Correlators in higher spin AdS_3 holography with loop corrections

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"Focus Week on Quantum Gravity and Holography"

Introduction and our results

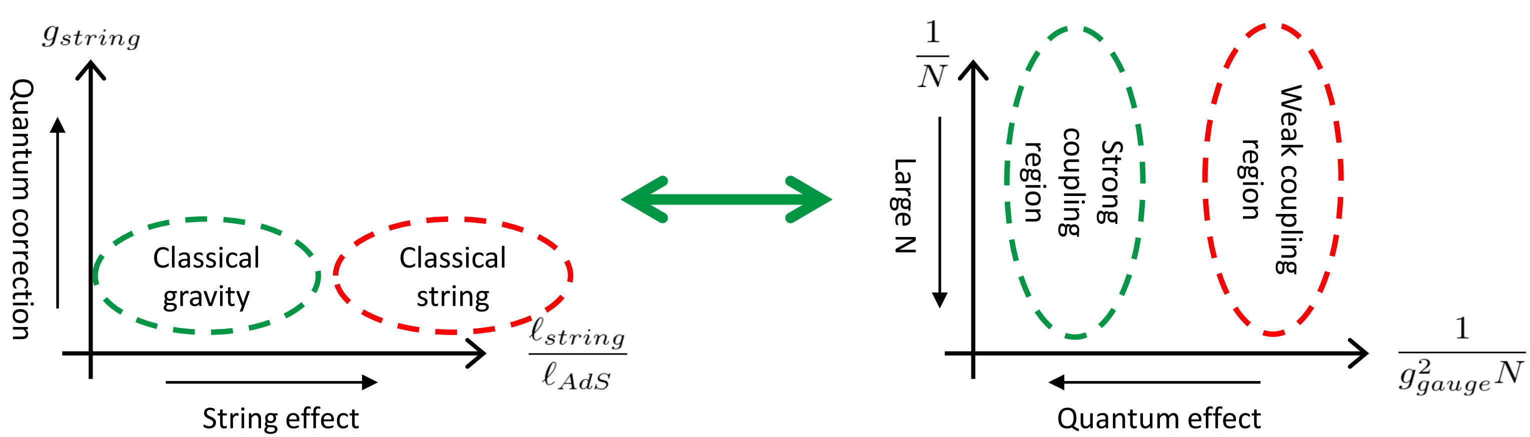
- Holography offers a way to learn quantum aspects of gravity
  - Generically strong/weak duality

Quantum effects in gravity ⟷ 1/N corrections in CFT

- Parameter

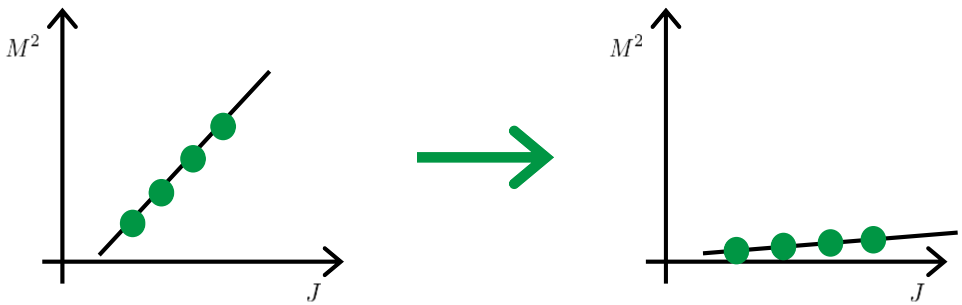
Superstring theory on AdS

Gauge theory

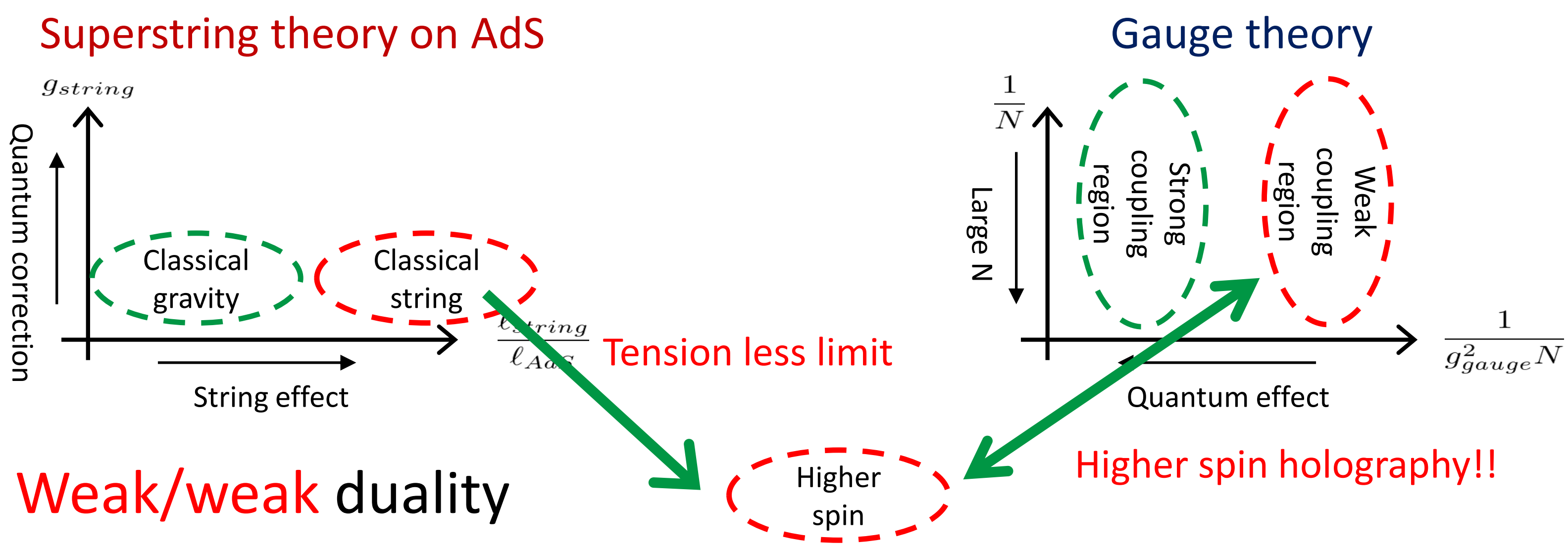


Introduction and our results

- Tension less limit → Massless higher spin



- Higher spin holography



- Weak/weak duality

Introduction and our results

- Gaberdiel-Gopakumar conjecture [Gaberdiel-Gopakumar '10]
  - 3d gauge theory/2d CFT correspondence for higher spin
  - We focus on large c limit

[Castro-Gopakumar-Gutperle-Raeymaekers '11, Gaberdiel-Gopakumar, Perlmutter-Prochazka-Raeymaekers '12]

3d sl(N) Chern-Simons theory w/ Wilson lines ⟷ 2d W_N conformal model w/ W_N symmetry

- Our aim is to understand quantum aspects in this conjecture
  - Calculate quantum corrections in the bulk CS gravity
  - Reproduce the results of boundary CFT

Introduction and our results

- Previous works
  - CS gravity + Wilson line → Liouvile conformal blocks
    [Verlinde '90]
  - Wilson line + CFT → $1/c$ expansion of conformal blocks
    [Fitzpatric-Kaplan-Li-Wang '16]
  - Wilson line → Conformal weight at $1/c$ order
    [Besken-Hedge-Kraus '17]
- In this talk (only spin2)
  - We propose a new regularization prescription in HS gravity with the symmetry of dual CFT by utilizing open Wilson lines
  - We reproduce the conformal weight up to $1/c^2$ order

Plan of talk

1. Introduction and our results

2. Wilson line methods

3. Regularization prescription

4. Conclusion

Plan of talk

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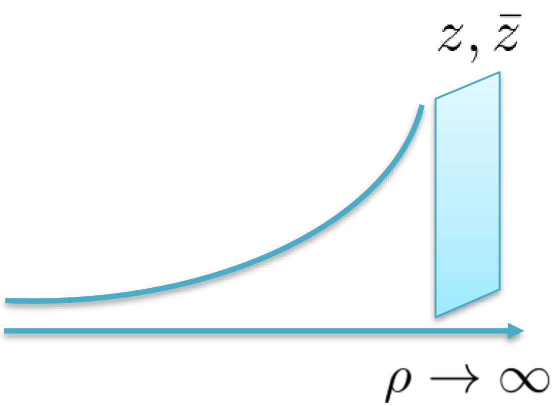
Wilson line methods

- sl(2) Chern-Simons gravity
  - Gauge field (Solution of EOM)

$$A = e^{-\rho L_0} a(z) e^{\rho L_0} dz + L_0 d\rho$$

  - Boundary DOF

$\longrightarrow$ sl(2) WZW model



- Asymptotic AdS condition

$$(A - A_{AdS})\,|_{\rho\to\infty} = \mathcal{O}(1)$$

$$\longrightarrow \quad a(z) = L_1 + \frac{6}{c} T(z) L_{-1}$$

  - Virasoro symmetry in boundary

Wilson line methods

- Wilson line operator

$$W(z_f, z_i) = P\exp\left[\int_{z_i}^{z_f} dz a(z)\right] = P\exp\left[\int_{z_i}^{z_f} (L_1 + \frac{6}{c}T(z)L_{-1})dz\right]$$

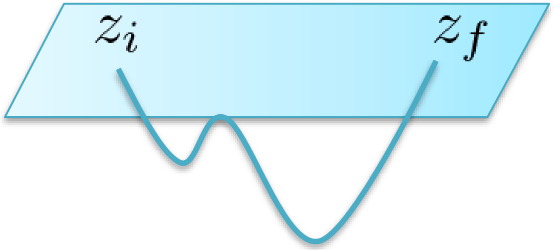
- Expectation value of Wilson line (leading order)

$$\langle \mathcal{O}_h(z)\bar{\mathcal{O}}_h(0)\rangle = \langle W_{h_0}(z)\rangle$$

$$\langle \mathcal{O}_h(z)\bar{\mathcal{O}}_h(0)T(\infty)\rangle = \langle W_{h_0}(z)T(\infty)\rangle$$

- Correlators of *T*(*z*)

$$\langle T(z_1)T(z_2)\rangle = \frac{c/2}{(z_1 - z_2)^4}$$



- Divergences would arise at the coincident points of *T*(*z*) in the integral

Wilson line methods

- CFT results
  - 2pt function is fixed by symmetry

$$\langle \mathcal{O}_h(z)\bar{\mathcal{O}}_h(0)\rangle = \frac{1}{z^{2h}}$$

  - Overall factor is depend on the definition of $\mathcal{O}$

→ Depend on conformal weight

  - Conformal weight is obtained in CFT

$$h = h_0 + \frac{1}{c}h_1 + \frac{1}{c^2}h_2 + \mathcal{O}(c^{-3})$$

$$\langle \mathcal{O}_h(z)\bar{\mathcal{O}}_h(0)\rangle = \frac{1}{z^{2h_0}}\left[1 - \frac{1}{c}2h_1\log(z) + \frac{1}{c^2}(2h_1^2\log^2(z) - 2h_2\log(z))\right] + \cdots$$

  - We reproduce this from the bulk gravity

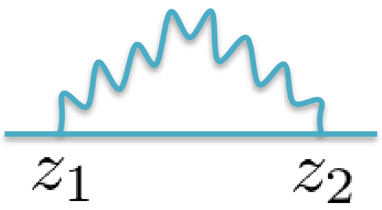
Plan of talk

1. Introduction and our results
2. Wilson line methods
3. Regularization prescription
4. Conclusion

Regularization prescription

- Prescription for regularization
  - Divergences

$$\langle T(z_1)T(z_2)\rangle = \frac{c/2}{(z_1-z_2)^4}$$



  - Removing divergences

1. Introduce a regulator

$$\langle T(z_1)T(z_2)\rangle = \frac{c/2}{(z_1-z_2)^{4-2\epsilon}}$$

Scale invariance is not broken

2. Removing divergences

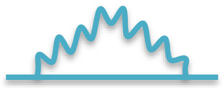
$$W(z_f, z_i) = \mathcal{N}_2 P \exp\left[\int_{z_i}^{z_f} (L_1 + \frac{6}{c} c_2 T(z) L_{-1}) dz\right]$$

3. Fixed by Ward identity

$$\langle \mathcal{O}_h(z)\bar{\mathcal{O}}_h(0)T(\infty)\rangle = h z^2 \langle \mathcal{O}_h(z)\bar{\mathcal{O}}_h(0)\rangle$$

Regularization prescription

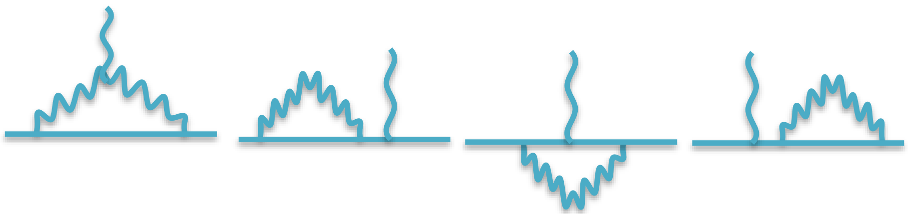
- Fix c_2 and redefine N_2, c_2
  - 1-loop corrections of 2pt functions



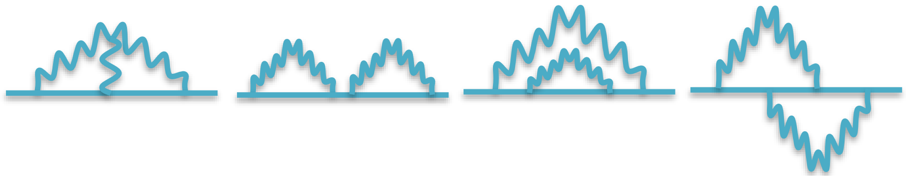
$$c_2 = 1 + \mathcal{O}(c^{-1})$$

Absorbed by redefining N_2

  - 1-loop corrections of 3pt functions



  - 2-loop corrections of 2pt functions



$$c_2 = 1 + \frac{1}{c} c_2^{(1)} + \mathcal{O}(c^{-2})$$

$c_2^{(1)}$ is fixed by conformal Ward identity

Absorbed by redefining N_2, c_2

- We reproduce $1/c^2$ corrections of 2pt functions using CFT data!!

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Conclusion

- Holography offers a way to learn quantum aspects of gravity
- This is generically strong/weak duality so it is difficult to apply
- A useful way is higher spin gauge theory
- We focus on Gaberdiel-Gopakumar conjecture and propose a new regularization prescription in CS gravity with dual CFT data

Conclusion

- Futurework
  - A way to determine the interaction parameter without referring to explicit boundary data

- Extension of this prescription
  - Higher spin: W_3 case

    → (Hikida-TU ’17) [arXiv:1708.08657]
  - Conformal blocks

    → (Hikida-TU ’18) [arXiv:1801.08549]
  - Introduce supersymmetry (Hikida-TU in progress)

Thank you!!

Back up slides

Quantum corrections of boundary 3pt

- Operator product expansion

Include the information of three point function

$$\mathcal{O}_1(z_1)\mathcal{O}_2(z_2) = \sum_p \frac{C_{12p}}{z_{12}^{h_1+h_2-h_p}\bar{z}_{12}^{h_1+h_2-\bar{h}_p}}\mathcal{A}_p(z_2) + \cdots$$

- Comparison of the both side by 1/N order

$$\langle \mathcal{O}_1(\infty)\mathcal{O}_2(1)\mathcal{O}_3(z)\mathcal{O}_4(0)\rangle = \sum_p \frac{C_{12p}C_{34p}}{|z|^{2(h_3+h_4)}}\mathcal{F}(c,h_i,h_p,z)\bar{\mathcal{F}}(c,h_i,\bar{h}_p,\bar{z})$$

Coulomb gas method [Papadodimas-Raju '12]

Zamolodchikov's recursion relation [Zamolodchikov '84, Perlmutter, Beccaria-Fachechi-Macorini '15]

- We evaluate 1/N corrections of 3pt function only up to spin8