Exploring Double Field Theory[1]

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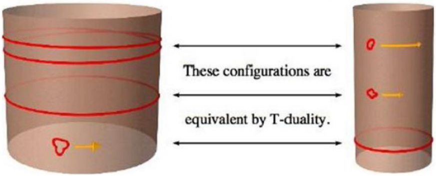
Introduction

The 5 superstring theories are all related by dualities. In particular:

T-duality



$$p = \frac{n}{R} \quad n \in \mathbb{Z} \qquad w = \frac{m}{\tilde{R}} \quad m \in \mathbb{Z}$$

$$R \longleftrightarrow \tilde{R} = \frac{\alpha'}{R}$$

$$n \longleftrightarrow m$$

Introduction

What is DFT?: DFT is a field theory proposal for incorporating the T-duality of string theory ($O(D,D)$) as a manifest symmetry of a space-time action (Duff(1990), Tseytlin(1991), Siegel (1993), C.Hull, B. Zwiebach and O. Hohm (2009))

$$p_\mu \leftrightarrow x^\mu, \quad \omega^\mu \leftrightarrow \tilde{x}_\mu \quad \rightarrow S = \int dx d\tilde{x} \mathcal{L}(x, \tilde{x})$$

Action of DFT (only NSNS-fields):

$$S_{DFT} = \int dX^{2D} e^{-2d} \mathcal{R}(\mathcal{H}, d)$$

$$\mathcal{R} \equiv 4\,\mathcal{H}^{MN}\partial_M\partial_N d - \partial_M\partial_N\mathcal{H}^{MN} + 4\partial_M\mathcal{H}^{MN}\,\partial_N d - 4\,\mathcal{H}^{MN}\partial_M d\,\partial_N d$$
$$-\tfrac{1}{2}\mathcal{H}^{MN}\partial_M\mathcal{H}^{KL}\partial_K\mathcal{H}_{NL} + \tfrac{1}{8}\,\mathcal{H}^{MN}\partial_M\mathcal{H}^{KL}\,\partial_N\mathcal{H}_{KL} + \Delta_{S.C.}$$

$$X^M = \begin{pmatrix} \tilde{x}_i \\ x^i \end{pmatrix}, \quad d = \phi - \frac{1}{2}\log\sqrt{g}\,, \quad \mathcal{H}_{MN} = \begin{pmatrix} g^{ij} & -g^{ik}B_{kj} \\ B_{ik}g^{kj} & g_{ij} - B_{ik}g^{kl}B_{lj} \end{pmatrix}.$$

Properties:

- S_{DFT} is invariant under the Generalized Lie Derivative:

$$\mathcal{L}_\xi A^M \equiv \xi^P \partial_P A^M - (\partial_P \xi^M - \partial^M \xi_P) A^P$$

- The theory is consistent when: $\partial_M \partial^M (...) = 0, \;\; \partial_M (...) \partial^M (...) = 0$

$\longrightarrow$ A Solution $\tilde{\partial}^i{=}0$: $S_{DFT} \rightarrow S_{NSNS} \rightarrow$ DFT is not truly double! .

Relaxation of the S.C.

Lets try to obtain weaker versions of the S.C.:

$$\text{Impose: } \Delta_{\xi_1}\delta_{\xi_2}V^M = 0.$$

- The gauge algebra closes.
- $\partial^M\partial_M\mathcal{E}_{[A}{}^Q\mathcal{E}_{B]Q} - 2\partial_Q\mathcal{E}_A{}^P\mathcal{E}_{BP}\partial_Q d = 0 \longrightarrow \delta_\Lambda S = 0.$
- $-\frac{3}{4}\mathcal{E}_E{}^M\partial_M\mathcal{E}_{[A}{}^N\mathcal{E}_{BN}\mathcal{E}^{EQ}\partial_Q\mathcal{E}_C{}^P\mathcal{E}_{D]P} = 0 \rightarrow \delta_\xi S = 0.$

Conclusions

- We have found weaker versions of the S.C. allowing for consistency of the theory.
- Non-trivial solutions: $\mathcal{E}_A{}^M(X) = \hat{E}_A{}^I(x) U_I{}^M(Y)$, $d = \hat{d}(x) + \lambda(Y)$ and gauge parameters: $\xi^M(X) = \lambda^A(x) \hat{E}_A{}^I(x) U_I{}^M(Y)$.