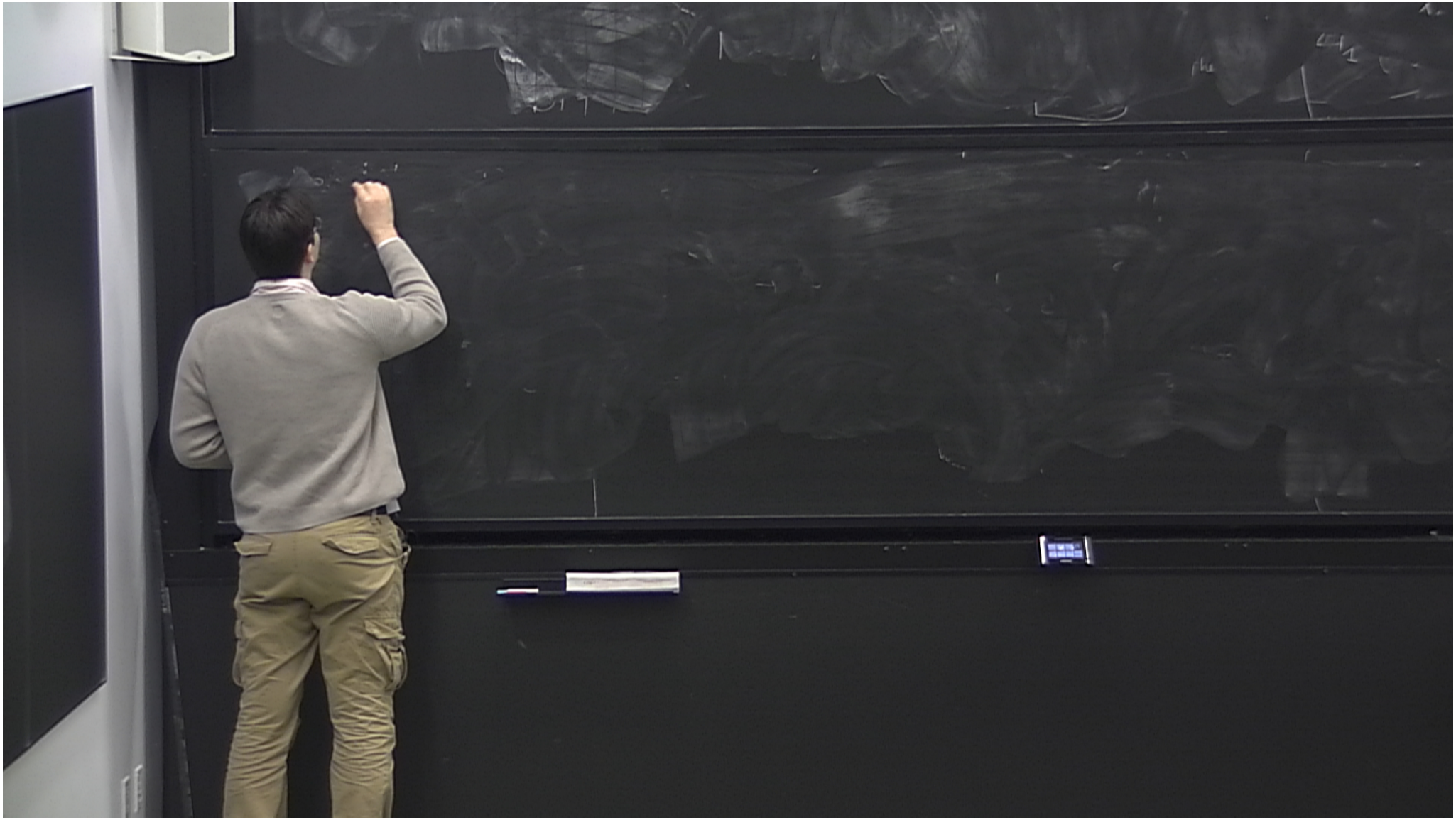
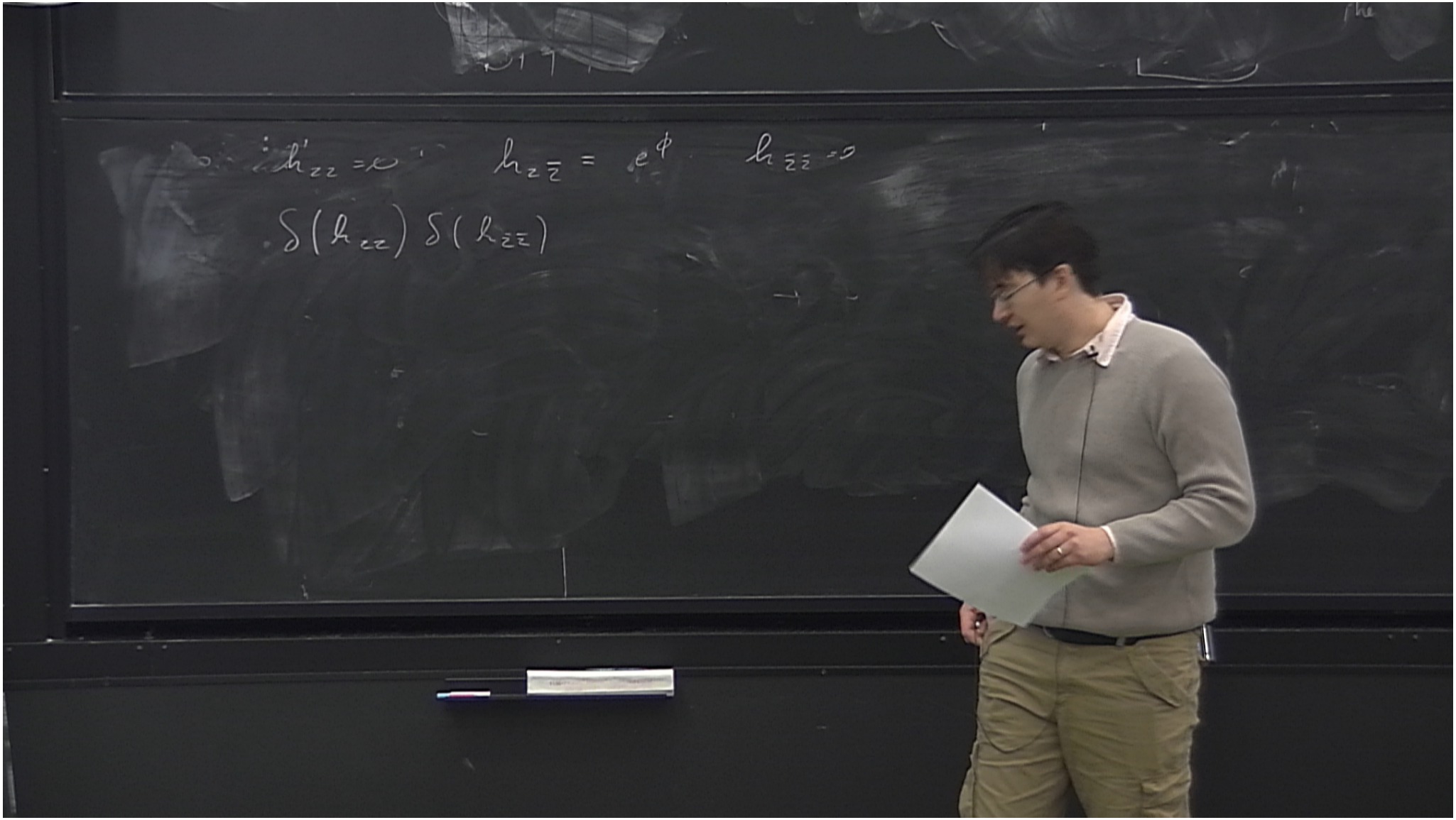
Title: 13/14 PSI - String Theory Review - Lecture 6

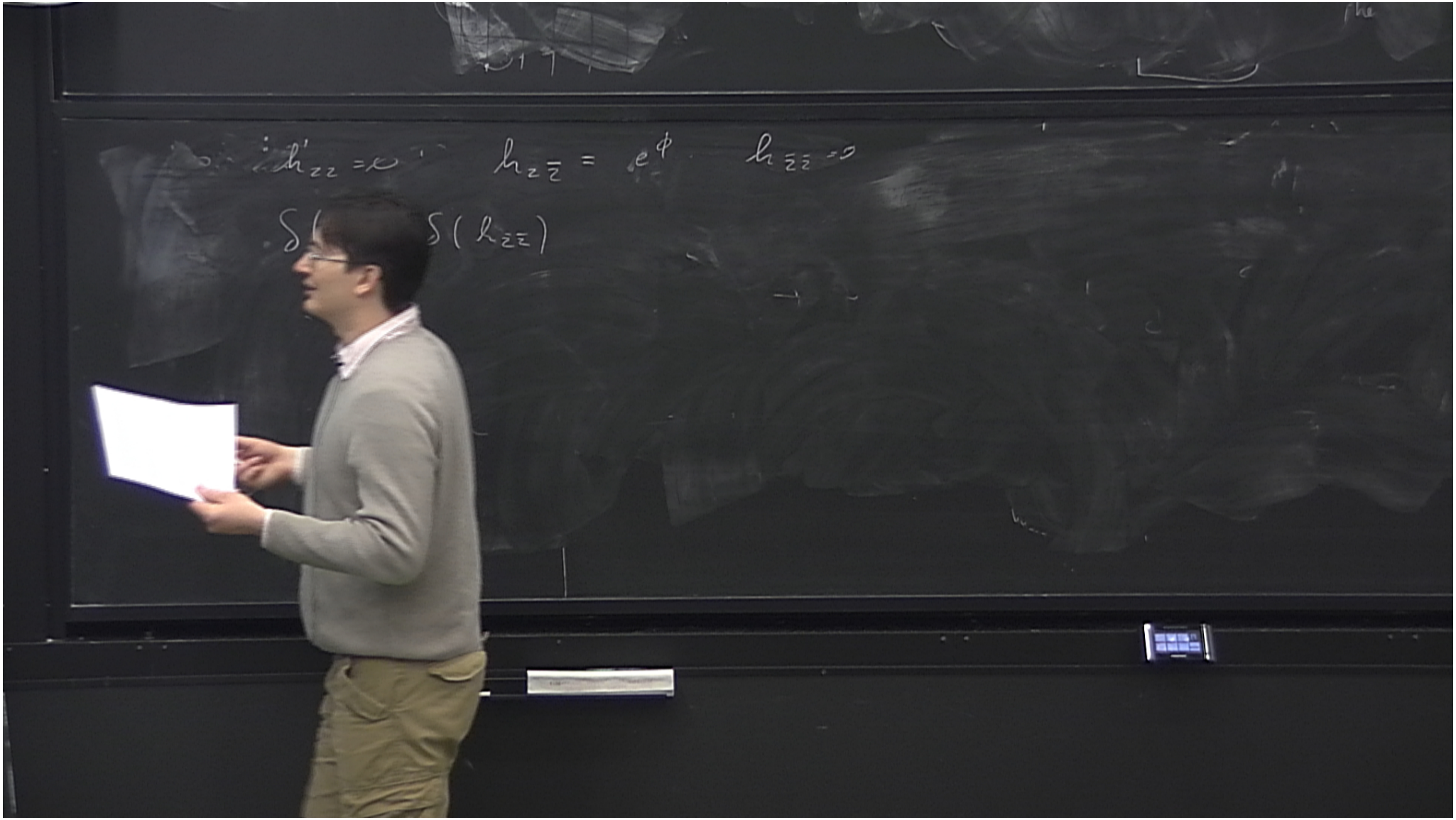
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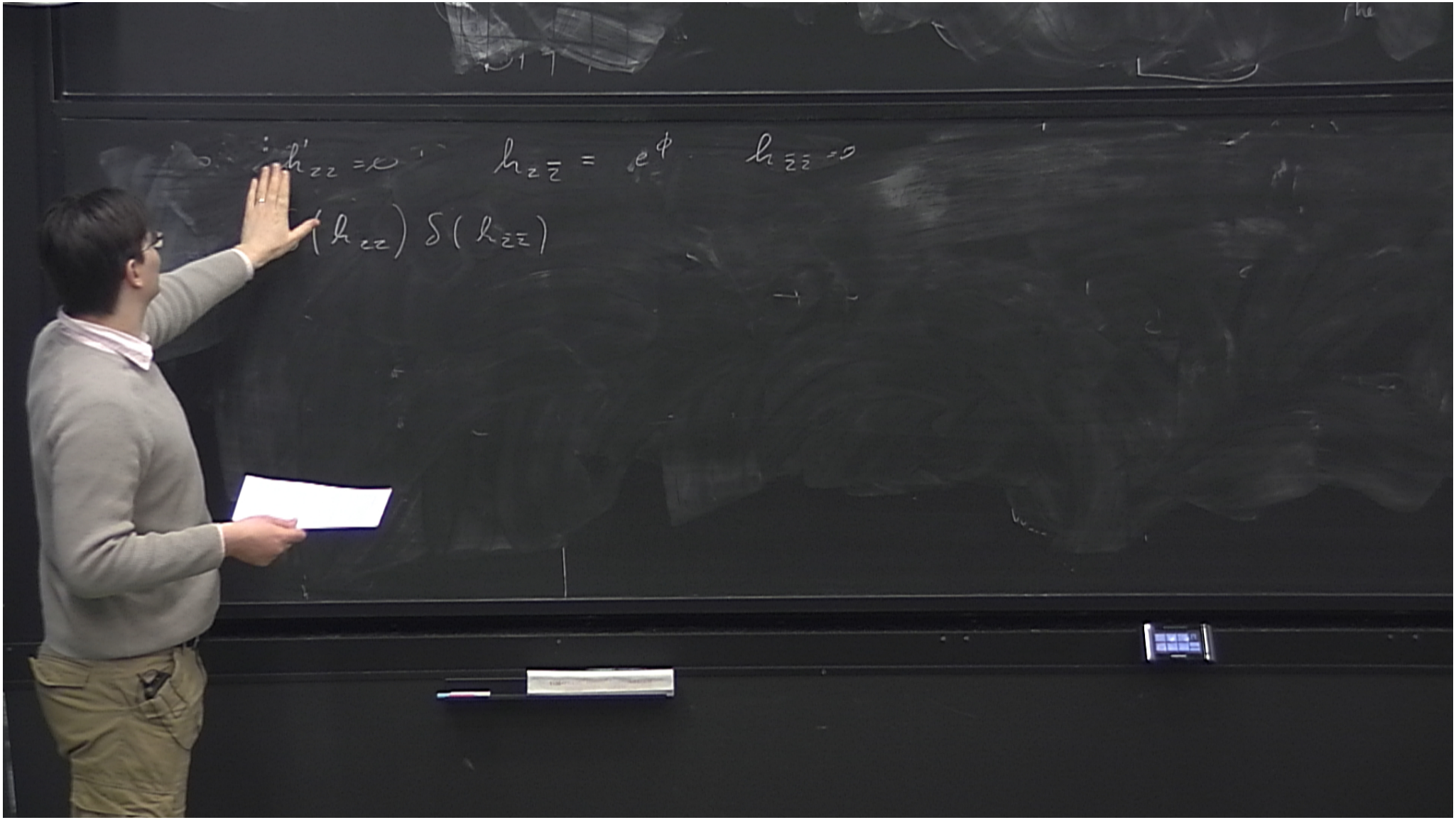
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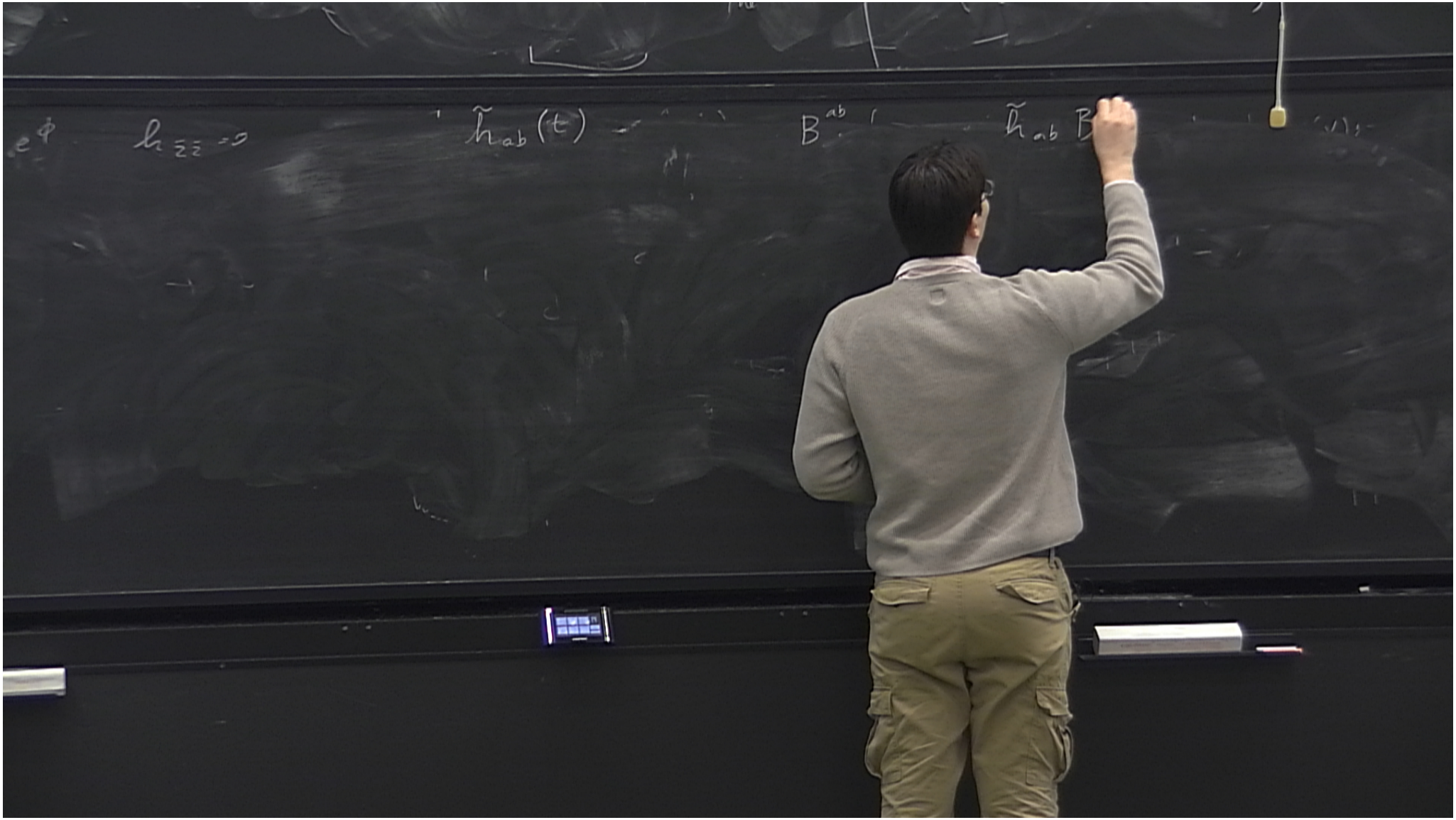
Abstract:

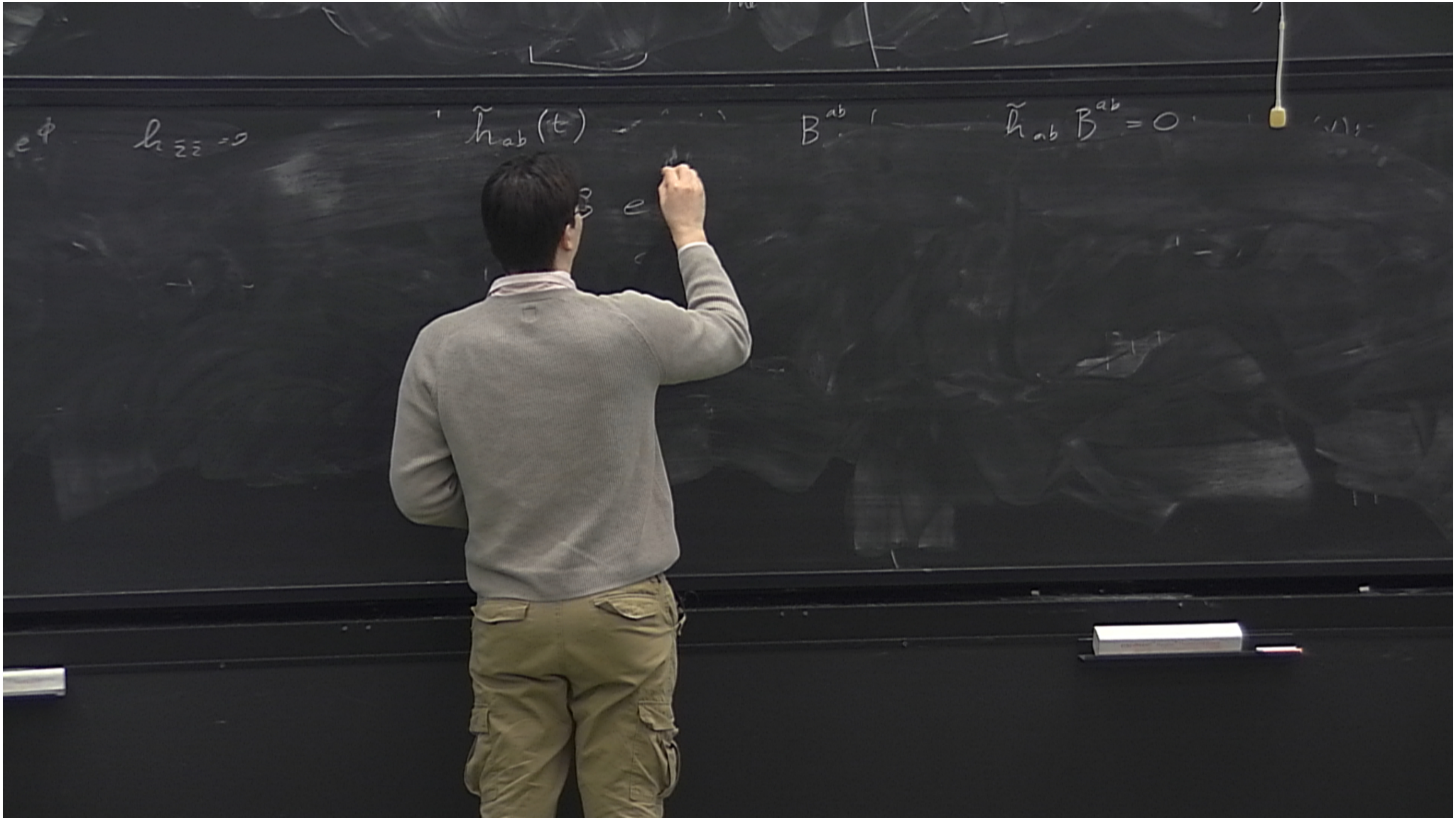


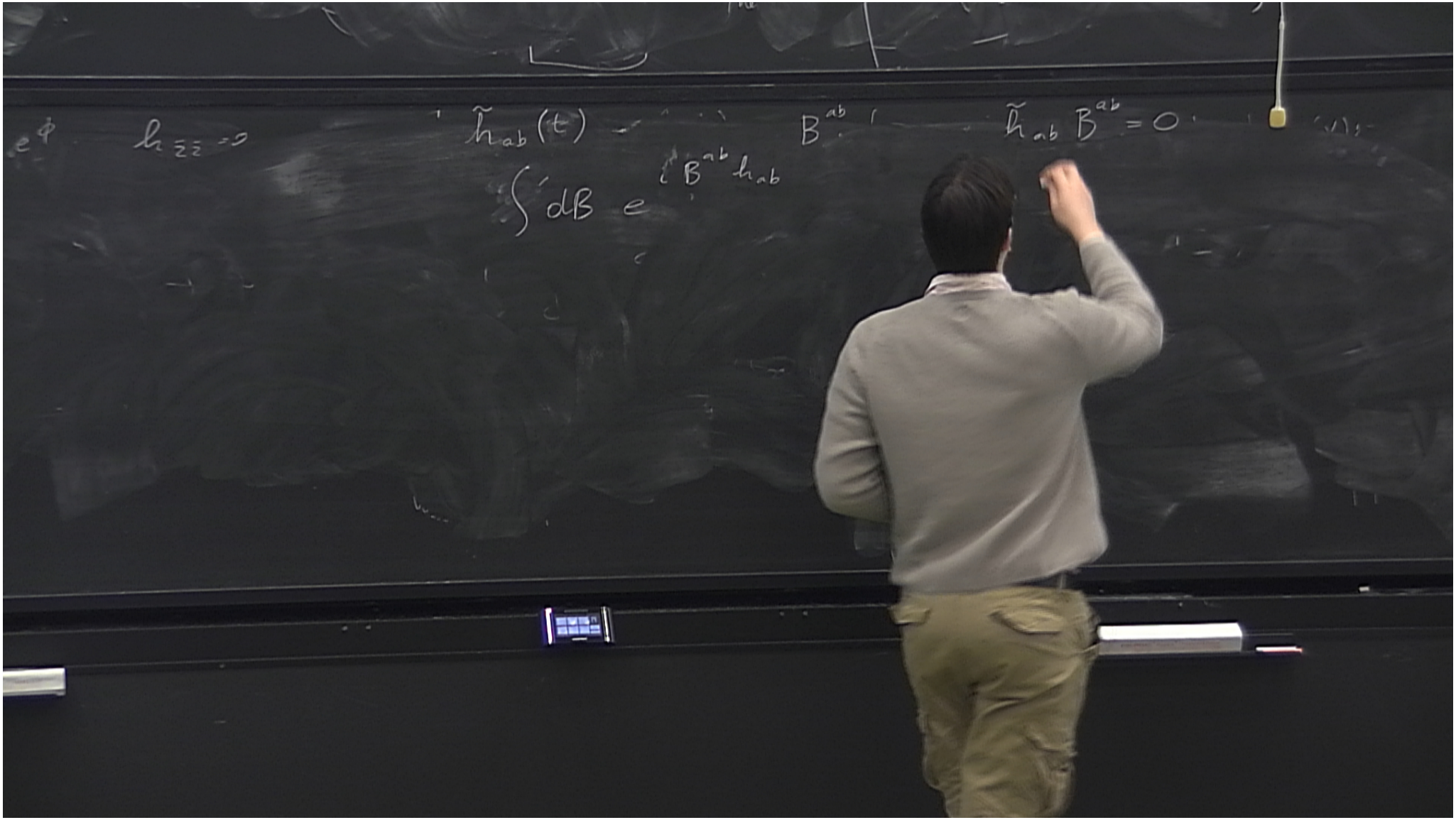

$h_{zz} = 0$
$h_{z\bar{z}} = e^{\phi}$
$h_{\bar{z}\bar{z}} = 0$
$\delta(h_{zz})\,\delta(h_{\bar{z}\bar{z}})$


$h_{zz} = e^{\omega}$
$h_{z\bar{z}} = e^{\phi}$
$h_{\bar{z}\bar{z}} = 0$
$\delta($
$\delta(h_{\bar{z}\bar{z}})$

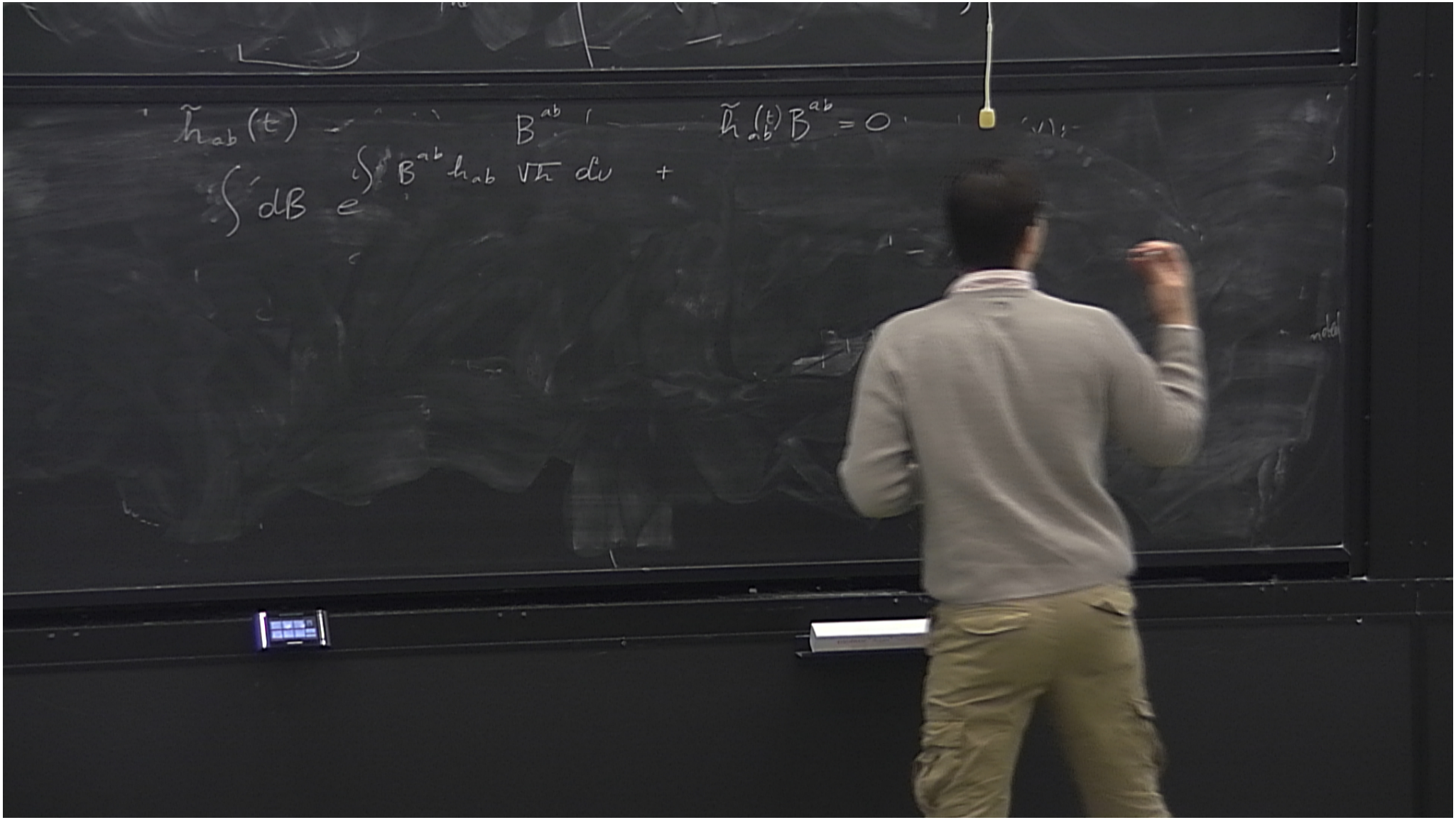

$h'_{zz} = e^{\omega}$
$h_{z\bar{z}} = e^{\phi}$
$h_{\bar{z}\bar{z}} = 0$
$\delta(h_{zz})\,\delta(h_{\bar{z}\bar{z}})$

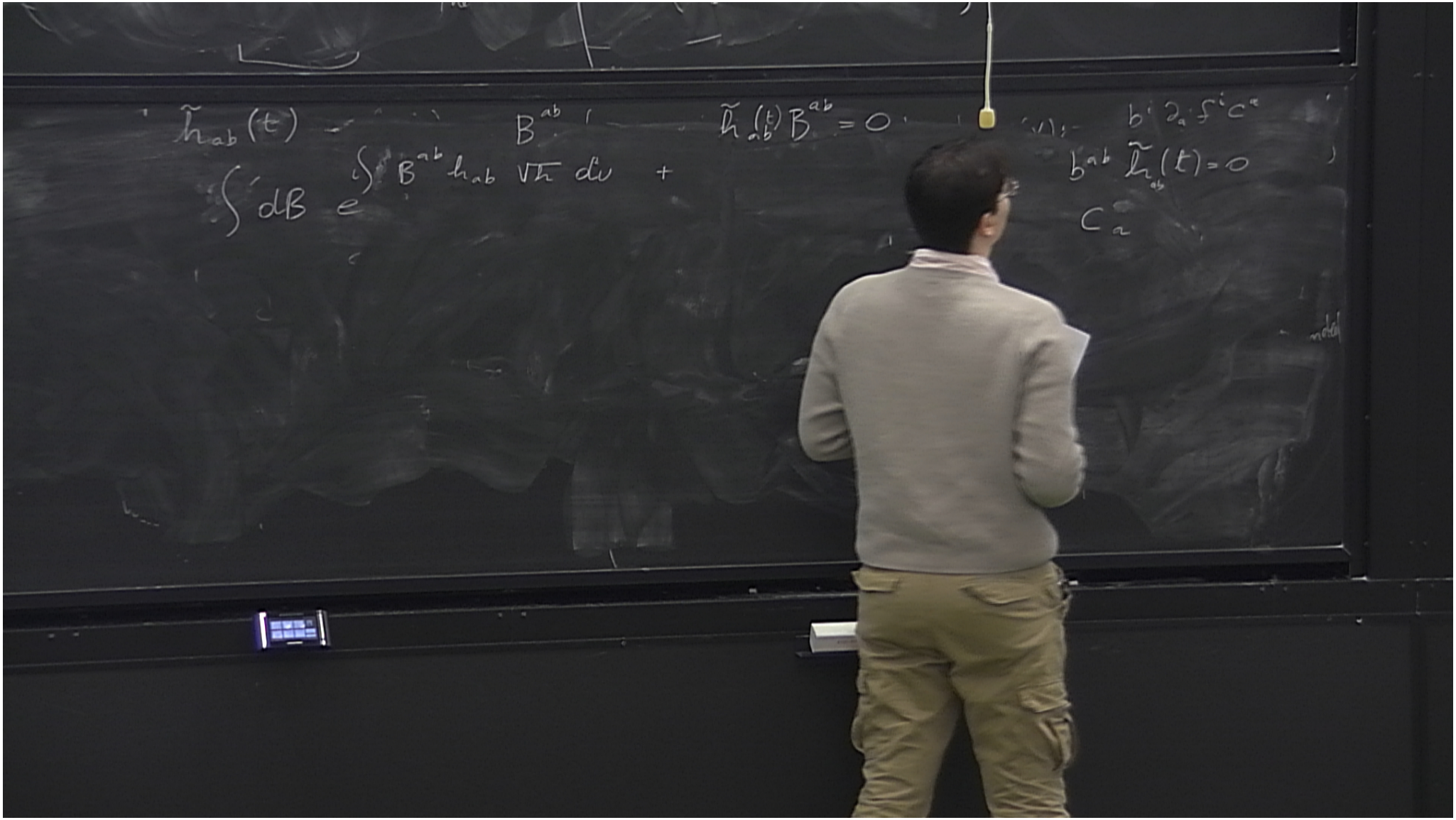

$\tilde{h}_{ab}(t)$
B^{ab}

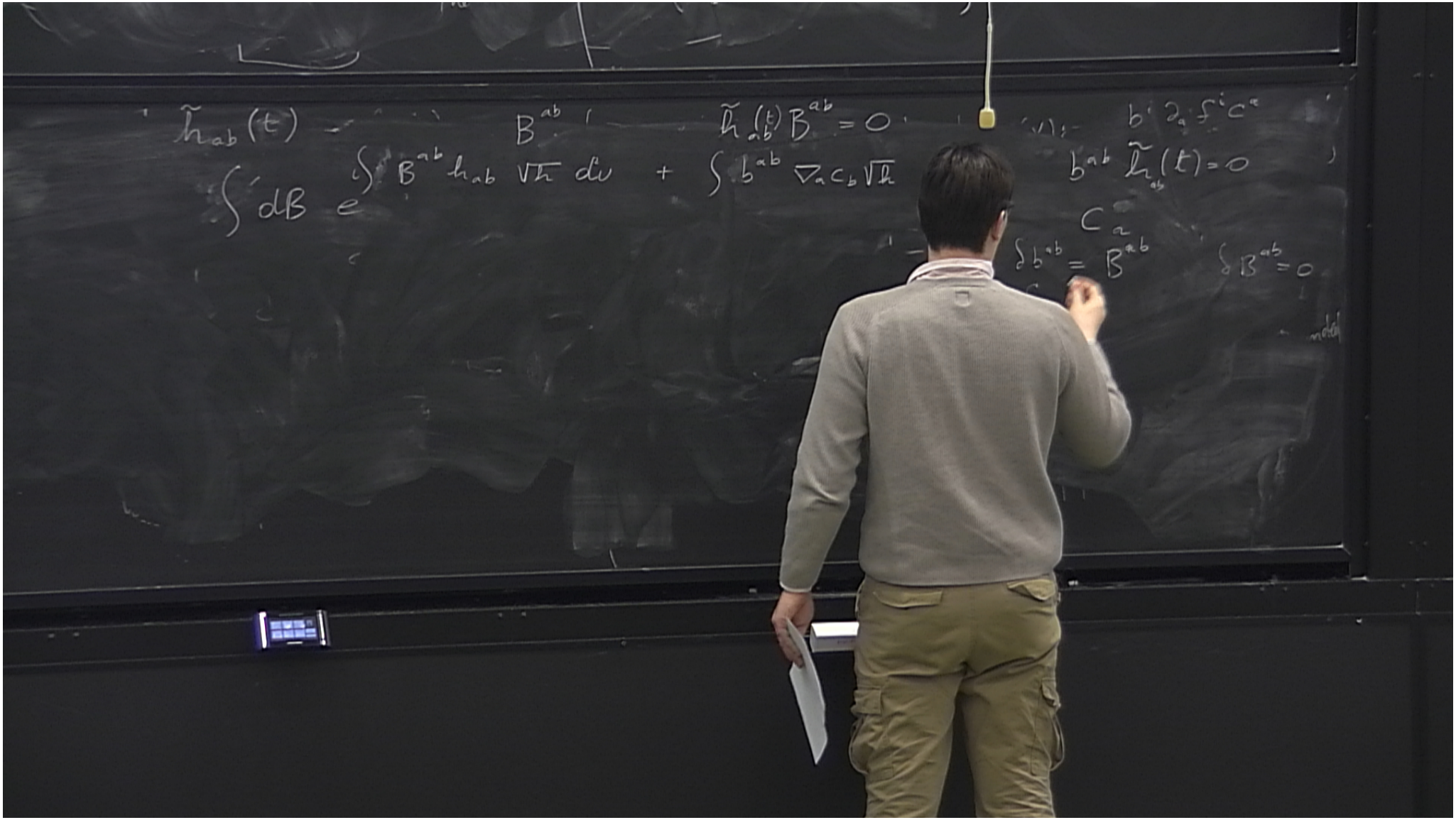

e^{ϕ}
$h_{z\bar{z}} = 0$
$\tilde{h}_{ab}(t)$
B^{ab}
$\tilde{h}_{ab} B^{ab} = 0$

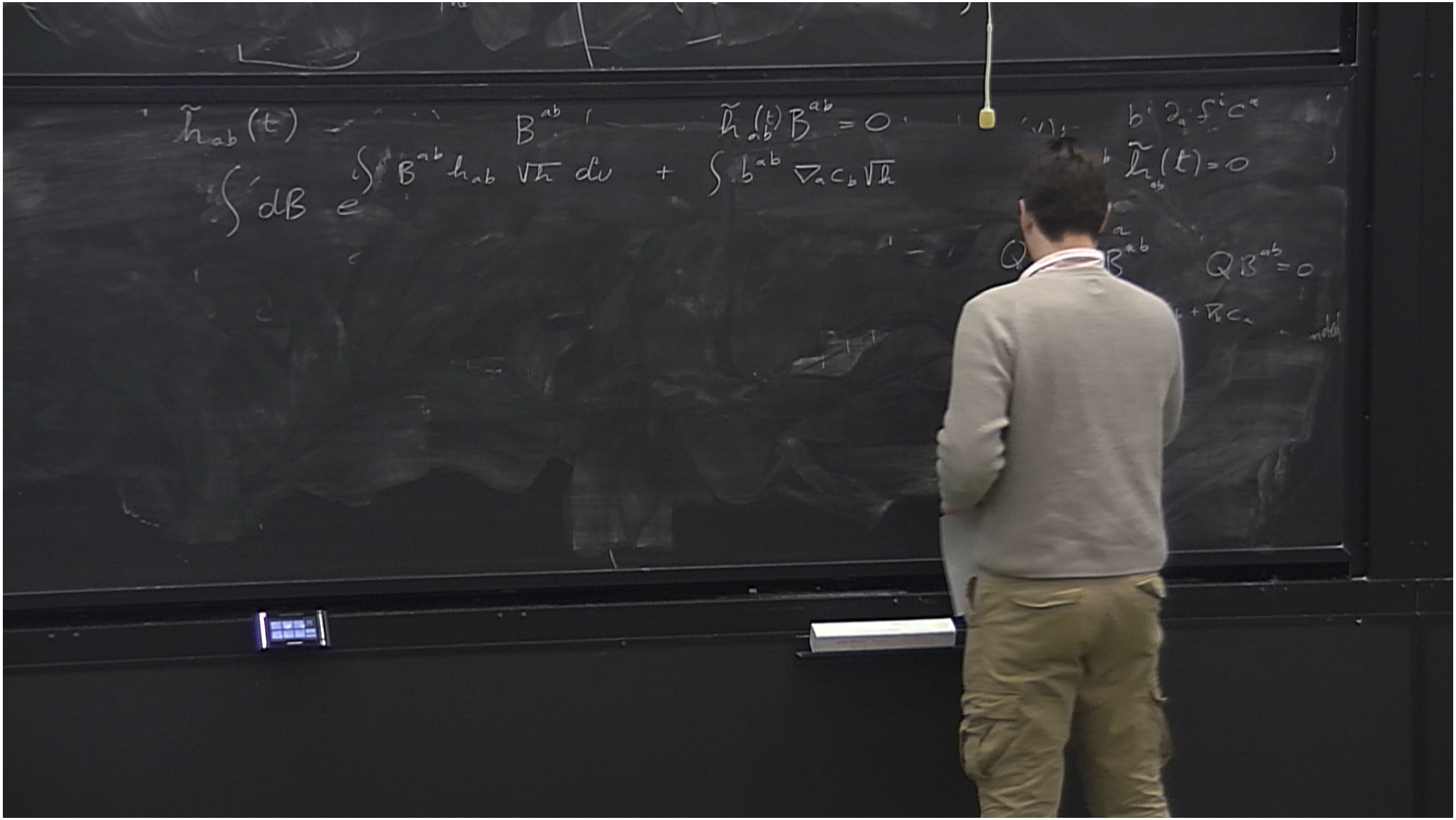

e^{ϕ} $h_{z\bar{z}} = 0$
$\tilde{h}_{ab}(t)$ B^{ab} $\tilde{h}_{ab} B^{ab} = 0$
$\int dB \; e^{i B^{ab} h_{ab}}$

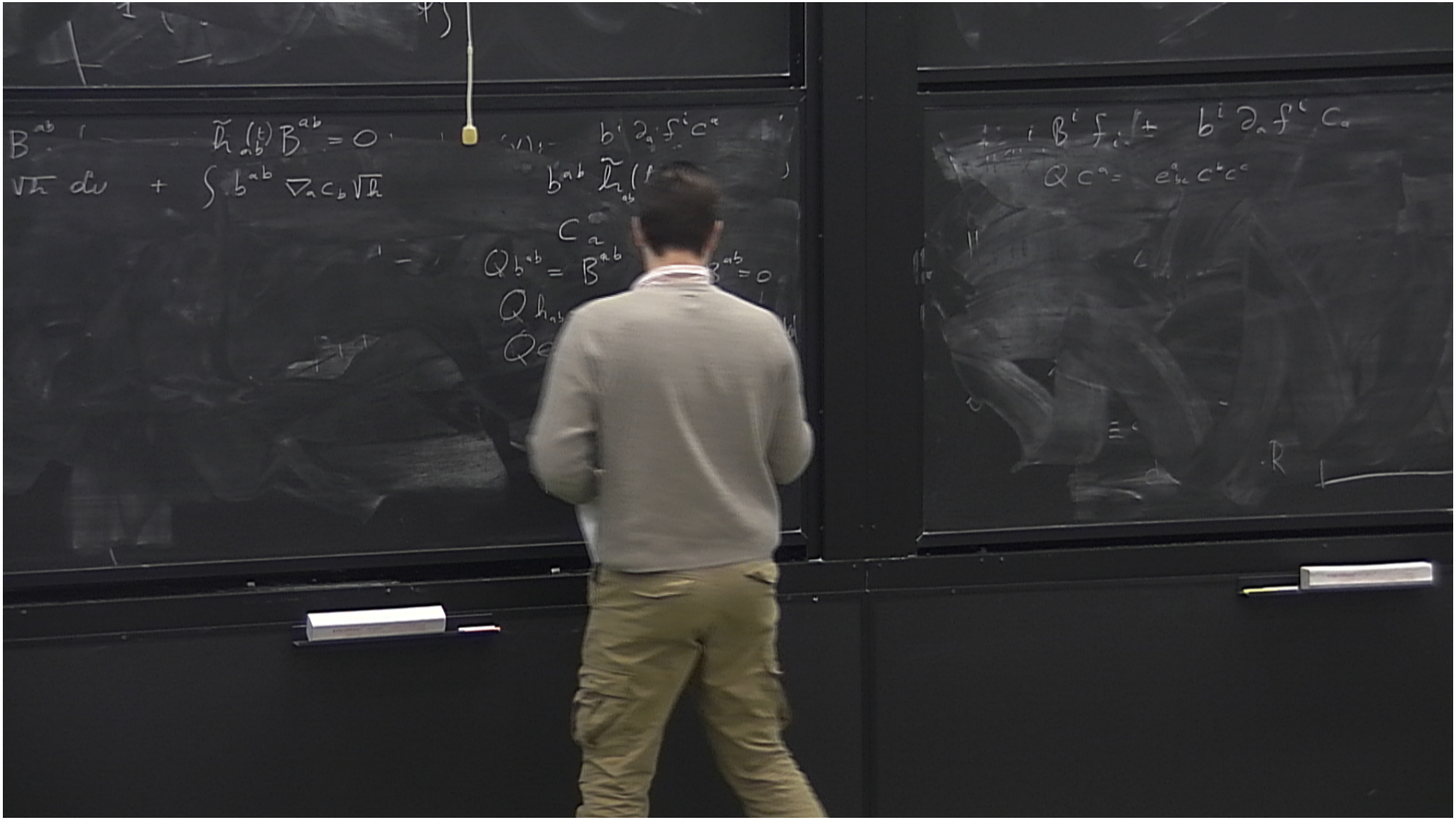

$\tilde{h}_{ab}(t)$
B^{ab}
$\tilde{h}^{(t)}_{ab} B^{ab} = 0$
$\int dB \; e^{i B^{ab} h_{ab}}$

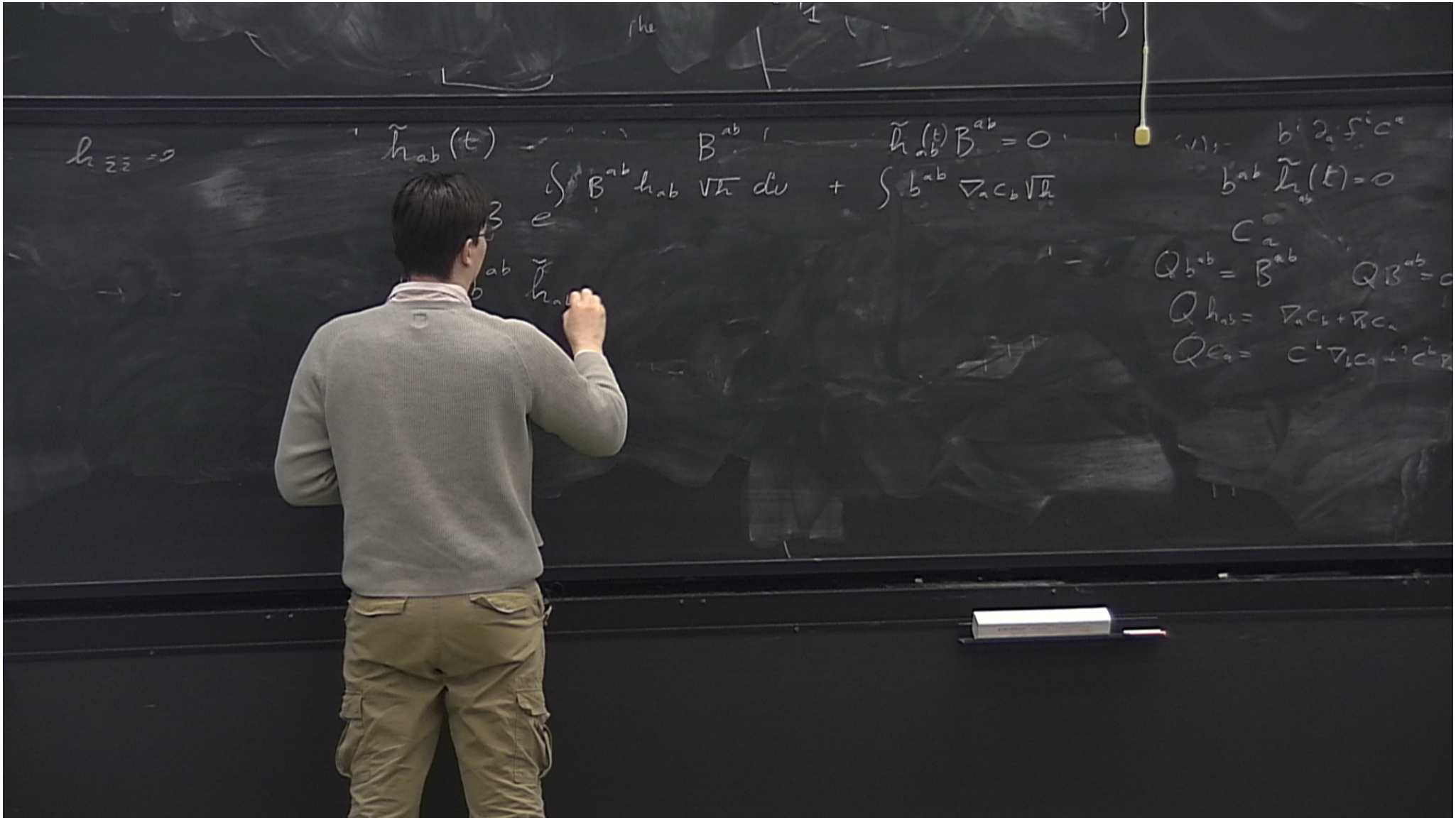

$\tilde{h}_{ab}(t)$
B^{ab}
$\tilde{h}^{(t)}_{ab} B^{ab} = 0$
$\int dB\, e^{i\int B^{ab} h_{ab} \sqrt{h}\, dv} +$

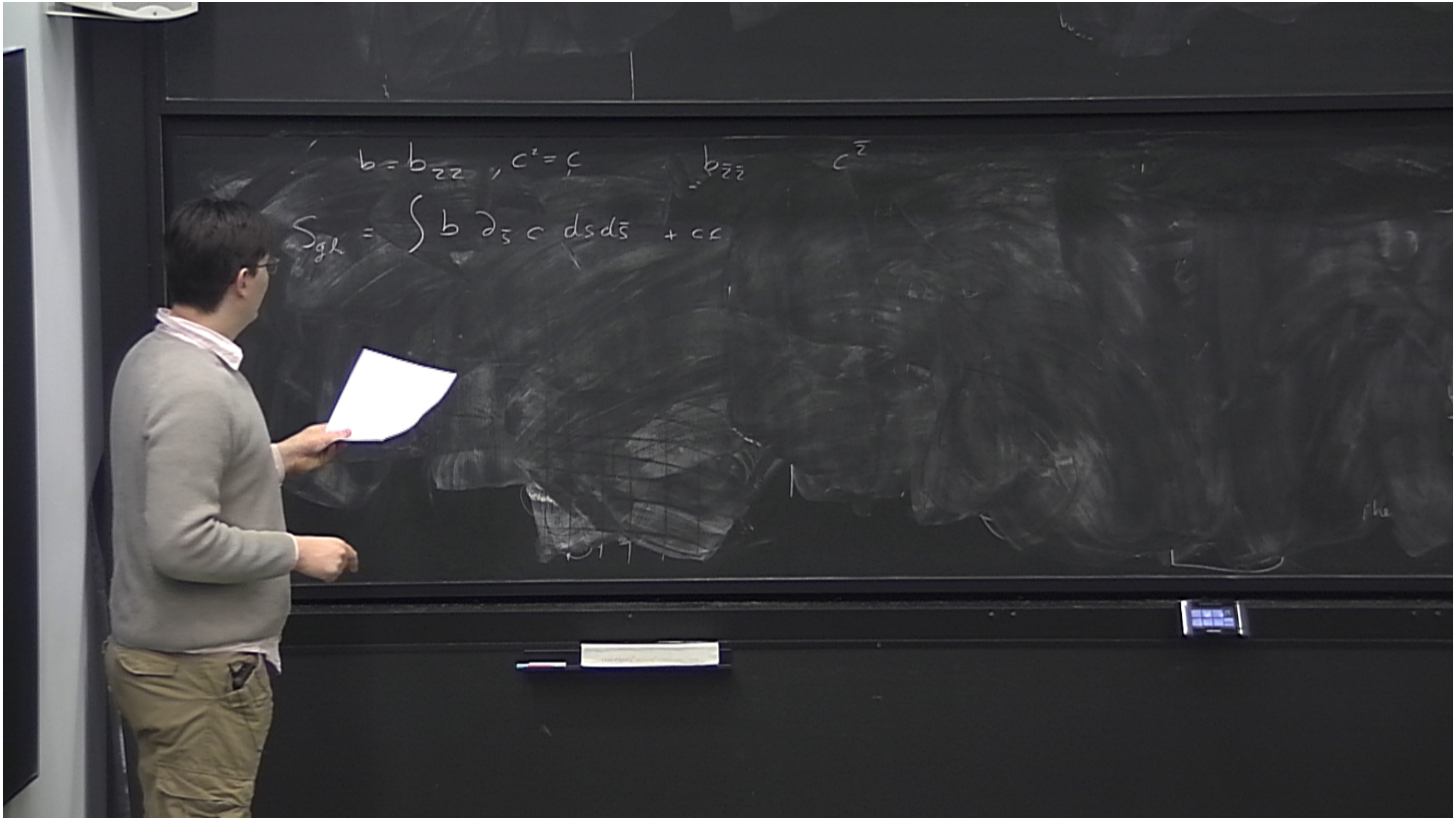

$\tilde{h}_{ab}(t)$
B^{ab}
$\tilde{h}^{(t)}_{ab} B^{ab} = 0$
$\int dB\, e^{i\int B^{ab} h_{ab} \sqrt{h}\, dv} +$
$b^{ab} \tilde{h}_{ab}(t) = 0$
C_2

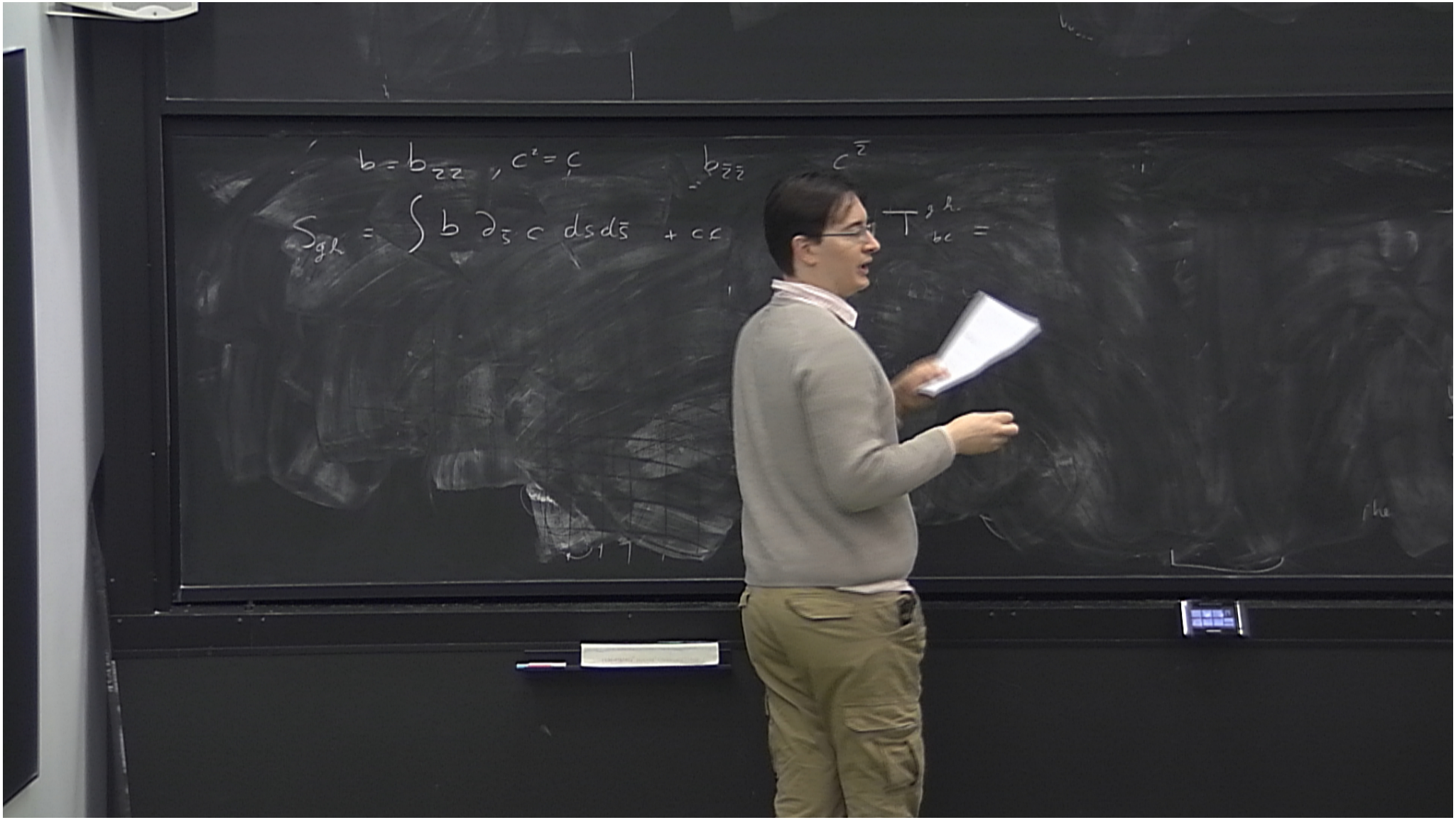

$\tilde{h}_{ab}(t)$
B^{ab}
$\tilde{h}^{(t)}_{ab} B^{ab} = 0$
$\int dB\, e^{\int B^{ab} h_{ab} \sqrt{h}\, dv + \int b^{ab} \nabla_a c_b \sqrt{h}}$
$b^{ab} \tilde{h}_{ab}(t) = 0$
$\delta b^{ab} = B^{ab}$
$\delta B^{ab} = 0$

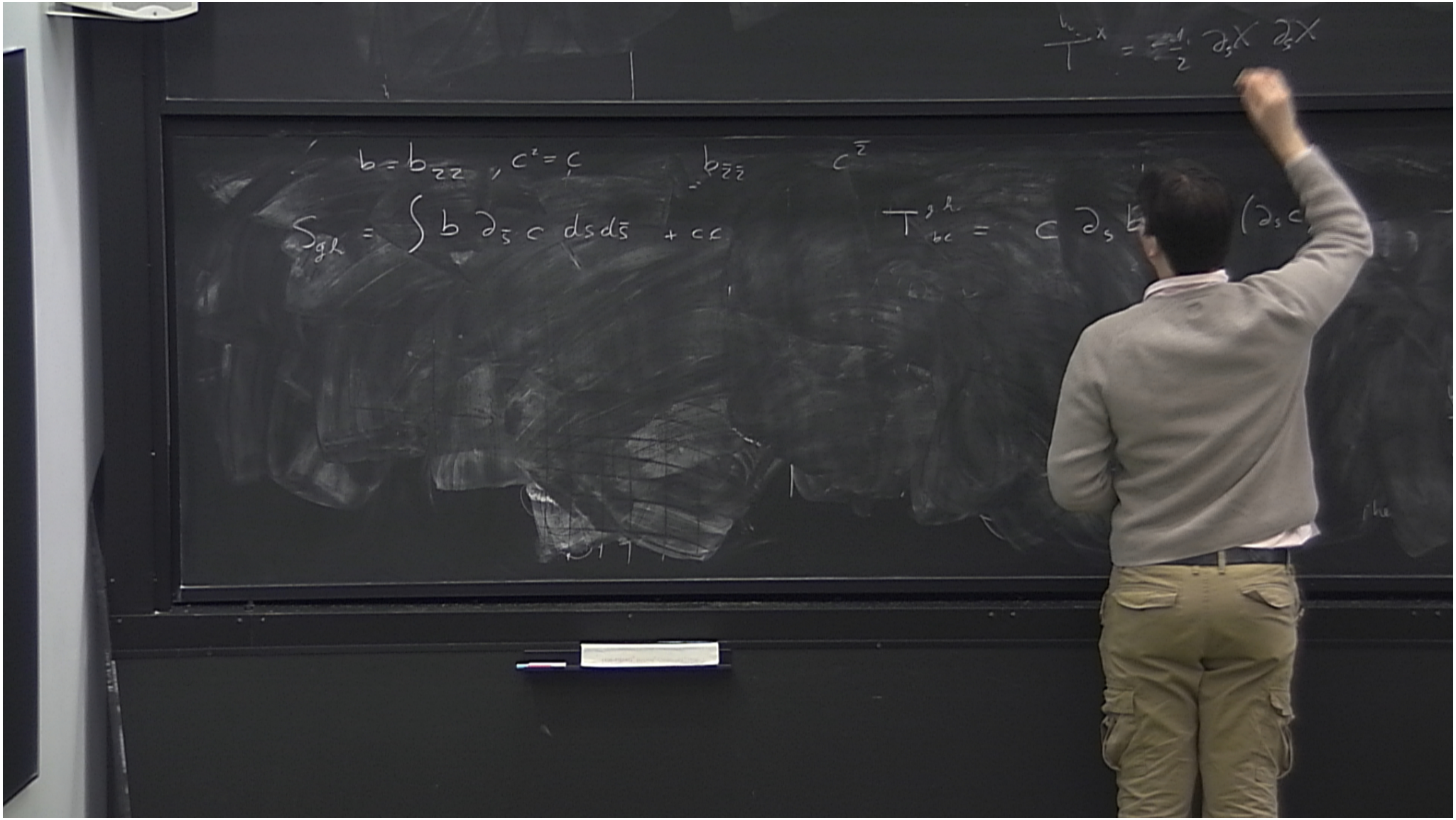

$\tilde{h}_{ab}(t)$
B^{ab}
$\tilde{h}^{(t)}_{ab} B^{ab} = 0$
$\int dB\, e^{i\int B^{ab} h_{ab}\sqrt{h}\, dv + \int b^{ab} \nabla_a c_b \sqrt{h}}$
$b\, \partial_a f^i c^a$
$\tilde{h}_{ab}(t) = 0$
$Q B^{ab} = 0$

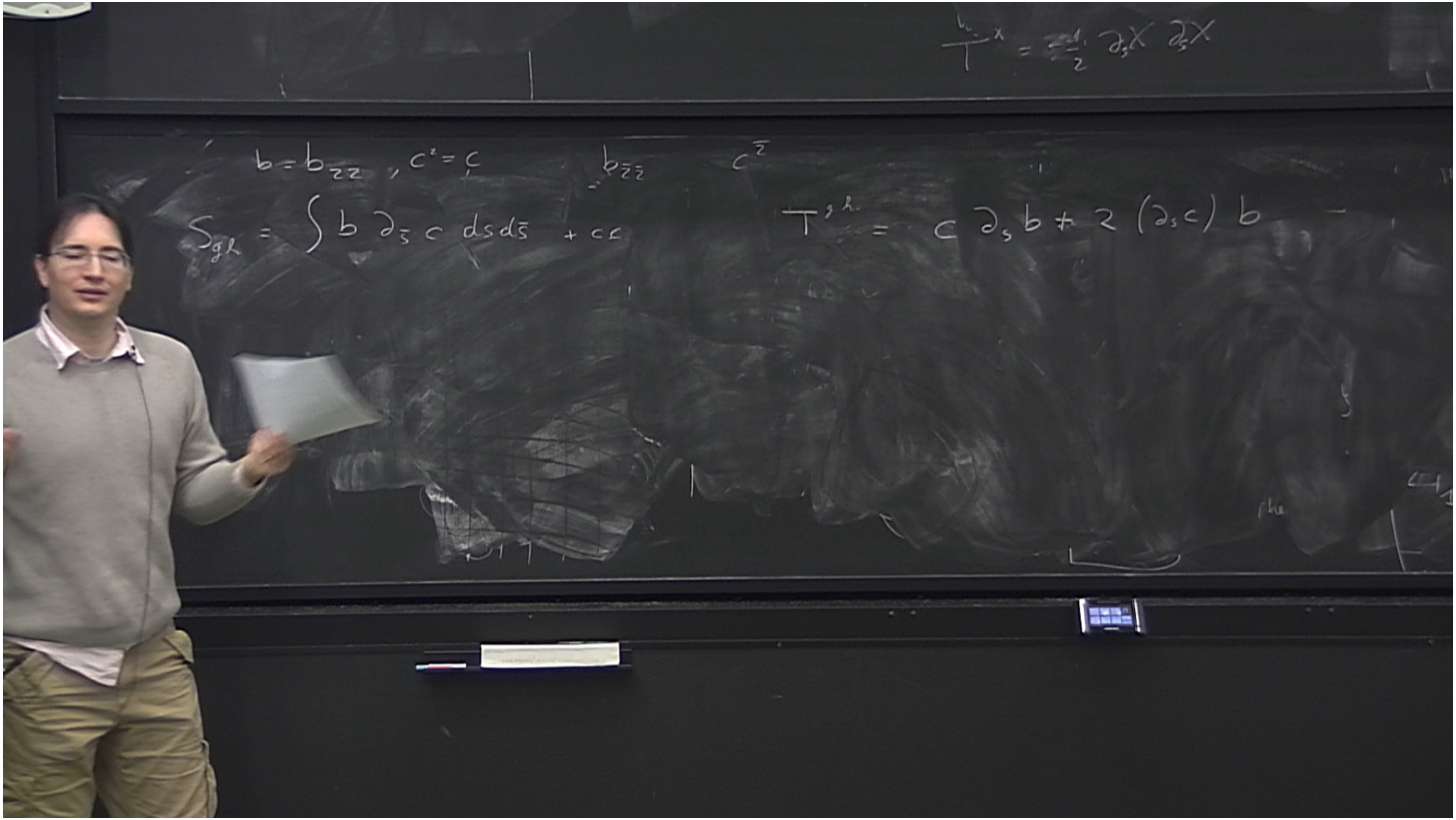


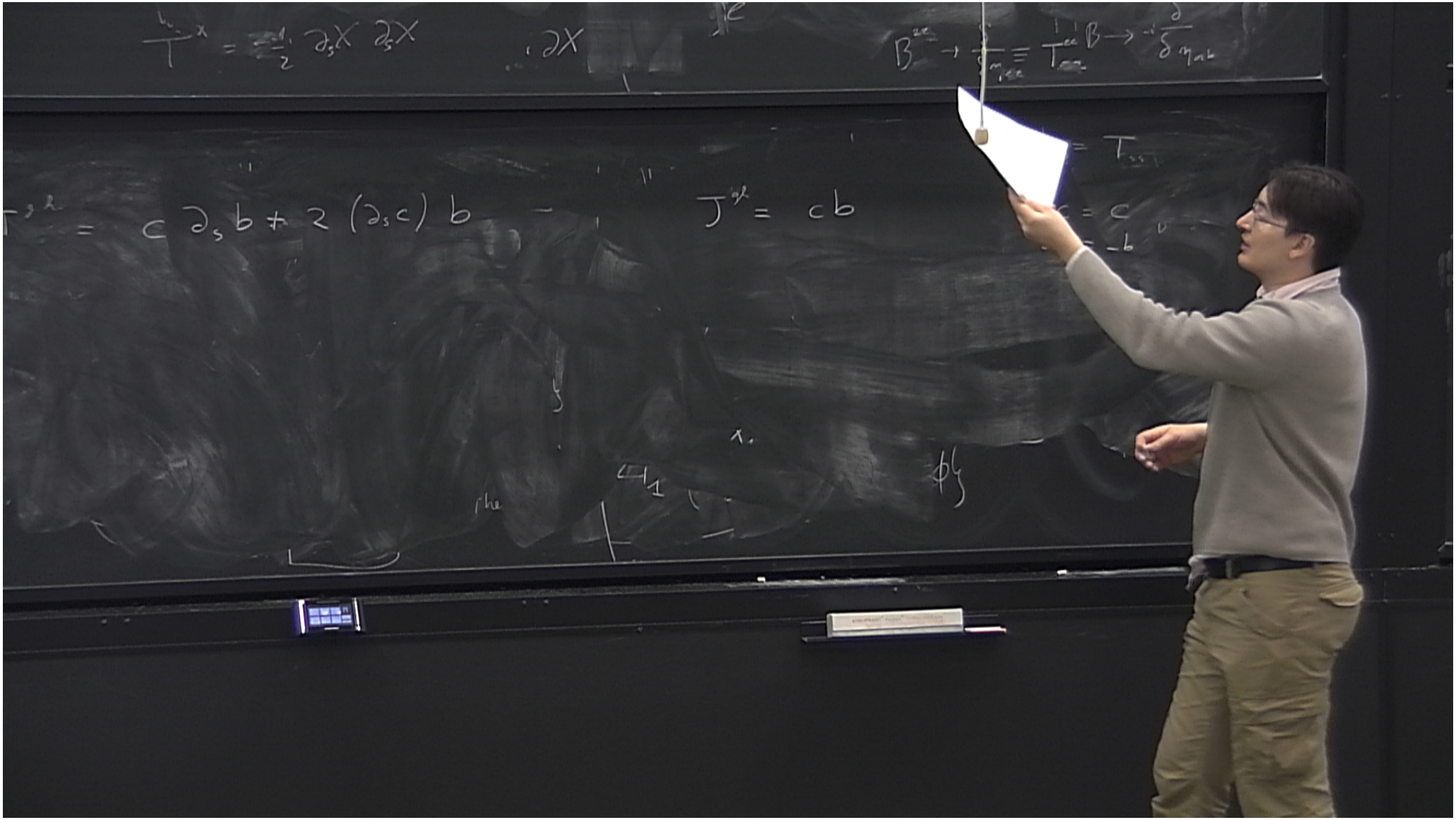

$h_{zz} = 0$
$\tilde{h}_{ab}(t)$
B^{ab}
$\tilde{h}_{ab}(t) B^{ab} = 0$
$\int B^{ab} h_{ab} \sqrt{h}\, dv + \int b^{ab} \nabla_a c_b \sqrt{h}$
$b^{ab} \tilde{h}_{ab}(t) = 0$
$Q_b{}^{ab} = B^{ab}$
$Q h_{ab} = \nabla_a c_b + \nabla_b c_a$

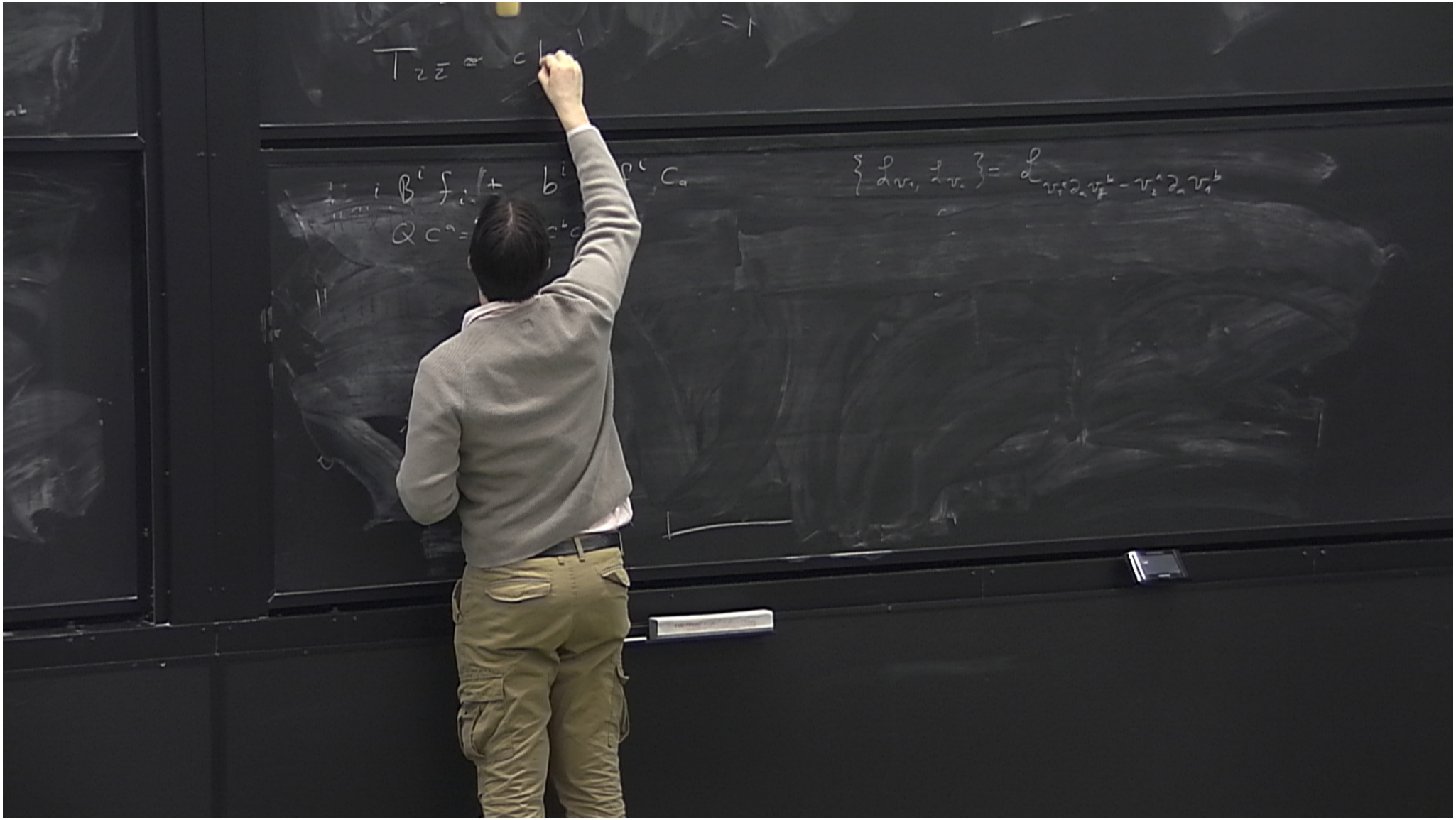

$b = b_{zz}$, $c^z = c$
$b_{\bar{z}\bar{z}}$
$c^{\bar{z}}$
$S_{gh} = \int b\, \partial_{\bar{s}} c\, ds d\bar{s} + cc$

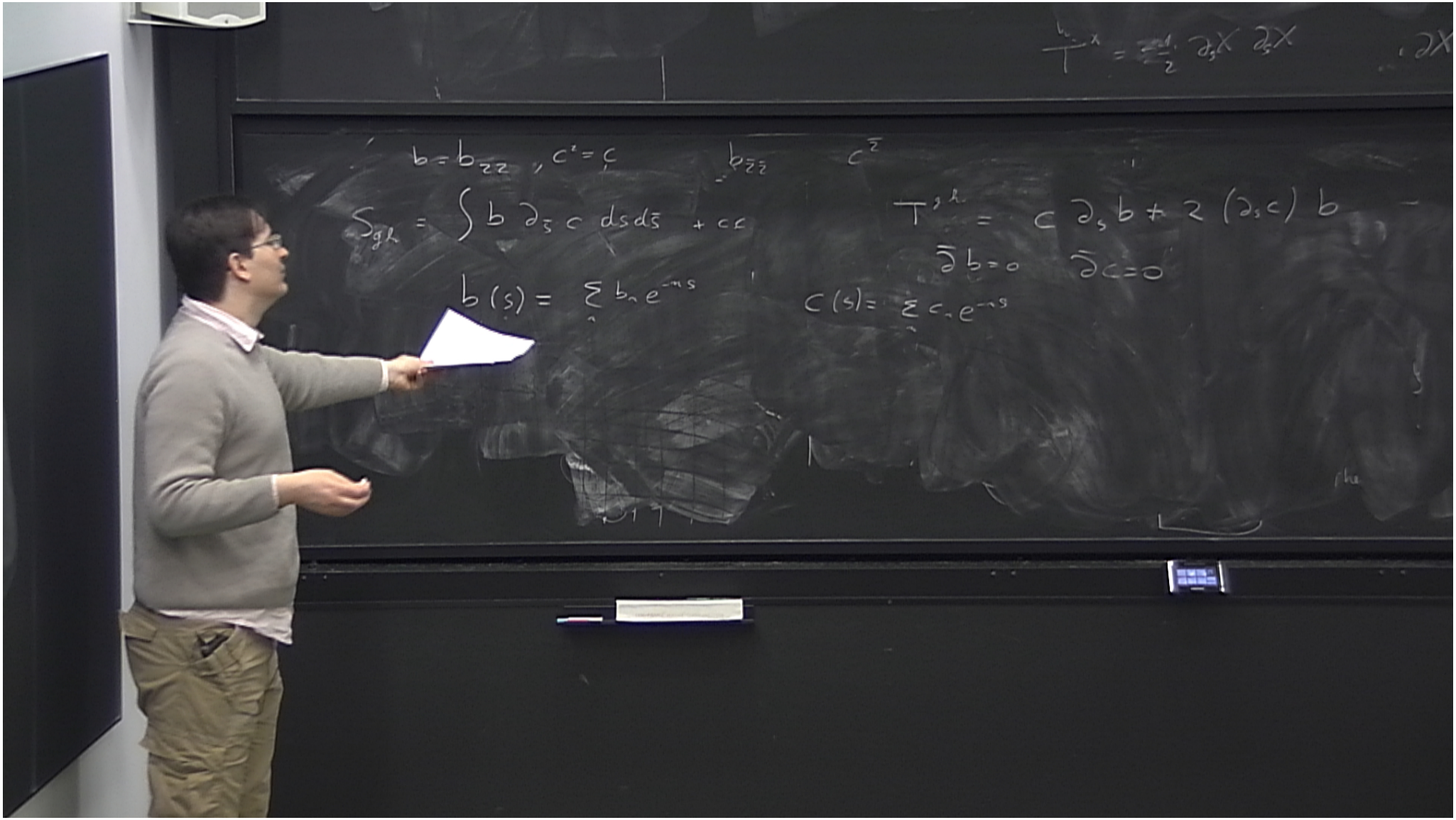

b = b_zz , c^z = c
b_z̄z̄
c^z̄
S_gh = ∫ b ∂_z̄ c ds dz̄ + cc
T^gh_bc =

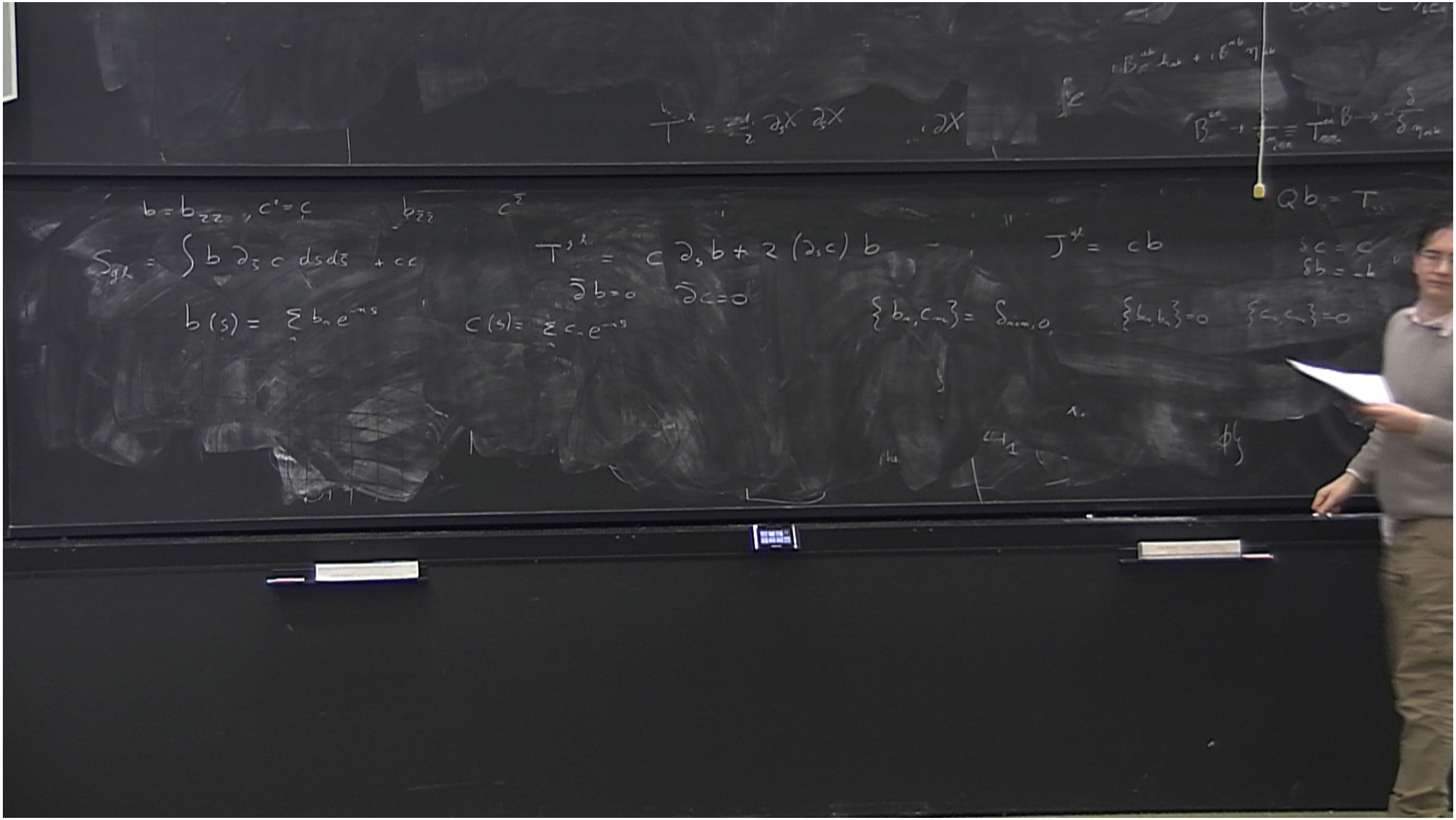

$b = b_{zz}$, $c^z = c$
$b_{\bar{z}\bar{z}}$
$c^{\bar{z}}$
$S_{gh} = \int b\, \partial_{\bar{s}} c\, ds d\bar{s} + cc$
$T^{gh}_{bc} = c\, \partial_s b$
$(\partial_s c$

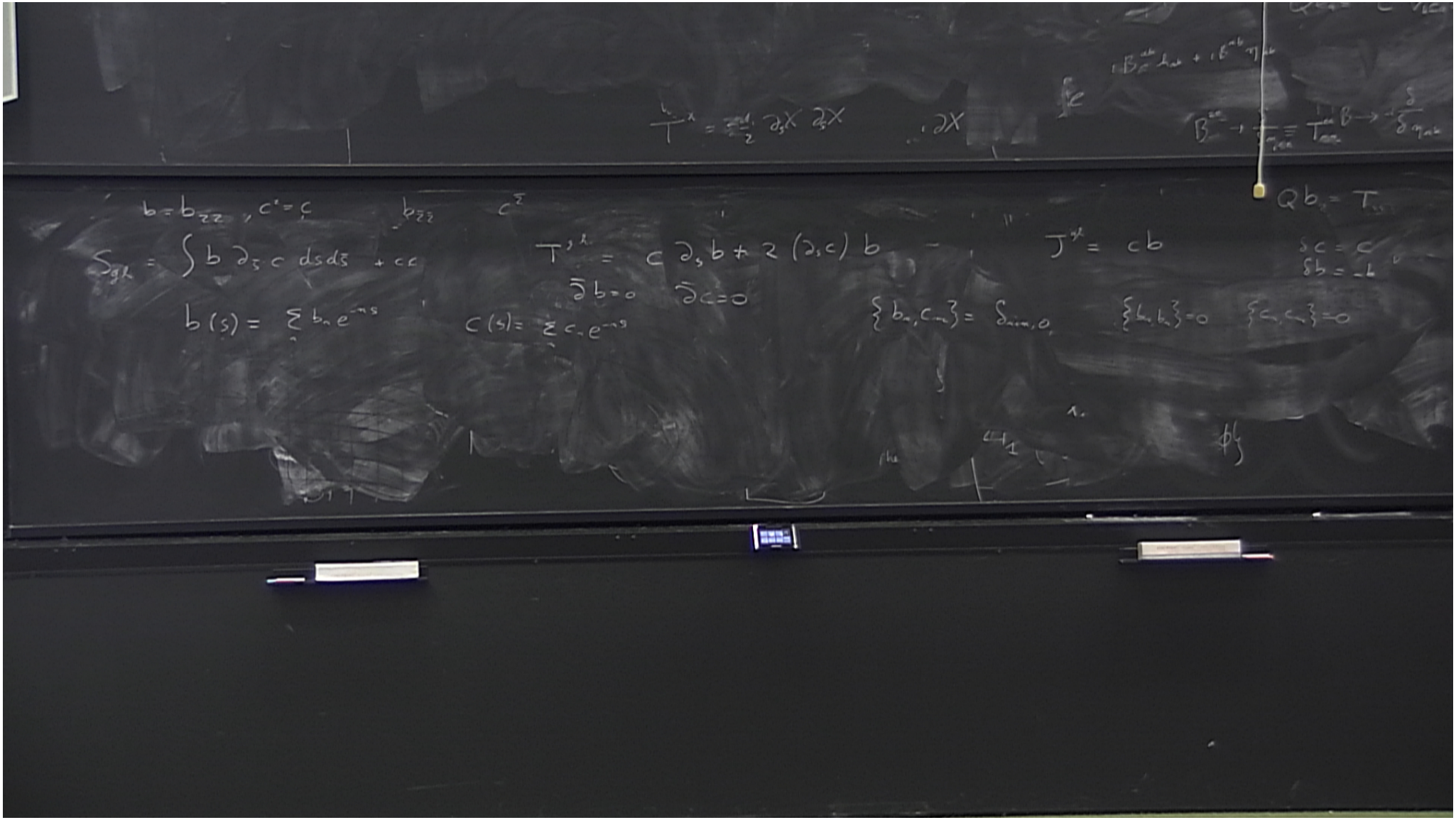

$T^{X} = -\frac{1}{2} \partial_s X \partial_s X$
$b = b_{zz}$, $c^z = c$
$b_{\bar{z}\bar{z}}$
$c^{\bar{z}}$
$S_{gh} = \int b \partial_{\bar{s}} c \, ds d\bar{s} + cc$
$T^{gh} = c \partial_s b + 2 (\partial_s c) b$

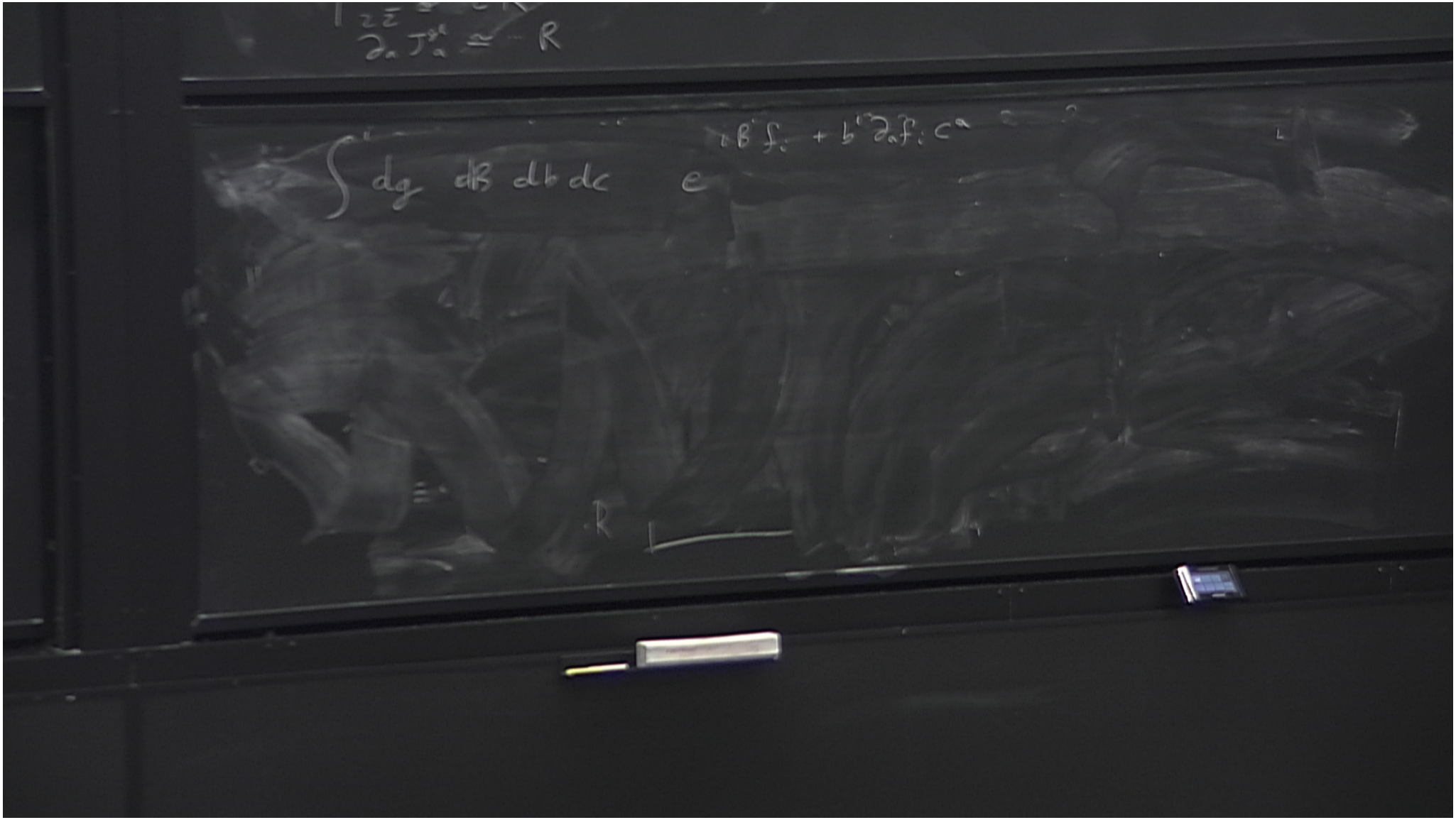

$T^{x} = -\frac{1}{2}\partial_s X\,\partial_s X$
∂X
$B^{zz} \to \frac{1}{g_{zz}} \equiv T^{zz}_{zz} B \to -i\frac{\partial}{\partial g_{zz}}$
$= T_{ss}$
$= c$
$= -b$
$= c\,\partial_s b + 2(\partial_s c)\,b$
$J^{zz} = cb$
the

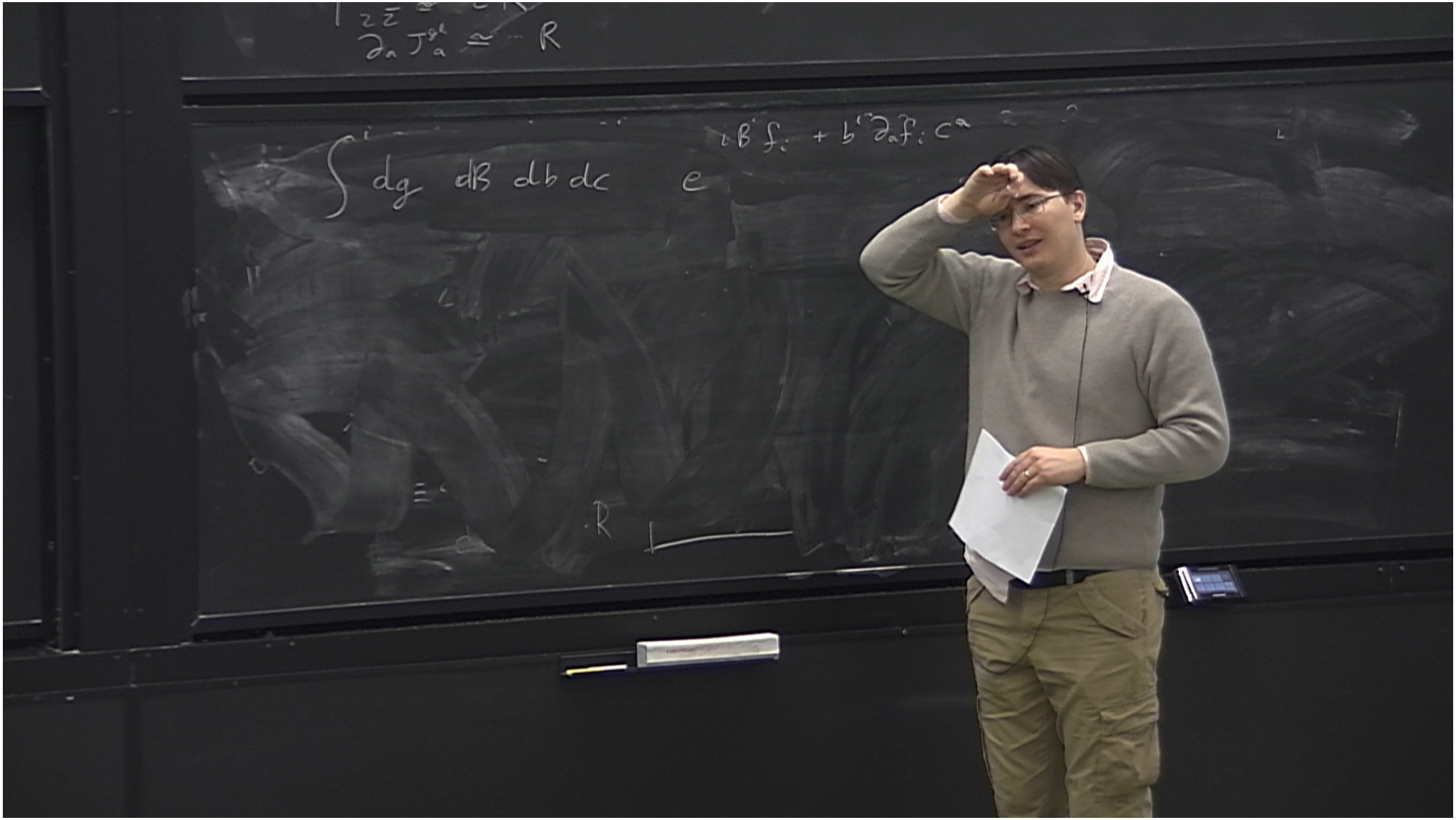


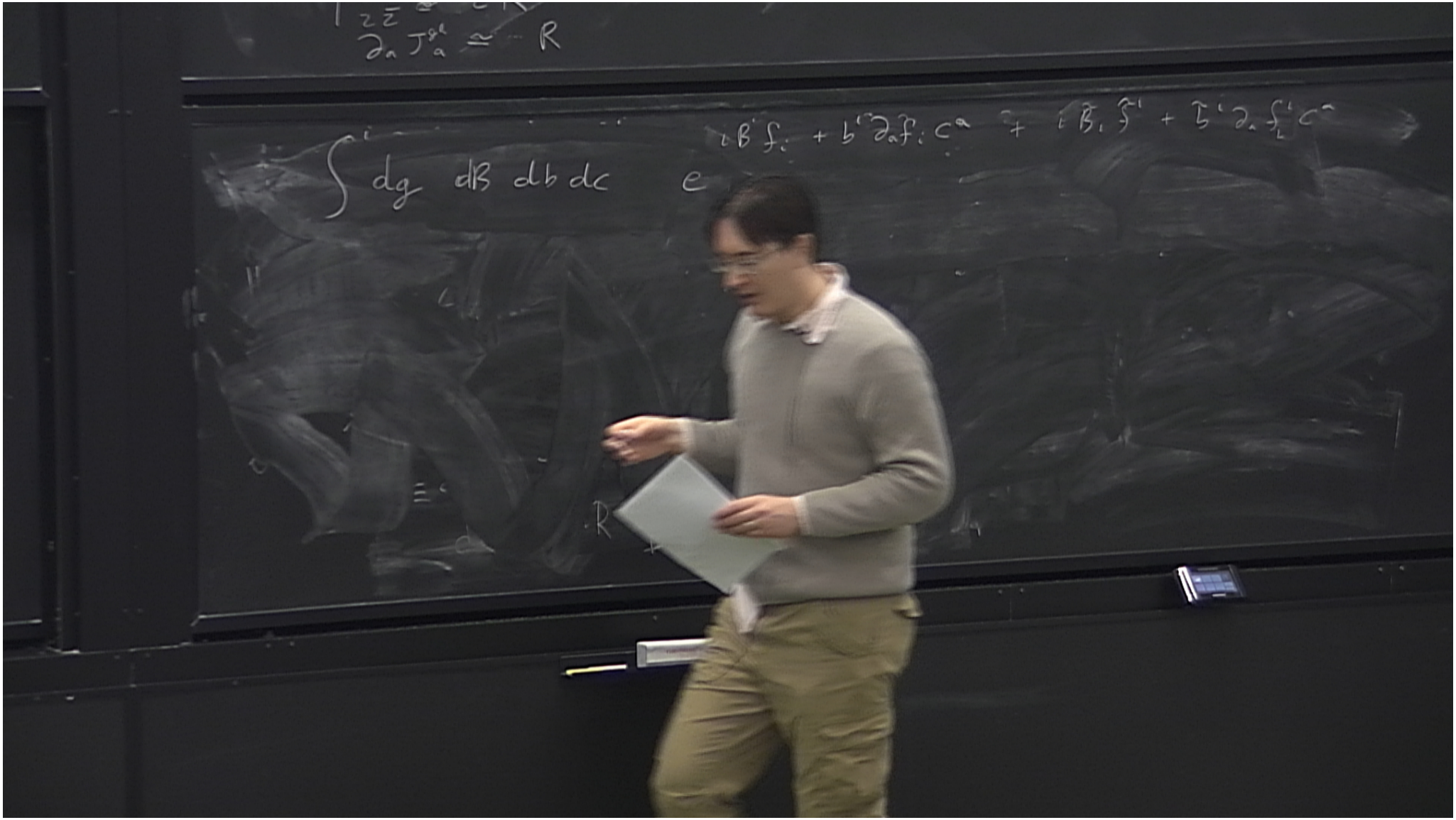

$T^{\mu\nu} = -\frac{1}{2}\partial_s X \partial_s X$
$b = b_{zz}$, $c^z = c$
$b_{\bar{z}\bar{z}}$
$c^{\bar{z}}$
$S_{gh} = \int b\,\partial_{\bar{s}} c\, ds d\bar{s} + cc$
$T^{gh} = c\,\partial_s b + 2(\partial_s c)\,b$
$\bar{\partial} b = 0$
$\bar{\partial} c = 0$
$b(s) = \sum_n b_n e^{-ns}$
$c(s) = \sum_n c_n e^{-ns}$

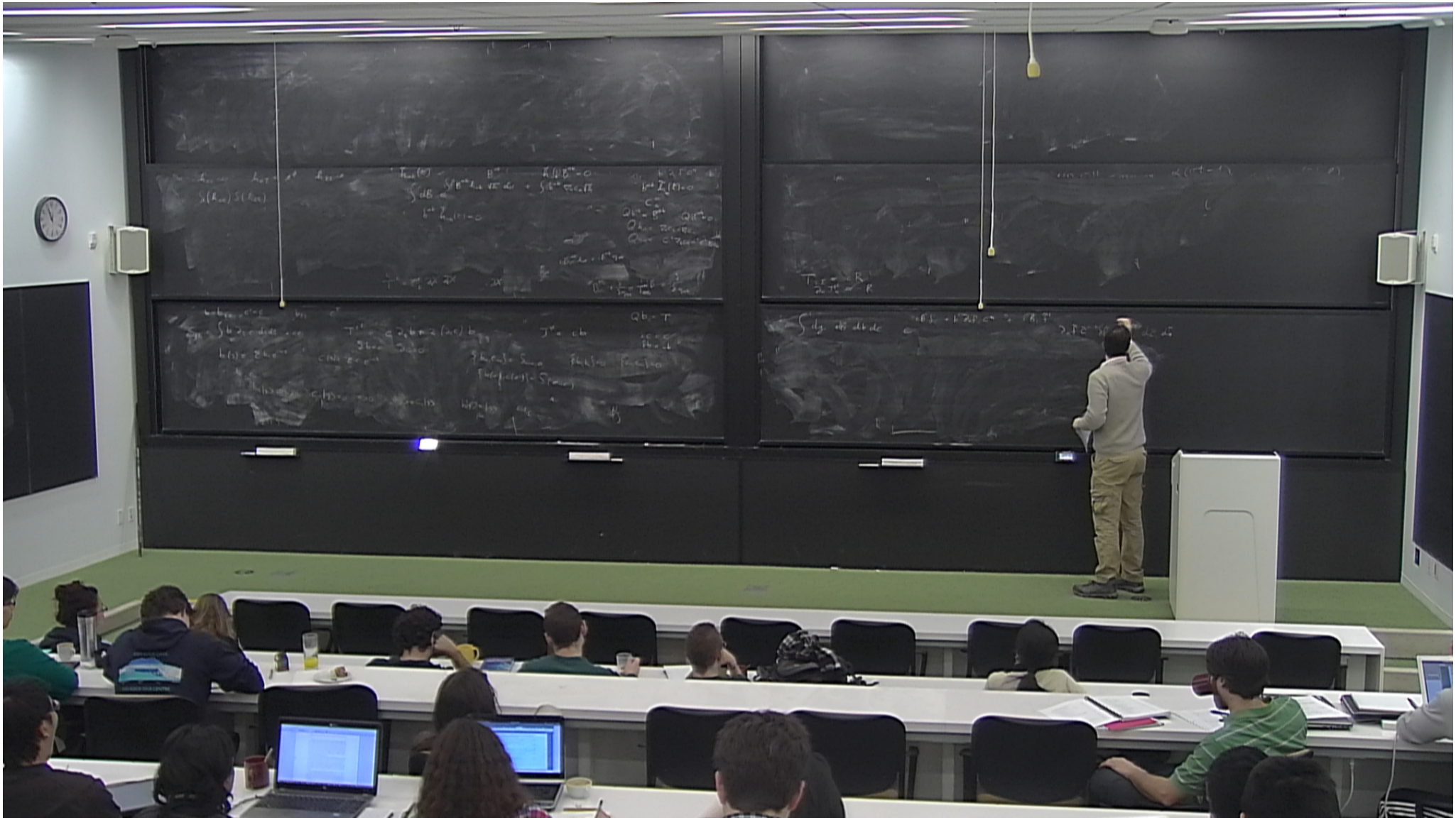

$b = b_{zz}$, $c = c$
b_{zz}
c^{z}
$S_{gh} = \int b\,\partial_{\bar z} c\, ds d\bar s + cc$
$T^{gh} = c\,\partial_s b + 2(\partial_s c)\,b$
$J^{gh} = cb$
$\delta c = c$
$\delta b = -b$
$\bar\partial b = 0$
$\bar\partial c = 0$
$b(s) = \sum b_n e^{-ns}$
$c(s) = \sum c_n e^{-ns}$
$\{b_n, c_m\} = \delta_{n+m,0}$
$\{b_n, b_m\} = 0$
$\{c_n, c_m\} = 0$
$Qb_n = T_n$

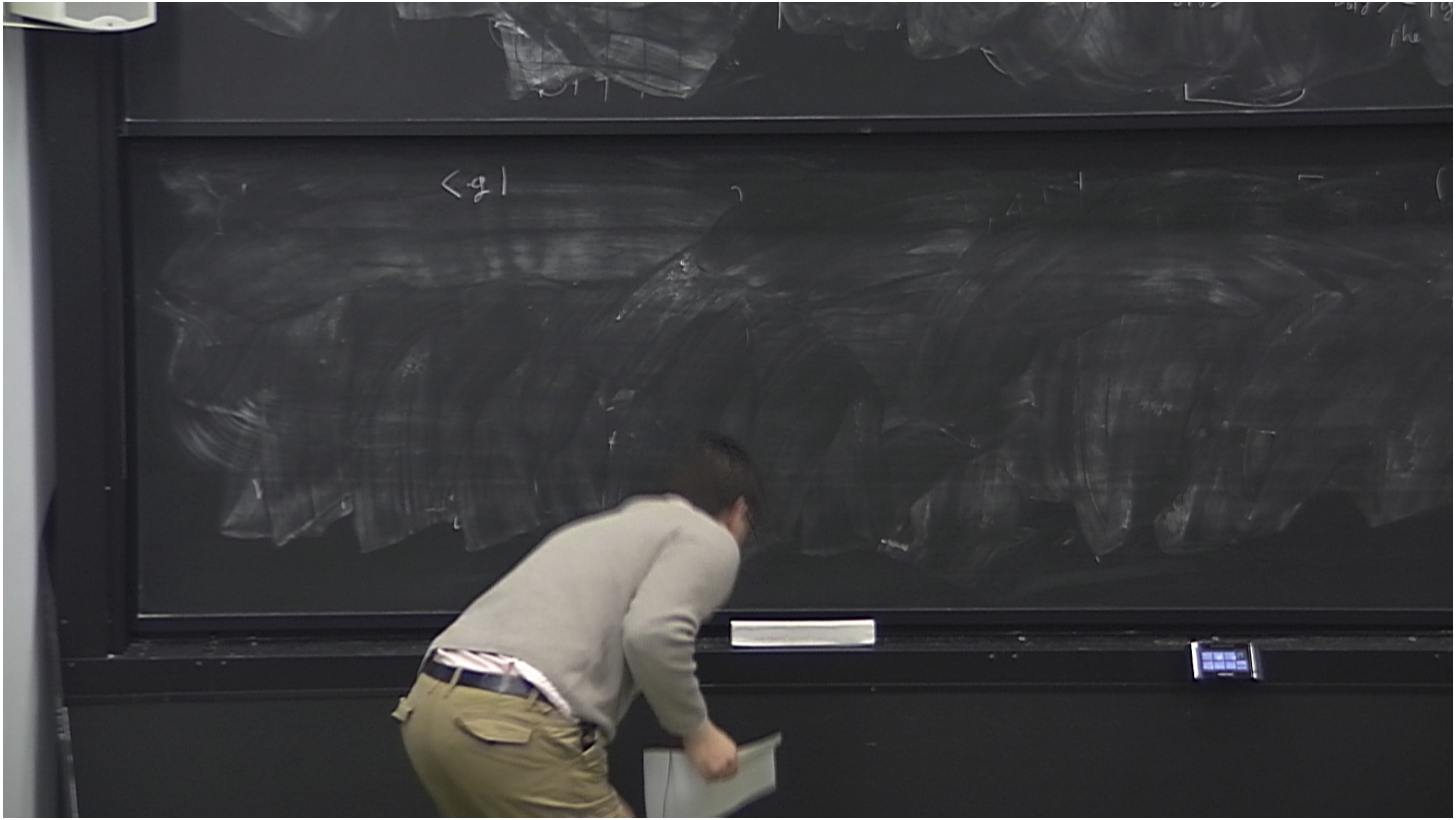

$b = b_{zz}$, $c = c$
$S_{gh} = \int b\, \partial_\xi c\, ds\, d\xi + cc$
$b(s) = \sum b_n e^{-ns}$
$c(s) = \sum c_n e^{-ns}$
$T^{gh} = c\, \partial_s b + 2(\partial_s c)\, b$
$\bar\partial b = 0$ $\bar\partial c = 0$
$J^{gh} = cb$
$\{b_n, c_m\} = \delta_{n+m,0}$ $\{b_n, b_m\} = 0$ $\{c_n, c_m\} = 0$
$Qb_n = T_n$
$\delta c = c$
$\delta b = -b$

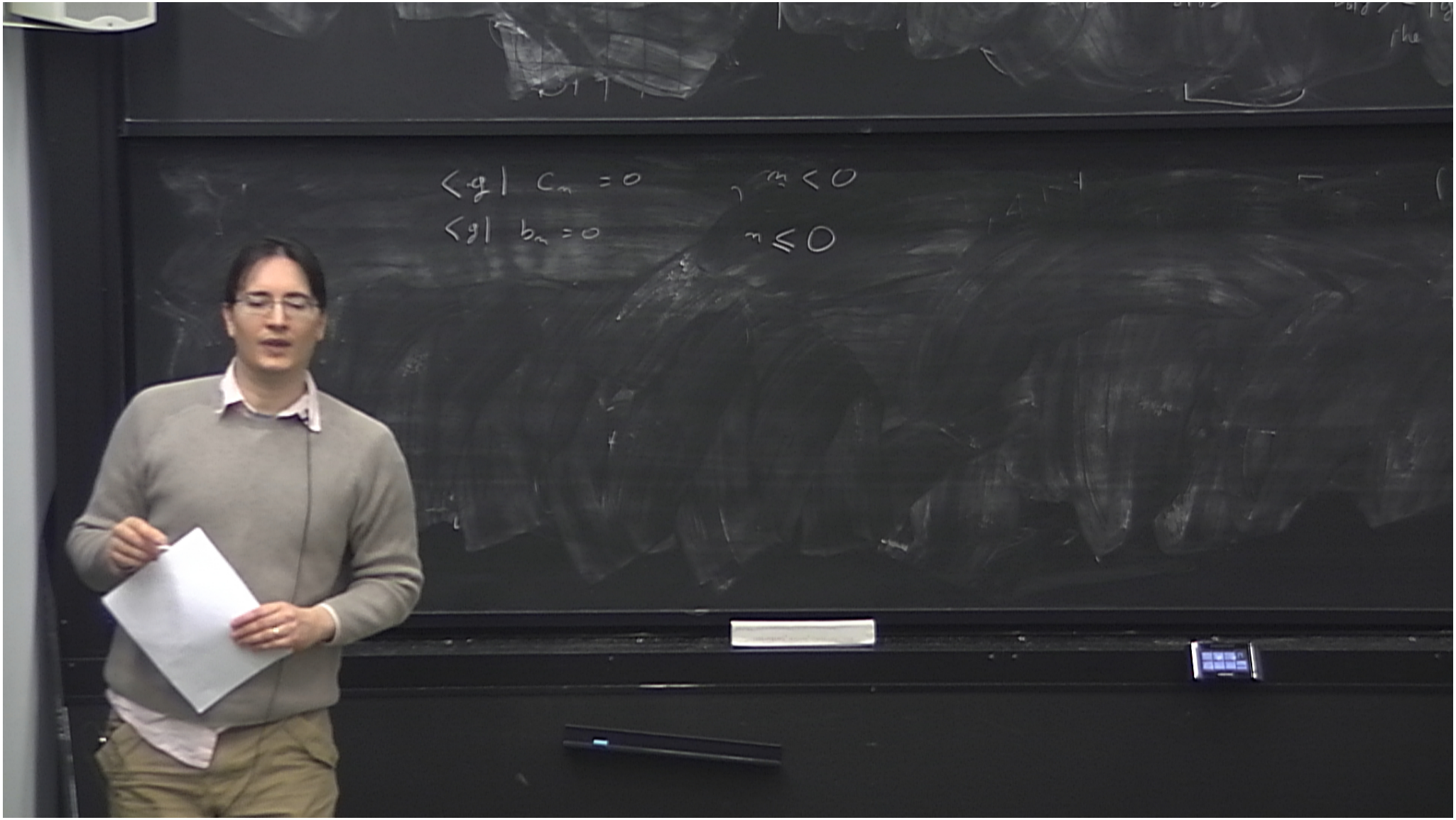

$\partial_a J^a_a \simeq R$
$\int dg\ dB\ db\ dc\ e$
$+B^i f_i + b^i \partial_a f_i c^a$
R

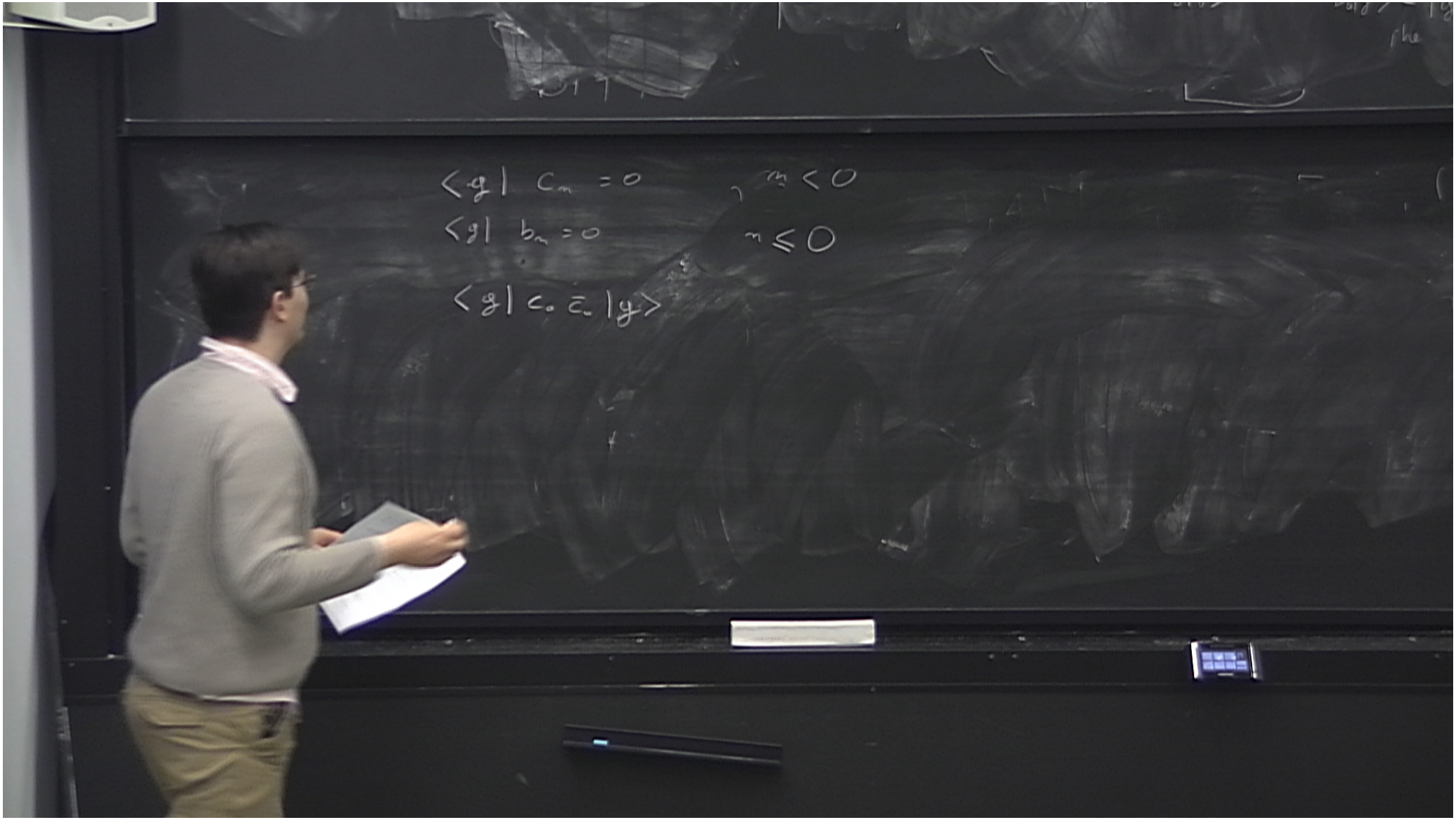

$\partial_a J^{ab}_a \cong R$
$\int dg\ dB\ db\ dc\ e$
$+ b' \partial_a f_i c^a$

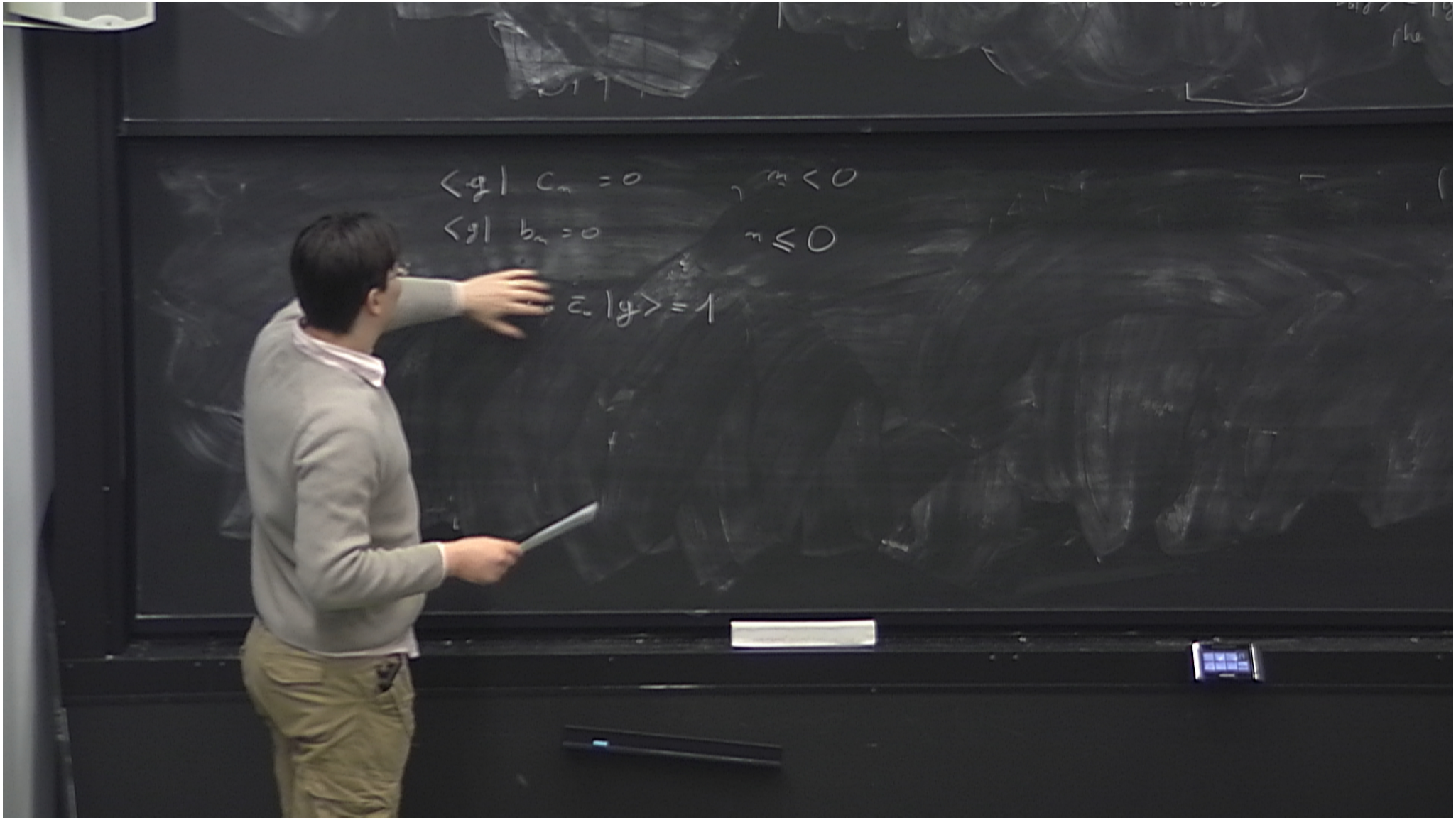

$\partial_a J^{a\alpha}_a \simeq R$
$\int dg\ dB\ db\ dc\ e$
$ib^a f_i + b^a \partial_a f_i c^a + i\bar{B}_i \bar{f}^i + \bar{b}^i \partial_a f^i_j c^a$

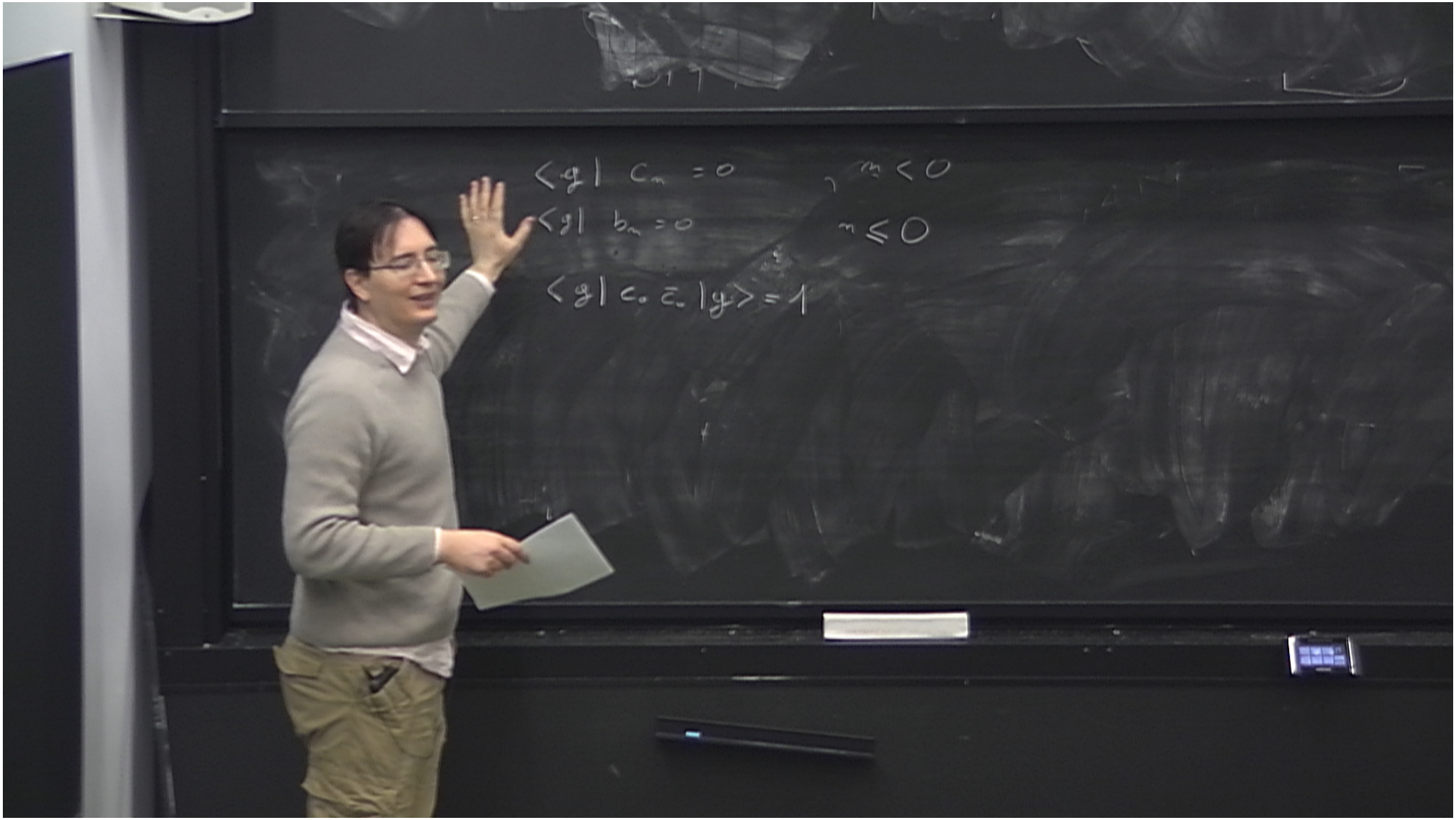


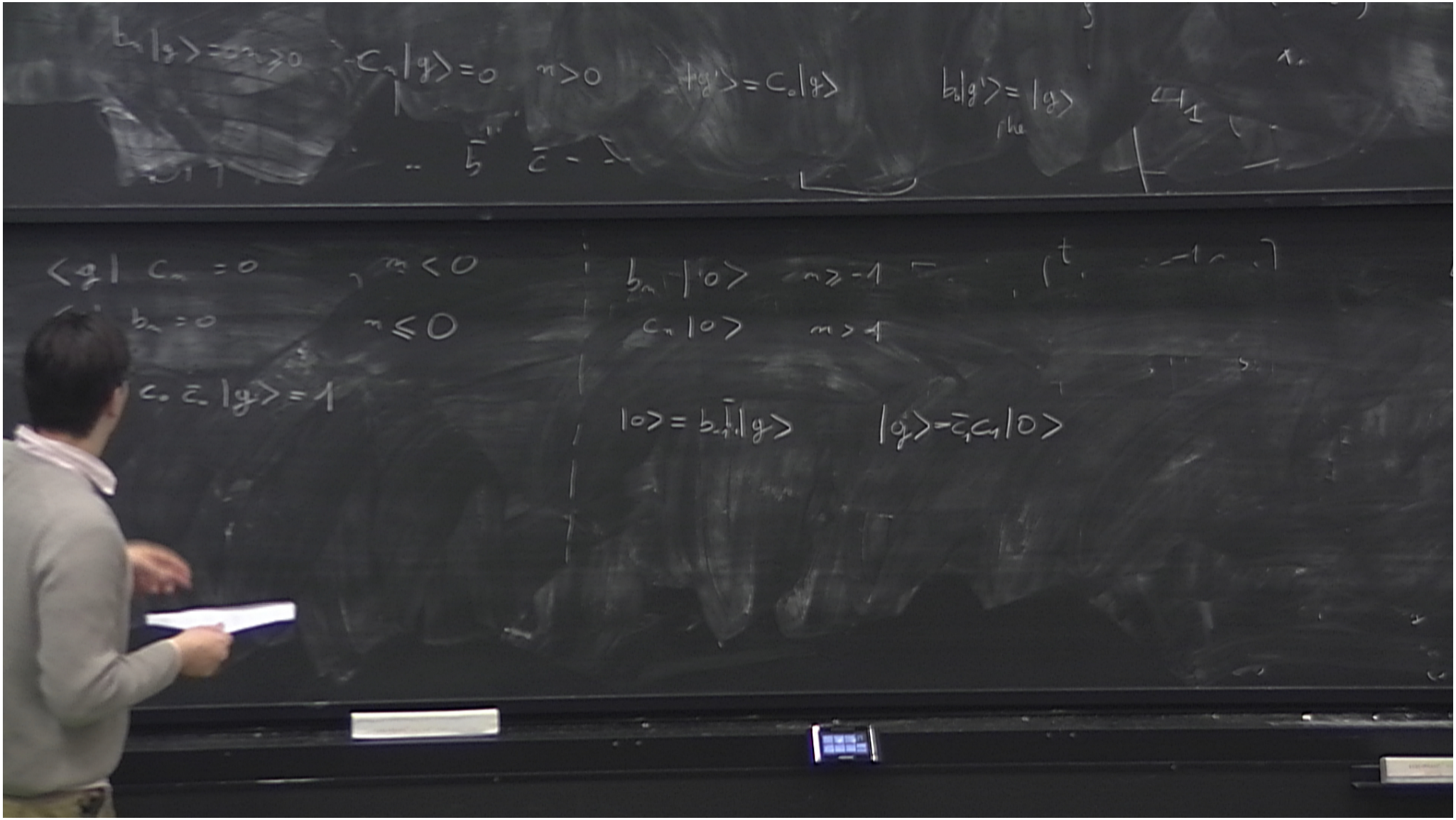

⟨g|

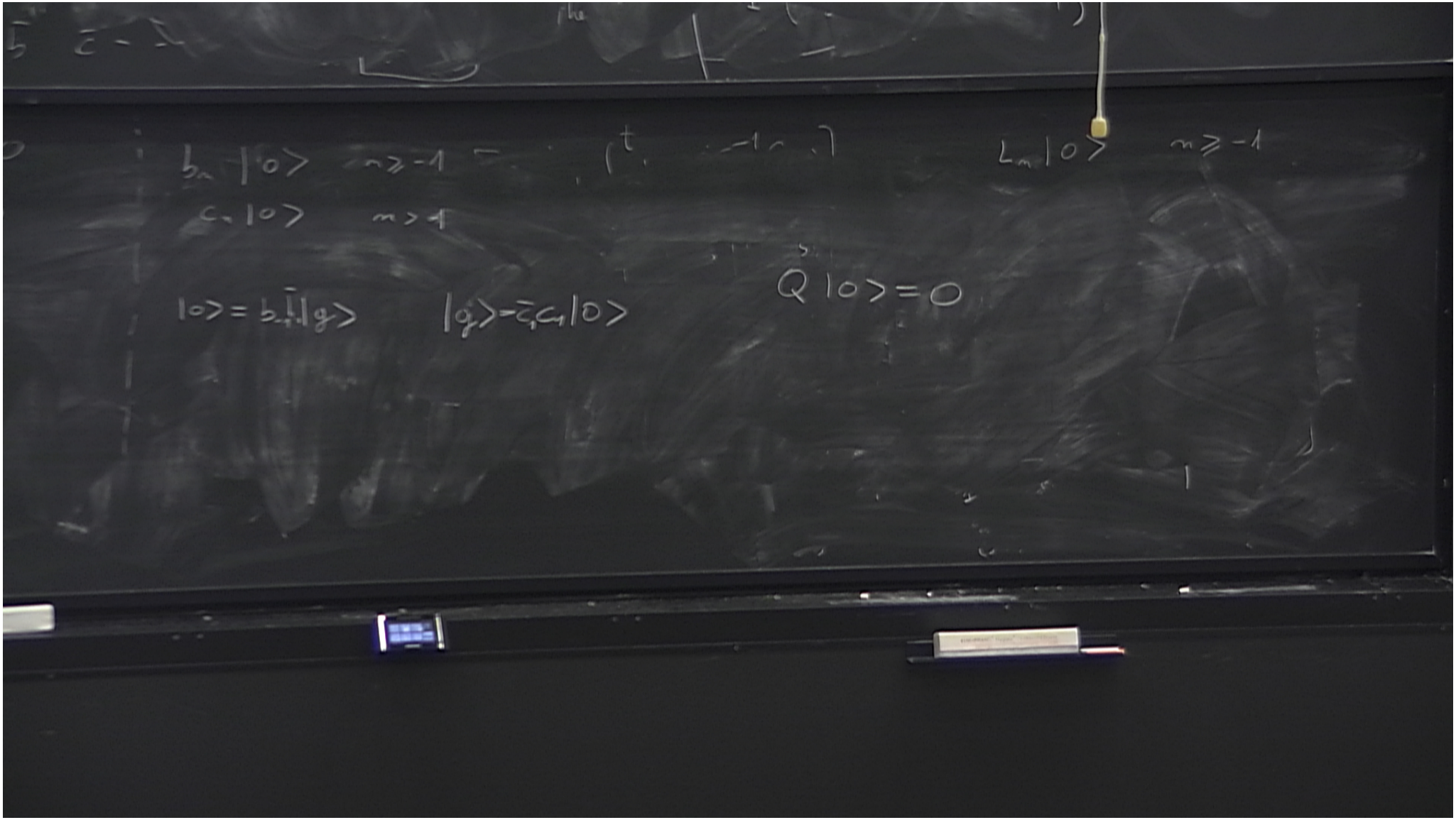

⟨g| $C_m = 0$, $m < 0$
⟨g| $b_m = 0$ $m \leq 0$

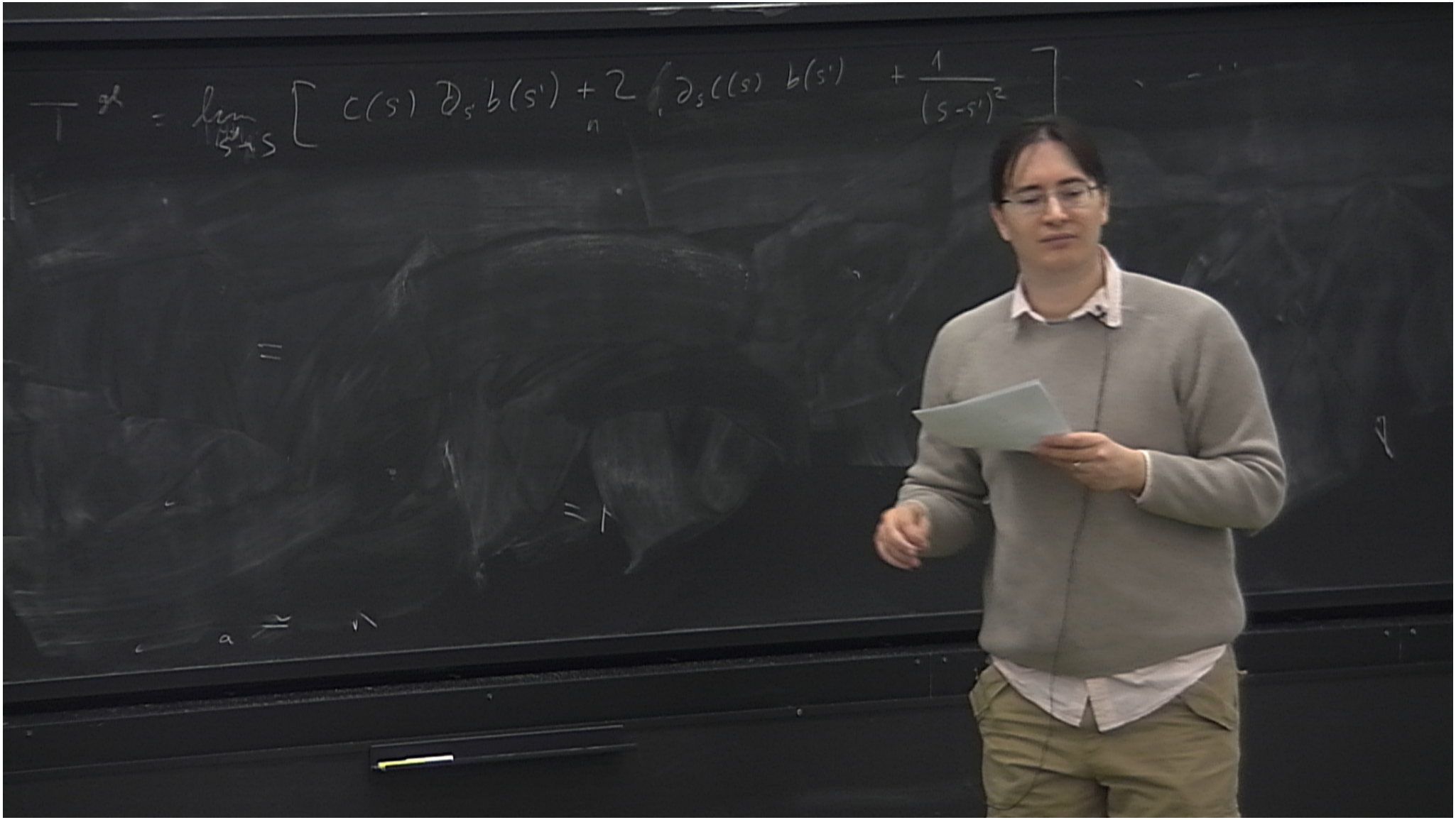

$\langle g | c_m = 0 \quad m < 0$
$\langle g | b_m = 0 \quad m \leq 0$
$\langle g | c_0 \bar{c}_0 | g \rangle$

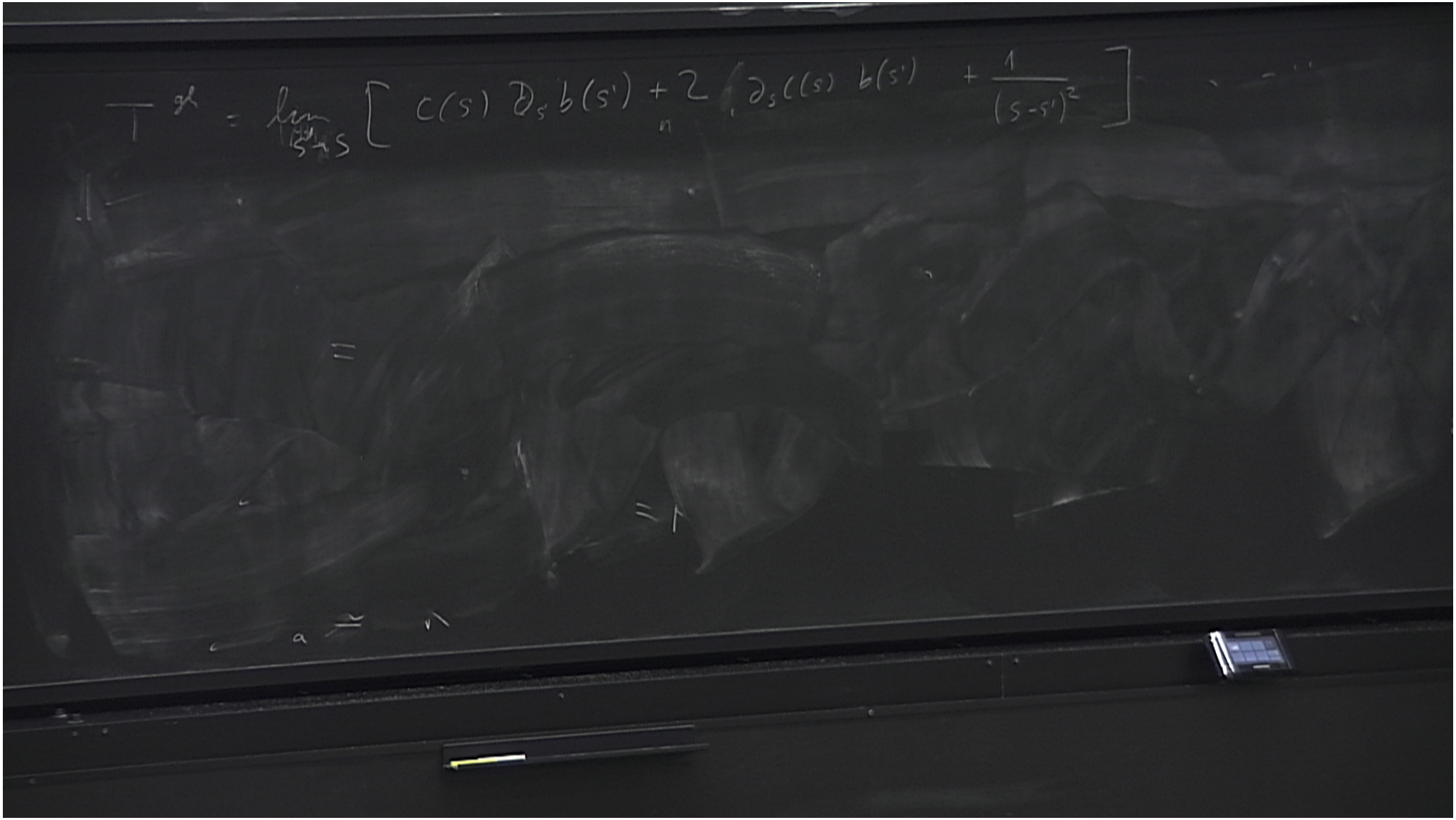

$\langle g| c_n = 0 \quad n < 0$
$\langle g| b_n = 0 \quad n \leq 0$
$c_1 |g\rangle = 1$

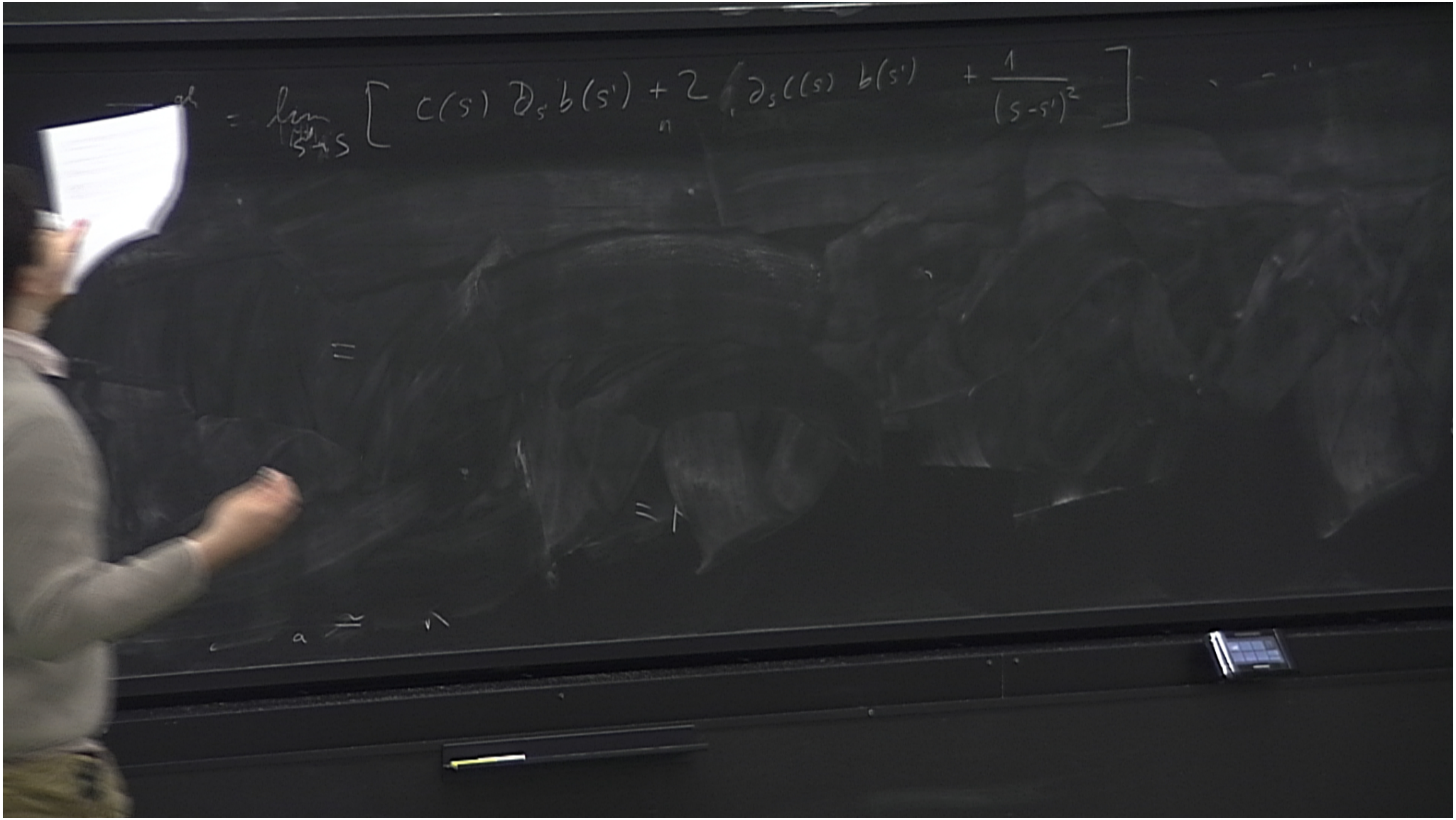

$\langle g | c_m = 0 \quad , m < 0$
$\langle g | b_m = 0 \quad m \leq 0$
$\langle g | c_0 \bar{c}_0 | g \rangle = 1$

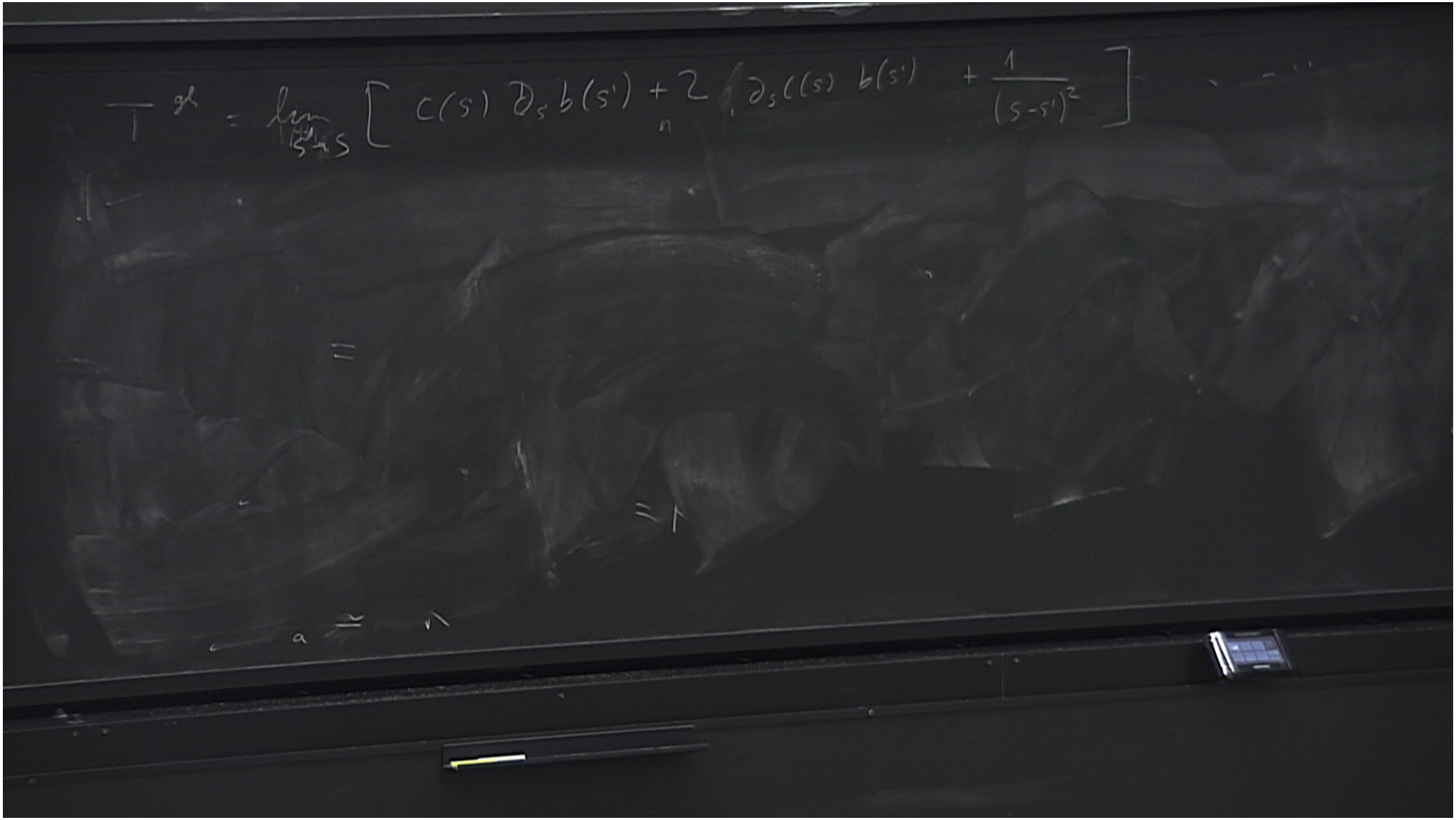

$b_n|g\rangle = 0 \quad n \geq 0$
$c_n|g\rangle = 0 \quad n > 0$
$|g'\rangle = c_0|g\rangle$
$b_0|g'\rangle = |g\rangle$
$\langle g| c_n = 0 \quad n < 0$
$b_n = 0 \quad n \leq 0$
$c_0 \bar{c}_1 |g\rangle = 1$
$b_n|0\rangle \quad n \geq -1$
$c_n|0\rangle \quad n > 1$
$|0\rangle = b_{-1}\bar{1}|g\rangle$
$|g\rangle = \bar{c}_1 c_1 |0\rangle$

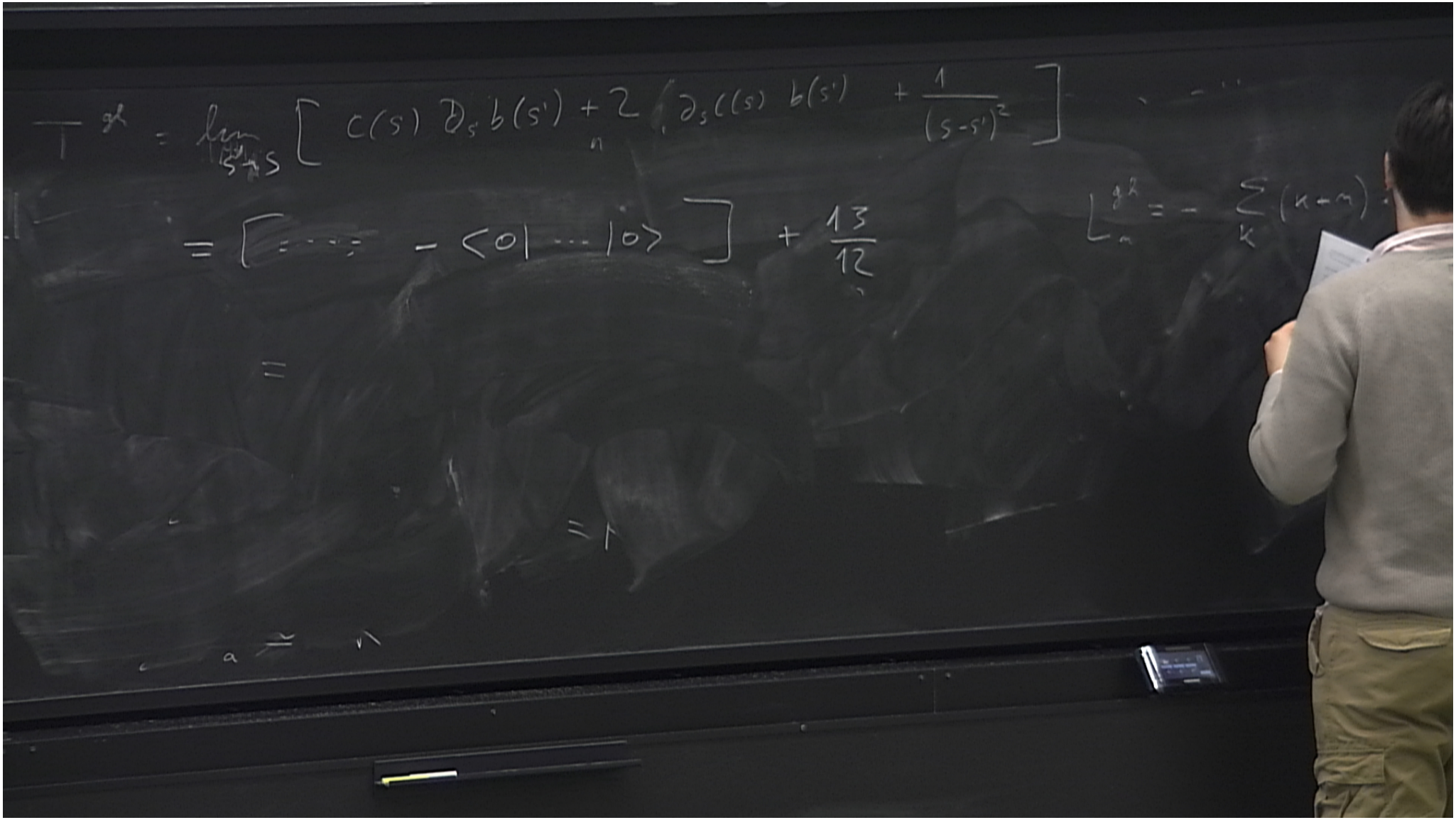

$b_m|0\rangle$ $m \geq -1$
$c_m|0\rangle$ $m > 1$
$L_m|0\rangle$ $m \geq -1$
$|0\rangle = b_{-1}|g\rangle$
$|g\rangle = c_1|0\rangle$
$Q|0\rangle = 0$

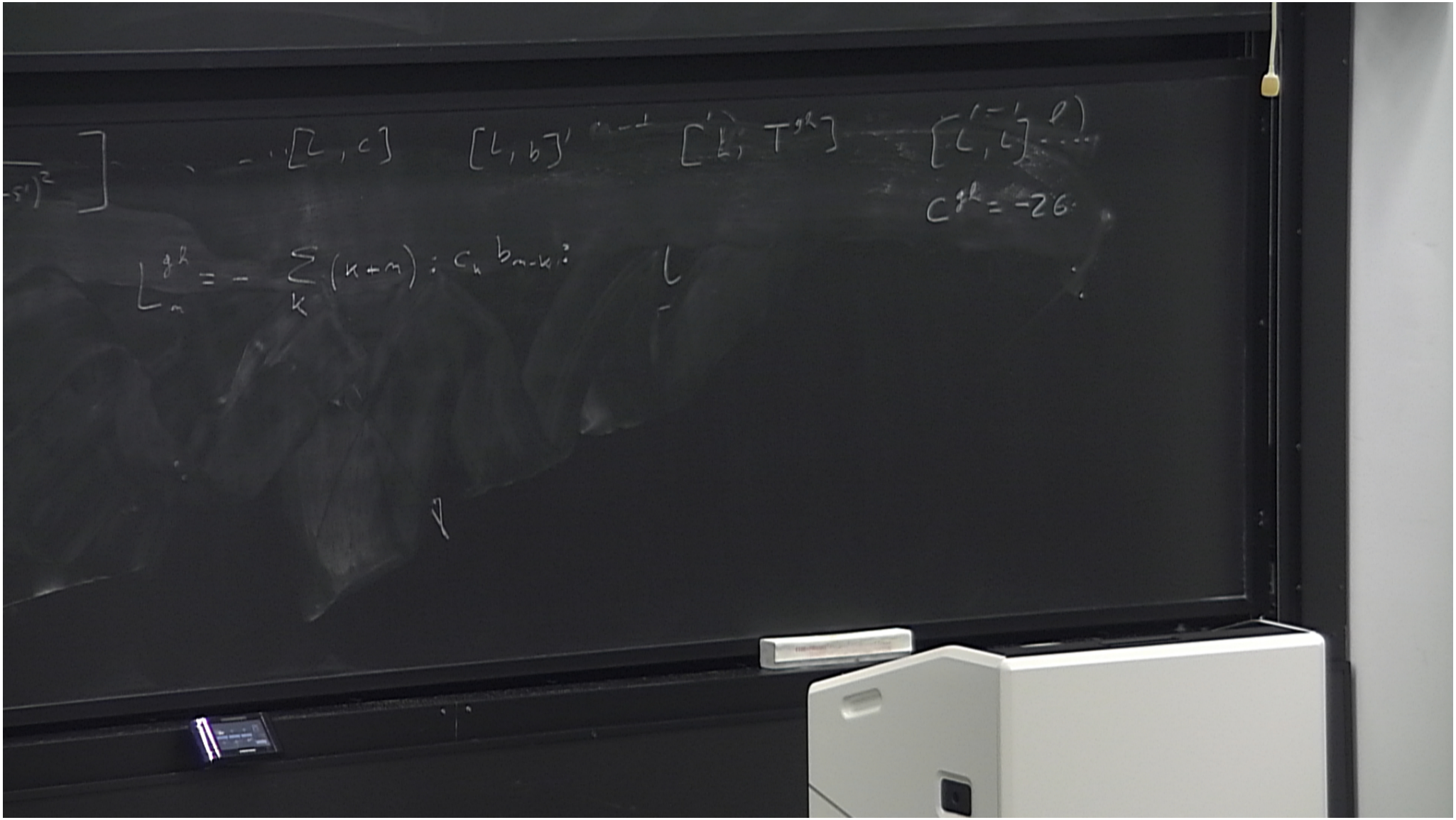

$T^{ab} = \lim_{s' \to s} \left[c(s)\, \partial_{s'} b(s') + 2 \left(\partial_{s'} c(s)\, b(s') + \frac{1}{(s-s')^2} \right) \right]$

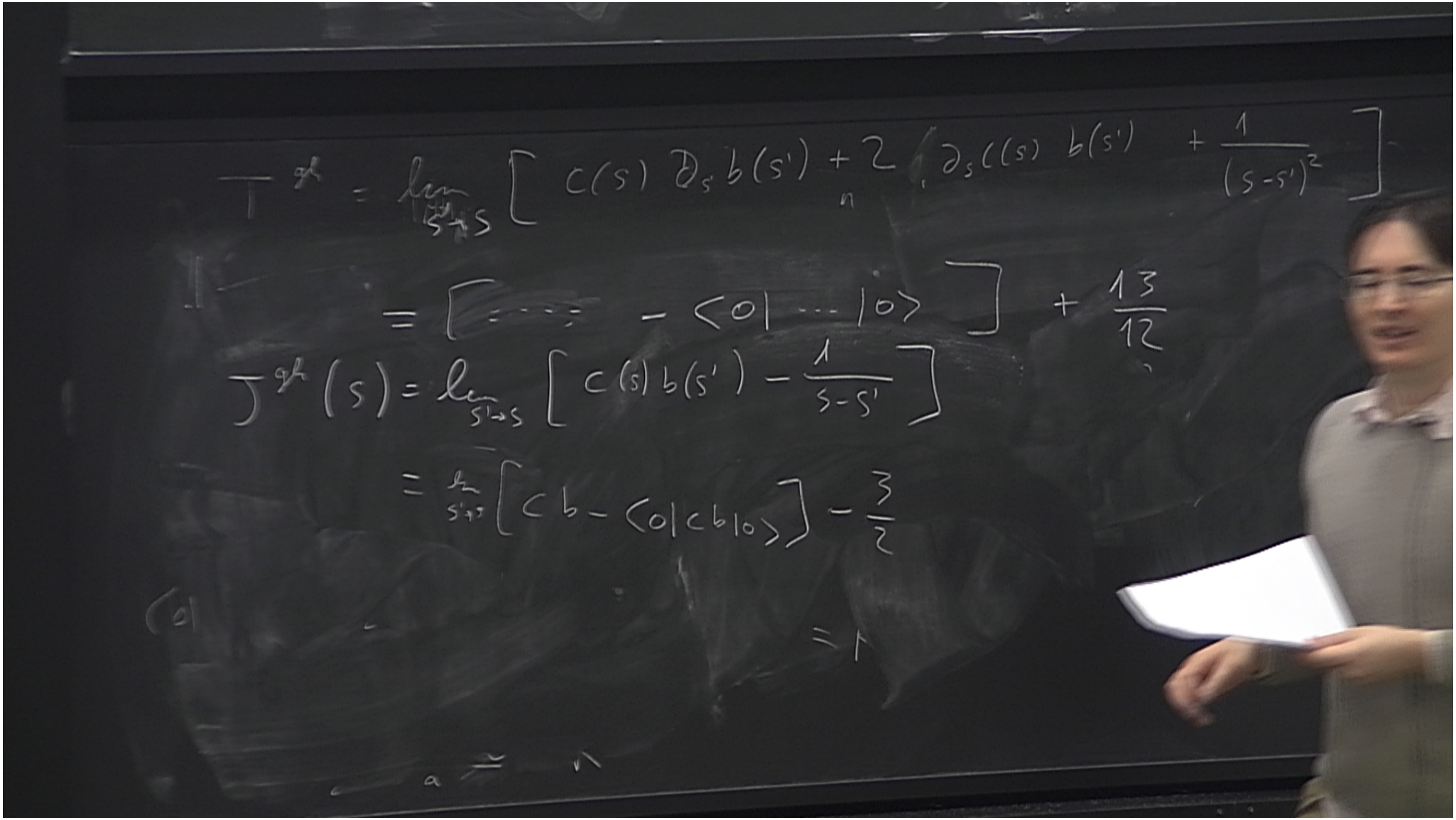

$T^{gl} = \lim_{s' \to s} \left[c(s)\, \partial_{s'} b(s') + 2 \left(\partial_{s'} c(s)\, b(s') + \frac{1}{(s-s')^2} \right) \right]$
$=$
$= 1$
$a \simeq 1$

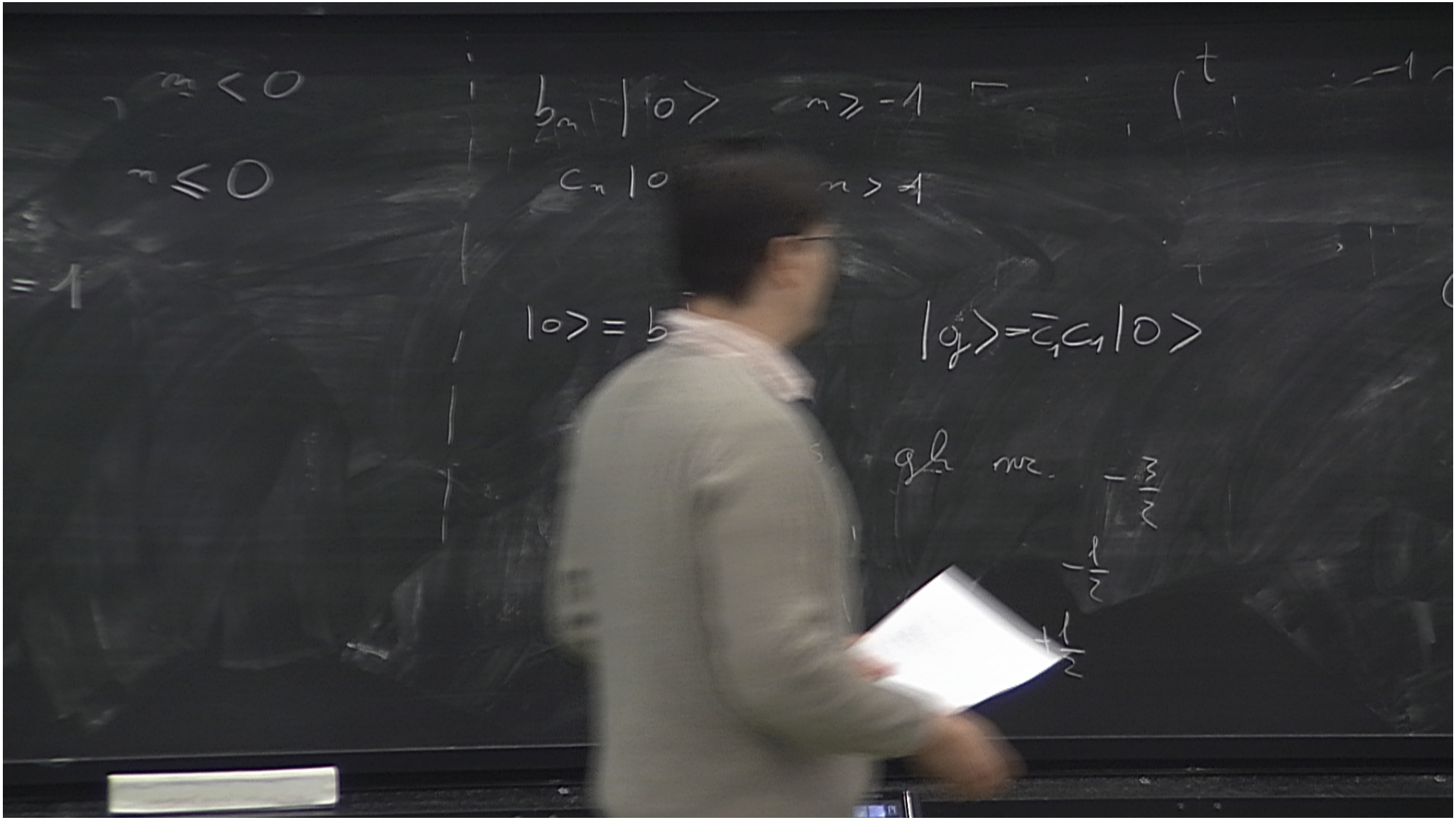

$= \lim_{s' \to s} \left[c(s)\, \partial_s b(s') + 2 \left(\partial_s c(s)\, b(s') + \frac{1}{(s-s')^2} \right) \right]$
$=$
$= 1$
$a \simeq 1$

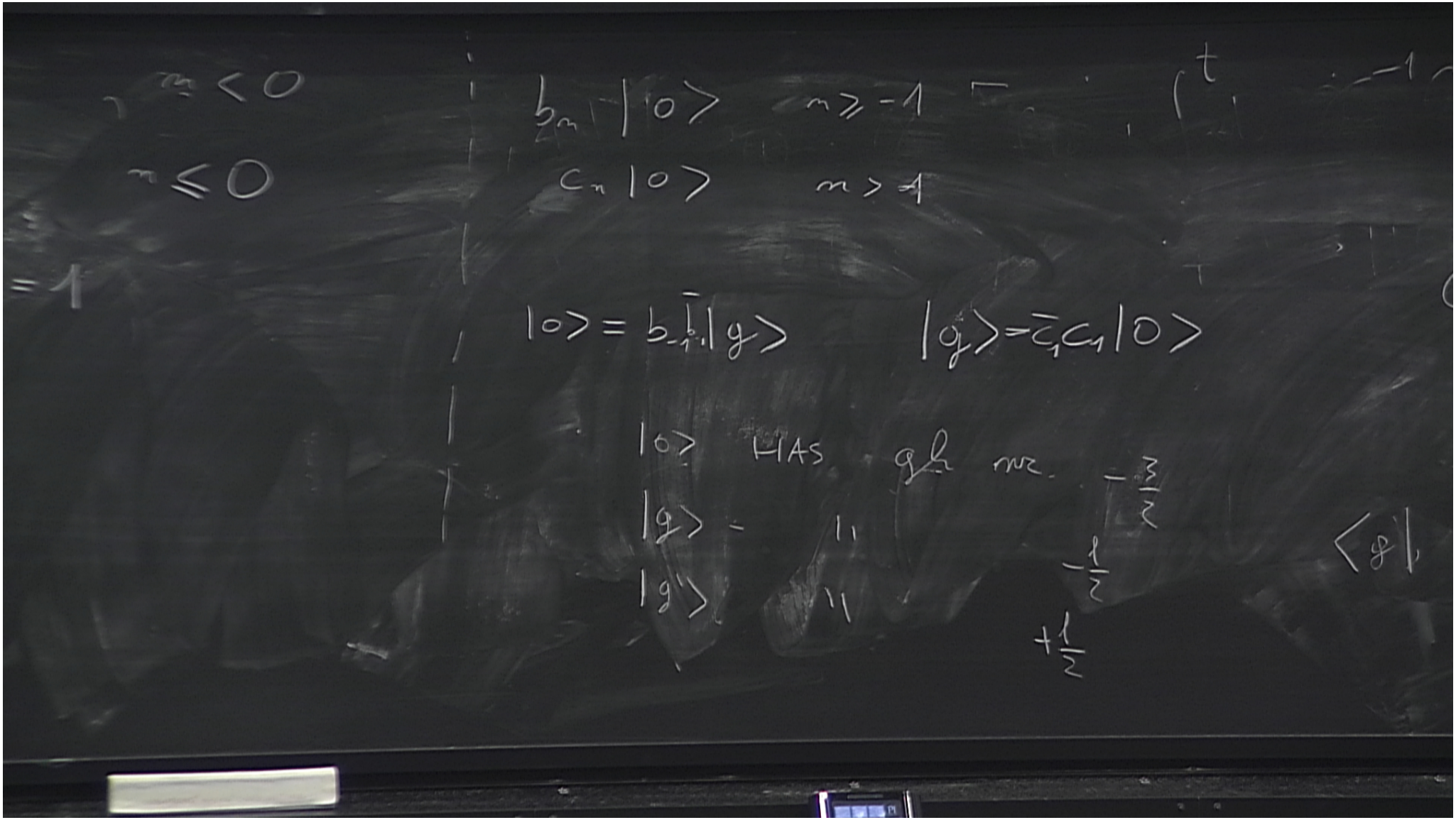

$T^{gl} = \lim_{s' \to s} \left[c(s)\, \partial_s b(s') + \frac{2}{n} \partial_s c(s)\, b(s') + \frac{1}{(s-s')^2} \right]$
=
= 1
a ≃ 1

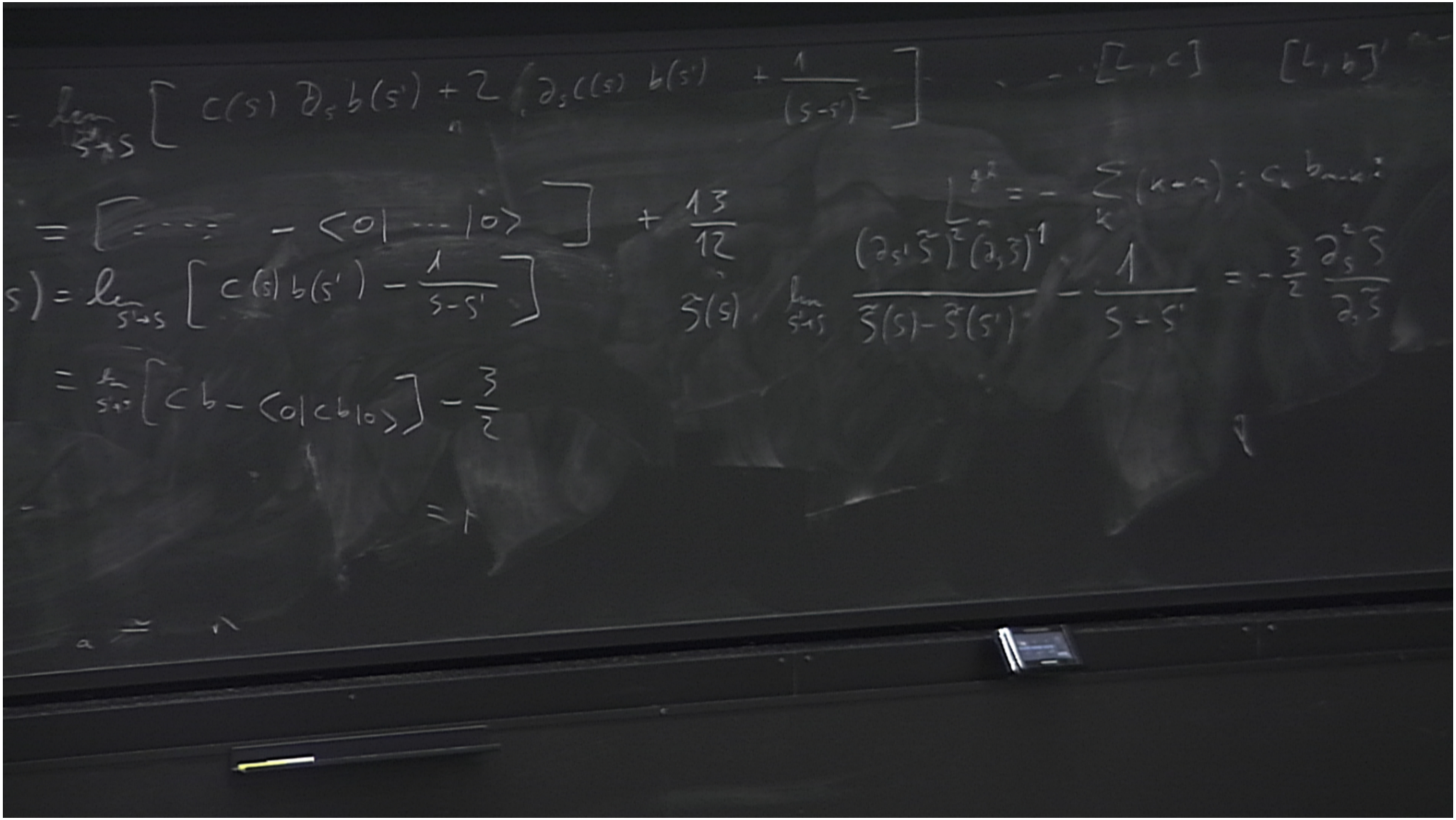

$T^{gh} = \lim_{s' \to s} \left[c(s)\, \partial_{s'} b(s') + 2 \left(\partial_{s'} c(s)\, b(s') + \frac{1}{(s-s')^2} \right) \right]$
$= \left[\cdots - \langle 0 | \cdots | 0 \rangle \right] + \frac{13}{12}$
$L_n^{gh} = - \sum_k (k-m)$

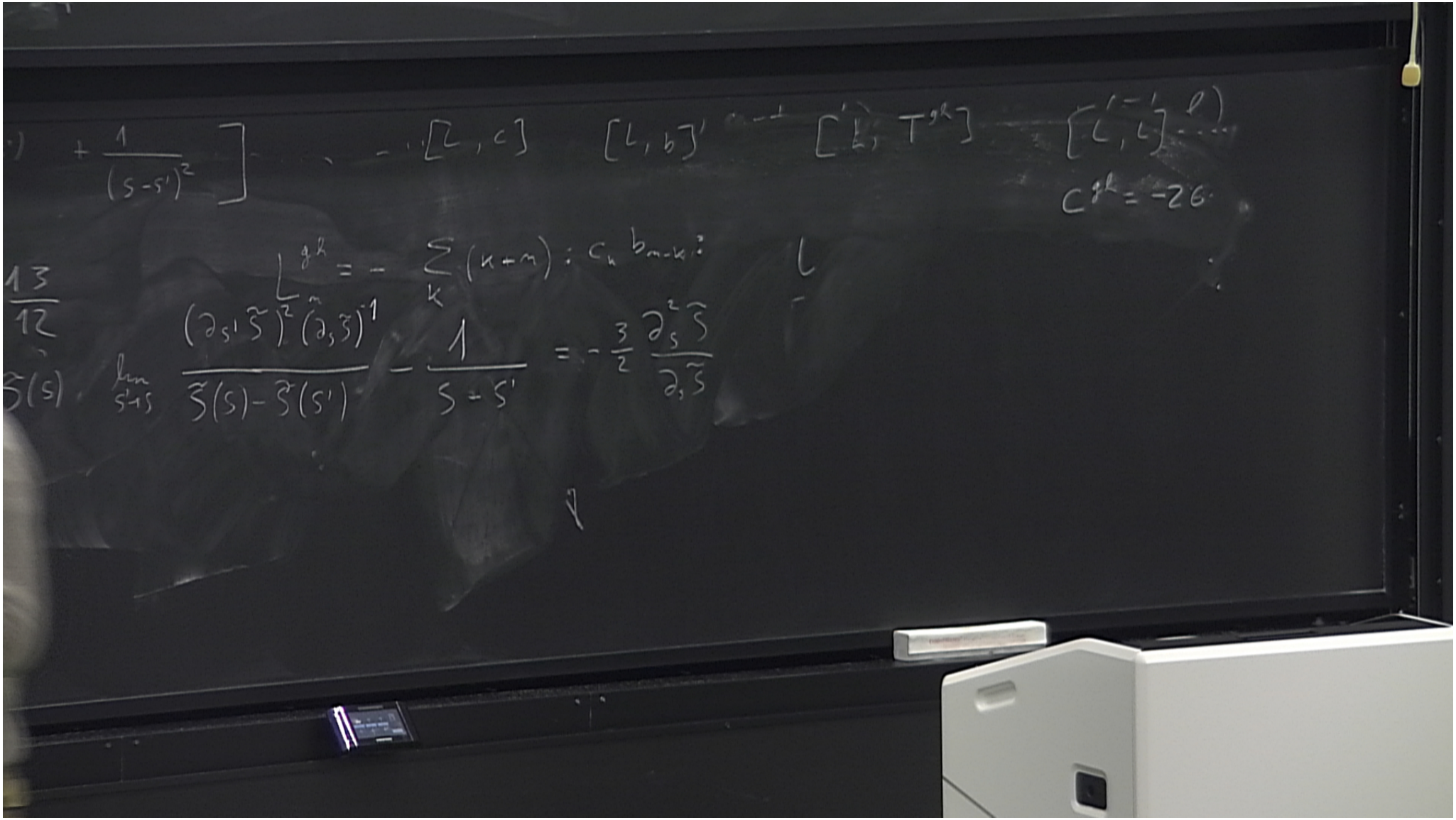

$L_m^{gh} = -\sum_k (k+m) : c_k b_{m-k} :$
$C^{gh} = -26$

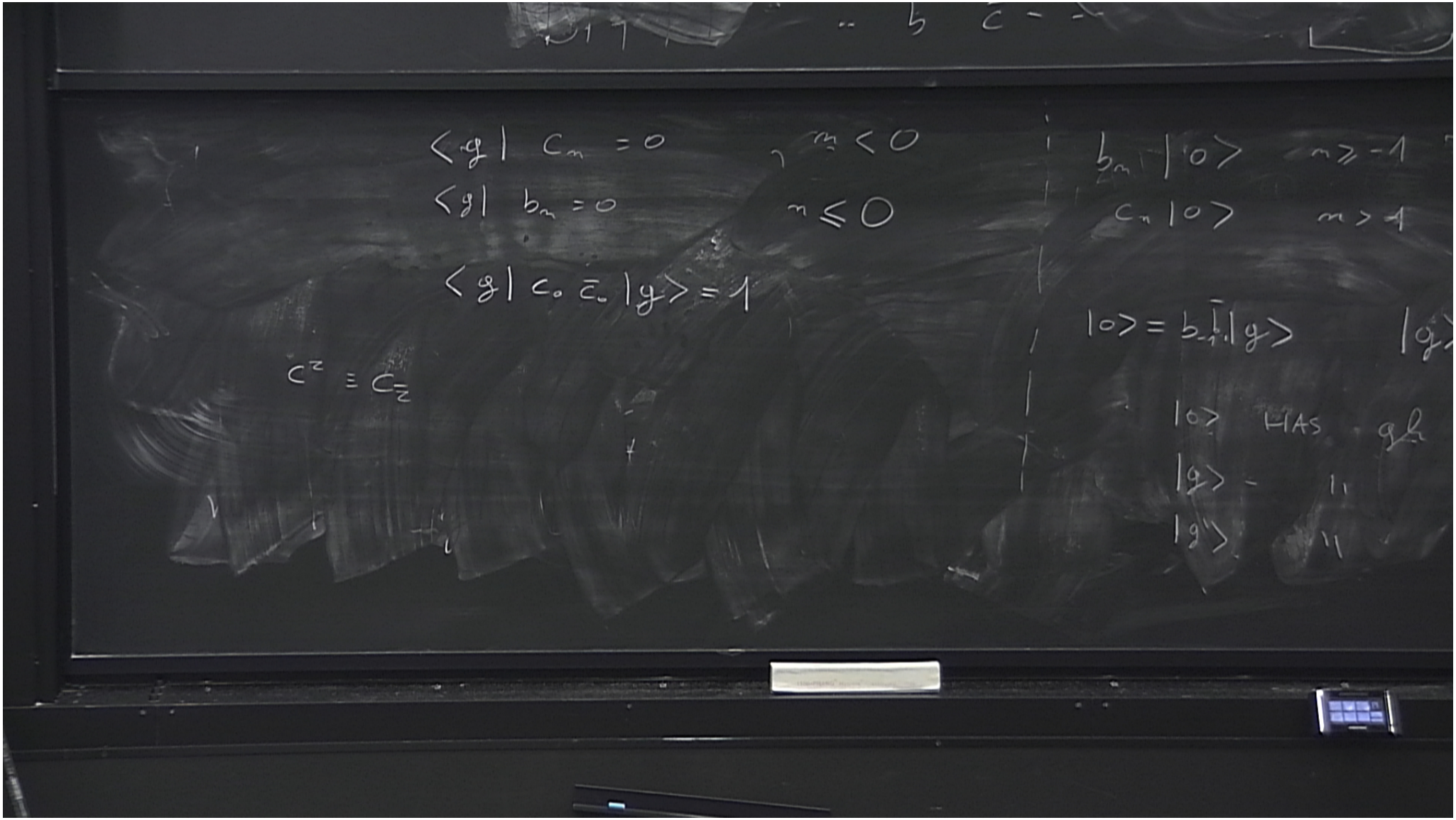

$T^{gh} = \lim_{s' \to s} \left[c(s)\, \partial_s b(s') + 2\, \partial_s c(s)\, b(s') + \frac{1}{(s-s')^2} \right]$
$= \left[\ldots - \langle 0 | \ldots | 0 \rangle \right] + \frac{13}{12}$
$J^{gh}(s) = \lim_{s' \to s} \left[c(s) b(s') - \frac{1}{s-s'} \right]$
$= \lim_{s' \to s} \left[cb - \langle 0 | cb | 0 \rangle \right] - \frac{3}{2}$
$= 1$

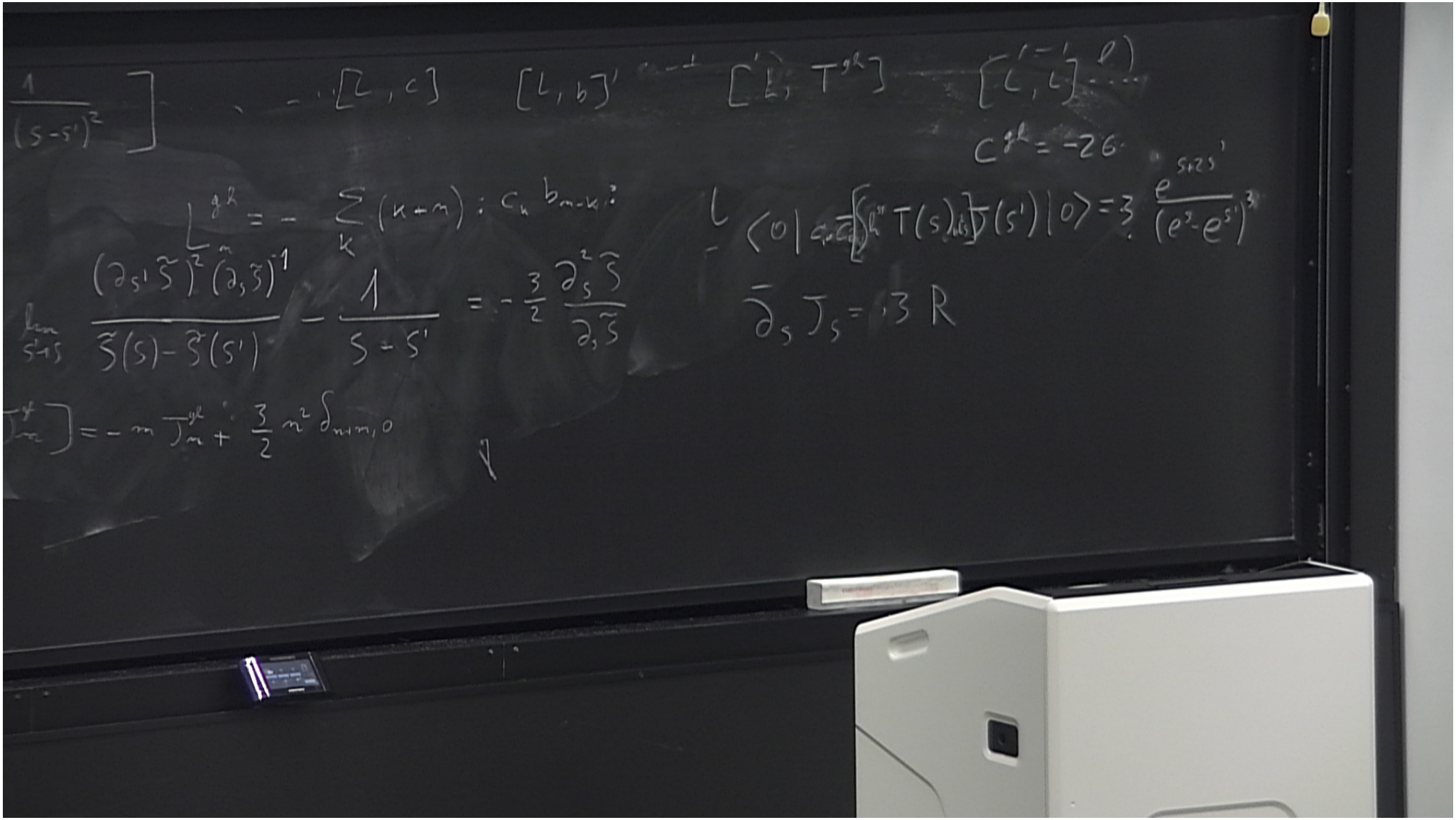

$n<0$
$n\leq 0$
$b_n|0\rangle$ $n\geq -1$
$c_n|0$ $n>1$
$|0\rangle = b$
$|q\bar{q}\rangle = \bar{c}_1 c_1 |0\rangle$
$-\frac{3}{2}$
$-\frac{1}{2}$
$+\frac{1}{2}$

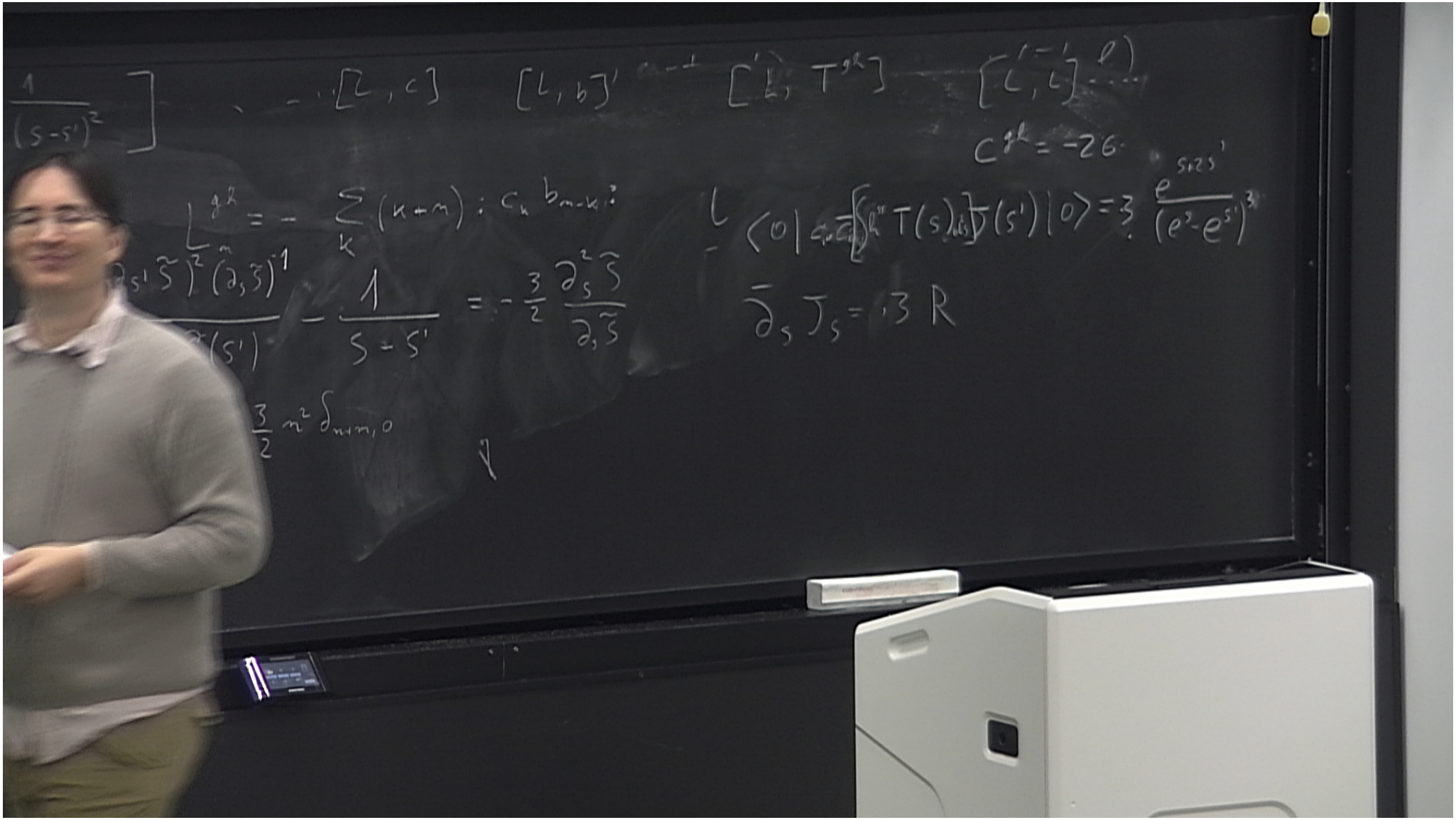

$m<0$
$m\leq 0$
$=1$
$b_m|0\rangle \quad m\geq -1$
$c_n|0\rangle \quad n>1$
$|0\rangle = b_{-1}\bar{b}_{-1}|g\rangle \qquad |\bar{g}\rangle = \bar{c}_1 c_1|0\rangle$
$|0\rangle$ HAS gh nr.
$|g\rangle$ -
$|\bar{g}\rangle$
$-\frac{3}{2}$
$-\frac{1}{2}$
$+\frac{1}{2}$
$\langle g|$

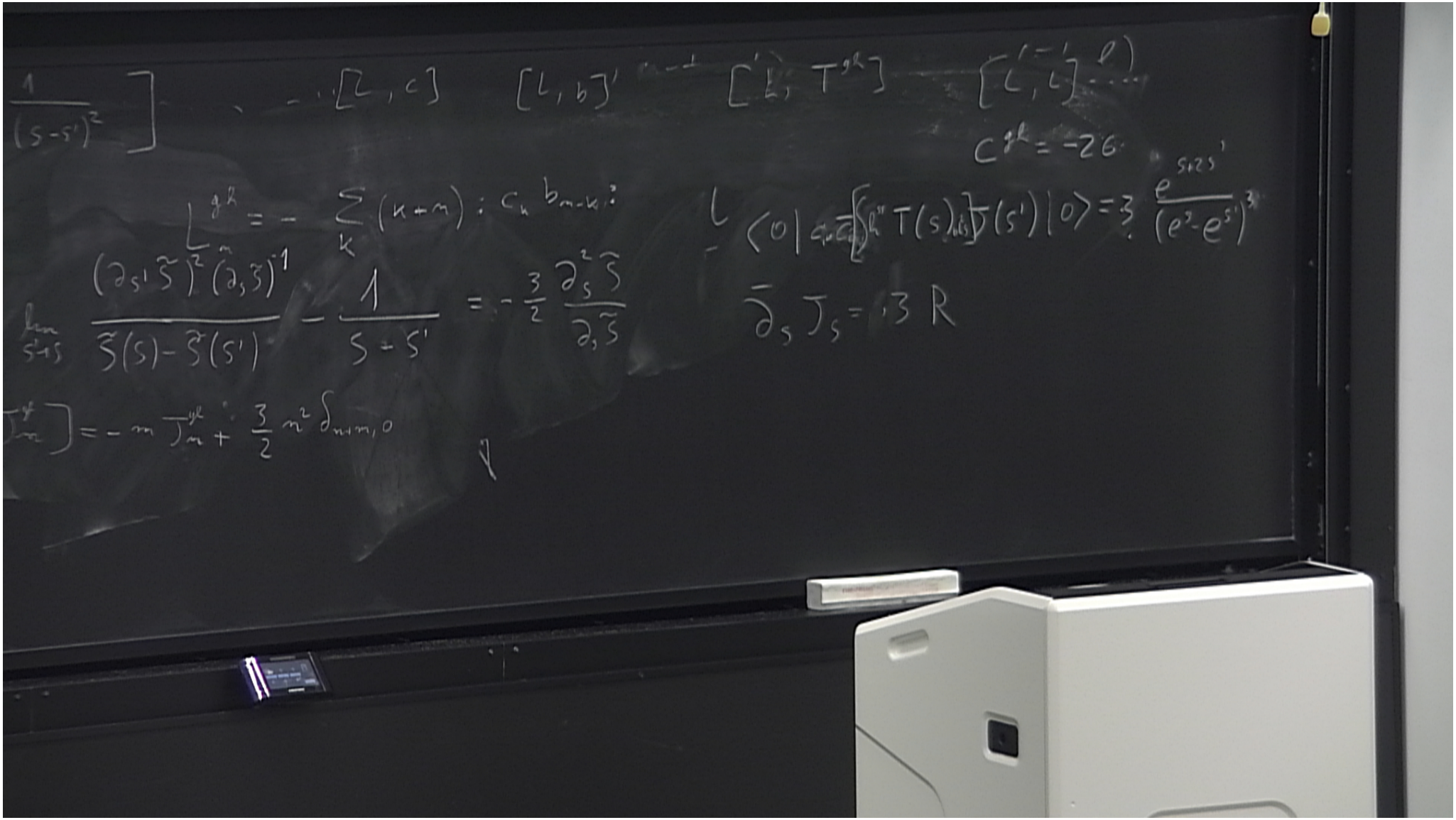



$+\frac{1}{(s-s')^2}\Big]$
$[L,c]$ $[L,b]$ $[L,T^{gk}]$ $[L,L]$
$C^{gk}=-26$
$L_m^{gk}=-\sum_k (k+m):c_k\,b_{m-k}:$
$\frac{13}{12}$
$\tilde{S}(s)$ $\lim_{s'\to s}$ $\frac{(\partial_{s'}\tilde{S})^2(\partial_s\tilde{S})^{-1}}{\tilde{S}(s)-\tilde{S}(s')}-\frac{1}{s-s'}=-\frac{3}{2}\frac{\partial_s^2\tilde{S}}{\partial_s\tilde{S}}$


$\langle g| c_m = 0 \quad m < 0$
$\langle g| b_m = 0 \quad n \leq 0$
$\langle g| c_0 \bar{c}_0 |g\rangle = 1$
$c^z \equiv c_z$
$b_m |0\rangle \quad m \geq -1$
$c_n |0\rangle \quad n > 1$
$|0\rangle = b_{-1} \bar{b}_{-1} |g\rangle$
$|0\rangle$ HAS
$|g\rangle$
$|g'\rangle$


$\frac{1}{(s-s')^2}$
$[L, c]$
$[L, b]'$
$[L, T^{gh}]$
$[L, L]$
$C^{gh} = -26$
$L_m^{gh} = -\sum_k (k+m) : c_k b_{m-k} :$
$\lim_{s' \to s} \frac{(\partial_{s'} \tilde{s})^2 (\partial_s \tilde{s})^{-1}}{\tilde{s}(s) - \tilde{s}(s')} - \frac{1}{s-s'} = -\frac{3}{2} \frac{\partial_s^2 \tilde{s}}{\partial_s \tilde{s}}$
$\langle 0 | c_n c_m T(s) T(s') | 0 \rangle = 3 \frac{e^{s+s'}}{(e^s - e^{s'})^3}$
$\bar{\partial}_s J_s = 3R$
$= -m J_m^{gh} + \frac{3}{2} m^2 \delta_{n+m,0}$


$\frac{1}{(s-s')^2}$
$[L, c]$
$[L, b]'$
$[L, T^{gh}]$
$[c, c]$
$c^{gh} = -26$
$L_m^{gh} = -\sum_k (k+m) : c_k b_{m-k} :$
$\frac{1}{s-s'}$
$= -\frac{3}{2}\frac{\partial_s^2 \tilde{s}}{\partial_s \tilde{s}}$
$\frac{3}{2} n^2 \delta_{n+m,0}$
$\langle 0 | c_n c_m [b^{gh} T(s)] T(s') | 0 \rangle = 3 \frac{e^{s+s'}}{(e^s - e^{s'})^3}$
$\bar{\partial}_s J_s = \frac{1}{3} R$


$\frac{1}{(s-s')^2}$
$[L, c]$
$[L, b]'$
$[L, T^{gh}]$
$[L, L]$
$c^{gh} = -26$
$L_m^{gh} = -\sum_k (k+m) : c_k b_{m-k} :$
$\lim_{s' \to s} \frac{(\partial_{s'} \tilde{s})^2 (\partial_s \tilde{s})^{-1}}{\tilde{s}(s) - \tilde{s}(s')} - \frac{1}{s-s'} = -\frac{3}{2} \frac{\partial_s^2 \tilde{s}}{\partial_s \tilde{s}}$
$\bar{\partial}_s J_s = \frac{3}{2} R$
$[J_m^{gh}] = -m J_m^{gh} + \frac{3}{2} m^2 \delta_{n+m,0}$