

Cosmological Higgs mechanism and dark matter creation in a string theory framework

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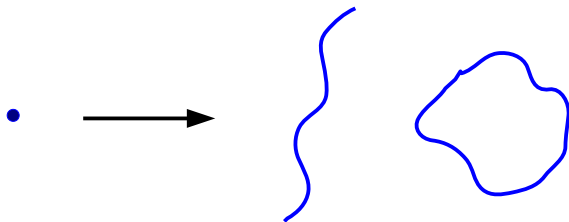
PhD title: Cosmological aspects in string theory

École Polytechnique, CPHT

November 15, 2018

String theory

Particles of dimension zero \rightarrow strings of dimension one



Internal modes (excitations)

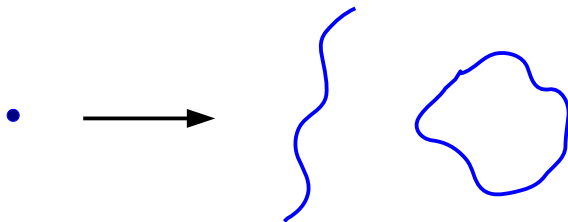
\rightarrow physical particles

Seen from far away *i.e.*

at low energy \rightarrow points

String theory

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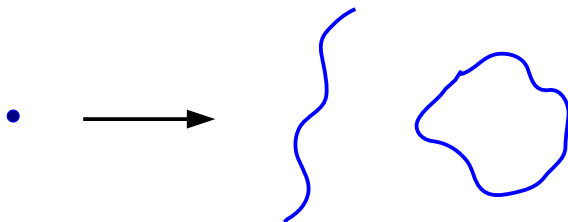
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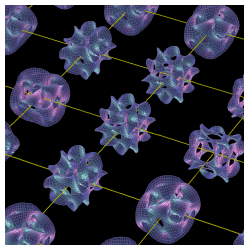
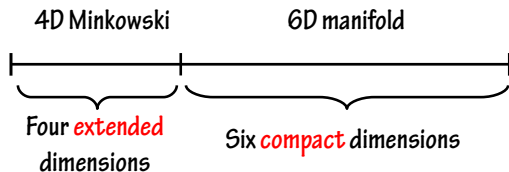
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Strings live in ten dimensions \Rightarrow extra dimensions

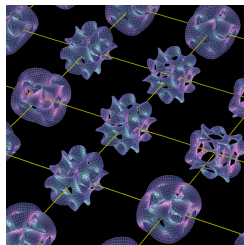
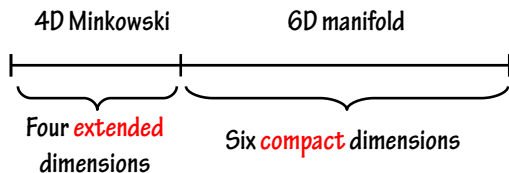


The choice of compact manifold affects the effective 4-dimensional theory

The internal space is dynamical

Compactification \Rightarrow strings have new quantum numbers

Strings live in ten dimensions \Rightarrow extra dimensions

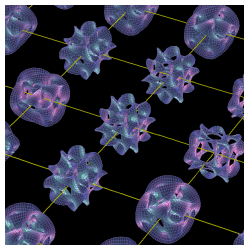
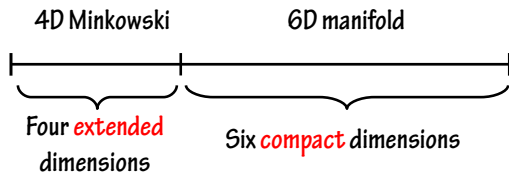


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Strings live in ten dimensions \Rightarrow **extra dimensions**

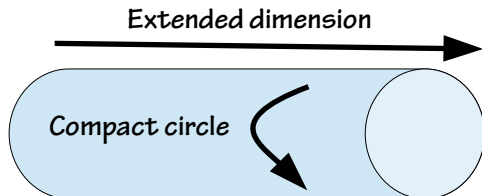


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Compactification \Rightarrow strings have **new quantum numbers**

Momentum and winding



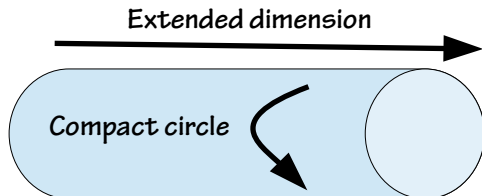
The string can move around the circle \Rightarrow the wave function is quantized

\rightarrow momentum number m

The string can wrap around the circle, let's say n times

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Mass formula

The mass of a state for a closed string:

$$M^2 = 2N_L + 2N_R + \left(\frac{m}{R}\right)^2 + (nR)^2 - 4$$

where N_L and N_R are the oscillator numbers (for left and right oscillations)

Massless states

→ $N_L = N_R = 1$ and $m = n = 0$

If the radius is one (self-dual radius):

→ **additional massless states** with $N_L = 0$, $N_R = 1$ and $m = n = \pm 1$

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The mechanism

We want to build a mechanism to cosmologically trigger a transition between $R = 1$ and $R \rightarrow cste$

→ the additional massless states will **acquire a huge mass** instantaneously

Cosmological Higgs mechanism

The system

String at finite temperature with spontaneously broken supersymmetry

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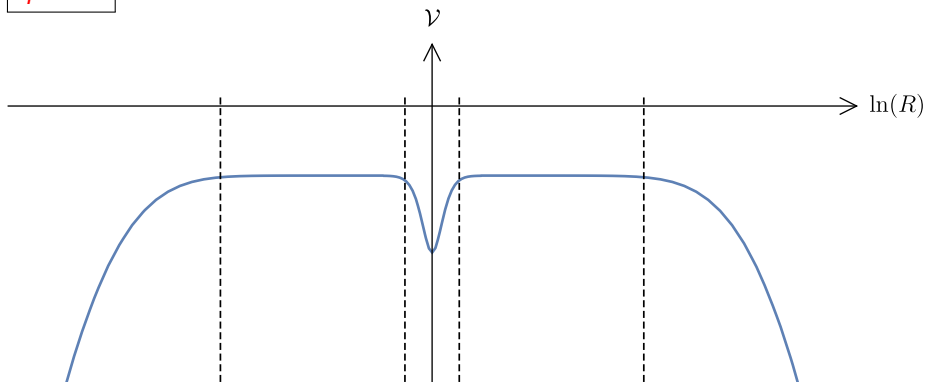
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Evolution

Only talk about T , M (breaking scale) and R | $\mathcal{V} = \sum_{\text{bosons}} \# - \sum_{\text{fermions}} \#$

We can build models with the following behaviour:

$$\frac{M}{T} < 1$$

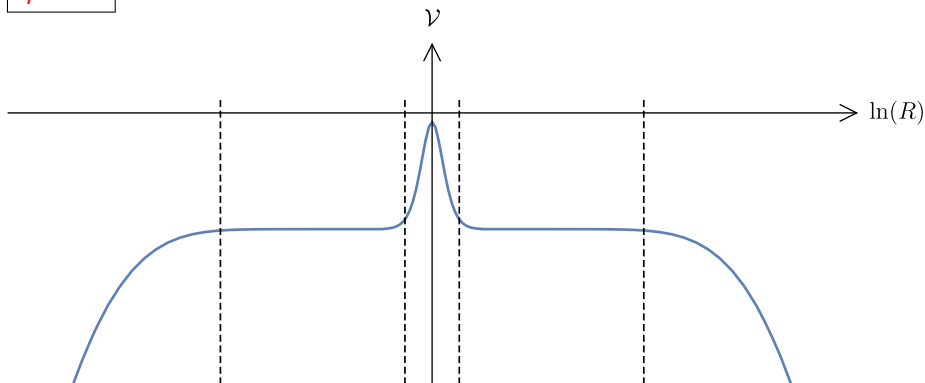


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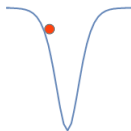
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Higgsification process

- start with $M < T$
- start with R in the well
- R oscillates around 1 and the system follows an attractor $M = u_c T$
- if $u_c > 1$ (depends on the model), the well in the potential becomes a bump
- R becomes unstable and will fall along its potential to stabilize

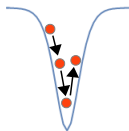


→ creation of non-relativistic (very heavy) mass

→ could play the role of **dark matter**

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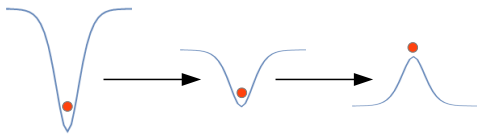


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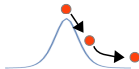
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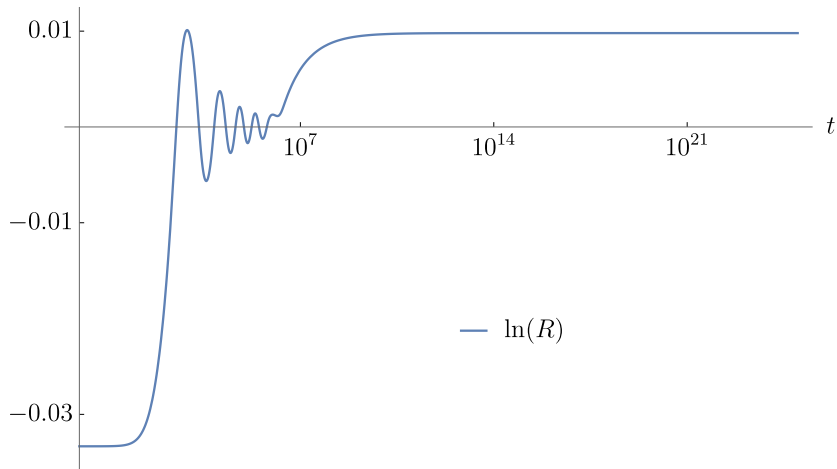


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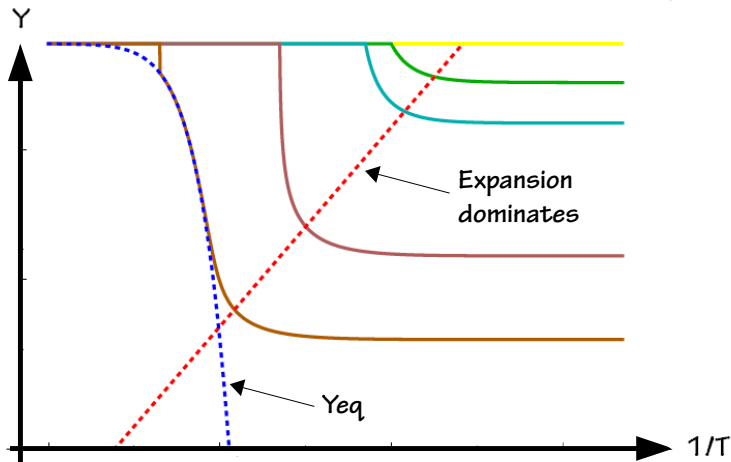
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Higgsification process



Relic density

Density $n(t) \rightarrow$ Boltzmann equation:
$$\frac{dn}{dt} = \underbrace{-3Hn}_{\text{dilution}} - \underbrace{\langle \sigma v \rangle (n^2 - n_{\text{eq}}^2)}_{\text{thermal equilibrium}}$$



Thank you for your attention!