

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

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1 Superfields

1.1 Vector Superfields

SF	Spin $\frac{1}{2}$	Spin 1	$SU(N)$	Coupling	Name
\hat{B}	$\lambda_{\hat{B}}$	B	$U(1)$	g_1	hypercharge
\hat{W}	$\lambda_{\hat{W}}$	W	$SU(2)$	g_2	left
\hat{g}	$\lambda_{\hat{g}}$	g	$SU(3)$	g_3	color
$\hat{B}p$	λ_{Bp}	Bp	$U(1)$	g'_1	Ncharge

1.2 Chiral Superfields

SF	Spin 0	Spin $\frac{1}{2}$	Generations	$(U(1) \otimes SU(2) \otimes SU(3) \otimes U(1))$
\hat{q}	\tilde{q}	q	3	$(\frac{1}{6}, \mathbf{2}, \mathbf{3}, 1)$
\hat{l}	\tilde{l}	l	3	$(-\frac{1}{2}, \mathbf{2}, \mathbf{1}, 2)$
\hat{H}_d	H_d	\tilde{H}_d	1	$(-\frac{1}{2}, \mathbf{2}, \mathbf{1}, -3)$
\hat{H}_u	H_u	\tilde{H}_u	1	$(\frac{1}{2}, \mathbf{2}, \mathbf{1}, -2)$
\hat{d}	\tilde{d}_R^*	d_R^*	3	$(\frac{1}{3}, \mathbf{1}, \bar{\mathbf{3}}, 2)$
\hat{u}	\tilde{u}_R^*	u_R^*	3	$(-\frac{2}{3}, \mathbf{1}, \bar{\mathbf{3}}, 1)$
\hat{e}	\tilde{e}_R^*	e_R^*	3	$(1, \mathbf{1}, \mathbf{1}, 1)$
\hat{s}	S	\tilde{S}	1	$(0, \mathbf{1}, \mathbf{1}, Q_S)$
$\text{SF}(\text{sbar})$	\bar{S}_R	FsbarR	1	$(0, \mathbf{1}, \mathbf{1}, -Q_S)$
$\hat{D}x$	$\tilde{D}x_L$	FDxL	3	$(-\frac{1}{3}, \mathbf{1}, \mathbf{3}, -2)$
$\hat{\bar{D}}x$	$\tilde{D}x_R^*$	conj(FDxbarR)	3	$(\frac{1}{3}, \mathbf{1}, \bar{\mathbf{3}}, -3)$
\hat{H}'	H'	FHp	1	$(-\frac{1}{2}, \mathbf{2}, \mathbf{1}, 2)$
$\hat{\bar{H}}'$	\bar{H}'	FHpbar	1	$(\frac{1}{2}, \mathbf{2}, \mathbf{1}, -2)$
$\text{SF}(\phi)$	ϕ_R	FphiR	1	$(0, \mathbf{1}, \mathbf{1}, 0)$

2 Superpotential and Lagrangian

2.1 Superpotential

$$\begin{aligned}
W = & XiF_1 \text{SF}(\phi) + \mu' \hat{\bar{H}}' \hat{H}' + \frac{1}{2} Mu_{phi} \text{SF}(\phi) \text{SF}(\phi) - Y_d \hat{d} \hat{q} \hat{H}_d - Y_e \hat{e} \hat{l} \hat{H}_d + \frac{1}{3} \kappa' \text{SF}(\phi) \text{SF}(\phi) \text{SF}(\phi) - \sigma \text{SF}(\phi) \hat{s} \text{SF}(\text{sbar}) \\
& + \kappa \hat{s} \hat{D}x \hat{\bar{D}}x + \lambda \hat{s} \hat{H}_u \hat{H}_d + Y_u \hat{u} \hat{q} \hat{H}_u
\end{aligned} \tag{1}$$

2.2 Softbreaking terms

$$\begin{aligned}
-L_{SB,W} = & + \frac{1}{2} \phi_R^2 B_{muphi} - H'^0 \bar{H}'^0 B_{\mu'} + H'^- \bar{H}'^+ B_{\mu'} + \phi_R \xi_S + \frac{1}{3} \phi_R^3 T_{\kappa'} - H_d^0 H_u^0 ST_\lambda + H_d^- H_u^+ ST_\lambda - \phi_R \bar{S}_R ST_\sigma \\
& + H_d^0 \tilde{d}_{R,i\alpha}^* \delta_{\alpha\beta} \delta_{ij} \tilde{d}_{L,j\beta} T_{d,ij} - H_d^- \tilde{d}_{R,i\alpha}^* \delta_{\alpha\beta} \delta_{ij} \tilde{u}_{L,j\beta} T_{d,ij} + H_d^0 \tilde{e}_{R,i}^* \delta_{ij} \tilde{e}_{L,j} T_{e,ij} \\
& - H_d^- \tilde{e}_{R,i}^* \delta_{ij} \tilde{\nu}_{L,j} T_{e,ij} - H_u^+ \tilde{u}_{R,i\alpha}^* \delta_{\alpha\beta} \delta_{ij} \tilde{d}_{L,j\beta} T_{u,ij} + H_u^0 \tilde{u}_{R,i\alpha}^* \delta_{\alpha\beta} \delta_{ij} \tilde{u}_{L,j\beta} T_{u,ij} \\
& + S \tilde{D} x_{R,k\gamma}^* \delta_{\beta\gamma} \delta_{jk} \tilde{D} x_{L,j\beta} T_{\kappa,jk} + \text{h.c.}
\end{aligned} \tag{2}$$

$$\begin{aligned}
-L_{SB,\phi} = & + m_{h_{13}}^2 |H_d^0|^2 + m_{h_{13}}^2 |H_d^-|^2 + m_{h'}^2 |H'^0|^2 + m_{h'}^2 |H'^-|^2 + m_{h'}^2 |\bar{H}'^0|^2 + m_{h'}^2 |\bar{H}'^+|^2 + m_{h_{23}}^2 |H_u^0|^2 \\
& + m_{h_{23}}^2 |H_u^+|^2 + m_{phi}^2 |\phi_R|^2 + m_{sbar3}^2 |\bar{S}_R|^2 + m_{s3}^2 |S|^2 + \tilde{d}_{L,i\alpha}^* \delta_{\alpha\beta} m_{q,ij}^2 \tilde{d}_{L,j\beta} + \tilde{d}_{R,i\alpha}^* \delta_{\alpha\beta} m_{d,ij}^2 \tilde{d}_{R,j\beta} \\
& + \tilde{D} x_{R,i\alpha}^* \delta_{\alpha\beta} \delta_{ij} m_{X,ij}^2 \tilde{D} x_{R,j\beta} + \tilde{D} x_{L,i\alpha}^* \delta_{\alpha\beta} \delta_{ij} m_{X,ij}^2 \tilde{D} x_{L,j\beta} + \tilde{e}_{L,i}^* m_{l,ij}^2 \tilde{e}_{L,j} + \tilde{e}_{R,i}^* m_{e,ij}^2 \tilde{e}_{R,j} \\
& + \tilde{u}_{L,i\alpha}^* \delta_{\alpha\beta} m_{q,ij}^2 \tilde{u}_{L,j\beta} + \tilde{u}_{R,i\alpha}^* \delta_{\alpha\beta} m_{u,ij}^2 \tilde{u}_{R,j\beta} + \tilde{\nu}_{L,i}^* m_{l,ij}^2 \tilde{\nu}_{L,j}
\end{aligned} \tag{3}$$

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

2.3 Gauge fixing terms

2.3.1 Gauge fixing terms for eigenstates 'GaugeES'

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

2.3.2 Gauge fixing terms for eigenstates 'EWSB'

$$\begin{aligned}
L_{GF} = & -\frac{1}{2} |\partial_\mu g|^2 \xi_g^{-1} - \frac{1}{2} |\partial_\mu \gamma|^2 \xi_\gamma^{-1} - \left| -\frac{i}{2} g_2 \left(H_d^- v_1 - v_2 H_u^{+,*} \right) \xi_{W^-} + \partial_\mu W^- \right|^2 \xi_{W^-}^{-1} \\
& - \frac{1}{2} \left| \frac{1}{2} \left(2 \partial_\mu Z \right. \right. \\
& + \xi_Z \left(g_2 \left(\sigma_d v_1 - \sigma_u v_2 \right) \cos \Theta_W \cos \Theta'_W + g_1 \left(\sigma_d v_1 - \sigma_u v_2 \right) \cos \Theta'_W \sin \Theta_W \right. \right. \\
& \left. \left. - 2 g_1' \left(2 \sigma_u v_2 + 3 \sigma_d v_1 - Q_S \sigma_s v_s + Q_{S \text{sigmaSbar} v s b} \right) \sin \Theta'_W \right) \right|^2 \xi_Z^{-1} \\
& - \frac{1}{2} \left| \frac{1}{2} \left(2 \partial_\mu Z' \right. \right. \\
& \left. \left. - \xi_{Z'} \left(2 g_1' \left(2 \sigma_u v_2 + 3 \sigma_d v_1 - Q_S \sigma_s v_s + Q_{S \text{sigmaSbar} v s b} \right) \cos \Theta'_W \right. \right. \right. \\
& \left. \left. + \left(\sigma_d v_1 - \sigma_u v_2 \right) \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) \right|^2 \xi_{Z'}^{-1}
\end{aligned} \tag{6}$$

2.4 Fields integrated out

None

3 Renormalization Group Equations

3.1 Anomalous Dimensions

$$\gamma_{\hat{q}}^{(1)} = -\frac{1}{60} \left(160g_3^2 + 2g_1^2 + 3g_{1'}^2 + 90g_2^2 \right) \mathbf{1} + Y_d^\dagger Y_d + Y_u^\dagger Y_u \quad (7)$$

$$\begin{aligned} \gamma_{\hat{q}}^{(2)} = & +\frac{1}{7200} \left(2024g_1^4 - 8g_1^2 \left(-160g_3^2 + 51g_{1'}^2 - 90g_2^2 \right) + 120g_{1'}^2 \left(16g_3^2 + 9g_2^2 \right) + 200 \left(189g_2^4 + 256g_3^4 + 288g_2^2g_3^2 \right) \right. \\ & \left. + 9g_{1'}^4 \left(2Q_S^2 + 251 \right) \right) \mathbf{1} \\ & + \frac{1}{5} \left(-10 \left(Y_d^\dagger Y_d Y_d^\dagger Y_d + Y_u^\dagger Y_u Y_u^\dagger Y_u \right) + Y_d^\dagger Y_d \left(-15 \text{Tr} \left(Y_d Y_d^\dagger \right) + 2g_1^2 + 3g_{1'}^2 - 5|\lambda|^2 - 5 \text{Tr} \left(Y_e Y_e^\dagger \right) \right) \right. \\ & \left. + Y_u^\dagger Y_u \left(-15 \text{Tr} \left(Y_u Y_u^\dagger \right) + 4g_1^2 - 5|\lambda|^2 + g_{1'}^2 \right) \right) \end{aligned} \quad (8)$$

$$\gamma_{\hat{t}}^{(1)} = -\frac{1}{10} \left(15g_2^2 + 2g_{1'}^2 + 3g_1^2 \right) \mathbf{1} + Y_e^\dagger Y_e \quad (9)$$

$$\begin{aligned} \gamma_{\hat{t}}^{(2)} = & \frac{1}{200} \left(\left(1050g_2^4 + 120g_1^2g_2^2 + 12g_1^2 \left(15g_2^2 + 8g_{1'}^2 \right) + 522g_1^4 + g_{1'}^4 \left(2Q_S^2 + 257 \right) \right) \mathbf{1} \right. \\ & \left. + 20 \left(-20Y_e^\dagger Y_e Y_e^\dagger Y_e + Y_e^\dagger Y_e \left(-10|\lambda|^2 - 10 \text{Tr} \left(Y_e Y_e^\dagger \right) + 12g_1^2 - 30 \text{Tr} \left(Y_d Y_d^\dagger \right) + 3g_{1'}^2 \right) \right) \right) \end{aligned} \quad (10)$$

$$\gamma_{\hat{H}_d}^{(1)} = 3 \text{Tr} \left(Y_d Y_d^\dagger \right) - \frac{3}{10} g_1^2 - \frac{3}{2} g_2^2 - \frac{9}{20} g_{1'}^2 + |\lambda|^2 + \text{Tr} \left(Y_e Y_e^\dagger \right) \quad (11)$$

$$\begin{aligned} \gamma_{\hat{H}_d}^{(2)} = & -3\lambda^2 \lambda^{*,2} + \frac{1}{20} |\lambda|^2 \left(-20\sigma\sigma'^*,* - 5g_{1'}^2 - 60 \text{Tr} \left(\kappa \kappa^\dagger \right) - 60 \text{Tr} \left(Y_u Y_u^\dagger \right) + g_{1'}^2 Q_S^2 \right) \\ & + \frac{1}{800} \left(-160 \left(2g_1^2 + 3g_{1'}^2 - 80g_3^2 \right) \text{Tr} \left(Y_d Y_d^\dagger \right) + 160 \left(6g_1^2 - g_{1'}^2 \right) \text{Tr} \left(Y_e Y_e^\dagger \right) \right. \\ & + 3 \left(696g_1^4 - 72g_1^2g_{1'}^2 + 801g_{1'}^4 + 240g_1^2g_2^2 + 360g_{1'}^2g_2^2 + 1400g_2^4 + 6g_{1'}^4 Q_S^2 - 2400 \text{Tr} \left(Y_d Y_d^\dagger Y_d Y_d^\dagger \right) \right. \\ & \left. \left. - 800 \text{Tr} \left(Y_d Y_u^\dagger Y_u Y_d^\dagger \right) - 800 \text{Tr} \left(Y_e Y_e^\dagger Y_e Y_e^\dagger \right) \right) \right) \end{aligned} \quad (12)$$

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

$$\begin{aligned} \gamma_{\hat{H}_u}^{(2)} = & \frac{1}{200} \left(522g_1^4 + 96g_1^2g_{1'}^2 + 257g_{1'}^4 + 180g_1^2g_2^2 + 120g_{1'}^2g_2^2 + 1050g_2^4 + 2g_{1'}^4 Q_S^2 - 600\lambda^2 \lambda^{*,2} \right. \\ & + 20 \left(160g_3^2 - 3g_{1'}^2 + 8g_1^2 \right) \text{Tr} \left(Y_u Y_u^\dagger \right) \\ & + 10|\lambda|^2 \left(-20 \text{Tr} \left(Y_e Y_e^\dagger \right) - 20\sigma\sigma'^*,* + 5g_{1'}^2 - 60 \text{Tr} \left(\kappa \kappa^\dagger \right) - 60 \text{Tr} \left(Y_d Y_d^\dagger \right) + g_{1'}^2 Q_S^2 \right) \\ & \left. - 600 \text{Tr} \left(Y_d Y_u^\dagger Y_u Y_d^\dagger \right) - 1800 \text{Tr} \left(Y_u Y_u^\dagger Y_u Y_u^\dagger \right) \right) \end{aligned} \quad (14)$$

$$\gamma_{\hat{d}}^{(1)} = \frac{1}{15} \left(- \left(2g_1^2 + 3g_{1'}^2 + 40g_3^2 \right) \mathbf{1} + 30Y_d^* Y_d^T \right) \quad (15)$$

$$\begin{aligned} \gamma_{\hat{d}}^{(2)} = & +\frac{1}{1800} \left(12800g_3^4 - 16g_1^2 \left(21g_{1'}^2 - 80g_3^2 \right) + 1920g_{1'}^2g_3^2 + 2048g_1^4 + 9g_{1'}^4 \left(2Q_S^2 + 257 \right) \right) \mathbf{1} \\ & - 2 \left(Y_d^* Y_d^T Y_d^* Y_d^T + Y_d^* Y_u^T Y_u^* Y_d^T \right) \\ & + Y_d^* Y_d^T \left(-2|\lambda|^2 - 2 \text{Tr} \left(Y_e Y_e^\dagger \right) + 6g_2^2 - 6 \text{Tr} \left(Y_d Y_d^\dagger \right) + \frac{2}{5} g_1^2 + \frac{3}{5} g_{1'}^2 \right) \end{aligned} \quad (16)$$

$$\gamma_{\hat{u}}^{(1)} = 2Y_u^* Y_u^T - \frac{1}{60} (160g_3^2 + 32g_1^2 + 3g_{1'}^2) \mathbf{1} \quad (17)$$

$$\begin{aligned} \gamma_{\hat{u}}^{(2)} = & + \frac{1}{7200} (1920g_{1'}^2 g_3^2 + 34304g_1^4 + 51200g_3^4 + 64g_1^2 (320g_3^2 + 33g_{1'}^2) + 9g_{1'}^4 (2Q_S^2 + 251)) \mathbf{1} \\ & - \frac{2}{5} (5(Y_u^* Y_d^T Y_d^* Y_u^T + Y_u^* Y_u^T Y_u^* Y_u^T) + Y_u^* Y_u^T (-15g_2^2 + 15\text{Tr}(Y_u Y_u^\dagger) + 5|\lambda|^2 - g_{1'}^2 + g_1^2)) \end{aligned} \quad (18)$$

$$\gamma_{\hat{e}}^{(1)} = 2Y_e^* Y_e^T - \frac{1}{20} (24g_1^2 + g_{1'}^2) \mathbf{1} \quad (19)$$

$$\begin{aligned} \gamma_{\hat{e}}^{(2)} = & + \frac{1}{800} (-192g_{1'}^2 g_1^2 + 9216g_1^4 + g_{1'}^4 (2Q_S^2 + 251)) \mathbf{1} \\ & - \frac{2}{5} (5Y_e^* Y_e^T Y_e^* Y_e^T + Y_e^* Y_e^T (-15g_2^2 + 15\text{Tr}(Y_d Y_d^\dagger) - 3g_{1'}^2 + 3g_1^2 + 5|\lambda|^2 + 5\text{Tr}(Y_e Y_e^\dagger))) \end{aligned} \quad (20)$$

$$\gamma_{\hat{s}}^{(1)} = 2|\lambda|^2 + 3\text{Tr}(\kappa\kappa^\dagger) - \frac{1}{20} g_{1'}^2 Q_S^2 + |\sigma|^2 \quad (21)$$

$$\begin{aligned} \gamma_{\hat{s}}^{(2)} = & + \frac{249}{800} g_{1'}^4 Q_S^2 + \frac{1}{200} g_{1'}^4 Q_S^4 - 4\lambda^2 \lambda^{*,2} - 2\sigma|\kappa'|^2 \sigma'^{*} - 2\sigma^2 \sigma'^{*,2} \\ & + \frac{1}{10} |\lambda|^2 (12g_1^2 + 13g_{1'}^2 - 20\text{Tr}(Y_e Y_e^\dagger) + 60g_2^2 - 60\text{Tr}(Y_d Y_d^\dagger) - 60\text{Tr}(Y_u Y_u^\dagger) - g_{1'}^2 Q_S^2) \\ & + \frac{4}{5} g_1^2 \text{Tr}(\kappa\kappa^\dagger) + \frac{39}{20} g_{1'}^2 \text{Tr}(\kappa\kappa^\dagger) + 16g_3^2 \text{Tr}(\kappa\kappa^\dagger) - \frac{3}{20} g_{1'}^2 Q_S^2 \text{Tr}(\kappa\kappa^\dagger) - 6\text{Tr}(\kappa\kappa^\dagger \kappa\kappa^\dagger) \end{aligned} \quad (22)$$

$$\gamma_{\text{SF}(\text{sbar})}^{(1)} = -\frac{1}{20} g_{1'}^2 Q_S^2 + |\sigma|^2 \quad (23)$$

$$\gamma_{\text{SF}(\text{sbar})}^{(2)} = -2\sigma^2 \sigma'^{*,2} - 2\sigma|\kappa'|^2 \sigma'^{*} - 2\sigma|\lambda|^2 \sigma'^{*} - 3|\sigma|^2 \text{Tr}(\kappa\kappa^\dagger) + \frac{1}{200} g_{1'}^4 Q_S^4 + \frac{249}{800} g_{1'}^4 Q_S^2 \quad (24)$$

$$\gamma_{\hat{D}x}^{(1)} = -\frac{1}{15} (2g_1^2 + 3g_{1'}^2 + 40g_3^2) \mathbf{1} + \kappa^* \kappa^T \quad (25)$$

$$\begin{aligned} \gamma_{\hat{D}x}^{(2)} = & + \frac{1}{1800} (12800g_3^4 - 16g_1^2 (21g_{1'}^2 - 80g_3^2) + 1920g_{1'}^2 g_3^2 + 2048g_1^4 + 9g_{1'}^4 (2Q_S^2 + 257)) \mathbf{1} - \kappa^* \kappa^T \kappa^* \kappa^T \\ & + \kappa^* \kappa^T (-2|\lambda|^2 - 3\text{Tr}(\kappa\kappa^\dagger) + \frac{1}{20} g_{1'}^2 Q_S^2 + \frac{1}{4} g_{1'}^2 - |\sigma|^2) \end{aligned} \quad (26)$$

$$\gamma_{\hat{D}x}^{(1)} = -\frac{1}{60} (160g_3^2 + 27g_{1'}^2 + 8g_1^2) \mathbf{1} + \kappa^\dagger \kappa \quad (27)$$

$$\begin{aligned} \gamma_{\hat{D}x}^{(2)} = & + \frac{1}{7200} (128g_1^2 (27g_{1'}^2 + 40g_3^2) + 17280g_{1'}^2 g_3^2 + 51200g_3^4 + 8192g_1^4 + 81g_{1'}^4 (2Q_S^2 + 267)) \mathbf{1} - \kappa^\dagger \kappa \kappa^\dagger \kappa \\ & + \kappa^\dagger \kappa (-2|\lambda|^2 - 3\text{Tr}(\kappa\kappa^\dagger) + \frac{1}{20} g_{1'}^2 Q_S^2 - \frac{1}{4} g_{1'}^2 - |\sigma|^2) \end{aligned} \quad (28)$$

$$\gamma_{\hat{H}'}^{(1)} = \frac{1}{10} (-15g_2^2 - 2g_{1'}^2 - 3g_1^2) \quad (29)$$

$$\gamma_{\hat{H}'}^{(2)} = \frac{1}{200} (1050g_2^4 + 120g_{1'}^2 g_2^2 + 12g_1^2 (15g_2^2 + 8g_{1'}^2) + 522g_1^4 + g_{1'}^4 (2Q_S^2 + 257)) \quad (30)$$

$$\gamma_{\hat{H}'}^{(1)} = \frac{1}{10} (-15g_2^2 - 2g_{1'}^2 - 3g_1^2) \quad (31)$$

$$\gamma_{\hat{H}'}^{(2)} = \frac{1}{200} (1050g_2^4 + 120g_{1'}^2 g_2^2 + 12g_1^2 (15g_2^2 + 8g_{1'}^2) + 522g_1^4 + g_{1'}^4 (2Q_S^2 + 257)) \quad (32)$$

$$\gamma_{\text{SF}}^{(1)}(\phi) = 2|\kappa'|^2 + |\sigma|^2 \quad (33)$$

$$\gamma_{\text{SF}}^{(2)}(\phi) = -4\sigma|\kappa'|^2\sigma'^{*} - 8\kappa'^{*,2}\kappa'^{*,2} - \frac{1}{10}|\sigma|^2(20\lambda\lambda^* + 20\sigma\sigma'^{*} + 30\text{Tr}(\kappa\kappa^\dagger) - g_1^2 Q_S^2) \quad (34)$$

3.2 Gauge Couplings

$$\beta_{g_1}^{(1)} = \frac{42}{5}g_1^3 \quad (35)$$

$$\begin{aligned} \beta_{g_1}^{(2)} = & \frac{1}{50}g_1^3(432g_1^2 + 123g_1'^2 + 360g_2^2 + 1200g_3^2 - 60|\lambda|^2 - 140\text{Tr}(Y_d Y_d^\dagger) - 180\text{Tr}(Y_e Y_e^\dagger) - 260\text{Tr}(Y_u Y_u^\dagger) \\ & - 40\text{Tr}(\kappa\kappa^\dagger)) \end{aligned} \quad (36)$$

$$\beta_{g_2}^{(1)} = 2g_2^3 \quad (37)$$

$$\beta_{g_2}^{(2)} = \frac{1}{10}g_2^3(-20|\lambda|^2 - 20\text{Tr}(Y_e Y_e^\dagger) + 21g_1'^2 + 240g_3^2 + 24g_1^2 + 320g_2^2 - 60\text{Tr}(Y_d Y_d^\dagger) - 60\text{Tr}(Y_u Y_u^\dagger)) \quad (38)$$

$$\beta_{g_3}^{(1)} = 0 \quad (39)$$

$$\beta_{g_3}^{(2)} = g_3^3(-2\text{Tr}(\kappa\kappa^\dagger) + 3g_1'^2 + 3g_1^2 + 48g_3^2 - 4\text{Tr}(Y_d Y_d^\dagger) - 4\text{Tr}(Y_u Y_u^\dagger) + 9g_2^2) \quad (40)$$

$$\beta_{g_1'}^{(1)} = \frac{1}{40}g_1'^3(2Q_S^2 + 249) \quad (41)$$

$$\begin{aligned} \beta_{g_1'}^{(2)} = & \frac{1}{400}g_1'^3(984g_1^2 + 1401g_1'^2 + 2520g_2^2 + 9600g_3^2 + 2g_1'^2 Q_S^4 - 40(13 + Q_S^2)|\lambda|^2 - 40Q_S^2|\sigma|^2 - 1680\text{Tr}(Y_d Y_d^\dagger) \\ & - 560\text{Tr}(Y_e Y_e^\dagger) - 720\text{Tr}(Y_u Y_u^\dagger) - 780\text{Tr}(\kappa\kappa^\dagger) - 60Q_S^2\text{Tr}(\kappa\kappa^\dagger)) \end{aligned} \quad (42)$$

3.3 Gaugino Mass Parameters

$$\beta_{M_1}^{(1)} = \frac{84}{5}g_1^2 M_1 \quad (43)$$

$$\begin{aligned} \beta_{M_1}^{(2)} = & \frac{1}{25}g_1^2(864g_1^2 M_1 + 123g_1'^2 M_1 + 360g_2^2 M_1 + 1200g_3^2 M_1 + 123g_1'^2 M_1' + 1200g_3^2 M_3 + 360g_2^2 M_2 \\ & - 60\lambda^*(M_1\lambda - T_\lambda) - 140M_1\text{Tr}(Y_d Y_d^\dagger) - 180M_1\text{Tr}(Y_e Y_e^\dagger) - 260M_1\text{Tr}(Y_u Y_u^\dagger) - 40M_1\text{Tr}(\kappa\kappa^\dagger) \\ & + 140\text{Tr}(Y_d^\dagger T_d) + 180\text{Tr}(Y_e^\dagger T_e) + 260\text{Tr}(Y_u^\dagger T_u) + 40\text{Tr}(\kappa^\dagger T_\kappa)) \end{aligned} \quad (44)$$

$$\beta_{M_2}^{(1)} = 4g_2^2 M_2 \quad (45)$$

$$\begin{aligned} \beta_{M_2}^{(2)} = & \frac{1}{5}g_2^2(24g_1^2 M_1 + 21g_1'^2 M_1' + 240g_3^2 M_3 + 24g_1^2 M_2 + 21g_1'^2 M_2 + 640g_2^2 M_2 + 240g_3^2 M_2 - 20\lambda^*(M_2\lambda - T_\lambda) \\ & - 60M_2\text{Tr}(Y_d Y_d^\dagger) - 20M_2\text{Tr}(Y_e Y_e^\dagger) - 60M_2\text{Tr}(Y_u Y_u^\dagger) + 60\text{Tr}(Y_d^\dagger T_d) + 20\text{Tr}(Y_e^\dagger T_e) \end{aligned}$$

$$+ 60\text{Tr}\left(Y_u^\dagger T_u\right)\right) \quad (46)$$

$$\beta_{M_3}^{(1)} = 0 \quad (47)$$

$$\begin{aligned} \beta_{M_3}^{(2)} = & 2g_3^2\left(3g_1^2M_1 + 3g_1^2M_1' + 3g_1^2M_3 + 3g_1^2M_3' + 9g_2^2M_3 + 96g_3^2M_3 + 9g_2^2M_2 - 4M_3\text{Tr}\left(Y_dY_d^\dagger\right)\right. \\ & \left.- 4M_3\text{Tr}\left(Y_uY_u^\dagger\right) - 2M_3\text{Tr}\left(\kappa\kappa^\dagger\right) + 4\text{Tr}\left(Y_d^\dagger T_d\right) + 4\text{Tr}\left(Y_u^\dagger T_u\right) + 2\text{Tr}\left(\kappa^\dagger T_\kappa\right)\right) \end{aligned} \quad (48)$$

$$\beta_{M_1'}^{(1)} = \frac{1}{20}g_1^2M_1'\left(2Q_S^2 + 249\right) \quad (49)$$

$$\begin{aligned} \beta_{M_1'}^{(2)} = & \frac{1}{100}g_1^2\left(492g_1^2M_1 + 492g_1^2M_1' + 1401g_1^2M_1' + 1260g_2^2M_1' + 4800g_3^2M_1' + 4800g_3^2M_3 + 1260g_2^2M_2\right. \\ & + 2g_1^2M_1'Q_S^4 - 20\left(13 + Q_S^2\right)\lambda^*\left(M_1'\lambda - T_\lambda\right) - 20Q_S^2\sigma'^*\left(M_1'\sigma - T_\sigma\right) - 840M_1'\text{Tr}\left(Y_dY_d^\dagger\right) \\ & - 280M_1'\text{Tr}\left(Y_eY_e^\dagger\right) - 360M_1'\text{Tr}\left(Y_uY_u^\dagger\right) - 390M_1'\text{Tr}\left(\kappa\kappa^\dagger\right) - 30M_1'Q_S^2\text{Tr}\left(\kappa\kappa^\dagger\right) + 840\text{Tr}\left(Y_d^\dagger T_d\right) \\ & \left. + 280\text{Tr}\left(Y_e^\dagger T_e\right) + 360\text{Tr}\left(Y_u^\dagger T_u\right) + 390\text{Tr}\left(\kappa^\dagger T_\kappa\right) + 30Q_S^2\text{Tr}\left(\kappa^\dagger T_\kappa\right)\right) \end{aligned} \quad (50)$$

3.4 Trilinear Superpotential Parameters

$$\beta_{Y_d}^{(1)} = 3Y_dY_d^\dagger Y_d + Y_d\left(-3g_2^2 + 3\text{Tr}\left(Y_dY_d^\dagger\right) - \frac{16}{3}g_3^2 - \frac{7}{10}g_{1'}^2 - \frac{7}{15}g_1^2 + |\lambda|^2 + \text{Tr}\left(Y_eY_e^\dagger\right)\right) + Y_dY_u^\dagger Y_u \quad (51)$$

$$\begin{aligned} \beta_{Y_d}^{(2)} = & + \frac{4}{5}g_1^2Y_dY_u^\dagger Y_u + \frac{1}{5}g_{1'}^2Y_dY_u^\dagger Y_u - |\lambda|^2Y_dY_u^\dagger Y_u - 4Y_dY_d^\dagger Y_dY_d^\dagger Y_d \\ & - 2Y_dY_u^\dagger Y_uY_d^\dagger Y_d - 2Y_dY_u^\dagger Y_uY_u^\dagger Y_u \\ & + Y_dY_d^\dagger Y_d\left(-3|\lambda|^2 - 3\text{Tr}\left(Y_eY_e^\dagger\right) + 6g_2^2 - 9\text{Tr}\left(Y_dY_d^\dagger\right) + \frac{4}{5}g_1^2 + \frac{6}{5}g_{1'}^2\right) \\ & - 3Y_dY_u^\dagger Y_u\text{Tr}\left(Y_uY_u^\dagger\right) \\ & + Y_d\left(\frac{1813}{450}g_1^4 - \frac{77}{150}g_1^2g_{1'}^2 + \frac{1841}{400}g_{1'}^4 + g_1^2g_2^2 + \frac{3}{2}g_{1'}^2g_2^2 + \frac{21}{2}g_2^4 + \frac{8}{9}g_1^2g_3^2 + \frac{4}{3}g_{1'}^2g_3^2 + 8g_2^2g_3^2\right. \\ & + \frac{128}{9}g_3^4 + \frac{7}{200}g_{1'}^4Q_S^2 - 3\lambda^2\lambda^{*,2} - \frac{1}{5}\left(2g_1^2 + 3g_{1'}^2 - 80g_3^2\right)\text{Tr}\left(Y_dY_d^\dagger\right) + \frac{6}{5}g_1^2\text{Tr}\left(Y_eY_e^\dagger\right) \\ & - \frac{1}{5}g_{1'}^2\text{Tr}\left(Y_eY_e^\dagger\right) + \frac{1}{20}|\lambda|^2\left(-20\sigma\sigma'^* - 5g_{1'}^2 - 60\text{Tr}\left(\kappa\kappa^\dagger\right) - 60\text{Tr}\left(Y_uY_u^\dagger\right) + g_{1'}^2Q_S^2\right) \\ & \left. - 9\text{Tr}\left(Y_dY_d^\dagger Y_dY_d^\dagger\right) - 3\text{Tr}\left(Y_dY_u^\dagger Y_uY_d^\dagger\right) - 3\text{Tr}\left(Y_eY_e^\dagger Y_eY_e^\dagger\right)\right) \end{aligned} \quad (52)$$

$$\beta_{Y_e}^{(1)} = 3Y_eY_e^\dagger Y_e + Y_e\left(-3g_2^2 + 3\text{Tr}\left(Y_dY_d^\dagger\right) - \frac{7}{10}g_{1'}^2 - \frac{9}{5}g_1^2 + |\lambda|^2 + \text{Tr}\left(Y_eY_e^\dagger\right)\right) \quad (53)$$

$$\begin{aligned} \beta_{Y_e}^{(2)} = & -4Y_eY_e^\dagger Y_eY_e^\dagger Y_e + \frac{3}{2}Y_eY_e^\dagger Y_e\left(-2|\lambda|^2 - 2\text{Tr}\left(Y_eY_e^\dagger\right) + 4g_2^2 - 6\text{Tr}\left(Y_dY_d^\dagger\right) + g_{1'}^2\right) \\ & + \frac{1}{400}Y_e\left(6696g_1^4 - 12g_1^2g_{1'}^2 + 1841g_{1'}^4 + 720g_1^2g_2^2 + 780g_{1'}^2g_2^2 + 4200g_2^4 + 14g_{1'}^4Q_S^2 - 1200\lambda^2\lambda^{*,2}\right. \\ & \left.- 80\left(2g_1^2 + 3g_{1'}^2 - 80g_3^2\right)\text{Tr}\left(Y_dY_d^\dagger\right) + 480g_1^2\text{Tr}\left(Y_eY_e^\dagger\right) - 80g_{1'}^2\text{Tr}\left(Y_eY_e^\dagger\right)\right) \end{aligned}$$

$$\begin{aligned}
& + 20|\lambda|^2 \left(-20\sigma\sigma'^{*} - 5g_1^2 - 60\text{Tr}(\kappa\kappa^\dagger) - 60\text{Tr}(Y_u Y_u^\dagger) + g_1^2 Q_S^2 \right) - 3600\text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) \\
& - 1200\text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 1200\text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger)
\end{aligned} \tag{54}$$

$$\beta_{\kappa'}^{(1)} = 3\kappa' \left(2|\kappa'|^2 + |\sigma|^2 \right) \tag{55}$$

$$\beta_{\kappa'}^{(2)} = -\frac{3}{10}\kappa' \left(40\sigma|\kappa'|^2\sigma'^{*} + 80\kappa'^2\kappa'^{*,2} + |\sigma|^2 \left(20\lambda\lambda^* + 20\sigma\sigma'^{*} + 30\text{Tr}(\kappa\kappa^\dagger) - g_1^2 Q_S^2 \right) \right) \tag{56}$$

$$\beta_\sigma^{(1)} = 2\sigma|\kappa'|^2 + 2\sigma|\lambda|^2 + 3\sigma^2\sigma'^{*} + 3\sigma\text{Tr}(\kappa\kappa^\dagger) - \frac{1}{10}g_1^2 Q_S^2 \tag{57}$$

$$\begin{aligned}
\beta_\sigma^{(2)} = & -\frac{1}{400}\sigma \left(-249g_1^4 Q_S^2 - 4g_1^4 Q_S^4 - 40g_1^2 Q_S^2 |\sigma|^2 + 3200\kappa'^2\kappa'^{*,2} + 1600\lambda^2\lambda^{*,2} + 3200\sigma|\kappa'|^2\sigma'^{*} \right. \\
& + 2400\sigma^2\sigma'^{*,2} \\
& - 40|\lambda|^2 \left(12g_1^2 + 13g_1^2 - 20\text{Tr}(Y_e Y_e^\dagger) - 40\sigma\sigma'^{*} + 60g_2^2 - 60\text{Tr}(Y_d Y_d^\dagger) - 60\text{Tr}(Y_u Y_u^\dagger) - g_1^2 Q_S^2 \right) \\
& - 320g_1^2 \text{Tr}(\kappa\kappa^\dagger) - 780g_1^2 \text{Tr}(\kappa\kappa^\dagger) - 6400g_3^2 \text{Tr}(\kappa\kappa^\dagger) + 60g_1^2 Q_S^2 \text{Tr}(\kappa\kappa^\dagger) \\
& \left. + 2400|\sigma|^2 \text{Tr}(\kappa\kappa^\dagger) + 2400\text{Tr}(\kappa\kappa^\dagger \kappa\kappa^\dagger) \right)
\end{aligned} \tag{58}$$

$$\beta_\kappa^{(1)} = 2\kappa\kappa^\dagger \kappa + \kappa \left(2|\lambda|^2 + 3\text{Tr}(\kappa\kappa^\dagger) - \frac{1}{20}g_1^2 Q_S^2 - \frac{13}{20}g_1^2 - \frac{16}{3}g_3^2 - \frac{4}{15}g_1^2 + |\sigma|^2 \right) \tag{59}$$

$$\begin{aligned}
\beta_\kappa^{(2)} = & -2\kappa\kappa^\dagger \kappa\kappa^\dagger \kappa + \kappa\kappa^\dagger \kappa \left(-2|\sigma|^2 - 4|\lambda|^2 - 6\text{Tr}(\kappa\kappa^\dagger) + \frac{1}{10}g_1^2 Q_S^2 \right) \\
& + \kappa \left(\frac{512}{225}g_1^4 + \frac{22}{75}g_1^2 g_1^2 + \frac{3431}{800}g_1^4 + \frac{64}{45}g_1^2 g_3^2 + \frac{52}{15}g_1^2 g_3^2 + \frac{128}{9}g_3^4 + \frac{11}{32}g_1^4 Q_S^2 + \frac{1}{200}g_1^4 Q_S^4 - 4\lambda^2\lambda^{*,2} \right. \\
& - 2\sigma|\kappa'|^2\sigma'^{*} - 2\sigma^2\sigma'^{*,2} \\
& + \frac{1}{10}|\lambda|^2 \left(12g_1^2 + 13g_1^2 - 20\text{Tr}(Y_e Y_e^\dagger) + 60g_2^2 - 60\text{Tr}(Y_d Y_d^\dagger) - 60\text{Tr}(Y_u Y_u^\dagger) - g_1^2 Q_S^2 \right) \\
& \left. + \frac{4}{5}g_1^2 \text{Tr}(\kappa\kappa^\dagger) + \frac{39}{20}g_1^2 \text{Tr}(\kappa\kappa^\dagger) + 16g_3^2 \text{Tr}(\kappa\kappa^\dagger) - \frac{3}{20}g_1^2 Q_S^2 \text{Tr}(\kappa\kappa^\dagger) - 6\text{Tr}(\kappa\kappa^\dagger \kappa\kappa^\dagger) \right)
\end{aligned} \tag{60}$$

$$\begin{aligned}
\beta_\lambda^{(1)} = & \frac{1}{20}\lambda \left(-12g_1^2 - 13g_1^2 - 60g_2^2 - g_1^2 Q_S^2 + 80|\lambda|^2 + 20|\sigma|^2 + 60\text{Tr}(Y_d Y_d^\dagger) + 20\text{Tr}(Y_e Y_e^\dagger) \right. \\
& \left. + 60\text{Tr}(Y_u Y_u^\dagger) + 60\text{Tr}(\kappa\kappa^\dagger) \right)
\end{aligned} \tag{61}$$

$$\begin{aligned}
\beta_\lambda^{(2)} = & -\frac{1}{800}\lambda \left(-4176g_1^4 - 168g_1^2 g_1^2 - 3431g_1^4 - 1440g_1^2 g_2^2 - 1560g_1^2 g_2^2 - 8400g_2^4 - 275g_1^4 Q_S^2 \right. \\
& - 4g_1^4 Q_S^4 + 8000\lambda^2\lambda^{*,2} + 1600\sigma|\kappa'|^2\sigma'^{*} + 1600\sigma^2\sigma'^{*,2} + 320g_1^2 \text{Tr}(Y_d Y_d^\dagger) \\
& + 480g_1^2 \text{Tr}(Y_d Y_d^\dagger) - 12800g_3^2 \text{Tr}(Y_d Y_d^\dagger) - 960g_1^2 \text{Tr}(Y_e Y_e^\dagger) + 160g_1^2 \text{Tr}(Y_e Y_e^\dagger) \\
& - 640g_1^2 \text{Tr}(Y_u Y_u^\dagger) + 240g_1^2 \text{Tr}(Y_u Y_u^\dagger) - 12800g_3^2 \text{Tr}(Y_u Y_u^\dagger) \\
& - 80|\lambda|^2 \left(12g_1^2 + 13g_1^2 - 20\sigma\sigma'^{*} - 30\text{Tr}(Y_e Y_e^\dagger) + 60g_2^2 - 60\text{Tr}(\kappa\kappa^\dagger) - 90\text{Tr}(Y_d Y_d^\dagger) - 90\text{Tr}(Y_u Y_u^\dagger) \right) \\
& \left. - 640g_1^2 \text{Tr}(\kappa\kappa^\dagger) - 1560g_1^2 \text{Tr}(\kappa\kappa^\dagger) - 12800g_3^2 \text{Tr}(\kappa\kappa^\dagger) + 120g_1^2 Q_S^2 \text{Tr}(\kappa\kappa^\dagger) \right)
\end{aligned}$$

$$\begin{aligned}
& + 7200\text{Tr}\left(Y_d Y_d^\dagger Y_d Y_d^\dagger\right) + 4800\text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) + 2400\text{Tr}\left(Y_e Y_e^\dagger Y_e Y_e^\dagger\right) + 7200\text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right) \\
& + 4800\text{Tr}\left(\kappa \kappa^\dagger \kappa \kappa^\dagger\right)
\end{aligned} \tag{62}$$

$$\beta_{Y_u}^{(1)} = 3Y_u Y_u^\dagger Y_u - \frac{1}{30}Y_u \left(160g_3^2 + 26g_1^2 - 30|\lambda|^2 + 90g_2^2 - 90\text{Tr}\left(Y_u Y_u^\dagger\right) + 9g_{1'}^2\right) + Y_u Y_d^\dagger Y_d \tag{63}$$

$$\begin{aligned}
\beta_{Y_u}^{(2)} = & + \frac{2}{5}g_1^2 Y_u Y_u^\dagger Y_u + \frac{3}{5}g_1^2 Y_u Y_u^\dagger Y_u + 6g_2^2 Y_u Y_u^\dagger Y_u - 3|\lambda|^2 Y_u Y_u^\dagger Y_u \\
& - 2Y_u Y_d^\dagger Y_d Y_d^\dagger Y_d - 2Y_u Y_d^\dagger Y_d Y_u^\dagger Y_u - 4Y_u Y_u^\dagger Y_u Y_u^\dagger Y_u \\
& + \frac{1}{5}Y_u Y_d^\dagger Y_d \left(-15\text{Tr}\left(Y_d Y_d^\dagger\right) + 2g_1^2 + 3g_{1'}^2 - 5|\lambda|^2 - 5\text{Tr}\left(Y_e Y_e^\dagger\right)\right) - 9Y_u Y_u^\dagger Y_u \text{Tr}\left(Y_u Y_u^\dagger\right) \\
& + Y_u \left(\frac{689}{90}g_1^4 + \frac{43}{60}g_1^2 g_{1'}^2 + \frac{153}{80}g_1^4 + g_1^2 g_2^2 + \frac{3}{4}g_1^2 g_{1'}^2 + \frac{21}{2}g_2^4 + \frac{136}{45}g_1^2 g_3^2 + \frac{8}{15}g_1^2 g_3^2 + 8g_2^2 g_3^2\right. \\
& + \frac{128}{9}g_3^4 + \frac{3}{200}g_1^4 Q_S^2 - 3\lambda^2 \lambda^{*,2} + \frac{1}{10}\left(160g_3^2 - 3g_{1'}^2 + 8g_1^2\right)\text{Tr}\left(Y_u Y_u^\dagger\right) \\
& + \frac{1}{20}|\lambda|^2 \left(-20\text{Tr}\left(Y_e Y_e^\dagger\right) - 20\sigma\sigma'^{*} + 5g_{1'}^2 - 60\text{Tr}\left(\kappa \kappa^\dagger\right) - 60\text{Tr}\left(Y_d Y_d^\dagger\right) + g_1^2 Q_S^2\right) \\
& \left. - 3\text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) - 9\text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right)\right)
\end{aligned} \tag{64}$$

3.5 Bilinear Superpotential Parameters

$$\beta_{\mu'}^{(1)} = -\frac{1}{5}\left(15g_2^2 + 2g_{1'}^2 + 3g_1^2\right)\mu' \tag{65}$$

$$\beta_{\mu'}^{(2)} = \frac{1}{100}\left(1050g_2^4 + 120g_1^2 g_2^2 + 12g_1^2\left(15g_2^2 + 8g_{1'}^2\right) + 522g_1^4 + g_1^4\left(2Q_S^2 + 257\right)\right)\mu' \tag{66}$$

$$\beta_{Mu_{phi}}^{(1)} = 2Mu_{phi}\left(2|\kappa'|^2 + |\sigma|^2\right) \tag{67}$$

$$\beta_{Mu_{phi}}^{(2)} = -\frac{1}{5}Mu_{phi}\left(40\sigma|\kappa'|^2\sigma'^{*} + 80\kappa'^2\kappa'^{*,2} + |\sigma|^2\left(20\lambda\lambda^* + 20\sigma\sigma'^{*} + 30\text{Tr}\left(\kappa \kappa^\dagger\right) - g_1^2 Q_S^2\right)\right) \tag{68}$$

3.6 Linear Superpotential Parameters

$$\beta_{XiF_1}^{(1)} = XiF_1\left(2|\kappa'|^2 + |\sigma|^2\right) \tag{69}$$

$$\beta_{XiF_1}^{(2)} = -\frac{1}{10}XiF_1\left(40\sigma|\kappa'|^2\sigma'^{*} + 80\kappa'^2\kappa'^{*,2} + |\sigma|^2\left(20\lambda\lambda^* + 20\sigma\sigma'^{*} + 30\text{Tr}\left(\kappa \kappa^\dagger\right) - g_1^2 Q_S^2\right)\right) \tag{70}$$

3.7 Trilinear Soft-Breaking Parameters

$$\beta_{T_d}^{(1)} = +4Y_d Y_d^\dagger T_d + 2Y_d Y_u^\dagger T_u + 5T_d Y_d^\dagger Y_d + T_d Y_u^\dagger Y_u - \frac{7}{15}g_1^2 T_d - \frac{7}{10}g_{1'}^2 T_d - 3g_2^2 T_d$$

$$\begin{aligned}
& -\frac{16}{3}g_3^2T_d + |\lambda|^2T_d + 3T_d\text{Tr}\left(Y_dY_d^\dagger\right) + T_d\text{Tr}\left(Y_eY_e^\dagger\right) \\
& + Y_d\left(2\lambda^*T_\lambda + 2\text{Tr}\left(Y_e^\dagger T_e\right) + 6g_2^2M_2 + 6\text{Tr}\left(Y_d^\dagger T_d\right) + \frac{14}{15}g_1^2M_1 + \frac{32}{3}g_3^2M_3 + \frac{7}{5}g_1^2M_1'\right) \\
\beta_{T_d}^{(2)} = & + \frac{6}{5}g_1^2Y_dY_d^\dagger T_d + \frac{9}{5}g_1^2Y_dY_d^\dagger T_d + 6g_2^2Y_dY_d^\dagger T_d - 4|\lambda|^2Y_dY_d^\dagger T_d \\
& - \frac{8}{5}g_1^2M_1Y_dY_u^\dagger Y_u - \frac{2}{5}g_1^2M_1'Y_dY_u^\dagger Y_u + \frac{8}{5}g_1^2Y_dY_u^\dagger T_u + \frac{2}{5}g_1^2Y_dY_u^\dagger T_u \\
& - 2|\lambda|^2Y_dY_u^\dagger T_u + \frac{6}{5}g_1^2T_dY_d^\dagger Y_d + \frac{9}{5}g_1^2T_dY_d^\dagger Y_d + 12g_2^2T_dY_d^\dagger Y_d \\
& - 5|\lambda|^2T_dY_d^\dagger Y_d + \frac{4}{5}g_1^2T_dY_u^\dagger Y_u + \frac{1}{5}g_1^2T_dY_u^\dagger Y_u - |\lambda|^2T_dY_u^\dagger Y_u \\
& - 6Y_dY_d^\dagger Y_dY_d^\dagger T_d - 8Y_dY_d^\dagger T_dY_d^\dagger Y_d - 2Y_dY_u^\dagger Y_uY_d^\dagger T_d - 4Y_dY_u^\dagger Y_uY_u^\dagger T_u \\
& - 4Y_dY_u^\dagger T_uY_d^\dagger Y_d - 4Y_dY_u^\dagger T_uY_u^\dagger Y_u - 6T_dY_d^\dagger Y_dY_d^\dagger Y_d - 4T_dY_u^\dagger Y_uY_d^\dagger Y_d \\
& - 2T_dY_u^\dagger Y_uY_u^\dagger Y_u + \frac{1813}{450}g_1^4T_d + \frac{49}{150}g_1^2g_1^2T_d + \frac{1841}{400}g_1^4T_d + g_1^2g_2^2T_d + \frac{3}{2}g_1^2g_2^2T_d + \frac{21}{2}g_2^4T_d \\
& + \frac{8}{9}g_1^2g_3^2T_d + \frac{4}{3}g_1^2g_3^2T_d + 8g_2^2g_3^2T_d + \frac{128}{9}g_3^4T_d + \frac{7}{200}g_1^4Q_S^2T_d - \frac{1}{4}g_1^2|\lambda|^2T_d \\
& + \frac{1}{20}g_1^2Q_S^2|\lambda|^2T_d - 3\lambda^2\lambda^{*,2}T_d - \sigma|\lambda|^2\sigma'^*T_d - 2\lambda^*Y_dY_u^\dagger Y_uT_\lambda \\
& - 12Y_dY_d^\dagger T_d\text{Tr}\left(Y_dY_d^\dagger\right) - 15T_dY_d^\dagger Y_d\text{Tr}\left(Y_dY_d^\dagger\right) - \frac{2}{5}g_1^2T_d\text{Tr}\left(Y_dY_d^\dagger\right) \\
& - \frac{3}{5}g_1^2T_d\text{Tr}\left(Y_dY_d^\dagger\right) + 16g_3^2T_d\text{Tr}\left(Y_dY_d^\dagger\right) - 4Y_dY_d^\dagger T_d\text{Tr}\left(Y_eY_e^\dagger\right) \\
& - 5T_dY_d^\dagger Y_d\text{Tr}\left(Y_eY_e^\dagger\right) + \frac{6}{5}g_1^2T_d\text{Tr}\left(Y_eY_e^\dagger\right) - \frac{1}{5}g_1^2T_d\text{Tr}\left(Y_eY_e^\dagger\right) \\
& - 6Y_dY_u^\dagger T_u\text{Tr}\left(Y_uY_u^\dagger\right) - 3T_dY_u^\dagger Y_u\text{Tr}\left(Y_uY_u^\dagger\right) - 3|\lambda|^2T_d\text{Tr}\left(Y_uY_u^\dagger\right) \\
& - 3|\lambda|^2T_d\text{Tr}\left(\kappa\kappa^\dagger\right) \\
& - \frac{2}{5}Y_dY_d^\dagger Y_d\left(15\lambda^*T_\lambda + 15\text{Tr}\left(Y_e^\dagger T_e\right) + 30g_2^2M_2 + 45\text{Tr}\left(Y_d^\dagger T_d\right) + 4g_1^2M_1 + 6g_1^2M_1'\right) \\
& - 6Y_dY_u^\dagger Y_u\text{Tr}\left(Y_u^\dagger T_u\right) - 9T_d\text{Tr}\left(Y_dY_d^\dagger Y_dY_d^\dagger\right) - 3T_d\text{Tr}\left(Y_dY_u^\dagger Y_uY_d^\dagger\right) \\
& - 3T_d\text{Tr}\left(Y_eY_e^\dagger Y_eY_e^\dagger\right) \\
& - \frac{1}{900}Y_d\left(14504g_1^4M_1 + 588g_1^2g_1^2M_1 + 1800g_1^2g_2^2M_1 + 1600g_1^2g_3^2M_1 + 588g_1^2g_1^2M_1' + 16569g_1^4M_1' \right. \\
& + 2700g_1^2g_2^2M_1' + 2400g_1^2g_3^2M_1' + 1600g_1^2g_3^2M_3 + 2400g_1^2g_3^2M_3 + 14400g_2^2g_3^2M_3 \\
& + 51200g_3^4M_3 + 1800g_1^2g_2^2M_2 + 2700g_1^2g_2^2M_2 + 37800g_2^4M_2 + 14400g_2^2g_3^2M_2 + 126g_1^4M_1'Q_S^2 \\
& + 10800\lambda\lambda^{*,2}T_\lambda - 360\left(2g_1^2M_1 + 3g_1^2M_1' - 80g_3^2M_3\right)\text{Tr}\left(Y_dY_d^\dagger\right) + 2160g_1^2M_1\text{Tr}\left(Y_eY_e^\dagger\right) \\
& - 360g_1^2M_1'\text{Tr}\left(Y_eY_e^\dagger\right) + 720g_1^2\text{Tr}\left(Y_d^\dagger T_d\right) + 1080g_1^2\text{Tr}\left(Y_d^\dagger T_d\right) - 28800g_3^2\text{Tr}\left(Y_d^\dagger T_d\right) \\
& \left. - 2160g_1^2\text{Tr}\left(Y_e^\dagger T_e\right) + 360g_1^2\text{Tr}\left(Y_e^\dagger T_e\right)\right)
\end{aligned} \tag{71}$$

$$\begin{aligned}
& + 90\lambda^* \left(T_\lambda \left(20|\sigma|^2 + 5g_1'^2 + 60\text{Tr}(\kappa\kappa^\dagger) + 60\text{Tr}(Y_u Y_u^\dagger) - g_1'^2 Q_S^2 \right) \right. \\
& + \lambda \left(20\sigma'^* T_\sigma - 5g_1'^2 M_1' + 60\text{Tr}(\kappa^\dagger T_\kappa) + 60\text{Tr}(Y_u^\dagger T_u) + g_1'^2 M_1' Q_S^2 \right) \\
& \left. + 32400\text{Tr}(Y_d Y_d^\dagger T_d Y_d^\dagger) + 5400\text{Tr}(Y_d Y_u^\dagger T_u Y_d^\dagger) + 10800\text{Tr}(Y_e Y_e^\dagger T_e Y_e^\dagger) + 5400\text{Tr}(Y_u Y_d^\dagger T_d Y_u^\dagger) \right) \quad (72)
\end{aligned}$$

$$\begin{aligned}
\beta_{T_e}^{(1)} = & + 4Y_e Y_e^\dagger T_e + 5T_e Y_e^\dagger Y_e - \frac{9}{5}g_1^2 T_e - \frac{7}{10}g_1'^2 T_e - 3g_2^2 T_e + |\lambda|^2 T_e + 3T_e \text{Tr}(Y_d Y_d^\dagger) \\
& + T_e \text{Tr}(Y_e Y_e^\dagger) + Y_e \left(2\lambda^* T_\lambda + 2\text{Tr}(Y_e^\dagger T_e) + 6g_2^2 M_2 + 6\text{Tr}(Y_d^\dagger T_d) + \frac{18}{5}g_1^2 M_1 + \frac{7}{5}g_1'^2 M_1' \right) \quad (73)
\end{aligned}$$

$$\begin{aligned}
\beta_{T_e}^{(2)} = & + \frac{6}{5}g_1^2 Y_e Y_e^\dagger T_e + \frac{9}{5}g_1'^2 Y_e Y_e^\dagger T_e + 6g_2^2 Y_e Y_e^\dagger T_e - 4|\lambda|^2 Y_e Y_e^\dagger T_e \\
& - \frac{6}{5}g_1^2 T_e Y_e^\dagger Y_e + \frac{27}{10}g_1'^2 T_e Y_e^\dagger Y_e + 12g_2^2 T_e Y_e^\dagger Y_e - 5|\lambda|^2 T_e Y_e^\dagger Y_e \\
& - 6Y_e Y_e^\dagger Y_e Y_e^\dagger T_e - 8Y_e Y_e^\dagger T_e Y_e^\dagger Y_e - 6T_e Y_e^\dagger Y_e Y_e^\dagger Y_e + \frac{837}{50}g_1^4 T_e + \frac{51}{100}g_1^2 g_1'^2 T_e + \frac{1841}{400}g_1^4 T_e \\
& + \frac{9}{5}g_1^2 g_2^2 T_e + \frac{39}{20}g_1^2 g_2^2 T_e + \frac{21}{2}g_2^4 T_e + \frac{7}{200}g_1^4 Q_S^2 T_e - \frac{1}{4}g_1'^2 |\lambda|^2 T_e + \frac{1}{20}g_1^2 Q_S^2 |\lambda|^2 T_e \\
& - 3\lambda^2 \lambda^{*,2} T_e - \sigma |\lambda|^2 \sigma'^* T_e - 12Y_e Y_e^\dagger T_e \text{Tr}(Y_d Y_d^\dagger) - 15T_e Y_e^\dagger Y_e \text{Tr}(Y_d Y_d^\dagger) \\
& - \frac{2}{5}g_1^2 T_e \text{Tr}(Y_d Y_d^\dagger) - \frac{3}{5}g_1'^2 T_e \text{Tr}(Y_d Y_d^\dagger) + 16g_3^2 T_e \text{Tr}(Y_d Y_d^\dagger) - 4Y_e Y_e^\dagger T_e \text{Tr}(Y_e Y_e^\dagger) \\
& - 5T_e Y_e^\dagger Y_e \text{Tr}(Y_e Y_e^\dagger) + \frac{6}{5}g_1^2 T_e \text{Tr}(Y_e Y_e^\dagger) - \frac{1}{5}g_1'^2 T_e \text{Tr}(Y_e Y_e^\dagger) \\
& - 3|\lambda|^2 T_e \text{Tr}(Y_u Y_u^\dagger) - 3|\lambda|^2 T_e \text{Tr}(\kappa\kappa^\dagger) \\
& - 3Y_e Y_e^\dagger Y_e \left(2\lambda^* T_\lambda + 2\text{Tr}(Y_e^\dagger T_e) + 4g_2^2 M_2 + 6\text{Tr}(Y_d^\dagger T_d) + g_1'^2 M_1' \right) - 9T_e \text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) \\
& - 3T_e \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 3T_e \text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) \\
& - \frac{1}{100}Y_e \left(6696g_1^4 M_1 + 102g_1^2 g_1'^2 M_1 + 360g_1^2 g_2^2 M_1 + 102g_1^2 g_1'^2 M_1' + 1841g_1^4 M_1' + 390g_1^2 g_2^2 M_1' \right. \\
& + 360g_1^2 g_2^2 M_2 + 390g_1'^2 g_2^2 M_2 + 4200g_2^4 M_2 + 14g_1^4 M_1' Q_S^2 + 1200\lambda\lambda^{*,2} T_\lambda \\
& - 40 \left(2g_1^2 M_1 + 3g_1'^2 M_1' - 80g_3^2 M_3 \right) \text{Tr}(Y_d Y_d^\dagger) + 240g_1^2 M_1 \text{Tr}(Y_e Y_e^\dagger) - 40g_1'^2 M_1' \text{Tr}(Y_e Y_e^\dagger) \\
& + 80g_1^2 \text{Tr}(Y_d^\dagger T_d) + 120g_1'^2 \text{Tr}(Y_d^\dagger T_d) - 3200g_3^2 \text{Tr}(Y_d^\dagger T_d) - 240g_1^2 \text{Tr}(Y_e^\dagger T_e) \\
& + 40g_1'^2 \text{Tr}(Y_e^\dagger T_e) \\
& + 10\lambda^* \left(T_\lambda \left(20|\sigma|^2 + 5g_1'^2 + 60\text{Tr}(\kappa\kappa^\dagger) + 60\text{Tr}(Y_u Y_u^\dagger) - g_1'^2 Q_S^2 \right) \right. \\
& + \lambda \left(20\sigma'^* T_\sigma - 5g_1'^2 M_1' + 60\text{Tr}(\kappa^\dagger T_\kappa) + 60\text{Tr}(Y_u^\dagger T_u) + g_1'^2 M_1' Q_S^2 \right) \\
& \left. + 3600\text{Tr}(Y_d Y_d^\dagger T_d Y_d^\dagger) + 600\text{Tr}(Y_d Y_u^\dagger T_u Y_d^\dagger) + 1200\text{Tr}(Y_e Y_e^\dagger T_e Y_e^\dagger) + 600\text{Tr}(Y_u Y_d^\dagger T_d Y_u^\dagger) \right) \quad (74)
\end{aligned}$$

$$\beta_{T_{\kappa'}}^{(1)} = 3 \left(6|\kappa'|^2 T_{\kappa'} + \sigma'^* \left(2\kappa' T_\sigma + \sigma T_{\kappa'} \right) \right) \quad (75)$$

$$\begin{aligned}
\beta_{T_{\kappa'}}^{(2)} = & -\frac{3}{10} \left(400\kappa'^2 \kappa'^{*2} T_{\kappa'} + 20\sigma\sigma'^{*2} \left(4\kappa' T_{\sigma} + \sigma T_{\kappa'} \right) \right. \\
& + \sigma'^{*} \left(\sigma T_{\kappa'} \left(120|\kappa'|^2 + 20|\lambda|^2 + 30\text{Tr}(\kappa\kappa^\dagger) - g_1^2 Q_S^2 \right) \right. \\
& \left. \left. + 2\kappa' \left(20\lambda^* \left(\lambda T_{\sigma} + \sigma T_{\lambda} \right) + \sigma \left(30\text{Tr}(\kappa^\dagger T_{\kappa}) + g_1^2 M_1' Q_S^2 \right) + T_{\sigma} \left(30\text{Tr}(\kappa\kappa^\dagger) + 40|\kappa'|^2 - g_1^2 Q_S^2 \right) \right) \right) \right) \quad (76)
\end{aligned}$$

$$\begin{aligned}
\beta_{T_{\sigma}}^{(1)} = & +\frac{1}{5} g_1^2 M_1' Q_S^2 \sigma - \frac{1}{10} g_1^2 Q_S^2 T_{\sigma} + 9|\sigma|^2 T_{\sigma} + 2\kappa'^{*} \left(2\sigma T_{\kappa'} + \kappa' T_{\sigma} \right) + 2\lambda^* \left(2\sigma T_{\lambda} + \lambda T_{\sigma} \right) \\
& + 3T_{\sigma} \text{Tr}(\kappa\kappa^\dagger) + 6\sigma \text{Tr}(\kappa^\dagger T_{\kappa}) \quad (77)
\end{aligned}$$

$$\begin{aligned}
\beta_{T_{\sigma}}^{(2)} = & -\frac{249}{100} g_1^4 M_1' Q_S^2 \sigma - \frac{1}{25} g_1^4 M_1' Q_S^4 \sigma - 32\kappa' \sigma \kappa'^{*2} T_{\kappa'} + \frac{249}{400} g_1^4 Q_S^2 T_{\sigma} + \frac{1}{100} g_1^4 Q_S^4 T_{\sigma} \\
& - 8\kappa'^2 \kappa'^{*2} T_{\sigma} - 30\sigma^2 \sigma'^{*2} T_{\sigma} - 4\lambda\lambda'^{*2} \left(4\sigma T_{\lambda} + \lambda T_{\sigma} \right) - \frac{8}{5} g_1^2 M_1 \sigma \text{Tr}(\kappa\kappa^\dagger) \\
& - \frac{39}{10} g_1^2 M_1' \sigma \text{Tr}(\kappa\kappa^\dagger) - 32g_3^2 M_3 \sigma \text{Tr}(\kappa\kappa^\dagger) + \frac{3}{10} g_1^2 M_1' Q_S^2 \sigma \text{Tr}(\kappa\kappa^\dagger) \\
& + \frac{4}{5} g_1^2 T_{\sigma} \text{Tr}(\kappa\kappa^\dagger) + \frac{39}{20} g_1^2 T_{\sigma} \text{Tr}(\kappa\kappa^\dagger) + 16g_3^2 T_{\sigma} \text{Tr}(\kappa\kappa^\dagger) - \frac{3}{20} g_1^2 Q_S^2 T_{\sigma} \text{Tr}(\kappa\kappa^\dagger) \\
& - \frac{1}{10} \lambda^* \left(2\sigma T_{\lambda} \left(-12g_1^2 - 13g_1'^2 + 20\text{Tr}(Y_e Y_e^\dagger) + 40|\sigma|^2 - 60g_2^2 + 60\text{Tr}(Y_d Y_d^\dagger) + 60\text{Tr}(Y_u Y_u^\dagger) + g_1^2 Q_S^2 \right) \right. \\
& + \lambda \left(T_{\sigma} \left(120|\sigma|^2 - 12g_1^2 - 13g_1'^2 + 20\text{Tr}(Y_e Y_e^\dagger) - 60g_2^2 + 60\text{Tr}(Y_d Y_d^\dagger) + 60\text{Tr}(Y_u Y_u^\dagger) + g_1^2 Q_S^2 \right) \right. \\
& + 2\sigma \left(12g_1^2 M_1 + 13g_1^2 M_1' + 20\text{Tr}(Y_e^\dagger T_e) + 60g_2^2 M_2 + 60\text{Tr}(Y_d^\dagger T_d) + 60\text{Tr}(Y_u^\dagger T_u) - g_1^2 M_1' Q_S^2 \right) \left. \right) \\
& + \frac{8}{5} g_1^2 \sigma \text{Tr}(\kappa^\dagger T_{\kappa}) + \frac{39}{10} g_1^2 \sigma \text{Tr}(\kappa^\dagger T_{\kappa}) + 32g_3^2 \sigma \text{Tr}(\kappa^\dagger T_{\kappa}) - \frac{3}{10} g_1^2 Q_S^2 \sigma \text{Tr}(\kappa^\dagger T_{\kappa}) \\
& - \frac{1}{10} |\sigma|^2 \left(120\sigma \text{Tr}(\kappa^\dagger T_{\kappa}) + 180T_{\sigma} \text{Tr}(\kappa\kappa^\dagger) + 2g_1^2 M_1' Q_S^2 \sigma - 3g_1^2 Q_S^2 T_{\sigma} + 80\kappa'^{*} \left(2\sigma T_{\kappa'} + 3\kappa' T_{\sigma} \right) \right) \\
& - 6T_{\sigma} \text{Tr}(\kappa\kappa^\dagger \kappa\kappa^\dagger) - 24\sigma \text{Tr}(\kappa\kappa^\dagger T_{\kappa} \kappa^\dagger) \quad (78)
\end{aligned}$$

$$\begin{aligned}
\beta_{T_{\kappa}}^{(1)} = & +3\kappa\kappa^\dagger T_{\kappa} + 3T_{\kappa} \kappa^\dagger \kappa - \frac{4}{15} g_1^2 T_{\kappa} - \frac{13}{20} g_1^2 T_{\kappa} - \frac{16}{3} g_3^2 T_{\kappa} - \frac{1}{20} g_1^2 Q_S^2 T_{\kappa} + 2|\lambda|^2 T_{\kappa} \\
& + |\sigma|^2 T_{\kappa} + 3T_{\kappa} \text{Tr}(\kappa\kappa^\dagger) \\
& + \frac{1}{30} \kappa \left(120\lambda^* T_{\lambda} + 16g_1^2 M_1 + 180\text{Tr}(\kappa^\dagger T_{\kappa}) + 320g_3^2 M_3 + 39g_1^2 M_1' + 3g_1^2 M_1' Q_S^2 + 60\sigma'^{*} T_{\sigma} \right) \quad (79)
\end{aligned}$$

$$\begin{aligned}
\beta_{T_{\kappa}}^{(2)} = & -\frac{1}{4} g_1^2 \kappa\kappa^\dagger T_{\kappa} + \frac{3}{20} g_1^2 Q_S^2 \kappa\kappa^\dagger T_{\kappa} - 6|\lambda|^2 \kappa\kappa^\dagger T_{\kappa} - 3|\sigma|^2 \kappa\kappa^\dagger T_{\kappa} \\
& + \frac{1}{4} g_1^2 T_{\kappa} \kappa^\dagger \kappa + \frac{3}{20} g_1^2 Q_S^2 T_{\kappa} \kappa^\dagger \kappa - 6|\lambda|^2 T_{\kappa} \kappa^\dagger \kappa - 3|\sigma|^2 T_{\kappa} \kappa^\dagger \kappa \\
& - 3\kappa\kappa^\dagger \kappa\kappa^\dagger T_{\kappa} - 4\kappa\kappa^\dagger T_{\kappa} \kappa^\dagger \kappa - 3T_{\kappa} \kappa^\dagger \kappa\kappa^\dagger \kappa + \frac{512}{225} g_1^4 T_{\kappa} + \frac{13}{75} g_1^2 g_1'^2 T_{\kappa} + \frac{3431}{800} g_1^4 T_{\kappa} \\
& + \frac{64}{45} g_1^2 g_3^2 T_{\kappa} + \frac{52}{15} g_1^2 g_3^2 T_{\kappa} + \frac{128}{9} g_3^4 T_{\kappa} + \frac{11}{32} g_1^4 Q_S^2 T_{\kappa} + \frac{1}{200} g_1^4 Q_S^4 T_{\kappa} + \frac{6}{5} g_1^2 |\lambda|^2 T_{\kappa} \\
& + \frac{13}{10} g_1^2 |\lambda|^2 T_{\kappa} + 6g_2^2 |\lambda|^2 T_{\kappa} - \frac{1}{10} g_1^2 Q_S^2 |\lambda|^2 T_{\kappa} - 4\lambda^2 \lambda'^{*2} T_{\kappa} - 2\sigma|\kappa'|^2 \sigma'^{*} T_{\kappa}
\end{aligned}$$

$$\begin{aligned}
& -2\sigma^2\sigma'^{*,2}T_\kappa - 6|\lambda|^2T_\kappa\text{Tr}\left(Y_dY_d^\dagger\right) - 2|\lambda|^2T_\kappa\text{Tr}\left(Y_eY_e^\dagger\right) - 6|\lambda|^2T_\kappa\text{Tr}\left(Y_uY_u^\dagger\right) \\
& - 9\kappa\kappa^\dagger T_\kappa\text{Tr}\left(\kappa\kappa^\dagger\right) - 9T_\kappa\kappa^\dagger\kappa\text{Tr}\left(\kappa\kappa^\dagger\right) + \frac{4}{5}g_1^2T_\kappa\text{Tr}\left(\kappa\kappa^\dagger\right) + \frac{39}{20}g_1^2T_\kappa\text{Tr}\left(\kappa\kappa^\dagger\right) \\
& + 16g_3^2T_\kappa\text{Tr}\left(\kappa\kappa^\dagger\right) - \frac{3}{20}g_1^2Q_S^2T_\kappa\text{Tr}\left(\kappa\kappa^\dagger\right) \\
& - \frac{1}{5}\kappa\kappa^\dagger\kappa\left(20\sigma'^{*,2}T_\sigma + 40\lambda^*T_\lambda + 60\text{Tr}\left(\kappa^\dagger T_\kappa\right) + g_1^2M_1'Q_S^2\right) - 6T_\kappa\text{Tr}\left(\kappa\kappa^\dagger\kappa\kappa^\dagger\right) \\
& - \frac{1}{1800}\kappa\left(16384g_1^4M_1 + 624g_1^2g_1^2M_1 + 5120g_1^2g_3^2M_1 + 624g_1^2g_1^2M_1' + 30879g_1^4M_1' + 12480g_1^2g_3^2M_1' \right. \\
& + 5120g_1^2g_3^2M_3 + 12480g_1^2g_3^2M_3 + 102400g_3^4M_3 + 2475g_1^4M_1'Q_S^2 + 36g_1^4M_1'Q_S^4 + 28800\lambda\lambda^{*,2}T_\lambda \\
& + 14400\sigma\sigma'^{*,2}T_\sigma + 7200\kappa'^{*,2}\sigma'^{*,2}\left(\kappa'T_\sigma + \sigma T_{\kappa'}\right) + 2880g_1^2M_1\text{Tr}\left(\kappa\kappa^\dagger\right) + 7020g_1^2M_1'\text{Tr}\left(\kappa\kappa^\dagger\right) \\
& + 57600g_3^2M_3\text{Tr}\left(\kappa\kappa^\dagger\right) - 540g_1^2M_1'Q_S^2\text{Tr}\left(\kappa\kappa^\dagger\right) \\
& + 360\lambda^*\left(T_\lambda\left(-12g_1^2 - 13g_1^2 + 20\text{Tr}\left(Y_eY_e^\dagger\right) - 60g_2^2 + 60\text{Tr}\left(Y_dY_d^\dagger\right) + 60\text{Tr}\left(Y_uY_u^\dagger\right) + g_1^2Q_S^2\right) \right. \\
& + \lambda\left(12g_1^2M_1 + 13g_1^2M_1' + 20\text{Tr}\left(Y_e^\dagger T_e\right) + 60g_2^2M_2 + 60\text{Tr}\left(Y_d^\dagger T_d\right) + 60\text{Tr}\left(Y_u^\dagger T_u\right) - g_1^2M_1'Q_S^2\right) \\
& - 2880g_1^2\text{Tr}\left(\kappa^\dagger T_\kappa\right) - 7020g_1^2\text{Tr}\left(\kappa^\dagger T_\kappa\right) - 57600g_3^2\text{Tr}\left(\kappa^\dagger T_\kappa\right) + 540g_1^2Q_S^2\text{Tr}\left(\kappa^\dagger T_\kappa\right) \\
& \left. + 43200\text{Tr}\left(\kappa\kappa^\dagger T_\kappa\kappa^\dagger\right)\right) \tag{80}
\end{aligned}$$

$$\begin{aligned}
\beta_{T_\lambda}^{(1)} = & +T_\lambda\left(-\frac{3}{5}g_1^2 - \frac{13}{20}g_1^2 - 3g_2^2 - \frac{1}{20}g_1^2Q_S^2 + 12|\lambda|^2 + |\sigma|^2 + 3\text{Tr}\left(Y_dY_d^\dagger\right) + \text{Tr}\left(Y_eY_e^\dagger\right) + 3\text{Tr}\left(Y_uY_u^\dagger\right) \right. \\
& + 3\text{Tr}\left(\kappa\kappa^\dagger\right) \\
& + \frac{1}{10}\lambda\left(12g_1^2M_1 + 13g_1^2M_1' + 60g_2^2M_2 + g_1^2M_1'Q_S^2 + 20\sigma'^{*,2}T_\sigma + 60\text{Tr}\left(Y_d^\dagger T_d\right) + 20\text{Tr}\left(Y_e^\dagger T_e\right) \right. \\
& \left. + 60\text{Tr}\left(Y_u^\dagger T_u\right) + 60\text{Tr}\left(\kappa^\dagger T_\kappa\right)\right) \tag{81}
\end{aligned}$$

$$\begin{aligned}
\beta_{T_\lambda}^{(2)} = & -\frac{522}{25}g_1^4M_1\lambda - \frac{39}{50}g_1^2g_1^2M_1\lambda - \frac{18}{5}g_1^2g_2^2M_1\lambda - \frac{39}{50}g_1^2g_1^2M_1'\lambda - \frac{3431}{200}g_1^4M_1'\lambda - \frac{39}{10}g_1^2g_2^2M_1'\lambda \\
& - \frac{18}{5}g_1^2g_2^2M_2\lambda - \frac{39}{10}g_1^2g_2^2M_2\lambda - 42g_2^4M_2\lambda - \frac{11}{8}g_1^4M_1'Q_S^2\lambda - \frac{1}{50}g_1^4M_1'Q_S^4\lambda + \frac{261}{50}g_1^4T_\lambda \\
& + \frac{39}{100}g_1^2g_1^2T_\lambda + \frac{3431}{800}g_1^4T_\lambda + \frac{9}{5}g_1^2g_2^2T_\lambda + \frac{39}{20}g_1^2g_2^2T_\lambda + \frac{21}{2}g_2^4T_\lambda + \frac{11}{32}g_1^4Q_S^2T_\lambda \\
& + \frac{1}{200}g_1^4Q_S^4T_\lambda - 50\lambda^2\lambda^{*,2}T_\lambda - 2\sigma^2\sigma'^{*,2}T_\lambda - 8\lambda\sigma\sigma'^{*,2}T_\sigma \\
& - 2\kappa'^{*,2}\sigma'^{*,2}\left(2\kappa'\lambda T_\sigma + 2\lambda\sigma T_{\kappa'} + \kappa'\sigma T_\lambda\right) + \frac{4}{5}g_1^2M_1\lambda\text{Tr}\left(Y_dY_d^\dagger\right) + \frac{6}{5}g_1^2M_1'\lambda\text{Tr}\left(Y_dY_d^\dagger\right) \\
& - 32g_3^2M_3\lambda\text{Tr}\left(Y_dY_d^\dagger\right) - \frac{2}{5}g_1^2T_\lambda\text{Tr}\left(Y_dY_d^\dagger\right) - \frac{3}{5}g_1^2T_\lambda\text{Tr}\left(Y_dY_d^\dagger\right) + 16g_3^2T_\lambda\text{Tr}\left(Y_dY_d^\dagger\right) \\
& - \frac{12}{5}g_1^2M_1\lambda\text{Tr}\left(Y_eY_e^\dagger\right) + \frac{2}{5}g_1^2M_1'\lambda\text{Tr}\left(Y_eY_e^\dagger\right) + \frac{6}{5}g_1^2T_\lambda\text{Tr}\left(Y_eY_e^\dagger\right) - \frac{1}{5}g_1^2T_\lambda\text{Tr}\left(Y_eY_e^\dagger\right) \\
& - \frac{8}{5}g_1^2M_1\lambda\text{Tr}\left(Y_uY_u^\dagger\right) + \frac{3}{5}g_1^2M_1'\lambda\text{Tr}\left(Y_uY_u^\dagger\right) - 32g_3^2M_3\lambda\text{Tr}\left(Y_uY_u^\dagger\right)
\end{aligned}$$

$$\begin{aligned}
& + \frac{4}{5}g_1^2 T_\lambda \text{Tr}(Y_u Y_u^\dagger) - \frac{3}{10}g_1^2 T_\lambda \text{Tr}(Y_u Y_u^\dagger) + 16g_3^2 T_\lambda \text{Tr}(Y_u Y_u^\dagger) - \frac{8}{5}g_1^2 M_1 \lambda \text{Tr}(\kappa \kappa^\dagger) \\
& - \frac{39}{10}g_1^2 M_1' \lambda \text{Tr}(\kappa \kappa^\dagger) - 32g_3^2 M_3 \lambda \text{Tr}(\kappa \kappa^\dagger) + \frac{3}{10}g_1^2 M_1' Q_S^2 \lambda \text{Tr}(\kappa \kappa^\dagger) + \frac{4}{5}g_1^2 T_\lambda \text{Tr}(\kappa \kappa^\dagger) \\
& + \frac{39}{20}g_1^2 T_\lambda \text{Tr}(\kappa \kappa^\dagger) + 16g_3^2 T_\lambda \text{Tr}(\kappa \kappa^\dagger) - \frac{3}{20}g_1^2 Q_S^2 T_\lambda \text{Tr}(\kappa \kappa^\dagger) - \frac{4}{5}g_1^2 \lambda \text{Tr}(Y_d^\dagger T_d) \\
& - \frac{6}{5}g_1^2 \lambda \text{Tr}(Y_d^\dagger T_d) + 32g_3^2 \lambda \text{Tr}(Y_d^\dagger T_d) + \frac{12}{5}g_1^2 \lambda \text{Tr}(Y_e^\dagger T_e) - \frac{2}{5}g_1^2 \lambda \text{Tr}(Y_e^\dagger T_e) \\
& + \frac{8}{5}g_1^2 \lambda \text{Tr}(Y_u^\dagger T_u) - \frac{3}{5}g_1^2 \lambda \text{Tr}(Y_u^\dagger T_u) + 32g_3^2 \lambda \text{Tr}(Y_u^\dagger T_u) + \frac{8}{5}g_1^2 \lambda \text{Tr}(\kappa^\dagger T_\kappa) \\
& + \frac{39}{10}g_1^2 \lambda \text{Tr}(\kappa^\dagger T_\kappa) + 32g_3^2 \lambda \text{Tr}(\kappa^\dagger T_\kappa) - \frac{3}{10}g_1^2 Q_S^2 \lambda \text{Tr}(\kappa^\dagger T_\kappa) \\
& - \frac{1}{10}|\lambda|^2 \left(-3T_\lambda (12g_1^2 + 13g_1^2 - 20\sigma\sigma'^* - 30\text{Tr}(Y_e Y_e^\dagger) + 60g_2^2 - 60\text{Tr}(\kappa \kappa^\dagger) - 90\text{Tr}(Y_d Y_d^\dagger) - 90\text{Tr}(Y_u Y_u^\dagger)) \right. \\
& + 2\lambda (12g_1^2 M_1 + 13g_1^2 M_1' + 60g_2^2 M_2 + 20\sigma'\sigma^* T_\sigma + 90\text{Tr}(Y_d^\dagger T_d) + 30\text{Tr}(Y_e^\dagger T_e) + 90\text{Tr}(Y_u^\dagger T_u) \\
& \left. + 60\text{Tr}(\kappa^\dagger T_\kappa) \right) \\
& - 9T_\lambda \text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) - 36\lambda \text{Tr}(Y_d Y_d^\dagger T_d Y_d^\dagger) - 6T_\lambda \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 12\lambda \text{Tr}(Y_d Y_u^\dagger T_u Y_d^\dagger) \\
& - 3T_\lambda \text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) - 12\lambda \text{Tr}(Y_e Y_e^\dagger T_e Y_e^\dagger) - 12\lambda \text{Tr}(Y_u Y_d^\dagger T_d Y_u^\dagger) - 9T_\lambda \text{Tr}(Y_u Y_u^\dagger Y_u Y_u^\dagger) \\
& - 36\lambda \text{Tr}(Y_u Y_u^\dagger T_u Y_u^\dagger) - 6T_\lambda \text{Tr}(\kappa \kappa^\dagger \kappa \kappa^\dagger) - 24\lambda \text{Tr}(\kappa \kappa^\dagger T_\kappa \kappa^\dagger)
\end{aligned} \tag{82}$$

$$\begin{aligned}
\beta_{T_u}^{(1)} & = +2Y_u Y_d^\dagger T_d + 4Y_u Y_u^\dagger T_u + T_u Y_d^\dagger Y_d + 5T_u Y_u^\dagger Y_u - \frac{13}{15}g_1^2 T_u - \frac{3}{10}g_1^2 T_u - 3g_2^2 T_u \\
& - \frac{16}{3}g_3^2 T_u + |\lambda|^2 T_u + 3T_u \text{Tr}(Y_u Y_u^\dagger) \\
& + Y_u \left(2\lambda^* T_\lambda + 6g_2^2 M_2 + 6\text{Tr}(Y_u^\dagger T_u) + \frac{26}{15}g_1^2 M_1 + \frac{32}{3}g_3^2 M_3 + \frac{3}{5}g_1^2 M_1' \right)
\end{aligned} \tag{83}$$

$$\begin{aligned}
\beta_{T_u}^{(2)} & = +\frac{4}{5}g_1^2 Y_u Y_d^\dagger T_d + \frac{6}{5}g_1^2 Y_u Y_d^\dagger T_d - 2|\lambda|^2 Y_u Y_d^\dagger T_d - \frac{4}{5}g_1^2 M_1 Y_u Y_u^\dagger Y_u \\
& - \frac{6}{5}g_1^2 M_1' Y_u Y_u^\dagger Y_u - 12g_2^2 M_2 Y_u Y_u^\dagger Y_u + \frac{6}{5}g_1^2 Y_u Y_u^\dagger T_u + \frac{4}{5}g_1^2 Y_u Y_u^\dagger T_u \\
& + 6g_2^2 Y_u Y_u^\dagger T_u - 4|\lambda|^2 Y_u Y_u^\dagger T_u + \frac{2}{5}g_1^2 T_u Y_d^\dagger Y_d + \frac{3}{5}g_1^2 T_u Y_d^\dagger Y_d \\
& - |\lambda|^2 T_u Y_d^\dagger Y_d + g_1^2 T_u Y_u^\dagger Y_u + 12g_2^2 T_u Y_u^\dagger Y_u - 5|\lambda|^2 T_u Y_u^\dagger Y_u \\
& - 4Y_u Y_d^\dagger Y_d Y_d^\dagger T_d - 2Y_u Y_d^\dagger Y_d Y_u^\dagger T_u - 4Y_u Y_d^\dagger T_d Y_d^\dagger Y_d - 4Y_u Y_d^\dagger T_d Y_u^\dagger Y_u \\
& - 6Y_u Y_u^\dagger Y_u Y_u^\dagger T_u - 8Y_u Y_u^\dagger T_u Y_u^\dagger Y_u - 2T_u Y_d^\dagger Y_d Y_d^\dagger Y_d - 4T_u Y_d^\dagger Y_d Y_u^\dagger Y_u \\
& - 6T_u Y_u^\dagger Y_u Y_u^\dagger Y_u + \frac{689}{90}g_1^4 T_u + \frac{53}{300}g_1^2 g_1^2 T_u + \frac{153}{80}g_1^4 T_u + g_1^2 g_2^2 T_u + \frac{3}{4}g_1^2 g_2^2 T_u + \frac{21}{2}g_2^4 T_u \\
& + \frac{136}{45}g_1^2 g_3^2 T_u + \frac{8}{15}g_1^2 g_3^2 T_u + 8g_2^2 g_3^2 T_u + \frac{128}{9}g_3^4 T_u + \frac{3}{200}g_1^4 Q_S^2 T_u + \frac{1}{4}g_1^2 |\lambda|^2 T_u \\
& + \frac{1}{20}g_1^2 Q_S^2 |\lambda|^2 T_u - 3\lambda^2 \lambda'^* T_u - \sigma |\lambda|^2 \sigma'^* T_u - 6\lambda^* Y_u Y_u^\dagger Y_u T_\lambda
\end{aligned}$$

$$\begin{aligned}
& -6Y_u Y_d^\dagger T_d \text{Tr}(Y_d Y_d^\dagger) - 3T_u Y_d^\dagger Y_d \text{Tr}(Y_d Y_d^\dagger) - 3|\lambda|^2 T_u \text{Tr}(Y_d Y_d^\dagger) \\
& -2Y_u Y_d^\dagger T_d \text{Tr}(Y_e Y_e^\dagger) - T_u Y_d^\dagger Y_d \text{Tr}(Y_e Y_e^\dagger) - |\lambda|^2 T_u \text{Tr}(Y_e Y_e^\dagger) \\
& -12Y_u Y_u^\dagger T_u \text{Tr}(Y_u Y_u^\dagger) - 15T_u Y_u^\dagger Y_u \text{Tr}(Y_u Y_u^\dagger) + \frac{4}{5}g_1^2 T_u \text{Tr}(Y_u Y_u^\dagger) \\
& -\frac{3}{10}g_1^2 T_u \text{Tr}(Y_u Y_u^\dagger) + 16g_3^2 T_u \text{Tr}(Y_u Y_u^\dagger) - 3|\lambda|^2 T_u \text{Tr}(\kappa \kappa^\dagger) \\
& -\frac{2}{5}Y_u Y_d^\dagger Y_d \left(15\text{Tr}(Y_d^\dagger T_d) + 2g_1^2 M_1 + 3g_1^2 M_1' + 5\lambda^* T_\lambda + 5\text{Tr}(Y_e^\dagger T_e)\right) \\
& -18Y_u Y_u^\dagger Y_u \text{Tr}(Y_u^\dagger T_u) - 3T_u \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 9T_u \text{Tr}(Y_u Y_u^\dagger Y_u Y_u^\dagger) \\
& -\frac{1}{900}Y_u \left(27560g_1^4 M_1 + 318g_1^2 g_1'^2 M_1 + 1800g_1^2 g_2^2 M_1 + 5440g_1^2 g_3^2 M_1 + 318g_1^2 g_1'^2 M_1' + 6885g_1^4 M_1' \right. \\
& + 1350g_1^2 g_2^2 M_1' + 960g_1^2 g_3^2 M_1' + 5440g_1^2 g_3^2 M_3 + 960g_1^2 g_3^2 M_3 + 14400g_2^2 g_3^2 M_3 + 51200g_3^4 M_3 \\
& + 1800g_1^2 g_2^2 M_2 + 1350g_1^2 g_2^2 M_2 + 37800g_2^4 M_2 + 14400g_2^2 g_3^2 M_2 + 54g_1^4 M_1' Q_S^2 + 10800\lambda\lambda^{*,2} T_\lambda \\
& + 180(160g_3^2 M_3 - 3g_1^2 M_1' + 8g_1^2 M_1) \text{Tr}(Y_u Y_u^\dagger) - 1440g_1^2 \text{Tr}(Y_u^\dagger T_u) + 540g_1^2 \text{Tr}(Y_u^\dagger T_u) \\
& \left. - 28800g_3^2 \text{Tr}(Y_u^\dagger T_u)\right) \\
& + 90\lambda^* \left(T_\lambda \left(20\text{Tr}(Y_e Y_e^\dagger) + 20|\sigma|^2 - 5g_1'^2 + 60\text{Tr}(\kappa \kappa^\dagger) + 60\text{Tr}(Y_d Y_d^\dagger) - g_1'^2 Q_S^2\right) \right. \\
& + \lambda \left(20\text{Tr}(Y_e^\dagger T_e) + 20\sigma'^* T_\sigma + 5g_1'^2 M_1' + 60\text{Tr}(\kappa^\dagger T_\kappa) + 60\text{Tr}(Y_d^\dagger T_d) + g_1'^2 M_1' Q_S^2\right) \\
& \left. + 5400\text{Tr}(Y_d Y_u^\dagger T_u Y_d^\dagger) + 5400\text{Tr}(Y_u Y_d^\dagger T_d Y_u^\dagger) + 32400\text{Tr}(Y_u Y_u^\dagger T_u Y_u^\dagger)\right)
\end{aligned} \tag{84}$$

3.8 Bilinear Soft-Breaking Parameters

$$\beta_{B_{\mu'}}^{(1)} = \frac{1}{5} \left(- \left(15g_2^2 + 2g_1'^2 + 3g_1^2\right) B_{\mu'} + 2 \left(15g_2^2 M_2 + 2g_1'^2 M_1' + 3g_1^2 M_1\right) \mu' \right) \tag{85}$$

$$\begin{aligned}
\beta_{B_{\mu'}}^{(2)} = & \frac{1}{100} \left(-4 \left(1050g_2^4 M_2 + 522g_1^4 M_1 + 60g_1'^2 g_2^2 (M_1' + M_2) + 6g_1^2 (15g_2^2 (M_1 + M_2) + 2g_1'^2 (M_1 + M_1'))\right) + g_1^4 M_1' (2Q_S^2 + 257) \right. \\
& \left. + (1050g_2^4 + 120g_1'^2 g_2^2 + 12g_1^2 (15g_2^2 + 2g_1'^2) + 522g_1^4 + g_1^4 (2Q_S^2 + 257)) B_{\mu'} \right)
\end{aligned} \tag{86}$$

$$\beta_{B_{muphi}}^{(1)} = 2|\sigma|^2 B_{muphi} + 4M u_{phi} \sigma'^* T_\sigma + 8|\kappa'|^2 B_{muphi} + 8M u_{phi} \kappa'^* T_{\kappa'} \tag{87}$$

$$\begin{aligned}
\beta_{B_{muphi}}^{(2)} = & -\frac{1}{5} B_{muphi} \left(160\kappa'^2 \kappa'^{*,2} + 80\sigma|\kappa'|^2 \sigma'^* + |\sigma|^2 (20\lambda\lambda^* + 20\sigma\sigma'^* + 30\text{Tr}(\kappa \kappa^\dagger) - g_1'^2 Q_S^2)\right) \\
& -\frac{2}{5} M u_{phi} \left(200\kappa' \kappa'^{*,2} T_{\kappa'} + 40\sigma\sigma'^{*,2} T_\sigma \right. \\
& + \sigma'^* \left(g_1'^2 M_1' Q_S^2 \sigma - g_1'^2 Q_S^2 T_\sigma + 20\kappa'^* (2\sigma T_{\kappa'} + 3\kappa' T_\sigma) + 20\lambda^* (\lambda T_\sigma + \sigma T_\lambda) + 30T_\sigma \text{Tr}(\kappa \kappa^\dagger) \right. \\
& \left. \left. + 30\sigma \text{Tr}(\kappa^\dagger T_\kappa)\right)\right)
\end{aligned} \tag{88}$$

3.9 Linear Soft-Breaking Parameters

$$\beta_{\xi_S}^{(1)} = 2B_{muphi}^* T_{\kappa'} + 2|\kappa'|^2 \xi_S + 2Mu_{phi} B_{muphi} \kappa'^* + 2XiF_1 \sigma'^* T_\sigma + 4m_{phi}^2 \kappa' Mu_{phi}^* + 4XiF_1 \kappa'^* T_{\kappa'} + |\sigma|^2 \xi_S \quad (89)$$

$$\begin{aligned} \beta_{\xi_S}^{(2)} = & -\frac{1}{5} g_1^2 M_1' Q_S^2 XiF_1 |\sigma|^2 - 4Mu_{phi} \left(2|\kappa'|^2 + |\sigma|^2 \right) B_{muphi} \kappa'^* + \frac{1}{10} g_1^2 Q_S^2 |\sigma|^2 \xi_S - 8\kappa'^2 \kappa'^* \xi_S \\ & - 4\sigma |\kappa'|^2 \sigma'^* \xi_S - 2\sigma |\lambda|^2 \sigma'^* \xi_S - 2\sigma^2 \sigma'^* \xi_S - 8XiF_1 |\sigma|^2 \kappa'^* T_{\kappa'} - 8Mu_{phi}^2 \kappa'^* T_{\kappa'} \\ & - 32\kappa' XiF_1 \kappa'^* T_{\kappa'} - 16|\kappa'|^2 B_{muphi}^* T_{\kappa'} - 4|\sigma|^2 B_{muphi}^* T_{\kappa'} \\ & - 4Mu_{phi}^* \left(10m_{phi}^2 \kappa'^2 \kappa'^* + \left(3m_{phi}^2 + m_{s_3}^2 + m_{sbar_3}^2 \right) \kappa' |\sigma|^2 + 4\kappa' |T_{\kappa'}|^2 + \kappa' |T_\sigma|^2 + \sigma T_\sigma^* T_{\kappa'} \right) \\ & - 4XiF_1 |\sigma|^2 \lambda^* T_\lambda + \frac{1}{5} g_1^2 Q_S^2 XiF_1 \sigma'^* T_\sigma - 8XiF_1 |\kappa'|^2 \sigma'^* T_\sigma - 4XiF_1 |\lambda|^2 \sigma'^* T_\sigma \\ & - 4Mu_{phi}^2 \kappa'^* \sigma'^* T_\sigma - 8XiF_1 \sigma \sigma'^* T_\sigma - 4\kappa' \sigma'^* B_{muphi}^* T_\sigma - 3|\sigma|^2 \xi_S \text{Tr}(\kappa \kappa^\dagger) \\ & - 6XiF_1 \sigma'^* T_\sigma \text{Tr}(\kappa \kappa^\dagger) - 6XiF_1 |\sigma|^2 \text{Tr}(\kappa^\dagger T_\kappa) \end{aligned} \quad (90)$$

3.10 Soft-Breaking Scalar Masses

$$\sigma_{1,1} = \sqrt{\frac{3}{5}} g_1 \left(-2\text{Tr}(m_u^2) - \text{Tr}(m_l^2) - \text{Tr}(m_X^2) - m_{h_{13}}^2 - m_{h'}^2 + m_{h'}^2 + m_{h_{23}}^2 + \text{Tr}(m_d^2) + \text{Tr}(m_X^2) + \text{Tr}(m_e^2) + \text{Tr}(m_q^2) \right) \quad (91)$$

$$\begin{aligned} \sigma_{1,4} = & \frac{1}{2} \frac{1}{\sqrt{10}} g_1' \left(-6m_{h_{13}}^2 + 4m_{h'}^2 - 4m_{h'}^2 - 4m_{h_{23}}^2 + m_{s_3}^2 Q_S - m_{sbar_3}^2 Q_S + 6\text{Tr}(m_d^2) - 6\text{Tr}(m_X^2) - 9\text{Tr}(m_X^2) + \text{Tr}(m_e^2) + 4\text{Tr}(m_u^2) \right. \\ & \left. + 6\text{Tr}(m_q^2) + 3\text{Tr}(m_u^2) \right) \end{aligned} \quad (92)$$

$$\sigma_{2,11} = \frac{1}{10} g_1^2 \left(2\text{Tr}(m_X^2) + 2\text{Tr}(m_d^2) + 2\text{Tr}(m_X^2) + 3m_{h'}^2 + 3\text{Tr}(m_l^2) + 3m_{h_{13}}^2 + 3m_{h'}^2 + 3m_{h_{23}}^2 + 6\text{Tr}(m_e^2) + 8\text{Tr}(m_u^2) + \text{Tr}(m_q^2) \right) \quad (93)$$

$$\sigma_{2,14} = \frac{1}{10} \sqrt{\frac{3}{2}} g_1 g_1' \left(-2m_{h'}^2 + 2\text{Tr}(m_d^2) - 2\text{Tr}(m_l^2) - 2\text{Tr}(m_u^2) + 2\text{Tr}(m_X^2) - 2m_{h'}^2 - 2m_{h_{23}}^2 - 3\text{Tr}(m_X^2) + 3m_{h_{13}}^2 + \text{Tr}(m_e^2) + \text{Tr}(m_q^2) \right) \quad (94)$$

$$\begin{aligned} \sigma_{3,1} = & \frac{1}{40} \frac{1}{\sqrt{15}} g_1 \left(-18g_1^2 m_{h_{13}}^2 - 27g_1^2 m_{h_{13}}^2 - 90g_2^2 m_{h_{13}}^2 - 18g_1^2 m_{h'}^2 - 12g_1^2 m_{h'}^2 - 90g_2^2 m_{h'}^2 + 18g_1^2 m_{h'}^2 \right. \\ & + 12g_1^2 m_{h'}^2 + 90g_2^2 m_{h'}^2 + 18g_1^2 m_{h_{23}}^2 + 12g_1^2 m_{h_{23}}^2 + 90g_2^2 m_{h_{23}}^2 + 60 \left(-m_{h_{23}}^2 + m_{h_{13}}^2 \right) |\lambda|^2 \\ & + 4 \left(2g_1^2 + 3g_1^2 + 40g_3^2 \right) \text{Tr}(m_d^2) - 8g_1^2 \text{Tr}(m_X^2) - 12g_1^2 \text{Tr}(m_X^2) - 160g_3^2 \text{Tr}(m_X^2) + 8g_1^2 \text{Tr}(m_X^2) \\ & + 27g_1^2 \text{Tr}(m_X^2) + 160g_3^2 \text{Tr}(m_X^2) + 72g_1^2 \text{Tr}(m_e^2) + 3g_1^2 \text{Tr}(m_e^2) - 18g_1^2 \text{Tr}(m_l^2) - 12g_1^2 \text{Tr}(m_l^2) \\ & - 90g_2^2 \text{Tr}(m_l^2) + 2g_1^2 \text{Tr}(m_q^2) + 3g_1^2 \text{Tr}(m_q^2) + 90g_2^2 \text{Tr}(m_q^2) + 160g_3^2 \text{Tr}(m_q^2) - 64g_1^2 \text{Tr}(m_u^2) \\ & \left. - 6g_1^2 \text{Tr}(m_u^2) - 320g_3^2 \text{Tr}(m_u^2) + 180m_{h_{13}}^2 \text{Tr}(Y_d Y_d^\dagger) + 60m_{h_{13}}^2 \text{Tr}(Y_e Y_e^\dagger) - 180m_{h_{23}}^2 \text{Tr}(Y_u Y_u^\dagger) \right) \end{aligned}$$

$$\begin{aligned}
& + 60\text{Tr}\left(m_X^2 \kappa \kappa^\dagger\right) - 60\text{Tr}\left(m_X^2 \kappa^\dagger \kappa\right) - 120\text{Tr}\left(Y_d Y_d^\dagger m_d^{2*}\right) - 60\text{Tr}\left(Y_d m_q^{2*} Y_d^\dagger\right) - 120\text{Tr}\left(Y_e Y_e^\dagger m_e^{2*}\right) \\
& + 60\text{Tr}\left(Y_e m_l^{2*} Y_e^\dagger\right) + 240\text{Tr}\left(Y_u Y_u^\dagger m_u^{2*}\right) - 60\text{Tr}\left(Y_u m_q^{2*} Y_u^\dagger\right)
\end{aligned} \tag{95}$$

$$\sigma_{2,2} = \frac{1}{2} \left(3\text{Tr}\left(m_q^2\right) + m_{h_{13}}^2 + m_{h'}^2 + m_{h'}^2 + m_{h_{23}}^2 + \text{Tr}\left(m_l^2\right) \right) \tag{96}$$

$$\sigma_{2,3} = \frac{1}{2} \left(2\text{Tr}\left(m_q^2\right) + \text{Tr}\left(m_d^2\right) + \text{Tr}\left(m_X^2\right) + \text{Tr}\left(m_X^2\right) + \text{Tr}\left(m_u^2\right) \right) \tag{97}$$

$$\sigma_{2,41} = \frac{1}{10} \sqrt{\frac{3}{2}} g_1 g'_1 \left(-2m_{h'}^2 + 2\text{Tr}\left(m_d^2\right) - 2\text{Tr}\left(m_l^2\right) - 2\text{Tr}\left(m_u^2\right) + 2\text{Tr}\left(m_X^2\right) - 2m_{h'}^2 - 2m_{h_{23}}^2 - 3\text{Tr}\left(m_X^2\right) + 3m_{h_{13}}^2 + \text{Tr}\left(m_e^2\right) + \text{Tr}\left(m_l^2\right) \right) \tag{98}$$

$$\begin{aligned} \sigma_{2,44} = & \frac{1}{40} g_1^2 \left(18m_{h_{13}}^2 + 8m_{h'}^2 + 8m_{h'}^2 + 8m_{h_{23}}^2 + m_{s_3}^2 Q_S^2 + m_{s_{bar3}}^2 Q_S^2 + 12\text{Tr}\left(m_d^2\right) + 12\text{Tr}\left(m_X^2\right) + 27\text{Tr}\left(m_X^2\right) + \text{Tr}\left(m_e^2\right) + 8\text{Tr}\left(m_l^2\right) \right. \\ & \left. + 6\text{Tr}\left(m_q^2\right) + 3\text{Tr}\left(m_u^2\right) \right) \end{aligned} \tag{99}$$

$$\begin{aligned}
\sigma_{3,4} = & \frac{1}{80} \frac{1}{\sqrt{10}} g'_1 \left(-36g_1^2 m_{h_{13}}^2 - 54g_1^2 m_{h_{13}}^2 - 180g_2^2 m_{h_{13}}^2 + 24g_1^2 m_{h'}^2 + 16g_1^2 m_{h'}^2 + 120g_2^2 m_{h'}^2 - 24g_1^2 m_{h'}^2 \right. \\
& - 16g_1^2 m_{h'}^2 - 120g_2^2 m_{h'}^2 - 24g_1^2 m_{h_{23}}^2 - 16g_1^2 m_{h_{23}}^2 - 120g_2^2 m_{h_{23}}^2 + g_1^2 m_{s_3}^2 Q_S^3 - g_1^2 m_{s_{bar3}}^2 Q_S^3 \\
& + 40 \left(2m_{h_{23}}^2 + 3m_{h_{13}}^2 - m_{s_3}^2 Q_S \right) |\lambda|^2 - 20 \left(-m_{s_{bar3}}^2 + m_{s_3}^2 \right) Q_S |\sigma|^2 + 16g_1^2 \text{Tr}\left(m_d^2\right) + 24g_1^2 \text{Tr}\left(m_d^2\right) \\
& + 320g_3^2 \text{Tr}\left(m_d^2\right) - 16g_1^2 \text{Tr}\left(m_X^2\right) - 24g_1^2 \text{Tr}\left(m_X^2\right) - 320g_3^2 \text{Tr}\left(m_X^2\right) - 24g_1^2 \text{Tr}\left(m_X^2\right) - 81g_1^2 \text{Tr}\left(m_X^2\right) \\
& - 480g_3^2 \text{Tr}\left(m_X^2\right) + 24g_1^2 \text{Tr}\left(m_e^2\right) + g_1^2 \text{Tr}\left(m_e^2\right) + 24g_1^2 \text{Tr}\left(m_l^2\right) + 16g_1^2 \text{Tr}\left(m_l^2\right) + 120g_2^2 \text{Tr}\left(m_l^2\right) \\
& + 4g_1^2 \text{Tr}\left(m_q^2\right) + 6g_1^2 \text{Tr}\left(m_q^2\right) + 180g_2^2 \text{Tr}\left(m_q^2\right) + 320g_3^2 \text{Tr}\left(m_q^2\right) + 32g_1^2 \text{Tr}\left(m_u^2\right) + 3g_1^2 \text{Tr}\left(m_u^2\right) \\
& + 160g_3^2 \text{Tr}\left(m_u^2\right) + 360m_{h_{13}}^2 \text{Tr}\left(Y_d Y_d^\dagger\right) + 120m_{h_{13}}^2 \text{Tr}\left(Y_e Y_e^\dagger\right) + 240m_{h_{23}}^2 \text{Tr}\left(Y_u Y_u^\dagger\right) \\
& - 60m_{s_3}^2 Q_S \text{Tr}\left(\kappa \kappa^\dagger\right) + 120\text{Tr}\left(m_X^2 \kappa \kappa^\dagger\right) + 180\text{Tr}\left(m_X^2 \kappa^\dagger \kappa\right) - 240\text{Tr}\left(Y_d Y_d^\dagger m_d^{2*}\right) \\
& - 120\text{Tr}\left(Y_d m_q^{2*} Y_d^\dagger\right) - 40\text{Tr}\left(Y_e Y_e^\dagger m_e^{2*}\right) - 80\text{Tr}\left(Y_e m_l^{2*} Y_e^\dagger\right) - 120\text{Tr}\left(Y_u Y_u^\dagger m_u^{2*}\right) \\
& \left. - 120\text{Tr}\left(Y_u m_q^{2*} Y_u^\dagger\right) \right)
\end{aligned} \tag{100}$$

$$\begin{aligned}
\beta_{m_q^2}^{(1)} = & -\frac{2}{15} g_1^2 \mathbf{1} |M_1|^2 - \frac{1}{5} g_1^2 \mathbf{1} |M'_1|^2 - \frac{32}{3} g_3^2 \mathbf{1} |M_3|^2 - 6g_2^2 \mathbf{1} |M_2|^2 + 2m_{h_{13}}^2 Y_d^\dagger Y_d + 2m_{h_{23}}^2 Y_u^\dagger Y_u \\
& + 2T_d^\dagger T_d + 2T_u^\dagger T_u + m_q^2 Y_d^\dagger Y_d + m_q^2 Y_u^\dagger Y_u + 2Y_d^\dagger m_d^2 Y_d + Y_d^\dagger Y_d m_q^2 \\
& + 2Y_u^\dagger m_u^2 Y_u + Y_u^\dagger Y_u m_q^2 + \frac{1}{\sqrt{15}} g_1 \mathbf{1} \sigma_{1,1} + \frac{1}{\sqrt{10}} g'_1 \mathbf{1} \sigma_{1,4}
\end{aligned} \tag{101}$$

$$\begin{aligned}
\beta_{m_q^2}^{(2)} = & + \frac{32}{45} g_1^2 g_3^2 \mathbf{1} |M_3|^2 + \frac{16}{15} g_1^2 g_3^2 \mathbf{1} |M_3|^2 + 32g_2^2 g_3^2 \mathbf{1} |M_3|^2 + \frac{160}{3} g_3^4 \mathbf{1} |M_3|^2 + \frac{2}{5} g_1^2 g_2^2 \mathbf{1} |M_2|^2 \\
& + \frac{3}{5} g_1^2 g_2^2 \mathbf{1} |M_2|^2 + 51g_2^4 \mathbf{1} |M_2|^2 + 32g_2^2 g_3^2 \mathbf{1} |M_2|^2 + \frac{16}{45} g_1^2 g_3^2 M_1 \mathbf{1} M_3^* + \frac{8}{15} g_1^2 g_3^2 M'_1 \mathbf{1} M_3^* \\
& + 16g_2^2 g_3^2 M_2 \mathbf{1} M_3^* + \frac{1}{5} g_1^2 g_2^2 M_1 \mathbf{1} M_2^* + \frac{3}{10} g_1^2 g_2^2 M'_1 \mathbf{1} M_2^* + 16g_2^2 g_3^2 M_3 \mathbf{1} M_2^*
\end{aligned}$$

$$\begin{aligned}
& + \frac{4}{5}g_1^2 m_{h_{13}}^2 Y_d^\dagger Y_d + \frac{6}{5}g_1^2 m_{h_{13}}^2 Y_d^\dagger Y_d - 4m_{h_{13}}^2 |\lambda|^2 Y_d^\dagger Y_d - 2m_{h_{23}}^2 |\lambda|^2 Y_d^\dagger Y_d \\
& - 2m_{s_3}^2 |\lambda|^2 Y_d^\dagger Y_d - 2|T_\lambda|^2 Y_d^\dagger Y_d - 2\lambda T_\lambda^* Y_d^\dagger T_d + \frac{8}{5}g_1^2 m_{h_{23}}^2 Y_u^\dagger Y_u \\
& + \frac{2}{5}g_1^2 m_{h_{23}}^2 Y_u^\dagger Y_u - 2m_{h_{13}}^2 |\lambda|^2 Y_u^\dagger Y_u - 4m_{h_{23}}^2 |\lambda|^2 Y_u^\dagger Y_u \\
& - 2m_{s_3}^2 |\lambda|^2 Y_u^\dagger Y_u - 2|T_\lambda|^2 Y_u^\dagger Y_u \\
& + \frac{1}{450}g_1^2 M_1^* \left(\left(10 \left(16g_3^2 (2M_1 + M_3) + 9g_2^2 (2M_1 + M_2) \right) + 1518g_1^2 M_1 - 51g_1^2 (2M_1 + M_1') \right) \right) \mathbf{1} \\
& + 360 \left(2M_1 Y_d^\dagger Y_d - 2Y_u^\dagger T_u + 4M_1 Y_u^\dagger Y_u - Y_d^\dagger T_d \right) \\
& + \frac{1}{600}g_1^2 M_1' \left(\left(20 \left(16g_3^2 (2M_1' + M_3) + 9g_2^2 (2M_1' + M_2) \right) - 68g_1^2 (2M_1' + M_1) + 9g_1^2 M_1' (2Q_S^2 + 251) \right) \right) \mathbf{1} \\
& + 240 \left(2M_1' Y_u^\dagger Y_u - 3Y_d^\dagger T_d + 6M_1' Y_d^\dagger Y_d - Y_u^\dagger T_u \right) \\
& - 2\lambda T_\lambda^* Y_u^\dagger T_u - \frac{4}{5}g_1^2 M_1 T_d^\dagger Y_d - \frac{6}{5}g_1^2 M_1' T_d^\dagger Y_d + \frac{4}{5}g_1^2 T_d^\dagger T_d \\
& + \frac{6}{5}g_1^2 T_d^\dagger T_d - 2|\lambda|^2 T_d^\dagger T_d - \frac{8}{5}g_1^2 M_1 T_u^\dagger Y_u - \frac{2}{5}g_1^2 M_1' T_u^\dagger Y_u \\
& + \frac{8}{5}g_1^2 T_u^\dagger T_u + \frac{2}{5}g_1^2 T_u^\dagger T_u - 2|\lambda|^2 T_u^\dagger T_u + \frac{2}{5}g_1^2 m_q^2 Y_d^\dagger Y_d \\
& + \frac{3}{5}g_1^2 m_q^2 Y_d^\dagger Y_d - |\lambda|^2 m_q^2 Y_d^\dagger Y_d + \frac{4}{5}g_1^2 m_q^2 Y_u^\dagger Y_u + \frac{1}{5}g_1^2 m_q^2 Y_u^\dagger Y_u \\
& - |\lambda|^2 m_q^2 Y_u^\dagger Y_u + \frac{4}{5}g_1^2 Y_d^\dagger m_d^2 Y_d + \frac{6}{5}g_1^2 Y_d^\dagger m_d^2 Y_d - 2|\lambda|^2 Y_d^\dagger m_d^2 Y_d \\
& + \frac{2}{5}g_1^2 Y_d^\dagger Y_d m_q^2 + \frac{3}{5}g_1^2 Y_d^\dagger Y_d m_q^2 - |\lambda|^2 Y_d^\dagger Y_d m_q^2 + \frac{8}{5}g_1^2 Y_u^\dagger m_u^2 Y_u \\
& + \frac{2}{5}g_1^2 Y_u^\dagger m_u^2 Y_u - 2|\lambda|^2 Y_u^\dagger m_u^2 Y_u + \frac{4}{5}g_1^2 Y_u^\dagger Y_u m_q^2 + \frac{1}{5}g_1^2 Y_u^\dagger Y_u m_q^2 \\
& - |\lambda|^2 Y_u^\dagger Y_u m_q^2 - 8m_{h_{13}}^2 Y_d^\dagger Y_d Y_d^\dagger Y_d - 4Y_d^\dagger Y_d T_d^\dagger T_d - 4Y_d^\dagger T_d T_d^\dagger Y_d \\
& - 8m_{h_{23}}^2 Y_u^\dagger Y_u Y_u^\dagger Y_u - 4Y_u^\dagger Y_u T_u^\dagger T_u - 4Y_u^\dagger T_u T_u^\dagger Y_u - 4T_d^\dagger Y_d Y_d^\dagger T_d \\
& - 4T_d^\dagger T_d Y_d^\dagger Y_d - 4T_u^\dagger Y_u Y_u^\dagger T_u - 4T_u^\dagger T_u Y_u^\dagger Y_u - 2m_q^2 Y_d^\dagger Y_d Y_d^\dagger Y_d \\
& - 2m_q^2 Y_u^\dagger Y_u Y_u^\dagger Y_u - 4Y_d^\dagger m_d^2 Y_d Y_d^\dagger Y_d - 4Y_d^\dagger Y_d m_q^2 Y_d^\dagger Y_d - 4Y_d^\dagger Y_d Y_d^\dagger m_d^2 Y_d \\
& - 2Y_d^\dagger Y_d Y_d^\dagger Y_d m_q^2 - 4Y_u^\dagger m_u^2 Y_u Y_u^\dagger Y_u - 4Y_u^\dagger Y_u m_q^2 Y_u^\dagger Y_u - 4Y_u^\dagger Y_u Y_u^\dagger m_u^2 Y_u \\
& - 2Y_u^\dagger Y_u Y_u^\dagger Y_u m_q^2 - 2\lambda^* T_d^\dagger Y_d T_\lambda - 2\lambda^* T_u^\dagger Y_u T_\lambda + 6g_2^4 \mathbf{1}_{\sigma_{2,2}} + \frac{32}{3}g_3^4 \mathbf{1}_{\sigma_{2,3}} + \frac{2}{15}g_1^2 \mathbf{1}_{\sigma_{2,11}} \\
& + \frac{1}{5}\sqrt{\frac{2}{3}}g_1 g_1' \mathbf{1}_{\sigma_{2,14}} + \frac{1}{5}\sqrt{\frac{2}{3}}g_1 g_1' \mathbf{1}_{\sigma_{2,41}} + \frac{1}{5}g_1^2 \mathbf{1}_{\sigma_{2,44}} + 4\frac{1}{\sqrt{15}}g_1 \mathbf{1}_{\sigma_{3,1}} + 2\sqrt{\frac{2}{5}}g_1' \mathbf{1}_{\sigma_{3,4}} \\
& - 12m_{h_{13}}^2 Y_d^\dagger Y_d \text{Tr}(Y_d Y_d^\dagger) - 6T_d^\dagger T_d \text{Tr}(Y_d Y_d^\dagger) - 3m_q^2 Y_d^\dagger Y_d \text{Tr}(Y_d Y_d^\dagger) \\
& - 6Y_d^\dagger m_d^2 Y_d \text{Tr}(Y_d Y_d^\dagger) - 3Y_d^\dagger Y_d m_q^2 \text{Tr}(Y_d Y_d^\dagger) - 4m_{h_{13}}^2 Y_d^\dagger Y_d \text{Tr}(Y_e Y_e^\dagger) \\
& - 2T_d^\dagger T_d \text{Tr}(Y_e Y_e^\dagger) - m_q^2 Y_d^\dagger Y_d \text{Tr}(Y_e Y_e^\dagger) - 2Y_d^\dagger m_d^2 Y_d \text{Tr}(Y_e Y_e^\dagger)
\end{aligned}$$

$$\begin{aligned}
& -Y_d^\dagger Y_d m_q^2 \text{Tr}(Y_e Y_e^\dagger) - 12m_{h_{23}}^2 Y_u^\dagger Y_u \text{Tr}(Y_u Y_u^\dagger) - 6T_u^\dagger T_u \text{Tr}(Y_u Y_u^\dagger) \\
& - 3m_q^2 Y_u^\dagger Y_u \text{Tr}(Y_u Y_u^\dagger) - 6Y_u^\dagger m_u^2 Y_u \text{Tr}(Y_u Y_u^\dagger) - 3Y_u^\dagger Y_u m_q^2 \text{Tr}(Y_u Y_u^\dagger) \\
& - 6T_d^\dagger Y_d \text{Tr}(Y_d^\dagger T_d) - 2T_d^\dagger Y_d \text{Tr}(Y_e^\dagger T_e) - 6T_u^\dagger Y_u \text{Tr}(Y_u^\dagger T_u) \\
& - 6Y_d^\dagger T_d \text{Tr}(T_d^* Y_d^T) - 6Y_d^\dagger Y_d \text{Tr}(T_d^* T_d^T) - 2Y_d^\dagger T_d \text{Tr}(T_e^* Y_e^T) \\
& - 2Y_d^\dagger Y_d \text{Tr}(T_e^* T_e^T) - 6Y_u^\dagger T_u \text{Tr}(T_u^* Y_u^T) - 6Y_u^\dagger Y_u \text{Tr}(T_u^* T_u^T) \\
& - 6Y_d^\dagger Y_d \text{Tr}(m_d^2 Y_d Y_d^\dagger) - 2Y_d^\dagger Y_d \text{Tr}(m_e^2 Y_e Y_e^\dagger) - 2Y_d^\dagger Y_d \text{Tr}(m_l^2 Y_e^\dagger Y_e) \\
& - 6Y_d^\dagger Y_d \text{Tr}(m_q^2 Y_d^\dagger Y_d) - 6Y_u^\dagger Y_u \text{Tr}(m_q^2 Y_u^\dagger Y_u) - 6Y_u^\dagger Y_u \text{Tr}(m_u^2 Y_u Y_u^\dagger)
\end{aligned} \tag{102}$$

$$\begin{aligned}
\beta_{m_l^2}^{(1)} = & -\frac{6}{5}g_1^2 \mathbf{1} |M_1|^2 - \frac{4}{5}g_1'^2 \mathbf{1} |M_1'|^2 - 6g_2^2 \mathbf{1} |M_2|^2 + 2m_{h_{13}}^2 Y_e^\dagger Y_e + 2T_e^\dagger T_e + m_l^2 Y_e^\dagger Y_e \\
& + 2Y_e^\dagger m_e^2 Y_e + Y_e^\dagger Y_e m_l^2 - \sqrt{\frac{3}{5}}g_1 \mathbf{1} \sigma_{1,1} + \sqrt{\frac{2}{5}}g_1' \mathbf{1} \sigma_{1,4}
\end{aligned} \tag{103}$$

$$\begin{aligned}
\beta_{m_l^2}^{(2)} = & +\frac{18}{5}g_1^2 g_2^2 \mathbf{1} |M_2|^2 + \frac{12}{5}g_1'^2 g_2^2 \mathbf{1} |M_2|^2 + 51g_2^4 \mathbf{1} |M_2|^2 + \frac{9}{5}g_1^2 g_2^2 M_1 \mathbf{1} M_2^* + \frac{6}{5}g_1'^2 g_2^2 M_1' \mathbf{1} M_2^* \\
& + \frac{12}{5}g_1^2 m_{h_{13}}^2 Y_e^\dagger Y_e + \frac{3}{5}g_1'^2 m_{h_{13}}^2 Y_e^\dagger Y_e - 4m_{h_{13}}^2 |\lambda|^2 Y_e^\dagger Y_e - 2m_{h_{23}}^2 |\lambda|^2 Y_e^\dagger Y_e \\
& - 2m_{s_3}^2 |\lambda|^2 Y_e^\dagger Y_e - 2|T_\lambda|^2 Y_e^\dagger Y_e \\
& + \frac{3}{25}g_1^2 M_1^* \left((15g_2^2 (2M_1 + M_2) + 261g_1^2 M_1 + 8g_1'^2 (2M_1 + M_1')) \mathbf{1} - 20Y_e^\dagger T_e + 40M_1 Y_e^\dagger Y_e \right) \\
& + \frac{3}{50}g_1'^2 M_1'^* \left((-10Y_e^\dagger T_e + (16g_1^2 (2M_1' + M_1) + 20g_2^2 (2M_1' + M_2) + g_1'^2 M_1' (2Q_S^2 + 257)) \mathbf{1} + 20M_1' Y_e^\dagger Y_e \right) \\
& - 2\lambda T_\lambda^* Y_e^\dagger T_e - \frac{12}{5}g_1^2 M_1 T_e^\dagger Y_e - \frac{3}{5}g_1'^2 M_1' T_e^\dagger Y_e + \frac{12}{5}g_1^2 T_e^\dagger T_e \\
& + \frac{3}{5}g_1'^2 T_e^\dagger T_e - 2|\lambda|^2 T_e^\dagger T_e + \frac{6}{5}g_1^2 m_l^2 Y_e^\dagger Y_e + \frac{3}{10}g_1'^2 m_l^2 Y_e^\dagger Y_e \\
& - |\lambda|^2 m_l^2 Y_e^\dagger Y_e + \frac{12}{5}g_1^2 Y_e^\dagger m_e^2 Y_e + \frac{3}{5}g_1'^2 Y_e^\dagger m_e^2 Y_e - 2|\lambda|^2 Y_e^\dagger m_e^2 Y_e \\
& + \frac{6}{5}g_1^2 Y_e^\dagger Y_e m_l^2 + \frac{3}{10}g_1'^2 Y_e^\dagger Y_e m_l^2 - |\lambda|^2 Y_e^\dagger Y_e m_l^2 - 8m_{h_{13}}^2 Y_e^\dagger Y_e Y_e^\dagger Y_e \\
& - 4Y_e^\dagger Y_e T_e^\dagger T_e - 4Y_e^\dagger T_e T_e^\dagger Y_e - 4T_e^\dagger Y_e Y_e^\dagger T_e - 4T_e^\dagger T_e Y_e^\dagger Y_e \\
& - 2m_l^2 Y_e^\dagger Y_e Y_e^\dagger Y_e - 4Y_e^\dagger m_e^2 Y_e Y_e^\dagger Y_e - 4Y_e^\dagger Y_e m_l^2 Y_e^\dagger Y_e - 4Y_e^\dagger Y_e Y_e^\dagger m_e^2 Y_e \\
& - 2Y_e^\dagger Y_e Y_e^\dagger Y_e m_l^2 - 2\lambda^* T_e^\dagger Y_e T_\lambda + 6g_2^4 \mathbf{1} \sigma_{2,2} + \frac{6}{5}g_1^2 \mathbf{1} \sigma_{2,11} - \frac{2}{5}\sqrt{6}g_1 g_1' \mathbf{1} \sigma_{2,14} - \frac{2}{5}\sqrt{6}g_1 g_1' \mathbf{1} \sigma_{2,41} \\
& + \frac{4}{5}g_1'^2 \mathbf{1} \sigma_{2,44} - 4\sqrt{\frac{3}{5}}g_1 \mathbf{1} \sigma_{3,1} + 4\sqrt{\frac{2}{5}}g_1' \mathbf{1} \sigma_{3,4} - 12m_{h_{13}}^2 Y_e^\dagger Y_e \text{Tr}(Y_d Y_d^\dagger) - 6T_e^\dagger T_e \text{Tr}(Y_d Y_d^\dagger) \\
& - 3m_l^2 Y_e^\dagger Y_e \text{Tr}(Y_d Y_d^\dagger) - 6Y_e^\dagger m_e^2 Y_e \text{Tr}(Y_d Y_d^\dagger) - 3Y_e^\dagger Y_e m_l^2 \text{Tr}(Y_d Y_d^\dagger) \\
& - 4m_{h_{13}}^2 Y_e^\dagger Y_e \text{Tr}(Y_e Y_e^\dagger) - 2T_e^\dagger T_e \text{Tr}(Y_e Y_e^\dagger) - m_l^2 Y_e^\dagger Y_e \text{Tr}(Y_e Y_e^\dagger)
\end{aligned}$$

$$\begin{aligned}
& -2Y_e^\dagger m_e^2 Y_e \text{Tr}(Y_e Y_e^\dagger) - Y_e^\dagger Y_e m_l^2 \text{Tr}(Y_e Y_e^\dagger) - 6T_e^\dagger Y_e \text{Tr}(Y_d^\dagger T_d) \\
& -2T_e^\dagger Y_e \text{Tr}(Y_e^\dagger T_e) - 6Y_e^\dagger T_e \text{Tr}(T_d^* Y_d^T) - 6Y_e^\dagger Y_e \text{Tr}(T_d^* T_d^T) \\
& -2Y_e^\dagger T_e \text{Tr}(T_e^* Y_e^T) - 2Y_e^\dagger Y_e \text{Tr}(T_e^* T_e^T) - 6Y_e^\dagger Y_e \text{Tr}(m_d^2 Y_d Y_d^\dagger) \\
& -2Y_e^\dagger Y_e \text{Tr}(m_e^2 Y_e Y_e^\dagger) - 2Y_e^\dagger Y_e \text{Tr}(m_l^2 Y_e^\dagger Y_e) - 6Y_e^\dagger Y_e \text{Tr}(m_q^2 Y_d^\dagger Y_d)
\end{aligned} \tag{104}$$

$$\begin{aligned}
\beta_{m_{h13}^2}^{(1)} &= -\frac{6}{5}g_1^2|M_1|^2 - \frac{9}{5}g_1^2|M_1'|^2 - 6g_2^2|M_2|^2 + 2m_{h13}^2|\lambda|^2 + 2m_{h23}^2|\lambda|^2 + 2m_{s3}^2|\lambda|^2 + 2|T_\lambda|^2 \\
& -\sqrt{\frac{3}{5}}g_1\sigma_{1,1} - 3\frac{1}{\sqrt{10}}g_1'\sigma_{1,4} + 6m_{h13}^2 \text{Tr}(Y_d Y_d^\dagger) + 2m_{h13}^2 \text{Tr}(Y_e Y_e^\dagger) + 6\text{Tr}(T_d^* T_d^T) + 2\text{Tr}(T_e^* T_e^T) \\
& + 6\text{Tr}(m_d^2 Y_d Y_d^\dagger) + 2\text{Tr}(m_e^2 Y_e Y_e^\dagger) + 2\text{Tr}(m_l^2 Y_e^\dagger Y_e) + 6\text{Tr}(m_q^2 Y_d^\dagger Y_d)
\end{aligned} \tag{105}$$

$$\begin{aligned}
\beta_{m_{h13}^2}^{(2)} &= \frac{1}{200} \left(4g_1^2 M_1^* (1566g_1^2 M_1 - 54g_1^2 M_1 + 180g_2^2 M_1 - 27g_1^2 M_1' + 90g_2^2 M_2 - 80M_1 \text{Tr}(Y_d Y_d^\dagger) + 240M_1 \text{Tr}(Y_e Y_e^\dagger) \right. \\
& + 40\text{Tr}(Y_d^\dagger T_d) - 120\text{Tr}(Y_e^\dagger T_e) \Big) \\
& + g_1^2 M_1'^* \left(-108g_1^2 M_1 - 216g_1^2 M_1' + 7209g_1^2 M_1' + 1080g_2^2 M_1' + 540g_2^2 M_2 + 54g_1^2 M_1' Q_S^2 \right. \\
& + 20 \left(-5 + Q_S^2 \right) \lambda^* \left(2M_1' \lambda - T_\lambda \right) - 480M_1' \text{Tr}(Y_d Y_d^\dagger) - 160M_1' \text{Tr}(Y_e Y_e^\dagger) + 240\text{Tr}(Y_d^\dagger T_d) + 80\text{Tr}(Y_e^\dagger T_e) \Big) \\
& + 20 \left(-5g_1^2 |T_\lambda|^2 + g_1^2 Q_S^2 |T_\lambda|^2 + 3g_2^2 (170g_2^2 M_2 + 6g_1^2 (2M_2 + M_1) + 9g_1^2 (2M_2 + M_1')) M_2^* \right. \\
& - 120 \left(m_{h13}^2 + m_{h23}^2 + m_{s3}^2 \right) \lambda^2 \lambda^{*,2} + 5g_1^2 M_1' \lambda T_\lambda^* - g_1^2 M_1' Q_S^2 \lambda T_\lambda^* - 20|\sigma|^2 T_\lambda^* T_\lambda \\
& - 20\lambda \sigma'^* T_\lambda^* T_\sigma + 60g_2^4 \sigma_{2,2} + 12g_1^2 \sigma_{2,11} + 6\sqrt{6}g_1 g_1' \sigma_{2,14} + 6\sqrt{6}g_1 g_1' \sigma_{2,41} + 18g_1^2 \sigma_{2,44} \\
& - 8\sqrt{15}g_1 \sigma_{3,1} - 12\sqrt{10}g_1' \sigma_{3,4} - 8g_1^2 m_{h13}^2 \text{Tr}(Y_d Y_d^\dagger) - 12g_1^2 m_{h13}^2 \text{Tr}(Y_e Y_e^\dagger) \\
& + 320g_3^2 m_{h13}^2 \text{Tr}(Y_d Y_d^\dagger) + 640g_3^2 |M_3|^2 \text{Tr}(Y_d Y_d^\dagger) + 24g_1^2 m_{h13}^2 \text{Tr}(Y_e Y_e^\dagger) \\
& - 4g_1^2 m_{h13}^2 \text{Tr}(Y_e Y_e^\dagger) - 60|T_\lambda|^2 \text{Tr}(Y_u Y_u^\dagger) - 60|T_\lambda|^2 \text{Tr}(\kappa \kappa^\dagger) - 320g_3^2 M_3^* \text{Tr}(Y_d^\dagger T_d) \\
& - 60\lambda T_\lambda^* \text{Tr}(Y_u^\dagger T_u) - 60\lambda T_\lambda^* \text{Tr}(\kappa^\dagger T_\kappa) + 8g_1^2 M_1 \text{Tr}(T_d^* Y_d^T) + 12g_1^2 M_1' \text{Tr}(T_d^* Y_d^T) \\
& - 320g_3^2 M_3 \text{Tr}(T_d^* Y_d^T) - 8g_1^2 \text{Tr}(T_d^* T_d^T) - 12g_1^2 \text{Tr}(T_d^* T_d^T) + 320g_3^2 \text{Tr}(T_d^* T_d^T) \\
& - 24g_1^2 M_1 \text{Tr}(T_e^* Y_e^T) + 4g_1^2 M_1' \text{Tr}(T_e^* Y_e^T) + 24g_1^2 \text{Tr}(T_e^* T_e^T) - 4g_1^2 \text{Tr}(T_e^* T_e^T) \\
& - 8g_1^2 \text{Tr}(m_d^2 Y_d Y_d^\dagger) - 12g_1^2 \text{Tr}(m_d^2 Y_d Y_d^\dagger) + 320g_3^2 \text{Tr}(m_d^2 Y_d Y_d^\dagger) + 24g_1^2 \text{Tr}(m_e^2 Y_e Y_e^\dagger) \\
& - 4g_1^2 \text{Tr}(m_e^2 Y_e Y_e^\dagger) + 24g_1^2 \text{Tr}(m_l^2 Y_e^\dagger Y_e) - 4g_1^2 \text{Tr}(m_l^2 Y_e^\dagger Y_e) - 8g_1^2 \text{Tr}(m_q^2 Y_d^\dagger Y_d) \\
& - 12g_1^2 \text{Tr}(m_q^2 Y_d^\dagger Y_d) + 320g_3^2 \text{Tr}(m_q^2 Y_d^\dagger Y_d) \\
& + \lambda^* \left(-5g_1^2 m_{h13}^2 \lambda - 5g_1^2 m_{h23}^2 \lambda - 5g_1^2 m_{s3}^2 \lambda + g_1^2 m_{h13}^2 Q_S^2 \lambda + g_1^2 m_{h23}^2 Q_S^2 \lambda + g_1^2 m_{s3}^2 Q_S^2 \lambda \right. \\
& \left. - 20 \left(2m_{s3}^2 + m_{h13}^2 + m_{h23}^2 + m_{phi}^2 + m_{bar3}^2 \right) \lambda |\sigma|^2 - 240\lambda |T_\lambda|^2 - 20\lambda |T_\sigma|^2 - 20\sigma T_\sigma^* T_\lambda \right)
\end{aligned}$$

$$\begin{aligned}
& -60m_{h_{13}}^2 \lambda \text{Tr}(Y_u Y_u^\dagger) - 120m_{h_{23}}^2 \lambda \text{Tr}(Y_u Y_u^\dagger) - 60m_{s_3}^2 \lambda \text{Tr}(Y_u Y_u^\dagger) - 60m_{h_{13}}^2 \lambda \text{Tr}(\kappa \kappa^\dagger) \\
& - 60m_{h_{23}}^2 \lambda \text{Tr}(\kappa \kappa^\dagger) - 120m_{s_3}^2 \lambda \text{Tr}(\kappa \kappa^\dagger) - 60T_\lambda \text{Tr}(T_u^* Y_u^T) - 60\lambda \text{Tr}(T_u^* T_u^T) - 60T_\lambda \text{Tr}(T_\kappa^* \kappa^T) \\
& - 60\lambda \text{Tr}(T_\kappa^* T_\kappa^T) - 60\lambda \text{Tr}(m_q^2 Y_u^\dagger Y_u) - 60\lambda \text{Tr}(m_u^2 Y_u Y_u^\dagger) - 60\lambda \text{Tr}(\kappa \kappa^\dagger m_X^{2*}) \\
& - 60\lambda \text{Tr}(\kappa m_X^{2*} \kappa^\dagger) \\
& - 360m_{h_{13}}^2 \text{Tr}(Y_d Y_d^\dagger Y_d Y_d^\dagger) - 360\text{Tr}(Y_d Y_d^\dagger T_d T_d^\dagger) - 60m_{h_{13}}^2 \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) \\
& - 60m_{h_{23}}^2 \text{Tr}(Y_d Y_u^\dagger Y_u Y_d^\dagger) - 60\text{Tr}(Y_d Y_u^\dagger T_u T_d^\dagger) - 360\text{Tr}(Y_d T_d^\dagger T_d Y_d^\dagger) \\
& - 60\text{Tr}(Y_d T_u^\dagger T_u Y_d^\dagger) - 120m_{h_{13}}^2 \text{Tr}(Y_e Y_e^\dagger Y_e Y_e^\dagger) - 120\text{Tr}(Y_e Y_e^\dagger T_e T_e^\dagger) \\
& - 120\text{Tr}(Y_e T_e^\dagger T_e Y_e^\dagger) - 60\text{Tr}(Y_u Y_d^\dagger T_d T_u^\dagger) - 60\text{Tr}(Y_u T_d^\dagger T_d Y_u^\dagger) - 360\text{Tr}(m_d^2 Y_d Y_d^\dagger Y_d Y_d^\dagger) \\
& - 60\text{Tr}(m_d^2 Y_d Y_u^\dagger Y_u Y_d^\dagger) - 120\text{Tr}(m_e^2 Y_e Y_e^\dagger Y_e Y_e^\dagger) - 120\text{Tr}(m_l^2 Y_e^\dagger Y_e Y_e^\dagger Y_e) \\
& - 360\text{Tr}(m_q^2 Y_d^\dagger Y_d Y_d^\dagger Y_d) - 60\text{Tr}(m_q^2 Y_d^\dagger Y_d Y_u^\dagger Y_u) - 60\text{Tr}(m_q^2 Y_u^\dagger Y_u Y_d^\dagger Y_d) \\
& - 60\text{Tr}(m_u^2 Y_u Y_d^\dagger Y_d Y_u^\dagger) \Big) \tag{106}
\end{aligned}$$

$$\begin{aligned}
\beta_{m_{h_{23}}^2}^{(1)} &= -\frac{6}{5}g_1^2|M_1|^2 - \frac{4}{5}g_1^2|M_1'|^2 - 6g_2^2|M_2|^2 + 2m_{h_{13}}^2|\lambda|^2 + 2m_{h_{23}}^2|\lambda|^2 + 2m_{s_3}^2|\lambda|^2 + 2|T_\lambda|^2 \\
&+ \sqrt{\frac{3}{5}}g_1\sigma_{1,1} - \sqrt{\frac{2}{5}}g_1'\sigma_{1,4} + 6m_{h_{23}}^2 \text{Tr}(Y_u Y_u^\dagger) + 6\text{Tr}(T_u^* T_u^T) + 6\text{Tr}(m_q^2 Y_u^\dagger Y_u) + 6\text{Tr}(m_u^2 Y_u Y_u^\dagger) \tag{107}
\end{aligned}$$

$$\begin{aligned}
\beta_{m_{h_{23}}^2}^{(2)} &= +\frac{18}{5}g_1^2g_2^2|M_2|^2 + \frac{12}{5}g_1^2g_2^2|M_2'|^2 + 51g_2^4|M_2|^2 + \frac{1}{2}g_1^2m_{h_{13}}^2|\lambda|^2 + \frac{1}{2}g_1^2m_{h_{23}}^2|\lambda|^2 \\
&+ \frac{1}{2}g_1^2m_{s_3}^2|\lambda|^2 + \frac{1}{10}g_1^2m_{h_{13}}^2Q_S^2|\lambda|^2 + \frac{1}{10}g_1^2m_{h_{23}}^2Q_S^2|\lambda|^2 + \frac{1}{10}g_1^2m_{s_3}^2Q_S^2|\lambda|^2 \\
&+ \frac{1}{2}g_1^2|T_\lambda|^2 + \frac{1}{10}g_1^2Q_S^2|T_\lambda|^2 + \frac{9}{5}g_1^2g_2^2M_1M_2^* + \frac{6}{5}g_1^2g_2^2M_1'M_2^* - 12m_{h_{13}}^2\lambda^2\lambda^{*,2} \\
&- 12m_{h_{23}}^2\lambda^2\lambda^{*,2} - 12m_{s_3}^2\lambda^2\lambda^{*,2} - 2m_{h_{13}}^2\sigma|\lambda|^2\sigma'^{*} - 2m_{h_{23}}^2\sigma|\lambda|^2\sigma'^{*} - 2m_{phi}^2\sigma|\lambda|^2\sigma'^{*} \\
&- 4m_{s_3}^2\sigma|\lambda|^2\sigma'^{*} - 2m_{sbar3}^2\sigma|\lambda|^2\sigma'^{*} - \frac{1}{2}g_1^2M_1'\lambda T_\lambda^* - \frac{1}{10}g_1^2M_1'Q_S^2\lambda T_\lambda^* \\
&- 24|\lambda|^2T_\lambda^*T_\lambda - 2|\sigma|^2T_\lambda^*T_\lambda - 2\sigma\lambda^*T_\sigma^*T_\lambda - 2\lambda\sigma'^{*}T_\lambda^*T_\sigma - 2|\lambda|^2T_\sigma^*T_\sigma + 6g_2^4\sigma_{2,2} \\
&+ \frac{6}{5}g_1^2\sigma_{2,11} - \frac{2}{5}\sqrt{6}g_1g_1'\sigma_{2,14} - \frac{2}{5}\sqrt{6}g_1g_1'\sigma_{2,41} + \frac{4}{5}g_1^2\sigma_{2,44} + 4\sqrt{\frac{3}{5}}g_1\sigma_{3,1} - 4\sqrt{\frac{2}{5}}g_1'\sigma_{3,4} - 12m_{h_{13}}^2|\lambda|^2\text{Tr}(Y_d Y_d^\dagger) \\
&- 6m_{h_{23}}^2|\lambda|^2\text{Tr}(Y_d Y_d^\dagger) - 6m_{s_3}^2|\lambda|^2\text{Tr}(Y_d Y_d^\dagger) - 6|T_\lambda|^2\text{Tr}(Y_d Y_d^\dagger) \\
&- 4m_{h_{13}}^2|\lambda|^2\text{Tr}(Y_e Y_e^\dagger) - 2m_{h_{23}}^2|\lambda|^2\text{Tr}(Y_e Y_e^\dagger) - 2m_{s_3}^2|\lambda|^2\text{Tr}(Y_e Y_e^\dagger) \\
&- 2|T_\lambda|^2\text{Tr}(Y_e Y_e^\dagger) + \frac{8}{5}g_1^2m_{h_{23}}^2 \text{Tr}(Y_u Y_u^\dagger) - \frac{3}{5}g_1^2m_{h_{23}}^2 \text{Tr}(Y_u Y_u^\dagger) + 32g_3^2m_{h_{23}}^2 \text{Tr}(Y_u Y_u^\dagger) \\
&+ 64g_3^2|M_3|^2\text{Tr}(Y_u Y_u^\dagger) - 6m_{h_{13}}^2|\lambda|^2\text{Tr}(\kappa \kappa^\dagger) - 6m_{h_{23}}^2|\lambda|^2\text{Tr}(\kappa \kappa^\dagger)
\end{aligned}$$

$$\begin{aligned}
& -12m_{s_3}^2|\lambda|^2\text{Tr}(\kappa\kappa^\dagger) - 6|T_\lambda|^2\text{Tr}(\kappa\kappa^\dagger) - 6\lambda T_\lambda^*\text{Tr}(Y_d^\dagger T_d) - 2\lambda T_\lambda^*\text{Tr}(Y_e^\dagger T_e) \\
& + \frac{1}{25}g_1^2M_1^*(24g_1^2M_1' - 40\text{Tr}(Y_u^\dagger T_u) + 45g_2^2M_2 + 48g_1^2M_1 + 783g_1^2M_1 + 80M_1\text{Tr}(Y_uY_u^\dagger) + 90g_2^2M_1) \\
& - 32g_3^2M_3^*\text{Tr}(Y_u^\dagger T_u) \\
& + \frac{1}{50}g_1^2M_1'^*(48g_1^2M_1 + 96g_1^2M_1' + 771g_1^2M_1' + 120g_2^2M_1' + 60g_2^2M_2 + 6g_1^2M_1'Q_S^2 + 5(5 + Q_S^2)\lambda^*(2M_1'\lambda - T_\lambda) \\
& - 60M_1'\text{Tr}(Y_uY_u^\dagger) + 30\text{Tr}(Y_u^\dagger T_u)) \\
& - 6\lambda T_\lambda^*\text{Tr}(\kappa^\dagger T_\kappa) - 6\lambda^*T_\lambda\text{Tr}(T_d^*Y_d^T) - 6|\lambda|^2\text{Tr}(T_d^*T_d^T) - 2\lambda^*T_\lambda\text{Tr}(T_e^*Y_e^T) \\
& - 2|\lambda|^2\text{Tr}(T_e^*T_e^T) - \frac{8}{5}g_1^2M_1\text{Tr}(T_u^*Y_u^T) + \frac{3}{5}g_1^2M_1'\text{Tr}(T_u^*Y_u^T) - 32g_3^2M_3\text{Tr}(T_u^*Y_u^T) \\
& + \frac{8}{5}g_1^2\text{Tr}(T_u^*T_u^T) - \frac{3}{5}g_1^2\text{Tr}(T_u^*T_u^T) + 32g_3^2\text{Tr}(T_u^*T_u^T) - 6\lambda^*T_\lambda\text{Tr}(T_\kappa^*\kappa^T) \\
& - 6|\lambda|^2\text{Tr}(T_\kappa^*T_\kappa^T) - 6|\lambda|^2\text{Tr}(m_d^2Y_dY_d^\dagger) - 2|\lambda|^2\text{Tr}(m_e^2Y_eY_e^\dagger) - 2|\lambda|^2\text{Tr}(m_l^2Y_e^\dagger Y_e) \\
& - 6|\lambda|^2\text{Tr}(m_q^2Y_d^\dagger Y_d) + \frac{8}{5}g_1^2\text{Tr}(m_q^2Y_u^\dagger Y_u) - \frac{3}{5}g_1^2\text{Tr}(m_q^2Y_u^\dagger Y_u) + 32g_3^2\text{Tr}(m_q^2Y_u^\dagger Y_u) \\
& + \frac{8}{5}g_1^2\text{Tr}(m_u^2Y_uY_u^\dagger) - \frac{3}{5}g_1^2\text{Tr}(m_u^2Y_uY_u^\dagger) + 32g_3^2\text{Tr}(m_u^2Y_uY_u^\dagger) - 6|\lambda|^2\text{Tr}(\kappa\kappa^\dagger m_X^{2*}) \\
& - 6|\lambda|^2\text{Tr}(\kappa m_X^{2*}\kappa^\dagger) - 6m_{h_{13}}^2\text{Tr}(Y_dY_u^\dagger Y_uY_d^\dagger) - 6m_{h_{23}}^2\text{Tr}(Y_dY_u^\dagger Y_uY_d^\dagger) \\
& - 6\text{Tr}(Y_dY_u^\dagger T_uT_d^\dagger) - 6\text{Tr}(Y_dT_u^\dagger T_uY_d^\dagger) - 6\text{Tr}(Y_uY_d^\dagger T_dT_u^\dagger) - 36m_{h_{23}}^2\text{Tr}(Y_uY_u^\dagger Y_uY_u^\dagger) \\
& - 36\text{Tr}(Y_uY_u^\dagger T_uT_u^\dagger) - 6\text{Tr}(Y_uT_d^\dagger T_dY_u^\dagger) - 36\text{Tr}(Y_uT_u^\dagger T_uY_u^\dagger) \\
& - 6\text{Tr}(m_d^2Y_dY_u^\dagger Y_uY_d^\dagger) - 6\text{Tr}(m_q^2Y_d^\dagger Y_dY_u^\dagger Y_u) - 6\text{Tr}(m_q^2Y_u^\dagger Y_uY_d^\dagger Y_d) \\
& - 36\text{Tr}(m_q^2Y_u^\dagger Y_uY_u^\dagger Y_u) - 6\text{Tr}(m_u^2Y_uY_d^\dagger Y_dY_u^\dagger) - 36\text{Tr}(m_u^2Y_uY_u^\dagger Y_uY_u^\dagger)
\end{aligned} \tag{108}$$

$$\begin{aligned}
\beta_{m_d^2}^{(1)} &= -\frac{8}{15}g_1^2\mathbf{1}|M_1|^2 - \frac{4}{5}g_1^2\mathbf{1}|M_1'|^2 - \frac{32}{3}g_3^2\mathbf{1}|M_3|^2 + 4m_{h_{13}}^2Y_dY_d^\dagger + 4T_dT_d^\dagger + 2m_d^2Y_dY_d^\dagger \\
&+ 4Y_dm_q^2Y_d^\dagger + 2Y_dY_d^\dagger m_d^2 + 2\frac{1}{\sqrt{15}}g_1\mathbf{1}\sigma_{1,1} + \sqrt{\frac{2}{5}}g_1'\mathbf{1}\sigma_{1,4}
\end{aligned} \tag{109}$$

$$\begin{aligned}
\beta_{m_d^2}^{(2)} &= +\frac{128}{45}g_1^2g_3^2\mathbf{1}|M_3|^2 + \frac{64}{15}g_1^2g_3^2\mathbf{1}|M_3|^2 + \frac{160}{3}g_3^4\mathbf{1}|M_3|^2 + \frac{64}{45}g_1^2g_3^2M_1\mathbf{1}M_3^* + \frac{32}{15}g_1^2g_3^2M_1'\mathbf{1}M_3^* \\
&+ \frac{4}{5}g_1^2m_{h_{13}}^2Y_dY_d^\dagger + \frac{6}{5}g_1^2m_{h_{13}}^2Y_dY_d^\dagger + 12g_2^2m_{h_{13}}^2Y_dY_d^\dagger + 24g_2^2|M_2|^2Y_dY_d^\dagger \\
&- 8m_{h_{13}}^2|\lambda|^2Y_dY_d^\dagger - 4m_{h_{23}}^2|\lambda|^2Y_dY_d^\dagger - 4m_{s_3}^2|\lambda|^2Y_dY_d^\dagger - 4|T_\lambda|^2Y_dY_d^\dagger \\
&- \frac{4}{5}g_1^2M_1Y_dT_d^\dagger - \frac{6}{5}g_1^2M_1'Y_dT_d^\dagger - 12g_2^2M_2Y_dT_d^\dagger \\
&+ \frac{1}{150}g_1^2M_1'^*(180(2M_1'Y_dY_d^\dagger - T_dY_d^\dagger) + (320g_3^2(2M_1' + M_3) - 56g_1^2(2M_1' + M_1) + 9g_1^2M_1'(2Q_S^2 + 257)))\mathbf{1}) \\
&+ \frac{4}{225}g_1^2M_1^*((-21g_1^2(2M_1 + M_1') + 768g_1^2M_1 + 80g_3^2(2M_1 + M_3))\mathbf{1} - 45T_dY_d^\dagger + 90M_1Y_dY_d^\dagger)
\end{aligned}$$

$$\begin{aligned}
& -12g_2^2 M_2^* T_d Y_d^\dagger - 4\lambda T_\lambda^* T_d Y_d^\dagger + \frac{4}{5}g_1^2 T_d T_d^\dagger + \frac{6}{5}g_1^2 T_d T_d^\dagger \\
& + 12g_2^2 T_d T_d^\dagger - 4|\lambda|^2 T_d T_d^\dagger + \frac{2}{5}g_1^2 m_d^2 Y_d Y_d^\dagger + \frac{3}{5}g_1^2 m_d^2 Y_d Y_d^\dagger \\
& + 6g_2^2 m_d^2 Y_d Y_d^\dagger - 2|\lambda|^2 m_d^2 Y_d Y_d^\dagger + \frac{4}{5}g_1^2 Y_d m_q^2 Y_d^\dagger + \frac{6}{5}g_1^2 Y_d m_q^2 Y_d^\dagger \\
& + 12g_2^2 Y_d m_q^2 Y_d^\dagger - 4|\lambda|^2 Y_d m_q^2 Y_d^\dagger + \frac{2}{5}g_1^2 Y_d Y_d^\dagger m_d^2 + \frac{3}{5}g_1^2 Y_d Y_d^\dagger m_d^2 \\
& + 6g_2^2 Y_d Y_d^\dagger m_d^2 - 2|\lambda|^2 Y_d Y_d^\dagger m_d^2 - 8m_{h_{13}}^2 Y_d Y_d^\dagger Y_d Y_d^\dagger - 4Y_d Y_d^\dagger T_d T_d^\dagger \\
& - 4m_{h_{13}}^2 Y_d Y_u^\dagger Y_u Y_d^\dagger - 4m_{h_{23}}^2 Y_d Y_u^\dagger Y_u Y_d^\dagger - 4Y_d Y_u^\dagger T_u T_d^\dagger \\
& - 4Y_d T_d^\dagger T_d Y_d^\dagger - 4Y_d T_u^\dagger T_u Y_d^\dagger - 4T_d Y_d^\dagger Y_d T_d^\dagger - 4T_d Y_u^\dagger Y_u T_d^\dagger \\
& - 4T_d T_d^\dagger Y_d Y_d^\dagger - 4T_d T_u^\dagger Y_u Y_d^\dagger - 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 - 4\lambda^* Y_d T_d^\dagger T_\lambda + \frac{32}{3}g_3^4 \mathbf{1}\sigma_{2,3} + \frac{8}{15}g_1^2 \mathbf{1}\sigma_{2,11} + \frac{4}{5}\sqrt{\frac{2}{3}}g_1 g_1' \mathbf{1}\sigma_{2,14} + \frac{4}{5}\sqrt{\frac{2}{3}}g_1 g_1' \mathbf{1}\sigma_{2,41} \\
& + \frac{4}{5}g_1^2 \mathbf{1}\sigma_{2,44} + 8\frac{1}{\sqrt{15}}g_1 \mathbf{1}\sigma_{3,1} + 4\sqrt{\frac{2}{5}}g_1' \mathbf{1}\sigma_{3,4} - 24m_{h_{13}}^2 Y_d Y_d^\dagger \text{Tr}(Y_d Y_d^\dagger) \\
& - 12T_d T_d^\dagger \text{Tr}(Y_d Y_d^\dagger) - 6m_d^2 Y_d Y_d^\dagger \text{Tr}(Y_d Y_d^\dagger) - 12Y_d m_q^2 Y_d^\dagger \text{Tr}(Y_d Y_d^\dagger) \\
& - 6Y_d Y_d^\dagger m_d^2 \text{Tr}(Y_d Y_d^\dagger) - 8m_{h_{13}}^2 Y_d Y_d^\dagger \text{Tr}(Y_e Y_e^\dagger) - 4T_d T_d^\dagger \text{Tr}(Y_e Y_e^\dagger) \\
& - 2m_d^2 Y_d Y_d^\dagger \text{Tr}(Y_e Y_e^\dagger) - 4Y_d m_q^2 Y_d^\dagger \text{Tr}(Y_e Y_e^\dagger) - 2Y_d Y_d^\dagger m_d^2 \text{Tr}(Y_e Y_e^\dagger) \\
& - 12Y_d T_d^\dagger \text{Tr}(Y_d^\dagger T_d) - 4Y_d T_d^\dagger \text{Tr}(Y_e^\dagger T_e) - 12T_d Y_d^\dagger \text{Tr}(T_d^* Y_d^T) \\
& - 12Y_d Y_d^\dagger \text{Tr}(T_d^* T_d^T) - 4T_d Y_d^\dagger \text{Tr}(T_e^* Y_e^T) - 4Y_d Y_d^\dagger \text{Tr}(T_e^* T_e^T) \\
& - 12Y_d Y_d^\dagger \text{Tr}(m_d^2 Y_d Y_d^\dagger) - 4Y_d Y_d^\dagger \text{Tr}(m_e^2 Y_e Y_e^\dagger) - 4Y_d Y_d^\dagger \text{Tr}(m_l^2 Y_e^\dagger Y_e) \\
& - 12Y_d Y_d^\dagger \text{Tr}(m_q^2 Y_d^\dagger Y_d)
\end{aligned} \tag{110}$$

$$\begin{aligned}
\beta_{m_u^2}^{(1)} &= -\frac{32}{15}g_1^2 \mathbf{1}|M_1|^2 - \frac{1}{5}g_1^2 \mathbf{1}|M_1'|^2 - \frac{32}{3}g_3^2 \mathbf{1}|M_3|^2 + 4m_{h_{23}}^2 Y_u Y_u^\dagger + 4T_u T_u^\dagger + 2m_u^2 Y_u Y_u^\dagger \\
& + 4Y_u m_q^2 Y_u^\dagger + 2Y_u Y_u^\dagger m_u^2 - 4\frac{1}{\sqrt{15}}g_1 \mathbf{1}\sigma_{1,1} + \frac{1}{\sqrt{10}}g_1' \mathbf{1}\sigma_{1,4}
\end{aligned} \tag{111}$$

$$\begin{aligned}
\beta_{m_u^2}^{(2)} &= +\frac{512}{45}g_1^2 g_3^2 \mathbf{1}|M_3|^2 + \frac{16}{15}g_1^2 g_3^2 \mathbf{1}|M_3|^2 + \frac{160}{3}g_3^4 \mathbf{1}|M_3|^2 + \frac{256}{45}g_1^2 g_3^2 M_1 \mathbf{1}M_3^* + \frac{8}{15}g_1^2 g_3^2 M_1' \mathbf{1}M_3^* \\
& - \frac{4}{5}g_1^2 m_{h_{23}}^2 Y_u Y_u^\dagger + \frac{4}{5}g_1^2 m_{h_{23}}^2 Y_u Y_u^\dagger + 12g_2^2 m_{h_{23}}^2 Y_u Y_u^\dagger + 24g_2^2 |M_2|^2 Y_u Y_u^\dagger \\
& - 4m_{h_{13}}^2 |\lambda|^2 Y_u Y_u^\dagger - 8m_{h_{23}}^2 |\lambda|^2 Y_u Y_u^\dagger - 4m_{s_3}^2 |\lambda|^2 Y_u Y_u^\dagger - 4|T_\lambda|^2 Y_u Y_u^\dagger \\
& + \frac{4}{5}g_1^2 M_1 Y_u T_u^\dagger - \frac{4}{5}g_1^2 M_1' Y_u T_u^\dagger - 12g_2^2 M_2 Y_u T_u^\dagger
\end{aligned}$$

$$\begin{aligned}
& + \frac{1}{600} g_1^2 M_1'^* \left(\left(320 g_3^2 (2M_1' + M_3) + 352 g_1^2 (2M_1' + M_1) + 9 g_1^2 M_1' (2Q_S^2 + 251) \right) \mathbf{1} + 480 (2M_1' Y_u Y_u^\dagger - T_u Y_u^\dagger) \right) \\
& - 12 g_2^2 M_2^* T_u Y_u^\dagger - 4 \lambda T_\lambda^* T_u Y_u^\dagger \\
& + \frac{4}{225} g_1^2 M_1^* \left(\left(320 g_3^2 (2M_1 + M_3) + 3216 g_1^2 M_1 + 33 g_1^2 (2M_1 + M_1') \right) \mathbf{1} + 45 (-2M_1 Y_u Y_u^\dagger + T_u Y_u^\dagger) \right) \\
& - \frac{4}{5} g_1^2 T_u T_u^\dagger + \frac{4}{5} g_1^2 T_u T_u^\dagger + 12 g_2^2 T_u T_u^\dagger - 4 |\lambda|^2 T_u T_u^\dagger \\
& - \frac{2}{5} g_1^2 m_u^2 Y_u Y_u^\dagger + \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 - 2 |\lambda|^2 m_u^2 Y_u Y_u^\dagger \\
& - \frac{4}{5} g_1^2 Y_u m_q^2 Y_u^\dagger + \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 - 4 |\lambda|^2 Y_u m_q^2 Y_u^\dagger \\
& - \frac{2}{5} g_1^2 Y_u Y_u^\dagger m_u^2 + \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 - 2 |\lambda|^2 Y_u Y_u^\dagger m_u^2 \\
& - 4 m_{h_{13}}^2 Y_u Y_d^\dagger Y_d Y_u^\dagger - 4 m_{h_{23}}^2 Y_u Y_d^\dagger Y_d Y_u^\dagger - 4 Y_u Y_d^\dagger T_d T_u^\dagger \\
& - 8 m_{h_{23}}^2 Y_u Y_u^\dagger Y_u Y_u^\dagger - 4 Y_u Y_u^\dagger T_u T_u^\dagger - 4 Y_u T_d^\dagger T_d Y_u^\dagger - 4 Y_u T_u^\dagger T_u Y_u^\dagger \\
& - 4 T_u Y_d^\dagger Y_d T_u^\dagger - 4 T_u Y_u^\dagger Y_u T_u^\dagger - 4 T_u T_d^\dagger Y_d Y_u^\dagger - 4 T_u T_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 - 4 \lambda^* Y_u T_u^\dagger T_\lambda + \frac{32}{3} g_3^4 \mathbf{1}_{\sigma_{2,3}} \\
& + \frac{32}{15} g_1^2 \mathbf{1}_{\sigma_{2,11}} - \frac{4}{5} \sqrt{\frac{2}{3}} g_1 g_1' \mathbf{1}_{\sigma_{2,14}} - \frac{4}{5} \sqrt{\frac{2}{3}} g_1 g_1' \mathbf{1}_{\sigma_{2,41}} + \frac{1}{5} g_1^2 \mathbf{1}_{\sigma_{2,44}} - 16 \frac{1}{\sqrt{15}} g_1 \mathbf{1}_{\sigma_{3,1}} + 2 \sqrt{\frac{2}{5}} g_1' \mathbf{1}_{\sigma_{3,4}} \\
& - 24 m_{h_{23}}^2 Y_u Y_u^\dagger \text{Tr}(Y_u Y_u^\dagger) - 12 T_u T_u^\dagger \text{Tr}(Y_u Y_u^\dagger) - 6 m_u^2 Y_u Y_u^\dagger \text{Tr}(Y_u Y_u^\dagger) \\
& - 12 Y_u m_q^2 Y_u^\dagger \text{Tr}(Y_u Y_u^\dagger) - 6 Y_u Y_u^\dagger m_u^2 \text{Tr}(Y_u Y_u^\dagger) - 12 Y_u T_u^\dagger \text{Tr}(Y_u^\dagger T_u) \\
& - 12 T_u Y_u^\dagger \text{Tr}(T_u^* Y_u^T) - 12 Y_u Y_u^\dagger \text{Tr}(T_u^* T_u^T) - 12 Y_u Y_u^\dagger \text{Tr}(m_q^2 Y_u^\dagger Y_u) \\
& - 12 Y_u Y_u^\dagger \text{Tr}(m_u^2 Y_u Y_u^\dagger)
\end{aligned} \tag{112}$$

$$\begin{aligned}
\beta_{m_e^2}^{(1)} &= -\frac{24}{5} g_1^2 \mathbf{1} |M_1|^2 - \frac{1}{5} g_1^2 \mathbf{1} |M_1'|^2 + 4 m_{h_{13}}^2 Y_e Y_e^\dagger + 4 T_e T_e^\dagger + 2 m_e^2 Y_e Y_e^\dagger + 4 Y_e m_l^2 Y_e^\dagger \\
& + 2 Y_e Y_e^\dagger m_e^2 + 2 \sqrt{\frac{3}{5}} g_1 \mathbf{1}_{\sigma_{1,1}} + \frac{1}{\sqrt{10}} g_1' \mathbf{1}_{\sigma_{1,4}}
\end{aligned} \tag{113}$$

$$\begin{aligned}
\beta_{m_e^2}^{(2)} &= -\frac{12}{5} g_1^2 m_{h_{13}}^2 Y_e Y_e^\dagger + \frac{12}{5} g_1^2 m_{h_{13}}^2 Y_e Y_e^\dagger + 12 g_2^2 m_{h_{13}}^2 Y_e Y_e^\dagger + 24 g_2^2 |M_2|^2 Y_e Y_e^\dagger \\
& - 8 m_{h_{13}}^2 |\lambda|^2 Y_e Y_e^\dagger - 4 m_{h_{23}}^2 |\lambda|^2 Y_e Y_e^\dagger - 4 m_{s_3}^2 |\lambda|^2 Y_e Y_e^\dagger - 4 |T_\lambda|^2 Y_e Y_e^\dagger \\
& + \frac{12}{5} g_1^2 M_1 Y_e T_e^\dagger - \frac{12}{5} g_1^2 M_1' Y_e T_e^\dagger - 12 g_2^2 M_2 Y_e T_e^\dagger \\
& + \frac{3}{200} g_1^2 M_1'^* \left(160 (2M_1' Y_e Y_e^\dagger - T_e Y_e^\dagger) + (-32 g_1^2 (2M_1' + M_1) + g_1^2 M_1' (2Q_S^2 + 251)) \mathbf{1} \right) \\
& - 12 g_2^2 M_2^* T_e Y_e^\dagger - 4 \lambda T_\lambda^* T_e Y_e^\dagger
\end{aligned}$$

$$\begin{aligned}
& + \frac{12}{25} g_1^2 M_1^* \left(\left(288 g_1^2 M_1 - g_1'^2 (2M_1 + M_1') \right) \mathbf{1} + 5 \left(-2M_1 Y_e Y_e^\dagger + T_e Y_e^\dagger \right) \right) - \frac{12}{5} g_1^2 T_e T_e^\dagger \\
& + \frac{12}{5} g_1^2 T_e T_e^\dagger + 12 g_2^2 T_e T_e^\dagger - 4 |\lambda|^2 T_e T_e^\dagger - \frac{6}{5} g_1^2 m_e^2 Y_e Y_e^\dagger \\
& + \frac{6}{5} g_1^2 m_e^2 Y_e Y_e^\dagger + 6 g_2^2 m_e^2 Y_e Y_e^\dagger - 2 |\lambda|^2 m_e^2 Y_e Y_e^\dagger - \frac{12}{5} g_1^2 Y_e m_l^2 Y_e^\dagger \\
& + \frac{12}{5} g_1^2 Y_e m_l^2 Y_e^\dagger + 12 g_2^2 Y_e m_l^2 Y_e^\dagger - 4 |\lambda|^2 Y_e m_l^2 Y_e^\dagger - \frac{6}{5} g_1^2 Y_e Y_e^\dagger m_e^2 \\
& + \frac{6}{5} g_1^2 Y_e Y_e^\dagger m_e^2 + 6 g_2^2 Y_e Y_e^\dagger m_e^2 - 2 |\lambda|^2 Y_e Y_e^\dagger m_e^2 - 8 m_{h_{13}}^2 Y_e Y_e^\dagger Y_e Y_e^\dagger \\
& - 4 Y_e Y_e^\dagger T_e T_e^\dagger - 4 Y_e T_e^\dagger T_e Y_e^\dagger - 4 T_e Y_e^\dagger Y_e T_e^\dagger - 4 T_e T_e^\dagger Y_e Y_e^\dagger \\
& - 2 m_e^2 Y_e Y_e^\dagger Y_e Y_e^\dagger - 4 Y_e m_l^2 Y_e^\dagger Y_e Y_e^\dagger - 4 Y_e Y_e^\dagger m_e^2 Y_e Y_e^\dagger - 4 Y_e Y_e^\dagger Y_e m_l^2 Y_e^\dagger \\
& - 2 Y_e Y_e^\dagger Y_e Y_e^\dagger m_e^2 - 4 \lambda^* Y_e T_e^\dagger T_\lambda + \frac{24}{5} g_1^2 \mathbf{1} \sigma_{2,11} + \frac{2}{5} \sqrt{6} g_1 g_1' \mathbf{1} \sigma_{2,14} + \frac{2}{5} \sqrt{6} g_1 g_1' \mathbf{1} \sigma_{2,41} + \frac{1}{5} g_1^2 \mathbf{1} \sigma_{2,44} \\
& + 8 \sqrt{\frac{3}{5}} g_1 \mathbf{1} \sigma_{3,1} + 2 \sqrt{\frac{2}{5}} g_1' \mathbf{1} \sigma_{3,4} - 24 m_{h_{13}}^2 Y_e Y_e^\dagger \text{Tr} \left(Y_d Y_d^\dagger \right) - 12 T_e T_e^\dagger \text{Tr} \left(Y_d Y_d^\dagger \right) \\
& - 6 m_e^2 Y_e Y_e^\dagger \text{Tr} \left(Y_d Y_d^\dagger \right) - 12 Y_e m_l^2 Y_e^\dagger \text{Tr} \left(Y_d Y_d^\dagger \right) - 6 Y_e Y_e^\dagger m_e^2 \text{Tr} \left(Y_d Y_d^\dagger \right) \\
& - 8 m_{h_{13}}^2 Y_e Y_e^\dagger \text{Tr} \left(Y_e Y_e^\dagger \right) - 4 T_e T_e^\dagger \text{Tr} \left(Y_e Y_e^\dagger \right) - 2 m_e^2 Y_e Y_e^\dagger \text{Tr} \left(Y_e Y_e^\dagger \right) \\
& - 4 Y_e m_l^2 Y_e^\dagger \text{Tr} \left(Y_e Y_e^\dagger \right) - 2 Y_e Y_e^\dagger m_e^2 \text{Tr} \left(Y_e Y_e^\dagger \right) - 12 Y_e T_e^\dagger \text{Tr} \left(Y_d^\dagger T_d \right) \\
& - 4 Y_e T_e^\dagger \text{Tr} \left(Y_e^\dagger T_e \right) - 12 T_e Y_e^\dagger \text{Tr} \left(T_d^* Y_d^T \right) - 12 Y_e Y_e^\dagger \text{Tr} \left(T_d^* T_d^T \right) \\
& - 4 T_e Y_e^\dagger \text{Tr} \left(T_e^* Y_e^T \right) - 4 Y_e Y_e^\dagger \text{Tr} \left(T_e^* T_e^T \right) - 12 Y_e Y_e^\dagger \text{Tr} \left(m_d^2 Y_d Y_d^\dagger \right) \\
& - 4 Y_e Y_e^\dagger \text{Tr} \left(m_e^2 Y_e Y_e^\dagger \right) - 4 Y_e Y_e^\dagger \text{Tr} \left(m_l^2 Y_e^\dagger Y_e \right) - 12 Y_e Y_e^\dagger \text{Tr} \left(m_q^2 Y_d^\dagger Y_d \right)
\end{aligned} \tag{114}$$

$$\begin{aligned}
\beta_{m_{s_3}^2}^{(1)} &= -\frac{1}{5} g_1^2 Q_S^2 |M_1'|^2 + 4 \left(m_{h_{13}}^2 + m_{h_{23}}^2 + m_{s_3}^2 \right) |\lambda|^2 + 2 m_{phi}^2 |\sigma|^2 + 2 m_{s_3}^2 |\sigma|^2 + 2 m_{sbar_3}^2 |\sigma|^2 + 4 |T_\lambda|^2 \\
&+ 2 |T_\sigma|^2 + \frac{1}{\sqrt{10}} g_1' Q_S \sigma_{1,4} + 6 m_{s_3}^2 \text{Tr} \left(\kappa \kappa^\dagger \right) + 6 \text{Tr} \left(T_\kappa^* T_\kappa^T \right) + 6 \text{Tr} \left(\kappa \kappa^\dagger m_X^{2*} \right) + 6 \text{Tr} \left(\kappa m_X^{2*} \kappa^\dagger \right)
\end{aligned} \tag{115}$$

$$\begin{aligned}
\beta_{m_{s_3}^2}^{(2)} &= \frac{1}{200} \left(g_1'^2 M_1'^* \left(3 \left(20 \left(-13 + Q_S^2 \right) \text{Tr} \left(\kappa^\dagger T_\kappa \right) - 40 M_1' \left(-13 + Q_S^2 \right) \text{Tr} \left(\kappa \kappa^\dagger \right) + g_1'^2 M_1' Q_S^2 \left(4 Q_S^2 + 249 \right) \right) - 40 \left(-13 + Q_S^2 \right) \lambda^* \right. \right. \\
&+ 20 \left(24 g_1^2 |T_\lambda|^2 + 26 g_1'^2 |T_\lambda|^2 + 120 g_2^2 |T_\lambda|^2 - 2 g_1'^2 Q_S^2 |T_\lambda|^2 - 160 \left(m_{h_{13}}^2 + m_{h_{23}}^2 + m_{s_3}^2 \right) \lambda^2 \lambda^{*,2} \right. \\
&- 80 m_{phi}^2 \sigma^2 \sigma'^{*,2} - 80 m_{s_3}^2 \sigma^2 \sigma'^{*,2} - 80 m_{sbar_3}^2 \sigma^2 \sigma'^{*,2} - 24 g_1^2 M_1 \lambda T_\lambda^* - 26 g_1'^2 M_1' \lambda T_\lambda^* \\
&- 120 g_2^2 M_2 \lambda T_\lambda^* + 2 g_1'^2 M_1' Q_S^2 \lambda T_\lambda^* - 40 |\sigma|^2 T_{\kappa',*} T_{\kappa'} - 40 \kappa' \sigma'^* T_{\kappa',*} T_\sigma - 160 |\sigma|^2 T_\sigma^* T_\sigma \\
&- 40 \kappa'^* \left(\left(4 m_{phi}^2 + m_{s_3}^2 + m_{sbar_3}^2 \right) \kappa' |\sigma|^2 + T_\sigma^* \left(\kappa' T_\sigma + \sigma T_{\kappa'} \right) \right) + 2 g_1'^2 Q_S^2 \sigma_{2,44} + 4 \sqrt{10} g_1' Q_S \sigma_{3,4} \\
&- 120 |T_\lambda|^2 \text{Tr} \left(Y_d Y_d^\dagger \right) - 40 |T_\lambda|^2 \text{Tr} \left(Y_e Y_e^\dagger \right) - 120 |T_\lambda|^2 \text{Tr} \left(Y_u Y_u^\dagger \right) + 16 g_1^2 m_{s_3}^2 \text{Tr} \left(\kappa \kappa^\dagger \right) \\
&+ 39 g_1'^2 m_{s_3}^2 \text{Tr} \left(\kappa \kappa^\dagger \right) + 320 g_3^2 m_{s_3}^2 \text{Tr} \left(\kappa \kappa^\dagger \right) - 3 g_1^2 m_{s_3}^2 Q_S^2 \text{Tr} \left(\kappa \kappa^\dagger \right) \\
&+ 32 g_1^2 |M_1|^2 \text{Tr} \left(\kappa \kappa^\dagger \right) + 640 g_3^2 |M_3|^2 \text{Tr} \left(\kappa \kappa^\dagger \right) - 120 \lambda T_\lambda^* \text{Tr} \left(Y_d^\dagger T_d \right) - 40 \lambda T_\lambda^* \text{Tr} \left(Y_e^\dagger T_e \right)
\end{aligned}$$

$$\begin{aligned}
& -120\lambda T_\lambda^* \text{Tr}(Y_u^\dagger T_u) - 16g_1^2 M_1^* \text{Tr}(\kappa^\dagger T_\kappa) - 320g_3^2 M_3^* \text{Tr}(\kappa^\dagger T_\kappa) - 16g_1^2 M_1 \text{Tr}(T_\kappa^* \kappa^T) \\
& - 39g_1^2 M_1' \text{Tr}(T_\kappa^* \kappa^T) - 320g_3^2 M_3 \text{Tr}(T_\kappa^* \kappa^T) + 3g_1^2 M_1' Q_S^2 \text{Tr}(T_\kappa^* \kappa^T) + 16g_1^2 \text{Tr}(T_\kappa^* T_\kappa^T) \\
& + 39g_1^2 \text{Tr}(T_\kappa^* T_\kappa^T) + 320g_3^2 \text{Tr}(T_\kappa^* T_\kappa^T) - 3g_1^2 Q_S^2 \text{Tr}(T_\kappa^* T_\kappa^T) \\
& + 2\lambda^* \left(12g_1^2 m_{h_{13}}^2 \lambda + 13g_1^2 m_{h_{13}}^2 \lambda + 60g_2^2 m_{h_{13}}^2 \lambda + 12g_1^2 m_{h_{23}}^2 \lambda + 13g_1^2 m_{h_{23}}^2 \lambda + 60g_2^2 m_{h_{23}}^2 \lambda \right. \\
& + 12g_1^2 m_{s_3}^2 \lambda + 13g_1^2 m_{s_3}^2 \lambda + 60g_2^2 m_{s_3}^2 \lambda - g_1^2 m_{h_{13}}^2 Q_S^2 \lambda - g_1^2 m_{h_{23}}^2 Q_S^2 \lambda \\
& - g_1^2 m_{s_3}^2 Q_S^2 \lambda - 160\lambda |T_\lambda|^2 + 12g_1^2 M_1^* (2M_1 \lambda - T_\lambda) + 60g_2^2 M_2^* (2M_2 \lambda - T_\lambda) \\
& - 120m_{h_{13}}^2 \lambda \text{Tr}(Y_d Y_d^\dagger) - 60m_{h_{23}}^2 \lambda \text{Tr}(Y_d Y_d^\dagger) - 60m_{s_3}^2 \lambda \text{Tr}(Y_d Y_d^\dagger) - 40m_{h_{13}}^2 \lambda \text{Tr}(Y_e Y_e^\dagger) \\
& - 20m_{h_{23}}^2 \lambda \text{Tr}(Y_e Y_e^\dagger) - 20m_{s_3}^2 \lambda \text{Tr}(Y_e Y_e^\dagger) - 60m_{h_{13}}^2 \lambda \text{Tr}(Y_u Y_u^\dagger) - 120m_{h_{23}}^2 \lambda \text{Tr}(Y_u Y_u^\dagger) \\
& - 60m_{s_3}^2 \lambda \text{Tr}(Y_u Y_u^\dagger) - 60T_\lambda \text{Tr}(T_d^* Y_d^T) - 60\lambda \text{Tr}(T_d^* T_d^T) - 20T_\lambda \text{Tr}(T_e^* Y_e^T) - 20\lambda \text{Tr}(T_e^* T_e^T) \\
& - 60T_\lambda \text{Tr}(T_u^* Y_u^T) - 60\lambda \text{Tr}(T_u^* T_u^T) - 60\lambda \text{Tr}(m_d^2 Y_d Y_d^\dagger) - 20\lambda \text{Tr}(m_e^2 Y_e Y_e^\dagger) \\
& - 20\lambda \text{Tr}(m_l^2 Y_e Y_e^\dagger) - 60\lambda \text{Tr}(m_q^2 Y_d^\dagger Y_d) - 60\lambda \text{Tr}(m_q^2 Y_u^\dagger Y_u) - 60\lambda \text{Tr}(m_u^2 Y_u Y_u^\dagger) \\
& + 16g_1^2 \text{Tr}(\kappa \kappa^\dagger m_X^{2*}) + 39g_1^2 \text{Tr}(\kappa \kappa^\dagger m_X^{2*}) + 320g_3^2 \text{Tr}(\kappa \kappa^\dagger m_X^{2*}) - 3g_1^2 Q_S^2 \text{Tr}(\kappa \kappa^\dagger m_X^{2*}) \\
& + 16g_1^2 \text{Tr}(\kappa m_X^{2*} \kappa^\dagger) + 39g_1^2 \text{Tr}(\kappa m_X^{2*} \kappa^\dagger) + 320g_3^2 \text{Tr}(\kappa m_X^{2*} \kappa^\dagger) - 3g_1^2 Q_S^2 \text{Tr}(\kappa m_X^{2*} \kappa^\dagger) \\
& - 240m_{s_3}^2 \text{Tr}(\kappa \kappa^\dagger \kappa \kappa^\dagger) - 240\text{Tr}(\kappa \kappa^\dagger T_\kappa T_\kappa^\dagger) - 240\text{Tr}(\kappa T_\kappa^\dagger T_\kappa \kappa^\dagger) - 120\text{Tr}(\kappa \kappa^\dagger \kappa \kappa^\dagger m_X^{2*}) \\
& - 120\text{Tr}(\kappa \kappa^\dagger \kappa m_X^{2*} \kappa^\dagger) - 120\text{Tr}(\kappa \kappa^\dagger m_X^{2*} \kappa \kappa^\dagger) - 120\text{Tr}(\kappa m_X^{2*} \kappa^\dagger \kappa \kappa^\dagger) \Big) \tag{116}
\end{aligned}$$

$$\beta_{m_{sbar3}}^{(1)} = 2(m_{phi}^2 + m_{s_3}^2 + m_{sbar3}^2) |\sigma|^2 + 2|T_\sigma|^2 - \frac{1}{5} g_1^2 Q_S^2 |M_1'|^2 - \frac{1}{\sqrt{10}} g_1' Q_S \sigma_{1,4} \tag{117}$$

$$\begin{aligned}
\beta_{m_{sbar3}}^{(2)} = & + \frac{3}{200} g_1^4 Q_S^2 (4Q_S^2 + 249) |M_1'|^2 - 4m_{h_{13}}^2 \sigma |\lambda|^2 \sigma'^{*} - 4m_{h_{23}}^2 \sigma |\lambda|^2 \sigma'^{*} - 4m_{phi}^2 \sigma |\lambda|^2 \sigma'^{*} \\
& - 8m_{s_3}^2 \sigma |\lambda|^2 \sigma'^{*} - 4m_{sbar3}^2 \sigma |\lambda|^2 \sigma'^{*} - 8m_{phi}^2 \sigma^2 \sigma'^{*,2} - 8m_{s_3}^2 \sigma^2 \sigma'^{*,2} - 8m_{sbar3}^2 \sigma^2 \sigma'^{*,2} \\
& - 4|\sigma|^2 T_{\kappa',*} T_{\kappa'} - 4|\sigma|^2 T_\lambda^* T_\lambda - 4\sigma \lambda^* T_\sigma^* T_\lambda - 4\kappa' \sigma'^{*} T_{\kappa',*} T_\sigma - 4\lambda \sigma'^{*} T_\lambda^* T_\sigma \\
& - 4|\lambda|^2 T_\sigma^* T_\sigma - 16|\sigma|^2 T_\sigma^* T_\sigma - 4\kappa'^{*} \left((4m_{phi}^2 + m_{s_3}^2 + m_{sbar3}^2) \kappa' |\sigma|^2 + T_\sigma^* (\kappa' T_\sigma + \sigma T_{\kappa'}) \right) \\
& + \frac{1}{5} g_1^2 Q_S^2 \sigma_{2,44} - 2\sqrt{\frac{2}{5}} g_1' Q_S \sigma_{3,4} - 6m_{phi}^2 |\sigma|^2 \text{Tr}(\kappa \kappa^\dagger) - 12m_{s_3}^2 |\sigma|^2 \text{Tr}(\kappa \kappa^\dagger) \\
& - 6m_{sbar3}^2 |\sigma|^2 \text{Tr}(\kappa \kappa^\dagger) - 6|T_\sigma|^2 \text{Tr}(\kappa \kappa^\dagger) - 6\sigma T_\sigma^* \text{Tr}(\kappa^\dagger T_\kappa) - 6\sigma'^{*} T_\sigma \text{Tr}(T_\kappa^* \kappa^T) \\
& - 6|\sigma|^2 \text{Tr}(T_\kappa^* T_\kappa^T) - 6|\sigma|^2 \text{Tr}(\kappa \kappa^\dagger m_X^{2*}) - 6|\sigma|^2 \text{Tr}(\kappa m_X^{2*} \kappa^\dagger) \tag{118}
\end{aligned}$$

$$\begin{aligned}
\beta_{m_X}^{(1)} = & -\frac{8}{15} g_1^2 \mathbf{1} |M_1|^2 - \frac{4}{5} g_1^2 \mathbf{1} |M_1'|^2 - \frac{32}{3} g_3^2 \mathbf{1} |M_3|^2 + 2m_{s_3}^2 \kappa^* \kappa^T + 2T_\kappa^* T_\kappa^T + m_X^2 \kappa^* \kappa^T \\
& + 2\kappa^* m_X^2 \kappa^T + \kappa^* \kappa^T m_X^2 - 2\frac{1}{\sqrt{15}} g_1 \mathbf{1} \sigma_{1,1} - \sqrt{\frac{2}{5}} g_1' \mathbf{1} \sigma_{1,4} \tag{119}
\end{aligned}$$

$$\begin{aligned}
\beta_{m_X^2}^{(2)} = & + \frac{128}{45} g_1^2 g_3^2 \mathbf{1} |M_3|^2 + \frac{64}{15} g_1^2 g_3^2 \mathbf{1} |M_3|^2 + \frac{160}{3} g_3^4 \mathbf{1} |M_3|^2 \\
& + \frac{4}{225} g_1^2 \left(-21 g_1^2 (2M_1 + M_1') + 768 g_1^2 M_1 + 80 g_3^2 (2M_1 + M_3) \right) \mathbf{1} M_1^* + \frac{64}{45} g_1^2 g_3^2 M_1 \mathbf{1} M_3^* + \frac{32}{15} g_1^2 g_3^2 M_1' \mathbf{1} M_3^* \\
& + \frac{1}{2} g_1^2 m_{s_3}^2 \kappa^* \kappa^T + \frac{1}{10} g_1^2 m_{s_3}^2 Q_S^2 \kappa^* \kappa^T - 4 m_{h_{13}}^2 |\lambda|^2 \kappa^* \kappa^T - 4 m_{h_{23}}^2 |\lambda|^2 \kappa^* \kappa^T \\
& - 8 m_{s_3}^2 |\lambda|^2 \kappa^* \kappa^T - 2 m_{phi}^2 |\sigma|^2 \kappa^* \kappa^T - 4 m_{s_3}^2 |\sigma|^2 \kappa^* \kappa^T - 2 m_{s_{bar3}}^2 |\sigma|^2 \kappa^* \kappa^T \\
& - 4 |T_\lambda|^2 \kappa^* \kappa^T - 2 |T_\sigma|^2 \kappa^* \kappa^T \\
& + \frac{1}{150} g_1^2 M_1'^* \left(15 (5 + Q_S^2) (2M_1' \kappa^* \kappa^T - \kappa^* T_\kappa^T) + (320 g_3^2 (2M_1' + M_3) - 56 g_1^2 (2M_1' + M_1) + 9 g_1^2 M_1' (2Q_S^2 + 257)) \mathbf{1} \right) \\
& - 4 \lambda T_\lambda^* \kappa^* T_\kappa^T - 2 \sigma T_\sigma^* \kappa^* T_\kappa^T - \frac{1}{2} g_1^2 M_1' T_\kappa^* \kappa^T - \frac{1}{10} g_1^2 M_1' Q_S^2 T_\kappa^* \kappa^T \\
& + \frac{1}{2} g_1^2 T_\kappa^* T_\kappa^T + \frac{1}{10} g_1^2 Q_S^2 T_\kappa^* T_\kappa^T - 4 |\lambda|^2 T_\kappa^* T_\kappa^T - 2 |\sigma|^2 T_\kappa^* T_\kappa^T \\
& + \frac{1}{4} g_1^2 m_X^2 \kappa^* \kappa^T + \frac{1}{20} g_1^2 Q_S^2 m_X^2 \kappa^* \kappa^T - 2 |\lambda|^2 m_X^2 \kappa^* \kappa^T - |\sigma|^2 m_X^2 \kappa^* \kappa^T \\
& + \frac{1}{2} g_1^2 \kappa^* m_X^2 \kappa^T + \frac{1}{10} g_1^2 Q_S^2 \kappa^* m_X^2 \kappa^T - 4 |\lambda|^2 \kappa^* m_X^2 \kappa^T - 2 |\sigma|^2 \kappa^* m_X^2 \kappa^T \\
& + \frac{1}{4} g_1^2 \kappa^* \kappa^T m_X^2 + \frac{1}{20} g_1^2 Q_S^2 \kappa^* \kappa^T m_X^2 - 2 |\lambda|^2 \kappa^* \kappa^T m_X^2 - |\sigma|^2 \kappa^* \kappa^T m_X^2 \\
& - 4 m_{s_3}^2 \kappa^* \kappa^T \kappa^* \kappa^T - 2 \kappa^* \kappa^T T_\kappa^* T_\kappa^T - 2 \kappa^* T_\kappa^T T_\kappa^* \kappa^T - 2 T_\kappa^* \kappa^T \kappa^* T_\kappa^T \\
& - 2 T_\kappa^* T_\kappa^T \kappa^* \kappa^T - m_X^2 \kappa^* \kappa^T \kappa^* \kappa^T - 2 \kappa^* m_X^2 \kappa^T \kappa^* \kappa^T - 2 \kappa^* \kappa^T m_X^2 \kappa^* \kappa^T \\
& - 2 \kappa^* \kappa^T \kappa^* m_X^2 \kappa^T - \kappa^* \kappa^T \kappa^* \kappa^T m_X^2 - 4 \lambda^* T_\kappa^* \kappa^T T_\lambda - 2 \sigma'^* T_\kappa^* \kappa^T T_\sigma + \frac{32}{3} g_3^4 \mathbf{1} \sigma_{2,3} \\
& + \frac{8}{15} g_1^2 \mathbf{1} \sigma_{2,11} + \frac{4}{5} \sqrt{\frac{2}{3}} g_1 g_1' \mathbf{1} \sigma_{2,14} + \frac{4}{5} \sqrt{\frac{2}{3}} g_1 g_1' \mathbf{1} \sigma_{2,41} + \frac{4}{5} g_1^2 \mathbf{1} \sigma_{2,44} - 8 \frac{1}{\sqrt{15}} g_1 \mathbf{1} \sigma_{3,1} - 4 \sqrt{\frac{2}{5}} g_1' \mathbf{1} \sigma_{3,4} \\
& - 12 m_{s_3}^2 \kappa^* \kappa^T \text{Tr}(\kappa \kappa^\dagger) - 6 T_\kappa^* T_\kappa^T \text{Tr}(\kappa \kappa^\dagger) - 3 m_X^2 \kappa^* \kappa^T \text{Tr}(\kappa \kappa^\dagger) \\
& - 6 \kappa^* m_X^2 \kappa^T \text{Tr}(\kappa \kappa^\dagger) - 3 \kappa^* \kappa^T m_X^2 \text{Tr}(\kappa \kappa^\dagger) - 6 T_\kappa^* \kappa^T \text{Tr}(\kappa^\dagger T_\kappa) \\
& - 6 \kappa^* T_\kappa^T \text{Tr}(T_\kappa^* \kappa^T) - 6 \kappa^* \kappa^T \text{Tr}(T_\kappa^* T_\kappa^T) - 6 \kappa^* \kappa^T \text{Tr}(\kappa \kappa^\dagger m_X^{2*}) \\
& - 6 \kappa^* \kappa^T \text{Tr}(\kappa m_X^{2*} \kappa^\dagger) \tag{120}
\end{aligned}$$

$$\begin{aligned}
\beta_{m_X^2}^{(1)} = & - \frac{8}{15} g_1^2 \mathbf{1} |M_1|^2 - \frac{9}{5} g_1^2 \mathbf{1} |M_1'|^2 - \frac{32}{3} g_3^2 \mathbf{1} |M_3|^2 + 2 m_{s_3}^2 \kappa^T \kappa^* + 2 T_\kappa^T T_\kappa^* + m_X^2 \kappa^T \kappa^* \\
& + 2 \kappa^T m_X^2 \kappa^* + \kappa^T \kappa^* m_X^2 + 2 \frac{1}{\sqrt{15}} g_1 \mathbf{1} \sigma_{1,1} - 3 \frac{1}{\sqrt{10}} g_1' \mathbf{1} \sigma_{1,4} \tag{121}
\end{aligned}$$

$$\begin{aligned}
\beta_{m_X^2}^{(2)} = & + \frac{128}{45} g_1^2 g_3^2 \mathbf{1} |M_3|^2 + \frac{48}{5} g_1^2 g_3^2 \mathbf{1} |M_3|^2 + \frac{160}{3} g_3^4 \mathbf{1} |M_3|^2 \\
& + \frac{8}{225} g_1^2 \left(27 g_1^2 (2M_1 + M_1') + 384 g_1^2 M_1 + 40 g_3^2 (2M_1 + M_3) \right) \mathbf{1} M_1^* + \frac{64}{45} g_1^2 g_3^2 M_1 \mathbf{1} M_3^* + \frac{24}{5} g_1^2 g_3^2 M_1' \mathbf{1} M_3^* \\
& - \frac{1}{2} g_1^2 m_{s_3}^2 \kappa^T \kappa^* + \frac{1}{10} g_1^2 m_{s_3}^2 Q_S^2 \kappa^T \kappa^* - 4 m_{h_{13}}^2 |\lambda|^2 \kappa^T \kappa^* - 4 m_{h_{23}}^2 |\lambda|^2 \kappa^T \kappa^*
\end{aligned}$$

$$\begin{aligned}
& -8m_{s_3}^2 |\lambda|^2 \kappa^T \kappa^* - 2m_{phi}^2 |\sigma|^2 \kappa^T \kappa^* - 4m_{s_3}^2 |\sigma|^2 \kappa^T \kappa^* - 2m_{sbar_3}^2 |\sigma|^2 \kappa^T \kappa^* \\
& -4|T_\lambda|^2 \kappa^T \kappa^* - 2|T_\sigma|^2 \kappa^T \kappa^* + \frac{1}{2}g_1^2 M_1' \kappa^T T_\kappa^* - \frac{1}{10}g_1^2 M_1' Q_S^2 \kappa^T T_\kappa^* \\
& + \frac{1}{200}g_1^2 M_1'^* \left(20 \left(-5 + Q_S^2 \right) \left(2M_1' \kappa^T \kappa^* - T_\kappa^T \kappa^* \right) + 3 \left(320g_3^2 \left(2M_1' + M_3 \right) + 64g_1^2 \left(2M_1' + M_1 \right) + 9g_1^2 M_1' \left(2Q_S^2 + 267 \right) \right) \mathbf{1} \right) \\
& -4\lambda T_\lambda^* T_\kappa^T \kappa^* - 2\sigma T_\sigma^* T_\kappa^T \kappa^* - \frac{1}{2}g_1^2 T_\kappa^T T_\kappa^* + \frac{1}{10}g_1^2 Q_S^2 T_\kappa^T T_\kappa^* \\
& -4|\lambda|^2 T_\kappa^T T_\kappa^* - 2|\sigma|^2 T_\kappa^T T_\kappa^* - \frac{1}{4}g_1^2 m_X^2 \kappa^T \kappa^* + \frac{1}{20}g_1^2 Q_S^2 m_X^2 \kappa^T \kappa^* \\
& -2|\lambda|^2 m_X^2 \kappa^T \kappa^* - |\sigma|^2 m_X^2 \kappa^T \kappa^* - \frac{1}{2}g_1^2 \kappa^T m_X^2 \kappa^* + \frac{1}{10}g_1^2 Q_S^2 \kappa^T m_X^2 \kappa^* \\
& -4|\lambda|^2 \kappa^T m_X^2 \kappa^* - 2|\sigma|^2 \kappa^T m_X^2 \kappa^* - \frac{1}{4}g_1^2 \kappa^T \kappa^* m_X^2 + \frac{1}{20}g_1^2 Q_S^2 \kappa^T \kappa^* m_X^2 \\
& -2|\lambda|^2 \kappa^T \kappa^* m_X^2 - |\sigma|^2 \kappa^T \kappa^* m_X^2 - 4m_{s_3}^2 \kappa^T \kappa^* \kappa^T \kappa^* - 2\kappa^T \kappa^* T_\kappa^T T_\kappa^* \\
& -2\kappa^T T_\kappa^* T_\kappa^T \kappa^* - 2T_\kappa^T \kappa^* \kappa^T T_\kappa^* - 2T_\kappa^T T_\kappa^* \kappa^T \kappa^* - m_X^2 \kappa^T \kappa^* \kappa^T \kappa^* \\
& -2\kappa^T m_X^2 \kappa^* \kappa^T \kappa^* - 2\kappa^T \kappa^* m_X^2 \kappa^T \kappa^* - 2\kappa^T \kappa^* \kappa^T m_X^2 \kappa^* - \kappa^T \kappa^* \kappa^T \kappa^* m_X^2 - 4\lambda^* \kappa^T T_\kappa^* T_\lambda \\
& -2\sigma'^* \kappa^T T_\kappa^* T_\sigma + \frac{32}{3}g_3^4 \mathbf{1}_{\sigma_{2,3}} + \frac{8}{15}g_1^2 \mathbf{1}_{\sigma_{2,11}} - \frac{2}{5}\sqrt{6}g_1 g_1' \mathbf{1}_{\sigma_{2,14}} - \frac{2}{5}\sqrt{6}g_1 g_1' \mathbf{1}_{\sigma_{2,41}} + \frac{9}{5}g_1^2 \mathbf{1}_{\sigma_{2,44}} \\
& + 8\frac{1}{\sqrt{15}}g_1 \mathbf{1}_{\sigma_{3,1}} - 6\sqrt{\frac{2}{5}}g_1' \mathbf{1}_{\sigma_{3,4}} - 12m_{s_3}^2 \kappa^T \kappa^* \text{Tr}(\kappa \kappa^\dagger) - 6T_\kappa^T T_\kappa^* \text{Tr}(\kappa \kappa^\dagger) \\
& - 3m_X^2 \kappa^T \kappa^* \text{Tr}(\kappa \kappa^\dagger) - 6\kappa^T m_X^2 \kappa^* \text{Tr}(\kappa \kappa^\dagger) - 3\kappa^T \kappa^* m_X^2 \text{Tr}(\kappa \kappa^\dagger) \\
& - 6\kappa^T T_\kappa^* \text{Tr}(\kappa^\dagger T_\kappa) - 6T_\kappa^T \kappa^* \text{Tr}(T_\kappa^* \kappa^T) - 6\kappa^T \kappa^* \text{Tr}(T_\kappa^* T_\kappa^T) \\
& - 6\kappa^T \kappa^* \text{Tr}(\kappa \kappa^\dagger m_X^{2*}) - 6\kappa^T \kappa^* \text{Tr}(\kappa m_X^{2*} \kappa^\dagger)
\end{aligned} \tag{122}$$

$$\beta_{m_h^2}^{(1)} = \frac{1}{5} \left(-30g_2^2 |M_2|^2 - 4g_1^2 |M_1'|^2 - 6g_1^2 |M_1|^2 + \sqrt{10}g_1' \sigma_{1,4} - \sqrt{15}g_1 \sigma_{1,1} \right) \tag{123}$$

$$\begin{aligned}
\beta_{m_h^2}^{(2)} = & \frac{1}{50} \left(6g_1^2 \left(15g_2^2 \left(2M_1 + M_2 \right) + 261g_1^2 M_1 + 8g_1^2 \left(2M_1 + M_1' \right) \right) M_1^* \right. \\
& + 3g_1^2 \left(16g_1^2 \left(2M_1' + M_1 \right) + 20g_2^2 \left(2M_1' + M_2 \right) + g_1^2 M_1' \left(2Q_S^2 + 257 \right) \right) M_1'^* \\
& + 10 \left(3g_2^2 \left(2g_1^2 \left(2M_2 + M_1' \right) + 3g_1^2 \left(2M_2 + M_1 \right) + 85g_2^2 M_2 \right) M_2^* + 30g_2^4 \sigma_{2,2} + 6g_1^2 \sigma_{2,11} - 2\sqrt{6}g_1 g_1' \sigma_{2,14} \right. \\
& \left. \left. - 2\sqrt{6}g_1 g_1' \sigma_{2,41} + 4g_1^2 \sigma_{2,44} - 4\sqrt{15}g_1 \sigma_{3,1} + 4\sqrt{10}g_1' \sigma_{3,4} \right) \right)
\end{aligned} \tag{124}$$

$$\beta_{m_h^2}^{(1)} = \frac{1}{5} \left(-30g_2^2 |M_2|^2 - 4g_1^2 |M_1'|^2 - 6g_1^2 |M_1|^2 - \sqrt{10}g_1' \sigma_{1,4} + \sqrt{15}g_1 \sigma_{1,1} \right) \tag{125}$$

$$\begin{aligned}
\beta_{m_h^2}^{(2)} = & \frac{1}{50} \left(6g_1^2 \left(15g_2^2 \left(2M_1 + M_2 \right) + 261g_1^2 M_1 + 8g_1^2 \left(2M_1 + M_1' \right) \right) M_1^* \right. \\
& + 3g_1^2 \left(16g_1^2 \left(2M_1' + M_1 \right) + 20g_2^2 \left(2M_1' + M_2 \right) + g_1^2 M_1' \left(2Q_S^2 + 257 \right) \right) M_1'^* \\
& + 10 \left(3g_2^2 \left(2g_1^2 \left(2M_2 + M_1' \right) + 3g_1^2 \left(2M_2 + M_1 \right) + 85g_2^2 M_2 \right) M_2^* + 30g_2^4 \sigma_{2,2} + 6g_1^2 \sigma_{2,11} - 2\sqrt{6}g_1 g_1' \sigma_{2,14} \right.
\end{aligned}$$

$$- 2\sqrt{6}g_1g'_1\sigma_{2,41} + 4g_1^2\sigma_{2,44} + 4\sqrt{15}g_1\sigma_{3,1} - 4\sqrt{10}g'_1\sigma_{3,4}) \quad (126)$$

$$\beta_{m_{phi}^2}^{(1)} = 2\left(2|T_{\kappa'}|^2 + 6m_{phi}^2|\kappa'|^2 + (m_{phi}^2 + m_{s_3}^2 + m_{sbar_3}^2)|\sigma|^2 + |T_\sigma|^2\right) \quad (127)$$

$$\begin{aligned} \beta_{m_{phi}^2}^{(2)} = & -96m_{phi}^2\kappa'^{*,2} - 8(m_{phi}^2 + m_{s_3}^2 + m_{sbar_3}^2)\sigma^2\sigma'^{*,2} \\ & - 8\kappa'^{*}\left((4m_{phi}^2 + m_{s_3}^2 + m_{sbar_3}^2)\kappa'|\sigma|^2 + 8\kappa'|T_{\kappa'}|^2 + T_\sigma^*(\kappa'T_\sigma + \sigma T_{\kappa'})\right) \\ & - \frac{1}{5}T_\sigma^*\left(20\lambda^*(\lambda T_\sigma + \sigma T_\lambda) + 30\sigma\text{Tr}(\kappa^\dagger T_\kappa) + 30T_\sigma\text{Tr}(\kappa\kappa^\dagger) + g_1^2M_1'Q_S^2\sigma - g_1^2Q_S^2T_\sigma\right) \\ & + \frac{1}{5}\sigma'^{*}\left(g_1^2m_{phi}^2Q_S^2\sigma + g_1^2m_{s_3}^2Q_S^2\sigma + g_1^2m_{sbar_3}^2Q_S^2\sigma - 20(2m_{s_3}^2 + m_{h_{13}}^2 + m_{h_{23}}^2 + m_{phi}^2 + m_{sbar_3}^2)\sigma|\lambda|^2\right. \\ & - 40\sigma|T_{\kappa'}|^2 - 20\sigma|T_\lambda|^2 - 80\sigma|T_\sigma|^2 + g_1^2Q_S^2M_1'^*(2M_1'\sigma - T_\sigma) - 40\kappa'T_{\kappa',*}T_\sigma \\ & - 20\lambda T_\lambda^*T_\sigma - 30m_{phi}^2\sigma\text{Tr}(\kappa\kappa^\dagger) - 60m_{s_3}^2\sigma\text{Tr}(\kappa\kappa^\dagger) - 30m_{sbar_3}^2\sigma\text{Tr}(\kappa\kappa^\dagger) - 30T_\sigma\text{Tr}(T_\kappa^*\kappa^T) \\ & \left. - 30\sigma\text{Tr}(T_\kappa^*T_\kappa^T) - 30\sigma\text{Tr}(\kappa\kappa^\dagger m_X^{2*}) - 30\sigma\text{Tr}(\kappa m_X^{2*}\kappa^\dagger)\right) \end{aligned} \quad (128)$$

3.11 Vacuum expectation values

$$\beta_{v_1}^{(1)} = \frac{1}{40}v_1\left(-120\text{Tr}(Y_dY_d^\dagger) + 30g_2^2 + 30g_2^2\text{Xi} - 40|\lambda|^2 - 40\text{Tr}(Y_eY_e^\dagger) + 6g_1^2 + 6g_1^2\text{Xi} + 9g_1^2 + 9g_1^2\text{Xi}\right) \quad (129)$$

$$\begin{aligned} \beta_{v_1}^{(2)} = & \frac{1}{1600}v_1\left(-2088g_1^4 + 216g_1^2g_1'^2 - 2403g_1'^4 - 720g_1^2g_2^2 - 1080g_1^2g_2'^2 - 6000g_2^4 - 18g_1^4Q_S^2 - 36g_1^4\text{Xi}\right. \\ & - 108g_1^2g_1'\text{Xi} - 81g_1'^4\text{Xi} - 360g_1^2g_2^2\text{Xi} - 540g_1^2g_2'^2\text{Xi} + 3500g_2^4\text{Xi} + 36g_1^4\text{Xi}^2 + 108g_1^2g_1'^2\text{Xi}^2 + 81g_1'^4\text{Xi}^2 \\ & + 360g_1^2g_2^2\text{Xi}^2 + 540g_1^2g_2'^2\text{Xi}^2 - 900g_2^4\text{Xi}^2 + 4800\lambda^2\lambda'^{*,2} \\ & - 80(2g_1^2(9\text{Xi} - 4) + 320g_3^2 + 3g_1'^2(9\text{Xi} - 4) + 90g_2^2\text{Xi})\text{Tr}(Y_dY_d^\dagger) - 1920g_1^2\text{Tr}(Y_eY_e^\dagger) + 320g_1'^2\text{Tr}(Y_eY_e^\dagger) \\ & - 480g_1^2\text{Xi}\text{Tr}(Y_eY_e^\dagger) - 720g_1'^2\text{Xi}\text{Tr}(Y_eY_e^\dagger) - 2400g_2^2\text{Xi}\text{Tr}(Y_eY_e^\dagger) \\ & - 80|\lambda|^2(-20\sigma\sigma'^{*} + 30g_2^2\text{Xi} - 5g_1'^2 - 60\text{Tr}(\kappa\kappa^\dagger) - 60\text{Tr}(Y_uY_u^\dagger) + 6g_1^2\text{Xi} + 9g_1'^2\text{Xi} + g_1'^2Q_S^2) \\ & \left. + 14400\text{Tr}(Y_dY_d^\dagger Y_dY_d^\dagger) + 4800\text{Tr}(Y_dY_u^\dagger Y_uY_d^\dagger) + 4800\text{Tr}(Y_eY_e^\dagger Y_eY_e^\dagger)\right) \end{aligned} \quad (130)$$

$$\beta_{v_2}^{(1)} = \frac{1}{20}v_2\left((15g_2^2 + 2g_1'^2 + 3g_1^2)(1 + \text{Xi}) - 20|\lambda|^2 - 60\text{Tr}(Y_uY_u^\dagger)\right) \quad (131)$$

$$\begin{aligned} \beta_{v_2}^{(2)} = & \frac{1}{400}v_2\left(-522g_1^4 - 96g_1^2g_1'^2 - 257g_1'^4 - 180g_1^2g_2^2 - 120g_1^2g_2'^2 - 1500g_2^4 - 2g_1^4Q_S^2 - 9g_1^4\text{Xi}\right. \\ & - 12g_1^2g_1'\text{Xi} - 4g_1'^4\text{Xi} - 90g_1^2g_2^2\text{Xi} - 60g_1^2g_2'^2\text{Xi} + 875g_2^4\text{Xi} + 9g_1^4\text{Xi}^2 + 12g_1^2g_1'^2\text{Xi}^2 + 4g_1'^4\text{Xi}^2 \\ & + 90g_1^2g_2^2\text{Xi}^2 + 60g_1^2g_2'^2\text{Xi}^2 - 225g_2^4\text{Xi}^2 + 1200\lambda^2\lambda'^{*,2} \\ & - 40(5(32g_3^2 + 9g_2^2\text{Xi}) + g_1'^2(6\text{Xi} - 3) + g_1^2(9\text{Xi} + 8))\text{Tr}(Y_uY_u^\dagger) \\ & \left. - 20|\lambda|^2(-20\text{Tr}(Y_eY_e^\dagger) - 20\sigma\sigma'^{*} + 30g_2^2\text{Xi} + 4g_1'^2\text{Xi} + 5g_1'^2 - 60\text{Tr}(\kappa\kappa^\dagger) - 60\text{Tr}(Y_dY_d^\dagger) + 6g_1^2\text{Xi} + g_1'^2Q_S^2)\right) \end{aligned}$$

$$+ 1200\text{Tr}\left(Y_d Y_u^\dagger Y_u Y_d^\dagger\right) + 3600\text{Tr}\left(Y_u Y_u^\dagger Y_u Y_u^\dagger\right) \quad (132)$$

$$\beta_{v_s}^{(1)} = \frac{1}{40}v_s \left(-120\text{Tr}\left(\kappa\kappa^\dagger\right) - 40|\sigma|^2 - 80|\lambda|^2 + g_1^2 Q_S^2 + g_1^2 Q_S^2 \text{Xi} \right) \quad (133)$$

$$\begin{aligned} \beta_{v_s}^{(2)} = & \frac{1}{1600}v_s \left(-249g_1^4 Q_S^2 - 4g_1^4 Q_S^4 - g_1^4 Q_S^4 \text{Xi} + g_1^4 Q_S^4 \text{Xi}^2 - 80|\sigma|^2 \left(-40\kappa'\kappa'^{*} + g_1^2 Q_S^2 \text{Xi} \right) + 6400\lambda^2 \lambda^{*,2} \right. \\ & + 3200\sigma^2 \sigma'^{*,2} \\ & - 160|\lambda|^2 \left(12g_1^2 + 13g_1^2 - 20\text{Tr}\left(Y_e Y_e^\dagger\right) + 60g_2^2 - 60\text{Tr}\left(Y_d Y_d^\dagger\right) - 60\text{Tr}\left(Y_u Y_u^\dagger\right) - g_1^2 Q_S^2 + g_1^2 Q_S^2 \text{Xi} \right) \\ & - 1280g_1^2 \text{Tr}\left(\kappa\kappa^\dagger\right) - 3120g_1^2 \text{Tr}\left(\kappa\kappa^\dagger\right) - 25600g_3^2 \text{Tr}\left(\kappa\kappa^\dagger\right) + 240g_1^2 Q_S^2 \text{Tr}\left(\kappa\kappa^\dagger\right) \\ & \left. - 240g_1^2 Q_S^2 \text{Xi} \text{Tr}\left(\kappa\kappa^\dagger\right) + 9600\text{Tr}\left(\kappa\kappa^\dagger \kappa\kappa^\dagger\right) \right) \end{aligned} \quad (134)$$

$$\beta_{v_{sb}}^{(1)} = \frac{1}{40}v_{sb} \left(-40|\sigma|^2 + g_1^2 Q_S^2 \left(1 + \text{Xi} \right) \right) \quad (135)$$

$$\beta_{v_{sb}}^{(2)} = \frac{1}{1600}v_{sb} \left(3200\sigma^2 \sigma'^{*,2} - 80|\sigma|^2 \left(-40\kappa'\kappa'^{*} - 40\lambda\lambda^* - 60\text{Tr}\left(\kappa\kappa^\dagger\right) + g_1^2 Q_S^2 \text{Xi} \right) + g_1^4 Q_S^2 \left(Q_S^2 \left(-\text{Xi} - 4 + \text{Xi}^2 \right) - 249 \right) \right) \quad (136)$$

$$\beta_{v_{phi}}^{(1)} = -v_{phi} \left(2|\kappa'|^2 + |\sigma|^2 \right) \quad (137)$$

$$\beta_{v_{phi}}^{(2)} = 4v_{phi}\sigma|\kappa'|^2\sigma'^{*} + 8v_{phi}\kappa'^2\kappa'^{*,2} + \frac{1}{10}v_{phi}|\sigma|^2 \left(20\lambda\lambda^* + 20\sigma\sigma'^{*} + 30\text{Tr}\left(\kappa\kappa^\dagger\right) - g_1^2 Q_S^2 \right) \quad (138)$$

4 Field Rotations

4.1 Rotations in gauge sector for eigenstates 'EWSB'

$$\begin{pmatrix} B_\rho \\ W_{3\rho} \\ Bp_\rho \end{pmatrix} = Z^{\gamma Z Z'} \begin{pmatrix} \gamma_\rho \\ Z_\rho \\ Z'_\rho \end{pmatrix} \quad (139)$$

$$\begin{pmatrix} W_{1\rho} \\ W_{2\rho} \end{pmatrix} = Z^W \begin{pmatrix} W_\rho^- \\ W_\rho^- \end{pmatrix} \quad (140)$$

$$\begin{pmatrix} \lambda_{\tilde{W},1} \\ \lambda_{\tilde{W},2} \\ \lambda_{\tilde{W},3} \end{pmatrix} = Z^{\tilde{W}} \begin{pmatrix} \tilde{W}^- \\ \tilde{W}^+ \\ \tilde{W}^0 \end{pmatrix} \quad (141)$$

$$(142)$$

The mixing matrices are parametrized by

$$Z^{\gamma ZZ'} = \begin{pmatrix} \cos \Theta_W & -\cos \Theta'_W \sin \Theta_W & \sin \Theta_W \sin \Theta'_W \\ \sin \Theta_W & \cos \Theta_W \cos \Theta'_W & -\cos \Theta_W \sin \Theta'_W \\ 0 & \sin \Theta'_W & \cos \Theta'_W \end{pmatrix} \quad (143)$$

$$Z^W = \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ -i\frac{1}{\sqrt{2}} & i\frac{1}{\sqrt{2}} \end{pmatrix} \quad (144)$$

$$Z^{\tilde{W}} = \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \\ -i\frac{1}{\sqrt{2}} & i\frac{1}{\sqrt{2}} & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad (145)$$

$$(146)$$

4.2 Rotations in Mass sector for eigenstates 'EWSB'

4.2.1 Mass Matrices for Scalars

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

$$m_d^2 = \begin{pmatrix} m_{\tilde{d}_L \tilde{d}_L^*} & \frac{1}{2} \text{Delta} \left(\sqrt{2} v_1 T_d^\dagger - v_s v_2 \lambda Y_d^\dagger \right) \delta_{\alpha_1 \beta_2} \\ \frac{1}{2} \text{Delta} \delta_{\alpha_2 \beta_1} \left(\sqrt{2} v_1 T_d - v_s v_2 Y_d \lambda^* \right) & m_{\tilde{d}_R \tilde{d}_R^*} \end{pmatrix} \quad (147)$$

$$m_{\tilde{d}_L \tilde{d}_L^*} = -\frac{1}{24} \mathbf{1} \left(3 \left(4g_1^2 \left(2v_2^2 + 3v_1^2 + Q_S \left(-v_s^2 + v_s b^2 \right) \right) + g_2^2 \left(-v_2^2 + v_1^2 \right) \right) + g_1^2 \left(-v_2^2 + v_1^2 \right) \right) \delta_{\alpha_1 \beta_1} \\ + \frac{1}{2} \left(2m_q^2 + \mathbf{1} v_1^2 Y_d Y_{d,o_1 o_1}^* \right) \delta_{\alpha_1 \beta_1} \quad (148)$$

$$m_{\tilde{d}_R \tilde{d}_R^*} = -\frac{1}{12} \mathbf{1} \left(12g_1^2 \left(2v_2^2 + 3v_1^2 + Q_S \left(-v_s^2 + v_s b^2 \right) \right) + g_1^2 \left(-v_2^2 + v_1^2 \right) \right) \delta_{\alpha_2 \beta_2} + \frac{1}{2} \delta_{\alpha_2 \beta_2} \left(2m_d^2 + \mathbf{1} v_1^2 Y_d^\dagger Y_{d,o_2 o_2} \right) \quad (149)$$

This matrix is diagonalized by Z^D :

$$Z^D m_d^2 Z^{D,\dagger} = m_{2,\tilde{d}}^{dia} \quad (150)$$

with

$$\tilde{d}_{L,i\alpha} = \sum_j Z_{ji}^{D,*} \tilde{d}_{j\alpha}, \quad \tilde{d}_{R,i\alpha} = \sum_j Z_{ji}^{D,*} \tilde{d}_{j\alpha} \quad (151)$$

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

$$m_{\tilde{\nu}}^2 = \left(\frac{1}{8} \mathbf{1} \left(-8g_1^2 \left(2v_2^2 + 3v_1^2 + Q_S \left(-v_s^2 + v_s b^2 \right) \right) + \left(g_1^2 + g_2^2 \right) \left(-v_2^2 + v_1^2 \right) \right) + m_l^2 \right) \quad (152)$$

This matrix is diagonalized by Z^V :

$$Z^V m_{\tilde{\nu}}^2 Z^{V,\dagger} = m_{2,\tilde{\nu}}^{dia} \quad (153)$$

with

$$\tilde{\nu}_{L,i} = \sum_j Z_{ji}^{V,*} \tilde{\nu}_j \quad (154)$$

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

$$m_{\tilde{u}}^2 = \begin{pmatrix} m_{\tilde{u}_L \tilde{u}_L^*} & \frac{1}{2} \text{Delta} \left(\sqrt{2} v_2 T_u^\dagger - v_1 v_s \lambda Y_u^\dagger \right) \delta_{\alpha_1 \beta_2} \\ \frac{1}{2} \text{Delta} \delta_{\alpha_2 \beta_1} \left(\sqrt{2} v_2 T_u - v_1 v_s Y_u \lambda^* \right) & m_{\tilde{u}_R \tilde{u}_R^*} \end{pmatrix} \quad (155)$$

$$m_{\tilde{u}_L \tilde{u}_L^*} = -\frac{1}{24} \mathbf{1} \left(3 \left(4g_1^2 \left(2v_2^2 + 3v_1^2 + Q_S \left(-v_s^2 + v s b^2 \right) \right) + g_2^2 \left(-v_1^2 + v_2^2 \right) \right) + g_1^2 \left(-v_2^2 + v_1^2 \right) \right) \delta_{\alpha_1 \beta_1} \\ + \frac{1}{2} \left(2m_q^2 + \mathbf{1} v_2^2 Y_u Y_{u,o_1 o_1}^* \right) \delta_{\alpha_1 \beta_1} \quad (156)$$

$$m_{\tilde{u}_R \tilde{u}_R^*} = \frac{1}{2} \delta_{\alpha_2 \beta_2} \left(2m_u^2 + \mathbf{1} v_2^2 Y_u^\dagger Y_{u,o_2 o_2} \right) + \frac{1}{6} \mathbf{1} \left(-3g_1^2 \left(2v_2^2 + 3v_1^2 + Q_S \left(-v_s^2 + v s b^2 \right) \right) + g_1^2 \left(-v_2^2 + v_1^2 \right) \right) \delta_{\alpha_2 \beta_2} \quad (157)$$

This matrix is diagonalized by Z^U :

$$Z^U m_{\tilde{u}}^2 Z^{U,\dagger} = m_{2,\tilde{u}}^{dia} \quad (158)$$

with

$$\tilde{u}_{L,i\alpha} = \sum_j Z_{ji}^{U,*} \tilde{u}_{j\alpha}, \quad \tilde{u}_{R,i\alpha} = \sum_j Z_{ji}^{U,*} \tilde{u}_{j\alpha} \quad (159)$$

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

$$m_{\tilde{e}}^2 = \begin{pmatrix} m_{\tilde{e}_L \tilde{e}_L^*} & \frac{1}{2} \text{Delta} \left(\sqrt{2} v_1 T_e^\dagger - v_s v_2 \lambda Y_e^\dagger \right) \\ \frac{1}{2} \text{Delta} \left(\sqrt{2} v_1 T_e - v_s v_2 Y_e \lambda^* \right) & m_{\tilde{e}_R \tilde{e}_R^*} \end{pmatrix} \quad (160)$$

$$m_{\tilde{e}_L \tilde{e}_L^*} = \frac{1}{2} \mathbf{1} v_1^2 Y_e Y_{e,o_1 o_1}^* + \frac{1}{8} \mathbf{1} \left(-8g_1^2 \left(2v_2^2 + 3v_1^2 + Q_S \left(-v_s^2 + v s b^2 \right) \right) + g_1^2 \left(-v_2^2 + v_1^2 \right) + g_2^2 \left(-v_1^2 + v_2^2 \right) \right) + m_l^2 \quad (161)$$

$$m_{\tilde{e}_R \tilde{e}_R^*} = \frac{1}{2} \mathbf{1} v_1^2 Y_e^\dagger Y_{e,o_2 o_2} - \frac{1}{4} \mathbf{1} \left(2g_1^2 \left(2v_2^2 + 3v_1^2 + Q_S \left(-v_s^2 + v s b^2 \right) \right) + g_1^2 \left(-v_2^2 + v_1^2 \right) \right) + m_e^2 \quad (162)$$

This matrix is diagonalized by Z^E :

$$Z^E m_{\tilde{e}}^2 Z^{E,\dagger} = m_{2,\tilde{e}}^{dia} \quad (163)$$

with

$$\tilde{e}_{L,i} = \sum_j Z_{ji}^{E,*} \tilde{e}_j, \quad \tilde{e}_{R,i} = \sum_j Z_{ji}^{E,*} \tilde{e}_j \quad (164)$$

- **Mass matrix for SExotics**, Basis: $(\tilde{D}x_{L,\alpha_1}, \tilde{D}x_{R,\alpha_2}), (\tilde{D}x_{L,\beta_1}^*, \tilde{D}x_{R,\beta_2}^*)$

$$m_{\tilde{x}}^2 = \begin{pmatrix} m_{\tilde{D}x_L \tilde{D}x_L^*} & -\frac{1}{2} \text{Delta} \left(-\sqrt{2} v_s T_\kappa^* + (v_1 v_2 \lambda + v \text{phivsb} \sigma) \kappa^* \right) \delta_{\alpha_1 \beta_2} \\ m_{\tilde{D}x_L \tilde{D}x_R^*} & m_{\tilde{D}x_R \tilde{D}x_R^*} \end{pmatrix} \quad (165)$$

$$m_{\tilde{D}x_L \tilde{D}x_L^*} = \frac{1}{12} \mathbf{1} \left(12g_1^2, (2v_2^2 + 3v_1^2 + Q_S(-v_s^2 + v s b^2)) + g_1^2(-v_2^2 + v_1^2) \right) \delta_{\alpha_1 \beta_1} + \frac{1}{2} \mathbf{1} \delta_{\alpha_1 \beta_1} (2m_X^2 + v_s^2 \kappa_{o_1 o_1}^* \kappa^T) \quad (166)$$

$$m_{\tilde{D}x_L \tilde{D}x_R^*} = -\frac{1}{2} \text{Delta} \delta_{\alpha_2 \beta_1} \left(-\sqrt{2} v_s T_\kappa^T + (v_1 v_2 \lambda^* + v \text{phivsb} \sigma'^*) \kappa^T \right) \quad (167)$$

$$m_{\tilde{D}x_R \tilde{D}x_R^*} = \frac{1}{12} \mathbf{1} \left(18g_1^2, (2v_2^2 + 3v_1^2 + Q_S(-v_s^2 + v s b^2)) + g_1^2(-v_1^2 + v_2^2) \right) \delta_{\alpha_2 \beta_2} + \frac{1}{2} \mathbf{1} \delta_{\alpha_2 \beta_2} (2m_X^2 + v_s^2 \kappa^* \kappa_{o_2 o_2}) \quad (168)$$

This matrix is diagonalized by Z^{Dx} :

$$Z^{Dx} m_{\tilde{x}}^2 Z^{Dx,\dagger} = m_{2,\tilde{x}}^{dia} \quad (169)$$

with

$$\tilde{D}x_{L,i\alpha} = \sum_j Z_{ji}^{Dx,*} \tilde{x}_{j\alpha}, \quad \tilde{D}x_{R,i\alpha} = \sum_j Z_{ji}^{Dx,*} \tilde{x}_{j\alpha} \quad (170)$$

- **Mass matrix for Higgs**, Basis: $(\phi_d, \phi_u, \phi_s, \text{phiSbar}, \text{phiPhi}), (\phi_d, \phi_u, \phi_s, \text{phiSbar}, \text{phiPhi})$

$$m_h^2 = \begin{pmatrix} m_{\phi_d \phi_d} & m_{\phi_u \phi_d} & m_{\phi_s \phi_d} & m_{\text{phiSbar} \phi_d} & \frac{1}{2} v s b v_2 \Re(\sigma \lambda^*) \\ m_{\phi_d \phi_u} & m_{\phi_u \phi_u} & m_{\phi_s \phi_u} & m_{\text{phiSbar} \phi_u} & \frac{1}{2} v_1 v s b \Re(\sigma \lambda^*) \\ m_{\phi_d \phi_s} & m_{\phi_u \phi_s} & m_{\phi_s \phi_s} & m_{\text{phiSbar} \phi_s} & m_{\text{phiPhi} \phi_s} \\ m_{\phi_d \text{phiSbar}} & m_{\phi_u \text{phiSbar}} & m_{\phi_s \text{phiSbar}} & m_{\text{phiSbar} \text{phiSbar}} & m_{\text{phiPhi} \text{phiSbar}} \\ \frac{1}{2} v s b v_2 \Re(\sigma \lambda^*) & \frac{1}{2} v_1 v s b \Re(\sigma \lambda^*) & m_{\phi_s \text{phiPhi}} & m_{\text{phiSbar} \text{phiPhi}} & m_{\text{phiPhi} \text{phiPhi}} \end{pmatrix} \quad (171)$$

$$m_{\phi_d \phi_d} = \frac{1}{2} (v_s^2 + v_2^2) |\lambda|^2 + \frac{1}{8} \left(-(-24g_1^2 + g_1^2 + g_2^2) v_2^2 + 3(4g_1^2 (9v_1^2 + Q_S(-v_s^2 + v s b^2)) + (g_1^2 + g_2^2) v_1^2) \right) + m_{h_{23}}^2 \quad (172)$$

$$m_{\phi_d \phi_u} = -\frac{1}{4} \left(-24g_1^2 + g_1^2 + g_2^2 \right) v_1 v_2 + \frac{1}{4} \left(-2\sqrt{2} v_s \Re(T_\lambda) + (4v_1 v_2 \lambda + v \text{phivsb} \sigma) \lambda^* + v \text{phivsb} \lambda \sigma'^* \right) \quad (173)$$

$$m_{\phi_u \phi_u} = \frac{1}{2} (v_1^2 + v_s^2) |\lambda|^2 + \frac{1}{8} \left(8g_1^2 (3v_1^2 + 6v_2^2 + Q_S(-v_s^2 + v s b^2)) + (-g_1^2 - g_2^2) (-3v_2^2 + v_1^2) \right) + m_{h_{23}}^2 \quad (174)$$

$$m_{\phi_d \phi_s} = -3g_1^2 Q_S v_1 v_s - \frac{1}{\sqrt{2}} v_2 \Re(T_\lambda) + v_1 v_s |\lambda|^2 \quad (175)$$

$$m_{\phi_u \phi_s} = -2g_1^2 Q_S v_s v_2 - \frac{1}{\sqrt{2}} v_1 \Re(T_\lambda) + v_s v_2 |\lambda|^2 \quad (176)$$

$$m_{\phi_s \phi_s} = \frac{1}{2} g_1^2 Q_S \left(-2v_2^2 - 3v_1^2 + Q_S (3v_s^2 - vsb^2) \right) + \frac{1}{2} \left((v_1^2 + v_2^2) |\lambda|^2 + (vphi^2 + vsb^2) |\sigma|^2 \right) + m_{s_3}^2 \quad (177)$$

$$m_{\phi_d \text{PhiSbar}} = 3g_1^2 Q_S v_1 vsb + \frac{1}{2} vphi v_2 \Re(\sigma \lambda^*) \quad (178)$$

$$m_{\phi_u \text{PhiSbar}} = 2g_1^2 Q_S vsbv_2 + \frac{1}{2} v_1 vphi \Re(\sigma \lambda^*) \quad (179)$$

$$m_{\phi_s \text{PhiSbar}} = \frac{1}{4} \left(-2 \left((-2v_s vsb\sigma + XiF_1) \sigma'^* + \sigma XiF_1^* \right) - 2vphi^2 \Re(\sigma \kappa'^*) - \sqrt{2} vphi \left(2\Re(\sigma Mu_{phi}^*) + 2\Re(T_\sigma) \right) \right) - g_1^2 \quad (180)$$

$$m_{\text{PhiSbarPhiSbar}} = \frac{1}{2} g_1^2 Q_S \left(2v_2^2 + 3 \left(Q_S vsb^2 + v_1^2 \right) - Q_S v_s^2 \right) + \frac{1}{2} (vphi^2 + v_s^2) |\sigma|^2 + m_{sbar_3}^2 \quad (181)$$

$$m_{\phi_s \text{PhiPhi}} = -\frac{1}{4} vsb \left(4vphi \Re(\sigma \kappa'^*) + \sqrt{2} \left(2\Re(\sigma Mu_{phi}^*) + 2\Re(T_\sigma) \right) \right) + vphi v_s |\sigma|^2 \quad (182)$$

$$m_{\text{PhiSbarPhiPhi}} = \frac{1}{4} \left(2v_1 v_2 \Re(\sigma \lambda^*) + 4vphi vsb |\sigma|^2 - v_s \left(4vphi \Re(\sigma \kappa'^*) + \sqrt{2} \left(2\Re(\sigma Mu_{phi}^*) + 2\Re(T_\sigma) \right) \right) \right) \quad (183)$$

$$\begin{aligned} m_{\text{PhiPhiPhiPhi}} &= +m_{phi}^2 \\ &+ \frac{1}{2} \left((v_s^2 + vsb^2) |\sigma|^2 + \left(2Mu_{phi} + 3\sqrt{2} vphi \kappa' \right) Mu_{phi}^* + \left(2XiF_1 + 3\sqrt{2} Mu_{phi} vphi + 6vphi^2 \kappa' - v_s vsb\sigma \right) \kappa'^* \right. \\ &\left. + 2\sqrt{2} vphi \Re(T_{\kappa'}) \right) \end{aligned} \quad (184)$$

This matrix is diagonalized by U_H :

$$U_H m_h^2 U_H^\dagger = m_{2,h}^{dia} \quad (185)$$

with

$$\phi_d = \sum_j U_{H,j1}^* h_j, \quad \phi_u = \sum_j U_{H,j2}^* h_j, \quad \phi_s = \sum_j U_{H,j3}^* h_j \quad (186)$$

$$\text{PhiSbar} = \sum_j U_{H,j4}^* h_j, \quad \text{PhiPhi} = \sum_j U_{H,j5}^* h_j \quad (187)$$

- **Mass matrix for Pseudo-Scalar Higgs, Basis:** $(\sigma_d, \sigma_u, \sigma_s, \text{sigmaSbar}, \text{sigmaPhi}), (\sigma_d, \sigma_u, \sigma_s, \text{sigmaSbar}, \text{sigmaPhi})$

$$m_{A^0}^2 = \begin{pmatrix} m_{\sigma_d \sigma_d} & m_{\sigma_u \sigma_d} & \frac{1}{\sqrt{2}} v_2 \Re(T_\lambda) & \frac{1}{2} vphi v_2 \Re(\sigma \lambda^*) & \frac{1}{2} vsbv_2 \Re(\sigma \lambda^*) \\ m_{\sigma_d \sigma_u} & m_{\sigma_u \sigma_u} & \frac{1}{\sqrt{2}} v_1 \Re(T_\lambda) & \frac{1}{2} v_1 vphi \Re(\sigma \lambda^*) & \frac{1}{2} v_1 vsb \Re(\sigma \lambda^*) \\ \frac{1}{\sqrt{2}} v_2 \Re(T_\lambda) & \frac{1}{\sqrt{2}} v_1 \Re(T_\lambda) & m_{\sigma_s \sigma_s} & m_{\text{sigmaSbar} \sigma_s} & m_{\text{sigmaPhi} \sigma_s} \\ \frac{1}{2} vphi v_2 \Re(\sigma \lambda^*) & \frac{1}{2} v_1 vphi \Re(\sigma \lambda^*) & m_{\sigma_s \text{sigmaSbar}} & m_{\text{sigmaSbar} \text{sigmaSbar}} & m_{\text{sigmaPhi} \text{sigmaSbar}} \\ \frac{1}{2} vsbv_2 \Re(\sigma \lambda^*) & \frac{1}{2} v_1 vsb \Re(\sigma \lambda^*) & m_{\sigma_s \text{sigmaPhi}} & m_{\text{sigmaSbar} \text{sigmaPhi}} & m_{\text{sigmaPhi} \text{sigmaPhi}} \end{pmatrix} + \xi_Z m^2(Z) + \xi_{Z'} m^2(Z') \quad (188)$$

$$m_{\sigma_d \sigma_d} = \frac{1}{2} (v_s^2 + v_2^2) |\lambda|^2 + \frac{1}{8} \left(12g_1^2 (2v_2^2 + 3v_1^2 + Q_S (-v_s^2 + vsb^2)) + (g_1^2 + g_2^2) (-v_2^2 + v_1^2) \right) + m_{h_{13}}^2 \quad (189)$$

$$m_{\sigma_d \sigma_u} = \frac{1}{4} \left(2\sqrt{2}v_s \Re(T_\lambda) - 2v_{\phi} v_{sb} \Re(\sigma \lambda^*) \right) \quad (190)$$

$$m_{\sigma_u \sigma_u} = \frac{1}{2} \left(v_1^2 + v_s^2 \right) |\lambda|^2 + \frac{1}{8} \left(8g_1'^2 \left(2v_2^2 + 3v_1^2 + Q_S \left(-v_s^2 + v_{sb}^2 \right) \right) + \left(g_1^2 + g_2^2 \right) \left(-v_1^2 + v_2^2 \right) \right) + m_{h_{23}}^2 \quad (191)$$

$$m_{\sigma_s \sigma_s} = \frac{1}{2} g_1'^2 Q_S \left(-2v_2^2 - 3v_1^2 + Q_S \left(-v_{sb}^2 + v_s^2 \right) \right) + \frac{1}{2} \left(\left(v_1^2 + v_2^2 \right) |\lambda|^2 + \left(v_{\phi}^2 + v_{sb}^2 \right) |\sigma|^2 \right) + m_{s_3}^2 \quad (192)$$

$$m_{\sigma_s \text{sigmaSbar}} = \frac{1}{4} \left(2v_{\phi}^2 \Re(\sigma \kappa'^*) + 4\Re(\sigma X i F_1^*) + \sqrt{2}v_{\phi} \left(2\Re(\sigma M u_{\phi}^*) + 2\Re(T_\sigma) \right) \right) \quad (193)$$

$$m_{\text{sigmaSbarsigmaSbar}} = \frac{1}{2} g_1'^2 Q_S \left(2v_2^2 + 3v_1^2 + Q_S \left(-v_s^2 + v_{sb}^2 \right) \right) + \frac{1}{2} \left(v_{\phi}^2 + v_s^2 \right) |\sigma|^2 + m_{s_{bar_3}}^2 \quad (194)$$

$$m_{\sigma_s \text{sigmaPhi}} = -\frac{1}{4} v_{sb} \left(4v_{\phi} \Re(\sigma \kappa'^*) + \sqrt{2} \left(2\Re(\sigma M u_{\phi}^*) - 2\Re(T_\sigma) \right) \right) \quad (195)$$

$$m_{\text{sigmaSbarsigmaPhi}} = \frac{1}{4} \left(-2v_1 v_2 \Re(\sigma \lambda^*) - v_s \left(4v_{\phi} \Re(\sigma \kappa'^*) + \sqrt{2} \left(-2\Re(T_\sigma) + M u_{\phi} \sigma'^* \right) + \sqrt{2} \sigma M u_{\phi}^* \right) \right) \quad (196)$$

$$\begin{aligned} m_{\text{sigmaPhi sigmaPhi}} &= +m_{\phi}^2 \\ &+ \frac{1}{2} \left(\left(2M u_{\phi} + \sqrt{2}v_{\phi} \kappa' \right) M u_{\phi}^* + \left(2v_{\phi}^2 \kappa' - 2X i F_1 + \sqrt{2}M u_{\phi} v_{\phi} + v_s v_{sb} \right) \kappa'^* + \left(\left(v_s^2 + v_{sb}^2 \right) \sigma \right. \right. \\ &\quad \left. \left. - 2\sqrt{2}v_{\phi} \Re(T_{\kappa'}) \right) \right) \end{aligned} \quad (197)$$

Gauge fixing contributions:

$$m^2(\xi_Z) = \begin{pmatrix} m_{\sigma_d \sigma_d} & m_{\sigma_u \sigma_d} & m_{\sigma_s \sigma_d} & m_{\text{sigmaSbar} \sigma_d} & 0 \\ m_{\sigma_d \sigma_u} & m_{\sigma_u \sigma_u} & m_{\sigma_s \sigma_u} & m_{\text{sigmaSbar} \sigma_u} & 0 \\ m_{\sigma_d \sigma_s} & m_{\sigma_u \sigma_s} & m_{\sigma_s \sigma_s} & m_{\text{sigmaSbar} \sigma_s} & 0 \\ m_{\sigma_d \text{sigmaSbar}} & m_{\sigma_u \text{sigmaSbar}} & m_{\sigma_s \text{sigmaSbar}} & m_{\text{sigmaSbarsigmaSbar}} & 0 \\ 0 & 0 & 0 & 0 & 0 \end{pmatrix} \quad (198)$$

$$m_{\sigma_d \sigma_d} = \frac{1}{4} v_1^2 \left(-6g_1' \sin \Theta'_W + \cos \Theta'_W \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \right)^2 \quad (199)$$

$$m_{\sigma_d \sigma_u} = -\frac{1}{4} v_1 v_2 \left(-6g_1' \sin \Theta'_W + \cos \Theta'_W \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \right) \left(4g_1' \sin \Theta'_W + \cos \Theta'_W \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \right) \quad (200)$$

$$m_{\sigma_u \sigma_u} = \frac{1}{4} v_2^2 \left(4g_1' \sin \Theta'_W + \cos \Theta'_W \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \right)^2 \quad (201)$$

$$m_{\sigma_d \sigma_s} = \frac{1}{2} g_1' Q_S v_1 v_s \sin \Theta'_W \left(-6g_1' \sin \Theta'_W + \cos \Theta'_W \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \right) \quad (202)$$

$$m_{\sigma_u \sigma_s} = -\frac{1}{2} g_1' Q_S v_s v_2 \sin \Theta'_W \left(4g_1' \sin \Theta'_W + \cos \Theta'_W \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \right) \quad (203)$$

$$m_{\sigma_s \sigma_s} = g_1'^2 Q_S^2 v_s^2 \sin^2 \Theta_W \quad (204)$$

$$m_{\sigma_d \text{sigmaSbar}} = \frac{1}{2} g_1' Q_S v_1 v_{sb} \sin \Theta'_W \left(6g_1' \sin \Theta'_W - \cos \Theta'_W \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \right) \quad (205)$$

$$m_{\sigma_u \text{sigmaSbar}} = \frac{1}{2} g_1' Q_S v s b v_2 \sin \Theta'_W \left(4g_1' \sin \Theta'_W + \cos \Theta'_W \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \right) \quad (206)$$

$$m_{\sigma_s \text{sigmaSbar}} = -g_1'^2 Q_S^2 v_s v s b \sin \Theta_W'^2 \quad (207)$$

$$m_{\text{sigmaSbarsigmaSbar}} = g_1'^2 Q_S^2 v s b^2 \sin \Theta_W'^2 \quad (208)$$

$$m^2(\xi_{Z'}) = \begin{pmatrix} m_{\sigma_d \sigma_d} & m_{\sigma_u \sigma_d} & m_{\sigma_s \sigma_d} & m_{\text{sigmaSbar} \sigma_d} & 0 \\ m_{\sigma_d \sigma_u} & m_{\sigma_u \sigma_u} & m_{\sigma_s \sigma_u} & m_{\text{sigmaSbar} \sigma_u} & 0 \\ m_{\sigma_d \sigma_s} & m_{\sigma_u \sigma_s} & m_{\sigma_s \sigma_s} & m_{\text{sigmaSbar} \sigma_s} & 0 \\ m_{\sigma_d \text{sigmaSbar}} & m_{\sigma_u \text{sigmaSbar}} & m_{\sigma_s \text{sigmaSbar}} & m_{\text{sigmaSbarsigmaSbar}} & 0 \\ 0 & 0 & 0 & 0 & 0 \end{pmatrix} \quad (209)$$

$$m_{\sigma_d \sigma_d} = \frac{1}{4} v_1^2 \left(6g_1' \cos \Theta'_W + \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right)^2 \quad (210)$$

$$m_{\sigma_d \sigma_u} = \frac{1}{4} v_1 v_2 \left(24g_1'^2 \cos \Theta_W'^2 - \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \left(g_1' \sin 2\Theta'_W + \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta_W'^2 \right) \right) \quad (211)$$

$$m_{\sigma_u \sigma_u} = \frac{1}{4} v_2^2 \left(-4g_1' \cos \Theta'_W + \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right)^2 \quad (212)$$

$$m_{\sigma_d \sigma_s} = -\frac{1}{2} g_1' Q_S v_1 v_s \cos \Theta'_W \left(6g_1' \cos \Theta'_W + \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) \quad (213)$$

$$m_{\sigma_u \sigma_s} = \frac{1}{2} g_1' Q_S v_s v_2 \cos \Theta'_W \left(-4g_1' \cos \Theta'_W + \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) \quad (214)$$

$$m_{\sigma_s \sigma_s} = g_1'^2 Q_S^2 v_s^2 \cos \Theta_W'^2 \quad (215)$$

$$m_{\sigma_d \text{sigmaSbar}} = \frac{1}{2} g_1' Q_S v_1 v s b \cos \Theta'_W \left(6g_1' \cos \Theta'_W + \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) \quad (216)$$

$$m_{\sigma_u \text{sigmaSbar}} = \frac{1}{2} g_1' Q_S v s b v_2 \cos \Theta'_W \left(4g_1' \cos \Theta'_W - \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) \quad (217)$$

$$m_{\sigma_s \text{sigmaSbar}} = -g_1'^2 Q_S^2 v_s v s b \cos \Theta_W'^2 \quad (218)$$

$$m_{\text{sigmaSbarsigmaSbar}} = g_1'^2 Q_S^2 v s b^2 \cos \Theta_W'^2 \quad (219)$$

This matrix is diagonalized by U_A :

$$U_A m_{A^0}^2 U_A^\dagger = m_{2,A^0}^{dia} \quad (220)$$

with

$$\sigma_d = \sum_j U_{A,j1} A_j^0, \quad \sigma_u = \sum_j U_{A,j2} A_j^0, \quad \sigma_s = \sum_j U_{A,j3} A_j^0 \quad (221)$$

$$\text{sigmaSbar} = \sum_j U_{A,j4} A_j^0, \quad \text{sigmaPhi} = \sum_j U_{A,j5} A_j^0 \quad (222)$$

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

$$m_{H^-}^2 = \begin{pmatrix} m_{H_d^- H_d^{-,*}} & m_{H_u^{+,*} H_d^{-,*}} \\ m_{H_d^- H_u^+} & m_{H_u^{+,*} H_u^+} \end{pmatrix} + \xi_{W^-} m^2(W^-) \quad (223)$$

$$m_{H_d^- H_d^{-,*}} = \frac{1}{2} v_s^2 |\lambda|^2 + \frac{1}{8} \left(12g_{1'}^2 (2v_2^2 + 3v_1^2 + Q_S (-v_s^2 + v s b^2)) + g_1^2 (-v_2^2 + v_1^2) + g_2^2 (v_1^2 + v_2^2) \right) + m_{h_{13}}^2 \quad (224)$$

$$m_{H_d^- H_u^+} = \frac{1}{2} \left(-\lambda (v_1 v_2 \lambda^* + v p h i v s b \sigma'^{*,*}) + \sqrt{2} v_s T_\lambda \right) + \frac{1}{4} g_2^2 v_1 v_2 \quad (225)$$

$$m_{H_u^{+,*} H_u^+} = \frac{1}{2} v_s^2 |\lambda|^2 + \frac{1}{8} \left(8g_{1'}^2 (2v_2^2 + 3v_1^2 + Q_S (-v_s^2 + v s b^2)) + g_1^2 (-v_1^2 + v_2^2) + g_2^2 (v_1^2 + v_2^2) \right) + m_{h_{23}}^2 \quad (226)$$

Gauge fixing contributions:

$$m^2(\xi_{W^-}) = \begin{pmatrix} \frac{1}{4} g_2^2 v_1^2 & -\frac{1}{4} g_2^2 v_1 v_2 \\ -\frac{1}{4} g_2^2 v_1 v_2 & \frac{1}{4} g_2^2 v_2^2 \end{pmatrix} \quad (227)$$

This matrix is diagonalized by U_+ :

$$U_+ m_{H^-}^2 U_+^\dagger = m_{2,H^-}^{dia} \quad (228)$$

with

$$H_d^- = \sum_j U_{+,j1}^* H_j^-, \quad H_u^+ = \sum_j U_{+,j2} H_j^+ \quad (229)$$

- **Mass matrix for Neutral Prime-Higgs, Basis:** $(H'^0, \bar{H}'^{0,*}), (H'^{0,*}, \bar{H}'^0)$

$$m_{H'^0}^2 = \begin{pmatrix} m_{H'^0 H'^{0,*}} & -B_{\mu'}^* \\ -B_{\mu'} & m_{\bar{H}'^0 H'^0} \end{pmatrix} \quad (230)$$

$$m_{H'^0 H'^{0,*}} = \frac{1}{8} \left(-8g_{1'}^2 (2v_2^2 + 3v_1^2 + Q_S (-v_s^2 + v s b^2)) + (g_1^2 + g_2^2) (-v_2^2 + v_1^2) \right) + m_{h'}^2 + |\mu'|^2 \quad (231)$$

$$m_{\bar{H}'^0 H'^0} = \frac{1}{8} \left(8g_{1'}^2 (2v_2^2 + 3v_1^2 + Q_S (-v_s^2 + v s b^2)) + (g_1^2 + g_2^2) (-v_1^2 + v_2^2) \right) + m_{h'}^2 + |\mu'|^2 \quad (232)$$

This matrix is diagonalized by \tilde{h}'^0 :

$$\tilde{h}'^0 m_{H'^0}^2 \tilde{h}'^{0,\dagger} = m_{2,H'^0}^{dia} \quad (233)$$

with

$$H'^0 = \sum_j U H p 0_{j1}^* H_j'^0, \quad \bar{H}'^0 = \sum_j U H p 0_{j2} H_j'^{0,*} \quad (234)$$

- **Mass matrix for Charged Prime-Higgs**, Basis: $(H'^-, \bar{H}'^{+,*}), (H'^-, *, \bar{H}'^+)$

$$m_{H'^-}^2 = \begin{pmatrix} m_{H'^-H'^-,*} & B_{\mu'}^* \\ B_{\mu'} & m_{\bar{H}'^+,*\bar{H}'^+} \end{pmatrix} \quad (235)$$

$$m_{H'^-H'^-,*} = \frac{1}{8} \left(-8g_{1'}^2 (2v_2^2 + 3v_1^2 + Q_S (-v_s^2 + v_s b^2)) + g_1^2 (-v_2^2 + v_1^2) + g_2^2 (-v_1^2 + v_2^2) \right) + m_{h'}^2 + |\mu'|^2 \quad (236)$$

$$m_{\bar{H}'^+,*\bar{H}'^+} = \frac{1}{8} \left(8g_{1'}^2 (2v_2^2 + 3v_1^2 + Q_S (-v_s^2 + v_s b^2)) + g_1^2 (-v_1^2 + v_2^2) + g_2^2 (-v_2^2 + v_1^2) \right) + m_{h'}^2 + |\mu'|^2 \quad (237)$$

This matrix is diagonalized by $UHpp$:

$$UHpp m_{H'^-}^2 UHpp^\dagger = m_{2,H'^-}^{dia} \quad (238)$$

with

$$H'^- = \sum_j UHpp_{j1}^* H_j'^-, \quad \bar{H}'^+ = \sum_j UHpp_{j2} H_j'^+ \quad (239)$$

4.2.2 Mass Matrices for Fermions

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

$$m_{\tilde{\chi}^0} = \begin{pmatrix} M_1 & 0 & -\frac{1}{2}g_1 v_1 & \frac{1}{2}g_1 v_2 & 0 & 0 & 0 & 0 \\ 0 & M_2 & \frac{1}{2}g_2 v_1 & -\frac{1}{2}g_2 v_2 & 0 & 0 & 0 & 0 \\ -\frac{1}{2}g_1 v_1 & \frac{1}{2}g_2 v_1 & 0 & -\frac{1}{\sqrt{2}}v_s \lambda & -\frac{1}{\sqrt{2}}v_2 \lambda & 0 & 0 & -3g_1' v_1 \\ \frac{1}{2}g_1 v_2 & -\frac{1}{2}g_2 v_2 & -\frac{1}{\sqrt{2}}v_s \lambda & 0 & -\frac{1}{\sqrt{2}}v_1 \lambda & 0 & 0 & -2g_1' v_2 \\ 0 & 0 & -\frac{1}{\sqrt{2}}v_2 \lambda & -\frac{1}{\sqrt{2}}v_1 \lambda & 0 & -\frac{1}{\sqrt{2}}v_{phi} \sigma & -\frac{1}{\sqrt{2}}v_{sb} \sigma & g_1' Q_S v_s \\ 0 & 0 & 0 & 0 & -\frac{1}{\sqrt{2}}v_{phi} \sigma & 0 & m_{\text{Fphi}R\text{Fsb}R} & -g_1' Q_S v_{sb} \\ 0 & 0 & 0 & 0 & -\frac{1}{\sqrt{2}}v_{sb} \sigma & m_{\text{Fsb}R\text{Fphi}R} & m_{\text{Fphi}R\text{Fphi}R} & 0 \\ 0 & 0 & -3g_1' v_1 & -2g_1' v_2 & g_1' Q_S v_s & -g_1' Q_S v_{sb} & 0 & M_1' \end{pmatrix} \quad (240)$$

$$m_{\text{Fsb}R\text{Fphi}R} = -\frac{1}{\sqrt{2}}v_s \sigma \quad (241)$$

$$m_{\text{Fphi}R\text{Fphi}R} = \sqrt{2}v_{phi} \kappa' + M u_{phi} \quad (242)$$

This matrix is diagonalized by N :

$$N^* m_{\tilde{\chi}^0} N^\dagger = m_{\tilde{\chi}^0}^{dia} \quad (243)$$

with

$$\lambda_{\bar{B}} = \sum_j N_{j1}^* \lambda_j^0, \quad \tilde{W}^0 = \sum_j N_{j2}^* \lambda_j^0, \quad \tilde{H}_d^0 = \sum_j N_{j3}^* \lambda_j^0 \quad (244)$$

$$\tilde{H}_u^0 = \sum_j N_{j4}^* \lambda_j^0, \quad \tilde{S} = \sum_j N_{j5}^* \lambda_j^0, \quad \text{FsbarR} = \sum_j N_{j6}^* \lambda_j^0 \quad (245)$$

$$\text{FphiR} = \sum_j N_{j7}^* \lambda_j^0, \quad \lambda_{Bp} = \sum_j N_{j8}^* \lambda_j^0 \quad (246)$$

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

$$m_{\tilde{\chi}^-} = \begin{pmatrix} M_2 & \frac{1}{\sqrt{2}} g_2 v_2 \\ \frac{1}{\sqrt{2}} g_2 v_1 & \frac{1}{\sqrt{2}} v_s \lambda \end{pmatrix} \quad (247)$$

This matrix is diagonalized by U and V

$$U^* m_{\tilde{\chi}^-} V^\dagger = m_{\tilde{\chi}^-}^{dia} \quad (248)$$

with

$$\tilde{W}^- = \sum_{t_2} U_{j1}^* \lambda_j^-, \quad \tilde{H}_d^- = \sum_{t_2} U_{j2}^* \lambda_j^- \quad (249)$$

$$\tilde{W}^+ = \sum_{t_2} V_{1j}^* \lambda_j^+, \quad \tilde{H}_u^+ = \sum_{t_2} V_{2j}^* \lambda_j^+ \quad (250)$$

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

$$m_e = \begin{pmatrix} \frac{1}{\sqrt{2}} \mathbf{1} v_1 Y_e^T \end{pmatrix} \quad (251)$$

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

$$U_L^{e,*} m_e U_R^{e,\dagger} = m_e^{dia} \quad (252)$$

with

$$e_{L,i} = \sum_{t_2} U_{L,ji}^{e,*} E_{L,j} \quad (253)$$

$$e_{R,i} = \sum_{t_2} U_{R,ij}^e E_{R,j}^* \quad (254)$$

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

$$m_d = \begin{pmatrix} \frac{1}{\sqrt{2}} \mathbf{1} v_1 \delta_{\alpha_1 \beta_1} Y_d^T \end{pmatrix} \quad (255)$$

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

$$U_L^{d,*} m_d U_R^{d,\dagger} = m_d^{dia} \quad (256)$$

with

$$d_{L,i\alpha} = \sum_{t_2} U_{L,ji}^{d,*} D_{L,j\alpha} \quad (257)$$

$$d_{R,i\alpha} = \sum_{t_2} U_{R,ij}^d D_{R,j\alpha}^* \quad (258)$$

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

$$m_u = \left(\frac{1}{\sqrt{2}} \mathbf{1} v_2 \delta_{\alpha_1 \beta_1} Y_u^T \right) \quad (259)$$

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

$$U_L^{u,*} m_u U_R^{u,\dagger} = m_u^{dia} \quad (260)$$

with

$$u_{L,i\alpha} = \sum_{t_2} U_{L,ji}^{u,*} U_{L,j\alpha} \quad (261)$$

$$u_{R,i\alpha} = \sum_{t_2} U_{R,ij}^u U_{R,j\alpha}^* \quad (262)$$

- **Mass matrix for Exotics**, Basis: $\left(\text{FDxL}(\{\text{cm1}\}) \right), \left(\text{conj}(\text{FDxbarR}(\{\text{cn1}\})) \right)$

$$m_x = \left(\frac{1}{\sqrt{2}} \mathbf{1} v_s \kappa \delta_{\alpha_1 \beta_1} \right) \quad (263)$$

This matrix is diagonalized by $ZDXL$ and $ZDXR$

$$ZDXL^* m_x ZDXR^\dagger = m_x^{dia} \quad (264)$$

with

$$\text{FDxL}(\{\text{gt1}, \text{ct1}\}) = \sum_{t_2} ZDXL_{ji}^* X_{L,j\alpha} \quad (265)$$

$$\text{FDxbarR}(\{\text{gt1}, \text{ct1}\}) = \sum_{t_2} ZDXR_{ij} X_{L,j\alpha}^* \quad (266)$$

- **Mass matrix for Prime Neutralinos**, Basis: $(\tilde{h}'^0, \tilde{h}'^0), (\tilde{h}'^0, \tilde{h}'^0)$

$$m_{\tilde{\chi}'^0} = \begin{pmatrix} 0 & -\mu' \\ -\mu' & 0 \end{pmatrix} \quad (267)$$

This matrix is diagonalized by ZNp :

$$ZNp^* m_{\tilde{\chi}'^0} ZNp^\dagger = m_{\tilde{\chi}'^0}^{dia} \quad (268)$$

with

$$\tilde{h}'^0 = \sum_j ZNp_{j1}^* \text{L0p}(\{\text{gt2}\}), \quad \tilde{h}'^0 = \sum_j ZNp_{j2}^* \text{L0p}(\{\text{gt2}\}) \quad (269)$$

5 Vacuum Expectation Values

$$H_d^0 = \frac{1}{\sqrt{2}}\phi_d + \frac{1}{\sqrt{2}}v_1 + i\frac{1}{\sqrt{2}}\sigma_d \quad (270)$$

$$H_u^0 = \frac{1}{\sqrt{2}}\phi_u + \frac{1}{\sqrt{2}}v_2 + i\frac{1}{\sqrt{2}}\sigma_u \quad (271)$$

$$S = \frac{1}{\sqrt{2}}\phi_s + \frac{1}{\sqrt{2}}v_s + i\frac{1}{\sqrt{2}}\sigma_s \quad (272)$$

$$\bar{S}_R = \frac{1}{\sqrt{2}}\text{phiSbar} + \frac{1}{\sqrt{2}}vsb + i\frac{1}{\sqrt{2}}\text{sigmaSbar} \quad (273)$$

$$\phi_R = \frac{1}{\sqrt{2}}\text{phiPhi} + \frac{1}{\sqrt{2}}vphi + i\frac{1}{\sqrt{2}}\text{sigmaPhi} \quad (274)$$

6 Tadpole Equations

$$\begin{aligned} \frac{\partial V}{\partial \phi_d} = & +\frac{1}{8}v_1\left(12g_1^2\left(2v_2^2+3v_1^2+Q_S\left(-v_s^2+vsb^2\right)\right)+\left(g_1^2+g_2^2\right)\left(-v_2+v_1\right)\left(v_1+v_2\right)\right) \\ & +\frac{1}{4}\left(\left(2v_1\left(v_s^2+v_2^2\right)\lambda+vphivsbv_2\sigma\right)\lambda^*+4m_{h_{13}}^2v_1+v_2\left(-2\sqrt{2}v_s\Re\left(T_\lambda\right)+vphivsb\lambda\sigma'^{*}\right)\right) \end{aligned} \quad (275)$$

$$\begin{aligned} \frac{\partial V}{\partial \phi_u} = & +\frac{1}{8}v_2\left(8g_1^2\left(2v_2^2+3v_1^2+Q_S\left(-v_s^2+vsb^2\right)\right)+\left(g_1^2+g_2^2\right)\left(-v_1^2+v_2^2\right)\right) \\ & +\frac{1}{4}\left(\left(2\left(v_1^2+v_s^2\right)v_2\lambda+v_1vphivsb\sigma\right)\lambda^*+4m_{h_{23}}^2v_2+v_1\left(-2\sqrt{2}v_s\Re\left(T_\lambda\right)+vphivsb\lambda\sigma'^{*}\right)\right) \end{aligned} \quad (276)$$

$$\begin{aligned} \frac{\partial V}{\partial \phi_s} = & +\frac{1}{2}g_1^2Q_Sv_s\left(-2v_2^2-3v_1^2+Q_S\left(-vsb+vs\right)\left(v_s+vsb\right)\right) \\ & +\frac{1}{4}\left(-vphi^2\left(\left(-2v_s\sigma+vsb\kappa'\right)\sigma'^{*}+vsb\sigma\kappa'^{*}\right)\right. \\ & +2\left(2m_{s_3}^2v_s-\sqrt{2}v_1v_2\Re\left(T_\lambda\right)+vsb\left(-\sigma XiF_1^*+\left(v_svsb\sigma-XiF_1\right)\sigma'^{*}\right)+v_s\left(v_1^2+v_2^2\right)|\lambda|^2\right) \\ & \left.-\sqrt{2}vphivsb\left(Mu_{phi}\sigma'^{*}+\sigma Mu_{phi}^*+T_\sigma^*+T_\sigma\right)\right) \end{aligned} \quad (277)$$

$$\begin{aligned} \frac{\partial V}{\partial \text{phiSbar}} = & +\frac{1}{2}g_1^2Q_Svsb\left(2v_2^2+3v_1^2+Q_S\left(-v_s^2+vsb^2\right)\right) \\ & +\frac{1}{4}\left(4m_{sbar_3}^2vsb-vphi^2\left(\left(-2vsb\sigma+v_s\kappa'\right)\sigma'^{*}+v_s\sigma\kappa'^{*}\right)+2v_s\left(-\sigma XiF_1^*+\left(v_svsb\sigma-XiF_1\right)\sigma'^{*}\right)\right. \\ & \left.+vphi\left(-\sqrt{2}v_s\left(2\Re\left(T_\sigma\right)+Mu_{phi}\sigma'^{*}+\sigma Mu_{phi}^*\right)+v_1v_2\left(\lambda\sigma'^{*}+\sigma\lambda^*\right)\right)\right) \end{aligned} \quad (278)$$

$$\begin{aligned} \frac{\partial V}{\partial \text{phiPhi}} = & \frac{1}{4}\left(4\left(m_{phi}^2vphi+vphi^3|\kappa'|^2\right)+\left(4Mu_{phi}vphi+\sqrt{2}\left(2XiF_1+3vphi^2\kappa'-v_svsb\sigma\right)\right)Mu_{phi}^*\right. \\ & +2vphi\left(2\left(\kappa'XiF_1^*+\Re\left(B_{mu_{phi}}\right)\right)+\left(2XiF_1-v_svsb\sigma\right)\kappa'^{*}+\left(\left(v_s^2+vsb^2\right)\sigma-v_svsb\kappa'\right)\sigma'^{*}\right) \\ & \left.+\sqrt{2}\left(2\left(Mu_{phi}XiF_1^*+\xi_S^*+\xi_S\right)+vphi^2\left(3Mu_{phi}\kappa'^{*}+T_{\kappa',*}+T_{\kappa'}\right)-v_svsbT_\sigma^*\right)\right) \end{aligned}$$

$$+ v s b \left(\sqrt{2} v_s \left(- M u_{phi} \sigma'^{*} - T_\sigma \right) + v_1 \left(v_2 \lambda \sigma'^{*} + v_2 \sigma \lambda^* \right) \right) \quad (279)$$

7 Particle content for eigenstates 'EWSB'

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

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

8.1 One Loop Self-Energy

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

$$\begin{aligned}
 \Pi_{i,j}(p^2) = & +4\Gamma_{\tilde{d}_i, \tilde{d}_j^*, W^+, W^-} \left(-\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2\Gamma_{\tilde{d}_i, \tilde{d}_j^*, Z, Z} \left(-\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) \\
 & + 2\Gamma_{\tilde{d}_i, \tilde{d}_j^*, Z', Z'} \left(-\frac{1}{2} \text{rMS} m_{Z'}^2 + A_0(m_{Z'}^2) \right) - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, H_a^+, H_a^-} \\
 & - \sum_{a=1}^2 A_0(m_{H_a'^0}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, H_a'^0, *} \Gamma_{H_a'^0} - \sum_{a=1}^2 A_0(m_{H_a'^-}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, H_a'^+, H_a'^-} \\
 & - \sum_{a=1}^3 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, \tilde{\nu}_a^*, \tilde{\nu}_a} \\
 & - 2 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^2 B_0(p^2, m_{u_a}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} \left(\Gamma_{\tilde{d}_j^*, u_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{d}_i^*, u_a, \tilde{\chi}_b^-}^R + \Gamma_{\tilde{d}_j^*, u_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{d}_i^*, u_a, \tilde{\chi}_b^-}^L \right) \\
 & + \sum_{a=1}^3 \sum_{b=1}^2 G_0(p^2, m_{u_a}^2, m_{\tilde{\chi}_b^-}^2) \left(\Gamma_{\tilde{d}_j^*, u_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{d}_i^*, u_a, \tilde{\chi}_b^-}^L + \Gamma_{\tilde{d}_j^*, u_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{d}_i^*, u_a, \tilde{\chi}_b^-}^R \right) \\
 & - 2 \sum_{a=1}^3 m_{d_a} \sum_{b=1}^8 B_0(p^2, m_{d_a}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_b^0} \left(\Gamma_{\tilde{d}_j^*, d_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{d}_i^*, d_a, \tilde{\chi}_b^0}^R + \Gamma_{\tilde{d}_j^*, d_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{d}_i^*, d_a, \tilde{\chi}_b^0}^L \right) \\
 & + \sum_{a=1}^3 \sum_{b=1}^8 G_0(p^2, m_{d_a}^2, m_{\tilde{\chi}_b^0}^2) \left(\Gamma_{\tilde{d}_j^*, d_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{d}_i^*, d_a, \tilde{\chi}_b^0}^L + \Gamma_{\tilde{d}_j^*, d_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{d}_i^*, d_a, \tilde{\chi}_b^0}^R \right) \\
 & - \frac{1}{2} \sum_{a=1}^5 A_0(m_{A_a^0}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, A_a^0, A_a^0} - \frac{1}{2} \sum_{a=1}^5 A_0(m_{h_a}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, h_a, h_a} \\
 & - C \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, \tilde{d}_a^*, \tilde{d}_a} - C \sum_{a=1}^6 A_0(m_{\tilde{x}_a}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, \tilde{x}_a^*, \tilde{x}_a} \\
 & - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, \tilde{e}_a^*, \tilde{e}_a} - C \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_i, \tilde{d}_j^*, \tilde{u}_a^*, \tilde{u}_a} \\
 & + \sum_{a=1}^6 \sum_{b=1}^2 B_0(p^2, m_{\tilde{u}_a}^2, m_{H_b^-}^2) \Gamma_{\tilde{d}_j^*, \tilde{u}_a, H_b^-}^* \Gamma_{\tilde{d}_i^*, \tilde{u}_a, H_b^-}
 \end{aligned}$$

$$\begin{aligned}
& + \sum_{a=1}^6 \sum_{b=1}^5 B_0(p^2, m_{\tilde{d}_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j^*, \tilde{d}_a, A_b^0}^* \Gamma_{\tilde{d}_i^*, \tilde{d}_a, A_b^0} + \sum_{a=1}^6 \sum_{b=1}^5 B_0(p^2, m_{\tilde{d}_a}^2, m_{h_b}^2) \Gamma_{\tilde{d}_j^*, \tilde{d}_a, h_b}^* \Gamma_{\tilde{d}_i^*, \tilde{d}_a, h_b} \\
& - \frac{8}{3} m_{\tilde{g}} \sum_{b=1}^3 B_0(p^2, m_{\tilde{g}}^2, m_{d_b}^2) m_{d_b} \left(\Gamma_{\tilde{d}_j^*, \tilde{g}_1, d_b}^{L*} \Gamma_{\tilde{d}_i^*, \tilde{g}_1, d_b}^R + \Gamma_{\tilde{d}_j^*, \tilde{g}_1, d_b}^{R*} \Gamma_{\tilde{d}_i^*, \tilde{g}_1, d_b}^L \right) \\
& + \frac{4}{3} \sum_{b=1}^3 G_0(p^2, m_{\tilde{g}}^2, m_{d_b}^2) \left(\Gamma_{\tilde{d}_j^*, \tilde{g}_1, d_b}^{L*} \Gamma_{\tilde{d}_i^*, \tilde{g}_1, d_b}^L + \Gamma_{\tilde{d}_j^*, \tilde{g}_1, d_b}^{R*} \Gamma_{\tilde{d}_i^*, \tilde{g}_1, d_b}^R \right) \\
& + \frac{4}{3} \sum_{b=1}^6 \Gamma_{\tilde{d}_j^*, g, \tilde{d}_b}^* \Gamma_{\tilde{d}_i^*, g, \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, 0) + \sum_{b=1}^6 \Gamma_{\tilde{d}_j^*, \gamma, \tilde{d}_b}^* \Gamma_{\tilde{d}_i^*, \gamma, \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, 0) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{d}_j^*, Z, \tilde{d}_b}^* \Gamma_{\tilde{d}_i^*, Z, \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, m_Z^2) + \sum_{b=1}^6 \Gamma_{\tilde{d}_j^*, Z', \tilde{d}_b}^* \Gamma_{\tilde{d}_i^*, Z', \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, m_{Z'}^2) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{d}_j^*, W^-, \tilde{u}_b}^* \Gamma_{\tilde{d}_i^*, W^-, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, m_{W^-}^2) \tag{280}
\end{aligned}$$

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

$$\begin{aligned}
\Pi_{i,j}(p^2) = & +4\Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, W^+, W^-} \left(-\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2\Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, Z, Z} \left(-\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) \\
& + 2\Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, Z', Z'} \left(-\frac{1}{2} \text{rMS} m_{Z'}^2 + A_0(m_{Z'}^2) \right) - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, H_a^+, H_a^-} \\
& - \sum_{a=1}^2 A_0(m_{H_a'^0}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, H_a'^0, H_a'^0} - \sum_{a=1}^2 A_0(m_{H_a'^-}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, H_a'^+, H_a'^-} \\
& - 2 \sum_{a=1}^2 m_{\tilde{\chi}_a^-} \sum_{b=1}^3 B_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{e_b}^2) m_{e_b} \left(\Gamma_{\tilde{\nu}_j^*, \tilde{\chi}_a^+, e_b}^{L*} \Gamma_{\tilde{\nu}_i^*, \tilde{\chi}_a^+, e_b}^R + \Gamma_{\tilde{\nu}_j^*, \tilde{\chi}_a^+, e_b}^{R*} \Gamma_{\tilde{\nu}_i^*, \tilde{\chi}_a^+, e_b}^L \right) \\
& + \sum_{a=1}^2 \sum_{b=1}^3 G_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{e_b}^2) \left(\Gamma_{\tilde{\nu}_j^*, \tilde{\chi}_a^+, e_b}^{L*} \Gamma_{\tilde{\nu}_i^*, \tilde{\chi}_a^+, e_b}^L + \Gamma_{\tilde{\nu}_j^*, \tilde{\chi}_a^+, e_b}^{R*} \Gamma_{\tilde{\nu}_i^*, \tilde{\chi}_a^+, e_b}^R \right) \\
& + \sum_{a=1}^2 \sum_{b=1}^6 B_0(p^2, m_{H_a^-}^2, m_{\tilde{e}_b}^2) \Gamma_{\tilde{\nu}_j^*, H_a^+, \tilde{e}_b}^* \Gamma_{\tilde{\nu}_i^*, H_a^+, \tilde{e}_b} - \sum_{a=1}^3 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, \tilde{\nu}_a^*, \tilde{\nu}_a} \\
& + \sum_{a=1}^3 \sum_{b=1}^5 B_0(p^2, m_{\tilde{\nu}_a}^2, m_{h_b}^2) \Gamma_{\tilde{\nu}_j^*, \tilde{\nu}_a, h_b}^* \Gamma_{\tilde{\nu}_i^*, \tilde{\nu}_a, h_b} \\
& - 2 \sum_{a=1}^3 m_{\nu_a} \sum_{b=1}^8 B_0(p^2, m_{\nu_a}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_b^0} \left(\Gamma_{\tilde{\nu}_j^*, \nu_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\nu}_i^*, \nu_a, \tilde{\chi}_b^0}^R + \Gamma_{\tilde{\nu}_j^*, \nu_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\nu}_i^*, \nu_a, \tilde{\chi}_b^0}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^8 G_0(p^2, m_{\nu_a}^2, m_{\tilde{\chi}_b^0}^2) \left(\Gamma_{\tilde{\nu}_j^*, \nu_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\nu}_i^*, \nu_a, \tilde{\chi}_b^0}^L + \Gamma_{\tilde{\nu}_j^*, \nu_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\nu}_i^*, \nu_a, \tilde{\chi}_b^0}^R \right)
\end{aligned}$$

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^5 A_0(m_{A_a^0}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, A_a^0, A_a^0} - \frac{1}{2} \sum_{a=1}^5 A_0(m_{h_a}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, h_a, h_a} \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, \tilde{d}_a^*, \tilde{d}_a} - 3 \sum_{a=1}^6 A_0(m_{\tilde{x}_a}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, \tilde{x}_a^*, \tilde{x}_a} \\
& - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, \tilde{e}_a^*, \tilde{e}_a} - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{\nu}_i, \tilde{\nu}_j^*, \tilde{u}_a^*, \tilde{u}_a} \\
& + \sum_{b=1}^3 \Gamma_{\tilde{\nu}_j^*, Z, \tilde{\nu}_b}^* \Gamma_{\tilde{\nu}_i^*, Z, \tilde{\nu}_b} F_0(p^2, m_{\tilde{\nu}_b}^2, m_Z^2) + \sum_{b=1}^3 \Gamma_{\tilde{\nu}_j^*, Z', \tilde{\nu}_b}^* \Gamma_{\tilde{\nu}_i^*, Z', \tilde{\nu}_b} F_0(p^2, m_{\tilde{\nu}_b}^2, m_{Z'}^2) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{\nu}_j^*, W^+, \tilde{e}_b}^* \Gamma_{\tilde{\nu}_i^*, W^+, \tilde{e}_b} F_0(p^2, m_{\tilde{e}_b}^2, m_{W^-}^2)
\end{aligned} \tag{281}$$

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

$$\begin{aligned}
\Pi_{i,j}(p^2) = & +4\Gamma_{\tilde{u}_i, \tilde{u}_j^*, W^+, W^-} \left(-\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2\Gamma_{\tilde{u}_i, \tilde{u}_j^*, Z, Z} \left(-\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) \\
& + 2\Gamma_{\tilde{u}_i, \tilde{u}_j^*, Z', Z'} \left(-\frac{1}{2} \text{rMS} m_{Z'}^2 + A_0(m_{Z'}^2) \right) - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, H_a^+, H_a^-} \\
& - \sum_{a=1}^2 A_0(m_{H_a'^0}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, H_a'^0, H_a'^0} - \sum_{a=1}^2 A_0(m_{H_a'^-}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, H_a'^+, H_a'^-} \\
& - 2 \sum_{a=1}^2 m_{\tilde{\chi}_a^-} \sum_{b=1}^3 B_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{d}_b}^2) m_{\tilde{d}_b} \left(\Gamma_{\tilde{u}_j^*, \tilde{\chi}_a^+, \tilde{d}_b}^{L*} \Gamma_{\tilde{u}_i^*, \tilde{\chi}_a^+, \tilde{d}_b}^R + \Gamma_{\tilde{u}_j^*, \tilde{\chi}_a^+, \tilde{d}_b}^{R*} \Gamma_{\tilde{u}_i^*, \tilde{\chi}_a^+, \tilde{d}_b}^L \right) \\
& + \sum_{a=1}^2 \sum_{b=1}^3 G_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{d}_b}^2) \left(\Gamma_{\tilde{u}_j^*, \tilde{\chi}_a^+, \tilde{d}_b}^{L*} \Gamma_{\tilde{u}_i^*, \tilde{\chi}_a^+, \tilde{d}_b}^L + \Gamma_{\tilde{u}_j^*, \tilde{\chi}_a^+, \tilde{d}_b}^{R*} \Gamma_{\tilde{u}_i^*, \tilde{\chi}_a^+, \tilde{d}_b}^R \right) \\
& + \sum_{a=1}^2 \sum_{b=1}^6 B_0(p^2, m_{H_a^-}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{u}_j^*, H_a^+, \tilde{d}_b}^* \Gamma_{\tilde{u}_i^*, H_a^+, \tilde{d}_b} - \sum_{a=1}^3 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, \tilde{\nu}_a^*, \tilde{\nu}_a} \\
& - 2 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^8 B_0(p^2, m_{u_a}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_b^0} \left(\Gamma_{\tilde{u}_j^*, u_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{u}_i^*, u_a, \tilde{\chi}_b^0}^R + \Gamma_{\tilde{u}_j^*, u_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{u}_i^*, u_a, \tilde{\chi}_b^0}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^8 G_0(p^2, m_{u_a}^2, m_{\tilde{\chi}_b^0}^2) \left(\Gamma_{\tilde{u}_j^*, u_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{u}_i^*, u_a, \tilde{\chi}_b^0}^L + \Gamma_{\tilde{u}_j^*, u_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{u}_i^*, u_a, \tilde{\chi}_b^0}^R \right) \\
& - \frac{1}{2} \sum_{a=1}^5 A_0(m_{A_a^0}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, A_a^0, A_a^0} - \frac{1}{2} \sum_{a=1}^5 A_0(m_{h_a}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, h_a, h_a} \\
& - C \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, \tilde{d}_a^*, \tilde{d}_a} - C \sum_{a=1}^6 A_0(m_{\tilde{x}_a}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, \tilde{x}_a^*, \tilde{x}_a}
\end{aligned}$$

$$\begin{aligned}
& - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, \tilde{e}_a^*, \tilde{e}_a} - C \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_i, \tilde{u}_j^*, \tilde{u}_a^*, \tilde{u}_a} \\
& + \sum_{a=1}^6 \sum_{b=1}^5 B_0(p^2, m_{\tilde{u}_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{u}_j^*, \tilde{u}_a, A_b^0}^* \Gamma_{\tilde{u}_i^*, \tilde{u}_a, A_b^0} + \sum_{a=1}^6 \sum_{b=1}^5 B_0(p^2, m_{\tilde{u}_a}^2, m_{h_b}^2) \Gamma_{\tilde{u}_j^*, \tilde{u}_a, h_b}^* \Gamma_{\tilde{u}_i^*, \tilde{u}_a, h_b} \\
& - \frac{8}{3} m_{\tilde{g}} \sum_{b=1}^3 B_0(p^2, m_{\tilde{g}}^2, m_{u_b}^2) m_{u_b} \left(\Gamma_{\tilde{u}_j^*, \tilde{g}_1, u_b}^{L*} \Gamma_{\tilde{u}_i^*, \tilde{g}_1, u_b}^R + \Gamma_{\tilde{u}_j^*, \tilde{g}_1, u_b}^{R*} \Gamma_{\tilde{u}_i^*, \tilde{g}_1, u_b}^L \right) \\
& + \frac{4}{3} \sum_{b=1}^3 G_0(p^2, m_{\tilde{g}}^2, m_{u_b}^2) \left(\Gamma_{\tilde{u}_j^*, \tilde{g}_1, u_b}^{L*} \Gamma_{\tilde{u}_i^*, \tilde{g}_1, u_b}^L + \Gamma_{\tilde{u}_j^*, \tilde{g}_1, u_b}^{R*} \Gamma_{\tilde{u}_i^*, \tilde{g}_1, u_b}^R \right) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, W^+, \tilde{d}_b}^* \Gamma_{\tilde{u}_i^*, W^+, \tilde{d}_b} F_0(p^2, m_{\tilde{d}_b}^2, m_{W^-}^2) + \frac{4}{3} \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, g, \tilde{u}_b}^* \Gamma_{\tilde{u}_i^*, g, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, 0) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, \gamma, \tilde{u}_b}^* \Gamma_{\tilde{u}_i^*, \gamma, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, 0) + \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, Z, \tilde{u}_b}^* \Gamma_{\tilde{u}_i^*, Z, \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, m_Z^2) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{u}_j^*, Z', \tilde{u}_b}^* \Gamma_{\tilde{u}_i^*, Z', \tilde{u}_b} F_0(p^2, m_{\tilde{u}_b}^2, m_{Z'}^2) \tag{282}
\end{aligned}$$

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

$$\begin{aligned}
\Pi_{i,j}(p^2) = & +4\Gamma_{\tilde{e}_i, \tilde{e}_j^*, W^+, W^-} \left(-\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2\Gamma_{\tilde{e}_i, \tilde{e}_j^*, Z, Z} \left(-\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) \\
& + 2\Gamma_{\tilde{e}_i, \tilde{e}_j^*, Z', Z'} \left(-\frac{1}{2} \text{rMS} m_{Z'}^2 + A_0(m_{Z'}^2) \right) - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, H_a^+, H_a^-} \\
& - \sum_{a=1}^2 A_0(m_{H_a'^0}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, H_a'^0, H_a'^0} - \sum_{a=1}^2 A_0(m_{H_a'^-}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, H_a'^+, H_a'^-} \\
& - \sum_{a=1}^3 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, \tilde{\nu}_a^*, \tilde{\nu}_a} + \sum_{a=1}^3 \sum_{b=1}^2 B_0(p^2, m_{\tilde{\nu}_a}^2, m_{H_b^-}^2) \Gamma_{\tilde{e}_j^*, \tilde{\nu}_a, H_b^-}^* \Gamma_{\tilde{e}_i^*, \tilde{\nu}_a, H_b^-} \\
& - 2 \sum_{a=1}^3 m_{\nu_a} \sum_{b=1}^2 B_0(p^2, m_{\nu_a}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} \left(\Gamma_{\tilde{e}_j^*, \nu_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{e}_i^*, \nu_a, \tilde{\chi}_b^-}^R + \Gamma_{\tilde{e}_j^*, \nu_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{e}_i^*, \nu_a, \tilde{\chi}_b^-}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^2 G_0(p^2, m_{\nu_a}^2, m_{\tilde{\chi}_b^-}^2) \left(\Gamma_{\tilde{e}_j^*, \nu_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{e}_i^*, \nu_a, \tilde{\chi}_b^-}^L + \Gamma_{\tilde{e}_j^*, \nu_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{e}_i^*, \nu_a, \tilde{\chi}_b^-}^R \right) \\
& - 2 \sum_{a=1}^3 m_{e_a} \sum_{b=1}^8 B_0(p^2, m_{e_a}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_b^0} \left(\Gamma_{\tilde{e}_j^*, e_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{e}_i^*, e_a, \tilde{\chi}_b^0}^R + \Gamma_{\tilde{e}_j^*, e_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{e}_i^*, e_a, \tilde{\chi}_b^0}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^8 G_0(p^2, m_{e_a}^2, m_{\tilde{\chi}_b^0}^2) \left(\Gamma_{\tilde{e}_j^*, e_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{e}_i^*, e_a, \tilde{\chi}_b^0}^L + \Gamma_{\tilde{e}_j^*, e_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{e}_i^*, e_a, \tilde{\chi}_b^0}^R \right)
\end{aligned}$$

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^5 A_0(m_{A_a^0}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, A_a^0, A_a^0} - \frac{1}{2} \sum_{a=1}^5 A_0(m_{h_a}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, h_a, h_a} \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, \tilde{d}_a^*, \tilde{d}_a} - 3 \sum_{a=1}^6 A_0(m_{\tilde{x}_a}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, \tilde{x}_a^*, \tilde{x}_a} \\
& - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, \tilde{e}_a^*, \tilde{e}_a} - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{e}_i, \tilde{e}_j^*, \tilde{u}_a^*, \tilde{u}_a} \\
& + \sum_{a=1}^6 \sum_{b=1}^5 B_0(p^2, m_{\tilde{e}_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{e}_j^*, \tilde{e}_a, A_b^0}^* \Gamma_{\tilde{e}_i^*, \tilde{e}_a, A_b^0} + \sum_{a=1}^6 \sum_{b=1}^5 B_0(p^2, m_{\tilde{e}_a}^2, m_{h_b}^2) \Gamma_{\tilde{e}_j^*, \tilde{e}_a, h_b}^* \Gamma_{\tilde{e}_i^*, \tilde{e}_a, h_b} \\
& + \sum_{b=1}^3 \Gamma_{\tilde{e}_j^*, W^-, \tilde{\nu}_b}^* \Gamma_{\tilde{e}_i^*, W^-, \tilde{\nu}_b} F_0(p^2, m_{\tilde{\nu}_b}^2, m_{W^-}^2) + \sum_{b=1}^6 \Gamma_{\tilde{e}_j^*, \gamma, \tilde{e}_b}^* \Gamma_{\tilde{e}_i^*, \gamma, \tilde{e}_b} F_0(p^2, m_{\tilde{e}_b}^2, 0) \\
& + \sum_{b=1}^6 \Gamma_{\tilde{e}_j^*, Z, \tilde{e}_b}^* \Gamma_{\tilde{e}_i^*, Z, \tilde{e}_b} F_0(p^2, m_{\tilde{e}_b}^2, m_Z^2) + \sum_{b=1}^6 \Gamma_{\tilde{e}_j^*, Z', \tilde{e}_b}^* \Gamma_{\tilde{e}_i^*, Z', \tilde{e}_b} F_0(p^2, m_{\tilde{e}_b}^2, m_{Z'}^2) \tag{283}
\end{aligned}$$

• Self-Energy for SExotics (\tilde{x})

$$\begin{aligned}
\Pi_{i,j}(p^2) = & +2\Gamma_{\tilde{x}_i, \tilde{x}_j^*, Z, Z} \left(-\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) + 2\Gamma_{\tilde{x}_i, \tilde{x}_j^*, Z', Z'} \left(-\frac{1}{2} \text{rMS} m_{Z'}^2 + A_0(m_{Z'}^2) \right) \\
& - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\tilde{x}_i, \tilde{x}_j^*, H_a^+, H_a^-} - \sum_{a=1}^2 A_0(m_{H_a'^0}^2) \Gamma_{\tilde{x}_i, \tilde{x}_j^*, H_a'^0, H_a'^0} \\
& - \sum_{a=1}^2 A_0(m_{H_a'^-}^2) \Gamma_{\tilde{x}_i, \tilde{x}_j^*, H_a'^+, H_a'^-} - \sum_{a=1}^3 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{x}_i, \tilde{x}_j^*, \tilde{\nu}_a^*, \tilde{\nu}_a} \\
& - 2 \sum_{a=1}^3 m_{x_a} \sum_{b=1}^8 B_0(p^2, m_{x_a}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_b^0} \left(\Gamma_{\tilde{x}_j^*, x_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{x}_i^*, x_a, \tilde{\chi}_b^0}^R + \Gamma_{\tilde{x}_j^*, x_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{x}_i^*, x_a, \tilde{\chi}_b^0}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^8 G_0(p^2, m_{x_a}^2, m_{\tilde{\chi}_b^0}^2) \left(\Gamma_{\tilde{x}_j^*, x_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{x}_i^*, x_a, \tilde{\chi}_b^0}^L + \Gamma_{\tilde{x}_j^*, x_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{x}_i^*, x_a, \tilde{\chi}_b^0}^R \right) \\
& - \frac{1}{2} \sum_{a=1}^5 A_0(m_{A_a^0}^2) \Gamma_{\tilde{x}_i, \tilde{x}_j^*, A_a^0, A_a^0} - \frac{1}{2} \sum_{a=1}^5 A_0(m_{h_a}^2) \Gamma_{\tilde{x}_i, \tilde{x}_j^*, h_a, h_a} \\
& - C \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{x}_i, \tilde{x}_j^*, \tilde{d}_a^*, \tilde{d}_a} - C \sum_{a=1}^6 A_0(m_{\tilde{x}_a}^2) \Gamma_{\tilde{x}_i, \tilde{x}_j^*, \tilde{x}_a^*, \tilde{x}_a} \\
& - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{x}_i, \tilde{x}_j^*, \tilde{e}_a^*, \tilde{e}_a} - C \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{x}_i, \tilde{x}_j^*, \tilde{u}_a^*, \tilde{u}_a} \\
& + \sum_{a=1}^6 \sum_{b=1}^5 B_0(p^2, m_{\tilde{x}_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{x}_j^*, \tilde{x}_a, A_b^0}^* \Gamma_{\tilde{x}_i^*, \tilde{x}_a, A_b^0} + \sum_{a=1}^6 \sum_{b=1}^5 B_0(p^2, m_{\tilde{x}_a}^2, m_{h_b}^2) \Gamma_{\tilde{x}_j^*, \tilde{x}_a, h_b}^* \Gamma_{\tilde{x}_i^*, \tilde{x}_a, h_b}
\end{aligned}$$

$$\begin{aligned}
& -\frac{8}{3}m_{\tilde{g}}\sum_{b=1}^3B_0\left(p^2,m_{\tilde{g}}^2,m_{x_b}^2\right)m_{x_b}\left(\Gamma_{\tilde{x}_j^*,\tilde{g}_1,x_b}^{L*}\Gamma_{\tilde{x}_i^*,\tilde{g}_1,x_b}^R+\Gamma_{\tilde{x}_j^*,\tilde{g}_1,x_b}^{R*}\Gamma_{\tilde{x}_i^*,\tilde{g}_1,x_b}^L\right) \\
& +\frac{4}{3}\sum_{b=1}^3G_0\left(p^2,m_{\tilde{g}}^2,m_{x_b}^2\right)\left(\Gamma_{\tilde{x}_j^*,\tilde{g}_1,x_b}^{L*}\Gamma_{\tilde{x}_i^*,\tilde{g}_1,x_b}^L+\Gamma_{\tilde{x}_j^*,\tilde{g}_1,x_b}^{R*}\Gamma_{\tilde{x}_i^*,\tilde{g}_1,x_b}^R\right) \\
& +\frac{4}{3}\sum_{b=1}^6\Gamma_{\tilde{x}_j^*,g,\tilde{x}_b}^*\Gamma_{\tilde{x}_i^*,g,\tilde{x}_b}F_0\left(p^2,m_{\tilde{x}_b}^2,0\right)+\sum_{b=1}^6\Gamma_{\tilde{x}_j^*,\gamma,\tilde{x}_b}^*\Gamma_{\tilde{x}_i^*,\gamma,\tilde{x}_b}F_0\left(p^2,m_{\tilde{x}_b}^2,0\right) \\
& +\sum_{b=1}^6\Gamma_{\tilde{x}_j^*,Z,\tilde{x}_b}^*\Gamma_{\tilde{x}_i^*,Z,\tilde{x}_b}F_0\left(p^2,m_{\tilde{x}_b}^2,m_Z^2\right)+\sum_{b=1}^6\Gamma_{\tilde{x}_j^*,Z',\tilde{x}_b}^*\Gamma_{\tilde{x}_i^*,Z',\tilde{x}_b}F_0\left(p^2,m_{\tilde{x}_b}^2,m_{Z'}^2\right)
\end{aligned} \tag{284}$$

• Self-Energy for Higgs (h)

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

$$\begin{aligned}
& -6 \sum_{a=1}^3 m_{d_a} \sum_{b=1}^3 B_0(p^2, m_{d_a}^2, m_{d_b}^2) m_{d_b} \left(\Gamma_{\check{h}_j, \bar{d}_a, d_b}^{L*} \Gamma_{\check{h}_i, \bar{d}_a, d_b}^R + \Gamma_{\check{h}_j, \bar{d}_a, d_b}^{R*} \Gamma_{\check{h}_i, \bar{d}_a, d_b}^L \right) \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{d_a}^2, m_{d_b}^2) \left(\Gamma_{\check{h}_j, \bar{d}_a, d_b}^{L*} \Gamma_{\check{h}_i, \bar{d}_a, d_b}^L + \Gamma_{\check{h}_j, \bar{d}_a, d_b}^{R*} \Gamma_{\check{h}_i, \bar{d}_a, d_b}^R \right) \\
& - 6 \sum_{a=1}^3 m_{x_a} \sum_{b=1}^3 B_0(p^2, m_{x_a}^2, m_{x_b}^2) m_{x_b} \left(\Gamma_{\check{h}_j, \bar{x}_a, x_b}^{L*} \Gamma_{\check{h}_i, \bar{x}_a, x_b}^R + \Gamma_{\check{h}_j, \bar{x}_a, x_b}^{R*} \Gamma_{\check{h}_i, \bar{x}_a, x_b}^L \right) \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{x_a}^2, m_{x_b}^2) \left(\Gamma_{\check{h}_j, \bar{x}_a, x_b}^{L*} \Gamma_{\check{h}_i, \bar{x}_a, x_b}^L + \Gamma_{\check{h}_j, \bar{x}_a, x_b}^{R*} \Gamma_{\check{h}_i, \bar{x}_a, x_b}^R \right) \\
& - 2 \sum_{a=1}^3 m_{e_a} \sum_{b=1}^3 B_0(p^2, m_{e_a}^2, m_{e_b}^2) m_{e_b} \left(\Gamma_{\check{h}_j, \bar{e}_a, e_b}^{L*} \Gamma_{\check{h}_i, \bar{e}_a, e_b}^R + \Gamma_{\check{h}_j, \bar{e}_a, e_b}^{R*} \Gamma_{\check{h}_i, \bar{e}_a, e_b}^L \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{e_a}^2, m_{e_b}^2) \left(\Gamma_{\check{h}_j, \bar{e}_a, e_b}^{L*} \Gamma_{\check{h}_i, \bar{e}_a, e_b}^L + \Gamma_{\check{h}_j, \bar{e}_a, e_b}^{R*} \Gamma_{\check{h}_i, \bar{e}_a, e_b}^R \right) \\
& - 6 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^3 B_0(p^2, m_{u_a}^2, m_{u_b}^2) m_{u_b} \left(\Gamma_{\check{h}_j, \bar{u}_a, u_b}^{L*} \Gamma_{\check{h}_i, \bar{u}_a, u_b}^R + \Gamma_{\check{h}_j, \bar{u}_a, u_b}^{R*} \Gamma_{\check{h}_i, \bar{u}_a, u_b}^L \right) \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{u_a}^2, m_{u_b}^2) \left(\Gamma_{\check{h}_j, \bar{u}_a, u_b}^{L*} \Gamma_{\check{h}_i, \bar{u}_a, u_b}^L + \Gamma_{\check{h}_j, \bar{u}_a, u_b}^{R*} \Gamma_{\check{h}_i, \bar{u}_a, u_b}^R \right) \\
& - \frac{1}{2} \sum_{a=1}^5 A_0(m_{A_a^0}^2) \Gamma_{\check{h}_i, \check{h}_j, A_a^0, A_a^0} - \frac{1}{2} \sum_{a=1}^5 A_0(m_{h_a}^2) \Gamma_{\check{h}_i, \check{h}_j, h_a, h_a} \\
& + \frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^5 B_0(p^2, m_{A_a^0}^2, m_{A_b^0}^2) \Gamma_{\check{h}_j, A_a^0, A_b^0}^* \Gamma_{\check{h}_i, A_a^0, A_b^0} \\
& + \sum_{a=1}^5 \sum_{b=1}^5 B_0(p^2, m_{h_a}^2, m_{A_b^0}^2) \Gamma_{\check{h}_j, h_a, A_b^0}^* \Gamma_{\check{h}_i, h_a, A_b^0} + \frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^5 B_0(p^2, m_{h_a}^2, m_{h_b}^2) \Gamma_{\check{h}_j, h_a, h_b}^* \Gamma_{\check{h}_i, h_a, h_b} \\
& - 3 \sum_{a=1}^6 A_0(m_{\bar{d}_a}^2) \Gamma_{\check{h}_i, \check{h}_j, \bar{d}_a^*, \bar{d}_a} - 3 \sum_{a=1}^6 A_0(m_{\bar{x}_a}^2) \Gamma_{\check{h}_i, \check{h}_j, \bar{x}_a^*, \bar{x}_a} \\
& - \sum_{a=1}^6 A_0(m_{\bar{e}_a}^2) \Gamma_{\check{h}_i, \check{h}_j, \bar{e}_a^*, \bar{e}_a} - 3 \sum_{a=1}^6 A_0(m_{\bar{u}_a}^2) \Gamma_{\check{h}_i, \check{h}_j, \bar{u}_a^*, \bar{u}_a} \\
& + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\bar{d}_a}^2, m_{\bar{d}_b}^2) \Gamma_{\check{h}_j, \bar{d}_a^*, \bar{d}_b}^* \Gamma_{\check{h}_i, \bar{d}_a^*, \bar{d}_b} \\
& + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\bar{x}_a}^2, m_{\bar{x}_b}^2) \Gamma_{\check{h}_j, \bar{x}_a^*, \bar{x}_b}^* \Gamma_{\check{h}_i, \bar{x}_a^*, \bar{x}_b} + \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\bar{e}_a}^2, m_{\bar{e}_b}^2) \Gamma_{\check{h}_j, \bar{e}_a^*, \bar{e}_b}^* \Gamma_{\check{h}_i, \bar{e}_a^*, \bar{e}_b}
\end{aligned}$$

$$\begin{aligned}
& + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{u}_a}^2, m_{\tilde{u}_b}^2) \Gamma_{\tilde{h}_j, \tilde{u}_a^*, \tilde{u}_b}^* \Gamma_{\tilde{h}_i, \tilde{u}_a^*, \tilde{u}_b} \\
& - \sum_{a=1}^8 m_{\tilde{\chi}_a^0} \sum_{b=1}^8 B_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_b^0} \left(\Gamma_{\tilde{h}_j, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R + \Gamma_{\tilde{h}_j, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^L \right) \\
& + \frac{1}{2} \sum_{a=1}^8 \sum_{b=1}^8 G_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2) \left(\Gamma_{\tilde{h}_j, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^L + \Gamma_{\tilde{h}_j, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R \right) \\
& + 2 \sum_{b=1}^2 \Gamma_{\tilde{h}_j, W^+, H_b^-}^* \Gamma_{\tilde{h}_i, W^+, H_b^-} F_0(p^2, m_{H_b^-}^2, m_{W^-}^2) + \sum_{b=1}^5 \Gamma_{\tilde{h}_j, Z, A_b^0}^* \Gamma_{\tilde{h}_i, Z, A_b^0} F_0(p^2, m_{A_b^0}^2, m_Z^2) \\
& + \sum_{b=1}^5 \Gamma_{\tilde{h}_j, Z', A_b^0}^* \Gamma_{\tilde{h}_i, Z', A_b^0} F_0(p^2, m_{A_b^0}^2, m_{Z'}^2) \tag{285}
\end{aligned}$$

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

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

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

$$\begin{aligned}
& - \sum_{a=1}^8 m_{\tilde{\chi}_a^0} \sum_{b=1}^8 B_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_b^0} \left(\Gamma_{\tilde{A}_j^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R + \Gamma_{\tilde{A}_j^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^L \right) \\
& + \frac{1}{2} \sum_{a=1}^8 \sum_{b=1}^8 G_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2) \left(\Gamma_{\tilde{A}_j^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^L + \Gamma_{\tilde{A}_j^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{A}_i^0, \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R \right) \\
& + 2 \sum_{b=1}^2 \Gamma_{\tilde{A}_j^0, W^+, H_b^-}^* \Gamma_{\tilde{A}_i^0, W^+, H_b^-} F_0(p^2, m_{H_b^-}^2, m_{W^-}^2) + \sum_{b=1}^5 \Gamma_{\tilde{A}_j^0, Z, h_b}^* \Gamma_{\tilde{A}_i^0, Z, h_b} F_0(p^2, m_{h_b}^2, m_Z^2) \\
& + \sum_{b=1}^5 \Gamma_{\tilde{A}_j^0, Z', h_b}^* \Gamma_{\tilde{A}_i^0, Z', h_b} F_0(p^2, m_{h_b}^2, m_{Z'}^2) \tag{286}
\end{aligned}$$

• Self-Energy for Charged Higgs (H^-)

$$\begin{aligned}
\Pi_{i,j}(p^2) = & +4 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, 0, m_{W^-}^2) \right) \Gamma_{\tilde{H}_j^+, W^-, \gamma}^* \Gamma_{\tilde{H}_i^+, W^-, \gamma} + 4 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{W^-}^2, m_Z^2) \right) \Gamma_{\tilde{H}_j^+, Z, W^-}^* \Gamma_{\tilde{H}_i^+, Z, W^-} \\
& + 4 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{W^-}^2, m_{Z'}^2) \right) \Gamma_{\tilde{H}_j^+, Z', W^-}^* \Gamma_{\tilde{H}_i^+, Z', W^-} - B_0(p^2, m_{\eta^Z}^2, m_{\eta^+}^2) \Gamma_{\tilde{H}_j^+, \eta^+, \eta^Z}^* \Gamma_{\tilde{H}_i^-, \eta^+, \eta^Z} \\
& - B_0(p^2, m_{\eta^{Z'}}^2, m_{\eta^+}^2) \Gamma_{\tilde{H}_j^+, \eta^+, \eta^{Z'}}^* \Gamma_{\tilde{H}_i^-, \eta^+, \eta^{Z'}} - B_0(p^2, m_{\eta^-}^2, m_{\eta^Z}^2) \Gamma_{\tilde{H}_j^+, \eta^Z, \eta^-}^* \Gamma_{\tilde{H}_i^-, \eta^Z, \eta^-} \\
& - B_0(p^2, m_{\eta^+}^2, m_{\eta^{Z'}}^2) \Gamma_{\tilde{H}_j^+, \eta^Z, \eta^+}^* \Gamma_{\tilde{H}_i^-, \eta^Z, \eta^+} + 4 \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, W^+, W^-} - \left(-\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) \\
& + 2 \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, Z, Z} \left(-\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right) + 2 \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, Z', Z'} \left(-\frac{1}{2} \text{rMS} m_{Z'}^2 + A_0(m_{Z'}^2) \right) \\
& - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, H_a^+, H_a^-} - \sum_{a=1}^2 A_0(m_{H_a'^0}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, H_a'^0, *} H_a'^0 \\
& - \sum_{a=1}^2 A_0(m_{H_a'^-}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, H_a'^+, H_a'^-} + \sum_{a=1}^2 \sum_{b=1}^2 B_0(p^2, m_{H_a'^0}^2, m_{H_b'^-}^2) \Gamma_{\tilde{H}_j^+, H_a'^0, *} H_b'^- \Gamma_{\tilde{H}_i^+, H_a'^0, *} H_b'^- \\
& + \sum_{a=1}^2 \sum_{b=1}^5 B_0(p^2, m_{H_a^-}^2, m_{A_b^0}^2) \Gamma_{\tilde{H}_j^+, H_a^-, A_b^0}^* \Gamma_{\tilde{H}_i^+, H_a^-, A_b^0} \\
& + \sum_{a=1}^2 \sum_{b=1}^5 B_0(p^2, m_{H_a^-}^2, m_{h_b}^2) \Gamma_{\tilde{H}_j^+, H_a^-, h_b}^* \Gamma_{\tilde{H}_i^+, H_a^-, h_b} - \sum_{a=1}^3 A_0(m_{\nu_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \nu_a^*, \nu_a} \\
& - 6 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^3 B_0(p^2, m_{u_a}^2, m_{d_b}^2) m_{d_b} \left(\Gamma_{\tilde{H}_j^+, \bar{u}_a, d_b}^{L*} \Gamma_{\tilde{H}_i^+, \bar{u}_a, d_b}^R + \Gamma_{\tilde{H}_j^+, \bar{u}_a, d_b}^{R*} \Gamma_{\tilde{H}_i^+, \bar{u}_a, d_b}^L \right) \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{u_a}^2, m_{d_b}^2) \left(\Gamma_{\tilde{H}_j^+, \bar{u}_a, d_b}^{L*} \Gamma_{\tilde{H}_i^+, \bar{u}_a, d_b}^L + \Gamma_{\tilde{H}_j^+, \bar{u}_a, d_b}^{R*} \Gamma_{\tilde{H}_i^+, \bar{u}_a, d_b}^R \right) \\
& - 2 \sum_{a=1}^3 m_{\nu_a} \sum_{b=1}^3 B_0(p^2, m_{\nu_a}^2, m_{e_b}^2) m_{e_b} \left(\Gamma_{\tilde{H}_j^+, \bar{\nu}_a, e_b}^{L*} \Gamma_{\tilde{H}_i^+, \bar{\nu}_a, e_b}^R + \Gamma_{\tilde{H}_j^+, \bar{\nu}_a, e_b}^{R*} \Gamma_{\tilde{H}_i^+, \bar{\nu}_a, e_b}^L \right)
\end{aligned}$$

$$\begin{aligned}
& + \sum_{a=1}^3 \sum_{b=1}^3 G_0(p^2, m_{\nu_a}^2, m_{e_b}^2) \left(\Gamma_{\tilde{H}_j^+, \tilde{\nu}_a, e_b}^{L*} \Gamma_{\tilde{H}_i^+, \tilde{\nu}_a, e_b}^L + \Gamma_{\tilde{H}_j^+, \tilde{\nu}_a, e_b}^{R*} \Gamma_{\tilde{H}_i^+, \tilde{\nu}_a, e_b}^R \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^6 B_0(p^2, m_{\nu_a}^2, m_{\tilde{e}_b}^2) \Gamma_{\tilde{H}_j^+, \tilde{\nu}_a^*, \tilde{e}_b}^* \Gamma_{\tilde{H}_i^+, \tilde{\nu}_a^*, \tilde{e}_b} - \frac{1}{2} \sum_{a=1}^5 A_0(m_{A_a^0}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, A_a^0, A_a^0} \\
& - \frac{1}{2} \sum_{a=1}^5 A_0(m_{h_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, h_a, h_a} - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \tilde{d}_a^*, \tilde{d}_a} \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{x}_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \tilde{x}_a^*, \tilde{x}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \tilde{e}_a^*, \tilde{e}_a} \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{H}_i^-, \tilde{H}_j^+, \tilde{u}_a^*, \tilde{u}_a} + 3 \sum_{a=1}^6 \sum_{b=1}^6 B_0(p^2, m_{\tilde{u}_a}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{H}_j^+, \tilde{u}_a^*, \tilde{d}_b}^* \Gamma_{\tilde{H}_i^+, \tilde{u}_a^*, \tilde{d}_b} \\
& - 2 \sum_{a=1}^8 m_{\tilde{\chi}_a^0} \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^-}^2) m_{\tilde{\chi}_b^-} \left(\Gamma_{\tilde{H}_j^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{H}_i^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^R + \Gamma_{\tilde{H}_j^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{H}_i^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^L \right) \\
& + \sum_{a=1}^8 \sum_{b=1}^2 G_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^-}^2) \left(\Gamma_{\tilde{H}_j^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{H}_i^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^L + \Gamma_{\tilde{H}_j^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{H}_i^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^R \right) \\
& + \sum_{b=1}^2 \Gamma_{\tilde{H}_j^+, \gamma, H_b^-}^* \Gamma_{\tilde{H}_i^+, \gamma, H_b^-} F_0(p^2, m_{H_b^-}^2, 0) + \sum_{b=1}^2 \Gamma_{\tilde{H}_j^+, Z, H_b^-}^* \Gamma_{\tilde{H}_i^+, Z, H_b^-} F_0(p^2, m_{H_b^-}^2, m_Z^2) \\
& + \sum_{b=1}^2 \Gamma_{\tilde{H}_j^+, Z', H_b^-}^* \Gamma_{\tilde{H}_i^+, Z', H_b^-} F_0(p^2, m_{H_b^-}^2, m_{Z'}^2) + \sum_{b=1}^5 \Gamma_{\tilde{H}_j^+, W^-, A_b^0}^* \Gamma_{\tilde{H}_i^+, W^-, A_b^0} F_0(p^2, m_{A_b^0}^2, m_{W^-}^2) \\
& + \sum_{b=1}^5 \Gamma_{\tilde{H}_j^+, W^-, h_b}^* \Gamma_{\tilde{H}_i^+, W^-, h_b} F_0(p^2, m_{h_b}^2, m_{W^-}^2) \tag{287}
\end{aligned}$$

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

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

$$\begin{aligned}
& + \sum_{a=1}^5 \sum_{b=1}^8 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{h_a}^2) \Gamma_{\tilde{\chi}_j^0, h_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^0, h_a, \tilde{\chi}_b^0}^R \\
& + 6 \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{d}_a^*, d_b}^{L*} m_{d_b} \Gamma_{\tilde{\chi}_i^0, \tilde{d}_a^*, d_b}^R \\
& + 6 \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{x_b}^2, m_{\tilde{x}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{x}_a^*, x_b}^{L*} m_{x_b} \Gamma_{\tilde{\chi}_i^0, \tilde{x}_a^*, x_b}^R \\
& + 2 \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{e_b}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{e}_a^*, e_b}^{L*} m_{e_b} \Gamma_{\tilde{\chi}_i^0, \tilde{e}_a^*, e_b}^R \\
& + 6 \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{u}_a^*, u_b}^{L*} m_{u_b} \Gamma_{\tilde{\chi}_i^0, \tilde{u}_a^*, u_b}^R \\
& + \sum_{a=1}^8 m_{\tilde{\chi}_a^0} \sum_{b=1}^5 B_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{A_b^0}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{\chi}_a^0, A_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{\chi}_a^0, A_b^0}^R \\
& - 8 \sum_{b=1}^2 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{W^-}^2) \right) \Gamma_{\tilde{\chi}_j^0, W^+, \tilde{\chi}_b^-}^{R*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^0, W^+, \tilde{\chi}_b^-}^L \\
& - 4 \sum_{b=1}^8 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_Z^2) \right) \Gamma_{\tilde{\chi}_j^0, Z, \tilde{\chi}_b^0}^{R*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^0, Z, \tilde{\chi}_b^0}^L \\
& - 4 \sum_{b=1}^8 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{Z'}^2) \right) \Gamma_{\tilde{\chi}_j^0, Z', \tilde{\chi}_b^0}^{R*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^0, Z', \tilde{\chi}_b^0}^L \tag{288} \\
\Sigma_{i,j}^R(p^2) = & - \sum_{a=1}^2 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{H_a^-}^2) \Gamma_{\tilde{\chi}_j^0, H_a^+, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^0, H_a^+, \tilde{\chi}_b^-}^R \\
& - \sum_{a=1}^2 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b'^0}^2, m_{H_a'^0}^2) \Gamma_{\tilde{\chi}_j^0, H_a'^0, \tilde{\chi}_b'^0}^{R*} \Gamma_{\tilde{\chi}_i^0, H_a'^0, \tilde{\chi}_b'^0}^R \\
& - \sum_{a=1}^2 B_1(p^2, m_{\tilde{\chi}^-}^2, m_{H_a^-}^2) \Gamma_{\tilde{\chi}_j^0, H_a'^+, \text{ChaP}}^{R*} \left(\{1\} \right) \Gamma_{\tilde{\chi}_i^0, H_a'^+, \text{ChaP}}^R \left(\{1\} \right) \\
& - \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{\nu_b}^2, m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{\nu}_a^*, \nu_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{\nu}_a^*, \nu_b}^R \\
& - \frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^8 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{h_a}^2) \Gamma_{\tilde{\chi}_j^0, h_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, h_a, \tilde{\chi}_b^0}^R \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{d}_a^*, d_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{d}_a^*, d_b}^R
\end{aligned}$$

$$\begin{aligned}
& -3 \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{x_b}^2, m_{\tilde{x}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{x}_a^*, x_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{x}_a^*, x_b}^R \\
& - \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{e}_a^*, e_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{e}_a^*, e_b}^R \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{u}_a^*, u_b}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{u}_a^*, u_b}^R \\
& - \frac{1}{2} \sum_{a=1}^8 \sum_{b=1}^5 B_1(p^2, m_{\tilde{\chi}_a^0}^2, m_{A_b^0}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{\chi}_a^0, A_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, \tilde{\chi}_a^0, A_b^0}^R \\
& - 2 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{W^-}^2) \Gamma_{\tilde{\chi}_j^0, W^+, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^0, W^+, \tilde{\chi}_b^-}^L - \sum_{b=1}^8 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_Z^2) \Gamma_{\tilde{\chi}_j^0, Z, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, Z, \tilde{\chi}_b^0}^L \\
& - \sum_{b=1}^8 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{Z'}^2) \Gamma_{\tilde{\chi}_j^0, Z', \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, Z', \tilde{\chi}_b^0}^L \tag{289}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) = & - \sum_{a=1}^2 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{H_a^-}^2) \Gamma_{\tilde{\chi}_j^0, H_a^+, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^0, H_a^+, \tilde{\chi}_b^-}^L \\
& - \sum_{a=1}^2 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b'^0}^2, m_{H_a'^0}^2) \Gamma_{\tilde{\chi}_j^0, H_a'^0, *, \tilde{\chi}_b'^0}^{L*} \Gamma_{\tilde{\chi}_i^0, H_a'^0, *, \tilde{\chi}_b'^0}^L \\
& - \sum_{a=1}^2 B_1(p^2, m_{\tilde{\chi}^-}^2, m_{H_a^-}^2) \Gamma_{\tilde{\chi}_j^0, H_a'^+, \text{ChaP}}^{L*} \left(\{1\} \right) \Gamma_{\tilde{\chi}_i^0, H_a'^+, \text{ChaP}}^L \left(\{1\} \right) \\
& - \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{\nu_b}^2, m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{\nu}_a^*, \nu_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{\nu}_a^*, \nu_b}^L \\
& - \frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^8 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{h_a}^2) \Gamma_{\tilde{\chi}_j^0, h_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, h_a, \tilde{\chi}_b^0}^L \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{d}_a^*, d_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{d}_a^*, d_b}^L \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{x_b}^2, m_{\tilde{x}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{x}_a^*, x_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{x}_a^*, x_b}^L \\
& - \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{e}_a^*, e_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{e}_a^*, e_b}^L \\
& - 3 \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{\chi}_j^0, \tilde{u}_a^*, u_b}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{u}_a^*, u_b}^L
\end{aligned}$$

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^8 \sum_{b=1}^5 B_1 \left(p^2, m_{\tilde{\chi}_a^0}^2, m_{A_b^0}^2 \right) \Gamma_{\tilde{\chi}_j^0, \tilde{\chi}_a^0, A_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, \tilde{\chi}_a^0, A_b^0}^L \\
& - 2 \sum_{b=1}^2 B_1 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{W^-}^2 \right) \Gamma_{\tilde{\chi}_j^0, W^+, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^0, W^+, \tilde{\chi}_b^-}^R - \sum_{b=1}^8 B_1 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_Z^2 \right) \Gamma_{\tilde{\chi}_j^0, Z, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, Z, \tilde{\chi}_b^0}^R \\
& - \sum_{b=1}^8 B_1 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{Z'}^2 \right) \Gamma_{\tilde{\chi}_j^0, Z', \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, Z', \tilde{\chi}_b^0}^R
\end{aligned} \tag{290}$$

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

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) = & + \sum_{a=1}^2 \sum_{b=1}^2 B_0 \left(p^2, m_{\tilde{\chi}_b'^0}^2, m_{H_a'^-}^2 \right) \Gamma_{\tilde{\chi}_j^+, H_a'^-, \tilde{\chi}_b'^0}^{L*} m_{\tilde{\chi}_b'^0} \Gamma_{\tilde{\chi}_i^+, H_a'^-, \tilde{\chi}_b'^0}^R \\
& + \sum_{a=1}^2 m_{\tilde{\chi}_a^-} \sum_{b=1}^5 B_0 \left(p^2, m_{\tilde{\chi}_a^-}^2, m_{A_b^0}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{\chi}_a^-, A_b^0}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{\chi}_a^-, A_b^0}^R \\
& + \sum_{a=1}^2 \sum_{b=1}^8 B_0 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{H_a^-}^2 \right) \Gamma_{\tilde{\chi}_j^+, H_a^-, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^+, H_a^-, \tilde{\chi}_b^0}^R \\
& + m_{\tilde{\chi}^-} \sum_{a=1}^2 B_0 \left(p^2, m_{\tilde{\chi}^-}^2, m_{H_a'^0}^2 \right) \Gamma_{\tilde{\chi}_j^+, H_a'^0, *, \text{ChaP}}^{L*} \left(\{1\} \right) \Gamma_{\tilde{\chi}_i^+, H_a'^0, *, \text{ChaP}}^R \left(\{1\} \right) \\
& + \sum_{a=1}^3 \sum_{b=1}^3 B_0 \left(p^2, m_{e_b}^2, m_{\tilde{\nu}_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{\nu}_a^*, e_b}^{L*} m_{e_b} \Gamma_{\tilde{\chi}_i^+, \tilde{\nu}_a^*, e_b}^R \\
& + 3 \sum_{a=1}^3 m_{u_a} \sum_{b=1}^6 B_0 \left(p^2, m_{u_a}^2, m_{\tilde{d}_b}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a, \tilde{d}_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a, \tilde{d}_b}^R \\
& + \sum_{a=1}^3 m_{\nu_a} \sum_{b=1}^6 B_0 \left(p^2, m_{\nu_a}^2, m_{\tilde{e}_b}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{\nu}_a, \tilde{e}_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{\nu}_a, \tilde{e}_b}^R \\
& + \sum_{a=1}^5 \sum_{b=1}^2 B_0 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{h_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, h_a, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^+, h_a, \tilde{\chi}_b^-}^R \\
& + 3 \sum_{a=1}^6 \sum_{b=1}^3 B_0 \left(p^2, m_{\tilde{d}_b}^2, m_{\tilde{u}_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a^*, \tilde{d}_b}^{L*} m_{\tilde{d}_b} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a^*, \tilde{d}_b}^R \\
& - 4 \sum_{b=1}^2 \left(-\frac{1}{2} \text{rMS} + B_0 \left(p^2, m_{\tilde{\chi}_b^-}^2, 0 \right) \right) \Gamma_{\tilde{\chi}_j^+, \gamma, \tilde{\chi}_b^-}^{R*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^+, \gamma, \tilde{\chi}_b^-}^L \\
& - 4 \sum_{b=1}^2 \left(-\frac{1}{2} \text{rMS} + B_0 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_Z^2 \right) \right) \Gamma_{\tilde{\chi}_j^+, Z, \tilde{\chi}_b^-}^{R*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^+, Z, \tilde{\chi}_b^-}^L
\end{aligned}$$

$$\begin{aligned}
& -4 \sum_{b=1}^2 \left(-\frac{1}{2} \text{rMS} + B_0 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{Z'}^2 \right) \right) \Gamma_{\tilde{\chi}_j^+, Z', \tilde{\chi}_b^-}^{R*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{\chi}_i^+, Z', \tilde{\chi}_b^-}^L \\
& -4 \sum_{b=1}^8 \left(-\frac{1}{2} \text{rMS} + B_0 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{W^-}^2 \right) \right) \Gamma_{\tilde{\chi}_j^+, W^-, \tilde{\chi}_b^0}^{R*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^+, W^-, \tilde{\chi}_b^0}^L
\end{aligned} \tag{291}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) = & -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^2 B_1 \left(p^2, m_{\tilde{\chi}_b'^0}^2, m_{H_a'^-}^2 \right) \Gamma_{\tilde{\chi}_j^+, H_a'^-, \tilde{\chi}_b'^0}^{R*} \Gamma_{\tilde{\chi}_i^+, H_a'^-, \tilde{\chi}_b'^0}^R \\
& -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^5 B_1 \left(p^2, m_{\tilde{\chi}_a^-}^2, m_{A_b^0}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{\chi}_a^-, A_b^0}^{R*} \Gamma_{\tilde{\chi}_i^+, \tilde{\chi}_a^-, A_b^0}^R \\
& -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^8 B_1 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{H_a^-}^2 \right) \Gamma_{\tilde{\chi}_j^+, H_a^-, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^+, H_a^-, \tilde{\chi}_b^0}^R \\
& -\frac{1}{2} \sum_{a=1}^2 B_1 \left(p^2, m_{\tilde{\chi}^-}^2, m_{H_a'^0}^2 \right) \Gamma_{\tilde{\chi}_j^+, H_a'^0, *, \text{ChaP}}^{R*} \left(\{1\} \right) \Gamma_{\tilde{\chi}_i^+, H_a'^0, *, \text{ChaP}}^R \left(\{1\} \right) \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1 \left(p^2, m_{e_b}^2, m_{\tilde{\nu}_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{\nu}_a^*, e_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \tilde{\nu}_a^*, e_b}^R \\
& -\frac{3}{2} \sum_{a=1}^3 \sum_{b=1}^6 B_1 \left(p^2, m_{u_a}^2, m_{\tilde{d}_b}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a, \tilde{d}_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a, \tilde{d}_b}^R \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^6 B_1 \left(p^2, m_{\nu_a}^2, m_{\tilde{e}_b}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{\nu}_a, \tilde{e}_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \tilde{\nu}_a, \tilde{e}_b}^R \\
& -\frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^2 B_1 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{h_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, h_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^+, h_a, \tilde{\chi}_b^-}^R \\
& -\frac{3}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1 \left(p^2, m_{d_b}^2, m_{\tilde{u}_a}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a^*, d_b}^{R*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a^*, d_b}^R - \sum_{b=1}^2 B_1 \left(p^2, m_{\tilde{\chi}_b^-}^2, 0 \right) \Gamma_{\tilde{\chi}_j^+, \gamma, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^+, \gamma, \tilde{\chi}_b^-}^L \\
& -\sum_{b=1}^2 B_1 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_Z^2 \right) \Gamma_{\tilde{\chi}_j^+, Z, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^+, Z, \tilde{\chi}_b^-}^L - \sum_{b=1}^2 B_1 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{Z'}^2 \right) \Gamma_{\tilde{\chi}_j^+, Z', \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^+, Z', \tilde{\chi}_b^-}^L \\
& -\sum_{b=1}^8 B_1 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{W^-}^2 \right) \Gamma_{\tilde{\chi}_j^+, W^-, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^+, W^-, \tilde{\chi}_b^0}^L
\end{aligned} \tag{292}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) = & -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^2 B_1 \left(p^2, m_{\tilde{\chi}_b'^0}^2, m_{H_a'^-}^2 \right) \Gamma_{\tilde{\chi}_j^+, H_a'^-, \tilde{\chi}_b'^0}^{L*} \Gamma_{\tilde{\chi}_i^+, H_a'^-, \tilde{\chi}_b'^0}^L \\
& -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^5 B_1 \left(p^2, m_{\tilde{\chi}_a^-}^2, m_{A_b^0}^2 \right) \Gamma_{\tilde{\chi}_j^+, \tilde{\chi}_a^-, A_b^0}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{\chi}_a^-, A_b^0}^L
\end{aligned}$$

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^8 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{H_a^-}^2) \Gamma_{\tilde{\chi}_j^+, H_a^-, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^+, H_a^-, \tilde{\chi}_b^0}^L \\
& -\frac{1}{2} \sum_{a=1}^2 B_1(p^2, m_{\tilde{\chi}'^-}^2, m_{H_a'^0}^2) \Gamma_{\tilde{\chi}_j^+, H_a'^0, *, \text{ChaP}(\{1\})}^{L*} \Gamma_{\tilde{\chi}_i^+, H_a'^0, *, \text{ChaP}(\{1\})}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{\nu}_a^*, e_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{\nu}_a^*, e_b}^L \\
& -\frac{3}{2} \sum_{a=1}^3 \sum_{b=1}^6 B_1(p^2, m_{u_a}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a, \tilde{d}_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a, \tilde{d}_b}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^6 B_1(p^2, m_{\nu_a}^2, m_{\tilde{e}_b}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{\nu}_a, \tilde{e}_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{\nu}_a, \tilde{e}_b}^L \\
& -\frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{h_a}^2) \Gamma_{\tilde{\chi}_j^+, h_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^+, h_a, \tilde{\chi}_b^-}^L \\
& -\frac{3}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{\chi}_j^+, \tilde{u}_a^*, d_b}^{L*} \Gamma_{\tilde{\chi}_i^+, \tilde{u}_a^*, d_b}^L - \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, 0) \Gamma_{\tilde{\chi}_j^+, \gamma, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^+, \gamma, \tilde{\chi}_b^-}^R \\
& -\sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_Z^2) \Gamma_{\tilde{\chi}_j^+, Z, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^+, Z, \tilde{\chi}_b^-}^R - \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{Z'}^2) \Gamma_{\tilde{\chi}_j^+, Z', \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^+, Z', \tilde{\chi}_b^-}^R \\
& -\sum_{b=1}^8 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{W^-}^2) \Gamma_{\tilde{\chi}_j^+, W^-, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^+, W^-, \tilde{\chi}_b^0}^R \tag{293}
\end{aligned}$$

• Self-Energy for Leptons (e)

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) = & + \sum_{a=1}^2 \sum_{b=1}^3 B_0(p^2, m_{\nu_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{e}_j, H_a^-, \nu_b}^{L*} m_{\nu_b} \Gamma_{\tilde{e}_i, H_a^-, \nu_b}^R \\
& + \sum_{a=1}^3 \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{e}_j, \tilde{\nu}_a, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{e}_i, \tilde{\nu}_a, \tilde{\chi}_b^-}^R \\
& + \sum_{a=1}^3 m_{e_a} \sum_{b=1}^5 B_0(p^2, m_{e_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{e}_j, e_a, A_b^0}^{L*} \Gamma_{\tilde{e}_i, e_a, A_b^0}^R \\
& + \sum_{a=1}^5 \sum_{b=1}^3 B_0(p^2, m_{e_b}^2, m_{h_a}^2) \Gamma_{\tilde{e}_j, h_a, e_b}^{L*} m_{e_b} \Gamma_{\tilde{e}_i, h_a, e_b}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^8 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{e}_j, \tilde{e}_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{e}_i, \tilde{e}_a, \tilde{\chi}_b^0}^R
\end{aligned}$$

$$\begin{aligned}
& -4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{e_b}^2, 0) \right) \Gamma_{\tilde{e}_j, \gamma, e_b}^{R*} m_{e_b} \Gamma_{\tilde{e}_i, \gamma, e_b}^L \\
& -4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{\nu_b}^2, m_{W^-}^2) \right) \Gamma_{\tilde{e}_j, W^-, \nu_b}^{R*} m_{\nu_b} \Gamma_{\tilde{e}_i, W^-, \nu_b}^L \\
& -4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{e_b}^2, m_Z^2) \right) \Gamma_{\tilde{e}_j, Z, e_b}^{R*} m_{e_b} \Gamma_{\tilde{e}_i, Z, e_b}^L \\
& -4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{e_b}^2, m_{Z'}^2) \right) \Gamma_{\tilde{e}_j, Z', e_b}^{R*} m_{e_b} \Gamma_{\tilde{e}_i, Z', e_b}^L
\end{aligned} \tag{294}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) &= -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{\nu_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{e}_j, H_a^-, \nu_b}^{R*} \Gamma_{\tilde{e}_i, H_a^-, \nu_b}^R \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{\nu}_a}^2) \Gamma_{\tilde{e}_j, \tilde{\nu}_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{e}_i, \tilde{\nu}_a, \tilde{\chi}_b^-}^R \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^5 B_1(p^2, m_{e_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{e}_j, e_a, A_b^0}^{R*} \Gamma_{\tilde{e}_i, e_a, A_b^0}^R \\
& -\frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{h_a}^2) \Gamma_{\tilde{e}_j, h_a, e_b}^{R*} \Gamma_{\tilde{e}_i, h_a, e_b}^R \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^8 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{e}_j, \tilde{e}_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{e}_i, \tilde{e}_a, \tilde{\chi}_b^0}^R - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, 0) \Gamma_{\tilde{e}_j, \gamma, e_b}^{L*} \Gamma_{\tilde{e}_i, \gamma, e_b}^L \\
& -\sum_{b=1}^3 B_1(p^2, m_{\nu_b}^2, m_{W^-}^2) \Gamma_{\tilde{e}_j, W^-, \nu_b}^{L*} \Gamma_{\tilde{e}_i, W^-, \nu_b}^L - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_Z^2) \Gamma_{\tilde{e}_j, Z, e_b}^{L*} \Gamma_{\tilde{e}_i, Z, e_b}^L \\
& -\sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{Z'}^2) \Gamma_{\tilde{e}_j, Z', e_b}^{L*} \Gamma_{\tilde{e}_i, Z', e_b}^L
\end{aligned} \tag{295}$$

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

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^8 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{e}_a}^2) \Gamma_{\tilde{e}_j, \tilde{e}_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{e}_i, \tilde{e}_a, \tilde{\chi}_b^0}^L - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, 0) \Gamma_{\tilde{e}_j, \gamma, e_b}^{R*} \Gamma_{\tilde{e}_i, \gamma, e_b}^R \\
& - \sum_{b=1}^3 B_1(p^2, m_{\nu_b}^2, m_{W^-}^2) \Gamma_{\tilde{e}_j, W^-, \nu_b}^{R*} \Gamma_{\tilde{e}_i, W^-, \nu_b}^R - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_Z^2) \Gamma_{\tilde{e}_j, Z, e_b}^{R*} \Gamma_{\tilde{e}_i, Z, e_b}^R \\
& - \sum_{b=1}^3 B_1(p^2, m_{e_b}^2, m_{Z'}^2) \Gamma_{\tilde{e}_j, Z', e_b}^{R*} \Gamma_{\tilde{e}_i, Z', e_b}^R
\end{aligned} \tag{296}$$

• Self-Energy for Down-Quarks (d)

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) = & + \sum_{a=1}^2 \sum_{b=1}^3 B_0(p^2, m_{u_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{d}_j, H_a^-, u_b}^{L*} m_{u_b} \Gamma_{\tilde{d}_i, H_a^-, u_b}^R \\
& + \sum_{a=1}^3 m_{d_a} \sum_{b=1}^5 B_0(p^2, m_{d_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j, d_a, A_b^0}^{L*} \Gamma_{\tilde{d}_i, d_a, A_b^0}^R \\
& + \sum_{a=1}^5 \sum_{b=1}^3 B_0(p^2, m_{d_b}^2, m_{h_a}^2) \Gamma_{\tilde{d}_j, h_a, d_b}^{L*} m_{d_b} \Gamma_{\tilde{d}_i, h_a, d_b}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_j, \tilde{u}_a, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\tilde{d}_i, \tilde{u}_a, \tilde{\chi}_b^-}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^8 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{\chi}_b^0}^R \\
& + \frac{4}{3} m_{\tilde{g}} \sum_{a=1}^6 B_0(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{g}_1}^R - \frac{16}{3} \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, 0) \right) \Gamma_{\tilde{d}_j, g, d_b}^{R*} m_{d_b} \Gamma_{\tilde{d}_i, g, d_b}^L \\
& - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, 0) \right) \Gamma_{\tilde{d}_j, \gamma, d_b}^{R*} m_{d_b} \Gamma_{\tilde{d}_i, \gamma, d_b}^L \\
& - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, m_{W^-}^2) \right) \Gamma_{\tilde{d}_j, W^-, u_b}^{R*} m_{u_b} \Gamma_{\tilde{d}_i, W^-, u_b}^L \\
& - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, m_Z^2) \right) \Gamma_{\tilde{d}_j, Z, d_b}^{R*} m_{d_b} \Gamma_{\tilde{d}_i, Z, d_b}^L \\
& - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, m_{Z'}^2) \right) \Gamma_{\tilde{d}_j, Z', d_b}^{R*} m_{d_b} \Gamma_{\tilde{d}_i, Z', d_b}^L
\end{aligned} \tag{297}$$

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

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^5 B_1(p^2, m_{d_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j, d_a, A_b^0}^{R*} \Gamma_{\tilde{d}_i, d_a, A_b^0}^R \\
& -\frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{h_a}^2) \Gamma_{\tilde{d}_j, h_a, d_b}^{R*} \Gamma_{\tilde{d}_i, h_a, d_b}^R \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_j, \tilde{u}_a, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{d}_i, \tilde{u}_a, \tilde{\chi}_b^-}^R \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^8 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{\chi}_b^0}^R \\
& -\frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{g}_1}^{R*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{g}_1}^R - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, g, d_b}^{L*} \Gamma_{\tilde{d}_i, g, d_b}^L \\
& -\sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, \gamma, d_b}^{L*} \Gamma_{\tilde{d}_i, \gamma, d_b}^L - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{W^-}^2) \Gamma_{\tilde{d}_j, W^-, u_b}^{L*} \Gamma_{\tilde{d}_i, W^-, u_b}^L \\
& -\sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_Z^2) \Gamma_{\tilde{d}_j, Z, d_b}^{L*} \Gamma_{\tilde{d}_i, Z, d_b}^L - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{Z'}^2) \Gamma_{\tilde{d}_j, Z', d_b}^{L*} \Gamma_{\tilde{d}_i, Z', d_b}^L \tag{298}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) = & -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{d}_j, H_a^-, u_b}^{L*} \Gamma_{\tilde{d}_i, H_a^-, u_b}^L \\
& -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^5 B_1(p^2, m_{d_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{d}_j, d_a, A_b^0}^{L*} \Gamma_{\tilde{d}_i, d_a, A_b^0}^L \\
& -\frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{h_a}^2) \Gamma_{\tilde{d}_j, h_a, d_b}^{L*} \Gamma_{\tilde{d}_i, h_a, d_b}^L \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{d}_j, \tilde{u}_a, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{d}_i, \tilde{u}_a, \tilde{\chi}_b^-}^L \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^8 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{\chi}_b^0}^L \\
& -\frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{d}_j, \tilde{d}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{d}_i, \tilde{d}_a, \tilde{g}_1}^L - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, g, d_b}^{R*} \Gamma_{\tilde{d}_i, g, d_b}^R \\
& -\sum_{b=1}^3 B_1(p^2, m_{d_b}^2, 0) \Gamma_{\tilde{d}_j, \gamma, d_b}^{R*} \Gamma_{\tilde{d}_i, \gamma, d_b}^R - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{W^-}^2) \Gamma_{\tilde{d}_j, W^-, u_b}^{R*} \Gamma_{\tilde{d}_i, W^-, u_b}^R \\
& -\sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_Z^2) \Gamma_{\tilde{d}_j, Z, d_b}^{R*} \Gamma_{\tilde{d}_i, Z, d_b}^R - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{Z'}^2) \Gamma_{\tilde{d}_j, Z', d_b}^{R*} \Gamma_{\tilde{d}_i, Z', d_b}^R \tag{299}
\end{aligned}$$

• Self-Energy for Up-Quarks (u)

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) = & + \sum_{a=1}^2 \sum_{b=1}^3 B_0(p^2, m_{d_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{u}_j, H_a^+, d_b}^{L*} m_{d_b} \Gamma_{\tilde{u}_i, H_a^+, d_b}^R \\
& + \sum_{a=1}^2 m_{\tilde{\chi}_a^-} \sum_{b=1}^6 B_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{u}_j, \tilde{\chi}_a^+, \tilde{d}_b}^{L*} \Gamma_{\tilde{u}_i, \tilde{\chi}_a^+, \tilde{d}_b}^R \\
& + \sum_{a=1}^3 m_{u_a} \sum_{b=1}^5 B_0(p^2, m_{u_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{u}_j, u_a, A_b^0}^{L*} \Gamma_{\tilde{u}_i, u_a, A_b^0}^R \\
& + \sum_{a=1}^5 \sum_{b=1}^3 B_0(p^2, m_{u_b}^2, m_{h_a}^2) \Gamma_{\tilde{u}_j, h_a, u_b}^{L*} m_{u_b} \Gamma_{\tilde{u}_i, h_a, u_b}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^8 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{\chi}_b^0}^R \\
& + \frac{4}{3} m_{\tilde{g}} \sum_{a=1}^6 B_0(p^2, m_{\tilde{g}}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{g}_1}^R - \frac{16}{3} \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, 0) \right) \Gamma_{\tilde{u}_j, g, u_b}^{R*} m_{u_b} \Gamma_{\tilde{u}_i, g, u_b}^L \\
& - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, 0) \right) \Gamma_{\tilde{u}_j, \gamma, u_b}^{R*} m_{u_b} \Gamma_{\tilde{u}_i, \gamma, u_b}^L - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, m_Z^2) \right) \Gamma_{\tilde{u}_j, Z, u_b}^{R*} m_{u_b} \Gamma_{\tilde{u}_i, Z, u_b}^L \\
& - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{u_b}^2, m_{Z'}^2) \right) \Gamma_{\tilde{u}_j, Z', u_b}^{R*} m_{u_b} \Gamma_{\tilde{u}_i, Z', u_b}^L \\
& - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{d_b}^2, m_{W^-}^2) \right) \Gamma_{\tilde{u}_j, W^+, d_b}^{R*} m_{d_b} \Gamma_{\tilde{u}_i, W^+, d_b}^L \tag{300}
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) = & -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{u}_j, H_a^+, d_b}^{R*} \Gamma_{\tilde{u}_i, H_a^+, d_b}^R \\
& - \frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^6 B_1(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{d}_b}^2) \Gamma_{\tilde{u}_j, \tilde{\chi}_a^+, \tilde{d}_b}^{R*} \Gamma_{\tilde{u}_i, \tilde{\chi}_a^+, \tilde{d}_b}^R \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^5 B_1(p^2, m_{u_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{u}_j, u_a, A_b^0}^{R*} \Gamma_{\tilde{u}_i, u_a, A_b^0}^R \\
& - \frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{h_a}^2) \Gamma_{\tilde{u}_j, h_a, u_b}^{R*} \Gamma_{\tilde{u}_i, h_a, u_b}^R \\
& - \frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^8 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{\chi}_b^0}^R \\
& - \frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{g}_1}^{R*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{g}_1}^R - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, g, u_b}^{L*} \Gamma_{\tilde{u}_i, g, u_b}^L
\end{aligned}$$

$$\begin{aligned}
& - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, \gamma, u_b}^{L*} \Gamma_{\tilde{u}_i, \gamma, u_b}^L - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_Z^2) \Gamma_{\tilde{u}_j, Z, u_b}^{L*} \Gamma_{\tilde{u}_i, Z, u_b}^L \\
& - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{Z'}^2) \Gamma_{\tilde{u}_j, Z', u_b}^{L*} \Gamma_{\tilde{u}_i, Z', u_b}^L - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{W^-}^2) \Gamma_{\tilde{u}_j, W^+, d_b}^{L*} \Gamma_{\tilde{u}_i, W^+, d_b}^L
\end{aligned} \tag{301}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) = & -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{H_a^-}^2) \Gamma_{\tilde{u}_j, H_a^+, d_b}^{L*} \Gamma_{\tilde{u}_i, H_a^+, d_b}^L \\
& - \frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^6 B_1(p^2, m_{\tilde{\chi}_a^-}^2, m_{d_b}^2) \Gamma_{\tilde{u}_j, \tilde{\chi}_a^+, \tilde{d}_b}^{L*} \Gamma_{\tilde{u}_i, \tilde{\chi}_a^+, \tilde{d}_b}^L \\
& - \frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^5 B_1(p^2, m_{u_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{u}_j, u_a, A_b^0}^{L*} \Gamma_{\tilde{u}_i, u_a, A_b^0}^L \\
& - \frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{h_a}^2) \Gamma_{\tilde{u}_j, h_a, u_b}^{L*} \Gamma_{\tilde{u}_i, h_a, u_b}^L \\
& - \frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^8 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{\chi}_b^0}^L \\
& - \frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{u}_j, \tilde{u}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{u}_i, \tilde{u}_a, \tilde{g}_1}^L - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, g, u_b}^{R*} \Gamma_{\tilde{u}_i, g, u_b}^R \\
& - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, 0) \Gamma_{\tilde{u}_j, \gamma, u_b}^{R*} \Gamma_{\tilde{u}_i, \gamma, u_b}^R - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_Z^2) \Gamma_{\tilde{u}_j, Z, u_b}^{R*} \Gamma_{\tilde{u}_i, Z, u_b}^R \\
& - \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{Z'}^2) \Gamma_{\tilde{u}_j, Z', u_b}^{R*} \Gamma_{\tilde{u}_i, Z', u_b}^R - \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{W^-}^2) \Gamma_{\tilde{u}_j, W^+, d_b}^{R*} \Gamma_{\tilde{u}_i, W^+, d_b}^R
\end{aligned} \tag{302}$$

• **Self-Energy for Exotics** (x)

$$\begin{aligned}
\Sigma_{i,j}^S(p^2) = & + \sum_{a=1}^3 m_{x_a} \sum_{b=1}^5 B_0(p^2, m_{x_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{x}_j, x_a, A_b^0}^{L*} \Gamma_{\tilde{x}_i, x_a, A_b^0}^R \\
& + \sum_{a=1}^5 \sum_{b=1}^3 B_0(p^2, m_{x_b}^2, m_{h_a}^2) \Gamma_{\tilde{x}_j, h_a, x_b}^{L*} m_{x_b} \Gamma_{\tilde{x}_i, h_a, x_b}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^8 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{x}_a}^2) \Gamma_{\tilde{x}_j, \tilde{x}_a, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{x}_i, \tilde{x}_a, \tilde{\chi}_b^0}^R \\
& + \frac{4}{3} m_{\tilde{g}} \sum_{a=1}^6 B_0(p^2, m_{\tilde{g}}^2, m_{\tilde{x}_a}^2) \Gamma_{\tilde{x}_j, \tilde{x}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{x}_i, \tilde{x}_a, \tilde{g}_1}^R - \frac{16}{3} \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{x_b}^2, 0) \right) \Gamma_{\tilde{x}_j, g, x_b}^{R*} m_{x_b} \Gamma_{\tilde{x}_i, g, x_b}^L
\end{aligned}$$

$$\begin{aligned}
& -4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{x_b}^2, 0) \right) \Gamma_{\tilde{x}_j, \gamma, x_b}^{R*} m_{x_b} \Gamma_{\tilde{x}_i, \gamma, x_b}^L - 4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{x_b}^2, m_Z^2) \right) \Gamma_{\tilde{x}_j, Z, x_b}^{R*} m_{x_b} \Gamma_{\tilde{x}_i, Z, x_b}^L \\
& -4 \sum_{b=1}^3 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{x_b}^2, m_{Z'}^2) \right) \Gamma_{\tilde{x}_j, Z', x_b}^{R*} m_{x_b} \Gamma_{\tilde{x}_i, Z', x_b}^L
\end{aligned} \tag{303}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) &= -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^5 B_1(p^2, m_{x_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{x}_j, x_a, A_b^0}^{R*} \Gamma_{\tilde{x}_i, x_a, A_b^0}^R \\
& -\frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^3 B_1(p^2, m_{x_b}^2, m_{h_a}^2) \Gamma_{\tilde{x}_j, h_a, x_b}^{R*} \Gamma_{\tilde{x}_i, h_a, x_b}^R \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^8 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{x}_a}^2) \Gamma_{\tilde{x}_j, \tilde{x}_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{x}_i, \tilde{x}_a, \tilde{\chi}_b^0}^R \\
& -\frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{x}_a}^2) \Gamma_{\tilde{x}_j, \tilde{x}_a, \tilde{g}_1}^{R*} \Gamma_{\tilde{x}_i, \tilde{x}_a, \tilde{g}_1}^R - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{x_b}^2, 0) \Gamma_{\tilde{x}_j, g, x_b}^{L*} \Gamma_{\tilde{x}_i, g, x_b}^L \\
& -\sum_{b=1}^3 B_1(p^2, m_{x_b}^2, 0) \Gamma_{\tilde{x}_j, \gamma, x_b}^{L*} \Gamma_{\tilde{x}_i, \gamma, x_b}^L - \sum_{b=1}^3 B_1(p^2, m_{x_b}^2, m_Z^2) \Gamma_{\tilde{x}_j, Z, x_b}^{L*} \Gamma_{\tilde{x}_i, Z, x_b}^L \\
& -\sum_{b=1}^3 B_1(p^2, m_{x_b}^2, m_{Z'}^2) \Gamma_{\tilde{x}_j, Z', x_b}^{L*} \Gamma_{\tilde{x}_i, Z', x_b}^L
\end{aligned} \tag{304}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) &= -\frac{1}{2} \sum_{a=1}^3 \sum_{b=1}^5 B_1(p^2, m_{x_a}^2, m_{A_b^0}^2) \Gamma_{\tilde{x}_j, x_a, A_b^0}^{L*} \Gamma_{\tilde{x}_i, x_a, A_b^0}^L \\
& -\frac{1}{2} \sum_{a=1}^5 \sum_{b=1}^3 B_1(p^2, m_{x_b}^2, m_{h_a}^2) \Gamma_{\tilde{x}_j, h_a, x_b}^{L*} \Gamma_{\tilde{x}_i, h_a, x_b}^L \\
& -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^8 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{\tilde{x}_a}^2) \Gamma_{\tilde{x}_j, \tilde{x}_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{x}_i, \tilde{x}_a, \tilde{\chi}_b^0}^L \\
& -\frac{2}{3} \sum_{a=1}^6 B_1(p^2, m_{\tilde{g}}^2, m_{\tilde{x}_a}^2) \Gamma_{\tilde{x}_j, \tilde{x}_a, \tilde{g}_1}^{L*} \Gamma_{\tilde{x}_i, \tilde{x}_a, \tilde{g}_1}^L - \frac{4}{3} \sum_{b=1}^3 B_1(p^2, m_{x_b}^2, 0) \Gamma_{\tilde{x}_j, g, x_b}^{R*} \Gamma_{\tilde{x}_i, g, x_b}^R \\
& -\sum_{b=1}^3 B_1(p^2, m_{x_b}^2, 0) \Gamma_{\tilde{x}_j, \gamma, x_b}^{R*} \Gamma_{\tilde{x}_i, \gamma, x_b}^R - \sum_{b=1}^3 B_1(p^2, m_{x_b}^2, m_Z^2) \Gamma_{\tilde{x}_j, Z, x_b}^{R*} \Gamma_{\tilde{x}_i, Z, x_b}^R \\
& -\sum_{b=1}^3 B_1(p^2, m_{x_b}^2, m_{Z'}^2) \Gamma_{\tilde{x}_j, Z', x_b}^{R*} \Gamma_{\tilde{x}_i, Z', x_b}^R
\end{aligned} \tag{305}$$

• **Self-Energy for Neutral Prime-Higgs (H'^0)**

$$\Pi_{i,j}(p^2) = +4\Gamma_{\tilde{H}'^0, \tilde{H}'^0, *, W^+, W^-} \left(-\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2\Gamma_{\tilde{H}'^0, \tilde{H}'^0, *, Z, Z} \left(-\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right)$$

$$\begin{aligned}
& + 2\Gamma_{\check{H}'_i, \check{H}'_j, *, Z', Z'} \left(-\frac{1}{2} \text{rMS} m_{Z'}^2 + A_0(m_{Z'}^2) \right) - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\check{H}'_i, \check{H}'_j, *, H_a^+, H_a^-} \\
& - \sum_{a=1}^2 A_0(m_{H_a'^0}^2) \Gamma_{\check{H}'_i, \check{H}'_j, *, H_a'^0, H_a'^0} - \sum_{a=1}^2 A_0(m_{H_a'^-}^2) \Gamma_{\check{H}'_i, \check{H}'_j, *, H_a'^+, H_a'^-} \\
& + \sum_{a=1}^2 \sum_{b=1}^2 B_0(p^2, m_{H_a^-}^2, m_{H_b'^-}^2) \Gamma_{\check{H}'_j, *, H_a^+, H_b'^-}^* \Gamma_{\check{H}'_i, *, H_a^+, H_b'^-} \\
& + \sum_{a=1}^2 \sum_{b=1}^5 B_0(p^2, m_{H_a'^0}^2, m_{H_b}^2) \Gamma_{\check{H}'_j, *, H_a'^0, H_b}^* \Gamma_{\check{H}'_i, *, H_a'^0, H_b} \\
& - \sum_{a=1}^2 m_{\tilde{\chi}'_a} \sum_{b=1}^8 B_0(p^2, m_{\tilde{\chi}'_a}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_b^0} \left(\Gamma_{\check{H}'_j, *, \tilde{\chi}'_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\check{H}'_i, *, \tilde{\chi}_a, \tilde{\chi}_b^0}^R + \Gamma_{\check{H}'_j, *, \tilde{\chi}'_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\check{H}'_i, *, \tilde{\chi}_a, \tilde{\chi}_b^0}^L \right) \\
& + \frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^8 G_0(p^2, m_{\tilde{\chi}'_a}^2, m_{\tilde{\chi}_b^0}^2) \left(\Gamma_{\check{H}'_j, *, \tilde{\chi}'_a, \tilde{\chi}_b^0}^{L*} \Gamma_{\check{H}'_i, *, \tilde{\chi}_a, \tilde{\chi}_b^0}^L + \Gamma_{\check{H}'_j, *, \tilde{\chi}'_a, \tilde{\chi}_b^0}^{R*} \Gamma_{\check{H}'_i, *, \tilde{\chi}_a, \tilde{\chi}_b^0}^R \right) \\
& - 2m_{\tilde{\chi}'-} \sum_{a=1}^2 B_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{\chi}'-}^2) m_{\tilde{\chi}_a^-} \left(\Gamma_{\check{H}'_j, *, \tilde{\chi}_a^+, \text{ChAP}(\{1\})}^{L*} \Gamma_{\check{H}'_i, *, \tilde{\chi}_a^+, \text{ChAP}(\{1\})}^R + \Gamma_{\check{H}'_j, *, \tilde{\chi}_a^+, \text{ChAP}(\{1\})}^{R*} \Gamma_{\check{H}'_i, *, \tilde{\chi}_a^+, \text{ChAP}(\{1\})}^L \right) \\
& + \sum_{a=1}^2 G_0(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{\chi}'-}^2) \left(\Gamma_{\check{H}'_j, *, \tilde{\chi}_a^+, \text{ChAP}(\{1\})}^{L*} \Gamma_{\check{H}'_i, *, \tilde{\chi}_a^+, \text{ChAP}(\{1\})}^L + \Gamma_{\check{H}'_j, *, \tilde{\chi}_a^+, \text{ChAP}(\{1\})}^{R*} \Gamma_{\check{H}'_i, *, \tilde{\chi}_a^+, \text{ChAP}(\{1\})}^R \right) \\
& - \sum_{a=1}^3 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\check{H}'_i, \check{H}'_j, *, \tilde{\nu}_a^*, \tilde{\nu}_a} - \frac{1}{2} \sum_{a=1}^5 A_0(m_{A_a^0}^2) \Gamma_{\check{H}'_i, \check{H}'_j, *, A_a^0, A_a^0} \\
& - \frac{1}{2} \sum_{a=1}^5 A_0(m_{H_a}^2) \Gamma_{\check{H}'_i, \check{H}'_j, *, H_a, H_a} - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\check{H}'_i, \check{H}'_j, *, \tilde{d}_a^*, \tilde{d}_a} \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{x}_a}^2) \Gamma_{\check{H}'_i, \check{H}'_j, *, \tilde{x}_a^*, \tilde{x}_a} - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\check{H}'_i, \check{H}'_j, *, \tilde{e}_a^*, \tilde{e}_a} \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\check{H}'_i, \check{H}'_j, *, \tilde{u}_a^*, \tilde{u}_a} + \sum_{b=1}^2 \Gamma_{\check{H}'_j, *, Z, H_b'^0}^* \Gamma_{\check{H}'_i, *, Z, H_b'^0} F_0(p^2, m_{H_b'^0}^2, m_Z^2) \\
& + \sum_{b=1}^2 \Gamma_{\check{H}'_j, *, Z', H_b'^0}^* \Gamma_{\check{H}'_i, *, Z', H_b'^0} F_0(p^2, m_{H_b'^0}^2, m_{Z'}^2) + \sum_{b=1}^2 \Gamma_{\check{H}'_j, *, W^+, H_b'^-}^* \Gamma_{\check{H}'_i, *, W^+, H_b'^-} F_0(p^2, m_{H_b'^-}^2, m_{W^-}^2)
\end{aligned} \tag{306}$$

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

$$\Pi_{i,j}(p^2) = +4\Gamma_{\check{H}'_i^-, \check{H}'_j^+, W^+, W^-} \left(-\frac{1}{2} \text{rMS} m_{W^-}^2 + A_0(m_{W^-}^2) \right) + 2\Gamma_{\check{H}'_i^-, \check{H}'_j^+, Z, Z} \left(-\frac{1}{2} \text{rMS} m_Z^2 + A_0(m_Z^2) \right)$$

$$\begin{aligned}
& + 2\Gamma_{\check{H}_i^-, \check{H}_j^+, Z', Z'} \left(-\frac{1}{2} \text{rMS} m_{Z'}^2 + A_0(m_{Z'}^2) \right) - \sum_{a=1}^2 A_0(m_{H_a^-}^2) \Gamma_{\check{H}_i^-, \check{H}_j^+, H_a^+, H_a^-} \\
& - \sum_{a=1}^2 A_0(m_{H_a'^0}^2) \Gamma_{\check{H}_i^-, \check{H}_j^+, H_a'^0, * , H_a'^0} - \sum_{a=1}^2 A_0(m_{H_a'^-}^2) \Gamma_{\check{H}_i^-, \check{H}_j^+, H_a'^+, H_a'^-} \\
& + \sum_{a=1}^2 \sum_{b=1}^2 B_0(p^2, m_{H_a'^0}^2, m_{H_b^-}^2) \Gamma_{\check{H}_j^+, H_a'^0, H_b^-}^* \Gamma_{\check{H}_i^+, H_a'^0, H_b^-} \\
& - 2 \sum_{a=1}^2 m_{\check{\chi}_a'^0} \sum_{b=1}^2 B_0(p^2, m_{\check{\chi}_a'^0}^2, m_{\check{\chi}_b^-}^2) m_{\check{\chi}_b^-} \left(\Gamma_{\check{H}_j^+, \check{\chi}_a'^0, \check{\chi}_b^-}^{L*} \Gamma_{\check{H}_i^+, \check{\chi}_a'^0, \check{\chi}_b^-}^R + \Gamma_{\check{H}_j^+, \check{\chi}_a'^0, \check{\chi}_b^-}^{R*} \Gamma_{\check{H}_i^+, \check{\chi}_a'^0, \check{\chi}_b^-}^L \right) \\
& + \sum_{a=1}^2 \sum_{b=1}^2 G_0(p^2, m_{\check{\chi}_a'^0}^2, m_{\check{\chi}_b^-}^2) \left(\Gamma_{\check{H}_j^+, \check{\chi}_a'^0, \check{\chi}_b^-}^{L*} \Gamma_{\check{H}_i^+, \check{\chi}_a'^0, \check{\chi}_b^-}^L + \Gamma_{\check{H}_j^+, \check{\chi}_a'^0, \check{\chi}_b^-}^{R*} \Gamma_{\check{H}_i^+, \check{\chi}_a'^0, \check{\chi}_b^-}^R \right) \\
& + \sum_{a=1}^2 \sum_{b=1}^5 B_0(p^2, m_{H_a'^-}^2, m_{h_b}^2) \Gamma_{\check{H}_j^+, H_a'^-, h_b}^* \Gamma_{\check{H}_i^+, H_a'^-, h_b} - \sum_{a=1}^3 A_0(m_{\tilde{\nu}_a}^2) \Gamma_{\check{H}_i^-, \check{H}_j^+, \tilde{\nu}_a^*, \tilde{\nu}_a} \\
& - \frac{1}{2} \sum_{a=1}^5 A_0(m_{A_a^0}^2) \Gamma_{\check{H}_i^-, \check{H}_j^+, A_a^0, A_a^0} - \frac{1}{2} \sum_{a=1}^5 A_0(m_{h_a}^2) \Gamma_{\check{H}_i^-, \check{H}_j^+, h_a, h_a} \\
& - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\check{H}_i^-, \check{H}_j^+, \tilde{d}_a^*, \tilde{d}_a} - 3 \sum_{a=1}^6 A_0(m_{\tilde{x}_a}^2) \Gamma_{\check{H}_i^-, \check{H}_j^+, \tilde{x}_a^*, \tilde{x}_a} \\
& - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\check{H}_i^-, \check{H}_j^+, \tilde{e}_a^*, \tilde{e}_a} - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\check{H}_i^-, \check{H}_j^+, \tilde{u}_a^*, \tilde{u}_a} \\
& - 2m_{\check{\chi}'^-} \sum_{a=1}^8 B_0(p^2, m_{\check{\chi}_a'^0}^2, m_{\check{\chi}'^-}^2) m_{\check{\chi}_a'^0} \left(\Gamma_{\check{H}_j^+, \check{\chi}_a'^0, \text{ChaP}(\{1\})}^{L*} \Gamma_{\check{H}_i^+, \check{\chi}_a'^0, \text{ChaP}(\{1\})}^R + \Gamma_{\check{H}_j^+, \check{\chi}_a'^0, \text{ChaP}(\{1\})}^{R*} \Gamma_{\check{H}_i^+, \check{\chi}_a'^0, \text{ChaP}(\{1\})}^L \right) \\
& + \sum_{a=1}^8 G_0(p^2, m_{\check{\chi}_a'^0}^2, m_{\check{\chi}'^-}^2) \left(\Gamma_{\check{H}_j^+, \check{\chi}_a'^0, \text{ChaP}(\{1\})}^{L*} \Gamma_{\check{H}_i^+, \check{\chi}_a'^0, \text{ChaP}(\{1\})}^L + \Gamma_{\check{H}_j^+, \check{\chi}_a'^0, \text{ChaP}(\{1\})}^{R*} \Gamma_{\check{H}_i^+, \check{\chi}_a'^0, \text{ChaP}(\{1\})}^R \right) \\
& + \sum_{b=1}^2 \Gamma_{\check{H}_j^+, W^-, H_b'^0}^* \Gamma_{\check{H}_i^+, W^-, H_b'^0} F_0(p^2, m_{H_b'^0}^2, m_{W^-}^2) + \sum_{b=1}^2 \Gamma_{\check{H}_j^+, \gamma, H_b'^-}^* \Gamma_{\check{H}_i^+, \gamma, H_b'^-} F_0(p^2, m_{H_b'^-}^2, 0) \\
& + \sum_{b=1}^2 \Gamma_{\check{H}_j^+, Z, H_b'^-}^* \Gamma_{\check{H}_i^+, Z, H_b'^-} F_0(p^2, m_{H_b'^-}^2, m_Z^2) + \sum_{b=1}^2 \Gamma_{\check{H}_j^+, Z', H_b'^-}^* \Gamma_{\check{H}_i^+, Z', H_b'^-} F_0(p^2, m_{H_b'^-}^2, m_{Z'}^2)
\end{aligned} \tag{307}$$

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

$$\Sigma_{i,j}^S(p^2) = +2 \sum_{a=1}^2 \sum_{b=1}^2 B_0(p^2, m_{\check{\chi}_b'^0}^2, m_{H_a'^-}^2) \Gamma_{\check{\chi}_j'^0, H_a'^+, \check{\chi}_b^-}^{L*} m_{\check{\chi}_b^-} \Gamma_{\check{\chi}_i'^0, H_a'^+, \check{\chi}_b^-}^R$$

$$\begin{aligned}
& + 2 \sum_{a=1}^2 \sum_{b=1}^8 B_0 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{H_a'^0}^2 \right) \Gamma_{\tilde{\chi}_j^0, H_a'^0, *, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^0, H_a'^0, *, \tilde{\chi}_b^0}^R \\
& - 4 \sum_{b=1}^2 \left(-\frac{1}{2} \text{rMS} + B_0 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_Z^2 \right) \right) \Gamma_{\tilde{\chi}_j^0, Z, \tilde{\chi}_b^0}^{R*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^0, Z, \tilde{\chi}_b^0}^L \\
& - 4 \sum_{b=1}^2 \left(-\frac{1}{2} \text{rMS} + B_0 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{Z'}^2 \right) \right) \Gamma_{\tilde{\chi}_j^0, Z', \tilde{\chi}_b^0}^{R*} m_{\tilde{\chi}_b^0} \Gamma_{\tilde{\chi}_i^0, Z', \tilde{\chi}_b^0}^L \\
& - 8 \left(-\frac{1}{2} \text{rMS} + B_0 \left(p^2, m_{\tilde{\chi}^0}^2, m_{W^-}^2 \right) \right) \Gamma_{\tilde{\chi}_j^0, W^+, \text{ChaP}(\{1\})}^{R*} m_{\tilde{\chi}^0} \Gamma_{\tilde{\chi}_i^0, W^+, \text{ChaP}(\{1\})}^L \quad (308)
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^R(p^2) &= - \sum_{a=1}^2 \sum_{b=1}^2 B_1 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{H_a'^-}^2 \right) \Gamma_{\tilde{\chi}_j^0, H_a'^-, \tilde{\chi}_b^-}^{R*} \Gamma_{\tilde{\chi}_i^0, H_a'^-, \tilde{\chi}_b^-}^R \\
& - \sum_{a=1}^2 \sum_{b=1}^8 B_1 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{H_a'^0}^2 \right) \Gamma_{\tilde{\chi}_j^0, H_a'^0, *, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, H_a'^0, *, \tilde{\chi}_b^0}^R \\
& - \sum_{b=1}^2 B_1 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_Z^2 \right) \Gamma_{\tilde{\chi}_j^0, Z, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, Z, \tilde{\chi}_b^0}^L - \sum_{b=1}^2 B_1 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{Z'}^2 \right) \Gamma_{\tilde{\chi}_j^0, Z', \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, Z', \tilde{\chi}_b^0}^L \\
& - 2 B_1 \left(p^2, m_{\tilde{\chi}^0}^2, m_{W^-}^2 \right) \Gamma_{\tilde{\chi}_j^0, W^+, \text{ChaP}(\{1\})}^{L*} \Gamma_{\tilde{\chi}_i^0, W^+, \text{ChaP}(\{1\})}^L \quad (309)
\end{aligned}$$

$$\begin{aligned}
\Sigma_{i,j}^L(p^2) &= - \sum_{a=1}^2 \sum_{b=1}^2 B_1 \left(p^2, m_{\tilde{\chi}_b^-}^2, m_{H_a'^-}^2 \right) \Gamma_{\tilde{\chi}_j^0, H_a'^-, \tilde{\chi}_b^-}^{L*} \Gamma_{\tilde{\chi}_i^0, H_a'^-, \tilde{\chi}_b^-}^L \\
& - \sum_{a=1}^2 \sum_{b=1}^8 B_1 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{H_a'^0}^2 \right) \Gamma_{\tilde{\chi}_j^0, H_a'^0, *, \tilde{\chi}_b^0}^{L*} \Gamma_{\tilde{\chi}_i^0, H_a'^0, *, \tilde{\chi}_b^0}^L \\
& - \sum_{b=1}^2 B_1 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_Z^2 \right) \Gamma_{\tilde{\chi}_j^0, Z, \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, Z, \tilde{\chi}_b^0}^R - \sum_{b=1}^2 B_1 \left(p^2, m_{\tilde{\chi}_b^0}^2, m_{Z'}^2 \right) \Gamma_{\tilde{\chi}_j^0, Z', \tilde{\chi}_b^0}^{R*} \Gamma_{\tilde{\chi}_i^0, Z', \tilde{\chi}_b^0}^R \\
& - 2 B_1 \left(p^2, m_{\tilde{\chi}^0}^2, m_{W^-}^2 \right) \Gamma_{\tilde{\chi}_j^0, W^+, \text{ChaP}(\{1\})}^{R*} \Gamma_{\tilde{\chi}_i^0, W^+, \text{ChaP}(\{1\})}^R \quad (310)
\end{aligned}$$

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

$$\begin{aligned}
\Sigma^S(p^2) &= + \sum_{a=1}^6 \sum_{b=1}^3 B_0 \left(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2 \right) \Gamma_{\tilde{g}_j, \tilde{d}_a^*, d_b}^{L*} m_{d_b} \Gamma_{\tilde{g}_i, \tilde{d}_a^*, d_b}^R \\
& + \sum_{a=1}^6 \sum_{b=1}^3 B_0 \left(p^2, m_{x_b}^2, m_{\tilde{x}_a}^2 \right) \Gamma_{\tilde{g}_j, \tilde{x}_a^*, x_b}^{L*} m_{x_b} \Gamma_{\tilde{g}_i, \tilde{x}_a^*, x_b}^R
\end{aligned}$$

$$+ \sum_{a=1}^6 \sum_{b=1}^3 B_0(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{g}_j, \tilde{u}_a^*, u_b}^{L*} m_{u_b} \Gamma_{\tilde{g}_i, \tilde{u}_a^*, u_b}^R - 12 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{g}}^2, 0) \right) \Gamma_{\tilde{g}_j, g, \tilde{g}_1}^{R*} m_{\tilde{g}} \Gamma_{\tilde{g}_i, g, \tilde{g}_1}^L \quad (311)$$

$$\begin{aligned} \Sigma^R(p^2) = & -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{g}_j, \tilde{d}_a^*, d_b}^{R*} \Gamma_{\tilde{g}_i, \tilde{d}_a^*, d_b}^R \\ & -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{x_b}^2, m_{\tilde{x}_a}^2) \Gamma_{\tilde{g}_j, \tilde{x}_a^*, x_b}^{R*} \Gamma_{\tilde{g}_i, \tilde{x}_a^*, x_b}^R \\ & -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{g}_j, \tilde{u}_a^*, u_b}^{R*} \Gamma_{\tilde{g}_i, \tilde{u}_a^*, u_b}^R - 3B_1(p^2, m_{\tilde{g}}^2, 0) \Gamma_{\tilde{g}_j, g, \tilde{g}_1}^{L*} \Gamma_{\tilde{g}_i, g, \tilde{g}_1}^L \end{aligned} \quad (312)$$

$$\begin{aligned} \Sigma^L(p^2) = & -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{d_b}^2, m_{\tilde{d}_a}^2) \Gamma_{\tilde{g}_j, \tilde{d}_a^*, d_b}^{L*} \Gamma_{\tilde{g}_i, \tilde{d}_a^*, d_b}^L \\ & -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{x_b}^2, m_{\tilde{x}_a}^2) \Gamma_{\tilde{g}_j, \tilde{x}_a^*, x_b}^{L*} \Gamma_{\tilde{g}_i, \tilde{x}_a^*, x_b}^L \\ & -\frac{1}{2} \sum_{a=1}^6 \sum_{b=1}^3 B_1(p^2, m_{u_b}^2, m_{\tilde{u}_a}^2) \Gamma_{\tilde{g}_j, \tilde{u}_a^*, u_b}^{L*} \Gamma_{\tilde{g}_i, \tilde{u}_a^*, u_b}^L - 3B_1(p^2, m_{\tilde{g}}^2, 0) \Gamma_{\tilde{g}_j, g, \tilde{g}_1}^{R*} \Gamma_{\tilde{g}_i, g, \tilde{g}_1}^R \end{aligned} \quad (313)$$

• **Self-Energy for Prime Chargino** ($\tilde{\chi}^{\prime -}$)

$$\begin{aligned} \Sigma^S(p^2) = & + \sum_{a=1}^2 \sum_{b=1}^2 B_0(p^2, m_{\tilde{\chi}_b^-}^2, m_{H_a'^0}^2) \Gamma_{\text{ChaP}(\{\text{gO2}\}), H_a'^0, \tilde{\chi}_b^-}^{L*} m_{\tilde{\chi}_b^-} \Gamma_{\text{ChaP}(\{\text{gO1}\}), H_a'^0, \tilde{\chi}_b^-}^R \\ & + \sum_{a=1}^2 \sum_{b=1}^8 B_0(p^2, m_{\tilde{\chi}_b^0}^2, m_{H_a'^-}^2) \Gamma_{\text{ChaP}(\{\text{gO2}\}), H_a'^-, \tilde{\chi}_b^0}^{L*} m_{\tilde{\chi}_b^0} \Gamma_{\text{ChaP}(\{\text{gO1}\}), H_a'^-, \tilde{\chi}_b^0}^R \\ & - 4 \sum_{b=1}^2 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}_b'^0}^2, m_{W^-}^2) \right) \Gamma_{\text{ChaP}(\{\text{gO2}\}), W^-, \tilde{\chi}_b'^0}^{R*} m_{\tilde{\chi}_b'^0} \Gamma_{\text{ChaP}(\{\text{gO1}\}), W^-, \tilde{\chi}_b'^0}^L \\ & - 4 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}^{\prime -}}^2, 0) \right) \Gamma_{\text{ChaP}(\{\text{gO2}\}), \gamma, \text{ChaP}(\{1\})}^{R*} m_{\tilde{\chi}^{\prime -}} \Gamma_{\text{ChaP}(\{\text{gO1}\}), \gamma, \text{ChaP}(\{1\})}^L \\ & - 4 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}^{\prime -}}^2, m_Z^2) \right) \Gamma_{\text{ChaP}(\{\text{gO2}\}), Z, \text{ChaP}(\{1\})}^{R*} m_{\tilde{\chi}^{\prime -}} \Gamma_{\text{ChaP}(\{\text{gO1}\}), Z, \text{ChaP}(\{1\})}^L \\ & - 4 \left(-\frac{1}{2} \text{rMS} + B_0(p^2, m_{\tilde{\chi}^{\prime -}}^2, m_{Z'}^2) \right) \Gamma_{\text{ChaP}(\{\text{gO2}\}), Z', \text{ChaP}(\{1\})}^{R*} m_{\tilde{\chi}^{\prime -}} \Gamma_{\text{ChaP}(\{\text{gO1}\}), Z', \text{ChaP}(\{1\})}^L \quad (314) \\ \Sigma^R(p^2) = & -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{H_a'^0}^2) \Gamma_{\text{ChaP}(\{\text{gO2}\}), H_a'^0, \tilde{\chi}_b^-}^{R*} \Gamma_{\text{ChaP}(\{\text{gO1}\}), H_a'^0, \tilde{\chi}_b^-}^R \end{aligned}$$

$$\begin{aligned}
& -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^8 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{H_a'^-}^2) \Gamma_{\text{ChaP}(\{\text{gO2}\}), H_a'^-, \tilde{\chi}_b^0}^{R*} \Gamma_{\text{ChaP}(\{\text{gO1}\}), H_a'^-, \tilde{\chi}_b^0}^R \\
& - \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{W^-}^2) \Gamma_{\text{ChaP}(\{\text{gO2}\}), W^-, \tilde{\chi}_b^0}^{L*} \Gamma_{\text{ChaP}(\{\text{gO1}\}), W^-, \tilde{\chi}_b^0}^L - B_1(p^2, m_{\tilde{\chi}^0}^2, 0) \Gamma_{\text{ChaP}(\{\text{gO2}\}), \gamma, \text{ChaP}(\{1\})}^{L*} \Gamma_{\text{ChaP}(\{1\})}^L \\
& - B_1(p^2, m_{\tilde{\chi}^0}^2, m_Z^2) \Gamma_{\text{ChaP}(\{\text{gO2}\}), Z, \text{ChaP}(\{1\})}^{L*} \Gamma_{\text{ChaP}(\{\text{gO1}\}), Z, \text{ChaP}(\{1\})}^L - B_1(p^2, m_{\tilde{\chi}^0}^2, m_{Z'}^2) \Gamma_{\text{ChaP}(\{\text{gO2}\}), Z', \text{ChaP}(\{1\})}^{L*} \Gamma_{\text{ChaP}(\{1\})}^L
\end{aligned} \tag{315}$$

$$\begin{aligned}
\Sigma^L(p^2) &= -\frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^-}^2, m_{H_a'^-}^2) \Gamma_{\text{ChaP}(\{\text{gO2}\}), H_a'^-, \tilde{\chi}_b^-}^{L*} \Gamma_{\text{ChaP}(\{\text{gO1}\}), H_a'^-, \tilde{\chi}_b^-}^L \\
& - \frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^8 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{H_a'^-}^2) \Gamma_{\text{ChaP}(\{\text{gO2}\}), H_a'^-, \tilde{\chi}_b^0}^{L*} \Gamma_{\text{ChaP}(\{\text{gO1}\}), H_a'^-, \tilde{\chi}_b^0}^L \\
& - \sum_{b=1}^2 B_1(p^2, m_{\tilde{\chi}_b^0}^2, m_{W^-}^2) \Gamma_{\text{ChaP}(\{\text{gO2}\}), W^-, \tilde{\chi}_b^0}^{R*} \Gamma_{\text{ChaP}(\{\text{gO1}\}), W^-, \tilde{\chi}_b^0}^R - B_1(p^2, m_{\tilde{\chi}^0}^2, 0) \Gamma_{\text{ChaP}(\{\text{gO2}\}), \gamma, \text{ChaP}(\{1\})}^{R*} \Gamma_{\text{ChaP}(\{1\})}^R \\
& - B_1(p^2, m_{\tilde{\chi}^0}^2, m_Z^2) \Gamma_{\text{ChaP}(\{\text{gO2}\}), Z, \text{ChaP}(\{1\})}^{R*} \Gamma_{\text{ChaP}(\{\text{gO1}\}), Z, \text{ChaP}(\{1\})}^R - B_1(p^2, m_{\tilde{\chi}^0}^2, m_{Z'}^2) \Gamma_{\text{ChaP}(\{\text{gO2}\}), Z', \text{ChaP}(\{1\})}^{R*} \Gamma_{\text{ChaP}(\{1\})}^R
\end{aligned} \tag{316}$$

• **Self-Energy for Z-Boson** (Z)

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

$$\begin{aligned}
& + \sum_{a=1}^2 \sum_{b=1}^2 \left[\left(|\Gamma_{Z, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^L|^2 + |\Gamma_{Z, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^R|^2 \right) H_0 \left(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{\chi}_b^-}^2 \right) \right. \\
& + 4B_0 \left(p^2, m_{\tilde{\chi}_a^-}^2, m_{\tilde{\chi}_b^-}^2 \right) m_{\tilde{\chi}_a^-} m_{\tilde{\chi}_b^-} \Re \left(\Gamma_{Z, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^{L*} \Gamma_{Z, \tilde{\chi}_a^+, \tilde{\chi}_b^-}^R \right) \left. \right] \\
& + \frac{1}{2} \sum_{a=1}^2 \sum_{b=1}^2 \left[\left(|\Gamma_{Z, \tilde{\chi}'_0, \tilde{\chi}'_0}^L|^2 + |\Gamma_{Z, \tilde{\chi}'_0, \tilde{\chi}'_0}^R|^2 \right) H_0 \left(p^2, m_{\tilde{\chi}'_0}^2, m_{\tilde{\chi}'_0}^2 \right) \right. \\
& + 4B_0 \left(p^2, m_{\tilde{\chi}'_0}^2, m_{\tilde{\chi}'_0}^2 \right) m_{\tilde{\chi}'_0} m_{\tilde{\chi}'_0} \Re \left(\Gamma_{Z, \tilde{\chi}'_0, \tilde{\chi}'_0}^{L*} \Gamma_{Z, \tilde{\chi}'_0, \tilde{\chi}'_0}^R \right) \left. \right] \\
& + \sum_{a=1}^3 A_0 \left(m_{\tilde{\nu}_a}^2 \right) \Gamma_{Z, Z, \tilde{\nu}_a^*, \tilde{\nu}_a} - 4 \sum_{a=1}^3 \sum_{b=1}^3 |\Gamma_{Z, \tilde{\nu}_a^*, \tilde{\nu}_b}|^2 B_{00} \left(p^2, m_{\tilde{\nu}_a}^2, m_{\tilde{\nu}_b}^2 \right) \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 \left[\left(|\Gamma_{Z, \tilde{d}_a, d_b}^L|^2 + |\Gamma_{Z, \tilde{d}_a, d_b}^R|^2 \right) H_0 \left(p^2, m_{d_a}^2, m_{d_b}^2 \right) \right. \\
& + 4B_0 \left(p^2, m_{d_a}^2, m_{d_b}^2 \right) m_{d_a} m_{d_b} \Re \left(\Gamma_{Z, \tilde{d}_a, d_b}^{L*} \Gamma_{Z, \tilde{d}_a, d_b}^R \right) \left. \right] \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 \left[\left(|\Gamma_{Z, \tilde{x}_a, x_b}^L|^2 + |\Gamma_{Z, \tilde{x}_a, x_b}^R|^2 \right) H_0 \left(p^2, m_{x_a}^2, m_{x_b}^2 \right) \right. \\
& + 4B_0 \left(p^2, m_{x_a}^2, m_{x_b}^2 \right) m_{x_a} m_{x_b} \Re \left(\Gamma_{Z, \tilde{x}_a, x_b}^{L*} \Gamma_{Z, \tilde{x}_a, x_b}^R \right) \left. \right] \\
& + \sum_{a=1}^3 \sum_{b=1}^3 \left[\left(|\Gamma_{Z, \tilde{e}_a, e_b}^L|^2 + |\Gamma_{Z, \tilde{e}_a, e_b}^R|^2 \right) H_0 \left(p^2, m_{e_a}^2, m_{e_b}^2 \right) \right. \\
& + 4B_0 \left(p^2, m_{e_a}^2, m_{e_b}^2 \right) m_{e_a} m_{e_b} \Re \left(\Gamma_{Z, \tilde{e}_a, e_b}^{L*} \Gamma_{Z, \tilde{e}_a, e_b}^R \right) \left. \right] \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 \left[\left(|\Gamma_{Z, \tilde{u}_a, u_b}^L|^2 + |\Gamma_{Z, \tilde{u}_a, u_b}^R|^2 \right) H_0 \left(p^2, m_{u_a}^2, m_{u_b}^2 \right) \right. \\
& + 4B_0 \left(p^2, m_{u_a}^2, m_{u_b}^2 \right) m_{u_a} m_{u_b} \Re \left(\Gamma_{Z, \tilde{u}_a, u_b}^{L*} \Gamma_{Z, \tilde{u}_a, u_b}^R \right) \left. \right] \\
& + \sum_{a=1}^3 \sum_{b=1}^3 \left[\left(|\Gamma_{Z, \tilde{\nu}_a, \nu_b}^L|^2 + |\Gamma_{Z, \tilde{\nu}_a, \nu_b}^R|^2 \right) H_0 \left(p^2, m_{\nu_a}^2, m_{\nu_b}^2 \right) \right. \\
& + 4B_0 \left(p^2, m_{\nu_a}^2, m_{\nu_b}^2 \right) m_{\nu_a} m_{\nu_b} \Re \left(\Gamma_{Z, \tilde{\nu}_a, \nu_b}^{L*} \Gamma_{Z, \tilde{\nu}_a, \nu_b}^R \right) \left. \right] \\
& + \frac{1}{2} \sum_{a=1}^5 A_0 \left(m_{A_a^0}^2 \right) \Gamma_{Z, Z, A_a^0, A_a^0} + \frac{1}{2} \sum_{a=1}^5 A_0 \left(m_{h_a}^2 \right) \Gamma_{Z, Z, h_a, h_a} \\
& - 4 \sum_{a=1}^5 \sum_{b=1}^5 |\Gamma_{Z, h_a, A_b^0}|^2 B_{00} \left(p^2, m_{A_b^0}^2, m_{h_a}^2 \right) + 3 \sum_{a=1}^6 A_0 \left(m_{\tilde{d}_a}^2 \right) \Gamma_{Z, Z, \tilde{d}_a^*, \tilde{d}_a} \\
& + 3 \sum_{a=1}^6 A_0 \left(m_{\tilde{x}_a}^2 \right) \Gamma_{Z, Z, \tilde{x}_a^*, \tilde{x}_a} + \sum_{a=1}^6 A_0 \left(m_{\tilde{e}_a}^2 \right) \Gamma_{Z, Z, \tilde{e}_a^*, \tilde{e}_a} + 3 \sum_{a=1}^6 A_0 \left(m_{\tilde{u}_a}^2 \right) \Gamma_{Z, Z, \tilde{u}_a^*, \tilde{u}_a}
\end{aligned}$$

$$\begin{aligned}
& -12 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z, \tilde{d}_a^*, \tilde{d}_b}|^2 B_{00}(p^2, m_{\tilde{d}_a}^2, m_{\tilde{d}_b}^2) - 12 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z, \tilde{x}_a^*, \tilde{x}_b}|^2 B_{00}(p^2, m_{\tilde{x}_a}^2, m_{\tilde{x}_b}^2) \\
& - 4 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z, \tilde{e}_a^*, \tilde{e}_b}|^2 B_{00}(p^2, m_{\tilde{e}_a}^2, m_{\tilde{e}_b}^2) - 12 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z, \tilde{u}_a^*, \tilde{u}_b}|^2 B_{00}(p^2, m_{\tilde{u}_a}^2, m_{\tilde{u}_b}^2) \\
& + \frac{1}{2} \sum_{a=1}^8 \sum_{b=1}^8 \left[\left(|\Gamma_{Z, \tilde{\chi}_a^0}^L|^2 + |\Gamma_{Z, \tilde{\chi}_a^0}^R|^2 \right) H_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2) \right. \\
& \left. + 4B_0(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2) m_{\tilde{\chi}_a^0} m_{\tilde{\chi}_b^0} \Re(\Gamma_{Z, \tilde{\chi}_a^0}^{L*} \Gamma_{Z, \tilde{\chi}_b^0}^R) \right] \\
& + 2 \sum_{b=1}^2 |\Gamma_{Z, W^+, H_b^-}|^2 B_0(p^2, m_{W^-}^2, m_{H_b^-}^2) + \sum_{b=1}^5 |\Gamma_{Z, Z, h_b}|^2 B_0(p^2, m_Z^2, m_{h_b}^2) \\
& + \sum_{b=1}^5 |\Gamma_{Z, Z', h_b}|^2 B_0(p^2, m_{Z'}^2, m_{h_b}^2) + 2\text{rMS} m_{W^-}^2 \Gamma_{Z, Z, W^+, W^-}^1 - A_0(m_{W^-}^2) \left(4\Gamma_{Z, Z, W^+, W^-}^1 + \Gamma_{Z, Z, W^+, W^-}^2 + \Gamma_{Z, Z, W^+, W^-}^3 \right)
\end{aligned} \tag{317}$$

• **Self-Energy for Z'-Boson** (Z')

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

$$\begin{aligned}
& + 4B_0 \left(p^2, m_{\tilde{\chi}'_0}^2, m_{\tilde{\chi}'_0}^2 \right) m_{\tilde{\chi}'_0} m_{\tilde{\chi}'_0} \Re \left(\Gamma_{Z', \tilde{\chi}'_0, \tilde{\chi}'_0}^{L*} \Gamma_{Z', \tilde{\chi}'_0, \tilde{\chi}'_0}^R \right) \\
& + \sum_{a=1}^3 A_0 \left(m_{\tilde{\nu}_a}^2 \right) \Gamma_{Z', Z', \tilde{\nu}_a^*, \tilde{\nu}_a} - 4 \sum_{a=1}^3 \sum_{b=1}^3 |\Gamma_{Z', \tilde{\nu}_a^*, \tilde{\nu}_b}|^2 B_{00} \left(p^2, m_{\tilde{\nu}_a}^2, m_{\tilde{\nu}_b}^2 \right) \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 \left[\left(|\Gamma_{Z', \tilde{d}_a, d_b}^L|^2 + |\Gamma_{Z', \tilde{d}_a, d_b}^R|^2 \right) H_0 \left(p^2, m_{\tilde{d}_a}^2, m_{d_b}^2 \right) \right. \\
& + 4B_0 \left(p^2, m_{\tilde{d}_a}^2, m_{\tilde{d}_b}^2 \right) m_{\tilde{d}_a} m_{\tilde{d}_b} \Re \left(\Gamma_{Z', \tilde{d}_a, d_b}^{L*} \Gamma_{Z', \tilde{d}_a, d_b}^R \right) \left. \right] \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 \left[\left(|\Gamma_{Z', \tilde{x}_a, x_b}^L|^2 + |\Gamma_{Z', \tilde{x}_a, x_b}^R|^2 \right) H_0 \left(p^2, m_{\tilde{x}_a}^2, m_{x_b}^2 \right) \right. \\
& + 4B_0 \left(p^2, m_{\tilde{x}_a}^2, m_{x_b}^2 \right) m_{\tilde{x}_a} m_{x_b} \Re \left(\Gamma_{Z', \tilde{x}_a, x_b}^{L*} \Gamma_{Z', \tilde{x}_a, x_b}^R \right) \left. \right] \\
& + \sum_{a=1}^3 \sum_{b=1}^3 \left[\left(|\Gamma_{Z', \tilde{e}_a, e_b}^L|^2 + |\Gamma_{Z', \tilde{e}_a, e_b}^R|^2 \right) H_0 \left(p^2, m_{\tilde{e}_a}^2, m_{e_b}^2 \right) \right. \\
& + 4B_0 \left(p^2, m_{\tilde{e}_a}^2, m_{e_b}^2 \right) m_{\tilde{e}_a} m_{e_b} \Re \left(\Gamma_{Z', \tilde{e}_a, e_b}^{L*} \Gamma_{Z', \tilde{e}_a, e_b}^R \right) \left. \right] \\
& + 3 \sum_{a=1}^3 \sum_{b=1}^3 \left[\left(|\Gamma_{Z', \tilde{u}_a, u_b}^L|^2 + |\Gamma_{Z', \tilde{u}_a, u_b}^R|^2 \right) H_0 \left(p^2, m_{\tilde{u}_a}^2, m_{u_b}^2 \right) \right. \\
& + 4B_0 \left(p^2, m_{\tilde{u}_a}^2, m_{u_b}^2 \right) m_{\tilde{u}_a} m_{u_b} \Re \left(\Gamma_{Z', \tilde{u}_a, u_b}^{L*} \Gamma_{Z', \tilde{u}_a, u_b}^R \right) \left. \right] \\
& + \sum_{a=1}^3 \sum_{b=1}^3 \left[\left(|\Gamma_{Z', \tilde{\nu}_a, \nu_b}^L|^2 + |\Gamma_{Z', \tilde{\nu}_a, \nu_b}^R|^2 \right) H_0 \left(p^2, m_{\tilde{\nu}_a}^2, m_{\nu_b}^2 \right) \right. \\
& + 4B_0 \left(p^2, m_{\tilde{\nu}_a}^2, m_{\nu_b}^2 \right) m_{\tilde{\nu}_a} m_{\nu_b} \Re \left(\Gamma_{Z', \tilde{\nu}_a, \nu_b}^{L*} \Gamma_{Z', \tilde{\nu}_a, \nu_b}^R \right) \left. \right] \\
& + \frac{1}{2} \sum_{a=1}^5 A_0 \left(m_{A_a^0}^2 \right) \Gamma_{Z', Z', A_a^0, A_a^0} + \frac{1}{2} \sum_{a=1}^5 A_0 \left(m_{h_a}^2 \right) \Gamma_{Z', Z', h_a, h_a} \\
& - 4 \sum_{a=1}^5 \sum_{b=1}^5 |\Gamma_{Z', h_a, A_b^0}|^2 B_{00} \left(p^2, m_{A_b^0}^2, m_{h_a}^2 \right) + 3 \sum_{a=1}^6 A_0 \left(m_{\tilde{d}_a}^2 \right) \Gamma_{Z', Z', \tilde{d}_a^*, \tilde{d}_a} \\
& + 3 \sum_{a=1}^6 A_0 \left(m_{\tilde{x}_a}^2 \right) \Gamma_{Z', Z', \tilde{x}_a^*, \tilde{x}_a} + \sum_{a=1}^6 A_0 \left(m_{\tilde{e}_a}^2 \right) \Gamma_{Z', Z', \tilde{e}_a^*, \tilde{e}_a} + 3 \sum_{a=1}^6 A_0 \left(m_{\tilde{u}_a}^2 \right) \Gamma_{Z', Z', \tilde{u}_a^*, \tilde{u}_a} \\
& - 12 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z', \tilde{d}_a^*, \tilde{d}_b}|^2 B_{00} \left(p^2, m_{\tilde{d}_a}^2, m_{\tilde{d}_b}^2 \right) - 12 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z', \tilde{x}_a^*, \tilde{x}_b}|^2 B_{00} \left(p^2, m_{\tilde{x}_a}^2, m_{\tilde{x}_b}^2 \right) \\
& - 4 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z', \tilde{e}_a^*, \tilde{e}_b}|^2 B_{00} \left(p^2, m_{\tilde{e}_a}^2, m_{\tilde{e}_b}^2 \right) - 12 \sum_{a=1}^6 \sum_{b=1}^6 |\Gamma_{Z', \tilde{u}_a^*, \tilde{u}_b}|^2 B_{00} \left(p^2, m_{\tilde{u}_a}^2, m_{\tilde{u}_b}^2 \right) \\
& + \frac{1}{2} \sum_{a=1}^8 \sum_{b=1}^8 \left[\left(|\Gamma_{Z', \tilde{\chi}_a^0, \tilde{\chi}_b^0}^L|^2 + |\Gamma_{Z', \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R|^2 \right) H_0 \left(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2 \right) \right.
\end{aligned}$$

$$\begin{aligned}
& + 4B_0 \left(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^0}^2 \right) m_{\tilde{\chi}_a^0} m_{\tilde{\chi}_b^0} \Re \left(\Gamma_{Z', \tilde{\chi}_a^0, \tilde{\chi}_b^0}^{L*} \Gamma_{Z', \tilde{\chi}_a^0, \tilde{\chi}_b^0}^R \right) \Big] \\
& + 2 \sum_{b=1}^2 |\Gamma_{Z', W^+, H_b^-}|^2 B_0 \left(p^2, m_{W^-}^2, m_{H_b^-}^2 \right) + \sum_{b=1}^5 |\Gamma_{Z', Z, h_b}|^2 B_0 \left(p^2, m_Z^2, m_{h_b}^2 \right) \\
& + \sum_{b=1}^5 |\Gamma_{Z', Z', h_b}|^2 B_0 \left(p^2, m_{Z'}^2, m_{h_b}^2 \right) + 2\text{rMS} m_{W^-}^2 \Gamma_{Z', Z', W^+, W^-}^1 - A_0 \left(m_{W^-}^2 \right) \left(4\Gamma_{Z', Z', W^+, W^-}^1 + \Gamma_{Z', Z', W^+, W^-}^2 + \Gamma_{Z', Z', W^+, W^-}^3 \right)
\end{aligned} \tag{318}$$

• **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} \left(p^2, m_{\tilde{d}_b}^2, m_{\tilde{u}_a}^2 \right) + 2\text{rMS} m_{W^-}^2 \Gamma_{W^-, W^+, W^+, W^-}^1 + 3 \sum_{a=1}^3 \sum_{b=1}^3 \left[\left(|\Gamma_{W^+, \tilde{u}_a, d_b}^L|^2 + |\Gamma_{W^+, \tilde{u}_a, d_b}^R|^2 \right) B_{00} \left(p^2, m_{\tilde{u}_a}^2, m_{d_b}^2 \right) \right. \\
& + 4B_0 \left(p^2, m_{\tilde{u}_a}^2, m_{d_b}^2 \right) m_{d_b} m_{\tilde{u}_a} \Re \left(\Gamma_{W^+, \tilde{u}_a, d_b}^{L*} \Gamma_{W^+, \tilde{u}_a, d_b}^R \right) \Big] + 3 \sum_{a=1}^6 A_0 \left(m_{\tilde{d}_a}^2 \right) \Gamma_{W^-, W^+, \tilde{d}_a^*, \tilde{d}_a^-} + 3 \sum_{a=1}^6 A_0 \left(m_{\tilde{u}_a}^2 \right) \Gamma_{W^-, W^+, \tilde{u}_a^*, \tilde{u}_a^-} \\
& + 4B_0 \left(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}^-}^2 \right) m_{\tilde{\chi}^-} m_{\tilde{\chi}_a^0} \Re \left(\Gamma_{W^+, \tilde{\chi}_a^0, \text{ChaP}(\{1\})}^{L*} \Gamma_{W^+, \tilde{\chi}_a^0, \text{ChaP}(\{1\})}^R \right) + \sum_{a=1}^3 A_0 \left(m_{\tilde{\nu}_a}^2 \right) \Gamma_{W^-, W^+, \tilde{\nu}_a^*, \tilde{\nu}_a^-} + \sum_{a=1}^3 \sum_{b=1}^3 \left[\left(|\Gamma_{W^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^L|^2 + |\Gamma_{W^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^R|^2 \right) B_{00} \left(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^-}^2 \right) \right. \\
& + 4B_0 \left(p^2, m_{\tilde{\nu}_a}^2, m_{e_b}^2 \right) m_{e_b} m_{\tilde{\nu}_a} \Re \left(\Gamma_{W^+, \tilde{\nu}_a, e_b}^{L*} \Gamma_{W^+, \tilde{\nu}_a, e_b}^R \right) \Big] + \sum_{a=1}^6 A_0 \left(m_{\tilde{e}_a}^2 \right) \Gamma_{W^-, W^+, \tilde{e}_a^*, \tilde{e}_a^-} + \sum_{a=1}^8 \sum_{b=1}^2 \left[\left(|\Gamma_{W^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^L|^2 + |\Gamma_{W^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^R|^2 \right) B_{00} \left(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^-}^2 \right) \right. \\
& + 4B_0 \left(p^2, m_{\tilde{\chi}_a^0}^2, m_{\tilde{\chi}_b^-}^2 \right) m_{\tilde{\chi}_b^-} m_{\tilde{\chi}_a^0} \Re \left(\Gamma_{W^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^{L*} \Gamma_{W^+, \tilde{\chi}_a^0, \tilde{\chi}_b^-}^R \right) \Big] + \sum_{b=1}^2 |\Gamma_{W^+, \gamma, H_b^-}|^2 B_0 \left(p^2, 0, m_{H_b^-}^2 \right) + \sum_{b=1}^2 |\Gamma_{W^+, Z, H_b^-}|^2 B_0 \left(p^2, 0, m_{H_b^-}^2 \right)
\end{aligned} \tag{319}$$

8.2 Tadpoles

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

$$\begin{aligned}
& + 2 \sum_{a=1}^3 A_0(m_{e_a}^2) m_{e_a} \left(\Gamma_{\tilde{h}_i, \bar{e}_a, e_a}^L + \Gamma_{\tilde{h}_i, \bar{e}_a, e_a}^R \right) \\
& + 6 \sum_{a=1}^3 A_0(m_{u_a}^2) m_{u_a} \left(\Gamma_{\tilde{h}_i, \bar{u}_a, u_a}^L + \Gamma_{\tilde{h}_i, \bar{u}_a, u_a}^R \right) - \frac{1}{2} \sum_{a=1}^5 A_0(m_{A_a^0}^2) \Gamma_{\tilde{h}_i, A_a^0, A_a^0} \\
& - \frac{1}{2} \sum_{a=1}^5 A_0(m_{h_a}^2) \Gamma_{\tilde{h}_i, h_a, h_a} - 3 \sum_{a=1}^6 A_0(m_{\tilde{d}_a}^2) \Gamma_{\tilde{h}_i, \tilde{d}_a^*, \tilde{d}_a} - 3 \sum_{a=1}^6 A_0(m_{\tilde{x}_a}^2) \Gamma_{\tilde{h}_i, \tilde{x}_a^*, \tilde{x}_a} \\
& - \sum_{a=1}^6 A_0(m_{\tilde{e}_a}^2) \Gamma_{\tilde{h}_i, \tilde{e}_a^*, \tilde{e}_a} - 3 \sum_{a=1}^6 A_0(m_{\tilde{u}_a}^2) \Gamma_{\tilde{h}_i, \tilde{u}_a^*, \tilde{u}_a} \\
& + \sum_{a=1}^8 A_0(m_{\tilde{\chi}_a^0}^2) m_{\tilde{\chi}_a^0} \left(\Gamma_{\tilde{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_a^0}^L + \Gamma_{\tilde{h}_i, \tilde{\chi}_a^0, \tilde{\chi}_a^0}^R \right)
\end{aligned} \tag{320}$$

9 Interactions for eigenstates 'EWSB'

9.1 Three Scalar-Interaction

$$\begin{aligned}
& \frac{1}{4} \left(-v\phi\sigma\lambda^* U_{A,i4} U_{A,j2} U_{A,k1} + v\phi\lambda\sigma'^* U_{A,i4} U_{A,j2} U_{A,k1} - v\sigma\lambda^* U_{A,i5} U_{A,j2} U_{A,k1} \right. \\
& + v\sigma\lambda\sigma'^* U_{A,i5} U_{A,j2} U_{A,k1} - v\phi\sigma\lambda^* U_{A,i2} U_{A,j4} U_{A,k1} + v\phi\lambda\sigma'^* U_{A,i2} U_{A,j4} U_{A,k1} \\
& + v_2\sigma\lambda^* U_{A,i5} U_{A,j4} U_{A,k1} - v_2\lambda\sigma'^* U_{A,i5} U_{A,j4} U_{A,k1} - v\sigma\lambda^* U_{A,i2} U_{A,j5} U_{A,k1} \\
& + v\sigma\lambda\sigma'^* U_{A,i2} U_{A,j5} U_{A,k1} + v_2\sigma\lambda^* U_{A,i4} U_{A,j5} U_{A,k1} - v_2\lambda\sigma'^* U_{A,i4} U_{A,j5} U_{A,k1} \\
& - v\phi\sigma\lambda^* U_{A,i4} U_{A,j1} U_{A,k2} + v\phi\lambda\sigma'^* U_{A,i4} U_{A,j1} U_{A,k2} - v\sigma\lambda^* U_{A,i5} U_{A,j1} U_{A,k2} \\
& + v\sigma\lambda\sigma'^* U_{A,i5} U_{A,j1} U_{A,k2} - v\phi\sigma\lambda^* U_{A,i1} U_{A,j4} U_{A,k2} + v\phi\lambda\sigma'^* U_{A,i1} U_{A,j4} U_{A,k2} \\
& + v_1\sigma\lambda^* U_{A,i5} U_{A,j4} U_{A,k2} - v_1\lambda\sigma'^* U_{A,i5} U_{A,j4} U_{A,k2} - v\sigma\lambda^* U_{A,i1} U_{A,j5} U_{A,k2} \\
& + v\sigma\lambda\sigma'^* U_{A,i1} U_{A,j5} U_{A,k2} + v_1\sigma\lambda^* U_{A,i4} U_{A,j5} U_{A,k2} - v_1\lambda\sigma'^* U_{A,i4} U_{A,j5} U_{A,k2} \\
& - \sqrt{2}\sigma M u_{phi}^* U_{A,i5} U_{A,j4} U_{A,k3} - 2v\phi\sigma\kappa'^* U_{A,i5} U_{A,j4} U_{A,k3} + \sqrt{2}M u_{phi}\sigma'^* U_{A,i5} U_{A,j4} U_{A,k3} \\
& + 2v\phi\kappa'\sigma'^* U_{A,i5} U_{A,j4} U_{A,k3} - \sqrt{2}T_\sigma^* U_{A,i5} U_{A,j4} U_{A,k3} + \sqrt{2}T_\sigma U_{A,i5} U_{A,j4} U_{A,k3} \\
& - \sqrt{2}\sigma M u_{phi}^* U_{A,i4} U_{A,j5} U_{A,k3} - 2v\phi\sigma\kappa'^* U_{A,i4} U_{A,j5} U_{A,k3} + \sqrt{2}M u_{phi}\sigma'^* U_{A,i4} U_{A,j5} U_{A,k3} \\
& + 2v\phi\kappa'\sigma'^* U_{A,i4} U_{A,j5} U_{A,k3} - \sqrt{2}T_\sigma^* U_{A,i4} U_{A,j5} U_{A,k3} + \sqrt{2}T_\sigma U_{A,i4} U_{A,j5} U_{A,k3}
\end{aligned}$$

$$\begin{aligned}
& + 2vsb\sigma\kappa'^*U_{A,i5}U_{A,j5}U_{A,k3} - 2vsb\kappa'\sigma'^*U_{A,i5}U_{A,j5}U_{A,k3} \\
& - \sqrt{2}T_\lambda^*(U_{A,i1}(U_{A,j2}U_{A,k3} + U_{A,j3}U_{A,k2}) + U_{A,i2}(U_{A,j1}U_{A,k3} + U_{A,j3}U_{A,k1}) + U_{A,i3}(U_{A,j1}U_{A,k2} + U_{A,j2}U_{A,k1})) \\
& + \sqrt{2}T_\lambda(U_{A,i1}(U_{A,j2}U_{A,k3} + U_{A,j3}U_{A,k2}) + U_{A,i2}(U_{A,j1}U_{A,k3} + U_{A,j3}U_{A,k1}) + U_{A,i3}(U_{A,j1}U_{A,k2} + U_{A,j2}U_{A,k1})) \\
& - vphi\sigma\lambda^*U_{A,i2}U_{A,j1}U_{A,k4} + vphi\lambda\sigma'^*U_{A,i2}U_{A,j1}U_{A,k4} + v_2\sigma\lambda^*U_{A,i5}U_{A,j1}U_{A,k4} \\
& - v_2\lambda\sigma'^*U_{A,i5}U_{A,j1}U_{A,k4} - vphi\sigma\lambda^*U_{A,i1}U_{A,j2}U_{A,k4} + vphi\lambda\sigma'^*U_{A,i1}U_{A,j2}U_{A,k4} \\
& + v_1\sigma\lambda^*U_{A,i5}U_{A,j2}U_{A,k4} - v_1\lambda\sigma'^*U_{A,i5}U_{A,j2}U_{A,k4} - \sqrt{2}\sigma Mu_{phi}^*U_{A,i5}U_{A,j3}U_{A,k4} \\
& - 2vphi\sigma\kappa'^*U_{A,i5}U_{A,j3}U_{A,k4} + \sqrt{2}Mu_{phi}\sigma'^*U_{A,i5}U_{A,j3}U_{A,k4} + 2vphi\kappa'\sigma'^*U_{A,i5}U_{A,j3}U_{A,k4} \\
& - \sqrt{2}T_\sigma^*U_{A,i5}U_{A,j3}U_{A,k4} + \sqrt{2}T_\sigma U_{A,i5}U_{A,j3}U_{A,k4} + v_2\sigma\lambda^*U_{A,i1}U_{A,j5}U_{A,k4} \\
& - v_2\lambda\sigma'^*U_{A,i1}U_{A,j5}U_{A,k4} + v_1\sigma\lambda^*U_{A,i2}U_{A,j5}U_{A,k4} - v_1\lambda\sigma'^*U_{A,i2}U_{A,j5}U_{A,k4} \\
& - \sqrt{2}\sigma Mu_{phi}^*U_{A,i3}U_{A,j5}U_{A,k4} - 2vphi\sigma\kappa'^*U_{A,i3}U_{A,j5}U_{A,k4} + \sqrt{2}Mu_{phi}\sigma'^*U_{A,i3}U_{A,j5}U_{A,k4} \\
& + 2vphi\kappa'\sigma'^*U_{A,i3}U_{A,j5}U_{A,k4} - \sqrt{2}T_\sigma^*U_{A,i3}U_{A,j5}U_{A,k4} + \sqrt{2}T_\sigma U_{A,i3}U_{A,j5}U_{A,k4} \\
& + 2v_s\sigma\kappa'^*U_{A,i5}U_{A,j5}U_{A,k4} - 2v_s\kappa'\sigma'^*U_{A,i5}U_{A,j5}U_{A,k4} - vsb\sigma\lambda^*U_{A,i2}U_{A,j1}U_{A,k5} \\
& + vsb\lambda\sigma'^*U_{A,i2}U_{A,j1}U_{A,k5} + v_2\sigma\lambda^*U_{A,i4}U_{A,j1}U_{A,k5} - v_2\lambda\sigma'^*U_{A,i4}U_{A,j1}U_{A,k5} \\
& - vsb\sigma\lambda^*U_{A,i1}U_{A,j2}U_{A,k5} + vsb\lambda\sigma'^*U_{A,i1}U_{A,j2}U_{A,k5} + v_1\sigma\lambda^*U_{A,i4}U_{A,j2}U_{A,k5} \\
& - v_1\lambda\sigma'^*U_{A,i4}U_{A,j2}U_{A,k5} - \sqrt{2}\sigma Mu_{phi}^*U_{A,i4}U_{A,j3}U_{A,k5} - 2vphi\sigma\kappa'^*U_{A,i4}U_{A,j3}U_{A,k5} \\
& + \sqrt{2}Mu_{phi}\sigma'^*U_{A,i4}U_{A,j3}U_{A,k5} + 2vphi\kappa'\sigma'^*U_{A,i4}U_{A,j3}U_{A,k5} - \sqrt{2}T_\sigma^*U_{A,i4}U_{A,j3}U_{A,k5} \\
& + \sqrt{2}T_\sigma U_{A,i4}U_{A,j3}U_{A,k5} + 2vsb\sigma\kappa'^*U_{A,i5}U_{A,j3}U_{A,k5} - 2vsb\kappa'\sigma'^*U_{A,i5}U_{A,j3}U_{A,k5} \\
& + v_2\sigma\lambda^*U_{A,i1}U_{A,j4}U_{A,k5} - v_2\lambda\sigma'^*U_{A,i1}U_{A,j4}U_{A,k5} + v_1\sigma\lambda^*U_{A,i2}U_{A,j4}U_{A,k5} \\
& - v_1\lambda\sigma'^*U_{A,i2}U_{A,j4}U_{A,k5} - \sqrt{2}\sigma Mu_{phi}^*U_{A,i3}U_{A,j4}U_{A,k5} - 2vphi\sigma\kappa'^*U_{A,i3}U_{A,j4}U_{A,k5} \\
& + \sqrt{2}Mu_{phi}\sigma'^*U_{A,i3}U_{A,j4}U_{A,k5} + 2vphi\kappa'\sigma'^*U_{A,i3}U_{A,j4}U_{A,k5} - \sqrt{2}T_\sigma^*U_{A,i3}U_{A,j4}U_{A,k5} \\
& + \sqrt{2}T_\sigma U_{A,i3}U_{A,j4}U_{A,k5} + 2v_s\sigma\kappa'^*U_{A,i5}U_{A,j4}U_{A,k5} - 2v_s\kappa'\sigma'^*U_{A,i5}U_{A,j4}U_{A,k5} \\
& + 2vsb\sigma\kappa'^*U_{A,i3}U_{A,j5}U_{A,k5} - 2vsb\kappa'\sigma'^*U_{A,i3}U_{A,j5}U_{A,k5} + 2v_s\sigma\kappa'^*U_{A,i4}U_{A,j5}U_{A,k5} \\
& - 2v_s\kappa'\sigma'^*U_{A,i4}U_{A,j5}U_{A,k5} + 6\sqrt{2}\kappa' Mu_{phi}^*U_{A,i5}U_{A,j5}U_{A,k5} - 6\sqrt{2}Mu_{phi}\kappa'^*U_{A,i5}U_{A,j5}U_{A,k5} \\
& + 2\sqrt{2}T_{\kappa'}^*U_{A,i5}U_{A,j5}U_{A,k5} - 2\sqrt{2}T_{\kappa'}U_{A,i5}U_{A,j5}U_{A,k5} \Big) \tag{321}
\end{aligned}$$

$$\begin{aligned}
& \frac{i}{4} \left(12g_1^2 Q_S v_s U_{H,k3}^* U_{A,i1} U_{A,j1} - 4v_s |\lambda|^2 U_{H,k3}^* U_{A,i1} U_{A,j1} - 12g_1^2 Q_S v s b U_{H,k4}^* U_{A,i1} U_{A,j1} \right. \\
& - \sqrt{2} T_\lambda^* U_{H,k3}^* U_{A,i2} U_{A,j1} + v p h i \sigma \lambda^* U_{H,k4}^* U_{A,i2} U_{A,j1} + v p h i \lambda \sigma'^* U_{H,k4}^* U_{A,i2} U_{A,j1} \\
& + v s b \sigma \lambda^* U_{H,k5}^* U_{A,i2} U_{A,j1} + v s b \lambda \sigma'^* U_{H,k5}^* U_{A,i2} U_{A,j1} - \sqrt{2} U_{H,k3}^* T_\lambda U_{A,i2} U_{A,j1} \\
& - v_2 \sigma \lambda^* U_{H,k5}^* U_{A,i4} U_{A,j1} - v_2 \lambda \sigma'^* U_{H,k5}^* U_{A,i4} U_{A,j1} - v_2 \sigma \lambda^* U_{H,k4}^* U_{A,i5} U_{A,j1} \\
& - v_2 \lambda \sigma'^* U_{H,k4}^* U_{A,i5} U_{A,j1} - \sqrt{2} T_\lambda^* U_{H,k3}^* U_{A,i1} U_{A,j2} + v p h i \sigma \lambda^* U_{H,k4}^* U_{A,i1} U_{A,j2} \\
& + v p h i \lambda \sigma'^* U_{H,k4}^* U_{A,i1} U_{A,j2} + v s b \sigma \lambda^* U_{H,k5}^* U_{A,i1} U_{A,j2} + v s b \lambda \sigma'^* U_{H,k5}^* U_{A,i1} U_{A,j2} \\
& - \sqrt{2} U_{H,k3}^* T_\lambda U_{A,i1} U_{A,j2} + 8g_1^2 Q_S v_s U_{H,k3}^* U_{A,i2} U_{A,j2} - 4v_s |\lambda|^2 U_{H,k3}^* U_{A,i2} U_{A,j2} \\
& - 8g_1^2 Q_S v s b U_{H,k4}^* U_{A,i2} U_{A,j2} - v_1 \sigma \lambda^* U_{H,k5}^* U_{A,i4} U_{A,j2} - v_1 \lambda \sigma'^* U_{H,k5}^* U_{A,i4} U_{A,j2} \\
& - v_1 \sigma \lambda^* U_{H,k4}^* U_{A,i5} U_{A,j2} - v_1 \lambda \sigma'^* U_{H,k4}^* U_{A,i5} U_{A,j2} - 4g_1^2 Q_S^2 v_s U_{H,k3}^* U_{A,i3} U_{A,j3} \\
& + 4g_1^2 Q_S^2 v s b U_{H,k4}^* U_{A,i3} U_{A,j3} - 4v s b |\sigma|^2 U_{H,k4}^* U_{A,i3} U_{A,j3} - 4v p h i |\sigma|^2 U_{H,k5}^* U_{A,i3} U_{A,j3} \\
& - \sqrt{2} \sigma M u_{p h i}^* U_{H,k5}^* U_{A,i4} U_{A,j3} - 2v p h i \sigma \kappa'^* U_{H,k5}^* U_{A,i4} U_{A,j3} - \sqrt{2} M u_{p h i} \sigma'^* U_{H,k5}^* U_{A,i4} U_{A,j3} \\
& - 2v p h i \kappa' \sigma'^* U_{H,k5}^* U_{A,i4} U_{A,j3} - \sqrt{2} T_\sigma^* U_{H,k5}^* U_{A,i4} U_{A,j3} - \sqrt{2} U_{H,k5}^* T_\sigma U_{A,i4} U_{A,j3} \\
& + \sqrt{2} \sigma M u_{p h i}^* U_{H,k4}^* U_{A,i5} U_{A,j3} + 2v p h i \sigma \kappa'^* U_{H,k4}^* U_{A,i5} U_{A,j3} + \sqrt{2} M u_{p h i} \sigma'^* U_{H,k4}^* U_{A,i5} U_{A,j3} \\
& + 2v p h i \kappa' \sigma'^* U_{H,k4}^* U_{A,i5} U_{A,j3} - \sqrt{2} T_\sigma^* U_{H,k4}^* U_{A,i5} U_{A,j3} + 2v s b \sigma \kappa'^* U_{H,k5}^* U_{A,i5} U_{A,j3} \\
& + 2v s b \kappa' \sigma'^* U_{H,k5}^* U_{A,i5} U_{A,j3} - \sqrt{2} U_{H,k4}^* T_\sigma U_{A,i5} U_{A,j3} - v_2 \sigma \lambda^* U_{H,k5}^* U_{A,i1} U_{A,j4} \\
& - v_2 \lambda \sigma'^* U_{H,k5}^* U_{A,i1} U_{A,j4} - v_1 \sigma \lambda^* U_{H,k5}^* U_{A,i2} U_{A,j4} - v_1 \lambda \sigma'^* U_{H,k5}^* U_{A,i2} U_{A,j4} \\
& - \sqrt{2} \sigma M u_{p h i}^* U_{H,k5}^* U_{A,i3} U_{A,j4} - 2v p h i \sigma \kappa'^* U_{H,k5}^* U_{A,i3} U_{A,j4} - \sqrt{2} M u_{p h i} \sigma'^* U_{H,k5}^* U_{A,i3} U_{A,j4} \\
& - 2v p h i \kappa' \sigma'^* U_{H,k5}^* U_{A,i3} U_{A,j4} - \sqrt{2} T_\sigma^* U_{H,k5}^* U_{A,i3} U_{A,j4} - \sqrt{2} U_{H,k5}^* T_\sigma U_{A,i3} U_{A,j4} \\
& + 4g_1^2 Q_S^2 v_s U_{H,k3}^* U_{A,i4} U_{A,j4} - 4v_s |\sigma|^2 U_{H,k3}^* U_{A,i4} U_{A,j4} - 4g_1^2 Q_S^2 v s b U_{H,k4}^* U_{A,i4} U_{A,j4} \\
& - 4v p h i |\sigma|^2 U_{H,k5}^* U_{A,i4} U_{A,j4} + \sqrt{2} \sigma M u_{p h i}^* U_{H,k3}^* U_{A,i5} U_{A,j4} + 2v p h i \sigma \kappa'^* U_{H,k3}^* U_{A,i5} U_{A,j4} \\
& + \sqrt{2} M u_{p h i} \sigma'^* U_{H,k3}^* U_{A,i5} U_{A,j4} + 2v p h i \kappa' \sigma'^* U_{H,k3}^* U_{A,i5} U_{A,j4} - \sqrt{2} T_\sigma^* U_{H,k3}^* U_{A,i5} U_{A,j4} \\
& + 2v_s \sigma \kappa'^* U_{H,k5}^* U_{A,i5} U_{A,j4} + 2v_s \kappa' \sigma'^* U_{H,k5}^* U_{A,i5} U_{A,j4} - \sqrt{2} U_{H,k3}^* T_\sigma U_{A,i5} U_{A,j4} \\
& - v_2 \sigma \lambda^* U_{H,k4}^* U_{A,i1} U_{A,j5} - v_2 \lambda \sigma'^* U_{H,k4}^* U_{A,i1} U_{A,j5} - v_1 \sigma \lambda^* U_{H,k4}^* U_{A,i2} U_{A,j5} \\
& - v_1 \lambda \sigma'^* U_{H,k4}^* U_{A,i2} U_{A,j5} + \sqrt{2} \sigma M u_{p h i}^* U_{H,k4}^* U_{A,i3} U_{A,j5} + 2v p h i \sigma \kappa'^* U_{H,k4}^* U_{A,i3} U_{A,j5} \\
& + \sqrt{2} M u_{p h i} \sigma'^* U_{H,k4}^* U_{A,i3} U_{A,j5} + 2v p h i \kappa' \sigma'^* U_{H,k4}^* U_{A,i3} U_{A,j5} - \sqrt{2} T_\sigma^* U_{H,k4}^* U_{A,i3} U_{A,j5} \\
& + 2v s b \sigma \kappa'^* U_{H,k5}^* U_{A,i3} U_{A,j5} + 2v s b \kappa' \sigma'^* U_{H,k5}^* U_{A,i3} U_{A,j5} - \sqrt{2} U_{H,k4}^* T_\sigma U_{A,i3} U_{A,j5} \\
& + \sqrt{2} \sigma M u_{p h i}^* U_{H,k3}^* U_{A,i4} U_{A,j5} + 2v p h i \sigma \kappa'^* U_{H,k3}^* U_{A,i4} U_{A,j5} + \sqrt{2} M u_{p h i} \sigma'^* U_{H,k3}^* U_{A,i4} U_{A,j5} \\
& + 2v p h i \kappa' \sigma'^* U_{H,k3}^* U_{A,i4} U_{A,j5} - \sqrt{2} T_\sigma^* U_{H,k3}^* U_{A,i4} U_{A,j5} + 2v_s \sigma \kappa'^* U_{H,k5}^* U_{A,i4} U_{A,j5} \\
& + 2v_s \kappa' \sigma'^* U_{H,k5}^* U_{A,i4} U_{A,j5} - \sqrt{2} U_{H,k3}^* T_\sigma U_{A,i4} U_{A,j5} - 4v_s |\sigma|^2 U_{H,k3}^* U_{A,i5} U_{A,j5} \\
& - 2v s b \sigma \kappa'^* U_{H,k3}^* U_{A,i5} U_{A,j5} - 2v s b \kappa' \sigma'^* U_{H,k3}^* U_{A,i5} U_{A,j5} - 4v s b |\sigma|^2 U_{H,k4}^* U_{A,i5} U_{A,j5} \\
& - 2v_s \sigma \kappa'^* U_{H,k4}^* U_{A,i5} U_{A,j5} - 2v_s \kappa' \sigma'^* U_{H,k4}^* U_{A,i5} U_{A,j5} - 8v p h i |\kappa'|^2 U_{H,k5}^* U_{A,i5} U_{A,j5} \\
& - 2\sqrt{2} \kappa' M u_{p h i}^* U_{H,k5}^* U_{A,i5} U_{A,j5} - 2\sqrt{2} M u_{p h i} \kappa'^* U_{H,k5}^* U_{A,i5} U_{A,j5} + 2\sqrt{2} T_{\kappa'}^* U_{H,k5}^* U_{A,i5} U_{A,j5}
\end{aligned}$$

$$\begin{aligned}
& + 2\sqrt{2}U_{H,k5}^*T_{\kappa'}U_{A,i5}U_{A,j5} \\
& + U_{H,k2}^*\left(-\sqrt{2}T_{\lambda}^*U_{A,i3}U_{A,j1}-\sqrt{2}T_{\lambda}U_{A,i3}U_{A,j1}-vphi\sigma\lambda^*U_{A,i4}U_{A,j1}-vphi\lambda\sigma'^*U_{A,i4}U_{A,j1}\right. \\
& - vsb\sigma\lambda^*U_{A,i5}U_{A,j1}-vsb\lambda\sigma'^*U_{A,i5}U_{A,j1}-g_1^2v_2U_{A,i2}U_{A,j2}-16g_1^2v_2U_{A,i2}U_{A,j2} \\
& - g_2^2v_2U_{A,i2}U_{A,j2}+8g_1^2Q_Sv_2U_{A,i3}U_{A,j3}-4v_2|\lambda|^2U_{A,i3}U_{A,j3}-8g_1^2Q_Sv_2U_{A,i4}U_{A,j4} \\
& + v_1\sigma\lambda^*U_{A,i5}U_{A,j4}+v_1\lambda\sigma'^*U_{A,i5}U_{A,j4}+v_1\sigma\lambda^*U_{A,i4}U_{A,j5}+v_1\lambda\sigma'^*U_{A,i4}U_{A,j5} \\
& + U_{A,i1}\left(v_2\left(-24g_1^2-4|\lambda|^2+g_1^2+g_2^2\right)U_{A,j1}-\sqrt{2}T_{\lambda}^*U_{A,j3}-\sqrt{2}T_{\lambda}U_{A,j3}-vphi\sigma\lambda^*U_{A,j4}\right. \\
& \left.-vphi\lambda\sigma'^*U_{A,j4}-vsb\sigma\lambda^*U_{A,j5}-vsb\lambda\sigma'^*U_{A,j5}\right)\Big) \\
& - U_{H,k1}^*\left(\left(36g_1^2+g_1^2+g_2^2\right)v_1U_{A,i1}U_{A,j1}+\sqrt{2}T_{\lambda}^*U_{A,i3}U_{A,j2}+\sqrt{2}T_{\lambda}U_{A,i3}U_{A,j2}+vphi\sigma\lambda^*U_{A,i4}U_{A,j2}\right. \\
& + vphi\lambda\sigma'^*U_{A,i4}U_{A,j2}+vsb\sigma\lambda^*U_{A,i5}U_{A,j2}+vsb\lambda\sigma'^*U_{A,i5}U_{A,j2}-12g_1^2Q_Sv_1U_{A,i3}U_{A,j3} \\
& + 4v_1|\lambda|^2U_{A,i3}U_{A,j3}+12g_1^2Q_Sv_1U_{A,i4}U_{A,j4}-v_2\sigma\lambda^*U_{A,i5}U_{A,j4}-v_2\lambda\sigma'^*U_{A,i5}U_{A,j4} \\
& - v_2\sigma\lambda^*U_{A,i4}U_{A,j5}-v_2\lambda\sigma'^*U_{A,i4}U_{A,j5} \\
& + U_{A,i2}\left(-v_1\left(-24g_1^2-4|\lambda|^2+g_1^2+g_2^2\right)U_{A,j2}+\sqrt{2}T_{\lambda}^*U_{A,j3}+\sqrt{2}T_{\lambda}U_{A,j3}+vphi\sigma\lambda^*U_{A,j4}+vphi\lambda\sigma'^*U_{A,j4}\right. \\
& \left.+vsb\sigma\lambda^*U_{A,j5}+vsb\lambda\sigma'^*U_{A,j5}\right)\Big)\Big) \tag{322}
\end{aligned}$$

$$\begin{aligned}
& \frac{1}{4}\left(vphi\lambda\sigma'^*U_{H,j4}^*U_{H,k2}^*U_{A,i1}+vsb\lambda\sigma'^*U_{H,j5}^*U_{H,k2}^*U_{A,i1}+vphi\lambda\sigma'^*U_{H,j2}^*U_{H,k4}^*U_{A,i1}\right. \\
& + v_2\lambda\sigma'^*U_{H,j5}^*U_{H,k4}^*U_{A,i1}+vsb\lambda\sigma'^*U_{H,j2}^*U_{H,k5}^*U_{A,i1}+v_2\lambda\sigma'^*U_{H,j4}^*U_{H,k5}^*U_{A,i1} \\
& - \sqrt{2}U_{H,j3}^*U_{H,k2}^*T_{\lambda}U_{A,i1}-\sqrt{2}U_{H,j2}^*U_{H,k3}^*T_{\lambda}U_{A,i1}+vphi\lambda\sigma'^*U_{H,j4}^*U_{H,k1}^*U_{A,i2} \\
& + vsb\lambda\sigma'^*U_{H,j5}^*U_{H,k1}^*U_{A,i2}+vphi\lambda\sigma'^*U_{H,j1}^*U_{H,k4}^*U_{A,i2}+v_1\lambda\sigma'^*U_{H,j5}^*U_{H,k4}^*U_{A,i2} \\
& + vsb\lambda\sigma'^*U_{H,j1}^*U_{H,k5}^*U_{A,i2}+v_1\lambda\sigma'^*U_{H,j4}^*U_{H,k5}^*U_{A,i2}-\sqrt{2}U_{H,j3}^*U_{H,k1}^*T_{\lambda}U_{A,i2} \\
& - \sqrt{2}U_{H,j1}^*U_{H,k3}^*T_{\lambda}U_{A,i2}-\sqrt{2}\sigma Mu_{phi}^*U_{H,j5}^*U_{H,k4}^*U_{A,i3}-2vphi\sigma\kappa'^*U_{H,j5}^*U_{H,k4}^*U_{A,i3} \\
& + \sqrt{2}Mu_{phi}\sigma'^*U_{H,j5}^*U_{H,k4}^*U_{A,i3}+2vphi\kappa'\sigma'^*U_{H,j5}^*U_{H,k4}^*U_{A,i3}+\sqrt{2}T_{\sigma}^*U_{H,j5}^*U_{H,k4}^*U_{A,i3} \\
& - \sqrt{2}\sigma Mu_{phi}^*U_{H,j4}^*U_{H,k5}^*U_{A,i3}-2vphi\sigma\kappa'^*U_{H,j4}^*U_{H,k5}^*U_{A,i3}+\sqrt{2}Mu_{phi}\sigma'^*U_{H,j4}^*U_{H,k5}^*U_{A,i3} \\
& + 2vphi\kappa'\sigma'^*U_{H,j4}^*U_{H,k5}^*U_{A,i3}+\sqrt{2}T_{\sigma}^*U_{H,j4}^*U_{H,k5}^*U_{A,i3}-2vsb\sigma\kappa'^*U_{H,j5}^*U_{H,k5}^*U_{A,i3}
\end{aligned}$$

$$\begin{aligned}
& + 2vsb\kappa'\sigma'^*U_{H,j5}^*U_{H,k5}^*U_{A,i3} - \sqrt{2}U_{H,j2}^*U_{H,k1}^*T_\lambda U_{A,i3} - \sqrt{2}U_{H,j1}^*U_{H,k2}^*T_\lambda U_{A,i3} \\
& - \sqrt{2}U_{H,j5}^*U_{H,k4}^*T_\sigma U_{A,i3} - \sqrt{2}U_{H,j4}^*U_{H,k5}^*T_\sigma U_{A,i3} \\
& + \sqrt{2}T_\lambda^*\left(U_{H,j1}^*\left(U_{H,k2}^*U_{A,i3} + U_{H,k3}^*U_{A,i2}\right) + U_{H,j2}^*\left(U_{H,k1}^*U_{A,i3} + U_{H,k3}^*U_{A,i1}\right) + U_{H,j3}^*\left(U_{H,k1}^*U_{A,i2} + U_{H,k2}^*U_{A,i1}\right)\right) \\
& - vphi\lambda\sigma'^*U_{H,j2}^*U_{H,k1}^*U_{A,i4} - v_2\lambda\sigma'^*U_{H,j5}^*U_{H,k1}^*U_{A,i4} - vphi\lambda\sigma'^*U_{H,j1}^*U_{H,k2}^*U_{A,i4} \\
& - v_1\lambda\sigma'^*U_{H,j5}^*U_{H,k2}^*U_{A,i4} - \sqrt{2}\sigma Mu_{phi}^*U_{H,j5}^*U_{H,k3}^*U_{A,i4} - 2vphi\sigma\kappa'^*U_{H,j5}^*U_{H,k3}^*U_{A,i4} \\
& + \sqrt{2}Mu_{phi}\sigma'^*U_{H,j5}^*U_{H,k3}^*U_{A,i4} + 2vphi\kappa'\sigma'^*U_{H,j5}^*U_{H,k3}^*U_{A,i4} + \sqrt{2}T_\sigma^*U_{H,j5}^*U_{H,k3}^*U_{A,i4} \\
& - v_2\lambda\sigma'^*U_{H,j1}^*U_{H,k5}^*U_{A,i4} - v_1\lambda\sigma'^*U_{H,j2}^*U_{H,k5}^*U_{A,i4} - \sqrt{2}\sigma Mu_{phi}^*U_{H,j3}^*U_{H,k5}^*U_{A,i4} \\
& - 2vphi\sigma\kappa'^*U_{H,j3}^*U_{H,k5}^*U_{A,i4} + \sqrt{2}Mu_{phi}\sigma'^*U_{H,j3}^*U_{H,k5}^*U_{A,i4} + 2vphi\kappa'\sigma'^*U_{H,j3}^*U_{H,k5}^*U_{A,i4} \\
& + \sqrt{2}T_\sigma^*U_{H,j3}^*U_{H,k5}^*U_{A,i4} - 2v_s\sigma\kappa'^*U_{H,j5}^*U_{H,k5}^*U_{A,i4} + 2v_s\kappa'\sigma'^*U_{H,j5}^*U_{H,k5}^*U_{A,i4} \\
& - \sqrt{2}U_{H,j5}^*U_{H,k3}^*T_\sigma U_{A,i4} - \sqrt{2}U_{H,j3}^*U_{H,k5}^*T_\sigma U_{A,i4} - vsb\lambda\sigma'^*U_{H,j2}^*U_{H,k1}^*U_{A,i5} \\
& - v_2\lambda\sigma'^*U_{H,j4}^*U_{H,k1}^*U_{A,i5} - vsb\lambda\sigma'^*U_{H,j1}^*U_{H,k2}^*U_{A,i5} - v_1\lambda\sigma'^*U_{H,j4}^*U_{H,k2}^*U_{A,i5} \\
& + \sqrt{2}\sigma Mu_{phi}^*U_{H,j4}^*U_{H,k3}^*U_{A,i5} + 2vphi\sigma\kappa'^*U_{H,j4}^*U_{H,k3}^*U_{A,i5} - \sqrt{2}Mu_{phi}\sigma'^*U_{H,j4}^*U_{H,k3}^*U_{A,i5} \\
& - 2vphi\kappa'\sigma'^*U_{H,j4}^*U_{H,k3}^*U_{A,i5} + \sqrt{2}T_\sigma^*U_{H,j4}^*U_{H,k3}^*U_{A,i5} + 2vsb\sigma\kappa'^*U_{H,j5}^*U_{H,k3}^*U_{A,i5} \\
& - 2vsb\kappa'\sigma'^*U_{H,j5}^*U_{H,k3}^*U_{A,i5} - v_2\lambda\sigma'^*U_{H,j1}^*U_{H,k4}^*U_{A,i5} - v_1\lambda\sigma'^*U_{H,j2}^*U_{H,k4}^*U_{A,i5} \\
& + \sqrt{2}\sigma Mu_{phi}^*U_{H,j3}^*U_{H,k4}^*U_{A,i5} + 2vphi\sigma\kappa'^*U_{H,j3}^*U_{H,k4}^*U_{A,i5} - \sqrt{2}Mu_{phi}\sigma'^*U_{H,j3}^*U_{H,k4}^*U_{A,i5} \\
& - 2vphi\kappa'\sigma'^*U_{H,j3}^*U_{H,k4}^*U_{A,i5} + \sqrt{2}T_\sigma^*U_{H,j3}^*U_{H,k4}^*U_{A,i5} + 2v_s\sigma\kappa'^*U_{H,j5}^*U_{H,k4}^*U_{A,i5} \\
& - 2v_s\kappa'\sigma'^*U_{H,j5}^*U_{H,k4}^*U_{A,i5} + 2vsb\sigma\kappa'^*U_{H,j3}^*U_{H,k5}^*U_{A,i5} - 2vsb\kappa'\sigma'^*U_{H,j3}^*U_{H,k5}^*U_{A,i5} \\
& + 2v_s\sigma\kappa'^*U_{H,j4}^*U_{H,k5}^*U_{A,i5} - 2v_s\kappa'\sigma'^*U_{H,j4}^*U_{H,k5}^*U_{A,i5} + 2\sqrt{2}\kappa' Mu_{phi}^*U_{H,j5}^*U_{H,k5}^*U_{A,i5} \\
& - 2\sqrt{2}Mu_{phi}\kappa'^*U_{H,j5}^*U_{H,k5}^*U_{A,i5} - 2\sqrt{2}T_{\kappa'}^*U_{H,j5}^*U_{H,k5}^*U_{A,i5} + 2\sqrt{2}U_{H,j5}^*U_{H,k5}^*T_{\kappa'} U_{A,i5} \\
& - \sqrt{2}U_{H,j4}^*U_{H,k3}^*T_\sigma U_{A,i5} - \sqrt{2}U_{H,j3}^*U_{H,k4}^*T_\sigma U_{A,i5} \\
& + \sigma\lambda^*\left(-vphiU_{H,j2}^*U_{H,k4}^*U_{A,i1} - vsbU_{H,j2}^*U_{H,k5}^*U_{A,i1} - vphiU_{H,j1}^*U_{H,k4}^*U_{A,i2} - vsbU_{H,j1}^*U_{H,k5}^*U_{A,i2}\right. \\
& + vphiU_{H,j2}^*U_{H,k1}^*U_{A,i4} + vphiU_{H,j1}^*U_{H,k2}^*U_{A,i4} + v_2U_{H,j1}^*U_{H,k5}^*U_{A,i4} + v_1U_{H,j2}^*U_{H,k5}^*U_{A,i4} \\
& \left.- U_{H,j5}^*\left(U_{H,k1}^*\left(-v_2U_{A,i4} + vsbU_{A,i2}\right) + U_{H,k2}^*\left(-v_1U_{A,i4} + vsbU_{A,i1}\right) + U_{H,k4}^*\left(v_1U_{A,i2} + v_2U_{A,i1}\right)\right)\right) \\
& + vsbU_{H,j2}^*U_{H,k1}^*U_{A,i5} + vsbU_{H,j1}^*U_{H,k2}^*U_{A,i5} + v_2U_{H,j1}^*U_{H,k4}^*U_{A,i5} + v_1U_{H,j2}^*U_{H,k4}^*U_{A,i5} \\
& \left.- U_{H,j4}^*\left(U_{H,k1}^*\left(-v_2U_{A,i5} + vphiU_{A,i2}\right) + U_{H,k2}^*\left(-v_1U_{A,i5} + vphiU_{A,i1}\right) + U_{H,k5}^*\left(v_1U_{A,i2} + v_2U_{A,i1}\right)\right)\right) \quad (323)
\end{aligned}$$

$$\begin{aligned}
& \frac{1}{4} \left(U_{+,j2}^* \left(-2 \left(\sigma \lambda^* \left(vphi U_{A,i4} + vsb U_{A,i5} \right) + \sqrt{2} T_\lambda^* U_{A,i3} \right) + v_1 \left(-2|\lambda|^2 + g_2^2 \right) U_{A,i2} + v_2 \left(-2|\lambda|^2 + g_2^2 \right) U_{A,i1} \right) U_{+,k1} \right. \\
& \left. + U_{+,j1}^* \left(2 \left(\lambda \sigma'^* \left(vphi U_{A,i4} + vsb U_{A,i5} \right) + \sqrt{2} T_\lambda U_{A,i3} \right) - v_1 \left(-2|\lambda|^2 + g_2^2 \right) U_{A,i2} - v_2 \left(-2|\lambda|^2 + g_2^2 \right) U_{A,i1} \right) U_{+,k2} \right) \\
& \hspace{25em} (324)
\end{aligned}$$

$$\begin{aligned}
& -\frac{1}{2} \delta_{\beta\gamma} \left(\sqrt{2} \sum_{a=1}^3 Z_{j3+a}^{D,*} T_{d,aa}^* Z_{ka}^D U_{A,i1} - \sqrt{2} \sum_{a=1}^3 Z_{ja}^{D,*} Z_{k3+a}^D T_{d,aa} U_{A,i1} \right. \\
& \left. + \left(\lambda \sum_{a=1}^3 Y_{d,aa}^* Z_{j3+a}^{D,*} Z_{ka}^D - \lambda^* \sum_{a=1}^3 Z_{ja}^{D,*} Y_{d,aa} Z_{k3+a}^D \right) \left(v_2 U_{A,i3} + v_s U_{A,i2} \right) \right) \\
& \hspace{25em} (325)
\end{aligned}$$

$$\begin{aligned}
& -\frac{1}{2}\delta_{\beta\gamma}\left(-\lambda^*\sum_{a=1}^3Z_{ja}^{Dx,*}Z_{k3+a}^{Dx}\kappa_{aa}\left(v_1U_{A,i2}+v_2U_{A,i1}\right)+\sqrt{2}\sum_{a=1}^3Z_{j3+a}^{Dx,*}T_{\kappa,aa}^*Z_{ka}^{Dx}U_{A,i3}\right. \\
& -\sqrt{2}\sum_{a=1}^3Z_{ja}^{Dx,*}Z_{k3+a}^{Dx}T_{\kappa,aa}U_{A,i3}-vphi\sigma'^*,*\sum_{a=1}^3Z_{ja}^{Dx,*}Z_{k3+a}^{Dx}\kappa_{aa}U_{A,i4} \\
& -vsb\sigma'^*,*\sum_{a=1}^3Z_{ja}^{Dx,*}Z_{k3+a}^{Dx}\kappa_{aa}U_{A,i5} \\
& \left.+\sum_{a=1}^3Z_{j3+a}^{Dx,*}\kappa_{aa}^*Z_{ka}^{Dx}\left(v_1\lambda U_{A,i2}+v_2\lambda U_{A,i1}+vphi\sigma U_{A,i4}+vsb\sigma U_{A,i5}\right)\right) \tag{326}
\end{aligned}$$

$$\begin{aligned}
& \frac{1}{2}\left(-\sqrt{2}\sum_{a=1}^3Z_{j3+a}^{E,*}T_{e,aa}^*Z_{ka}^EU_{A,i1}+\sqrt{2}\sum_{a=1}^3Z_{ja}^{E,*}Z_{k3+a}^ET_{e,aa}U_{A,i1}\right. \\
& \left.-\left(\lambda\sum_{a=1}^3Y_{e,aa}^*Z_{j3+a}^{E,*}Z_{ka}^E-\lambda^*\sum_{a=1}^3Z_{ja}^{E,*}Y_{e,aa}Z_{k3+a}^E\right)\left(v_2U_{A,i3}+v_sU_{A,i2}\right)\right) \tag{327}
\end{aligned}$$

$$-\frac{1}{2}\delta_{\beta\gamma}\left(\sqrt{2}\left(-\sum_{a=1}^3Z_{ja}^{U,*}Z_{k3+a}^UT_{u,aa}+\sum_{a=1}^3Z_{j3+a}^{U,*}T_{u,aa}^*Z_{ka}^U\right)U_{A,i2}\right)$$

$$+ \lambda \sum_{a=1}^3 Y_{u,aa}^* Z_{j3+a}^{U,*} Z_{ka}^U \left(v_1 U_{A,i3} + v_s U_{A,i1} \right) - \lambda^* \sum_{a=1}^3 Z_{ja}^{U,*} Y_{u,aa} Z_{k3+a}^U \left(v_1 U_{A,i3} + v_s U_{A,i1} \right) \quad (328)$$

$$\begin{aligned}
& \frac{i}{4} \left(12g_1^2 Q_S v_s U_{H,i3}^* U_{H,j1}^* U_{H,k1}^* - 4v_s |\lambda|^2 U_{H,i3}^* U_{H,j1}^* U_{H,k1}^* - 12g_1^2 Q_S v_{sb} U_{H,i4}^* U_{H,j1}^* U_{H,k1}^* \right. \\
& + \sqrt{2} T_\lambda^* U_{H,i3}^* U_{H,j2}^* U_{H,k1}^* - v_{phi} \sigma \lambda^* U_{H,i4}^* U_{H,j2}^* U_{H,k1}^* - v_{phi} \lambda \sigma'^* U_{H,i4}^* U_{H,j2}^* U_{H,k1}^* \\
& - v_{sb} \sigma \lambda^* U_{H,i5}^* U_{H,j2}^* U_{H,k1}^* - v_{sb} \lambda \sigma'^* U_{H,i5}^* U_{H,j2}^* U_{H,k1}^* + 12g_1^2 Q_S v_1 U_{H,i3}^* U_{H,j3}^* U_{H,k1}^* \\
& - 4v_1 |\lambda|^2 U_{H,i3}^* U_{H,j3}^* U_{H,k1}^* - 12g_1^2 Q_S v_1 U_{H,i4}^* U_{H,j4}^* U_{H,k1}^* \\
& - v_2 \sigma \lambda^* U_{H,i5}^* U_{H,j4}^* U_{H,k1}^* - v_2 \lambda \sigma'^* U_{H,i5}^* U_{H,j4}^* U_{H,k1}^* - v_2 \sigma \lambda^* U_{H,i4}^* U_{H,j5}^* U_{H,k1}^* \\
& - v_2 \lambda \sigma'^* U_{H,i4}^* U_{H,j5}^* U_{H,k1}^* + \sqrt{2} T_\lambda^* U_{H,i3}^* U_{H,j1}^* U_{H,k2}^* - v_{phi} \sigma \lambda^* U_{H,i4}^* U_{H,j1}^* U_{H,k2}^* \\
& - v_{phi} \lambda \sigma'^* U_{H,i4}^* U_{H,j1}^* U_{H,k2}^* - v_{sb} \sigma \lambda^* U_{H,i5}^* U_{H,j1}^* U_{H,k2}^* - v_{sb} \lambda \sigma'^* U_{H,i5}^* U_{H,j1}^* U_{H,k2}^* \\
& + 8g_1^2 Q_S v_s U_{H,i3}^* U_{H,j2}^* U_{H,k2}^* - 4v_s |\lambda|^2 U_{H,i3}^* U_{H,j2}^* U_{H,k2}^* - 8g_1^2 Q_S v_{sb} U_{H,i4}^* U_{H,j2}^* U_{H,k2}^* \\
& + 8g_1^2 Q_S v_2 U_{H,i3}^* U_{H,j3}^* U_{H,k2}^* - 4v_2 |\lambda|^2 U_{H,i3}^* U_{H,j3}^* U_{H,k2}^* \\
& - 8g_1^2 Q_S v_2 U_{H,i4}^* U_{H,j4}^* U_{H,k2}^* - v_1 \sigma \lambda^* U_{H,i5}^* U_{H,j4}^* U_{H,k2}^* - v_1 \lambda \sigma'^* U_{H,i5}^* U_{H,j4}^* U_{H,k2}^* \\
& - v_1 \sigma \lambda^* U_{H,i4}^* U_{H,j5}^* U_{H,k2}^* - v_1 \lambda \sigma'^* U_{H,i4}^* U_{H,j5}^* U_{H,k2}^* + 12g_1^2 Q_S v_1 U_{H,i3}^* U_{H,j1}^* U_{H,k3}^* \\
& - 4v_1 |\lambda|^2 U_{H,i3}^* U_{H,j1}^* U_{H,k3}^* + 8g_1^2 Q_S v_2 U_{H,i3}^* U_{H,j2}^* U_{H,k3}^* - 4v_2 |\lambda|^2 U_{H,i3}^* U_{H,j2}^* U_{H,k3}^* \\
& - 12g_1^2 Q_S^2 v_s U_{H,i3}^* U_{H,j3}^* U_{H,k3}^* + 4g_1^2 Q_S^2 v_{sb} U_{H,i4}^* U_{H,j3}^* U_{H,k3}^* \\
& - 4v_{sb} |\sigma|^2 U_{H,i4}^* U_{H,j3}^* U_{H,k3}^* - 4v_{phi} |\sigma|^2 U_{H,i5}^* U_{H,j3}^* U_{H,k3}^* + 4g_1^2 Q_S^2 v_{sb} U_{H,i3}^* U_{H,j4}^* U_{H,k3}^* \\
& - 4v_{sb} |\sigma|^2 U_{H,i3}^* U_{H,j4}^* U_{H,k3}^* + 4g_1^2 Q_S^2 v_s U_{H,i4}^* U_{H,j4}^* U_{H,k3}^* - 4v_s |\sigma|^2 U_{H,i4}^* U_{H,j4}^* U_{H,k3}^* \\
& + \sqrt{2} \sigma M u_{phi}^* U_{H,i5}^* U_{H,j4}^* U_{H,k3}^* + 2v_{phi} \sigma \kappa'^* U_{H,i5}^* U_{H,j4}^* U_{H,k3}^* + \sqrt{2} M u_{phi} \sigma'^* U_{H,i5}^* U_{H,j4}^* U_{H,k3}^* \\
& + 2v_{phi} \kappa' \sigma'^* U_{H,i5}^* U_{H,j4}^* U_{H,k3}^* + \sqrt{2} T_\sigma^* U_{H,i5}^* U_{H,j4}^* U_{H,k3}^* - 4v_{phi} |\sigma|^2 U_{H,i3}^* U_{H,j5}^* U_{H,k3}^* \\
& + \sqrt{2} \sigma M u_{phi}^* U_{H,i4}^* U_{H,j5}^* U_{H,k3}^* + 2v_{phi} \sigma \kappa'^* U_{H,i4}^* U_{H,j5}^* U_{H,k3}^* + \sqrt{2} M u_{phi} \sigma'^* U_{H,i4}^* U_{H,j5}^* U_{H,k3}^* \\
& + 2v_{phi} \kappa' \sigma'^* U_{H,i4}^* U_{H,j5}^* U_{H,k3}^* + \sqrt{2} T_\sigma^* U_{H,i4}^* U_{H,j5}^* U_{H,k3}^* - 4v_s |\sigma|^2 U_{H,i5}^* U_{H,j5}^* U_{H,k3}^* \\
& + 2v_{sb} \sigma \kappa'^* U_{H,i5}^* U_{H,j5}^* U_{H,k3}^* + 2v_{sb} \kappa' \sigma'^* U_{H,i5}^* U_{H,j5}^* U_{H,k3}^* - 12g_1^2 Q_S v_1 U_{H,i4}^* U_{H,j1}^* U_{H,k4}^* \\
& - v_2 \sigma \lambda^* U_{H,i5}^* U_{H,j1}^* U_{H,k4}^* - v_2 \lambda \sigma'^* U_{H,i5}^* U_{H,j1}^* U_{H,k4}^* - 8g_1^2 Q_S v_2 U_{H,i4}^* U_{H,j2}^* U_{H,k4}^* \\
& - v_1 \sigma \lambda^* U_{H,i5}^* U_{H,j2}^* U_{H,k4}^* - v_1 \lambda \sigma'^* U_{H,i5}^* U_{H,j2}^* U_{H,k4}^* + 4g_1^2 Q_S^2 v_{sb} U_{H,i3}^* U_{H,j3}^* U_{H,k4}^*
\end{aligned}$$

$$\begin{aligned}
& -4vsb|\sigma|^2 U_{H,i3}^* U_{H,j3}^* U_{H,k4}^* + 4g_1^2 Q_S^2 v_s U_{H,i4}^* U_{H,j3}^* U_{H,k4}^* - 4v_s |\sigma|^2 U_{H,i4}^* U_{H,j3}^* U_{H,k4}^* \\
& + \sqrt{2} \sigma M u_{phi}^* U_{H,i5}^* U_{H,j3}^* U_{H,k4}^* + 2vphi\sigma\kappa'^* U_{H,i5}^* U_{H,j3}^* U_{H,k4}^* + \sqrt{2} M u_{phi} \sigma'^* U_{H,i5}^* U_{H,j3}^* U_{H,k4}^* \\
& + 2vphi\kappa'\sigma'^* U_{H,i5}^* U_{H,j3}^* U_{H,k4}^* + \sqrt{2} T_\sigma^* U_{H,i5}^* U_{H,j3}^* U_{H,k4}^* + 4g_1^2 Q_S^2 v_s U_{H,i3}^* U_{H,j4}^* U_{H,k4}^* \\
& - 4v_s |\sigma|^2 U_{H,i3}^* U_{H,j4}^* U_{H,k4}^* - 12g_1^2 Q_S^2 vsb U_{H,i4}^* U_{H,j4}^* U_{H,k4}^* - 4vphi|\sigma|^2 U_{H,i5}^* U_{H,j4}^* U_{H,k4}^* \\
& + \sqrt{2} \sigma M u_{phi}^* U_{H,i3}^* U_{H,j5}^* U_{H,k4}^* + 2vphi\sigma\kappa'^* U_{H,i3}^* U_{H,j5}^* U_{H,k4}^* + \sqrt{2} M u_{phi} \sigma'^* U_{H,i3}^* U_{H,j5}^* U_{H,k4}^* \\
& + 2vphi\kappa'\sigma'^* U_{H,i3}^* U_{H,j5}^* U_{H,k4}^* + \sqrt{2} T_\sigma^* U_{H,i3}^* U_{H,j5}^* U_{H,k4}^* - 4vphi|\sigma|^2 U_{H,i4}^* U_{H,j5}^* U_{H,k4}^* \\
& - 4vsb|\sigma|^2 U_{H,i5}^* U_{H,j5}^* U_{H,k4}^* + 2v_s \sigma\kappa'^* U_{H,i5}^* U_{H,j5}^* U_{H,k4}^* + 2v_s \kappa'\sigma'^* U_{H,i5}^* U_{H,j5}^* U_{H,k4}^* \\
& - v_2 \sigma\lambda^* U_{H,i4}^* U_{H,j1}^* U_{H,k5}^* - v_2 \lambda\sigma'^* U_{H,i4}^* U_{H,j1}^* U_{H,k5}^* - v_1 \sigma\lambda^* U_{H,i4}^* U_{H,j2}^* U_{H,k5}^* \\
& - v_1 \lambda\sigma'^* U_{H,i4}^* U_{H,j2}^* U_{H,k5}^* - 4vphi|\sigma|^2 U_{H,i3}^* U_{H,j3}^* U_{H,k5}^* + \sqrt{2} \sigma M u_{phi}^* U_{H,i4}^* U_{H,j3}^* U_{H,k5}^* \\
& + 2vphi\sigma\kappa'^* U_{H,i4}^* U_{H,j3}^* U_{H,k5}^* + \sqrt{2} M u_{phi} \sigma'^* U_{H,i4}^* U_{H,j3}^* U_{H,k5}^* + 2vphi\kappa'\sigma'^* U_{H,i4}^* U_{H,j3}^* U_{H,k5}^* \\
& + \sqrt{2} T_\sigma^* U_{H,i4}^* U_{H,j3}^* U_{H,k5}^* - 4v_s |\sigma|^2 U_{H,i5}^* U_{H,j3}^* U_{H,k5}^* + 2vsb\sigma\kappa'^* U_{H,i5}^* U_{H,j3}^* U_{H,k5}^* \\
& + 2vsb\kappa'\sigma'^* U_{H,i5}^* U_{H,j3}^* U_{H,k5}^* + \sqrt{2} \sigma M u_{phi}^* U_{H,i3}^* U_{H,j4}^* U_{H,k5}^* + 2vphi\sigma\kappa'^* U_{H,i3}^* U_{H,j4}^* U_{H,k5}^* \\
& + \sqrt{2} M u_{phi} \sigma'^* U_{H,i3}^* U_{H,j4}^* U_{H,k5}^* + 2vphi\kappa'\sigma'^* U_{H,i3}^* U_{H,j4}^* U_{H,k5}^* + \sqrt{2} T_\sigma^* U_{H,i3}^* U_{H,j4}^* U_{H,k5}^* \\
& - 4vphi|\sigma|^2 U_{H,i4}^* U_{H,j4}^* U_{H,k5}^* - 4vsb|\sigma|^2 U_{H,i5}^* U_{H,j4}^* U_{H,k5}^* + 2v_s \sigma\kappa'^* U_{H,i5}^* U_{H,j4}^* U_{H,k5}^* \\
& + 2v_s \kappa'\sigma'^* U_{H,i5}^* U_{H,j4}^* U_{H,k5}^* - 4v_s |\sigma|^2 U_{H,i3}^* U_{H,j5}^* U_{H,k5}^* + 2vsb\sigma\kappa'^* U_{H,i3}^* U_{H,j5}^* U_{H,k5}^* \\
& + 2vsb\kappa'\sigma'^* U_{H,i3}^* U_{H,j5}^* U_{H,k5}^* - 4vsb|\sigma|^2 U_{H,i4}^* U_{H,j5}^* U_{H,k5}^* + 2v_s \sigma\kappa'^* U_{H,i4}^* U_{H,j5}^* U_{H,k5}^* \\
& + 2v_s \kappa'\sigma'^* U_{H,i4}^* U_{H,j5}^* U_{H,k5}^* - 24vphi|\kappa'|^2 U_{H,i5}^* U_{H,j5}^* U_{H,k5}^* - 6\sqrt{2} \kappa' M u_{phi}^* U_{H,i5}^* U_{H,j5}^* U_{H,k5}^* \\
& - 6\sqrt{2} M u_{phi} \kappa'^* U_{H,i5}^* U_{H,j5}^* U_{H,k5}^* - 2\sqrt{2} T_{\kappa'}^* U_{H,i5}^* U_{H,j5}^* U_{H,k5}^* - 2\sqrt{2} U_{H,i5}^* U_{H,j5}^* U_{H,k5}^* T_{\kappa'} \\
& + \sqrt{2} U_{H,i3}^* U_{H,j2}^* U_{H,k1}^* T_\lambda + \sqrt{2} U_{H,i3}^* U_{H,j1}^* U_{H,k2}^* T_\lambda \\
& - U_{H,i1}^* \left(-12g_1^2 Q_S v_s U_{H,j3}^* U_{H,k1}^* + 4v_s |\lambda|^2 U_{H,j3}^* U_{H,k1}^* + 12g_1^2 Q_S vsb U_{H,j4}^* U_{H,k1}^* \right. \\
& - \sqrt{2} T_\lambda^* U_{H,j3}^* U_{H,k2}^* + vphi\sigma\lambda^* U_{H,j4}^* U_{H,k2}^* + vphi\lambda\sigma'^* U_{H,j4}^* U_{H,k2}^* + vsb\sigma\lambda^* U_{H,j5}^* U_{H,k2}^* \\
& + vsb\lambda\sigma'^* U_{H,j5}^* U_{H,k2}^* - 12g_1^2 Q_S v_1 U_{H,j3}^* U_{H,k3}^* + 4v_1 |\lambda|^2 U_{H,j3}^* U_{H,k3}^* \\
& + 12g_1^2 Q_S v_1 U_{H,j4}^* U_{H,k4}^* + v_2 \sigma\lambda^* U_{H,j5}^* U_{H,k4}^* + v_2 \lambda\sigma'^* U_{H,j5}^* U_{H,k4}^* \\
& + U_{H,j1}^* \left(3(36g_1^2 + g_1^2 + g_2^2) v_1 U_{H,k1}^* - v_2 (-24g_1^2 - 4|\lambda|^2 + g_1^2 + g_2^2) U_{H,k2}^* \right. \\
& + 4(3g_1^2 Q_S vsb U_{H,k4}^* + (-3g_1^2 Q_S v_s + v_s |\lambda|^2) U_{H,k3}^*) \left. \right) \\
& + v_2 \sigma\lambda^* U_{H,j4}^* U_{H,k5}^* + v_2 \lambda\sigma'^* U_{H,j4}^* U_{H,k5}^* - \sqrt{2} U_{H,j3}^* U_{H,k2}^* T_\lambda \\
& + U_{H,j2}^* \left(-v_2 (-24g_1^2 - 4|\lambda|^2 + g_1^2 + g_2^2) U_{H,k1}^* - v_1 (-24g_1^2 - 4|\lambda|^2 + g_1^2 + g_2^2) U_{H,k2}^* \right. \\
& - \sqrt{2} T_\lambda^* U_{H,k3}^* + vphi\sigma\lambda^* U_{H,k4}^* + vphi\lambda\sigma'^* U_{H,k4}^* + vsb\sigma\lambda^* U_{H,k5}^* + vsb\lambda\sigma'^* U_{H,k5}^* - \sqrt{2} U_{H,k3}^* T_\lambda \left. \right) \\
& + U_{H,i2}^* \left(\sqrt{2} T_\lambda^* U_{H,j3}^* U_{H,k1}^* - vphi\sigma\lambda^* U_{H,j4}^* U_{H,k1}^* - vphi\lambda\sigma'^* U_{H,j4}^* U_{H,k1}^* - vsb\sigma\lambda^* U_{H,j5}^* U_{H,k1}^* \right. \\
& - vsb\lambda\sigma'^* U_{H,j5}^* U_{H,k1}^* + 8g_1^2 Q_S v_s U_{H,j3}^* U_{H,k2}^* - 4v_s |\lambda|^2 U_{H,j3}^* U_{H,k2}^*
\end{aligned}$$

$$\begin{aligned}
& -8g_{1'}^2 Q_S v s b U_{H,j4}^* U_{H,k2}^* + 8g_{1'}^2 Q_S v_2 U_{H,j3}^* U_{H,k3}^* - 4v_2 |\lambda|^2 U_{H,j3}^* U_{H,k3}^* \\
& -8g_{1'}^2 Q_S v_2 U_{H,j4}^* U_{H,k4}^* - v_1 \sigma \lambda^* U_{H,j5}^* U_{H,k4}^* - v_1 \lambda \sigma'^* U_{H,j5}^* U_{H,k4}^* \\
& + U_{H,j2}^* \left(v_1 \left(-24g_{1'}^2 - 4|\lambda|^2 + g_1^2 + g_2^2 \right) U_{H,k1}^* - 3 \left(16g_{1'}^2 + g_1^2 + g_2^2 \right) v_2 U_{H,k2}^* + 8g_{1'}^2 Q_S v_s U_{H,k3}^* \right. \\
& \left. - 4v_s |\lambda|^2 U_{H,k3}^* - 8g_{1'}^2 Q_S v s b U_{H,k4}^* \right) \\
& - v_1 \sigma \lambda^* U_{H,j4}^* U_{H,k5}^* - v_1 \lambda \sigma'^* U_{H,j4}^* U_{H,k5}^* + \sqrt{2} U_{H,j3}^* U_{H,k1}^* T_\lambda \\
& + U_{H,j1}^* \left(v_2 \left(-24g_{1'}^2 - 4|\lambda|^2 + g_1^2 + g_2^2 \right) U_{H,k1}^* + v_1 \left(-24g_{1'}^2 - 4|\lambda|^2 + g_1^2 + g_2^2 \right) U_{H,k2}^* + \sqrt{2} T_\lambda^* U_{H,k3}^* \right. \\
& \left. - v \phi i \sigma \lambda^* U_{H,k4}^* - v \phi i \lambda \sigma'^* U_{H,k4}^* - v s b \sigma \lambda^* U_{H,k5}^* - v s b \lambda \sigma'^* U_{H,k5}^* + \sqrt{2} U_{H,k3}^* T_\lambda \right) \\
& + \sqrt{2} U_{H,i5}^* U_{H,j4}^* U_{H,k3}^* T_\sigma + \sqrt{2} U_{H,i4}^* U_{H,j5}^* U_{H,k3}^* T_\sigma + \sqrt{2} U_{H,i5}^* U_{H,j3}^* U_{H,k4}^* T_\sigma \\
& + \sqrt{2} U_{H,i3}^* U_{H,j5}^* U_{H,k4}^* T_\sigma + \sqrt{2} U_{H,i4}^* U_{H,j3}^* U_{H,k5}^* T_\sigma + \sqrt{2} U_{H,i3}^* U_{H,j4}^* U_{H,k5}^* T_\sigma \Big) \tag{329}
\end{aligned}$$

$$\begin{aligned}
& \frac{i}{4} \left(U_{H,i2}^* \left(-U_{+,j2}^* \left(\left(16g_{1'}^2 + g_1^2 + g_2^2 \right) v_2 U_{+,k2} + v_1 \left(-2|\lambda|^2 + g_2^2 \right) U_{+,k1} \right) \right. \right. \\
& \left. \left. + U_{+,j1}^* \left(\left(-24g_{1'}^2 - g_2^2 + g_1^2 \right) v_2 U_{+,k1} - v_1 \left(-2|\lambda|^2 + g_2^2 \right) U_{+,k2} \right) \right) \right. \\
& \left. - U_{H,i1}^* \left(U_{+,j2}^* \left(\left(24g_{1'}^2 - g_1^2 + g_2^2 \right) v_1 U_{+,k2} + v_2 \left(-2|\lambda|^2 + g_2^2 \right) U_{+,k1} \right) \right. \right. \\
& \left. \left. + U_{+,j1}^* \left(\left(36g_{1'}^2 + g_1^2 + g_2^2 \right) v_1 U_{+,k1} + v_2 \left(-2|\lambda|^2 + g_2^2 \right) U_{+,k2} \right) \right) \right. \\
& \left. + 2 \left(v s b U_{H,i5}^* \left(\lambda \sigma'^* U_{+,j1}^* U_{+,k2} + \sigma \lambda^* U_{+,j2}^* U_{+,k1} \right) \right. \right. \\
& \left. \left. + U_{H,i4}^* \left(U_{+,j1}^* \left(-6g_{1'}^2 Q_S v s b U_{+,k1} + v \phi i \lambda \sigma'^* U_{+,k2} \right) + U_{+,j2}^* \left(-4g_{1'}^2 Q_S v s b U_{+,k2} + v \phi i \sigma \lambda^* U_{+,k1} \right) \right) \right. \right. \\
& \left. \left. + U_{H,i3}^* \left(-U_{+,j2}^* \left(2v_s \left(-2g_{1'}^2 Q_S + |\lambda|^2 \right) U_{+,k2} + \sqrt{2} T_\lambda^* U_{+,k1} \right) \right. \right. \right. \\
& \left. \left. \left. + U_{+,j1}^* \left(\left(-2v_s |\lambda|^2 + 6g_{1'}^2 Q_S v_s \right) U_{+,k1} - \sqrt{2} T_\lambda U_{+,k2} \right) \right) \right) \right) \Big) \tag{330}
\end{aligned}$$

$$\begin{aligned}
& \frac{i}{12} \delta_{\beta\gamma} \left(U_{H,i2}^* \left(- \left(3 \left(-8g_1^2 + g_2^2 \right) + g_1^2 \right) v_2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D + 6v_s \lambda \sum_{a=1}^3 Y_{d,aa}^* Z_{j3+a}^{D,*} Z_{ka}^D \right. \right. \\
& - 2g_1^2 v_2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{k3+a}^D + 48g_1^2 v_2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{k3+a}^D + 6v_s \lambda^* \sum_{a=1}^3 Z_{ja}^{D,*} Y_{d,aa} Z_{k3+a}^D \left. \right) \\
& + 6 \left(2g_1^2 Q_S v s b U_{H,i4}^* \left(2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{k3+a}^D + \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \right) \right. \\
& + U_{H,i3}^* \left(-2g_1^2 Q_S v_s \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D + v_2 \lambda \sum_{a=1}^3 Y_{d,aa}^* Z_{j3+a}^{D,*} Z_{ka}^D - 4g_1^2 Q_S v_s \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{k3+a}^D \right. \\
& + v_2 \lambda^* \sum_{a=1}^3 Z_{ja}^{D,*} Y_{d,aa} Z_{k3+a}^D \left. \right) \left. \right) \\
& + U_{H,i1}^* \left(\left(36g_1^2 + 3g_2^2 + g_1^2 \right) v_1 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \right. \\
& - 2 \left(3\sqrt{2} \sum_{a=1}^3 Z_{j3+a}^{D,*} T_{d,aa}^* Z_{ka}^D - \left(36g_1^2 + g_1^2 \right) v_1 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{k3+a}^D + 3\sqrt{2} \sum_{a=1}^3 Z_{ja}^{D,*} Z_{k3+a}^D T_{d,aa} \right. \\
& + 6v_1 \sum_{b=1}^3 |Y_{d,bb}|^2 Z_{jb}^{D,*} Z_{kb}^D + 6v_1 \sum_{b=1}^3 |Y_{d,bb}|^2 Z_{j3+b}^{D,*} Z_{k3+b}^D \left. \right) \left. \right) \quad (331)
\end{aligned}$$

$$\begin{aligned}
& \frac{i}{6} \delta_{\beta\gamma} \left(U_{H,i2}^* \left(\left(-24g_{1'}^2 + g_1^2 \right) v_2 \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{ka}^{Dx} + 3v_1 \lambda \sum_{a=1}^3 Z_{j3+a}^{Dx,*} \kappa_{aa}^* Z_{ka}^{Dx} - g_1^2 v_2 \sum_{a=1}^3 Z_{j3+a}^{Dx,*} Z_{k3+a}^{Dx} \right. \right. \\
& - 36g_{1'}^2 v_2 \sum_{a=1}^3 Z_{j3+a}^{Dx,*} Z_{k3+a}^{Dx} + 3v_1 \lambda^* \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{k3+a}^{Dx} \kappa_{aa} \left. \right) \\
& + U_{H,i1}^* \left(- \left(36g_{1'}^2 + g_1^2 \right) v_1 \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{ka}^{Dx} + 3v_2 \lambda \sum_{a=1}^3 Z_{j3+a}^{Dx,*} \kappa_{aa}^* Z_{ka}^{Dx} + g_1^2 v_1 \sum_{a=1}^3 Z_{j3+a}^{Dx,*} Z_{k3+a}^{Dx} \right. \\
& - 54g_{1'}^2 v_1 \sum_{a=1}^3 Z_{j3+a}^{Dx,*} Z_{k3+a}^{Dx} + 3v_2 \lambda^* \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{k3+a}^{Dx} \kappa_{aa} \left. \right) \\
& + 3 \left(v s b U_{H,i5}^* \left(\sigma'^*,* \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{k3+a}^{Dx} \kappa_{aa} + \sigma \sum_{a=1}^3 Z_{j3+a}^{Dx,*} \kappa_{aa}^* Z_{ka}^{Dx} \right) \right. \\
& + U_{H,i4}^* \left(-4g_{1'}^2 Q_S v s b \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{ka}^{Dx} + v p h i \sigma \sum_{a=1}^3 Z_{j3+a}^{Dx,*} \kappa_{aa}^* Z_{ka}^{Dx} - 6g_{1'}^2 Q_S v s b \sum_{a=1}^3 Z_{j3+a}^{Dx,*} Z_{k3+a}^{Dx} \right. \\
& + v p h i \sigma'^*,* \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{k3+a}^{Dx} \kappa_{aa} \left. \right) \\
& + U_{H,i3}^* \left(4g_{1'}^2 Q_S v s \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{ka}^{Dx} - \sqrt{2} \sum_{a=1}^3 Z_{j3+a}^{Dx,*} T_{\kappa,aa}^* Z_{ka}^{Dx} + 6g_{1'}^2 Q_S v s \sum_{a=1}^3 Z_{j3+a}^{Dx,*} Z_{k3+a}^{Dx} \right. \\
& - \sqrt{2} \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{k3+a}^{Dx} T_{\kappa,aa} - 2v_s \sum_{b=1}^3 |\kappa_{bb}|^2 Z_{jb}^{Dx,*} Z_{kb}^{Dx} - 2v_s \sum_{b=1}^3 |\kappa_{bb}|^2 Z_{j3+b}^{Dx,*} Z_{k3+b}^{Dx} \left. \right) \left. \right) \quad (332)
\end{aligned}$$

$$\begin{aligned}
& \frac{i}{4} \left(-8g_{1'}^2 Q_S v s U_{H,i3}^* \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E + 8g_{1'}^2 Q_S v s b U_{H,i4}^* \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \right. \\
& + 2v_2 \lambda U_{H,i3}^* \sum_{a=1}^3 Y_{e,aa}^* Z_{j3+a}^{E,*} Z_{ka}^E - 4g_{1'}^2 Q_S v s U_{H,i3}^* \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E \\
& + 4g_{1'}^2 Q_S v s b U_{H,i4}^* \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E + 2v_2 \lambda^* U_{H,i3}^* \sum_{a=1}^3 Z_{ja}^{E,*} Y_{e,aa} Z_{k3+a}^E \left. \right)
\end{aligned}$$

$$\begin{aligned}
& + U_{H,i2}^* \left(\left(16g_{1'}^2 - g_2^2 + g_1^2 \right) v_2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \right. \\
& + 2 \left(v_s \lambda \sum_{a=1}^3 Y_{e,aa}^* Z_{j3+a}^{E,*} Z_{ka}^E - \left(-4g_{1'}^2 + g_1^2 \right) v_2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E \right. \\
& \left. \left. + v_s \lambda^* \sum_{a=1}^3 Z_{ja}^{E,*} Y_{e,aa} Z_{k3+a}^E \right) \right) \\
& + U_{H,i1}^* \left(\left(24g_{1'}^2 - g_1^2 + g_2^2 \right) v_1 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{ka}^E \right. \\
& - 2 \left(\sqrt{2} \sum_{a=1}^3 Z_{j3+a}^{E,*} T_{e,aa}^* Z_{ka}^E - \left(6g_{1'}^2 + g_1^2 \right) v_1 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E + \sqrt{2} \sum_{a=1}^3 Z_{ja}^{E,*} Z_{k3+a}^E T_{e,aa} \right. \\
& \left. \left. + 2v_1 \sum_{b=1}^3 |Y_{e,bb}|^2 Z_{jb}^{E,*} Z_{kb}^E + 2v_1 \sum_{b=1}^3 |Y_{e,bb}|^2 Z_{j3+b}^{E,*} Z_{k3+b}^E \right) \right) \Big) \tag{333}
\end{aligned}$$

$$-\frac{i}{4} \left(- \left(16g_{1'}^2 + g_1^2 + g_2^2 \right) v_2 U_{H,i2}^* + \left(-24g_{1'}^2 + g_1^2 + g_2^2 \right) v_1 U_{H,i1}^* + 8g_{1'}^2 Q_S \left(-v_s b U_{H,i4}^* + v_s U_{H,i3}^* \right) \right) \left(U_H p 0_{j1}^* U_H p 0_{k1} - U_H p 0_{j2}^* U \right. \tag{334}$$

$$-\frac{i}{4} \left(\left(-16g_{1'}^2 - g_1^2 + g_2^2 \right) v_2 U_{H,i2}^* + \left(-24g_{1'}^2 - g_2^2 + g_1^2 \right) v_1 U_{H,i1}^* + 8g_{1'}^2 Q_S \left(-v_s b U_{H,i4}^* + v_s U_{H,i3}^* \right) \right) \left(U_H p p_{j1}^* U_H p p_{k1} - U_H p p_{j2}^* U \right. \tag{335}$$

$$\begin{aligned}
& \frac{i}{12} \delta_{\beta\gamma} \left(U_{H,i1}^* \left((36g_1^2 - 3g_2^2 + g_1^2) v_1 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U + 6v_s \lambda \sum_{a=1}^3 Y_{u,aa}^* Z_{j3+a}^{U,*} Z_{ka}^U \right. \right. \\
& - 4g_1^2 v_1 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U + 36g_1^2 v_1 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U + 6v_s \lambda^* \sum_{a=1}^3 Z_{ja}^{U,*} Y_{u,aa} Z_{k3+a}^U \Big) \\
& + 6 \left(2g_1^2 Q_S v s b U_{H,i4}^* \delta_{jk} \right. \\
& + U_{H,i3}^* \left(-2g_1^2 Q_S v_s \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U + v_1 \lambda \sum_{a=1}^3 Y_{u,aa}^* Z_{j3+a}^{U,*} Z_{ka}^U - 2g_1^2 Q_S v_s \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \right. \\
& \left. \left. + v_1 \lambda^* \sum_{a=1}^3 Z_{ja}^{U,*} Y_{u,aa} Z_{k3+a}^U \right) \right) \\
& - U_{H,i2}^* \left(\left(-3(8g_1^2 + g_2^2) + g_1^2 \right) v_2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \right. \\
& + 2 \left(3\sqrt{2} \sum_{a=1}^3 Z_{j3+a}^{U,*} T_{u,aa}^* Z_{ka}^U - 2(6g_1^2 + g_1^2) v_2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U + 3\sqrt{2} \sum_{a=1}^3 Z_{ja}^{U,*} Z_{k3+a}^U T_{u,aa} \right. \\
& \left. \left. + 6v_2 \sum_{b=1}^3 |Y_{u,bb}|^2 Z_{jb}^{U,*} Z_{kb}^U + 6v_2 \sum_{b=1}^3 |Y_{u,bb}|^2 Z_{j3+b}^{U,*} Z_{k3+b}^U \right) \right) \Big) \tag{336}
\end{aligned}$$

$$\frac{i}{4} \left((16g_1'^2 + g_1^2 + g_2^2) v_2 U_{H,i2}^* - \left(-24g_1'^2 + g_1^2 + g_2^2 \right) v_1 U_{H,i1}^* + 8g_1'^2 Q_S \left(v s b U_{H,i4}^* - v_s U_{H,i3}^* \right) \right) \delta_{jk} \quad (337)$$

$$- \frac{i}{2} \frac{1}{\sqrt{2}} g_2^2 \left(v_1 U_{+,i1}^* + v_2 U_{+,i2}^* \right) \left(U H p 0_{j1}^* U H p p_{k1} + U H p 0_{j2}^* U H p p_{k2} \right) \quad (338)$$

$$\begin{aligned} & - \frac{i}{4} \delta_{\beta\gamma} \left(U_{+,i2}^* \left(\sqrt{2} g_2^2 v_2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^D \right. \right. \\ & - 2 \left(2 \sum_{a=1}^3 Z_{j3+a}^{U,*} T_{u,aa}^* Z_{ka}^D \right. \\ & + \sqrt{2} \left(v_1 \sum_{b=1}^3 Y_{u,bb}^* Z_{j3+b}^{U,*} Y_{d,bb} Z_{k3+b}^D + v_2 \sum_{b=1}^3 |Y_{u,bb}|^2 Z_{jb}^{U,*} Z_{kb}^D + v_s \lambda^* \sum_{a=1}^3 Z_{ja}^{U,*} Y_{d,aa} Z_{k3+a}^D \right) \Big) \Big) \\ & + U_{+,i1}^* \left(\sqrt{2} g_2^2 v_1 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^D \right. \\ & - 2 \left(\sqrt{2} v_s \lambda \sum_{a=1}^3 Y_{u,aa}^* Z_{j3+a}^{U,*} Z_{ka}^D + 2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{k3+a}^D T_{d,aa} \right. \\ & \left. \left. \left. + \sqrt{2} \left(v_1 \sum_{b=1}^3 |Y_{d,bb}|^2 Z_{jb}^{U,*} Z_{kb}^D + v_2 \sum_{b=1}^3 Y_{u,bb}^* Z_{j3+b}^{U,*} Y_{d,bb} Z_{k3+b}^D \right) \right) \right) \right) \Big) \end{aligned} \quad (339)$$

$$\begin{aligned}
& \frac{i}{4} \left(\sqrt{2} U_{+,i2}^* \left(2v_s \lambda^* \sum_{a=1}^3 Z_{ja}^{V,*} Y_{e,aa} Z_{k3+a}^E - g_2^2 v_2 \sum_{a=1}^3 Z_{ja}^{V,*} Z_{ka}^E \right) \right. \\
& \left. + U_{+,i1}^* \left(2\sqrt{2} v_1 \sum_{b=1}^3 |Y_{e,bb}|^2 Z_{jb}^{V,*} Z_{kb}^E + 4 \sum_{a=1}^3 Z_{ja}^{V,*} Z_{k3+a}^E T_{e,aa} - \sqrt{2} g_2^2 v_1 \sum_{a=1}^3 Z_{ja}^{V,*} Z_{ka}^E \right) \right) \quad (340)
\end{aligned}$$

$$\begin{aligned}
& -\frac{i}{4} \delta_{\alpha\gamma} \left(\sqrt{2} g_2^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^U \left(v_1 U_{+,j1} + v_2 U_{+,j2} \right) \right. \\
& - 2 \left(2 \sum_{a=1}^3 Z_{i3+a}^{D,*} T_{d,aa}^* Z_{ka}^U U_{+,j1} + \sqrt{2} v_s \lambda^* \sum_{a=1}^3 Z_{ia}^{D,*} Y_{u,aa} Z_{k3+a}^U U_{+,j1} \right. \\
& + \sqrt{2} v_1 \sum_{b=1}^3 |Y_{d,bb}|^2 Z_{ib}^{D,*} Z_{kb}^U U_{+,j1} + \sqrt{2} v_2 \sum_{b=1}^3 Y_{d,bb}^* Z_{i3+b}^{D,*} Y_{u,bb} Z_{k3+b}^U U_{+,j1} \\
& + \sqrt{2} v_s \lambda \sum_{a=1}^3 Y_{d,aa}^* Z_{i3+a}^{D,*} Z_{ka}^U U_{+,j2} + 2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{k3+a}^U T_{u,aa} U_{+,j2} \\
& \left. \left. + \sqrt{2} v_2 \sum_{b=1}^3 |Y_{u,bb}|^2 Z_{ib}^{D,*} Z_{kb}^U U_{+,j2} + \sqrt{2} v_1 \sum_{b=1}^3 Y_{d,bb}^* Z_{i3+b}^{D,*} Y_{u,bb} Z_{k3+b}^U U_{+,j2} \right) \right) \quad (341)
\end{aligned}$$

$$\begin{aligned}
& \frac{i}{4} \left(-\sqrt{2}g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^V (v_1 U_{+,j1} + v_2 U_{+,j2}) \right. \\
& + 2 \left(2 \sum_{a=1}^3 Z_{i3+a}^{E,*} T_{e,aa}^* Z_{ka}^V U_{+,j1} \right. \\
& \left. \left. + \sqrt{2} \left(v_1 \sum_{b=1}^3 |Y_{e,bb}|^2 Z_{ib}^{E,*} Z_{kb}^V U_{+,j1} + v_s \lambda \sum_{a=1}^3 Y_{e,aa}^* Z_{i3+a}^{E,*} Z_{ka}^V U_{+,j2} \right) \right) \right) \quad (342)
\end{aligned}$$

$$- \frac{i}{2} \frac{1}{\sqrt{2}} g_2^2 \left(U H p p_{i1}^* U H p 0_{k1} + U H p p_{i2}^* U H p 0_{k2} \right) (v_1 U_{+,j1} + v_2 U_{+,j2}) \quad (343)$$

9.2 Two Scalar-One Vector Boson-Interaction

$$\begin{aligned}
& \frac{1}{2} \left(U_{H,j1}^* \left(-6g'_1 \sin \Theta'_W + g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right) U_{A,i1} \right. \\
& - U_{H,j2}^* \left(4g'_1 \sin \Theta'_W + g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right) U_{A,i2} \\
& \left. + 2g'_1 Q_S \sin \Theta'_W \left(U_{H,j3}^* U_{A,i3} - U_{H,j4}^* U_{A,i4} \right) \right) \left(-p_\mu^{h_j} + p_\mu^{A_i^0} \right)
\end{aligned} \tag{344}$$

$$\begin{aligned}
& \frac{1}{2} \left(-U_{H,j1}^* \left(6g'_1 \cos \Theta'_W + \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) U_{A,i1} \right. \\
& - U_{H,j2}^* \left(4g'_1 \cos \Theta'_W - \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) U_{A,i2} \\
& \left. - 2g'_1 Q_S \cos \Theta'_W \left(-U_{H,j3}^* U_{A,i3} + U_{H,j4}^* U_{A,i4} \right) \right) \left(-p_\mu^{h_j} + p_\mu^{A_i^0} \right)
\end{aligned} \tag{345}$$

$$\frac{1}{2} g_2 \left(U_{+,j1}^* U_{A,i1} + U_{+,j2}^* U_{A,i2} \right) \left(-p_\mu^{H_j^-} + p_\mu^{A_i^0} \right) \tag{346}$$

$$\frac{1}{2}g_2\left(U_{A,i1}U_{+,j1}+U_{A,i2}U_{+,j2}\right)\left(-p_\mu^{H_j^+}+p_\mu^{A_i^0}\right) \quad (347)$$

$$\frac{i}{2}g_2\left(U_{H,i1}^*U_{+,j1}^*-U_{H,i2}^*U_{+,j2}^*\right)\left(-p_\mu^{H_j^-}+p_\mu^{h_i}\right) \quad (348)$$

$$-\frac{i}{2}g_2\left(U_{H,i1}^*U_{+,j1}-U_{H,i2}^*U_{+,j2}\right)\left(-p_\mu^{H_j^+}+p_\mu^{h_i}\right) \quad (349)$$

$$\frac{i}{2}\delta_{ij}\left(g_1\cos\Theta_W+g_2\sin\Theta_W\right)\left(-p_\mu^{H_j^+}+p_\mu^{H_i^-}\right) \quad (350)$$

$$\begin{aligned}
& \frac{i}{2} \left(U_{+,i1}^* \left(6g'_1 \sin \Theta'_W - g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right) U_{+,j1} \right. \\
& \left. + U_{+,i2}^* \left(-4g'_1 \sin \Theta'_W - g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right) U_{+,j2} \right) \left(-p_\mu^{H_j^+} + p_\mu^{H_i^-} \right)
\end{aligned} \tag{351}$$

$$\begin{aligned}
& \frac{i}{2} \left(U_{+,i1}^* \left(6g'_1 \cos \Theta'_W + \left(g_1 \sin \Theta_W - g_2 \cos \Theta_W \right) \sin \Theta'_W \right) U_{+,j1} \right. \\
& \left. + U_{+,i2}^* \left(-4g'_1 \cos \Theta'_W + \left(g_1 \sin \Theta_W - g_2 \cos \Theta_W \right) \sin \Theta'_W \right) U_{+,j2} \right) \left(-p_\mu^{H_j^+} + p_\mu^{H_i^-} \right)
\end{aligned} \tag{352}$$

$$-\frac{i}{2} g_3 \delta_{ij} \lambda_{\beta,\alpha}^\gamma \left(-p_\mu^{\tilde{d}_{j\beta}^*} + p_\mu^{\tilde{d}_{i\alpha}} \right) \tag{353}$$

$$-\frac{i}{6}\delta_{\alpha\beta}\left(-2g_1\cos\Theta_W\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{j3+a}^D+\left(-3g_2\sin\Theta_W+g_1\cos\Theta_W\right)\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^D\right)\left(-p_\mu^{\tilde{d}_{j\beta}^*}+p_\mu^{\tilde{d}_{i\alpha}}\right) \quad (354)$$

$$\begin{aligned} &\frac{i}{6}\delta_{\alpha\beta}\left(\left(3g_2\cos\Theta_W\cos\Theta'_W-6g'_1\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\right)\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^D\right. \\ &\quad \left.-2\left(-6g'_1\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\right)\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{j3+a}^D\right)\left(-p_\mu^{\tilde{d}_{j\beta}^*}+p_\mu^{\tilde{d}_{i\alpha}}\right) \end{aligned} \quad (355)$$

$$-\frac{i}{6}\delta_{\alpha\beta}\left(\left(\left(3g_2\cos\Theta_W+g_1\sin\Theta_W\right)\sin\Theta'_W+6g'_1\cos\Theta'_W\right)\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^D\right.$$

$$-2\left(6g'_1\cos\Theta'_W+g_1\sin\Theta_W\sin\Theta'_W\right)\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{j3+a}^D\left(-p_\mu^{\tilde{d}_{j\beta}^*}+p_\mu^{\tilde{d}_{i\alpha}}\right) \quad (356)$$

$$-i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^3Z_{ia}^{D,*}Z_{ja}^U\left(-p_\mu^{\tilde{u}_{j\beta}^*}+p_\mu^{\tilde{d}_{i\alpha}}\right) \quad (357)$$

$$-\frac{i}{2}g_3\delta_{ij}\lambda_{\beta,\alpha}^\gamma\left(-p_\mu^{\tilde{x}_{j\beta}^*}+p_\mu^{\tilde{x}_{i\alpha}}\right) \quad (358)$$

$$\frac{i}{3}g_1\cos\Theta_W\delta_{\alpha\beta}\delta_{ij}\left(-p_\mu^{\tilde{x}_{j\beta}^*}+p_\mu^{\tilde{x}_{i\alpha}}\right) \quad (359)$$

$$\begin{aligned}
& -\frac{i}{3}\delta_{\alpha\beta}\left(\left(-6g'_1\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\right)\sum_{a=1}^3Z_{ia}^{Dx,*}Z_{ja}^{Dx}\right. \\
& \left.+ \left(9g'_1\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\right)\sum_{a=1}^3Z_{i3+a}^{Dx,*}Z_{j3+a}^{Dx}\right)\left(-p_\mu^{\tilde{x}_{j\beta}^*}+p_\mu^{\tilde{x}_{i\alpha}}\right)
\end{aligned} \tag{360}$$

$$\begin{aligned}
& \frac{i}{3}\delta_{\alpha\beta}\left(\left(6g'_1\cos\Theta'_W+g_1\sin\Theta_W\sin\Theta'_W\right)\sum_{a=1}^3Z_{ia}^{Dx,*}Z_{ja}^{Dx}\right. \\
& \left.+ \left(-9g'_1\cos\Theta'_W+g_1\sin\Theta_W\sin\Theta'_W\right)\sum_{a=1}^3Z_{i3+a}^{Dx,*}Z_{j3+a}^{Dx}\right)\left(-p_\mu^{\tilde{x}_{j\beta}^*}+p_\mu^{\tilde{x}_{i\alpha}}\right)
\end{aligned} \tag{361}$$

$$\frac{i}{2} \left(2g_1 \cos \Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E + \left(g_1 \cos \Theta_W + g_2 \sin \Theta_W \right) \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right) \left(-p_\mu^{\tilde{e}_j^*} + p_\mu^{\tilde{e}_i} \right) \quad (362)$$

$$\begin{aligned} & \frac{i}{2} \left(\left(-4g'_1 \sin \Theta'_W - g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right) \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right. \\ & \left. + 2 \left(-g_1 \cos \Theta'_W \sin \Theta_W + g'_1 \sin \Theta'_W \right) \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \right) \left(-p_\mu^{\tilde{e}_j^*} + p_\mu^{\tilde{e}_i} \right) \end{aligned} \quad (363)$$

$$\begin{aligned} & -\frac{i}{2} \left(\left(4g'_1 \cos \Theta'_W + \left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right. \\ & \left. - 2 \left(g'_1 \cos \Theta'_W + g_1 \sin \Theta_W \sin \Theta'_W \right) \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \right) \left(-p_\mu^{\tilde{e}_j^*} + p_\mu^{\tilde{e}_i} \right) \end{aligned} \quad (364)$$

$$-i \frac{1}{\sqrt{2}} g_2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^V \left(-p_{\mu}^{\tilde{\nu}_j^*} + p_{\mu}^{\tilde{e}_i} \right) \quad (365)$$

$$-i \frac{1}{\sqrt{2}} g_2 \left(U H p 0_{i1}^* U H p p_{j1} - U H p 0_{i2}^* U H p p_{j2} \right) \left(-p_{\mu}^{H_j'^+} + p_{\mu}^{H_i'^0} \right) \quad (366)$$

$$-\frac{i}{2} \delta_{ij} \left(4g_1' \sin \Theta_W' + g_1 \cos \Theta_W' \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta_W' \right) \left(-p_{\mu}^{H_j'^{0,*}} + p_{\mu}^{H_i'^0} \right) \quad (367)$$

$$-\frac{i}{2}\delta_{ij}\left(4g'_1\cos\Theta'_W-(g_1\sin\Theta_W+g_2\cos\Theta_W)\sin\Theta'_W\right)\left(-p_\mu^{H_j'^{0,*}}+p_\mu^{H_i'^0}\right) \quad (368)$$

$$\frac{i}{2}\delta_{ij}\left(g_1\cos\Theta_W+g_2\sin\Theta_W\right)\left(-p_\mu^{H_j'^+}+p_\mu^{H_i'^-}\right) \quad (369)$$

$$\frac{i}{2}\delta_{ij}\left(-4g'_1\sin\Theta'_W-g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\right)\left(-p_\mu^{H_j'^+}+p_\mu^{H_i'^-}\right) \quad (370)$$

$$-\frac{i}{2}\delta_{ij}\left(4g'_1\cos\Theta'_W+\left(-g_1\sin\Theta_W+g_2\cos\Theta_W\right)\sin\Theta'_W\right)\left(-p_\mu^{H_j'^+}+p_\mu^{H_i'^-}\right) \quad (371)$$

$$-i\frac{1}{\sqrt{2}}g_2\left(UHp p_{i1}^*UHp0_{j1}-UHp p_{i2}^*UHp0_{j2}\right)\left(-p_\mu^{H_j'^{0,*}}+p_\mu^{H_i'^-}\right) \quad (372)$$

$$-\frac{i}{2}g_3\delta_{ij}\lambda_{\beta,\alpha}^\gamma\left(-p_\mu^{\tilde{u}_{j\beta}^*}+p_\mu^{\tilde{u}_{i\alpha}}\right) \quad (373)$$

$$-\frac{i}{6}\delta_{\alpha\beta}\left(\left(3g_2\sin\Theta_W+g_1\cos\Theta_W\right)\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^U+4g_1\cos\Theta_W\sum_{a=1}^3Z_{i3+a}^{U,*}Z_{j3+a}^U\right)\left(-p_\mu^{\tilde{u}_{j\beta}^*}+p_\mu^{\tilde{u}_{i\alpha}}\right) \quad (374)$$

$$-i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^D\left(-p_\mu^{\tilde{d}_{j\beta}^*}+p_\mu^{\tilde{u}_{i\alpha}}\right) \quad (375)$$

$$\begin{aligned} &-\frac{i}{6}\delta_{\alpha\beta}\left(\left(3g_2\cos\Theta_W\cos\Theta'_W+6g'_1\sin\Theta'_W-g_1\cos\Theta'_W\sin\Theta_W\right)\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^U\right. \\ &\left.-2\left(2g_1\cos\Theta'_W\sin\Theta_W+3g'_1\sin\Theta'_W\right)\sum_{a=1}^3Z_{i3+a}^{U,*}Z_{j3+a}^U\right)\left(-p_\mu^{\tilde{u}_{j\beta}^*}+p_\mu^{\tilde{u}_{i\alpha}}\right) \end{aligned} \quad (376)$$

$$\begin{aligned}
& -\frac{i}{6}\delta_{\alpha\beta}\left(\left(\left(-3g_2\cos\Theta_W+g_1\sin\Theta_W\right)\sin\Theta'_W+6g'_1\cos\Theta'_W\right)\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^U\right. \\
& \left.+2\left(2g_1\sin\Theta_W\sin\Theta'_W-3g'_1\cos\Theta'_W\right)\sum_{a=1}^3Z_{i3+a}^{U,*}Z_{j3+a}^U\right)\left(-p_\mu^{\tilde{u}_{j\beta}^*}+p_\mu^{\tilde{u}_{i\alpha}}\right)
\end{aligned} \tag{377}$$

$$-i\frac{1}{\sqrt{2}}g_2\sum_{a=1}^3Z_{ia}^{V,*}Z_{ja}^E\left(-p_\mu^{\tilde{e}_j^*}+p_\mu^{\tilde{\nu}_i}\right) \tag{378}$$

$$-\frac{i}{2}\delta_{ij}\left(4g'_1\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\right)\left(-p_\mu^{\tilde{\nu}_j^*}+p_\mu^{\tilde{\nu}_i}\right) \tag{379}$$

$$-\frac{i}{2}\delta_{ij}\left(4g'_1\cos\Theta'_W-\left(g_1\sin\Theta_W+g_2\cos\Theta_W\right)\sin\Theta'_W\right)\left(-p_\mu^{\tilde{\nu}_j^*}+p_\mu^{\tilde{\nu}_i}\right) \quad (380)$$

9.3 One Scalar-Two Vector Boson-Interaction

$$\frac{i}{2}g_2^2\left(v_1U_{H,i1}^*+v_2U_{H,i2}^*\right)\left(g_{\sigma\mu}\right) \quad (381)$$

$$\begin{aligned} & \frac{i}{2}\left(4g_1^2Q_S^2\left(vsbU_{H,i4}^*+v_sU_{H,i3}^*\right)\sin\Theta'^2_W\right. \\ & +v_1U_{H,i1}^*\left(-6g'_1\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\right)^2 \\ & \left.+v_2U_{H,i2}^*\left(4g'_1\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\right)^2\right)\left(g_{\sigma\mu}\right) \end{aligned} \quad (382)$$

$$\begin{aligned}
& \frac{i}{2} \left(-v_1 U_{H,i1}^* \left(6g_1 g_1' \cos \Theta_W'^2 \sin \Theta_W + g_2^2 \cos \Theta_W'^2 \cos \Theta_W' \sin \Theta_W' \right. \right. \\
& + \cos \Theta_W' \left(-36g_1'^2 + g_1^2 \sin \Theta_W'^2 \right) \sin \Theta_W' - 6g_1 g_1' \sin \Theta_W \sin \Theta_W'^2 \\
& + 2g_2 \cos \Theta_W \left(3g_1' \cos \Theta_W'^2 - 3g_1' \sin \Theta_W'^2 + g_1 \cos \Theta_W' \sin \Theta_W \sin \Theta_W' \right) \Big) \\
& + 2g_1'^2 Q_S^2 \left(v_{sb} U_{H,i4}^* + v_s U_{H,i3}^* \right) \sin 2\Theta_W' \\
& - v_2 U_{H,i2}^* \left(-4g_1 g_1' \cos \Theta_W'^2 \sin \Theta_W + g_2^2 \cos \Theta_W'^2 \cos \Theta_W' \sin \Theta_W' \right. \\
& + g_1^2 \cos \Theta_W' \sin \Theta_W'^2 \sin \Theta_W' \\
& + 2g_2 \cos \Theta_W \left(-2g_1' \cos \Theta_W'^2 + 2g_1' \sin \Theta_W'^2 + g_1 \cos \Theta_W' \sin \Theta_W \sin \Theta_W' \right) \\
& \left. \left. + 4g_1' \left(-2g_1' \sin 2\Theta_W' + g_1 \sin \Theta_W \sin \Theta_W'^2 \right) \right) \right) (g_{\sigma\mu}) \tag{383}
\end{aligned}$$

$$\begin{aligned}
& \frac{i}{2} \left(4g_1'^2 Q_S^2 \left(v_{sb} U_{H,i4}^* + v_s U_{H,i3}^* \right) \cos \Theta_W'^2 \right. \\
& + v_2 U_{H,i2}^* \left(-4g_1' \cos \Theta_W' + \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta_W' \right)^2 \\
& \left. + v_1 U_{H,i1}^* \left(6g_1' \cos \Theta_W' + \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta_W' \right)^2 \right) (g_{\sigma\mu}) \tag{384}
\end{aligned}$$

$$-\frac{i}{2}g_1g_2\left(v_1U_{+,i1}^*-v_2U_{+,i2}^*\right)\cos\Theta_W\left(g_{\sigma\mu}\right) \quad (385)$$

$$\begin{aligned} &\frac{i}{2}g_2\left(v_1U_{+,i1}^*\left(-6g_1'\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\right)\right. \\ &\left.-v_2U_{+,i2}^*\left(4g_1'\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\right)\right)\left(g_{\sigma\mu}\right) \end{aligned} \quad (386)$$

$$\begin{aligned} &-\frac{i}{2}g_2\left(v_2U_{+,i2}^*\left(4g_1'\cos\Theta'_W-g_1\sin\Theta_W\sin\Theta'_W\right)\right. \\ &\left.+v_1U_{+,i1}^*\left(6g_1'\cos\Theta'_W+g_1\sin\Theta_W\sin\Theta'_W\right)\right)\left(g_{\sigma\mu}\right) \end{aligned} \quad (387)$$

$$-\frac{i}{2}g_1g_2\cos\Theta_W\left(v_1U_{+,i1}-v_2U_{+,i2}\right)\left(g_{\sigma\mu}\right) \quad (388)$$

$$\begin{aligned} &\frac{i}{2}g_2\left(v_1\left(-6g'_1\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\right)U_{+,i1}\right. \\ &\left.-v_2\left(4g'_1\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\right)U_{+,i2}\right)\left(g_{\sigma\mu}\right) \end{aligned} \quad (389)$$

$$\begin{aligned} &-\frac{i}{2}g_2\left(v_1\left(6g'_1\cos\Theta'_W+g_1\sin\Theta_W\sin\Theta'_W\right)U_{+,i1}\right. \\ &\left.+v_2\left(4g'_1\cos\Theta'_W-g_1\sin\Theta_W\sin\Theta'_W\right)U_{+,i2}\right)\left(g_{\sigma\mu}\right) \end{aligned} \quad (390)$$

9.4 Two Fermion-One Vector Boson-Interaction

$$-\frac{i}{2}g_2\left(2U_{j1}^*N_{i2}+\sqrt{2}U_{j2}^*N_{i3}\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (391)$$

$$+\frac{i}{2}g_2\left(2N_{i2}^*V_{j1}-\sqrt{2}N_{i4}^*V_{j2}\right)\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (392)$$

$$\frac{i}{2}\left(2g_2U_{j1}^*\sin\Theta_W U_{i1}+U_{j2}^*\left(g_1\cos\Theta_W+g_2\sin\Theta_W\right)U_{i2}\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (393)$$

$$+\frac{i}{2}\left(2g_2V_{i1}^*\sin\Theta_W V_{j1}+V_{i2}^*\left(g_1\cos\Theta_W+g_2\sin\Theta_W\right)V_{j2}\right)\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (394)$$

$$\begin{aligned} & \frac{i}{2} \left(2g_2 U_{j1}^* \cos \Theta_W \cos \Theta'_W U_{i1} \right. \\ & \left. + U_{j2}^* \left(6g'_1 \sin \Theta'_W - g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right) U_{i2} \right) \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \end{aligned} \quad (395)$$

$$\begin{aligned} & + \frac{i}{2} \left(2g_2 V_{i1}^* \cos \Theta_W \cos \Theta'_W V_{j1} \right. \\ & \left. + V_{i2}^* \left(-4g'_1 \sin \Theta'_W - g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right) V_{j2} \right) \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \end{aligned} \quad (396)$$

$$\begin{aligned} & - \frac{i}{2} \left(2g_2 U_{j1}^* \cos \Theta_W \sin \Theta'_W U_{i1} \right. \\ & \left. + U_{j2}^* \left(-6g'_1 \cos \Theta'_W + \left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) U_{i2} \right) \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \end{aligned} \quad (397)$$

$$\begin{aligned} & + - \frac{i}{2} \left(2g_2 V_{i1}^* \cos \Theta_W \sin \Theta'_W V_{j1} \right. \\ & \left. + V_{i2}^* \left(4g'_1 \cos \Theta'_W + \left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) V_{j2} \right) \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \end{aligned} \quad (398)$$

$$- i \frac{1}{\sqrt{2}} g_2 Z N p_{i1} \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (399)$$

$$+ i \frac{1}{\sqrt{2}} g_2 Z N p_{i2}^* \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (400)$$

$$\frac{i}{2} \left(g_1 \cos \Theta_W + g_2 \sin \Theta_W \right) \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (401)$$

$$+ \frac{i}{2} \left(g_1 \cos \Theta_W + g_2 \sin \Theta_W \right) \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (402)$$

$$\frac{i}{2} \left(-4g'_1 \sin \Theta'_W - g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right) \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (403)$$

$$+ \frac{i}{2} \left(-4g'_1 \sin \Theta'_W - g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right) \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (404)$$

$$- \frac{i}{2} \left(4g'_1 \cos \Theta'_W + \left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (405)$$

$$+ - \frac{i}{2} \left(4g'_1 \cos \Theta'_W + \left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (406)$$

$$\begin{aligned}
& -\frac{i}{2} \left(N_{j3}^* \left(-6g'_1 \sin \Theta'_W + g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right) N_{i3} \right. \\
& - N_{j4}^* \left(4g'_1 \sin \Theta'_W + g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right) N_{i4} \\
& + 2g'_1 Q_S \sin \Theta'_W \left(N_{j5}^* N_{i5} - N_{j6}^* N_{i6} \right) \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \Big) \quad (407)
\end{aligned}$$

$$\begin{aligned}
& + \frac{i}{2} \left(N_{i3}^* \left(-6g'_1 \sin \Theta'_W + g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right) N_{j3} \right. \\
& - N_{i4}^* \left(4g'_1 \sin \Theta'_W + g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right) N_{j4} \\
& + 2g'_1 Q_S \sin \Theta'_W \left(N_{i5}^* N_{j5} - N_{i6}^* N_{j6} \right) \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \Big) \quad (408)
\end{aligned}$$

$$\begin{aligned}
& \frac{i}{2} \left(N_{j3}^* \left(6g'_1 \cos \Theta'_W + \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) N_{i3} \right. \\
& + N_{j4}^* \left(4g'_1 \cos \Theta'_W - \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) N_{i4} \\
& + 2g'_1 Q_S \cos \Theta'_W \left(-N_{j5}^* N_{i5} + N_{j6}^* N_{i6} \right) \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \Big) \quad (409)
\end{aligned}$$

$$\begin{aligned}
& + \frac{i}{2} \left(N_{i3}^* \left(6g'_1 \cos \Theta'_W + \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) N_{j3} \right. \\
& + N_{i4}^* \left(4g'_1 \cos \Theta'_W - \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) N_{j4} \\
& + 2g'_1 Q_S \cos \Theta'_W \left(-N_{i5}^* N_{j5} + N_{i6}^* N_{j6} \right) \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \Big) \quad (410)
\end{aligned}$$

$$-\frac{i}{2}g_2\left(2N_{j2}^*U_{i1}+\sqrt{2}N_{j3}^*U_{i2}\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (411)$$

$$+\frac{i}{2}g_2\left(2V_{i1}^*N_{j2}-\sqrt{2}V_{i2}^*N_{j4}\right)\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (412)$$

$$-\frac{i}{2}\left(4g_1'\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\right)\left(ZNp_{j1}^*ZNp_{i1}-ZNp_{j2}^*ZNp_{i2}\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (413)$$

$$+\frac{i}{2}\left(4g_1'\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\right)\left(ZNp_{i1}^*ZNp_{j1}-ZNp_{i2}^*ZNp_{j2}\right)\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (414)$$

$$\frac{i}{4}\left(2\left(g_1\sin\Theta_W+g_2\cos\Theta_W\right)\sin\Theta'_W-8g_1'\cos\Theta'_W\right)\left(ZNp_{j1}^*ZNp_{i1}-ZNp_{j2}^*ZNp_{i2}\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (415)$$

$$+\frac{i}{2}\left(4g_1'\cos\Theta'_W-\left(g_1\sin\Theta_W+g_2\cos\Theta_W\right)\sin\Theta'_W\right)\left(ZNp_{i1}^*ZNp_{j1}-ZNp_{i2}^*ZNp_{j2}\right)\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (416)$$

$$-i \frac{1}{\sqrt{2}} g_2 Z N p_{j1}^* \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (417)$$

$$+ i \frac{1}{\sqrt{2}} g_2 Z N p_{j2} \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (418)$$

$$- \frac{i}{2} g_3 \delta_{ij} \lambda_{\alpha,\beta}^\gamma \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (419)$$

$$+ - \frac{i}{2} g_3 \delta_{ij} \lambda_{\alpha,\beta}^\gamma \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (420)$$

$$- \frac{i}{6} \delta_{\alpha\beta} \delta_{ij} \left(-3g_2 \sin \Theta_W + g_1 \cos \Theta_W \right) \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (421)$$

$$+ \frac{i}{3} g_1 \cos \Theta_W \delta_{\alpha\beta} \delta_{ij} \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (422)$$

$$\frac{i}{6} \delta_{\alpha\beta} \delta_{ij} \left(3g_2 \cos \Theta_W \cos \Theta'_W - 6g'_1 \sin \Theta'_W + g_1 \cos \Theta'_W \sin \Theta_W \right) \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (423)$$

$$+ -\frac{i}{3} \delta_{\alpha\beta} \delta_{ij} \left(-6g'_1 \sin \Theta'_W + g_1 \cos \Theta'_W \sin \Theta_W \right) \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (424)$$

$$- \frac{i}{6} \delta_{\alpha\beta} \delta_{ij} \left(\left(3g_2 \cos \Theta_W + g_1 \sin \Theta_W \right) \sin \Theta'_W + 6g'_1 \cos \Theta'_W \right) \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (425)$$

$$+ \frac{i}{3} \delta_{\alpha\beta} \delta_{ij} \left(6g'_1 \cos \Theta'_W + g_1 \sin \Theta_W \sin \Theta'_W \right) \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (426)$$

$$-i \frac{1}{\sqrt{2}} g_2 \delta_{\alpha\beta} \sum_{a=1}^3 U_{L,ja}^{d,*} U_{L,ia}^u \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (427)$$

$$- \frac{i}{2} g_3 \delta_{ij} \lambda_{\alpha,\beta}^\gamma \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (428)$$

$$+ - \frac{i}{2} g_3 \delta_{ij} \lambda_{\alpha,\beta}^\gamma \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (429)$$

$$\frac{i}{3} g_1 \cos \Theta_W \delta_{\alpha\beta} \delta_{ij} \left(\gamma_\mu \cdot \frac{1 - \gamma_5}{2} \right) \quad (430)$$

$$+ \frac{i}{3} g_1 \cos \Theta_W \delta_{\alpha\beta} \delta_{ij} \left(\gamma_\mu \cdot \frac{1 + \gamma_5}{2} \right) \quad (431)$$

$$-\frac{i}{3}\delta_{\alpha\beta}\delta_{ij}\left(-6g'_1\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (432)$$

$$+\frac{i}{3}\delta_{\alpha\beta}\delta_{ij}\left(9g'_1\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W\right)\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (433)$$

$$\frac{i}{3}\delta_{\alpha\beta}\delta_{ij}\left(6g'_1\cos\Theta'_W+g_1\sin\Theta_W\sin\Theta'_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (434)$$

$$+\frac{i}{3}\delta_{\alpha\beta}\delta_{ij}\left(9g'_1\cos\Theta'_W-g_1\sin\Theta_W\sin\Theta'_W\right)\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (435)$$

$$\frac{i}{2}\delta_{ij}\left(g_1\cos\Theta_W+g_2\sin\Theta_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (436)$$

$$+ig_1\cos\Theta_W\delta_{ij}\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (437)$$

$$\frac{i}{2}\delta_{ij}\left(-4g'_1\sin\Theta'_W - g_1\cos\Theta'_W\sin\Theta_W + g_2\cos\Theta_W\cos\Theta'_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (438)$$

$$+ -i\delta_{ij}\left(g_1\cos\Theta'_W\sin\Theta_W - g'_1\sin\Theta'_W\right)\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (439)$$

$$- \frac{i}{2}\delta_{ij}\left(4g'_1\cos\Theta'_W + \left(-g_1\sin\Theta_W + g_2\cos\Theta_W\right)\sin\Theta'_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (440)$$

$$+ i\delta_{ij}\left(g'_1\cos\Theta'_W + g_1\sin\Theta_W\sin\Theta'_W\right)\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (441)$$

$$- i\frac{1}{\sqrt{2}}g_2U_{L,ji}^{e,*}\Theta_{i,3}\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (442)$$

$$-\frac{i}{2}g_3\delta_{ij}\lambda_{\alpha,\beta}^\gamma\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (443)$$

$$+\frac{i}{2}g_3\delta_{ij}\lambda_{\alpha,\beta}^\gamma\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (444)$$

$$-\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(3g_2\sin\Theta_W+g_1\cos\Theta_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (445)$$

$$+\frac{2i}{3}g_1\cos\Theta_W\delta_{\alpha\beta}\delta_{ij}\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (446)$$

$$-i\frac{1}{\sqrt{2}}g_2\delta_{\alpha\beta}\sum_{a=1}^3U_{L,ja}^{u,*}U_{L,ia}^d\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (447)$$

$$-\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(3g_2\cos\Theta_W\cos\Theta'_W+6g'_1\sin\Theta'_W-g_1\cos\Theta'_W\sin\Theta_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (448)$$

$$+\frac{i}{3}\delta_{\alpha\beta}\delta_{ij}\left(2g_1\cos\Theta'_W\sin\Theta_W+3g'_1\sin\Theta'_W\right)\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (449)$$

$$-\frac{i}{6}\delta_{\alpha\beta}\delta_{ij}\left(\left(-3g_2\cos\Theta_W+g_1\sin\Theta_W\right)\sin\Theta'_W+6g'_1\cos\Theta'_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (450)$$

$$+\frac{i}{3}\delta_{\alpha\beta}\delta_{ij}\left(-2g_1\sin\Theta_W\sin\Theta'_W+3g'_1\cos\Theta'_W\right)\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (451)$$

$$-i\frac{1}{\sqrt{2}}g_2\Theta_{j,3}U_{L,ij}^e\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (452)$$

$$-\frac{i}{2}\delta_{ij}\left(4g'_1\sin\Theta'_W+g_1\cos\Theta'_W\sin\Theta_W+g_2\cos\Theta_W\cos\Theta'_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (453)$$

$$-\frac{i}{2}\delta_{ij}\left(4g'_1\cos\Theta'_W-\left(g_1\sin\Theta_W+g_2\cos\Theta_W\right)\sin\Theta'_W\right)\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (454)$$

$$-g_3|\phi_{\tilde{g}}|^2f_{\alpha,\beta,\gamma}\left(\gamma_\mu\cdot\frac{1-\gamma_5}{2}\right) \quad (455)$$

$$+ -g_3|\phi_{\tilde{g}}|^2f_{\alpha,\beta,\gamma}\left(\gamma_\mu\cdot\frac{1+\gamma_5}{2}\right) \quad (456)$$

9.5 Two Fermion-One Scalar Boson-Interaction

$$- \frac{1}{\sqrt{2}} \left(g_2 U_{j1}^* V_{i2}^* U_{A,k2} + U_{j2}^* \left(g_2 V_{i1}^* U_{A,k1} - \lambda V_{i2}^* U_{A,k3} \right) \right) \left(\frac{1 - \gamma_5}{2} \right) \quad (457)$$

$$+ \frac{1}{\sqrt{2}} \left(g_2 U_{i1} V_{j2} U_{A,k2} + U_{i2} \left(g_2 V_{j1} U_{A,k1} - \lambda^* V_{j2} U_{A,k3} \right) \right) \left(\frac{1 + \gamma_5}{2} \right) \quad (458)$$

$$\begin{aligned} & \frac{1}{2} \left(-g_2 N_{i2}^* N_{j3}^* U_{A,k1} + 6g_1' N_{i8}^* N_{j3}^* U_{A,k1} - \sqrt{2} \lambda N_{i5}^* N_{j4}^* U_{A,k1} - \sqrt{2} \lambda N_{i4}^* N_{j5}^* U_{A,k1} \right. \\ & - g_1 N_{i4}^* N_{j1}^* U_{A,k2} + g_2 N_{i4}^* N_{j2}^* U_{A,k2} - \sqrt{2} \lambda N_{i5}^* N_{j3}^* U_{A,k2} + g_2 N_{i2}^* N_{j4}^* U_{A,k2} \\ & + 4g_1' N_{i8}^* N_{j4}^* U_{A,k2} + 4g_1' N_{i4}^* N_{j8}^* U_{A,k2} - N_{i1}^* \left(-g_1 N_{j3}^* U_{A,k1} + g_1 N_{j4}^* U_{A,k2} \right) \\ & - \sqrt{2} \lambda N_{i4}^* N_{j3}^* U_{A,k3} - 2g_1' Q_S N_{i8}^* N_{j5}^* U_{A,k3} - \sqrt{2} \sigma N_{i7}^* N_{j6}^* U_{A,k3} \\ & - \sqrt{2} \sigma N_{i6}^* N_{j7}^* U_{A,k3} - 2g_1' Q_S N_{i5}^* N_{j8}^* U_{A,k3} \\ & - N_{i3}^* \left(-6g_1' N_{j8}^* U_{A,k1} - g_1 N_{j1}^* U_{A,k1} + g_2 N_{j2}^* U_{A,k1} + \sqrt{2} \lambda N_{j4}^* U_{A,k3} + \sqrt{2} \lambda N_{j5}^* U_{A,k2} \right) \\ & - \sqrt{2} \sigma N_{i7}^* N_{j5}^* U_{A,k4} + 2g_1' Q_S N_{i8}^* N_{j6}^* U_{A,k4} - \sqrt{2} \sigma N_{i5}^* N_{j7}^* U_{A,k4} \\ & + 2g_1' Q_S N_{i6}^* N_{j8}^* U_{A,k4} - \sqrt{2} \sigma N_{i6}^* N_{j5}^* U_{A,k5} - \sqrt{2} \sigma N_{i5}^* N_{j6}^* U_{A,k5} \\ & \left. + 2\sqrt{2} \kappa' N_{i7}^* N_{j7}^* U_{A,k5} \right) \left(\frac{1 - \gamma_5}{2} \right) \quad (459) \end{aligned}$$

$$\begin{aligned} & + \frac{1}{2} \left(\sqrt{2} \lambda^* U_{A,k3} N_{i4} N_{j3} + \sqrt{2} \lambda^* U_{A,k3} N_{i3} N_{j4} + \sqrt{2} \sigma'^* U_{A,k5} N_{i6} N_{j5} + \sqrt{2} \sigma'^* U_{A,k4} N_{i7} N_{j5} \right. \\ & + 2g_1' Q_S U_{A,k3} N_{i8} N_{j5} + \sqrt{2} \sigma'^* U_{A,k5} N_{i5} N_{j6} + \sqrt{2} \sigma'^* U_{A,k3} N_{i7} N_{j6} - 2g_1' Q_S U_{A,k4} N_{i8} N_{j6} \\ & + \sqrt{2} \sigma'^* U_{A,k4} N_{i5} N_{j7} + \sqrt{2} \sigma'^* U_{A,k3} N_{i6} N_{j7} - 2\sqrt{2} \kappa'^* U_{A,k5} N_{i7} N_{j7} + 2g_1' Q_S U_{A,k3} N_{i5} N_{j8} \\ & - 2g_1' Q_S U_{A,k4} N_{i6} N_{j8} \\ & + U_{A,k1} \left(-g_1 N_{i1} N_{j3} + g_2 N_{i2} N_{j3} - 6g_1' N_{i8} N_{j3} + \sqrt{2} \lambda^* N_{i5} N_{j4} + \sqrt{2} \lambda^* N_{i4} N_{j5} \right. \\ & \left. + N_{i3} \left(-6g_1' N_{j8} - g_1 N_{j1} + g_2 N_{j2} \right) \right) \\ & + U_{A,k2} \left(\left(-4g_1' N_{i8} + g_1 N_{i1} - g_2 N_{i2} \right) N_{j4} + \sqrt{2} \lambda^* \left(N_{i3} N_{j5} + N_{i5} N_{j3} \right) \right. \\ & \left. + N_{i4} \left(-4g_1' N_{j8} + g_1 N_{j1} - g_2 N_{j2} \right) \right) \left(\frac{1 + \gamma_5}{2} \right) \quad (460) \end{aligned}$$

$$\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{a=1}^3 U_{L,ja}^{d,*} U_{R,ia}^{d,*} Y_{d,aa} U_{A,k1} \left(\frac{1-\gamma_5}{2} \right) \quad (461)$$

$$+ -\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{a=1}^3 Y_{d,aa}^* U_{L,ia}^d U_{R,ja}^d U_{A,k1} \left(\frac{1+\gamma_5}{2} \right) \quad (462)$$

$$\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{a=1}^3 ZDXL_{ja}^* ZDXR_{ia}^* \kappa_{aa} U_{A,k3} \left(\frac{1-\gamma_5}{2} \right) \quad (463)$$

$$+ -\frac{1}{\sqrt{2}}\delta_{\alpha\beta}\sum_{a=1}^3 \kappa_{aa}^* ZDXL_{ia} ZDXR_{ja} U_{A,k3} \left(\frac{1+\gamma_5}{2} \right) \quad (464)$$

$$\frac{1}{\sqrt{2}} \sum_{a=1}^3 U_{L,ja}^{e,*} U_{R,ia}^{e,*} Y_{e,aa} U_{A,k1} \left(\frac{1-\gamma_5}{2} \right) \quad (465)$$

$$+ -\frac{1}{\sqrt{2}} \sum_{a=1}^3 Y_{e,aa}^* U_{L,ia}^e U_{R,ja}^e U_{A,k1} \left(\frac{1+\gamma_5}{2} \right) \quad (466)$$

$$\frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{a=1}^3 U_{L,ja}^{u,*} U_{R,ia}^{u,*} Y_{u,aa} U_{A,k2} \left(\frac{1-\gamma_5}{2} \right) \quad (467)$$

$$+ -\frac{1}{\sqrt{2}} \delta_{\alpha\beta} \sum_{a=1}^3 Y_{u,aa}^* U_{L,ia}^u U_{R,ja}^u U_{A,k2} \left(\frac{1+\gamma_5}{2} \right) \quad (468)$$

$$i \left(-g_2 U_{j1}^* N_{i3}^* U_{+,k1} + U_{j2}^* \left(3\sqrt{2} g_1' N_{i8}^* U_{+,k1} + \frac{1}{\sqrt{2}} g_1 N_{i1}^* U_{+,k1} + \frac{1}{\sqrt{2}} g_2 N_{i2}^* U_{+,k1} - \lambda N_{i5}^* U_{+,k2} \right) \right) \left(\frac{1-\gamma_5}{2} \right) \quad (469)$$

$$+ i \left(-\frac{1}{2} \left(2g_2 V_{j1} N_{i4} + \sqrt{2} V_{j2} \left(-4g_1' N_{i8} + g_1 N_{i1} + g_2 N_{i2} \right) \right) U_{+,k2} - \lambda^* V_{j2} N_{i5} U_{+,k1} \right) \left(\frac{1+\gamma_5}{2} \right) \quad (470)$$

$$-ig_2 U_{j1}^* Z N p_{i1}^* U H p p_{k1} \left(\frac{1-\gamma_5}{2} \right) \quad (471)$$

$$+ -ig_2 U H p p_{k2} V_{j1} Z N p_{i2} \left(\frac{1+\gamma_5}{2} \right) \quad (472)$$

$$i\delta_{\beta\gamma} \left(-g_2 U_{i1}^* \sum_{a=1}^3 U_{L,ja}^{u,*} Z_{ka}^D + U_{i2}^* \sum_{a=1}^3 U_{L,ja}^{u,*} Y_{d,aa} Z_{k3+a}^D \right) \left(\frac{1-\gamma_5}{2} \right) \quad (473)$$

$$+ i\delta_{\beta\gamma} \sum_{a=1}^3 Y_{u,aa}^* Z_{ka}^D U_{R,ja}^u V_{i2} \left(\frac{1+\gamma_5}{2} \right) \quad (474)$$

$$i\Theta_{j,3}\left(-g_2U_{i1}^*Z_{kj}^E+U_{i2}^*Y_{e,jj}Z_{k3+j}^E\right)\left(\frac{1-\gamma_5}{2}\right) \quad (475)$$

$$-i\frac{1}{\sqrt{2}}\left(g_2U_{j1}^*V_{i2}^*U_{H,k2}^*+U_{j2}^*\left(g_2V_{i1}^*U_{H,k1}^*+\lambda V_{i2}^*U_{H,k3}^*\right)\right)\left(\frac{1-\gamma_5}{2}\right) \quad (476)$$

$$+ -i\frac{1}{\sqrt{2}}\left(g_2U_{H,k1}^*U_{i2}V_{j1}+\left(g_2U_{H,k2}^*U_{i1}+\lambda^*U_{H,k3}^*U_{i2}\right)V_{j2}\right)\left(\frac{1+\gamma_5}{2}\right) \quad (477)$$

$$-ig_2UHp0_{k2}^*U_{j1}^*\left(\frac{1-\gamma_5}{2}\right) \quad (478)$$

$$+ -ig_2UHp0_{k1}^*V_{j1}\left(\frac{1+\gamma_5}{2}\right) \quad (479)$$

$$iU_{j2}^* \delta_{\alpha\gamma} \sum_{a=1}^3 U_{R,ia}^{d,*} Z_{ka}^{U,*} Y_{d,aa} \left(\frac{1-\gamma_5}{2} \right) \quad (480)$$

$$+ i\delta_{\alpha\gamma} \left(-g_2 \sum_{a=1}^3 Z_{ka}^{U,*} U_{L,ia}^d V_{j1} + \sum_{a=1}^3 Y_{u,aa}^* Z_{k3+a}^{U,*} U_{L,ia}^d V_{j2} \right) \left(\frac{1+\gamma_5}{2} \right) \quad (481)$$

$$iU_{j2}^* \sum_{a=1}^3 U_{R,ia}^{e,*} Z_{ka}^{V,*} Y_{e,aa} \left(\frac{1-\gamma_5}{2} \right) \quad (482)$$

$$+ -ig_2 \sum_{a=1}^3 Z_{ka}^{V,*} U_{L,ia}^e V_{j1} \left(\frac{1+\gamma_5}{2} \right) \quad (483)$$

$$i \frac{1}{\sqrt{2}} \left(-4g'_1 N_{i8}^* + g_1 N_{i1}^* + g_2 N_{i2}^* \right) UHpp_{k1} \left(\frac{1-\gamma_5}{2} \right) \quad (484)$$

$$+ -i \frac{1}{\sqrt{2}} UHpp_{k2} \left(-4g'_1 N_{i8} + g_1 N_{i1} + g_2 N_{i2} \right) \left(\frac{1+\gamma_5}{2} \right) \quad (485)$$

$$-ig_2 V_{i1}^* U H p_{k1} \left(\frac{1 - \gamma_5}{2} \right) \quad (486)$$

$$+ -ig_2 U H p_{k2} U_{i1} \left(\frac{1 + \gamma_5}{2} \right) \quad (487)$$

$$\begin{aligned}
& \frac{i}{2} \left(\sqrt{2} \lambda U_{H,k3}^* N_{i4}^* N_{j3}^* + \sqrt{2} \lambda U_{H,k3}^* N_{i3}^* N_{j4}^* + \sqrt{2} \sigma U_{H,k5}^* N_{i6}^* N_{j5}^* + \sqrt{2} \sigma U_{H,k4}^* N_{i7}^* N_{j5}^* \right. \\
& - 2g_1' Q_S U_{H,k3}^* N_{i8}^* N_{j5}^* + \sqrt{2} \sigma U_{H,k5}^* N_{i5}^* N_{j6}^* + \sqrt{2} \sigma U_{H,k3}^* N_{i7}^* N_{j6}^* \\
& + 2g_1' Q_S U_{H,k4}^* N_{i8}^* N_{j6}^* + \sqrt{2} \sigma U_{H,k4}^* N_{i5}^* N_{j7}^* + \sqrt{2} \sigma U_{H,k3}^* N_{i6}^* N_{j7}^* \\
& - 2\sqrt{2} \kappa' U_{H,k5}^* N_{i7}^* N_{j7}^* - 2g_1' Q_S U_{H,k3}^* N_{i5}^* N_{j8}^* + 2g_1' Q_S U_{H,k4}^* N_{i6}^* N_{j8}^* \\
& + U_{H,k2}^* \left(\sqrt{2} \lambda N_{i5}^* N_{j3}^* - g_1 N_{i1}^* N_{j4}^* + g_2 N_{i2}^* N_{j4}^* + 4g_1' N_{i8}^* N_{j4}^* + \sqrt{2} \lambda N_{i3}^* N_{j5}^* \right. \\
& \left. + N_{i4}^* \left(4g_1' N_{j8}^* - g_1 N_{j1}^* + g_2 N_{j2}^* \right) \right) \\
& + U_{H,k1}^* \left(g_1 N_{i1}^* N_{j3}^* - g_2 N_{i2}^* N_{j3}^* + 6g_1' N_{i8}^* N_{j3}^* + \sqrt{2} \lambda N_{i5}^* N_{j4}^* + \sqrt{2} \lambda N_{i4}^* N_{j5}^* \right. \\
& \left. + N_{i3}^* \left(6g_1' N_{j8}^* + g_1 N_{j1}^* - g_2 N_{j2}^* \right) \right) \left(\frac{1 - \gamma_5}{2} \right) \\
& + \frac{i}{2} \left(\sqrt{2} \lambda^* U_{H,k3}^* N_{i4} N_{j3} + \sqrt{2} \lambda^* U_{H,k3}^* N_{i3} N_{j4} + \sqrt{2} \sigma'^* U_{H,k5}^* N_{i6} N_{j5} + \sqrt{2} \sigma'^* U_{H,k4}^* N_{i7} N_{j5} \right. \\
& - 2g_1' Q_S U_{H,k3}^* N_{i8} N_{j5} + \sqrt{2} \sigma'^* U_{H,k5}^* N_{i5} N_{j6} + \sqrt{2} \sigma'^* U_{H,k3}^* N_{i7} N_{j6} + 2g_1' Q_S U_{H,k4}^* N_{i8} N_{j6} \\
& + \sqrt{2} \sigma'^* U_{H,k4}^* N_{i5} N_{j7} + \sqrt{2} \sigma'^* U_{H,k3}^* N_{i6} N_{j7} - 2\sqrt{2} \kappa'^* U_{H,k5}^* N_{i7} N_{j7} - 2g_1' Q_S U_{H,k3}^* N_{i5} N_{j8} \\
& \left. \left. + 2g_1' Q_S U_{H,k4}^* N_{i6} N_{j8} \right) \right) \quad (488)
\end{aligned}$$

$$\begin{aligned}
& + 2g'_1 Q_S U_{H,k4}^* N_{i6} N_{j8} \\
& + U_{H,k2}^* \left((4g'_1 N_{i8} - g_1 N_{i1} + g_2 N_{i2}) N_{j4} + N_{i4} (4g'_1 N_{j8} - g_1 N_{j1} + g_2 N_{j2}) + \sqrt{2} \lambda^* (N_{i3} N_{j5} + N_{i5} N_{j3}) \right) \\
& + U_{H,k1}^* \left(g_1 N_{i1} N_{j3} - g_2 N_{i2} N_{j3} + 6g'_1 N_{i8} N_{j3} + \sqrt{2} \lambda^* N_{i5} N_{j4} + \sqrt{2} \lambda^* N_{i4} N_{j5} \right. \\
& \left. + N_{i3} (6g'_1 N_{j8} + g_1 N_{j1} - g_2 N_{j2}) \right) \left(\frac{1 + \gamma_5}{2} \right)
\end{aligned} \tag{489}$$

$$i \frac{1}{\sqrt{2}} U H p 0_{k2}^* \left(4g'_1 N_{i8}^* - g_1 N_{i1}^* + g_2 N_{i2}^* \right) Z N p_{j2}^* \left(\frac{1 - \gamma_5}{2} \right) \tag{490}$$

$$+ i \frac{1}{\sqrt{2}} U H p 0_{k1}^* \left(-4g'_1 N_{i8} + g_1 N_{i1} - g_2 N_{i2} \right) Z N p_{j1} \left(\frac{1 + \gamma_5}{2} \right) \tag{491}$$

$$i \frac{1}{\sqrt{2}} \left(-4g'_1 N_{i8}^* + g_1 N_{i1}^* - g_2 N_{i2}^* \right) Z N p_{j1}^* U H p 0_{k1} \left(\frac{1 - \gamma_5}{2} \right) \tag{492}$$

$$+ i \frac{1}{\sqrt{2}} U H p 0_{k2} \left(4g'_1 N_{i8} - g_1 N_{i1} + g_2 N_{i2} \right) Z N p_{j2} \left(\frac{1 + \gamma_5}{2} \right) \tag{493}$$

$$\begin{aligned}
& -\frac{i}{6}\delta_{\beta\gamma}\left(\sqrt{2}g_1N_{i1}^*\sum_{a=1}^3U_{L,ja}^{d,*}Z_{ka}^D-3\sqrt{2}g_2N_{i2}^*\sum_{a=1}^3U_{L,ja}^{d,*}Z_{ka}^D+6\sqrt{2}g_1'N_{i8}^*\sum_{a=1}^3U_{L,ja}^{d,*}Z_{ka}^D\right. \\
& \left.+6N_{i3}^*\sum_{a=1}^3U_{L,ja}^{d,*}Y_{d,aa}Z_{k3+a}^D\right)\left(\frac{1-\gamma_5}{2}\right) \tag{494}
\end{aligned}$$

$$\begin{aligned}
& +-\frac{i}{3}\delta_{\beta\gamma}\left(3\sum_{a=1}^3Y_{d,aa}^*Z_{ka}^DU_{R,ja}^dN_{i3}+\sqrt{2}\sum_{a=1}^3Z_{k3+a}^DU_{R,ja}^d\left(6g_1'N_{i8}+g_1N_{i1}\right)\right)\left(\frac{1+\gamma_5}{2}\right) \tag{495}
\end{aligned}$$

$$\begin{aligned}
& \frac{i}{3}\delta_{\beta\gamma}\left(-3N_{i5}^*\sum_{a=1}^3ZDXL_{ja}^*Z_{k3+a}^{Dx}\kappa_{aa}+6\sqrt{2}g_1'N_{i8}^*\sum_{a=1}^3ZDXL_{ja}^*Z_{ka}^{Dx}+\sqrt{2}g_1N_{i1}^*\sum_{a=1}^3ZDXL_{ja}^*Z_{ka}^{Dx}\right)\left(\frac{1-\gamma_5}{2}\right) \tag{496}
\end{aligned}$$

$$\begin{aligned}
& +-\frac{i}{3}\delta_{\beta\gamma}\left(3\sum_{a=1}^3\kappa_{aa}^*Z_{ka}^{Dx}ZDXR_{ja}N_{i5}+\sqrt{2}\sum_{a=1}^3Z_{k3+a}^{Dx}ZDXR_{ja}\left(-9g_1'N_{i8}+g_1N_{i1}\right)\right)\left(\frac{1+\gamma_5}{2}\right) \tag{497}
\end{aligned}$$

$$\begin{aligned}
& i \left(\frac{1}{\sqrt{2}} g_1 N_{i1}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{ka}^E + \frac{1}{\sqrt{2}} g_2 N_{i2}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{ka}^E - 2\sqrt{2} g_1' N_{i8}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{ka}^E \right. \\
& \left. - N_{i3}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Y_{e,aa} Z_{k3+a}^E \right) \left(\frac{1-\gamma_5}{2} \right) \tag{498}
\end{aligned}$$

$$+ i \left(-\sqrt{2} \sum_{a=1}^3 Z_{k3+a}^E U_{R,ja}^e \left(g_1 N_{i1} + g_1' N_{i8} \right) - \sum_{a=1}^3 Y_{e,aa}^* Z_{ka}^E U_{R,ja}^e N_{i3} \right) \left(\frac{1+\gamma_5}{2} \right) \tag{499}$$

$$\begin{aligned}
& -\frac{i}{6} \delta_{\beta\gamma} \left(\sqrt{2} g_1 N_{i1}^* \sum_{a=1}^3 U_{L,ja}^{u,*} Z_{ka}^U + 3\sqrt{2} g_2 N_{i2}^* \sum_{a=1}^3 U_{L,ja}^{u,*} Z_{ka}^U + 6\sqrt{2} g_1' N_{i8}^* \sum_{a=1}^3 U_{L,ja}^{u,*} Z_{ka}^U \right. \\
& \left. + 6 N_{i4}^* \sum_{a=1}^3 U_{L,ja}^{u,*} Y_{u,aa} Z_{k3+a}^U \right) \left(\frac{1-\gamma_5}{2} \right) \tag{500}
\end{aligned}$$

$$+ \frac{i}{3} \delta_{\beta\gamma} \left(-3 \sum_{a=1}^3 Y_{u,aa}^* Z_{ka}^U U_{R,ja}^u N_{i4} + \sqrt{2} \sum_{a=1}^3 Z_{k3+a}^U U_{R,ja}^u \left(2g_1 N_{i1} - 3g_1' N_{i8} \right) \right) \left(\frac{1+\gamma_5}{2} \right) \tag{501}$$

$$i \frac{1}{\sqrt{2}} \left(-4g'_1 N_{i8}^* + g_1 N_{i1}^* - g_2 N_{i2}^* \right) \Theta_{j,3} Z_{kj}^V \left(\frac{1-\gamma_5}{2} \right) \quad (502)$$

$$i \left(-\frac{1}{2} V_{i2}^* \left(2\lambda N_{j5}^* U_{+,k1}^* + \sqrt{2} \left(-4g'_1 N_{j8}^* + g_1 N_{j1}^* + g_2 N_{j2}^* \right) U_{+,k2}^* \right) - g_2 V_{i1}^* N_{j4}^* U_{+,k2}^* \right) \left(\frac{1-\gamma_5}{2} \right) \quad (503)$$

$$+ i \left(\frac{1}{2} U_{+,k1}^* \left(-2g_2 U_{i1} N_{j3} + \sqrt{2} U_{i2} \left(6g'_1 N_{j8} + g_1 N_{j1} + g_2 N_{j2} \right) \right) - \lambda^* U_{+,k2}^* U_{i2} N_{j5} \right) \left(\frac{1+\gamma_5}{2} \right) \quad (504)$$

$$-\frac{i}{3} \delta_{\alpha\gamma} \left(3N_{j3}^* \sum_{a=1}^3 Z_{ka}^{D,*} U_{R,ia}^{d,*} Y_{d,aa} + 6\sqrt{2} g'_1 N_{j8}^* \sum_{a=1}^3 Z_{k3+a}^{D,*} U_{R,ia}^{d,*} + \sqrt{2} g_1 N_{j1}^* \sum_{a=1}^3 Z_{k3+a}^{D,*} U_{R,ia}^{d,*} \right) \left(\frac{1-\gamma_5}{2} \right) \quad (505)$$

$$+ -\frac{i}{6} \delta_{\alpha\gamma} \left(6 \sum_{a=1}^3 Y_{d,aa}^* Z_{k3+a}^{D,*} U_{L,ia}^d N_{j3} + \sqrt{2} \sum_{a=1}^3 Z_{ka}^{D,*} U_{L,ia}^d \left(-3g_2 N_{j2} + 6g'_1 N_{j8} + g_1 N_{j1} \right) \right) \left(\frac{1+\gamma_5}{2} \right) \quad (506)$$

$$-\frac{i}{3}\delta_{\alpha\gamma}\left(3N_{j5}^*\sum_{a=1}^3Z_{ka}^{Dx,*}ZDXR_{ia}^*\kappa_{aa}-9\sqrt{2}g_1'N_{j8}^*\sum_{a=1}^3Z_{k3+a}^{Dx,*}ZDXR_{ia}^*+\sqrt{2}g_1N_{j1}^*\sum_{a=1}^3Z_{k3+a}^{Dx,*}ZDXR_{ia}^*\right)\left(\frac{1-\gamma_5}{2}\right) \quad (507)$$

$$+\frac{i}{3}\delta_{\alpha\gamma}\left(-3\sum_{a=1}^3Z_{k3+a}^{Dx,*}\kappa_{aa}^*ZDXL_{ia}N_{j5}+\sqrt{2}\sum_{a=1}^3Z_{ka}^{Dx,*}ZDXL_{ia}\left(6g_1'N_{j8}+g_1N_{j1}\right)\right)\left(\frac{1+\gamma_5}{2}\right) \quad (508)$$

$$i\left(-\sqrt{2}g_1N_{j1}^*\sum_{a=1}^3Z_{k3+a}^{E,*}U_{R,ia}^{e,*}-\sqrt{2}g_1'N_{j8}^*\sum_{a=1}^3Z_{k3+a}^{E,*}U_{R,ia}^{e,*}\right. \\ \left.-N_{j3}^*\sum_{a=1}^3Z_{ka}^{E,*}U_{R,ia}^{e,*}Y_{e,aa}\right)\left(\frac{1-\gamma_5}{2}\right) \quad (509)$$

$$+i\left(\frac{1}{\sqrt{2}}\sum_{a=1}^3Z_{ka}^{E,*}U_{L,ia}^e\left(-4g_1'N_{j8}+g_1N_{j1}+g_2N_{j2}\right)-\sum_{a=1}^3Y_{e,aa}^*Z_{k3+a}^{E,*}U_{L,ia}^eN_{j3}\right)\left(\frac{1+\gamma_5}{2}\right) \quad (510)$$

$$-i \frac{1}{\sqrt{2}} U H p p_{k2}^* \left(-4g_1' N_{j8}^* + g_1 N_{j1}^* + g_2 N_{j2}^* \right) \left(\frac{1-\gamma_5}{2} \right) \quad (511)$$

$$+ i \frac{1}{\sqrt{2}} U H p p_{k1}^* \left(-4g_1' N_{j8} + g_1 N_{j1} + g_2 N_{j2} \right) \left(\frac{1+\gamma_5}{2} \right) \quad (512)$$

$$\frac{i}{3} \delta_{\alpha\gamma} \left(2\sqrt{2} g_1 N_{j1}^* \sum_{a=1}^3 Z_{k3+a}^{U,*} U_{R,ia}^{u,*} - 3 \left(N_{j4}^* \sum_{a=1}^3 Z_{ka}^{U,*} U_{R,ia}^{u,*} Y_{u,aa} + \sqrt{2} g_1' N_{j8}^* \sum_{a=1}^3 Z_{k3+a}^{U,*} U_{R,ia}^{u,*} \right) \right) \left(\frac{1-\gamma_5}{2} \right) \quad (513)$$

$$+ -\frac{i}{6} \delta_{\alpha\gamma} \left(6 \sum_{a=1}^3 Y_{u,aa}^* Z_{k3+a}^{U,*} U_{L,ia}^u N_{j4} + \sqrt{2} \sum_{a=1}^3 Z_{ka}^{U,*} U_{L,ia}^u \left(3g_2 N_{j2} + 6g_1' N_{j8} + g_1 N_{j1} \right) \right) \left(\frac{1+\gamma_5}{2} \right) \quad (514)$$

(515)

$$+ i \frac{1}{\sqrt{2}} Z_{ki}^{V,*} \Theta_{i,3} \left(-4g'_1 N_{j8} + g_1 N_{j1} - g_2 N_{j2} \right) \left(\frac{1 + \gamma_5}{2} \right) \quad (516)$$

$$- i g_2 U H p p_{k2}^* V_{i1}^* Z N p_{j2}^* \left(\frac{1 - \gamma_5}{2} \right) \quad (517)$$

$$+ -i g_2 U H p p_{k1}^* U_{i1} Z N p_{j1} \left(\frac{1 + \gamma_5}{2} \right) \quad (518)$$

$$- i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\gamma,\beta}^\alpha \sum_{a=1}^3 U_{L,ja}^{d,*} Z_{ka}^D \left(\frac{1 - \gamma_5}{2} \right) \quad (519)$$

$$+ i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\gamma,\beta}^\alpha \sum_{a=1}^3 Z_{k3+a}^D U_{R,ja}^d \left(\frac{1 + \gamma_5}{2} \right) \quad (520)$$

$$-i\frac{1}{\sqrt{2}}U_{H,k1}^*\delta_{\alpha\beta}\sum_{a=1}^3U_{L,ja}^{d,*}U_{R,ia}^{d,*}Y_{d,aa}\left(\frac{1-\gamma_5}{2}\right) \quad (521)$$

$$+ -i\frac{1}{\sqrt{2}}U_{H,k1}^*\delta_{\alpha\beta}\sum_{a=1}^3Y_{d,aa}^*U_{L,ia}^dU_{R,ja}^d\left(\frac{1+\gamma_5}{2}\right) \quad (522)$$

$$i\delta_{\beta\gamma}\left(-g_2V_{i1}^*\sum_{a=1}^3U_{L,ja}^{d,*}Z_{ka}^U+V_{i2}^*\sum_{a=1}^3U_{L,ja}^{d,*}Y_{u,aa}Z_{k3+a}^U\right)\left(\frac{1-\gamma_5}{2}\right) \quad (523)$$

$$+ i\delta_{\beta\gamma}\sum_{a=1}^3Y_{d,aa}^*U_{R,ja}^dZ_{ka}^U U_{i2}\left(\frac{1+\gamma_5}{2}\right) \quad (524)$$

$$i\delta_{\alpha\beta}\sum_{a=1}^3U_{L,ja}^{d,*}U_{R,ia}^{u,*}Y_{u,aa}U_{+,k2}\left(\frac{1-\gamma_5}{2}\right) \quad (525)$$

$$+ i\delta_{\alpha\beta}\sum_{a=1}^3Y_{d,aa}^*U_{R,ja}^dU_{L,ia}^uU_{+,k1}\left(\frac{1+\gamma_5}{2}\right) \quad (526)$$

$$-i \frac{1}{\sqrt{2}} g_3 \phi_{\bar{g}}^* \lambda_{\gamma, \beta}^\alpha \sum_{a=1}^3 ZDX L_{ja}^* Z_{ka}^{Dx} \left(\frac{1 - \gamma_5}{2} \right) \quad (527)$$

$$+ i \frac{1}{\sqrt{2}} g_3 \phi_{\bar{g}}^* \lambda_{\gamma, \beta}^\alpha \sum_{a=1}^3 Z_{k3+a}^{Dx} ZDX R_{ja} \left(\frac{1 + \gamma_5}{2} \right) \quad (528)$$

$$-i \frac{1}{\sqrt{2}} U_{H,k3}^* \delta_{\alpha\beta} \sum_{a=1}^3 ZDX L_{ja}^* ZDX R_{ia}^* \kappa_{aa} \left(\frac{1 - \gamma_5}{2} \right) \quad (529)$$

$$+ -i \frac{1}{\sqrt{2}} U_{H,k3}^* \delta_{\alpha\beta} \sum_{a=1}^3 \kappa_{aa}^* ZDX L_{ia} ZDX R_{ja} \left(\frac{1 + \gamma_5}{2} \right) \quad (530)$$

$$-i \frac{1}{\sqrt{2}} U_{H,k1}^* \sum_{a=1}^3 U_{L,ja}^{e,*} U_{R,ia}^e Y_{e,aa} \left(\frac{1-\gamma_5}{2} \right) \quad (531)$$

$$+ -i \frac{1}{\sqrt{2}} U_{H,k1}^* \sum_{a=1}^3 Y_{e,aa}^* U_{L,ia}^e U_{R,ja}^e \left(\frac{1+\gamma_5}{2} \right) \quad (532)$$

$$-ig_2 V_{i1}^* \sum_{a=1}^3 U_{L,ja}^{e,*} Z_{ka}^V \left(\frac{1-\gamma_5}{2} \right) \quad (533)$$

$$+ i \sum_{a=1}^3 Y_{e,aa}^* U_{R,ja}^e Z_{ka}^V U_{i2} \left(\frac{1+\gamma_5}{2} \right) \quad (534)$$

$$+ i Y_{e,ii}^* \Theta_{i,3} U_{R,ji}^e U_{+,k1} \left(\frac{1+\gamma_5}{2} \right) \quad (535)$$

$$+ i Y_{e,ii}^* \Theta_{i,3} U_{R,ji}^e U_{+,k1} \left(\frac{1+\gamma_5}{2} \right) \quad (536)$$

$$-i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\gamma, \beta}^\alpha \sum_{a=1}^3 U_{L,ja}^{u,*} Z_{ka}^U \left(\frac{1 - \gamma_5}{2} \right) \quad (537)$$

$$+ i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\gamma, \beta}^\alpha \sum_{a=1}^3 Z_{k3+a}^U U_{R,ja}^u \left(\frac{1 + \gamma_5}{2} \right) \quad (538)$$

$$-i \frac{1}{\sqrt{2}} U_{H,k2}^* \delta_{\alpha\beta} \sum_{a=1}^3 U_{L,ja}^{u,*} U_{R,ia}^{u,*} Y_{u,aa} \left(\frac{1 - \gamma_5}{2} \right) \quad (539)$$

$$+ -i \frac{1}{\sqrt{2}} U_{H,k2}^* \delta_{\alpha\beta} \sum_{a=1}^3 Y_{u,aa}^* U_{L,ia}^u U_{R,ja}^u \left(\frac{1 + \gamma_5}{2} \right) \quad (540)$$

$$iU_{+,k1}^* \delta_{\alpha\beta} \sum_{a=1}^3 U_{R,ia}^{d,*} U_{L,ja}^{u,*} Y_{d,aa} \left(\frac{1-\gamma_5}{2} \right) \quad (541)$$

$$+ iU_{+,k2}^* \delta_{\alpha\beta} \sum_{a=1}^3 Y_{u,aa}^* U_{L,ia}^d U_{R,ja}^u \left(\frac{1+\gamma_5}{2} \right) \quad (542)$$

$$iU_{R,ij}^{e,*} U_{+,k1}^* \Theta_{j,3} Y_{e,jj} \left(\frac{1-\gamma_5}{2} \right) \quad (543)$$

$$i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}} \lambda_{\alpha,\gamma}^\beta \sum_{a=1}^3 Z_{k3+a}^{D,*} U_{R,ia}^{d,*} \left(\frac{1-\gamma_5}{2} \right) \quad (544)$$

$$+ -i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\alpha,\gamma}^\beta \sum_{a=1}^3 Z_{ka}^{D,*} U_{L,ia}^d \left(\frac{1+\gamma_5}{2} \right) \quad (545)$$

$$i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}} \lambda_{\alpha, \gamma}^{\beta} \sum_{a=1}^3 Z_{k3+a}^{Dx,*} Z_{DX} R_{ia}^* \left(\frac{1-\gamma_5}{2} \right) \quad (546)$$

$$+ -i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\alpha, \gamma}^{\beta} \sum_{a=1}^3 Z_{ka}^{Dx,*} Z_{DX} L_{ia} \left(\frac{1+\gamma_5}{2} \right) \quad (547)$$

$$i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}} \lambda_{\alpha, \gamma}^{\beta} \sum_{a=1}^3 Z_{k3+a}^{U,*} U_{R,ia}^{u,*} \left(\frac{1-\gamma_5}{2} \right) \quad (548)$$

$$+ -i \frac{1}{\sqrt{2}} g_3 \phi_{\tilde{g}}^* \lambda_{\alpha, \gamma}^{\beta} \sum_{a=1}^3 Z_{ka}^{U,*} U_{L,ia}^u \left(\frac{1+\gamma_5}{2} \right) \quad (549)$$

$$i V_{i2}^* \delta_{\beta\gamma} \sum_{a=1}^3 Z_{ka}^{D,*} U_{R,ja}^{u,*} Y_{u,aa} \left(\frac{1-\gamma_5}{2} \right) \quad (550)$$

$$+ i \delta_{\beta\gamma} \left(-g_2 \sum_{a=1}^3 Z_{ka}^{D,*} U_{L,ja}^u U_{i1} + \sum_{a=1}^3 Y_{d,aa}^* Z_{k3+a}^{D,*} U_{L,ja}^u U_{i2} \right) \left(\frac{1+\gamma_5}{2} \right) \quad (551)$$

(552)

$$+ i\Theta_{j,3} \left(-g_2 Z_{kj}^{E,*} U_{i1} + Y_{e,jj}^* Z_{k3+j}^{E,*} U_{i2} \right) \left(\frac{1+\gamma_5}{2} \right) \quad (553)$$

9.6 Three Vector Boson-Interaction

$$g_3 f_{\alpha,\beta,\gamma} \left(g_{\rho\mu} \left(-p_\sigma^{g\gamma\mu} + p_\sigma^{g\alpha\rho} \right) + g_{\rho\sigma} \left(-p_\mu^{g\alpha\rho} + p_\mu^{g\beta\sigma} \right) + g_{\sigma\mu} \left(-p_\rho^{g\beta\sigma} + p_\rho^{g\gamma\mu} \right) \right) \quad (554)$$

$$ig_2 \sin \Theta_W \left(g_{\rho\mu} \left(-p_\sigma^{W^-} + p_\sigma^{W^+} \right) + g_{\rho\sigma} \left(-p_\mu^{W^+} + p_\mu^{\gamma\sigma} \right) + g_{\sigma\mu} \left(-p_\rho^{\gamma\sigma} + p_\rho^{W^-} \right) \right) \quad (555)$$

$$-ig_2 \cos \Theta_W \cos \Theta'_W \left(g_{\rho\mu} \left(-p_\sigma^{Z_\mu} + p_\sigma^{W_\rho^+} \right) + g_{\rho\sigma} \left(-p_\mu^{W_\rho^+} + p_\mu^{W_\sigma^-} \right) + g_{\sigma\mu} \left(-p_\rho^{W_\sigma^-} + p_\rho^{Z_\mu} \right) \right) \quad (556)$$

$$ig_2 \cos \Theta_W \sin \Theta'_W \left(g_{\rho\mu} \left(-p_\sigma^{Z'_\mu} + p_\sigma^{W_\rho^+} \right) + g_{\rho\sigma} \left(-p_\mu^{W_\rho^+} + p_\mu^{W_\sigma^-} \right) + g_{\sigma\mu} \left(-p_\rho^{W_\sigma^-} + p_\rho^{Z'_\mu} \right) \right) \quad (557)$$

9.7 Four Scalar-Interaction

$$\begin{aligned} & \frac{i}{4} \left(12g_1^2 Q_S U_{A,i3} U_{A,j3} U_{A,k1} U_{A,l1} - 4|\lambda|^2 U_{A,i3} U_{A,j3} U_{A,k1} U_{A,l1} - 12g_1^2 Q_S U_{A,i4} U_{A,j4} U_{A,k1} U_{A,l1} \right. \\ & - \sigma \lambda^* U_{A,i5} U_{A,j4} U_{A,k2} U_{A,l1} - \lambda \sigma'^* U_{A,i5} U_{A,j4} U_{A,k2} U_{A,l1} - \sigma \lambda^* U_{A,i4} U_{A,j5} U_{A,k2} U_{A,l1} \\ & \left. - \lambda \sigma'^* U_{A,i4} U_{A,j5} U_{A,k2} U_{A,l1} + 12g_1^2 Q_S U_{A,i3} U_{A,j1} U_{A,k3} U_{A,l1} - 4|\lambda|^2 U_{A,i3} U_{A,j1} U_{A,k3} U_{A,l1} \right) \end{aligned}$$

$$\begin{aligned}
& -12g_1^2 Q_S U_{A,i4} U_{A,j1} U_{A,k4} U_{A,l1} - \sigma \lambda^* U_{A,i5} U_{A,j2} U_{A,k4} U_{A,l1} - \lambda \sigma'^* U_{A,i5} U_{A,j2} U_{A,k4} U_{A,l1} \\
& - \sigma \lambda^* U_{A,i4} U_{A,j2} U_{A,k5} U_{A,l1} - \lambda \sigma'^* U_{A,i4} U_{A,j2} U_{A,k5} U_{A,l1} - \sigma \lambda^* U_{A,i5} U_{A,j4} U_{A,k1} U_{A,l2} \\
& - \lambda \sigma'^* U_{A,i5} U_{A,j4} U_{A,k1} U_{A,l2} - \sigma \lambda^* U_{A,i4} U_{A,j5} U_{A,k1} U_{A,l2} - \lambda \sigma'^* U_{A,i4} U_{A,j5} U_{A,k1} U_{A,l2} \\
& + 8g_1^2 Q_S U_{A,i3} U_{A,j3} U_{A,k2} U_{A,l2} - 4|\lambda|^2 U_{A,i3} U_{A,j3} U_{A,k2} U_{A,l2} - 8g_1^2 Q_S U_{A,i4} U_{A,j4} U_{A,k2} U_{A,l2} \\
& + 8g_1^2 Q_S U_{A,i3} U_{A,j2} U_{A,k3} U_{A,l2} - 4|\lambda|^2 U_{A,i3} U_{A,j2} U_{A,k3} U_{A,l2} - \sigma \lambda^* U_{A,i5} U_{A,j1} U_{A,k4} U_{A,l2} \\
& - \lambda \sigma'^* U_{A,i5} U_{A,j1} U_{A,k4} U_{A,l2} - 8g_1^2 Q_S U_{A,i4} U_{A,j2} U_{A,k4} U_{A,l2} - \sigma \lambda^* U_{A,i4} U_{A,j1} U_{A,k5} U_{A,l2} \\
& - \lambda \sigma'^* U_{A,i4} U_{A,j1} U_{A,k5} U_{A,l2} + 12g_1^2 Q_S U_{A,i3} U_{A,j1} U_{A,k1} U_{A,l3} - 4|\lambda|^2 U_{A,i3} U_{A,j1} U_{A,k1} U_{A,l3} \\
& + 8g_1^2 Q_S U_{A,i3} U_{A,j2} U_{A,k2} U_{A,l3} - 4|\lambda|^2 U_{A,i3} U_{A,j2} U_{A,k2} U_{A,l3} \\
& - 12g_1^2 Q_S^2 U_{A,i3} U_{A,j3} U_{A,k3} U_{A,l3} + 4g_1^2 Q_S^2 U_{A,i4} U_{A,j4} U_{A,k3} U_{A,l3} \\
& - 4|\sigma|^2 U_{A,i4} U_{A,j4} U_{A,k3} U_{A,l3} - 4|\sigma|^2 U_{A,i5} U_{A,j5} U_{A,k3} U_{A,l3} + 4g_1^2 Q_S^2 U_{A,i4} U_{A,j3} U_{A,k4} U_{A,l3} \\
& - 4|\sigma|^2 U_{A,i4} U_{A,j3} U_{A,k4} U_{A,l3} + 4g_1^2 Q_S^2 U_{A,i3} U_{A,j4} U_{A,k4} U_{A,l3} - 4|\sigma|^2 U_{A,i3} U_{A,j4} U_{A,k4} U_{A,l3} \\
& + 2\sigma \kappa'^* U_{A,i5} U_{A,j5} U_{A,k4} U_{A,l3} + 2\kappa' \sigma'^* U_{A,i5} U_{A,j5} U_{A,k4} U_{A,l3} - 4|\sigma|^2 U_{A,i5} U_{A,j3} U_{A,k5} U_{A,l3} \\
& + 2\sigma \kappa'^* U_{A,i5} U_{A,j4} U_{A,k5} U_{A,l3} + 2\kappa' \sigma'^* U_{A,i5} U_{A,j4} U_{A,k5} U_{A,l3} - 4|\sigma|^2 U_{A,i3} U_{A,j5} U_{A,k5} U_{A,l3} \\
& + 2\sigma \kappa'^* U_{A,i4} U_{A,j5} U_{A,k5} U_{A,l3} + 2\kappa' \sigma'^* U_{A,i4} U_{A,j5} U_{A,k5} U_{A,l3} - 12g_1^2 Q_S U_{A,i4} U_{A,j1} U_{A,k1} U_{A,l4} \\
& - \sigma \lambda^* U_{A,i5} U_{A,j2} U_{A,k1} U_{A,l4} - \lambda \sigma'^* U_{A,i5} U_{A,j2} U_{A,k1} U_{A,l4} - \sigma \lambda^* U_{A,i5} U_{A,j1} U_{A,k2} U_{A,l4} \\
& - \lambda \sigma'^* U_{A,i5} U_{A,j1} U_{A,k2} U_{A,l4} - 8g_1^2 Q_S U_{A,i4} U_{A,j2} U_{A,k2} U_{A,l4} + 4g_1^2 Q_S^2 U_{A,i4} U_{A,j3} U_{A,k3} U_{A,l4} \\
& - 4|\sigma|^2 U_{A,i4} U_{A,j3} U_{A,k3} U_{A,l4} + 4g_1^2 Q_S^2 U_{A,i3} U_{A,j4} U_{A,k3} U_{A,l4} - 4|\sigma|^2 U_{A,i3} U_{A,j4} U_{A,k3} U_{A,l4} \\
& + 2\sigma \kappa'^* U_{A,i5} U_{A,j5} U_{A,k3} U_{A,l4} + 2\kappa' \sigma'^* U_{A,i5} U_{A,j5} U_{A,k3} U_{A,l4} + 4g_1^2 Q_S^2 U_{A,i3} U_{A,j3} U_{A,k4} U_{A,l4} \\
& - 4|\sigma|^2 U_{A,i3} U_{A,j3} U_{A,k4} U_{A,l4} - 12g_1^2 Q_S^2 U_{A,i4} U_{A,j4} U_{A,k4} U_{A,l4} \\
& - 4|\sigma|^2 U_{A,i5} U_{A,j5} U_{A,k4} U_{A,l4} + 2\sigma \kappa'^* U_{A,i5} U_{A,j3} U_{A,k5} U_{A,l4} + 2\kappa' \sigma'^* U_{A,i5} U_{A,j3} U_{A,k5} U_{A,l4} \\
& - 4|\sigma|^2 U_{A,i5} U_{A,j4} U_{A,k5} U_{A,l4} + 2\sigma \kappa'^* U_{A,i3} U_{A,j5} U_{A,k5} U_{A,l4} + 2\kappa' \sigma'^* U_{A,i3} U_{A,j5} U_{A,k5} U_{A,l4} \\
& - 4|\sigma|^2 U_{A,i4} U_{A,j5} U_{A,k5} U_{A,l4} - \sigma \lambda^* U_{A,i4} U_{A,j2} U_{A,k1} U_{A,l5} - \lambda \sigma'^* U_{A,i4} U_{A,j2} U_{A,k1} U_{A,l5} \\
& - \sigma \lambda^* U_{A,i4} U_{A,j1} U_{A,k2} U_{A,l5} - \lambda \sigma'^* U_{A,i4} U_{A,j1} U_{A,k2} U_{A,l5} - 4|\sigma|^2 U_{A,i5} U_{A,j3} U_{A,k3} U_{A,l5} \\
& + 2\sigma \kappa'^* U_{A,i5} U_{A,j4} U_{A,k3} U_{A,l5} + 2\kappa' \sigma'^* U_{A,i5} U_{A,j4} U_{A,k3} U_{A,l5} - 4|\sigma|^2 U_{A,i3} U_{A,j5} U_{A,k3} U_{A,l5} \\
& + 2\sigma \kappa'^* U_{A,i4} U_{A,j5} U_{A,k3} U_{A,l5} + 2\kappa' \sigma'^* U_{A,i4} U_{A,j5} U_{A,k3} U_{A,l5} + 2\sigma \kappa'^* U_{A,i5} U_{A,j3} U_{A,k4} U_{A,l5} \\
& + 2\kappa' \sigma'^* U_{A,i5} U_{A,j3} U_{A,k4} U_{A,l5} - 4|\sigma|^2 U_{A,i5} U_{A,j4} U_{A,k4} U_{A,l5} + 2\sigma \kappa'^* U_{A,i3} U_{A,j5} U_{A,k4} U_{A,l5} \\
& + 2\kappa' \sigma'^* U_{A,i3} U_{A,j5} U_{A,k4} U_{A,l5} - 4|\sigma|^2 U_{A,i4} U_{A,j5} U_{A,k4} U_{A,l5} - 4|\sigma|^2 U_{A,i3} U_{A,j3} U_{A,k5} U_{A,l5} \\
& + 2\sigma \kappa'^* U_{A,i4} U_{A,j3} U_{A,k5} U_{A,l5} + 2\kappa' \sigma'^* U_{A,i4} U_{A,j3} U_{A,k5} U_{A,l5} + 2\sigma \kappa'^* U_{A,i3} U_{A,j4} U_{A,k5} U_{A,l5} \\
& + 2\kappa' \sigma'^* U_{A,i3} U_{A,j4} U_{A,k5} U_{A,l5} - 4|\sigma|^2 U_{A,i4} U_{A,j4} U_{A,k5} U_{A,l5} - 24|\kappa'|^2 U_{A,i5} U_{A,j5} U_{A,k5} U_{A,l5} \\
& + U_{A,i2} \left(-\sigma \lambda^* U_{A,j5} U_{A,k4} U_{A,l1} - \lambda \sigma'^* U_{A,j5} U_{A,k4} U_{A,l1} - \sigma \lambda^* U_{A,j4} U_{A,k5} U_{A,l1} \right. \\
& - \lambda \sigma'^* U_{A,j4} U_{A,k5} U_{A,l1} + 8g_1^2 Q_S U_{A,j3} U_{A,k3} U_{A,l2} - 4|\lambda|^2 U_{A,j3} U_{A,k3} U_{A,l2} \\
& - 8g_1^2 Q_S U_{A,j4} U_{A,k4} U_{A,l2} + 8g_1^2 Q_S U_{A,j3} U_{A,k2} U_{A,l3} - 4|\lambda|^2 U_{A,j3} U_{A,k2} U_{A,l3} \\
& - \sigma \lambda^* U_{A,j5} U_{A,k1} U_{A,l4} - \lambda \sigma'^* U_{A,j5} U_{A,k1} U_{A,l4} - 8g_1^2 Q_S U_{A,j4} U_{A,k2} U_{A,l4} \\
& \left. + U_{A,j2} \left(\left(-24g_1^2 - 4|\lambda|^2 + g_1^2 + g_2^2 \right) U_{A,k1} U_{A,l1} - 3 \left(16g_1^2 + g_1^2 + g_2^2 \right) U_{A,k2} U_{A,l2} + 8g_1^2 Q_S U_{A,k3} U_{A,l3} \right) \right)
\end{aligned}$$

$$\begin{aligned}
& -4|\lambda|^2 U_{A,k3} U_{A,l3} - 8g_1'^2 Q_S U_{A,k4} U_{A,l4} \Big) \\
& -\sigma\lambda^* U_{A,j4} U_{A,k1} U_{A,l5} - \lambda\sigma'^* U_{A,j4} U_{A,k1} U_{A,l5} \\
& + U_{A,j1} \Big(\Big(-24g_1'^2 - 4|\lambda|^2 + g_1^2 + g_2^2 \Big) U_{A,k2} U_{A,l1} + \Big(-24g_1'^2 - 4|\lambda|^2 + g_1^2 + g_2^2 \Big) U_{A,k1} U_{A,l2} \\
& - \Big(\lambda\sigma'^* + \sigma\lambda^* \Big) \Big(U_{A,k4} U_{A,l5} + U_{A,k5} U_{A,l4} \Big) \Big) \\
& - U_{A,i1} \Big(-12g_1'^2 Q_S U_{A,j3} U_{A,k3} U_{A,l1} + 4|\lambda|^2 U_{A,j3} U_{A,k3} U_{A,l1} + 12g_1'^2 Q_S U_{A,j4} U_{A,k4} U_{A,l1} \\
& + \sigma\lambda^* U_{A,j5} U_{A,k4} U_{A,l2} + \lambda\sigma'^* U_{A,j5} U_{A,k4} U_{A,l2} + \sigma\lambda^* U_{A,j4} U_{A,k5} U_{A,l2} + \lambda\sigma'^* U_{A,j4} U_{A,k5} U_{A,l2} \\
& - 12g_1'^2 Q_S U_{A,j3} U_{A,k1} U_{A,l3} + 4|\lambda|^2 U_{A,j3} U_{A,k1} U_{A,l3} + 12g_1'^2 Q_S U_{A,j4} U_{A,k1} U_{A,l4} \\
& + \sigma\lambda^* U_{A,j5} U_{A,k2} U_{A,l4} + \lambda\sigma'^* U_{A,j5} U_{A,k2} U_{A,l4} \\
& + U_{A,j1} \Big(3 \Big(36g_1'^2 + g_1^2 + g_2^2 \Big) U_{A,k1} U_{A,l1} - \Big(-24g_1'^2 - 4|\lambda|^2 + g_1^2 + g_2^2 \Big) U_{A,k2} U_{A,l2} \\
& + 4 \Big(\Big(-3g_1'^2 Q_S + |\lambda|^2 \Big) U_{A,k3} U_{A,l3} + 3g_1'^2 Q_S U_{A,k4} U_{A,l4} \Big) \Big) \\
& + \sigma\lambda^* U_{A,j4} U_{A,k2} U_{A,l5} + \lambda\sigma'^* U_{A,j4} U_{A,k2} U_{A,l5} \\
& + U_{A,j2} \Big(- \Big(-24g_1'^2 - 4|\lambda|^2 + g_1^2 + g_2^2 \Big) U_{A,k2} U_{A,l1} - \Big(-24g_1'^2 - 4|\lambda|^2 + g_1^2 + g_2^2 \Big) U_{A,k1} U_{A,l2} \\
& + \Big(\lambda\sigma'^* + \sigma\lambda^* \Big) \Big(U_{A,k4} U_{A,l5} + U_{A,k5} U_{A,l4} \Big) \Big) \Big) \Big) \tag{558}
\end{aligned}$$

$$\begin{aligned}
& \frac{1}{4} \Big(-\sigma\lambda^* \Big(-U_{H,l2}^* U_{A,i5} U_{A,j4} U_{A,k1} - U_{H,l2}^* U_{A,i4} U_{A,j5} U_{A,k1} - U_{H,l1}^* U_{A,i5} U_{A,j4} U_{A,k2} \\
& - U_{H,l1}^* U_{A,i4} U_{A,j5} U_{A,k2} - U_{H,l2}^* U_{A,i5} U_{A,j1} U_{A,k4} - U_{H,l1}^* U_{A,i5} U_{A,j2} U_{A,k4} \\
& - U_{H,l2}^* U_{A,i1} U_{A,j5} U_{A,k4} - U_{H,l1}^* U_{A,i2} U_{A,j5} U_{A,k4} \\
& + U_{H,l5}^* \Big(U_{A,i1} \Big(U_{A,j2} U_{A,k4} + U_{A,j4} U_{A,k2} \Big) + U_{A,i2} \Big(U_{A,j1} U_{A,k4} + U_{A,j4} U_{A,k1} \Big) + U_{A,i4} \Big(U_{A,j1} U_{A,k2} + U_{A,j2} U_{A,k1} \Big) \Big) \\
& - U_{H,l2}^* U_{A,i4} U_{A,j1} U_{A,k5} - U_{H,l1}^* U_{A,i4} U_{A,j2} U_{A,k5} - U_{H,l2}^* U_{A,i1} U_{A,j4} U_{A,k5} \\
& - U_{H,l1}^* U_{A,i2} U_{A,j4} U_{A,k5} \\
& + U_{H,l4}^* \Big(U_{A,i1} \Big(U_{A,j2} U_{A,k5} + U_{A,j5} U_{A,k2} \Big) + U_{A,i2} \Big(U_{A,j1} U_{A,k5} + U_{A,j5} U_{A,k1} \Big) + U_{A,i5} \Big(U_{A,j1} U_{A,k2} + U_{A,j2} U_{A,k1} \Big) \Big) \\
& - 2\sigma\kappa'^* \Big(-U_{H,l4}^* \Big(U_{A,i3} U_{A,j5} U_{A,k5} + U_{A,i5} \Big(U_{A,j3} U_{A,k5} + U_{A,j5} U_{A,k3} \Big) \Big) \Big)
\end{aligned}$$

$$\begin{aligned}
& + U_{H,l5}^* \left(U_{A,i3} \left(U_{A,j4} U_{A,k5} + U_{A,j5} U_{A,k4} \right) + U_{A,i4} \left(U_{A,j3} U_{A,k5} + U_{A,j5} U_{A,k3} \right) + U_{A,i5} \left(U_{A,j3} U_{A,k4} + U_{A,j4} U_{A,k3} \right) \right) \\
& - U_{H,l3}^* \left(U_{A,i4} U_{A,j5} U_{A,k5} + U_{A,i5} \left(U_{A,j4} U_{A,k5} + U_{A,j5} U_{A,k4} \right) \right) \\
& - \sigma'^* \left(\lambda U_{H,l2}^* U_{A,i5} U_{A,j4} U_{A,k1} + \lambda U_{H,l2}^* U_{A,i4} U_{A,j5} U_{A,k1} + \lambda U_{H,l1}^* U_{A,i5} U_{A,j4} U_{A,k2} \right. \\
& + \lambda U_{H,l1}^* U_{A,i4} U_{A,j5} U_{A,k2} + \lambda U_{H,l2}^* U_{A,i5} U_{A,j1} U_{A,k4} + \lambda U_{H,l1}^* U_{A,i5} U_{A,j2} U_{A,k4} \\
& + \lambda U_{H,l2}^* U_{A,i1} U_{A,j5} U_{A,k4} + \lambda U_{H,l1}^* U_{A,i2} U_{A,j5} U_{A,k4} + 2\kappa' U_{H,l3}^* U_{A,i5} U_{A,j5} U_{A,k4} \\
& + \lambda U_{H,l2}^* U_{A,i4} U_{A,j1} U_{A,k5} + \lambda U_{H,l1}^* U_{A,i4} U_{A,j2} U_{A,k5} + \lambda U_{H,l2}^* U_{A,i1} U_{A,j4} U_{A,k5} \\
& + \lambda U_{H,l1}^* U_{A,i2} U_{A,j4} U_{A,k5} + 2\kappa' U_{H,l3}^* U_{A,i5} U_{A,j4} U_{A,k5} + 2\kappa' U_{H,l3}^* U_{A,i4} U_{A,j5} U_{A,k5} \\
& - U_{H,l5}^* \left(\lambda U_{A,i1} U_{A,j4} U_{A,k2} + 2\kappa' U_{A,i5} U_{A,j4} U_{A,k3} + \lambda U_{A,i1} U_{A,j2} U_{A,k4} + 2\kappa' U_{A,i5} U_{A,j3} U_{A,k4} \right. \\
& + 2\kappa' U_{A,i3} U_{A,j5} U_{A,k4} + \lambda U_{A,i2} \left(U_{A,j1} U_{A,k4} + U_{A,j4} U_{A,k1} \right) + 2\kappa' U_{A,i3} U_{A,j4} U_{A,k5} \\
& + U_{A,i4} \left(2\kappa' U_{A,j3} U_{A,k5} + 2\kappa' U_{A,j5} U_{A,k3} + \lambda U_{A,j1} U_{A,k2} + \lambda U_{A,j2} U_{A,k1} \right) \\
& - U_{H,l4}^* \left(\lambda U_{A,i1} U_{A,j5} U_{A,k2} + \lambda U_{A,i1} U_{A,j2} U_{A,k5} - 2\kappa' U_{A,i3} U_{A,j5} U_{A,k5} + \lambda U_{A,i2} \left(U_{A,j1} U_{A,k5} + U_{A,j5} U_{A,k1} \right) \right. \\
& + U_{A,i5} \left(- 2\kappa' \left(U_{A,j3} U_{A,k5} + U_{A,j5} U_{A,k3} \right) + \lambda U_{A,j1} U_{A,k2} + \lambda U_{A,j2} U_{A,k1} \right) \left. \right) \left. \right) \left. \right) \quad (559)
\end{aligned}$$

$$\begin{aligned}
& \frac{i}{4} \left(12g_1'^2 Q_S U_{H,k3}^* U_{H,l3}^* U_{A,i1} U_{A,j1} - 4|\lambda|^2 U_{H,k3}^* U_{H,l3}^* U_{A,i1} U_{A,j1} \right. \\
& - 12g_1'^2 Q_S U_{H,k4}^* U_{H,l4}^* U_{A,i1} U_{A,j1} + \sigma \lambda^* U_{H,k5}^* U_{H,l4}^* U_{A,i2} U_{A,j1} + \lambda \sigma'^* U_{H,k5}^* U_{H,l4}^* U_{A,i2} U_{A,j1} \\
& + \sigma \lambda^* U_{H,k4}^* U_{H,l5}^* U_{A,i2} U_{A,j1} + \lambda \sigma'^* U_{H,k4}^* U_{H,l5}^* U_{A,i2} U_{A,j1} - \sigma \lambda^* U_{H,k5}^* U_{H,l2}^* U_{A,i4} U_{A,j1} \\
& - \lambda \sigma'^* U_{H,k5}^* U_{H,l2}^* U_{A,i4} U_{A,j1} - \sigma \lambda^* U_{H,k4}^* U_{H,l2}^* U_{A,i5} U_{A,j1} \\
& - \lambda \sigma'^* U_{H,k4}^* U_{H,l2}^* U_{A,i5} U_{A,j1} + \sigma \lambda^* U_{H,k5}^* U_{H,l4}^* U_{A,i1} U_{A,j2} + \lambda \sigma'^* U_{H,k5}^* U_{H,l4}^* U_{A,i1} U_{A,j2} \\
& + \sigma \lambda^* U_{H,k4}^* U_{H,l5}^* U_{A,i1} U_{A,j2} + \lambda \sigma'^* U_{H,k4}^* U_{H,l5}^* U_{A,i1} U_{A,j2} + 8g_1'^2 Q_S U_{H,k3}^* U_{H,l3}^* U_{A,i2} U_{A,j2} \\
& - 4|\lambda|^2 U_{H,k3}^* U_{H,l3}^* U_{A,i2} U_{A,j2} - 8g_1'^2 Q_S U_{H,k4}^* U_{H,l4}^* U_{A,i2} U_{A,j2} \\
& - \sigma \lambda^* U_{H,k5}^* U_{H,l1}^* U_{A,i4} U_{A,j2} - \lambda \sigma'^* U_{H,k5}^* U_{H,l1}^* U_{A,i4} U_{A,j2} \\
& - \sigma \lambda^* U_{H,k4}^* U_{H,l1}^* U_{A,i5} U_{A,j2} - \lambda \sigma'^* U_{H,k4}^* U_{H,l1}^* U_{A,i5} U_{A,j2} \\
& - 4g_1'^2 Q_S^2 U_{H,k3}^* U_{H,l3}^* U_{A,i3} U_{A,j3} + 4g_1'^2 Q_S^2 U_{H,k4}^* U_{H,l4}^* U_{A,i3} U_{A,j3} \left. \right)
\end{aligned}$$

$$\begin{aligned}
& -4|\sigma|^2 U_{H,k4}^* U_{H,l4}^* U_{A,i3} U_{A,j3} - 4|\sigma|^2 U_{H,k5}^* U_{H,l5}^* U_{A,i3} U_{A,j3} \\
& - 2\sigma\kappa'^* U_{H,k5}^* U_{H,l5}^* U_{A,i4} U_{A,j3} - 2\kappa'\sigma'^* U_{H,k5}^* U_{H,l5}^* U_{A,i4} U_{A,j3} \\
& + 2\sigma\kappa'^* U_{H,k5}^* U_{H,l4}^* U_{A,i5} U_{A,j3} + 2\kappa'\sigma'^* U_{H,k5}^* U_{H,l4}^* U_{A,i5} U_{A,j3} \\
& + 2\sigma\kappa'^* U_{H,k4}^* U_{H,l5}^* U_{A,i5} U_{A,j3} + 2\kappa'\sigma'^* U_{H,k4}^* U_{H,l5}^* U_{A,i5} U_{A,j3} \\
& - \sigma\lambda^* U_{H,k5}^* U_{H,l2}^* U_{A,i1} U_{A,j4} - \lambda\sigma'^* U_{H,k5}^* U_{H,l2}^* U_{A,i1} U_{A,j4} \\
& - \sigma\lambda^* U_{H,k5}^* U_{H,l1}^* U_{A,i2} U_{A,j4} - \lambda\sigma'^* U_{H,k5}^* U_{H,l1}^* U_{A,i2} U_{A,j4} \\
& - 2\sigma\kappa'^* U_{H,k5}^* U_{H,l5}^* U_{A,i3} U_{A,j4} - 2\kappa'\sigma'^* U_{H,k5}^* U_{H,l5}^* U_{A,i3} U_{A,j4} \\
& + 4g_1^2 Q_S^2 U_{H,k3}^* U_{H,l3}^* U_{A,i4} U_{A,j4} - 4|\sigma|^2 U_{H,k3}^* U_{H,l3}^* U_{A,i4} U_{A,j4} \\
& - 4g_1^2 Q_S^2 U_{H,k4}^* U_{H,l4}^* U_{A,i4} U_{A,j4} - 4|\sigma|^2 U_{H,k5}^* U_{H,l5}^* U_{A,i4} U_{A,j4} \\
& + 2\sigma\kappa'^* U_{H,k5}^* U_{H,l3}^* U_{A,i5} U_{A,j4} + 2\kappa'\sigma'^* U_{H,k5}^* U_{H,l3}^* U_{A,i5} U_{A,j4} \\
& + 2\sigma\kappa'^* U_{H,k3}^* U_{H,l5}^* U_{A,i5} U_{A,j4} + 2\kappa'\sigma'^* U_{H,k3}^* U_{H,l5}^* U_{A,i5} U_{A,j4} \\
& - \sigma\lambda^* U_{H,k4}^* U_{H,l2}^* U_{A,i1} U_{A,j5} - \lambda\sigma'^* U_{H,k4}^* U_{H,l2}^* U_{A,i1} U_{A,j5} \\
& - \sigma\lambda^* U_{H,k4}^* U_{H,l1}^* U_{A,i2} U_{A,j5} - \lambda\sigma'^* U_{H,k4}^* U_{H,l1}^* U_{A,i2} U_{A,j5} \\
& + 2\sigma\kappa'^* U_{H,k5}^* U_{H,l4}^* U_{A,i3} U_{A,j5} + 2\kappa'\sigma'^* U_{H,k5}^* U_{H,l4}^* U_{A,i3} U_{A,j5} \\
& + 2\sigma\kappa'^* U_{H,k4}^* U_{H,l5}^* U_{A,i3} U_{A,j5} + 2\kappa'\sigma'^* U_{H,k4}^* U_{H,l5}^* U_{A,i3} U_{A,j5} \\
& + 2\sigma\kappa'^* U_{H,k5}^* U_{H,l3}^* U_{A,i4} U_{A,j5} + 2\kappa'\sigma'^* U_{H,k5}^* U_{H,l3}^* U_{A,i4} U_{A,j5} \\
& + 2\sigma\kappa'^* U_{H,k3}^* U_{H,l5}^* U_{A,i4} U_{A,j5} + 2\kappa'\sigma'^* U_{H,k3}^* U_{H,l5}^* U_{A,i4} U_{A,j5} \\
& - 4|\sigma|^2 U_{H,k3}^* U_{H,l3}^* U_{A,i5} U_{A,j5} - 2\sigma\kappa'^* U_{H,k4}^* U_{H,l3}^* U_{A,i5} U_{A,j5} \\
& - 2\kappa'\sigma'^* U_{H,k4}^* U_{H,l3}^* U_{A,i5} U_{A,j5} - 2\sigma\kappa'^* U_{H,k3}^* U_{H,l4}^* U_{A,i5} U_{A,j5} \\
& - 2\kappa'\sigma'^* U_{H,k3}^* U_{H,l4}^* U_{A,i5} U_{A,j5} - 4|\sigma|^2 U_{H,k4}^* U_{H,l4}^* U_{A,i5} U_{A,j5} \\
& - 8|\kappa'|^2 U_{H,k5}^* U_{H,l5}^* U_{A,i5} U_{A,j5} \\
& + U_{H,k2}^* \left(U_{H,l2}^* \left(\left(-24g_1^2 - 4|\lambda|^2 + g_1^2 + g_2^2 \right) U_{A,i1} U_{A,j1} - \left(16g_1^2 + g_1^2 + g_2^2 \right) U_{A,i2} U_{A,j2} + 8g_1^2 Q_S U_{A,i3} U_{A,j3} \right. \right. \\
& \left. \left. - 4|\lambda|^2 U_{A,i3} U_{A,j3} - 8g_1^2 Q_S U_{A,i4} U_{A,j4} \right) \right. \\
& \left. - \left(\lambda\sigma'^* + \sigma\lambda^* \right) \left(-U_{H,l1}^* \left(U_{A,i4} U_{A,j5} + U_{A,i5} U_{A,j4} \right) + U_{H,l4}^* \left(U_{A,i1} U_{A,j5} + U_{A,i5} U_{A,j1} \right) + U_{H,l5}^* \left(U_{A,i1} U_{A,j4} + U_{A,i4} U_{A,j1} \right) \right) \right) \\
& - U_{H,k1}^* \left(U_{H,l1}^* \left(\left(36g_1^2 + g_1^2 + g_2^2 \right) U_{A,i1} U_{A,j1} - \left(-24g_1^2 - 4|\lambda|^2 + g_1^2 + g_2^2 \right) U_{A,i2} U_{A,j2} \right. \right. \\
& \left. \left. + 4 \left(-3g_1^2 Q_S + |\lambda|^2 \right) U_{A,i3} U_{A,j3} + 3g_1^2 Q_S U_{A,i4} U_{A,j4} \right) \right) \\
& \left. + \left(\lambda\sigma'^* + \sigma\lambda^* \right) \left(-U_{H,l2}^* \left(U_{A,i4} U_{A,j5} + U_{A,i5} U_{A,j4} \right) + U_{H,l4}^* \left(U_{A,i2} U_{A,j5} + U_{A,i5} U_{A,j2} \right) + U_{H,l5}^* \left(U_{A,i2} U_{A,j4} + U_{A,i4} U_{A,j2} \right) \right) \right) \right) \\
& \hspace{15em} (560)
\end{aligned}$$

$$\begin{aligned}
& \frac{i}{4} \left(U_{+,k2}^* \left(U_{A,i1} \left(\left(-24g_{1'}^2 - g_2^2 + g_1^2 \right) U_{A,j1} U_{+,l2} + \left(-2|\lambda|^2 + g_2^2 \right) U_{A,j2} U_{+,l1} \right) \right. \right. \\
& + U_{A,i2} \left(- \left(16g_{1'}^2 + g_1^2 + g_2^2 \right) U_{A,j2} U_{+,l2} + \left(-2|\lambda|^2 + g_2^2 \right) U_{A,j1} U_{+,l1} \right) \\
& - 2 \left(4g_{1'}^2 Q_S \left(-U_{A,i3} U_{A,j3} + U_{A,i4} U_{A,j4} \right) U_{+,l2} \right. \\
& + \lambda^* \left(2\lambda U_{A,i3} U_{A,j3} U_{+,l2} + \sigma U_{A,i4} U_{A,j5} U_{+,l1} + \sigma U_{A,i5} U_{A,j4} U_{+,l1} \right) \left. \right) \\
& - U_{+,k1}^* \left(U_{A,i2} \left(\left(24g_{1'}^2 - g_1^2 + g_2^2 \right) U_{A,j2} U_{+,l1} - \left(-2|\lambda|^2 + g_2^2 \right) U_{A,j1} U_{+,l2} \right) \right. \\
& + U_{A,i1} \left(- \left(-2|\lambda|^2 + g_2^2 \right) U_{A,j2} U_{+,l2} + \left(36g_{1'}^2 + g_1^2 + g_2^2 \right) U_{A,j1} U_{+,l1} \right) \\
& + 2 \left(2 \left(-3g_{1'}^2 Q_S + |\lambda|^2 \right) U_{A,i3} U_{A,j3} U_{+,l1} + \lambda \sigma'^* U_{A,i5} U_{A,j4} U_{+,l2} \right. \\
& + U_{A,i4} \left(6g_{1'}^2 Q_S U_{A,j4} U_{+,l1} + \lambda \sigma'^* U_{A,j5} U_{+,l2} \right) \left. \right) \left. \right) \quad (561)
\end{aligned}$$

$$\begin{aligned}
& \frac{i}{12} \delta_{\gamma\delta} \left(\sum_{a=1}^3 Z_{ka}^{D,*} Z_{la}^D \left(\left(36g_{1'}^2 + 3g_2^2 + g_1^2 \right) U_{A,i1} U_{A,j1} - \left(-24g_{1'}^2 + 3g_2^2 + g_1^2 \right) U_{A,i2} U_{A,j2} \right. \right. \\
& + 12g_{1'}^2 Q_S \left(-U_{A,i3} U_{A,j3} + U_{A,i4} U_{A,j4} \right) \left. \right) \\
& + 2 \left(-3 \left(2 \sum_{b=1}^3 |Y_{d,bb}|^2 Z_{kb}^{D,*} Z_{lb}^D U_{A,i1} U_{A,j1} + 2 \sum_{b=1}^3 |Y_{d,bb}|^2 Z_{k3+b}^{D,*} Z_{l3+b}^D U_{A,i1} U_{A,j1} \right. \right.
\end{aligned}$$

$$\begin{aligned}
& + \left(\lambda \sum_{a=1}^3 Y_{d,aa}^* Z_{k3+a}^{D,*} Z_{la}^D + \lambda^* \sum_{a=1}^3 Z_{ka}^{D,*} Y_{d,aa} Z_{l3+a}^D \right) \left(U_{A,i2} U_{A,j3} + U_{A,i3} U_{A,j2} \right) \\
& + \sum_{a=1}^3 Z_{k3+a}^{D,*} Z_{l3+a}^D \left(12g_1^2 Q_S \left(-U_{A,i3} U_{A,j3} + U_{A,i4} U_{A,j4} \right) - \left(-24g_1^2 + g_1^2 \right) U_{A,i2} U_{A,j2} + \left(36g_1^2 + g_1^2 \right) U_{A,i1} U_{A,j1} \right) \Big) \\
\end{aligned} \tag{562}$$

$$\begin{aligned}
& - \frac{i}{6} \delta_{\gamma\delta} \left(\sum_{a=1}^3 Z_{ka}^{Dx,*} Z_{la}^{Dx} \left(12g_1^2 Q_S \left(-U_{A,i3} U_{A,j3} + U_{A,i4} U_{A,j4} \right) - \left(-24g_1^2 + g_1^2 \right) U_{A,i2} U_{A,j2} + \left(36g_1^2 + g_1^2 \right) U_{A,i1} U_{A,j1} \right) \right. \\
& + \sum_{a=1}^3 Z_{k3+a}^{Dx,*} Z_{l3+a}^{Dx} \left(18g_1^2 Q_S \left(-U_{A,i3} U_{A,j3} + U_{A,i4} U_{A,j4} \right) + \left(36g_1^2 + g_1^2 \right) U_{A,i2} U_{A,j2} - \left(-54g_1^2 + g_1^2 \right) U_{A,i1} U_{A,j1} \right) \\
& + 3 \left(\lambda^* \sum_{a=1}^3 Z_{ka}^{Dx,*} Z_{l3+a}^{Dx} \kappa_{aa} \left(U_{A,i1} U_{A,j2} + U_{A,i2} U_{A,j1} \right) + 2 \sum_{b=1}^3 |\kappa_{bb}|^2 Z_{kb}^{Dx,*} Z_{lb}^{Dx} U_{A,i3} U_{A,j3} \right. \\
& + 2 \sum_{b=1}^3 |\kappa_{bb}|^2 Z_{k3+b}^{Dx,*} Z_{l3+b}^{Dx} U_{A,i3} U_{A,j3} + \sigma'^* \sum_{a=1}^3 Z_{ka}^{Dx,*} Z_{l3+a}^{Dx} \kappa_{aa} U_{A,i5} U_{A,j4} \\
& + \sigma'^* \sum_{a=1}^3 Z_{ka}^{Dx,*} Z_{l3+a}^{Dx} \kappa_{aa} U_{A,i4} U_{A,j5} \\
& \left. + \sum_{a=1}^3 Z_{k3+a}^{Dx,*} \kappa_{aa}^* Z_{la}^{Dx} \left(\lambda U_{A,i1} U_{A,j2} + \lambda U_{A,i2} U_{A,j1} + \sigma U_{A,i4} U_{A,j5} + \sigma U_{A,i5} U_{A,j4} \right) \right) \Big) \\
\end{aligned} \tag{563}$$

$$\begin{aligned}
& \frac{i}{4} \left(\sum_{a=1}^3 Z_{ka}^{E,*} Z_{la}^E \left((24g_{1'}^2 - g_1^2 + g_2^2) U_{A,i1} U_{A,j1} + (16g_{1'}^2 - g_2^2 + g_1^2) U_{A,i2} U_{A,j2} \right. \right. \\
& + 8g_{1'}^2 Q_S \left(-U_{A,i3} U_{A,j3} + U_{A,i4} U_{A,j4} \right) \Big) \\
& + 2 \left(-2 \sum_{b=1}^3 |Y_{e,bb}|^2 Z_{kb}^{E,*} Z_{lb}^E U_{A,i1} U_{A,j1} - 2 \sum_{b=1}^3 |Y_{e,bb}|^2 Z_{k3+b}^{E,*} Z_{l3+b}^E U_{A,i1} U_{A,j1} \right. \\
& - \lambda \sum_{a=1}^3 Y_{e,aa}^* Z_{k3+a}^{E,*} Z_{la}^E U_{A,i3} U_{A,j2} - \lambda^* \sum_{a=1}^3 Z_{ka}^{E,*} Y_{e,aa} Z_{l3+a}^E U_{A,i3} U_{A,j2} \\
& - \lambda \sum_{a=1}^3 Y_{e,aa}^* Z_{k3+a}^{E,*} Z_{la}^E U_{A,i2} U_{A,j3} - \lambda^* \sum_{a=1}^3 Z_{ka}^{E,*} Y_{e,aa} Z_{l3+a}^E U_{A,i2} U_{A,j3} \\
& \left. \left. + \sum_{a=1}^3 Z_{k3+a}^{E,*} Z_{l3+a}^E \left(2g_{1'}^2 Q_S \left(-U_{A,i3} U_{A,j3} + U_{A,i4} U_{A,j4} \right) - \left(-4g_{1'}^2 + g_1^2 \right) U_{A,i2} U_{A,j2} + \left(6g_{1'}^2 + g_1^2 \right) U_{A,i1} U_{A,j1} \right) \right) \right) \\
& \hspace{20em} (564)
\end{aligned}$$

$$\begin{aligned}
& -\frac{i}{4} \left(UHp0_{k1}^* UHp0_{l1} - UHp0_{k2}^* UHp0_{l2} \right) \left(\left(-24g_{1'}^2 + g_1^2 + g_2^2 \right) U_{A,i1} U_{A,j1} - \left(16g_{1'}^2 + g_1^2 + g_2^2 \right) U_{A,i2} U_{A,j2} \right. \\
& \left. + 8g_{1'}^2 Q_S \left(U_{A,i3} U_{A,j3} - U_{A,i4} U_{A,j4} \right) \right) \\
& \hspace{20em} (565)
\end{aligned}$$

$$\begin{aligned}
& -\frac{i}{4}\left(UHpp_{k1}^*UHpp_{l1}-UHpp_{k2}^*UHpp_{l2}\right)\left(\left(-24g_1^2-g_2^2+g_1^2\right)U_{A,i1}U_{A,j1}+\left(-16g_1^2-g_1^2+g_2^2\right)U_{A,i2}U_{A,j2}\right. \\
& \left.+8g_1^2Q_S\left(U_{A,i3}U_{A,j3}-U_{A,i4}U_{A,j4}\right)\right)
\end{aligned} \tag{566}$$

$$\begin{aligned}
& \frac{i}{12}\delta_{\gamma\delta}\left(\sum_{a=1}^3Z_{ka}^{U,*}Z_{la}^U\left(\left(36g_1^2-3g_2^2+g_1^2\right)U_{A,i1}U_{A,j1}+\left(24g_1^2+3g_2^2-g_1^2\right)U_{A,i2}U_{A,j2}\right.\right. \\
& \left.+12g_1^2Q_S\left(-U_{A,i3}U_{A,j3}+U_{A,i4}U_{A,j4}\right)\right) \\
& -2\left(3\left(2\left(\sum_{b=1}^3|Y_{u,bb}|^2Z_{kb}^{U,*}Z_{lb}^U+\sum_{b=1}^3|Y_{u,bb}|^2Z_{k3+b}^{U,*}Z_{l3+b}^U\right)U_{A,i2}U_{A,j2}\right.\right. \\
& \left.+ \lambda\sum_{a=1}^3Y_{u,aa}^*Z_{k3+a}^{U,*}Z_{la}^U\left(U_{A,i1}U_{A,j3}+U_{A,i3}U_{A,j1}\right)\right. \\
& \left.+ \lambda^*\sum_{a=1}^3Z_{ka}^{U,*}Y_{u,aa}Z_{l3+a}^U\left(U_{A,i1}U_{A,j3}+U_{A,i3}U_{A,j1}\right)\right) \\
& \left.+2\sum_{a=1}^3Z_{k3+a}^{U,*}Z_{l3+a}^U\left(3g_1^2Q_S\left(U_{A,i3}U_{A,j3}-U_{A,i4}U_{A,j4}\right)-\left(6g_1^2+g_1^2\right)U_{A,i2}U_{A,j2}+\left(-9g_1^2+g_1^2\right)U_{A,i1}U_{A,j1}\right)\right)
\end{aligned} \tag{567}$$

$$\begin{aligned}
& \frac{i}{4} \delta_{kl} \left(- \left(-24g_1'^2 + g_1^2 + g_2^2 \right) U_{A,i1} U_{A,j1} + \left(16g_1'^2 + g_1^2 + g_2^2 \right) U_{A,i2} U_{A,j2} \right. \\
& \left. + 8g_1'^2 Q_S \left(-U_{A,i3} U_{A,j3} + U_{A,i4} U_{A,j4} \right) \right)
\end{aligned} \tag{568}$$

$$\begin{aligned}
& \frac{1}{4} \left(-\sigma \lambda^* \left(U_{H,j2}^* U_{H,k5}^* U_{H,l4}^* U_{A,i1} + U_{H,j2}^* U_{H,k4}^* U_{H,l5}^* U_{A,i1} + U_{H,j1}^* U_{H,k5}^* U_{H,l4}^* U_{A,i2} \right. \right. \\
& + U_{H,j1}^* U_{H,k4}^* U_{H,l5}^* U_{A,i2} - U_{H,j2}^* U_{H,k5}^* U_{H,l1}^* U_{A,i4} - U_{H,j1}^* U_{H,k5}^* U_{H,l2}^* U_{A,i4} \\
& - U_{H,j2}^* U_{H,k1}^* U_{H,l5}^* U_{A,i4} - U_{H,j1}^* U_{H,k2}^* U_{H,l5}^* U_{A,i4} \\
& + U_{H,j5}^* \left(U_{H,k4}^* \left(U_{H,l1}^* U_{A,i2} + U_{H,l2}^* U_{A,i1} \right) + U_{H,k2}^* \left(-U_{H,l1}^* U_{A,i4} + U_{H,l4}^* U_{A,i1} \right) \right. \\
& \left. \left. + U_{H,k1}^* \left(-U_{H,l2}^* U_{A,i4} + U_{H,l4}^* U_{A,i2} \right) \right) \right. \\
& - U_{H,j2}^* U_{H,k4}^* U_{H,l1}^* U_{A,i5} - U_{H,j1}^* U_{H,k4}^* U_{H,l2}^* U_{A,i5} - U_{H,j2}^* U_{H,k1}^* U_{H,l4}^* U_{A,i5} \\
& - U_{H,j1}^* U_{H,k2}^* U_{H,l4}^* U_{A,i5} \\
& + U_{H,j4}^* \left(U_{H,k5}^* \left(U_{H,l1}^* U_{A,i2} + U_{H,l2}^* U_{A,i1} \right) + U_{H,k2}^* \left(-U_{H,l1}^* U_{A,i5} + U_{H,l5}^* U_{A,i1} \right) \right. \\
& \left. \left. + U_{H,k1}^* \left(-U_{H,l2}^* U_{A,i5} + U_{H,l5}^* U_{A,i2} \right) \right) \right) \\
& - \sigma'^* \left(-\lambda U_{H,j2}^* U_{H,k5}^* U_{H,l4}^* U_{A,i1} - \lambda U_{H,j2}^* U_{H,k4}^* U_{H,l5}^* U_{A,i1} - \lambda U_{H,j1}^* U_{H,k5}^* U_{H,l4}^* U_{A,i2} \right. \\
& - \lambda U_{H,j1}^* U_{H,k4}^* U_{H,l5}^* U_{A,i2} + \lambda U_{H,j2}^* U_{H,k5}^* U_{H,l1}^* U_{A,i4} + \lambda U_{H,j1}^* U_{H,k5}^* U_{H,l2}^* U_{A,i4} \\
& + \lambda U_{H,j2}^* U_{H,k1}^* U_{H,l5}^* U_{A,i4} + \lambda U_{H,j1}^* U_{H,k2}^* U_{H,l5}^* U_{A,i4} - 2\kappa' U_{H,j3}^* U_{H,k5}^* U_{H,l5}^* U_{A,i4} \\
& + \lambda U_{H,j2}^* U_{H,k4}^* U_{H,l1}^* U_{A,i5} + \lambda U_{H,j1}^* U_{H,k4}^* U_{H,l2}^* U_{A,i5} + \lambda U_{H,j2}^* U_{H,k1}^* U_{H,l4}^* U_{A,i5} \\
& + \lambda U_{H,j1}^* U_{H,k2}^* U_{H,l4}^* U_{A,i5} + 2\kappa' U_{H,j3}^* U_{H,k5}^* U_{H,l4}^* U_{A,i5} + 2\kappa' U_{H,j3}^* U_{H,k4}^* U_{H,l5}^* U_{A,i5} \\
& - U_{H,j5}^* \left(\lambda U_{H,k1}^* U_{H,l4}^* U_{A,i2} + 2\kappa' U_{H,k5}^* U_{H,l4}^* U_{A,i3} - \lambda U_{H,k1}^* U_{H,l2}^* U_{A,i4} + 2\kappa' U_{H,k5}^* U_{H,l3}^* U_{A,i4} \right. \\
& + 2\kappa' U_{H,k3}^* U_{H,l5}^* U_{A,i4} + \lambda U_{H,k2}^* \left(-U_{H,l1}^* U_{A,i4} + U_{H,l4}^* U_{A,i1} \right) - 2\kappa' U_{H,k3}^* U_{H,l4}^* U_{A,i5} \\
& \left. \left. + U_{H,k4}^* \left(-2\kappa' U_{H,l3}^* U_{A,i5} + 2\kappa' U_{H,l5}^* U_{A,i3} + \lambda U_{H,l1}^* U_{A,i2} + \lambda U_{H,l2}^* U_{A,i1} \right) \right) \right) \\
& - U_{H,j4}^* \left(\lambda U_{H,k1}^* U_{H,l5}^* U_{A,i2} - \lambda U_{H,k1}^* U_{H,l2}^* U_{A,i5} - 2\kappa' U_{H,k3}^* U_{H,l5}^* U_{A,i5} \right.
\end{aligned}$$

$$\begin{aligned}
& + \lambda U_{H,k2}^* \left(-U_{H,l1}^* U_{A,i5} + U_{H,l5}^* U_{A,i1} \right) \\
& + U_{H,k5}^* \left(-2\kappa' U_{H,l3}^* U_{A,i5} + 2\kappa' U_{H,l5}^* U_{A,i3} + \lambda U_{H,l1}^* U_{A,i2} + \lambda U_{H,l2}^* U_{A,i1} \right) \Big) \\
& - 2\sigma \kappa'^* \left(U_{H,j4}^* \left(-U_{H,k3}^* U_{H,l5}^* U_{A,i5} + U_{H,k5}^* \left(-U_{H,l3}^* U_{A,i5} + U_{H,l5}^* U_{A,i3} \right) \right) \right. \\
& + U_{H,j5}^* \left(U_{H,k5}^* \left(U_{H,l3}^* U_{A,i4} + U_{H,l4}^* U_{A,i3} \right) + U_{H,k4}^* \left(-U_{H,l3}^* U_{A,i5} + U_{H,l5}^* U_{A,i3} \right) \right. \\
& + U_{H,k3}^* \left(-U_{H,l4}^* U_{A,i5} + U_{H,l5}^* U_{A,i4} \right) \Big) \\
& \left. + U_{H,j3}^* \left(-U_{H,k4}^* U_{H,l5}^* U_{A,i5} + U_{H,k5}^* \left(-U_{H,l4}^* U_{A,i5} + U_{H,l5}^* U_{A,i4} \right) \right) \right) \Big) \quad (569)
\end{aligned}$$

$$\begin{aligned}
& \frac{1}{4} \left(\left(-2|\lambda|^2 + g_2^2 \right) U_{H,j2}^* U_{A,i1} \left(-U_{+,k1}^* U_{+,l2} + U_{+,k2}^* U_{+,l1} \right) \right. \\
& + \left(-2|\lambda|^2 + g_2^2 \right) U_{H,j1}^* U_{A,i2} \left(-U_{+,k1}^* U_{+,l2} + U_{+,k2}^* U_{+,l1} \right) \\
& \left. - 2 \left(U_{H,j4}^* U_{A,i5} + U_{H,j5}^* U_{A,i4} \right) \left(-\lambda \sigma'^* U_{+,k1}^* U_{+,l2} + \sigma \lambda^* U_{+,k2}^* U_{+,l1} \right) \right) \quad (570)
\end{aligned}$$

$$-\frac{1}{2}\delta_{\gamma\delta}\left(\lambda\sum_{a=1}^3Y_{d,aa}^*Z_{k3+a}^DZ_{la}^D-\lambda^*\sum_{a=1}^3Z_{ka}^DY_{d,aa}^*Z_{l3+a}^D\right)\left(U_{H,j2}^*U_{A,i3}+U_{H,j3}^*U_{A,i2}\right) \quad (571)$$

$$\begin{aligned}
& -\frac{1}{2}\delta_{\gamma\delta}\left(U_{H,j2}^*\left(\lambda\sum_{a=1}^3Z_{k3+a}^{Dx,*}\kappa_{aa}^*Z_{la}^{Dx}-\lambda^*\sum_{a=1}^3Z_{ka}^{Dx,*}Z_{l3+a}^{Dx}\kappa_{aa}\right)U_{A,i1}\right. \\
& + U_{H,j1}^*\left(\lambda\sum_{a=1}^3Z_{k3+a}^{Dx,*}\kappa_{aa}^*Z_{la}^{Dx}-\lambda^*\sum_{a=1}^3Z_{ka}^{Dx,*}Z_{l3+a}^{Dx}\kappa_{aa}\right)U_{A,i2} \\
& \left. + \left(-\sigma'^*\sum_{a=1}^3Z_{ka}^{Dx,*}Z_{l3+a}^{Dx}\kappa_{aa}+\sigma\sum_{a=1}^3Z_{k3+a}^{Dx,*}\kappa_{aa}^*Z_{la}^{Dx}\right)\left(U_{H,j4}^*U_{A,i5}+U_{H,j5}^*U_{A,i4}\right)\right) \tag{572}
\end{aligned}$$

$$-\frac{1}{2}\left(\lambda\sum_{a=1}^3Y_{e,aa}^*Z_{k3+a}^{E,*}Z_{la}^E-\lambda^*\sum_{a=1}^3Z_{ka}^{E,*}Y_{e,aa}Z_{l3+a}^E\right)\left(U_{H,j2}^*U_{A,i3}+U_{H,j3}^*U_{A,i2}\right) \tag{573}$$

$$-\frac{1}{2}\delta_{\gamma\delta}\left(\lambda\sum_{a=1}^3Y_{u,aa}^*Z_{k3+a}^{U,*}Z_{la}^U-\lambda^*\sum_{a=1}^3Z_{ka}^{U,*}Y_{u,aa}Z_{l3+a}^U\right)\left(U_{H,j1}^*U_{A,i3}+U_{H,j3}^*U_{A,i1}\right) \quad (574)$$

$$-\frac{1}{2}\frac{1}{\sqrt{2}}g_2^2\left(UHp0_{k1}^*UHppl_1+UHp0_{k2}^*UHppl_2\right)\left(U_{+,j1}^*U_{A,i1}-U_{+,j2}^*U_{A,i2}\right) \quad (575)$$

$$\begin{aligned} & -\frac{1}{2}\frac{1}{\sqrt{2}}\delta_{\gamma\delta}\left(U_{+,j1}^*\left(g_2^2\sum_{a=1}^3Z_{ka}^{U,*}Z_{la}^DU_{A,i1}-2\sum_{b=1}^3|Y_{d,bb}|^2Z_{kb}^{U,*}Z_{lb}^DU_{A,i1}\right.\right. \\ & \left.-2\sum_{b=1}^3Y_{u,bb}^*Z_{k3+b}^{U,*}Y_{d,bb}Z_{l3+b}^DU_{A,i2}+2\lambda\sum_{a=1}^3Y_{u,aa}^*Z_{k3+a}^{U,*}Z_{la}^DU_{A,i3}\right) \\ & +U_{+,j2}^*\left(2\sum_{b=1}^3Y_{u,bb}^*Z_{k3+b}^{U,*}Y_{d,bb}Z_{l3+b}^DU_{A,i1}-g_2^2\sum_{a=1}^3Z_{ka}^{U,*}Z_{la}^DU_{A,i2}\right. \\ & \left.+2\sum_{b=1}^3|Y_{u,bb}|^2Z_{kb}^{U,*}Z_{lb}^DU_{A,i2}-2\lambda^*\sum_{a=1}^3Z_{ka}^{U,*}Y_{d,aa}Z_{l3+a}^DU_{A,i3}\right) \end{aligned} \quad (576)$$

$$\begin{aligned}
& -\frac{1}{2} \frac{1}{\sqrt{2}} \left(U_{+,j1}^* \left(-2 \sum_{b=1}^3 |Y_{e,bb}|^2 Z_{kb}^{V,*} Z_{lb}^E + g_2^2 \sum_{a=1}^3 Z_{ka}^{V,*} Z_{la}^E \right) U_{A,i1} \right. \\
& \left. - U_{+,j2}^* \left(2\lambda^* \sum_{a=1}^3 Z_{ka}^{V,*} Y_{e,aa} Z_{l3+a}^E U_{A,i3} + g_2^2 \sum_{a=1}^3 Z_{ka}^{V,*} Z_{la}^E U_{A,i2} \right) \right) \quad (577)
\end{aligned}$$

$$\begin{aligned}
& \frac{1}{2} \frac{1}{\sqrt{2}} \delta_{\beta\delta} \left(g_2^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^U \left(U_{A,i1} U_{+,k1} - U_{A,i2} U_{+,k2} \right) \right. \\
& + 2 \left(- \sum_{b=1}^3 |Y_{d,bb}|^2 Z_{jb}^{D,*} Z_{lb}^U U_{A,i1} U_{+,k1} + \lambda^* \sum_{a=1}^3 Z_{ja}^{D,*} Y_{u,aa} Z_{l3+a}^U U_{A,i3} U_{+,k1} \right. \\
& + \sum_{b=1}^3 |Y_{u,bb}|^2 Z_{jb}^{D,*} Z_{lb}^U U_{A,i2} U_{+,k2} - \lambda \sum_{a=1}^3 Y_{d,aa}^* Z_{j3+a}^{D,*} Z_{la}^U U_{A,i3} U_{+,k2} \\
& \left. \left. + \sum_{b=1}^3 Y_{d,bb}^* Z_{j3+b}^{D,*} Y_{u,bb} Z_{l3+b}^U \left(U_{A,i1} U_{+,k2} - U_{A,i2} U_{+,k1} \right) \right) \right) \quad (578)
\end{aligned}$$

$$\begin{aligned}
& \frac{1}{2} \frac{1}{\sqrt{2}} \left(g_2^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^V \left(U_{A,i1} U_{+,k1} - U_{A,i2} U_{+,k2} \right) \right. \\
& \left. - 2 \left(\lambda \sum_{a=1}^3 Y_{e,aa}^* Z_{j3+a}^{E,*} Z_{la}^V U_{A,i3} U_{+,k2} + \sum_{b=1}^3 |Y_{e,bb}|^2 Z_{jb}^{E,*} Z_{lb}^V U_{A,i1} U_{+,k1} \right) \right)
\end{aligned} \tag{579}$$

$$\frac{1}{2} \frac{1}{\sqrt{2}} g_2^2 \left(U H p p_{j1}^* U H p 0_{l1} + U H p p_{j2}^* U H p 0_{l2} \right) \left(U_{A,i1} U_{+,k1} - U_{A,i2} U_{+,k2} \right) \tag{580}$$

$$\frac{i}{4} \left(12 g_1^2 Q_S U_{H,i3}^* U_{H,j3}^* U_{H,k1}^* U_{H,l1}^* - 4 |\lambda|^2 U_{H,i3}^* U_{H,j3}^* U_{H,k1}^* U_{H,l1}^* \right)$$

$$\begin{aligned}
& -12g_1^2 Q_S U_{H,i4}^* U_{H,j4}^* U_{H,k1}^* U_{H,l1}^* - \sigma \lambda^* U_{H,i5}^* U_{H,j4}^* U_{H,k2}^* U_{H,l1}^* \\
& - \lambda \sigma'^* U_{H,i5}^* U_{H,j4}^* U_{H,k2}^* U_{H,l1}^* - \sigma \lambda^* U_{H,i4}^* U_{H,j5}^* U_{H,k2}^* U_{H,l1}^* \\
& - \lambda \sigma'^* U_{H,i4}^* U_{H,j5}^* U_{H,k2}^* U_{H,l1}^* + 12g_1^2 Q_S U_{H,i3}^* U_{H,j1}^* U_{H,k3}^* U_{H,l1}^* \\
& - 4|\lambda|^2 U_{H,i3}^* U_{H,j1}^* U_{H,k3}^* U_{H,l1}^* - 12g_1^2 Q_S U_{H,i4}^* U_{H,j1}^* U_{H,k4}^* U_{H,l1}^* \\
& - \sigma \lambda^* U_{H,i5}^* U_{H,j2}^* U_{H,k4}^* U_{H,l1}^* - \lambda \sigma'^* U_{H,i5}^* U_{H,j2}^* U_{H,k4}^* U_{H,l1}^* \\
& - \sigma \lambda^* U_{H,i4}^* U_{H,j2}^* U_{H,k5}^* U_{H,l1}^* - \lambda \sigma'^* U_{H,i4}^* U_{H,j2}^* U_{H,k5}^* U_{H,l1}^* \\
& - \sigma \lambda^* U_{H,i5}^* U_{H,j4}^* U_{H,k1}^* U_{H,l2}^* - \lambda \sigma'^* U_{H,i5}^* U_{H,j4}^* U_{H,k1}^* U_{H,l2}^* \\
& - \sigma \lambda^* U_{H,i4}^* U_{H,j5}^* U_{H,k1}^* U_{H,l2}^* - \lambda \sigma'^* U_{H,i4}^* U_{H,j5}^* U_{H,k1}^* U_{H,l2}^* \\
& + 8g_1^2 Q_S U_{H,i3}^* U_{H,j3}^* U_{H,k2}^* U_{H,l2}^* - 4|\lambda|^2 U_{H,i3}^* U_{H,j3}^* U_{H,k2}^* U_{H,l2}^* \\
& - 8g_1^2 Q_S U_{H,i4}^* U_{H,j4}^* U_{H,k2}^* U_{H,l2}^* + 8g_1^2 Q_S U_{H,i3}^* U_{H,j2}^* U_{H,k3}^* U_{H,l2}^* \\
& - 4|\lambda|^2 U_{H,i3}^* U_{H,j2}^* U_{H,k3}^* U_{H,l2}^* - \sigma \lambda^* U_{H,i5}^* U_{H,j1}^* U_{H,k4}^* U_{H,l2}^* \\
& - \lambda \sigma'^* U_{H,i5}^* U_{H,j1}^* U_{H,k4}^* U_{H,l2}^* - 8g_1^2 Q_S U_{H,i4}^* U_{H,j2}^* U_{H,k4}^* U_{H,l2}^* \\
& - \sigma \lambda^* U_{H,i4}^* U_{H,j1}^* U_{H,k5}^* U_{H,l2}^* - \lambda \sigma'^* U_{H,i4}^* U_{H,j1}^* U_{H,k5}^* U_{H,l2}^* \\
& + 12g_1^2 Q_S U_{H,i3}^* U_{H,j1}^* U_{H,k1}^* U_{H,l3}^* - 4|\lambda|^2 U_{H,i3}^* U_{H,j1}^* U_{H,k1}^* U_{H,l3}^* \\
& + 8g_1^2 Q_S U_{H,i3}^* U_{H,j2}^* U_{H,k2}^* U_{H,l3}^* - 4|\lambda|^2 U_{H,i3}^* U_{H,j2}^* U_{H,k2}^* U_{H,l3}^* \\
& - 12g_1^2 Q_S^2 U_{H,i3}^* U_{H,j3}^* U_{H,k3}^* U_{H,l3}^* + 4g_1^2 Q_S^2 U_{H,i4}^* U_{H,j4}^* U_{H,k3}^* U_{H,l3}^* \\
& - 4|\sigma|^2 U_{H,i4}^* U_{H,j4}^* U_{H,k3}^* U_{H,l3}^* - 4|\sigma|^2 U_{H,i5}^* U_{H,j5}^* U_{H,k3}^* U_{H,l3}^* \\
& + 4g_1^2 Q_S^2 U_{H,i4}^* U_{H,j3}^* U_{H,k4}^* U_{H,l3}^* - 4|\sigma|^2 U_{H,i4}^* U_{H,j3}^* U_{H,k4}^* U_{H,l3}^* \\
& + 4g_1^2 Q_S^2 U_{H,i3}^* U_{H,j4}^* U_{H,k4}^* U_{H,l3}^* - 4|\sigma|^2 U_{H,i3}^* U_{H,j4}^* U_{H,k4}^* U_{H,l3}^* \\
& + 2\sigma \kappa'^* U_{H,i5}^* U_{H,j5}^* U_{H,k4}^* U_{H,l3}^* + 2\kappa' \sigma'^* U_{H,i5}^* U_{H,j5}^* U_{H,k4}^* U_{H,l3}^* \\
& - 4|\sigma|^2 U_{H,i5}^* U_{H,j3}^* U_{H,k5}^* U_{H,l3}^* + 2\sigma \kappa'^* U_{H,i5}^* U_{H,j4}^* U_{H,k5}^* U_{H,l3}^* \\
& + 2\kappa' \sigma'^* U_{H,i5}^* U_{H,j4}^* U_{H,k5}^* U_{H,l3}^* - 4|\sigma|^2 U_{H,i3}^* U_{H,j5}^* U_{H,k5}^* U_{H,l3}^* \\
& + 2\sigma \kappa'^* U_{H,i4}^* U_{H,j5}^* U_{H,k5}^* U_{H,l3}^* + 2\kappa' \sigma'^* U_{H,i4}^* U_{H,j5}^* U_{H,k5}^* U_{H,l3}^* \\
& - 12g_1^2 Q_S U_{H,i4}^* U_{H,j1}^* U_{H,k1}^* U_{H,l4}^* - \sigma \lambda^* U_{H,i5}^* U_{H,j2}^* U_{H,k1}^* U_{H,l4}^* \\
& - \lambda \sigma'^* U_{H,i5}^* U_{H,j2}^* U_{H,k1}^* U_{H,l4}^* - \sigma \lambda^* U_{H,i5}^* U_{H,j1}^* U_{H,k2}^* U_{H,l4}^* \\
& - \lambda \sigma'^* U_{H,i5}^* U_{H,j1}^* U_{H,k2}^* U_{H,l4}^* - 8g_1^2 Q_S U_{H,i4}^* U_{H,j2}^* U_{H,k2}^* U_{H,l4}^* \\
& + 4g_1^2 Q_S^2 U_{H,i4}^* U_{H,j3}^* U_{H,k3}^* U_{H,l4}^* - 4|\sigma|^2 U_{H,i4}^* U_{H,j3}^* U_{H,k3}^* U_{H,l4}^* \\
& + 4g_1^2 Q_S^2 U_{H,i3}^* U_{H,j4}^* U_{H,k3}^* U_{H,l4}^* - 4|\sigma|^2 U_{H,i3}^* U_{H,j4}^* U_{H,k3}^* U_{H,l4}^* \\
& + 2\sigma \kappa'^* U_{H,i5}^* U_{H,j5}^* U_{H,k3}^* U_{H,l4}^* + 2\kappa' \sigma'^* U_{H,i5}^* U_{H,j5}^* U_{H,k3}^* U_{H,l4}^* \\
& + 4g_1^2 Q_S^2 U_{H,i3}^* U_{H,j3}^* U_{H,k4}^* U_{H,l4}^* - 4|\sigma|^2 U_{H,i3}^* U_{H,j3}^* U_{H,k4}^* U_{H,l4}^* \\
& - 12g_1^2 Q_S^2 U_{H,i4}^* U_{H,j4}^* U_{H,k4}^* U_{H,l4}^* - 4|\sigma|^2 U_{H,i5}^* U_{H,j5}^* U_{H,k4}^* U_{H,l4}^* \\
& + 2\sigma \kappa'^* U_{H,i5}^* U_{H,j3}^* U_{H,k5}^* U_{H,l4}^* + 2\kappa' \sigma'^* U_{H,i5}^* U_{H,j3}^* U_{H,k5}^* U_{H,l4}^* \\
& - 4|\sigma|^2 U_{H,i5}^* U_{H,j4}^* U_{H,k5}^* U_{H,l4}^* + 2\sigma \kappa'^* U_{H,i3}^* U_{H,j5}^* U_{H,k5}^* U_{H,l4}^*
\end{aligned}$$

$$\begin{aligned}
& + 2\kappa'\sigma'^*U_{H,i3}^*U_{H,j5}^*U_{H,k5}^*U_{H,l4}^* - 4|\sigma|^2U_{H,i4}^*U_{H,j5}^*U_{H,k5}^*U_{H,l4}^* \\
& - \sigma\lambda^*U_{H,i4}^*U_{H,j2}^*U_{H,k1}^*U_{H,l5}^* - \lambda\sigma'^*U_{H,i4}^*U_{H,j2}^*U_{H,k1}^*U_{H,l5}^* \\
& - \sigma\lambda^*U_{H,i4}^*U_{H,j1}^*U_{H,k2}^*U_{H,l5}^* - \lambda\sigma'^*U_{H,i4}^*U_{H,j1}^*U_{H,k2}^*U_{H,l5}^* \\
& - 4|\sigma|^2U_{H,i5}^*U_{H,j3}^*U_{H,k3}^*U_{H,l5}^* + 2\sigma\kappa'^*U_{H,i5}^*U_{H,j4}^*U_{H,k3}^*U_{H,l5}^* \\
& + 2\kappa'\sigma'^*U_{H,i5}^*U_{H,j4}^*U_{H,k3}^*U_{H,l5}^* - 4|\sigma|^2U_{H,i3}^*U_{H,j5}^*U_{H,k3}^*U_{H,l5}^* \\
& + 2\sigma\kappa'^*U_{H,i4}^*U_{H,j5}^*U_{H,k3}^*U_{H,l5}^* + 2\kappa'\sigma'^*U_{H,i4}^*U_{H,j5}^*U_{H,k3}^*U_{H,l5}^* \\
& + 2\sigma\kappa'^*U_{H,i5}^*U_{H,j3}^*U_{H,k4}^*U_{H,l5}^* + 2\kappa'\sigma'^*U_{H,i5}^*U_{H,j3}^*U_{H,k4}^*U_{H,l5}^* \\
& - 4|\sigma|^2U_{H,i5}^*U_{H,j4}^*U_{H,k4}^*U_{H,l5}^* + 2\sigma\kappa'^*U_{H,i3}^*U_{H,j5}^*U_{H,k4}^*U_{H,l5}^* \\
& + 2\kappa'\sigma'^*U_{H,i3}^*U_{H,j5}^*U_{H,k4}^*U_{H,l5}^* - 4|\sigma|^2U_{H,i4}^*U_{H,j5}^*U_{H,k4}^*U_{H,l5}^* \\
& - 4|\sigma|^2U_{H,i3}^*U_{H,j3}^*U_{H,k5}^*U_{H,l5}^* + 2\sigma\kappa'^*U_{H,i4}^*U_{H,j3}^*U_{H,k5}^*U_{H,l5}^* \\
& + 2\kappa'\sigma'^*U_{H,i4}^*U_{H,j3}^*U_{H,k5}^*U_{H,l5}^* + 2\sigma\kappa'^*U_{H,i3}^*U_{H,j4}^*U_{H,k5}^*U_{H,l5}^* \\
& + 2\kappa'\sigma'^*U_{H,i3}^*U_{H,j4}^*U_{H,k5}^*U_{H,l5}^* - 4|\sigma|^2U_{H,i4}^*U_{H,j4}^*U_{H,k5}^*U_{H,l5}^* \\
& - 24|\kappa'|^2U_{H,i5}^*U_{H,j5}^*U_{H,k5}^*U_{H,l5}^* \\
& + U_{H,i2}^* \left(-\sigma\lambda^*U_{H,j5}^*U_{H,k4}^*U_{H,l1}^* - \lambda\sigma'^*U_{H,j5}^*U_{H,k4}^*U_{H,l1}^* - \sigma\lambda^*U_{H,j4}^*U_{H,k5}^*U_{H,l1}^* \right. \\
& - \lambda\sigma'^*U_{H,j4}^*U_{H,k5}^*U_{H,l1}^* + 8g_1^2Q_SU_{H,j3}^*U_{H,k3}^*U_{H,l2}^* - 4|\lambda|^2U_{H,j3}^*U_{H,k3}^*U_{H,l2}^* \\
& - 8g_1^2Q_SU_{H,j4}^*U_{H,k4}^*U_{H,l2}^* + 8g_1^2Q_SU_{H,j3}^*U_{H,k2}^*U_{H,l3}^* - 4|\lambda|^2U_{H,j3}^*U_{H,k2}^*U_{H,l3}^* \\
& - \sigma\lambda^*U_{H,j5}^*U_{H,k1}^*U_{H,l4}^* - \lambda\sigma'^*U_{H,j5}^*U_{H,k1}^*U_{H,l4}^* - 8g_1^2Q_SU_{H,j4}^*U_{H,k2}^*U_{H,l4}^* \\
& + U_{H,j2}^* \left(\left(-24g_1^2 - 4|\lambda|^2 + g_1^2 + g_2^2 \right) U_{H,k1}^*U_{H,l1}^* - 3 \left(16g_1^2 + g_1^2 + g_2^2 \right) U_{H,k2}^*U_{H,l2}^* \right. \\
& + 8g_1^2Q_SU_{H,k3}^*U_{H,l3}^* - 4|\lambda|^2U_{H,k3}^*U_{H,l3}^* - 8g_1^2Q_SU_{H,k4}^*U_{H,l4}^* \left. \right) \\
& - \sigma\lambda^*U_{H,j4}^*U_{H,k1}^*U_{H,l5}^* - \lambda\sigma'^*U_{H,j4}^*U_{H,k1}^*U_{H,l5}^* \\
& + U_{H,j1}^* \left(\left(-24g_1^2 - 4|\lambda|^2 + g_1^2 + g_2^2 \right) U_{H,k2}^*U_{H,l1}^* + \left(-24g_1^2 - 4|\lambda|^2 + g_1^2 + g_2^2 \right) U_{H,k1}^*U_{H,l2}^* \right. \\
& - \left(\lambda\sigma'^* + \sigma\lambda^* \right) \left(U_{H,k4}^*U_{H,l5}^* + U_{H,k5}^*U_{H,l4}^* \right) \left. \right) \\
& - U_{H,i1}^* \left(-12g_1^2Q_SU_{H,j3}^*U_{H,k3}^*U_{H,l1}^* + 4|\lambda|^2U_{H,j3}^*U_{H,k3}^*U_{H,l1}^* + 12g_1^2Q_SU_{H,j4}^*U_{H,k4}^*U_{H,l1}^* \right. \\
& + \sigma\lambda^*U_{H,j5}^*U_{H,k4}^*U_{H,l2}^* + \lambda\sigma'^*U_{H,j5}^*U_{H,k4}^*U_{H,l2}^* + \sigma\lambda^*U_{H,j4}^*U_{H,k5}^*U_{H,l2}^* \\
& + \lambda\sigma'^*U_{H,j4}^*U_{H,k5}^*U_{H,l2}^* - 12g_1^2Q_SU_{H,j3}^*U_{H,k1}^*U_{H,l3}^* + 4|\lambda|^2U_{H,j3}^*U_{H,k1}^*U_{H,l3}^* \\
& + 12g_1^2Q_SU_{H,j4}^*U_{H,k1}^*U_{H,l4}^* + \sigma\lambda^*U_{H,j5}^*U_{H,k2}^*U_{H,l4}^* + \lambda\sigma'^*U_{H,j5}^*U_{H,k2}^*U_{H,l4}^* \\
& + U_{H,j1}^* \left(3 \left(36g_1^2 + g_1^2 + g_2^2 \right) U_{H,k1}^*U_{H,l1}^* - \left(-24g_1^2 - 4|\lambda|^2 + g_1^2 + g_2^2 \right) U_{H,k2}^*U_{H,l2}^* \right. \\
& + 4 \left(\left(-3g_1^2Q_S + |\lambda|^2 \right) U_{H,k3}^*U_{H,l3}^* + 3g_1^2Q_SU_{H,k4}^*U_{H,l4}^* \right) \left. \right) \\
& + \sigma\lambda^*U_{H,j4}^*U_{H,k2}^*U_{H,l5}^* + \lambda\sigma'^*U_{H,j4}^*U_{H,k2}^*U_{H,l5}^* \\
& + U_{H,j2}^* \left(- \left(-24g_1^2 - 4|\lambda|^2 + g_1^2 + g_2^2 \right) U_{H,k2}^*U_{H,l1}^* - \left(-24g_1^2 - 4|\lambda|^2 + g_1^2 + g_2^2 \right) U_{H,k1}^*U_{H,l2}^* \right)
\end{aligned}$$

$$+ \left(\lambda \sigma'^{*} + \sigma \lambda^* \right) \left(U_{H,k4}^* U_{H,l5}^* + U_{H,k5}^* U_{H,l4}^* \right) \right) \right) \quad (581)$$

$$\begin{aligned} & \frac{i}{4} \left(U_{H,i2}^* \left(- \left(-2|\lambda|^2 + g_2^2 \right) U_{H,j1}^* \left(U_{+,k1}^* U_{+,l2} + U_{+,k2}^* U_{+,l1} \right) \right. \right. \\ & + U_{H,j2}^* \left(- \left(16g_1'^2 + g_1^2 + g_2^2 \right) U_{+,k2}^* U_{+,l2} + \left(-24g_1'^2 - g_2^2 + g_1^2 \right) U_{+,k1}^* U_{+,l1} \right) \\ & - U_{H,i1}^* \left(\left(-2|\lambda|^2 + g_2^2 \right) U_{H,j2}^* \left(U_{+,k1}^* U_{+,l2} + U_{+,k2}^* U_{+,l1} \right) \right. \\ & + U_{H,j1}^* \left(\left(24g_1'^2 - g_1^2 + g_2^2 \right) U_{+,k2}^* U_{+,l2} + \left(36g_1'^2 + g_1^2 + g_2^2 \right) U_{+,k1}^* U_{+,l1} \right) \\ & + 2 \left(U_{H,i5}^* U_{H,j4}^* \left(\lambda \sigma'^{*} U_{+,k1}^* U_{+,l2} + \sigma \lambda^* U_{+,k2}^* U_{+,l1} \right) \right. \\ & + 2 U_{H,i3}^* U_{H,j3}^* \left(\left(2g_1'^2 Q_S - |\lambda|^2 \right) U_{+,k2}^* U_{+,l2} + \left(3g_1'^2 Q_S - |\lambda|^2 \right) U_{+,k1}^* U_{+,l1} \right) \\ & \left. \left. \left. + U_{H,i4}^* \left(-2g_1'^2 Q_S U_{H,j4}^* \left(2U_{+,k2}^* U_{+,l2} + 3U_{+,k1}^* U_{+,l1} \right) + U_{H,j5}^* \left(\lambda \sigma'^{*} U_{+,k1}^* U_{+,l2} + \sigma \lambda^* U_{+,k2}^* U_{+,l1} \right) \right) \right) \right) \right) \quad (582) \end{aligned}$$

$$\begin{aligned} & \frac{i}{12} \delta_{\gamma\delta} \left(U_{H,i2}^* \left(- U_{H,j2}^* \left(2 \left(-24g_1'^2 + g_1^2 \right) \sum_{a=1}^3 Z_{k3+a}^{D,*} Z_{l3+a}^D + \left(-24g_1'^2 + 3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{D,*} Z_{la}^D \right) \right. \right. \\ & \left. \left. + 6 U_{H,j3}^* \left(\lambda \sum_{a=1}^3 Y_{d,aa}^* Z_{k3+a}^{D,*} Z_{la}^D + \lambda^* \sum_{a=1}^3 Z_{ka}^{D,*} Y_{d,aa} Z_{l3+a}^D \right) \right) \right) \end{aligned}$$

$$\begin{aligned}
& + 6 \left(2g_{1'}^2 Q_S U_{H,i4}^* U_{H,j4}^* \left(2 \sum_{a=1}^3 Z_{k3+a}^{D,*} Z_{l3+a}^D + \sum_{a=1}^3 Z_{ka}^{D,*} Z_{la}^D \right) \right. \\
& + U_{H,i3}^* \left(-2g_{1'}^2 Q_S U_{H,j3}^* \left(2 \sum_{a=1}^3 Z_{k3+a}^{D,*} Z_{l3+a}^D + \sum_{a=1}^3 Z_{ka}^{D,*} Z_{la}^D \right) \right. \\
& + U_{H,j2}^* \left(\lambda \sum_{a=1}^3 Y_{d,aa}^* Z_{k3+a}^{D,*} Z_{la}^D + \lambda^* \sum_{a=1}^3 Z_{ka}^{D,*} Y_{d,aa} Z_{l3+a}^D \right) \left. \right) \\
& + U_{H,i1}^* U_{H,j1}^* \left(\left(36g_{1'}^2 + 3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{D,*} Z_{la}^D \right. \\
& + 2 \left(\left(36g_{1'}^2 + g_1^2 \right) \sum_{a=1}^3 Z_{k3+a}^{D,*} Z_{l3+a}^D - 6 \left(\sum_{b=1}^3 |Y_{d,bb}|^2 Z_{kb}^{D,*} Z_{lb}^D + \sum_{b=1}^3 |Y_{d,bb}|^2 Z_{k3+b}^{D,*} Z_{l3+b}^D \right) \right) \left. \right) \quad (583)
\end{aligned}$$

$$\begin{aligned}
& \frac{i}{6} \delta_{\gamma\delta} \left(U_{H,i2}^* \left(U_{H,j2}^* \left(\left(-24g_{1'}^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{Dx,*} Z_{la}^{Dx} - \left(36g_{1'}^2 + g_1^2 \right) \sum_{a=1}^3 Z_{k3+a}^{Dx,*} Z_{l3+a}^{Dx} \right) \right. \right. \\
& + 3U_{H,j1}^* \left(\lambda \sum_{a=1}^3 Z_{k3+a}^{Dx,*} \kappa_{aa}^* Z_{la}^{Dx} + \lambda^* \sum_{a=1}^3 Z_{ka}^{Dx,*} Z_{l3+a}^{Dx} \kappa_{aa} \right) \left. \right) \\
& + U_{H,i1}^* \left(-U_{H,j1}^* \left(\left(36g_{1'}^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{Dx,*} Z_{la}^{Dx} - \left(-54g_{1'}^2 + g_1^2 \right) \sum_{a=1}^3 Z_{k3+a}^{Dx,*} Z_{l3+a}^{Dx} \right) \right. \\
& + 3U_{H,j2}^* \left(\lambda \sum_{a=1}^3 Z_{k3+a}^{Dx,*} \kappa_{aa}^* Z_{la}^{Dx} + \lambda^* \sum_{a=1}^3 Z_{ka}^{Dx,*} Z_{l3+a}^{Dx} \kappa_{aa} \right) \left. \right) \\
& + 3 \left(U_{H,i5}^* U_{H,j4}^* \left(\sigma'^* \sum_{a=1}^3 Z_{ka}^{Dx,*} Z_{l3+a}^{Dx} \kappa_{aa} + \sigma \sum_{a=1}^3 Z_{k3+a}^{Dx,*} \kappa_{aa}^* Z_{la}^{Dx} \right) \right. \\
& + U_{H,i4}^* \left(-2g_{1'}^2 Q_S U_{H,j4}^* \left(2 \sum_{a=1}^3 Z_{ka}^{Dx,*} Z_{la}^{Dx} + 3 \sum_{a=1}^3 Z_{k3+a}^{Dx,*} Z_{l3+a}^{Dx} \right) \right. \\
& + U_{H,j5}^* \left(\sigma'^* \sum_{a=1}^3 Z_{ka}^{Dx,*} Z_{l3+a}^{Dx} \kappa_{aa} + \sigma \sum_{a=1}^3 Z_{k3+a}^{Dx,*} \kappa_{aa}^* Z_{la}^{Dx} \right) \left. \right)
\end{aligned}$$

$$\begin{aligned}
& + 2U_{H,i3}^* U_{H,j3}^* \left(2g_{1'}^2 Q_S \sum_{a=1}^3 Z_{ka}^{Dx,*} Z_{la}^{Dx} + 3g_{1'}^2 Q_S \sum_{a=1}^3 Z_{k3+a}^{Dx,*} Z_{l3+a}^{Dx} - \sum_{b=1}^3 |\kappa_{bb}|^2 Z_{kb}^{Dx,*} Z_{lb}^{Dx} \right. \\
& \left. - \sum_{b=1}^3 |\kappa_{bb}|^2 Z_{k3+b}^{Dx,*} Z_{l3+b}^{Dx} \right) \Big) \Big) \Big) \quad (584)
\end{aligned}$$

$$\begin{aligned}
& \frac{i}{4} \Big(-8g_{1'}^2 Q_S U_{H,i3}^* U_{H,j3}^* \sum_{a=1}^3 Z_{ka}^{E,*} Z_{la}^E + 8g_{1'}^2 Q_S U_{H,i4}^* U_{H,j4}^* \sum_{a=1}^3 Z_{ka}^{E,*} Z_{la}^E \\
& + 2\lambda U_{H,i3}^* U_{H,j2}^* \sum_{a=1}^3 Y_{e,aa}^* Z_{k3+a}^{E,*} Z_{la}^E - 4g_{1'}^2 Q_S U_{H,i3}^* U_{H,j3}^* \sum_{a=1}^3 Z_{k3+a}^{E,*} Z_{l3+a}^E \\
& + 4g_{1'}^2 Q_S U_{H,i4}^* U_{H,j4}^* \sum_{a=1}^3 Z_{k3+a}^{E,*} Z_{l3+a}^E + 2\lambda^* U_{H,i3}^* U_{H,j2}^* \sum_{a=1}^3 Z_{ka}^{E,*} Y_{e,aa} Z_{l3+a}^E \\
& + U_{H,i2}^* \Big(U_{H,j2}^* \Big((16g_{1'}^2 - g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ka}^{E,*} Z_{la}^E - 2 \Big(-4g_{1'}^2 + g_1^2 \Big) \sum_{a=1}^3 Z_{k3+a}^{E,*} Z_{l3+a}^E \Big) \\
& + 2U_{H,j3}^* \Big(\lambda \sum_{a=1}^3 Y_{e,aa}^* Z_{k3+a}^{E,*} Z_{la}^E + \lambda^* \sum_{a=1}^3 Z_{ka}^{E,*} Y_{e,aa} Z_{l3+a}^E \Big) \Big) \\
& + U_{H,i1}^* U_{H,j1}^* \Big((24g_{1'}^2 - g_1^2 + g_2^2) \sum_{a=1}^3 Z_{ka}^{E,*} Z_{la}^E \\
& + 2 \Big(-2 \Big(\sum_{b=1}^3 |Y_{e,bb}|^2 Z_{kb}^{E,*} Z_{lb}^E + \sum_{b=1}^3 |Y_{e,bb}|^2 Z_{k3+b}^{E,*} Z_{l3+b}^E \Big) + (6g_{1'}^2 + g_1^2) \sum_{a=1}^3 Z_{k3+a}^{E,*} Z_{l3+a}^E \Big) \Big) \Big) \quad (585)
\end{aligned}$$

$$\begin{aligned}
& -\frac{i}{4}\left(\left(-24g_{1'}^2 + g_1^2 + g_2^2\right)U_{H,i1}^*U_{H,j1}^* - \left(16g_{1'}^2 + g_1^2 + g_2^2\right)U_{H,i2}^*U_{H,j2}^*\right. \\
& \left.+ 8g_{1'}^2Q_S\left(U_{H,i3}^*U_{H,j3}^* - U_{H,i4}^*U_{H,j4}^*\right)\right)\left(UHp0_{k1}^*UHp0_{l1} - UHp0_{k2}^*UHp0_{l2}\right)
\end{aligned} \tag{586}$$

$$\begin{aligned}
& -\frac{i}{4}\left(\left(-24g_{1'}^2 - g_2^2 + g_1^2\right)U_{H,i1}^*U_{H,j1}^* + \left(-16g_{1'}^2 - g_1^2 + g_2^2\right)U_{H,i2}^*U_{H,j2}^*\right. \\
& \left.+ 8g_{1'}^2Q_S\left(U_{H,i3}^*U_{H,j3}^* - U_{H,i4}^*U_{H,j4}^*\right)\right)\left(UHpp_{k1}^*UHppl1 - UHpp_{k2}^*UHppl2\right)
\end{aligned} \tag{587}$$

$$\frac{i}{12}\delta_{\gamma\delta}\left(U_{H,i1}^*\left(U_{H,j1}^*\left(\left(36g_{1'}^2 - 3g_2^2 + g_1^2\right)\sum_{a=1}^3Z_{ka}^{U,*}Z_{la}^U - 4\left(-9g_{1'}^2 + g_1^2\right)\sum_{a=1}^3Z_{k3+a}^{U,*}Z_{l3+a}^U\right)\right.\right.$$

$$\begin{aligned}
& + 6U_{H,j3}^* \left(\lambda \sum_{a=1}^3 Y_{u,aa}^* Z_{k3+a}^{U,*} Z_{la}^U + \lambda^* \sum_{a=1}^3 Z_{ka}^{U,*} Y_{u,aa} Z_{l3+a}^U \right) \\
& + 6 \left(2g_{1'}^2 Q_S U_{H,i4}^* U_{H,j4}^* \delta_{kl} \right. \\
& + U_{H,i3}^* \left(-2g_{1'}^2 Q_S U_{H,j3}^* \delta_{kl} + U_{H,j1}^* \left(\lambda \sum_{a=1}^3 Y_{u,aa}^* Z_{k3+a}^{U,*} Z_{la}^U + \lambda^* \sum_{a=1}^3 Z_{ka}^{U,*} Y_{u,aa} Z_{l3+a}^U \right) \right) \\
& + U_{H,i2}^* U_{H,j2}^* \left(\left(3(8g_{1'}^2 + g_2^2) - g_1^2 \right) \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^U \right. \\
& \left. \left. + 4 \left(-3 \left(\sum_{b=1}^3 |Y_{u,bb}|^2 Z_{kb}^{U,*} Z_{lb}^U + \sum_{b=1}^3 |Y_{u,bb}|^2 Z_{k3+b}^{U,*} Z_{l3+b}^U \right) + (6g_{1'}^2 + g_1^2) \sum_{a=1}^3 Z_{k3+a}^{U,*} Z_{l3+a}^U \right) \right) \right) \delta_{kl}
\end{aligned} \tag{588}$$

$$\begin{aligned}
& \frac{i}{4} \left(- \left(-24g_{1'}^2 + g_1^2 + g_2^2 \right) U_{H,i1}^* U_{H,j1}^* + \left(16g_{1'}^2 + g_1^2 + g_2^2 \right) U_{H,i2}^* U_{H,j2}^* \right. \\
& \left. + 8g_{1'}^2 Q_S \left(-U_{H,i3}^* U_{H,j3}^* + U_{H,i4}^* U_{H,j4}^* \right) \right) \delta_{kl}
\end{aligned} \tag{589}$$

$$- \frac{i}{2} \frac{1}{\sqrt{2}} g_2^2 \left(U_{H,i1}^* U_{+,j1}^* + U_{H,i2}^* U_{+,j2}^* \right) \left(U H p 0_{k1}^* U H p p_{l1} + U H p 0_{k2}^* U H p p_{l2} \right) \tag{590}$$

$$\begin{aligned}
& \frac{i}{2} \frac{1}{\sqrt{2}} \delta_{\gamma\delta} \left(2U_{H,i3}^* \left(\lambda U_{+,j1}^* \sum_{a=1}^3 Y_{u,aa}^* Z_{k3+a}^{U,*} Z_{la}^D + \lambda^* U_{+,j2}^* \sum_{a=1}^3 Z_{ka}^{U,*} Y_{d,aa} Z_{l3+a}^D \right) \right. \\
& + U_{H,i2}^* \left(U_{+,j2}^* \left(2 \sum_{b=1}^3 |Y_{u,bb}|^2 Z_{kb}^{U,*} Z_{lb}^D - g_2^2 \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^D \right) \right. \\
& + 2U_{+,j1}^* \sum_{b=1}^3 Y_{u,bb}^* Z_{k3+b}^{U,*} Y_{d,bb} Z_{l3+b}^D \left. \right) \\
& + U_{H,i1}^* \left(U_{+,j1}^* \left(2 \sum_{b=1}^3 |Y_{d,bb}|^2 Z_{kb}^{U,*} Z_{lb}^D - g_2^2 \sum_{a=1}^3 Z_{ka}^{U,*} Z_{la}^D \right) \right. \\
& \left. \left. + 2U_{+,j2}^* \sum_{b=1}^3 Y_{u,bb}^* Z_{k3+b}^{U,*} Y_{d,bb} Z_{l3+b}^D \right) \right) \quad (591)
\end{aligned}$$

$$\begin{aligned}
& - \frac{i}{2} \frac{1}{\sqrt{2}} \left(U_{+,j2}^* \left(- 2\lambda^* U_{H,i3}^* \sum_{a=1}^3 Z_{ka}^{V,*} Y_{e,aa} Z_{l3+a}^E + g_2^2 U_{H,i2}^* \sum_{a=1}^3 Z_{ka}^{V,*} Z_{la}^E \right) \right. \\
& \left. + U_{H,i1}^* U_{+,j1}^* \left(- 2 \sum_{b=1}^3 |Y_{e,bb}|^2 Z_{kb}^{V,*} Z_{lb}^E + g_2^2 \sum_{a=1}^3 Z_{ka}^{V,*} Z_{la}^E \right) \right) \quad (592)
\end{aligned}$$

$$\begin{aligned}
& \frac{i}{2} \frac{1}{\sqrt{2}} \delta_{\beta\delta} \left(2\lambda^* U_{H,i3}^* \sum_{a=1}^3 Z_{ja}^{D,*} Y_{u,aa} Z_{l3+a}^U U_{+,k1} + 2U_{H,i2}^* \sum_{b=1}^3 Y_{d,bb}^* Z_{j3+b}^{D,*} Y_{u,bb} Z_{l3+b}^U U_{+,k1} \right. \\
& - g_2^2 U_{H,i2}^* \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^U U_{+,k2} + 2\lambda U_{H,i3}^* \sum_{a=1}^3 Y_{d,aa}^* Z_{j3+a}^{D,*} Z_{la}^U U_{+,k2} \\
& + 2U_{H,i2}^* \sum_{b=1}^3 |Y_{u,bb}|^2 Z_{jb}^{D,*} Z_{lb}^U U_{+,k2} \\
& + U_{H,i1}^* \left(-g_2^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^U U_{+,k1} + 2 \sum_{b=1}^3 |Y_{d,bb}|^2 Z_{jb}^{D,*} Z_{lb}^U U_{+,k1} \right. \\
& \left. \left. + 2 \sum_{b=1}^3 Y_{d,bb}^* Z_{j3+b}^{D,*} Y_{u,bb} Z_{l3+b}^U U_{+,k2} \right) \right) \tag{593}
\end{aligned}$$

$$\begin{aligned}
& - \frac{i}{2} \frac{1}{\sqrt{2}} \left(U_{H,i1}^* \left(-2 \sum_{b=1}^3 |Y_{e,bb}|^2 Z_{jb}^{E,*} Z_{lb}^V + g_2^2 \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^V \right) U_{+,k1} \right. \\
& \left. + \left(-2\lambda U_{H,i3}^* \sum_{a=1}^3 Y_{e,aa}^* Z_{j3+a}^{E,*} Z_{la}^V + g_2^2 U_{H,i2}^* \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^V \right) U_{+,k2} \right) \tag{594}
\end{aligned}$$

$$- \frac{i}{2} \frac{1}{\sqrt{2}} g_2^2 \left(U H p p_{j1}^* U H p 0_{l1} + U H p p_{j2}^* U H p 0_{l2} \right) \left(U_{H,i1}^* U_{+,k1} + U_{H,i2}^* U_{+,k2} \right) \quad (595)$$

$$\begin{aligned} & \frac{i}{4} \left(U_{+,i2}^* \left(-2 \left(16g_{1'}^2 + g_1^2 + g_2^2 \right) U_{+,j2}^* U_{+,k2} U_{+,l2} + \left(-24g_{1'}^2 - 4|\lambda|^2 + g_1^2 + g_2^2 \right) U_{+,j1}^* \left(U_{+,k1} U_{+,l2} + U_{+,k2} U_{+,l1} \right) \right) \right. \\ & \left. + U_{+,i1}^* \left(-2 \left(36g_{1'}^2 + g_1^2 + g_2^2 \right) U_{+,j1}^* U_{+,k1} U_{+,l1} + \left(-24g_{1'}^2 - 4|\lambda|^2 + g_1^2 + g_2^2 \right) U_{+,j2}^* \left(U_{+,k1} U_{+,l2} + U_{+,k2} U_{+,l1} \right) \right) \right) \end{aligned} \quad (596)$$

$$\frac{i}{12} \delta_{\beta\delta} \left(U_{+,i1}^* \left(\left(36g_{1'}^2 - 3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^D \right) \right)$$

$$\begin{aligned}
& + 2 \left(\left(36g_{1'}^2 + g_1^2 \right) \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{l3+a}^D - 6 \sum_{b=1}^3 |Y_{d,bb}|^2 Z_{j3+b}^{D,*} Z_{l3+b}^D \right) U_{+,k1} \\
& + U_{+,i2}^* \left(\left(3 \left(8g_{1'}^2 + g_2^2 \right) - g_1^2 \right) \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^D \right. \\
& \left. - 2 \left(\left(-24g_{1'}^2 + g_1^2 \right) \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{l3+a}^D + 6 \sum_{b=1}^3 |Y_{u,bb}|^2 Z_{jb}^{D,*} Z_{lb}^D \right) U_{+,k2} \right)
\end{aligned} \tag{597}$$

$$\begin{aligned}
& - \frac{i}{6} \delta_{\beta\delta} \left(U_{+,i1}^* \left(\left(36g_{1'}^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{la}^{Dx} U_{+,k1} - \left(-54g_{1'}^2 + g_1^2 \right) \sum_{a=1}^3 Z_{j3+a}^{Dx,*} Z_{l3+a}^{Dx} U_{+,k1} \right. \right. \\
& \left. \left. + 6\lambda \sum_{a=1}^3 Z_{j3+a}^{Dx,*} \kappa_{aa}^* Z_{la}^{Dx} U_{+,k2} \right) \right. \\
& \left. + U_{+,i2}^* \left(6\lambda^* \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{l3+a}^{Dx} \kappa_{aa} U_{+,k1} \right. \right. \\
& \left. \left. + \left(- \left(-24g_{1'}^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{la}^{Dx} + \left(36g_{1'}^2 + g_1^2 \right) \sum_{a=1}^3 Z_{j3+a}^{Dx,*} Z_{l3+a}^{Dx} \right) U_{+,k2} \right) \right)
\end{aligned} \tag{598}$$

$$\frac{i}{4} \left(-U_{+,i1}^* \left(\left(-24g_{1'}^2 + g_1^2 + g_2^2 \right) \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^E \right. \right.$$

$$\begin{aligned}
& -2 \left(-2 \sum_{b=1}^3 |Y_{e,bb}|^2 Z_{j3+b}^{E,*} Z_{l3+b}^E + (6g_{1'}^2 + g_1^2) \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{l3+a}^E \right) U_{+,k1} \\
& + U_{+,i2}^* \left((16g_{1'}^2 + g_1^2 + g_2^2) \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^E - 2 \left(-4g_{1'}^2 + g_1^2 \right) \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{l3+a}^E \right) U_{+,k2}
\end{aligned} \tag{599}$$

$$-\frac{i}{4} \left(UHp0_{j1}^* UHp0_{l1} - UHp0_{j2}^* UHp0_{l2} \right) \left(\left(-16g_{1'}^2 - g_1^2 + g_2^2 \right) U_{+,i2}^* U_{+,k2} + \left(-24g_{1'}^2 - g_2^2 + g_1^2 \right) U_{+,i1}^* U_{+,k1} \right) \tag{600}$$

$$-\frac{i}{4} \left(UHpp_{j1}^* UHpp_{l1} - UHpp_{j2}^* UHpp_{l2} \right) \left(- \left(16g_{1'}^2 + g_1^2 + g_2^2 \right) U_{+,i2}^* U_{+,k2} + \left(-24g_{1'}^2 + g_1^2 + g_2^2 \right) U_{+,i1}^* U_{+,k1} \right) \tag{601}$$

$$\begin{aligned}
& \frac{i}{12} \delta_{\beta\delta} \left(U_{+,i1}^* \left(\left(36g_{1'}^2 + 3g_2^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \right. \right. \\
& - 4 \left(3 \sum_{b=1}^3 |Y_{d,bb}|^2 Z_{jb}^{U,*} Z_{lb}^U + \left(-9g_{1'}^2 + g_1^2 \right) \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U \right) \Big) U_{+,k1} \\
& + U_{+,i2}^* \left(- \left(3 \left(-8g_{1'}^2 + g_2^2 \right) + g_1^2 \right) \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \right. \\
& \left. \left. + 4 \left(-3 \sum_{b=1}^3 |Y_{u,bb}|^2 Z_{j3+b}^{U,*} Z_{l3+b}^U + \left(6g_{1'}^2 + g_1^2 \right) \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U \right) \right) U_{+,k2} \right) \quad (602)
\end{aligned}$$

$$\begin{aligned}
& \frac{i}{4} \left(U_{+,i1}^* \left(\left(24g_{1'}^2 - g_1^2 + g_2^2 \right) \delta_{jl} - 4 \sum_{b=1}^3 |Y_{e,bb}|^2 Z_{jb}^{V,*} Z_{lb}^V \right) U_{+,k1} \right. \\
& \left. + \left(16g_{1'}^2 - g_2^2 + g_1^2 \right) U_{+,i2}^* \delta_{jl} U_{+,k2} \right) \quad (603)
\end{aligned}$$

$$\begin{aligned}
& \frac{i}{72} \left(-\delta_{\alpha\gamma} \delta_{\beta\delta} \left(72 \sum_{a=1}^3 Z_{ja}^{D,*} Y_{d,aa} Z_{l3+a}^D \sum_{b=1}^3 Y_{d,bb}^* Z_{i3+b}^{D,*} Z_{kb}^D + 18g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D \right. \right. \\
& \left. - 18g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D \right)
\end{aligned}$$

$$\begin{aligned}
& + 2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{l3+a}^D \left((2g_1^2 - 3g_3^2 + 72g_{1'}^2) \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + (36g_{1'}^2 + 3g_3^2 + g_1^2) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \\
& + \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^D \left(2(36g_{1'}^2 + 3g_3^2 + g_1^2) \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + (36g_{1'}^2 - 6g_3^2 + 9g_2^2 + g_1^2) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \\
& - 18g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{k3+b}^D + 18g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{k3+b}^D \\
& + 18g_3^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D - 18g_3^2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D \\
& + g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{lb}^D + 36g_{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 + 72g_{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 + 72 \sum_{a=1}^3 Z_{ia}^{D,*} Y_{d,aa} Z_{k3+a}^D \sum_{b=1}^3 Y_{d,bb} Z_{j3+b}^{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 + 72g_{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 \\
& + 144g_{1'}^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{l3+b}^D - 6g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{l3+b}^D \Big) \\
& - \delta_{\alpha\delta} \delta_{\beta\gamma} \left(g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D + 36g_{1'}^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D \right. \\
& + 9g_2^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D - 6g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D \\
& \left. + 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D + 72g_{1'}^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D \right)
\end{aligned}$$

$$\begin{aligned}
& + 6g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{kb}^D + 72 \sum_{a=1}^3 Z_{ia}^{D,*} Y_{d,aa} Z_{l3+a}^D \sum_{b=1}^3 Y_{d,bb}^* Z_{j3+b}^{D,*} Z_{kb}^D \\
& + 18g_3^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{la}^D \left(- \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \\
& - 18g_3^2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{l3+a}^D \left(- \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \\
& + 2g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{k3+b}^D + 72g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{k3+b}^D \\
& + 6g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{k3+b}^D + 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{k3+b}^D \\
& + 144g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{k3+b}^D - 6g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{l3+a}^D \sum_{b=1}^3 Z_{j3+b}^{D,*} Z_{k3+b}^D \\
& + g_1^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D + 36g_1^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D \\
& + 9g_2^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D - 6g_3^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D \\
& + 2g_1^2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D + 72g_1^2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D \\
& + 6g_3^2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^D + 72 \sum_{a=1}^3 Z_{ja}^{D,*} Y_{d,aa} Z_{k3+a}^D \sum_{b=1}^3 Y_{d,bb}^* Z_{i3+b}^{D,*} Z_{lb}^D \\
& + 18g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{lb}^D - 18g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{D,*} Z_{lb}^D \\
& + 2g_1^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{l3+b}^D + 72g_1^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{l3+b}^D \\
& + 6g_3^2 \sum_{a=1}^3 Z_{ja}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{l3+b}^D + 4g_1^2 \sum_{a=1}^3 Z_{j3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{l3+b}^D \\
& + 144g_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 \Big) \Big)
\end{aligned} \tag{604}$$

$$\begin{aligned}
& \frac{i}{36} \left(-9g_3^2 \delta_{\alpha\delta} \delta_{\beta\gamma} \left(\sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{la}^{Dx} \left(-\sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \right. \right. \\
& + \sum_{a=1}^3 Z_{j3+a}^{Dx,*} Z_{l3+a}^{Dx} \left(-\sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D + \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D \right) \\
& + \left(-\sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D + \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \right) \left(-\sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{l3+b}^{Dx} + \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{lb}^{Dx} \right) \Big) \\
& + \delta_{\alpha\gamma} \delta_{\beta\delta} \left(\sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{la}^{Dx} \left(\left(2g_1^2 - 3g_3^2 + 72g_1'^2 \right) \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \left(36g_1'^2 + 3g_3^2 + g_1^2 \right) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \right. \\
& + \sum_{a=1}^3 Z_{j3+a}^{Dx,*} Z_{l3+a}^{Dx} \left(\left(108g_1'^2 - 2g_1^2 + 3g_3^2 \right) \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D - \left(3g_3^2 - 54g_1'^2 + g_1^2 \right) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \\
& + g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{lb}^{Dx} + 36g_1'^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{lb}^{Dx} \\
& + 3g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{lb}^{Dx} + 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{lb}^{Dx} \\
& + 72g_1'^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{lb}^{Dx} - 3g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{lb}^{Dx} \\
& - g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{l3+b}^{Dx} + 54g_1'^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{l3+b}^{Dx} \\
& - 3g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{l3+b}^{Dx} - 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{l3+b}^{Dx} \\
& \left. + 108g_1'^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{l3+b}^{Dx} + 3g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{l3+b}^{Dx} \right) \Big) \quad (605)
\end{aligned}$$

$$\begin{aligned}
& -\frac{i}{24}\delta_{\alpha\gamma}\left(24\sum_{a=1}^3Z_{ja}^{E,*}Y_{e,aa}Z_{l3+a}^E\sum_{b=1}^3Y_{d,bb}^*Z_{i3+b}^{D,*}Z_{kb}^D\right. \\
& +2\left(6g_{1'}^2+g_1^2\right)\sum_{a=1}^3Z_{j3+a}^{E,*}Z_{l3+a}^E\left(2\sum_{b=1}^3Z_{i3+b}^{D,*}Z_{k3+b}^D+\sum_{b=1}^3Z_{ib}^{D,*}Z_{kb}^D\right) \\
& +\sum_{a=1}^3Z_{ja}^{E,*}Z_{la}^E\left(-2\left(-24g_{1'}^2+g_1^2\right)\sum_{b=1}^3Z_{i3+b}^{D,*}Z_{k3+b}^D+\left(24g_{1'}^2+3g_2^2-g_1^2\right)\sum_{b=1}^3Z_{ib}^{D,*}Z_{kb}^D\right) \\
& -g_1^2\sum_{a=1}^3Z_{ia}^{D,*}Z_{ka}^D\sum_{b=1}^3Z_{jb}^{E,*}Z_{lb}^E+24g_{1'}^2\sum_{a=1}^3Z_{ia}^{D,*}Z_{ka}^D\sum_{b=1}^3Z_{jb}^{E,*}Z_{lb}^E \\
& +3g_2^2\sum_{a=1}^3Z_{ia}^{D,*}Z_{ka}^D\sum_{b=1}^3Z_{jb}^{E,*}Z_{lb}^E-2g_1^2\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{k3+a}^D\sum_{b=1}^3Z_{jb}^{E,*}Z_{lb}^E \\
& +48g_{1'}^2\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{k3+a}^D\sum_{b=1}^3Z_{jb}^{E,*}Z_{lb}^E+24\sum_{a=1}^3Z_{ia}^{D,*}Y_{d,aa}Z_{k3+a}^D\sum_{b=1}^3Y_{e,bb}^*Z_{j3+b}^{E,*}Z_{lb}^E \\
& +2g_1^2\sum_{a=1}^3Z_{ia}^{D,*}Z_{ka}^D\sum_{b=1}^3Z_{j3+b}^{E,*}Z_{l3+b}^E+12g_{1'}^2\sum_{a=1}^3Z_{ia}^{D,*}Z_{ka}^D\sum_{b=1}^3Z_{j3+b}^{E,*}Z_{l3+b}^E \\
& \left.+4g_1^2\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{k3+a}^D\sum_{b=1}^3Z_{j3+b}^{E,*}Z_{l3+b}^E+24g_{1'}^2\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{k3+a}^D\sum_{b=1}^3Z_{j3+b}^{E,*}Z_{l3+b}^E\right) \tag{606}
\end{aligned}$$

$$\frac{i}{12}\delta_{\alpha\gamma}\left(2\left(-24g_{1'}^2+g_1^2\right)\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{k3+a}^D+\left(3\left(-8g_{1'}^2+g_2^2\right)+g_1^2\right)\sum_{a=1}^3Z_{ia}^{D,*}Z_{ka}^D\right)\left(UHp0_{j1}^*UHp0_{l1}-UHp0_{j2}^*UHp0_{l2}\right)$$

(607)

$$-\frac{i}{2}g_2^2\delta_{\alpha\delta}\sum_{a=1}^3Z_{ia}^{D,*}Z_{la}^U\left(UHp0_{j1}^*UHp0_{k1}+UHp0_{j2}^*UHp0_{k2}\right)$$

(608)

$$\frac{i}{12}\delta_{\alpha\gamma}\left(2\left(-24g_{1'}^2+g_1^2\right)\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{k3+a}^D+\left(-3\left(8g_{1'}^2+g_2^2\right)+g_1^2\right)\sum_{a=1}^3Z_{ia}^{D,*}Z_{ka}^D\right)\left(UHpp_{j1}^*UHpp_{l1}-UHpp_{j2}^*UHpp_{l2}\right)$$

(609)

$$\begin{aligned}
& \frac{i}{72} \left(-\delta_{\alpha\gamma}\delta_{\beta\delta} \left(\sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U \left(-2 \left(-36g_1'^2 + 3g_3^2 + 4g_1^2 \right) \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \left(36g_1'^2 - 4g_1^2 + 6g_3^2 \right) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \right. \right. \\
& + \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \left(2 \left(36g_1'^2 + 3g_3^2 + g_1^2 \right) \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \left(36g_1'^2 - 6g_3^2 - 9g_2^2 + g_1^2 \right) \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \\
& + g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U + 36g_1'^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& - 9g_2^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U - 6g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& + 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U + 72g_1'^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& + 6g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U - 4g_1^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + 36g_1'^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U + 6g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& - 8g_1^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U + 72g_1'^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& \left. - 6g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \right) \\
& - 18\delta_{\alpha\delta}\delta_{\beta\gamma} \left(g_2^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^D + 4 \sum_{a=1}^3 Z_{ia}^{D,*} Y_{u,aa} Z_{l3+a}^U \sum_{b=1}^3 Y_{u,bb}^* Z_{j3+b}^{U,*} Z_{kb}^D \right. \\
& + g_3^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \left(- \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D + \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D \right) \\
& + g_3^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U \left(- \sum_{b=1}^3 Z_{ib}^{D,*} Z_{kb}^D + \sum_{b=1}^3 Z_{i3+b}^{D,*} Z_{k3+b}^D \right) \\
& + g_2^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^D \sum_{b=1}^3 Z_{ib}^{D,*} Z_{lb}^U + 4 \sum_{a=1}^3 Z_{ja}^{U,*} Y_{d,aa} Z_{k3+a}^D \sum_{b=1}^3 Y_{d,bb}^* Z_{i3+b}^{D,*} Z_{lb}^U \\
& + g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U - g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& \left. - g_3^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ka}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U + g_3^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{k3+a}^D \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \right) \Big) \tag{610}
\end{aligned}$$

$$\frac{i}{12}\delta_{\alpha\gamma}\delta_{jl}\left(2\left(-24g_1^2+g_1^2\right)\sum_{a=1}^3Z_{i3+a}^{D,*}Z_{k3+a}^D+\left(3\left(-8g_1^2+g_2^2\right)+g_1^2\right)\sum_{a=1}^3Z_{ia}^{D,*}Z_{ka}^D\right) \quad (611)$$

$$\begin{aligned} & -\frac{i}{4}\delta_{\alpha\delta}\left(g_2^2\sum_{a=1}^3Z_{ia}^{D,*}Z_{la}^U\sum_{b=1}^3Z_{jb}^{V,*}Z_{kb}^E+g_2^2\sum_{a=1}^3Z_{ja}^{V,*}Z_{ka}^E\sum_{b=1}^3Z_{ib}^{D,*}Z_{lb}^U\right. \\ & \left.+4\sum_{a=1}^3Z_{ja}^{V,*}Y_{e,aa}Z_{k3+a}^E\sum_{b=1}^3Y_{d,bb}^*Z_{i3+b}^{D,*}Z_{lb}^U\right) \end{aligned} \quad (612)$$

$$\frac{i}{36}\left(-\delta_{\alpha\gamma}\delta_{\beta\delta}\left(9g_3^2\sum_{a=1}^3Z_{ia}^{Dx,*}Z_{la}^{Dx}\sum_{b=1}^3Z_{jb}^{Dx,*}Z_{kb}^{Dx}-9g_3^2\sum_{a=1}^3Z_{i3+a}^{Dx,*}Z_{l3+a}^{Dx}\sum_{b=1}^3Z_{jb}^{Dx,*}Z_{kb}^{Dx}\right.\right.$$

$$\begin{aligned}
& + 36 \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{l3+a}^{Dx} \kappa_{aa} \sum_{b=1}^3 Z_{i3+b}^{Dx,*} \kappa_{bb}^* Z_{kb}^{Dx} \\
& + \sum_{a=1}^3 Z_{j3+a}^{Dx,*} Z_{l3+a}^{Dx} \left((108g_1^2 - 2g_1^2 + 3g_3^2) \sum_{b=1}^3 Z_{ib}^{Dx,*} Z_{kb}^{Dx} + (162g_1^2 + 2g_1^2 - 3g_3^2) \sum_{b=1}^3 Z_{i3+b}^{Dx,*} Z_{k3+b}^{Dx} \right) \\
& + \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{la}^{Dx} \left((108g_1^2 - 2g_1^2 + 3g_3^2) \sum_{b=1}^3 Z_{i3+b}^{Dx,*} Z_{k3+b}^{Dx} + (2g_1^2 - 3g_3^2 + 72g_1^2) \sum_{b=1}^3 Z_{ib}^{Dx,*} Z_{kb}^{Dx} \right) \\
& - 9g_3^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{la}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{k3+b}^{Dx} + 9g_3^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{l3+a}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{k3+b}^{Dx} \\
& + 9g_3^2 \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{ib}^{Dx,*} Z_{lb}^{Dx} - 9g_3^2 \sum_{a=1}^3 Z_{j3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{ib}^{Dx,*} Z_{lb}^{Dx} \\
& + 2g_1^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{lb}^{Dx} + 72g_1^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{lb}^{Dx} \\
& - 3g_3^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{lb}^{Dx} - 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{lb}^{Dx} \\
& + 108g_1^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{lb}^{Dx} + 3g_3^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{lb}^{Dx} \\
& + 36 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{k3+a}^{Dx} \kappa_{aa} \sum_{b=1}^3 Z_{j3+b}^{Dx,*} \kappa_{bb}^* Z_{lb}^{Dx} - 9g_3^2 \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{i3+b}^{Dx,*} Z_{l3+b}^{Dx} \\
& + 9g_3^2 \sum_{a=1}^3 Z_{j3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{i3+b}^{Dx,*} Z_{l3+b}^{Dx} - 2g_1^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{l3+b}^{Dx} \\
& + 108g_1^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{l3+b}^{Dx} + 3g_3^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{l3+b}^{Dx} \\
& + 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{l3+b}^{Dx} + 162g_1^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{l3+b}^{Dx} \\
& - 3g_3^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{l3+b}^{Dx} \Big) \\
& - \delta_{\alpha\delta} \delta_{\beta\gamma} \left(2g_1^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{la}^{Dx} \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{kb}^{Dx} + 72g_1^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{la}^{Dx} \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{kb}^{Dx} \right. \\
& \left. - 3g_3^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{la}^{Dx} \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{kb}^{Dx} - 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{l3+a}^{Dx} \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{kb}^{Dx} \right)
\end{aligned}$$

$$\begin{aligned}
& + 108g_1^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{l3+a}^{Dx} \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{kb}^{Dx} + 3g_3^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{l3+a}^{Dx} \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{kb}^{Dx} \\
& + 36 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{l3+a}^{Dx} \kappa_{aa} \sum_{b=1}^3 Z_{j3+b}^{Dx,*} \kappa_{bb}^* Z_{kb}^{Dx} \\
& + 9g_3^2 \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{la}^{Dx} \left(- \sum_{b=1}^3 Z_{i3+b}^{Dx,*} Z_{k3+b}^{Dx} + \sum_{b=1}^3 Z_{ib}^{Dx,*} Z_{kb}^{Dx} \right) \\
& + 9g_3^2 \sum_{a=1}^3 Z_{j3+a}^{Dx,*} Z_{l3+a}^{Dx} \left(- \sum_{b=1}^3 Z_{ib}^{Dx,*} Z_{kb}^{Dx} + \sum_{b=1}^3 Z_{i3+b}^{Dx,*} Z_{k3+b}^{Dx} \right) \\
& - 2g_1^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{la}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{k3+b}^{Dx} + 108g_1^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{la}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{k3+b}^{Dx} \\
& + 3g_3^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{la}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{k3+b}^{Dx} + 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{l3+a}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{k3+b}^{Dx} \\
& + 162g_1^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{l3+a}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{k3+b}^{Dx} - 3g_3^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{l3+a}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{k3+b}^{Dx} \\
& + 2g_1^2 \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{ib}^{Dx,*} Z_{lb}^{Dx} + 72g_1^2 \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{ib}^{Dx,*} Z_{lb}^{Dx} \\
& - 3g_3^2 \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{ib}^{Dx,*} Z_{lb}^{Dx} - 2g_1^2 \sum_{a=1}^3 Z_{j3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{ib}^{Dx,*} Z_{lb}^{Dx} \\
& + 108g_1^2 \sum_{a=1}^3 Z_{j3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{ib}^{Dx,*} Z_{lb}^{Dx} + 3g_3^2 \sum_{a=1}^3 Z_{j3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{ib}^{Dx,*} Z_{lb}^{Dx} \\
& + 9g_3^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{lb}^{Dx} - 9g_3^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{jb}^{Dx,*} Z_{lb}^{Dx} \\
& + 36 \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{k3+a}^{Dx} \kappa_{aa} \sum_{b=1}^3 Z_{i3+b}^{Dx,*} \kappa_{bb}^* Z_{lb}^{Dx} - 2g_1^2 \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{i3+b}^{Dx,*} Z_{l3+b}^{Dx} \\
& + 108g_1^2 \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{i3+b}^{Dx,*} Z_{l3+b}^{Dx} + 3g_3^2 \sum_{a=1}^3 Z_{ja}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{i3+b}^{Dx,*} Z_{l3+b}^{Dx} \\
& + 2g_1^2 \sum_{a=1}^3 Z_{j3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{i3+b}^{Dx,*} Z_{l3+b}^{Dx} + 162g_1^2 \sum_{a=1}^3 Z_{j3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{i3+b}^{Dx,*} Z_{l3+b}^{Dx} \\
& - 3g_3^2 \sum_{a=1}^3 Z_{j3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{i3+b}^{Dx,*} Z_{l3+b}^{Dx} - 9g_3^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{l3+b}^{Dx}
\end{aligned}$$

$$+ 9g_3^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{Dx,*} Z_{l3+b}^{Dx} \Big) \Big) \quad (613)$$

$$\begin{aligned} & \frac{i}{12} \delta_{\alpha\gamma} \Big(2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{l3+a}^E \Big((6g_1^2 + g_1^2) \sum_{b=1}^3 Z_{ib}^{Dx,*} Z_{kb}^{Dx} - (-9g_1^2 + g_1^2) \sum_{b=1}^3 Z_{i3+b}^{Dx,*} Z_{k3+b}^{Dx} \Big) \\ & + \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^E \Big(-(-24g_1^2 + g_1^2) \sum_{b=1}^3 Z_{ib}^{Dx,*} Z_{kb}^{Dx} + (36g_1^2 + g_1^2) \sum_{b=1}^3 Z_{i3+b}^{Dx,*} Z_{k3+b}^{Dx} \Big) \\ & - g_1^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E + 24g_1^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E \\ & + g_1^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E + 36g_1^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E \\ & + 2g_1^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E + 12g_1^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \\ & - 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E + 18g_1^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \Big) \quad (614) \end{aligned}$$

$$- \frac{i}{6} \delta_{\alpha\gamma} \Big((-24g_1^2 + g_1^2) \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ka}^{Dx} - (36g_1^2 + g_1^2) \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{k3+a}^{Dx} \Big) \Big(UHp0_{j1}^* UHp0_{l1} - UHp0_{j2}^* UHp0_{l2} \Big) \quad (615)$$

$$-\frac{i}{6}\delta_{\alpha\gamma}\left(\left(-24g_1^2+g_1^2\right)\sum_{a=1}^3Z_{ia}^{Dx,*}Z_{ka}^{Dx}-\left(36g_1^2+g_1^2\right)\sum_{a=1}^3Z_{i3+a}^{Dx,*}Z_{k3+a}^{Dx}\right)\left(UHpp_{j1}^*UHpp_{l1}-UHpp_{j2}^*UHpp_{l2}\right) \quad (616)$$

$$\begin{aligned} & \frac{i}{36}\left(-9g_3^2\delta_{\alpha\delta}\delta_{\beta\gamma}\left(\sum_{a=1}^3Z_{ja}^{U,*}Z_{la}^U\left(-\sum_{b=1}^3Z_{i3+b}^{Dx,*}Z_{k3+b}^{Dx}+\sum_{b=1}^3Z_{ib}^{Dx,*}Z_{kb}^{Dx}\right)\right.\right. \\ & +\sum_{a=1}^3Z_{j3+a}^{U,*}Z_{l3+a}^U\left(-\sum_{b=1}^3Z_{ib}^{Dx,*}Z_{kb}^{Dx}+\sum_{b=1}^3Z_{i3+b}^{Dx,*}Z_{k3+b}^{Dx}\right) \\ & +\left(-\sum_{a=1}^3Z_{i3+a}^{Dx,*}Z_{k3+a}^{Dx}+\sum_{a=1}^3Z_{ia}^{Dx,*}Z_{ka}^{Dx}\right)\left(-\sum_{b=1}^3Z_{j3+b}^{U,*}Z_{l3+b}^U+\sum_{b=1}^3Z_{jb}^{U,*}Z_{lb}^U\right)\Big) \\ & +\delta_{\alpha\gamma}\delta_{\beta\delta}\left(\sum_{a=1}^3Z_{ja}^{U,*}Z_{la}^U\left(\left(36g_1^2+3g_3^2+g_1^2\right)\sum_{b=1}^3Z_{ib}^{Dx,*}Z_{kb}^{Dx}-\left(3g_3^2-54g_1^2+g_1^2\right)\sum_{b=1}^3Z_{i3+b}^{Dx,*}Z_{k3+b}^{Dx}\right)\right. \\ & +\sum_{a=1}^3Z_{j3+a}^{U,*}Z_{l3+a}^U\left(\left(36g_1^2-3g_3^2-4g_1^2\right)\sum_{b=1}^3Z_{ib}^{Dx,*}Z_{kb}^{Dx}+\left(3g_3^2+4g_1^2+54g_1^2\right)\sum_{b=1}^3Z_{i3+b}^{Dx,*}Z_{k3+b}^{Dx}\right) \\ & +g_1^2\sum_{a=1}^3Z_{ia}^{Dx,*}Z_{ka}^{Dx}\sum_{b=1}^3Z_{jb}^{U,*}Z_{lb}^U+36g_1^2\sum_{a=1}^3Z_{ia}^{Dx,*}Z_{ka}^{Dx}\sum_{b=1}^3Z_{jb}^{U,*}Z_{lb}^U \\ & +3g_3^2\sum_{a=1}^3Z_{ia}^{Dx,*}Z_{ka}^{Dx}\sum_{b=1}^3Z_{jb}^{U,*}Z_{lb}^U-g_1^2\sum_{a=1}^3Z_{i3+a}^{Dx,*}Z_{k3+a}^{Dx}\sum_{b=1}^3Z_{jb}^{U,*}Z_{lb}^U \end{aligned}$$

$$\begin{aligned}
& + 54g_1^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U - 3g_3^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\
& - 4g_1^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U + 36g_1^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& - 3g_3^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ka}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U + 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + 54g_1^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U + 3g_3^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{k3+a}^{Dx} \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \Big) \tag{617}
\end{aligned}$$

$$- \frac{i}{6} \delta_{\alpha\gamma} \delta_{jl} \left(\left(-24g_1^2 + g_1^2 \right) \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ka}^{Dx} - \left(36g_1^2 + g_1^2 \right) \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{k3+a}^{Dx} \right) \tag{618}$$

$$\begin{aligned}
& \frac{i}{8} \left(-8 \sum_{a=1}^3 Z_{ja}^{E,*} Y_{e,aa} Z_{l3+a}^E \sum_{b=1}^3 Y_{e,bb}^* Z_{i3+b}^{E,*} Z_{kb}^E - g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{kb}^E \right. \\
& \left. - 16g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{kb}^E - g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{kb}^E \right)
\end{aligned}$$

$$\begin{aligned}
& + 2g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{l3+a}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{kb}^E - 8g_{1'}^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{l3+a}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{kb}^E \\
& - 8 \sum_{a=1}^3 Z_{ia}^{E,*} Y_{e,aa} Z_{l3+a}^E \sum_{b=1}^3 Y_{e,bb}^* Z_{j3+b}^{E,*} Z_{kb}^E \\
& - \sum_{a=1}^3 Z_{ja}^{E,*} Z_{la}^E \left((16g_{1'}^2 + g_1^2 + g_2^2) \sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^E - 2(-4g_{1'}^2 + g_1^2) \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{k3+b}^E \right) \\
& + 2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{l3+a}^E \left(-2(g_1^2 + g_{1'}^2) \sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{k3+b}^E + (-4g_{1'}^2 + g_1^2) \sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^E \right) \\
& + 2g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{k3+b}^E - 8g_{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 - 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 - 16g_{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 \\
& - 8g_{1'}^2 \sum_{a=1}^3 Z_{j3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^E - 8 \sum_{a=1}^3 Z_{ja}^{E,*} Y_{e,aa} Z_{k3+a}^E \sum_{b=1}^3 Y_{e,bb}^* Z_{i3+b}^{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 - 16g_{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 \\
& - 8g_{1'}^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{jb}^{E,*} Z_{lb}^E - 8 \sum_{a=1}^3 Z_{ia}^{E,*} Y_{e,aa} Z_{k3+a}^E \sum_{b=1}^3 Y_{e,bb}^* Z_{j3+b}^{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 - 8g_{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 - 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 - 8g_{1'}^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E
\end{aligned}$$

$$-4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E - 4g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{E,*} Z_{l3+b}^E \quad (619)$$

$$-\frac{i}{4} \left((16g_1^2 - g_2^2 + g_1^2) \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E - 2 \left(-4g_1^2 + g_1^2 \right) \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \right) \left(UHp0_{j1}^* UHp0_{l1} - UHp0_{j2}^* UHp0_{l2} \right) \quad (620)$$

$$-\frac{i}{2} g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^V \left(UHp0_{j1}^* UHp0_{k1} + UHp0_{j2}^* UHp0_{k2} \right) \quad (621)$$

$$-\frac{i}{4}\left((16g_{1'}^2 + g_1^2 + g_2^2)\sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E - 2(-4g_{1'}^2 + g_1^2)\sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E\right)\left(UHpp_{j1}^* UHpp_{l1} - UHpp_{j2}^* UHpp_{l2}\right) \quad (622)$$

$$\begin{aligned} & -\frac{i}{4}\delta_{\beta\gamma}\left(g_2^2\sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^V\sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^D + g_2^2\sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^D\sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^V\right. \\ & \left.+ 4\sum_{a=1}^3 Z_{ja}^{U,*} Y_{d,aa} Z_{k3+a}^D\sum_{b=1}^3 Y_{e,bb}^* Z_{i3+b}^{E,*} Z_{lb}^V\right) \end{aligned} \quad (623)$$

$$\begin{aligned} & -\frac{i}{24}\delta_{\beta\delta}\left(4\sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U\left((-2g_1^2 + 3g_{1'}^2)\sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{k3+b}^E + (6g_{1'}^2 + g_1^2)\sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^E\right)\right. \\ & + \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U\left(-(-24g_{1'}^2 + 3g_2^2 + g_1^2)\sum_{b=1}^3 Z_{ib}^{E,*} Z_{kb}^E + 2(6g_{1'}^2 + g_1^2)\sum_{b=1}^3 Z_{i3+b}^{E,*} Z_{k3+b}^E\right) \\ & - g_1^2\sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E\sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U + 24g_{1'}^2\sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E\sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U \\ & \left.- 3g_2^2\sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E\sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U + 2g_1^2\sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E\sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U\right) \end{aligned}$$

$$\begin{aligned}
& + 12g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U + 4g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + 24g_1^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U - 8g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \\
& + 12g_1^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \Big) \tag{624}
\end{aligned}$$

$$\begin{aligned}
& \frac{i}{4} \Big(\delta_{jl} \Big(\Big(-16g_1^2 - g_1^2 + g_2^2 \Big) \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ka}^E + 2 \Big(-4g_1^2 + g_1^2 \Big) \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{k3+a}^E \Big) \\
& - g_2^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{la}^V \sum_{b=1}^3 Z_{jb}^{V,*} Z_{kb}^E - g_2^2 \sum_{a=1}^3 Z_{ja}^{V,*} Z_{ka}^E \sum_{b=1}^3 Z_{ib}^{E,*} Z_{lb}^V \\
& - 4 \sum_{a=1}^3 Z_{ja}^{V,*} Y_{e,aa} Z_{k3+a}^E \sum_{b=1}^3 Y_{e,bb}^* Z_{i3+b}^{E,*} Z_{lb}^V \Big) \tag{625}
\end{aligned}$$

$$- \frac{i}{4} \Big(16g_1^2 + g_1^2 + g_2^2 \Big) \Big(UHp0_{i1}^* \Big(2UHp0_{j1}^* UHp0_{k1} UHp0_{l1} - UHp0_{j2}^* \Big(UHp0_{k1} UHp0_{l2} + UHp0_{k2} UHp0_{l1} \Big) \Big) - UHp0_{i2}^* \Big(-2UHp0_{j1}^* UHp0_{k1} UHp0_{l1} + UHp0_{j2}^* UHp0_{k1} UHp0_{l2} \Big) \Big) \tag{626}$$

$$\begin{aligned}
& \frac{i}{4} \left(UHp0_{i2}^* \left(- \left(16g_1^2 + g_1^2 + g_2^2 \right) UHpp_{j2}^* UHp0_{k2} UHpp_{l2} + UHpp_{j1}^* \left(\left(16g_1^2 - g_2^2 + g_1^2 \right) UHp0_{k2} UHpp_{l1} - 2g_2^2 UHp0_{k1} UHpp_{l2} \right) \right) \right. \\
& \left. - UHp0_{i1}^* \left(\left(16g_1^2 + g_1^2 + g_2^2 \right) UHpp_{j1}^* UHp0_{k1} UHpp_{l1} + UHpp_{j2}^* \left(\left(-16g_1^2 - g_1^2 + g_2^2 \right) UHp0_{k1} UHpp_{l2} + 2g_2^2 UHp0_{k2} UHpp_{l1} \right) \right) \right) \\
& \hspace{25em} (627)
\end{aligned}$$

$$\begin{aligned}
& \frac{i}{12} \delta_{\beta\delta} \left(\left(-3 \left(8g_1^2 + g_2^2 \right) + g_1^2 \right) \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U - 4 \left(6g_1^2 + g_1^2 \right) \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U \right) \left(UHp0_{i1}^* UHp0_{k1} - UHp0_{i2}^* UHp0_{k2} \right) \\
& \hspace{25em} (628)
\end{aligned}$$

$$- \frac{i}{4} \left(16g_1^2 + g_1^2 + g_2^2 \right) \delta_{jl} \left(UHp0_{i1}^* UHp0_{k1} - UHp0_{i2}^* UHp0_{k2} \right) \hspace{10em} (629)$$

$$-\frac{i}{4}\left(16g_{1'}^2 + g_1^2 + g_2^2\right)\left(UHpp_{i1}^*\left(2UHpp_{j1}^*UHpp_{k1}UHpp_{l1} - UHpp_{j2}^*\left(UHpp_{k1}UHpp_{l2} + UHpp_{k2}UHpp_{l1}\right)\right) - UHpp_{i2}^*\left(-2UHpp_{j1}^*UHpp_{k1}UHpp_{l1} + UHpp_{j2}^*UHpp_{k1}UHpp_{l2} + UHpp_{j2}^*UHpp_{k2}UHpp_{l1}\right)\right) \quad (630)$$

$$-\frac{i}{2}g_2^2\delta_{\beta\gamma}\sum_{a=1}^3Z_{ja}^{U,*}Z_{ka}^D\left(UHpp_{i1}^*UHpp_{l1} + UHpp_{i2}^*UHpp_{l2}\right) \quad (631)$$

$$\frac{i}{12}\delta_{\beta\delta}\left(\left(3\left(-8g_{1'}^2 + g_2^2\right) + g_1^2\right)\sum_{a=1}^3Z_{ja}^{U,*}Z_{la}^U - 4\left(6g_{1'}^2 + g_1^2\right)\sum_{a=1}^3Z_{j3+a}^{U,*}Z_{l3+a}^U\right)\left(UHpp_{i1}^*UHpp_{k1} - UHpp_{i2}^*UHpp_{k2}\right) \quad (632)$$

$$-\frac{i}{2}g_2^2 \sum_{a=1}^3 Z_{ja}^{V,*} Z_{ka}^E \left(UHp p_{i1}^* UHp 0_{l1} + UHp p_{i2}^* UHp 0_{l2} \right) \quad (633)$$

$$-\frac{i}{4} \left(16g_1'^2 - g_2^2 + g_1^2 \right) \delta_{jl} \left(UHp p_{i1}^* UHp p_{k1} - UHp p_{i2}^* UHp p_{k2} \right) \quad (634)$$

$$\begin{aligned} & \frac{i}{72} \left(-\delta_{\alpha\gamma} \delta_{\beta\delta} \left(72 \sum_{a=1}^3 Z_{ja}^{U,*} Y_{u,aa} Z_{l3+a}^U \sum_{b=1}^3 Y_{u,bb}^* Z_{i3+b}^{U,*} Z_{kb}^U + 18g_3^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U \right. \right. \\ & \left. \left. - 18g_3^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{l3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U \right) \right) \end{aligned}$$

$$\begin{aligned}
& + \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U \left(2(18g_1^2 - 3g_3^2 + 8g_1^2) \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{k3+b}^U + (36g_1^2 - 4g_1^2 + 6g_3^2) \sum_{b=1}^3 Z_{ib}^{U,*} Z_{kb}^U \right) \\
& + \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \left(2(18g_1^2 - 2g_1^2 + 3g_3^2) \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{k3+b}^U + (36g_1^2 - 6g_3^2 + 9g_2^2 + g_1^2) \sum_{b=1}^3 Z_{ib}^{U,*} Z_{kb}^U \right) \\
& - 18g_3^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{k3+b}^U + 18g_3^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{l3+a}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{k3+b}^U \\
& + 18g_3^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U - 18g_3^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{ib}^{U,*} Z_{lb}^U \\
& + g_1^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{lb}^U + 36g_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 + 36g_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 + 72 \sum_{a=1}^3 Z_{ia}^{U,*} Y_{u,aa} Z_{k3+a}^U \sum_{b=1}^3 Y_{u,bb}^* Z_{j3+b}^{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 + 36g_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 \\
& + 36g_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 \\
& - \delta_{\alpha\delta} \delta_{\beta\gamma} \left(g_1^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U + 36g_1^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U \right. \\
& + 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 \\
& \left. - 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 + 36g_1^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{l3+a}^U \sum_{b=1}^3 Z_{jb}^{U,*} Z_{kb}^U \right)
\end{aligned}$$

$$\begin{aligned}
& + 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 + 72 \sum_{a=1}^3 Z_{ia}^{U,*} Y_{u,aa} Z_{l3+a}^U \sum_{b=1}^3 Y_{u,bb}^* Z_{j3+b}^{U,*} Z_{kb}^U \\
& + 18g_3^2 \sum_{a=1}^3 Z_{ja}^{U,*} Z_{la}^U \left(- \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{k3+b}^U + \sum_{b=1}^3 Z_{ib}^{U,*} Z_{kb}^U \right) \\
& - 18g_3^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{l3+a}^U \left(- \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{k3+b}^U + \sum_{b=1}^3 Z_{ib}^{U,*} Z_{kb}^U \right) \\
& - 4g_1^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{la}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{k3+b}^U + 36g_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 \\
& + 36g_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 + 36g_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 + 36g_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 + 72 \sum_{a=1}^3 Z_{ja}^{U,*} Y_{u,aa} Z_{k3+a}^U \sum_{b=1}^3 Y_{u,bb}^* Z_{i3+b}^{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 + 36g_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 \\
& + 36g_1^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U - 6g_3^2 \sum_{a=1}^3 Z_{j3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{i3+b}^{U,*} Z_{l3+b}^U \\
& - 18g_3^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ka}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U + 18g_3^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{k3+a}^U \sum_{b=1}^3 Z_{j3+b}^{U,*} Z_{l3+b}^U \Big) \Big)
\end{aligned} \tag{635}$$

$$\frac{i}{12}\delta_{\alpha\gamma}\delta_{jl}\left(\left(-3\left(8g_{1'}^2+g_2^2\right)+g_1^2\right)\sum_{a=1}^3Z_{ia}^{U,*}Z_{ka}^U-4\left(6g_{1'}^2+g_1^2\right)\sum_{a=1}^3Z_{i3+a}^{U,*}Z_{k3+a}^U\right) \quad (636)$$

$$-\frac{i}{4}\left(16g_{1'}^2+g_1^2+g_2^2\right)\left(\delta_{ik}\delta_{jl}+\delta_{il}\delta_{jk}\right) \quad (637)$$

9.8 Two Scalar-Two Vector Boson-Interaction

$$\left(\frac{i}{2}g_2^2U_{A,i1}U_{A,j1}+\frac{i}{2}g_2^2U_{A,i2}U_{A,j2}\right)\left(g_{\mu\nu}\right) \quad (638)$$

$$\begin{aligned}
& \left(+ \frac{i}{2} g_2^2 \cos \Theta_W^2 \cos \Theta_W'^2 U_{A,i1} U_{A,j1} + i g_1 g_2 \cos \Theta_W \cos \Theta_W'^2 \sin \Theta_W U_{A,i1} U_{A,j1} \right. \\
& + \frac{i}{2} g_1^2 \cos \Theta_W'^2 \sin \Theta_W^2 U_{A,i1} U_{A,j1} - 6 i g_1' g_2 \cos \Theta_W \cos \Theta_W' \sin \Theta_W' U_{A,i1} U_{A,j1} \\
& - 6 i g_1 g_1' \cos \Theta_W' \sin \Theta_W \sin \Theta_W' U_{A,i1} U_{A,j1} + 18 i g_1'^2 \sin \Theta_W'^2 U_{A,i1} U_{A,j1} \\
& + \frac{i}{2} g_2^2 \cos \Theta_W^2 \cos \Theta_W'^2 U_{A,i2} U_{A,j2} + i g_1 g_2 \cos \Theta_W \cos \Theta_W'^2 \sin \Theta_W U_{A,i2} U_{A,j2} \\
& + \frac{i}{2} g_1^2 \cos \Theta_W'^2 \sin \Theta_W^2 U_{A,i2} U_{A,j2} + 4 i g_1' g_2 \cos \Theta_W \cos \Theta_W' \sin \Theta_W' U_{A,i2} U_{A,j2} \\
& + 4 i g_1 g_1' \cos \Theta_W' \sin \Theta_W \sin \Theta_W' U_{A,i2} U_{A,j2} + 8 i g_1'^2 \sin \Theta_W'^2 U_{A,i2} U_{A,j2} \\
& \left. + 2 i g_1'^2 Q_S^2 \sin \Theta_W'^2 U_{A,i3} U_{A,j3} + 2 i g_1'^2 Q_S^2 \sin \Theta_W'^2 U_{A,i4} U_{A,j4} \right) (g_{\mu\nu}) \tag{639}
\end{aligned}$$

$$\begin{aligned}
& \left(- 3 i g_1' g_2 \cos \Theta_W \cos \Theta_W'^2 U_{A,i1} U_{A,j1} - 3 i g_1 g_1' \cos \Theta_W'^2 \sin \Theta_W U_{A,i1} U_{A,j1} \right. \\
& + 18 i g_1'^2 \cos \Theta_W' \sin \Theta_W' U_{A,i1} U_{A,j1} - \frac{i}{2} g_2^2 \cos \Theta_W^2 \cos \Theta_W' \sin \Theta_W' U_{A,i1} U_{A,j1} \\
& - i g_1 g_2 \cos \Theta_W \cos \Theta_W' \sin \Theta_W \sin \Theta_W' U_{A,i1} U_{A,j1} \\
& - \frac{i}{2} g_1^2 \cos \Theta_W' \sin \Theta_W^2 \sin \Theta_W' U_{A,i1} U_{A,j1} + 3 i g_1' g_2 \cos \Theta_W \sin \Theta_W'^2 U_{A,i1} U_{A,j1} \\
& + 3 i g_1 g_1' \sin \Theta_W \sin \Theta_W'^2 U_{A,i1} U_{A,j1} + 2 i g_1' g_2 \cos \Theta_W \cos \Theta_W'^2 U_{A,i2} U_{A,j2} \\
& \left. + 2 i g_1 g_1' \cos \Theta_W'^2 \sin \Theta_W U_{A,i2} U_{A,j2} - \frac{i}{2} g_2^2 \cos \Theta_W^2 \cos \Theta_W' \sin \Theta_W' U_{A,i2} U_{A,j2} \right)
\end{aligned}$$

$$\begin{aligned}
& -ig_1g_2 \cos \Theta_W \cos \Theta'_W \sin \Theta_W \sin \Theta'_W U_{A,i2} U_{A,j2} \\
& -\frac{i}{2}g_1^2 \cos \Theta'_W \sin \Theta_W^2 \sin \Theta'_W U_{A,i2} U_{A,j2} - 2ig_1'g_2 \cos \Theta_W \sin \Theta_W'^2 U_{A,i2} U_{A,j2} \\
& - 2ig_1g_1' \sin \Theta_W \sin \Theta_W'^2 U_{A,i2} U_{A,j2} + 4ig_1'^2 \sin 2\Theta'_W U_{A,i2} U_{A,j2} \\
& + ig_1^2 Q_S^2 \sin 2\Theta'_W U_{A,i3} U_{A,j3} + ig_1'^2 Q_S^2 \sin 2\Theta'_W U_{A,i4} U_{A,j4} \Big) (g_{\mu\nu})
\end{aligned} \tag{640}$$

$$\begin{aligned}
& \Big(+ 18ig_1'^2 \cos \Theta_W'^2 U_{A,i1} U_{A,j1} + 6ig_1'g_2 \cos \Theta_W \cos \Theta'_W \sin \Theta'_W U_{A,i1} U_{A,j1} \\
& + 6ig_1g_1' \cos \Theta'_W \sin \Theta_W \sin \Theta'_W U_{A,i1} U_{A,j1} + \frac{i}{2}g_2^2 \cos \Theta_W^2 \sin \Theta_W'^2 U_{A,i1} U_{A,j1} \\
& + ig_1g_2 \cos \Theta_W \sin \Theta_W \sin \Theta_W'^2 U_{A,i1} U_{A,j1} + \frac{i}{2}g_1^2 \sin \Theta_W^2 \sin \Theta_W'^2 U_{A,i1} U_{A,j1} \\
& + 8ig_1'^2 \cos \Theta_W'^2 U_{A,i2} U_{A,j2} - 4ig_1'g_2 \cos \Theta_W \cos \Theta'_W \sin \Theta'_W U_{A,i2} U_{A,j2} \\
& - 4ig_1g_1' \cos \Theta'_W \sin \Theta_W \sin \Theta'_W U_{A,i2} U_{A,j2} + \frac{i}{2}g_2^2 \cos \Theta_W^2 \sin \Theta_W'^2 U_{A,i2} U_{A,j2} \\
& + ig_1g_2 \cos \Theta_W \sin \Theta_W \sin \Theta_W'^2 U_{A,i2} U_{A,j2} + \frac{i}{2}g_1^2 \sin \Theta_W^2 \sin \Theta_W'^2 U_{A,i2} U_{A,j2} \\
& + 2ig_1^2 Q_S^2 \cos \Theta_W'^2 U_{A,i3} U_{A,j3} + 2ig_1'^2 Q_S^2 \cos \Theta_W'^2 U_{A,i4} U_{A,j4} \Big) (g_{\mu\nu})
\end{aligned} \tag{641}$$

$$\left(-\frac{1}{2}g_1g_2 U_{+,j1}^* \cos \Theta_W U_{A,i1} - \frac{1}{2}g_1g_2 U_{+,j2}^* \cos \Theta_W U_{A,i2} \right) (g_{\mu\nu}) \tag{642}$$

$$\begin{aligned}
& \left(+\frac{1}{2}g_1g_2U_{+,j1}^* \cos \Theta'_W \sin \Theta_W U_{A,i1} - 3g'_1g_2U_{+,j1}^* \sin \Theta'_W U_{A,i1} \right. \\
& \left. +\frac{1}{2}g_1g_2U_{+,j2}^* \cos \Theta'_W \sin \Theta_W U_{A,i2} + 2g'_1g_2U_{+,j2}^* \sin \Theta'_W U_{A,i2} \right) (g_{\mu\nu})
\end{aligned} \tag{643}$$

$$\begin{aligned}
& \left(-3g'_1g_2U_{+,j1}^* \cos \Theta'_W U_{A,i1} - \frac{1}{2}g_1g_2U_{+,j1}^* \sin \Theta_W \sin \Theta'_W U_{A,i1} \right. \\
& \left. + 2g'_1g_2U_{+,j2}^* \cos \Theta'_W U_{A,i2} - \frac{1}{2}g_1g_2U_{+,j2}^* \sin \Theta_W \sin \Theta'_W U_{A,i2} \right) (g_{\mu\nu})
\end{aligned} \tag{644}$$

$$\left(\frac{1}{2}g_1g_2 \cos \Theta_W U_{A,i1} U_{+,j1} + \frac{1}{2}g_1g_2 \cos \Theta_W U_{A,i2} U_{+,j2} \right) (g_{\mu\nu}) \tag{645}$$

$$\begin{aligned}
& \left(-\frac{1}{2}g_1g_2 \cos \Theta'_W \sin \Theta_W U_{A,i1}U_{+,j1} + 3g'_1g_2 \sin \Theta'_W U_{A,i1}U_{+,j1} \right. \\
& \left. -\frac{1}{2}g_1g_2 \cos \Theta'_W \sin \Theta_W U_{A,i2}U_{+,j2} - 2g'_1g_2 \sin \Theta'_W U_{A,i2}U_{+,j2} \right) (g_{\mu\nu})
\end{aligned} \tag{646}$$

$$\begin{aligned}
& \left(+3g'_1g_2 \cos \Theta'_W U_{A,i1}U_{+,j1} + \frac{1}{2}g_1g_2 \sin \Theta_W \sin \Theta'_W U_{A,i1}U_{+,j1} \right. \\
& \left. -2g'_1g_2 \cos \Theta'_W U_{A,i2}U_{+,j2} + \frac{1}{2}g_1g_2 \sin \Theta_W \sin \Theta'_W U_{A,i2}U_{+,j2} \right) (g_{\mu\nu})
\end{aligned} \tag{647}$$

$$\left(\frac{i}{2}g_2^2 U_{H,i1}^* U_{H,j1}^* + \frac{i}{2}g_2^2 U_{H,i2}^* U_{H,j2}^* \right) (g_{\mu\nu}) \tag{648}$$

$$\begin{aligned}
& \left(+ \frac{i}{2} g_2^2 U_{H,i1}^* U_{H,j1}^* \cos \Theta_W^2 \cos \Theta_W'^2 + \frac{i}{2} g_2^2 U_{H,i2}^* U_{H,j2}^* \cos \Theta_W^2 \cos \Theta_W'^2 \right. \\
& + i g_1 g_2 U_{H,i1}^* U_{H,j1}^* \cos \Theta_W \cos \Theta_W'^2 \sin \Theta_W \\
& + i g_1 g_2 U_{H,i2}^* U_{H,j2}^* \cos \Theta_W \cos \Theta_W'^2 \sin \Theta_W + \frac{i}{2} g_1^2 U_{H,i1}^* U_{H,j1}^* \cos \Theta_W'^2 \sin \Theta_W^2 \\
& + \frac{i}{2} g_1^2 U_{H,i2}^* U_{H,j2}^* \cos \Theta_W'^2 \sin \Theta_W^2 - 6 i g_1' g_2 U_{H,i1}^* U_{H,j1}^* \cos \Theta_W \cos \Theta_W' \sin \Theta_W' \\
& + 4 i g_1' g_2 U_{H,i2}^* U_{H,j2}^* \cos \Theta_W \cos \Theta_W' \sin \Theta_W' \\
& - 6 i g_1 g_1' U_{H,i1}^* U_{H,j1}^* \cos \Theta_W' \sin \Theta_W \sin \Theta_W' \\
& + 4 i g_1 g_1' U_{H,i2}^* U_{H,j2}^* \cos \Theta_W' \sin \Theta_W \sin \Theta_W' + 18 i g_1'^2 U_{H,i1}^* U_{H,j1}^* \sin \Theta_W'^2 \\
& + 8 i g_1'^2 U_{H,i2}^* U_{H,j2}^* \sin \Theta_W'^2 + 2 i g_1'^2 Q_S^2 U_{H,i3}^* U_{H,j3}^* \sin \Theta_W'^2 \\
& \left. + 2 i g_1'^2 Q_S^2 U_{H,i4}^* U_{H,j4}^* \sin \Theta_W'^2 \right) (g_{\mu\nu})
\end{aligned} \tag{649}$$

$$\begin{aligned}
& \left(- 3 i g_1' g_2 U_{H,i1}^* U_{H,j1}^* \cos \Theta_W \cos \Theta_W'^2 + 2 i g_1' g_2 U_{H,i2}^* U_{H,j2}^* \cos \Theta_W \cos \Theta_W'^2 \right. \\
& - 3 i g_1 g_1' U_{H,i1}^* U_{H,j1}^* \cos \Theta_W'^2 \sin \Theta_W + 2 i g_1 g_1' U_{H,i2}^* U_{H,j2}^* \cos \Theta_W'^2 \sin \Theta_W \\
& + 18 i g_1'^2 U_{H,i1}^* U_{H,j1}^* \cos \Theta_W' \sin \Theta_W' - \frac{i}{2} g_2^2 U_{H,i1}^* U_{H,j1}^* \cos \Theta_W^2 \cos \Theta_W' \sin \Theta_W' \\
& \left. - \frac{i}{2} g_2^2 U_{H,i2}^* U_{H,j2}^* \cos \Theta_W^2 \cos \Theta_W' \sin \Theta_W' \right)
\end{aligned}$$

$$\begin{aligned}
& -ig_1g_2U_{H,i1}^*U_{H,j1}^*\cos\Theta_W\cos\Theta'_W\sin\Theta_W\sin\Theta'_W \\
& -ig_1g_2U_{H,i2}^*U_{H,j2}^*\cos\Theta_W\cos\Theta'_W\sin\Theta_W\sin\Theta'_W \\
& -\frac{i}{2}g_1^2U_{H,i1}^*U_{H,j1}^*\cos\Theta'_W\sin\Theta_W^2\sin\Theta'_W \\
& -\frac{i}{2}g_1^2U_{H,i2}^*U_{H,j2}^*\cos\Theta'_W\sin\Theta_W^2\sin\Theta'_W + 3ig_1'g_2U_{H,i1}^*U_{H,j1}^*\cos\Theta_W\sin\Theta_W'^2 \\
& -2ig_1'g_2U_{H,i2}^*U_{H,j2}^*\cos\Theta_W\sin\Theta_W'^2 + 3ig_1g_1'U_{H,i1}^*U_{H,j1}^*\sin\Theta_W\sin\Theta_W'^2 \\
& -2ig_1g_1'U_{H,i2}^*U_{H,j2}^*\sin\Theta_W\sin\Theta_W'^2 + 4ig_1^2U_{H,i2}^*U_{H,j2}^*\sin 2\Theta'_W \\
& + ig_1^2Q_S^2U_{H,i3}^*U_{H,j3}^*\sin 2\Theta'_W + ig_1^2Q_S^2U_{H,i4}^*U_{H,j4}^*\sin 2\Theta'_W \Big) (g_{\mu\nu})
\end{aligned} \tag{650}$$

$$\begin{aligned}
& \Big(+ 18ig_1^2U_{H,i1}^*U_{H,j1}^*\cos\Theta_W'^2 + 8ig_1^2U_{H,i2}^*U_{H,j2}^*\cos\Theta_W'^2 \\
& + 2ig_1^2Q_S^2U_{H,i3}^*U_{H,j3}^*\cos\Theta_W'^2 + 2ig_1^2Q_S^2U_{H,i4}^*U_{H,j4}^*\cos\Theta_W'^2 \\
& + 6ig_1'g_2U_{H,i1}^*U_{H,j1}^*\cos\Theta_W\cos\Theta'_W\sin\Theta'_W \\
& - 4ig_1'g_2U_{H,i2}^*U_{H,j2}^*\cos\Theta_W\cos\Theta'_W\sin\Theta'_W \\
& + 6ig_1g_1'U_{H,i1}^*U_{H,j1}^*\cos\Theta'_W\sin\Theta_W\sin\Theta'_W \\
& - 4ig_1g_1'U_{H,i2}^*U_{H,j2}^*\cos\Theta'_W\sin\Theta_W\sin\Theta'_W + \frac{i}{2}g_2^2U_{H,i1}^*U_{H,j1}^*\cos\Theta_W^2\sin\Theta_W'^2 \\
& + \frac{i}{2}g_2^2U_{H,i2}^*U_{H,j2}^*\cos\Theta_W^2\sin\Theta_W'^2 + ig_1g_2U_{H,i1}^*U_{H,j1}^*\cos\Theta_W\sin\Theta_W\sin\Theta_W'^2 \\
& + ig_1g_2U_{H,i2}^*U_{H,j2}^*\cos\Theta_W\sin\Theta_W\sin\Theta_W'^2 + \frac{i}{2}g_1^2U_{H,i1}^*U_{H,j1}^*\sin\Theta_W^2\sin\Theta_W'^2 \\
& + \frac{i}{2}g_1^2U_{H,i2}^*U_{H,j2}^*\sin\Theta_W^2\sin\Theta_W'^2 \Big) (g_{\mu\nu})
\end{aligned} \tag{651}$$

$$\left(-\frac{i}{2}g_1g_2U_{H,i1}^*U_{+,j1}^*\cos\Theta_W + \frac{i}{2}g_1g_2U_{H,i2}^*U_{+,j2}^*\cos\Theta_W \right) (g_{\mu\nu}) \quad (652)$$

$$\begin{aligned} & \left(+\frac{i}{2}g_1g_2U_{H,i1}^*U_{+,j1}^*\cos\Theta'_W\sin\Theta_W - \frac{i}{2}g_1g_2U_{H,i2}^*U_{+,j2}^*\cos\Theta'_W\sin\Theta_W \right. \\ & \left. - 3ig_1'g_2U_{H,i1}^*U_{+,j1}^*\sin\Theta'_W - 2ig_1'g_2U_{H,i2}^*U_{+,j2}^*\sin\Theta'_W \right) (g_{\mu\nu}) \end{aligned} \quad (653)$$

$$\begin{aligned} & \left(-3ig_1'g_2U_{H,i1}^*U_{+,j1}^*\cos\Theta'_W - 2ig_1'g_2U_{H,i2}^*U_{+,j2}^*\cos\Theta'_W \right. \\ & \left. - \frac{i}{2}g_1g_2U_{H,i1}^*U_{+,j1}^*\sin\Theta_W\sin\Theta'_W + \frac{i}{2}g_1g_2U_{H,i2}^*U_{+,j2}^*\sin\Theta_W\sin\Theta'_W \right) (g_{\mu\nu}) \end{aligned} \quad (654)$$

$$\left(-\frac{i}{2}g_1g_2U_{H,i1}^*\cos\Theta_WU_{+,j1} + \frac{i}{2}g_1g_2U_{H,i2}^*\cos\Theta_WU_{+,j2} \right) \left(g_{\mu\nu} \right) \quad (655)$$

$$\begin{aligned} & \left(+\frac{i}{2}g_1g_2U_{H,i1}^*\cos\Theta'_W\sin\Theta_WU_{+,j1} - 3ig_1'g_2U_{H,i1}^*\sin\Theta'_WU_{+,j1} \right. \\ & \left. -\frac{i}{2}g_1g_2U_{H,i2}^*\cos\Theta'_W\sin\Theta_WU_{+,j2} - 2ig_1'g_2U_{H,i2}^*\sin\Theta'_WU_{+,j2} \right) \left(g_{\mu\nu} \right) \end{aligned} \quad (656)$$

$$\begin{aligned} & \left(-3ig_1'g_2U_{H,i1}^*\cos\Theta'_WU_{+,j1} - \frac{i}{2}g_1g_2U_{H,i1}^*\sin\Theta_W\sin\Theta'_WU_{+,j1} \right. \\ & \left. -2ig_1'g_2U_{H,i2}^*\cos\Theta'_WU_{+,j2} + \frac{i}{2}g_1g_2U_{H,i2}^*\sin\Theta_W\sin\Theta'_WU_{+,j2} \right) \left(g_{\mu\nu} \right) \end{aligned} \quad (657)$$

$$\begin{aligned}
& \left(+ \frac{i}{2} g_1^2 U_{+,i1}^* \cos \Theta_W^2 U_{+,j1} + i g_1 g_2 U_{+,i1}^* \cos \Theta_W \sin \Theta_W U_{+,j1} \right. \\
& + \frac{i}{2} g_2^2 U_{+,i1}^* \sin \Theta_W^2 U_{+,j1} + \frac{i}{2} g_1^2 U_{+,i2}^* \cos \Theta_W^2 U_{+,j2} \\
& \left. + i g_1 g_2 U_{+,i2}^* \cos \Theta_W \sin \Theta_W U_{+,j2} + \frac{i}{2} g_2^2 U_{+,i2}^* \sin \Theta_W^2 U_{+,j2} \right) (g_{\mu\nu})
\end{aligned} \tag{658}$$

$$\begin{aligned}
& \left(+ \frac{i}{2} g_1 g_2 U_{+,i1}^* \cos \Theta_W^2 \cos \Theta'_W U_{+,j1} - \frac{i}{2} g_1^2 U_{+,i1}^* \cos \Theta_W \cos \Theta'_W \sin \Theta_W U_{+,j1} \right. \\
& + \frac{i}{2} g_2^2 U_{+,i1}^* \cos \Theta_W \cos \Theta'_W \sin \Theta_W U_{+,j1} - \frac{i}{2} g_1 g_2 U_{+,i1}^* \cos \Theta'_W \sin \Theta_W^2 U_{+,j1} \\
& + 3i g_1 g'_1 U_{+,i1}^* \cos \Theta_W \sin \Theta'_W U_{+,j1} + 3i g'_1 g_2 U_{+,i1}^* \sin \Theta_W \sin \Theta'_W U_{+,j1} \\
& + \frac{i}{2} g_1 g_2 U_{+,i2}^* \cos \Theta_W^2 \cos \Theta'_W U_{+,j2} - \frac{i}{2} g_1^2 U_{+,i2}^* \cos \Theta_W \cos \Theta'_W \sin \Theta_W U_{+,j2} \\
& + \frac{i}{2} g_2^2 U_{+,i2}^* \cos \Theta_W \cos \Theta'_W \sin \Theta_W U_{+,j2} - \frac{i}{2} g_1 g_2 U_{+,i2}^* \cos \Theta'_W \sin \Theta_W^2 U_{+,j2} \\
& \left. - 2i g_1 g'_1 U_{+,i2}^* \cos \Theta_W \sin \Theta'_W U_{+,j2} - 2i g'_1 g_2 U_{+,i2}^* \sin \Theta_W \sin \Theta'_W U_{+,j2} \right) (g_{\mu\nu})
\end{aligned} \tag{659}$$

$$\begin{aligned}
& \left(+ 3ig_1g_1'U_{+,i1}^* \cos \Theta_W \cos \Theta'_W U_{+,j1} + 3ig_1'g_2U_{+,i1}^* \cos \Theta'_W \sin \Theta_W U_{+,j1} \right. \\
& - \frac{i}{2}g_1g_2U_{+,i1}^* \cos \Theta_W^2 \sin \Theta'_W U_{+,j1} + \frac{i}{2}g_1^2U_{+,i1}^* \cos \Theta_W \sin \Theta_W \sin \Theta'_W U_{+,j1} \\
& - \frac{i}{2}g_2^2U_{+,i1}^* \cos \Theta_W \sin \Theta_W \sin \Theta'_W U_{+,j1} + \frac{i}{2}g_1g_2U_{+,i1}^* \sin \Theta_W^2 \sin \Theta'_W U_{+,j1} \\
& - 2ig_1g_1'U_{+,i2}^* \cos \Theta_W \cos \Theta'_W U_{+,j2} - 2ig_1'g_2U_{+,i2}^* \cos \Theta'_W \sin \Theta_W U_{+,j2} \\
& - \frac{i}{2}g_1g_2U_{+,i2}^* \cos \Theta_W^2 \sin \Theta'_W U_{+,j2} + \frac{i}{2}g_1^2U_{+,i2}^* \cos \Theta_W \sin \Theta_W \sin \Theta'_W U_{+,j2} \\
& \left. - \frac{i}{2}g_2^2U_{+,i2}^* \cos \Theta_W \sin \Theta_W \sin \Theta'_W U_{+,j2} + \frac{i}{2}g_1g_2U_{+,i2}^* \sin \Theta_W^2 \sin \Theta'_W U_{+,j2} \right) (g_{\mu\nu}) \tag{660}
\end{aligned}$$

$$\left(\frac{i}{2}g_2^2U_{+,i1}^*U_{+,j1} + \frac{i}{2}g_2^2U_{+,i2}^*U_{+,j2} \right) (g_{\mu\nu}) \tag{661}$$

$$\begin{aligned}
& \left(+ \frac{i}{2} g_2^2 U_{+,i1}^* \cos \Theta_W^2 \cos \Theta_W'^2 U_{+,j1} - i g_1 g_2 U_{+,i1}^* \cos \Theta_W \cos \Theta_W'^2 \sin \Theta_W U_{+,j1} \right. \\
& + \frac{i}{2} g_1^2 U_{+,i1}^* \cos \Theta_W'^2 \sin \Theta_W^2 U_{+,j1} + 6 i g_1' g_2 U_{+,i1}^* \cos \Theta_W \cos \Theta_W' \sin \Theta_W' U_{+,j1} \\
& - 6 i g_1 g_1' U_{+,i1}^* \cos \Theta_W' \sin \Theta_W \sin \Theta_W' U_{+,j1} + 18 i g_1^2 U_{+,i1}^* \sin \Theta_W'^2 U_{+,j1} \\
& + \frac{i}{2} g_2^2 U_{+,i2}^* \cos \Theta_W^2 \cos \Theta_W'^2 U_{+,j2} - i g_1 g_2 U_{+,i2}^* \cos \Theta_W \cos \Theta_W'^2 \sin \Theta_W U_{+,j2} \\
& + \frac{i}{2} g_1^2 U_{+,i2}^* \cos \Theta_W'^2 \sin \Theta_W^2 U_{+,j2} - 4 i g_1' g_2 U_{+,i2}^* \cos \Theta_W \cos \Theta_W' \sin \Theta_W' U_{+,j2} \\
& \left. + 4 i g_1 g_1' U_{+,i2}^* \cos \Theta_W' \sin \Theta_W \sin \Theta_W' U_{+,j2} + 8 i g_1^2 U_{+,i2}^* \sin \Theta_W'^2 U_{+,j2} \right) (g_{\mu\nu}) \tag{662}
\end{aligned}$$

$$\begin{aligned}
& \left(+ 3 i g_1' g_2 U_{+,i1}^* \cos \Theta_W \cos \Theta_W'^2 U_{+,j1} - 3 i g_1 g_1' U_{+,i1}^* \cos \Theta_W'^2 \sin \Theta_W U_{+,j1} \right. \\
& + 18 i g_1^2 U_{+,i1}^* \cos \Theta_W' \sin \Theta_W' U_{+,j1} - \frac{i}{2} g_2^2 U_{+,i1}^* \cos \Theta_W^2 \cos \Theta_W' \sin \Theta_W' U_{+,j1} \\
& + i g_1 g_2 U_{+,i1}^* \cos \Theta_W \cos \Theta_W' \sin \Theta_W \sin \Theta_W' U_{+,j1} \\
& - \frac{i}{2} g_1^2 U_{+,i1}^* \cos \Theta_W' \sin \Theta_W^2 \sin \Theta_W' U_{+,j1} - 3 i g_1' g_2 U_{+,i1}^* \cos \Theta_W \sin \Theta_W'^2 U_{+,j1} \\
& + 3 i g_1 g_1' U_{+,i1}^* \sin \Theta_W \sin \Theta_W'^2 U_{+,j1} - 2 i g_1' g_2 U_{+,i2}^* \cos \Theta_W \cos \Theta_W'^2 U_{+,j2} \\
& + 2 i g_1 g_1' U_{+,i2}^* \cos \Theta_W'^2 \sin \Theta_W U_{+,j2} - \frac{i}{2} g_2^2 U_{+,i2}^* \cos \Theta_W^2 \cos \Theta_W' \sin \Theta_W' U_{+,j2} \\
& + i g_1 g_2 U_{+,i2}^* \cos \Theta_W \cos \Theta_W' \sin \Theta_W \sin \Theta_W' U_{+,j2} \\
& - \frac{i}{2} g_1^2 U_{+,i2}^* \cos \Theta_W' \sin \Theta_W^2 \sin \Theta_W' U_{+,j2} + 2 i g_1' g_2 U_{+,i2}^* \cos \Theta_W \sin \Theta_W'^2 U_{+,j2} \\
& \left. - 2 i g_1 g_1' U_{+,i2}^* \sin \Theta_W \sin \Theta_W'^2 U_{+,j2} + 4 i g_1^2 U_{+,i2}^* \sin 2 \Theta_W' U_{+,j2} \right) (g_{\mu\nu}) \tag{663}
\end{aligned}$$

$$\begin{aligned}
& \left(+18ig_1^2 U_{+,i1}^* \cos \Theta_W'^2 U_{+,j1} - 6ig_1' g_2 U_{+,i1}^* \cos \Theta_W \cos \Theta_W' \sin \Theta_W' U_{+,j1} \right. \\
& + 6ig_1 g_1' U_{+,i1}^* \cos \Theta_W' \sin \Theta_W \sin \Theta_W' U_{+,j1} + \frac{i}{2} g_2^2 U_{+,i1}^* \cos \Theta_W^2 \sin \Theta_W'^2 U_{+,j1} \\
& - ig_1 g_2 U_{+,i1}^* \cos \Theta_W \sin \Theta_W \sin \Theta_W'^2 U_{+,j1} + \frac{i}{2} g_1^2 U_{+,i1}^* \sin \Theta_W^2 \sin \Theta_W'^2 U_{+,j1} \\
& + 8ig_1^2 U_{+,i2}^* \cos \Theta_W'^2 U_{+,j2} + 4ig_1' g_2 U_{+,i2}^* \cos \Theta_W \cos \Theta_W' \sin \Theta_W' U_{+,j2} \\
& - 4ig_1 g_1' U_{+,i2}^* \cos \Theta_W' \sin \Theta_W \sin \Theta_W' U_{+,j2} + \frac{i}{2} g_2^2 U_{+,i2}^* \cos \Theta_W^2 \sin \Theta_W'^2 U_{+,j2} \\
& \left. - ig_1 g_2 U_{+,i2}^* \cos \Theta_W \sin \Theta_W \sin \Theta_W'^2 U_{+,j2} + \frac{i}{2} g_1^2 U_{+,i2}^* \sin \Theta_W^2 \sin \Theta_W'^2 U_{+,j2} \right) (g_{\mu\nu}) \tag{664}
\end{aligned}$$

$$\left(\frac{i}{4} g_3^2 \delta_{ij} \sum_{a=1}^3 \lambda_{a,\alpha}^\gamma \lambda_{\beta,a}^\delta + \frac{i}{4} g_3^2 \delta_{ij} \sum_{a=1}^3 \lambda_{\beta,a}^\gamma \lambda_{a,\alpha}^\delta \right) (g_{\mu\nu}) \tag{665}$$

$$\begin{aligned}
& \left(+ \frac{i}{6} g_1 g_3 \cos \Theta_W \lambda_{\beta, \alpha}^\gamma \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D - \frac{i}{2} g_2 g_3 \lambda_{\beta, \alpha}^\gamma \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \right. \\
& \left. - \frac{i}{3} g_1 g_3 \cos \Theta_W \lambda_{\beta, \alpha}^\gamma \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \right) (g_{\mu\nu})
\end{aligned} \tag{666}$$

$$\begin{aligned}
& \left(- \frac{i}{2} g_2 g_3 \cos \Theta_W \cos \Theta'_W \lambda_{\beta, \alpha}^\gamma \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \right. \\
& - \frac{i}{6} g_1 g_3 \cos \Theta'_W \lambda_{\beta, \alpha}^\gamma \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D + i g'_1 g_3 \lambda_{\beta, \alpha}^\gamma \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& \left. + \frac{i}{3} g_1 g_3 \cos \Theta'_W \lambda_{\beta, \alpha}^\gamma \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D - 2 i g'_1 g_3 \lambda_{\beta, \alpha}^\gamma \sin \Theta'_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \right) (g_{\mu\nu})
\end{aligned} \tag{667}$$

$$\begin{aligned}
& \left(+ ig'_1 g_3 \cos \Theta'_W \lambda_{\beta, \alpha}^\gamma \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D + \frac{i}{2} g_2 g_3 \cos \Theta_W \lambda_{\beta, \alpha}^\gamma \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \right. \\
& + \frac{i}{6} g_1 g_3 \lambda_{\beta, \alpha}^\gamma \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D - 2ig'_1 g_3 \cos \Theta'_W \lambda_{\beta, \alpha}^\gamma \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \\
& \left. - \frac{i}{3} g_1 g_3 \lambda_{\beta, \alpha}^\gamma \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \right) (g_{\mu\nu})
\end{aligned} \tag{668}$$

$$i \frac{1}{\sqrt{2}} g_2 g_3 \lambda_{\beta, \alpha}^\delta \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U (g_{\mu\nu}) \tag{669}$$

$$\begin{aligned}
& \left(+ \frac{i}{18} g_1^2 \cos \Theta_W^2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D - \frac{i}{3} g_1 g_2 \cos \Theta_W \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \right. \\
& \left. + \frac{i}{2} g_2^2 \delta_{\alpha\beta} \sin \Theta_W^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D + \frac{2i}{9} g_1^2 \cos \Theta_W^2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \right) (g_{\mu\nu})
\end{aligned} \tag{670}$$

$$\begin{aligned}
& \left(- \frac{i}{6} g_1 g_2 \cos \Theta_W^2 \cos \Theta'_W \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \right. \\
& - \frac{i}{18} g_1^2 \cos \Theta_W \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& + \frac{i}{2} g_2^2 \cos \Theta_W \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& + \frac{i}{6} g_1 g_2 \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& + \frac{i}{3} g_1 g'_1 \cos \Theta_W \delta_{\alpha\beta} \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& - i g'_1 g_2 \delta_{\alpha\beta} \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& - \frac{2i}{9} g_1^2 \cos \Theta_W \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \\
& \left. + \frac{4i}{3} g_1 g'_1 \cos \Theta_W \delta_{\alpha\beta} \sin \Theta'_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \right) (g_{\mu\nu})
\end{aligned} \tag{671}$$

$$\begin{aligned}
& \left(+\frac{i}{3}g_1g_1' \cos \Theta_W \cos \Theta'_W \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \right. \\
& - ig_1'g_2 \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& + \frac{i}{6}g_1g_2 \cos \Theta_W^2 \delta_{\alpha\beta} \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& + \frac{i}{18}g_1^2 \cos \Theta_W \delta_{\alpha\beta} \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& - \frac{i}{2}g_2^2 \cos \Theta_W \delta_{\alpha\beta} \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& - \frac{i}{6}g_1g_2 \delta_{\alpha\beta} \sin \Theta_W^2 \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& + \frac{4i}{3}g_1g_1' \cos \Theta_W \cos \Theta'_W \delta_{\alpha\beta} \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \\
& \left. + \frac{2i}{9}g_1^2 \cos \Theta_W \delta_{\alpha\beta} \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \right) (g_{\mu\nu}) \tag{672}
\end{aligned}$$

$$\frac{i}{3} \frac{1}{\sqrt{2}} g_1 g_2 \cos \Theta_W \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U (g_{\mu\nu}) \quad (673)$$

$$\frac{i}{2} g_2^2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D (g_{\mu\nu}) \quad (674)$$

$$\begin{aligned} & \left(+ \frac{i}{2} g_2^2 \cos \Theta_W^2 \cos \Theta_W'^2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \right. \\ & + \frac{i}{3} g_1 g_2 \cos \Theta_W \cos \Theta_W'^2 \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\ & + \frac{i}{18} g_1^2 \cos \Theta_W'^2 \delta_{\alpha\beta} \sin \Theta_W^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\ & - 2i g_1' g_2 \cos \Theta_W \cos \Theta_W' \delta_{\alpha\beta} \sin \Theta_W' \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\ & \left. - \frac{2i}{3} g_1 g_1' \cos \Theta_W' \delta_{\alpha\beta} \sin \Theta_W \sin \Theta_W' \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \right) \end{aligned}$$

$$\begin{aligned}
& + 2ig_1^2 \delta_{\alpha\beta} \sin \Theta_W'^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D + \frac{2i}{9} g_1^2 \cos \Theta_W'^2 \delta_{\alpha\beta} \sin \Theta_W'^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \\
& - \frac{8i}{3} g_1 g_1' \cos \Theta_W' \delta_{\alpha\beta} \sin \Theta_W \sin \Theta_W' \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \\
& + 8ig_1^2 \delta_{\alpha\beta} \sin \Theta_W'^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \Big) (g_{\mu\nu})
\end{aligned} \tag{675}$$

$$\begin{aligned}
& \Big(-ig_1' g_2 \cos \Theta_W \cos \Theta_W'^2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& - \frac{i}{3} g_1 g_1' \cos \Theta_W'^2 \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& + 2ig_1^2 \cos \Theta_W' \delta_{\alpha\beta} \sin \Theta_W' \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& - \frac{i}{2} g_2^2 \cos \Theta_W'^2 \cos \Theta_W' \delta_{\alpha\beta} \sin \Theta_W' \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& - \frac{i}{3} g_1 g_2 \cos \Theta_W \cos \Theta_W' \delta_{\alpha\beta} \sin \Theta_W \sin \Theta_W' \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& - \frac{i}{18} g_1^2 \cos \Theta_W' \delta_{\alpha\beta} \sin \Theta_W'^2 \sin \Theta_W' \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& + ig_1' g_2 \cos \Theta_W \delta_{\alpha\beta} \sin \Theta_W'^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& + \frac{i}{3} g_1 g_1' \delta_{\alpha\beta} \sin \Theta_W \sin \Theta_W'^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& - \frac{4i}{3} g_1 g_1' \cos \Theta_W'^2 \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D
\end{aligned}$$

$$\begin{aligned}
& -\frac{2i}{9}g_1^2 \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W^2 \sin \Theta'_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \\
& + \frac{4i}{3}g_1 g'_1 \delta_{\alpha\beta} \sin \Theta_W \sin \Theta_W^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D + 4i g_1^2 \delta_{\alpha\beta} \sin 2\Theta'_W \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \Big) (g_{\mu\nu})
\end{aligned} \tag{676}$$

$$\left(-\frac{i}{3} \frac{1}{\sqrt{2}} g_1 g_2 \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U + i\sqrt{2} g'_1 g_2 \delta_{\alpha\beta} \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U \right) (g_{\mu\nu})$$

$$\begin{aligned}
& \left(+2i g_1^2 \cos \Theta_W^2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D + 2i g'_1 g_2 \cos \Theta_W \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \right. \\
& + \frac{2i}{3} g_1 g'_1 \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& + \frac{i}{2} g_2^2 \cos \Theta_W^2 \delta_{\alpha\beta} \sin \Theta_W^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \\
& \left. + \frac{i}{3} g_1 g_2 \cos \Theta_W \delta_{\alpha\beta} \sin \Theta_W \sin \Theta_W^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D \right)
\end{aligned}$$

$$\begin{aligned}
& + \frac{i}{18} g_1^2 \delta_{\alpha\beta} \sin \Theta_W^2 \sin \Theta_W'^2 \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^D + 8i g_1'^2 \cos \Theta_W'^2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \\
& + \frac{8i}{3} g_1 g_1' \cos \Theta_W' \delta_{\alpha\beta} \sin \Theta_W \sin \Theta_W' \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \\
& + \frac{2i}{9} g_1^2 \delta_{\alpha\beta} \sin \Theta_W^2 \sin \Theta_W'^2 \sum_{a=1}^3 Z_{i3+a}^{D,*} Z_{j3+a}^D \Big) (g_{\mu\nu})
\end{aligned} \tag{678}$$

$$\left(\frac{i}{3} \frac{1}{\sqrt{2}} g_1 g_2 \delta_{\alpha\beta} \sin \Theta_W \sin \Theta_W' \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U + i\sqrt{2} g_1' g_2 \cos \Theta_W' \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{D,*} Z_{ja}^U \right) (g_{\mu\nu}) \tag{679}$$

$$\left(\frac{i}{4} g_3^2 \delta_{ij} \sum_{a=1}^3 \lambda_{a,\alpha}^\gamma \lambda_{\beta,a}^\delta + \frac{i}{4} g_3^2 \delta_{ij} \sum_{a=1}^3 \lambda_{\beta,a}^\gamma \lambda_{a,\alpha}^\delta \right) (g_{\mu\nu}) \tag{680}$$

$$-\frac{i}{3}g_1g_3\cos\Theta_W\delta_{ij}\lambda_{\beta,\alpha}^\gamma\left(g_{\mu\nu}\right) \quad (681)$$

$$\begin{aligned} & \left(+\frac{i}{3}g_1g_3\cos\Theta'_W\lambda_{\beta,\alpha}^\gamma\sin\Theta_W\sum_{a=1}^3Z_{ia}^{Dx,*}Z_{ja}^{Dx}-2ig'_1g_3\lambda_{\beta,\alpha}^\gamma\sin\Theta'_W\sum_{a=1}^3Z_{ia}^{Dx,*}Z_{ja}^{Dx} \right. \\ & \left. +\frac{i}{3}g_1g_3\cos\Theta'_W\lambda_{\beta,\alpha}^\gamma\sin\Theta_W\sum_{a=1}^3Z_{i3+a}^{Dx,*}Z_{j3+a}^{Dx}+3ig'_1g_3\lambda_{\beta,\alpha}^\gamma\sin\Theta'_W\sum_{a=1}^3Z_{i3+a}^{Dx,*}Z_{j3+a}^{Dx} \right)\left(g_{\mu\nu}\right) \end{aligned} \quad (682)$$

$$\left(-2ig'_1g_3\cos\Theta'_W\lambda_{\beta,\alpha}^\gamma\sum_{a=1}^3Z_{ia}^{Dx,*}Z_{ja}^{Dx}-\frac{i}{3}g_1g_3\lambda_{\beta,\alpha}^\gamma\sin\Theta_W\sin\Theta'_W\sum_{a=1}^3Z_{ia}^{Dx,*}Z_{ja}^{Dx} \right)$$

$$+ 3ig_1'g_3 \cos \Theta'_W \lambda_{\beta,\alpha}^\gamma \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{j3+a}^{Dx} - \frac{i}{3} g_1 g_3 \lambda_{\beta,\alpha}^\gamma \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{j3+a}^{Dx} \Big) (g_{\mu\nu}) \quad (683)$$

$$\frac{2i}{9} g_1^2 \cos \Theta_W^2 \delta_{\alpha\beta} \delta_{ij} (g_{\mu\nu}) \quad (684)$$

$$\begin{aligned} & \left(-\frac{2i}{9} g_1^2 \cos \Theta_W \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ja}^{Dx} \right. \\ & + \frac{4i}{3} g_1 g_1' \cos \Theta_W \delta_{\alpha\beta} \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ja}^{Dx} \\ & - \frac{2i}{9} g_1^2 \cos \Theta_W \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{j3+a}^{Dx} \\ & \left. - 2ig_1 g_1' \cos \Theta_W \delta_{\alpha\beta} \sin \Theta'_W \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{j3+a}^{Dx} \right) (g_{\mu\nu}) \quad (685) \end{aligned}$$

$$\begin{aligned}
& \left(+ \frac{4i}{3} g_1 g'_1 \cos \Theta_W \cos \Theta'_W \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ja}^{Dx} \right. \\
& + \frac{2i}{9} g_1^2 \cos \Theta_W \delta_{\alpha\beta} \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ja}^{Dx} \\
& - 2i g_1 g'_1 \cos \Theta_W \cos \Theta'_W \delta_{\alpha\beta} \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{j3+a}^{Dx} \\
& \left. + \frac{2i}{9} g_1^2 \cos \Theta_W \delta_{\alpha\beta} \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{j3+a}^{Dx} \right) (g_{\mu\nu})
\end{aligned} \tag{686}$$

$$\begin{aligned}
& \left(+ \frac{2i}{9} g_1^2 \cos \Theta'^2_W \delta_{\alpha\beta} \sin \Theta_W^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ja}^{Dx} \right. \\
& - \frac{8i}{3} g_1 g'_1 \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ja}^{Dx} \\
& + 8i g_1^2 \delta_{\alpha\beta} \sin \Theta'^2_W \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ja}^{Dx} + \frac{2i}{9} g_1^2 \cos \Theta'^2_W \delta_{\alpha\beta} \sin \Theta_W^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{j3+a}^{Dx} \\
& \left. + 4i g_1 g'_1 \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{j3+a}^{Dx} \right)
\end{aligned}$$

$$+ 18ig_1^2 \delta_{\alpha\beta} \sin \Theta_W^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{j3+a}^{Dx} \Big) (g_{\mu\nu}) \quad (687)$$

$$\begin{aligned} & \left(-\frac{4i}{3} g_1 g_1' \cos \Theta_W'^2 \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ja}^{Dx} \right. \\ & + 8ig_1^2 \cos \Theta_W' \delta_{\alpha\beta} \sin \Theta_W' \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ja}^{Dx} \\ & - \frac{2i}{9} g_1^2 \cos \Theta_W' \delta_{\alpha\beta} \sin \Theta_W^2 \sin \Theta_W' \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ja}^{Dx} \\ & + \frac{4i}{3} g_1 g_1' \delta_{\alpha\beta} \sin \Theta_W \sin \Theta_W'^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ja}^{Dx} \\ & + 2ig_1 g_1' \cos \Theta_W'^2 \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{j3+a}^{Dx} \\ & + 18ig_1^2 \cos \Theta_W' \delta_{\alpha\beta} \sin \Theta_W' \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{j3+a}^{Dx} \\ & - \frac{2i}{9} g_1^2 \cos \Theta_W' \delta_{\alpha\beta} \sin \Theta_W^2 \sin \Theta_W' \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{j3+a}^{Dx} \\ & \left. - 2ig_1 g_1' \delta_{\alpha\beta} \sin \Theta_W \sin \Theta_W'^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{j3+a}^{Dx} \right) (g_{\mu\nu}) \quad (688) \end{aligned}$$

$$\begin{aligned}
& \left(+ 8ig_1'^2 \cos \Theta_W'^2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ja}^{Dx} + \frac{8i}{3} g_1 g_1' \cos \Theta_W' \delta_{\alpha\beta} \sin \Theta_W \sin \Theta_W' \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ja}^{Dx} \right. \\
& + \frac{2i}{9} g_1^2 \delta_{\alpha\beta} \sin \Theta_W^2 \sin \Theta_W'^2 \sum_{a=1}^3 Z_{ia}^{Dx,*} Z_{ja}^{Dx} + 18ig_1'^2 \cos \Theta_W'^2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{j3+a}^{Dx} \\
& - 4ig_1 g_1' \cos \Theta_W' \delta_{\alpha\beta} \sin \Theta_W \sin \Theta_W' \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{j3+a}^{Dx} \\
& \left. + \frac{2i}{9} g_1^2 \delta_{\alpha\beta} \sin \Theta_W^2 \sin \Theta_W'^2 \sum_{a=1}^3 Z_{i3+a}^{Dx,*} Z_{j3+a}^{Dx} \right) (g_{\mu\nu})
\end{aligned} \tag{689}$$

$$\begin{aligned}
& \left(+ \frac{i}{2} g_1^2 \cos \Theta_W^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E + ig_1 g_2 \cos \Theta_W \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right. \\
& \left. + \frac{i}{2} g_2^2 \sin \Theta_W^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E + 2ig_1^2 \cos \Theta_W^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \right) (g_{\mu\nu})
\end{aligned} \tag{690}$$

$$\begin{aligned}
& \left(+ \frac{i}{2} g_1 g_2 \cos \Theta_W^2 \cos \Theta'_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right. \\
& - \frac{i}{2} g_1^2 \cos \Theta_W \cos \Theta'_W \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \\
& + \frac{i}{2} g_2^2 \cos \Theta_W \cos \Theta'_W \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \\
& - \frac{i}{2} g_1 g_2 \cos \Theta'_W \sin \Theta_W^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E - 2i g_1 g'_1 \cos \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \\
& - 2i g'_1 g_2 \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \\
& - 2i g_1^2 \cos \Theta_W \cos \Theta'_W \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \\
& \left. + 2i g_1 g'_1 \cos \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \right) (g_{\mu\nu}) \tag{691}
\end{aligned}$$

$$\left(- 2i g_1 g'_1 \cos \Theta_W \cos \Theta'_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E - 2i g'_1 g_2 \cos \Theta'_W \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right.$$

$$\begin{aligned}
& -\frac{i}{2}g_1g_2\cos\Theta_W^2\sin\Theta'_W\sum_{a=1}^3Z_{ia}^{E,*}Z_{ja}^E \\
& +\frac{i}{2}g_1^2\cos\Theta_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^3Z_{ia}^{E,*}Z_{ja}^E \\
& -\frac{i}{2}g_2^2\cos\Theta_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^3Z_{ia}^{E,*}Z_{ja}^E \\
& +\frac{i}{2}g_1g_2\sin\Theta_W^2\sin\Theta'_W\sum_{a=1}^3Z_{ia}^{E,*}Z_{ja}^E+2ig_1g'_1\cos\Theta_W\cos\Theta'_W\sum_{a=1}^3Z_{i3+a}^{E,*}Z_{j3+a}^E \\
& +2ig_1^2\cos\Theta_W\sin\Theta_W\sin\Theta'_W\sum_{a=1}^3Z_{i3+a}^{E,*}Z_{j3+a}^E\Big)(g_{\mu\nu})
\end{aligned} \tag{692}$$

$$-i\frac{1}{\sqrt{2}}g_1g_2\cos\Theta_W\sum_{a=1}^3Z_{ia}^{E,*}Z_{ja}^V(g_{\mu\nu}) \tag{693}$$

$$\frac{i}{2}g_2^2\sum_{a=1}^3Z_{ia}^{E,*}Z_{ja}^E(g_{\mu\nu}) \tag{694}$$

$$\begin{aligned}
& \left(+ \frac{i}{2} g_2^2 \cos \Theta_W^2 \cos \Theta_W'^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right. \\
& - i g_1 g_2 \cos \Theta_W \cos \Theta_W'^2 \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \\
& + \frac{i}{2} g_1^2 \cos \Theta_W'^2 \sin \Theta_W^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \\
& - 4 i g_1' g_2 \cos \Theta_W \cos \Theta_W' \sin \Theta_W' \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \\
& + 4 i g_1 g_1' \cos \Theta_W' \sin \Theta_W \sin \Theta_W' \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E + 8 i g_1'^2 \sin \Theta_W'^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \\
& + 2 i g_1^2 \cos \Theta_W'^2 \sin \Theta_W^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \\
& \left. - 4 i g_1 g_1' \cos \Theta_W' \sin \Theta_W \sin \Theta_W' \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E + 2 i g_1'^2 \sin \Theta_W'^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \right) (g_{\mu\nu}) \quad (695)
\end{aligned}$$

$$\left(- 2 i g_1' g_2 \cos \Theta_W \cos \Theta_W'^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E + 2 i g_1 g_1' \cos \Theta_W'^2 \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right)$$

$$\begin{aligned}
& -\frac{i}{2}g_2^2 \cos \Theta_W^2 \cos \Theta'_W \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \\
& + ig_1 g_2 \cos \Theta_W \cos \Theta'_W \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \\
& -\frac{i}{2}g_1^2 \cos \Theta'_W \sin \Theta_W^2 \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \\
& + 2ig_1' g_2 \cos \Theta_W \sin \Theta_W'^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E - 2ig_1 g_1' \sin \Theta_W \sin \Theta_W'^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \\
& + 4ig_1'^2 \sin 2\Theta'_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E - 2ig_1 g_1' \cos \Theta_W'^2 \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \\
& + 2ig_1'^2 \cos \Theta'_W \sin \Theta'_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \\
& - 2ig_1^2 \cos \Theta'_W \sin \Theta_W^2 \sin \Theta'_W \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \\
& + 2ig_1 g_1' \sin \Theta_W \sin \Theta_W'^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \Big) (g_{\mu\nu}) \tag{696}
\end{aligned}$$

$$\left(2i\sqrt{2}g_1' g_2 \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^V + i\frac{1}{\sqrt{2}}g_1 g_2 \cos \Theta'_W \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^V \right) (g_{\mu\nu}) \tag{697}$$

$$\begin{aligned}
& \left(+ 8ig_1^2 \cos \Theta_W' \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E + 4ig_1' g_2 \cos \Theta_W \cos \Theta_W' \sin \Theta_W' \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \right. \\
& - 4ig_1 g_1' \cos \Theta_W' \sin \Theta_W \sin \Theta_W' \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \\
& + \frac{i}{2} g_2^2 \cos \Theta_W^2 \sin \Theta_W'^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \\
& - ig_1 g_2 \cos \Theta_W \sin \Theta_W \sin \Theta_W'^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E \\
& + \frac{i}{2} g_1^2 \sin \Theta_W^2 \sin \Theta_W'^2 \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^E + 2ig_1^2 \cos \Theta_W'^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \\
& + 4ig_1 g_1' \cos \Theta_W' \sin \Theta_W \sin \Theta_W' \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \\
& \left. + 2ig_1^2 \sin \Theta_W^2 \sin \Theta_W'^2 \sum_{a=1}^3 Z_{i3+a}^{E,*} Z_{j3+a}^E \right) (g_{\mu\nu}) \tag{698}
\end{aligned}$$

$$\left(2i\sqrt{2}g_1' g_2 \cos \Theta_W' \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^V - i\frac{1}{\sqrt{2}} g_1 g_2 \sin \Theta_W \sin \Theta_W' \sum_{a=1}^3 Z_{ia}^{E,*} Z_{ja}^V \right) (g_{\mu\nu}) \tag{699}$$

$$\left(-i\frac{1}{\sqrt{2}}g_1g_2UHp0_{i1}^* \cos \Theta_W UHpp_{j1} + i\frac{1}{\sqrt{2}}g_1g_2UHp0_{i2}^* \cos \Theta_W UHpp_{j2} \right) \left(g_{\mu\nu} \right) \quad (700)$$

$$\begin{aligned} & \left(+i\frac{1}{\sqrt{2}}g_1g_2UHp0_{i1}^* \cos \Theta'_W \sin \Theta_W UHpp_{j1} + 2i\sqrt{2}g'_1g_2UHp0_{i1}^* \sin \Theta'_W UHpp_{j1} \right. \\ & \left. - i\frac{1}{\sqrt{2}}g_1g_2UHp0_{i2}^* \cos \Theta'_W \sin \Theta_W UHpp_{j2} - 2i\sqrt{2}g'_1g_2UHp0_{i2}^* \sin \Theta'_W UHpp_{j2} \right) \left(g_{\mu\nu} \right) \end{aligned} \quad (701)$$

$$\begin{aligned} & \left(+2i\sqrt{2}g'_1g_2UHp0_{i1}^* \cos \Theta'_W UHpp_{j1} - i\frac{1}{\sqrt{2}}g_1g_2UHp0_{i1}^* \sin \Theta_W \sin \Theta'_W UHpp_{j1} \right. \\ & \left. - 2i\sqrt{2}g'_1g_2UHp0_{i2}^* \cos \Theta'_W UHpp_{j2} + i\frac{1}{\sqrt{2}}g_1g_2UHp0_{i2}^* \sin \Theta_W \sin \Theta'_W UHpp_{j2} \right) \left(g_{\mu\nu} \right) \end{aligned} \quad (702)$$

$$\left(\frac{i}{2} g_2^2 U H p 0_{i1}^* U H p 0_{j1} + \frac{i}{2} g_2^2 U H p 0_{i2}^* U H p 0_{j2} \right) (g_{\mu\nu}) \quad (703)$$

$$\begin{aligned} & \left(+ \frac{i}{2} g_2^2 U H p 0_{i1}^* \cos \Theta_W^2 \cos \Theta_W'^2 U H p 0_{j1} + i g_1 g_2 U H p 0_{i1}^* \cos \Theta_W \cos \Theta_W'^2 \sin \Theta_W U H p 0_{j1} \right. \\ & + \frac{i}{2} g_1^2 U H p 0_{i1}^* \cos \Theta_W'^2 \sin \Theta_W^2 U H p 0_{j1} + 4 i g_1' g_2 U H p 0_{i1}^* \cos \Theta_W \cos \Theta_W' \sin \Theta_W' U H p 0_{j1} \\ & + 4 i g_1 g_1' U H p 0_{i1}^* \cos \Theta_W' \sin \Theta_W \sin \Theta_W' U H p 0_{j1} + 8 i g_1^2 U H p 0_{i1}^* \sin \Theta_W'^2 U H p 0_{j1} \\ & + \frac{i}{2} g_2^2 U H p 0_{i2}^* \cos \Theta_W^2 \cos \Theta_W'^2 U H p 0_{j2} + i g_1 g_2 U H p 0_{i2}^* \cos \Theta_W \cos \Theta_W'^2 \sin \Theta_W U H p 0_{j2} \\ & + \frac{i}{2} g_1^2 U H p 0_{i2}^* \cos \Theta_W'^2 \sin \Theta_W^2 U H p 0_{j2} + 4 i g_1' g_2 U H p 0_{i2}^* \cos \Theta_W \cos \Theta_W' \sin \Theta_W' U H p 0_{j2} \\ & \left. + 4 i g_1 g_1' U H p 0_{i2}^* \cos \Theta_W' \sin \Theta_W \sin \Theta_W' U H p 0_{j2} + 8 i g_1^2 U H p 0_{i2}^* \sin \Theta_W'^2 U H p 0_{j2} \right) (g_{\mu\nu}) \quad (704) \end{aligned}$$

$$\begin{aligned}
& \left(+ 2ig_1'g_2UHp0_{i1}^* \cos \Theta_W \cos \Theta_W'^2 UHp0_{j1} + 2ig_1g_2'UHp0_{i1}^* \cos \Theta_W' \sin \Theta_W UHp0_{j1} \right. \\
& + \frac{i}{4}g_1^2UHp0_{i1}^* \cos \Theta_W^2 \cos \Theta_W' \sin \Theta_W' UHp0_{j1} - \frac{i}{4}g_2^2UHp0_{i1}^* \cos \Theta_W^2 \cos \Theta_W' \sin \Theta_W' UHp0_{j1} \\
& - ig_1g_2UHp0_{i1}^* \cos \Theta_W \cos \Theta_W' \sin \Theta_W \sin \Theta_W' UHp0_{j1} - 2ig_1'g_2UHp0_{i1}^* \cos \Theta_W \sin \Theta_W'^2 UHp0_{j1} \\
& - 2ig_1g_2'UHp0_{i1}^* \sin \Theta_W \sin \Theta_W'^2 UHp0_{j1} - \frac{3i}{16}g_1^2UHp0_{i1}^* \sin 2\Theta_W' UHp0_{j1} + 4ig_1^2UHp0_{i1}^* \sin 2\Theta_W' UHp0_{j1} \\
& - \frac{i}{16}g_2^2UHp0_{i1}^* \sin 2\Theta_W' UHp0_{j1} + \frac{i}{16}g_1^2UHp0_{i1}^* \cos 2\Theta_W \sin 2\Theta_W' UHp0_{j1} \\
& - \frac{i}{16}g_2^2UHp0_{i1}^* \cos 2\Theta_W \sin 2\Theta_W' UHp0_{j1} + 2ig_1'g_2UHp0_{i2}^* \cos \Theta_W \cos \Theta_W'^2 UHp0_{j2} \\
& + 2ig_1g_2'UHp0_{i2}^* \cos \Theta_W' \sin \Theta_W UHp0_{j2} + \frac{i}{4}g_1^2UHp0_{i2}^* \cos \Theta_W^2 \cos \Theta_W' \sin \Theta_W' UHp0_{j2} \\
& - \frac{i}{4}g_2^2UHp0_{i2}^* \cos \Theta_W^2 \cos \Theta_W' \sin \Theta_W' UHp0_{j2} \\
& - ig_1g_2UHp0_{i2}^* \cos \Theta_W \cos \Theta_W' \sin \Theta_W \sin \Theta_W' UHp0_{j2} - 2ig_1'g_2UHp0_{i2}^* \cos \Theta_W \sin \Theta_W'^2 UHp0_{j2} \\
& - 2ig_1g_2'UHp0_{i2}^* \sin \Theta_W \sin \Theta_W'^2 UHp0_{j2} - \frac{3i}{16}g_1^2UHp0_{i2}^* \sin 2\Theta_W' UHp0_{j2} + 4ig_1^2UHp0_{i2}^* \sin 2\Theta_W' UHp0_{j2} \\
& - \frac{i}{16}g_2^2UHp0_{i2}^* \sin 2\Theta_W' UHp0_{j2} + \frac{i}{16}g_1^2UHp0_{i2}^* \cos 2\Theta_W \sin 2\Theta_W' UHp0_{j2} \\
& \left. - \frac{i}{16}g_2^2UHp0_{i2}^* \cos 2\Theta_W \sin 2\Theta_W' UHp0_{j2} \right) (g_{\mu\nu}) \tag{705}
\end{aligned}$$

$$\begin{aligned}
& \left(+ 8ig_1^2UHp0_{i1}^* \cos \Theta_W'^2 UHp0_{j1} - 4ig_1'g_2UHp0_{i1}^* \cos \Theta_W \cos \Theta_W' \sin \Theta_W' UHp0_{j1} \right. \\
& - 4ig_1g_2'UHp0_{i1}^* \cos \Theta_W' \sin \Theta_W \sin \Theta_W' UHp0_{j1} + \frac{i}{2}g_2^2UHp0_{i1}^* \cos \Theta_W^2 \sin \Theta_W'^2 UHp0_{j1} \\
& + ig_1g_2UHp0_{i1}^* \cos \Theta_W \sin \Theta_W \sin \Theta_W'^2 UHp0_{j1} + \frac{i}{2}g_1^2UHp0_{i1}^* \sin \Theta_W^2 \sin \Theta_W'^2 UHp0_{j1} \\
& + 8ig_1^2UHp0_{i2}^* \cos \Theta_W'^2 UHp0_{j2} - 4ig_1'g_2UHp0_{i2}^* \cos \Theta_W \cos \Theta_W' \sin \Theta_W' UHp0_{j2} \\
& - 4ig_1g_2'UHp0_{i2}^* \cos \Theta_W' \sin \Theta_W \sin \Theta_W' UHp0_{j2} + \frac{i}{2}g_2^2UHp0_{i2}^* \cos \Theta_W^2 \sin \Theta_W'^2 UHp0_{j2} \\
& \left. + ig_1g_2UHp0_{i2}^* \cos \Theta_W \sin \Theta_W \sin \Theta_W'^2 UHp0_{j2} + \frac{i}{2}g_1^2UHp0_{i2}^* \sin \Theta_W^2 \sin \Theta_W'^2 UHp0_{j2} \right) (g_{\mu\nu}) \tag{706}
\end{aligned}$$

$$\begin{aligned}
& \left(+\frac{i}{2}g_1^2 UHpp_{i1}^* \cos \Theta_W^2 UHpp_{j1} + ig_1g_2 UHpp_{i1}^* \cos \Theta_W \sin \Theta_W UHpp_{j1} + \frac{i}{2}g_2^2 UHpp_{i1}^* \sin \Theta_W^2 UHpp_{j1} \right. \\
& \left. + \frac{i}{2}g_1^2 UHpp_{i2}^* \cos \Theta_W^2 UHpp_{j2} + ig_1g_2 UHpp_{i2}^* \cos \Theta_W \sin \Theta_W UHpp_{j2} + \frac{i}{2}g_2^2 UHpp_{i2}^* \sin \Theta_W^2 UHpp_{j2} \right) (g_{\mu\nu}) \quad (707)
\end{aligned}$$

$$\begin{aligned}
& \left(+\frac{i}{2}g_1g_2 UHpp_{i1}^* \cos \Theta_W^2 \cos \Theta'_W UHpp_{j1} - \frac{i}{2}g_1^2 UHpp_{i1}^* \cos \Theta_W \cos \Theta'_W \sin \Theta_W UHpp_{j1} \right. \\
& + \frac{i}{2}g_2^2 UHpp_{i1}^* \cos \Theta_W \cos \Theta'_W \sin \Theta_W UHpp_{j1} - \frac{i}{2}g_1g_2 UHpp_{i1}^* \cos \Theta'_W \sin \Theta_W^2 UHpp_{j1} \\
& - 2ig_1g'_1 UHpp_{i1}^* \cos \Theta_W \sin \Theta'_W UHpp_{j1} - 2ig'_1g_2 UHpp_{i1}^* \sin \Theta_W \sin \Theta'_W UHpp_{j1} \\
& + \frac{i}{2}g_1g_2 UHpp_{i2}^* \cos \Theta_W^2 \cos \Theta'_W UHpp_{j2} - \frac{i}{2}g_1^2 UHpp_{i2}^* \cos \Theta_W \cos \Theta'_W \sin \Theta_W UHpp_{j2} \\
& + \frac{i}{2}g_2^2 UHpp_{i2}^* \cos \Theta_W \cos \Theta'_W \sin \Theta_W UHpp_{j2} - \frac{i}{2}g_1g_2 UHpp_{i2}^* \cos \Theta'_W \sin \Theta_W^2 UHpp_{j2} \\
& \left. - 2ig_1g'_1 UHpp_{i2}^* \cos \Theta_W \sin \Theta'_W UHpp_{j2} - 2ig'_1g_2 UHpp_{i2}^* \sin \Theta_W \sin \Theta'_W UHpp_{j2} \right) (g_{\mu\nu}) \quad (708)
\end{aligned}$$

$$\begin{aligned}
& \left(-2ig_1g'_1UHpp_{i1}^* \cos \Theta_W \cos \Theta'_W UHpp_{j1} - 2ig'_1g_2UHpp_{i1}^* \cos \Theta'_W \sin \Theta_W UHpp_{j1} \right. \\
& - \frac{i}{2}g_1g_2UHpp_{i1}^* \cos \Theta_W^2 \sin \Theta'_W UHpp_{j1} + \frac{i}{2}g_1^2UHpp_{i1}^* \cos \Theta_W \sin \Theta_W \sin \Theta'_W UHpp_{j1} \\
& - \frac{i}{2}g_2^2UHpp_{i1}^* \cos \Theta_W \sin \Theta_W \sin \Theta'_W UHpp_{j1} + \frac{i}{2}g_1g_2UHpp_{i1}^* \sin \Theta_W^2 \sin \Theta'_W UHpp_{j1} \\
& - 2ig_1g'_1UHpp_{i2}^* \cos \Theta_W \cos \Theta'_W UHpp_{j2} - 2ig'_1g_2UHpp_{i2}^* \cos \Theta'_W \sin \Theta_W UHpp_{j2} \\
& - \frac{i}{2}g_1g_2UHpp_{i2}^* \cos \Theta_W^2 \sin \Theta'_W UHpp_{j2} + \frac{i}{2}g_1^2UHpp_{i2}^* \cos \Theta_W \sin \Theta_W \sin \Theta'_W UHpp_{j2} \\
& \left. - \frac{i}{2}g_2^2UHpp_{i2}^* \cos \Theta_W \sin \Theta_W \sin \Theta'_W UHpp_{j2} + \frac{i}{2}g_1g_2UHpp_{i2}^* \sin \Theta_W^2 \sin \Theta'_W UHpp_{j2} \right) (g_{\mu\nu}) \quad (709)
\end{aligned}$$

$$\left(-i\frac{1}{\sqrt{2}}g_1g_2UHpp_{i1}^* \cos \Theta_W UHp0_{j1} + i\frac{1}{\sqrt{2}}g_1g_2UHpp_{i2}^* \cos \Theta_W UHp0_{j2} \right) (g_{\mu\nu}) \quad (710)$$

$$\left(\frac{i}{2}g_2^2 UHpp_{i1}^* UHpp_{j1} + \frac{i}{2}g_2^2 UHpp_{i2}^* UHpp_{j2}\right)(g_{\mu\nu}) \quad (711)$$

$$\begin{aligned} & \left(+ \frac{i}{2}g_2^2 UHpp_{i1}^* \cos \Theta_W^2 \cos \Theta_W'^2 UHpp_{j1} - ig_1g_2 UHpp_{i1}^* \cos \Theta_W \cos \Theta_W'^2 \sin \Theta_W UHpp_{j1} \right. \\ & + \frac{i}{2}g_1^2 UHpp_{i1}^* \cos \Theta_W'^2 \sin \Theta_W^2 UHpp_{j1} - 4ig_1'g_2 UHpp_{i1}^* \cos \Theta_W \cos \Theta_W' \sin \Theta_W' UHpp_{j1} \\ & + 4ig_1g_1' UHpp_{i1}^* \cos \Theta_W' \sin \Theta_W \sin \Theta_W' UHpp_{j1} + 8ig_1^2 UHpp_{i1}^* \sin \Theta_W'^2 UHpp_{j1} \\ & + \frac{i}{2}g_2^2 UHpp_{i2}^* \cos \Theta_W^2 \cos \Theta_W'^2 UHpp_{j2} - ig_1g_2 UHpp_{i2}^* \cos \Theta_W \cos \Theta_W'^2 \sin \Theta_W UHpp_{j2} \\ & + \frac{i}{2}g_1^2 UHpp_{i2}^* \cos \Theta_W'^2 \sin \Theta_W^2 UHpp_{j2} - 4ig_1'g_2 UHpp_{i2}^* \cos \Theta_W \cos \Theta_W' \sin \Theta_W' UHpp_{j2} \\ & \left. + 4ig_1g_1' UHpp_{i2}^* \cos \Theta_W' \sin \Theta_W \sin \Theta_W' UHpp_{j2} + 8ig_1^2 UHpp_{i2}^* \sin \Theta_W'^2 UHpp_{j2} \right)(g_{\mu\nu}) \quad (712) \end{aligned}$$

$$\begin{aligned} & \left(- 2ig_1'g_2 UHpp_{i1}^* \cos \Theta_W \cos 2\Theta_W' UHpp_{j1} + 2ig_1g_1' UHpp_{i1}^* \cos \Theta_W'^2 \sin \Theta_W UHpp_{j1} \right. \\ & + \frac{i}{4}g_1^2 UHpp_{i1}^* \cos \Theta_W^2 \cos \Theta_W' \sin \Theta_W' UHpp_{j1} - \frac{i}{4}g_2^2 UHpp_{i1}^* \cos \Theta_W^2 \cos \Theta_W' \sin \Theta_W' UHpp_{j1} \\ & - 2ig_1g_1' UHpp_{i1}^* \sin \Theta_W \sin \Theta_W'^2 UHpp_{j1} - \frac{3i}{16}g_1^2 UHpp_{i1}^* \sin 2\Theta_W' UHpp_{j1} + 4ig_1^2 UHpp_{i1}^* \sin 2\Theta_W' UHpp_{j1} \\ & \left. - \frac{i}{16}g_2^2 UHpp_{i1}^* \sin 2\Theta_W' UHpp_{j1} + \frac{i}{16}g_1^2 UHpp_{i1}^* \cos 2\Theta_W \sin 2\Theta_W' UHpp_{j1} \right) \end{aligned}$$

$$\begin{aligned}
& -\frac{i}{16}g_2^2 UHpp_{i1}^* \cos 2\Theta_W \sin 2\Theta'_W UHpp_{j1} + \frac{i}{4}g_1g_2 UHpp_{i1}^* \sin 2\Theta_W \sin 2\Theta'_W UHpp_{j1} \\
& -2ig_1'g_2 UHpp_{i2}^* \cos \Theta_W \cos 2\Theta'_W UHpp_{j2} + 2ig_1g_1' UHpp_{i2}^* \cos \Theta_W^2 \sin \Theta_W UHpp_{j2} \\
& + \frac{i}{4}g_1^2 UHpp_{i2}^* \cos \Theta_W^2 \cos \Theta'_W \sin \Theta'_W UHpp_{j2} - \frac{i}{4}g_2^2 UHpp_{i2}^* \cos \Theta_W^2 \cos \Theta'_W \sin \Theta'_W UHpp_{j2} \\
& -2ig_1g_1' UHpp_{i2}^* \sin \Theta_W \sin \Theta_W^2 UHpp_{j2} - \frac{3i}{16}g_1^2 UHpp_{i2}^* \sin 2\Theta'_W UHpp_{j2} + 4ig_1^2 UHpp_{i2}^* \sin 2\Theta'_W UHpp_{j2} \\
& -\frac{i}{16}g_2^2 UHpp_{i2}^* \sin 2\Theta'_W UHpp_{j2} + \frac{i}{16}g_1^2 UHpp_{i2}^* \cos 2\Theta_W \sin 2\Theta'_W UHpp_{j2} \\
& -\frac{i}{16}g_2^2 UHpp_{i2}^* \cos 2\Theta_W \sin 2\Theta'_W UHpp_{j2} + \frac{i}{4}g_1g_2 UHpp_{i2}^* \sin 2\Theta_W \sin 2\Theta'_W UHpp_{j2} \Big) (g_{\mu\nu}) \tag{713}
\end{aligned}$$

$$\begin{aligned}
& \left(+i\frac{1}{\sqrt{2}}g_1g_2 UHpp_{i1}^* \cos \Theta'_W \sin \Theta_W UHp0_{j1} + 2i\sqrt{2}g_1'g_2 UHpp_{i1}^* \sin \Theta'_W UHp0_{j1} \right. \\
& \left. -i\frac{1}{\sqrt{2}}g_1g_2 UHpp_{i2}^* \cos \Theta'_W \sin \Theta_W UHp0_{j2} - 2i\sqrt{2}g_1'g_2 UHpp_{i2}^* \sin \Theta'_W UHp0_{j2} \right) (g_{\mu\nu}) \tag{714}
\end{aligned}$$

$$\begin{aligned}
& \left(+8ig_1^2 UHpp_{i1}^* \cos \Theta_W^2 UHpp_{j1} + 4ig_1'g_2 UHpp_{i1}^* \cos \Theta_W \cos \Theta'_W \sin \Theta'_W UHpp_{j1} \right. \\
& -4ig_1g_1' UHpp_{i1}^* \cos \Theta'_W \sin \Theta_W \sin \Theta'_W UHpp_{j1} + \frac{i}{2}g_2^2 UHpp_{i1}^* \cos \Theta_W^2 \sin \Theta_W^2 UHpp_{j1} \\
& \left. -ig_1g_2 UHpp_{i1}^* \cos \Theta_W \sin \Theta_W \sin \Theta_W^2 UHpp_{j1} + \frac{i}{2}g_1^2 UHpp_{i1}^* \sin \Theta_W^2 \sin \Theta_W^2 UHpp_{j1} \right)
\end{aligned}$$

$$\begin{aligned}
& + 8ig_1^2 UHpp_{i2}^* \cos \Theta_W'^2 UHpp_{j2} + 4ig_1' g_2 UHpp_{i2}^* \cos \Theta_W \cos \Theta_W' \sin \Theta_W' UHpp_{j2} \\
& - 4ig_1 g_1' UHpp_{i2}^* \cos \Theta_W' \sin \Theta_W \sin \Theta_W' UHpp_{j2} + \frac{i}{2} g_2^2 UHpp_{i2}^* \cos \Theta_W^2 \sin \Theta_W'^2 UHpp_{j2} \\
& - ig_1 g_2 UHpp_{i2}^* \cos \Theta_W \sin \Theta_W \sin \Theta_W'^2 UHpp_{j2} + \frac{i}{2} g_1^2 UHpp_{i2}^* \sin \Theta_W^2 \sin \Theta_W'^2 UHpp_{j2} \Big) (g_{\mu\nu}) \quad (715)
\end{aligned}$$

$$\begin{aligned}
& \left(+ 2i\sqrt{2}g_1' g_2 UHpp_{i1}^* \cos \Theta_W' UHp0_{j1} - i\frac{1}{\sqrt{2}} g_1 g_2 UHpp_{i1}^* \sin \Theta_W \sin \Theta_W' UHp0_{j1} \right. \\
& \left. - 2i\sqrt{2}g_1' g_2 UHpp_{i2}^* \cos \Theta_W' UHp0_{j2} + i\frac{1}{\sqrt{2}} g_1 g_2 UHpp_{i2}^* \sin \Theta_W \sin \Theta_W' UHp0_{j2} \right) (g_{\mu\nu}) \quad (716)
\end{aligned}$$

$$\left(\frac{i}{4} g_3^2 \delta_{ij} \sum_{a=1}^3 \lambda_{a,\alpha}^\gamma \lambda_{\beta,a}^\delta + \frac{i}{4} g_3^2 \delta_{ij} \sum_{a=1}^3 \lambda_{\beta,a}^\gamma \lambda_{a,\alpha}^\delta \right) (g_{\mu\nu}) \quad (717)$$

$$\begin{aligned}
& \left(+ \frac{i}{6} g_1 g_3 \cos \Theta_W \lambda_{\beta, \alpha}^\gamma \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U + \frac{i}{2} g_2 g_3 \lambda_{\beta, \alpha}^\gamma \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \right. \\
& \left. + \frac{2i}{3} g_1 g_3 \cos \Theta_W \lambda_{\beta, \alpha}^\gamma \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \right) (g_{\mu\nu})
\end{aligned} \tag{718}$$

$$i \frac{1}{\sqrt{2}} g_2 g_3 \lambda_{\beta, \alpha}^\gamma \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D (g_{\mu\nu}) \tag{719}$$

$$\begin{aligned}
& \left(+ \frac{i}{2} g_2 g_3 \cos \Theta_W \cos \Theta'_W \lambda_{\beta, \alpha}^\gamma \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U - \frac{i}{6} g_1 g_3 \cos \Theta'_W \lambda_{\beta, \alpha}^\gamma \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \right. \\
& + i g'_1 g_3 \lambda_{\beta, \alpha}^\gamma \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U - \frac{2i}{3} g_1 g_3 \cos \Theta'_W \lambda_{\beta, \alpha}^\gamma \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \\
& \left. - i g'_1 g_3 \lambda_{\beta, \alpha}^\gamma \sin \Theta'_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \right) (g_{\mu\nu})
\end{aligned} \tag{720}$$

$$\begin{aligned}
& \left(+ig'_1g_3\cos\Theta'_W\lambda_{\beta,\alpha}^\gamma\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^U - \frac{i}{2}g_2g_3\cos\Theta_W\lambda_{\beta,\alpha}^\gamma\sin\Theta'_W\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^U \right. \\
& + \frac{i}{6}g_1g_3\lambda_{\beta,\alpha}^\gamma\sin\Theta_W\sin\Theta'_W\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^U - ig'_1g_3\cos\Theta'_W\lambda_{\beta,\alpha}^\gamma\sum_{a=1}^3Z_{i3+a}^{U,*}Z_{j3+a}^U \\
& \left. + \frac{2i}{3}g_1g_3\lambda_{\beta,\alpha}^\gamma\sin\Theta_W\sin\Theta'_W\sum_{a=1}^3Z_{i3+a}^{U,*}Z_{j3+a}^U \right) (g_{\mu\nu})
\end{aligned} \tag{721}$$

$$\begin{aligned}
& \left(+\frac{i}{18}g_1^2\cos\Theta_W^2\delta_{\alpha\beta}\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^U + \frac{i}{3}g_1g_2\cos\Theta_W\delta_{\alpha\beta}\sin\Theta_W\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^U \right. \\
& \left. + \frac{i}{2}g_2^2\delta_{\alpha\beta}\sin\Theta_W^2\sum_{a=1}^3Z_{ia}^{U,*}Z_{ja}^U + \frac{8i}{9}g_1^2\cos\Theta_W^2\delta_{\alpha\beta}\sum_{a=1}^3Z_{i3+a}^{U,*}Z_{j3+a}^U \right) (g_{\mu\nu})
\end{aligned} \tag{722}$$

$$\frac{i}{3} \frac{1}{\sqrt{2}} g_1 g_2 \cos \Theta_W \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D (g_{\mu\nu}) \quad (723)$$

$$\begin{aligned} & \left(+ \frac{i}{6} g_1 g_2 \cos \Theta_W^2 \cos \Theta'_W \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \right. \\ & - \frac{i}{18} g_1^2 \cos \Theta_W \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\ & + \frac{i}{2} g_2^2 \cos \Theta_W \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\ & - \frac{i}{6} g_1 g_2 \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\ & + \frac{i}{3} g_1 g'_1 \cos \Theta_W \delta_{\alpha\beta} \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U + i g'_1 g_2 \delta_{\alpha\beta} \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\ & - \frac{8i}{9} g_1^2 \cos \Theta_W \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \\ & \left. - \frac{4i}{3} g_1 g'_1 \cos \Theta_W \delta_{\alpha\beta} \sin \Theta'_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \right) (g_{\mu\nu}) \quad (724) \end{aligned}$$

$$\begin{aligned}
& \left(+ \frac{i}{3} g_1 g'_1 \cos \Theta_W \cos \Theta'_W \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U + i g'_1 g_2 \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \right. \\
& - \frac{i}{6} g_1 g_2 \cos \Theta_W^2 \delta_{\alpha\beta} \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\
& + \frac{i}{18} g_1^2 \cos \Theta_W \delta_{\alpha\beta} \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\
& - \frac{i}{2} g_2^2 \cos \Theta_W \delta_{\alpha\beta} \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\
& + \frac{i}{6} g_1 g_2 \delta_{\alpha\beta} \sin \Theta_W^2 \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\
& - \frac{4i}{3} g_1 g'_1 \cos \Theta_W \cos \Theta'_W \delta_{\alpha\beta} \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \\
& \left. + \frac{4i}{9} g_1^2 \delta_{\alpha\beta} \sin 2\Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \right) (g_{\mu\nu}) \tag{725}
\end{aligned}$$

$$\left(- \frac{i}{3} \frac{1}{\sqrt{2}} g_1 g_2 \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D + i \sqrt{2} g'_1 g_2 \delta_{\alpha\beta} \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D \right) (g_{\mu\nu}) \tag{726}$$

$$\left(\frac{i}{3} \frac{1}{\sqrt{2}} g_1 g_2 \delta_{\alpha\beta} \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D + i\sqrt{2} g'_1 g_2 \cos \Theta'_W \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^D \right) (g_{\mu\nu}) \quad (727)$$

$$\frac{i}{2} g_2^2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U (g_{\mu\nu}) \quad (728)$$

$$\begin{aligned} & \left(+ \frac{i}{2} g_2^2 \cos \Theta_W^2 \cos \Theta_W'^2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \right. \\ & \left. - \frac{i}{3} g_1 g_2 \cos \Theta_W \cos \Theta_W'^2 \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \right) \end{aligned}$$

$$\begin{aligned}
& + \frac{i}{18} g_1^2 \cos \Theta_W^2 \delta_{\alpha\beta} \sin \Theta_W^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\
& + 2i g_1' g_2 \cos \Theta_W \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\
& - \frac{2i}{3} g_1 g_1' \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\
& + 2i g_1^2 \delta_{\alpha\beta} \sin \Theta_W^2 \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U + \frac{8i}{9} g_1^2 \cos \Theta_W^2 \delta_{\alpha\beta} \sin \Theta_W^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \\
& + \frac{8i}{3} g_1 g_1' \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \\
& + 2i g_1^2 \delta_{\alpha\beta} \sin \Theta_W^2 \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \Big) (g_{\mu\nu}) \tag{729}
\end{aligned}$$

$$\begin{aligned}
& \Big(+ i g_1' g_2 \cos \Theta_W \cos \Theta_W^2 \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\
& - \frac{i}{3} g_1 g_1' \cos \Theta_W^2 \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\
& + 2i g_1^2 \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\
& - \frac{i}{2} g_2^2 \cos \Theta_W^2 \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\
& + \frac{i}{3} g_1 g_2 \cos \Theta_W \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\
& - \frac{i}{18} g_1^2 \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W^2 \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U
\end{aligned}$$

$$\begin{aligned}
& -ig'_1g_2 \cos \Theta_W \delta_{\alpha\beta} \sin \Theta'^2_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\
& + \frac{i}{3} g_1 g'_1 \delta_{\alpha\beta} \sin \Theta_W \sin \Theta'^2_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\
& + \frac{4i}{3} g_1 g'_1 \cos \Theta'^2_W \delta_{\alpha\beta} \sin \Theta_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \\
& + 2ig_1'^2 \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta'_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \\
& - \frac{4i}{3} g_1 g'_1 \delta_{\alpha\beta} \sin \Theta_W \sin \Theta'^2_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \\
& - \frac{4i}{9} g_1^2 \delta_{\alpha\beta} \sin \Theta_W^2 \sin 2\Theta'_W \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \Big) (g_{\mu\nu})
\end{aligned} \tag{730}$$

$$\begin{aligned}
& \left(+ 2ig_1'^2 \cos \Theta'^2_W \delta_{\alpha\beta} \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \right. \\
& - 2ig'_1g_2 \cos \Theta_W \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\
& + \frac{2i}{3} g_1 g'_1 \cos \Theta'_W \delta_{\alpha\beta} \sin \Theta_W \sin \Theta'_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\
& + \frac{i}{2} g_2^2 \cos \Theta_W^2 \delta_{\alpha\beta} \sin \Theta'^2_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\
& - \frac{i}{3} g_1 g_2 \cos \Theta_W \delta_{\alpha\beta} \sin \Theta_W \sin \Theta'^2_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U \\
& \left. + \frac{i}{18} g_1^2 \delta_{\alpha\beta} \sin \Theta_W^2 \sin \Theta'^2_W \sum_{a=1}^3 Z_{ia}^{U,*} Z_{ja}^U + 2ig_1'^2 \cos \Theta'^2_W \delta_{\alpha\beta} \sum_{a=1}^3 Z_{i3+a}^{U,*} Z_{j3+a}^U \right)
\end{aligned}$$

$$\begin{aligned}
& -\frac{8i}{3}g_1g'_1\cos\Theta'_W\delta_{\alpha\beta}\sin\Theta_W\sin\Theta'_W\sum_{a=1}^3Z_{i3+a}^{U,*}Z_{j3+a}^U \\
& +\frac{8i}{9}g_1^2\delta_{\alpha\beta}\sin\Theta_W^2\sin\Theta'^2_W\sum_{a=1}^3Z_{i3+a}^{U,*}Z_{j3+a}^U\Big)(g_{\mu\nu})
\end{aligned} \tag{731}$$

$$-i\frac{1}{\sqrt{2}}g_1g_2\cos\Theta_W\sum_{a=1}^3Z_{ia}^{V,*}Z_{ja}^E(g_{\mu\nu}) \tag{732}$$

$$\left(2i\sqrt{2}g'_1g_2\sin\Theta'_W\sum_{a=1}^3Z_{ia}^{V,*}Z_{ja}^E+i\frac{1}{\sqrt{2}}g_1g_2\cos\Theta'_W\sin\Theta_W\sum_{a=1}^3Z_{ia}^{V,*}Z_{ja}^E\right)(g_{\mu\nu}) \tag{733}$$

$$\left(2i\sqrt{2}g_1'g_2\cos\Theta_W\sum_{a=1}^3Z_{ia}^{V,*}Z_{ja}^E-i\frac{1}{\sqrt{2}}g_1g_2\sin\Theta_W\sin\Theta_W'\sum_{a=1}^3Z_{ia}^{V,*}Z_{ja}^E\right)(g_{\mu\nu}) \quad (734)$$

$$\frac{i}{2}g_2^2\delta_{ij}(g_{\mu\nu}) \quad (735)$$

$$\begin{aligned} &\left(+\frac{i}{2}g_2^2\cos\Theta_W^2\cos\Theta_W'^2\delta_{ij}+ig_1g_2\cos\Theta_W\cos\Theta_W'^2\delta_{ij}\sin\Theta_W\right. \\ &+\frac{i}{2}g_1^2\cos\Theta_W'^2\delta_{ij}\sin\Theta_W^2+4ig_1'g_2\cos\Theta_W\cos\Theta_W'\delta_{ij}\sin\Theta_W' \\ &\left.+4ig_1g_1'\cos\Theta_W'\delta_{ij}\sin\Theta_W\sin\Theta_W'+8ig_1^2\delta_{ij}\sin\Theta_W'^2\right)(g_{\mu\nu}) \end{aligned} \quad (736)$$

$$\begin{aligned}
& \left(+ 2ig_1'g_2 \cos \Theta_W \cos \Theta_W'^2 \delta_{ij} + 2ig_1g_1' \cos \Theta_W'^2 \delta_{ij} \sin \Theta_W \right. \\
& - \frac{i}{2}g_2^2 \cos \Theta_W^2 \cos \Theta_W' \delta_{ij} \sin \Theta_W' - ig_1g_2 \cos \Theta_W \cos \Theta_W' \delta_{ij} \sin \Theta_W \sin \Theta_W' \\
& - \frac{i}{2}g_1^2 \cos \Theta_W' \delta_{ij} \sin \Theta_W^2 \sin \Theta_W' - 2ig_1'g_2 \cos \Theta_W \delta_{ij} \sin \Theta_W'^2 \\
& \left. - 2ig_1g_1' \delta_{ij} \sin \Theta_W \sin \Theta_W'^2 + 4ig_1^2 \delta_{ij} \sin 2\Theta_W' \right) (g_{\mu\nu})
\end{aligned} \tag{737}$$

$$\begin{aligned}
& \left(+ 8ig_1'^2 \cos \Theta_W'^2 \delta_{ij} - 4ig_1'g_2 \cos \Theta_W \cos \Theta_W' \delta_{ij} \sin \Theta_W' \right. \\
& - 4ig_1g_1' \cos \Theta_W' \delta_{ij} \sin \Theta_W \sin \Theta_W' + \frac{i}{2}g_2^2 \cos \Theta_W^2 \delta_{ij} \sin \Theta_W'^2 \\
& \left. + ig_1g_2 \cos \Theta_W \delta_{ij} \sin \Theta_W \sin \Theta_W'^2 + \frac{i}{2}g_1^2 \delta_{ij} \sin \Theta_W^2 \sin \Theta_W'^2 \right) (g_{\mu\nu})
\end{aligned} \tag{738}$$

9.9 Four Vector Boson-Interaction

$$ig_3^2 \left(- \sum_{a=1}^8 f_{\alpha,\delta,a} f_{\beta,\gamma,a} - \sum_{a=1}^8 f_{\alpha,\gamma,a} f_{\beta,\delta,a} \right) (g_{\rho\sigma} g_{\mu\nu}) \tag{739}$$

$$+ ig_3^2 \left(- \sum_{a=1}^8 f_{\alpha,\beta,a} f_{\gamma,\delta,a} + \sum_{a=1}^8 f_{\alpha,\delta,a} f_{\beta,\gamma,a} \right) (g_{\rho\mu} g_{\sigma\nu}) \tag{740}$$

$$+ ig_3^2 \left(\sum_{a=1}^8 f_{\alpha,\gamma,a} f_{\beta,\delta,a} + \sum_{a=1}^8 f_{\alpha,\beta,a} f_{\gamma,\delta,a} \right) (g_{\rho\nu} g_{\sigma\mu}) \quad (741)$$

$$ig_2^2 \sin \Theta_W^2 (g_{\rho\sigma} g_{\mu\nu}) \quad (742)$$

$$+ ig_2^2 \sin \Theta_W^2 (g_{\rho\mu} g_{\sigma\nu}) \quad (743)$$

$$+ -2ig_2^2 \sin \Theta_W^2 (g_{\rho\nu} g_{\sigma\mu}) \quad (744)$$

$$\frac{i}{2} g_2^2 \cos \Theta'_W \sin 2\Theta_W (g_{\rho\sigma} g_{\mu\nu}) \quad (745)$$

$$+ -ig_2^2 \cos \Theta'_W \sin 2\Theta_W (g_{\rho\mu} g_{\sigma\nu}) \quad (746)$$

$$+ \frac{i}{2} g_2^2 \cos \Theta'_W \sin 2\Theta_W (g_{\rho\nu} g_{\sigma\mu}) \quad (747)$$

$$-\frac{i}{2}g_2^2 \sin 2\Theta_W \sin \Theta'_W \left(g_{\rho\sigma}g_{\mu\nu}\right) \quad (748)$$

$$+ ig_2^2 \sin 2\Theta_W \sin \Theta'_W \left(g_{\rho\mu}g_{\sigma\nu}\right) \quad (749)$$

$$+ -\frac{i}{2}g_2^2 \sin 2\Theta_W \sin \Theta'_W \left(g_{\rho\nu}g_{\sigma\mu}\right) \quad (750)$$

$$2ig_2^2 \left(g_{\rho\sigma}g_{\mu\nu}\right) \quad (751)$$

$$+ -ig_2^2 \left(g_{\rho\mu}g_{\sigma\nu}\right) \quad (752)$$

$$+ -ig_2^2 \left(g_{\rho\nu}g_{\sigma\mu}\right) \quad (753)$$

$$- 2ig_2^2 \cos \Theta_W^2 \cos \Theta_W'^2 \left(g_{\rho\sigma} g_{\mu\nu} \right) \quad (754)$$

$$+ ig_2^2 \cos \Theta_W^2 \cos \Theta_W'^2 \left(g_{\rho\mu} g_{\sigma\nu} \right) \quad (755)$$

$$+ ig_2^2 \cos \Theta_W^2 \cos \Theta_W'^2 \left(g_{\rho\nu} g_{\sigma\mu} \right) \quad (756)$$

$$ig_2^2 \cos \Theta_W^2 \sin 2\Theta'_W \left(g_{\rho\sigma} g_{\mu\nu} \right) \quad (757)$$

$$+ -\frac{i}{2} g_2^2 \cos \Theta_W^2 \sin 2\Theta'_W \left(g_{\rho\mu} g_{\sigma\nu} \right) \quad (758)$$

$$+ -\frac{i}{2} g_2^2 \cos \Theta_W^2 \sin 2\Theta'_W \left(g_{\rho\nu} g_{\sigma\mu} \right) \quad (759)$$

$$- 2ig_2^2 \cos \Theta_W^2 \sin \Theta_W'^2 \left(g_{\rho\sigma} g_{\mu\nu} \right) \quad (760)$$

$$+ ig_2^2 \cos \Theta_W^2 \sin \Theta_W'^2 \left(g_{\rho\mu} g_{\sigma\nu} \right) \quad (761)$$

$$+ ig_2^2 \cos \Theta_W^2 \sin \Theta_W'^2 \left(g_{\rho\nu} g_{\sigma\mu} \right) \quad (762)$$

9.10 Two Ghosts-One Vector Boson-Interaction

$$g_3 f_{\alpha,\beta,\gamma} \left(p_\mu^{\eta_\beta^G} \right) \quad (763)$$

$$i g_2 \sin \Theta_W \left(p_\mu^{\eta^\gamma} \right) \quad (764)$$

$$- i g_2 \sin \Theta_W \left(p_\mu^{\eta^\gamma} \right) \quad (765)$$

$$-ig_2 \sin \Theta_W \left(p_\mu^{\eta^-} \right) \quad (766)$$

$$-ig_2 \cos \Theta_W \cos \Theta'_W \left(p_\mu^{\eta^-} \right) \quad (767)$$

$$ig_2 \cos \Theta_W \sin \Theta'_W \left(p_\mu^{\eta^-} \right) \quad (768)$$

$$ig_2 \sin \Theta_W \left(p_\mu^{\eta^-} \right) \quad (769)$$

$$ig_2 \cos \Theta_W \cos \Theta'_W \left(p_\mu^{\eta^-} \right) \quad (770)$$

$$- ig_2 \cos \Theta_W \sin \Theta'_W \left(p_\mu^{\eta^-} \right) \quad (771)$$

$$ig_2 \sin \Theta_W \left(p_\mu^{\eta^+} \right) \tag{772}$$

$$-ig_2 \sin \Theta_W \left(p_\mu^{\eta^+} \right) \tag{773}$$

$$-ig_2 \cos \Theta_W \cos \Theta'_W \left(p_\mu^{\eta^+} \right) \tag{774}$$

$$ig_2 \cos \Theta_W \sin \Theta'_W \left(p_\mu^{\eta^+} \right) \quad (775)$$

$$ig_2 \cos \Theta_W \cos \Theta'_W \left(p_\mu^{\eta^+} \right) \quad (776)$$

$$-ig_2 \cos \Theta_W \sin \Theta'_W \left(p_\mu^{\eta^+} \right) \quad (777)$$

$$ig_2 \cos \Theta_W \cos \Theta'_W \left(p_\mu^{\eta^Z} \right) \quad (778)$$

$$-ig_2 \cos \Theta_W \cos \Theta'_W \left(p_\mu^{\eta^Z} \right) \quad (779)$$

$$-ig_2 \cos \Theta_W \sin \Theta'_W \left(p_\mu^{\eta^{Z'}} \right) \quad (780)$$

$$ig_2 \cos \Theta_W \sin \Theta'_W \left(p_\mu^{\eta^{Z'}} \right) \quad (781)$$

9.11 Two Ghosts-One Scalar-Interaction

$$\frac{1}{4} g_2^2 \xi_{W^-} \left(v_1 U_{A,k1} - v_2 U_{A,k2} \right) \quad (782)$$

$$- \frac{1}{4} g_2^2 \xi_{W^-} \left(v_1 U_{A,k1} - v_2 U_{A,k2} \right) \quad (783)$$

$$\frac{i}{4}g_2\left(v_1U_{+,k1}^*-v_2U_{+,k2}^*\right)\xi_{W-}\left(g_1\cos\Theta_W+g_2\sin\Theta_W\right) \quad (784)$$

$$\frac{i}{4}g_2\xi_{W-}\left(g_1\cos\Theta_W+g_2\sin\Theta_W\right)\left(v_1U_{+,k1}-v_2U_{+,k2}\right) \quad (785)$$

$$-\frac{i}{4}g_2^2\left(v_1U_{H,k1}^*+v_2U_{H,k2}^*\right)\xi_{W-} \quad (786)$$

$$\begin{aligned}
& \frac{i}{4} g_2 \xi_Z \left(-v_1 \left(-6g'_1 \sin \Theta'_W + g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right) U_{+,k1} \right. \\
& \left. + v_2 \left(4g'_1 \sin \Theta'_W + g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right) U_{+,k2} \right)
\end{aligned} \tag{787}$$

$$\begin{aligned}
& \frac{i}{4} g_2 \xi_{Z'} \left(v_1 \left(6g'_1 \cos \Theta'_W + \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) U_{+,k1} \right. \\
& \left. + v_2 \left(4g'_1 \cos \Theta'_W - \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) U_{+,k2} \right)
\end{aligned} \tag{788}$$

$$-\frac{i}{4} g_2^2 \left(v_1 U_{H,k1}^* + v_2 U_{H,k2}^* \right) \xi_{W^-} \tag{789}$$

$$\begin{aligned}
& \frac{i}{4} g_2 \xi_Z \left(-v_1 U_{+,k1}^* \left(-6g_1' \sin \Theta'_W + g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right) \right. \\
& \left. + v_2 U_{+,k2}^* \left(4g_1' \sin \Theta'_W + g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right) \right)
\end{aligned} \tag{790}$$

$$\begin{aligned}
& \frac{i}{4} g_2 \xi_{Z'} \left(v_2 U_{+,k2}^* \left(4g_1' \cos \Theta'_W - \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) \right. \\
& \left. + v_1 U_{+,k1}^* \left(6g_1' \cos \Theta'_W + \left(g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) \right)
\end{aligned} \tag{791}$$

$$-\frac{i}{4} \xi_Z \left(4g_1'^2 Q_S^2 \left(v s b U_{H,k4}^* + v_s U_{H,k3}^* \right) \sin \Theta'^2_W \right)$$

$$\begin{aligned}
& + v_1 U_{H,k1}^* \left(-6g_1' \sin \Theta'_W + g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right)^2 \\
& + v_2 U_{H,k2}^* \left(4g_1' \sin \Theta'_W + g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right)^2
\end{aligned} \tag{792}$$

$$\begin{aligned}
& \frac{i}{4} \xi_{Z'} \left(v_1 U_{H,k1}^* \left(6g_1 g_1' \cos \Theta'^2_W \sin \Theta_W + g_2^2 \cos \Theta_W^2 \cos \Theta'_W \sin \Theta'_W \right. \right. \\
& + \cos \Theta'_W \left(-36g_1'^2 + g_1^2 \sin \Theta_W^2 \right) \sin \Theta'_W - 6g_1 g_1' \sin \Theta_W \sin \Theta'^2_W \\
& + 2g_2 \cos \Theta_W \left(3g_1' \cos \Theta'^2_W - 3g_1' \sin \Theta'^2_W + g_1 \cos \Theta'_W \sin \Theta_W \sin \Theta'_W \right) \Big) \\
& - 2g_1'^2 Q_S^2 \left(v_{sb} U_{H,k4}^* + v_s U_{H,k3}^* \right) \sin 2\Theta'_W \\
& + v_2 U_{H,k2}^* \left(-4g_1 g_1' \cos \Theta'^2_W \sin \Theta_W + g_2^2 \cos \Theta_W^2 \cos \Theta'_W \sin \Theta'_W \right. \\
& + g_1^2 \cos \Theta'_W \sin \Theta_W^2 \sin \Theta'_W \\
& + 2g_2 \cos \Theta_W \left(-2g_1' \cos \Theta'^2_W + 2g_1' \sin \Theta'^2_W + g_1 \cos \Theta'_W \sin \Theta_W \sin \Theta'_W \right) \\
& \left. \left. + 4g_1' \left(-2g_1' \sin 2\Theta'_W + g_1 \sin \Theta_W \sin \Theta'^2_W \right) \right) \right)
\end{aligned} \tag{793}$$

$$\begin{aligned}
& \frac{i}{4} g_2 \xi_{W-} \left(v_2 U_{+,k2}^* \left(4g_1' \sin \Theta'_W + g_1 \cos \Theta'_W \sin \Theta_W - g_2 \cos \Theta_W \cos \Theta'_W \right) \right. \\
& \left. + v_1 U_{+,k1}^* \left(6g_1' \sin \Theta'_W - g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right) \right)
\end{aligned} \tag{794}$$

$$\begin{aligned}
& \frac{i}{4} g_2 \xi_{W-} \left(v_1 \left(6g'_1 \sin \Theta'_W - g_1 \cos \Theta'_W \sin \Theta_W + g_2 \cos \Theta_W \cos \Theta'_W \right) U_{+,k1} \right. \\
& \left. + v_2 \left(4g'_1 \sin \Theta'_W + g_1 \cos \Theta'_W \sin \Theta_W - g_2 \cos \Theta_W \cos \Theta'_W \right) U_{+,k2} \right)
\end{aligned} \tag{795}$$

$$\begin{aligned}
& \frac{i}{4} \xi_Z \left(v_1 U_{H,k1}^* \left(6g_1 g'_1 \cos \Theta'^2_W \sin \Theta_W + g_2^2 \cos \Theta_W^2 \cos \Theta'_W \sin \Theta'_W \right. \right. \\
& + \cos \Theta'_W \left(-36g_1^2 + g_1^2 \sin \Theta_W^2 \right) \sin \Theta'_W - 6g_1 g'_1 \sin \Theta_W \sin \Theta'^2_W \\
& + 2g_2 \cos \Theta_W \left(3g'_1 \cos \Theta'^2_W - 3g'_1 \sin \Theta'^2_W + g_1 \cos \Theta'_W \sin \Theta_W \sin \Theta'_W \right) \Big) \\
& - 2g_1^2 Q_S^2 \left(v_{sb} U_{H,k4}^* + v_s U_{H,k3}^* \right) \sin 2\Theta'_W \\
& + v_2 U_{H,k2}^* \left(-4g_1 g'_1 \cos \Theta'^2_W \sin \Theta_W + g_2^2 \cos \Theta_W^2 \cos \Theta'_W \sin \Theta'_W \right. \\
& + g_1^2 \cos \Theta'_W \sin \Theta_W^2 \sin \Theta'_W \\
& + 2g_2 \cos \Theta_W \left(-2g'_1 \cos \Theta'^2_W + 2g'_1 \sin \Theta'^2_W + g_1 \cos \Theta'_W \sin \Theta_W \sin \Theta'_W \right) \\
& \left. \left. + 4g'_1 \left(-2g'_1 \sin 2\Theta'_W + g_1 \sin \Theta_W \sin \Theta'^2_W \right) \right) \right)
\end{aligned} \tag{796}$$

$$\begin{aligned}
& -\frac{i}{4}\xi_{Z'}\left(4g_1^2Q_S^2\left(vsbU_{H,k4}^*+v_sU_{H,k3}^*\right)\cos\Theta_W'^2\right. \\
& +v_2U_{H,k2}^*\left(-4g_1'\cos\Theta_W'+\left(g_1\sin\Theta_W+g_2\cos\Theta_W\right)\sin\Theta_W'\right)^2 \\
& \left.+v_1U_{H,k1}^*\left(6g_1'\cos\Theta_W'+\left(g_1\sin\Theta_W+g_2\cos\Theta_W\right)\sin\Theta_W'\right)^2\right)
\end{aligned} \tag{797}$$

$$\begin{aligned}
& \frac{i}{4}g_2\xi_{W-}\left(v_2U_{+,k2}^*\left(4g_1'\cos\Theta_W'+\left(-g_1\sin\Theta_W+g_2\cos\Theta_W\right)\sin\Theta_W'\right)\right. \\
& \left.+v_1U_{+,k1}^*\left(6g_1'\cos\Theta_W'+\left(g_1\sin\Theta_W-g_2\cos\Theta_W\right)\sin\Theta_W'\right)\right)
\end{aligned} \tag{798}$$

$$\begin{aligned}
& \frac{i}{4} g_2 \xi_{W-} \left(v_1 \left(6g'_1 \cos \Theta'_W + \left(g_1 \sin \Theta_W - g_2 \cos \Theta_W \right) \sin \Theta'_W \right) U_{+,k1} \right. \\
& \left. + v_2 \left(4g'_1 \cos \Theta'_W + \left(-g_1 \sin \Theta_W + g_2 \cos \Theta_W \right) \sin \Theta'_W \right) U_{+,k2} \right)
\end{aligned} \tag{799}$$

10 Clebsch-Gordan Coefficients