STRINGS AND D-BRANES

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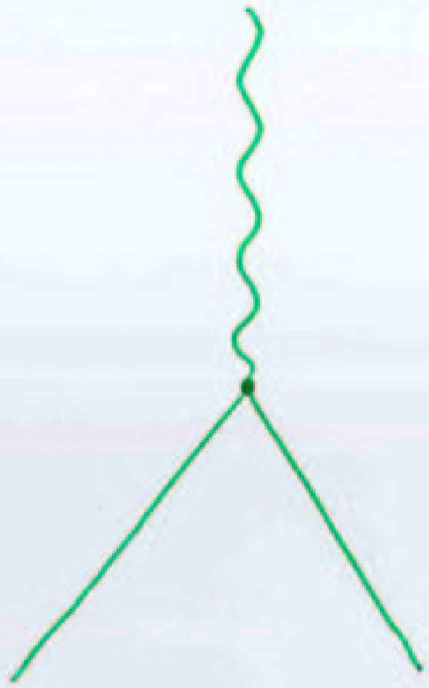
„The Standard Model is the most painful humiliation of physics today"

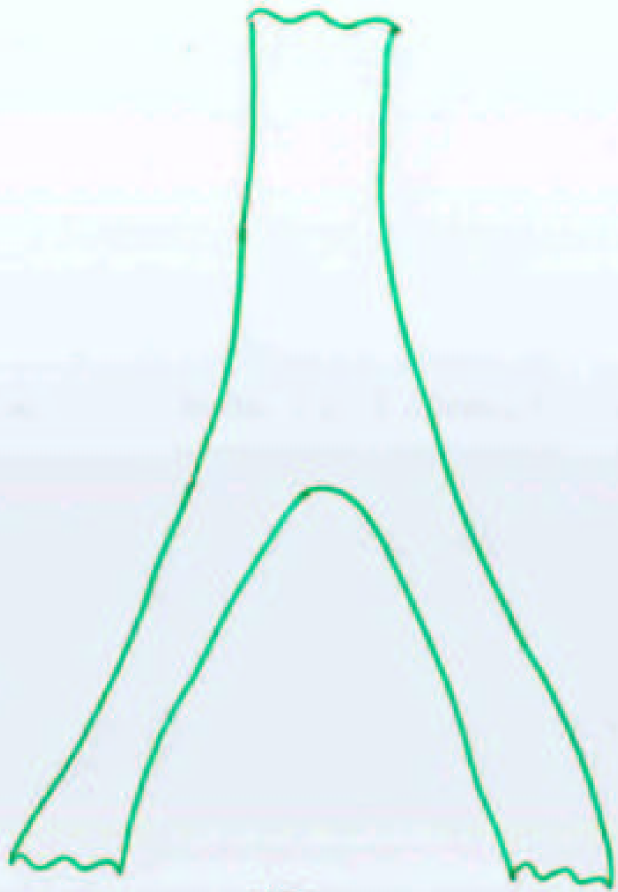
– Prof. T. Schücker

FERMIONS		BOSONS
	[SUSY]	
u d c s t d e ν_e μ ν_μ τ ν_τ	U(1)× SU(2)× SU(3) YM	γ W, Z g
	?	G

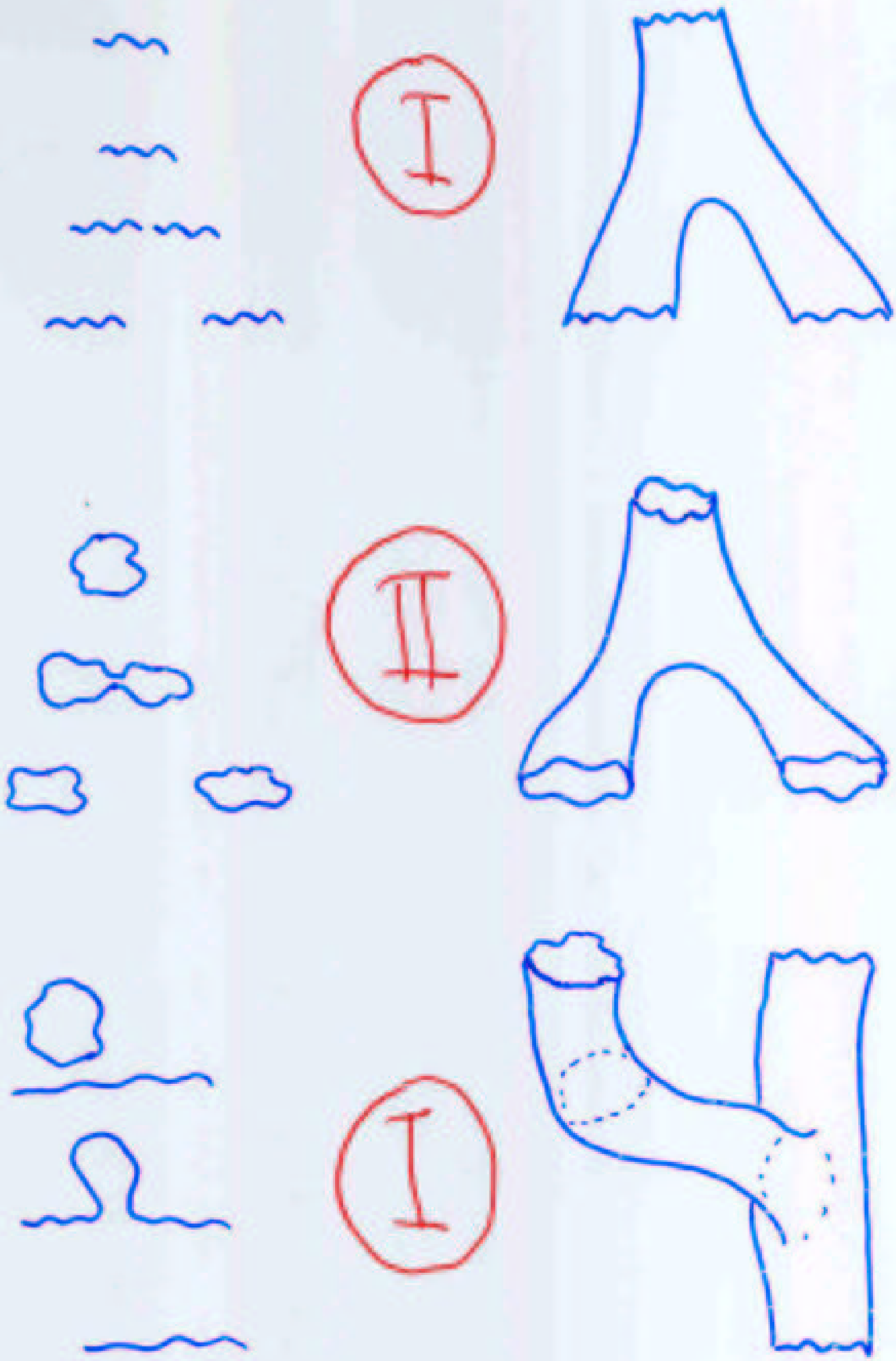
- charges ?
- couplings ?
- masses ?
- generations ?
- gravitation ?
- Planck-scale ?



QFT

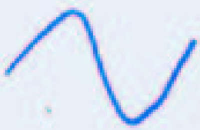


ST


I
II
I

Spectrum:

$a_1^{\dagger\mu}|vac\rangle$



$a_2^{\dagger\mu}|vac\rangle$

$a_3^{\dagger\mu}|vac\rangle$

$\vdots$

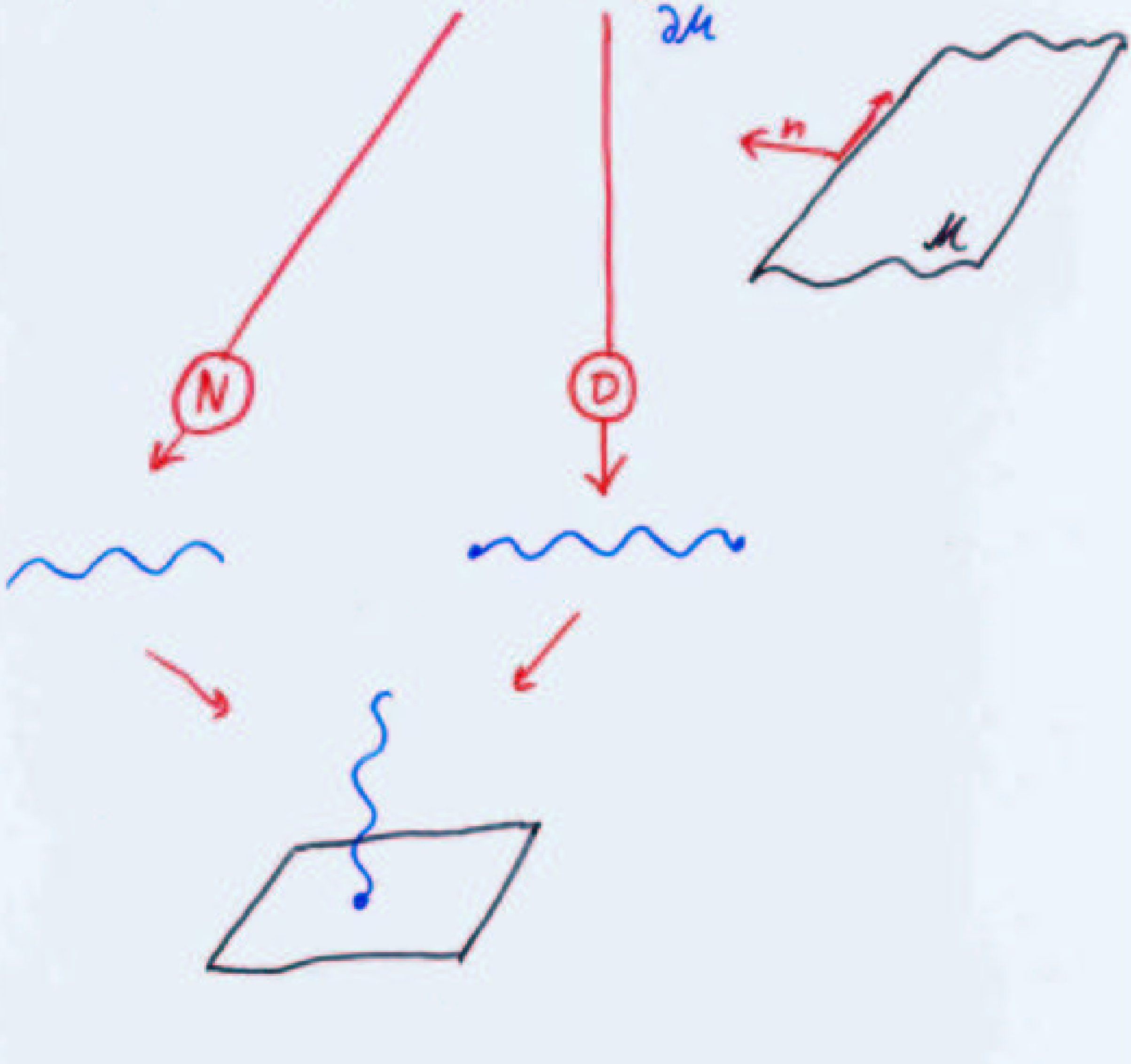
mass formula: $m^2 \sim N - c$

Action $\sim$ area of worldsheet

$$S[X] \sim \int_{\mathcal{M}} d\sigma\, d\tau\; \partial_\alpha X^\mu \partial^\alpha X_\mu$$

$$\delta S \overset{!}{=} 0 \;\longrightarrow\; \partial^2 X^\mu = 0$$

$$\delta S \overset{!}{=} 0 \;\longrightarrow\; \partial_n X^\mu \cdot \delta X_\mu \Big|_{\partial\mathcal{M}} = 0$$



D-membrane = D2 - brane ⟶ 1+2 dim.

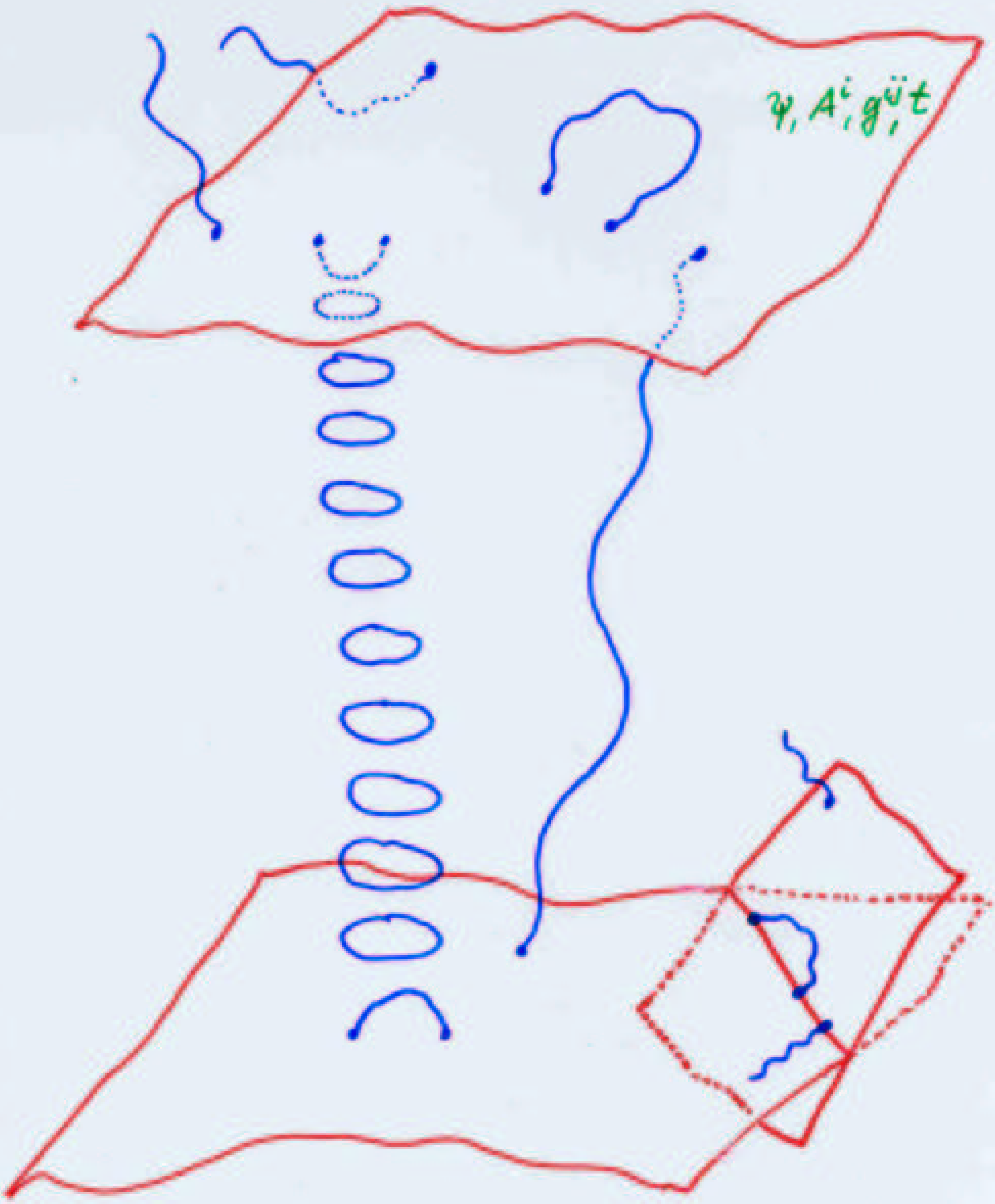
D-string = D1 - brane ⟶ 1+1 dim.

D-particle = D0 - brane ⟶ 1+0 dim.

D-instanton = D(-1) - brane ⟶ 0+0 dim.

⋮

D9 - brane ⟶ 1+9 dim.
(„space filling")


ψ, A^i, g^{ij}, t

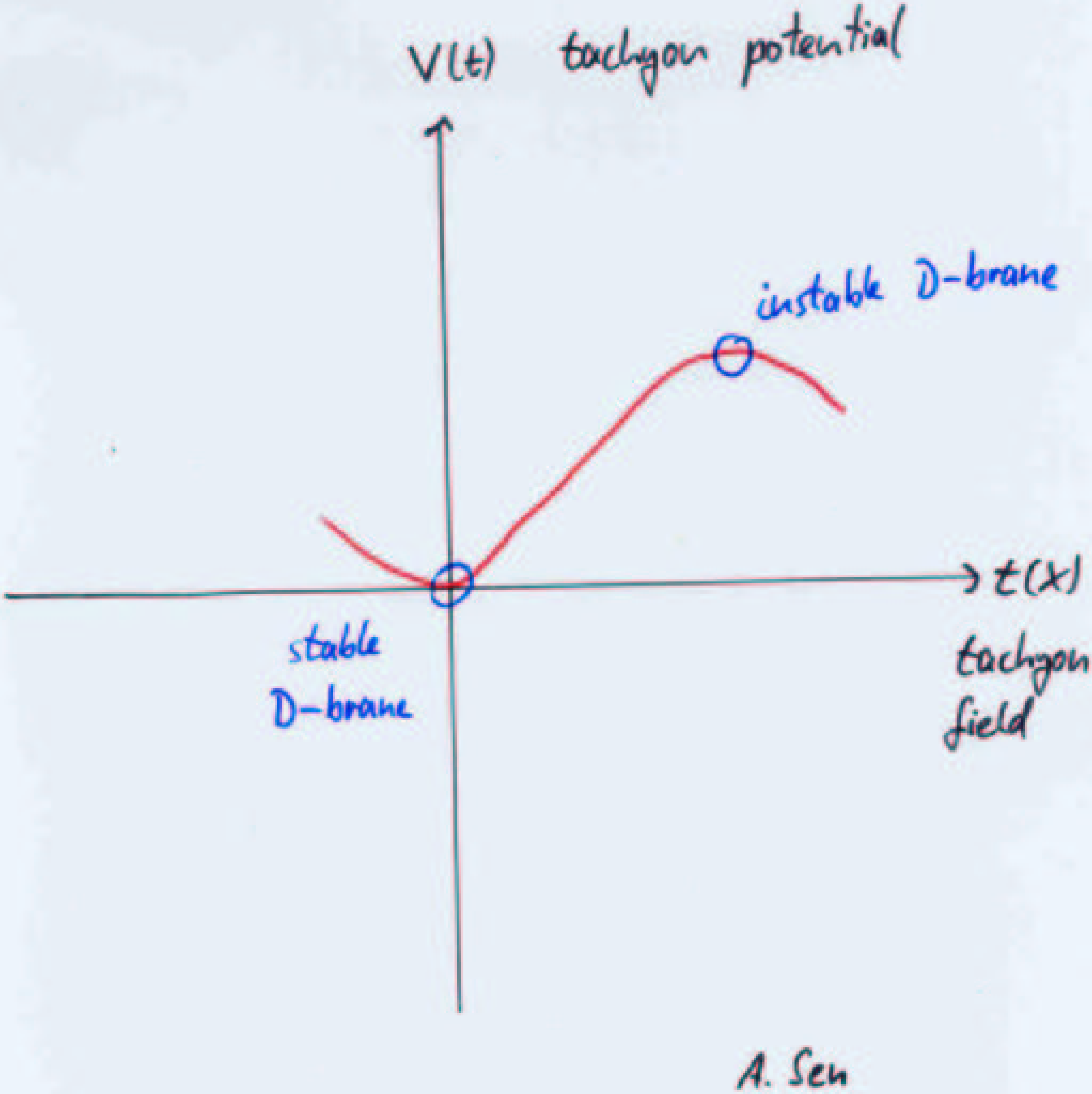
bosonic Dp: all branes are instable

susy Dp:

type IIA: D(2p+1) instable
D(2p) stable

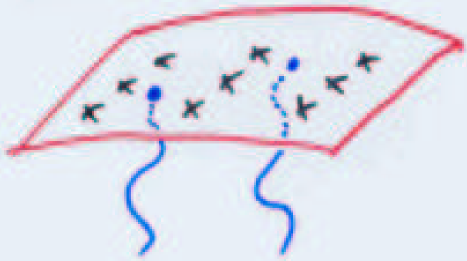
type IIB: D(2p+1) stable
D(2p) instable

Dp-D$\bar{p}$: instable



V(t) tachyon potential
instable D-brane
t(x)
tachyon field
stable D-brane
A. Sen

strings can generate „magnetic" background fields: $B_{\mu\nu}$



$$[X^\mu, X^\nu]_* = i\,\Theta^{\mu\nu}\,, \qquad \Theta \sim B^{-1}$$

$$\mathbb{R}^2 \longrightarrow \mathbb{R}^2_\Theta \longrightarrow \mathcal{H}$$

$$A \cdot B \longrightarrow A * B = A\, e^{i \overleftarrow{\partial}_\mu \Theta^{\mu\nu} \overrightarrow{\partial}_\nu} B$$

N. Seiberg, E. Witten

effective action for ncD2:

$$S \sim \int d^{2n}x \left(\frac{1}{\theta} D_\mu t D^\mu t - V_*(t) + \frac{1}{\theta} F^2 + \dots \right)$$

$$V_*(t) \sim t * t * t + \dots$$

static limit $\longrightarrow$ $S \sim \int dx^0 \, tr_{\mathcal{H}} V_*(t)$

$\Rightarrow V_*' = 0$ solitons!

properties:

- t solution $\Longrightarrow$ $t * t$ solution
- t is a projection
- $t(\lambda x) = \lambda t(x)$

Lagrange-density: $\mathcal{L} \sim \mathrm{tr}_{\mathcal{X}} V(t)$

- invariant under unitary transformations

$$t \mapsto u t \bar{u} \qquad u\bar{u} = 1 = \bar{u}u$$

- isometries

$$\langle \psi | \chi \rangle \mapsto \langle \psi | \bar{u} u | \chi \rangle = \langle \psi | \chi \rangle$$

- ∞-dim. Hilbert space

$$\bar{u}u = 1 \not\Rightarrow u\bar{u} = 1$$

- non-unitary isometries

$$S := \sum_{n=0}^{\infty} |n+1\rangle\langle n| \qquad S: |n\rangle \mapsto |n+1\rangle$$

e.g. $\bar{S}S = \sum_{n=0} |n\rangle\langle n| = 1_{\mathcal{X}}$

$$S\bar{S} = \sum_{n=1} |n\rangle\langle n| = 1_{\mathcal{X}} - |0\rangle\langle 0|$$

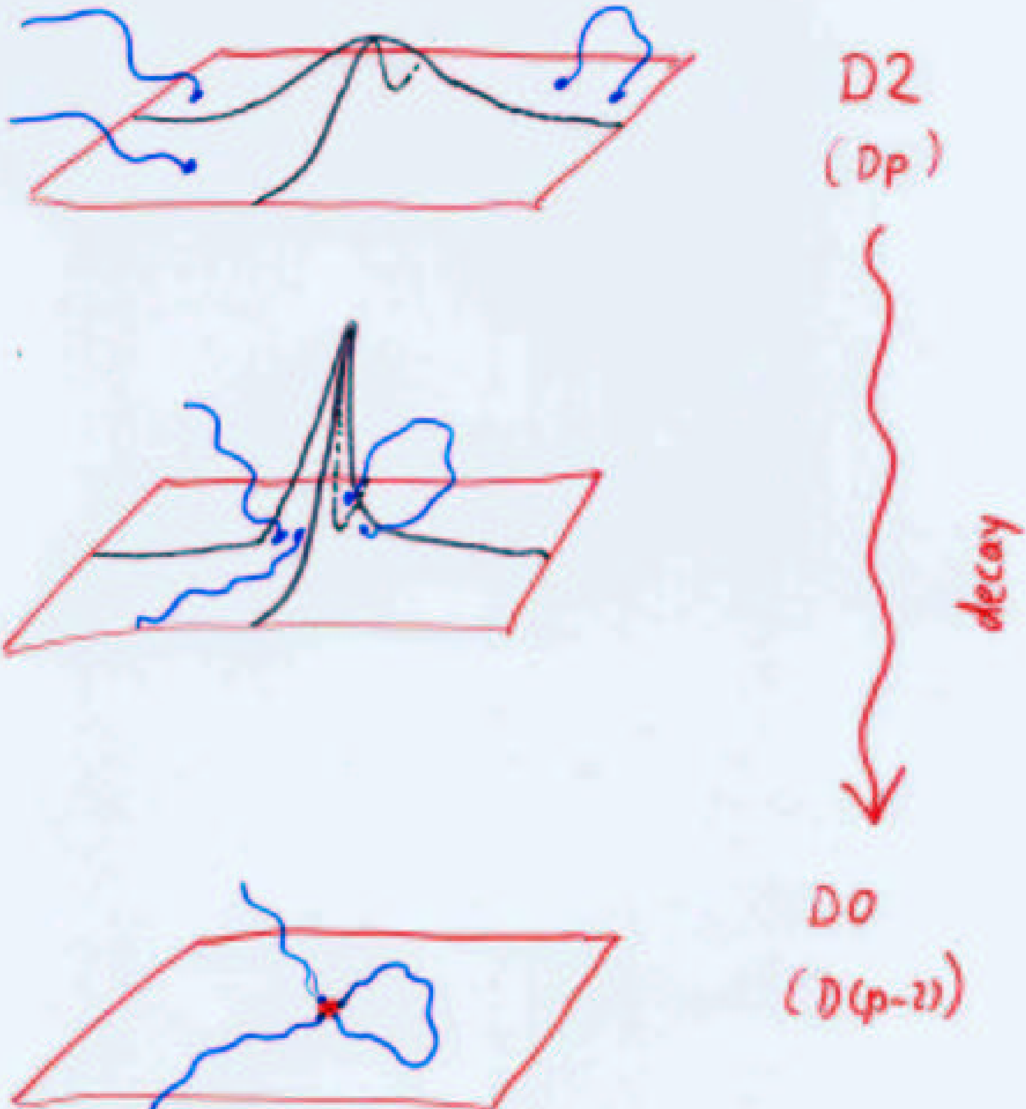
- construction of soliton solutions

t solution $\Rightarrow$ $S^n t \bar{S}^n$ solution

e.g. $t = S^n \lambda_n 1 \bar{S}^n = \lambda_n (1 - P_n)$

with $P_n = \sum_{k=0}^{n-1} |k\rangle\langle k|$

simplest solution: $t_0(r) = 2e^{-\theta r^2}$



summary:

- ST is a reasonable BASIS for a ToE
- ST contains D-branes
- tachyons induce D-brane decays
- magnetic fields generate noncommutative geometries
- D-branes are noncommutative solitons of the tachyon field

application:

- tachyon matter in cosmology
- solution of string field theories
- better understanding of new theories (M-theory ...)

Literatur

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