

# Brief Review on String Field Theory

**Maiko Kohriki**

Elementary Particle Physics Group

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# Outline

## Open String Field Theory (SFT)

1. Motivation for SFT
2. Successful results in SFT
3. Problems in Superstring Field Theory

# Motivation of SFT — Point Particle

## Quantum Mechanics (1st quantization)

- Dynamics of a particle in the given background
- No creation or annihilation



## Field Theory (2nd quantization)

- Non-perturbative phenomena (soliton, instanton,...)
- Form of potential
- Vacuum

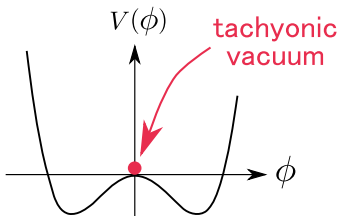


Figure: Higgs potential

# Motivation of SFT — String

## String theory (1st quantization)

string oscillation modes  $\Leftrightarrow$  fields

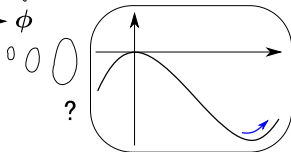
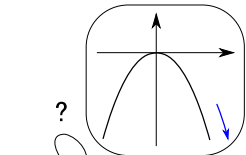
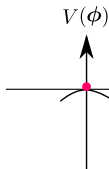


Open bosonic string:

field	$\phi(x)$	$A^\mu(x)$	$\dots$
$(\text{mass})^2$	$-\frac{4}{\alpha'}$	$0$	$\dots$

$\uparrow$   
tachyon

Existence of tachyon  
 $\downarrow$   
unstable vacuum



**String Field Theory (2nd quantization)**

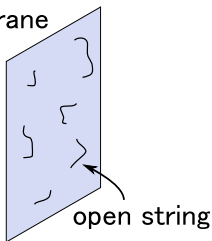
# D-brane

D $p$ -brane:  $(p + 1)$ -dimensional object

D1-brane  $\rightarrow$  line

D25-brane  $\rightarrow$  spacetime filling  
(critical dimension is 26-dim)

D-brane

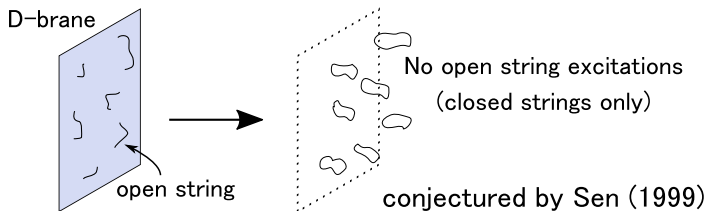


Open strings can end on D-brane



Open string theory  
is the theory on D-brane

# Successful results in SFT



→ **SFT proved Sen's conjecture**

[Schnabl (2005)], [Ellwood, Schnabl (2006)]

**Other vacuum solutions:** (→ new properties of D-branes?)

Static solutions [Eler, Schnabl (2009)], ...

Marginal deformation, rolling tachyon, ...

Lump solution [Bonora, Maccaferri, Tolla (2010)]

Multiple-brane solution [Murata, Schnabl (in progress)]

# Superstring Field Theory

I reviewed some remarkable results in **Bosonic** SFT.

→ How about **Super**string Field Theory?

⇒ Some problems remain unresolved.

Open Superstring Field Theory (SSFT):

- Cubic type
  - ▶ Analytic solutions
  - ▶ **[problems]** Gauge fixing procedure
    - associated with **'picture'**
- Wess-Zumino-Witten type

# What is 'picture' ?

super ghosts  $\beta(z), \gamma(z)$   $[\gamma_s, \beta_r] = \delta_{s+r,0}$

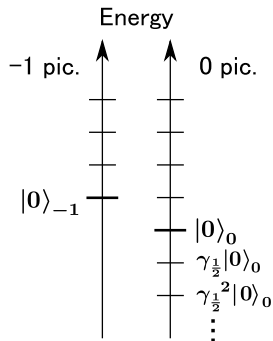
**$l$ -picture Fock vacuum** ( $l$ : picture number)

$$\beta_r |0\rangle_l = 0 \quad (r > -\frac{3}{2} - l), \quad \gamma_r |0\rangle_l = 0 \quad (r > \frac{1}{2} + l)$$

superstring  $\rightarrow$   $\begin{cases} \text{Neveu-Schwarz sector} \\ \text{Ramond sector} \end{cases}$

for Neveu-Schwarz (NS) string:

picture	creation	annihilation
-1	$\dots, \beta_{-\frac{3}{2}}, \beta_{-\frac{1}{2}}$	$\beta_{\frac{1}{2}}, \beta_{\frac{3}{2}}, \dots$
natural	$\dots, \gamma_{-\frac{3}{2}}, \gamma_{-\frac{1}{2}}$	$\gamma_{\frac{1}{2}}, \gamma_{\frac{3}{2}}, \dots$
0	$\dots, \beta_{-\frac{3}{2}}$	$\beta_{-\frac{1}{2}}, \beta_{\frac{1}{2}}, \dots$
unnatural	$\dots, \gamma_{-\frac{1}{2}}, \gamma_{\frac{1}{2}}$	$\gamma_{\frac{3}{2}}, \dots$





# Our research interest

Cubic SSFT [Witten (1986)] (in natural picture)

→ **Problem**: divergent contact term

⇒ **Modified Cubic SSFT**

[Preitschopf-Thorn-Yost, Arefeva-Medvedev-Zubarev (1990)]

NS string fields in **0-picture** (Ramond fields in natural picture)

We work on the problems associated with picture:

## Our approaches

- 1st quantization of 0-picture NS string

[MK, Kunitomo, Murata (2010)]

- Gauge fixing (compatible with perturbative calculations)

[MK, Kugo, Kunitomo, Murata (in progress)]