New FI D-terms in supergravity (Part 2)

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Outline

- FI D-term in supergravity
- New D-term [Cribiori, Farakos, Tournoy, Van Proeyen '17]
- Matter coupling
- D-brane origin

Reminder: FI term in supergravity

D-term breaking

- vector multiplet $V = \{v_\mu, \lambda, D\} \to$ D-term breaking: $< D > \neq 0$ [Fayet, Iliopoulos '74; Freedman '77]

For D-term breaking embed: ξD (= Fayet-Iliopoulos term) in supergravity

$$\mathcal{L} = \frac{1}{2}D^2 - \xi D + \dots \tag{1}$$

For this we take

$$-\frac{1}{4}\left[\lambda^2\right] = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} + \frac{1}{2}D^2 + \text{fermions} \tag{2}$$

$$+$$

$$\mathcal{L}_{\text{FI}} = -\xi D + \dots \tag{3}$$

New D-term

- New way to embed Fayet-Iliopoulos D-term to supergravity [Cribiori, Farakos, Tournoy, Van Proeyen '17]
- No gauging of the R-symmetry required
- Linear supersymmetry off-shell
- No higher derivative terms in the bosonic sector
- Electromagnetic duality

Pure FI term

New D-term

$$\mathcal{L}_{\text{New}} = -\xi \left[\frac{\lambda^2 \bar{\lambda}^2}{\Sigma(\bar{\lambda}^2)\bar{\Sigma}(\bar{\lambda}^2)} (V)_D \right]_D - \frac{1}{4} \left[\lambda^2 \right]_F \tag{4}$$

- No gauged $U(1)_R$
- Ill-defined $\xi \to 0$ limit: No limit where supersymmetry is restored
- Scalar potential

$$V = \frac{1}{2}\xi^2 \tag{5}$$

Matter coupled FI term

New D-term

$$\mathcal{L}_{\text{New}} = -3\left[e^{-\frac{1}{3}K}\right]_D + [W]_F - \xi\left[\frac{\lambda^2\bar{\lambda}^2}{\Sigma(\bar{\lambda}^2)\bar{\Sigma}(\bar{\lambda}^2)}(V)_D\right]_D - \frac{1}{4}\left[\lambda^2\right]_F \tag{6}$$

- Kähler potential $K(\Phi^i, \bar{\Phi}^i)$ and superpotentital $W(\Phi^i)$ with N chiral superfields $\Phi^i = \left\{\phi^i, \Omega^i, F^i\right\}$
- No gauged $U(1)_R \rightarrow$ **generic W is allowed**
- Ill-defined $\xi \rightarrow 0$ limit: No limit where supersymmetry is restored
- Scalar potential

$$V = e^K\left(|\nabla W|^2 - 3|W|^2\right) + \frac{1}{2}\xi^2 e^{2K/3} \tag{7}$$

Example

Consider one chiral superfield T

$$K(T,\bar{T}) = -3\log(T+\bar{T})\,, \quad W(T) = W_0 + Ae^{-aT} \qquad (8)$$

couple to the D-term

$$V = V_{\rm sugra} + \frac{\xi^2}{2}e^{2K/3} \quad \rightarrow \quad V = V_{\rm sugra} + \frac{\xi^2}{2(T+\bar{T})^2} \qquad (9)$$

- Same scalar potential of the KKLT uplift! [Kachru, Kallosh, Linde, Trivedi '03]
- No need for constrained superfields and non-linear susy
- Back and forth relationship between de Sitter supergravity models [Bergshoeff, Freedman, Kallosh, Van Proeyen '15; Hasegawa, Yamada '15'] and new D-term [Cribiori, Farakos, Tournoy, Van Proeyen '17]

DBI origin?

- The nilpotent superfield can be found on the worldvolume of the $\overline{D3}$-brane action [Kallosh, Vercnocke, Wrase '14]
- What if we keep the complete vector multiplet on $\overline{D3}$
  - Consistent truncation
  - Generically the only massless fields are the vector v_μ and the goldstino

What we've discovered so far [Cribiori, Farakos, Tournoy]

Take the supersymmetrized BI action

$$\mathcal{L}_{BI} = -\det(A_m^n)\sqrt{\det\left(\eta_{ab} + \mathcal{F}_{ab}\right)} \quad (10)$$

$$A_m^n = \delta_m^n + \bar{\lambda}\gamma^n\partial_m\lambda \quad (11)$$

$$\mathcal{F}_{ab} = (A^{-1})_a^n(A^{-1})_b^m F_{mn} \quad (12)$$

and take the expansion for small field-strength

$$\mathcal{L} = -\det(A_m^n) - \frac{1}{4}\det(A_m^n)\mathcal{F}^2 \quad (13)$$

- Equivalent to the new D-term Lagrangian
- **Not** equivalent to the standard FI Lagrangian!

Conclusions

New D-term:

- Embeds FI terms in supergravity without gauging R-symmetry
- Captures effective physics of KKLT
- Can be recast into known nilpotent sugra models and vice versa
- Has a string theory origin

Thank You!