MAX-PLANCK-INSTITUT
FÜR PHYSIK

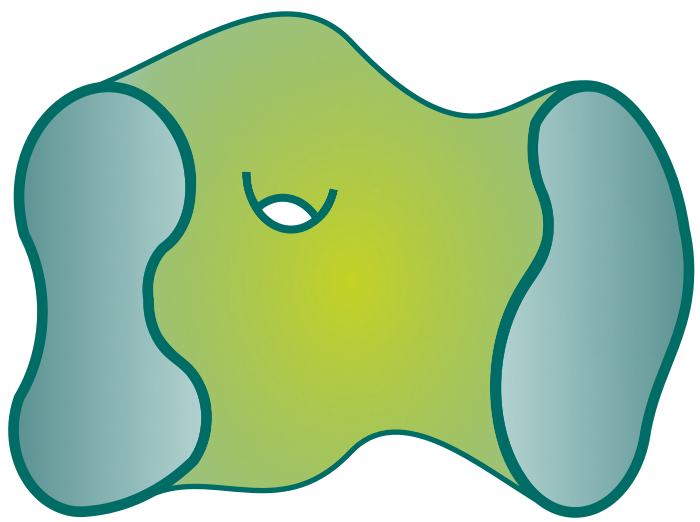
Dynamical Cobordism of a 9d Domain Wall and its companion 7-brane

Based on 2205.09782, with R. Blumenhagen, N. Cribiori, C. Kneißl

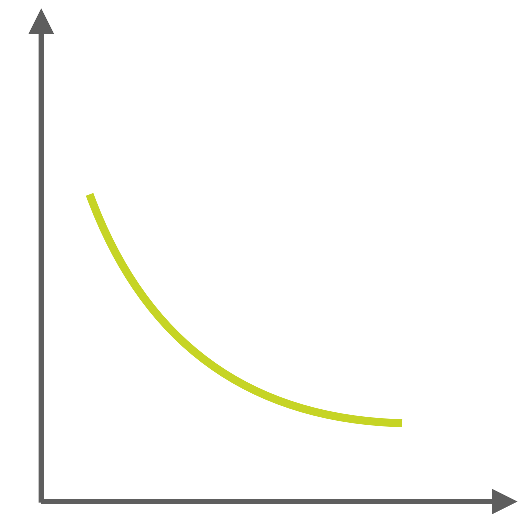
Andriana Makridou

String Phenomenology - Liverpool, 05/07/22

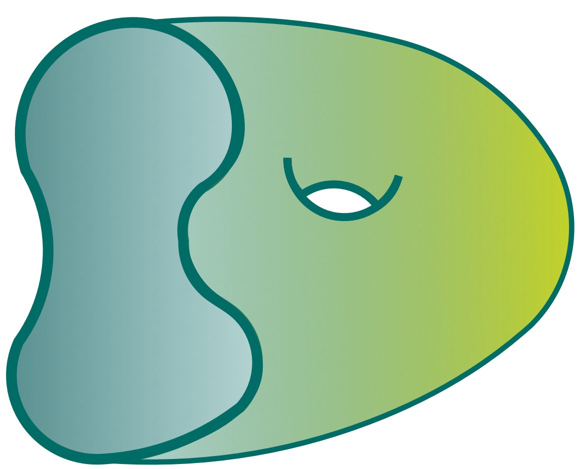
Outline



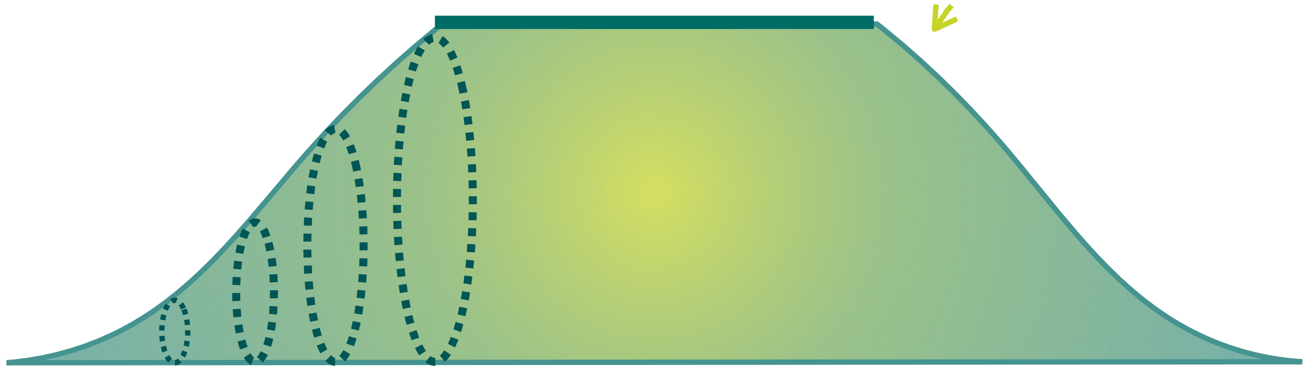
Cobordism



Dynamical Tadpoles

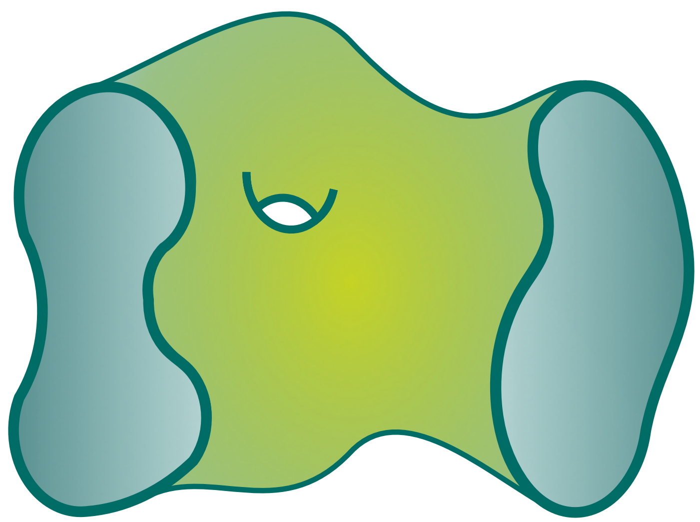


Cobordism Conjecture



9d Domain Wall

Outline



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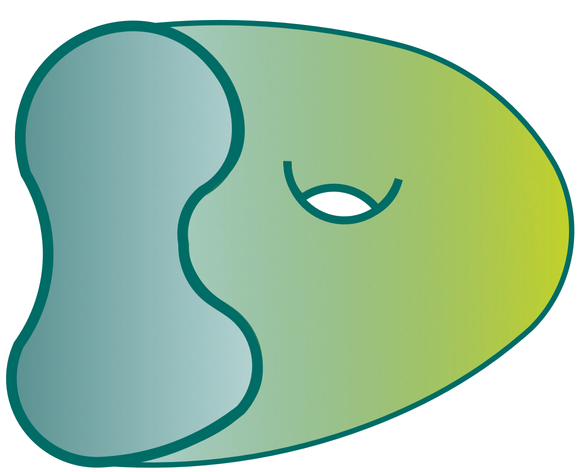

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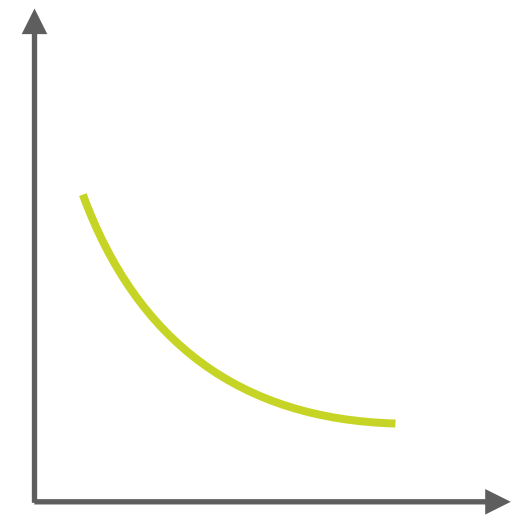

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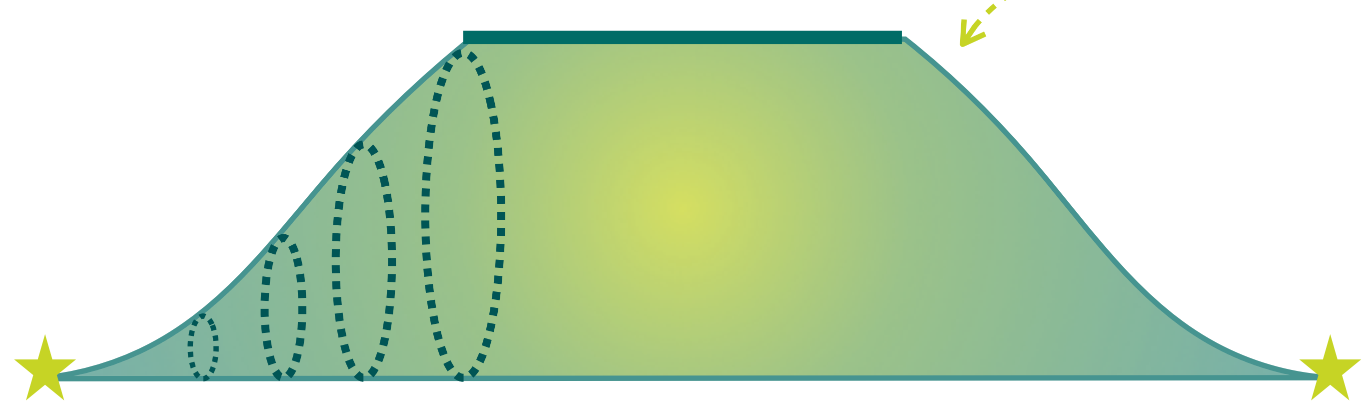
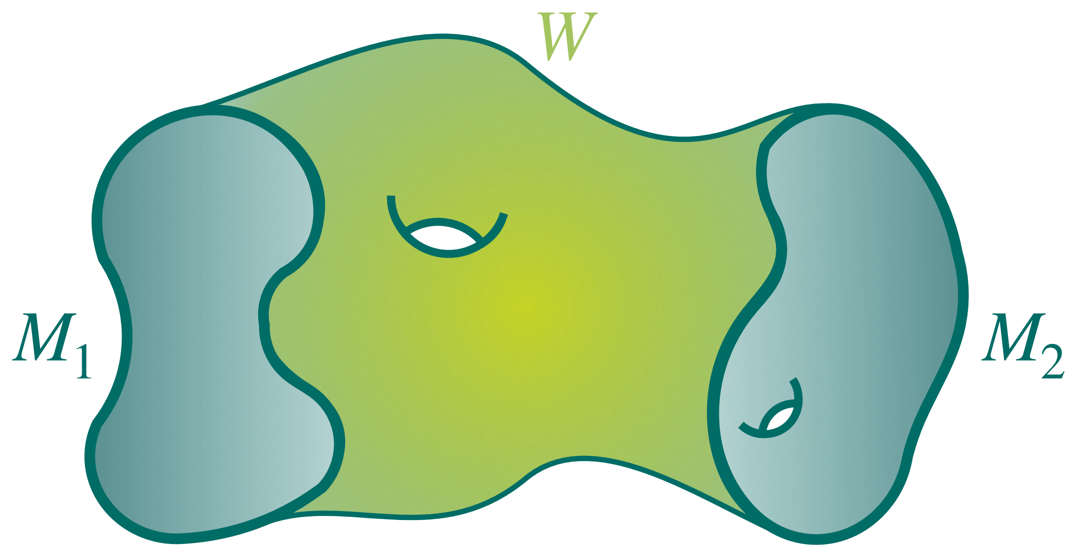


9d Domain Wall
+
7-Brane Defects

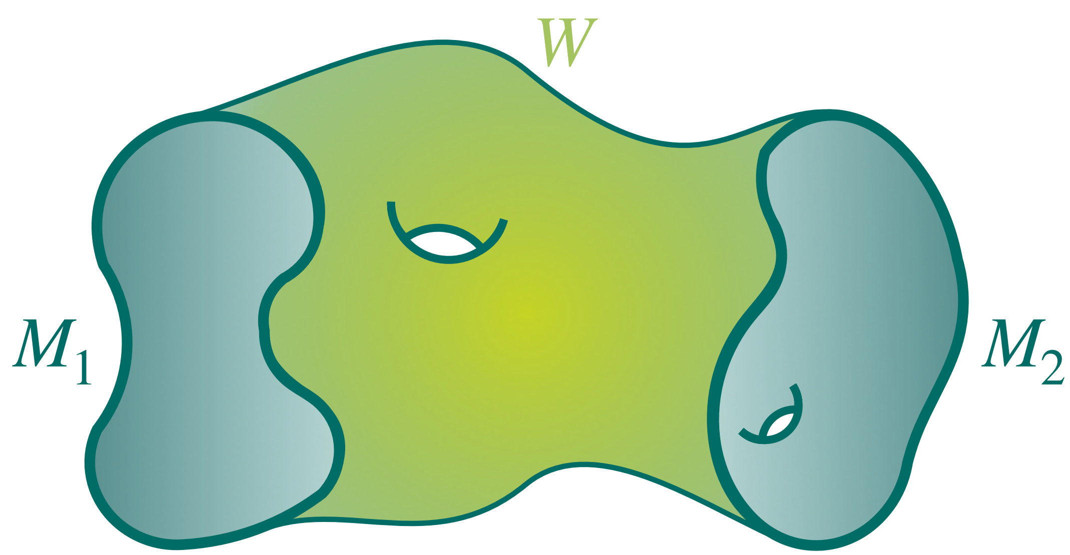
Cobordism



$$M_1 \sim M_2 \Leftrightarrow \exists W \text{ s.t. } \partial \mathrm{W} = \mathrm{M}_1 \sqcup \mathrm{M}_2$$

$$\Omega_k^{QG} = \{\text{compact, closed, k} - \text{dim. backgrounds}\} / \sim$$

Cobordism



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$$\Omega_k^{QG} = \{\text{compact, closed, k} - \text{dim. backgrounds}\}/\sim$$

Compactify down to D=d-k dimensions:

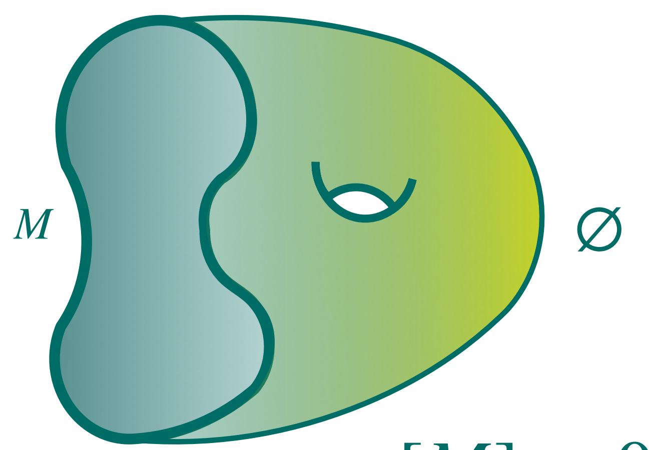
Cobordism Conjecture

[McNamara, Vafa '19]

$$\Omega_k^{\xi} \neq 0 \Leftrightarrow (d-k-1)\text{-dim. global symmetry}$$

with charges labelled by $[M] \in \Omega_k^{QG}$

But: No global symmetries in quantum gravity $\rightarrow$ Cobordism Conjecture
e.g. [Banks, Seiberg '10] [McNamara, Vafa '19]



$[M] = 0$

All Cobordism Classes should be trivial

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

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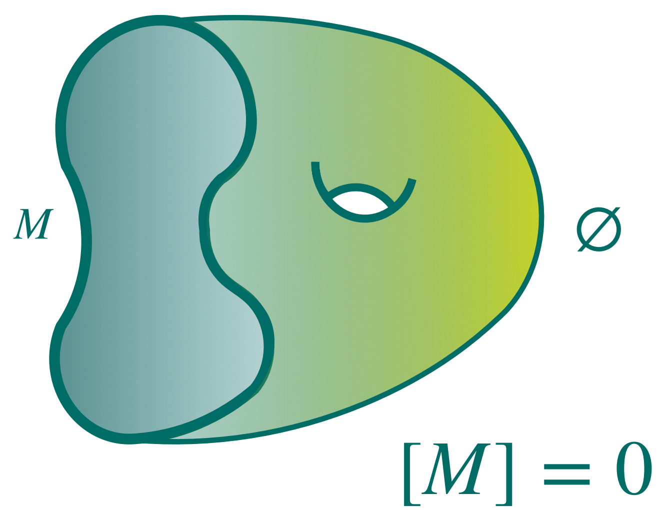

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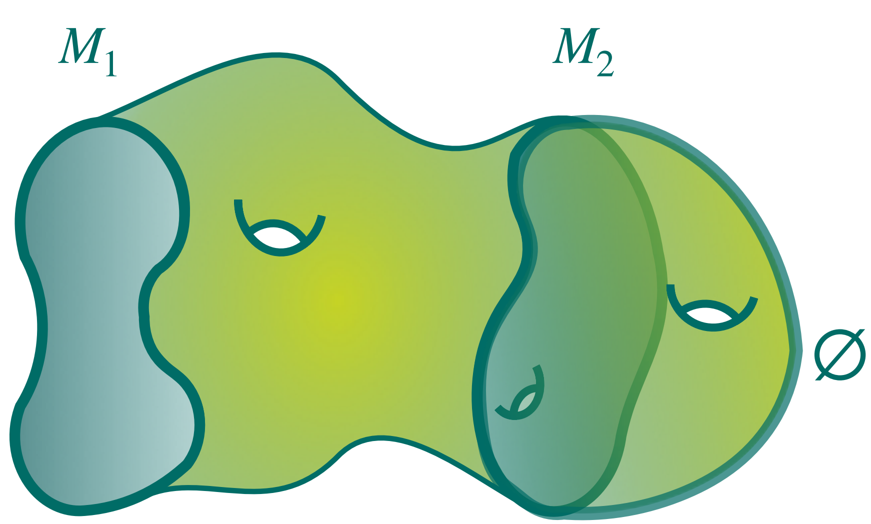

In D=d-k dimensions:

Cobordism Conjecture Consequences

$$\Omega_k^{\widetilde{QG}} \neq 0$$

Breaking

Gauging

$$\Omega_k^{\widetilde{QG}} \to \Omega_k^{\widetilde{QG}+\text{defects}} = 0$$

$$0 = [M] \in \Omega^{\widetilde{QG}} \neq 0$$

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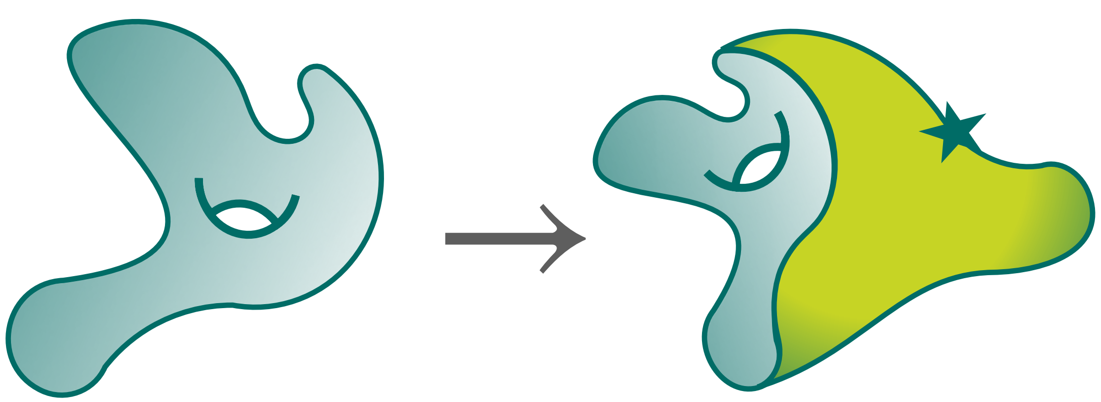
See talks
by Blumenhagen and Kneißl!



$0 \neq [M] \in \Omega_k^{\widetilde{QG}}$

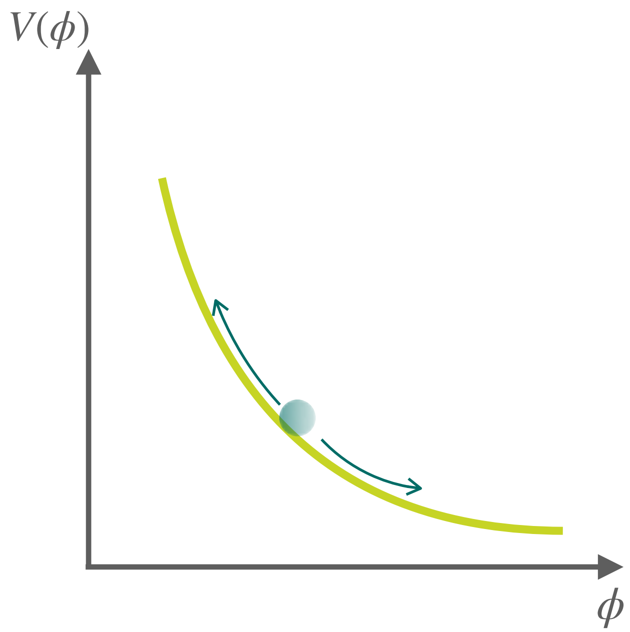
$[M] = 0 = \Omega_k^{\widetilde{QG}+\text{defects}}$

Possibly new defects
detected!

[McNamara, Vafa ’19], [Montero, Vafa ’20]

Tadpoles & Dynamical Cobordism

[Sugimoto '99]
[Antoniadis, Dudas, Sagnotti '99]
[Angelantonj '99]
...
recently : [Raucci '22]



Dynamical tadpoles - No vacuum, running solutions

Naturally occurring in supersymmetry-breaking potentials

Example: Sugimoto Model [Sugimoto '99]

Solution with dynamical compactification to 9d
[Dudas, Mourad '00]

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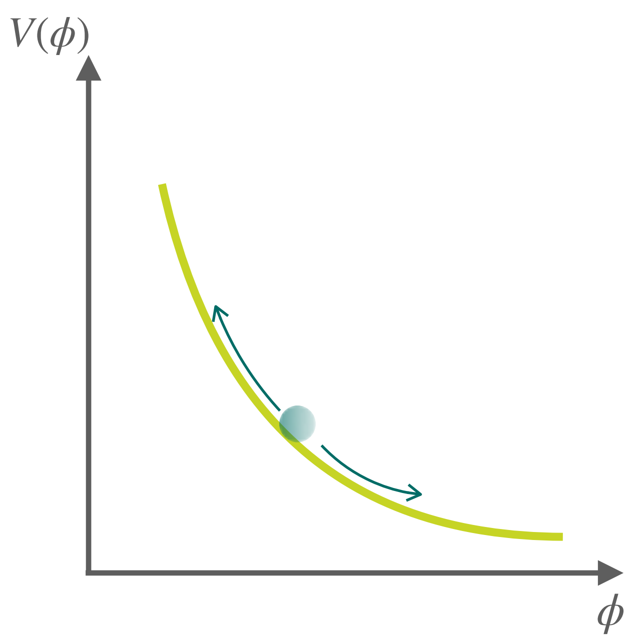

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Reinterpretation in Cobordism Terms

[Buratti, Delgado, Uranga '21]
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[Angius, Calderon-Infante, Delgado, Huertas, Uranga '22]

Solution extends in finite spacetime distance Δ, with $\Delta \sim \mathscr{T}^{-n}$

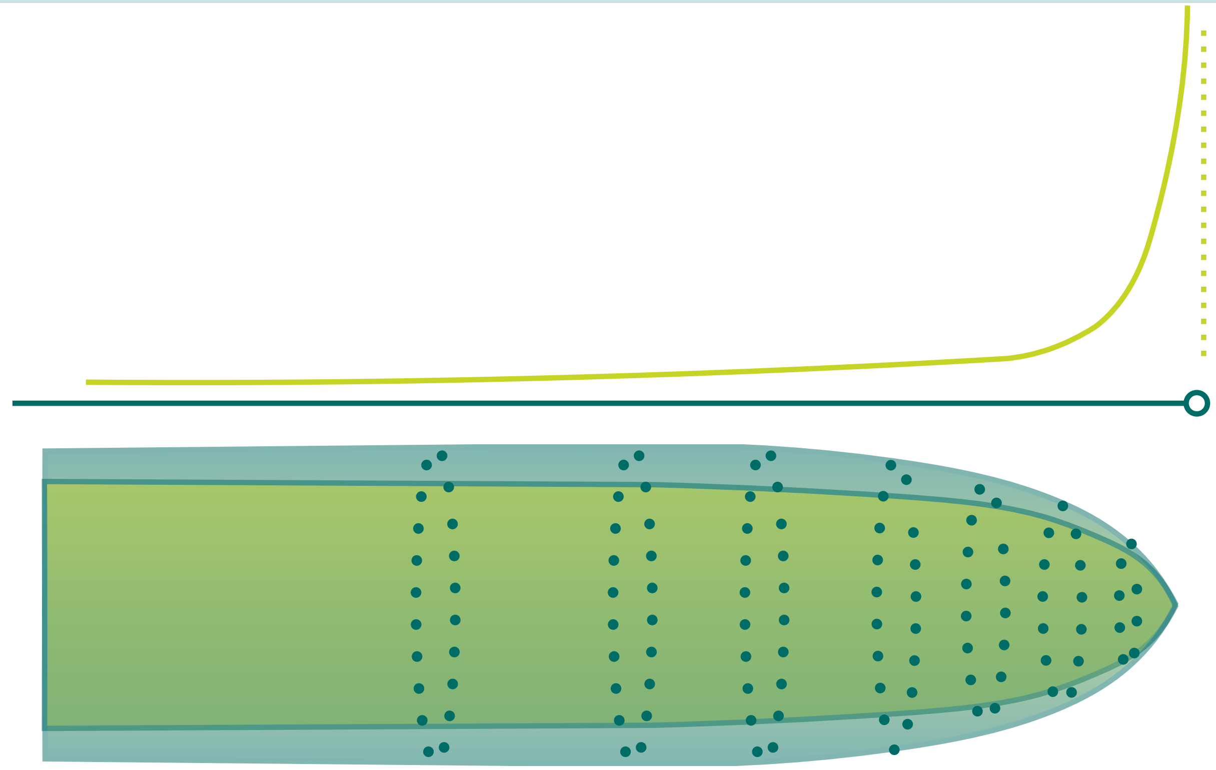
Tadpole strength

Mechanism: "apparent singularity" = cobordism defect.

For field distance $D \to \infty$ at singularity: Wall of Nothing/End-of-the-world brane

Cobordism distance conjecture: $\Delta \sim e^{-\frac{1}{2}\delta D}, \quad |\mathscr{R}| \sim e^{\delta D}$

Tadpoles & Dynamical Cobordism



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9-dimensional Domain Wall

Goal: Backreaction of gauge neutral, non-supersymmetric 9-dimensional object w/ brane-like dilaton coupling

[Blumenhagen, Font '00]

Physical realisation: non-BPS $\tilde{D}8$-brane, non-SUSY stack of $16 \times \bar{D}8 + O8^{++}$

Action: $$S = \frac{1}{2\kappa_{10}^2}\int d^{10}x\sqrt{-G}\left(\mathscr{R} - \frac{1}{2}(\partial\Phi)^2\right) - T\int d^{10}\sqrt{-g}\,e^{\frac{5}{4}\Phi}\delta(r)\,.$$

transverse direction

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Solution Ansatz: $$ds^2 = e^{2\mathscr{A}(r,y)} ds_8^2 + e^{2\mathscr{B}(r,y)}(dr^2 + dy^2)\,.$$

$$\mathscr{A} = A(r) + U(y) \qquad \mathscr{B} = B(r) + V(y) \qquad \Phi = \chi(r) + \psi(y)$$

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$\mathcal{A} = A(r) + U(y)$ $\qquad$ $\mathcal{B} = B(r) + V(y)$ $\qquad$ $\Phi = \chi(r) + \psi(y)$

Solution I

$$A(r) = \frac{1}{8}\log\Big|\sin\big(8K(|r| - \frac{R}{2})\big)\Big|$$

$$\chi(r) = -\frac{3}{2}\log\Big|\tan\big(4K(|r| - \frac{R}{2})\big)\Big| + \phi_0$$

$$\vdots$$

$$\psi(y) = -Ky$$

Solutions $II^{\pm}$

[Blumenhagen, Font '00]

$$A(r) = \frac{1}{8}\log\Big|\sin\big(8K(|r| - \frac{R}{2})\big)\Big|$$

$$\chi(r) = \frac{\alpha^{\pm}}{8}\log\Big|\sin\big(8K(|r| - \frac{R}{2})\big)\Big| \mp \log\Big|\tan\big(4K(|r| - \frac{R}{2})\big)\Big| + \phi_0$$

$$\vdots$$

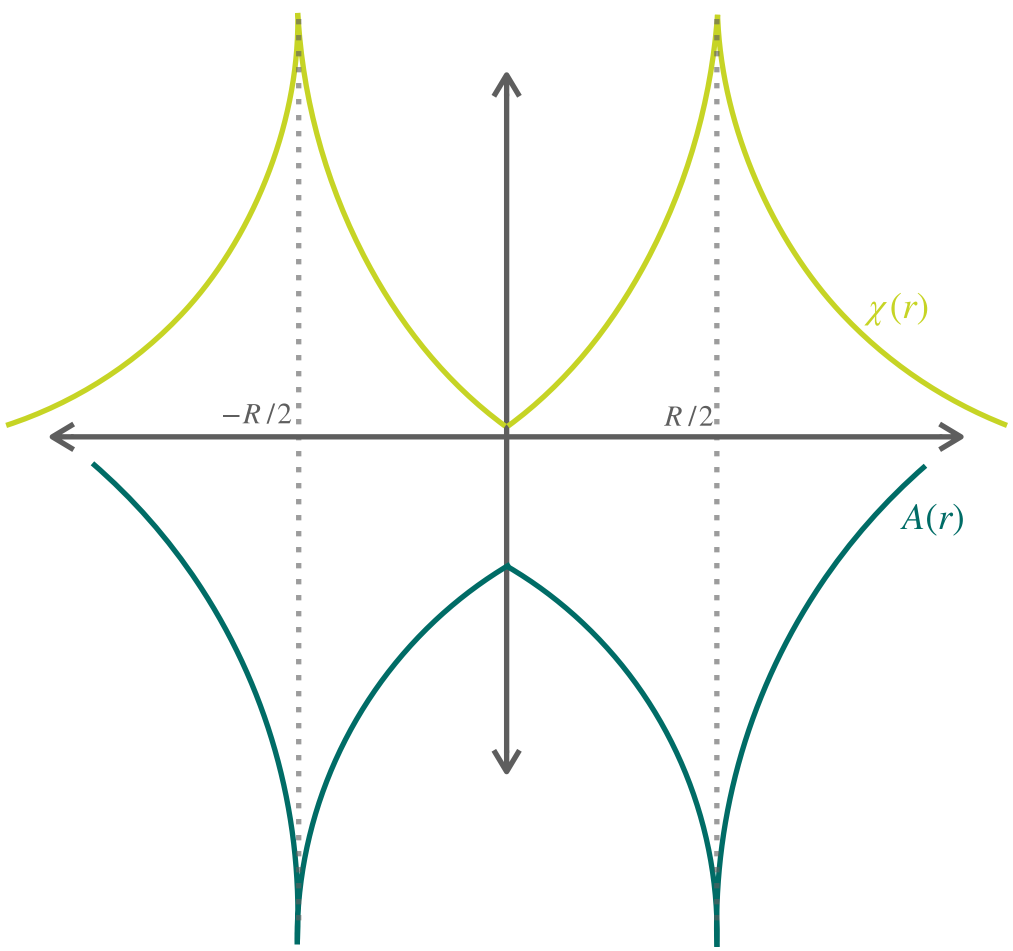
$$U(y) = \frac{1}{8}\log\big(\cosh(8Ky)\big)$$

Qualitative behavior

r-direction spontaneously compactified on S^1 with radius R: $e^{\frac{5}{4}\phi_0} \sim \dfrac{1}{\underset{\kappa_{10}^2 T}{\lambda} R}$

Logarithmic singularities at $r = \pm \dfrac{R}{2}$, string coupling diverges

y-direction: infinite length in sols I, II^-, becomes finite interval in sol II^+



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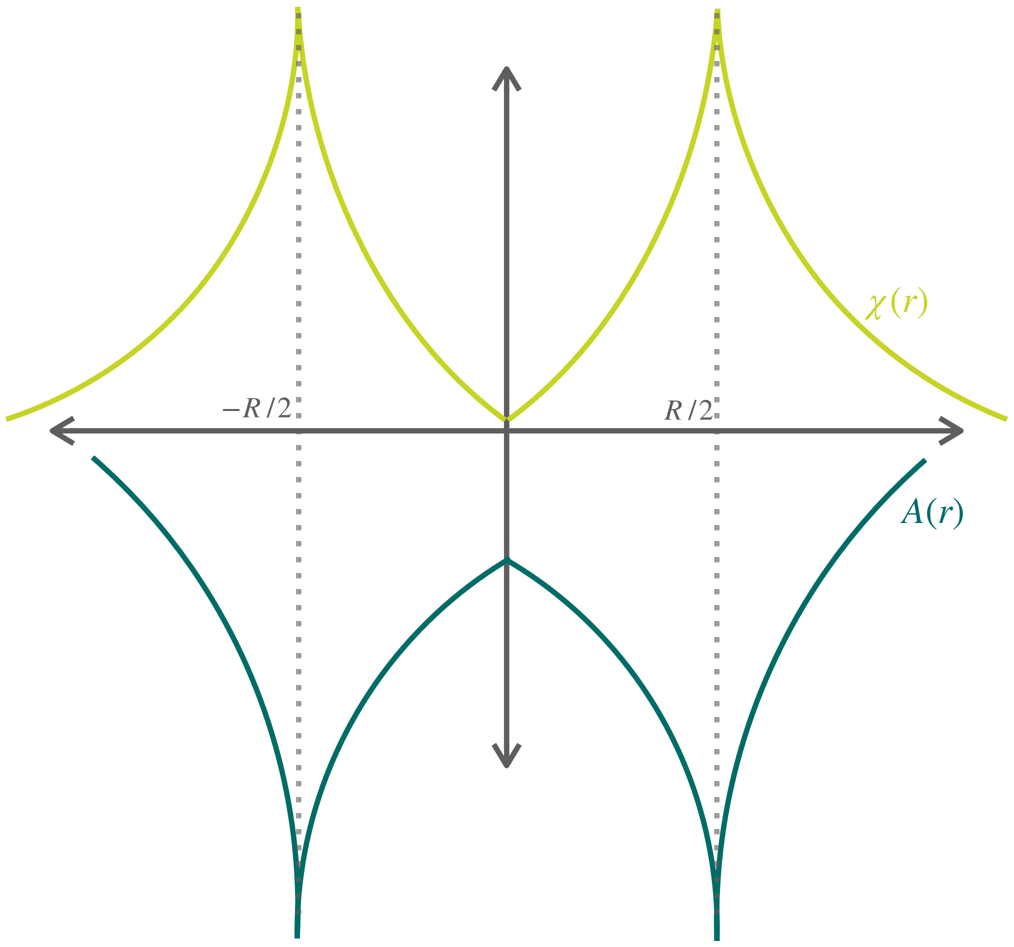

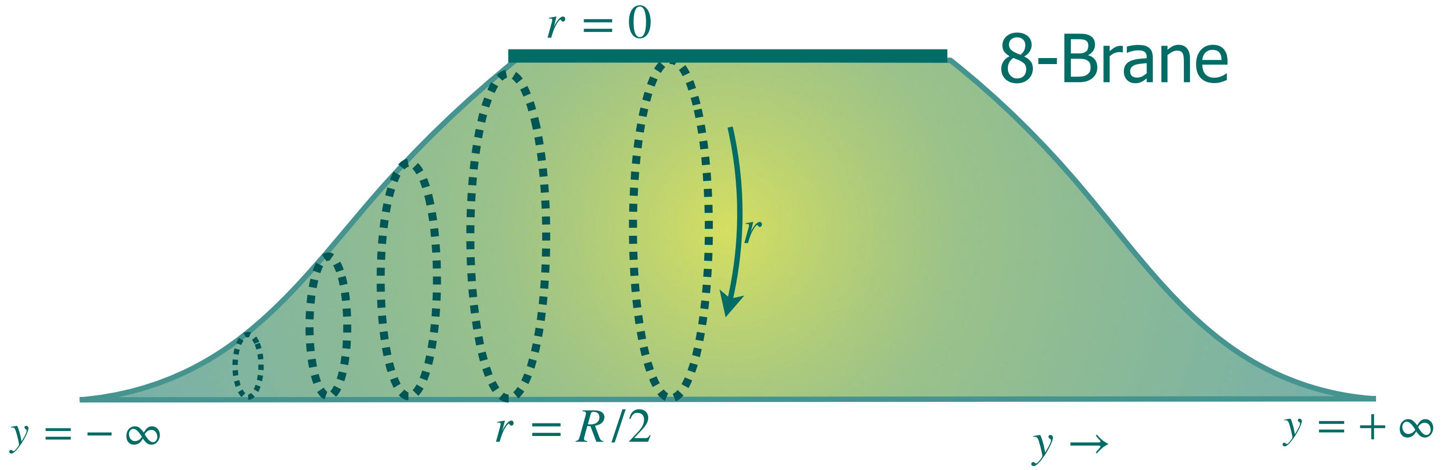

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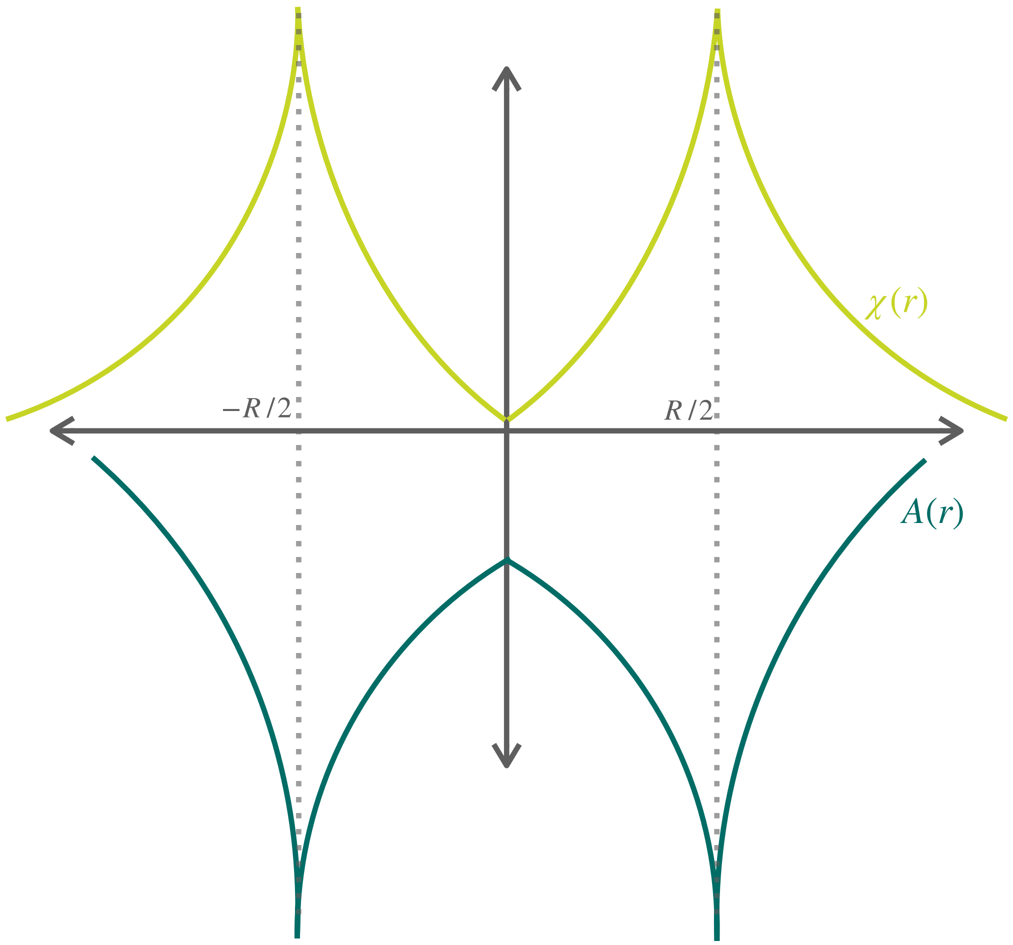

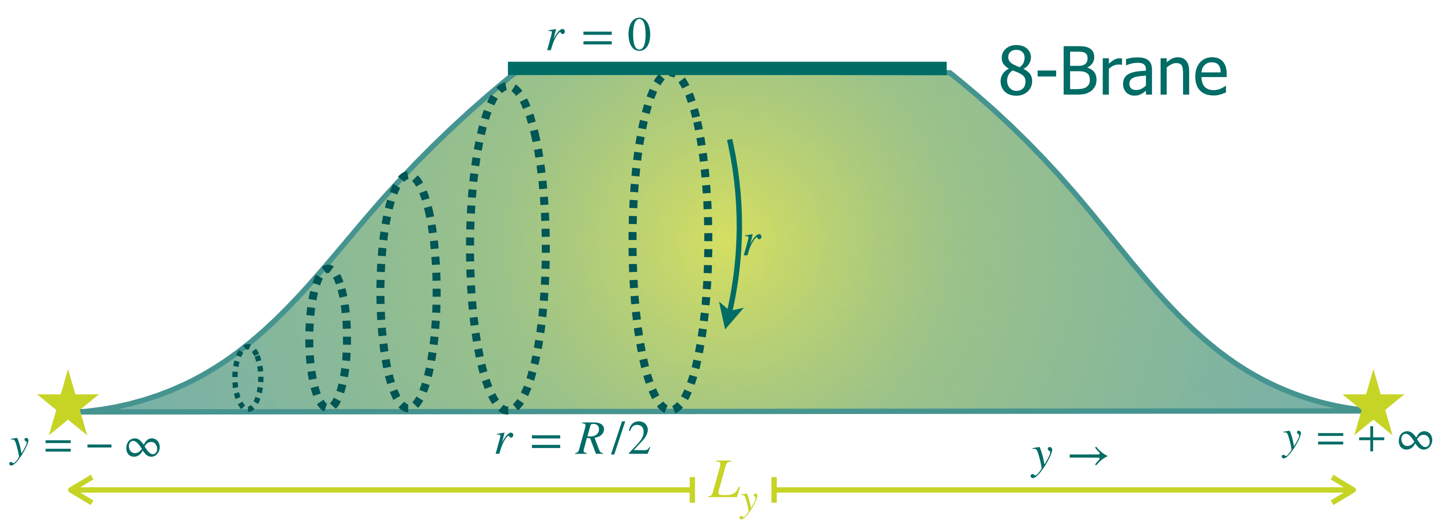

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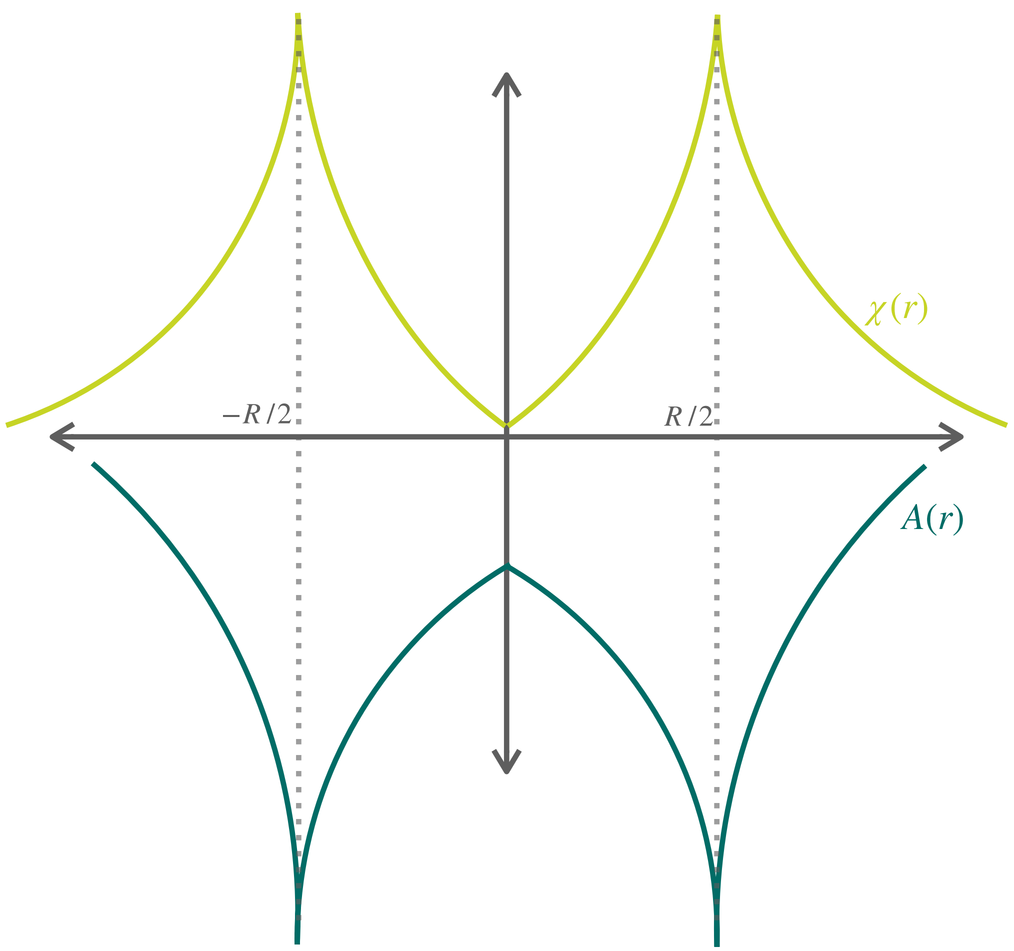

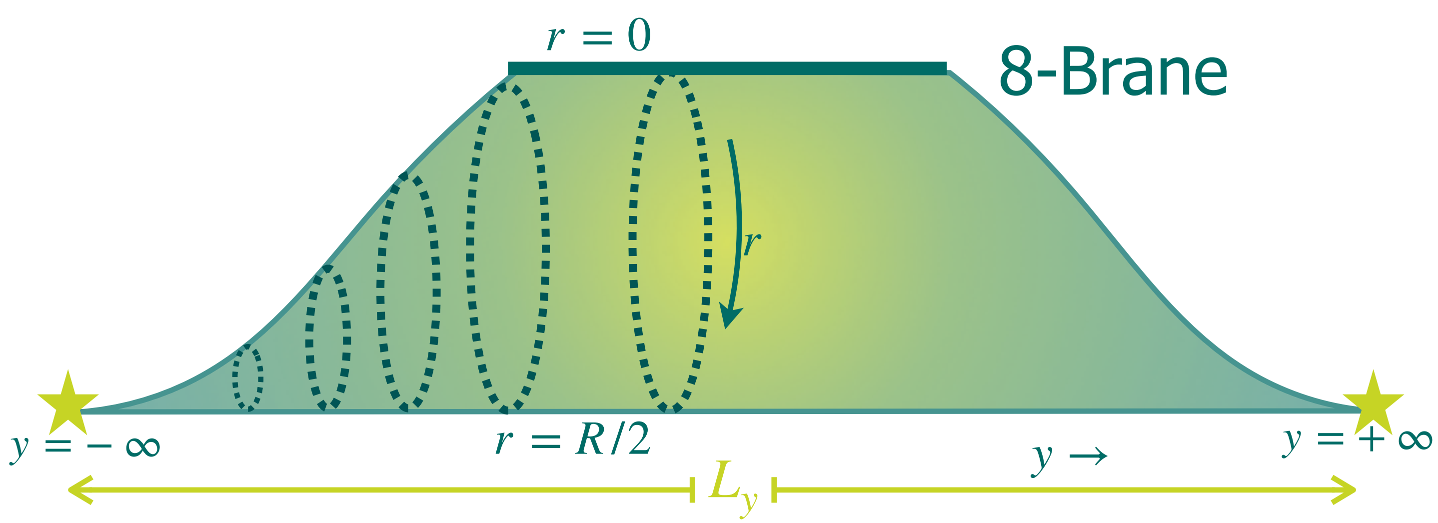

$$\Delta \sim L_y \sim \mathcal{T}^{-1}$$

$$\Delta \sim e^{-\sqrt{2}D}$$

$$|\mathcal{R}| \sim e^{2\sqrt{2}D}$$

ETW Defects

Input: 8-dimensional defect : log-singularity, S^1 direction capped off

Poincaré symmetry along the “brane” preserved

2d transversal rotational symmetry broken

Non-Isotropic Solution Ansatz: $$ds^2 = e^{2\hat{\mathscr{A}}(\rho,\phi)}ds_8^2 + e^{2\hat{\mathscr{B}}(\rho,\phi)}(d\rho^2 + \rho^2 d\phi^2)\,.$$

Separation of variables

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Separation of variables

Solutions: $$\hat{A}(\rho) = \frac{1}{8}\log\left|\cosh\left(8\hat{K}\log(\frac{\rho}{\rho_0})\right)\right| \qquad \hat{B}(\rho) = -\log\left(\frac{\rho}{\rho_0}\right) + \left(\frac{\hat{\alpha}^2}{32} - \frac{7}{2}\right)\hat{A}(\rho)$$

$$\hat{\chi}(\rho) = \hat{\alpha}\hat{A}(\rho)$$

$$\vdots$$

$$\hat{\psi}(\phi) = \frac{\hat{\alpha}}{8}\log\left|\cos(8\hat{K}\phi)\right| \pm 2\log\left|\tan(4\hat{K}\phi + \frac{\pi}{4})\right|$$

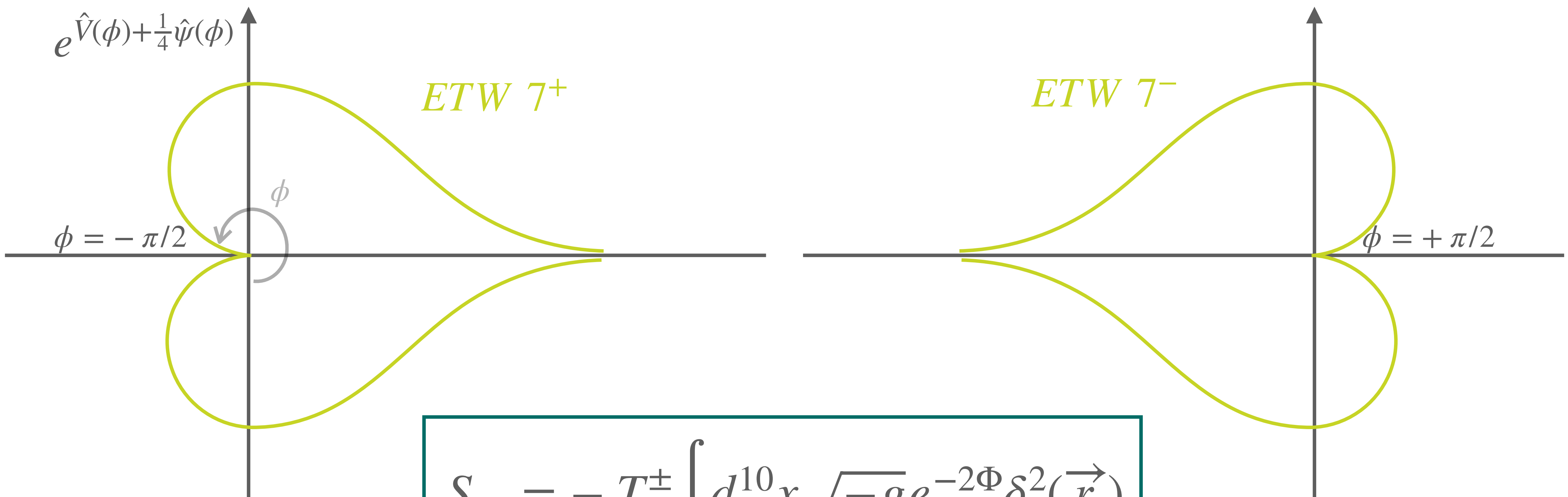
$ETW\ 7^{\pm}$

Qualitative behavior

Logarithmic singularities at $\rho = 0$, string coupling diverges

For appropriate constant ($\hat{\alpha} = \alpha^+$) same scaling as 9d defect

Dynamical Cobordism scaling satisfied: $\Delta \sim e^{-\sqrt{2}D}$, $|\mathcal{R}| \sim e^{2\sqrt{2}D}$



$$\boxed{S_{str} = -T_7^{\pm} \int d^{10}x \sqrt{-g}\, e^{-2\Phi} \delta^2(\vec{r})}$$

with $\kappa_{10}^2 T_7 = 2\pi$

Cobordism Interpretation

Backreaction of 9d Domain Wall

↓

Spontaneous compactification on S^1

↓

$\boxed{\text{Cobordism Group: } \Omega_1^{\xi} \neq 0}$

Cobordism Interpretation

Backreaction of 9d Domain Wall

$\downarrow$

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$\downarrow$

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Solution II^+

Finite L_y, breaking possible

$\downarrow$

Solutions $ETW\ 7^{\pm}$

$\downarrow$

$$\Delta \sim e^{-\sqrt{2}D}$$

$$|\mathscr{R}| \sim e^{2\sqrt{2}D}$$

Spacetime capped off

$\downarrow$

$$\Omega^{\xi + ETW7^{\pm}} = 0$$

Cobordism Interpretation

Backreaction of 9d Domain Wall

$\downarrow$

Spontaneous compactification on S^1

$\downarrow$

$\boxed{\text{Cobordism Group: } \Omega_1^{\xi} \neq 0}$

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Solutions $ETW\ 7^{\pm}$

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$|\mathscr{R}| \sim e^{2\sqrt{2}D}$

Spacetime capped off

$\downarrow$

$\Omega^{\xi+ETW7^{\pm}} = 0$

Solutions I, II^+

Infinite L_y, defects not in EFT, gauging

$\downarrow$

non-BPS $\tilde{D}8$ brane

$\downarrow$

$\xi = \mathrm{Spin} \rightarrow KO^{-1}(pt)$

[Blumenhagen, Cribiori '21]

$\mathbb{Z}_2$ charge cancellation

$\downarrow$

Single $\tilde{D}8$ inconsistent

Summary and Outlook

Concrete example for physical realization of dynamical cobordism:

Explanation of singularities in preexisting solution, expected scalings satisfied,
Eom for defect solved $\rightarrow$ new 7-brane defect

Generalization to higher co-dimension objects
Independent verification of new defect

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Thank you!