Gauge Mediation from Emergent SUSY

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[Goh, Luty & SPN(hep-th/0309103)]
[Goh, SPN & Okada(hep-ph/0511301)]
[Goh, SPN & Okada(in progress)]

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Introduction

Background

- What is Gauge Mediation from Emergent Supersymmetry?

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- Motivation
  - An Alternative to GMSB
    - No need for traditional DSB
    - Averts gravitino constraints
    - Different phenomenology
  - Part of Susy w.o. Susy
    - No Susy flavor problem
    - Another class of realizations

Big Picture

Big Picture I: CFT

- Key assumption: We live in a superconformal basin.

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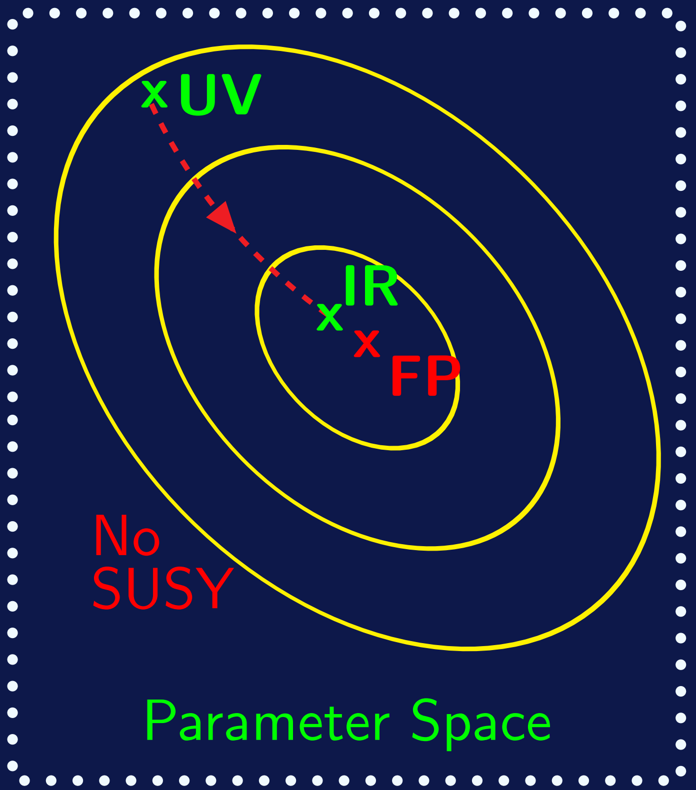

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  - Start at the edge
  - Flows towards the fixed point
  - Flow terminated before f.p.

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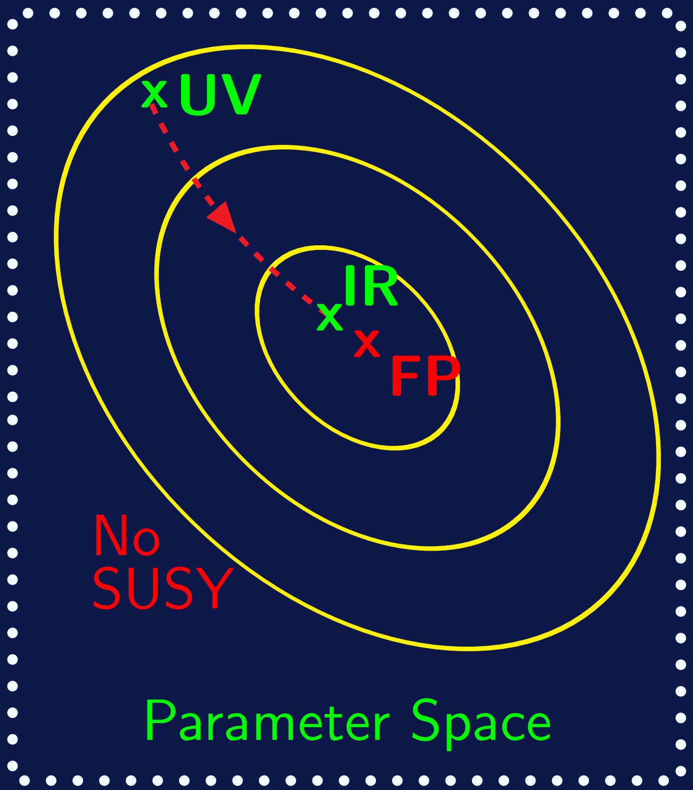

- Features
  - Start at the edge
  - Flows towards the fixed point
  - Flow terminated before f.p.
- Subtler Features
  - Susy breaking operators
  - Anomalous dimensions
  - Fundamental vs Emergent fields
  - Emergent Susy

- For more insights, use AdS-CFT dictionary.

Big Picture II: AdS dual

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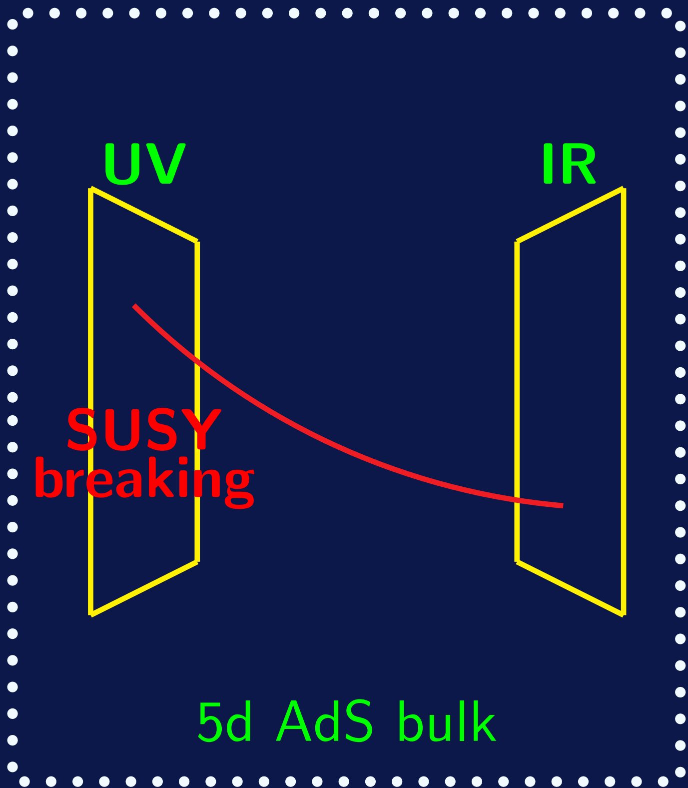

- Features
  - UV brane
  - Bulk
  - IR brane

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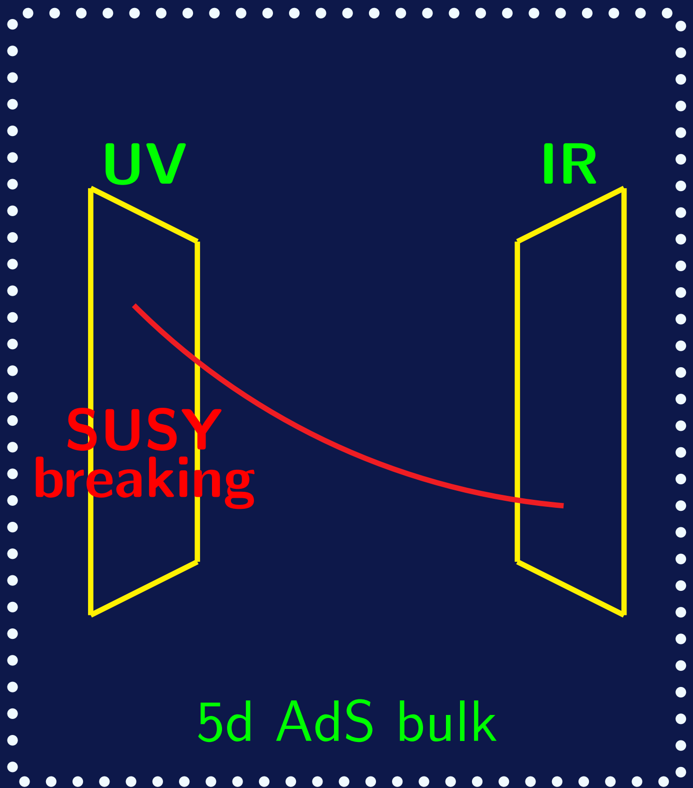

- Features
  - UV brane
  - Bulk
  - IR brane
- Subtler Features
  - Susy breaking transmission
  - Bulk scalar masses
  - Bulk vs IR-localized fields
  - Emergent Susy

- Much easier to construct an explicit example on the AdS side.

Setup

Setup I: Explicit Model

- Randall-Sundrum model on a $S^1/Z_2 \times Z_2$ orbifold

$$ds^2 = e^{-2\sigma(y)}\eta_{\mu\nu}dx^\mu dx^\nu + dy^2.$$

- Action is given by

$$S = \frac{M_5^3}{k}\int d^4x \int d^4\theta(\omega^\dagger\omega - \varphi^\dagger\varphi) + \int d^4x \int_0^\ell dy L_{hyp},$$

where $\omega = e^{-k\ell} + \cdots + \theta^2 F_\omega$ and $\varphi = 1 + \theta^2 F_\varphi$.

- Hypermultiplet action is

$$L_{hyp} = \int d^4\theta e^{-2\sigma}(\Phi^\dagger\Phi + \tilde{\Phi}^\dagger\tilde{\Phi}) + \left[\int d^2\theta e^{-3\sigma}\left(\tfrac{1}{2}\tilde{\Phi}\overleftrightarrow{\partial}_y\Phi + c\sigma'\tilde{\Phi}\Phi\right) + \text{h.c.}\right] - \delta(y)U(\Phi, \tilde{\Phi}, F, \tilde{F}) + \delta(y-\ell)\omega^3\left[\int d^4\theta\, W(\Phi, \tilde{\Phi}) + \text{h.c.}\right]$$

Setup II: EoM Solutions

- General solution (for $0 < y < \ell$) is

$$
\begin{aligned}
F &= F_0 e^{-(c-\frac{3}{2})\sigma} \\
\tilde{F} &= \tilde{F}_0 \frac{\sigma'}{k} e^{(c+\frac{3}{2})\sigma} \\
\Phi &= \Phi_0 e^{-(c-\frac{3}{2})\sigma} - \frac{\tilde{F}_0^\dagger}{(2c+1)k} e^{(c+\frac{5}{2})\sigma} \\
\tilde{\Phi} &= \tilde{\Phi}_0 e^{(c+\frac{3}{2})\sigma} - \frac{F_0^\dagger}{(2c-1)k} e^{-(c-\frac{5}{2})\sigma}
\end{aligned}
$$

- The prefactors are determined from the junction conditions.
- Digression: AdS-CFT dictionary

$$\dim(O_{\Phi,\tilde{\Phi}}) = 2 + |c \pm \tfrac{1}{2}|$$

SUSY breaking

SUSY breaking I: Various Mechanisms

- 5-d gravity loop contribution is $m_{\text{gravity}} \sim \omega^2$. [Gregoire et al(hep-th/0411216)]
- Effective 4-d Lagrangian that characterizes the soft SUSY breaking masses from the various mechanisms

$$L_{soft} = -V_{\text{eff},\omega} + \int d^4\theta \omega^\dagger \omega \Big[1 + (1 + \Phi_{\text{IR}}^\dagger \Phi_{IR}) (Q^\dagger Q + X^\dagger X + \bar{X}^\dagger \bar{X})\Big] + \int d^2\theta\, \omega^3 \Phi \bar{X} X + \text{h.c.}$$

- For the models of interest, scale of anomaly mediation is $m_{\text{anomaly}} \sim \frac{F_\omega}{\omega} = \frac{1}{\omega}\frac{\partial V_{\text{eff},\omega}}{\partial \omega} \sim \Lambda_{\text{IR}} \omega^{d-5}$. [Luty & Sundrum(hep-th/0012158)]
- After canonical normalization, direct mediation contributes $m_{\text{direct}}^2 \sim F_{\text{IR}}^\dagger F_{\text{IR}}$. Generally, flavor non-diagonal. [Goh, Luty & SPN(hep-th/0309103)]
- What about gauge mediation?

SUSY breaking II: Gauge Mediation

- Mass matrix of the scalar messengers is completely specified.

$$m^2_{\text{messenger}} = \begin{pmatrix} \omega^\dagger\omega|\Phi_{\text{IR}}|^2 + |F_{\text{IR}}|^2 & \omega F_{\text{IR}} \\ \omega^\dagger F^\dagger_{\text{IR}} & \omega^\dagger\omega|\Phi_{\text{IR}}|^2 + |F_{\text{IR}}|^2 \end{pmatrix}$$

- Scale of gauge mediation is $m_{\text{gauge}} \sim \frac{F_{\text{IR}}}{\Phi_{\text{IR}}}$ subject to certain constraints.
- For a particular class of theories, we have

$$m_{\text{soft}} \sim \begin{cases} \frac{F_{\text{IR}}}{\Phi_{\text{IR}}} & \sim \Lambda_{\text{IR}}\omega^{\frac{d-5}{3}} & \textit{gauge} & \checkmark \Rightarrow d > 5 \\ F_{\text{IR}} & \sim \Lambda_{\text{IR}}\omega^{\frac{2(d-5)}{3}} & \textit{direct} & \textit{subdom.} \\ \frac{F_\omega}{\omega} & \sim \Lambda_{IR}\omega^{d-5} & \textit{anomaly} & \textit{subdom.} \\ & \sim \Lambda_{IR}\omega & \textit{gravity} & \textit{subdom?} \end{cases}$$

Stabilization

Stabilization I: Brane Potentials

- For gauge mediation to dominate, the following is required: $(+,+)$ orbifold parity, $d > 5$ ($c < -\frac{5}{2}$) and the potentials

$$U = b(\Phi_{\rm UV} + \Phi^{\dagger}_{\rm UV}), \qquad W = a\Phi^3_{\rm IR}$$

- Effective potential is

$$V_{\rm eff} = \frac{3b}{4}\Phi_{\rm IR}\omega^{d-1} + \ldots = -A\omega^{4\frac{d-2}{3}} + \ldots$$

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- Introduce Ψ :$(+,+)$ orbifold parity, $c > 0$ (good only for stabilization) and potentials

$$U = b'\Psi_{\rm UV}^2 + b_2' F + {\rm h.c.}, \qquad W = a'\Psi_{\rm IR}^2$$

- Hence for stabilization, $d' \gtrsim \frac{2d+5}{3}$.
- Checked SUSY breaking.

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Stabilization II: Phenomenology

- Combining FCNC and Casimir constraints, and taking $m_{\text{soft}} \sim 100$ GeV and $M_5 = 2.4 \times 10^{18}$ GeV,

$$\begin{aligned} 6.16 \leq \quad & d & \leq 6.5 \\ 6.2 \times 10^8 \text{GeV} \geq \quad & \Lambda_{\text{IR}} & \geq 1.0 \times 10^8 \text{GeV} \\ 1.6 \times 10^{-3} \leq \quad & \frac{m_{\text{direct}}}{m_{\text{gauge}}} & \leq 10^{-2} \end{aligned}$$

- Phenomenological Differences with conventional GMSB
  - Heavy Gravitino
  - Non-negligible FCNC
  - Presence of radion
  - . . .
- Work In Progress.

Conclusions

Final Word

- GMES is interesting as
  - An Alternative to GMSB
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    - Averts gravitino constraints
    - Different phenomenology
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