Moduli Spaces of AdS Vacua in $d = 7$ Supergravity

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work in progress
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June 11, 2015

Motivation

- AdS/CFT duality:

$$\begin{array}{ccc} \text{SUGRA} & \longleftrightarrow & d\text{-dim. SCFT} \\ \text{on } AdS_{d+1} & & \text{on the boundary} \end{array}$$

- Deformations of the theory:

$$\begin{array}{ccc} \text{Moduli space} & \overset{?}{\longleftrightarrow} & \text{Conformal manifold} \\ \text{of AdS solution} & & \text{of dual SCFT} \end{array}$$

- Here: Explicit calculation of the moduli space of AdS_7 solutions.

  (AdS_4: [de Alwis, Louis, McAllister, Triendl, Westphal '13][Louis, Triendl '14])

$d = 7$, $N = 2$ Supergravity

[Bergshoeff, Koh, Sezgin '85]

- $d = 7$: Two possible supergravities: $\mathcal{N} = 2$ and $\mathcal{N} = 4$
- Here: $\mathcal{N} = 2$ (16 supercharges)
- field content
  - gravity multiplet

$$\left(e_\mu^m, \psi^A, A_\mu^i, \chi^A, B_{\mu\nu}, \sigma\right) , \qquad A = 1, 2 , \quad i = 1, 2, 3$$

  - n vector multiplets

$$\left(A_\mu^r, \lambda^{rA}, \phi^{ri}\right) , \qquad r = 1, \ldots, n$$

- scalar manifold

$$\frac{SO(3, n)}{SO(3) \times SO(n)}$$

The gauged theory

- in total $n+3$ vectors $A^I = (A^i, A^r)$, $I = 1, \ldots, n+3$, there is a global $SO(3,n)$ symmetry

- gauge a subgroup
$$G \subset SO(3,n)$$

- described by structure constants ${f_{IJ}}^K$ $(I = 1, \ldots, n+3)$, i.e.
$$[T_I, T_J] = {f_{IJ}}^K T_K$$

- constraint on the structure constants
$${f_{IK}}^L \eta_{LJ} + {f_{JK}}^L \eta_{LI} = 0$$
reduces the number of possible (non-)compact generators of G

- non-trivial potential $V(\sigma, \phi_{ir})$

Supersymmetric AdS solutions

- A supersymmetric solution needs to satisfy

$$\delta\psi_\mu = \delta\chi = \delta\lambda^r = 0\,.$$

$\Rightarrow$ For $\langle V \rangle < 0$: Conditions on the structure constants:

$$f_{ijk} = g\epsilon_{ijk}\,, \quad f_{ijr} = 0$$

Solution: possible gauge groups

$$G = G_0 \times H = \left\{ \begin{array}{l} SO(3) \\ SO(3,1) \\ SL(3,\mathbb{R}) \end{array} \right\} \times H\,,$$

with $H \subset SO(n)$ arbitrary.

(See also: [Karndumri '14])

The Moduli Space

- Find flat directions $\delta\phi_{ir}$ that preserve SUSY conditions.

- Result:

$$\delta\phi_{ir} = f_{irs}\lambda^s \,,$$

  for λ^s arbitrary.

- $\#$ of indep. flat directions is given by $\mathrm{rank}\,(f_{ir,s})$.

- f_{irs} correspond to non-compact directions of the gauge group G

$$\Rightarrow \quad \mathcal{M}_{\delta\phi} = \frac{G_0}{SO(3)}$$

Spontaneous breaking of the gauge group

- Evaluated in the vacuum the Lagrangian contains a term of the form

$$\left(f_{irs} A^s\right)^2$$

- $\mathrm{rank}\left(f_{ir,s}\right)$ vectors obtain a mass.

Spontaneous breaking of the gauge group

$$G = \begin{Bmatrix} SO(3) \\ SO(3,1) \\ SL(3,\mathbb{R}) \end{Bmatrix} \times H \quad \to \quad SO(3) \times H \,.$$

- All massless scalars $\delta\phi_{ir}$ are eaten by massive vectors.

True moduli space

$$\mathcal{M}_{AdS} = \begin{Bmatrix} \text{isolated} \\ \text{points} \end{Bmatrix}$$

AdS/CFT correspondence

The holographic principle

$\mathcal{N} = 2$ SUGRA on AdS_7 $\Leftrightarrow$ $d = 6$, $\mathcal{N} = (1,0)$ SCFT on the boundary of AdS_7

- gauge symmetry: $\Leftrightarrow$ global symmetry:

  $SO(3) \times H$ $\qquad$ $SU(2)_R \times H_{\text{flavour}}$

- scalar field with mass m $\Leftrightarrow$ conf. operator of dimension

$$\Delta = \frac{6}{2} + \sqrt{\left(\frac{6}{2}\right)^2 + m^2 L^2}$$

Conformal manifold

- Deform a SCFT by operators $\mathcal{O}_i$:

$$S \to S + \sum_i \int \varphi^i \mathcal{O}_i$$

- Deformations that do not break superconformal invariance: exactly marginal operators

- Conformal manifold $\mathcal{C}$ = space of exactly marginal couplings φ^i.

- necessary condition: φ^i is dimensionless $\quad \Rightarrow \quad \Delta_{\mathcal{O}_i} = 6$

AdS/CFT:

$$\mathcal{M}_{AdS} \cong \mathcal{C}$$

Classification of marginal operators

- Marginal deformations of the Lagrangian need to satisfy:
  - $\Delta = 6$.
  - Invariance under SUSY: Annihilated by all supercharges.
  - Invariance under Lorentz and R-symmetry transformations: No uncontracted indices.
- List of possible operators:
  - $\mathcal{O}$
  - $\{Q_{i\alpha}, \mathcal{O}^{i\alpha}\}$
  - $\{Q_{i\alpha}, [Q^i_\beta, \mathcal{O}^{\alpha\beta}]\}$
  - ...
- Use unitarity bounds [Minwalla '98] to rule out all possible candidates.

Result

$$\mathcal{C} = \begin{Bmatrix} \text{isolated} \\ \text{points} \end{Bmatrix}$$

(Compare [Green, Komargodski, Seiberg '10] for $d = 4$, $\mathcal{N} = 1$)

Conclusions & Outlook

Conclusions:

- $d = 7$, $\mathcal{N} = 2$ SUGRA admits AdS solutions iff the gauge group is

$$G = \left\{ \begin{array}{l} SO(3) \\ SO(3,1) \\ SL(3,\mathbb{R}) \end{array} \right\} \times H \quad \rightarrow \quad SO(3) \times H \,.$$

- All massless scalars are Goldstone bosons $\rightarrow$ The moduli space consists only of isolated points.
- There are indeed no marginal operators in the dual SCFT.

Further directions:

- Understand relation to full $AdS_7 \times Y_{3/4}$ theory.