T-Branes and α'-Corrections

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Based on: *Marchesano, S.S. '16*

Introduction

- Computed α'-corrections to BPS conditions of IIB/F-theory 7-brane background with T-branes
- Work in local perspective on a $\mathbb{C}^2$-patch: World-volume theory is described by a twisted 8d SYM with bosonic components A, Φ *[Beasley et al., 2009]*
- A diagonal Higgs-vev can be understood as a system of (intersecting) 7-branes
- Backgrounds for which the Higgs Φ acquires a vev, which is non-zero and nilpotent over some locus have been dubbed *T-branes*, and are not always related to intersecting 7-branes

  [Cecotti et al., 2011]

Introduction

- Very distinct effects from diagonal vevs: Phantom curves, more matter, matter at points *[Collinucci and Savelli, 2014]*
- Renewed interest in F-theory:
  Matrix factorisations *[Collinucci and Savelli, 2015]*,
  limiting mixed Hodge structures *[Anderson et al., 2014]*
- Also phenomenologically interesting: Induce mass for top-quark in SU(5) GUTs *[Font et al., 2013]*

D-terms and Generalised Calibrated Submanifolds

- A BPS brane is related to a generalised calibrated submanifold: $(\Sigma, \mathcal{F})$
- compactification data can be packed into two pure spinors $\Psi_1 = e^{iJ}$, $\Psi_2 = \Omega$ (unwarped case) *[Grana et al., 2005]*
- Calibration conditions split up into
  $W = \int_{\mathcal{S}} \mathrm{P}\left[\Psi_2 \wedge e^{B}\right] \wedge e^{\lambda F}$
  $D = \int_{\mathcal{S}} \mathrm{P}\left[\mathrm{Im}\Psi_1 \wedge e^{B}\right] \wedge e^{\lambda F}, \qquad \lambda = 2\pi\alpha'$
- in low-energy description correspond to F- and D-term conditions *[Martucci, 2006]*

D-terms and Generalised Calibrated Submanifolds

- F-term conditions are protected from α'-corrections
- D-terms can be brought to the form

$$D = \lambda \int_{\mathcal{S}_4} S\Big\{\omega \wedge F + 2i\lambda^2 \mathrm{D}\Phi \wedge \overline{\mathrm{D}\Phi} \wedge F + [\Phi, \overline{\Phi}](\omega^2 - \lambda^2 F \wedge F)\Big\}$$

- intersecting brane backgrounds $[\Phi, \overline{\Phi}] = 0$
- for T-branes this is not the case

α'-Corrections to Intersecting branes

- Before dealing with T-branes, consider simpler case $\Phi_{\rm h} = \begin{pmatrix} nx & 0 \\ 0 & -nx \end{pmatrix}$. D-terms simplify to

$$D = \lambda \int_{\mathcal{S}_4} \Big(\underbrace{\omega \wedge F + 2i\lambda^2 \partial\Phi \wedge \overline{\partial\Phi} \wedge F}_{\mathrm{P}_{\rm ab}[\omega]\wedge F} \Big)$$

- Diagonal flux satisfies D-term equations

$$\Rightarrow F_{x\bar{x}} = -\left(1 + 4\lambda^2 |n|^2\right) F_{y\bar{y}}$$

- it introduces non-primitive flux with higher order α'-corrections

α'-Corrections to Intersecting branes

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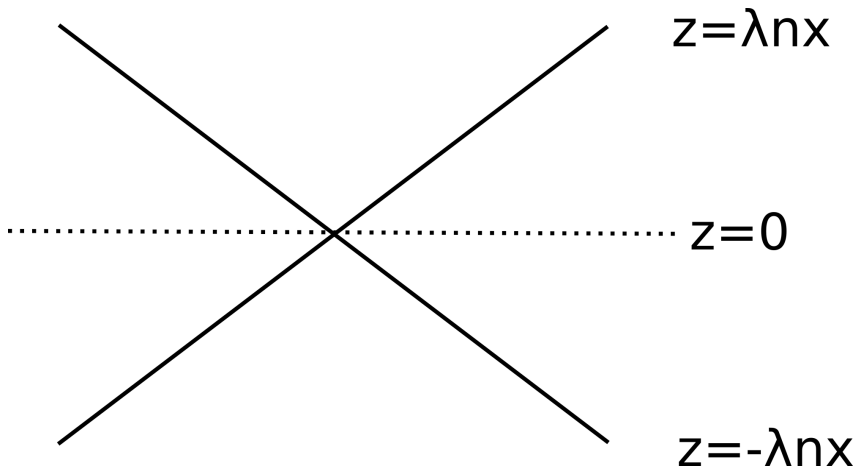
- We considered gauge theory on $\{z = 0\}$ but the flux is primitive along the branes location $\{z = \pm\lambda nx\}$



α'-Corrections to a T-brane

- Consider effect of T-brane w/o presence of further int. branes
  $\Phi = \begin{pmatrix} 0 & e^f \\ axe^{-f} & 0 \end{pmatrix}$
- We parametrise the flux as $F = -i\partial\overline{\partial} f \sigma_3 + F^{\mathrm{id}} \cdot \mathbf{1}$ and moreover
  $P \equiv F^{\mathrm{id}}\Big|_{\mathrm{prim.}}$
  $N \equiv F^{\mathrm{id}}\Big|_{\mathrm{non-prim.}}$
  $O \equiv F^{\mathrm{id}}_{x\bar{y}}$
- subscripts indicate the order in $\lambda = 2\pi\alpha'$, e.g.
  $P = \sum_{i=0}^{\infty} \lambda^{2i} P_i$

α'-Corrections to a T-brane

- D-terms can be brought to form

$$\left(\partial_x \overline{\partial}_{\overline{x}} + \partial_y \overline{\partial}_{\overline{y}}\right) f = e^{2f} - |x|^2 |m|^2 e^{-2f}$$

$$N_0 = 0$$

$$\underbrace{(\ldots)}_{\text{expr. in f}} \left(\partial\overline{\partial} f\right)^2 = P_i^2 - N_i^2 + |O_i|^2$$

$$N_{i+1} = \underbrace{(\ldots)}_{\text{expr. in f}} \left(P_i - N_i\right)$$

- This restricts the solutions severely: E.g. the ansatz $f = f(x, \overline{x})$ implies $P = N = O = 0$ at all orders
  $\Rightarrow$ At leading order in α' non-trivial solutions were still allowed!
- Leading order constant flux, may require non-constant corrections

The $SU(3)$ example

- What happens if we combine the two?
- Phenomenologically, models of the following type are interesting

$$\Phi_{\mathrm{h}} = \begin{pmatrix} \mu^2 y & im & 0 \\ -ixm^2 & \mu^2 y & 0 \\ 0 & 0 & -2\mu^2 y \end{pmatrix} = m \cdot E^+ + xm^2 \cdot E^- + \mu^2 y \cdot Q$$

- we go to unitarity gauge via the ansatz $g = \frac{f(x,\bar{x})}{2}[E^+, E^-]$ yielding a differential eq. of Painlevé type $\partial_x \bar{\partial}_{\bar{x}} f = |m|^2 \left(e^{2f} - |x|^2 |m|^2 e^{-2f}\right)$ which was known before

The $SU(3)$ example

- How is flux in the other diagonal components constrained?
- Solutions purely within $SU(3)$ are not consistent and one has to introduce flux in $\mathbf{1}$
- 33-flux only receives abelian pull back correction
- Both T-brane and intersecting brane part induce non-primitive fluxes in the T-brane block

$$F_{\text{non-prim.}}\Big|_{\text{T-brane}} = \lambda^2|m|^2 \underbrace{(\dots)}_{\text{expr. in f}} F_{y\bar{y}}\Big|_{\text{T-brane}} - 2\lambda^2|\mu|^4 F_{x\bar{x}}\Big|_{33}$$

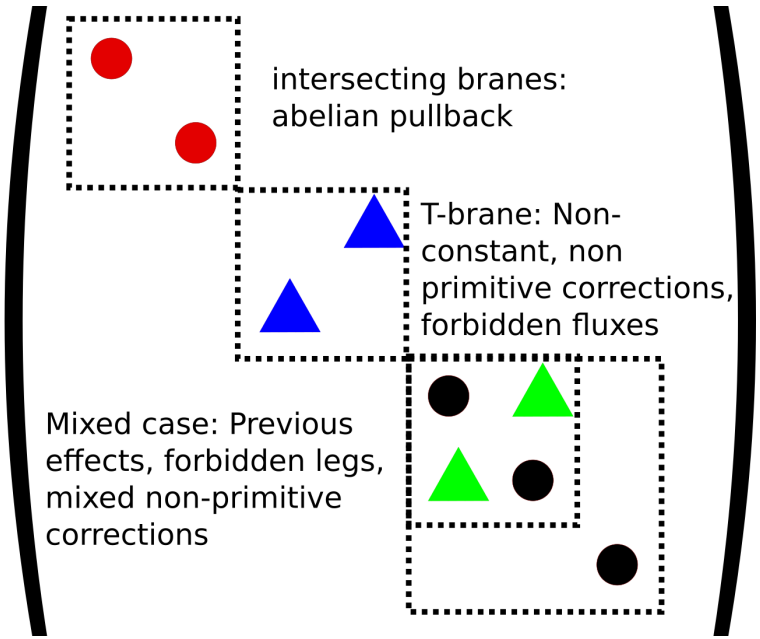
- Flux with mixed legs has to vanish

$$F_{x\bar{y}}\Big|_{\text{T-brane}} = F_{y\bar{x}}\Big|_{\text{T-brane}} = 0$$

Conclusions

- Receive more D-term equations at higher order in α'
- Corrections in α' exclude many leading order flux-solutions

$\Phi =$



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