A vacuum selection mechanism from the bulk tachyon?

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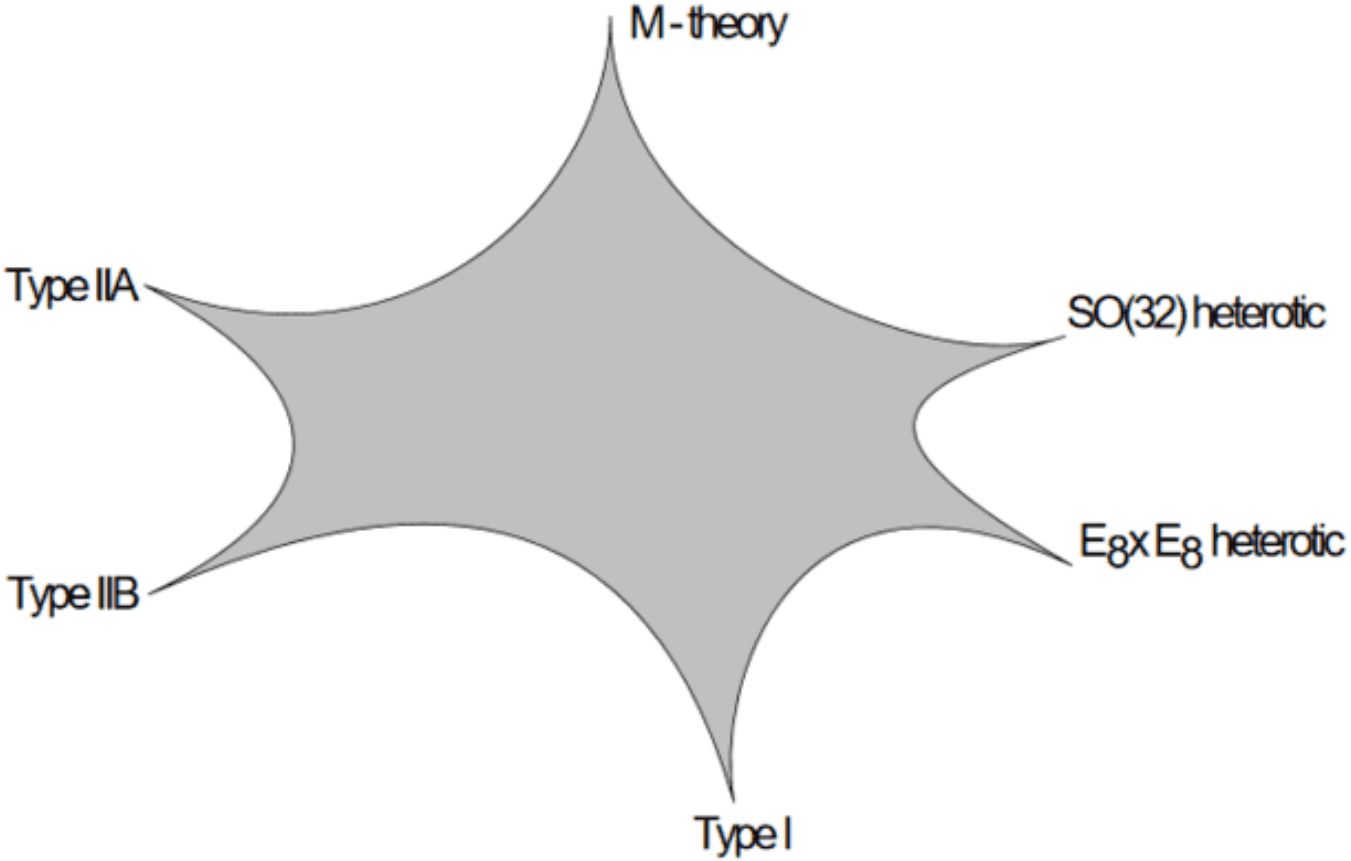
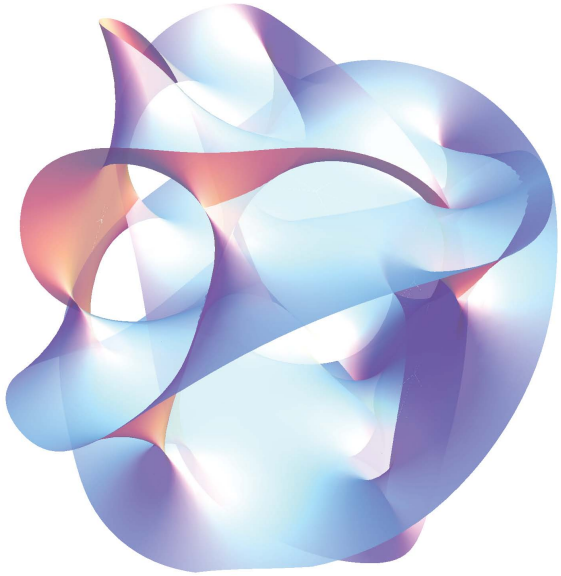
Construction of String Theory

- Start with bosonic String Theory $\rightarrow$ 26D
- add spin 1/2 fermions $\rightarrow$ 5 Superstring Theories $\rightarrow$ 10D (M-theory 11D)



Construction of String Theory

- Start with bosonic String Theory $\rightarrow$ 26D
- add spin 1/2 fermions $\rightarrow$ 5 Superstring Theories $\rightarrow$ 10D
- Compactifications $\rightarrow$ 4D



Construction of String Theory

- Start with bosonic String Theory $\rightarrow$ 26D
- add spin 1/2 fermions $\rightarrow$ 5 Superstring Theories $\rightarrow$ 10D
- Compactifications $\rightarrow$ 4D
- But: (perhaps) Infinite number of compactifications/vacua

$\rightarrow$ no predictions beside no-go theorems possible

Choices made on the way

- Quantize Polyakov action instead of Nambu-Goto action
- No Background fields (linear dilaton allows D=4 bosonic string)
- Adding spin 1/2 fermions
- Choose one of the 5 theories.
- Choose one of the $> 10^{2500}$ vacua.

Choices made on the way

- Quantize Polyakov action instead of Nambu-Goto action

$\rightarrow$Classicly equivalent and no-one knows how to quantize Nambu-Goto....

Choices made on the way

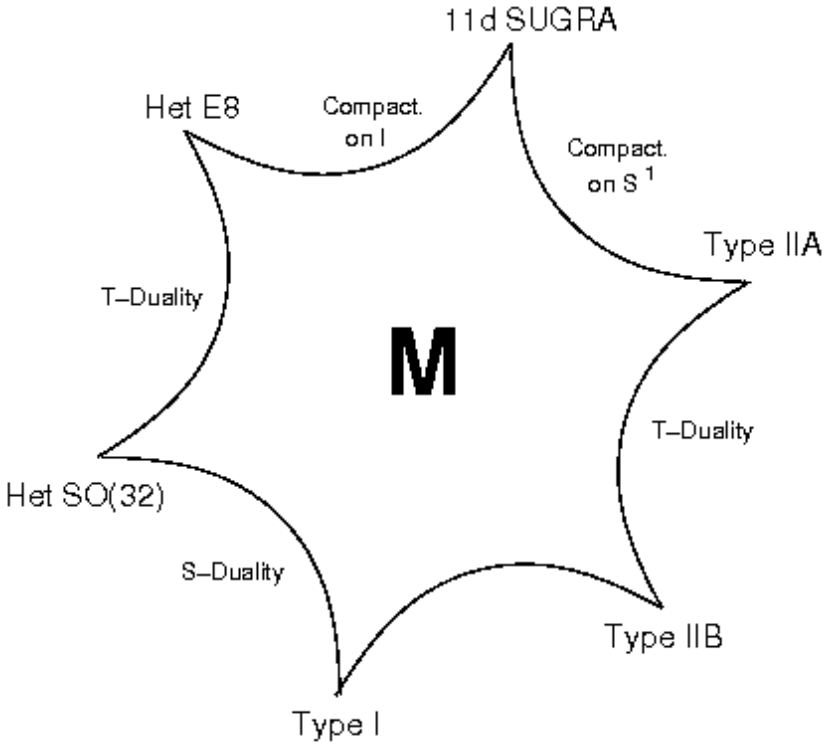
- No Background fields (linear dilaton allows D=4 bosonic string)

$\rightarrow$ Theory of everything should not have some unexplained background fields
$\rightarrow$ String field theory ($\approx$ non-perturbative formulation of String theory) is proven to be background independent.

Choices made on the way

- Choose one of the 5 superstring theories.

→ A whole web of dualities arises
→ only part of the non-perturbative formulation

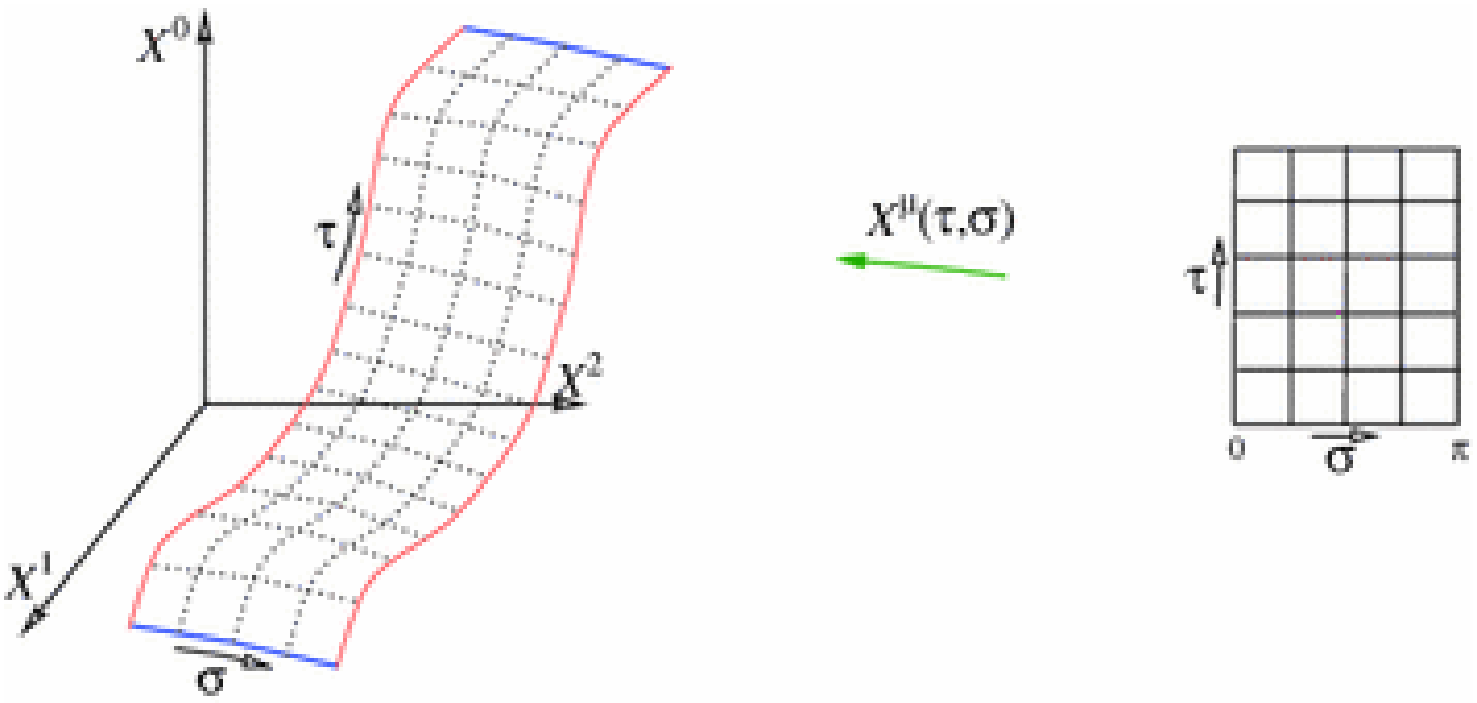


What remains?

- add spin 1/2 fermions.
- Choose one of the $> 10^{2500}$ vacua.

Conformal Description of the Bosonic String

- String forms an 2-dimensional world sheet (time+1-d extension)
- Action=volume of the world sheet.
- position of string in 26-d space-time is described by 26 scalar fields X^μ



- Result: 2d CFT
- But no fermions and a tachyon in the spectrum

Moving Between Theories

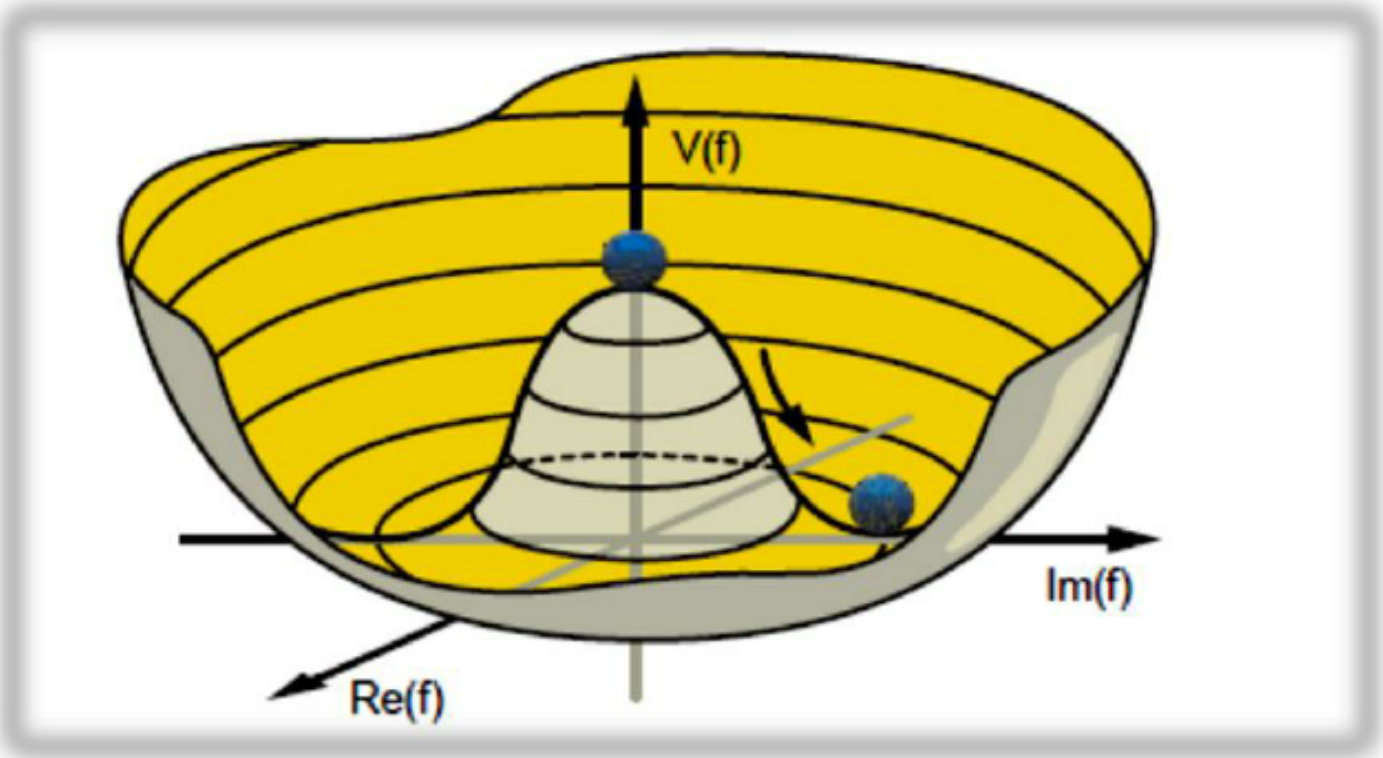
- Energy momentum Tensor T of 2d CFT defines the theory.
- Deformations of this tensor lead to new theories.
- String field theory is perturbatively formulated on the space of 2d CFTs around a reference CFT.
- Space-time fields are coefficients of the deformation!

$$T = T_0 + t(x^\mu) \cdot c + A_\mu(x^\nu) \cdot \alpha^\mu c + ... \tag{1}$$

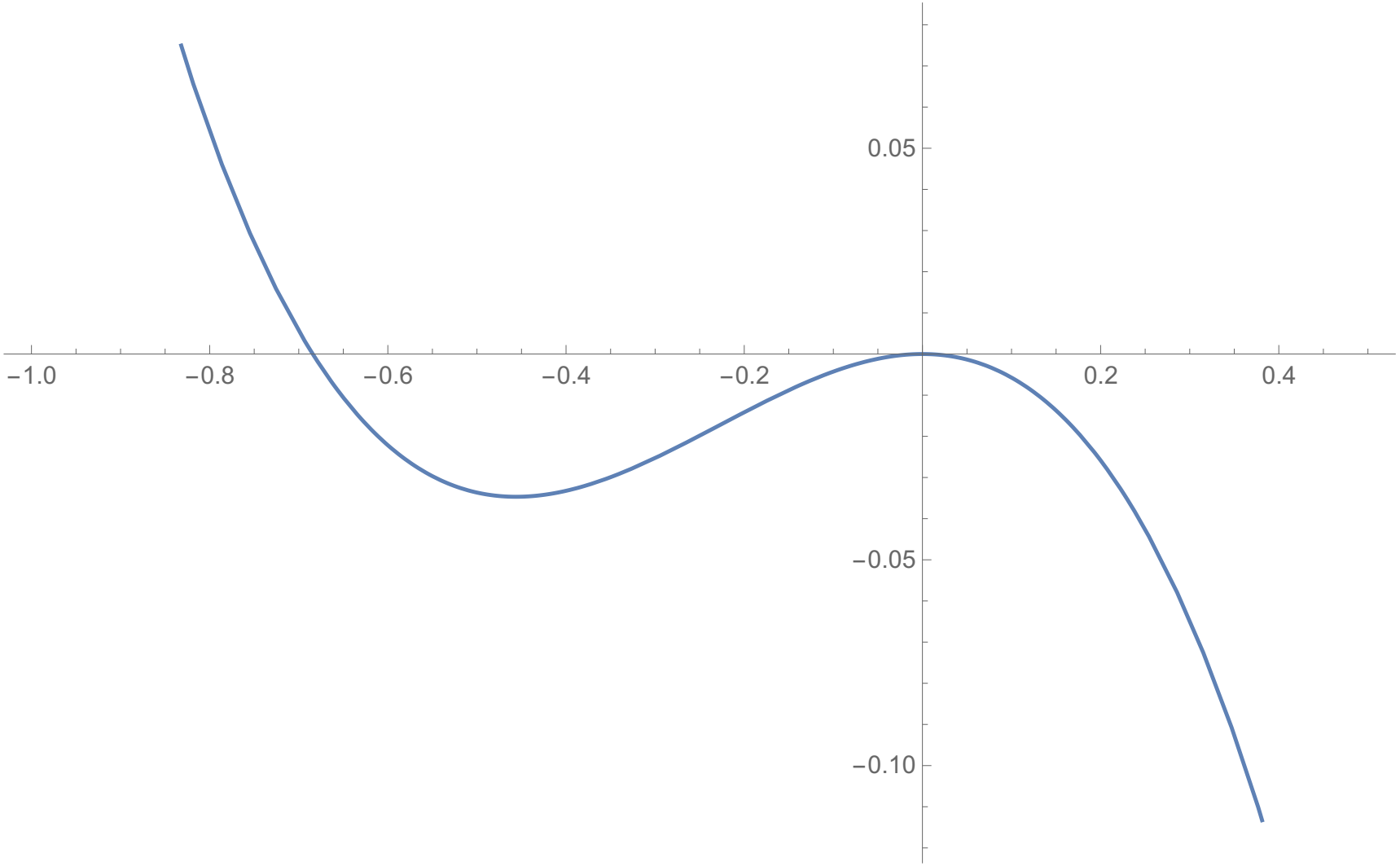
Tachyon

- Field of negative m^2
- Signals instability of the vacuum.
- Are nothing to be feared (e.g. Higgs)
- Potential V allows identification of the new vacuum.

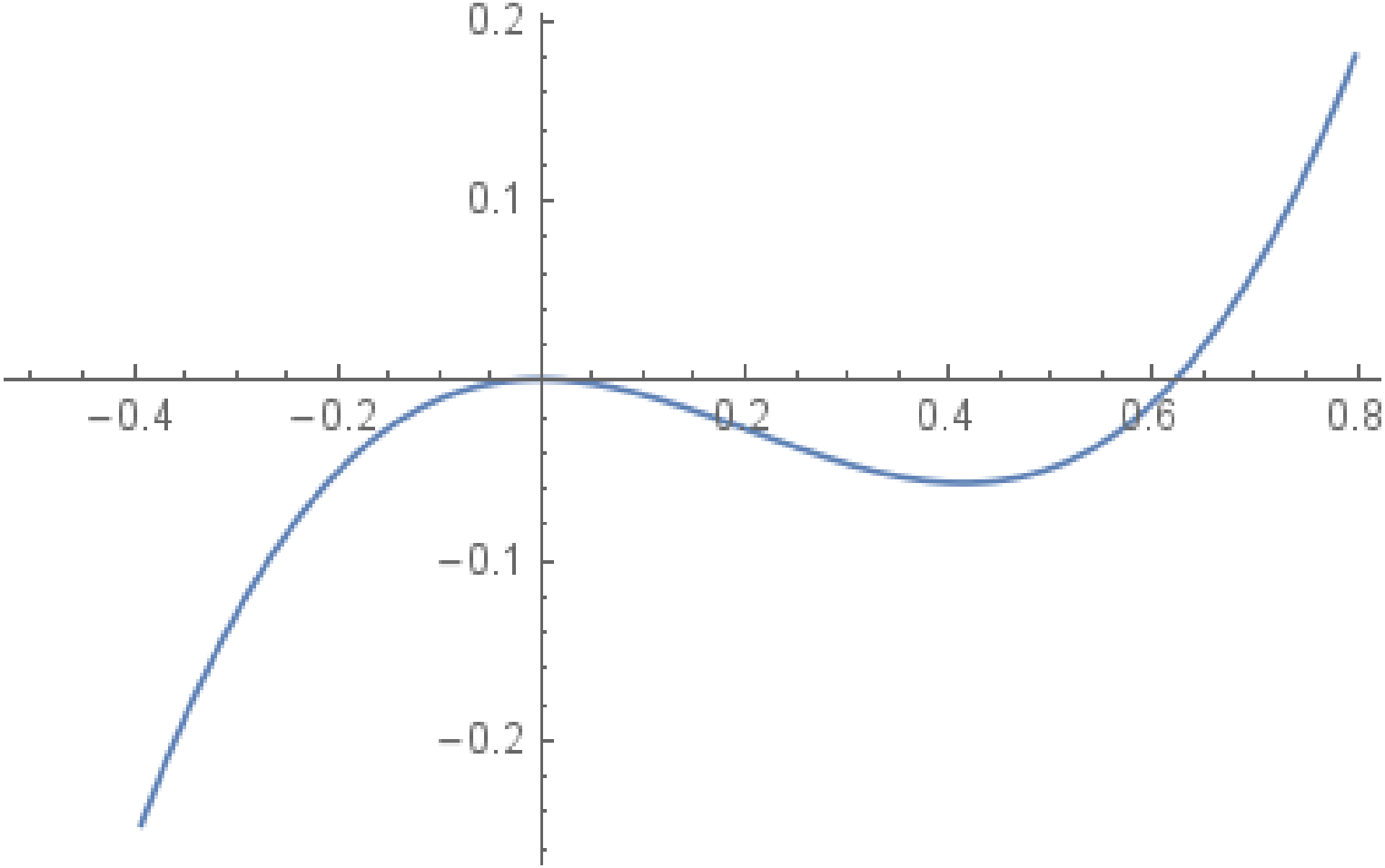
Higgs potential



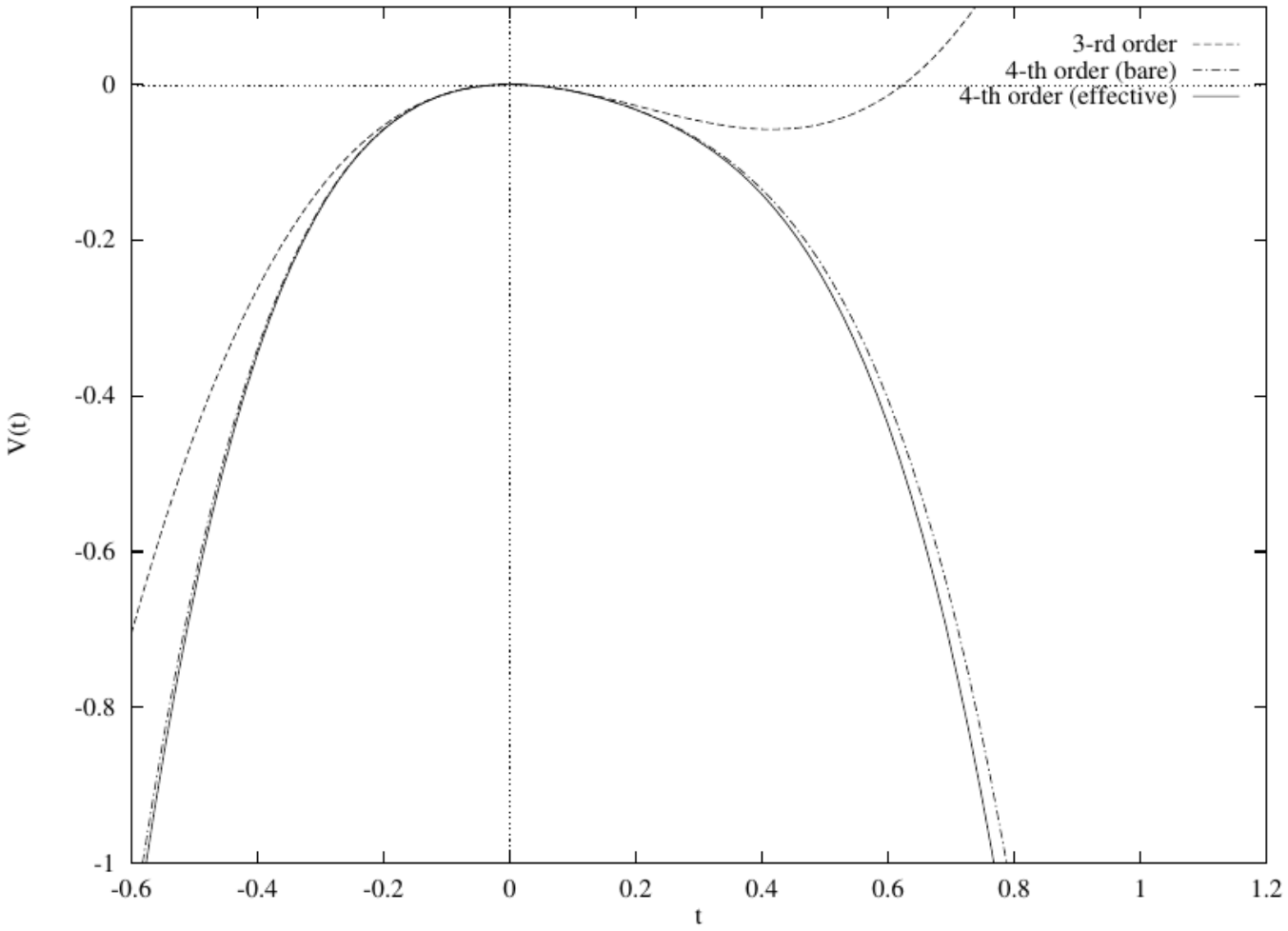
Potential of the Bosonic Open String Tachyon



Potential of the Bosonic Closed String Tachyon (cubic order)



Potential of the Bosonic Closed String Tachyon (quartic order)



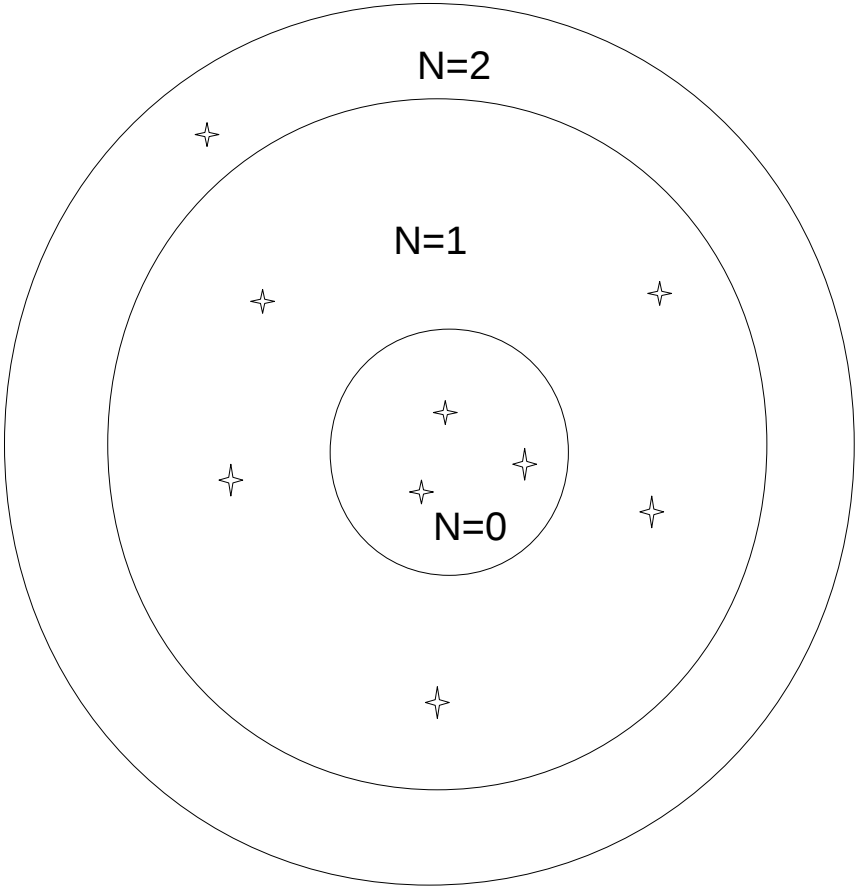
Potential of the Bosonic Closed String Tachyon

- The quartic order destabilizes the vacuum!
- Quintic terms reintroduce the stable point [Moeller 2007]
- Infinite series of terms.
- Interpretation lacking.

The forgotten Magic: The Berkovits embedding

- In 1993 Berkovits and Vafa showed that the bosonic string is part of the superstring moduli space. ("On the Uniqueness of String Theory ")
- 26D model $\in$ 10D model, this is crazy but works conformally!
- Adds spin 3/2 and -1/2 fermions instead of 1/2!(= spin shifted ghosts)

The Complete picture



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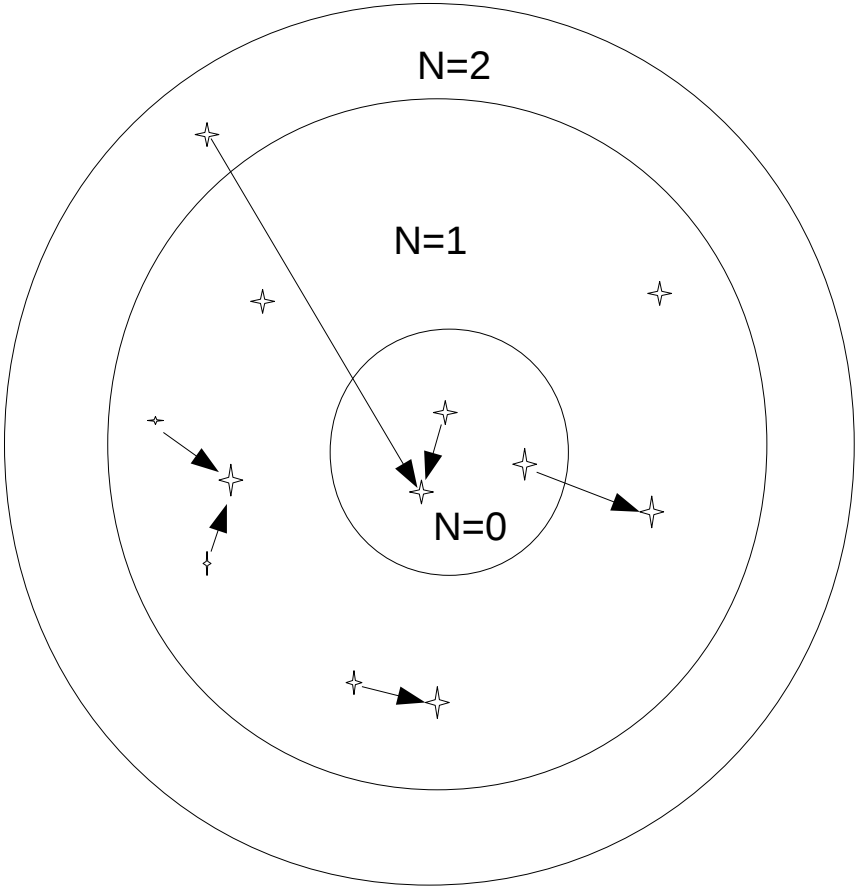

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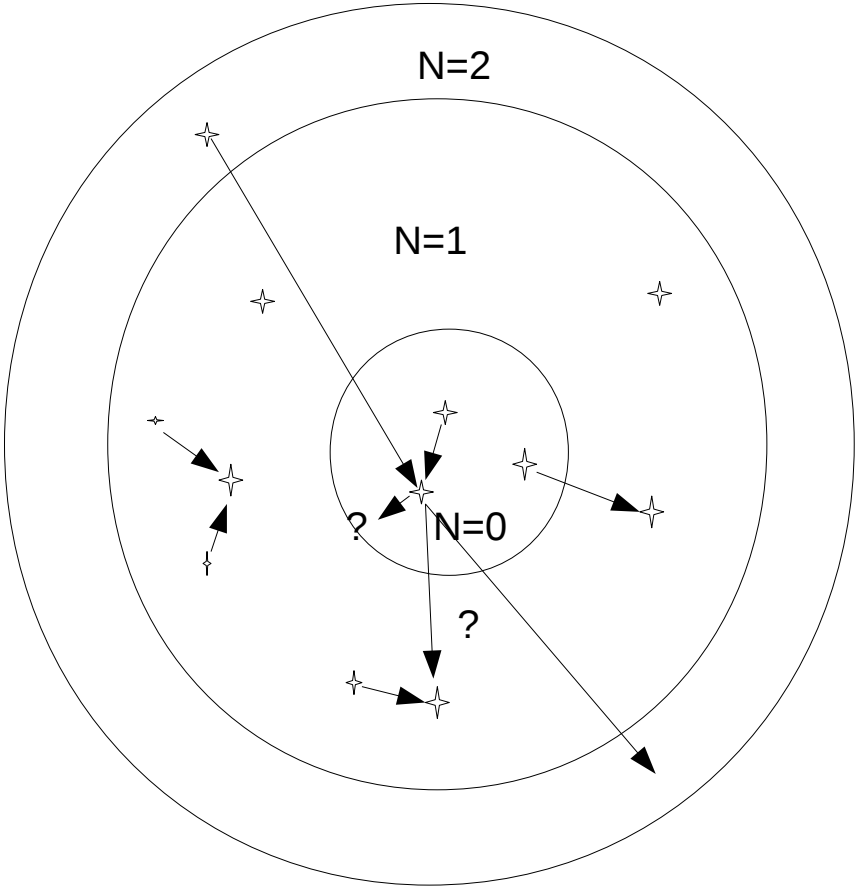
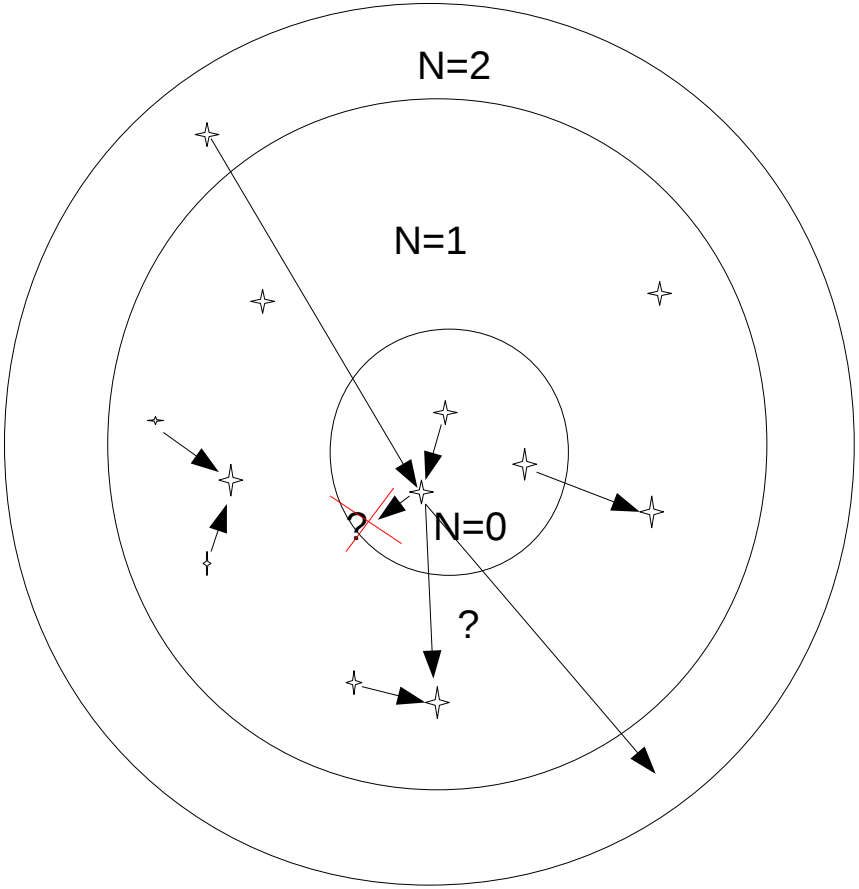


The Endpoint of the closed Bosonic Bulk Tachyon Condensation

How to determine which one is correct?

- Use Berkovits embedding + closed superstring field theory
- Subspace of the string field (matter ghost number -1) reproduces the bosonic result
- But fermionic directions destabilize the vacuum
- The Moeller Vacuum is false and only a boundary effect!

The Complete picture



Two possibilities

- The tachyon leads to a known D=10 $N = 1$ superstring theory→would complete the picture but does not help at all...
- The tachyon leads to a unknown D=4 $N = 2$ superstring theory, which could be the true vacuum of string theory!

Work in progress!

Thank you