

CONFORMAL

SEQUESTERING

SIMPLIFIED

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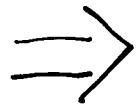
+

Martin Schmaltz

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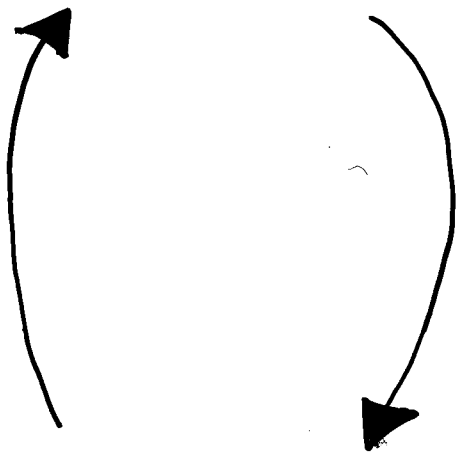
# WHY?

SUSY  
Little Hierarchy  
Problem



Broaden search  
of ideas/signals  
 $\lesssim$  experimental  
data

HOW? DIRECTION?



## SUSY FLAVOR PROBLEM

EFT Mechanisms for Sfermion flavor-blindness:

GMSB

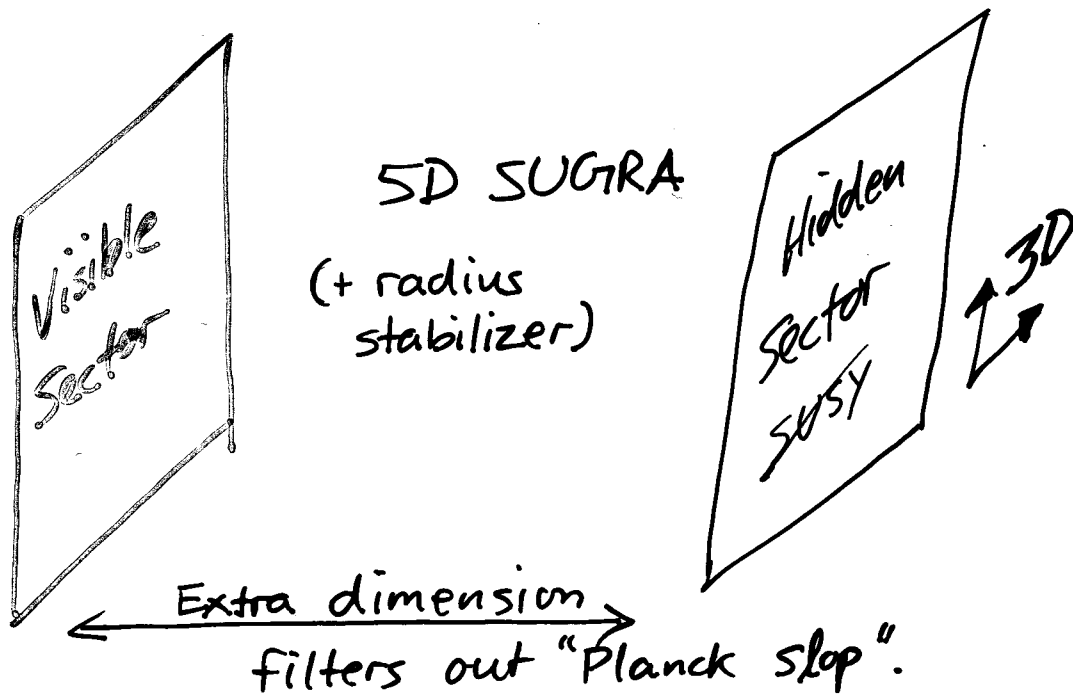
AMSB

$\tilde{G}$ MSB

Gravity-loop  
mediation  
Hybrids

Prerequisite — "Sequestering"  
ie. suppression of flavor  
"Planck stop".

# Extra-dimensional Sequestering in EFT



Randall, Sundrum '98  
Luty, Sundrum '99

String Theory UV completion  
might spoil sequestering  
by overpopulating the Bulk??

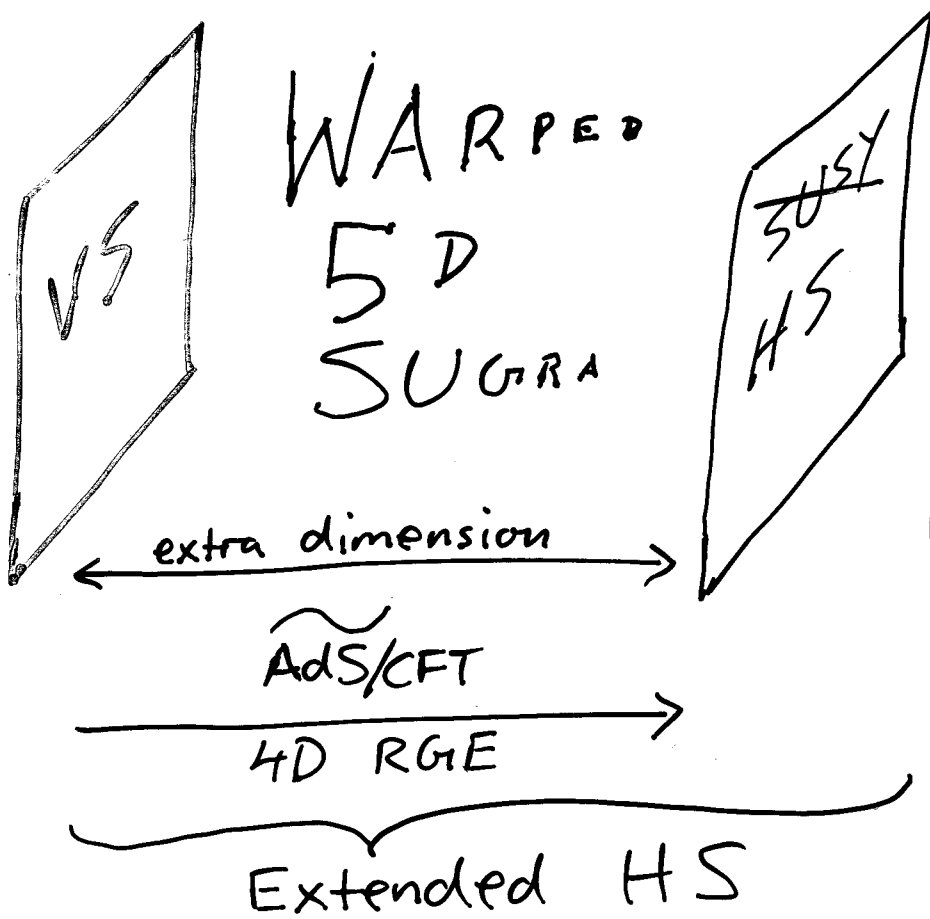
Anisimov, Dine, Graesser, Thomas '02

Kachru, McGreevy, Suracek '06

Is there a renormalizable path to  
sequestering? What are the rules?

# Conformal Sequestering

For  $\tilde{G}$ MSB: Nelson, Strassler '00'0



For AMSB:  
Luty, Sundrum '01, '02, '03

Advantage:

Extra-dimensional  
non-renormalizable  
 $N=2$  SUGRA + ...  
EFT



Broader class of  
4D renormalizable  
 $N=1$  flat space  
QFT.

(but strongly  
non-perturbative)

# LITTLE SUGRA

General Coord. Invariance  $\Rightarrow$  Conformal Invariance

requires  $g_{\mu\nu}^{(x)}$

requires only

$$g_{\mu\nu}^{(x)} \equiv \phi^2(x) \eta_{\mu\nu}$$

+ SUSY  $\downarrow$

Only part of SUGRA that can get Lorentz invariant VEV  $\leftarrow$

$\Phi \equiv$  chiral S'Field.  
"compensator"

$\Rightarrow$  AMSB

Randall, Sundrum '98

Giudice, Luty, Murayama, Rattazzi '98

$$\mathcal{L}_{\text{VS}} = \int d^4\theta Z(\mu|\Phi|) |Q|^2 + \int d^2\theta \underbrace{\tau(\mu\Phi)}_{\text{scale invariant}} W_\alpha^2 + \lambda Q^3$$

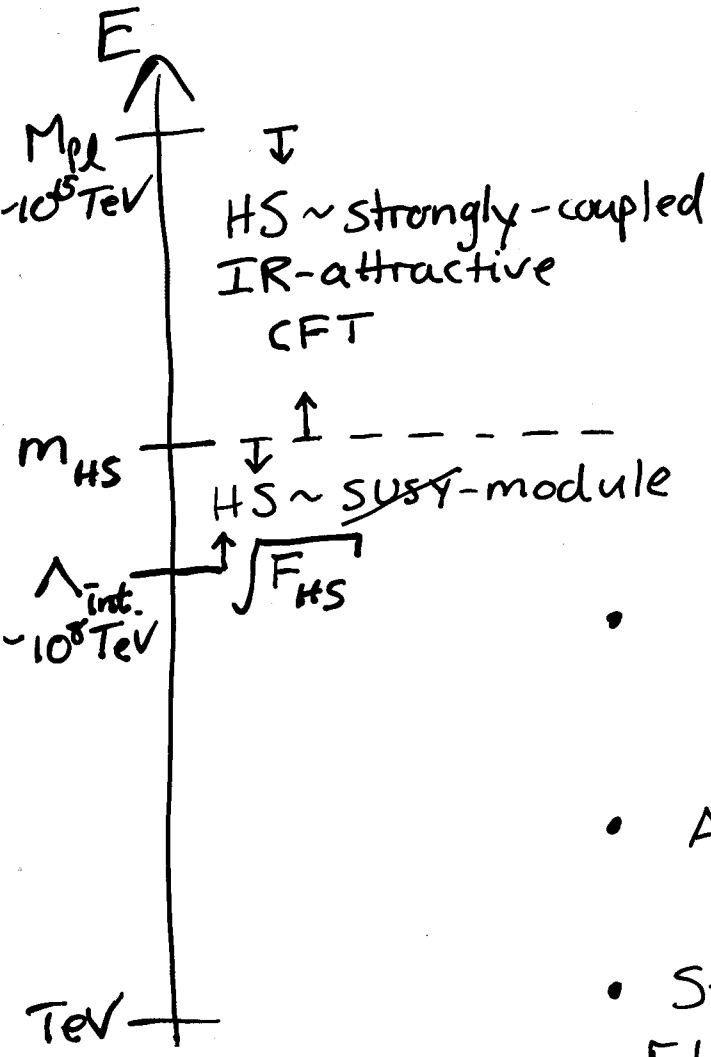
$$\Rightarrow \left. \begin{aligned} m_{\frac{1}{2}} &\sim \frac{\beta(g)}{g^2} F_\Phi \\ m_0^2 &\sim \frac{d\delta(g)\beta(g)}{dg} |F_\Phi|^2 \\ A &\sim \gamma F_\Phi \end{aligned} \right\} \approx \text{Flavor-blind.}$$

# ~~FLAVOR~~ PLANCK SLOP

Flat spacetime  $\Rightarrow F_{\Phi} \sim F_{HS} / M_{Pl}$

$\Rightarrow \Delta \mathcal{L} = \frac{c_{ij}}{M_{Pl}^2} \int d^4\theta \underbrace{X^\dagger X}_{HS} \underbrace{Q_i^\dagger Q_j}_{VS}$  dominates AMSB naively.

## CONFORMAL SEQUESTERING



$$\mathcal{L}_{HS_{CFT}} + \sum_{\mathcal{O}} \mathcal{O}_{HS} \cdot \tilde{\mathcal{O}}_{VS}$$

$\downarrow$  RGE

$$\mathcal{L}_{HS_{CFT}} + \sum_{\mathcal{O}} \left(\frac{\mu}{M_{Pl}}\right)^{\gamma_{\mathcal{O}}} \mathcal{O}_{HS} \cdot \tilde{\mathcal{O}}_{VS}$$

- The  $\gamma_{\mathcal{O}}$  hard to compute, but  $\sim \mathcal{O}(1)$  & +ve.
- AMSB requires  $\left(\frac{m_{HS}}{M_{Pl}}\right)^{\gamma} \sim 10^{-6}$  so we are at the edge.
- Strongly motivates program of Flavor & CP tests.

# SYMMETRY:

## FRIEND AND FOE

Discovering + understanding strongly-coupled CFTs (as basis for HS) greatly aided by (HS) symmetries.

But symmetry  $\Rightarrow$  symmetry currents.

e.g.  $t_{\alpha\beta} \bar{\Psi}_{X_\alpha} \gamma_\mu \Psi_{X_\beta} \in t_{\alpha\beta} \underbrace{X_\alpha^\dagger X_\beta}_{\text{vanishing anomalous dimension!}}$

$\uparrow$   
HS symmetry generator

$$\Delta \mathcal{L} = \int d^4\theta t_{\alpha\beta} X_\alpha^\dagger X_\beta Q_i^\dagger Q_j$$

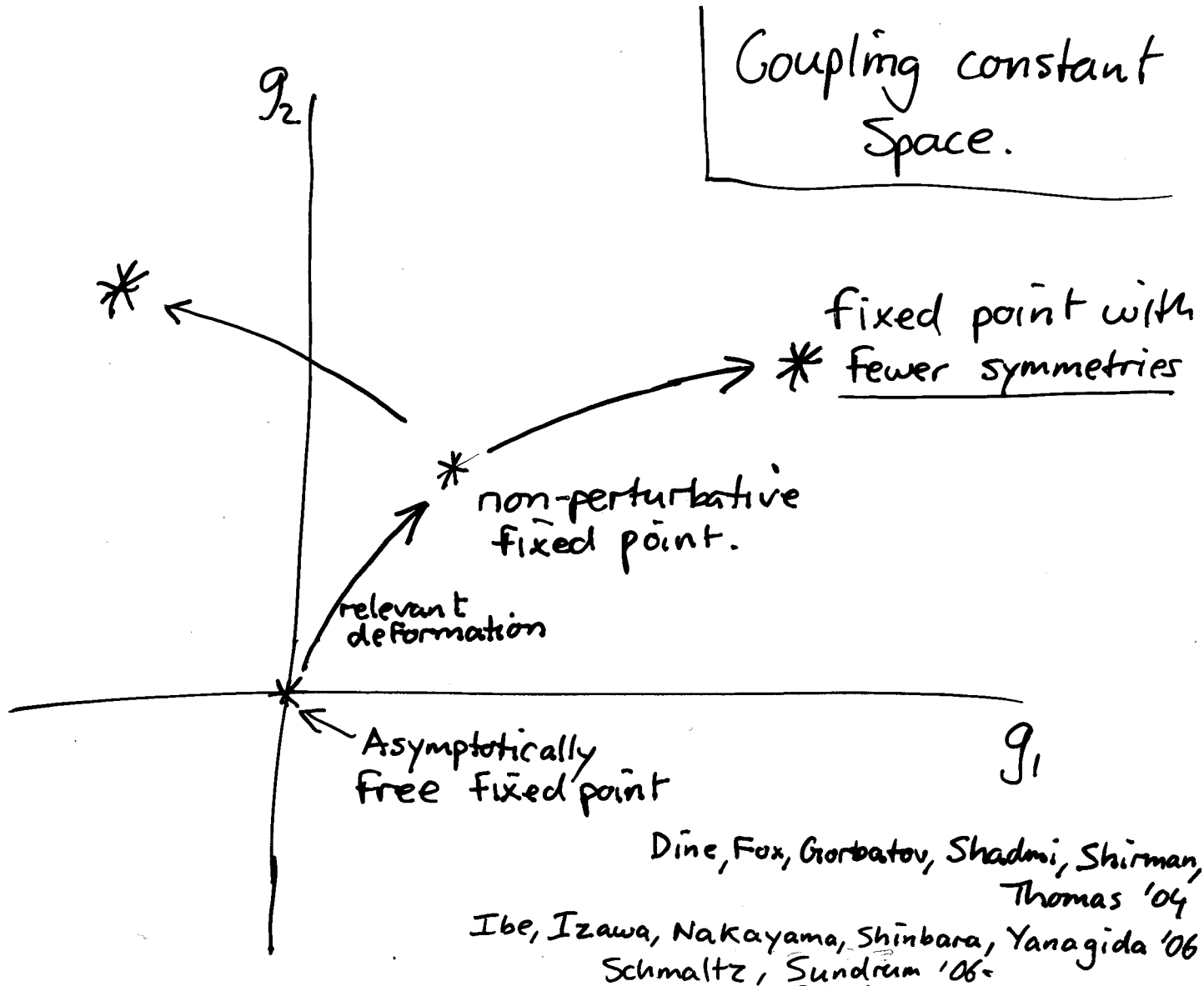
DANGEROUS!

Luty, Sundrum '01

Categorization of specific dangers/loopholes:

Schmaltz, Sundrum '06

# DESIGNER CFTs FOR HS MODEL-BUILDING



How generic & plausible is  
conformal sequestering in this  
CFT LANDSCAPE ?



# SIMPLE SAMPLE

Schmaltz, Sundrum '06

$$\mathcal{L}_{HS} = \int d^4\theta (\bar{X}_\alpha^\dagger \bar{X}_\alpha + X_\alpha^\dagger X_\alpha + A^\dagger A) + \int d^2\theta W_\alpha^2$$

$$+ \int d^2\theta (\lambda_* A^3 + m_A A^2 + m_x \bar{X}_\alpha X_\alpha) + h.c.$$

$$m_x \lesssim m_A \ll M_{Pl}$$

SU(N) gauge theory + adjoint A

+ F "flavors"  $X_\alpha + \bar{X}_\alpha$ ,  $N < F < \frac{3N}{2}$

$m_x = 0$  : Kutasov '95; Kutasov, Schwimmer '95

$\Rightarrow$  flows to IR CFT,  $g_*$ ,  $\lambda_*$  STRONG,  
until  $m_A$ , below which  $\rightarrow$  SQCD<sub>N,F</sub>

$m_x \neq 0$  SQCD<sub>N,F</sub> : Intriligator, Seiberg, Shih '06

$\Rightarrow$  ~~SUSY~~  
by metastable vacuum

$$F_{(\bar{X}X)} \sim m_x \Lambda_{SQCD}$$

$$\xrightarrow{\text{here}} \sim m_x^{(IR)} m_A$$

lifetime  $\propto \exp(-\frac{m_A}{m_x})^{\#}$

# SYMMETRIES OF CONFORMAL REGIME

( $m_X, m_A = 0$ )

V. Naively  $U(F)_X \otimes U(F)_{\bar{X}} \otimes U(1)_A \otimes U(1)_R$

= 
 $SU(F)_X \otimes SU(F)_{\bar{X}} \otimes U(1)_{\text{"Baryon"}}$ 
 $\otimes U(1)_R$

$\otimes U(1)_{\text{"axial"}}$   $\otimes U(1)_A$   
 ↓ strong anomaly      ↓ strong  $\lambda_*$

- i.e. symmetries of SQCD.

Imposing  $SU(F)_{X+\bar{X}}$  symmetry on theory (or weakly gauging it) eliminates  $U(1)_{\text{axial}}$

$\Delta \mathcal{L}_{\text{HS-VS}} = \int d^4\theta X_\alpha^\dagger t_{\alpha\beta} X_\beta Q_i^\dagger Q_j$   
 $SU(F)_X \otimes SU(F)_{\bar{X}}$  generator

- $U(1)_{\text{Baryon}}$  accidental symmetry of entire HS model  $\Rightarrow$  on general grounds  $(\bar{X}^\dagger \bar{X} - X^\dagger X)|_D = 0$
- Emergent symmetries can be sought in dual description. Absent for  $F > N$  ✓ Kutasov 1995

• HS FULLY SEQUESTERS.

# FUTURE

GMSB + AMSB Hybrids in conformal sequestering  
of Poppitz-Trivedi ('97) type: Sundrum '04

Can  $SU(F)$  gauge theory  $\Rightarrow$   $SU(5)_{vs}$  GUT?

Model-building / phenomenology targeting  
Weak scale little hierarchy problem.

SIMPLICITÉ — GENERICITÉ — PLAUSIBILITÉ

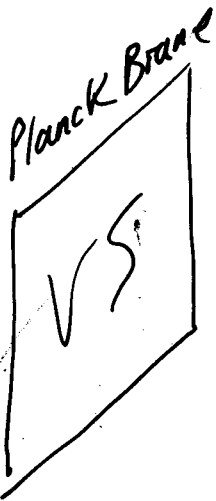
✓

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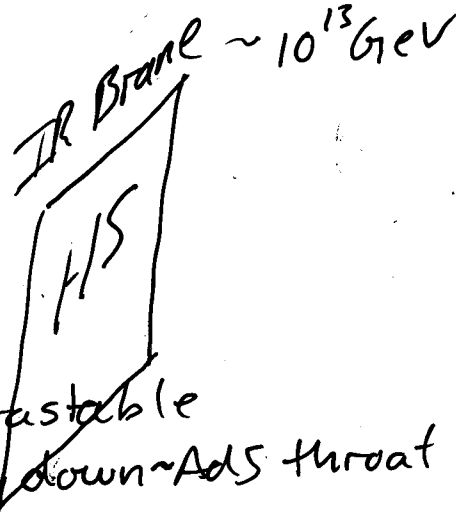
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related: Ooguri, Ookouchi '06  
CFT landscape

AdS/CFT "dual" cartoon:



Warped Bulk  
SUGRA  
+  $U(1)^n$   
gauge theory



Metastable  
SUSY down  $\sim$  AdS throat

What is connection of these ideas to  
post-KKL.T string theory / world view?