

Title: String Theory Lecture

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Collection: String Theory 2023/24

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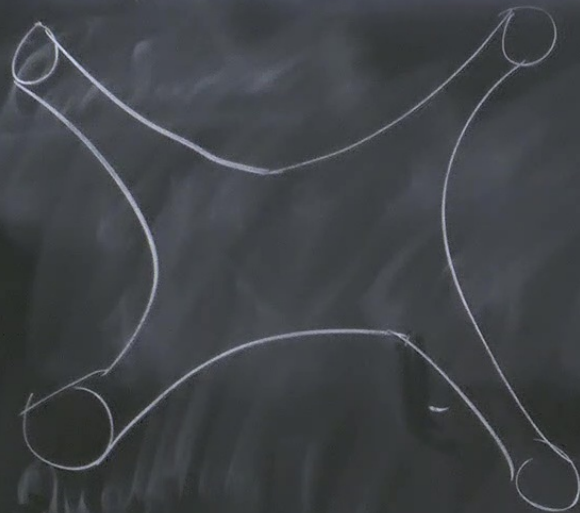
$$A_4 = \prod_{1 \leq i < j \leq 3} |z_0 - z_j| \int_{\mathbb{C} - \{z_1, z_2, z_3\}} d^2 z_4 \prod_{1 \leq i \leq 3} |z_4 - z_i|^{2p_4 - p_i} \delta(z_4)$$

$$\bar{z}_i = z_i^* \subset \mathbb{C} \subset \mathbb{C}^2_{(z_4, \bar{z}_4)}$$

$$2p_4 - p_i \geq 1 - 2 \Rightarrow (p_4 + p_i) \geq 2$$

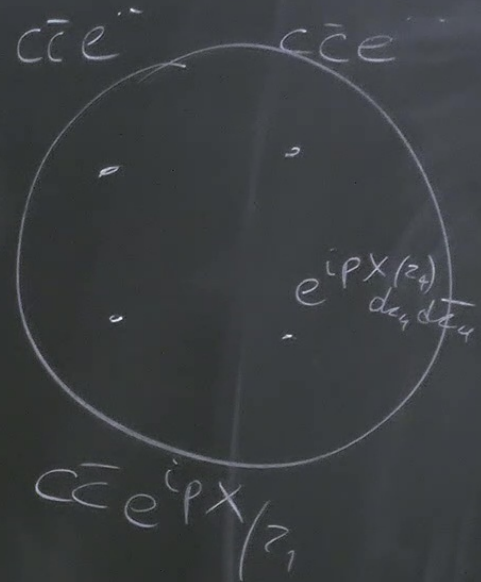
$$\sim |z_4|^{2p_4 \sum p_i} = |z_4|^{2p_4 \sum p_i}$$

$$t = \frac{(z_4 - z_1)(z_2 - z_3)}{(z_4 - z_3)(z_2 - z_1)}$$



$|p\rangle \otimes |g\rangle$

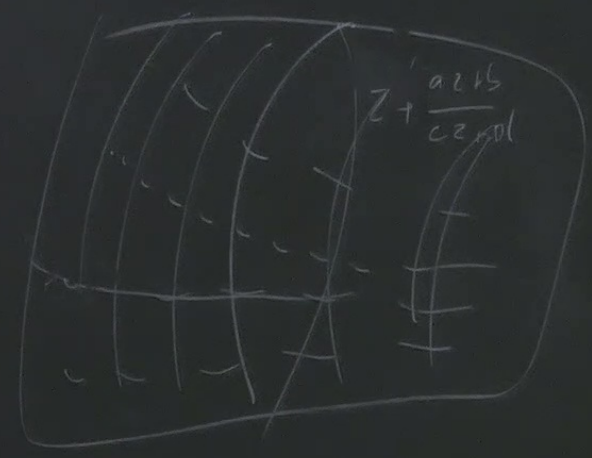
\downarrow



$$\left[(c + dz) (\bar{c} + d\bar{z}) e^{ipx} \right] \leftarrow \prod_{l=1}^L e^{i p \cdot X(l)} \cdot \prod_{i=1}^L (c(z_i) + dz_i) (\bar{c}(\bar{z}_i) + d\bar{z}_i)$$

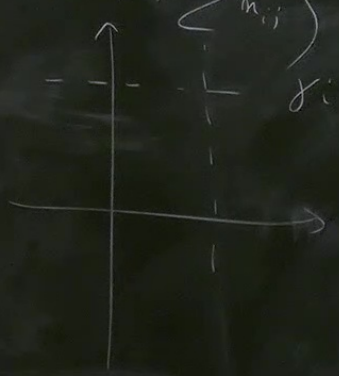
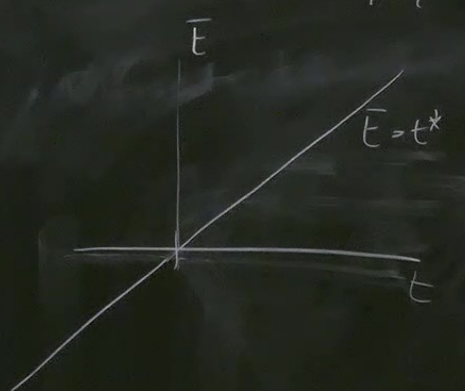
$$\left\langle \prod_{i=1}^g (c(z_i) + dz_i) (\bar{c}(\bar{z}_i) + d\bar{z}_i) \right\rangle$$

CLOSED
IN \mathbb{P}^g



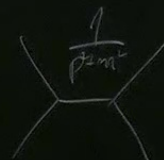
$$A_3 = \int_{C_{-i0, 13}} dz |t|^{2p_4 - p_1} |1-t|^{2p_4 - p_2}$$

$$A_2 = \int_{\delta_1}^{\delta_2} dt |t|^{2p_4 - p_1} |1-t|^{2p_4 - p_2} = \int_{\delta_1}^{\delta_2} E^{-p_4 - p_1} (1-t)^{p_4 - p_2} dt$$



$$g(z_4) \sim |z_4|^{2p_4 \Sigma R} = |z_4|^{-2p_4^2} = |z_4|^{-4} \quad \frac{dz_4 d\bar{z}_4}{|z_4|^{-4}} = d\frac{1}{z_4} d\frac{1}{\bar{z}_4}$$

$$t = \frac{(z_4 - z_1)(z_2 - z_3)}{(z_4 - z_3)(z_2 - z_1)}$$



$$= \frac{\Gamma(1+p_4-p_1) \Gamma(1+p_4-p_2) \Gamma(1+p_4-p_3)}{\Gamma(-p_4-p_1) \Gamma(-p_4-p_2) \Gamma(-p_4-p_3)}$$

$$\int_{\bar{t}^{p_4-p_1}} (\bar{t}^{p_4-p_2})^{p_4-p_2} d\bar{t}$$

VIRASORO - SHAPIRO

$$S = -(p_1+p_2)^2$$

$$\frac{\Gamma(-1-\frac{s}{2}) \Gamma(-1-\frac{t}{2}) \Gamma(-1-\frac{u}{2})}{\Gamma(2+\frac{s}{2}) \Gamma(2+\frac{t}{2}) \Gamma(2+\frac{u}{2})}$$

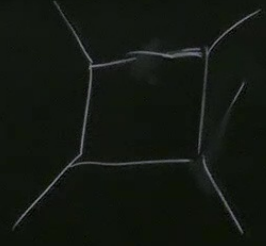
$$-1-\frac{s}{2} = 0, -1, -2, -3$$

$$S = -2, 0, 2, 4, 6, 8, \dots$$

$$\sum_{s=2n} f_n(t)$$

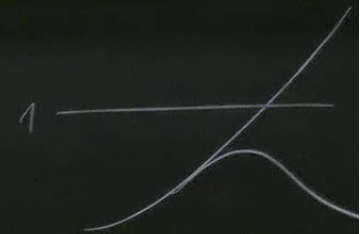
$$\text{Res}_{s=2n} A_s(s) = f_n(t) = \prod_{k=0}^{n-2} (p_4-p_2-k)(p_4-p_3-k)$$

$$h\sqrt{2\pi} \pm \frac{1}{422}$$



$$\Gamma(z) \xrightarrow{z \rightarrow \infty} e^{z \ln z - z - \frac{1}{2} \pi z - h \sqrt{2\pi} + \frac{1}{12z}}$$

$$A_s \sim e^{-\zeta h s - t h t - u h u}$$



$$\int \partial X \bar{\partial} X^\dagger dz + \int I(z, \bar{z}) dz$$

$$z \rightarrow f(z')$$

$$L_0[\sigma] = |E\rangle$$

$$\rightarrow L_0[I] = 0$$

I: PRIMARY OF

$$I(z, \bar{z}) \frac{dz d\bar{z}}{dz d\bar{z}} = I(z', \bar{z}') \frac{dz' d\bar{z}'}{dz d\bar{z}}$$

DEFORMATIONS ←

$$I \circ J \bar{z}^n J$$

$(z, \bar{z}) \quad dz \quad \bar{z} \rightarrow f(z')$

$L_0 |I\rangle = |I\rangle$

$L_n |I\rangle = 0 \quad n > 0$

$|I\rangle = L_{-1} |J\rangle$

$L_{-n} |J\rangle$

DOES

I : PRIMARY OF DIM (1,1)

$(z, \bar{z}) \quad \frac{dz' d\bar{z}'}{dz d\bar{z}}$

DEFORMATIONS \longleftrightarrow STRING STATES

$e^{\int I} = 1 + \int I + \frac{1}{2} (\int I)^2 + \dots$

$\int_{SCALE} \langle e^{\int I} \dots \rangle = \langle e^{\int I + \delta I} \dots \rangle$

$z \rightarrow f(z')$ $L_0 |I\rangle = |I\rangle$ $|I\rangle = L_{-1} |J\rangle$ DOES NOTHING
 $L_n |I\rangle = 0 \quad n > 0$ $L_{-n} |J\rangle$

I : PRIMARY OF DIM (1,1)

BETA FUNCTION \longrightarrow INTERACTIONS

DEFORMATIONS \longleftrightarrow STRING STATES

"BETA FUNCTION"

$\int I = 1 + \int I + \frac{1}{2} (\int I)^2 + \dots$ $\int_{SCALE} \langle e^{\int I} \dots \rangle = \langle e^{\int I + \delta \int I(I)} \dots \rangle$