Applications of Exceptional Field Theory to the AdS/CFT correspondence

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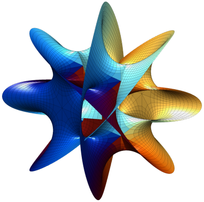
28th June 2022

with Bobev, Galli, Giambrone, Guarino, Josse, Nicolai, Petrini, Robinson, Samtleben, Sterckx, Trigiante, van Muiden, Waldram

Geometry of Compactification = Physics

10-dimensional String Theory



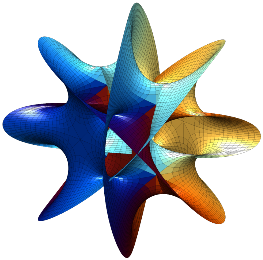
4-dimensional theory

E.g.

- Moduli $\rightarrow$ massless scalar fields
- Kaluza-Klein modes $\rightarrow$ massive fields

Ricci-flat vs flux compactifications

Ricci-flat

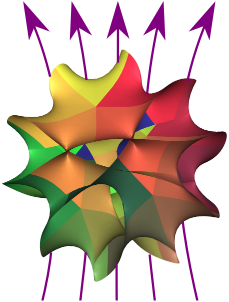


- Moduli ✓
- Uplift 4-d theory → Calabi-Yau data ✓
- Quantum corrections (some control) ✓

SUSY → "Special holonomy" spaces, Calabi-Yau

Ricci-flat vs flux compactifications

Flux compactification



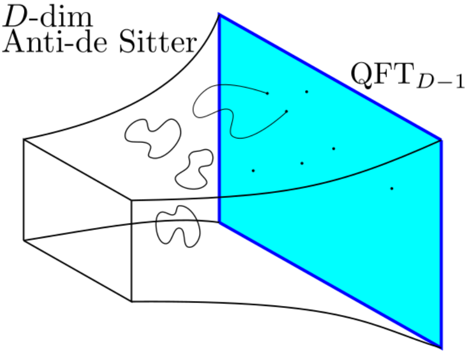
- Moduli ✗
- Uplift 4-d theory $\rightarrow$ Geometric data ✗
- Quantum corrections ✗

Not "special holonomy" spaces: Fluxes $\rightarrow$ torsion

Exceptional Field Theory

AdS/CFT correspondence

All known AdS vacua of String Theory are flux compactifications!

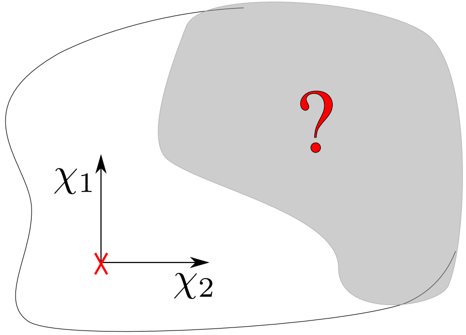


Crucial *quantitative* tool for strongly-coupled CFTs

Conformal manifold & anomalous dimensions

Moduli ⇔ (exactly) marginal deformations

$$L_{\mathrm{CFT}} \to L_{\mathrm{CFT}} + \chi_i \mathcal{O}^i$$

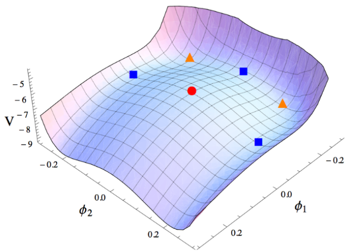


Kaluza-Klein masses ⇔ anomalous dimensions

Lower-dimensional “toy models” vs String Theory

> Use lower-dimensional gauged supergravity to study AdS

- Only subset of fluctuations and masses
- (Misleading?) subset of conformal manifold



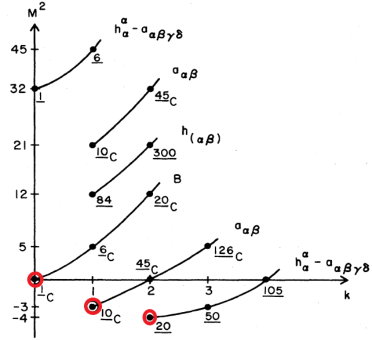


FIG. 2. Mass spectrum of scalars.

Two goals:

Uplift D-dim gauged supergravity to String Theory

Spectrum of masses $\Leftrightarrow$ anomalous dimensions

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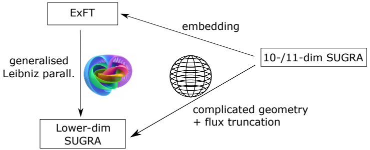
Uplift D-dim gauged supergravity to String Theory

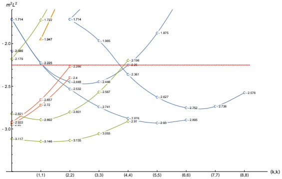
Spectrum of masses $\Leftrightarrow$ anomalous dimensions

Dangers of trusting lower-dimensional supergravity!

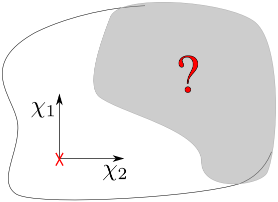
Exceptional Field Theory
& consistent truncations



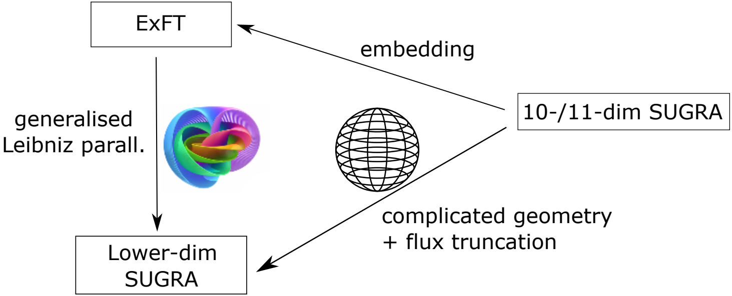
Kaluza-Klein spectroscopy



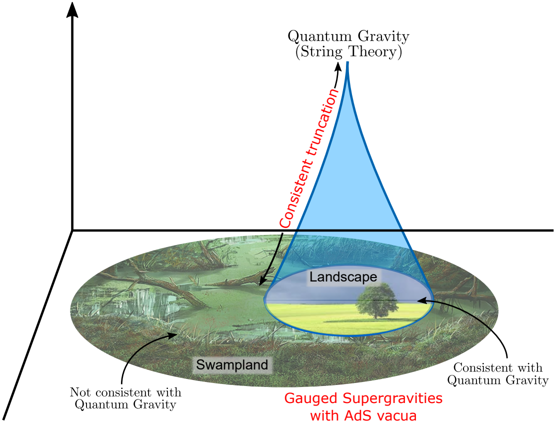
Applications



Exceptional field theory
& consistent truncations



Which gauged supergravities actually arise from String Theory?



Consistent truncation

No well-controlled AdS vacua of String Theory have scale separation

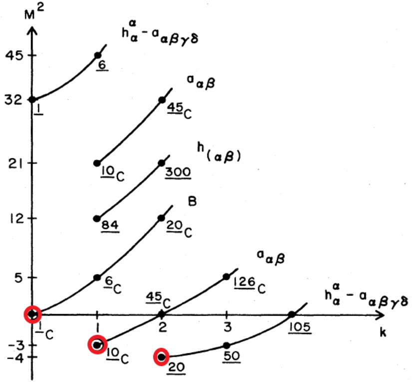


FIG. 2. Mass spectrum of scalars.

Consistent truncation:
All solutions of lower-dim. theory → solutions of 10-d/11-d SUGRA

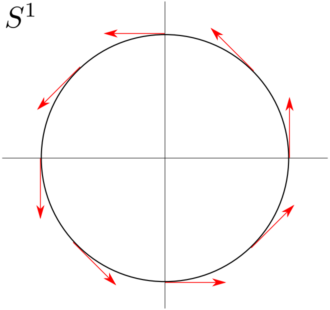
Consistent truncation

Non-linear embedding of lower-dimensional supergravity into 10-/11-d supergravity

- All solutions of lower-d SUGRA $\rightarrow$ solutions of 10-/11-d SUGRA
- Non-linearity: highly non-trivial!
- Symmetry arguments crucial for consistency & construction

Consistent truncation on group manifold

Symmetry arguments crucial for consistency, e.g. group manifold



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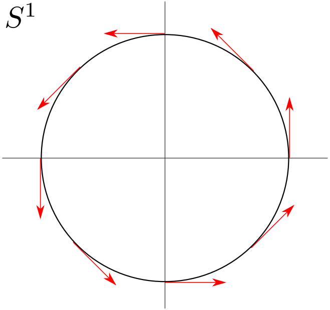


$$U_m{}^\mu \in \mathsf{GL}(D)$$

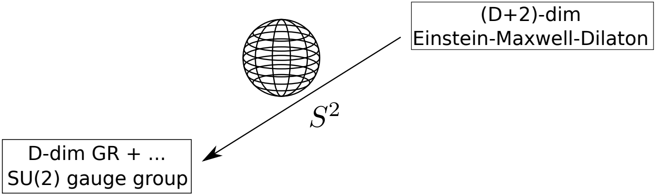
$$L_{U_m} U_n = f_{mn}{}^p U_p$$

$$g_{\mu\nu}(x, y) = g_{mn}(x)\,(U^{-1})_\mu{}^m(y)(U^{-1})_\nu{}^n(y)$$

Larger symmetry groups from generalising geometry

Symmetry argument for other consistent truncations?

$$S = \int d^{D+2}x \sqrt{|g|} \left(R_g - (\nabla\phi)^2 - e^{\alpha\phi} F^2 \right)$$



$$ds^2_{D+2} = Y^{\frac{1}{D}} \left(\Delta^{\frac{1}{D}} ds^2_D + g^{-2} \Delta^{-\frac{D-1}{D}} T^{-1}_{ij} \mathfrak{D}\mu^i \mathfrak{D}\mu^j \right) ,$$

$$e^{\sqrt{\frac{2(D)}{D+1}}\hat{\phi}} = \Delta^{-1} Y^{\frac{D-1}{D+1}} ,$$

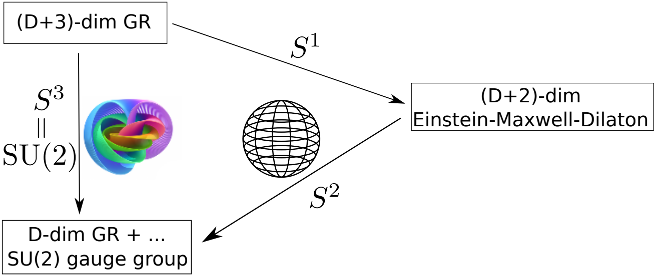
$$\hat{F}_2 = \frac{1}{2}\epsilon_{ijk} \left(g^{-1}\Delta^{-2}\mu^i \mathfrak{D}\mu^j \wedge \mathfrak{D}\mu^k - 2g^{-1}\Delta^{-2}\mathfrak{D}\mu^i \wedge \mathfrak{D}T_{jl} T_{km}\mu^l \mu^m - \Delta^{-1} F^{ij}_{(2)} T_{kl}\mu^l \right) .$$

[Cvetic, Lü, Pope '00]

Larger symmetry groups from generalising geometry

Symmetry argument for other consistent truncations?

$$S = \int d^{D+3}x \sqrt{|G|}\,(R_G)$$



$$U_m{}^{\mu} \in \mathrm{GL}(3)$$

$$L_{U_m} U_n = f_{mn}{}^{p} U_p$$

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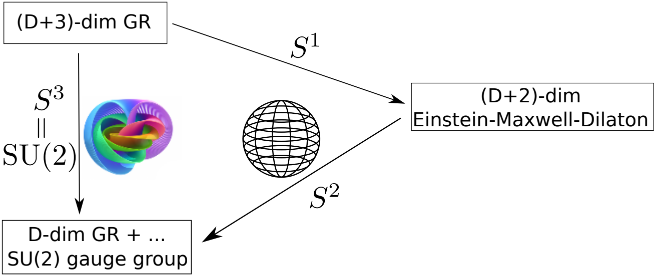

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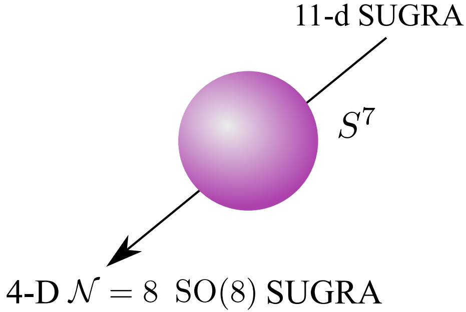
[Cvetic, Lü, Pope, Gibbons '03]

Consistent truncations beyond group manifolds

Consistent truncations of 10-d/11-d SUGRA beyond group manifolds?



[de Wit, Nicolai '82]

Exceptional Field Theory

[Berman, Perry '10], [Coimbra, Strickland-Constable, Waldram '11], [Hohm, Samtleben '13], ...

Exceptional Field Theory: Unify metric + fluxes of supergravity

11-d SUGRA on $M_4 \times C_7$:

$$\{g\,,\ C_{(3)}\,,\ C_{(6)}\,,\ldots\} = \mathcal{M}_{MN} \in \frac{E_{7(7)}}{\mathrm{SU}(8)}\,.$$

Diffeo + gauge transf $\rightarrow$ generalised vector field $V^M \in \mathbf{56}$ of $E_{7(7)}$
Lie derivative $\rightarrow$ generalised Lie derivative

$$\mathcal{L}_V = V^M\partial_M - (\partial \times_{adj} V) = \text{diffeo} + \text{gauge transf}\,,$$

with $\partial_M = \left(\partial_i\,,\ \partial^{ij}\,,\ \partial^{ijklm}\,,\ \ldots\right) = \left(\partial_i\,,\ 0\,,\ \ldots\,,\ 0\right)$.

Exceptional Field Theory = reformulation of supergravity

Exceptional Field Theory: Reformulation of 10-/11-d supergravity

$$\{g\,,\ C_{(3)}\,,\ C_{(6)}\,,\ \ldots\} = \mathcal{M}_{MN}$$

$$L = R - \frac{1}{48} F_{\mu\nu\lambda\rho} F^{\mu\nu\lambda\rho} + \ldots$$

with $F_{\mu\nu\rho\lambda} = 4\partial_{[\mu} C_{\nu\rho\lambda]}$.

Exceptional Field Theory = reformulation of supergravity

Exceptional Field Theory: Reformulation of 10-/11-d supergravity

$$\{g\,,\ C_{(3)}\,,\ C_{(6)}\,,\ \ldots\} = \mathcal{M}_{MN}$$

$$\begin{aligned} L &= R - \frac{1}{48} F_{\mu\nu\lambda\rho} F^{\mu\nu\lambda\rho} + \ldots \\ &= \mathcal{M}^{MN} \partial_M \mathcal{M}^{PQ} \partial_N \mathcal{M}_{PQ} + \ldots \end{aligned}$$

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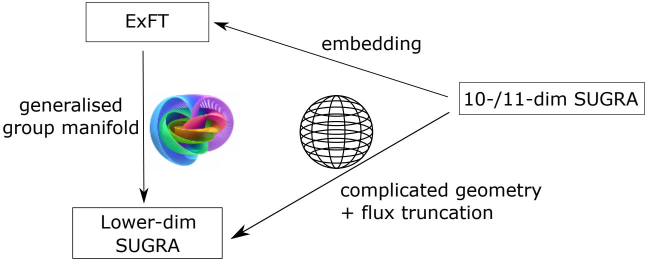
Generalised Lie derivative ⇒ generalised Ricci scalar

Exceptional Field Theory and consistent truncations

Consistent truncations captured by
"generalised group manifolds" in ExFT



$$U_A{}^M \in E_{7(7)}$$

$$\mathcal{L}_{U_A} U_B = X_{AB}{}^C U_C$$

$$\mathcal{M}_{MN}(x, Y) = M_{AB}(x)(U^{-1})_M{}^A(Y)(U^{-1})_N{}^B(Y)$$

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Consistent truncations captured by
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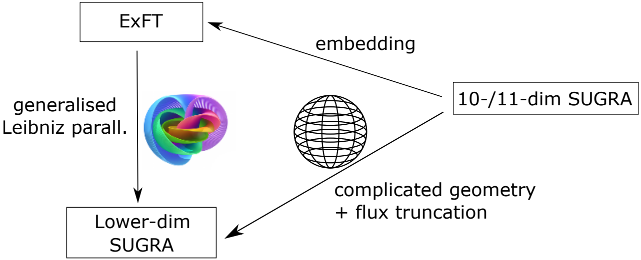

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Uplifting AdS vacua to string theory

Consistent truncations on S^p, $H^{p,q}$, $S^p \times S^q$, ...
to maximal gSUGRA

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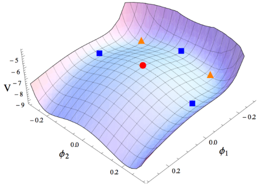

Uplifting AdS vacua to string theory

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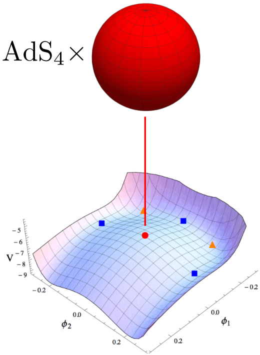

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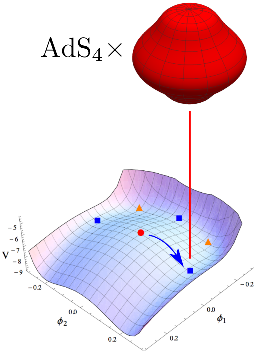

Warped compactifications with few/no remaining (super-)symmetries

Uplifting AdS vacua to string theory

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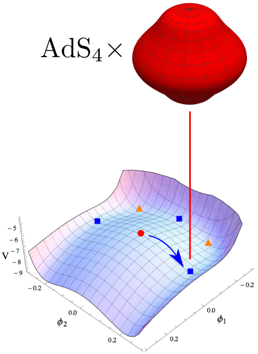
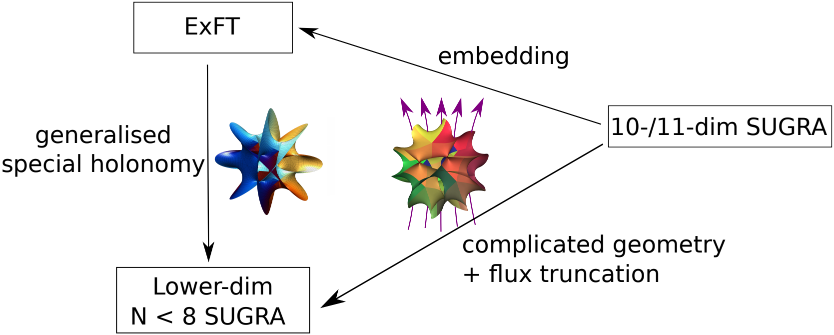


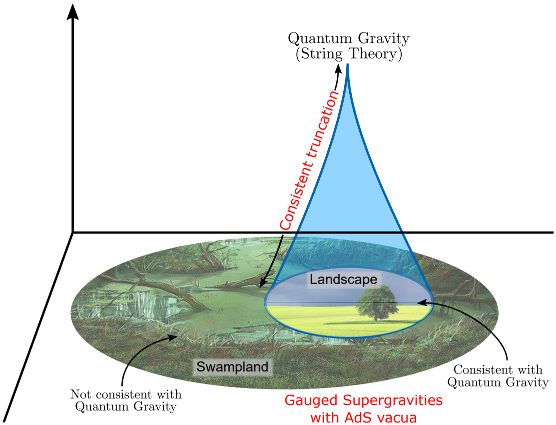
Multiplication by $E_{7(7)}$ matrix!

Less SUSY consistent truncation $\longleftrightarrow$ "generalised special holonomy"

[Cassani, Galli, Josse, EM, Petrini, Samtleben, Vall Camell, Waldram, ...]



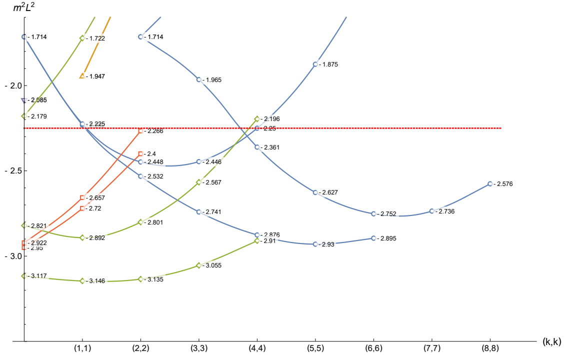
String Theory origin ⇒ Constraints on lower-dim theories



E.g.

- Symmetric scalar manifolds
- Small number of matter multiplets
- No-go theorems for gauge groups

Kaluza-Klein spectroscopy



Kaluza-Klein spectroscopy

Consistent truncation:

- Lower-dimensional theory
- Compute subset of masses for any vacuum!

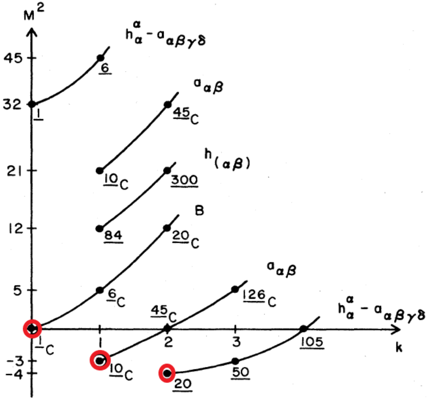
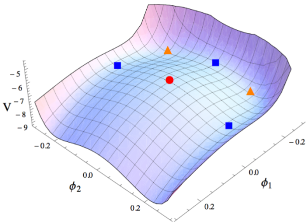


FIG. 2. Mass spectrum of scalars.



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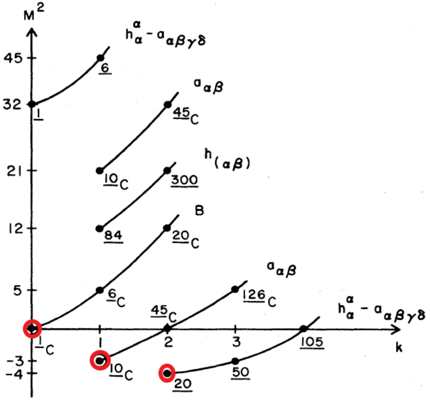

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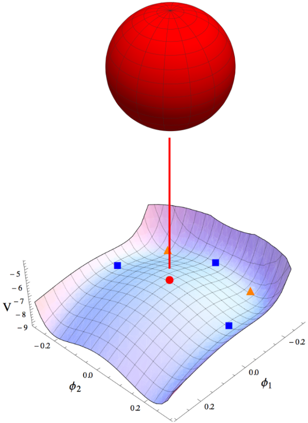

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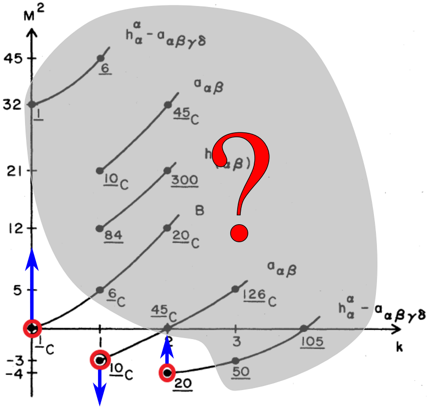

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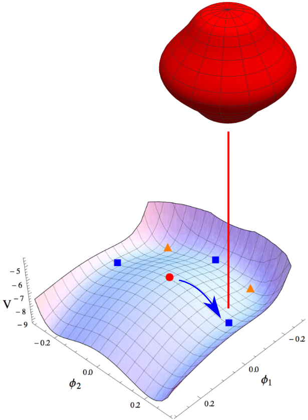

Kaluza-Klein spectroscopy

Consiste

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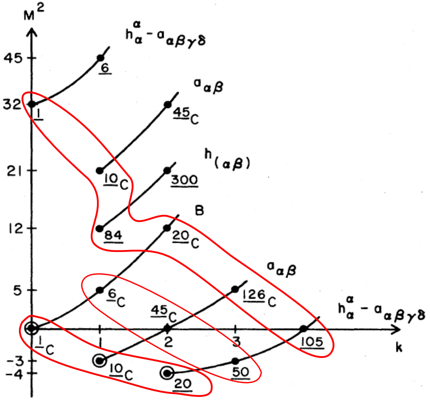
- Co

[EM, Samtleben Phys. Rev. Lett. 2020]
Extend this to full KK spectrum using ExFT!



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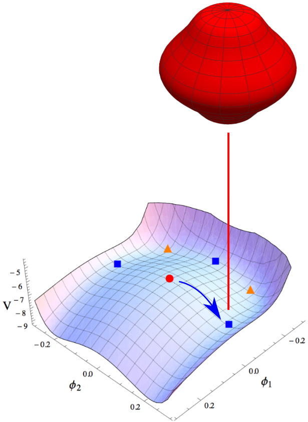


Traditional Kaluza-Klein spectroscopy

Traditionally:

- Spin-2 fields [Bachas, Estes '11] ✓
- $M_{int} = \frac{G}{H}$ ✓

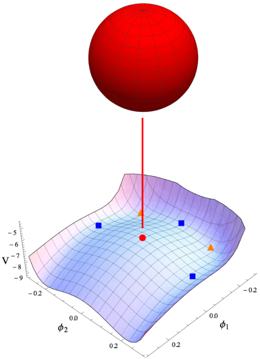
Here: [EM, Samtleben Phys. Rev. Lett. 2020]

- Warped compactifications with few or no remaining (super-)symmetries!
- Spectrum along RG flow

KK spectroscopy strategy

First at max symmetric point:

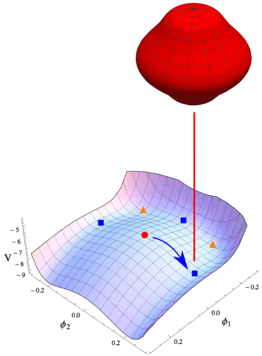
$$\mathcal{M}_{MN}(x, Y) = \delta_{AB}(U^{-1})_M{}^A(Y)(U^{-1})_N{}^B(Y)$$



KK spectroscopy strategy

Then at less symmetric point:

$\mathcal{M}_{MN}(x, Y) = M_{AB}(x)(U^{-1})_M{}^A(Y)(U^{-1})_N{}^B(Y)$



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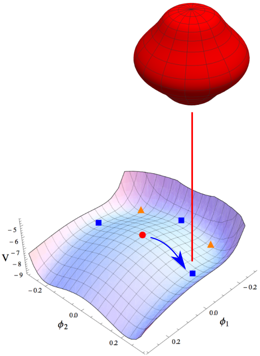
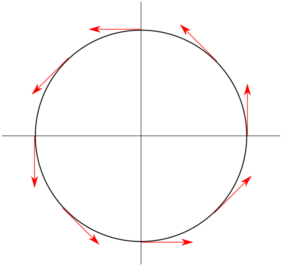


Multiplication by $E_{7(7)}$ matrix, $M_{AB}(x)$!

KK spectroscopy at max. symmetric point

${U_A}^M \in E_{7(7)}$ give basis for all fields



Only need scalar harmonics: $\mathcal{Y}_\Sigma$

c.f. $h_{ij}(x, y) = \sum_\ell h^{(\ell)}(x)\mathcal{Y}^{(\ell)}_{(ij)}(y), \quad b_{ij}(x, y) = \sum_\ell b^{(\ell)}(x)\mathcal{Y}^{(\ell)}_{[ij]}(y)$

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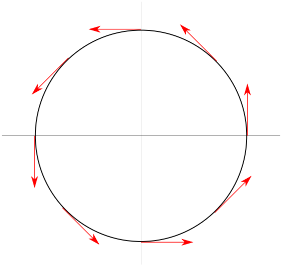
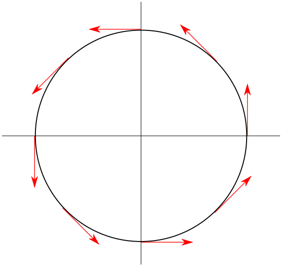


Only need scalar harmonics: $\mathcal{Y}_\Sigma$

$$\mathcal{M}_{MN}(x, Y) \in E_{7(7)}/\mathrm{SU}(8)$$

KK spectroscopy at max. symmetric point

${U_A}^M \in E_{7(7)}$ give basis for all fields



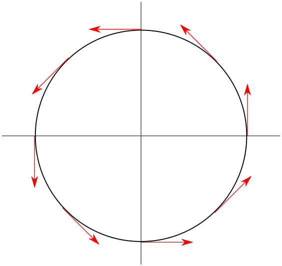
Only need scalar harmonics: $\mathcal{Y}_\Sigma$

$$\mathcal{M}_{MN}(x,Y) = (\delta_{AB} + {j_{AB}}^{\Sigma}(x)\mathcal{Y}_\Sigma)(U^{-1})_M{}^A(Y)(U^{-1})_N{}^B(Y)$$

$${j_{AB}}^{\Sigma} \in \mathfrak{e}_{7(7)} \ominus \mathfrak{su}(8)$$

KK spectroscopy at max. symmetric point

${U_A}^M \in E_{7(7)}$ give basis for all fields



Only need scalar harmonics: $\mathcal{Y}_\Sigma$

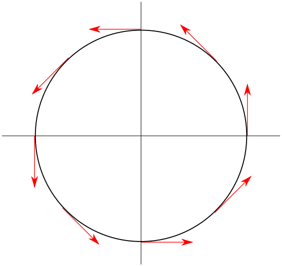
$$\mathcal{M}_{MN}(x,Y) = (\delta_{AB} + {j_{AB}}^{\Sigma}(x)\mathcal{Y}_\Sigma)(U^{-1})_M{}^A(Y)(U^{-1})_N{}^B(Y)$$

$${j_{AB}}^\Sigma \in \mathfrak{e}_{7(7)} \ominus \mathfrak{su}(8)$$

KK Ansatz = consistent truncation $\otimes$ scalar harmonics

KK spectroscopy at max. symmetric point

${U_A}^M \in E_{7(7)}$ give basis for all fields



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$${j_{AB}}^{\Sigma} \in \mathfrak{e}_{7(7)} \ominus \mathfrak{su}(8)$$

Immediate mass diagonalisation!

Mass matrix

- Lower-dim info:

$$\mathcal{L}_{U_A} U_B = X_{AB}{}^C U_C \,,$$

- Higher-dim info:

$$\mathcal{L}_{U_A} \mathcal{Y}_\Sigma = L_{K_A} \mathcal{Y}_\Sigma = \mathcal{T}_{A\,\Sigma}{}^{\Omega} \mathcal{Y}_\Omega \,.$$

Algebraic mass matrix:

$$\mathbb{M}^{(\mathrm{scalar})}_{I\Sigma,J\Omega} = \mathbb{M}^{(0)}_{IJ}\, \delta_{\Sigma\Omega} + \delta_{IJ}\, \mathbb{M}^{(\mathrm{spin-2})}_{\Sigma\Omega} + \mathcal{N}_{IJ}{}^C \mathcal{T}_{C,\Omega\Sigma}$$

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- Lower-dim SUGRA mass matrix $\mathbb{M}^{(0)}_{IJ}$

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- Lower-dim SUGRA mass matrix $\mathbb{M}^{(0)}_{IJ}$

$$\begin{aligned}\mathbb{M}^{(0)}_{IJ} = &\frac{1}{7}\left(X_{AE}{}^F X_{BE}{}^F + X_{EA}{}^F X_{EB}{}^F + X_{EF}{}^A X_{EF}{}^B + 7\,X_{AE}{}^F X_{BF}{}^E\right)\mathcal{P}_{AD}{}^I \mathcal{P}_{BD}{}^J \\ &+ \frac{2}{7}\left(X_{AC}{}^E X_{BD}{}^E - X_{AE}{}^C X_{BE}{}^D - X_{EA}{}^C X_{EB}{}^D\right)\mathcal{P}_{AB}{}^I \mathcal{P}_{CD}{}^J \\ &+ \frac{1}{6}\,\mathcal{P}_{AB}{}^I \mathcal{P}_{CD}{}^J\, X_{FA}{}^B X_{FC}{}^D \,.\end{aligned}$$

Mass matrix

- Lower-dim info:
$$\mathcal{L}_{U_A} U_B = X_{AB}{}^C U_C\,,$$
- Higher-dim info:
$$\mathcal{L}_{U_A}\mathcal{Y}_\Sigma = L_{K_A}\mathcal{Y}_\Sigma = \mathcal{T}_{A\,\Sigma}{}^{\Omega}\mathcal{Y}_\Omega\,.$$

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- Lower-dim SUGRA mass matrix $\mathbb{M}^{(0)}_{IJ}$
- Spin-2 mass matrix $\mathbb{M}^{(\mathrm{spin-2})}_{\Sigma\Omega} = \mathcal{T}_{A,\Sigma\Lambda}\mathcal{T}_{A,\Lambda\Omega}$

Mass matrix

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$$\mathcal{L}_{U_A} U_B = X_{AB}{}^C U_C \,,$$
- Higher-dim info:
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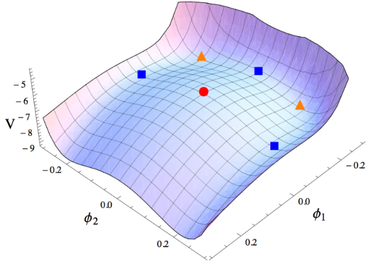
Algebraic mass matrix:

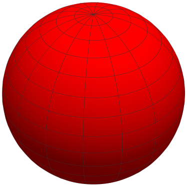
$$\mathbb{M}^{(\mathrm{scalar})}_{I\Sigma,J\Omega} = \mathbb{M}^{(0)}_{IJ}\,\delta_{\Sigma\Omega} + \delta_{IJ}\,\mathbb{M}^{(\mathrm{spin}-2)}_{\Sigma\Omega} + \mathcal{N}_{IJ}{}^{C}\mathcal{T}_{C,\Omega\Sigma}$$

- Lower-dim SUGRA mass matrix $\mathbb{M}^{(0)}_{IJ}$
- Spin-2 mass matrix $\mathbb{M}^{(\mathrm{spin}-2)}_{\Sigma\Omega} = \mathcal{T}_{A,\Sigma\Lambda}\mathcal{T}_{A,\Lambda\Omega}$
- Key object:
$$\mathcal{N}_{IJ}{}^{C} = -4(X_{CA}{}^{B} + 12\,X_{AB}{}^{C})\mathcal{P}^{AD}{}_{[I}\mathcal{P}^{BD}{}_{J]}\,.$$

KK spectroscopy at less symmetric point

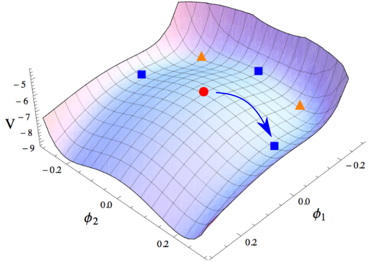


$\longleftrightarrow$

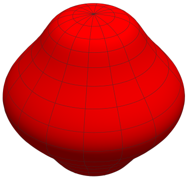


KK Ansatz = consistent truncation $\otimes$ scalar harmonics

KK spectroscopy at less symmetric point



$\longleftrightarrow$



KK Ansatz = consistent truncation $\otimes$ scalar harmonics

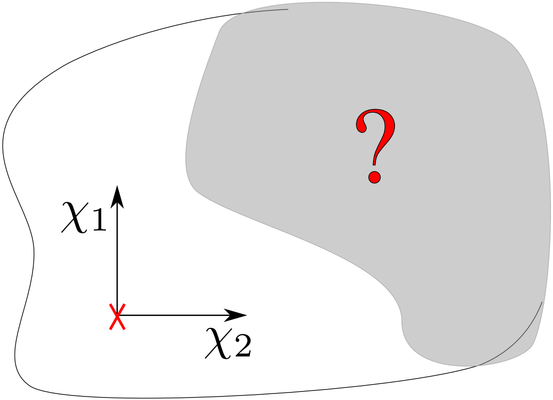
Multiplication by $E_{7(7)}$ matrix, $M_{AB}(x)$!

Use same harmonics as for max. symmetric point

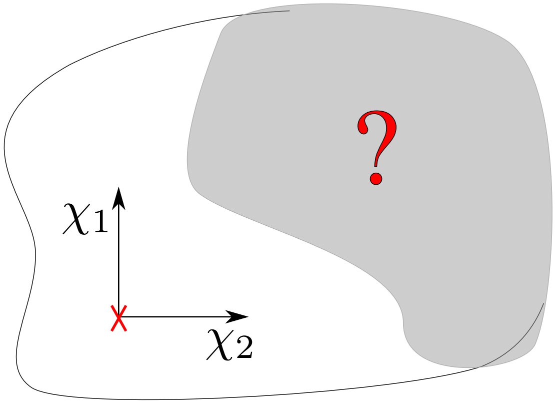
KK Spectroscopy Summary

- No need for explicit metric
- Only scalar harmonics of maximally symmetric point (round sphere)
- ExFT KK Ansatz $\Longrightarrow$ Differential problem $\rightarrow$ algebraic problem
- Compute full spectrum for any vacuum in consistent truncation
- Spectrum for compactifications with few/no remaining (super-)symmetries

Applications

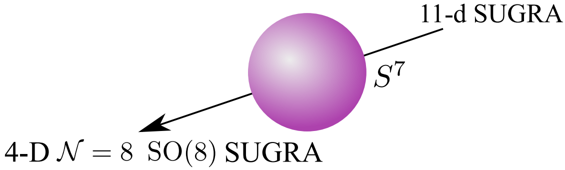


Applications

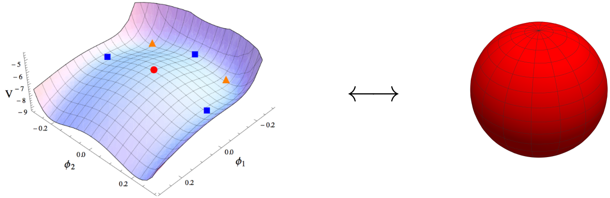


1. Stability of non-SUSY AdS
2. Global properties of conformal manifold

Ex 1. Non-SUSY SO(3)× SO(3) AdS_4 vacua

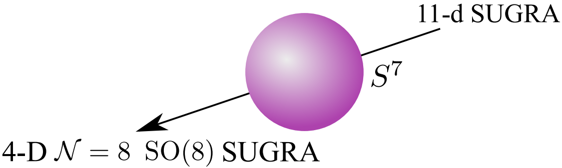


- Only one non-SUSY vacuum that is stable in 4-d! [Fischbacher, Pilch, Warner '10], [Comsa, Firsching, Fischbacher '19]
- Non-SUSY SO(3) × SO(3) AdS_4 vacuum [Warner '83]



- Instability?

Ex 1. Non-SUSY SO(3)× SO(3) AdS$_4$ vacua



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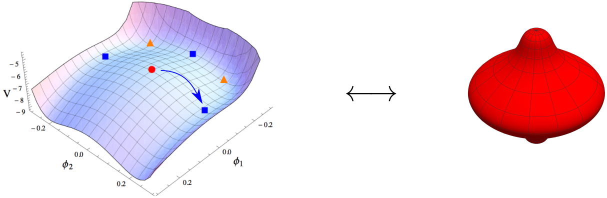


- Instability?

Ex 1. Perturbative stability?

4-d "zero-mode" stability enough for 11-d perturbative stability?

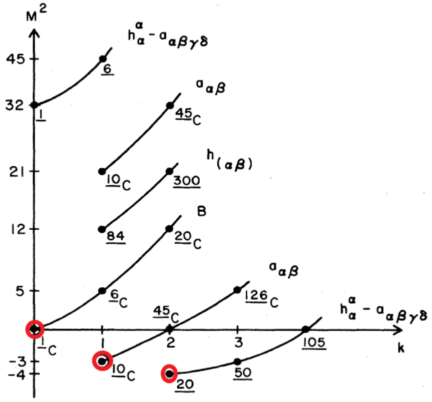
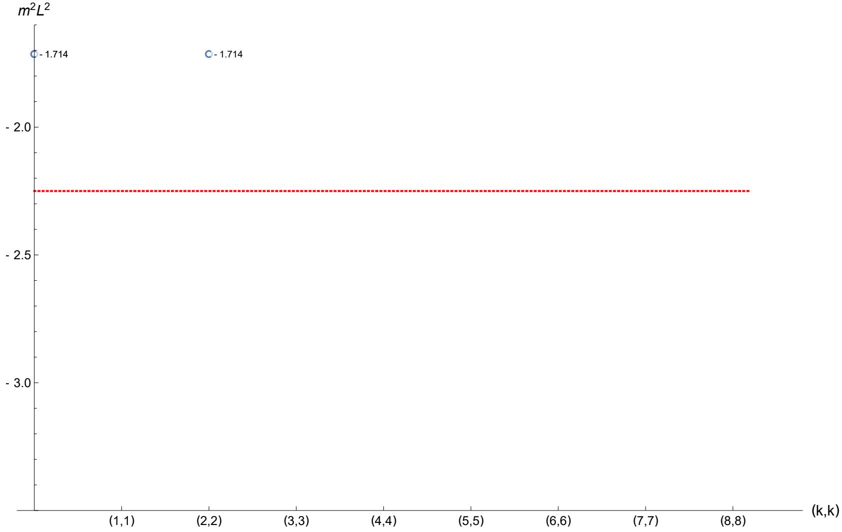


FIG. 2. Mass spectrum of scalars.

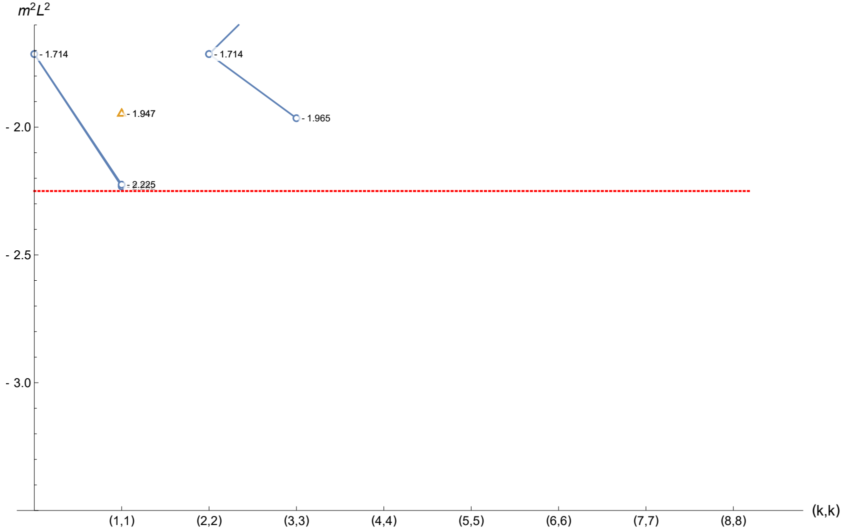
Ex 1. Tachyonic KK modes

Modes $\ell = 0$: $\mathcal{N} = 8$ supergravity multiplet [Fischbacher, Pilch, Warner '10]



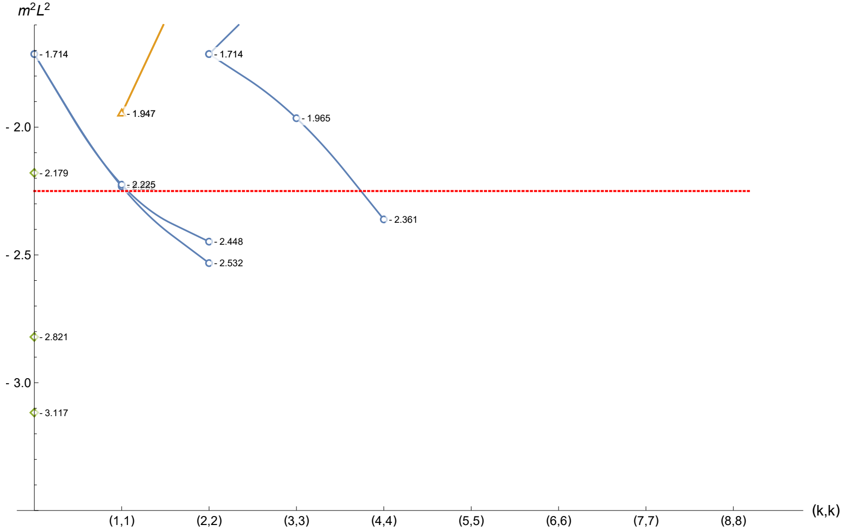
Ex 1. Tachyonic KK modes

Modes $\ell \leq 1$: still stable! [EM, Nicolai, Samtleben '20]



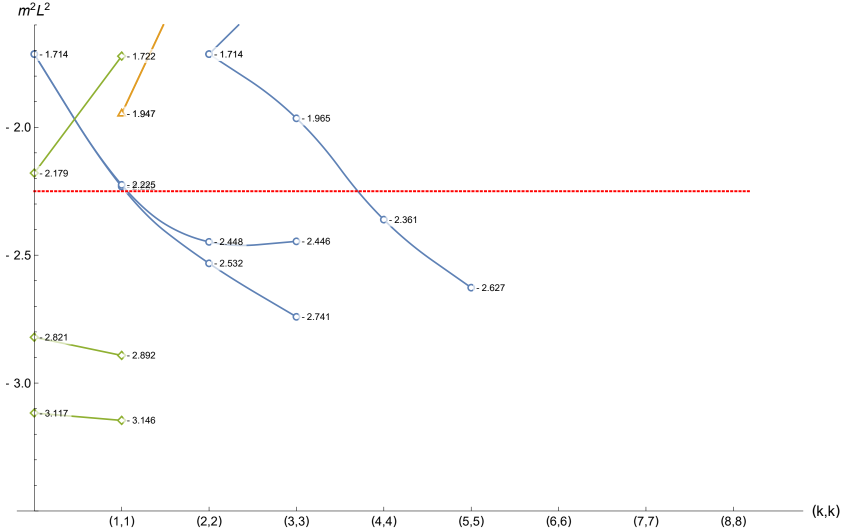
Ex 1. Tachyonic KK modes

Modes $\ell \leq 2$: **tachyons!** [EM, Nicolai, Samtleben '20]



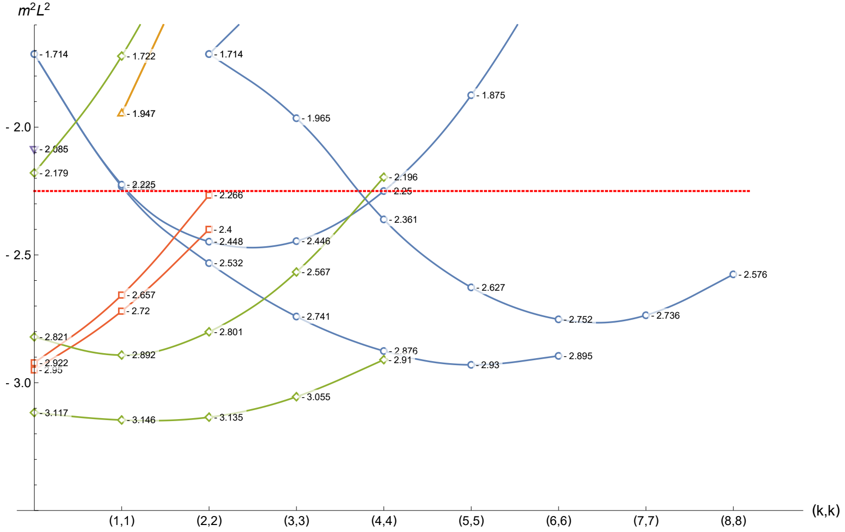
Ex 1. Tachyonic KK modes

Modes $\ell \leq 3$ [EM, Nicolai, Samtleben '20]



Ex 1. Tachyonic KK modes

Modes $\ell \leq 6$ [EM, Nicolai, Samtleben '20]



Ex 1. Kaluza-Klein instability

Higher KK modes are tachyonic!
[EM, Nicolai, Samtleben '20]

- Non-SUSY $SO(3) \times SO(3)$ AdS_4 [Warner '83] is perturbatively unstable
- "Zero-mode" stability does not guarantee perturbative stability in higher dimensions
- Related to brane-jet instability [Bena, Pilch, Warner '20]?

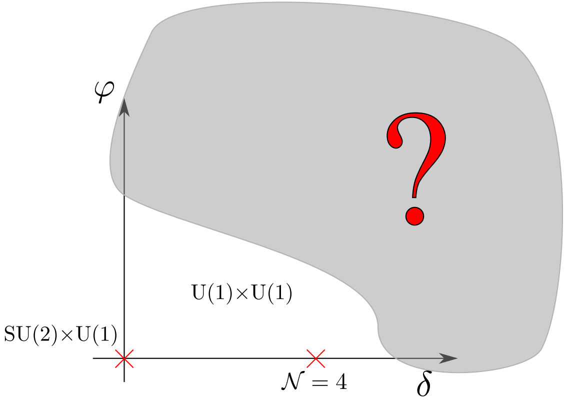
- Examples of perturbatively stable non-SUSY AdS_4 vacua in 10-d [Guarino, EM, Samtleben '20]
  Non-SUSY exactly marginal deformation? [Giambrone, Guarino, EM, Samtleben, Sterckx, Trigiante '21]

Ex 2. $\mathcal{N} = 2$ AdS$_4$ family

$[\mathrm{SO}(6) \times \mathrm{SO}(1,1)] \ltimes \mathbb{R}^{12}$ supergravity

2 moduli $(\varphi, \delta) \in \mathbb{R}^2_{\geq 0}$ in 4-d theory $\Leftrightarrow$ $\mathcal{N} = 2$ conformal manifold

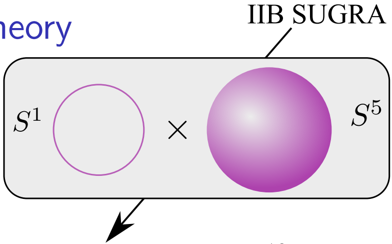
[Guarino, Sterckx, Trigiante '20], [Bobev, Gautason, van Muiden '21]



Expected to be compact e.g. [Perlmutter, Rasteli, Vafa, Valenzuela, '20]

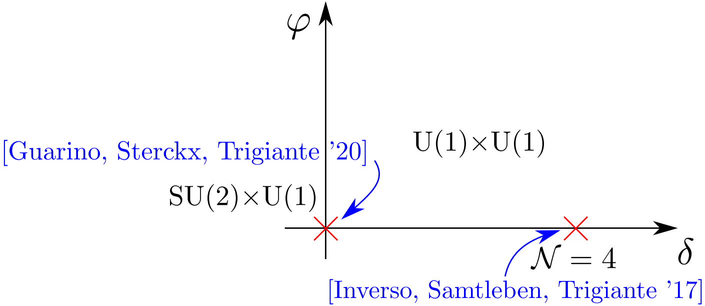
Ex 2. Uplift to IIB string theory

[Inverso, Samtleben, Trigiante '16]



4-D $[\mathrm{SO}(6) \times \mathrm{SO}(1,1)] \ltimes \mathbb{R}^{12}$ SUGRA

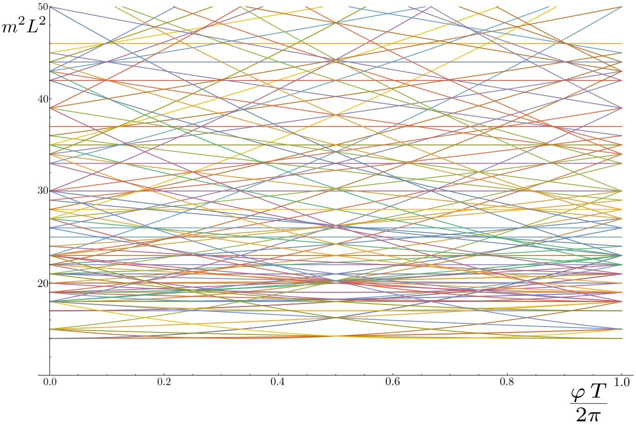
$\mathrm{AdS}_4 \times S^5 \times S^1$ "S-fold" of IIB



Ex 2. Global properties of the $\mathcal{N}=2$ conformal manifold

$\mathrm{AdS}_4 \times S^5 \times S^1$ KK spectrum along φ direction

[Giambrone, EM, Samtleben, Trigiante '21]

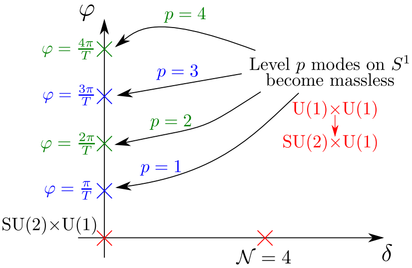


$\varphi \sim \varphi + \frac{2\pi}{T}$, T radius of S^1

Ex 2. Space invaders

Higher KK modes become massless when $\varphi = \frac{p\,\pi}{T}$, $p \in \mathbb{Z}$

[Giambrone, EM, Samtleben, Trigiante '21]



Spectrum identical for $\varphi = \frac{2\,p\,\pi}{T}$, $p \in \mathbb{Z}$

Spectrum differs for $\varphi = \frac{(2\,p+1)\,\pi}{T}$, $p \in \mathbb{Z}$

Ex 2. KK spectrum along $\mathcal{N}=2$ conformal manifold

[Giambrone, EM, Samtleben, Trigiante '21]

- $\varphi \in \mathbb{R}^+$ is a 4-d artefact
- $\varphi \in [0, \frac{2\pi}{T})$ in 10 dimensions
- KK spectrum as fct of φ:

$$\Delta = \frac{1}{2} + \sqrt{\frac{17}{4} + \frac{1}{2}R^2 - J(J+1) - 2k(k+1) + \ell(\ell+4) + 4(\frac{\pi\, n}{T} - j\,\varphi)^2}\,.$$

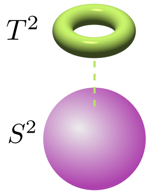
Lorentz spin: J
SU(2) spin: k
$U(1)_R$ charge: R
U(1) $\subset$ SU(2) Cartan: j
S^5 level: ℓ
S^1 level: n

- KK spectrum as fct of δ: non-compact? [Bobev, Gautason, van Muiden '21], [Cesàro, Larios, Varela '21]

Ex 2. φ as complex structure deformation

[Giambrone, EM, Samtleben, Trigiante '21]

- φ-family: $\mathrm{AdS}_4 \times S^5 \times S^1_\eta$: $S^5 \to S^3 \times S^2$
- S^3 Hopf fibre & S^1_η:



$$\tau = \frac{i}{4\pi} - \frac{\varphi T}{2\pi}$$

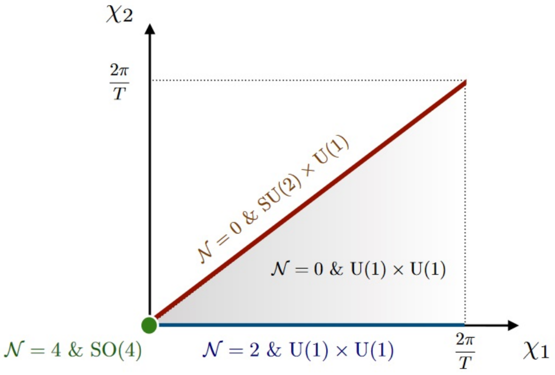
$$\varphi \to \varphi + \tfrac{2\pi}{T} \implies \tau \to \tau - 1$$

- φ deformation: locally $\to$ coordinate transformation

Similar in other S-fold vacua [Cesàro, Larios, Varela '22]

Ex 3. Non-SUSY flat deformations

2 new flat directions χ_1, χ_2 of 4-D supergravity [Guarino, Sterckx '21]



Non-supersymmetric conformal manifold?

Ex 3. Evidence for non-SUSY exactly marginal deformations

Non-SUSY exactly marginal deformations not expected to exist

Evidence for a miracle

[Giambrone, Guarino, EM, Samtleben, Sterckx, Trigiante '21]

- Perturbative stability
- Non-perturbative stability
- $\frac{1}{N}$ corrections

χ_1, χ_2 deformations are locally coordinate transformations!

Ex 3. KK Spectroscopy

[Giambrone, Guarino, EM, Samtleben, Sterckx, Trigiante '21]

KK spectroscopy → full KK spectrum

Perturbatively stable!

$$\Delta = \frac{3}{2} + a + \frac{1}{2}\sqrt{9 + 2\ell(\ell+4) + 4\ell_1(\ell_1+1) + 4\ell_2(\ell_2+1) + 2\left(\frac{2n\pi}{T} + j_1\chi_1 + j_2\chi_2\right)^2}\,.$$

Position within $\mathcal{N} = 4$ multiplet: a
SO(4) spin: ℓ_1, ℓ_2
Charges under U(1) × U(1) Cartan: j_1, j_2
S^5 level: ℓ
S^1 level: n

Ex 3. Non-perturbative stability?

[Giambrone, Guarino, EM, Samtleben, Sterckx, Trigiante '21]

- Probe-brane analysis: $T > Q$
  Branes more stable than in SUSY case!
- No Ooguri-Vafa instability [Ooguri, Vafa '16]
- S^1 and S^5 protected against "bubble of nothing" [Witten '82]
- D3-brane bubble of nothing [Bomans, Cassani, Dibitetto, Petri '21] ??

Ex 3. $\frac{1}{N}$ corrections

[Giambrone, Guarino, EM, Samtleben, Sterckx, Trigiante '21]

Flat directions lifted by $\frac{1}{N}$ corrections?

Protection by diffeomorphism symmetry

- χ_1, χ_2 $\rightarrow$ coordinate transformations (locally)
- χ_1, χ_2 do not appear in diffeo-invariant quantities

Also applies to $\mathcal{N} = 1$ exactly marginal deformations

[Bobev, Gautason, van Muiden '21]

Ex 3. $\frac{1}{N}$ corrections

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Also applies to $\mathcal{N} = 1$ exactly marginal deformations
[Bobev, Gautason, van Muiden '21]

Corrections from D5-instantons?

$vol_{\mathrm{S}^5 \times \mathrm{S}^1}$ independent of χ_1, χ_2

Conclusions

Using ExFT:

- Embedding of lower-dimensional AdS vacua into string theory
- Anomalous dimensions of operators
- Higher KK modes crucial for physics, e.g. compactness, stability
- Non-supersymmetric AdS/CFT?
- Non-supersymmetric exactly marginal deformations?

Open questions

- Correlation functions?
- Vacua of less SUSY gSUGRA?
- Spectrum along RG flow without consistent truncation?
- $\Lambda \geq 0$?

Thank you!