Higher dimensional membrane world models

Putting the standard model on a brane

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Theoretical Particle Physics

Introduction

Brane world history:

- Rubakov and Shaposhnikov, 1983: left handed massless fermions can be trapped.
- Dvali and Shifman, 1997: trap gauge fields by breaking the gauge symmetry on the brane.
- Randall and Sundrum, 1999: extra dimensions can be infinite and gravity still 4D.

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We present a 5D model which reduces to 4D standard model and general relativity.

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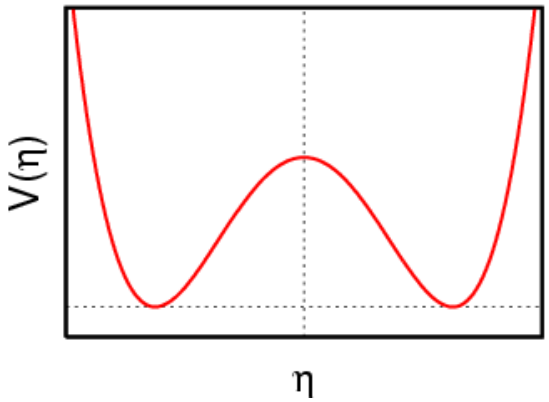

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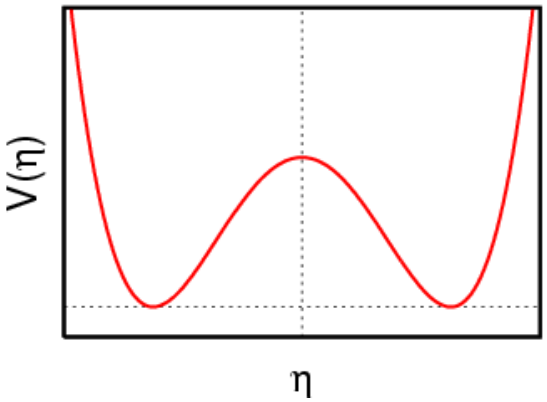

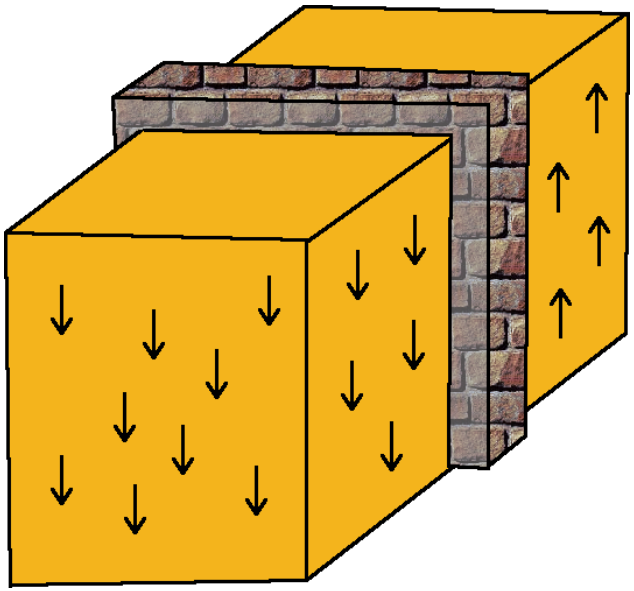

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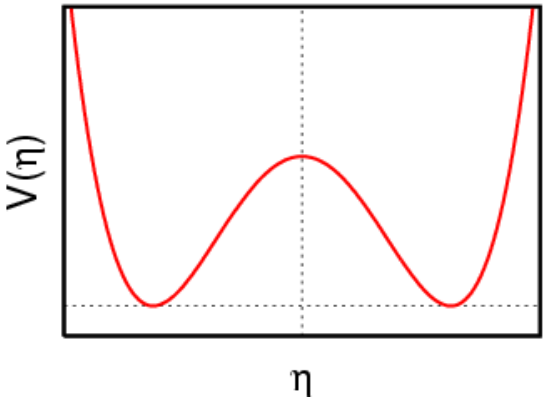

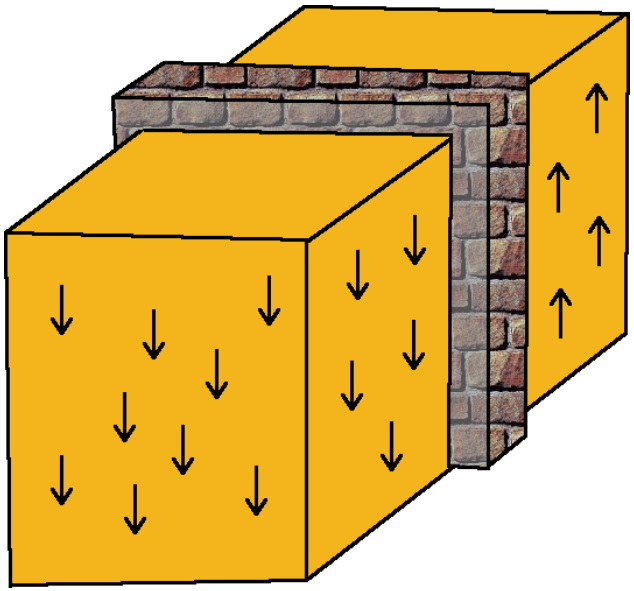

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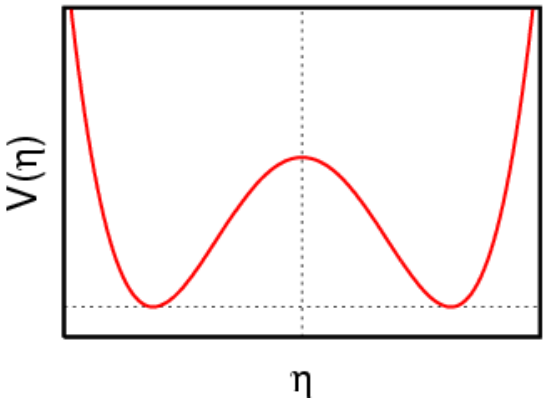

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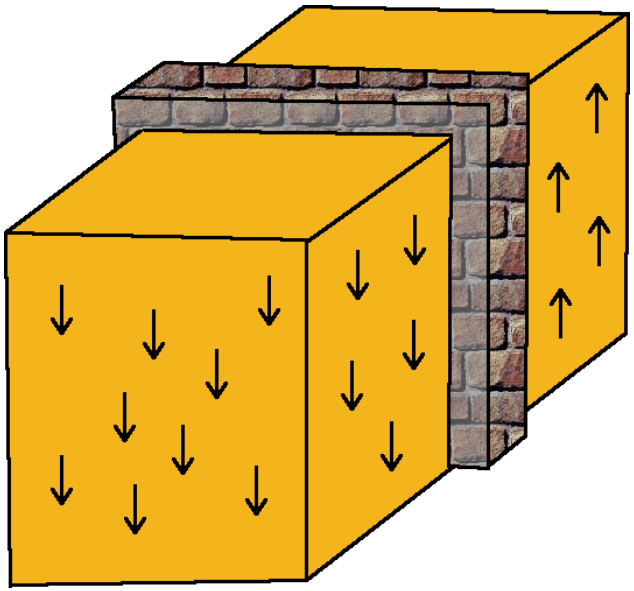

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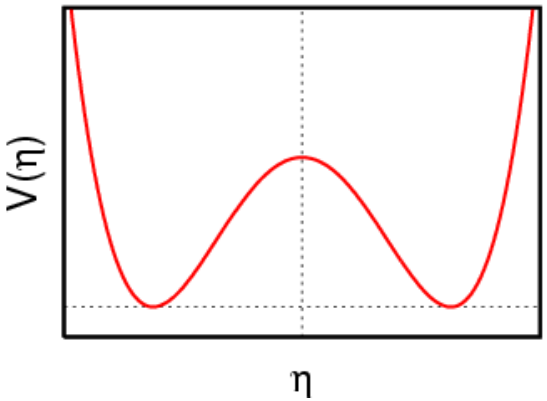

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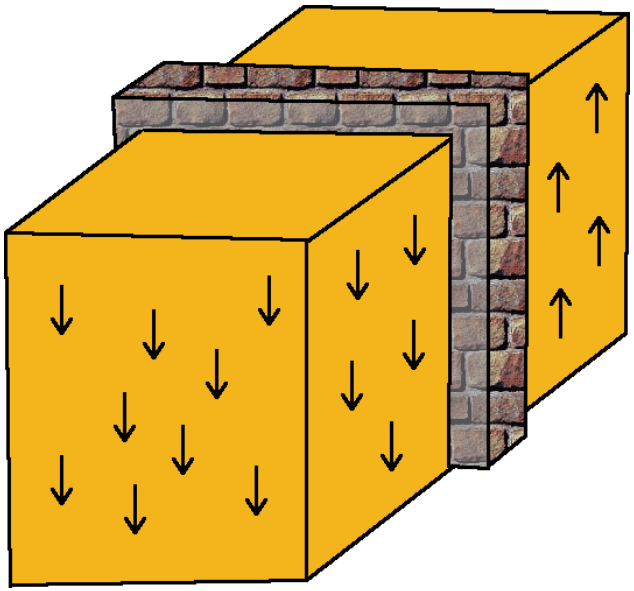

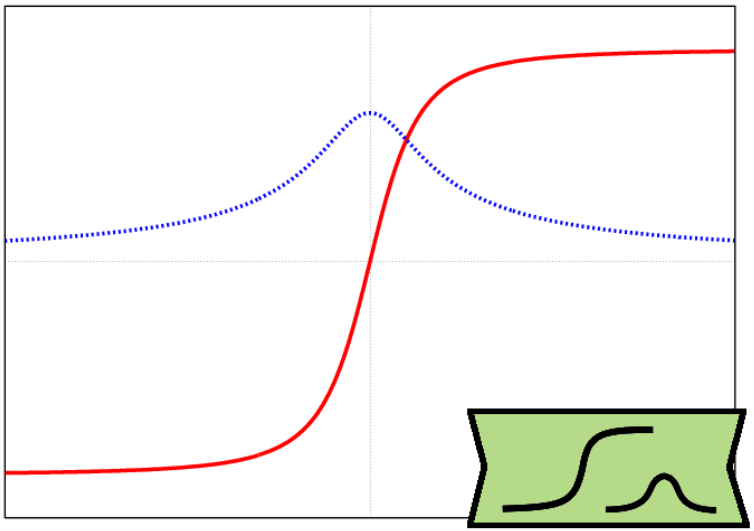

SU(5) grand unified theories

SM is: $SU(3)_{\text{col}} \otimes SU(2)_{\text{L}} \otimes U(1)_{\text{Y}}$
with gauge fields: G^{μ}_{1-8} $W^{\mu}_{1,2,3}$ B^{μ} (break to G^{μ}_{1-8} $W^{\mu}_{\pm}$ Z^{μ}_{0} A^{μ}).

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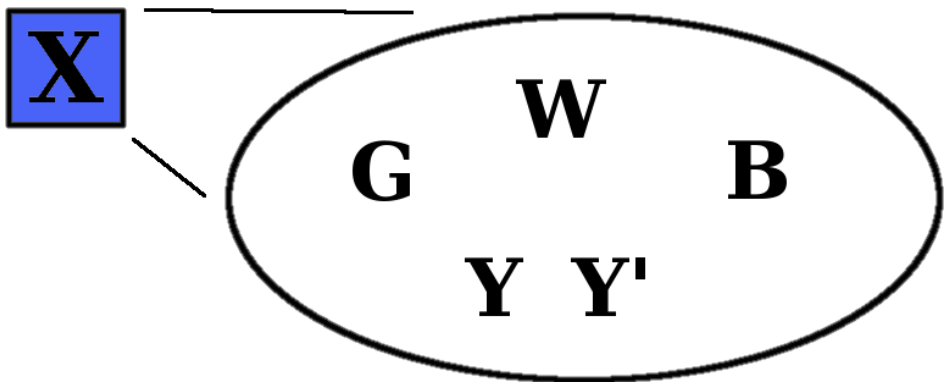

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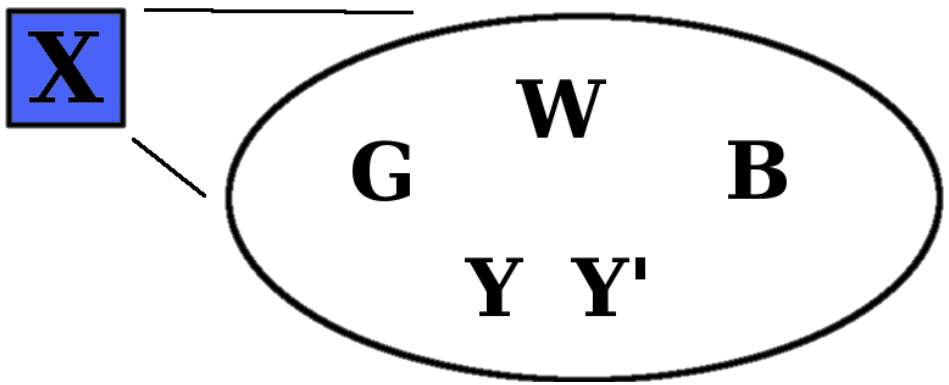
- only 1 gauge constant – but wrong predictions!
- proton decay induced by Y and Y'.



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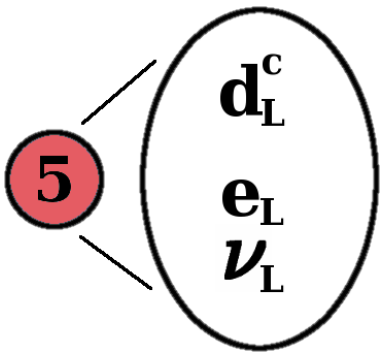

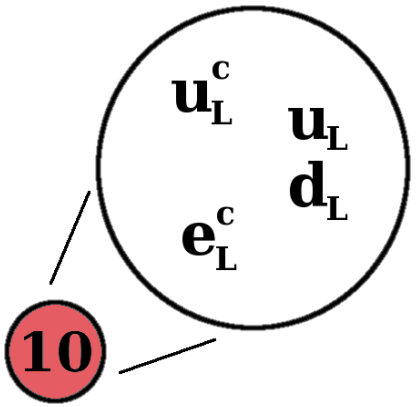

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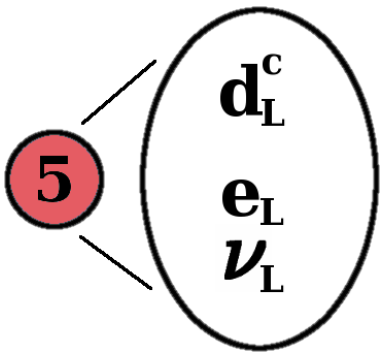

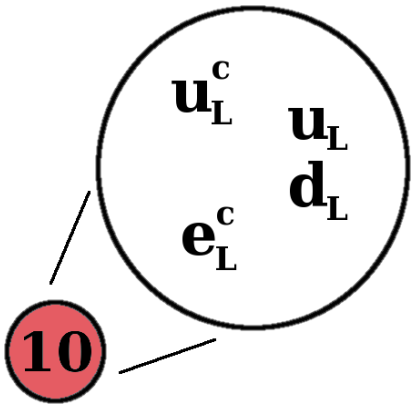

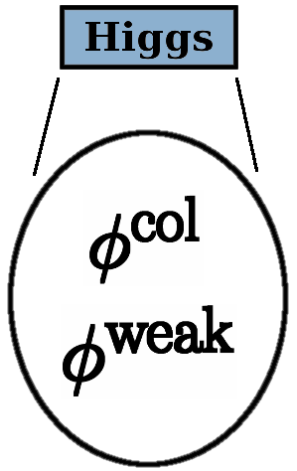

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- unwanted coloured Higgs
- wrong mass relations: $m_e = m_d$!

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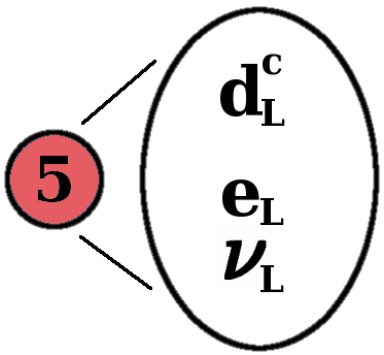

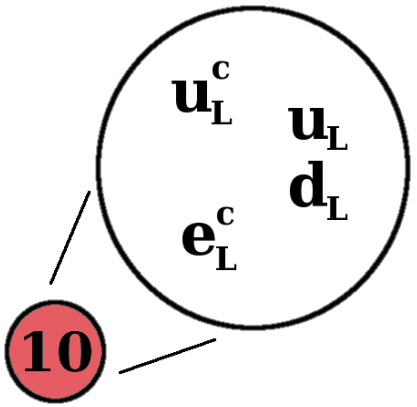

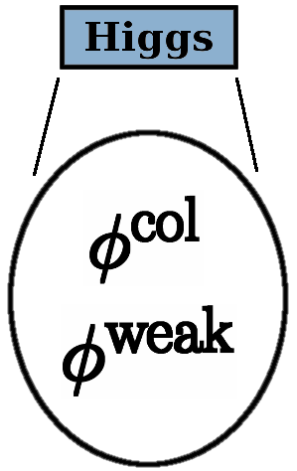

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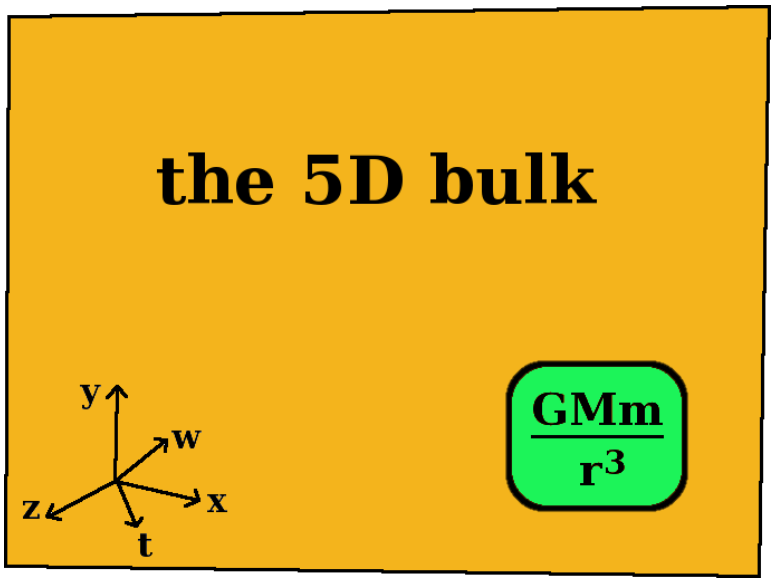

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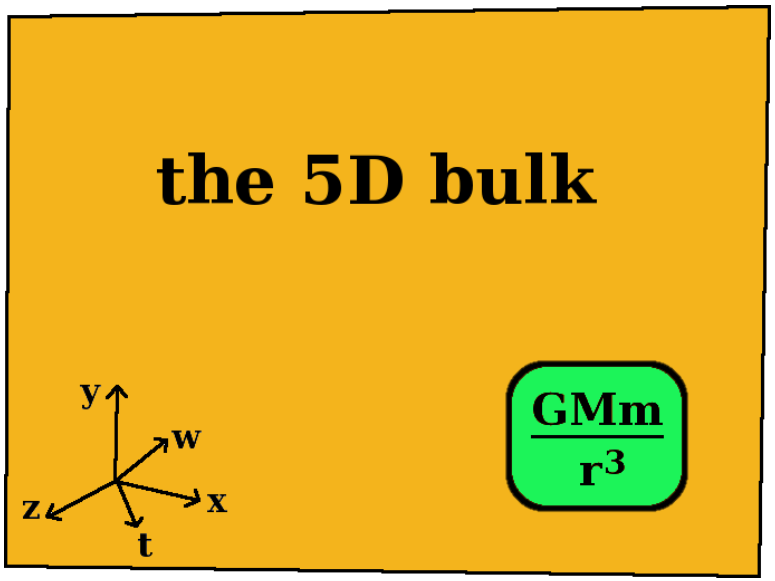

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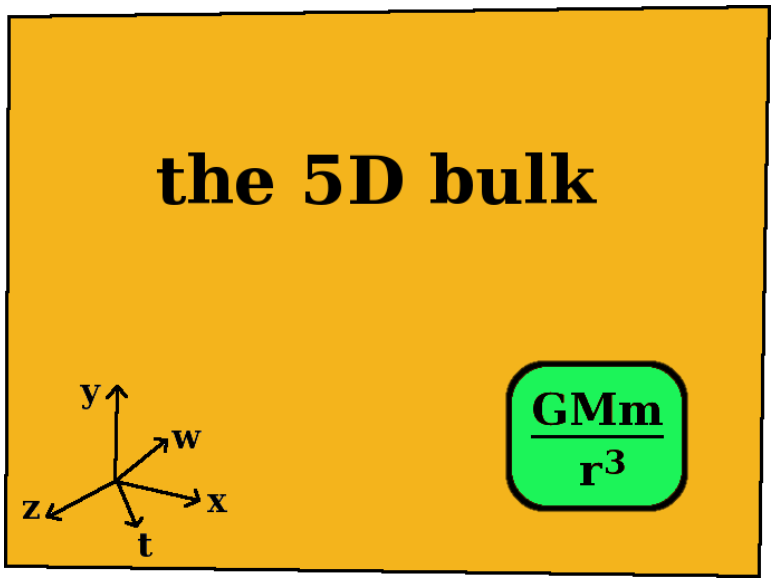

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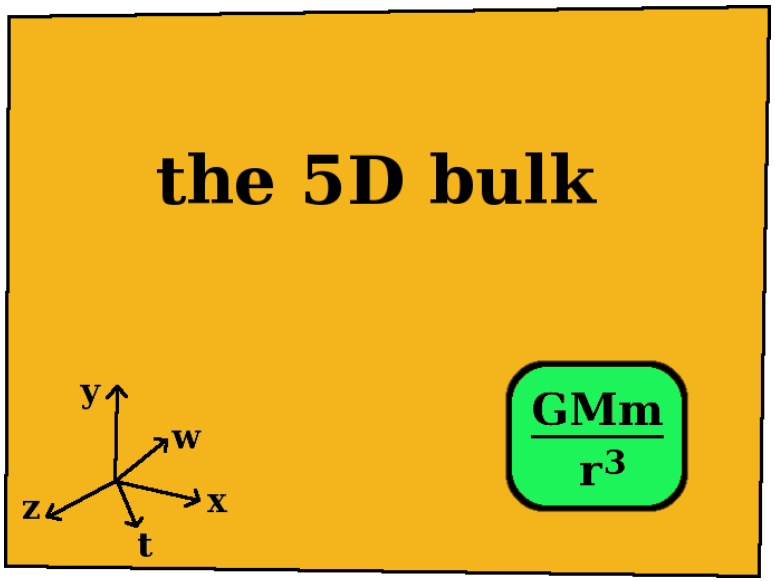

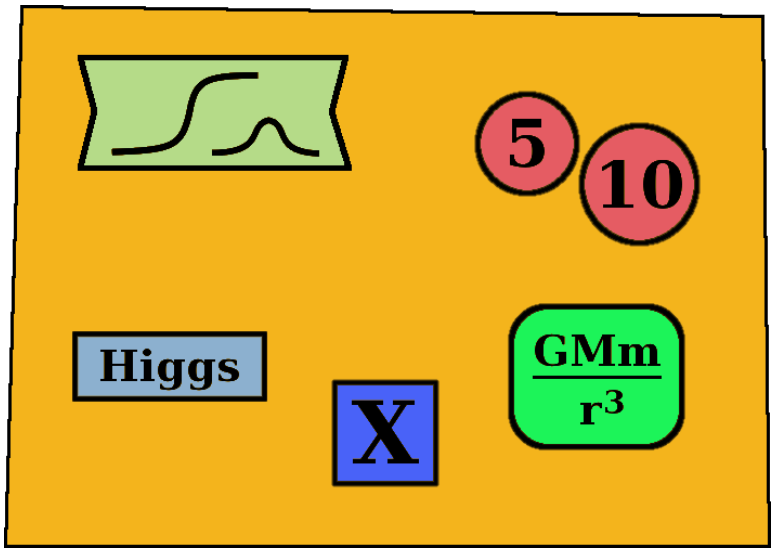

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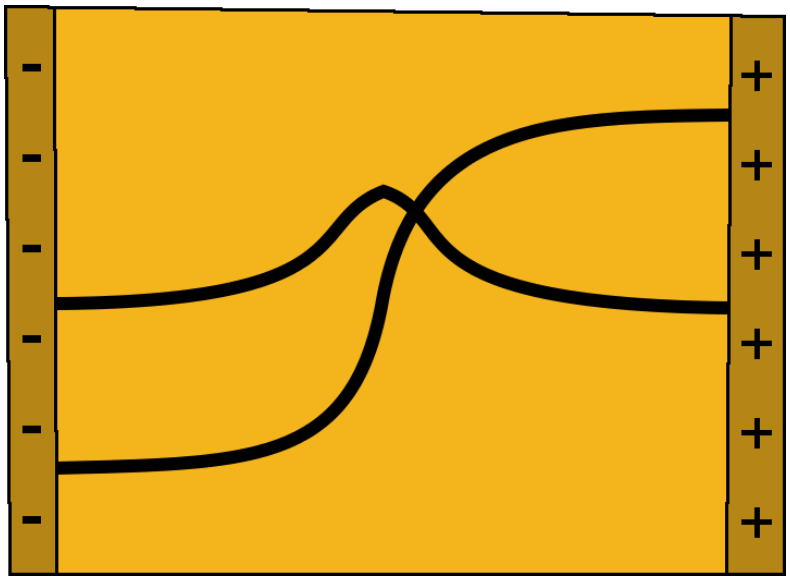

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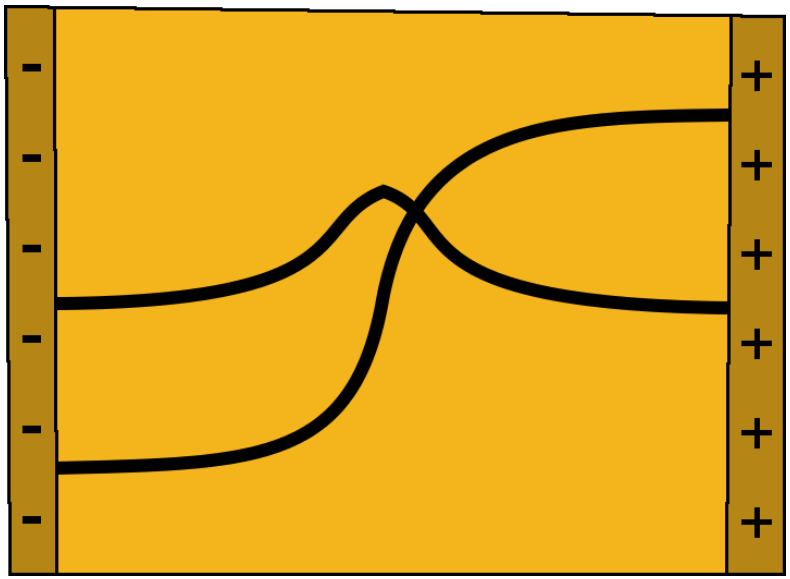

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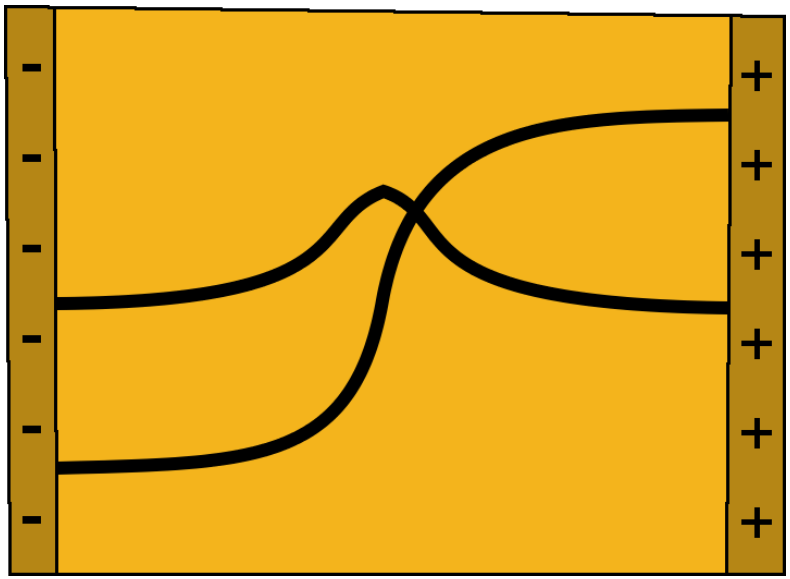

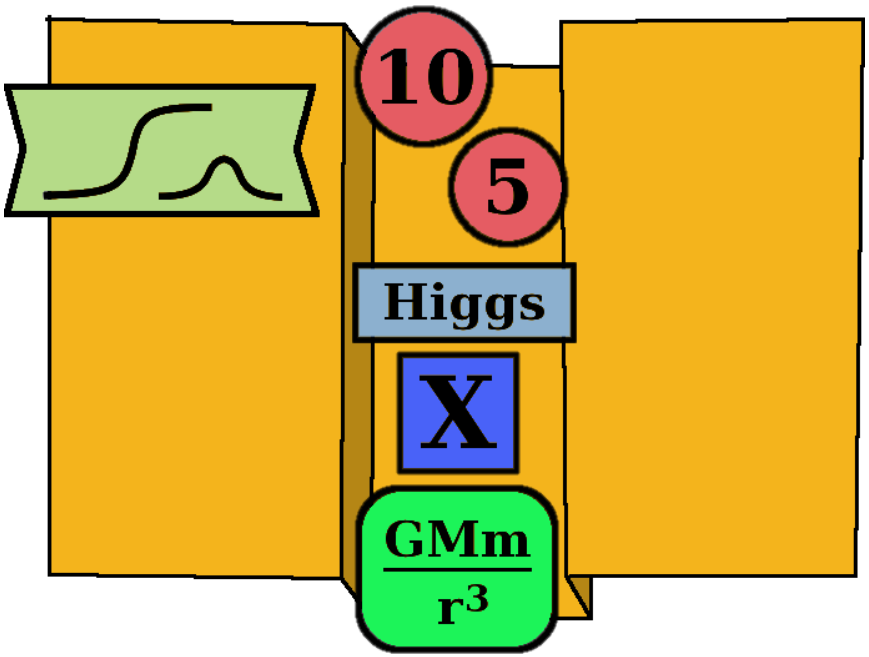

Trapping gravity – RS2

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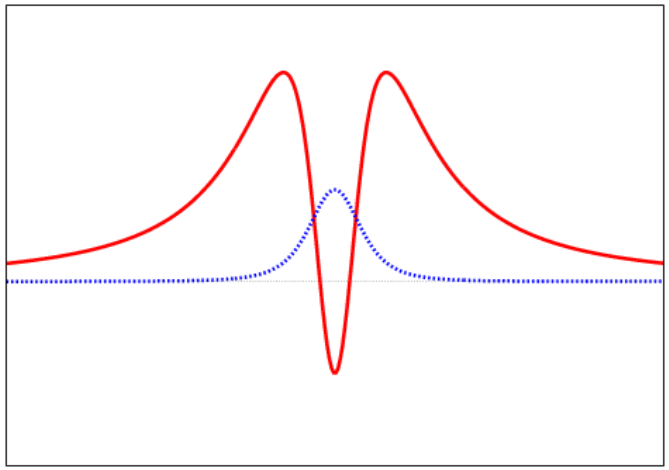

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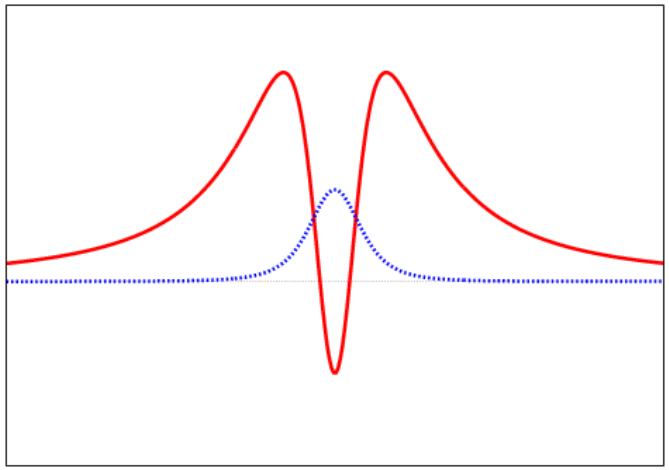

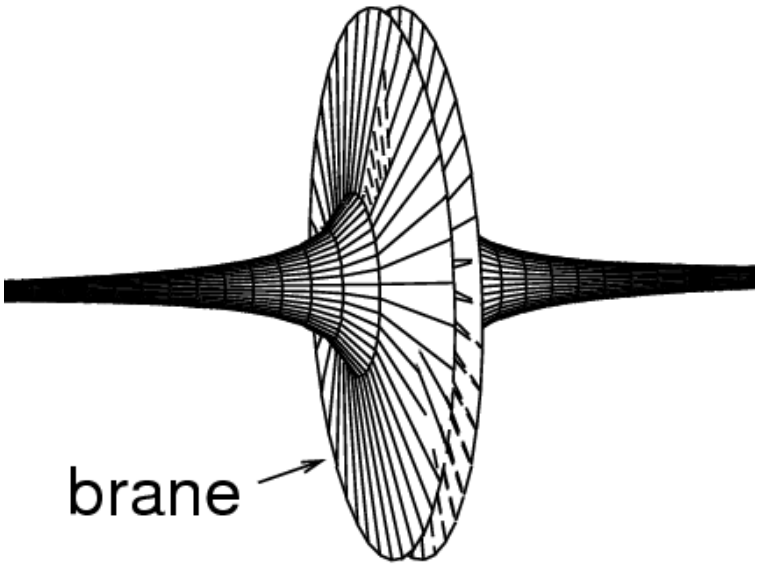

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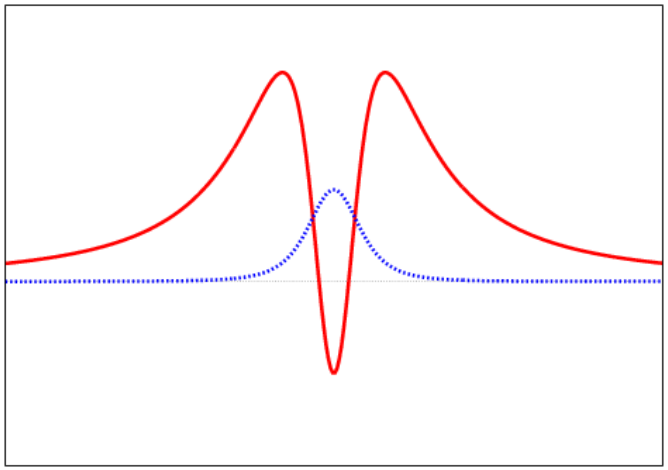

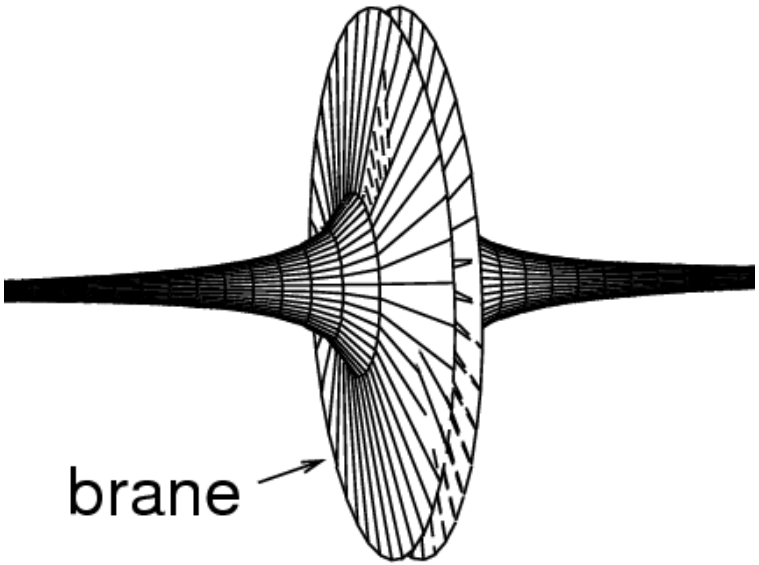

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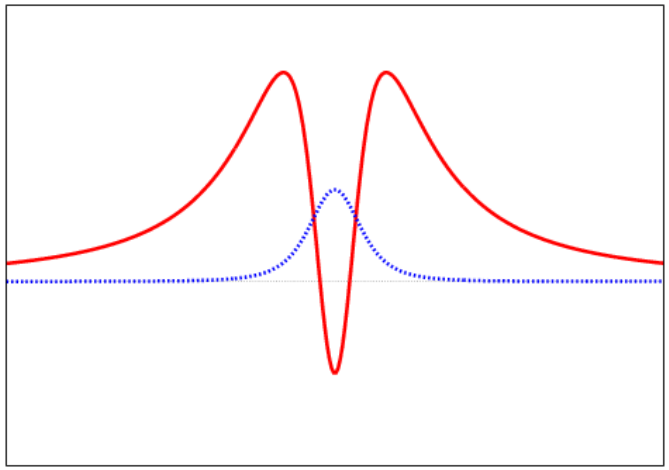

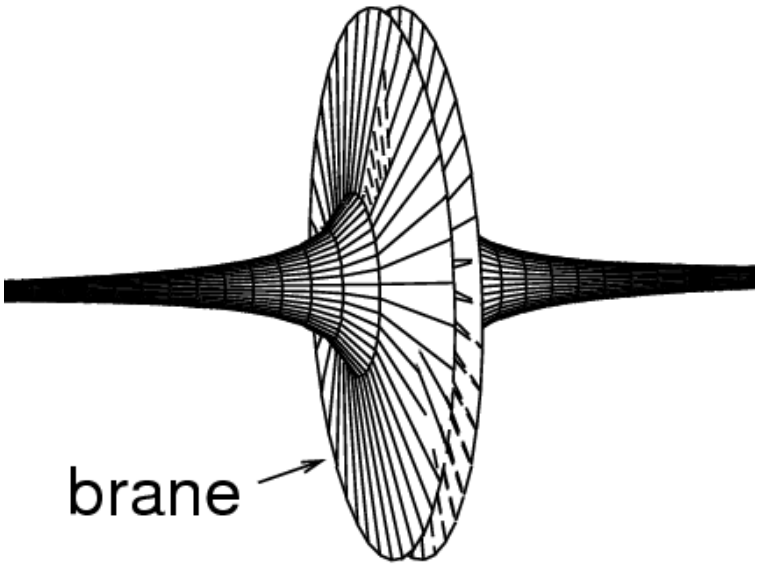

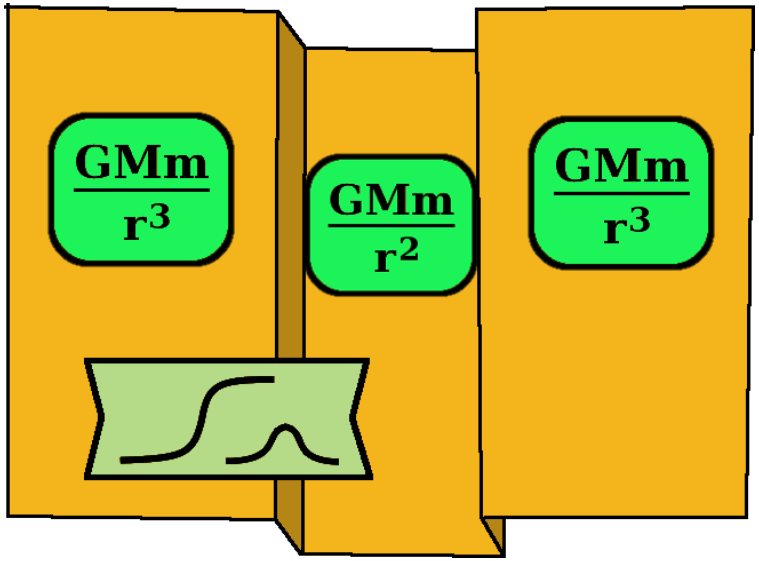

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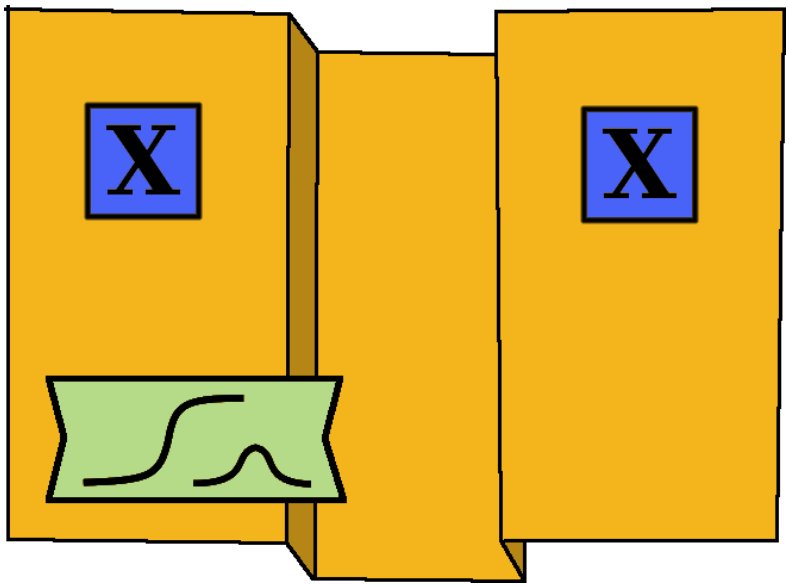

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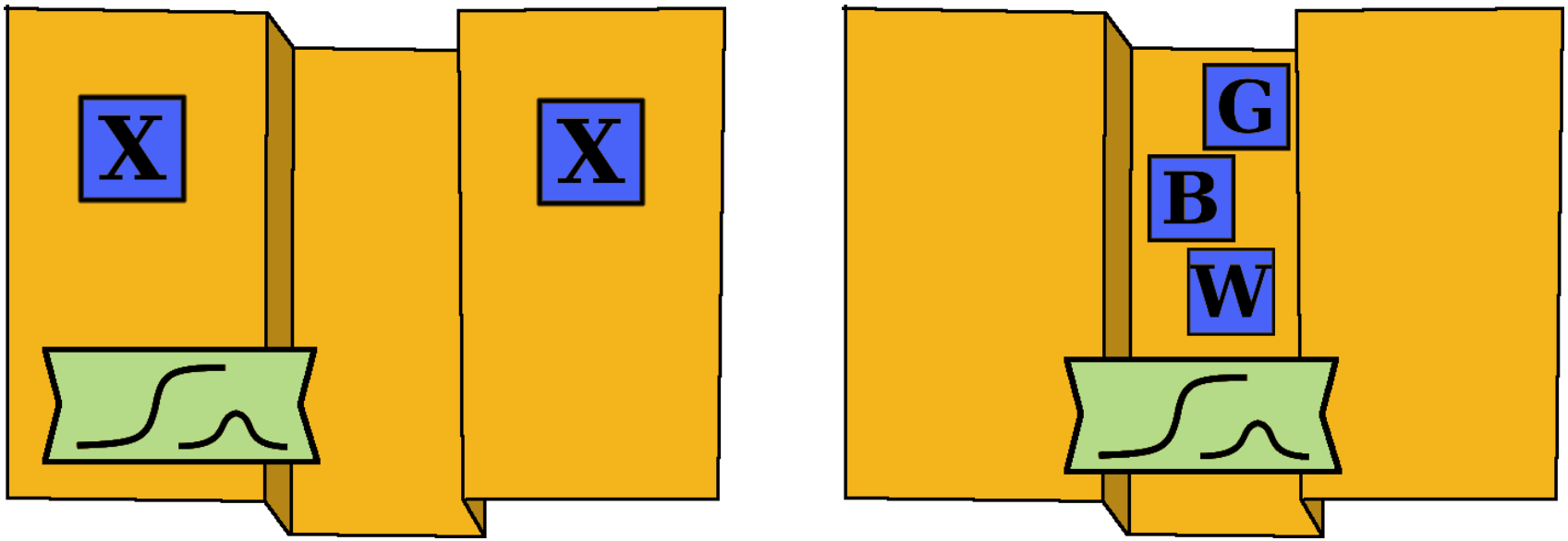

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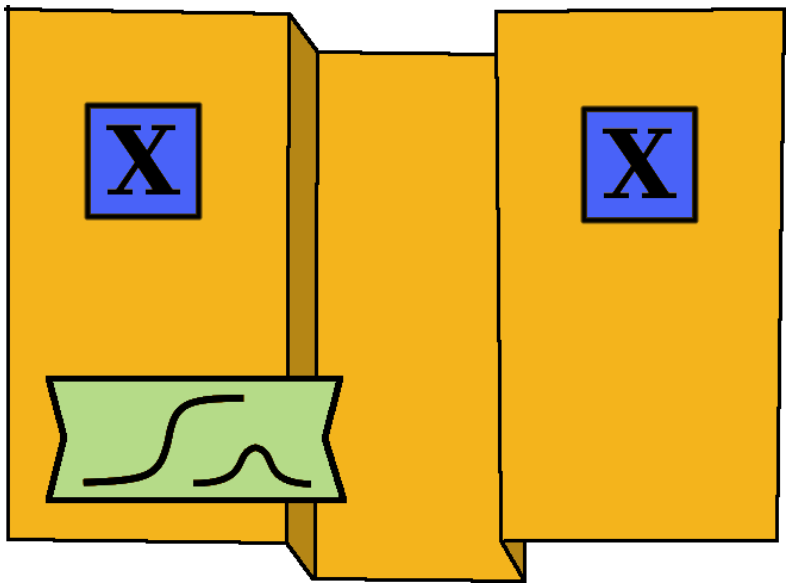
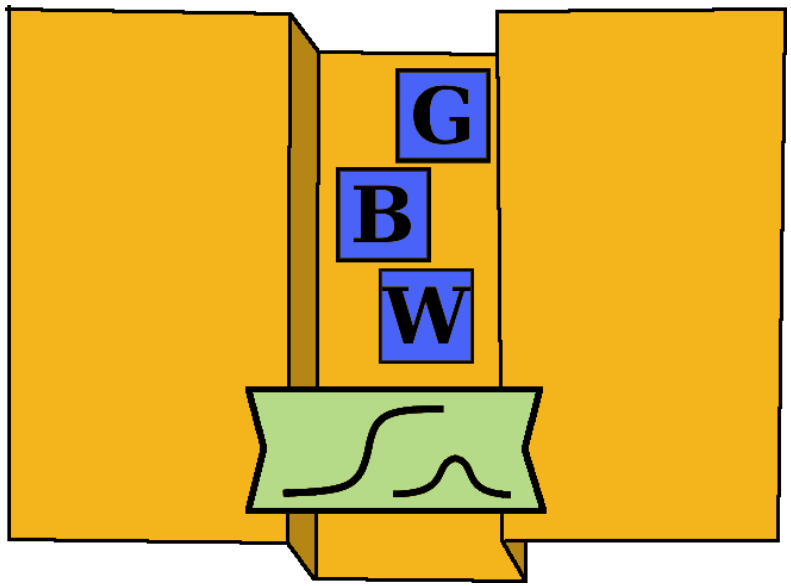
- When $\chi \neq 0$ we break $SU(5) \rightarrow$ SM.
- Energy cost for SM bosons to become $SU(5)$ bosons.
- Bosons trapped when broken: trapped and broken on brane.
- Gauge universality – equivalent charge for all positions in extra dimension.





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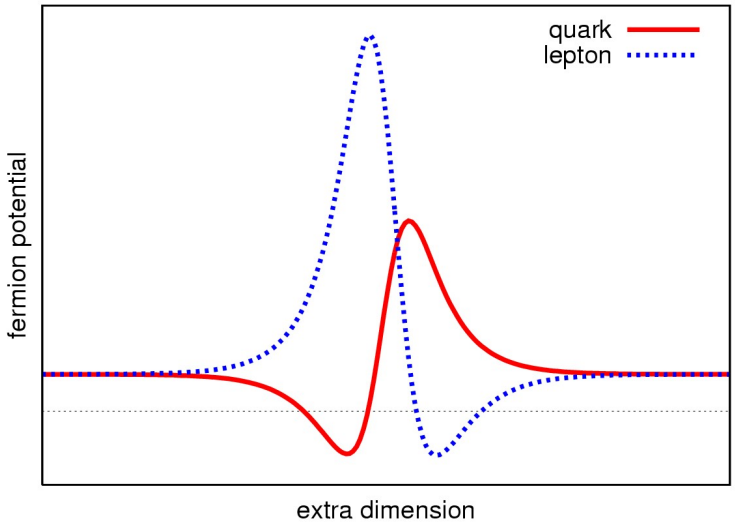

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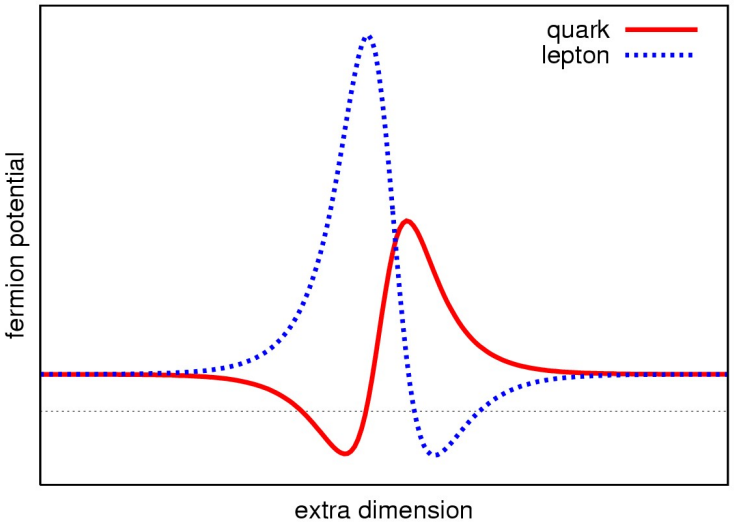

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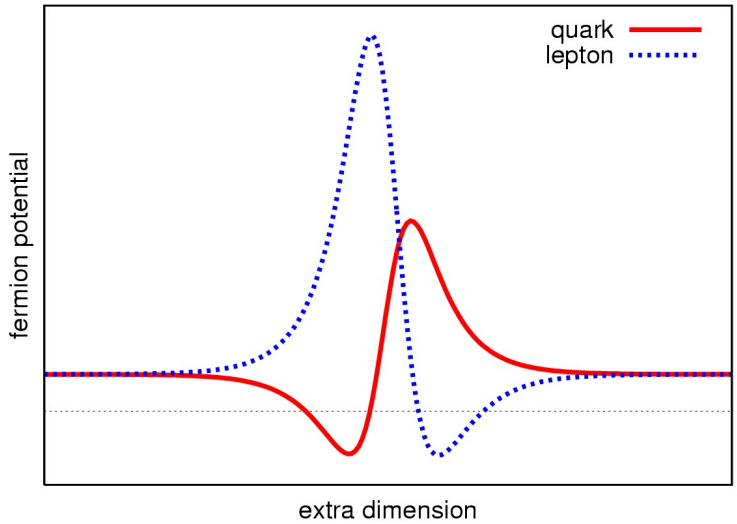

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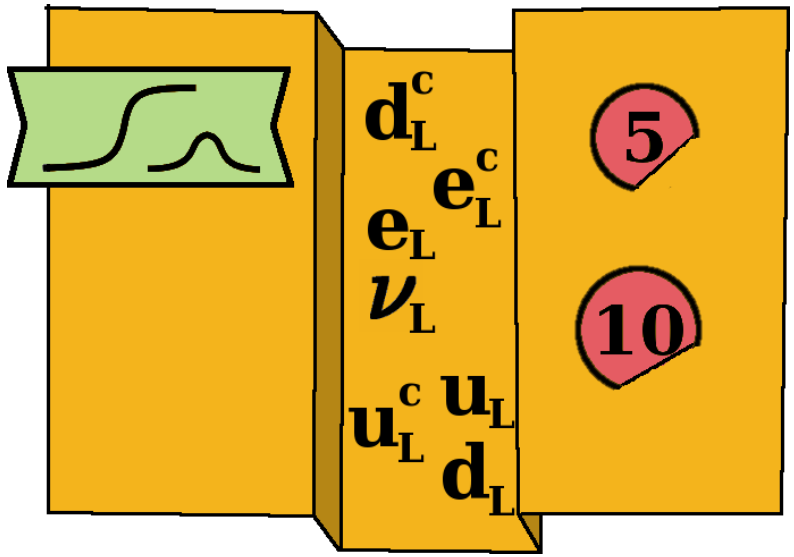

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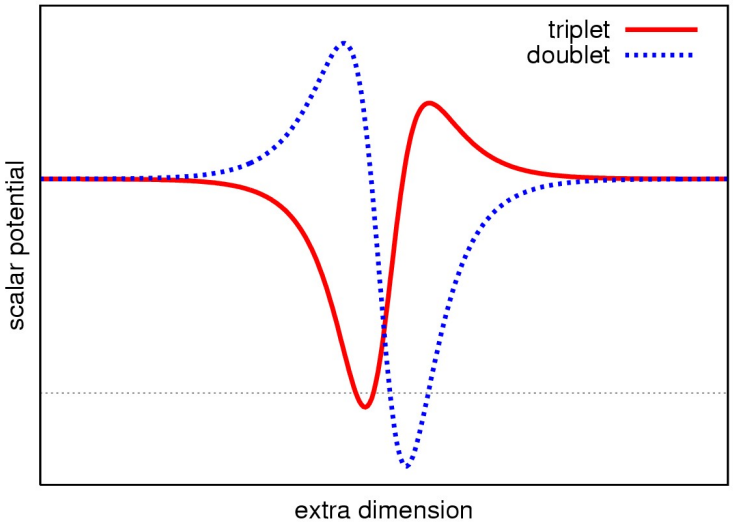

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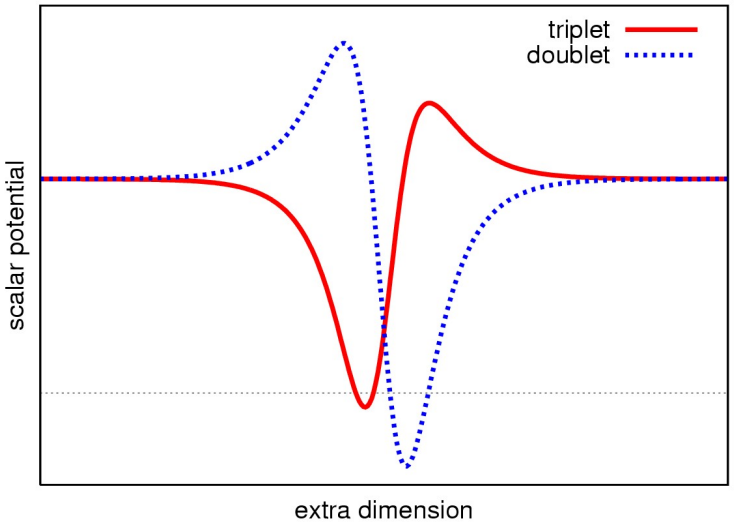

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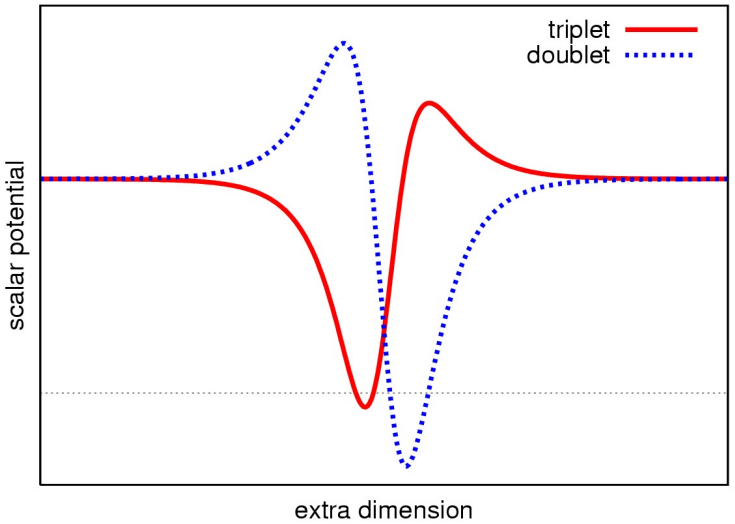

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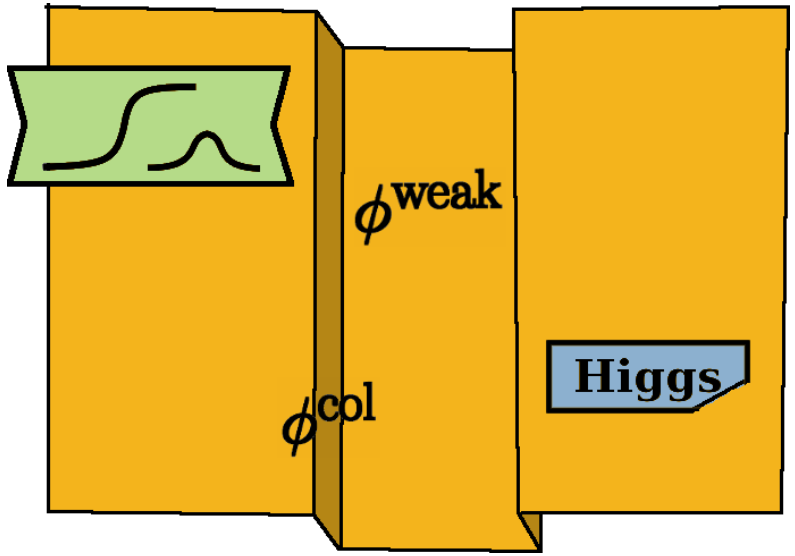

The standard model and general relativity

Almost there:

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Conclusions and further work

The standard model and general relativity on a brane:

- trapping fields η and χ.
- gravity is warped and trapped.
- gauge fields X are trapped and broken.
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Work to be done:

- 3 generations of fermions.
- Neutrino masses.
- Parameter count and parameter space search.
- Phenomenology: proton decay; coupling to extra modes.
- Gauge coupling unification.
- Cosmology.