Smearing NS-branes

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string theory - not only a theory of strings

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string theory - also a theory of "dynamical" branes?

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brane charges

Are D-branes electrically charged?

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- electrically charged point particle under a gauge field A

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- electrically charged p-brane under $p+1$-form C_{p+1}

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- Bianchi identity (Maxwell's equations)

$$dF_2 = 0 \ , \qquad d \star F_2 = J$$

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- higher dimensional D-branes magnetically charged

$$\tilde{q} \int_{\Sigma_{D-p-2}} \tilde{C}_{D-p-1}$$

low-energy effective description

- p-brane solution

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  - typically boils down to a Poisson equation

$$\Delta_{D-p-1} Z_p = \delta^{(D-p-1)}(r)$$

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$$\text{where } \mathrm{d}\hat{s}_4^2 = \sum_{m=1\ldots 4} (\mathrm{d}x^m)^2 \ , \ r_4^2 = \sum_{m=1\ldots 4} (x^m)^2 \ , \ f_H = e^{2\phi_H} + \frac{q}{r_4^2}$$

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branes related by stringy dualities

Are there more branes related by string dualities?

Smearing/T-dualizing p-brane solutions

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- Buscher rules (radial inversion) take care of the correct powers of the warp factor in the metric

$$\begin{cases} Z_p(r) \to Z_p(r)^{-1} \; , & \text{T-duality transverse to the brane} \\ Z_p(r)^{-1} \to Z_p(r) \; , & \text{T-duality along the brane} \end{cases}$$

T-duality chain of NS-branes

$NS5-\text{brane}$

T-duality chain of *NS*-branes

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Hassler, Lüst '13

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- sources the geometric flux

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$$Q_\varphi{}^{xy} = -f_Q^{-\frac{3}{2}} \partial_\rho f_Q$$

Excursion II: β-supergravity

- no non-geometric flux present in standard supergravity

$$\mathcal{L}_{\mathrm{NSNS}} \equiv e^{-2\phi}\sqrt{|g|}\left(\mathcal{R}(g) + 4(\partial\phi)^2 - \frac{1}{2}H^2\right)$$

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How do we make non-geometric fluxes appear?

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- β-supergravity (rewriting $\mathcal{L}_{\rm NSNS}$)

$$\tilde{\mathcal{L}}_\beta = e^{-2d}\left(\mathcal{R}(\tilde{g}) + 4(\partial\tilde{\phi})^2 + 4(\beta^{ab}\partial_b\tilde{\phi} - \mathcal{T}^a)^2 + \mathcal{R}_Q - \frac{1}{2}R^{acd}{f^b}_{cd}\eta_{ab} - \frac{1}{2}R^2\right)$$

  - with non-geometric NS-fluxes ${Q_a}^{bc}$, R^{abc}

NSNS Bianchi identities without sources

- Bianchi identity for H-flux in standard supergravity

$$\mathcal{D}A = 2e^{\phi}(d - H\wedge)(e^{-\phi}A)\,, \qquad \mathcal{D}^2 = 0 \;\Leftrightarrow\; d^2 = 0 \text{ and } dH = 0$$

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$$\mathcal{D}^2 = 0 \;\Leftrightarrow\; \begin{cases} \partial_{[b} f^a{}_{cd]} - f^a{}_{e[b} f^e{}_{cd]} = 0 \\ \partial_{[a} Q_{f]}{}^{de} - \beta^{g[d} \partial_g f^{e]}{}_{af} - \frac{1}{2} Q_g{}^{de} f^g{}_{af} + 2 Q_{[a}{}^{g[d} f^{e]}{}_{f]g} = 0 \\ \partial_a R^{ghi} - 3\beta^{d[g} \partial_d Q_a{}^{hi]} + 3 R^{d[gh} f^{i]}{}_{ad} - 3 Q_a{}^{d[g} Q_d{}^{hi]} = 0 \\ \beta^{g[d} \partial_g R^{abc]} + \frac{3}{2} R^{g[da} Q_g{}^{bc]} = 0 \end{cases}$$

Blumenhagen, Deser, Plauschinn & Rennecke '12

sourced corrected Bianchi identities for *NS*-branes

- smearing warp factors and Poisson equations

$$\begin{cases} f_H = const + \frac{q}{r_4^2} \\ \qquad\qquad\qquad \downarrow \int \\ \end{cases}$$

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$$\begin{cases} f_H = const + \frac{q}{r_4^2} \\ f_K = const + \frac{q\pi}{r_3} \\ f_Q = const - 2q\pi \ln r_2 \\ \\ \end{cases} \downarrow \int$$

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  - $NS5$-brane

$$\partial_{[a} H_{bcd]} - \frac{3}{2} f^e{}_{[ab} H_{cd]e} = \frac{C_H}{4}\ \epsilon_{4\perp abcd} \delta^{(4)}(r_4)$$

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  - *KK*-monopole

$$\partial_{[b} f^a{}_{cd]} - f^a{}_{e[b} f^e{}_{cd]} = \frac{C_K}{3}\ \epsilon_{3\perp bcd}\ \epsilon_1{}^{||a} \delta^{(3)}(r_3)$$

Villadoro & Zwirner '07

sourced corrected Bianchi identities for *NS*-branes

- smearing warp factors and Poisson equations

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$$\partial_{[b} f^a{}_{cd]} - f^a{}_{e[b} f^e{}_{cd]} = \frac{C_K}{3}\ \epsilon_{3\perp bcd}\ \epsilon_1{}^{||a} \delta^{(3)}(r_3)$$

  - *Q*-brane

Villadoro & Zwirner '07

$$\partial_{[a} Q_{b]}{}^{cd} - \beta^{g[c} \partial_g f^{d]}{}_{ab} - \frac{1}{2} Q_g{}^{cd} f^g{}_{ab} + 2 Q_{[a}{}^{g[c} b^{d]}{}_{f]g} = \frac{C_Q}{2}\ \epsilon_{2\perp ab}\ \epsilon_2{}^{||cd} \delta^{(2)}(r_2)$$

The end

Thank you!