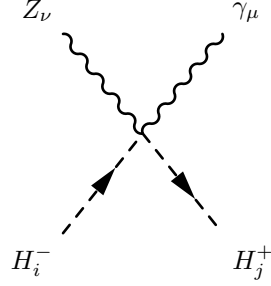
$$-\frac{i}{2}g_L\left(Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+\right)\left(g_{RB}ZZ_{23} + g_RZZ_{33}\right)\left(g_{\mu\nu}\right) \quad (515)$$


---



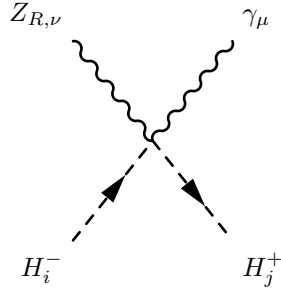
$$\frac{i}{2}\left(Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+\right)\left(g_LZZ_{11} + g_{RB}ZZ_{21} + g_RZZ_{31}\right)^2\left(g_{\mu\nu}\right) \quad (516)$$


---



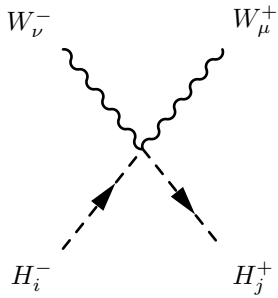
$$\frac{i}{2} \left( Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+ \right) \left( g_L Z Z_{11} + g_{RB} Z Z_{21} + g_R Z Z_{31} \right) \left( g_L Z Z_{12} + g_{RB} Z Z_{22} + g_R Z Z_{32} \right) \left( g_{\mu\nu} \right) \quad (517)$$


---



$$\frac{i}{2} \left( Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+ \right) \left( g_L Z Z_{11} + g_{RB} Z Z_{21} + g_R Z Z_{31} \right) \left( g_L Z Z_{13} + g_{RB} Z Z_{23} + g_R Z Z_{33} \right) \left( g_{\mu\nu} \right) \quad (518)$$

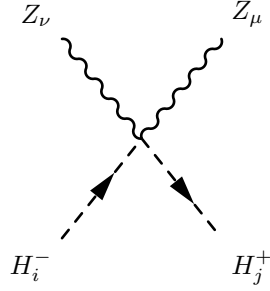

---



$$\frac{i}{2} g_L^2 \left( Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+ \right) \left( g_{\mu\nu} \right) \quad (519)$$

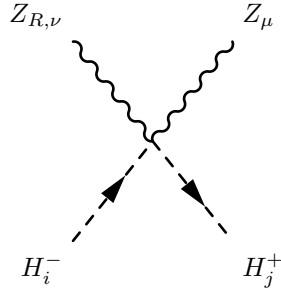

---





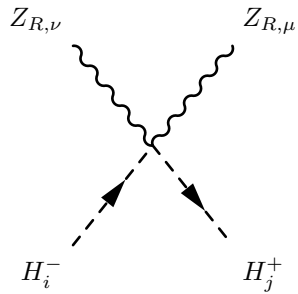
$$\frac{i}{2} \left( Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+ \right) \left( g_L Z Z_{12} + g_{RB} Z Z_{22} + g_R Z Z_{32} \right)^2 (g_{\mu\nu}) \quad (520)$$


---



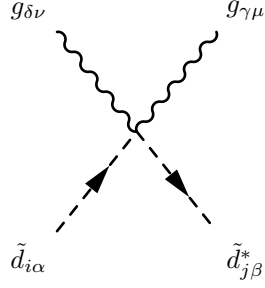
$$\frac{i}{2} \left( Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+ \right) \left( g_L Z Z_{12} + g_{RB} Z Z_{22} + g_R Z Z_{32} \right) \left( g_L Z Z_{13} + g_{RB} Z Z_{23} + g_R Z Z_{33} \right) (g_{\mu\nu}) \quad (521)$$


---



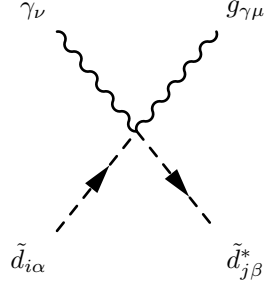
$$\frac{i}{2} \left( Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+ \right) \left( g_L Z Z_{13} + g_{RB} Z Z_{23} + g_R Z Z_{33} \right)^2 (g_{\mu\nu}) \quad (522)$$


---



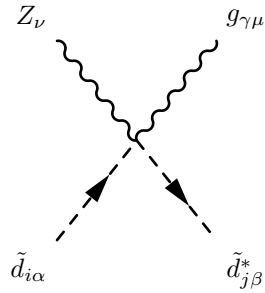
$$\frac{i}{4} g_s^2 \delta_{ij} \left( \sum_{a=1}^3 \lambda_{a,\alpha}^\gamma \lambda_{\beta,a}^\delta + \sum_{a=1}^3 \lambda_{\beta,a}^\gamma \lambda_{a,\alpha}^\delta \right) (g_{\mu\nu}) \quad (523)$$


---



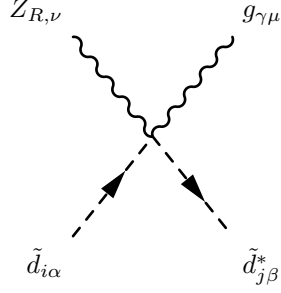
$$-\frac{i}{6} g_s \lambda_{\beta,\alpha}^\gamma \left( - \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \left( -3g_{RB} Z Z_{21} + \left( -3g_R + g_{BR} \right) Z Z_{31} + g_{BL} Z Z_{21} \right) + \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \left( 3g_L Z Z_{11} - g_{BL} Z Z_{21} - g_{BR} Z Z_{31} \right) \right) \quad (524)$$


---



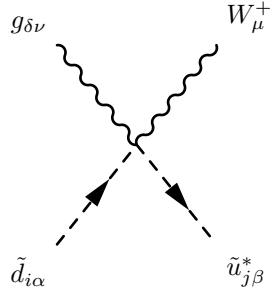
$$-\frac{i}{6} g_s \lambda_{\beta,\alpha}^\gamma \left( - \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \left( -3g_{RB} Z Z_{22} + \left( -3g_R + g_{BR} \right) Z Z_{32} + g_{BL} Z Z_{22} \right) + \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \left( 3g_L Z Z_{12} - g_{BL} Z Z_{22} - g_{BR} Z Z_{32} \right) \right) \quad (525)$$


---



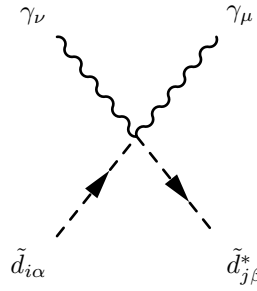
$$-\frac{i}{6}g_s\lambda_{\beta,\alpha}^\gamma\left(-\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{j3+a}^D\left(-3g_{RB}ZZ_{23}+\left(-3g_R+g_{BR}\right)ZZ_{33}+g_{BL}ZZ_{23}\right)+\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^D\left(3g_LZZ_{13}-g_{BL}ZZ_{23}-g_{BR}ZZ_{33}\right)\right) \quad (526)$$


---



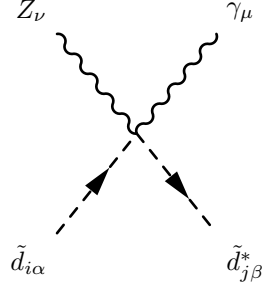
$$i\frac{1}{\sqrt{2}}g_s g_L\lambda_{\beta,\alpha}^\delta\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^U(g_{\mu\nu}) \quad (527)$$


---

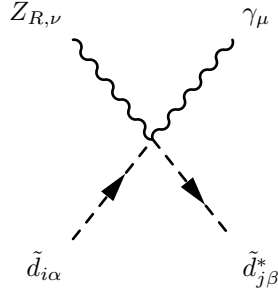


$$\frac{i}{18}\delta_{\alpha\beta}\left(\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{j3+a}^D\left(-3g_{RB}ZZ_{21}+\left(-3g_R+g_{BR}\right)ZZ_{31}+g_{BL}ZZ_{21}\right)\right)^2+\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^D\left(-3g_LZZ_{11}+g_{BL}ZZ_{21}+g_{BR}ZZ_{31}\right)^2 \quad (528)$$

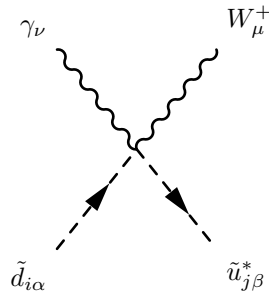

---



$$\begin{aligned}
& \frac{i}{18} \delta_{\alpha\beta} \left( \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D (3g_L Z Z_{11} - g_{BL} Z Z_{21} - g_{BR} Z Z_{31}) (3g_L Z Z_{12} - g_{BL} Z Z_{22} - g_{BR} Z Z_{32}) \right. \\
& \left. + \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \left( -3g_{RB} Z Z_{21} + (-3g_R + g_{BR}) Z Z_{31} + g_{BL} Z Z_{21} \right) \left( -3g_{RB} Z Z_{22} + (-3g_R + g_{BR}) Z Z_{32} + g_{BL} Z Z_{22} \right) \right) (g_{\mu\nu})
\end{aligned} \tag{529}$$

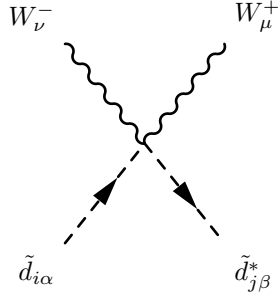


$$\begin{aligned}
& \frac{i}{18} \delta_{\alpha\beta} \left( \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D (3g_L Z Z_{11} - g_{BL} Z Z_{21} - g_{BR} Z Z_{31}) (3g_L Z Z_{13} - g_{BL} Z Z_{23} - g_{BR} Z Z_{33}) \right. \\
& \left. + \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \left( -3g_{RB} Z Z_{21} + (-3g_R + g_{BR}) Z Z_{31} + g_{BL} Z Z_{21} \right) \left( -3g_{RB} Z Z_{23} + (-3g_R + g_{BR}) Z Z_{33} + g_{BL} Z Z_{23} \right) \right) (g_{\mu\nu})
\end{aligned} \tag{530}$$



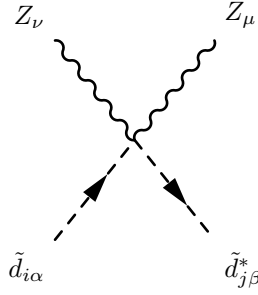
$$\frac{i}{3} \frac{1}{\sqrt{2}} g_L \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U (g_{BL} Z Z_{21} + g_{BR} Z Z_{31}) (g_{\mu\nu}) \quad (531)$$


---



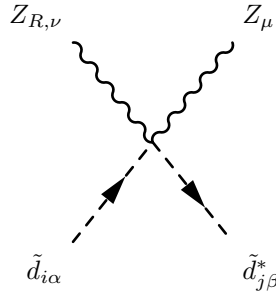
$$\frac{i}{2} g_L^2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D (g_{\mu\nu}) \quad (532)$$


---



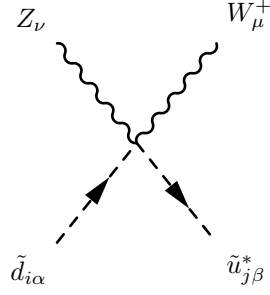
$$\frac{i}{18} \delta_{\alpha\beta} \left( \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \left( -3g_{RB} Z Z_{22} + (-3g_R + g_{BR}) Z Z_{32} + g_{BL} Z Z_{22} \right)^2 + \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \left( -3g_L Z Z_{12} + g_{BL} Z Z_{22} + g_{BR} Z Z_{32} \right)^2 \right) \quad (533)$$


---



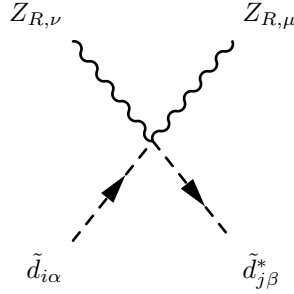
$$\begin{aligned}
& \frac{i}{18} \delta_{\alpha\beta} \left( \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \left( 3g_L Z Z_{12} - g_{BL} Z Z_{22} - g_{BR} Z Z_{32} \right) \left( 3g_L Z Z_{13} - g_{BL} Z Z_{23} - g_{BR} Z Z_{33} \right) \right. \\
& \left. + \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \left( -3g_{RB} Z Z_{22} + \left( -3g_R + g_{BR} \right) Z Z_{32} + g_{BL} Z Z_{22} \right) \left( -3g_{RB} Z Z_{23} + \left( -3g_R + g_{BR} \right) Z Z_{33} + g_{BL} Z Z_{23} \right) \right) (g_{\mu\nu})
\end{aligned} \tag{534}$$


---



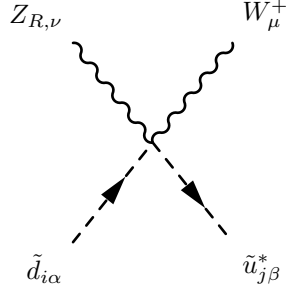
$$\frac{i}{3} \frac{1}{\sqrt{2}} g_L \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U \left( g_{BL} Z Z_{22} + g_{BR} Z Z_{32} \right) (g_{\mu\nu}) \tag{535}$$


---



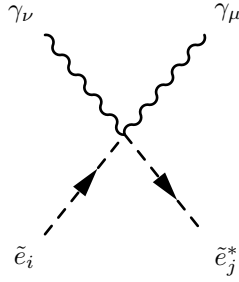
$$\begin{aligned}
& \frac{i}{18} \delta_{\alpha\beta} \left( \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \left( -3g_{RB} Z Z_{23} + \left( -3g_R + g_{BR} \right) Z Z_{33} + g_{BL} Z Z_{23} \right)^2 + \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \left( -3g_L Z Z_{13} + g_{BL} Z Z_{23} + g_{BR} Z Z_{33} \right)^2 \right)
\end{aligned} \tag{536}$$


---



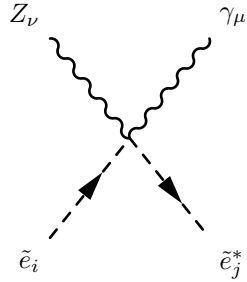
$$\frac{i}{3} \frac{1}{\sqrt{2}} g_L \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U (g_{BL} Z Z_{23} + g_{BR} Z Z_{33}) (g_{\mu\nu}) \quad (537)$$


---



$$\frac{i}{2} \left( \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E (g_{BL} Z Z_{21} + (g_{BR} + g_R) Z Z_{31} + g_{RB} Z Z_{21})^2 + \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E (g_{BL} Z Z_{21} + g_{BR} Z Z_{31} + g_L Z Z_{11})^2 \right) (g_{\mu\nu}) \quad (538)$$

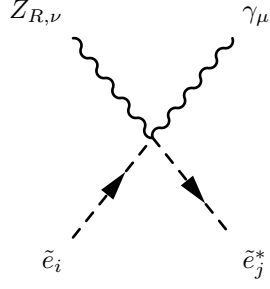

---



$$\frac{i}{2} \left( \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E (g_{BL} Z Z_{21} + g_{BR} Z Z_{31} + g_L Z Z_{11}) (g_{BL} Z Z_{22} + g_{BR} Z Z_{32} + g_L Z Z_{12}) \right)$$

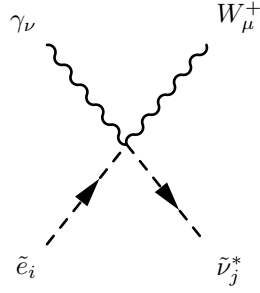
$$+ \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \left( g_{BL} Z Z_{21} + (g_{BR} + g_R) Z Z_{31} + g_{RB} Z Z_{21} \right) \left( g_{BL} Z Z_{22} + (g_{BR} + g_R) Z Z_{32} + g_{RB} Z Z_{22} \right) (g_{\mu\nu}) \quad (539)$$


---



$$\frac{i}{2} \left( \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \left( g_{BL} Z Z_{21} + g_{BR} Z Z_{31} + g_L Z Z_{11} \right) \left( g_{BL} Z Z_{23} + g_{BR} Z Z_{33} + g_L Z Z_{13} \right) \right. \\ \left. + \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \left( g_{BL} Z Z_{21} + (g_{BR} + g_R) Z Z_{31} + g_{RB} Z Z_{21} \right) \left( g_{BL} Z Z_{23} + (g_{BR} + g_R) Z Z_{33} + g_{RB} Z Z_{23} \right) \right) (g_{\mu\nu}) \quad (540)$$

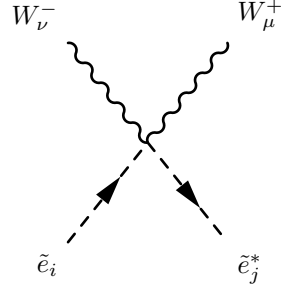

---



$$- i \frac{1}{\sqrt{2}} g_L \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^V \left( g_{BL} Z Z_{21} + g_{BR} Z Z_{31} \right) (g_{\mu\nu}) \quad (541)$$

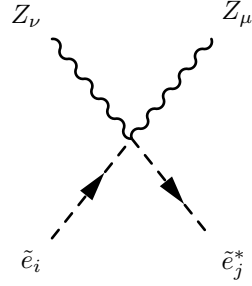

---





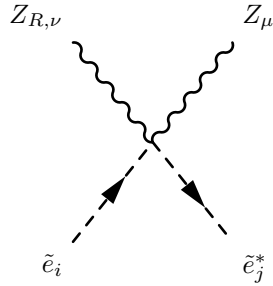
$$\frac{i}{2} g_L^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E (g_{\mu\nu}) \quad (542)$$


---



$$\frac{i}{2} \left( \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \left( g_{BL} Z Z_{22} + (g_{BR} + g_R) Z Z_{32} + g_{RB} Z Z_{22} \right)^2 + \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \left( g_{BL} Z Z_{22} + g_{BR} Z Z_{32} + g_L Z Z_{12} \right)^2 \right) (g_{\mu\nu}) \quad (543)$$

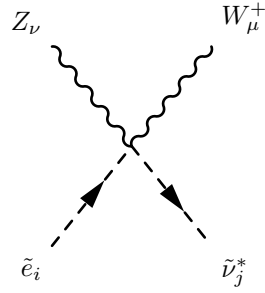

---



$$\frac{i}{2} \left( \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \left( g_{BL} Z Z_{22} + g_{BR} Z Z_{32} + g_L Z Z_{12} \right) \left( g_{BL} Z Z_{23} + g_{BR} Z Z_{33} + g_L Z Z_{13} \right) \right)$$

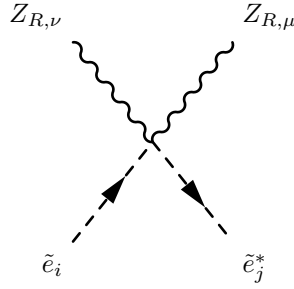
$$+ \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \left( g_{BL} Z Z_{22} + (g_{BR} + g_R) Z Z_{32} + g_{RB} Z Z_{22} \right) \left( g_{BL} Z Z_{23} + (g_{BR} + g_R) Z Z_{33} + g_{RB} Z Z_{23} \right) (g_{\mu\nu}) \quad (544)$$


---



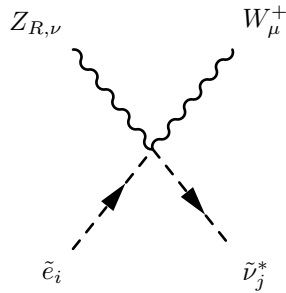
$$- i \frac{1}{\sqrt{2}} g_L \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^V \left( g_{BL} Z Z_{22} + g_{BR} Z Z_{32} \right) (g_{\mu\nu}) \quad (545)$$


---



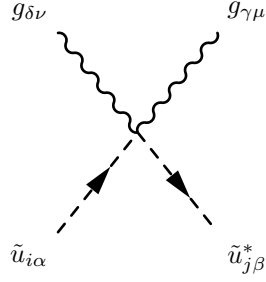
$$\frac{i}{2} \left( \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \left( g_{BL} Z Z_{23} + (g_{BR} + g_R) Z Z_{33} + g_{RB} Z Z_{23} \right)^2 + \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \left( g_{BL} Z Z_{23} + g_{BR} Z Z_{33} + g_L Z Z_{13} \right)^2 \right) (g_{\mu\nu}) \quad (546)$$


---



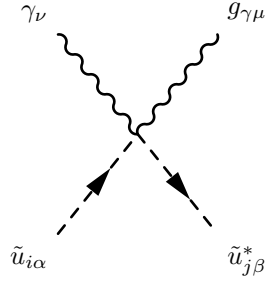
$$-i \frac{1}{\sqrt{2}} g_L \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^V (g_{BL} Z Z_{23} + g_{BR} Z Z_{33}) (g_{\mu\nu}) \quad (547)$$


---



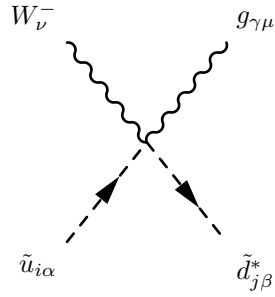
$$\frac{i}{4} g_s^2 \delta_{ij} \left( \sum_{a=1}^3 \lambda_{a,\alpha}^\gamma \lambda_{\beta,a}^\delta + \sum_{a=1}^3 \lambda_{\beta,a}^\gamma \lambda_{a,\alpha}^\delta \right) (g_{\mu\nu}) \quad (548)$$


---



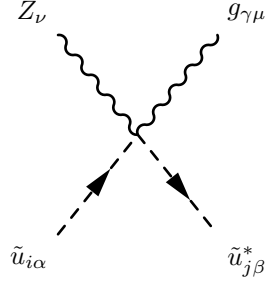
$$\frac{i}{6} g_s \lambda_{\beta,\alpha}^\gamma \left( \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U (3g_{RB} Z Z_{21} + (3g_R + g_{BR}) Z Z_{31} + g_{BL} Z Z_{21}) + \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U (3g_L Z Z_{11} + g_{BL} Z Z_{21} + g_{BR} Z Z_{31}) \right) (g_{\mu\nu}) \quad (549)$$


---



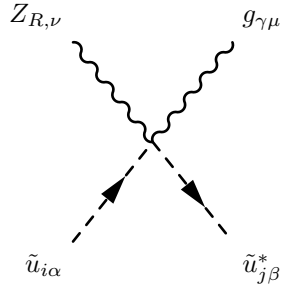
$$i \frac{1}{\sqrt{2}} g_s g_L \lambda_{\beta, \alpha}^\gamma \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D (g_{\mu\nu}) \quad (550)$$


---



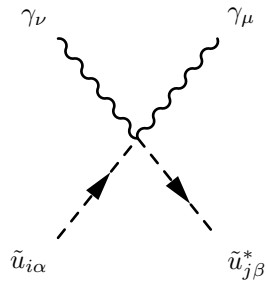
$$\frac{i}{6} g_s \lambda_{\beta, \alpha}^\gamma \left( \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \left( 3g_{RB} Z Z_{22} + (3g_R + g_{BR}) Z Z_{32} + g_{BL} Z Z_{22} \right) + \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \left( 3g_L Z Z_{12} + g_{BL} Z Z_{22} + g_{BR} Z Z_{32} \right) \right) (g_{\mu\nu}) \quad (551)$$


---



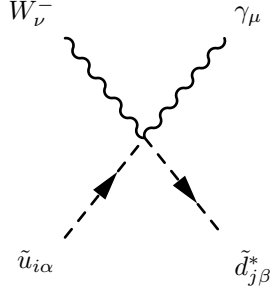
$$\frac{i}{6} g_s \lambda_{\beta, \alpha}^\gamma \left( \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \left( 3g_{RB} Z Z_{23} + (3g_R + g_{BR}) Z Z_{33} + g_{BL} Z Z_{23} \right) + \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \left( 3g_L Z Z_{13} + g_{BL} Z Z_{23} + g_{BR} Z Z_{33} \right) \right) (g_{\mu\nu}) \quad (552)$$


---



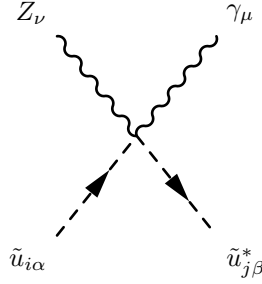
$$\frac{i}{18} \delta_{\alpha\beta} \left( \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \left( 3g_{RB}ZZ_{21} + (3g_R + g_{BR})ZZ_{31} + g_{BL}ZZ_{21} \right)^2 + \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \left( 3g_LZZ_{11} + g_{BL}ZZ_{21} + g_{BR}ZZ_{31} \right)^2 \right) (g_{\mu\nu}) \quad (553)$$


---



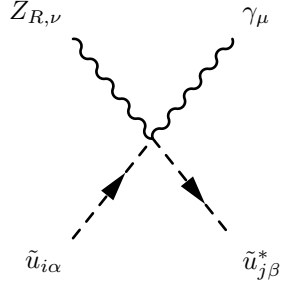
$$\frac{i}{3} \frac{1}{\sqrt{2}} g_L \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D \left( g_{BL}ZZ_{21} + g_{BR}ZZ_{31} \right) (g_{\mu\nu}) \quad (554)$$


---



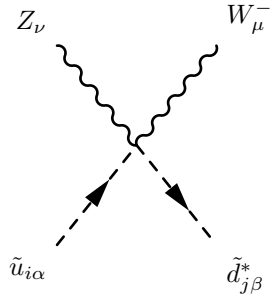
$$\begin{aligned} & \frac{i}{18} \delta_{\alpha\beta} \left( \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \left( 3g_LZZ_{11} + g_{BL}ZZ_{21} + g_{BR}ZZ_{31} \right) \left( 3g_LZZ_{12} + g_{BL}ZZ_{22} + g_{BR}ZZ_{32} \right) \right. \\ & \left. + \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \left( 3g_{RB}ZZ_{21} + (3g_R + g_{BR})ZZ_{31} + g_{BL}ZZ_{21} \right) \left( 3g_{RB}ZZ_{22} + (3g_R + g_{BR})ZZ_{32} + g_{BL}ZZ_{22} \right) \right) (g_{\mu\nu}) \quad (555) \end{aligned}$$


---



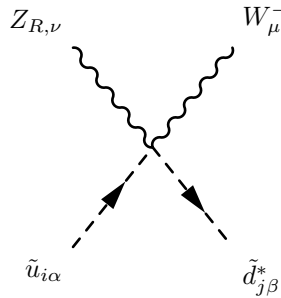
$$\frac{i}{18} \delta_{\alpha\beta} \left( \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \left( 3g_L Z Z_{11} + g_{BL} Z Z_{21} + g_{BR} Z Z_{31} \right) \left( 3g_L Z Z_{13} + g_{BL} Z Z_{23} + g_{BR} Z Z_{33} \right) \right. \\ \left. + \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \left( 3g_{RB} Z Z_{21} + (3g_R + g_{BR}) Z Z_{31} + g_{BL} Z Z_{21} \right) \left( 3g_{RB} Z Z_{23} + (3g_R + g_{BR}) Z Z_{33} + g_{BL} Z Z_{23} \right) \right) (g_{\mu\nu}) \quad (556)$$


---



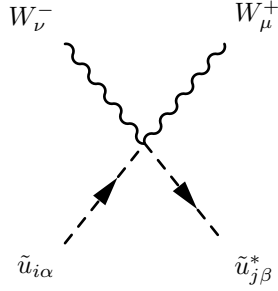
$$\frac{i}{3} \frac{1}{\sqrt{2}} g_L \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D \left( g_{BL} Z Z_{22} + g_{BR} Z Z_{32} \right) (g_{\mu\nu}) \quad (557)$$


---



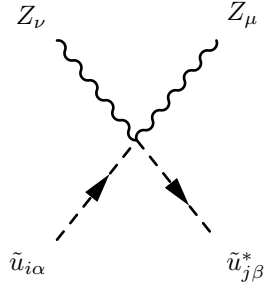
$$\frac{i}{3} \frac{1}{\sqrt{2}} g_L \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D (g_{BL} Z Z_{23} + g_{BR} Z Z_{33}) (g_{\mu\nu}) \quad (558)$$


---



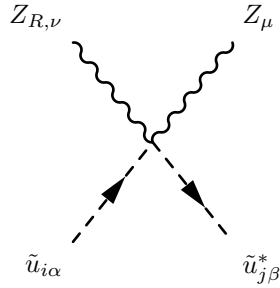
$$\frac{i}{2} g_L^2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U (g_{\mu\nu}) \quad (559)$$


---



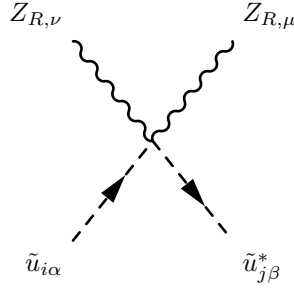
$$\frac{i}{18} \delta_{\alpha\beta} \left( \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U (3g_{RB} Z Z_{22} + (3g_R + g_{BR}) Z Z_{32} + g_{BL} Z Z_{22})^2 + \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U (3g_L Z Z_{12} + g_{BL} Z Z_{22} + g_{BR} Z Z_{32})^2 \right) (g_{\mu\nu}) \quad (560)$$


---



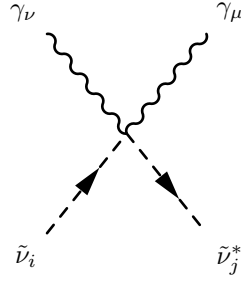
$$\begin{aligned}
& \frac{i}{18} \delta_{\alpha\beta} \left( \sum_{a=1}^3 Z_{i_a}^{U,*} Z_{j_a}^U \left( 3g_L Z Z_{12} + g_{BL} Z Z_{22} + g_{BR} Z Z_{32} \right) \left( 3g_L Z Z_{13} + g_{BL} Z Z_{23} + g_{BR} Z Z_{33} \right) \right. \\
& \left. + \sum_{a=1}^3 Z_{i_{3+a}}^{U,*} Z_{j_{3+a}}^U \left( 3g_{RB} Z Z_{22} + (3g_R + g_{BR}) Z Z_{32} + g_{BL} Z Z_{22} \right) \left( 3g_{RB} Z Z_{23} + (3g_R + g_{BR}) Z Z_{33} + g_{BL} Z Z_{23} \right) \right) (g_{\mu\nu})
\end{aligned} \tag{561}$$


---



$$\begin{aligned}
& \frac{i}{18} \delta_{\alpha\beta} \left( \sum_{a=1}^3 Z_{i_{3+a}}^{U,*} Z_{j_{3+a}}^U \left( 3g_{RB} Z Z_{23} + (3g_R + g_{BR}) Z Z_{33} + g_{BL} Z Z_{23} \right)^2 + \sum_{a=1}^3 Z_{i_a}^{U,*} Z_{j_a}^U \left( 3g_L Z Z_{13} + g_{BL} Z Z_{23} + g_{BR} Z Z_{33} \right)^2 \right) (g_{\mu\nu})
\end{aligned} \tag{562}$$

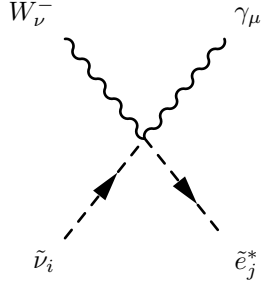

---



$$\begin{aligned}
& \frac{i}{2} \left( \sum_{a=1}^3 Z_{i_{3+a}}^{V,*} Z_{j_{3+a}}^V \left( g_{BL} Z Z_{21} - g_{RB} Z Z_{21} + (-g_R + g_{BR}) Z Z_{31} \right)^2 + \sum_{a=1}^3 Z_{i_a}^{V,*} Z_{j_a}^V \left( g_{BL} Z Z_{21} + g_{BR} Z Z_{31} - g_L Z Z_{11} \right)^2 \right) (g_{\mu\nu})
\end{aligned} \tag{563}$$

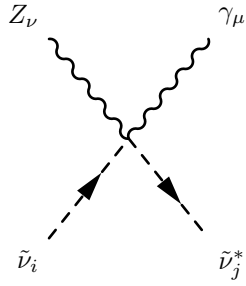

---





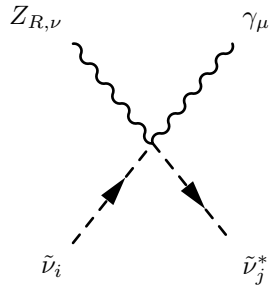
$$-i \frac{1}{\sqrt{2}} g_L \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ja}^E (g_{BL} Z Z_{21} + g_{BR} Z Z_{31}) (g_{\mu\nu}) \quad (564)$$


---



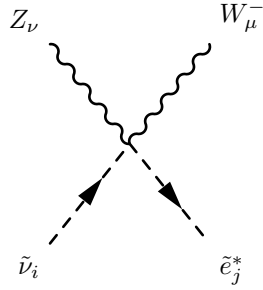
$$\begin{aligned} & \frac{i}{2} \left( \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ja}^V (-g_{BL} Z Z_{21} - g_{BR} Z Z_{31} + g_L Z Z_{11}) (-g_{BL} Z Z_{22} - g_{BR} Z Z_{32} + g_L Z Z_{12}) \right. \\ & \left. + \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{j3+a}^V (g_{BL} Z Z_{21} - g_{RB} Z Z_{21} + (-g_R + g_{BR}) Z Z_{31}) (g_{BL} Z Z_{22} - g_{RB} Z Z_{22} + (-g_R + g_{BR}) Z Z_{32}) \right) (g_{\mu\nu}) \end{aligned} \quad (565)$$


---



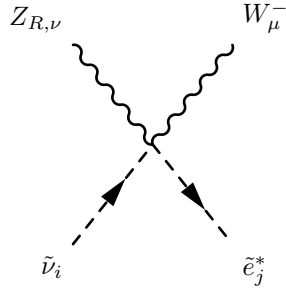
$$\begin{aligned}
& \frac{i}{2} \left( \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ja}^V \left( -g_{BL}ZZ_{21} - g_{BR}ZZ_{31} + g_LZZ_{11} \right) \left( -g_{BL}ZZ_{23} - g_{BR}ZZ_{33} + g_LZZ_{13} \right) \right. \\
& \left. + \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{j3+a}^V \left( g_{BL}ZZ_{21} - g_{RB}ZZ_{21} + \left( -g_R + g_{BR} \right) ZZ_{31} \right) \left( g_{BL}ZZ_{23} - g_{RB}ZZ_{23} + \left( -g_R + g_{BR} \right) ZZ_{33} \right) \right) (g_{\mu\nu})
\end{aligned} \tag{566}$$


---



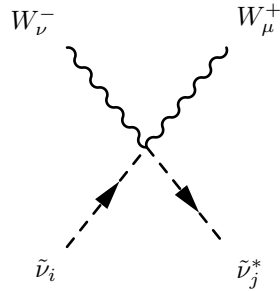
$$-i \frac{1}{\sqrt{2}} g_L \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ja}^E \left( g_{BL}ZZ_{22} + g_{BR}ZZ_{32} \right) (g_{\mu\nu}) \tag{567}$$


---



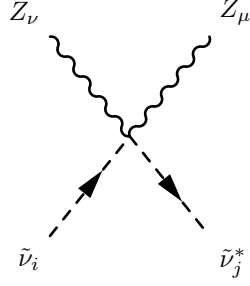
$$-i \frac{1}{\sqrt{2}} g_L \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ja}^E \left( g_{BL}ZZ_{23} + g_{BR}ZZ_{33} \right) (g_{\mu\nu}) \tag{568}$$


---



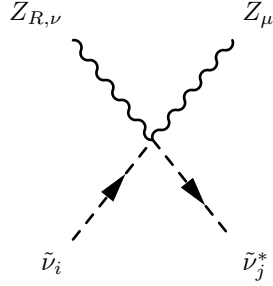
$$\frac{i}{2} g_L^2 \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ja}^V (g_{\mu\nu}) \quad (569)$$


---



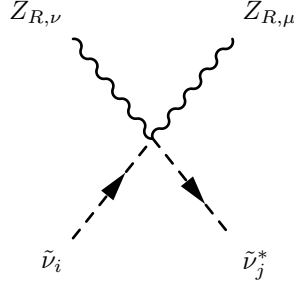
$$\frac{i}{2} \left( \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{j3+a}^V (g_{BL} Z Z_{22} - g_{RB} Z Z_{22} + (-g_R + g_{BR}) Z Z_{32})^2 + \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ja}^V (g_{BL} Z Z_{22} + g_{BR} Z Z_{32} - g_L Z Z_{12})^2 \right) (g_{\mu\nu}) \quad (570)$$


---



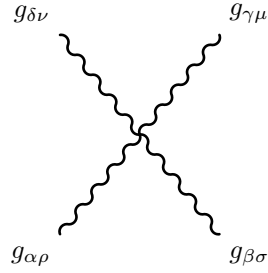
$$\begin{aligned} & \frac{i}{2} \left( \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ja}^V (-g_{BL} Z Z_{22} - g_{BR} Z Z_{32} + g_L Z Z_{12}) (-g_{BL} Z Z_{23} - g_{BR} Z Z_{33} + g_L Z Z_{13}) \right. \\ & \left. + \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{j3+a}^V (g_{BL} Z Z_{22} - g_{RB} Z Z_{22} + (-g_R + g_{BR}) Z Z_{32}) (g_{BL} Z Z_{23} - g_{RB} Z Z_{23} + (-g_R + g_{BR}) Z Z_{33}) \right) (g_{\mu\nu}) \quad (571) \end{aligned}$$


---



$$\frac{i}{2} \left( \sum_{a=1}^3 Z_{i3+a}^{V,*} Z_{j3+a}^V \left( g_{BL} Z Z_{23} - g_{RB} Z Z_{23} + (-g_R + g_{BR}) Z Z_{33} \right)^2 + \sum_{a=1}^3 Z_{ia}^{V,*} Z_{ja}^V \left( g_{BL} Z Z_{23} + g_{BR} Z Z_{33} - g_L Z Z_{13} \right)^2 \right) (g_{\mu\nu}) \quad (572)$$

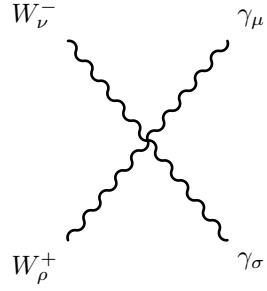
## 9.9 Four Vector Boson-Interaction



$$-ig_s^2 \left( \sum_{a=1}^8 f_{\alpha,\delta,a} f_{\beta,\gamma,a} + \sum_{a=1}^8 f_{\alpha,\gamma,a} f_{\beta,\delta,a} \right) (g_{\rho\sigma} g_{\mu\nu}) \quad (573)$$

$$+ ig_s^2 \left( - \sum_{a=1}^8 f_{\alpha,\beta,a} f_{\gamma,\delta,a} + \sum_{a=1}^8 f_{\alpha,\delta,a} f_{\beta,\gamma,a} \right) (g_{\rho\mu} g_{\sigma\nu}) \quad (574)$$

$$+ ig_s^2 \left( \sum_{a=1}^8 f_{\alpha,\gamma,a} f_{\beta,\delta,a} + \sum_{a=1}^8 f_{\alpha,\beta,a} f_{\gamma,\delta,a} \right) (g_{\rho\nu} g_{\sigma\mu}) \quad (575)$$

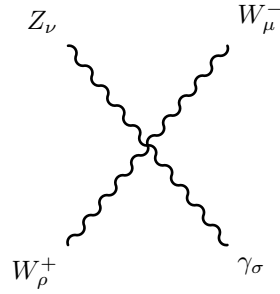


$$ig_L^2 ZZ_{11}^2 (g_{\rho\sigma} g_{\mu\nu}) \quad (576)$$

$$+ ig_L^2 ZZ_{11}^2 (g_{\rho\mu} g_{\sigma\nu}) \quad (577)$$

$$+ -2ig_L^2 ZZ_{11}^2 (g_{\rho\nu} g_{\sigma\mu}) \quad (578)$$


---

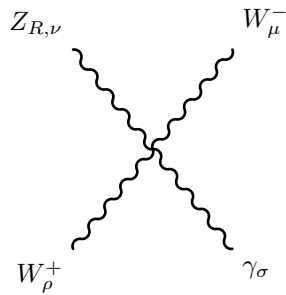


$$ig_L^2 ZZ_{11} ZZ_{12} (g_{\rho\sigma} g_{\mu\nu}) \quad (579)$$

$$+ -2ig_L^2 ZZ_{11} ZZ_{12} (g_{\rho\mu} g_{\sigma\nu}) \quad (580)$$

$$+ ig_L^2 ZZ_{11} ZZ_{12} (g_{\rho\nu} g_{\sigma\mu}) \quad (581)$$


---

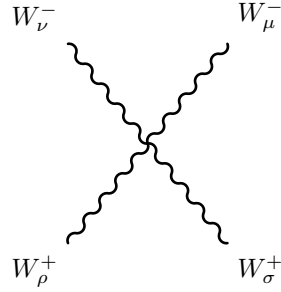


$$ig_L^2 ZZ_{11}ZZ_{13}(g_{\rho\sigma}g_{\mu\nu}) \quad (582)$$

$$+ -2ig_L^2 ZZ_{11}ZZ_{13}(g_{\rho\mu}g_{\sigma\nu}) \quad (583)$$

$$+ ig_L^2 ZZ_{11}ZZ_{13}(g_{\rho\nu}g_{\sigma\mu}) \quad (584)$$


---

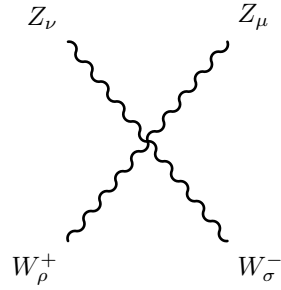


$$2ig_L^2(g_{\rho\sigma}g_{\mu\nu}) \quad (585)$$

$$+ -ig_L^2(g_{\rho\mu}g_{\sigma\nu}) \quad (586)$$

$$+ -ig_L^2(g_{\rho\nu}g_{\sigma\mu}) \quad (587)$$


---

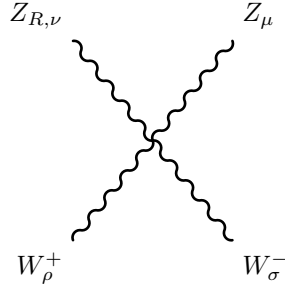


$$- 2ig_L^2 ZZ_{12}^2(g_{\rho\sigma}g_{\mu\nu}) \quad (588)$$

$$+ ig_L^2 ZZ_{12}^2(g_{\rho\mu}g_{\sigma\nu}) \quad (589)$$

$$+ ig_L^2 ZZ_{12}^2(g_{\rho\nu}g_{\sigma\mu}) \quad (590)$$

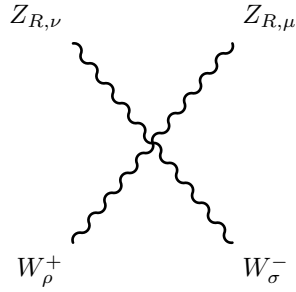

---



$$- 2ig_L^2 ZZ_{12}ZZ_{13} (g_{\rho\sigma}g_{\mu\nu}) \quad (591)$$

$$+ ig_L^2 ZZ_{12}ZZ_{13} (g_{\rho\mu}g_{\sigma\nu}) \quad (592)$$

$$+ ig_L^2 ZZ_{12}ZZ_{13} (g_{\rho\nu}g_{\sigma\mu}) \quad (593)$$

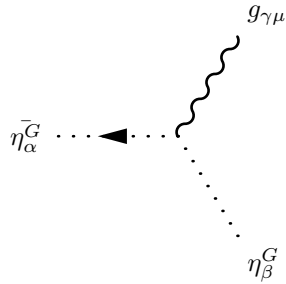


$$- 2ig_L^2 ZZ_{13}^2 (g_{\rho\sigma}g_{\mu\nu}) \quad (594)$$

$$+ ig_L^2 ZZ_{13}^2 (g_{\rho\mu}g_{\sigma\nu}) \quad (595)$$

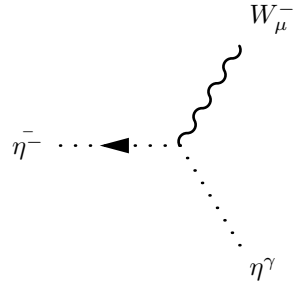
$$+ ig_L^2 ZZ_{13}^2 (g_{\rho\nu}g_{\sigma\mu}) \quad (596)$$

## 9.10 Two Ghosts-One Vector Boson-Interaction



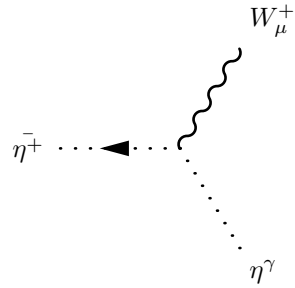
$$g_s f_{\alpha,\beta,\gamma} \left( p_\mu^{\eta_\beta^G} \right) \quad (597)$$


---



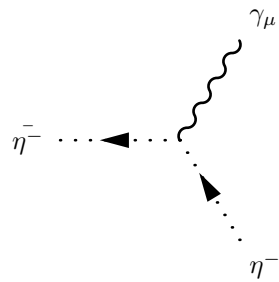
$$i g_L Z Z_{11} \left( p_\mu^{\eta^\gamma} \right) \quad (598)$$


---



$$- i g_L Z Z_{11}^* \left( p_\mu^{\eta^\gamma} \right) \quad (599)$$

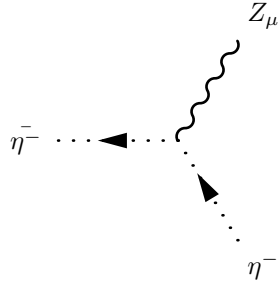

---



$$- i g_L Z Z_{11} \left( p_\mu^{\eta^-} \right) \quad (600)$$

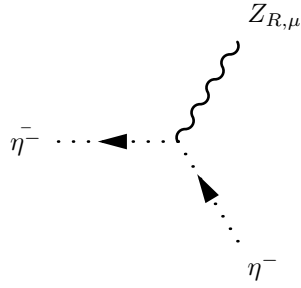

---





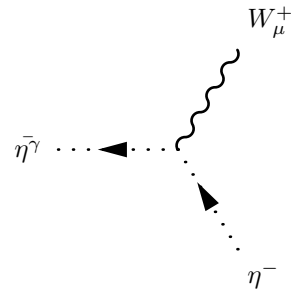
$$-ig_L Z Z_{12} (p_\mu^{\eta^-}) \quad (601)$$


---



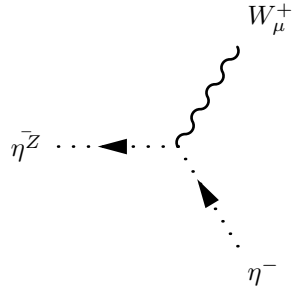
$$-ig_L Z Z_{13} (p_\mu^{\eta^-}) \quad (602)$$


---



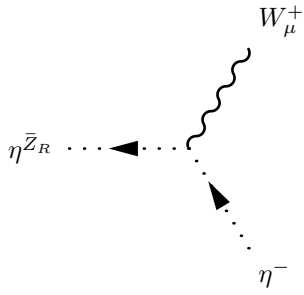
$$ig_L Z Z_{11}^* (p_\mu^{\eta^-}) \quad (603)$$


---



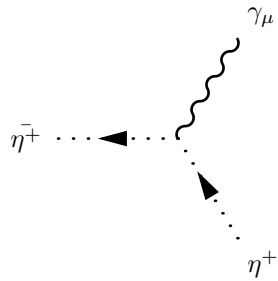
$$ig_L Z Z_{12}^* (p_\mu^{\eta^-}) \quad (604)$$


---



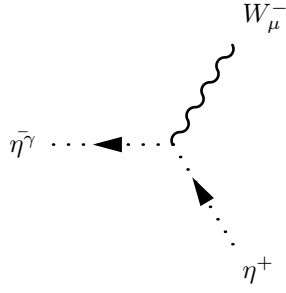
$$ig_L Z Z_{13}^* (p_\mu^{\eta^-}) \quad (605)$$


---



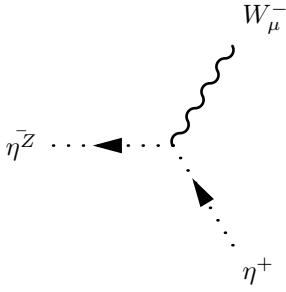
$$ig_L Z Z_{11}^* (p_\mu^{\eta^+}) \quad (606)$$


---



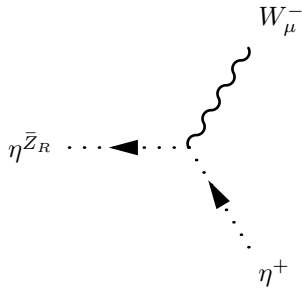
$$-ig_L Z Z_{11}^* (p_\mu^{\eta^+}) \quad (607)$$


---



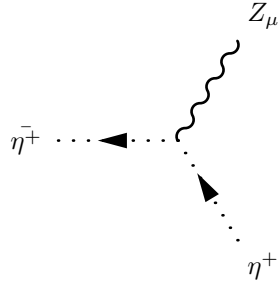
$$-ig_L Z Z_{12}^* (p_\mu^{\eta^+}) \quad (608)$$


---



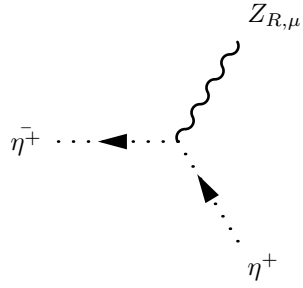
$$-ig_L Z Z_{13}^* (p_\mu^{\eta^+}) \quad (609)$$


---



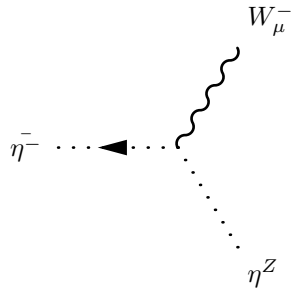
$$ig_L Z Z_{12}^* (p_\mu^{\eta^+}) \quad (610)$$


---



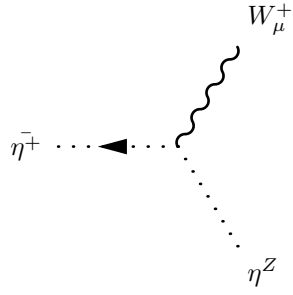
$$ig_L Z Z_{13}^* (p_\mu^{\eta^+}) \quad (611)$$


---



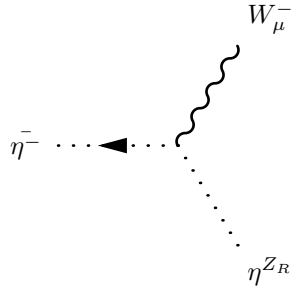
$$ig_L Z Z_{12} (p_\mu^{\eta^Z}) \quad (612)$$


---



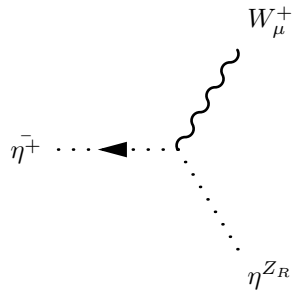
---


$$-ig_L Z Z_{12}^* (p_\mu^{\eta^Z}) \quad (613)$$



---

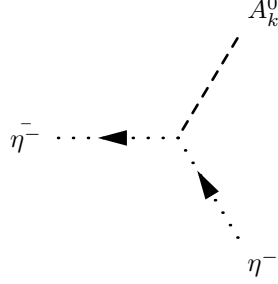

$$ig_L Z Z_{13} (p_\mu^{\eta^{Z_R}}) \quad (614)$$



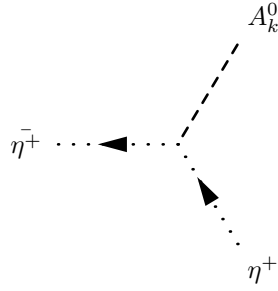
---


$$-ig_L Z Z_{13}^* (p_\mu^{\eta^{Z_R}}) \quad (615)$$

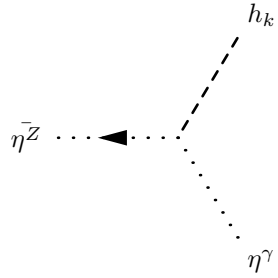
### 9.11 Two Ghosts-One Scalar-Interaction



$$\frac{1}{4}g_L^2\xi_{W^-}\left(v_dZ_{k1}^A - v_uZ_{k2}^A\right) \quad (616)$$

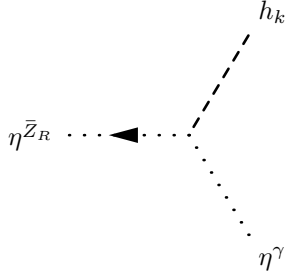


$$\frac{1}{4}g_L^2\xi_{W^-}\left(-v_dZ_{k1}^A + v_uZ_{k2}^A\right) \quad (617)$$



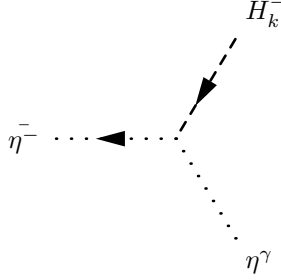
$$\begin{aligned} & -\frac{i}{8}\xi_Z\left(-g_Lg_Rv_dZZ_{32}^*Z_{k1}^HZZ_{11}-g_Lg_Rv_uZZ_{32}^*Z_{k2}^HZZ_{11}+g_L^2v_dZ_{k1}^HZZ_{11}ZZ_{12}+g_L^2v_uZ_{k2}^HZZ_{11}ZZ_{12}\right. \\ & +g_Rg_{RB}v_dZZ_{32}^*Z_{k1}^HZZ_{21}+g_Rg_{RB}v_uZZ_{32}^*Z_{k2}^HZZ_{21}+g_{BL}g_{BR}v_{\bar{\chi}_R}ZZ_{32}^*Z_{k3}^HZZ_{21}-g_{BL}g_{R}v_{\bar{\chi}_R}ZZ_{32}^*Z_{k3}^HZZ_{21} \\ & \left.-g_{BR}g_{RB}v_{\bar{\chi}_R}ZZ_{32}^*Z_{k3}^HZZ_{21}+g_Rg_{RB}v_{\bar{\chi}_R}ZZ_{32}^*Z_{k3}^HZZ_{21}+g_{BL}g_{BR}v_{\chi_R}ZZ_{32}^*Z_{k4}^HZZ_{21}-g_{BL}g_{R}v_{\chi_R}ZZ_{32}^*Z_{k4}^HZZ_{21}\right) \end{aligned}$$

$$\begin{aligned}
& -g_{BR}g_{RB}v_{\chi_R}ZZ_{32}^*Z_{k4}^HZZ_{21} + g_{R}g_{RB}v_{\chi_R}ZZ_{32}^*Z_{k4}^HZZ_{21} - g_Lg_{RB}v_dZ_{k1}^HZZ_{12}ZZ_{21} - g_Lg_{RB}v_uZ_{k2}^HZZ_{12}ZZ_{21} \\
& -g_Lg_{RB}v_dZ_{k1}^HZZ_{11}ZZ_{22} - g_Lg_{RB}v_uZ_{k2}^HZZ_{11}ZZ_{22} + g_{RB}^2v_dZ_{k1}^HZZ_{21}ZZ_{22} + g_{RB}^2v_uZ_{k2}^HZZ_{21}ZZ_{22} \\
& + g_{BL}^2v_{\bar{\chi}_R}Z_{k3}^HZZ_{21}ZZ_{22} - 2g_{BL}g_{RB}v_{\bar{\chi}_R}Z_{k3}^HZZ_{21}ZZ_{22} + g_{RB}^2v_{\bar{\chi}_R}Z_{k3}^HZZ_{21}ZZ_{22} + g_{BL}^2v_{\chi_R}Z_{k4}^HZZ_{21}ZZ_{22} \\
& - 2g_{BL}g_{RB}v_{\chi_R}Z_{k4}^HZZ_{21}ZZ_{22} + g_{RB}^2v_{\chi_R}Z_{k4}^HZZ_{21}ZZ_{22} + g_R^2v_dZZ_{32}^*Z_{k1}^HZZ_{31} + g_R^2v_uZZ_{32}^*Z_{k2}^HZZ_{31} \\
& + g_{BR}^2v_{\bar{\chi}_R}ZZ_{32}^*Z_{k3}^HZZ_{31} - 2g_{BR}g_{R}v_{\bar{\chi}_R}ZZ_{32}^*Z_{k3}^HZZ_{31} + g_R^2v_{\bar{\chi}_R}ZZ_{32}^*Z_{k3}^HZZ_{31} + g_{BR}^2v_{\chi_R}ZZ_{32}^*Z_{k4}^HZZ_{31} \\
& - 2g_{BR}g_{R}v_{\chi_R}ZZ_{32}^*Z_{k4}^HZZ_{31} + g_R^2v_{\chi_R}ZZ_{32}^*Z_{k4}^HZZ_{31} - g_Lg_{R}v_dZ_{k1}^HZZ_{12}ZZ_{31} - g_Lg_{R}v_uZ_{k2}^HZZ_{12}ZZ_{31} \\
& + g_{R}g_{RB}v_dZ_{k1}^HZZ_{22}ZZ_{31} + g_{R}g_{RB}v_uZ_{k2}^HZZ_{22}ZZ_{31} + g_{BL}g_{BR}v_{\bar{\chi}_R}Z_{k3}^HZZ_{22}ZZ_{31} - g_{BL}g_{R}v_{\bar{\chi}_R}Z_{k3}^HZZ_{22}ZZ_{31} \\
& - g_{BR}g_{RB}v_{\bar{\chi}_R}Z_{k3}^HZZ_{22}ZZ_{31} + g_{R}g_{RB}v_{\bar{\chi}_R}Z_{k3}^HZZ_{22}ZZ_{31} + g_{BL}g_{BR}v_{\chi_R}Z_{k4}^HZZ_{22}ZZ_{31} - g_{BL}g_{R}v_{\chi_R}Z_{k4}^HZZ_{22}ZZ_{31} \\
& - g_{BR}g_{RB}v_{\chi_R}Z_{k4}^HZZ_{22}ZZ_{31} + g_{R}g_{RB}v_{\chi_R}Z_{k4}^HZZ_{22}ZZ_{31} + g_LZZ_{12}^*(v_dZ_{k1}^H + v_uZ_{k2}^H)(g_LZZ_{11} - g_{RB}ZZ_{21} - g_RZZ_{31}) \\
& + ZZ_{22}^*\left(\left(-g_{RB} + g_{BL}\right)\left(v_{\bar{\chi}_R}Z_{k3}^H + v_{\chi_R}Z_{k4}^H\right)\left(g_{BL}ZZ_{21} - g_{RB}ZZ_{21} + \left(-g_R + g_{BR}\right)ZZ_{31}\right) + g_{RB}v_dZ_{k1}^H\left(-g_LZZ_{11} + g_{RB}ZZ_{21} - \right.\right. \\
& \left.\left.+ g_{RB}v_uZ_{k2}^H\left(-g_LZZ_{11} + g_{RB}ZZ_{21} + g_RZZ_{31}\right)\right)\right) \\
& - g_Lg_{R}v_dZ_{k1}^HZZ_{11}ZZ_{32} - g_Lg_{R}v_uZ_{k2}^HZZ_{11}ZZ_{32} + g_{R}g_{RB}v_dZ_{k1}^HZZ_{21}ZZ_{32} + g_{R}g_{RB}v_uZ_{k2}^HZZ_{21}ZZ_{32} \\
& + g_{BL}g_{BR}v_{\bar{\chi}_R}Z_{k3}^HZZ_{21}ZZ_{32} - g_{BL}g_{R}v_{\bar{\chi}_R}Z_{k3}^HZZ_{21}ZZ_{32} - g_{BR}g_{RB}v_{\bar{\chi}_R}Z_{k3}^HZZ_{21}ZZ_{32} + g_{R}g_{RB}v_{\bar{\chi}_R}Z_{k3}^HZZ_{21}ZZ_{32} \\
& + g_{BL}g_{BR}v_{\chi_R}Z_{k4}^HZZ_{21}ZZ_{32} - g_{BL}g_{R}v_{\chi_R}Z_{k4}^HZZ_{21}ZZ_{32} - g_{BR}g_{RB}v_{\chi_R}Z_{k4}^HZZ_{21}ZZ_{32} + g_{R}g_{RB}v_{\chi_R}Z_{k4}^HZZ_{21}ZZ_{32} \\
& + g_R^2v_dZ_{k1}^HZZ_{31}ZZ_{32} + g_R^2v_uZ_{k2}^HZZ_{31}ZZ_{32} + g_{BR}^2v_{\bar{\chi}_R}Z_{k3}^HZZ_{31}ZZ_{32} - 2g_{BR}g_{R}v_{\bar{\chi}_R}Z_{k3}^HZZ_{31}ZZ_{32} \\
& + g_R^2v_{\bar{\chi}_R}Z_{k3}^HZZ_{31}ZZ_{32} + g_{BR}^2v_{\chi_R}Z_{k4}^HZZ_{31}ZZ_{32} - 2g_{BR}g_{R}v_{\chi_R}Z_{k4}^HZZ_{31}ZZ_{32} + g_R^2v_{\chi_R}Z_{k4}^HZZ_{31}ZZ_{32}
\end{aligned} \tag{618}$$

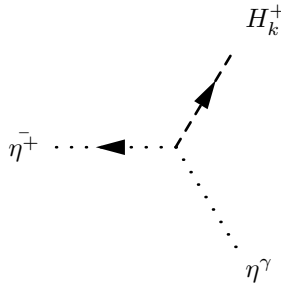


$$\begin{aligned}
& -\frac{i}{8}\xi_{Z_R}\left(-g_Lg_{R}v_dZZ_{33}^*Z_{k1}^HZZ_{11} - g_Lg_{R}v_uZZ_{33}^*Z_{k2}^HZZ_{11} + g_L^2v_dZ_{k1}^HZZ_{11}ZZ_{13} + g_L^2v_uZ_{k2}^HZZ_{11}ZZ_{13}\right. \\
& + g_{R}g_{RB}v_dZZ_{33}^*Z_{k1}^HZZ_{21} + g_{R}g_{RB}v_uZZ_{33}^*Z_{k2}^HZZ_{21} + g_{BL}g_{BR}v_{\bar{\chi}_R}ZZ_{33}^*Z_{k3}^HZZ_{21} - g_{BL}g_{R}v_{\bar{\chi}_R}ZZ_{33}^*Z_{k3}^HZZ_{21} \\
& - g_{BR}g_{RB}v_{\bar{\chi}_R}ZZ_{33}^*Z_{k3}^HZZ_{21} + g_{R}g_{RB}v_{\bar{\chi}_R}ZZ_{33}^*Z_{k3}^HZZ_{21} + g_{BL}g_{BR}v_{\chi_R}ZZ_{33}^*Z_{k4}^HZZ_{21} - g_{BL}g_{R}v_{\chi_R}ZZ_{33}^*Z_{k4}^HZZ_{21} \\
& - g_{BR}g_{RB}v_{\chi_R}ZZ_{33}^*Z_{k4}^HZZ_{21} + g_{R}g_{RB}v_{\chi_R}ZZ_{33}^*Z_{k4}^HZZ_{21} - g_Lg_{R}v_dZ_{k1}^HZZ_{13}ZZ_{21} - g_Lg_{R}v_uZ_{k2}^HZZ_{13}ZZ_{21} \\
& - g_Lg_{RB}v_dZ_{k1}^HZZ_{11}ZZ_{23} - g_Lg_{RB}v_uZ_{k2}^HZZ_{11}ZZ_{23} + g_{RB}^2v_dZ_{k1}^HZZ_{21}ZZ_{23} + g_{RB}^2v_uZ_{k2}^HZZ_{21}ZZ_{23} \\
& + g_{BL}^2v_{\bar{\chi}_R}Z_{k3}^HZZ_{21}ZZ_{23} - 2g_{BL}g_{RB}v_{\bar{\chi}_R}Z_{k3}^HZZ_{21}ZZ_{23} + g_{RB}^2v_{\bar{\chi}_R}Z_{k3}^HZZ_{21}ZZ_{23} + g_{BL}^2v_{\chi_R}Z_{k4}^HZZ_{21}ZZ_{23} \\
& \left.- 2g_{BL}g_{RB}v_{\chi_R}Z_{k4}^HZZ_{21}ZZ_{23} + g_{RB}^2v_{\chi_R}Z_{k4}^HZZ_{21}ZZ_{23} + g_R^2v_dZZ_{33}^*Z_{k1}^HZZ_{31} + g_R^2v_uZZ_{33}^*Z_{k2}^HZZ_{31}\right)
\end{aligned}$$

$$\begin{aligned}
& + g_{BR}^2 v_{\bar{\chi}_R} Z Z_{33}^* Z_{k3}^H Z Z_{31} - 2g_{BR} g_R v_{\bar{\chi}_R} Z Z_{33}^* Z_{k3}^H Z Z_{31} + g_R^2 v_{\bar{\chi}_R} Z Z_{33}^* Z_{k3}^H Z Z_{31} + g_{BR}^2 v_{\chi_R} Z Z_{33}^* Z_{k4}^H Z Z_{31} \\
& - 2g_{BR} g_R v_{\chi_R} Z Z_{33}^* Z_{k4}^H Z Z_{31} + g_R^2 v_{\chi_R} Z Z_{33}^* Z_{k4}^H Z Z_{31} - g_L g_R v_d Z_{k1}^H Z Z_{13} Z Z_{31} - g_L g_R v_u Z_{k2}^H Z Z_{13} Z Z_{31} \\
& + g_R g_{RB} v_d Z_{k1}^H Z Z_{23} Z Z_{31} + g_R g_{RB} v_u Z_{k2}^H Z Z_{23} Z Z_{31} + g_{BL} g_{BR} v_{\bar{\chi}_R} Z_{k3}^H Z Z_{23} Z Z_{31} - g_{BL} g_R v_{\bar{\chi}_R} Z_{k3}^H Z Z_{23} Z Z_{31} \\
& - g_{BR} g_{RB} v_{\bar{\chi}_R} Z_{k3}^H Z Z_{23} Z Z_{31} + g_R g_{RB} v_{\bar{\chi}_R} Z_{k3}^H Z Z_{23} Z Z_{31} + g_{BL} g_{BR} v_{\chi_R} Z_{k4}^H Z Z_{23} Z Z_{31} - g_{BL} g_R v_{\chi_R} Z_{k4}^H Z Z_{23} Z Z_{31} \\
& - g_{BR} g_{RB} v_{\chi_R} Z_{k4}^H Z Z_{23} Z Z_{31} + g_R g_{RB} v_{\chi_R} Z_{k4}^H Z Z_{23} Z Z_{31} + g_L Z Z_{13}^* (v_d Z_{k1}^H + v_u Z_{k2}^H) (g_L Z Z_{11} - g_{RB} Z Z_{21} - g_R Z Z_{31}) \\
& + Z Z_{23}^* \left( (-g_{RB} + g_{BL}) (v_{\bar{\chi}_R} Z_{k3}^H + v_{\chi_R} Z_{k4}^H) (g_{BL} Z Z_{21} - g_{RB} Z Z_{21} + (-g_R + g_{BR}) Z Z_{31}) + g_{RB} v_d Z_{k1}^H (-g_L Z Z_{11} + g_{RB} Z Z_{21} - \right. \\
& \left. + g_{RB} v_u Z_{k2}^H (-g_L Z Z_{11} + g_{RB} Z Z_{21} + g_R Z Z_{31})) \right) \\
& - g_L g_R v_d Z_{k1}^H Z Z_{11} Z Z_{33} - g_L g_R v_u Z_{k2}^H Z Z_{11} Z Z_{33} + g_R g_{RB} v_d Z_{k1}^H Z Z_{21} Z Z_{33} + g_R g_{RB} v_u Z_{k2}^H Z Z_{21} Z Z_{33} \\
& + g_{BL} g_{BR} v_{\bar{\chi}_R} Z_{k3}^H Z Z_{21} Z Z_{33} - g_{BL} g_R v_{\bar{\chi}_R} Z_{k3}^H Z Z_{21} Z Z_{33} - g_{BR} g_{RB} v_{\bar{\chi}_R} Z_{k3}^H Z Z_{21} Z Z_{33} + g_R g_{RB} v_{\bar{\chi}_R} Z_{k3}^H Z Z_{21} Z Z_{33} \\
& + g_{BL} g_{BR} v_{\chi_R} Z_{k4}^H Z Z_{21} Z Z_{33} - g_{BL} g_R v_{\chi_R} Z_{k4}^H Z Z_{21} Z Z_{33} - g_{BR} g_{RB} v_{\chi_R} Z_{k4}^H Z Z_{21} Z Z_{33} + g_R g_{RB} v_{\chi_R} Z_{k4}^H Z Z_{21} Z Z_{33} \\
& + g_R^2 v_d Z_{k1}^H Z Z_{31} Z Z_{33} + g_R^2 v_u Z_{k2}^H Z Z_{31} Z Z_{33} + g_{BR}^2 v_{\bar{\chi}_R} Z_{k3}^H Z Z_{31} Z Z_{33} - 2g_{BR} g_R v_{\bar{\chi}_R} Z_{k3}^H Z Z_{31} Z Z_{33} \\
& + g_R^2 v_{\bar{\chi}_R} Z_{k3}^H Z Z_{31} Z Z_{33} + g_{BR}^2 v_{\chi_R} Z_{k4}^H Z Z_{31} Z Z_{33} - 2g_{BR} g_R v_{\chi_R} Z_{k4}^H Z Z_{31} Z Z_{33} + g_R^2 v_{\chi_R} Z_{k4}^H Z Z_{31} Z Z_{33} \tag{619}
\end{aligned}$$



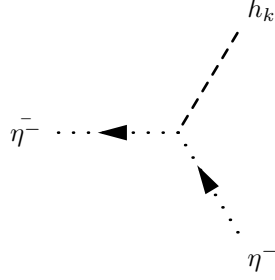
$$\begin{aligned}
& - \frac{i}{4} g_L \xi_W^- \left( g_L v_u Z Z_{11}^* Z_{k2}^+ + g_{RB} v_u Z Z_{21}^* Z_{k2}^+ + g_R v_u Z Z_{31}^* Z_{k2}^+ - g_L v_d Z_{k1}^+ Z Z_{11} - g_{RB} v_d Z_{k1}^+ Z Z_{21} \right. \\
& \left. - g_R v_d Z_{k1}^+ Z Z_{31} \right) \tag{620}
\end{aligned}$$





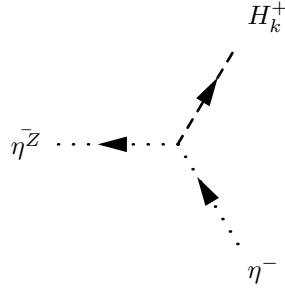
$$\frac{i}{4}g_L\xi_{W^-}\left(g_Lv_dZZ_{11}^*Z_{k1}^+ + g_{RB}v_dZZ_{21}^*Z_{k1}^+ + g_Rv_dZZ_{31}^*Z_{k1}^+ - g_Lv_uZ_{k2}^+ZZ_{11} - g_{RB}v_uZ_{k2}^+ZZ_{21} - g_Rv_uZ_{k2}^+ZZ_{31}\right) \quad (621)$$


---



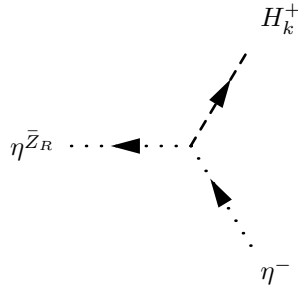
$$-\frac{i}{4}g_L^2\xi_{W^-}\left(v_dZ_{k1}^H + v_uZ_{k2}^H\right) \quad (622)$$


---



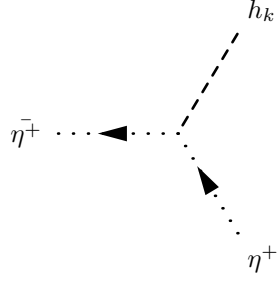
$$-\frac{i}{8}g_L\xi_Z\left(v_dZ_{k1}^+ - v_uZ_{k2}^+\right)\left(g_LZZ_{12}^* + g_LZZ_{12} - g_{RB}ZZ_{22}^* - g_{RB}ZZ_{22} - g_RZZ_{32}^* - g_RZZ_{32}\right) \quad (623)$$


---



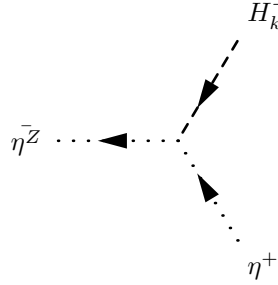
$$-\frac{i}{8}g_L\xi_{Z_R}\left(v_dZ_{k1}^+ - v_uZ_{k2}^+\right)\left(g_LZZ_{13}^* + g_LZZ_{13} - g_{RB}ZZ_{23}^* - g_{RB}ZZ_{23} - g_RZZ_{33}^* - g_RZZ_{33}\right) \quad (624)$$


---



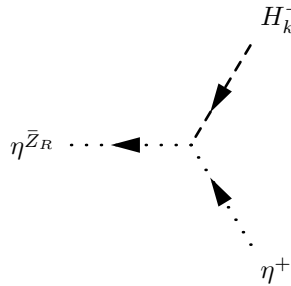
$$-\frac{i}{4}g_L^2\xi_{W^-}\left(v_d Z_{k1}^H + v_u Z_{k2}^H\right) \quad (625)$$


---



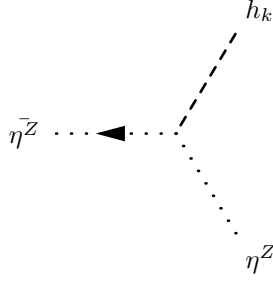
$$-\frac{i}{8}g_L\xi_Z\left(v_d Z_{k1}^+ - v_u Z_{k2}^+\right)\left(g_L Z Z_{12}^* + g_L Z Z_{12} - g_{RB} Z Z_{22}^* - g_{RB} Z Z_{22} - g_R Z Z_{32}^* - g_R Z Z_{32}\right) \quad (626)$$


---

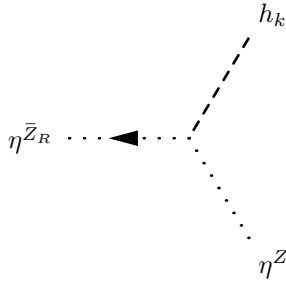


$$-\frac{i}{8}g_L\xi_{Z_R}\left(v_d Z_{k1}^+ - v_u Z_{k2}^+\right)\left(g_L Z Z_{13}^* + g_L Z Z_{13} - g_{RB} Z Z_{23}^* - g_{RB} Z Z_{23} - g_R Z Z_{33}^* - g_R Z Z_{33}\right) \quad (627)$$

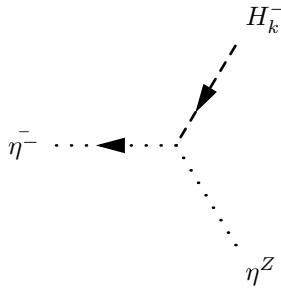

---



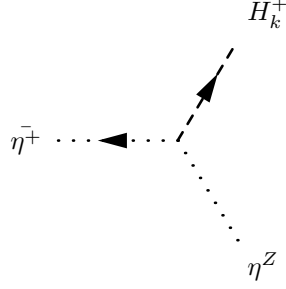
$$\begin{aligned}
& -\frac{i}{8}\xi_Z \left( g_R^2 v_d |ZZ_{32}|^2 Z_{k1}^H + g_R^2 v_u |ZZ_{32}|^2 Z_{k2}^H + g_{BR}^2 v_{\bar{\chi}_R} |ZZ_{32}|^2 Z_{k3}^H - 2g_{BR}g_R v_{\bar{\chi}_R} |ZZ_{32}|^2 Z_{k3}^H \right. \\
& + g_R^2 v_{\bar{\chi}_R} |ZZ_{32}|^2 Z_{k3}^H + g_{BR}^2 v_{\chi_R} |ZZ_{32}|^2 Z_{k4}^H - 2g_{BR}g_R v_{\chi_R} |ZZ_{32}|^2 Z_{k4}^H + g_R^2 v_{\chi_R} |ZZ_{32}|^2 Z_{k4}^H \\
& - g_L g_R v_d Z Z_{32}^* Z_{k1}^H Z Z_{12} - g_L g_R v_u Z Z_{32}^* Z_{k2}^H Z Z_{12} + g_L^2 v_d Z_{k1}^H Z Z_{12}^2 + g_L^2 v_u Z_{k2}^H Z Z_{12}^2 \\
& + g_R g_{RB} v_d Z Z_{32}^* Z_{k1}^H Z Z_{22} + g_R g_{RB} v_u Z Z_{32}^* Z_{k2}^H Z Z_{22} + g_{BL} g_{BR} v_{\bar{\chi}_R} Z Z_{32}^* Z_{k3}^H Z Z_{22} - g_{BL} g_R v_{\bar{\chi}_R} Z Z_{32}^* Z_{k3}^H Z Z_{22} \\
& - g_{BR} g_{RB} v_{\bar{\chi}_R} Z Z_{32}^* Z_{k3}^H Z Z_{22} + g_R g_{RB} v_{\bar{\chi}_R} Z Z_{32}^* Z_{k3}^H Z Z_{22} + g_{BL} g_{BR} v_{\chi_R} Z Z_{32}^* Z_{k4}^H Z Z_{22} - g_{BL} g_R v_{\chi_R} Z Z_{32}^* Z_{k4}^H Z Z_{22} \\
& - g_{BR} g_{RB} v_{\chi_R} Z Z_{32}^* Z_{k4}^H Z Z_{22} + g_R g_{RB} v_{\chi_R} Z Z_{32}^* Z_{k4}^H Z Z_{22} - 2g_L g_{RB} v_d Z_{k1}^H Z Z_{12} Z Z_{22} - 2g_L g_{RB} v_u Z_{k2}^H Z Z_{12} Z Z_{22} \\
& + g_{RB}^2 v_d Z_{k1}^H Z Z_{22}^2 + g_{RB}^2 v_u Z_{k2}^H Z Z_{22}^2 + g_{BL}^2 v_{\bar{\chi}_R} Z_{k3}^H Z Z_{22}^2 - 2g_{BL} g_{RB} v_{\bar{\chi}_R} Z_{k3}^H Z Z_{22}^2 \\
& + g_{RB}^2 v_{\bar{\chi}_R} Z_{k3}^H Z Z_{22}^2 + g_{BL}^2 v_{\chi_R} Z_{k4}^H Z Z_{22}^2 - 2g_{BL} g_{RB} v_{\chi_R} Z_{k4}^H Z Z_{22}^2 + g_{RB}^2 v_{\chi_R} Z_{k4}^H Z Z_{22}^2 \\
& - 2g_L g_R v_d Z_{k1}^H Z Z_{12} Z Z_{32} - 2g_L g_R v_u Z_{k2}^H Z Z_{12} Z Z_{32} + 2g_R g_{RB} v_d Z_{k1}^H Z Z_{22} Z Z_{32} + 2g_R g_{RB} v_u Z_{k2}^H Z Z_{22} Z Z_{32} \\
& + 2g_{BL} g_{BR} v_{\bar{\chi}_R} Z_{k3}^H Z Z_{22} Z Z_{32} - 2g_{BL} g_R v_{\bar{\chi}_R} Z_{k3}^H Z Z_{22} Z Z_{32} - 2g_{BR} g_{RB} v_{\bar{\chi}_R} Z_{k3}^H Z Z_{22} Z Z_{32} + 2g_R g_{RB} v_{\bar{\chi}_R} Z_{k3}^H Z Z_{22} Z Z_{32} \\
& + 2g_{BL} g_{BR} v_{\chi_R} Z_{k4}^H Z Z_{22} Z Z_{32} - 2g_{BL} g_R v_{\chi_R} Z_{k4}^H Z Z_{22} Z Z_{32} - 2g_{BR} g_{RB} v_{\chi_R} Z_{k4}^H Z Z_{22} Z Z_{32} + 2g_R g_{RB} v_{\chi_R} Z_{k4}^H Z Z_{22} Z Z_{32} \\
& + g_R^2 v_d Z_{k1}^H Z Z_{32}^2 + g_R^2 v_u Z_{k2}^H Z Z_{32}^2 + g_{BR}^2 v_{\bar{\chi}_R} Z_{k3}^H Z Z_{32}^2 - 2g_{BR} g_R v_{\bar{\chi}_R} Z_{k3}^H Z Z_{32}^2 \\
& + g_R^2 v_{\bar{\chi}_R} Z_{k3}^H Z Z_{32}^2 + g_{BR}^2 v_{\chi_R} Z_{k4}^H Z Z_{32}^2 - 2g_{BR} g_R v_{\chi_R} Z_{k4}^H Z Z_{32}^2 + g_R^2 v_{\chi_R} Z_{k4}^H Z Z_{32}^2 \\
& + g_L Z Z_{12}^* \left( v_d Z_{k1}^H + v_u Z_{k2}^H \right) \left( g_L Z Z_{12} - g_{RB} Z Z_{22} - g_R Z Z_{32} \right) \\
& + Z Z_{22}^* \left( \left( -g_{RB} + g_{BL} \right) \left( v_{\bar{\chi}_R} Z_{k3}^H + v_{\chi_R} Z_{k4}^H \right) \left( g_{BL} Z Z_{22} - g_{RB} Z Z_{22} + \left( -g_R + g_{BR} \right) Z Z_{32} \right) + g_{RB} v_d Z_{k1}^H \left( -g_L Z Z_{12} + g_{RB} Z Z_{22} - \right. \right. \\
& \left. \left. + g_{RB} v_u Z_{k2}^H \left( -g_L Z Z_{12} + g_{RB} Z Z_{22} + g_R Z Z_{32} \right) \right) \right) \tag{628}
\end{aligned}$$



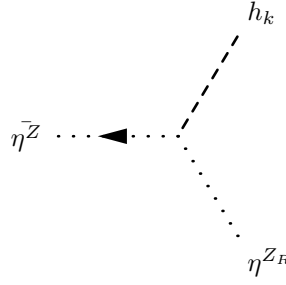
$$\begin{aligned}
& -\frac{i}{8}\xi_{Z_R}\left(-g_L g_R v_d Z Z_{33}^* Z_{k_1}^H Z Z_{12} - g_L g_R v_u Z Z_{33}^* Z_{k_2}^H Z Z_{12} + g_L^2 v_d Z_{k_1}^H Z Z_{12} Z Z_{13} + g_L^2 v_u Z_{k_2}^H Z Z_{12} Z Z_{13}\right. \\
& + g_R g_R v_d Z Z_{33}^* Z_{k_1}^H Z Z_{22} + g_R g_R v_u Z Z_{33}^* Z_{k_2}^H Z Z_{22} + g_B L g_B v_{\bar{\chi}_R} Z Z_{33}^* Z_{k_3}^H Z Z_{22} - g_B L g_R v_{\bar{\chi}_R} Z Z_{33}^* Z_{k_3}^H Z Z_{22} \\
& - g_B R g_R v_{\bar{\chi}_R} Z Z_{33}^* Z_{k_3}^H Z Z_{22} + g_R g_R v_{\bar{\chi}_R} Z Z_{33}^* Z_{k_3}^H Z Z_{22} + g_B L g_B v_{\chi_R} Z Z_{33}^* Z_{k_4}^H Z Z_{22} - g_B L g_R v_{\chi_R} Z Z_{33}^* Z_{k_4}^H Z Z_{22} \\
& - g_B R g_R v_{\chi_R} Z Z_{33}^* Z_{k_4}^H Z Z_{22} + g_R g_R v_{\chi_R} Z Z_{33}^* Z_{k_4}^H Z Z_{22} - g_L g_R v_d Z_{k_1}^H Z Z_{13} Z Z_{22} - g_L g_R v_u Z_{k_2}^H Z Z_{13} Z Z_{22} \\
& - g_L g_R v_d Z_{k_1}^H Z Z_{12} Z Z_{23} - g_L g_R v_u Z_{k_2}^H Z Z_{12} Z Z_{23} + g_R^2 v_d Z_{k_1}^H Z Z_{22} Z Z_{23} + g_R^2 v_u Z_{k_2}^H Z Z_{22} Z Z_{23} \\
& + g_B^2 v_{\bar{\chi}_R} Z_{k_3}^H Z Z_{22} Z Z_{23} - 2g_B L g_R v_{\bar{\chi}_R} Z_{k_3}^H Z Z_{22} Z Z_{23} + g_R^2 v_{\bar{\chi}_R} Z_{k_3}^H Z Z_{22} Z Z_{23} + g_B^2 v_{\chi_R} Z_{k_4}^H Z Z_{22} Z Z_{23} \\
& - 2g_B L g_R v_{\chi_R} Z_{k_4}^H Z Z_{22} Z Z_{23} + g_R^2 v_{\chi_R} Z_{k_4}^H Z Z_{22} Z Z_{23} + g_R^2 v_d Z Z_{33}^* Z_{k_1}^H Z Z_{32} + g_R^2 v_u Z Z_{33}^* Z_{k_2}^H Z Z_{32} \\
& + g_B^2 v_{\bar{\chi}_R} Z Z_{33}^* Z_{k_3}^H Z Z_{32} - 2g_B R g_R v_{\bar{\chi}_R} Z Z_{33}^* Z_{k_3}^H Z Z_{32} + g_R^2 v_{\bar{\chi}_R} Z Z_{33}^* Z_{k_3}^H Z Z_{32} + g_B^2 v_{\chi_R} Z Z_{33}^* Z_{k_4}^H Z Z_{32} \\
& - 2g_B R g_R v_{\chi_R} Z Z_{33}^* Z_{k_4}^H Z Z_{32} + g_R^2 v_{\chi_R} Z Z_{33}^* Z_{k_4}^H Z Z_{32} - g_L g_R v_d Z_{k_1}^H Z Z_{13} Z Z_{32} - g_L g_R v_u Z_{k_2}^H Z Z_{13} Z Z_{32} \\
& + g_R g_R v_d Z_{k_1}^H Z Z_{23} Z Z_{32} + g_R g_R v_u Z_{k_2}^H Z Z_{23} Z Z_{32} + g_B L g_B v_{\bar{\chi}_R} Z_{k_3}^H Z Z_{23} Z Z_{32} - g_B L g_R v_{\bar{\chi}_R} Z_{k_3}^H Z Z_{23} Z Z_{32} \\
& - g_B R g_R v_{\bar{\chi}_R} Z_{k_3}^H Z Z_{23} Z Z_{32} + g_R g_R v_{\bar{\chi}_R} Z_{k_3}^H Z Z_{23} Z Z_{32} + g_B L g_B v_{\chi_R} Z_{k_4}^H Z Z_{23} Z Z_{32} - g_B L g_R v_{\chi_R} Z_{k_4}^H Z Z_{23} Z Z_{32} \\
& - g_B R g_R v_{\chi_R} Z_{k_4}^H Z Z_{23} Z Z_{32} + g_R g_R v_{\chi_R} Z_{k_4}^H Z Z_{23} Z Z_{32} + g_L Z Z_{13}^* \left(v_d Z_{k_1}^H + v_u Z_{k_2}^H\right) \left(g_L Z Z_{12} - g_R B Z Z_{22} - g_R Z Z_{32}\right) \\
& + Z Z_{23}^* \left(\left(-g_R B + g_B L\right) \left(v_{\bar{\chi}_R} Z_{k_3}^H + v_{\chi_R} Z_{k_4}^H\right) \left(g_B L Z Z_{22} - g_R B Z Z_{22} + \left(-g_R + g_B R\right) Z Z_{32}\right) + g_R B v_d Z_{k_1}^H \left(-g_L Z Z_{12} + g_R B Z Z_{22} -\right.\right. \\
& \left.\left.+ g_R B v_u Z_{k_2}^H \left(-g_L Z Z_{12} + g_R B Z Z_{22} + g_R Z Z_{32}\right)\right)\right) \\
& - g_L g_R v_d Z_{k_1}^H Z Z_{12} Z Z_{33} - g_L g_R v_u Z_{k_2}^H Z Z_{12} Z Z_{33} + g_R g_R v_d Z_{k_1}^H Z Z_{22} Z Z_{33} + g_R g_R v_u Z_{k_2}^H Z Z_{22} Z Z_{33} \\
& + g_B L g_B v_{\bar{\chi}_R} Z_{k_3}^H Z Z_{22} Z Z_{33} - g_B L g_R v_{\bar{\chi}_R} Z_{k_3}^H Z Z_{22} Z Z_{33} - g_B R g_R v_{\bar{\chi}_R} Z_{k_3}^H Z Z_{22} Z Z_{33} + g_R g_R v_{\bar{\chi}_R} Z_{k_3}^H Z Z_{22} Z Z_{33} \\
& + g_B L g_B v_{\chi_R} Z_{k_4}^H Z Z_{22} Z Z_{33} - g_B L g_R v_{\chi_R} Z_{k_4}^H Z Z_{22} Z Z_{33} - g_B R g_R v_{\chi_R} Z_{k_4}^H Z Z_{22} Z Z_{33} + g_R g_R v_{\chi_R} Z_{k_4}^H Z Z_{22} Z Z_{33} \\
& + g_R^2 v_d Z_{k_1}^H Z Z_{32} Z Z_{33} + g_R^2 v_u Z_{k_2}^H Z Z_{32} Z Z_{33} + g_B^2 v_{\bar{\chi}_R} Z_{k_3}^H Z Z_{32} Z Z_{33} - 2g_B R g_R v_{\bar{\chi}_R} Z_{k_3}^H Z Z_{32} Z Z_{33} \\
& \left. + g_R^2 v_{\bar{\chi}_R} Z_{k_3}^H Z Z_{32} Z Z_{33} + g_B^2 v_{\chi_R} Z_{k_4}^H Z Z_{32} Z Z_{33} - 2g_B R g_R v_{\chi_R} Z_{k_4}^H Z Z_{32} Z Z_{33} + g_R^2 v_{\chi_R} Z_{k_4}^H Z Z_{32} Z Z_{33}\right) \quad (629)
\end{aligned}$$



$$\begin{aligned}
& -\frac{i}{4}g_L \xi_{W^-} \left(g_L v_u Z Z_{12}^* Z_{k_2}^+ + g_R B v_u Z Z_{22}^* Z_{k_2}^+ + g_R v_u Z Z_{32}^* Z_{k_2}^+ - g_L v_d Z_{k_1}^+ Z Z_{12} - g_R B v_d Z_{k_1}^+ Z Z_{22} \right. \\
& \left. - g_R v_d Z_{k_1}^+ Z Z_{32}\right) \quad (630)
\end{aligned}$$

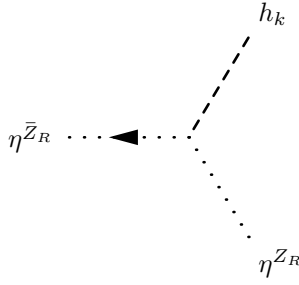


$$\begin{aligned}
& \frac{i}{4} g_L \xi_W^- \left( g_L v_d Z Z_{12}^* Z_{k1}^+ + g_{RB} v_d Z Z_{22}^* Z_{k1}^+ + g_R v_d Z Z_{32}^* Z_{k1}^+ - g_L v_u Z_{k2}^+ Z Z_{12} - g_{RB} v_u Z_{k2}^+ Z Z_{22} \right. \\
& \left. - g_R v_u Z_{k2}^+ Z Z_{32} \right) \tag{631}
\end{aligned}$$

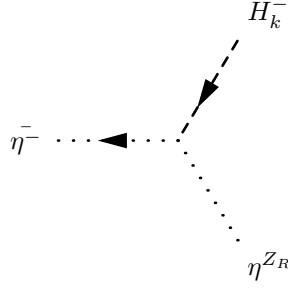


$$\begin{aligned}
& - \frac{i}{8} \xi_Z \left( -g_L g_R v_d Z Z_{32}^* Z_{k1}^H Z Z_{13} - g_L g_R v_u Z Z_{32}^* Z_{k2}^H Z Z_{13} + g_L^2 v_d Z_{k1}^H Z Z_{12} Z Z_{13} + g_L^2 v_u Z_{k2}^H Z Z_{12} Z Z_{13} \right. \\
& - g_L g_{RB} v_d Z_{k1}^H Z Z_{13} Z Z_{22} - g_L g_{RB} v_u Z_{k2}^H Z Z_{13} Z Z_{22} + g_R g_{RB} v_d Z Z_{32}^* Z_{k1}^H Z Z_{23} + g_R g_{RB} v_u Z Z_{32}^* Z_{k2}^H Z Z_{23} \\
& + g_{BL} g_{BR} v_{\bar{\chi}_R} Z Z_{32}^* Z_{k3}^H Z Z_{23} - g_{BL} g_R v_{\bar{\chi}_R} Z Z_{32}^* Z_{k3}^H Z Z_{23} - g_{BR} g_{RB} v_{\bar{\chi}_R} Z Z_{32}^* Z_{k3}^H Z Z_{23} + g_R g_{RB} v_{\bar{\chi}_R} Z Z_{32}^* Z_{k3}^H Z Z_{23} \\
& + g_{BL} g_{BR} v_{\chi_R} Z Z_{32}^* Z_{k4}^H Z Z_{23} - g_{BL} g_R v_{\chi_R} Z Z_{32}^* Z_{k4}^H Z Z_{23} - g_{BR} g_{RB} v_{\chi_R} Z Z_{32}^* Z_{k4}^H Z Z_{23} + g_R g_{RB} v_{\chi_R} Z Z_{32}^* Z_{k4}^H Z Z_{23} \\
& - g_L g_{RB} v_d Z_{k1}^H Z Z_{12} Z Z_{23} - g_L g_{RB} v_u Z_{k2}^H Z Z_{12} Z Z_{23} + g_{RB}^2 v_d Z_{k1}^H Z Z_{22} Z Z_{23} + g_{RB}^2 v_u Z_{k2}^H Z Z_{22} Z Z_{23} \\
& + g_{BL}^2 v_{\bar{\chi}_R} Z_{k3}^H Z Z_{22} Z Z_{23} - 2g_{BL} g_{RB} v_{\bar{\chi}_R} Z_{k3}^H Z Z_{22} Z Z_{23} + g_{RB}^2 v_{\bar{\chi}_R} Z_{k3}^H Z Z_{22} Z Z_{23} + g_{BL}^2 v_{\chi_R} Z_{k4}^H Z Z_{22} Z Z_{23} \\
& - 2g_{BL} g_{RB} v_{\chi_R} Z_{k4}^H Z Z_{22} Z Z_{23} + g_{RB}^2 v_{\chi_R} Z_{k4}^H Z Z_{22} Z Z_{23} - g_L g_R v_d Z_{k1}^H Z Z_{13} Z Z_{32} - g_L g_R v_u Z_{k2}^H Z Z_{13} Z Z_{32} \\
& + g_R g_{RB} v_d Z_{k1}^H Z Z_{23} Z Z_{32} + g_R g_{RB} v_u Z_{k2}^H Z Z_{23} Z Z_{32} + g_{BL} g_{BR} v_{\bar{\chi}_R} Z_{k3}^H Z Z_{23} Z Z_{32} - g_{BL} g_R v_{\bar{\chi}_R} Z_{k3}^H Z Z_{23} Z Z_{32} \\
& - g_{BR} g_{RB} v_{\bar{\chi}_R} Z_{k3}^H Z Z_{23} Z Z_{32} + g_R g_{RB} v_{\bar{\chi}_R} Z_{k3}^H Z Z_{23} Z Z_{32} + g_{BL} g_{BR} v_{\chi_R} Z_{k4}^H Z Z_{23} Z Z_{32} - g_{BL} g_R v_{\chi_R} Z_{k4}^H Z Z_{23} Z Z_{32} \\
& - g_{BR} g_{RB} v_{\chi_R} Z_{k4}^H Z Z_{23} Z Z_{32} + g_R g_{RB} v_{\chi_R} Z_{k4}^H Z Z_{23} Z Z_{32} + g_R^2 v_d Z Z_{32}^* Z_{k1}^H Z Z_{33} + g_R^2 v_u Z Z_{32}^* Z_{k2}^H Z Z_{33} \\
& + g_{BR}^2 v_{\bar{\chi}_R} Z Z_{32}^* Z_{k3}^H Z Z_{33} - 2g_{BR} g_R v_{\bar{\chi}_R} Z Z_{32}^* Z_{k3}^H Z Z_{33} + g_R^2 v_{\bar{\chi}_R} Z Z_{32}^* Z_{k3}^H Z Z_{33} + g_{BR}^2 v_{\chi_R} Z Z_{32}^* Z_{k4}^H Z Z_{33} \\
& - 2g_{BR} g_R v_{\chi_R} Z Z_{32}^* Z_{k4}^H Z Z_{33} + g_R^2 v_{\chi_R} Z Z_{32}^* Z_{k4}^H Z Z_{33} - g_L g_R v_d Z_{k1}^H Z Z_{12} Z Z_{33} - g_L g_R v_u Z_{k2}^H Z Z_{12} Z Z_{33} \\
& + g_R g_{RB} v_d Z_{k1}^H Z Z_{22} Z Z_{33} + g_R g_{RB} v_u Z_{k2}^H Z Z_{22} Z Z_{33} + g_{BL} g_{BR} v_{\bar{\chi}_R} Z_{k3}^H Z Z_{22} Z Z_{33} - g_{BL} g_R v_{\bar{\chi}_R} Z_{k3}^H Z Z_{22} Z Z_{33}
\end{aligned}$$

$$\begin{aligned}
& -g_{BR}g_{RB}v_{\bar{\chi}_R}Z_{k3}^HZZ_{22}ZZ_{33} + g_Rg_{RB}v_{\bar{\chi}_R}Z_{k3}^HZZ_{22}ZZ_{33} + g_{BL}g_{BR}v_{\chi_R}Z_{k4}^HZZ_{22}ZZ_{33} - g_{BL}g_Rv_{\chi_R}Z_{k4}^HZZ_{22}ZZ_{33} \\
& -g_{BR}g_{RB}v_{\chi_R}Z_{k4}^HZZ_{22}ZZ_{33} + g_Rg_{RB}v_{\chi_R}Z_{k4}^HZZ_{22}ZZ_{33} + g_R^2v_dZ_{k1}^HZZ_{32}ZZ_{33} + g_R^2v_uZ_{k2}^HZZ_{32}ZZ_{33} \\
& + g_{BR}^2v_{\bar{\chi}_R}Z_{k3}^HZZ_{32}ZZ_{33} - 2g_{BR}g_Rv_{\bar{\chi}_R}Z_{k3}^HZZ_{32}ZZ_{33} + g_R^2v_{\bar{\chi}_R}Z_{k3}^HZZ_{32}ZZ_{33} + g_{BR}^2v_{\chi_R}Z_{k4}^HZZ_{32}ZZ_{33} \\
& - 2g_{BR}g_Rv_{\chi_R}Z_{k4}^HZZ_{32}ZZ_{33} + g_R^2v_{\chi_R}Z_{k4}^HZZ_{32}ZZ_{33} + g_LZZ_{12}^*(v_dZ_{k1}^H + v_uZ_{k2}^H)(g_LZZ_{13} - g_{RB}ZZ_{23} - g_RZZ_{33}) \\
& + ZZ_{22}^*\left(\left(-g_{RB} + g_{BL}\right)\left(v_{\bar{\chi}_R}Z_{k3}^H + v_{\chi_R}Z_{k4}^H\right)\left(g_{BL}ZZ_{23} - g_{RB}ZZ_{23} + \left(-g_R + g_{BR}\right)ZZ_{33}\right) + g_{RB}v_dZ_{k1}^H\left(-g_LZZ_{13} + g_{RB}ZZ_{23} - \right.\right. \\
& \left.\left.+ g_{RB}v_uZ_{k2}^H\left(-g_LZZ_{13} + g_{RB}ZZ_{23} + g_RZZ_{33}\right)\right)\right) \tag{632}
\end{aligned}$$

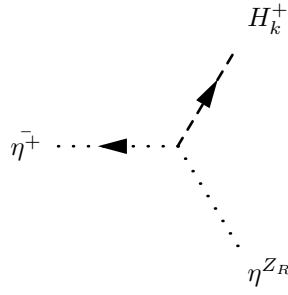


$$\begin{aligned}
& -\frac{i}{8}\xi_{Z_R}\left(g_R^2v_d|ZZ_{33}|^2Z_{k1}^H + g_R^2v_u|ZZ_{33}|^2Z_{k2}^H + g_{BR}^2v_{\bar{\chi}_R}|ZZ_{33}|^2Z_{k3}^H - 2g_{BR}g_Rv_{\bar{\chi}_R}|ZZ_{33}|^2Z_{k3}^H\right. \\
& + g_R^2v_{\bar{\chi}_R}|ZZ_{33}|^2Z_{k3}^H + g_{BR}^2v_{\chi_R}|ZZ_{33}|^2Z_{k4}^H - 2g_{BR}g_Rv_{\chi_R}|ZZ_{33}|^2Z_{k4}^H + g_R^2v_{\chi_R}|ZZ_{33}|^2Z_{k4}^H \\
& - g_Lg_Rv_dZZ_{33}^*Z_{k1}^HZZ_{13} - g_Lg_Rv_uZZ_{33}^*Z_{k2}^HZZ_{13} + g_L^2v_dZ_{k1}^HZZ_{13}^2 + g_L^2v_uZ_{k2}^HZZ_{13}^2 \\
& + g_Rg_{RB}v_dZZ_{33}^*Z_{k1}^HZZ_{23} + g_Rg_{RB}v_uZZ_{33}^*Z_{k2}^HZZ_{23} + g_{BL}g_{BR}v_{\bar{\chi}_R}ZZ_{33}^*Z_{k3}^HZZ_{23} - g_{BL}g_Rv_{\bar{\chi}_R}ZZ_{33}^*Z_{k3}^HZZ_{23} \\
& - g_{BR}g_{RB}v_{\bar{\chi}_R}ZZ_{33}^*Z_{k3}^HZZ_{23} + g_Rg_{RB}v_{\bar{\chi}_R}ZZ_{33}^*Z_{k3}^HZZ_{23} + g_{BL}g_{BR}v_{\chi_R}ZZ_{33}^*Z_{k4}^HZZ_{23} - g_{BL}g_Rv_{\chi_R}ZZ_{33}^*Z_{k4}^HZZ_{23} \\
& - g_{BR}g_{RB}v_{\chi_R}ZZ_{33}^*Z_{k4}^HZZ_{23} + g_Rg_{RB}v_{\chi_R}ZZ_{33}^*Z_{k4}^HZZ_{23} - 2g_Lg_{RB}v_dZ_{k1}^HZZ_{13}ZZ_{23} - 2g_Lg_{RB}v_uZ_{k2}^HZZ_{13}ZZ_{23} \\
& + g_{RB}^2v_dZ_{k1}^HZZ_{23}^2 + g_{RB}^2v_uZ_{k2}^HZZ_{23}^2 + g_{BL}^2v_{\bar{\chi}_R}Z_{k3}^HZZ_{23}^2 - 2g_{BL}g_{RB}v_{\bar{\chi}_R}Z_{k3}^HZZ_{23}^2 \\
& + g_{BR}^2v_{\bar{\chi}_R}Z_{k3}^HZZ_{23}^2 + g_{BL}^2v_{\chi_R}Z_{k4}^HZZ_{23}^2 - 2g_{BL}g_{RB}v_{\chi_R}Z_{k4}^HZZ_{23}^2 + g_{RB}^2v_{\chi_R}Z_{k4}^HZZ_{23}^2 \\
& - 2g_Lg_Rv_dZ_{k1}^HZZ_{13}ZZ_{33} - 2g_Lg_Rv_uZ_{k2}^HZZ_{13}ZZ_{33} + 2g_Rg_{RB}v_dZ_{k1}^HZZ_{23}ZZ_{33} + 2g_Rg_{RB}v_uZ_{k2}^HZZ_{23}ZZ_{33} \\
& + 2g_{BL}g_{BR}v_{\bar{\chi}_R}Z_{k3}^HZZ_{23}ZZ_{33} - 2g_{BL}g_Rv_{\bar{\chi}_R}Z_{k3}^HZZ_{23}ZZ_{33} - 2g_{BR}g_{RB}v_{\bar{\chi}_R}Z_{k3}^HZZ_{23}ZZ_{33} + 2g_Rg_{RB}v_{\bar{\chi}_R}Z_{k3}^HZZ_{23}ZZ_{33} \\
& + 2g_{BL}g_{BR}v_{\chi_R}Z_{k4}^HZZ_{23}ZZ_{33} - 2g_{BL}g_Rv_{\chi_R}Z_{k4}^HZZ_{23}ZZ_{33} - 2g_{BR}g_{RB}v_{\chi_R}Z_{k4}^HZZ_{23}ZZ_{33} + 2g_Rg_{RB}v_{\chi_R}Z_{k4}^HZZ_{23}ZZ_{33} \\
& + g_R^2v_dZ_{k1}^HZZ_{33}^2 + g_R^2v_uZ_{k2}^HZZ_{33}^2 + g_{BR}^2v_{\bar{\chi}_R}Z_{k3}^HZZ_{33}^2 - 2g_{BR}g_Rv_{\bar{\chi}_R}Z_{k3}^HZZ_{33}^2 \\
& + g_R^2v_{\bar{\chi}_R}Z_{k3}^HZZ_{33}^2 + g_{BR}^2v_{\chi_R}Z_{k4}^HZZ_{33}^2 - 2g_{BR}g_Rv_{\chi_R}Z_{k4}^HZZ_{33}^2 + g_R^2v_{\chi_R}Z_{k4}^HZZ_{33}^2 \\
& + g_LZZ_{13}^*(v_dZ_{k1}^H + v_uZ_{k2}^H)(g_LZZ_{13} - g_{RB}ZZ_{23} - g_RZZ_{33}) \\
& + ZZ_{23}^*\left(\left(-g_{RB} + g_{BL}\right)\left(v_{\bar{\chi}_R}Z_{k3}^H + v_{\chi_R}Z_{k4}^H\right)\left(g_{BL}ZZ_{23} - g_{RB}ZZ_{23} + \left(-g_R + g_{BR}\right)ZZ_{33}\right) + g_{RB}v_dZ_{k1}^H\left(-g_LZZ_{13} + g_{RB}ZZ_{23} - \right.\right. \\
& \left.\left.+ g_{RB}v_uZ_{k2}^H\left(-g_LZZ_{13} + g_{RB}ZZ_{23} + g_RZZ_{33}\right)\right)\right) \tag{633}
\end{aligned}$$



$$\begin{aligned}
& -\frac{i}{4}g_L\xi_{W^-}\left(g_Lv_uZZ_{13}^*Z_{k2}^+ + g_{RB}v_uZZ_{23}^*Z_{k2}^+ + g_Rv_uZZ_{33}^*Z_{k2}^+ - g_Lv_dZ_{k1}^+ZZ_{13} - g_{RB}v_dZ_{k1}^+ZZ_{23} \right. \\
& \left. - g_Rv_dZ_{k1}^+ZZ_{33}\right)
\end{aligned} \tag{634}$$


---



$$\begin{aligned}
& \frac{i}{4}g_L\xi_{W^-}\left(g_Lv_dZZ_{13}^*Z_{k1}^+ + g_{RB}v_dZZ_{23}^*Z_{k1}^+ + g_Rv_dZZ_{33}^*Z_{k1}^+ - g_Lv_uZ_{k2}^+ZZ_{13} - g_{RB}v_uZ_{k2}^+ZZ_{23} \right. \\
& \left. - g_Rv_uZ_{k2}^+ZZ_{33}\right)
\end{aligned} \tag{635}$$


---

## 10 Clebsch-Gordan Coefficients