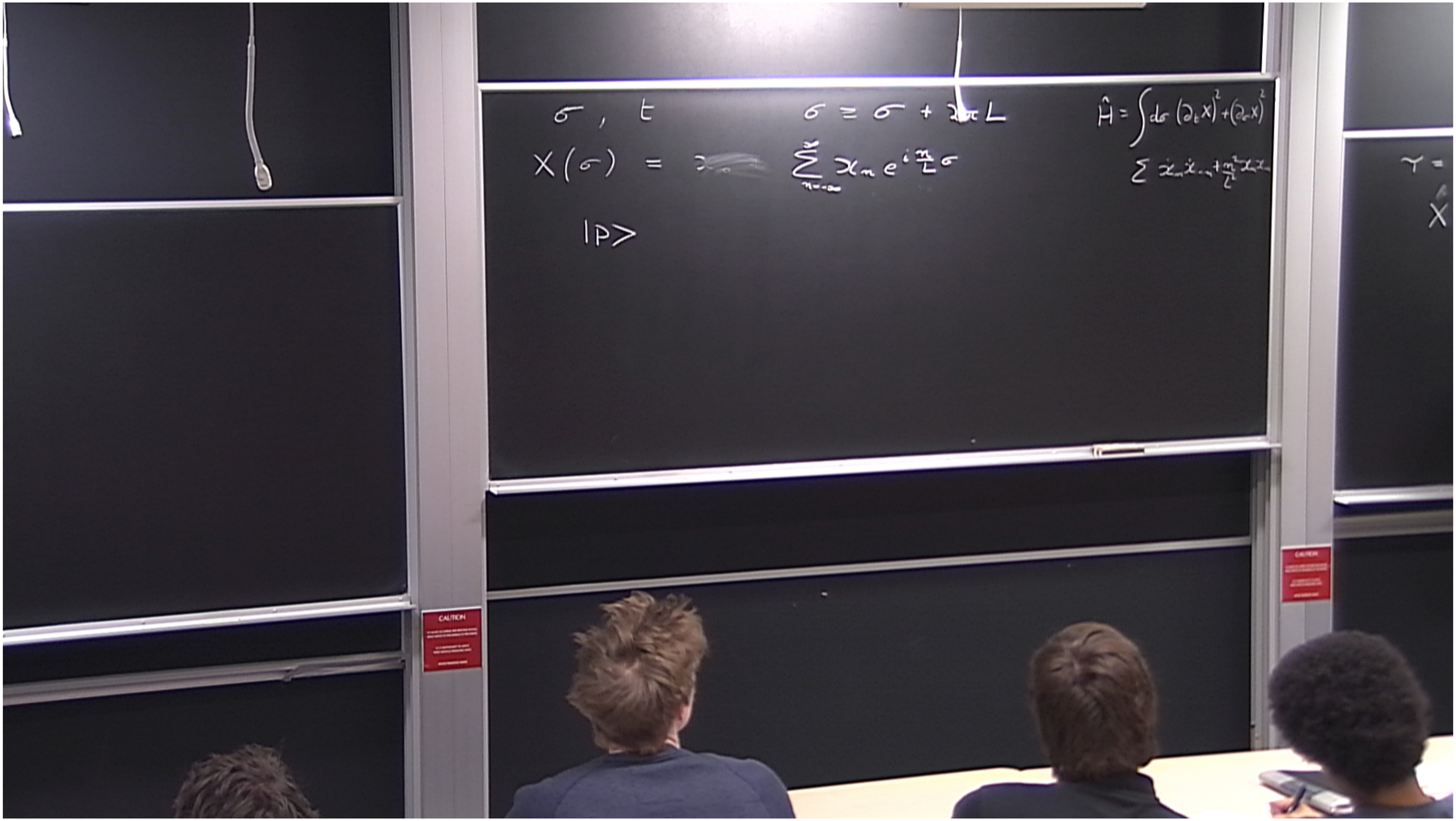
Title: String Theory Review-3

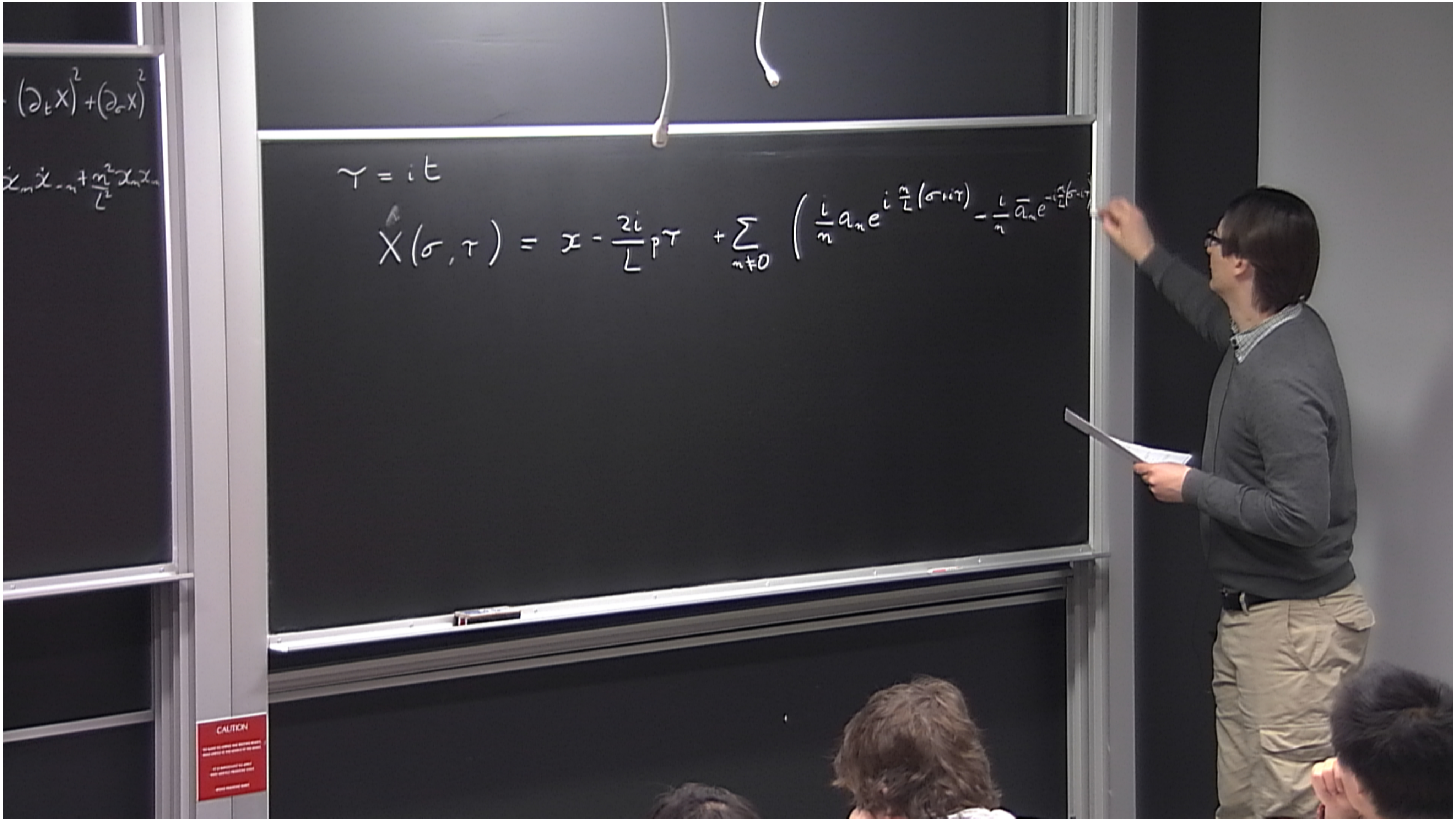
Date: Jan 28, 2015 10:15 AM

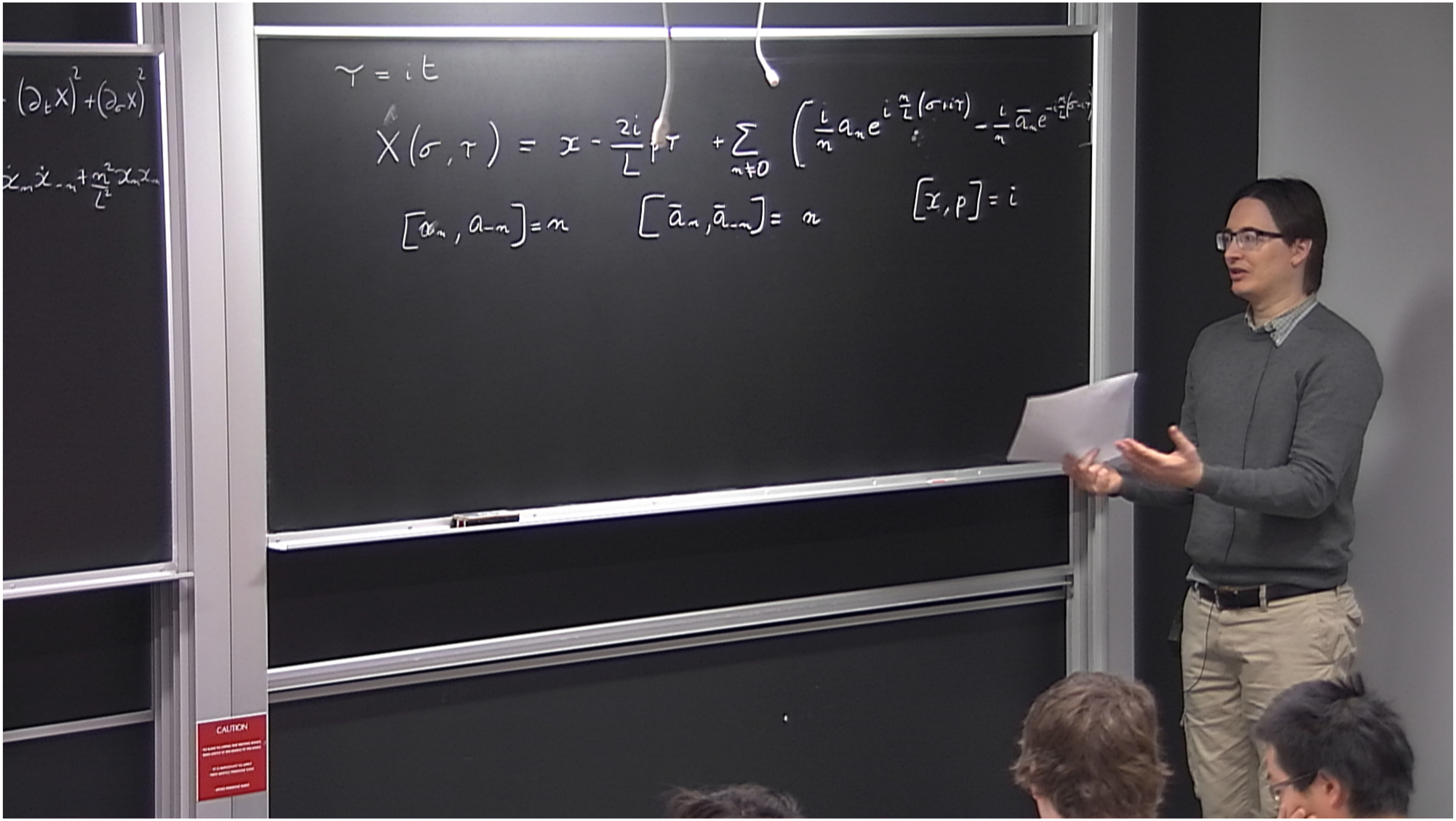
URL: http://pirsa.org/15010064

Abstract:



σ , t
σ ≅ σ + 2πL
X(σ) =
|P>

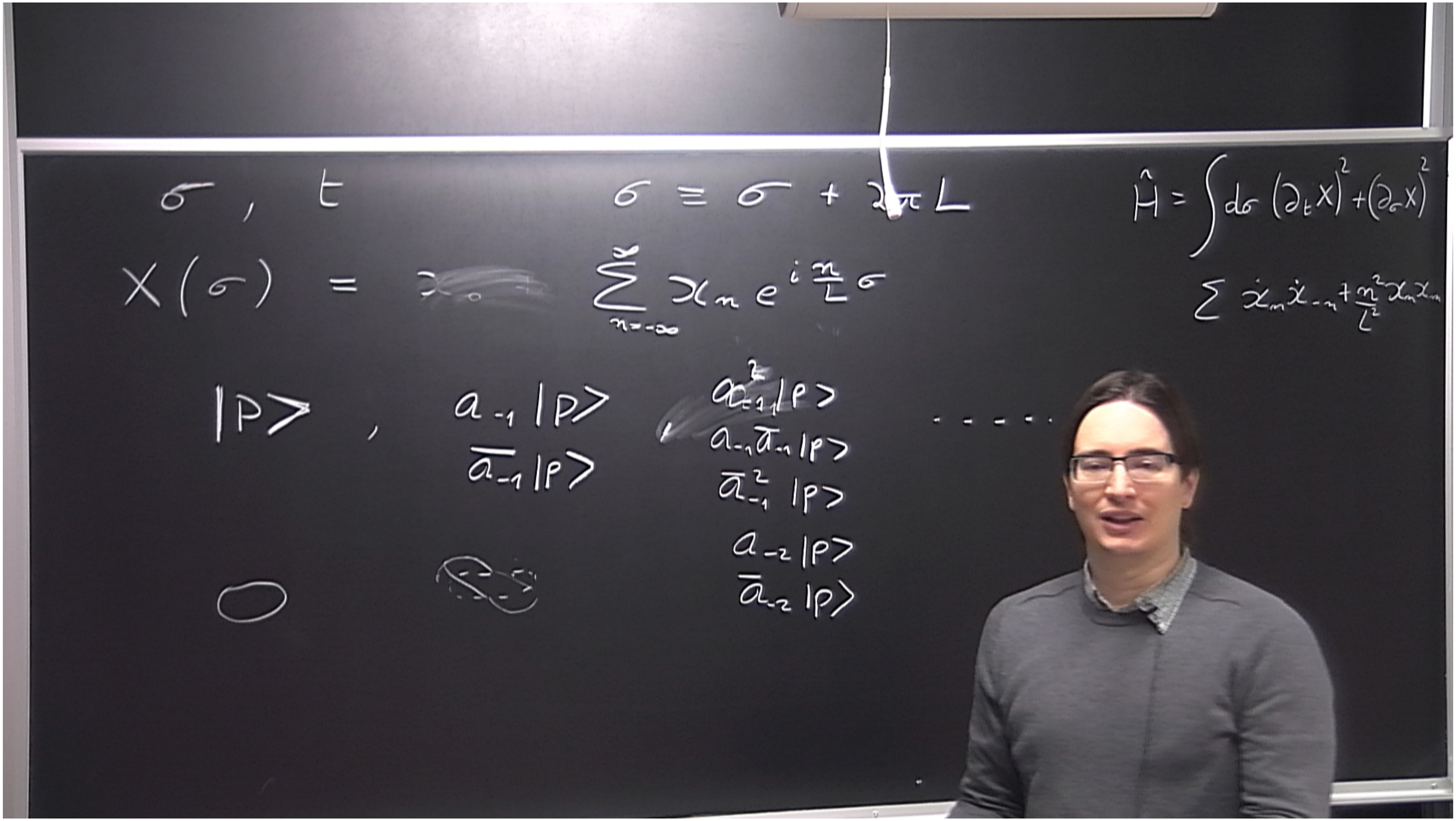

τ = it
X(σ, τ) = x - 2i/L pτ + Σ_{n≠0} (i/n a_n e^{i n/L (σ+iτ)} - i/n ā_n

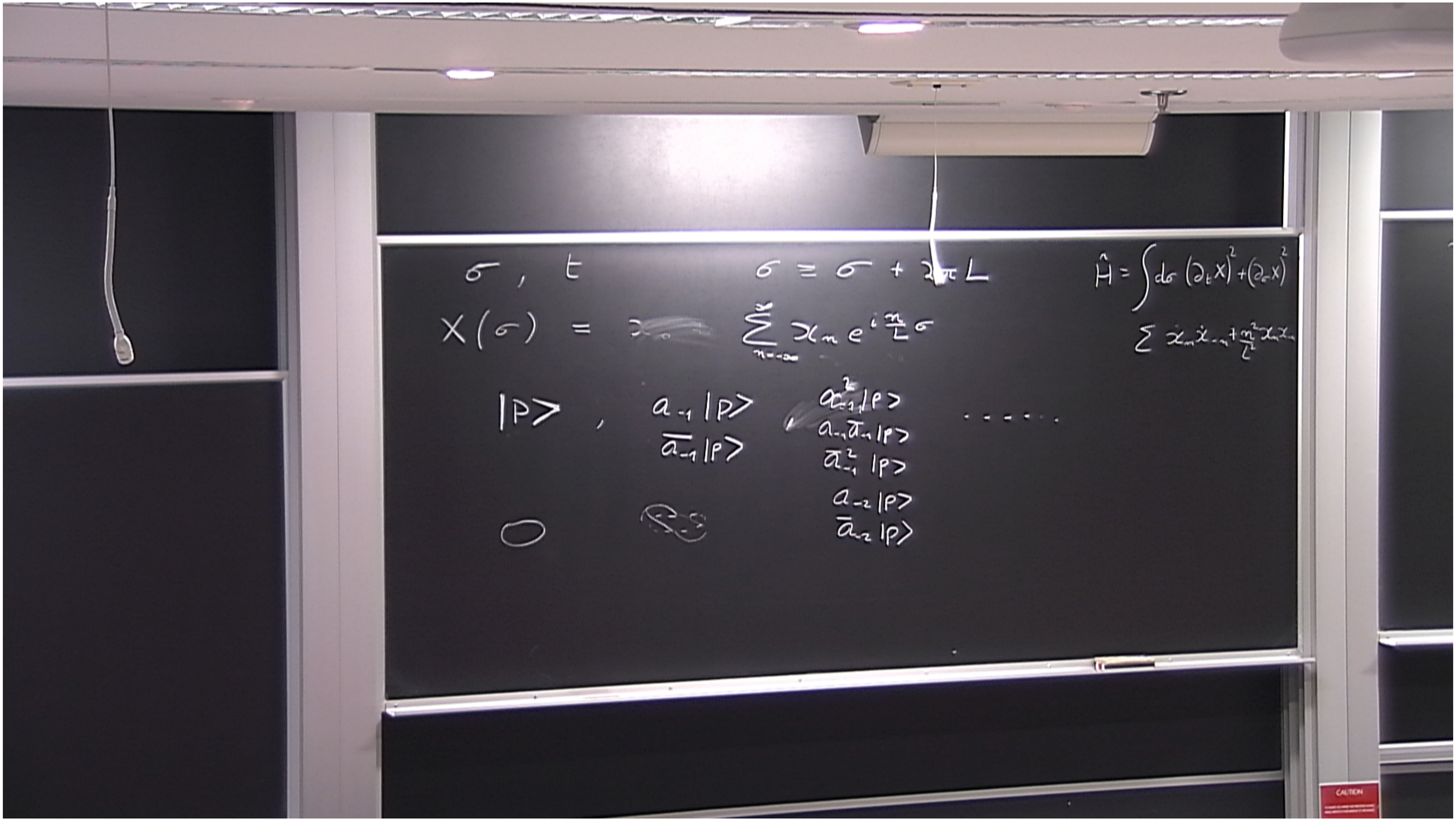

τ = it
[x, p] = i
[ā_n, ā_-n] = n
CAUTION

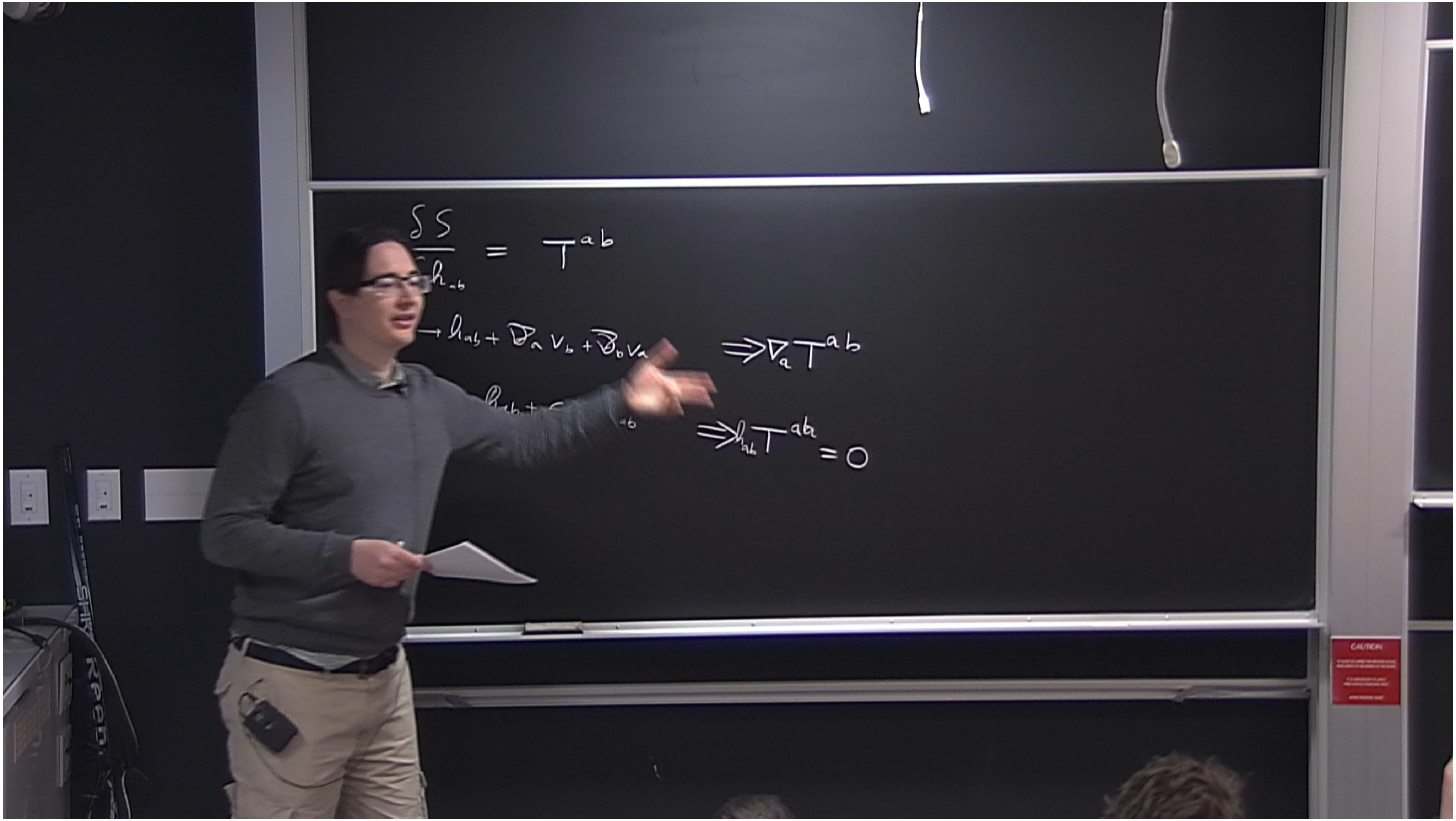
$$\tau = it$$

$$X(\sigma,\tau) = x - \frac{2i}{L} p\tau + \sum_{n\neq 0}\left(\frac{i}{n} a_n e^{i\frac{n}{L}(\sigma + i\tau)} - \frac{i}{n}\bar{a}_n e^{-i\frac{n}{L}(\sigma - i\tau)}\right)$$

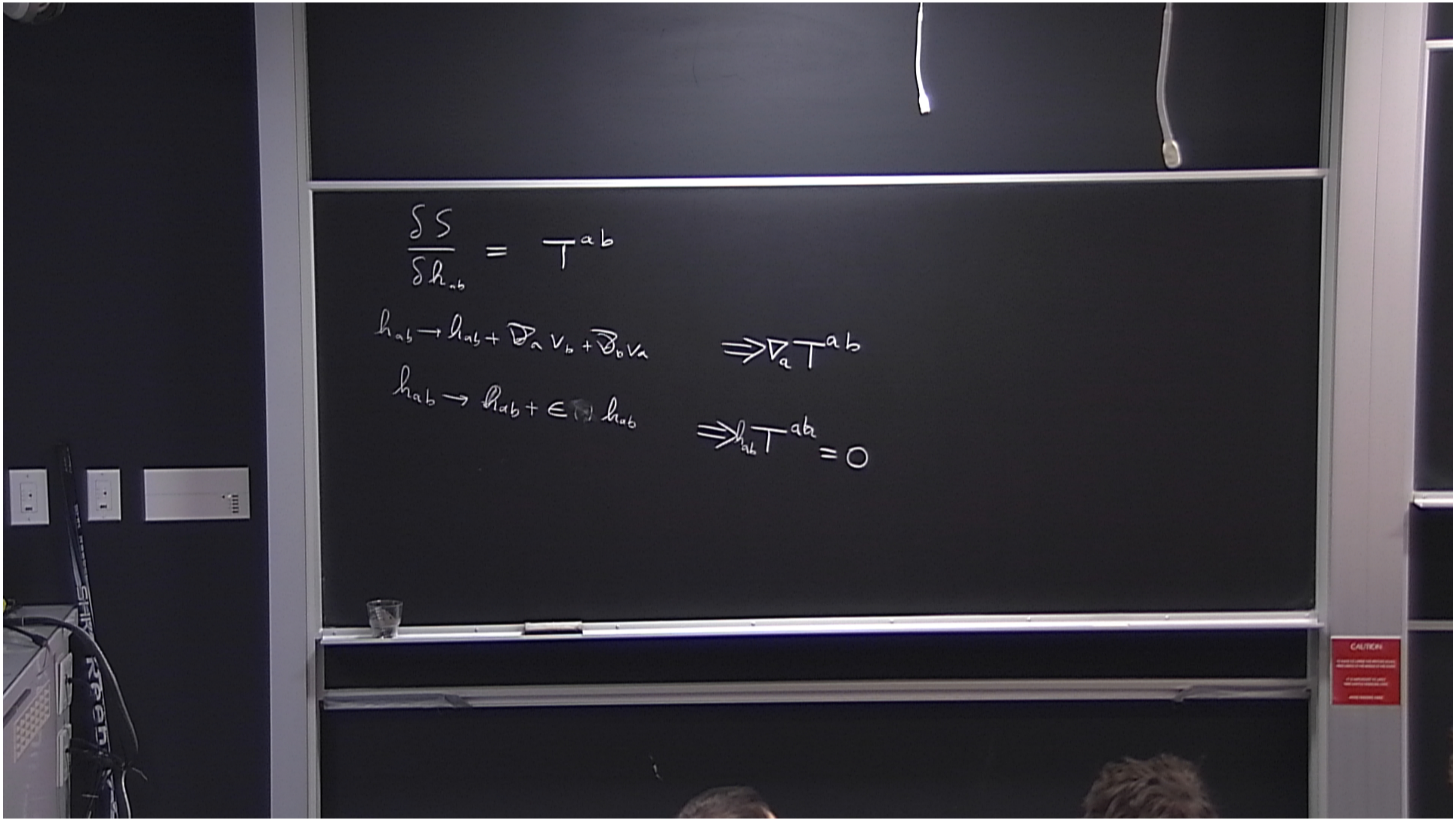
$$[a_n, a_{-n}] = n \qquad [\bar{a}_n, \bar{a}_{-n}] = n \qquad [x, p] = i$$


$\sigma \,,\; t$
$\sigma \equiv \sigma + 2\pi L$
$\hat{H} = \int d\sigma\, (\partial_t X)^2 + (\partial_\sigma X)^2$
$X(\sigma) = \sum_{n=-\infty}^{\infty} x_n e^{i \frac{n}{L} \sigma}$
$\sum \dot{x}_n \dot{x}_{-n} + \frac{n^2}{L^2} x_n x_{-n}$
$|p\rangle \,,$
$a_{-1}|p\rangle$
$\bar{a}_{-1}|p\rangle$
$a_{-1}^2|p\rangle$
$a_{-1}\bar{a}_{-1}|p\rangle$
$\bar{a}_{-1}^2|p\rangle$
$a_{-2}|p\rangle$
$\bar{a}_{-2}|p\rangle$
$\ldots\ldots$

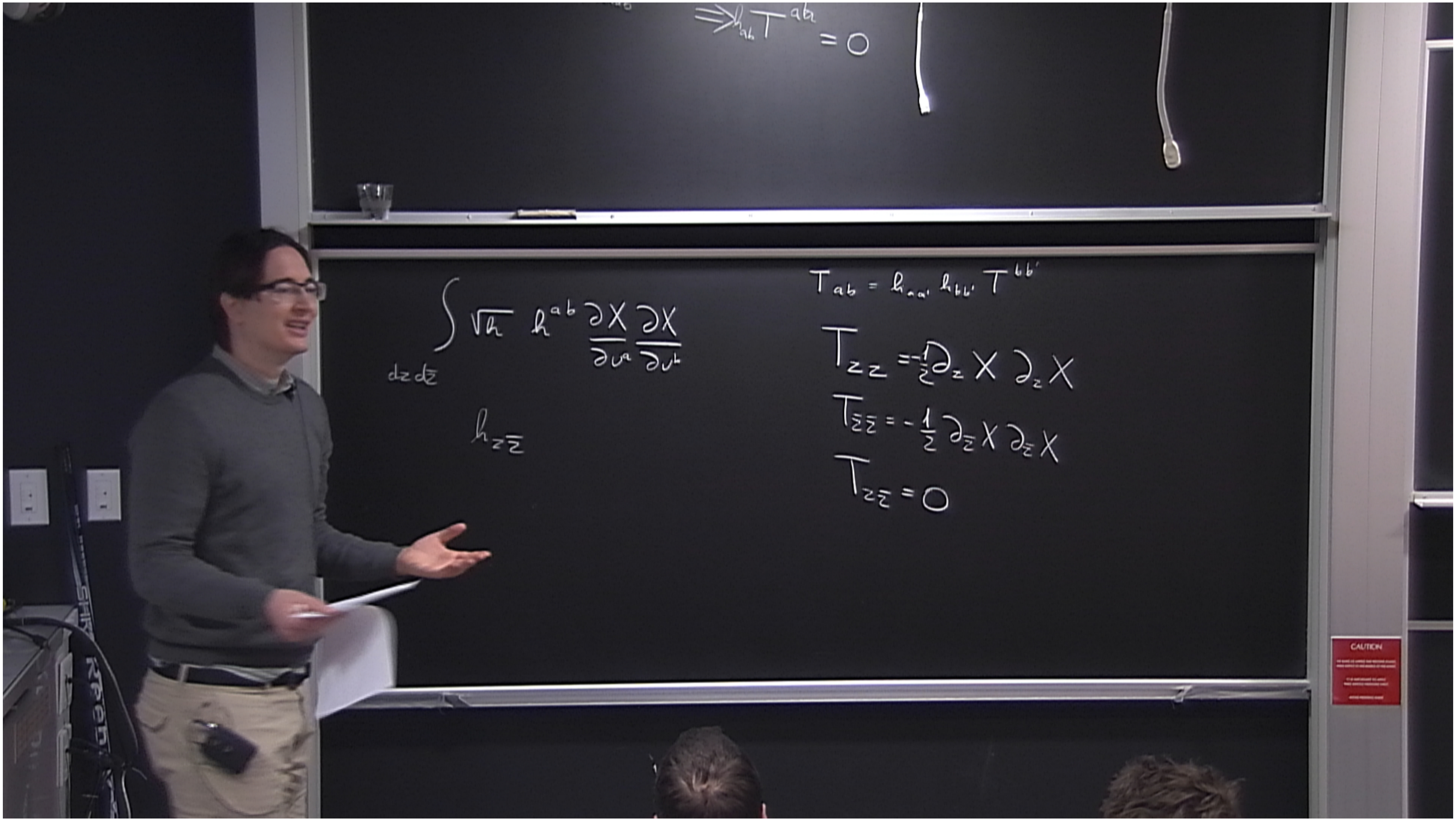

σ , t
σ ≡ σ + 2πL
X(σ) = Σ x_n e^{i n/L σ}
|p⟩ , a_{-1}|p⟩
ā_{-1}|p⟩
a_{-1}^2|p⟩
a_{-1}ā_{-1}|p⟩
ā_{-1}^2|p⟩
a_{-2}|p⟩
ā_{-2}|p⟩
CAUTION

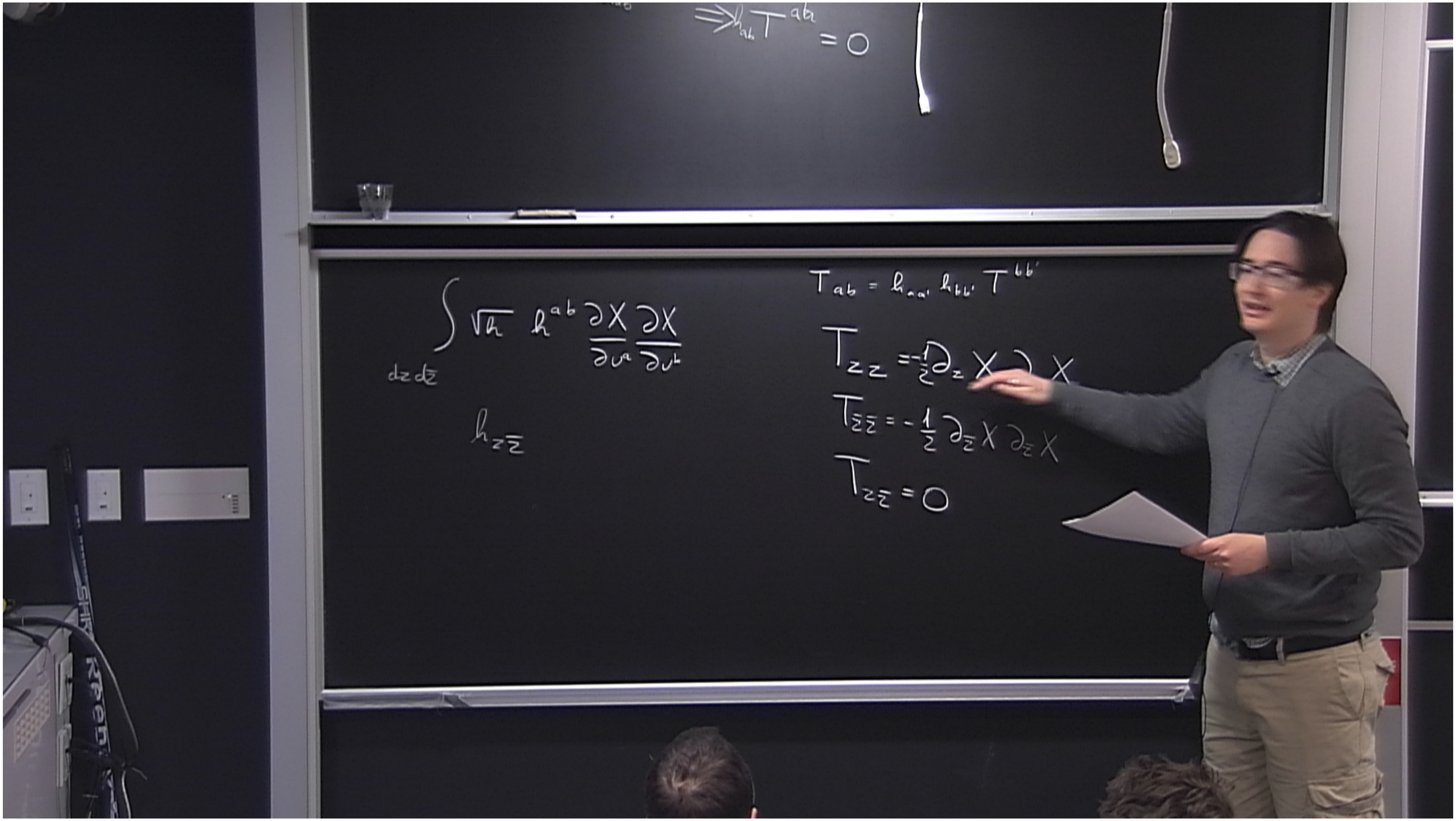


$\frac{\delta S}{\delta h_{ab}} = T^{ab}$
$\Rightarrow \nabla_a T^{ab}$
$\Rightarrow h_{ab} T^{ab} = 0$



$\frac{\delta S}{\delta h_{ab}} = T^{ab}$
$h_{ab} \to h_{ab} + \nabla_a v_b + \nabla_b v_a$
$\Rightarrow \nabla_a T^{ab}$
$h_{ab} \to h_{ab} + \epsilon \, h_{ab}$
$\Rightarrow h_{ab} T^{ab} = 0$


$\Rightarrow h_{ab} T^{ab} = 0$
$\int_{dz d\bar{z}} \sqrt{h}\, h^{ab} \frac{\partial X}{\partial \sigma^a} \frac{\partial X}{\partial \sigma^b}$
$h_{z\bar{z}}$
$T_{ab} = h_{aa'} h_{bb'} T^{a'b'}$
$T_{zz} = -\frac{1}{2} \partial_z X \partial_z X$
$T_{\bar{z}\bar{z}} = -\frac{1}{2} \partial_{\bar{z}} X \partial_{\bar{z}} X$
$T_{z\bar{z}} = 0$
CAUTION

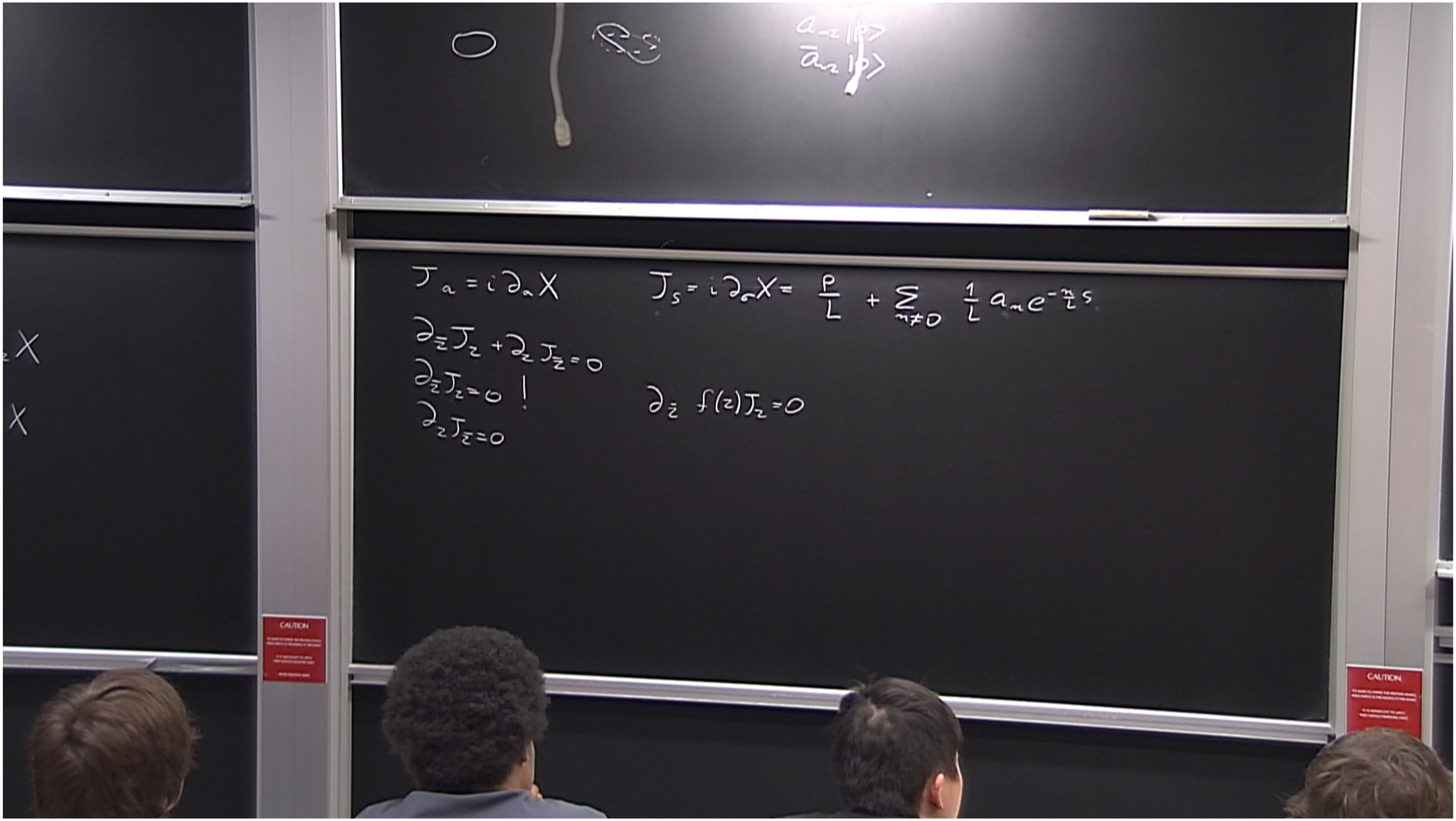

$\Rightarrow h_{ab} T^{ab} = 0$
$\int_{dz d\bar{z}} \sqrt{h}\, h^{ab} \frac{\partial X}{\partial \sigma^a} \frac{\partial X}{\partial \sigma^b}$
$h_{z\bar{z}}$
$T_{ab} = h_{aa'} h_{bb'} T^{bb'}$
$T_{zz} = -\frac{1}{2} \partial_z X \partial X$
$T_{\bar{z}\bar{z}} = -\frac{1}{2} \partial_{\bar{z}} X \partial_{\bar{z}} X$
$T_{z\bar{z}} = 0$

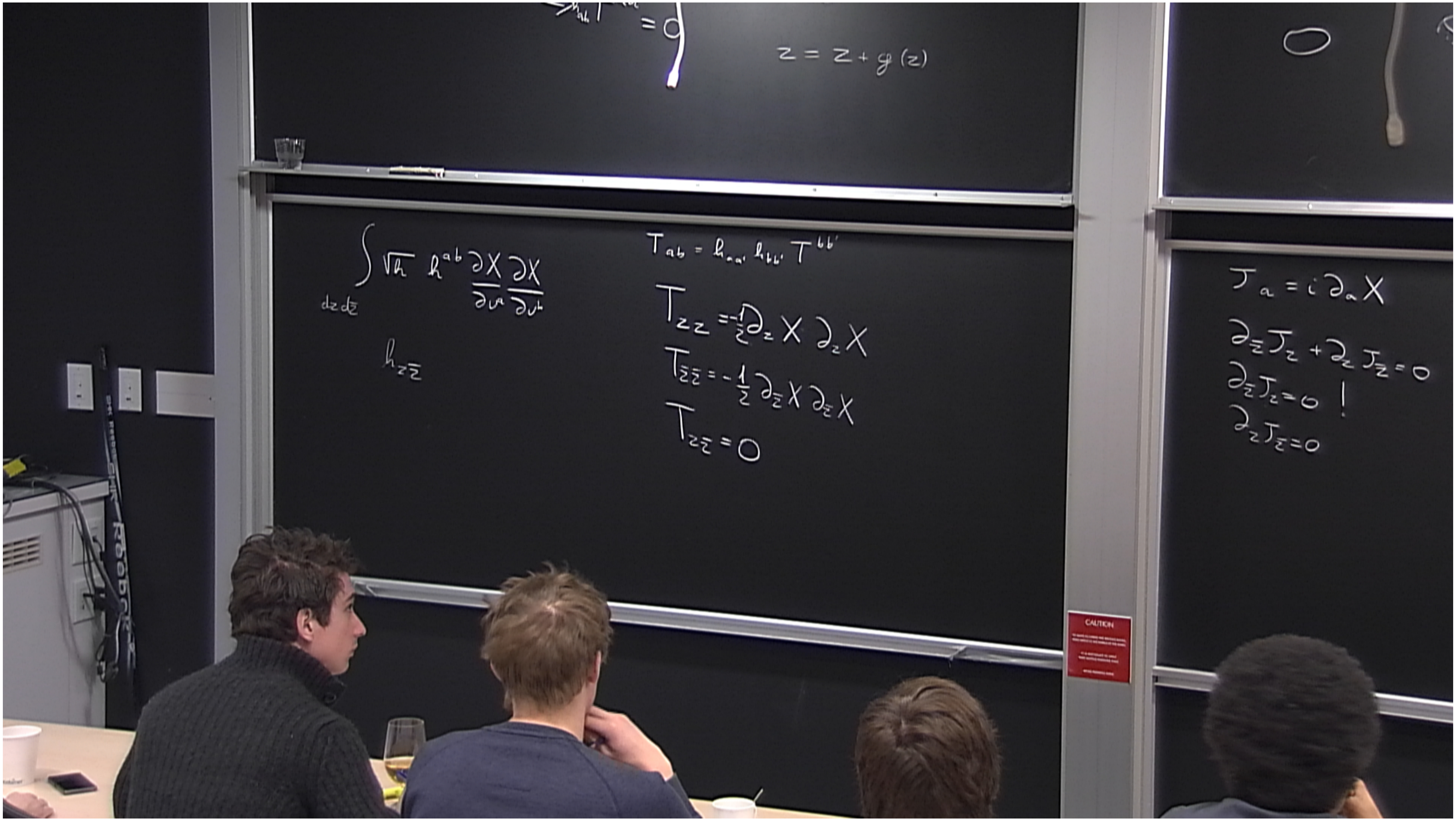
$$\tau = it \qquad \varsigma = \tau - i\sigma$$

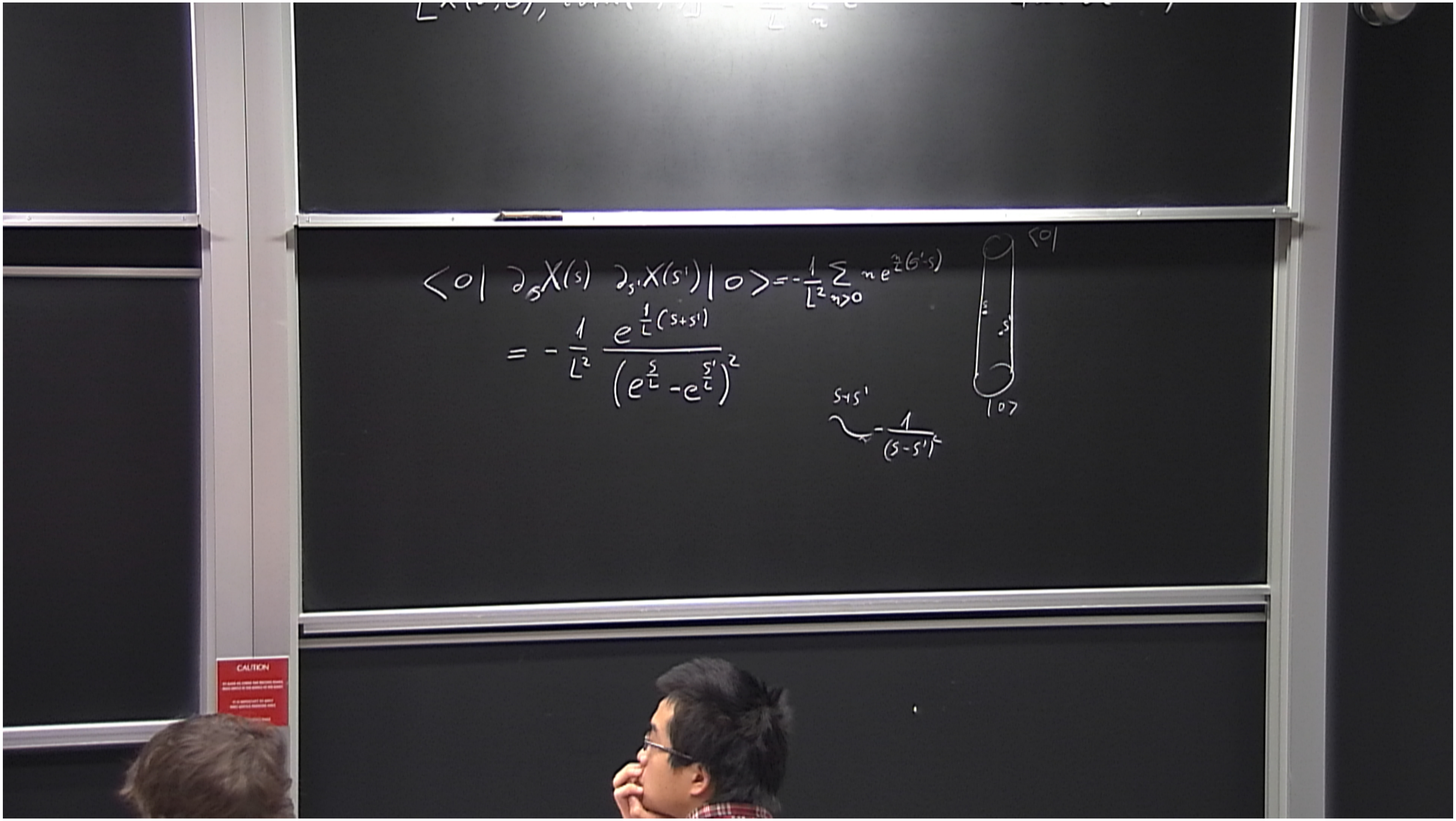
$$X(\sigma,\tau) = x - \frac{2i}{L} p\tau + \sum_{n\neq 0}\left(\frac{i}{n} a_n e^{i\frac{n}{L}(\sigma+i\tau)} - \frac{i}{n}\bar{a}_n e^{-i\frac{n}{L}(\sigma-i\tau)}\right)$$

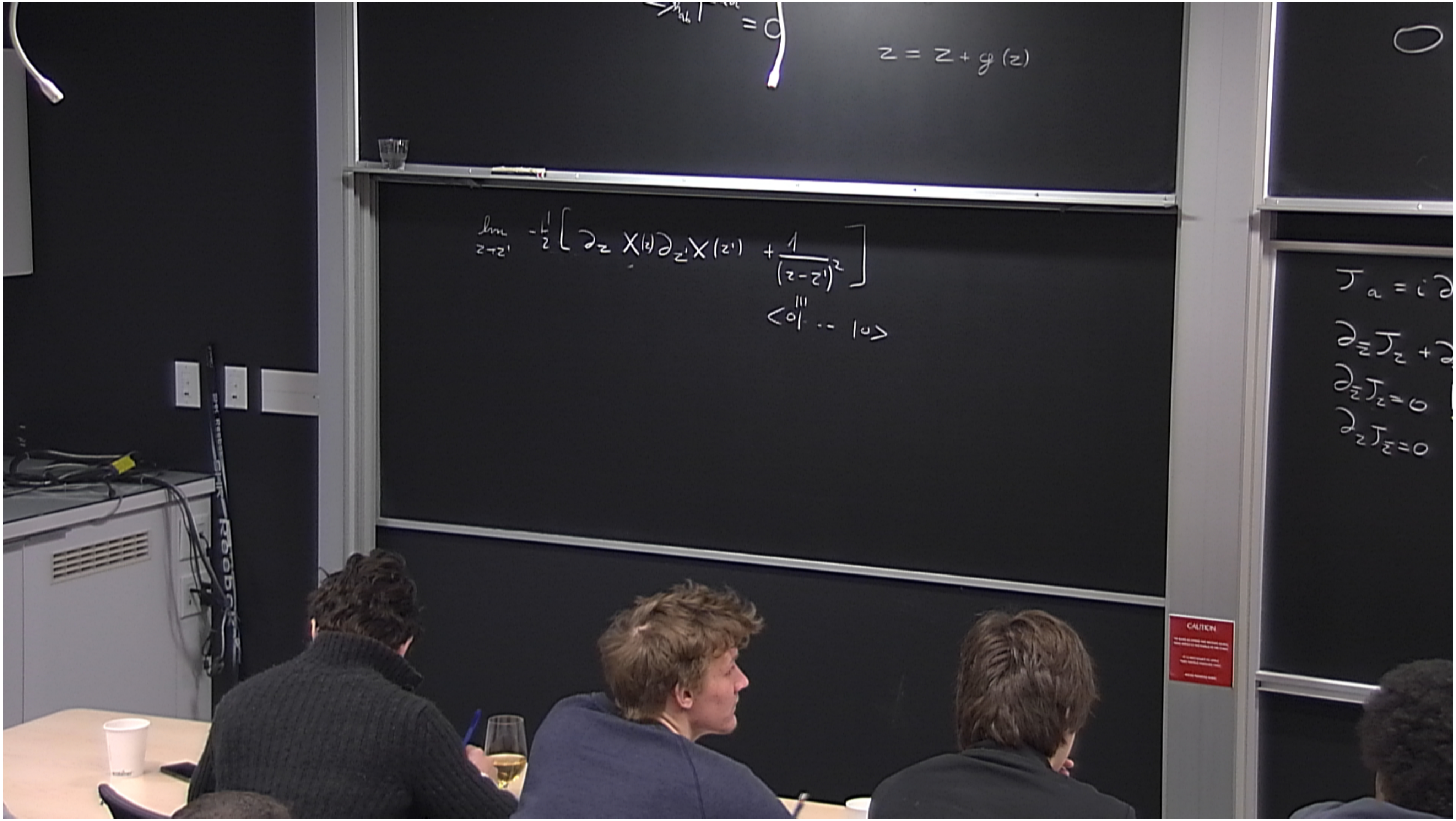
$$[a_m, a_{-m}] = m \qquad [\bar{a}_m, \bar{a}_{-m}] = m \qquad [x, p] = i$$

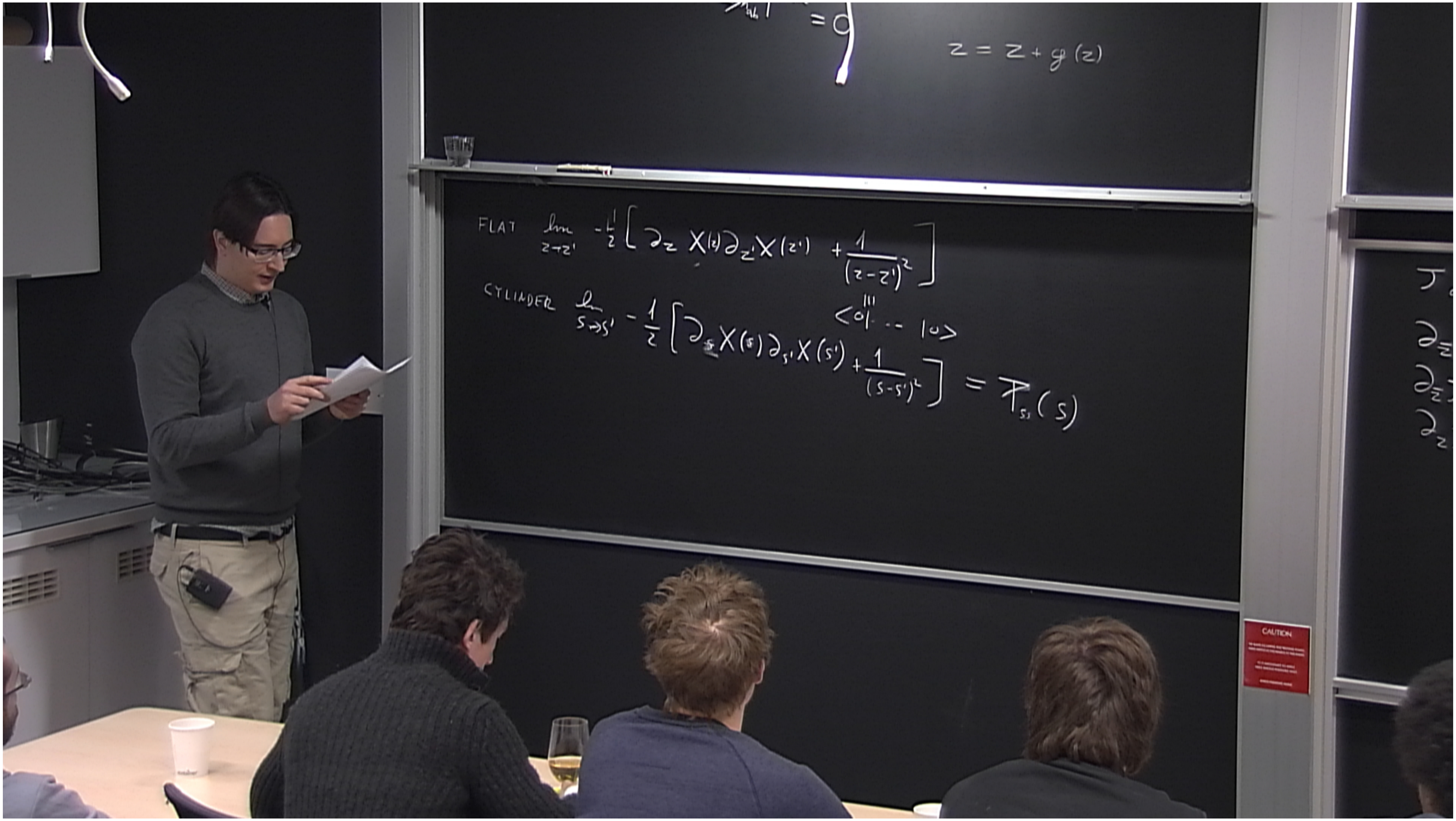
$$[X(\sigma,0), i\partial_\tau X(\sigma',0)] = \frac{2i}{L}\sum_n e^{i\frac{n}{L}(\sigma-\sigma')} = 4\pi i\,\delta(\sigma-\sigma')$$

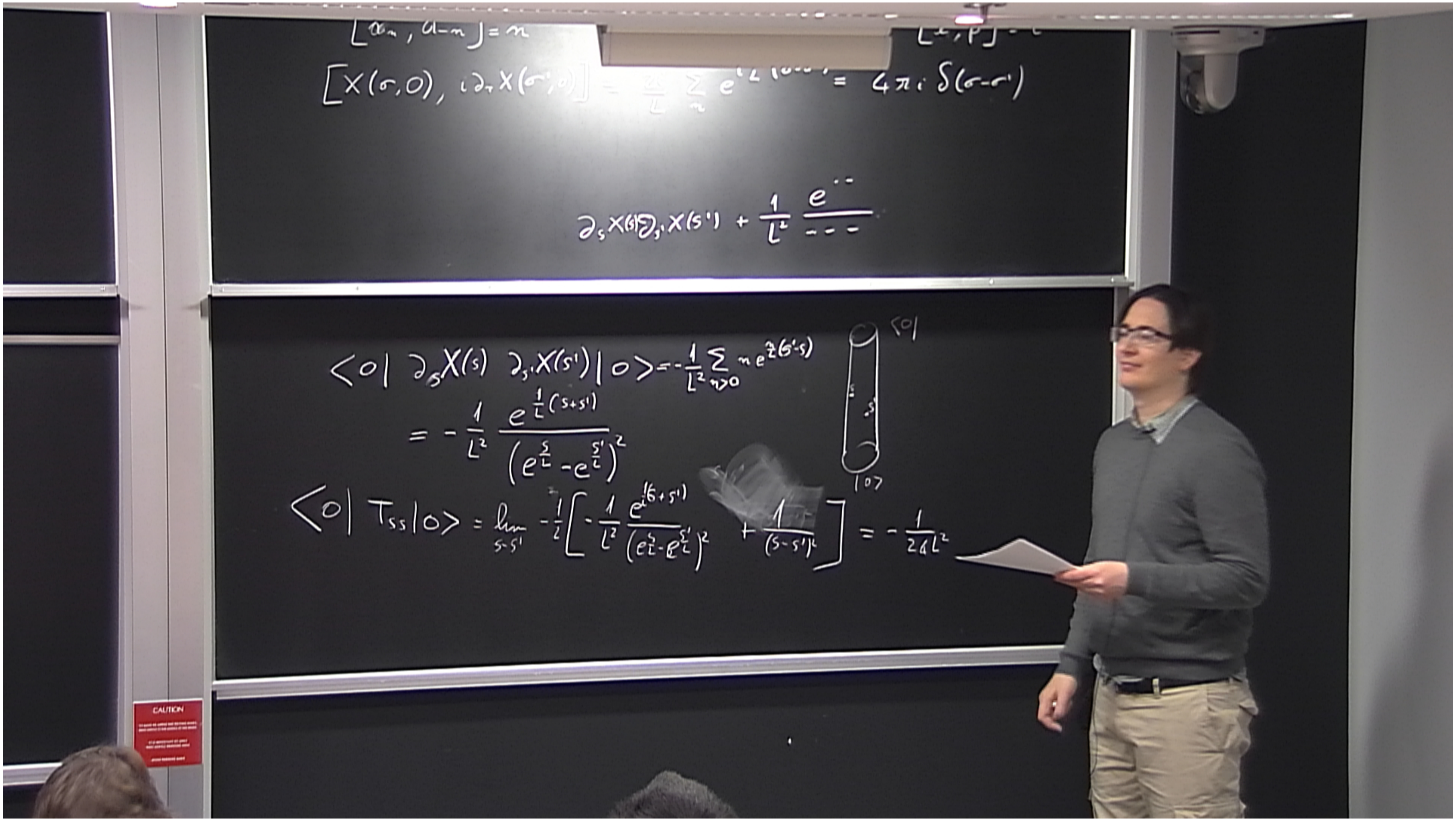

$a_{-2}|p\rangle$
$\bar{a}_{-2}|p\rangle$
$J_a = i\partial_a X$
$J_s = i\partial_\sigma X = \frac{p}{L} + \sum_{n\neq 0} \frac{1}{L} a_n e^{-\frac{n}{L}s}$
$\partial_{\bar{z}} J_z + \partial_z J_{\bar{z}} = 0$
$\partial_{\bar{z}} J_z = 0$!
$\partial_z J_{\bar{z}} = 0$
$\partial_{\bar{z}} f(z) J_z = 0$
CAUTION
CAUTION

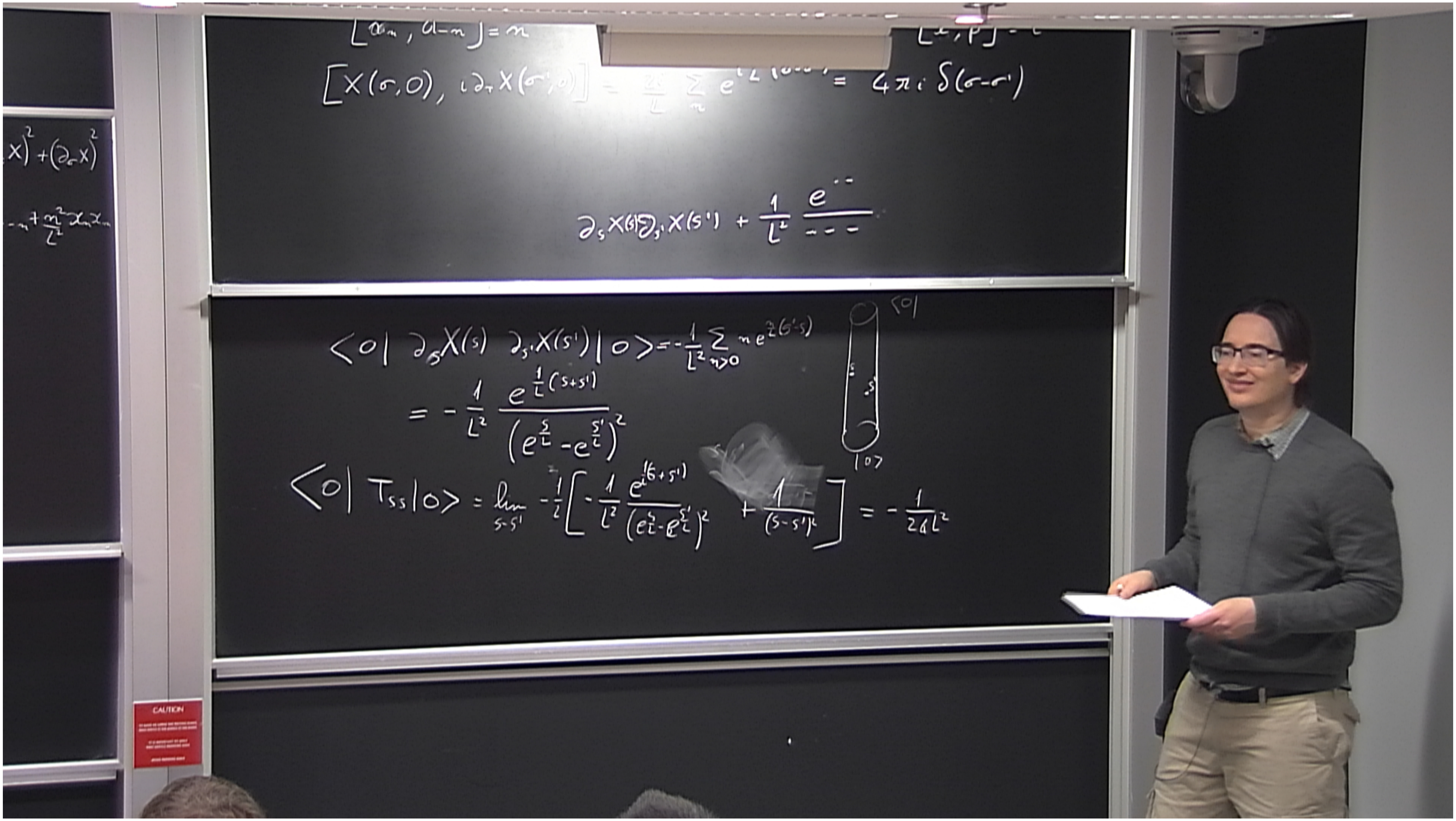

z = z + g(z)
$\int_{dz d\bar{z}} \sqrt{h}\, h^{ab} \frac{\partial X}{\partial \sigma^a} \frac{\partial X}{\partial \sigma^b}$
$h_{z\bar{z}}$
$T_{ab} = h_{aa'} h_{bb'} T^{a'b'}$
$T_{zz} = -\frac{1}{2} \partial_z X \partial_z X$
$T_{\bar{z}\bar{z}} = -\frac{1}{2} \partial_{\bar{z}} X \partial_{\bar{z}} X$
$T_{z\bar{z}} = 0$
$J_a = i \partial_a X$
$\partial_{\bar{z}} J_z + \partial_z J_{\bar{z}} = 0$
$\partial_{\bar{z}} J_z = 0$!
$\partial_z J_{\bar{z}} = 0$
CAUTION

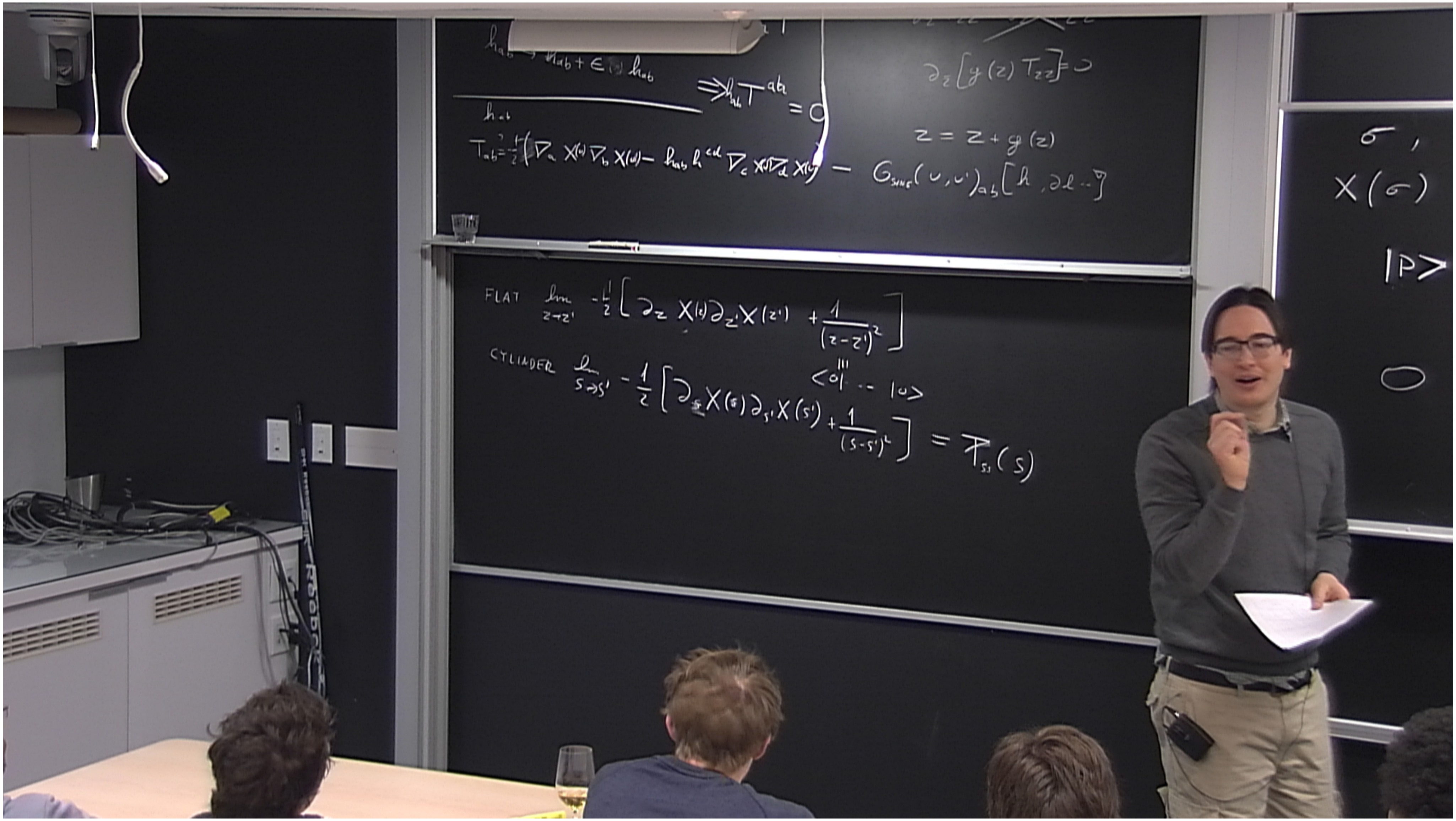

$\langle 0 | \partial_s X(s) \, \partial_{s'} X(s') | 0 \rangle = -\frac{1}{L^2} \sum_{n>0} n \, e^{\frac{n}{L}(s'-s)}$
$= -\frac{1}{L^2} \frac{e^{\frac{1}{L}(s+s')}}{\left(e^{\frac{s}{L}} - e^{\frac{s'}{L}}\right)^2}$
$s \to s'$
$\sim -\frac{1}{(s-s')^2}$
$\langle 0|$
s
s'
$|0\rangle$

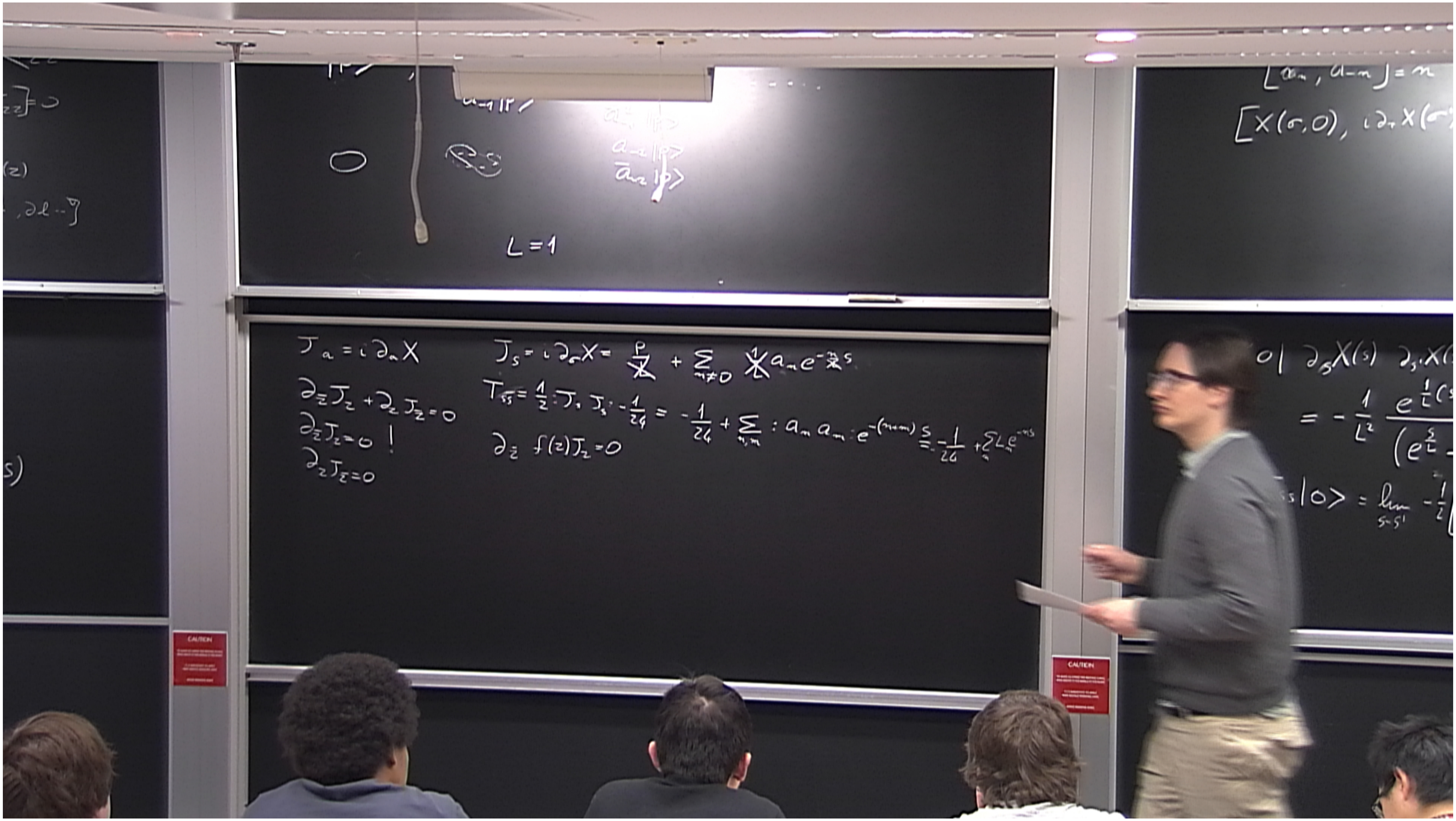


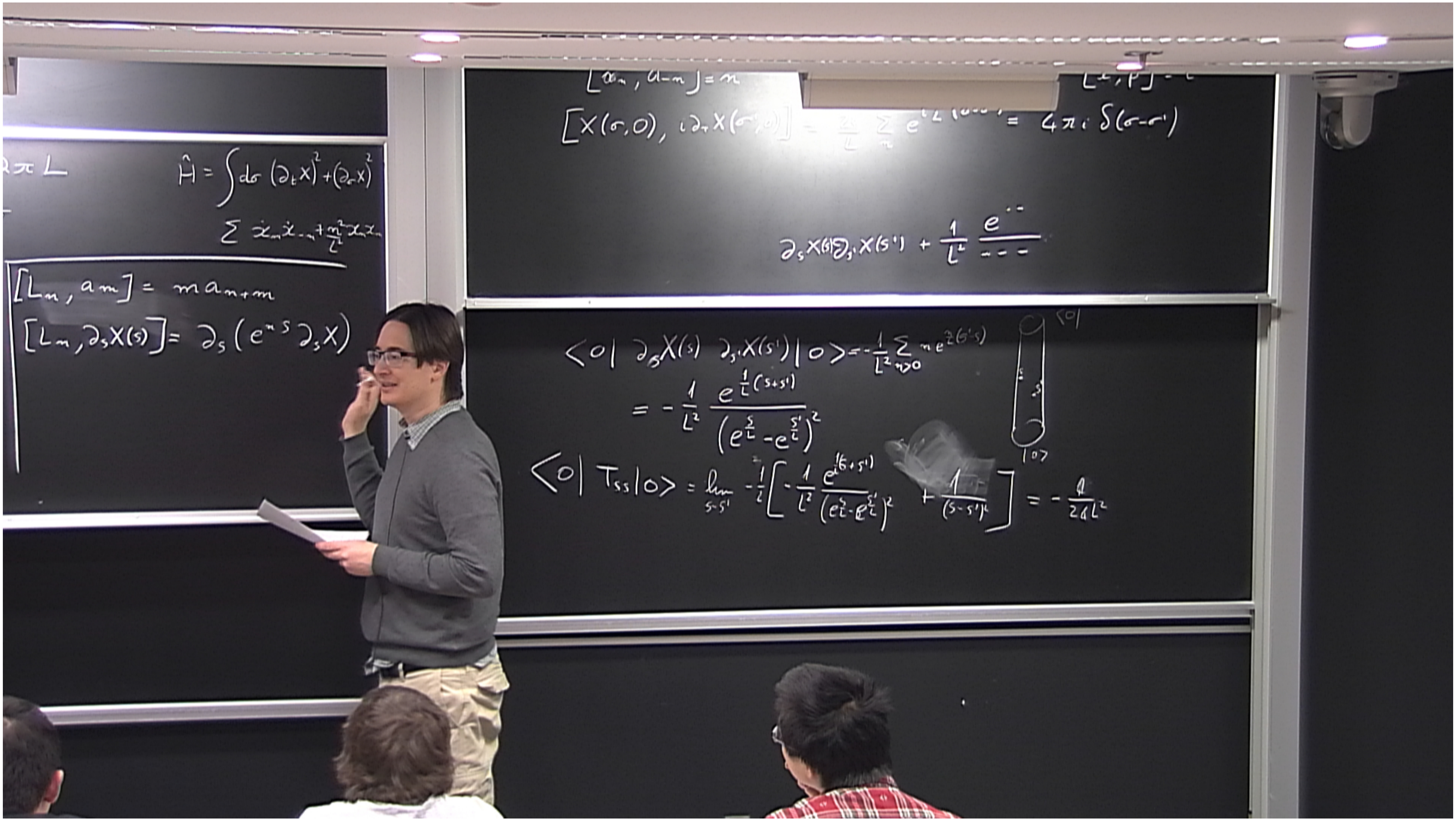

FLAT
CYLINDER
CAUTION

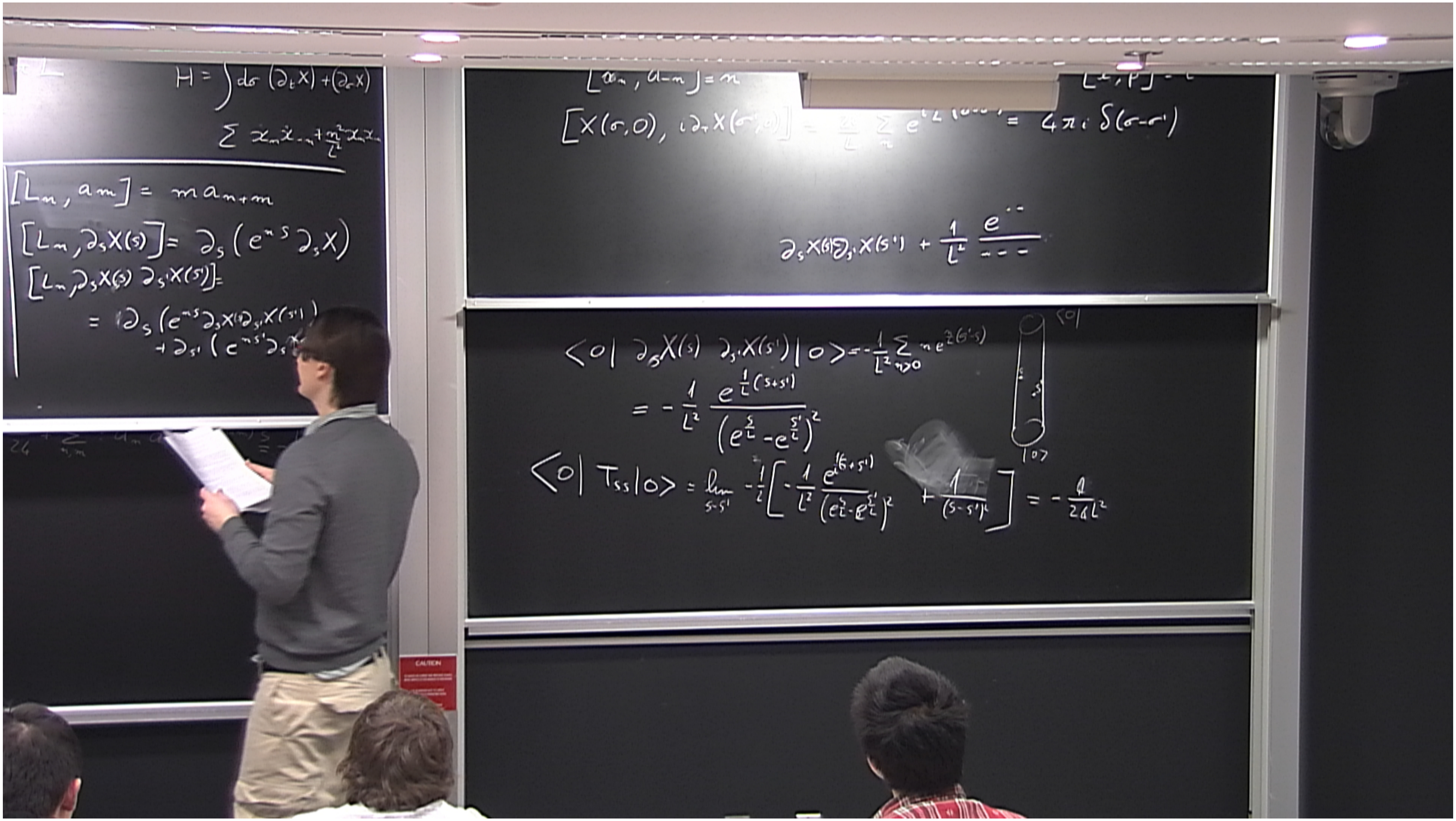

[X(σ,0), i∂_τ X(σ',0)] = 4πi δ(σ-σ')
⟨0| ∂_s X(s) ∂_s' X(s') |0⟩ = -1/L² Σ_{n>0} n e^{n/L (s'-s)}
= -1/L² e^{1/L (s+s')} / (e^{s/L} - e^{s'/L})²
⟨0| T_ss |0⟩ = lim_{s→s'} -1/2 [-1/L² e^{1/L(s+s')} / (e^{s/L} - e^{s'/L})² + 1/(s-s')²] = -1/(24L²)
CAUTION


[X(σ,0), i∂τX(σ',0)] = 2π/L Σn e^... = 4πi δ(σ−σ')
∂sX(s)∂s'X(s') + 1/L² e^../---
<0| ∂sX(s) ∂s'X(s') |0> = −1/L² Σn>0 n e^{n/L(s'−s)}
= −1/L² e^{1/L(s+s')} / (e^{s/L} − e^{s'/L})²
<0| Tss |0> = lim s→s' −1/2 [−1/L² e^{1/L(s+s')} / (e^{s/L} − e^{s'/L})² + 1/(s−s')²] = −1/(24L²)
<0|
|0>
CAUTION


FLAT
CYLINDER


L = 1
$J_a = i\partial_a X$
$\partial_{\bar z} J_z + \partial_z J_{\bar z} = 0$
$\partial_{\bar z} J_z = 0$!
$\partial_z J_{\bar z} = 0$
$\partial_{\bar z} f(z) J_z = 0$


[X(σ,0), i∂_t X(σ',0)] = 4πi δ(σ−σ')
Ĥ = ∫dσ (∂_t X)^2 + (∂_σ X)^2
[L_n, a_m] = m a_{n+m}
[L_n, ∂_s X(s)] = ∂_s (e^{ns} ∂_s X)
<0| ∂_s X(s) ∂_{s'} X(s') |0>
<0| T_{ss} |0>


H = ∫dσ (∂_t X) + (∂_σ X)
[L_n, a_m] = m a_{n+m}
[L_n, ∂_s X(s)] = ∂_s (e^{ns} ∂_s X)
[X(σ,0), i∂_τ X(σ',0)] = 4πi δ(σ−σ')
<0| ∂_s X(s) ∂_{s'} X(s') |0>
<0| T_{ss} |0>
CAUTION