Further we have let each coupling constant be re-scaled by $g \to -2g$ so that they coincide with our choices in the SM — hence

$$F^i_{\mu\nu} = \partial_\mu A^i_\nu - \partial_\nu A^i_\mu + g_2 \epsilon_{ijk} A^j_\mu A^k_\nu$$

$$B_{\mu\nu} = \partial_\mu B_\nu - \partial_\nu B_\mu$$

$$G^m_{\mu\nu} = \partial_\mu G^m_\nu - \partial_\nu G^m_\mu + g_3 f_{mnp} G^n_\mu G^p_\nu$$

and similarly in the covariant derivatives.

Next consider the form of the gauged Kähler potential action term. In general it has the form

$$\Gamma_{SK} = \frac{1}{16}\int dV \, K_S \quad \text{with}$$

$$K_S = Z_k(\theta,\bar\theta)\, \bar\Phi\, e^{g V \cdot T}\, \Phi$$

where recall that Φ is in a particular representation of the gauge group

$$\phi'_a = \left(e^{ig\Lambda^i T^i}\right)_{ab}\phi_b$$
$$\bar{\phi}'_a = \bar{\phi}_b\left(e^{-ig\bar{\Lambda}^i T^i}\right)_{ba}$$

with chiral gauge parameters $D_\alpha \bar{\Lambda}^i = 0$ & $\bar{D}_{\dot\alpha}\Lambda^i = 0$. The gauge field recall transforms as

$$e^{gV'^i T^i} = e^{ig\bar{\Lambda}\cdot T} e^{gV\cdot T} e^{-ig\Lambda\cdot T}$$

So that

$$K = K(\bar{\phi}\, e^{gV\cdot T}\phi) = \bar{\phi}_a\left(e^{gV^i T^i}\right)_{ab}\phi_b$$

is gauge invariant $K' = K$.

Once again we can transform to the W-Z gauge so that

$$V^i = \theta\sigma^\mu\bar{\theta}A^i_\mu + \frac{1}{2}\bar{\theta}^2\theta^\alpha\lambda^i_\alpha + \frac{1}{2}\theta^2\bar{\theta}_{\dot\alpha}\bar{\lambda}^{i\dot\alpha}$$
$$+\frac{1}{4}\theta^2\bar{\theta}^2 D^i$$

with $A_\mu, \lambda, \bar{\lambda}, D$ in the W-Z gauge as is the matter field ϕ_a

i.e. $\phi'_a = (e^{ig\Lambda_{WZ}\cdot T})_{ab}\phi_b \xrightarrow{\text{re-label}} \phi_a$, etc.

As before we are left with a residual "ordinary" gauge transformation after the W-Z gauge is chosen;

$$\phi'_a = (e^{ig\Lambda\cdot T})_{ab}\phi_b \quad \text{with } \Lambda^i = e^{-i\theta\gamma\bar\theta}\,\omega^i(x)$$

$$\bar\phi'_a = \bar\phi_b(e^{-ig\bar\Lambda\cdot T})_{ba} \quad \text{with } \bar\Lambda^i = e^{+i\theta\gamma\bar\theta}\,\omega^i(x)$$

i.e. $\omega^{i\dagger} = \omega^i$.

From the chiral & anti-chiral representation point of view, we have

$$\phi'_a = e^{-i\theta\gamma\bar\theta}(A'_a + \theta\psi'_a + \theta^2 F'_a)$$

$$= e^{-i\theta\gamma\bar\theta}(e^{ig\omega\cdot T})_{ab}(A_b + \theta\psi_b + \theta^2 F_b)$$

&

$$\bar\phi'_a = e^{+i\theta\gamma\bar\theta}(\bar A'_a + \bar\theta\bar\psi'_a + \bar\theta^2 \bar F'_a)$$

$$= e^{+i\theta\gamma\bar\theta}(\bar A_b + \bar\theta\bar\psi_b + \bar\theta^2\bar F_b)(e^{-ig\omega\cdot T})_{ba}$$

Once again we can expand $e^{gV\cdot T}$ in the W-Z gauge

$$e^{\pm gV\cdot T} = 1 \pm gV\cdot T + \frac{1}{2}g^2(V\cdot T)(V\cdot T)$$

$$= 1 \pm g\theta\sigma^\mu\bar{\theta}(A_\mu\cdot T) \pm \frac{g}{2}\theta^2\bar{\theta}_{\dot\alpha}(\bar{\lambda}^{\dot\alpha}\cdot T)$$

$$\pm \frac{g}{2}\bar{\theta}^2\theta^\alpha(\lambda_\alpha\cdot T)$$

$$\pm \frac{g}{4}\theta^2\bar{\theta}^2\left(D\cdot T \pm g(A_\mu\cdot T)(A^\mu\cdot T)\right)$$

Along with the matter fields

$$\bar{\Phi}_a\Phi_b = \left(e^{+i\theta\not{\partial}\bar{\theta}}(\bar{A}_a + \bar{\theta}\bar{\psi}_a + \bar{\theta}^2\bar{F}_a)\right)\left(e^{-i\theta\not{\partial}\bar{\theta}}(A_b + \theta\psi_b + \theta^2 F_b)\right)$$

$$= \Big[\bar{A}_a + \bar{\theta}\bar{\psi}_a + \bar{\theta}^2\bar{F}_a + i\theta\not{\partial}\bar{\theta}\bar{A}_a - \frac{i}{2}\bar{\theta}^2\theta\not{\partial}\bar{\psi}_a$$

$$- \frac{1}{4}\theta^2\bar{\theta}^2\partial^2\bar{A}_a\Big] \times \Big[A_b + \theta\psi_b + \theta^2 F_b - i\theta\not{\partial}\bar{\theta}A_b$$

$$+ \frac{i}{2}\theta^2\psi_b\overleftarrow{\not{\partial}}\bar{\theta} - \frac{1}{4}\theta^2\bar{\theta}^2\partial^2 A\Big]$$

Recall also that the soft SUSY breaking terms are included in the $\theta,\bar{\theta}$ dependent wave-function factor

$$Z_K(\theta,\bar{\theta}) = Z_K(1 - m_K\theta^2 - \bar{m}_K\bar{\theta}^2 - m^2\theta^2\bar{\theta}^2)$$

For the SUSY invariant matter kinetic energy terms we must integrate over the vector measure picking out the D-term from this big product, that is the $\theta^2\bar\theta^2$ term

$$\Gamma_{SK} = \frac{1}{16}\int dV\, K_S = \frac{1}{16}\int dV\, Z_K(\theta,\bar\theta)\, \bar\Phi_a (e^{gV\cdot T})_{ab}\, \Phi_b$$

Consider the soft-breaking terms first:

1) $-Z_K \quad m^2\theta^2\bar\theta^2\, \bar\Phi_a (e^{gV\cdot T})_{ab}\Phi_b = -Z_K m^2 \theta^2\bar\theta^2 A_a^\dagger A_a$

2) $-Z_K \quad m_K \theta^2\, \bar\Phi e^{gV\cdot T}\Phi = -Z_K m_K\, \theta^2 [\bar\theta^2 \bar F_a A_a]$

3) $-Z_K \quad \bar m_K \bar\theta^2\, \bar\Phi e^{gV\cdot T}\Phi = -Z_K \bar m_K\, \bar\theta^2 [\theta^2 \bar A_a F_a]$

Finally we are left with the SUSY gauge invariant kinetic energy terms

$$\left(\bar\Phi e^{gV\cdot T}\Phi\right)_D = \frac{g}{4}\theta^2\bar\theta^2 \bar A\left(D\cdot T + g(A_\mu\cdot T)(A^\mu\cdot T)\right)A$$

$$+\frac{g}{2}\bar A\,\bar\theta^2\theta^\alpha(\lambda_\alpha\cdot T)\theta\psi + \frac{g}{2}\bar\theta\bar\psi\,\theta^2\bar\theta_{\dot\alpha}(\bar\lambda^{\dot\alpha}\cdot T)A$$

$$+g\bar A\,\theta\sigma^\mu\bar\theta(A_\mu\cdot T)(-i\theta\not\partial\bar\theta A) + g\bar\theta\bar\psi\,\theta\sigma^\mu\bar\theta(A_\mu\cdot T)\theta\psi$$

$$+g\,i\theta\not\partial\bar\theta\bar A\,\theta\sigma^\mu\bar\theta(A_\mu\cdot T)A + \bar A_a\left(-\frac{1}{4}\theta^2\bar\theta^2\partial^2 A_a\right)$$

$$+\bar\theta\bar\psi_a \tfrac{i}{2}\theta^2\partial_\mu\psi_a\sigma^\mu\bar\theta + \bar\theta^2\bar F_a\theta^2 F_a$$

$$+i\theta\not{\partial}\bar\theta\bar A_a(-i\theta\not{\partial}\bar\theta A_a) - \tfrac{i}{2}\bar\theta^2\theta\not{\partial}\bar\psi_a\theta\psi_a$$

$$-\tfrac{1}{4}\theta^2\bar\theta^2\partial^2\bar A_a A_a \,.$$

As usual we must exploit the θ & σ^μ identities:

The last 6 terms which came from the 1 in $e^{gV\cdot T}$ we analyzed earlier see p. -283- to -285- to obtain

$$\theta^2\bar\theta^2\left[\bar F_a F_a + \tfrac{i}{4}\psi_a\overleftrightarrow{\not{\partial}}\bar\psi_a + \partial_\mu\bar A_a\partial^\mu A_a - \tfrac{1}{4}\partial^2(\bar A_a A_a)\right]$$

So we are left with the gauge coupling terms to analyze:

$$\tfrac{g}{2}\bar A\bar\theta^2\theta^\alpha(\lambda_\alpha\cdot T)\theta\psi = -\tfrac{g}{2}\bar A\bar\theta^2\theta^\alpha\theta^\beta(\lambda_\alpha\cdot T)\psi_\beta$$

$$= -\tfrac{g}{4}\theta^2\bar\theta^2\bar A(\lambda\cdot T)\psi$$

$$\tfrac{g}{2}\bar\theta\bar\psi\theta^2\bar\theta_{\dot\alpha}(\bar\lambda^{\dot\alpha}\cdot T)A = \tfrac{g}{2}\bar\theta_{\dot\beta}\bar\psi^{\dot\beta}\theta^2\bar\theta_{\dot\alpha}(\bar\lambda^{\dot\alpha}\cdot T)A$$

$$= -\tfrac{g}{2}\theta^2\bar\theta^{\dot\beta}\bar\theta^{\dot\alpha}\bar\psi_{\dot\beta}(\bar\lambda_{\dot\alpha}\cdot T)A$$

$$= -\tfrac{g}{4}\theta^2\bar\theta^2\bar\psi(\bar\lambda\cdot T)A$$

✓ $g\bar{A}\,\theta\sigma^\mu\bar{\theta}(A_\mu\cdot T)(-i\theta\not\partial\bar{\theta}A)$

$= -ig\bar{A}\,\theta^\alpha\bar{\theta}^{\dot\alpha}(\sigma^\mu_{\alpha\dot\alpha}A_\mu\cdot T)\theta^\beta\bar{\theta}^{\dot\beta}\not\partial_{\beta\dot\beta}A$

$= -\frac{ig}{4}\theta^2\bar{\theta}^2\bar{A}(\sigma^\mu_{\alpha\dot\alpha}A_\mu\cdot T)\not\partial^{\dot\alpha\alpha}A$

$= -\frac{ig}{2}\theta^2\bar{\theta}^2\bar{A}(A_\mu\cdot T)\partial^\mu A$

$\left(\mathrm{Tr}\{\sigma^\mu\bar{\sigma}^\nu\} = 2\eta^{\mu\nu}\right)$

✓ $g\,i\theta\not\partial\bar{\theta}\bar{A}\,\theta\sigma^\mu\bar{\theta}(A_\mu\cdot T)A$

$= ig\,\theta^\alpha\bar{\theta}^{\dot\alpha}\not\partial_{\alpha\dot\alpha}\bar{A}\,\theta^\beta\bar{\theta}^{\dot\beta}(\sigma^\mu_{\beta\dot\beta}A_\mu\cdot T)A$

$= \frac{ig}{4}\theta^2\bar{\theta}^2\not\partial_{\alpha\dot\alpha}\bar{A}\,\bar{\sigma}^{\mu\dot\alpha\alpha}(A_\mu\cdot T)A$

$= \frac{ig}{2}\theta^2\bar{\theta}^2\partial^\mu\bar{A}(A_\mu\cdot T)A$

✓ $g\bar{\theta}\bar{\psi}\,\theta\sigma^\mu\bar{\theta}(A_\mu\cdot T)\theta\psi$

$= -g\,\bar{\theta}^{\dot\alpha}\bar{\psi}_{\dot\alpha}\,\theta^\beta\sigma^\mu_{\beta\dot\beta}\bar{\theta}^{\dot\beta}(A_\mu\cdot T)\theta^\alpha\psi_\alpha$

$= -\frac{g}{4}\theta^2\bar{\theta}^2\bar{\psi}_{\dot\alpha}\bar{\sigma}^{\mu\dot\alpha\alpha}(A_\mu\cdot T)\psi_\alpha = +\frac{g}{4}\theta^2\bar{\theta}^2\psi\sigma^\mu(A_\mu\cdot T^T)\bar{\psi}$

T^T

$= T^*$

So bringing this altogether we find

$$\left(\bar{\phi}\, e^{gV\cdot T}\phi\right)_D = \theta^2\bar{\theta}^2\Big[\bar{F}_a F_a + \frac{g}{4}\bar{A}T^i A D^i$$
$$- \frac{1}{4}\partial^2(\bar{A}_a A_a)$$
$$+ \frac{i}{4}\bar{\psi}\bar{\sigma}^\mu\left[\partial_\mu\psi + \frac{ig}{2}(A_\mu\cdot T)\psi\right]$$
$$- \frac{i}{4}\left[\partial_\mu\bar{\psi} - \frac{ig}{2}\bar{\psi}(A_\mu\cdot T)\right]\bar{\sigma}^\mu\psi$$
$$+ \left[\partial_\mu\bar{A} - \frac{ig}{2}\bar{A}(A_\mu\cdot T)\right]\left[\partial^\mu A + \frac{ig}{2}(A^\mu\cdot T)A\right]$$
$$- \frac{g}{4}\left(\bar{A}(\lambda\cdot T)\psi + \bar{\psi}(\bar{\lambda}\cdot T)A\right)\Big]$$

Hence we find

$$\Gamma_{SK} = \frac{1}{16}\int dV\, K_S = \frac{1}{16}\int dV\, Z_K(\theta,\bar{\theta})\,\bar{\phi}\, e^{gV\cdot T}\phi$$
$$= \int d^4x\, \mathcal{L}_{SK} = \int d^4x\left(\mathcal{L}_K + \mathcal{L}_{\$K}\right)$$

where

$$\mathcal{L}_{\$K} = -m^2 A_a^\dagger A_a - m_K F_a A_a$$
$$- \bar{m}_K A_a^\dagger F_a$$

while the SUSY invariant Lagrangian is

$$\boxed{\begin{aligned}\mathcal{L}_K = F_a^\dagger F_a - g\left(A_a^\dagger T^i_{ab} A_b\right) D^i \\ + \frac{i}{2}\bar{\psi}\bar{\sigma}^\mu \overleftrightarrow{D}_\mu \psi + (D_\mu A)^\dagger D^\mu A \\ + g\sqrt{2}\left(A^\dagger(\lambda\cdot T)\psi + \bar{\psi}(\bar{\lambda}\cdot T)A\right)\end{aligned}}$$

where once again we have chosen $Z_K = 1$ and re-scaled $g \to -2g$ and

$$\psi \to \sqrt{2}\,\psi \qquad D \to \sqrt{4}\,D$$
$$\bar{\psi} \to \sqrt{2}\,\bar{\psi} \qquad \lambda \to \sqrt{4}\,\lambda$$
$$\bar{\lambda} \to \sqrt{4}\,\bar{\lambda}$$

Thus we see that the Kähler action results in the usual gauge coupling of the matter & smatter fields with the additional gaugino "Yukawa" type coupling to the matter-smatter pair. Finally it includes the auxiliary F-field quadratic as well as the D-field coupling to the scalar field bi-linear $A^\dagger T^i A$.

The covariant derivatives are given by

$D_\mu^{ab} A_b = \Big)\ D_\mu A_a = \partial_\mu A_a - ig(A_\mu \cdot T)_{ab} A_b$

$(D_\mu A_a)^\dagger = \partial_\mu A_a^\dagger + ig A_b^\dagger (A_\mu \cdot T)_{ba}$

$D_\mu \psi_a = \partial_\mu \psi_a - ig(A_\mu \cdot T)_{ab} \psi_b$

$D_\mu \bar{\psi}_a = \partial_\mu \bar{\psi}_a + ig \bar{\psi}_b (A_\mu \cdot T)_{ba}$

Note: Since $T^{i\dagger} = T^i \Leftrightarrow T^{iT} = T^{i*}$

$D_\mu \bar{\psi}_a = \partial_\mu \bar{\psi}_a + ig(A_\mu \cdot T^*)_{ab} \bar{\psi}_b$ as well.

That is $\bar{\psi} \bar{\sigma}^\mu (A_\mu \cdot T) \psi = -\psi (A_\mu \cdot T^T) \sigma^\mu \bar{\psi}$

$= -\psi (A_\mu \cdot T^*) \sigma^\mu \bar{\psi}$

So $\frac{i}{2} \bar{\psi} \bar{\sigma}^\mu [\partial_\mu - ig(A_\mu \cdot T)] \psi$

$= -\frac{i}{2} [\partial_\mu \psi - ig \psi (A_\mu \cdot T^*)] \sigma^\mu \bar{\psi}$

ξ

$-\frac{i}{2} [\partial_\mu \bar{\psi} + ig \bar{\psi} (A_\mu \cdot T)] \bar{\sigma}^\mu \psi$

$= +\frac{i}{2} \psi \sigma^\mu [\partial_\mu \bar{\psi} + ig(A_\mu \cdot T^*) \bar{\psi}]$

Hence

$$\frac{i}{2}\bar{\psi}\bar{\sigma}^\mu \overleftrightarrow{D}_\mu \psi = +\frac{i}{2}\psi\sigma^\mu \overleftrightarrow{D}^*_\mu \bar{\psi}$$

where

$$D^*_\mu \psi = \partial_\mu \psi - ig\psi(A_\mu\cdot T)^*$$

$$D^*_\mu \bar{\psi} = \partial_\mu \bar{\psi} + ig(A_\mu\cdot T^*)\bar{\psi}$$

Or we can write the kinetic terms as

$$\frac{i}{2}\bar{\psi}\bar{\sigma}^\mu[\partial_\mu\psi - ig(A_\mu\cdot T)\psi]$$

$$-\frac{i}{2}[\partial_\mu\bar{\psi} + ig\bar{\psi}(A_\mu\cdot T)]\bar{\sigma}^\mu\psi$$

$$= \frac{i}{2}\bar{\psi}\bar{\sigma}^\mu[\partial_\mu\psi - ig(A_\mu\cdot T)\psi]$$

$$+\frac{i}{2}\psi\sigma^\mu[\partial_\mu\bar{\psi} - ig(A_\mu\cdot(-T^*))\bar{\psi}]$$

---

we see that if ψ is a representation d then $\bar{\psi}$ is representation d^* transforming with $-T^*$ instead of T.

Since $[-T^{i*}, -T^{j*}] = [T^{iT}, T^{jT}]$

$$= [T^j, T^i]^T = if_{jik}T^{kT}$$

$$= -if_{ijk}T^{kT} = if_{ijk}(-T^{k*})$$

any rep. $\underset{(d)}{T^i}$ then also $\underset{(d^*)}{(-T^{i*})}$ is a rep.

Hence we can list the Kähler terms for the MSSM using this general result. First recall all the matter superfields:

Superfield	SM field	spartner	(3,2,1)
$L_m = \begin{pmatrix} \nu_m \\ e_m \end{pmatrix}$	$l_{mL} = \begin{pmatrix} \nu_{mL} \\ e_{mL} \end{pmatrix}$	$\tilde{l}_m = \begin{pmatrix} \tilde{\nu}_m \\ \tilde{e}_m \end{pmatrix}$	$(1, 2, -\frac{1}{2})$
$Q^a_m = \begin{pmatrix} u^a_m \\ d^a_m \end{pmatrix}$	$q^a_{mL} = \begin{pmatrix} u^a_{mL} \\ d^a_{mL} \end{pmatrix}$	$\tilde{q}^a_m = \begin{pmatrix} \tilde{u}^a_m \\ \tilde{d}^a_m \end{pmatrix}$	$(3, 2, +\frac{1}{6})$
E^c_m	$e^c_{mL} = e^+_{mL}$	$\tilde{e}^c_m$	$(1, 1, +1)$
U^{ca}_m	u^{ca}_{mL}	$\tilde{u}^{ca}_m$	$(\bar{3}, 1, -\frac{2}{3})$
D^{ca}_m	d^{ca}_{mL}	$\tilde{d}^{ca}_m$	$(\bar{3}, 1, +\frac{1}{3})$
H_u	$H_u = \begin{pmatrix} H^+_u \\ H^0_u \end{pmatrix}$	$\tilde{H}_u$	$(1, 2, +\frac{1}{2})$
H_d	$H_d = \begin{pmatrix} H^0_d \\ H^-_d \end{pmatrix}$	$\tilde{H}_d$	$(1, 2, -\frac{1}{2})$

(Recall: $\Psi_D = \begin{pmatrix} \eta \\ \bar{\chi} \end{pmatrix}$; $\Psi_L = \begin{pmatrix} \eta \\ 0 \end{pmatrix}$; $\Psi_R = \begin{pmatrix} 0 \\ \bar{\chi} \end{pmatrix}$)
(also $Q = T_3 + Y$)

Let the "left" fields be Weyl: $\nu_L = \nu$, $e_L = e$ etc.
Surpress L everywhere

So we see that the Kähler terms will be quite lengthy; in order to simplify integrate by parts so that the fermion KE becomes

$$\frac{i}{2}\bar{\psi}\bar{\sigma}^\mu \overleftrightarrow{D}_\mu \psi \longrightarrow i\bar{\psi}\bar{\sigma}^\mu D_\mu \psi$$

with $D_\mu \psi = \partial_\mu \psi - ig(A_\mu \cdot T)\psi$

So we find for the MSSM

$$\begin{aligned}
\mathcal{L}_K = & \bar{F}_{\nu m} F_{\nu m} + \bar{F}_{em} F_{em} + \bar{F}^a_{um} F^a_{um} + \bar{F}^a_{dm} F^a_{dm} \\
& + \bar{F}_{e^c_m} F_{e^c_m} + \bar{F}^a_{u^c_m} F^a_{u^c_m} + \bar{F}^a_{d^c_m} F^a_{d^c_m} \\
& + \bar{F}^+_u F^+_u + \bar{F}^0_u F^0_u + \bar{F}^0_d F^0_d + \bar{F}^-_d F^-_d \\
& - g_1 D_1 \Big[-\tfrac{1}{2} \tilde{\nu}^\dagger_m \tilde{\nu}_m - \tfrac{1}{2} \tilde{e}^\dagger_m \tilde{e}_m + \tfrac{1}{6} \tilde{u}^{a\dagger}_m \tilde{u}^a_m \\
& \quad + \tfrac{1}{6} \tilde{d}^{a\dagger}_m \tilde{d}^a_m + \tilde{e}^{c\dagger}_m \tilde{e}^c_m - \tfrac{2}{3} \tilde{u}^{ca\dagger}_m \tilde{u}^{ca}_m \\
& \quad + \tfrac{1}{3} \tilde{d}^{ca\dagger}_m \tilde{d}^{ca}_m + \tfrac{1}{2} H^\dagger_u H_u - \tfrac{1}{2} H^\dagger_d H_d \Big] \\
& - g_2 D^i_2 \Big[\tilde{l}^\dagger_m \frac{\sigma^i}{2} \tilde{l}_m + \tilde{q}^{a\dagger}_m \frac{\sigma^i}{2} \tilde{q}^a_m \\
& \quad + H^\dagger_u \frac{\sigma^i}{2} H_u + H^\dagger_d \frac{\sigma^i}{2} H_d \Big]
\end{aligned}$$

(let F=1,2,3 family index instead of "m" if confusion)

$$- g_3 D_3^m \Big[\tilde{q}_F^\dagger \frac{\lambda^m}{2} \tilde{q}_F - \tilde{u}_F^{c\dagger} \frac{\lambda^m}{2} \tilde{u}_F^c - \tilde{d}_F^{c\dagger} \frac{\lambda^m}{2} \tilde{d}_F^c \Big]$$

$$+\sqrt{2} g_1 \Big[-\tfrac{1}{2} \tilde{l}_F^\dagger \tilde{B} l_F + \tfrac{1}{6} \tilde{q}_F^{\dagger a} \tilde{B} q_F^a - \tfrac{1}{2} \bar{l}_F \bar{\tilde{B}} \tilde{l}_F + \tfrac{1}{6} \bar{q}_F^a \bar{\tilde{B}} \tilde{q}_F^a$$
$$+ \tilde{e}_m^{c\dagger} \tilde{B} e_m^c + \bar{e}_m^c \bar{\tilde{B}} \tilde{e}_m^c$$
$$- \tfrac{2}{3} \tilde{u}_F^{ca\dagger} \tilde{B} u_F^{ca} - \tfrac{2}{3} \bar{u}_F^{ca} \bar{\tilde{B}} \tilde{u}_F^{ca}$$
$$+ \tfrac{1}{3} \tilde{d}_F^{ca\dagger} \tilde{B} d_F^{ca} + \tfrac{1}{3} \bar{d}_F^{ca} \bar{\tilde{B}} \tilde{d}_F^{ca}$$
$$+ \tfrac{1}{2} H_u^\dagger \tilde{B} \tilde{H}_u + \tfrac{1}{2} \bar{\tilde{H}}_u \bar{\tilde{B}} H_u$$
$$- \tfrac{1}{2} H_d^\dagger \tilde{B} \tilde{H}_d - \tfrac{1}{2} \bar{\tilde{H}}_d \bar{\tilde{B}} H_d \Big]$$

$$+\sqrt{2} g_2 \Big[\tilde{l}_F^\dagger \left(\tilde{A}^i \frac{\sigma^i}{2}\right) l_F + \bar{l}_F \left(\bar{\tilde{A}}^i \frac{\sigma^i}{2}\right) \tilde{l}_F$$
$$+ \tilde{q}_F^{a\dagger} \left(\tilde{A}^i \frac{\sigma^i}{2}\right) q_F^a + \bar{q}_F^a \left(\bar{\tilde{A}}^i \frac{\sigma^i}{2}\right) \tilde{q}_F^a$$
$$+ H_u^\dagger \left(\tilde{A}^i \frac{\sigma^i}{2}\right) \tilde{H}_u + \bar{\tilde{H}}_u \left(\bar{\tilde{A}}^i \frac{\sigma^i}{2}\right) H_u$$
$$+ H_d^\dagger \left(\tilde{A}^i \frac{\sigma^i}{2}\right) \tilde{H}_d + \bar{\tilde{H}}_d \left(\bar{\tilde{A}}^i \frac{\sigma^i}{2}\right) H_d \Big]$$

$$+\sqrt{2}\,g_3\Big[\tilde{q}_F^{\dagger}\Big(\tilde{G}^m\frac{\lambda^m}{2}\Big)q_F + \bar{q}_F\Big(\tilde{\bar{G}}^m\frac{\lambda^m}{2}\Big)\tilde{q}_F$$

$$-\tilde{u}^{c\,\dagger}_F\Big(\tilde{G}^m\frac{\lambda^m}{2}\Big)u^c_F - \bar{u}^c_F\Big(\tilde{\bar{G}}^m\frac{\lambda^m}{2}\Big)\tilde{u}^c_F$$

$$-\tilde{d}^{c\,\dagger}_F\Big(\tilde{G}^m\frac{\lambda^m}{2}\Big)d^c_F - \bar{d}^c_F\Big(\tilde{\bar{G}}^m\frac{\lambda^m}{2}\Big)\tilde{d}^c_F\Big]$$

$$+i\bar{l}_F\bar{\sigma}^\mu D_\mu l_F + i\bar{q}_F\bar{\sigma}^\mu D_\mu q_F$$

$$+i\,\bar{e}^c_F\bar{\sigma}^\mu D_\mu e^c_F + i\,\bar{u}^c_F\bar{\sigma}^\mu D_\mu u^c_F$$

$$+i\,\bar{d}^c_F\bar{\sigma}^\mu D_\mu d^c_F + i\,\bar{\tilde{H}}_u\bar{\sigma}^\mu D_\mu \tilde{H}_u$$

$$+i\,\bar{\tilde{H}}_d\bar{\sigma}^\mu D_\mu \tilde{H}_d$$

$$+(D_\mu\tilde{l}_F)^\dagger(D^\mu\tilde{l}_F) + (D_\mu\tilde{q}_F)^\dagger(D^\mu\tilde{q}_F)$$

$$+(D_\mu\tilde{e}^c_F)^\dagger(D^\mu\tilde{e}^c_F) + (D_\mu\tilde{u}^c_F)^\dagger(D^\mu\tilde{u}^c_F)$$

$$+(D_\mu\tilde{d}^c_F)^\dagger(D^\mu\tilde{d}^c_F) + (D_\mu H_u)^\dagger(D^\mu H_u)$$

$$+(D_\mu H_d)^\dagger(D^\mu H_d)$$

where the covariant derivatives are given by

$$D_\mu l_F = \left[\partial_\mu - \frac{ig_2}{2}\vec{\sigma}\cdot\vec{A}_\mu + \frac{ig_1}{2}B_\mu\right] l_F$$

$$D_\mu \tilde{l}_F = \left[\partial_\mu - \frac{ig_2}{2}\vec{\sigma}\cdot\vec{A}_\mu + \frac{ig_1}{2}B_\mu\right] \tilde{l}_F$$

$$D_\mu^{ab} q_F^b = \left[\left(\partial_\mu - \frac{ig_2}{2}\vec{\sigma}\cdot\vec{A}_\mu - \frac{ig_1}{6}B_\mu\right)\delta^{ab} - \frac{ig_3}{2}\left(\vec{\lambda}\cdot\vec{G}_\mu\right)_{ab}\right] q_F^b$$

$$D_\mu^{ab} \tilde{q}_F^b = \left[\left(\partial_\mu - \frac{ig_2}{2}\vec{\sigma}\cdot\vec{A}_\mu - \frac{ig_1}{6}B_\mu\right)\delta^{ab} - \frac{ig_3}{2}\left(\vec{\lambda}\cdot\vec{G}_\mu\right)_{ab}\right] \tilde{q}_F^b$$

$$D_\mu e_F^c = \left(\partial_\mu - ig_1 B_\mu\right) e_F^c$$

$$D_\mu^{ab} u_F^{cb} = \left[\left(\partial_\mu + \frac{2i}{3}g_1 B_\mu\right)\delta^{ab} + \frac{ig_3}{2}\left(\vec{\lambda}\cdot\vec{G}_\mu\right)^{*}_{ab}\right] u_F^{cb}$$

$$D_\mu^{ab} d_F^{cb} = \left[\left(\partial_\mu - \frac{i}{3}g_1 B_\mu\right)\delta^{ab} + \frac{ig_3}{2}\left(\vec{\lambda}\cdot\vec{G}_\mu\right)^{T}_{ab}\right] d_F^{cb}$$

$$D_\mu \tilde{e}_F^c = \left(\partial_\mu - ig_1 B_\mu\right) \tilde{e}_F^c$$

$$D_\mu^{ab} \tilde{u}_F^{cb} = \left[\left(\partial_\mu + \frac{2i}{3}g_1 B_\mu\right)\delta^{ab} + \frac{ig_3}{2}\left(\vec{\lambda}\cdot\vec{G}_\mu\right)^{T}_{ab}\right] \tilde{u}_F^{cb}$$

$$D_\mu^{ab} \tilde{d}_F^{cb} = \left[\left(\partial_\mu - \frac{i}{3}g_1 B_\mu\right)\delta^{ab} + \frac{ig_3}{2}\left(\vec{\lambda}\cdot\vec{G}_\mu\right)^{T}_{ab}\right] \tilde{d}_F^{cb}$$

$$D_\mu H_u = \left(\partial_\mu - \frac{ig_2}{2}\vec{\sigma}\cdot\vec{A}_\mu - \frac{ig_1}{2}B_\mu\right)H_u$$

$$D_\mu H_d = \left(\partial_\mu - \frac{ig_2}{2}\vec{\sigma}\cdot\vec{A}_\mu + \frac{ig_1}{2}B_\mu\right)H_d$$

$$D_\mu \tilde{H}_u = \left(\partial_\mu - \frac{ig_2}{2}\vec{\sigma}\cdot\vec{A}_\mu - \frac{ig_1}{2}B_\mu\right)\tilde{H}_u$$

$$D_\mu \tilde{H}_d = \left(\partial_\mu - \frac{ig_2}{2}\vec{\sigma}\cdot\vec{A}_\mu + \frac{ig_1}{2}B_\mu\right)\tilde{H}_d$$

Quite a few terms!!

Finally we have the soft-SUSY breaking terms

$$\mathcal{L}_{\not{S}K} = -\tilde{l}^\dagger_F m^2_{lFG}\tilde{l}_G - F^\dagger_{lF} m_{KlFG}\tilde{l}_G - \tilde{l}^\dagger_F \bar{m}_{KlFG} F_{lG}$$

$$-\tilde{q}^\dagger_F m^2_{qFG}\tilde{q}_G - F^\dagger_q m_{Kq}\tilde{q} - \tilde{q}^\dagger \bar{m}_{Kq} F_q$$

$$-\tilde{e}^{c\dagger} m^2_{e^c}\tilde{e}^c - F^\dagger_{e^c} m_{Ke^c}\tilde{e}^c - \tilde{e}^{c\dagger}\bar{m}_{Ke^c}F_{e^c}$$

$$-\tilde{u}^{c\dagger} m^2_{u^c}\tilde{u}^c - F^\dagger_{u^c} m_{Ku^c}\tilde{u}^c - \tilde{u}^{c\dagger}\bar{m}_{Ku^c}F_{u^c}$$

$$-\tilde{d}^{c\dagger} m^2_{d^c}\tilde{d}^c - F^\dagger_{d^c} m_{Kd^c}\tilde{d}^c - \tilde{d}^{c\dagger}\bar{m}_{Kd^c}F_{d^c}$$

$$-m^2_{Hu}H^\dagger_u H_u - m_{KHu}F^\dagger_{Hu}H_u - \bar{m}_{KHu}H^\dagger_u F_{Hu}$$

$$-m^2_{Hd}H^\dagger_d H_d - m_{KHd}F^\dagger_{Hd}H_d - \bar{m}_{KHd}H^\dagger_d F_{Hd}$$