Living between two singularities

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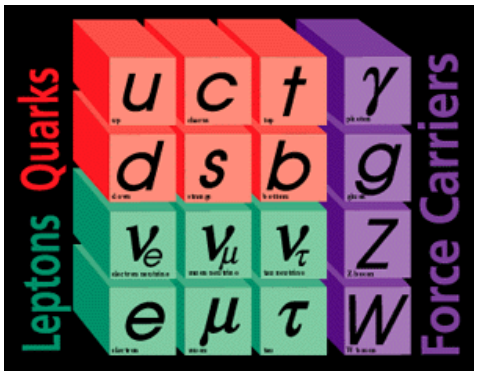
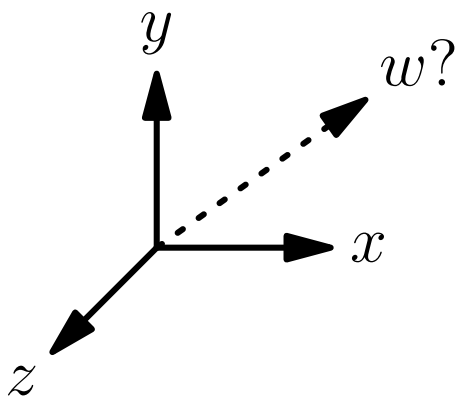
Overview





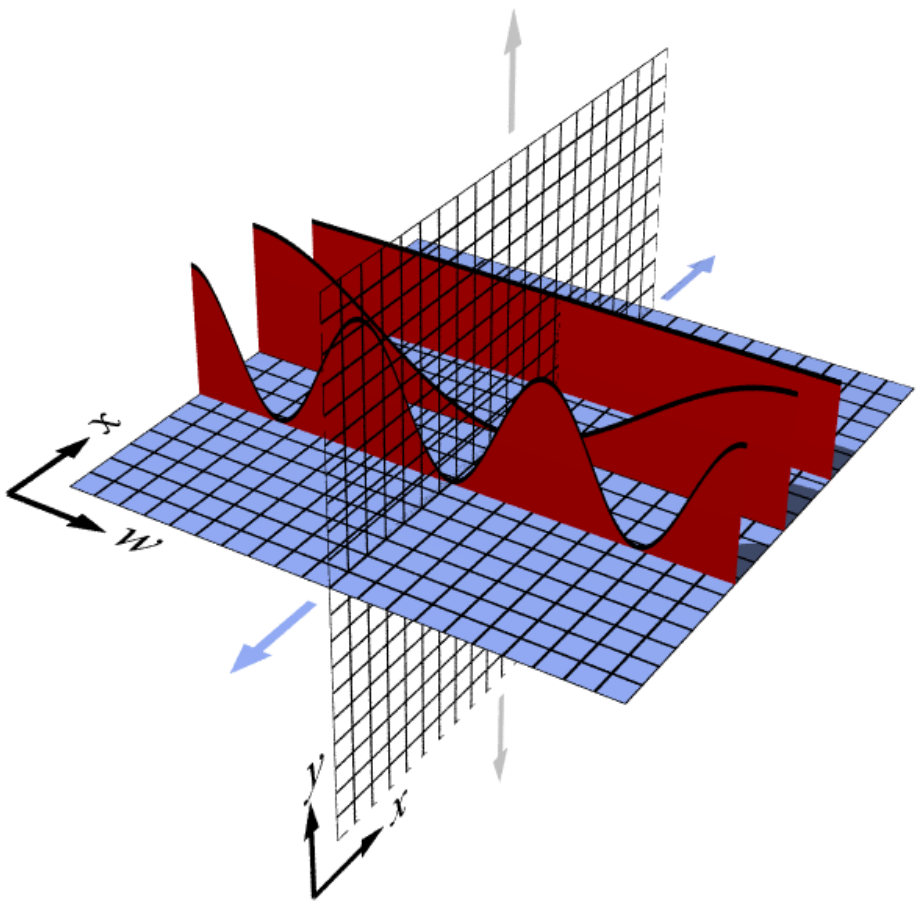
Physics beyond the standard model: *compact* extra dimensions.

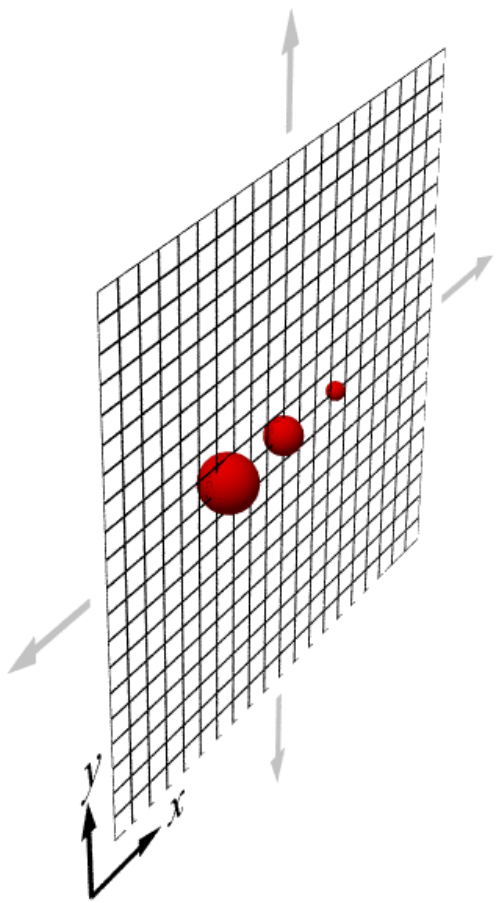
- Constructing extra dimensional models with singularities.
- Why extra dimensions are useful.
- Stabilising the distance between singularities.
- Shielding the singularities.

Extra dimensions

w is extra space dimension, integrate it out to get 4D theory.

$$\int \left(\right) dw =$$

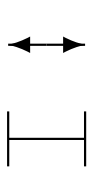
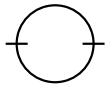




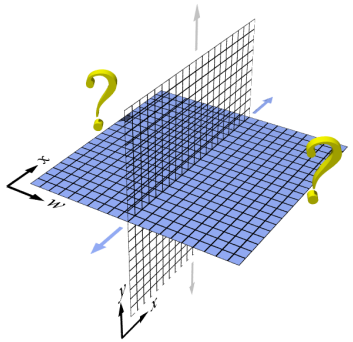
Separation of variables: $\Psi(x^\mu, w) = f(w)\psi(x^\mu) \rightarrow$ Kaluza-Klein modes.

Edge of the extra dimension

Need a way to "end" the extra dimension:

 infinite  periodic

 branes (hard walls)



Edge of the extra dimension

Need a way to "end" the extra dimension:

- $\longleftrightarrow$ infinite
- ◯ periodic
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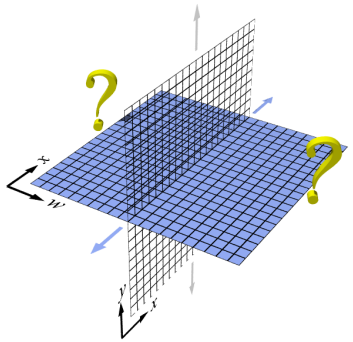
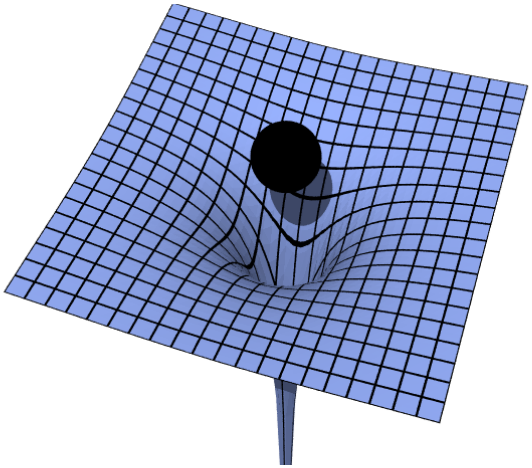


Or: a singularity.



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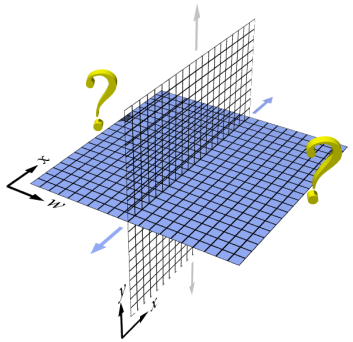

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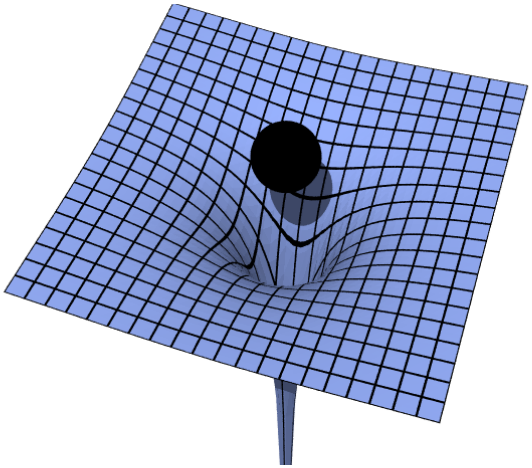
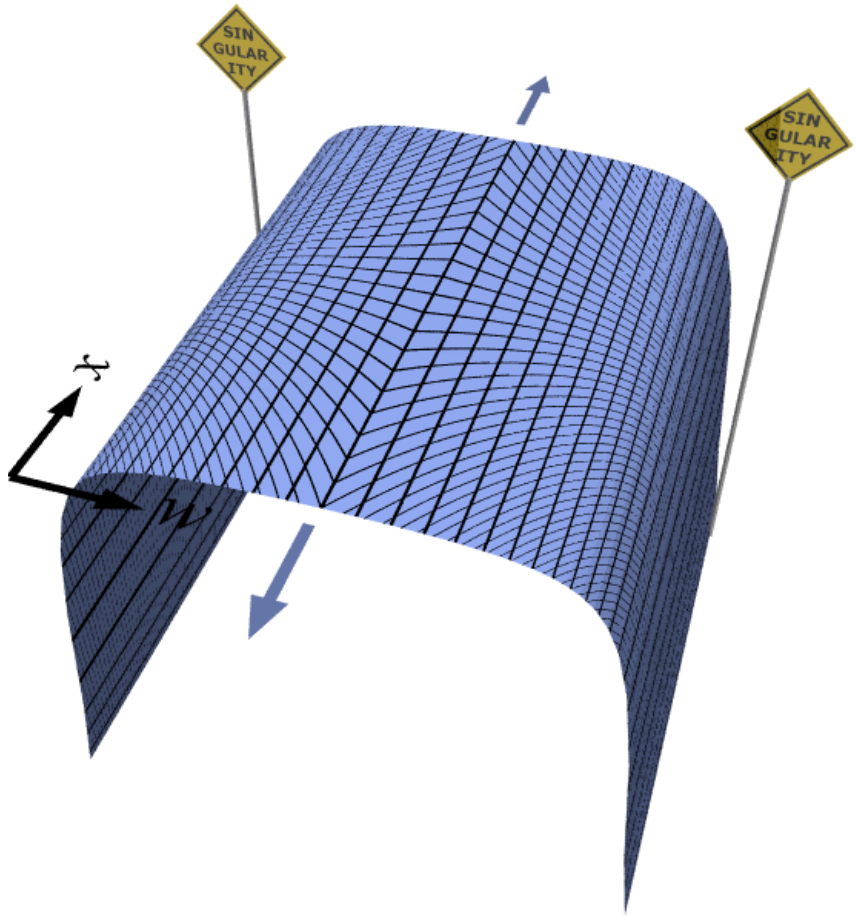


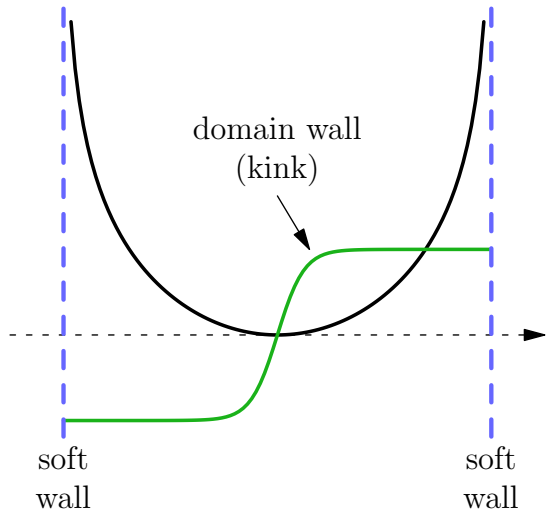


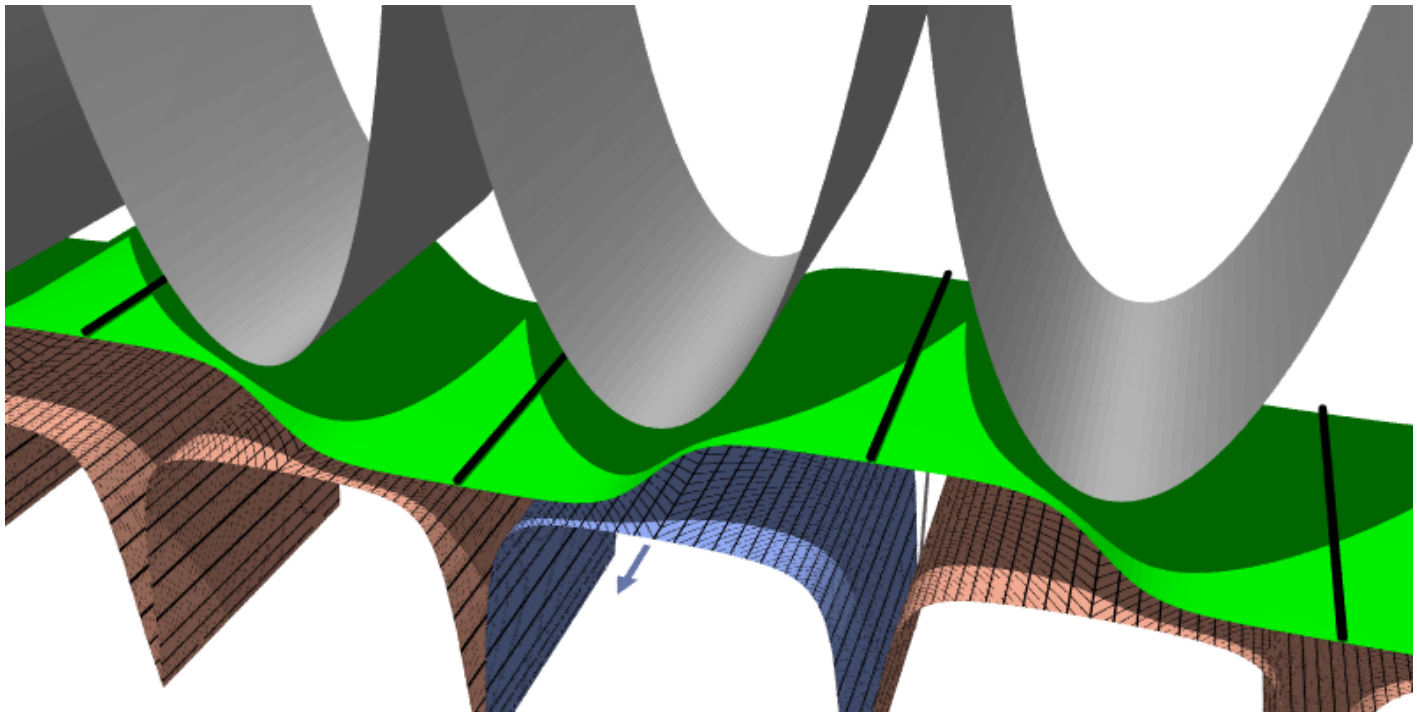
$$ds^2 = e^{-2\sigma(w)}\eta_{\mu\nu}dx^\mu dx^\nu + dw^2.$$

- R, σ diverge at edge.
- Line of singularity: soft wall.

Soft walls

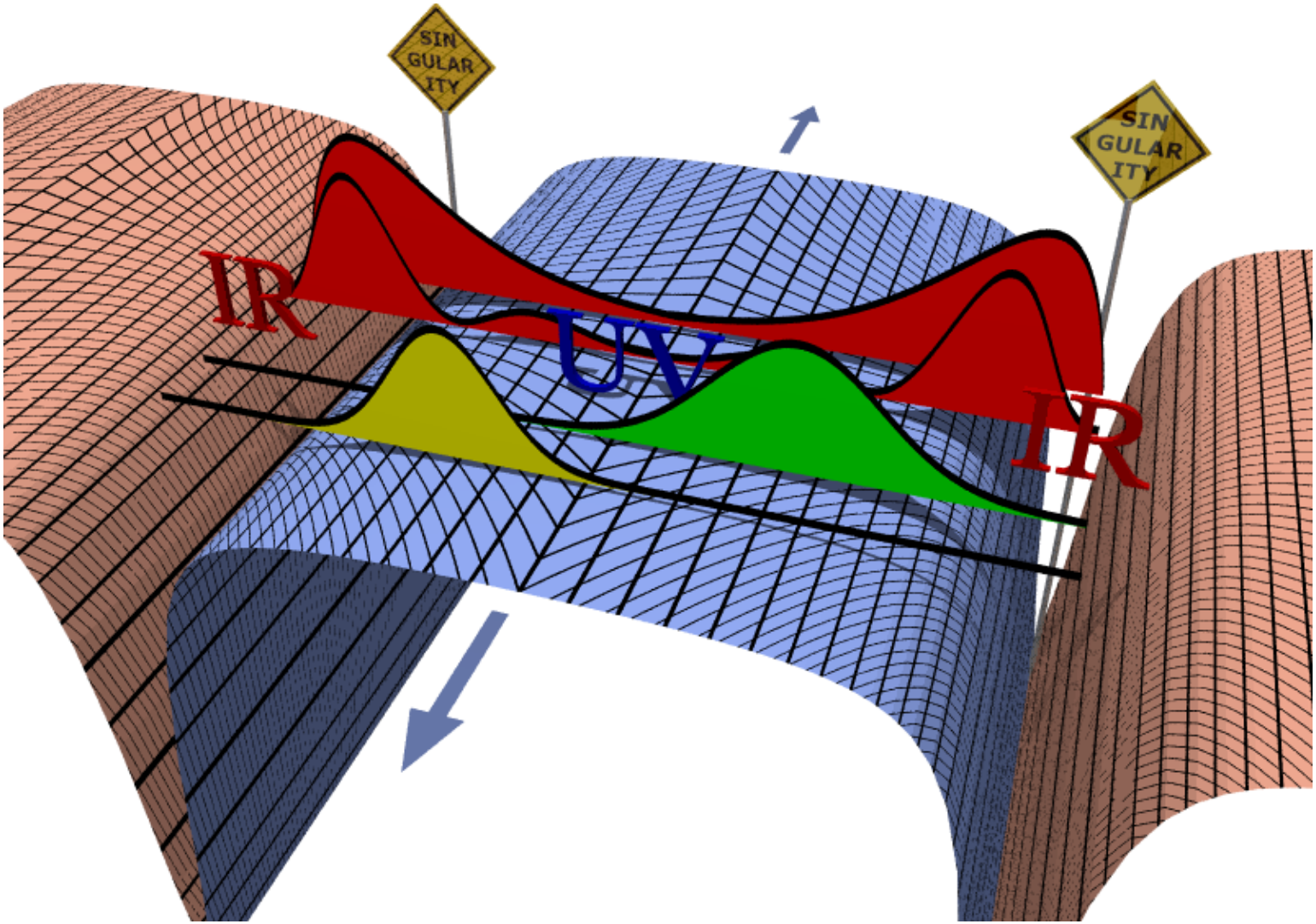
- Line of singularity supported two scalar fields: dilaton and kink.
- Space is repeated.
- Integrated energy density is zero (cosmological constant is zero).
- Can escape from singularity.





Use of extra dimensions

- Electroweak hierarchy: $M_{\text{Planck}} \xrightarrow{\text{redshift}} M_{EW}$.
- Mass hierarchy and couplings set by overlap integrals.



Stabilising the extra dimension

Electroweak scale (and other things) set by size of extra dimension.

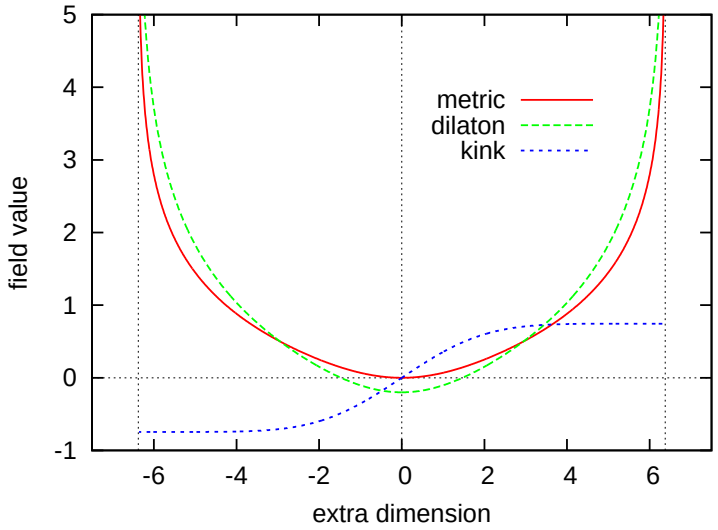
$\longrightarrow$ stabilise distance between singularities.

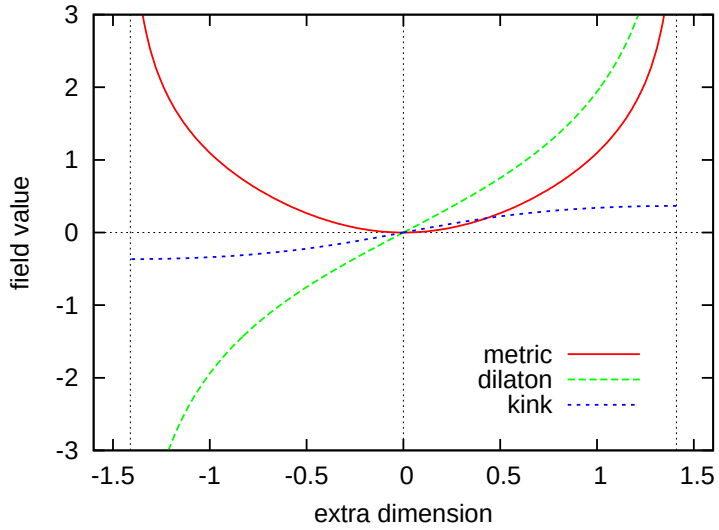
Odd kink and even dilaton:

- massless 4D particle (zero mode/moduli field),
- exciting this particle changes size of extra dimension!

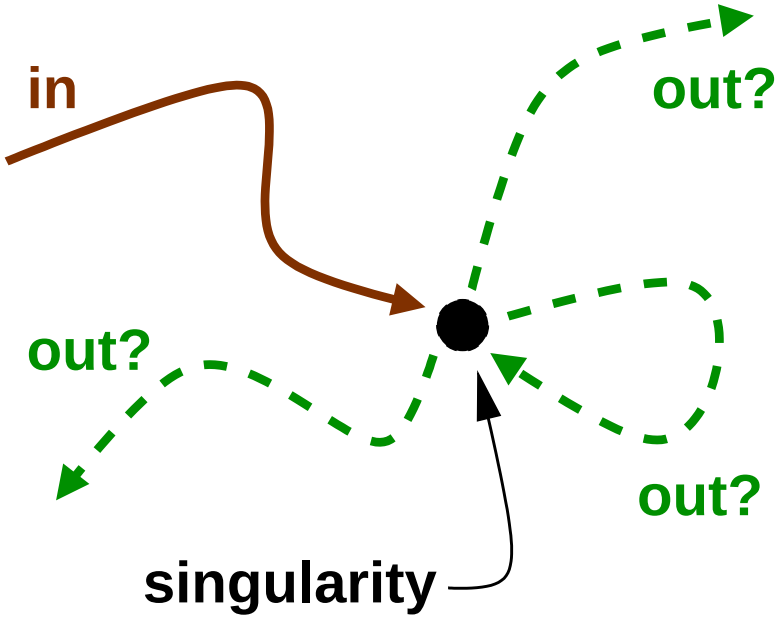
Odd kink and odd dilaton:

- parity banishes the massless 4D particle,
- distance between singularities stabilised.





Shielding the singularity

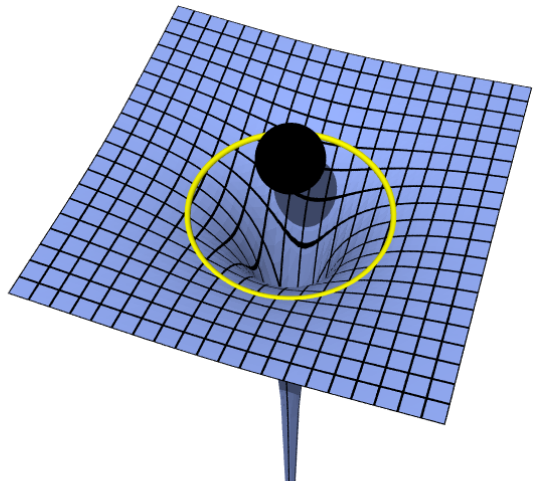


Geodesics end at singularity.

Can go in *and* come out.

Quantum gravity unknown
$\longrightarrow$ unable to predict what comes out,
$\longrightarrow$ must shield singularities.

Try to create a
black-hole-like horizon.

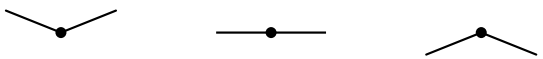


Shielding the singularity

Line of horizon shields line of singularity:

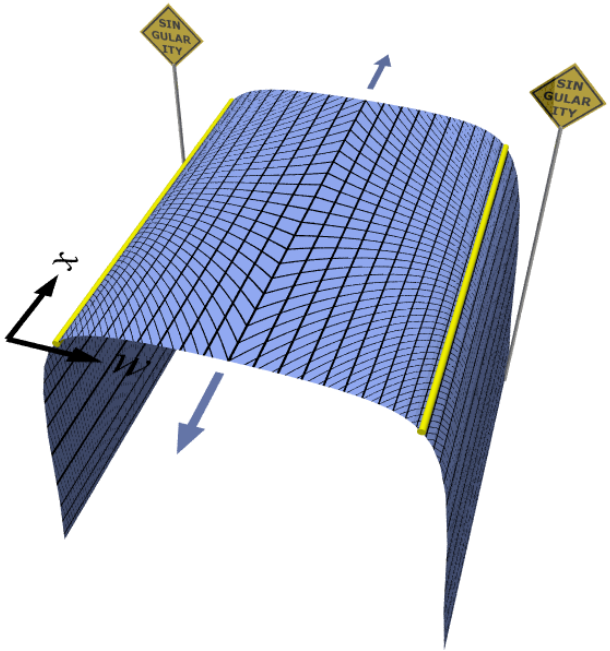
$$ds^2 = e^{2\sigma(w)}\left[-h(w)dt^2 + d\vec{x}^2\right] + h(w)^{-1}dw^2$$

$$h'(0^+) = \tfrac{1}{2}(1+w)\rho_{\text{brane}}$$

Sign of $h'(0^+)$: 

Want $h'(0^+) < 0$

$\rightarrow$ need ghost matter on brane at origin!



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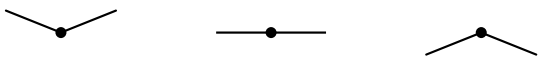
Sign of $h'(0^+)$: 

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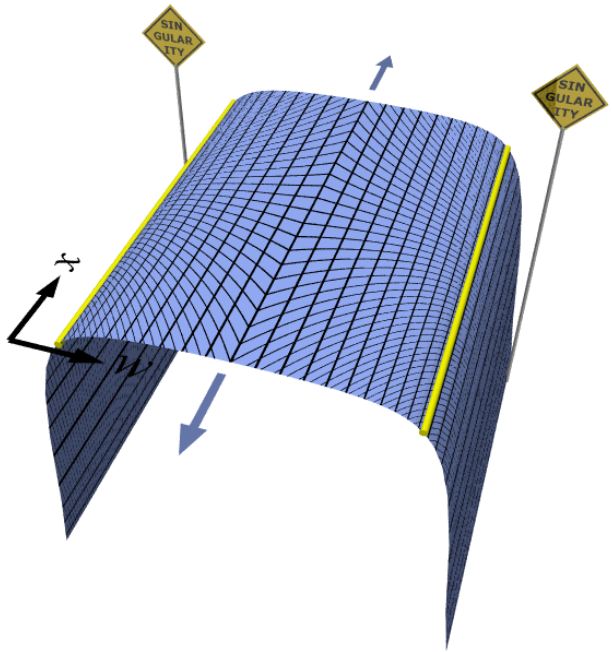
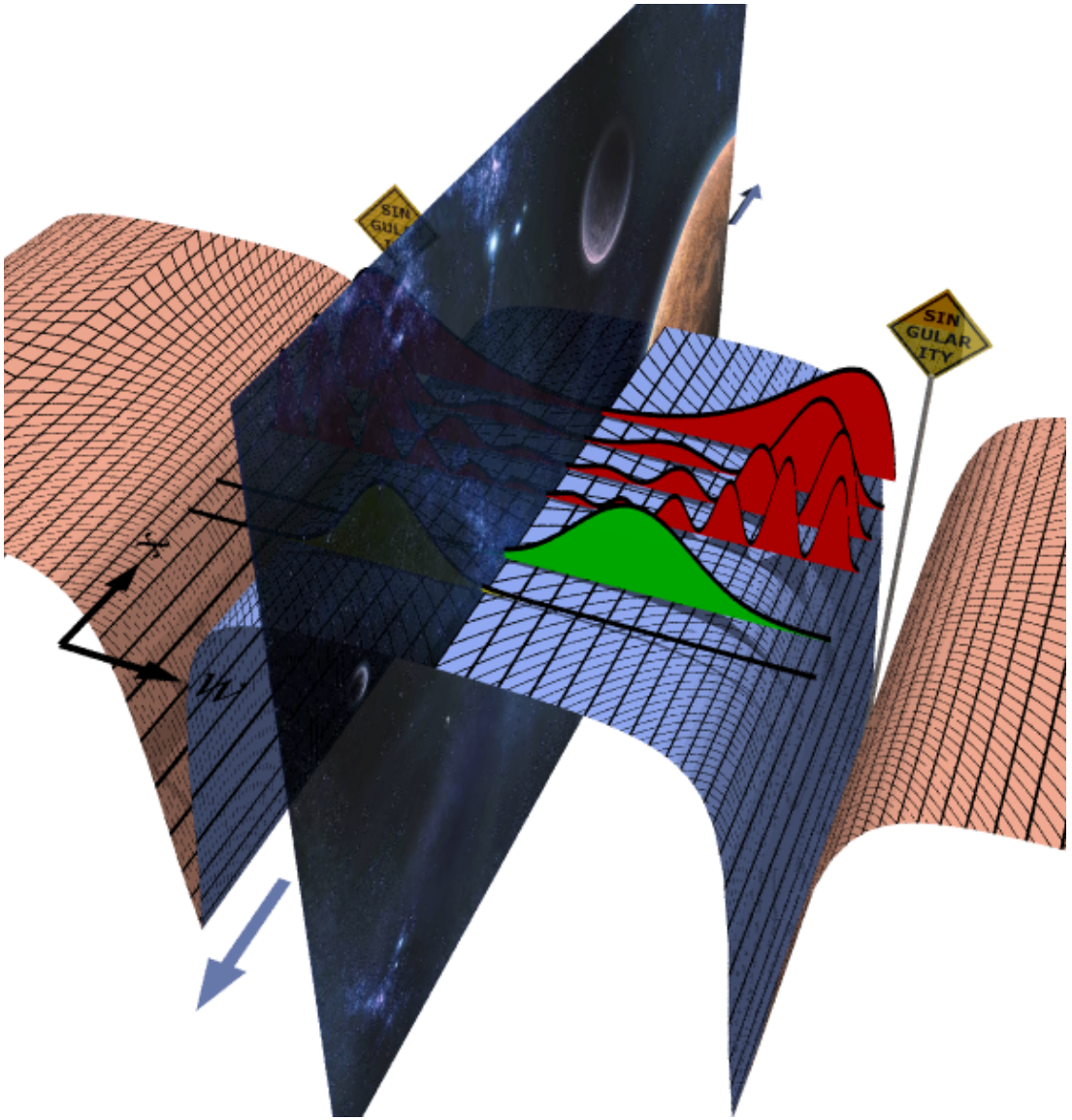


Plan B: place singularities "infinitely" far away:

- Finite physical distance w_*.
- Infinite time for particles to reach singularity: $t = \int_0^{w_*} e^{\sigma(w)}\, dw$.
- Puts tighter constraints on parameters of the model.
- Can still solve the hierarchy problem.

Conclusions



- Integrate out the extra dimension: 5D $\longrightarrow$ 4D.
- Singularities at edges.
- Supported by scalar fields.
- Solve EW hierarchy problem.
- Stabilise by parity.
- Shield by placing them "infinitely" far away.

References

Randall-Sundrum warped metric:

- Randall & Sundrum, PRL 83, 3370 (1999)

Original soft-wall motivation (AdS/QCD and linear Regge trajectories):

- Karch, Katz, Son & Stephanov, PRD 74, 015005 (2006)

Continued work on soft-wall models:

- Batell & Gherghetta, PRD 78, 026002 (2008)
- Falkowski & Perez-Victoria, JHEP 12, 107 (2008)
- Batell, Gherghetta & Sword, PRD 78, 116011 (2008)
- Cabrer, von Gersdorff & Quiros, arXiv:0907.5361
- Aybat & Santiago, PRD 80, 035005 (2009)
- Aybat & DPG, JHEP 09, 010 (2010)