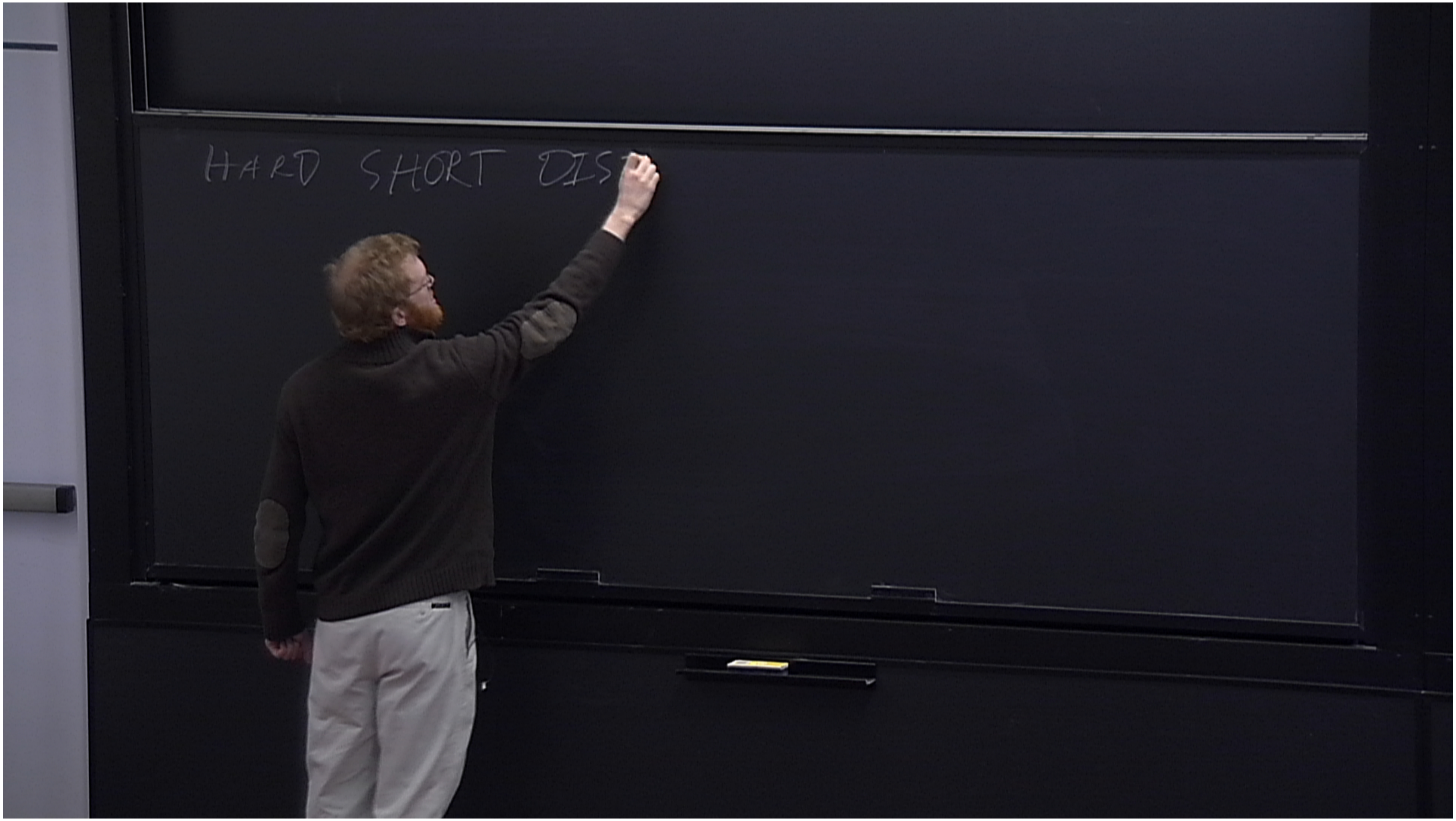
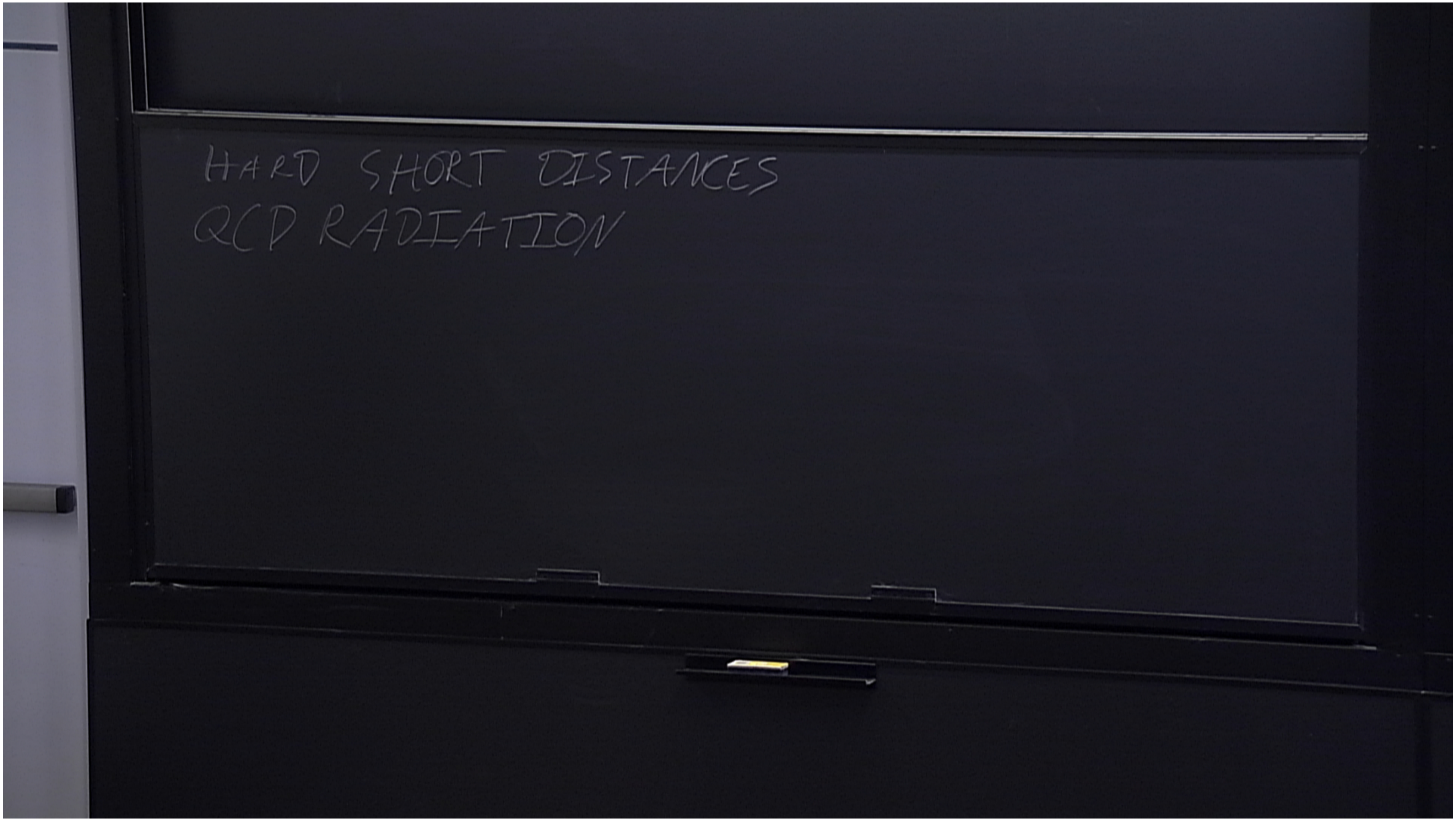
Title: A Systematic Approach to Rapidity Divergences

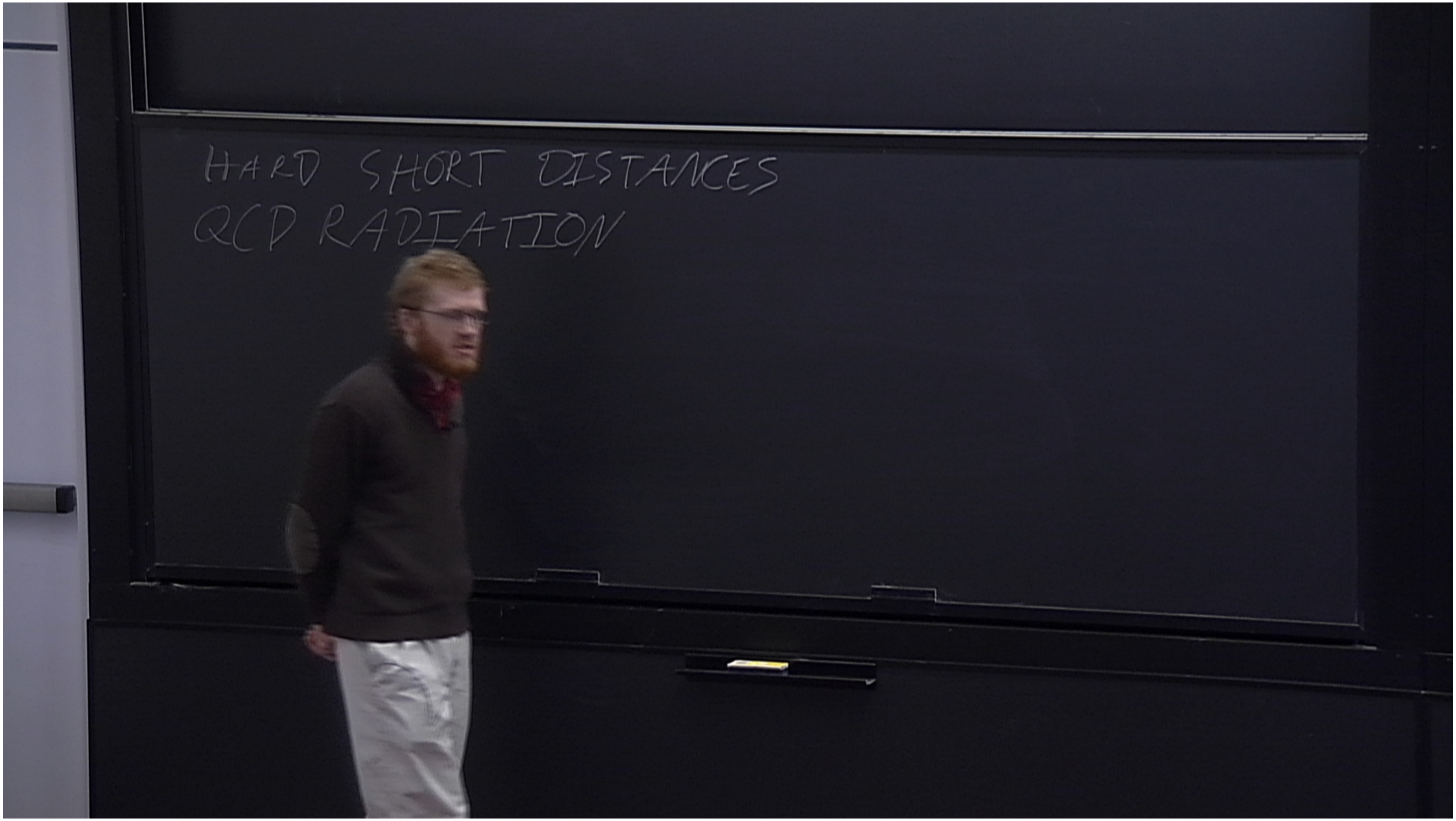
Date: Dec 08, 2011 10:00 AM

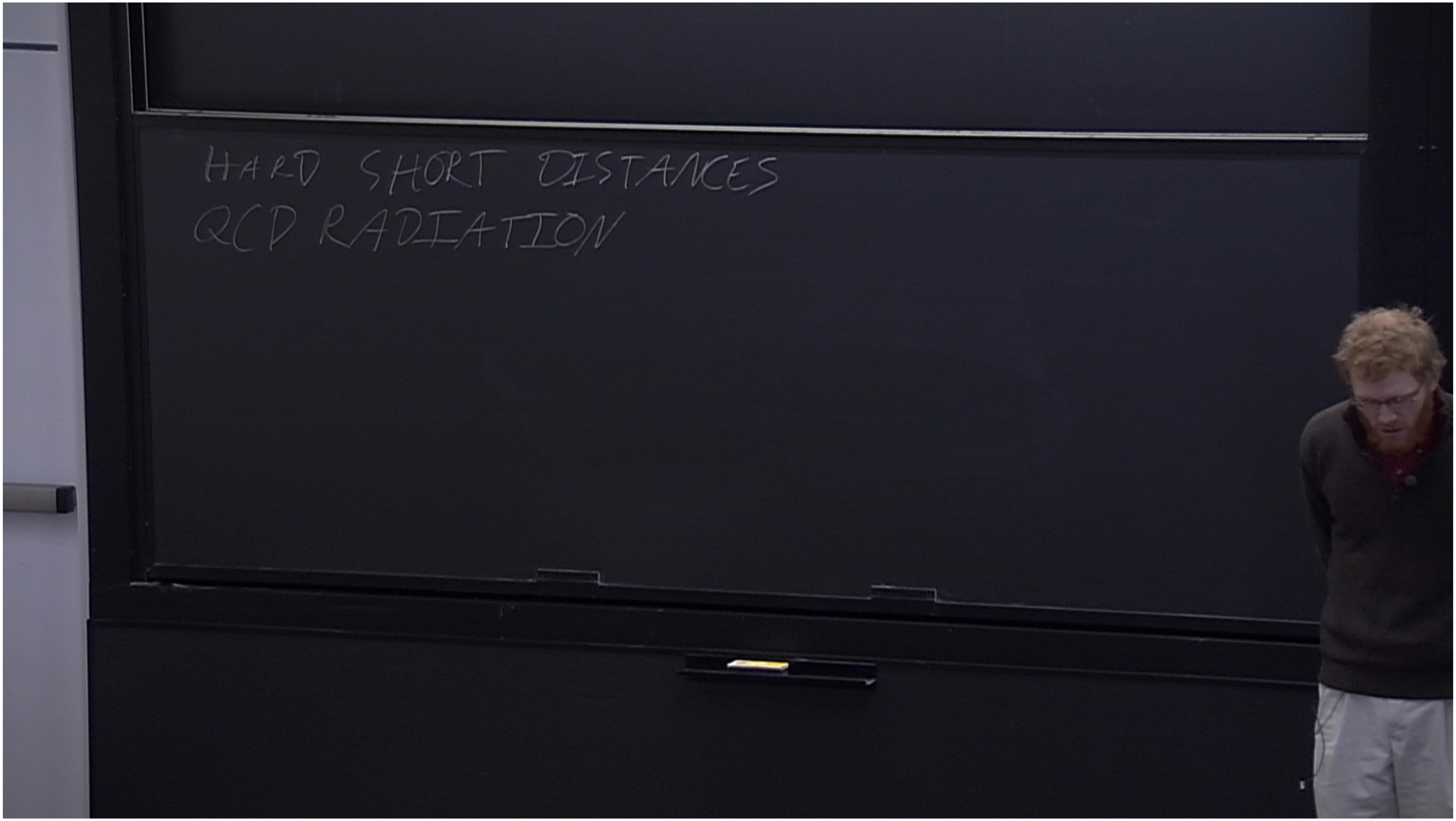
URL: http://pirsa.org/11120061

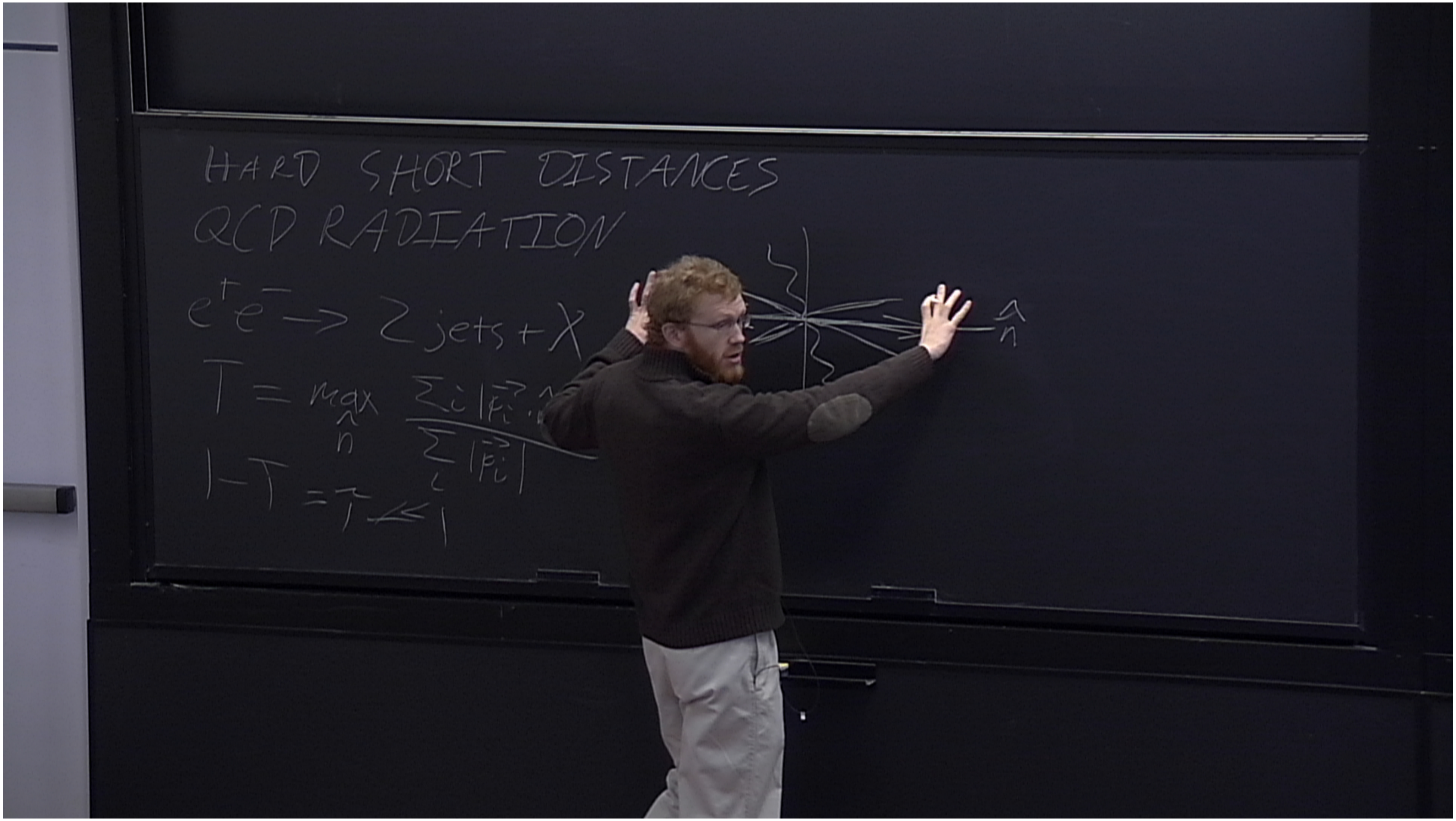
Abstract: I will discuss how to construct a consistent effective field theory when the differing modes of the theory have the same invariant mass scale. I will sketch some phenomenological applications of the formalism relevant for the LHC.


HARD SHORT DIS

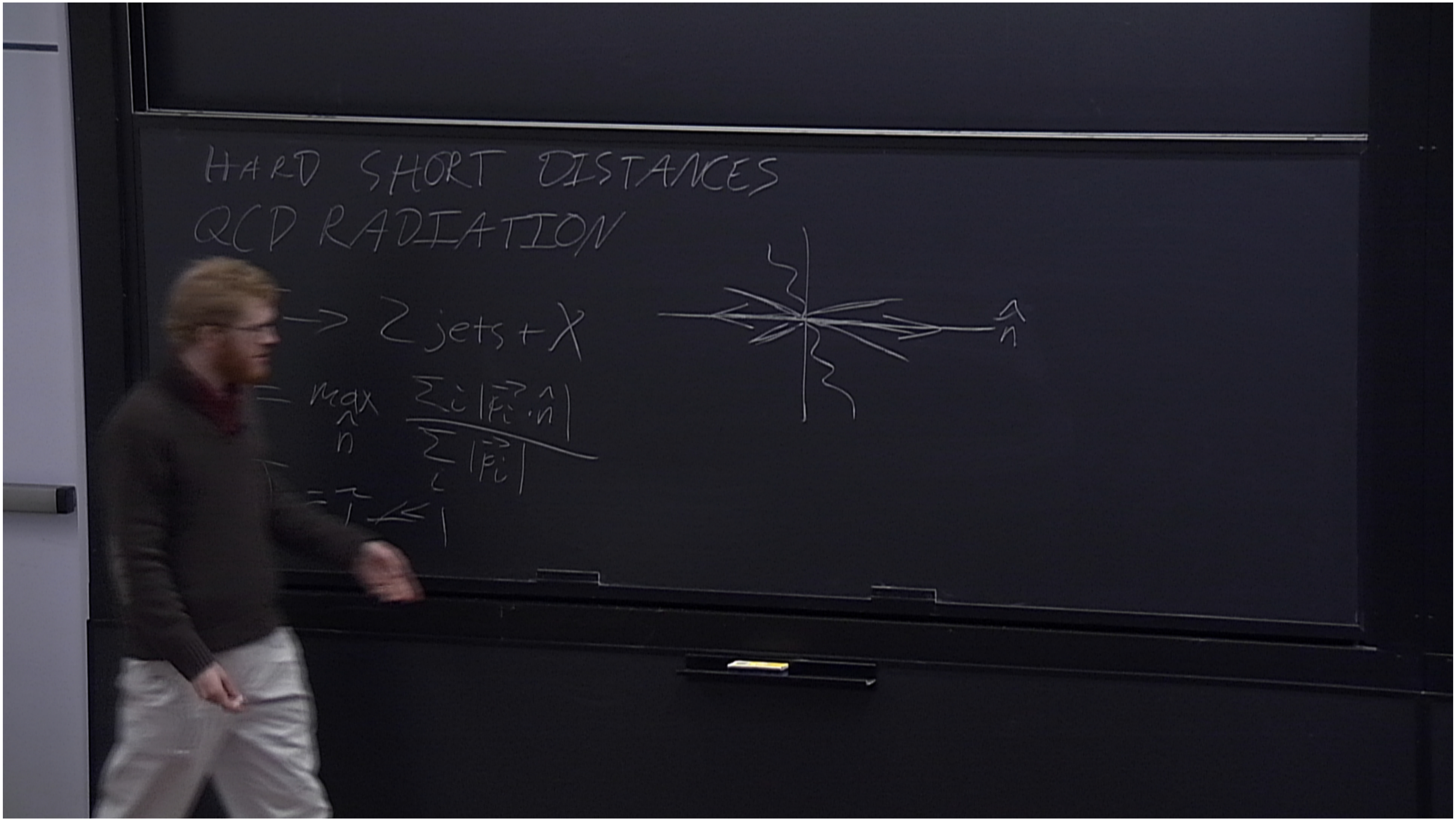

HARD SHORT DISTANCES
QCD RADIATION

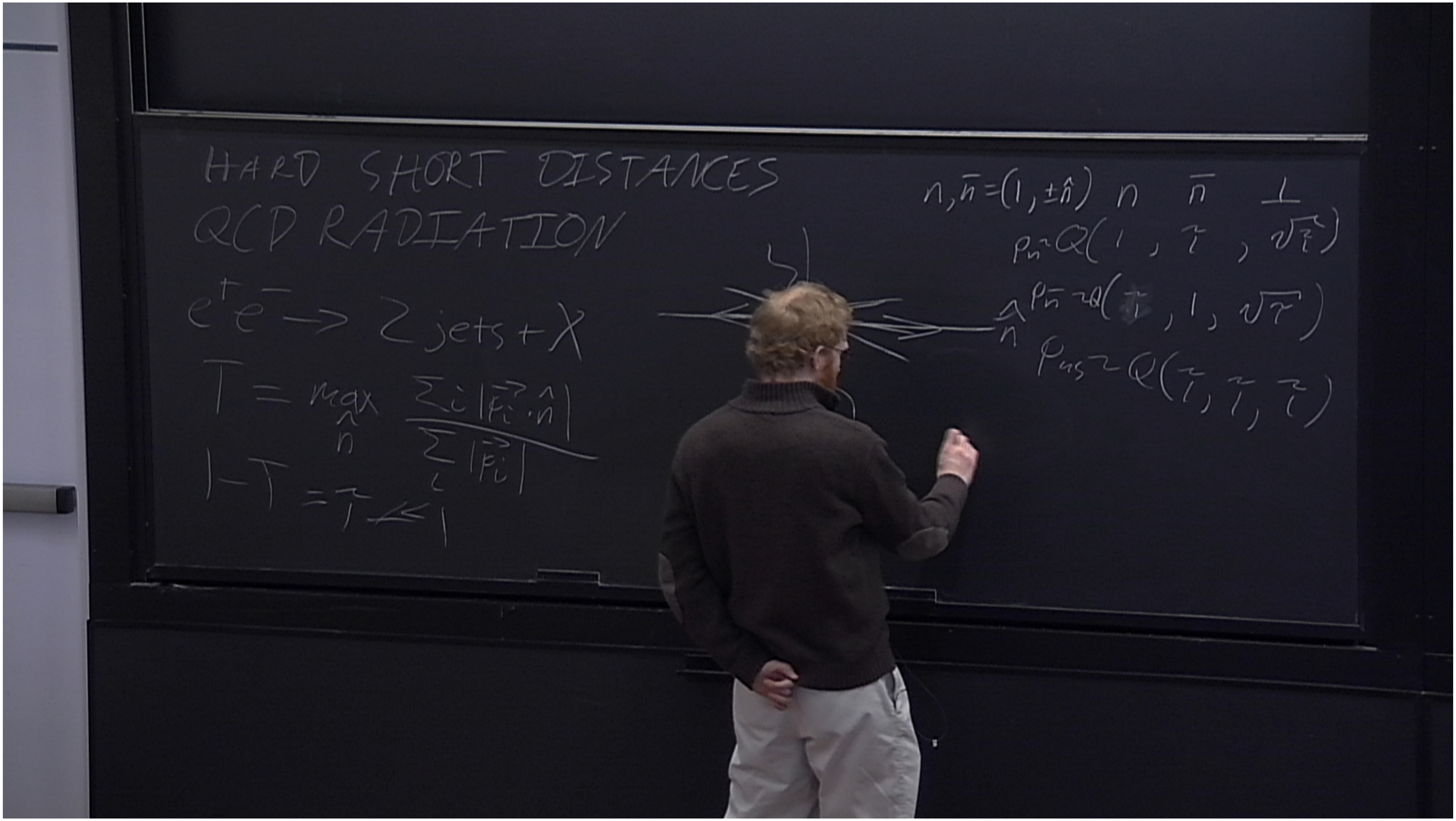

HARD SHORT DISTANCES
QCD RADIATION

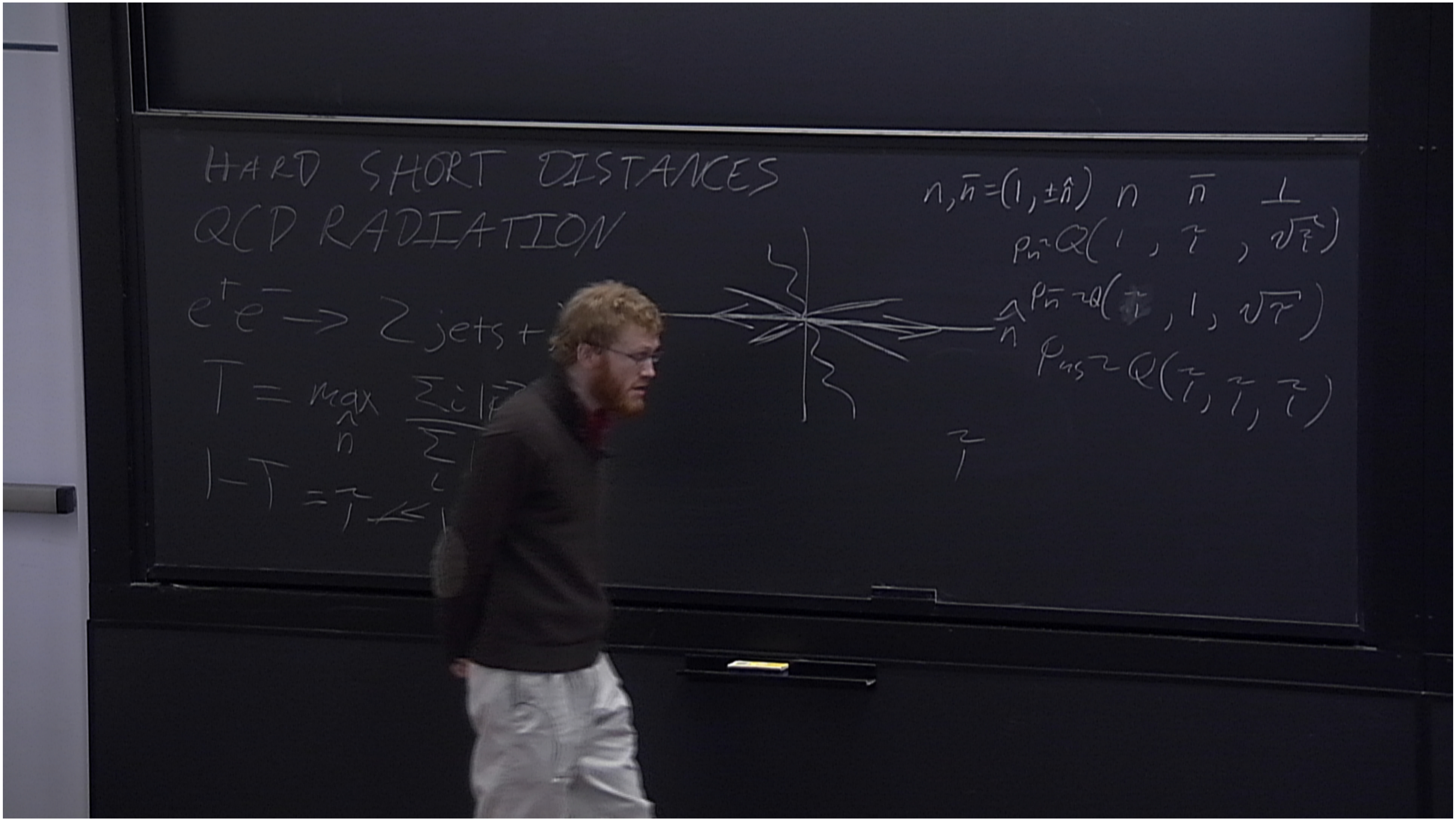

HARD SHORT DISTANCES
QCD RADIATION

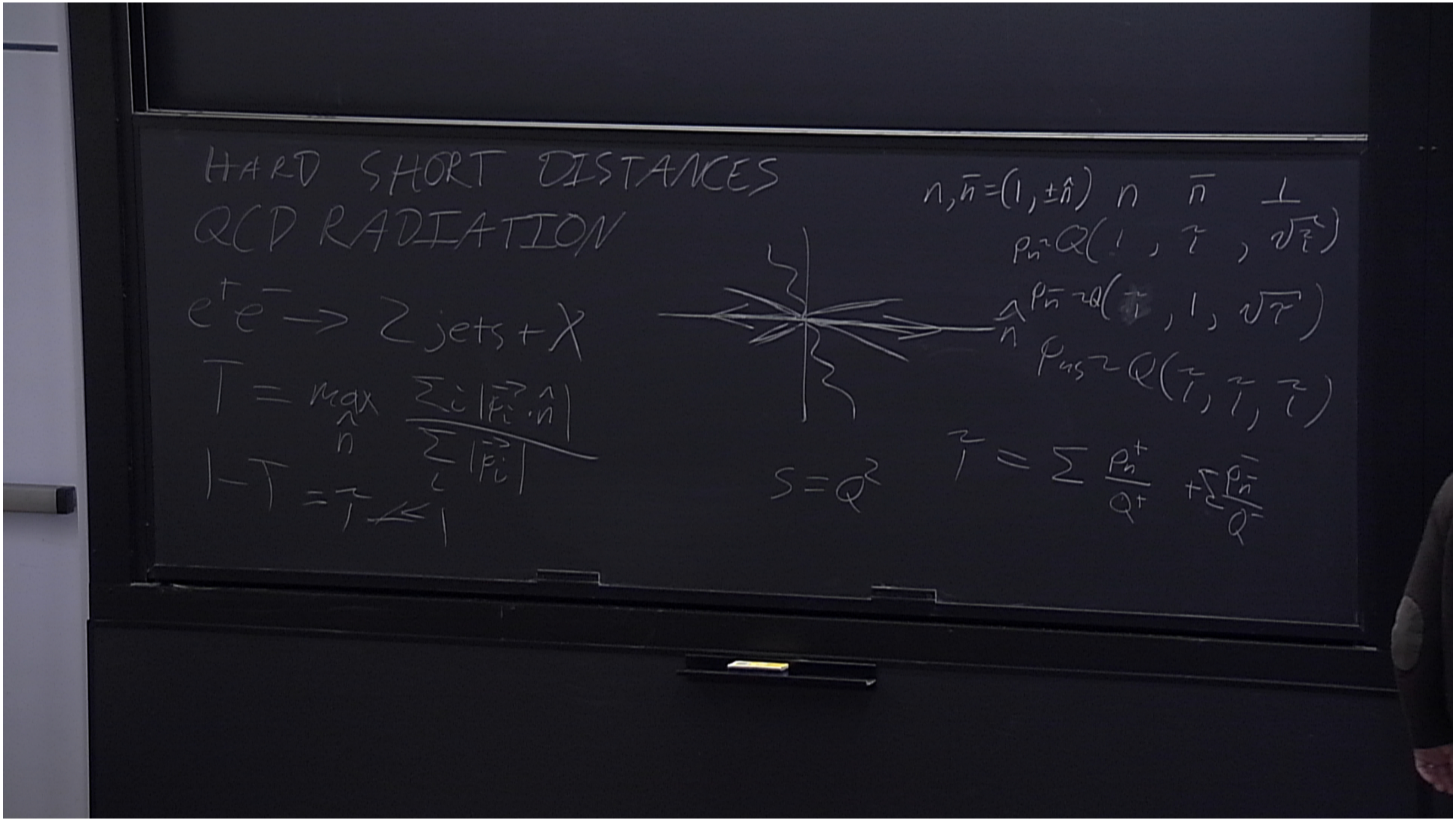


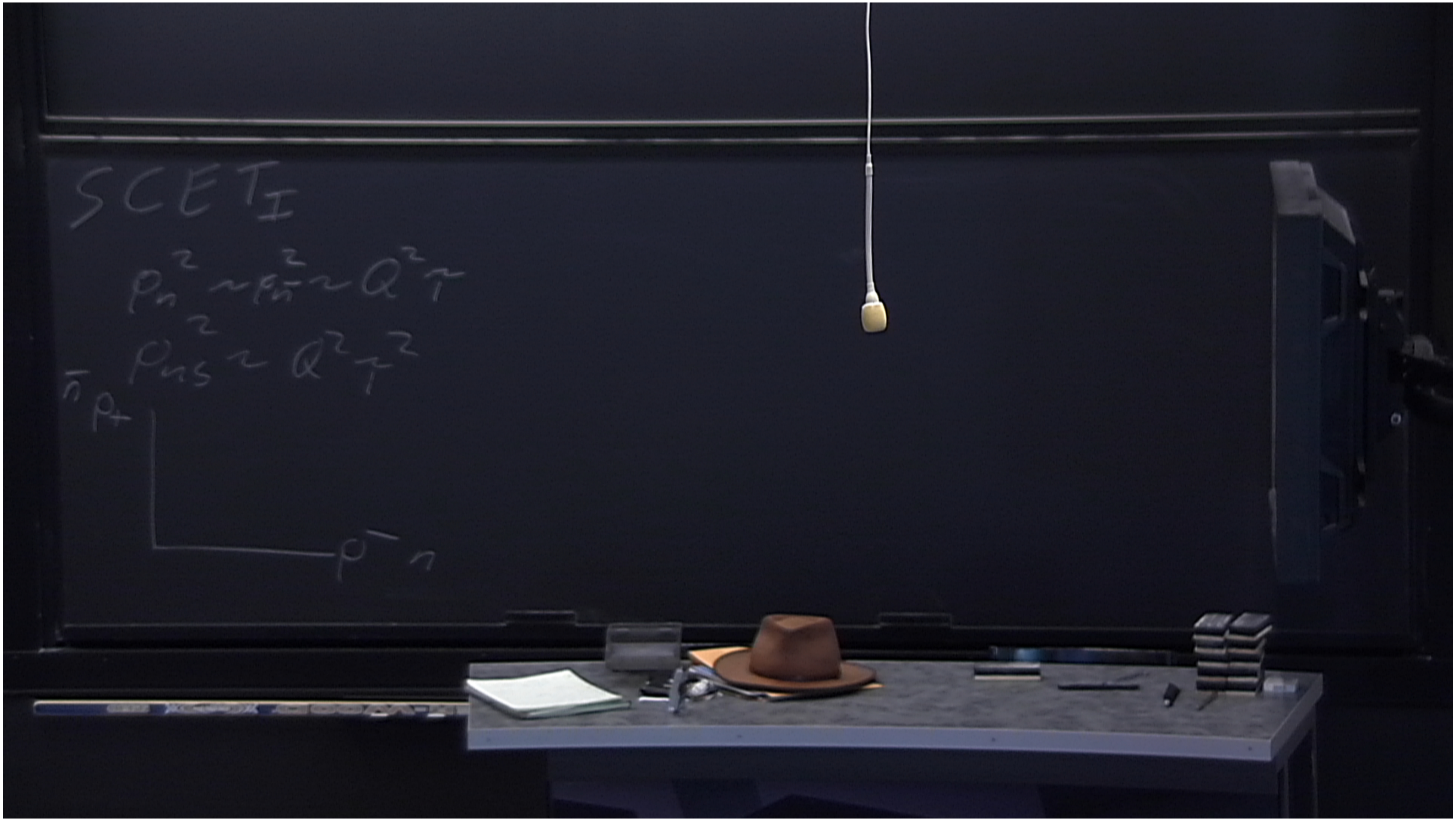
HARD SHORT DISTANCES
QCD RADIATION
e+e- → 2 jets + X
T = max Σi |pi · n| / Σi |pi|
n
1 - T = τ << 1
n

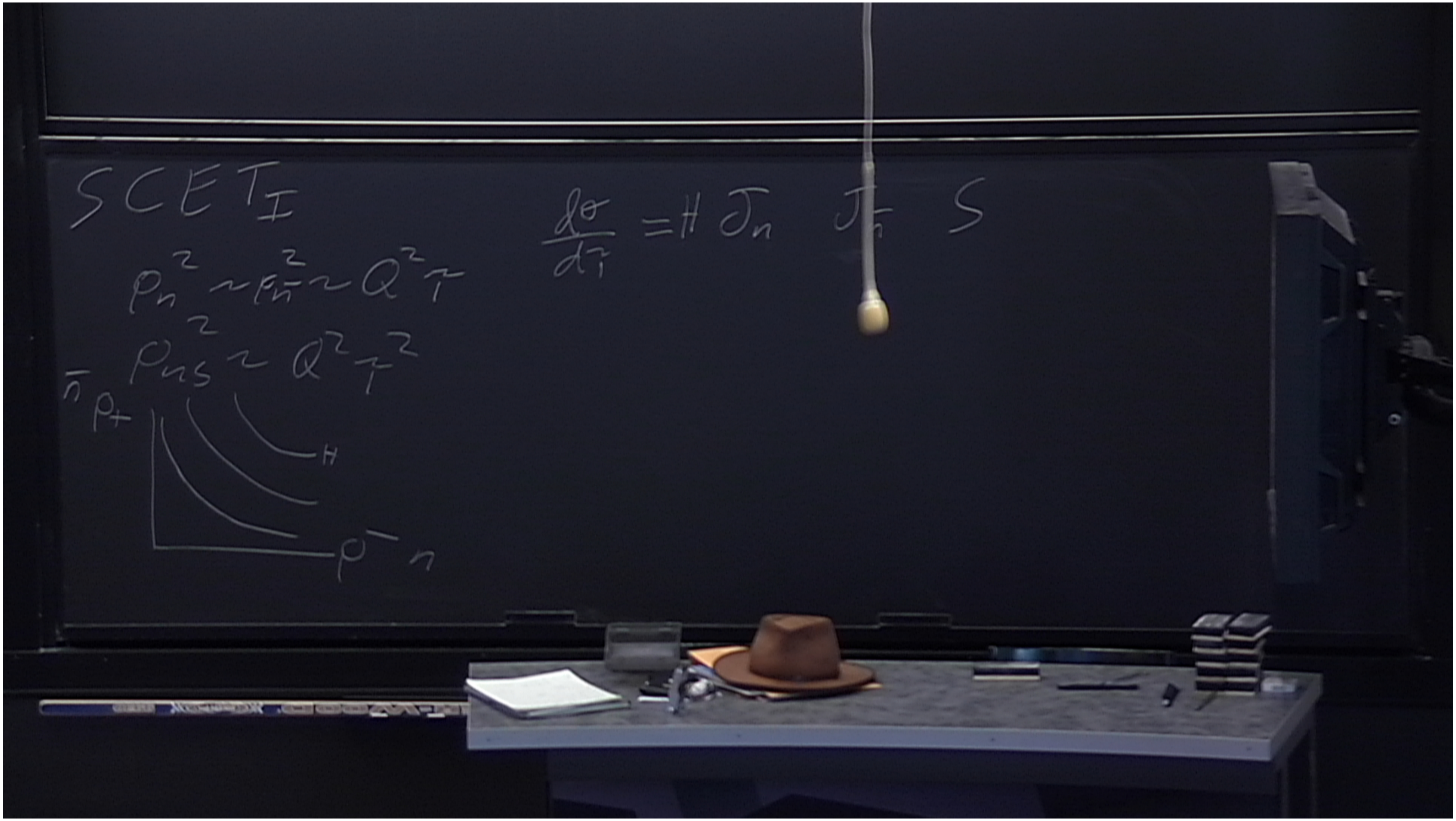

HARD SHORT DISTANCES
QCD RADIATION
Σ jets + X
max

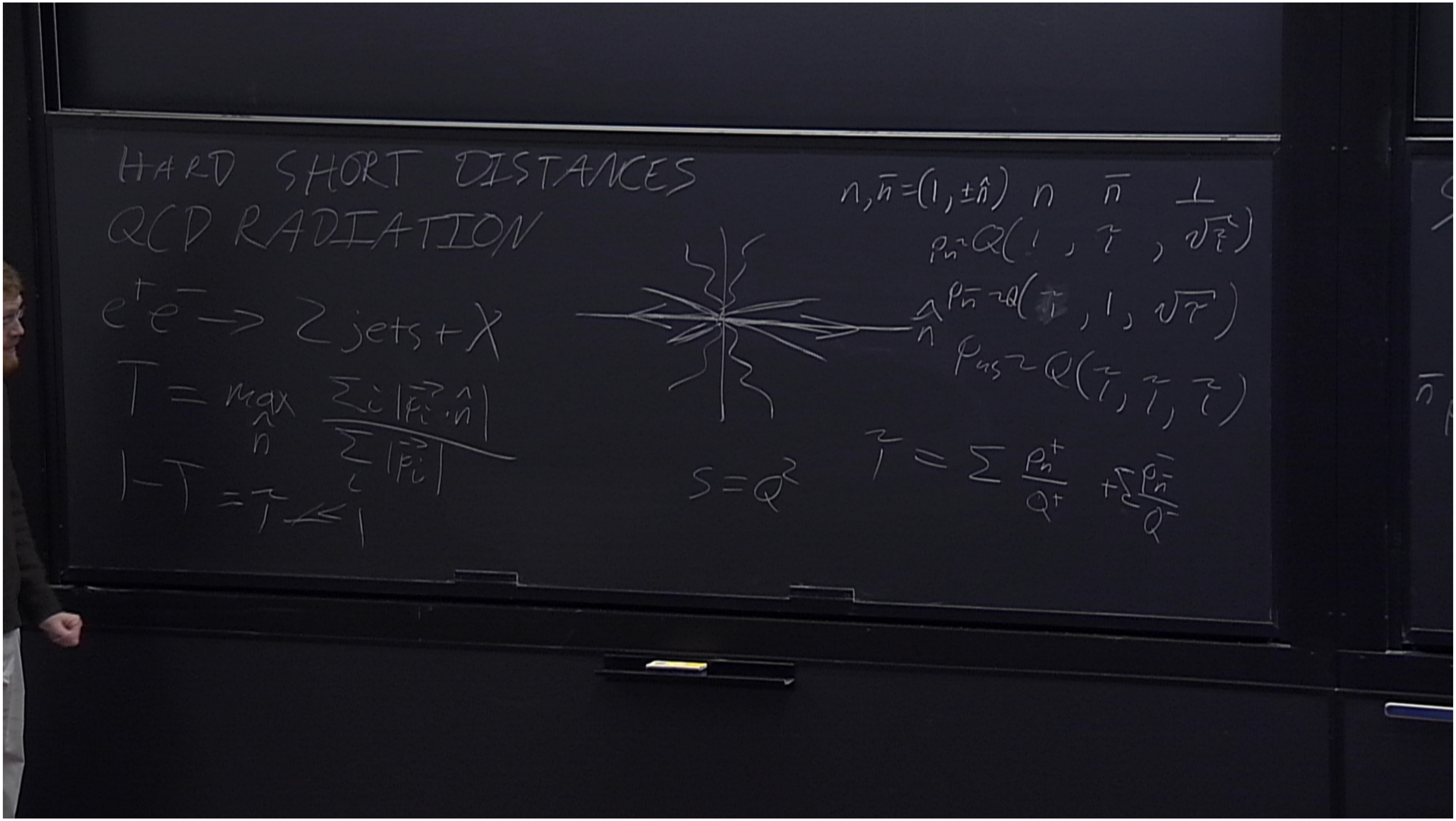

HARD SHORT DISTANCES
QCD RADIATION
e+e− → 2 jets + X
T = max_n̂ Σi |p⃗i · n̂| / Σi |p⃗i|
1 − T = τ ≪ 1
n, n̄ = (1, ±n̂) n n̄ ⊥
pn ~ Q(1 , τ , √τ)
pn̄ ~ Q(τ , 1 , √τ)
pus ~ Q(τ , τ , τ)

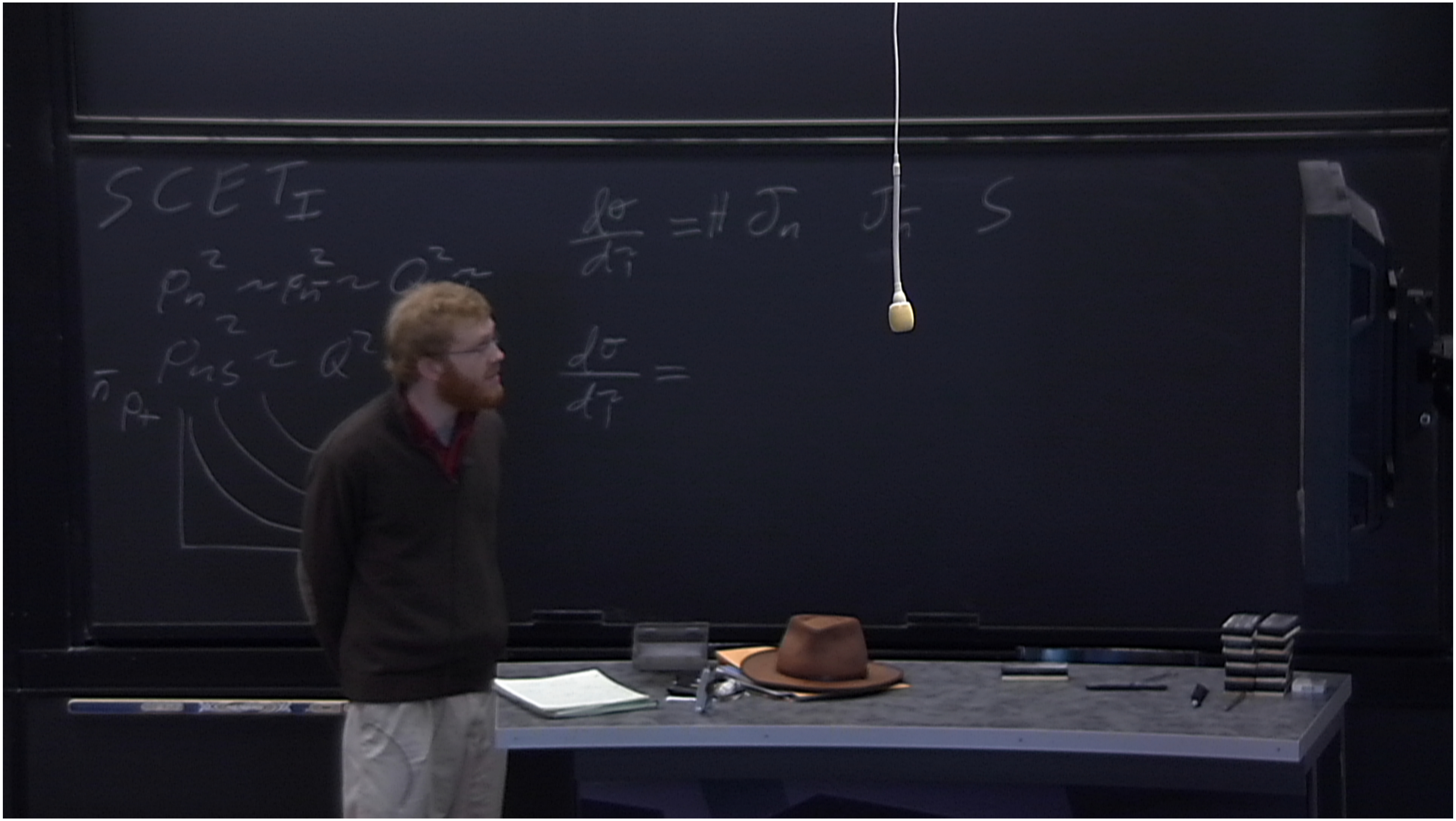

HARD SHORT DISTANCES
QCD RADIATION

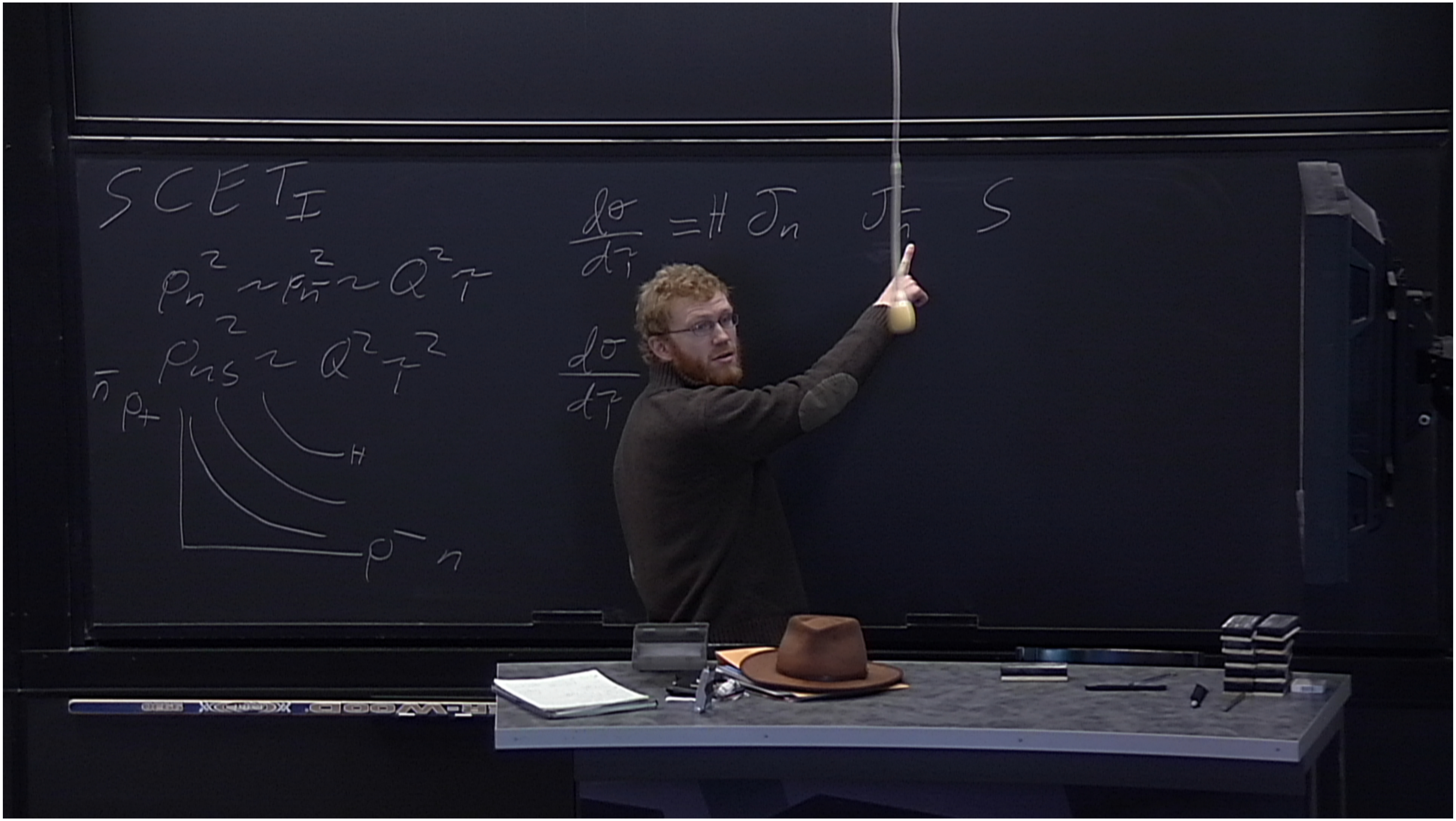

HARD SHORT DISTANCES
QCD RADIATION
e+e- → 2 jets + X
T = max_n̂ Σi |p⃗i · n̂| / Σi |p⃗i|
1 − T = τ ≪ 1
s = Q²
n, n̄ = (1, ±n̂)   n   n̄   ⊥
pn ~ Q(1, τ, √τ)
pn̄ ~ Q(τ, 1, √τ)
pus ~ Q(τ, τ, τ)
τ = Σ pn+/Q+ + Σ pn̄−/Q−

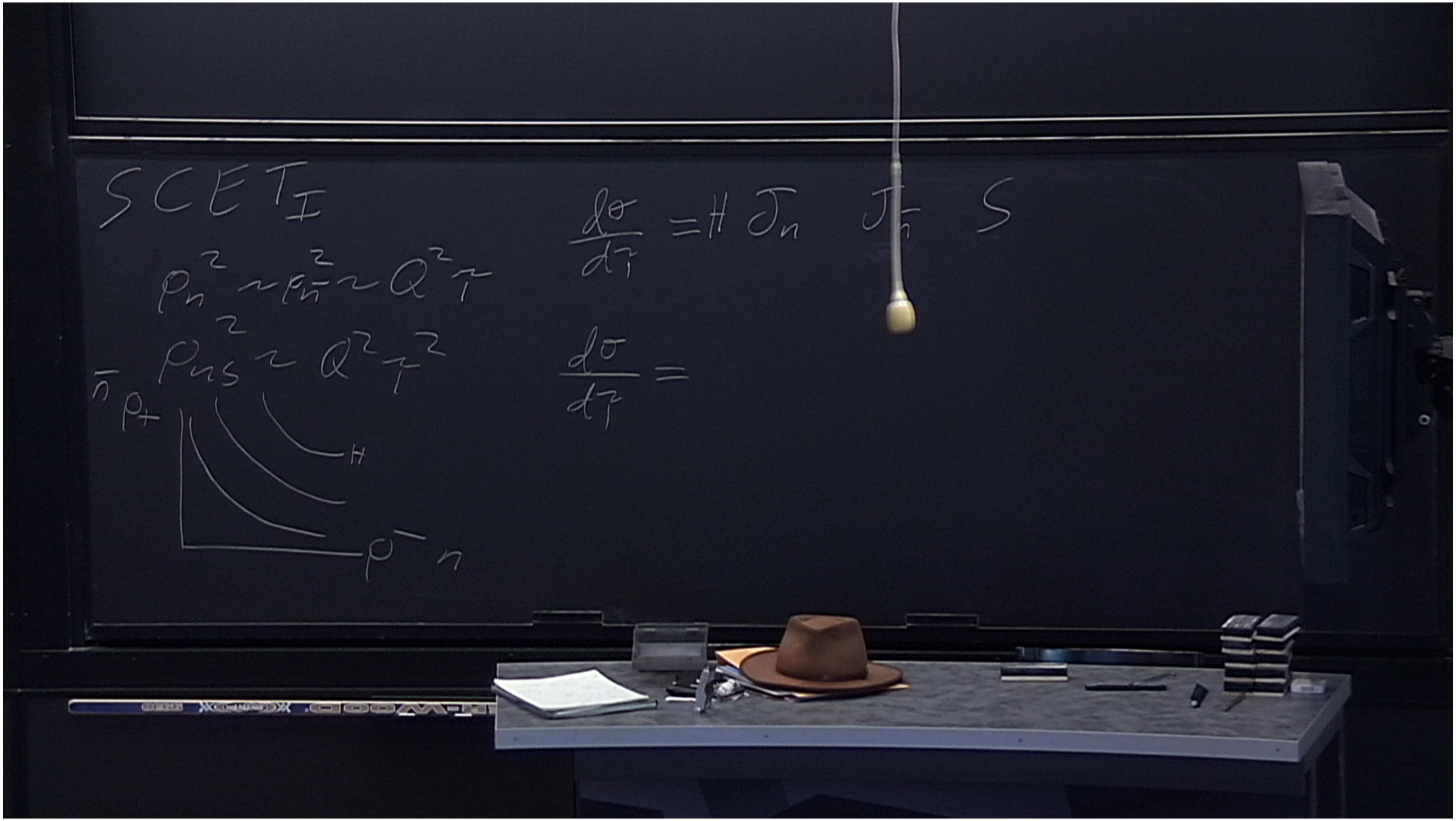

SCET_I
p_n^2 ~ p_n̄^2 ~ Q^2 λ^2
p_us^2 ~ Q^2 λ^2

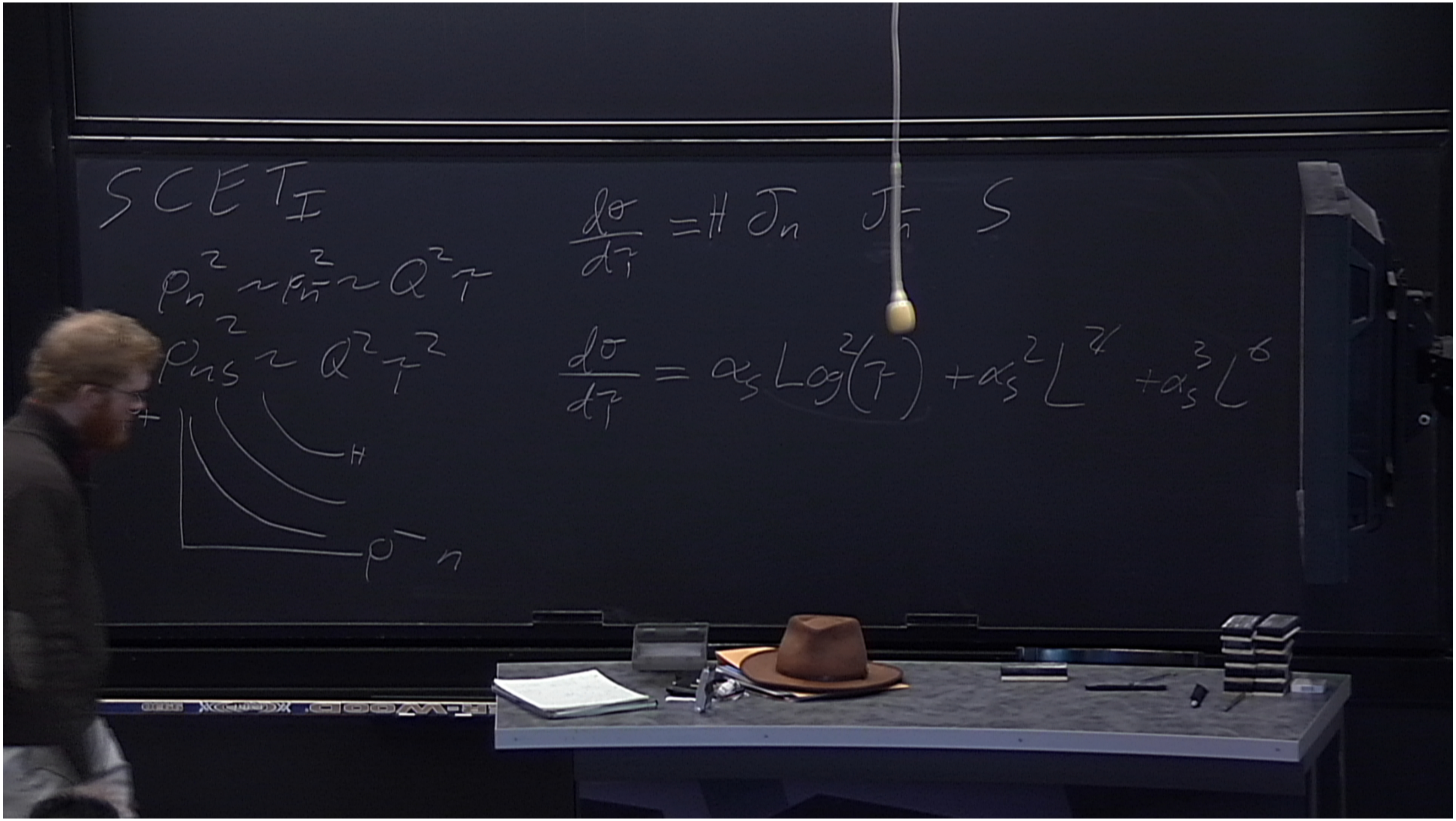

SCET_I
p_n^2 ~ p_n̄^2 ~ Q^2 τ
p_us^2 ~ Q^2 τ^2
dσ/dτ = H J_n J_n̄ S

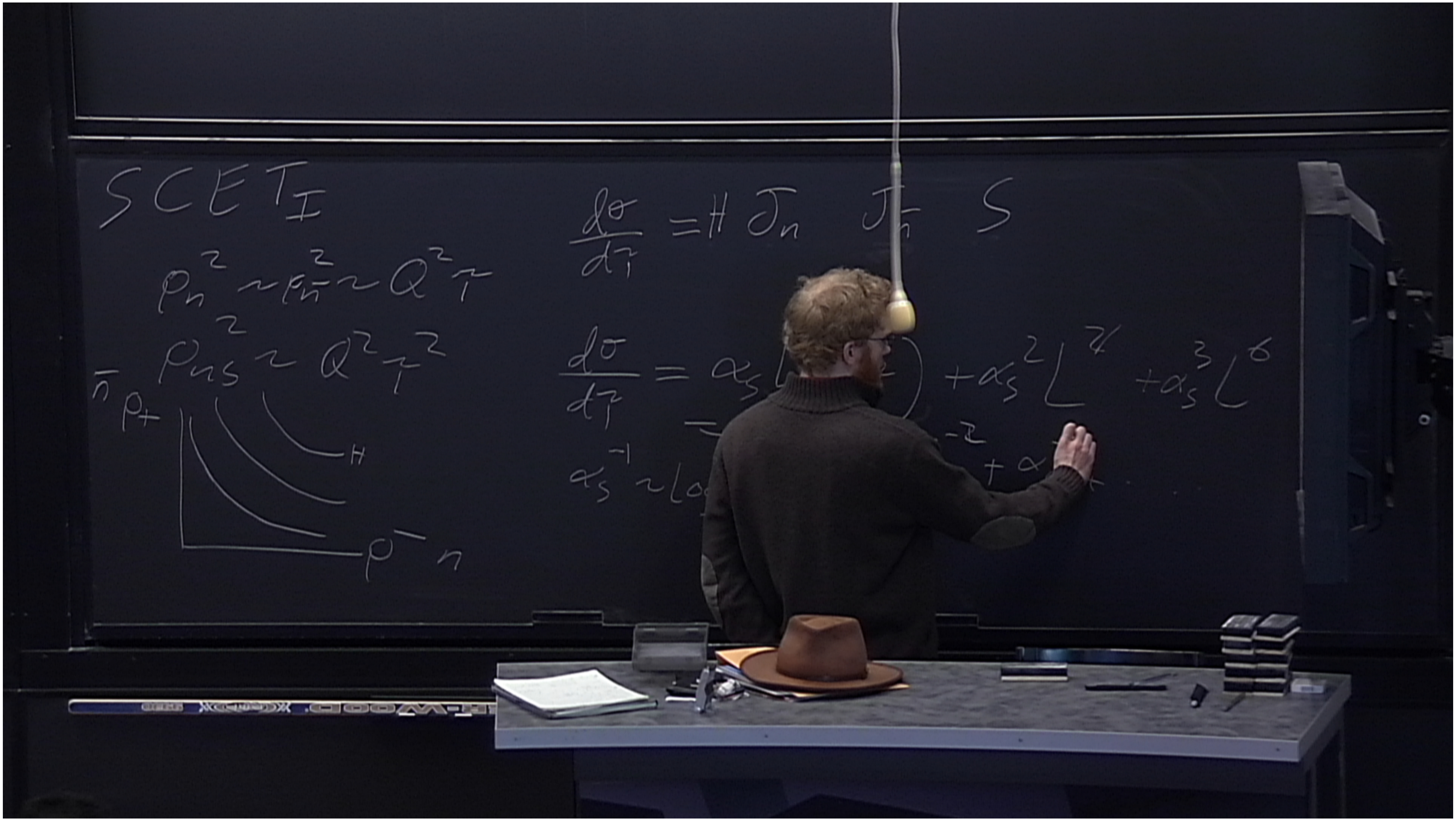

HARD SHORT DISTANCES
QCD RADIATION
e+e- → 2 jets + X
T = max Σ_i |p_i · n̂| / Σ_i |p_i|
1 − T = τ ≪ 1
s = Q²
n, n̄ = (1, ±n̂)   n   n̄   ⊥
p_n ~ Q(1, τ, √τ)
p_n̄ ~ Q(τ, 1, √τ)
p_us ~ Q(τ, τ, τ)
τ = Σ p_n⁺/Q⁺ + Σ p_n̄⁻/Q⁻

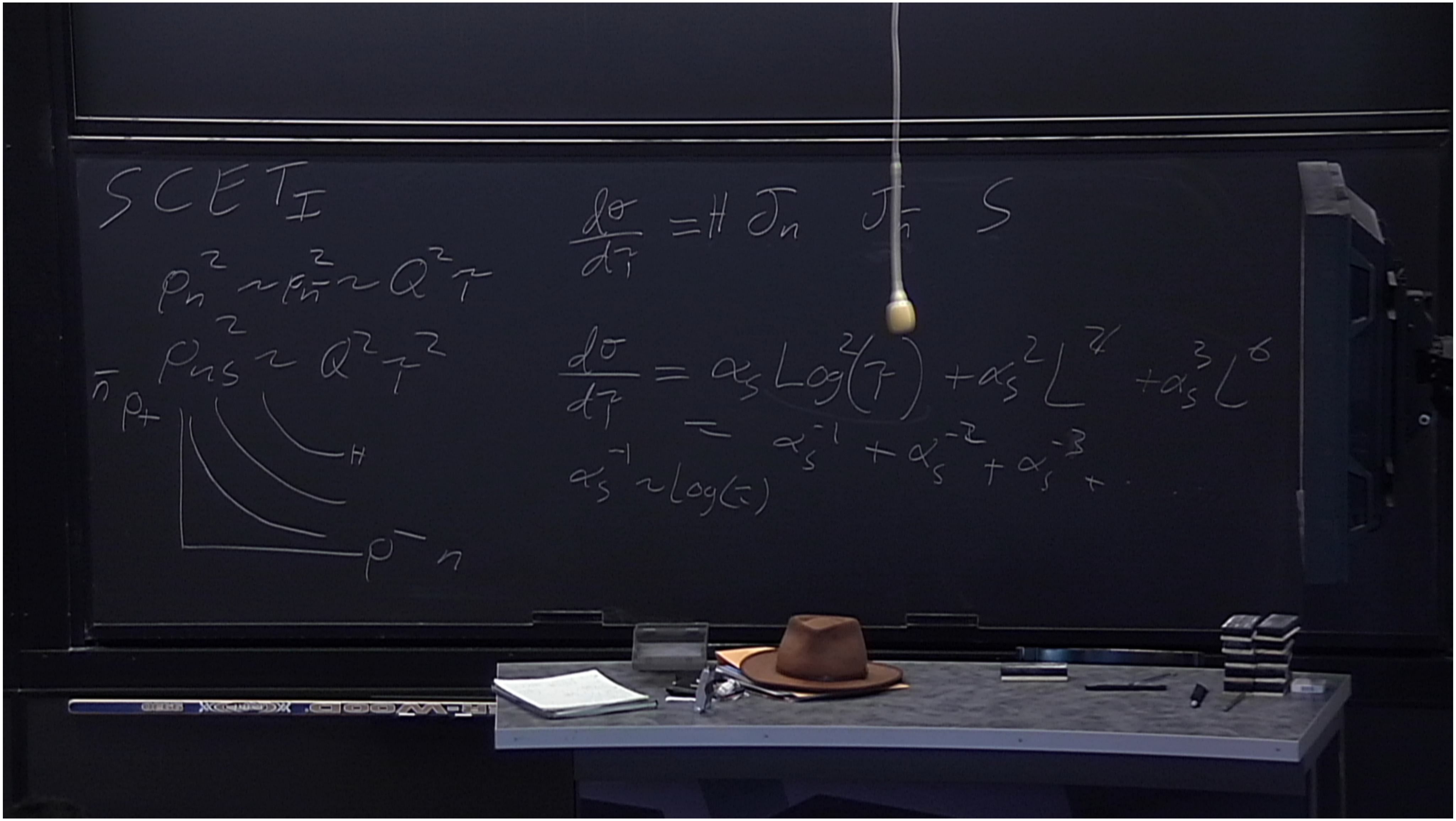


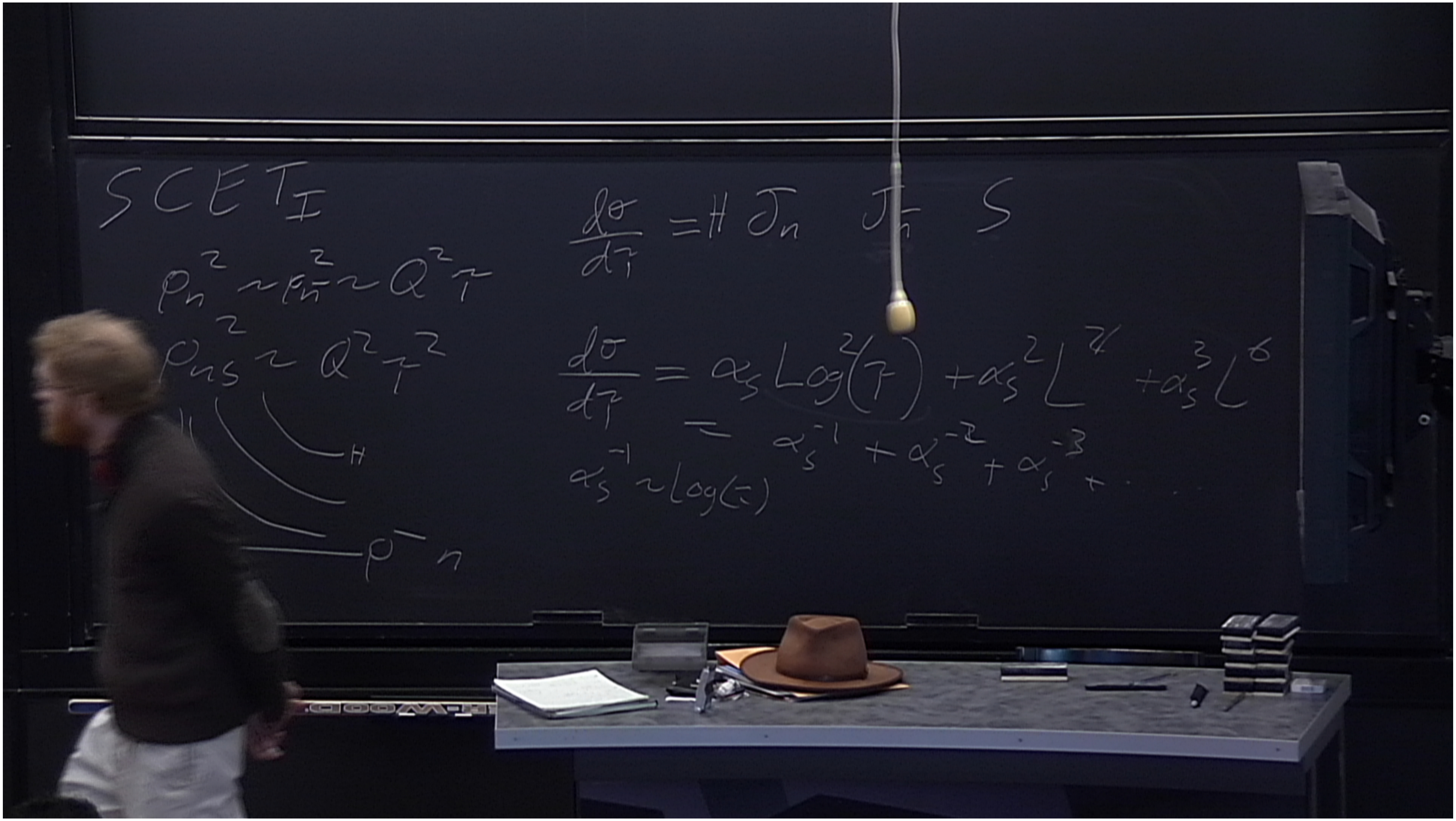

SCET I
H
S

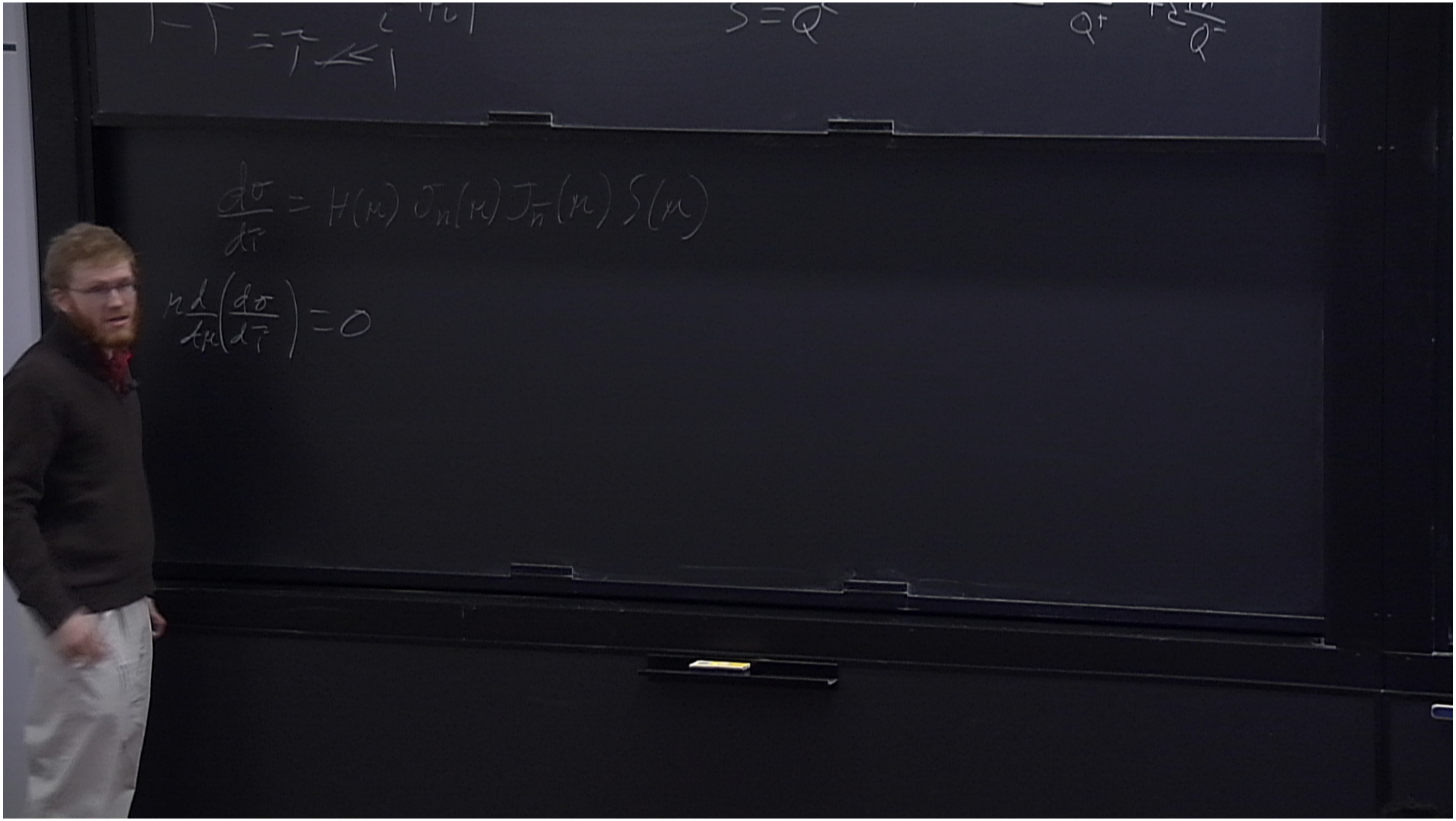

SCET I
dσ/dτ = H J n J n̄ S
p n 2 ~ p n̄ 2 ~ Q 2 τ
p us 2 ~ Q 2 τ 2
dσ/dτ =
n̄ p+
H
p- n

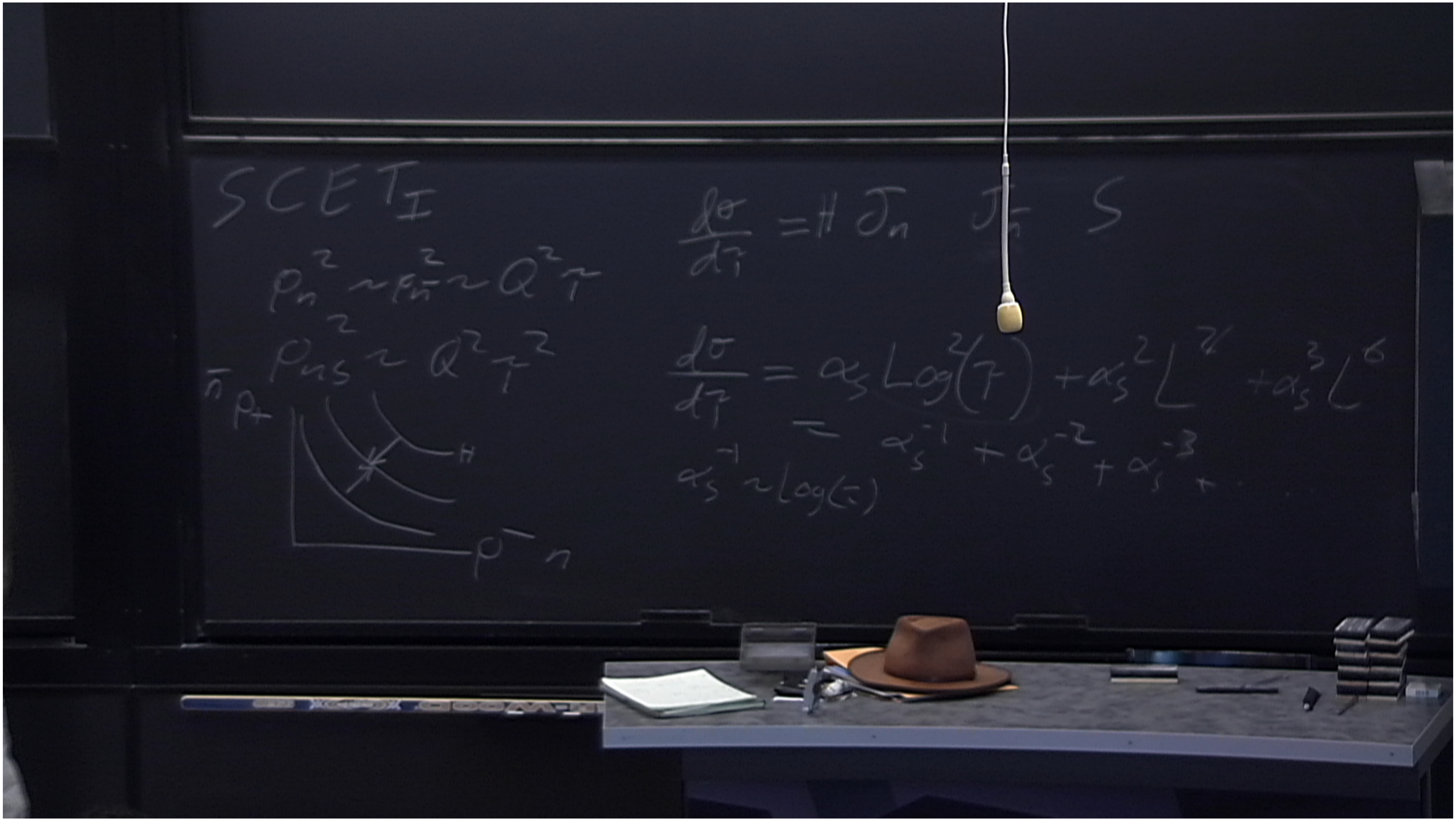

SCET I
dσ/dτ = H J_n J_n̄ S
p_n^2 ~ p_n̄^2 ~ Q^2 τ
p_us^2 ~ Q^2 τ^2
dσ/dτ = α_s Log^2(τ) + α_s^2 L^4 + α_s^3 L^6

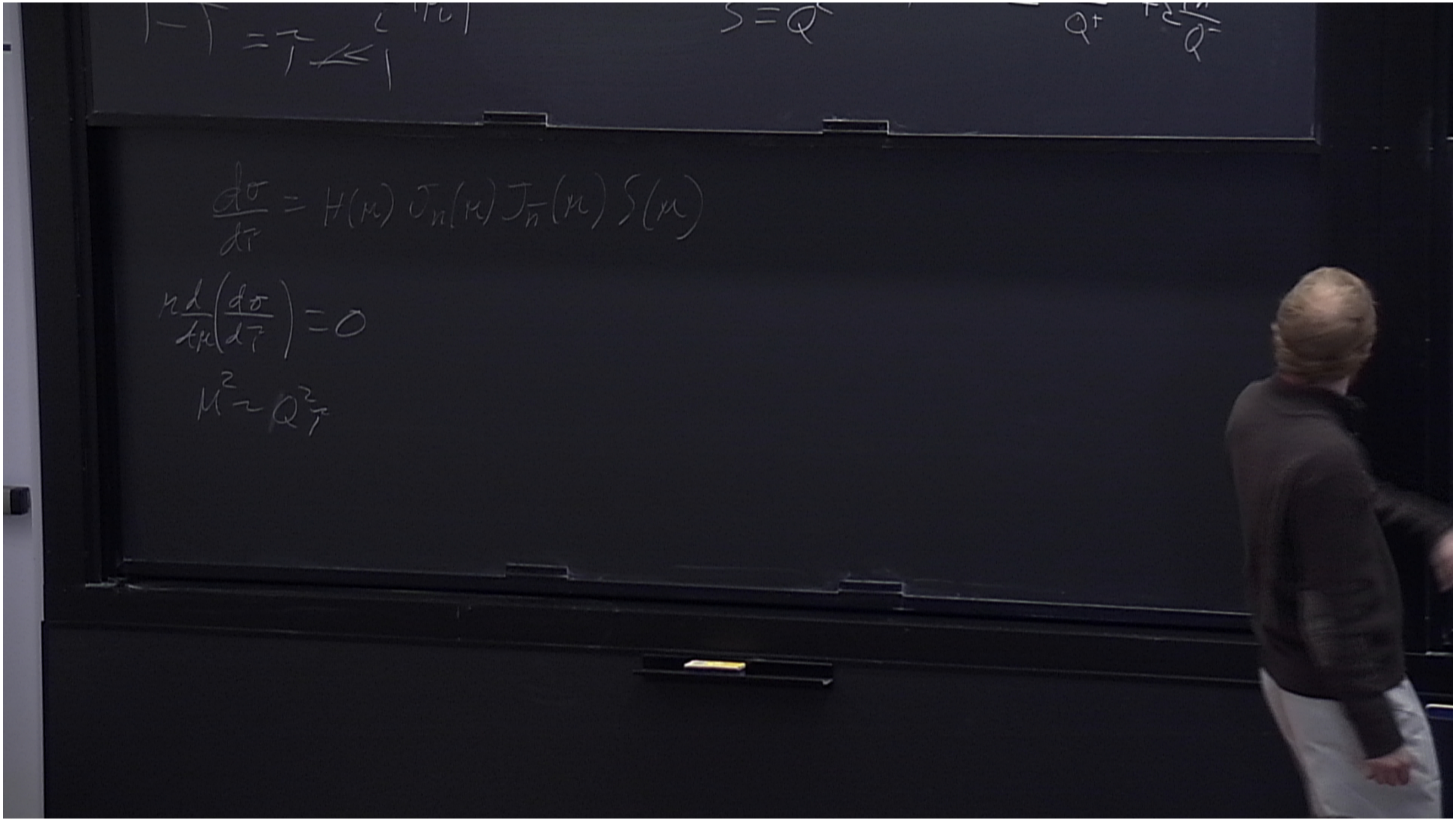

SCET I

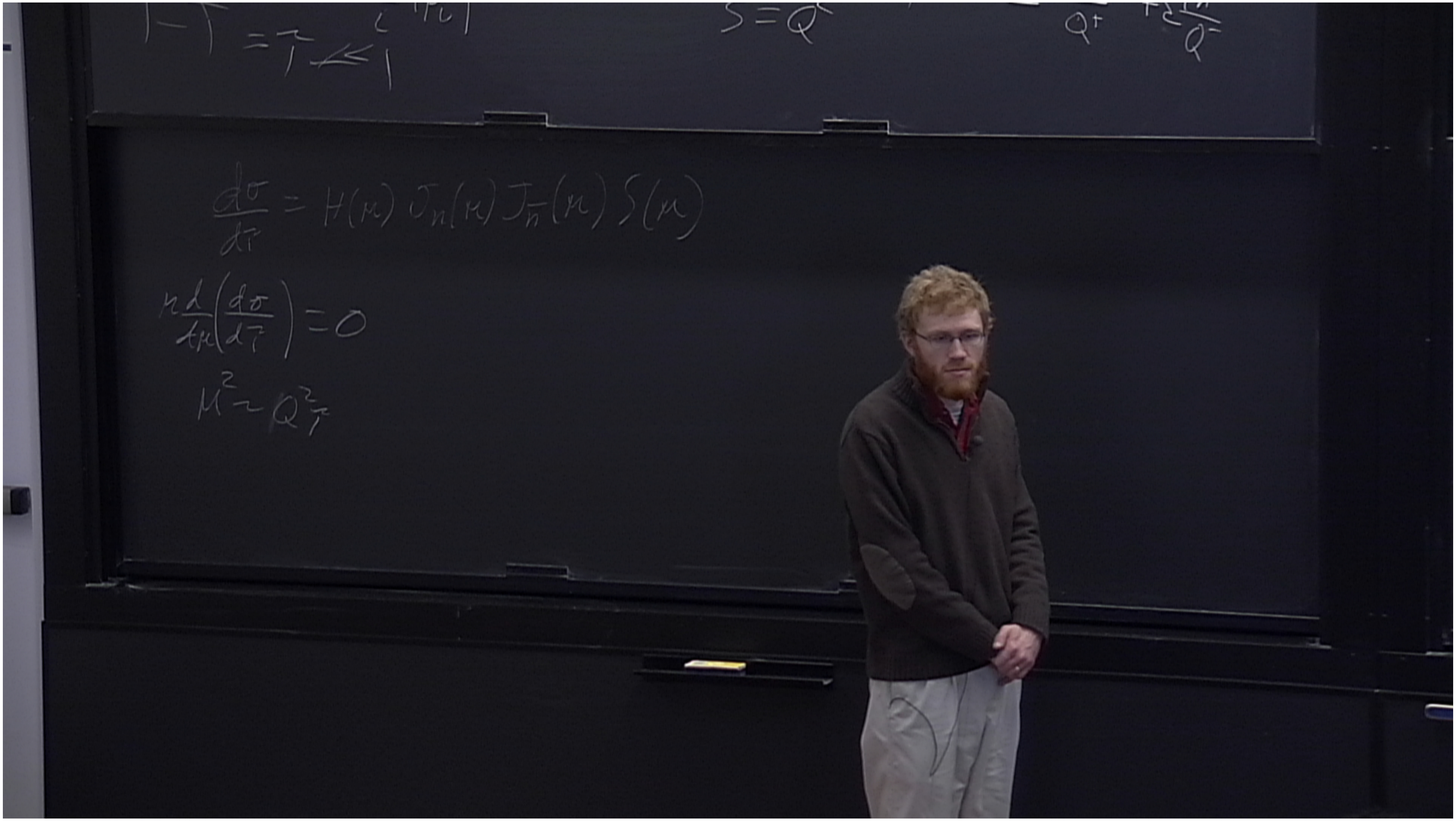

SCET_I
dσ/dτ = H J_n J_n̄ S
p_n^2 ~ p_n̄^2 ~ Q^2 τ
p_us^2 ~ Q^2 τ^2
n̄ p_+
H
p^- n
dσ/dτ = α_s Log^2(τ) + α_s^2 L^4 + α_s^3 L^6
= α_s^-1 + α_s^-2 + α_s^-3 + ...
α_s^-1 ~ Log(τ)


SCET_I
dσ/dτ = H J_n J_n̄ S
dσ/dτ = α_s Log²(τ) + α_s² L⁴ + α_s³ L⁶
= α_s⁻¹ + α_s⁻² + α_s⁻³ + ...
α_s⁻¹ ~ Log(τ)

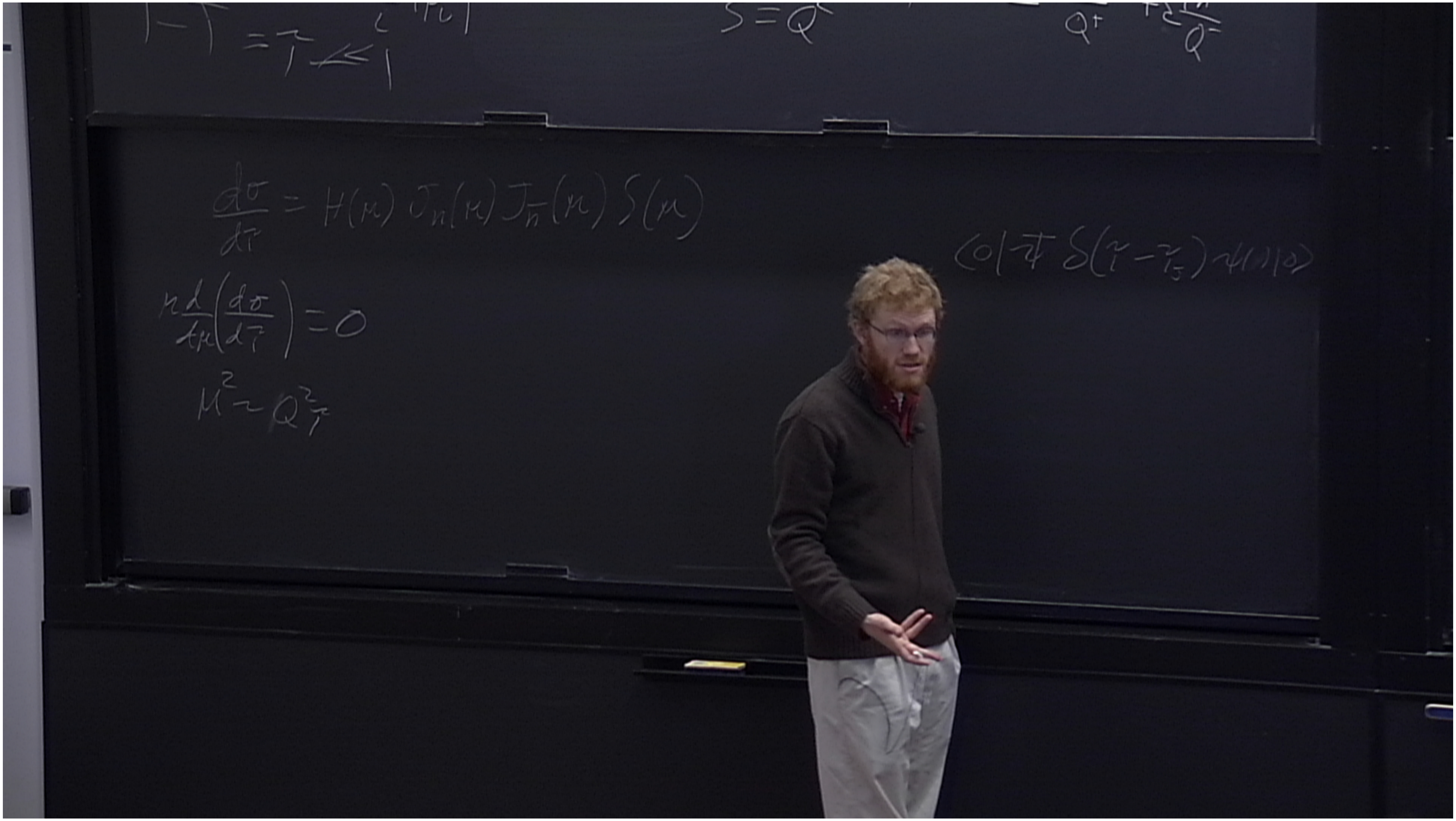

dσ/dτ = H(μ) J_n(μ) J_n̄(μ) S(μ)
μ d/dμ (dσ/dτ) = 0

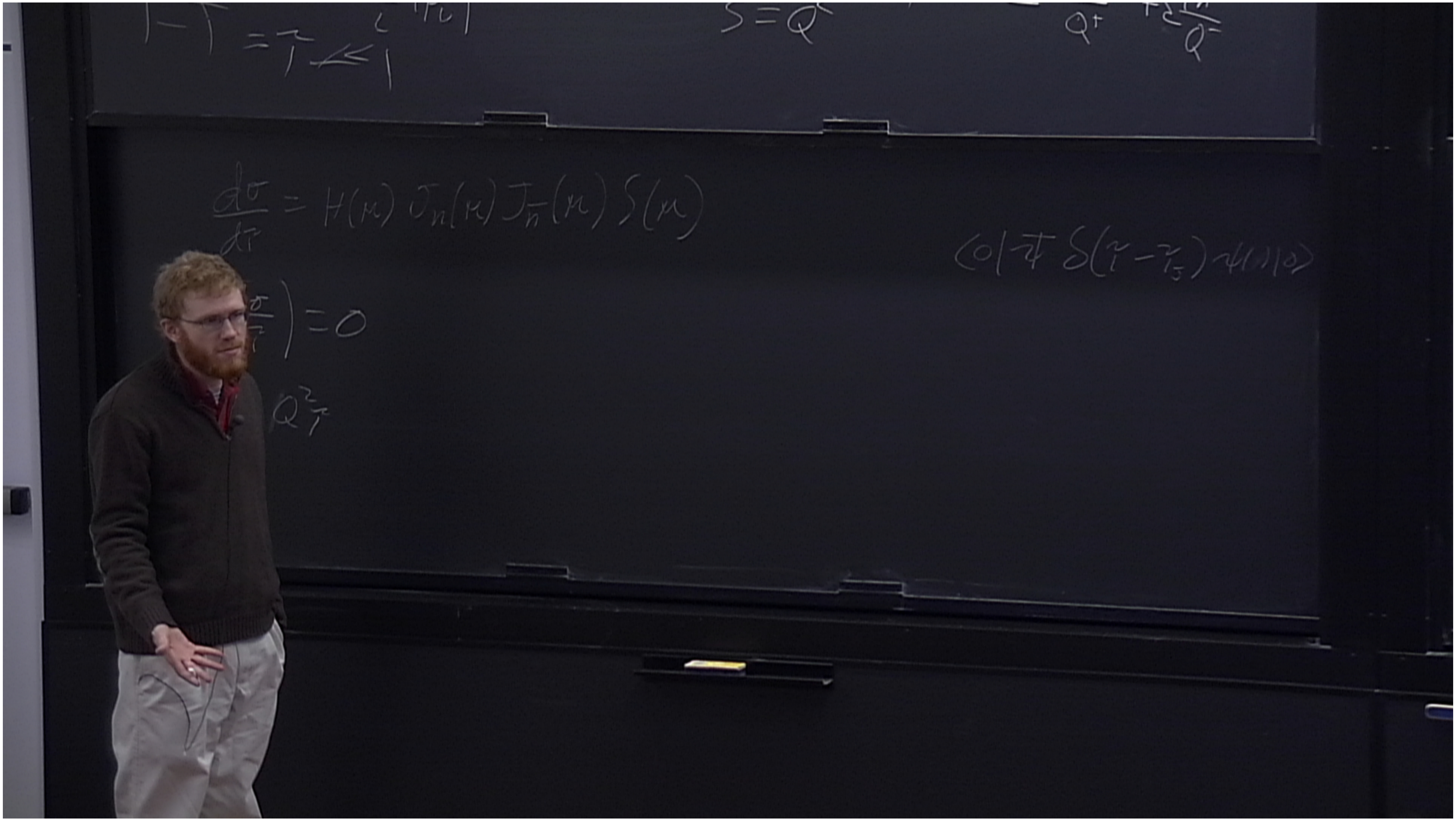

SCET I
dσ/dτ = H J_n J_n̄ S
p_n² ~ p_n̄² ~ Q² τ
p_us² ~ Q² τ²
dσ/dτ = α_s Log²(τ) + α_s² L⁴ + α_s³ L⁶
= α_s⁻¹ + α_s⁻² + α_s⁻³ + ...
α_s⁻¹ ~ Log(τ)


$\frac{d\sigma}{d\tau} = H(\mu) J_n(\mu) J_{\bar{n}}(\mu) S(\mu)$
$\mu \frac{d}{d\mu}\left(\frac{d\sigma}{d\tau}\right) = 0$
$\mu^2 \sim Q^2 \tau$



dσ/dτ = H(μ) J_n(μ) J_n̄(μ) S(μ)
μ d/dμ (dσ/dτ) = 0
μ² ~ Q²τ

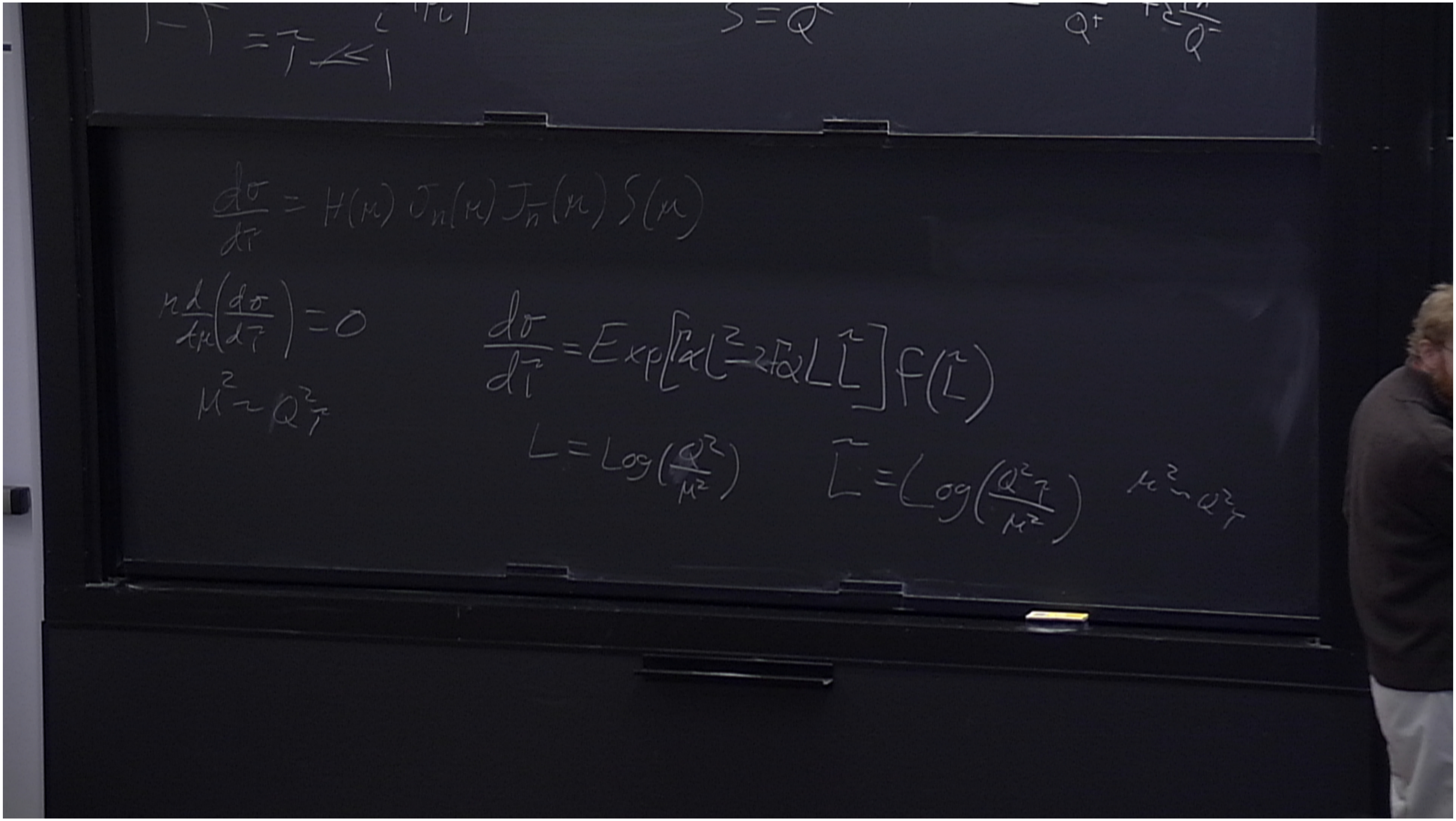

$\frac{d\sigma}{d\tau} = H(\mu) J_n(\mu) J_{\bar{n}}(\mu) S(\mu)$
$\mu \frac{d}{d\mu}\left(\frac{d\sigma}{d\tau}\right) = 0$
$\mu^2 \sim Q^2 \tau$

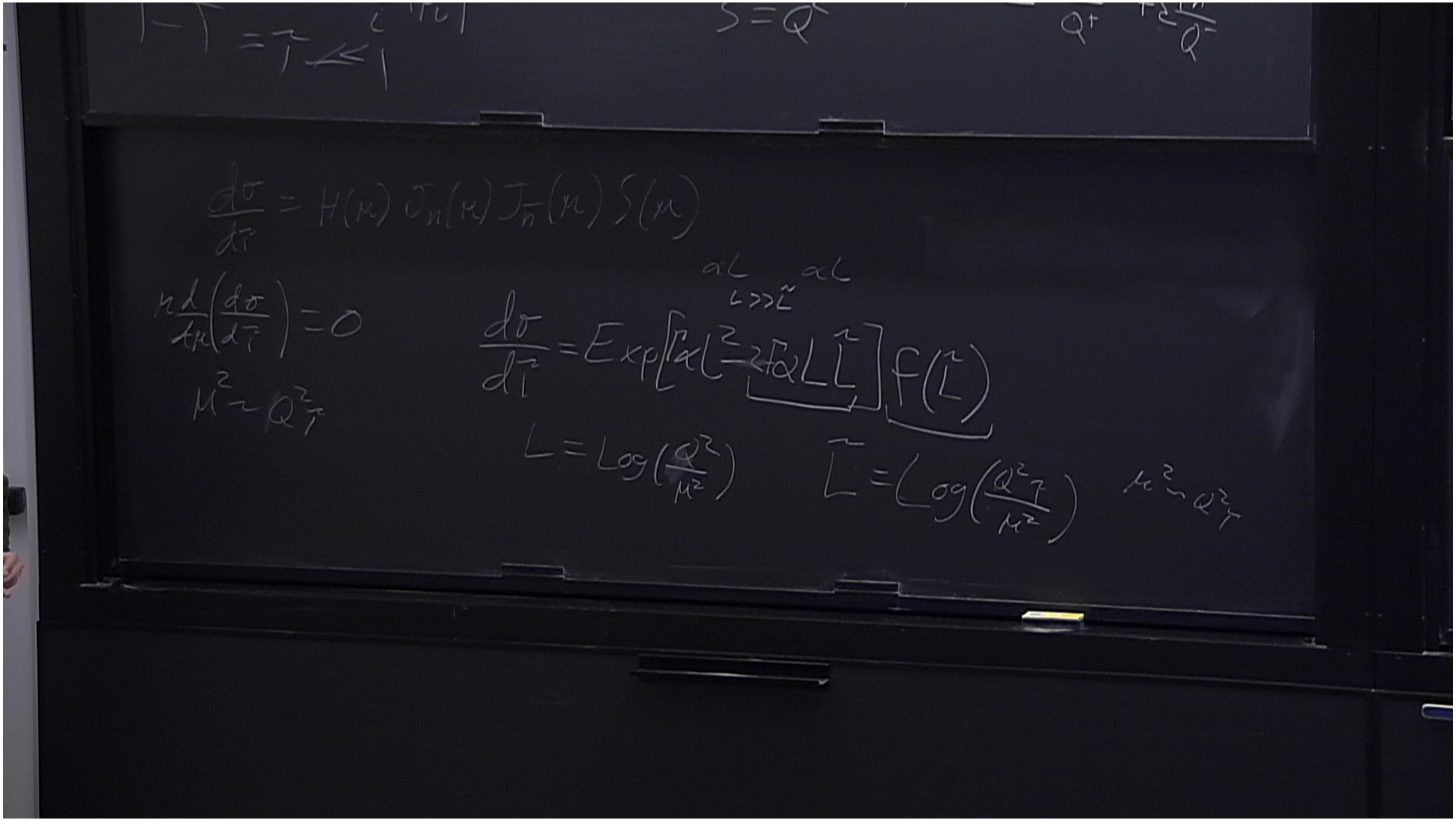

dσ/dτ = H(μ) J_n(μ) J_n̄(μ) S(μ)

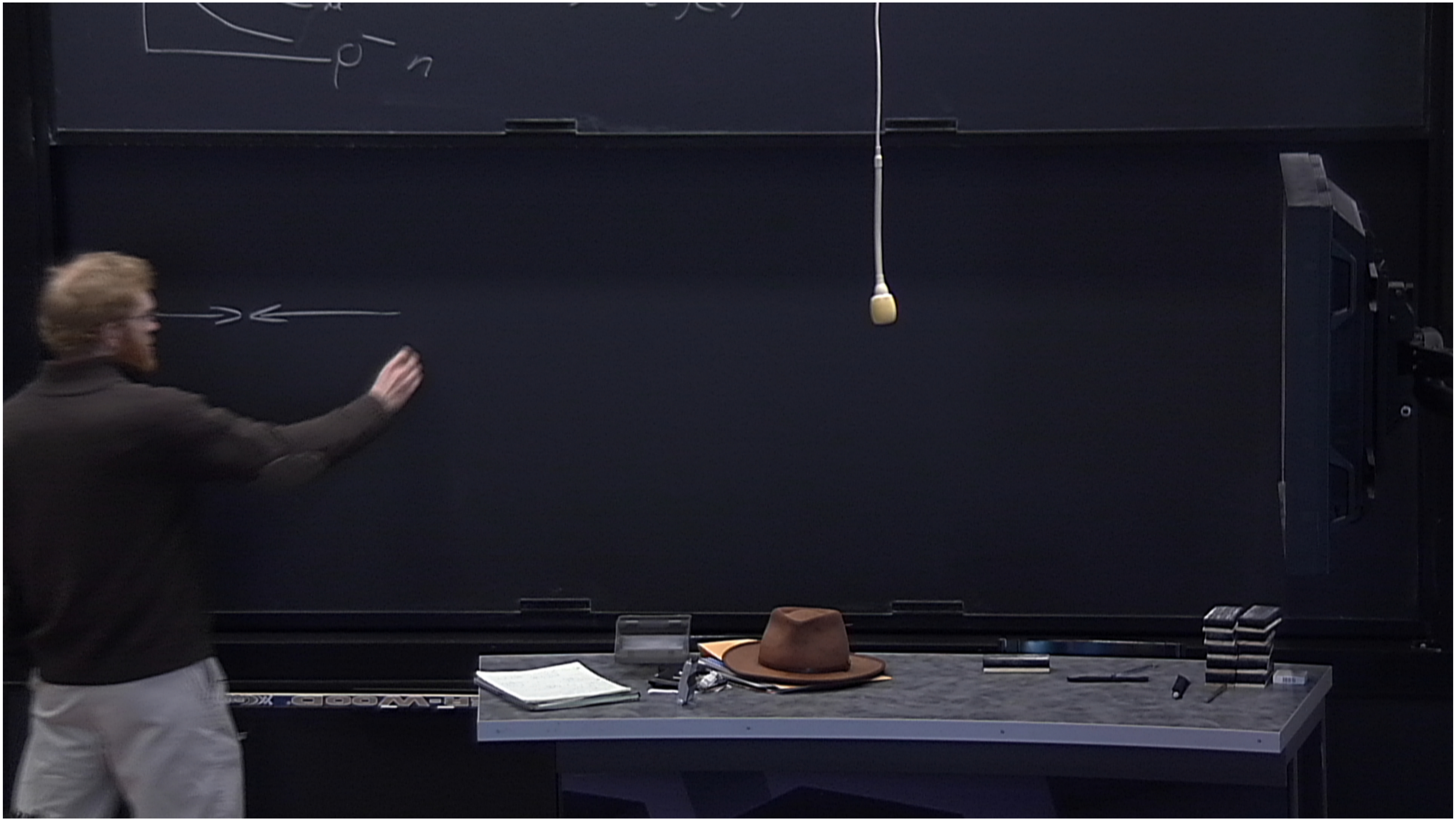
$$\frac{d\sigma}{d\tau} = H(\mu)\, J_n(\mu)\, J_{\bar{n}}(\mu)\, S(\mu)$$

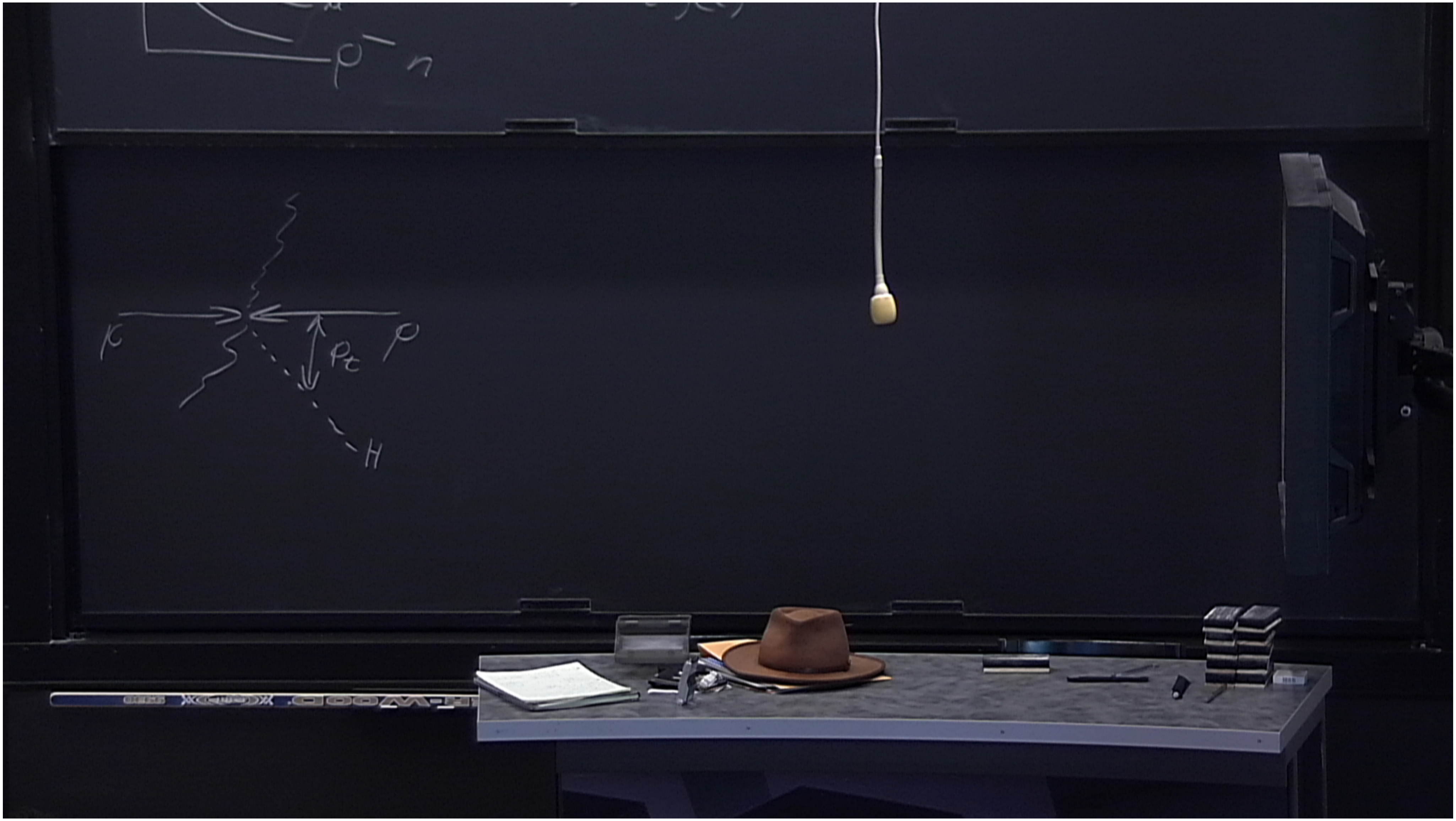
$$\mu \frac{d}{d\mu}\left(\frac{d\sigma}{d\tau}\right) = 0$$

$$\mu^2 \sim Q^2 \tau$$

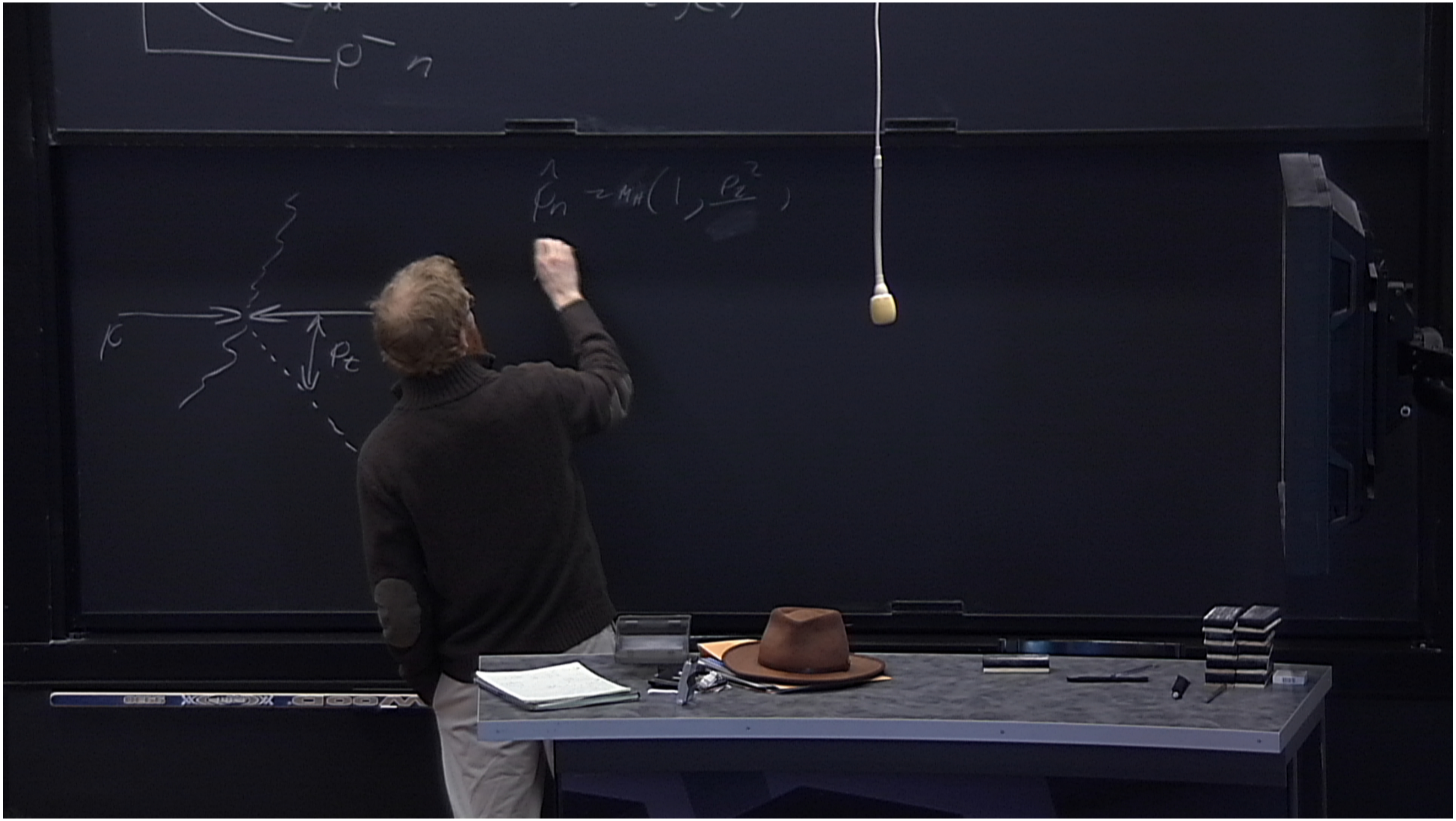

$\frac{d\sigma}{d\tau} = H(\mu) J_n(\mu) J_{\bar{n}}(\mu) S(\mu)$
$\mu \frac{d}{d\mu}\left(\frac{d\sigma}{d\tau}\right) = 0$
$\mu^2 \sim Q^2\tau$
$\frac{d\sigma}{d\tau} = \mathrm{Exp}[\Gamma\alpha L^2 - 2\Gamma\alpha L \tilde{L}] f(\tilde{L})$
$L = \mathrm{Log}\left(\frac{Q^2}{\mu^2}\right)$
$\tilde{L} = \mathrm{Log}\left(\frac{Q^2\tau}{\mu^2}\right)$
$\mu^2 \sim Q^2\tau$

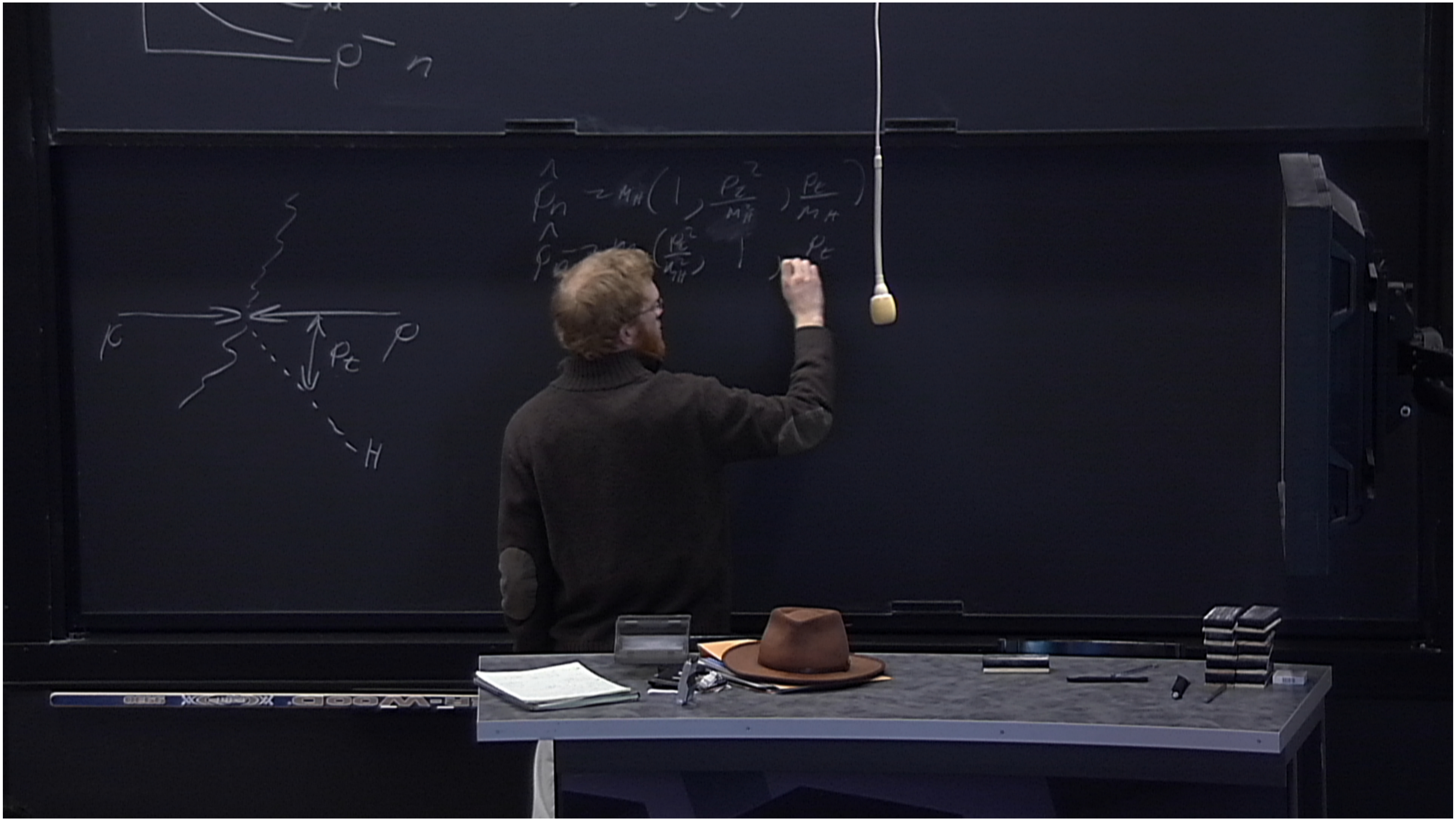

dσ/dτ = H(μ) J_n(μ) J_n̄(μ) S(μ)
μ d/dμ (dσ/dτ) = 0
μ² ~ Q²τ
αL
L >> L̃
αL
dσ/dτ = Exp[Γα L² − 2Γα L L̃] f(L̃)
L = Log(Q²/μ²)
L̃ = Log(Q²τ/μ²)
μ² ~ Q²τ

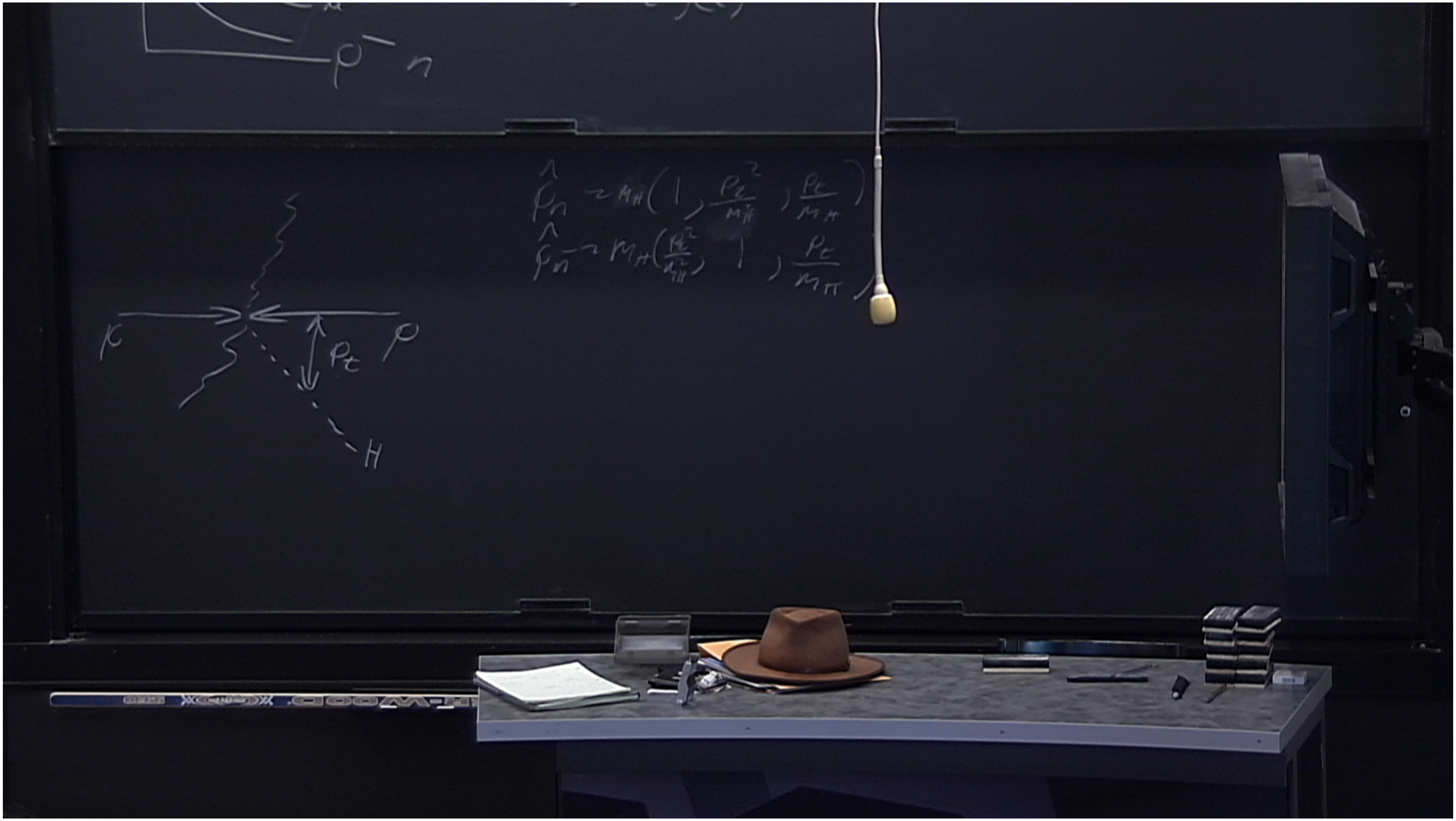


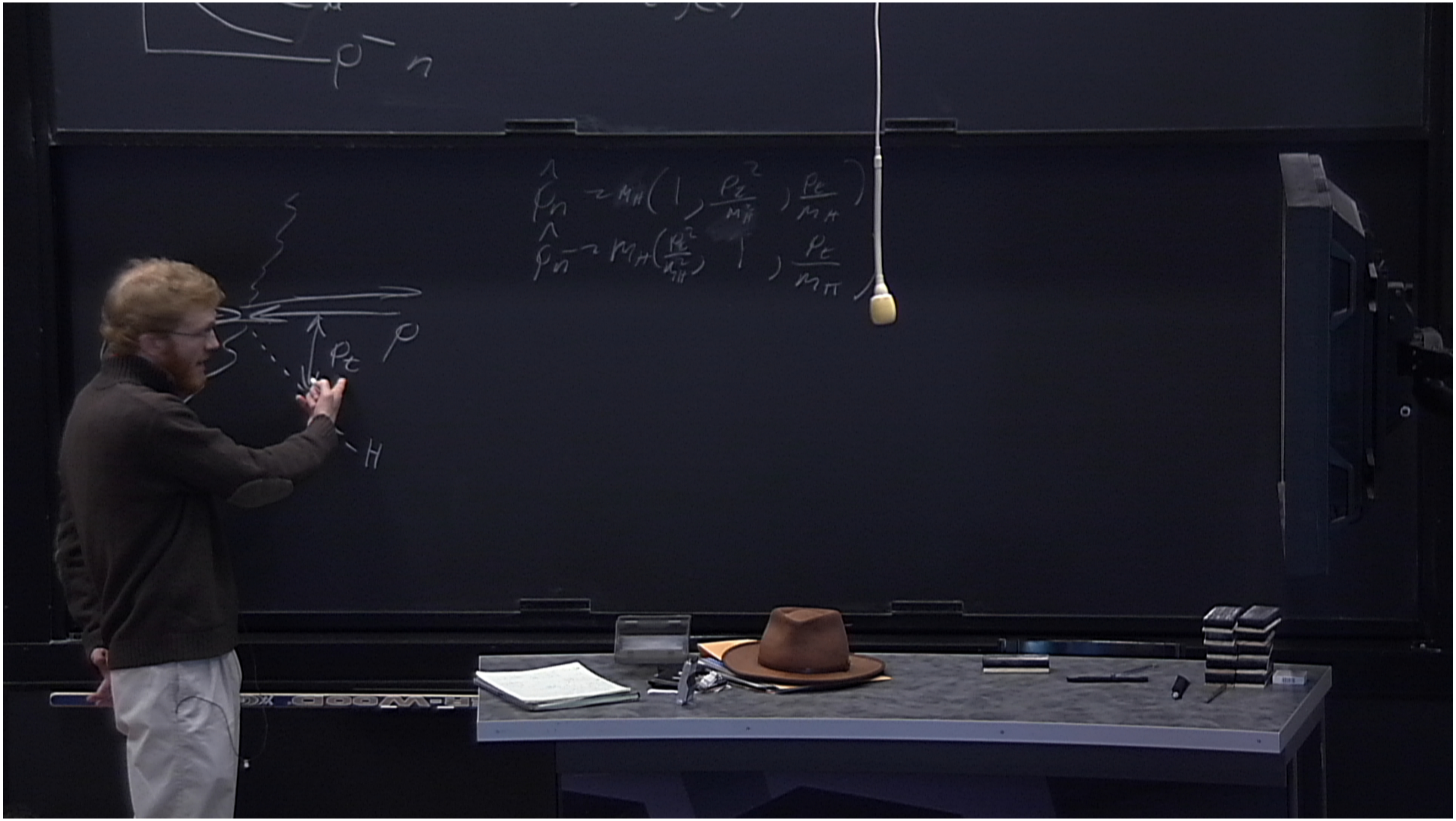


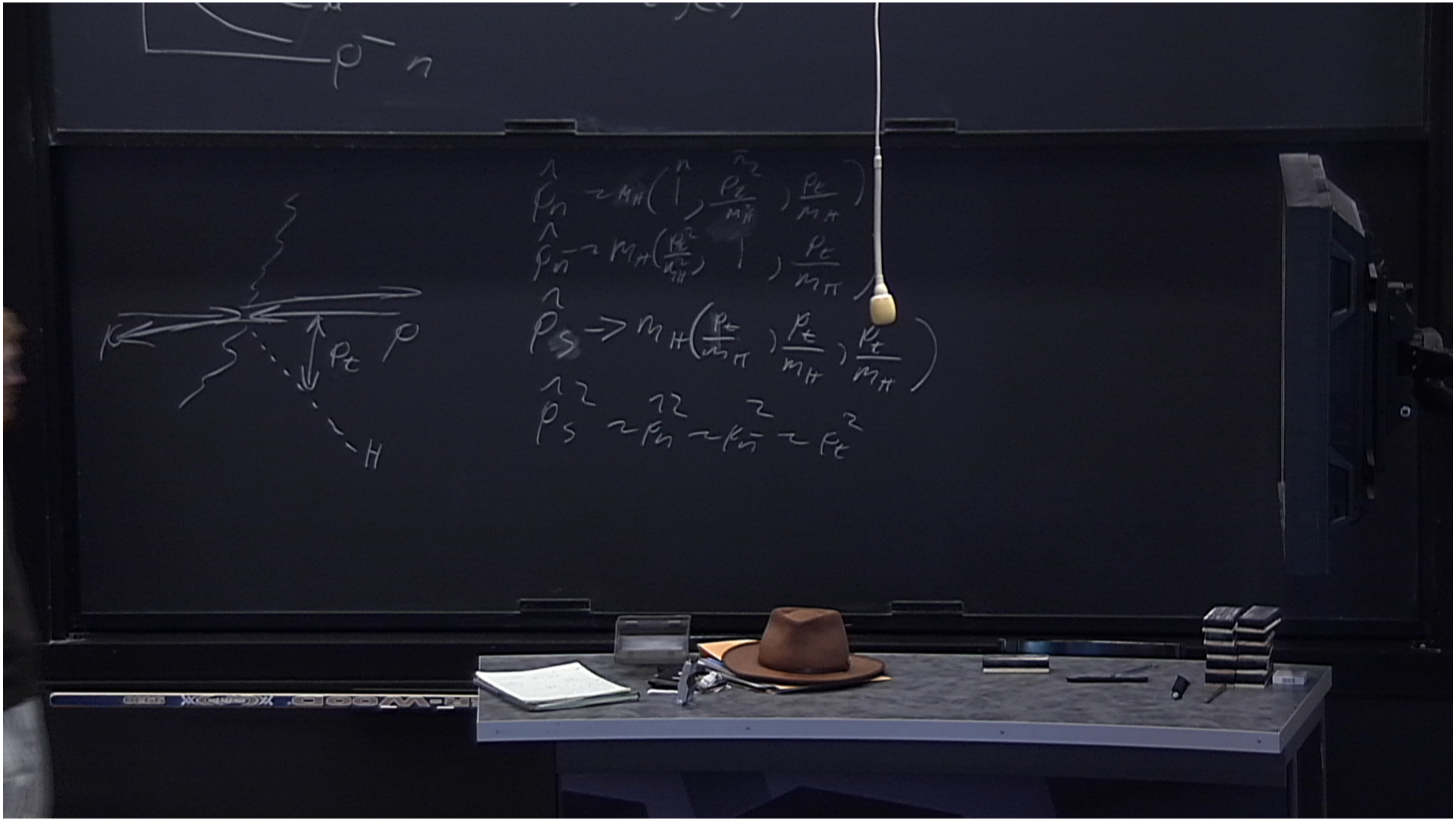
p
n
p
p_t
H

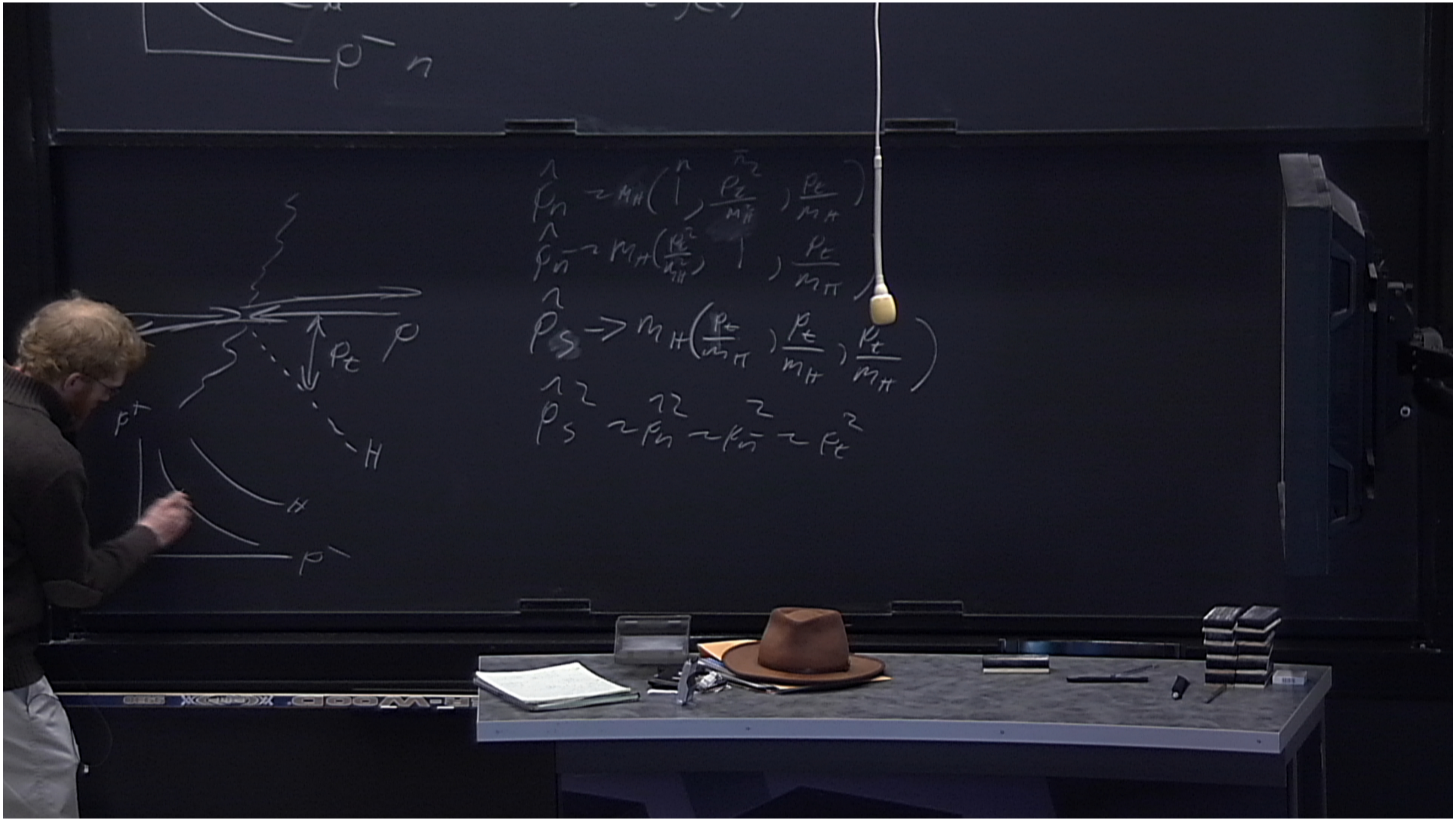


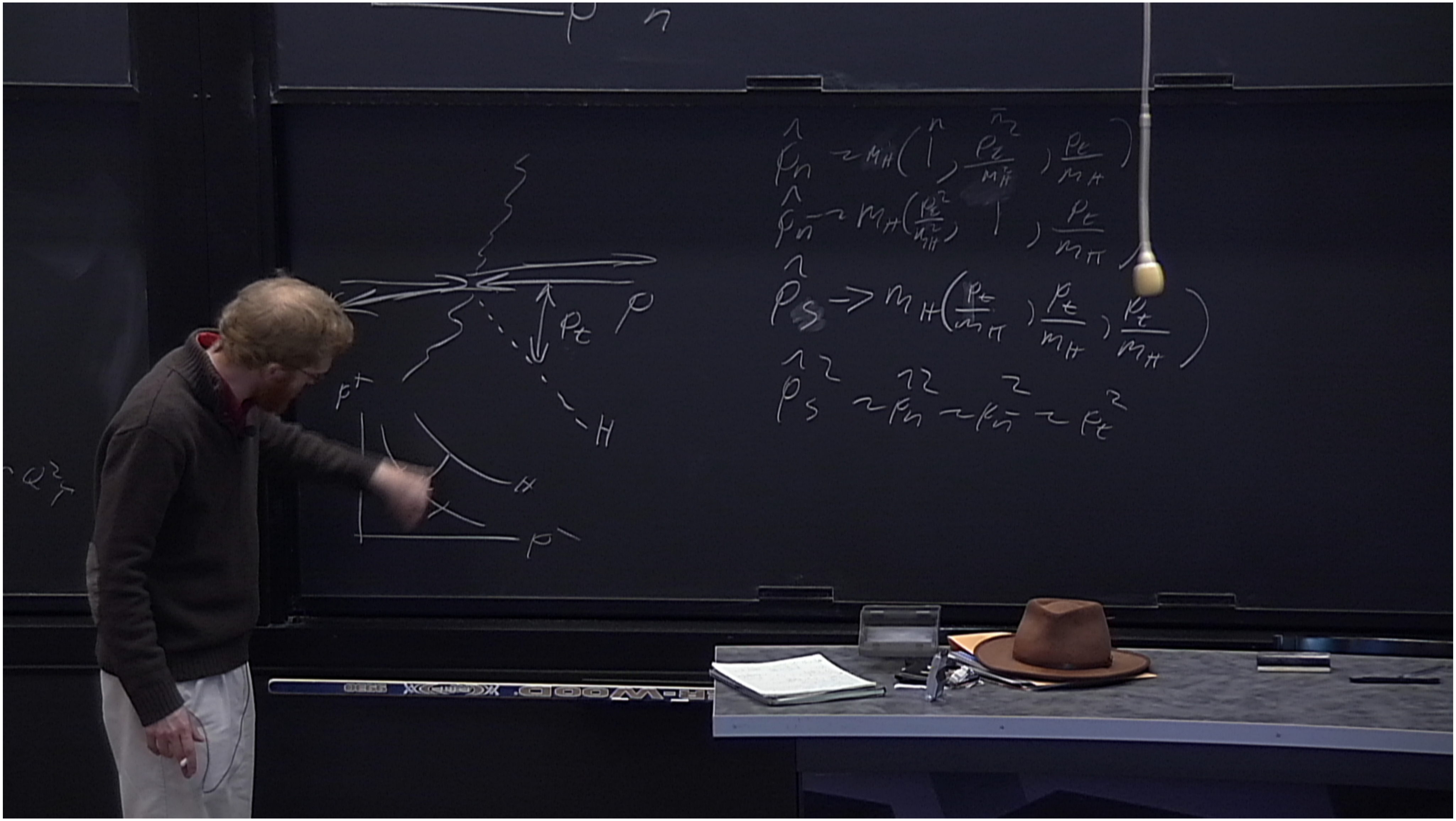


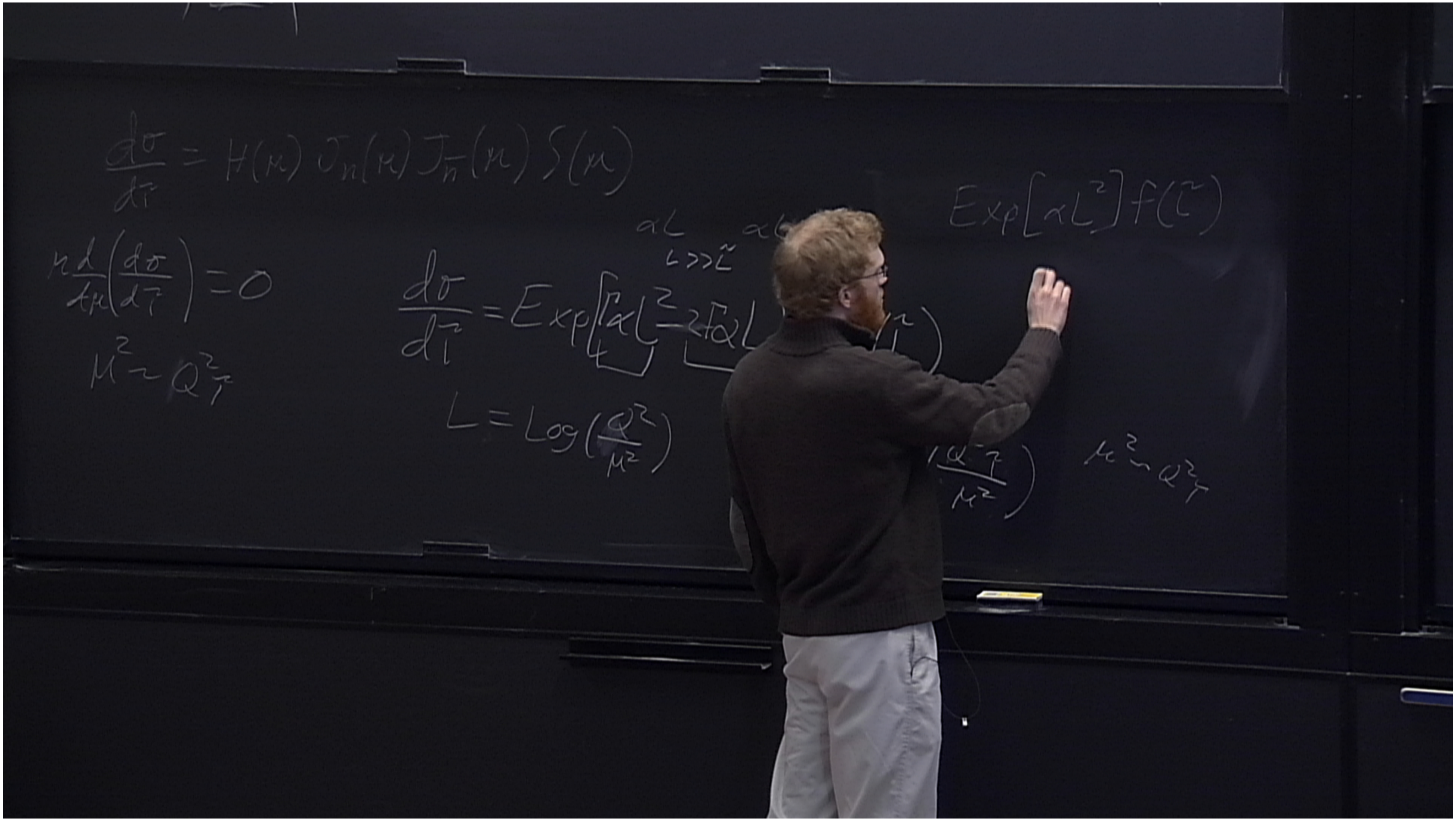


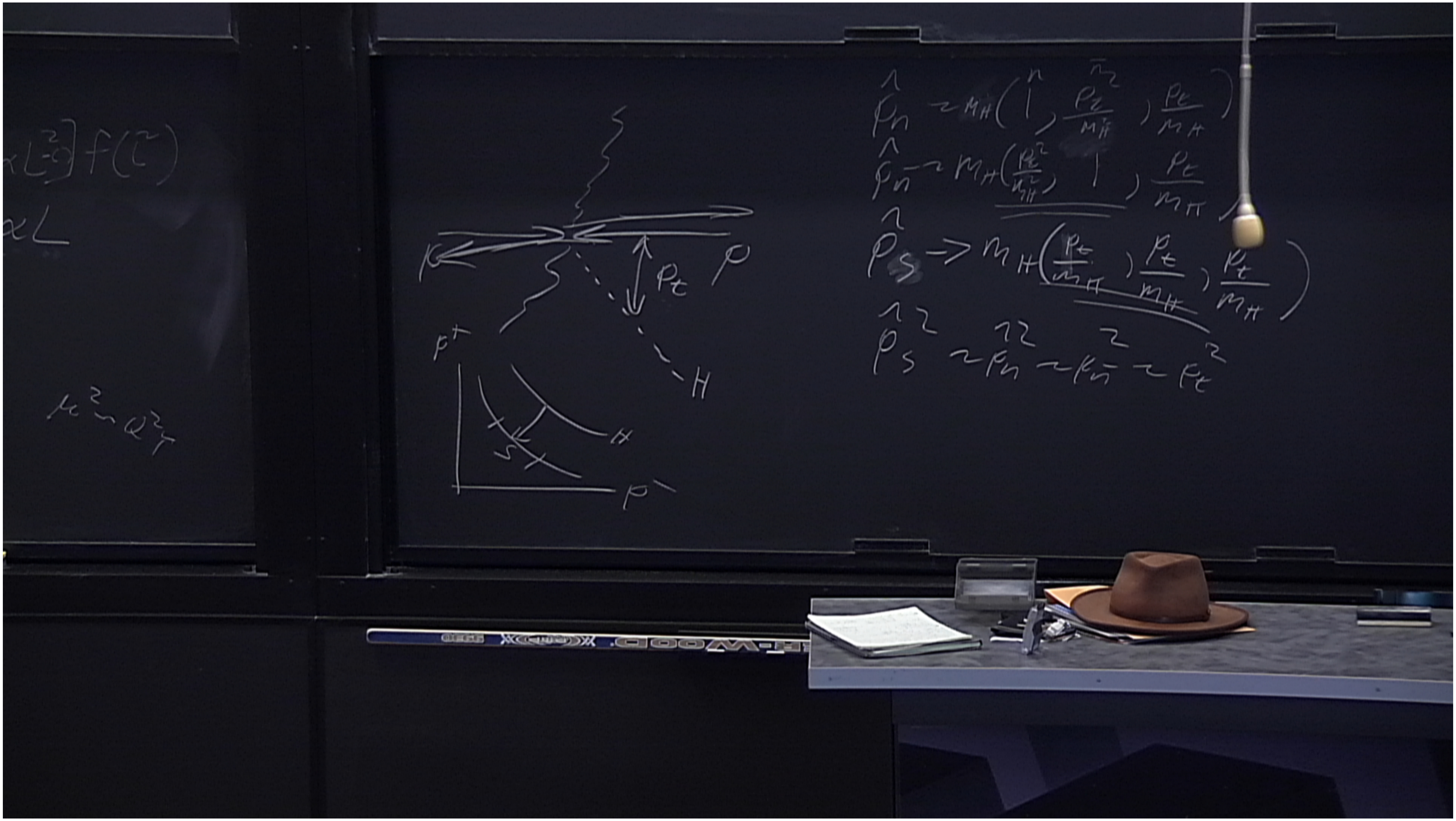


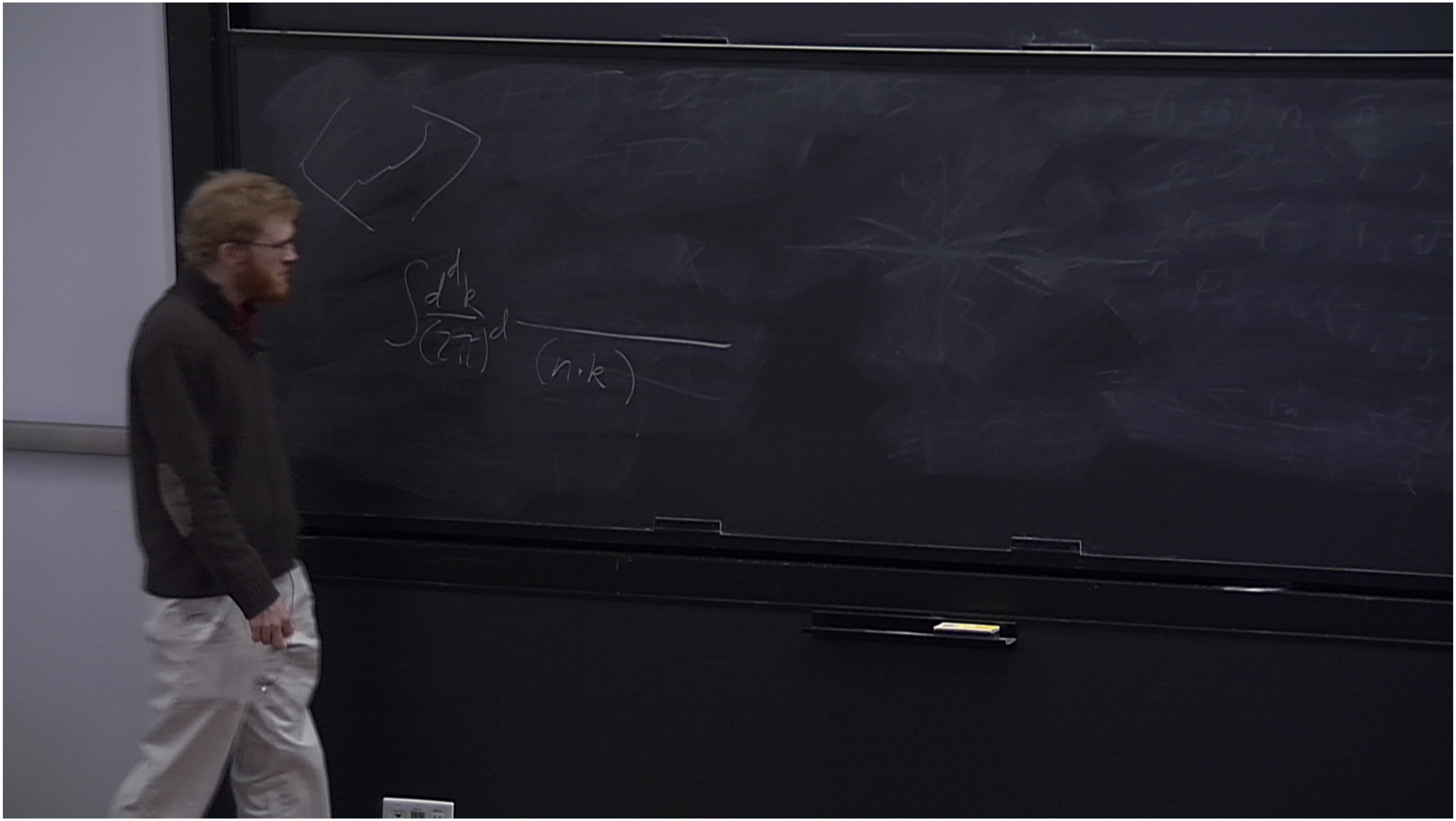




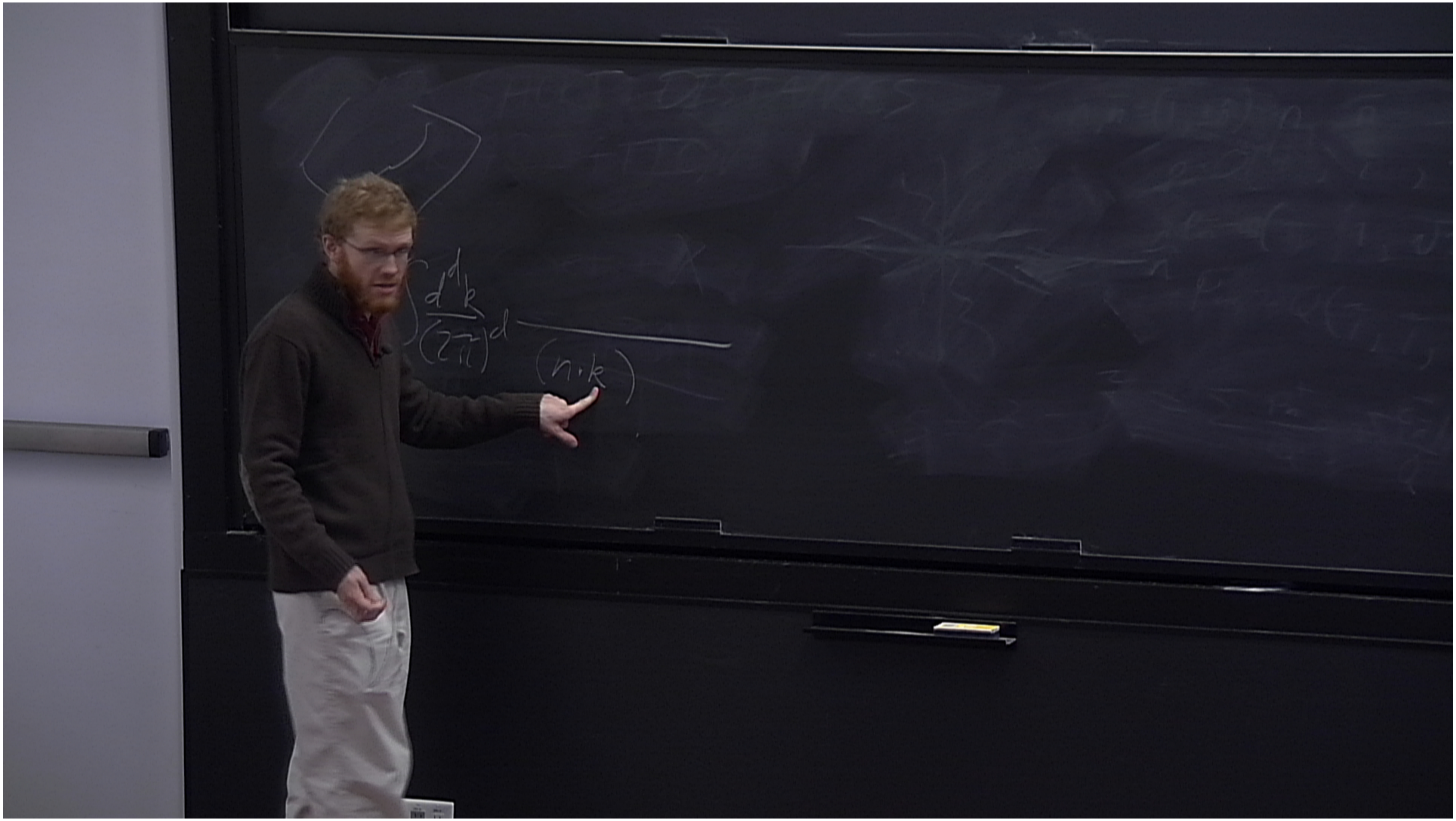


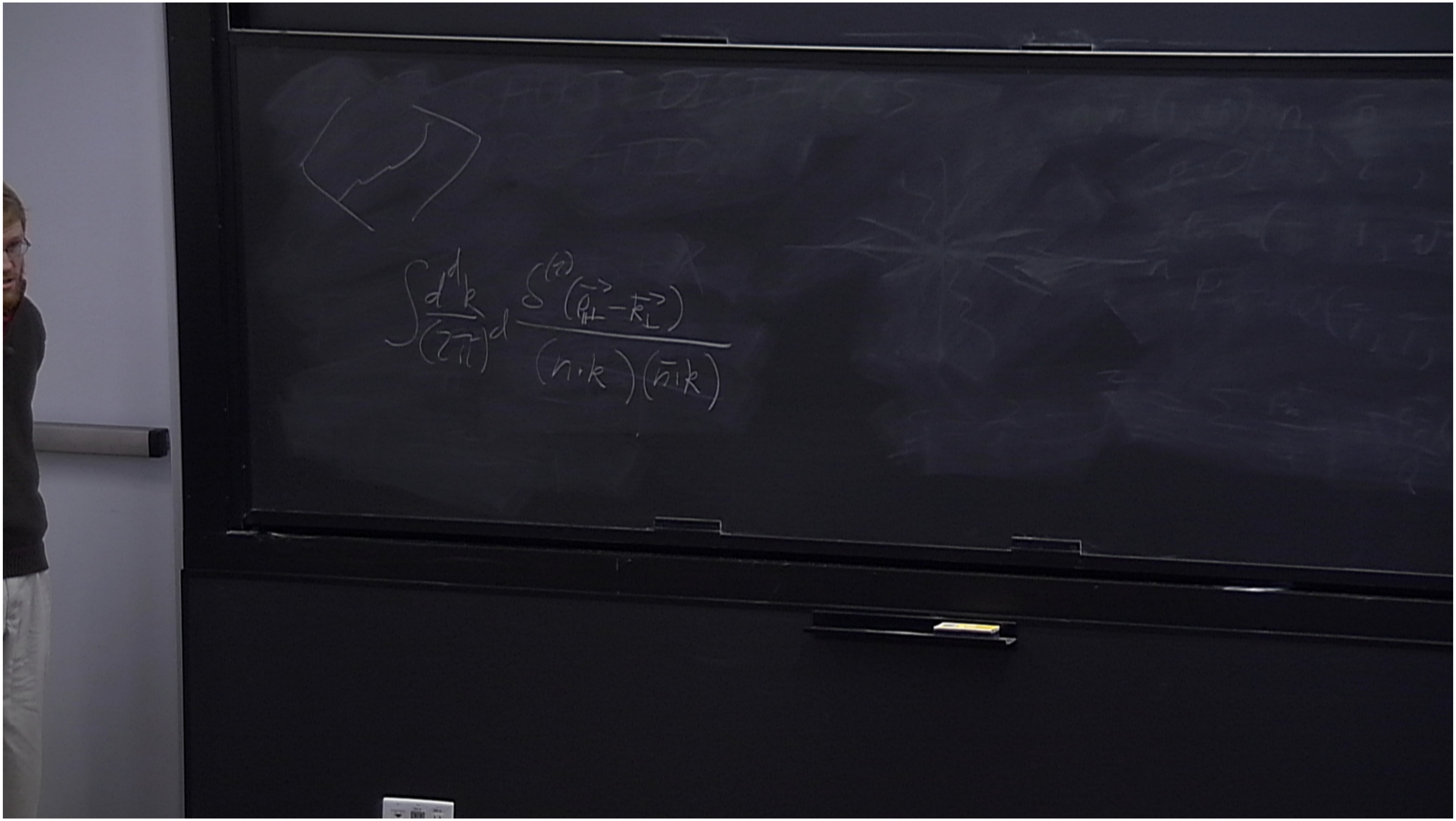


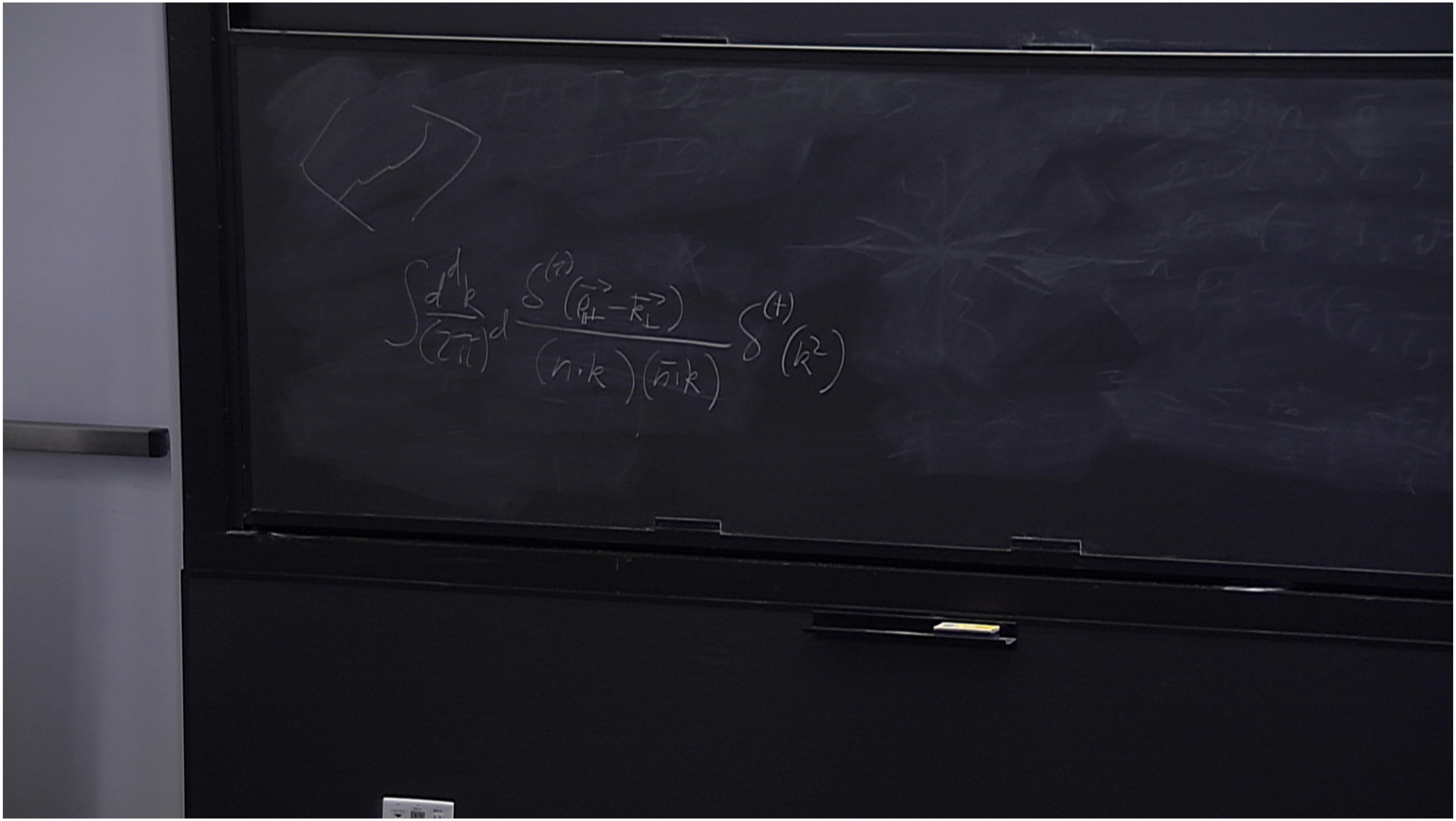


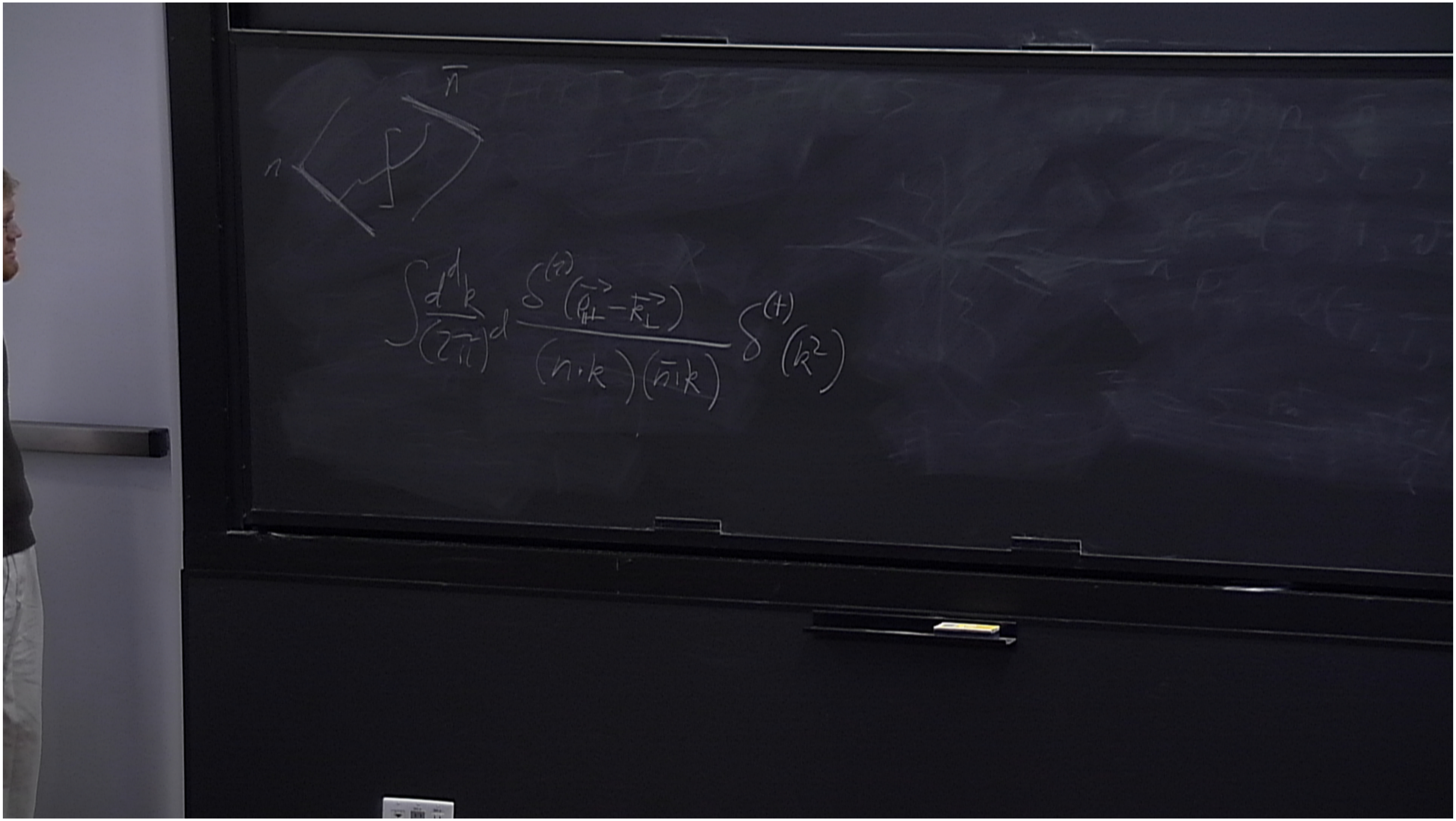


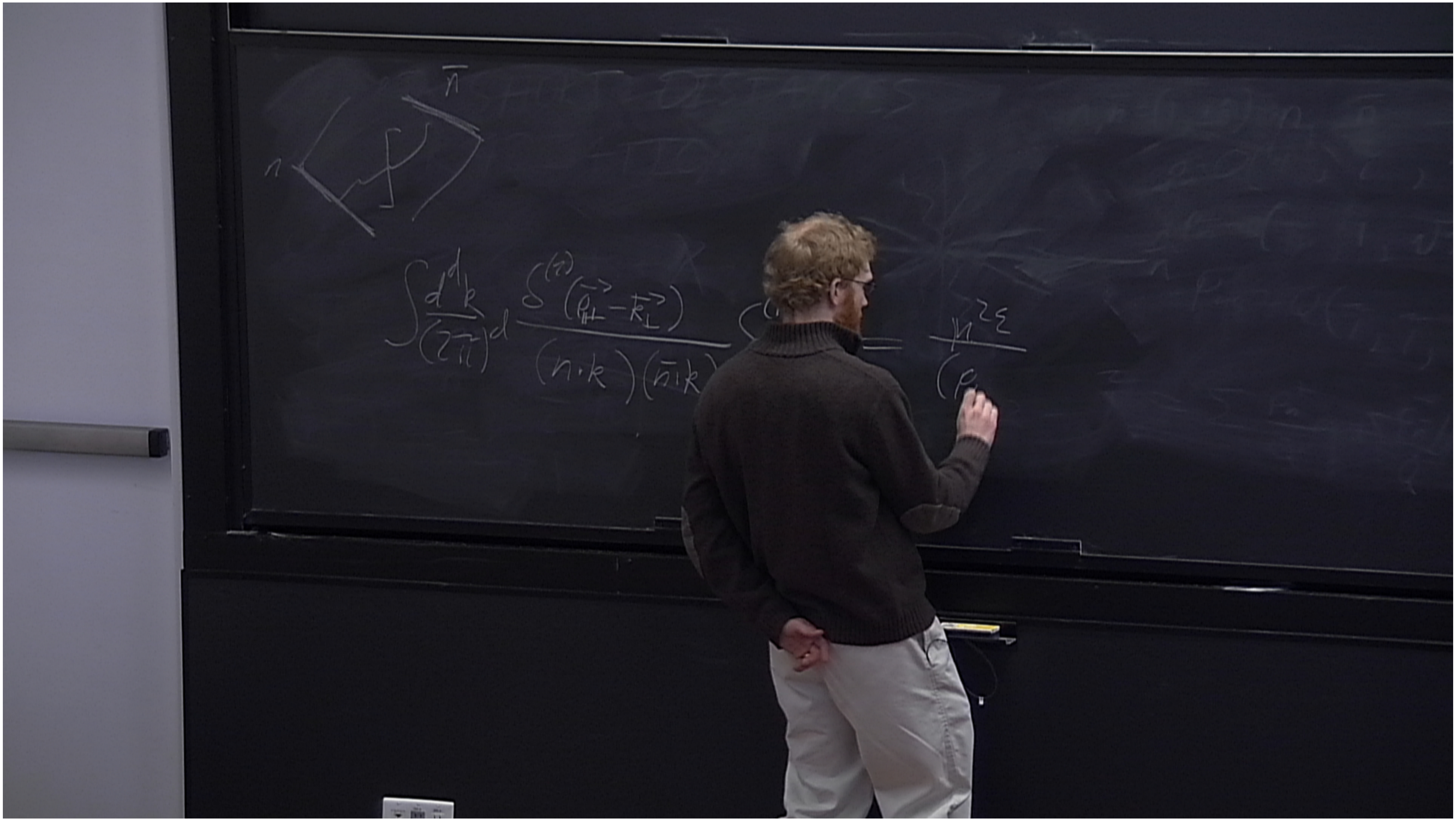
(n·k)

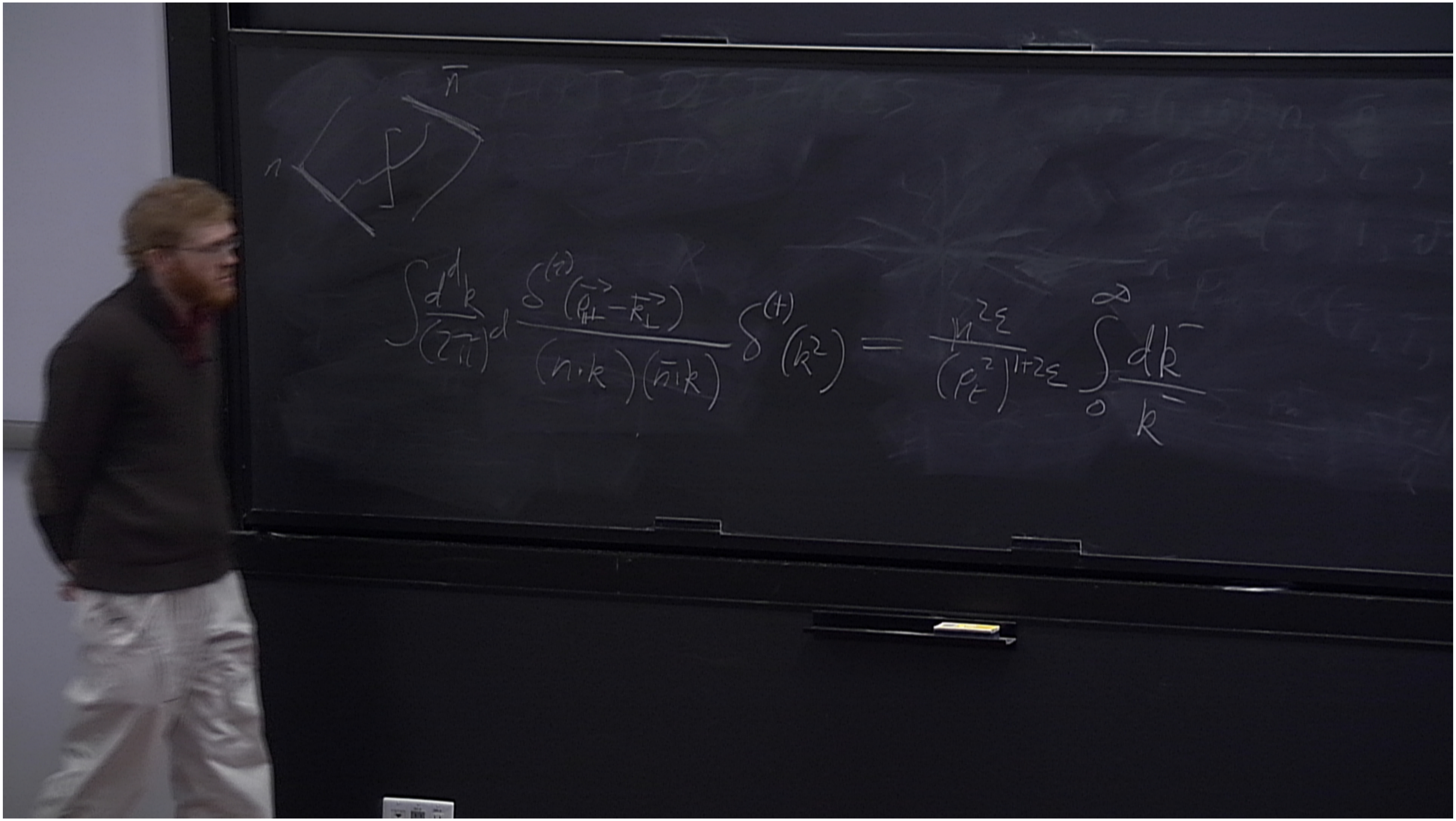

$\int \frac{d^d k}{(2\pi)^d}$
$(n \cdot k)$

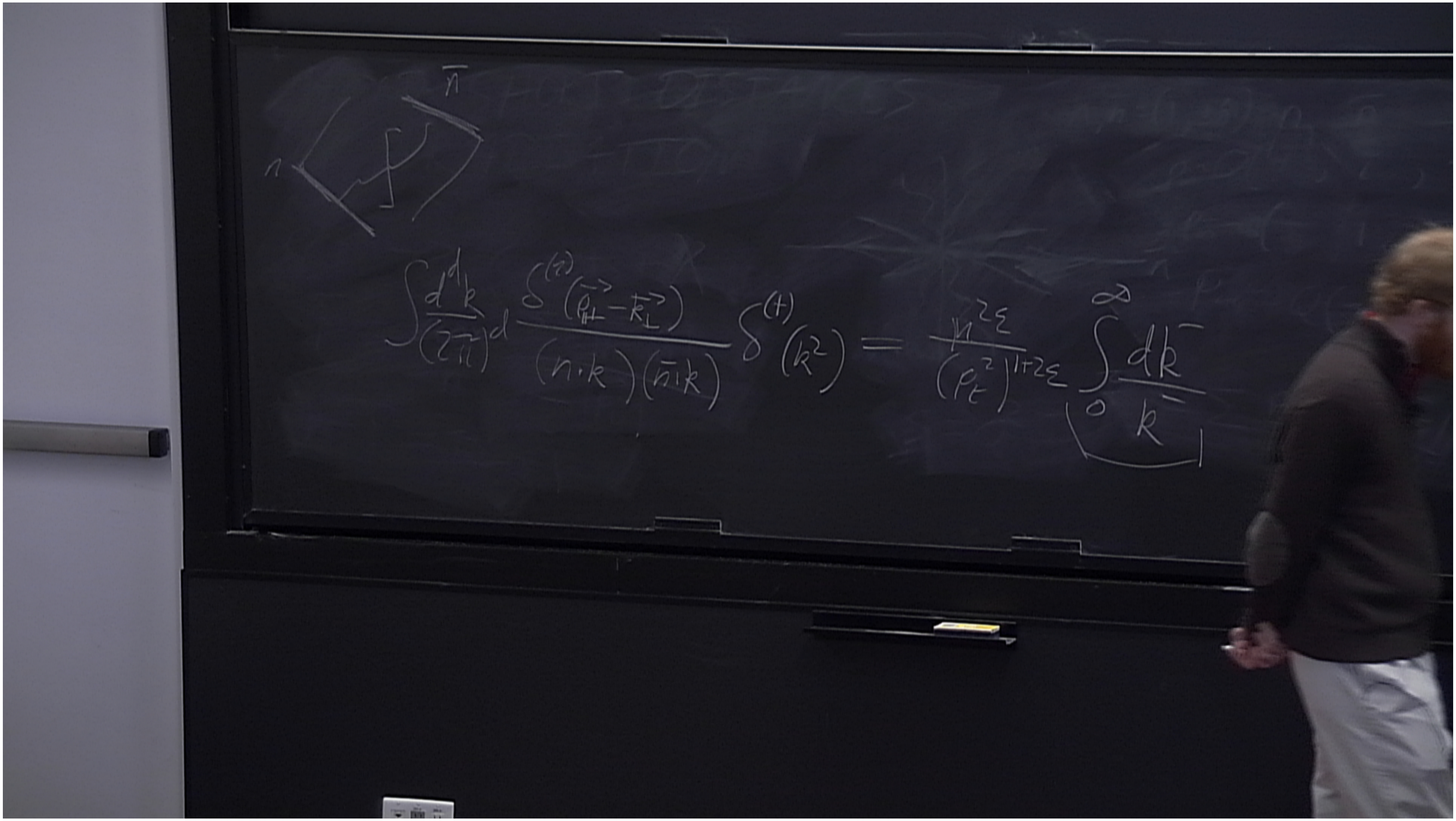

$\int \frac{d^dk}{(2\pi)^d} \frac{\delta^{(2)}(\vec{p}_\perp - \vec{k}_\perp)}{(n\cdot k)(\bar{n}\cdot k)}$

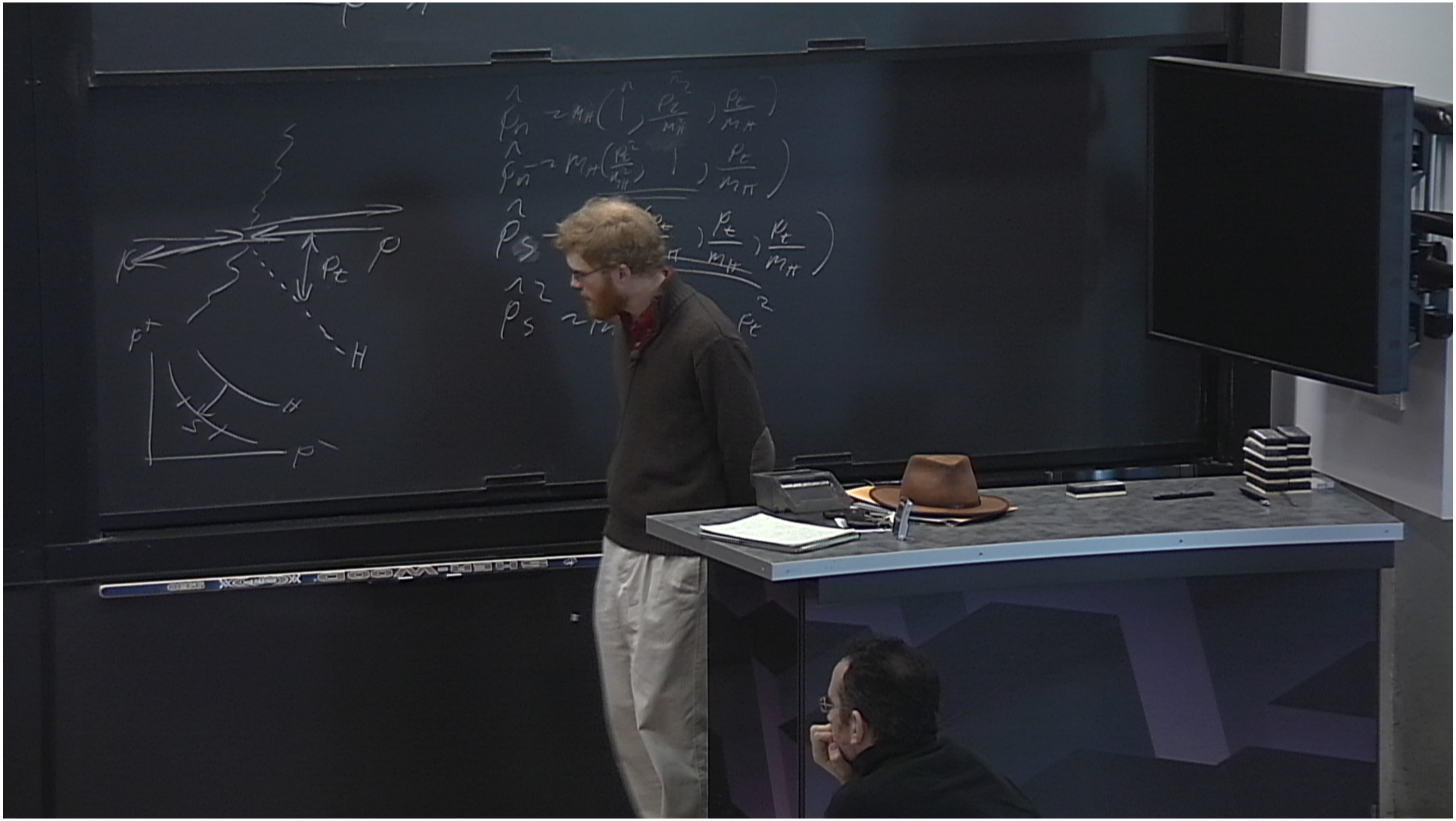

$\int \frac{d^d k}{(2\pi)^d} \frac{\delta^{(2)}(\vec{p}_{\perp} - \vec{k}_{\perp})}{(n \cdot k)(\bar{n} \cdot k)} \delta^{(+)}(k^2)$

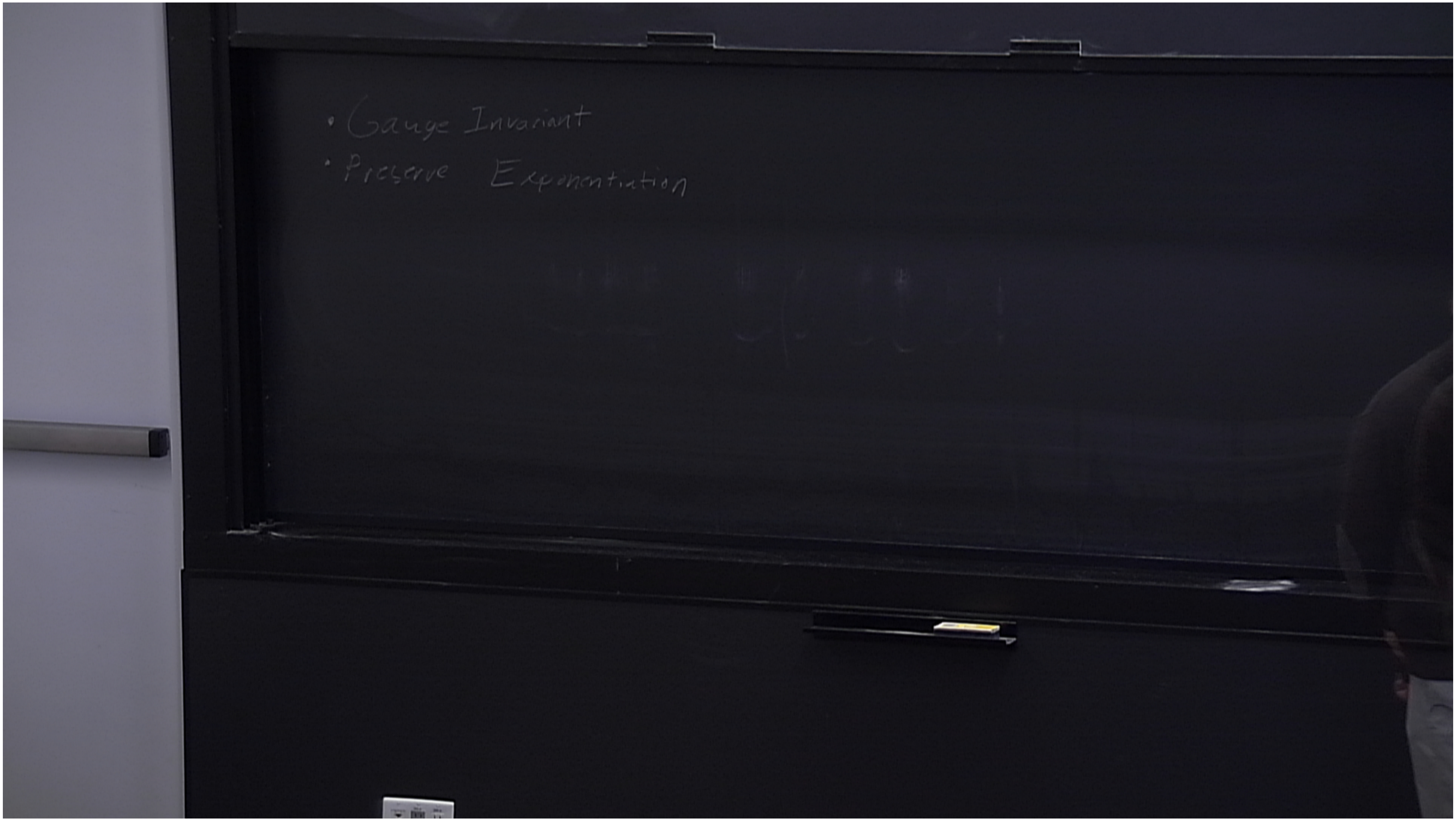

$\bar{n}$
n
$\int \frac{d^d k}{(2\pi)^d} \frac{\delta^{(2)}(\vec{p}_{\perp} - \vec{k}_{\perp})}{(n \cdot k)(\bar{n} \cdot k)} \delta^{(+)}(k^2)$






$\bar{n}$
n
$\int \frac{d^d k}{(2\pi)^d} \frac{\delta^{(2)}(\vec{p}_\perp - \vec{k}_\perp)}{(n\cdot k)(\bar{n}\cdot k)} \delta^{(+)}(k^2) = \frac{\mu^{2\varepsilon}}{(p_t^2)^{1+2\varepsilon}} \int_0^\infty \frac{dk^-}{k^-}$

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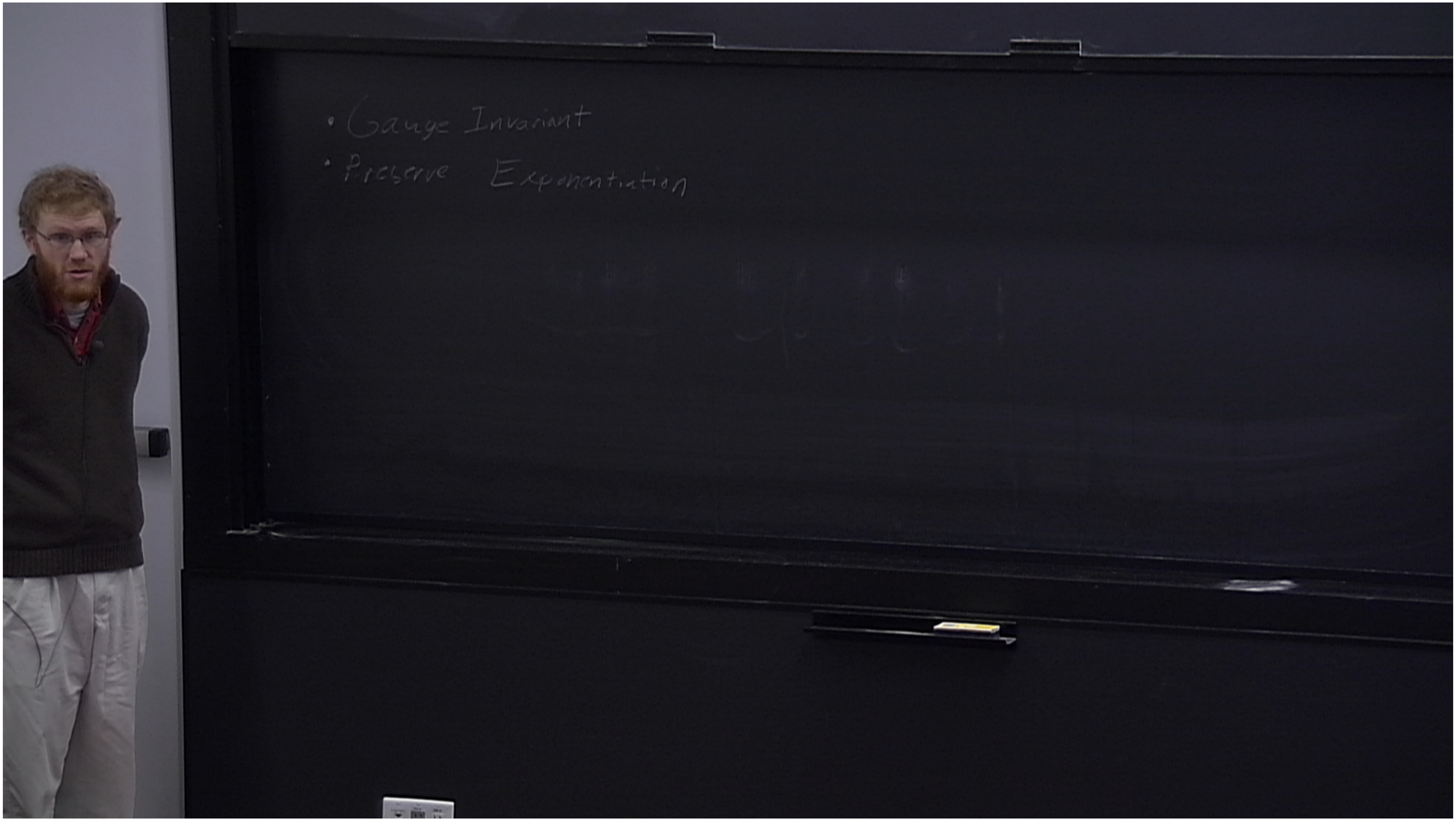
• Preserve Exponentiation


• Gauge Invariant
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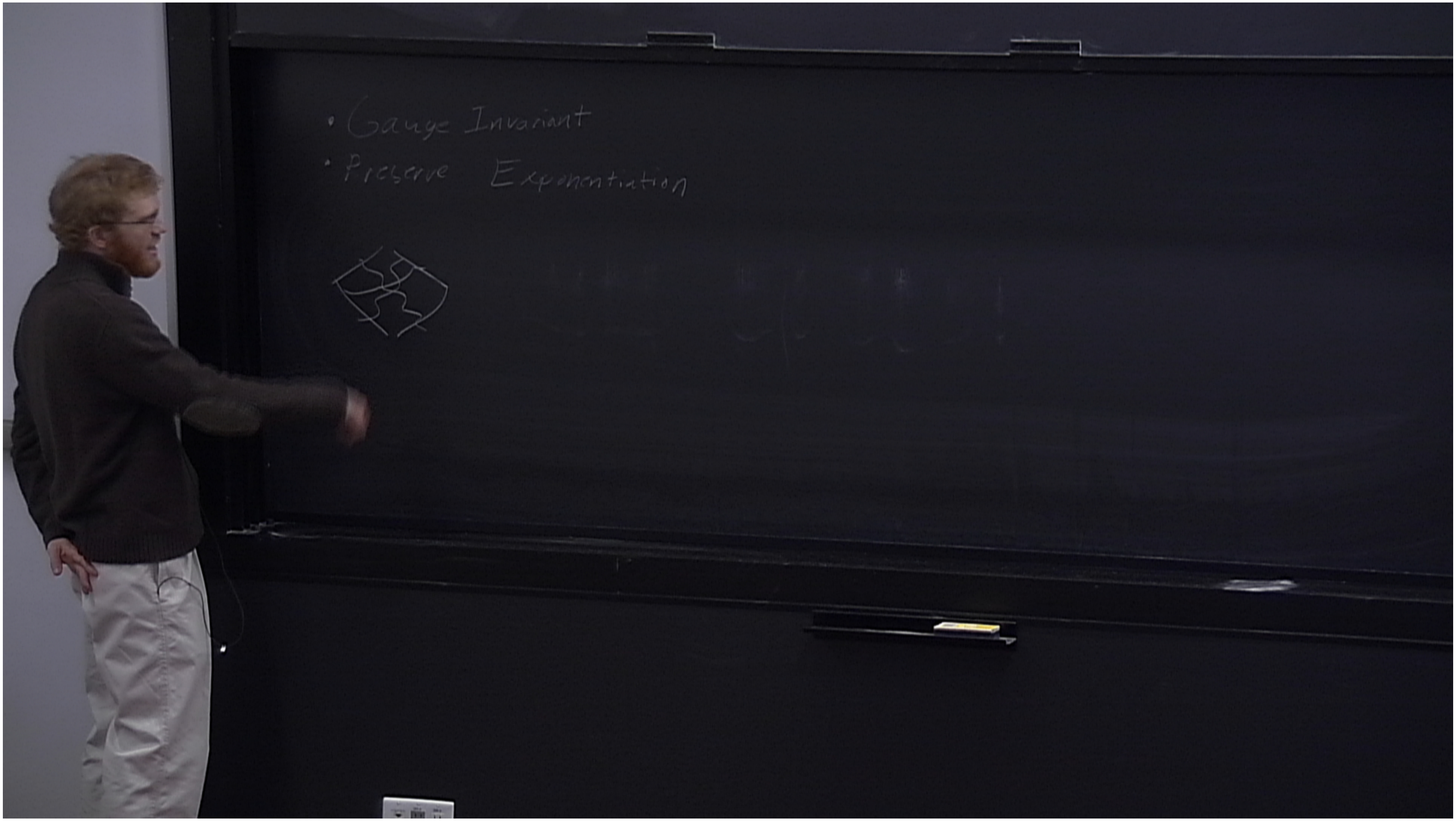
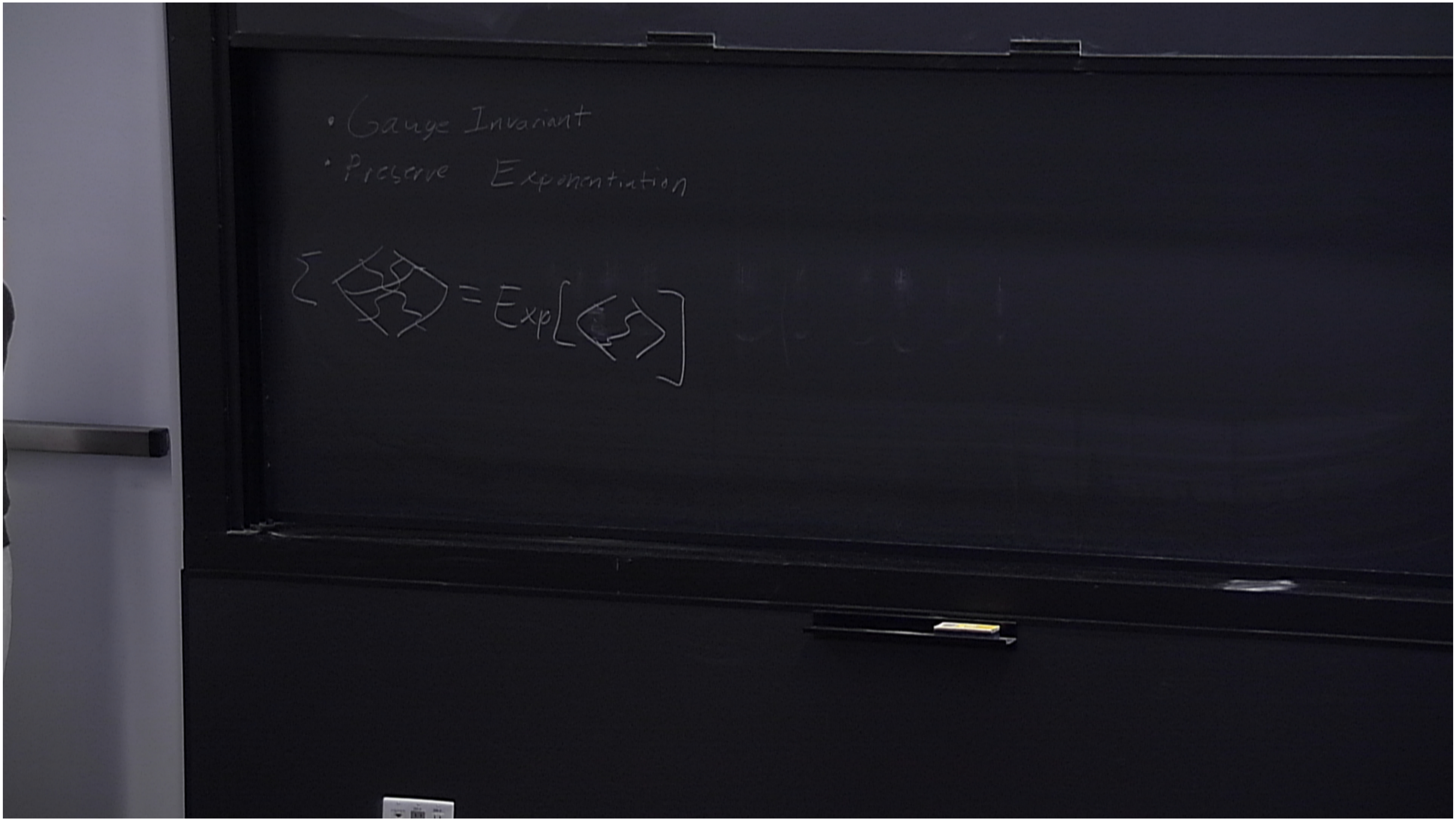
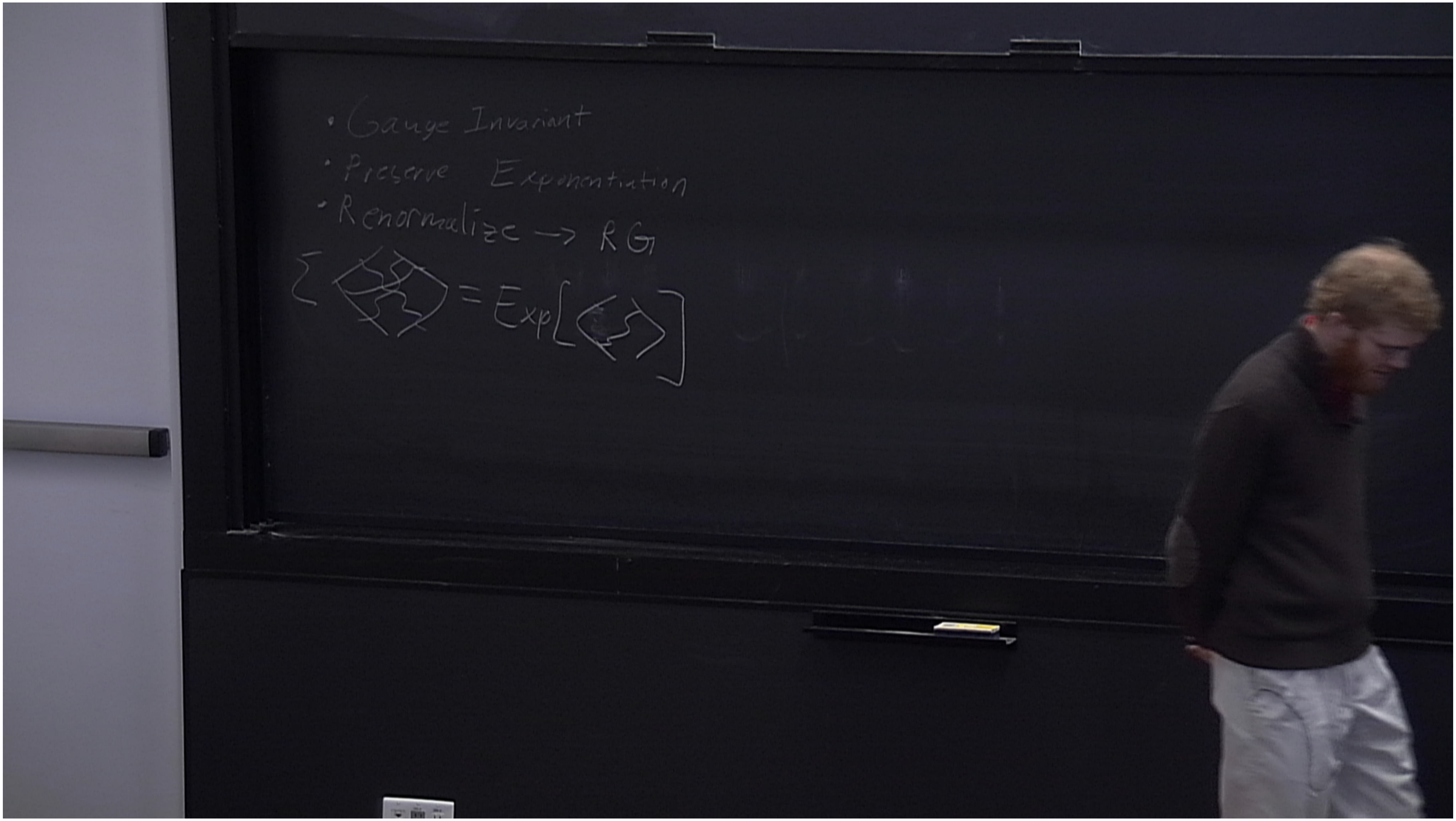
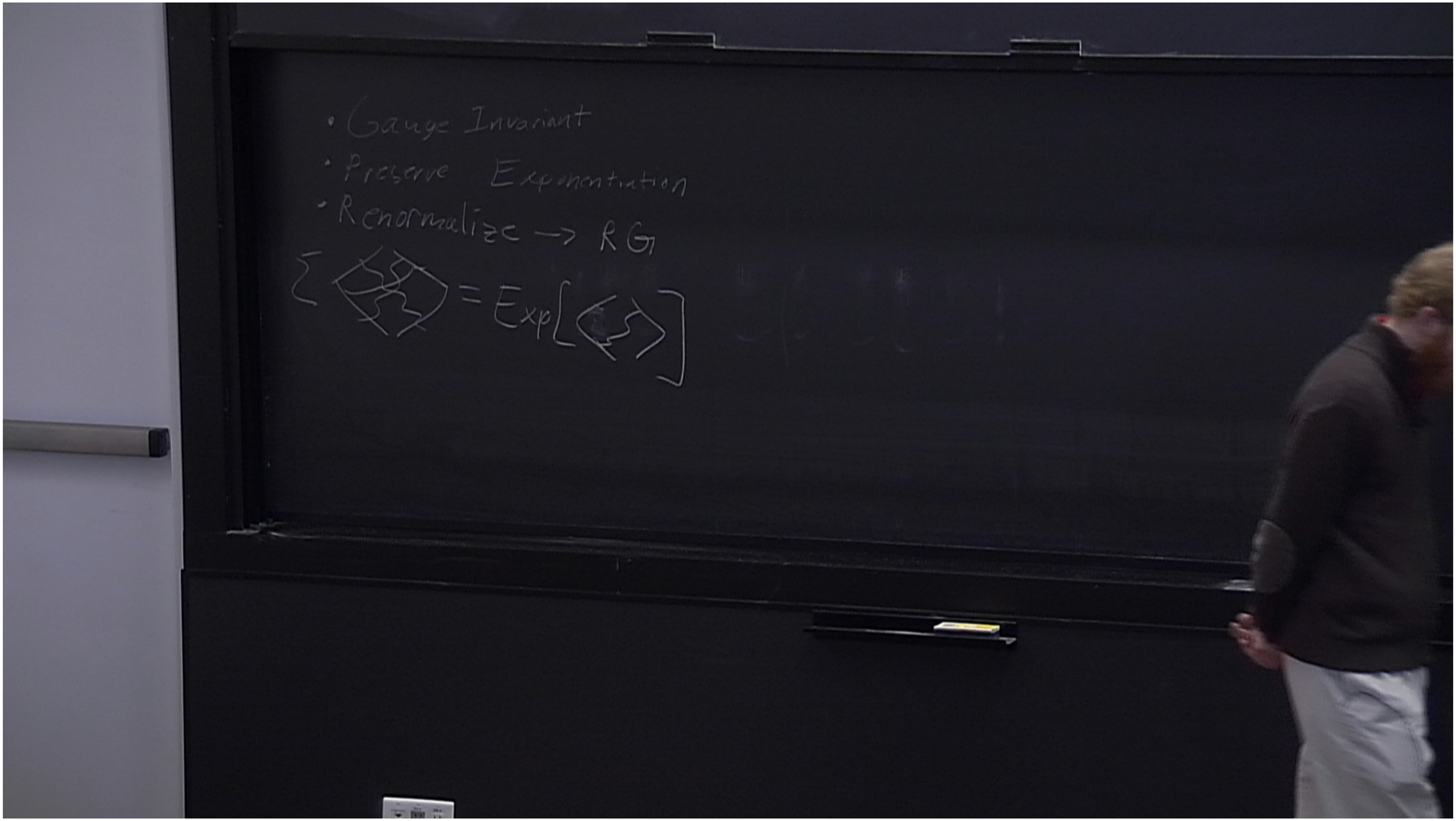
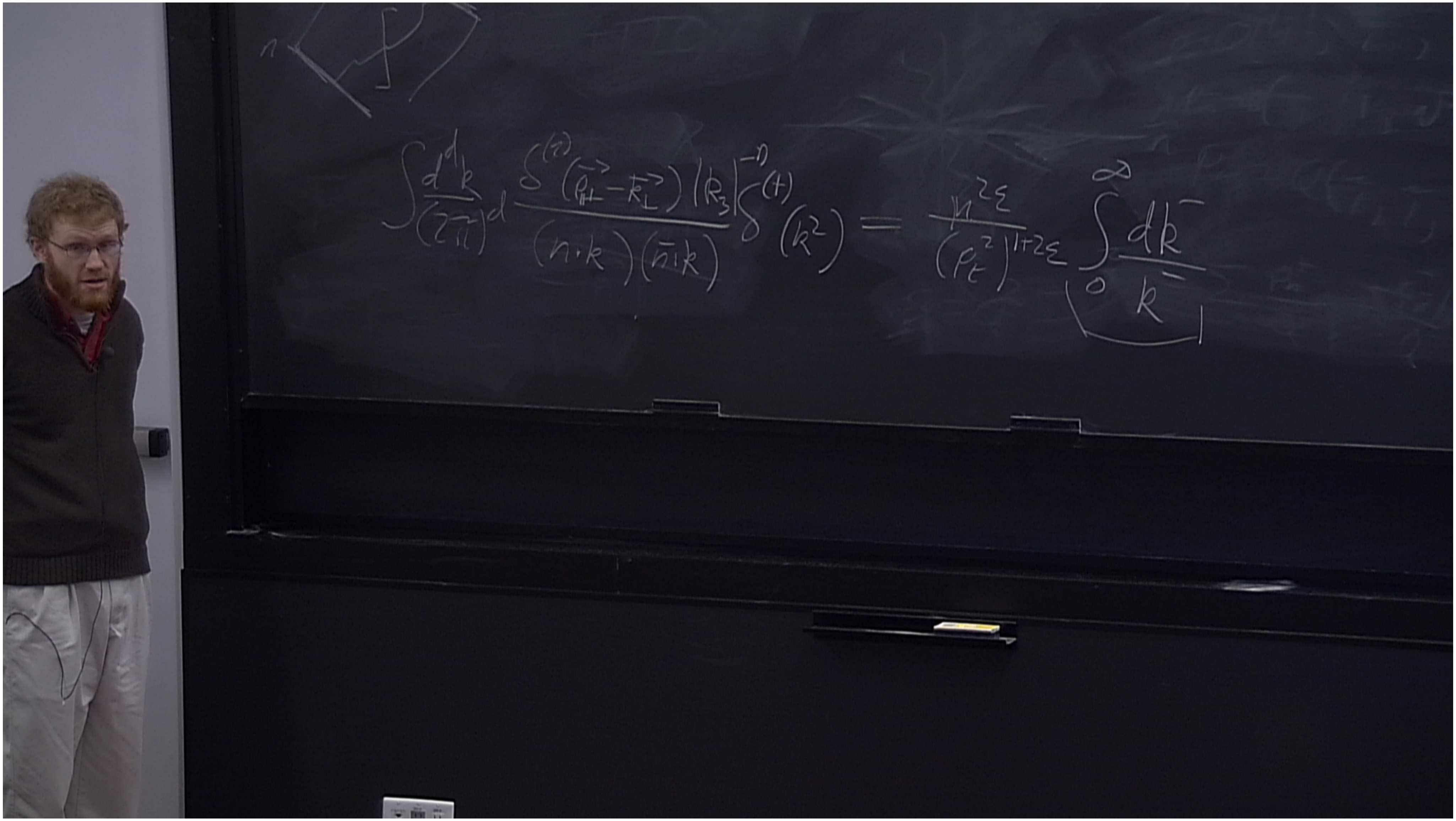
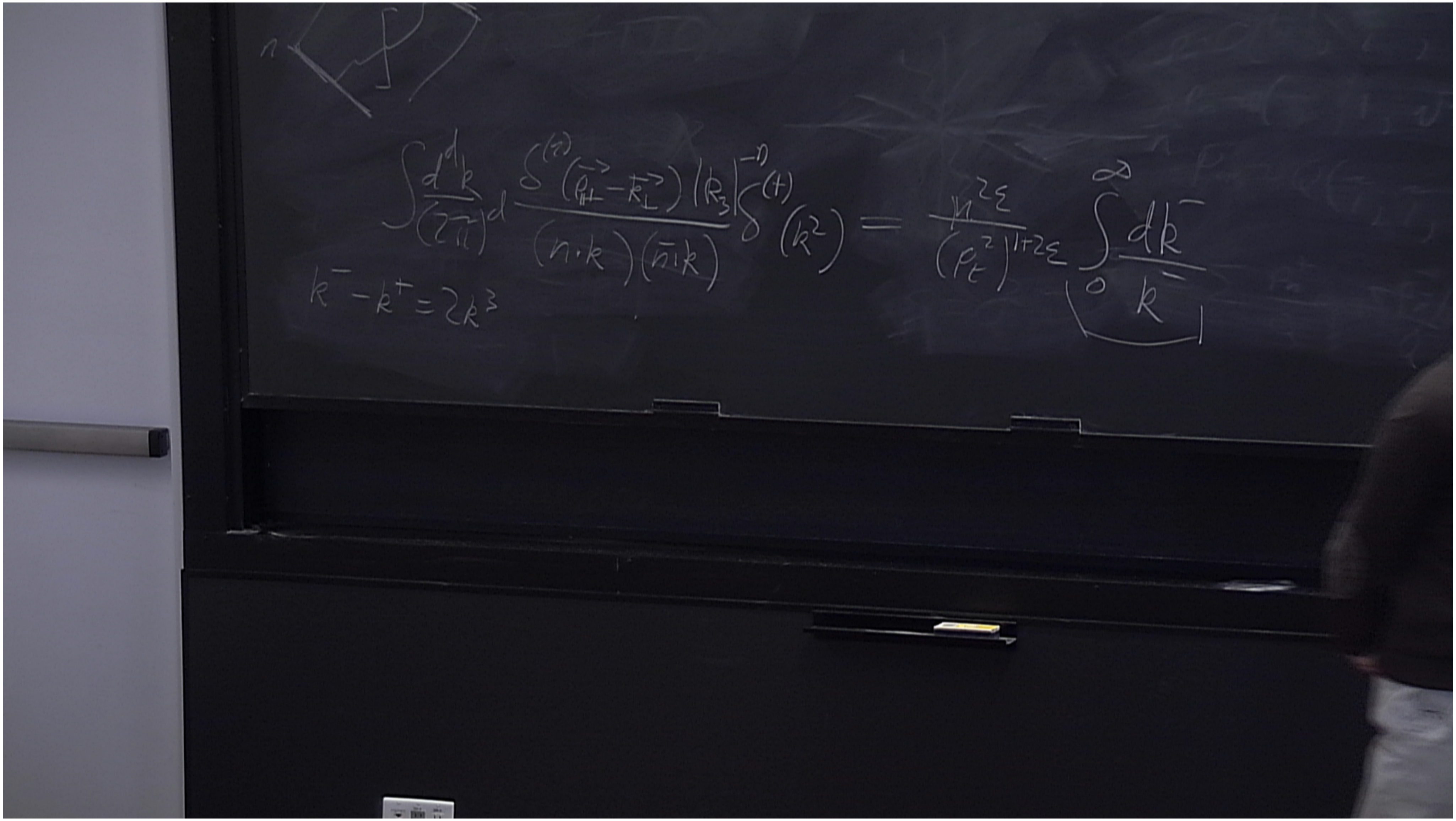

• Gauge Invariant
• Preserve Exponentiation

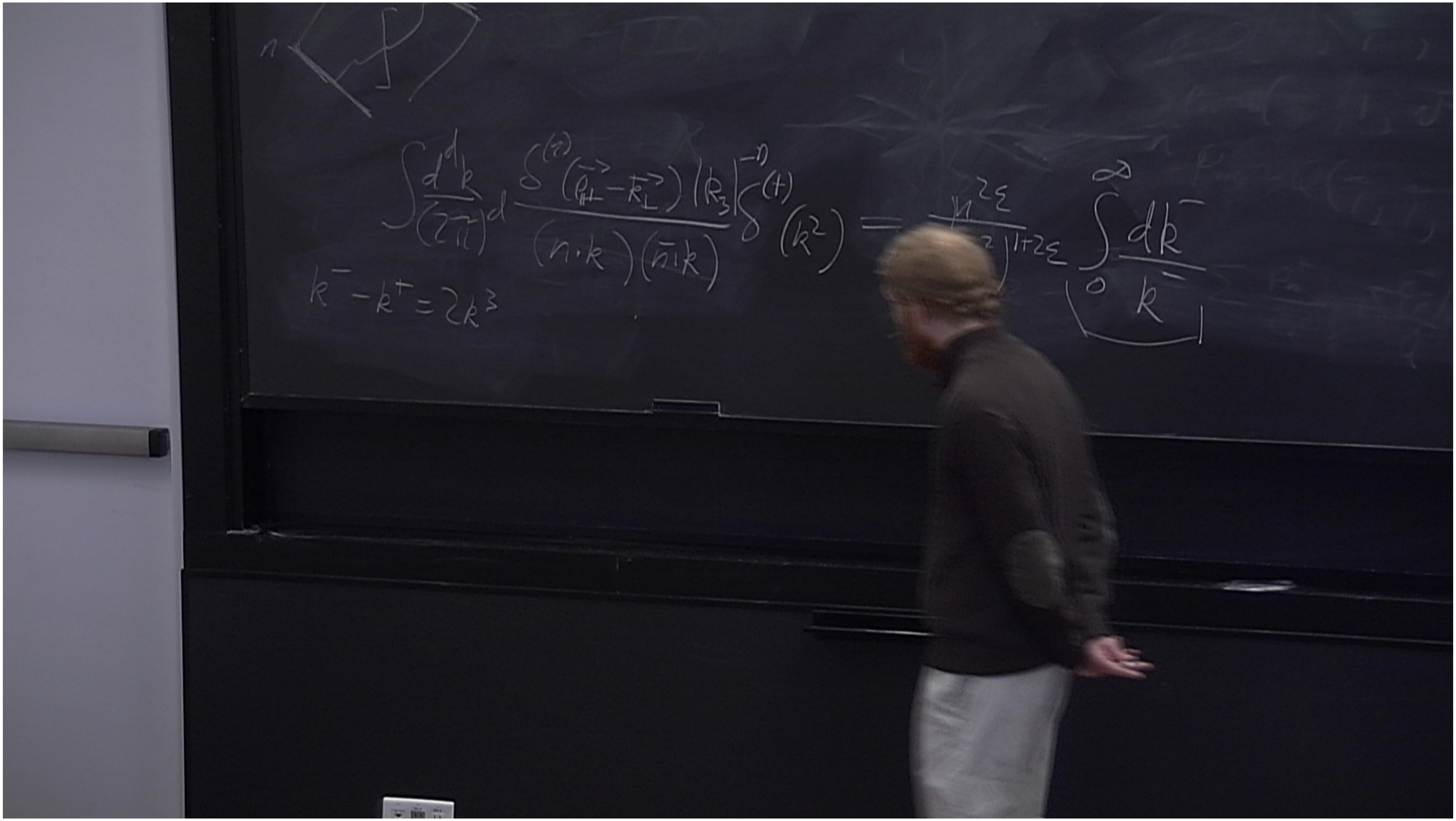

• Gauge Invariant
• Preserve Exponentiation
= Exp

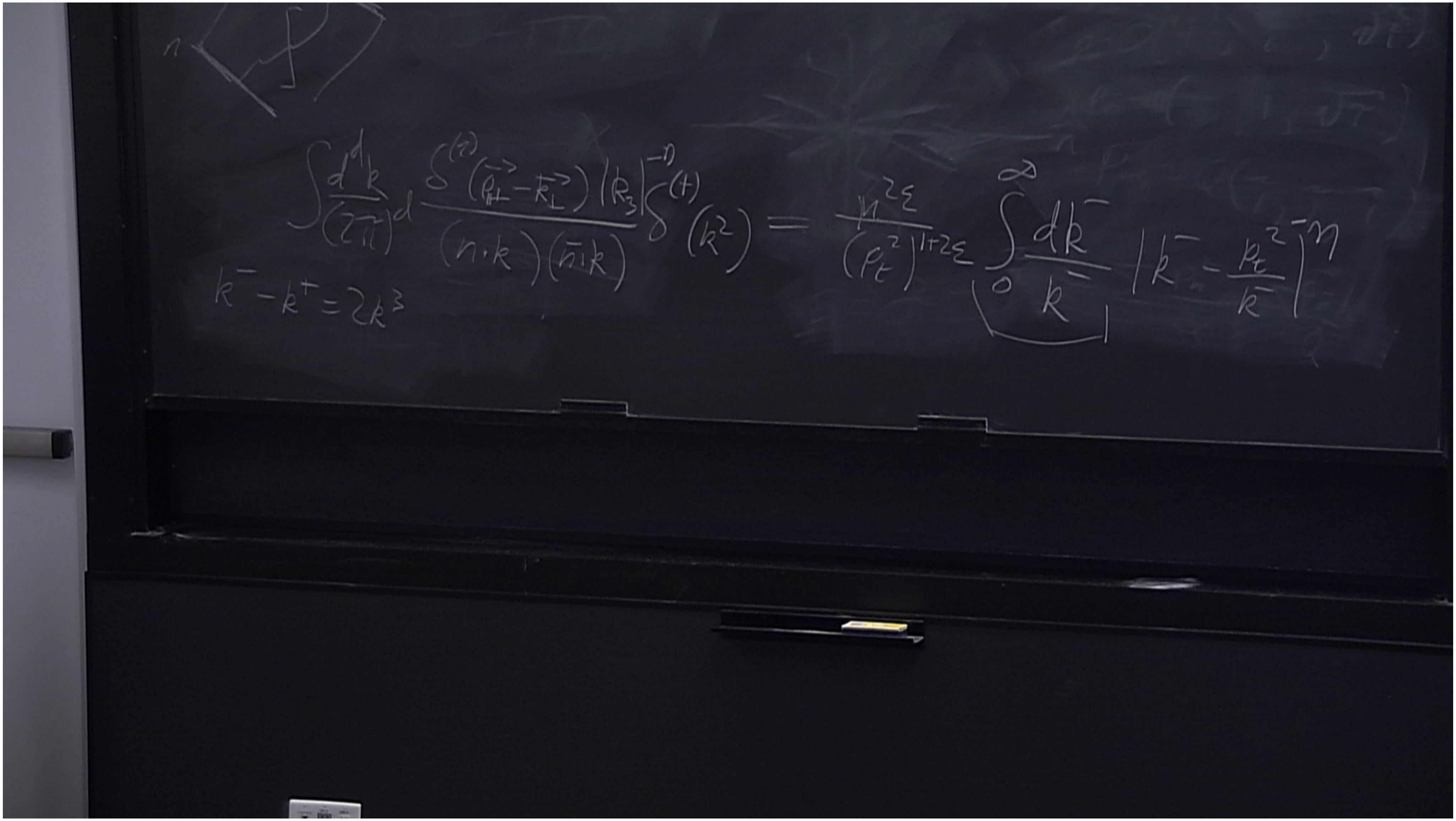

• Gauge Invariant
• Preserve Exponentiation
• Renormalize → RG
= Exp[ ]

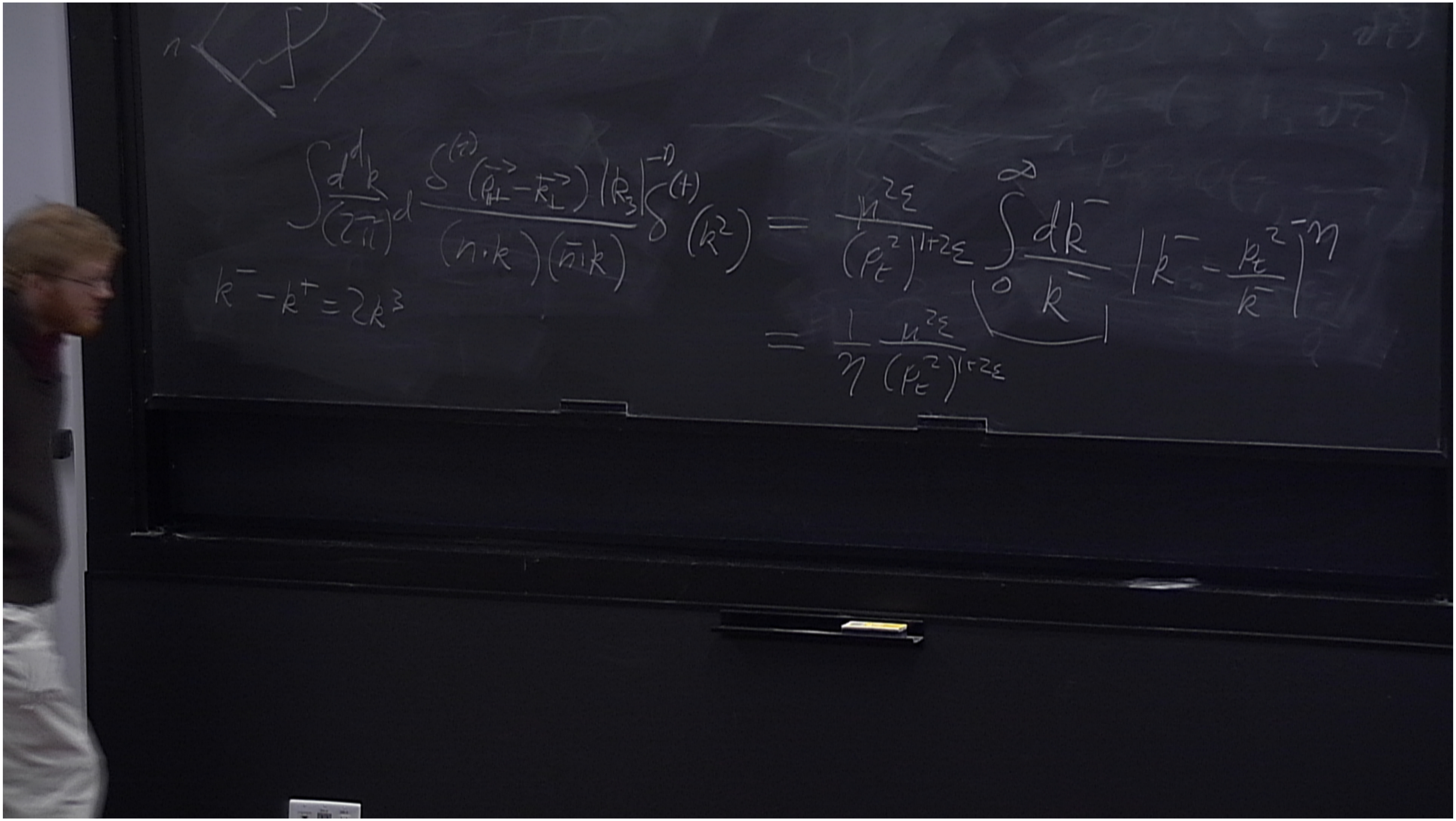

• Gauge Invariant
• Preserve Exponentiation
• Renormalize → RG
= Exp

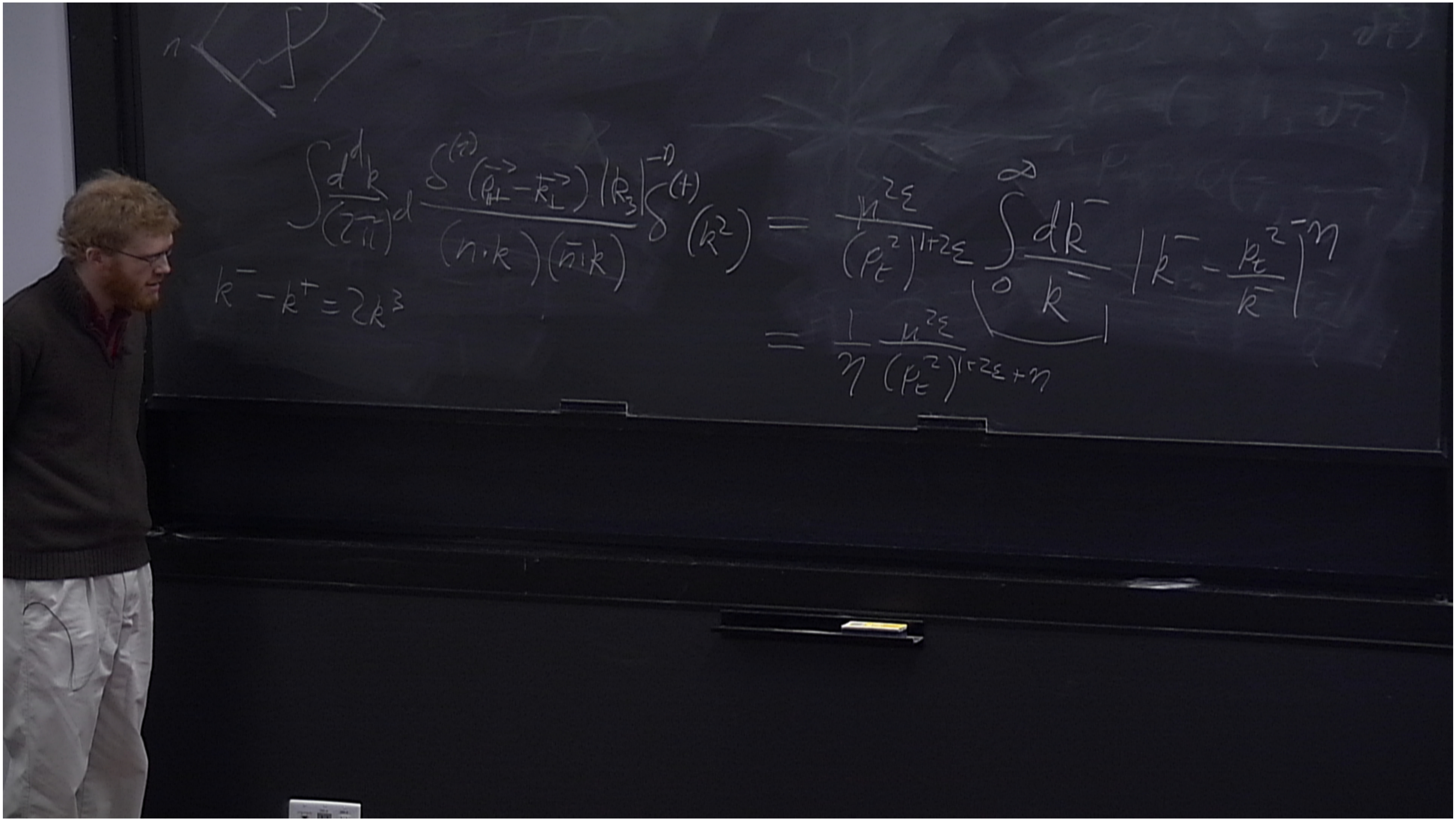



∫ d^d k/(2π)^d δ^(2)(p⃗⊥ − k⃗⊥) |k3|^−D δ^(+)(k²)/((n·k)(n̄·k)) = μ^2ε/(pt²)^(1+2ε) ∫_0^∞ dk⁻/k⁻
k⁻ − k⁺ = 2k³

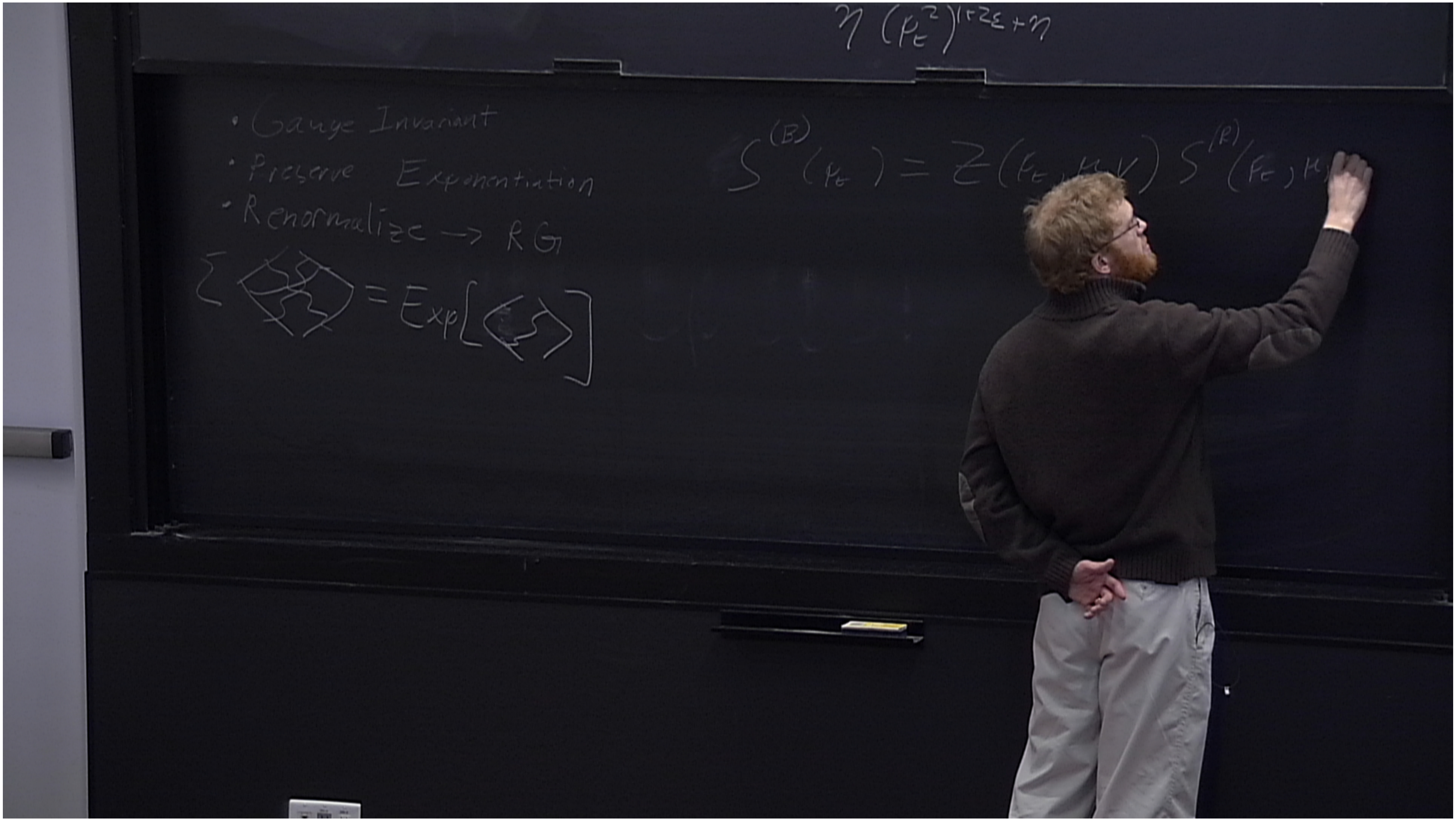

k⁻ − k⁺ = 2k³

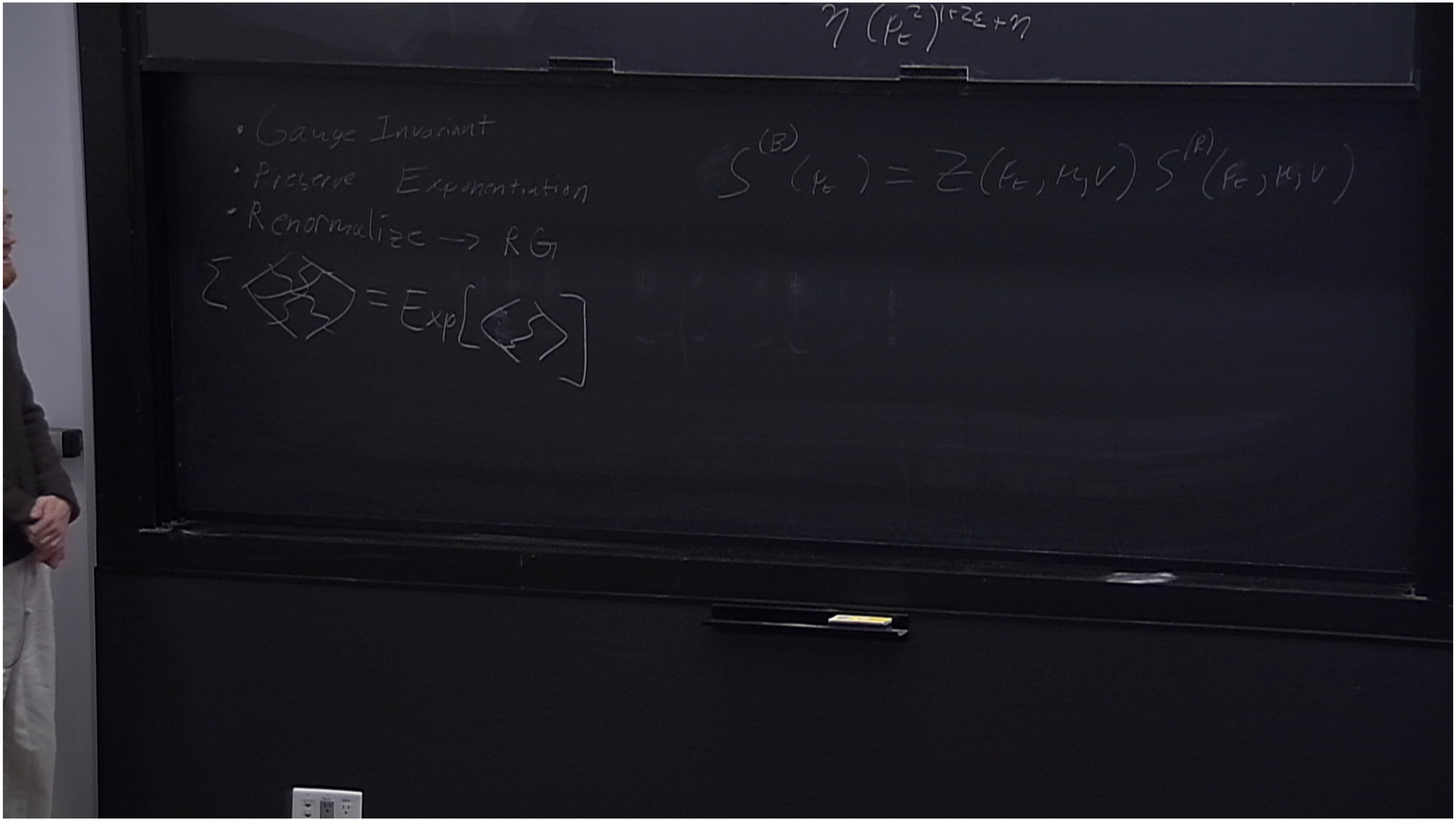

$\int \frac{d^d k}{(2\pi)^d} \frac{\delta^{(2)}(\vec{p}_\perp - \vec{k}_\perp)\, |k_3|^{-\eta}}{(n\cdot k)(\bar{n}\cdot k)} \delta^{(+)}(k^2) = \frac{\nu^{2\varepsilon}}{(p_t^2)^{1+2\varepsilon}} \int_0^\infty \frac{dk^-}{k^-} \left| k^- - \frac{p_t^2}{k^-} \right|^{-\eta}$
$k^- - k^+ = 2k^3$

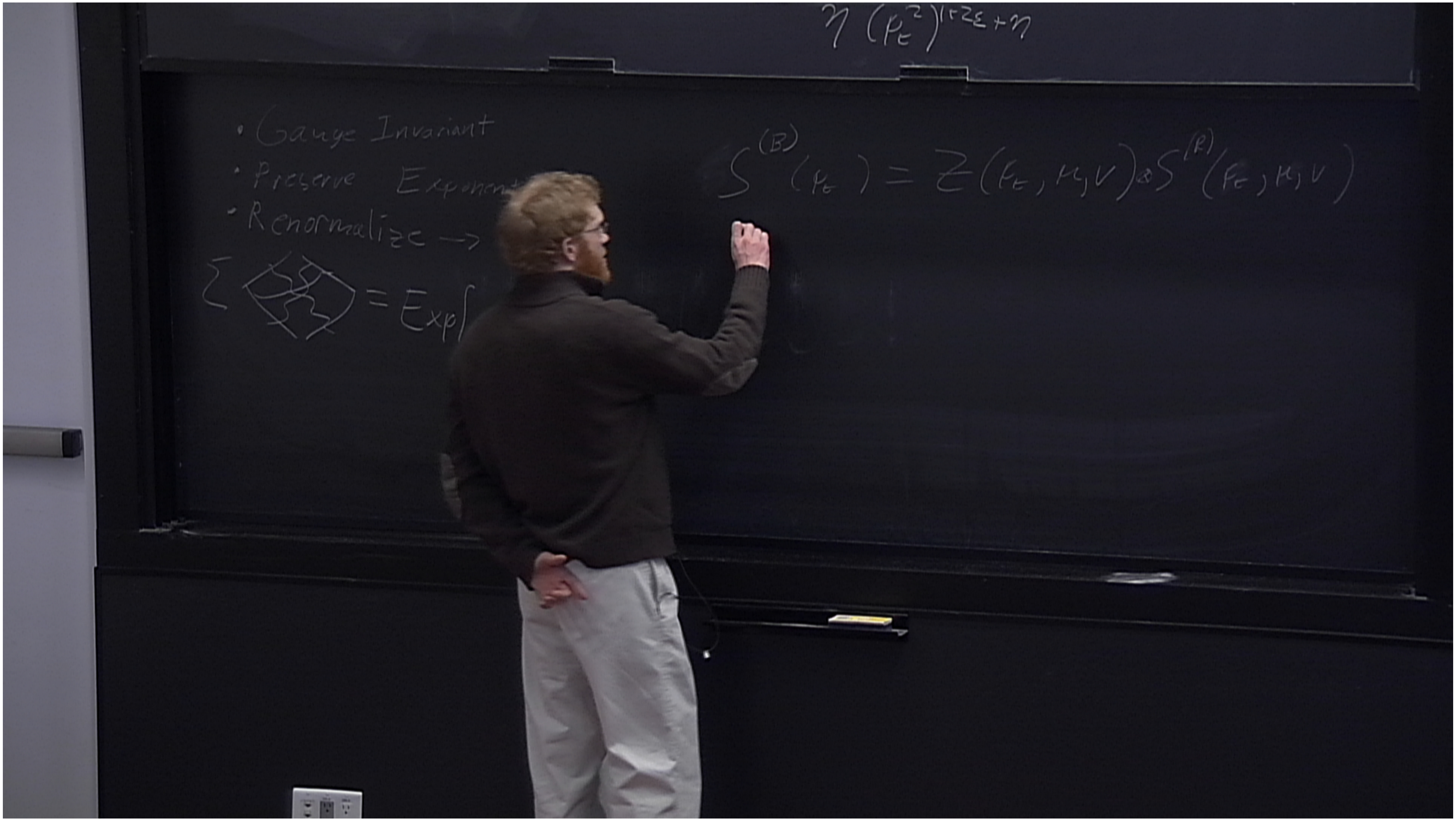

$\int \frac{d^d k}{(2\pi)^d} \frac{\delta^{(2)}(\vec{p}_\perp - \vec{k}_\perp) |k_3|^{-\eta}}{(n \cdot k)(\bar{n} \cdot k)} \delta^{(+)}(k^2) = \frac{\mu^{2\varepsilon}}{(p_t^2)^{1+2\varepsilon}} \int_0^\infty \frac{dk^-}{k^-} \left| k^- - \frac{p_t^2}{k^-} \right|^{-\eta}$
$k^- - k^+ = 2k^3$
$= \frac{1}{\eta} \frac{\mu^{2\varepsilon}}{(p_t^2)^{1+2\varepsilon}}$

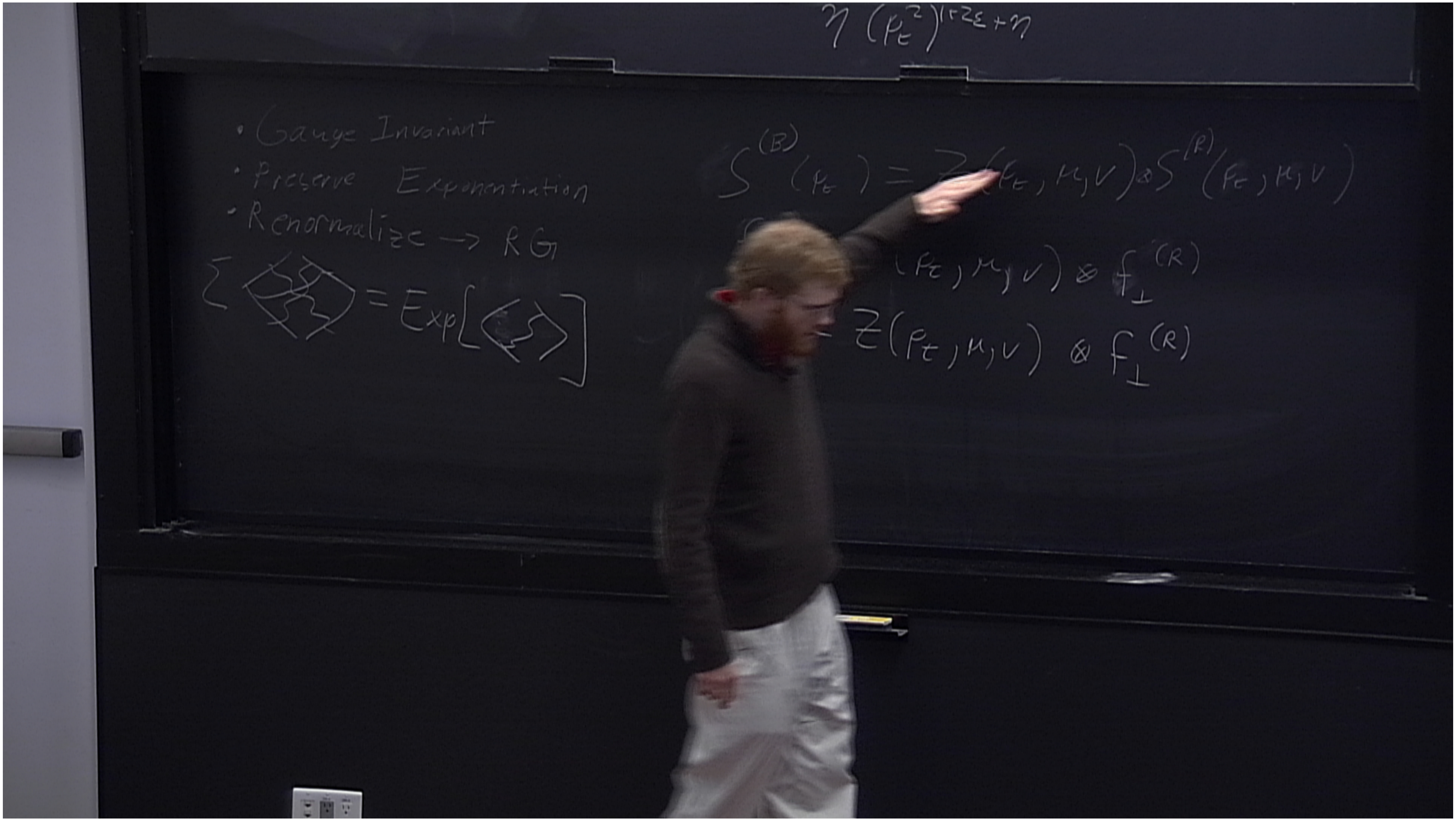


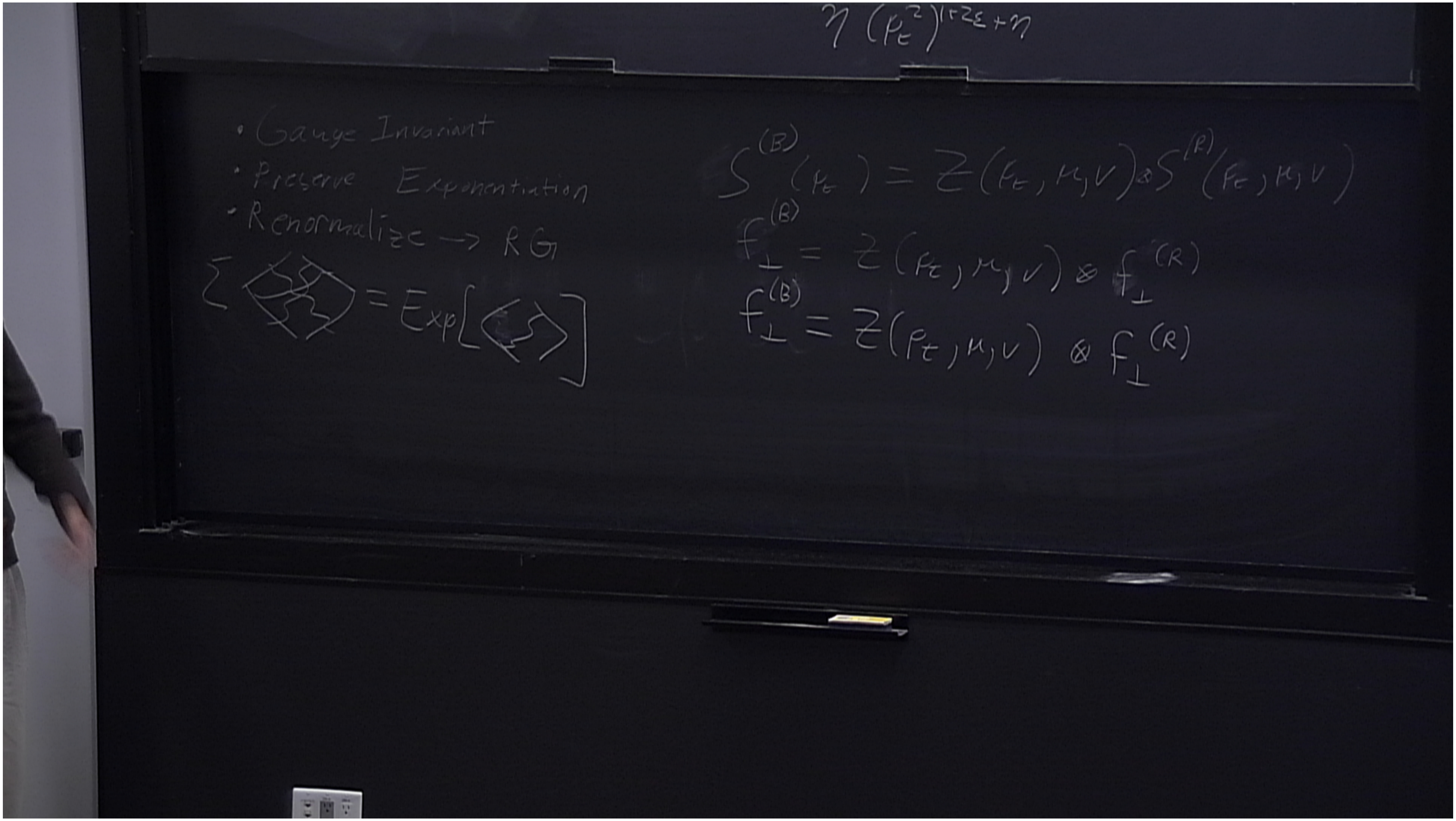
$\int \frac{d^d k}{(2\pi)^d} \frac{\delta^{(2)}(\vec{p}_\perp - \vec{k}_\perp)\,|k_3|^{-\eta}}{(n\cdot k)(\bar{n}\cdot k)} \delta^{(+)}(k^2) = \frac{\mu^{2\epsilon}}{(p_t^2)^{1+2\epsilon}} \int_0^\infty \frac{dk^-}{k^-} \left| k^- - \frac{p_t^2}{k^-} \right|^{-\eta}$
$= \frac{1}{\eta} \frac{\mu^{2\epsilon}}{(p_t^2)^{1+2\epsilon+\eta}}$
$k^- - k^+ = 2k^3$

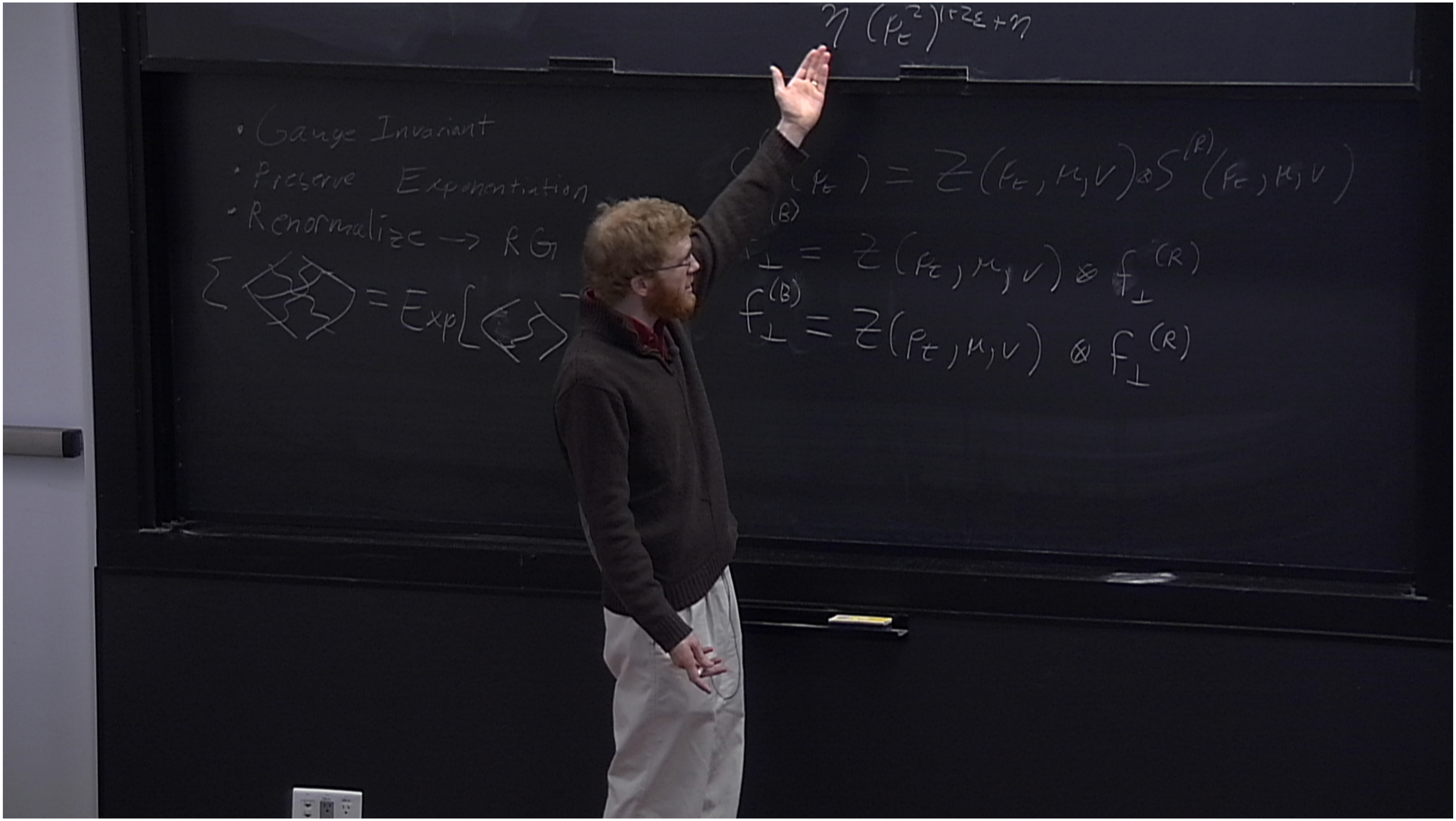

• Gauge Invariant
• Preserve Exponentiation
• Renormalize → RG

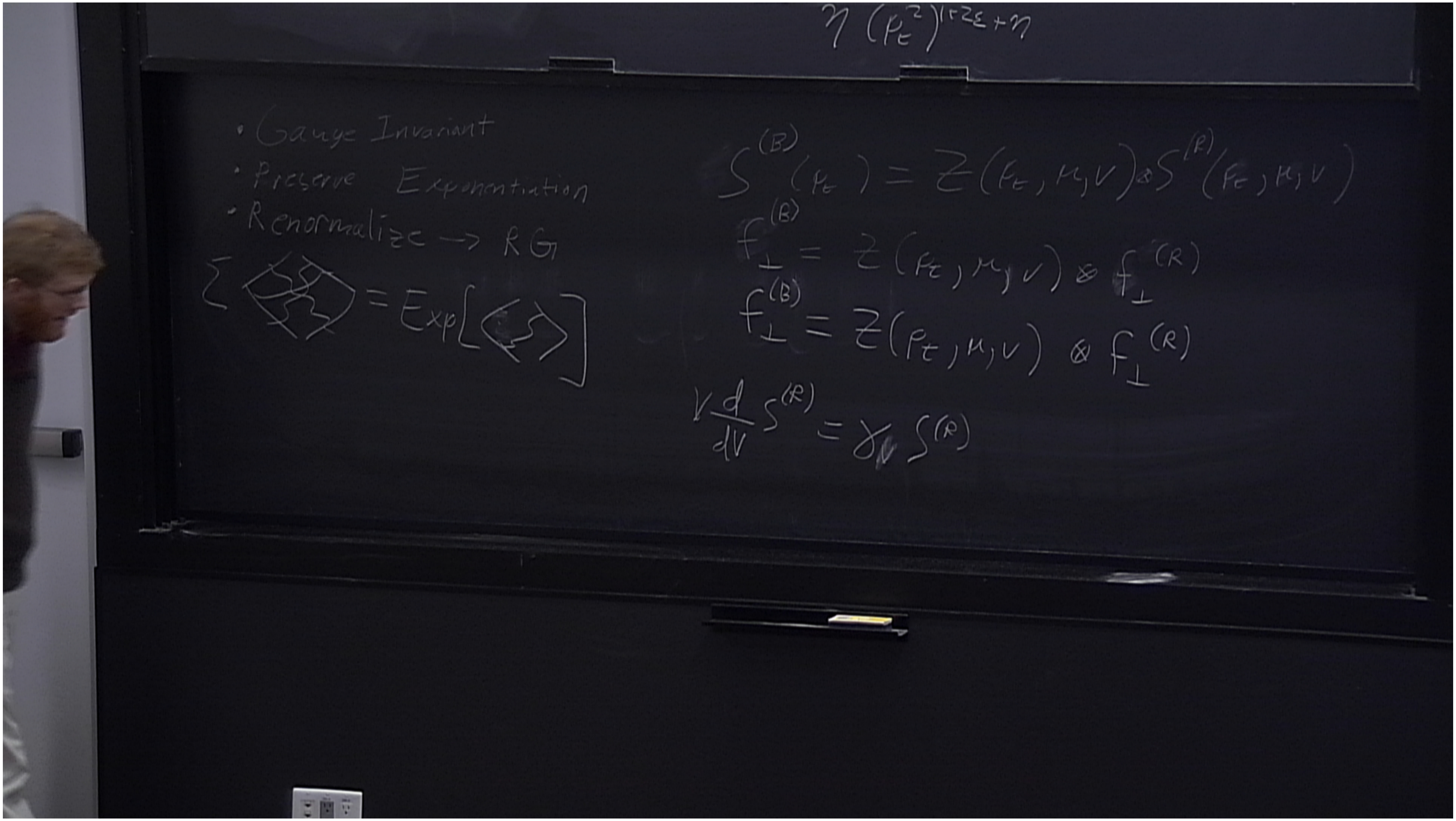

$\eta\,(p_t^2)^{1+2\varepsilon+\eta}$
• Gauge Invariant
• Preserve Exponentiation
• Renormalize → RG
$S^{(B)}(p_t) = Z(p_t, \mu, \nu)\, S^{(R)}(p_t, \mu, \nu)$
= Exp

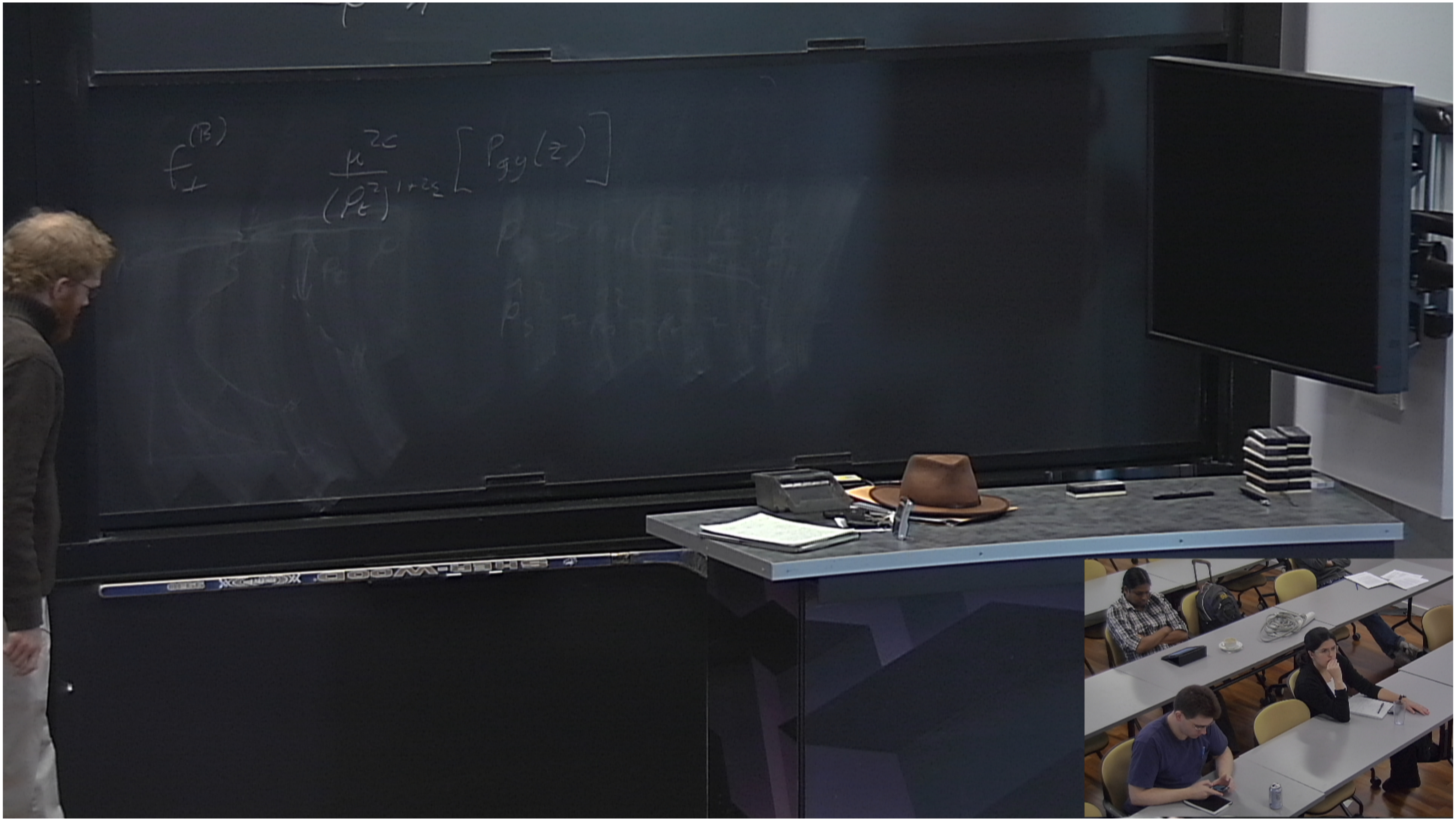

• Gauge Invariant
• Preserve Exponent
• Renormalize →

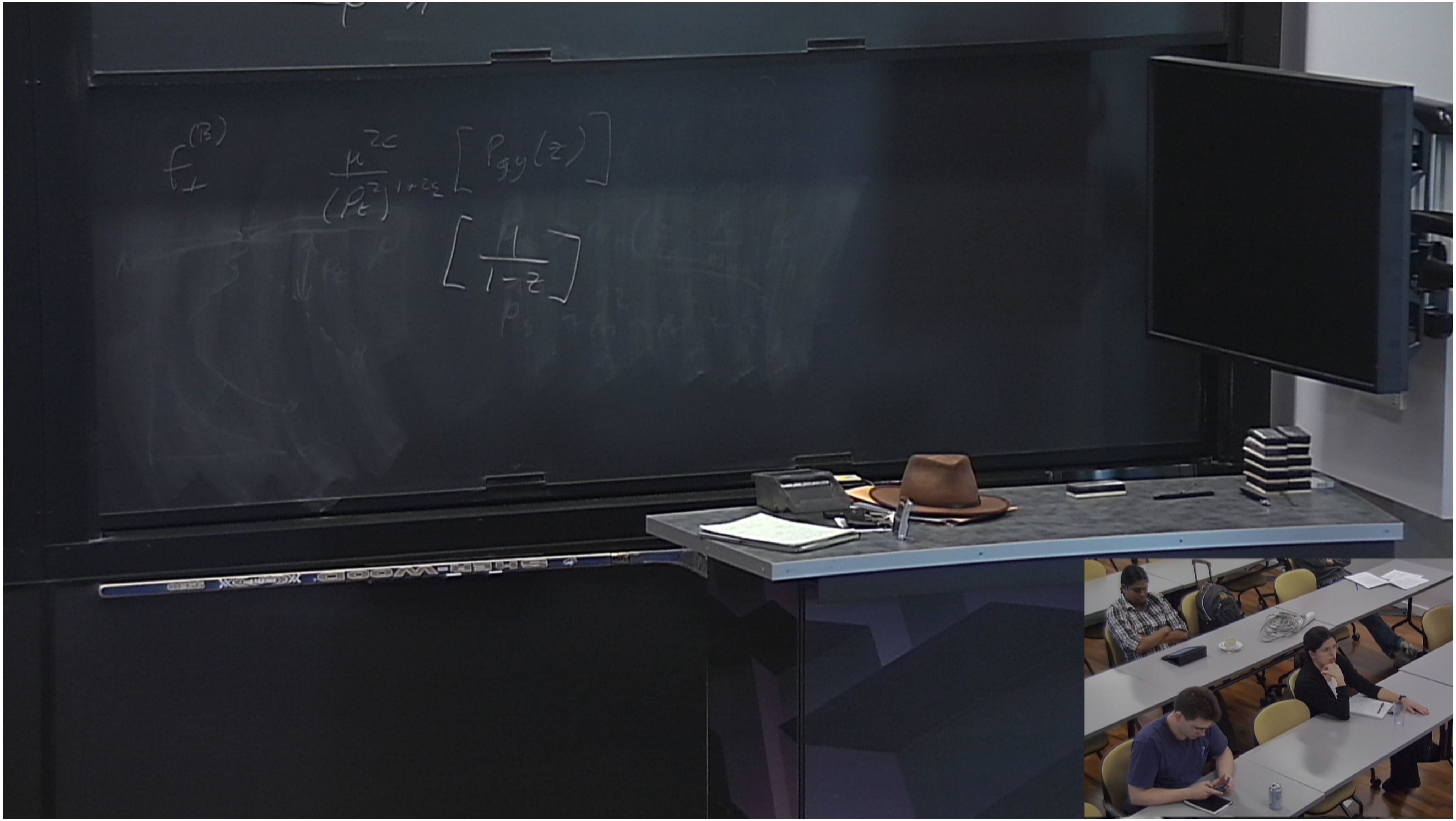

• Gauge Invariant
• Preserve Exponentiation
• Renormalize → RG
= Exp

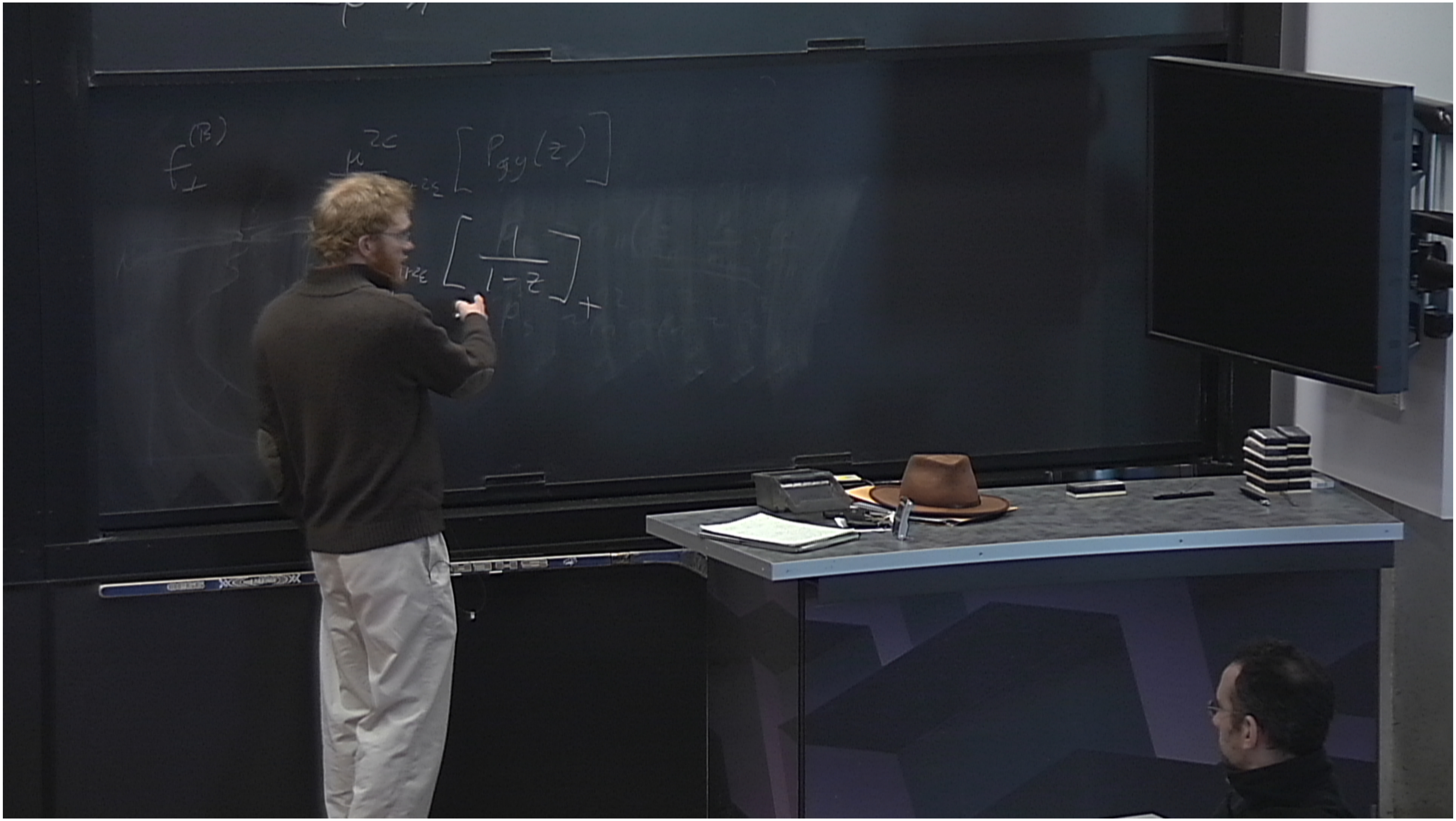

η (p_t^2)^{1+2ε+η}
• Gauge Invariant
• Preserve Exponentiation
• Renormalize → RG
= Exp
S^(B)(p_t) = Z(p_t, μ, ν) ⊗ S^(R)(p_t, μ, ν)
f_⊥^(B) = Z(p_t, μ, ν) ⊗ f_⊥^(R)
f_⊥^(B) = Z(p_t, μ, ν) ⊗ f_⊥^(R)

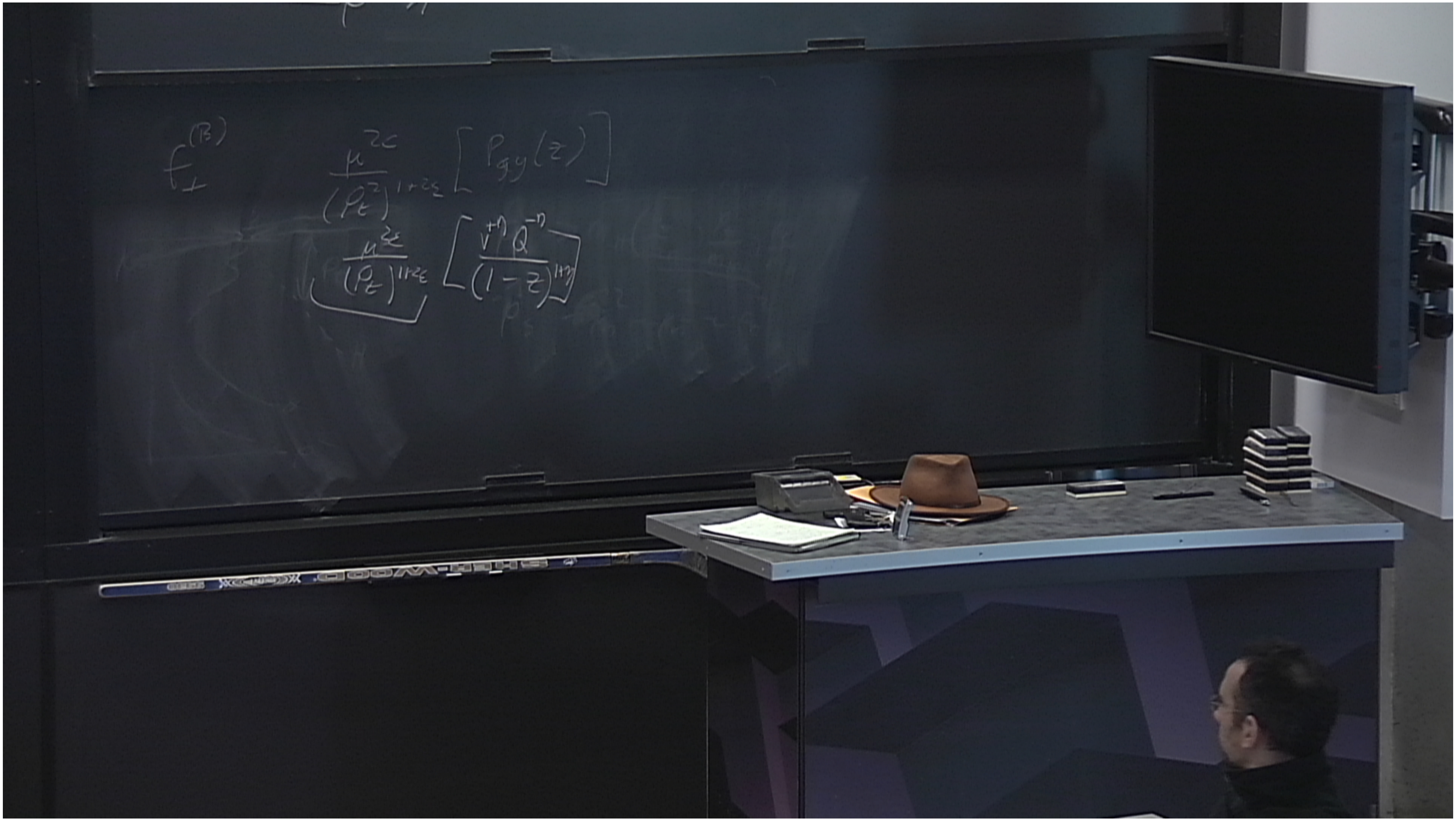

• Gauge Invariant
• Preserve Exponentiation
• Renormalize → RG
$f_\perp^{(B)} = Z(p_t, \mu, \nu) \otimes f_\perp^{(R)}$

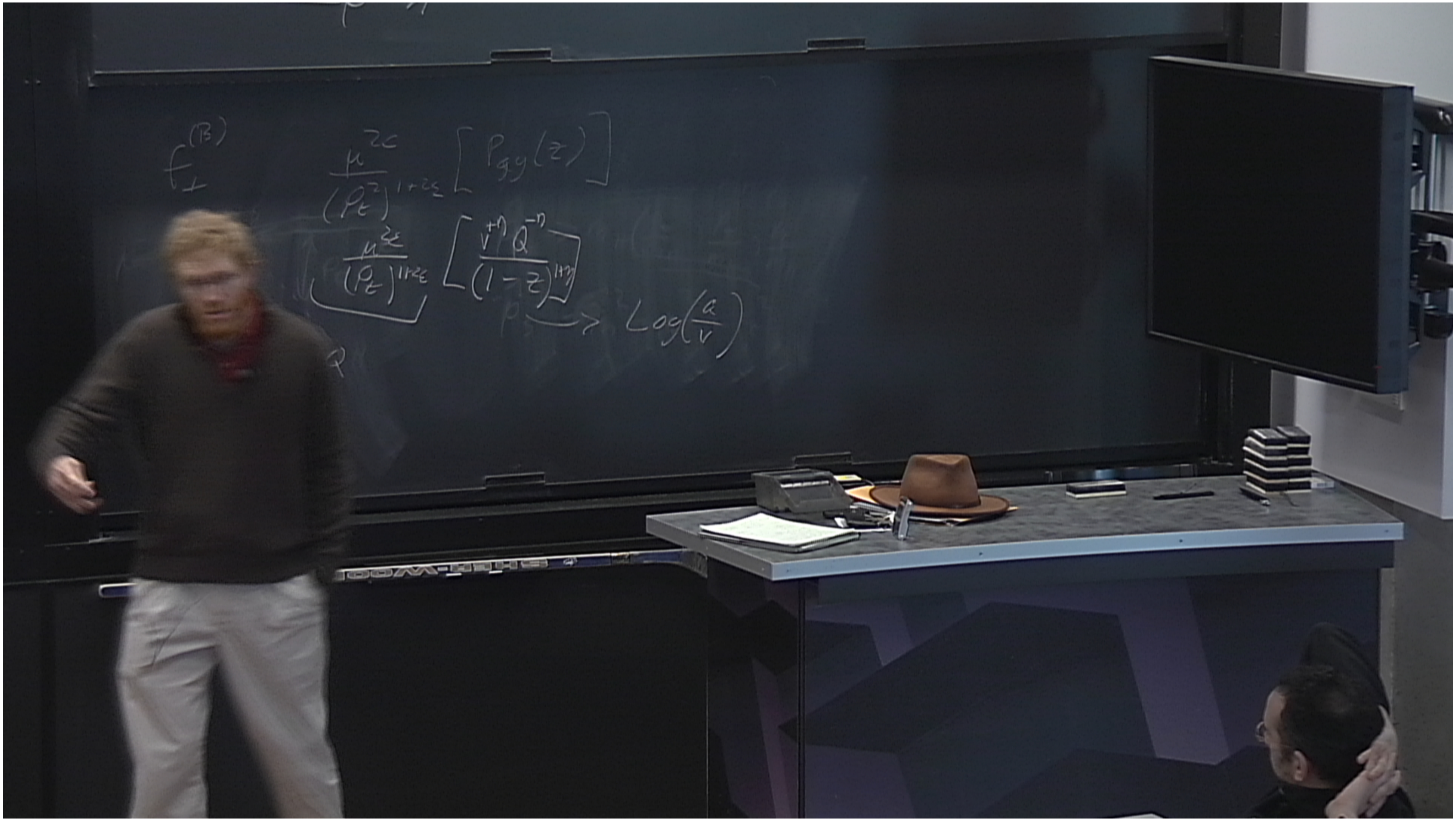

η (p_t^2)^{1+2ε+η}
• Gauge Invariant
• Preserve Exponentiation
• Renormalize → RG
Σ = Exp[ ]
S^(B)(p_t) = Z(p_t, μ, ν) ⊗ S^(R)(p_t, μ, ν)
f_⊥^(B) = Z(p_t, μ, ν) ⊗ f_⊥^(R)
f_⊥^(B) = Z(p_t, μ, ν) ⊗ f_⊥^(R)
ν d/dν S^(R) = γ_ν S^(R)

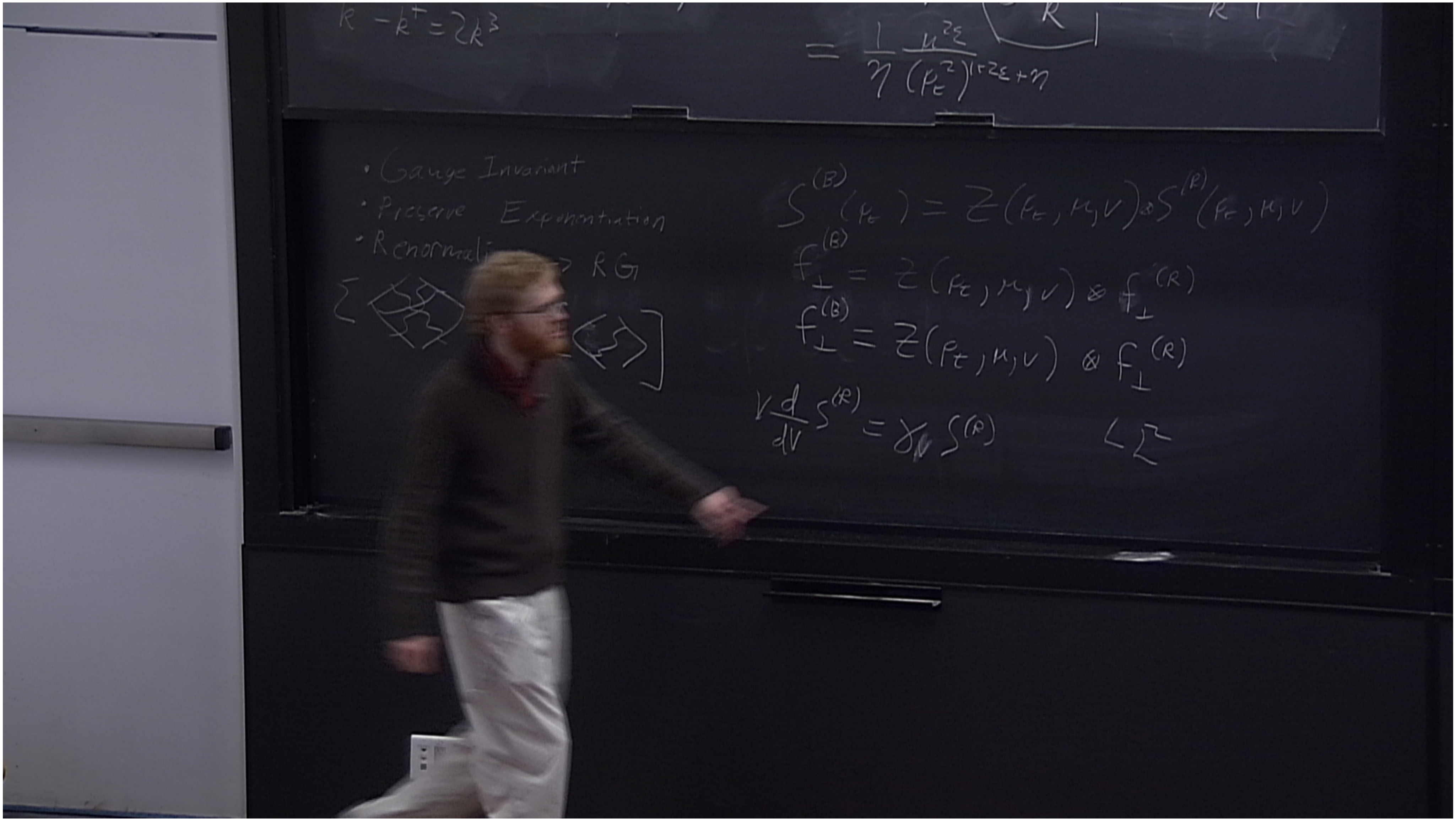








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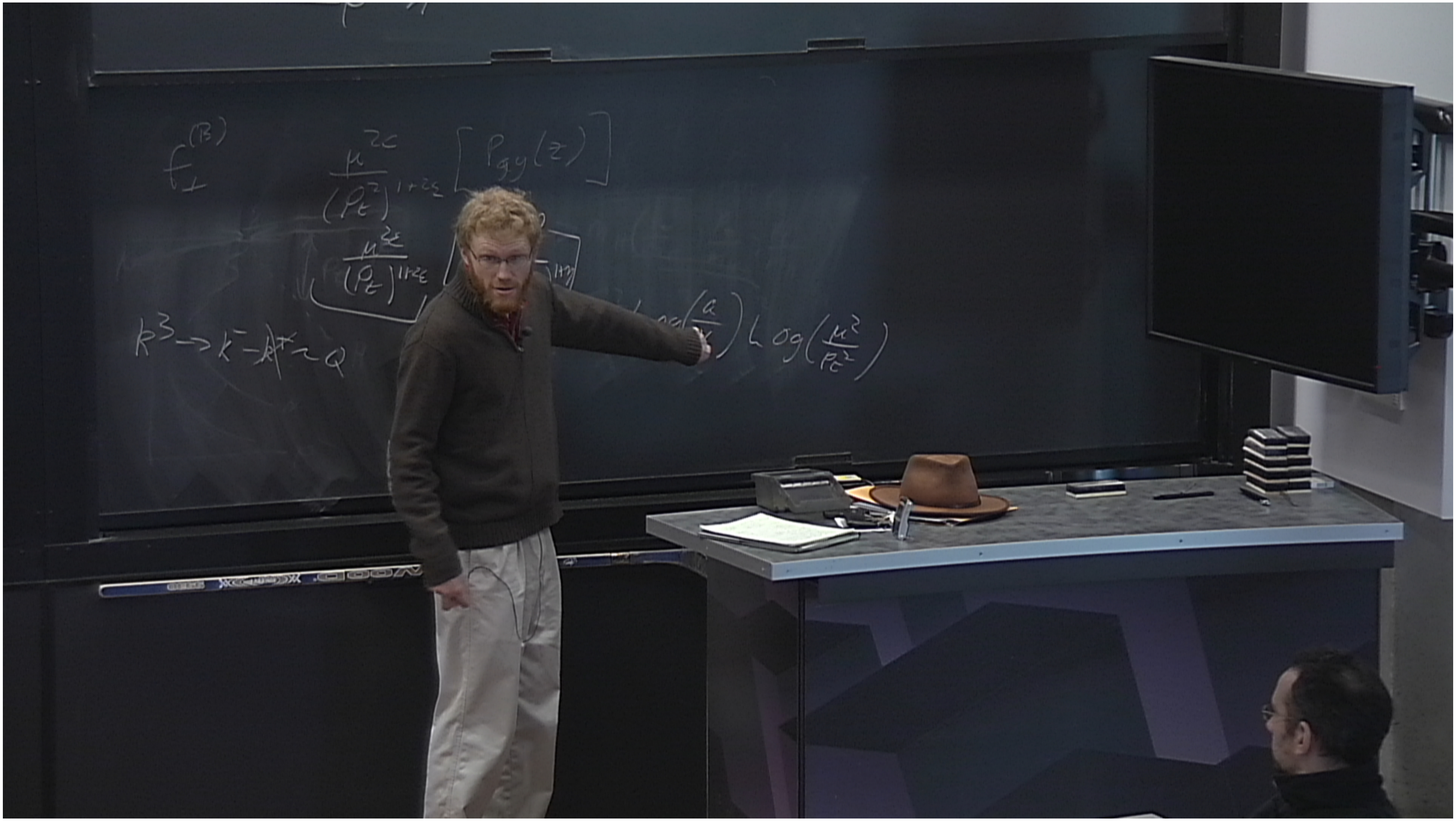
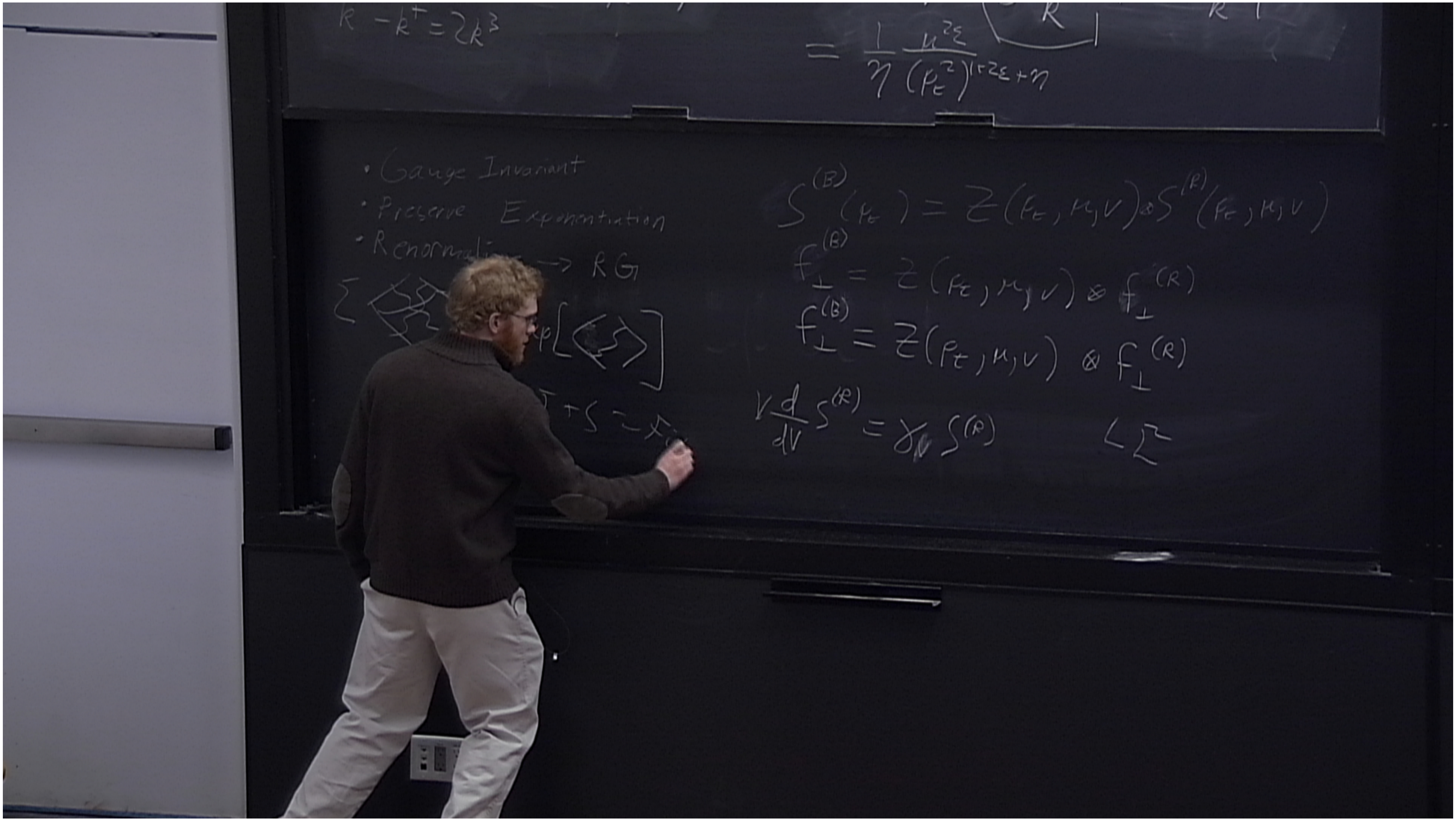
• Preserve Exponentiation
RG




• Gauge Invariant
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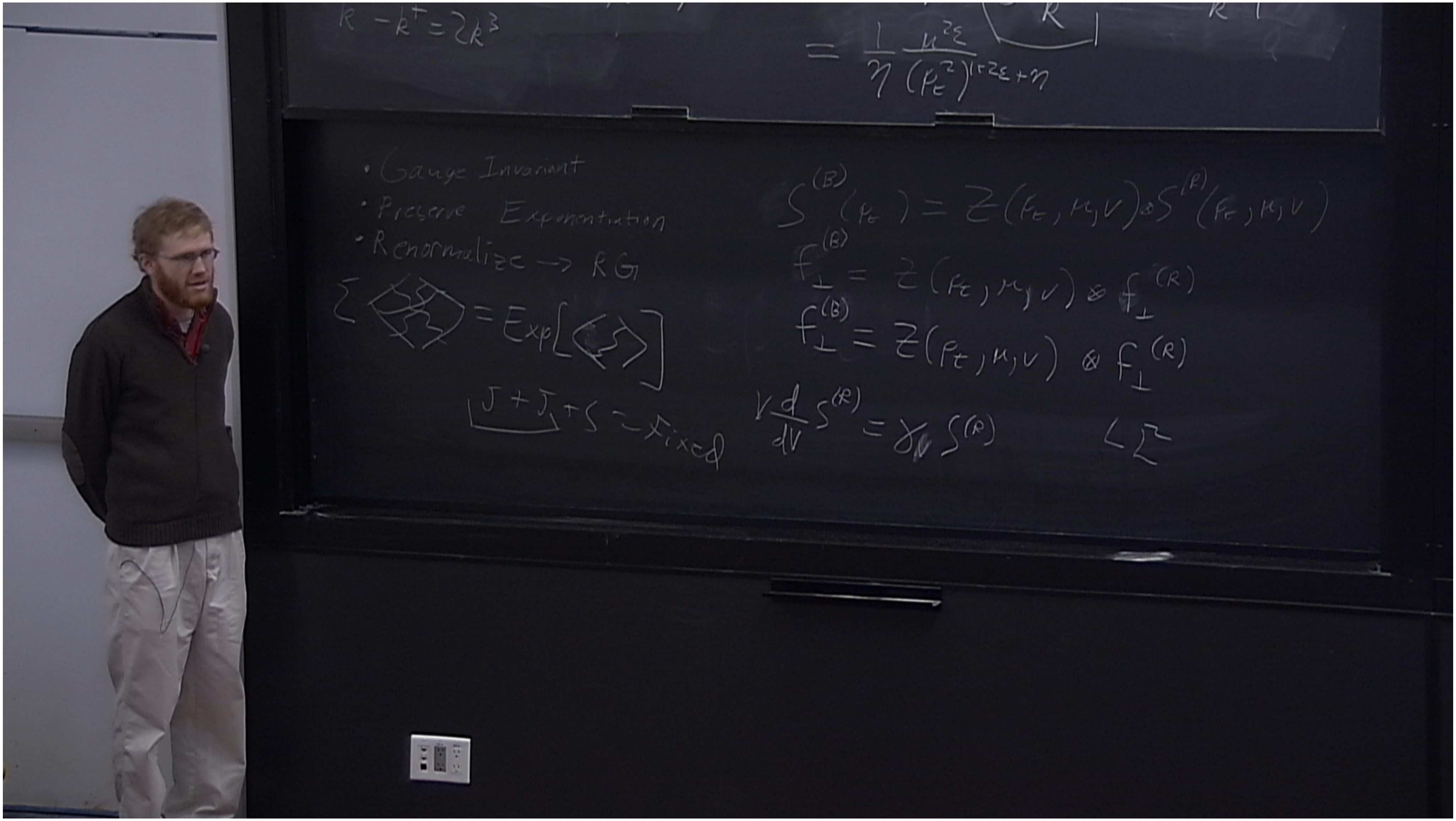
• Gauge Invariant
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