LOCALIZATION OF EFFECTIVE ACTIONS IN OPEN SUPERSTRING FIELD THEORY

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AIM: COMPUTE THE TREE-LEVEL EFFECTIVE POTENTIAL FOR MASSLESS OPEN STRING STATES FROM OSFT

$\updownarrow$

DETERMINE THE ALGEBRAIC PART OF NON-ABELIAN DBI.

Given ~~a~~ a SFT this is in principle straightforward:

$$S_0[\phi] = S_0[\phi^{(l)} + \phi^{(h)}] \Rightarrow \frac{\delta S_0}{\delta \phi^{(h)}} = 0 \rightarrow \phi^{(h)} = \phi^{(h)}(\phi^{(l)})$$

$$\boxed{S_{eff}[\phi^{(l)}] = S_0[\phi^{(l)} + \phi^{(h)}(\phi^{(l)})]}$$

$\Rightarrow$ We will consider Berkovits OSSFT in the NS sector (sensible at tree-level)

[redacted]

$$\Phi = \Phi^{(l)} + \Phi^{(h)} \quad \begin{cases} \in H_{LARGE} & (\eta_0 \Phi \neq 0) \\ \text{pict} = 0 \\ \text{ghost} = 0 \end{cases}$$

For our purposes it is useful to rewrite the WZW-like action as

$$S[\Phi] = \mathrm{Tr}\left[(\eta\Phi)\,\frac{ad_\Phi - 1 + e^{-ad_\Phi}}{ad_\Phi^2}\,(Q\Phi)\right] =$$

$$= \cancel{} - \frac{1}{2}\mathrm{Tr}\left[\eta\Phi\; Q\Phi\right] - \sum_{n=1}^{\infty}\frac{(-1)^n}{(n+2)!}\mathrm{Tr}\left[\eta\Phi\; ad_\Phi^n\, Q\Phi\right]$$

<u>VARIATION</u>

$$\delta S[\Phi] = \mathrm{Tr}\left[e^{-\Phi}\delta e^{\Phi}\,\eta_0\left(e^{-\Phi} Q e^{\Phi}\right)\right] =$$

$$= \mathrm{Tr}\left[\delta\Phi\,\frac{e^{ad_\Phi}-1}{ad_\Phi}\,\eta_0\,\frac{1-e^{-ad_\Phi}}{ad_\Phi}\,Q\Phi\right]$$

Fix a gauge: $b_0\Phi = 0 \quad \xi_0\Phi = 0$

Then the physical massless states are the kernel of L_0

$$\Phi^{(l)} = P_0\,\Phi \qquad \Phi^{(h)} = (1-P_0)\,\Phi = \bar{P}_0\,\Phi$$

$P_0 \to$ projector on the kernel of L_0.

In our example

$$\Phi^{(l)} = c\,\gamma^{-1}\,\mathbb{V}_{1/2}$$ $\to$ superconformal primary of $h=1/2$

$$\begin{cases} \eta Q\Phi^{(l)} = 0 \\ L_0\Phi^{(l)} = 0 \end{cases}$$

$$\begin{cases} Q\Phi^{(l)} = c\,\mathbb{V}_1 - \gamma\,\mathbb{V}_{1/2} \\ \eta\Phi^{(l)} = c\,\mathbb{V}_{1/2}\,\underbrace{e^{-\phi}}_{\delta(\gamma)} \end{cases}$$

eom for $\phi^{(4)}$:

$$\bar{P}_0 \frac{e^{ad_\Phi}-1}{ad_\Phi} \eta_0 \frac{1-e^{-ad_\Phi}}{ad_\Phi} Q\Phi \Big|_{\Phi=\Phi^{(e)}+\Phi^{(4)}} = 0 \qquad (1)$$

Solve perturbatively:

$$\Phi = g\Phi^{(e)} + \sum_{n=2}^{\infty} g^n \Phi_n^{(4)}$$ → and plug in the action ⟶

$\boxed{\text{expanding (1) in powers of } g \text{ one finds equations for}}$

$$\eta Q \Phi_2^{(4)} = \bar{P}_0 \frac{1}{2}[\eta\Phi^{(e)}, Q\Phi^{(e)}]$$

$$\eta Q \Phi_3^{(4)} = \bar{P}_0 (\text{ .... longer -- })$$

$\vdots \qquad \vdots$

$$\Rightarrow \Phi_n^{(4)} = \xi_0 \frac{b_0}{L_0} (\text{stuff determined of lower orders})$$

ex: $\boxed{\Phi_2^{(4)} = \frac{1}{2}\xi_0 \frac{b_0}{L_0} \bar{P}_0 [\eta_0\Phi^{(e)}, Q\Phi^{(e)}]}$

etc...

At quartic order we find

$$S^{(4)}_{eff} = \frac{1}{8}\operatorname{Tr}\Big[[M\Phi, Q\Phi]\,\xi_0\frac{b_0}{L_0}P\,[M\Phi, Q\Phi]\Big]_{\text{prop.}}$$

$$-\frac{1}{24}\operatorname{Tr}\Big[[M\Phi,\Phi]\;[\Phi, Q\Phi]\Big]_{\text{contact}}$$

In case $\Phi = c\,\gamma^{-1}A_\mu\psi^\mu(0)|0\rangle$ this has been computed by Berkovits-Schnabl 03 07 019

$$= \Big(-\frac{1}{4}\operatorname{tr}[A_\mu A^\mu A_\nu A^\nu] - \frac{1}{8}[A_\mu A_\nu A^\mu A^\nu]\Big)_{\text{prop}}$$

$$+\Big(-\frac{1}{8}\operatorname{tr}[A_\mu A_\nu A^\mu A^\nu] + \frac{1}{2}[A_\mu A^\mu A_\nu A^\nu]\Big)_{\text{contact}}$$

$$= -\frac{1}{8}\operatorname{tr}\Big[[A_\mu, A_\nu][A^\mu, A^\nu]\Big]$$

$\Rightarrow$ We will present another way of doing the computation which significantly simplifies the effort.

The computation can be simplified assuming

$$\mathbb{V}_{1/2} = \mathbb{V}_{1/2}^{(+)} + \mathbb{V}_{1/2}^{(-)} \qquad J_0 \mathbb{V}_{1/2}^{(\pm)} = \pm \mathbb{V}_{1/2}^{(\pm)}$$

idea from Sen 1508.02481 Sect. 8.1

In general this is realized together with an $N=1 \to N=2$ enhancement (typically needed to have spacetime fermions)

$$T_F = T_F^{(+)} + T_F^{(-)}$$

$$\begin{cases} T_F^{(+)}(z)\, T_F^{(-)}(w) = \dfrac{2\frac{c}{3}}{(z-w)^3} + \dfrac{J(w)}{(z-w)^2} + \dots \\ J(z)\, T_F^{(\pm)}(w) = \pm \dfrac{T_F^{\pm}(w)}{z-w} \end{cases}$$

part of the $N=2$ SC algebra

→ Realized by gauge field, transverse scalars to D-branes, DP/D(P+4) open strings → <u>See Alberto Merlano Talk</u>

⇒ Advantage the net J charge inside a correlator must vanish.

~~⇒ This essentially picks up only terms~~

$S^{(4)}[\Phi^{(+)} + \Phi^{(-)}]$ only terms with an equal number of $\Phi^{(+)}$ and $\Phi^{(-)}$ survive.

Computing we have

$$S^{(4)}\left[\Phi^{(+)}+\Phi^{(-)}\right] = S^{(4)}_{prop}\left[\Phi^{(+)}+\Phi^{(-)}\right] + S^{(4)}_{cont}\left[\Phi^{(+)}+\Phi^{(-)}\right]$$

Working on $S^{(4)}_{prop}$ and using

- $\eta Q\,\Phi^{(+)} = 0$
- $\langle \eta(\ldots)\rangle = \langle Q(\ldots)\rangle = 0$
- Conservation of J-charge
- $\left[Q, \frac{b_0}{L_0}\bar{P}\right] = \bar{P} = 1 - P_0$

<u>we find</u>:

$$S^{(4)}_{prop} = \frac{1}{4}\mathrm{Tr}\Big[\left[\Phi^{(-)},\eta\Phi^{(-)}\right]P_0\left[\Phi^{(+)},Q\Phi^{+}\right] + \left[\Phi^{(+)},\Phi^{-}\right]P_0\left[\eta\Phi^{-},Q\Phi^{+}\right]\Big]$$

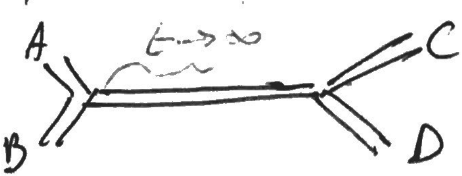
$$- S^{(4)}_{cont}\left[\Phi^{(+)}+\Phi^{(-)}\right]$$

$\hookrightarrow$ <u>cancels with the elementary</u> <u>vertex</u>

<u>what remains is localized at the boundary of moduli space</u>

$$P_0 = [redacted] \lim_{t\to\infty} e^{-tL_0} =$$

$$\mathrm{Tr}\left[(A * B)\,P_0\,(C * D)\right] =$$



$\Rightarrow$ only the level zero contribution of $A*B$ and $C*D$ is participating explicitly we find

$$P_0\left[\Phi^{(+)}, Q\Phi^{(+)}\right] = 2c\, \mathbb{H}_1^{(+)}(0)|0\rangle \qquad (J=2)$$

$$P_0\left[\Phi^{(-)}, \eta\,\Phi^{(-)}\right] = 2c\partial c\,\xi\, e^{-2\phi}\,\mathbb{H}_1^{(-)}(0)|0\rangle \qquad (J=-2)$$

$$P_0\left[\eta\Phi^{(-)}, Q\Phi^{(+)}\right] = c\,\eta\,\mathbb{H}_0(0)|0\rangle \qquad (J=0)$$

$$P_0\left[\Phi^{(-)}, \Phi^{(+)}\right] = c\partial c\,\xi\partial\xi\, e^{-2\phi}\,\mathbb{H}_0(0)|0\rangle \qquad (J=0)$$

The "AUXILIARY FIELDS" $\mathbb{H}$ are defined as

$$\mathbb{V}_{1/2}^{(\pm)}(x)\,\mathbb{V}_{1/2}^{(\pm)}(-x) = \mathbb{H}_1^{(\pm)}(0) + \text{reg}\dots$$

$$\mathbb{V}_{1/2}^{(\pm)}(x)\,\mathbb{V}_{1/2}^{(\mp)}(-x) - \mathbb{V}_{1/2}^{(\mp)}(x)\,\mathbb{V}_{1/2}^{(\pm)}(-x) = \frac{1}{2x}\,\mathbb{H}_0$$

↳ proportional to the identity.

Then, computing the trivial ghost correlators one finds

$$\boxed{S^{(4)}(\Phi) = \operatorname{tr}\left[\langle \mathbb{H}_1^{(+)}|\mathbb{H}_1^{(-)}\rangle + \frac{1}{4}\langle\mathbb{H}_0|\mathbb{H}_0\rangle\right]}$$

↳ Simple matter 2-point functions!

↳ Continues on A. Merlano slides.