Singlet-Stabilized Minimal Gauge Mediation

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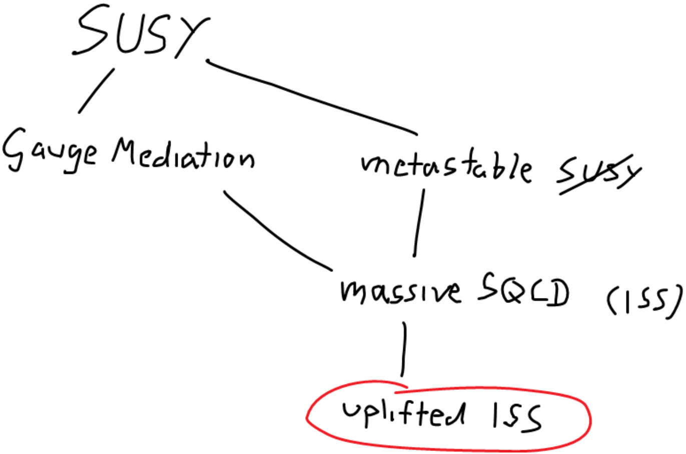
Outline

1. Review & Motivation
2. Singlet-Stabilized Minimal Gauge Mediation
3. Stabilizing the Uplifted Vacuum

Review & Motivation



SUSY solves the Hierarchy Problem

1. How is SUSY-breaking transmitted to SSM?
2. How is SUSY broken?

How is SUSY-breaking transmitted to SSM?

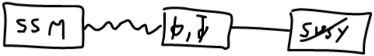
Gravity Mediation: always there

- $m_{soft} \sim \dfrac{F}{M_{pl}^*}$
- Problems:
  - $\longrightarrow$ Flavor
  - $\longrightarrow$ calculability

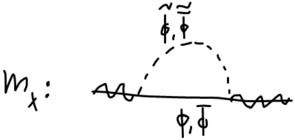
Gauge Mediation

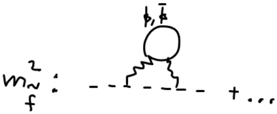
- flavor universal soft masses
- requires lower SUSY-breaking scale
- often calculable

- Minimal Gauge Mediation



$$W_{eff} = X\bar{\phi}\phi \quad \text{where} \quad \langle X \rangle = X + \theta^2 F \quad \Rightarrow \quad m_{\text{soft}} \sim \frac{\alpha}{4\pi}\frac{F}{X}$$





- **Direct Gauge Mediation**

  - G_{SM} embedded in flavor group of SUSY-breaking sector
  - Very compatible with ‘dynamical SUSY-breaking’ ideal!

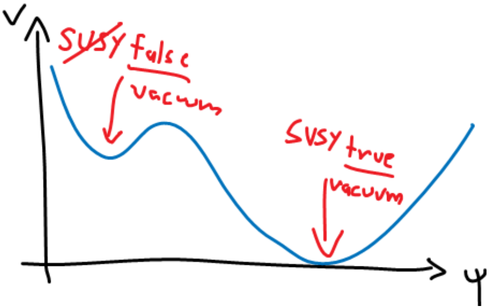
How is SUSY broken?

- Want a model where $m_{\cancel{SUSY}} \ll M_{pl}$ is dynamically generated: Dynamical SUSY Breaking (DSB).
- Known example of small dynamical mass scale in nature: Λ_{QCD} (due to logarithmic running of gauge coupling).
  $\Rightarrow$ Will probably need nonperturbative physics!
- True ~~SUSY~~ very difficult! (Witten Index Argument).
  - No SUSY-vacua $\rightarrow$ either chiral or contain massless matter
  - 3-2, 4-1, ITIY, ...
  - Difficult to make into realistic DGM model

How about metastable ~~SUSY~~?

Allowing the existence of SUSY-vacua removes many restrictions.

$\Rightarrow$ now just need to make sure that there is an uplifted local minimum of the potential.



Of course the false vacuum should have a lifetime longer than the age of the universe!

Split-SUSY Spectrum in Direct Gauge Mediation

Another very good reason for metastable ~~SUSY~~
(apart from increased model building freedom/simplicity)

- Problem: in Direct Gauge Mediation often get $m_\lambda \ll m_{\tilde{f}}$
- Little Hierarchy Problem!
- Can show that this is due to global vacuum structure of the theory.
- m_λ vanishes to LO in ~~SUSY~~ if we live in lowest-lying vacuum of the renormalizable theory (Komargodski, Shih 2009).
  (Making ~~SUSY~~ maximal does not help.)
- $\Rightarrow$ **metastable ~~SUSY~~!**

Remark

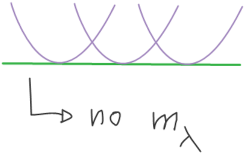
It is useful to elaborate slightly on this.

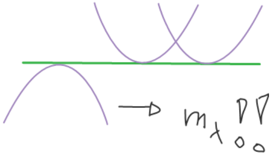
Many models of dynamical SUSY breaking can be described by a generalized O'Raifeartaigh model at low energies.

Such a model always has a field that is undetermined at tree-level but gets a potential at 1-loop: **Pseudomodulus (PM)**.

If this model implements Direct Gauge Mediation, then messengers which are

- tachyonic for some values of the PM contribute to m_λ
- stable everywhere do not contribute to m_λ





Some earlier models:

- Luty, Terning 1998
- Dine, Nelson, Nir, Shirman 1995
- Banks 2005
- ...

Turns out metastable ~~SUSY~~ is generic!

Simplest example:
SUSY-QCD with small quark mass

(Intriligator, Seiberg, Shih 2006).

SUSY-QCD & Seiberg Duality

Start with $SU(N_c)$ SUSY-QCD with N_f vector-like quarks:

	$SU(N_c)$	$SU(N_f)$	$SU(N_f)$	$U(1)_B$	$U(1)_R$
Q	$\square$	$\square$	1	1	$\frac{N_f - N_c}{N_c}$
$\overline{Q}$	$\overline{\square}$	1	$\overline{\square}$	-1	$\frac{N_f - N_c}{N_c}$

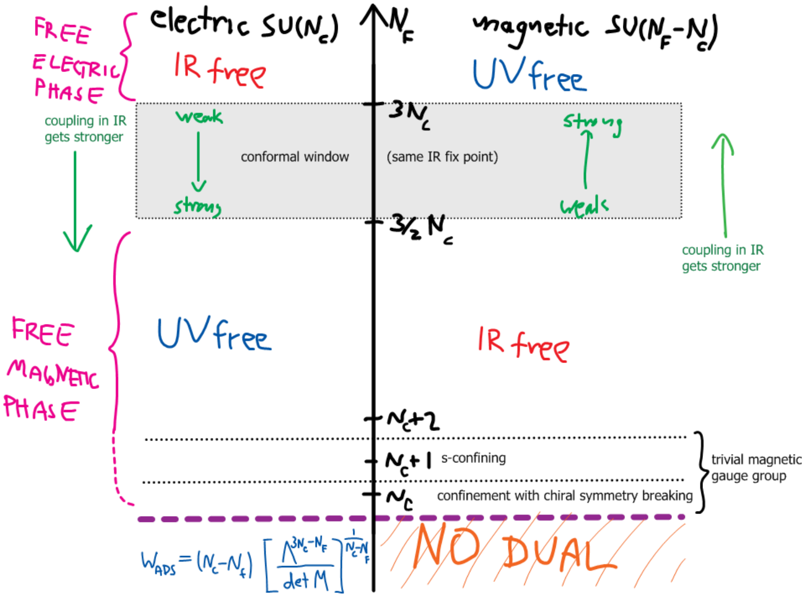
$N_f < 3N_c \rightarrow$ asymptotically free $\rightarrow$ strongly coupled for $E < \Lambda$

For $N_c + 1 \geq N_f \geq 3/2 N_c$ the strongly coupled IR-physics is described by another SUSY-QCD which is IR-free

	$SU(N_f - N_c)$	$SU(N_f)$	$SU(N_f)$	$U(1)_B$	$U(1)_R$
q	$\square$	$\overline{\square}$	1	$\frac{N_c}{N_f - N_c}$	$\frac{N_c}{N_f}$
$\bar{q}$	$\overline{\square}$	1	$\square$	$-\frac{N_c}{N_f - N_c}$	$\frac{N_c}{N_f}$
M	1	$\square$	$\overline{\square}$	0	$2\frac{N_f - N_c}{N_f}$

$$W = \mathrm{Tr}\, q M \bar{q}$$

SUSY-QCD & Seiberg Duality



The ISS Model

- Consider SQCD in free magnetic phase with small quark mass:

$$SU(N_c) \;\text{ with }\; W = mQ\overline{Q} \quad \Rightarrow \quad \cancel{SU(N_f)^2} \to SU(N_f)$$

  where $m \ll \Lambda$ (does not affect duality).

- magnetic theory: $SU(N)$ with $W = h\mathrm{Tr}qM\bar{q} \underbrace{- h\mu^2}_{\sim\Lambda m} \mathrm{Tr}M$

  (Define $N = N_f - N_c$)

- Notice apparent R-symmetry $R(q, \bar{q}, M) = 0, 0, 2$

- **SUSY-breaking** by rank condition: $F_{M_j^i} = \underbrace{hq^i\bar{q}_j}_{\text{rank } N} - \underbrace{h\mu^2\delta_j^i}_{\text{rank } N_f \geq 3N}$

Where is the SUSY-vacuum?

- We know this theory has a SUSY-minimum. Where is it in the magnetic description?
- Consider large meson VEVs: $W = h\mathrm{Tr}qM\bar{q} - \ h\mu^2\mathrm{Tr}M$
- squarks get large mass $\rightarrow$ integrate out
  $\rightarrow$ pure SYM
  $\rightarrow$ gaugino condensation
  $\rightarrow$ SUSY minimum (nonperturbative SUSY-restoration!)

$$q = \bar{q} = 0, \quad M = \Lambda_m \left(\frac{\mu}{\Lambda_m}\right)^{2N/(N_f - N)}$$

- *R*-symmetry was accidental! It is weakly but explicitly broken by gauge anomaly $\Rightarrow$ meta-stable SUSY-breaking!

“Semi-Dynamical" Meta-Stable SUSY-Breaking

ISS is not true dynamical meta-stable SUSY-breaking due to the small quark mass put in by hand.

However, its simplicity & non-perturbative mechanism make it an instructive model-building sand box!

Use it to build a model of Direct Gauge Mediation.

ISS and Direct Gauge Mediation

- $$\langle q\bar{q}\rangle = \begin{array}{cc} N & N_F - N \\ \left(\begin{array}{cc} \mu^2 & \\ & 0 \end{array}\right) & \begin{array}{c} N \\ N_F - N \end{array} \end{array} \Rightarrow \begin{array}{c} \cancel{SU(N)\times SU(N_f)} \\ \downarrow \\ SU(N)_D \times SU(N_f - N) \end{array}$$

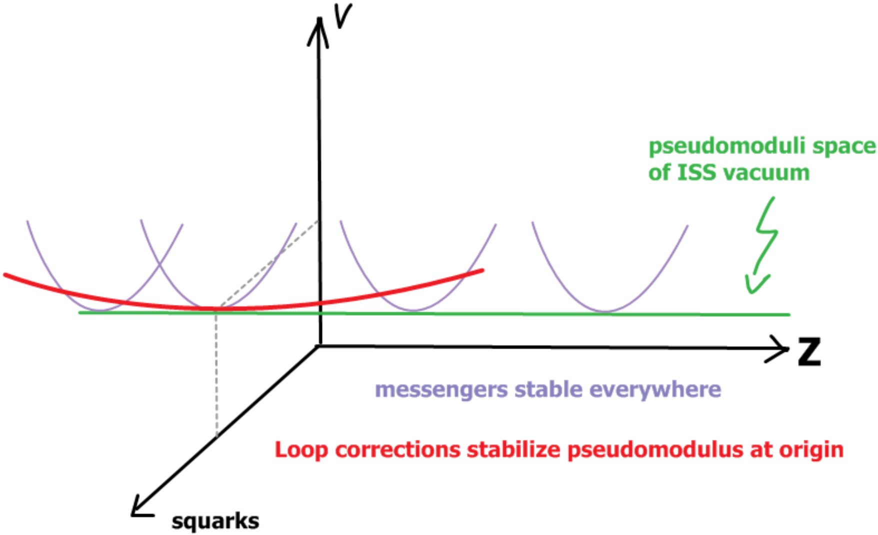
- Decompose fields into representations of unbroken symmetries:

$$M = \begin{array}{cc} \begin{array}{cc} N & N_F - N \end{array} & \\ \left(\begin{array}{cc} V & Y \\ \bar{Y} & Z \end{array}\right) & \begin{array}{c} N \\ N_F - N \end{array} \end{array}, \quad q = \left(\begin{array}{cc} \mu + \chi_1 & \rho_1 \end{array}\right), \quad \bar{q} = \left(\begin{array}{c} \mu + \bar{\chi}_1 \\ \bar{\rho}_1 \end{array}\right)$$

Pseudomodulus: no potential at tree-level. Loop effects stabilize it at the origin $\Rightarrow U(1)_R$ is unbroken!

Embed G_{SM} in $SU(N_f - N)$: vectors could be messengers of DGM!

ISS Vacuum


V
pseudomoduli space
of ISS vacuum
Z
messengers stable everywhere
Loop corrections stabilize pseudomodulus at origin
squarks

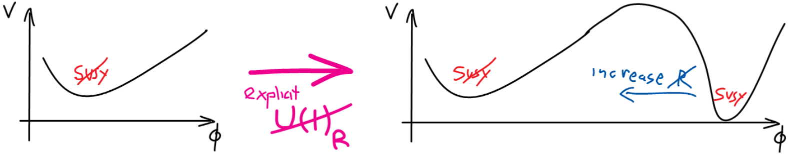
Problems

- Unbroken R-symmetry forbids gaugino masses (violations from NP effects too small) $\rightarrow$ must give the pseudomodulus Z a VEV!

$$M = \begin{array}{cc} & \begin{array}{cc} N & N_F-N \end{array} \\ & \left(\begin{array}{cc} V & Y \\ \overline{Y} & Z \end{array} \right) \begin{array}{c} N \\ N_F-N \end{array} \end{array}$$

- Even if we break R-symmetry spontaneously the ISS vacuum is still the lowest-lying vacuum in the renormalizable theory $\rightarrow$ suppressed gaugino mass!

$\Rightarrow$ Need to break R-symmetry explicitly!



Deforming the ISS Model

There are many ways to break the magnetic R-symmetry *spontaneously*, but to break it *explicitly* we must add terms of the form

$$\delta W_{el} \sim \frac{1}{\Lambda_{UV}} Q\overline{Q}Q\overline{Q} \quad \longrightarrow \quad \delta W_{mag} \sim \epsilon \mu M^2 \quad \text{where} \quad \epsilon \sim \frac{\Lambda^2}{\mu \Lambda_{UV}} \ll 1$$

This introducs new SUSY-vacua at $M \sim \mu/\epsilon$!

Good:

- Get gaugino mass at LO in $\cancel{\text{SUSY}}$

Bad:

- strong tension between reasonable m_λ and lifetime of false vacuum
- deformation can be non-generic or contrived

New Idea: Uplift the ISS Model

- In the ISS vacuum, $\langle q\bar{q}\rangle$ has maximum rank N.
- Let's expand around a configuration with fewer squark VEVs instead:

$$\mathrm{rank}\langle q\bar{q}\rangle = k < N$$

  At tree-level there will be tachyonic stuff but just run with it for now!
- Different symmetry breaking pattern:

$$\cancel{SU(N)\times SU(N_f)\times U(1)_R\times U(1)_B} \rightarrow SU(N-k)\times SU(k)_D\times SU(N_f-k)\times U(1)_{B'}\times U(1)_{B''}$$

New Idea: Uplift the ISS Model

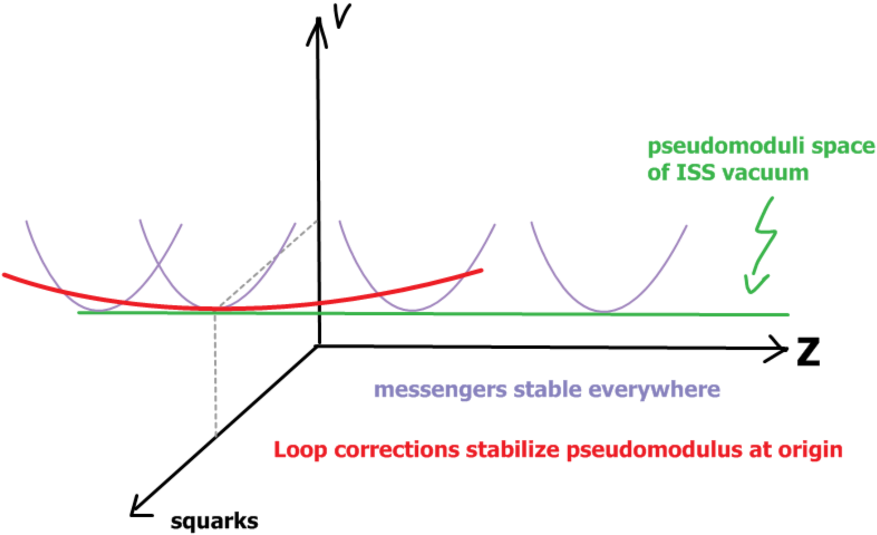
$$M = \begin{array}{cc} & \begin{array}{cc} k & N_F-k \end{array} \\ & \left(\begin{array}{cc} V & Y \\ \overline{Y} & Z \end{array} \right) \begin{array}{c} k \\ N_F-k \end{array} \end{array}$$

$$q = \begin{array}{c} \begin{array}{cc} k & N_F-k \end{array} \\ \left(\begin{array}{cc} \mu + \chi_1 & \rho_1 \\ \chi_2 & \rho_2 \end{array} \right) \begin{array}{c} k \\ N-k \end{array} \end{array} \qquad \overline{q} = \begin{array}{c} \begin{array}{cc} k & N-k \end{array} \\ \left(\begin{array}{cc} \mu + \overline{\chi}_1 & \overline{\chi}_2 \\ \overline{\rho}_1 & \overline{\rho}_2 \end{array} \right) \begin{array}{c} k \\ N_F-k \end{array} \end{array}$$

Direct Gauge Mediation: Embed G_{SM} in $SU(N_f - k)$

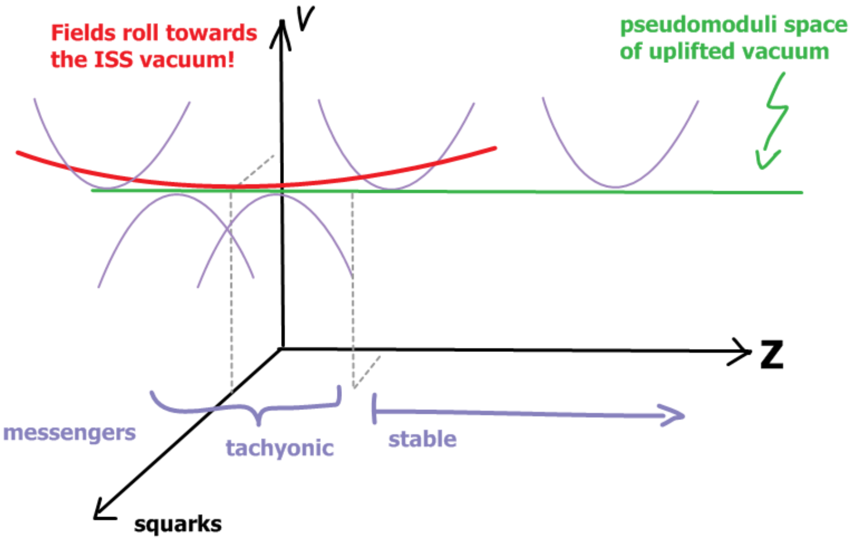
- flat at tree-level: pseudomodulus
- messengers stable everywhere: do not help with m_λ
- these messengers are tachyonic for $|Z| < \mu \Rightarrow$ generate gaugino mass at LO!

ISS Vacuum

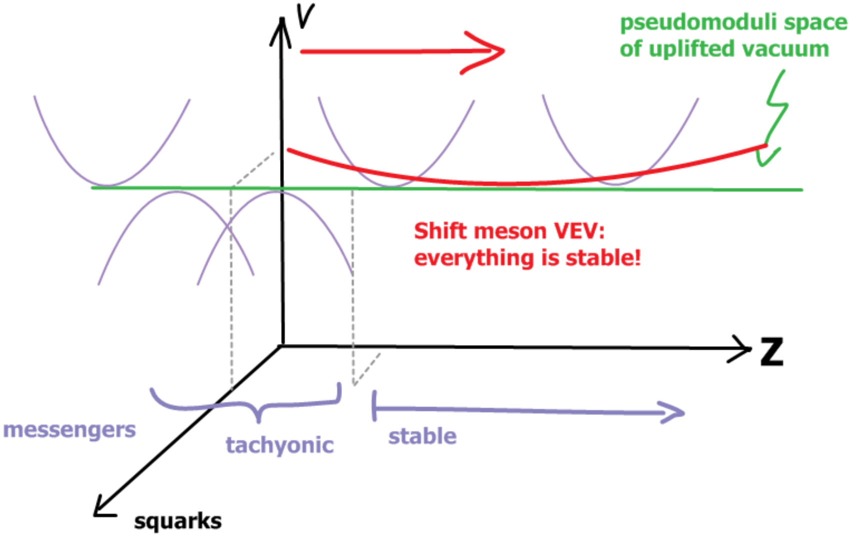


V
pseudomoduli space
of ISS vacuum
Z
messengers stable everywhere
Loop corrections stabilize pseudomodulus at origin
squarks

Uplifted Vacuum



Model Building Quest



GKK Model (Giveon, Komargodski, Katz 2009)

- magnetic theory: $W = h\mathrm{Tr}qM\bar{q} \; - \; h\mu^2\mathrm{Tr}M, \qquad M = \begin{pmatrix} V & Y \\ \bar{Y} & Z \end{pmatrix}$

- Need to give meson a VEV $\langle Z \rangle > \mu$

- Problem: in a renormalizable WZ model can't have ~~SUSY~~ vacuum if one of the VEVs $\gg$ mass scales in Lagrangian.

- Possible Solution: Split quark masses:

$$\mu^2 \times 1 \quad \longrightarrow \quad \begin{array}{cc} \begin{array}{cc} k & N_F-k \end{array} & \\ \begin{pmatrix} \mu_1 & \\ & \mu_2 \end{pmatrix} & \begin{array}{c} k \\ N_F-k \end{array} \end{array} \qquad \text{where} \quad \mu_1 \gg \mu_2$$

- $\rho_2, \bar{\rho}_2$ messengers tachyonic for $|Z| < \mu_2$

Leaves possible window for ~~SUSY~~ minimum: $\mu_2 \ll |Z| \ll \mu_1$

GKK Model (Giveon, Komargodski, Katz 2009)

To shift Z-VEV, again break R-symmetry explicitly by adding extremely finely tuned meson deformations

$$\delta W_{mag} = \epsilon_1 \mu_2 \mathrm{Tr}(Z^2) + \epsilon_2 \mu_2 \left(\mathrm{Tr} Z\right)^2$$

Good:

- It works! Get reasonable gaugino masses.
- Very important proof-of-principle!

Bad:

- Extremely contrived form of deformations
- Non-generic couplings
- Imposed mass hierarchies
- Requires enormous flavor symmetries, at least $SU(24)$
  $\Rightarrow$ **Landau Pole of SM gauge couplings below M_{GUT}**

Our Goals

We want to build new & improved ISS model!

- Needs to be uplifted to solve gaugino mass problem
- Want hidden sector to be minimal, i.e. $SU(5)$ flavor symmetry. This will avoid the Landau Pole.

Also would like minimal clutter (contrived deformations, nongeneric couplings).

Singlet-Stabilized

Minimal Gauge Mediation

Start Building Our Model

Choose Magnetic Gauge Group $SU(N)$

Possible number of squark VEVs: $\mathrm{rank}\langle q\bar{q}\rangle = k = 0, 1, \ldots N$
$\Rightarrow$ make minimal choice $N = 1$
$\Rightarrow$ trivial magnetic gauge group
Only two pseudomoduli spaces: ISS ($k = 1$) and **uplifted ($k = 0$)**

Choose Flavor Group $SU(N_f)$

Want minimal hidden flavor group to avoid Landau Pole.
Uplifted ISS has unbroken flavor group $SU(N_f - k)$, with $k = 0$ here.
$\Rightarrow$ Choose $N_f = 5$.

Start Building Our Model

Ansatz for magnetic theory: "$SU(1)_c$" $\times$ $SU(5)_f$

$$W = h\bar{\phi}_i M^i_j \phi^j - hf^2 M^i_i .$$

	$SU(5)$	$U(1)$	$U(1)_R$
ϕ^i	$\square$	1	0
$\bar{\phi}_j$	$\bar{\square}$	-1	0
M	$\mathrm{Adj} + 1$	0	2

Identify $SU(5)$ flavor group with G_{SM}

Both these fundamentals will be tachyonic for small $|M|$ in the uplifted pseudomoduli space

$\Rightarrow$ **A Single Pair Of Minimal Gauge Mediation Messengers!**

Need to stabilize the meson at nonzero VEV.

Need to generate Meson VEV

Deform the model to generate an effective potential (tree + loop) which pushes the meson away from the origin.

- Meson Deformations: $\delta W_{mag} \sim \epsilon f M^2$?
  From GKK we know this can't work for our small flavor group.
- Baryon Deformations: $\delta W_{el} \sim \frac{1}{\Lambda_{UV}^2} Q^5 \rightarrow \delta W_{mag} \sim m\phi\phi$?
  Only works for $SU(7)_f \rightarrow SU(2)_f \times SU(5)_f$. Very non-renormalizable in electric theory.
- **Add A Singlet Sector Coupled To The Meson!**
  (Witten 1981; Dine & Mason 2006; Csaki, Shirman & Terning 2006)

Inverted Hierarchy Mechanism (Witten 1981)

- Take an O'Raifeartaigh Model that ~~SUSY~~. It will have a pseudomodulus X.
- If there are no gauge interactions, the effective potential at 1-loop will look like

$$V_{tree} = M^4\lambda^2 \quad \longrightarrow \quad V_{eff} = M^4\lambda^2\left[1 + b\frac{\lambda^2}{8\pi^2}\log\frac{|X|^2}{\Lambda^2}\right]$$

SUSY-breaking scale, tree contribtion, 1-loop contribution

Inverted Hierarchy Mechanism (Witten 1981)

- This can be written as

$$V_{eff} = M^4 \lambda(X)^2 \quad \text{where} \quad \lambda(X)^2 = \lambda^2 \left[1 + b \frac{\lambda^2}{8\pi^2} \log \frac{|X|^2}{\Lambda^2} \right]$$

- Effective coupling λ increases with X: consequence of RGE
  $\Rightarrow$ X is stabilized at the origin.

- Gauge Interactions try to decrease λ for larger X
  $\Rightarrow$ can drive X away from the origin!

Add Singlet Sector To Our Model

$$W = h\bar{\phi}M\phi + (-hf^2 + dS\overline{S})\mathrm{Tr}M + m'(S\overline{Z} + Z\overline{S})$$

	$SU(5)$	$U(1)$	$U(1)_R$	$U(1)_S$
ϕ^i	$\square$	1	0	0
$\bar{\phi}_j$	$\overline{\square}$	-1	0	0
M	$\mathrm{Adj}+1$	0	2	0
Z	1	0	2	1
$\overline{Z}$	1	0	2	-1
S	1	0	0	1
$\overline{S}$	1	0	0	-1

For m' not too large, singlets get VEV

$\rightarrow \cancel{U(1)_S}$ and $\cancel{U(1)_R}$

$\rightarrow$ negative log contribution in 1-loop potential $V_{\mathrm{CW}}(M)$

$\Rightarrow \langle M \rangle \neq 0$ possible

Not quite done!

- Split up the meson M into singlet and adjoint components

$$M = M_{adj} + M_{sing}$$

- M_{sing} is stabilized by the singlet sector

$$V_{\mathrm{CW}}(M_{sing}) = V_{\mathrm{CW}}^{\mathrm{mess}} + V_{\mathrm{CW}}^{\mathrm{sing}}$$

drives towards region where messengers are tachyonic
drives away from region where messengers are tachyonic

- What about the **adjoint meson**?

$$V_{\mathrm{CW}}(M_{adj}) = V_{\mathrm{CW}}^{\mathrm{mess}}$$

TACHYONIC!

Fix the Adjoint Instability

How to stabilize the Adjoint Meson?

1. Add Flavor Adjoint: $\Delta W_{mag} = m_{adj} M K$
   $\rightarrow$ **Landau Pole**

2. Couple to field with $R = -2$ that gets a VEV
   $\Delta W_{mag} = M M A$
   $\rightarrow$ complicated & highly non-renormalizable in electric theory

3. **Meson Deformation**: $\Delta W_{mag} = m_{adj} \mathrm{Tr}\left(M_{adj}\right)^2 \qquad (\not{R})$

Some simple Meson Deformations are very hard to avoid in uplifted ISS models!

Complete Model for ~~SUSY~~ Sector in SSMGM

Magnetic Theory below scale Λ:

Trivial Gauge Group, $SU(5)$ flavor symmetry:

$$W = h\bar{\phi}_i M^i_j \phi^j + (-hf^2 + dS\bar{S})\mathrm{Tr}M + m'(Z\bar{S} + S\bar{Z}) + m_{adj}\mathrm{Tr}(M'^2) + a\frac{\det M}{\Lambda_m^2}$$

(Instanton Term restores SUSY for $M \sim \sqrt{f\Lambda}$)

Electric Theory above scale Λ:

augmented massive $SU(4)_c \times SU(5)_f$

$$W = \left(\tilde{f} + \frac{\tilde{d}}{\Lambda_{UV}} S\bar{S}\right) Q\bar{Q} + m'(Z\bar{S} + S\bar{Z}) + \frac{\tilde{c}}{\Lambda_{UV}}\mathrm{Tr}\left(Q\bar{Q}\right)'^2$$

Scales of Parameters

$$W = h\bar{\phi}_i M^i_j \phi^j + (-hf^2 + dS\bar{S})\mathrm{Tr}M + m'(Z\bar{S} + S\bar{Z}) + m_{adj}\mathrm{Tr}(M'^2) + a\frac{\det M}{\Lambda_m^2}$$

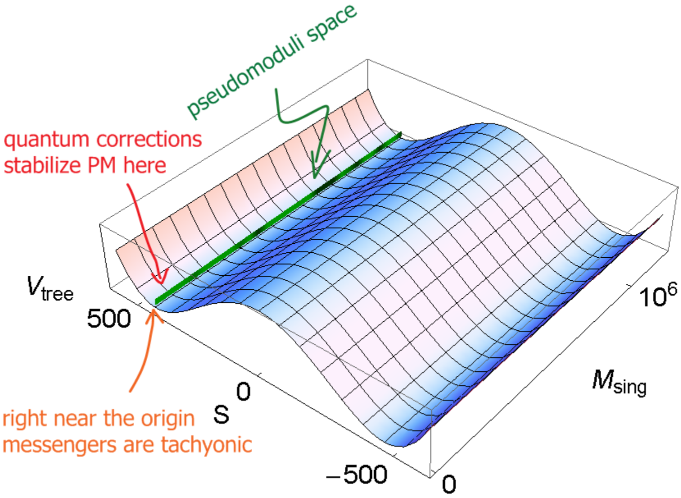
- $m', f \ll \Lambda$ free parameters. Generally $f \gtrsim 10m'$.
- $\Lambda \lesssim \Lambda_{UV}/100$ for calculability. But no minima for $\Lambda \ll \Lambda_{UV}/100$.

	Λ	Λ_{UV}	
Scenario 1	10^{16}	10^{18}	(GeV)
Scenario 2	10^{14}	10^{16}	

- $h \sim 1$ unknown.
- typical size of $d \sim \frac{\Lambda}{\Lambda_{UV}} \sim 0.01$, $m_{adj} \sim d\Lambda$.

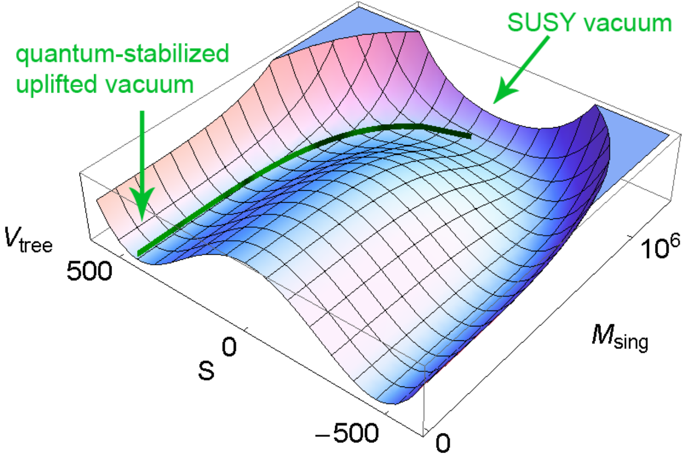
  Is tiny $d \ll h \sim 1$ problematic for analysis at 1-loop? NO!

Vacuum Structure without Instanton Term

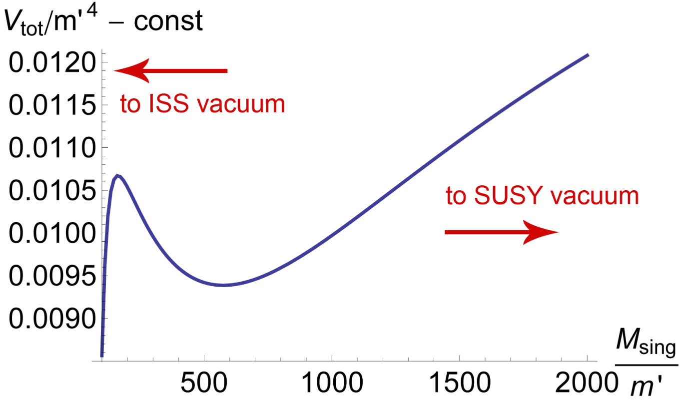


Effect of Instanton Term

Creates SUSY-minimum at $M_{sing} \sim \sqrt{\Lambda f}$



Effective Potential Along Pseudomoduli Space



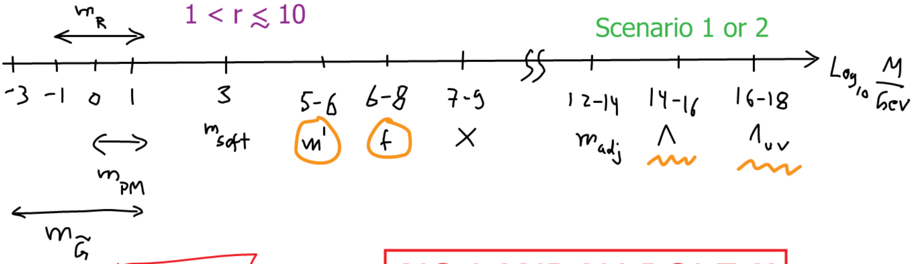
Meson stabilized at $\langle M_{sing} \rangle = O(1) \times \sqrt{\frac{h}{d}} f$

Direct Gauge Mediation

Gauge $SU(5)$ flavor symmetry and identify with G_{SM}.

$$W_{eff} = X\bar{\phi}\phi \quad \text{where} \quad X = \frac{h}{\sqrt{N_f}} M_{sing} \quad \Rightarrow \quad m_{soft} \sim \frac{\alpha}{4\pi}\frac{F}{X}$$

Important parameter for scales is $r = \sqrt{N_f h d}\,\frac{f}{m'} > 1$.



$\boxed{r \lesssim 10}$

NO LANDAU POLE !!

Stabilizing

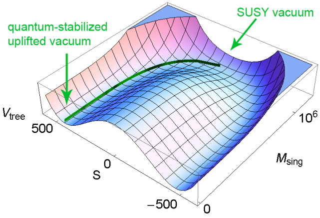
the Uplifted Vacuum

We need to understand the stabilization in detail

Why bother? We know that it's possible to get minima in the effective potential along the pseudomoduli space.

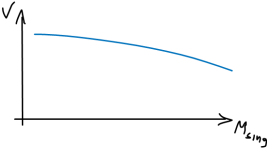
- Need to understand whether existence of minima is generic or tuned
  $\longrightarrow$ If tuned, what conditions must be satisfied by the UV completion to make it generic?
- We have $d \ll h$, so how do we know we can trust our 1-loop calculation?

Effective Potential Along Uplifted Pseudomoduli Space

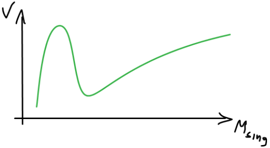


$$V_{eff} = V_{tree} + V_{\text{CW}}$$

$$V_{tree} = \text{const} - c\frac{m'^2}{\Lambda}M_{sing}^4$$



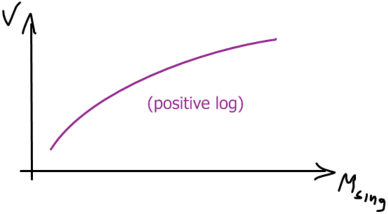
$$V_{\text{CW}} = \frac{1}{64\pi^2}\text{STr}\, m^4 \log\frac{m^2}{\Lambda^2}$$



(masses depend on M_{sing} ↔ pseudomodulus)

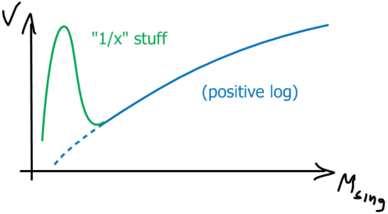
1-Loop Contribution

Messengers



Singlet masses depending on g

Singlet masses NOT depending on g



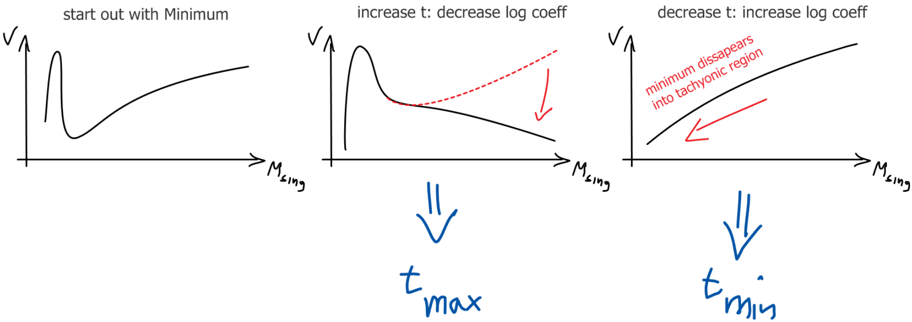
$$V_{\mathrm{CW}} = \text{const}$$

$$+\frac{1}{8\pi}(1-t)\log M_{sing}$$

$$+\text{“}\frac{1}{x}\text{ stuff”}$$

Nature of Tuning

$$V_{\mathrm{CW}} = \frac{1}{8\pi}(1-t)\log M_{sing} + \text{“}\frac{1}{x}\text{ stuff”} + \text{const}$$



Severity of Tuning

We find that $\frac{1}{2} \lesssim t \lesssim 1$ is required for minimum:

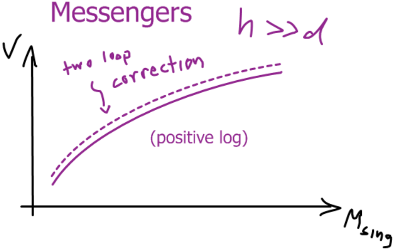
$$\frac{m'}{f} = 2g\sqrt{N_f \frac{d}{h}} \left(1 - \frac{d^2}{h^2} \frac{N_f}{2} t\right)$$

$\Rightarrow 10^{-4}$ tuning!

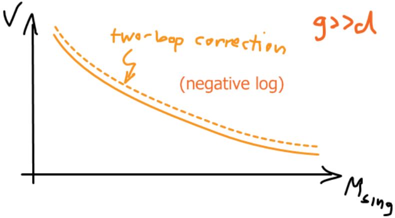
- Typical for such models.
- Ideally explain with UV completion.

Can We Trust 1-Loop calculation?

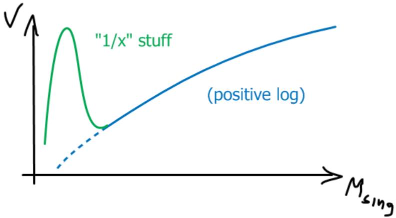
Messengers



Singlet masses depending on g



Singlet masses NOT depending on g



"Large" 2-loop corrections do NOT affect part of V_{cw} that generates local minimum

Conclusions

Conclusions

- ISS models are an extremely simple example of non-perturbative meta-stable SUSY-breaking.
- Problems:
  - Many Direct Gauge Mediation Models have Landau Poles.
  - Uplifted ISS models avoid tiny gaugino masses but are difficult to stabilize.
- We proposed Singlet-Stabilized Minimal Gauge Mediation: a 'minimal' uplifted ISS model with $SU(5)$ flavor symmetry. $\Rightarrow$ No Landau Pole, No Gaugino Mass Problem.
- Lots of work to be done to address the origin of smaller mass scales (ISS) and problems with tuning & UV completion (SSMGM).