Marginal Deformations and Classical Solutions in Open Superstring Field Theory

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Introduction

- String Field Theory (SFT) is a candidate for nonperturbative formulation of string theory.
- In bosonic SFT, some phenomena such as tachyon condensation have been investigated extensively using *level truncation numerically and exact solutions analytically*.
- In super SFT, similar works are done although concrete and detailed analysis is less developed than bosonic case.
- *We have constructed a class of exact classical solutions to super SFT and studied their properties.*

Contents

A brief review of super SFT

- We use Berkovits' open super SFT.

The action for NS(+) sector is given by

WZW type

$$S[\Phi]$$
$$= \frac{1}{2g^2}\langle\langle (e^{-\Phi}Q_B e^{\Phi})(e^{-\Phi}\eta_0 e^{\Phi}) - \int_0^1 dt (e^{-t\Phi}\partial_t e^{t\Phi})\{(e^{-t\Phi}Q_B e^{t\Phi}), (e^{-t\Phi}\eta_0 e^{t\Phi})\}\rangle\rangle$$
$$= -\frac{1}{g^2}\int_0^1 dt \langle\langle (\eta_0\Phi)(e^{-t\Phi}Q_B e^{t\Phi})\rangle\rangle$$

[Berkovits-Okawa-Zwiebach(2004)]

$$= -\frac{1}{g^2}\sum_{M,N=0}^{\infty}\frac{(-1)^M}{(M+N+2)(M+N+1)M!N!}\langle\langle (\eta_0\Phi)\Phi^M(Q_B\Phi)\Phi^N\rangle\rangle\,.$$

String field Φ : ghost number 0, picture number 0, Grassmann even, represented by $X^\mu, \psi^\mu, b, c, \phi, \xi, \eta \quad (\beta = e^{-\phi}\partial\xi, \gamma = \eta e^{\phi})$

$$Q_B = \oint \frac{dz}{2\pi i}(c(T^m - \tfrac{1}{2}(\partial\phi)^2 - \partial^2\phi + \partial\xi\eta) + bc\partial c + \eta e^{\phi}G^m - \eta\partial\eta e^{2\phi}b)(z)$$

$$\eta_0 = \oint \frac{dz}{2\pi i}\eta(z)$$

$Q_{\rm B}, \eta_0$ such as $Q_{\rm B}^2 = 0,\ \eta_0^2 = 0,\ \{Q_{\rm B}, \eta_0\} = 0$

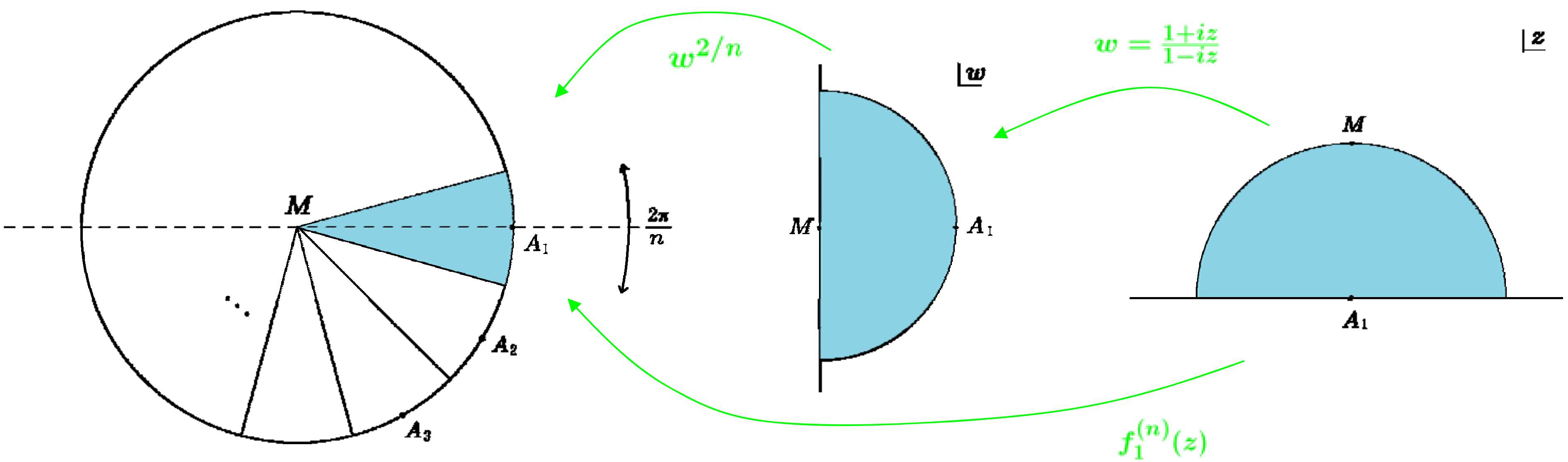
are derivation with respect to the star product:

$$Q_{\rm B}(A * B) = Q_{\rm B}A * B + (-1)^{|A|} A * Q_{\rm B}B, \quad \eta_0(A * B) = \eta_0 A * B + (-1)^{|A|} A * \eta_0 B$$

The star product is given by 3-string vertex: $|A * B\rangle = \langle A|\langle B|V_3\rangle$

n-string vertex is defined using CFT correlator in the *large* Hilbert space:

$$\langle V_n|A_1\rangle \cdots |A_n\rangle = \langle\langle A_1 \cdots A_n \rangle\rangle := \left\langle f_1^{(n)}[\mathcal{O}_{A_1}] \cdots f_n^{(n)}[\mathcal{O}_{A_n}] \right\rangle$$
$$= \langle A_1|(\cdots(A_2 * A_3) * \cdots * A_{n-1}) * A_n\rangle = \langle A_1|A_2 * \cdots * A_n\rangle$$



- Variation of the action: $\delta S = \frac{1}{g^2}\langle\langle e^{-\Phi}\delta e^{\Phi}\,\eta_0(e^{-\Phi}Q_{\mathrm{B}}e^{\Phi})\rangle\rangle$
- Equation of motion: $\eta_0(e^{-\Phi}Q_{\mathrm{B}}e^{\Phi}) = 0$
- Gauge transformation: $\delta e^{\Phi} = Q_{\mathrm{B}}\Lambda_0 * e^{\Phi} + e^{\Phi} * \eta_0\Lambda_1$
- Re-expansion of the action around a classical solution Φ_0 :

$$S[\Phi] = S[\Phi_0] + S'[\Phi'] \qquad (\ e^{\Phi} = e^{\Phi_0}e^{\Phi'}\ )$$

where $S'[\Phi'] = S[\Phi']|_{Q_{\mathrm{B}}\to Q'_{\mathrm{B}}}$

New BRST operator Q'_{B} is a derivation such as

$$Q'_{\mathrm{B}}A = Q_{\mathrm{B}}A + e^{-\Phi_0}Q_{\mathrm{B}}e^{\Phi_0} * A - (-1)^{|A|}A * e^{-\Phi_0}Q_{\mathrm{B}}e^{\Phi_0}$$

which satisfies $Q'^2_{\mathrm{B}} = 0,\ \{Q'_{\mathrm{B}}, \eta_0\} = 0$

A class of classical solutions

- We find a class of classical solutions to EOM:

$$\Phi_0 = -\tilde{V}_L(F)I$$ where

$$\tilde{V}_L(F) \equiv \int_{C_{\rm left}} \frac{dz}{2\pi i} F(z)\tilde{v}(z), \quad F(-1/z) = z^2 F(z), \quad \tilde{v}(z) \equiv \frac{1}{\sqrt{2}} c\xi e^{-\phi}\psi(z),$$

and $|I\rangle$ is the identity string field.

In fact, we can compute $$e^{-\Phi_0} Q_{\rm B} e^{\Phi_0} = -V_L(F)I + \frac{1}{4}C_L(F^2)I$$ where

$$V_L(F) \equiv \int_{C_{\rm left}} \frac{dz}{2\pi i} F(z)v(z), \quad v(z) = \frac{i}{2\sqrt{\alpha'}} c\partial X(z) + \frac{1}{\sqrt{2}}\eta e^{\phi}\psi(z), \quad C_L(F^2) \equiv \int_{C_{\rm left}} \frac{dz}{2\pi i} F(z)^2 c(z).$$

⇨ $$\eta_0(e^{-\Phi_0} Q_{\rm B} e^{\Phi_0}) = 0$$ due to $$\eta_0|I\rangle = 0$$

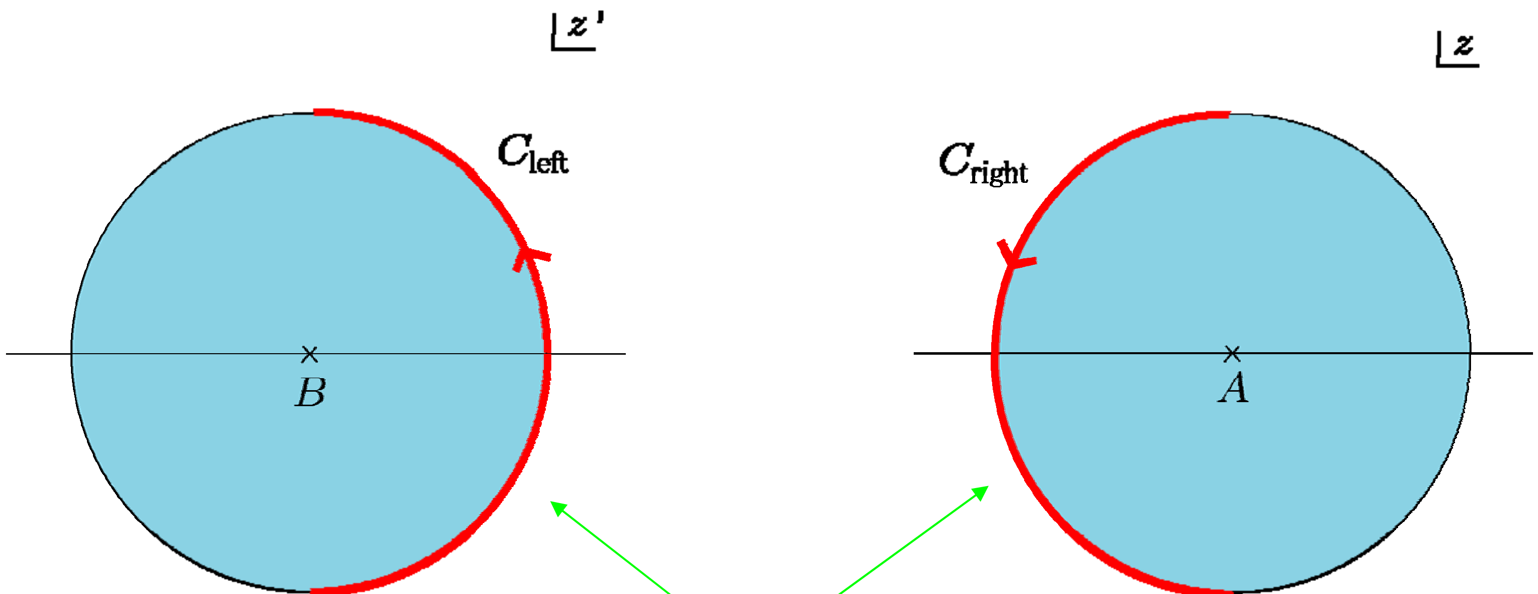
We have used following properties in calculations:

$$\Sigma_R(F)A * B = -(-1)^{|\sigma||A|} A * \Sigma_L(F)B,$$

$$\Sigma_R(F)I = -\Sigma_L(F)I, \quad \Sigma_L(F)I * A = \Sigma_L(F)A,$$ where

$$\Sigma_{L/R}(F) \equiv \int_{C_{\mathrm{left/right}}} \frac{dz}{2\pi i} F(z)\sigma(z), \quad F(-1/z) = z^{2(1-h)}F(z)$$

and $\sigma(z)$ is a primary field with conformal dimension h.



identified by $zz' = -1$ in $A * B$

Properties of our classical solutions

- Vacuum energy vanishes at our solution: $\Phi_0 = -\tilde{V}_L(F)I.$

By replacing F with tF, we have $\eta_0(e^{-t\Phi_0}Q_{\mathrm{B}}e^{t\Phi_0}) = 0.$

Therefore we can estimate as

$$S[\Phi_0] = \frac{1}{g^2}\int_0^1 dt\langle\langle\Phi_0\,\eta_0(e^{-t\Phi_0}Q_{\mathrm{B}}e^{t\Phi_0})\rangle\rangle = 0.$$

※ We have used Berkovits-Okawa-Zwiebach's expression of the action.

※ This derivation is rather direct than counterpart in *bosonic* SFT.

- $\Phi_0 = -\tilde{V}_L(F)I$ has well-defined oscillator expression in the sense that each coefficient is convergent.

Explicitly, the solution can be expanded as

$$
\begin{aligned}
&|\Phi_0\rangle \\
&= \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \frac{d\sigma}{\sqrt{2}\pi} e^{i\sigma} F(e^{i\sigma}) \Big[c_1 (2\cos\sigma)^{-1} + c_0 i \tan\sigma + c_{-1}\left(1 + (2\cos\sigma)^{-1}\right) \\
&\qquad\qquad + 2\sum_{m\geq 1}\left(c_{-2m} i \sin 2m\sigma + c_{-(2m+1)} \cos(2m+1)\sigma \right)\Big] \\
&\quad \times \left[\xi_0 + 2\sum_{l\geq 1}\left(\xi_{-2l}\cos 2l\sigma + \xi_{-(2l-1)} i \sin(2l-1)\sigma \right)\right] \\
&\quad \times \exp\left[\sum_{p\geq 1}\left(\frac{\cos 2p\sigma}{p} j_{-2p} + \frac{2i\sin(2p-1)\sigma}{2p-1} j_{-(2p-1)} \right)\right] e^{-\hat{\phi}_0} \\
&\quad \times \sum_{k=0}^{\infty}\Big[\psi_{-(2k+\frac{1}{2})} \sum_{q=0}^{k} \frac{(-1)^{k-q}(2(k-q))!}{2^{2(k-q)}((k-q)!)^2(2(k-q)-1)} \cos(2q+1)\sigma \\
&\qquad\qquad + \psi_{-(2k+\frac{3}{2})} \sum_{q=0}^{k} \frac{(-1)^{k-q}(2(k-q))!}{2^{2(k-q)}((k-q)!)^2(2(k-q)-1)} i \sin 2(q+1)\sigma \Big] |I\rangle \\
&= \frac{1}{\sqrt{2}}\Big(\int_{C_{\text{left}}} \frac{dz}{2\pi i} F(z) c_1 \xi_0 \psi_{-\frac{1}{2}} \\
&\quad + \int_{C_{\text{left}}} \frac{dz}{2\pi i} F(z)(z^{-1} - z)\left((c_0\xi_0 + c_1\xi_{-1} + c_1\xi_0 j_{-1})\psi_{-\frac{1}{2}} + c_1\xi_0\psi_{-\frac{3}{2}} \right) + \cdots \Big) e^{-\hat{\phi}_0} |I\rangle .
\end{aligned}
$$

The divergent from $(\cos\sigma)^{-1}$ at the midpoint is cancelled by $F(-1/z) = z^2 F(z)$.

The identity string field $|I\rangle$ can be expressed using oscillators:

$$|I\rangle = e^{E_{Xbc}+E_{\psi\phi\xi\eta}}|p^\mu = 0, q = 0\rangle$$ where

$$E_{Xbc} = \sum_{n\geq 1}\frac{-(-1)^n}{2n}\alpha^\mu_{-n}\alpha_{-n\mu} + \sum_{n\geq 2}(-1)^n c_{-n}b_{-n} - \sum_{k\geq 1}(-1)^k(2c_0 b_{-2k} + (c_1 - c_{-1})b_{-2k-1})$$

$$E_{\psi\phi\xi\eta} = \sum_{r,s\geq 1/2}\frac{I_{rs}}{2}\psi^\mu_{-r}\psi_{-s\mu} + \sum_{n\geq 1}\frac{(-1)^n}{2n}(j_{-n})^2 - \sum_{k\geq 1}\frac{(-1)^k}{k}j_{-2k} + \sum_{n\geq 1}(-1)^n\eta_{-n}\xi_{-n}$$

$$I_{rs} = \begin{cases} -\frac{r(2s-1)}{r^2-s^2}\left(\frac{-1}{4}\right)^{\frac{r+s}{2}}\frac{(r-\frac{1}{2})!(s-\frac{3}{2})!}{[(\frac{1}{2}(r-\frac{1}{2}))!(\frac{1}{2}(s-\frac{3}{2}))!]^2} & (r-\frac{1}{2}:\text{even}; s-\frac{1}{2}:\text{odd}) \\ -\frac{s(2r-1)}{r^2-s^2}\left(\frac{-1}{4}\right)^{\frac{r+s}{2}}\frac{(r-\frac{3}{2})!(s-\frac{1}{2})!}{[(\frac{1}{2}(r-\frac{3}{2}))!(\frac{1}{2}(s-\frac{1}{2}))!]^2} & (r-\frac{1}{2}:\text{odd}; s-\frac{1}{2}:\text{even}) \\ 0 & (\text{otherwise}) \end{cases},$$

The above Neumann coefficients are computed from $h_I(z) = 2z/(1-z^2)$ as 1-string LPP vertex: $\langle I|A\rangle = \langle h_I[\mathcal{O}_A(0)]\rangle$ in the large Hilbert space.
In particular, $Q_{\rm B}|I\rangle = 0$, $\eta_0|I\rangle = 0$.

- New BRST operator around this solution:

$$\begin{aligned} Q'_{\rm B} &= Q_{\rm B} - V_L(F) - V_R(F) + \frac{1}{4}(C_L(F^2) + C_R(F^2)) \\ &= e^{\frac{i}{2\sqrt{\alpha'}}(X_L(F)+X_R(F))} Q_{\rm B}\, e^{-\frac{i}{2\sqrt{\alpha'}}(X_L(F)+X_R(F))}, \end{aligned}$$

$$X_{L/R}(F) \equiv \int_{C_{\rm left/right}} \frac{dz}{2\pi i} F(z) X(z).$$

Therefore, noting $[X_{\rm L/R}(F), \eta_0] = 0,$ a field redefinition

$$\Phi'' = e^{-\frac{i}{2\sqrt{\alpha'}}(X_L(F)+X_R(F))}\Phi' = e^{-\frac{i}{2\sqrt{\alpha'}}X_L(F)I} * \Phi' * e^{\frac{i}{2\sqrt{\alpha'}}X_L(F)I}$$

reproduces the original action in the sense that

$$S[\Phi] = S[\Phi_0] + S'[\Phi'] = S[\Phi''].$$

$$\begin{array}{c} \shortparallel \\ 0 \end{array} \quad (\ e^{\Phi} = e^{\Phi_0} e^{\Phi'} \ )$$

By introducing the Chan-Paton factor i,j, this field redefinition becomes

$$\begin{aligned}\Phi''_{ij} &= e^{-\frac{i}{2\sqrt{\alpha'}}X_L(F_i)I} * \Phi'_{ij} * e^{\frac{i}{2\sqrt{\alpha'}}X_L(F_j)I} \\ &= e^{-\frac{i}{2\sqrt{\alpha'}}(X_L(F_i)+X_R(F_j))}\Phi'_{ij} = e^{-\frac{i}{2\sqrt{\alpha'}}(f_i-f_j)\hat{x}+\cdots}\Phi'_{ij}\end{aligned}$$

where $f_i = \int_{C_{\rm left}} \frac{dz}{2\pi i} F_i(z) = -\int_{C_{\rm right}} \frac{dz}{2\pi i} F_i(z), \quad X(z) = \hat{x} + \cdots .$

Namely, it induces a momentum shift: $p \to p - \frac{1}{2\sqrt{\alpha'}}(f_i - f_j).$

This effect is just the same as background Wilson lines.

• Our solution can be rewritten as a *locally* pure gauge form:

$$e^{\Phi_0} = \exp\left\{Q_{\rm B}\left(-\frac{1}{2\sqrt{\alpha'}}\Omega_L(F)I\right)\right\} * \exp\left\{\eta_0\left(-\frac{i}{2\sqrt{\alpha'}}\xi_0 X_L(F)I\right)\right\},$$

$$\Omega_L(F) \equiv \int_{C_{\rm left}} \frac{dz}{2\pi i} F(z)\, i\, c\xi\partial\xi e^{-2\phi}\, X(z),$$

which becomes nontrivial when the direction of X is compactified.

Comment on Ramond sector and supersymmetry

- For string fields (Φ, Ψ) in (NS(+),R(+)) sector, (which have (gh#,pic#)=(0,0),(0,1/2), respectively,) the equations of motion are given by [Berkovits]

$$f_1 \equiv \eta_0(e^{-\Phi}Q_{\mathrm{B}}e^{\Phi}) + (\eta_0\Psi)^2 = 0,$$
$$f_2 \equiv e^{-\Phi}(Q_{\mathrm{B}}(e^{\Phi}(\eta_0\Psi)e^{-\Phi}))e^{\Phi} = 0\,.$$

Under the gauge transformation

$$\begin{cases} \delta e^{\Phi} = e^{\Phi}(\eta_0\Lambda_1 - \{\eta_0\Psi, \Lambda_{\frac{1}{2}}\}) + (Q_{\mathrm{B}}\Lambda_0)e^{\Phi}\,, \\ \delta\Psi = \eta_0\Lambda_{\frac{3}{2}} + [\Psi, \eta_0\Lambda_1] + Q_{\mathrm{B}}\Lambda_{\frac{1}{2}} + \{e^{-\Phi}Q_{\mathrm{B}}e^{\Phi}, \Lambda_{\frac{1}{2}}\}\,, \end{cases}$$

the equations of motion transform covariantly:

$$\delta f_1 = [f_1, \eta_0\Lambda_1] - \eta_0[f_2, \Lambda_{\frac{1}{2}}]\,,$$
$$\delta f_2 = [f_1, Q_{\mathrm{B}}\Lambda_{\frac{1}{2}} + \{e^{-\Phi}Q_{\mathrm{B}}e^{\Phi}, \Lambda_{\frac{1}{2}}\}] + [f_2, \eta_0\Lambda_1] - \{[f_2, \Lambda_{\frac{1}{2}}], \eta_0\Psi\}\,.$$

Λ_P : gauge parameter with pic# P.

Let us consider a particular parameter $\Lambda_{\frac{1}{2}} = \epsilon_\alpha \int_{C_{\rm left}} \frac{dz}{2\pi i} \xi S^\alpha_{(-1/2)}(z) I.$

(This is an analogy with counterpart in Witten's *cubic* super SFT.)

We *define* a global space-time SUSY transformation:

$$\delta_\epsilon e^\Phi = -e^\Phi \mathcal{S}(\epsilon)\eta_0\Psi, \quad \delta_\epsilon(\eta_0\Psi) = \eta_0\mathcal{S}(\epsilon)(e^{-\Phi}Q_{\rm B}e^\Phi),$$

$$\mathcal{S}(\epsilon) \equiv \epsilon_\alpha \oint \frac{dz}{2\pi i}\xi S^\alpha_{(-1/2)}(z).$$

The equations of motion transform as

$$\begin{aligned} \delta_\epsilon f_1 &= \eta_0\mathcal{S}(\epsilon) f_2 \,, \\ \delta_\epsilon f_2 &= -\{Q_{\rm B}, \mathcal{S}(\epsilon)\} f_1 + [f_1, \mathcal{S}(\epsilon)(e^{-\Phi}Q_{\rm B}e^\Phi)] + \{\mathcal{S}(\epsilon) f_2, \eta_0\Psi\}, \end{aligned}$$

which preserve EOMs: $(f_1, f_2) = (0,0) \quad \Rightarrow \quad (\delta_\epsilon f_1, \delta_\epsilon f_2) = (0,0).$

⇩

Our solution $(\Phi, \Psi) = (-\tilde{V}_L(F) I, 0)$ is invariant under this transformation.

Note: δ_ϵ reproduces usual SUSY transformation in 10d super Yang-Mills theory at linearized level and on-shell.

Concretely, for massless fields, we expand string fields as

$$|\Phi_A\rangle = \int \frac{d^{10}p}{(2\pi)^{10}}(\tilde{A}_\mu(p)c\xi e^{-\phi}\psi^\mu(0) + \tilde{B}(p)c\partial c\xi\partial\xi e^{-2\phi}(0))|p^\mu, q=0\rangle,$$
$$|\Psi_\lambda\rangle = \int \frac{d^{10}p}{(2\pi)^{10}}\tilde{\lambda}_\alpha(p)\xi S^\alpha_{(-1/2)}c(0)|p^\mu, q=0\rangle\,,$$

and we have calculated $\delta_\epsilon|\Phi_A\rangle,\ \delta_\epsilon(\eta_0|\Psi_\lambda\rangle)$ up to linear terms.

Using linearized equation of motion:

$$Q_{\mathrm{B}}\eta_0|\Phi_A\rangle = 0, \quad Q_{\mathrm{B}}\eta_0|\Psi_\lambda\rangle = 0,$$

we have obtained a transformation for component fields:

$$\delta_\epsilon A_\mu = -i\epsilon\Gamma_\mu C\lambda, \quad \delta_\epsilon\lambda = \frac{i}{2}\sqrt{\frac{\alpha'}{2}}F_{\mu\nu}(\epsilon\Gamma^{\mu\nu}), \quad (F_{\mu\nu} \equiv \partial_\mu A_\nu - \partial_\nu A_\mu).$$

Generalization

- In the construction of our solutions, we have used U(1) supercurrent:

$$\mathbf{J}(z,\theta) = \psi(z) + \theta\frac{i}{\sqrt{2\alpha'}}\partial X(z).$$

$$\Downarrow$$

It can be generalized to supercurrent associated with G

$$\mathbf{J}^a(z,\theta) = \psi^a(z) + \theta J^a(z) \qquad (a = 1,\cdots,\mathrm{dim}G)$$

such as

$$\psi^a(y)\psi^b(z) \sim \frac{1}{y-z}\frac{1}{2}\Omega^{ab},$$
$$J^a(y)\psi^b(z) \sim \frac{1}{y-z}f^{ab}{}_c\psi^c(z),$$
$$J^a(y)J^b(z) \sim \frac{1}{(y-z)^2}\frac{1}{2}\Omega^{ab} + \frac{1}{y-z}f^{ab}{}_cJ^c(z),$$

where

$$f^{ab}{}_c = -f^{ba}{}_c, \qquad f^{ab}{}_df^{cd}{}_e + f^{bc}{}_df^{ad}{}_e + f^{ca}{}_df^{bd}{}_e = 0,$$
$$\Omega^{ab} = \Omega^{ba}, \qquad f^{ab}{}_c\Omega^{cd} + f^{ad}{}_c\Omega^{cb} = 0.$$

Suppose $\exists\ \Omega_{ab}$ such as $\Omega^{ac}\Omega_{cb} = \delta^a_b$. Then, matter super Virasoro operators are given by Sugawara construction:

$$T^{\mathrm{m}}(z) \;=\; \Omega_{ab}\!:\!(J^a J^b + \partial\psi^a\psi^b)\!:\!(z) + \frac{2}{3}\Omega_{ad}\Omega_{be}f^{de}{}_c\!:\!(J^a\!:\!\psi^b\psi^c\!: + \psi^a\!:(\psi^b J^c - J^b\psi^c)\!:)\!:\!(z),$$
$$G^{\mathrm{m}}(z) \;=\; 2\Omega_{ab}:J^a\psi^b:(z) + \frac{4}{3}\Omega_{ad}\Omega_{be}f^{de}{}_c\!:\!\psi^a\!:\!\psi^b\psi^c\!::(z)\,,$$

where the central charge is $c^{\mathrm{m}} = \frac{3}{2}\mathrm{dim}G - f^{ac}{}_d f^{bd}{}_c\Omega_{ab}.$ [Mohammedi(1994)]

We suppose $c^{\mathrm{m}} = 15$ for super SFT.

In this case, we have similarly confirmed that

$$\Phi_0 = -\tilde{V}^a_L(F_a)I\,,$$
$$\tilde{V}^a_L(F_a) \equiv \int_{C_{\mathrm{left}}} \frac{dz}{2\pi i}F_a(z)\tilde{v}^a(z), \quad F_a(-1/z) = z^2 F_a(z)\,,$$
$$\tilde{v}^a(z) \equiv \frac{1}{\sqrt{2}}c\xi e^{-\phi}\psi^a(z)\,,$$

satisfies equation of motion: $\eta_0(e^{-\Phi_0}Q_{\mathrm{B}}e^{\Phi_0}) = 0.$

It corresponds to a marginal deformation by J^a.

- Inclusion of GSO(−) sector

Super SFT on a non-BPS brane [Berkovits,Berkovits-Sen-Zwiebach(2000)]

$$S[\hat{\Phi}] = -\frac{1}{2g^2}\int_0^1 dt\,\mathrm{Tr}\langle\langle(\hat{\eta}_0\hat{\Phi})(e^{-t\hat{\Phi}}\hat{Q}_{\mathrm{B}}e^{t\hat{\Phi}})\rangle\rangle\,,$$

$$\hat{Q}_{\mathrm{B}} = Q_{\mathrm{B}}\otimes\sigma_3, \qquad \hat{\eta}_0 = \eta_0\otimes\sigma_3\,,$$

$$\hat{\Phi} = \Phi_+\otimes 1 + \Phi_-\otimes\sigma_1\,,$$

where Φ_+ : GSO(+), Φ_- : GSO(−).

Equation of motion: $\hat{\eta}_0(e^{-\hat{\Phi}}\hat{Q}_{\mathrm{B}}e^{\hat{\Phi}}) = 0\,.$

By compactifying a direction to S^1 with the critical radius $\sqrt{2\alpha'}$
we obtain SU(2) supercurrent.
Therefore, we can similarly construct a class of solutions which have both GSO(+) and GSO(−) sector.
One of them corresponds to a marginal deformation which represents a process: non-BPS Dp brane → D(p-1)-anti D(p-1) [Sen(1998)].

Details will be shown in [I.Kishimoto-T.Takahashi (to appear)].

Summary and Discussion

- We have constructed a class of exact classical solutions to Berkovits' super SFT, which have vanishing vacuum energy.
- We find that our solution represents background Wilson line (including Ramond sector).
- We have identified "global space-time SUSY transformaion" in Berkovits' super SFT and found that our solution is invariant under it.
- We have also construct a class of solutions by supercurrents generally, which correspond to marginal deformations in conformal field theory.
- GSO(−) solutions can be similarly constructed at the critical radius using the SU(2) supercurrent.

- Our solution corresponds to a super extension of “marginal solution” [Takahashi-Tanimoto(2001)] in bosonic SFT.

$$\Psi_0 = -V_L^a(F_a)I - \frac{1}{4}g^{ab}C_L(F_aF_b)I, \quad V_L^a(f) \equiv \int_{C_{\rm left}} \frac{dz}{2\pi i}\frac{1}{\sqrt{2}}f(z)cJ^a(z)$$

$$\Downarrow$$

$$e^{-\Phi_0}Q_{\rm B}e^{\Phi_0} = -V_L^a(F_a)I + \frac{1}{8}\Omega^{ab}C_L(F_aF_b)I,$$

$$V_L^a(f) \equiv \int_{C_{\rm left}} \frac{dz}{2\pi i}\frac{1}{\sqrt{2}}f(z)(cJ^a + \eta e^{\phi}\psi^a)(z)$$

- Can we construct an exact *universal* solution to super SFT which corresponds to tachyon condensation on non-BPS D9 brane?
- Can we evaluate potential height *if* we obtain a universal solution such as bosonic SFT?
- Can we find an appropriate consistent regularization for $\langle I|(\cdots)|I\rangle$?
- ….