A supersymmetric electrowerk scale seesaw model Superpotential, Rotations and Interactions for eigenstates 'EWSB' including Renormalization Group Equations including one-loop Self-Energies

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833,2011 (1002.0840) , **Comput.Phys.Commun.181:1077-1086,2010 (0909.2863)** , **arXiv: 0806.0538**
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Contents

1 Superfields **3**
- 1.1 Vector Superfields . . . 3
- 1.2 Chiral Superfields . . . 3

2 Superpotential and Lagrangian **3**
- 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

3 Renormalization Group Equations **4**
- 3.1 Anomalous Dimensions . . . 4
- 3.2 Gauge Couplings . . . 5
- 3.3 Gaugino Mass Parameters . . . 6
- 3.4 Trilinear Superpotential Parameters . . . 6
- 3.5 Bilinear Superpotential Parameters . . . 8
- 3.6 Trilinear Soft-Breaking Parameters . . . 8
- 3.7 Bilinear Soft-Breaking Parameters . . . 11
- 3.8 Soft-Breaking Scalar Masses . . . 12
- 3.9 Vacuum expectation values . . . 20

4 Field Rotations **20**
- 4.1 Rotations in gauge sector for eigenstates `'EWSB'` . . . 20
- 4.2 Rotations in Mass sector for eigenstates `'EWSB'` . . . 21
  - 4.2.1 Mass Matrices for Scalars . . . 21
  - 4.2.2 Mass Matrices for Fermions . . . 25

5 Vacuum Expectation Values **27**

6 Tadpole Equations **27**

7 Particle content for eigenstates `'EWSB'` **28**

8 One Loop Self-Energy and One Loop Tadpoles for eigenstates `'EWSB'` **28**
- 8.1 One Loop Self-Energy . . . 28
- 8.2 Tadpoles . . . 53

9 Interactions for eigenstates `'EWSB'` **54**
- 9.1 Three Scalar-Interaction . . . 54
- 9.2 Two Scalar-One Vector Boson-Interaction . . . 70
- 9.3 One Scalar-Two Vector Boson-Interaction . . . 78
- 9.4 Two Fermion-One Vector Boson-Interaction . . . 80
- 9.5 Two Fermion-One Scalar Boson-Interaction . . . 86

9.6 Three Vector Boson-Interaction . . . 103
9.7 Four Scalar-Interaction . . . 104
9.8 Two Scalar-Two Vector Boson-Interaction . . . 156
9.9 Four Vector Boson-Interaction . . . 174
9.10 Two Ghosts-One Vector Boson-Interaction . . . 176
9.11 Two Ghosts-One Scalar-Interaction . . . 180

10 Clebsch-Gordan Coefficients **184**

1 Superfields

1.1 Vector Superfields

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

1.2 Chiral Superfields

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

2 Superpotential and Lagrangian

2.1 Superpotential

$$\begin{aligned} W =& \mu_H \, \hat{H}_u \, \hat{H}_d \, + \mu_{NS} \, \hat{\nu} \, \hat{s} \, - y_d \, \hat{d} \, \hat{q} \, \hat{H}_d \, - y_e \, \hat{e} \, \hat{l} \, \hat{H}_d \, + \frac{1}{2} \lambda \, \hat{s} \, \hat{s} \, \hat{X} \, + y_u \, \hat{u} \, \hat{q} \, \hat{H}_u \, + Y_\nu \, \hat{\nu} \, \hat{l} \, \hat{H}_u \\ & + \frac{1}{3} \kappa \, \hat{X} \, \hat{X} \, \hat{X} \end{aligned} \tag{1}$$

2.2 Softbreaking terms

$$\begin{aligned} -L_{SB,W} =& - H_d^0 H_u^0 b_H + H_d^- H_u^+ b_H + \frac{1}{3} X^3 A_\kappa + \tilde{N}_i^{c,*} \tilde{S}_j b_{NS,ij} + \frac{1}{2} X \tilde{S}_i \tilde{S}_j A_{\lambda,ij} + H_d^0 \tilde{d}_{R,i\alpha}^* \delta_{\alpha\beta} \tilde{d}_{L,j\beta} A_{d,ij} \\ & - H_d^- \tilde{d}_{R,i\alpha}^* \delta_{\alpha\beta} \tilde{u}_{L,j\beta} A_{d,ij} + H_d^0 \tilde{e}_{R,i}^* \tilde{e}_{L,j} A_{e,ij} - H_d^- \tilde{e}_{R,i}^* \tilde{\nu}_{L,j} A_{e,ij} - H_u^+ \tilde{u}_{R,i\alpha}^* \delta_{\alpha\beta} \tilde{d}_{L,j\beta} A_{u,ij} \\ & + H_u^0 \tilde{u}_{R,i\alpha}^* \delta_{\alpha\beta} \tilde{u}_{L,j\beta} A_{u,ij} - H_u^+ \tilde{N}_i^{c,*} \tilde{e}_{L,j} A_{\nu,ij} + H_u^0 \tilde{N}_i^{c,*} \tilde{\nu}_{L,j} A_{\nu,ij} + \text{h.c.} \end{aligned} \tag{2}$$

$$-L_{SB,\phi} = + m_{H_d}^2 |H_d^0|^2 + m_{H_d}^2 |H_d^-|^2 + m_{H_u}^2 |H_u^0|^2 + m_{H_u}^2 |H_u^+|^2 + M_X^2 |X|^2 + \tilde{d}_{L,i\alpha}^* \delta_{\alpha\beta} m_{q,ij}^2 \tilde{d}_{L,j\beta}$$

$$+\tilde{d}^*_{R,i\alpha}\delta_{\alpha\beta}m^2_{d,ij}\tilde{d}_{R,j\beta}+\tilde{e}^*_{L,i}m^2_{l,ij}\tilde{e}_{L,j}+\tilde{e}^*_{R,i}m^2_{e,ij}\tilde{e}_{R,j}+\tilde{S}^*_i M^2_{\tilde{S},ij}\tilde{S}_j+\tilde{u}^*_{L,i\alpha}\delta_{\alpha\beta}m^2_{q,ij}\tilde{u}_{L,j\beta}$$
$$+\tilde{u}^*_{R,i\alpha}\delta_{\alpha\beta}m^2_{u,ij}\tilde{u}_{R,j\beta}+\tilde{\nu}^*_{L,i}m^2_{l,ij}\tilde{\nu}_{L,j}+\tilde{N}^{c,*}_i M^2_{\tilde{N}^c,ij}\tilde{N}^c_j \tag{3}$$
$$-L_{SB,\lambda}=\frac{1}{2}\Big(\lambda^2_{\tilde{B}}M_1\delta_{ij}+M_2\delta_{ij}\lambda_{\tilde{W},i}\lambda_{\tilde{W},j}+M_3\delta_{ij}\lambda_{\tilde{g},\alpha}\lambda_{\tilde{g},\beta}+\text{h.c.}\Big) \tag{4}$$

2.3 Gauge fixing terms

2.3.1 Gauge fixing terms for eigenstates 'GaugeES'

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

2.3.2 Gauge fixing terms for eigenstates 'EWSB'

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

2.4 Fields integrated out

None

3 Renormalization Group Equations

3.1 Anomalous Dimensions

$$\gamma^{(1)}_{\hat{q}}=-\frac{1}{30}\Big(45g_2^2+80g_3^2+g_1^2\Big)\mathbf{1}+y_d^\dagger y_d+y_u^\dagger y_u \tag{7}$$
$$\gamma^{(2)}_{\hat{q}}=+\Big(8g_2^2g_3^2+\frac{15}{4}g_2^4+\frac{1}{90}g_1^2\Big(16g_3^2+9g_2^2\Big)+\frac{199}{900}g_1^4-\frac{8}{9}g_3^4\Big)\mathbf{1}+\frac{4}{5}g_1^2y_u^\dagger y_u-2y_d^\dagger y_d y_d^\dagger y_d$$
$$-2y_u^\dagger y_u y_u^\dagger y_u+y_d^\dagger y_d\Big(-3\text{Tr}\Big(y_d y_d^\dagger\Big)+\frac{2}{5}g_1^2-\text{Tr}\Big(y_e y_e^\dagger\Big)\Big)-3y_u^\dagger y_u\text{Tr}\Big(y_u y_u^\dagger\Big)$$
$$-y_u^\dagger y_u\text{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \tag{8}$$
$$\gamma^{(1)}_{\hat{l}}=-\frac{3}{10}\Big(5g_2^2+g_1^2\Big)\mathbf{1}+y_e^\dagger y_e+Y_\nu^\dagger Y_\nu \tag{9}$$
$$\gamma^{(2)}_{\hat{l}}=+\frac{3}{100}\Big(125g_2^4+30g_1^2g_2^2+69g_1^4\Big)\mathbf{1}-2y_e^\dagger y_e y_e^\dagger y_e-2Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu$$
$$+y_e^\dagger y_e\Big(-3\text{Tr}\Big(y_d y_d^\dagger\Big)+\frac{6}{5}g_1^2-\text{Tr}\Big(y_e y_e^\dagger\Big)\Big)-3Y_\nu^\dagger Y_\nu\text{Tr}\Big(y_u y_u^\dagger\Big)$$
$$-Y_\nu^\dagger Y_\nu\text{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \tag{10}$$
$$\gamma^{(1)}_{\hat{H}_d}=3\text{Tr}\Big(y_d y_d^\dagger\Big)-\frac{3}{10}\Big(5g_2^2+g_1^2\Big)+\text{Tr}\Big(y_e y_e^\dagger\Big) \tag{11}$$

$$\gamma^{(2)}_{\hat{H}_d} = +\frac{207}{100}g_1^4 + \frac{9}{10}g_1^2g_2^2 + \frac{15}{4}g_2^4 - \frac{2}{5}\Big(-40g_3^2 + g_1^2\Big)\mathrm{Tr}\Big(y_d y_d^\dagger\Big) + \frac{6}{5}g_1^2\mathrm{Tr}\Big(y_e y_e^\dagger\Big) - 9\mathrm{Tr}\Big(y_d y_d^\dagger y_d y_d^\dagger\Big)$$
$$- 3\mathrm{Tr}\Big(y_d y_u^\dagger y_u y_d^\dagger\Big) - 3\mathrm{Tr}\Big(y_e y_e^\dagger y_e y_e^\dagger\Big) - \mathrm{Tr}\Big(y_e Y_\nu^\dagger Y_\nu y_e^\dagger\Big) \tag{12}$$

$$\gamma^{(1)}_{\hat{H}_u} = 3\mathrm{Tr}\Big(y_u y_u^\dagger\Big) - \frac{3}{10}\Big(5g_2^2 + g_1^2\Big) + \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \tag{13}$$

$$\gamma^{(2)}_{\hat{H}_u} = +\frac{207}{100}g_1^4 + \frac{9}{10}g_1^2g_2^2 + \frac{15}{4}g_2^4 + \frac{4}{5}\Big(20g_3^2 + g_1^2\Big)\mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 3\mathrm{Tr}\Big(y_d y_u^\dagger y_u y_d^\dagger\Big)$$
$$- \mathrm{Tr}\Big(y_e Y_\nu^\dagger Y_\nu y_e^\dagger\Big) - 9\mathrm{Tr}\Big(y_u y_u^\dagger y_u y_u^\dagger\Big) - 3\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\Big) \tag{14}$$

$$\gamma^{(1)}_{\hat{d}} = 2y_d^* y_d^T - \frac{2}{15}\Big(20g_3^2 + g_1^2\Big)\mathbf{1} \tag{15}$$

$$\gamma^{(2)}_{\hat{d}} = +\frac{2}{225}\Big(-100g_3^4 + 101g_1^4 + 80g_1^2g_3^2\Big)\mathbf{1} - 2\Big(y_d^* y_d^T y_d^* y_d^T + y_d^* y_u^T y_u^* y_d^T\Big)$$
$$+ y_d^* y_d^T\Big(-2\mathrm{Tr}\Big(y_e y_e^\dagger\Big) + 6g_2^2 - 6\mathrm{Tr}\Big(y_d y_d^\dagger\Big) + \frac{2}{5}g_1^2\Big) \tag{16}$$

$$\gamma^{(1)}_{\hat{u}} = 2y_u^* y_u^T - \frac{8}{15}\Big(5g_3^2 + g_1^2\Big)\mathbf{1} \tag{17}$$

$$\gamma^{(2)}_{\hat{u}} = +\frac{8}{225}\Big(107g_1^4 - 25g_3^4 + 80g_1^2g_3^2\Big)\mathbf{1}$$
$$- \frac{2}{5}\Big(5\Big(y_u^* y_d^T y_d^* y_u^T + y_u^* y_u^T y_u^* y_u^T\Big) + y_u^* y_u^T\Big(-15g_2^2 + 15\mathrm{Tr}\Big(y_u y_u^\dagger\Big) + 5\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) + g_1^2\Big)\Big) \tag{18}$$

$$\gamma^{(1)}_{\hat{e}} = 2y_e^* y_e^T - \frac{6}{5}g_1^2\mathbf{1} \tag{19}$$

$$\gamma^{(2)}_{\hat{e}} = +\frac{234}{25}g_1^4\mathbf{1} - 2\Big(y_e^* y_e^T y_e^* y_e^T + y_e^* Y_\nu^T Y_\nu^* y_e^T\Big)$$
$$+ y_e^* y_e^T\Big(-2\mathrm{Tr}\Big(y_e y_e^\dagger\Big) + 6g_2^2 - 6\mathrm{Tr}\Big(y_d y_d^\dagger\Big) - \frac{6}{5}g_1^2\Big) \tag{20}$$

$$\gamma^{(1)}_{\hat{\nu}} = 2Y_\nu^* Y_\nu^T \tag{21}$$

$$\gamma^{(2)}_{\hat{\nu}} = -2\Big(Y_\nu^* y_e^T y_e^* Y_\nu^T + Y_\nu^* Y_\nu^T Y_\nu^* Y_\nu^T\Big) + Y_\nu^* Y_\nu^T\Big(-2\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) + 6g_2^2 - 6\mathrm{Tr}\Big(y_u y_u^\dagger\Big) + \frac{6}{5}g_1^2\Big) \tag{22}$$

$$\gamma^{(1)}_{\hat{s}} = \lambda^*\lambda \tag{23}$$

$$\gamma^{(2)}_{\hat{s}} = -2|\kappa|^2\lambda^*\lambda - \frac{1}{2}\lambda^*\lambda\mathrm{Tr}\Big(\lambda\lambda^*\Big) - \lambda^*\lambda\lambda^*\lambda \tag{24}$$

$$\gamma^{(1)}_{\hat{X}} = \frac{1}{2}\Big(4|\kappa|^2 + \mathrm{Tr}\Big(\lambda\lambda^*\Big)\Big) \tag{25}$$

$$\gamma^{(2)}_{\hat{X}} = -2|\kappa|^2\mathrm{Tr}\Big(\lambda\lambda^*\Big) - 8\kappa^2\kappa^{*,2} - \mathrm{Tr}\Big(\lambda\lambda^*\lambda\lambda^*\Big) \tag{26}$$

3.2 Gauge Couplings

$$\beta^{(1)}_{g_1} = \frac{33}{5}g_1^3 \tag{27}$$

$$\beta_{g_1}^{(2)} = \frac{1}{25}g_1^3\Big(- 130\mathrm{Tr}\Big(y_u y_u^\dagger\Big) + 135g_2^2 + 199g_1^2 - 30\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) + 440g_3^2 - 70\mathrm{Tr}\Big(y_d y_d^\dagger\Big) - 90\mathrm{Tr}\Big(y_e y_e^\dagger\Big)\Big) \tag{28}$$

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

$$\beta_{g_2}^{(2)} = \frac{1}{5}g_2^3\Big(- 10\mathrm{Tr}\Big(y_e y_e^\dagger\Big) - 10\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) + 120g_3^2 + 125g_2^2 - 30\mathrm{Tr}\Big(y_d y_d^\dagger\Big) - 30\mathrm{Tr}\Big(y_u y_u^\dagger\Big) + 9g_1^2\Big) \tag{30}$$

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

$$\beta_{g_3}^{(2)} = \frac{1}{5}g_3^3\Big(11g_1^2 - 20\mathrm{Tr}\Big(y_d y_d^\dagger\Big) - 20\mathrm{Tr}\Big(y_u y_u^\dagger\Big) + 45g_2^2 + 70g_3^2\Big) \tag{32}$$

3.3 Gaugino Mass Parameters

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

$$\begin{aligned}\beta_{M_1}^{(2)} = \frac{2}{25}g_1^2\Big(&398g_1^2M_1 + 135g_2^2M_1 + 440g_3^2M_1 + 440g_3^2M_3 + 135g_2^2M_2 - 70M_1\mathrm{Tr}\Big(y_d y_d^\dagger\Big) - 90M_1\mathrm{Tr}\Big(y_e y_e^\dagger\Big)\\ &- 130M_1\mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 30M_1\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) + 70\mathrm{Tr}\Big(y_d^\dagger A_d\Big) + 90\mathrm{Tr}\Big(y_e^\dagger A_e\Big) + 130\mathrm{Tr}\Big(y_u^\dagger A_u\Big) + 30\mathrm{Tr}\Big(Y_\nu^\dagger A_\nu\Big)\Big)\end{aligned} \tag{34}$$

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

$$\begin{aligned}\beta_{M_2}^{(2)} = \frac{2}{5}g_2^2\Big(&9g_1^2M_1 + 120g_3^2M_3 + 9g_1^2M_2 + 250g_2^2M_2 + 120g_3^2M_2 - 30M_2\mathrm{Tr}\Big(y_d y_d^\dagger\Big) - 10M_2\mathrm{Tr}\Big(y_e y_e^\dagger\Big)\\ &- 30M_2\mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 10M_2\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) + 30\mathrm{Tr}\Big(y_d^\dagger A_d\Big) + 10\mathrm{Tr}\Big(y_e^\dagger A_e\Big) + 30\mathrm{Tr}\Big(y_u^\dagger A_u\Big) + 10\mathrm{Tr}\Big(Y_\nu^\dagger A_\nu\Big)\Big)\end{aligned} \tag{36}$$

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

$$\begin{aligned}\beta_{M_3}^{(2)} = \frac{2}{5}g_3^2\Big(&11g_1^2M_1 + 11g_1^2M_3 + 45g_2^2M_3 + 140g_3^2M_3 + 45g_2^2M_2 - 20M_3\mathrm{Tr}\Big(y_d y_d^\dagger\Big) - 20M_3\mathrm{Tr}\Big(y_u y_u^\dagger\Big)\\ &+ 20\mathrm{Tr}\Big(y_d^\dagger A_d\Big) + 20\mathrm{Tr}\Big(y_u^\dagger A_u\Big)\Big)\end{aligned} \tag{38}$$

3.4 Trilinear Superpotential Parameters

$$\beta_{y_d}^{(1)} = 3y_d y_d^\dagger y_d + y_d\Big(- 3g_2^2 + 3\mathrm{Tr}\Big(y_d y_d^\dagger\Big) - \frac{16}{3}g_3^2 - \frac{7}{15}g_1^2 + \mathrm{Tr}\Big(y_e y_e^\dagger\Big)\Big) + y_d y_u^\dagger y_u \tag{39}$$

$$\begin{aligned}\beta_{y_d}^{(2)} = &+\frac{4}{5}g_1^2 y_d y_u^\dagger y_u - 4y_d y_d^\dagger y_d y_d^\dagger y_d - 2y_d y_u^\dagger y_u y_d^\dagger y_d - 2y_d y_u^\dagger y_u y_u^\dagger y_u\\ &+ y_d y_d^\dagger y_d\Big(- 3\mathrm{Tr}\Big(y_e y_e^\dagger\Big) + 6g_2^2 - 9\mathrm{Tr}\Big(y_d y_d^\dagger\Big) + \frac{4}{5}g_1^2\Big) - 3y_d y_u^\dagger y_u\mathrm{Tr}\Big(y_u y_u^\dagger\Big)\\ &- y_d y_u^\dagger y_u\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big)\\ &+ y_d\Big(\frac{287}{90}g_1^4 + g_1^2g_2^2 + \frac{15}{2}g_2^4 + \frac{8}{9}g_1^2g_3^2 + 8g_2^2g_3^2 - \frac{16}{9}g_3^4 - \frac{2}{5}\Big(- 40g_3^2 + g_1^2\Big)\mathrm{Tr}\Big(y_d y_d^\dagger\Big)\\ &+ \frac{6}{5}g_1^2\mathrm{Tr}\Big(y_e y_e^\dagger\Big) - 9\mathrm{Tr}\Big(y_d y_d^\dagger y_d y_d^\dagger\Big) - 3\mathrm{Tr}\Big(y_d y_u^\dagger y_u y_d^\dagger\Big) - 3\mathrm{Tr}\Big(y_e y_e^\dagger y_e y_e^\dagger\Big)\end{aligned}$$

$$- \mathrm{Tr}\Big(y_e Y_\nu^\dagger Y_\nu y_e^\dagger\Big)\Big) \tag{40}$$

$$\beta_{y_e}^{(1)} = 3y_e y_e^\dagger y_e + y_e\Big(-3g_2^2 + 3\mathrm{Tr}\Big(y_d y_d^\dagger\Big) - \frac{9}{5}g_1^2 + \mathrm{Tr}\Big(y_e y_e^\dagger\Big)\Big) + y_e Y_\nu^\dagger Y_\nu \tag{41}$$

$$\begin{aligned}\beta_{y_e}^{(2)} = {} & -4y_e y_e^\dagger y_e y_e^\dagger y_e - 2y_e Y_\nu^\dagger Y_\nu y_e^\dagger y_e - 2y_e Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu \\ & + y_e y_e^\dagger y_e\Big(-3\mathrm{Tr}\Big(y_e y_e^\dagger\Big) + 6g_2^2 - 9\mathrm{Tr}\Big(y_d y_d^\dagger\Big)\Big) - 3y_e Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(y_u y_u^\dagger\Big) \\ & - y_e Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \\ & + \frac{1}{10}y_e\Big(135g_1^4 + 18g_1^2 g_2^2 + 75g_2^4 - 4\Big(-40g_3^2 + g_1^2\Big)\mathrm{Tr}\Big(y_d y_d^\dagger\Big) + 12g_1^2\mathrm{Tr}\Big(y_e y_e^\dagger\Big) - 90\mathrm{Tr}\Big(y_d y_d^\dagger y_d y_d^\dagger\Big) \\ & - 30\mathrm{Tr}\Big(y_d y_u^\dagger y_u y_d^\dagger\Big) - 30\mathrm{Tr}\Big(y_e y_e^\dagger y_e y_e^\dagger\Big) - 10\mathrm{Tr}\Big(y_e Y_\nu^\dagger Y_\nu y_e^\dagger\Big)\Big)\end{aligned} \tag{42}$$

$$\beta_\lambda^{(1)} = 2\lambda|\kappa|^2 + 2\lambda\lambda^*\lambda + \frac{1}{2}\lambda\mathrm{Tr}\Big(\lambda\lambda^*\Big) \tag{43}$$

$$\begin{aligned}\beta_\lambda^{(2)} = {} & -8\kappa^2\lambda\kappa^{*,2} - 2\lambda\lambda^*\lambda\lambda^*\lambda - \lambda\lambda^*\lambda\mathrm{Tr}\Big(\lambda\lambda^*\Big) - 2|\kappa|^2\Big(2\lambda\lambda^*\lambda + \lambda\mathrm{Tr}\Big(\lambda\lambda^*\Big)\Big) \\ & - \lambda\mathrm{Tr}\Big(\lambda\lambda^*\lambda\lambda^*\Big)\end{aligned} \tag{44}$$

$$\beta_{y_u}^{(1)} = 3y_u y_u^\dagger y_u + y_u\Big(-3g_2^2 + 3\mathrm{Tr}\Big(y_u y_u^\dagger\Big) - \frac{13}{15}g_1^2 - \frac{16}{3}g_3^2 + \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big)\Big) + y_u y_d^\dagger y_d \tag{45}$$

$$\begin{aligned}\beta_{y_u}^{(2)} = {} & +\frac{2}{5}g_1^2 y_u y_u^\dagger y_u + 6g_2^2 y_u y_u^\dagger y_u - 2y_u y_d^\dagger y_d y_d^\dagger y_d - 2y_u y_d^\dagger y_d y_u^\dagger y_u \\ & - 4y_u y_u^\dagger y_u y_u^\dagger y_u + y_u y_d^\dagger y_d\Big(-3\mathrm{Tr}\Big(y_d y_d^\dagger\Big) + \frac{2}{5}g_1^2 - \mathrm{Tr}\Big(y_e y_e^\dagger\Big)\Big) - 9y_u y_u^\dagger y_u \mathrm{Tr}\Big(y_u y_u^\dagger\Big) \\ & - 3y_u y_u^\dagger y_u \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \\ & + y_u\Big(\frac{2743}{450}g_1^4 + g_1^2 g_2^2 + \frac{15}{2}g_2^4 + \frac{136}{45}g_1^2 g_3^2 + 8g_2^2 g_3^2 - \frac{16}{9}g_3^4 + \frac{4}{5}\Big(20g_3^2 + g_1^2\Big)\mathrm{Tr}\Big(y_u y_u^\dagger\Big) \\ & - 3\mathrm{Tr}\Big(y_d y_u^\dagger y_u y_d^\dagger\Big) - \mathrm{Tr}\Big(y_e Y_\nu^\dagger Y_\nu y_e^\dagger\Big) - 9\mathrm{Tr}\Big(y_u y_u^\dagger y_u y_u^\dagger\Big) - 3\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\Big)\Big)\end{aligned} \tag{46}$$

$$\beta_{Y_\nu}^{(1)} = 3Y_\nu Y_\nu^\dagger Y_\nu + Y_\nu\Big(-3g_2^2 + 3\mathrm{Tr}\Big(y_u y_u^\dagger\Big) - \frac{3}{5}g_1^2 + \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big)\Big) + Y_\nu y_e^\dagger y_e \tag{47}$$

$$\begin{aligned}\beta_{Y_\nu}^{(2)} = {} & +\frac{6}{5}g_1^2 Y_\nu Y_\nu^\dagger Y_\nu + 6g_2^2 Y_\nu Y_\nu^\dagger Y_\nu - 2Y_\nu y_e^\dagger y_e y_e^\dagger y_e - 2Y_\nu y_e^\dagger y_e Y_\nu^\dagger Y_\nu \\ & - 4Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu + Y_\nu y_e^\dagger y_e\Big(-3\mathrm{Tr}\Big(y_d y_d^\dagger\Big) + \frac{6}{5}g_1^2 - \mathrm{Tr}\Big(y_e y_e^\dagger\Big)\Big) - 9Y_\nu Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(y_u y_u^\dagger\Big) \\ & - 3Y_\nu Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \\ & + Y_\nu\Big(\frac{207}{50}g_1^4 + \frac{9}{5}g_1^2 g_2^2 + \frac{15}{2}g_2^4 + \frac{4}{5}\Big(20g_3^2 + g_1^2\Big)\mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 3\mathrm{Tr}\Big(y_d y_u^\dagger y_u y_d^\dagger\Big) \\ & - \mathrm{Tr}\Big(y_e Y_\nu^\dagger Y_\nu y_e^\dagger\Big) - 9\mathrm{Tr}\Big(y_u y_u^\dagger y_u y_u^\dagger\Big) - 3\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\Big)\Big)\end{aligned} \tag{48}$$

$$\beta_\kappa^{(1)} = \frac{3}{2}\kappa\Big(4|\kappa|^2 + \mathrm{Tr}\Big(\lambda\lambda^*\Big)\Big) \tag{49}$$

$$\beta_\kappa^{(2)} = -3\kappa\Big(2|\kappa|^2\mathrm{Tr}\Big(\lambda\lambda^*\Big) + 8\kappa^2\kappa^{*,2} + \mathrm{Tr}\Big(\lambda\lambda^*\lambda\lambda^*\Big)\Big) \tag{50}$$

3.5 Bilinear Superpotential Parameters

$$\beta^{(1)}_{\mu_H} = -3g_2^2\mu_H + 3\mu_H \mathrm{Tr}\Big(y_d y_d^\dagger\Big) + 3\mu_H \mathrm{Tr}\Big(y_u y_u^\dagger\Big) - \frac{3}{5}g_1^2\mu_H + \mu_H \mathrm{Tr}\Big(y_e y_e^\dagger\Big) + \mu_H \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \tag{51}$$

$$\begin{aligned}\beta^{(2)}_{\mu_H} = {} & \frac{1}{50}\mu_H\Big(207g_1^4 + 90g_1^2g_2^2 + 375g_2^4 - 20\Big(-40g_3^2 + g_1^2\Big)\mathrm{Tr}\Big(y_d y_d^\dagger\Big) + 60g_1^2\mathrm{Tr}\Big(y_e y_e^\dagger\Big) + 40g_1^2\mathrm{Tr}\Big(y_u y_u^\dagger\Big) \\ & + 800g_3^2\mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 450\mathrm{Tr}\Big(y_d y_d^\dagger y_d y_d^\dagger\Big) - 300\mathrm{Tr}\Big(y_d y_u^\dagger y_u y_d^\dagger\Big) - 150\mathrm{Tr}\Big(y_e y_e^\dagger y_e y_e^\dagger\Big) \\ & - 100\mathrm{Tr}\Big(y_e Y_\nu^\dagger Y_\nu y_e^\dagger\Big) - 450\mathrm{Tr}\Big(y_u y_u^\dagger y_u y_u^\dagger\Big) - 150\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\Big)\Big)\end{aligned} \tag{52}$$

$$\beta^{(1)}_{\mu_{NS}} = 2Y_\nu Y_\nu^\dagger \mu_{NS} + \mu_{NS}\lambda^*\lambda \tag{53}$$

$$\begin{aligned}\beta^{(2)}_{\mu_{NS}} = {} & -2|\kappa|^2\mu_{NS}\lambda^*\lambda + \frac{6}{5}g_1^2 Y_\nu Y_\nu^\dagger \mu_{NS} + 6g_2^2 Y_\nu Y_\nu^\dagger \mu_{NS} - \mu_{NS}\lambda^*\lambda\lambda^*\lambda \\ & - 2Y_\nu y_e^\dagger y_e Y_\nu^\dagger \mu_{NS} - 2Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger \mu_{NS} - \frac{1}{2}\mu_{NS}\lambda^*\lambda \mathrm{Tr}\Big(\lambda\lambda^*\Big) \\ & - 6Y_\nu Y_\nu^\dagger \mu_{NS}\mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 2Y_\nu Y_\nu^\dagger \mu_{NS}\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big)\end{aligned} \tag{54}$$

3.6 Trilinear Soft-Breaking Parameters

$$\begin{aligned}\beta^{(1)}_{A_d} = {} & +4y_d y_d^\dagger A_d + 2y_d y_u^\dagger A_u + 5A_d y_d^\dagger y_d + A_d y_u^\dagger y_u - \frac{7}{15}g_1^2 A_d - 3g_2^2 A_d - \frac{16}{3}g_3^2 A_d \\ & + 3A_d\mathrm{Tr}\Big(y_d y_d^\dagger\Big) + A_d\mathrm{Tr}\Big(y_e y_e^\dagger\Big) + y_d\Big(2\mathrm{Tr}\Big(y_e^\dagger A_e\Big) + 6g_2^2 M_2 + 6\mathrm{Tr}\Big(y_d^\dagger A_d\Big) + \frac{14}{15}g_1^2 M_1 + \frac{32}{3}g_3^2 M_3\Big)\end{aligned} \tag{55}$$

$$\begin{aligned}\beta^{(2)}_{A_d} = {} & +\frac{6}{5}g_1^2 y_d y_d^\dagger A_d + 6g_2^2 y_d y_d^\dagger A_d - \frac{8}{5}g_1^2 M_1 y_d y_u^\dagger y_u + \frac{8}{5}g_1^2 y_d y_u^\dagger A_u \\ & + \frac{6}{5}g_1^2 A_d y_d^\dagger y_d + 12g_2^2 A_d y_d^\dagger y_d + \frac{4}{5}g_1^2 A_d y_u^\dagger y_u - 6y_d y_d^\dagger y_d y_d^\dagger A_d \\ & - 8y_d y_d^\dagger A_d y_d^\dagger y_d - 2y_d y_u^\dagger y_u y_d^\dagger A_d - 4y_d y_u^\dagger y_u y_u^\dagger A_u - 4y_d y_u^\dagger A_u y_d^\dagger y_d \\ & - 4y_d y_u^\dagger A_u y_u^\dagger y_u - 6A_d y_d^\dagger y_d y_d^\dagger y_d - 4A_d y_u^\dagger y_u y_d^\dagger y_d - 2A_d y_u^\dagger y_u y_u^\dagger y_u \\ & + \frac{287}{90}g_1^4 A_d + g_1^2 g_2^2 A_d + \frac{15}{2}g_2^4 A_d + \frac{8}{9}g_1^2 g_3^2 A_d + 8g_2^2 g_3^2 A_d - \frac{16}{9}g_3^4 A_d \\ & - 12y_d y_d^\dagger A_d \mathrm{Tr}\Big(y_d y_d^\dagger\Big) - 15A_d y_d^\dagger y_d \mathrm{Tr}\Big(y_d y_d^\dagger\Big) - \frac{2}{5}g_1^2 A_d \mathrm{Tr}\Big(y_d y_d^\dagger\Big) \\ & + 16g_3^2 A_d \mathrm{Tr}\Big(y_d y_d^\dagger\Big) - 4y_d y_d^\dagger A_d \mathrm{Tr}\Big(y_e y_e^\dagger\Big) - 5A_d y_d^\dagger y_d \mathrm{Tr}\Big(y_e y_e^\dagger\Big) \\ & + \frac{6}{5}g_1^2 A_d \mathrm{Tr}\Big(y_e y_e^\dagger\Big) - 6y_d y_u^\dagger A_u \mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 3A_d y_u^\dagger y_u \mathrm{Tr}\Big(y_u y_u^\dagger\Big) \\ & - 2y_d y_u^\dagger A_u \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) - A_d y_u^\dagger y_u \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \\ & - \frac{2}{5}y_d y_d^\dagger y_d\Big(15\mathrm{Tr}\Big(y_e^\dagger A_e\Big) + 30g_2^2 M_2 + 45\mathrm{Tr}\Big(y_d^\dagger A_d\Big) + 4g_1^2 M_1\Big) - 6y_d y_u^\dagger y_u \mathrm{Tr}\Big(y_u^\dagger A_u\Big)\end{aligned}$$

$$
\begin{aligned}
&- 2y_d y_u^\dagger y_u \mathrm{Tr}\Big(Y_\nu^\dagger A_\nu\Big) - 9A_d \mathrm{Tr}\Big(y_d y_d^\dagger y_d y_d^\dagger\Big) - 3A_d \mathrm{Tr}\Big(y_d y_u^\dagger y_u y_d^\dagger\Big) \\
&- 3A_d \mathrm{Tr}\Big(y_e y_e^\dagger y_e y_e^\dagger\Big) - A_d \mathrm{Tr}\Big(y_e Y_\nu^\dagger Y_\nu y_e^\dagger\Big) \\
&- \frac{2}{45} y_d \Big(287 g_1^4 M_1 + 45 g_1^2 g_2^2 M_1 + 40 g_1^2 g_3^2 M_1 + 40 g_1^2 g_3^2 M_3 + 360 g_2^2 g_3^2 M_3 - 160 g_3^4 M_3 \\
&+ 45 g_1^2 g_2^2 M_2 + 675 g_2^4 M_2 + 360 g_2^2 g_3^2 M_2 - 18\Big(- 40 g_3^2 M_3 + g_1^2 M_1\Big) \mathrm{Tr}\Big(y_d y_d^\dagger\Big) \\
&+ 54 g_1^2 M_1 \mathrm{Tr}\Big(y_e y_e^\dagger\Big) + 18 g_1^2 \mathrm{Tr}\Big(y_d^\dagger A_d\Big) - 720 g_3^2 \mathrm{Tr}\Big(y_d^\dagger A_d\Big) - 54 g_1^2 \mathrm{Tr}\Big(y_e^\dagger A_e\Big) \\
&+ 810 \mathrm{Tr}\Big(y_d y_d^\dagger A_d y_d^\dagger\Big) + 135 \mathrm{Tr}\Big(y_d y_u^\dagger A_u y_d^\dagger\Big) + 270 \mathrm{Tr}\Big(y_e y_e^\dagger A_e y_e^\dagger\Big) + 45 \mathrm{Tr}\Big(y_e Y_\nu^\dagger A_\nu y_e^\dagger\Big) \\
&+ 135 \mathrm{Tr}\Big(y_u y_d^\dagger A_d y_u^\dagger\Big) + 45 \mathrm{Tr}\Big(Y_\nu y_e^\dagger A_e Y_\nu^\dagger\Big)\Big)
\end{aligned} \tag{56}
$$

$$
\begin{aligned}
\beta_{A_e}^{(1)} = &+ 4y_e y_e^\dagger A_e + 2y_e Y_\nu^\dagger A_\nu + 5A_e y_e^\dagger y_e + A_e Y_\nu^\dagger Y_\nu - \frac{9}{5} g_1^2 A_e - 3g_2^2 A_e \\
&+ 3A_e \mathrm{Tr}\Big(y_d y_d^\dagger\Big) + A_e \mathrm{Tr}\Big(y_e y_e^\dagger\Big) + y_e \Big(2\mathrm{Tr}\Big(y_e^\dagger A_e\Big) + 6g_2^2 M_2 + 6\mathrm{Tr}\Big(y_d^\dagger A_d\Big) + \frac{18}{5} g_1^2 M_1\Big)
\end{aligned} \tag{57}
$$

$$
\begin{aligned}
\beta_{A_e}^{(2)} = &+ \frac{6}{5} g_1^2 y_e y_e^\dagger A_e + 6 g_2^2 y_e y_e^\dagger A_e - \frac{6}{5} g_1^2 A_e y_e^\dagger y_e + 12 g_2^2 A_e y_e^\dagger y_e \\
&- 6 y_e y_e^\dagger y_e y_e^\dagger A_e - 8 y_e y_e^\dagger A_e y_e^\dagger y_e - 2 y_e Y_\nu^\dagger Y_\nu y_e^\dagger A_e - 4 y_e Y_\nu^\dagger Y_\nu Y_\nu^\dagger A_\nu \\
&- 4 y_e Y_\nu^\dagger A_\nu y_e^\dagger y_e - 4 y_e Y_\nu^\dagger A_\nu Y_\nu^\dagger Y_\nu - 6 A_e y_e^\dagger y_e y_e^\dagger y_e - 4 A_e Y_\nu^\dagger Y_\nu y_e^\dagger y_e \\
&- 2 A_e Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu + \frac{27}{2} g_1^4 A_e + \frac{9}{5} g_1^2 g_2^2 A_e + \frac{15}{2} g_2^4 A_e - 12 y_e y_e^\dagger A_e \mathrm{Tr}\Big(y_d y_d^\dagger\Big) \\
&- 15 A_e y_e^\dagger y_e \mathrm{Tr}\Big(y_d y_d^\dagger\Big) - \frac{2}{5} g_1^2 A_e \mathrm{Tr}\Big(y_d y_d^\dagger\Big) + 16 g_3^2 A_e \mathrm{Tr}\Big(y_d y_d^\dagger\Big) \\
&- 4 y_e y_e^\dagger A_e \mathrm{Tr}\Big(y_e y_e^\dagger\Big) - 5 A_e y_e^\dagger y_e \mathrm{Tr}\Big(y_e y_e^\dagger\Big) + \frac{6}{5} g_1^2 A_e \mathrm{Tr}\Big(y_e y_e^\dagger\Big) \\
&- 6 y_e Y_\nu^\dagger A_\nu \mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 3 A_e Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 2 y_e Y_\nu^\dagger A_\nu \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \\
&- A_e Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) - 6 y_e y_e^\dagger y_e \Big(2 g_2^2 M_2 + 3\mathrm{Tr}\Big(y_d^\dagger A_d\Big) + \mathrm{Tr}\Big(y_e^\dagger A_e\Big)\Big) \\
&- 6 y_e Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(y_u^\dagger A_u\Big) - 2 y_e Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(Y_\nu^\dagger A_\nu\Big) - 9 A_e \mathrm{Tr}\Big(y_d y_d^\dagger y_d y_d^\dagger\Big) \\
&- 3 A_e \mathrm{Tr}\Big(y_d y_u^\dagger y_u y_d^\dagger\Big) - 3 A_e \mathrm{Tr}\Big(y_e y_e^\dagger y_e y_e^\dagger\Big) - A_e \mathrm{Tr}\Big(y_e Y_\nu^\dagger Y_\nu y_e^\dagger\Big) \\
&- \frac{2}{5} y_e \Big(135 g_1^4 M_1 + 9 g_1^2 g_2^2 M_1 + 9 g_1^2 g_2^2 M_2 + 75 g_2^4 M_2 + \Big(- 2 g_1^2 M_1 + 80 g_3^2 M_3\Big) \mathrm{Tr}\Big(y_d y_d^\dagger\Big) \\
&+ 6 g_1^2 M_1 \mathrm{Tr}\Big(y_e y_e^\dagger\Big) + 2 g_1^2 \mathrm{Tr}\Big(y_d^\dagger A_d\Big) - 80 g_3^2 \mathrm{Tr}\Big(y_d^\dagger A_d\Big) - 6 g_1^2 \mathrm{Tr}\Big(y_e^\dagger A_e\Big) \\
&+ 90 \mathrm{Tr}\Big(y_d y_d^\dagger A_d y_d^\dagger\Big) + 15 \mathrm{Tr}\Big(y_d y_u^\dagger A_u y_d^\dagger\Big) + 30 \mathrm{Tr}\Big(y_e y_e^\dagger A_e y_e^\dagger\Big) + 5 \mathrm{Tr}\Big(y_e Y_\nu^\dagger A_\nu y_e^\dagger\Big) \\
&+ 15 \mathrm{Tr}\Big(y_u y_d^\dagger A_d y_u^\dagger\Big) + 5 \mathrm{Tr}\Big(Y_\nu y_e^\dagger A_e Y_\nu^\dagger\Big)\Big)
\end{aligned} \tag{58}
$$

$$
\beta_{A_\lambda}^{(1)} = 2\kappa^* \Big(2\lambda A_\kappa + \kappa A_\lambda\Big) + 3 A_\lambda \lambda^* \lambda + 3 \lambda \lambda^* A_\lambda + \frac{1}{2} A_\lambda \mathrm{Tr}\Big(\lambda \lambda^*\Big) + \lambda \mathrm{Tr}\Big(\lambda^* A_\lambda\Big) \tag{59}
$$

$$
\beta_{A_\lambda}^{(2)} = -8 \kappa \kappa^{*,2} \Big(4\lambda A_\kappa + \kappa A_\lambda\Big)
$$

$$
\begin{aligned}
&- 2\kappa^*\Big(2\lambda\Big(A_\kappa \mathrm{Tr}\Big(\lambda\lambda^*\Big) + \kappa \mathrm{Tr}\Big(\lambda^* A_\lambda\Big)\Big) + 3\kappa A_\lambda \lambda^*\lambda + 3\kappa\lambda\lambda^* A_\lambda + 4\lambda\lambda^*\lambda A_\kappa + \kappa A_\lambda \mathrm{Tr}\Big(\lambda\lambda^*\Big)\Big) \\
&+ \frac{1}{2}\Big(- 6\lambda\lambda^*\lambda\lambda^* A_\lambda - 8\lambda\lambda^* A_\lambda \lambda^*\lambda - 6A_\lambda \lambda^*\lambda\lambda^*\lambda - 3\lambda\lambda^* A_\lambda \mathrm{Tr}\Big(\lambda\lambda^*\Big) - 3A_\lambda \lambda^*\lambda \mathrm{Tr}\Big(\lambda\lambda^*\Big) \\
&- 4\lambda\lambda^*\lambda \mathrm{Tr}\Big(\lambda^* A_\lambda\Big) - 2A_\lambda \mathrm{Tr}\Big(\lambda\lambda^*\lambda\lambda^*\Big) - 8\lambda \mathrm{Tr}\Big(\lambda\lambda^* A_\lambda \lambda^*\Big)\Big)
\end{aligned} \tag{60}
$$

$$
\begin{aligned}
\beta^{(1)}_{A_u} =& + 2y_u y_d^\dagger A_d + 4y_u y_u^\dagger A_u + A_u y_d^\dagger y_d + 5A_u y_u^\dagger y_u - \frac{13}{15} g_1^2 A_u - 3g_2^2 A_u - \frac{16}{3} g_3^2 A_u \\
&+ 3A_u \mathrm{Tr}\Big(y_u y_u^\dagger\Big) + A_u \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) + y_u\Big(2\mathrm{Tr}\Big(Y_\nu^\dagger A_\nu\Big) + 6g_2^2 M_2 + 6\mathrm{Tr}\Big(y_u^\dagger A_u\Big) + \frac{26}{15} g_1^2 M_1 + \frac{32}{3} g_3^2 M_3\Big)
\end{aligned} \tag{61}
$$

$$
\begin{aligned}
\beta^{(2)}_{A_u} =& + \frac{4}{5} g_1^2 y_u y_d^\dagger A_d - \frac{4}{5} g_1^2 M_1 y_u y_u^\dagger y_u - 12 g_2^2 M_2 y_u y_u^\dagger y_u + \frac{6}{5} g_1^2 y_u y_u^\dagger A_u \\
&+ 6g_2^2 y_u y_u^\dagger A_u + \frac{2}{5} g_1^2 A_u y_d^\dagger y_d + 12 g_2^2 A_u y_u^\dagger y_u - 4 y_u y_d^\dagger y_d y_d^\dagger A_d \\
&- 2y_u y_d^\dagger y_d y_u^\dagger A_u - 4 y_u y_d^\dagger A_d y_d^\dagger y_d - 4 y_u y_d^\dagger A_d y_u^\dagger y_u - 6 y_u y_u^\dagger y_u y_u^\dagger A_u \\
&- 8 y_u y_u^\dagger A_u y_u^\dagger y_u - 2A_u y_d^\dagger y_d y_d^\dagger y_d - 4A_u y_d^\dagger y_d y_u^\dagger y_u - 6A_u y_u^\dagger y_u y_u^\dagger y_u + \frac{2743}{450} g_1^4 A_u \\
&+ g_1^2 g_2^2 A_u + \frac{15}{2} g_2^4 A_u + \frac{136}{45} g_1^2 g_3^2 A_u + 8 g_2^2 g_3^2 A_u - \frac{16}{9} g_3^4 A_u - 6 y_u y_d^\dagger A_d \mathrm{Tr}\Big(y_d y_d^\dagger\Big) \\
&- 3A_u y_d^\dagger y_d \mathrm{Tr}\Big(y_d y_d^\dagger\Big) - 2 y_u y_d^\dagger A_d \mathrm{Tr}\Big(y_e y_e^\dagger\Big) - A_u y_d^\dagger y_d \mathrm{Tr}\Big(y_e y_e^\dagger\Big) \\
&- 12 y_u y_u^\dagger A_u \mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 15 A_u y_u^\dagger y_u \mathrm{Tr}\Big(y_u y_u^\dagger\Big) + \frac{4}{5} g_1^2 A_u \mathrm{Tr}\Big(y_u y_u^\dagger\Big) \\
&+ 16 g_3^2 A_u \mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 4 y_u y_u^\dagger A_u \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) - 5 A_u y_u^\dagger y_u \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \\
&- \frac{2}{5} y_u y_d^\dagger y_d \Big(15 \mathrm{Tr}\Big(y_d^\dagger A_d\Big) + 2 g_1^2 M_1 + 5 \mathrm{Tr}\Big(y_e^\dagger A_e\Big)\Big) - 18 y_u y_u^\dagger y_u \mathrm{Tr}\Big(y_u^\dagger A_u\Big) \\
&- 6 y_u y_u^\dagger y_u \mathrm{Tr}\Big(Y_\nu^\dagger A_\nu\Big) - 3A_u \mathrm{Tr}\Big(y_d y_u^\dagger y_u y_d^\dagger\Big) - A_u \mathrm{Tr}\Big(y_e Y_\nu^\dagger Y_\nu y_e^\dagger\Big) \\
&- 9A_u \mathrm{Tr}\Big(y_u y_u^\dagger y_u y_u^\dagger\Big) - 3A_u \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\Big) \\
&+ y_u\Big(- \frac{5486}{225} g_1^4 M_1 - 2 g_1^2 g_2^2 M_1 - \frac{272}{45} g_1^2 g_3^2 M_1 - \frac{272}{45} g_1^2 g_3^2 M_3 - 16 g_2^2 g_3^2 M_3 + \frac{64}{9} g_3^4 M_3 \\
&- 2 g_1^2 g_2^2 M_2 - 30 g_2^4 M_2 - 16 g_2^2 g_3^2 M_2 - \frac{8}{5}\Big(20 g_3^2 M_3 + g_1^2 M_1\Big) \mathrm{Tr}\Big(y_u y_u^\dagger\Big) \\
&+ \frac{8}{5}\Big(20 g_3^2 + g_1^2\Big) \mathrm{Tr}\Big(y_u^\dagger A_u\Big) - 6 \mathrm{Tr}\Big(y_d y_u^\dagger A_u y_d^\dagger\Big) - 2 \mathrm{Tr}\Big(y_e Y_\nu^\dagger A_\nu y_e^\dagger\Big) - 6 \mathrm{Tr}\Big(y_u y_d^\dagger A_d y_u^\dagger\Big) \\
&- 36 \mathrm{Tr}\Big(y_u y_u^\dagger A_u y_u^\dagger\Big) - 2 \mathrm{Tr}\Big(Y_\nu y_e^\dagger A_e Y_\nu^\dagger\Big) - 12 \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger A_\nu Y_\nu^\dagger\Big)\Big)
\end{aligned} \tag{62}
$$

$$
\begin{aligned}
\beta^{(1)}_{A_\nu} =& + 2Y_\nu y_e^\dagger A_e + 4 Y_\nu Y_\nu^\dagger A_\nu + A_\nu y_e^\dagger y_e + 5 A_\nu Y_\nu^\dagger Y_\nu - \frac{3}{5} g_1^2 A_\nu - 3 g_2^2 A_\nu \\
&+ 3A_\nu \mathrm{Tr}\Big(y_u y_u^\dagger\Big) + A_\nu \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) + Y_\nu\Big(2\mathrm{Tr}\Big(Y_\nu^\dagger A_\nu\Big) + 6 g_2^2 M_2 + 6 \mathrm{Tr}\Big(y_u^\dagger A_u\Big) + \frac{6}{5} g_1^2 M_1\Big)
\end{aligned} \tag{63}
$$

$$
\begin{aligned}
\beta^{(2)}_{A_\nu} =& + \frac{12}{5} g_1^2 Y_\nu y_e^\dagger A_e - \frac{12}{5} g_1^2 M_1 Y_\nu Y_\nu^\dagger Y_\nu - 12 g_2^2 M_2 Y_\nu Y_\nu^\dagger Y_\nu + \frac{6}{5} g_1^2 Y_\nu Y_\nu^\dagger A_\nu \\
&+ 6 g_2^2 Y_\nu Y_\nu^\dagger A_\nu + \frac{6}{5} g_1^2 A_\nu y_e^\dagger y_e + \frac{12}{5} g_1^2 A_\nu Y_\nu^\dagger Y_\nu + 12 g_2^2 A_\nu Y_\nu^\dagger Y_\nu
\end{aligned}
$$

$$
\begin{aligned}
&- 4Y_\nu y_e^\dagger y_e y_e^\dagger A_e - 2Y_\nu y_e^\dagger y_e Y_\nu^\dagger A_\nu - 4Y_\nu y_e^\dagger A_e y_e^\dagger y_e - 4Y_\nu y_e^\dagger A_e Y_\nu^\dagger Y_\nu \\
&- 6Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger A_\nu - 8Y_\nu Y_\nu^\dagger A_\nu Y_\nu^\dagger Y_\nu - 2A_\nu y_e^\dagger y_e y_e^\dagger y_e - 4A_\nu y_e^\dagger y_e Y_\nu^\dagger Y_\nu \\
&- 6A_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu + \frac{207}{50} g_1^4 A_\nu + \frac{9}{5} g_1^2 g_2^2 A_\nu + \frac{15}{2} g_2^4 A_\nu - 6Y_\nu y_e^\dagger A_e \mathrm{Tr}\Big(y_d y_d^\dagger\Big) \\
&- 3A_\nu y_e^\dagger y_e \mathrm{Tr}\Big(y_d y_d^\dagger\Big) - 2Y_\nu y_e^\dagger A_e \mathrm{Tr}\Big(y_e y_e^\dagger\Big) - A_\nu y_e^\dagger y_e \mathrm{Tr}\Big(y_e y_e^\dagger\Big) \\
&- 12Y_\nu Y_\nu^\dagger A_\nu \mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 15A_\nu Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(y_u y_u^\dagger\Big) + \frac{4}{5} g_1^2 A_\nu \mathrm{Tr}\Big(y_u y_u^\dagger\Big) \\
&+ 16 g_3^2 A_\nu \mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 4Y_\nu Y_\nu^\dagger A_\nu \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) - 5A_\nu Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \\
&- \frac{2}{5} Y_\nu y_e^\dagger y_e \Big(15\mathrm{Tr}\Big(y_d^\dagger A_d\Big) + 5\mathrm{Tr}\Big(y_e^\dagger A_e\Big) + 6g_1^2 M_1\Big) - 18 Y_\nu Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(y_u^\dagger A_u\Big) \\
&- 6Y_\nu Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(Y_\nu^\dagger A_\nu\Big) - 3A_\nu \mathrm{Tr}\Big(y_d y_u^\dagger y_u y_d^\dagger\Big) - A_\nu \mathrm{Tr}\Big(y_e Y_\nu^\dagger Y_\nu y_e^\dagger\Big) \\
&- 9A_\nu \mathrm{Tr}\Big(y_u y_u^\dagger y_u y_u^\dagger\Big) - 3A_\nu \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\Big) \\
&- \frac{2}{25} Y_\nu \Big(207 g_1^4 M_1 + 45 g_1^2 g_2^2 M_1 + 45 g_1^2 g_2^2 M_2 + 375 g_2^4 M_2 + 20\Big(20 g_3^2 M_3 + g_1^2 M_1\Big)\mathrm{Tr}\Big(y_u y_u^\dagger\Big) \\
&- 20\Big(20 g_3^2 + g_1^2\Big)\mathrm{Tr}\Big(y_u^\dagger A_u\Big) + 75\mathrm{Tr}\Big(y_d y_u^\dagger A_u y_d^\dagger\Big) + 25\mathrm{Tr}\Big(y_e Y_\nu^\dagger A_\nu y_e^\dagger\Big) \\
&+ 75\mathrm{Tr}\Big(y_u y_d^\dagger A_d y_u^\dagger\Big) + 450\mathrm{Tr}\Big(y_u y_u^\dagger A_u y_u^\dagger\Big) + 25\mathrm{Tr}\Big(Y_\nu y_e^\dagger A_e Y_\nu^\dagger\Big) + 150\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger A_\nu Y_\nu^\dagger\Big)\Big)
\end{aligned} \tag{64}
$$

$$
\beta_{A_\kappa}^{(1)} = 18|\kappa|^2 A_\kappa + 3\kappa \mathrm{Tr}\Big(\lambda^* A_\lambda\Big) + \frac{3}{2} A_\kappa \mathrm{Tr}\Big(\lambda\lambda^*\Big) \tag{65}
$$

$$
\beta_{A_\kappa}^{(2)} = -3\Big(2|\kappa|^2\Big(2\kappa \mathrm{Tr}\Big(\lambda^* A_\lambda\Big) + 3A_\kappa \mathrm{Tr}\Big(\lambda\lambda^*\Big)\Big) + 40\kappa^2 \kappa^{*,2} A_\kappa + 4\kappa \mathrm{Tr}\Big(\lambda\lambda^* A_\lambda \lambda^*\Big) + A_\kappa \mathrm{Tr}\Big(\lambda\lambda^*\lambda\lambda^*\Big)\Big) \tag{66}
$$

3.7 Bilinear Soft-Breaking Parameters

$$
\begin{aligned}
\beta_{b_H}^{(1)} &= +b_H\Big(- 3g_2^2 + 3\mathrm{Tr}\Big(y_d y_d^\dagger\Big) + 3\mathrm{Tr}\Big(y_u y_u^\dagger\Big) - \frac{3}{5} g_1^2 + \mathrm{Tr}\Big(y_e y_e^\dagger\Big) + \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big)\Big) \\
&\quad + \frac{2}{5}\mu_H\Big(15 g_2^2 M_2 + 15\mathrm{Tr}\Big(y_d^\dagger A_d\Big) + 15\mathrm{Tr}\Big(y_u^\dagger A_u\Big) + 3g_1^2 M_1 + 5\mathrm{Tr}\Big(y_e^\dagger A_e\Big) + 5\mathrm{Tr}\Big(Y_\nu^\dagger A_\nu\Big)\Big)
\end{aligned} \tag{67}
$$

$$
\begin{aligned}
\beta_{b_H}^{(2)} &= +b_H\Big(\frac{207}{50} g_1^4 + \frac{9}{5} g_1^2 g_2^2 + \frac{15}{2} g_2^4 - \frac{2}{5}\Big(- 40 g_3^2 + g_1^2\Big)\mathrm{Tr}\Big(y_d y_d^\dagger\Big) + \frac{6}{5} g_1^2 \mathrm{Tr}\Big(y_e y_e^\dagger\Big) + \frac{4}{5} g_1^2 \mathrm{Tr}\Big(y_u y_u^\dagger\Big) \\
&\quad + 16 g_3^2 \mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 9\mathrm{Tr}\Big(y_d y_d^\dagger y_d y_d^\dagger\Big) - 6\mathrm{Tr}\Big(y_d y_u^\dagger y_u y_d^\dagger\Big) - 3\mathrm{Tr}\Big(y_e y_e^\dagger y_e y_e^\dagger\Big) \\
&\quad - 2\mathrm{Tr}\Big(y_e Y_\nu^\dagger Y_\nu y_e^\dagger\Big) - 9\mathrm{Tr}\Big(y_u y_u^\dagger y_u y_u^\dagger\Big) - 3\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\Big)\Big) \\
&\quad - \frac{2}{25}\mu_H\Big(207 g_1^4 M_1 + 45 g_1^2 g_2^2 M_1 + 45 g_1^2 g_2^2 M_2 + 375 g_2^4 M_2 - 10\Big(- 40 g_3^2 M_3 + g_1^2 M_1\Big)\mathrm{Tr}\Big(y_d y_d^\dagger\Big) \\
&\quad + 30 g_1^2 M_1 \mathrm{Tr}\Big(y_e y_e^\dagger\Big) + 20 g_1^2 M_1 \mathrm{Tr}\Big(y_u y_u^\dagger\Big) + 400 g_3^2 M_3 \mathrm{Tr}\Big(y_u y_u^\dagger\Big) + 10 g_1^2 \mathrm{Tr}\Big(y_d^\dagger A_d\Big) \\
&\quad - 400 g_3^2 \mathrm{Tr}\Big(y_d^\dagger A_d\Big) - 30 g_1^2 \mathrm{Tr}\Big(y_e^\dagger A_e\Big) - 20 g_1^2 \mathrm{Tr}\Big(y_u^\dagger A_u\Big) - 400 g_3^2 \mathrm{Tr}\Big(y_u^\dagger A_u\Big)
\end{aligned}
$$

$$+ 450\mathrm{Tr}\Big(y_d y_d^\dagger A_d y_d^\dagger\Big) + 150\mathrm{Tr}\Big(y_d y_u^\dagger A_u y_d^\dagger\Big) + 150\mathrm{Tr}\Big(y_e y_e^\dagger A_e y_e^\dagger\Big) + 50\mathrm{Tr}\Big(y_e Y_\nu^\dagger A_\nu y_e^\dagger\Big)$$
$$+ 150\mathrm{Tr}\Big(y_u y_d^\dagger A_d y_u^\dagger\Big) + 450\mathrm{Tr}\Big(y_u y_u^\dagger A_u y_u^\dagger\Big) + 50\mathrm{Tr}\Big(Y_\nu y_e^\dagger A_e Y_\nu^\dagger\Big) + 150\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger A_\nu Y_\nu^\dagger\Big)\Big) \tag{68}$$

$$\beta^{(1)}_{b_{NS}} = 2\mu_{NS}\lambda^* A_\lambda + 2Y_\nu Y_\nu^\dagger b_{NS} + 4A_\nu Y_\nu^\dagger \mu_{NS} + b_{NS}\lambda^*\lambda \tag{69}$$

$$\begin{aligned}\beta^{(2)}_{b_{NS}} &= -\frac{12}{5}g_1^2 M_1 Y_\nu Y_\nu^\dagger \mu_{NS} - 12 g_2^2 M_2 Y_\nu Y_\nu^\dagger \mu_{NS} + \frac{6}{5}g_1^2 Y_\nu Y_\nu^\dagger b_{NS} + 6 g_2^2 Y_\nu Y_\nu^\dagger b_{NS} \\ &+ \frac{12}{5}g_1^2 A_\nu Y_\nu^\dagger \mu_{NS} + 12 g_2^2 A_\nu Y_\nu^\dagger \mu_{NS} - 2\mu_{NS}\lambda^*\lambda\lambda^* A_\lambda - 2\mu_{NS}\lambda^* A_\lambda \lambda^*\lambda \\ &- 2Y_\nu y_e^\dagger y_e Y_\nu^\dagger b_{NS} - 4Y_\nu y_e^\dagger A_e Y_\nu^\dagger \mu_{NS} - 2Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger b_{NS} - 4Y_\nu Y_\nu^\dagger A_\nu Y_\nu^\dagger \mu_{NS} \\ &- b_{NS}\lambda^*\lambda\lambda^*\lambda - 4A_\nu y_e^\dagger y_e Y_\nu^\dagger \mu_{NS} - 4A_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger \mu_{NS} \\ &- 2\kappa^*\Big(2\mu_{NS}\lambda^*\lambda A_\kappa + \kappa\Big(2\mu_{NS}\lambda^* A_\lambda + b_{NS}\lambda^*\lambda\Big)\Big) - \mu_{NS}\lambda^* A_\lambda \mathrm{Tr}\Big(\lambda\lambda^*\Big) - \frac{1}{2}b_{NS}\lambda^*\lambda\mathrm{Tr}\Big(\lambda\lambda^*\Big) \\ &- 6Y_\nu Y_\nu^\dagger b_{NS}\mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 12A_\nu Y_\nu^\dagger \mu_{NS}\mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 2Y_\nu Y_\nu^\dagger b_{NS}\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \\ &- 4A_\nu Y_\nu^\dagger \mu_{NS}\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) - 12Y_\nu Y_\nu^\dagger \mu_{NS}\mathrm{Tr}\Big(y_u^\dagger A_u\Big) - 4Y_\nu Y_\nu^\dagger \mu_{NS}\mathrm{Tr}\Big(Y_\nu^\dagger A_\nu\Big) \\ &- \mu_{NS}\lambda^*\lambda\mathrm{Tr}\Big(\lambda^* A_\lambda\Big)\end{aligned} \tag{70}$$

3.8 Soft-Breaking Scalar Masses

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

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

$$\begin{aligned}\sigma_{3,1} &= \frac{1}{20}\frac{1}{\sqrt{15}}g_1\Big(-9g_1^2 m_{H_d}^2 - 45g_2^2 m_{H_d}^2 + 9g_1^2 m_{H_u}^2 + 45g_2^2 m_{H_u}^2 + 4\Big(20g_3^2 + g_1^2\Big)\mathrm{Tr}\Big(m_d^2\Big) + 36g_1^2\mathrm{Tr}\Big(m_e^2\Big) \\ &- 9g_1^2\mathrm{Tr}\Big(m_l^2\Big) - 45g_2^2\mathrm{Tr}\Big(m_l^2\Big) + g_1^2\mathrm{Tr}\Big(m_q^2\Big) + 45g_2^2\mathrm{Tr}\Big(m_q^2\Big) + 80g_3^2\mathrm{Tr}\Big(m_q^2\Big) - 32g_1^2\mathrm{Tr}\Big(m_u^2\Big) \\ &- 160g_3^2\mathrm{Tr}\Big(m_u^2\Big) + 90m_{H_d}^2\mathrm{Tr}\Big(y_d y_d^\dagger\Big) + 30m_{H_d}^2\mathrm{Tr}\Big(y_e y_e^\dagger\Big) - 90m_{H_u}^2\mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 30m_{H_u}^2\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \\ &- 60\mathrm{Tr}\Big(y_d y_d^\dagger m_d^{2*}\Big) - 30\mathrm{Tr}\Big(y_d m_q^{2*} y_d^\dagger\Big) - 60\mathrm{Tr}\Big(y_e y_e^\dagger m_e^{2*}\Big) + 30\mathrm{Tr}\Big(y_e m_l^{2*} y_e^\dagger\Big) \\ &+ 120\mathrm{Tr}\Big(y_u y_u^\dagger m_u^{2*}\Big) - 30\mathrm{Tr}\Big(y_u m_q^{2*} y_u^\dagger\Big) + 30\mathrm{Tr}\Big(Y_\nu m_l^{2*} Y_\nu^\dagger\Big)\Big)\end{aligned} \tag{73}$$

$$\sigma_{2,2} = \frac{1}{2}\Big(3\mathrm{Tr}\Big(m_q^2\Big) + m_{H_d}^2 + m_{H_u}^2 + \mathrm{Tr}\Big(m_l^2\Big)\Big) \tag{74}$$

$$\sigma_{2,3} = \frac{1}{2}\Big(2\mathrm{Tr}\Big(m_q^2\Big) + \mathrm{Tr}\Big(m_d^2\Big) + \mathrm{Tr}\Big(m_u^2\Big)\Big) \tag{75}$$

$$\begin{aligned}\beta^{(1)}_{m_q^2} &= -\frac{2}{15}g_1^2\mathbf{1}|M_1|^2 - \frac{32}{3}g_3^2\mathbf{1}|M_3|^2 - 6g_2^2\mathbf{1}|M_2|^2 + 2m_{H_d}^2 y_d^\dagger y_d + 2m_{H_u}^2 y_u^\dagger y_u + 2A_d^\dagger A_d \\ &+ 2A_u^\dagger A_u + m_q^2 y_d^\dagger y_d + m_q^2 y_u^\dagger y_u + 2y_d^\dagger m_d^2 y_d + y_d^\dagger y_d m_q^2 + 2y_u^\dagger m_u^2 y_u\end{aligned}$$

$$
\begin{aligned}
&+ y_u^\dagger y_u m_q^2 + \frac{1}{\sqrt{15}} g_1 \mathbf{1} \sigma_{1,1} \qquad (76)\\
\beta^{(2)}_{m_q^2} =& + \frac{2}{5} g_1^2 g_2^2 \mathbf{1} |M_2|^2 + 33 g_2^4 \mathbf{1} |M_2|^2 + 32 g_2^2 g_3^2 \mathbf{1} |M_2|^2 \\
&+ \frac{16}{45} g_3^2 \Big(15 \Big(3 g_2^2 \Big(2M_3 + M_2 \Big) - 8 g_3^2 M_3 \Big) + g_1^2 \Big(2M_3 + M_1 \Big) \Big) \mathbf{1} M_3^* + \frac{1}{5} g_1^2 g_2^2 M_1 \mathbf{1} M_2^* + 16 g_2^2 g_3^2 M_3 \mathbf{1} M_2^* \\
&+ \frac{4}{5} g_1^2 m_{H_d}^2 y_d^\dagger y_d + \frac{8}{5} g_1^2 m_{H_u}^2 y_u^\dagger y_u \\
&+ \frac{1}{225} g_1^2 M_1^* \Big(\Big(5 \Big(16 g_3^2 \Big(2M_1 + M_3 \Big) + 9 g_2^2 \Big(2M_1 + M_2 \Big) \Big) + 597 g_1^2 M_1 \Big) \mathbf{1} \\
&+ 180 \Big(2M_1 y_d^\dagger y_d - 2 y_u^\dagger A_u + 4 M_1 y_u^\dagger y_u - y_d^\dagger A_d \Big) \Big) \\
&- \frac{4}{5} g_1^2 M_1 A_d^\dagger y_d + \frac{4}{5} g_1^2 A_d^\dagger A_d - \frac{8}{5} g_1^2 M_1 A_u^\dagger y_u + \frac{8}{5} g_1^2 A_u^\dagger A_u \\
&+ \frac{2}{5} g_1^2 m_q^2 y_d^\dagger y_d + \frac{4}{5} g_1^2 m_q^2 y_u^\dagger y_u + \frac{4}{5} g_1^2 y_d^\dagger m_d^2 y_d + \frac{2}{5} g_1^2 y_d^\dagger y_d m_q^2 \\
&+ \frac{8}{5} g_1^2 y_u^\dagger m_u^2 y_u + \frac{4}{5} g_1^2 y_u^\dagger y_u m_q^2 - 8 m_{H_d}^2 y_d^\dagger y_d y_d^\dagger y_d - 4 y_d^\dagger y_d A_d^\dagger A_d \\
&- 4 y_d^\dagger A_d A_d^\dagger y_d - 8 m_{H_u}^2 y_u^\dagger y_u y_u^\dagger y_u - 4 y_u^\dagger y_u A_u^\dagger A_u - 4 y_u^\dagger A_u A_u^\dagger y_u \\
&- 4 A_d^\dagger y_d y_d^\dagger A_d - 4 A_d^\dagger A_d y_d^\dagger y_d - 4 A_u^\dagger y_u y_u^\dagger A_u - 4 A_u^\dagger A_u y_u^\dagger y_u \\
&- 2 m_q^2 y_d^\dagger y_d y_d^\dagger y_d - 2 m_q^2 y_u^\dagger y_u y_u^\dagger y_u - 4 y_d^\dagger m_d^2 y_d y_d^\dagger y_d - 4 y_d^\dagger y_d m_q^2 y_d^\dagger y_d \\
&- 4 y_d^\dagger y_d y_d^\dagger m_d^2 y_d - 2 y_d^\dagger y_d y_d^\dagger y_d m_q^2 - 4 y_u^\dagger m_u^2 y_u y_u^\dagger y_u - 4 y_u^\dagger y_u m_q^2 y_u^\dagger y_u \\
&- 4 y_u^\dagger y_u y_u^\dagger m_u^2 y_u - 2 y_u^\dagger y_u y_u^\dagger y_u m_q^2 + 6 g_2^4 \mathbf{1} \sigma_{2,2} + \frac{32}{3} g_3^4 \mathbf{1} \sigma_{2,3} + \frac{2}{15} g_1^2 \mathbf{1} \sigma_{2,11} + 4 \frac{1}{\sqrt{15}} g_1 \mathbf{1} \sigma_{3,1} \\
&- 12 m_{H_d}^2 y_d^\dagger y_d \mathrm{Tr}\Big(y_d y_d^\dagger \Big) - 6 A_d^\dagger A_d \mathrm{Tr}\Big(y_d y_d^\dagger \Big) - 3 m_q^2 y_d^\dagger y_d \mathrm{Tr}\Big(y_d y_d^\dagger \Big) \\
&- 6 y_d^\dagger m_d^2 y_d \mathrm{Tr}\Big(y_d y_d^\dagger \Big) - 3 y_d^\dagger y_d m_q^2 \mathrm{Tr}\Big(y_d y_d^\dagger \Big) - 4 m_{H_d}^2 y_d^\dagger y_d \mathrm{Tr}\Big(y_e y_e^\dagger \Big) \\
&- 2 A_d^\dagger A_d \mathrm{Tr}\Big(y_e y_e^\dagger \Big) - m_q^2 y_d^\dagger y_d \mathrm{Tr}\Big(y_e y_e^\dagger \Big) - 2 y_d^\dagger m_d^2 y_d \mathrm{Tr}\Big(y_e y_e^\dagger \Big) \\
&- y_d^\dagger y_d m_q^2 \mathrm{Tr}\Big(y_e y_e^\dagger \Big) - 12 m_{H_u}^2 y_u^\dagger y_u \mathrm{Tr}\Big(y_u y_u^\dagger \Big) - 6 A_u^\dagger A_u \mathrm{Tr}\Big(y_u y_u^\dagger \Big) \\
&- 3 m_q^2 y_u^\dagger y_u \mathrm{Tr}\Big(y_u y_u^\dagger \Big) - 6 y_u^\dagger m_u^2 y_u \mathrm{Tr}\Big(y_u y_u^\dagger \Big) - 3 y_u^\dagger y_u m_q^2 \mathrm{Tr}\Big(y_u y_u^\dagger \Big) \\
&- 4 m_{H_u}^2 y_u^\dagger y_u \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger \Big) - 2 A_u^\dagger A_u \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger \Big) - m_q^2 y_u^\dagger y_u \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger \Big) \\
&- 2 y_u^\dagger m_u^2 y_u \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger \Big) - y_u^\dagger y_u m_q^2 \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger \Big) - 6 A_d^\dagger y_d \mathrm{Tr}\Big(y_d^\dagger A_d \Big) \\
&- 2 A_d^\dagger y_d \mathrm{Tr}\Big(y_e^\dagger A_e \Big) - 6 A_u^\dagger y_u \mathrm{Tr}\Big(y_u^\dagger A_u \Big) - 2 A_u^\dagger y_u \mathrm{Tr}\Big(Y_\nu^\dagger A_\nu \Big) \\
&- 6 y_d^\dagger A_d \mathrm{Tr}\Big(A_d^* y_d^T \Big) - 6 y_d^\dagger y_d \mathrm{Tr}\Big(A_d^* A_d^T \Big) - 2 y_d^\dagger A_d \mathrm{Tr}\Big(A_e^* y_e^T \Big) \\
&- 2 y_d^\dagger y_d \mathrm{Tr}\Big(A_e^* A_e^T \Big) - 6 y_u^\dagger A_u \mathrm{Tr}\Big(A_u^* y_u^T \Big) - 6 y_u^\dagger y_u \mathrm{Tr}\Big(A_u^* A_u^T \Big) \\
&- 2 y_u^\dagger A_u \mathrm{Tr}\Big(A_\nu^* Y_\nu^T \Big) - 2 y_u^\dagger y_u \mathrm{Tr}\Big(A_\nu^* A_\nu^T \Big) - 6 y_d^\dagger y_d \mathrm{Tr}\Big(m_d^2 y_d y_d^\dagger \Big)
\end{aligned}
$$

$$
\begin{aligned}
&- 2y_d^\dagger y_d \mathrm{Tr}\Big(m_e^2 y_e y_e^\dagger\Big) - 2y_d^\dagger y_d \mathrm{Tr}\Big(m_l^2 y_e^\dagger y_e\Big) - 2y_u^\dagger y_u \mathrm{Tr}\Big(m_l^2 Y_\nu^\dagger Y_\nu\Big) \\
&- 6y_d^\dagger y_d \mathrm{Tr}\Big(m_q^2 y_d^\dagger y_d\Big) - 6y_u^\dagger y_u \mathrm{Tr}\Big(m_q^2 y_u^\dagger y_u\Big) - 6y_u^\dagger y_u \mathrm{Tr}\Big(m_u^2 y_u y_u^\dagger\Big) \\
&- 2y_u^\dagger y_u \mathrm{Tr}\Big(M_{\tilde{N}^c}^2 Y_\nu Y_\nu^\dagger\Big) \qquad (77)
\end{aligned}
$$

$$
\begin{aligned}
\beta_{m_l^2}^{(1)} =& -\frac{6}{5} g_1^2 \mathbf{1} |M_1|^2 - 6 g_2^2 \mathbf{1} |M_2|^2 + 2 m_{H_d}^2 y_e^\dagger y_e + 2 m_{H_u}^2 Y_\nu^\dagger Y_\nu + 2 A_e^\dagger A_e + 2 A_\nu^\dagger A_\nu \\
&+ m_l^2 y_e^\dagger y_e + m_l^2 Y_\nu^\dagger Y_\nu + 2 y_e^\dagger m_e^2 y_e + y_e^\dagger y_e m_l^2 + 2 Y_\nu^\dagger M_{\tilde{N}^c}^2 Y_\nu + Y_\nu^\dagger Y_\nu m_l^2 \\
&- \sqrt{\frac{3}{5}} g_1 \mathbf{1} \sigma_{1,1} \qquad (78)
\end{aligned}
$$

$$
\begin{aligned}
\beta_{m_l^2}^{(2)} =& +\frac{3}{5} g_2^2 \Big(3 g_1^2 \Big(2M_2 + M_1\Big) + 55 g_2^2 M_2\Big) \mathbf{1} M_2^* + \frac{12}{5} g_1^2 m_{H_d}^2 y_e^\dagger y_e \\
&+ \frac{3}{25} g_1^2 M_1^* \Big(- 20 y_e^\dagger A_e + 3\Big(5 g_2^2 \Big(2M_1 + M_2\Big) + 69 g_1^2 M_1\Big) \mathbf{1} + 40 M_1 y_e^\dagger y_e\Big) - \frac{12}{5} g_1^2 M_1 A_e^\dagger y_e \\
&+ \frac{12}{5} g_1^2 A_e^\dagger A_e + \frac{6}{5} g_1^2 m_l^2 y_e^\dagger y_e + \frac{12}{5} g_1^2 y_e^\dagger m_e^2 y_e + \frac{6}{5} g_1^2 y_e^\dagger y_e m_l^2 \\
&- 8 m_{H_d}^2 y_e^\dagger y_e y_e^\dagger y_e - 4 y_e^\dagger y_e A_e^\dagger A_e - 4 y_e^\dagger A_e A_e^\dagger y_e - 8 m_{H_u}^2 Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu \\
&- 4 Y_\nu^\dagger Y_\nu A_\nu^\dagger A_\nu - 4 Y_\nu^\dagger A_\nu A_\nu^\dagger Y_\nu - 4 A_e^\dagger y_e y_e^\dagger A_e - 4 A_e^\dagger A_e y_e^\dagger y_e \\
&- 4 A_\nu^\dagger Y_\nu Y_\nu^\dagger A_\nu - 4 A_\nu^\dagger A_\nu Y_\nu^\dagger Y_\nu - 2 m_l^2 y_e^\dagger y_e y_e^\dagger y_e - 2 m_l^2 Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu \\
&- 4 y_e^\dagger m_e^2 y_e y_e^\dagger y_e - 4 y_e^\dagger y_e m_l^2 y_e^\dagger y_e - 4 y_e^\dagger y_e y_e^\dagger m_e^2 y_e - 2 y_e^\dagger y_e y_e^\dagger y_e m_l^2 \\
&- 4 Y_\nu^\dagger M_{\tilde{N}^c}^2 Y_\nu Y_\nu^\dagger Y_\nu - 4 Y_\nu^\dagger Y_\nu m_l^2 Y_\nu^\dagger Y_\nu - 4 Y_\nu^\dagger Y_\nu Y_\nu^\dagger M_{\tilde{N}^c}^2 Y_\nu - 2 Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu m_l^2 + 6 g_2^4 \mathbf{1} \sigma_{2,2} \\
&+ \frac{6}{5} g_1^2 \mathbf{1} \sigma_{2,11} - 4 \sqrt{\frac{3}{5}} g_1 \mathbf{1} \sigma_{3,1} - 12 m_{H_d}^2 y_e^\dagger y_e \mathrm{Tr}\Big(y_d y_d^\dagger\Big) - 6 A_e^\dagger A_e \mathrm{Tr}\Big(y_d y_d^\dagger\Big) \\
&- 3 m_l^2 y_e^\dagger y_e \mathrm{Tr}\Big(y_d y_d^\dagger\Big) - 6 y_e^\dagger m_e^2 y_e \mathrm{Tr}\Big(y_d y_d^\dagger\Big) - 3 y_e^\dagger y_e m_l^2 \mathrm{Tr}\Big(y_d y_d^\dagger\Big) \\
&- 4 m_{H_d}^2 y_e^\dagger y_e \mathrm{Tr}\Big(y_e y_e^\dagger\Big) - 2 A_e^\dagger A_e \mathrm{Tr}\Big(y_e y_e^\dagger\Big) - m_l^2 y_e^\dagger y_e \mathrm{Tr}\Big(y_e y_e^\dagger\Big) \\
&- 2 y_e^\dagger m_e^2 y_e \mathrm{Tr}\Big(y_e y_e^\dagger\Big) - y_e^\dagger y_e m_l^2 \mathrm{Tr}\Big(y_e y_e^\dagger\Big) - 12 m_{H_u}^2 Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(y_u y_u^\dagger\Big) \\
&- 6 A_\nu^\dagger A_\nu \mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 3 m_l^2 Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 6 Y_\nu^\dagger M_{\tilde{N}^c}^2 Y_\nu \mathrm{Tr}\Big(y_u y_u^\dagger\Big) \\
&- 3 Y_\nu^\dagger Y_\nu m_l^2 \mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 4 m_{H_u}^2 Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) - 2 A_\nu^\dagger A_\nu \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \\
&- m_l^2 Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) - 2 Y_\nu^\dagger M_{\tilde{N}^c}^2 Y_\nu \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) - Y_\nu^\dagger Y_\nu m_l^2 \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \\
&- 6 A_e^\dagger y_e \mathrm{Tr}\Big(y_d^\dagger A_d\Big) - 2 A_e^\dagger y_e \mathrm{Tr}\Big(y_e^\dagger A_e\Big) - 6 A_\nu^\dagger Y_\nu \mathrm{Tr}\Big(y_u^\dagger A_u\Big) \\
&- 2 A_\nu^\dagger Y_\nu \mathrm{Tr}\Big(Y_\nu^\dagger A_\nu\Big) - 6 y_e^\dagger A_e \mathrm{Tr}\Big(A_d^* y_d^T\Big) - 6 y_e^\dagger y_e \mathrm{Tr}\Big(A_d^* A_d^T\Big) \\
&- 2 y_e^\dagger A_e \mathrm{Tr}\Big(A_e^* y_e^T\Big) - 2 y_e^\dagger y_e \mathrm{Tr}\Big(A_e^* A_e^T\Big) - 6 Y_\nu^\dagger A_\nu \mathrm{Tr}\Big(A_u^* y_u^T\Big) \\
&- 6 Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(A_u^* A_u^T\Big) - 2 Y_\nu^\dagger A_\nu \mathrm{Tr}\Big(A_\nu^* Y_\nu^T\Big) - 2 Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(A_\nu^* A_\nu^T\Big)
\end{aligned}
$$

$$
\begin{aligned}
&- 6y_e^\dagger y_e \mathrm{Tr}\Big(m_d^2 y_d y_d^\dagger\Big) - 2y_e^\dagger y_e \mathrm{Tr}\Big(m_e^2 y_e y_e^\dagger\Big) - 2y_e^\dagger y_e \mathrm{Tr}\Big(m_l^2 y_e^\dagger y_e\Big) \\
&- 2Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(m_l^2 Y_\nu^\dagger Y_\nu\Big) - 6y_e^\dagger y_e \mathrm{Tr}\Big(m_q^2 y_d^\dagger y_d\Big) - 6Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(m_q^2 y_u^\dagger y_u\Big) \\
&- 6Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(m_u^2 y_u y_u^\dagger\Big) - 2Y_\nu^\dagger Y_\nu \mathrm{Tr}\Big(M_{\tilde{N}^c}^2 Y_\nu Y_\nu^\dagger\Big) \qquad (79)
\end{aligned}
$$

$$
\begin{aligned}
\beta^{(1)}_{m^2_{H_d}} &= -\frac{6}{5}g_1^2|M_1|^2 - 6g_2^2|M_2|^2 - \sqrt{\frac{3}{5}}g_1\sigma_{1,1} + 6m_{H_d}^2 \mathrm{Tr}\Big(y_d y_d^\dagger\Big) + 2m_{H_d}^2 \mathrm{Tr}\Big(y_e y_e^\dagger\Big) + 6\mathrm{Tr}\Big(A_d^* A_d^T\Big) \\
&+ 2\mathrm{Tr}\Big(A_e^* A_e^T\Big) + 6\mathrm{Tr}\Big(m_d^2 y_d y_d^\dagger\Big) + 2\mathrm{Tr}\Big(m_e^2 y_e y_e^\dagger\Big) + 2\mathrm{Tr}\Big(m_l^2 y_e^\dagger y_e\Big) + 6\mathrm{Tr}\Big(m_q^2 y_d^\dagger y_d\Big) \qquad (80)
\end{aligned}
$$

$$
\begin{aligned}
\beta^{(2)}_{m^2_{H_d}} &= \frac{1}{25}\Big(15g_2^2\Big(3g_1^2\Big(2M_2 + M_1\Big) + 55g_2^2 M_2\Big)M_2^* \\
&+ g_1^2 M_1^*\Big(621g_1^2 M_1 + 90g_2^2 M_1 + 45g_2^2 M_2 - 40M_1 \mathrm{Tr}\Big(y_d y_d^\dagger\Big) + 120M_1 \mathrm{Tr}\Big(y_e y_e^\dagger\Big) + 20\mathrm{Tr}\Big(y_d^\dagger A_d\Big) \\
&- 60\mathrm{Tr}\Big(y_e^\dagger A_e\Big)\Big) \\
&+ 10\Big(15g_2^4\sigma_{2,2} + 3g_1^2\sigma_{2,11} - 2\sqrt{15}g_1\sigma_{3,1} + \Big(160g_3^2|M_3|^2 - 2g_1^2 m_{H_d}^2 + 80g_3^2 m_{H_d}^2\Big)\mathrm{Tr}\Big(y_d y_d^\dagger\Big) \\
&+ 6g_1^2 m_{H_d}^2 \mathrm{Tr}\Big(y_e y_e^\dagger\Big) - 80g_3^2 M_3^* \mathrm{Tr}\Big(y_d^\dagger A_d\Big) + 2g_1^2 M_1 \mathrm{Tr}\Big(A_d^* y_d^T\Big) - 80g_3^2 M_3 \mathrm{Tr}\Big(A_d^* y_d^T\Big) \\
&- 2g_1^2 \mathrm{Tr}\Big(A_d^* A_d^T\Big) + 80g_3^2 \mathrm{Tr}\Big(A_d^* A_d^T\Big) - 6g_1^2 M_1 \mathrm{Tr}\Big(A_e^* y_e^T\Big) + 6g_1^2 \mathrm{Tr}\Big(A_e^* A_e^T\Big) \\
&- 2g_1^2 \mathrm{Tr}\Big(m_d^2 y_d y_d^\dagger\Big) + 80g_3^2 \mathrm{Tr}\Big(m_d^2 y_d y_d^\dagger\Big) + 6g_1^2 \mathrm{Tr}\Big(m_e^2 y_e y_e^\dagger\Big) + 6g_1^2 \mathrm{Tr}\Big(m_l^2 y_e^\dagger y_e\Big) \\
&- 2g_1^2 \mathrm{Tr}\Big(m_q^2 y_d^\dagger y_d\Big) + 80g_3^2 \mathrm{Tr}\Big(m_q^2 y_d^\dagger y_d\Big) - 90m_{H_d}^2 \mathrm{Tr}\Big(y_d y_d^\dagger y_d y_d^\dagger\Big) - 90\mathrm{Tr}\Big(y_d y_d^\dagger A_d A_d^\dagger\Big) \\
&- 15m_{H_d}^2 \mathrm{Tr}\Big(y_d y_u^\dagger y_u y_d^\dagger\Big) - 15m_{H_u}^2 \mathrm{Tr}\Big(y_d y_u^\dagger y_u y_d^\dagger\Big) - 15\mathrm{Tr}\Big(y_d y_u^\dagger A_u A_d^\dagger\Big) \\
&- 90\mathrm{Tr}\Big(y_d A_d^\dagger A_d y_d^\dagger\Big) - 15\mathrm{Tr}\Big(y_d A_u^\dagger A_u y_d^\dagger\Big) - 30m_{H_d}^2 \mathrm{Tr}\Big(y_e y_e^\dagger y_e y_e^\dagger\Big) - 30\mathrm{Tr}\Big(y_e y_e^\dagger A_e A_e^\dagger\Big) \\
&- 5m_{H_d}^2 \mathrm{Tr}\Big(y_e Y_\nu^\dagger Y_\nu y_e^\dagger\Big) - 5m_{H_u}^2 \mathrm{Tr}\Big(y_e Y_\nu^\dagger Y_\nu y_e^\dagger\Big) - 5\mathrm{Tr}\Big(y_e Y_\nu^\dagger A_\nu A_e^\dagger\Big) \\
&- 30\mathrm{Tr}\Big(y_e A_e^\dagger A_e y_e^\dagger\Big) - 5\mathrm{Tr}\Big(y_e A_\nu^\dagger A_\nu y_e^\dagger\Big) - 15\mathrm{Tr}\Big(y_u y_d^\dagger A_d A_u^\dagger\Big) - 15\mathrm{Tr}\Big(y_u A_d^\dagger A_d y_u^\dagger\Big) \\
&- 5\mathrm{Tr}\Big(Y_\nu y_e^\dagger A_e A_\nu^\dagger\Big) - 5\mathrm{Tr}\Big(Y_\nu A_e^\dagger A_e Y_\nu^\dagger\Big) - 90\mathrm{Tr}\Big(m_d^2 y_d y_d^\dagger y_d y_d^\dagger\Big) \\
&- 15\mathrm{Tr}\Big(m_d^2 y_d y_u^\dagger y_u y_d^\dagger\Big) - 30\mathrm{Tr}\Big(m_e^2 y_e y_e^\dagger y_e y_e^\dagger\Big) - 5\mathrm{Tr}\Big(m_e^2 y_e Y_\nu^\dagger Y_\nu y_e^\dagger\Big) \\
&- 30\mathrm{Tr}\Big(m_l^2 y_e^\dagger y_e y_e^\dagger y_e\Big) - 5\mathrm{Tr}\Big(m_l^2 y_e^\dagger y_e Y_\nu^\dagger Y_\nu\Big) - 5\mathrm{Tr}\Big(m_l^2 Y_\nu^\dagger Y_\nu y_e^\dagger y_e\Big) \\
&- 90\mathrm{Tr}\Big(m_q^2 y_d^\dagger y_d y_d^\dagger y_d\Big) - 15\mathrm{Tr}\Big(m_q^2 y_d^\dagger y_d y_u^\dagger y_u\Big) - 15\mathrm{Tr}\Big(m_q^2 y_u^\dagger y_u y_d^\dagger y_d\Big) \\
&- 15\mathrm{Tr}\Big(m_u^2 y_u y_d^\dagger y_d y_u^\dagger\Big) - 5\mathrm{Tr}\Big(M_{\tilde{N}^c}^2 Y_\nu y_e^\dagger y_e Y_\nu^\dagger\Big)\Big)\Big) \qquad (81)
\end{aligned}
$$

$$
\begin{aligned}
\beta^{(1)}_{m^2_{H_u}} &= -\frac{6}{5}g_1^2|M_1|^2 - 6g_2^2|M_2|^2 + \sqrt{\frac{3}{5}}g_1\sigma_{1,1} + 6m_{H_u}^2 \mathrm{Tr}\Big(y_u y_u^\dagger\Big) + 2m_{H_u}^2 \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) + 6\mathrm{Tr}\Big(A_u^* A_u^T\Big) \\
&+ 2\mathrm{Tr}\Big(A_\nu^* A_\nu^T\Big) + 2\mathrm{Tr}\Big(m_l^2 Y_\nu^\dagger Y_\nu\Big) + 6\mathrm{Tr}\Big(m_q^2 y_u^\dagger y_u\Big) + 6\mathrm{Tr}\Big(m_u^2 y_u y_u^\dagger\Big) + 2\mathrm{Tr}\Big(M_{\tilde{N}^c}^2 Y_\nu Y_\nu^\dagger\Big) \qquad (82)
\end{aligned}
$$

$$
\begin{aligned}
\beta^{(2)}_{m^2_{H_u}} =& +\frac{3}{5}g_2^2\Big(3g_1^2\Big(2M_2+M_1\Big)+55g_2^2M_2\Big)M_2^* + 6g_2^4\sigma_{2,2} + \frac{6}{5}g_1^2\sigma_{2,11} + 4\sqrt{\frac{3}{5}}g_1\sigma_{3,1} + \frac{8}{5}g_1^2m^2_{H_u}\mathrm{Tr}\Big(y_uy_u^\dagger\Big)\\
&+ 32g_3^2m^2_{H_u}\mathrm{Tr}\Big(y_uy_u^\dagger\Big) + 64g_3^2|M_3|^2\mathrm{Tr}\Big(y_uy_u^\dagger\Big)\\
&+ \frac{1}{25}g_1^2M_1^*\Big(-40\mathrm{Tr}\Big(y_u^\dagger A_u\Big) + 45g_2^2M_2 + 621g_1^2M_1 + 80M_1\mathrm{Tr}\Big(y_uy_u^\dagger\Big) + 90g_2^2M_1\Big)\\
&- 32g_3^2M_3^*\mathrm{Tr}\Big(y_u^\dagger A_u\Big) - \frac{8}{5}g_1^2M_1\mathrm{Tr}\Big(A_u^*y_u^T\Big) - 32g_3^2M_3\mathrm{Tr}\Big(A_u^*y_u^T\Big) + \frac{8}{5}g_1^2\mathrm{Tr}\Big(A_u^*A_u^T\Big)\\
&+ 32g_3^2\mathrm{Tr}\Big(A_u^*A_u^T\Big) + \frac{8}{5}g_1^2\mathrm{Tr}\Big(m_q^2y_u^\dagger y_u\Big) + 32g_3^2\mathrm{Tr}\Big(m_q^2y_u^\dagger y_u\Big) + \frac{8}{5}g_1^2\mathrm{Tr}\Big(m_u^2y_uy_u^\dagger\Big)\\
&+ 32g_3^2\mathrm{Tr}\Big(m_u^2y_uy_u^\dagger\Big) - 6m^2_{H_d}\mathrm{Tr}\Big(y_dy_u^\dagger y_uy_d^\dagger\Big) - 6m^2_{H_u}\mathrm{Tr}\Big(y_dy_u^\dagger y_uy_d^\dagger\Big)\\
&- 6\mathrm{Tr}\Big(y_dy_u^\dagger A_uA_d^\dagger\Big) - 6\mathrm{Tr}\Big(y_dA_u^\dagger A_uy_d^\dagger\Big) - 2m^2_{H_d}\mathrm{Tr}\Big(y_eY_\nu^\dagger Y_\nu y_e^\dagger\Big)\\
&- 2m^2_{H_u}\mathrm{Tr}\Big(y_eY_\nu^\dagger Y_\nu y_e^\dagger\Big) - 2\mathrm{Tr}\Big(y_eY_\nu^\dagger A_\nu A_e^\dagger\Big) - 2\mathrm{Tr}\Big(y_eA_\nu^\dagger A_\nu y_e^\dagger\Big)\\
&- 6\mathrm{Tr}\Big(y_uy_d^\dagger A_dA_u^\dagger\Big) - 36m^2_{H_u}\mathrm{Tr}\Big(y_uy_u^\dagger y_uy_u^\dagger\Big) - 36\mathrm{Tr}\Big(y_uy_u^\dagger A_uA_u^\dagger\Big) - 6\mathrm{Tr}\Big(y_uA_d^\dagger A_dy_u^\dagger\Big)\\
&- 36\mathrm{Tr}\Big(y_uA_u^\dagger A_uy_u^\dagger\Big) - 2\mathrm{Tr}\Big(Y_\nu y_e^\dagger A_eA_\nu^\dagger\Big) - 12m^2_{H_u}\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\Big) - 12\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger A_\nu A_\nu^\dagger\Big)\\
&- 2\mathrm{Tr}\Big(Y_\nu A_e^\dagger A_eY_\nu^\dagger\Big) - 12\mathrm{Tr}\Big(Y_\nu A_\nu^\dagger A_\nu Y_\nu^\dagger\Big) - 6\mathrm{Tr}\Big(m_d^2y_dy_u^\dagger y_uy_d^\dagger\Big)\\
&- 2\mathrm{Tr}\Big(m_e^2y_eY_\nu^\dagger Y_\nu y_e^\dagger\Big) - 2\mathrm{Tr}\Big(m_l^2y_e^\dagger y_eY_\nu^\dagger Y_\nu\Big) - 2\mathrm{Tr}\Big(m_l^2Y_\nu^\dagger Y_\nu y_e^\dagger y_e\Big)\\
&- 12\mathrm{Tr}\Big(m_l^2Y_\nu^\dagger Y_\nu Y_\nu^\dagger Y_\nu\Big) - 6\mathrm{Tr}\Big(m_q^2y_d^\dagger y_dy_u^\dagger y_u\Big) - 6\mathrm{Tr}\Big(m_q^2y_u^\dagger y_uy_d^\dagger y_d\Big)\\
&- 36\mathrm{Tr}\Big(m_q^2y_u^\dagger y_uy_u^\dagger y_u\Big) - 6\mathrm{Tr}\Big(m_u^2y_uy_d^\dagger y_dy_u^\dagger\Big) - 36\mathrm{Tr}\Big(m_u^2y_uy_u^\dagger y_uy_u^\dagger\Big)\\
&- 2\mathrm{Tr}\Big(M^2_{\tilde{N}^c}Y_\nu y_e^\dagger y_eY_\nu^\dagger\Big) - 12\mathrm{Tr}\Big(M^2_{\tilde{N}^c}Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\Big)
\end{aligned}
\tag{83}
$$

$$
\begin{aligned}
\beta^{(1)}_{m_d^2} =& -\frac{8}{15}g_1^2\mathbf{1}|M_1|^2 - \frac{32}{3}g_3^2\mathbf{1}|M_3|^2 + 4m^2_{H_d}y_dy_d^\dagger + 4A_dA_d^\dagger + 2m_d^2y_dy_d^\dagger + 4y_dm_q^2y_d^\dagger\\
&+ 2y_dy_d^\dagger m_d^2 + 2\frac{1}{\sqrt{15}}g_1\mathbf{1}\sigma_{1,1}
\end{aligned}
\tag{84}
$$

$$
\begin{aligned}
\beta^{(2)}_{m_d^2} =& +\frac{64}{45}g_3^2\Big(-30g_3^2M_3 + g_1^2\Big(2M_3+M_1\Big)\Big)\mathbf{1}M_3^* + \frac{4}{5}g_1^2m^2_{H_d}y_dy_d^\dagger + 12g_2^2m^2_{H_d}y_dy_d^\dagger\\
&+ 24g_2^2|M_2|^2y_dy_d^\dagger - \frac{4}{5}g_1^2M_1y_dA_d^\dagger - 12g_2^2M_2y_dA_d^\dagger\\
&+ \frac{4}{225}g_1^2M_1^*\Big(2\Big(303g_1^2M_1 + 40g_3^2\Big(2M_1+M_3\Big)\Big)\mathbf{1} - 45A_dy_d^\dagger + 90M_1y_dy_d^\dagger\Big) - 12g_2^2M_2^*A_dy_d^\dagger\\
&+ \frac{4}{5}g_1^2A_dA_d^\dagger + 12g_2^2A_dA_d^\dagger + \frac{2}{5}g_1^2m_d^2y_dy_d^\dagger + 6g_2^2m_d^2y_dy_d^\dagger\\
&+ \frac{4}{5}g_1^2y_dm_q^2y_d^\dagger + 12g_2^2y_dm_q^2y_d^\dagger + \frac{2}{5}g_1^2y_dy_d^\dagger m_d^2 + 6g_2^2y_dy_d^\dagger m_d^2\\
&- 8m^2_{H_d}y_dy_d^\dagger y_dy_d^\dagger - 4y_dy_d^\dagger A_dA_d^\dagger - 4m^2_{H_d}y_dy_u^\dagger y_uy_d^\dagger\\
&- 4m^2_{H_u}y_dy_u^\dagger y_uy_d^\dagger - 4y_dy_u^\dagger A_uA_d^\dagger - 4y_dA_d^\dagger A_dy_d^\dagger - 4y_dA_u^\dagger A_uy_d^\dagger
\end{aligned}
$$

$$
\begin{aligned}
&- 4A_d y_d^\dagger y_d A_d^\dagger - 4A_d y_u^\dagger y_u A_d^\dagger - 4A_d A_d^\dagger y_d y_d^\dagger - 4A_d A_u^\dagger y_u y_d^\dagger \\
&- 2m_d^2 y_d y_d^\dagger y_d y_d^\dagger - 2m_d^2 y_d y_u^\dagger y_u y_d^\dagger - 4y_d m_q^2 y_d^\dagger y_d y_d^\dagger - 4y_d m_q^2 y_u^\dagger y_u y_d^\dagger \\
&- 4y_d y_d^\dagger m_d^2 y_d y_d^\dagger - 4y_d y_d^\dagger y_d m_q^2 y_d^\dagger - 2y_d y_d^\dagger y_d y_d^\dagger m_d^2 - 4y_d y_u^\dagger m_u^2 y_u y_d^\dagger \\
&- 4y_d y_u^\dagger y_u m_q^2 y_d^\dagger - 2y_d y_u^\dagger y_u y_d^\dagger m_d^2 + \frac{32}{3} g_3^4 \mathbf{1}\sigma_{2,3} + \frac{8}{15} g_1^2 \mathbf{1}\sigma_{2,11} + 8\frac{1}{\sqrt{15}} g_1 \mathbf{1}\sigma_{3,1} \\
&- 24 m_{H_d}^2 y_d y_d^\dagger \mathrm{Tr}\Big(y_d y_d^\dagger\Big) - 12 A_d A_d^\dagger \mathrm{Tr}\Big(y_d y_d^\dagger\Big) - 6 m_d^2 y_d y_d^\dagger \mathrm{Tr}\Big(y_d y_d^\dagger\Big) \\
&- 12 y_d m_q^2 y_d^\dagger \mathrm{Tr}\Big(y_d y_d^\dagger\Big) - 6 y_d y_d^\dagger m_d^2 \mathrm{Tr}\Big(y_d y_d^\dagger\Big) - 8 m_{H_d}^2 y_d y_d^\dagger \mathrm{Tr}\Big(y_e y_e^\dagger\Big) \\
&- 4 A_d A_d^\dagger \mathrm{Tr}\Big(y_e y_e^\dagger\Big) - 2 m_d^2 y_d y_d^\dagger \mathrm{Tr}\Big(y_e y_e^\dagger\Big) - 4 y_d m_q^2 y_d^\dagger \mathrm{Tr}\Big(y_e y_e^\dagger\Big) \\
&- 2 y_d y_d^\dagger m_d^2 \mathrm{Tr}\Big(y_e y_e^\dagger\Big) - 12 y_d A_d^\dagger \mathrm{Tr}\Big(y_d^\dagger A_d\Big) - 4 y_d A_d^\dagger \mathrm{Tr}\Big(y_e^\dagger A_e\Big) \\
&- 12 A_d y_d^\dagger \mathrm{Tr}\Big(A_d^* y_d^T\Big) - 12 y_d y_d^\dagger \mathrm{Tr}\Big(A_d^* A_d^T\Big) - 4 A_d y_d^\dagger \mathrm{Tr}\Big(A_e^* y_e^T\Big)
\end{aligned}
$$

$$
\begin{aligned}
&- 4 y_d y_d^\dagger \mathrm{Tr}\Big(A_e^* A_e^T\Big) - 12 y_d y_d^\dagger \mathrm{Tr}\Big(m_d^2 y_d y_d^\dagger\Big) - 4 y_d y_d^\dagger \mathrm{Tr}\Big(m_e^2 y_e y_e^\dagger\Big) \\
&- 4 y_d y_d^\dagger \mathrm{Tr}\Big(m_l^2 y_e^\dagger y_e\Big) - 12 y_d y_d^\dagger \mathrm{Tr}\Big(m_q^2 y_d^\dagger y_d\Big)
\end{aligned} \tag{85}
$$

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

$$
\begin{aligned}
\beta_{m_u^2}^{(2)} &= -\frac{128}{45} g_3^2 \Big(15 g_3^2 M_3 - 2 g_1^2 \Big(2M_3 + M_1\Big)\Big) \mathbf{1} M_3^* - \frac{4}{5} g_1^2 m_{H_u}^2 y_u y_u^\dagger + 12 g_2^2 m_{H_u}^2 y_u y_u^\dagger \\
&+ 24 g_2^2 |M_2|^2 y_u y_u^\dagger + \frac{4}{5} g_1^2 M_1 y_u A_u^\dagger - 12 g_2^2 M_2 y_u A_u^\dagger - 12 g_2^2 M_2^* A_u y_u^\dagger \\
&+ \frac{4}{225} g_1^2 M_1^* \Big(45\Big(- 2M_1 y_u y_u^\dagger + A_u y_u^\dagger\Big) + 8\Big(321 g_1^2 M_1 + 40 g_3^2 \Big(2M_1 + M_3\Big)\Big)\mathbf{1}\Big) - \frac{4}{5} g_1^2 A_u A_u^\dagger \\
&+ 12 g_2^2 A_u A_u^\dagger - \frac{2}{5} g_1^2 m_u^2 y_u y_u^\dagger + 6 g_2^2 m_u^2 y_u y_u^\dagger - \frac{4}{5} g_1^2 y_u m_q^2 y_u^\dagger \\
&+ 12 g_2^2 y_u m_q^2 y_u^\dagger - \frac{2}{5} g_1^2 y_u y_u^\dagger m_u^2 + 6 g_2^2 y_u y_u^\dagger m_u^2 - 4 m_{H_d}^2 y_u y_d^\dagger y_d y_u^\dagger \\
&- 4 m_{H_u}^2 y_u y_d^\dagger y_d y_u^\dagger - 4 y_u y_d^\dagger A_d A_u^\dagger - 8 m_{H_u}^2 y_u y_u^\dagger y_u y_u^\dagger - 4 y_u y_u^\dagger A_u A_u^\dagger \\
&- 4 y_u A_d^\dagger A_d y_u^\dagger - 4 y_u A_u^\dagger A_u y_u^\dagger - 4 A_u y_d^\dagger y_d A_u^\dagger - 4 A_u y_u^\dagger y_u A_u^\dagger \\
&- 4 A_u A_d^\dagger y_d y_u^\dagger - 4 A_u A_u^\dagger y_u y_u^\dagger - 2 m_u^2 y_u y_d^\dagger y_d y_u^\dagger - 2 m_u^2 y_u y_u^\dagger y_u y_u^\dagger \\
&- 4 y_u m_q^2 y_d^\dagger y_d y_u^\dagger - 4 y_u m_q^2 y_u^\dagger y_u y_u^\dagger - 4 y_u y_d^\dagger m_d^2 y_d y_u^\dagger \\
&- 4 y_u y_d^\dagger y_d m_q^2 y_u^\dagger - 2 y_u y_d^\dagger y_d y_u^\dagger m_u^2 - 4 y_u y_u^\dagger m_u^2 y_u y_u^\dagger - 4 y_u y_u^\dagger y_u m_q^2 y_u^\dagger \\
&- 2 y_u y_u^\dagger y_u y_u^\dagger m_u^2 + \frac{32}{3} g_3^4 \mathbf{1}\sigma_{2,3} + \frac{32}{15} g_1^2 \mathbf{1}\sigma_{2,11} - 16\frac{1}{\sqrt{15}} g_1 \mathbf{1}\sigma_{3,1} - 24 m_{H_u}^2 y_u y_u^\dagger \mathrm{Tr}\Big(y_u y_u^\dagger\Big) \\
&- 12 A_u A_u^\dagger \mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 6 m_u^2 y_u y_u^\dagger \mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 12 y_u m_q^2 y_u^\dagger \mathrm{Tr}\Big(y_u y_u^\dagger\Big)
\end{aligned}
$$

$$
\begin{aligned}
&- 6y_u y_u^\dagger m_u^2 \mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 8m_{H_u}^2 y_u y_u^\dagger \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) - 4A_u A_u^\dagger \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \\
&- 2m_u^2 y_u y_u^\dagger \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) - 4y_u m_q^2 y_u^\dagger \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) - 2y_u y_u^\dagger m_u^2 \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \\
&- 12y_u A_u^\dagger \mathrm{Tr}\Big(y_u^\dagger A_u\Big) - 4y_u A_u^\dagger \mathrm{Tr}\Big(Y_\nu^\dagger A_\nu\Big) - 12A_u y_u^\dagger \mathrm{Tr}\Big(A_u^* y_u^T\Big) \\
&- 12y_u y_u^\dagger \mathrm{Tr}\Big(A_u^* A_u^T\Big) - 4A_u y_u^\dagger \mathrm{Tr}\Big(A_\nu^* Y_\nu^T\Big) - 4y_u y_u^\dagger \mathrm{Tr}\Big(A_\nu^* A_\nu^T\Big) \\
&- 4y_u y_u^\dagger \mathrm{Tr}\Big(m_l^2 Y_\nu^\dagger Y_\nu\Big) - 12y_u y_u^\dagger \mathrm{Tr}\Big(m_q^2 y_u^\dagger y_u\Big) - 12y_u y_u^\dagger \mathrm{Tr}\Big(m_u^2 y_u y_u^\dagger\Big) \\
&- 4y_u y_u^\dagger \mathrm{Tr}\Big(M_{\tilde{N}^c}^2 Y_\nu Y_\nu^\dagger\Big)
\end{aligned} \tag{87}
$$

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

$$
\begin{aligned}
\beta_{m_e^2}^{(2)} &= \frac{2}{25}\Big(6g_1^2 M_1^* \Big(234 g_1^2 M_1 \mathbf{1} + 5\Big(-2M_1 y_e y_e^\dagger + A_e y_e^\dagger\Big)\Big) + 20 g_1 \mathbf{1}\Big(3g_1 \sigma_{2,11} + \sqrt{15}\sigma_{3,1}\Big) \\
&- 5\Big(30 g_2^2 M_2^* A_e y_e^\dagger + 6g_1^2 A_e A_e^\dagger - 30 g_2^2 A_e A_e^\dagger + 3g_1^2 m_e^2 y_e y_e^\dagger \\
&- 15 g_2^2 m_e^2 y_e y_e^\dagger + 6g_1^2 y_e m_l^2 y_e^\dagger - 30 g_2^2 y_e m_l^2 y_e^\dagger + 3g_1^2 y_e y_e^\dagger m_e^2 \\
&- 15 g_2^2 y_e y_e^\dagger m_e^2 + 20 m_{H_d}^2 y_e y_e^\dagger y_e y_e^\dagger + 10 y_e y_e^\dagger A_e A_e^\dagger + 10 m_{H_d}^2 y_e Y_\nu^\dagger Y_\nu y_e^\dagger \\
&+ 10 m_{H_u}^2 y_e Y_\nu^\dagger Y_\nu y_e^\dagger + 10 y_e Y_\nu^\dagger A_\nu A_e^\dagger + 10 y_e A_e^\dagger A_e y_e^\dagger + 10 y_e A_\nu^\dagger A_\nu y_e^\dagger \\
&+ 10 A_e y_e^\dagger y_e A_e^\dagger + 10 A_e Y_\nu^\dagger Y_\nu A_e^\dagger + 10 A_e A_e^\dagger y_e y_e^\dagger + 10 A_e A_\nu^\dagger Y_\nu y_e^\dagger \\
&+ 5 m_e^2 y_e y_e^\dagger y_e y_e^\dagger + 5 m_e^2 y_e Y_\nu^\dagger Y_\nu y_e^\dagger + 10 y_e m_l^2 y_e^\dagger y_e y_e^\dagger + 10 y_e m_l^2 Y_\nu^\dagger Y_\nu y_e^\dagger \\
&+ 10 y_e y_e^\dagger m_e^2 y_e y_e^\dagger + 10 y_e y_e^\dagger y_e m_l^2 y_e^\dagger + 5 y_e y_e^\dagger y_e y_e^\dagger m_e^2 + 10 y_e Y_\nu^\dagger M_{\tilde{N}^c}^2 Y_\nu y_e^\dagger \\
&+ 10 y_e Y_\nu^\dagger Y_\nu m_l^2 y_e^\dagger + 5 y_e Y_\nu^\dagger Y_\nu y_e^\dagger m_e^2 + 30 A_e A_e^\dagger \mathrm{Tr}\Big(y_d y_d^\dagger\Big) \\
&+ 15 m_e^2 y_e y_e^\dagger \mathrm{Tr}\Big(y_d y_d^\dagger\Big) + 30 y_e m_l^2 y_e^\dagger \mathrm{Tr}\Big(y_d y_d^\dagger\Big) + 15 y_e y_e^\dagger m_e^2 \mathrm{Tr}\Big(y_d y_d^\dagger\Big) \\
&+ 10 A_e A_e^\dagger \mathrm{Tr}\Big(y_e y_e^\dagger\Big) + 5 m_e^2 y_e y_e^\dagger \mathrm{Tr}\Big(y_e y_e^\dagger\Big) + 10 y_e m_l^2 y_e^\dagger \mathrm{Tr}\Big(y_e y_e^\dagger\Big) \\
&+ 5 y_e y_e^\dagger m_e^2 \mathrm{Tr}\Big(y_e y_e^\dagger\Big) + y_e A_e^\dagger \Big(10 \mathrm{Tr}\Big(y_e^\dagger A_e\Big) + 30 g_2^2 M_2 + 30 \mathrm{Tr}\Big(y_d^\dagger A_d\Big) - 6 g_1^2 M_1\Big) \\
&+ 30 A_e y_e^\dagger \mathrm{Tr}\Big(A_d^* y_d^T\Big) + 10 A_e y_e^\dagger \mathrm{Tr}\Big(A_e^* y_e^T\Big) \\
&+ 2 y_e y_e^\dagger \Big(3g_1^2 m_{H_d}^2 - 15 g_2^2 m_{H_d}^2 - 30 g_2^2 |M_2|^2 + 30 m_{H_d}^2 \mathrm{Tr}\Big(y_d y_d^\dagger\Big) + 10 m_{H_d}^2 \mathrm{Tr}\Big(y_e y_e^\dagger\Big) + 15 \mathrm{Tr}\Big(A_d^* A_d^T\Big) \\
&+ 5 \mathrm{Tr}\Big(A_e^* A_e^T\Big) + 15 \mathrm{Tr}\Big(m_d^2 y_d y_d^\dagger\Big) + 5 \mathrm{Tr}\Big(m_e^2 y_e y_e^\dagger\Big) + 5 \mathrm{Tr}\Big(m_l^2 y_e^\dagger y_e\Big) + 15 \mathrm{Tr}\Big(m_q^2 y_d^\dagger y_d\Big)\Big)\Big)\Big)
\end{aligned} \tag{89}
$$

$$
\beta_{M_{\tilde{N}^c}^2}^{(1)} = 2\Big(2A_\nu A_\nu^\dagger + 2m_{H_u}^2 Y_\nu Y_\nu^\dagger + 2Y_\nu m_l^2 Y_\nu^\dagger + M_{\tilde{N}^c}^2 Y_\nu Y_\nu^\dagger + Y_\nu Y_\nu^\dagger M_{\tilde{N}^c}^2\Big) \tag{90}
$$

$$
\begin{aligned}
\beta_{M_{\tilde{N}^c}^2}^{(2)} &= -\frac{2}{5}\Big(6g_1^2 M_1^* A_\nu Y_\nu^\dagger + 30 g_2^2 M_2^* A_\nu Y_\nu^\dagger - 6g_1^2 A_\nu A_\nu^\dagger - 30 g_2^2 A_\nu A_\nu^\dagger \\
&- 3g_1^2 M_{\tilde{N}^c}^2 Y_\nu Y_\nu^\dagger - 15 g_2^2 M_{\tilde{N}^c}^2 Y_\nu Y_\nu^\dagger - 6g_1^2 Y_\nu m_l^2 Y_\nu^\dagger - 30 g_2^2 Y_\nu m_l^2 Y_\nu^\dagger
\end{aligned}
$$

$$
\begin{aligned}
&- 3g_1^2 Y_\nu Y_\nu^\dagger M_{\tilde{N}^c}^2 - 15g_2^2 Y_\nu Y_\nu^\dagger M_{\tilde{N}^c}^2 + 10m_{H_d}^2 Y_\nu y_e^\dagger y_e Y_\nu^\dagger \\
&+ 10m_{H_u}^2 Y_\nu y_e^\dagger y_e Y_\nu^\dagger + 10Y_\nu y_e^\dagger A_e A_\nu^\dagger + 20m_{H_u}^2 Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger + 10Y_\nu Y_\nu^\dagger A_\nu A_\nu^\dagger \\
&+ 10Y_\nu A_e^\dagger A_e Y_\nu^\dagger + 10Y_\nu A_\nu^\dagger A_\nu Y_\nu^\dagger + 10A_\nu y_e^\dagger y_e A_\nu^\dagger + 10A_\nu Y_\nu^\dagger Y_\nu A_\nu^\dagger \\
&+ 10A_\nu A_e^\dagger y_e Y_\nu^\dagger + 10A_\nu A_\nu^\dagger Y_\nu Y_\nu^\dagger + 5M_{\tilde{N}^c}^2 Y_\nu y_e^\dagger y_e Y_\nu^\dagger + 5M_{\tilde{N}^c}^2 Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger \\
&+ 10Y_\nu m_l^2 y_e^\dagger y_e Y_\nu^\dagger + 10Y_\nu m_l^2 Y_\nu^\dagger Y_\nu Y_\nu^\dagger + 10Y_\nu y_e^\dagger m_e^2 y_e Y_\nu^\dagger \\
&+ 10Y_\nu y_e^\dagger y_e m_l^2 Y_\nu^\dagger + 5Y_\nu y_e^\dagger y_e Y_\nu^\dagger M_{\tilde{N}^c}^2 + 10Y_\nu Y_\nu^\dagger M_{\tilde{N}^c}^2 Y_\nu Y_\nu^\dagger + 10Y_\nu Y_\nu^\dagger Y_\nu m_l^2 Y_\nu^\dagger \\
&+ 5Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger M_{\tilde{N}^c}^2 + 30A_\nu A_\nu^\dagger \mathrm{Tr}\Big(y_u y_u^\dagger\Big) + 15M_{\tilde{N}^c}^2 Y_\nu Y_\nu^\dagger \mathrm{Tr}\Big(y_u y_u^\dagger\Big) \\
&+ 30Y_\nu m_l^2 Y_\nu^\dagger \mathrm{Tr}\Big(y_u y_u^\dagger\Big) + 15Y_\nu Y_\nu^\dagger M_{\tilde{N}^c}^2 \mathrm{Tr}\Big(y_u y_u^\dagger\Big) + 10A_\nu A_\nu^\dagger \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \\
&+ 5M_{\tilde{N}^c}^2 Y_\nu Y_\nu^\dagger \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) + 10Y_\nu m_l^2 Y_\nu^\dagger \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) + 5Y_\nu Y_\nu^\dagger M_{\tilde{N}^c}^2 \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \\
&+ 2Y_\nu A_\nu^\dagger \Big(15g_2^2 M_2 + 15\mathrm{Tr}\Big(y_u^\dagger A_u\Big) + 3g_1^2 M_1 + 5\mathrm{Tr}\Big(Y_\nu^\dagger A_\nu\Big)\Big) + 30A_\nu Y_\nu^\dagger \mathrm{Tr}\Big(A_u^* y_u^T\Big) \\
&+ 10A_\nu Y_\nu^\dagger \mathrm{Tr}\Big(A_\nu^* Y_\nu^T\Big)\Big) \\
&+ \frac{4}{5} Y_\nu Y_\nu^\dagger \Big(3g_1^2 m_{H_u}^2 + 15g_2^2 m_{H_u}^2 + 6g_1^2 |M_1|^2 + 30g_2^2 |M_2|^2 - 30m_{H_u}^2 \mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 10m_{H_u}^2 \mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \\
&- 15\mathrm{Tr}\Big(A_u^* A_u^T\Big) - 5\mathrm{Tr}\Big(A_\nu^* A_\nu^T\Big) - 5\mathrm{Tr}\Big(m_l^2 Y_\nu^\dagger Y_\nu\Big) - 15\mathrm{Tr}\Big(m_q^2 y_u^\dagger y_u\Big) - 15\mathrm{Tr}\Big(m_u^2 y_u y_u^\dagger\Big) \\
&- 5\mathrm{Tr}\Big(M_{\tilde{N}^c}^2 Y_\nu Y_\nu^\dagger\Big)\Big) \qquad (91)
\end{aligned}
$$

$$
\beta_{M_{\tilde{S}}^2}^{(1)} = 2A_\lambda^* A_\lambda + 2\lambda^* M_{\tilde{S}}^{2*} \lambda + 2M_X^2 \lambda^* \lambda + M_{\tilde{S}}^2 \lambda^* \lambda + \lambda^* \lambda M_{\tilde{S}}^2 \qquad (92)
$$

$$
\begin{aligned}
\beta_{M_{\tilde{S}}^2}^{(2)} = \frac{1}{2}\Big(&- 8M_X^2 \lambda^* \lambda \lambda^* \lambda - 4\lambda^* \lambda A_\lambda^* A_\lambda - 4\lambda^* A_\lambda A_\lambda^* \lambda - 4A_\lambda^* \lambda \lambda^* A_\lambda - 4A_\lambda^* A_\lambda \lambda^* \lambda \\
&- 2M_{\tilde{S}}^2 \lambda^* \lambda \lambda^* \lambda - 4\lambda^* \lambda M_{\tilde{S}}^2 \lambda^* \lambda - 2\lambda^* \lambda \lambda^* \lambda M_{\tilde{S}}^2 - 4\lambda^* \lambda \lambda^* M_{\tilde{S}}^{2*} \lambda - 4\lambda^* M_{\tilde{S}}^{2*} \lambda \lambda^* \lambda \\
&- 8A_\kappa^* \Big(\kappa \lambda^* A_\lambda + \lambda^* \lambda A_\kappa\Big) \\
&- 4\kappa^* \Big(2A_\lambda^* \lambda A_\kappa + 8\kappa M_X^2 \lambda^* \lambda + \kappa \Big(2A_\lambda^* A_\lambda + 2\lambda^* M_{\tilde{S}}^{2*} \lambda + M_{\tilde{S}}^2 \lambda^* \lambda + \lambda^* \lambda M_{\tilde{S}}^2\Big)\Big) \\
&- 4M_X^2 \lambda^* \lambda \mathrm{Tr}\Big(\lambda \lambda^*\Big) - 2A_\lambda^* A_\lambda \mathrm{Tr}\Big(\lambda \lambda^*\Big) - M_{\tilde{S}}^2 \lambda^* \lambda \mathrm{Tr}\Big(\lambda \lambda^*\Big) - \lambda^* \lambda M_{\tilde{S}}^2 \mathrm{Tr}\Big(\lambda \lambda^*\Big) \\
&- 2\lambda^* M_{\tilde{S}}^{2*} \lambda \mathrm{Tr}\Big(\lambda \lambda^*\Big) - 2\lambda^* A_\lambda \mathrm{Tr}\Big(\lambda A_\lambda^*\Big) - 2A_\lambda^* \lambda \mathrm{Tr}\Big(\lambda^* A_\lambda\Big) - 2\lambda^* \lambda \mathrm{Tr}\Big(A_\lambda^* A_\lambda\Big) \\
&- 4\lambda^* \lambda \mathrm{Tr}\Big(\lambda M_{\tilde{S}}^2 \lambda^*\Big)\Big) \qquad (93)
\end{aligned}
$$

$$
\beta_{M_X^2}^{(1)} = 12M_X^2 |\kappa|^2 + 2\mathrm{Tr}\Big(\lambda M_{\tilde{S}}^2 \lambda^*\Big) + 4|A_\kappa|^2 + M_X^2 \mathrm{Tr}\Big(\lambda \lambda^*\Big) + \mathrm{Tr}\Big(A_\lambda^* A_\lambda\Big) \qquad (94)
$$

$$
\begin{aligned}
\beta_{M_X^2}^{(2)} = &-4\Big(24\kappa^2 M_X^2 \kappa^{*,2} + A_\kappa^* \Big(A_\kappa \mathrm{Tr}\Big(\lambda \lambda^*\Big) + \kappa \mathrm{Tr}\Big(\lambda^* A_\lambda\Big)\Big) \\
&+ \kappa^* \Big(16\kappa |A_\kappa|^2 + 2\kappa \mathrm{Tr}\Big(\lambda M_{\tilde{S}}^2 \lambda^*\Big) + 4\kappa M_X^2 \mathrm{Tr}\Big(\lambda \lambda^*\Big) + A_\kappa \mathrm{Tr}\Big(\lambda A_\lambda^*\Big) + \kappa \mathrm{Tr}\Big(A_\lambda^* A_\lambda\Big)\Big) + M_X^2 \mathrm{Tr}\Big(\lambda \lambda^* \lambda \lambda^*\Big) \\
&+ \mathrm{Tr}\Big(\lambda \lambda^* A_\lambda A_\lambda^*\Big) + \mathrm{Tr}\Big(\lambda A_\lambda^* A_\lambda \lambda^*\Big) + \mathrm{Tr}\Big(\lambda M_{\tilde{S}}^2 \lambda^* \lambda \lambda^*\Big) + \mathrm{Tr}\Big(\lambda \lambda^* \lambda M_{\tilde{S}}^2 \lambda^*\Big)\Big) \qquad (95)
\end{aligned}
$$

3.9 Vacuum expectation values

$$\beta_{v_d}^{(1)} = \frac{1}{20}v_d\Big(-20\mathrm{Tr}\Big(y_e y_e^\dagger\Big) + 3\Big(5g_2^2 + g_1^2\Big)\Big(1 + \mathrm{Xi}\Big) - 60\mathrm{Tr}\Big(y_d y_d^\dagger\Big)\Big) \tag{96}$$

$$\begin{aligned}\beta_{v_d}^{(2)} = \frac{1}{400}v_d\Big(&-414g_1^4 - 180g_1^2g_2^2 - 1200g_2^4 - 9g_1^4\mathrm{Xi} - 90g_1^2g_2^2\mathrm{Xi} + 875g_2^4\mathrm{Xi} + 9g_1^4\mathrm{Xi}^2 + 90g_1^2g_2^2\mathrm{Xi}^2 \\ &- 225g_2^4\mathrm{Xi}^2 - 40\Big(5\Big(32g_3^2 + 9g_2^2\mathrm{Xi}\Big) + g_1^2\Big(9\mathrm{Xi} - 4\Big)\Big)\mathrm{Tr}\Big(y_d y_d^\dagger\Big) - 120\Big(5g_2^2\mathrm{Xi} + g_1^2\Big(4 + \mathrm{Xi}\Big)\Big)\mathrm{Tr}\Big(y_e y_e^\dagger\Big) \\ &+ 3600\mathrm{Tr}\Big(y_d y_d^\dagger y_d y_d^\dagger\Big) + 1200\mathrm{Tr}\Big(y_d y_u^\dagger y_u y_d^\dagger\Big) + 1200\mathrm{Tr}\Big(y_e y_e^\dagger y_e y_e^\dagger\Big) + 400\mathrm{Tr}\Big(y_e Y_\nu^\dagger Y_\nu y_e^\dagger\Big)\Big)\end{aligned} \tag{97}$$

$$\beta_{v_u}^{(1)} = \frac{1}{20}v_u\Big(-20\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) + 3\Big(5g_2^2 + g_1^2\Big)\Big(1 + \mathrm{Xi}\Big) - 60\mathrm{Tr}\Big(y_u y_u^\dagger\Big)\Big) \tag{98}$$

$$\begin{aligned}\beta_{v_u}^{(2)} = \frac{1}{400}v_u\Big(&-414g_1^4 - 180g_1^2g_2^2 - 1200g_2^4 - 9g_1^4\mathrm{Xi} - 90g_1^2g_2^2\mathrm{Xi} + 875g_2^4\mathrm{Xi} + 9g_1^4\mathrm{Xi}^2 + 90g_1^2g_2^2\mathrm{Xi}^2 \\ &- 225g_2^4\mathrm{Xi}^2 - 40\Big(5\Big(32g_3^2 + 9g_2^2\mathrm{Xi}\Big) + g_1^2\Big(9\mathrm{Xi} + 8\Big)\Big)\mathrm{Tr}\Big(y_u y_u^\dagger\Big) - 120\Big(5g_2^2 + g_1^2\Big)\mathrm{Xi}\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger\Big) \\ &+ 1200\mathrm{Tr}\Big(y_d y_u^\dagger y_u y_d^\dagger\Big) + 400\mathrm{Tr}\Big(y_e Y_\nu^\dagger Y_\nu y_e^\dagger\Big) + 3600\mathrm{Tr}\Big(y_u y_u^\dagger y_u y_u^\dagger\Big) + 1200\mathrm{Tr}\Big(Y_\nu Y_\nu^\dagger Y_\nu Y_\nu^\dagger\Big)\Big)\end{aligned} \tag{99}$$

$$\beta_{v_X}^{(1)} = -\frac{1}{2}v_X\Big(4|\kappa|^2 + \mathrm{Tr}\Big(\lambda\lambda^*\Big)\Big) \tag{100}$$

$$\beta_{v_X}^{(2)} = v_X\Big(2|\kappa|^2\mathrm{Tr}\Big(\lambda\lambda^*\Big) + 8\kappa^2\kappa^{*,2} + \mathrm{Tr}\Big(\lambda\lambda^*\lambda\lambda^*\Big)\Big) \tag{101}$$

4 Field Rotations

4.1 Rotations in gauge sector for eigenstates 'EWSB'

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

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

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

$$\tag{105}$$

The mixing matrices are parametrized by

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

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

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

$$\tag{109}$$

4.2 Rotations in Mass sector for eigenstates 'EWSB'

4.2.1 Mass Matrices for Scalars

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

$$m^2_{\tilde{d}} = \begin{pmatrix} m_{\tilde{d}_L \tilde{d}^*_L} & \frac{1}{\sqrt{2}}\Big(- \mu_H v_u y_d^\dagger + v_d A_d^\dagger\Big)\delta_{\alpha_1\beta_2} \\ \frac{1}{\sqrt{2}}\delta_{\alpha_2\beta_1}\Big(v_d A_d - v_u y_d \mu_H^*\Big) & m_{\tilde{d}_R \tilde{d}^*_R} \end{pmatrix} \tag{110}$$

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

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

This matrix is diagonalized by Z^D:

$$Z^D m^2_{\tilde{d}} Z^{D,\dagger} = m^{dia}_{2,\tilde{d}} \tag{113}$$

with

$$\tilde{d}_{L,i\alpha} = \sum_j Z^{D,*}_{ji}\tilde{d}_{j\alpha}\,, \qquad \tilde{d}_{R,i\alpha} = \sum_j Z^{D,*}_{ji}\tilde{d}_{j\alpha} \tag{114}$$

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

$$m^2_{\tilde{\nu}^I} = \begin{pmatrix} m_{\sigma_L\sigma_L} & m^T_{\sigma_R\sigma_L} & \frac{1}{\sqrt{2}}v_u\Re\Big(Y_\nu^T\mu^*_{NS}\Big) \\ m_{\sigma_L\sigma_R} & m_{\sigma_R\sigma_R} & -\frac{1}{\sqrt{2}}v_X\Re\Big(\mu_{NS}\lambda^*\Big) + \Re\Big(b_{NS}\Big) \\ \frac{1}{\sqrt{2}}v_u\Re\Big(\mu^T_{NS}Y^*_\nu\Big) & -\frac{1}{\sqrt{2}}v_X\Re\Big(\lambda\mu^\dagger_{NS}\Big) + \Re\Big(b^T_{NS}\Big) & m_{\sigma_S\sigma_S} \end{pmatrix} \tag{115}$$

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

$$m_{\sigma_L\sigma_R} = -\frac{1}{2}\frac{1}{\sqrt{2}}\Big(2v_d\Re\Big(Y_\nu\mu_H^*\Big) - 2v_u\Re\Big(A_\nu\Big)\Big) \tag{117}$$

$$m_{\sigma_R\sigma_R} = \frac{1}{4}\Big(2\Big(2\Re\Big(M^2_{\tilde{N}^c}\Big) + 2\Re\Big(\mu_{NS}\mu^\dagger_{NS}\Big)\Big) + 2v_u^2\Re\Big(Y_\nu Y_\nu^\dagger\Big)\Big) \tag{118}$$

$$m_{\sigma_S\sigma_S} = \frac{1}{4}\Big(2\Big(2\Re\Big(M_{\tilde{S}}^2\Big) + 2\Re\Big(\mu_{NS}^T\mu_{NS}^*\Big)\Big) + v_X\Big(-2\sqrt{2}\Re\Big(A_\lambda\Big) + v_X\Big(-2\Re\Big(\lambda\kappa^*\Big) + 2\Re\Big(\lambda\lambda^*\Big)\Big)\Big)\Big) \tag{119}$$

This matrix is diagonalized by Z^I:

$$Z^I m_{\tilde{\nu}^I}^2 Z^{I,\dagger} = m_{2,\tilde{\nu}^I}^{dia} \tag{120}$$

with

$$\sigma_{L,i} = \sum_j Z_{ji}^{I,*}\tilde{\nu}_j^I\,, \qquad \sigma_{R,i} = \sum_j Z_{ji}^{I,*}\tilde{\nu}_j^I\,, \qquad \sigma_{S,i} = \sum_j Z_{ji}^{I,*}\tilde{\nu}_j^I \tag{121}$$

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

$$m_{\tilde{\nu}^R}^2 = \begin{pmatrix} m_{\phi_L\phi_L} & m_{\phi_R\phi_L}^T & \frac{1}{\sqrt{2}}v_u\Re\Big(Y_\nu^T\mu_{NS}^*\Big) \\ m_{\phi_L\phi_R} & m_{\phi_R\phi_R} & \frac{1}{\sqrt{2}}v_X\Re\Big(\mu_{NS}\lambda^*\Big) + \Re\Big(b_{NS}\Big) \\ \frac{1}{\sqrt{2}}v_u\Re\Big(\mu_{NS}^T Y_\nu^*\Big) & \frac{1}{\sqrt{2}}v_X\Re\Big(\lambda\mu_{NS}^\dagger\Big) + \Re\Big(b_{NS}^T\Big) & m_{\phi_S\phi_S} \end{pmatrix} \tag{122}$$

$$m_{\phi_L\phi_L} = \frac{1}{4}\Big(2v_u^2\Re\Big(Y_\nu^T Y_\nu^*\Big) + 4\Re\Big(m_l^2\Big)\Big) + \frac{1}{8}\Big(g_1^2+g_2^2\Big)\mathbf{1}\Big(-v_u^2+v_d^2\Big) \tag{123}$$

$$m_{\phi_L\phi_R} = -\frac{1}{2}\frac{1}{\sqrt{2}}\Big(2v_d\Re\Big(Y_\nu\mu_H^*\Big) - 2v_u\Re\Big(A_\nu\Big)\Big) \tag{124}$$

$$m_{\phi_R\phi_R} = \frac{1}{4}\Big(2\Big(2\Re\Big(M_{\tilde{N}^c}^2\Big) + 2\Re\Big(\mu_{NS}\mu_{NS}^\dagger\Big)\Big) + 2v_u^2\Re\Big(Y_\nu Y_\nu^\dagger\Big)\Big) \tag{125}$$

$$m_{\phi_S\phi_S} = \frac{1}{4}\Big(2\Big(2\Re\Big(M_{\tilde{S}}^2\Big) + 2\Re\Big(\mu_{NS}^T\mu_{NS}^*\Big)\Big) + v_X\Big(2\sqrt{2}\Re\Big(A_\lambda\Big) + v_X\Big(2\Re\Big(\lambda\kappa^*\Big) + 2\Re\Big(\lambda\lambda^*\Big)\Big)\Big)\Big) \tag{126}$$

This matrix is diagonalized by Z^R:

$$Z^R m_{\tilde{\nu}^R}^2 Z^{R,\dagger} = m_{2,\tilde{\nu}^R}^{dia} \tag{127}$$

with

$$\phi_{L,i} = \sum_j Z_{ji}^{R,*}\tilde{\nu}_j^R\,, \qquad \phi_{R,i} = \sum_j Z_{ji}^{R,*}\tilde{\nu}_j^R\,, \qquad \phi_{S,i} = \sum_j Z_{ji}^{R,*}\tilde{\nu}_j^R \tag{128}$$

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

$$m_{\tilde{u}}^2 = \begin{pmatrix} m_{\tilde{u}_L\tilde{u}_L^*} & \frac{1}{\sqrt{2}}\Big(-\mu_H v_d y_u^\dagger + v_u A_u^\dagger\Big)\delta_{\alpha_1\beta_2} \\ \frac{1}{\sqrt{2}}\delta_{\alpha_2\beta_1}\Big(-v_d y_u\mu_H^* + v_u A_u\Big) & m_{\tilde{u}_R\tilde{u}_R^*} \end{pmatrix} \tag{129}$$

$$m_{\tilde{u}_L\tilde{u}_L^*} = -\frac{1}{24}\Big(-3g_2^2+g_1^2\Big)\mathbf{1}\Big(-v_u^2+v_d^2\Big)\delta_{\alpha_1\beta_1} + \frac{1}{2}\delta_{\alpha_1\beta_1}\Big(2m_q^2 + v_u^2 y_u^\dagger y_u\Big) \tag{130}$$

$$m_{\tilde{u}_R\tilde{u}_R^*} = \frac{1}{2}\delta_{\alpha_2\beta_2}\Big(2m_u^2 + v_u^2 y_u y_u^\dagger\Big) + \frac{1}{6}g_1^2\mathbf{1}\Big(-v_u^2+v_d^2\Big)\delta_{\alpha_2\beta_2} \tag{131}$$

This matrix is diagonalized by Z^U:

$$Z^U m^2_{\tilde{u}} Z^{U,\dagger} = m^{dia}_{2,\tilde{u}} \tag{132}$$

with

$$\tilde{u}_{L,i\alpha} = \sum_j Z^{U,*}_{ji} \tilde{u}_{j\alpha}\,, \qquad \tilde{u}_{R,i\alpha} = \sum_j Z^{U,*}_{ji} \tilde{u}_{j\alpha} \tag{133}$$

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

$$m^2_{\tilde{e}} = \begin{pmatrix} m_{\tilde{e}_L \tilde{e}^*_L} & \frac{1}{\sqrt{2}}\Big(- \mu_H v_u y^\dagger_e + v_d A^\dagger_e\Big) \\ \frac{1}{\sqrt{2}}\Big(v_d A_e - v_u y_e \mu^*_H\Big) & m_{\tilde{e}_R \tilde{e}^*_R} \end{pmatrix} \tag{134}$$

$$m_{\tilde{e}_L \tilde{e}^*_L} = \frac{1}{2} v_d^2 y^\dagger_e y_e + \frac{1}{8}\Big(- g_2^2 + g_1^2\Big)\mathbf{1}\Big(- v_u^2 + v_d^2\Big) + m_l^2 \tag{135}$$

$$m_{\tilde{e}_R \tilde{e}^*_R} = \frac{1}{2} v_d^2 y_e y^\dagger_e + \frac{1}{4} g_1^2 \mathbf{1}\Big(- v_d^2 + v_u^2\Big) + m_e^2 \tag{136}$$

This matrix is diagonalized by Z^E:

$$Z^E m^2_{\tilde{e}} Z^{E,\dagger} = m^{dia}_{2,\tilde{e}} \tag{137}$$

with

$$\tilde{e}_{L,i} = \sum_j Z^{E,*}_{ji} \tilde{e}_j\,, \qquad \tilde{e}_{R,i} = \sum_j Z^{E,*}_{ji} \tilde{e}_j \tag{138}$$

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

$$m^2_h = \begin{pmatrix} m_{\phi_d \phi_d} & -\frac{1}{4}\Big(g_1^2 + g_2^2\Big) v_d v_u - \Re\Big(b_H\Big) & 0 \\ -\frac{1}{4}\Big(g_1^2 + g_2^2\Big) v_d v_u - \Re\Big(b_H\Big) & m_{\phi_u \phi_u} & 0 \\ 0 & 0 & m_{\phi_X \phi_X} \end{pmatrix} \tag{139}$$

$$m_{\phi_d \phi_d} = \frac{1}{8}\Big(g_1^2 + g_2^2\Big)\Big(3 v_d^2 - v_u^2\Big) + m^2_{H_d} + |\mu_H|^2 \tag{140}$$

$$m_{\phi_u \phi_u} = -\frac{1}{8}\Big(g_1^2 + g_2^2\Big)\Big(- 3 v_u^2 + v_d^2\Big) + m^2_{H_u} + |\mu_H|^2 \tag{141}$$

$$m_{\phi_X \phi_X} = v_X\Big(3 v_X |\kappa|^2 + \sqrt{2}\Re\Big(A_\kappa\Big)\Big) + M_X^2 \tag{142}$$

This matrix is diagonalized by Z^H:

$$Z^H m^2_h Z^{H,\dagger} = m^{dia}_{2,h} \tag{143}$$

with

$$\phi_d = \sum_j Z^H_{j1} h_j\,, \qquad \phi_u = \sum_j Z^H_{j2} h_j\,, \qquad \phi_X = \sum_j Z^H_{j3} h_j \tag{144}$$

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

$$m^2_{A^0} = \begin{pmatrix} m_{\sigma_d\sigma_d} & \Re\Big(b_H\Big) & 0 \\ \Re\Big(b_H\Big) & m_{\sigma_u\sigma_u} & 0 \\ 0 & 0 & m_{\sigma_X\sigma_X} \end{pmatrix} + \xi_Z m^2(Z) \tag{145}$$

$$m_{\sigma_d\sigma_d} = \frac{1}{8}\Big(g_1^2 + g_2^2\Big)\Big(-v_u^2 + v_d^2\Big) + m^2_{H_d} + |\mu_H|^2 \tag{146}$$

$$m_{\sigma_u\sigma_u} = -\frac{1}{8}\Big(g_1^2 + g_2^2\Big)\Big(-v_u^2 + v_d^2\Big) + m^2_{H_u} + |\mu_H|^2 \tag{147}$$

$$m_{\sigma_X\sigma_X} = v_X\Big(-\sqrt{2}\Re\Big(A_\kappa\Big) + v_X|\kappa|^2\Big) + M_X^2 \tag{148}$$

Gauge fixing contributions:

$$m^2(\xi_Z) = \begin{pmatrix} m_{\sigma_d\sigma_d} & m_{\sigma_u\sigma_d} & 0 \\ m_{\sigma_d\sigma_u} & m_{\sigma_u\sigma_u} & 0 \\ 0 & 0 & 0 \end{pmatrix} \tag{149}$$

$$m_{\sigma_d\sigma_d} = \frac{1}{4}v_d^2\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W\Big)^2 \tag{150}$$

$$m_{\sigma_d\sigma_u} = -\frac{1}{4}v_d v_u\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W\Big)^2 \tag{151}$$

$$m_{\sigma_u\sigma_u} = \frac{1}{4}v_u^2\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W\Big)^2 \tag{152}$$

This matrix is diagonalized by Z^A:

$$Z^A m^2_{A^0} Z^{A,\dagger} = m^{dia}_{2,A^0} \tag{153}$$

with

$$\sigma_d = \sum_j Z^A_{j1} A^0_j\,, \qquad \sigma_u = \sum_j Z^A_{j2} A^0_j\,, \qquad \sigma_X = \sum_j Z^A_{j3} A^0_j \tag{154}$$

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

$$m^2_{H^-} = \begin{pmatrix} m_{H_d^- H_d^{-,*}} & \frac{1}{4}g_2^2 v_d v_u + b_H^* \\ \frac{1}{4}g_2^2 v_d v_u + b_H & m_{H_u^{+,*} H_u^+} \end{pmatrix} + \xi_{W^-} m^2(W^-) \tag{155}$$

$$m_{H_d^- H_d^{-,*}} = \frac{1}{8}\Big(g_1^2\Big(-v_u^2 + v_d^2\Big) + g_2^2\Big(v_d^2 + v_u^2\Big)\Big) + m^2_{H_d} + |\mu_H|^2 \tag{156}$$

$$m_{H_u^{+,*} H_u^+} = \frac{1}{8}\Big(g_1^2\Big(-v_d^2 + v_u^2\Big) + g_2^2\Big(v_d^2 + v_u^2\Big)\Big) + m^2_{H_u} + |\mu_H|^2 \tag{157}$$

Gauge fixing contributions:

$$m^2(\xi_{W^-}) = \begin{pmatrix} \frac{1}{4}g_2^2 v_d^2 & -\frac{1}{4}g_2^2 v_d v_u \\ -\frac{1}{4}g_2^2 v_d v_u & \frac{1}{4}g_2^2 v_u^2 \end{pmatrix} \tag{158}$$

This matrix is diagonalized by Z^+:

$$Z^+ m_{H^-}^2 Z^{+,\dagger} = m_{2,H^-}^{dia} \tag{159}$$

with

$$H_d^- = \sum_j Z_{j1}^+ H_j^- \,, \qquad H_u^+ = \sum_j Z_{j2}^+ H_j^+ \tag{160}$$

4.2.2 Mass Matrices for Fermions

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

$$m_{\tilde{\chi}^0} = \begin{pmatrix} M_1 & 0 & -\frac{1}{2}g_1 v_d & \frac{1}{2}g_1 v_u & 0 \\ 0 & M_2 & \frac{1}{2}g_2 v_d & -\frac{1}{2}g_2 v_u & 0 \\ -\frac{1}{2}g_1 v_d & \frac{1}{2}g_2 v_d & 0 & -\mu_H & 0 \\ \frac{1}{2}g_1 v_u & -\frac{1}{2}g_2 v_u & -\mu_H & 0 & 0 \\ 0 & 0 & 0 & 0 & \sqrt{2}\kappa v_X \end{pmatrix} \tag{161}$$

This matrix is diagonalized by N:

$$N^* m_{\tilde{\chi}^0} N^\dagger = m_{\tilde{\chi}^0}^{dia} \tag{162}$$

with

$$\lambda_{\tilde{B}} = \sum_j N_{j1}^* \lambda_j^0 \,, \qquad \tilde{W}^0 = \sum_j N_{j2}^* \lambda_j^0 \,, \qquad \tilde{H}_d^0 = \sum_j N_{j3}^* \lambda_j^0 \tag{163}$$

$$\tilde{H}_u^0 = \sum_j N_{j4}^* \lambda_j^0 \,, \qquad \tilde{X} = \sum_j N_{j5}^* \lambda_j^0 \tag{164}$$

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

$$m_\nu = \begin{pmatrix} 0 & \frac{1}{\sqrt{2}} v_u Y_\nu^T & 0 \\ \frac{1}{\sqrt{2}} v_u Y_\nu & 0 & \mu_{NS} \\ 0 & \mu_{NS}^T & \frac{1}{\sqrt{2}}\lambda v_X \end{pmatrix} \tag{165}$$

This matrix is diagonalized by U^V:

$$U^{V,*} m_\nu U^{V,\dagger} = m_\nu^{dia} \tag{166}$$

with

$$\nu_{L,i} = \sum_j U_{ji}^{V,*} \nu_{M,j} \,, \qquad \nu_{R,i} = \sum_j U_{ji}^V \nu_{M,j}^* \,, \qquad S_i = \sum_j U_{ji}^{V,*} \nu_{M,j} \tag{167}$$

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

$$m_{\tilde{\chi}^-} = \begin{pmatrix} M_2 & \frac{1}{\sqrt{2}} g_2 v_u \\ \frac{1}{\sqrt{2}} g_2 v_d & \mu_H \end{pmatrix} \tag{168}$$

This matrix is diagonalized by U and V

$$U^* m_{\tilde{\chi}^-} V^\dagger = m_{\tilde{\chi}^-}^{dia} \tag{169}$$

with

$$\tilde{W}^- = \sum_{t_2} U_{j1}^* \lambda_j^- , \qquad \tilde{H}_d^- = \sum_{t_2} U_{j2}^* \lambda_j^- \tag{170}$$

$$\tilde{W}^+ = \sum_{t_2} V_{1j}^* \lambda_j^+ , \qquad \tilde{H}_u^+ = \sum_{t_2} V_{2j}^* \lambda_j^+ \tag{171}$$

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

$$m_e = \begin{pmatrix} \frac{1}{\sqrt{2}} v_d y_e^T \end{pmatrix} \tag{172}$$

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

$$U_L^{e,*} m_e U_R^{e,\dagger} = m_e^{dia} \tag{173}$$

with

$$e_{L,i} = \sum_{t_2} U_{L,ji}^{e,*} E_{L,j} \tag{174}$$

$$e_{R,i} = \sum_{t_2} U_{R,ij}^{e} E_{R,j}^* \tag{175}$$

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

$$m_d = \begin{pmatrix} \frac{1}{\sqrt{2}} v_d \delta_{\alpha_1 \beta_1} y_d^T \end{pmatrix} \tag{176}$$

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

$$U_L^{d,*} m_d U_R^{d,\dagger} = m_d^{dia} \tag{177}$$

with

$$d_{L,i\alpha} = \sum_{t_2} U_{L,ji}^{d,*} D_{L,j\alpha} \tag{178}$$

$$d_{R,i\alpha} = \sum_{t_2} U_{R,ij}^{d} D_{R,j\alpha}^* \tag{179}$$

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

$$m_u = \begin{pmatrix} \frac{1}{\sqrt{2}} v_u \delta_{\alpha_1\beta_1} y_u^T \end{pmatrix} \tag{180}$$

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

$$U_L^{u,*} m_u U_R^{u,\dagger} = m_u^{dia} \tag{181}$$

with

$$u_{L,i\alpha} = \sum_{t_2} U_{L,ji}^{u,*} U_{L,j\alpha} \tag{182}$$

$$u_{R,i\alpha} = \sum_{t_2} U_{R,ij}^{u} U_{R,j\alpha}^{*} \tag{183}$$

5 Vacuum Expectation Values

$$H_d^0 = \frac{1}{\sqrt{2}}\phi_d + \frac{1}{\sqrt{2}} v_d + i\frac{1}{\sqrt{2}}\sigma_d \tag{184}$$

$$H_u^0 = \frac{1}{\sqrt{2}}\phi_u + \frac{1}{\sqrt{2}} v_u + i\frac{1}{\sqrt{2}}\sigma_u \tag{185}$$

$$X = \frac{1}{\sqrt{2}}\phi_X + \frac{1}{\sqrt{2}} v_X + i\frac{1}{\sqrt{2}}\sigma_X \tag{186}$$

$$\tilde{\nu}_L = \frac{1}{\sqrt{2}}\phi_L + i\frac{1}{\sqrt{2}}\sigma_L \tag{187}$$

$$\tilde{N}^c = \frac{1}{\sqrt{2}}\phi_R + i\frac{1}{\sqrt{2}}\sigma_R \tag{188}$$

$$\tilde{S} = \frac{1}{\sqrt{2}}\phi_S + i\frac{1}{\sqrt{2}}\sigma_S \tag{189}$$

6 Tadpole Equations

$$\frac{\partial V}{\partial \phi_d} = -\frac{1}{2} v_u \Big(b_H + b_H^*\Big) + \frac{1}{8}\Big(g_1^2 + g_2^2\Big) v_d \Big(-v_u + v_d\Big)\Big(v_d + v_u\Big) + v_d\Big(m_{H_d}^2 + |\mu_H|^2\Big) \tag{190}$$

$$\frac{\partial V}{\partial \phi_u} = \frac{1}{8}\Big(g_1^2 + g_2^2\Big) v_u \Big(-v_d^2 + v_u^2\Big) - v_d \Re\Big(b_H\Big) + v_u\Big(m_{H_u}^2 + |\mu_H|^2\Big) \tag{191}$$

$$\frac{\partial V}{\partial \phi_X} = \frac{1}{\sqrt{2}} v_X^2 \Re\Big(A_\kappa\Big) + M_X^2 v_X + v_X^3 |\kappa|^2 \tag{192}$$

$$\frac{\partial V}{\partial \phi_{Li}} = 0 \tag{193}$$

$$\frac{\partial V}{\partial \phi_{Ri}} = 0 \tag{194}$$

$$\frac{\partial V}{\partial \phi_{Si}} = 0 \tag{195}$$

7 Particle content for eigenstates 'EWSB'

Name	Type	complex/real	Generations	Indices
$\tilde{d}$	Scalar	complex	6	generation, 6, color, 3
$\tilde{\nu}^I$	Scalar	real	7	generation, 7
$\tilde{\nu}^R$	Scalar	real	7	generation, 7
$\tilde{u}$	Scalar	complex	6	generation, 6, color, 3
$\tilde{e}$	Scalar	complex	6	generation, 6
h	Scalar	real	3	generation, 3
A^0	Scalar	real	3	generation, 3
H^-	Scalar	complex	2	generation, 2
$\tilde{g}$	Fermion	Majorana	1	color, 8
$\tilde{\chi}^0$	Fermion	Majorana	5	generation, 5
ν	Fermion	Majorana	7	generation, 7
$\tilde{\chi}^-$	Fermion	Dirac	2	generation, 2
e	Fermion	Dirac	3	generation, 3
d	Fermion	Dirac	3	generation, 3, color, 3
u	Fermion	Dirac	3	generation, 3, color, 3
g	Vector	real	1	color, 8, lorentz, 4
γ	Vector	real	1	lorentz, 4
Z	Vector	real	1	lorentz, 4
W^-	Vector	complex	1	lorentz, 4
η^G	Ghost	real	1	color, 8
η^γ	Ghost	real	1	
η^Z	Ghost	real	1	
η^-	Ghost	complex	1	
η^+	Ghost	complex	1	

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

8.1 One Loop Self-Energy

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

$$
\begin{aligned}
\Pi_{i,j}(p^2) = &+4\Gamma_{\tilde{\tilde{d}}_{i2^*},\tilde{\tilde{d}}^*_{j\text{-}1^*},W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{W^-}+A_0\Big(m^2_{W^-}\Big)\Big)+2\Gamma_{\tilde{\tilde{d}}_{i2^*},\tilde{\tilde{d}}^*_{j\text{-}1^*},Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{Z}+A_0\Big(m^2_{Z}\Big)\Big)\\
&-\sum_{a=1}^{2}A_0\Big(m^2_{H^-_a}\Big)\Gamma_{\tilde{\tilde{d}}_{i2^*},\tilde{\tilde{d}}^*_{j\text{-}1^*},H^+_a,H^-_a}-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{A^0_a}\Big)\Gamma_{\tilde{\tilde{d}}_{i2^*},\tilde{\tilde{d}}^*_{j\text{-}1^*},A^0_a,A^0_a}\\
&-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{h_a}\Big)\Gamma_{\tilde{\tilde{d}}_{i2^*},\tilde{\tilde{d}}^*_{j\text{-}1^*},h_a,h_a}\\
&-2\sum_{a=1}^{3}m_{u_a}\sum_{b=1}^{2}B_0\Big(p^2,m^2_{u_a},m^2_{\tilde{\chi}^-_b}\Big)m_{\tilde{\chi}^-_b}\Big(\Gamma^{L*}_{\tilde{\tilde{d}}^*_j,u_a,\tilde{\chi}^-_b}\Gamma^{R}_{\tilde{\tilde{d}}^*_i,u_a,\tilde{\chi}^-_b}+\Gamma^{R*}_{\tilde{\tilde{d}}^*_j,u_a,\tilde{\chi}^-_b}\Gamma^{L}_{\tilde{\tilde{d}}^*_i,u_a,\tilde{\chi}^-_b}\Big)\\
&+\sum_{a=1}^{3}\sum_{b=1}^{2}G_0\Big(p^2,m^2_{u_a},m^2_{\tilde{\chi}^-_b}\Big)\Big(\Gamma^{L*}_{\tilde{\tilde{d}}^*_j,u_a,\tilde{\chi}^-_b}\Gamma^{L}_{\tilde{\tilde{d}}^*_i,u_a,\tilde{\chi}^-_b}+\Gamma^{R*}_{\tilde{\tilde{d}}^*_j,u_a,\tilde{\chi}^-_b}\Gamma^{R}_{\tilde{\tilde{d}}^*_i,u_a,\tilde{\chi}^-_b}\Big)\\
&-2\sum_{a=1}^{3}m_{d_a}\sum_{b=1}^{5}B_0\Big(p^2,m^2_{d_a},m^2_{\tilde{\chi}^0_b}\Big)m_{\tilde{\chi}^0_b}\Big(\Gamma^{L*}_{\tilde{\tilde{d}}^*_j,d_a,\tilde{\chi}^0_b}\Gamma^{R}_{\tilde{\tilde{d}}^*_i,d_a,\tilde{\chi}^0_b}+\Gamma^{R*}_{\tilde{\tilde{d}}^*_j,d_a,\tilde{\chi}^0_b}\Gamma^{L}_{\tilde{\tilde{d}}^*_i,d_a,\tilde{\chi}^0_b}\Big)\\
&+\sum_{a=1}^{3}\sum_{b=1}^{5}G_0\Big(p^2,m^2_{d_a},m^2_{\tilde{\chi}^0_b}\Big)\Big(\Gamma^{L*}_{\tilde{\tilde{d}}^*_j,d_a,\tilde{\chi}^0_b}\Gamma^{L}_{\tilde{\tilde{d}}^*_i,d_a,\tilde{\chi}^0_b}+\Gamma^{R*}_{\tilde{\tilde{d}}^*_j,d_a,\tilde{\chi}^0_b}\Gamma^{R}_{\tilde{\tilde{d}}^*_i,d_a,\tilde{\chi}^0_b}\Big)\\
&-C\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{d}_a}\Big)\Gamma_{\tilde{\tilde{d}}_{i2^*},\tilde{\tilde{d}}^*_{j\text{-}1^*},\tilde{d}^*_a,\tilde{d}_a}-\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{e}_a}\Big)\Gamma_{\tilde{\tilde{d}}_{i2^*},\tilde{\tilde{d}}^*_{j\text{-}1^*},\tilde{e}^*_a,\tilde{e}_a}\\
&-C\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{u}_a}\Big)\Gamma_{\tilde{\tilde{d}}_{i2^*},\tilde{\tilde{d}}^*_{j\text{-}1^*},\tilde{u}^*_a,\tilde{u}_a}+\sum_{a=1}^{6}\sum_{b=1}^{2}B_0\Big(p^2,m^2_{\tilde{u}_a},m^2_{H^-_b}\Big)\Gamma^{*}_{\tilde{\tilde{d}}^*_j,\tilde{u}_a,H^-_b}\Gamma_{\tilde{\tilde{d}}^*_i,\tilde{u}_a,H^-_b}\\
&+\sum_{a=1}^{6}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{d}_a},m^2_{A^0_b}\Big)\Gamma^{*}_{\tilde{\tilde{d}}^*_j,\tilde{d}_a,A^0_b}\Gamma_{\tilde{\tilde{d}}^*_i,\tilde{d}_a,A^0_b}+\sum_{a=1}^{6}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{d}_a},m^2_{h_b}\Big)\Gamma^{*}_{\tilde{\tilde{d}}^*_j,\tilde{d}_a,h_b}\Gamma_{\tilde{\tilde{d}}^*_i,\tilde{d}_a,h_b}\\
&-\frac{1}{2}\sum_{a=1}^{7}A_0\Big(m^2_{\tilde{\nu}^I_a}\Big)\Gamma_{\tilde{\tilde{d}}_{i2^*},\tilde{\tilde{d}}^*_{j\text{-}1^*},\tilde{\nu}^I_a,\tilde{\nu}^I_a}-\frac{1}{2}\sum_{a=1}^{7}A_0\Big(m^2_{\tilde{\nu}^R_a}\Big)\Gamma_{\tilde{\tilde{d}}_{i2^*},\tilde{\tilde{d}}^*_{j\text{-}1^*},\tilde{\nu}^R_a,\tilde{\nu}^R_a}\\
&-\frac{8}{3}m_{\tilde{g}}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{g}},m^2_{d_b}\Big)m_{d_b}\Big(\Gamma^{L*}_{\tilde{\tilde{d}}^*_j,\tilde{g}_1,d_b}\Gamma^{R}_{\tilde{\tilde{d}}^*_i,\tilde{g}_1,d_b}+\Gamma^{R*}_{\tilde{\tilde{d}}^*_j,\tilde{g}_1,d_b}\Gamma^{L}_{\tilde{\tilde{d}}^*_i,\tilde{g}_1,d_b}\Big)\\
&+\frac{4}{3}\sum_{b=1}^{3}G_0\Big(p^2,m^2_{\tilde{g}},m^2_{d_b}\Big)\Big(\Gamma^{L*}_{\tilde{\tilde{d}}^*_j,\tilde{g}_1,d_b}\Gamma^{L}_{\tilde{\tilde{d}}^*_i,\tilde{g}_1,d_b}+\Gamma^{R*}_{\tilde{\tilde{d}}^*_j,\tilde{g}_1,d_b}\Gamma^{R}_{\tilde{\tilde{d}}^*_i,\tilde{g}_1,d_b}\Big)\\
&+\frac{4}{3}\sum_{b=1}^{6}\Gamma^{*}_{\tilde{\tilde{d}}^*_j,g,\tilde{d}_b}\Gamma_{\tilde{\tilde{d}}^*_i,g,\tilde{d}_b}F_0\Big(p^2,m^2_{\tilde{d}_b},0\Big)+\sum_{b=1}^{6}\Gamma^{*}_{\tilde{\tilde{d}}^*_j,\gamma,\tilde{d}_b}\Gamma_{\tilde{\tilde{d}}^*_i,\gamma,\tilde{d}_b}F_0\Big(p^2,m^2_{\tilde{d}_b},0\Big)\\
&+\sum_{b=1}^{6}\Gamma^{*}_{\tilde{\tilde{d}}^*_j,Z,\tilde{d}_b}\Gamma_{\tilde{\tilde{d}}^*_i,Z,\tilde{d}_b}F_0\Big(p^2,m^2_{\tilde{d}_b},m^2_{Z}\Big)+\sum_{b=1}^{6}\Gamma^{*}_{\tilde{\tilde{d}}^*_j,W^-,\tilde{u}_b}\Gamma_{\tilde{\tilde{d}}^*_i,W^-,\tilde{u}_b}F_0\Big(p^2,m^2_{\tilde{u}_b},m^2_{W^-}\Big)
\end{aligned}
\tag{196}
$$

- **Self-Energy for CP-odd Sneutrino** $(\tilde{\nu}^I)$

$$
\begin{aligned}
\Pi_{i,j}(p^2) = &+4\Gamma_{\check{\nu}^I_{i2^*},\check{\nu}^I_{j\text{-}1^*},W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{W^-}+A_0\Big(m^2_{W^-}\Big)\Big)+2\Gamma_{\check{\nu}^I_{i2^*},\check{\nu}^I_{j\text{-}1^*},Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{Z}+A_0\Big(m^2_{Z}\Big)\Big)\\
&-\sum_{a=1}^{2}A_0\Big(m^2_{H^-_a}\Big)\Gamma_{\check{\nu}^I_{i2^*},\check{\nu}^I_{j\text{-}1^*},H^+_a,H^-_a}-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{A^0_a}\Big)\Gamma_{\check{\nu}^I_{i2^*},\check{\nu}^I_{j\text{-}1^*},A^0_a,A^0_a}\\
&-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{h_a}\Big)\Gamma_{\check{\nu}^I_{i2^*},\check{\nu}^I_{j\text{-}1^*},h_a,h_a}\\
&-4\sum_{a=1}^{3}m_{e_a}\sum_{b=1}^{2}B_0\Big(p^2,m^2_{e_a},m^2_{\tilde{\chi}^-_b}\Big)m_{\tilde{\chi}^-_b}\Big(\Gamma^{L*}_{\check{\nu}^I_j,\bar{e}_a,\tilde{\chi}^-_b}\Gamma^{R}_{\check{\nu}^I_i,\bar{e}_a,\tilde{\chi}^-_b}+\Gamma^{R*}_{\check{\nu}^I_j,\bar{e}_a,\tilde{\chi}^-_b}\Gamma^{L}_{\check{\nu}^I_i,\bar{e}_a,\tilde{\chi}^-_b}\Big)\\
&+2\sum_{a=1}^{3}\sum_{b=1}^{2}G_0\Big(p^2,m^2_{e_a},m^2_{\tilde{\chi}^-_b}\Big)\Big(\Gamma^{L*}_{\check{\nu}^I_j,\bar{e}_a,\tilde{\chi}^-_b}\Gamma^{L}_{\check{\nu}^I_i,\bar{e}_a,\tilde{\chi}^-_b}+\Gamma^{R*}_{\check{\nu}^I_j,\bar{e}_a,\tilde{\chi}^-_b}\Gamma^{R}_{\check{\nu}^I_i,\bar{e}_a,\tilde{\chi}^-_b}\Big)\\
&-3\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{d}_a}\Big)\Gamma_{\check{\nu}^I_{i2^*},\check{\nu}^I_{j\text{-}1^*},\tilde{d}^*_a,\tilde{d}_a}-\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{e}_a}\Big)\Gamma_{\check{\nu}^I_{i2^*},\check{\nu}^I_{j\text{-}1^*},\tilde{e}^*_a,\tilde{e}_a}\\
&-3\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{u}_a}\Big)\Gamma_{\check{\nu}^I_{i2^*},\check{\nu}^I_{j\text{-}1^*},\tilde{u}^*_a,\tilde{u}_a}+2\sum_{a=1}^{6}\sum_{b=1}^{2}B_0\Big(p^2,m^2_{\tilde{e}_a},m^2_{H^-_b}\Big)\Gamma^{*}_{\check{\nu}^I_j,\tilde{e}^*_a,H^-_b}\Gamma_{\check{\nu}^I_i,\tilde{e}^*_a,H^-_b}\\
&-\frac{1}{2}\sum_{a=1}^{7}A_0\Big(m^2_{\tilde{\nu}^I_a}\Big)\Gamma_{\check{\nu}^I_{i2^*},\check{\nu}^I_{j\text{-}1^*},\tilde{\nu}^I_a,\tilde{\nu}^I_a}-\frac{1}{2}\sum_{a=1}^{7}A_0\Big(m^2_{\tilde{\nu}^R_a}\Big)\Gamma_{\check{\nu}^I_{i2^*},\check{\nu}^I_{j\text{-}1^*},\tilde{\nu}^R_a,\tilde{\nu}^R_a}\\
&+\sum_{a=1}^{7}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{\nu}^I_a},m^2_{A^0_b}\Big)\Gamma^{*}_{\check{\nu}^I_j,\tilde{\nu}^I_a,A^0_b}\Gamma_{\check{\nu}^I_i,\tilde{\nu}^I_a,A^0_b}\\
&+\sum_{a=1}^{7}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{\nu}^I_a},m^2_{h_b}\Big)\Gamma^{*}_{\check{\nu}^I_j,\tilde{\nu}^I_a,h_b}\Gamma_{\check{\nu}^I_i,\tilde{\nu}^I_a,h_b}\\
&+\sum_{a=1}^{7}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{\nu}^R_a},m^2_{A^0_b}\Big)\Gamma^{*}_{\check{\nu}^I_j,\tilde{\nu}^R_a,A^0_b}\Gamma_{\check{\nu}^I_i,\tilde{\nu}^R_a,A^0_b}\\
&+\sum_{a=1}^{7}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{\nu}^R_a},m^2_{h_b}\Big)\Gamma^{*}_{\check{\nu}^I_j,\tilde{\nu}^R_a,h_b}\Gamma_{\check{\nu}^I_i,\tilde{\nu}^R_a,h_b}\\
&-2\sum_{a=1}^{7}m_{\nu_a}\sum_{b=1}^{5}B_0\Big(p^2,m^2_{\nu_a},m^2_{\tilde{\chi}^0_b}\Big)m_{\tilde{\chi}^0_b}\Big(\Gamma^{L*}_{\check{\nu}^I_j,\nu_a,\tilde{\chi}^0_b}\Gamma^{R}_{\check{\nu}^I_i,\nu_a,\tilde{\chi}^0_b}+\Gamma^{R*}_{\check{\nu}^I_j,\nu_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{\nu}^I_i,\nu_a,\tilde{\chi}^0_b}\Big)\\
&+\sum_{a=1}^{7}\sum_{b=1}^{5}G_0\Big(p^2,m^2_{\nu_a},m^2_{\tilde{\chi}^0_b}\Big)\Big(\Gamma^{L*}_{\check{\nu}^I_j,\nu_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{\nu}^I_i,\nu_a,\tilde{\chi}^0_b}+\Gamma^{R*}_{\check{\nu}^I_j,\nu_a,\tilde{\chi}^0_b}\Gamma^{R}_{\check{\nu}^I_i,\nu_a,\tilde{\chi}^0_b}\Big)\\
&+2\sum_{b=1}^{6}\Gamma^{*}_{\check{\nu}^I_j,W^+,\tilde{e}_b}\Gamma_{\check{\nu}^I_i,W^+,\tilde{e}_b}F_0\Big(p^2,m^2_{\tilde{e}_b},m^2_{W^-}\Big)+\sum_{b=1}^{7}\Gamma^{*}_{\check{\nu}^I_j,Z,\tilde{\nu}^R_b}\Gamma_{\check{\nu}^I_i,Z,\tilde{\nu}^R_b}F_0\Big(p^2,m^2_{\tilde{\nu}^R_b},m^2_{Z}\Big)
\end{aligned}
\tag{197}
$$

- **Self-Energy for CP-even Sneutrino** $(\tilde{\nu}^R)$

$$
\begin{aligned}
\Pi_{i,j}(p^2) = &+4\Gamma_{\check{\nu}^R_{i2^*},\check{\nu}^R_{j\text{-}1^*},W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{W^-}+A_0\Big(m^2_{W^-}\Big)\Big)+2\Gamma_{\check{\nu}^R_{i2^*},\check{\nu}^R_{j\text{-}1^*},Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{Z}+A_0\Big(m^2_{Z}\Big)\Big)\\
&-\sum_{a=1}^{2}A_0\Big(m^2_{H^-_a}\Big)\Gamma_{\check{\nu}^R_{i2^*},\check{\nu}^R_{j\text{-}1^*},H^+_a,H^-_a}-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{A^0_a}\Big)\Gamma_{\check{\nu}^R_{i2^*},\check{\nu}^R_{j\text{-}1^*},A^0_a,A^0_a}\\
&-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{h_a}\Big)\Gamma_{\check{\nu}^R_{i2^*},\check{\nu}^R_{j\text{-}1^*},h_a,h_a}\\
&-4\sum_{a=1}^{3}m_{e_a}\sum_{b=1}^{2}B_0\Big(p^2,m^2_{e_a},m^2_{\tilde{\chi}^-_b}\Big)m_{\tilde{\chi}^-_b}\Big(\Gamma^{L*}_{\check{\nu}^R_j,\bar{e}_a,\tilde{\chi}^-_b}\Gamma^{R}_{\check{\nu}^R_i,\bar{e}_a,\tilde{\chi}^-_b}+\Gamma^{R*}_{\check{\nu}^R_j,\bar{e}_a,\tilde{\chi}^-_b}\Gamma^{L}_{\check{\nu}^R_i,\bar{e}_a,\tilde{\chi}^-_b}\Big)\\
&+2\sum_{a=1}^{3}\sum_{b=1}^{2}G_0\Big(p^2,m^2_{e_a},m^2_{\tilde{\chi}^-_b}\Big)\Big(\Gamma^{L*}_{\check{\nu}^R_j,\bar{e}_a,\tilde{\chi}^-_b}\Gamma^{L}_{\check{\nu}^R_i,\bar{e}_a,\tilde{\chi}^-_b}+\Gamma^{R*}_{\check{\nu}^R_j,\bar{e}_a,\tilde{\chi}^-_b}\Gamma^{R}_{\check{\nu}^R_i,\bar{e}_a,\tilde{\chi}^-_b}\Big)\\
&-3\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{d}_a}\Big)\Gamma_{\check{\nu}^R_{i2^*},\check{\nu}^R_{j\text{-}1^*},\tilde{d}^*_a,\tilde{d}_a}-\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{e}_a}\Big)\Gamma_{\check{\nu}^R_{i2^*},\check{\nu}^R_{j\text{-}1^*},\tilde{e}^*_a,\tilde{e}_a}\\
&-3\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{u}_a}\Big)\Gamma_{\check{\nu}^R_{i2^*},\check{\nu}^R_{j\text{-}1^*},\tilde{u}^*_a,\tilde{u}_a}+2\sum_{a=1}^{6}\sum_{b=1}^{2}B_0\Big(p^2,m^2_{\tilde{e}_a},m^2_{H^-_b}\Big)\Gamma^{*}_{\check{\nu}^R_j,\tilde{e}^*_a,H^-_b}\Gamma_{\check{\nu}^R_i,\tilde{e}^*_a,H^-_b}\\
&-\frac{1}{2}\sum_{a=1}^{7}A_0\Big(m^2_{\tilde{\nu}^I_a}\Big)\Gamma_{\check{\nu}^R_{i2^*},\check{\nu}^R_{j\text{-}1^*},\tilde{\nu}^I_a,\tilde{\nu}^I_a}-\frac{1}{2}\sum_{a=1}^{7}A_0\Big(m^2_{\tilde{\nu}^R_a}\Big)\Gamma_{\check{\nu}^R_{i2^*},\check{\nu}^R_{j\text{-}1^*},\tilde{\nu}^R_a,\tilde{\nu}^R_a}\\
&+\sum_{a=1}^{7}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{\nu}^I_a},m^2_{A^0_b}\Big)\Gamma^{*}_{\check{\nu}^R_j,\tilde{\nu}^I_a,A^0_b}\Gamma_{\check{\nu}^R_i,\tilde{\nu}^I_a,A^0_b}\\
&+\sum_{a=1}^{7}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{\nu}^I_a},m^2_{h_b}\Big)\Gamma^{*}_{\check{\nu}^R_j,\tilde{\nu}^I_a,h_b}\Gamma_{\check{\nu}^R_i,\tilde{\nu}^I_a,h_b}\\
&+\sum_{a=1}^{7}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{\nu}^R_a},m^2_{A^0_b}\Big)\Gamma^{*}_{\check{\nu}^R_j,\tilde{\nu}^R_a,A^0_b}\Gamma_{\check{\nu}^R_i,\tilde{\nu}^R_a,A^0_b}\\
&+\sum_{a=1}^{7}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{\nu}^R_a},m^2_{h_b}\Big)\Gamma^{*}_{\check{\nu}^R_j,\tilde{\nu}^R_a,h_b}\Gamma_{\check{\nu}^R_i,\tilde{\nu}^R_a,h_b}\\
&-2\sum_{a=1}^{7}m_{\nu_a}\sum_{b=1}^{5}B_0\Big(p^2,m^2_{\nu_a},m^2_{\tilde{\chi}^0_b}\Big)m_{\tilde{\chi}^0_b}\Big(\Gamma^{L*}_{\check{\nu}^R_j,\nu_a,\tilde{\chi}^0_b}\Gamma^{R}_{\check{\nu}^R_i,\nu_a,\tilde{\chi}^0_b}+\Gamma^{R*}_{\check{\nu}^R_j,\nu_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{\nu}^R_i,\nu_a,\tilde{\chi}^0_b}\Big)\\
&+\sum_{a=1}^{7}\sum_{b=1}^{5}G_0\Big(p^2,m^2_{\nu_a},m^2_{\tilde{\chi}^0_b}\Big)\Big(\Gamma^{L*}_{\check{\nu}^R_j,\nu_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{\nu}^R_i,\nu_a,\tilde{\chi}^0_b}+\Gamma^{R*}_{\check{\nu}^R_j,\nu_a,\tilde{\chi}^0_b}\Gamma^{R}_{\check{\nu}^R_i,\nu_a,\tilde{\chi}^0_b}\Big)\\
&+2\sum_{b=1}^{6}\Gamma^{*}_{\check{\nu}^R_j,W^+,\tilde{e}_b}\Gamma_{\check{\nu}^R_i,W^+,\tilde{e}_b}F_0\Big(p^2,m^2_{\tilde{e}_b},m^2_{W^-}\Big)+\sum_{b=1}^{7}\Gamma^{*}_{\check{\nu}^R_j,Z,\tilde{\nu}^I_b}\Gamma_{\check{\nu}^R_i,Z,\tilde{\nu}^I_b}F_0\Big(p^2,m^2_{\tilde{\nu}^I_b},m^2_{Z}\Big)
\end{aligned}
\tag{198}
$$

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

$$
\begin{aligned}
\Pi_{i,j}(p^2) = {} & +4\Gamma_{\check{\tilde{u}}_{i2^*},\check{\tilde{u}}^*_{j\text{-}1^*},W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{W^-}+A_0\Big(m^2_{W^-}\Big)\Big)+2\Gamma_{\check{\tilde{u}}_{i2^*},\check{\tilde{u}}^*_{j\text{-}1^*},Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{Z}+A_0\Big(m^2_{Z}\Big)\Big)\\
& -\sum_{a=1}^{2}A_0\Big(m^2_{H^-_a}\Big)\Gamma_{\check{\tilde{u}}_{i2^*},\check{\tilde{u}}^*_{j\text{-}1^*},H^+_a,H^-_a}\\
& -2\sum_{a=1}^{2}m_{\tilde{\chi}^-_a}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{\chi}^-_a},m^2_{d_b}\Big)m_{d_b}\Big(\Gamma^{L*}_{\check{\tilde{u}}^*_j,\tilde{\chi}^+_a,d_b}\Gamma^{R}_{\check{\tilde{u}}^*_i,\tilde{\chi}^+_a,d_b}+\Gamma^{R*}_{\check{\tilde{u}}^*_j,\tilde{\chi}^+_a,d_b}\Gamma^{L}_{\check{\tilde{u}}^*_i,\tilde{\chi}^+_a,d_b}\Big)\\
& +\sum_{a=1}^{2}\sum_{b=1}^{3}G_0\Big(p^2,m^2_{\tilde{\chi}^-_a},m^2_{d_b}\Big)\Big(\Gamma^{L*}_{\check{\tilde{u}}^*_j,\tilde{\chi}^+_a,d_b}\Gamma^{L}_{\check{\tilde{u}}^*_i,\tilde{\chi}^+_a,d_b}+\Gamma^{R*}_{\check{\tilde{u}}^*_j,\tilde{\chi}^+_a,d_b}\Gamma^{R}_{\check{\tilde{u}}^*_i,\tilde{\chi}^+_a,d_b}\Big)\\
& +\sum_{a=1}^{2}\sum_{b=1}^{6}B_0\Big(p^2,m^2_{H^-_a},m^2_{\tilde{d}_b}\Big)\Gamma^{*}_{\check{\tilde{u}}^*_j,H^+_a,\tilde{d}_b}\Gamma_{\check{\tilde{u}}^*_i,H^+_a,\tilde{d}_b}-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{A^0_a}\Big)\Gamma_{\check{\tilde{u}}_{i2^*},\check{\tilde{u}}^*_{j\text{-}1^*},A^0_a,A^0_a}\\
& -\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{h_a}\Big)\Gamma_{\check{\tilde{u}}_{i2^*},\check{\tilde{u}}^*_{j\text{-}1^*},h_a,h_a}\\
& -2\sum_{a=1}^{3}m_{u_a}\sum_{b=1}^{5}B_0\Big(p^2,m^2_{u_a},m^2_{\tilde{\chi}^0_b}\Big)m_{\tilde{\chi}^0_b}\Big(\Gamma^{L*}_{\check{\tilde{u}}^*_j,u_a,\tilde{\chi}^0_b}\Gamma^{R}_{\check{\tilde{u}}^*_i,u_a,\tilde{\chi}^0_b}+\Gamma^{R*}_{\check{\tilde{u}}^*_j,u_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{\tilde{u}}^*_i,u_a,\tilde{\chi}^0_b}\Big)\\
& +\sum_{a=1}^{3}\sum_{b=1}^{5}G_0\Big(p^2,m^2_{u_a},m^2_{\tilde{\chi}^0_b}\Big)\Big(\Gamma^{L*}_{\check{\tilde{u}}^*_j,u_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{\tilde{u}}^*_i,u_a,\tilde{\chi}^0_b}+\Gamma^{R*}_{\check{\tilde{u}}^*_j,u_a,\tilde{\chi}^0_b}\Gamma^{R}_{\check{\tilde{u}}^*_i,u_a,\tilde{\chi}^0_b}\Big)\\
& -C\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{d}_a}\Big)\Gamma_{\check{\tilde{u}}_{i2^*},\check{\tilde{u}}^*_{j\text{-}1^*},\tilde{d}^*_a,\tilde{d}_a}-\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{e}_a}\Big)\Gamma_{\check{\tilde{u}}_{i2^*},\check{\tilde{u}}^*_{j\text{-}1^*},\tilde{e}^*_a,\tilde{e}_a}\\
& -C\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{u}_a}\Big)\Gamma_{\check{\tilde{u}}_{i2^*},\check{\tilde{u}}^*_{j\text{-}1^*},\tilde{u}^*_a,\tilde{u}_a}+\sum_{a=1}^{6}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{u}_a},m^2_{A^0_b}\Big)\Gamma^{*}_{\check{\tilde{u}}^*_j,\tilde{u}_a,A^0_b}\Gamma_{\check{\tilde{u}}^*_i,\tilde{u}_a,A^0_b}\\
& +\sum_{a=1}^{6}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{u}_a},m^2_{h_b}\Big)\Gamma^{*}_{\check{\tilde{u}}^*_j,\tilde{u}_a,h_b}\Gamma_{\check{\tilde{u}}^*_i,\tilde{u}_a,h_b}-\frac{1}{2}\sum_{a=1}^{7}A_0\Big(m^2_{\tilde{\nu}^I_a}\Big)\Gamma_{\check{\tilde{u}}_{i2^*},\check{\tilde{u}}^*_{j\text{-}1^*},\tilde{\nu}^I_a,\tilde{\nu}^I_a}\\
& -\frac{1}{2}\sum_{a=1}^{7}A_0\Big(m^2_{\tilde{\nu}^R_a}\Big)\Gamma_{\check{\tilde{u}}_{i2^*},\check{\tilde{u}}^*_{j\text{-}1^*},\tilde{\nu}^R_a,\tilde{\nu}^R_a}\\
& -\frac{8}{3}m_{\tilde{g}}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{g}},m^2_{u_b}\Big)m_{u_b}\Big(\Gamma^{L*}_{\check{\tilde{u}}^*_j,\tilde{g}_1,u_b}\Gamma^{R}_{\check{\tilde{u}}^*_i,\tilde{g}_1,u_b}+\Gamma^{R*}_{\check{\tilde{u}}^*_j,\tilde{g}_1,u_b}\Gamma^{L}_{\check{\tilde{u}}^*_i,\tilde{g}_1,u_b}\Big)\\
& +\frac{4}{3}\sum_{b=1}^{3}G_0\Big(p^2,m^2_{\tilde{g}},m^2_{u_b}\Big)\Big(\Gamma^{L*}_{\check{\tilde{u}}^*_j,\tilde{g}_1,u_b}\Gamma^{L}_{\check{\tilde{u}}^*_i,\tilde{g}_1,u_b}+\Gamma^{R*}_{\check{\tilde{u}}^*_j,\tilde{g}_1,u_b}\Gamma^{R}_{\check{\tilde{u}}^*_i,\tilde{g}_1,u_b}\Big)\\
& +\sum_{b=1}^{6}\Gamma^{*}_{\check{\tilde{u}}^*_j,W^+,\tilde{d}_b}\Gamma_{\check{\tilde{u}}^*_i,W^+,\tilde{d}_b}F_0\Big(p^2,m^2_{\tilde{d}_b},m^2_{W^-}\Big)+\frac{4}{3}\sum_{b=1}^{6}\Gamma^{*}_{\check{\tilde{u}}^*_j,g,\tilde{u}_b}\Gamma_{\check{\tilde{u}}^*_i,g,\tilde{u}_b}F_0\Big(p^2,m^2_{\tilde{u}_b},0\Big)
\end{aligned}
$$

$$+\sum_{b=1}^{6}\Gamma^{*}_{\check{\tilde{u}}^{*}_{j},\gamma,\tilde{u}_b}\Gamma_{\check{\tilde{u}}^{*}_{i},\gamma,\tilde{u}_b}F_0\Big(p^2,m^2_{\tilde{u}_b},0\Big)+\sum_{b=1}^{6}\Gamma^{*}_{\check{\tilde{u}}^{*}_{j},Z,\tilde{u}_b}\Gamma_{\check{\tilde{u}}^{*}_{i},Z,\tilde{u}_b}F_0\Big(p^2,m^2_{\tilde{u}_b},m^2_Z\Big) \tag{199}$$

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

$$\begin{aligned}
\Pi_{i,j}(p^2) = {}& +4\Gamma_{\check{\tilde{e}}_{i2^*},\check{\tilde{e}}^{*}_{j\text{-}1^*},W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{W^-}+A_0\Big(m^2_{W^-}\Big)\Big)+2\Gamma_{\check{\tilde{e}}_{i2^*},\check{\tilde{e}}^{*}_{j\text{-}1^*},Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m^2_Z+A_0\Big(m^2_Z\Big)\Big)\\
&-\sum_{a=1}^{2}A_0\Big(m^2_{H^-_a}\Big)\Gamma_{\check{\tilde{e}}_{i2^*},\check{\tilde{e}}^{*}_{j\text{-}1^*},H^+_a,H^-_a}-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{A^0_a}\Big)\Gamma_{\check{\tilde{e}}_{i2^*},\check{\tilde{e}}^{*}_{j\text{-}1^*},A^0_a,A^0_a}\\
&-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{h_a}\Big)\Gamma_{\check{\tilde{e}}_{i2^*},\check{\tilde{e}}^{*}_{j\text{-}1^*},h_a,h_a}\\
&-2\sum_{a=1}^{3}m_{e_a}\sum_{b=1}^{5}B_0\Big(p^2,m^2_{e_a},m^2_{\tilde{\chi}^0_b}\Big)m_{\tilde{\chi}^0_b}\Big(\Gamma^{L*}_{\check{\tilde{e}}^{*}_{j},e_a,\tilde{\chi}^0_b}\Gamma^{R}_{\check{\tilde{e}}^{*}_{i},e_a,\tilde{\chi}^0_b}+\Gamma^{R*}_{\check{\tilde{e}}^{*}_{j},e_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{\tilde{e}}^{*}_{i},e_a,\tilde{\chi}^0_b}\Big)\\
&+\sum_{a=1}^{3}\sum_{b=1}^{5}G_0\Big(p^2,m^2_{e_a},m^2_{\tilde{\chi}^0_b}\Big)\Big(\Gamma^{L*}_{\check{\tilde{e}}^{*}_{j},e_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{\tilde{e}}^{*}_{i},e_a,\tilde{\chi}^0_b}+\Gamma^{R*}_{\check{\tilde{e}}^{*}_{j},e_a,\tilde{\chi}^0_b}\Gamma^{R}_{\check{\tilde{e}}^{*}_{i},e_a,\tilde{\chi}^0_b}\Big)\\
&-3\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{d}_a}\Big)\Gamma_{\check{\tilde{e}}_{i2^*},\check{\tilde{e}}^{*}_{j\text{-}1^*},\tilde{d}^*_a,\tilde{d}_a}-\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{e}_a}\Big)\Gamma_{\check{\tilde{e}}_{i2^*},\check{\tilde{e}}^{*}_{j\text{-}1^*},\tilde{e}^*_a,\tilde{e}_a}\\
&-3\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{u}_a}\Big)\Gamma_{\check{\tilde{e}}_{i2^*},\check{\tilde{e}}^{*}_{j\text{-}1^*},\tilde{u}^*_a,\tilde{u}_a}+\sum_{a=1}^{6}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{e}_a},m^2_{A^0_b}\Big)\Gamma^{*}_{\check{\tilde{e}}^{*}_{j},\tilde{e}_a,A^0_b}\Gamma_{\check{\tilde{e}}^{*}_{i},\tilde{e}_a,A^0_b}\\
&+\sum_{a=1}^{6}\sum_{b=1}^{3}B_0\Big(p^2,m^2_{\tilde{e}_a},m^2_{h_b}\Big)\Gamma^{*}_{\check{\tilde{e}}^{*}_{j},\tilde{e}_a,h_b}\Gamma_{\check{\tilde{e}}^{*}_{i},\tilde{e}_a,h_b}-\frac{1}{2}\sum_{a=1}^{7}A_0\Big(m^2_{\tilde{\nu}^I_a}\Big)\Gamma_{\check{\tilde{e}}_{i2^*},\check{\tilde{e}}^{*}_{j\text{-}1^*},\tilde{\nu}^I_a,\tilde{\nu}^I_a}\\
&-\frac{1}{2}\sum_{a=1}^{7}A_0\Big(m^2_{\tilde{\nu}^R_a}\Big)\Gamma_{\check{\tilde{e}}_{i2^*},\check{\tilde{e}}^{*}_{j\text{-}1^*},\tilde{\nu}^R_a,\tilde{\nu}^R_a}+\sum_{a=1}^{7}\sum_{b=1}^{2}B_0\Big(p^2,m^2_{\tilde{\nu}^I_a},m^2_{H^-_b}\Big)\Gamma^{*}_{\check{\tilde{e}}^{*}_{j},\tilde{\nu}^I_a,H^-_b}\Gamma_{\check{\tilde{e}}^{*}_{i},\tilde{\nu}^I_a,H^-_b}\\
&+\sum_{a=1}^{7}\sum_{b=1}^{2}B_0\Big(p^2,m^2_{\tilde{\nu}^R_a},m^2_{H^-_b}\Big)\Gamma^{*}_{\check{\tilde{e}}^{*}_{j},\tilde{\nu}^R_a,H^-_b}\Gamma_{\check{\tilde{e}}^{*}_{i},\tilde{\nu}^R_a,H^-_b}\\
&-2\sum_{a=1}^{7}m_{\nu_a}\sum_{b=1}^{2}B_0\Big(p^2,m^2_{\nu_a},m^2_{\tilde{\chi}^-_b}\Big)m_{\tilde{\chi}^-_b}\Big(\Gamma^{L*}_{\check{\tilde{e}}^{*}_{j},\nu_a,\tilde{\chi}^-_b}\Gamma^{R}_{\check{\tilde{e}}^{*}_{i},\nu_a,\tilde{\chi}^-_b}+\Gamma^{R*}_{\check{\tilde{e}}^{*}_{j},\nu_a,\tilde{\chi}^-_b}\Gamma^{L}_{\check{\tilde{e}}^{*}_{i},\nu_a,\tilde{\chi}^-_b}\Big)\\
&+\sum_{a=1}^{7}\sum_{b=1}^{2}G_0\Big(p^2,m^2_{\nu_a},m^2_{\tilde{\chi}^-_b}\Big)\Big(\Gamma^{L*}_{\check{\tilde{e}}^{*}_{j},\nu_a,\tilde{\chi}^-_b}\Gamma^{L}_{\check{\tilde{e}}^{*}_{i},\nu_a,\tilde{\chi}^-_b}+\Gamma^{R*}_{\check{\tilde{e}}^{*}_{j},\nu_a,\tilde{\chi}^-_b}\Gamma^{R}_{\check{\tilde{e}}^{*}_{i},\nu_a,\tilde{\chi}^-_b}\Big)\\
&+\sum_{b=1}^{6}\Gamma^{*}_{\check{\tilde{e}}^{*}_{j},\gamma,\tilde{e}_b}\Gamma_{\check{\tilde{e}}^{*}_{i},\gamma,\tilde{e}_b}F_0\Big(p^2,m^2_{\tilde{e}_b},0\Big)+\sum_{b=1}^{6}\Gamma^{*}_{\check{\tilde{e}}^{*}_{j},Z,\tilde{e}_b}\Gamma_{\check{\tilde{e}}^{*}_{i},Z,\tilde{e}_b}F_0\Big(p^2,m^2_{\tilde{e}_b},m^2_Z\Big)\\
&+\sum_{b=1}^{7}\Gamma^{*}_{\check{\tilde{e}}^{*}_{j},W^-,\tilde{\nu}^I_b}\Gamma_{\check{\tilde{e}}^{*}_{i},W^-,\tilde{\nu}^I_b}F_0\Big(p^2,m^2_{\tilde{\nu}^I_b},m^2_{W^-}\Big)+\sum_{b=1}^{7}\Gamma^{*}_{\check{\tilde{e}}^{*}_{j},W^-,\tilde{\nu}^R_b}\Gamma_{\check{\tilde{e}}^{*}_{i},W^-,\tilde{\nu}^R_b}F_0\Big(p^2,m^2_{\tilde{\nu}^R_b},m^2_{W^-}\Big)
\end{aligned} \tag{200}$$

- **Self-Energy for Higgs** (h)

$$
\begin{aligned}
\Pi_{i,j}(p^2) = &+2\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m_Z^2,m_Z^2\Big)\Big)\Gamma^*_{\check{h}_j,Z,Z}\Gamma_{\check{h}_i,Z,Z}+4\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2,m_{W^-}^2,m_{W^-}^2\Big)\Big)\Gamma^*_{\check{h}_j,W^+,W^-}\Gamma_{\check{h}_i,W^+,W^-}\\
&-B_0\Big(p^2,m_{\eta^-}^2,m_{\eta^-}^2\Big)\Gamma_{\check{h}_i,\bar{\eta^-},\eta^-}\Gamma_{\check{h}_j,\bar{\eta^-},\eta^-}-B_0\Big(p^2,m_{\eta^+}^2,m_{\eta^+}^2\Big)\Gamma_{\check{h}_i,\bar{\eta^+},\eta^+}\Gamma_{\check{h}_j,\bar{\eta^+},\eta^+}\\
&-B_0\Big(p^2,m_{\eta^Z}^2,m_{\eta^Z}^2\Big)\Gamma_{\check{h}_i,\bar{\eta^Z},\eta^Z}\Gamma_{\check{h}_j,\bar{\eta^Z},\eta^Z}+4\Gamma_{\check{h}_{i2^*},\check{h}_{j\text{-}1^*},W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m_{W^-}^2+A_0\Big(m_{W^-}^2\Big)\Big)\\
&+2\Gamma_{\check{h}_{i2^*},\check{h}_{j\text{-}1^*},Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m_Z^2+A_0\Big(m_Z^2\Big)\Big)-\sum_{a=1}^{2}A_0\Big(m_{H_a^-}^2\Big)\Gamma_{\check{h}_{i2^*},\check{h}_{j\text{-}1^*},H_a^+,H_a^-}\\
&+\sum_{a=1}^{2}\sum_{b=1}^{2}B_0\Big(p^2,m_{H_a^-}^2,m_{H_b^-}^2\Big)\Gamma^*_{\check{h}_j,H_a^+,H_b^-}\Gamma_{\check{h}_i,H_a^+,H_b^-}\\
&-2\sum_{a=1}^{2}m_{\tilde{\chi}_a^-}\sum_{b=1}^{2}B_0\Big(p^2,m_{\tilde{\chi}_a^-}^2,m_{\tilde{\chi}_b^-}^2\Big)m_{\tilde{\chi}_b^-}\Big(\Gamma^{L*}_{\check{h}_j,\tilde{\chi}_a^+,\tilde{\chi}_b^-}\Gamma^{R}_{\check{h}_i,\tilde{\chi}_a^+,\tilde{\chi}_b^-}+\Gamma^{R*}_{\check{h}_j,\tilde{\chi}_a^+,\tilde{\chi}_b^-}\Gamma^{L}_{\check{h}_i,\tilde{\chi}_a^+,\tilde{\chi}_b^-}\Big)\\
&+\sum_{a=1}^{2}\sum_{b=1}^{2}G_0\Big(p^2,m_{\tilde{\chi}_a^-}^2,m_{\tilde{\chi}_b^-}^2\Big)\Big(\Gamma^{L*}_{\check{h}_j,\tilde{\chi}_a^+,\tilde{\chi}_b^-}\Gamma^{L}_{\check{h}_i,\tilde{\chi}_a^+,\tilde{\chi}_b^-}+\Gamma^{R*}_{\check{h}_j,\tilde{\chi}_a^+,\tilde{\chi}_b^-}\Gamma^{R}_{\check{h}_i,\tilde{\chi}_a^+,\tilde{\chi}_b^-}\Big)\\
&-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m_{A_a^0}^2\Big)\Gamma_{\check{h}_{i2^*},\check{h}_{j\text{-}1^*},A_a^0,A_a^0}-\frac{1}{2}\sum_{a=1}^{3}A_0\Big(m_{h_a}^2\Big)\Gamma_{\check{h}_{i2^*},\check{h}_{j\text{-}1^*},h_a,h_a}\\
&+\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3}B_0\Big(p^2,m_{A_a^0}^2,m_{A_b^0}^2\Big)\Gamma^*_{\check{h}_j,A_a^0,A_b^0}\Gamma_{\check{h}_i,A_a^0,A_b^0}\\
&+\sum_{a=1}^{3}\sum_{b=1}^{3}B_0\Big(p^2,m_{h_a}^2,m_{A_b^0}^2\Big)\Gamma^*_{\check{h}_j,h_a,A_b^0}\Gamma_{\check{h}_i,h_a,A_b^0}+\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3}B_0\Big(p^2,m_{h_a}^2,m_{h_b}^2\Big)\Gamma^*_{\check{h}_j,h_a,h_b}\Gamma_{\check{h}_i,h_a,h_b}\\
&-6\sum_{a=1}^{3}m_{d_a}\sum_{b=1}^{3}B_0\Big(p^2,m_{d_a}^2,m_{d_b}^2\Big)m_{d_b}\Big(\Gamma^{L*}_{\check{h}_j,\bar{d}_a,d_b}\Gamma^{R}_{\check{h}_i,\bar{d}_a,d_b}+\Gamma^{R*}_{\check{h}_j,\bar{d}_a,d_b}\Gamma^{L}_{\check{h}_i,\bar{d}_a,d_b}\Big)\\
&+3\sum_{a=1}^{3}\sum_{b=1}^{3}G_0\Big(p^2,m_{d_a}^2,m_{d_b}^2\Big)\Big(\Gamma^{L*}_{\check{h}_j,\bar{d}_a,d_b}\Gamma^{L}_{\check{h}_i,\bar{d}_a,d_b}+\Gamma^{R*}_{\check{h}_j,\bar{d}_a,d_b}\Gamma^{R}_{\check{h}_i,\bar{d}_a,d_b}\Big)\\
&-2\sum_{a=1}^{3}m_{e_a}\sum_{b=1}^{3}B_0\Big(p^2,m_{e_a}^2,m_{e_b}^2\Big)m_{e_b}\Big(\Gamma^{L*}_{\check{h}_j,\bar{e}_a,e_b}\Gamma^{R}_{\check{h}_i,\bar{e}_a,e_b}+\Gamma^{R*}_{\check{h}_j,\bar{e}_a,e_b}\Gamma^{L}_{\check{h}_i,\bar{e}_a,e_b}\Big)\\
&+\sum_{a=1}^{3}\sum_{b=1}^{3}G_0\Big(p^2,m_{e_a}^2,m_{e_b}^2\Big)\Big(\Gamma^{L*}_{\check{h}_j,\bar{e}_a,e_b}\Gamma^{L}_{\check{h}_i,\bar{e}_a,e_b}+\Gamma^{R*}_{\check{h}_j,\bar{e}_a,e_b}\Gamma^{R}_{\check{h}_i,\bar{e}_a,e_b}\Big)\\
&-6\sum_{a=1}^{3}m_{u_a}\sum_{b=1}^{3}B_0\Big(p^2,m_{u_a}^2,m_{u_b}^2\Big)m_{u_b}\Big(\Gamma^{L*}_{\check{h}_j,\bar{u}_a,u_b}\Gamma^{R}_{\check{h}_i,\bar{u}_a,u_b}+\Gamma^{R*}_{\check{h}_j,\bar{u}_a,u_b}\Gamma^{L}_{\check{h}_i,\bar{u}_a,u_b}\Big)\\
&+3\sum_{a=1}^{3}\sum_{b=1}^{3}G_0\Big(p^2,m_{u_a}^2,m_{u_b}^2\Big)\Big(\Gamma^{L*}_{\check{h}_j,\bar{u}_a,u_b}\Gamma^{L}_{\check{h}_i,\bar{u}_a,u_b}+\Gamma^{R*}_{\check{h}_j,\bar{u}_a,u_b}\Gamma^{R}_{\check{h}_i,\bar{u}_a,u_b}\Big)
\end{aligned}
$$

$$
\begin{aligned}
&- \sum_{a=1}^{5} m_{\tilde{\chi}_a^0} \sum_{b=1}^{5} B_0\Big(p^2, m^2_{\tilde{\chi}_a^0}, m^2_{\tilde{\chi}_b^0}\Big) m_{\tilde{\chi}_b^0} \Big(\Gamma^{L*}_{\check{h}_j,\tilde{\chi}_a^0,\tilde{\chi}_b^0} \Gamma^{R}_{\check{h}_i,\tilde{\chi}_a^0,\tilde{\chi}_b^0} + \Gamma^{R*}_{\check{h}_j,\tilde{\chi}_a^0,\tilde{\chi}_b^0} \Gamma^{L}_{\check{h}_i,\tilde{\chi}_a^0,\tilde{\chi}_b^0}\Big) \\
&+ \frac{1}{2} \sum_{a=1}^{5} \sum_{b=1}^{5} G_0\Big(p^2, m^2_{\tilde{\chi}_a^0}, m^2_{\tilde{\chi}_b^0}\Big) \Big(\Gamma^{L*}_{\check{h}_j,\tilde{\chi}_a^0,\tilde{\chi}_b^0} \Gamma^{L}_{\check{h}_i,\tilde{\chi}_a^0,\tilde{\chi}_b^0} + \Gamma^{R*}_{\check{h}_j,\tilde{\chi}_a^0,\tilde{\chi}_b^0} \Gamma^{R}_{\check{h}_i,\tilde{\chi}_a^0,\tilde{\chi}_b^0}\Big) \\
&- 3 \sum_{a=1}^{6} A_0\Big(m^2_{\tilde{d}_a}\Big) \Gamma_{\check{h}_{i2^*},\check{h}_{j\text{-}1^*},\tilde{d}^*_a,\tilde{d}_a} - \sum_{a=1}^{6} A_0\Big(m^2_{\tilde{e}_a}\Big) \Gamma_{\check{h}_{i2^*},\check{h}_{j\text{-}1^*},\tilde{e}^*_a,\tilde{e}_a} \\
&- 3 \sum_{a=1}^{6} A_0\Big(m^2_{\tilde{u}_a}\Big) \Gamma_{\check{h}_{i2^*},\check{h}_{j\text{-}1^*},\tilde{u}^*_a,\tilde{u}_a} + 3 \sum_{a=1}^{6} \sum_{b=1}^{6} B_0\Big(p^2, m^2_{\tilde{d}_a}, m^2_{\tilde{d}_b}\Big) \Gamma^*_{\check{h}_j,\tilde{d}^*_a,\tilde{d}_b} \Gamma_{\check{h}_i,\tilde{d}^*_a,\tilde{d}_b} \\
&+ \sum_{a=1}^{6} \sum_{b=1}^{6} B_0\Big(p^2, m^2_{\tilde{e}_a}, m^2_{\tilde{e}_b}\Big) \Gamma^*_{\check{h}_j,\tilde{e}^*_a,\tilde{e}_b} \Gamma_{\check{h}_i,\tilde{e}^*_a,\tilde{e}_b} + 3 \sum_{a=1}^{6} \sum_{b=1}^{6} B_0\Big(p^2, m^2_{\tilde{u}_a}, m^2_{\tilde{u}_b}\Big) \Gamma^*_{\check{h}_j,\tilde{u}^*_a,\tilde{u}_b} \Gamma_{\check{h}_i,\tilde{u}^*_a,\tilde{u}_b} \\
&- \frac{1}{2} \sum_{a=1}^{7} A_0\Big(m^2_{\tilde{\nu}_a^I}\Big) \Gamma_{\check{h}_{i2^*},\check{h}_{j\text{-}1^*},\tilde{\nu}^I_a,\tilde{\nu}^I_a} - \frac{1}{2} \sum_{a=1}^{7} A_0\Big(m^2_{\tilde{\nu}_a^R}\Big) \Gamma_{\check{h}_{i2^*},\check{h}_{j\text{-}1^*},\tilde{\nu}^R_a,\tilde{\nu}^R_a} \\
&+ \frac{1}{2} \sum_{a=1}^{7} \sum_{b=1}^{7} B_0\Big(p^2, m^2_{\tilde{\nu}_a^I}, m^2_{\tilde{\nu}_b^I}\Big) \Gamma^*_{\check{h}_j,\tilde{\nu}^I_a,\tilde{\nu}^I_b} \Gamma_{\check{h}_i,\tilde{\nu}^I_a,\tilde{\nu}^I_b} \\
&+ \sum_{a=1}^{7} \sum_{b=1}^{7} B_0\Big(p^2, m^2_{\tilde{\nu}_a^R}, m^2_{\tilde{\nu}_b^I}\Big) \Gamma^*_{\check{h}_j,\tilde{\nu}^R_a,\tilde{\nu}^I_b} \Gamma_{\check{h}_i,\tilde{\nu}^R_a,\tilde{\nu}^I_b} \\
&+ \frac{1}{2} \sum_{a=1}^{7} \sum_{b=1}^{7} B_0\Big(p^2, m^2_{\tilde{\nu}_a^R}, m^2_{\tilde{\nu}_b^R}\Big) \Gamma^*_{\check{h}_j,\tilde{\nu}^R_a,\tilde{\nu}^R_b} \Gamma_{\check{h}_i,\tilde{\nu}^R_a,\tilde{\nu}^R_b} \\
&- \sum_{a=1}^{7} m_{\nu_a} \sum_{b=1}^{7} B_0\Big(p^2, m^2_{\nu_a}, m^2_{\nu_b}\Big) m_{\nu_b} \Big(\Gamma^{L*}_{\check{h}_j,\nu_a,\nu_b} \Gamma^{R}_{\check{h}_i,\nu_a,\nu_b} + \Gamma^{R*}_{\check{h}_j,\nu_a,\nu_b} \Gamma^{L}_{\check{h}_i,\nu_a,\nu_b}\Big) \\
&+ \frac{1}{2} \sum_{a=1}^{7} \sum_{b=1}^{7} G_0\Big(p^2, m^2_{\nu_a}, m^2_{\nu_b}\Big) \Big(\Gamma^{L*}_{\check{h}_j,\nu_a,\nu_b} \Gamma^{L}_{\check{h}_i,\nu_a,\nu_b} + \Gamma^{R*}_{\check{h}_j,\nu_a,\nu_b} \Gamma^{R}_{\check{h}_i,\nu_a,\nu_b}\Big) \\
&+ 2 \sum_{b=1}^{2} \Gamma^*_{\check{h}_j,W^+,H_b^-} \Gamma_{\check{h}_i,W^+,H_b^-} F_0\Big(p^2, m^2_{H_b^-}, m^2_{W^-}\Big) + \sum_{b=1}^{3} \Gamma^*_{\check{h}_j,Z,A^0_b} \Gamma_{\check{h}_i,Z,A^0_b} F_0\Big(p^2, m^2_{A^0_b}, m^2_Z\Big)
\end{aligned} \tag{201}
$$

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

$$
\begin{aligned}
\Pi_{i,j}(p^2) = &- B_0\Big(p^2, m^2_{\eta^-}, m^2_{\eta^-}\Big) \Gamma_{\check{A}^0_i,\eta^-,\eta^-} \Gamma_{\check{A}^0_j,\eta^-,\eta^-} - B_0\Big(p^2, m^2_{\eta^+}, m^2_{\eta^+}\Big) \Gamma_{\check{A}^0_i,\eta^+,\eta^+} \Gamma_{\check{A}^0_j,\eta^+,\eta^+} \\
&+ 4\Gamma_{\check{A}^0_{i2^*},\check{A}^0_{j\text{-}1^*},W^+,W^-} \Big(- \frac{1}{2} \mathrm{rMS} m^2_{W^-} + A_0\Big(m^2_{W^-}\Big)\Big) + 2\Gamma_{\check{A}^0_{i2^*},\check{A}^0_{j\text{-}1^*},Z,Z} \Big(- \frac{1}{2} \mathrm{rMS} m^2_Z + A_0\Big(m^2_Z\Big)\Big) \\
&- \sum_{a=1}^{2} A_0\Big(m^2_{H_a^-}\Big) \Gamma_{\check{A}^0_{i2^*},\check{A}^0_{j\text{-}1^*},H_a^+,H_a^-} + \sum_{a=1}^{2} \sum_{b=1}^{2} B_0\Big(p^2, m^2_{H_a^-}, m^2_{H_b^-}\Big) \Gamma^*_{\check{A}^0_j,H_a^+,H_b^-} \Gamma_{\check{A}^0_i,H_a^+,H_b^-}
\end{aligned}
$$

$$
\begin{aligned}
&- 2\sum_{a=1}^{2} m_{\tilde{\chi}_a^-} \sum_{b=1}^{2} B_0\Big(p^2, m^2_{\tilde{\chi}_a^-}, m^2_{\tilde{\chi}_b^-}\Big) m_{\tilde{\chi}_b^-} \Big(\Gamma^{L*}_{\check{A}^0_j,\tilde{\chi}_a^+,\tilde{\chi}_b^-} \Gamma^{R}_{\check{A}^0_i,\tilde{\chi}_a^+,\tilde{\chi}_b^-} + \Gamma^{R*}_{\check{A}^0_j,\tilde{\chi}_a^+,\tilde{\chi}_b^-} \Gamma^{L}_{\check{A}^0_i,\tilde{\chi}_a^+,\tilde{\chi}_b^-}\Big) \\
&+ \sum_{a=1}^{2}\sum_{b=1}^{2} G_0\Big(p^2, m^2_{\tilde{\chi}_a^-}, m^2_{\tilde{\chi}_b^-}\Big) \Big(\Gamma^{L*}_{\check{A}^0_j,\tilde{\chi}_a^+,\tilde{\chi}_b^-} \Gamma^{L}_{\check{A}^0_i,\tilde{\chi}_a^+,\tilde{\chi}_b^-} + \Gamma^{R*}_{\check{A}^0_j,\tilde{\chi}_a^+,\tilde{\chi}_b^-} \Gamma^{R}_{\check{A}^0_i,\tilde{\chi}_a^+,\tilde{\chi}_b^-}\Big) \\
&- \frac{1}{2}\sum_{a=1}^{3} A_0\Big(m^2_{A^0_a}\Big) \Gamma_{\check{A}^0_{i2^*},\check{A}^0_{j\text{-}1^*},A^0_a,A^0_a} - \frac{1}{2}\sum_{a=1}^{3} A_0\Big(m^2_{h_a}\Big) \Gamma_{\check{A}^0_{i2^*},\check{A}^0_{j\text{-}1^*},h_a,h_a} \\
&+ \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{A^0_a}, m^2_{A^0_b}\Big) \Gamma^*_{\check{A}^0_j,A^0_a,A^0_b} \Gamma_{\check{A}^0_i,A^0_a,A^0_b} \\
&+ \sum_{a=1}^{3}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{h_a}, m^2_{A^0_b}\Big) \Gamma^*_{\check{A}^0_j,h_a,A^0_b} \Gamma_{\check{A}^0_i,h_a,A^0_b} \\
&+ \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{h_a}, m^2_{h_b}\Big) \Gamma^*_{\check{A}^0_j,h_a,h_b} \Gamma_{\check{A}^0_i,h_a,h_b} \\
&- 6\sum_{a=1}^{3} m_{d_a} \sum_{b=1}^{3} B_0\Big(p^2, m^2_{d_a}, m^2_{d_b}\Big) m_{d_b} \Big(\Gamma^{L*}_{\check{A}^0_j,\bar{d}_a,d_b} \Gamma^{R}_{\check{A}^0_i,\bar{d}_a,d_b} + \Gamma^{R*}_{\check{A}^0_j,\bar{d}_a,d_b} \Gamma^{L}_{\check{A}^0_i,\bar{d}_a,d_b}\Big) \\
&+ 3\sum_{a=1}^{3}\sum_{b=1}^{3} G_0\Big(p^2, m^2_{d_a}, m^2_{d_b}\Big) \Big(\Gamma^{L*}_{\check{A}^0_j,\bar{d}_a,d_b} \Gamma^{L}_{\check{A}^0_i,\bar{d}_a,d_b} + \Gamma^{R*}_{\check{A}^0_j,\bar{d}_a,d_b} \Gamma^{R}_{\check{A}^0_i,\bar{d}_a,d_b}\Big) \\
&- 2\sum_{a=1}^{3} m_{e_a} \sum_{b=1}^{3} B_0\Big(p^2, m^2_{e_a}, m^2_{e_b}\Big) m_{e_b} \Big(\Gamma^{L*}_{\check{A}^0_j,\bar{e}_a,e_b} \Gamma^{R}_{\check{A}^0_i,\bar{e}_a,e_b} + \Gamma^{R*}_{\check{A}^0_j,\bar{e}_a,e_b} \Gamma^{L}_{\check{A}^0_i,\bar{e}_a,e_b}\Big) \\
&+ \sum_{a=1}^{3}\sum_{b=1}^{3} G_0\Big(p^2, m^2_{e_a}, m^2_{e_b}\Big) \Big(\Gamma^{L*}_{\check{A}^0_j,\bar{e}_a,e_b} \Gamma^{L}_{\check{A}^0_i,\bar{e}_a,e_b} + \Gamma^{R*}_{\check{A}^0_j,\bar{e}_a,e_b} \Gamma^{R}_{\check{A}^0_i,\bar{e}_a,e_b}\Big) \\
&- 6\sum_{a=1}^{3} m_{u_a} \sum_{b=1}^{3} B_0\Big(p^2, m^2_{u_a}, m^2_{u_b}\Big) m_{u_b} \Big(\Gamma^{L*}_{\check{A}^0_j,\bar{u}_a,u_b} \Gamma^{R}_{\check{A}^0_i,\bar{u}_a,u_b} + \Gamma^{R*}_{\check{A}^0_j,\bar{u}_a,u_b} \Gamma^{L}_{\check{A}^0_i,\bar{u}_a,u_b}\Big) \\
&+ 3\sum_{a=1}^{3}\sum_{b=1}^{3} G_0\Big(p^2, m^2_{u_a}, m^2_{u_b}\Big) \Big(\Gamma^{L*}_{\check{A}^0_j,\bar{u}_a,u_b} \Gamma^{L}_{\check{A}^0_i,\bar{u}_a,u_b} + \Gamma^{R*}_{\check{A}^0_j,\bar{u}_a,u_b} \Gamma^{R}_{\check{A}^0_i,\bar{u}_a,u_b}\Big) \\
&- \sum_{a=1}^{5} m_{\tilde{\chi}_a^0} \sum_{b=1}^{5} B_0\Big(p^2, m^2_{\tilde{\chi}_a^0}, m^2_{\tilde{\chi}_b^0}\Big) m_{\tilde{\chi}_b^0} \Big(\Gamma^{L*}_{\check{A}^0_j,\tilde{\chi}_a^0,\tilde{\chi}_b^0} \Gamma^{R}_{\check{A}^0_i,\tilde{\chi}_a^0,\tilde{\chi}_b^0} + \Gamma^{R*}_{\check{A}^0_j,\tilde{\chi}_a^0,\tilde{\chi}_b^0} \Gamma^{L}_{\check{A}^0_i,\tilde{\chi}_a^0,\tilde{\chi}_b^0}\Big) \\
&+ \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{5} G_0\Big(p^2, m^2_{\tilde{\chi}_a^0}, m^2_{\tilde{\chi}_b^0}\Big) \Big(\Gamma^{L*}_{\check{A}^0_j,\tilde{\chi}_a^0,\tilde{\chi}_b^0} \Gamma^{L}_{\check{A}^0_i,\tilde{\chi}_a^0,\tilde{\chi}_b^0} + \Gamma^{R*}_{\check{A}^0_j,\tilde{\chi}_a^0,\tilde{\chi}_b^0} \Gamma^{R}_{\check{A}^0_i,\tilde{\chi}_a^0,\tilde{\chi}_b^0}\Big) \\
&- 3\sum_{a=1}^{6} A_0\Big(m^2_{\tilde{d}_a}\Big) \Gamma_{\check{A}^0_{i2^*},\check{A}^0_{j\text{-}1^*},\tilde{d}^*_a,\tilde{d}_a} - \sum_{a=1}^{6} A_0\Big(m^2_{\tilde{e}_a}\Big) \Gamma_{\check{A}^0_{i2^*},\check{A}^0_{j\text{-}1^*},\tilde{e}^*_a,\tilde{e}_a}
\end{aligned}
$$

$$
\begin{aligned}
&- 3\sum_{a=1}^{6} A_0\Big(m^2_{\tilde{u}_a}\Big)\Gamma_{\check{A}^0_{i2^*},\check{A}^0_{j\text{-}1^*},\tilde{u}^*_a,\tilde{u}_a} + 3\sum_{a=1}^{6}\sum_{b=1}^{6} B_0\Big(p^2, m^2_{\tilde{d}_a}, m^2_{\tilde{d}_b}\Big)\Gamma^*_{\check{A}^0_j,\tilde{d}^*_a,\tilde{d}_b}\Gamma_{\check{A}^0_i,\tilde{d}^*_a,\tilde{d}_b}\\
&+ \sum_{a=1}^{6}\sum_{b=1}^{6} B_0\Big(p^2, m^2_{\tilde{e}_a}, m^2_{\tilde{e}_b}\Big)\Gamma^*_{\check{A}^0_j,\tilde{e}^*_a,\tilde{e}_b}\Gamma_{\check{A}^0_i,\tilde{e}^*_a,\tilde{e}_b}\\
&+ 3\sum_{a=1}^{6}\sum_{b=1}^{6} B_0\Big(p^2, m^2_{\tilde{u}_a}, m^2_{\tilde{u}_b}\Big)\Gamma^*_{\check{A}^0_j,\tilde{u}^*_a,\tilde{u}_b}\Gamma_{\check{A}^0_i,\tilde{u}^*_a,\tilde{u}_b} - \frac{1}{2}\sum_{a=1}^{7} A_0\Big(m^2_{\tilde{\nu}^I_a}\Big)\Gamma_{\check{A}^0_{i2^*},\check{A}^0_{j\text{-}1^*},\tilde{\nu}^I_a,\tilde{\nu}^I_a}\\
&- \frac{1}{2}\sum_{a=1}^{7} A_0\Big(m^2_{\tilde{\nu}^R_a}\Big)\Gamma_{\check{A}^0_{i2^*},\check{A}^0_{j\text{-}1^*},\tilde{\nu}^R_a,\tilde{\nu}^R_a} + \frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{7} B_0\Big(p^2, m^2_{\tilde{\nu}^I_a}, m^2_{\tilde{\nu}^I_b}\Big)\Gamma^*_{\check{A}^0_j,\tilde{\nu}^I_a,\tilde{\nu}^I_b}\Gamma_{\check{A}^0_i,\tilde{\nu}^I_a,\tilde{\nu}^I_b}\\
&+ \sum_{a=1}^{7}\sum_{b=1}^{7} B_0\Big(p^2, m^2_{\tilde{\nu}^R_a}, m^2_{\tilde{\nu}^I_b}\Big)\Gamma^*_{\check{A}^0_j,\tilde{\nu}^R_a,\tilde{\nu}^I_b}\Gamma_{\check{A}^0_i,\tilde{\nu}^R_a,\tilde{\nu}^I_b}\\
&+ \frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{7} B_0\Big(p^2, m^2_{\tilde{\nu}^R_a}, m^2_{\tilde{\nu}^R_b}\Big)\Gamma^*_{\check{A}^0_j,\tilde{\nu}^R_a,\tilde{\nu}^R_b}\Gamma_{\check{A}^0_i,\tilde{\nu}^R_a,\tilde{\nu}^R_b}\\
&- \sum_{a=1}^{7} m_{\nu_a}\sum_{b=1}^{7} B_0\Big(p^2, m^2_{\nu_a}, m^2_{\nu_b}\Big)m_{\nu_b}\Big(\Gamma^{L*}_{\check{A}^0_j,\nu_a,\nu_b}\Gamma^{R}_{\check{A}^0_i,\nu_a,\nu_b} + \Gamma^{R*}_{\check{A}^0_j,\nu_a,\nu_b}\Gamma^{L}_{\check{A}^0_i,\nu_a,\nu_b}\Big)\\
&+ \frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{7} G_0\Big(p^2, m^2_{\nu_a}, m^2_{\nu_b}\Big)\Big(\Gamma^{L*}_{\check{A}^0_j,\nu_a,\nu_b}\Gamma^{L}_{\check{A}^0_i,\nu_a,\nu_b} + \Gamma^{R*}_{\check{A}^0_j,\nu_a,\nu_b}\Gamma^{R}_{\check{A}^0_i,\nu_a,\nu_b}\Big)\\
&+ 2\sum_{b=1}^{2}\Gamma^*_{\check{A}^0_j,W^+,H^-_b}\Gamma_{\check{A}^0_i,W^+,H^-_b}F_0\Big(p^2, m^2_{H^-_b}, m^2_{W^-}\Big) + \sum_{b=1}^{3}\Gamma^*_{\check{A}^0_j,Z,h_b}\Gamma_{\check{A}^0_i,Z,h_b}F_0\Big(p^2, m^2_{h_b}, m^2_Z\Big) \qquad (202)
\end{aligned}
$$

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

$$
\begin{aligned}
\Pi_{i,j}(p^2) = &+4\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, 0, m^2_{W^-}\Big)\Big)\Gamma^*_{\check{H}^+_j,W^-,\gamma}\Gamma_{\check{H}^+_i,W^-,\gamma} + 4\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{W^-}, m^2_Z\Big)\Big)\Gamma^*_{\check{H}^+_j,Z,W^-}\Gamma_{\check{H}^+_i,Z,W^-}\\
&- B_0\Big(p^2, m^2_{\eta^Z}, m^2_{\eta^+}\Big)\Gamma_{\check{H}^+_i,\eta^-,\eta^Z}\Gamma_{\check{H}^-_j,\eta^+,\eta^-} - B_0\Big(p^2, m^2_{\eta^-}, m^2_{\eta^Z}\Big)\Gamma_{\check{H}^+_i,\eta^-,\eta^Z}\Gamma_{\check{H}^-_j,\eta^Z,\eta^-}\\
&+ 4\Gamma_{\check{H}^-_{i2^*},\check{H}^+_{j\text{-}1^*},W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{W^-} + A_0\Big(m^2_{W^-}\Big)\Big) + 2\Gamma_{\check{H}^-_{i2^*},\check{H}^+_{j\text{-}1^*},Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m^2_Z + A_0\Big(m^2_Z\Big)\Big)\\
&- \sum_{a=1}^{2} A_0\Big(m^2_{H^-_a}\Big)\Gamma_{\check{H}^-_{i2^*},\check{H}^+_{j\text{-}1^*},H^+_a,H^-_a} + \sum_{a=1}^{2}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{H^-_a}, m^2_{A^0_b}\Big)\Gamma^*_{\check{H}^+_j,H^-_a,A^0_b}\Gamma_{\check{H}^+_i,H^-_a,A^0_b}\\
&+ \sum_{a=1}^{2}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{H^-_a}, m^2_{h_b}\Big)\Gamma^*_{\check{H}^+_j,H^-_a,h_b}\Gamma_{\check{H}^+_i,H^-_a,h_b} - \frac{1}{2}\sum_{a=1}^{3} A_0\Big(m^2_{A^0_a}\Big)\Gamma_{\check{H}^-_{i2^*},\check{H}^+_{j\text{-}1^*},A^0_a,A^0_a}\\
&- \frac{1}{2}\sum_{a=1}^{3} A_0\Big(m^2_{h_a}\Big)\Gamma_{\check{H}^-_{i2^*},\check{H}^+_{j\text{-}1^*},h_a,h_a}
\end{aligned}
$$

$$
\begin{aligned}
&- 6\sum_{a=1}^{3} m_{u_a} \sum_{b=1}^{3} B_0\Big(p^2, m_{u_a}^2, m_{d_b}^2\Big) m_{d_b} \Big(\Gamma^{L*}_{\check{H}_j^+,\bar{u}_a,d_b}\Gamma^{R}_{\check{H}_i^+,\bar{u}_a,d_b} + \Gamma^{R*}_{\check{H}_j^+,\bar{u}_a,d_b}\Gamma^{L}_{\check{H}_i^+,\bar{u}_a,d_b}\Big) \\
&+ 3\sum_{a=1}^{3}\sum_{b=1}^{3} G_0\Big(p^2, m_{u_a}^2, m_{d_b}^2\Big)\Big(\Gamma^{L*}_{\check{H}_j^+,\bar{u}_a,d_b}\Gamma^{L}_{\check{H}_i^+,\bar{u}_a,d_b} + \Gamma^{R*}_{\check{H}_j^+,\bar{u}_a,d_b}\Gamma^{R}_{\check{H}_i^+,\bar{u}_a,d_b}\Big) \\
&- 2\sum_{a=1}^{5} m_{\tilde{\chi}_a^0} \sum_{b=1}^{2} B_0\Big(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^-}^2\Big) m_{\tilde{\chi}_b^-} \Big(\Gamma^{L*}_{\check{H}_j^+,\tilde{\chi}_a^0,\tilde{\chi}_b^-}\Gamma^{R}_{\check{H}_i^+,\tilde{\chi}_a^0,\tilde{\chi}_b^-} + \Gamma^{R*}_{\check{H}_j^+,\tilde{\chi}_a^0,\tilde{\chi}_b^-}\Gamma^{L}_{\check{H}_i^+,\tilde{\chi}_a^0,\tilde{\chi}_b^-}\Big) \\
&+ \sum_{a=1}^{5}\sum_{b=1}^{2} G_0\Big(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^-}^2\Big)\Big(\Gamma^{L*}_{\check{H}_j^+,\tilde{\chi}_a^0,\tilde{\chi}_b^-}\Gamma^{L}_{\check{H}_i^+,\tilde{\chi}_a^0,\tilde{\chi}_b^-} + \Gamma^{R*}_{\check{H}_j^+,\tilde{\chi}_a^0,\tilde{\chi}_b^-}\Gamma^{R}_{\check{H}_i^+,\tilde{\chi}_a^0,\tilde{\chi}_b^-}\Big) \\
&- 3\sum_{a=1}^{6} A_0\Big(m_{\tilde{d}_a}^2\Big)\Gamma_{\check{H}^-_{i2^*},\check{H}^+_{j\text{-}1^*},\tilde{d}_a^*,\tilde{d}_a} - \sum_{a=1}^{6} A_0\Big(m_{\tilde{e}_a}^2\Big)\Gamma_{\check{H}^-_{i2^*},\check{H}^+_{j\text{-}1^*},\tilde{e}_a^*,\tilde{e}_a} \\
&- 3\sum_{a=1}^{6} A_0\Big(m_{\tilde{u}_a}^2\Big)\Gamma_{\check{H}^-_{i2^*},\check{H}^+_{j\text{-}1^*},\tilde{u}_a^*,\tilde{u}_a} + 3\sum_{a=1}^{6}\sum_{b=1}^{6} B_0\Big(p^2, m_{\tilde{u}_a}^2, m_{\tilde{d}_b}^2\Big)\Gamma^*_{\check{H}_j^+,\tilde{u}_a^*,\tilde{d}_b}\Gamma_{\check{H}_i^+,\tilde{u}_a^*,\tilde{d}_b} \\
&- \frac{1}{2}\sum_{a=1}^{7} A_0\Big(m_{\tilde{\nu}_a^I}^2\Big)\Gamma_{\check{H}^-_{i2^*},\check{H}^+_{j\text{-}1^*},\tilde{\nu}_a^I,\tilde{\nu}_a^I} - \frac{1}{2}\sum_{a=1}^{7} A_0\Big(m_{\tilde{\nu}_a^R}^2\Big)\Gamma_{\check{H}^-_{i2^*},\check{H}^+_{j\text{-}1^*},\tilde{\nu}_a^R,\tilde{\nu}_a^R} \\
&- 2\sum_{a=1}^{7} m_{\nu_a} \sum_{b=1}^{3} B_0\Big(p^2, m_{\nu_a}^2, m_{e_b}^2\Big) m_{e_b} \Big(\Gamma^{L*}_{\check{H}_j^+,\nu_a,e_b}\Gamma^{R}_{\check{H}_i^+,\nu_a,e_b} + \Gamma^{R*}_{\check{H}_j^+,\nu_a,e_b}\Gamma^{L}_{\check{H}_i^+,\nu_a,e_b}\Big) \\
&+ \sum_{a=1}^{7}\sum_{b=1}^{3} G_0\Big(p^2, m_{\nu_a}^2, m_{e_b}^2\Big)\Big(\Gamma^{L*}_{\check{H}_j^+,\nu_a,e_b}\Gamma^{L}_{\check{H}_i^+,\nu_a,e_b} + \Gamma^{R*}_{\check{H}_j^+,\nu_a,e_b}\Gamma^{R}_{\check{H}_i^+,\nu_a,e_b}\Big) \\
&+ \sum_{a=1}^{7}\sum_{b=1}^{6} B_0\Big(p^2, m_{\tilde{\nu}_a^I}^2, m_{\tilde{e}_b}^2\Big)\Gamma^*_{\check{H}_j^+,\tilde{\nu}_a^I,\tilde{e}_b}\Gamma_{\check{H}_i^+,\tilde{\nu}_a^I,\tilde{e}_b} \\
&+ \sum_{a=1}^{7}\sum_{b=1}^{6} B_0\Big(p^2, m_{\tilde{\nu}_a^R}^2, m_{\tilde{e}_b}^2\Big)\Gamma^*_{\check{H}_j^+,\tilde{\nu}_a^R,\tilde{e}_b}\Gamma_{\check{H}_i^+,\tilde{\nu}_a^R,\tilde{e}_b} + \sum_{b=1}^{2}\Gamma^*_{\check{H}_j^+,\gamma,H_b^-}\Gamma_{\check{H}_i^+,\gamma,H_b^-} F_0\Big(p^2, m_{H_b^-}^2, 0\Big) \\
&+ \sum_{b=1}^{2}\Gamma^*_{\check{H}_j^+,Z,H_b^-}\Gamma_{\check{H}_i^+,Z,H_b^-} F_0\Big(p^2, m_{H_b^-}^2, m_Z^2\Big) + \sum_{b=1}^{3}\Gamma^*_{\check{H}_j^+,W^-,A_b^0}\Gamma_{\check{H}_i^+,W^-,A_b^0} F_0\Big(p^2, m_{A_b^0}^2, m_{W^-}^2\Big) \\
&+ \sum_{b=1}^{3}\Gamma^*_{\check{H}_j^+,W^-,h_b}\Gamma_{\check{H}_i^+,W^-,h_b} F_0\Big(p^2, m_{h_b}^2, m_{W^-}^2\Big)
\end{aligned} \tag{203}
$$

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

$$
\Sigma^S_{i,j}(p^2) = + \sum_{a=1}^{2} m_{\tilde{\chi}_a^-} \sum_{b=1}^{2} B_0\Big(p^2, m_{\tilde{\chi}_a^-}^2, m_{H_b^-}^2\Big)\Gamma^{L*}_{\tilde{\chi}_j^0,\tilde{\chi}_a^+,H_b^-}\Gamma^{R}_{\tilde{\chi}_i^0,\tilde{\chi}_a^+,H_b^-}
$$

$$
\begin{aligned}
&+\sum_{a=1}^{2}\sum_{b=1}^{2} B_0\Big(p^2, m^2_{\tilde{\chi}_b^-}, m^2_{H_a^-}\Big)\Gamma^{L*}_{\tilde{\chi}_j^0,H_a^+,\tilde{\chi}_b^-} m_{\tilde{\chi}_b^-}\Gamma^{R}_{\tilde{\chi}_i^0,H_a^+,\tilde{\chi}_b^-}\\
&-4\sum_{a=1}^{2}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2, m^2_{\tilde{\chi}_a^-}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}_j^0,\tilde{\chi}_a^+,W^-} m_{\tilde{\chi}_a^-}\Gamma^{L}_{\tilde{\chi}_i^0,\tilde{\chi}_a^+,W^-}\\
&+\sum_{a=1}^{3}\sum_{b=1}^{5} B_0\Big(p^2, m^2_{\tilde{\chi}_b^0}, m^2_{h_a}\Big)\Gamma^{L*}_{\tilde{\chi}_j^0,h_a,\tilde{\chi}_b^0} m_{\tilde{\chi}_b^0}\Gamma^{R}_{\tilde{\chi}_i^0,h_a,\tilde{\chi}_b^0}\\
&+3\sum_{a=1}^{3} m_{d_a}\sum_{b=1}^{6} B_0\Big(p^2, m^2_{d_a}, m^2_{\tilde{d}_b}\Big)\Gamma^{L*}_{\tilde{\chi}_j^0,\bar{d}_a,\tilde{d}_b}\Gamma^{R}_{\tilde{\chi}_i^0,\bar{d}_a,\tilde{d}_b}\\
&+\sum_{a=1}^{3} m_{e_a}\sum_{b=1}^{6} B_0\Big(p^2, m^2_{e_a}, m^2_{\tilde{e}_b}\Big)\Gamma^{L*}_{\tilde{\chi}_j^0,\bar{e}_a,\tilde{e}_b}\Gamma^{R}_{\tilde{\chi}_i^0,\bar{e}_a,\tilde{e}_b}\\
&+3\sum_{a=1}^{3} m_{u_a}\sum_{b=1}^{6} B_0\Big(p^2, m^2_{u_a}, m^2_{\tilde{u}_b}\Big)\Gamma^{L*}_{\tilde{\chi}_j^0,\bar{u}_a,\tilde{u}_b}\Gamma^{R}_{\tilde{\chi}_i^0,\bar{u}_a,\tilde{u}_b}\\
&+\sum_{a=1}^{5} m_{\tilde{\chi}_a^0}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{\tilde{\chi}_a^0}, m^2_{A_b^0}\Big)\Gamma^{L*}_{\tilde{\chi}_j^0,\tilde{\chi}_a^0,A_b^0}\Gamma^{R}_{\tilde{\chi}_i^0,\tilde{\chi}_a^0,A_b^0}\\
&+3\sum_{a=1}^{6}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{d_b}, m^2_{\tilde{d}_a}\Big)\Gamma^{L*}_{\tilde{\chi}_j^0,\tilde{d}_a^*,d_b} m_{d_b}\Gamma^{R}_{\tilde{\chi}_i^0,\tilde{d}_a^*,d_b}\\
&+\sum_{a=1}^{6}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{e_b}, m^2_{\tilde{e}_a}\Big)\Gamma^{L*}_{\tilde{\chi}_j^0,\tilde{e}_a^*,e_b} m_{e_b}\Gamma^{R}_{\tilde{\chi}_i^0,\tilde{e}_a^*,e_b}\\
&+3\sum_{a=1}^{6}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{u_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{L*}_{\tilde{\chi}_j^0,\tilde{u}_a^*,u_b} m_{u_b}\Gamma^{R}_{\tilde{\chi}_i^0,\tilde{u}_a^*,u_b}\\
&+\sum_{a=1}^{7}\sum_{b=1}^{7} B_0\Big(p^2, m^2_{\nu_b}, m^2_{\tilde{\nu}_a^I}\Big)\Gamma^{L*}_{\tilde{\chi}_j^0,\tilde{\nu}_a^I,\nu_b} m_{\nu_b}\Gamma^{R}_{\tilde{\chi}_i^0,\tilde{\nu}_a^I,\nu_b}\\
&+\sum_{a=1}^{7}\sum_{b=1}^{7} B_0\Big(p^2, m^2_{\nu_b}, m^2_{\tilde{\nu}_a^R}\Big)\Gamma^{L*}_{\tilde{\chi}_j^0,\tilde{\nu}_a^R,\nu_b} m_{\nu_b}\Gamma^{R}_{\tilde{\chi}_i^0,\tilde{\nu}_a^R,\nu_b}\\
&-4\sum_{b=1}^{2}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2, m^2_{\tilde{\chi}_b^-}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}_j^0,W^+,\tilde{\chi}_b^-} m_{\tilde{\chi}_b^-}\Gamma^{L}_{\tilde{\chi}_i^0,W^+,\tilde{\chi}_b^-}\\
&-4\sum_{b=1}^{5}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2, m^2_{\tilde{\chi}_b^0}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}_j^0,Z,\tilde{\chi}_b^0} m_{\tilde{\chi}_b^0}\Gamma^{L}_{\tilde{\chi}_i^0,Z,\tilde{\chi}_b^0}
\end{aligned}
\tag{204}
$$

$$
\Sigma^R_{i,j}(p^2) = -\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\tilde{\chi}_a^-}, m^2_{H_b^-}\Big)\Gamma^{R*}_{\tilde{\chi}_j^0,\tilde{\chi}_a^+,H_b^-}\Gamma^{R}_{\tilde{\chi}_i^0,\tilde{\chi}_a^+,H_b^-}
$$

$$
\begin{aligned}
&- \frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{H^-_a}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,H^+_a,\tilde{\chi}^-_b}\Gamma^{R}_{\tilde{\chi}^0_i,H^+_a,\tilde{\chi}^-_b} \\
&- \sum_{a=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^-_a}, m^2_{W^-}\Big)\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{\chi}^+_a,W^-}\Gamma^{L}_{\tilde{\chi}^0_i,\tilde{\chi}^+_a,W^-} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{h_a}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,h_a,\tilde{\chi}^0_b}\Gamma^{R}_{\tilde{\chi}^0_i,h_a,\tilde{\chi}^0_b} \\
&- \frac{3}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{d_a}, m^2_{\tilde{d}_b}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,\bar{d}_a,\tilde{d}_b}\Gamma^{R}_{\tilde{\chi}^0_i,\bar{d}_a,\tilde{d}_b} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{e_a}, m^2_{\tilde{e}_b}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,\bar{e}_a,\tilde{e}_b}\Gamma^{R}_{\tilde{\chi}^0_i,\bar{e}_a,\tilde{e}_b} \\
&- \frac{3}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{u_a}, m^2_{\tilde{u}_b}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,\bar{u}_a,\tilde{u}_b}\Gamma^{R}_{\tilde{\chi}^0_i,\bar{u}_a,\tilde{u}_b} \\
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{\tilde{\chi}^0_a}, m^2_{A^0_b}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,\tilde{\chi}^0_a,A^0_b}\Gamma^{R}_{\tilde{\chi}^0_i,\tilde{\chi}^0_a,A^0_b} \\
&- \frac{3}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{d_b}, m^2_{\tilde{d}_a}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,\tilde{d}^*_a,d_b}\Gamma^{R}_{\tilde{\chi}^0_i,\tilde{d}^*_a,d_b} \\
&- \frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{\tilde{e}_a}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,\tilde{e}^*_a,e_b}\Gamma^{R}_{\tilde{\chi}^0_i,\tilde{e}^*_a,e_b} \\
&- \frac{3}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,\tilde{u}^*_a,u_b}\Gamma^{R}_{\tilde{\chi}^0_i,\tilde{u}^*_a,u_b} \\
&- \frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{7} B_1\Big(p^2, m^2_{\nu_b}, m^2_{\tilde{\nu}^I_a}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,\tilde{\nu}^I_a,\nu_b}\Gamma^{R}_{\tilde{\chi}^0_i,\tilde{\nu}^I_a,\nu_b} \\
&- \frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{7} B_1\Big(p^2, m^2_{\nu_b}, m^2_{\tilde{\nu}^R_a}\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,\tilde{\nu}^R_a,\nu_b}\Gamma^{R}_{\tilde{\chi}^0_i,\tilde{\nu}^R_a,\nu_b} \\
&- \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{W^-}\Big)\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,W^+,\tilde{\chi}^-_b}\Gamma^{L}_{\tilde{\chi}^0_i,W^+,\tilde{\chi}^-_b} \\
&- \sum_{b=1}^{5}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{Z}\Big)\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,Z,\tilde{\chi}^0_b}\Gamma^{L}_{\tilde{\chi}^0_i,Z,\tilde{\chi}^0_b} \qquad (205)
\end{aligned}
$$

$$
\Sigma^L_{i,j}(p^2) = -\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\tilde{\chi}^-_a}, m^2_{H^-_b}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{\chi}^+_a,H^-_b}\Gamma^{L}_{\tilde{\chi}^0_i,\tilde{\chi}^+_a,H^-_b}
$$

$$
\begin{aligned}
&- \frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,H^+_a,\tilde{\chi}^-_b}\Gamma^{L}_{\tilde{\chi}^0_i,H^+_a,\tilde{\chi}^-_b} \\
&- \sum_{a=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^-_a}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,\tilde{\chi}^+_a,W^-}\Gamma^{R}_{\tilde{\chi}^0_i,\tilde{\chi}^+_a,W^-} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,h_a,\tilde{\chi}^0_b}\Gamma^{L}_{\tilde{\chi}^0_i,h_a,\tilde{\chi}^0_b} \\
&- \frac{3}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{d_a}, m^2_{\tilde{d}_b}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\bar{d}_a,\tilde{d}_b}\Gamma^{L}_{\tilde{\chi}^0_i,\bar{d}_a,\tilde{d}_b} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{e_a}, m^2_{\tilde{e}_b}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\bar{e}_a,\tilde{e}_b}\Gamma^{L}_{\tilde{\chi}^0_i,\bar{e}_a,\tilde{e}_b} \\
&- \frac{3}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{u_a}, m^2_{\tilde{u}_b}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\bar{u}_a,\tilde{u}_b}\Gamma^{L}_{\tilde{\chi}^0_i,\bar{u}_a,\tilde{u}_b} \\
&- \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{\tilde{\chi}^0_a}, m^2_{A^0_b}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{\chi}^0_a,A^0_b}\Gamma^{L}_{\tilde{\chi}^0_i,\tilde{\chi}^0_a,A^0_b} \\
&- \frac{3}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{d_b}, m^2_{\tilde{d}_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{d}^*_a,d_b}\Gamma^{L}_{\tilde{\chi}^0_i,\tilde{d}^*_a,d_b} \\
&- \frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{\tilde{e}_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{e}^*_a,e_b}\Gamma^{L}_{\tilde{\chi}^0_i,\tilde{e}^*_a,e_b} \\
&- \frac{3}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{u_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{u}^*_a,u_b}\Gamma^{L}_{\tilde{\chi}^0_i,\tilde{u}^*_a,u_b} \\
&- \frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{7} B_1\Big(p^2, m^2_{\nu_b}, m^2_{\tilde{\nu}^I_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{\nu}^I_a,\nu_b}\Gamma^{L}_{\tilde{\chi}^0_i,\tilde{\nu}^I_a,\nu_b} \\
&- \frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{7} B_1\Big(p^2, m^2_{\nu_b}, m^2_{\tilde{\nu}^R_a}\Big)\Gamma^{L*}_{\tilde{\chi}^0_j,\tilde{\nu}^R_a,\nu_b}\Gamma^{L}_{\tilde{\chi}^0_i,\tilde{\nu}^R_a,\nu_b} \\
&- \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,W^+,\tilde{\chi}^-_b}\Gamma^{R}_{\tilde{\chi}^0_i,W^+,\tilde{\chi}^-_b} \\
&- \sum_{b=1}^{5}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^0_j,Z,\tilde{\chi}^0_b}\Gamma^{R}_{\tilde{\chi}^0_i,Z,\tilde{\chi}^0_b}
\end{aligned}
\tag{206}
$$

- **Self-Energy for Neutrinos** (ν)

$$
\Sigma^S_{i,j}(p^2) = +\sum_{a=1}^{2}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{e_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\check{\nu}_j,H^+_a,e_b} m_{e_b}\Gamma^{R}_{\check{\nu}_i,H^+_a,e_b}
$$

$$
\begin{aligned}
&+\sum_{a=1}^{2} m_{\tilde{\chi}_a^-}\sum_{b=1}^{6} B_0\Big(p^2, m^2_{\tilde{\chi}_a^-}, m^2_{\tilde{e}_b}\Big)\Gamma^{L*}_{\check{\nu}_j,\tilde{\chi}_a^+,\tilde{e}_b}\Gamma^{R}_{\check{\nu}_i,\tilde{\chi}_a^+,\tilde{e}_b}\\
&+\sum_{a=1}^{3} m_{e_a}\sum_{b=1}^{2} B_0\Big(p^2, m^2_{e_a}, m^2_{H_b^-}\Big)\Gamma^{L*}_{\check{\nu}_j,\bar{e}_a,H_b^-}\Gamma^{R}_{\check{\nu}_i,\bar{e}_a,H_b^-}\\
&+\sum_{a=1}^{3}\sum_{b=1}^{7} B_0\Big(p^2, m^2_{\nu_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\check{\nu}_j,h_a,\nu_b} m_{\nu_b}\Gamma^{R}_{\check{\nu}_i,h_a,\nu_b}\\
&-4\sum_{a=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2, m^2_{e_a}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,\bar{e}_a,W^-} m_{e_a}\Gamma^{L}_{\check{\nu}_i,\bar{e}_a,W^-}\\
&+\sum_{a=1}^{6}\sum_{b=1}^{2} B_0\Big(p^2, m^2_{\tilde{\chi}_b^-}, m^2_{\tilde{e}_a}\Big)\Gamma^{L*}_{\check{\nu}_j,\tilde{e}_a^*,\tilde{\chi}_b^-} m_{\tilde{\chi}_b^-}\Gamma^{R}_{\check{\nu}_i,\tilde{e}_a^*,\tilde{\chi}_b^-}\\
&+\sum_{a=1}^{7} m_{\nu_a}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{\nu_a}, m^2_{A_b^0}\Big)\Gamma^{L*}_{\check{\nu}_j,\nu_a,A_b^0}\Gamma^{R}_{\check{\nu}_i,\nu_a,A_b^0}\\
&+\sum_{a=1}^{7}\sum_{b=1}^{5} B_0\Big(p^2, m^2_{\tilde{\chi}_b^0}, m^2_{\tilde{\nu}_a^I}\Big)\Gamma^{L*}_{\check{\nu}_j,\tilde{\nu}_a^I,\tilde{\chi}_b^0} m_{\tilde{\chi}_b^0}\Gamma^{R}_{\check{\nu}_i,\tilde{\nu}_a^I,\tilde{\chi}_b^0}\\
&+\sum_{a=1}^{7}\sum_{b=1}^{5} B_0\Big(p^2, m^2_{\tilde{\chi}_b^0}, m^2_{\tilde{\nu}_a^R}\Big)\Gamma^{L*}_{\check{\nu}_j,\tilde{\nu}_a^R,\tilde{\chi}_b^0} m_{\tilde{\chi}_b^0}\Gamma^{R}_{\check{\nu}_i,\tilde{\nu}_a^R,\tilde{\chi}_b^0}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2, m^2_{e_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,W^+,e_b} m_{e_b}\Gamma^{L}_{\check{\nu}_i,W^+,e_b}\\
&-4\sum_{b=1}^{7}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2, m^2_{\nu_b}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,Z,\nu_b} m_{\nu_b}\Gamma^{L}_{\check{\nu}_i,Z,\nu_b} \qquad (207)\\
\Sigma^R_{i,j}(p^2) &= -\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{H_a^-}\Big)\Gamma^{R*}_{\check{\nu}_j,H_a^+,e_b}\Gamma^{R}_{\check{\nu}_i,H_a^+,e_b}\\
&-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{\tilde{\chi}_a^-}, m^2_{\tilde{e}_b}\Big)\Gamma^{R*}_{\check{\nu}_j,\tilde{\chi}_a^+,\tilde{e}_b}\Gamma^{R}_{\check{\nu}_i,\tilde{\chi}_a^+,\tilde{e}_b}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{e_a}, m^2_{H_b^-}\Big)\Gamma^{R*}_{\check{\nu}_j,\bar{e}_a,H_b^-}\Gamma^{R}_{\check{\nu}_i,\bar{e}_a,H_b^-}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{7} B_1\Big(p^2, m^2_{\nu_b}, m^2_{h_a}\Big)\Gamma^{R*}_{\check{\nu}_j,h_a,\nu_b}\Gamma^{R}_{\check{\nu}_i,h_a,\nu_b}-\sum_{a=1}^{3}\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2, m^2_{e_a}, m^2_{W^-}\Big)\Big)\Gamma^{L*}_{\check{\nu}_j,\bar{e}_a,W^-}\Gamma^{L}_{\check{\nu}_i,\bar{e}_a,W^-}\\
&-\frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\tilde{\chi}_b^-}, m^2_{\tilde{e}_a}\Big)\Gamma^{R*}_{\check{\nu}_j,\tilde{e}_a^*,\tilde{\chi}_b^-}\Gamma^{R}_{\check{\nu}_i,\tilde{e}_a^*,\tilde{\chi}_b^-}
\end{aligned}
$$

$$
\begin{aligned}
&- \frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{\nu_a}, m^2_{A^0_b}\Big)\Gamma^{R*}_{\check{\nu}_j,\nu_a,A^0_b}\Gamma^{R}_{\check{\nu}_i,\nu_a,A^0_b} \\
&- \frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{\tilde{\nu}^I_a}\Big)\Gamma^{R*}_{\check{\nu}_j,\tilde{\nu}^I_a,\tilde{\chi}^0_b}\Gamma^{R}_{\check{\nu}_i,\tilde{\nu}^I_a,\tilde{\chi}^0_b} \\
&- \frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{\tilde{\nu}^R_a}\Big)\Gamma^{R*}_{\check{\nu}_j,\tilde{\nu}^R_a,\tilde{\chi}^0_b}\Gamma^{R}_{\check{\nu}_i,\tilde{\nu}^R_a,\tilde{\chi}^0_b} \\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{e_b}, m^2_{W^-}\Big)\Big)\Gamma^{L*}_{\check{\nu}_j,W^+,e_b}\Gamma^{L}_{\check{\nu}_i,W^+,e_b} - \sum_{b=1}^{7}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu_b}, m^2_Z\Big)\Big)\Gamma^{L*}_{\check{\nu}_j,Z,\nu_b}\Gamma^{L}_{\check{\nu}_i,Z,\nu_b}
\end{aligned}
\tag{208}
$$

$$
\begin{aligned}
\Sigma^L_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\check{\nu}_j,H^+_a,e_b}\Gamma^{L}_{\check{\nu}_i,H^+_a,e_b} \\
&- \frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{\tilde{\chi}^-_a}, m^2_{\tilde{e}_b}\Big)\Gamma^{L*}_{\check{\nu}_j,\tilde{\chi}^+_a,\tilde{e}_b}\Gamma^{L}_{\check{\nu}_i,\tilde{\chi}^+_a,\tilde{e}_b} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\bar{e}_a}, m^2_{H^-_b}\Big)\Gamma^{L*}_{\check{\nu}_j,\bar{e}_a,H^-_b}\Gamma^{L}_{\check{\nu}_i,\bar{e}_a,H^-_b} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{7} B_1\Big(p^2, m^2_{\nu_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\check{\nu}_j,h_a,\nu_b}\Gamma^{L}_{\check{\nu}_i,h_a,\nu_b} - \sum_{a=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\bar{e}_a}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,\bar{e}_a,W^-}\Gamma^{R}_{\check{\nu}_i,\bar{e}_a,W^-} \\
&- \frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{\tilde{e}_a}\Big)\Gamma^{L*}_{\check{\nu}_j,\tilde{e}^*_a,\tilde{\chi}^-_b}\Gamma^{L}_{\check{\nu}_i,\tilde{e}^*_a,\tilde{\chi}^-_b} \\
&- \frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{\nu_a}, m^2_{A^0_b}\Big)\Gamma^{L*}_{\check{\nu}_j,\nu_a,A^0_b}\Gamma^{L}_{\check{\nu}_i,\nu_a,A^0_b} \\
&- \frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{\tilde{\nu}^I_a}\Big)\Gamma^{L*}_{\check{\nu}_j,\tilde{\nu}^I_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{\nu}_i,\tilde{\nu}^I_a,\tilde{\chi}^0_b} \\
&- \frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{\tilde{\nu}^R_a}\Big)\Gamma^{L*}_{\check{\nu}_j,\tilde{\nu}^R_a,\tilde{\chi}^0_b}\Gamma^{L}_{\check{\nu}_i,\tilde{\nu}^R_a,\tilde{\chi}^0_b} \\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{e_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,W^+,e_b}\Gamma^{R}_{\check{\nu}_i,W^+,e_b} - \sum_{b=1}^{7}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu_b}, m^2_Z\Big)\Big)\Gamma^{R*}_{\check{\nu}_j,Z,\nu_b}\Gamma^{R}_{\check{\nu}_i,Z,\nu_b}
\end{aligned}
\tag{209}
$$

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

$$
\Sigma^S_{i,j}(p^2) = +\sum_{a=1}^{2} m_{\tilde{\chi}^-_a}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{\tilde{\chi}^-_a}, m^2_{A^0_b}\Big)\Gamma^{L*}_{\check{\tilde{\chi}}^+_j,\tilde{\chi}^-_a,A^0_b}\Gamma^{R}_{\check{\tilde{\chi}}^+_i,\tilde{\chi}^-_a,A^0_b}
$$

$$
\begin{aligned}
&+\sum_{a=1}^{2}\sum_{b=1}^{5} B_0\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\tilde{\tilde{\chi}}^+_j,H^-_a,\tilde{\chi}^0_b} m_{\tilde{\chi}^0_b}\Gamma^{R}_{\tilde{\tilde{\chi}}^+_i,H^-_a,\tilde{\chi}^0_b}\\
&+\sum_{a=1}^{3}\sum_{b=1}^{2} B_0\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\tilde{\tilde{\chi}}^+_j,h_a,\tilde{\chi}^-_b} m_{\tilde{\chi}^-_b}\Gamma^{R}_{\tilde{\tilde{\chi}}^+_i,h_a,\tilde{\chi}^-_b}\\
&+3\sum_{a=1}^{3} m_{u_a}\sum_{b=1}^{6} B_0\Big(p^2, m^2_{u_a}, m^2_{\tilde{d}_b}\Big)\Gamma^{L*}_{\tilde{\tilde{\chi}}^+_j,\bar{u}_a,\tilde{d}_b}\Gamma^{R}_{\tilde{\tilde{\chi}}^+_i,\bar{u}_a,\tilde{d}_b}\\
&+3\sum_{a=1}^{6}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{d_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{L*}_{\tilde{\tilde{\chi}}^+_j,\tilde{u}^*_a,d_b} m_{d_b}\Gamma^{R}_{\tilde{\tilde{\chi}}^+_i,\tilde{u}^*_a,d_b}\\
&+\sum_{a=1}^{6}\sum_{b=1}^{7} B_0\Big(p^2, m^2_{\nu_b}, m^2_{\tilde{e}_a}\Big)\Gamma^{L*}_{\tilde{\tilde{\chi}}^+_j,\tilde{e}_a,\nu_b} m_{\nu_b}\Gamma^{R}_{\tilde{\tilde{\chi}}^+_i,\tilde{e}_a,\nu_b}\\
&+\sum_{a=1}^{7}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{e_b}, m^2_{\tilde{\nu}^I_a}\Big)\Gamma^{L*}_{\tilde{\tilde{\chi}}^+_j,\tilde{\nu}^I_a,e_b} m_{e_b}\Gamma^{R}_{\tilde{\tilde{\chi}}^+_i,\tilde{\nu}^I_a,e_b}\\
&+\sum_{a=1}^{7}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{e_b}, m^2_{\tilde{\nu}^R_a}\Big)\Gamma^{L*}_{\tilde{\tilde{\chi}}^+_j,\tilde{\nu}^R_a,e_b} m_{e_b}\Gamma^{R}_{\tilde{\tilde{\chi}}^+_i,\tilde{\nu}^R_a,e_b}\\
&-4\sum_{b=1}^{2}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2, m^2_{\tilde{\chi}^-_b}, 0\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{\chi}}^+_j,\gamma,\tilde{\chi}^-_b} m_{\tilde{\chi}^-_b}\Gamma^{L}_{\tilde{\tilde{\chi}}^+_i,\gamma,\tilde{\chi}^-_b}\\
&-4\sum_{b=1}^{2}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{\chi}}^+_j,Z,\tilde{\chi}^-_b} m_{\tilde{\chi}^-_b}\Gamma^{L}_{\tilde{\tilde{\chi}}^+_i,Z,\tilde{\chi}^-_b}\\
&-4\sum_{b=1}^{5}\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{\chi}}^+_j,W^-,\tilde{\chi}^0_b} m_{\tilde{\chi}^0_b}\Gamma^{L}_{\tilde{\tilde{\chi}}^+_i,W^-,\tilde{\chi}^0_b} \qquad (210)\\
\Sigma^R_{i,j}(p^2) &= -\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{\tilde{\chi}^-_a}, m^2_{A^0_b}\Big)\Gamma^{R*}_{\tilde{\tilde{\chi}}^+_j,\tilde{\chi}^-_a,A^0_b}\Gamma^{R}_{\tilde{\tilde{\chi}}^+_i,\tilde{\chi}^-_a,A^0_b}\\
&-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{H^-_a}\Big)\Gamma^{R*}_{\tilde{\tilde{\chi}}^+_j,H^-_a,\tilde{\chi}^0_b}\Gamma^{R}_{\tilde{\tilde{\chi}}^+_i,H^-_a,\tilde{\chi}^0_b}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{h_a}\Big)\Gamma^{R*}_{\tilde{\tilde{\chi}}^+_j,h_a,\tilde{\chi}^-_b}\Gamma^{R}_{\tilde{\tilde{\chi}}^+_i,h_a,\tilde{\chi}^-_b}\\
&-\frac{3}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{u_a}, m^2_{\tilde{d}_b}\Big)\Gamma^{R*}_{\tilde{\tilde{\chi}}^+_j,\bar{u}_a,\tilde{d}_b}\Gamma^{R}_{\tilde{\tilde{\chi}}^+_i,\bar{u}_a,\tilde{d}_b}\\
&-\frac{3}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{d_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{R*}_{\tilde{\tilde{\chi}}^+_j,\tilde{u}^*_a,d_b}\Gamma^{R}_{\tilde{\tilde{\chi}}^+_i,\tilde{u}^*_a,d_b}
\end{aligned}
$$

$$
\begin{aligned}
&- \frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{7} B_1\Big(p^2, m^2_{\nu_b}, m^2_{\tilde{e}_a}\Big)\Gamma^{R*}_{\tilde{\chi}^+_j,\tilde{e}_a,\nu_b}\Gamma^{R}_{\tilde{\chi}^+_i,\tilde{e}_a,\nu_b} \\
&- \frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{\tilde{\nu}^I_a}\Big)\Gamma^{R*}_{\tilde{\chi}^+_j,\tilde{\nu}^I_a,e_b}\Gamma^{R}_{\tilde{\chi}^+_i,\tilde{\nu}^I_a,e_b} \\
&- \frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{\tilde{\nu}^R_a}\Big)\Gamma^{R*}_{\tilde{\chi}^+_j,\tilde{\nu}^R_a,e_b}\Gamma^{R}_{\tilde{\chi}^+_i,\tilde{\nu}^R_a,e_b} \\
&- \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, 0\Big)\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,\gamma,\tilde{\chi}^-_b}\Gamma^{L}_{\tilde{\chi}^+_i,\gamma,\tilde{\chi}^-_b} - \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_Z\Big)\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,Z,\tilde{\chi}^-_b}\Gamma^{L}_{\tilde{\chi}^+_i,Z,\tilde{\chi}^-_b} \\
&- \sum_{b=1}^{5}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{W^-}\Big)\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,W^-,\tilde{\chi}^0_b}\Gamma^{L}_{\tilde{\chi}^+_i,W^-,\tilde{\chi}^0_b} \qquad (211)
\end{aligned}
$$

$$
\begin{aligned}
\Sigma^L_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{\tilde{\chi}^-_a}, m^2_{A^0_b}\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,\tilde{\chi}^-_a,A^0_b}\Gamma^{L}_{\tilde{\chi}^+_i,\tilde{\chi}^-_a,A^0_b} \\
&- \frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,H^-_a,\tilde{\chi}^0_b}\Gamma^{L}_{\tilde{\chi}^+_i,H^-_a,\tilde{\chi}^0_b} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,h_a,\tilde{\chi}^-_b}\Gamma^{L}_{\tilde{\chi}^+_i,h_a,\tilde{\chi}^-_b} \\
&- \frac{3}{2}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m^2_{u_a}, m^2_{\tilde{d}_b}\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,\bar{u}_a,\tilde{d}_b}\Gamma^{L}_{\tilde{\chi}^+_i,\bar{u}_a,\tilde{d}_b} \\
&- \frac{3}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{d_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,\tilde{u}^*_a,d_b}\Gamma^{L}_{\tilde{\chi}^+_i,\tilde{u}^*_a,d_b} \\
&- \frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{7} B_1\Big(p^2, m^2_{\nu_b}, m^2_{\tilde{e}_a}\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,\tilde{e}_a,\nu_b}\Gamma^{L}_{\tilde{\chi}^+_i,\tilde{e}_a,\nu_b} \\
&- \frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{\tilde{\nu}^I_a}\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,\tilde{\nu}^I_a,e_b}\Gamma^{L}_{\tilde{\chi}^+_i,\tilde{\nu}^I_a,e_b} \\
&- \frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{\tilde{\nu}^R_a}\Big)\Gamma^{L*}_{\tilde{\chi}^+_j,\tilde{\nu}^R_a,e_b}\Gamma^{L}_{\tilde{\chi}^+_i,\tilde{\nu}^R_a,e_b} \\
&- \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, 0\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^+_j,\gamma,\tilde{\chi}^-_b}\Gamma^{R}_{\tilde{\chi}^+_i,\gamma,\tilde{\chi}^-_b} - \sum_{b=1}^{2}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_Z\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^+_j,Z,\tilde{\chi}^-_b}\Gamma^{R}_{\tilde{\chi}^+_i,Z,\tilde{\chi}^-_b} \\
&- \sum_{b=1}^{5}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\tilde{\chi}^+_j,W^-,\tilde{\chi}^0_b}\Gamma^{R}_{\tilde{\chi}^+_i,W^-,\tilde{\chi}^0_b} \qquad (212)
\end{aligned}
$$

- **Self-Energy for Leptons** (e)

$$
\begin{aligned}
\Sigma^S_{i,j}(p^2) = &+\sum_{a=1}^{2}\sum_{b=1}^{7} B_0\Big(p^2, m^2_{\nu_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\check{e}_j,H^-_a,\nu_b} m_{\nu_b}\Gamma^{R}_{\check{e}_i,H^-_a,\nu_b}\\
&+\sum_{a=1}^{3} m_{e_a}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{e_a}, m^2_{A^0_b}\Big)\Gamma^{L*}_{\check{e}_j,e_a,A^0_b}\Gamma^{R}_{\check{e}_i,e_a,A^0_b}\\
&+\sum_{a=1}^{3}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{e_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\check{e}_j,h_a,e_b} m_{e_b}\Gamma^{R}_{\check{e}_i,h_a,e_b}\\
&+\sum_{a=1}^{6}\sum_{b=1}^{5} B_0\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{\tilde{e}_a}\Big)\Gamma^{L*}_{\check{e}_j,\tilde{e}_a,\tilde{\chi}^0_b} m_{\tilde{\chi}^0_b}\Gamma^{R}_{\check{e}_i,\tilde{e}_a,\tilde{\chi}^0_b}\\
&+\sum_{a=1}^{7}\sum_{b=1}^{2} B_0\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{\tilde{\nu}^I_a}\Big)\Gamma^{L*}_{\check{e}_j,\tilde{\nu}^I_a,\tilde{\chi}^-_b} m_{\tilde{\chi}^-_b}\Gamma^{R}_{\check{e}_i,\tilde{\nu}^I_a,\tilde{\chi}^-_b}\\
&+\sum_{a=1}^{7}\sum_{b=1}^{2} B_0\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{\tilde{\nu}^R_a}\Big)\Gamma^{L*}_{\check{e}_j,\tilde{\nu}^R_a,\tilde{\chi}^-_b} m_{\tilde{\chi}^-_b}\Gamma^{R}_{\check{e}_i,\tilde{\nu}^R_a,\tilde{\chi}^-_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{e_b}, 0\Big)\Big)\Gamma^{R*}_{\check{e}_j,\gamma,e_b} m_{e_b}\Gamma^{L}_{\check{e}_i,\gamma,e_b} - 4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{e_b}, m^2_Z\Big)\Big)\Gamma^{R*}_{\check{e}_j,Z,e_b} m_{e_b}\Gamma^{L}_{\check{e}_i,Z,e_b}\\
&-4\sum_{b=1}^{7}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{\nu_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\check{e}_j,W^-,\nu_b} m_{\nu_b}\Gamma^{L}_{\check{e}_i,W^-,\nu_b} \qquad (213)\\
\Sigma^R_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{7} B_1\Big(p^2, m^2_{\nu_b}, m^2_{H^-_a}\Big)\Gamma^{R*}_{\check{e}_j,H^-_a,\nu_b}\Gamma^{R}_{\check{e}_i,H^-_a,\nu_b}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_a}, m^2_{A^0_b}\Big)\Gamma^{R*}_{\check{e}_j,e_a,A^0_b}\Gamma^{R}_{\check{e}_i,e_a,A^0_b}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{h_a}\Big)\Gamma^{R*}_{\check{e}_j,h_a,e_b}\Gamma^{R}_{\check{e}_i,h_a,e_b}\\
&-\frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{\tilde{e}_a}\Big)\Gamma^{R*}_{\check{e}_j,\tilde{e}_a,\tilde{\chi}^0_b}\Gamma^{R}_{\check{e}_i,\tilde{e}_a,\tilde{\chi}^0_b}\\
&-\frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{\tilde{\nu}^I_a}\Big)\Gamma^{R*}_{\check{e}_j,\tilde{\nu}^I_a,\tilde{\chi}^-_b}\Gamma^{R}_{\check{e}_i,\tilde{\nu}^I_a,\tilde{\chi}^-_b}\\
&-\frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{\tilde{\nu}^R_a}\Big)\Gamma^{R*}_{\check{e}_j,\tilde{\nu}^R_a,\tilde{\chi}^-_b}\Gamma^{R}_{\check{e}_i,\tilde{\nu}^R_a,\tilde{\chi}^-_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{e_b}, 0\Big)\Big)\Gamma^{L*}_{\check{e}_j,\gamma,e_b}\Gamma^{L}_{\check{e}_i,\gamma,e_b}\\
&-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{e_b}, m^2_Z\Big)\Big)\Gamma^{L*}_{\check{e}_j,Z,e_b}\Gamma^{L}_{\check{e}_i,Z,e_b} - \sum_{b=1}^{7}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu_b}, m^2_{W^-}\Big)\Big)\Gamma^{L*}_{\check{e}_j,W^-,\nu_b}\Gamma^{L}_{\check{e}_i,W^-,\nu_b} \qquad (214)
\end{aligned}
$$

$$
\begin{aligned}
\Sigma^L_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{7} B_1\Big(p^2, m^2_{\nu_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\tilde{\tilde{e}}_j,H^-_a,\nu_b}\Gamma^{L}_{\tilde{\tilde{e}}_i,H^-_a,\nu_b}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_a}, m^2_{A^0_b}\Big)\Gamma^{L*}_{\tilde{\tilde{e}}_j,e_a,A^0_b}\Gamma^{L}_{\tilde{\tilde{e}}_i,e_a,A^0_b}\\
&-\frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m^2_{e_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\tilde{\tilde{e}}_j,h_a,e_b}\Gamma^{L}_{\tilde{\tilde{e}}_i,h_a,e_b}\\
&-\frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{5} B_1\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{\tilde{\tilde{e}}_a}\Big)\Gamma^{L*}_{\tilde{\tilde{e}}_j,\tilde{e}_a,\tilde{\chi}^0_b}\Gamma^{L}_{\tilde{\tilde{e}}_i,\tilde{e}_a,\tilde{\chi}^0_b}\\
&-\frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{\tilde{\nu}^I_a}\Big)\Gamma^{L*}_{\tilde{\tilde{e}}_j,\tilde{\nu}^I_a,\tilde{\chi}^-_b}\Gamma^{L}_{\tilde{\tilde{e}}_i,\tilde{\nu}^I_a,\tilde{\chi}^-_b}\\
&-\frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{2} B_1\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{\tilde{\nu}^R_a}\Big)\Gamma^{L*}_{\tilde{\tilde{e}}_j,\tilde{\nu}^R_a,\tilde{\chi}^-_b}\Gamma^{L}_{\tilde{\tilde{e}}_i,\tilde{\nu}^R_a,\tilde{\chi}^-_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{e_b}, 0\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{e}}_j,\gamma,e_b}\Gamma^{R}_{\tilde{\tilde{e}}_i,\gamma,e_b}\\
&-\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{e_b}, m^2_{Z}\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{e}}_j,Z,e_b}\Gamma^{R}_{\tilde{\tilde{e}}_i,Z,e_b} - \sum_{b=1}^{7}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m^2_{\nu_b}, m^2_{W^-}\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{e}}_j,W^-,\nu_b}\Gamma^{R}_{\tilde{\tilde{e}}_i,W^-,\nu_b}
\end{aligned}
\tag{215}
$$

- **Self-Energy for Down-Quarks** (d)

$$
\begin{aligned}
\Sigma^S_{i,j}(p^2) = &+\sum_{a=1}^{2}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{u_b}, m^2_{H^-_a}\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,H^-_a,u_b} m_{u_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,H^-_a,u_b}\\
&+\sum_{a=1}^{3} m_{d_a}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{d_a}, m^2_{A^0_b}\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,d_a,A^0_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,d_a,A^0_b}\\
&+\sum_{a=1}^{3}\sum_{b=1}^{3} B_0\Big(p^2, m^2_{d_b}, m^2_{h_a}\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,h_a,d_b} m_{d_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,h_a,d_b}\\
&+\sum_{a=1}^{6}\sum_{b=1}^{2} B_0\Big(p^2, m^2_{\tilde{\chi}^-_b}, m^2_{\tilde{u}_a}\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,\tilde{u}_a,\tilde{\chi}^-_b} m_{\tilde{\chi}^-_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,\tilde{u}_a,\tilde{\chi}^-_b}\\
&+\sum_{a=1}^{6}\sum_{b=1}^{5} B_0\Big(p^2, m^2_{\tilde{\chi}^0_b}, m^2_{\tilde{d}_a}\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,\tilde{d}_a,\tilde{\chi}^0_b} m_{\tilde{\chi}^0_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,\tilde{d}_a,\tilde{\chi}^0_b}\\
&+\frac{4}{3} m_{\tilde{g}}\sum_{a=1}^{6} B_0\Big(p^2, m^2_{\tilde{g}}, m^2_{\tilde{d}_a}\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,\tilde{d}_a,\tilde{g}_1}\Gamma^{R}_{\tilde{\tilde{d}}_i,\tilde{d}_a,\tilde{g}_1} - \frac{16}{3}\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{d_b}, 0\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,g,d_b} m_{d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,g,d_b}\\
&-4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m^2_{d_b}, 0\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,\gamma,d_b} m_{d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,\gamma,d_b}
\end{aligned}
$$

$$
\begin{aligned}
&- 4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{u_b}^2, m_{W^-}^2\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,W^-,u_b} m_{u_b} \Gamma^{L}_{\tilde{\tilde{d}}_i,W^-,u_b} \\
&- 4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{d_b}^2, m_Z^2\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,Z,d_b} m_{d_b} \Gamma^{L}_{\tilde{\tilde{d}}_i,Z,d_b} \qquad (216)
\end{aligned}
$$

$$
\begin{aligned}
\Sigma^R_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m_{u_b}^2, m_{H_a^-}^2\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,H_a^-,u_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,H_a^-,u_b} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{d_a}^2, m_{A_b^0}^2\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,d_a,A_b^0}\Gamma^{R}_{\tilde{\tilde{d}}_i,d_a,A_b^0} \\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, m_{h_a}^2\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,h_a,d_b}\Gamma^{R}_{\tilde{\tilde{d}}_i,h_a,d_b} \\
&- \frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{2} B_1\Big(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,\tilde{u}_a,\tilde{\chi}_b^-}\Gamma^{R}_{\tilde{\tilde{d}}_i,\tilde{u}_a,\tilde{\chi}_b^-} \\
&- \frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{5} B_1\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,\tilde{d}_a,\tilde{\chi}_b^0}\Gamma^{R}_{\tilde{\tilde{d}}_i,\tilde{d}_a,\tilde{\chi}_b^0} \\
&- \frac{2}{3}\sum_{a=1}^{6} B_1\Big(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2\Big)\Gamma^{R*}_{\tilde{\tilde{d}}_j,\tilde{d}_a,\tilde{g}_1}\Gamma^{R}_{\tilde{\tilde{d}}_i,\tilde{d}_a,\tilde{g}_1} - \frac{4}{3}\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, 0\Big)\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,g,d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,g,d_b} \\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, 0\Big)\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,\gamma,d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,\gamma,d_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{u_b}^2, m_{W^-}^2\Big)\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,W^-,u_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,W^-,u_b} \\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, m_Z^2\Big)\Big)\Gamma^{L*}_{\tilde{\tilde{d}}_j,Z,d_b}\Gamma^{L}_{\tilde{\tilde{d}}_i,Z,d_b} \qquad (217)
\end{aligned}
$$

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

$$
\begin{aligned}
&- \frac{2}{3}\sum_{a=1}^{6} B_1\Big(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2\Big)\Gamma^{L*}_{\check{\tilde{d}}_j,\tilde{d}_a,\tilde{g}_1}\Gamma^{L}_{\check{\tilde{d}}_i,\tilde{d}_a,\tilde{g}_1} - \frac{4}{3}\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, 0\Big)\Big)\Gamma^{R*}_{\check{\tilde{d}}_j,g,d_b}\Gamma^{R}_{\check{\tilde{d}}_i,g,d_b}\\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, 0\Big)\Big)\Gamma^{R*}_{\check{\tilde{d}}_j,\gamma,d_b}\Gamma^{R}_{\check{\tilde{d}}_i,\gamma,d_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{u_b}^2, m_{W^-}^2\Big)\Big)\Gamma^{R*}_{\check{\tilde{d}}_j,W^-,u_b}\Gamma^{R}_{\check{\tilde{d}}_i,W^-,u_b}\\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, m_Z^2\Big)\Big)\Gamma^{R*}_{\check{\tilde{d}}_j,Z,d_b}\Gamma^{R}_{\check{\tilde{d}}_i,Z,d_b} \qquad (218)
\end{aligned}
$$

- **Self-Energy for Up-Quarks** (u)

$$
\begin{aligned}
\Sigma^{S}_{i,j}(p^2) = &+ \sum_{a=1}^{2}\sum_{b=1}^{3} B_0\Big(p^2, m_{d_b}^2, m_{H_a^-}^2\Big)\Gamma^{L*}_{\check{\tilde{u}}_j,H_a^+,d_b} m_{d_b}\Gamma^{R}_{\check{\tilde{u}}_i,H_a^+,d_b}\\
&+ \sum_{a=1}^{2} m_{\tilde{\chi}_a^-}\sum_{b=1}^{6} B_0\Big(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{d}_b}^2\Big)\Gamma^{L*}_{\check{\tilde{u}}_j,\tilde{\chi}_a^+,\tilde{d}_b}\Gamma^{R}_{\check{\tilde{u}}_i,\tilde{\chi}_a^+,\tilde{d}_b}\\
&+ \sum_{a=1}^{3} m_{u_a}\sum_{b=1}^{3} B_0\Big(p^2, m_{u_a}^2, m_{A_b^0}^2\Big)\Gamma^{L*}_{\check{\tilde{u}}_j,u_a,A_b^0}\Gamma^{R}_{\check{\tilde{u}}_i,u_a,A_b^0}\\
&+ \sum_{a=1}^{3}\sum_{b=1}^{3} B_0\Big(p^2, m_{u_b}^2, m_{h_a}^2\Big)\Gamma^{L*}_{\check{\tilde{u}}_j,h_a,u_b} m_{u_b}\Gamma^{R}_{\check{\tilde{u}}_i,h_a,u_b}\\
&+ \sum_{a=1}^{6}\sum_{b=1}^{5} B_0\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{u}_a}^2\Big)\Gamma^{L*}_{\check{\tilde{u}}_j,\tilde{u}_a,\tilde{\chi}_b^0} m_{\tilde{\chi}_b^0}\Gamma^{R}_{\check{\tilde{u}}_i,\tilde{u}_a,\tilde{\chi}_b^0}\\
&+ \frac{4}{3} m_{\tilde{g}}\sum_{a=1}^{6} B_0\Big(p^2, m_{\tilde{g}}^2, m_{\tilde{u}_a}^2\Big)\Gamma^{L*}_{\check{\tilde{u}}_j,\tilde{u}_a,\tilde{g}_1}\Gamma^{R}_{\check{\tilde{u}}_i,\tilde{u}_a,\tilde{g}_1} - \frac{16}{3}\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{u_b}^2, 0\Big)\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,g,u_b} m_{u_b}\Gamma^{L}_{\check{\tilde{u}}_i,g,u_b}\\
&- 4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{u_b}^2, 0\Big)\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,\gamma,u_b} m_{u_b}\Gamma^{L}_{\check{\tilde{u}}_i,\gamma,u_b} - 4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{u_b}^2, m_Z^2\Big)\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,Z,u_b} m_{u_b}\Gamma^{L}_{\check{\tilde{u}}_i,Z,u_b}\\
&- 4\sum_{b=1}^{3}\Big(-\frac{1}{2}\mathrm{rMS} + B_0\Big(p^2, m_{d_b}^2, m_{W^-}^2\Big)\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,W^+,d_b} m_{d_b}\Gamma^{L}_{\check{\tilde{u}}_i,W^+,d_b} \qquad (219)\\
\Sigma^{R}_{i,j}(p^2) = &- \frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, m_{H_a^-}^2\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,H_a^+,d_b}\Gamma^{R}_{\check{\tilde{u}}_i,H_a^+,d_b}\\
&- \frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{6} B_1\Big(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{d}_b}^2\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,\tilde{\chi}_a^+,\tilde{d}_b}\Gamma^{R}_{\check{\tilde{u}}_i,\tilde{\chi}_a^+,\tilde{d}_b}\\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{u_a}^2, m_{A_b^0}^2\Big)\Gamma^{R*}_{\check{\tilde{u}}_j,u_a,A_b^0}\Gamma^{R}_{\check{\tilde{u}}_i,u_a,A_b^0}
\end{aligned}
$$

$$
\begin{aligned}
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{u_b}^2, m_{h_a}^2\Big)\Gamma^{R*}_{\tilde{\tilde{u}}_j,h_a,u_b}\Gamma^{R}_{\tilde{\tilde{u}}_i,h_a,u_b}\\
&- \frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{5} B_1\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{u}_a}^2\Big)\Gamma^{R*}_{\tilde{\tilde{u}}_j,\tilde{u}_a,\tilde{\chi}_b^0}\Gamma^{R}_{\tilde{\tilde{u}}_i,\tilde{u}_a,\tilde{\chi}_b^0}\\
&- \frac{2}{3}\sum_{a=1}^{6} B_1\Big(p^2, m_{\tilde{g}}^2, m_{\tilde{u}_a}^2\Big)\Gamma^{R*}_{\tilde{\tilde{u}}_j,\tilde{u}_a,\tilde{g}_1}\Gamma^{R}_{\tilde{\tilde{u}}_i,\tilde{u}_a,\tilde{g}_1} - \frac{4}{3}\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{u_b}^2, 0\Big)\Big)\Gamma^{L*}_{\tilde{\tilde{u}}_j,g,u_b}\Gamma^{L}_{\tilde{\tilde{u}}_i,g,u_b}\\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{u_b}^2, 0\Big)\Big)\Gamma^{L*}_{\tilde{\tilde{u}}_j,\gamma,u_b}\Gamma^{L}_{\tilde{\tilde{u}}_i,\gamma,u_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{u_b}^2, m_Z^2\Big)\Big)\Gamma^{L*}_{\tilde{\tilde{u}}_j,Z,u_b}\Gamma^{L}_{\tilde{\tilde{u}}_i,Z,u_b}\\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, m_{W^-}^2\Big)\Big)\Gamma^{L*}_{\tilde{\tilde{u}}_j,W^+,d_b}\Gamma^{L}_{\tilde{\tilde{u}}_i,W^+,d_b} \qquad (220)
\end{aligned}
$$

$$
\begin{aligned}
\Sigma^L_{i,j}(p^2) = &-\frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, m_{H_a^-}^2\Big)\Gamma^{L*}_{\tilde{\tilde{u}}_j,H_a^+,d_b}\Gamma^{L}_{\tilde{\tilde{u}}_i,H_a^+,d_b}\\
&- \frac{1}{2}\sum_{a=1}^{2}\sum_{b=1}^{6} B_1\Big(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{d}_b}^2\Big)\Gamma^{L*}_{\tilde{\tilde{u}}_j,\tilde{\chi}_a^+,\tilde{d}_b}\Gamma^{L}_{\tilde{\tilde{u}}_i,\tilde{\chi}_a^+,\tilde{d}_b}\\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{u_a}^2, m_{A_b^0}^2\Big)\Gamma^{L*}_{\tilde{\tilde{u}}_j,u_a,A_b^0}\Gamma^{L}_{\tilde{\tilde{u}}_i,u_a,A_b^0}\\
&- \frac{1}{2}\sum_{a=1}^{3}\sum_{b=1}^{3} B_1\Big(p^2, m_{u_b}^2, m_{h_a}^2\Big)\Gamma^{L*}_{\tilde{\tilde{u}}_j,h_a,u_b}\Gamma^{L}_{\tilde{\tilde{u}}_i,h_a,u_b}\\
&- \frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{5} B_1\Big(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{u}_a}^2\Big)\Gamma^{L*}_{\tilde{\tilde{u}}_j,\tilde{u}_a,\tilde{\chi}_b^0}\Gamma^{L}_{\tilde{\tilde{u}}_i,\tilde{u}_a,\tilde{\chi}_b^0}\\
&- \frac{2}{3}\sum_{a=1}^{6} B_1\Big(p^2, m_{\tilde{g}}^2, m_{\tilde{u}_a}^2\Big)\Gamma^{L*}_{\tilde{\tilde{u}}_j,\tilde{u}_a,\tilde{g}_1}\Gamma^{L}_{\tilde{\tilde{u}}_i,\tilde{u}_a,\tilde{g}_1} - \frac{4}{3}\sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{u_b}^2, 0\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{u}}_j,g,u_b}\Gamma^{R}_{\tilde{\tilde{u}}_i,g,u_b}\\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{u_b}^2, 0\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{u}}_j,\gamma,u_b}\Gamma^{R}_{\tilde{\tilde{u}}_i,\gamma,u_b} - \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{u_b}^2, m_Z^2\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{u}}_j,Z,u_b}\Gamma^{R}_{\tilde{\tilde{u}}_i,Z,u_b}\\
&- \sum_{b=1}^{3}\Big(\frac{1}{2}\mathrm{rMS} + B_1\Big(p^2, m_{d_b}^2, m_{W^-}^2\Big)\Big)\Gamma^{R*}_{\tilde{\tilde{u}}_j,W^+,d_b}\Gamma^{R}_{\tilde{\tilde{u}}_i,W^+,d_b} \qquad (221)
\end{aligned}
$$

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

$$
\Sigma^S(p^2) = +\frac{1}{2}\sum_{a=1}^{3} m_{d_a}\sum_{b=1}^{6} B_0\Big(p^2, m_{d_a}^2, m_{\tilde{d}_b}^2\Big)\Gamma^{L*}_{\tilde{g}_j,\bar{d}_a,\tilde{d}_b}\Gamma^{R}_{\tilde{g}_i,\bar{d}_a,\tilde{d}_b}
$$

$$
\begin{aligned}
&+\frac{1}{2}\sum_{a=1}^{3} m_{u_a}\sum_{b=1}^{6} B_0\Big(p^2, m_{u_a}^2, m_{\tilde{u}_b}^2\Big)\Gamma^{L*}_{\tilde{g}_j,\bar{u}_a,\tilde{u}_b}\Gamma^{R}_{\tilde{g}_i,\bar{u}_a,\tilde{u}_b}\\
&+\frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_0\Big(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2\Big)\Gamma^{L*}_{\tilde{g}_j,\tilde{d}_a^*,d_b} m_{d_b}\Gamma^{R}_{\tilde{g}_i,\tilde{d}_a^*,d_b}\\
&+\frac{1}{2}\sum_{a=1}^{6}\sum_{b=1}^{3} B_0\Big(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2\Big)\Gamma^{L*}_{\tilde{g}_j,\tilde{u}_a^*,u_b} m_{u_b}\Gamma^{R}_{\tilde{g}_i,\tilde{u}_a^*,u_b}\\
&-12\Big(-\frac{1}{2}\mathrm{rMS}+B_0\Big(p^2, m_{\tilde{g}}^2, 0\Big)\Big)\Gamma^{R*}_{\tilde{g}_j,g,\tilde{g}_1} m_{\tilde{g}}\Gamma^{L}_{\tilde{g}_i,g,\tilde{g}_1}
\end{aligned}
\tag{222}
$$

$$
\begin{aligned}
\Sigma^R(p^2) = &-\frac{1}{4}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m_{d_a}^2, m_{\tilde{d}_b}^2\Big)\Gamma^{R*}_{\tilde{g}_j,\bar{d}_a,\tilde{d}_b}\Gamma^{R}_{\tilde{g}_i,\bar{d}_a,\tilde{d}_b}\\
&-\frac{1}{4}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m_{u_a}^2, m_{\tilde{u}_b}^2\Big)\Gamma^{R*}_{\tilde{g}_j,\bar{u}_a,\tilde{u}_b}\Gamma^{R}_{\tilde{g}_i,\bar{u}_a,\tilde{u}_b}\\
&-\frac{1}{4}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2\Big)\Gamma^{R*}_{\tilde{g}_j,\tilde{d}_a^*,d_b}\Gamma^{R}_{\tilde{g}_i,\tilde{d}_a^*,d_b}\\
&-\frac{1}{4}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2\Big)\Gamma^{R*}_{\tilde{g}_j,\tilde{u}_a^*,u_b}\Gamma^{R}_{\tilde{g}_i,\tilde{u}_a^*,u_b}-3\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2, m_{\tilde{g}}^2, 0\Big)\Big)\Gamma^{L*}_{\tilde{g}_j,g,\tilde{g}_1}\Gamma^{L}_{\tilde{g}_i,g,\tilde{g}_1}
\end{aligned}
\tag{223}
$$

$$
\begin{aligned}
\Sigma^L(p^2) = &-\frac{1}{4}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m_{d_a}^2, m_{\tilde{d}_b}^2\Big)\Gamma^{L*}_{\tilde{g}_j,\bar{d}_a,\tilde{d}_b}\Gamma^{L}_{\tilde{g}_i,\bar{d}_a,\tilde{d}_b}\\
&-\frac{1}{4}\sum_{a=1}^{3}\sum_{b=1}^{6} B_1\Big(p^2, m_{u_a}^2, m_{\tilde{u}_b}^2\Big)\Gamma^{L*}_{\tilde{g}_j,\bar{u}_a,\tilde{u}_b}\Gamma^{L}_{\tilde{g}_i,\bar{u}_a,\tilde{u}_b}\\
&-\frac{1}{4}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2\Big)\Gamma^{L*}_{\tilde{g}_j,\tilde{d}_a^*,d_b}\Gamma^{L}_{\tilde{g}_i,\tilde{d}_a^*,d_b}\\
&-\frac{1}{4}\sum_{a=1}^{6}\sum_{b=1}^{3} B_1\Big(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2\Big)\Gamma^{L*}_{\tilde{g}_j,\tilde{u}_a^*,u_b}\Gamma^{L}_{\tilde{g}_i,\tilde{u}_a^*,u_b}-3\Big(\frac{1}{2}\mathrm{rMS}+B_1\Big(p^2, m_{\tilde{g}}^2, 0\Big)\Big)\Gamma^{R*}_{\tilde{g}_j,g,\tilde{g}_1}\Gamma^{R}_{\tilde{g}_i,g,\tilde{g}_1}
\end{aligned}
\tag{224}
$$

- **Self-Energy for Z-Boson** (Z)

$$
\begin{aligned}
\Pi(p^2) = &+|\Gamma_{Z,\eta^-,\eta^-}|^2 B_{00}\Big(p^2, m_{\eta^-}^2, m_{\eta^-}^2\Big)+|\Gamma_{Z,\eta^+,\eta^+}|^2 B_{00}\Big(p^2, m_{\eta^+}^2, m_{\eta^+}^2\Big)\\
&-|\Gamma_{Z,W^+,W^-}|^2\Big(10B_{00}\Big(p^2, m_{W^-}^2, m_{W^-}^2\Big)+2A_0\Big(m_{W^-}^2\Big)-2\mathrm{rMS}\Big(2m_{W^-}^2-\frac{1}{3}p^2\Big)+B_0\Big(p^2, m_{W^-}^2, m_{W^-}^2\Big)\Big(2m_{W^-}^2+4p^2\Big)\Big)\\
&+\sum_{a=1}^{2} A_0\Big(m_{H_a^-}^2\Big)\Gamma_{Z,Z,H_a^+,H_a^-}-4\sum_{a=1}^{2}\sum_{b=1}^{2}|\Gamma_{Z,H_a^+,H_b^-}|^2 B_{00}\Big(p^2, m_{H_a^-}^2, m_{H_b^-}^2\Big)\\
&+\sum_{a=1}^{2}\sum_{b=1}^{2}\Big[\Big(|\Gamma^L_{Z,\tilde{\chi}_a^+,\tilde{\chi}_b^-}|^2+|\Gamma^R_{Z,\tilde{\chi}_a^+,\tilde{\chi}_b^-}|^2\Big)H_0\Big(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{\chi}_b^-}^2\Big)
\end{aligned}
$$

$$
\begin{aligned}
&+ 4B_0\Big(p^2, m^2_{\tilde{\chi}^-_a}, m^2_{\tilde{\chi}^-_b}\Big) m_{\tilde{\chi}^-_a} m_{\tilde{\chi}^-_b} \Re\Big(\Gamma^{L*}_{Z,\tilde{\chi}^+_a,\tilde{\chi}^-_b} \Gamma^{R}_{Z,\tilde{\chi}^+_a,\tilde{\chi}^-_b}\Big)\Big] \\
&+ \frac{1}{2}\sum_{a=1}^{3} A_0\Big(m^2_{A^0_a}\Big)\Gamma_{Z,Z,A^0_a,A^0_a} + \frac{1}{2}\sum_{a=1}^{3} A_0\Big(m^2_{h_a}\Big)\Gamma_{Z,Z,h_a,h_a} \\
&- 4\sum_{a=1}^{3}\sum_{b=1}^{3} |\Gamma_{Z,h_a,A^0_b}|^2 B_{00}\Big(p^2, m^2_{A^0_b}, m^2_{h_a}\Big) \\
&+ 3\sum_{a=1}^{3}\sum_{b=1}^{3}\Big[\Big(|\Gamma^{L}_{Z,\bar{d}_a,d_b}|^2 + |\Gamma^{R}_{Z,\bar{d}_a,d_b}|^2\Big) H_0\Big(p^2, m^2_{d_a}, m^2_{d_b}\Big) \\
&+ 4B_0\Big(p^2, m^2_{d_a}, m^2_{d_b}\Big) m_{d_a} m_{d_b} \Re\Big(\Gamma^{L*}_{Z,\bar{d}_a,d_b} \Gamma^{R}_{Z,\bar{d}_a,d_b}\Big)\Big] \\
&+ \sum_{a=1}^{3}\sum_{b=1}^{3}\Big[\Big(|\Gamma^{L}_{Z,\bar{e}_a,e_b}|^2 + |\Gamma^{R}_{Z,\bar{e}_a,e_b}|^2\Big) H_0\Big(p^2, m^2_{e_a}, m^2_{e_b}\Big) \\
&+ 4B_0\Big(p^2, m^2_{e_a}, m^2_{e_b}\Big) m_{e_a} m_{e_b} \Re\Big(\Gamma^{L*}_{Z,\bar{e}_a,e_b} \Gamma^{R}_{Z,\bar{e}_a,e_b}\Big)\Big] \\
&+ 3\sum_{a=1}^{3}\sum_{b=1}^{3}\Big[\Big(|\Gamma^{L}_{Z,\bar{u}_a,u_b}|^2 + |\Gamma^{R}_{Z,\bar{u}_a,u_b}|^2\Big) H_0\Big(p^2, m^2_{u_a}, m^2_{u_b}\Big) \\
&+ 4B_0\Big(p^2, m^2_{u_a}, m^2_{u_b}\Big) m_{u_a} m_{u_b} \Re\Big(\Gamma^{L*}_{Z,\bar{u}_a,u_b} \Gamma^{R}_{Z,\bar{u}_a,u_b}\Big)\Big] \\
&+ \frac{1}{2}\sum_{a=1}^{5}\sum_{b=1}^{5}\Big[\Big(|\Gamma^{L}_{Z,\tilde{\chi}^0_a,\tilde{\chi}^0_b}|^2 + |\Gamma^{R}_{Z,\tilde{\chi}^0_a,\tilde{\chi}^0_b}|^2\Big) H_0\Big(p^2, m^2_{\tilde{\chi}^0_a}, m^2_{\tilde{\chi}^0_b}\Big) \\
&+ 4B_0\Big(p^2, m^2_{\tilde{\chi}^0_a}, m^2_{\tilde{\chi}^0_b}\Big) m_{\tilde{\chi}^0_a} m_{\tilde{\chi}^0_b} \Re\Big(\Gamma^{L*}_{Z,\tilde{\chi}^0_a,\tilde{\chi}^0_b} \Gamma^{R}_{Z,\tilde{\chi}^0_a,\tilde{\chi}^0_b}\Big)\Big] \\
&+ 3\sum_{a=1}^{6} A_0\Big(m^2_{\tilde{d}_a}\Big)\Gamma_{Z,Z,\tilde{d}^*_a,\tilde{d}_a} + \sum_{a=1}^{6} A_0\Big(m^2_{\tilde{e}_a}\Big)\Gamma_{Z,Z,\tilde{e}^*_a,\tilde{e}_a} + 3\sum_{a=1}^{6} A_0\Big(m^2_{\tilde{u}_a}\Big)\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}\Big(p^2, m^2_{\tilde{d}_a}, m^2_{\tilde{d}_b}\Big) - 4\sum_{a=1}^{6}\sum_{b=1}^{6} |\Gamma_{Z,\tilde{e}^*_a,\tilde{e}_b}|^2 B_{00}\Big(p^2, m^2_{\tilde{e}_a}, m^2_{\tilde{e}_b}\Big) \\
&- 12\sum_{a=1}^{6}\sum_{b=1}^{6} |\Gamma_{Z,\tilde{u}^*_a,\tilde{u}_b}|^2 B_{00}\Big(p^2, m^2_{\tilde{u}_a}, m^2_{\tilde{u}_b}\Big) + \frac{1}{2}\sum_{a=1}^{7} A_0\Big(m^2_{\tilde{\nu}^I_a}\Big)\Gamma_{Z,Z,\tilde{\nu}^I_a,\tilde{\nu}^I_a} \\
&+ \frac{1}{2}\sum_{a=1}^{7} A_0\Big(m^2_{\tilde{\nu}^R_a}\Big)\Gamma_{Z,Z,\tilde{\nu}^R_a,\tilde{\nu}^R_a} - 4\sum_{a=1}^{7}\sum_{b=1}^{7} |\Gamma_{Z,\tilde{\nu}^R_a,\tilde{\nu}^I_b}|^2 B_{00}\Big(p^2, m^2_{\tilde{\nu}^I_b}, m^2_{\tilde{\nu}^R_a}\Big) \\
&+ \frac{1}{2}\sum_{a=1}^{7}\sum_{b=1}^{7}\Big[\Big(|\Gamma^{L}_{Z,\nu_a,\nu_b}|^2 + |\Gamma^{R}_{Z,\nu_a,\nu_b}|^2\Big) H_0\Big(p^2, m^2_{\nu_a}, m^2_{\nu_b}\Big) \\
&+ 4B_0\Big(p^2, m^2_{\nu_a}, m^2_{\nu_b}\Big) m_{\nu_a} m_{\nu_b} \Re\Big(\Gamma^{L*}_{Z,\nu_a,\nu_b} \Gamma^{R}_{Z,\nu_a,\nu_b}\Big)\Big] \\
&+ 2\sum_{b=1}^{2} |\Gamma_{Z,W^+,H^-_b}|^2 B_0\Big(p^2, m^2_{W^-}, m^2_{H^-_b}\Big) + \sum_{b=1}^{3} |\Gamma_{Z,Z,h_b}|^2 B_0\Big(p^2, m^2_{Z}, m^2_{h_b}\Big) + 2\mathrm{rMS} m^2_{W^-} \Gamma^1_{Z,Z,W^+,W^-}
\end{aligned}
$$

$$- A_0\Big(m^2_{W^-}\Big)\Big(4\Gamma^1_{Z,Z,W^+,W^-} + \Gamma^2_{Z,Z,W^+,W^-} + \Gamma^3_{Z,Z,W^+,W^-}\Big) \tag{225}$$

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

$$\begin{aligned}
\Pi(p^2) = &-12\sum_{a=1}^{6}\sum_{b=1}^{6}|\Gamma_{W^+,\tilde{u}^*_a,\tilde{d}_b}|^2 B_{00}\Big(p^2, m^2_{\tilde{d}_b}, m^2_{\tilde{u}_a}\Big) + 2\mathrm{rMS}m^2_{W^-}\Gamma^1_{W^-,W^+,W^+,W^-} + 3\sum_{a=1}^{3}\sum_{b=1}^{3}\Big[\Big(|\Gamma^L_{W^+,\bar{u}_a,d_b}|^2 + |\Gamma^R_{W^+,\bar{u}_a,d_b}|^2\Big)A\\
&+ 4B_0\Big(p^2, m^2_{u_a}, m^2_{d_b}\Big)m_{d_b}m_{u_a}\Re\Big(\Gamma^{L*}_{W^+,\bar{u}_a,d_b}\Gamma^R_{W^+,\bar{u}_a,d_b}\Big)\Big] + 3\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{d}_a}\Big)\Gamma_{W^-,W^+,\tilde{d}^*_a,\tilde{d}_a} + 3\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{u}_a}\Big)\Gamma_{W^-,W^+,\tilde{u}^*_a,\tilde{u}_a} +\\
&+ 4B_0\Big(p^2, m^2_{\tilde{\chi}^0_a}, m^2_{\tilde{\chi}^-_b}\Big)m_{\tilde{\chi}^-_b}m_{\tilde{\chi}^0_a}\Re\Big(\Gamma^{L*}_{W^+,\tilde{\chi}^0_a,\tilde{\chi}^-_b}\Gamma^R_{W^+,\tilde{\chi}^0_a,\tilde{\chi}^-_b}\Big)\Big] + \sum_{a=1}^{6}A_0\Big(m^2_{\tilde{e}_a}\Big)\Gamma_{W^-,W^+,\tilde{e}^*_a,\tilde{e}_a} + \sum_{a=1}^{7}\sum_{b=1}^{3}\Big[\Big(|\Gamma^L_{W^+,\nu_a,e_b}|^2 + |\Gamma^R_{W^-}\\
&+ 4B_0\Big(p^2, m^2_{\nu_a}, m^2_{e_b}\Big)m_{e_b}m_{\nu_a}\Re\Big(\Gamma^{L*}_{W^+,\nu_a,e_b}\Gamma^R_{W^+,\nu_a,e_b}\Big)\Big] + \sum_{b=1}^{2}|\Gamma_{W^+,\gamma,H^-_b}|^2 B_0\Big(p^2, 0, m^2_{H^-_b}\Big) + \sum_{b=1}^{2}|\Gamma_{W^+,Z,H^-_b}|^2 B_0\Big(p^2, m^2_Z,
\end{aligned} \tag{226}$$

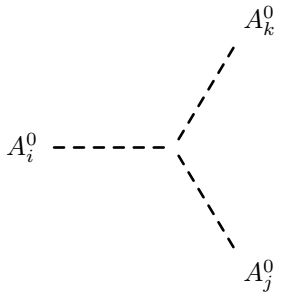
8.2 Tadpoles

$$\begin{aligned}
\delta t^{(1)}_h = &+ A_0\Big(m^2_{\eta^-}\Big)\Gamma_{\check{h}_i,\eta^-,\eta^-} + A_0\Big(m^2_{\eta^+}\Big)\Gamma_{\check{h}_i,\eta^+,\eta^+} + A_0\Big(m^2_{\eta^Z}\Big)\Gamma_{\check{h}_i,\eta^Z,\eta^Z}\\
&+ 4\Gamma_{\check{h}_i,W^+,W^-}\Big(-\frac{1}{2}\mathrm{rMS}m^2_{W^-} + A_0\Big(m^2_{W^-}\Big)\Big) + 2\Gamma_{\check{h}_i,Z,Z}\Big(-\frac{1}{2}\mathrm{rMS}m^2_Z + A_0\Big(m^2_Z\Big)\Big) - \sum_{a=1}^{2}A_0\Big(m^2_{H^-_a}\Big)\Gamma_{\check{h}_i,H^+_a,H^-_a}\\
&+ 2\sum_{a=1}^{2}A_0\Big(m^2_{\tilde{\chi}^-_a}\Big)m_{\tilde{\chi}^-_a}\Big(\Gamma^L_{\check{h}_i,\tilde{\chi}^+_a,\tilde{\chi}^-_a} + \Gamma^R_{\check{h}_i,\tilde{\chi}^+_a,\tilde{\chi}^-_a}\Big) - \frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{A^0_a}\Big)\Gamma_{\check{h}_i,A^0_a,A^0_a}\\
&- \frac{1}{2}\sum_{a=1}^{3}A_0\Big(m^2_{h_a}\Big)\Gamma_{\check{h}_i,h_a,h_a} + 6\sum_{a=1}^{3}A_0\Big(m^2_{d_a}\Big)m_{d_a}\Big(\Gamma^L_{\check{h}_i,\bar{d}_a,d_a} + \Gamma^R_{\check{h}_i,\bar{d}_a,d_a}\Big)\\
&+ 2\sum_{a=1}^{3}A_0\Big(m^2_{e_a}\Big)m_{e_a}\Big(\Gamma^L_{\check{h}_i,\bar{e}_a,e_a} + \Gamma^R_{\check{h}_i,\bar{e}_a,e_a}\Big)\\
&+ 6\sum_{a=1}^{3}A_0\Big(m^2_{u_a}\Big)m_{u_a}\Big(\Gamma^L_{\check{h}_i,\bar{u}_a,u_a} + \Gamma^R_{\check{h}_i,\bar{u}_a,u_a}\Big) + \sum_{a=1}^{5}A_0\Big(m^2_{\tilde{\chi}^0_a}\Big)m_{\tilde{\chi}^0_a}\Big(\Gamma^L_{\check{h}_i,\tilde{\chi}^0_a,\tilde{\chi}^0_a} + \Gamma^R_{\check{h}_i,\tilde{\chi}^0_a,\tilde{\chi}^0_a}\Big)\\
&- 3\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{d}_a}\Big)\Gamma_{\check{h}_i,\tilde{d}^*_a,\tilde{d}_a} - \sum_{a=1}^{6}A_0\Big(m^2_{\tilde{e}_a}\Big)\Gamma_{\check{h}_i,\tilde{e}^*_a,\tilde{e}_a} - 3\sum_{a=1}^{6}A_0\Big(m^2_{\tilde{u}_a}\Big)\Gamma_{\check{h}_i,\tilde{u}^*_a,\tilde{u}_a}\\
&- \frac{1}{2}\sum_{a=1}^{7}A_0\Big(m^2_{\tilde{\nu}^I_a}\Big)\Gamma_{\check{h}_i,\tilde{\nu}^I_a,\tilde{\nu}^I_a} - \frac{1}{2}\sum_{a=1}^{7}A_0\Big(m^2_{\tilde{\nu}^R_a}\Big)\Gamma_{\check{h}_i,\tilde{\nu}^R_a,\tilde{\nu}^R_a}\\
&+ \sum_{a=1}^{7}A_0\Big(m^2_{\nu_a}\Big)m_{\nu_a}\Big(\Gamma^L_{\check{h}_i,\nu_a,\nu_a} + \Gamma^R_{\check{h}_i,\nu_a,\nu_a}\Big)
\end{aligned} \tag{227}$$

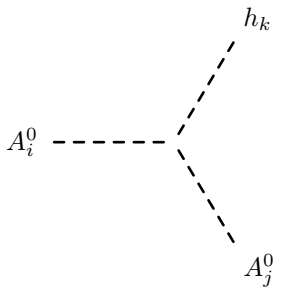
$$\delta t^{(1)}_{\tilde{\nu}^R} = 0 \tag{228}$$

9 Interactions for eigenstates 'EWSB'

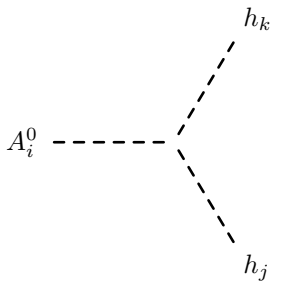
9.1 Three Scalar-Interaction



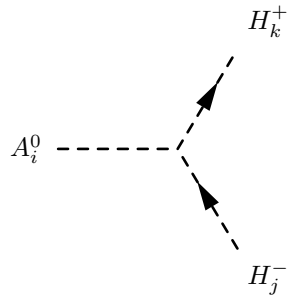
$$\frac{1}{\sqrt{2}}\Big(- A_\kappa + A^*_\kappa\Big) Z^A_{i3} Z^A_{j3} Z^A_{k3} \tag{229}$$



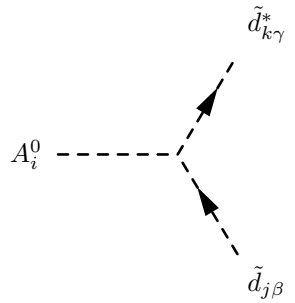
$$\begin{aligned} &- \frac{i}{4}\Big(\Big(g_1^2 + g_2^2\Big) Z^A_{i1} Z^A_{j1}\Big(v_d Z^H_{k1} - v_u Z^H_{k2}\Big) - \Big(g_1^2 + g_2^2\Big) Z^A_{i2} Z^A_{j2}\Big(v_d Z^H_{k1} - v_u Z^H_{k2}\Big) \\ &+ 2\Big(4 v_X |\kappa|^2 - \sqrt{2}\Big(A^*_\kappa + A_\kappa\Big)\Big) Z^A_{i3} Z^A_{j3} Z^H_{k3}\Big) \end{aligned} \tag{230}$$



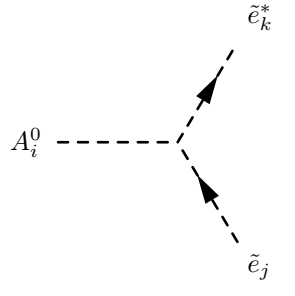
$$\frac{1}{\sqrt{2}}\Big(- A_\kappa^* + A_\kappa\Big) Z_{i3}^A Z_{j3}^H Z_{k3}^H \tag{231}$$



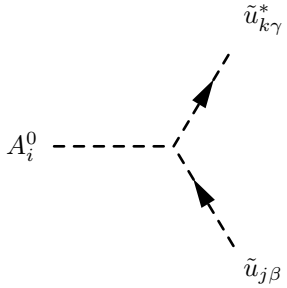
$$\frac{1}{4} g_2^2 \Big(v_d Z_{i2}^A + v_u Z_{i1}^A \Big) \Big(- Z_{j1}^+ Z_{k2}^+ + Z_{j2}^+ Z_{k1}^+ \Big) \tag{232}$$



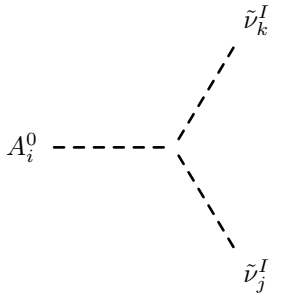
$$\begin{aligned} &\frac{1}{\sqrt{2}} \delta_{\beta\gamma} \Big(\sum_{b=1}^{3} Z_{jb}^{D,*} \sum_{a=1}^{3} Z_{k3+a}^D A_{d,ab} Z_{i1}^A - \sum_{b=1}^{3} \sum_{a=1}^{3} Z_{j3+a}^{D,*} A_{d,ab}^* Z_{kb}^D Z_{i1}^A \\ &+ \Big(- \mu_H \sum_{b=1}^{3} \sum_{a=1}^{3} y_{d,ab}^* Z_{j3+a}^{D,*} Z_{kb}^D + \mu_H^* \sum_{b=1}^{3} Z_{jb}^{D,*} \sum_{a=1}^{3} y_{d,ab} Z_{k3+a}^D \Big) Z_{i2}^A \Big) \end{aligned} \tag{233}$$



$$\frac{1}{\sqrt{2}}\Big(\sum_{b=1}^{3} Z^{E,*}_{jb}\sum_{a=1}^{3} Z^{E}_{k3+a}A_{e,ab}Z^{A}_{i1} - \sum_{b=1}^{3}\sum_{a=1}^{3} Z^{E,*}_{j3+a}A^{*}_{e,ab}Z^{E}_{kb}Z^{A}_{i1}$$
$$+\Big(-\mu_H\sum_{b=1}^{3}\sum_{a=1}^{3} y^{*}_{e,ab}Z^{E,*}_{j3+a}Z^{E}_{kb} + \mu^{*}_{H}\sum_{b=1}^{3} Z^{E,*}_{jb}\sum_{a=1}^{3} y_{e,ab}Z^{E}_{k3+a}\Big)Z^{A}_{i2}\Big) \tag{234}$$

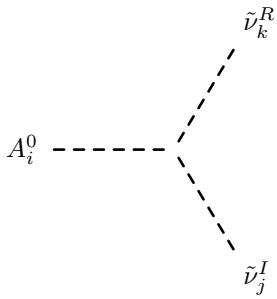


$$\frac{1}{\sqrt{2}}\delta_{\beta\gamma}\Big(\mu^{*}_{H}\sum_{b=1}^{3} Z^{U,*}_{jb}\sum_{a=1}^{3} y_{u,ab}Z^{U}_{k3+a}Z^{A}_{i1} - \mu_H\sum_{b=1}^{3}\sum_{a=1}^{3} y^{*}_{u,ab}Z^{U,*}_{j3+a}Z^{U}_{kb}Z^{A}_{i1}$$
$$+\Big(-\sum_{b=1}^{3}\sum_{a=1}^{3} Z^{U,*}_{j3+a}A^{*}_{u,ab}Z^{U}_{kb} + \sum_{b=1}^{3} Z^{U,*}_{jb}\sum_{a=1}^{3} Z^{U}_{k3+a}A_{u,ab}\Big)Z^{A}_{i2}\Big) \tag{235}$$



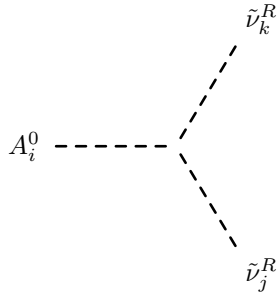
$$\frac{1}{8}\Big(-2\sqrt{2}\mu_H\sum_{b=1}^{3} Z^{I,*}_{kb}\sum_{a=1}^{2} Y^{*}_{\nu,ab}Z^{I,*}_{j3+a}Z^{A}_{i1} - 2\sqrt{2}\mu_H\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{2} Y^{*}_{\nu,ab}Z^{I,*}_{k3+a}Z^{A}_{i1}$$
$$+2\sqrt{2}\mu^{*}_{H}\sum_{b=1}^{3} Z^{I,*}_{kb}\sum_{a=1}^{2} Z^{I,*}_{j3+a}Y_{\nu,ab}Z^{A}_{i1} + 2\sqrt{2}\mu^{*}_{H}\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{2} Z^{I,*}_{k3+a}Y_{\nu,ab}Z^{A}_{i1}$$
$$-2\sqrt{2}\sum_{b=1}^{3} Z^{I,*}_{kb}\sum_{a=1}^{2} Z^{I,*}_{j3+a}A^{*}_{\nu,ab}Z^{A}_{i2} - 2\sqrt{2}\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{2} Z^{I,*}_{k3+a}A^{*}_{\nu,ab}Z^{A}_{i2}$$

$$
\begin{aligned}
&+2\sqrt{2}\sum_{b=1}^{3} Z^{I,*}_{kb}\sum_{a=1}^{2} Z^{I,*}_{j3+a}A_{\nu,ab}Z^{A}_{i2}+2\sqrt{2}\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{2} Z^{I,*}_{k3+a}A_{\nu,ab}Z^{A}_{i2}\\
&+2\sqrt{2}\sum_{c=1}^{2} Z^{I,*}_{k5+c}\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{2}\mu^{*}_{NS,ac}Y_{\nu,ab}Z^{A}_{i2}+2\sqrt{2}\sum_{c=1}^{2} Z^{I,*}_{j5+c}\sum_{b=1}^{3} Z^{I,*}_{kb}\sum_{a=1}^{2}\mu^{*}_{NS,ac}Y_{\nu,ab}Z^{A}_{i2}\\
&-2\sqrt{2}\sum_{c=1}^{3} Z^{I,*}_{kc}\sum_{b=1}^{2} Z^{I,*}_{j5+b}\sum_{a=1}^{2} Y^{*}_{\nu,ac}\mu_{NS,ab}Z^{A}_{i2}\\
&-2\sqrt{2}\sum_{c=1}^{3} Z^{I,*}_{jc}\sum_{b=1}^{2} Z^{I,*}_{k5+b}\sum_{a=1}^{2} Y^{*}_{\nu,ac}\mu_{NS,ab}Z^{A}_{i2}-2\kappa v_X\sum_{b=1}^{2} Z^{I,*}_{k5+b}\sum_{a=1}^{2}\lambda^{*}_{ab}Z^{I,*}_{j5+a}Z^{A}_{i3}\\
&-2\kappa v_X\sum_{b=1}^{2} Z^{I,*}_{j5+b}\sum_{a=1}^{2}\lambda^{*}_{ab}Z^{I,*}_{k5+a}Z^{A}_{i3}+\sqrt{2}\sum_{b=1}^{2} Z^{I,*}_{k5+b}\sum_{a=1}^{2} Z^{I,*}_{j5+a}A^{*}_{\lambda,ab}Z^{A}_{i3}\\
&+\sqrt{2}\sum_{b=1}^{2} Z^{I,*}_{j5+b}\sum_{a=1}^{2} Z^{I,*}_{k5+a}A^{*}_{\lambda,ab}Z^{A}_{i3}+2v_X\kappa^{*}\sum_{b=1}^{2} Z^{I,*}_{k5+b}\sum_{a=1}^{2} Z^{I,*}_{j5+a}\lambda_{ab}Z^{A}_{i3}\\
&+2v_X\kappa^{*}\sum_{b=1}^{2} Z^{I,*}_{j5+b}\sum_{a=1}^{2} Z^{I,*}_{k5+a}\lambda_{ab}Z^{A}_{i3}-\sqrt{2}\sum_{b=1}^{2} Z^{I,*}_{k5+b}\sum_{a=1}^{2} Z^{I,*}_{j5+a}A_{\lambda,ab}Z^{A}_{i3}\\
&-\sqrt{2}\sum_{b=1}^{2} Z^{I,*}_{j5+b}\sum_{a=1}^{2} Z^{I,*}_{k5+a}A_{\lambda,ab}Z^{A}_{i3}-2\sqrt{2}\sum_{c=1}^{2} Z^{I,*}_{k3+c}\sum_{b=1}^{2} Z^{I,*}_{j5+b}\sum_{a=1}^{2}\mu^{*}_{NS,ca}\lambda_{ab}Z^{A}_{i3}\\
&-2\sqrt{2}\sum_{c=1}^{2} Z^{I,*}_{j3+c}\sum_{b=1}^{2} Z^{I,*}_{k5+b}\sum_{a=1}^{2}\mu^{*}_{NS,ca}\lambda_{ab}Z^{A}_{i3}+2\sqrt{2}\sum_{c=1}^{2} Z^{I,*}_{k5+c}\sum_{b=1}^{2} Z^{I,*}_{j3+b}\sum_{a=1}^{2}\lambda^{*}_{ac}\mu_{NS,ba}Z^{A}_{i3}\\
&+2\sqrt{2}\sum_{c=1}^{2} Z^{I,*}_{j5+c}\sum_{b=1}^{2} Z^{I,*}_{k3+b}\sum_{a=1}^{2}\lambda^{*}_{ac}\mu_{NS,ba}Z^{A}_{i3}\Big)
\end{aligned}
\tag{236}
$$

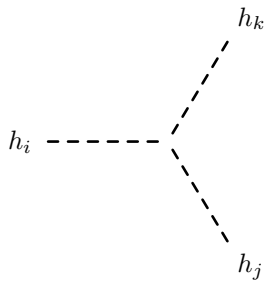


$$
\begin{aligned}
&-\frac{i}{8}\Big(2\sqrt{2}\mu_H\sum_{b=1}^{3} Z^{R,*}_{kb}\sum_{a=1}^{2} Y^{*}_{\nu,ab}Z^{I,*}_{j3+a}Z^{A}_{i1}-2\sqrt{2}\mu_H\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{2} Y^{*}_{\nu,ab}Z^{R,*}_{k3+a}Z^{A}_{i1}\\
&+2\sqrt{2}\mu^{*}_H\sum_{b=1}^{3} Z^{R,*}_{kb}\sum_{a=1}^{2} Z^{I,*}_{j3+a}Y_{\nu,ab}Z^{A}_{i1}-2\sqrt{2}\mu^{*}_H\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{2} Z^{R,*}_{k3+a}Y_{\nu,ab}Z^{A}_{i1}
\end{aligned}
$$

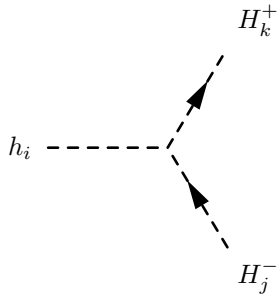
$$
\begin{aligned}
&+ 2\sqrt{2}\sum_{b=1}^{3} Z_{kb}^{R,*} \sum_{a=1}^{2} Z_{j3+a}^{I,*} A_{\nu,ab}^{*} Z_{i2}^{A} - 2\sqrt{2}\sum_{b=1}^{3} Z_{jb}^{I,*} \sum_{a=1}^{2} Z_{k3+a}^{R,*} A_{\nu,ab}^{*} Z_{i2}^{A} \\
&+ 2\sqrt{2}\sum_{b=1}^{3} Z_{kb}^{R,*} \sum_{a=1}^{2} Z_{j3+a}^{I,*} A_{\nu,ab} Z_{i2}^{A} - 2\sqrt{2}\sum_{b=1}^{3} Z_{jb}^{I,*} \sum_{a=1}^{2} Z_{k3+a}^{R,*} A_{\nu,ab} Z_{i2}^{A} \\
&- 2\sqrt{2}\sum_{c=1}^{2} Z_{k5+c}^{R,*} \sum_{b=1}^{3} Z_{jb}^{I,*} \sum_{a=1}^{2} \mu_{NS,ac}^{*} Y_{\nu,ab} Z_{i2}^{A} + 2\sqrt{2}\sum_{c=1}^{2} Z_{j5+c}^{I,*} \sum_{b=1}^{3} Z_{kb}^{R,*} \sum_{a=1}^{2} \mu_{NS,ac}^{*} Y_{\nu,ab} Z_{i2}^{A} \\
&+ 2\sqrt{2}\sum_{c=1}^{3} Z_{kc}^{R,*} \sum_{b=1}^{2} Z_{j5+b}^{I,*} \sum_{a=1}^{2} Y_{\nu,ac}^{*} \mu_{NS,ab} Z_{i2}^{A} - 2\sqrt{2}\sum_{c=1}^{3} Z_{jc}^{I,*} \sum_{b=1}^{2} Z_{k5+b}^{R,*} \sum_{a=1}^{2} Y_{\nu,ac}^{*} \mu_{NS,ab} Z_{i2}^{A} \\
&+ 2\kappa v_X \sum_{b=1}^{2} Z_{k5+b}^{R,*} \sum_{a=1}^{2} \lambda_{ab}^{*} Z_{j5+a}^{I,*} Z_{i3}^{A} + 2\kappa v_X \sum_{b=1}^{2} Z_{j5+b}^{I,*} \sum_{a=1}^{2} \lambda_{ab}^{*} Z_{k5+a}^{R,*} Z_{i3}^{A} \\
&- \sqrt{2}\sum_{b=1}^{2} Z_{k5+b}^{R,*} \sum_{a=1}^{2} Z_{j5+a}^{I,*} A_{\lambda,ab}^{*} Z_{i3}^{A} - \sqrt{2}\sum_{b=1}^{2} Z_{j5+b}^{I,*} \sum_{a=1}^{2} Z_{k5+a}^{R,*} A_{\lambda,ab}^{*} Z_{i3}^{A} \\
&+ 2v_X\kappa^{*} \sum_{b=1}^{2} Z_{k5+b}^{R,*} \sum_{a=1}^{2} Z_{j5+a}^{I,*} \lambda_{ab} Z_{i3}^{A} + 2v_X\kappa^{*} \sum_{b=1}^{2} Z_{j5+b}^{I,*} \sum_{a=1}^{2} Z_{k5+a}^{R,*} \lambda_{ab} Z_{i3}^{A} \\
&- \sqrt{2}\sum_{b=1}^{2} Z_{k5+b}^{R,*} \sum_{a=1}^{2} Z_{j5+a}^{I,*} A_{\lambda,ab} Z_{i3}^{A} - \sqrt{2}\sum_{b=1}^{2} Z_{j5+b}^{I,*} \sum_{a=1}^{2} Z_{k5+a}^{R,*} A_{\lambda,ab} Z_{i3}^{A} \\
&- 2\sqrt{2}\sum_{c=1}^{2} Z_{k3+c}^{R,*} \sum_{b=1}^{2} Z_{j5+b}^{I,*} \sum_{a=1}^{2} \mu_{NS,ca}^{*} \lambda_{ab} Z_{i3}^{A} \\
&- 2\sqrt{2}\sum_{c=1}^{2} Z_{j3+c}^{I,*} \sum_{b=1}^{2} Z_{k5+b}^{R,*} \sum_{a=1}^{2} \mu_{NS,ca}^{*} \lambda_{ab} Z_{i3}^{A} \\
&- 2\sqrt{2}\sum_{c=1}^{2} Z_{k5+c}^{R,*} \sum_{b=1}^{2} Z_{j3+b}^{I,*} \sum_{a=1}^{2} \lambda_{ac}^{*} \mu_{NS,ba} Z_{i3}^{A} \\
&- 2\sqrt{2}\sum_{c=1}^{2} Z_{j5+c}^{I,*} \sum_{b=1}^{2} Z_{k3+b}^{R,*} \sum_{a=1}^{2} \lambda_{ac}^{*} \mu_{NS,ba} Z_{i3}^{A}\Big)
\end{aligned}
\tag{237}
$$



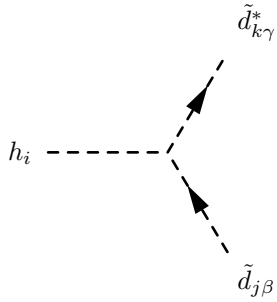
$$\frac{1}{8}\Big(- 2\sqrt{2}\mu_H \sum_{b=1}^{3} Z_{kb}^{R,*} \sum_{a=1}^{2} Y_{\nu,ab}^{*} Z_{j3+a}^{R,*} Z_{i1}^{A} - 2\sqrt{2}\mu_H \sum_{b=1}^{3} Z_{jb}^{R,*} \sum_{a=1}^{2} Y_{\nu,ab}^{*} Z_{k3+a}^{R,*} Z_{i1}^{A}$$
$$+ 2\sqrt{2}\mu_H^{*} \sum_{b=1}^{3} Z_{kb}^{R,*} \sum_{a=1}^{2} Z_{j3+a}^{R,*} Y_{\nu,ab} Z_{i1}^{A} + 2\sqrt{2}\mu_H^{*} \sum_{b=1}^{3} Z_{jb}^{R,*} \sum_{a=1}^{2} Z_{k3+a}^{R,*} Y_{\nu,ab} Z_{i1}^{A}$$
$$- 2\sqrt{2} \sum_{b=1}^{3} Z_{kb}^{R,*} \sum_{a=1}^{2} Z_{j3+a}^{R,*} A_{\nu,ab}^{*} Z_{i2}^{A} - 2\sqrt{2} \sum_{b=1}^{3} Z_{jb}^{R,*} \sum_{a=1}^{2} Z_{k3+a}^{R,*} A_{\nu,ab}^{*} Z_{i2}^{A}$$
$$+ 2\sqrt{2} \sum_{b=1}^{3} Z_{kb}^{R,*} \sum_{a=1}^{2} Z_{j3+a}^{R,*} A_{\nu,ab} Z_{i2}^{A} + 2\sqrt{2} \sum_{b=1}^{3} Z_{jb}^{R,*} \sum_{a=1}^{2} Z_{k3+a}^{R,*} A_{\nu,ab} Z_{i2}^{A}$$
$$+ 2\sqrt{2} \sum_{c=1}^{2} Z_{k5+c}^{R,*} \sum_{b=1}^{3} Z_{jb}^{R,*} \sum_{a=1}^{2} \mu_{NS,ac}^{*} Y_{\nu,ab} Z_{i2}^{A} + 2\sqrt{2} \sum_{c=1}^{2} Z_{j5+c}^{R,*} \sum_{b=1}^{3} Z_{kb}^{R,*} \sum_{a=1}^{2} \mu_{NS,ac}^{*} Y_{\nu,ab} Z_{i2}^{A}$$
$$- 2\sqrt{2} \sum_{c=1}^{3} Z_{kc}^{R,*} \sum_{b=1}^{2} Z_{j5+b}^{R,*} \sum_{a=1}^{2} Y_{\nu,ac}^{*} \mu_{NS,ab} Z_{i2}^{A}$$
$$- 2\sqrt{2} \sum_{c=1}^{3} Z_{jc}^{R,*} \sum_{b=1}^{2} Z_{k5+b}^{R,*} \sum_{a=1}^{2} Y_{\nu,ac}^{*} \mu_{NS,ab} Z_{i2}^{A} + 2\kappa v_X \sum_{b=1}^{2} Z_{k5+b}^{R,*} \sum_{a=1}^{2} \lambda_{ab}^{*} Z_{j5+a}^{R,*} Z_{i3}^{A}$$
$$+ 2\kappa v_X \sum_{b=1}^{2} Z_{j5+b}^{R,*} \sum_{a=1}^{2} \lambda_{ab}^{*} Z_{k5+a}^{R,*} Z_{i3}^{A} - \sqrt{2} \sum_{b=1}^{2} Z_{k5+b}^{R,*} \sum_{a=1}^{2} Z_{j5+a}^{R,*} A_{\lambda,ab}^{*} Z_{i3}^{A}$$
$$- \sqrt{2} \sum_{b=1}^{2} Z_{j5+b}^{R,*} \sum_{a=1}^{2} Z_{k5+a}^{R,*} A_{\lambda,ab}^{*} Z_{i3}^{A} - 2v_X \kappa^{*} \sum_{b=1}^{2} Z_{k5+b}^{R,*} \sum_{a=1}^{2} Z_{j5+a}^{R,*} \lambda_{ab} Z_{i3}^{A}$$
$$- 2v_X \kappa^{*} \sum_{b=1}^{2} Z_{j5+b}^{R,*} \sum_{a=1}^{2} Z_{k5+a}^{R,*} \lambda_{ab} Z_{i3}^{A} + \sqrt{2} \sum_{b=1}^{2} Z_{k5+b}^{R,*} \sum_{a=1}^{2} Z_{j5+a}^{R,*} A_{\lambda,ab} Z_{i3}^{A}$$
$$+ \sqrt{2} \sum_{b=1}^{2} Z_{j5+b}^{R,*} \sum_{a=1}^{2} Z_{k5+a}^{R,*} A_{\lambda,ab} Z_{i3}^{A} + 2\sqrt{2} \sum_{c=1}^{2} Z_{k3+c}^{R,*} \sum_{b=1}^{2} Z_{j5+b}^{R,*} \sum_{a=1}^{2} \mu_{NS,ca}^{*} \lambda_{ab} Z_{i3}^{A}$$
$$+ 2\sqrt{2} \sum_{c=1}^{2} Z_{j3+c}^{R,*} \sum_{b=1}^{2} Z_{k5+b}^{R,*} \sum_{a=1}^{2} \mu_{NS,ca}^{*} \lambda_{ab} Z_{i3}^{A} - 2\sqrt{2} \sum_{c=1}^{2} Z_{k5+c}^{R,*} \sum_{b=1}^{2} Z_{j3+b}^{R,*} \sum_{a=1}^{2} \lambda_{ac}^{*} \mu_{NS,ba} Z_{i3}^{A}$$
$$- 2\sqrt{2} \sum_{c=1}^{2} Z_{j5+c}^{R,*} \sum_{b=1}^{2} Z_{k3+b}^{R,*} \sum_{a=1}^{2} \lambda_{ac}^{*} \mu_{NS,ba} Z_{i3}^{A} \Big) \tag{238}$$



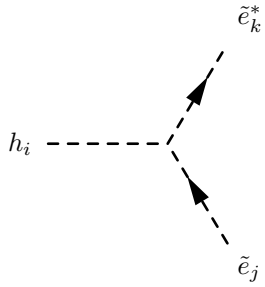
$$
\begin{aligned}
&-\frac{i}{4}\Big(-\Big(g_1^2+g_2^2\Big)Z_{i2}^H\Big(Z_{j1}^H\Big(v_dZ_{k2}^H+v_uZ_{k1}^H\Big)+Z_{j2}^H\Big(-3v_uZ_{k2}^H+v_dZ_{k1}^H\Big)\Big)\\
&+\Big(g_1^2+g_2^2\Big)Z_{i1}^H\Big(Z_{j1}^H\Big(3v_dZ_{k1}^H-v_uZ_{k2}^H\Big)-Z_{j2}^H\Big(v_dZ_{k2}^H+v_uZ_{k1}^H\Big)\Big)\\
&+2\Big(12v_X|\kappa|^2+\sqrt{2}\Big(A_\kappa^*+A_\kappa\Big)\Big)Z_{i3}^HZ_{j3}^HZ_{k3}^H\Big)
\end{aligned}
\tag{239}
$$



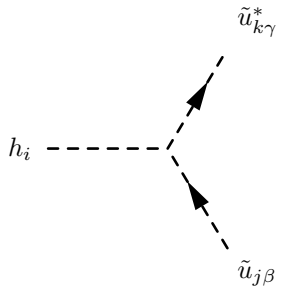
$$
\begin{aligned}
&-\frac{i}{4}\Big(Z_{i1}^H\Big(Z_{j1}^+\Big(\Big(g_1^2+g_2^2\Big)v_dZ_{k1}^++g_2^2v_uZ_{k2}^+\Big)+Z_{j2}^+\Big(\Big(-g_1^2+g_2^2\Big)v_dZ_{k2}^++g_2^2v_uZ_{k1}^+\Big)\Big)\\
&+Z_{i2}^H\Big(Z_{j1}^+\Big(\Big(-g_1^2+g_2^2\Big)v_uZ_{k1}^++g_2^2v_dZ_{k2}^+\Big)+Z_{j2}^+\Big(\Big(g_1^2+g_2^2\Big)v_uZ_{k2}^++g_2^2v_dZ_{k1}^+\Big)\Big)\Big)
\end{aligned}
\tag{240}
$$



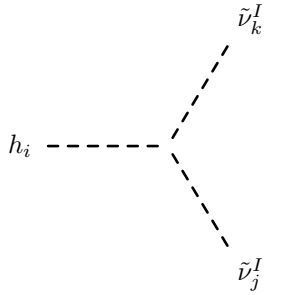
$$
\begin{aligned}
&\frac{i}{12}\delta_{\beta\gamma}\Big(\Big(3g_2^2+g_1^2\Big)\sum_{a=1}^{3}Z_{ja}^{D,*}Z_{ka}^{D}\Big(v_dZ_{i1}^{H}-v_uZ_{i2}^{H}\Big)\\
&+2\Big(g_1^2\sum_{a=1}^{3}Z_{j3+a}^{D,*}Z_{k3+a}^{D}\Big(v_dZ_{i1}^{H}-v_uZ_{i2}^{H}\Big)\\
&-3\Big(\sqrt{2}\sum_{b=1}^{3}Z_{jb}^{D,*}\sum_{a=1}^{3}Z_{k3+a}^{D}A_{d,ab}Z_{i1}^{H}+\sqrt{2}\sum_{b=1}^{3}\sum_{a=1}^{3}Z_{j3+a}^{D,*}A_{d,ab}^{*}Z_{kb}^{D}Z_{i1}^{H}\\
&+2v_d\sum_{c=1}^{3}Z_{j3+c}^{D,*}\sum_{b=1}^{3}\sum_{a=1}^{3}y_{d,ca}^{*}y_{d,ba}Z_{k3+b}^{D}Z_{i1}^{H}+2v_d\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{jb}^{D,*}\sum_{a=1}^{3}y_{d,ac}^{*}y_{d,ab}Z_{kc}^{D}Z_{i1}^{H}\\
&-\sqrt{2}\mu_H^{*}\sum_{b=1}^{3}Z_{jb}^{D,*}\sum_{a=1}^{3}y_{d,ab}Z_{k3+a}^{D}Z_{i2}^{H}-\sqrt{2}\mu_H\sum_{b=1}^{3}\sum_{a=1}^{3}y_{d,ab}^{*}Z_{j3+a}^{D,*}Z_{kb}^{D}Z_{i2}^{H}\Big)\Big)\Big)
\end{aligned}
\tag{241}
$$



$$
\begin{aligned}
&-\frac{i}{4}\Big(\Big(-g_2^2+g_1^2\Big)\sum_{a=1}^{3}Z_{ja}^{E,*}Z_{ka}^{E}\Big(v_dZ_{i1}^{H}-v_uZ_{i2}^{H}\Big)\\
&+2\Big(\sqrt{2}\sum_{b=1}^{3}Z_{jb}^{E,*}\sum_{a=1}^{3}Z_{k3+a}^{E}A_{e,ab}Z_{i1}^{H}+\sqrt{2}\sum_{b=1}^{3}\sum_{a=1}^{3}Z_{j3+a}^{E,*}A_{e,ab}^{*}Z_{kb}^{E}Z_{i1}^{H}\\
&+2v_d\sum_{c=1}^{3}Z_{j3+c}^{E,*}\sum_{b=1}^{3}\sum_{a=1}^{3}y_{e,ca}^{*}y_{e,ba}Z_{k3+b}^{E}Z_{i1}^{H}+2v_d\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{jb}^{E,*}\sum_{a=1}^{3}y_{e,ac}^{*}y_{e,ab}Z_{kc}^{E}Z_{i1}^{H}\\
&-\sqrt{2}\mu_H^{*}\sum_{b=1}^{3}Z_{jb}^{E,*}\sum_{a=1}^{3}y_{e,ab}Z_{k3+a}^{E}Z_{i2}^{H}-\sqrt{2}\mu_H\sum_{b=1}^{3}\sum_{a=1}^{3}y_{e,ab}^{*}Z_{j3+a}^{E,*}Z_{kb}^{E}Z_{i2}^{H}\\
&+g_1^2\sum_{a=1}^{3}Z_{j3+a}^{E,*}Z_{k3+a}^{E}\Big(-v_dZ_{i1}^{H}+v_uZ_{i2}^{H}\Big)\Big)\Big)
\end{aligned}
\tag{242}
$$



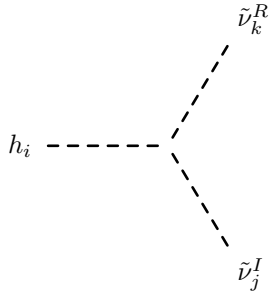
$$\frac{i}{12}\delta_{\beta\gamma}\Big(\Big(-3g_2^2+g_1^2\Big)\sum_{a=1}^{3}Z^{U,*}_{ja}Z^{U}_{ka}\Big(v_dZ^H_{i1}-v_uZ^H_{i2}\Big)$$
$$-2\Big(-3\sqrt{2}\mu^*_H\sum_{b=1}^{3}Z^{U,*}_{jb}\sum_{a=1}^{3}y_{u,ab}Z^U_{k3+a}Z^H_{i1}-3\sqrt{2}\mu_H\sum_{b=1}^{3}\sum_{a=1}^{3}y^*_{u,ab}Z^{U,*}_{j3+a}Z^U_{kb}Z^H_{i1}$$
$$+3\sqrt{2}\sum_{b=1}^{3}Z^{U,*}_{jb}\sum_{a=1}^{3}Z^U_{k3+a}A_{u,ab}Z^H_{i2}+3\sqrt{2}\sum_{b=1}^{3}\sum_{a=1}^{3}Z^{U,*}_{j3+a}A^*_{u,ab}Z^U_{kb}Z^H_{i2}$$
$$+6v_u\sum_{c=1}^{3}Z^{U,*}_{j3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}y^*_{u,ca}y_{u,ba}Z^U_{k3+b}Z^H_{i2}+6v_u\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{U,*}_{jb}\sum_{a=1}^{3}y^*_{u,ac}y_{u,ab}Z^U_{kc}Z^H_{i2}$$
$$+2g_1^2\sum_{a=1}^{3}Z^{U,*}_{j3+a}Z^U_{k3+a}\Big(v_dZ^H_{i1}-v_uZ^H_{i2}\Big)\Big)\Big) \tag{243}$$



$$\frac{i}{8}\Big(2\sqrt{2}\mu_H\sum_{b=1}^{3}Z^{I,*}_{kb}\sum_{a=1}^{2}Y^*_{\nu,ab}Z^{I,*}_{j3+a}Z^H_{i1}+2\sqrt{2}\mu_H\sum_{b=1}^{3}Z^{I,*}_{jb}\sum_{a=1}^{2}Y^*_{\nu,ab}Z^{I,*}_{k3+a}Z^H_{i1}$$
$$+2\sqrt{2}\mu^*_H\sum_{b=1}^{3}Z^{I,*}_{kb}\sum_{a=1}^{2}Z^{I,*}_{j3+a}Y_{\nu,ab}Z^H_{i1}+2\sqrt{2}\mu^*_H\sum_{b=1}^{3}Z^{I,*}_{jb}\sum_{a=1}^{2}Z^{I,*}_{k3+a}Y_{\nu,ab}Z^H_{i1}$$
$$-2\sqrt{2}\sum_{b=1}^{3}Z^{I,*}_{kb}\sum_{a=1}^{2}Z^{I,*}_{j3+a}A^*_{\nu,ab}Z^H_{i2}-2\sqrt{2}\sum_{b=1}^{3}Z^{I,*}_{jb}\sum_{a=1}^{2}Z^{I,*}_{k3+a}A^*_{\nu,ab}Z^H_{i2}$$

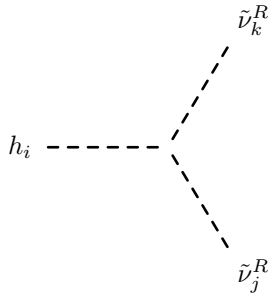
$$
\begin{aligned}
&- 2\sqrt{2}\sum_{b=1}^{3} Z_{kb}^{I,*}\sum_{a=1}^{2} Z_{j3+a}^{I,*} A_{\nu,ab} Z_{i2}^{H} - 2\sqrt{2}\sum_{b=1}^{3} Z_{jb}^{I,*}\sum_{a=1}^{2} Z_{k3+a}^{I,*} A_{\nu,ab} Z_{i2}^{H} \\
&- 4v_u \sum_{c=1}^{2} Z_{k3+c}^{I,*}\sum_{b=1}^{2} Z_{j3+b}^{I,*}\sum_{a=1}^{3} Y_{\nu,ca}^{*} Y_{\nu,ba} Z_{i2}^{H} \\
&- 4v_u \sum_{c=1}^{2} Z_{j3+c}^{I,*}\sum_{b=1}^{2} Z_{k3+b}^{I,*}\sum_{a=1}^{3} Y_{\nu,ca}^{*} Y_{\nu,ba} Z_{i2}^{H} \\
&- 2\sqrt{2}\sum_{c=1}^{2} Z_{k5+c}^{I,*}\sum_{b=1}^{3} Z_{jb}^{I,*}\sum_{a=1}^{2} \mu_{NS,ac}^{*} Y_{\nu,ab} Z_{i2}^{H} \\
&- 2\sqrt{2}\sum_{c=1}^{2} Z_{j5+c}^{I,*}\sum_{b=1}^{3} Z_{kb}^{I,*}\sum_{a=1}^{2} \mu_{NS,ac}^{*} Y_{\nu,ab} Z_{i2}^{H} \\
&- 2\sqrt{2}\sum_{c=1}^{3} Z_{kc}^{I,*}\sum_{b=1}^{2} Z_{j5+b}^{I,*}\sum_{a=1}^{2} Y_{\nu,ac}^{*} \mu_{NS,ab} Z_{i2}^{H} \\
&- 2\sqrt{2}\sum_{c=1}^{3} Z_{jc}^{I,*}\sum_{b=1}^{2} Z_{k5+b}^{I,*}\sum_{a=1}^{2} Y_{\nu,ac}^{*} \mu_{NS,ab} Z_{i2}^{H} \\
&- 4v_u \sum_{c=1}^{3} Z_{kc}^{I,*}\sum_{b=1}^{3} Z_{jb}^{I,*}\sum_{a=1}^{2} Y_{\nu,ac}^{*} Y_{\nu,ab} Z_{i2}^{H} - 4v_u \sum_{c=1}^{3} Z_{jc}^{I,*}\sum_{b=1}^{3} Z_{kb}^{I,*}\sum_{a=1}^{2} Y_{\nu,ac}^{*} Y_{\nu,ab} Z_{i2}^{H} \\
&- 2\Big(g_1^2 + g_2^2\Big)\sum_{a=1}^{3} Z_{ja}^{I,*} Z_{ka}^{I,*}\Big(v_d Z_{i1}^{H} - v_u Z_{i2}^{H}\Big) + 2\kappa v_X \sum_{b=1}^{2} Z_{k5+b}^{I,*}\sum_{a=1}^{2} \lambda_{ab}^{*} Z_{j5+a}^{I,*} Z_{i3}^{H} \\
&+ 2\kappa v_X \sum_{b=1}^{2} Z_{j5+b}^{I,*}\sum_{a=1}^{2} \lambda_{ab}^{*} Z_{k5+a}^{I,*} Z_{i3}^{H} + \sqrt{2}\sum_{b=1}^{2} Z_{k5+b}^{I,*}\sum_{a=1}^{2} Z_{j5+a}^{I,*} A_{\lambda,ab}^{*} Z_{i3}^{H} \\
&+ \sqrt{2}\sum_{b=1}^{2} Z_{j5+b}^{I,*}\sum_{a=1}^{2} Z_{k5+a}^{I,*} A_{\lambda,ab}^{*} Z_{i3}^{H} + 2v_X \kappa^{*}\sum_{b=1}^{2} Z_{k5+b}^{I,*}\sum_{a=1}^{2} Z_{j5+a}^{I,*} \lambda_{ab} Z_{i3}^{H} \\
&+ 2v_X \kappa^{*}\sum_{b=1}^{2} Z_{j5+b}^{I,*}\sum_{a=1}^{2} Z_{k5+a}^{I,*} \lambda_{ab} Z_{i3}^{H} + \sqrt{2}\sum_{b=1}^{2} Z_{k5+b}^{I,*}\sum_{a=1}^{2} Z_{j5+a}^{I,*} A_{\lambda,ab} Z_{i3}^{H} \\
&+ \sqrt{2}\sum_{b=1}^{2} Z_{j5+b}^{I,*}\sum_{a=1}^{2} Z_{k5+a}^{I,*} A_{\lambda,ab} Z_{i3}^{H} - 4v_X \sum_{c=1}^{2} Z_{k5+c}^{I,*}\sum_{b=1}^{2} Z_{j5+b}^{I,*}\sum_{a=1}^{2} \lambda_{ac}^{*} \lambda_{ab} Z_{i3}^{H} \\
&- 4v_X \sum_{c=1}^{2} Z_{j5+c}^{I,*}\sum_{b=1}^{2} Z_{k5+b}^{I,*}\sum_{a=1}^{2} \lambda_{ac}^{*} \lambda_{ab} Z_{i3}^{H} + 2\sqrt{2}\sum_{c=1}^{2} Z_{k3+c}^{I,*}\sum_{b=1}^{2} Z_{j5+b}^{I,*}\sum_{a=1}^{2} \mu_{NS,ca}^{*} \lambda_{ab} Z_{i3}^{H} \\
&+ 2\sqrt{2}\sum_{c=1}^{2} Z_{j3+c}^{I,*}\sum_{b=1}^{2} Z_{k5+b}^{I,*}\sum_{a=1}^{2} \mu_{NS,ca}^{*} \lambda_{ab} Z_{i3}^{H} + 2\sqrt{2}\sum_{c=1}^{2} Z_{k5+c}^{I,*}\sum_{b=1}^{2} Z_{j3+b}^{I,*}\sum_{a=1}^{2} \lambda_{ac}^{*} \mu_{NS,ba} Z_{i3}^{H}
\end{aligned}
$$

$$+ 2\sqrt{2}\sum_{c=1}^{2} Z^{I,*}_{j5+c}\sum_{b=1}^{2} Z^{I,*}_{k3+b}\sum_{a=1}^{2}\lambda^{*}_{ac}\mu_{NS,ba}Z^{H}_{i3}\Big) \tag{244}$$



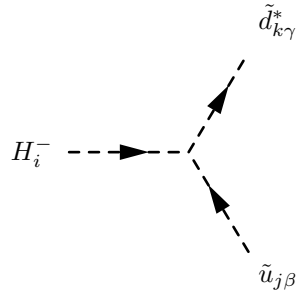
$$\frac{1}{8}\Big(- 2\sqrt{2}\mu_H\sum_{b=1}^{3} Z^{R,*}_{kb}\sum_{a=1}^{2} Y^{*}_{\nu,ab}Z^{I,*}_{j3+a}Z^{H}_{i1} + 2\sqrt{2}\mu_H\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{2} Y^{*}_{\nu,ab}Z^{R,*}_{k3+a}Z^{H}_{i1}$$
$$+ 2\sqrt{2}\mu^{*}_H\sum_{b=1}^{3} Z^{R,*}_{kb}\sum_{a=1}^{2} Z^{I,*}_{j3+a}Y_{\nu,ab}Z^{H}_{i1} - 2\sqrt{2}\mu^{*}_H\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{2} Z^{R,*}_{k3+a}Y_{\nu,ab}Z^{H}_{i1}$$
$$+ 2\sqrt{2}\sum_{b=1}^{3} Z^{R,*}_{kb}\sum_{a=1}^{2} Z^{I,*}_{j3+a}A^{*}_{\nu,ab}Z^{H}_{i2} - 2\sqrt{2}\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{2} Z^{R,*}_{k3+a}A^{*}_{\nu,ab}Z^{H}_{i2}$$
$$- 2\sqrt{2}\sum_{b=1}^{3} Z^{R,*}_{kb}\sum_{a=1}^{2} Z^{I,*}_{j3+a}A_{\nu,ab}Z^{H}_{i2} + 2\sqrt{2}\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{2} Z^{R,*}_{k3+a}A_{\nu,ab}Z^{H}_{i2}$$
$$- 4v_u\sum_{c=1}^{2} Z^{R,*}_{k3+c}\sum_{b=1}^{2} Z^{I,*}_{j3+b}\sum_{a=1}^{3} Y^{*}_{\nu,ca}Y_{\nu,ba}Z^{H}_{i2}$$
$$+ 4v_u\sum_{c=1}^{2} Z^{I,*}_{j3+c}\sum_{b=1}^{2} Z^{R,*}_{k3+b}\sum_{a=1}^{3} Y^{*}_{\nu,ca}Y_{\nu,ba}Z^{H}_{i2}$$
$$+ 2\sqrt{2}\sum_{c=1}^{2} Z^{R,*}_{k5+c}\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{2}\mu^{*}_{NS,ac}Y_{\nu,ab}Z^{H}_{i2} - 2\sqrt{2}\sum_{c=1}^{2} Z^{I,*}_{j5+c}\sum_{b=1}^{3} Z^{R,*}_{kb}\sum_{a=1}^{2}\mu^{*}_{NS,ac}Y_{\nu,ab}Z^{H}_{i2}$$
$$+ 2\sqrt{2}\sum_{c=1}^{3} Z^{R,*}_{kc}\sum_{b=1}^{2} Z^{I,*}_{j5+b}\sum_{a=1}^{2} Y^{*}_{\nu,ac}\mu_{NS,ab}Z^{H}_{i2} - 2\sqrt{2}\sum_{c=1}^{3} Z^{I,*}_{jc}\sum_{b=1}^{2} Z^{R,*}_{k5+b}\sum_{a=1}^{2} Y^{*}_{\nu,ac}\mu_{NS,ab}Z^{H}_{i2}$$
$$+ 4v_u\sum_{c=1}^{3} Z^{R,*}_{kc}\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{2} Y^{*}_{\nu,ac}Y_{\nu,ab}Z^{H}_{i2} - 4v_u\sum_{c=1}^{3} Z^{I,*}_{jc}\sum_{b=1}^{3} Z^{R,*}_{kb}\sum_{a=1}^{2} Y^{*}_{\nu,ac}Y_{\nu,ab}Z^{H}_{i2}$$
$$- 2\kappa v_X\sum_{b=1}^{2} Z^{R,*}_{k5+b}\sum_{a=1}^{2}\lambda^{*}_{ab}Z^{I,*}_{j5+a}Z^{H}_{i3} - 2\kappa v_X\sum_{b=1}^{2} Z^{I,*}_{j5+b}\sum_{a=1}^{2}\lambda^{*}_{ab}Z^{R,*}_{k5+a}Z^{H}_{i3}$$
$$- \sqrt{2}\sum_{b=1}^{2} Z^{R,*}_{k5+b}\sum_{a=1}^{2} Z^{I,*}_{j5+a}A^{*}_{\lambda,ab}Z^{H}_{i3} - \sqrt{2}\sum_{b=1}^{2} Z^{I,*}_{j5+b}\sum_{a=1}^{2} Z^{R,*}_{k5+a}A^{*}_{\lambda,ab}Z^{H}_{i3}$$

$$
\begin{aligned}
&+ 2v_X\kappa^* \sum_{b=1}^{2} Z^{R,*}_{k5+b} \sum_{a=1}^{2} Z^{I,*}_{j5+a} \lambda_{ab} Z^H_{i3} + 2v_X\kappa^* \sum_{b=1}^{2} Z^{I,*}_{j5+b} \sum_{a=1}^{2} Z^{R,*}_{k5+a} \lambda_{ab} Z^H_{i3} \\
&+ \sqrt{2} \sum_{b=1}^{2} Z^{R,*}_{k5+b} \sum_{a=1}^{2} Z^{I,*}_{j5+a} A_{\lambda,ab} Z^H_{i3} + \sqrt{2} \sum_{b=1}^{2} Z^{I,*}_{j5+b} \sum_{a=1}^{2} Z^{R,*}_{k5+a} A_{\lambda,ab} Z^H_{i3} \\
&+ 4v_X \sum_{c=1}^{2} Z^{R,*}_{k5+c} \sum_{b=1}^{2} Z^{I,*}_{j5+b} \sum_{a=1}^{2} \lambda^*_{ac} \lambda_{ab} Z^H_{i3} - 4v_X \sum_{c=1}^{2} Z^{I,*}_{j5+c} \sum_{b=1}^{2} Z^{R,*}_{k5+b} \sum_{a=1}^{2} \lambda^*_{ac} \lambda_{ab} Z^H_{i3} \\
&+ 2\sqrt{2} \sum_{c=1}^{2} Z^{R,*}_{k3+c} \sum_{b=1}^{2} Z^{I,*}_{j5+b} \sum_{a=1}^{2} \mu^*_{NS,ca} \lambda_{ab} Z^H_{i3} + 2\sqrt{2} \sum_{c=1}^{2} Z^{I,*}_{j3+c} \sum_{b=1}^{2} Z^{R,*}_{k5+b} \sum_{a=1}^{2} \mu^*_{NS,ca} \lambda_{ab} Z^H_{i3} \\
&- 2\sqrt{2} \sum_{c=1}^{2} Z^{R,*}_{k5+c} \sum_{b=1}^{2} Z^{I,*}_{j3+b} \sum_{a=1}^{2} \lambda^*_{ac} \mu_{NS,ba} Z^H_{i3} \\
&- 2\sqrt{2} \sum_{c=1}^{2} Z^{I,*}_{j5+c} \sum_{b=1}^{2} Z^{R,*}_{k3+b} \sum_{a=1}^{2} \lambda^*_{ac} \mu_{NS,ba} Z^H_{i3} \Big)
\end{aligned} \tag{245}
$$



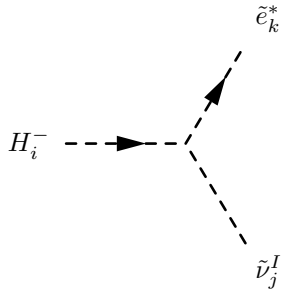
$$
\begin{aligned}
&- \frac{i}{8}\Big(- 2\sqrt{2}\mu_H \sum_{b=1}^{3} Z^{R,*}_{kb} \sum_{a=1}^{2} Y^*_{\nu,ab} Z^{R,*}_{j3+a} Z^H_{i1} - 2\sqrt{2}\mu_H \sum_{b=1}^{3} Z^{R,*}_{jb} \sum_{a=1}^{2} Y^*_{\nu,ab} Z^{R,*}_{k3+a} Z^H_{i1} \\
&- 2\sqrt{2}\mu^*_H \sum_{b=1}^{3} Z^{R,*}_{kb} \sum_{a=1}^{2} Z^{R,*}_{j3+a} Y_{\nu,ab} Z^H_{i1} - 2\sqrt{2}\mu^*_H \sum_{b=1}^{3} Z^{R,*}_{jb} \sum_{a=1}^{2} Z^{R,*}_{k3+a} Y_{\nu,ab} Z^H_{i1} \\
&+ 2\sqrt{2} \sum_{b=1}^{3} Z^{R,*}_{kb} \sum_{a=1}^{2} Z^{R,*}_{j3+a} A^*_{\nu,ab} Z^H_{i2} + 2\sqrt{2} \sum_{b=1}^{3} Z^{R,*}_{jb} \sum_{a=1}^{2} Z^{R,*}_{k3+a} A^*_{\nu,ab} Z^H_{i2} \\
&+ 2\sqrt{2} \sum_{b=1}^{3} Z^{R,*}_{kb} \sum_{a=1}^{2} Z^{R,*}_{j3+a} A_{\nu,ab} Z^H_{i2} + 2\sqrt{2} \sum_{b=1}^{3} Z^{R,*}_{jb} \sum_{a=1}^{2} Z^{R,*}_{k3+a} A_{\nu,ab} Z^H_{i2} \\
&+ 4v_u \sum_{c=1}^{2} Z^{R,*}_{k3+c} \sum_{b=1}^{2} Z^{R,*}_{j3+b} \sum_{a=1}^{3} Y^*_{\nu,ca} Y_{\nu,ba} Z^H_{i2} \\
&+ 4v_u \sum_{c=1}^{2} Z^{R,*}_{j3+c} \sum_{b=1}^{2} Z^{R,*}_{k3+b} \sum_{a=1}^{3} Y^*_{\nu,ca} Y_{\nu,ba} Z^H_{i2}
\end{aligned}
$$

$$
\begin{aligned}
&+ 2\sqrt{2}\sum_{c=1}^{2} Z^{R,*}_{k5+c}\sum_{b=1}^{3} Z^{R,*}_{jb}\sum_{a=1}^{2}\mu^{*}_{NS,ac}Y_{\nu,ab}Z^{H}_{i2} + 2\sqrt{2}\sum_{c=1}^{2} Z^{R,*}_{j5+c}\sum_{b=1}^{3} Z^{R,*}_{kb}\sum_{a=1}^{2}\mu^{*}_{NS,ac}Y_{\nu,ab}Z^{H}_{i2}\\
&+ 2\sqrt{2}\sum_{c=1}^{3} Z^{R,*}_{kc}\sum_{b=1}^{2} Z^{R,*}_{j5+b}\sum_{a=1}^{2}Y^{*}_{\nu,ac}\mu_{NS,ab}Z^{H}_{i2} + 2\sqrt{2}\sum_{c=1}^{3} Z^{R,*}_{jc}\sum_{b=1}^{2} Z^{R,*}_{k5+b}\sum_{a=1}^{2}Y^{*}_{\nu,ac}\mu_{NS,ab}Z^{H}_{i2}\\
&+ 4v_u\sum_{c=1}^{3} Z^{R,*}_{kc}\sum_{b=1}^{3} Z^{R,*}_{jb}\sum_{a=1}^{2}Y^{*}_{\nu,ac}Y_{\nu,ab}Z^{H}_{i2} + 4v_u\sum_{c=1}^{3} Z^{R,*}_{jc}\sum_{b=1}^{3} Z^{R,*}_{kb}\sum_{a=1}^{2}Y^{*}_{\nu,ac}Y_{\nu,ab}Z^{H}_{i2}\\
&+ 2\Big(g_1^2+g_2^2\Big)\sum_{a=1}^{3} Z^{R,*}_{ja}Z^{R,*}_{ka}\Big(v_dZ^{H}_{i1}-v_uZ^{H}_{i2}\Big) + 2\kappa v_X\sum_{b=1}^{2} Z^{R,*}_{k5+b}\sum_{a=1}^{2}\lambda^{*}_{ab}Z^{R,*}_{j5+a}Z^{H}_{i3}\\
&+ 2\kappa v_X\sum_{b=1}^{2} Z^{R,*}_{j5+b}\sum_{a=1}^{2}\lambda^{*}_{ab}Z^{R,*}_{k5+a}Z^{H}_{i3} + \sqrt{2}\sum_{b=1}^{2} Z^{R,*}_{k5+b}\sum_{a=1}^{2} Z^{R,*}_{j5+a}A^{*}_{\lambda,ab}Z^{H}_{i3}\\
&+ \sqrt{2}\sum_{b=1}^{2} Z^{R,*}_{j5+b}\sum_{a=1}^{2} Z^{R,*}_{k5+a}A^{*}_{\lambda,ab}Z^{H}_{i3} + 2v_X\kappa^{*}\sum_{b=1}^{2} Z^{R,*}_{k5+b}\sum_{a=1}^{2} Z^{R,*}_{j5+a}\lambda_{ab}Z^{H}_{i3}\\
&+ 2v_X\kappa^{*}\sum_{b=1}^{2} Z^{R,*}_{j5+b}\sum_{a=1}^{2} Z^{R,*}_{k5+a}\lambda_{ab}Z^{H}_{i3} + \sqrt{2}\sum_{b=1}^{2} Z^{R,*}_{k5+b}\sum_{a=1}^{2} Z^{R,*}_{j5+a}A_{\lambda,ab}Z^{H}_{i3}\\
&+ \sqrt{2}\sum_{b=1}^{2} Z^{R,*}_{j5+b}\sum_{a=1}^{2} Z^{R,*}_{k5+a}A_{\lambda,ab}Z^{H}_{i3} + 4v_X\sum_{c=1}^{2} Z^{R,*}_{k5+c}\sum_{b=1}^{2} Z^{R,*}_{j5+b}\sum_{a=1}^{2}\lambda^{*}_{ac}\lambda_{ab}Z^{H}_{i3}\\
&+ 4v_X\sum_{c=1}^{2} Z^{R,*}_{j5+c}\sum_{b=1}^{2} Z^{R,*}_{k5+b}\sum_{a=1}^{2}\lambda^{*}_{ac}\lambda_{ab}Z^{H}_{i3} + 2\sqrt{2}\sum_{c=1}^{2} Z^{R,*}_{k3+c}\sum_{b=1}^{2} Z^{R,*}_{j5+b}\sum_{a=1}^{2}\mu^{*}_{NS,ca}\lambda_{ab}Z^{H}_{i3}\\
&+ 2\sqrt{2}\sum_{c=1}^{2} Z^{R,*}_{j3+c}\sum_{b=1}^{2} Z^{R,*}_{k5+b}\sum_{a=1}^{2}\mu^{*}_{NS,ca}\lambda_{ab}Z^{H}_{i3} + 2\sqrt{2}\sum_{c=1}^{2} Z^{R,*}_{k5+c}\sum_{b=1}^{2} Z^{R,*}_{j3+b}\sum_{a=1}^{2}\lambda^{*}_{ac}\mu_{NS,ba}Z^{H}_{i3}\\
&+ 2\sqrt{2}\sum_{c=1}^{2} Z^{R,*}_{j5+c}\sum_{b=1}^{2} Z^{R,*}_{k3+b}\sum_{a=1}^{2}\lambda^{*}_{ac}\mu_{NS,ba}Z^{H}_{i3}\Big)
\end{aligned}
\tag{246}
$$

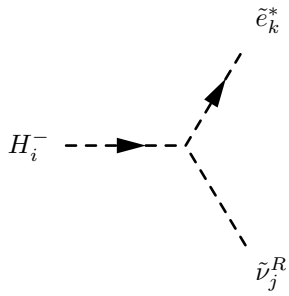


$$
-\frac{i}{4}\delta_{\beta\gamma}\Big(\sqrt{2}g_2^2\sum_{a=1}^{3} Z^{U,*}_{ja}Z^{D}_{ka}\Big(v_dZ^{+}_{i1}+v_uZ^{+}_{i2}\Big)
$$

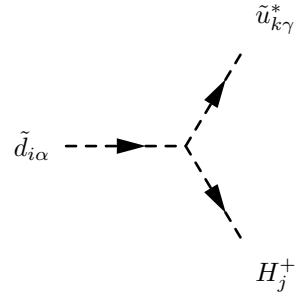
$$
\begin{aligned}
&- 2\Big(2\sum_{b=1}^{3} Z^{U,*}_{jb}\sum_{a=1}^{3} Z^{D}_{k3+a}A_{d,ab}Z^{+}_{i1} + 2\mu_H\sum_{b=1}^{3}\sum_{a=1}^{3} y^{*}_{u,ab}Z^{U,*}_{j3+a}Z^{D}_{kb}Z^{+}_{i1}\\
&+ \sqrt{2}v_u\sum_{c=1}^{3} Z^{U,*}_{j3+c}\sum_{b=1}^{3}\sum_{a=1}^{3} y^{*}_{u,ca}y_{d,ba}Z^{D}_{k3+b}Z^{+}_{i1}\\
&+ \sqrt{2}v_d\sum_{c=1}^{3}\sum_{b=1}^{3} Z^{U,*}_{jb}\sum_{a=1}^{3} y^{*}_{d,ac}y_{d,ab}Z^{D}_{kc}Z^{+}_{i1} + 2\mu^{*}_H\sum_{b=1}^{3} Z^{U,*}_{jb}\sum_{a=1}^{3} y_{d,ab}Z^{D}_{k3+a}Z^{+}_{i2}\\
&+ 2\sum_{b=1}^{3}\sum_{a=1}^{3} Z^{U,*}_{j3+a}A^{*}_{u,ab}Z^{D}_{kb}Z^{+}_{i2} + \sqrt{2}v_d\sum_{c=1}^{3} Z^{U,*}_{j3+c}\sum_{b=1}^{3}\sum_{a=1}^{3} y^{*}_{u,ca}y_{d,ba}Z^{D}_{k3+b}Z^{+}_{i2}\\
&+ \sqrt{2}v_u\sum_{c=1}^{3}\sum_{b=1}^{3} Z^{U,*}_{jb}\sum_{a=1}^{3} y^{*}_{u,ac}y_{u,ab}Z^{D}_{kc}Z^{+}_{i2}\Big)\Big)
\end{aligned}
\tag{247}
$$



$$
\begin{aligned}
&\frac{1}{4}\Big(g_2^2\sum_{a=1}^{3} Z^{I,*}_{ja}Z^{E}_{ka}\Big(v_dZ^{+}_{i1} + v_uZ^{+}_{i2}\Big)\\
&- 2\Big(\sqrt{2}\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{3} Z^{E}_{k3+a}A_{e,ab}Z^{+}_{i1} + \sqrt{2}\mu_H\sum_{b=1}^{3}\sum_{a=1}^{2} Y^{*}_{\nu,ab}Z^{I,*}_{j3+a}Z^{E}_{kb}Z^{+}_{i1}\\
&+ v_u\sum_{c=1}^{2} Z^{I,*}_{j3+c}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{\nu,ca}y_{e,ba}Z^{E}_{k3+b}Z^{+}_{i1} + v_d\sum_{c=1}^{3}\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{3} y^{*}_{e,ac}y_{e,ab}Z^{E}_{kc}Z^{+}_{i1}\\
&+ \sqrt{2}\mu^{*}_H\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{3} y_{e,ab}Z^{E}_{k3+a}Z^{+}_{i2} + \sqrt{2}\sum_{b=1}^{3}\sum_{a=1}^{2} Z^{I,*}_{j3+a}A^{*}_{\nu,ab}Z^{E}_{kb}Z^{+}_{i2}\\
&+ v_d\sum_{c=1}^{2} Z^{I,*}_{j3+c}\sum_{b=1}^{3}\sum_{a=1}^{3} Y^{*}_{\nu,ca}y_{e,ba}Z^{E}_{k3+b}Z^{+}_{i2} + \sqrt{2}\sum_{c=1}^{3}\sum_{b=1}^{2} Z^{I,*}_{j5+b}\sum_{a=1}^{2} Y^{*}_{\nu,ac}\mu_{NS,ab}Z^{E}_{kc}Z^{+}_{i2}\\
&+ v_u\sum_{c=1}^{3}\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{2} Y^{*}_{\nu,ac}Y_{\nu,ab}Z^{E}_{kc}Z^{+}_{i2}\Big)\Big)
\end{aligned}
\tag{248}
$$

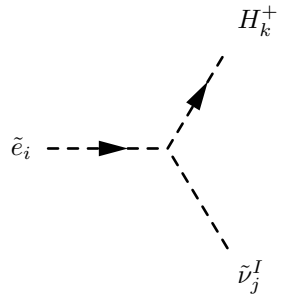


$$
\begin{aligned}
&-\frac{i}{4}\Big(g_2^2\sum_{a=1}^{3}Z_{ja}^{R,*}Z_{ka}^{E}\Big(v_dZ_{i1}^{+}+v_uZ_{i2}^{+}\Big)\\
&-2\Big(\sqrt{2}\sum_{b=1}^{3}Z_{jb}^{R,*}\sum_{a=1}^{3}Z_{k3+a}^{E}A_{e,ab}Z_{i1}^{+}+\sqrt{2}\mu_H\sum_{b=1}^{3}\sum_{a=1}^{2}Y_{\nu,ab}^{*}Z_{j3+a}^{R,*}Z_{kb}^{E}Z_{i1}^{+}\\
&+v_u\sum_{c=1}^{2}Z_{j3+c}^{R,*}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{\nu,ca}^{*}y_{e,ba}Z_{k3+b}^{E}Z_{i1}^{+}+v_d\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{jb}^{R,*}\sum_{a=1}^{3}y_{e,ac}^{*}y_{e,ab}Z_{kc}^{E}Z_{i1}^{+}\\
&+\sqrt{2}\mu_H^{*}\sum_{b=1}^{3}Z_{jb}^{R,*}\sum_{a=1}^{3}y_{e,ab}Z_{k3+a}^{E}Z_{i2}^{+}+\sqrt{2}\sum_{b=1}^{3}\sum_{a=1}^{2}Z_{j3+a}^{R,*}A_{\nu,ab}^{*}Z_{kb}^{E}Z_{i2}^{+}\\
&+v_d\sum_{c=1}^{2}Z_{j3+c}^{R,*}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{\nu,ca}^{*}y_{e,ba}Z_{k3+b}^{E}Z_{i2}^{+}+\sqrt{2}\sum_{c=1}^{3}\sum_{b=1}^{2}Z_{j5+b}^{R,*}\sum_{a=1}^{2}Y_{\nu,ac}^{*}\mu_{NS,ab}Z_{kc}^{E}Z_{i2}^{+}\\
&+v_u\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{jb}^{R,*}\sum_{a=1}^{2}Y_{\nu,ac}^{*}Y_{\nu,ab}Z_{kc}^{E}Z_{i2}^{+}\Big)\Big)
\end{aligned}
\tag{249}
$$

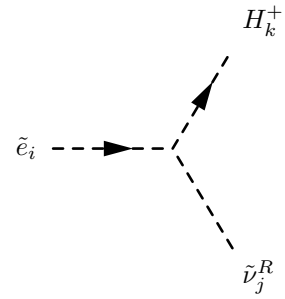


$$
\begin{aligned}
&-\frac{i}{4}\delta_{\alpha\gamma}\Big(\sqrt{2}g_2^2\sum_{a=1}^{3}Z_{ia}^{D,*}Z_{ka}^{U}\Big(v_dZ_{j1}^{+}+v_uZ_{j2}^{+}\Big)\\
&-2\Big(2\mu_H^{*}\sum_{b=1}^{3}Z_{ib}^{D,*}\sum_{a=1}^{3}y_{u,ab}Z_{k3+a}^{U}Z_{j1}^{+}+2\sum_{b=1}^{3}\sum_{a=1}^{3}Z_{i3+a}^{D,*}A_{d,ab}^{*}Z_{kb}^{U}Z_{j1}^{+}
\end{aligned}
$$

$$
\begin{aligned}
&+\sqrt{2}v_u\sum_{c=1}^{3}Z^{D,*}_{i3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}y^*_{d,ca}y_{u,ba}Z^U_{k3+b}Z^+_{j1}\\
&+\sqrt{2}v_d\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{D,*}_{ib}\sum_{a=1}^{3}y^*_{d,ac}y_{d,ab}Z^U_{kc}Z^+_{j1}+2\sum_{b=1}^{3}Z^{D,*}_{ib}\sum_{a=1}^{3}Z^U_{k3+a}A_{u,ab}Z^+_{j2}\\
&+2\mu_H\sum_{b=1}^{3}\sum_{a=1}^{3}y^*_{d,ab}Z^{D,*}_{i3+a}Z^U_{kb}Z^+_{j2}+\sqrt{2}v_d\sum_{c=1}^{3}Z^{D,*}_{i3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}y^*_{d,ca}y_{u,ba}Z^U_{k3+b}Z^+_{j2}\\
&+\sqrt{2}v_u\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{D,*}_{ib}\sum_{a=1}^{3}y^*_{u,ac}y_{u,ab}Z^U_{kc}Z^+_{j2}\Big)\Big)
\end{aligned}
\tag{250}
$$

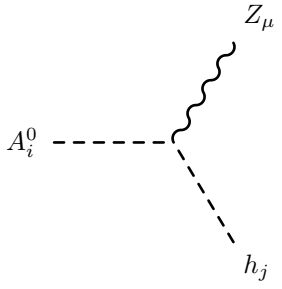


$$
\begin{aligned}
&\frac{1}{4}\Big(-g_2^2\sum_{a=1}^{3}Z^{E,*}_{ia}Z^{I,*}_{ja}\Big(v_dZ^+_{k1}+v_uZ^+_{k2}\Big)\\
&+2\Big(\sqrt{2}\mu^*_H\sum_{b=1}^{3}Z^{E,*}_{ib}\sum_{a=1}^{2}Z^{I,*}_{j3+a}Y_{\nu,ab}Z^+_{k1}+\sqrt{2}\sum_{b=1}^{3}Z^{I,*}_{jb}\sum_{a=1}^{3}Z^{E,*}_{i3+a}A^*_{e,ab}Z^+_{k1}\\
&+v_u\sum_{c=1}^{3}Z^{E,*}_{i3+c}\sum_{b=1}^{2}Z^{I,*}_{j3+b}\sum_{a=1}^{3}y^*_{e,ca}Y_{\nu,ba}Z^+_{k1}+v_d\sum_{c=1}^{3}Z^{I,*}_{jc}\sum_{b=1}^{3}Z^{E,*}_{ib}\sum_{a=1}^{3}y^*_{e,ac}y_{e,ab}Z^+_{k1}\\
&+\sqrt{2}\sum_{b=1}^{3}Z^{E,*}_{ib}\sum_{a=1}^{2}Z^{I,*}_{j3+a}A_{\nu,ab}Z^+_{k2}+\sqrt{2}\mu_H\sum_{b=1}^{3}Z^{I,*}_{jb}\sum_{a=1}^{3}y^*_{e,ab}Z^{E,*}_{i3+a}Z^+_{k2}\\
&+\sqrt{2}\sum_{c=1}^{2}Z^{I,*}_{j5+c}\sum_{b=1}^{3}Z^{E,*}_{ib}\sum_{a=1}^{2}\mu^*_{NS,ac}Y_{\nu,ab}Z^+_{k2}+v_d\sum_{c=1}^{3}Z^{E,*}_{i3+c}\sum_{b=1}^{2}Z^{I,*}_{j3+b}\sum_{a=1}^{3}y^*_{e,ca}Y_{\nu,ba}Z^+_{k2}\\
&+v_u\sum_{c=1}^{3}Z^{I,*}_{jc}\sum_{b=1}^{3}Z^{E,*}_{ib}\sum_{a=1}^{2}Y^*_{\nu,ac}Y_{\nu,ab}Z^+_{k2}\Big)\Big)
\end{aligned}
\tag{251}
$$

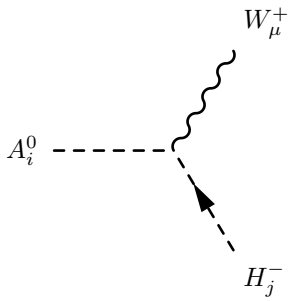


$$
\begin{aligned}
&-\frac{i}{4}\Big(g_2^2\sum_{a=1}^{3} Z_{ia}^{E,*} Z_{ja}^{R,*}\Big(v_d Z_{k1}^{+} + v_u Z_{k2}^{+}\Big)\\
&-2\Big(\sqrt{2}\mu_H^{*}\sum_{b=1}^{3} Z_{ib}^{E,*}\sum_{a=1}^{2} Z_{j3+a}^{R,*} Y_{\nu,ab} Z_{k1}^{+} + \sqrt{2}\sum_{b=1}^{3} Z_{jb}^{R,*}\sum_{a=1}^{3} Z_{i3+a}^{E,*} A_{e,ab}^{*} Z_{k1}^{+}\\
&+v_u\sum_{c=1}^{3} Z_{i3+c}^{E,*}\sum_{b=1}^{2} Z_{j3+b}^{R,*}\sum_{a=1}^{3} y_{e,ca}^{*} Y_{\nu,ba} Z_{k1}^{+} + v_d\sum_{c=1}^{3} Z_{jc}^{R,*}\sum_{b=1}^{3} Z_{ib}^{E,*}\sum_{a=1}^{3} y_{e,ac}^{*} y_{e,ab} Z_{k1}^{+}\\
&+\sqrt{2}\sum_{b=1}^{3} Z_{ib}^{E,*}\sum_{a=1}^{2} Z_{j3+a}^{R,*} A_{\nu,ab} Z_{k2}^{+} + \sqrt{2}\mu_H\sum_{b=1}^{3} Z_{jb}^{R,*}\sum_{a=1}^{3} y_{e,ab}^{*} Z_{i3+a}^{E,*} Z_{k2}^{+}\\
&+\sqrt{2}\sum_{c=1}^{2} Z_{j5+c}^{R,*}\sum_{b=1}^{3} Z_{ib}^{E,*}\sum_{a=1}^{2} \mu_{NS,ac}^{*} Y_{\nu,ab} Z_{k2}^{+} + v_d\sum_{c=1}^{3} Z_{i3+c}^{E,*}\sum_{b=1}^{2} Z_{j3+b}^{R,*}\sum_{a=1}^{3} y_{e,ca}^{*} Y_{\nu,ba} Z_{k2}^{+}\\
&+v_u\sum_{c=1}^{3} Z_{jc}^{R,*}\sum_{b=1}^{3} Z_{ib}^{E,*}\sum_{a=1}^{2} Y_{\nu,ac}^{*} Y_{\nu,ab} Z_{k2}^{+}\Big)\Big)
\end{aligned}
\tag{252}
$$

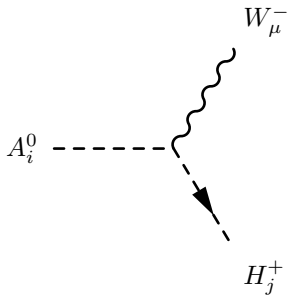
9.2 Two Scalar-One Vector Boson-Interaction



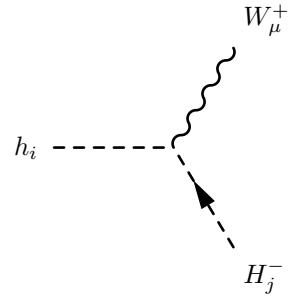
$$
\frac{1}{2}\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\Big(Z_{i1}^{A} Z_{j1}^{H} - Z_{i2}^{A} Z_{j2}^{H}\Big)\Big(-p_\mu^{h_j} + p_\mu^{A_i^0}\Big) \tag{253}
$$



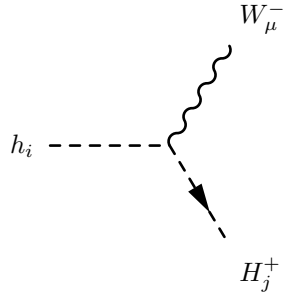
$$\frac{1}{2}g_2\Big(Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+\Big)\Big(-p_\mu^{H_j^-} + p_\mu^{A_i^0}\Big) \tag{254}$$



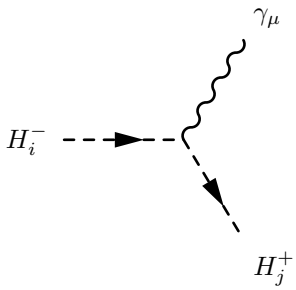
$$\frac{1}{2}g_2\Big(Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+\Big)\Big(-p_\mu^{H_j^+} + p_\mu^{A_i^0}\Big) \tag{255}$$



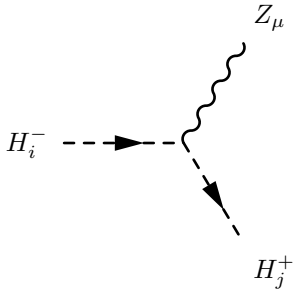
$$\frac{i}{2}g_2\Big(Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+\Big)\Big(-p_\mu^{H_j^-} + p_\mu^{h_i}\Big) \tag{256}$$



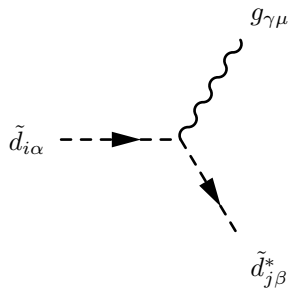
$$-\frac{i}{2}g_2\Big(Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+\Big)\Big(-p_\mu^{H_j^+} + p_\mu^{h_i}\Big) \tag{257}$$



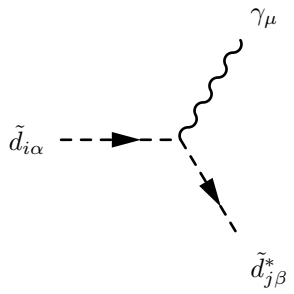
$$\frac{i}{2}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)\Big(Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+\Big)\Big(-p_\mu^{H_j^+} + p_\mu^{H_i^-}\Big) \tag{258}$$



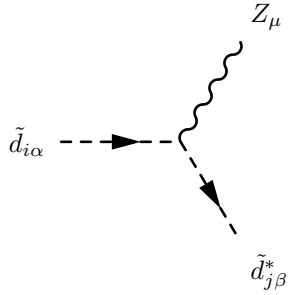
$$\frac{i}{2}\Big(-g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\Big(Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+\Big)\Big(-p_\mu^{H_j^+} + p_\mu^{H_i^-}\Big) \tag{259}$$



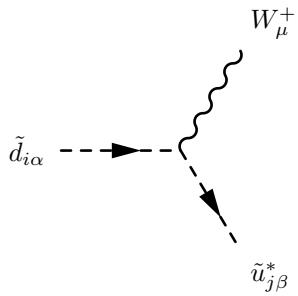
$$-\frac{i}{2}g_3\delta_{ij}\lambda^{\gamma}_{\beta,\alpha}\Big(-p_\mu^{\tilde{d}^*_{j\beta}}+p_\mu^{\tilde{d}_{i\alpha}}\Big) \tag{260}$$



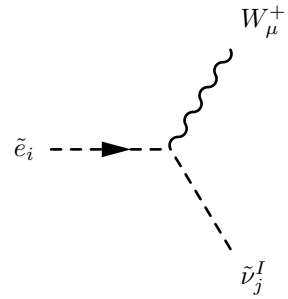
$$-\frac{i}{6}\delta_{\alpha\beta}\Big(-2g_1\cos\Theta_W\sum_{a=1}^{3}Z^{D,*}_{i3+a}Z^{D}_{j3+a}+\Big(-3g_2\sin\Theta_W+g_1\cos\Theta_W\Big)\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{D}_{ja}\Big)\Big(-p_\mu^{\tilde{d}^*_{j\beta}}+p_\mu^{\tilde{d}_{i\alpha}}\Big) \tag{261}$$



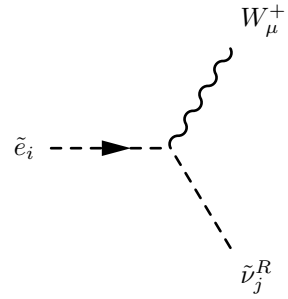
$$\frac{i}{6}\delta_{\alpha\beta}\Big(-2g_1\sin\Theta_W\sum_{a=1}^{3}Z^{D,*}_{i3+a}Z^{D}_{j3+a}+\Big(3g_2\cos\Theta_W+g_1\sin\Theta_W\Big)\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{D}_{ja}\Big)\Big(-p_\mu^{\tilde{d}^*_{j\beta}}+p_\mu^{\tilde{d}_{i\alpha}}\Big) \tag{262}$$



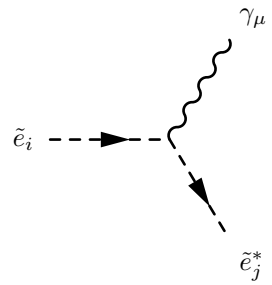
$$-i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{U}_{ja}\Big(-p_\mu^{\tilde{u}^*_{j\beta}}+p_\mu^{\tilde{d}_{i\alpha}}\Big) \tag{263}$$



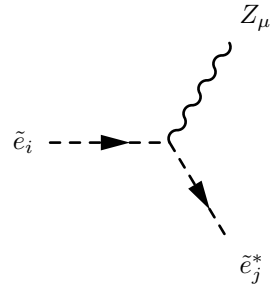
$$-\frac{1}{2}g_2\sum_{a=1}^{3}Z^{E,*}_{ia}Z^{I,*}_{ja}\Big(-p_\mu^{\tilde{\nu}^I_j}+p_\mu^{\tilde{e}_i}\Big) \tag{264}$$



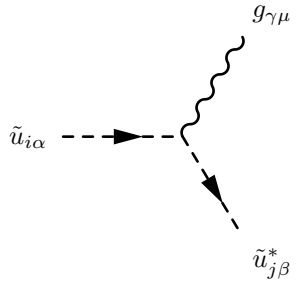
$$-\frac{i}{2}g_2\sum_{a=1}^{3}Z^{E,*}_{ia}Z^{R,*}_{ja}\Big(-p_\mu^{\tilde{\nu}^R_j}+p_\mu^{\tilde{e}_i}\Big) \tag{265}$$



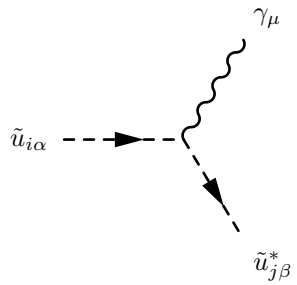
$$\frac{i}{2}\Big(2g_1\cos\Theta_W\sum_{a=1}^{3}Z^{E,*}_{i3+a}Z^{E}_{j3+a}+\Big(g_1\cos\Theta_W+g_2\sin\Theta_W\Big)\sum_{a=1}^{3}Z^{E,*}_{ia}Z^{E}_{ja}\Big)\Big(-p_\mu^{\tilde{e}_j^*}+p_\mu^{\tilde{e}_i}\Big) \tag{266}$$



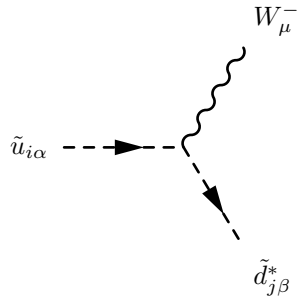
$$\frac{i}{2}\Big(-2g_1\sin\Theta_W\sum_{a=1}^{3}Z^{E,*}_{i3+a}Z^{E}_{j3+a}+\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\sum_{a=1}^{3}Z^{E,*}_{ia}Z^{E}_{ja}\Big)\Big(-p_\mu^{\tilde{e}_j^*}+p_\mu^{\tilde{e}_i}\Big) \tag{267}$$



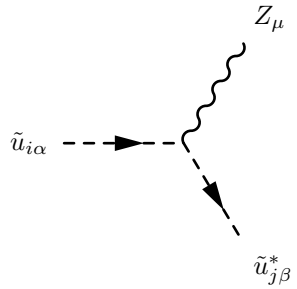
$$-\frac{i}{2}g_3\delta_{ij}\lambda^{\gamma}_{\beta,\alpha}\Big(-p_\mu^{\tilde{u}^*_{j\beta}}+p_\mu^{\tilde{u}_{i\alpha}}\Big) \tag{268}$$



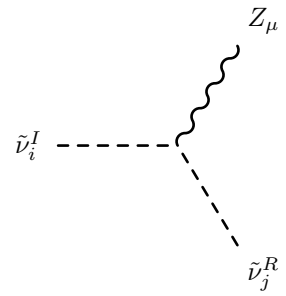
$$-\frac{i}{6}\delta_{\alpha\beta}\Big(\Big(3g_2\sin\Theta_W+g_1\cos\Theta_W\Big)\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{U}_{ja}+4g_1\cos\Theta_W\sum_{a=1}^{3}Z^{U,*}_{i3+a}Z^{U}_{j3+a}\Big)\Big(-p_\mu^{\tilde{u}^*_{j\beta}}+p_\mu^{\tilde{u}_{i\alpha}}\Big) \tag{269}$$



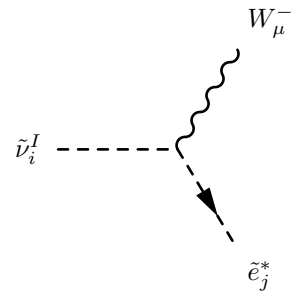
$$-i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{D}_{ja}\Big(-p_\mu^{\tilde{d}^*_{j\beta}}+p_\mu^{\tilde{u}_{i\alpha}}\Big) \tag{270}$$



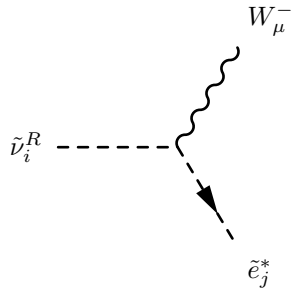
$$-\frac{i}{6}\delta_{\alpha\beta}\Big(\Big(3g_2\cos\Theta_W-g_1\sin\Theta_W\Big)\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{U}_{ja}-4g_1\sin\Theta_W\sum_{a=1}^{3}Z^{U,*}_{i3+a}Z^{U}_{j3+a}\Big)\Big(-p_\mu^{\tilde{u}^*_{j\beta}}+p_\mu^{\tilde{u}_{i\alpha}}\Big) \tag{271}$$



$$\frac{1}{2}\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W\Big) \sum_{a=1}^{3} Z_{ia}^{I,*} Z_{ja}^{R,*} \Big(- p_\mu^{\tilde{\nu}_j^R} + p_\mu^{\tilde{\nu}_i^I} \Big) \tag{272}$$

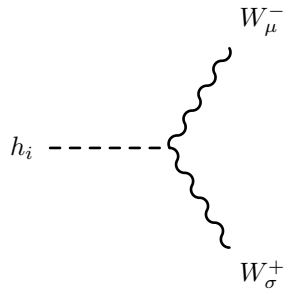


$$\frac{1}{2} g_2 \sum_{a=1}^{3} Z_{ia}^{I,*} Z_{ja}^{E} \Big(- p_\mu^{\tilde{e}_j^*} + p_\mu^{\tilde{\nu}_i^I} \Big) \tag{273}$$

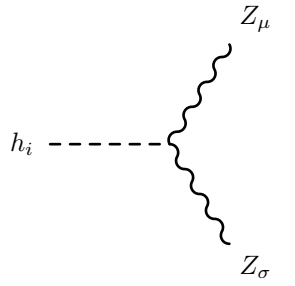


$$-\frac{i}{2} g_2 \sum_{a=1}^{3} Z_{ia}^{R,*} Z_{ja}^{E} \Big(- p_\mu^{\tilde{e}_j^*} + p_\mu^{\tilde{\nu}_i^R} \Big) \tag{274}$$

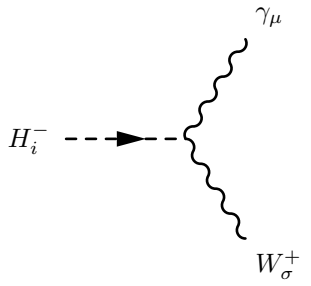
9.3 One Scalar-Two Vector Boson-Interaction



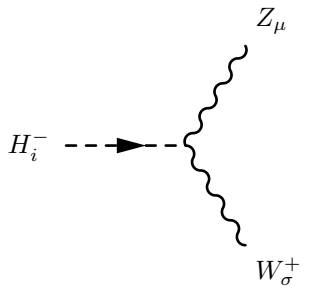
$$\frac{i}{2}g_2^2\Big(v_d Z_{i1}^H + v_u Z_{i2}^H\Big)\Big(g_{\sigma\mu}\Big) \tag{275}$$



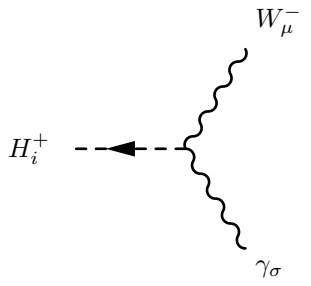
$$\frac{i}{2}\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)^2\Big(v_d Z_{i1}^H + v_u Z_{i2}^H\Big)\Big(g_{\sigma\mu}\Big) \tag{276}$$



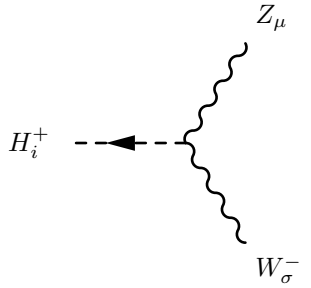
$$-\frac{i}{2}g_1 g_2\cos\Theta_W\Big(v_d Z_{i1}^+ - v_u Z_{i2}^+\Big)\Big(g_{\sigma\mu}\Big) \tag{277}$$



$$\frac{i}{2}g_1 g_2 \sin\Theta_W \Big(v_d Z_{i1}^+ - v_u Z_{i2}^+\Big)\Big(g_{\sigma\mu}\Big) \tag{278}$$

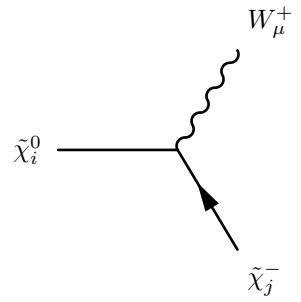


$$-\frac{i}{2}g_1 g_2 \cos\Theta_W \Big(v_d Z_{i1}^+ - v_u Z_{i2}^+\Big)\Big(g_{\sigma\mu}\Big) \tag{279}$$



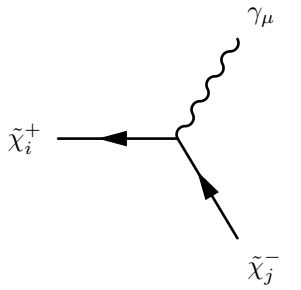
$$\frac{i}{2}g_1 g_2 \sin\Theta_W \Big(v_d Z_{i1}^+ - v_u Z_{i2}^+\Big)\Big(g_{\sigma\mu}\Big) \tag{280}$$

9.4 Two Fermion-One Vector Boson-Interaction



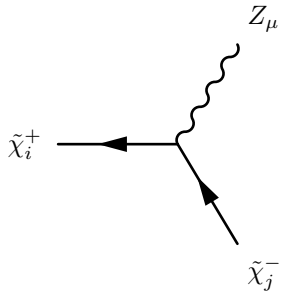
$$-\frac{i}{2}g_2\Big(2U_{j1}^*N_{i2}+\sqrt{2}U_{j2}^*N_{i3}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{281}$$

$$+\Big(i\frac{1}{\sqrt{2}}g_2N_{i4}^*V_{j2}-ig_2N_{i2}^*V_{j1}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{282}$$



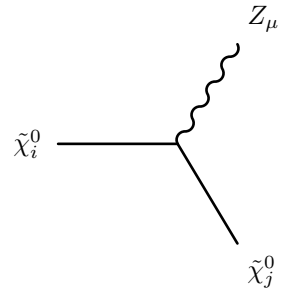
$$\frac{i}{2}\Big(2g_2U_{j1}^*\sin\Theta_WU_{i1}+U_{j2}^*\Big(g_1\cos\Theta_W+g_2\sin\Theta_W\Big)U_{i2}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{283}$$

$$+\frac{i}{2}\Big(2g_2V_{i1}^*\sin\Theta_WV_{j1}+V_{i2}^*\Big(g_1\cos\Theta_W+g_2\sin\Theta_W\Big)V_{j2}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{284}$$



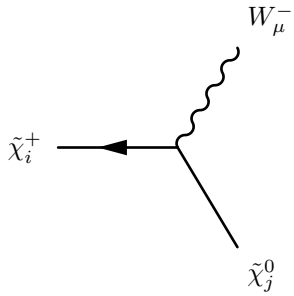
$$\frac{i}{2}\Big(2g_2U^*_{j1}\cos\Theta_W U_{i1}+U^*_{j2}\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)U_{i2}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{285}$$

$$+\ \frac{i}{2}\Big(2g_2V^*_{i1}\cos\Theta_W V_{j1}+V^*_{i2}\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)V_{j2}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{286}$$



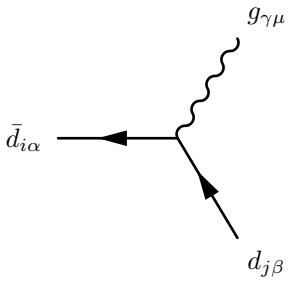
$$-\frac{i}{2}\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\Big(N^*_{j3}N_{i3}-N^*_{j4}N_{i4}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{287}$$

$$+\ \frac{i}{2}\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\Big(N^*_{i3}N_{j3}-N^*_{i4}N_{j4}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{288}$$



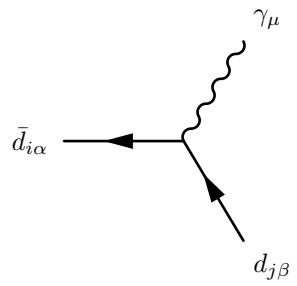
$$-\frac{i}{2}g_2\Big(2N^*_{j2}U_{i1}+\sqrt{2}N^*_{j3}U_{i2}\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{289}$$

$$+\ \Big(i\frac{1}{\sqrt{2}}g_2V^*_{i2}N_{j4}-ig_2V^*_{i1}N_{j2}\Big)\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{290}$$



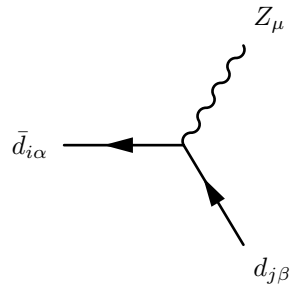
$$- \frac{i}{2} g_3 \delta_{ij} \lambda^{\gamma}_{\alpha,\beta} \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{291}$$

$$+ \; - \frac{i}{2} g_3 \delta_{ij} \lambda^{\gamma}_{\alpha,\beta} \Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2} \Big) \tag{292}$$



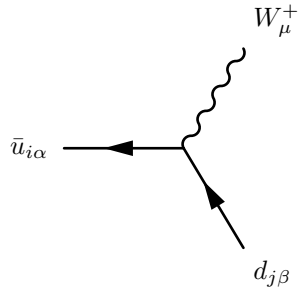
$$- \frac{i}{6} \delta_{\alpha\beta} \delta_{ij} \Big(- 3 g_2 \sin\Theta_W + g_1 \cos\Theta_W \Big) \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{293}$$

$$+ \; \frac{i}{3} g_1 \cos\Theta_W \delta_{\alpha\beta} \delta_{ij} \Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2} \Big) \tag{294}$$

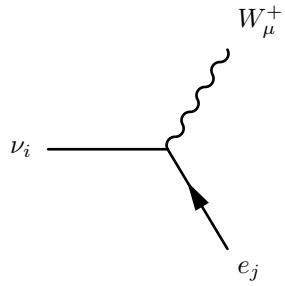


$$\frac{i}{6} \delta_{\alpha\beta} \delta_{ij} \Big(3 g_2 \cos\Theta_W + g_1 \sin\Theta_W \Big) \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{295}$$

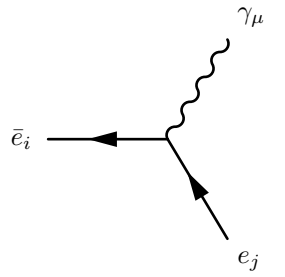
$$+ \; - \frac{i}{3} g_1 \delta_{\alpha\beta} \delta_{ij} \sin\Theta_W \Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2} \Big) \tag{296}$$



$$-i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^{3}U^{d,*}_{L,ja}U^{u}_{L,ia}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{297}$$

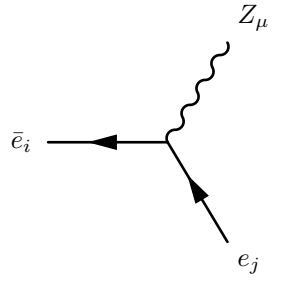


$$-i\frac{1}{\sqrt{2}}g_2\sum_{a=1}^{3}U^{e,*}_{L,ja}U^{V}_{ia}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{298}$$



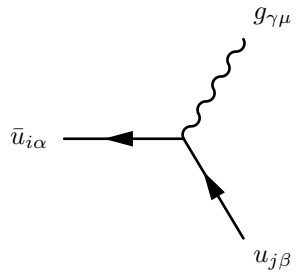
$$\frac{i}{2}\delta_{ij}\Big(g_1\cos\Theta_W+g_2\sin\Theta_W\Big)\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{299}$$

$$+\ ig_1\cos\Theta_W\delta_{ij}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{300}$$



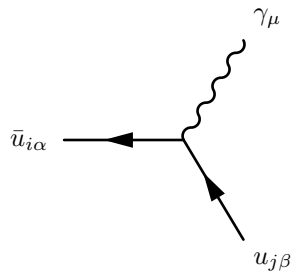
$$\frac{i}{2}\delta_{ij}\Big(- g_1 \sin\Theta_W + g_2 \cos\Theta_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{301}$$

$$+\ -ig_1\delta_{ij}\sin\Theta_W\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{302}$$



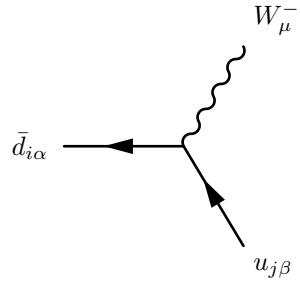
$$-\frac{i}{2}g_3\delta_{ij}\lambda^{\gamma}_{\alpha,\beta}\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{303}$$

$$+\ -\frac{i}{2}g_3\delta_{ij}\lambda^{\gamma}_{\alpha,\beta}\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{304}$$

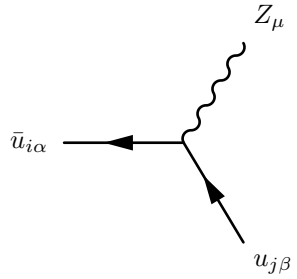


$$-\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\Big(3g_2 \sin\Theta_W + g_1\cos\Theta_W\Big)\Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2}\Big) \tag{305}$$

$$+\ -\frac{2i}{3}g_1\cos\Theta_W\delta_{\alpha\beta}\delta_{ij}\Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2}\Big) \tag{306}$$

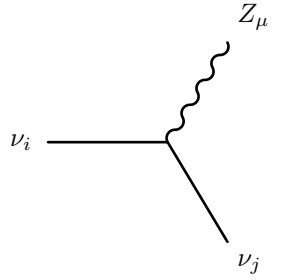


$$- i\frac{1}{\sqrt{2}} g_2 \delta_{\alpha\beta} \sum_{a=1}^{3} U^{u,*}_{L,ja} U^{d}_{L,ia} \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{307}$$



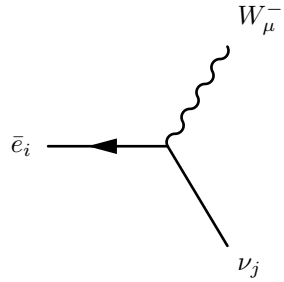
$$- \frac{i}{6} \delta_{\alpha\beta} \delta_{ij} \Big(3 g_2 \cos\Theta_W - g_1 \sin\Theta_W \Big) \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{308}$$

$$+ \frac{2i}{3} g_1 \delta_{\alpha\beta} \delta_{ij} \sin\Theta_W \Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2} \Big) \tag{309}$$

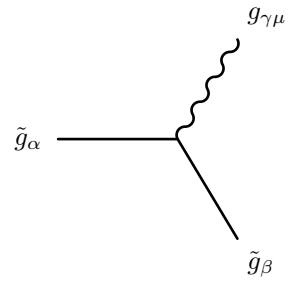


$$- \frac{i}{2} \Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) \sum_{a=1}^{3} U^{V,*}_{ja} U^{V}_{ia} \Big(\gamma_\mu \cdot \frac{1-\gamma_5}{2} \Big) \tag{310}$$

$$+ \frac{i}{2} \Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W \Big) \sum_{a=1}^{3} U^{V,*}_{ia} U^{V}_{ja} \Big(\gamma_\mu \cdot \frac{1+\gamma_5}{2} \Big) \tag{311}$$



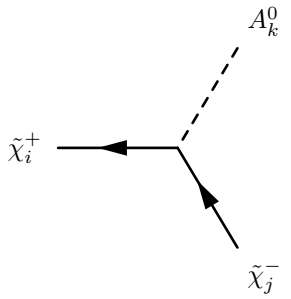
$$- i\frac{1}{\sqrt{2}}g_2\sum_{a=1}^{3}U_{ja}^{V,*}U_{L,ia}^{e}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{312}$$



$$- g_3|\phi_{\tilde{g}}|^2 f_{\alpha,\beta,\gamma}\Big(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\Big) \tag{313}$$

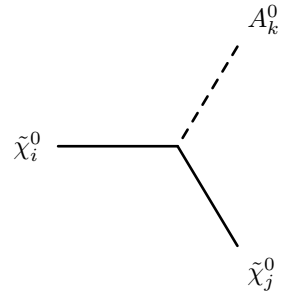
$$+\ -g_3|\phi_{\tilde{g}}|^2 f_{\alpha,\beta,\gamma}\Big(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\Big) \tag{314}$$

9.5 Two Fermion-One Scalar Boson-Interaction



$$- \frac{1}{\sqrt{2}}g_2\Big(U_{j1}^{*}V_{i2}^{*}Z_{k2}^{A}+U_{j2}^{*}V_{i1}^{*}Z_{k1}^{A}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{315}$$

$$+\ \frac{1}{\sqrt{2}}g_2\Big(U_{i1}V_{j2}Z_{k2}^{A}+U_{i2}V_{j1}Z_{k1}^{A}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{316}$$

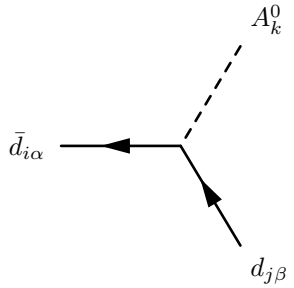


$$\frac{1}{2}\Big(N_{i3}^{*}\Big(g_1 N_{j1}^{*} - g_2 N_{j2}^{*}\Big)Z_{k1}^{A} - g_2 N_{i2}^{*} N_{j3}^{*} Z_{k1}^{A} - g_1 N_{i4}^{*} N_{j1}^{*} Z_{k2}^{A} + g_2 N_{i4}^{*} N_{j2}^{*} Z_{k2}^{A}$$

$$+ g_2 N_{i2}^{*} N_{j4}^{*} Z_{k2}^{A} + g_1 N_{i1}^{*}\Big(N_{j3}^{*} Z_{k1}^{A} - N_{j4}^{*} Z_{k2}^{A}\Big) + 2\sqrt{2}\kappa N_{i5}^{*} N_{j5}^{*} Z_{k3}^{A}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{317}$$

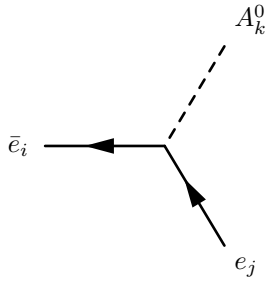
$$+ \frac{1}{2}\Big(Z_{k1}^{A}\Big(\Big(-g_1 N_{i1} + g_2 N_{i2}\Big)N_{j3} + N_{i3}\Big(-g_1 N_{j1} + g_2 N_{j2}\Big)\Big)$$

$$+ Z_{k2}^{A}\Big(\Big(g_1 N_{i1} - g_2 N_{i2}\Big)N_{j4} + N_{i4}\Big(g_1 N_{j1} - g_2 N_{j2}\Big)\Big) - 2\sqrt{2}\kappa^{*} Z_{k3}^{A} N_{i5} N_{j5}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{318}$$



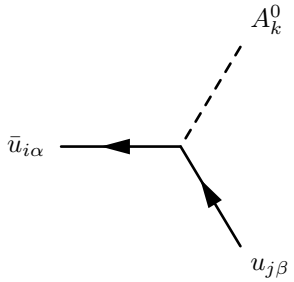
$$\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3} U_{L,jb}^{d,*}\sum_{a=1}^{3} U_{R,ia}^{d,*} y_{d,ab} Z_{k1}^{A}\Big(\frac{1-\gamma_5}{2}\Big) \tag{319}$$

$$+ -\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3} y_{d,ab}^{*} U_{R,ja}^{d} U_{L,ib}^{d} Z_{k1}^{A}\Big(\frac{1+\gamma_5}{2}\Big) \tag{320}$$



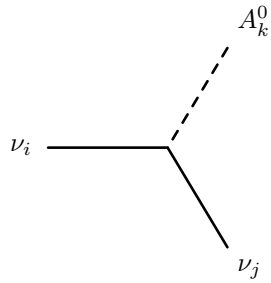
$$\frac{1}{\sqrt{2}}\sum_{b=1}^{3} U_{L,jb}^{e,*}\sum_{a=1}^{3} U_{R,ia}^{e,*} y_{e,ab} Z_{k1}^{A}\Big(\frac{1-\gamma_5}{2}\Big) \tag{321}$$

$$+ -\frac{1}{\sqrt{2}}\sum_{b=1}^{3}\sum_{a=1}^{3} y_{e,ab}^{*} U_{R,ja}^{e} U_{L,ib}^{e} Z_{k1}^{A}\Big(\frac{1+\gamma_5}{2}\Big) \tag{322}$$



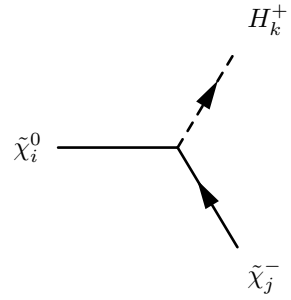
$$\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}U_{L,jb}^{u,*}\sum_{a=1}^{3}U_{R,ia}^{u,*}y_{u,ab}Z_{k2}^{A}\Big(\frac{1-\gamma_5}{2}\Big) \tag{323}$$

$$+\ -\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3}y_{u,ab}^{*}U_{R,ja}^{u}U_{L,ib}^{u}Z_{k2}^{A}\Big(\frac{1+\gamma_5}{2}\Big) \tag{324}$$



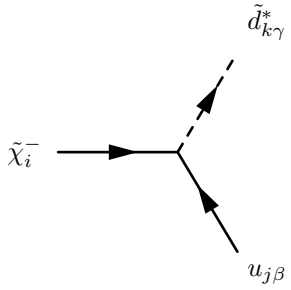
$$\begin{aligned}&\frac{1}{2}\frac{1}{\sqrt{2}}\Big(2\sum_{b=1}^{3}U_{jb}^{V,*}\sum_{a=1}^{2}U_{i3+a}^{V,*}Y_{\nu,ab}Z_{k2}^{A}+2\sum_{b=1}^{3}U_{ib}^{V,*}\sum_{a=1}^{2}U_{j3+a}^{V,*}Y_{\nu,ab}Z_{k2}^{A}\\&+\Big(\sum_{b=1}^{2}U_{j5+b}^{V,*}\sum_{a=1}^{2}U_{i5+a}^{V,*}\lambda_{ab}+\sum_{b=1}^{2}U_{i5+b}^{V,*}\sum_{a=1}^{2}U_{j5+a}^{V,*}\lambda_{ab}\Big)Z_{k3}^{A}\Big)\Big(\frac{1-\gamma_5}{2}\Big)\end{aligned} \tag{325}$$

$$\begin{aligned}&+\ -\frac{1}{2}\frac{1}{\sqrt{2}}\Big(2\sum_{b=1}^{3}\sum_{a=1}^{2}Y_{\nu,ab}^{*}U_{j3+a}^{V}U_{ib}^{V}Z_{k2}^{A}+2\sum_{b=1}^{3}\sum_{a=1}^{2}Y_{\nu,ab}^{*}U_{i3+a}^{V}U_{jb}^{V}Z_{k2}^{A}\\&+\Big(\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{ab}^{*}U_{j5+a}^{V}U_{i5+b}^{V}+\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{ab}^{*}U_{i5+a}^{V}U_{j5+b}^{V}\Big)Z_{k3}^{A}\Big)\Big(\frac{1+\gamma_5}{2}\Big)\end{aligned} \tag{326}$$



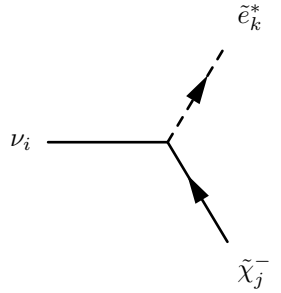
$$\frac{i}{2}\Big(- 2g_2 U_{j1}^* N_{i3}^* + \sqrt{2} U_{j2}^* \Big(g_1 N_{i1}^* + g_2 N_{i2}^* \Big) \Big) Z_{k1}^+ \Big(\frac{1-\gamma_5}{2} \Big) \tag{327}$$

$$+ \; -\frac{i}{2}\Big(2g_2 V_{j1} N_{i4} + \sqrt{2} V_{j2} \Big(g_1 N_{i1} + g_2 N_{i2} \Big) \Big) Z_{k2}^+ \Big(\frac{1+\gamma_5}{2} \Big) \tag{328}$$



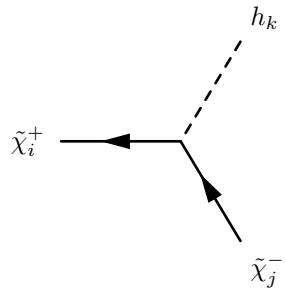
$$- i\delta_{\beta\gamma} \Big(g_2 U_{i1}^* \sum_{a=1}^{3} U_{L,ja}^{u,*} Z_{ka}^D - U_{i2}^* \sum_{b=1}^{3} U_{L,jb}^{u,*} \sum_{a=1}^{3} y_{d,ab} Z_{k3+a}^D \Big) \Big(\frac{1-\gamma_5}{2} \Big) \tag{329}$$

$$+ \; i\delta_{\beta\gamma} \sum_{b=1}^{3} \sum_{a=1}^{3} y_{u,ab}^* U_{R,ja}^u Z_{kb}^D V_{i2} \Big(\frac{1+\gamma_5}{2} \Big) \tag{330}$$



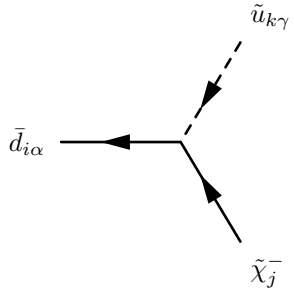
$$- i\Big(g_2 U^*_{j1} \sum_{a=1}^{3} U^{V,*}_{ia} Z^E_{ka} - U^*_{j2} \sum_{b=1}^{3} U^{V,*}_{ib} \sum_{a=1}^{3} y_{e,ab} Z^E_{k3+a}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{331}$$

$$+\ i \sum_{b=1}^{3} \sum_{a=1}^{2} Y^*_{\nu,ab} U^V_{i3+a} Z^E_{kb} V_{j2} \Big(\frac{1+\gamma_5}{2}\Big) \tag{332}$$



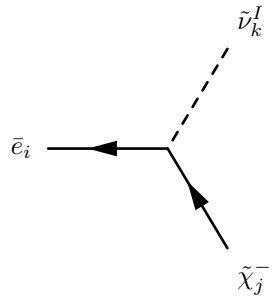
$$- i\frac{1}{\sqrt{2}} g_2 \Big(U^*_{j1} V^*_{i2} Z^H_{k2} + U^*_{j2} V^*_{i1} Z^H_{k1}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{333}$$

$$+\ -i\frac{1}{\sqrt{2}} g_2 \Big(U_{i1} V_{j2} Z^H_{k2} + U_{i2} V_{j1} Z^H_{k1}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{334}$$



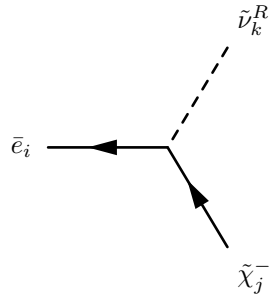
$$iU^*_{j2}\delta_{\alpha\gamma} \sum_{b=1}^{3} Z^{U,*}_{kb} \sum_{a=1}^{3} U^{d,*}_{R,ia} y_{d,ab} \Big(\frac{1-\gamma_5}{2}\Big) \tag{335}$$

$$+\ -i\delta_{\alpha\gamma}\Big(g_2 \sum_{a=1}^{3} Z^{U,*}_{ka} U^d_{L,ia} V_{j1} - \sum_{b=1}^{3} \sum_{a=1}^{3} y^*_{u,ab} Z^{U,*}_{k3+a} U^d_{L,ib} V_{j2}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{336}$$



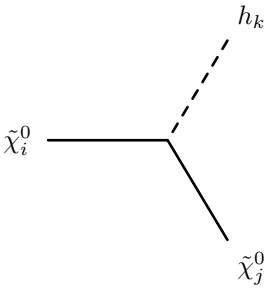
$$-\frac{1}{\sqrt{2}}U_{j2}^{*}\sum_{b=1}^{3}Z_{kb}^{I,*}\sum_{a=1}^{3}U_{R,ia}^{e,*}y_{e,ab}\Big(\frac{1-\gamma_5}{2}\Big) \tag{337}$$

$$+\frac{1}{\sqrt{2}}\Big(g_2\sum_{a=1}^{3}Z_{ka}^{I,*}U_{L,ia}^{e}V_{j1}-\sum_{b=1}^{3}\sum_{a=1}^{2}Y_{\nu,ab}^{*}Z_{k3+a}^{I,*}U_{L,ib}^{e}V_{j2}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{338}$$

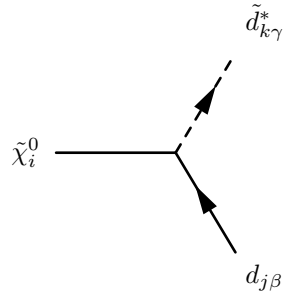


$$i\frac{1}{\sqrt{2}}U_{j2}^{*}\sum_{b=1}^{3}Z_{kb}^{R,*}\sum_{a=1}^{3}U_{R,ia}^{e,*}y_{e,ab}\Big(\frac{1-\gamma_5}{2}\Big) \tag{339}$$

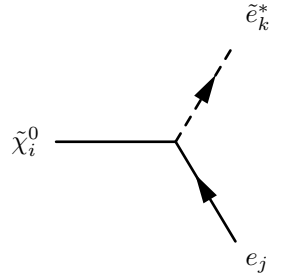
$$+\ -i\frac{1}{\sqrt{2}}\Big(g_2\sum_{a=1}^{3}Z_{ka}^{R,*}U_{L,ia}^{e}V_{j1}-\sum_{b=1}^{3}\sum_{a=1}^{2}Y_{\nu,ab}^{*}Z_{k3+a}^{R,*}U_{L,ib}^{e}V_{j2}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{340}$$



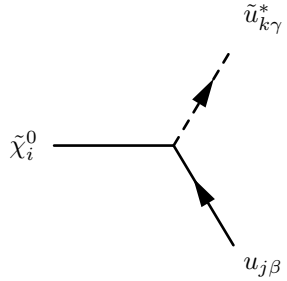
$$\frac{i}{2}\Big(N_{i3}^*\Big(g_1N_{j1}^* - g_2N_{j2}^*\Big)Z_{k1}^H - g_2N_{i2}^*N_{j3}^*Z_{k1}^H - g_1N_{i4}^*N_{j1}^*Z_{k2}^H + g_2N_{i4}^*N_{j2}^*Z_{k2}^H$$
$$+ g_2N_{i2}^*N_{j4}^*Z_{k2}^H + g_1N_{i1}^*\Big(N_{j3}^*Z_{k1}^H - N_{j4}^*Z_{k2}^H\Big) - 2\sqrt{2}\kappa N_{i5}^*N_{j5}^*Z_{k3}^H\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{341}$$
$$+ \frac{i}{2}\Big(Z_{k1}^H\Big(\Big(g_1N_{i1} - g_2N_{i2}\Big)N_{j3} + N_{i3}\Big(g_1N_{j1} - g_2N_{j2}\Big)\Big)$$
$$+ Z_{k2}^H\Big(\Big(-g_1N_{i1} + g_2N_{i2}\Big)N_{j4} + N_{i4}\Big(-g_1N_{j1} + g_2N_{j2}\Big)\Big) - 2\sqrt{2}\kappa^* Z_{k3}^H N_{i5}N_{j5}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{342}$$



$$-\frac{i}{6}\delta_{\beta\gamma}\Big(-3\sqrt{2}g_2N_{i2}^*\sum_{a=1}^{3}U_{L,ja}^{d,*}Z_{ka}^D + 6N_{i3}^*\sum_{b=1}^{3}U_{L,jb}^{d,*}\sum_{a=1}^{3}y_{d,ab}Z_{k3+a}^D + \sqrt{2}g_1N_{i1}^*\sum_{a=1}^{3}U_{L,ja}^{d,*}Z_{ka}^D\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{343}$$
$$+ -\frac{i}{3}\delta_{\beta\gamma}\Big(3\sum_{b=1}^{3}\sum_{a=1}^{3}y_{d,ab}^*U_{R,ja}^dZ_{kb}^DN_{i3} + \sqrt{2}g_1\sum_{a=1}^{3}Z_{k3+a}^DU_{R,ja}^dN_{i1}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{344}$$

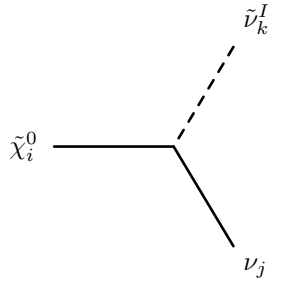


$$\frac{i}{2}\Big(-2N_{i3}^*\sum_{b=1}^{3}U_{L,jb}^{e,*}\sum_{a=1}^{3}y_{e,ab}Z_{k3+a}^E + \sqrt{2}g_1N_{i1}^*\sum_{a=1}^{3}U_{L,ja}^{e,*}Z_{ka}^E + \sqrt{2}g_2N_{i2}^*\sum_{a=1}^{3}U_{L,ja}^{e,*}Z_{ka}^E\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{345}$$
$$+ -i\Big(\sqrt{2}g_1\sum_{a=1}^{3}Z_{k3+a}^EU_{R,ja}^eN_{i1} + \sum_{b=1}^{3}\sum_{a=1}^{3}y_{e,ab}^*U_{R,ja}^eZ_{kb}^EN_{i3}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{346}$$



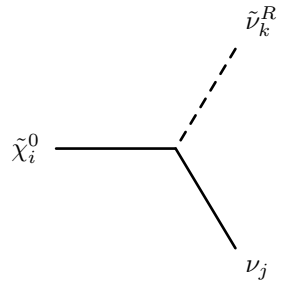
$$-\frac{i}{6}\delta_{\beta\gamma}\Big(3\sqrt{2}g_2N^*_{i2}\sum_{a=1}^{3}U^{u,*}_{L,ja}Z^U_{ka}+6N^*_{i4}\sum_{b=1}^{3}U^{u,*}_{L,jb}\sum_{a=1}^{3}y_{u,ab}Z^U_{k3+a}+\sqrt{2}g_1N^*_{i1}\sum_{a=1}^{3}U^{u,*}_{L,ja}Z^U_{ka}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{347}$$

$$+\frac{i}{3}\delta_{\beta\gamma}\Big(2\sqrt{2}g_1\sum_{a=1}^{3}Z^U_{k3+a}U^u_{R,ja}N_{i1}-3\sum_{b=1}^{3}\sum_{a=1}^{3}y^*_{u,ab}U^u_{R,ja}Z^U_{kb}N_{i4}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{348}$$

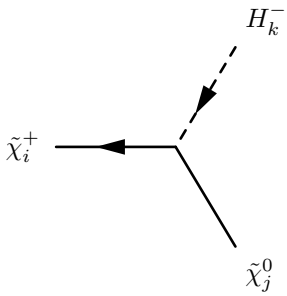


$$\begin{aligned}
&\frac{1}{4}\Big(2g_1N^*_{i1}\sum_{a=1}^{3}U^{V,*}_{ja}Z^{I,*}_{ka}-2g_2N^*_{i2}\sum_{a=1}^{3}U^{V,*}_{ja}Z^{I,*}_{ka}\\
&+\sqrt{2}\Big(N^*_{i5}\Big(\sum_{b=1}^{2}Z^{I,*}_{k5+b}\sum_{a=1}^{2}U^{V,*}_{j5+a}\lambda_{ab}+\sum_{b=1}^{2}U^{V,*}_{j5+b}\sum_{a=1}^{2}Z^{I,*}_{k5+a}\lambda_{ab}\Big)\\
&+2N^*_{i4}\Big(-\sum_{b=1}^{3}U^{V,*}_{jb}\sum_{a=1}^{2}Z^{I,*}_{k3+a}Y_{\nu,ab}+\sum_{b=1}^{3}Z^{I,*}_{kb}\sum_{a=1}^{2}U^{V,*}_{j3+a}Y_{\nu,ab}\Big)\Big)\Big)\Big(\frac{1-\gamma_5}{2}\Big)
\end{aligned} \tag{349}$$

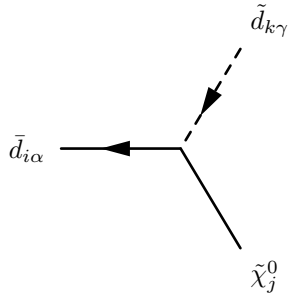
$$\begin{aligned}
&+\frac{1}{4}\Big(\sum_{a=1}^{3}Z^{I,*}_{ka}U^V_{ja}\Big(-2g_1N_{i1}+2g_2N_{i2}\Big)\\
&-\sqrt{2}\Big(2\sum_{b=1}^{3}Z^{I,*}_{kb}\sum_{a=1}^{2}Y^*_{\nu,ab}U^V_{j3+a}N_{i4}-2\sum_{b=1}^{3}\sum_{a=1}^{2}Y^*_{\nu,ab}Z^{I,*}_{k3+a}U^V_{jb}N_{i4}\\
&+\Big(\sum_{b=1}^{2}Z^{I,*}_{k5+b}\sum_{a=1}^{2}\lambda^*_{ab}U^V_{j5+a}+\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda^*_{ab}Z^{I,*}_{k5+a}U^V_{j5+b}\Big)N_{i5}\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big)
\end{aligned} \tag{350}$$



$$\frac{i}{4}\Big(2g_1N_{i1}^*\sum_{a=1}^{3}U_{ja}^{V,*}Z_{ka}^{R,*}-2g_2N_{i2}^*\sum_{a=1}^{3}U_{ja}^{V,*}Z_{ka}^{R,*}$$
$$-\sqrt{2}\Big(N_{i5}^*\Big(\sum_{b=1}^{2}Z_{k5+b}^{R,*}\sum_{a=1}^{2}U_{j5+a}^{V,*}\lambda_{ab}+\sum_{b=1}^{2}U_{j5+b}^{V,*}\sum_{a=1}^{2}Z_{k5+a}^{R,*}\lambda_{ab}\Big)$$
$$+2N_{i4}^*\Big(\sum_{b=1}^{3}Z_{kb}^{R,*}\sum_{a=1}^{2}U_{j3+a}^{V,*}Y_{\nu,ab}+\sum_{b=1}^{3}U_{jb}^{V,*}\sum_{a=1}^{2}Z_{k3+a}^{R,*}Y_{\nu,ab}\Big)\Big)\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{351}$$
$$+\frac{i}{4}\Big(2\sum_{a=1}^{3}Z_{ka}^{R,*}U_{ja}^{V}\Big(g_1N_{i1}-g_2N_{i2}\Big)$$
$$-\sqrt{2}\Big(2\sum_{b=1}^{3}Z_{kb}^{R,*}\sum_{a=1}^{2}Y_{\nu,ab}^{*}U_{j3+a}^{V}N_{i4}+2\sum_{b=1}^{3}\sum_{a=1}^{2}Y_{\nu,ab}^{*}Z_{k3+a}^{R,*}U_{jb}^{V}N_{i4}$$
$$+\Big(\sum_{b=1}^{2}Z_{k5+b}^{R,*}\sum_{a=1}^{2}\lambda_{ab}^{*}U_{j5+a}^{V}+\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda_{ab}^{*}Z_{k5+a}^{R,*}U_{j5+b}^{V}\Big)N_{i5}\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{352}$$

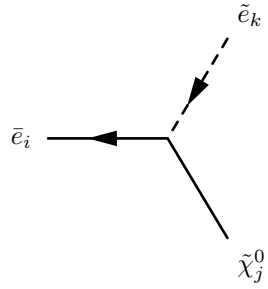


$$-\frac{i}{2}\Big(2g_2V_{i1}^*N_{j4}^*+\sqrt{2}V_{i2}^*\Big(g_1N_{j1}^*+g_2N_{j2}^*\Big)\Big)Z_{k2}^{+}\Big(\frac{1-\gamma_5}{2}\Big) \tag{353}$$
$$+\frac{i}{2}\Big(-2g_2U_{i1}N_{j3}+\sqrt{2}U_{i2}\Big(g_1N_{j1}+g_2N_{j2}\Big)\Big)Z_{k1}^{+}\Big(\frac{1+\gamma_5}{2}\Big) \tag{354}$$



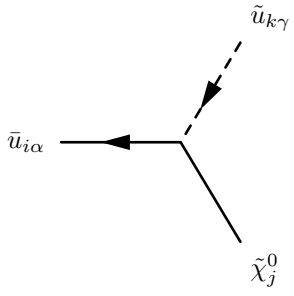
$$-\frac{i}{3}\delta_{\alpha\gamma}\Big(3N_{j3}^*\sum_{b=1}^{3}Z_{kb}^{D,*}\sum_{a=1}^{3}U_{R,ia}^{d,*}y_{d,ab}+\sqrt{2}g_1N_{j1}^*\sum_{a=1}^{3}Z_{k3+a}^{D,*}U_{R,ia}^{d,*}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{355}$$

$$+\ -\frac{i}{6}\delta_{\alpha\gamma}\Big(6\sum_{b=1}^{3}\sum_{a=1}^{3}y_{d,ab}^*Z_{k3+a}^{D,*}U_{L,ib}^{d}N_{j3}+\sqrt{2}\sum_{a=1}^{3}Z_{ka}^{D,*}U_{L,ia}^{d}\Big(-3g_2N_{j2}+g_1N_{j1}\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{356}$$



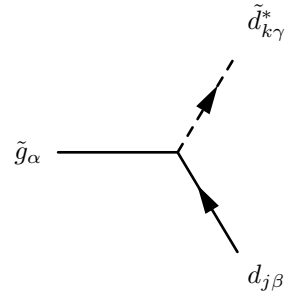
$$-i\Big(N_{j3}^*\sum_{b=1}^{3}Z_{kb}^{E,*}\sum_{a=1}^{3}U_{R,ia}^{e,*}y_{e,ab}+\sqrt{2}g_1N_{j1}^*\sum_{a=1}^{3}Z_{k3+a}^{E,*}U_{R,ia}^{e,*}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{357}$$

$$+\ \frac{i}{2}\Big(-2\sum_{b=1}^{3}\sum_{a=1}^{3}y_{e,ab}^*Z_{k3+a}^{E,*}U_{L,ib}^{e}N_{j3}+\sqrt{2}\sum_{a=1}^{3}Z_{ka}^{E,*}U_{L,ia}^{e}\Big(g_1N_{j1}+g_2N_{j2}\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{358}$$



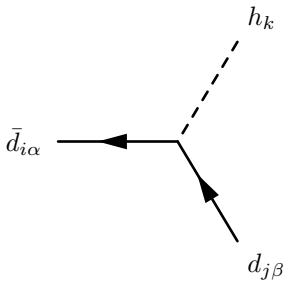
$$\frac{i}{3}\delta_{\alpha\gamma}\Big(2\sqrt{2}g_1 N^*_{j1}\sum_{a=1}^{3} Z^{U,*}_{k3+a}U^{u,*}_{R,ia} - 3N^*_{j4}\sum_{b=1}^{3} Z^{U,*}_{kb}\sum_{a=1}^{3} U^{u,*}_{R,ia}y_{u,ab}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{359}$$

$$+\ -\frac{i}{6}\delta_{\alpha\gamma}\Big(6\sum_{b=1}^{3}\sum_{a=1}^{3} y^*_{u,ab}Z^{U,*}_{k3+a}U^{u}_{L,ib}N_{j4} + \sqrt{2}\sum_{a=1}^{3} Z^{U,*}_{ka}U^{u}_{L,ia}\Big(3g_2N_{j2} + g_1N_{j1}\Big)\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{360}$$



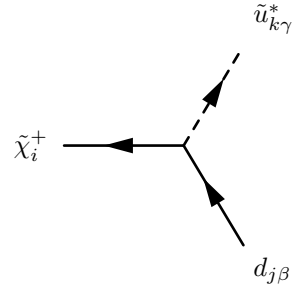
$$-\ i\frac{1}{\sqrt{2}}g_3\phi_{\tilde{g}}\lambda^{\alpha}_{\gamma,\beta}\sum_{a=1}^{3} U^{d,*}_{L,ja}Z^{D}_{ka}\Big(\frac{1-\gamma_5}{2}\Big) \tag{361}$$

$$+\ i\frac{1}{\sqrt{2}}g_3\phi^*_{\tilde{g}}\lambda^{\alpha}_{\gamma,\beta}\sum_{a=1}^{3} Z^{D}_{k3+a}U^{d}_{R,ja}\Big(\frac{1+\gamma_5}{2}\Big) \tag{362}$$



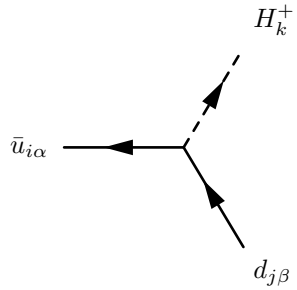
$$-\ i\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3} U^{d,*}_{L,jb}\sum_{a=1}^{3} U^{d,*}_{R,ia}y_{d,ab}Z^{H}_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{363}$$

$$+\ -i\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3} y^*_{d,ab}U^{d}_{R,ja}U^{d}_{L,ib}Z^{H}_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{364}$$



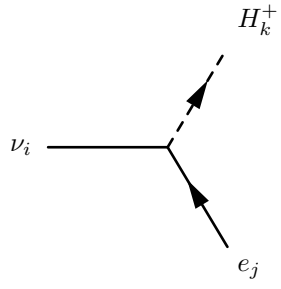
$$- i\delta_{\beta\gamma}\Big(g_2 V^*_{i1}\sum_{a=1}^{3} U^{d,*}_{L,ja} Z^U_{ka} - V^*_{i2}\sum_{b=1}^{3} U^{d,*}_{L,jb}\sum_{a=1}^{3} y_{u,ab} Z^U_{k3+a}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{365}$$

$$+\ i\delta_{\beta\gamma}\sum_{b=1}^{3}\sum_{a=1}^{3} y^*_{d,ab} U^d_{R,ja} Z^U_{kb} U_{i2}\Big(\frac{1+\gamma_5}{2}\Big) \tag{366}$$



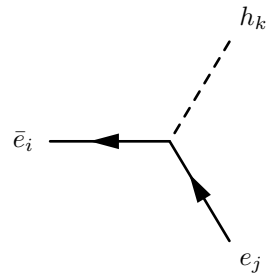
$$i\delta_{\alpha\beta}\sum_{b=1}^{3} U^{d,*}_{L,jb}\sum_{a=1}^{3} U^{u,*}_{R,ia} y_{u,ab} Z^+_{k2}\Big(\frac{1-\gamma_5}{2}\Big) \tag{367}$$

$$+\ i\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3} y^*_{d,ab} U^d_{R,ja} U^u_{L,ib} Z^+_{k1}\Big(\frac{1+\gamma_5}{2}\Big) \tag{368}$$



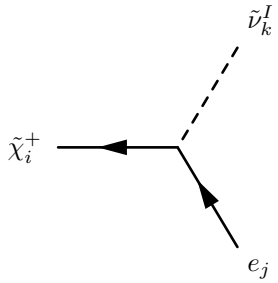
$$i\sum_{b=1}^{3} U_{L,jb}^{e,*} \sum_{a=1}^{2} U_{i3+a}^{V,*} Y_{\nu,ab} Z_{k2}^{+} \Big(\frac{1-\gamma_5}{2}\Big) \tag{369}$$

$$+\ i\sum_{b=1}^{3}\sum_{a=1}^{3} y_{e,ab}^{*} U_{R,ja}^{e} U_{ib}^{V} Z_{k1}^{+} \Big(\frac{1+\gamma_5}{2}\Big) \tag{370}$$



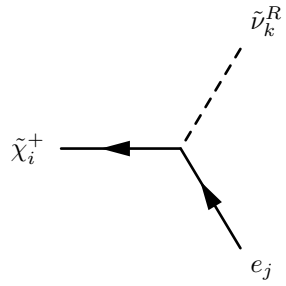
$$-\ i\frac{1}{\sqrt{2}}\sum_{b=1}^{3} U_{L,jb}^{e,*} \sum_{a=1}^{3} U_{R,ia}^{e,*} y_{e,ab} Z_{k1}^{H} \Big(\frac{1-\gamma_5}{2}\Big) \tag{371}$$

$$+\ -i\frac{1}{\sqrt{2}}\sum_{b=1}^{3}\sum_{a=1}^{3} y_{e,ab}^{*} U_{R,ja}^{e} U_{L,ib}^{e} Z_{k1}^{H} \Big(\frac{1+\gamma_5}{2}\Big) \tag{372}$$



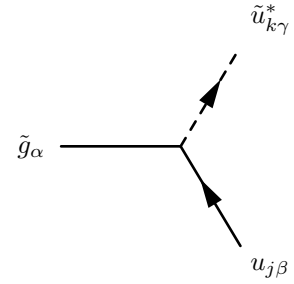
$$\frac{1}{\sqrt{2}}\Big(-g_2 V_{i1}^{*}\sum_{a=1}^{3} U_{L,ja}^{e,*} Z_{ka}^{I,*} + V_{i2}^{*}\sum_{b=1}^{3} U_{L,jb}^{e,*}\sum_{a=1}^{2} Z_{k3+a}^{I,*} Y_{\nu,ab}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{373}$$

$$+\ \frac{1}{\sqrt{2}}\sum_{b=1}^{3} Z_{kb}^{I,*}\sum_{a=1}^{3} y_{e,ab}^{*} U_{R,ja}^{e} U_{i2}\Big(\frac{1+\gamma_5}{2}\Big) \tag{374}$$



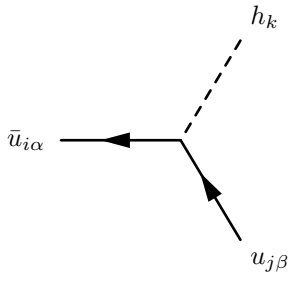
$$- i\frac{1}{\sqrt{2}}\Big(g_2 V_{i1}^* \sum_{a=1}^{3} U_{L,ja}^{e,*} Z_{ka}^{R,*} - V_{i2}^* \sum_{b=1}^{3} U_{L,jb}^{e,*} \sum_{a=1}^{2} Z_{k3+a}^{R,*} Y_{\nu,ab}\Big)\Big(\frac{1-\gamma_5}{2}\Big) \tag{375}$$

$$+ i\frac{1}{\sqrt{2}} \sum_{b=1}^{3} Z_{kb}^{R,*} \sum_{a=1}^{3} y_{e,ab}^* U_{R,ja}^{e} U_{i2}\Big(\frac{1+\gamma_5}{2}\Big) \tag{376}$$



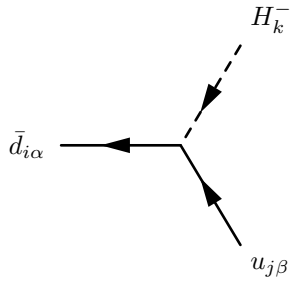
$$- i\frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}} \lambda_{\gamma,\beta}^{\alpha} \sum_{a=1}^{3} U_{L,ja}^{u,*} Z_{ka}^{U}\Big(\frac{1-\gamma_5}{2}\Big) \tag{377}$$

$$+ i\frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\gamma,\beta}^{\alpha} \sum_{a=1}^{3} Z_{k3+a}^{U} U_{R,ja}^{u}\Big(\frac{1+\gamma_5}{2}\Big) \tag{378}$$



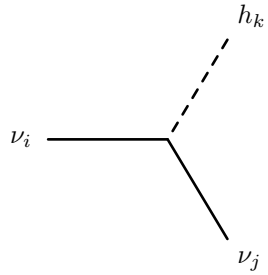
$$- i\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}U_{L,jb}^{u,*}\sum_{a=1}^{3}U_{R,ia}^{u,*}y_{u,ab}Z_{k2}^{H}\Big(\frac{1-\gamma_5}{2}\Big) \tag{379}$$

$$+\ -i\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3}y_{u,ab}^{*}U_{R,ja}^{u}U_{L,ib}^{u}Z_{k2}^{H}\Big(\frac{1+\gamma_5}{2}\Big) \tag{380}$$



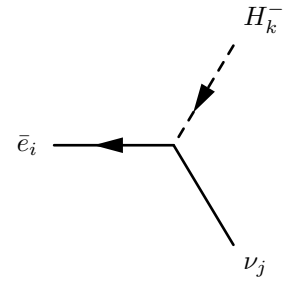
$$i\delta_{\alpha\beta}\sum_{b=1}^{3}U_{L,jb}^{u,*}\sum_{a=1}^{3}U_{R,ia}^{d,*}y_{d,ab}Z_{k1}^{+}\Big(\frac{1-\gamma_5}{2}\Big) \tag{381}$$

$$+\ i\delta_{\alpha\beta}\sum_{b=1}^{3}\sum_{a=1}^{3}y_{u,ab}^{*}U_{R,ja}^{u}U_{L,ib}^{d}Z_{k2}^{+}\Big(\frac{1+\gamma_5}{2}\Big) \tag{382}$$



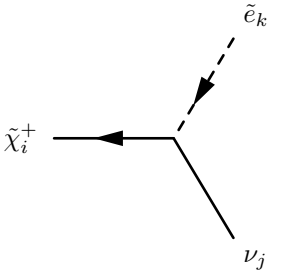
$$\begin{aligned}
&- \frac{i}{2}\frac{1}{\sqrt{2}}\Big(2\sum_{b=1}^{3}U_{jb}^{V,*}\sum_{a=1}^{2}U_{i3+a}^{V,*}Y_{\nu,ab}Z_{k2}^{H}+2\sum_{b=1}^{3}U_{ib}^{V,*}\sum_{a=1}^{2}U_{j3+a}^{V,*}Y_{\nu,ab}Z_{k2}^{H}\\
&+\Big(\sum_{b=1}^{2}U_{j5+b}^{V,*}\sum_{a=1}^{2}U_{i5+a}^{V,*}\lambda_{ab}+\sum_{b=1}^{2}U_{i5+b}^{V,*}\sum_{a=1}^{2}U_{j5+a}^{V,*}\lambda_{ab}\Big)Z_{k3}^{H}\Big)\Big(\frac{1-\gamma_5}{2}\Big)\\
&+\ -\frac{i}{2}\frac{1}{\sqrt{2}}\Big(2\sum_{b=1}^{3}\sum_{a=1}^{2}Y_{\nu,ab}^{*}U_{j3+a}^{V}U_{ib}^{V}Z_{k2}^{H}+2\sum_{b=1}^{3}\sum_{a=1}^{2}Y_{\nu,ab}^{*}U_{i3+a}^{V}U_{jb}^{V}Z_{k2}^{H}
\end{aligned} \tag{383}$$

$$+\Big(\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda^{*}_{ab}U^{V}_{j5+a}U^{V}_{i5+b}+\sum_{b=1}^{2}\sum_{a=1}^{2}\lambda^{*}_{ab}U^{V}_{i5+a}U^{V}_{j5+b}\Big)Z^{H}_{k3}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{384}$$



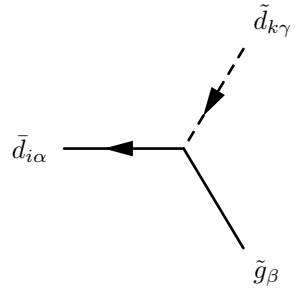
$$i\sum_{b=1}^{3}U^{V,*}_{jb}\sum_{a=1}^{3}U^{e,*}_{R,ia}y_{e,ab}Z^{+}_{k1}\Big(\frac{1-\gamma_5}{2}\Big) \tag{385}$$

$$+\ i\sum_{b=1}^{3}\sum_{a=1}^{2}Y^{*}_{\nu,ab}U^{V}_{j3+a}U^{e}_{L,ib}Z^{+}_{k2}\Big(\frac{1+\gamma_5}{2}\Big) \tag{386}$$



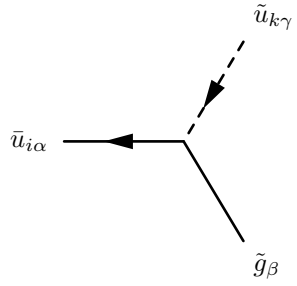
$$iV^{*}_{i2}\sum_{b=1}^{3}Z^{E,*}_{kb}\sum_{a=1}^{2}U^{V,*}_{j3+a}Y_{\nu,ab}\Big(\frac{1-\gamma_5}{2}\Big) \tag{387}$$

$$+\ -i\Big(g_2\sum_{a=1}^{3}Z^{E,*}_{ka}U^{V}_{ja}U_{i1}-\sum_{b=1}^{3}\sum_{a=1}^{3}y^{*}_{e,ab}Z^{E,*}_{k3+a}U^{V}_{jb}U_{i2}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{388}$$



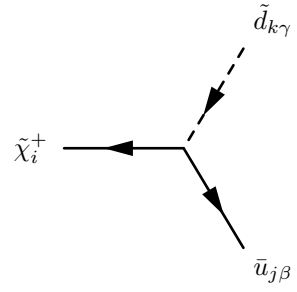
$$i\frac{1}{\sqrt{2}}g_3\phi_{\tilde{g}}\lambda^{\beta}_{\alpha,\gamma}\sum_{a=1}^{3}Z^{D,*}_{k3+a}U^{d,*}_{R,ia}\Big(\frac{1-\gamma_5}{2}\Big) \tag{389}$$

$$+\ -i\frac{1}{\sqrt{2}}g_3\phi^{*}_{\tilde{g}}\lambda^{\beta}_{\alpha,\gamma}\sum_{a=1}^{3}Z^{D,*}_{ka}U^{d}_{L,ia}\Big(\frac{1+\gamma_5}{2}\Big) \tag{390}$$



$$i\frac{1}{\sqrt{2}}g_3\phi_{\tilde{g}}\lambda^{\beta}_{\alpha,\gamma}\sum_{a=1}^{3}Z^{U,*}_{k3+a}U^{u,*}_{R,ia}\Big(\frac{1-\gamma_5}{2}\Big) \tag{391}$$

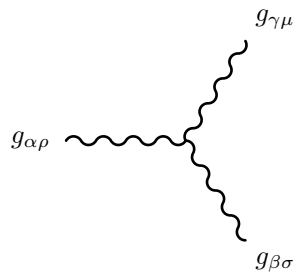
$$+\ -i\frac{1}{\sqrt{2}}g_3\phi^{*}_{\tilde{g}}\lambda^{\beta}_{\alpha,\gamma}\sum_{a=1}^{3}Z^{U,*}_{ka}U^{u}_{L,ia}\Big(\frac{1+\gamma_5}{2}\Big) \tag{392}$$



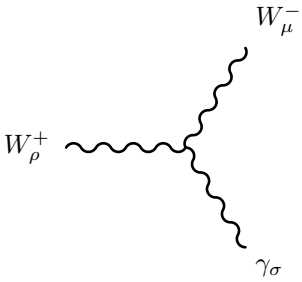
$$iV_{i2}^{*}\delta_{\beta\gamma}\sum_{b=1}^{3}Z_{kb}^{D,*}\sum_{a=1}^{3}U_{R,ja}^{u,*}y_{u,ab}\Big(\frac{1-\gamma_5}{2}\Big) \tag{393}$$

$$+\ -i\delta_{\beta\gamma}\Big(g_2\sum_{a=1}^{3}Z_{ka}^{D,*}U_{L,ja}^{u}U_{i1}-\sum_{b=1}^{3}\sum_{a=1}^{3}y_{d,ab}^{*}Z_{k3+a}^{D,*}U_{L,jb}^{u}U_{i2}\Big)\Big(\frac{1+\gamma_5}{2}\Big) \tag{394}$$

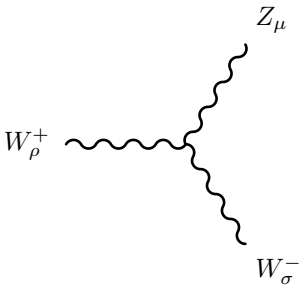
9.6 Three Vector Boson-Interaction



$$g_3 f_{\alpha,\beta,\gamma}\Big(g_{\rho\mu}\Big(-p_{\sigma}^{g_{\gamma\mu}}+p_{\sigma}^{g_{\alpha\rho}}\Big)+g_{\rho\sigma}\Big(-p_{\mu}^{g_{\alpha\rho}}+p_{\mu}^{g_{\beta\sigma}}\Big)+g_{\sigma\mu}\Big(-p_{\rho}^{g_{\beta\sigma}}+p_{\rho}^{g_{\gamma\mu}}\Big)\Big) \tag{395}$$

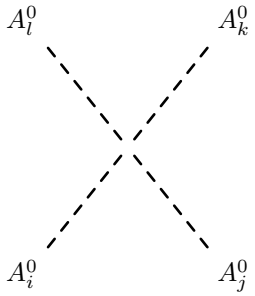


$$ig_2\sin\Theta_W\Big(g_{\rho\mu}\Big(-p_{\sigma}^{W_{\mu}^{-}}+p_{\sigma}^{W_{\rho}^{+}}\Big)+g_{\rho\sigma}\Big(-p_{\mu}^{W_{\rho}^{+}}+p_{\mu}^{\gamma_{\sigma}}\Big)+g_{\sigma\mu}\Big(-p_{\rho}^{\gamma_{\sigma}}+p_{\rho}^{W_{\mu}^{-}}\Big)\Big) \tag{396}$$

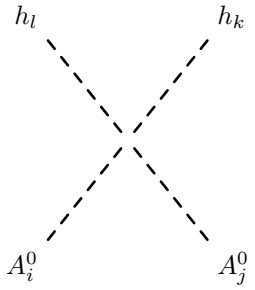


$$- ig_2 \cos\Theta_W \Big(g_{\rho\mu} \Big(- p_\sigma^{Z_\mu} + p_\sigma^{W_\rho^+} \Big) + g_{\rho\sigma} \Big(- p_\mu^{W_\rho^+} + p_\mu^{W_\sigma^-} \Big) + g_{\sigma\mu} \Big(- p_\rho^{W_\sigma^-} + p_\rho^{Z_\mu} \Big) \Big) \tag{397}$$

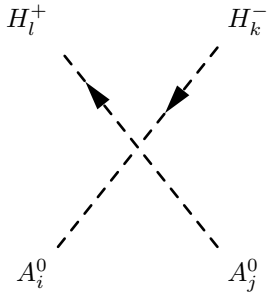
9.7 Four Scalar-Interaction



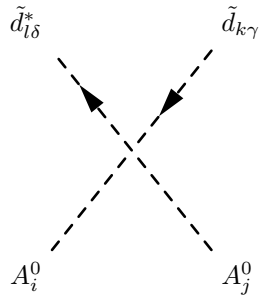
$$\begin{aligned} &- \frac{i}{4} \Big(- \Big(g_1^2 + g_2^2 \Big) Z_{i2}^A \Big(Z_{j1}^A \Big(Z_{k1}^A Z_{l2}^A + Z_{k2}^A Z_{l1}^A \Big) + Z_{j2}^A \Big(- 3 Z_{k2}^A Z_{l2}^A + Z_{k1}^A Z_{l1}^A \Big) \Big) \\ &+ \Big(g_1^2 + g_2^2 \Big) Z_{i1}^A \Big(Z_{j1}^A \Big(3 Z_{k1}^A Z_{l1}^A - Z_{k2}^A Z_{l2}^A \Big) - Z_{j2}^A \Big(Z_{k1}^A Z_{l2}^A + Z_{k2}^A Z_{l1}^A \Big) \Big) \\ &+ 24 |\kappa|^2 Z_{i3}^A Z_{j3}^A Z_{k3}^A Z_{l3}^A \Big) \end{aligned} \tag{398}$$



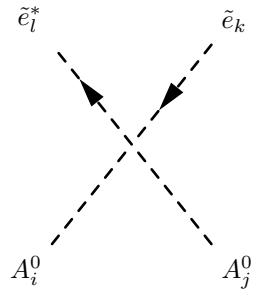
$$\begin{aligned} &- \frac{i}{4} \Big(\Big(g_1^2 + g_2^2 \Big) Z_{i1}^A Z_{j1}^A \Big(Z_{k1}^H Z_{l1}^H - Z_{k2}^H Z_{l2}^H \Big) - \Big(g_1^2 + g_2^2 \Big) Z_{i2}^A Z_{j2}^A \Big(Z_{k1}^H Z_{l1}^H - Z_{k2}^H Z_{l2}^H \Big) \\ &+ 8 |\kappa|^2 Z_{i3}^A Z_{j3}^A Z_{k3}^H Z_{l3}^H \Big) \end{aligned} \tag{399}$$



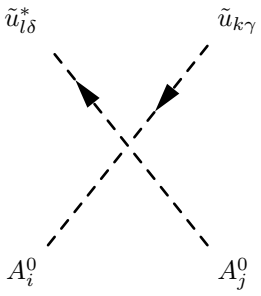
$$\frac{i}{4}\Big(Z^A_{i1}\Big(g_2^2 Z^A_{j2}\Big(Z^+_{k1}Z^+_{l2}+Z^+_{k2}Z^+_{l1}\Big)-Z^A_{j1}\Big(\Big(g_1^2+g_2^2\Big)Z^+_{k1}Z^+_{l1}+\Big(-g_1^2+g_2^2\Big)Z^+_{k2}Z^+_{l2}\Big)\Big)$$
$$+Z^A_{i2}\Big(g_2^2 Z^A_{j1}\Big(Z^+_{k1}Z^+_{l2}+Z^+_{k2}Z^+_{l1}\Big)+Z^A_{j2}\Big(-\Big(g_1^2+g_2^2\Big)Z^+_{k2}Z^+_{l2}+\Big(-g_2^2+g_1^2\Big)Z^+_{k1}Z^+_{l1}\Big)\Big)\Big) \tag{400}$$



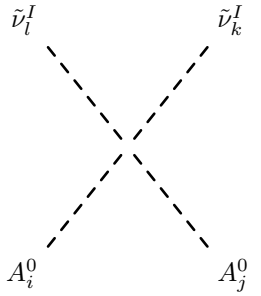
$$\frac{i}{12}\delta_{\gamma\delta}\Big(\Big(3g_2^2+g_1^2\Big)\sum_{a=1}^{3}Z^{D,*}_{ka}Z^D_{la}\Big(Z^A_{i1}Z^A_{j1}-Z^A_{i2}Z^A_{j2}\Big)$$
$$+2\Big(-6\Big(\sum_{c=1}^{3}Z^{D,*}_{k3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}y^*_{d,ca}y_{d,ba}Z^D_{l3+b}+\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{D,*}_{kb}\sum_{a=1}^{3}y^*_{d,ac}y_{d,ab}Z^D_{lc}\Big)Z^A_{i1}Z^A_{j1}$$
$$+g_1^2\sum_{a=1}^{3}Z^{D,*}_{k3+a}Z^D_{l3+a}\Big(Z^A_{i1}Z^A_{j1}-Z^A_{i2}Z^A_{j2}\Big)\Big)\Big) \tag{401}$$



$$-\frac{i}{4}\Big(4\Big(\sum_{c=1}^{3}Z^{E,*}_{k3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}y^*_{e,ca}y_{e,ba}Z^E_{l3+b}+\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{E,*}_{kb}\sum_{a=1}^{3}y^*_{e,ac}y_{e,ab}Z^E_{lc}\Big)Z^A_{i1}Z^A_{j1}$$
$$+\Big(-g_2^2+g_1^2\Big)\sum_{a=1}^{3}Z^{E,*}_{ka}Z^E_{la}\Big(Z^A_{i1}Z^A_{j1}-Z^A_{i2}Z^A_{j2}\Big)$$
$$+2g_1^2\sum_{a=1}^{3}Z^{E,*}_{k3+a}Z^E_{l3+a}\Big(-Z^A_{i1}Z^A_{j1}+Z^A_{i2}Z^A_{j2}\Big)\Big) \tag{402}$$

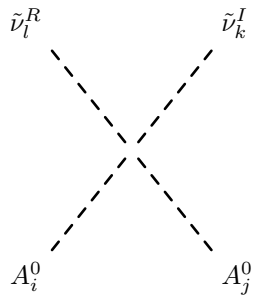


$$\frac{i}{12}\delta_{\gamma\delta}\Big(\Big(-3g_2^2+g_1^2\Big)\sum_{a=1}^{3}Z^{U,*}_{ka}Z^{U}_{la}\Big(Z^A_{i1}Z^A_{j1}-Z^A_{i2}Z^A_{j2}\Big)$$
$$-4\Big(3\Big(\sum_{c=1}^{3}Z^{U,*}_{k3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}y^*_{u,ca}y_{u,ba}Z^U_{l3+b}+\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{U,*}_{kb}\sum_{a=1}^{3}y^*_{u,ac}y_{u,ab}Z^U_{lc}\Big)Z^A_{i2}Z^A_{j2}$$
$$+g_1^2\sum_{a=1}^{3}Z^{U,*}_{k3+a}Z^U_{l3+a}\Big(Z^A_{i1}Z^A_{j1}-Z^A_{i2}Z^A_{j2}\Big)\Big)\Big) \tag{403}$$

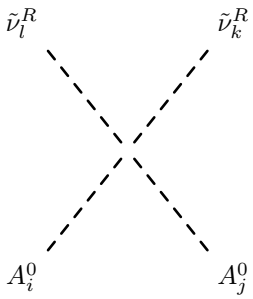


$$-\frac{i}{8}\Big(4\sum_{c=1}^{2}Z^{I,*}_{l3+c}\sum_{b=1}^{2}Z^{I,*}_{k3+b}\sum_{a=1}^{3}Y^*_{\nu,ca}Y_{\nu,ba}Z^A_{i2}Z^A_{j2}$$
$$+4\sum_{c=1}^{2}Z^{I,*}_{k3+c}\sum_{b=1}^{2}Z^{I,*}_{l3+b}\sum_{a=1}^{3}Y^*_{\nu,ca}Y_{\nu,ba}Z^A_{i2}Z^A_{j2}$$
$$+4\sum_{c=1}^{3}Z^{I,*}_{lc}\sum_{b=1}^{3}Z^{I,*}_{kb}\sum_{a=1}^{2}Y^*_{\nu,ac}Y_{\nu,ab}Z^A_{i2}Z^A_{j2}$$
$$+4\sum_{c=1}^{3}Z^{I,*}_{kc}\sum_{b=1}^{3}Z^{I,*}_{lb}\sum_{a=1}^{2}Y^*_{\nu,ac}Y_{\nu,ab}Z^A_{i2}Z^A_{j2}$$
$$+2\Big(g_1^2+g_2^2\Big)\sum_{a=1}^{3}Z^{I,*}_{ka}Z^{I,*}_{la}\Big(Z^A_{i1}Z^A_{j1}-Z^A_{i2}Z^A_{j2}\Big)+2\kappa\sum_{b=1}^{2}Z^{I,*}_{l5+b}\sum_{a=1}^{2}\lambda^*_{ab}Z^{I,*}_{k5+a}Z^A_{i3}Z^A_{j3}$$

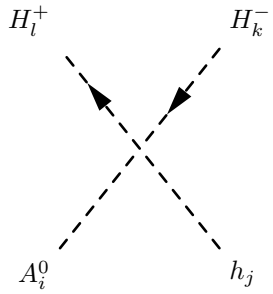
$$
\begin{aligned}
&+ 2\kappa \sum_{b=1}^{2} Z^{I,*}_{k5+b} \sum_{a=1}^{2} \lambda^*_{ab} Z^{I,*}_{l5+a} Z^A_{i3} Z^A_{j3} + 2\kappa^* \sum_{b=1}^{2} Z^{I,*}_{l5+b} \sum_{a=1}^{2} Z^{I,*}_{k5+a} \lambda_{ab} Z^A_{i3} Z^A_{j3} \\
&+ 2\kappa^* \sum_{b=1}^{2} Z^{I,*}_{k5+b} \sum_{a=1}^{2} Z^{I,*}_{l5+a} \lambda_{ab} Z^A_{i3} Z^A_{j3} + 4 \sum_{c=1}^{2} Z^{I,*}_{l5+c} \sum_{b=1}^{2} Z^{I,*}_{k5+b} \sum_{a=1}^{2} \lambda^*_{ac} \lambda_{ab} Z^A_{i3} Z^A_{j3} \\
&+ 4 \sum_{c=1}^{2} Z^{I,*}_{k5+c} \sum_{b=1}^{2} Z^{I,*}_{l5+b} \sum_{a=1}^{2} \lambda^*_{ac} \lambda_{ab} Z^A_{i3} Z^A_{j3} \Big)
\end{aligned} \tag{404}
$$



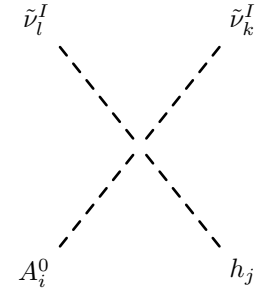
$$
\begin{aligned}
&\frac{1}{8}\Big(- 4 \sum_{c=1}^{2} Z^{R,*}_{l3+c} \sum_{b=1}^{2} Z^{I,*}_{k3+b} \sum_{a=1}^{3} Y^*_{\nu,ca} Y_{\nu,ba} Z^A_{i2} Z^A_{j2} \\
&+ 4 \sum_{c=1}^{2} Z^{I,*}_{k3+c} \sum_{b=1}^{2} Z^{R,*}_{l3+b} \sum_{a=1}^{3} Y^*_{\nu,ca} Y_{\nu,ba} Z^A_{i2} Z^A_{j2} \\
&+ 4 \sum_{c=1}^{3} Z^{R,*}_{lc} \sum_{b=1}^{3} Z^{I,*}_{kb} \sum_{a=1}^{2} Y^*_{\nu,ac} Y_{\nu,ab} Z^A_{i2} Z^A_{j2} \\
&- 4 \sum_{c=1}^{3} Z^{I,*}_{kc} \sum_{b=1}^{3} Z^{R,*}_{lb} \sum_{a=1}^{2} Y^*_{\nu,ac} Y_{\nu,ab} Z^A_{i2} Z^A_{j2} + 2\kappa \sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} \lambda^*_{ab} Z^{I,*}_{k5+a} Z^A_{i3} Z^A_{j3} \\
&+ 2\kappa \sum_{b=1}^{2} Z^{I,*}_{k5+b} \sum_{a=1}^{2} \lambda^*_{ab} Z^{R,*}_{l5+a} Z^A_{i3} Z^A_{j3} - 2\kappa^* \sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} Z^{I,*}_{k5+a} \lambda_{ab} Z^A_{i3} Z^A_{j3} \\
&- 2\kappa^* \sum_{b=1}^{2} Z^{I,*}_{k5+b} \sum_{a=1}^{2} Z^{R,*}_{l5+a} \lambda_{ab} Z^A_{i3} Z^A_{j3} + 4 \sum_{c=1}^{2} Z^{R,*}_{l5+c} \sum_{b=1}^{2} Z^{I,*}_{k5+b} \sum_{a=1}^{2} \lambda^*_{ac} \lambda_{ab} Z^A_{i3} Z^A_{j3} \\
&- 4 \sum_{c=1}^{2} Z^{I,*}_{k5+c} \sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} \lambda^*_{ac} \lambda_{ab} Z^A_{i3} Z^A_{j3} \Big)
\end{aligned} \tag{405}
$$



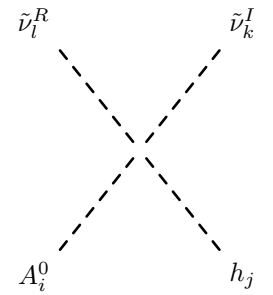
$$
\begin{aligned}
&-\frac{i}{8}\Big(4\sum_{c=1}^{2} Z^{R,*}_{l3+c}\sum_{b=1}^{2} Z^{R,*}_{k3+b}\sum_{a=1}^{3} Y^{*}_{\nu,ca}Y_{\nu,ba}Z^{A}_{i2}Z^{A}_{j2}\\
&+4\sum_{c=1}^{2} Z^{R,*}_{k3+c}\sum_{b=1}^{2} Z^{R,*}_{l3+b}\sum_{a=1}^{3} Y^{*}_{\nu,ca}Y_{\nu,ba}Z^{A}_{i2}Z^{A}_{j2}\\
&+4\sum_{c=1}^{3} Z^{R,*}_{lc}\sum_{b=1}^{3} Z^{R,*}_{kb}\sum_{a=1}^{2} Y^{*}_{\nu,ac}Y_{\nu,ab}Z^{A}_{i2}Z^{A}_{j2}\\
&+4\sum_{c=1}^{3} Z^{R,*}_{kc}\sum_{b=1}^{3} Z^{R,*}_{lb}\sum_{a=1}^{2} Y^{*}_{\nu,ac}Y_{\nu,ab}Z^{A}_{i2}Z^{A}_{j2}\\
&+2\Big(g_1^2+g_2^2\Big)\sum_{a=1}^{3} Z^{R,*}_{ka}Z^{R,*}_{la}\Big(Z^{A}_{i1}Z^{A}_{j1}-Z^{A}_{i2}Z^{A}_{j2}\Big)\\
&-2\kappa\sum_{b=1}^{2} Z^{R,*}_{l5+b}\sum_{a=1}^{2}\lambda^{*}_{ab}Z^{R,*}_{k5+a}Z^{A}_{i3}Z^{A}_{j3}-2\kappa\sum_{b=1}^{2} Z^{R,*}_{k5+b}\sum_{a=1}^{2}\lambda^{*}_{ab}Z^{R,*}_{l5+a}Z^{A}_{i3}Z^{A}_{j3}\\
&-2\kappa^{*}\sum_{b=1}^{2} Z^{R,*}_{l5+b}\sum_{a=1}^{2} Z^{R,*}_{k5+a}\lambda_{ab}Z^{A}_{i3}Z^{A}_{j3}-2\kappa^{*}\sum_{b=1}^{2} Z^{R,*}_{k5+b}\sum_{a=1}^{2} Z^{R,*}_{l5+a}\lambda_{ab}Z^{A}_{i3}Z^{A}_{j3}\\
&+4\sum_{c=1}^{2} Z^{R,*}_{l5+c}\sum_{b=1}^{2} Z^{R,*}_{k5+b}\sum_{a=1}^{2}\lambda^{*}_{ac}\lambda_{ab}Z^{A}_{i3}Z^{A}_{j3}\\
&+4\sum_{c=1}^{2} Z^{R,*}_{k5+c}\sum_{b=1}^{2} Z^{R,*}_{l5+b}\sum_{a=1}^{2}\lambda^{*}_{ac}\lambda_{ab}Z^{A}_{i3}Z^{A}_{j3}\Big)
\end{aligned}
\tag{406}
$$



$$\frac{1}{4}g_2^2\Big(Z_{i1}^A Z_{j2}^H + Z_{i2}^A Z_{j1}^H\Big)\Big(-Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+\Big) \tag{407}$$

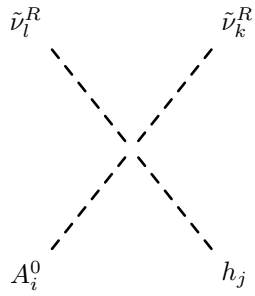


$$\begin{aligned}&-\frac{1}{4}\Big(\kappa\sum_{b=1}^{2}Z_{l5+b}^{I,*}\sum_{a=1}^{2}\lambda_{ab}^* Z_{k5+a}^{I,*} + \kappa\sum_{b=1}^{2}Z_{k5+b}^{I,*}\sum_{a=1}^{2}\lambda_{ab}^* Z_{l5+a}^{I,*}\\ &-\kappa^*\Big(\sum_{b=1}^{2}Z_{l5+b}^{I,*}\sum_{a=1}^{2}Z_{k5+a}^{I,*}\lambda_{ab} + \sum_{b=1}^{2}Z_{k5+b}^{I,*}\sum_{a=1}^{2}Z_{l5+a}^{I,*}\lambda_{ab}\Big)\Big)Z_{i3}^A Z_{j3}^H\end{aligned} \tag{408}$$

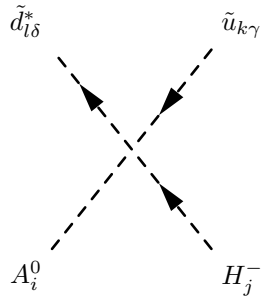


$$-\frac{i}{4}\Big(\kappa\sum_{b=1}^{2}Z_{l5+b}^{R,*}\sum_{a=1}^{2}\lambda_{ab}^* Z_{k5+a}^{I,*} + \kappa\sum_{b=1}^{2}Z_{k5+b}^{I,*}\sum_{a=1}^{2}\lambda_{ab}^* Z_{l5+a}^{R,*}$$

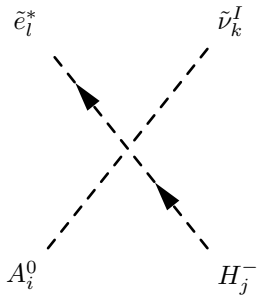
$$+\kappa^*\Big(\sum_{b=1}^{2} Z^{R,*}_{l5+b}\sum_{a=1}^{2} Z^{I,*}_{k5+a}\lambda_{ab}+\sum_{b=1}^{2} Z^{I,*}_{k5+b}\sum_{a=1}^{2} Z^{R,*}_{l5+a}\lambda_{ab}\Big)\Big)Z^{A}_{i3}Z^{H}_{j3} \tag{409}$$



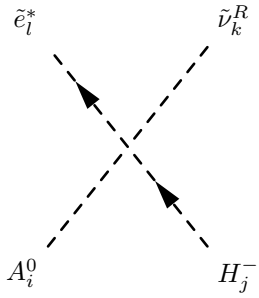
$$\begin{aligned}&\frac{1}{4}\Big(\kappa\sum_{b=1}^{2} Z^{R,*}_{l5+b}\sum_{a=1}^{2}\lambda^*_{ab}Z^{R,*}_{k5+a}+\kappa\sum_{b=1}^{2} Z^{R,*}_{k5+b}\sum_{a=1}^{2}\lambda^*_{ab}Z^{R,*}_{l5+a}\\&-\kappa^*\Big(\sum_{b=1}^{2} Z^{R,*}_{l5+b}\sum_{a=1}^{2} Z^{R,*}_{k5+a}\lambda_{ab}+\sum_{b=1}^{2} Z^{R,*}_{k5+b}\sum_{a=1}^{2} Z^{R,*}_{l5+a}\lambda_{ab}\Big)\Big)Z^{A}_{i3}Z^{H}_{j3}\end{aligned} \tag{410}$$



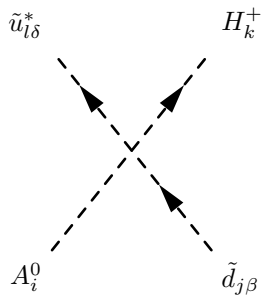
$$\begin{aligned}&\frac{1}{2}\frac{1}{\sqrt{2}}\delta_{\gamma\delta}\Big(g_2^2\sum_{a=1}^{3} Z^{U,*}_{ka}Z^{D}_{la}\Big(-Z^{A}_{i1}Z^{+}_{j1}+Z^{A}_{i2}Z^{+}_{j2}\Big)\\&+2\Big(\sum_{c=1}^{3}\sum_{b=1}^{3} Z^{U,*}_{kb}\sum_{a=1}^{3} y^*_{d,ac}y_{d,ab}Z^{D}_{lc}Z^{A}_{i1}Z^{+}_{j1}-\sum_{c=1}^{3}\sum_{b=1}^{3} Z^{U,*}_{kb}\sum_{a=1}^{3} y^*_{u,ac}y_{u,ab}Z^{D}_{lc}Z^{A}_{i2}Z^{+}_{j2}\\&+\sum_{c=1}^{3} Z^{U,*}_{k3+c}\sum_{b=1}^{3}\sum_{a=1}^{3} y^*_{u,ca}y_{d,ba}Z^{D}_{l3+b}\Big(-Z^{A}_{i1}Z^{+}_{j2}+Z^{A}_{i2}Z^{+}_{j1}\Big)\Big)\Big)\end{aligned} \tag{411}$$



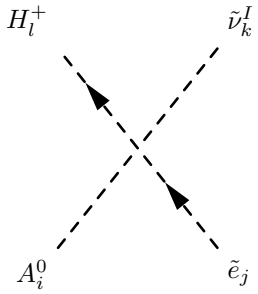
$$\frac{i}{4}\Big(g_2^2\sum_{a=1}^{3}Z_{ka}^{I,*}Z_{la}^{E}\Big(-Z_{i1}^{A}Z_{j1}^{+}+Z_{i2}^{A}Z_{j2}^{+}\Big)$$
$$+2\Big(\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{kb}^{I,*}\sum_{a=1}^{3}y_{e,ac}^{*}y_{e,ab}Z_{lc}^{E}Z_{i1}^{A}Z_{j1}^{+}-\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{kb}^{I,*}\sum_{a=1}^{2}Y_{\nu,ac}^{*}Y_{\nu,ab}Z_{lc}^{E}Z_{i2}^{A}Z_{j2}^{+}$$
$$+\sum_{c=1}^{2}Z_{k3+c}^{I,*}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{\nu,ca}^{*}y_{e,ba}Z_{l3+b}^{E}\Big(-Z_{i1}^{A}Z_{j2}^{+}+Z_{i2}^{A}Z_{j1}^{+}\Big)\Big)\Big) \tag{412}$$



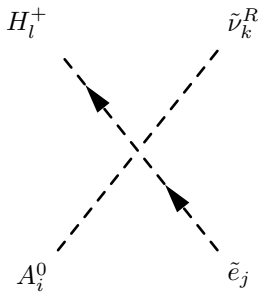
$$\frac{1}{4}\Big(g_2^2\sum_{a=1}^{3}Z_{ka}^{R,*}Z_{la}^{E}\Big(-Z_{i1}^{A}Z_{j1}^{+}+Z_{i2}^{A}Z_{j2}^{+}\Big)$$
$$+2\Big(\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{kb}^{R,*}\sum_{a=1}^{3}y_{e,ac}^{*}y_{e,ab}Z_{lc}^{E}Z_{i1}^{A}Z_{j1}^{+}-\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{kb}^{R,*}\sum_{a=1}^{2}Y_{\nu,ac}^{*}Y_{\nu,ab}Z_{lc}^{E}Z_{i2}^{A}Z_{j2}^{+}$$
$$+\sum_{c=1}^{2}Z_{k3+c}^{R,*}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{\nu,ca}^{*}y_{e,ba}Z_{l3+b}^{E}\Big(-Z_{i1}^{A}Z_{j2}^{+}+Z_{i2}^{A}Z_{j1}^{+}\Big)\Big)\Big) \tag{413}$$



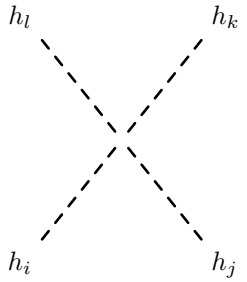
$$\frac{1}{2}\frac{1}{\sqrt{2}}\delta_{\beta\delta}\Big(-2\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}y^*_{d,ac}y_{d,ab}Z^U_{lc}Z^A_{i1}Z^+_{k1}$$
$$-2\sum_{c=1}^{3}Z^{D,*}_{j3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}y^*_{d,ca}y_{u,ba}Z^U_{l3+b}Z^A_{i2}Z^+_{k1}$$
$$+2\sum_{c=1}^{3}Z^{D,*}_{j3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}y^*_{d,ca}y_{u,ba}Z^U_{l3+b}Z^A_{i1}Z^+_{k2}$$
$$+2\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{D,*}_{jb}\sum_{a=1}^{3}y^*_{u,ac}y_{u,ab}Z^U_{lc}Z^A_{i2}Z^+_{k2}+g_2^2\sum_{a=1}^{3}Z^{D,*}_{ja}Z^U_{la}\Big(Z^A_{i1}Z^+_{k1}-Z^A_{i2}Z^+_{k2}\Big)\Big) \tag{414}$$



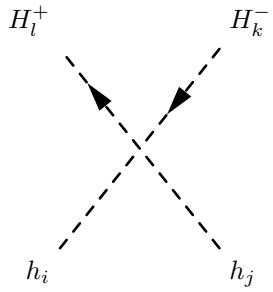
$$\frac{i}{4}\Big(g_2^2\sum_{a=1}^{3}Z^{E,*}_{ja}Z^{I,*}_{ka}\Big(-Z^A_{i1}Z^+_{l1}+Z^A_{i2}Z^+_{l2}\Big)$$
$$+2\Big(\sum_{c=1}^{3}Z^{I,*}_{kc}\sum_{b=1}^{3}Z^{E,*}_{jb}\sum_{a=1}^{3}y^*_{e,ac}y_{e,ab}Z^A_{i1}Z^+_{l1}$$
$$-\sum_{c=1}^{3}Z^{I,*}_{kc}\sum_{b=1}^{3}Z^{E,*}_{jb}\sum_{a=1}^{2}Y^*_{\nu,ac}Y_{\nu,ab}Z^A_{i2}Z^+_{l2}$$
$$+\sum_{c=1}^{3}Z^{E,*}_{j3+c}\sum_{b=1}^{2}Z^{I,*}_{k3+b}\sum_{a=1}^{3}y^*_{e,ca}Y_{\nu,ba}\Big(-Z^A_{i1}Z^+_{l2}+Z^A_{i2}Z^+_{l1}\Big)\Big)\Big) \tag{415}$$



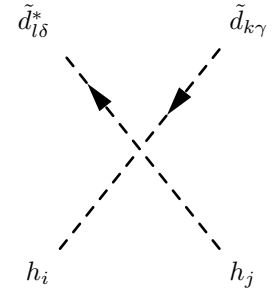
$$
\begin{aligned}
&\frac{1}{4}\Big(- 2\sum_{c=1}^{3} Z_{kc}^{R,*} \sum_{b=1}^{3} Z_{jb}^{E,*} \sum_{a=1}^{3} y_{e,ac}^{*} y_{e,ab} Z_{i1}^{A} Z_{l1}^{+} \\
&- 2\sum_{c=1}^{3} Z_{j3+c}^{E,*} \sum_{b=1}^{2} Z_{k3+b}^{R,*} \sum_{a=1}^{3} y_{e,ca}^{*} Y_{\nu,ba} Z_{i2}^{A} Z_{l1}^{+} \\
&+ 2\sum_{c=1}^{3} Z_{j3+c}^{E,*} \sum_{b=1}^{2} Z_{k3+b}^{R,*} \sum_{a=1}^{3} y_{e,ca}^{*} Y_{\nu,ba} Z_{i1}^{A} Z_{l2}^{+} \\
&+ 2\sum_{c=1}^{3} Z_{kc}^{R,*} \sum_{b=1}^{3} Z_{jb}^{E,*} \sum_{a=1}^{2} Y_{\nu,ac}^{*} Y_{\nu,ab} Z_{i2}^{A} Z_{l2}^{+} + g_2^2 \sum_{a=1}^{3} Z_{ja}^{E,*} Z_{ka}^{R,*} \Big(Z_{i1}^{A} Z_{l1}^{+} - Z_{i2}^{A} Z_{l2}^{+} \Big) \Big)
\end{aligned}
\tag{416}
$$



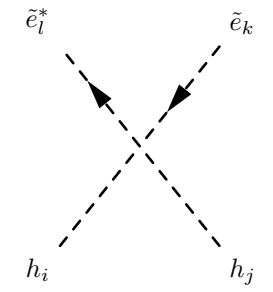
$$
\begin{aligned}
&- \frac{i}{4}\Big(- \Big(g_1^2 + g_2^2 \Big) Z_{i2}^{H} \Big(Z_{j1}^{H} \Big(Z_{k1}^{H} Z_{l2}^{H} + Z_{k2}^{H} Z_{l1}^{H} \Big) + Z_{j2}^{H} \Big(- 3 Z_{k2}^{H} Z_{l2}^{H} + Z_{k1}^{H} Z_{l1}^{H} \Big) \Big) \\
&+ \Big(g_1^2 + g_2^2 \Big) Z_{i1}^{H} \Big(Z_{j1}^{H} \Big(3 Z_{k1}^{H} Z_{l1}^{H} - Z_{k2}^{H} Z_{l2}^{H} \Big) - Z_{j2}^{H} \Big(Z_{k1}^{H} Z_{l2}^{H} + Z_{k2}^{H} Z_{l1}^{H} \Big) \Big) \\
&+ 24 |\kappa|^2 Z_{i3}^{H} Z_{j3}^{H} Z_{k3}^{H} Z_{l3}^{H} \Big)
\end{aligned}
\tag{417}
$$



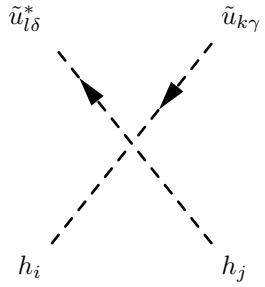
$$
\begin{aligned}
&-\frac{i}{4}\Big(Z_{i1}^H\Big(g_2^2 Z_{j2}^H\Big(Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+\Big) + Z_{j1}^H\Big(\Big(g_1^2+g_2^2\Big)Z_{k1}^+ Z_{l1}^+ + \Big(-g_1^2+g_2^2\Big)Z_{k2}^+ Z_{l2}^+\Big)\Big)\\
&+ Z_{i2}^H\Big(g_2^2 Z_{j1}^H\Big(Z_{k1}^+ Z_{l2}^+ + Z_{k2}^+ Z_{l1}^+\Big) + Z_{j2}^H\Big(\Big(-g_1^2+g_2^2\Big)Z_{k1}^+ Z_{l1}^+ + \Big(g_1^2+g_2^2\Big)Z_{k2}^+ Z_{l2}^+\Big)\Big)\Big)
\end{aligned}
\tag{418}
$$



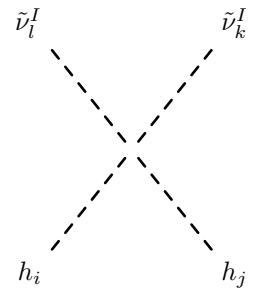
$$
\begin{aligned}
&\frac{i}{12}\delta_{\gamma\delta}\Big(\Big(3g_2^2+g_1^2\Big)\sum_{a=1}^{3} Z_{ka}^{D,*} Z_{la}^D\Big(Z_{i1}^H Z_{j1}^H - Z_{i2}^H Z_{j2}^H\Big)\\
&+ 2\Big(-6\Big(\sum_{c=1}^{3} Z_{k3+c}^{D,*}\sum_{b=1}^{3}\sum_{a=1}^{3} y_{d,ca}^* y_{d,ba} Z_{l3+b}^D + \sum_{c=1}^{3}\sum_{b=1}^{3} Z_{kb}^{D,*}\sum_{a=1}^{3} y_{d,ac}^* y_{d,ab} Z_{lc}^D\Big)Z_{i1}^H Z_{j1}^H\\
&+ g_1^2\sum_{a=1}^{3} Z_{k3+a}^{D,*} Z_{l3+a}^D\Big(Z_{i1}^H Z_{j1}^H - Z_{i2}^H Z_{j2}^H\Big)\Big)\Big)
\end{aligned}
\tag{419}
$$



$$
\begin{aligned}
&- \frac{i}{4}\Big(4\Big(\sum_{c=1}^{3} Z^{E,*}_{k3+c}\sum_{b=1}^{3}\sum_{a=1}^{3} y^{*}_{e,ca}y_{e,ba}Z^{E}_{l3+b} + \sum_{c=1}^{3}\sum_{b=1}^{3} Z^{E,*}_{kb}\sum_{a=1}^{3} y^{*}_{e,ac}y_{e,ab}Z^{E}_{lc}\Big)Z^{H}_{i1}Z^{H}_{j1}\\
&+ \Big(-g_2^2+g_1^2\Big)\sum_{a=1}^{3} Z^{E,*}_{ka}Z^{E}_{la}\Big(Z^{H}_{i1}Z^{H}_{j1} - Z^{H}_{i2}Z^{H}_{j2}\Big)\\
&+ 2g_1^2\sum_{a=1}^{3} Z^{E,*}_{k3+a}Z^{E}_{l3+a}\Big(-Z^{H}_{i1}Z^{H}_{j1} + Z^{H}_{i2}Z^{H}_{j2}\Big)\Big)
\end{aligned}
\tag{420}
$$

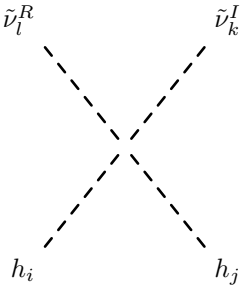


$$
\begin{aligned}
&\frac{i}{12}\delta_{\gamma\delta}\Big(\Big(-3g_2^2+g_1^2\Big)\sum_{a=1}^{3} Z^{U,*}_{ka}Z^{U}_{la}\Big(Z^{H}_{i1}Z^{H}_{j1} - Z^{H}_{i2}Z^{H}_{j2}\Big)\\
&- 4\Big(3\Big(\sum_{c=1}^{3} Z^{U,*}_{k3+c}\sum_{b=1}^{3}\sum_{a=1}^{3} y^{*}_{u,ca}y_{u,ba}Z^{U}_{l3+b} + \sum_{c=1}^{3}\sum_{b=1}^{3} Z^{U,*}_{kb}\sum_{a=1}^{3} y^{*}_{u,ac}y_{u,ab}Z^{U}_{lc}\Big)Z^{H}_{i2}Z^{H}_{j2}\\
&+ g_1^2\sum_{a=1}^{3} Z^{U,*}_{k3+a}Z^{U}_{l3+a}\Big(Z^{H}_{i1}Z^{H}_{j1} - Z^{H}_{i2}Z^{H}_{j2}\Big)\Big)\Big)
\end{aligned}
\tag{421}
$$



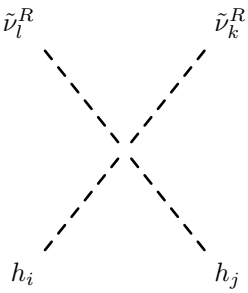
$$
- \frac{i}{8}\Big(4\sum_{c=1}^{2} Z^{I,*}_{l3+c}\sum_{b=1}^{2} Z^{I,*}_{k3+b}\sum_{a=1}^{3} Y^{*}_{\nu,ca}Y_{\nu,ba}Z^{H}_{i2}Z^{H}_{j2}
$$

$$
\begin{aligned}
&+4\sum_{c=1}^{2} Z^{I,*}_{k3+c}\sum_{b=1}^{2} Z^{I,*}_{l3+b}\sum_{a=1}^{3} Y^{*}_{\nu,ca}Y_{\nu,ba}Z^{H}_{i2}Z^{H}_{j2}\\
&+4\sum_{c=1}^{3} Z^{I,*}_{lc}\sum_{b=1}^{3} Z^{I,*}_{kb}\sum_{a=1}^{2} Y^{*}_{\nu,ac}Y_{\nu,ab}Z^{H}_{i2}Z^{H}_{j2}\\
&+4\sum_{c=1}^{3} Z^{I,*}_{kc}\sum_{b=1}^{3} Z^{I,*}_{lb}\sum_{a=1}^{2} Y^{*}_{\nu,ac}Y_{\nu,ab}Z^{H}_{i2}Z^{H}_{j2}\\
&+2\Big(g_1^2+g_2^2\Big)\sum_{a=1}^{3} Z^{I,*}_{ka}Z^{I,*}_{la}\Big(Z^{H}_{i1}Z^{H}_{j1}-Z^{H}_{i2}Z^{H}_{j2}\Big)\\
&-2\kappa\sum_{b=1}^{2} Z^{I,*}_{l5+b}\sum_{a=1}^{2}\lambda^{*}_{ab}Z^{I,*}_{k5+a}Z^{H}_{i3}Z^{H}_{j3}-2\kappa\sum_{b=1}^{2} Z^{I,*}_{k5+b}\sum_{a=1}^{2}\lambda^{*}_{ab}Z^{I,*}_{l5+a}Z^{H}_{i3}Z^{H}_{j3}\\
&-2\kappa^{*}\sum_{b=1}^{2} Z^{I,*}_{l5+b}\sum_{a=1}^{2} Z^{I,*}_{k5+a}\lambda_{ab}Z^{H}_{i3}Z^{H}_{j3}-2\kappa^{*}\sum_{b=1}^{2} Z^{I,*}_{k5+b}\sum_{a=1}^{2} Z^{I,*}_{l5+a}\lambda_{ab}Z^{H}_{i3}Z^{H}_{j3}\\
&+4\sum_{c=1}^{2} Z^{I,*}_{l5+c}\sum_{b=1}^{2} Z^{I,*}_{k5+b}\sum_{a=1}^{2}\lambda^{*}_{ac}\lambda_{ab}Z^{H}_{i3}Z^{H}_{j3}\\
&+4\sum_{c=1}^{2} Z^{I,*}_{k5+c}\sum_{b=1}^{2} Z^{I,*}_{l5+b}\sum_{a=1}^{2}\lambda^{*}_{ac}\lambda_{ab}Z^{H}_{i3}Z^{H}_{j3}\Big)
\end{aligned}
\tag{422}
$$

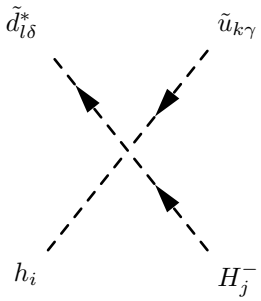


$$
\begin{aligned}
&\frac{1}{8}\Big(-4\sum_{c=1}^{2} Z^{R,*}_{l3+c}\sum_{b=1}^{2} Z^{I,*}_{k3+b}\sum_{a=1}^{3} Y^{*}_{\nu,ca}Y_{\nu,ba}Z^{H}_{i2}Z^{H}_{j2}\\
&+4\sum_{c=1}^{2} Z^{I,*}_{k3+c}\sum_{b=1}^{2} Z^{R,*}_{l3+b}\sum_{a=1}^{3} Y^{*}_{\nu,ca}Y_{\nu,ba}Z^{H}_{i2}Z^{H}_{j2}\\
&+4\sum_{c=1}^{3} Z^{R,*}_{lc}\sum_{b=1}^{3} Z^{I,*}_{kb}\sum_{a=1}^{2} Y^{*}_{\nu,ac}Y_{\nu,ab}Z^{H}_{i2}Z^{H}_{j2}\\
&-4\sum_{c=1}^{3} Z^{I,*}_{kc}\sum_{b=1}^{3} Z^{R,*}_{lb}\sum_{a=1}^{2} Y^{*}_{\nu,ac}Y_{\nu,ab}Z^{H}_{i2}Z^{H}_{j2}-2\kappa\sum_{b=1}^{2} Z^{R,*}_{l5+b}\sum_{a=1}^{2}\lambda^{*}_{ab}Z^{I,*}_{k5+a}Z^{H}_{i3}Z^{H}_{j3}
\end{aligned}
$$

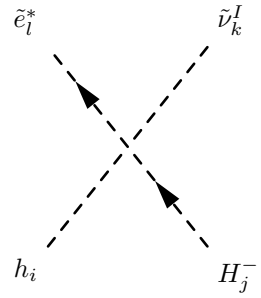
$$
\begin{aligned}
&- 2\kappa \sum_{b=1}^{2} Z^{I,*}_{k5+b} \sum_{a=1}^{2} \lambda^{*}_{ab} Z^{R,*}_{l5+a} Z^{H}_{i3} Z^{H}_{j3} + 2\kappa^{*} \sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} Z^{I,*}_{k5+a} \lambda_{ab} Z^{H}_{i3} Z^{H}_{j3} \\
&+ 2\kappa^{*} \sum_{b=1}^{2} Z^{I,*}_{k5+b} \sum_{a=1}^{2} Z^{R,*}_{l5+a} \lambda_{ab} Z^{H}_{i3} Z^{H}_{j3} + 4 \sum_{c=1}^{2} Z^{R,*}_{l5+c} \sum_{b=1}^{2} Z^{I,*}_{k5+b} \sum_{a=1}^{2} \lambda^{*}_{ac} \lambda_{ab} Z^{H}_{i3} Z^{H}_{j3} \\
&- 4 \sum_{c=1}^{2} Z^{I,*}_{k5+c} \sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} \lambda^{*}_{ac} \lambda_{ab} Z^{H}_{i3} Z^{H}_{j3} \Big)
\end{aligned} \tag{423}
$$



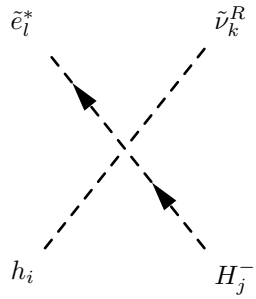
$$
\begin{aligned}
&- \frac{i}{8} \Big(4 \sum_{c=1}^{2} Z^{R,*}_{l3+c} \sum_{b=1}^{2} Z^{R,*}_{k3+b} \sum_{a=1}^{3} Y^{*}_{\nu,ca} Y_{\nu,ba} Z^{H}_{i2} Z^{H}_{j2} \\
&+ 4 \sum_{c=1}^{2} Z^{R,*}_{k3+c} \sum_{b=1}^{2} Z^{R,*}_{l3+b} \sum_{a=1}^{3} Y^{*}_{\nu,ca} Y_{\nu,ba} Z^{H}_{i2} Z^{H}_{j2} \\
&+ 4 \sum_{c=1}^{3} Z^{R,*}_{lc} \sum_{b=1}^{3} Z^{R,*}_{kb} \sum_{a=1}^{2} Y^{*}_{\nu,ac} Y_{\nu,ab} Z^{H}_{i2} Z^{H}_{j2} \\
&+ 4 \sum_{c=1}^{3} Z^{R,*}_{kc} \sum_{b=1}^{3} Z^{R,*}_{lb} \sum_{a=1}^{2} Y^{*}_{\nu,ac} Y_{\nu,ab} Z^{H}_{i2} Z^{H}_{j2} \\
&+ 2 \Big(g_1^2 + g_2^2 \Big) \sum_{a=1}^{3} Z^{R,*}_{ka} Z^{R,*}_{la} \Big(Z^{H}_{i1} Z^{H}_{j1} - Z^{H}_{i2} Z^{H}_{j2} \Big) + 2\kappa \sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} \lambda^{*}_{ab} Z^{R,*}_{k5+a} Z^{H}_{i3} Z^{H}_{j3} \\
&+ 2\kappa \sum_{b=1}^{2} Z^{R,*}_{k5+b} \sum_{a=1}^{2} \lambda^{*}_{ab} Z^{R,*}_{l5+a} Z^{H}_{i3} Z^{H}_{j3} + 2\kappa^{*} \sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} Z^{R,*}_{k5+a} \lambda_{ab} Z^{H}_{i3} Z^{H}_{j3} \\
&+ 2\kappa^{*} \sum_{b=1}^{2} Z^{R,*}_{k5+b} \sum_{a=1}^{2} Z^{R,*}_{l5+a} \lambda_{ab} Z^{H}_{i3} Z^{H}_{j3} + 4 \sum_{c=1}^{2} Z^{R,*}_{l5+c} \sum_{b=1}^{2} Z^{R,*}_{k5+b} \sum_{a=1}^{2} \lambda^{*}_{ac} \lambda_{ab} Z^{H}_{i3} Z^{H}_{j3} \\
&+ 4 \sum_{c=1}^{2} Z^{R,*}_{k5+c} \sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} \lambda^{*}_{ac} \lambda_{ab} Z^{H}_{i3} Z^{H}_{j3} \Big)
\end{aligned} \tag{424}
$$



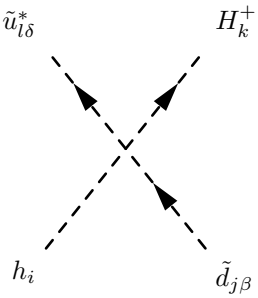
$$
\begin{aligned}
&-\frac{i}{2}\frac{1}{\sqrt{2}}\delta_{\gamma\delta}\Big(g_2^2\sum_{a=1}^{3}Z^{U,*}_{ka}Z^{D}_{la}\Big(Z^{H}_{i1}Z^{+}_{j1}+Z^{H}_{i2}Z^{+}_{j2}\Big)\\
&-2\Big(\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{U,*}_{kb}\sum_{a=1}^{3}y^{*}_{d,ac}y_{d,ab}Z^{D}_{lc}Z^{H}_{i1}Z^{+}_{j1}+\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{U,*}_{kb}\sum_{a=1}^{3}y^{*}_{u,ac}y_{u,ab}Z^{D}_{lc}Z^{H}_{i2}Z^{+}_{j2}\\
&+\sum_{c=1}^{3}Z^{U,*}_{k3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}y^{*}_{u,ca}y_{d,ba}Z^{D}_{l3+b}\Big(Z^{H}_{i1}Z^{+}_{j2}+Z^{H}_{i2}Z^{+}_{j1}\Big)\Big)\Big)
\end{aligned}
\tag{425}
$$



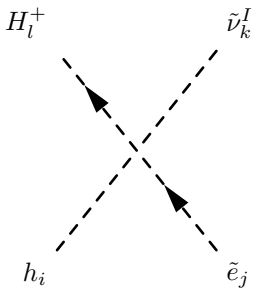
$$
\begin{aligned}
&\frac{1}{4}\Big(g_2^2\sum_{a=1}^{3}Z^{I,*}_{ka}Z^{E}_{la}\Big(Z^{H}_{i1}Z^{+}_{j1}+Z^{H}_{i2}Z^{+}_{j2}\Big)\\
&-2\Big(\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{I,*}_{kb}\sum_{a=1}^{3}y^{*}_{e,ac}y_{e,ab}Z^{E}_{lc}Z^{H}_{i1}Z^{+}_{j1}+\sum_{c=1}^{3}\sum_{b=1}^{3}Z^{I,*}_{kb}\sum_{a=1}^{2}Y^{*}_{\nu,ac}Y_{\nu,ab}Z^{E}_{lc}Z^{H}_{i2}Z^{+}_{j2}\\
&+\sum_{c=1}^{2}Z^{I,*}_{k3+c}\sum_{b=1}^{3}\sum_{a=1}^{3}Y^{*}_{\nu,ca}y_{e,ba}Z^{E}_{l3+b}\Big(Z^{H}_{i1}Z^{+}_{j2}+Z^{H}_{i2}Z^{+}_{j1}\Big)\Big)\Big)
\end{aligned}
\tag{426}
$$



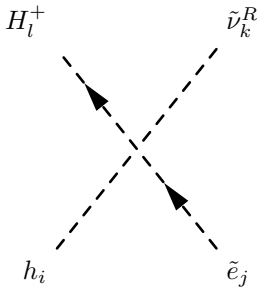
$$
\begin{aligned}
&-\frac{i}{4}\Big(g_2^2\sum_{a=1}^{3}Z_{ka}^{R,*}Z_{la}^{E}\Big(Z_{i1}^{H}Z_{j1}^{+}+Z_{i2}^{H}Z_{j2}^{+}\Big)\\
&-2\Big(\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{kb}^{R,*}\sum_{a=1}^{3}y_{e,ac}^{*}y_{e,ab}Z_{lc}^{E}Z_{i1}^{H}Z_{j1}^{+}+\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{kb}^{R,*}\sum_{a=1}^{2}Y_{\nu,ac}^{*}Y_{\nu,ab}Z_{lc}^{E}Z_{i2}^{H}Z_{j2}^{+}\\
&+\sum_{c=1}^{2}Z_{k3+c}^{R,*}\sum_{b=1}^{3}\sum_{a=1}^{3}Y_{\nu,ca}^{*}y_{e,ba}Z_{l3+b}^{E}\Big(Z_{i1}^{H}Z_{j2}^{+}+Z_{i2}^{H}Z_{j1}^{+}\Big)\Big)\Big)
\end{aligned}
\tag{427}
$$



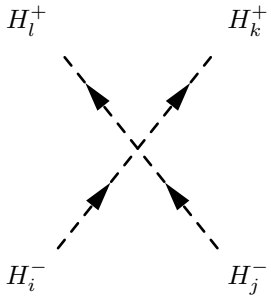
$$
\begin{aligned}
&-\frac{i}{2}\frac{1}{\sqrt{2}}\delta_{\beta\delta}\Big(g_2^2\sum_{a=1}^{3}Z_{ja}^{D,*}Z_{la}^{U}\Big(Z_{i1}^{H}Z_{k1}^{+}+Z_{i2}^{H}Z_{k2}^{+}\Big)\\
&-2\Big(\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{jb}^{D,*}\sum_{a=1}^{3}y_{d,ac}^{*}y_{d,ab}Z_{lc}^{U}Z_{i1}^{H}Z_{k1}^{+}+\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{jb}^{D,*}\sum_{a=1}^{3}y_{u,ac}^{*}y_{u,ab}Z_{lc}^{U}Z_{i2}^{H}Z_{k2}^{+}\\
&+\sum_{c=1}^{3}Z_{j3+c}^{D,*}\sum_{b=1}^{3}\sum_{a=1}^{3}y_{d,ca}^{*}y_{u,ba}Z_{l3+b}^{U}\Big(Z_{i1}^{H}Z_{k2}^{+}+Z_{i2}^{H}Z_{k1}^{+}\Big)\Big)\Big)
\end{aligned}
\tag{428}
$$



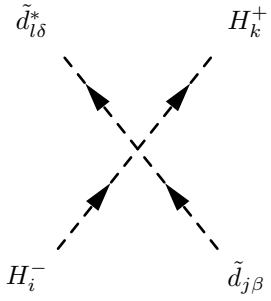
$$\frac{1}{4}\Big(- g_2^2 \sum_{a=1}^{3} Z_{ja}^{E,*} Z_{ka}^{I,*} \Big(Z_{i1}^H Z_{l1}^+ + Z_{i2}^H Z_{l2}^+ \Big) + 2\Big(\sum_{c=1}^{3} Z_{kc}^{I,*} \sum_{b=1}^{3} Z_{jb}^{E,*} \sum_{a=1}^{3} y_{e,ac}^* y_{e,ab} Z_{i1}^H Z_{l1}^+ + \sum_{c=1}^{3} Z_{kc}^{I,*} \sum_{b=1}^{3} Z_{jb}^{E,*} \sum_{a=1}^{2} Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H Z_{l2}^+ + \sum_{c=1}^{3} Z_{j3+c}^{E,*} \sum_{b=1}^{2} Z_{k3+b}^{I,*} \sum_{a=1}^{3} y_{e,ca}^* Y_{\nu,ba} \Big(Z_{i1}^H Z_{l2}^+ + Z_{i2}^H Z_{l1}^+ \Big) \Big) \Big) \tag{429}$$



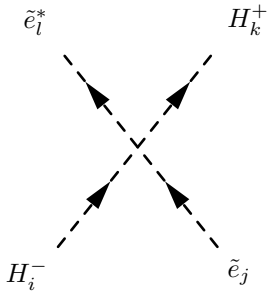
$$-\frac{i}{4}\Big(g_2^2 \sum_{a=1}^{3} Z_{ja}^{E,*} Z_{ka}^{R,*} \Big(Z_{i1}^H Z_{l1}^+ + Z_{i2}^H Z_{l2}^+ \Big) - 2\Big(\sum_{c=1}^{3} Z_{kc}^{R,*} \sum_{b=1}^{3} Z_{jb}^{E,*} \sum_{a=1}^{3} y_{e,ac}^* y_{e,ab} Z_{i1}^H Z_{l1}^+ + \sum_{c=1}^{3} Z_{kc}^{R,*} \sum_{b=1}^{3} Z_{jb}^{E,*} \sum_{a=1}^{2} Y_{\nu,ac}^* Y_{\nu,ab} Z_{i2}^H Z_{l2}^+ + \sum_{c=1}^{3} Z_{j3+c}^{E,*} \sum_{b=1}^{2} Z_{k3+b}^{R,*} \sum_{a=1}^{3} y_{e,ca}^* Y_{\nu,ba} \Big(Z_{i1}^H Z_{l2}^+ + Z_{i2}^H Z_{l1}^+ \Big) \Big) \Big) \tag{430}$$



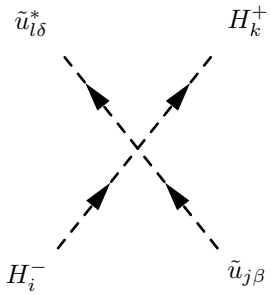
$$
\begin{aligned}
&-\frac{i}{4}\Big(g_1^2+g_2^2\Big)\Big(-Z_{i2}^+\Big(-2Z_{j2}^+Z_{k2}^+Z_{l2}^+ + Z_{j1}^+\Big(Z_{k1}^+Z_{l2}^+ + Z_{k2}^+Z_{l1}^+\Big)\Big) \\
&+ Z_{i1}^+\Big(2Z_{j1}^+Z_{k1}^+Z_{l1}^+ - Z_{j2}^+\Big(Z_{k1}^+Z_{l2}^+ + Z_{k2}^+Z_{l1}^+\Big)\Big)\Big)
\end{aligned} \tag{431}
$$



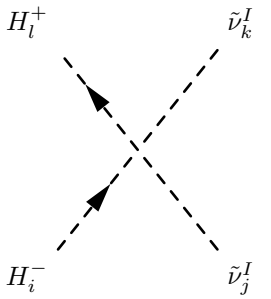
$$
\begin{aligned}
&\frac{i}{12}\delta_{\beta\delta}\Big(\Big(-3g_2^2+g_1^2\Big)\sum_{a=1}^{3}Z_{ja}^{D,*}Z_{la}^{D}\Big(Z_{i1}^+Z_{k1}^+ - Z_{i2}^+Z_{k2}^+\Big) \\
&+2\Big(g_1^2\sum_{a=1}^{3}Z_{j3+a}^{D,*}Z_{l3+a}^{D}\Big(Z_{i1}^+Z_{k1}^+ - Z_{i2}^+Z_{k2}^+\Big) \\
&-6\Big(\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{jb}^{D,*}\sum_{a=1}^{3}y_{u,ac}^*y_{u,ab}Z_{lc}^{D}Z_{i2}^+Z_{k2}^+ + \sum_{c=1}^{3}Z_{j3+c}^{D,*}\sum_{b=1}^{3}\sum_{a=1}^{3}y_{d,ca}^*y_{d,ba}Z_{l3+b}^{D}Z_{i1}^+Z_{k1}^+\Big)\Big)\Big)
\end{aligned} \tag{432}
$$



$$
\begin{aligned}
&-\frac{i}{4}\Big(\Big(g_1^2+g_2^2\Big)\sum_{a=1}^{3}Z_{ja}^{E,*}Z_{la}^{E}\Big(Z_{i1}^{+}Z_{k1}^{+}-Z_{i2}^{+}Z_{k2}^{+}\Big)\\
&+2g_1^2\sum_{a=1}^{3}Z_{j3+a}^{E,*}Z_{l3+a}^{E}\Big(-Z_{i1}^{+}Z_{k1}^{+}+Z_{i2}^{+}Z_{k2}^{+}\Big)\\
&+4\Big(\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{jb}^{E,*}\sum_{a=1}^{2}Y_{\nu,ac}^{*}Y_{\nu,ab}Z_{lc}^{E}Z_{i2}^{+}Z_{k2}^{+}+\sum_{c=1}^{3}Z_{j3+c}^{E,*}\sum_{b=1}^{3}\sum_{a=1}^{3}y_{e,ca}^{*}y_{e,ba}Z_{l3+b}^{E}Z_{i1}^{+}Z_{k1}^{+}\Big)\Big)
\end{aligned}
\tag{433}
$$

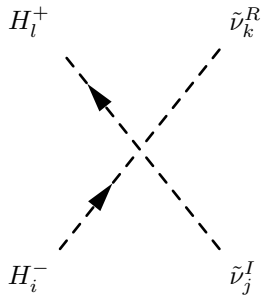


$$
\begin{aligned}
&\frac{i}{12}\delta_{\beta\delta}\Big(\Big(3g_2^2+g_1^2\Big)\sum_{a=1}^{3}Z_{ja}^{U,*}Z_{la}^{U}\Big(Z_{i1}^{+}Z_{k1}^{+}-Z_{i2}^{+}Z_{k2}^{+}\Big)\\
&-4\Big(g_1^2\sum_{a=1}^{3}Z_{j3+a}^{U,*}Z_{l3+a}^{U}\Big(Z_{i1}^{+}Z_{k1}^{+}-Z_{i2}^{+}Z_{k2}^{+}\Big)\\
&+3\Big(\sum_{c=1}^{3}\sum_{b=1}^{3}Z_{jb}^{U,*}\sum_{a=1}^{3}y_{d,ac}^{*}y_{d,ab}Z_{lc}^{U}Z_{i1}^{+}Z_{k1}^{+}+\sum_{c=1}^{3}Z_{j3+c}^{U,*}\sum_{b=1}^{3}\sum_{a=1}^{3}y_{u,ca}^{*}y_{u,ba}Z_{l3+b}^{U}Z_{i2}^{+}Z_{k2}^{+}\Big)\Big)\Big)
\end{aligned}
\tag{434}
$$

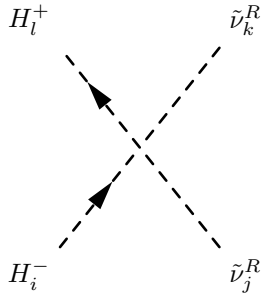


$$
-\frac{i}{4}\Big(\Big(-g_2^2+g_1^2\Big)\sum_{a=1}^{3}Z_{ja}^{I,*}Z_{ka}^{I,*}\Big(Z_{i1}^{+}Z_{l1}^{+}-Z_{i2}^{+}Z_{l2}^{+}\Big)
$$

$$+2\Big(\sum_{c=1}^{3} Z_{kc}^{I,*}\sum_{b=1}^{3} Z_{jb}^{I,*}\sum_{a=1}^{3} y_{e,ac}^{*}y_{e,ab}Z_{i1}^{+}Z_{l1}^{+}+\sum_{c=1}^{3} Z_{jc}^{I,*}\sum_{b=1}^{3} Z_{kb}^{I,*}\sum_{a=1}^{3} y_{e,ac}^{*}y_{e,ab}Z_{i1}^{+}Z_{l1}^{+}$$
$$+\Big(\sum_{c=1}^{2} Z_{k3+c}^{I,*}\sum_{b=1}^{2} Z_{j3+b}^{I,*}\sum_{a=1}^{3} Y_{\nu,ca}^{*}Y_{\nu,ba}+\sum_{c=1}^{2} Z_{j3+c}^{I,*}\sum_{b=1}^{2} Z_{k3+b}^{I,*}\sum_{a=1}^{3} Y_{\nu,ca}^{*}Y_{\nu,ba}\Big)Z_{i2}^{+}Z_{l2}^{+}\Big)\Big) \tag{435}$$

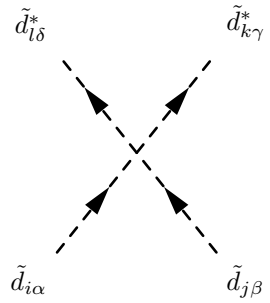


$$\frac{1}{2}\Big(\sum_{c=1}^{3} Z_{kc}^{R,*}\sum_{b=1}^{3} Z_{jb}^{I,*}\sum_{a=1}^{3} y_{e,ac}^{*}y_{e,ab}Z_{i1}^{+}Z_{l1}^{+}$$
$$-\sum_{c=1}^{3} Z_{jc}^{I,*}\sum_{b=1}^{3} Z_{kb}^{R,*}\sum_{a=1}^{3} y_{e,ac}^{*}y_{e,ab}Z_{i1}^{+}Z_{l1}^{+}$$
$$+\Big(-\sum_{c=1}^{2} Z_{k3+c}^{R,*}\sum_{b=1}^{2} Z_{j3+b}^{I,*}\sum_{a=1}^{3} Y_{\nu,ca}^{*}Y_{\nu,ba}+\sum_{c=1}^{2} Z_{j3+c}^{I,*}\sum_{b=1}^{2} Z_{k3+b}^{R,*}\sum_{a=1}^{3} Y_{\nu,ca}^{*}Y_{\nu,ba}\Big)Z_{i2}^{+}Z_{l2}^{+}\Big) \tag{436}$$



$$-\frac{i}{4}\Big(\Big(-g_2^2+g_1^2\Big)\sum_{a=1}^{3} Z_{ja}^{R,*}Z_{ka}^{R,*}\Big(Z_{i1}^{+}Z_{l1}^{+}-Z_{i2}^{+}Z_{l2}^{+}\Big)$$
$$+2\Big(\sum_{c=1}^{3} Z_{kc}^{R,*}\sum_{b=1}^{3} Z_{jb}^{R,*}\sum_{a=1}^{3} y_{e,ac}^{*}y_{e,ab}Z_{i1}^{+}Z_{l1}^{+}+\sum_{c=1}^{3} Z_{jc}^{R,*}\sum_{b=1}^{3} Z_{kb}^{R,*}\sum_{a=1}^{3} y_{e,ac}^{*}y_{e,ab}Z_{i1}^{+}Z_{l1}^{+}$$

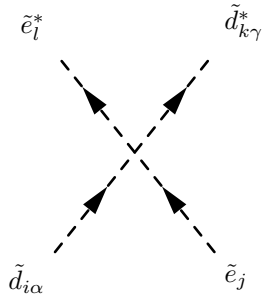
$$+\Big(\sum_{c=1}^{2} Z^{R,*}_{k3+c}\sum_{b=1}^{2} Z^{R,*}_{j3+b}\sum_{a=1}^{3} Y^{*}_{\nu,ca}Y_{\nu,ba}+\sum_{c=1}^{2} Z^{R,*}_{j3+c}\sum_{b=1}^{2} Z^{R,*}_{k3+b}\sum_{a=1}^{3} Y^{*}_{\nu,ca}Y_{\nu,ba}\Big)Z^{+}_{i2}Z^{+}_{l2}\Big)\Big) \tag{437}$$



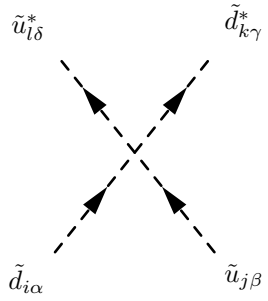
$$
\begin{aligned}
&-\frac{i}{72}\Big(\delta_{\alpha\delta}\delta_{\beta\gamma}\Big(g_1^2\sum_{a=1}^{3} Z^{D,*}_{ia}Z^{D}_{la}\sum_{b=1}^{3} Z^{D,*}_{jb}Z^{D}_{kb}+9g_2^2\sum_{a=1}^{3} Z^{D,*}_{ia}Z^{D}_{la}\sum_{b=1}^{3} Z^{D,*}_{jb}Z^{D}_{kb}\\
&-6g_3^2\sum_{a=1}^{3} Z^{D,*}_{ia}Z^{D}_{la}\sum_{b=1}^{3}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

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

$$
\begin{aligned}
&- 6g_3^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{j3+b}^{D,*} Z_{l3+b}^{D} \\
&+ 72 \sum_{b=1}^{3} Z_{jb}^{D,*} \sum_{a=1}^{3} y_{d,ab} Z_{l3+a}^{D} \sum_{d=1}^{3} \sum_{c=1}^{3} y_{d,cd}^{*} Z_{i3+c}^{D,*} Z_{kd}^{D} \\
&+ 72 \sum_{b=1}^{3} Z_{ib}^{D,*} \sum_{a=1}^{3} y_{d,ab} Z_{k3+a}^{D} \sum_{d=1}^{3} \sum_{c=1}^{3} y_{d,cd}^{*} Z_{j3+c}^{D,*} Z_{ld}^{D} \Big) \Big)
\end{aligned} \tag{438}
$$

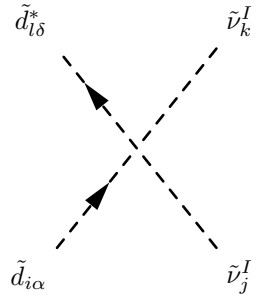


$$
\begin{aligned}
&\frac{i}{24} \delta_{\alpha\gamma} \Big(- 2g_1^2 \sum_{a=1}^{3} Z_{j3+a}^{E,*} Z_{l3+a}^{E} \Big(2 \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{k3+b}^{D} + \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{kb}^{D} \Big) \\
&+ \sum_{a=1}^{3} Z_{ja}^{E,*} Z_{la}^{E} \Big(2g_1^2 \sum_{b=1}^{3} Z_{i3+b}^{D,*} Z_{k3+b}^{D} + \Big(- 3g_2^2 + g_1^2 \Big) \sum_{b=1}^{3} Z_{ib}^{D,*} Z_{kb}^{D} \Big) \\
&+ g_1^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{jb}^{E,*} Z_{lb}^{E} - 3g_2^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{jb}^{E,*} Z_{lb}^{E} \\
&+ 2g_1^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{jb}^{E,*} Z_{lb}^{E} - 2g_1^2 \sum_{a=1}^{3} Z_{ia}^{D,*} Z_{ka}^{D} \sum_{b=1}^{3} Z_{j3+b}^{E,*} Z_{l3+b}^{E} \\
&- 4g_1^2 \sum_{a=1}^{3} Z_{i3+a}^{D,*} Z_{k3+a}^{D} \sum_{b=1}^{3} Z_{j3+b}^{E,*} Z_{l3+b}^{E} \\
&- 24 \sum_{b=1}^{3} Z_{jb}^{E,*} \sum_{a=1}^{3} y_{e,ab} Z_{l3+a}^{E} \sum_{d=1}^{3} \sum_{c=1}^{3} y_{d,cd}^{*} Z_{i3+c}^{D,*} Z_{kd}^{D} \\
&- 24 \sum_{b=1}^{3} Z_{ib}^{D,*} \sum_{a=1}^{3} y_{d,ab} Z_{k3+a}^{D} \sum_{d=1}^{3} \sum_{c=1}^{3} y_{e,cd}^{*} Z_{j3+c}^{E,*} Z_{ld}^{E} \Big)
\end{aligned} \tag{439}
$$

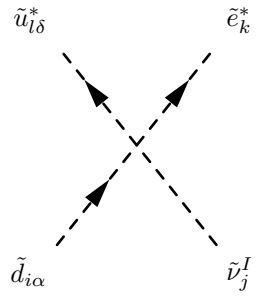


$$
\begin{aligned}
&- \frac{i}{72}\Big(\delta_{\alpha\gamma}\delta_{\beta\delta}\Big(\sum_{a=1}^{3} Z^{U,*}_{ja} Z^{U}_{la}\Big(2\Big(3g_3^2+g_1^2\Big)\sum_{b=1}^{3} Z^{D,*}_{i3+b} Z^{D}_{k3+b} + \Big(-6g_3^2-9g_2^2+g_1^2\Big)\sum_{b=1}^{3} Z^{D,*}_{ib} Z^{D}_{kb}\Big)\\
&- 2\sum_{a=1}^{3} Z^{U,*}_{j3+a} Z^{U}_{l3+a}\Big(\Big(2g_1^2-3g_3^2\Big)\sum_{b=1}^{3} Z^{D,*}_{ib} Z^{D}_{kb} + \Big(3g_3^2+4g_1^2\Big)\sum_{b=1}^{3} Z^{D,*}_{i3+b} Z^{D}_{k3+b}\Big)\\
&+ g_1^2\sum_{a=1}^{3} Z^{D,*}_{ia} Z^{D}_{ka}\sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb} - 9g_2^2\sum_{a=1}^{3} Z^{D,*}_{ia} Z^{D}_{ka}\sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb}\\
&- 6g_3^2\sum_{a=1}^{3} Z^{D,*}_{ia} Z^{D}_{ka}\sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb} + 2g_1^2\sum_{a=1}^{3} Z^{D,*}_{i3+a} Z^{D}_{k3+a}\sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb}\\
&+ 6g_3^2\sum_{a=1}^{3} Z^{D,*}_{i3+a} Z^{D}_{k3+a}\sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb} - 4g_1^2\sum_{a=1}^{3} Z^{D,*}_{ia} Z^{D}_{ka}\sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{l3+b}\\
&+ 6g_3^2\sum_{a=1}^{3} Z^{D,*}_{ia} Z^{D}_{ka}\sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{l3+b} - 8g_1^2\sum_{a=1}^{3} Z^{D,*}_{i3+a} Z^{D}_{k3+a}\sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{l3+b}\\
&- 6g_3^2\sum_{a=1}^{3} Z^{D,*}_{i3+a} Z^{D}_{k3+a}\sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{l3+b}\Big)\\
&+ 18\delta_{\alpha\delta}\delta_{\beta\gamma}\Big(g_2^2\sum_{a=1}^{3} Z^{D,*}_{ia} Z^{U}_{la}\sum_{b=1}^{3} Z^{U,*}_{jb} Z^{D}_{kb} + g_3^2\sum_{a=1}^{3} Z^{U,*}_{ja} Z^{U}_{la}\Big(-\sum_{b=1}^{3} Z^{D,*}_{i3+b} Z^{D}_{k3+b} + \sum_{b=1}^{3} Z^{D,*}_{ib} Z^{D}_{kb}\Big)\\
&+ g_3^2\sum_{a=1}^{3} Z^{U,*}_{j3+a} Z^{U}_{l3+a}\Big(-\sum_{b=1}^{3} Z^{D,*}_{ib} Z^{D}_{kb} + \sum_{b=1}^{3} Z^{D,*}_{i3+b} Z^{D}_{k3+b}\Big)\\
&+ g_2^2\sum_{a=1}^{3} Z^{U,*}_{ja} Z^{D}_{ka}\sum_{b=1}^{3} Z^{D,*}_{ib} Z^{U}_{lb} + g_3^2\sum_{a=1}^{3} Z^{D,*}_{ia} Z^{D}_{ka}\sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb}\\
&- g_3^2\sum_{a=1}^{3} Z^{D,*}_{i3+a} Z^{D}_{k3+a}\sum_{b=1}^{3} Z^{U,*}_{jb} Z^{U}_{lb} - g_3^2\sum_{a=1}^{3} Z^{D,*}_{ia} Z^{D}_{ka}\sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{l3+b}\\
&+ g_3^2\sum_{a=1}^{3} Z^{D,*}_{i3+a} Z^{D}_{k3+a}\sum_{b=1}^{3} Z^{U,*}_{j3+b} Z^{U}_{l3+b} + 4\sum_{b=1}^{3} Z^{D,*}_{ib}\sum_{a=1}^{3} y_{u,ab} Z^{U}_{l3+a}\sum_{d=1}^{3}\sum_{c=1}^{3} y^*_{u,cd} Z^{U,*}_{j3+c} Z^{D}_{kd}
\end{aligned}
$$

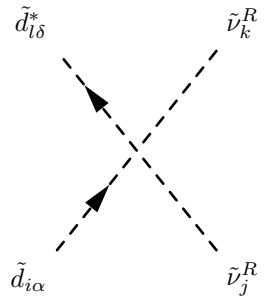
$$+ 4\sum_{b=1}^{3} Z^{U,*}_{jb} \sum_{a=1}^{3} y_{d,ab} Z^{D}_{k3+a} \sum_{d=1}^{3}\sum_{c=1}^{3} y^{*}_{d,cd} Z^{D,*}_{i3+c} Z^{U}_{ld}\Big)\Big) \tag{440}$$



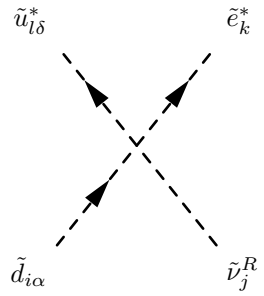
$$\frac{i}{24}\delta_{\alpha\delta}\Big(\Big(3g_2^2+g_1^2\Big)\sum_{a=1}^{3} Z^{D,*}_{ia} Z^{D}_{la} \sum_{b=1}^{3} Z^{I,*}_{jb} Z^{I,*}_{kb} + 2g_1^2 \sum_{a=1}^{3} Z^{D,*}_{i3+a} Z^{D}_{l3+a} \sum_{b=1}^{3} Z^{I,*}_{jb} Z^{I,*}_{kb}$$
$$+ \sum_{a=1}^{3} Z^{I,*}_{ja} Z^{I,*}_{ka} \Big(2g_1^2 \sum_{b=1}^{3} Z^{D,*}_{i3+b} Z^{D}_{l3+b} + \Big(3g_2^2+g_1^2\Big)\sum_{b=1}^{3} Z^{D,*}_{ib} Z^{D}_{lb}\Big)\Big) \tag{441}$$



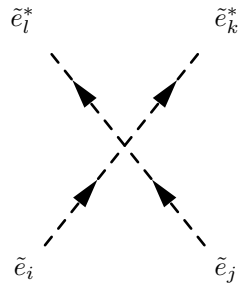
$$\frac{1}{4}\frac{1}{\sqrt{2}}\delta_{\alpha\delta}\Big(g_2^2 \sum_{a=1}^{3} Z^{D,*}_{ia} Z^{U}_{la} \sum_{b=1}^{3} Z^{I,*}_{jb} Z^{E}_{kb} + g_2^2 \sum_{a=1}^{3} Z^{I,*}_{ja} Z^{E}_{ka} \sum_{b=1}^{3} Z^{D,*}_{ib} Z^{U}_{lb}$$
$$+ 4\sum_{b=1}^{3} Z^{D,*}_{ib} \sum_{a=1}^{3} y_{u,ab} Z^{U}_{l3+a} \sum_{d=1}^{3}\sum_{c=1}^{2} Y^{*}_{\nu,cd} Z^{I,*}_{j3+c} Z^{E}_{kd}$$
$$+ 4\sum_{b=1}^{3} Z^{I,*}_{jb} \sum_{a=1}^{3} y_{e,ab} Z^{E}_{k3+a} \sum_{d=1}^{3}\sum_{c=1}^{3} y^{*}_{d,cd} Z^{D,*}_{i3+c} Z^{U}_{ld}\Big) \tag{442}$$



$$\frac{i}{24}\delta_{\alpha\delta}\Big(\Big(3g_2^2+g_1^2\Big)\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{D}_{la}\sum_{b=1}^{3}Z^{R,*}_{jb}Z^{R,*}_{kb}+2g_1^2\sum_{a=1}^{3}Z^{D,*}_{i3+a}Z^{D}_{l3+a}\sum_{b=1}^{3}Z^{R,*}_{jb}Z^{R,*}_{kb}$$
$$+\sum_{a=1}^{3}Z^{R,*}_{ja}Z^{R,*}_{ka}\Big(2g_1^2\sum_{b=1}^{3}Z^{D,*}_{i3+b}Z^{D}_{l3+b}+\Big(3g_2^2+g_1^2\Big)\sum_{b=1}^{3}Z^{D,*}_{ib}Z^{D}_{lb}\Big)\Big) \tag{443}$$

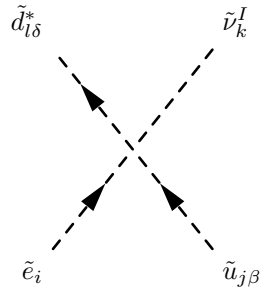


$$-\frac{i}{4}\frac{1}{\sqrt{2}}\delta_{\alpha\delta}\Big(g_2^2\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{U}_{la}\sum_{b=1}^{3}Z^{R,*}_{jb}Z^{E}_{kb}+g_2^2\sum_{a=1}^{3}Z^{R,*}_{ja}Z^{E}_{ka}\sum_{b=1}^{3}Z^{D,*}_{ib}Z^{U}_{lb}$$
$$+4\sum_{b=1}^{3}Z^{D,*}_{ib}\sum_{a=1}^{3}y_{u,ab}Z^{U}_{l3+a}\sum_{d=1}^{3}\sum_{c=1}^{2}Y^{*}_{\nu,cd}Z^{R,*}_{j3+c}Z^{E}_{kd}$$
$$+4\sum_{b=1}^{3}Z^{R,*}_{jb}\sum_{a=1}^{3}y_{e,ab}Z^{E}_{k3+a}\sum_{d=1}^{3}\sum_{c=1}^{3}y^{*}_{d,cd}Z^{D,*}_{i3+c}Z^{U}_{ld}\Big) \tag{444}$$

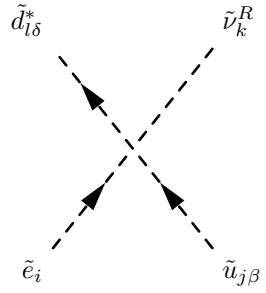


$$
\begin{aligned}
&-\frac{i}{8}\Big(g_1^2\sum_{a=1}^{3}Z_{ia}^{E,*}Z_{la}^{E}\sum_{b=1}^{3}Z_{jb}^{E,*}Z_{kb}^{E}+g_2^2\sum_{a=1}^{3}Z_{ia}^{E,*}Z_{la}^{E}\sum_{b=1}^{3}Z_{jb}^{E,*}Z_{kb}^{E}\\
&-2g_1^2\sum_{a=1}^{3}Z_{i3+a}^{E,*}Z_{l3+a}^{E}\sum_{b=1}^{3}Z_{jb}^{E,*}Z_{kb}^{E}\\
&-2g_1^2\sum_{a=1}^{3}Z_{j3+a}^{E,*}Z_{l3+a}^{E}\Big(-2\sum_{b=1}^{3}Z_{i3+b}^{E,*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

$$+ 8 \sum_{b=1}^{3} Z_{jb}^{E,*} \sum_{a=1}^{3} y_{e,ab} Z_{k3+a}^{E} \sum_{d=1}^{3} \sum_{c=1}^{3} y_{e,cd}^{*} Z_{i3+c}^{E,*} Z_{ld}^{E}$$
$$+ 8 \sum_{b=1}^{3} Z_{ib}^{E,*} \sum_{a=1}^{3} y_{e,ab} Z_{k3+a}^{E} \sum_{d=1}^{3} \sum_{c=1}^{3} y_{e,cd}^{*} Z_{j3+c}^{E,*} Z_{ld}^{E} \Big) \tag{445}$$

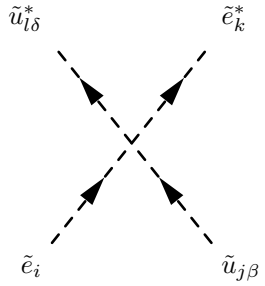


$$- \frac{1}{4} \frac{1}{\sqrt{2}} \delta_{\beta\delta} \Big(g_2^2 \sum_{a=1}^{3} Z_{ja}^{U,*} Z_{la}^{D} \sum_{b=1}^{3} Z_{ib}^{E,*} Z_{kb}^{I,*} + g_2^2 \sum_{a=1}^{3} Z_{ia}^{E,*} Z_{ka}^{I,*} \sum_{b=1}^{3} Z_{jb}^{U,*} Z_{lb}^{D}$$
$$+ 4 \sum_{b=1}^{3} Z_{jb}^{U,*} \sum_{a=1}^{3} y_{d,ab} Z_{l3+a}^{D} \sum_{d=1}^{3} Z_{kd}^{I,*} \sum_{c=1}^{3} y_{e,cd}^{*} Z_{i3+c}^{E,*}$$
$$+ 4 \sum_{b=1}^{3} Z_{ib}^{E,*} \sum_{a=1}^{2} Z_{k3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} \sum_{c=1}^{3} y_{u,cd}^{*} Z_{j3+c}^{U,*} Z_{ld}^{D} \Big) \tag{446}$$

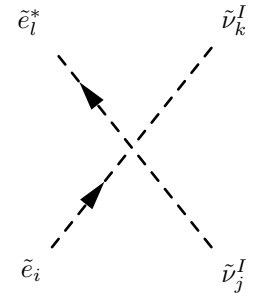


$$- \frac{i}{4} \frac{1}{\sqrt{2}} \delta_{\beta\delta} \Big(g_2^2 \sum_{a=1}^{3} Z_{ja}^{U,*} Z_{la}^{D} \sum_{b=1}^{3} Z_{ib}^{E,*} Z_{kb}^{R,*} + g_2^2 \sum_{a=1}^{3} Z_{ia}^{E,*} Z_{ka}^{R,*} \sum_{b=1}^{3} Z_{jb}^{U,*} Z_{lb}^{D}$$
$$+ 4 \sum_{b=1}^{3} Z_{jb}^{U,*} \sum_{a=1}^{3} y_{d,ab} Z_{l3+a}^{D}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

$$+ 4\sum_{b=1}^{3} Z_{ib}^{E,*} \sum_{a=1}^{2} Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3}\sum_{c=1}^{3} y_{u,cd}^{*} Z_{j3+c}^{U,*} Z_{ld}^{D}\Big) \tag{447}$$

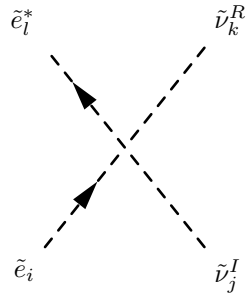


$$\begin{aligned}
&\frac{i}{24}\delta_{\beta\delta}\Big(- 4g_1^2 \sum_{a=1}^{3} Z_{j3+a}^{U,*} Z_{l3+a}^{U} \Big(- 2\sum_{b=1}^{3} Z_{i3+b}^{E,*} Z_{k3+b}^{E} + \sum_{b=1}^{3} Z_{ib}^{E,*} Z_{kb}^{E}\Big) \\
&+ \sum_{a=1}^{3} Z_{ja}^{U,*} Z_{la}^{U} \Big(- 2g_1^2 \sum_{b=1}^{3} Z_{i3+b}^{E,*} Z_{k3+b}^{E} + \Big(3g_2^2 + g_1^2\Big) \sum_{b=1}^{3} Z_{ib}^{E,*} Z_{kb}^{E}\Big) \\
&+ g_1^2 \sum_{a=1}^{3} Z_{ia}^{E,*} Z_{ka}^{E} \sum_{b=1}^{3} Z_{jb}^{U,*} Z_{lb}^{U} + 3g_2^2 \sum_{a=1}^{3} Z_{ia}^{E,*} Z_{ka}^{E} \sum_{b=1}^{3} Z_{jb}^{U,*} Z_{lb}^{U} \\
&- 2g_1^2 \sum_{a=1}^{3} Z_{i3+a}^{E,*} Z_{k3+a}^{E} \sum_{b=1}^{3} Z_{jb}^{U,*} Z_{lb}^{U} - 4g_1^2 \sum_{a=1}^{3} Z_{ia}^{E,*} Z_{ka}^{E} \sum_{b=1}^{3} Z_{j3+b}^{U,*} Z_{l3+b}^{U} \\
&+ 8g_1^2 \sum_{a=1}^{3} Z_{i3+a}^{E,*} Z_{k3+a}^{E} \sum_{b=1}^{3} Z_{j3+b}^{U,*} Z_{l3+b}^{U}\Big)
\end{aligned} \tag{448}$$



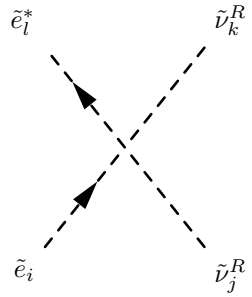
$$- \frac{i}{8}\Big(g_2^2 \sum_{a=1}^{3} Z_{ka}^{I,*} Z_{la}^{E} \sum_{b=1}^{3} Z_{ib}^{E,*} Z_{jb}^{I,*} + g_2^2 \sum_{a=1}^{3} Z_{ja}^{I,*} Z_{la}^{E} \sum_{b=1}^{3} Z_{ib}^{E,*} Z_{kb}^{I,*}$$

$$
\begin{aligned}
&+ g_1^2 \sum_{a=1}^{3} Z_{ia}^{E,*} Z_{la}^{E} \sum_{b=1}^{3} Z_{jb}^{I,*} Z_{kb}^{I,*} - g_2^2 \sum_{a=1}^{3} Z_{ia}^{E,*} Z_{la}^{E} \sum_{b=1}^{3} Z_{jb}^{I,*} Z_{kb}^{I,*} \\
&- 2g_1^2 \sum_{a=1}^{3} Z_{i3+a}^{E,*} Z_{l3+a}^{E} \sum_{b=1}^{3} Z_{jb}^{I,*} Z_{kb}^{I,*} + g_1^2 \sum_{a=1}^{3} Z_{ja}^{I,*} Z_{ka}^{I,*} \sum_{b=1}^{3} Z_{ib}^{E,*} Z_{lb}^{E} \\
&- g_2^2 \sum_{a=1}^{3} Z_{ja}^{I,*} Z_{ka}^{I,*} \sum_{b=1}^{3} Z_{ib}^{E,*} Z_{lb}^{E} + g_2^2 \sum_{a=1}^{3} Z_{ia}^{E,*} Z_{ka}^{I,*} \sum_{b=1}^{3} Z_{jb}^{I,*} Z_{lb}^{E} \\
&+ g_2^2 \sum_{a=1}^{3} Z_{ia}^{E,*} Z_{ja}^{I,*} \sum_{b=1}^{3} Z_{kb}^{I,*} Z_{lb}^{E} - 2g_1^2 \sum_{a=1}^{3} Z_{ja}^{I,*} Z_{ka}^{I,*} \sum_{b=1}^{3} Z_{i3+b}^{E,*} Z_{l3+b}^{E} \\
&+ 4 \sum_{b=1}^{3} Z_{kb}^{I,*} \sum_{a=1}^{3} y_{e,ab} Z_{l3+a}^{E} \sum_{d=1}^{3} Z_{jd}^{I,*} \sum_{c=1}^{3} y_{e,cd}^{*} Z_{i3+c}^{E,*} \\
&+ 4 \sum_{b=1}^{3} Z_{jb}^{I,*} \sum_{a=1}^{3} y_{e,ab} Z_{l3+a}^{E} \sum_{d=1}^{3} Z_{kd}^{I,*} \sum_{c=1}^{3} y_{e,cd}^{*} Z_{i3+c}^{E,*} \\
&+ 4 \sum_{b=1}^{3} Z_{ib}^{E,*} \sum_{a=1}^{2} Z_{k3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{I,*} Z_{ld}^{E} \\
&+ 4 \sum_{b=1}^{3} Z_{ib}^{E,*} \sum_{a=1}^{2} Z_{j3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{I,*} Z_{ld}^{E} \Big)
\end{aligned}
\tag{449}
$$

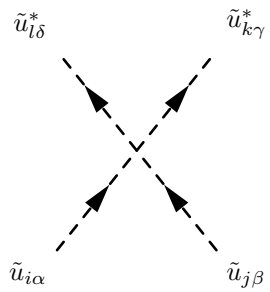


$$
\begin{aligned}
&\frac{1}{8}\Big(- g_2^2 \sum_{a=1}^{3} Z_{ka}^{R,*} Z_{la}^{E} \sum_{b=1}^{3} Z_{ib}^{E,*} Z_{jb}^{I,*} + g_2^2 \sum_{a=1}^{3} Z_{ja}^{I,*} Z_{la}^{E} \sum_{b=1}^{3} Z_{ib}^{E,*} Z_{kb}^{R,*} \\
&+ g_2^2 \sum_{a=1}^{3} Z_{ia}^{E,*} Z_{ka}^{R,*} \sum_{b=1}^{3} Z_{jb}^{I,*} Z_{lb}^{E}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

$$+ 4 \sum_{b=1}^{3} Z_{ib}^{E,*} \sum_{a=1}^{2} Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{I,*} Z_{ld}^{E}$$
$$- 4 \sum_{b=1}^{3} Z_{ib}^{E,*} \sum_{a=1}^{2} Z_{j3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{R,*} Z_{ld}^{E} \Big) \tag{450}$$



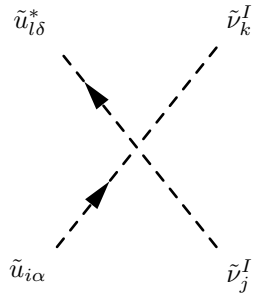
$$- \frac{i}{8} \Big(g_2^2 \sum_{a=1}^{3} Z_{ka}^{R,*} Z_{la}^{E} \sum_{b=1}^{3} Z_{ib}^{E,*} Z_{jb}^{R,*} + g_2^2 \sum_{a=1}^{3} Z_{ja}^{R,*} Z_{la}^{E} \sum_{b=1}^{3} Z_{ib}^{E,*} Z_{kb}^{R,*}$$
$$+ g_1^2 \sum_{a=1}^{3} Z_{ia}^{E,*} Z_{la}^{E} \sum_{b=1}^{3} Z_{jb}^{R,*} Z_{kb}^{R,*} - g_2^2 \sum_{a=1}^{3} Z_{ia}^{E,*} Z_{la}^{E} \sum_{b=1}^{3} Z_{jb}^{R,*} Z_{kb}^{R,*}$$
$$- 2 g_1^2 \sum_{a=1}^{3} Z_{i3+a}^{E,*} Z_{l3+a}^{E} \sum_{b=1}^{3} Z_{jb}^{R,*} Z_{kb}^{R,*} + g_1^2 \sum_{a=1}^{3} Z_{ja}^{R,*} Z_{ka}^{R,*} \sum_{b=1}^{3} Z_{ib}^{E,*} Z_{lb}^{E}$$
$$- g_2^2 \sum_{a=1}^{3} Z_{ja}^{R,*} Z_{ka}^{R,*} \sum_{b=1}^{3} Z_{ib}^{E,*} Z_{lb}^{E} + g_2^2 \sum_{a=1}^{3} Z_{ia}^{E,*} Z_{ka}^{R,*} \sum_{b=1}^{3} Z_{jb}^{R,*} Z_{lb}^{E}$$
$$+ g_2^2 \sum_{a=1}^{3} Z_{ia}^{E,*} Z_{ja}^{R,*} \sum_{b=1}^{3} Z_{kb}^{R,*} Z_{lb}^{E} - 2 g_1^2 \sum_{a=1}^{3} Z_{ja}^{R,*} Z_{ka}^{R,*} \sum_{b=1}^{3} Z_{i3+b}^{E,*} Z_{l3+b}^{E}$$
$$+ 4 \sum_{b=1}^{3} Z_{kb}^{R,*} \sum_{a=1}^{3} y_{e,ab} Z_{l3+a}^{E} \sum_{d=1}^{3} Z_{jd}^{R,*} \sum_{c=1}^{3} y_{e,cd}^{*} Z_{i3+c}^{E,*}$$
$$+ 4 \sum_{b=1}^{3} Z_{jb}^{R,*} \sum_{a=1}^{3} y_{e,ab} Z_{l3+a}^{E} \sum_{d=1}^{3} Z_{kd}^{R,*} \sum_{c=1}^{3} y_{e,cd}^{*} Z_{i3+c}^{E,*}$$
$$+ 4 \sum_{b=1}^{3} Z_{ib}^{E,*} \sum_{a=1}^{2} Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{R,*} Z_{ld}^{E}$$
$$+ 4 \sum_{b=1}^{3} Z_{ib}^{E,*} \sum_{a=1}^{2} Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{R,*} Z_{ld}^{E} \Big) \tag{451}$$



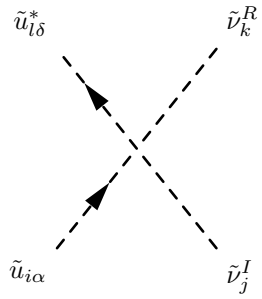
$$
\begin{aligned}
&-\frac{i}{72}\Big(\delta_{\alpha\delta}\delta_{\beta\gamma}\Big(g_1^2\sum_{a=1}^{3}Z_{ia}^{U,*}Z_{la}^{U}\sum_{b=1}^{3}Z_{jb}^{U,*}Z_{kb}^{U}+9g_2^2\sum_{a=1}^{3}Z_{ia}^{U,*}Z_{la}^{U}\sum_{b=1}^{3}Z_{jb}^{U,*}Z_{kb}^{U}\\
&-6g_3^2\sum_{a=1}^{3}Z_{ia}^{U,*}Z_{la}^{U}\sum_{b=1}^{3}Z_{jb}^{U,*}Z_{kb}^{U}-4g_1^2\sum_{a=1}^{3}Z_{i3+a}^{U,*}Z_{l3+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

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

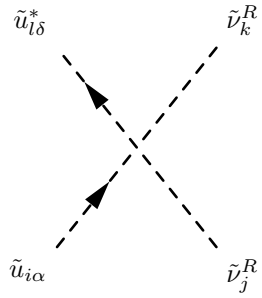
$$+ 72 \sum_{b=1}^{3} Z_{jb}^{U,*} \sum_{a=1}^{3} y_{u,ab} Z_{l3+a}^{U} \sum_{d=1}^{3} \sum_{c=1}^{3} y_{u,cd}^{*} Z_{i3+c}^{U,*} Z_{kd}^{U}$$
$$+ 72 \sum_{b=1}^{3} Z_{ib}^{U,*} \sum_{a=1}^{3} y_{u,ab} Z_{k3+a}^{U} \sum_{d=1}^{3} \sum_{c=1}^{3} y_{u,cd}^{*} Z_{j3+c}^{U,*} Z_{ld}^{U} \Big) \Big) \tag{452}$$



$$\frac{i}{24} \delta_{\alpha\delta} \Big(\Big(-3g_2^2 + g_1^2 \Big) \sum_{a=1}^{3} Z_{ia}^{U,*} Z_{la}^{U} \sum_{b=1}^{3} Z_{jb}^{I,*} Z_{kb}^{I,*} - 4g_1^2 \sum_{a=1}^{3} Z_{i3+a}^{U,*} Z_{l3+a}^{U} \sum_{b=1}^{3} Z_{jb}^{I,*} Z_{kb}^{I,*}$$
$$+ g_1^2 \sum_{a=1}^{3} Z_{ja}^{I,*} Z_{ka}^{I,*} \sum_{b=1}^{3} Z_{ib}^{U,*} Z_{lb}^{U} - 3g_2^2 \sum_{a=1}^{3} Z_{ja}^{I,*} Z_{ka}^{I,*} \sum_{b=1}^{3} Z_{ib}^{U,*} Z_{lb}^{U}$$
$$- 4g_1^2 \sum_{a=1}^{3} Z_{ja}^{I,*} Z_{ka}^{I,*} \sum_{b=1}^{3} Z_{i3+b}^{U,*} Z_{l3+b}^{U}$$
$$- 12 \sum_{b=1}^{3} Z_{ib}^{U,*} \sum_{a=1}^{3} y_{u,ab} Z_{l3+a}^{U} \sum_{d=1}^{3} Z_{kd}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{I,*}$$
$$- 12 \sum_{b=1}^{3} Z_{ib}^{U,*} \sum_{a=1}^{3} y_{u,ab} Z_{l3+a}^{U} \sum_{d=1}^{3} Z_{jd}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{I,*}$$
$$- 12 \sum_{b=1}^{3} Z_{kb}^{I,*} \sum_{a=1}^{2} Z_{j3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} \sum_{c=1}^{3} y_{u,cd}^{*} Z_{i3+c}^{U,*} Z_{ld}^{U}$$
$$- 12 \sum_{b=1}^{3} Z_{jb}^{I,*} \sum_{a=1}^{2} Z_{k3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} \sum_{c=1}^{3} y_{u,cd}^{*} Z_{i3+c}^{U,*} Z_{ld}^{U} \Big) \tag{453}$$

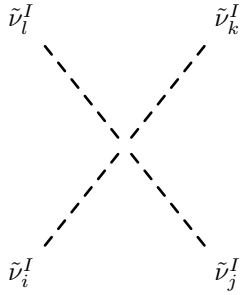


$$\frac{1}{2}\delta_{\alpha\delta}\Big(\sum_{b=1}^{3} Z^{U,*}_{ib}\sum_{a=1}^{3} y_{u,ab}Z^{U}_{l3+a}\Big(-\sum_{d=1}^{3} Z^{I,*}_{jd}\sum_{c=1}^{2} Y^{*}_{\nu,cd}Z^{R,*}_{k3+c}+\sum_{d=1}^{3} Z^{R,*}_{kd}\sum_{c=1}^{2} Y^{*}_{\nu,cd}Z^{I,*}_{j3+c}\Big)$$
$$+\Big(-\sum_{b=1}^{3} Z^{R,*}_{kb}\sum_{a=1}^{2} Z^{I,*}_{j3+a}Y_{\nu,ab}+\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{2} Z^{R,*}_{k3+a}Y_{\nu,ab}\Big)\sum_{d=1}^{3}\sum_{c=1}^{3} y^{*}_{u,cd}Z^{U,*}_{i3+c}Z^{U}_{ld}\Big) \tag{454}$$



$$\frac{i}{24}\delta_{\alpha\delta}\Big(\Big(-3g_2^2+g_1^2\Big)\sum_{a=1}^{3} Z^{U,*}_{ia}Z^{U}_{la}\sum_{b=1}^{3} Z^{R,*}_{jb}Z^{R,*}_{kb}-4g_1^2\sum_{a=1}^{3} Z^{U,*}_{i3+a}Z^{U}_{l3+a}\sum_{b=1}^{3} Z^{R,*}_{jb}Z^{R,*}_{kb}$$
$$+g_1^2\sum_{a=1}^{3} Z^{R,*}_{ja}Z^{R,*}_{ka}\sum_{b=1}^{3} Z^{U,*}_{ib}Z^{U}_{lb}-3g_2^2\sum_{a=1}^{3} Z^{R,*}_{ja}Z^{R,*}_{ka}\sum_{b=1}^{3} Z^{U,*}_{ib}Z^{U}_{lb}$$
$$-4g_1^2\sum_{a=1}^{3} Z^{R,*}_{ja}Z^{R,*}_{ka}\sum_{b=1}^{3} Z^{U,*}_{i3+b}Z^{U}_{l3+b}$$
$$-12\sum_{b=1}^{3} Z^{U,*}_{ib}\sum_{a=1}^{3} y_{u,ab}Z^{U}_{l3+a}\sum_{d=1}^{3} Z^{R,*}_{kd}\sum_{c=1}^{2} Y^{*}_{\nu,cd}Z^{R,*}_{j3+c}$$
$$-12\sum_{b=1}^{3} Z^{U,*}_{ib}\sum_{a=1}^{3} y_{u,ab}Z^{U}_{l3+a}\sum_{d=1}^{3} Z^{R,*}_{jd}\sum_{c=1}^{2} Y^{*}_{\nu,cd}Z^{R,*}_{k3+c}$$
$$-12\sum_{b=1}^{3} Z^{R,*}_{kb}\sum_{a=1}^{2} Z^{R,*}_{j3+a}Y_{\nu,ab}\sum_{d=1}^{3}\sum_{c=1}^{3} y^{*}_{u,cd}Z^{U,*}_{i3+c}Z^{U}_{ld}$$

$$- 12\sum_{b=1}^{3} Z_{jb}^{R,*} \sum_{a=1}^{2} Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3}\sum_{c=1}^{3} y_{u,cd}^{*} Z_{i3+c}^{U,*} Z_{ld}^{U}\Big) \tag{455}$$

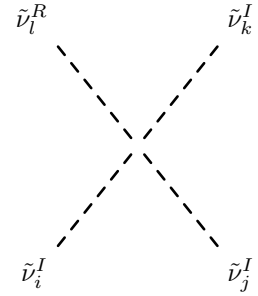


$$
\begin{aligned}
&- \frac{i}{16}\Big(2\Big(g_1^2+g_2^2\Big)\sum_{a=1}^{3} Z_{ka}^{I,*} Z_{la}^{I,*} \sum_{b=1}^{3} Z_{ib}^{I,*} Z_{jb}^{I,*} + 2\Big(g_1^2+g_2^2\Big)\sum_{a=1}^{3} Z_{ja}^{I,*} Z_{la}^{I,*} \sum_{b=1}^{3} Z_{ib}^{I,*} Z_{kb}^{I,*} \\
&+ 2g_1^2\sum_{a=1}^{3} Z_{ia}^{I,*} Z_{la}^{I,*} \sum_{b=1}^{3} Z_{jb}^{I,*} Z_{kb}^{I,*} + 2g_2^2\sum_{a=1}^{3} Z_{ia}^{I,*} Z_{la}^{I,*} \sum_{b=1}^{3} Z_{jb}^{I,*} Z_{kb}^{I,*} \\
&+ 2g_1^2\sum_{a=1}^{3} Z_{ja}^{I,*} Z_{ka}^{I,*} \sum_{b=1}^{3} Z_{ib}^{I,*} Z_{lb}^{I,*} + 2g_2^2\sum_{a=1}^{3} Z_{ja}^{I,*} Z_{ka}^{I,*} \sum_{b=1}^{3} Z_{ib}^{I,*} Z_{lb}^{I,*} \\
&+ 2g_1^2\sum_{a=1}^{3} Z_{ia}^{I,*} Z_{ka}^{I,*} \sum_{b=1}^{3} Z_{jb}^{I,*} Z_{lb}^{I,*} + 2g_2^2\sum_{a=1}^{3} Z_{ia}^{I,*} Z_{ka}^{I,*} \sum_{b=1}^{3} Z_{jb}^{I,*} Z_{lb}^{I,*} \\
&+ 2g_1^2\sum_{a=1}^{3} Z_{ia}^{I,*} Z_{ja}^{I,*} \sum_{b=1}^{3} Z_{kb}^{I,*} Z_{lb}^{I,*} + 2g_2^2\sum_{a=1}^{3} Z_{ia}^{I,*} Z_{ja}^{I,*} \sum_{b=1}^{3} Z_{kb}^{I,*} Z_{lb}^{I,*} \\
&+ \sum_{b=1}^{2} Z_{l5+b}^{I,*} \sum_{a=1}^{2} Z_{k5+a}^{I,*} \lambda_{ab} \sum_{d=1}^{2} Z_{j5+d}^{I,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{i5+c}^{I,*} \\
&+ \sum_{b=1}^{2} Z_{k5+b}^{I,*} \sum_{a=1}^{2} Z_{l5+a}^{I,*} \lambda_{ab} \sum_{d=1}^{2} Z_{j5+d}^{I,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{i5+c}^{I,*} \\
&+ \sum_{b=1}^{2} Z_{l5+b}^{I,*} \sum_{a=1}^{2} Z_{j5+a}^{I,*} \lambda_{ab} \sum_{d=1}^{2} Z_{k5+d}^{I,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{i5+c}^{I,*} \\
&+ \sum_{b=1}^{2} Z_{j5+b}^{I,*} \sum_{a=1}^{2} Z_{l5+a}^{I,*} \lambda_{ab} \sum_{d=1}^{2} Z_{k5+d}^{I,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{i5+c}^{I,*} \\
&+ \sum_{b=1}^{2} Z_{k5+b}^{I,*} \sum_{a=1}^{2} Z_{j5+a}^{I,*} \lambda_{ab} \sum_{d=1}^{2} Z_{l5+d}^{I,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{i5+c}^{I,*} \\
&+ \sum_{b=1}^{2} Z_{j5+b}^{I,*} \sum_{a=1}^{2} Z_{k5+a}^{I,*} \lambda_{ab} \sum_{d=1}^{2} Z_{l5+d}^{I,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{i5+c}^{I,*}
\end{aligned}
$$

$$+\sum_{b=1}^{2} Z^{I,*}_{l5+b} \sum_{a=1}^{2} Z^{I,*}_{k5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{j5+c}$$
$$+\sum_{b=1}^{2} Z^{I,*}_{k5+b} \sum_{a=1}^{2} Z^{I,*}_{l5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{j5+c}$$
$$+\sum_{b=1}^{2} Z^{I,*}_{l5+b} \sum_{a=1}^{2} Z^{I,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{k5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{j5+c}$$
$$+\sum_{b=1}^{2} Z^{I,*}_{i5+b} \sum_{a=1}^{2} Z^{I,*}_{l5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{k5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{j5+c}$$
$$+\sum_{b=1}^{2} Z^{I,*}_{k5+b} \sum_{a=1}^{2} Z^{I,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{j5+c}$$
$$+\sum_{b=1}^{2} Z^{I,*}_{i5+b} \sum_{a=1}^{2} Z^{I,*}_{k5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{j5+c}$$
$$+\sum_{b=1}^{2} Z^{I,*}_{l5+b} \sum_{a=1}^{2} Z^{I,*}_{j5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{k5+c}$$
$$+\sum_{b=1}^{2} Z^{I,*}_{j5+b} \sum_{a=1}^{2} Z^{I,*}_{l5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{k5+c}$$
$$+\sum_{b=1}^{2} Z^{I,*}_{l5+b} \sum_{a=1}^{2} Z^{I,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{j5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{k5+c}$$
$$+\sum_{b=1}^{2} Z^{I,*}_{i5+b} \sum_{a=1}^{2} Z^{I,*}_{l5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{j5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{k5+c}$$
$$+\sum_{b=1}^{2} Z^{I,*}_{j5+b} \sum_{a=1}^{2} Z^{I,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{k5+c}$$
$$+\sum_{b=1}^{2} Z^{I,*}_{i5+b} \sum_{a=1}^{2} Z^{I,*}_{j5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{k5+c}$$
$$+\sum_{b=1}^{2} Z^{I,*}_{k5+b} \sum_{a=1}^{2} Z^{I,*}_{j5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{l5+c}$$
$$+\sum_{b=1}^{2} Z^{I,*}_{j5+b} \sum_{a=1}^{2} Z^{I,*}_{k5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{l5+c}$$
$$+\sum_{b=1}^{2} Z^{I,*}_{k5+b} \sum_{a=1}^{2} Z^{I,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{j5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{l5+c}$$

$$
\begin{aligned}
&+ \sum_{b=1}^{2} Z_{i5+b}^{I,*} \sum_{a=1}^{2} Z_{k5+a}^{I,*} \lambda_{ab} \sum_{d=1}^{2} Z_{j5+d}^{I,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{l5+c}^{I,*} \\
&+ \sum_{b=1}^{2} Z_{j5+b}^{I,*} \sum_{a=1}^{2} Z_{i5+a}^{I,*} \lambda_{ab} \sum_{d=1}^{2} Z_{k5+d}^{I,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{l5+c}^{I,*} \\
&+ \sum_{b=1}^{2} Z_{i5+b}^{I,*} \sum_{a=1}^{2} Z_{j5+a}^{I,*} \lambda_{ab} \sum_{d=1}^{2} Z_{k5+d}^{I,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{l5+c}^{I,*} \\
&+ 4 \sum_{b=1}^{3} Z_{lb}^{I,*} \sum_{a=1}^{2} Z_{k3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{jd}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{i3+c}^{I,*} \\
&+ 4 \sum_{b=1}^{3} Z_{kb}^{I,*} \sum_{a=1}^{2} Z_{l3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{jd}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{i3+c}^{I,*} \\
&+ 4 \sum_{b=1}^{3} Z_{lb}^{I,*} \sum_{a=1}^{2} Z_{j3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{kd}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{i3+c}^{I,*} \\
&+ 4 \sum_{b=1}^{3} Z_{jb}^{I,*} \sum_{a=1}^{2} Z_{l3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{kd}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{i3+c}^{I,*} \\
&+ 4 \sum_{b=1}^{3} Z_{kb}^{I,*} \sum_{a=1}^{2} Z_{j3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{ld}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{i3+c}^{I,*} \\
&+ 4 \sum_{b=1}^{3} Z_{jb}^{I,*} \sum_{a=1}^{2} Z_{k3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{ld}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{i3+c}^{I,*} \\
&+ 4 \sum_{b=1}^{3} Z_{lb}^{I,*} \sum_{a=1}^{2} Z_{k3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{id}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{I,*} \\
&+ 4 \sum_{b=1}^{3} Z_{kb}^{I,*} \sum_{a=1}^{2} Z_{l3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{id}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{I,*} \\
&+ 4 \sum_{b=1}^{3} Z_{lb}^{I,*} \sum_{a=1}^{2} Z_{i3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{kd}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{I,*} \\
&+ 4 \sum_{b=1}^{3} Z_{ib}^{I,*} \sum_{a=1}^{2} Z_{l3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{kd}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{I,*} \\
&+ 4 \sum_{b=1}^{3} Z_{kb}^{I,*} \sum_{a=1}^{2} Z_{i3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{ld}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{I,*} \\
&+ 4 \sum_{b=1}^{3} Z_{ib}^{I,*} \sum_{a=1}^{2} Z_{k3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{ld}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{I,*}
\end{aligned}
$$

$$
\begin{aligned}
&+4\sum_{b=1}^{3} Z_{lb}^{I,*}\sum_{a=1}^{2} Z_{j3+a}^{I,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{id}^{I,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{I,*}\\
&+4\sum_{b=1}^{3} Z_{jb}^{I,*}\sum_{a=1}^{2} Z_{l3+a}^{I,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{id}^{I,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{I,*}\\
&+4\sum_{b=1}^{3} Z_{lb}^{I,*}\sum_{a=1}^{2} Z_{i3+a}^{I,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{jd}^{I,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{I,*}\\
&+4\sum_{b=1}^{3} Z_{ib}^{I,*}\sum_{a=1}^{2} Z_{l3+a}^{I,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{jd}^{I,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{I,*}\\
&+4\sum_{b=1}^{3} Z_{jb}^{I,*}\sum_{a=1}^{2} Z_{i3+a}^{I,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{ld}^{I,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{I,*}\\
&+4\sum_{b=1}^{3} Z_{ib}^{I,*}\sum_{a=1}^{2} Z_{j3+a}^{I,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{ld}^{I,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{I,*}\\
&+4\sum_{b=1}^{3} Z_{kb}^{I,*}\sum_{a=1}^{2} Z_{j3+a}^{I,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{id}^{I,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{I,*}\\
&+4\sum_{b=1}^{3} Z_{jb}^{I,*}\sum_{a=1}^{2} Z_{k3+a}^{I,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{id}^{I,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{I,*}\\
&+4\sum_{b=1}^{3} Z_{kb}^{I,*}\sum_{a=1}^{2} Z_{i3+a}^{I,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{jd}^{I,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{I,*}\\
&+4\sum_{b=1}^{3} Z_{ib}^{I,*}\sum_{a=1}^{2} Z_{k3+a}^{I,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{jd}^{I,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{I,*}\\
&+4\sum_{b=1}^{3} Z_{jb}^{I,*}\sum_{a=1}^{2} Z_{i3+a}^{I,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{kd}^{I,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{I,*}\\
&+4\sum_{b=1}^{3} Z_{ib}^{I,*}\sum_{a=1}^{2} Z_{j3+a}^{I,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{kd}^{I,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{I,*}\Big)
\end{aligned}
\tag{456}
$$

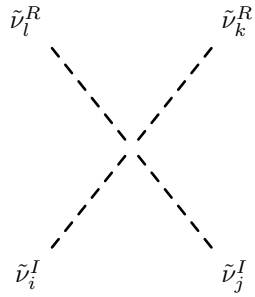


$$
\begin{aligned}
&\frac{1}{16}\Big(- \sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} Z^{I,*}_{j5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{k5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{i5+c} \\
&- \sum_{b=1}^{2} Z^{I,*}_{j5+b} \sum_{a=1}^{2} Z^{R,*}_{l5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{k5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{i5+c} \\
&+ \sum_{b=1}^{2} Z^{I,*}_{k5+b} \sum_{a=1}^{2} Z^{I,*}_{j5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{i5+c} \\
&+ \sum_{b=1}^{2} Z^{I,*}_{j5+b} \sum_{a=1}^{2} Z^{I,*}_{k5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{i5+c} \\
&- \sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} Z^{I,*}_{k5+a} \lambda_{ab} \Big(\sum_{d=1}^{2} Z^{I,*}_{j5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{i5+c} + \sum_{d=1}^{2} Z^{I,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{j5+c} \Big) \\
&- \sum_{b=1}^{2} Z^{I,*}_{k5+b} \sum_{a=1}^{2} Z^{R,*}_{l5+a} \lambda_{ab} \Big(\sum_{d=1}^{2} Z^{I,*}_{j5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{i5+c} + \sum_{d=1}^{2} Z^{I,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{j5+c} \Big) \\
&- \sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} Z^{I,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{k5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{j5+c} \\
&- \sum_{b=1}^{2} Z^{I,*}_{i5+b} \sum_{a=1}^{2} Z^{R,*}_{l5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{k5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{j5+c} \\
&+ \sum_{b=1}^{2} Z^{I,*}_{k5+b} \sum_{a=1}^{2} Z^{I,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{j5+c} \\
&+ \sum_{b=1}^{2} Z^{I,*}_{i5+b} \sum_{a=1}^{2} Z^{I,*}_{k5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{j5+c} \\
&- \sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} Z^{I,*}_{j5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{k5+c} \\
&- \sum_{b=1}^{2} Z^{I,*}_{j5+b} \sum_{a=1}^{2} Z^{R,*}_{l5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{k5+c} \\
&- \sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} Z^{I,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{j5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{k5+c} \\
&- \sum_{b=1}^{2} Z^{I,*}_{i5+b} \sum_{a=1}^{2} Z^{R,*}_{l5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{j5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{k5+c} \\
&+ \sum_{b=1}^{2} Z^{I,*}_{j5+b} \sum_{a=1}^{2} Z^{I,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{k5+c}
\end{aligned}
$$

$$+\sum_{b=1}^{2} Z^{I,*}_{i5+b}\sum_{a=1}^{2} Z^{I,*}_{j5+a}\lambda_{ab}\sum_{d=1}^{2} Z^{R,*}_{l5+d}\sum_{c=1}^{2}\lambda^{*}_{cd}Z^{I,*}_{k5+c}$$
$$+\sum_{b=1}^{2} Z^{I,*}_{k5+b}\sum_{a=1}^{2} Z^{I,*}_{j5+a}\lambda_{ab}\sum_{d=1}^{2} Z^{I,*}_{i5+d}\sum_{c=1}^{2}\lambda^{*}_{cd}Z^{R,*}_{l5+c}$$
$$+\sum_{b=1}^{2} Z^{I,*}_{j5+b}\sum_{a=1}^{2} Z^{I,*}_{k5+a}\lambda_{ab}\sum_{d=1}^{2} Z^{I,*}_{i5+d}\sum_{c=1}^{2}\lambda^{*}_{cd}Z^{R,*}_{l5+c}$$
$$+\sum_{b=1}^{2} Z^{I,*}_{k5+b}\sum_{a=1}^{2} Z^{I,*}_{i5+a}\lambda_{ab}\sum_{d=1}^{2} Z^{I,*}_{j5+d}\sum_{c=1}^{2}\lambda^{*}_{cd}Z^{R,*}_{l5+c}$$
$$+\sum_{b=1}^{2} Z^{I,*}_{i5+b}\sum_{a=1}^{2} Z^{I,*}_{k5+a}\lambda_{ab}\sum_{d=1}^{2} Z^{I,*}_{j5+d}\sum_{c=1}^{2}\lambda^{*}_{cd}Z^{R,*}_{l5+c}$$
$$+\sum_{b=1}^{2} Z^{I,*}_{j5+b}\sum_{a=1}^{2} Z^{I,*}_{i5+a}\lambda_{ab}\sum_{d=1}^{2} Z^{I,*}_{k5+d}\sum_{c=1}^{2}\lambda^{*}_{cd}Z^{R,*}_{l5+c}$$
$$+\sum_{b=1}^{2} Z^{I,*}_{i5+b}\sum_{a=1}^{2} Z^{I,*}_{j5+a}\lambda_{ab}\sum_{d=1}^{2} Z^{I,*}_{k5+d}\sum_{c=1}^{2}\lambda^{*}_{cd}Z^{R,*}_{l5+c}$$
$$-4\sum_{b=1}^{3} Z^{R,*}_{lb}\sum_{a=1}^{2} Z^{I,*}_{k3+a}Y_{\nu,ab}\sum_{d=1}^{3} Z^{I,*}_{jd}\sum_{c=1}^{2}Y^{*}_{\nu,cd}Z^{I,*}_{i3+c}$$
$$+4\sum_{b=1}^{3} Z^{I,*}_{kb}\sum_{a=1}^{2} Z^{R,*}_{l3+a}Y_{\nu,ab}\sum_{d=1}^{3} Z^{I,*}_{jd}\sum_{c=1}^{2}Y^{*}_{\nu,cd}Z^{I,*}_{i3+c}$$
$$-4\sum_{b=1}^{3} Z^{R,*}_{lb}\sum_{a=1}^{2} Z^{I,*}_{j3+a}Y_{\nu,ab}\sum_{d=1}^{3} Z^{I,*}_{kd}\sum_{c=1}^{2}Y^{*}_{\nu,cd}Z^{I,*}_{i3+c}$$
$$+4\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{2} Z^{R,*}_{l3+a}Y_{\nu,ab}\sum_{d=1}^{3} Z^{I,*}_{kd}\sum_{c=1}^{2}Y^{*}_{\nu,cd}Z^{I,*}_{i3+c}$$
$$+4\sum_{b=1}^{3} Z^{I,*}_{kb}\sum_{a=1}^{2} Z^{I,*}_{j3+a}Y_{\nu,ab}\sum_{d=1}^{3} Z^{R,*}_{ld}\sum_{c=1}^{2}Y^{*}_{\nu,cd}Z^{I,*}_{i3+c}$$
$$+4\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{2} Z^{I,*}_{k3+a}Y_{\nu,ab}\sum_{d=1}^{3} Z^{R,*}_{ld}\sum_{c=1}^{2}Y^{*}_{\nu,cd}Z^{I,*}_{i3+c}$$
$$-4\sum_{b=1}^{3} Z^{R,*}_{lb}\sum_{a=1}^{2} Z^{I,*}_{k3+a}Y_{\nu,ab}\sum_{d=1}^{3} Z^{I,*}_{id}\sum_{c=1}^{2}Y^{*}_{\nu,cd}Z^{I,*}_{j3+c}$$
$$+4\sum_{b=1}^{3} Z^{I,*}_{kb}\sum_{a=1}^{2} Z^{R,*}_{l3+a}Y_{\nu,ab}\sum_{d=1}^{3} Z^{I,*}_{id}\sum_{c=1}^{2}Y^{*}_{\nu,cd}Z^{I,*}_{j3+c}$$

$$
\begin{aligned}
&- 4 \sum_{b=1}^{3} Z_{lb}^{R,*} \sum_{a=1}^{2} Z_{i3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{kd}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{I,*} \\
&+ 4 \sum_{b=1}^{3} Z_{ib}^{I,*} \sum_{a=1}^{2} Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{kd}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{I,*} \\
&+ 4 \sum_{b=1}^{3} Z_{kb}^{I,*} \sum_{a=1}^{2} Z_{i3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{ld}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{I,*} \\
&+ 4 \sum_{b=1}^{3} Z_{ib}^{I,*} \sum_{a=1}^{2} Z_{k3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{ld}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{I,*} \\
&- 4 \sum_{b=1}^{3} Z_{lb}^{R,*} \sum_{a=1}^{2} Z_{j3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{id}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{I,*} \\
&+ 4 \sum_{b=1}^{3} Z_{jb}^{I,*} \sum_{a=1}^{2} Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{id}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{I,*} \\
&- 4 \sum_{b=1}^{3} Z_{lb}^{R,*} \sum_{a=1}^{2} Z_{i3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{jd}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{I,*} \\
&+ 4 \sum_{b=1}^{3} Z_{ib}^{I,*} \sum_{a=1}^{2} Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{jd}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{I,*} \\
&+ 4 \sum_{b=1}^{3} Z_{jb}^{I,*} \sum_{a=1}^{2} Z_{i3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{ld}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{I,*} \\
&+ 4 \sum_{b=1}^{3} Z_{ib}^{I,*} \sum_{a=1}^{2} Z_{j3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{ld}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{I,*} \\
&- 4 \sum_{b=1}^{3} Z_{kb}^{I,*} \sum_{a=1}^{2} Z_{j3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{id}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{R,*} \\
&- 4 \sum_{b=1}^{3} Z_{jb}^{I,*} \sum_{a=1}^{2} Z_{k3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{id}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{R,*} \\
&- 4 \sum_{b=1}^{3} Z_{kb}^{I,*} \sum_{a=1}^{2} Z_{i3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{jd}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{R,*} \\
&- 4 \sum_{b=1}^{3} Z_{ib}^{I,*} \sum_{a=1}^{2} Z_{k3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{jd}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{R,*} \\
&- 4 \sum_{b=1}^{3} Z_{jb}^{I,*} \sum_{a=1}^{2} Z_{i3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{kd}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{R,*}
\end{aligned}
$$

$$- 4 \sum_{b=1}^{3} Z_{ib}^{I,*} \sum_{a=1}^{2} Z_{j3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{kd}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{R,*} \Big) \tag{457}$$

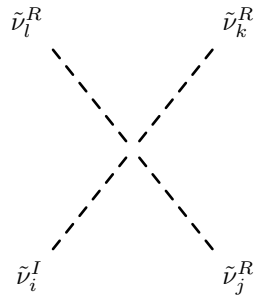


$$- \frac{i}{16} \Big(2 \Big(g_1^2 + g_2^2 \Big) \sum_{a=1}^{3} Z_{ka}^{R,*} Z_{la}^{R,*} \sum_{b=1}^{3} Z_{ib}^{I,*} Z_{jb}^{I,*} + 2 \Big(g_1^2 + g_2^2 \Big) \sum_{a=1}^{3} Z_{ia}^{I,*} Z_{ja}^{I,*} \sum_{b=1}^{3} Z_{kb}^{R,*} Z_{lb}^{R,*}$$
$$- \sum_{b=1}^{2} Z_{l5+b}^{R,*} \sum_{a=1}^{2} Z_{k5+a}^{R,*} \lambda_{ab} \sum_{d=1}^{2} Z_{j5+d}^{I,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{i5+c}^{I,*}$$
$$- \sum_{b=1}^{2} Z_{k5+b}^{R,*} \sum_{a=1}^{2} Z_{l5+a}^{R,*} \lambda_{ab} \sum_{d=1}^{2} Z_{j5+d}^{I,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{i5+c}^{I,*}$$
$$+ \sum_{b=1}^{2} Z_{l5+b}^{R,*} \sum_{a=1}^{2} Z_{j5+a}^{I,*} \lambda_{ab} \sum_{d=1}^{2} Z_{k5+d}^{R,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{i5+c}^{I,*}$$
$$+ \sum_{b=1}^{2} Z_{j5+b}^{I,*} \sum_{a=1}^{2} Z_{l5+a}^{R,*} \lambda_{ab} \sum_{d=1}^{2} Z_{k5+d}^{R,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{i5+c}^{I,*}$$
$$+ \sum_{b=1}^{2} Z_{k5+b}^{R,*} \sum_{a=1}^{2} Z_{j5+a}^{I,*} \lambda_{ab} \sum_{d=1}^{2} Z_{l5+d}^{R,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{i5+c}^{I,*}$$
$$+ \sum_{b=1}^{2} Z_{j5+b}^{I,*} \sum_{a=1}^{2} Z_{k5+a}^{R,*} \lambda_{ab} \sum_{d=1}^{2} Z_{l5+d}^{R,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{i5+c}^{I,*}$$
$$- \sum_{b=1}^{2} Z_{l5+b}^{R,*} \sum_{a=1}^{2} Z_{k5+a}^{R,*} \lambda_{ab} \sum_{d=1}^{2} Z_{i5+d}^{I,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{j5+c}^{I,*}$$
$$- \sum_{b=1}^{2} Z_{k5+b}^{R,*} \sum_{a=1}^{2} Z_{l5+a}^{R,*} \lambda_{ab} \sum_{d=1}^{2} Z_{i5+d}^{I,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{j5+c}^{I,*}$$
$$+ \sum_{b=1}^{2} Z_{l5+b}^{R,*} \sum_{a=1}^{2} Z_{i5+a}^{I,*} \lambda_{ab} \sum_{d=1}^{2} Z_{k5+d}^{R,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{j5+c}^{I,*}$$
$$+ \sum_{b=1}^{2} Z_{i5+b}^{I,*} \sum_{a=1}^{2} Z_{l5+a}^{R,*} \lambda_{ab} \sum_{d=1}^{2} Z_{k5+d}^{R,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{j5+c}^{I,*}$$

$$
\begin{aligned}
&+\sum_{b=1}^{2} Z^{R,*}_{k5+b} \sum_{a=1}^{2} Z^{I,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{j5+c} \\
&+\sum_{b=1}^{2} Z^{I,*}_{i5+b} \sum_{a=1}^{2} Z^{R,*}_{k5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{j5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} Z^{I,*}_{j5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{k5+c} \\
&+\sum_{b=1}^{2} Z^{I,*}_{j5+b} \sum_{a=1}^{2} Z^{R,*}_{l5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{k5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} Z^{I,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{j5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{k5+c} \\
&+\sum_{b=1}^{2} Z^{I,*}_{i5+b} \sum_{a=1}^{2} Z^{R,*}_{l5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{j5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{k5+c} \\
&-\sum_{b=1}^{2} Z^{I,*}_{j5+b} \sum_{a=1}^{2} Z^{I,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{k5+c} \\
&-\sum_{b=1}^{2} Z^{I,*}_{i5+b} \sum_{a=1}^{2} Z^{I,*}_{j5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{k5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{k5+b} \sum_{a=1}^{2} Z^{I,*}_{j5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{l5+c} \\
&+\sum_{b=1}^{2} Z^{I,*}_{j5+b} \sum_{a=1}^{2} Z^{R,*}_{k5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{l5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{k5+b} \sum_{a=1}^{2} Z^{I,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{j5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{l5+c} \\
&+\sum_{b=1}^{2} Z^{I,*}_{i5+b} \sum_{a=1}^{2} Z^{R,*}_{k5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{j5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{l5+c} \\
&-\sum_{b=1}^{2} Z^{I,*}_{j5+b} \sum_{a=1}^{2} Z^{I,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{k5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{l5+c} \\
&-\sum_{b=1}^{2} Z^{I,*}_{i5+b} \sum_{a=1}^{2} Z^{I,*}_{j5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{k5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{l5+c} \\
&+4 \sum_{b=1}^{3} Z^{R,*}_{lb} \sum_{a=1}^{2} Z^{R,*}_{k3+a} Y_{\nu,ab} \sum_{d=1}^{3} Z^{I,*}_{jd} \sum_{c=1}^{2} Y^{*}_{\nu,cd} Z^{I,*}_{i3+c}
\end{aligned}
$$

$$+4\sum_{b=1}^{3}Z_{kb}^{R,*}\sum_{a=1}^{2}Z_{l3+a}^{R,*}Y_{\nu,ab}\sum_{d=1}^{3}Z_{jd}^{I,*}\sum_{c=1}^{2}Y_{\nu,cd}^{*}Z_{i3+c}^{I,*}$$
$$+4\sum_{b=1}^{3}Z_{lb}^{R,*}\sum_{a=1}^{2}Z_{j3+a}^{I,*}Y_{\nu,ab}\sum_{d=1}^{3}Z_{kd}^{R,*}\sum_{c=1}^{2}Y_{\nu,cd}^{*}Z_{i3+c}^{I,*}$$
$$-4\sum_{b=1}^{3}Z_{jb}^{I,*}\sum_{a=1}^{2}Z_{l3+a}^{R,*}Y_{\nu,ab}\sum_{d=1}^{3}Z_{kd}^{R,*}\sum_{c=1}^{2}Y_{\nu,cd}^{*}Z_{i3+c}^{I,*}$$
$$+4\sum_{b=1}^{3}Z_{kb}^{R,*}\sum_{a=1}^{2}Z_{j3+a}^{I,*}Y_{\nu,ab}\sum_{d=1}^{3}Z_{ld}^{R,*}\sum_{c=1}^{2}Y_{\nu,cd}^{*}Z_{i3+c}^{I,*}$$
$$-4\sum_{b=1}^{3}Z_{jb}^{I,*}\sum_{a=1}^{2}Z_{k3+a}^{R,*}Y_{\nu,ab}\sum_{d=1}^{3}Z_{ld}^{R,*}\sum_{c=1}^{2}Y_{\nu,cd}^{*}Z_{i3+c}^{I,*}$$
$$+4\sum_{b=1}^{3}Z_{lb}^{R,*}\sum_{a=1}^{2}Z_{k3+a}^{R,*}Y_{\nu,ab}\sum_{d=1}^{3}Z_{id}^{I,*}\sum_{c=1}^{2}Y_{\nu,cd}^{*}Z_{j3+c}^{I,*}$$
$$+4\sum_{b=1}^{3}Z_{kb}^{R,*}\sum_{a=1}^{2}Z_{l3+a}^{R,*}Y_{\nu,ab}\sum_{d=1}^{3}Z_{id}^{I,*}\sum_{c=1}^{2}Y_{\nu,cd}^{*}Z_{j3+c}^{I,*}$$
$$+4\sum_{b=1}^{3}Z_{lb}^{R,*}\sum_{a=1}^{2}Z_{i3+a}^{I,*}Y_{\nu,ab}\sum_{d=1}^{3}Z_{kd}^{R,*}\sum_{c=1}^{2}Y_{\nu,cd}^{*}Z_{j3+c}^{I,*}$$
$$-4\sum_{b=1}^{3}Z_{ib}^{I,*}\sum_{a=1}^{2}Z_{l3+a}^{R,*}Y_{\nu,ab}\sum_{d=1}^{3}Z_{kd}^{R,*}\sum_{c=1}^{2}Y_{\nu,cd}^{*}Z_{j3+c}^{I,*}$$
$$+4\sum_{b=1}^{3}Z_{kb}^{R,*}\sum_{a=1}^{2}Z_{i3+a}^{I,*}Y_{\nu,ab}\sum_{d=1}^{3}Z_{ld}^{R,*}\sum_{c=1}^{2}Y_{\nu,cd}^{*}Z_{j3+c}^{I,*}$$
$$-4\sum_{b=1}^{3}Z_{ib}^{I,*}\sum_{a=1}^{2}Z_{k3+a}^{R,*}Y_{\nu,ab}\sum_{d=1}^{3}Z_{ld}^{R,*}\sum_{c=1}^{2}Y_{\nu,cd}^{*}Z_{j3+c}^{I,*}$$
$$-4\sum_{b=1}^{3}Z_{lb}^{R,*}\sum_{a=1}^{2}Z_{j3+a}^{I,*}Y_{\nu,ab}\sum_{d=1}^{3}Z_{id}^{I,*}\sum_{c=1}^{2}Y_{\nu,cd}^{*}Z_{k3+c}^{R,*}$$
$$+4\sum_{b=1}^{3}Z_{jb}^{I,*}\sum_{a=1}^{2}Z_{l3+a}^{R,*}Y_{\nu,ab}\sum_{d=1}^{3}Z_{id}^{I,*}\sum_{c=1}^{2}Y_{\nu,cd}^{*}Z_{k3+c}^{R,*}$$
$$-4\sum_{b=1}^{3}Z_{lb}^{R,*}\sum_{a=1}^{2}Z_{i3+a}^{I,*}Y_{\nu,ab}\sum_{d=1}^{3}Z_{jd}^{I,*}\sum_{c=1}^{2}Y_{\nu,cd}^{*}Z_{k3+c}^{R,*}$$
$$+4\sum_{b=1}^{3}Z_{ib}^{I,*}\sum_{a=1}^{2}Z_{l3+a}^{R,*}Y_{\nu,ab}\sum_{d=1}^{3}Z_{jd}^{I,*}\sum_{c=1}^{2}Y_{\nu,cd}^{*}Z_{k3+c}^{R,*}$$

$$
\begin{aligned}
&+4\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{2} Z^{I,*}_{i3+a} Y_{\nu,ab}\sum_{d=1}^{3} Z^{R,*}_{ld}\sum_{c=1}^{2} Y^{*}_{\nu,cd} Z^{R,*}_{k3+c}\\
&+4\sum_{b=1}^{3} Z^{I,*}_{ib}\sum_{a=1}^{2} Z^{I,*}_{j3+a} Y_{\nu,ab}\sum_{d=1}^{3} Z^{R,*}_{ld}\sum_{c=1}^{2} Y^{*}_{\nu,cd} Z^{R,*}_{k3+c}\\
&-4\sum_{b=1}^{3} Z^{R,*}_{kb}\sum_{a=1}^{2} Z^{I,*}_{j3+a} Y_{\nu,ab}\sum_{d=1}^{3} Z^{I,*}_{id}\sum_{c=1}^{2} Y^{*}_{\nu,cd} Z^{R,*}_{l3+c}\\
&+4\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{2} Z^{R,*}_{k3+a} Y_{\nu,ab}\sum_{d=1}^{3} Z^{I,*}_{id}\sum_{c=1}^{2} Y^{*}_{\nu,cd} Z^{R,*}_{l3+c}\\
&-4\sum_{b=1}^{3} Z^{R,*}_{kb}\sum_{a=1}^{2} Z^{I,*}_{i3+a} Y_{\nu,ab}\sum_{d=1}^{3} Z^{I,*}_{jd}\sum_{c=1}^{2} Y^{*}_{\nu,cd} Z^{R,*}_{l3+c}\\
&+4\sum_{b=1}^{3} Z^{I,*}_{ib}\sum_{a=1}^{2} Z^{R,*}_{k3+a} Y_{\nu,ab}\sum_{d=1}^{3} Z^{I,*}_{jd}\sum_{c=1}^{2} Y^{*}_{\nu,cd} Z^{R,*}_{l3+c}\\
&+4\sum_{b=1}^{3} Z^{I,*}_{jb}\sum_{a=1}^{2} Z^{I,*}_{i3+a} Y_{\nu,ab}\sum_{d=1}^{3} Z^{R,*}_{kd}\sum_{c=1}^{2} Y^{*}_{\nu,cd} Z^{R,*}_{l3+c}\\
&+4\sum_{b=1}^{3} Z^{I,*}_{ib}\sum_{a=1}^{2} Z^{I,*}_{j3+a} Y_{\nu,ab}\sum_{d=1}^{3} Z^{R,*}_{kd}\sum_{c=1}^{2} Y^{*}_{\nu,cd} Z^{R,*}_{l3+c}\Big)
\end{aligned}
\tag{458}
$$

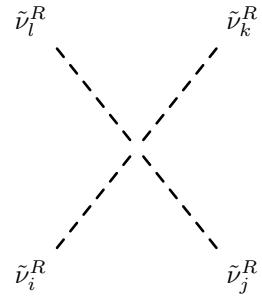


$$
\begin{aligned}
&\frac{1}{16}\Big(-\sum_{b=1}^{2} Z^{R,*}_{l5+b}\sum_{a=1}^{2} Z^{R,*}_{j5+a}\lambda_{ab}\sum_{d=1}^{2} Z^{R,*}_{k5+d}\sum_{c=1}^{2}\lambda^{*}_{cd} Z^{I,*}_{i5+c}\\
&-\sum_{b=1}^{2} Z^{R,*}_{j5+b}\sum_{a=1}^{2} Z^{R,*}_{l5+a}\lambda_{ab}\sum_{d=1}^{2} Z^{R,*}_{k5+d}\sum_{c=1}^{2}\lambda^{*}_{cd} Z^{I,*}_{i5+c}\\
&-\sum_{b=1}^{2} Z^{R,*}_{k5+b}\sum_{a=1}^{2} Z^{R,*}_{j5+a}\lambda_{ab}\sum_{d=1}^{2} Z^{R,*}_{l5+d}\sum_{c=1}^{2}\lambda^{*}_{cd} Z^{I,*}_{i5+c}\\
&-\sum_{b=1}^{2} Z^{R,*}_{j5+b}\sum_{a=1}^{2} Z^{R,*}_{k5+a}\lambda_{ab}\sum_{d=1}^{2} Z^{R,*}_{l5+d}\sum_{c=1}^{2}\lambda^{*}_{cd} Z^{I,*}_{i5+c}
\end{aligned}
$$

$$
\begin{aligned}
&-\sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} Z^{R,*}_{k5+a} \lambda_{ab} \Big(\sum_{d=1}^{2} Z^{R,*}_{j5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{i5+c} + \sum_{d=1}^{2} Z^{I,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{j5+c} \Big) \\
&-\sum_{b=1}^{2} Z^{R,*}_{k5+b} \sum_{a=1}^{2} Z^{R,*}_{l5+a} \lambda_{ab} \Big(\sum_{d=1}^{2} Z^{R,*}_{j5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{I,*}_{i5+c} + \sum_{d=1}^{2} Z^{I,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{j5+c} \Big) \\
&+\sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} Z^{I,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{k5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{j5+c} \\
&+\sum_{b=1}^{2} Z^{I,*}_{i5+b} \sum_{a=1}^{2} Z^{R,*}_{l5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{k5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{j5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{k5+b} \sum_{a=1}^{2} Z^{I,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{j5+c} \\
&+\sum_{b=1}^{2} Z^{I,*}_{i5+b} \sum_{a=1}^{2} Z^{R,*}_{k5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{j5+c} \\
&-\sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} Z^{R,*}_{j5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{k5+c} \\
&-\sum_{b=1}^{2} Z^{R,*}_{j5+b} \sum_{a=1}^{2} Z^{R,*}_{l5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{k5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} Z^{I,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{j5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{k5+c} \\
&+\sum_{b=1}^{2} Z^{I,*}_{i5+b} \sum_{a=1}^{2} Z^{R,*}_{l5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{j5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{k5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{j5+b} \sum_{a=1}^{2} Z^{I,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{k5+c} \\
&+\sum_{b=1}^{2} Z^{I,*}_{i5+b} \sum_{a=1}^{2} Z^{R,*}_{j5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{k5+c} \\
&-\sum_{b=1}^{2} Z^{R,*}_{k5+b} \sum_{a=1}^{2} Z^{R,*}_{j5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{l5+c} \\
&-\sum_{b=1}^{2} Z^{R,*}_{j5+b} \sum_{a=1}^{2} Z^{R,*}_{k5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{I,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{l5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{k5+b} \sum_{a=1}^{2} Z^{I,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{j5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{l5+c}
\end{aligned}
$$

$$+\sum_{b=1}^{2} Z_{i5+b}^{I,*} \sum_{a=1}^{2} Z_{k5+a}^{R,*} \lambda_{ab} \sum_{d=1}^{2} Z_{j5+d}^{R,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{l5+c}^{R,*}$$
$$+\sum_{b=1}^{2} Z_{j5+b}^{R,*} \sum_{a=1}^{2} Z_{i5+a}^{I,*} \lambda_{ab} \sum_{d=1}^{2} Z_{k5+d}^{R,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{l5+c}^{R,*}$$
$$+\sum_{b=1}^{2} Z_{i5+b}^{I,*} \sum_{a=1}^{2} Z_{j5+a}^{R,*} \lambda_{ab} \sum_{d=1}^{2} Z_{k5+d}^{R,*} \sum_{c=1}^{2} \lambda_{cd}^{*} Z_{l5+c}^{R,*}$$
$$+4\sum_{b=1}^{3} Z_{lb}^{R,*} \sum_{a=1}^{2} Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{jd}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{i3+c}^{I,*}$$
$$+4\sum_{b=1}^{3} Z_{kb}^{R,*} \sum_{a=1}^{2} Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{jd}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{i3+c}^{I,*}$$
$$+4\sum_{b=1}^{3} Z_{lb}^{R,*} \sum_{a=1}^{2} Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{kd}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{i3+c}^{I,*}$$
$$+4\sum_{b=1}^{3} Z_{jb}^{R,*} \sum_{a=1}^{2} Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{kd}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{i3+c}^{I,*}$$
$$+4\sum_{b=1}^{3} Z_{kb}^{R,*} \sum_{a=1}^{2} Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{ld}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{i3+c}^{I,*}$$
$$+4\sum_{b=1}^{3} Z_{jb}^{R,*} \sum_{a=1}^{2} Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{ld}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{i3+c}^{I,*}$$
$$-4\sum_{b=1}^{3} Z_{lb}^{R,*} \sum_{a=1}^{2} Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{id}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{R,*}$$
$$-4\sum_{b=1}^{3} Z_{kb}^{R,*} \sum_{a=1}^{2} Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{id}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{R,*}$$
$$-4\sum_{b=1}^{3} Z_{lb}^{R,*} \sum_{a=1}^{2} Z_{i3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{kd}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{R,*}$$
$$+4\sum_{b=1}^{3} Z_{ib}^{I,*} \sum_{a=1}^{2} Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{kd}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{R,*}$$
$$-4\sum_{b=1}^{3} Z_{kb}^{R,*} \sum_{a=1}^{2} Z_{i3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{ld}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{R,*}$$
$$+4\sum_{b=1}^{3} Z_{ib}^{I,*} \sum_{a=1}^{2} Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{ld}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{R,*}$$

$$
\begin{aligned}
&- 4 \sum_{b=1}^{3} Z_{lb}^{R,*} \sum_{a=1}^{2} Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{id}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{R,*} \\
&- 4 \sum_{b=1}^{3} Z_{jb}^{R,*} \sum_{a=1}^{2} Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{id}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{R,*} \\
&- 4 \sum_{b=1}^{3} Z_{lb}^{R,*} \sum_{a=1}^{2} Z_{i3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{jd}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{R,*} \\
&+ 4 \sum_{b=1}^{3} Z_{ib}^{I,*} \sum_{a=1}^{2} Z_{l3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{jd}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{R,*} \\
&- 4 \sum_{b=1}^{3} Z_{jb}^{R,*} \sum_{a=1}^{2} Z_{i3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{ld}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{R,*} \\
&+ 4 \sum_{b=1}^{3} Z_{ib}^{I,*} \sum_{a=1}^{2} Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{ld}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{R,*} \\
&- 4 \sum_{b=1}^{3} Z_{kb}^{R,*} \sum_{a=1}^{2} Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{id}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{R,*} \\
&- 4 \sum_{b=1}^{3} Z_{jb}^{R,*} \sum_{a=1}^{2} Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{id}^{I,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{R,*} \\
&- 4 \sum_{b=1}^{3} Z_{kb}^{R,*} \sum_{a=1}^{2} Z_{i3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{jd}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{R,*} \\
&+ 4 \sum_{b=1}^{3} Z_{ib}^{I,*} \sum_{a=1}^{2} Z_{k3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{jd}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{R,*} \\
&- 4 \sum_{b=1}^{3} Z_{jb}^{R,*} \sum_{a=1}^{2} Z_{i3+a}^{I,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{kd}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{R,*} \\
&+ 4 \sum_{b=1}^{3} Z_{ib}^{I,*} \sum_{a=1}^{2} Z_{j3+a}^{R,*} Y_{\nu,ab} \sum_{d=1}^{3} Z_{kd}^{R,*} \sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{R,*} \Big)
\end{aligned}
\tag{459}
$$



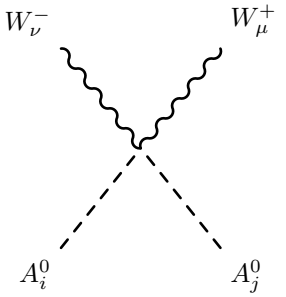
$$
\begin{aligned}
&-\frac{i}{16}\Big(2\Big(g_1^2+g_2^2\Big)\sum_{a=1}^{3}Z_{ka}^{R,*}Z_{la}^{R,*}\sum_{b=1}^{3}Z_{ib}^{R,*}Z_{jb}^{R,*}+2\Big(g_1^2+g_2^2\Big)\sum_{a=1}^{3}Z_{ja}^{R,*}Z_{la}^{R,*}\sum_{b=1}^{3}Z_{ib}^{R,*}Z_{kb}^{R,*}\\
&+2g_1^2\sum_{a=1}^{3}Z_{ia}^{R,*}Z_{la}^{R,*}\sum_{b=1}^{3}Z_{jb}^{R,*}Z_{kb}^{R,*}+2g_2^2\sum_{a=1}^{3}Z_{ia}^{R,*}Z_{la}^{R,*}\sum_{b=1}^{3}Z_{jb}^{R,*}Z_{kb}^{R,*}\\
&+2g_1^2\sum_{a=1}^{3}Z_{ja}^{R,*}Z_{ka}^{R,*}\sum_{b=1}^{3}Z_{ib}^{R,*}Z_{lb}^{R,*}+2g_2^2\sum_{a=1}^{3}Z_{ja}^{R,*}Z_{ka}^{R,*}\sum_{b=1}^{3}Z_{ib}^{R,*}Z_{lb}^{R,*}\\
&+2g_1^2\sum_{a=1}^{3}Z_{ia}^{R,*}Z_{ka}^{R,*}\sum_{b=1}^{3}Z_{jb}^{R,*}Z_{lb}^{R,*}+2g_2^2\sum_{a=1}^{3}Z_{ia}^{R,*}Z_{ka}^{R,*}\sum_{b=1}^{3}Z_{jb}^{R,*}Z_{lb}^{R,*}\\
&+2g_1^2\sum_{a=1}^{3}Z_{ia}^{R,*}Z_{ja}^{R,*}\sum_{b=1}^{3}Z_{kb}^{R,*}Z_{lb}^{R,*}+2g_2^2\sum_{a=1}^{3}Z_{ia}^{R,*}Z_{ja}^{R,*}\sum_{b=1}^{3}Z_{kb}^{R,*}Z_{lb}^{R,*}\\
&+\sum_{b=1}^{2}Z_{l5+b}^{R,*}\sum_{a=1}^{2}Z_{k5+a}^{R,*}\lambda_{ab}\sum_{d=1}^{2}Z_{j5+d}^{R,*}\sum_{c=1}^{2}\lambda_{cd}^{*}Z_{i5+c}^{R,*}\\
&+\sum_{b=1}^{2}Z_{k5+b}^{R,*}\sum_{a=1}^{2}Z_{l5+a}^{R,*}\lambda_{ab}\sum_{d=1}^{2}Z_{j5+d}^{R,*}\sum_{c=1}^{2}\lambda_{cd}^{*}Z_{i5+c}^{R,*}\\
&+\sum_{b=1}^{2}Z_{l5+b}^{R,*}\sum_{a=1}^{2}Z_{j5+a}^{R,*}\lambda_{ab}\sum_{d=1}^{2}Z_{k5+d}^{R,*}\sum_{c=1}^{2}\lambda_{cd}^{*}Z_{i5+c}^{R,*}\\
&+\sum_{b=1}^{2}Z_{j5+b}^{R,*}\sum_{a=1}^{2}Z_{l5+a}^{R,*}\lambda_{ab}\sum_{d=1}^{2}Z_{k5+d}^{R,*}\sum_{c=1}^{2}\lambda_{cd}^{*}Z_{i5+c}^{R,*}\\
&+\sum_{b=1}^{2}Z_{k5+b}^{R,*}\sum_{a=1}^{2}Z_{j5+a}^{R,*}\lambda_{ab}\sum_{d=1}^{2}Z_{l5+d}^{R,*}\sum_{c=1}^{2}\lambda_{cd}^{*}Z_{i5+c}^{R,*}\\
&+\sum_{b=1}^{2}Z_{j5+b}^{R,*}\sum_{a=1}^{2}Z_{k5+a}^{R,*}\lambda_{ab}\sum_{d=1}^{2}Z_{l5+d}^{R,*}\sum_{c=1}^{2}\lambda_{cd}^{*}Z_{i5+c}^{R,*}\\
&+\sum_{b=1}^{2}Z_{l5+b}^{R,*}\sum_{a=1}^{2}Z_{k5+a}^{R,*}\lambda_{ab}\sum_{d=1}^{2}Z_{i5+d}^{R,*}\sum_{c=1}^{2}\lambda_{cd}^{*}Z_{j5+c}^{R,*}\\
&+\sum_{b=1}^{2}Z_{k5+b}^{R,*}\sum_{a=1}^{2}Z_{l5+a}^{R,*}\lambda_{ab}\sum_{d=1}^{2}Z_{i5+d}^{R,*}\sum_{c=1}^{2}\lambda_{cd}^{*}Z_{j5+c}^{R,*}\\
&+\sum_{b=1}^{2}Z_{l5+b}^{R,*}\sum_{a=1}^{2}Z_{i5+a}^{R,*}\lambda_{ab}\sum_{d=1}^{2}Z_{k5+d}^{R,*}\sum_{c=1}^{2}\lambda_{cd}^{*}Z_{j5+c}^{R,*}\\
&+\sum_{b=1}^{2}Z_{i5+b}^{R,*}\sum_{a=1}^{2}Z_{l5+a}^{R,*}\lambda_{ab}\sum_{d=1}^{2}Z_{k5+d}^{R,*}\sum_{c=1}^{2}\lambda_{cd}^{*}Z_{j5+c}^{R,*}
\end{aligned}
$$

$$
\begin{aligned}
&+\sum_{b=1}^{2} Z^{R,*}_{k5+b} \sum_{a=1}^{2} Z^{R,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{j5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{i5+b} \sum_{a=1}^{2} Z^{R,*}_{k5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{j5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} Z^{R,*}_{j5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{k5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{j5+b} \sum_{a=1}^{2} Z^{R,*}_{l5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{k5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{l5+b} \sum_{a=1}^{2} Z^{R,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{j5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{k5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{i5+b} \sum_{a=1}^{2} Z^{R,*}_{l5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{j5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{k5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{j5+b} \sum_{a=1}^{2} Z^{R,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{k5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{i5+b} \sum_{a=1}^{2} Z^{R,*}_{j5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{l5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{k5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{k5+b} \sum_{a=1}^{2} Z^{R,*}_{j5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{l5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{j5+b} \sum_{a=1}^{2} Z^{R,*}_{k5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{i5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{l5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{k5+b} \sum_{a=1}^{2} Z^{R,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{j5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{l5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{i5+b} \sum_{a=1}^{2} Z^{R,*}_{k5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{j5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{l5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{j5+b} \sum_{a=1}^{2} Z^{R,*}_{i5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{k5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{l5+c} \\
&+\sum_{b=1}^{2} Z^{R,*}_{i5+b} \sum_{a=1}^{2} Z^{R,*}_{j5+a} \lambda_{ab} \sum_{d=1}^{2} Z^{R,*}_{k5+d} \sum_{c=1}^{2} \lambda^{*}_{cd} Z^{R,*}_{l5+c} \\
&+4 \sum_{b=1}^{3} Z^{R,*}_{lb} \sum_{a=1}^{2} Z^{R,*}_{k3+a} Y_{\nu,ab} \sum_{d=1}^{3} Z^{R,*}_{jd} \sum_{c=1}^{2} Y^{*}_{\nu,cd} Z^{R,*}_{i3+c}
\end{aligned}
$$

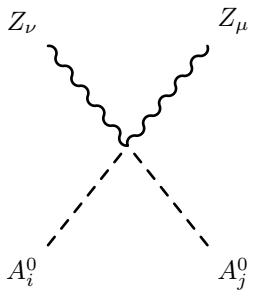
$$+4\sum_{b=1}^{3} Z_{kb}^{R,*}\sum_{a=1}^{2} Z_{l3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{jd}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{i3+c}^{R,*}$$
$$+4\sum_{b=1}^{3} Z_{lb}^{R,*}\sum_{a=1}^{2} Z_{j3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{kd}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{i3+c}^{R,*}$$
$$+4\sum_{b=1}^{3} Z_{jb}^{R,*}\sum_{a=1}^{2} Z_{l3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{kd}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{i3+c}^{R,*}$$
$$+4\sum_{b=1}^{3} Z_{kb}^{R,*}\sum_{a=1}^{2} Z_{j3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{ld}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{i3+c}^{R,*}$$
$$+4\sum_{b=1}^{3} Z_{jb}^{R,*}\sum_{a=1}^{2} Z_{k3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{ld}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{i3+c}^{R,*}$$
$$+4\sum_{b=1}^{3} Z_{lb}^{R,*}\sum_{a=1}^{2} Z_{k3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{id}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{R,*}$$
$$+4\sum_{b=1}^{3} Z_{kb}^{R,*}\sum_{a=1}^{2} Z_{l3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{id}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{R,*}$$
$$+4\sum_{b=1}^{3} Z_{lb}^{R,*}\sum_{a=1}^{2} Z_{i3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{kd}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{R,*}$$
$$+4\sum_{b=1}^{3} Z_{ib}^{R,*}\sum_{a=1}^{2} Z_{l3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{kd}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{R,*}$$
$$+4\sum_{b=1}^{3} Z_{kb}^{R,*}\sum_{a=1}^{2} Z_{i3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{ld}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{R,*}$$
$$+4\sum_{b=1}^{3} Z_{ib}^{R,*}\sum_{a=1}^{2} Z_{k3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{ld}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{j3+c}^{R,*}$$
$$+4\sum_{b=1}^{3} Z_{lb}^{R,*}\sum_{a=1}^{2} Z_{j3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{id}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{R,*}$$
$$+4\sum_{b=1}^{3} Z_{jb}^{R,*}\sum_{a=1}^{2} Z_{l3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{id}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{R,*}$$
$$+4\sum_{b=1}^{3} Z_{lb}^{R,*}\sum_{a=1}^{2} Z_{i3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{jd}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{R,*}$$
$$+4\sum_{b=1}^{3} Z_{ib}^{R,*}\sum_{a=1}^{2} Z_{l3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{jd}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{R,*}$$

$$
\begin{aligned}
&+4\sum_{b=1}^{3} Z_{jb}^{R,*}\sum_{a=1}^{2} Z_{i3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{ld}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{R,*}\\
&+4\sum_{b=1}^{3} Z_{ib}^{R,*}\sum_{a=1}^{2} Z_{j3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{ld}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{k3+c}^{R,*}\\
&+4\sum_{b=1}^{3} Z_{kb}^{R,*}\sum_{a=1}^{2} Z_{j3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{id}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{R,*}\\
&+4\sum_{b=1}^{3} Z_{jb}^{R,*}\sum_{a=1}^{2} Z_{k3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{id}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{R,*}\\
&+4\sum_{b=1}^{3} Z_{kb}^{R,*}\sum_{a=1}^{2} Z_{i3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{jd}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{R,*}\\
&+4\sum_{b=1}^{3} Z_{ib}^{R,*}\sum_{a=1}^{2} Z_{k3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{jd}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{R,*}\\
&+4\sum_{b=1}^{3} Z_{jb}^{R,*}\sum_{a=1}^{2} Z_{i3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{kd}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{R,*}\\
&+4\sum_{b=1}^{3} Z_{ib}^{R,*}\sum_{a=1}^{2} Z_{j3+a}^{R,*} Y_{\nu,ab}\sum_{d=1}^{3} Z_{kd}^{R,*}\sum_{c=1}^{2} Y_{\nu,cd}^{*} Z_{l3+c}^{R,*}\Big)
\end{aligned}
\tag{460}
$$

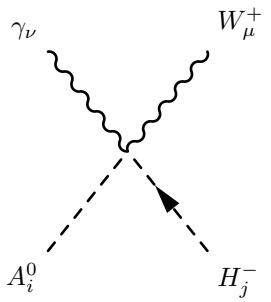
9.8 Two Scalar-Two Vector Boson-Interaction



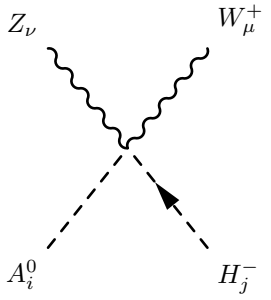
$$
\frac{i}{2} g_2^2 \Big(Z_{i1}^A Z_{j1}^A + Z_{i2}^A Z_{j2}^A \Big) \Big(g_{\mu\nu} \Big) \tag{461}
$$



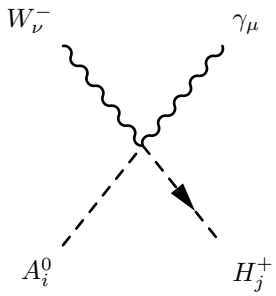
$$\frac{i}{2}\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W\Big)^2 \Big(Z_{i1}^A Z_{j1}^A + Z_{i2}^A Z_{j2}^A\Big)\Big(g_{\mu\nu}\Big) \tag{462}$$



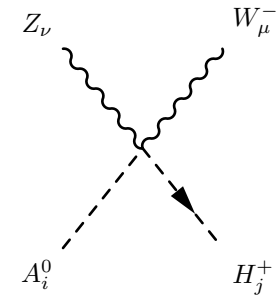
$$-\frac{1}{2} g_1 g_2 \cos\Theta_W \Big(Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big) \tag{463}$$



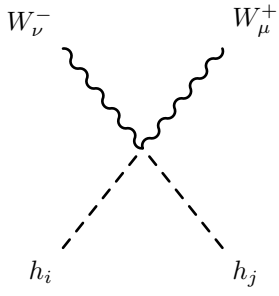
$$\frac{1}{2} g_1 g_2 \sin\Theta_W \Big(Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big) \tag{464}$$



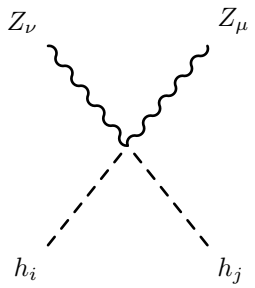
$$\frac{1}{2}g_1 g_2 \cos\Theta_W \Big(Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big) \tag{465}$$



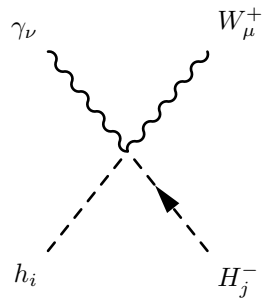
$$-\frac{1}{2}g_1 g_2 \sin\Theta_W \Big(Z_{i1}^A Z_{j1}^+ + Z_{i2}^A Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big) \tag{466}$$



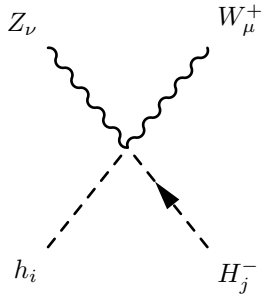
$$\frac{i}{2}g_2^2 \Big(Z_{i1}^H Z_{j1}^H + Z_{i2}^H Z_{j2}^H\Big)\Big(g_{\mu\nu}\Big) \tag{467}$$



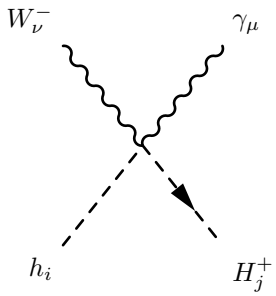
$$\frac{i}{2}\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W\Big)^2 \Big(Z^H_{i1} Z^H_{j1} + Z^H_{i2} Z^H_{j2}\Big)\Big(g_{\mu\nu}\Big) \tag{468}$$



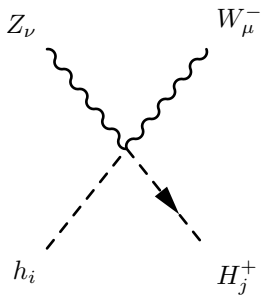
$$-\frac{i}{2} g_1 g_2 \cos\Theta_W \Big(Z^H_{i1} Z^+_{j1} - Z^H_{i2} Z^+_{j2}\Big)\Big(g_{\mu\nu}\Big) \tag{469}$$



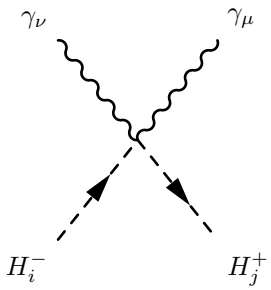
$$\frac{i}{2} g_1 g_2 \sin\Theta_W \Big(Z^H_{i1} Z^+_{j1} - Z^H_{i2} Z^+_{j2}\Big)\Big(g_{\mu\nu}\Big) \tag{470}$$



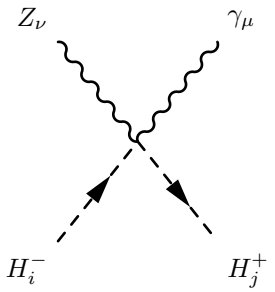
$$-\frac{i}{2}g_1 g_2 \cos\Theta_W \Big(Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big) \tag{471}$$



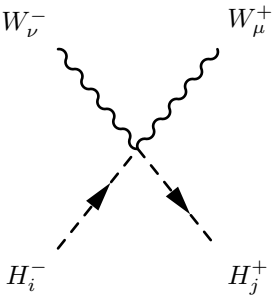
$$\frac{i}{2}g_1 g_2 \sin\Theta_W \Big(Z_{i1}^H Z_{j1}^+ - Z_{i2}^H Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big) \tag{472}$$



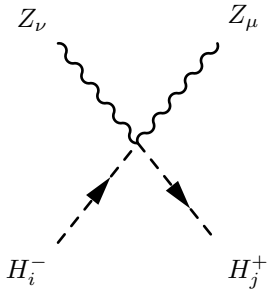
$$\frac{i}{2}\Big(g_1 \cos\Theta_W + g_2 \sin\Theta_W\Big)^2 \Big(Z_{i1}^+ Z_{j1}^+ + Z_{i2}^+ Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big) \tag{473}$$



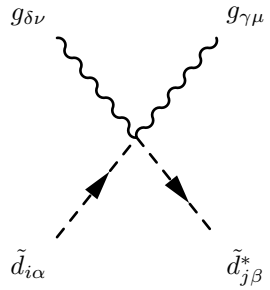
$$-\frac{i}{4}\Big(-2g_1g_2\cos 2\Theta_W+\Big(-g_2^2+g_1^2\Big)\sin 2\Theta_W\Big)\Big(Z_{i1}^+Z_{j1}^++Z_{i2}^+Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big) \tag{474}$$



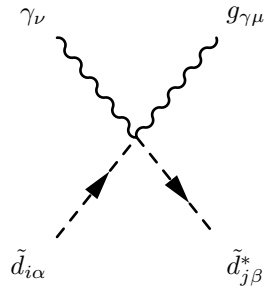
$$\frac{i}{2}g_2^2\Big(Z_{i1}^+Z_{j1}^++Z_{i2}^+Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big) \tag{475}$$



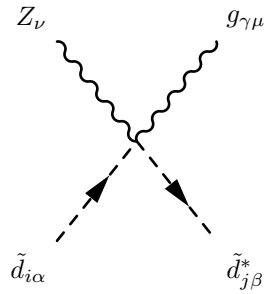
$$\frac{i}{2}\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)^2\Big(Z_{i1}^+Z_{j1}^++Z_{i2}^+Z_{j2}^+\Big)\Big(g_{\mu\nu}\Big) \tag{476}$$



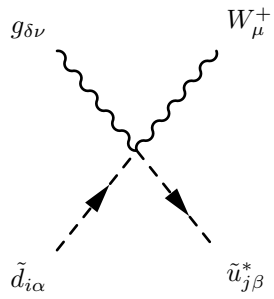
$$\frac{i}{4}g_3^2\delta_{ij}\Big(\sum_{a=1}^{3}\lambda^{\gamma}_{a,\alpha}\lambda^{\delta}_{\beta,a}+\sum_{a=1}^{3}\lambda^{\gamma}_{\beta,a}\lambda^{\delta}_{a,\alpha}\Big)\Big(g_{\mu\nu}\Big) \tag{477}$$



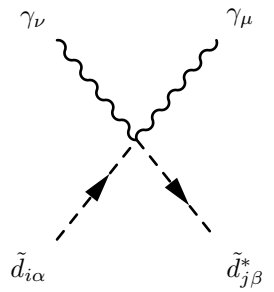
$$\frac{i}{6}g_3\lambda^{\gamma}_{\beta,\alpha}\Big(-2g_1\cos\Theta_W\sum_{a=1}^{3}Z^{D,*}_{i3+a}Z^{D}_{j3+a}+\Big(-3g_2\sin\Theta_W+g_1\cos\Theta_W\Big)\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{D}_{ja}\Big)\Big(g_{\mu\nu}\Big) \tag{478}$$



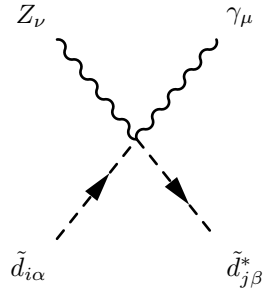
$$-\frac{i}{6}g_3\lambda^{\gamma}_{\beta,\alpha}\Big(-2g_1\sin\Theta_W\sum_{a=1}^{3}Z^{D,*}_{i3+a}Z^{D}_{j3+a}+\Big(3g_2\cos\Theta_W+g_1\sin\Theta_W\Big)\sum_{a=1}^{3}Z^{D,*}_{ia}Z^{D}_{ja}\Big)\Big(g_{\mu\nu}\Big) \tag{479}$$



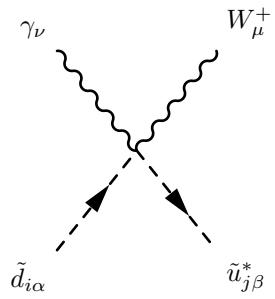
$$i\frac{1}{\sqrt{2}}g_2 g_3 \lambda^{\delta}_{\beta,\alpha}\sum_{a=1}^{3} Z^{D,*}_{ia} Z^{U}_{ja}\Big(g_{\mu\nu}\Big) \tag{480}$$



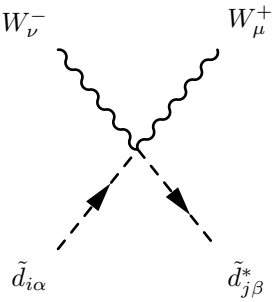
$$\frac{i}{18}\delta_{\alpha\beta}\Big(\Big(-3g_2\sin\Theta_W + g_1\cos\Theta_W\Big)^2\sum_{a=1}^{3} Z^{D,*}_{ia} Z^{D}_{ja} + 4g_1^2\cos\Theta_W^2\sum_{a=1}^{3} Z^{D,*}_{i3+a} Z^{D}_{j3+a}\Big)\Big(g_{\mu\nu}\Big) \tag{481}$$



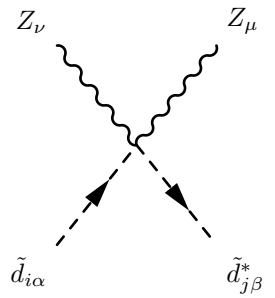
$$\begin{aligned}&-\frac{i}{36}\delta_{\alpha\beta}\Big(\Big(6g_1 g_2\cos 2\Theta_W + \Big(-9g_2^2 + g_1^2\Big)\sin 2\Theta_W\Big)\sum_{a=1}^{3} Z^{D,*}_{ia} Z^{D}_{ja}\\&+ 4g_1^2\sin 2\Theta_W\sum_{a=1}^{3} Z^{D,*}_{i3+a} Z^{D}_{j3+a}\Big)\Big(g_{\mu\nu}\Big)\end{aligned} \tag{482}$$



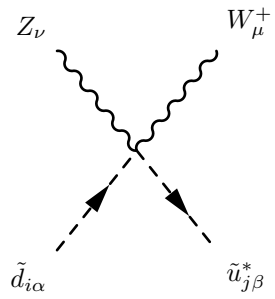
$$\frac{i}{3}\frac{1}{\sqrt{2}}g_1 g_2 \cos\Theta_W \delta_{\alpha\beta} \sum_{a=1}^{3} Z^{D,*}_{ia} Z^{U}_{ja} \Big(g_{\mu\nu} \Big) \tag{483}$$



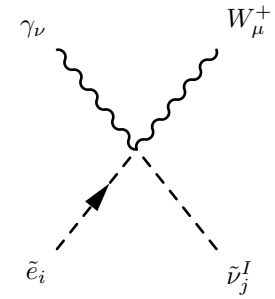
$$\frac{i}{2} g_2^2 \delta_{\alpha\beta} \sum_{a=1}^{3} Z^{D,*}_{ia} Z^{D}_{ja} \Big(g_{\mu\nu} \Big) \tag{484}$$



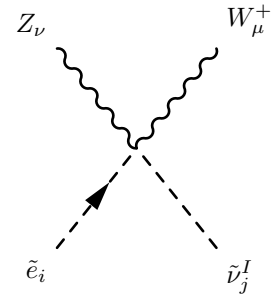
$$\frac{i}{18}\delta_{\alpha\beta}\Big(\Big(3g_2 \cos\Theta_W + g_1 \sin\Theta_W \Big)^2 \sum_{a=1}^{3} Z^{D,*}_{ia} Z^{D}_{ja} + 4 g_1^2 \sin\Theta_W^2 \sum_{a=1}^{3} Z^{D,*}_{i3+a} Z^{D}_{j3+a} \Big) \Big(g_{\mu\nu} \Big) \tag{485}$$



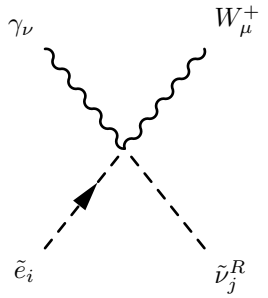
$$-\frac{i}{3}\frac{1}{\sqrt{2}}g_1 g_2 \delta_{\alpha\beta}\sin\Theta_W \sum_{a=1}^{3} Z^{D,*}_{ia} Z^{U}_{ja}\Big(g_{\mu\nu}\Big) \tag{486}$$



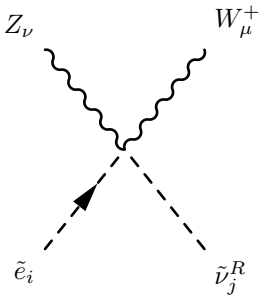
$$-\frac{1}{2}g_1 g_2 \cos\Theta_W \sum_{a=1}^{3} Z^{E,*}_{ia} Z^{I,*}_{ja}\Big(g_{\mu\nu}\Big) \tag{487}$$



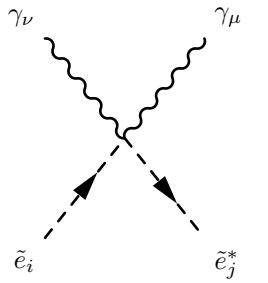
$$\frac{1}{2}g_1 g_2 \sin\Theta_W \sum_{a=1}^{3} Z^{E,*}_{ia} Z^{I,*}_{ja}\Big(g_{\mu\nu}\Big) \tag{488}$$



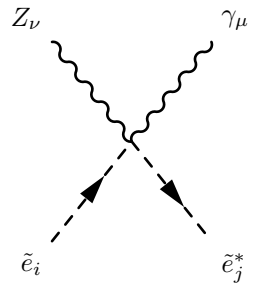
$$-\frac{i}{2}g_1 g_2 \cos\Theta_W \sum_{a=1}^{3} Z^{E,*}_{ia} Z^{R,*}_{ja} \Big(g_{\mu\nu}\Big) \tag{489}$$



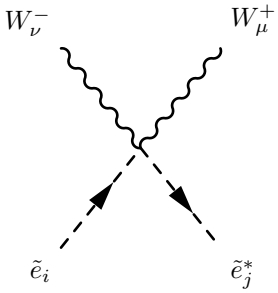
$$\frac{i}{2}g_1 g_2 \sin\Theta_W \sum_{a=1}^{3} Z^{E,*}_{ia} Z^{R,*}_{ja} \Big(g_{\mu\nu}\Big) \tag{490}$$



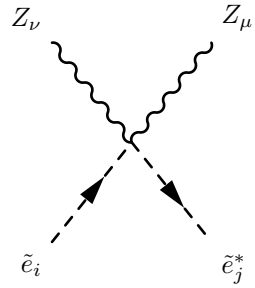
$$\frac{i}{2}\Big(4g_1^2 \cos\Theta_W^2 \sum_{a=1}^{3} Z^{E,*}_{i3+a} Z^{E}_{j3+a} + \Big(g_1 \cos\Theta_W + g_2 \sin\Theta_W\Big)^2 \sum_{a=1}^{3} Z^{E,*}_{ia} Z^{E}_{ja}\Big)\Big(g_{\mu\nu}\Big) \tag{491}$$



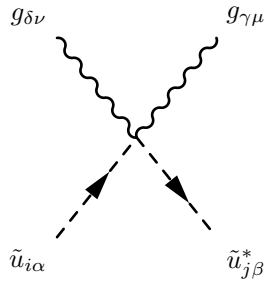
$$-\frac{i}{4}\Big(\Big(-2g_1g_2\cos 2\Theta_W+\Big(-g_2^2+g_1^2\Big)\sin 2\Theta_W\Big)\sum_{a=1}^{3}Z_{ia}^{E,*}Z_{ja}^{E}$$
$$+4g_1^2\sin 2\Theta_W\sum_{a=1}^{3}Z_{i3+a}^{E,*}Z_{j3+a}^{E}\Big)\Big(g_{\mu\nu}\Big) \tag{492}$$



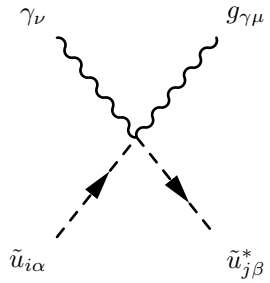
$$\frac{i}{2}g_2^2\sum_{a=1}^{3}Z_{ia}^{E,*}Z_{ja}^{E}\Big(g_{\mu\nu}\Big) \tag{493}$$



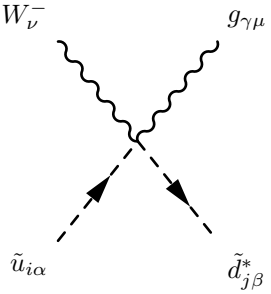
$$\frac{i}{2}\Big(4g_1^2\sin\Theta_W^2\sum_{a=1}^{3}Z_{i3+a}^{E,*}Z_{j3+a}^{E}+\Big(-g_1\sin\Theta_W+g_2\cos\Theta_W\Big)^2\sum_{a=1}^{3}Z_{ia}^{E,*}Z_{ja}^{E}\Big)\Big(g_{\mu\nu}\Big) \tag{494}$$



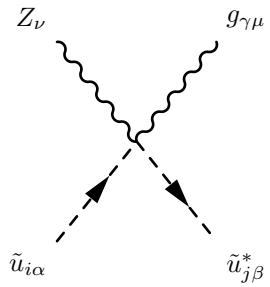
$$\frac{i}{4}g_3^2\delta_{ij}\Big(\sum_{a=1}^{3}\lambda^{\gamma}_{a,\alpha}\lambda^{\delta}_{\beta,a}+\sum_{a=1}^{3}\lambda^{\gamma}_{\beta,a}\lambda^{\delta}_{a,\alpha}\Big)\Big(g_{\mu\nu}\Big) \tag{495}$$



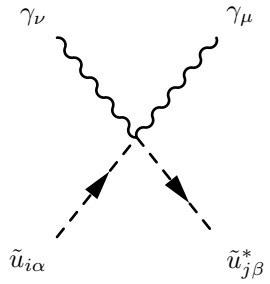
$$\frac{i}{6}g_3\lambda^{\gamma}_{\beta,\alpha}\Big(\Big(3g_2\sin\Theta_W+g_1\cos\Theta_W\Big)\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{U}_{ja}+4g_1\cos\Theta_W\sum_{a=1}^{3}Z^{U,*}_{i3+a}Z^{U}_{j3+a}\Big)\Big(g_{\mu\nu}\Big) \tag{496}$$



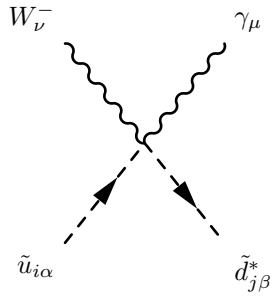
$$i\frac{1}{\sqrt{2}}g_2g_3\lambda^{\gamma}_{\beta,\alpha}\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{D}_{ja}\Big(g_{\mu\nu}\Big) \tag{497}$$



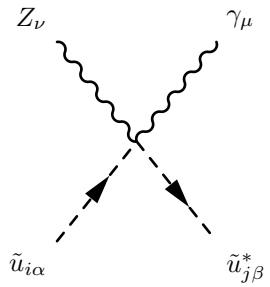
$$\frac{i}{6}g_3\lambda^{\gamma}_{\beta,\alpha}\Big(\Big(3g_2\cos\Theta_W - g_1\sin\Theta_W\Big)\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{U}_{ja} - 4g_1\sin\Theta_W\sum_{a=1}^{3}Z^{U,*}_{i3+a}Z^{U}_{j3+a}\Big)\Big(g_{\mu\nu}\Big) \tag{498}$$



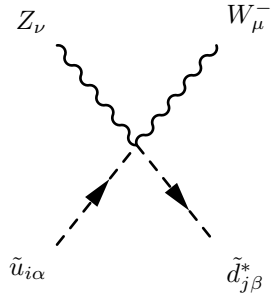
$$\frac{i}{18}\delta_{\alpha\beta}\Big(16g_1^2\cos\Theta_W^2\sum_{a=1}^{3}Z^{U,*}_{i3+a}Z^{U}_{j3+a} + \Big(3g_2\sin\Theta_W + g_1\cos\Theta_W\Big)^2\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{U}_{ja}\Big)\Big(g_{\mu\nu}\Big) \tag{499}$$



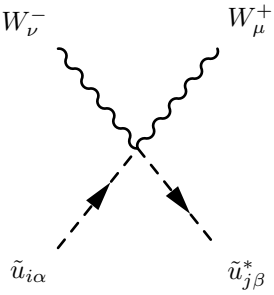
$$\frac{i}{3}\frac{1}{\sqrt{2}}g_1g_2\cos\Theta_W\delta_{\alpha\beta}\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{D}_{ja}\Big(g_{\mu\nu}\Big) \tag{500}$$



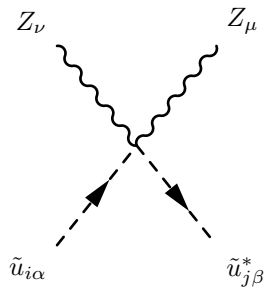
$$-\frac{i}{36}\delta_{\alpha\beta}\Big(\Big(-6g_1g_2\cos 2\Theta_W+\Big(-9g_2^2+g_1^2\Big)\sin 2\Theta_W\Big)\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{U}_{ja}$$
$$+16g_1^2\sin 2\Theta_W\sum_{a=1}^{3}Z^{U,*}_{i3+a}Z^{U}_{j3+a}\Big)\Big(g_{\mu\nu}\Big) \tag{501}$$



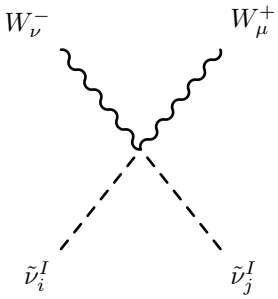
$$-\frac{i}{3}\frac{1}{\sqrt{2}}g_1g_2\delta_{\alpha\beta}\sin\Theta_W\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{D}_{ja}\Big(g_{\mu\nu}\Big) \tag{502}$$



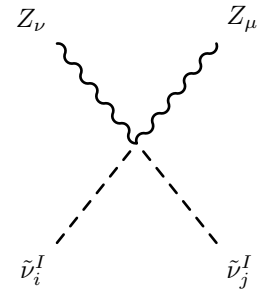
$$\frac{i}{2}g_2^2\delta_{\alpha\beta}\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{U}_{ja}\Big(g_{\mu\nu}\Big) \tag{503}$$



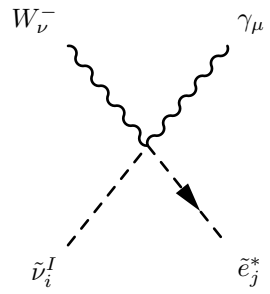
$$\frac{i}{18}\delta_{\alpha\beta}\Big(16g_1^2\sin\Theta_W^2\sum_{a=1}^{3}Z^{U,*}_{i3+a}Z^{U}_{j3+a}+\Big(-3g_2\cos\Theta_W+g_1\sin\Theta_W\Big)^2\sum_{a=1}^{3}Z^{U,*}_{ia}Z^{U}_{ja}\Big)\Big(g_{\mu\nu}\Big) \tag{504}$$



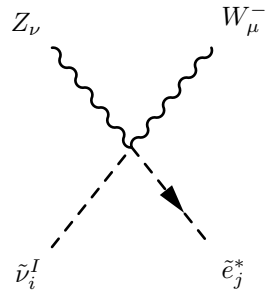
$$\frac{i}{2}g_2^2\sum_{a=1}^{3}Z^{I,*}_{ia}Z^{I,*}_{ja}\Big(g_{\mu\nu}\Big) \tag{505}$$



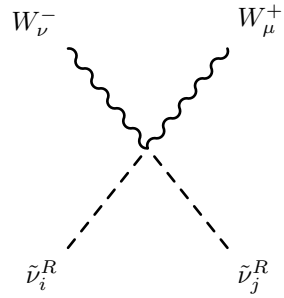
$$\frac{i}{2}\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)^2\sum_{a=1}^{3}Z^{I,*}_{ia}Z^{I,*}_{ja}\Big(g_{\mu\nu}\Big) \tag{506}$$



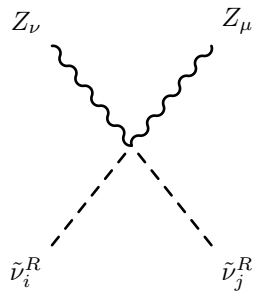
$$\frac{1}{2} g_1 g_2 \cos\Theta_W \sum_{a=1}^{3} Z_{ia}^{I,*} Z_{ja}^{E} \Big(g_{\mu\nu} \Big) \tag{507}$$



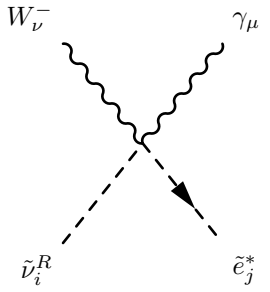
$$- \frac{1}{2} g_1 g_2 \sin\Theta_W \sum_{a=1}^{3} Z_{ia}^{I,*} Z_{ja}^{E} \Big(g_{\mu\nu} \Big) \tag{508}$$



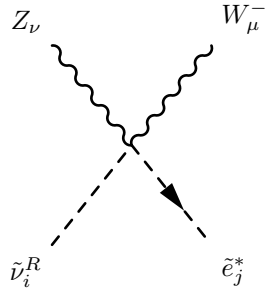
$$\frac{i}{2} g_2^2 \sum_{a=1}^{3} Z_{ia}^{R,*} Z_{ja}^{R,*} \Big(g_{\mu\nu} \Big) \tag{509}$$



$$\frac{i}{2}\Big(g_1 \sin\Theta_W + g_2 \cos\Theta_W\Big)^2 \sum_{a=1}^{3} Z_{ia}^{R,*} Z_{ja}^{R,*} \Big(g_{\mu\nu}\Big) \tag{510}$$

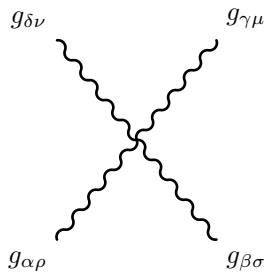


$$-\frac{i}{2} g_1 g_2 \cos\Theta_W \sum_{a=1}^{3} Z_{ia}^{R,*} Z_{ja}^{E} \Big(g_{\mu\nu}\Big) \tag{511}$$



$$\frac{i}{2} g_1 g_2 \sin\Theta_W \sum_{a=1}^{3} Z_{ia}^{R,*} Z_{ja}^{E} \Big(g_{\mu\nu}\Big) \tag{512}$$

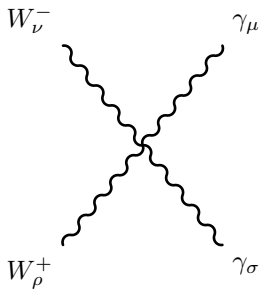
9.9 Four Vector Boson-Interaction



$$- ig_3^2\Big(\sum_{a=1}^{8} f_{\alpha,\delta,a}f_{\beta,\gamma,a} + \sum_{a=1}^{8} f_{\alpha,\gamma,a}f_{\beta,\delta,a}\Big)\Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{513}$$

$$+ ig_3^2\Big(-\sum_{a=1}^{8} f_{\alpha,\beta,a}f_{\gamma,\delta,a} + \sum_{a=1}^{8} f_{\alpha,\delta,a}f_{\beta,\gamma,a}\Big)\Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{514}$$

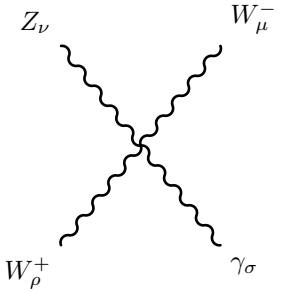
$$+ ig_3^2\Big(\sum_{a=1}^{8} f_{\alpha,\gamma,a}f_{\beta,\delta,a} + \sum_{a=1}^{8} f_{\alpha,\beta,a}f_{\gamma,\delta,a}\Big)\Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{515}$$



$$ig_2^2 \sin\Theta_W^2\Big(g_{\rho\sigma}g_{\mu\nu}\Big) \tag{516}$$

$$+ ig_2^2 \sin\Theta_W^2\Big(g_{\rho\mu}g_{\sigma\nu}\Big) \tag{517}$$

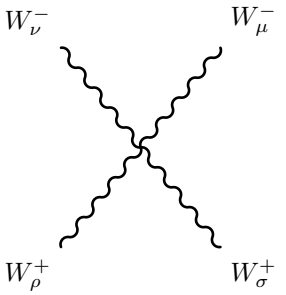
$$+ -2ig_2^2 \sin\Theta_W^2\Big(g_{\rho\nu}g_{\sigma\mu}\Big) \tag{518}$$



$$ig_2^2 \cos\Theta_W \sin\Theta_W \Big(g_{\rho\sigma} g_{\mu\nu}\Big) \tag{519}$$

$$+\ -ig_2^2 \sin 2\Theta_W \Big(g_{\rho\mu} g_{\sigma\nu}\Big) \tag{520}$$

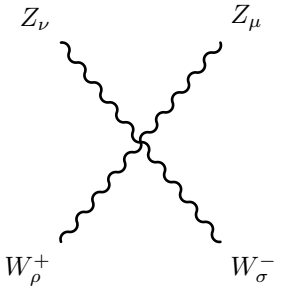
$$+\ ig_2^2 \cos\Theta_W \sin\Theta_W \Big(g_{\rho\nu} g_{\sigma\mu}\Big) \tag{521}$$



$$2ig_2^2 \Big(g_{\rho\sigma} g_{\mu\nu}\Big) \tag{522}$$

$$+\ -ig_2^2 \Big(g_{\rho\mu} g_{\sigma\nu}\Big) \tag{523}$$

$$+\ -ig_2^2 \Big(g_{\rho\nu} g_{\sigma\mu}\Big) \tag{524}$$

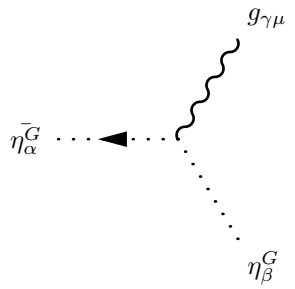


$$- 2ig_2^2 \cos\Theta_W^2 \Big(g_{\rho\sigma} g_{\mu\nu} \Big) \tag{525}$$

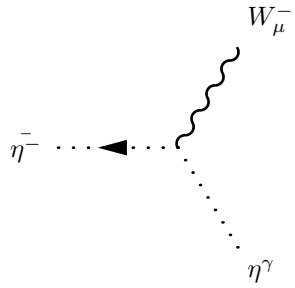
$$+ ig_2^2 \cos\Theta_W^2 \Big(g_{\rho\mu} g_{\sigma\nu} \Big) \tag{526}$$

$$+ ig_2^2 \cos\Theta_W^2 \Big(g_{\rho\nu} g_{\sigma\mu} \Big) \tag{527}$$

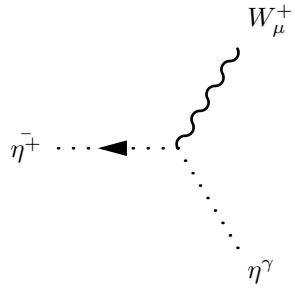
9.10 Two Ghosts-One Vector Boson-Interaction



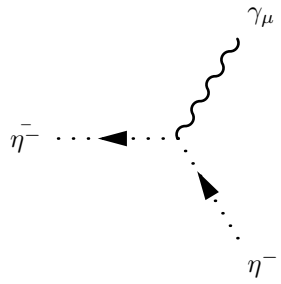
$$g_3 f_{\alpha,\beta,\gamma} \Big(p_\mu^{\eta_\beta^G} \Big) \tag{528}$$



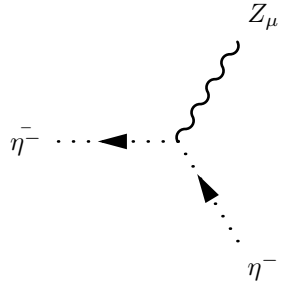
$$ig_2 \sin\Theta_W \Big(p_\mu^{\eta^\gamma} \Big) \tag{529}$$



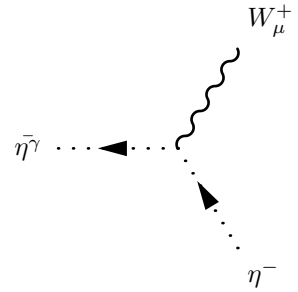
$$-ig_2 \sin\Theta_W \left(p_\mu^{\eta^\gamma}\right) \tag{530}$$



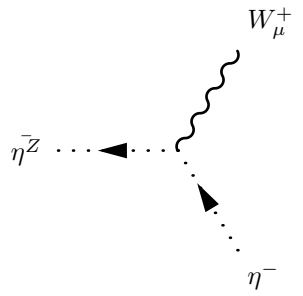
$$-ig_2 \sin\Theta_W \left(p_\mu^{\eta^-}\right) \tag{531}$$



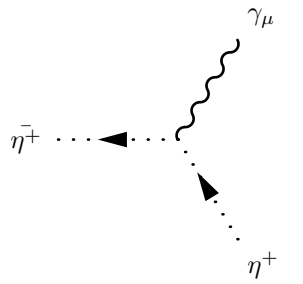
$$-ig_2 \cos\Theta_W \left(p_\mu^{\eta^-}\right) \tag{532}$$



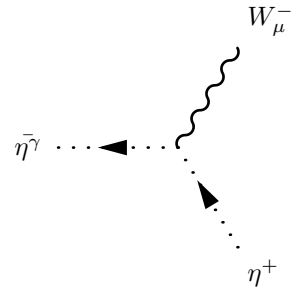
$$ig_2 \sin\Theta_W \left(p_\mu^{\eta^-}\right) \tag{533}$$



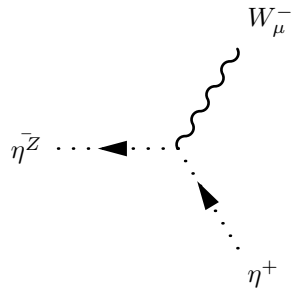
$$ig_2 \cos\Theta_W \left(p_\mu^{\eta^-}\right) \tag{534}$$



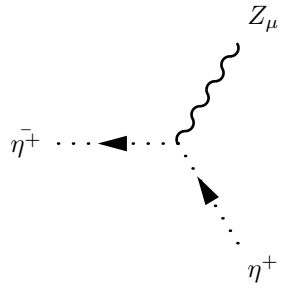
$$ig_2 \sin\Theta_W \left(p_\mu^{\eta^+}\right) \tag{535}$$



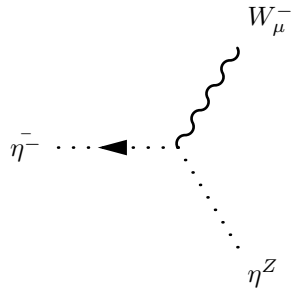
$$-ig_2 \sin\Theta_W \left(p_\mu^{\eta^+}\right) \tag{536}$$



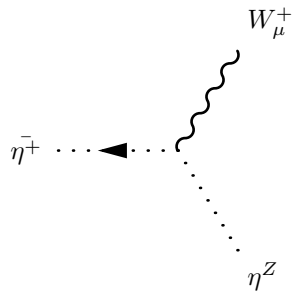
$$-ig_2 \cos\Theta_W \left(p_\mu^{\eta^+}\right) \tag{537}$$



$$ig_2 \cos\Theta_W \left(p_\mu^{\eta^+}\right) \tag{538}$$

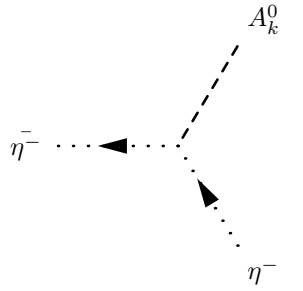


$$ig_2 \cos\Theta_W \left(p_\mu^{\eta^Z}\right) \tag{539}$$

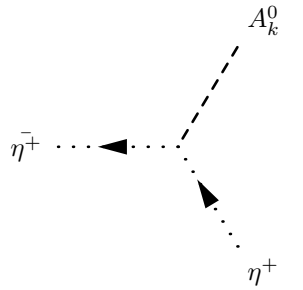


$$-ig_2 \cos\Theta_W \left(p_\mu^{\eta^Z}\right) \tag{540}$$

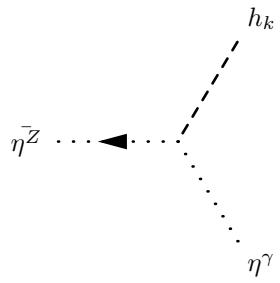
9.11 Two Ghosts-One Scalar-Interaction



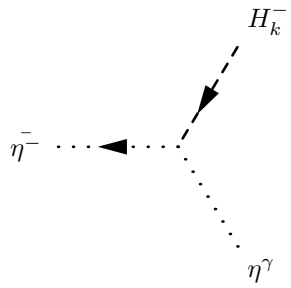
$$\frac{1}{4} g_2^2 \xi_{W^-} \left(v_d Z_{k1}^A - v_u Z_{k2}^A\right) \tag{541}$$



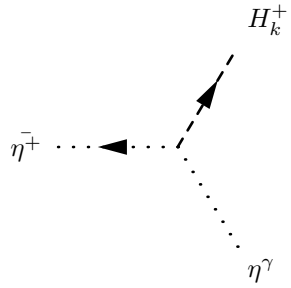
$$\frac{1}{4} g_2^2 \xi_{W^-} \left(-v_d Z_{k1}^A + v_u Z_{k2}^A\right) \tag{542}$$



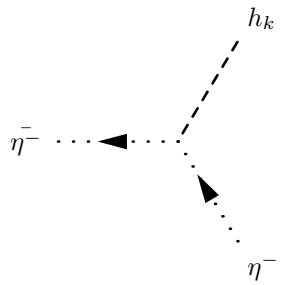
$$\frac{i}{8}\xi_Z\Big(2g_1g_2\cos 2\Theta_W + \Big(-g_2^2+g_1^2\Big)\sin 2\Theta_W\Big)\Big(v_dZ_{k1}^H + v_uZ_{k2}^H\Big) \tag{543}$$



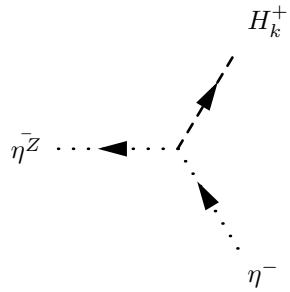
$$\frac{i}{4}g_2\xi_{W^-}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)\Big(v_dZ_{k1}^+ - v_uZ_{k2}^+\Big) \tag{544}$$



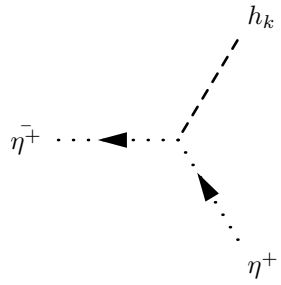
$$\frac{i}{4}g_2\xi_{W^-}\Big(g_1\cos\Theta_W + g_2\sin\Theta_W\Big)\Big(v_dZ_{k1}^+ - v_uZ_{k2}^+\Big) \tag{545}$$



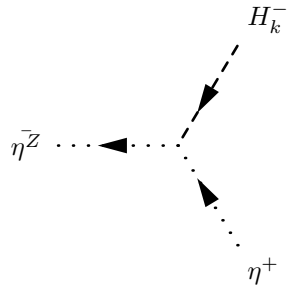
$$-\frac{i}{4}g_2^2\xi_{W^-}\Big(v_d Z_{k1}^H + v_u Z_{k2}^H\Big) \tag{546}$$



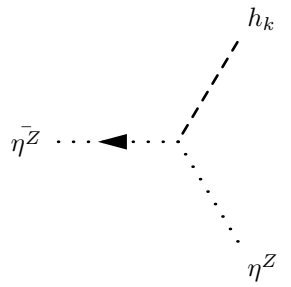
$$-\frac{i}{4}g_2\xi_Z\Big(g_1\sin\Theta_W + g_2\cos\Theta_W\Big)\Big(v_d Z_{k1}^+ - v_u Z_{k2}^+\Big) \tag{547}$$



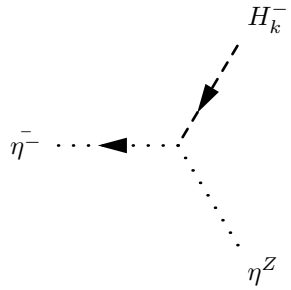
$$-\frac{i}{4}g_2^2\xi_{W^-}\Big(v_d Z_{k1}^H + v_u Z_{k2}^H\Big) \tag{548}$$



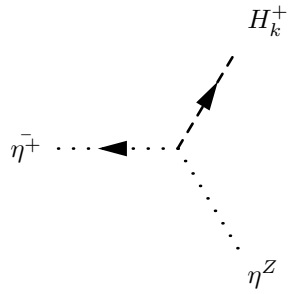
$$-\frac{i}{4}g_2\xi_Z\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)\Big(v_dZ_{k1}^+-v_uZ_{k2}^+\Big) \tag{549}$$



$$-\frac{i}{4}\xi_Z\Big(g_1\sin\Theta_W+g_2\cos\Theta_W\Big)^2\Big(v_dZ_{k1}^H+v_uZ_{k2}^H\Big) \tag{550}$$



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



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

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10 Clebsch-Gordan Coefficients