A Gauge Messenger Model

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Outline

1. Introduction
2. Little Hierarchy Problem
3. Radiatively Generated Maximal Stop Mixing Scenario for Higgs Mass
4. Gauge Messenger Model
5. Dark Matter Implication
6. Conclusion

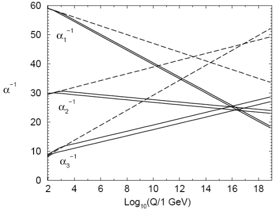
- Weak Scale SUSY addresses Big (Gauge) Hierarchy Problem.
  - In Nature, huge hierarchy between M_{Pl} and M_W.
  - This Big hierarchy between M_{Pl} and M_W can be destabilized by quantum correction of the Higgs mass parameters in the Standard Model (SM).

    $$\longrightarrow \quad \delta m_h^2 \sim \frac{1}{8\pi^2}\Lambda^2$$

  - SUSY introduces bosonic(fermionic) superpartner which cancels the original quantum divergences $\longrightarrow$ stabilize the big hierarchy.

    $$\longrightarrow \quad \delta m_h^2 \sim \frac{1}{8\pi^2} M_{\rm SUSY}^2 \log\Lambda$$

- There are several other good motivations for SUSY.
  - Gauge Coupling Unification with $M_{\rm GUT} \sim 2 \times 10^{16}$ GeV.

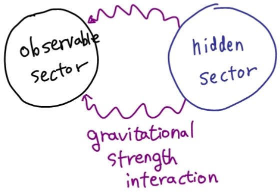


  - Compatible with EW precision data.
  - LSP Dark Matter with weak scale SUSY (with R-parity)
    - Bino LSP with substantial mixing with the Higgsino
      $M_1 \sim \mu \sim 100$ GeV
    - Higgino LSP ($\mu \ll M_1,\ M_2$)
      $\mu \sim 1$ or 2 TeV
    - Wino LSP ($M_2 \ll M_1,\ \mu$)
      $M_2 \sim 2$ or 2.5 TeV

- SUSY must be broken at weak scale. We need to seperate SUSY breaking *Hidden sector* from *Observable sector*.
  - We want to make SUSY a gauge symmetry in the fundamental theory $\rightarrow$ Spontaneous SUSY breaking.
  - If SUSY breaking field is coupled to observable fields by renormalizable interactions at tree level, $\exists$ light squark by *supertrace theorem.*

$$\mathrm{Tr}\ (-)^F m^2 = 0.$$

- Gravity Mediated SUSY Breaking (GrMSB)



- SUSY breaking scale

$$\langle F \rangle \sim 10^{11}\ \mathrm{GeV}.$$

- Soft mass scale

$$m_{\mathrm{soft}} \sim \frac{\langle F \rangle}{M_{\mathrm{Planck}}} \sim M_W.$$

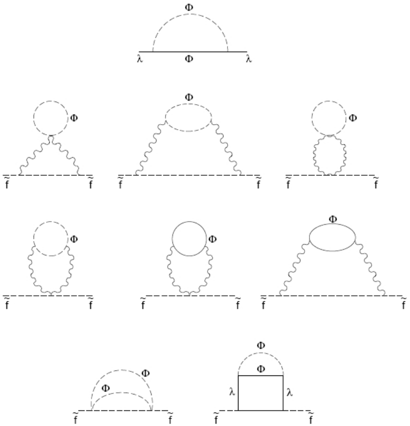
- Generic GrMSB has SUSY flavor problem
  - GrMSB depends on UV sensitive Kähler contact term

$$\mathcal{L} = \int d^4\theta \Omega(Z, Z^\dagger, Q, Q^\dagger) = \int d^4\theta \left(\Omega_0(Z, Z^\dagger) + \frac{Y_{ij}}{M_{\rm Pl}^2} Z Z^\dagger Q_i Q_j^\dagger + \ldots \right.$$

$\longrightarrow$ arbitrary flavor dependent Y_{ij} causes dangerous flavor violation effects. (FCNC, LFV)

- It is desirable to have UV-insensitive flavor independent SUSY breaking mediation. We have known such flavor-universal dynamics : *Gauge Interaction!*
- Note: Another flavor-universal dynamics : Mediation by pure supergravity supermultiplet. (Anomaly Mediation)
  $\longleftarrow$ We need to devise how to make AMSB dominate SUSY breaking.

- Gauge Mediated SUSY Breaking (GMSB)
  - SUSY breaking field is coupled to SM gauge-charged messengers only.
  - Soft masses are generated radiatively.



$$
\begin{aligned}
W &= X\Phi\bar{\Phi} \\
\langle X\rangle &= M + \theta^2 F \\
M_a &\sim \frac{\alpha_a}{4\pi}\frac{F}{M} \\
m_Q^2 &\sim \sum_a C_a(Q)\frac{\alpha_a^2}{(4\pi)^2}\left|\frac{F}{M}\right|^2
\end{aligned}
$$

- Do we always need to have another matter field for messengers? Why don't we use GUT gauge bosons X, Y as messengers? $\longrightarrow$ Gauge Messenger Model
- To realize this idea, SUSY breaking field is responsible for the mass generation of gauge fields X, Y and it must not generate tree-level mass for observable sector by renormalizable interaction.
- 24 Higgs Σ can play that role in $SU(5)$ GUT!

$$\langle\Sigma\rangle = M \begin{pmatrix} 2 & & & & \\ & 2 & & & \\ & & 2 & & \\ & & & -3 & \\ & & & & -3 \end{pmatrix} + \theta^2 F \begin{pmatrix} 2 & & & & \\ & 2 & & & \\ & & 2 & & \\ & & & -3 & \\ & & & & -3 \end{pmatrix}$$

- But Gauge Messenger model gives negative sfermion soft masses! So it was abandoned for a long time. $\longrightarrow$ Is it really a problem?

- SUSY suffers from *Little Hierarchy Problem*
  - We haven't found any experimental discovery of SUSY yet. Especially, LEP2 failed to find Higgs. Higgs mass is logarithmically sensitive to the SUSY breaking scale.

$$m_h^2 \approx M_Z^2 \cos^2 2\beta + \frac{3 G_F m_t^4}{\sqrt{2}\pi^2} \log \frac{m_{\tilde{t}}^2}{m_t^2}$$

$\longrightarrow$ Current observational bound $m_h \geq 114\mathrm{GeV}$. generically pushes up superpartner masses $m_{\tilde{t}}, m_{H_u}, \ldots$ to $\mathcal{O}(\mathrm{TeV})$
But the weak scale M_Z is determined by soft SUSY breaking parameters.

$$\frac{M_Z^2}{2} \approx -\mu^2(M_Z) - m_{H_u}^2(M_Z)$$

$\longrightarrow$ 0.5 % level fine-tuning $\longrightarrow$ Little Hierarchy Problem

- Starting from negative stop mass given at GUT scale, it has been known that this little hierarchy problem can be cured. (hep-ph/0601036 with R.Dermisek)
- Negative soft mass can imply our universe is now at a false vacuum, but cosmologically it's meta-stable.
- What theory of SUSY breaking gives such boundary condition?
- Gauge Messenger Model is in the right direction?

Little Hierarchy Problem

- In SM, Higgs mass is unfixed.

$$V = -m^2|\phi|^2 + \frac{\lambda}{4}|\phi|^4$$

(λ is arbitrary.)

$$\frac{\partial V}{\partial \phi} = 0$$

$$\rightarrow \langle|\phi|^2\rangle = \frac{2m^2}{\lambda}$$

$\rightarrow$ determines M_Z^2

$$m_\phi^2 = \frac{\partial^2 V}{\partial\phi\partial\phi^*} = -m^2 + \lambda|\phi|^2 = m^2$$

m^2 is independent of M_Z^2

- In MSSM, the quartic coupling is fixed by gauge interaction.
  $\longrightarrow$ Higgs mass is fixed.

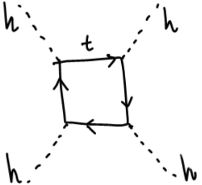
$$
\begin{aligned}
\lambda &= \frac{g_2^2 + g_Y^2}{2} \quad \rightarrow \quad \frac{\lambda}{2}\langle|\phi|^2\rangle = \frac{g_2^2 + g_Y^2}{4}\langle|\phi|^2\rangle \approx M_Z^2 \\
m_\phi^2 &= m^2 = \frac{\lambda}{2}\langle|\phi|^2\rangle \approx M_Z^2
\end{aligned}
$$

$$
\begin{aligned}
& m_{A^0}^2 = 2B\mu/\sin 2\beta \\
& m_{H^\pm}^2 = m_{A^0}^2 + m_W^2 \\
& m_{h^0,H^0}^2 = \frac{1}{2}\left(m_{A^0}^2 + m_Z^2 \mp \sqrt{(m_{A^0}^2 + m_Z^2)^2 - 4m_Z^2 m_{A^0}^2 \cos^2 2\beta}\right) \\
& \text{where } h_d = \begin{pmatrix} h_d^0 \\ h_d^- \end{pmatrix}, \quad h_u = \begin{pmatrix} h_u^+ \\ h_u^0 \end{pmatrix}, \quad \tan\beta = \langle h_u^0\rangle/\langle h_d^0\rangle
\end{aligned}
$$

- At tree level, $m_h \le M_Z|\cos 2\beta|$

- Radiative correction to Higgs mass
  - Effective Potential has radiative corrections of the form

$$V^1(Q) = V^0(Q) + \Delta V^1(Q)$$
$$\Delta V^1(Q) = \frac{1}{64\pi^2}\mathrm{Str}M^4(h)\left[\log\frac{M^2(h)}{Q^2} - \frac{3}{2}\right]$$



w/o mixing between $\tilde{t}_L$ and $\tilde{t}_R$,

$$m_h^2 \approx M_Z^2 \cos^2 2\beta + \frac{3 G_F m_t^4}{\sqrt{2}\pi^2}\log\frac{m_{\tilde{t}}^2}{m_t^2}$$

$\longrightarrow$ logarithmically sensitive to $m_{\tilde{t}}^2$.

- To have $m_h > 114\ \mathrm{GeV}$, $m_{\tilde{t}} \sim \mathcal{O}(\mathrm{TeV})$.

- Electroweak Symmetry Breaking is triggered mainly by two parameters μ and $m_{H_u}^2$ in MSSM:

$$\frac{M_Z^2}{2} \approx -\mu^2(M_Z) - m_{H_u}^2(M_Z)$$

- μ term does not change much from GUT scale value.

$$\frac{d\mu}{d\ln Q} = \frac{\mu}{16\pi^2}(3y_t^2 + \dots) \propto \mu \qquad \text{(no big change } 5 \sim 10\%\text{)}$$

- However, $m_{H_u}^2$ has a big radiative correction $\propto m_{\tilde{t}}^2$ through RG evolution.

$$\begin{aligned} \frac{dm_{H_u}^2}{d\log Q} &= \frac{3y_t^2}{8\pi^2}(m_{\tilde{Q}_3}^2 + m_{\tilde{t}^c}^2 + \dots) \\ \delta m_{H_u}^2 &\approx -\frac{3y_t^2}{4\pi^2} m_{\tilde{t}}^2 \log\frac{M_{\rm GUT}}{m_{\tilde{t}}} \approx -m_{\tilde{t}}^2 \sim \mathcal{O}(\mathrm{TeV})^2 \end{aligned}$$

- We need fine-tuning of parameters to get M_Z =90 GeV.

$$\frac{M_Z^2}{2} \approx -\mu^2(M_{\rm GUT}) - m_{H_u}^2(M_{\rm GUT}) + m_{\tilde{t}}^2$$

  - For $m_{\tilde{t}} \sim 1 \ {\rm TeV}$,
    $m_{H_u}^2(M_{\rm GUT}) \sim (1 \ {\rm TeV})^2$
    and $\mu^2(M_{\rm GUT}) \sim (1 \ {\rm TeV})^2$

$$\Delta = \frac{\frac{\delta M_Z^2}{M_Z^2}}{\frac{\delta M_{\rm UV}^2}{M_{\rm UV}^2}} \to \frac{2 m_{H_u}^2(M_{\rm GUT})}{M_Z^2} \sim 240$$

$\longrightarrow$ 0.5% fine tuning!

Radiatively generated Maximal Stop Mixing Scenario

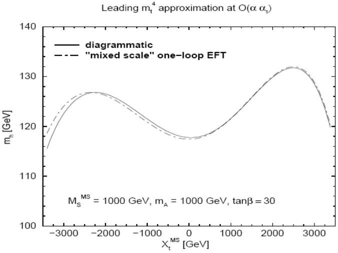
with R.Dermisek, hep-ph/0601036 (PRL 200803(2006))

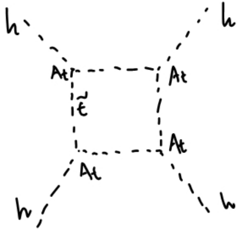
- Large Mixing between $\tilde{t}_L$ and $\tilde{t}_R$ helps higgs mass lift-up.

$$\mathcal{M}^2_{\tilde{t}} = \begin{pmatrix} m^2_{\tilde{Q}3} + m_t^2 + \dots & -m_{u3}(A_t^* + \mu \cot\beta) \\ -(A_t + \mu^* \cot\beta) m_{u3}^* & m^2_{\tilde{u}3} + m^2_{u3} + \dots \end{pmatrix}$$

$$m_h^2 \sim M_Z^2 + \frac{3G_F}{\sqrt{2}\pi^2}\left\{ m_t^4 \log\frac{M_S^2}{m_t^2} + \frac{A_t^2}{M_S^2} m_t^4 \left(1 - \frac{A_t^2}{12 M_S^2}\right)\right\}$$

$\rightarrow$ Maximum at $A_t = \pm\sqrt{6} M_S$.





- To satisfy LEP2 bound $m_h > 114\mathrm{GeV}$.
  for $m_{\tilde{t}}(M_Z) \approx 300\ \mathrm{GeV}$

$$\begin{aligned} |A_t(M_Z)| &\approx 450\mathrm{GeV}, \quad \tan\beta \gtrsim 50 \\ |A_t(M_Z)| &\approx 500\mathrm{GeV}, \quad \tan\beta \gtrsim 8 \\ |A_t(M_Z)| &\approx 600\mathrm{GeV}, \quad \tan\beta \gtrsim 6 \end{aligned}$$

- Therefore, $\left|\frac{A_t(M_Z)}{m_{\tilde{t}}(M_Z)}\right| \gtrsim 1.5$ is crucial.
- Unfortunately, the maximal mixing is not easily achieved due to the RG running.

- Expressions for Weak scale parameters in terms of UV parameters
(for $\tan\beta = 10$)

$$\begin{aligned} m_{\tilde{t}}^2(M_Z) &\approx 5.0M_3^2 + 0.6m_{\tilde{t}}^2 + 0.2A_t M_3 \\ M_3(M_Z) &\approx 3.0M_3 \\ A_t(M_Z) &\approx -2.3M_3 + 0.2A_t \end{aligned} \qquad (2)$$

$$\left|\frac{A_t(M_Z)}{M_{\tilde{t}}(M_Z)}\right| = \frac{|-2.3M_3 + 0.2A_t|}{\sqrt{5.0M_3^2 + 0.6m_{\tilde{t}}^2 + 0.2A_t M_3}} \lesssim 1 \text{ for positive } m_{\tilde{t}}^2.$$

- To achieve large stop mixing, we need negative stop mass at $M_{\rm GUT}$.

- Negative stop mass also reduces fine-tuning.
  - from the RG running of $m_{H_u}^2$,

$$\delta m_{H_u}^2 \approx -\frac{3y_t^2}{4\pi^2} m_{\tilde{t}}^2 \log \frac{\Lambda}{m_{\tilde{t}}},$$

while stop mass is negative, $m_{H_u}^2$ is lifted up. After stop mass becomes positive due to gluino, $m_{H_u}^2$ starts to drop down. This enables $m_{H_u}^2$ to stay around M_Z^2.

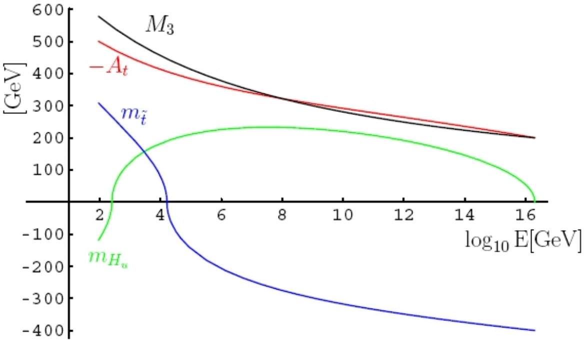
  - In terms of fine-tuning to obtain M_Z^2,

$$M_Z^2 \approx -1.9\mu^2 + 5.9M_3^2 - 1.2m_{H_u}^2 + 1.5m_{\tilde{t}}^2 - 0.8A_t M_3 + 0.2A_t^2 + \ldots$$

→ For $m_{\tilde{t}}^2 \approx -4M_3^2$, stop mass contribution almost cancels gluino contribution so that μ and m_{H_u} can be remained weak-scale value.

- Near $m_{\tilde{t}}^2 \approx -4M_3^2$,

$$\left|\frac{A_t(M_Z)}{M_{\tilde{t}}(M_Z)}\right| = \frac{|-2.3M_3 + 0.2A_t|}{\sqrt{5.0M_3^2 + 0.6m_{\tilde{t}}^2 + 0.2A_tM_3}} \sim -1.5 + 0.2\frac{A_t}{M_3}$$

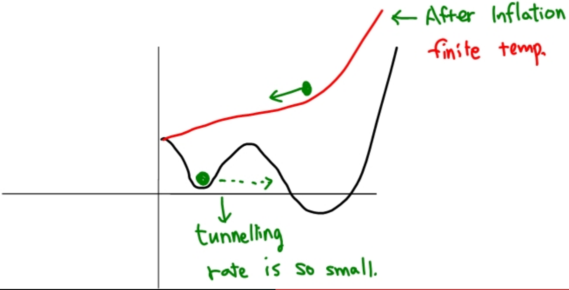


- Cosmologically Viable?
  - $m^2 < 0$ at high energy.
  - Along the D-flat direction, there is no quartic coupling.

$$V(\phi) \;=\; m^2|\phi|^2 + \frac{1}{M_{Pl}^{n-4}}|\phi|^n .$$

$\rightarrow$ Then $\langle\phi\rangle \sim (m^2 M_{Pl}^{n-4})^{\frac{1}{n-2}}$: Large VEV CCB minimum.

  - Finite temperature effective potential can be lifted up such that there is no CCB vacuum. then universe will settle down to the EW vacuum after inflation. Although CCB minimum is deeper, the tunnelling rate is negligible.



Gauge Messenger Model

- In SUSY GUT, X, Y gauge bosons $\in SU(5)/G_{321}$ become massive at $M_{\rm GUT}$ by adjoint chiral superfield Σ. We consider the case where F-term of Σ is also induced.

$$SU(5) \xrightarrow{\langle\Sigma\rangle} G_{321} = SU(3) \times SU(2) \times U(1)$$

$$\Sigma = M_{\rm GUT}\ {\rm diag}\,(2,2,2,-3,-3) + \theta^2 F\ {\rm diag}\,(2,2,2,-3,-3)$$

X, Y and $\lambda_{X,Y}$ are split in mass.

$$M_3 = 4\Lambda, \quad M_2 = 6\Lambda, \quad M_1 = 10\Lambda$$

$$m^2_{\tilde{Q}} = (-20 + 3b_G)\Lambda^2, \qquad m^2_{\tilde{u}^c} = (-16 + 4b_G)\Lambda^2,$$

$$m^2_{\tilde{d}^c} = (-12 + 2b_G)\Lambda^2, \qquad m^2_{\tilde{L}} = m^2_{H_u} = m^2_{H_d} = (-12 + 3b_G)\Lambda^2$$

$$m^2_{\tilde{e}^c} = (-12 + 2b_G)\Lambda^2,$$

$A_t = -10\Lambda$ where $\Lambda = \frac{\alpha_{GUT}}{4\pi}\left|\frac{F}{M}\right|$, b_G is β-func coeff. in $SU(5)$.

- Gaugino Masses are not universal and have opposite sign to conventional GMSB.

$$\longrightarrow b_X \frac{\alpha}{4\pi} \frac{F}{M}$$

: Bino is the heaviest at $M_{\rm GUT}$ scale.

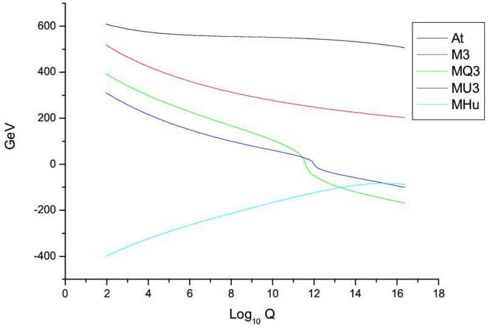
- Negative soft scalar masses are generated and squark masses are most negative.
- Large A term is generated. Easily make $\frac{A_t(M_Z)}{m_{\tilde{t}}(M_Z)}$ large.

- The best result from $b_G = 3$ case: (Analysis using SoftSUSY) for $\tan\beta = 20$ and $\Lambda = 50\ \mathrm{GeV}$,

$$M_S = \sqrt{m_{\tilde{t}_1} m_{\tilde{t}_2}} = 320\ \mathrm{GeV}, \qquad \frac{A_t(M_S)}{m_{\tilde{t}}(M_S)} = -2.08,$$

$$\rightarrow m_{h^0} = 114.4\ \mathrm{GeV}$$

$$\mu(M_S) = 363\ \mathrm{GeV} \rightarrow \Delta \sim 32 \rightarrow \text{ 3\% fine-tuning.}$$



Gravity Mediation

- Gravity Mediation is comparable to Gauge Mediation if $M_{\rm mess} = M_{\rm GUT}$
$$\frac{\alpha}{4\pi}\frac{F}{M} \sim \frac{F}{M_{\rm Pl}}$$
:
- We need an explanation for Gauge Mediation Dominance.
- The cutoff is $M_* = \sqrt{\frac{1}{8\pi^2}} M_{\rm Pl}$ for matter fields
- The cutoff is $M_{\rm Pl}$ for Higgs fields $\longrightarrow$ Giudice-Masiero Mechanism works. μ problem is solved.
- If this happens in Einstein frame Kahler potential, we get $m_0^2 = \frac{|F|^2}{M_{\rm Pl}^2}$ in all soft scalar masses.
- Large cutoff gives mSUGRA with $M_{\frac{1}{2}} \sim \frac{1}{4\pi} m_0$.

Gravity Mediation

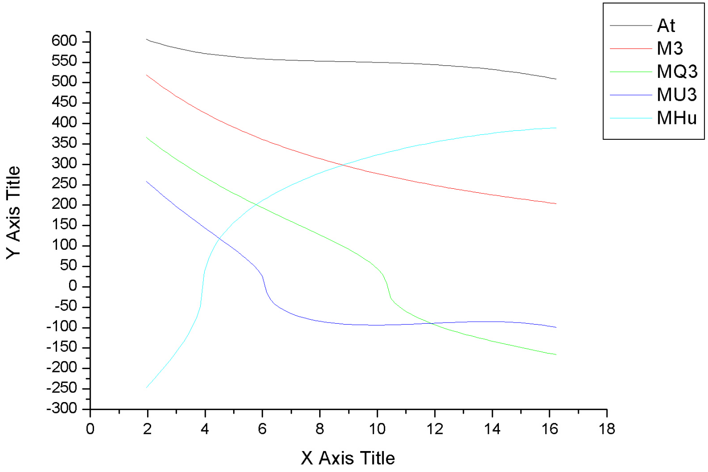
- GrMSB depends on UV sensitive Kähler contact term

$$\mathcal{L} = \int d^4\theta \Omega(Z, Z^\dagger, Q, Q^\dagger) = \int d^4\theta \left(\Omega_0(Z, Z^\dagger) + \frac{1}{M_*^2} Z Z^\dagger Q_i Q_j^\dagger + \dots \right) \quad (3)$$

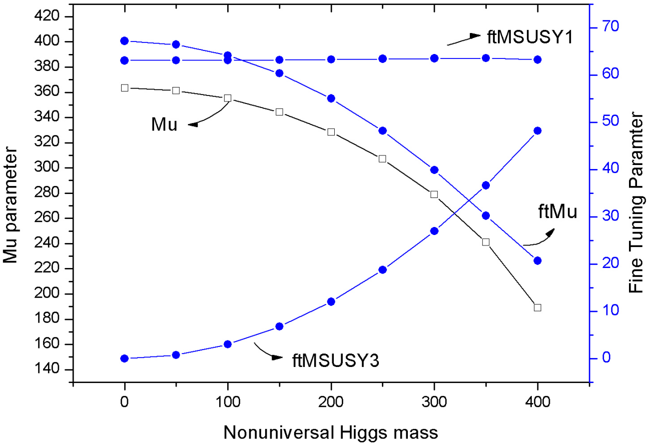
→ Note $M_*^2 = 8\pi^2 M_{\rm Pl}^2$.

- $\frac{F}{M_*} \sim \frac{1}{4\pi} \frac{F}{M_{\rm Pl}} \sim \frac{1}{4\pi} \Lambda$
- $\Lambda = \frac{\alpha_{\rm GUT}}{4\pi} \frac{F}{M_{\rm GUT}}$

- Gauge Messenger + Gravity Mediation only to Higgs
  - $m_{H_u}^2 = (400 GeV)^2$ added at the GUT scale



- Gauge Messenger + Gravity Mediation only to Higgs
  - μ becomes smaller but fine tuning stays

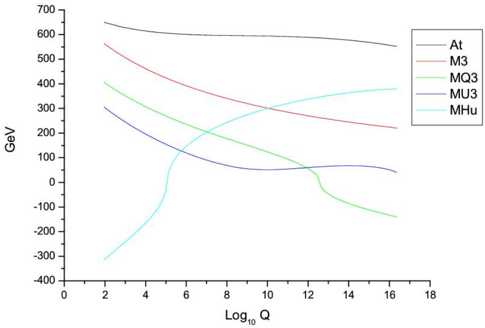


- Gauge Messenger + mSUGRA + nonuniversal Higgs
  for $\tan\beta = 26$ and $\Lambda = 55$ GeV, $m_0^2 = (120\ \mathrm{GeV})^2$,
  $m_{H_u}^2 = (370\ \mathrm{GeV})^2$

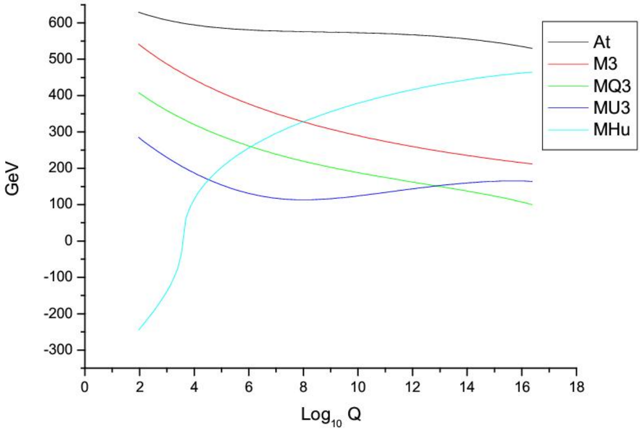
$$M_S = \sqrt{m_{\tilde{t}_1} m_{\tilde{t}_2}} = 350\ \mathrm{GeV}, \qquad \frac{A_t(M_S)}{m_{\tilde{t}}(M_S)} = -1.9,$$

$$\rightarrow m_{h^0} = 115\ \mathrm{GeV}$$

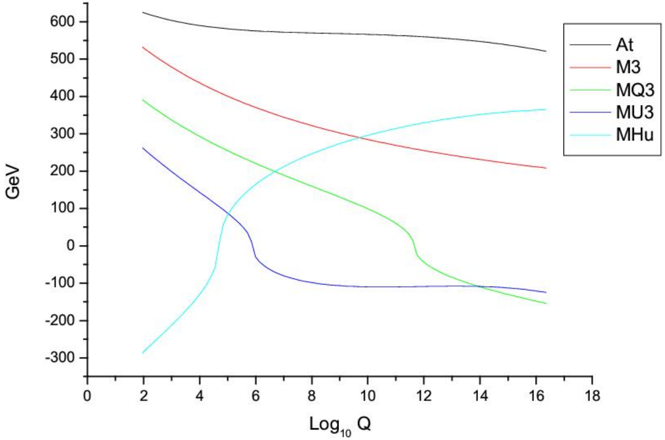
$$\mu(M_S) = 250\ \mathrm{GeV} \rightarrow \Delta \sim 15 \rightarrow 7\%\ \text{fine-tuning.}$$



- Gauge Messenger + mSUGRA + nonuniversal Higgs
  for $\tan\beta = 24$ and $\Lambda = 53$ GeV, $m_0^2 = (220\ \mathrm{GeV})^2$, $m_{H_u}^2 = (430\ \mathrm{GeV})^2$



- Gauge Messenger + mSUGRA + nonuniversal Higgs
  for $\tan\beta = 184$ and $\Lambda = 52\ \mathrm{GeV}$, $m_0^2 = (200\ \mathrm{GeV})^2$, $m_{H_u}^2 = (370\ \mathrm{GeV})^2$



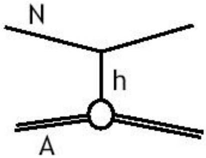
Dark Matter Implication

- Naturalness $\longrightarrow$ Small $\mu < 300\ GeV$ $\longrightarrow$ Higgsino/Bino LSP

Nucleon-Neutralino spin independent cross section with $\mu \sim M_1$

$$\begin{aligned} \sigma_{SI} &\simeq 3 \times 10^{-45} \left(\frac{115\ GeV}{m_h}\right)^4 \frac{M_Z^2 |M_1|^2}{(|\mu|^2 - |M_1|^2)^2}\ cm^2 \\ &\simeq 3 \times 10^{-45} \left(\frac{115\ GeV}{m_h}\right)^4 \left(\frac{M_Z}{\mu}\right)^2\ cm^2 \end{aligned}$$

- $\sigma_{SI} \simeq 3 \times 10^{-46}\ cm^2$ for $\mu = 300\ GeV$



Dark Matter Implication

- Heavy Higgs Mediation is also comparable for moderate tan β if $m_H^2/m_h^2 \sim \tan\beta$

Usual Bino LSP has an extra $(\frac{M_1}{\mu})^2$ suppression ($M_1 < \mu$)

$$
\begin{aligned}
\sigma_{SI} &\simeq 3\times 10^{-45}(\frac{115\ GeV}{m_h})^4\frac{M_Z^2|M_1|^2}{(|\mu|^2-|M_1|^2)^2}\ cm^2 \\
&\simeq 3\times 10^{-45}(\frac{115\ GeV}{m_h})^4(\frac{M_Z}{\mu})^2(\frac{M_1}{\mu})^2\ cm^2
\end{aligned}
$$

- $\sigma_{SI} \sim 4\times 10^{-47}\ cm^2$ for $\mu = 300\ GeV$, $M_1 = 100\ GeV$
- Comparable $M_1 \sim \mu$ can enhance the cross section by factor 10
- Light Higgs, Small $\mu \sim M_1$ are essential to raise up the cross section.

Conclusion

- Negative Stop Mass Squared
  $\rightarrow$ Large $A_t/M_{\tilde{t}}$ $\rightarrow$ lightest Higgs mass bound even with light stop.
- Non-universal Gaugino Masses
  Gauge messenger model $\rightarrow$ Non-universal gaugino mass, negative squark mass at GUT scale and large A term $\rightarrow$ smaller fine-tuning
- More Degenerate Spectrum at the EW scale
  Gluino and Bino/Wino ($< 500 \sim 600$ GeV) and squarks and sleptons also have similar masses ($< 500 \sim 600 GeV$). Gauge messenger model is one of the first concrete models having all these features. (Parameters : $\Lambda, \mu, B\mu$)

Conclusion

- Dark Matter Implication
  Based on naturalness, μ is 200 $\sim$ 400 GeV in the gauge messenger models. Bino mass is 300 $\sim$ 500 GeV, we have a Higgsino/Bino LSP.
- Strong Correlation
  between naturalness and neutralino-nucleon (SI) cross section : $\sigma_{SI} \sim 10^{-45}\ cm^2$ is generic for light Higgs and small μ
- Light Gluino, Light Stop
  Collider signal would be very interesting (LHC and even Tevatron)