# The exceptional form of massive IIA supergravity

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Superstring solutions, supersymmetry and geometry
Benasque May 4 2016

F. Ciceri, A. Guarino and GI, 1604.08602

NIKHEF

# Take-home message (1/2)

- **Exceptional Field Theory** captures *(locally on a coordinate patch)*
  the **11d** and **massless Type II supergravities** in an Exc. Generalised Geometry form

- It was unclear how to capture **massive Type IIA supergravity:**
  - There should be a **deformation** of the **massless IIA Ex. Gen. Geom.**
  - On the other hand, in EFT some **non-geometry** seemed necessary
  - There is a puzzle here…

- We solve this puzzle defining **deformed EFT's** (XFT's)
  (and show the relation with the expected, but not necessary, non-geometry)

# Take-home message (2/2)

EFT is based on a **generalised Lie derivative**
on an extended internal space (analogous to DFT)

$$\mathbb{L}_\Lambda U^M = \Lambda^N \underbrace{\partial_N}_{\frac{\partial}{\partial Y^M}} U^M - U^N \partial_N \Lambda^M + \underbrace{Y^{MN}{}_{PQ}}_{\text{A (very specific) } E_{n(n)} \text{ invariant tensor}} \partial_N \Lambda^P \, U^Q + (\lambda_U - \omega)\, \partial_P \Lambda^P U^M$$

**section condition:** $\quad Y^{PQ}{}_{MN}\, \partial_P \otimes \partial_Q = 0$

We define **non-derivative deformations** of the form

$$\widetilde{\mathbb{L}}_\Lambda = \mathbb{L}_\Lambda + \Lambda^M X_M$$

with $X_M$ an embedding tensor. Extra **$X$-constraint:**

$$X_{MN}{}^P\, \partial_P \quad = \quad 0$$

**For a certain $X$, we reproduce the *full* massive IIA. No dimensional reduction!!**

*(few-lines application: what massless IIA sphere truncations are consistent for mIIA)*

# Outline

- A Gauged Supergravity Appetizer
- Consistent truncations, EFT & EGG
- Mass*less* IIA vs. EFT
- The Romans mass & deformed EFT
- Relation to (non-)geometric EFT
- massive IIA on spheres (blackboard)

# Outline

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# Deformations of Gauged Supergravities

- **We will not do gauged supergravity here, but part of the motivation comes from it:**
  - Many gauged supergravities, only *some* have **uplift to 11d/10d**
  - **Classification** of gauged supergravities is **hard.**
  - Finding which ones have an **uplift** is **even harder.**

- **Exc. Generalised Geometry** & **Exc. Field Theory** help us

  …but they go beyond this: they can capture the **full 11d/10d theories**

# Deformations of Gauged Supergravities

Many gauged (D=4) supergravities come in
**families of inequivalent gaugings** (all sharing same gauge group)

- **$\omega$-deformation of SO(8) gauged max. sugras** [Dall'Agata, GI, Trigiante]

  only $\omega$=0 mod $\pi$/4 lifts to 11d sugra on $S^7$ [De Wit, Nicolai]

These are related to inequivalent E.m. embeddings of gauge connections
Explicit construction & classification: **"Symplectic Deformations"** [Dall'Agata, GI, Marrani]

$\mathcal{N} \geq 2$

$$\mathfrak{S}^0_{\text{red}} \equiv \underbrace{\mathbb{S}(X^0,\,\theta^0)}_{\text{embedding tensors}} \setminus \overbrace{\mathcal{N}_{\mathrm{Sp}(2n_\mathrm{v},\mathbb{R})}}^{\text{normalizer}}(\overbrace{\mathrm{G}_X}^{\text{gauge group on vectors}}) \,/\, \mathcal{N}_{\underbrace{\mathcal{G}_\mathrm{d}}_{\text{duality symmetries}}}(\mathrm{G}_X)$$

$$\mathbb{S}(X^0,\,\theta^0) \equiv \left\{ S \in \overbrace{\mathcal{S}_{\mathrm{Sp}(2n_\mathrm{v},\mathbb{R})}}^{\text{stabilizer}}(X^0) \mid S\theta^0 = \theta^0 m,\ m \in \frac{\overbrace{\mathcal{N}_{\mathcal{G}_\mathrm{m}}}^{\text{matter symmetries}}(\mathrm{H_m})}{\mathcal{C}_{\mathcal{G}_\mathrm{m}}(\underbrace{\mathrm{H_m}}_{\text{gauge group on matter}})} \right\}$$ [GI]

# Symplectic deformations of some N=8 gaugings

$$\mathrm{SO}(8),\ \mathrm{SO}(4,4): \qquad \mathfrak{S}_{\mathrm{red}} = S^1/\mathrm{D}_8, \qquad \text{fundamental domain: } \omega \in [0, \pi/8].$$
$$\mathrm{SO}(p, 8-p),\ p \neq 0, 4: \qquad \mathfrak{S}_{\mathrm{red}} = S^1/\mathrm{D}_4, \qquad \text{fundamental domain: } \omega \in [0, \pi/4].$$

No (geometric) upift to 11d sugra for the $\omega$-deformation

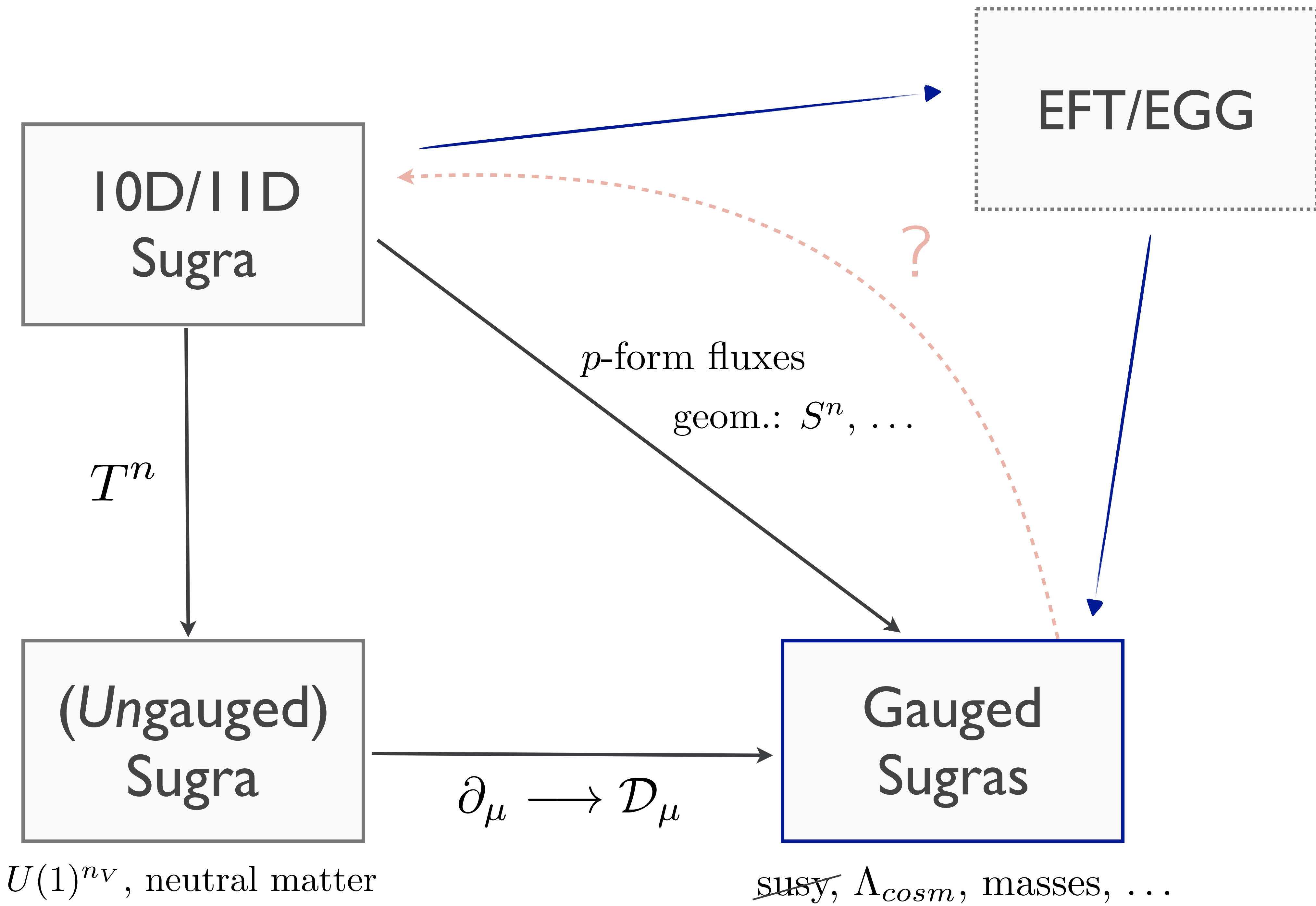
[De Wit, Nicolai] [Lee, Strict. Constable, Waldram]

$$\mathrm{ISO}(p, 7-p): \quad \omega = 0 \quad \text{or} \quad \omega \neq 0 \quad (\mathrm{mod}\ \pi/2).$$

Crucially, in [Dall'Agata, GI, Marrani] this is proven to be and **on/off** deformation.
Lifts to the on/off deformation of IIA on $S^6$ : **the Romans mass.** [Guarino, Varela]

(deformed ISO(7) is not really "dyonic", all charges are mutually local)

# Consistent Truncations & EFT




(inspired by Samtleben, 0808.4076)

# Consistent Truncations & EFT

- **Exc. Field Theory** can be used to construct **consistent truncations** [Hohm, Samtleben]
- **11d** and **massless type II** in single framework
- $\mathrm{E}_{n(n)}\times\mathrm{R}^{+}$ structures are made evident and can be exploited
- **Question: how can we embed massive type IIA in EFT?**
- massive IIA is reduced on $S^6$ using same Ansatz as massless (doable in EFT). Does this hold for lower-dim. spheres? [Guarino, Varela]
- **Puzzle:**
  - **mIIA** is a sugra theory **in its own right**. It should be captured by EFT upon solution of its (strong) **section constraint. BUT this is not the case!** [Berman et al.], [Blair Malek Park], [Bossard Kleinschmidt], [Bandos]
  - On the other hand, **in DFT non-geometry was necessary** [Hohm, Kwak] (dependence on a winding coord. for some RR potential)

# Supergravity, geometry & $E_{n(n)}$

**Basic idea of exceptional geometry:**

- **Repackage** fields and symmetries of **11d/10d Sugra** so that it **looks like** an **(11-n) dimensional maximal supergravity**.
- However, **no truncation is performed!** **Equivalent form of the full 11d/10d Sugra** we began with.
- Fields and symmetry parameters **fill out $E_{n(n)}$ representations** ($K(E_{n(n)})$ for fermions)
- Very **convenient** (if not necessary!) if you want to do **consistent truncation** to an **(11-n) dimensional theory.**
- But you may as well study **dynamics of full theory** without truncation!

# Exceptional Field Theory

There are **$E_{n(n)}\times R^{+}$ Exceptional Generalised Geometries** for

- **11d Supergravity** and **type IIA** (massless, so far!)
- **Type IIB**

**Exceptional Field Theory** is a framework that **captures both** **(in coord. patch)** by introducing extra internal coordinates

$$x^{\hat{\mu}} = (x^{\mu}\,,\ y^{m}) \longrightarrow (x^{\mu}\,,\ Y^{M})$$

$$\underset{\text{(or 10)}}{\mathbf{d=11}} = \mathbf{(11-n)} + \underset{(n-1)}{\mathbf{n}} \longrightarrow \mathbf{(11-n)} + \mathbf{R_{vec}}$$

Full $E_{n(n)}$ representation

Similar to Double Field Theory.

# Exceptional Field Theory

- There are EFT's in D = 9, …, 3 corresponding to the **$E_{n(n)}$ series**
- All fields depend on $(x^\mu\,,\ Y^M)$
  but there is a <u>**section condition**</u> **on Y dependence**

$$Y^{MN}{}_{PQ}\, \underbrace{\partial_M}_{\frac{\partial}{\partial Y^M}} \otimes \partial_N \;=\; 0$$

A (very specific) $E_{n(n)}$ invariant tensor

  imposed on any field, parameter, etc.

- Result: fields only really depend on $(x^\mu\,,\ y^m)$,
- but what $y^m$? **Two *maximal* solutions:**
  - n dimensional: **11d** Sugra coordinates
  - (n – 1) dimensional: **Type IIB** coordinates

11d

↓

IIB [SL(2)] IIA [$R^+$]

↓

$E_{2(2)}$ = SL(2)×$R^+$

↓

$E_{3(3)}$ = SL(2)×SL(3)

↓

$E_{4(4)}$ = SL(5)

↓

$E_{5(5)}$ =SO(5,5)

↓

$E_{6(6)}$

↓

$E_{7(7)}$

↓

$E_{8(8)}$

# Exceptional Field Theory

- **EFTs look like a (D=9,…,3) supergravity theory, but with an infinite set of fields and internal symmetries.**

- E.g. in D = 4, bosonic pseudo-action

$$S_{\rm EFT} = \int d^4x \int d^{56}Y\, e\, \Big[\, \underbrace{\hat R}_{\text{Ricci scalar}} + \frac{1}{48}\, g^{\mu\nu}\, \mathcal{D}_\mu \underbrace{\mathcal{M}^{MN}}_{E_{7(7)}/SU(8)\text{ scalar fields}}\, \mathcal{D}_\nu \mathcal{M}_{MN} - \frac{1}{8}\, \mathcal{M}_{MN}\, \mathcal{F}^{\mu\nu M} \mathcal{F}_{\mu\nu}{}^N + e^{-1}\, \mathcal{L}_{\rm top} - \underbrace{V_{\rm EFT}(\mathcal{M}, g)}_{\text{“scalar potential”}}\, \Big]$$

- Invariant under:
  - External diffemorphisms $\xi^\mu(x, Y)$
  - Internal **Generalised diffeomorphisms** acting as:

$$\mathbb{L}_\Lambda U^M = \Lambda^N \underbrace{\partial_N}_{\frac{\partial}{\partial Y^M}} U^M - U^N \partial_N \Lambda^M + \underbrace{Y^{MN}{}_{PQ}}_{\text{A (very specific) } E_{n(n)} \text{ invariant tensor}}\, \partial_N \Lambda^P\, U^Q + (\lambda_U - \omega)\, \partial_P \Lambda^P U^M$$

# IIA vs. EFT

- Section condition imposes:

$$(x^\mu\,,\;Y^M) \longrightarrow (x^\mu\,,\;y^m) \;=\; x^{\hat\mu}$$

$$\mathrm{D} + \mathrm{R}_1 \longrightarrow \mathrm{D} + \mathrm{k} \;\leq\; 11 \text{ or } 10$$

- For a certain choice of $\{y^m\}$ we get **massless IIA.**

*..and other p-form trfs in D dimensions*

$$\left.\begin{array}{l}\mathcal{L}_{\xi^\mu(x,y)}\\ \mathbb{L}_{\Lambda^M(x,y)}\end{array}\right\} \longrightarrow \left\{\begin{array}{l}\text{10d diffeos } (\,\xi^{\hat\mu}\,)\\ p\text{-form gauge trfs. } (\,\lambda_{(0)},\,\Xi_{(1)},\,\theta_{(2)}\,)\end{array}\right.$$

- For instance one can match the gauge trfs of the *D-dimensional vectors*

$$\begin{aligned}
\delta B_\mu{}^\alpha &= (\partial_\mu - B_\mu{}^\delta\,\partial_\delta)\,\xi^\alpha + \xi^\delta\,\partial_\delta B_\mu{}^\alpha\;,\\
\delta C_\mu &= \xi^\delta\,\partial_\delta C_\mu + (\partial_\mu - B_\mu{}^\delta\,\partial_\delta)\,\lambda\;,\\
\delta C_{\mu\beta} &= \xi^\delta\,\partial_\delta C_{\mu\beta} + C_{\mu\delta}\,\partial_\beta\xi^\delta + (\partial_\mu - B_\mu{}^\delta\,\partial_\delta)\,\Xi_\beta + B_\mu{}^\delta\,\partial_\beta\,\Xi_\delta\;,\\
\delta C_{\mu\beta\gamma} &= \xi^\delta\,\partial_\delta C_{\mu\beta\gamma} + 2\,C_{\mu\delta[\gamma}\,\partial_{\beta]}\xi^\delta + (\partial_\mu - B_\mu{}^\delta\,\partial_\delta)\,\theta_{\beta\gamma} + 2\,B_\mu{}^\delta\,\partial_{[\beta|}\,\theta_{\delta|\gamma]}\\
&\quad +2\,C_\mu\,\partial_{[\beta}\Xi_{\gamma]} - 2\,C_{\mu[\beta}\,\partial_{\gamma]}\lambda\;.
\end{aligned}$$

# mIIA vs. EFT

- **Massive IIA is not embedded in EFT**
  - Solutions of the section constraint only yield 11d or massless type II
  - A clear **obstruction** comes from the p-form gauge variations:

$$
\begin{aligned}
\delta B_\mu{}^\alpha &= (\partial_\mu - B_\mu{}^\delta\,\partial_\delta)\,\xi^\alpha + \xi^\delta\,\partial_\delta B_\mu{}^\alpha\ ,\\
\delta C_\mu &= \xi^\delta\,\partial_\delta C_\mu + (\partial_\mu - B_\mu{}^\delta\,\partial_\delta)\,\lambda - m_R\,B_\mu{}^\delta\,\Xi_\delta\ ,\\
\delta C_{\mu\beta} &= \xi^\delta\,\partial_\delta C_{\mu\beta} + C_{\mu\delta}\,\partial_\beta\xi^\delta + (\partial_\mu - B_\mu{}^\delta\,\partial_\delta)\,\Xi_\beta + B_\mu{}^\delta\,\partial_\beta\,\Xi_\delta\ ,\\
\delta C_{\mu\beta\gamma} &= \xi^\delta\,\partial_\delta C_{\mu\beta\gamma} + 2\,C_{\mu\delta[\gamma}\,\partial_{\beta]}\xi^\delta + (\partial_\mu - B_\mu{}^\delta\,\partial_\delta)\,\theta_{\beta\gamma} + 2\,B_\mu{}^\delta\,\partial_{[\beta|}\,\theta_{\delta|\gamma]}\\
&\quad +2\,C_\mu\,\partial_{[\beta}\Xi_{\gamma]} - 2\,C_{\mu[\beta}\,\partial_{\gamma]}\lambda - 2\,m_R\,C_{\mu[\beta}\,\Xi_{\gamma]}\ .
\end{aligned}
$$

  - **Terms without derivatives**,
    but action of $\xi^\mu$ and $\Lambda^M$ in EFT contain derivatives in every term!

# IIA vs. EFT

- We could take the **non-geometric route** (violate section condition),
- **BUT: massive IIA is a fine maximal Sugra!**
  There must be an exceptional generalised geometry for it.
- Which means: **new EFTs**
  with solutions of the section condition **that yield massive IIA**
- We reverse-engineered these new EFTs by **comparing gauge trfs**

  Trick: it is sufficient to do it on a subset of fields transforming faithfully under $\Xi_{(1)}$ variations, the rest follows by covariance.

# IIA vs. EFT

Massless IIA

$$\left.\begin{array}{c}\mathcal{L}_{\xi^\mu(x,y)}\\ \mathbb{L}_{\Lambda^M(x,y)}\end{array}\right\} \longrightarrow \left\{\begin{array}{l}\text{10d diffeos } (\,\xi^{\hat\mu}\,)\\ p\text{-form gauge trfs. } (\,\lambda_{(0)},\,\Xi_{(1)},\,\theta_{(2)}\,)\end{array}\right.$$

$$\Big\downarrow \text{ Turn on } m_R$$

$$\left.\begin{array}{c}\mathcal{L}_{\xi^\mu(x,y)}\\ \widetilde{\mathbb{L}}_{\Lambda^M(x,y)}\end{array}\right\} \xleftarrow[\text{Deduce}]{} \begin{aligned}\delta A_{\hat\mu} &= \partial_{\hat\mu}\lambda + m_R\,\Xi_{\hat\mu}\\ \delta B_{\hat\mu\hat\nu} &= 2\,\partial_{[\hat\mu}\,\Xi_{\hat\nu]}\\ \delta A_{\hat\mu\hat\nu\hat\rho} &= 3\,\partial_{[\hat\mu}\,\theta_{\hat\nu\hat\rho]} - 3\,A_{[\hat\mu\hat\nu}\,\partial_{\hat\rho]}\lambda - 3m_R\,B_{[\hat\mu\hat\nu}\Xi_{\hat\rho]}\end{aligned}$$

- **External diffeos**, **section condition** and **dictionary** don't change,
- only the **generalised Lie derivative** does, **let's see how**

# Deformed EFT ("XFT")

- $\widetilde{\mathbb{L}}_\Lambda$ now contains **non-derivative terms:**

$$\boxed{\widetilde{\mathbb{L}}_\Lambda V^M = \mathbb{L}_\Lambda V^M - X_{NP}{}^M \Lambda^N V^P}$$

- $X$ is a constant object encoding $m_R$ **, which we know for all EFTs :**
  - It appears in the D-dimensional maximal gauged supergravity obtained by **torus reduction of massive IIA.**
  - It's a special case of ***embedding tensor.***
    ***(this is not an assumption, it's a result.)***
- **Crucial:** we deduced this keeping only certain $\{y^m\}$ internal coords, we can now promote to $\{Y^M\}$ and find the **new section conditions**

# Deformed EFT: *consistency*

- In **standard EFT** closure and Jacobi of $\mathbb{L}$ require <u>**section condition**</u>

$$Y^{MN}{}_{PQ}\,\partial_M \otimes \partial_N \;=\; 0$$

- We need to repeat the same procedure for $\widetilde{\mathbb{L}}$ .
  Several constraints:
  - $Y^{MN}{}_{PQ}\,\partial_M \otimes \partial_N \;=\; 0$ is **unmodified** (good!)
  - ${X_{NP}}^{M}$ has same constraints as **embedding tensor** in gauged sugra
  - $\delta {X_{NP}}^{M} = 0$ under all gauge transformations (i.e.: it's not a tensor!)
  - Mixed condition: $\boxed{{X_{NP}}^{M}\partial_M = 0}$ (in particular: not a torsion!)

# Deformed EFT: *interpretation*

$$\underbrace{\widetilde{\mathbb{L}}_\Lambda V^M = \mathbb{L}_\Lambda V^M - X_{NP}{}^M \Lambda^N V^P}_{\text{Deformed EFT (XFT)}}$$

standard EFT internal syms

Gauged Sugra internal syms

**Deformed EFT (XFT)**

- The structure of EFTs is that of gauged maximal sugras with infinitely many fields and internal symmetries
- It is only natural to superpose it with a standard gauging
- Just like in gauged sugra, $X$ **breaks the global $\mathbf{E_{n(n)}}$ explicitly** (solving the section constraint does, too)
- Romans mass was a deformation already in 10d, instead of finding its "origin", we deformed EFT to implement it.

# Deformed EFT: *interpretation*

- Let's help us with an example: D=9 EFT, $E_{2(2)}=SL(2)\times R^{+}$
- Coordinates: external $x^\mu$ and $Y^M = (\underset{\text{11d}}{y^{\alpha=1,2}}\,,\ \underset{\text{type IIB}}{z})$
- Section condition $\partial_\alpha \times \partial_z = 0$ : **11d sugra** or **type IIB**

$$\widetilde{\mathbb{L}}_\Lambda V^M = \mathbb{L}_\Lambda V^M - X_{NP}{}^M\, \Lambda^N\, V^P \quad , \quad \text{with } X_{z\,2}{}^1 = m_R$$

- **New constraint:** $\boxed{m_R \times \partial_1 = 0}$

**kills 11d coordinate,** left with **massive IIA**, and **IIB** (with **F₁ flux**)

T-dual

# Deformed EFT: *interpretation*

- Same analysis in D=4:
- section condition + $X\partial$–condition have **several 10d/11d solutions**:

$$\xrightarrow{\text{T-duality}}$$

**massive IIA**, type **IIB**, massless **IIA** (with constant RR flux)
and
**11d Sugra** with Freund–Rubin parameter

six "windings" of original massive IIA coordinates, plus a seventh "dual M-theory circle"

- except for mIIA, other constant fluxes can be removed by redefinition of gauge potentials & gauge-parameters

# The XFT action in D=4

$$S_{\text{XFT}} = \int d^4x\, d^{56}Y\, e\, \Big[\, \hat{R}(X) + \frac{1}{48}\, g^{\mu\nu}\, \mathcal{D}_\mu \mathcal{M}^{MN}\, \mathcal{D}_\nu \mathcal{M}_{MN} - \frac{1}{8}\, \mathcal{M}_{MN}\, \mathcal{F}^{\mu\nu M} \mathcal{F}_{\mu\nu}{}^{N} + e^{-1}\, \mathcal{L}_{\text{top}}(X) - V_{\text{XFT}}(\mathcal{M}, g, X) \,\Big]$$

$$\mathcal{F}_{\mu\nu}{}^{M} = F_{\mu\nu}{}^{M} - 12\, [t^\alpha]^{MN} \partial_N B_{\mu\nu\,\alpha} - 2\, Z^{M,\alpha} B_{\mu\nu\,\alpha} - \frac{1}{2}\, \Omega^{MN} B_{\mu\nu\,N}$$

(twisted-self-dual)

satisfies sec. constraint algebraically,
and part of the X-constraint

$$\hat{R}_{\mu\nu}{}^{ab}(X) = R_{\mu\nu}{}^{ab}[\omega] + \mathcal{F}_{\mu\nu}{}^{M}\, e^{a\rho}\, \partial_M e_\rho{}^{b}$$

$$\mathcal{D}_\mu \equiv \partial_\mu - \widetilde{\mathbb{L}}_{A_\mu}$$

This is always a direct superposition of EFT and Gauged N=8 Sugra

# The XFT scalar potential in D=4

$$V_{\rm XFT}(\mathcal{M},g,X) \;=\; V_{\rm EFT}(\mathcal{M},g) \,+\, V_{\rm SUGRA}(\mathcal{M},X) \,+\, V_{\rm cross}(\mathcal{M},X)$$

$$\begin{aligned} V_{\rm EFT} = &-\frac{1}{48}\,\mathcal{M}^{MN}\,\partial_M\mathcal{M}^{KL}\,\partial_N\mathcal{M}_{KL} + \frac{1}{2}\,\mathcal{M}^{MN}\,\partial_M\mathcal{M}^{KL}\,\partial_L\mathcal{M}_{NK} \\ &-\frac{1}{2}\,g^{-1}\partial_M g\,\partial_N\mathcal{M}^{MN} - \frac{1}{4}\,\mathcal{M}^{MN}\,g^{-1}\partial_M g\,g^{-1}\partial_N g - \frac{1}{4}\,\mathcal{M}^{MN}\,\partial_M g^{\mu\nu}\,\partial_N g_{\mu\nu} \end{aligned}$$

$$V_{\rm SUGRA} = \frac{1}{168}\left[\,X_{MN}{}^P X_{QR}{}^S \mathcal{M}^{MQ}\mathcal{M}^{NR}\mathcal{M}_{PS} + 7 X_{MN}{}^P X_{QP}{}^N \mathcal{M}^{MQ}\,\right]$$

$$V_{\rm cross} = \frac{1}{12}\,\mathcal{M}^{MN}\mathcal{M}^{KL} X_{MK}{}^R\,\partial_N\mathcal{M}_{RL}$$

New cross-term!

# $m_R$ from EFT and non-geometry

- In DFT $m_R$ can be sourced by a **RR C$_{(1)}$ potential** with **linear dependence on a winding coordinate**

Hohm, Kwak - 2011

- The structure of EFT is more restrictive:
violating section condition can be done (locally), but requires care.

- We **relax** the section condition of EFT, and factorise its fields:

$$\mathbf{V}^M_{\mathrm{EFT}}(x,Y) = V^A_{\mathrm{XFT}}(x,Y)\, E_A{}^M(Y)$$

where $E$ are twist matrices such that $\mathbb{L}_{E_A} E_B{}^M = -X_{AB}{}^C E_C{}^M$

$$\boxed{\mathbb{L}_{\mathbf{\Lambda}} \mathbf{V}^M = (\widetilde{\mathbb{L}}_\Lambda V^A) E_A{}^M}$$

non-geom. EFT

XFT

- Notice that $\mathbf{\Lambda},\ \mathbf{V}$ do **not satisfy sec. cnd.,** but $\Lambda$ and $V$ **satisfy XFT ones**
Thus, $E$ can introduce non-geometric coordinate dependence in EFT

# $m_R$ from EFT and non-geometry

$$\mathbf{V}^M_{\text{EFT}}(x,Y) = V^A_{\text{XFT}}(x,Y)\, E_A{}^M(Y)$$

$$\boxed{\mathbb{L}_{\boldsymbol{\Lambda}} \mathbf{V}^M = (\widetilde{\mathbb{L}}_{\Lambda} V^A) E_A{}^M}$$

- This **non-geometric extension** of EFT allows e.g. to **source** $m_R$

$$E(Y)_A{}^M = E(Y^{\hat{P}})_A{}^M = \delta_A^M - \frac{1}{c'} Y^{\hat{P}} X^{\text{RR}\ M}_{\hat{P}A} \qquad (\text{no sum over } \hat{P}).$$

A single winding coord.

- **Crucial point:** we are extending to non-geometric coordinates, without truncating any of the physical ones **(not a SS reduction!)**
- !! Meaning of locally non-geometric backgrounds is still unclear, while XFT *solutions* are **globally well-defined (because mIIA is)**

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# Concluding

- **Exceptional Field Theories admit deformations**
  which *still preserve 10- and 11-dim. solutions of section conditions*
- *one such deformation implements* ***massive IIA***
- This is now a **new tool** in its own right.
- These deformations are **more general than the Romans mass!!**
  we have classified **all those allowing for 10d/11d solutions**
  (we could easily go further and recover higher dim. gauged sugras)
- We can (locally) implement a "SS extension Ansatz"
  to non-geometrically map EFT and XFT.
- Future: susy; D8 and 7-branes (& T/S-dualities); D=3;
  and of course: more solutions!

*Thank you!*