Title: String Theory Lecture

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$$h^{zz} = 0 \qquad h^{z\bar{z}} \qquad h^{\bar{z}\bar{z}} = 0$$

$$h_{z\bar{z}}\, dz\, d\bar{z}$$

$$b_{zz} = b \qquad b_{\bar{z}\bar{z}} = \bar{b}$$

$$\boxed{\{Q, b\} = T \qquad \{Q, \bar{b}\} = \bar{T}}$$

$$v^{z} \frac{\partial}{\partial z} + v^{\bar{z}} \frac{\partial}{\partial \bar{z}}$$

$$c^{z} = c \qquad c^{\bar{z}} = \bar{c}$$

$$\boxed{\{Q, X^{\mu}\} = c\,\partial X^{\mu} + \bar{c}\,\bar{\partial} X^{\mu}}$$

$h^{\bar z \bar z} = 0$

$v^z \frac{\partial}{\partial z} + v^{\bar z} \frac{\partial}{\partial \bar z}$

$\begin{pmatrix} \partial v & \partial \bar v \\ \bar\partial v & \bar\partial \bar v \end{pmatrix}$

$\{v, v'\} = v \partial v' - v' \partial v$

$c^z = c \qquad c^{\bar z} = \bar c$

$b_{\bar z \bar z} = \bar b$

$S_{gh} = \int [$

$$\boxed{\{Q, X^\mu\} = c\,\partial X^\mu + \bar c\,\bar\partial X^\mu}$$

$S_X = T \int$

$$\boxed{\{Q, \bar b\} = \bar T}$$

$\{Q, c\} = c\,\partial c$

$Q^2 = 0$

$Q \Rightarrow \oint J_{BRS}$

$$\begin{pmatrix} \partial v & \partial \bar v \\ \bar\partial v & \bar\partial \bar v \end{pmatrix}$$

$$v'\} = v\partial v' - v'\partial v$$

$$\delta h^{zz} = h^{z\bar z}\,\partial_{\bar z} v^{z} + \cdots$$

$$\delta h^{\bar z\bar z} = h^{z\bar z}\,\partial_{z} v^{\bar z}$$

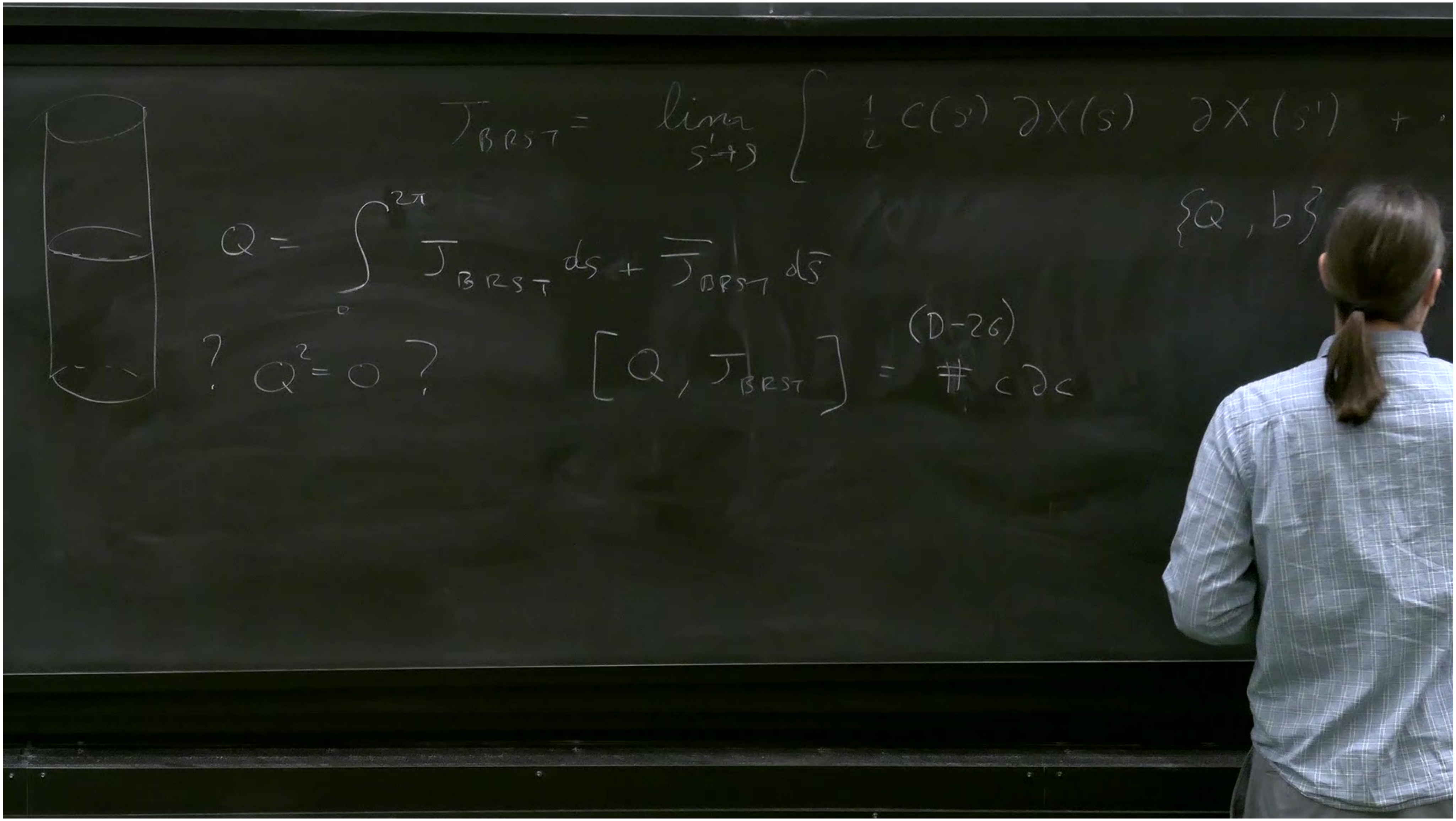
$$T_{z\bar z} = 0$$

$$S_{gh} = \int \left[b_{zz}\,\bar\partial c^{z} + b_{\bar z\bar z}\,\partial c^{\bar z} \right] dz\, d\bar z$$

$$\boxed{\bar c\,\bar\partial X^{\mu}}$$

$$S_X = T \int \partial X_\mu \bar\partial X^\mu \, dz\, d\bar z$$

$$Q \Rightarrow J_{BRST} = \tfrac{1}{2} c\,\partial X \partial X + \cdot\; b c \partial c$$


$J_{BRST} = \lim_{s' \to s} \int \frac{1}{2} c(s') \partial X(s) \, \partial X(s') + \dots$
$\{Q, b\}$
$Q = \int_0^{2\pi} J_{BRST} \, ds + \bar{J}_{BRST} \, d\bar{s}$
$(D-26)$
$? \; Q^2 = 0 \; ?$
$[Q, J_{BRST}] = \# \, c \partial c$

$$\partial X(\sigma') + \cdot\, b(\sigma)\; c(\sigma')\partial c(\sigma') \;-\; ?\;]$$

$$\{Q, b\} = T = T^X + T^{gh}$$

$$[L, L] = (\ )L + \frac{\#}{12} n^2(n-1)$$

$$\{Q, b_n\} = L_n$$

$$[L_m, \{Q, b_n\}] = \{\overset{0}{\overset{\|}{[L_m, Q]}}, b_n\} + \{Q, \overset{(m-n)\,b_{m+n}}{[L_m, b_n]}\} = (m-n)L_{n+m}$$

$$S_{gh} = \int b\,\bar\partial c \, dz\, d\bar z + \int \bar b\, \partial \bar c \, dz\, d\bar z$$

$$\bar\partial c = 0 \qquad \partial \bar c = 0$$
$$\bar\partial b = 0 \qquad \partial \bar b = 0$$

$$b_{zz} \qquad c^{z}$$

$$b' = b\left(\frac{dz}{dz'}\right)^{2}$$

$$c' = c\left(\frac{dz}{dz'}\right)^{-1}$$

$$T_{gh} = \underbrace{c\,\partial_s b}_{= -\partial_s b\, c} + 2\,\partial_s c\, b$$

$$J^{gh} = cb$$

$= 0$

$= 0$

$\langle b(s) \,|\, c(s') \rangle$

$$J^{gl} = \lim_{s \to s'} \left(b(s)\, c(s') - \frac{1}{s - s'} \right)$$

$$s = s(z) \qquad J_s = \left(b(s)\, c(s') - \frac{1}{s - s'} \right) = \cdots \Big($$

$$J_z = \left(b(z)\, c(z') - \frac{1}{z - z'} \right)$$

J^{gh} IS "ANOMALOUS" $\Rightarrow \langle O_1 \cdots O_n \rangle_\Sigma$ $\qquad \sum_i gh(O_i) = \text{NUMBER}(\Sigma)$

$$= \cdots \left(\left(\frac{dz}{ds}\right)^2 \left(\frac{ds'}{dz'}\right) b(z)\, c(z') - \frac{1}{s-s'} \right)$$

$$\left(\frac{dz}{ds}\right)^2 \left(\frac{ds'}{dz'}\right) \left(\cdots \right) + \left(\frac{dz}{ds}\right)^2 \left(\frac{ds'}{dz'}\right) \frac{1}{z-z'} - \frac{1}{s(z)-s(z')}$$

ALOUS" $\Rightarrow \langle O_1 \cdots O_n \rangle_\Sigma$ $\qquad \sum_i gh(O_i) = \text{NUMBER}(\Sigma)$

$\langle \quad \rangle_{S^2}$ $\qquad \# c - \# b = 3$

$$b(z)\,c(z') - \frac{1}{s-s'}\Bigg)$$

$$\cdots\Bigg) + \left(\frac{dz}{ds}\right)^2\left(\frac{ds'}{dz'}\right)\frac{1}{z-z'} - \frac{1}{s(z)-s(z')}$$

$\bar\partial c = 0 \qquad \partial \bar c = 0$

$\bar\partial b = 0 \qquad \partial \bar b = 0$

$$\bar\partial_s \langle b(s)\, c(s') \cdots \rangle = \cdot\, \delta^{(2)}(s-s')$$

$$\langle b(s)\, c(s') \cdots \rangle \sim \frac{1}{s-s'} + \cdots$$

$\partial_s c\, b$

$$[L^{gh}_m, L^{gh}_n] = (m-n) L^{gh}_{m+n} + \frac{-26}{12} n(n^2-1)\,\delta_{m+n,0}$$

$T^X + T^{gh}$ $\qquad$ # $D-26$

$$S_{gh} = \int b\,\bar\partial c \, dz\, d\bar z + \int \bar b\,\partial \bar c \, dz\, d\bar z \qquad \begin{array}{l}\bar\partial c = 0 \\ \bar\partial b = 0\end{array} \qquad \begin{array}{l}\partial \bar c = 0 \\ \partial \bar b = 0\end{array}$$

$b_{zz} \qquad c^z$

$$b' = b\left(\frac{dz}{dz'}\right)^2$$

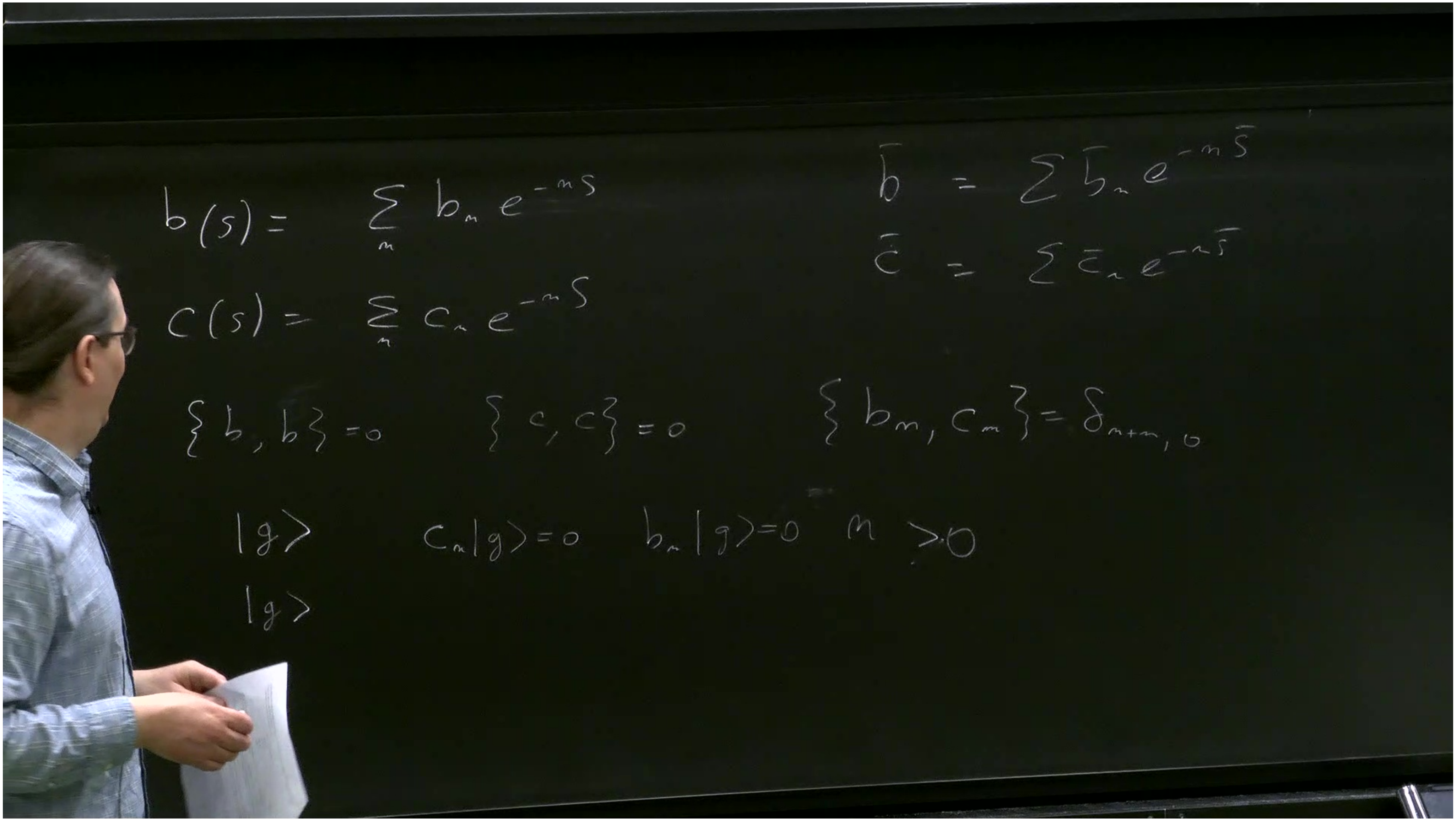
$$c' = c\left(\frac{dz}{dz'}\right)^{-1}$$

$$T_{gh} = \underset{\overset{\shortparallel}{-\partial_z b\, c}}{c\,\partial_z b} + 2\,\partial_z c\, b$$

$$J^{gh} = cb$$

$$T^X + T^{gh}$$

$[L$



$b(s) = \sum_n b_n e^{-ns}$
$\bar{b} = \sum \bar{b}_n e^{-n\bar{s}}$
$\bar{c} = \sum \bar{c}_n e^{-n\bar{s}}$
$c(s) = \sum_n c_n e^{-ns}$
$\{b, b\} = 0$
$\{c, c\} = 0$
$\{b_n, c_m\} = \delta_{n+m,0}$
$|g\rangle$
$c_n|g\rangle = 0$
$b_n|g\rangle = 0$
$n > 0$
$|g\rangle$

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

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

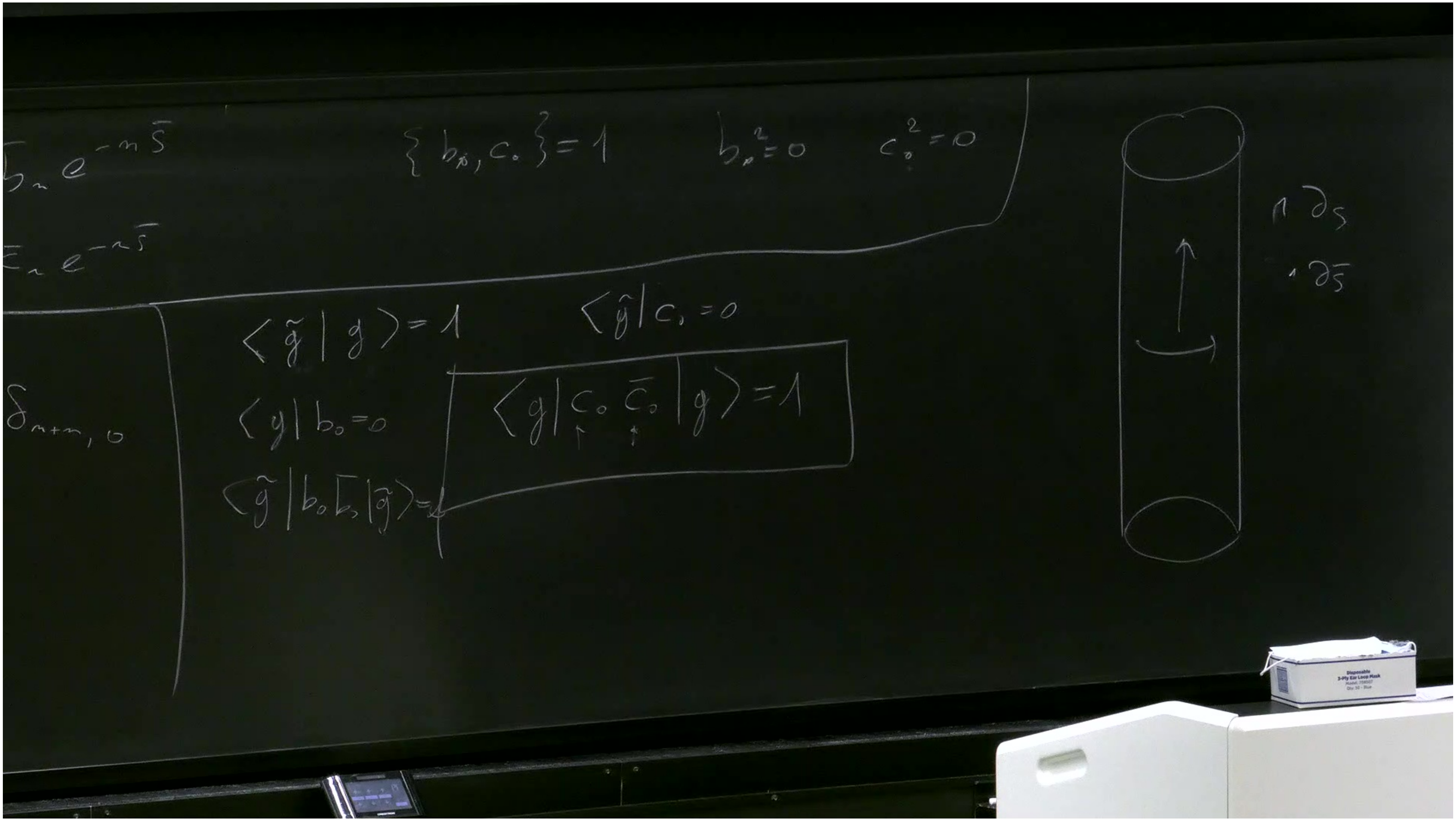
$$\{b, b\} = 0 \qquad \{c, c\} = 0 \qquad \{b_n, c_m\} = \delta_{n+m,0}$$

$$|g\rangle \qquad c_n|g\rangle = 0 \quad b_n|g\rangle = 0 \quad n > 0$$

$$c_0|g\rangle \underset{c_0}{\overset{b_0}{\rightleftarrows}} |g\rangle \qquad b_0|g\rangle = 0$$

$$\ldots \quad c_{-1}|g\rangle, \ldots$$

$$\ldots \quad b_{-1}|g\rangle \ldots$$


{b₀, c₀} = 1
b₀² = 0
c₀² = 0
⟨g̃ | g⟩ = 1
⟨g̃ | c₀ = 0
⟨g | b₀ = 0
⟨g | c₀ c̄₀ | g⟩ = 1
δ_{n+m,0}