ASPECTS OF DYNAMICAL COBORDISM IN ADS/CFT

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Based on [JH, Uranga, 2306.07335]

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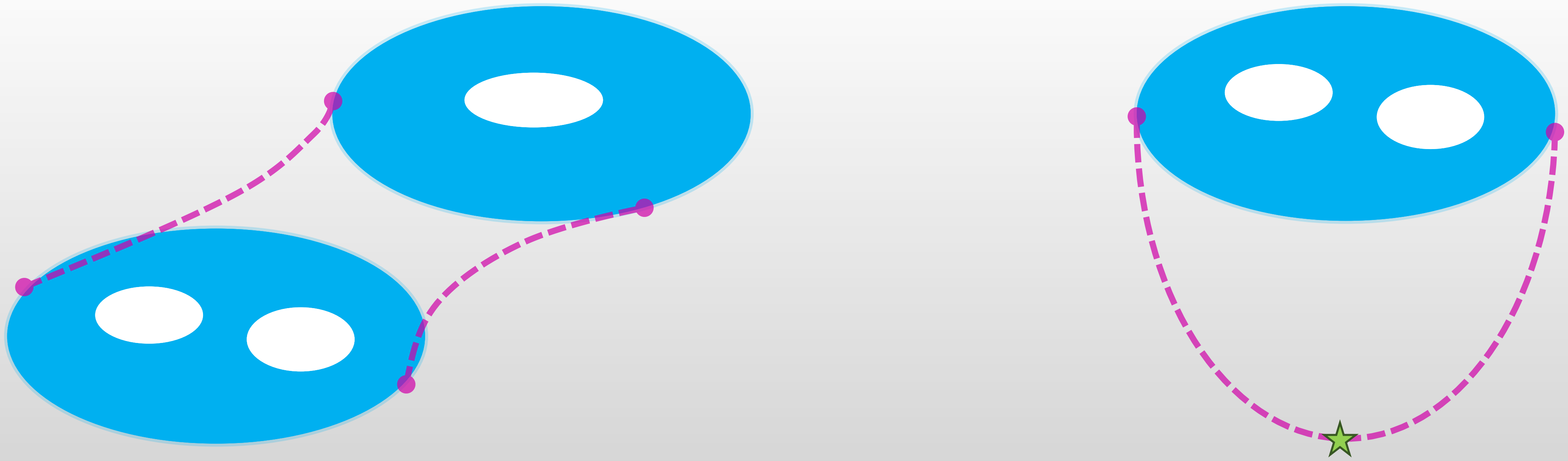
INTRODUCTION

COBORDISM CONJECTURE

[McNamara, Vafa, ’19]

The cobordism classes of any solution of Quantum Gravity have to be trivial



Dynamical Cobordism

[Angius, Buratti, Calderón-Infante, Delgado, JH, Uranga, '21-22]

[Blumenhagen, Cribiori, Kneissl, Makridou, Wang, '22-23]

- "Dynamical": The cobordism is a spacetime solution

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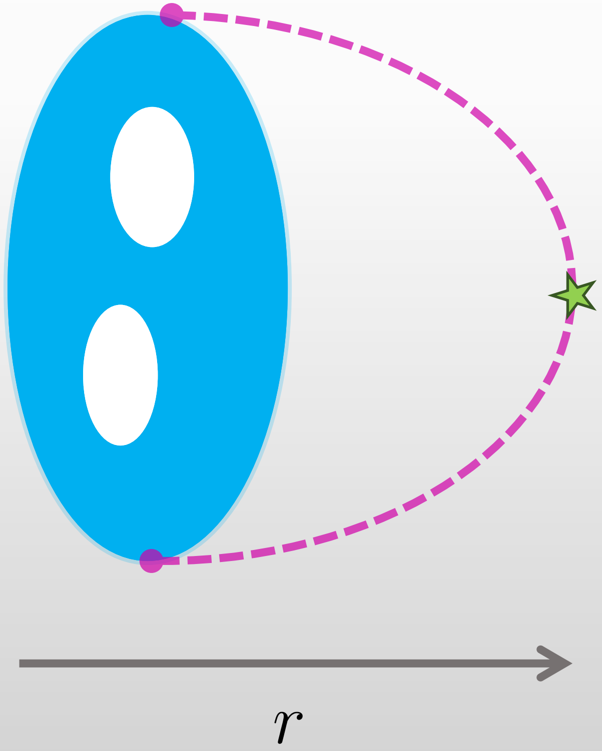

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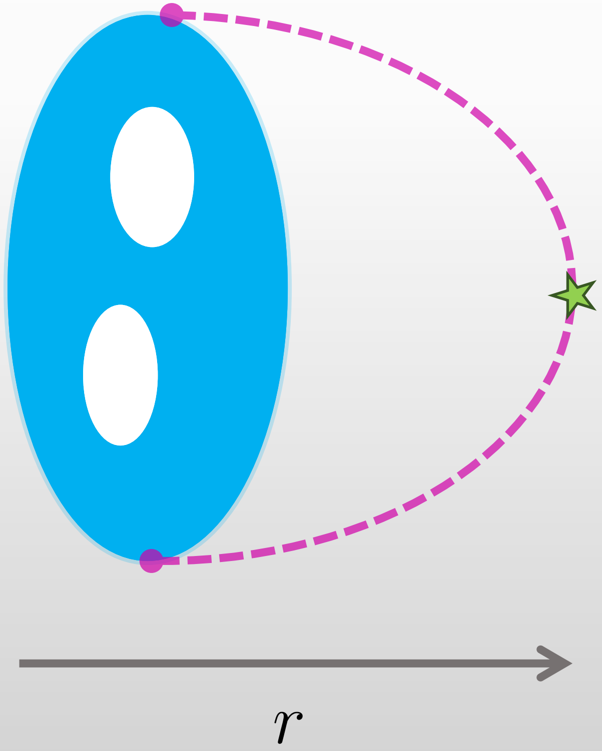

See Andriana, Bjoern, Christian and Roberta's talks!!

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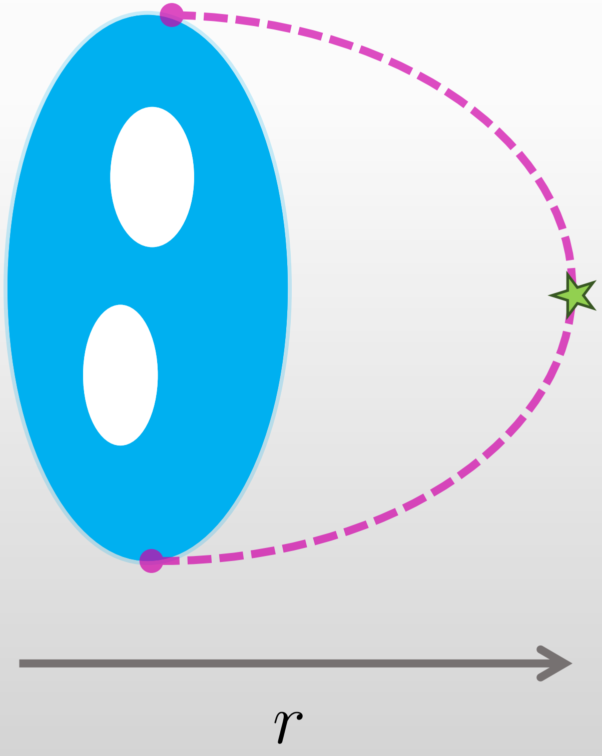

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These solutions have some issues…

$$V \to \infty$$

Sometimes the EFT breaks down near the ETW brane

THIS TALK: COBORDISM IN ADS/CFT

- We will present and explain the solution that interpolates between $AdS_5 \times S^5$ and nothing.

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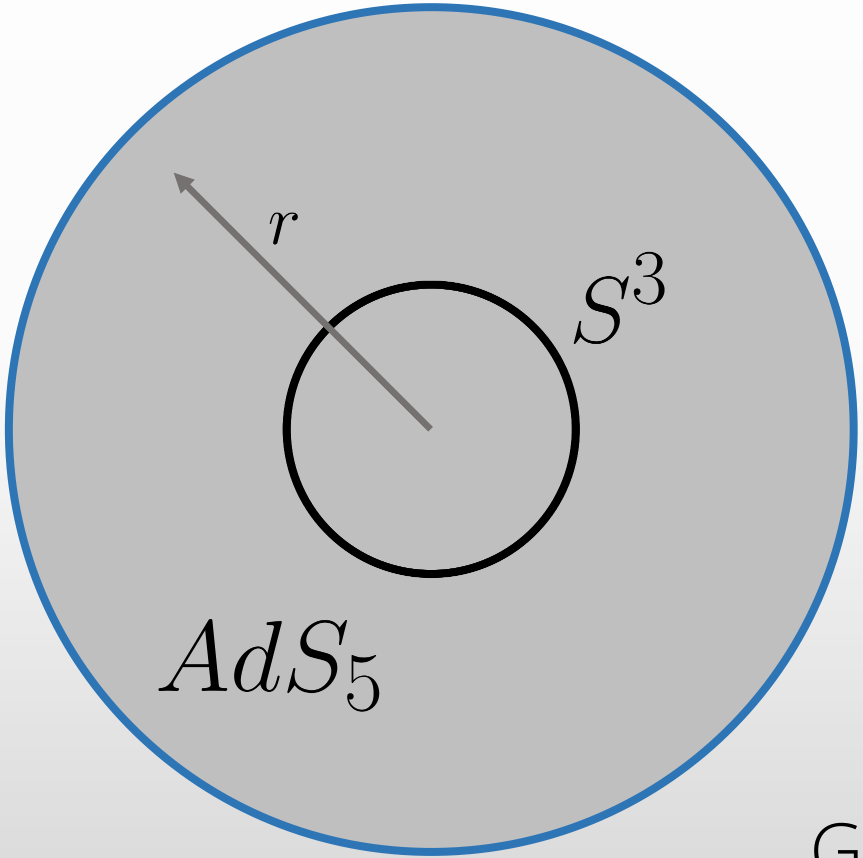
- We will present and explain the solution that interpolates between $AdS_5 \times S^5$ and nothing.

- We will study this setup in holography, the ETW brane (the cobordism to nothing), will have a holographic dual, so it is defined in the full quantum gravity, not only in the EFT.

A NOTE OF CAUTION



Global Coordinates

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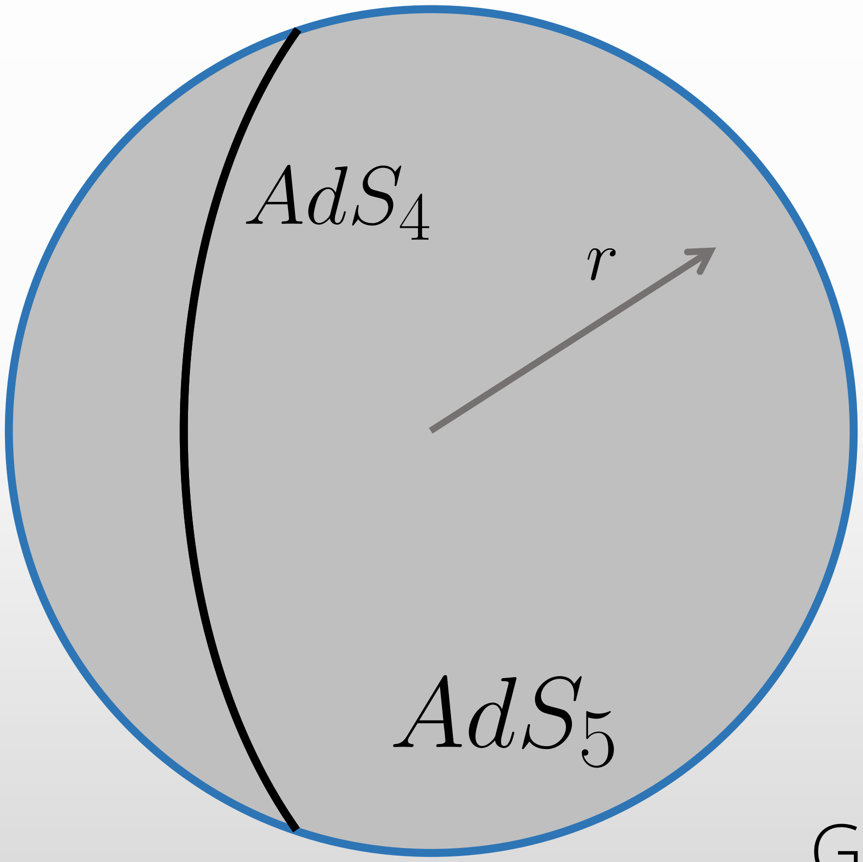
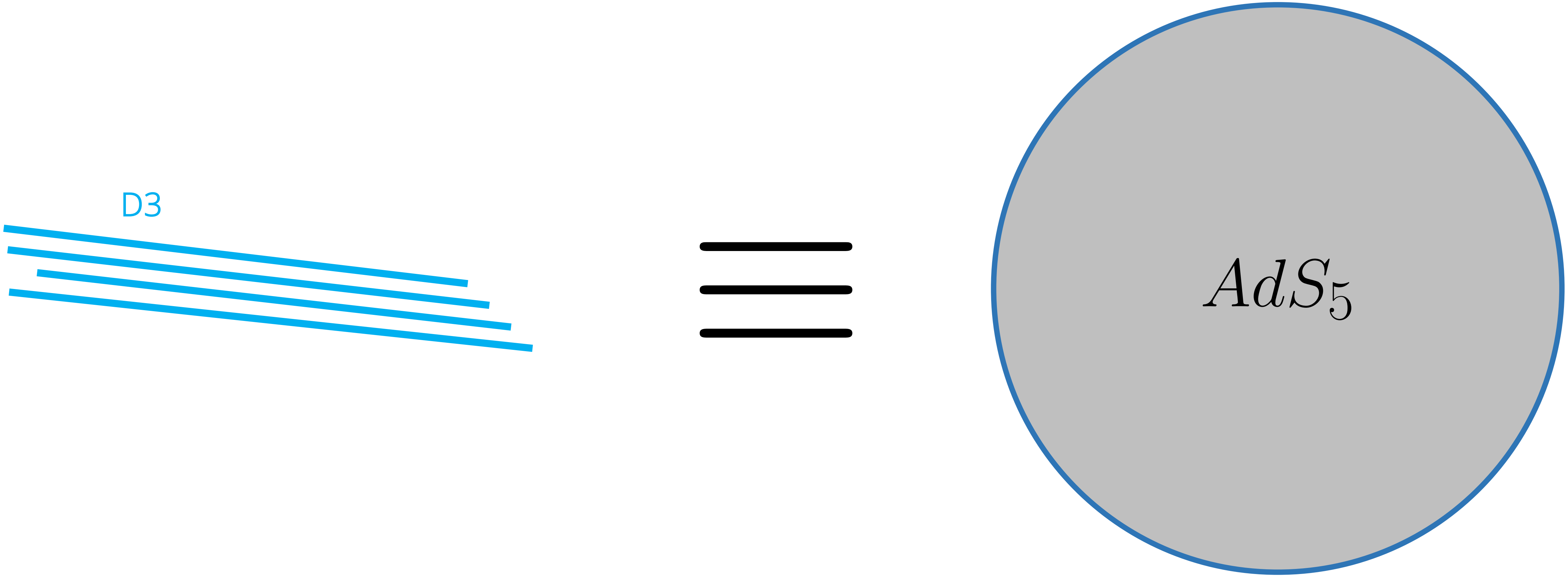


Global Coordinates

WHAT IS THE STRING THEORY INTERPRETATION OF THE ETW?



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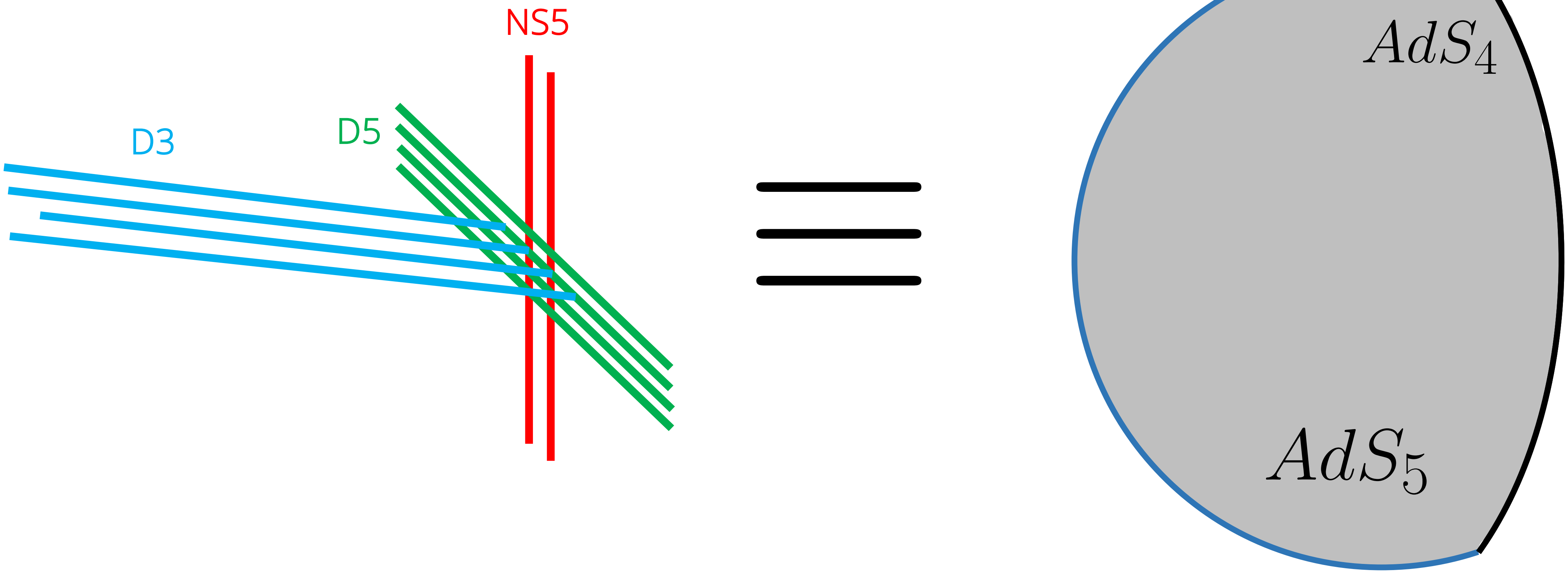

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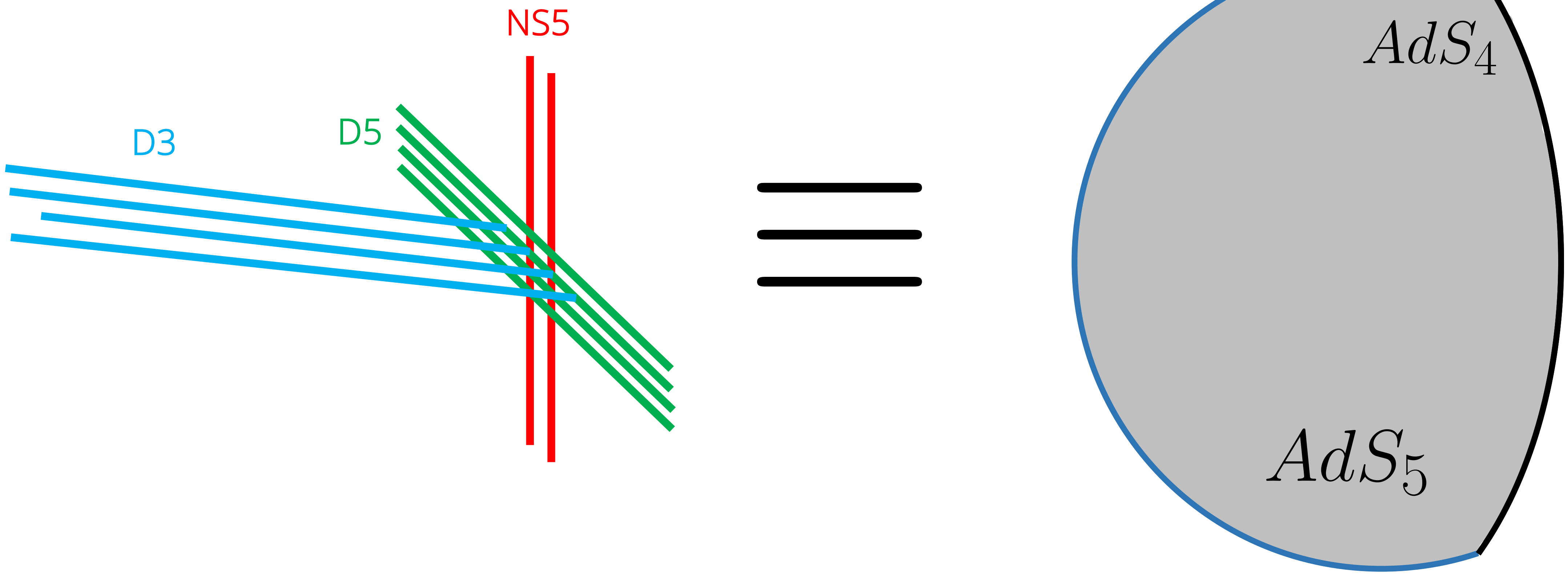
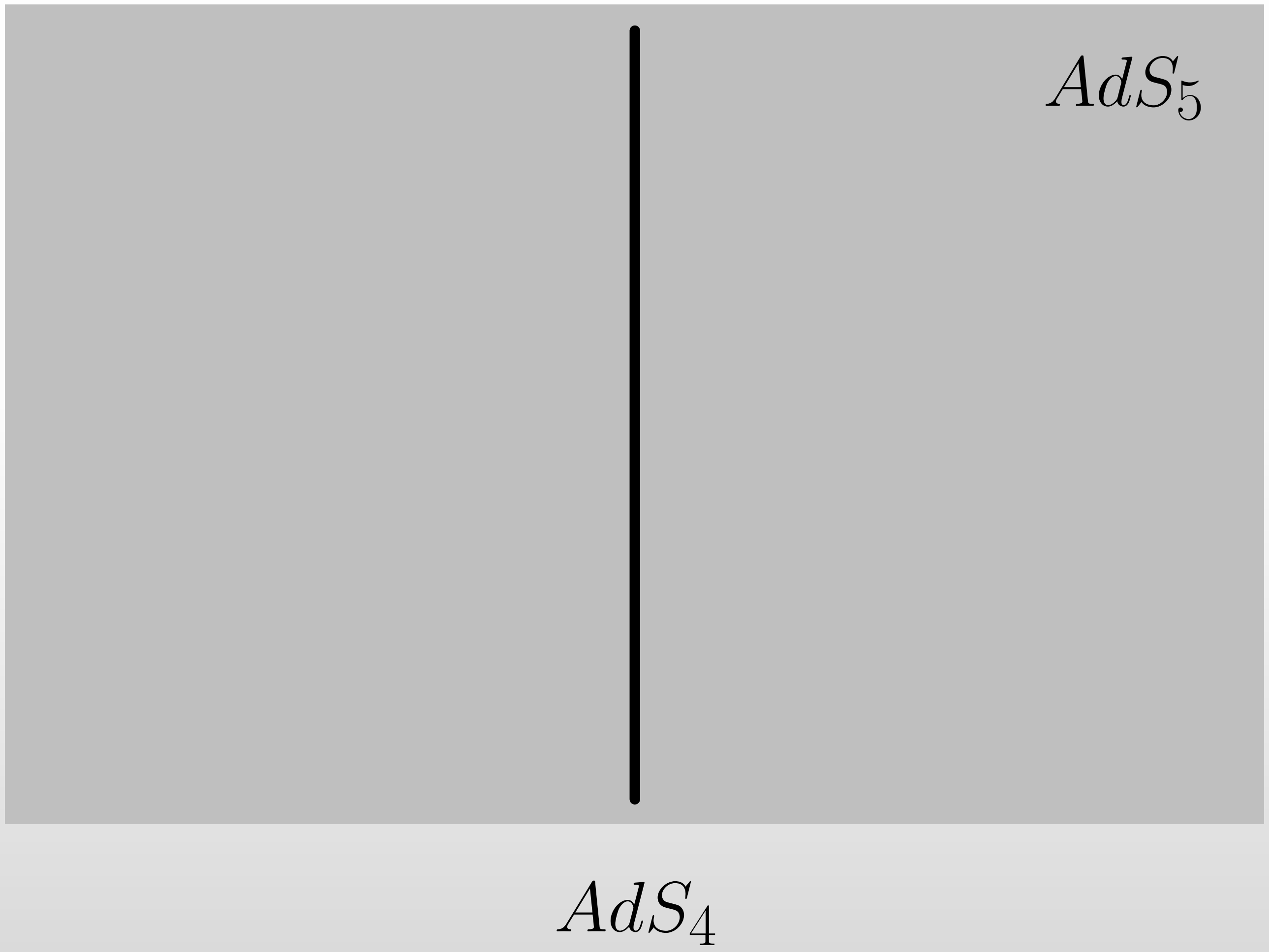
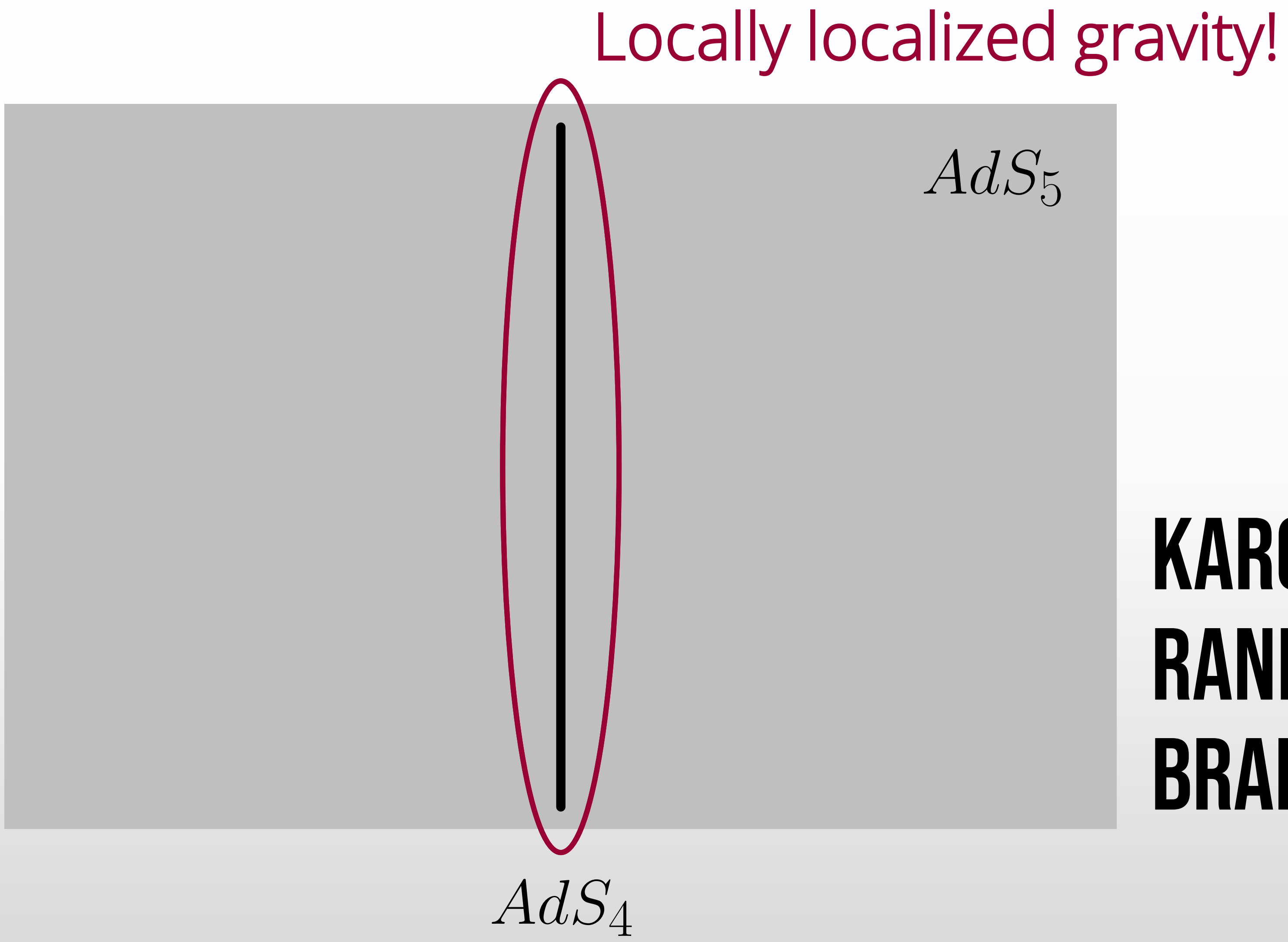


Holographic dual:

KARCH-RANDALL BRANE



[Karch, Randall, '00]



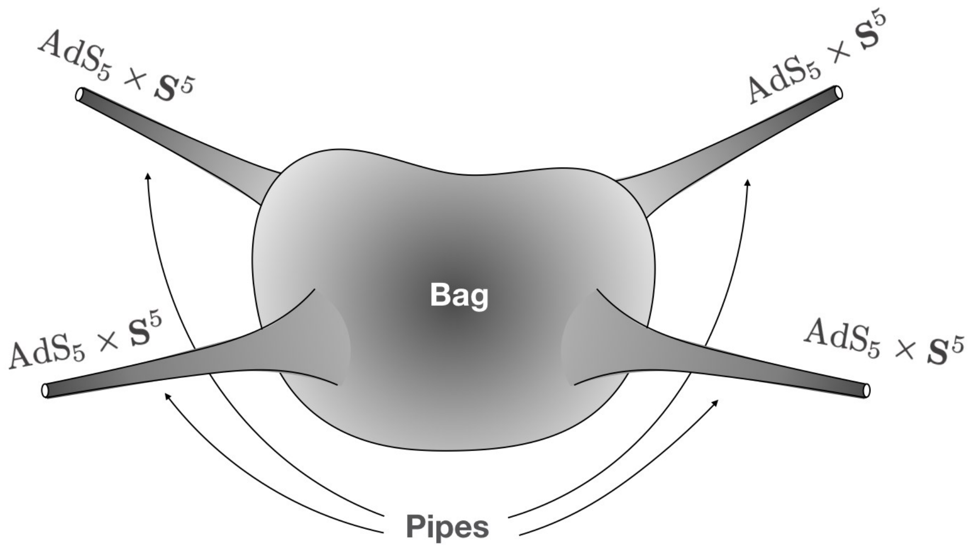
KARCH-RANDALL BRANE

[Karch, Randall, '00]

THE SOLUTION

BAGPIPE SOLUTIONS

[D'Hoker, Estes, Gutperle, '07]

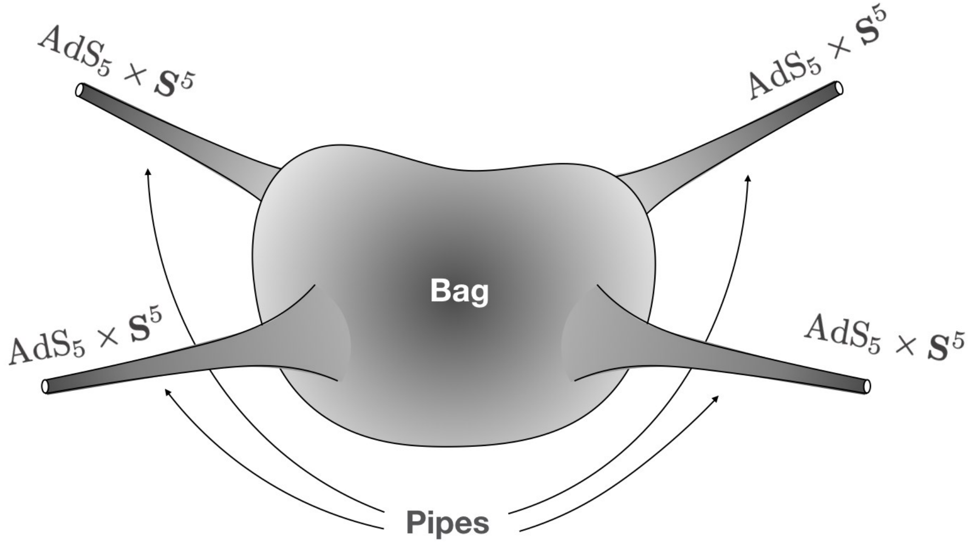


[D'Hoker, Estes, Gutperle, '07]

BAGPIPE SOLUTIONS

The theory has the symmetries

$$SO(2,3) \times SO(3) \times SO(3)$$



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The theory has the symmetries

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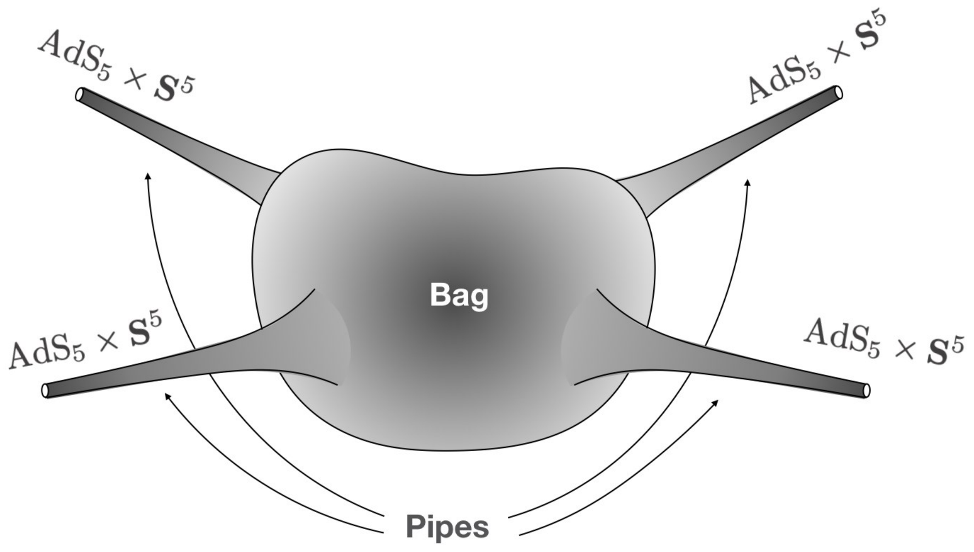
which in spacetimes translate to the manifold

$$\mathrm{AdS}_4 \times \mathbf{S}_1^2 \times \mathbf{S}_2^2 \times \Sigma$$

where everything is warped over the oriented Riemann surface Σ . The metric is:



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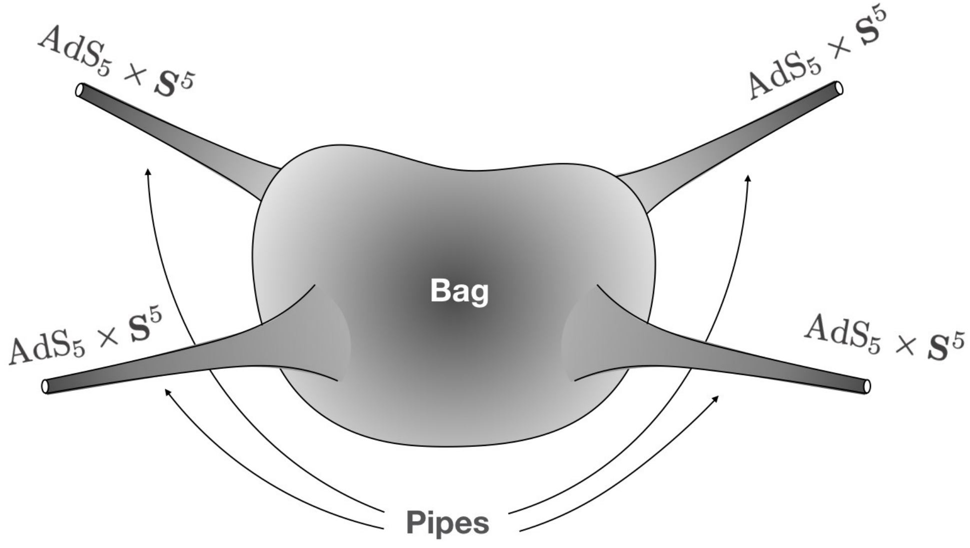

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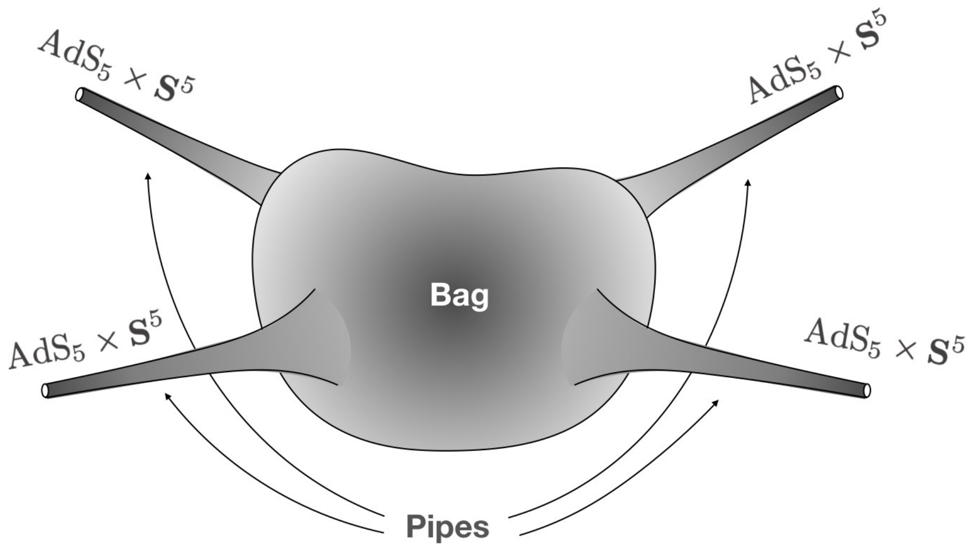

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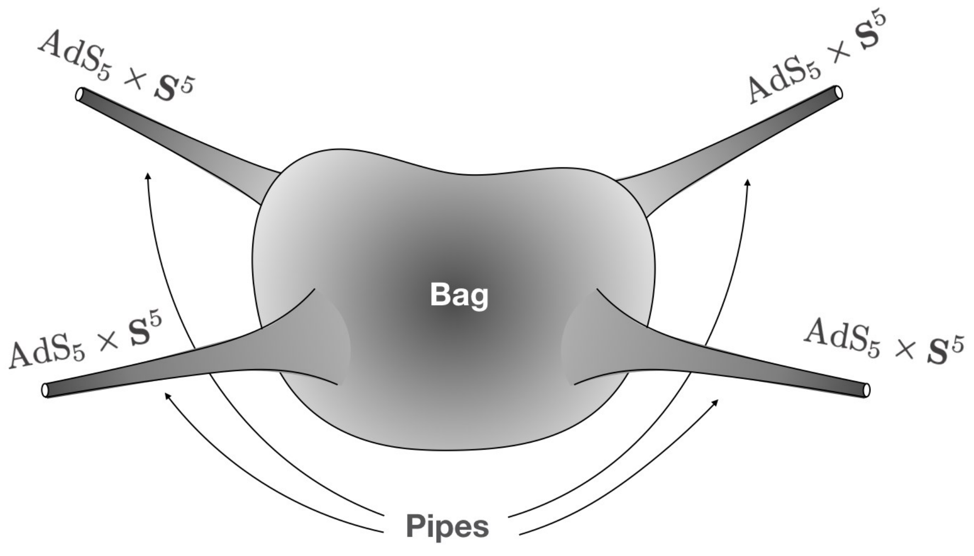
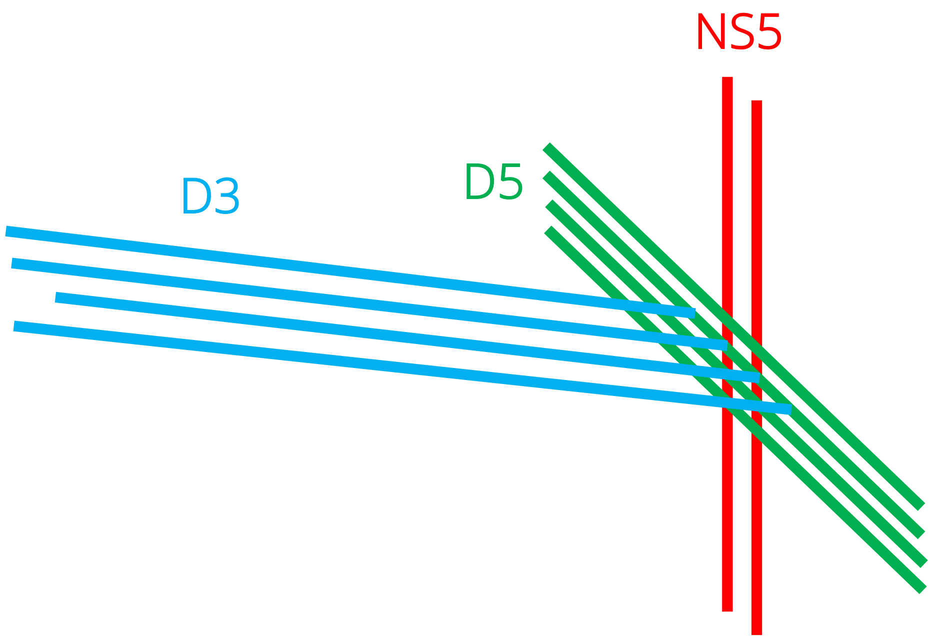
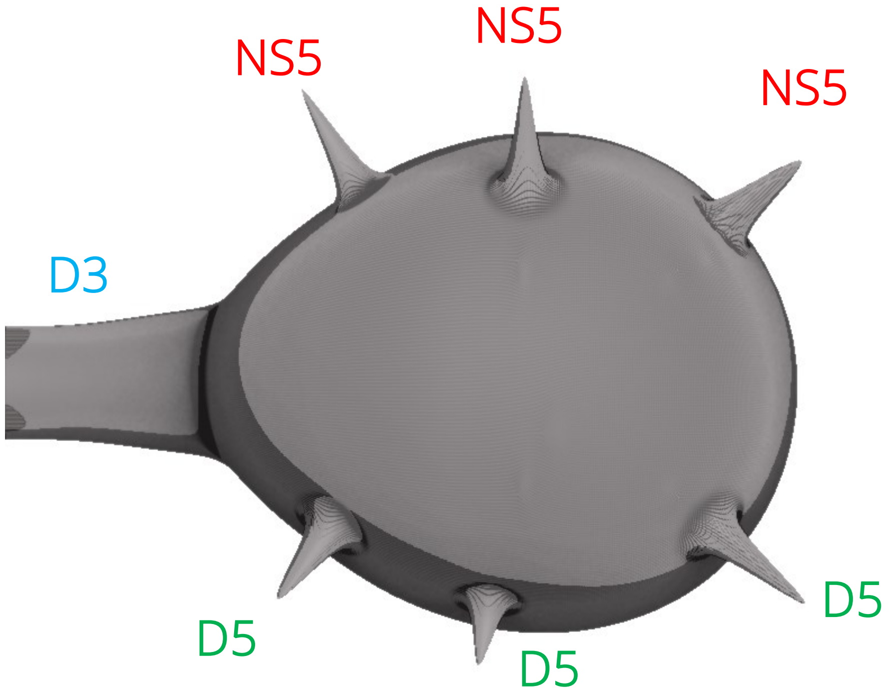
$$f_4 \equiv f_4(r, \varphi)$$
$$f_1 \equiv f_1(r, \varphi)$$
$$f_2 \equiv f_2(r, \varphi)$$
$$\rho \equiv \rho(r, \varphi)$$



D3- BRANES ENDING ON 5-BRANES

[Aharony, Berdichevsky, Berkooz, Shamir, ‘11]





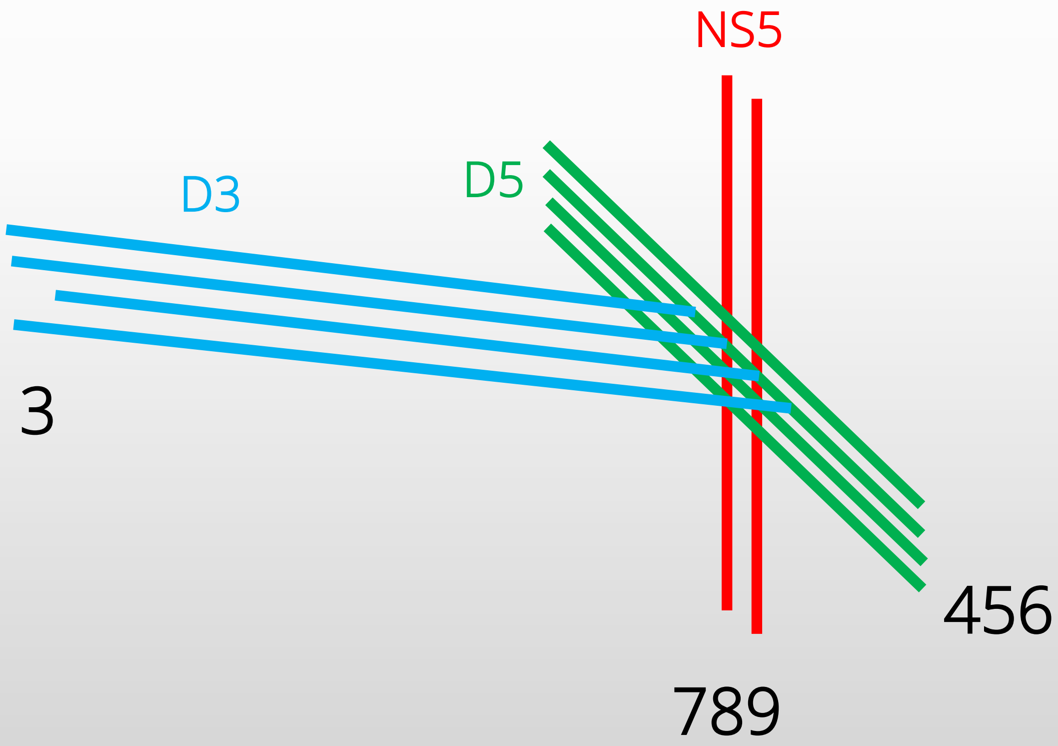
BRANE CONFIGURATION

$$ds^2 = f_4^2 ds^2_{AdS_4} + f_1^2 ds^2_{\mathbf{S}_1^2} + f_2^2 ds^2_{\mathbf{S}_2^2} + 4\rho^2(dr^2 + r^2 d\varphi^2)$$

AdS$_4$ φ

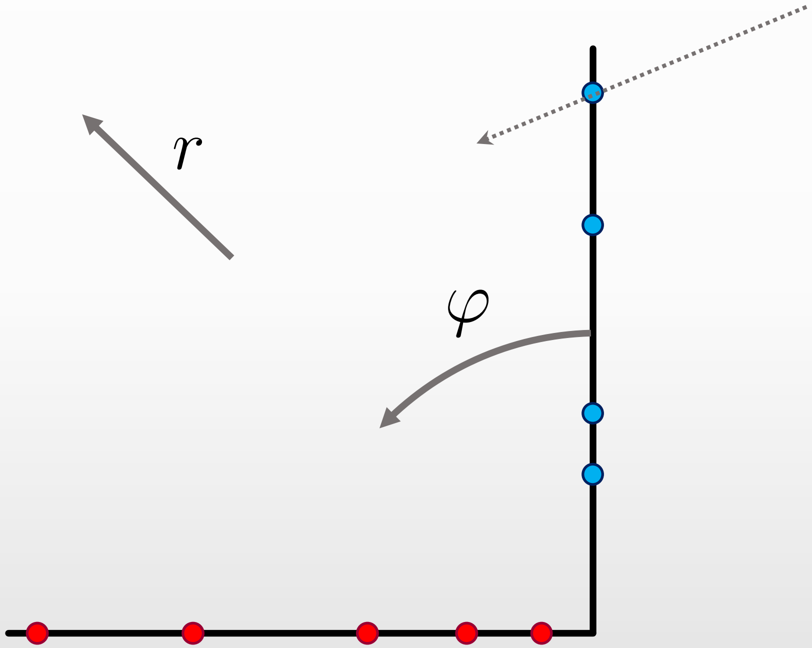
$D3$	0	1	2	3	$\times$	$\times$	$\times$	$\times$	$\times$	$\times$
$D5$	0	1	2	$\times$	4	5	6	$\times$	$\times$	$\times$
$NS5$	0	1	2	$\times$	$\times$	$\times$	$\times$	7	8	9

r $\mathbf{S}_1^2$ $\mathbf{S}_2^2$



ETW PICTURE

At each point on Σ,
we have $\mathrm{AdS}_4 \times \mathbf{S}_1^2 \times \mathbf{S}_2^2$



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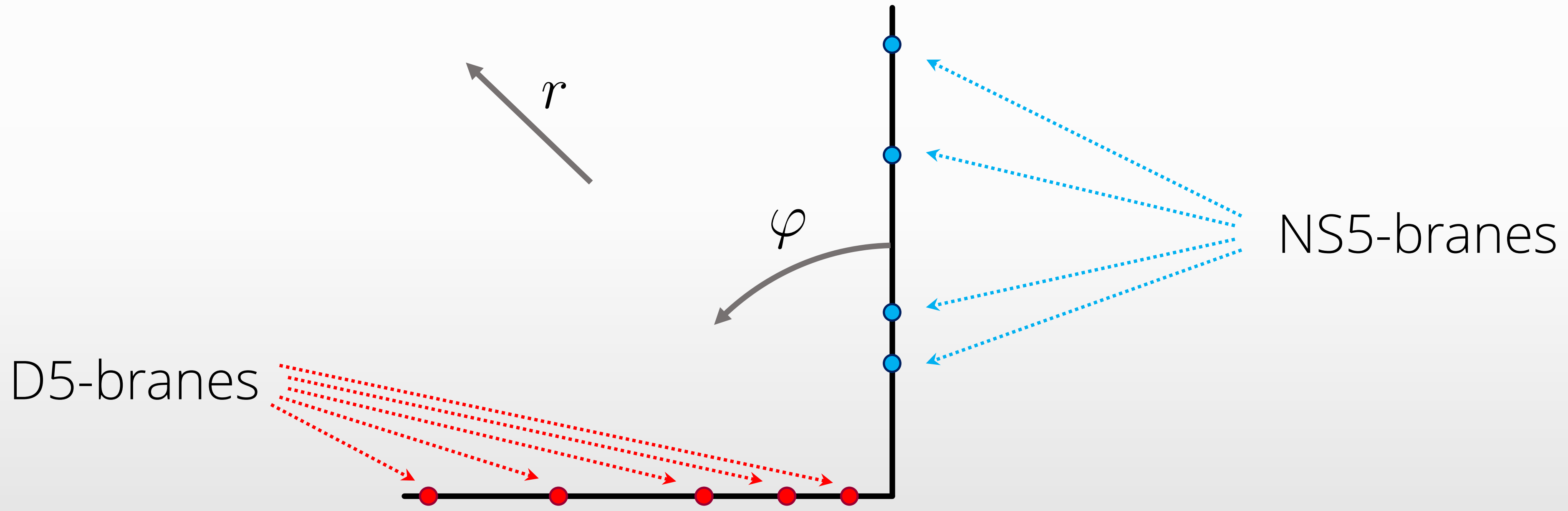

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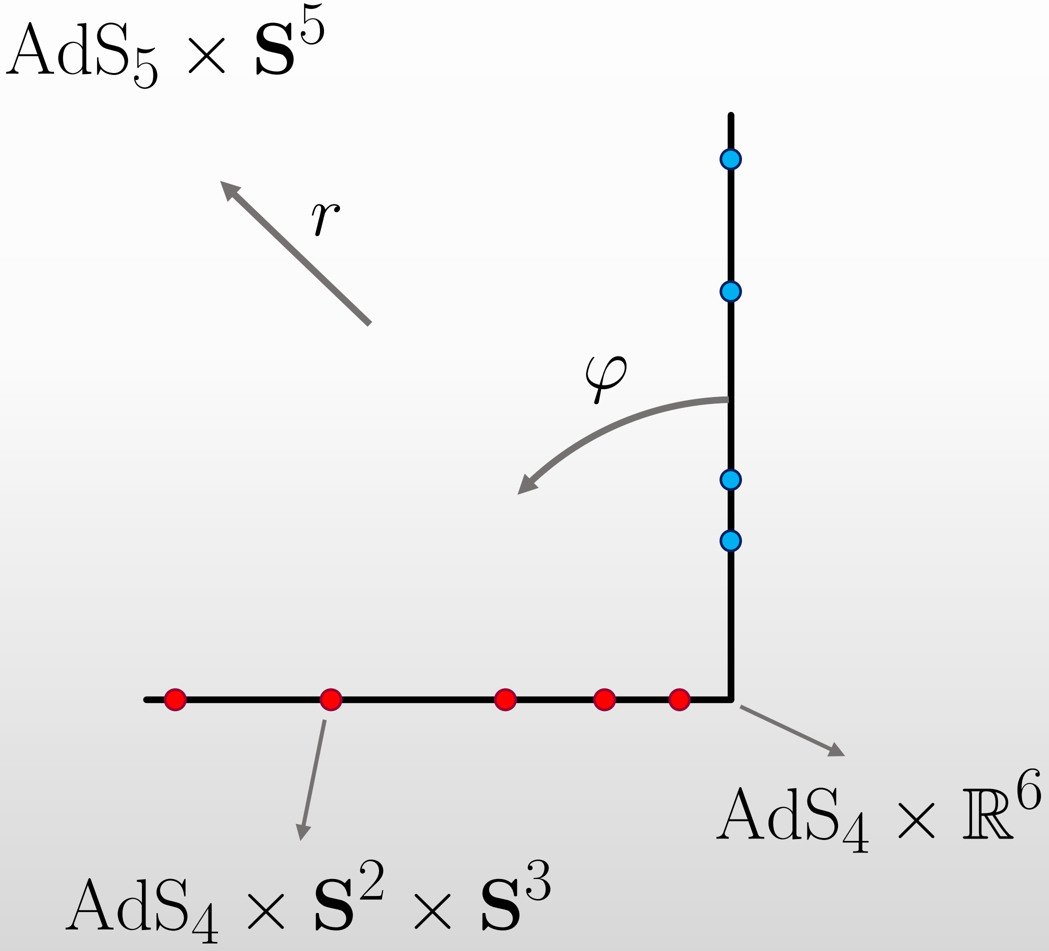

$\mathrm{AdS}_5 \times \mathbf{S}^5$
r
φ
$\mathrm{AdS}_4 \times \mathbb{R}^6$
$\mathrm{AdS}_4 \times \mathbf{S}^2 \times \mathbf{S}^3$

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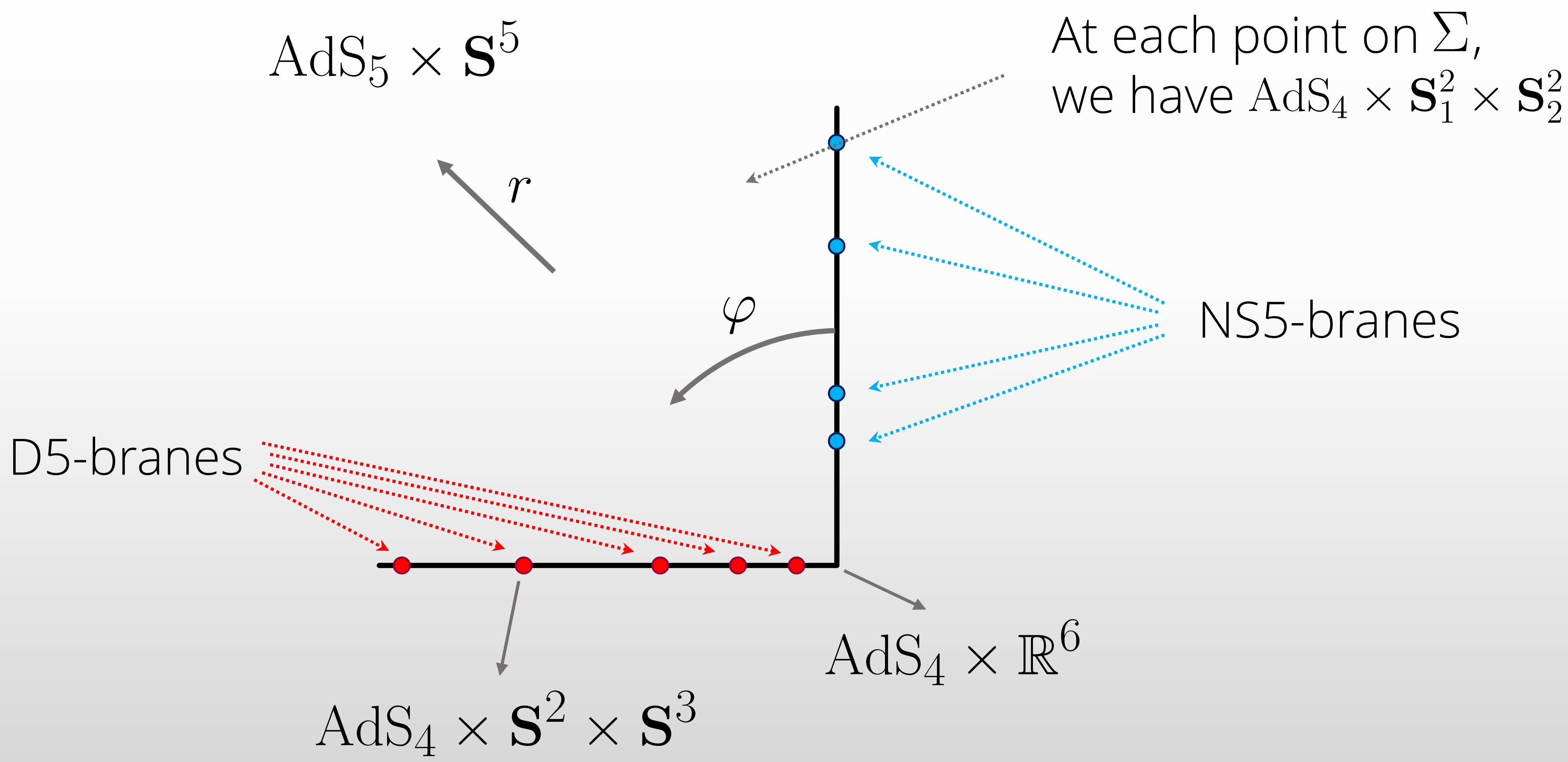

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D5-branes
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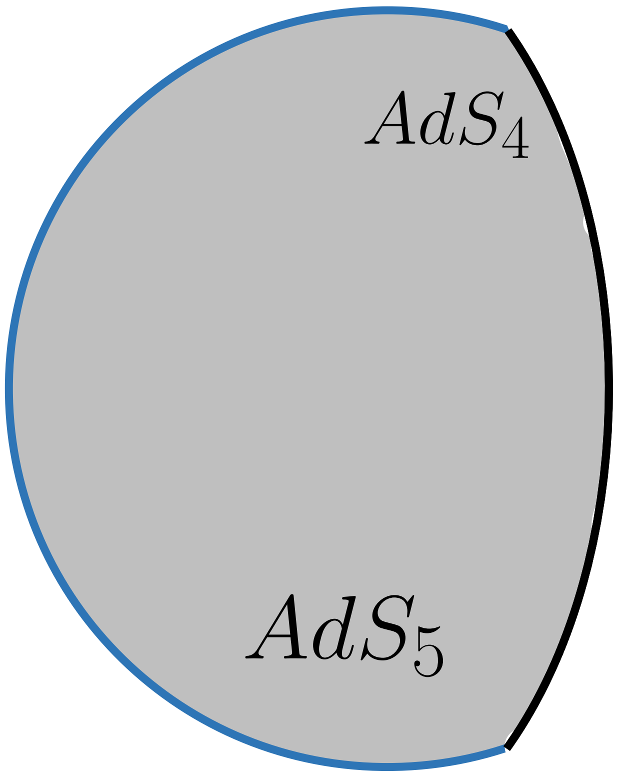
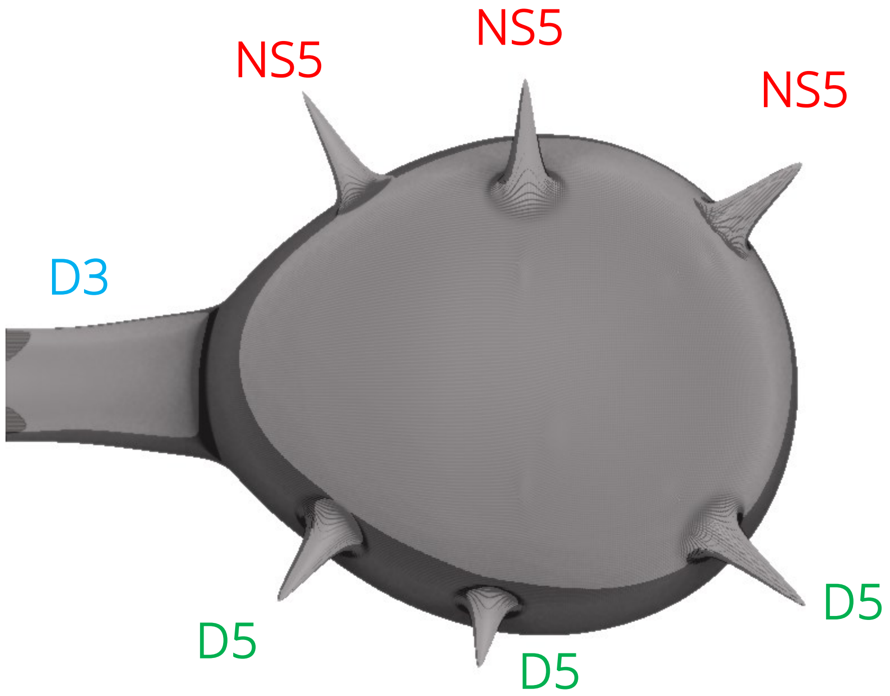
OUR RESULTS

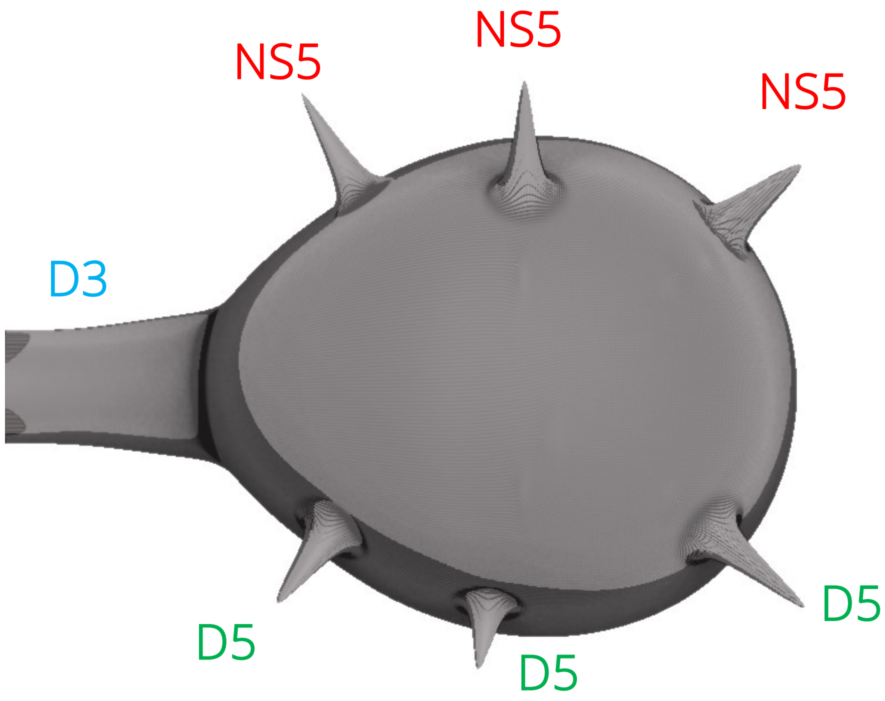
A STRINGY ETW-BRANE FOR ADS/CFT



$\Rightarrow$



SMOOTHING THE SOLUTION



But this is a complicated solution!

The 5-branes break the SO(6) rotational invariance of the S^5

We need to smooth the solution to compare with the Dynamical Cobordism results

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The SO(6) symmetry is broken down to SO(3)xSO(3) by the 5-branes

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This mode parametrizes the overall volume of the S^5

I: COMPACTIFY THE 2-SPHERES

$$ds^2 = f_4^2 ds^2_{AdS_4} + f_1^2 ds^2_{\mathbf{S}_1^2} + f_2^2 ds^2_{\mathbf{S}_2^2} + 4\rho^2(dr^2 + r^2 d\varphi^2)$$

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We reduce the 2-spheres parametrizing their volumes by radions

$$ds^2 = e^{-\frac{1}{2}(\sigma_1+\sigma_2)} ds_6^2 + e^{\frac{1}{\sqrt{2}}(a\sigma_1 - b\sigma_2)} ds^2_{\mathbf{S}_1^2} + e^{\frac{1}{\sqrt{2}}(a\sigma_2 - b\sigma_1)} ds^2_{\mathbf{S}_2^2}$$

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where

$$\sigma_1 = \log(f_1^a f_2^b), \quad \sigma_2 = \log(f_1^b f_2^a) \qquad a = 1 + \frac{1}{\sqrt{2}},\ b = 1 - \frac{1}{\sqrt{2}}$$

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$$ds^2 = e^{-\frac{1}{2}(\sigma_1+\sigma_2)} ds^2_6 + e^{\frac{1}{\sqrt{2}}(a\sigma_1 - b\sigma_2)} ds^2_{\mathbf{S}^2_1} + e^{\frac{1}{\sqrt{2}}(a\sigma_2 - b\sigma_1)} ds^2_{\mathbf{S}^2_2}$$

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and we get a 6d theory + radions:

$$ds^2_6 = \sqrt{f_1^2 f_2^2}\,[\, f_4^2 ds^2_{AdS_4} + 4\rho^2(dr^2 + r^2 d\varphi^2)\,]$$

II: Truncate to the zero mode

We do not yet have cod-1 manifold $$ds_6^2 = \sqrt{f_1^2 f_2^2}\,[\,f_4^2 ds^2_{AdS_4} + 4\rho^2(dr^2 + r^2 d\varphi^2)\,]$$

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We then truncate onto the zero mode of the KK tower (the SO(6) invariant sector)

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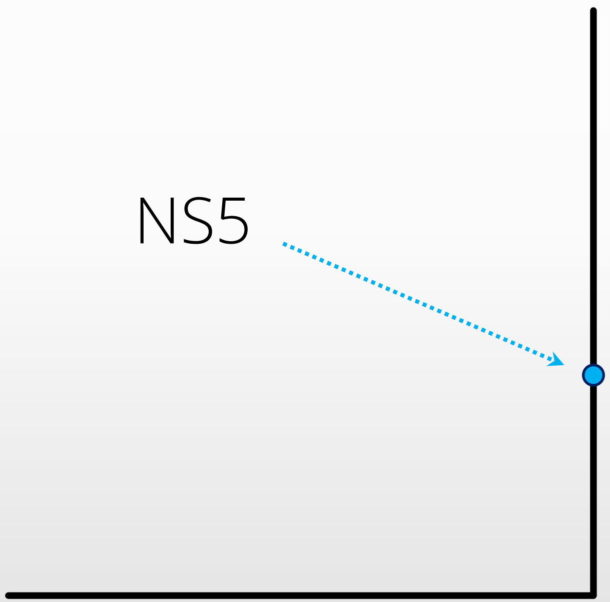
$$ds_5^2 = e^{2A(x)} ds^2_{AdS_4} + dx^2$$

EXAMPLE: THE GENUS ONE CASE



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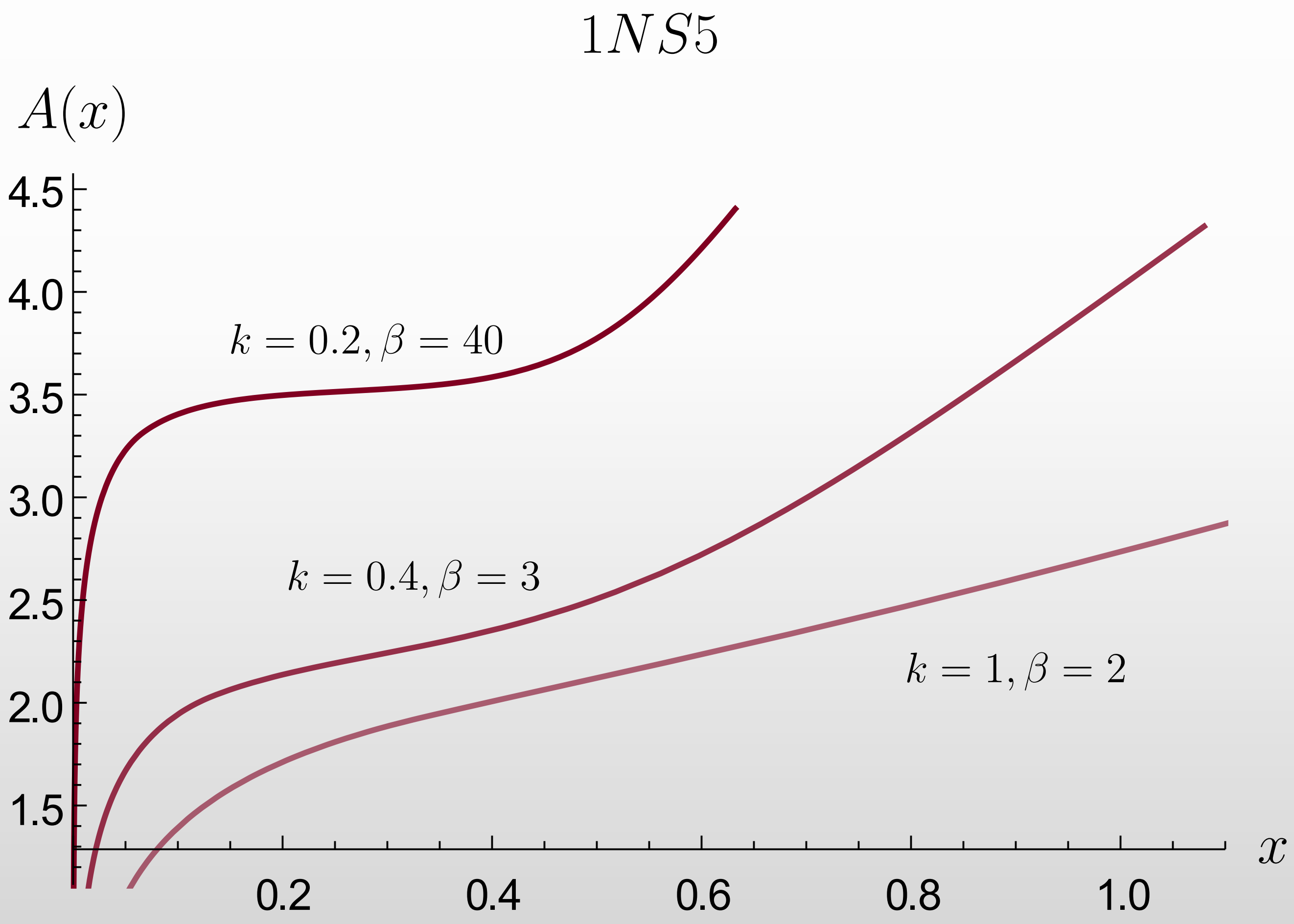

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Too simple, no bump!

LOCALIZATION OF GRAVITY IN KR

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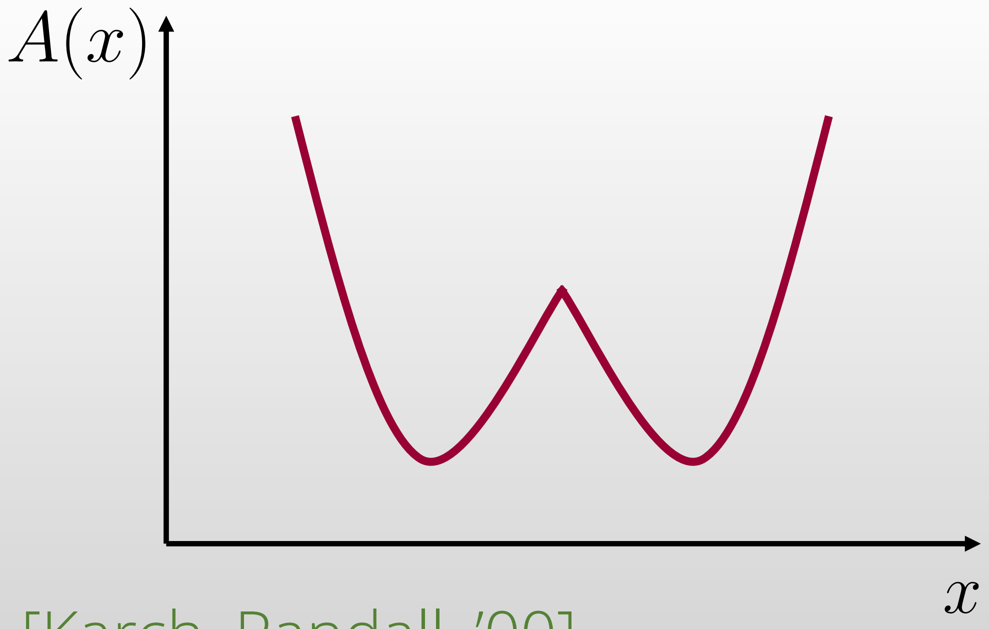
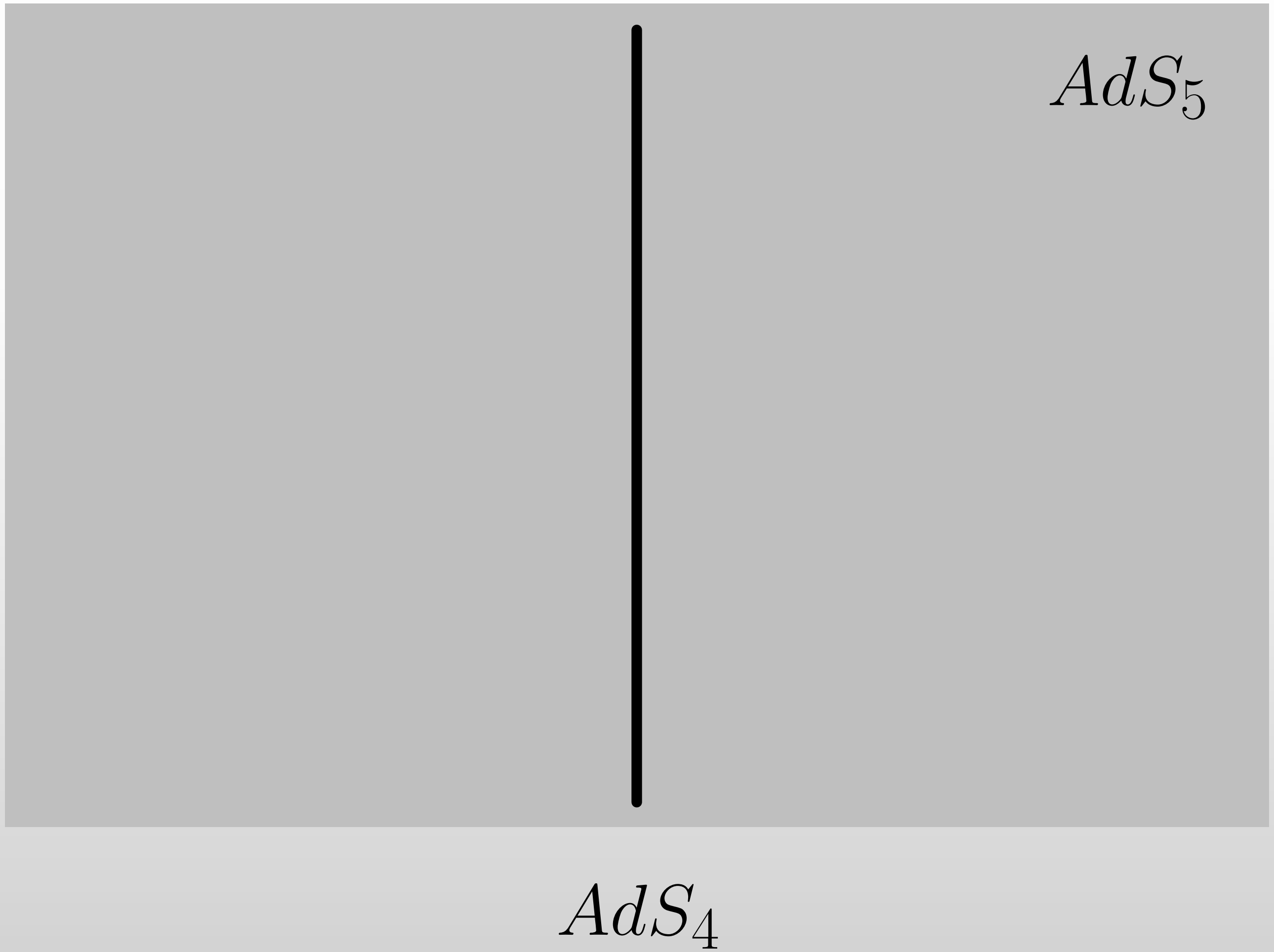


[Karch, Randall, '00]



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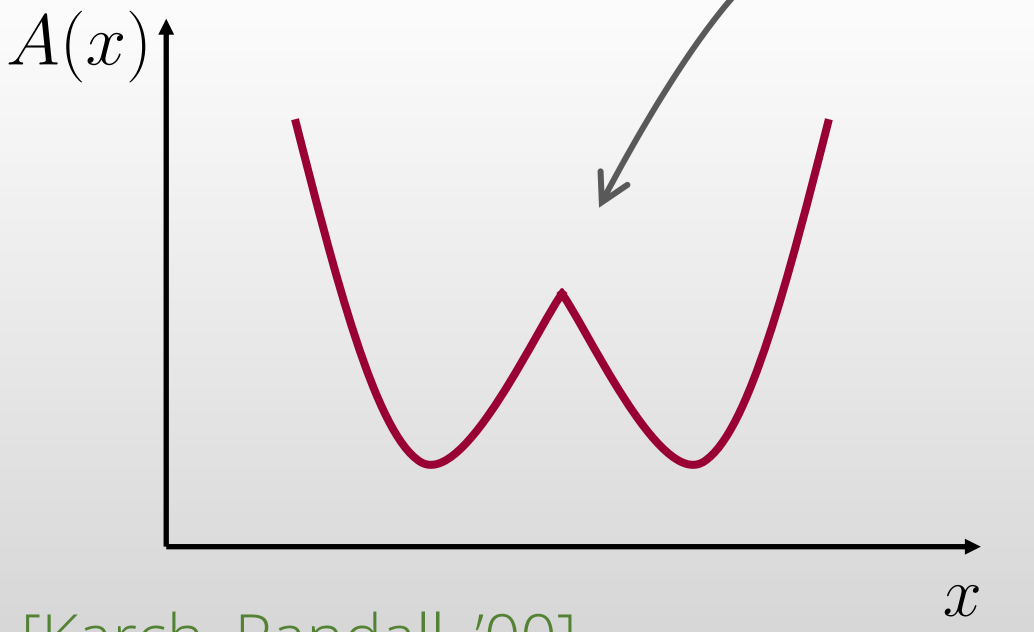


The graviton is bound on the brane!

We get a 4d massive graviton that couples to the 5d massless one

The mass is proportional to the coupling to the 5d space

[Karch, Randall, '00]

LOCALIZATION OF GRAVITY IN KR

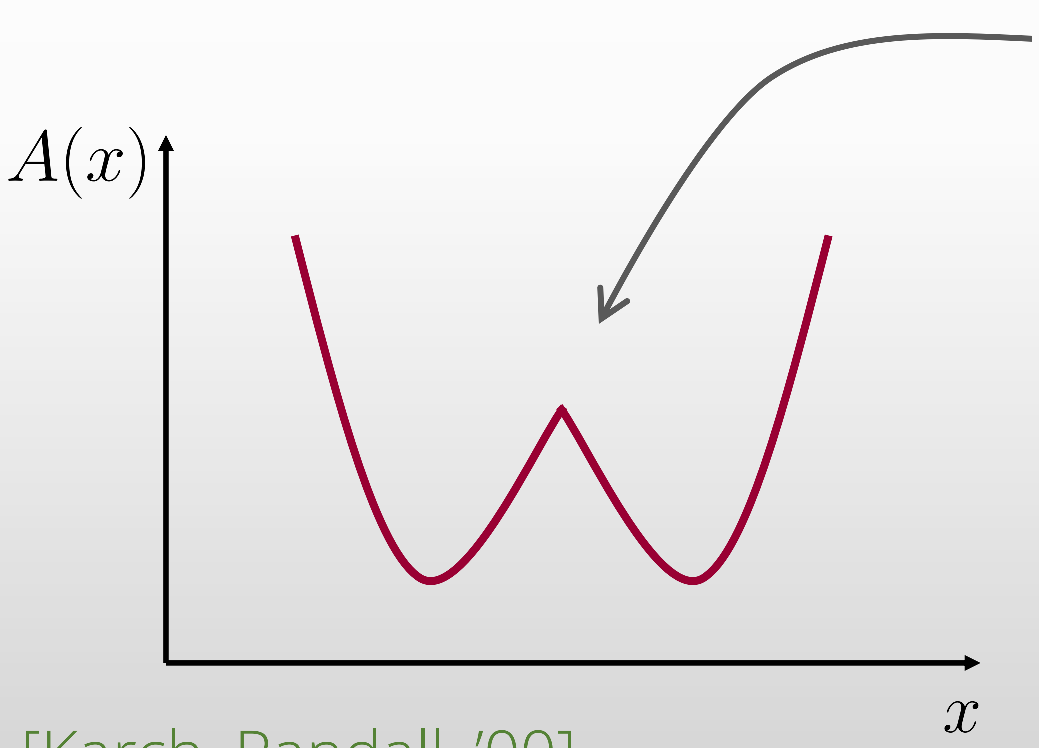
$$ds_5^2 = e^{2A(x)} ds^2_{AdS_4} + dx^2$$

Having a 4d massive graviton, means that holographically, we have a localized energy momentum tensor in our BCFT3 that couples to the CFT4

[Karch, Randall, '00]

LOCALIZATION OF GRAVITY IN KR

$$ds_5^2 = e^{2A(x)} ds^2_{AdS_4} + dx^2$$

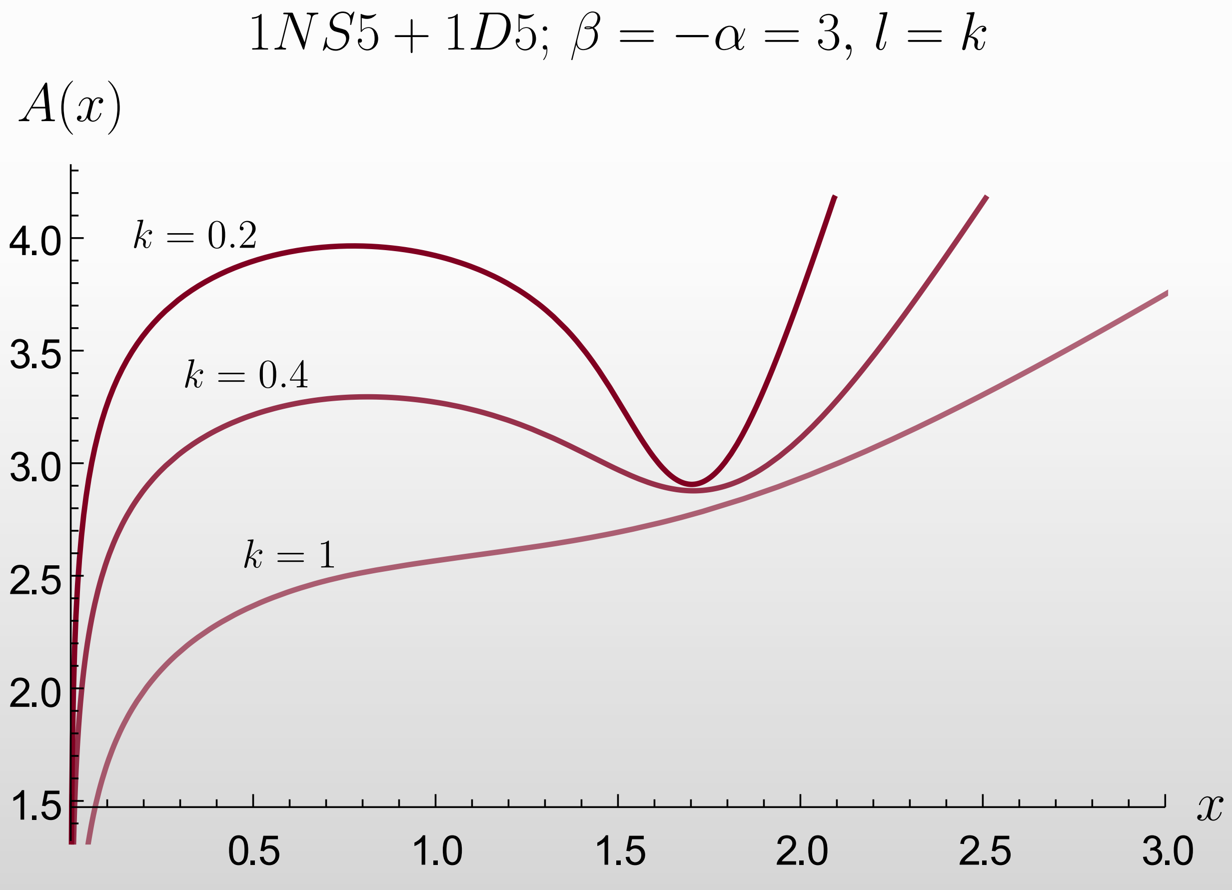


Having a 4d massive graviton, means that holographically, we have a localized energy momentum tensor in our BCFT3 that couples to the CFT4

→ Holographic interpretation of the ETW brane!!

[Karch, Randall, '00]

LOCALIZATION OF GRAVITY IN OUR SETUP



$$ds_5^2 = \hat{f}_4^2(r)ds^2_{AdS_4} + \hat{\rho}^2(r)dr^2$$

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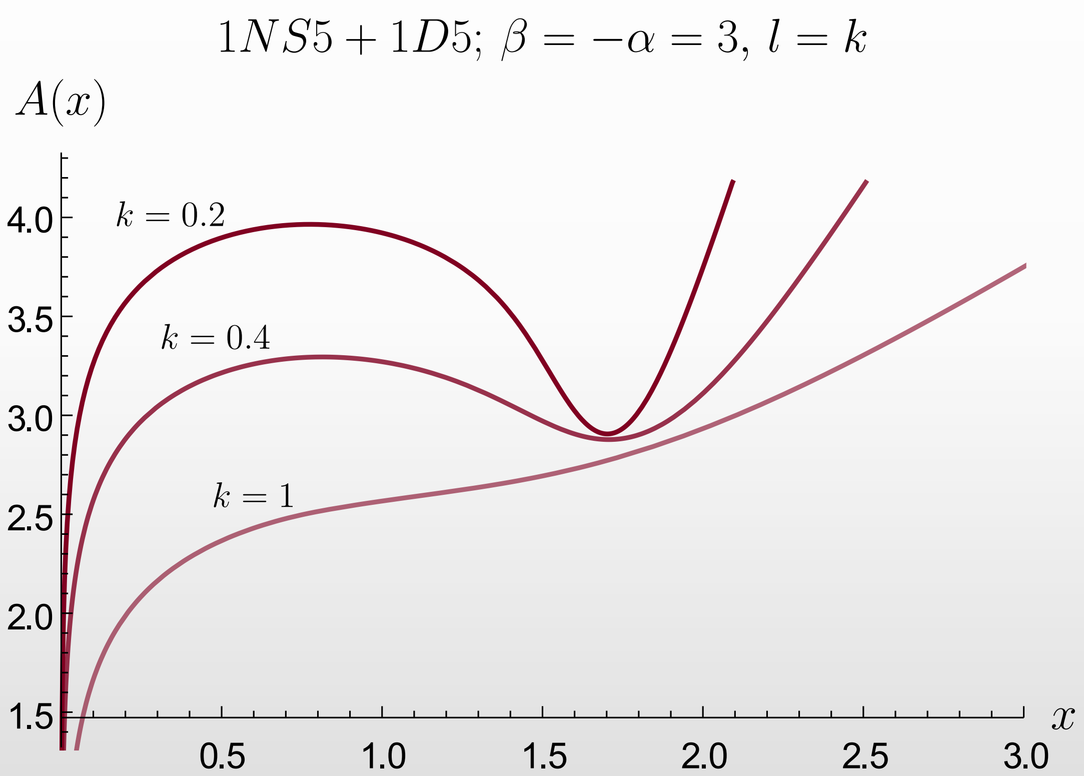
This is an explicit realization of a KR brane in string theory

LOCALIZATION OF GRAVITY IN OUR SETUP



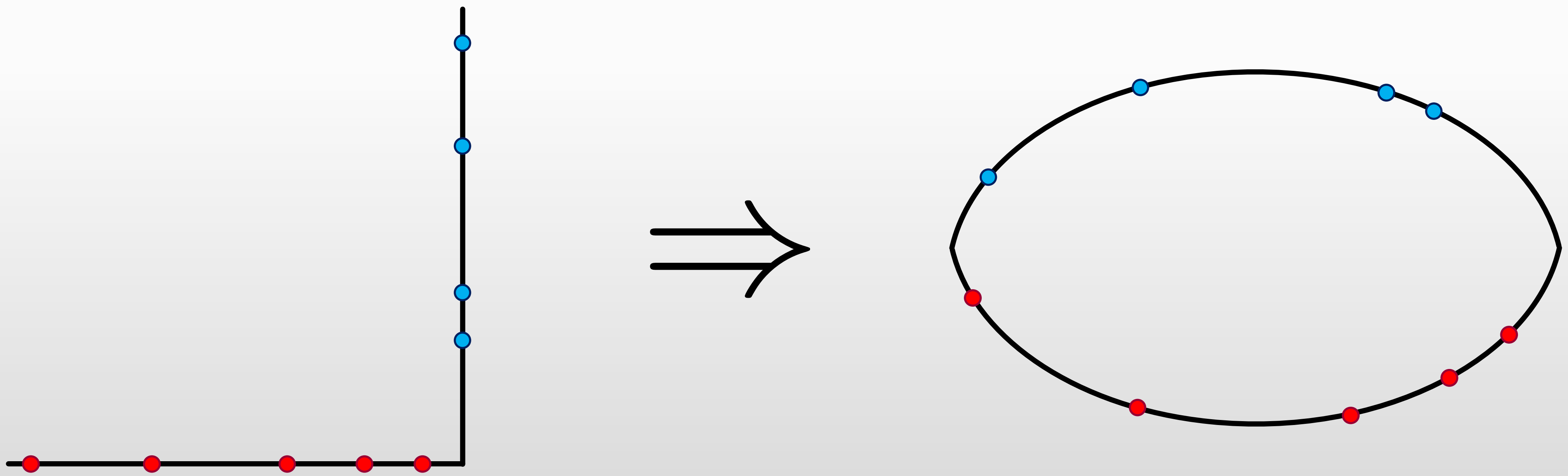
The Bag

The asymptotic AdS_5 throat

DOUBLE SCALING LIMIT

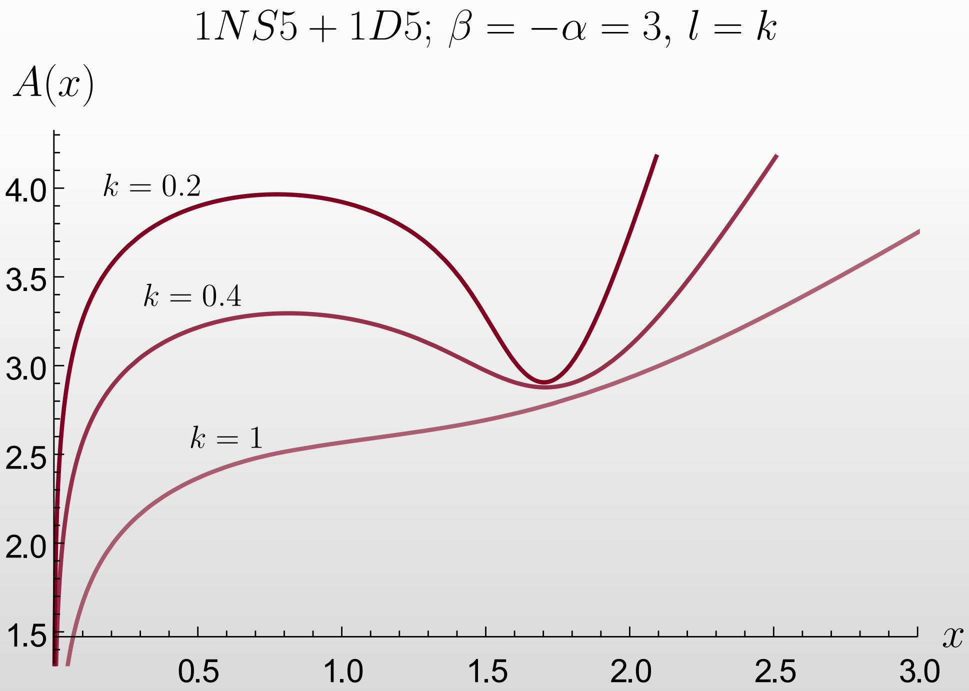
The double scaling limit makes the 5-form flux disappear and thus closes the AdS throat; so we get a compact geometry!

$$\mathrm{AdS}_4 \times \mathbf{X}_6$$

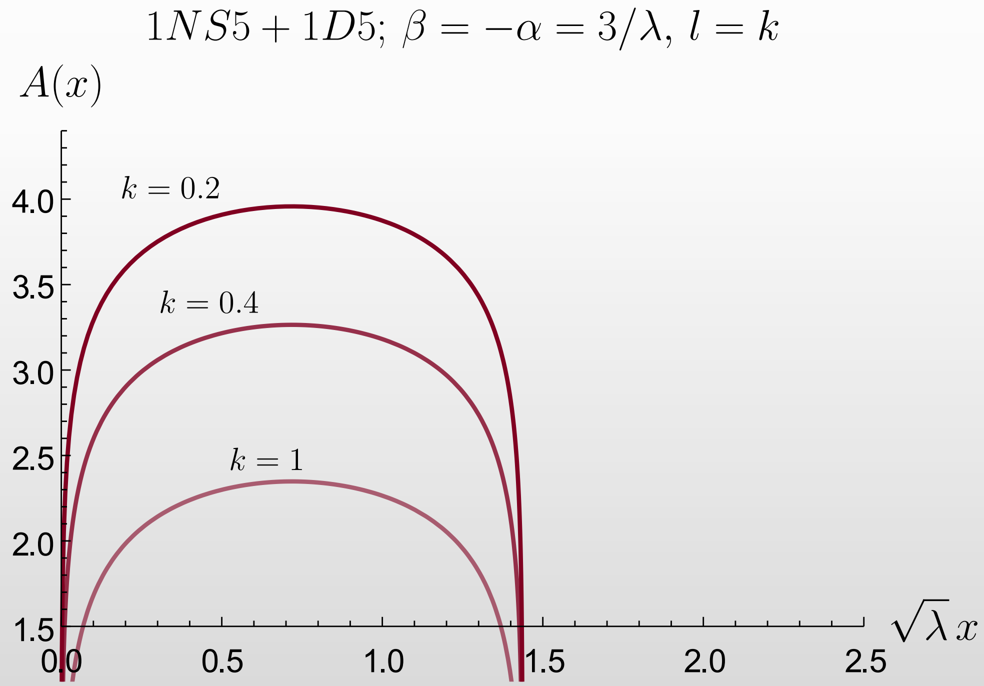


DOUBLE SCALING LIMIT

Only possible if you have both D5- and NS5-branes

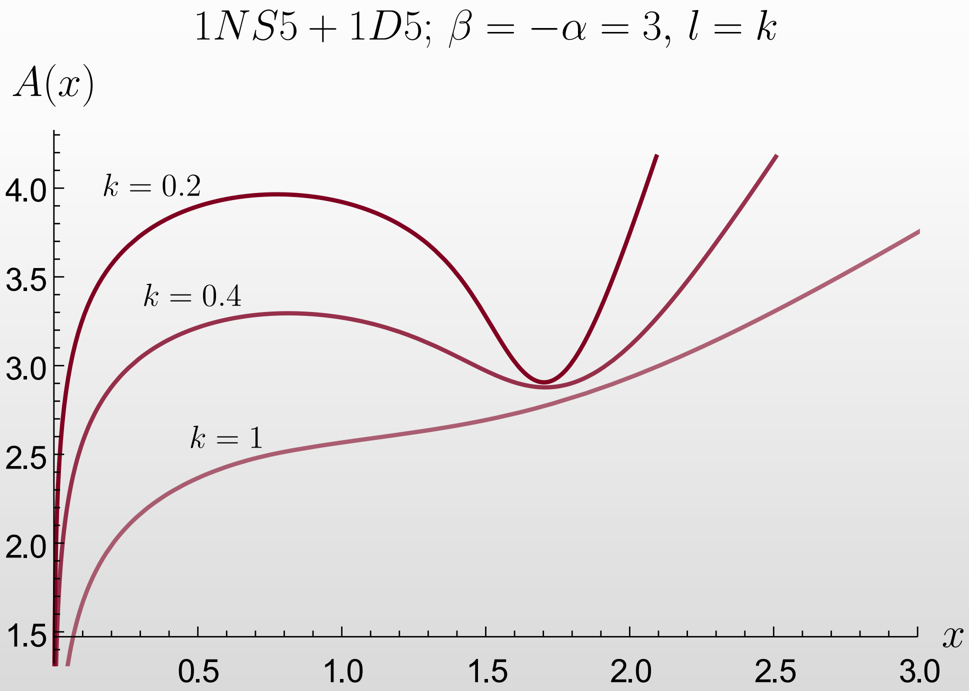


$\Rightarrow$



DOUBLE SCALING LIMIT

This double scaling limit isolates the dynamics of the ETW-brane!



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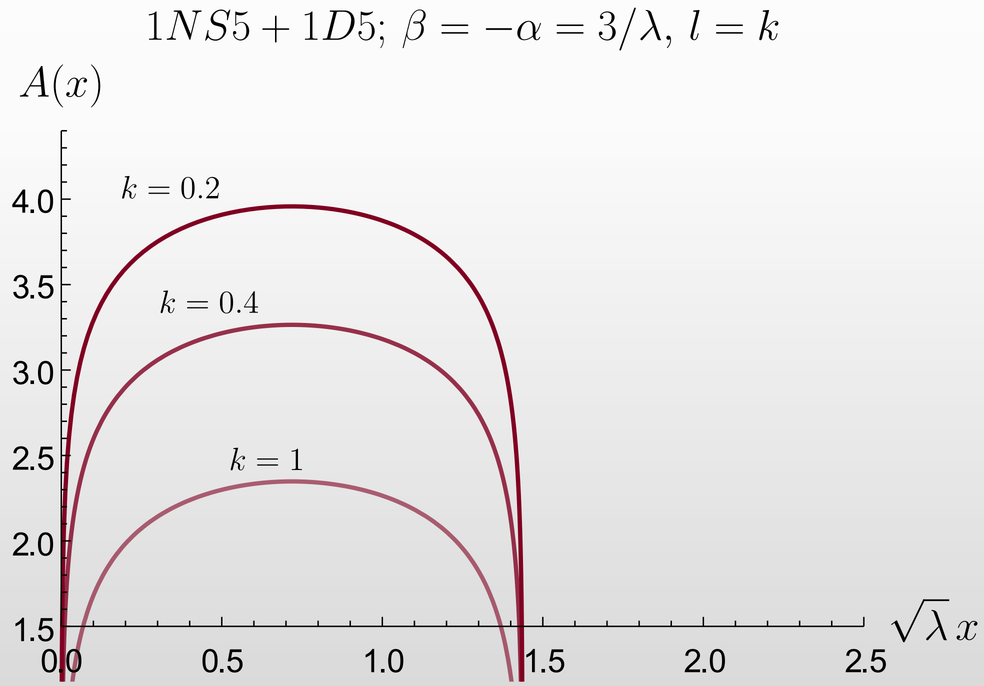
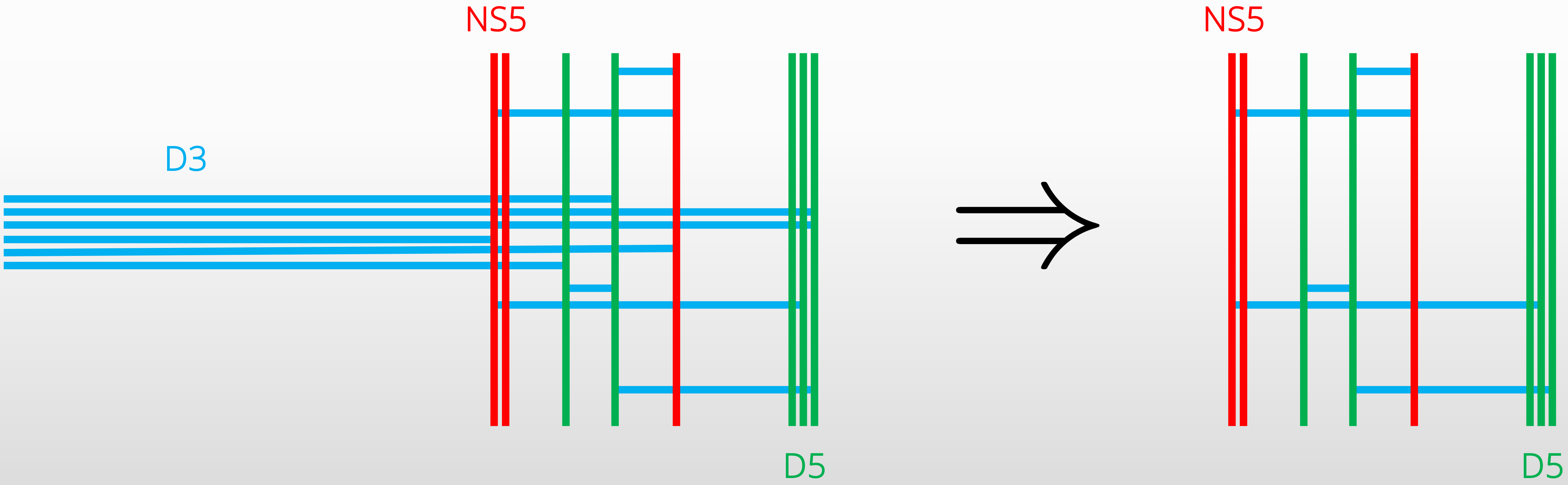


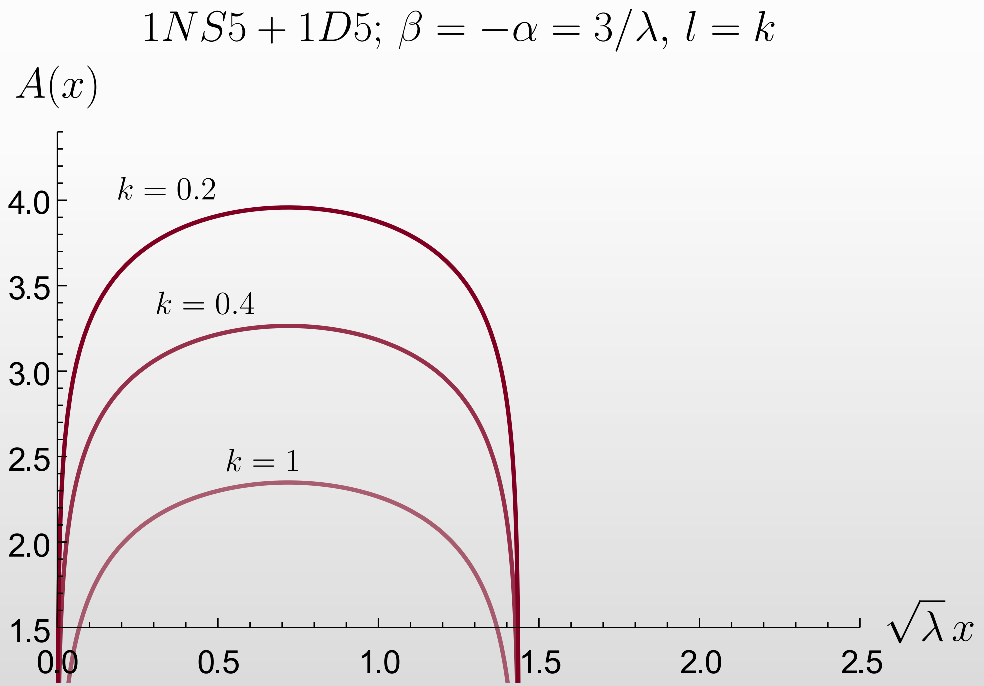
DOUBLE SCALING LIMIT

Which is that of a brane-web



DOUBLE SCALING LIMIT

In fact, provides the gravity dual of the 3d BCFT (wedge holography)



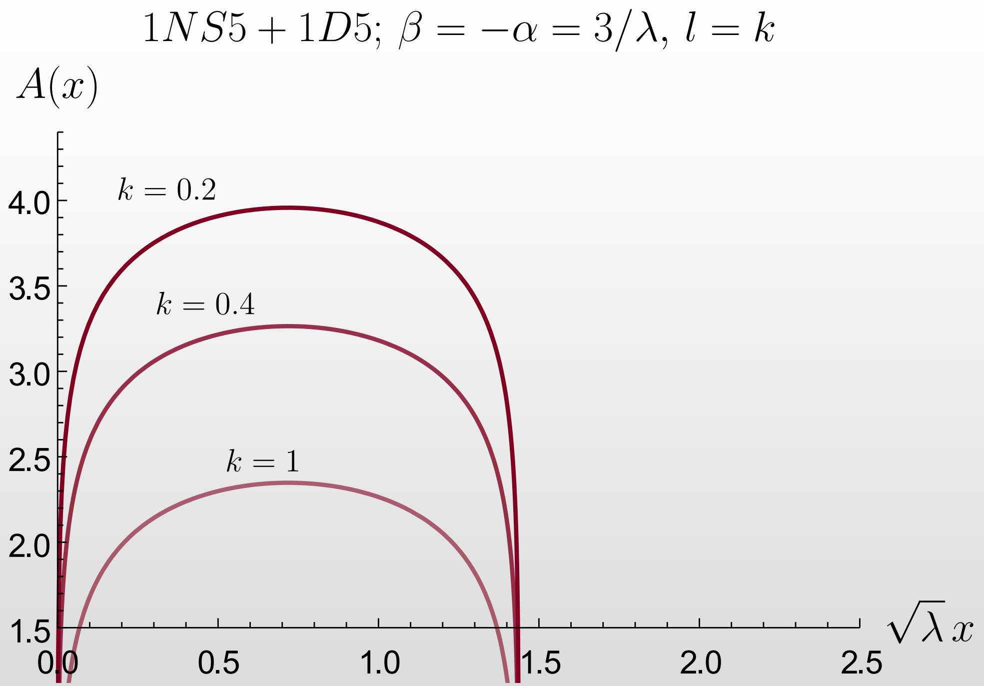
$$\mathrm{AdS}_4 \times \mathbf{X}_6$$

[Assel, Bachas, Estes, Gomis '11]

[Van Raamsdonk, Waddell, '21]

DOUBLE SCALING LIMIT

The fact that we can close the throat in a continuous fashion and make the space compact, is related to continuously making the 4d graviton massless



*The mass of the graviton is proportional to the size of the throat

[Demulder, Gnecchi, Lavdas, Lust, '22]

CONCLUSIONS

CONCLUSIONS AND FUTURE DIRECTIONS

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THANK YOU!