The Generalized Geometry of α'-corrections

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Based on work in progress with

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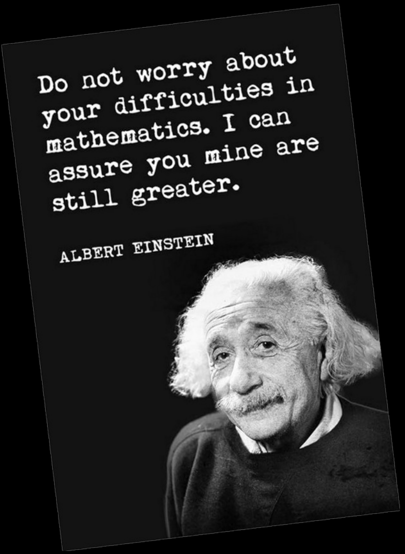
The Problem

- Einstein-Hilbert action is not renormalizable in d>2 → only EFT

$$S = \int \mathrm{d}x^d \sqrt{-g} \left(R + a_1 R^2 + a_2 R_{ij} R^{ij} + \dots \right)$$



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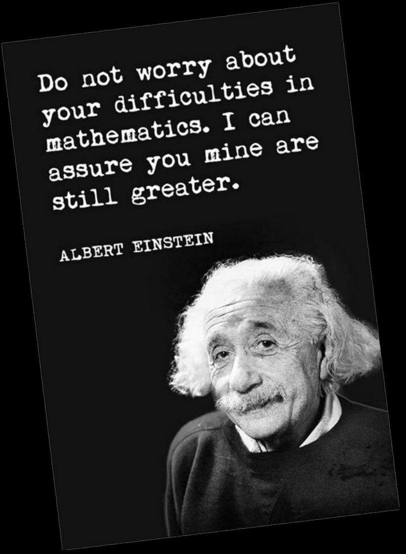
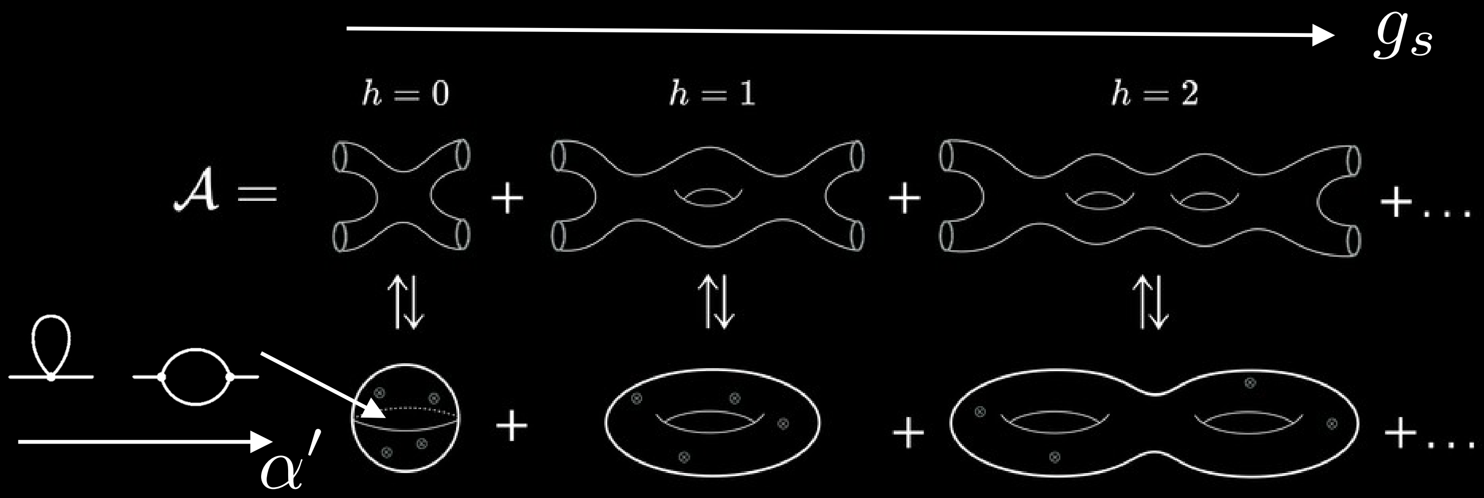
Question: How do we obtain all the coefficients ?

String Theory





NS/NS-sector @ leading order in α'

$$\widetilde{H}_{ijk} = H_{ijk} - \tfrac{3}{2} a \Omega^{(-)}_{ijk} + \tfrac{3}{2} b \Omega^{(+)}_{ijk}$$

$$S = \int \mathrm{d}x^d \sqrt{-g} e^{-2\phi} \Big(R + 4(\partial\phi)^2 - \frac{1}{12} \widetilde{H}^2 + \tfrac{a}{8} R^{(-)}_{ija}{}^{b} R^{(-)ij}{}_{b}{}^{a} + \tfrac{b}{8} R^{(+)}_{ija}{}^{b} R^{(+)ij}{}_{b}{}^{a} + \dots \Big)$$

$a = -\alpha, b = 0$	heterotic
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- 3 coefficients for terms with 2
- 8 coefficients for terms with 4
- 60 coefficients for terms with 6

derivatives

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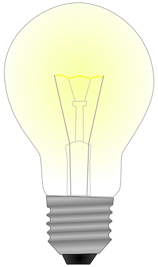
} derivatives

Too many terms. Nothing is known about > 8 derivatives.



A better approach:

Leverage <u>symmetry</u> to decrease number of possible terms.

Like diffeomorphisms, gauge-transformations and:

- SUSY
- Extended <u>Generalized Lorentz Symmetry</u> (today)
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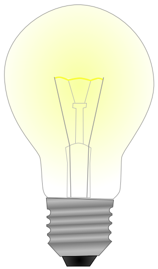

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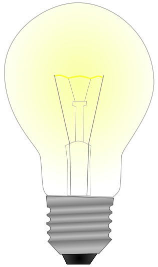
generalized frame

$$\mathrm{E}_A{}^I = \begin{pmatrix} e_a{}^i & e_a{}^j B_{ji} \\ 0 & e^a{}_i \end{pmatrix}$$



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invariant under O(d)xO(d) ⊂ O(d,d)

$$\eta_{AB} = \begin{pmatrix} 0 & \delta_\alpha^\beta \\ \delta_\beta^\alpha & 0 \end{pmatrix} \quad H_{AB} = \begin{pmatrix} \delta_{ab} & 0 \\ 0 & \delta^{ab} \end{pmatrix}$$

Leading Symmetries and Action

$$\delta E^A{}_M = \mathbb{L}_\xi E^A{}_M + \Lambda^A{}_B E^B{}_M \,, \qquad \Lambda^A{}_B \in \mathrm{O}(d) \times \mathrm{O}(d)$$

generalized Lie derivative

1) diffeomorphisms (gravity)
2) gauge tranformation

generalized Lorentz transformation

transformation of fermions

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generalized flux $\quad F_{ABC} = 3D_{[A}E_B{}^I E_{C]I}$ with $\mathrm{D}_A = E_A{}^i \partial_i$

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$$S = \int dx^d \, e^{-2d} \, \mathcal{R}$$

one unique invariant

$$\mathcal{R}(F_{ABC}, F_A, D_A, H_A B)$$

We need a Factory for Invariants...

<u>Symmetries</u>

- gen. diff
- gen. Lorentz

<u>Invariants</u>

$\mathcal{R}, \ldots$

Poláček-Siegel construction *

*) for mathematicians: symplectic reduction of Courant algebroids

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$\nabla_A E_B{}^M = 0$

Covariant derivative:

$$\nabla_A E_B{}^M = E_A{}^N \partial_N E_B{}^M + \Omega_{AB}{}^C E_C{}^M - E_A{}^N \Gamma_{NL}{}^M E_B{}^L$$

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<u>Curvature and torsion???:</u>

$$[\nabla_A, \nabla_B] V^C = R_{ABD}{}^C V^D + T_{AB}{}^D \nabla_D V^C$$

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2 connections are required: $\Omega_A^{\alpha}\,,\,\rho^{\alpha\beta}$ ← adjoint index of the gen. Lorentz group G_{S}

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$$\mathrm{O}(d+n,d+n) \to \mathrm{O}(d,d)\times G_{\mathrm{S}}\,, n=\dim(G_{\mathrm{S}})$$

$$\cup$$

$$G_{\mathrm{PS}} \supset G_{\mathrm{S}}$$

Choosing G_{S} and G_{PS}

Objective:

1) fix all connections by
   1) gauge fixing
   2) torsion constraints

   in terms of the generalized frame (and its derivatives)
2) as few invariants as possible

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We do the same in General Relativity.

$$G_{\rm S} = {\rm O}(d+p) \times {\rm O}(d+q)$$
$$G_{\rm PS} = {\rm O}(d+p, d+q)$$

Recursive embedding of G_{S}

- G_{PS} is generated by $K_{AB}, R_{\alpha}{}^{A}, R_{\alpha\beta}$
- and G_{S} by $\mathrm{t}_{\alpha} = (t_{\overline{\alpha}} \quad t_{\underline{\alpha}})$

How to relate them ???

left and right factors of G_{S}

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- exponential growth of generators
- can be truncated at every order

Torsion contraints and gauge fixing

- Poláček-Siegel construction results one quantity (product):

The twisted mega-space torsion $\mathcal{T}_{\mathcal{ABC}}$ ← fundamental index of G_{PS}

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- To fix them completely, we impose:

$$\mathcal{T}_{\overline{\mathcal{A}}\underline{\mathcal{BC}}} = \mathcal{T}_{\underline{\mathcal{A}}\overline{\mathcal{BC}}} = 0$$

Torsion contraint

$$\Omega^{\overline{\alpha}}_{\overline{a}} = \Omega^{\underline{\alpha}}_{\underline{a}} = \rho^{\overline{\alpha}\overline{\beta}} = \rho^{\underline{\alpha}\underline{\beta}} = 0$$

Gauge fixing of chiral/anti-chiral sector

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There is a hidden symmetry in string theory which controls higher-derivative(α')-corrections. How far can we push it?