Classification of Shift-Symmetric No-Scale Supergravities

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Introduction

No-Scale Supergravity ($\mathcal{N} = 1$, $d = 4$) $\equiv$ Models with $V = 0$ or $V \lesseqgtr 0$

- Studied for phenomenological reasons
- Low energy effective theory of string compactifications
- Many examples are known, but classification is still lacking (some questions remain open)
- Our focus: Models with a perturbative shift-symmetry
- Duality: Shift-symmetric chiral models $\leftrightarrow$ models with real linear multiplets

Goal: Classify shift-symmetric no-scale supergravities both for chiral and real linear multiplets (ungauged)

Chiral and Linear Multiplets

Chiral Multiplets T_i:

- $\bar{D}_{\dot{\alpha}} T_i = 0$
- Bosonic field content (T_i, F_i)
- $V = \mathrm{e}^K |W|^2 (K^{T_i T_j} K_{T_i} K_{T_j} - 3)$
- No-scale condition: $K^{T_i T_j} K_{T_i} K_{T_j} = p$

Real Linear Multiplets L^i:

- $L^i = \bar{L}^i$ and $(\bar{D}^2 - 8R) L^i = 0$
- Bosonic field content (L^i, B_2^i)
- $V = \mathrm{e}^K |W|^2 (L^i K_{L^i} - 3)$
- No-scale condition: $L^i K_{L^i} = p$

More on real linear multiplets in: [Binetruy, Girardi, R. Grimm '01], [T. Grimm '05]

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No-Scale Differential Equation

No-Scale Conditions as Partial Differential Equations

$$\begin{cases} K^{T_i T_j} K_{T_i} K_{T_j} = p & \text{(Chiral)} \\ L^i K_{L^i} = p & \text{(Real Linear)} \end{cases}$$

Define $K = -p \log Y$ and $\phi_i = \mathrm{Re}(T_i)$, then the no-scale condition reads

$$\begin{cases} \det(Y_{\phi_i \phi_j}) = 0 & \text{(Chiral)} \ , \quad \text{also in:} \\ L^i Y_{L^i} = -Y & \text{(Real Linear)} \end{cases}$$

[Barbieri, Cremmer, Ferrara '85]

Illustrative example: Single-field model [Cremmer, Ferrara, Kounnas, Nanopoulos '83]

$$K = -p \log(T + \bar{T}) \ , \qquad K = p \log(L)$$

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Solutions to No-Scale PDEs

No-Scale Models for Linear Multiplets

$$K = -p \log Y \ , \quad \text{and } Y \text{ homogeneous of degree } -1$$

Solving the homogeneous Monge-Ampere equation is more involved.
(Earlier studies in [Chaundy '35] [Fairlie, Leznov '95])

No-Scale Models for Chiral Multiplets

$$K = -p \log[\phi_i g^{(i)}(u_1, \ldots, u_{n-1}) + \tilde{Y}(u_1, \ldots, u_{n-1})]$$

$$u_A = u_A(\phi_1, \ldots, \phi_n) \ , \qquad A = 1, \ldots, n-1$$

$$\phi_i g^{(i)}_{u_A} + \tilde{Y}_{u_A} = 0 \ , \qquad A = 1, \ldots, n-1$$

Consistency check: Solutions match upon dualisation!

Special Classes of Solutions for Chiral Multiplets

Procedure for constructing explicit solutions:

1. Choose functions $(g^{(i)}, \tilde{Y})$
2. Solve constraint equations for $u_A(\phi)$

Subclass: Homogeneous-Type Kähler Potentials

$K = -p \log Y$ and Y homogeneous of degree 1 [Ferrara, Kounnas, Zwirner '94]

$\longrightarrow$ Arise by setting $\tilde{Y} = 0$

Many more non-homogeneous solutions exist!
Example: Particular solution in two-field case

$$K = -p \log(2 - \Delta) - \tfrac{p}{2}\Delta \ , \qquad \text{where} \qquad \Delta = \sqrt{\phi_2^2 - 4\phi_1}$$
$$W = \exp(\tfrac{p}{4} T_2)$$

No-Scale Supergravity from String Theory 1

Homogeneous type Kähler potentials from string compactifications:

1. Dilaton-Kähler moduli subsector of Heterotic on CY3 at large volume [Strominger '85], ...
2. Dilaton-Kähler moduli subsector of IIB on CY3 orientifolds with $O3/O7$ or $O5/O9$-planes and flux [Grimm, Louis '04]
3. Dilaton-Kähler moduli-complex structure moduli sector of IIA on CY3 orientifolds with $O6$-planes and flux [Grimm, Louis '04]
4. Similarly: M-theory on CY4 $\rightarrow \mathcal{N} = 2$ in $d = 3$ [Haack, Louis '01]

No-Scale Supergravity from String Theory 2

IIB 10D perturbative corrections [Becker, Becker, Haack, Louis '02]

$$g_s^{-2}(\alpha')^3 \quad + \quad (\alpha')^3 \quad + \quad \cdots$$

$g_s^{-2}(\alpha')^3$ → Homogeneity

$(\alpha')^3$ → ~~Homogeneity~~

Similarly homogeneity is preserved by α-corrections to M-theory

[Grimm, Keitel, Savelli, Weissenbacher '13]

Non-homogeneous no-scale type Kähler potentials are very 'abundant', but do they also arise in string theory?

Conclusions

- We solved the shift-symmetric no-scale condition for chiral and real linear multiplets and showed that the solutions match
- Non-homogeneous examples exist and can be constructed explicitly from the result

Future Directions:

- Construct more explicit examples
- Try to classify general no-scale models
- Can non-homogeneous Kähler potentials arise from string theory?

Thanks for your attention!