Vacuum distribution and tuning for F-type SUSY breaking

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Outline

Motivations

The effective field theory method and vacuum distributions

Including mass scales, results and implications

to appear [arXiv:1009.???? [hep-th]].

Motivations (1)

The SUSY breaking landscape

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- Including different mass scales M_S, M_K, M_P. As their ratio changes, how does the distribution behave?
- What is the limiting behaviour as some ratio of scales goes to 0? e.g. gravity decoupling, nearly canonical K"ahler.

Motivations (2)

Comparison to the SUSY vacuum distribution

- $N \sim F_0^6 \Lambda_0$ favors the highest F. But SUSY vacua live on other branches. How is the total number of SUSY-breaking vacua compared to SUSY ones?

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Model building

- R-symmetries are widely used to get SUSY breaking.
- Alternatively, one can tune parameters to get metastable SUSY breaking vacua. How much tuning in general do we need?

The general method (1)

The effective one-field model

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- The model is

$$W = \sum_n a_n z^n, \quad K = \sum_{n,m} c_{nm} \bar{z}^n z^m \ ,$$

$$\text{for SUSY:} \quad V = \frac{1}{\bar{\partial}\partial K} \bar{\partial}\bar{W} \partial W \ ,$$

$$\text{for SUGRA:} \quad V = e^K \left(\frac{1}{\bar{\partial}\partial K} \bar{D}\bar{W} D W - 3\bar{W} W \right) .$$

The general method (2)

Constraints on parameters

- Conditions to get SUSY breaking vacua of interest, Each condition gives some constraint on a_n's:
  1. Small SUSY breaking scale: $\Theta(F < F_0)$,
  2. Stationary: $\delta(V')$,
  3. Metastable: $\Theta(V'' > 0)$,
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- The total number of vacua is

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& N(F < F_0, 0 < V < \Lambda_0) \\
& = \int d\mu(a_n)\Theta(F < F_0)\delta(V')\Theta(V'' > 0)\Theta(0 < V < \Lambda_0) \ .
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- In small region $d\mu(a_n) \sim d^2a_0 d^2a_1 \ldots$.

Distributions (1)

General model calculation

- Take the effective one-field model $W = \sum_n a_n z^n$, $K = \sum_{n,m} c_{nm} \bar{z}^n z^m$, either SUSY or SUGRA. $a_n \sim c_{nm} \sim 1$.

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- Make $c_{11} = 1$, $c_{0n} = 0$, we have

$$
\begin{aligned}
V &= a_1^* a_1 - 3a_0^* a_0 \ , \\
\partial V &= 2a_1^* a_2 - 2c_{12} a_1^* a_1 - 2a_0^* a_1 \ , \\
\partial^2 V &= 6a_1^* a_3 - 8c_{12} a_1^* a_2 + (8c_{12}^2 - 6c_{13}) a_1^* a_1 + \\
&\quad - 2a_0^* a_2 - 2c_{12} a_0^* a_1 \ , \\
\bar{\partial}\partial V &= 4a_2^* a_2 - 4c_{12}^* a_1^* a_2 - 4c_{12} a_1 a_2^* + \\
&\quad + (8c_{12}^* c_{12} - 4c_{22}) a_1^* a_1 - 2a_0^* a_0 \ .
\end{aligned}
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Distributions (2)

Counting vacua

- Constraints on a_n's:

$$a_1 \sim a_2 \sim F, \quad a_3 \lesssim F, \quad a_0 \sim F - \frac{\Lambda}{F} \; .$$

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- The result is

$$N(F < F_0, 0 < V < \Lambda_0) \sim F_0^2 \cdot F_0^2 \cdot F_0^2 \cdot \Lambda_0 \sim F_0^6 \Lambda_0 \ .$$

Counting with mass scales (1)

General model with mass scales

- Assume 3 mass scales:
  - M_S: scale of SUSY dynamics,
  - M_K: scale of non-minimal corrections to Kähler,
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$$\text{for SUGRA:} \quad V = e^{\frac{K}{M_P^2}} \left(\frac{1}{\bar{\partial}\partial K} \bar{D}\bar{W} DW - \frac{3\bar{W}W}{M_P} \right) \ ,$$

$$DW = \partial W + \frac{1}{M_P^2} W \partial K \ .$$

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a_1 &\sim F \ , \\
a_2 &\sim F M_S \Big(\frac{1}{M_K} + \frac{1}{M_P}\Big) \ , \\
a_3 &\lesssim F M_S^2 \Big(\frac{1}{M_K^2} + \frac{1}{M_P^2}\Big) \ , \\
a_0 &\sim \frac{M_P}{M_S}\Big(F - \frac{\Lambda}{F M_S^4}\Big) \ .
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- $\delta(V') = \delta^2(\frac{1}{M_S}(z - z_0)) \sim F^2 M_S^4 (\frac{1}{M_K^4} + \frac{1}{M_P^4}) \delta^2(a_2 - a_{2(0)})$.

Counting with mass scales (3)

The result

- For SUSY:

$$N(F < F_0) \sim F_0^6 \frac{M_S^8}{M_K^8} \; .$$

$N \to 0$ as $M_K \to \infty$.

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- For SUGRA:

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  $M_K \to \infty$, N is still finite.

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SUSY breaking by parameter tuning

Amount of tuning

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- (THE END.)