

Hidden symmetries in holographic conformal correlators

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Summary

- 1 Introduction
- 2 From weak to strong coupling
- 3 Quantum gravity loop corrections
- 4 Outlook

Introduction

Motivation

AdS/CFT Correspondence

CFT on AdS boundary \Leftrightarrow *Quantum gravity in AdS*

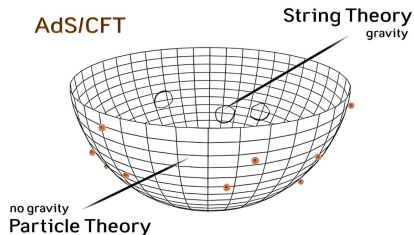


Figure: AdS/CFT Correspondence

Motivation

AdS/CFT Correspondence

CFT on AdS boundary \Leftrightarrow *Quantum gravity in AdS*

$$\begin{array}{ccc}
 \mathcal{N} = 4 \text{ SYM} & \Leftrightarrow & \text{Type IIB strings on } AdS_5 \times S^5 \\
 \downarrow \text{Introduce } \mathcal{N}=2 \text{ Hyper-multiplet} & & \downarrow \text{Introduce probe D7-branes} \\
 \mathcal{N} = 2 \text{ CFT} & \Leftrightarrow & \boxed{\text{Super gluons living on } AdS_5 \times S^3}
 \end{array}$$

Motivation: hidden conformal symmetry

Hidden conformal symmetry in various background

Uplifting the distances x_{ij}^2 in simplest cases to higher-dimensional distances $x_{ij}^2 - t_{ij}$ and obtain the results of correlators with **general external dimensions**

$$\mathcal{H}_{2222}^{(1)}(x_{ij}^2) \rightarrow \mathcal{H}_{p_1 p_2 p_3 p_4}^{(1)}(x_{ij}^2, t_{ij})$$

- $AdS_5 \times S^5$, the 10d distances [Caron-Huot, Trinh '18]
- $AdS_5 \times S^3$, the 8d distances [Alday, Behan, Ferrero, Zhou '21]

Such a higher-dimensional structure surprisingly exists *beyond this regime*.

Motivation: hidden conformal symmetry

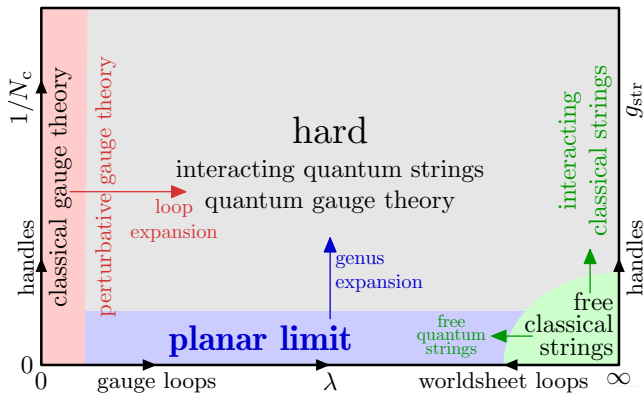


Figure: Map of the parameter space (N_c : rank of gauge group; λ : 't Hooft coupling) of $\mathcal{N} = 4$ SYM or strings on $AdS_5 \times S^5$. [Beisert, Ahn, Alday, Bajnok, Drummond, et al '10]

From weak to strong coupling

Weakly coupled regime

The correlators can be evaluated from the reduced integrands

$$G_{p_1 p_2 p_3 p_4}^{(\ell)} \propto R_{1234}^{\mathcal{N}=4} (2x_{12}^2 x_{13}^2 x_{14}^2 x_{23}^2 x_{23}^2 x_{34}^2) \int \prod_i \frac{d^4 x_{4+i}}{\pi^2} \mathcal{H}_{p_1 p_2 p_3 p_4}^{(\ell)}.$$

Hidden symmetry in weak coupling

The 10-dimensional symmetry could be turned around to recover the generic correlator from the simplest case [Caron-Huot, Coronado '21]

$$\mathcal{H}_{2222}^{(\ell)}(x_{ij}^2) \rightarrow \mathcal{H}_{2222}^{(\ell)}(x_{ij}^2 - t_{ij}) = \sum_{p_i=2}^{\infty} \mathcal{H}_{p_1 p_2 p_3 p_4}^{(\ell)}(x_{ij}^2, t_{ij}).$$

We found the similar 8d structures in $\mathcal{N} = 2$ theories [Du, Huang, Wang, Yuan, Zhou '24].

From weak to strong coupling

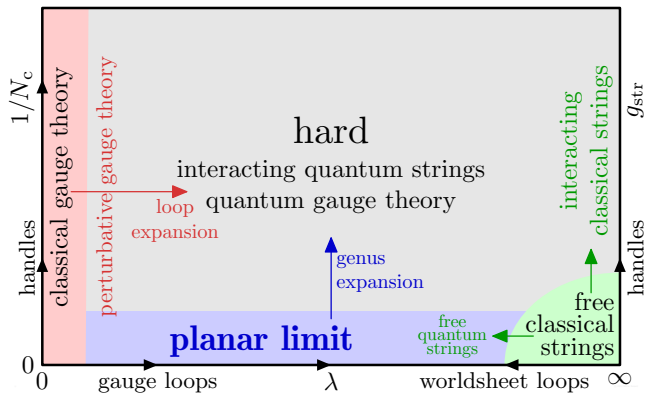


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From weak to strong coupling

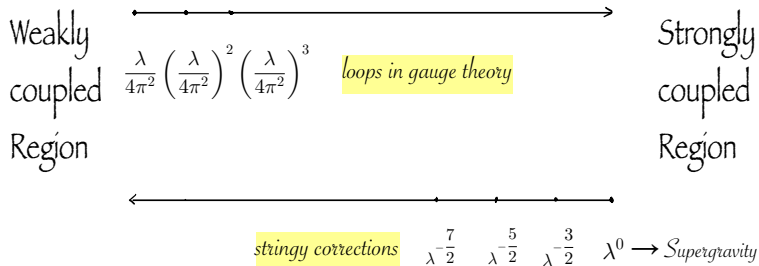


Figure: From weakly to strongly coupled regime in $\mathcal{N} = 4$ SYM.

Strongly coupled Region

Hidden symmetry at four-point

The tree-level supergraviton/supergluon enjoys the higher-dimensional hidden symmetry. For example, the gluon amplitude can be written as [Drummond, Glew, Santagata '22]

$$M_4 = R_{1234} \circ \widetilde{M}_4, \quad \widetilde{M}_4 = \frac{1}{(\rho_{12} - 1)(\rho_{14} - 1)}.$$

Extend hidden symmetry *beyond four-point functions?*

Strongly coupled Region

Hidden symmetry at five-point

We give the first concrete confirmation for the existence of the hidden eight-dimensional symmetries at the level of five points [Huang, Wang, Yuan, Zhang '24]

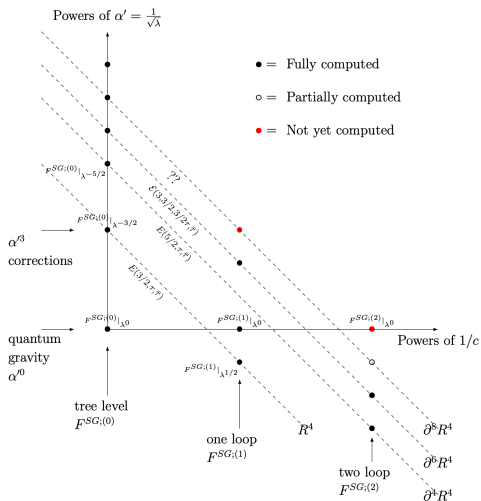
$$M_5 = R^{(1)} \circ \widetilde{M}_5^{(1)} + R^{(2)} \circ \widetilde{M}_5^{(2)} + (\text{cyclic}), \quad (1)$$

where

$$\begin{aligned} \widetilde{M}_5^{(1)} &= -\frac{1}{5(\rho_{12} - 1)(\rho_{23} - 1)(\rho_{34} - 1)}, \\ \widetilde{M}_5^{(2)} &= -\frac{2}{5(\rho_{12} - 1)(\rho_{23} - 1)(\rho_{45} - 1)}. \end{aligned}$$

Quantum gravity loop corrections

Quantum gravity loop corrections

Figure: Four-point correlators at strong coupling in $\mathcal{N} = 4$ [Heslop '22].

Quantum gravity loop corrections

Hidden symmetry beyond tree-level

There is nontrivial evidence for the persistence of the hidden conformal symmetry at one loop [Alday, Zhou '19]

$$\widetilde{M}_{22pp}^{(2)} = \hat{\Delta}^{(8)} \circ \hat{\mathcal{D}}_{22pp} \circ \mathcal{L}_{2222} .$$

We study the analytic behavior of supergluons and supergravitons with **arbitrary external dimensions** and find some hints for this hidden conformal symmetry.

Quantum gravity loop corrections

All N^2E one-loop correlators from hidden symmetry

We bootstrap all of the next-next-to-extremal one-loop four-point correlators of supergravitons and supergluons in AdS_5 using a differential representation [Huang, Wang, Yuan '24]

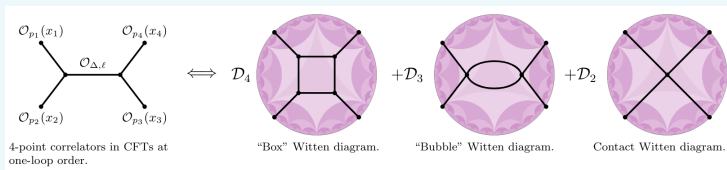


Figure: A correlator is written as differential operators acting on certain seed functions in this representation.

Quantum gravity loop corrections

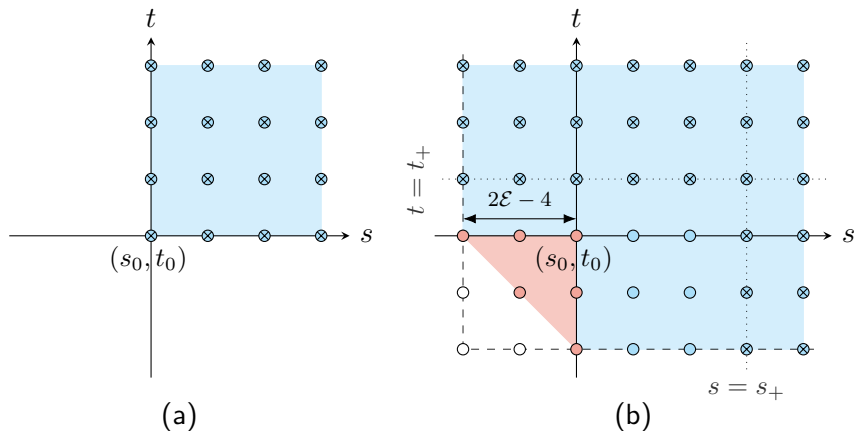


Figure: The universal pole structure of supergluons and supergravitons [Huang, Wang, Yuan, Zhou '23]; [Huang, Wang, Yuan 'work in progress].

Outlook

Outlook

- We found the hidden symmetries in the weakly coupled regime for $\mathcal{N} = 2$ theories.
- We gave the first concrete confirmation for the existence of the hidden eight-dimensional symmetries at the level of five points.
- We generalized the one-loop result to $\mathcal{N}^2\text{E}$ using a novel representation and studied the hidden symmetry for correlators with arbitrary external dimensions.
- ...

Thanks