

Title: PSI 2018/2019 - String Theory Review - Lecture 10

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Collection: PSI 2018/2019 - String Theory Review (Gaiotto)

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$\Sigma \xrightarrow{X}$ SPACE-TIME

$$\mu \partial_\mu G_{\nu e} = G_{\nu e} [G_{\mu}, \beta]$$

$$\mu \partial_\mu B_{\nu e} = \beta_{\nu e} [\dots]$$

$$\iint \partial_\alpha X^e \partial^\alpha X^\nu G_{\nu e}(X, \mu_{2d}) + \partial_{[i} X^\nu \partial_{\nu]} X^e B_{\nu e}$$

$$\kappa \partial_\mu B_{\nu e} = \overset{B}{\nu e} [\dots]$$

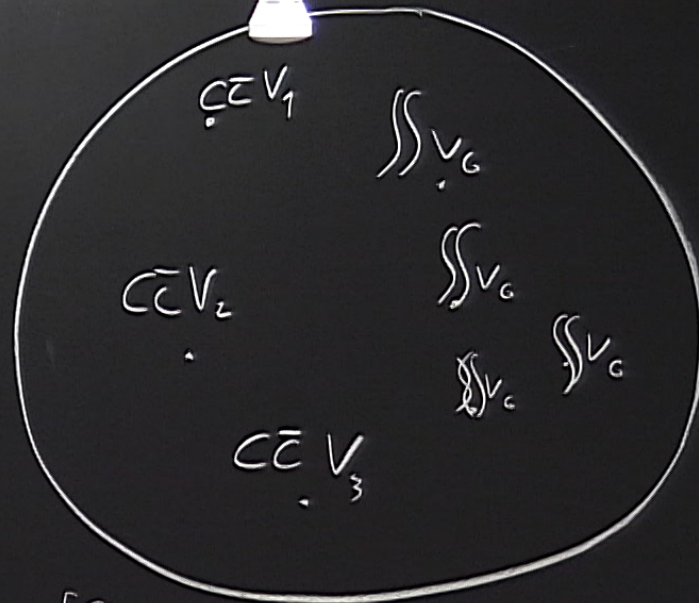
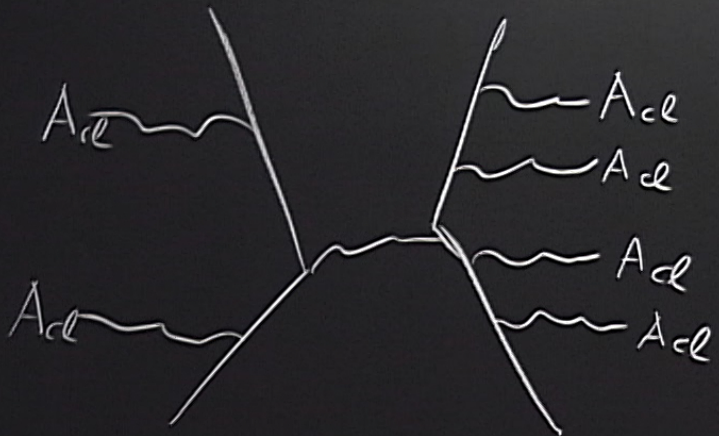
$$\frac{1}{\alpha'} \int \partial_\alpha X^e \partial^\alpha X^\nu G_{\nu e}(X, \mu_{2d}) + \partial_{[i} X^\nu \partial_{\nu]} X^e B_{ve}$$

$$\frac{1}{\alpha'} \int \partial_\mu X^\mu \partial^\mu X^\nu G_{\mu\nu}(X, \mu_{2d}) + \int \partial_\mu X^\nu \partial_\nu X^\mu B_{\mu\nu}$$

$$B_{\mu\nu}^G[G] - \alpha' R_{\mu\nu}[G] + \dots$$

$$\kappa \partial_\mu B_{\nu\sigma} = \beta_{\nu\sigma}^{\mu} [\dots]$$

CLASSICAL
SOLUTION
 X_{cl}



$$\sum_{n=0}^{\infty} \frac{1}{n!} \langle v_1 v_2 \dots [\iint V_G]^n \rangle = \langle v_1 v_2 e^{\iint V_G} \rangle$$

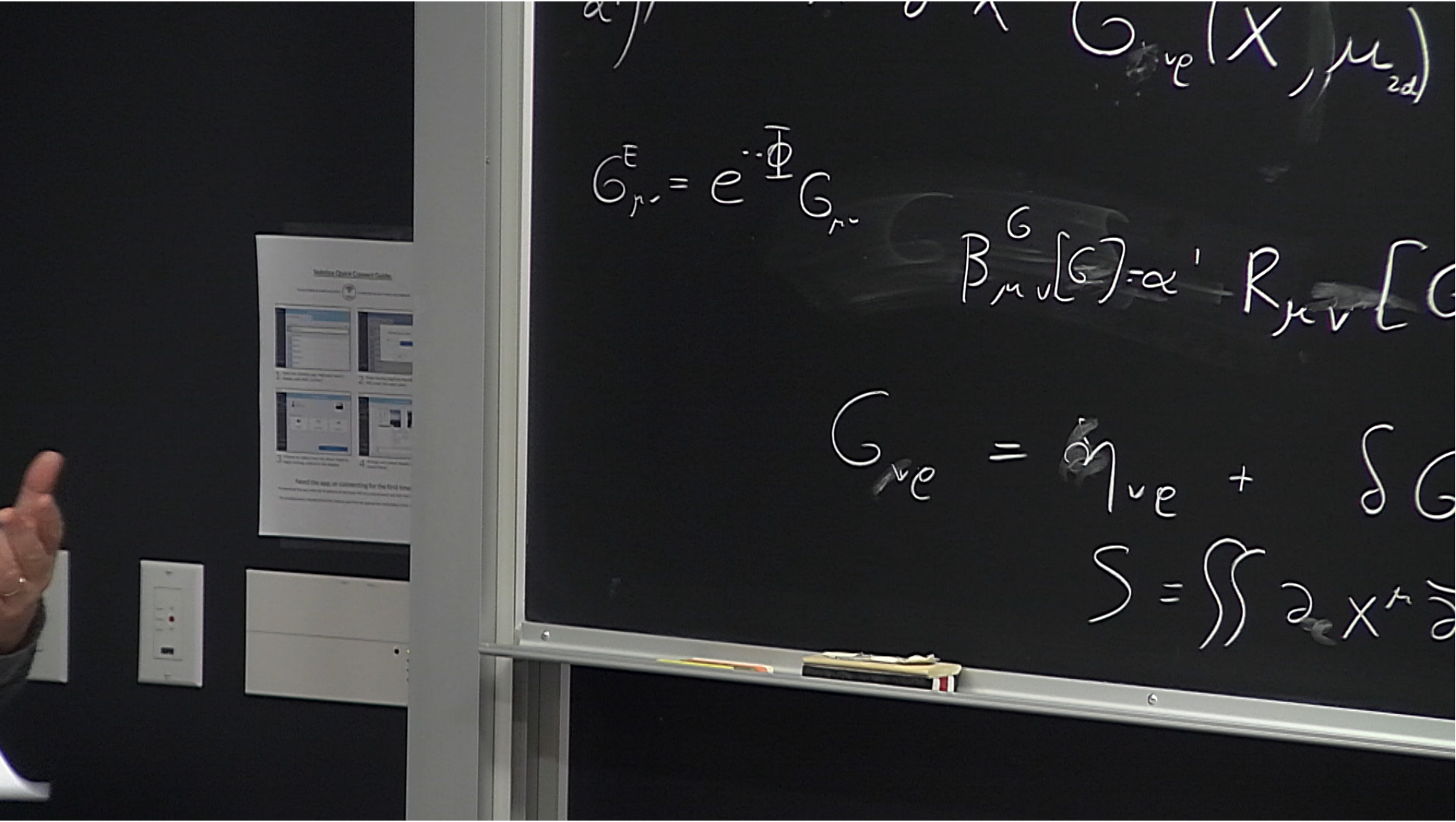
$$+ \partial_{[1} X^\nu \partial_{2]} X^\rho B_{\nu\rho} + \int (X) R^{(2)}[h]$$

$$- \alpha' R_{\mu\nu}[G] + \dots$$

$$+ \delta G_{\nu\rho}[X]$$

$$V_{\text{GRAVITON}} = \partial X^\mu \bar{\partial} X^\nu \epsilon_{\mu\nu}(p) e^{ip \cdot X}$$

$$\delta = \iint \partial X^\mu \bar{\partial} X_\mu + \iint \bar{\partial} X^\mu \bar{\partial} X^\rho \delta G_{\nu\rho}(X)$$



$$G_{\mu\nu}(X, \mu_{2d})$$

$$G_{\mu\nu}^E = e^{-\Phi} G_{\mu\nu}$$

$$B_{\mu\nu}^G = \alpha' R_{\mu\nu}$$

$$G_{\mu\nu} = \eta_{\mu\nu} + \delta G$$

$$S = \int \int \partial_\mu X^\mu \partial_\nu X^\nu$$

$\Sigma \xrightarrow{X}$ SPACE-TIME

$$\mu \partial_\mu G_{\nu\epsilon} = \beta_{\nu\epsilon}^G [G_{\mu\gamma}, \vec{B}]$$

$$\kappa \partial_\mu B_{\nu\epsilon} = \beta_{\nu\epsilon}^B [G_{\mu\gamma}, \vec{B}]$$

$$\frac{1}{a!} \iint \partial_\alpha X^\epsilon \partial^\alpha X^\nu G_{\nu\epsilon}(X, \mu_{\alpha\beta}) + \partial_\alpha X^\nu \partial_\beta X^\epsilon B_{\nu\epsilon} + \dots \in R^{(a)}[R]$$

$$G_{\mu\nu}^E = e^{-i\Phi} G_{\mu\nu} \quad \beta_{\mu\nu}^G [G] \propto R_{\mu\nu} [G] + \dots$$

$$V_{\text{GRAVITON}} = \partial X^\mu \bar{\partial} X^\nu \epsilon_{\mu\nu}(\theta) e^{ipX}$$

$$G_{\nu\epsilon} = \eta_{\nu\epsilon} + \delta G_{\nu\epsilon} [X]$$

$$S = \iint \partial X^\mu \bar{\partial} X_\mu + \iint \bar{\partial} X^\mu \bar{\partial} X^\epsilon \delta G_{\nu\epsilon} (X)$$

$$A = A_0 + e^{i\phi} g_s^2 A_1 + e^{i4\phi} g_s^4 A_2 \dots$$

CAUTION
DO NOT TOUCH THE SURFACE OF THE BOARD
OR THE BOARD OR SURFACE OF THE BOARD
OR THE BOARD OR SURFACE OF THE BOARD
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OR THE BOARD OR SURFACE OF THE BOARD

CAUTION
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$$G_{\mu\nu} = e^{\pm} G_{\mu\nu}$$

$$B_{\mu\nu}^G[G] = \alpha' R_{\mu\nu}[G] + \dots$$

$$\text{GRAVITON} = \partial X^\mu \bar{\partial} X^\nu \epsilon_{\mu\nu}(\rho) e^{ipX}$$

$$G_{\mu\nu} = \eta_{\mu\nu} + \delta G_{\mu\nu}[X]$$

$$S = \iint \partial X^\mu \bar{\partial} X_\mu + \iint \bar{\partial} X^\mu \bar{\partial} X^\nu \delta G_{\mu\nu}$$

$$\int^{\text{SPACE-TIME}} [G_{\mu\nu}]$$

$$\frac{\delta \int^{\text{SPACE-TIME}}}{\delta G_{\mu\nu}} = B_{\mu\nu}^G[---]$$

$$G_{\mu\nu} = e^{\pm} G_{\mu\nu}$$

$$B_{\mu\nu}^G = \alpha' R_{\mu\nu}[G] + \dots$$

$$\text{GRAVITON} = \partial x^\mu \bar{\partial} x^\nu \epsilon_{\mu\nu}(\phi) e^{i p \cdot X}$$

$$G_{\mu\nu} = \eta_{\mu\nu} + \delta G_{\mu\nu}[X]$$

$$S = \iint \partial x^\mu \bar{\partial} x_\mu + \iint \bar{\partial} x^\mu \bar{\partial} x^\nu \delta G_{\mu\nu}$$

$$\int_{\text{SPACE-TIME}} [G_{\mu\nu}, \dots]$$

$$\frac{\delta \int_{\text{SPACE-TIME}}}{\delta G_{\mu\nu}} = B_{\mu\nu}^G[\dots]$$

$$= \int dx^{26} \sqrt{-\det G} e^{-2\bar{\Phi}} \left[R - \frac{1}{12} (\partial_n B_{vej})^2 + 4(\partial_n \Phi)^2 \right]$$

$$G_{\mu\nu} = e^{\pm\phi} G_{\mu\nu}$$

$$B_{\mu\nu}^G = \alpha' R_{\mu\nu}[G] + \dots$$

$$\text{GRAVITON} = \partial X^\mu \bar{\partial} X^\nu \epsilon_{\mu\nu}(\phi) e^{ipX}$$

$$G_{\mu\nu} = \eta_{\mu\nu} + \delta G_{\mu\nu}[X]$$

$$S = \iint \partial X^\mu \bar{\partial} X_\mu + \iint \bar{\partial} X^\mu \bar{\partial} X^\nu \delta G_{\mu\nu}$$

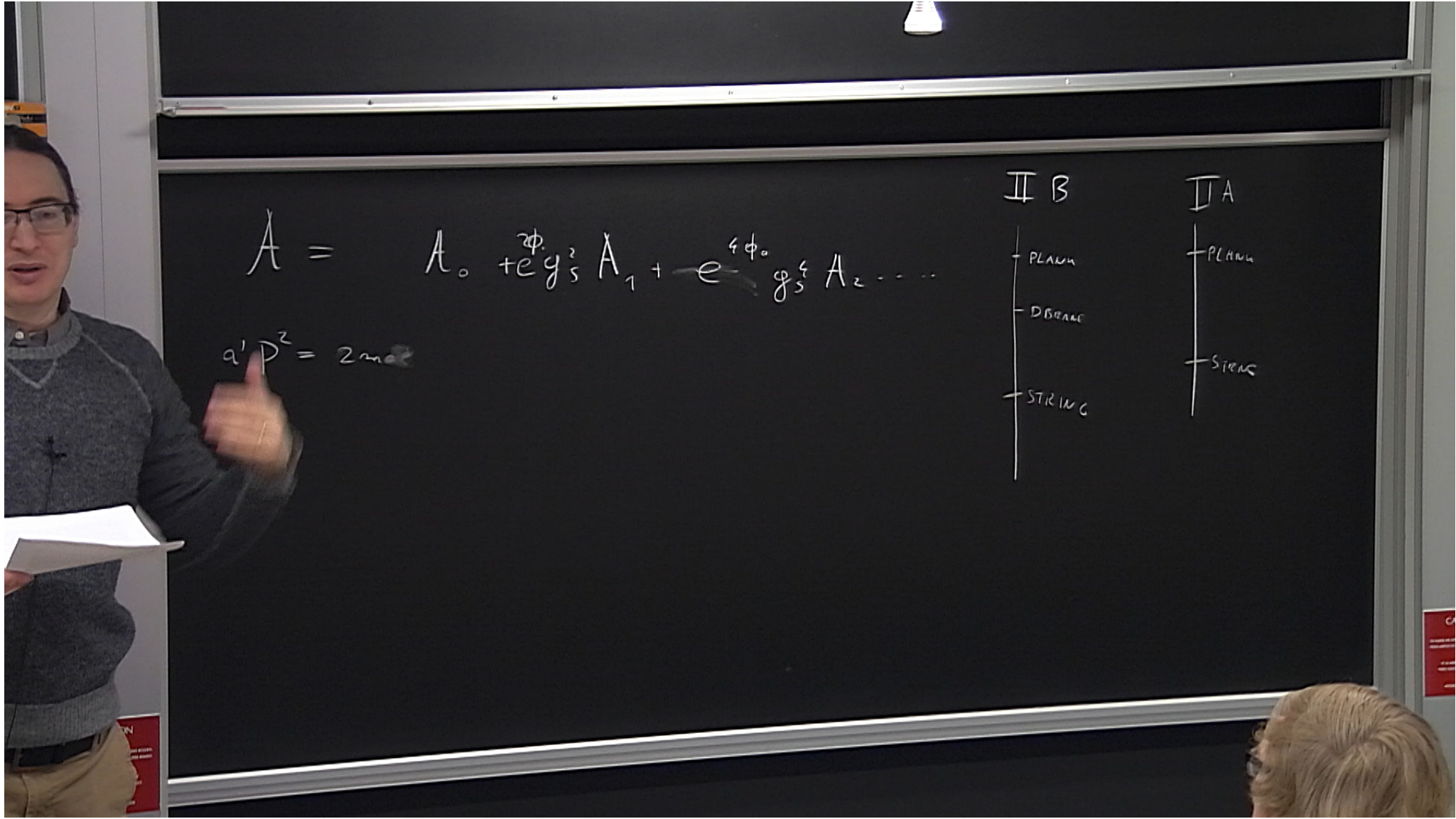
$$\int^{\text{SPACE-TIME}} [G_{\mu\nu}, \dots]$$

$$\frac{\delta \int^{\text{SPACE-TIME}}}{\delta G_{\mu\nu}} = B_{\mu\nu}^G[\dots]$$

$$= \frac{1}{g_s^4} \int d^2x \sqrt{-\det G} e^{-2\bar{\Phi}} \left[R - \frac{1}{12} (\partial_n B_{vej})^2 + 4(\partial_n \Phi)^2 \right]$$

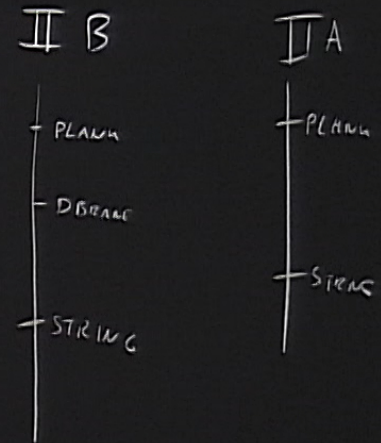
$$A = A_0 + e^{i\phi} g_s^2 A_1 + e^{i\phi} g_s^4 A_2 \dots$$
$$a' p^z = 2m$$

CAUTION
DO NOT TOUCH THE BOARD SURFACE
IF YOU TOUCH THE BOARD SURFACE
IT MAY DAMAGE THE BOARD SURFACE
OR CAUSE INJURY TO YOURSELF
OR OTHERS. PLEASE BE CAREFUL.



$$A = A_0 + e^{2\phi} g_s^2 A_1 + e^{4\phi} g_s^4 A_2 + \dots$$

$$\alpha' p^z = 2m\alpha'$$



$$\Sigma \rightarrow R^{d-1,1} \times \boxed{S^1}$$

$$S_Y = \iint \partial Y \bar{\partial} Y dz d\bar{z}$$

$$Y + 2\pi R w$$

$$\partial Y \quad \bar{\partial} Y$$

$$w \in \mathbb{Z}$$

$$p = \frac{n}{R}$$

$$Y(\sigma, \tau) = x - 2ip\tau + wR\sigma + \sum \frac{1}{n} a_n \dots$$



$|n, w\rangle$

$$L_0 = \frac{1}{2} \left(\frac{n}{R} - \frac{Rw}{2} \right)^2$$

$$\bar{L}_0 = \frac{1}{2} \left(\frac{n}{R} + \frac{Rw}{2} \right)^2$$

$$\Sigma \rightarrow R^{d-1,1} \times \underbrace{S^1}_{\gamma}$$

$$p^2_{-d+1} + \underbrace{\left(\frac{m}{R}\right)^2 + m^2}_{m_{KK}^2} = 0$$

$$S_{\gamma} = \iint \partial Y \bar{\partial} Y dz d\bar{z}$$

$$\begin{aligned} \gamma &= \tau + 2\pi R w \\ \partial Y & \quad \bar{\partial} Y \end{aligned} \quad \begin{aligned} w &\in \mathbb{Z} \\ p &= \frac{m}{R} \end{aligned}$$

$$Y(\sigma, \tau) = x - 2ip\tau + wR\sigma + \sum \frac{1}{n} a_n \dots$$

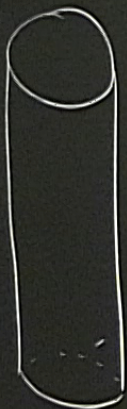


$|n, w\rangle$

$$L_0 = \frac{1}{2} \left(\frac{m}{R} - \frac{Rw}{2} \right)^2$$

$$\bar{L}_0 = \frac{1}{2} \left(\frac{m}{R} + \frac{Rw}{2} \right)^2$$

$$S_Y = \iint \partial Y \bar{\partial} Y dz d\bar{z}$$



Y

muy

$$Y \rightarrow Y + 2\pi R w$$

$$\partial Y = \partial \tilde{Y} \quad \bar{\partial} Y = -\bar{\partial} \tilde{Y} \quad p = \frac{n}{R} \quad w \in \mathbb{Z}$$

$$Y(\sigma, \tau) = x - 2ip\tau + wR\sigma + \sum \frac{1}{n} a_n - \bar{a}_n$$

$$|n, w\rangle \quad L_0 = \frac{1}{2} \left(\frac{n}{R} - \frac{Rw}{2} \right)^2$$

$$\bar{L}_0 = \frac{1}{2} \left(\frac{n}{R} + \frac{Rw}{2} \right)^2$$

$$\tilde{R} = \frac{2}{R} \quad \tilde{Y}(\sigma, \tau) = \tilde{x} - 2p\sigma + i w R \tau + \sum \dots a_n + \bar{a}_n$$

$$A = \text{CFT}_{c=d} \times \Sigma \rightarrow \mathbb{R}^{25-d,1}$$

$$|0\rangle, L_{-2}^{\text{CFT}} |0\rangle, \dots$$

$$|h_1, \bar{h}_1\rangle$$

$$|h_2, \bar{h}_2\rangle$$

⋮

$$|h, \bar{h}\rangle \otimes \alpha^{-1} \bar{a}^{-1} |P\rangle \otimes |g\rangle$$

$$P^2 = -2h - 2\bar{h}$$

CAUTION

NO FLAMMABLE LIQUIDS OR SOLIDS
OR GASES TO BE USED ON THIS BOARD

DO NOT TOUCH THE BOARD
OR THE SURFACE OF THE BOARD

SPECIAL PRECAUTIONS BOARD

CAUTION