# The Celestial Chiral Algebra of Self-Dual Gravity on Eguchi-Hanson Space

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# Motivation and Summary

Burns holography is the first **top-down** example of celestial holography.

[Costello, Parquette, Sharma '23]

QG in $4d$, $\Lambda = 0$ spacetime $\xleftrightarrow[\text{Holography}]{\text{Celestial}}$ **CCFT** on $\mathbb{CP}^1_{\text{celestial}}$

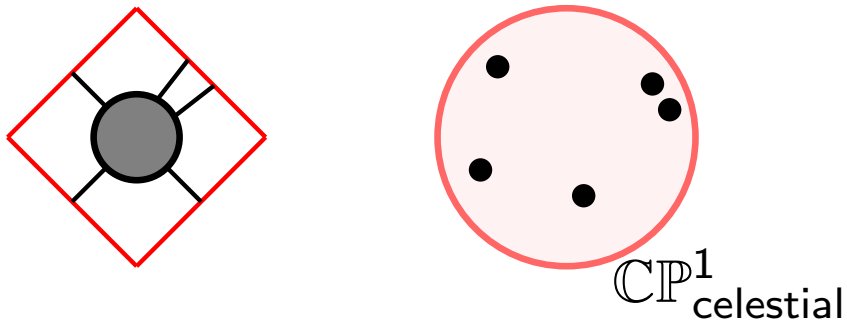
Version involving self-dual **Einstein** - rather than conformal - gravity?

How far we got: **Tree-level** dictionary between two geometric deformations of Eguchi-Hanson space (bulk for self-dual gravity) and two Lie-algebra deformations of the celestial chiral algebra $\mathcal{L}w_\wedge \subset \mathcal{L}w_{1+\infty}$.

[Bittleston, SH, Skinner '23]

# Celestial Chiral Algebras

- Collinear singularities of $4d$ amplitudes determine OPEs of $2d$ **celestial chiral algebras (CCAs)**. [Strominger '17], [Pasterski, Pate, Raclariu '21]




- In SDGR on $\mathbb{R}^4$ this leads to [Strominger '21], [Guevera, Himwich, Pate, Strominger '21]

$$w[p,q](z)w[r,s](0) \sim \frac{ps-qr}{z} w[p+r-1, q+s-1](0)$$

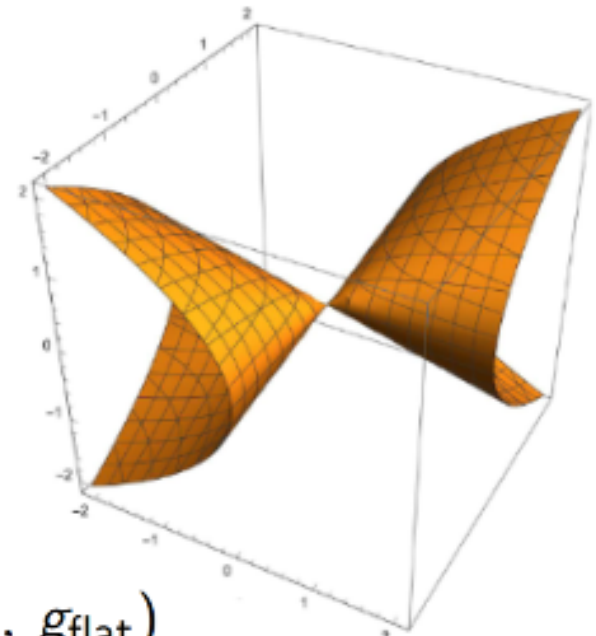
- On $\mathbb{R}^4/\mathbb{Z}_2$ it has a family of deformations $W_{\mathfrak{q}}(\mu)$ [Pope et al '90]

$$[W[p,q], W[r,s]] = \sum_{\ell \geq 0} \mathfrak{q}^{2\ell} f_\ell(p,q,r,s;\mu) W[p+r-2\ell-1, q+s-2\ell-1] \,.$$

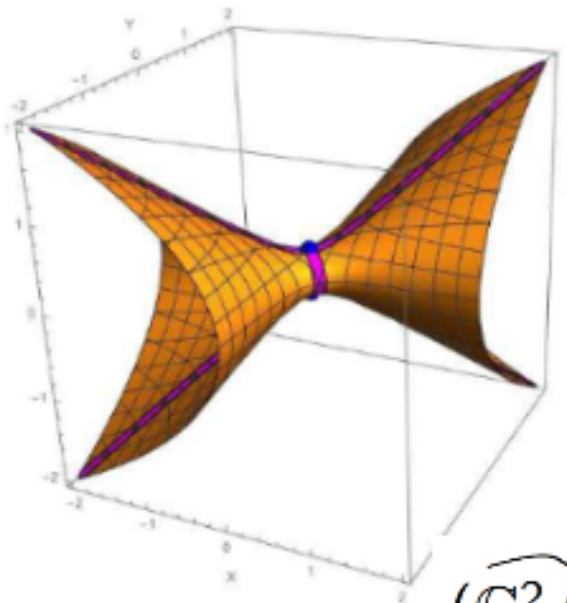
- Only $W_{\mathfrak{q}}(-3/16)$ extends from $\mathbb{R}^4/\mathbb{Z}_2$ to $\mathbb{R}^4$. [Bittleston], [Bu, SH, Skinner '22]

# Backreacting Twistor Space with a Defect Operator

- Selfdual gravity is classically described by **holomorphic Poisson BF theory** on twistor space $\mathbb{PT}/\mathbb{Z}_2$ [Mason, Wolf '07], [Penrose '76].
- Defect wrapping $\{0\} \times \mathbb{CP}^1$ backreacts the complex structure to the twistor space of **Eguchi-Hanson space**. [Bittleston, SH, Skinner '23]
- Similar to Burns space in context of BCOV theory. [Costello, Paquette, Sharma '23]



$(\mathbb{C}^2/\mathbb{Z}_2\,,\, g_{\text{flat}})$



$(\widetilde{\mathbb{C}^2/\mathbb{Z}_2}\,,\, g_{\text{EH}})$

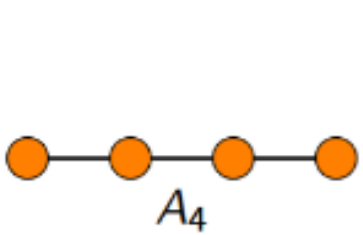
# The Dictionary

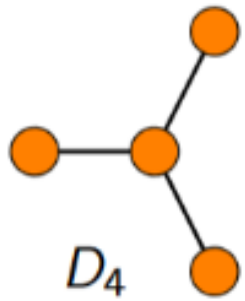
| Moyal-deformed SDGR on $(\widetilde{\mathbb{C}^2/\mathbb{Z}_2}, g_{EH})$ | $\mathcal{L}W_{\mathfrak{q}}(\mu)$ on $\mathbb{CP}^1_{\text{celestial}}$ |
|---|---|
| $\mathfrak{q}$ non-commutativity parameter | $\mathfrak{q}$ |
| $c$ radius of the Eguchi-Hanson core | $\mu = \frac{4c^2/\mathfrak{q}^2 - 3}{16}$ |

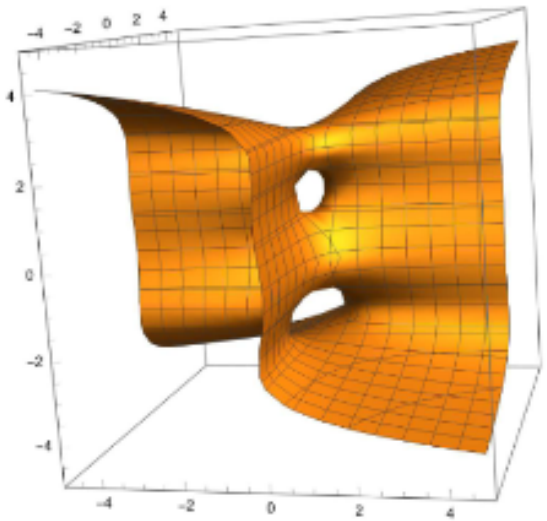
- Non-commutative background deforms Poisson to Moyal-bracket $\{f, g\} \to \{f, g\}_{\mathfrak{q}}$ which also deforms the CCA. [Bu, SH, Skinner '22]
- CCA of SDGR arises as $\lim_{\mathfrak{q}\to 0,\, \mu\to\infty} W_{\mathfrak{q}}(\mu)$ with $c^2 = 4\mathfrak{q}^2\mu$ fixed.

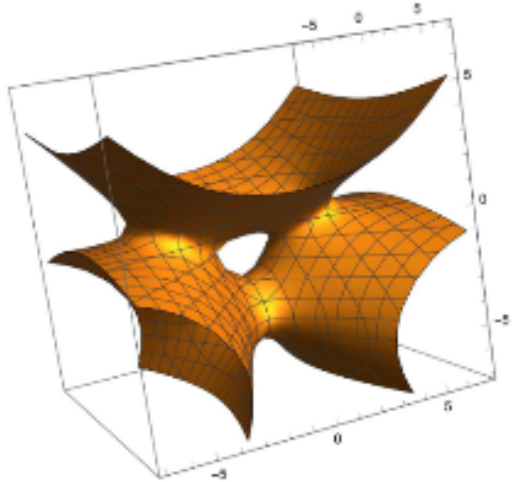
# Outlook [wip Bittleston, SH, Skinner]

- General **ALE space** is classified by $\Gamma \overset{\text{finite}}{\subset} SU(2)$. [Hitchin '79], [Kronheimer '89]
- Dictionary involving several deformations of the CCA. [in preperation]



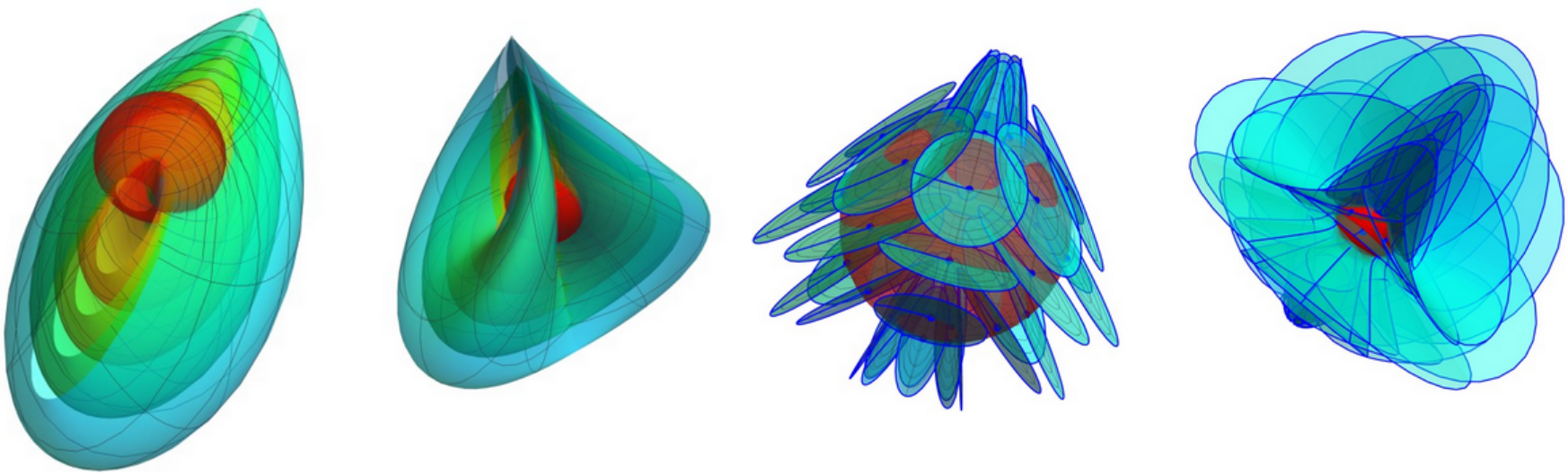





- Long term goal: Top-down string realisation.

# Fin

## Thank you for your attention![1]



[1] Thanks to Andy Hanson for allowing me to use his figures [Hanson, Sha '17]