

SUSY Breaking, Sequestering and String Theory

Daniel Green
SLAC and Stanford

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Why SUSY?

- **Solves** the Hierarchy Problem
- Gives a **computational** framework for understanding flavor problems, electro-weak symmetry breaking, etc.
- **May** yield dark matter candidates, Gauge coupling unification, etc.

What if the LHC finds SUSY?

- Can we explain the parameters in the MSSM (i.e. understand ~~SUSY~~ and its mediation)?
- Is Dark Matter explained?

Making flavor and soft masses work often ruins dark matter's 'prediction' of the weak scale

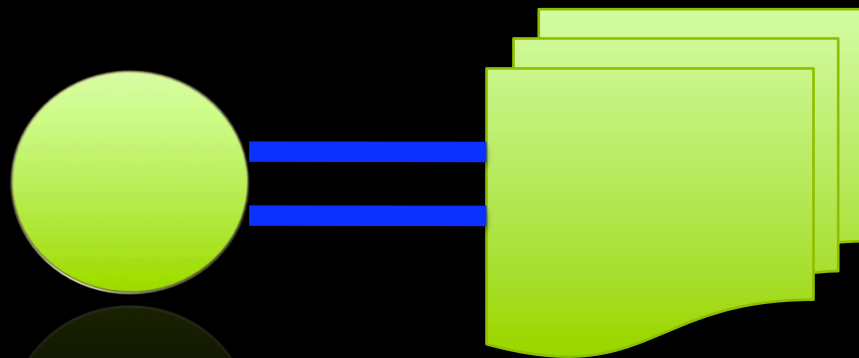
Can String Theory Help?

- New Mechanisms for ~~SUSY~~ and Mediation
- Allows for calculations in strongly coupled field theory models

Stringy Instantons


- Euclidian Branes are **localized in time** and extended in space.
- Strings that stretch from these branes to other branes gives rise to **Non-Perturbative effects**.
- Sometimes, these effects are **purely stringy**

Euclidean
Brane



Gauge Theory
on a Stack of
Branes

Branes at Singularities

- Singularities can contain many shrunken spheres
- Branes Wrapping these spheres give rise to gauge theory and particle spectrum
- If a sphere is not wrapped by brane, Euclidean Brane will  Stringy Instanton Aharony, Kachru;
Kachru, Simic

SUSY Breaking at Singularities

- These Stringy Instanton Effects can give rise to ~~SUSY~~ in extremely simple models.
- Can make 'retrofitted' versions of the Fayet, Polonyi and O'Raifeartaigh models with minimal particle content. *Aharony, Kachru, Silverstein*
- Using geometric transitions, can sum all the instantons *Aganagic, Beem, Kachru*

Sequestering

F-term ~~SUSY~~, Gravity and Gauge mediation give:

SUSY breaking F-term

$$\int d^2\theta \frac{S}{M} W_\alpha W^\alpha \quad \int d^4\theta \frac{S^\dagger S}{M^2} \Phi^\dagger \Phi$$

SM fields SM fields


Theory “Sequesters”: these contributions to the soft masses are **exponentially suppressed**

How to Sequester

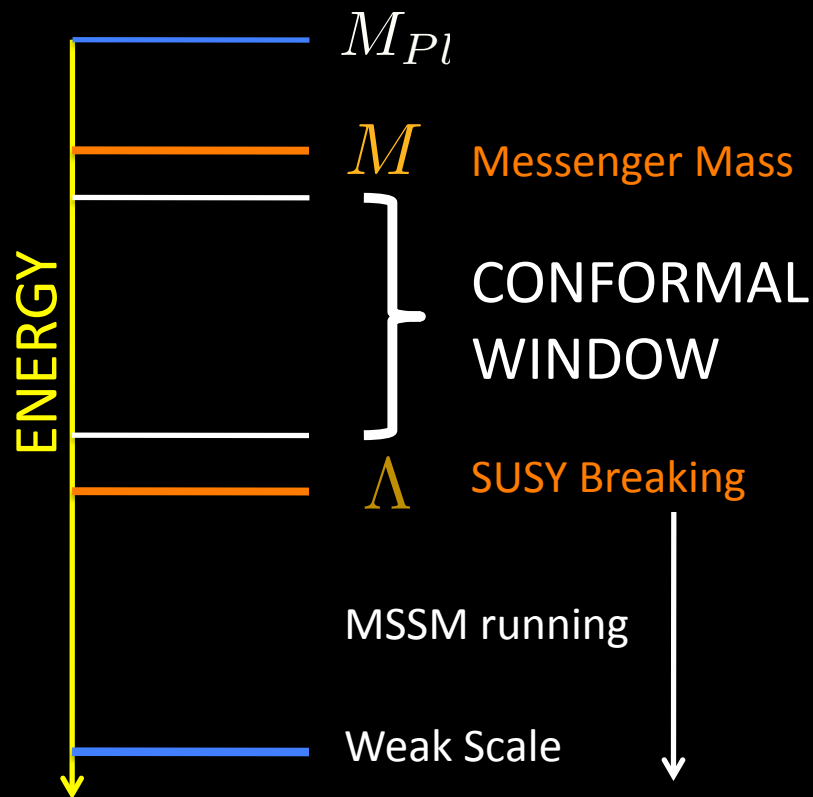
- Models with Extra Dimensions: We can separate fields by **large distances**



- Conformal Sequestering: ~~SUSY~~ Sector is Strongly coupled and S has a **large anomalous dimension**


$$S \rightarrow S \left(\frac{\Lambda}{\mu} \right)^{\Delta_1} \quad S^\dagger S \rightarrow \left(\frac{\Lambda}{\mu} \right)^{\Delta_2} S^\dagger S$$

Sequestered Gauge Mediation



Gravity Mediated Effects are suppressed by Sequestering

Gauge Mediated masses suppressed relative to gravitino mass



How Does this Help?

- Solves $\mu/B\mu$ problem if $2\Delta_1 < \Delta_2$
 - quadratic operators are suppressed relative to linear operators

Murayama, Nomura, Poland;
Roy, Schmaltz
- Get **Neutralino** Dark Matter!
 - Flavor problem usually means gravitino LSP
 - Sequestering allows us to increase the scale of SUSY breaking with gauge mediated spectrum

Craig, DG, Liu

Calculating in String Theory

- Want to know the Anomalous Dimensions
 - Field theory is strongly coupled so this is hard
- AdS-CFT relates these to a **mass spectrum**, so is calculable!
- Need to make sure there aren't dangerous operators, with canonical dimension!

Sequestering in String Theory

- Can Calculate Anomalous dimensions using AdS/CFT for Conformal Sequestering

Kachru, McAllister, Sundrum

- Equivalently can directly construct Extra-dimension Sequestering in String theory
- **Warping** is helpful

Kachru, McAllister, Sundrum

~~SUSY~~ and AdS/CFT

- Dynamical SUSY breaking using AdS/CFT side is still being developed

- Not purely D-term or F-term in CFT

DeWolfe, Kachru, Mulligan

- One would like to construct a calculable model with the nice properties of sequestered gauge mediation.

In Progress

Conclusion

- String theory can provide **new models** for SUSY breaking
- AdS/CFT allows for **Calculations** in Strongly Coupled models
- May provide insights into SUSY model building

Conclusion

Strings may help us tie up some of the loose ends of SUSY model building