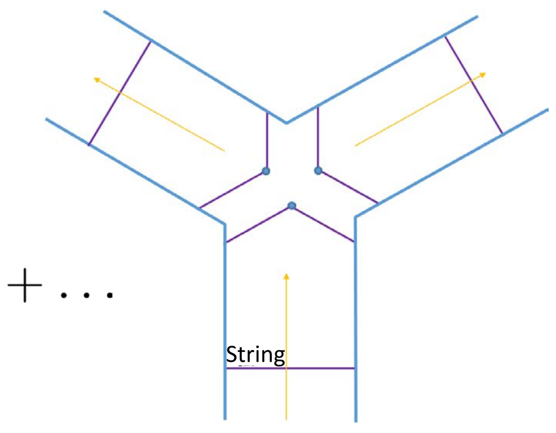
Singular Gauge Transformation and the Erler-Maccaferri Solution in Bosonic Open SFT

Nihon Univ. Sugita Kazuhiro

1 Introduction



■ String Field

$$\Psi = T(X)\hat{c}_1|0\rangle + A_\mu(X)\hat{\alpha}^\mu_{-1}\hat{c}_1|0\rangle + \frac{i}{\sqrt{2}}B(X)\hat{c}_0|0\rangle + \dots$$

■ Action [Witten '86]

$$S = -\frac{1}{g^2}\mathrm{Tr}[\frac{1}{2}\Psi * Q\Psi + \frac{1}{3}\Psi*\Psi*\Psi]$$

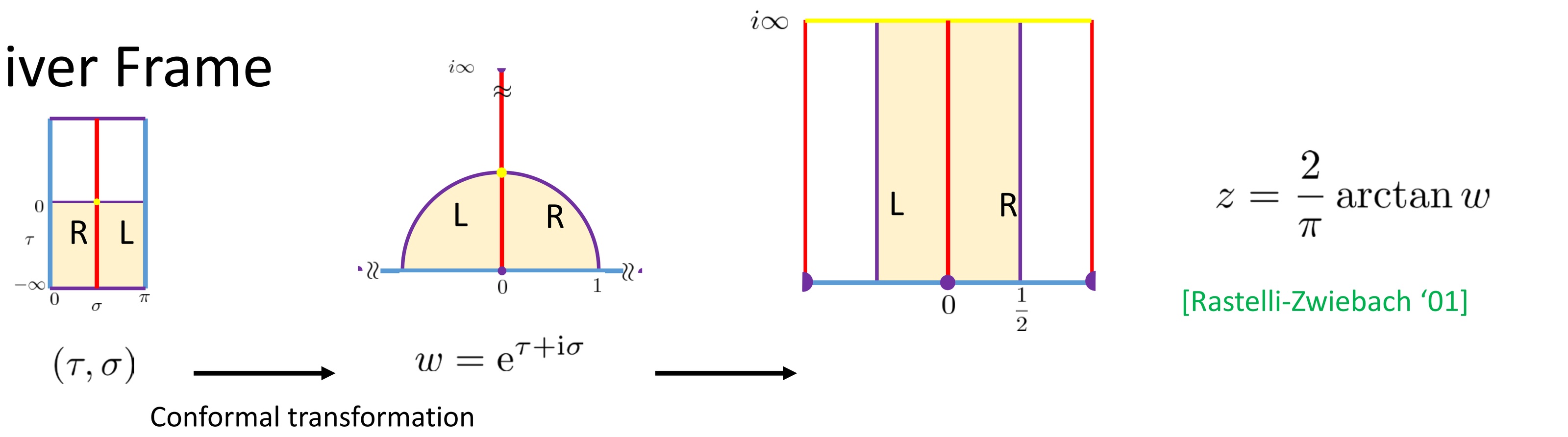
＊ Product : Midpoint interaction

Q : BRS operator

eq. of motion

$$Q\Psi + \Psi*\Psi = 0$$

■ Sliver Frame



$$z = \frac{2}{\pi}\arctan w$$

[Rastelli-Zwiebach '01]

■ KBc Algebra [Okawa '06]

$$[K,B]=0 \quad \{B,c\}=1 \quad B^2=c^2=0$$

$$QB = K \quad QK=0 \quad Qc = cKc$$

$$K = \int\frac{dz}{2\pi i}\hat{T}(z)|\mathrm{id}\rangle$$

$$B = \int\frac{dz}{2\pi i}\hat{b}(z)|\mathrm{id}\rangle$$

$$c = \hat{c}(0)|\mathrm{id}\rangle$$

$$|\mathrm{id}\rangle * \varphi = \varphi * |\mathrm{id}\rangle = \varphi$$

2 Gauge Transformation

■ Pure-gauge-form Solution [Okawa '06]

$$\Psi = cB\frac{K}{G(K)}c(1-G(K)) = UQU^{-1}$$

$$U_i = Bc + cBG_i(K)$$

$$U_iU_j = Bc + cBG_i(K)G_j(K)$$

$$U_i^{-1} = Bc + cB\frac{1}{G_i(K)}$$

Multiple brane Solution

ex.) Tachyon Vacuum Solution (D-brane × 0)

Perturbative Vacuum Solution (D-brane × 1)

Double Brane Solution (D-brane × 2)

■ Singular Gauge Transformation

$$G(K)|_{K\to 0} \sim K^{m_0}$$

$$G(K)|_{K\to -\infty} \sim (\frac{1}{K})^{m_\infty}$$

ex.)

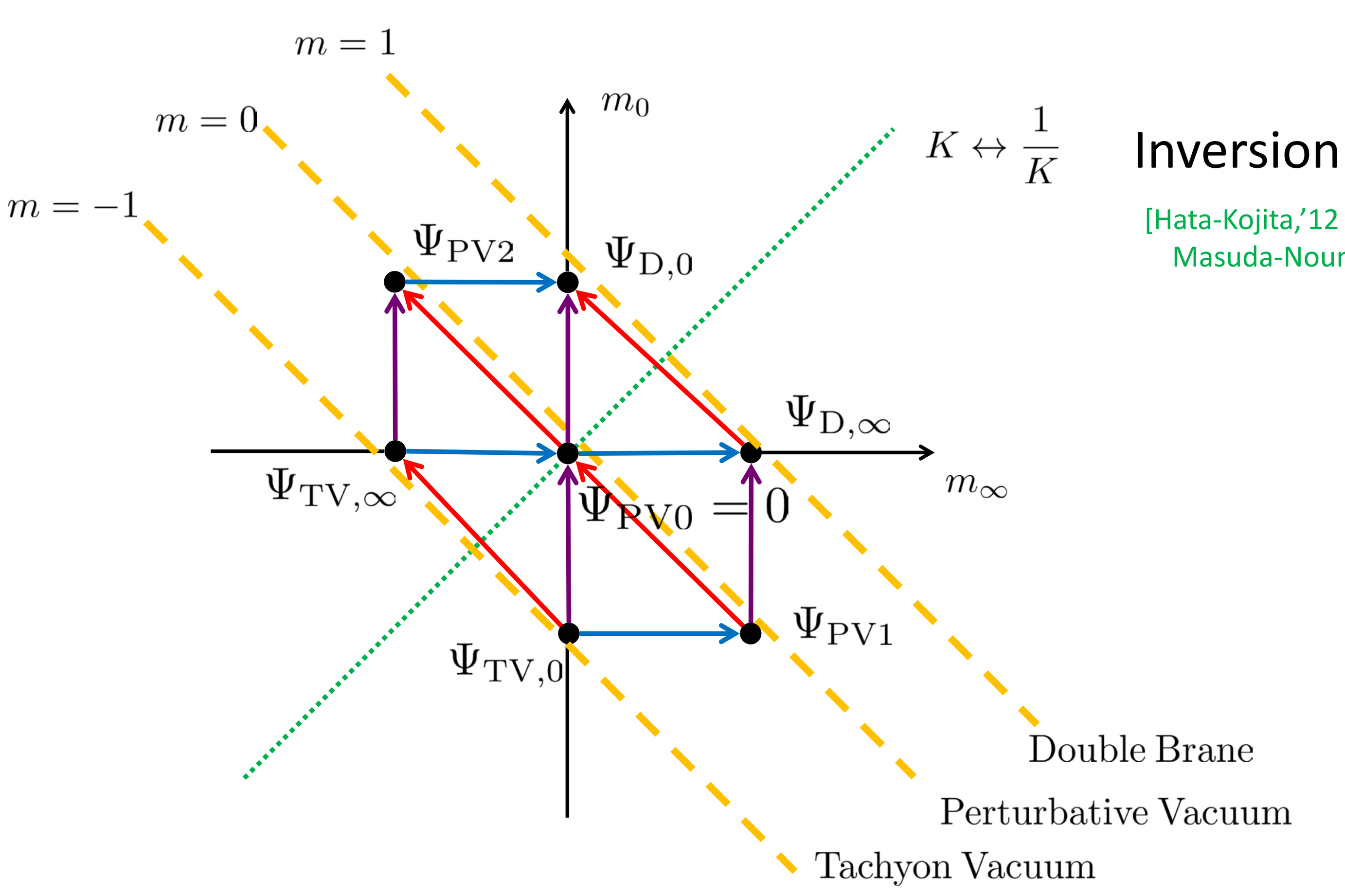
$$-\frac{K}{1-K} = \frac{1}{1-\frac{1}{K}} = -(K^1+\dots) = (\frac{1}{K})^0 + \dots$$

$$m = 1 + 0 = +1$$

Multiplicity (Singularity)

$$m = m_0 + m_\infty$$

[Murata-Schnabl '11, Hata-Kojita '12, Masuda-Noumi-Takahashi '12]



Inversion symmetry

[Hata-Kojita,'12 Masuda-Noumi-Takahashi '12, Erler '12]

$$U_{\mathrm{P}} = Bc + cB(-\frac{K}{1-K})$$

$$U_{\mathrm{R}} = Bc + cB(-K)$$

$$U_{\mathrm{B}} = Bc + cB(\frac{1}{1-K})$$

$$\Psi_{\mathrm{TV},0} = cB(K-1)c\frac{1}{1-K}$$

[Erler-Schnabl '09, ...]

$$\Psi_{\mathrm{PV1}} = -c(1+K)$$

[Arroyo '10, Zeze '10]

$$\Psi_{\mathrm{D},0} = -cB\frac{K^2}{1-K}c\frac{1}{K}$$

[Murata-Schnabl '11, Hata-Kojita '12, ...]

$$\Psi_{\mathrm{PV2}} = -cBK^2c\frac{1+K}{K}$$

3 Gauge Transformation for Lump Solution

■ Lump Solution : D24 brane [Erler-Maccaferri '14]

$$\Psi_{\mathrm{Lump}} = \Psi_{\mathrm{TV}} - \Sigma_{\mathrm{L}}\Psi_{\mathrm{TV}}\Sigma_{\mathrm{R}}$$

$\Sigma_{\mathrm{L,R}}$: ND twist operator (X^1)

$$X_1 \simeq X_1 + 2\pi R$$

$$\Sigma_{\mathrm{L,R}} = Q_{\mathrm{TV}}[A_{\mathrm{TV}}\sigma_{\mathrm{L,R}}]$$

$$Q_{\mathrm{TV}}\ \varphi = Q\varphi + [\Psi_{\mathrm{TV}},\varphi]_{\pm=(-)^\varphi}$$

$$A_{\mathrm{TV}} = B\frac{1}{G_{\mathrm{P}}K}$$

■ Gauge Transformation

$$\Psi' = U_{\mathrm{P}}(Q+\Psi_{\mathrm{Lump}})U_{\mathrm{P}}^{-1} = \underbrace{U_{\mathrm{P}}(Q+\Psi_{\mathrm{TV}})U_{\mathrm{P}}^{-1}}_{0} - U_{\mathrm{P}}\Sigma_{\mathrm{L}}\Psi_{\mathrm{TV}}\Sigma_{\mathrm{R}}U_{\mathrm{P}}^{-1}$$

$$(\ U_{\mathrm{P}}(Q+\Psi_{\mathrm{TV}})U_{\mathrm{P}}^{-1} = U_{\mathrm{P}}QU_{\mathrm{P}}^{-1} + U_{\mathrm{P}}(U_{\mathrm{P}}^{-1}QU_{\mathrm{P}})U_{\mathrm{P}}^{-1} = 0\ )$$

■ Energy

$$\mathrm{Tr}[\Psi'^3] = -\mathrm{Tr}[\Sigma_{\mathrm{L}}\Psi_{\mathrm{TV}}^3\Sigma_{\mathrm{R}}] = -\mathrm{Tr}[\Psi_{\mathrm{TV}}^3]_{\mathrm{BCFT}*}$$

$$E(\Psi') = -\frac{g_*}{2\pi^2}$$

$$E(\Psi_{\mathrm{Lump}}) = \frac{g_*-g_0}{2\pi^2} \qquad E(\Psi_{\mathrm{TV}}) = -\frac{g_0}{2\pi^2} = -E(D25)$$

g_0 : BCFT_0 partition function

g_* : BCFT_* partition function

$$E(\Psi') = E(\Psi_{\mathrm{Lump}}) + E(D25)$$

→ Ψ' : D24+D25

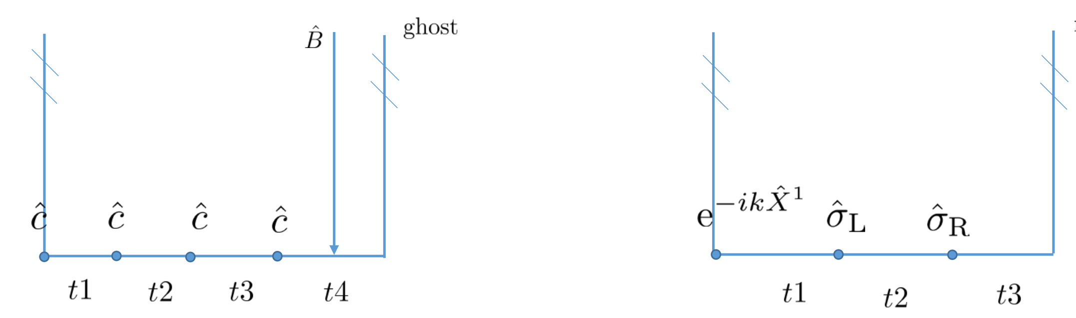
■ Profile of Tachyon field

$$T(X) \leftarrow \langle c\partial c\, e^{-i\frac{n}{R}X^1}, \Psi'\rangle \qquad \langle\hat{c}_{-1}\hat{c}_0\hat{c}_1\rangle \sim 1$$

Explicit form of Ψ'

$$\Psi' = U_{\mathrm{P}}(Q+\Psi_{\mathrm{Lump}})U_{\mathrm{P}}^{-1} = -cK\sigma_{\mathrm{L}}\frac{1}{1-K}\sigma_{\mathrm{R}}BKc\frac{1}{K}$$

Correlator in Sliver frame

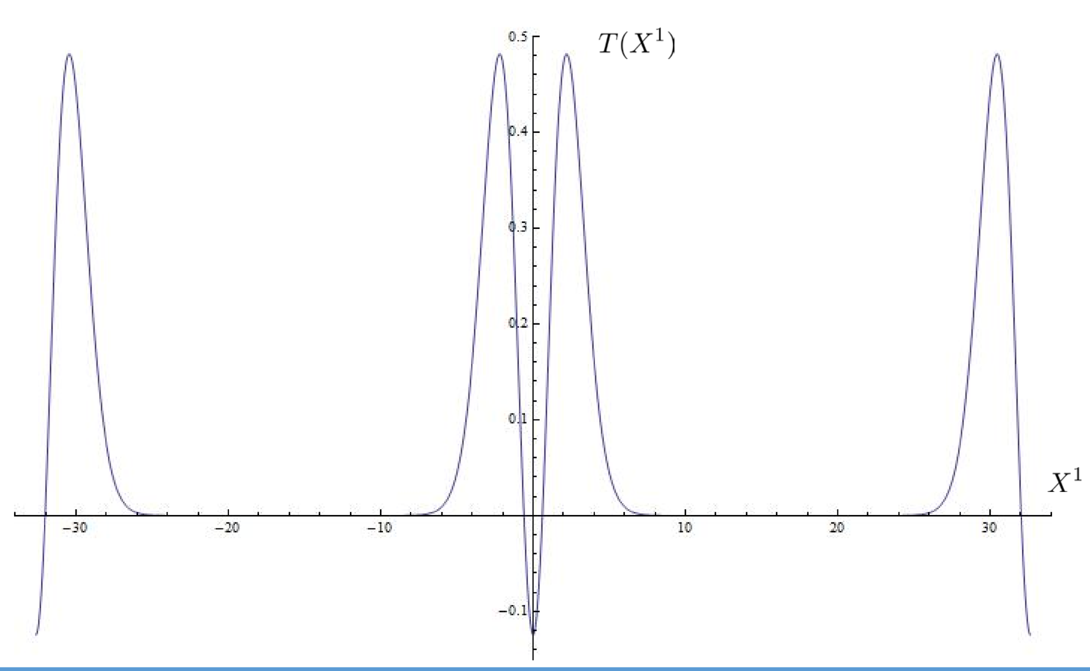


[Mukhopadhyay '01, Hashimoto '97, Recknagel-Schomerus -Fröhlich-Grandjean '00, Kiermaier-Okawa-Soler '11, ...]

$$\mathrm{Tr}[Bc\Omega^{t_1}c\Omega^{t_2}c\Omega^{t_3}c\Omega^{t_4}]$$
$$= -\frac{L^2}{4\pi^3}[t_3\sin 2\theta_1 - (t_2+t_3)\sin 2\theta_{1+2} - t_2\sin 2\theta_4 + t_1\sin 2\theta_3 - (t_1+t_2)\sin 2\theta_{2+3} + (L-t_4)\sin 2\theta_2]$$

$$\mathrm{Tr}[e^{-ikX^1}\Omega^{t_1}\sigma_{\mathrm{L}}\Omega^{t_2}\sigma_{\mathrm{L}}\Omega^{t_3}] = \frac{2^{-2k^2}}{R}[\frac{2\sin\theta_2}{L\sin\theta_1\sin\theta_{1+2}}]^{k^2}$$

$$\theta_i = \frac{\pi t_i}{L} \qquad L = \sum_i t_i \qquad k = \frac{n}{R}$$

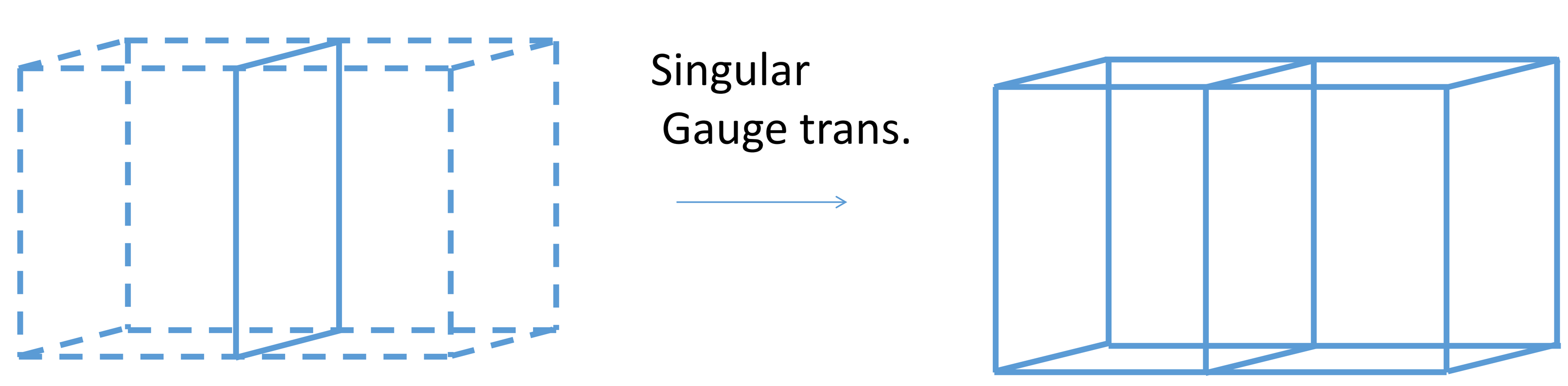


$$-2\pi R \le X^1 \le 2\pi R$$

$$R = 3\sqrt{3}$$

4 Conclusion and Future Work

■ Gauge transformation for D24 Lump Solution



Tachyon Vacua $+\ \mathrm{D24}|_{X^1=0}$

Perturbative Vacua $+\ \mathrm{D24}|_{X^1=0}$

■ Energy of Ψ' (eq. of mo (strong))

: 4 and 6 point function of ND twist operator

■ Another Gauge Transformation for Lump Solution

■ Multiple brane Solution

: Pure-gauge form solution – EM solution