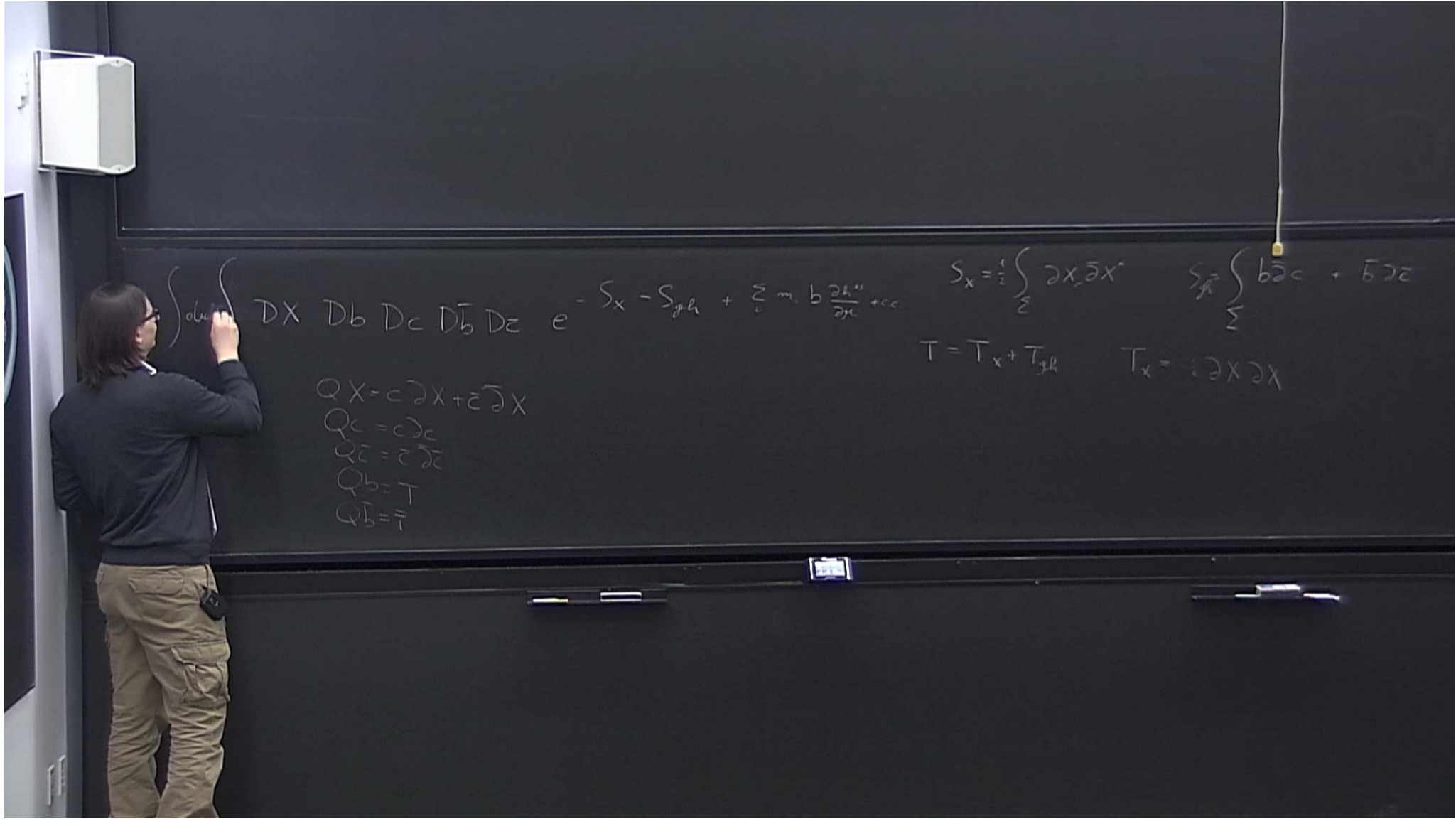


Title: PSI 2015/2016 String Theory - Lecture 7

Date: Feb 09, 2016 10:15 AM

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Abstract:



$$e^{-S_X - S_{gh}} + \sum_i m_i b \frac{\partial h^{31}}{\partial x_i} + cc$$

$$S_X = - \int \partial X \bar{\partial} X$$

$$S_{gh} = \int b \bar{\partial} c + \bar{b} \partial c$$

$$T = T_X + T_{gh}$$

$$T_X = \partial X \partial X$$

$$T_{gh} = c \partial b + 2(\partial c) b$$

$$Q(\partial X \bar{\partial} X) = \partial (c \partial X + \bar{c} \bar{\partial} X) \bar{\partial} X + cc = \partial (c \partial X \bar{\partial} X) + \partial X \bar{\partial} X \bar{\partial} c + cc$$

$$Q(b \bar{\partial} c) = T_X \bar{\partial} c + c \partial b \bar{\partial} c + 2(\partial c) b \bar{\partial} c - b \bar{\partial} (c \partial c) = -\partial (b c \bar{\partial} c)$$

$$\int_{\text{volume}} DX D_b D_c D_{\bar{b}} D_{\bar{c}} \epsilon$$

$$Q_{\mu} = m$$

$$Q_X = c \partial X + \bar{c} \bar{\partial} X$$

$$Q_c = c \partial c$$

$$Q_{\bar{c}} = \bar{c} \bar{\partial} \bar{c}$$

$$Q_b = T$$

$$Q_{\bar{b}} = \bar{T}$$

$$-S_{gh} + \sum_i m_i b \frac{\partial h^{ij}}{\partial x^i} + cc$$

$$S_X = \int \partial X \bar{\partial} X$$

$$T = T_X + T_{gh}$$

$$Q(\partial X \bar{\partial} X) = \partial(c \partial X + \bar{c} \bar{\partial} X)$$

$$Q(b \bar{\partial} c) = T_X \bar{\partial} c + c \partial b \bar{\partial}$$

$$X = c \partial c \partial X + \bar{c} \bar{\partial} \bar{c} \bar{\partial} X$$

$$= c \partial (c \partial X + \bar{c} \bar{\partial} X)$$

$$- \bar{c} \bar{\partial} (c \partial X + \bar{c} \bar{\partial} X)$$

$$\int_{\text{alveolar}} DX D_b D_c D_{\bar{b}} D_{\bar{c}} e^{-S_x - S_{gh}} + \sum_i m_i b \frac{\partial h_{ij}}{\partial x} + cc \quad S_x = \int \partial x \bar{\partial} x$$

$$Q_X = c \partial X + \bar{c} \bar{\partial} X$$

$$Q_c = c \partial c$$

$$Q_{\bar{c}} = \bar{c} \bar{\partial} \bar{c}$$

$$Q_b = T$$

$$Q_{\bar{b}} = \bar{T}$$

$$Q^2 X = c \partial c \partial X + \bar{c} \bar{\partial} \bar{c} \bar{\partial} X$$

$$= c \partial (c \partial X + \bar{c} \bar{\partial} X)$$

$$+ \bar{c} \bar{\partial} (c \partial X + \bar{c} \bar{\partial} X)$$

$$= -Q_c \partial \bar{\partial} X - c \bar{\partial} \partial \bar{c} X$$

$$T = T_x + T_{gh}$$

$$Q(\partial X \bar{\partial} X) = \partial (c \partial X + \bar{c} \bar{\partial} X)$$

$$Q(b \bar{c}) = T_x \bar{\partial} c + c \partial b \bar{\partial}$$

$$\begin{aligned} Q\bar{c} &= \bar{c}\bar{c} \\ Qb &= T \\ Q\bar{b} &= \bar{T} \end{aligned}$$

$$\begin{aligned} &= -\frac{\partial \bar{c}}{\partial x} - \frac{\partial \bar{c}}{\partial x} \\ &= -\frac{\partial \bar{c}}{\partial x} - \frac{\partial \bar{c}}{\partial x} \end{aligned}$$

$$\begin{aligned} \bar{c} &= 0 \\ \bar{b} &= 0 \end{aligned}$$

$$b(s) = \sum_n b_n e^{-ns}$$

$$c(s) = \sum_n e^{-ns} c_n$$

$$\bar{b}(s) = \sum_n e^{-ns} \bar{b}_n$$

$$\begin{aligned}
 Q_X &= c \partial_X + \bar{c} \bar{\partial}_X \\
 Q_c &= c \partial_c \\
 Q_{\bar{c}} &= \bar{c} \bar{\partial}_{\bar{c}} \\
 Q_b &= T \\
 Q_{\bar{b}} &= \bar{T}
 \end{aligned}$$

$$\begin{aligned}
 &= c \partial (c \partial_X + \bar{c} \bar{\partial}_X) \\
 &= \bar{c} \bar{\partial} (c \partial_X + \bar{c} \bar{\partial}_X) \\
 &= -(\partial \bar{c}) \bar{\partial}_X - \bar{c} \partial \bar{\partial}_X
 \end{aligned}$$

$$\begin{aligned}
 Q(\partial_X \bar{\partial}_X) &= \partial (c \partial_X + \bar{c} \bar{\partial}_X) \bar{\partial}_X + c \partial \bar{c} = \partial (c \partial_X + \bar{c} \bar{\partial}_X) \bar{\partial}_X + c \partial \bar{c} \\
 Q(b \bar{\partial}_c) &= T \bar{\partial}_c + c \partial b \bar{\partial}_c + 2(\partial c) b \bar{\partial}_c - b \bar{\partial} c
 \end{aligned}$$

$$\begin{aligned}
 \partial c &= 0 \\
 \bar{\partial} b &= 0
 \end{aligned}$$

$$b(s) = \sum_n b_n e^{-ns}$$

$$c(s) = \sum_n e^{-ns} c_n$$

$$\bar{b}(\bar{s}) = \sum_n e^{-n\bar{s}} \bar{b}_n$$

$$\bar{c}(\bar{s}) = \sum_n e^{-n\bar{s}} \bar{c}_n$$

$$\{b_n, c_m\} = \delta_{n+m, 0}$$

$$\{b_n, b_m\} = 0$$

$$\{c_n, c_m\} = 0$$



$$\{b_m, c_n\} = \delta_{n+m, 0} \quad \{b_m, b_n\} = 0 \quad \{c_m, c_n\} = 0$$

$ g\rangle$	$c_n  g\rangle = 0 \quad n > 0$	$b_n  g\rangle = 0 \quad n > 0$	$c_n  g\rangle = 0 \quad n > 0$	$b_n  g\rangle = 0 \quad n > 0$	
$c_n  g\rangle$	$ g\rangle = c_n  0\rangle$	$ 0\rangle = -b_n \bar{c}_n  g\rangle$	$c_n  0\rangle = 0 \quad n > 1$	$b_n  0\rangle = 0 \quad n > -1$	...
$\bar{c}_n  g\rangle$					
$c_n \bar{c}_n  g\rangle$		$\langle 0   b_n \quad n > -1$	$\langle 0   c_{-n} = 0 \quad n > 1$		
	$\langle g   = \langle 0   c_{-n} \bar{c}_n$				
	$\langle \tilde{0}  $	$\langle \tilde{0}   b_m = 0 \quad m > 1$	$\langle \tilde{0}   c_n = 0 \quad n > -1$	$\langle \tilde{0}   = \langle 0   c_{-n} \bar{c}_n c_{-n} \bar{c}_n$	

$$\langle \tilde{0} | 0 \rangle = 1$$

$$\langle g | c \bar{c}_0 | g \rangle = 1$$

$$\langle \tilde{0} | c(s) b(s') | 0 \rangle = \frac{e^{2s'-s}}{e^{s-s'}}$$

$$\langle g | c \bar{c}_0 c(s) b(s') | g \rangle$$



$$\iint ds ds' \underbrace{K(s, s')}_{\frac{1}{s-s'}} = b(s) \bar{c}(s')$$

$$T_{gh} = \lim_{s \rightarrow s'} \left[ c(s) \partial_{s'} b(s') + 2 (\partial_s c(s)) b(s') + \frac{1}{(s-s')^2} \right] = -c \partial b + 2 (\partial c) b + \frac{13}{12}$$

$$= \sum L_n^{\text{gh}} + \frac{13}{12}$$

$$[L_n^{\text{gh}}, L_m^{\text{gh}}] = (n-m) L_{n+m}^{\text{gh}} + \frac{c_{gh}}{12} (n^3 - m^3) \delta_{n+m,0}$$

$$c_{gh} = -26 \quad [L_m^{\text{gh}}, T^{\text{gh}}(s)] = \dots$$

$$L_n^k = - \sum_k (n+k) : c_k b_{n-k} :$$

$$J_{\mu}(s) = \lim_{s \rightarrow 1} \left[ c(s) b(s) - \frac{1}{(s-1)} \right] = : c b : - \frac{3}{2} = \sum J_n e^{-ns} \quad \begin{matrix} J_3 & J_2 \\ J_1 & J_0 \end{matrix}$$

$$\langle 0 | J(s) | 0 \rangle = -\frac{3}{2}$$

$$\int_0^{2\pi} J_T d\sigma = J_0 + \bar{J}_0$$

$$\begin{aligned} J_0 |0\rangle &= -\frac{3}{2} & J_0 |1\rangle &= -\frac{1}{2} \\ \langle 0 | J_0 &= -\frac{3}{2} & \langle 1 | J_0 &= \frac{1}{2} \\ \langle 0 | \bar{J}_0 &= \frac{3}{2} \end{aligned}$$

$$L_m^k = - \sum_k (n+k) : c_k b_{m-k} :$$

$$T_{\pm}(s) = \lim_{s' \rightarrow s} \left[ c(s) b(s') - \frac{1}{(s-s')} \right] = : c b : - \frac{3}{2} = \sum T_n e^{-ns} \quad \begin{matrix} T_s & T_{\bar{s}} \\ T_0 & \bar{T}_0 \end{matrix}$$

$$\langle \tilde{0} | T(s) | 0 \rangle = -\frac{3}{2}$$

$$\int_0^{2\pi} T_T d\sigma = T_0 + \bar{T}_0$$

$$\begin{aligned} T_0 | 0 \rangle &= -\frac{3}{2} | 0 \rangle & T_0 | \phi \rangle &= -\frac{1}{2} | \phi \rangle \\ \langle \tilde{0} | T_0 &= -\langle \tilde{0} | \frac{3}{2} & \langle \phi | T_0 &= \langle \phi | \frac{1}{2} \\ \langle 0 | T_0 &= \langle 0 | \frac{3}{2} \end{aligned}$$