On a new democratic, SL(2,R)-invariant formulation of type IIB

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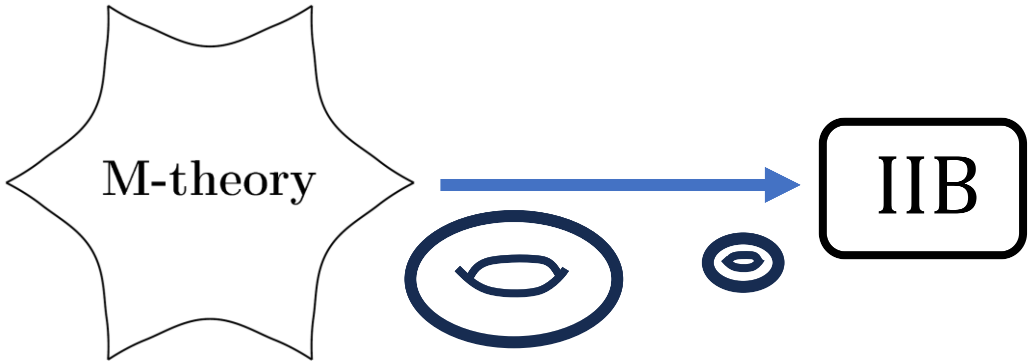
Setup:

Effective Bosonic sector of type IIB $\Longrightarrow$ $\left\{ g_{\mu\nu}\,, B_{\mu\nu}\,, \phi\,, C^{(0)}\,, C^{(2)}_{\mu\nu}\,, C^{(4)}_{\mu\nu\rho\sigma} \right\}$

Democratic formulation $\Longrightarrow$ $\left\{ C^{(6)}_{\mu\ldots\sigma}\,, C^{(8)}_{\mu\ldots\sigma} \right\}$

$SL(2,R)$ Duality $\Longrightarrow$



In a Nutshell

We propose a new **democratic** formulation **of type IIB** (bosonic) effective action with explicit $\boldsymbol{SL(2,R)}$ duality

[M.Z., T. Ortin, C. Gomez-Fayren, G. Giorgi, J. J. Fernandez-Melgarejo 24]

Motivations:

D7 branes couplings, fluxes compactifications, it's funny, …

Why is it not trivial?

Introduction of magnetic duals of RR fields

$$G^{(2n+1)} = (-1)^n \star G^{(9-2n)}$$

[E. Bergshoeff, R. Kallosh, T. Ortin, D. Roest, A. Van Proyen 01]

⇒ $SL(2,R)$ Duality ✗ | Democratic formulation ✓

How do fields transform?

$$\left\{ g_{\mu\nu}\,,\, B_{\mu\nu}\,,\, \phi\,,\, C^{(0)}\,,\, C^{(2)}_{\mu\nu}\,,\, C^{(4)}_{\mu\nu\rho\sigma} \right\} \Longrightarrow \left\{ g_{E\,\mu\nu}\,,\, \tau\,,\, \mathcal{B}_i\,,\, D \right\}$$

$$D = C^{(4)} - \frac{1}{2} B \wedge C^{(2)}$$

$$\tau = C^{(0)} + i e^{-\phi}$$

$$\mathcal{B}_i = \begin{pmatrix} C^{(2)} \\ B \end{pmatrix}$$

$g_{E\,\mu\nu}, D \longrightarrow$ **1**

$\tau \longrightarrow \dfrac{a\tau + b}{c\tau + d}$

$\mathcal{B}_i \longrightarrow$ **2**

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$\mathcal{B}_i \rightarrow \mathbf{2}$

Dualize the DILATON!

Scalar Fields dualization in a toy model

Action depends only on the field strength ⇨ Poincare' duality

$$L = \frac{1}{2} d\phi \wedge \star d\phi \longrightarrow d \star d\phi = 0 \longrightarrow G = \star d\phi$$

Scalar fields couplings

$$L = \frac{1}{2} g_{xy}(\phi)\, d\phi^x \wedge \star d\phi^y \longrightarrow D \star d\phi^x = 0 \longrightarrow ?$$

Idea 1

$g_{xy}(\phi)$ Isometries

$$K_A = K_A{}^x \frac{\partial}{\partial \phi^x}$$

$\longrightarrow$ $d \star K_A = 0$ $\longrightarrow$ $G_A = \star K_A$

We can define the **duals** via the scalar metric **isometries**!

Application

$$S[e^a,\phi^x] = \int (-1)^{d-1} \star (e^a \wedge e^b) \wedge R_{ab} + \tfrac{1}{2} g_{xy}(\phi) d\phi^x \wedge \star d\phi^y$$

In the case of scalar manifolds with the structure of symmetric coset spaces G/H

$$S_{\rm Dem}[e^a,\phi^x,C_A] = \int \Big\{ (-1)^{d-1} \star (e^a \wedge e^b) \wedge R_{ab} + \tfrac{1}{4} g_{xy} d\phi^x \wedge d\phi^y$$
$$\boxed{+ \frac{(-1)^d}{4} \mathfrak{M}^{AB} G_A \wedge \star G_B} - \frac{(-1)^d}{2} g^{AB} G_A \wedge \hat{k}_B \Big\} \,,$$

Application

$$S[e^a, \phi^x] = \int (-1)^{d-1} \star (e^a \wedge e^b) \wedge R_{ab} + \tfrac{1}{2} g_{xy}(\phi) d\phi^x \wedge \star d\phi^y$$

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$$+ \frac{(-1)^d}{4} \mathfrak{M}^{AB} G_A \wedge \star G_B - \frac{(-1)^d}{2} g^{AB} G_A \wedge \hat{k}_B \Big\} ,$$

$$\mathfrak{M}^{AB} = g^{AC} g^{BD} k_C{}^x k_D{}^y g_{xy}$$

NEW

Democratic Type IIB fields

$$G/H = \mathrm{SU}(1,1)/\mathrm{U}(1)$$

2 scalars: $\phi\,, C^{(0)}$

3 isometries: $C^{(8)}_A$ → Triplet transforming in the adjoint of SL(2,R)

$$\left\{ g_{E\,\mu\nu}\,, \tau\,, \mathcal{B}_i\,, D\,, \mathcal{B}^i\,, C^{(8)}_A \right\}$$

Democratic Type IIB action

$$S_{\text{Dem}}[e^a, \tau, \mathcal{B}_i, D, \mathcal{B}^i, C_A] = \int \Big\{ - \star(e^a \wedge e^b) \wedge R_{ab} + \tfrac{1}{4} g_{xy} d\phi^x \wedge \star d\phi^y + \tfrac{1}{4} \mathcal{M}^{ij} \mathcal{H}_i \wedge \star \mathcal{H}_j$$

$$+ \tfrac{1}{4} \mathcal{F} \wedge \star \mathcal{F} + \tfrac{1}{4} \mathcal{M}_{ij} \mathcal{H}^i \wedge \star \mathcal{H}^j + \tfrac{1}{4} \mathfrak{M}^{AB} G_A \wedge \star G_B$$

$$- \tfrac{1}{2} g^{AB} G_A \wedge \star \hat{k}_B + \tfrac{1}{4} \varepsilon^{ij} \mathcal{D} \wedge \mathcal{H}_i \wedge \mathcal{H}_j \Big\} \, .$$

$$G_A = \star \hat{k}_A$$

$$\mathcal{H}_i = \mathcal{M}_{ij} \star \mathcal{H}^j$$

$$G_A = dC_A + \tfrac{1}{2} (T_A)^i{}_k \mathcal{B}_i \wedge \mathcal{H}^k - \tfrac{1}{2} (T_A)^k{}_i \mathcal{B}^i \wedge \mathcal{H}_k$$
$$- \tfrac{1}{24} (T_A)^i{}_k \varepsilon^{kj} \varepsilon^{mn} \mathcal{B}_i \wedge \mathcal{B}_j \wedge \mathcal{B}_m \wedge \mathcal{H}_n$$

$$\mathcal{H}^i = d\mathcal{B}^i - \varepsilon^{ij} \mathcal{B}_j \wedge \left(d\mathcal{D} - \tfrac{1}{6} \varepsilon^{kl} \mathcal{B}_k \wedge \mathcal{H}_l \right)$$

$$(\mathcal{M}_{ij}) \equiv \frac{1}{\Im\mathrm{m}\, \tau} \begin{pmatrix} |\tau|^2 & \Re\mathrm{e}\, \tau \\ \Re\mathrm{e}\, \tau & 1 \end{pmatrix}$$

Idea 2

$$L = \frac{1}{2} g_{xy}(\phi) d\phi^x \wedge \star d\phi^y + \dots$$

$$K_A = {K_A}^x \frac{\partial}{\partial \phi^x}$$

$\longrightarrow$ $$d \star K_A + \dots = 0$$

If the isometries are part of the a duality group we can use Noether-Gaillard-Zumino theorem

$$dC_A = \star K_A + \dots$$