Minimal Holography

Higher spin gravity from solveable CFTs

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Based on: 1101.2910, 1106.1897, 1107.5098 and papers in progress
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Outline

Motivation

Higher Spin Holography

Applications/Examples

What makes holography tick?

$$\Lambda < 0$$

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AdS/CFT provides a non-perturbative definition of quantum gravity in certain circumstances (string theory, supersymmetry, $\Lambda < 0$, etc.)

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AdS/CFT provides a non-perturbative definition of quantum gravity in certain circumstances (string theory, supersymmetry, $\Lambda < 0$, etc.)

But how does it work?

1. How does a local extra dimension emerge from CFT?

What makes holography tick?

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But how does it work?

1. How does a local extra dimension emerge from CFT?

And when does it work?

2. When does CFT = AdS quantum gravity?
3. How does holography apply in other spacetimes?
4. Can time be an emergent dimension?

Simplified Holography

A possible approach:

- Find holographic dualities simple enough to solve, but complicated enough to look like gravity in d>2.

This talk: A summary of higher spin dualities

- Simple bulk: Higher spin gravity
- Simple boundary: Free CFTs and other exactly solveable models

(This is a toy model; higher spin gravity has no Einstein-gravity-like limit.)

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Higher Spin Gravity

Large (or infinite) number of massless fields, with spins

$$s = 0, 1, 2, 3, 4, \cdots, N$$

Spin-2 = graviton. Massless higher spin fields mean very large gauge symmetry extending diffeomorphism invariance.

Consistent interacting theory exists for $\Lambda \neq 0$

Fradkin and Vasiliev, 1987
Vasiliev, 1990

Toy model for string field theory in the stringy limit

AdS_4: Dual to Free Fields

Free fields have an infinite number of conserved currents of all spins:

$$J_{\mu_1 \cdots \mu_s} \sim \phi^a \partial_{(\mu_1} \cdots \partial_{\mu_s)} \phi^a$$

These are dual to bulk higher spin gauge fields:

$$J_{\mu_1 \cdots \mu_s} \leftrightarrow A_{\mu_1 \cdots \mu_s}$$

eg: Fronsdal 1979; Witten 02; Sezgin, Sundell 02; Mikhailov 02; Klebanov, Polyakov 02.

Roughly, the large gauge symmetry of the bulk theory guarantees that the boundary CFT_3 is exactly solveable (in this case, noninteracting).

In CFT_2 the result is solveable but interacting.

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1. Free Fields
2. Minimal Models
3. de Sitter Space

Example 1: The O(N) Model

Bulk

- Vasiliev's higher spin gravity in AdS_4

Boundary CFT_3

- The free O(N) model
- This CFT has an interacting IR fixed point that is dual to higher spin gravity with different boundary conditions.

  Klebanov, Polyakov 02; Giombi, Yin 09.

Evidence

- Symmetries
- RG flows
- 3-point functions

Example 2: Minimal Model CFTs

Bulk

- Vasiliev's higher spin gravity in AdS_3
  - Higher spin sector has no propagating degrees of freedom
  - Dynamics from boundary d.o.f., scalar field, and black holes.

Boundary

- 2d W_N minimal model CFTs
- Higher spin generalizations of the $c < 1$ Virasoro Minimal Models (eg Ising model)
- Exactly solveable
- Admit a classical limit in the bulk

Campoleoni et al '10; Henneaux, Rey '10; Gaberdiel, Gopakumar '10; Gaberdiel, Hartman '11; Gaberdiel et al '11

Minimal Model Results

Classical Limit

- Bulk spectrum = boundary spectrum at large N
- Matching known RG flows — Gaberdiel, Gopakumar, Hartman, Raju '11
- New RG flows from black hole solutions that interpolate between different W_N CFTs

  Ammon, Gutperle, Kraus, Perlmutter '11

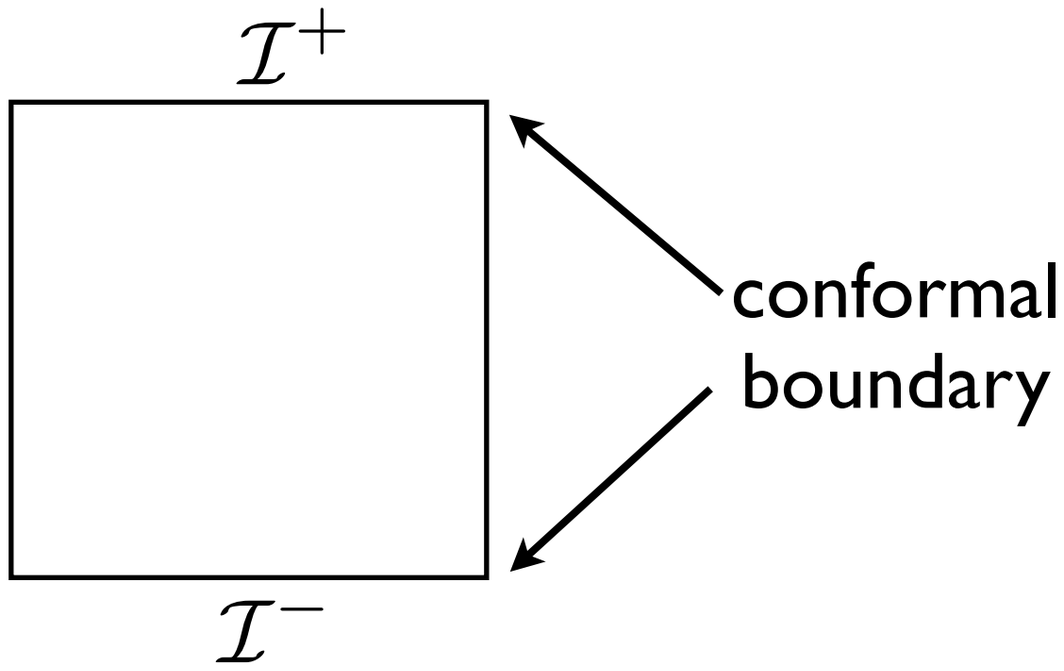
Quantum Limit

- In certain isolated cases, the full quantum theory has a bulk dual.

  Castro, Gaberdiel, Hartman, Maloney, Volpato (to appear)

Example 3: dS/CFT

The dS/CFT correspondence, if it exists, is very different from AdS/CFT because time is emergent:



A general dS/CFT dictionary has been proposed, but an explicit example is lacking.

Witten '01; Strominger '01; Maldacena '02.

Higher Spin dS/CFT

Anninos, Hartman, Strominger (to appear)

Bulk

- Vasiliev higher spin gravity in dS_4

Boundary

- The free Sp(N) CFT
- Anticommuting scalars; nonunitary

Motivation

$$\Lambda \sim N$$

- This is, roughly, the O(-N) model.

Conclusion

Higher spin gravity is dual to solveable (sometimes free) CFTs

Some open questions

- How does a local extra dimension emerge from CFT?

  Jevicki, Jin, Ye '10,'11; Douglas, Mazzucato, Razamat '10.

- Quantum effects and black hole thermodynamics

- RG flows, cosmological evolution, and the big bang