Pietro Ferrero
University of Oxford

M2- and D3-branes wrapped on spindles

Based on work with **JP Gauntlett, JM Perez Ipina, D Martelli, JF Sparks**

arXiv: **2011.10579** [hep-th]

arXiv: **2012.xxxx** [hep-th] (soon!)

A brief overview of the M2-branes picture

Microstates counting in AdS_4

Recently, progress for (BPS and extremal) AdS_4 black holes with horizon given by a Riemann surface Σ, with magnetic flux through Σ.

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  Topologically twisted index: **I-extremization**

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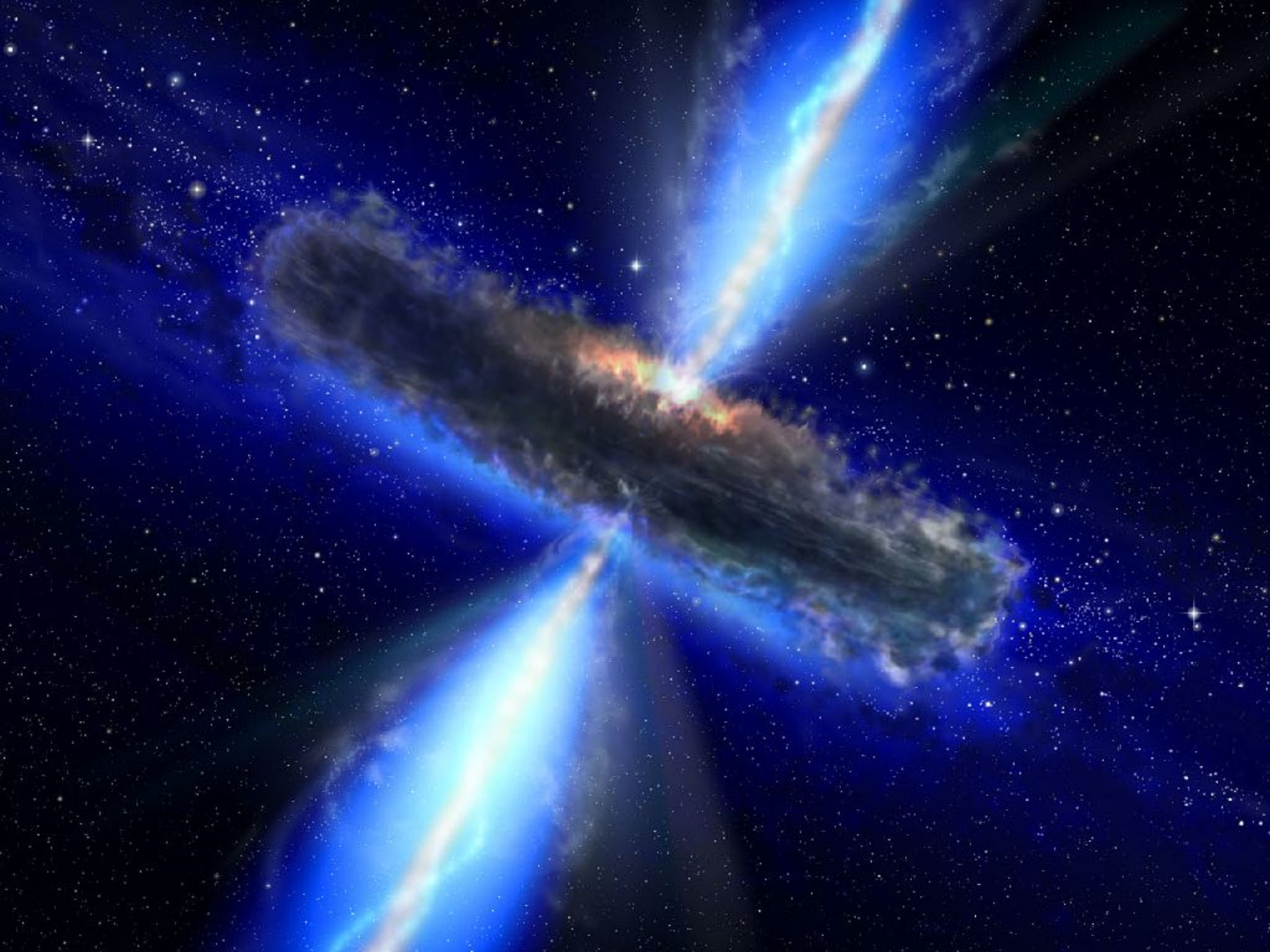
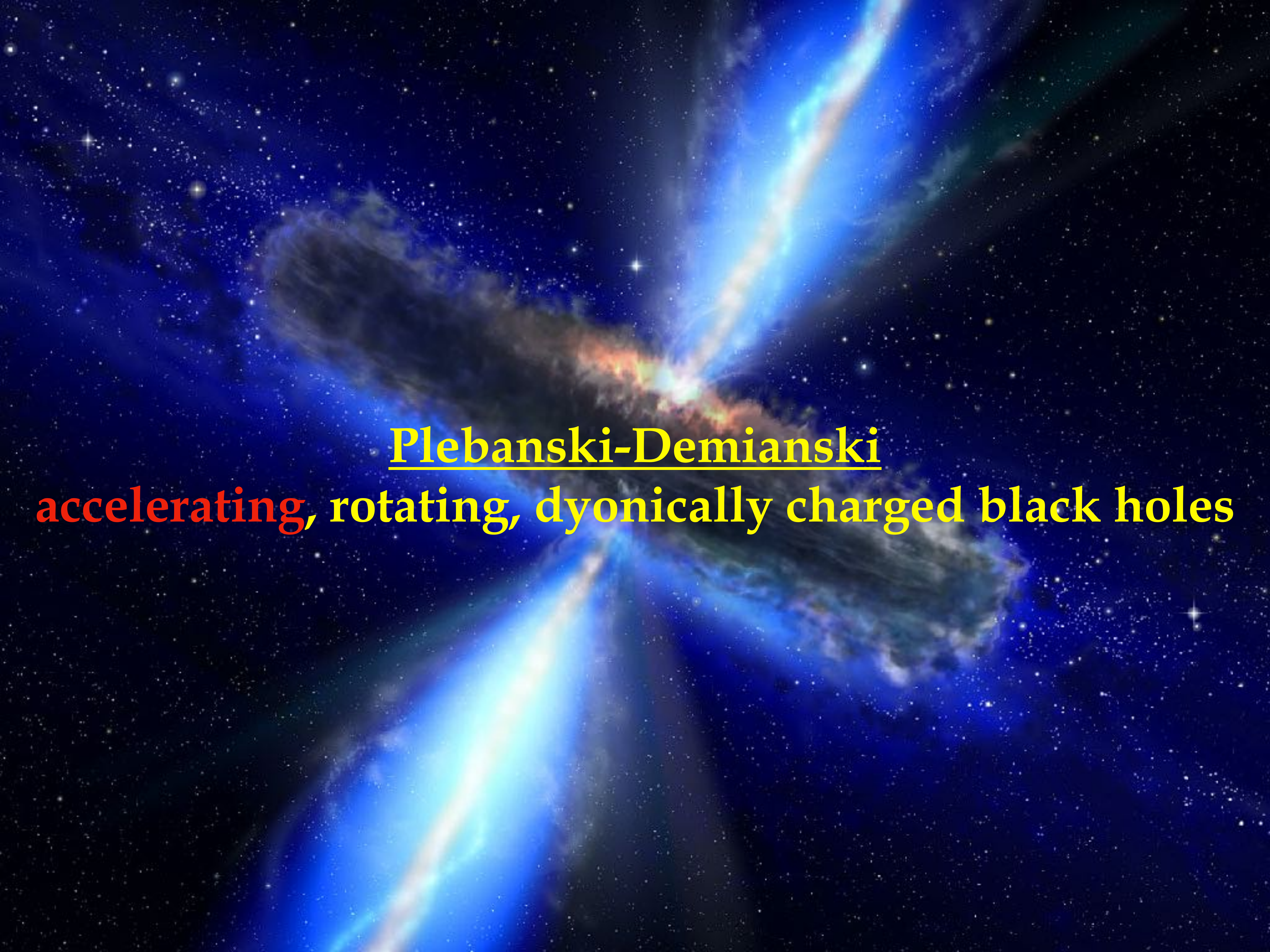
See e.g. Benini, Hristov, Zaffaroni 1511.04085 [hep-th]
Zaffaroni 1902.07176 [hep-th] for a review
…

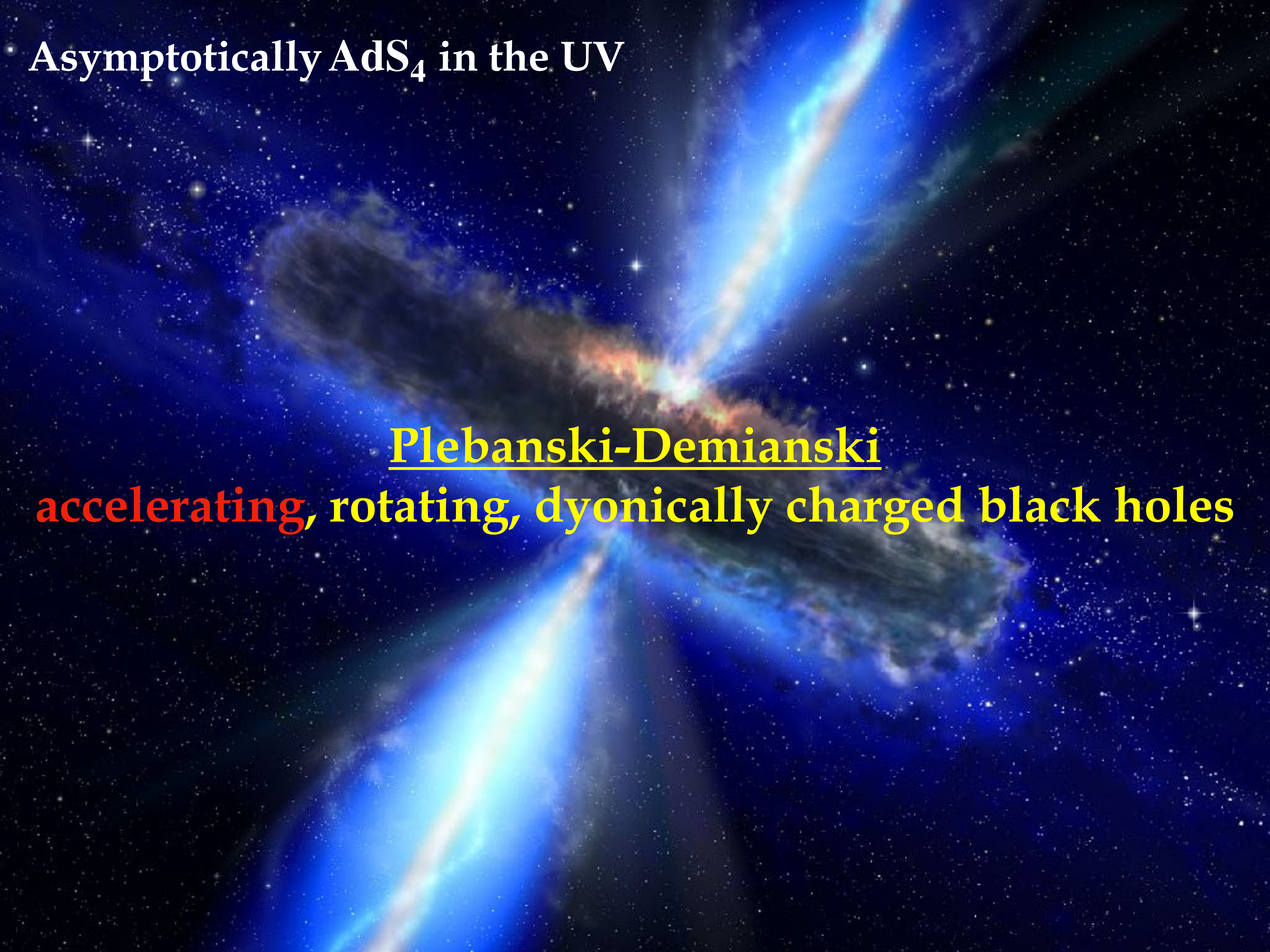




Plebanski-Demianski

accelerating, rotating, dyonically charged black holes

Asymptotically AdS_4 in the UV



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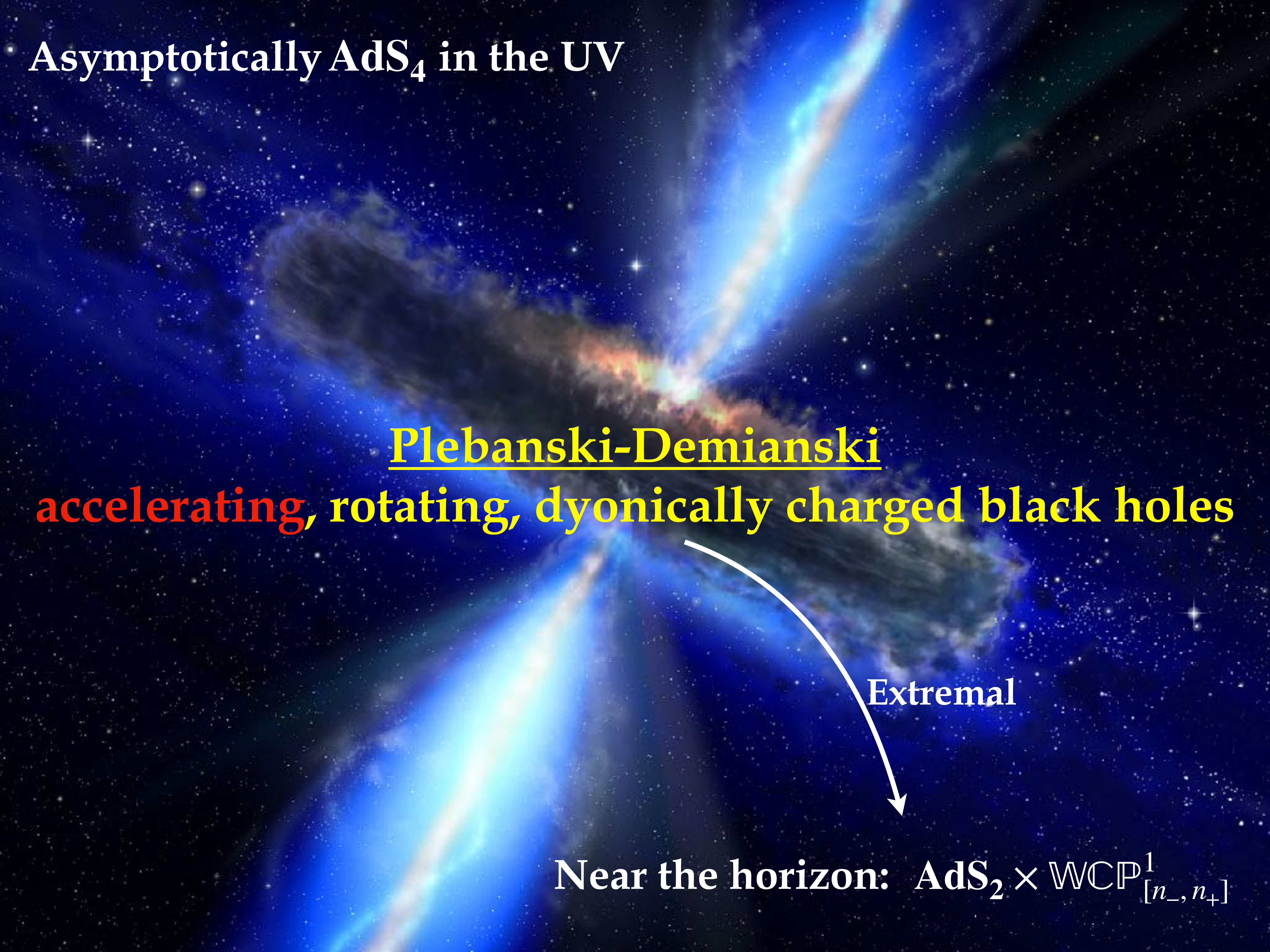
Extremal

Near the horizon: $\mathbf{AdS_2} \times \mathbb{WCP}^1_{[n_-,n_+]}$



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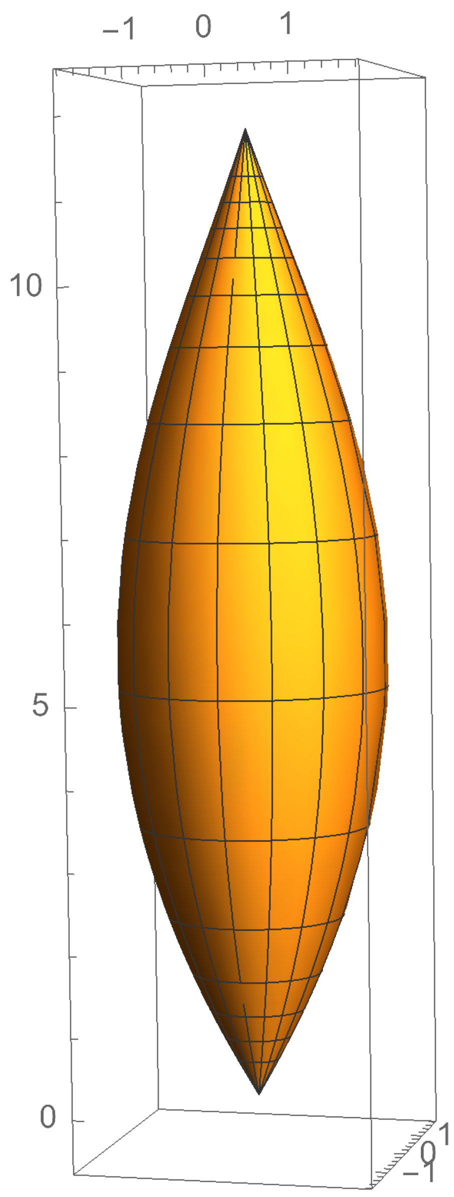

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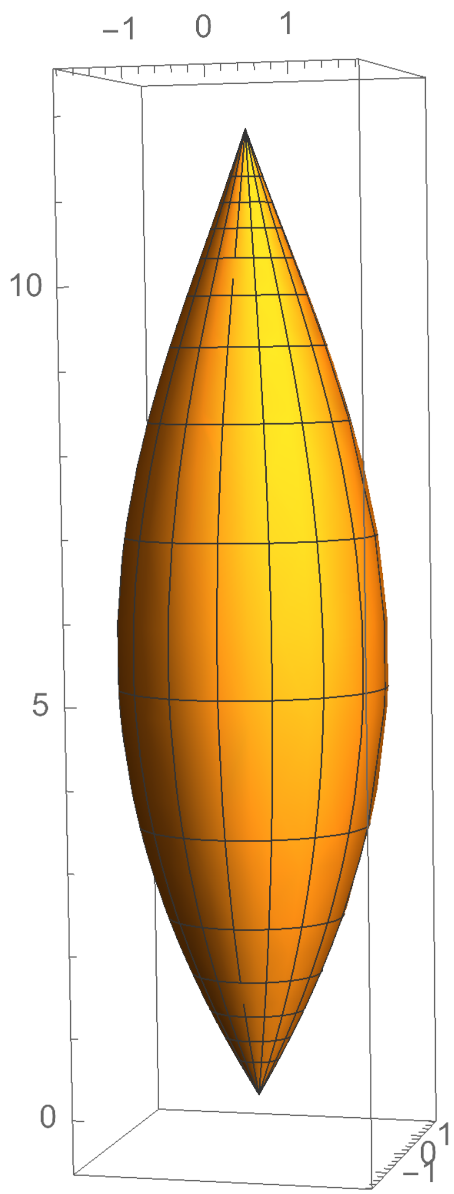

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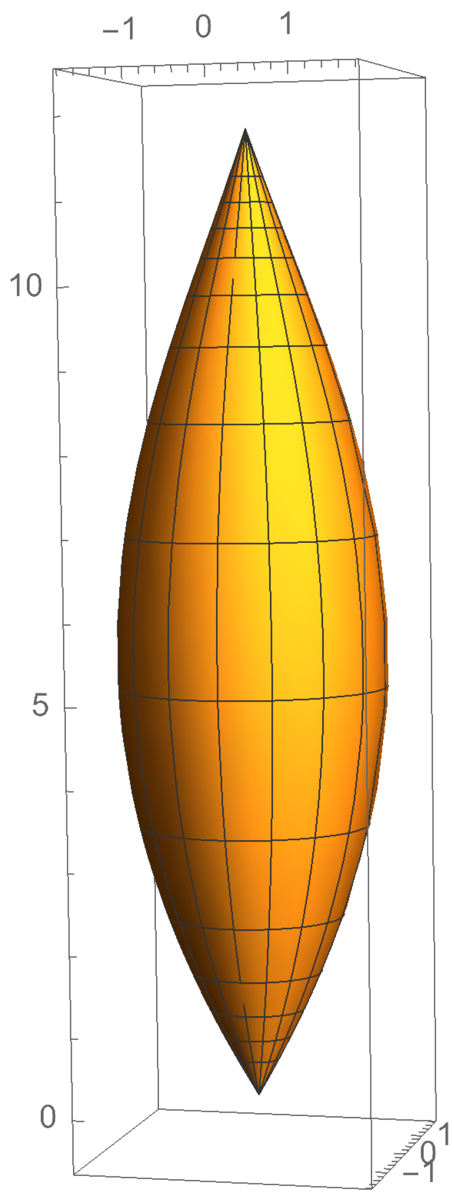

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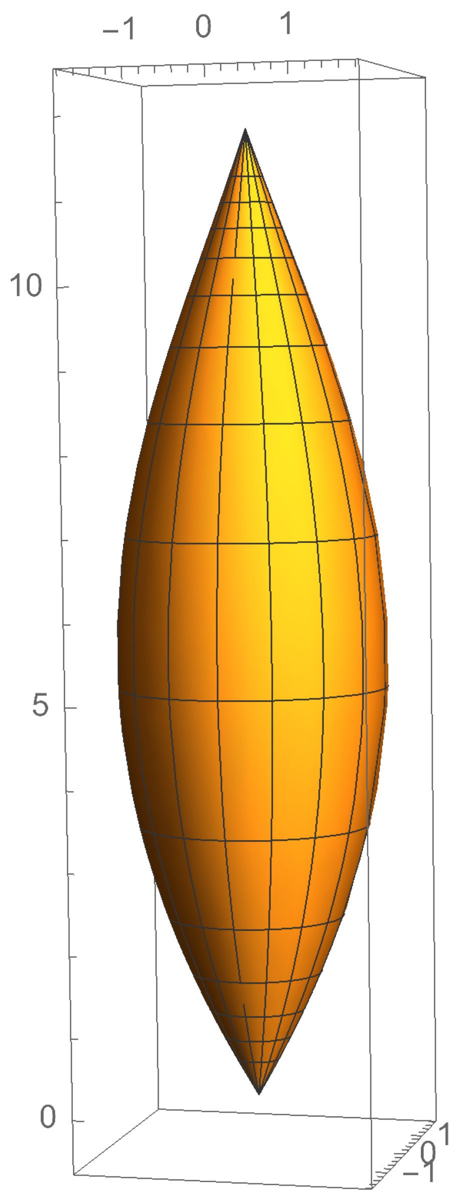

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…with a smooth uplift

They can be uplifted to **completely smooth** solutions of **11d supergravity!**

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Gauntlett, Kim, Waldram 0612253 [hep-th]


NYPD


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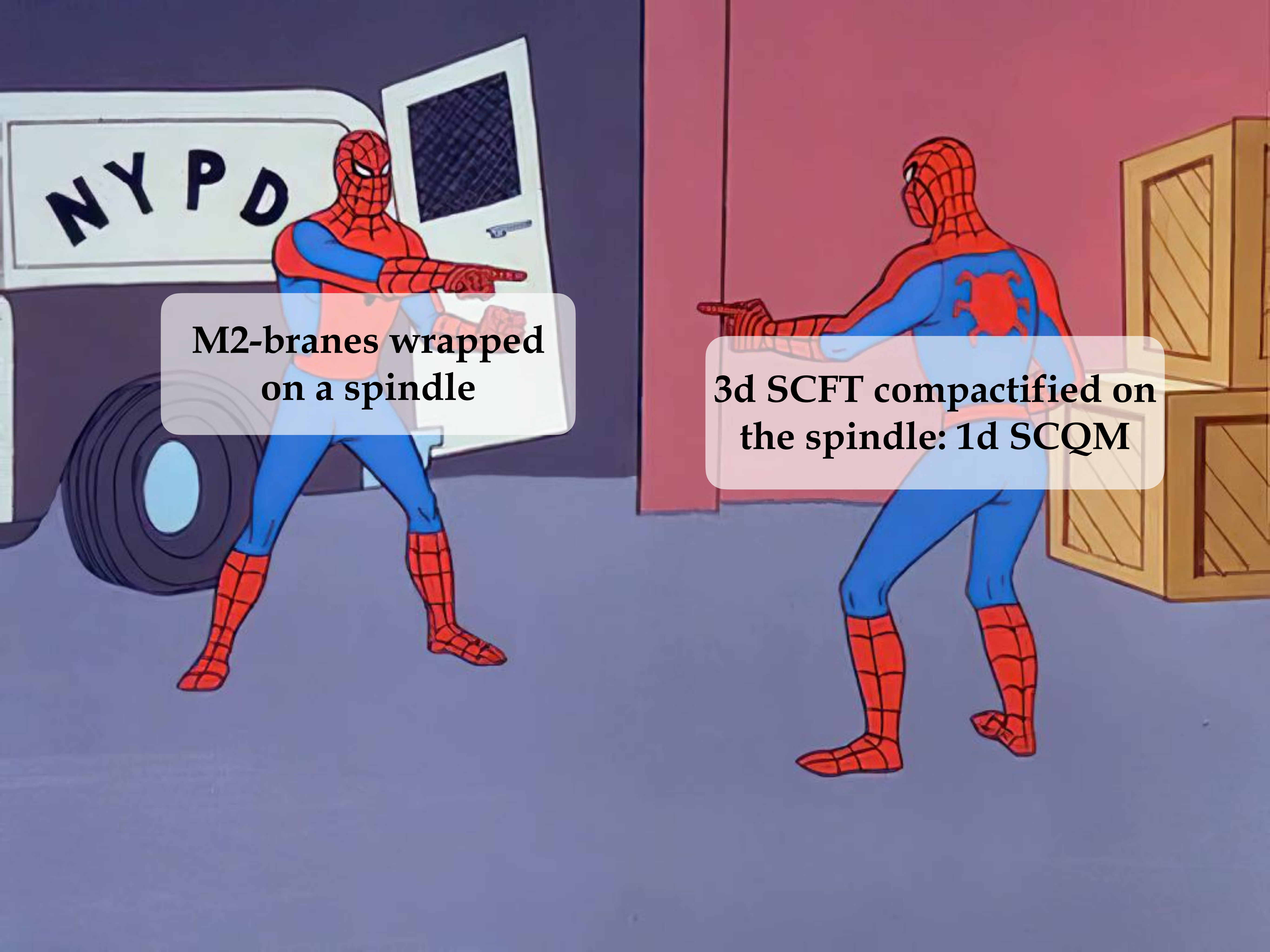
NYPD
M2-branes wrapped on a spindle
3d SCFT compactified on the spindle: 1d SCQM

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- **Entropy** of the extremal and supersymmetric black hole:

$$S_{BH} = \frac{\pi}{G_{(4)}} \frac{J}{Q_e} = \frac{\pi}{4\, G_{(4)}} \left(\sqrt{\chi^2 + 16 \left(Q_e^2 + Q_m^2 \right)} - \chi \right)$$

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- In the 1d SQM, the **R-symmetry** of the 3d SCFT mixes with the U(1) isometry of the spindle (even without rotation!):

$$R_{1d} = R_{3d} + 2\sqrt{2}\, \frac{n_+ n_- \sqrt{8\, n_-^2\, n_+^2\, Q_e^2 + n_-^2 + n_+^2}}{\sqrt{16\, n_-^2\, n_+^2\, Q_e^2 + n_-^2 + n_+^2}} \partial_\varphi$$

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- For **D3-branes** on a spindle: we reproduce entropy and mixing with a **Field Theory computation** (anomaly polynomial)

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- **PD black holes:** the 4d story and their regular uplift

- **Near-horizon limit:** entropy, spinors and R-symmetry

- **D3-branes on spindles:** $AdS_3 \times \mathbb{WCP}^1_{[n_-,n_+]}$ in 5d

Plebanski-Demianski black holes and 11d uplift

PD black holes in 4d

Most general solution to **4d Einstein-Maxwell*** theory (no NUT charge)

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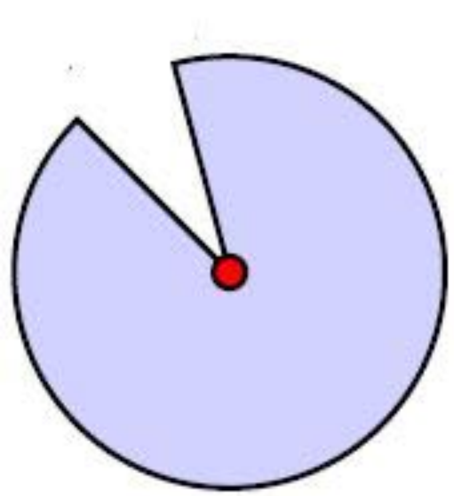
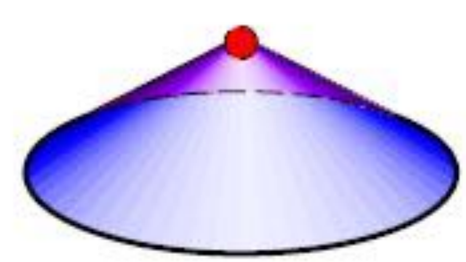
Due to the acceleration, $P_{-} \neq P_{+}$ we cannot make it regular! We have conical deficits at the two poles (with different deficit at each pole).





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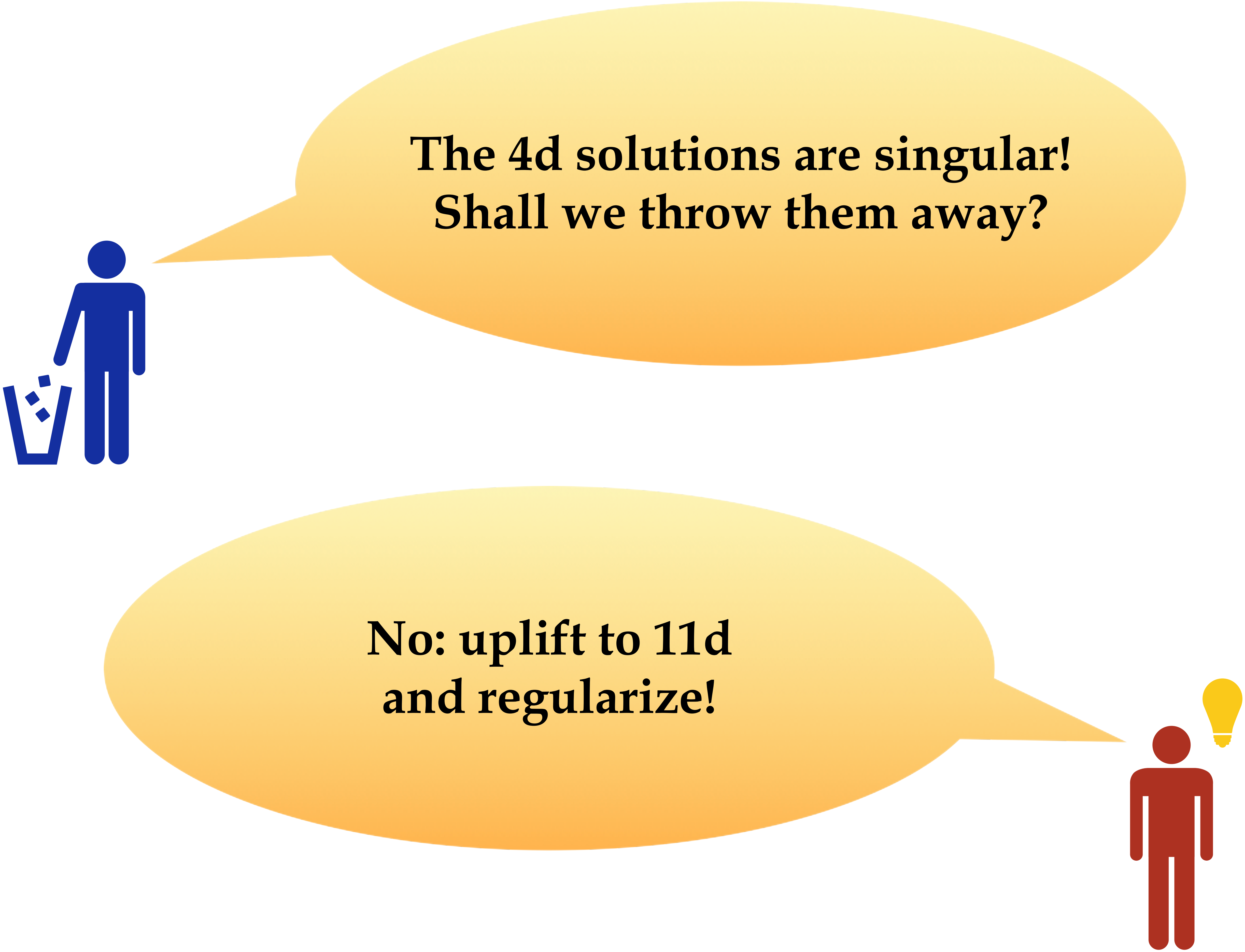
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No: uplift to 11d
and regularize!

The uplift to 11d

Gauntlett, Varela 0707.2315 [hep-th]

$$\mathrm{d}s_{11}^2 = \frac{1}{4}\ \mathrm{d}s_4^2 + ds^2(SE_7) = \frac{1}{4}\ \mathrm{d}s_4^2 + \left(\eta + \frac{1}{2}A\right)^2 + \mathrm{d}s^2(KE_6)$$

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This solves the eom of 11d supergravity and preserves SUSY

Regularize via the uplift

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1. "Quantize" the conical deficits, making the space in the θ, ϕ directions into a **spindle** $\mathbb{WCP}^1_{[n_-, n_+]}$

$$\frac{P_+}{P_-} = \frac{n_-}{n_+} \quad \Rightarrow \quad \Delta\phi = \frac{2\pi}{n_+ P_+} = \frac{2\pi}{n_- P_-}$$

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4. The **flux** G and its dual $*_{11} G$ are properly **quantized**

Near-horizon limit

The BPS & extremal horizon

$$ds^2 = \frac{1}{4}\left(y^2 + \mathtt{j}^2\right)\left(-\rho^2 d\tau^2 + \frac{d\rho^2}{\rho^2}\right) + \frac{y^2 + \mathtt{j}^2}{q(y)} dy^2 + \frac{q(y)}{4\left(y^2 + \mathtt{j}^2\right)}(dz + \mathtt{j}\,\rho\, d\tau)^2$$

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(Spinning) spindle

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The entropy

For a generic PD black hole we find entropy

$$S_{BH} = \frac{1}{4G_{(4)}} A = \frac{\left(r_+^2 + a^2\right) \Delta\phi}{2G_{(4)} \left(1 - \alpha^2 r_+^2\right)}$$

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Can we reproduce it from the Field Theory?
Done for central charge in $AdS_3 \times \mathbb{WCP}^1_{[n_-, n_+]}$ solutions!

The spinors

In these constructions, supersymmetry is typically preserved with a topological twist: $\gamma_{ab}\,\omega_\mu^{ab} \sim A_\mu$, in such a way that

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How is supersymmetry realized in the dual Field Theory?

The R-symmetry

The UV geometry is $AdS_4 \times SE_7$, with metric

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$$\boxed{R_{1d} = R_{3d} + 2\sqrt{1 - \mathrm{j}^2}\,\partial_z}$$

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First example of mixing between higher and lower dimensional R-symmetry (with no rotation)!

D3-branes on spindles

The type IIB picture

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$AdS_3 \times \mathbb{WCP}^1_{[n_-,n_+]}$ solutions of 5d minimal gauged supergravity

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$\downarrow$

Uplift to 10d

Regularization of conical deficits

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Completely regular $AdS_3 \times Y_7$ solutions of type IIB supergravity

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Gauntlett, Kim, Waldram 0612253 [hep-th]

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  → **Confirms our AdS/CFT interpretation!**

Thank you for the attention!