Brane solutions in non-supersymmetric strings

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Based on works with J. Mourad and A. Sagnotti

Plan

- ☐ Motivations
  - Non-susy tachyon-free string theories in 10D
  - Tadpole potentials
- ☐ Brane solutions in non-susy strings
  - Isometry-driven
  - Vacuum-driven
- ☐ Discussion

Motivations

Brane: gravity solution with ISO$(1,p)\times$SO$(9-p)$ isometries, interpolating

singularity $\longrightarrow$ flat space.

Is this still true for **non-supersymmetric setups**?

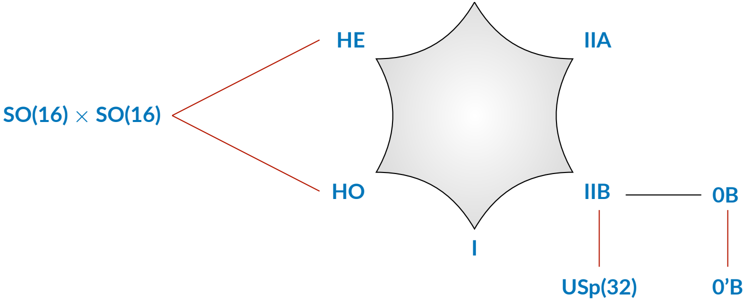
I focus on specific non-susy models, but the general considerations have wider applicability [parallel talks: Tarazi, Fraiman, Leone].

Non-susy tachyon-free string theories in 10D

① Heterotic: $SO(16) \times SO(16)$ [Alvarez-Gaume, Ginsparg, Moore, Vafa 1986; Dixon, Harvey 1986].

③ Orientifold of bosonic 0B: 0'B [Sagnotti 1995].

② Type IIB with $O9^+$ and 32 $\overline{D9}$: USp(32) [Sugimoto 1999].



Tadpole potentials

These models are **divergent**! e.g. $\mathcal{Z}_1$ for the orientifolds.

➠ **IR divergences** (tadpoles) $\rightarrow$ background shift, as a string-loop *correction*.
[Fischler, Susskind 1986; Callan, Lovelace, Nappi, Yost 1986–8; Tseytlin 1988–90]

$$S \sim \int (e^{-2\phi} + c_R)R + (e^{-2\phi} + c_\phi)4(\partial\phi)^2 - (e^{-2\phi} + c_H)\frac{1}{2}\frac{H^2}{3!} - \Lambda + \ldots$$

"tadpole" scalar potential $\boxed{\Lambda = T\, e^{\gamma\phi}\,,}$ $\gamma = \{0, -1\}$ $\Rightarrow$ runaway .

Brane solutions in non-susy strings

Worldsheet [Dudas, Mourad, Sagnotti 2001]: charged branes for all form fields

① SO(16) $\times$ SO(16): NS1 and NS5.

③ 0'B: D1, D3 and D5.

② USp(32): D1 and D5.

$+$ uncharged (generically unstable), K-charged, topologically charged, ...

What are the ***gravity solutions*** of these branes?

(previous related works [Antonelli, Basile 2019, Basile 2021-2])

Isometry-driven

Keep ISO$(1,p)\times$SO$(9-p)$ **isometries** (*branes and vacua*):
[Mourad, SR, Sagnotti 2024]

$$ds^2 = e^{2A(r)} dx_{p,1}^2 + e^{2B(r)} dr^2 + e^{2C(r)} d\Omega_{8-p}^2 \,, \qquad \phi = \phi(r) \,, \qquad F_{p+2} = F_{p+2}(r) \,.$$

In the harmonic gauge $B = (p+1)A + (8-p)C$,

$$\begin{pmatrix} X \\ Y \\ W \end{pmatrix}'' = \begin{pmatrix} + & 0 & - \\ 0 & + & \pm, 0 \\ + & \pm, 0 & +, 0 \end{pmatrix} \begin{pmatrix} e^X \\ e^Y \\ e^W \end{pmatrix} \,,$$

$X \sim$ curvature , $\quad Y \sim$ flux , $\quad W \sim$ tadpole .

- Curvature and tadpole: vacuum solutions and uncharged branes
  - Classification of **asymptotics**.
  - Global convexity and conserved quantity $\rightarrow$ partial matching of asymptotics.

- Curvature, tadpole and flux: flux vacua and charged branes
  - Classification of **asymptotics**.
  - D5 orientifold: flux decouples $\rightarrow$ previous case.

In all cases, *finite-distance singularity* [Antonelli, Basile 2019].
$\rightarrow$ dynamical cobordism [Angius, Basile, Blumenhagen, Buratti, Calderón-Infante, Cribiori, Delgado, Huertas, Kneissl, Makridou, Minnino, Mourad, SR, Sagnotti, Uranga, Wang, ... 2020-4].

Vacuum-driven

Keep **singularity** $\longrightarrow$ **vacuum** [Mourad, SR, Sagnotti 2024]: Dudas-Mourad

$$ds^2 = e^{2\Omega(z)}\left(dx_{8,1}^2 + dz^2\right) \,, \qquad \phi = \phi(z) \,.$$ [Dudas, Mourad 2000]

Branes in this vacuum:

$$\begin{aligned} ds^2 &= e^{2A(z,r)}dx_{p,1}^2 + e^{2B(z,r)}\left(dr^2 + r^2 d\Omega_{7-p}^2\right) + e^{2D(z,r)}dz^2 \,, \\ \phi &= \phi(z,r) \,, \qquad F_{p+2} = F_{p+2}(z,r) \,. \end{aligned}$$

- $dx_{8,1}^2 \to$ Ricci-flat: exact solution with 9D uncharged branes (*smeared*).
- Linearized solutions: compatible with singular boundary conditions as in [Mourad, Sagnotti 2023, Sagnotti's talk], matches the *expected charged branes*.

Discussion

- Brane solutions are *heavily deformed* in non-susy strings. We found
  - ISO$(1,p)\times$SO$(9-p)$ isometries and finite-distance singularities.
  - branes in Dudas-Mourad vacua.

- The latter is a special case of *branes in backgrounds*. Interesting option: branes in cosmological Dudas-Mourad

$$ds^2 = -e^{2D(t,r)}dt^2 + e^{2A(t,r)}dx_p^2 + e^{2B(t,r)}\left(dr^2 + r^2 d\Omega_{8-p}^2\right) \ .$$

- A comprehensive understanding may involve both approaches.