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Cobordism and Bubbles of Anything in String Theory

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Based on 23xx.xxxx with Arthur Hebecker, Johannes Walcher

Stringpheno Daejeon, July 6, 2023

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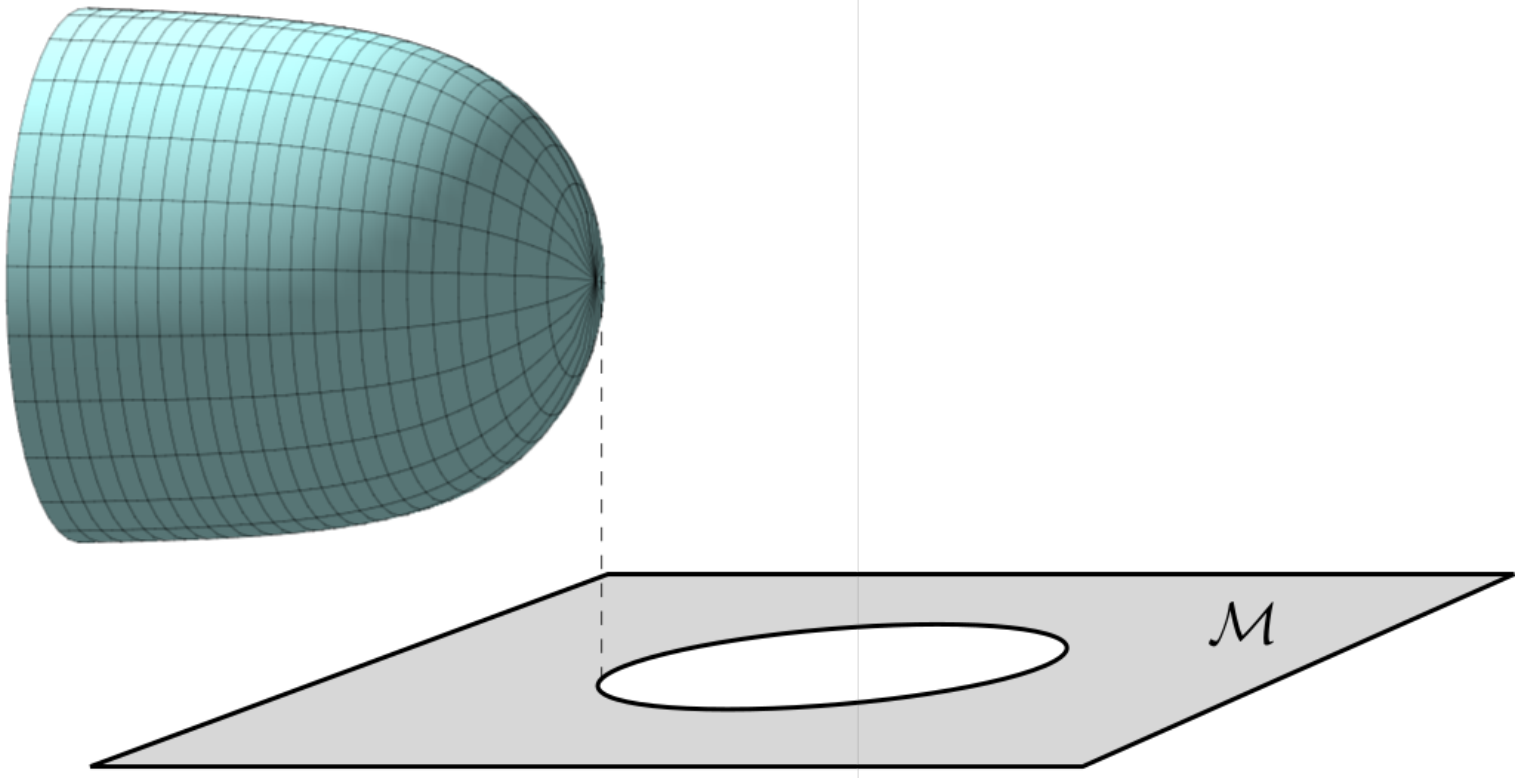
Bubbles of Nothing

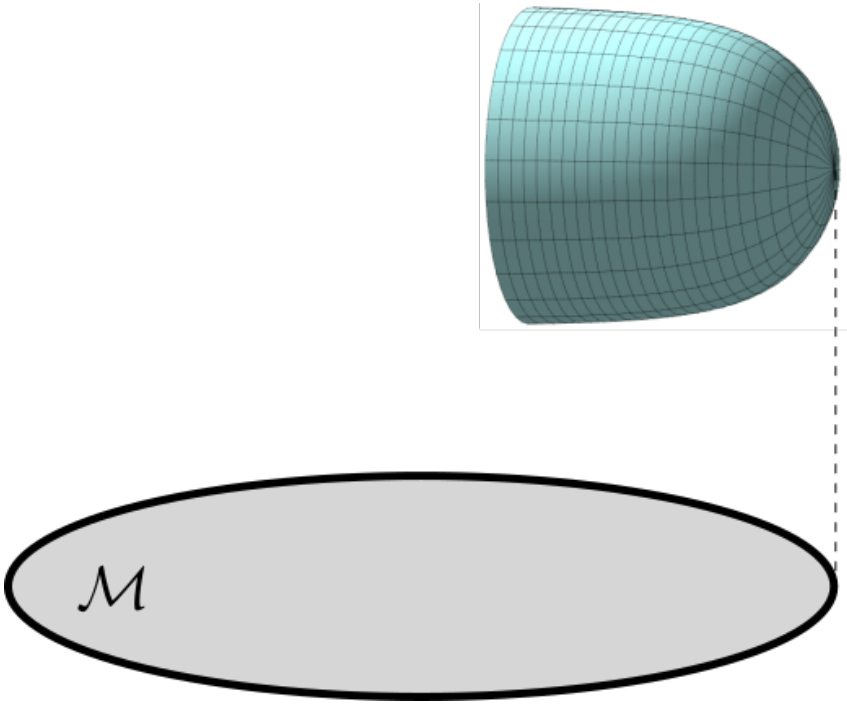
Witten bubble of nothing [Witten, 1982, García Etxebarria et al., 2020]



Vacuum decay of $\mathbb{M}_4 \times S^1$

Vacuum creation

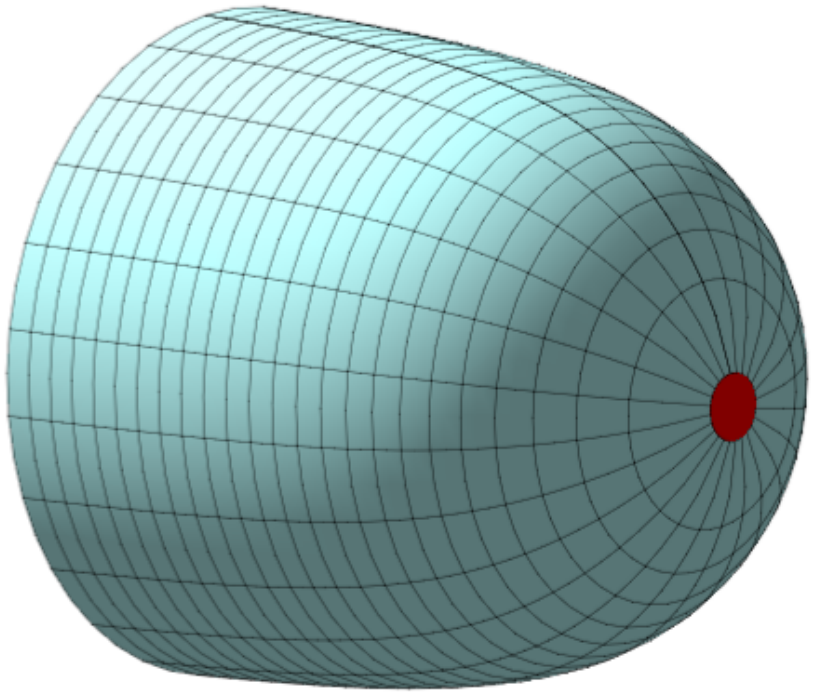
Bubbles of something [Hawking and Turok, 1998, Garriga, 1998, Blanco-Pillado et al., 2012]



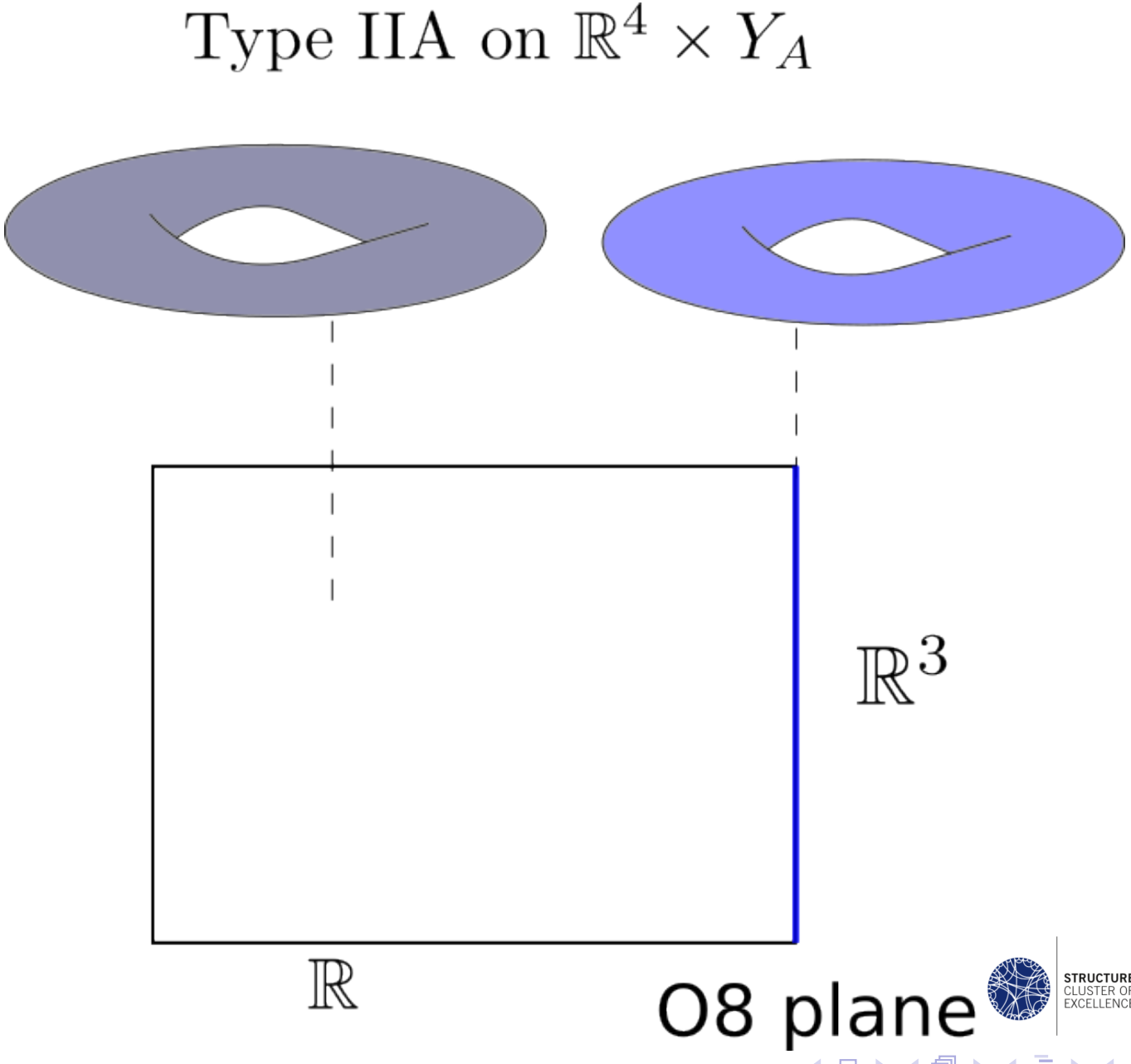
Cobordism conjecture [McNamara and Vafa, 2019]

Conjecture:

$$\Omega_k^{QG} = 0$$



Landscape applications *O8*



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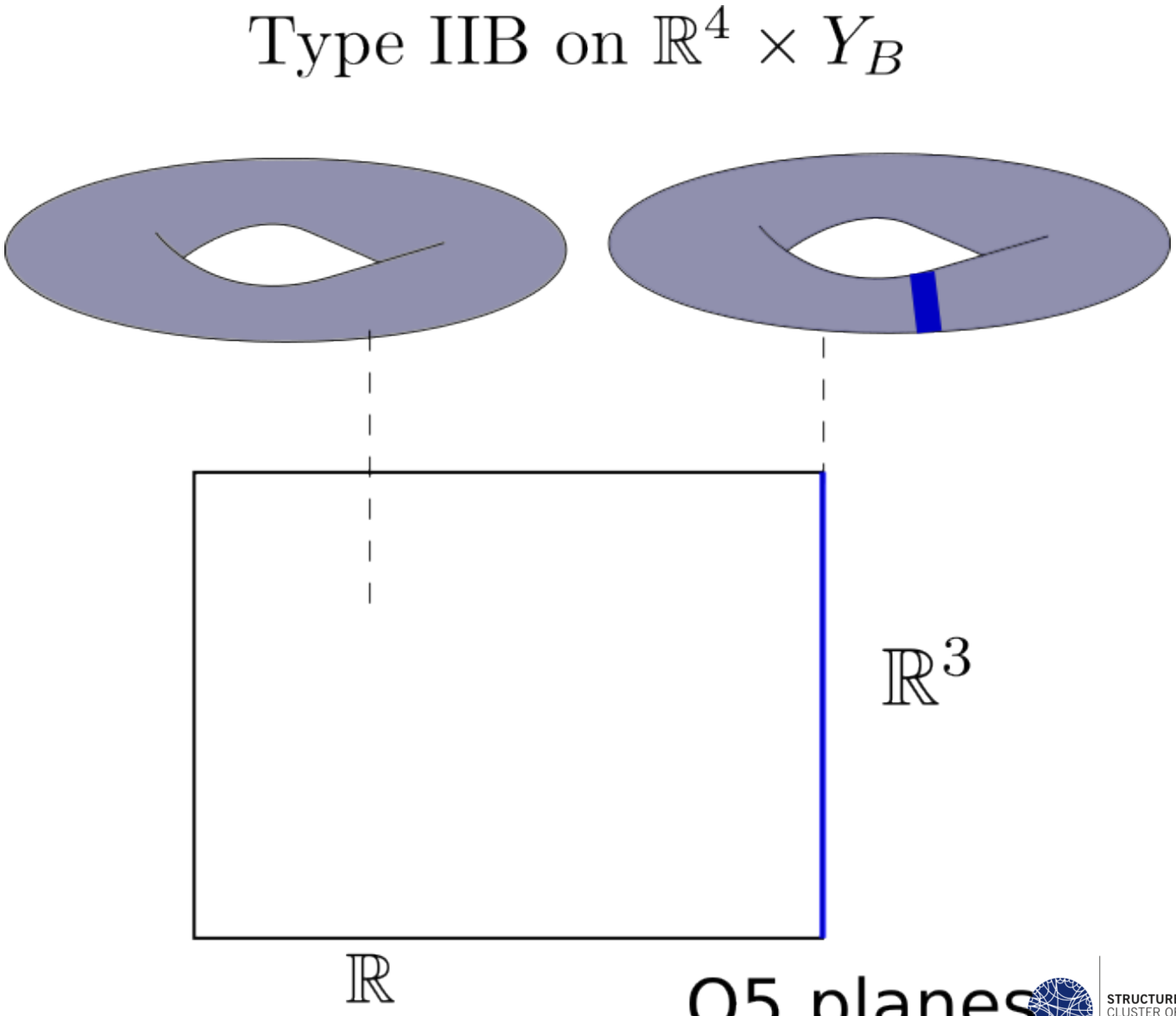
Landscape applications $O5$



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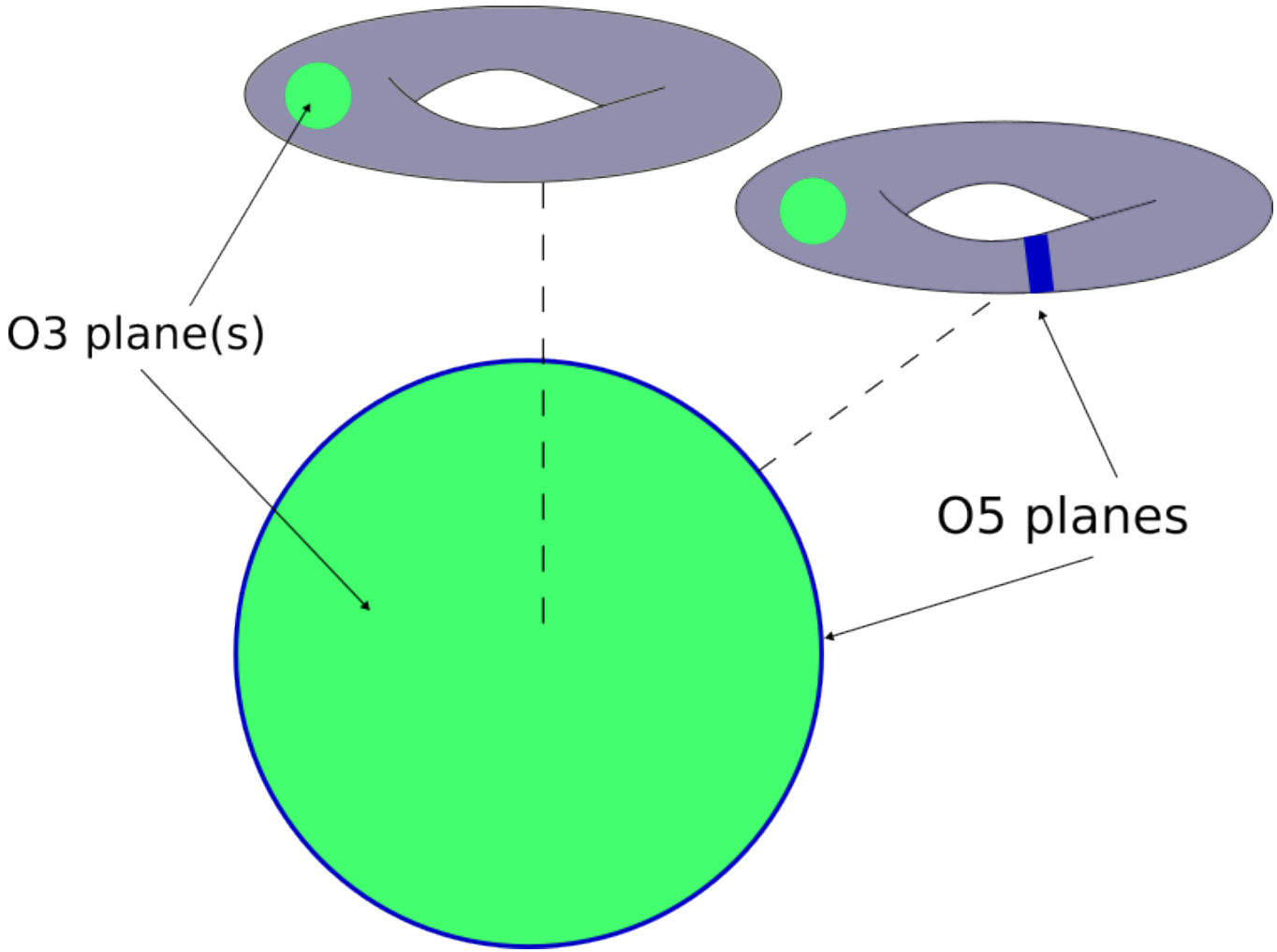
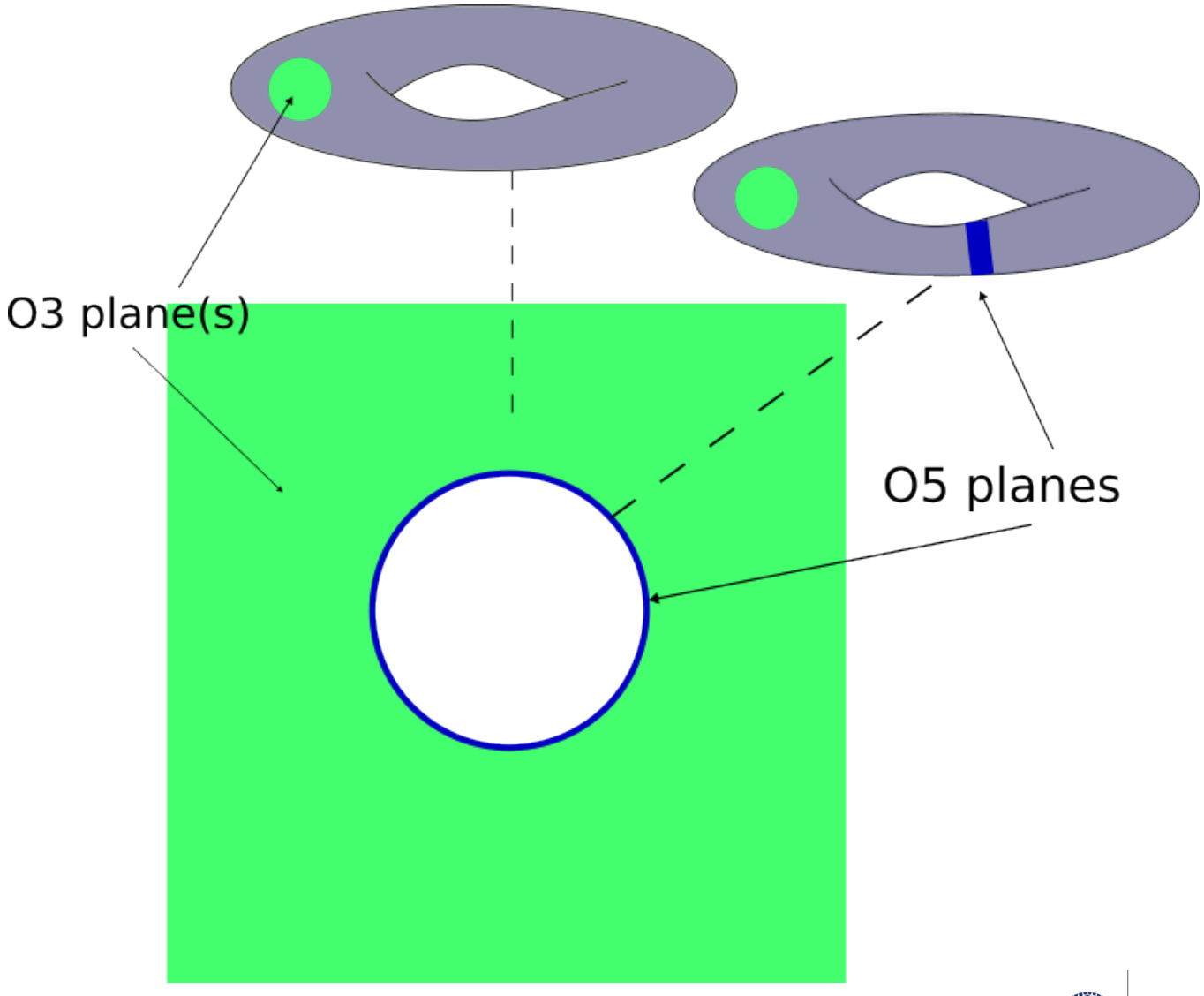
Landscape applications $O5/O3$



Landscape applications $O5/O3$ with bulk SUSY breaking



?

Calculations [Draper et al., 2021b, Draper et al., 2021a]

Action

$$S = \int_{\mathcal{M}} f^3 \left(-\frac{1}{2}\mathcal{R}_4 + \frac{1}{2}\phi'^2 + V(\phi) \right) - \int_{\partial\mathcal{M}} f|^3_{\partial\mathcal{M}} \left(\mathcal{K}_4 - T_4 \right)$$

ϕ: Volume modulus, only dynamical field

Einstein frame metric

$$dr^2 + f(r)^2 d\Omega_3^2$$

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Calculations

Solutions to the equations of motion ($V = 0$)

$$\phi(f) = \phi_0 - \frac{\sqrt{6}}{2}\text{arcsinh}\left(\frac{C}{\sqrt{6}f^2}\right)$$

Tunneling exponent on-shell

$$B = \pm\frac{2\pi^2}{\sqrt{6}}|C|$$

Calculations

Deficit-angle

$$1 - \frac{\theta}{2\pi} = \left.\frac{dR(x)}{dx}\right|_{x=0} = \left(\frac{\sqrt{6}}{32}\right)^{1/2} \frac{R_{KK}^6}{\eta^2} \frac{1}{\sqrt{C}}$$

Critical bubble radius

$$\rho_0 = \frac{R_{KK}}{4\left(1 - \frac{\theta}{2\pi}\right)} \left(\frac{R_{KK}}{\eta}\right)^3$$

Tunneling exponent on-shell

$$B = \frac{\pi^2 M_P^2 R_{KK}^2}{16\left(1 - \frac{\theta}{2\pi}\right)^2} \left(\frac{R_{KK}}{\eta}\right)^4$$

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Conclusions

- Explicit construction of an ETW brane for type IIB CY orientifold compactifications with $O3$ planes
- Expect a bubble of something solution for vacua with (at most) weakly broken SUSY
- Bubbles of nothing may be possible for stronger SUSY breaking in the bulk
- Generically: Expect a bubble of nothing or bubble of something
- Mechanism of effectively computing the decay/nucleation rate

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Thank You!

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