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Celestial Correlators from AdS space

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Abstract

- Recently, flat space holography has been a subject of growing interest in relation to scattering amplitudes. So far indeed most works have focused on going from scattering amplitudes to celestial correlators.
- I will describe an alternative perspective which focuses on recovering celestial correlator from AdS/CFT via suitable analytic continuations similar to those recently considered in the context of dS/CFT [3].

Introduction

- Three concrete realizations of holographic spaces are: the Minkowski space-time, AdS and dS [1].
- These spaces are strictly connected [2]: Minkowski space-time can be sliced by EAdS spaces inside the light-cone and by dS spaces outside (see **Fig. 1**).
- This suggests that a connection between flat, dS and AdS holography should exist.
- The far future (past) boundary of the holographic Minkowski space-time can be seen as the boundary of the unitary slice (see in **Fig.1**) inside or outside the light-cone [2].

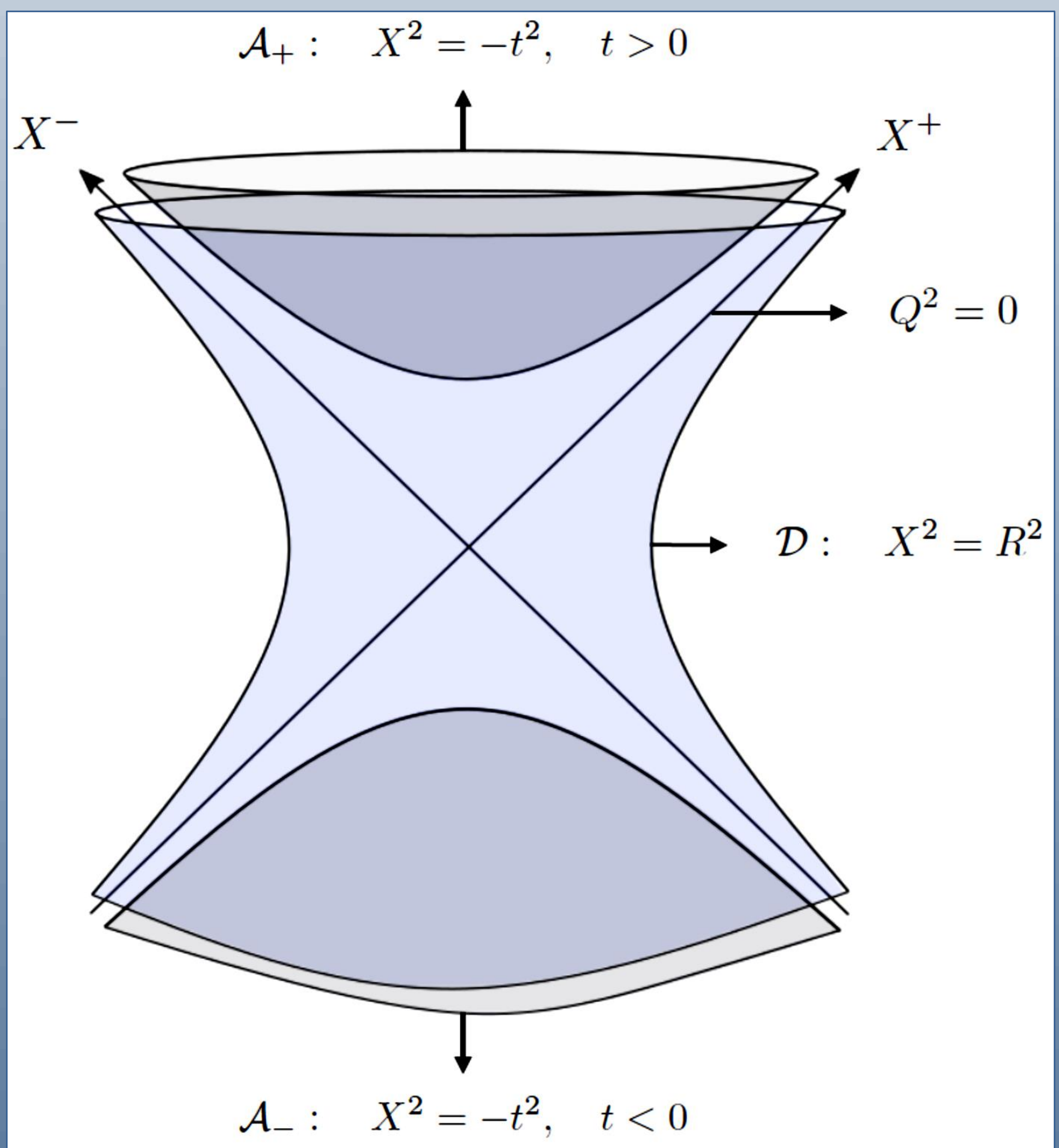

Figure 1 . Inside the future and past light-cone (regions A±) the Minkowski space-time is sliced by EAdS spaces; instead, outside the light-cone (region D) the foliation is made by Lorentzian dS spaces. The boundary of the upper (lower) unitary EAdS slice (in grey) is the far future (past) boundary of Minkowski, which also coincides with the far future (past) boundary of the unitary dS slice (in blue).

From dS to AdS and back

- The flat slicing in dS near the future boundary is

$$ds^2_{\text{dS}} = \frac{L^2_{\text{dS}}}{\eta^2}\left(-d\eta^2 + d\mathbf{x}^2\right)$$

where η, L_{dS} are the conformal time and the radius of dS.

- This is related to the EAdS flat slicing by the analytical continuation

$$z = -i\eta, \qquad L_{\text{AdS}} = -iL_{\text{dS}}$$

where z, L_{AdS} are the conformal time and the radius of EAdS.

- Computing the future boundary correlators in dS using the in-in (Schwinger-Keldysh) formalism, one can see [3] that all the contribution to the $\pm$brunch of the in-in contour in dS can be reached from the EAdS flat slicing via the Wick rotation (see **Fig. 2**)

$$z = -\eta e^{\pm\frac{\pi}{2}}.$$

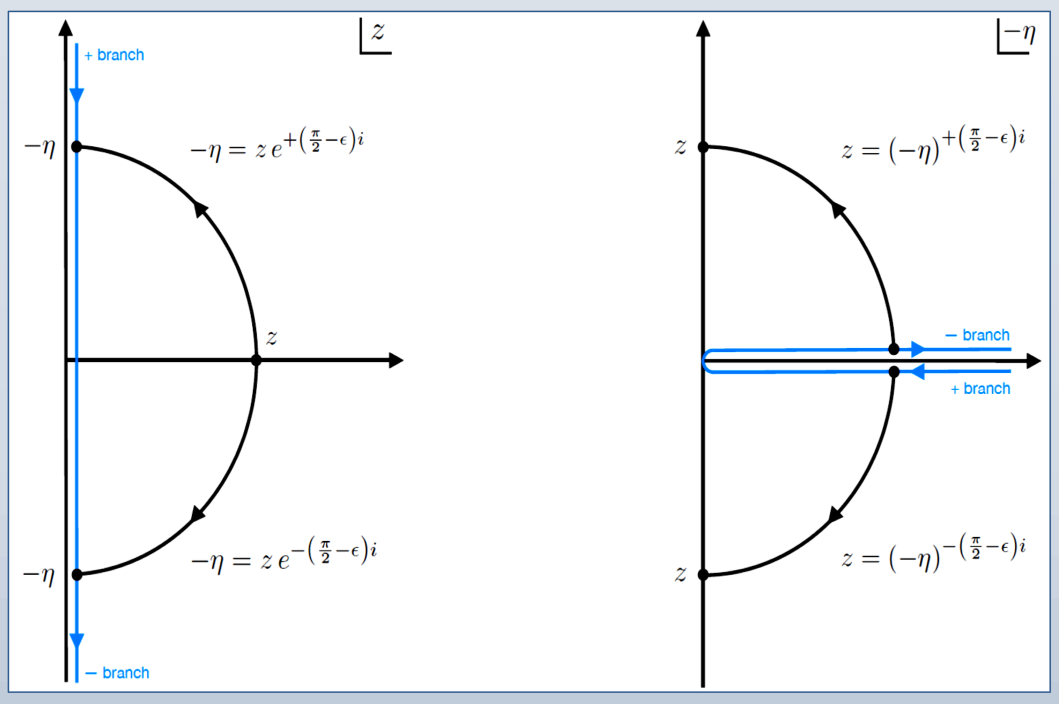

Figure 2. On the left: the (anti-)clockwise Wick rotation in the z plane allows us to land on the - (+) brunch of the dS in-in contour. On the right: from the + (-) brunch of the in-in contour of dS one moves to EAdS by a (anti-)clockwise rotation in η [3].

Conformal Primary Function

- The bulk-to-boundary propagators in flat holography are the conformal primary functions [4].
- They are conformal primary solutions of the field equations.
- For the massive scalar case, they admit the Fourier representation (up a normalization constant) [4]

$$\phi^{\pm}_{\Delta}(X;\pm Q) = \int_{H_{d+1}} [d\hat{p}]\, G_{\Delta}(\hat{p};Q)e^{\pm im\hat{p}\cdot X},$$

where Q is a far future boundary point and $G_{\Delta}(\hat{p},Q)$ is the bulk-to-boundary propagator in the upper brunch of the unitary EAdS slice H^+_{d+1}.

Celestial Contact Amplitude

- Consider a theory with ϕ_i, $i = 1,\dots,n$ scalar fields. The interaction vertex is

$$\mathcal{V}(X) = g\phi_1(X)\dots\phi_n(X).$$

- At the leading order in the coupling constant, the celestial contact amplitude is simply

$$-ig\int d^{d+2}X\, \phi^{\pm_1}_{\Delta_1}(X,\pm_1 Q_1)\dots\phi^{\pm_n}_{\Delta_n}(X,\pm_n Q_n),$$

where the $\pm_n$ labels stand for the out-going and in-coming particles.

- The foliation in **Fig. 1** suggests us to divide the integral over the regions

$$\int d^{d+2}X = \int_{\mathcal{A}_+} d^{d+2}X + \int_{\mathcal{A}_-} d^{d+2}X + \int_{\mathcal{D}_+} d^{d+2}X + \int_{\mathcal{D}_-} d^{d+2}X$$

where $X^+ > 0$ in $\mathcal{D}_+$ and $X^+ < 0$ in $\mathcal{D}_-$.

- After having applied the results of holography in every region, we find (see **Fig. 3**)

$$\tilde{\mathcal{A}}^{\text{contact}}_{\Delta_1\dots\Delta_n} = \underbrace{\left(c^{\pm_1\dots\pm_n}_{\mathcal{A}_+} + c^{\pm_1\dots\pm_n}_{\mathcal{A}_-} + c^{\pm_1\dots\pm_n}_{\mathcal{D}_+} + c^{\pm_1\dots\pm_n}_{\mathcal{D}_-}\right)}_{c^{\pm_1\dots\pm_n}_{\Delta_1\dots\Delta_n}} \tilde{\mathcal{A}}^{\text{AdS contact}}_{\Delta_1\dots\Delta_n}$$

where $\tilde{\mathcal{A}}^{\text{AdS contact}}_{\Delta_1\dots\Delta_n}$ is the amplitude on H^+_{d+1}.

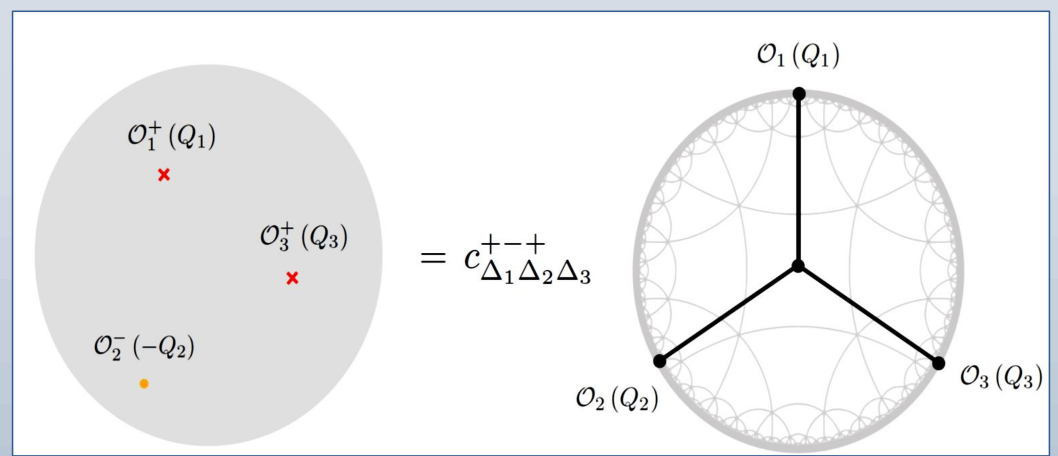

Figure 3. The grey disk on the left is the Minkowski space-time seen from above, while the circle on the right is the unitary EAdS slice. The crosswise (pointwise) insertion is a point on the far future (past) boundary of Minkowski. The equality pittorially shows that the three-point contact amplitudes in Minkowski and EAdS are related by a coefficient which depends on the messes and the conformal weights of the fields.

Conclusions and Outlook

- The celestial contact amplitudes are contact Witten amplitudes over the upper unitary hyperboloid times a coefficient which depends on the conformal weights and the masses of the fields.
- The contact diagrams are the building blocks for all the other processes (e.g. particle exchange), so we expect to extend this property to all orders in perturbation theory.
- From the above result, it is possible to determine the conformal partial waves of celestial correlators by exploiting the relation with EAdS diagrams.

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