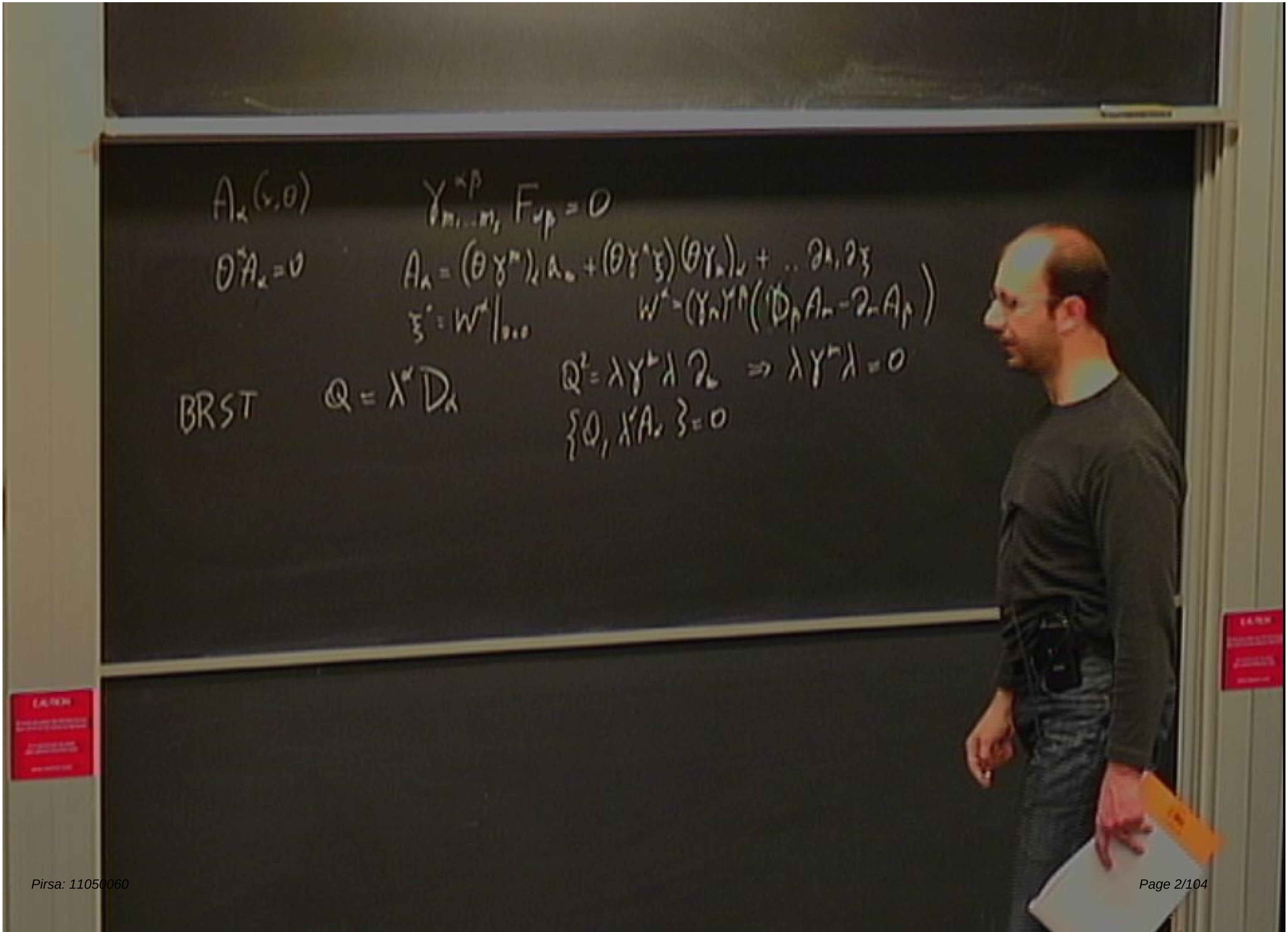
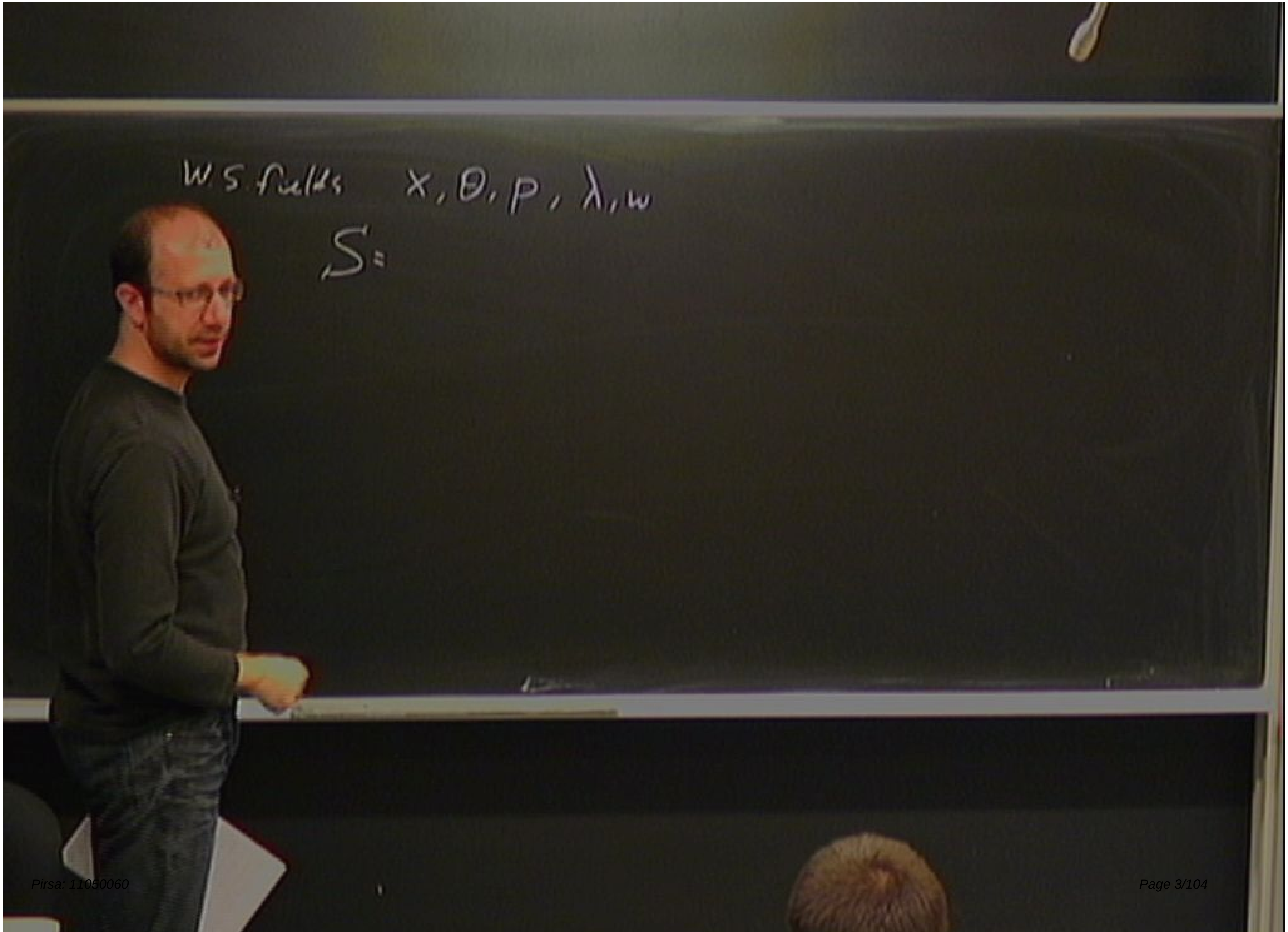
Title: Part 2: An introduction to the pure-spinor formalism for the superstring

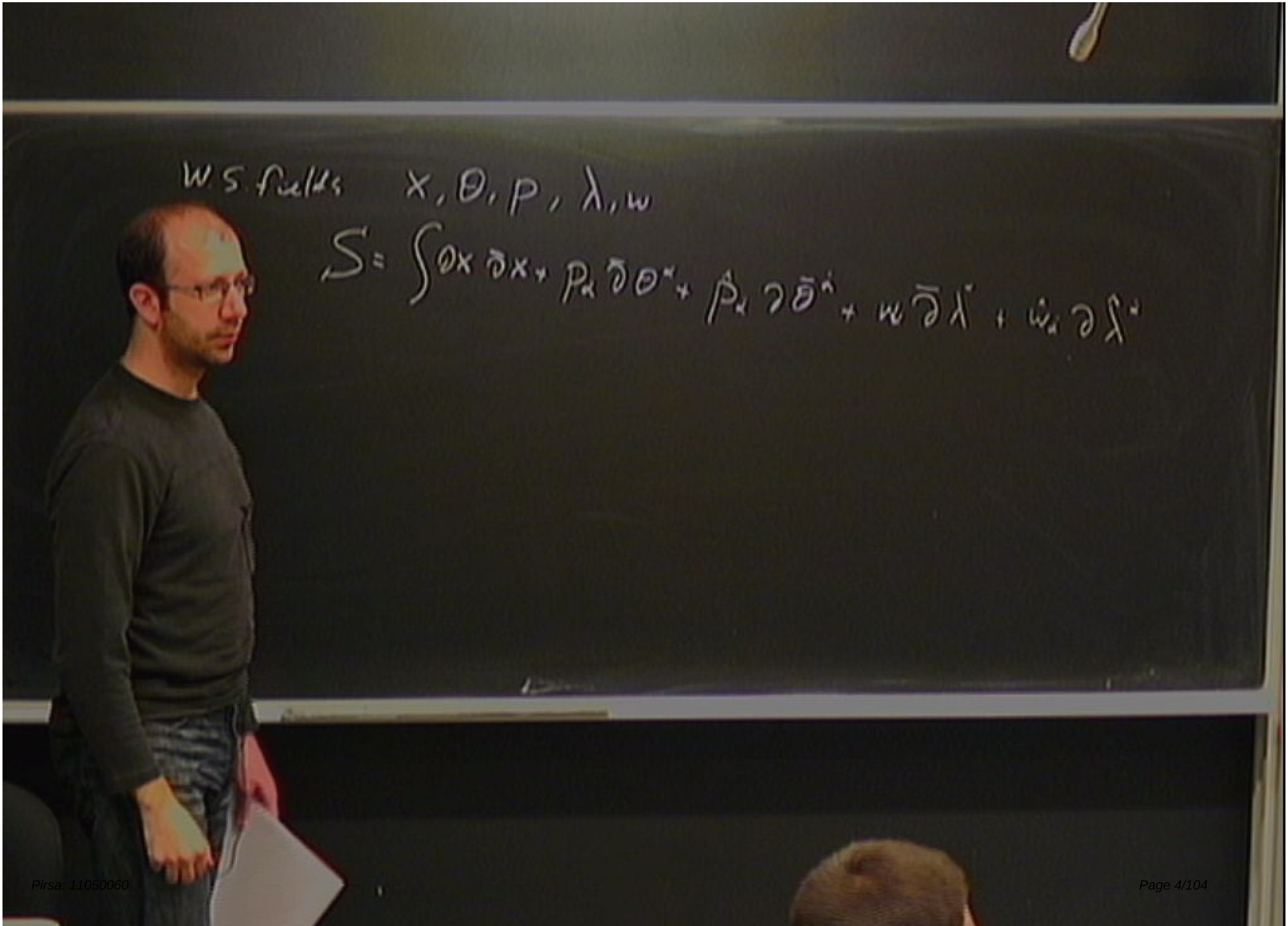
Date: May 12, 2011 11:00 AM

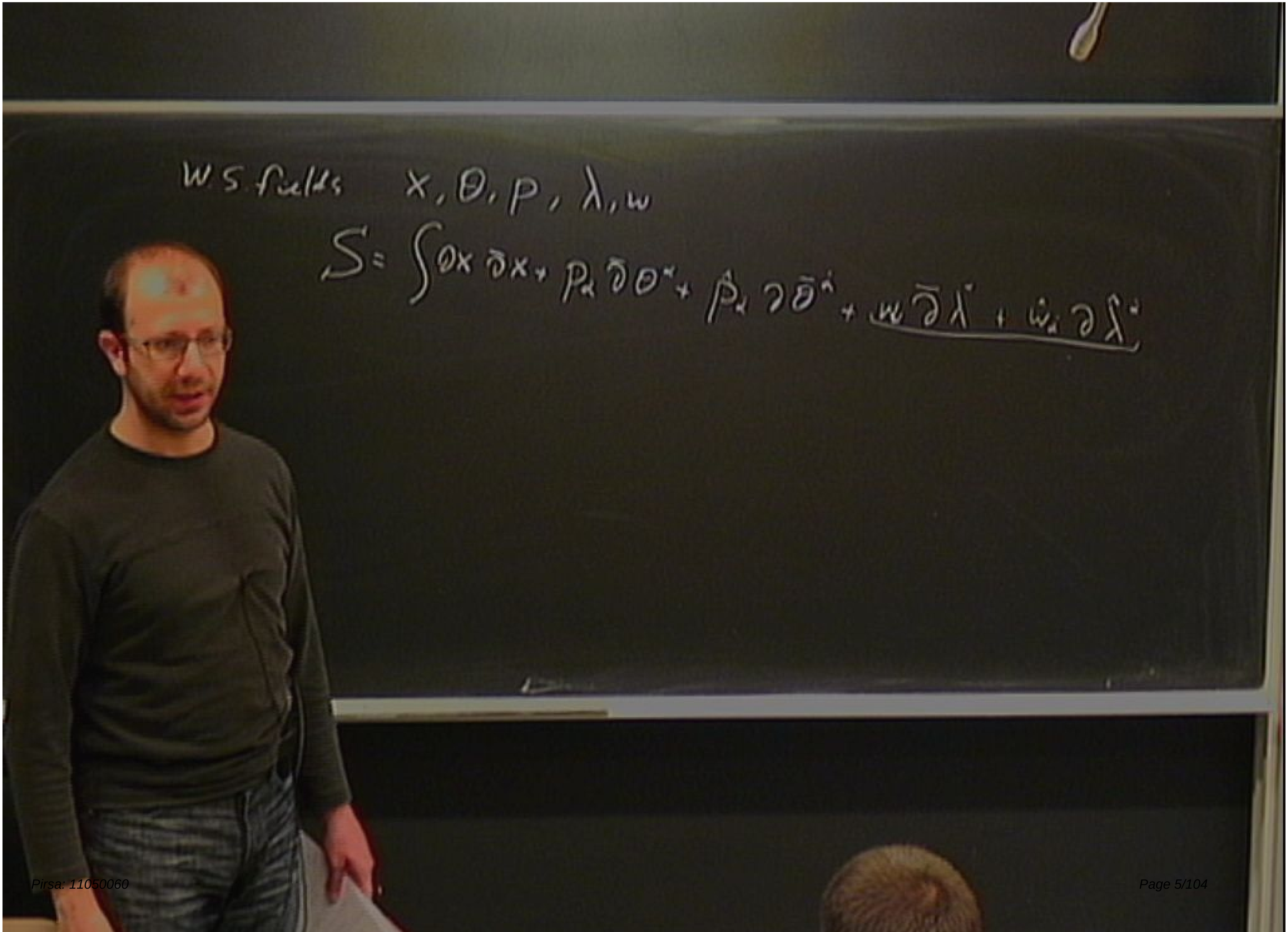
URL: http://pirsa.org/11050060

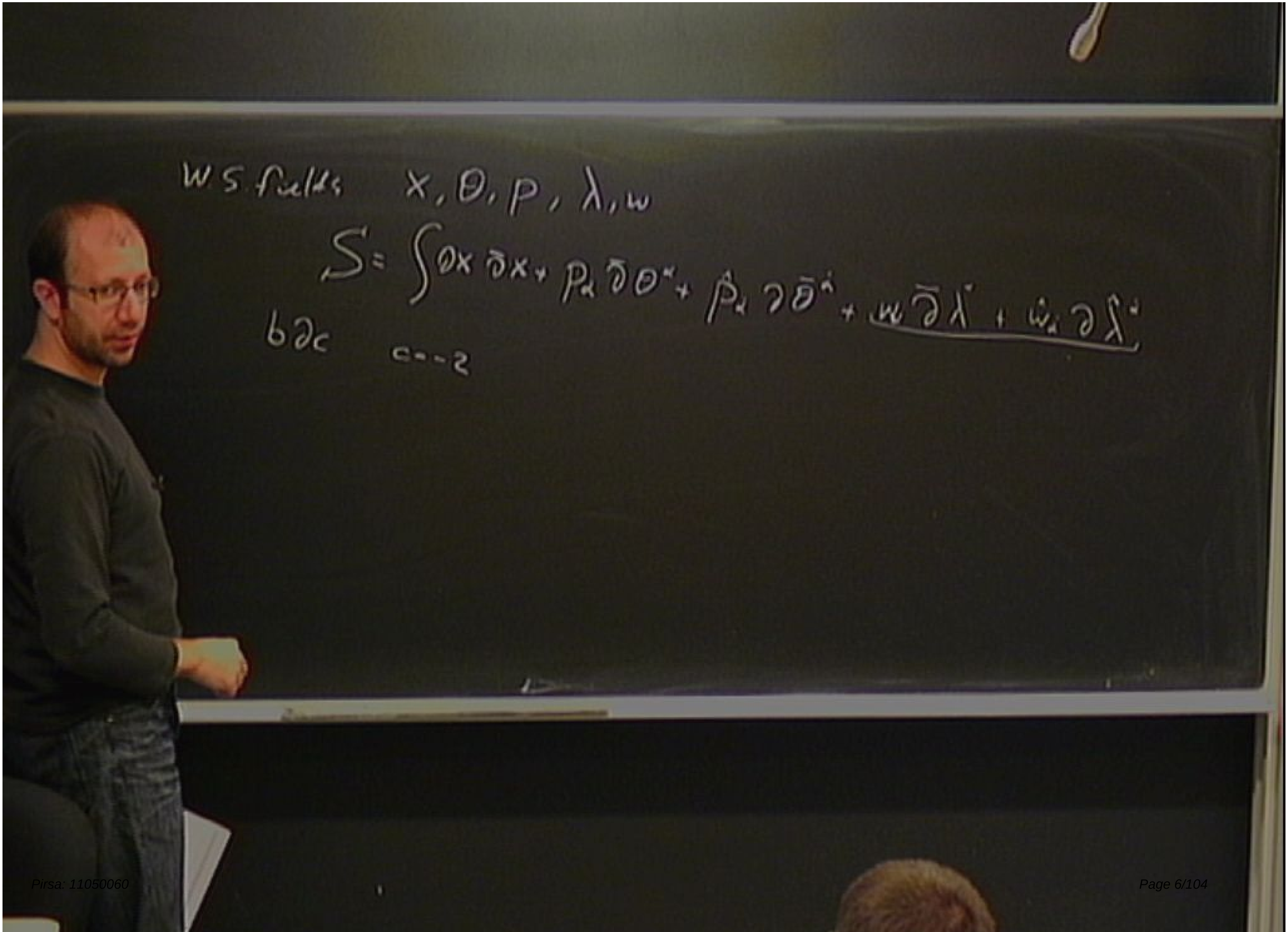
Abstract: Higher loop amplitudes and non-minimal formalism


$A_\alpha(x,\theta)$
$\gamma^{\alpha\beta}_{m_1 \dots m_5} F_{\alpha\beta} = 0$
$\theta^\alpha A_\alpha = 0$
$A_\alpha = (\theta\gamma^m)_\alpha a_m + (\theta\gamma^n\xi)(\theta\gamma_n)_\alpha + \dots \partial a, \partial\xi$
$\xi^\alpha = W^\alpha|_{\theta=0}$
$W^\alpha = (\gamma_m\gamma^n)(D_n A_m - \partial_m A_n)$
BRST
$Q = \lambda^\alpha D_\alpha$
$Q^2 = \lambda\gamma^m\lambda\,\partial_m \Rightarrow \lambda\gamma^m\lambda = 0$
$\{Q, \lambda^\alpha A_\alpha\} = 0$
CAUTION


W.S. fields X, Θ, p, λ, w
S=


W.S. fields x, θ, p, λ, w
S = ∫ ∂x ∂̄x + p_α ∂̄θ^α + p̂_α ∂θ̂^α + w_α ∂̄λ^α + ŵ_α ∂λ̂^α


W.S. fields x, θ, p, λ, w
$S = \int \partial x \bar{\partial} x + p_\alpha \bar{\partial} \theta^\alpha + \hat{p}_\alpha \partial \bar{\theta}^\alpha + w \bar{\partial} \lambda + \hat{w}_\alpha \partial \hat{\lambda}^\alpha$


W.S. fields X, θ, p, λ, w
$S = \int \partial x \bar\partial x + p_\alpha \bar\partial \theta^\alpha + \hat p_\alpha \partial \hat\theta^\alpha + w_\alpha \bar\partial \lambda^\alpha + \hat w_\alpha \partial \hat\lambda^\alpha$
$b\partial c$
$c = -2$

W.S. fields X, θ, p, λ, w

$$S = \int \partial x \bar{\partial} x + p_\alpha \bar{\partial} \theta^\alpha + \hat{p}_\alpha \partial \hat{\theta}^\alpha + w_\alpha \bar{\partial} \lambda^\alpha + \hat{w}_\alpha \partial \hat{\lambda}^\alpha$$

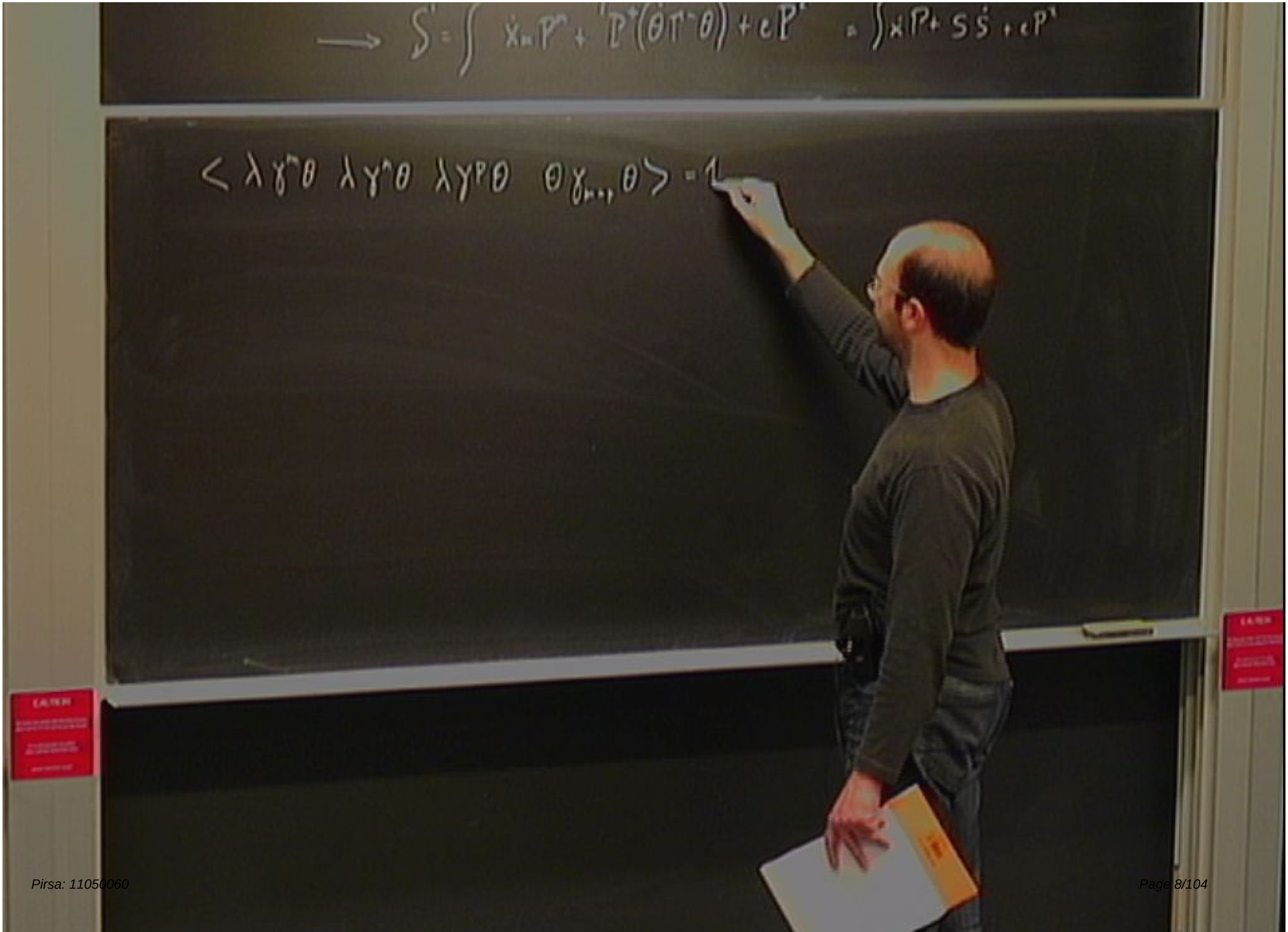
$b \partial c$ $\quad c = -2$, $+2$

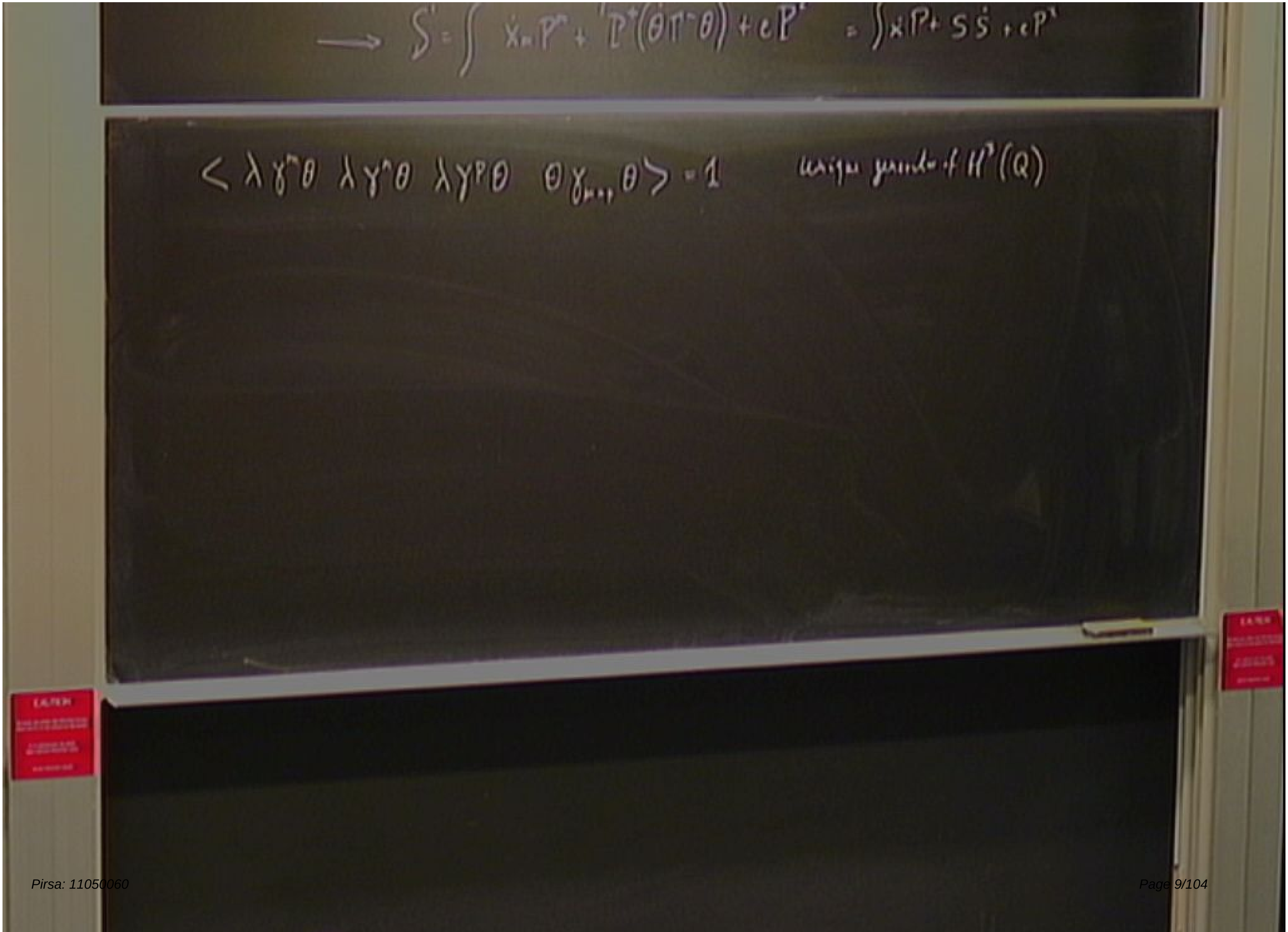
$c_x = 10$

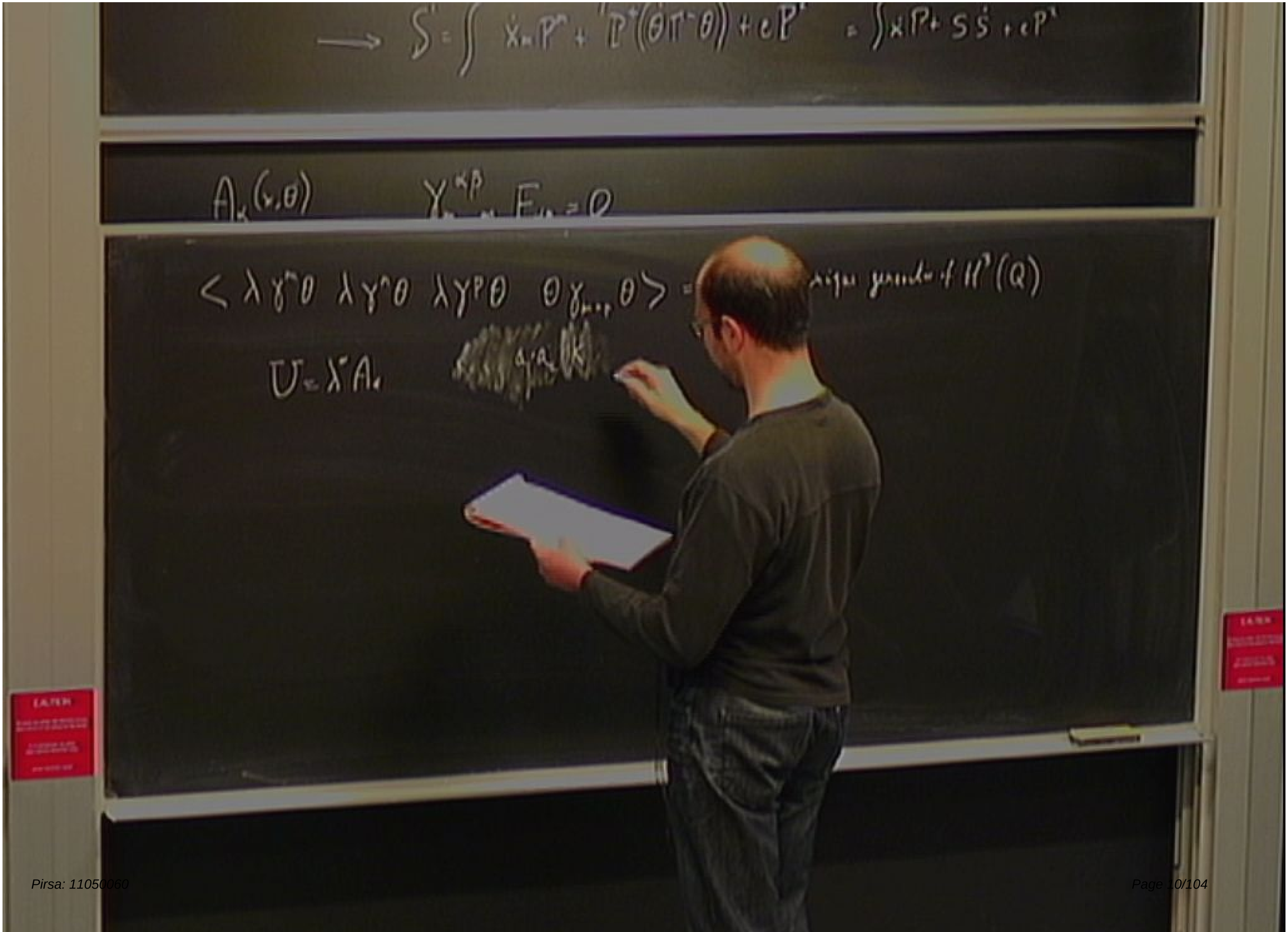
$c = -32$

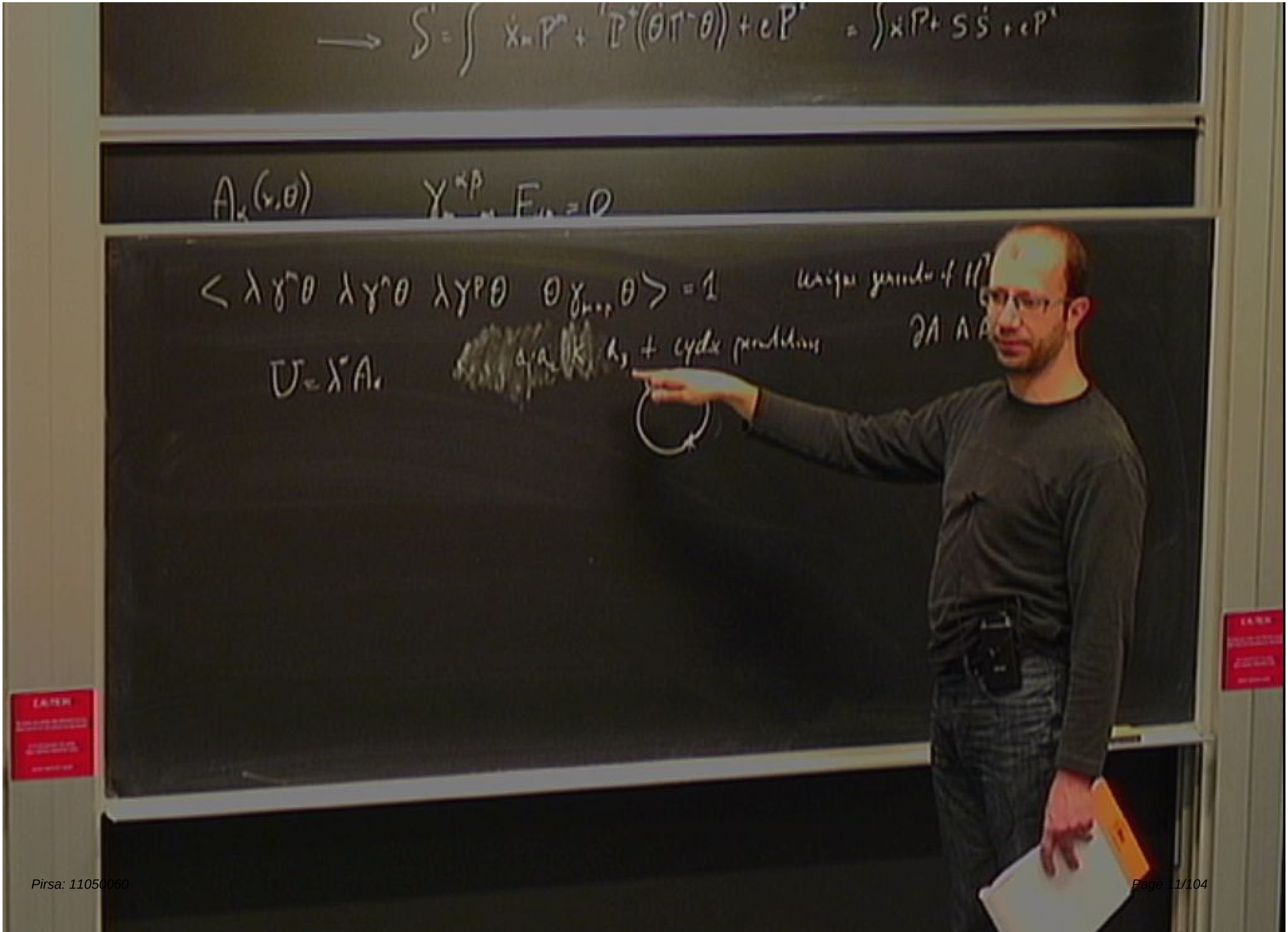
$c = 22$

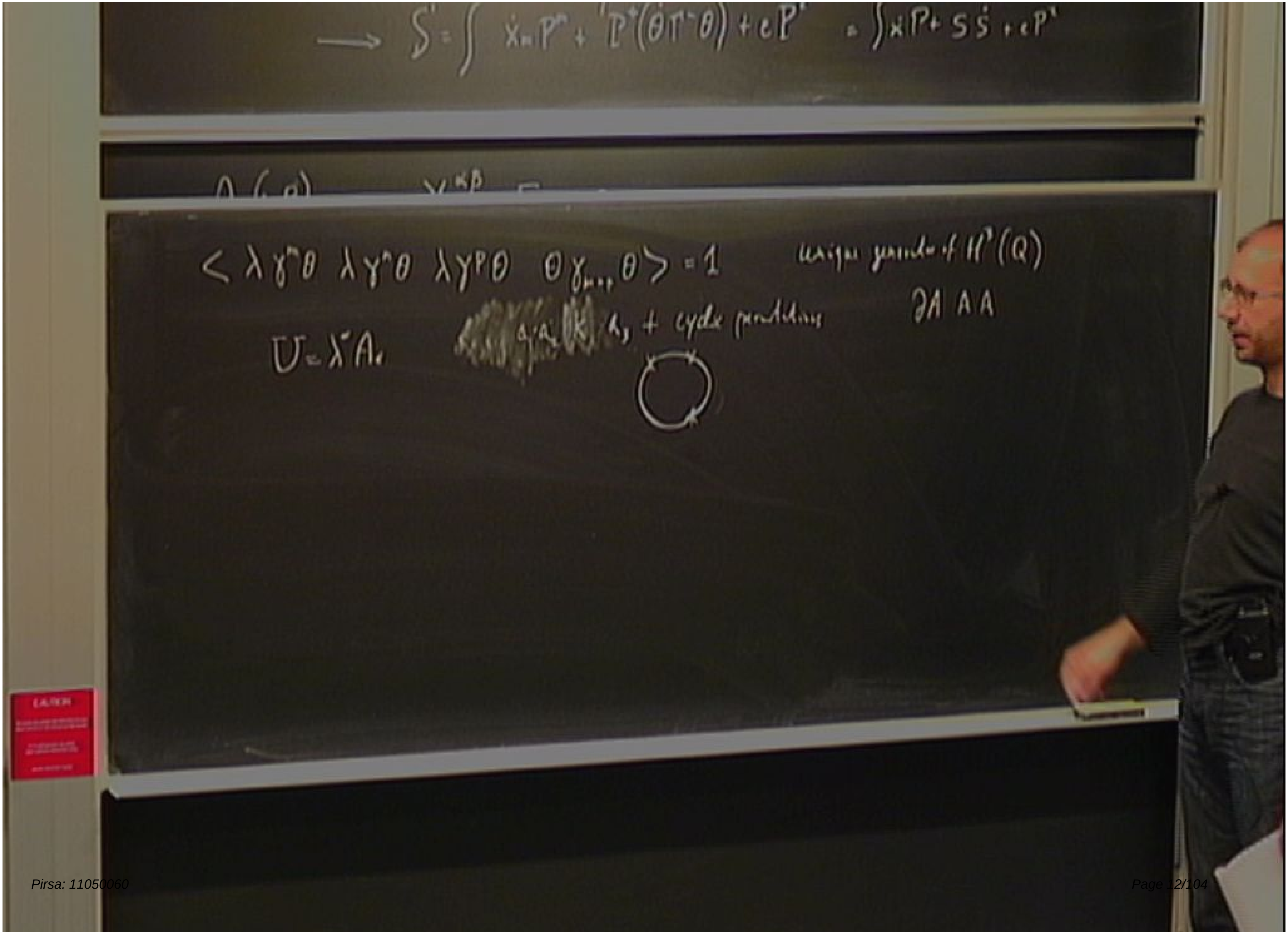
$c_{tot} = 0$


< λγ^m θ λγ^n θ λγ^p θ θγ_mnp θ > = 1

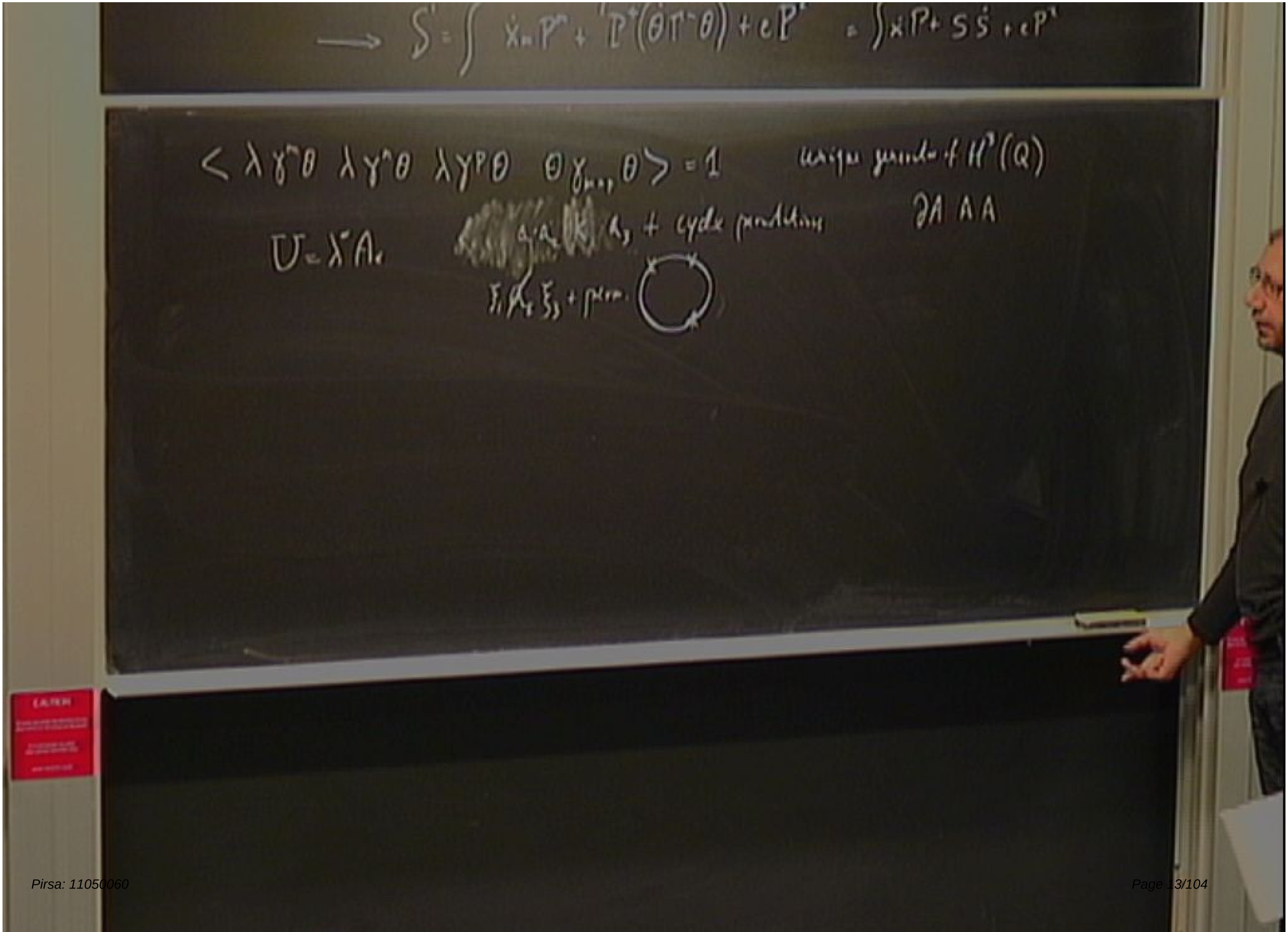

$\longrightarrow S' = \int \dot{X}_m P^m + P^+(\theta \Gamma^- \theta) + c P^- = \int \dot{x} P + S \dot{S} + c P^x$
$\langle \lambda \gamma^m \theta \; \lambda \gamma^n \theta \; \lambda \gamma^p \theta \; \theta \gamma_{mnp} \theta \rangle = 1$
unique generator of $H^5(Q)$







< λγ^m θ λγ^n θ λγ^p θ θγ_mnp θ > = 1
∂A A A
U = λ^α A_α
+ cyclic permutations

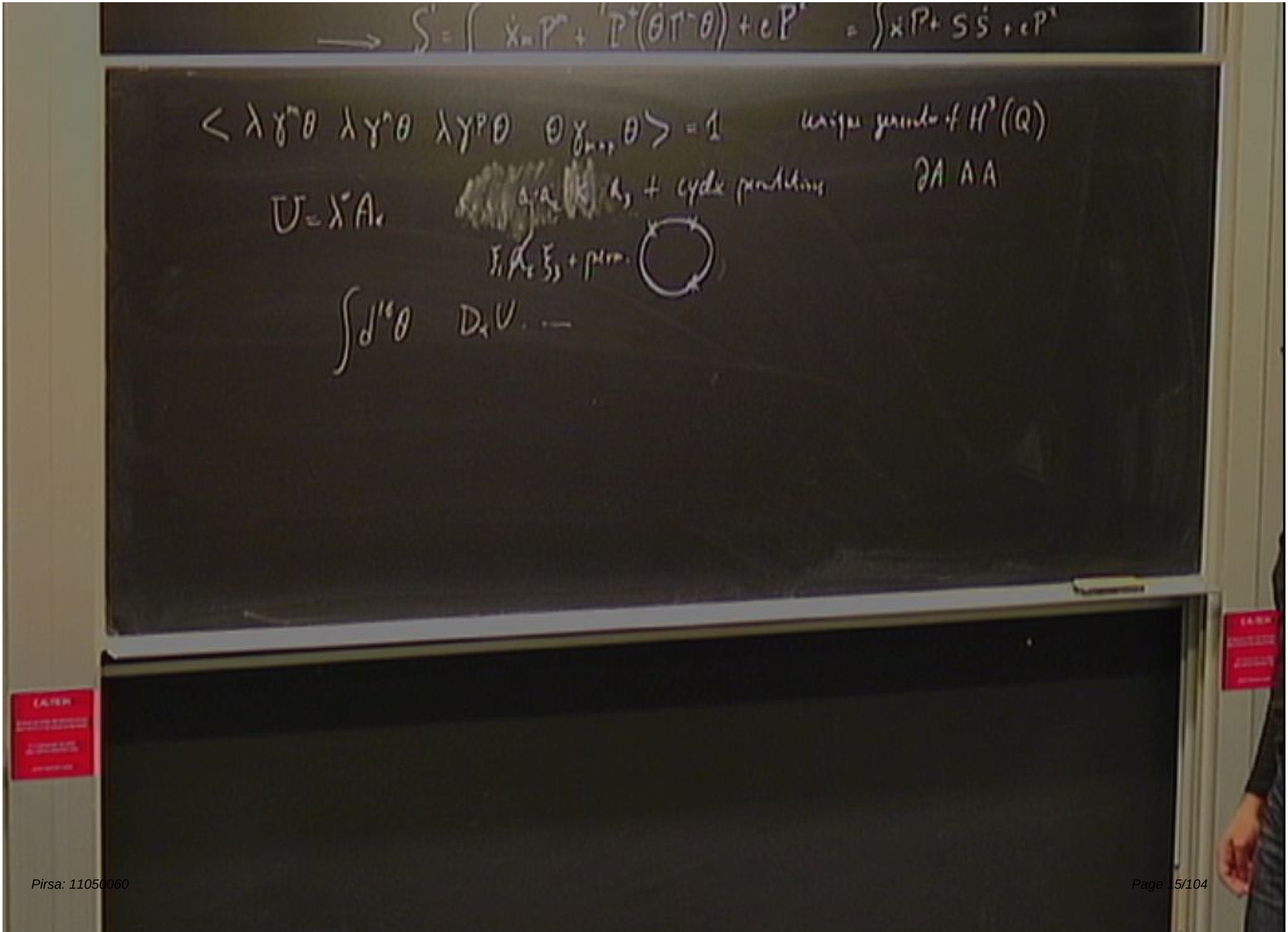

< λγ^mθ λγ^nθ λγ^pθ θγ_mnp θ > = 1
∂A A A
+ cycle permutations

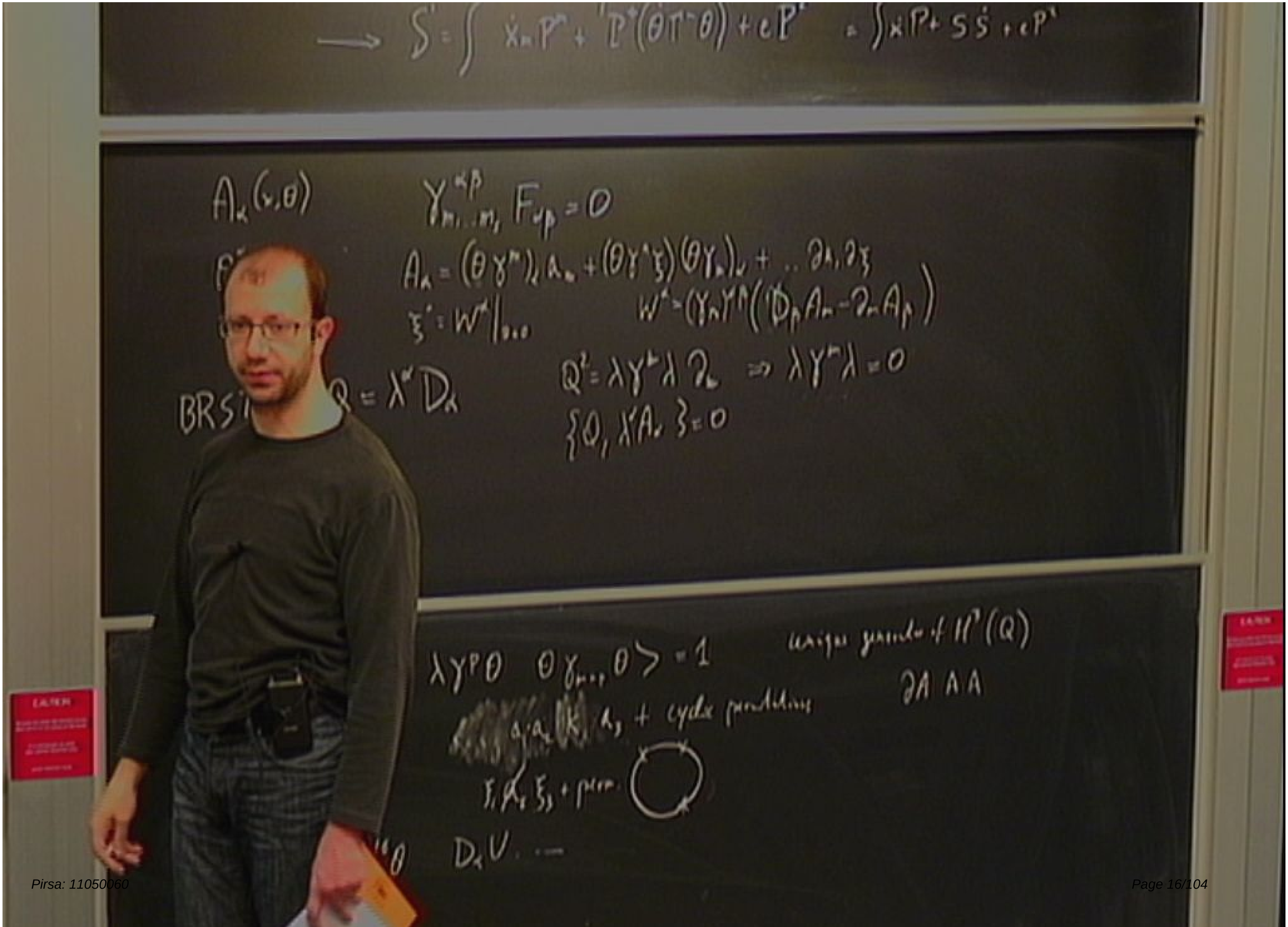
$\longrightarrow \quad S' = \int \dot{X}_m P^m + P^+(\theta \Gamma^- \dot{\theta}) + e P^2 \quad = \int \dot{x} P + S\dot{S} + e P^2$

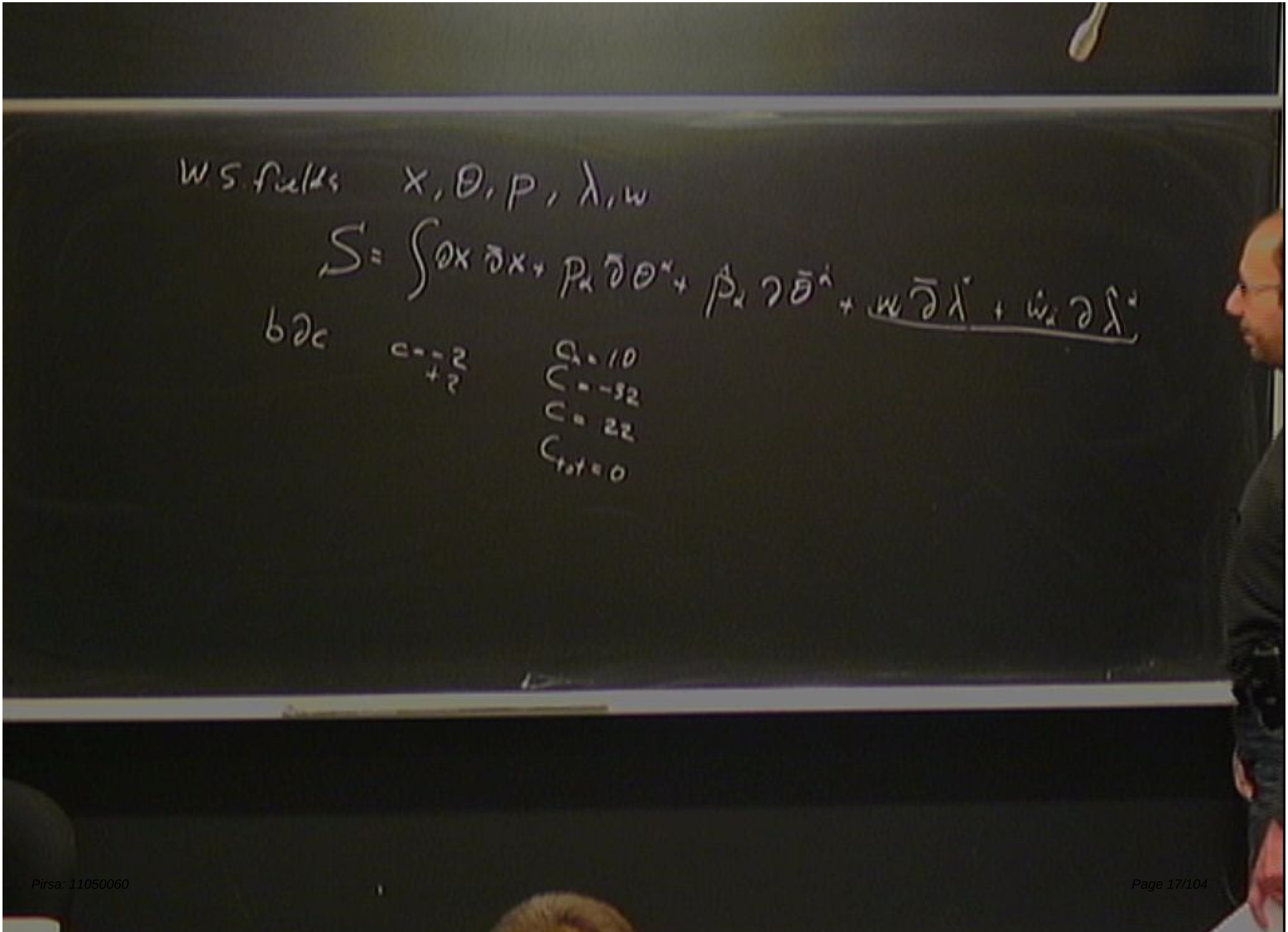
$< \lambda\gamma^m\theta \; \lambda\gamma^n\theta \; \lambda\gamma^p\theta \quad \theta\gamma_{mnp}\theta > = 1$ unique generator of $H^3(Q)$

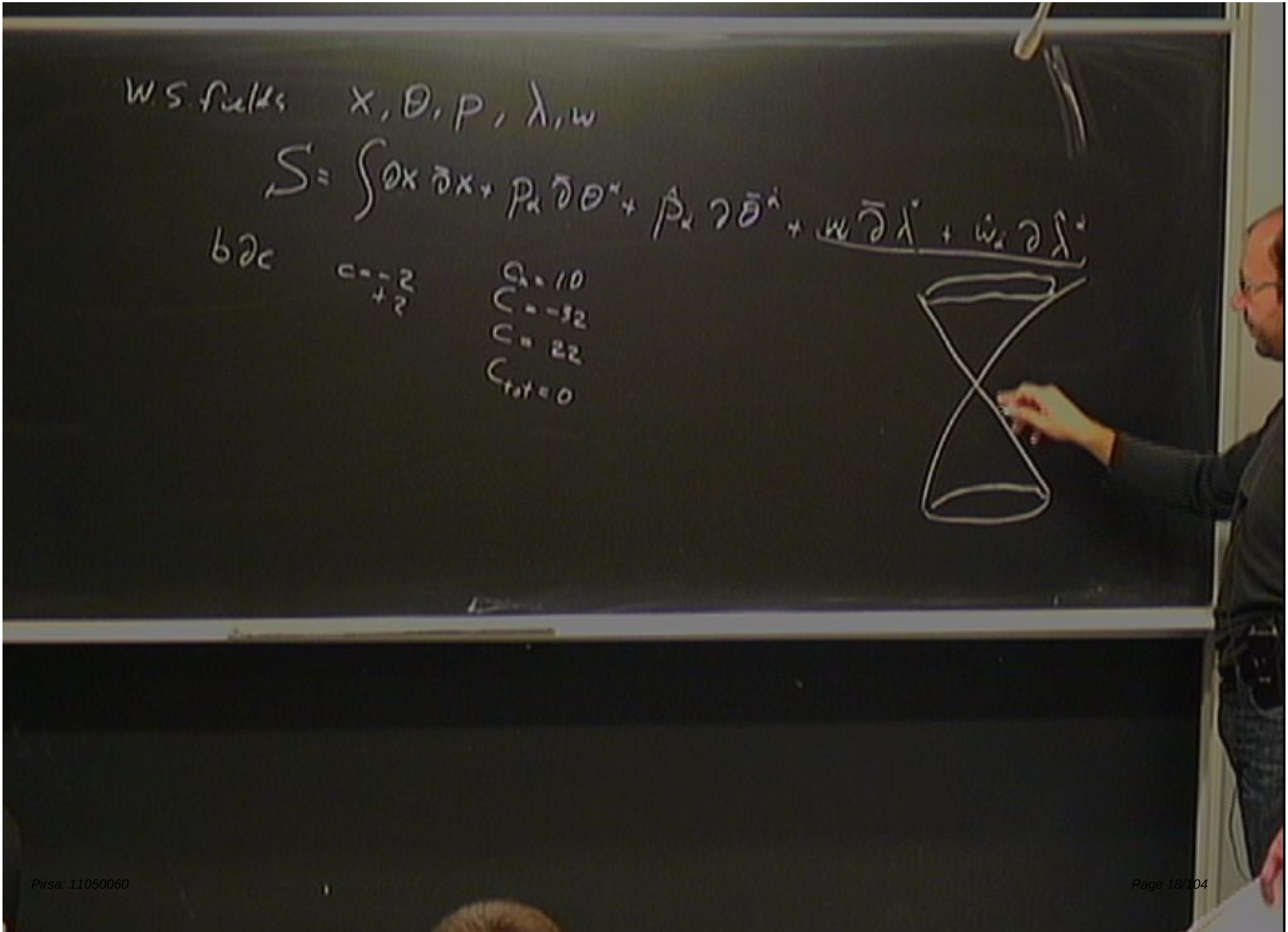
$U = \lambda^\alpha A_\alpha$ $\quad$ $A_1 A_2 A_3$ + cyclic permutations $\quad$ $\partial A \, A \, A$

$\xi_1 \xi_2 \xi_3$ + perm.


+ cyclic permutations
∂A A A


BRST
∂A A A


W.S. fields x, θ, p, λ, w
S = ∫ ∂x ∂̄x + p_α ∂̄θ^α + p̂_α ∂θ̂^α + w_α ∂̄λ^α + ŵ_α ∂λ̂^α
b∂c
c = -2
+2
C_λ = 10
C = -32
C = 22
C_tot = 0


W.S. fields x, θ, p, λ, w
S = ∫ ∂x ∂̄x + p_α ∂̄θ^α + p̂_α ∂θ̂^α + w ∂̄λ + ŵ_α ∂λ̂^α
b∂c
c = -2
+2
c_λ = 10
c = -32
c = 22
c_tot = 0

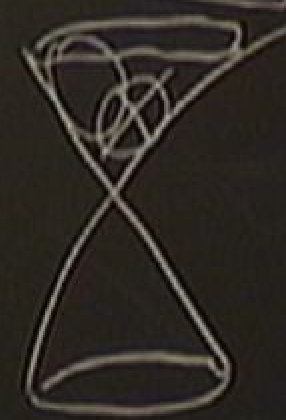
W.S. fields x, θ, p, λ, w

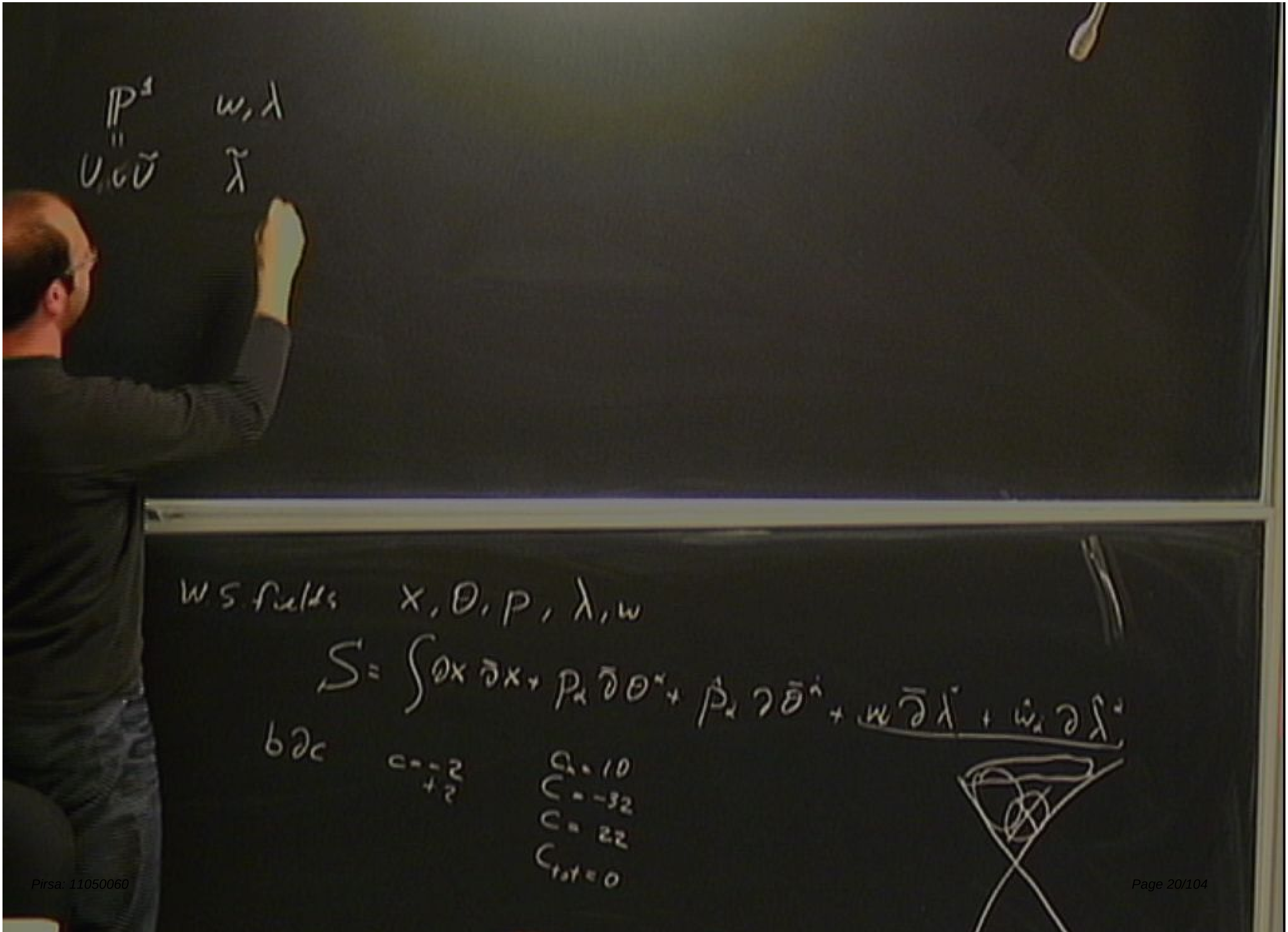
$$S = \int \partial x \bar{\partial} x + p_\alpha \bar{\partial}\theta^\alpha + \hat{p}_\alpha \partial \hat{\theta}^\alpha + w_\alpha \bar{\partial}\lambda^\alpha + \hat{w}_\alpha \partial \hat{\lambda}^\alpha$$

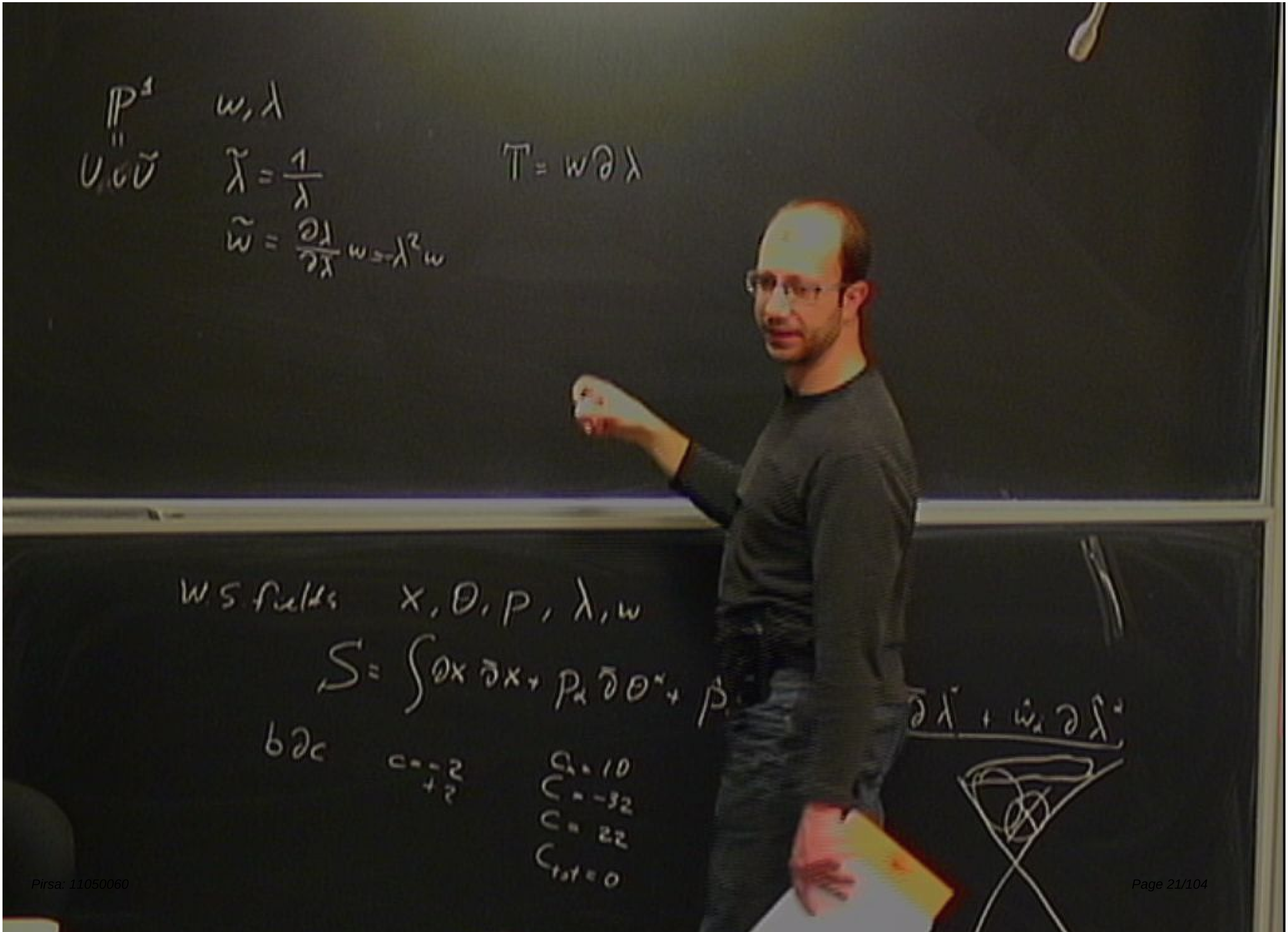
$b\partial c$

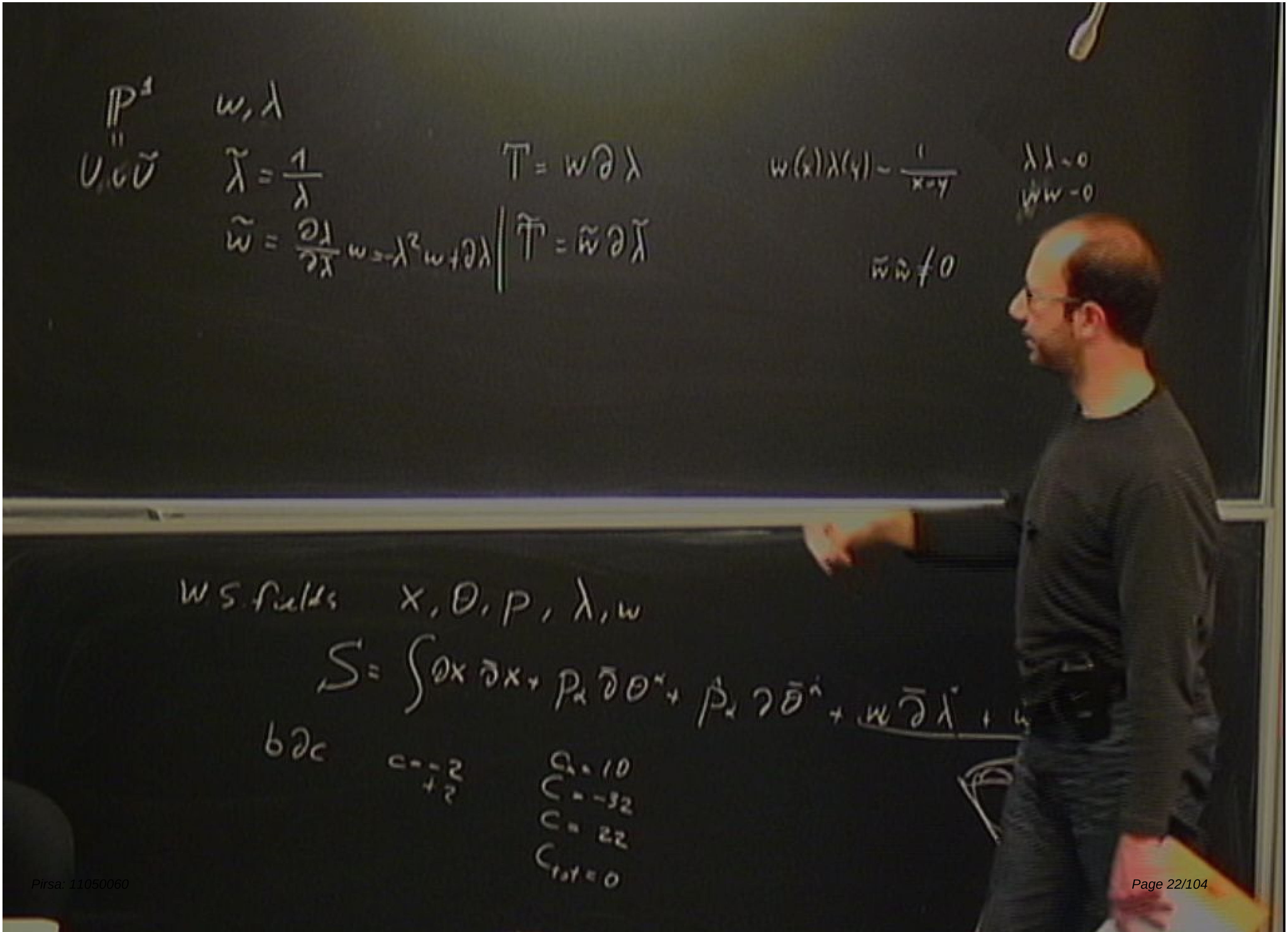
$c = -2$
$+2$

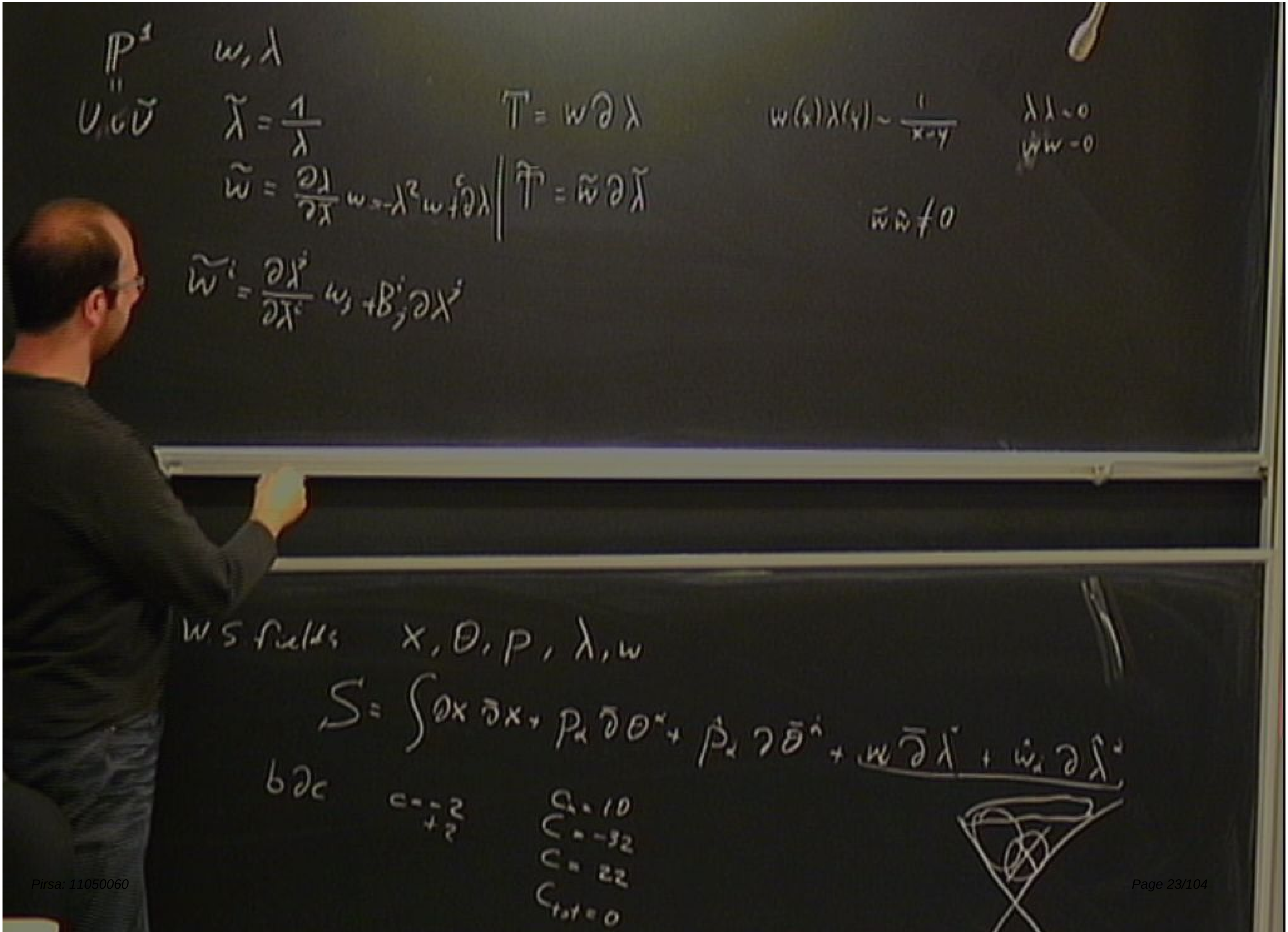
$c_x = 10$
$c = -32$
$c = 22$
$c_{tot} = 0$

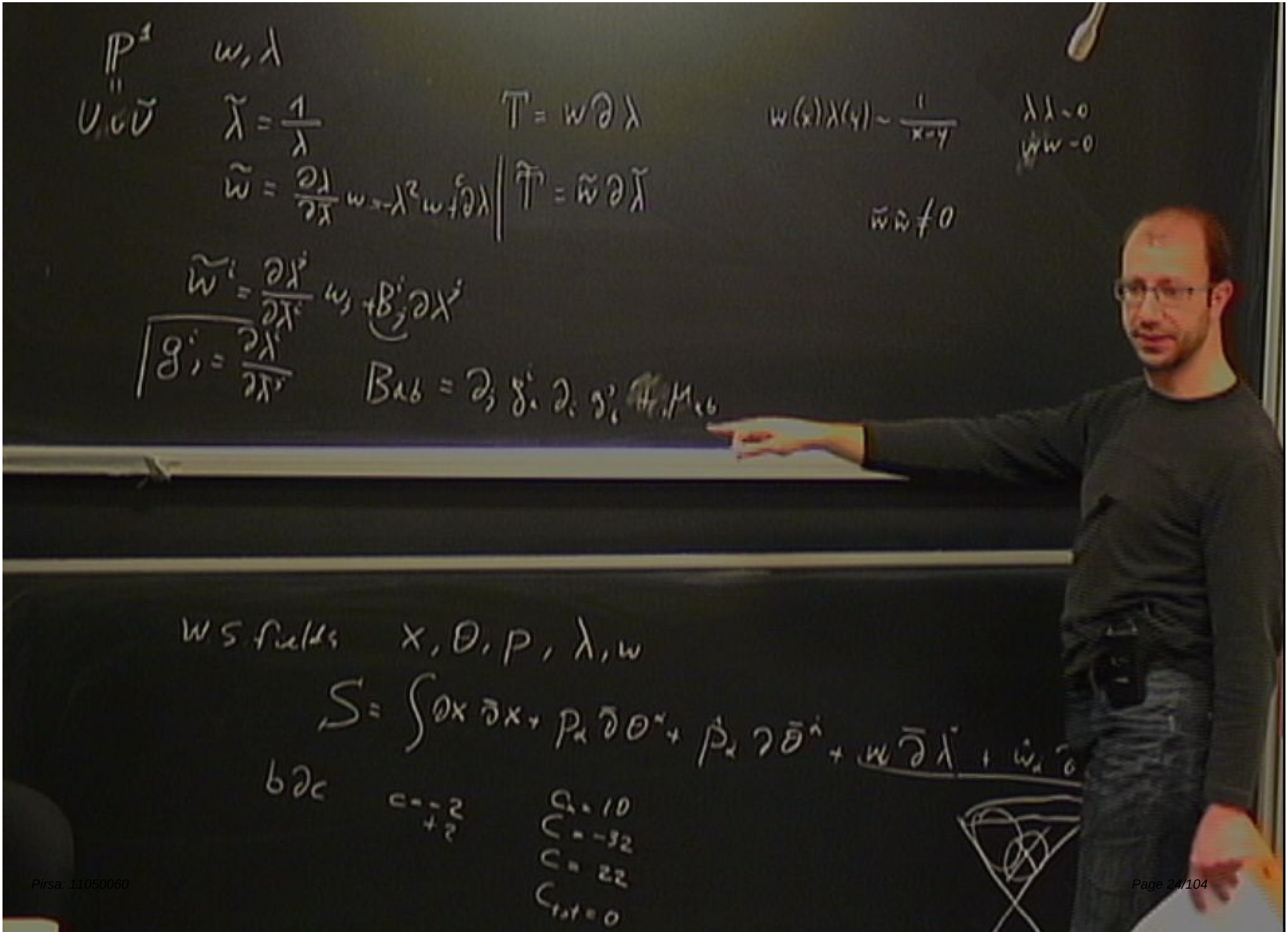


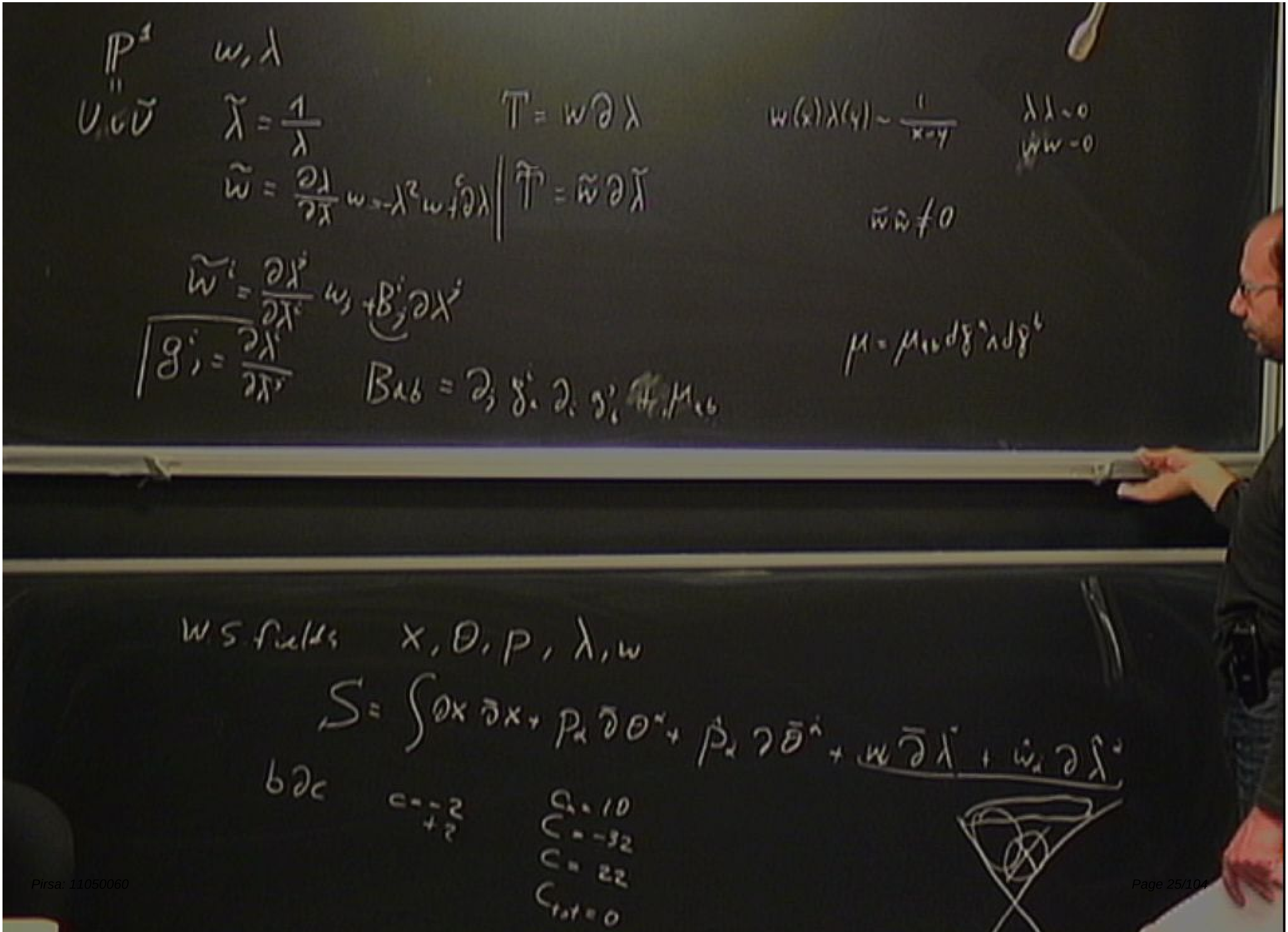

$\mathbb{P}^1$ w, λ
$U \cup \tilde{U}$ $\tilde{\lambda}$
W.S. fields X, θ, p, λ, w
$S = \int \partial x \bar{\partial} x + p_\alpha \bar{\partial} \theta^\alpha + \hat{p}_\alpha \partial \bar{\theta}^\alpha + w \bar{\partial} \lambda + \hat{w}_\alpha \partial \hat{\lambda}^\alpha$
$b \partial c$
$c = -2$
$+2$
$c_\lambda = 10$
$c = -32$
$c = 22$
$c_{tot} = 0$

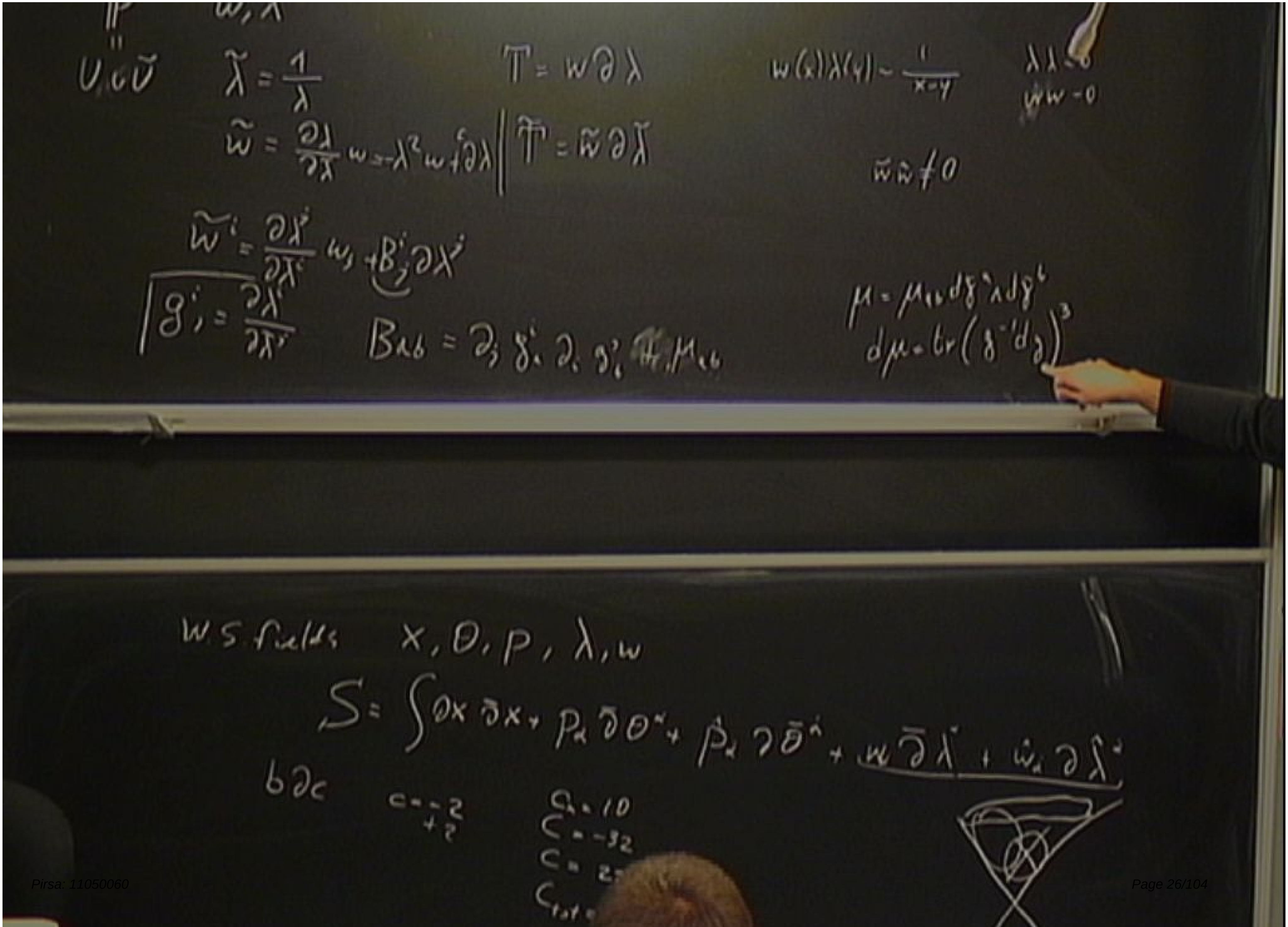

w, λ
T = w∂λ
W.S. fields X, θ, p, λ, w
b∂c
C = 10
C = -32
C = 22
C_tot = 0

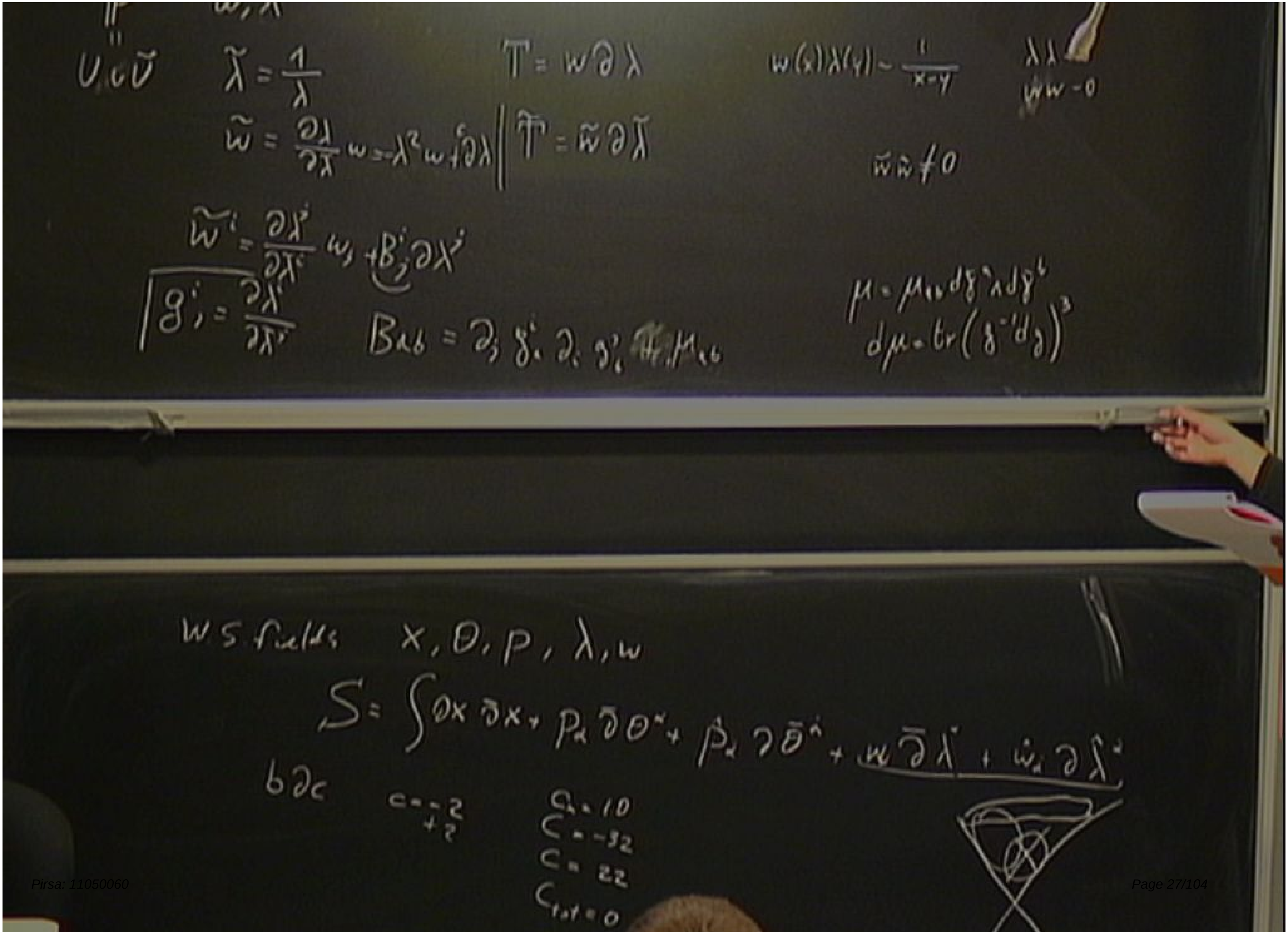

P¹ w, λ
λ̃ = 1/λ
T = w∂λ
w̃ = ∂λ/∂λ̃ w = -λ² w + ∂λ
T̃ = w̃∂λ̃
w(x)λ(y) ~ 1/(x-y)
w̃w̃ ≠ 0
W.S. fields X, Θ, p, λ, w
S = ∫∂x ∂̄x + p_α ∂̄θ^α + p̂_α ∂θ̄^α + w∂̄λ
b∂c
c = -2
+2
C = 10
C = -32
C = 22
C_tot = 0


P^1 w, λ
U ∪ Ũ λ̃ = 1/λ T = w∂λ
w(x)λ(y) ~ 1/(x−y)
λλ ~ 0
ww ~ 0
w̃ = ∂λ/∂λ̃ w = −λ^2 w + ∂λ
T̃ = w̃∂λ̃
w̃w̃ ≠ 0
w̃^i = ∂λ^j/∂λ̃^i w_j + B^i_j ∂λ^j
W.S. fields x, θ, p, λ, w
S = ∫ ∂x ∂̄x + p_α ∂̄θ^α + p̂_α ∂θ̂^α + w ∂̄λ + ŵ_α ∂λ̂^α
b∂c
c = −2
+2
c = 10
c = −32
c = 22
c_tot = 0


P^1 w, λ
T = w∂λ
w(x)λ(y) ~ 1/(x-y)
λλ ~ 0
w̃w̃ ≠ 0
WS fields X, θ, p, λ, w
b∂c
c = -2
C = 22
C_tot = 0


W.S. fields X, Θ, p, λ, w
b∂c
c = -2
+2
C = 10
C = -32
C = 22
C_tot = 0


λ̃ = 1/λ
T = w∂λ
T̃ = w̃∂λ̃
w̃w̃ ≠ 0
Bab
W.S. fields x, θ, p, λ, w
S =
b∂c


T = w∂λ
w(x)λ(y) ~ 1/(x-y)
λλ ~ 0
ww ~ 0
T = w̃ ∂λ̃
w̃w̃ ≠ 0
W.S. fields x, θ, p, λ, w
b∂c

$U \subset \tilde{U}$ $\quad \tilde{\lambda} = \frac{1}{\lambda}$ $\quad T = w \partial \lambda$ $\quad w(x)\lambda(y) \sim \frac{1}{x-y}$ $\quad \lambda\lambda$, $ww \sim 0$

$\tilde{w} = \frac{\partial \lambda}{\partial \tilde{\lambda}} w = -\lambda^2 w + \partial\lambda \quad \Big| \quad \tilde{T} = \tilde{w} \partial \tilde{\lambda}$ $\quad \tilde{w}\tilde{w} \neq 0$

$\tilde{w}^i = \frac{\partial \lambda^j}{\partial \tilde{\lambda}^i} w_j + B_{ij} \partial \lambda^j$

$g^i_j = \frac{\partial \lambda^i}{\partial \tilde{\lambda}^j}$ $\quad B_{ab} = \partial_j g^i_a \, \partial_i g^j_b \, \mu_{ab}$ $\quad \mu = \mu_{ab} \, dg^a \wedge dg^b$, $d\mu = \mathrm{tr}(g^{-1} dg)^3$

W.S. fields $\quad x, \theta, p, \lambda, w$

$$S = \int \partial x \bar{\partial} x + p_\alpha \bar{\partial} \theta^\alpha + \hat{p}_\alpha \partial \bar{\theta}^\alpha + w \bar{\partial} \lambda + \hat{w}_\alpha \partial \hat{\lambda}^\alpha$$

$b \partial c$ $\quad c = -2$, $+2$ $\quad c_x = 10$, $c = -32$, $c = 22$, $c_{tot} = 0$

$g^i_j = \frac{\partial \lambda^i}{\partial \lambda^j}$

$B_{ab} = \partial_j g^i_a \, \partial_i g^j_b \, \mu_{ab}$

$\mu = \mu_{ab} \, dg^a \wedge dg^b$

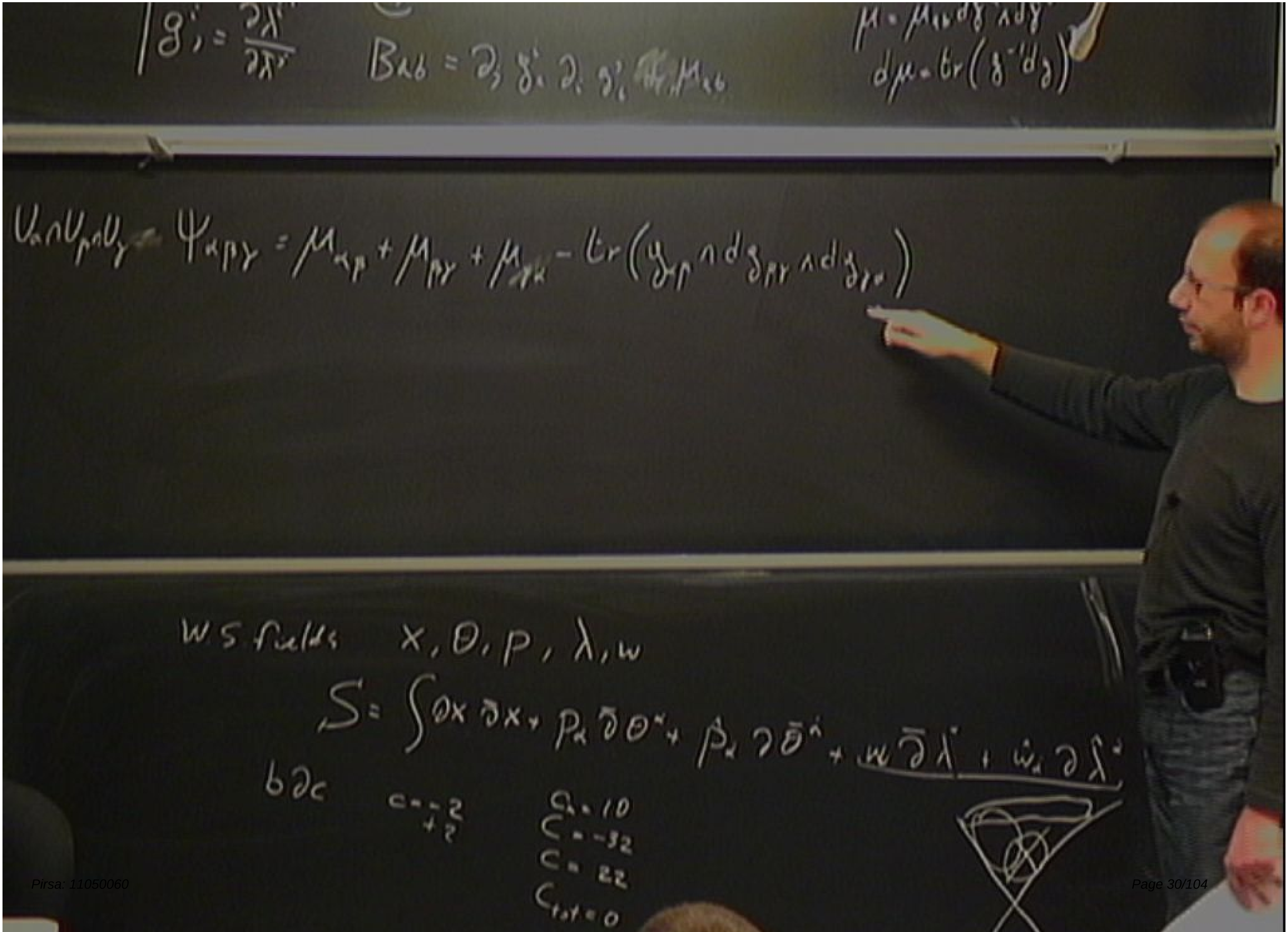
$d\mu = \mathrm{tr}(g^{-1} dg)^3$

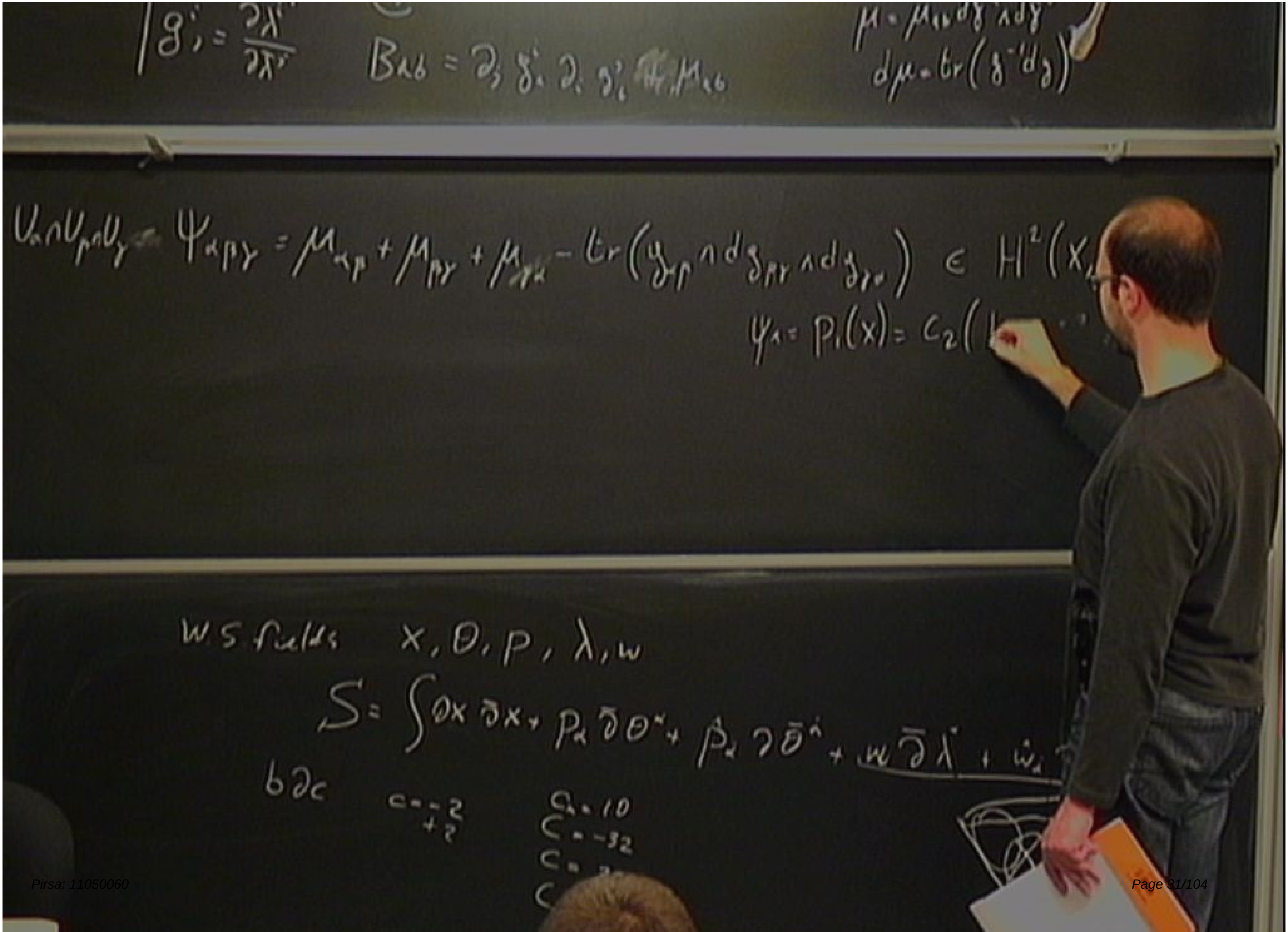
$U_\alpha \cap U_\beta \cap U_\gamma \quad \psi_{\alpha\beta\gamma} = \mu_{\alpha\beta}$

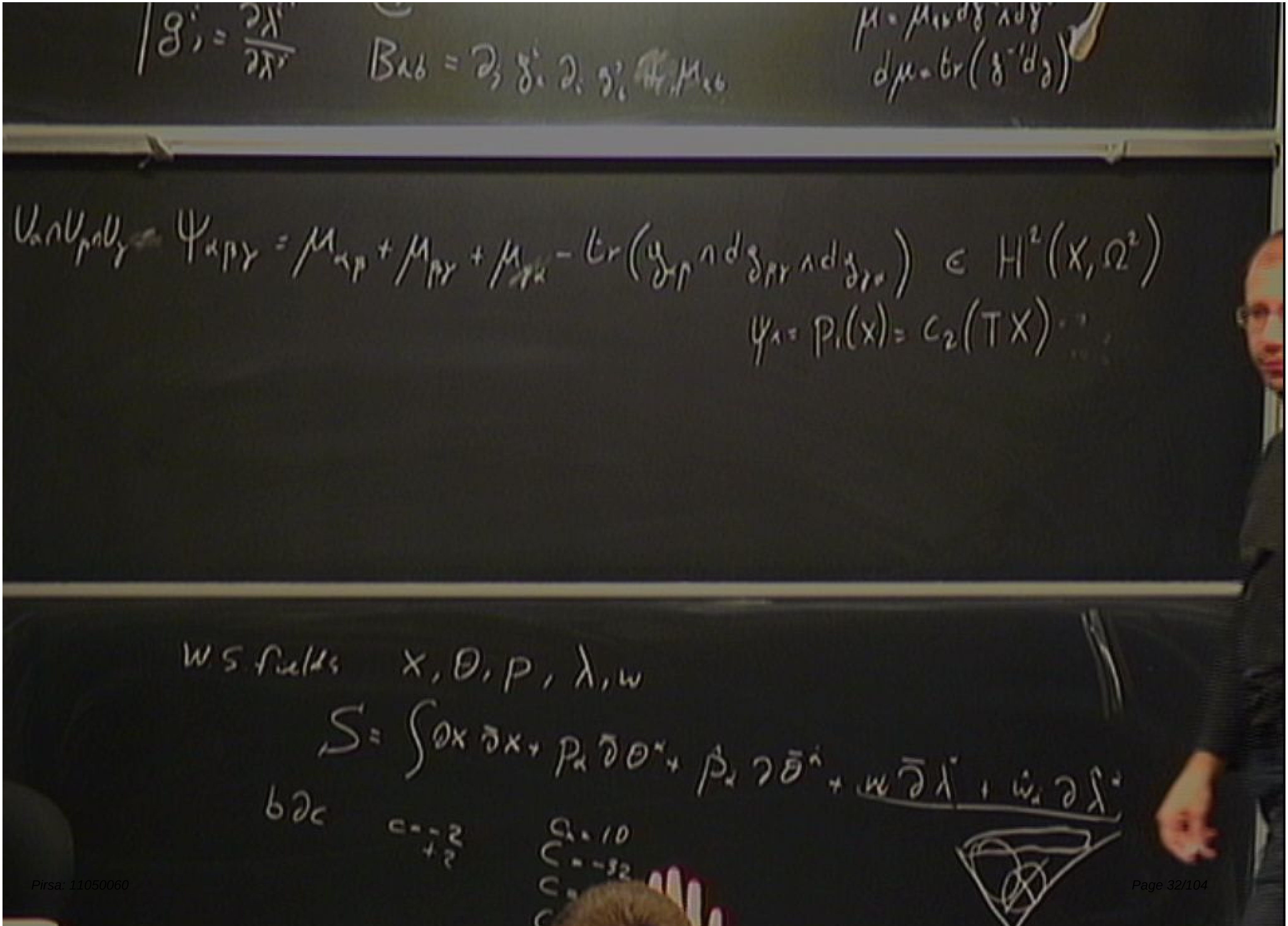
W.S. fields $\quad x, \theta, p, \lambda, w$

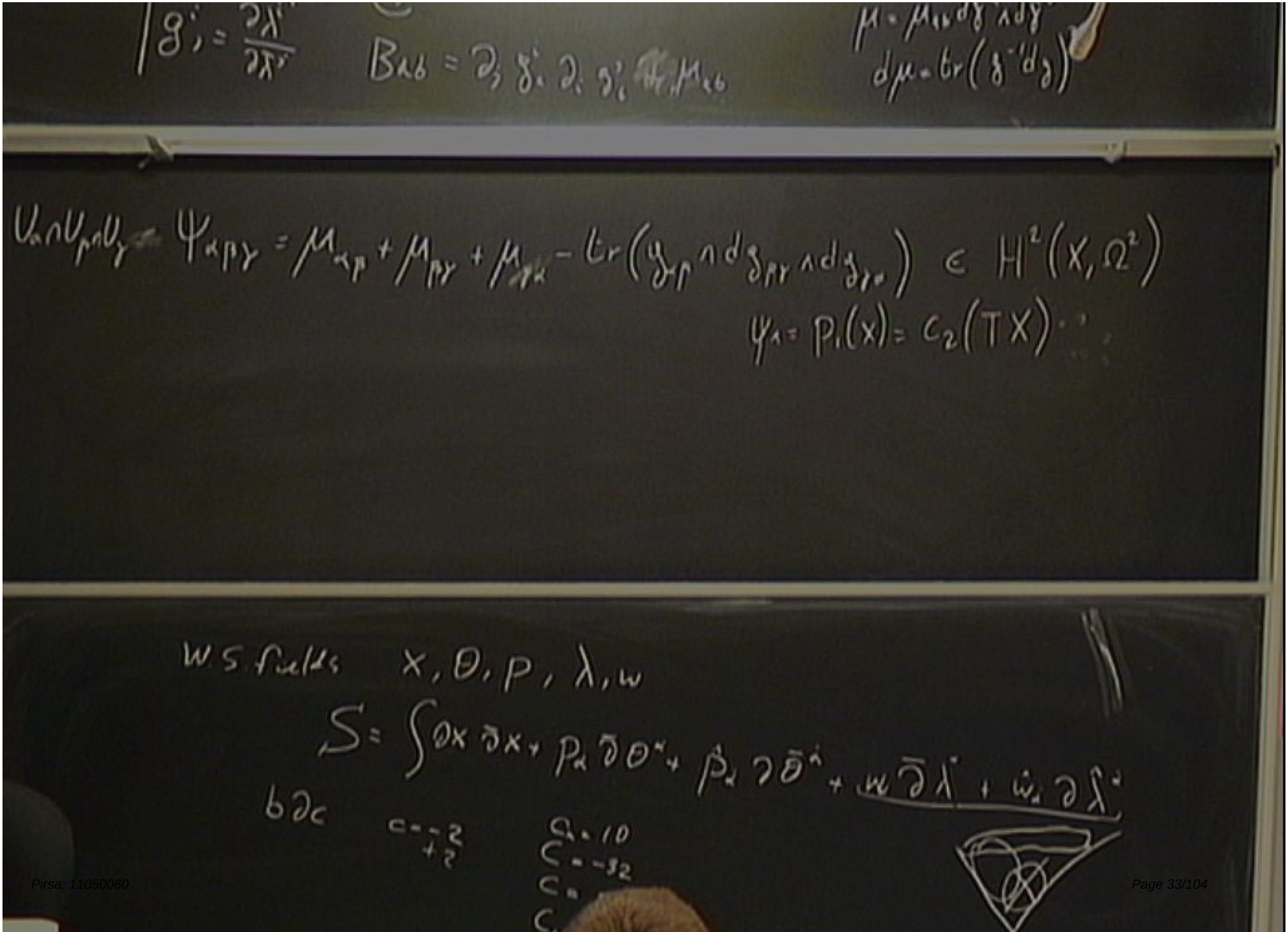
$$S = \int \partial x \, \bar\partial x + p_\alpha \bar\partial \theta^\alpha + \hat p_\alpha \partial \bar\theta^\alpha + w \bar\partial \lambda + \hat w_\alpha \partial \hat\lambda^\alpha$$

$b \partial c \qquad c = -2, +2 \qquad c_x = 10, \; c = -32, \; c = 22, \; c_{tot}$


dμ = tr(g⁻¹dg)
Uα∩Uβ∩Uγ Ψαβγ = μαβ + μβγ + μγα − tr(gαβ ∧ dgβγ ∧ dgγα)
WS fields x, θ, p, λ, w
bc
c = −2
+2
c = 10
c = −32
c = 22
ctot = 0


Bab = ∂j gi ∂i gj μab
dμ = tr(g⁻¹dg)
ψαβγ = μαβ + μβγ + μγα − tr(gαβ ∧ dgβγ ∧ dgγα) ∈ H²(X
ψα = p1(X) = c2(
w.s. fields x, θ, p, λ, w
S = ∫ ∂x ∂̄x + pα ∂̄θα + p̂α ∂θ̂α + w ∂̄λ + ŵα
b∂c
c = −2
+2
c = 10
c = −32


g^i_j = ∂λ^i/∂λ̃^j
B_ab = ∂_j g^i_a ∂_i g^j_b + μ_ab
μ = μ_ab dγ^a ∧ dγ^b
dμ = tr(g^-1 dg)^3
U_α ∩ U_β ∩ U_γ : ψ_αβγ = μ_αβ + μ_βγ + μ_γα − tr(g_αβ ∧ dg_βγ ∧ dg_γα) ∈ H^2(X, Ω^2)
ψ_α = p_1(X) = c_2(TX)
W.S. fields X, θ, p, λ, w
S = ∫ p∂x ∂̄x + p_α ∂̄θ^α + p̄_α ∂θ̄^α + w ∂̄λ^α + ŵ_α ∂λ̄^α
b∂c
c = −2
c = 10
c = −32


$g^i{}_j = \frac{\partial \lambda^i}{\partial \lambda^j}$
$B_{ab} = \partial_a g^i \partial_i g^j_b \mu_{ab}$
$\mu = \mu_{ab}\, d\gamma^a \wedge d\gamma^b$
$d\mu = tr(g^{-1}dg)$
$U_\alpha \cap U_\beta \cap U_\gamma$ $\Psi_{\alpha\beta\gamma} = \mu_{\alpha\beta} + \mu_{\beta\gamma} + \mu_{\gamma\alpha} - tr(g_{\alpha\beta} \wedge dg_{\beta\gamma} \wedge dg_{\gamma\alpha}) \in H^2(X, \Omega^2)$
$\psi_\alpha = p_1(X) = c_2(TX)$
w.s. fields X, Θ, p, λ, w
$S = \int \partial X \bar\partial X + p_\alpha \bar\partial \Theta^\alpha + \bar p_\alpha \partial \bar\Theta^\alpha + w \bar\partial \lambda + \hat w_\alpha \partial \hat\lambda^\alpha$
$b\partial c$
$c = -2$
$+2$
$c = 10$
$c = -32$

$$g^i_j = \frac{\partial \lambda^i}{\partial \lambda^j} \qquad B_{ab} = \partial_j g^i_a \partial_i g^j_b \, \mu_{ab}$$

$$\mu = \mu_{ab}\, dg^a \wedge dg^b \qquad d\mu = \mathrm{tr}(g^{-1} dg)$$

$$U_\alpha \cap U_\beta \cap U_\gamma \quad \psi_{\alpha\beta\gamma} = \mu_{\alpha\beta} + \mu_{\beta\gamma} + \mu_{\gamma\alpha} - \mathrm{tr}\left(g_{\alpha\beta} \wedge dg_{\beta\gamma} \wedge dg_{\gamma\alpha}\right) \in H^2(X, \Omega^2)$$

$$\psi_\lambda = p_1(X) = c_2(TX)$$

$$T_{(\lambda)} = w_{(\alpha)} \partial \lambda^{(\alpha)} + \partial^2 \log \Omega(\lambda) \qquad \Omega = \Omega(\lambda)\, d\lambda \wedge \ldots \wedge d\lambda$$

w.s. fields X, Θ, p, λ, w

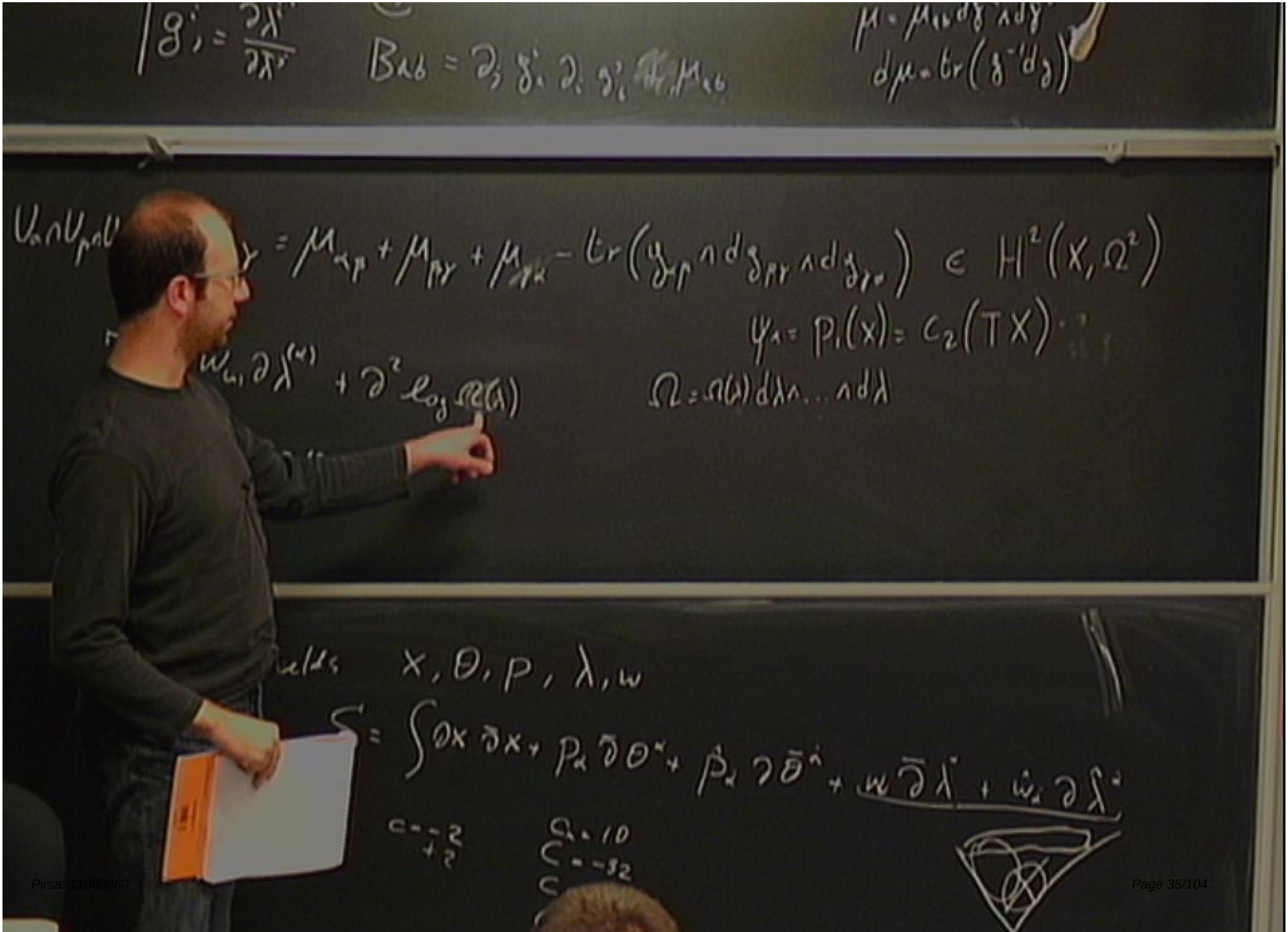
$$S = \int \partial X \bar\partial X + p_\alpha \bar\partial \theta^\alpha + \bar p_\alpha \partial \bar\theta^\alpha + \underline{w \bar\partial \lambda + \bar w_\alpha \partial \bar\lambda^\alpha}$$

$b \partial c$ $\quad c = -2$ $\quad +2$

$c = 10$

$c = -32$

$c = 22$


ψ_A = p_1(X) = c_2(TX)
∈ H^2(X, Ω^2)
X, Θ, p, λ, w

$g^i_j = \frac{\partial \lambda^i}{\partial \lambda^j}$ $B_{ab} = \partial_j g^i \partial_i g^j_b \ \mu_{ab}$

$\mu = \mu_{ab} dg \wedge dg$

$d\mu = tr(g^{-1} dg)$

$U_\alpha \cap U_\beta \cap U_\gamma$ $\psi_{\alpha\beta\gamma} = \mu_{\alpha\beta} + \mu_{\beta\gamma} + \mu_{\gamma\alpha} - tr(g_{\alpha\beta} \wedge dg_{\beta\gamma} \wedge dg_{\gamma\alpha}) \in H^2(X, \Omega^2)$

$\psi_\alpha = p_1(X) = c_2(TX)$

$T_{(\alpha)} = w_{(\alpha)} \partial \lambda^{(\alpha)} + \partial^2 \log \Omega(\lambda)$

$\Omega = \Omega(\lambda) d\lambda \wedge \ldots \wedge d\lambda$

$T_{(\alpha)} - T_{(\beta)} = 0$

$c_1(X) = 0$

w.s. fields X, Θ, p, λ, w

$S = \int \partial X \bar\partial X + p_\alpha \bar\partial \Theta^\alpha + \hat p_\alpha \partial \bar\Theta^\alpha + w \bar\partial \lambda + \hat w_\alpha \partial \hat\lambda^\alpha$

$b\partial c$ $c = -2$ $+2$ $c = 10$ $c = -32$

$g_i = \frac{\partial \lambda}{\partial \lambda}$ $B_{ab} = \partial_j g_i \, \partial_i g_i \, \mu_{ab}$ $\mu = \mu_{ab} dg \wedge dg$ $d\mu = tr(g^{-1} dg)$

$U_\alpha \cap U_\beta \cap U_\gamma$ $\Psi_{\alpha\beta\gamma} = \mu_{\alpha\beta} + \mu_{\beta\gamma} + \mu_{\gamma\alpha} - tr(g_{\alpha\beta} \wedge dg_{\beta\gamma} \wedge dg_{\gamma\alpha}) \in H^2(X, \Omega^2)$

$\psi_\alpha = p_1(X) = c_2(TX)$

$T_{(\alpha)} = w_{(\alpha)} \partial \lambda^{(\alpha)} + \partial^2 \log \Omega(\lambda)$

$\Omega = \Omega(\lambda) d\lambda \wedge \ldots \wedge d\lambda$

$T_{(\alpha)} - T_{(\beta)} = 0$

$c_1(X) = 0$

W.S. fields x, θ, p, λ, w

$$S = \int \partial x \bar{\partial} x + p_\alpha \bar{\partial} \theta^\alpha + \hat{p}_\alpha \partial \bar{\theta}^\alpha + w \bar{\partial} \lambda^\alpha + \hat{w}_\alpha \partial \hat{\lambda}^\alpha$$

$b \partial c$ $c = -2$ $+2$ $c_{x} = 10$ $c = -32$

$g^i_j = \frac{\partial\lambda^i}{\partial\lambda^j}$ $\quad B_{ab} = \partial_j g^i_a \partial_i g^j_b + \mu_{ab}$ $\quad \mu = \mu_{ab}\, dg^a \wedge dg^b$ $\quad d\mu = tr(g^{-1}dg)^3$

$U_\alpha \cap U_\beta \cap U_\gamma$: $\psi_{\alpha\beta\gamma} = \mu_{\alpha\beta} + \mu_{\beta\gamma} + \mu_{\gamma\alpha} - tr(g_{\alpha\beta} \wedge dg_{\beta\gamma} \wedge dg_{\gamma\alpha}) \in H^2(X, \Omega^2)$

$\psi_\alpha = p_1(X) = c_2(TX)$

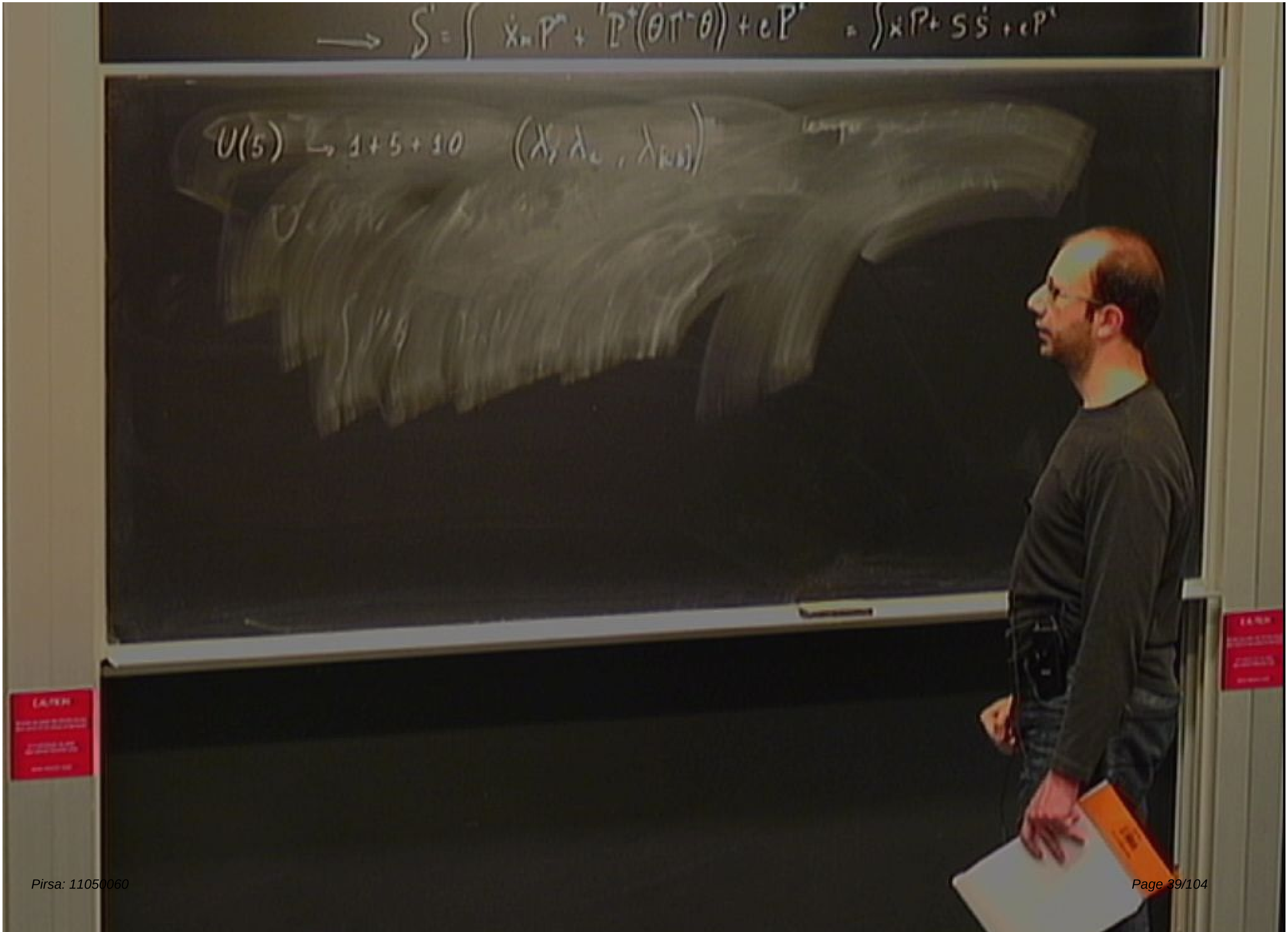
$T_{(\alpha)} = w_{(\alpha)} \partial\lambda^{(\alpha)} + \partial^2 \log \Omega(\lambda)$ $\quad \Omega = \Omega(\lambda)\, d\lambda \wedge \dots \wedge d\lambda$

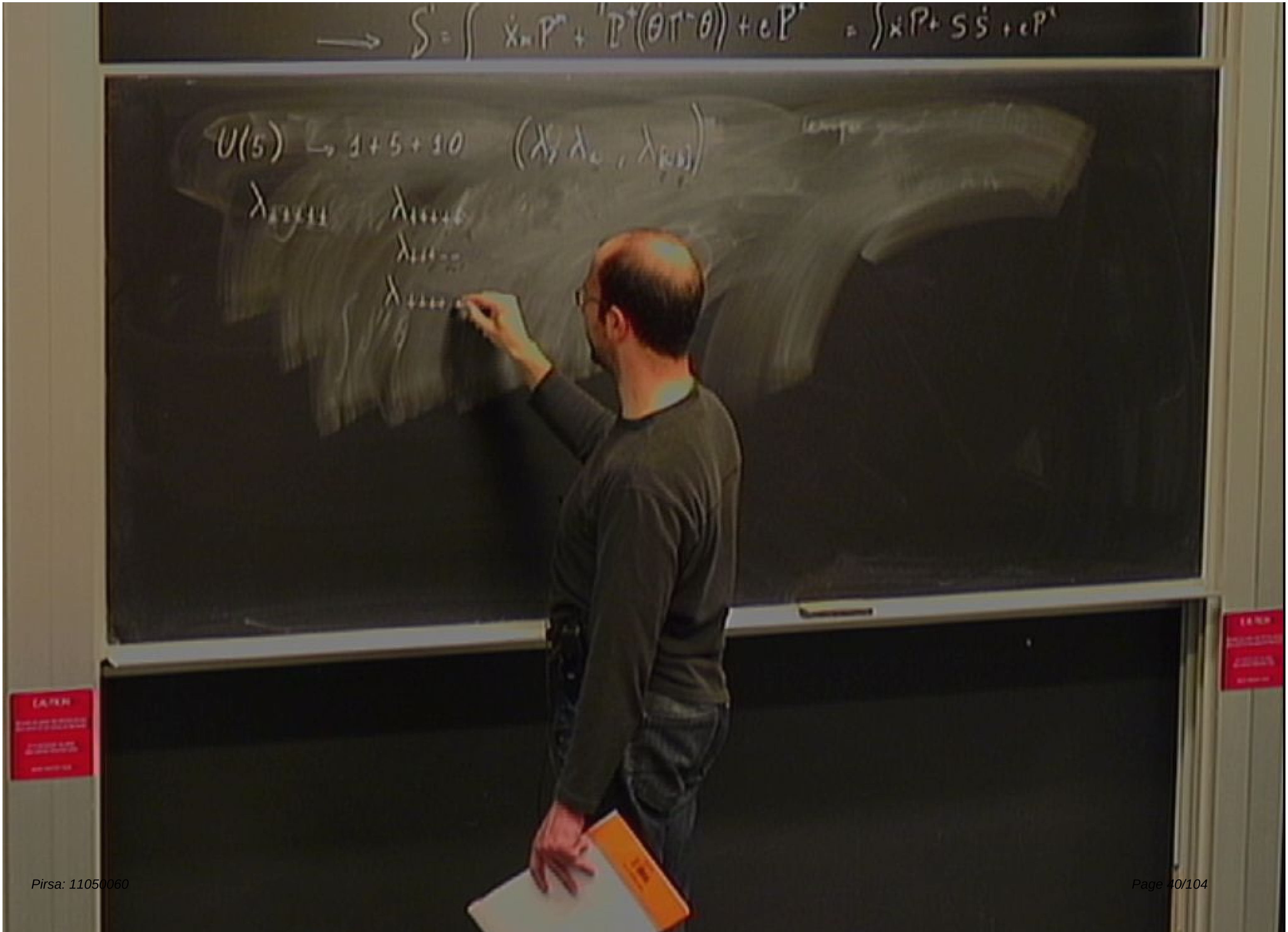
$T_{(\alpha)} - T_{(\beta)} = 0$ $\quad c_1(X) = 0$

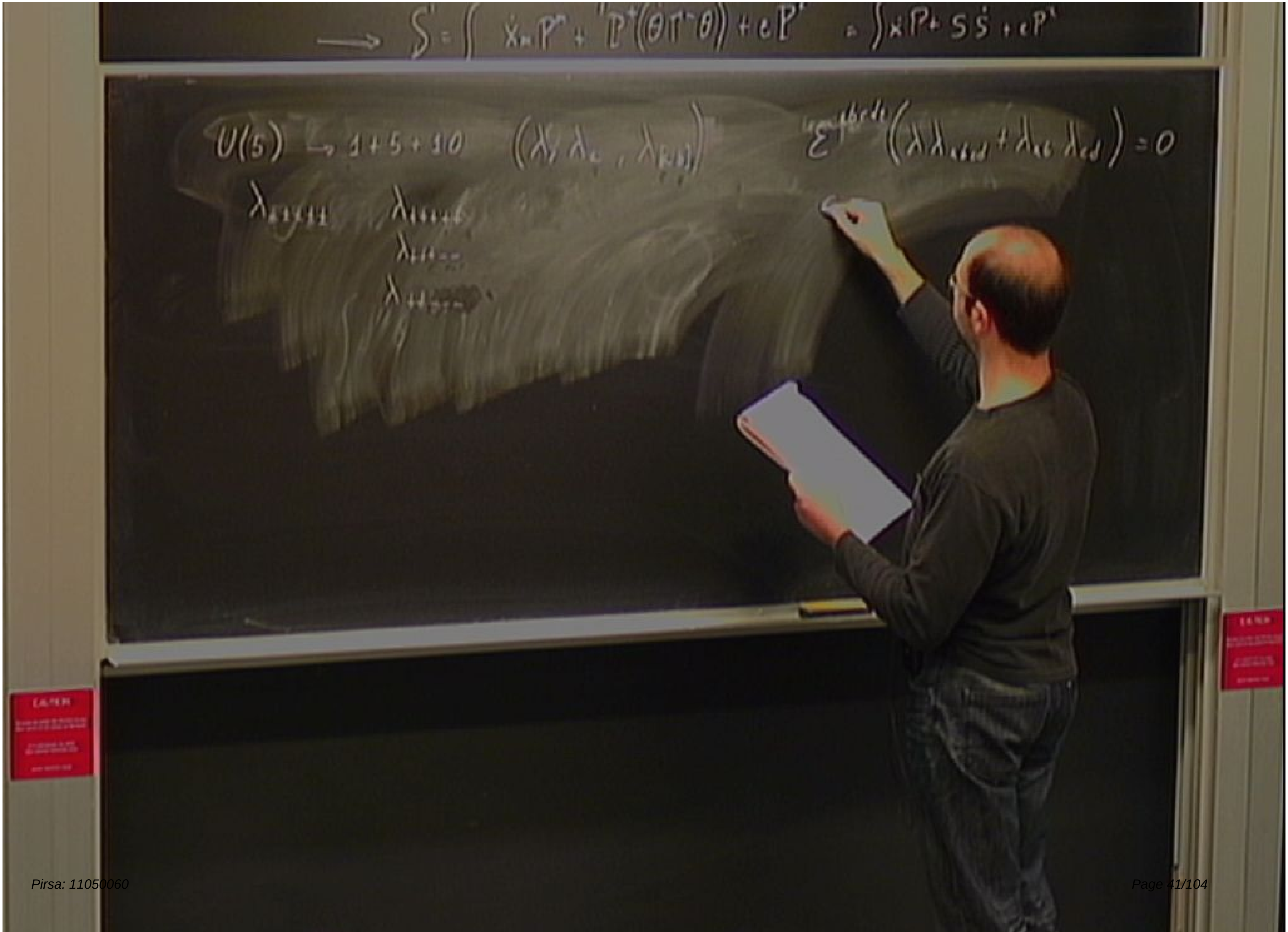
W.S. fields x, θ, p, λ, w

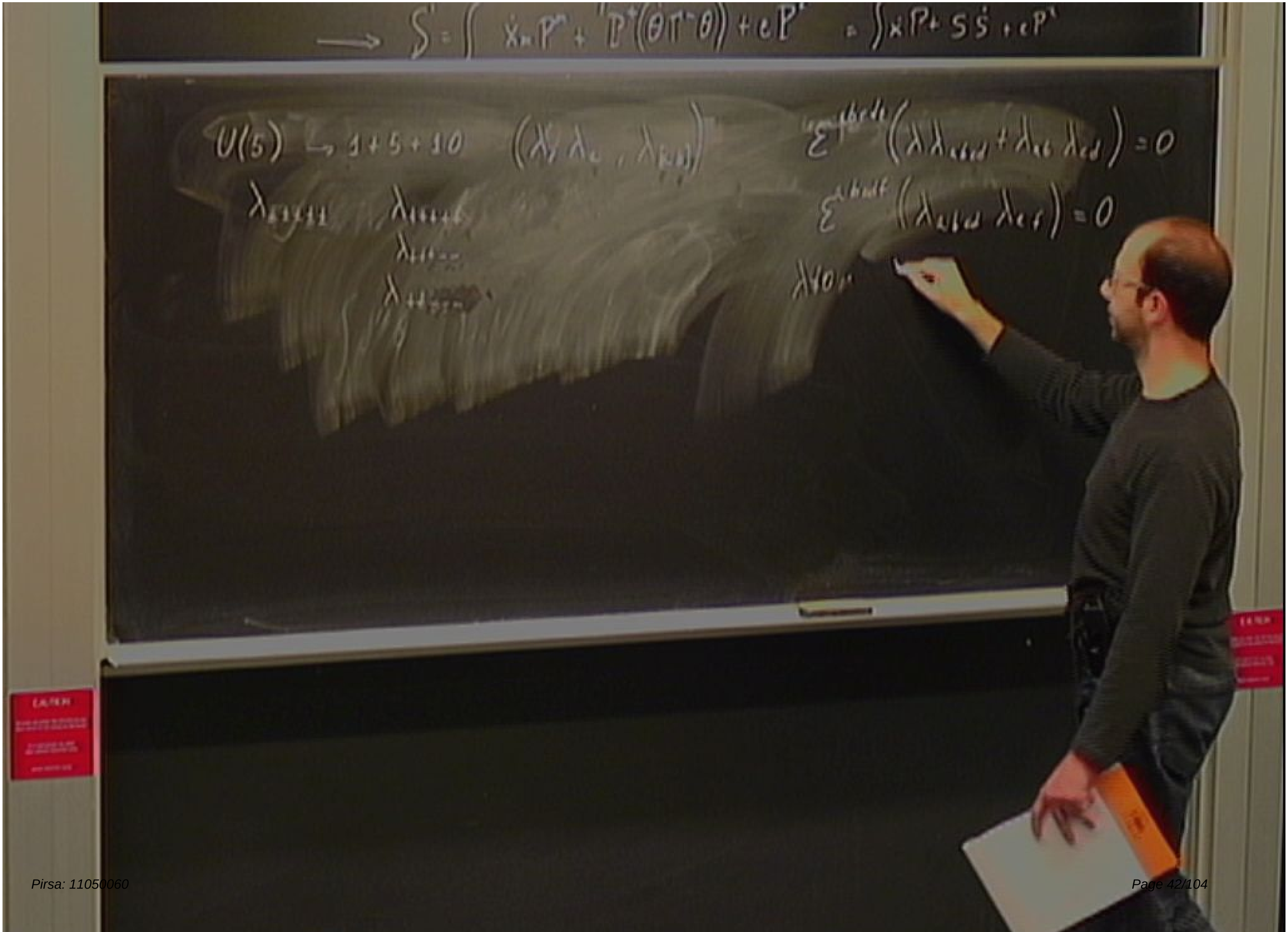
$$S = \int \partial x \bar\partial x + p_\alpha \bar\partial\theta^\alpha + \hat p_\alpha \partial\bar\theta^\alpha + \underline{w \bar\partial\lambda + \hat w_\alpha \partial\hat\lambda^\alpha}$$

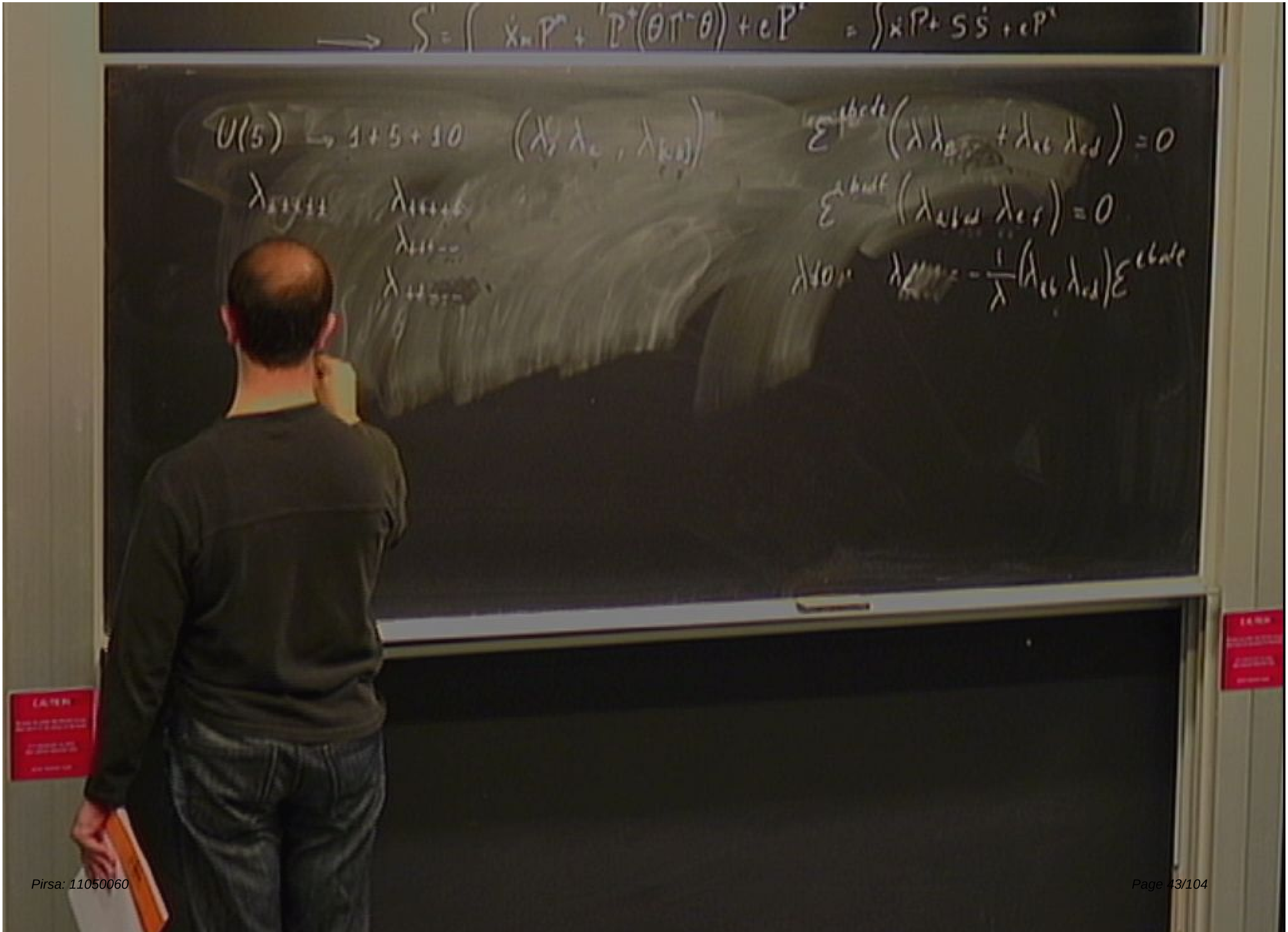
$b\partial c$ $\quad c = -2,\ +2$ $\quad c = 10$, $c = -32$, $c =$ …, c

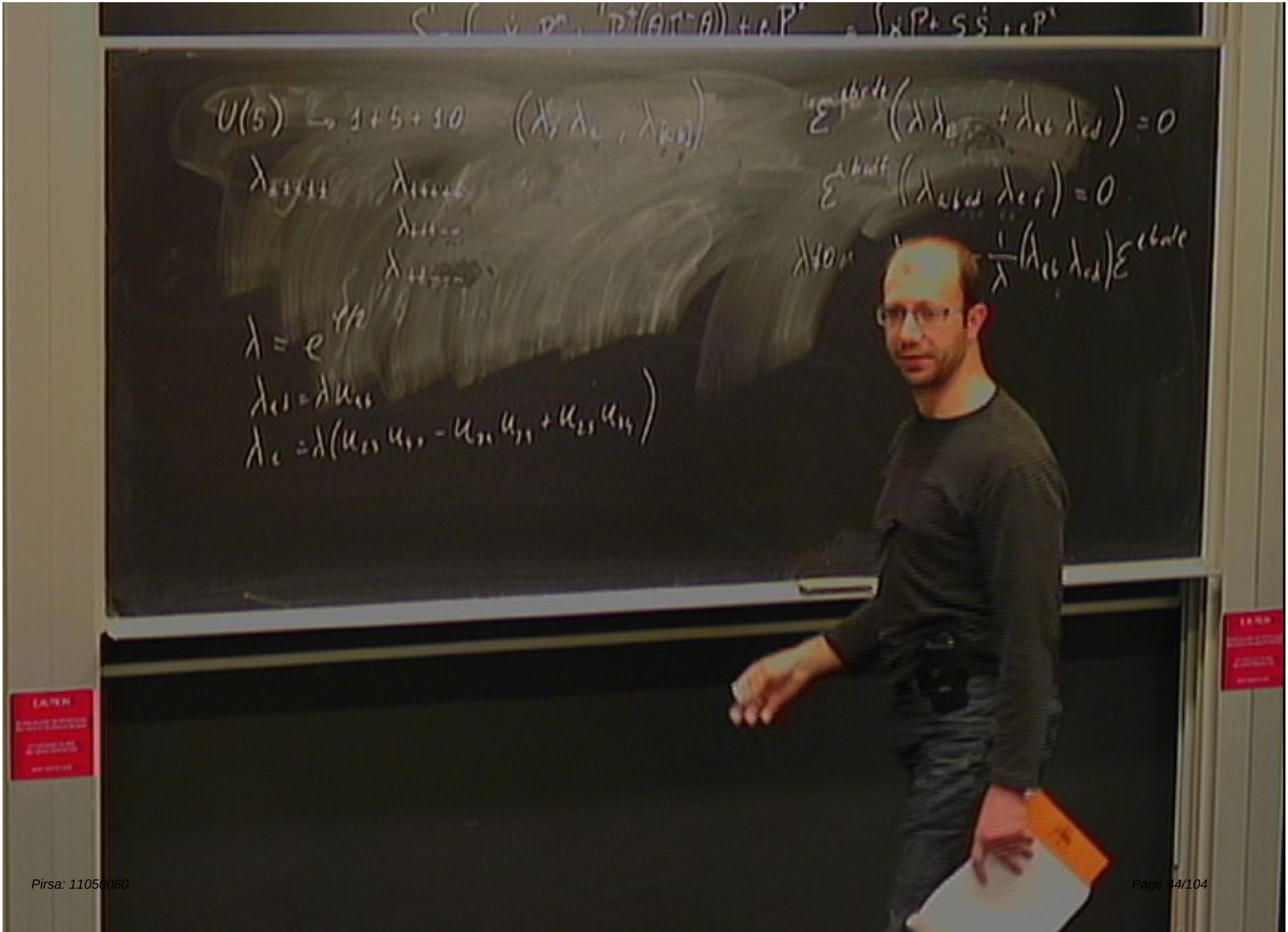

U(5) → 1+5+10

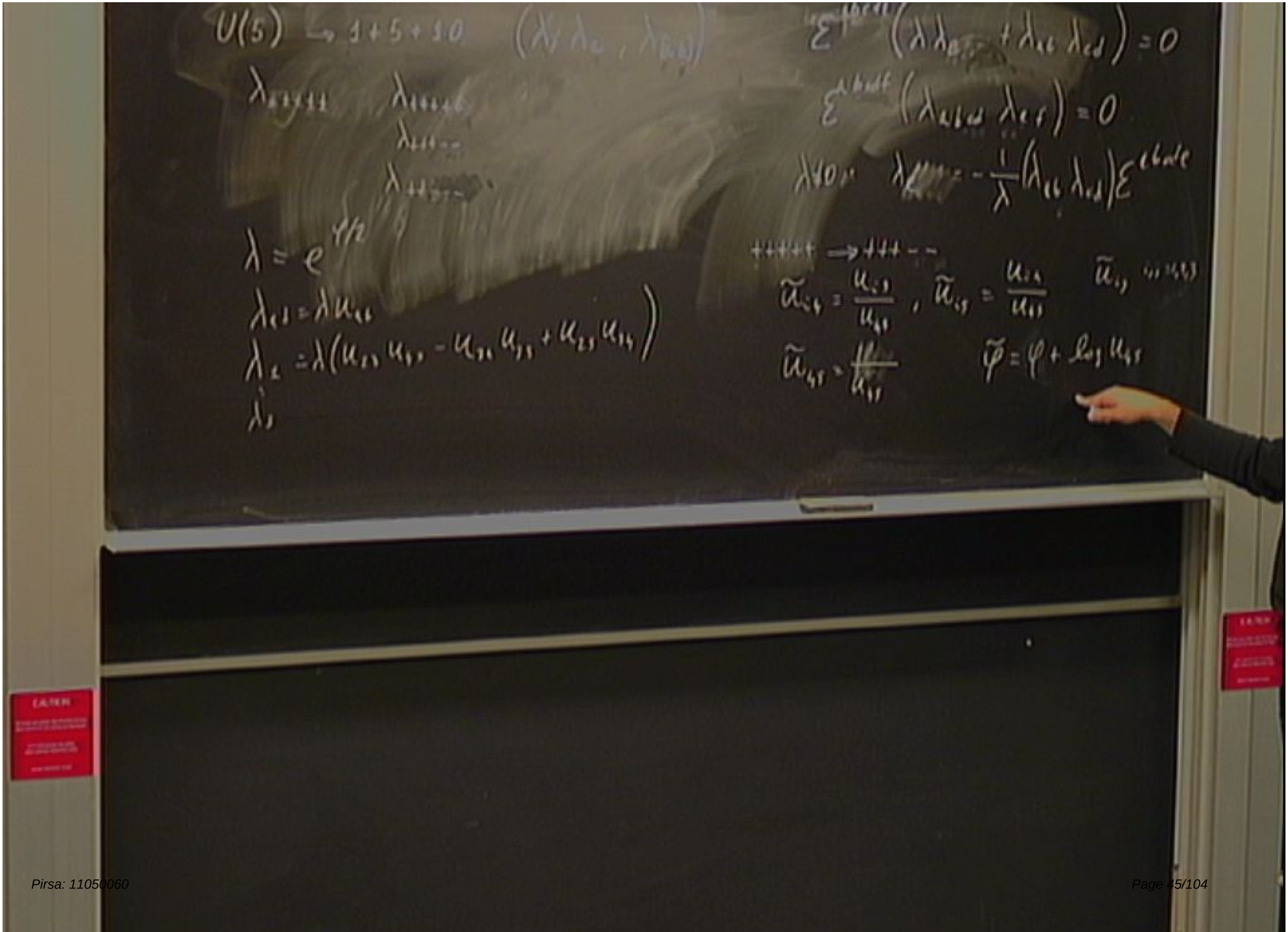


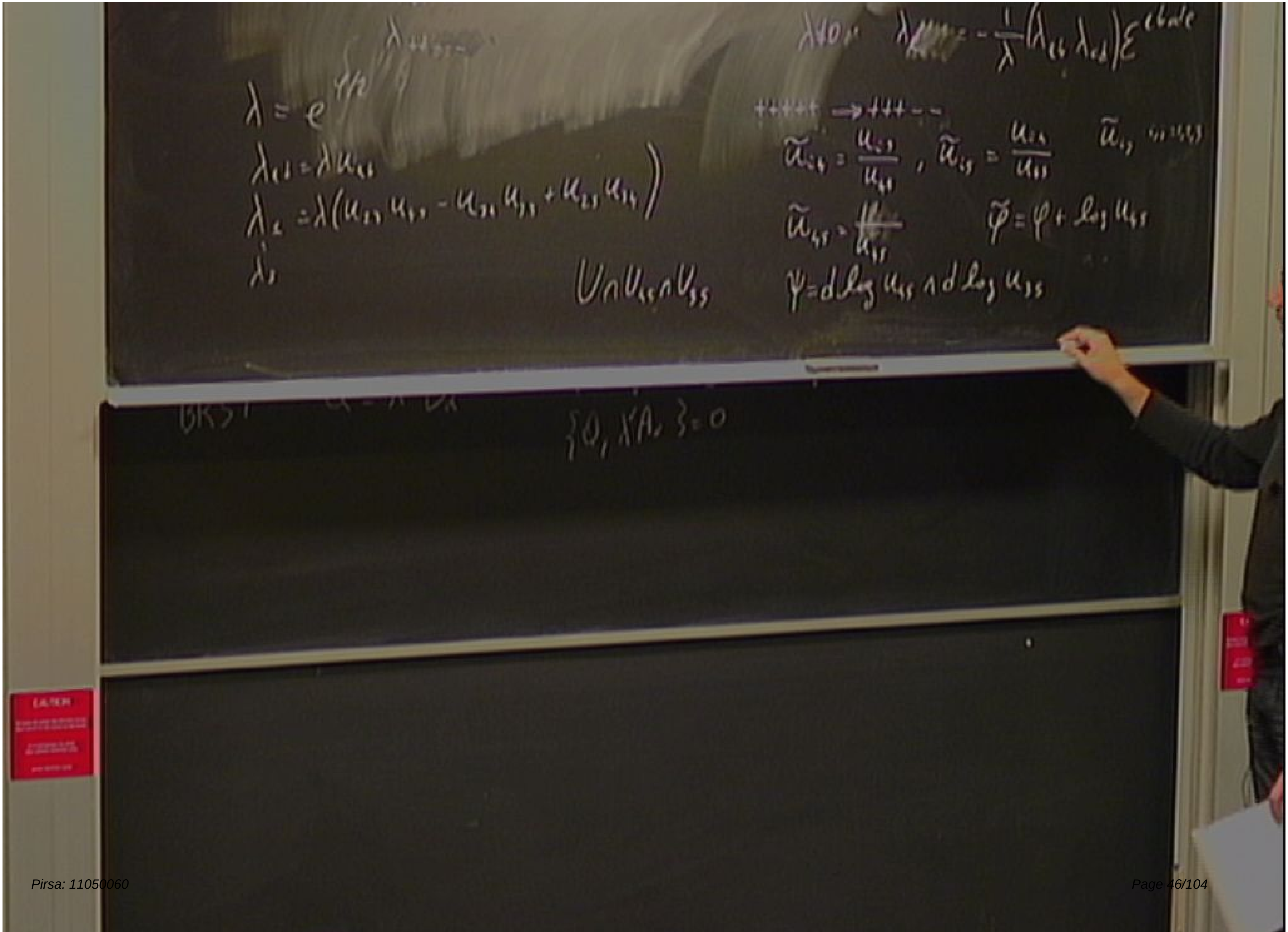

U(5) → 1 + 5 + 10

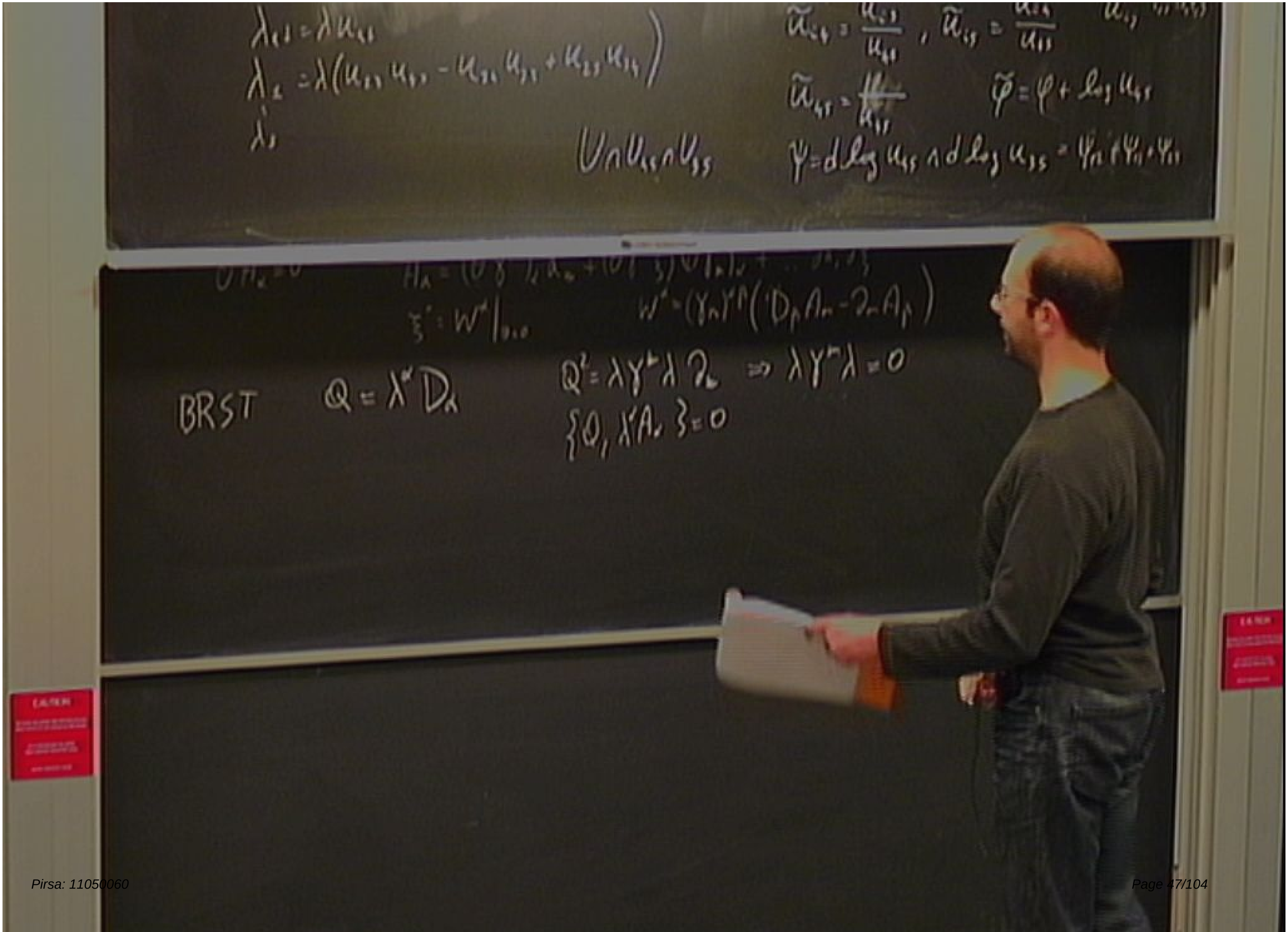


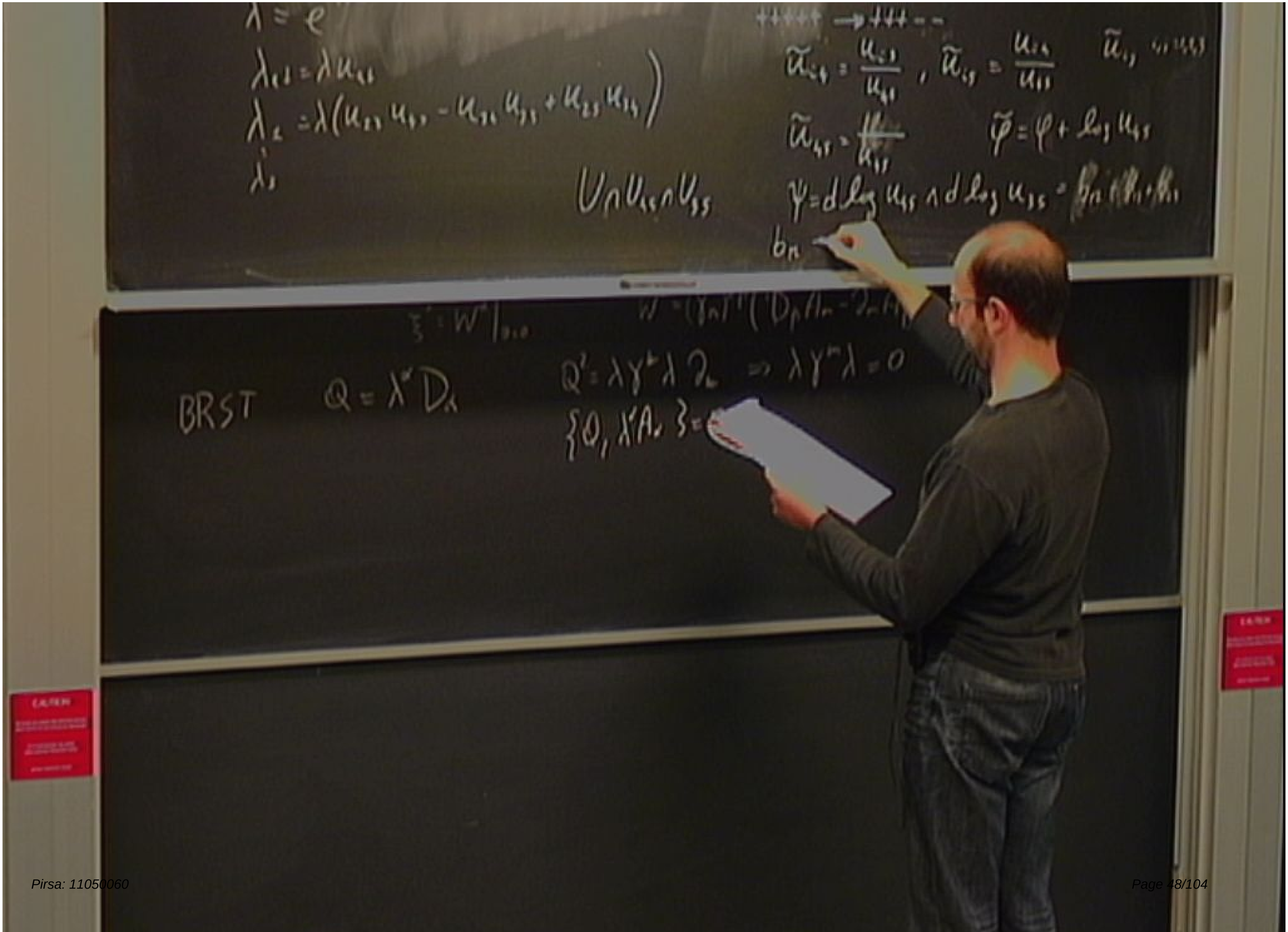


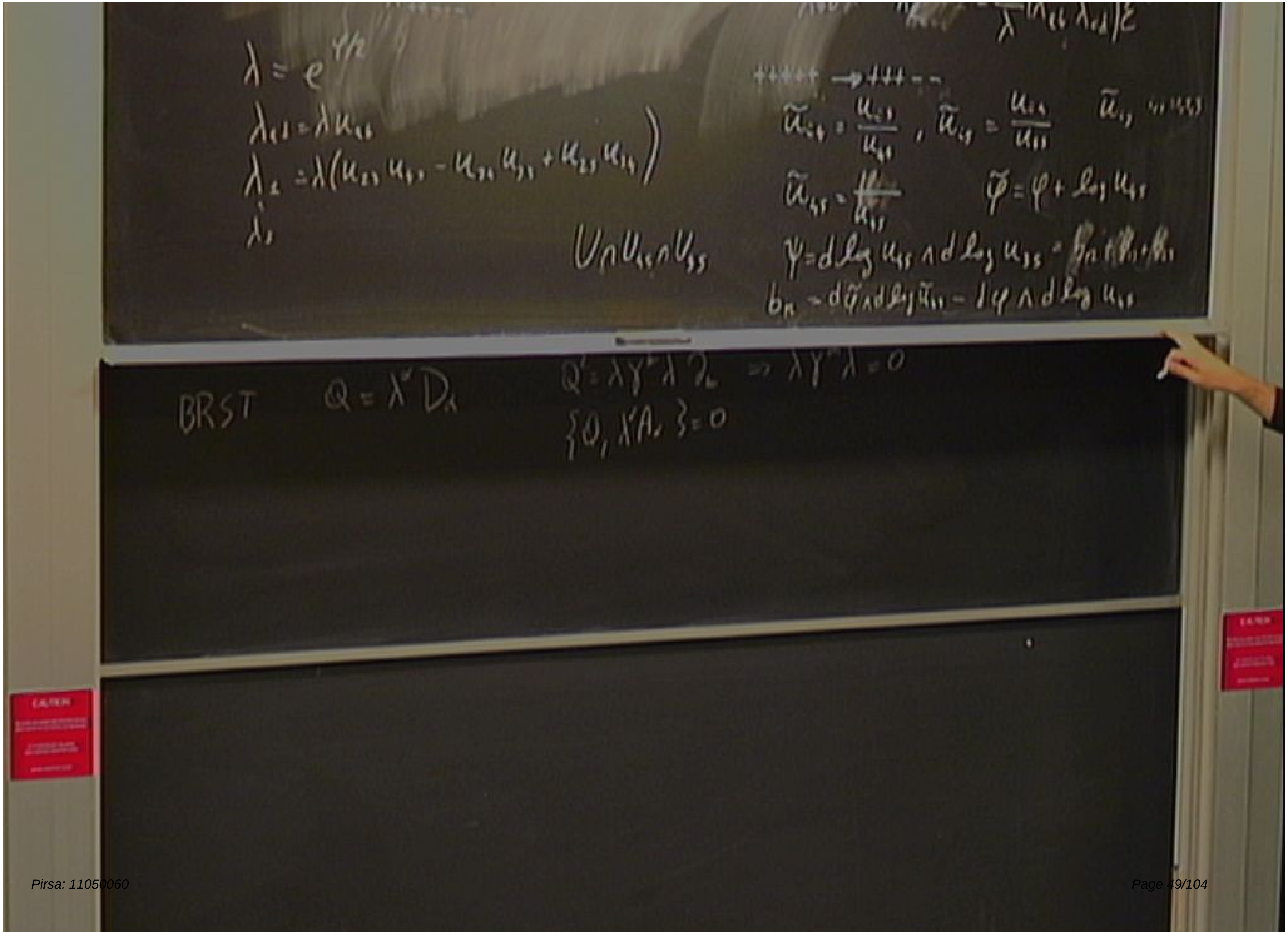

U(5) → 1 + 5 + 10

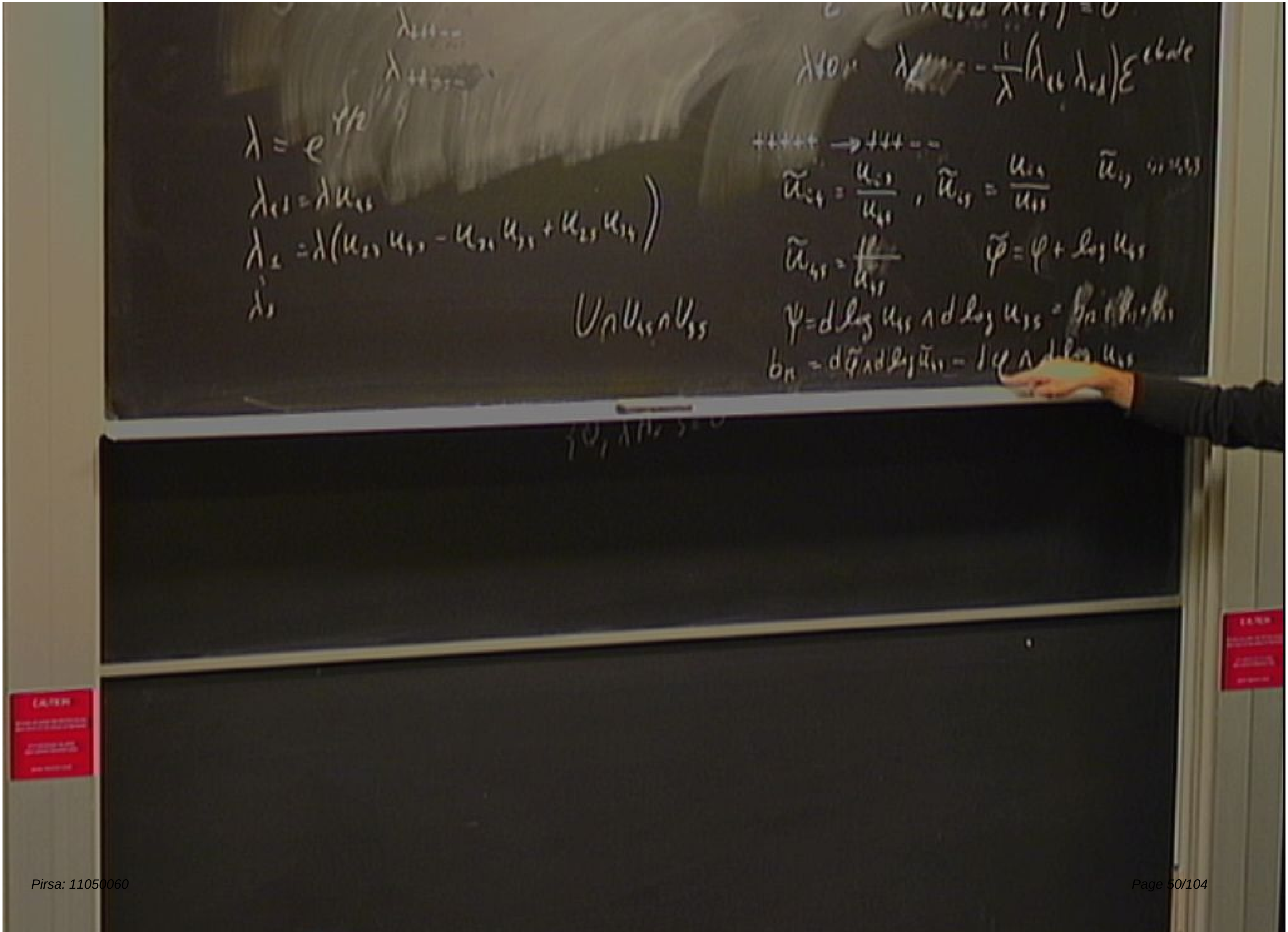

U(5) → 1 + 5 + 10
λ = e^{φ/2}
+++++ → +++ − −
φ̃ = φ + log u45

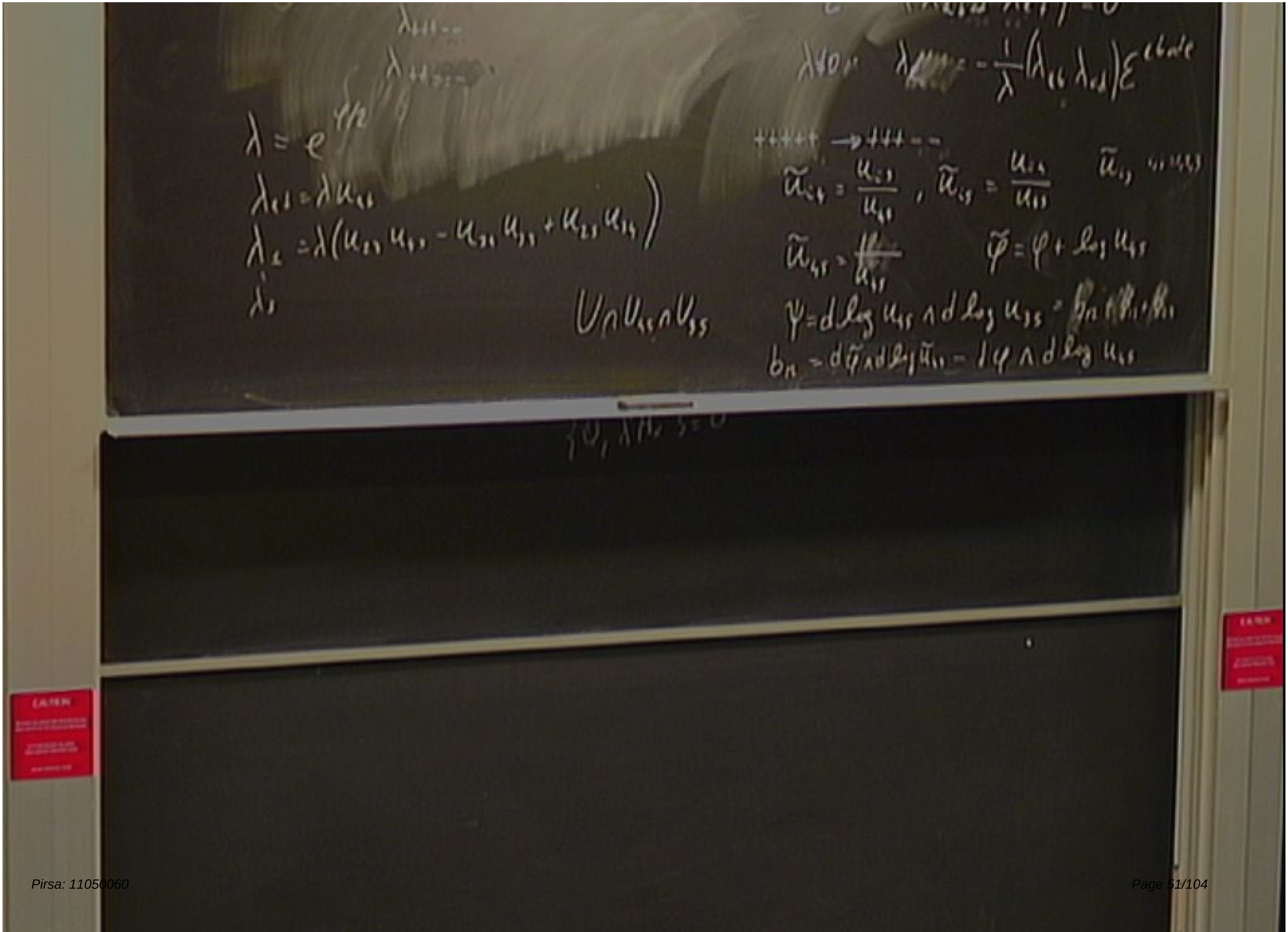

λ = e
λ_{cd} = λ u_{45}
ψ = d log u_{45} ∧ d log u_{35}
U ∩ U_{45} ∩ U_{35}
{Q, λA, } = 0
BRST

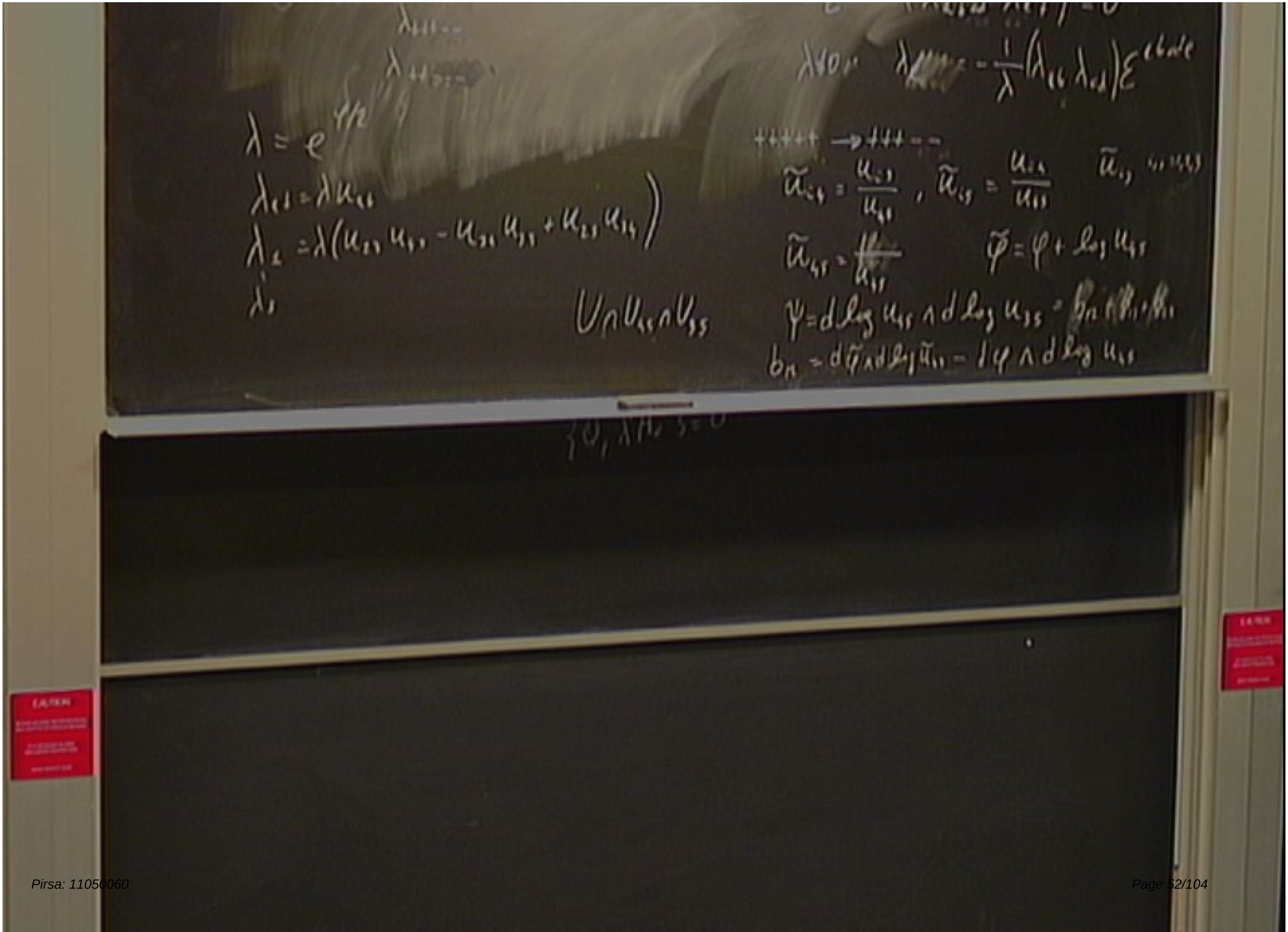

BRST
Q = λ^α D_α
Q² = λγ^m λ ∂_m ⇒ λγ^m λ = 0
{Q, λ^α A_α} = 0

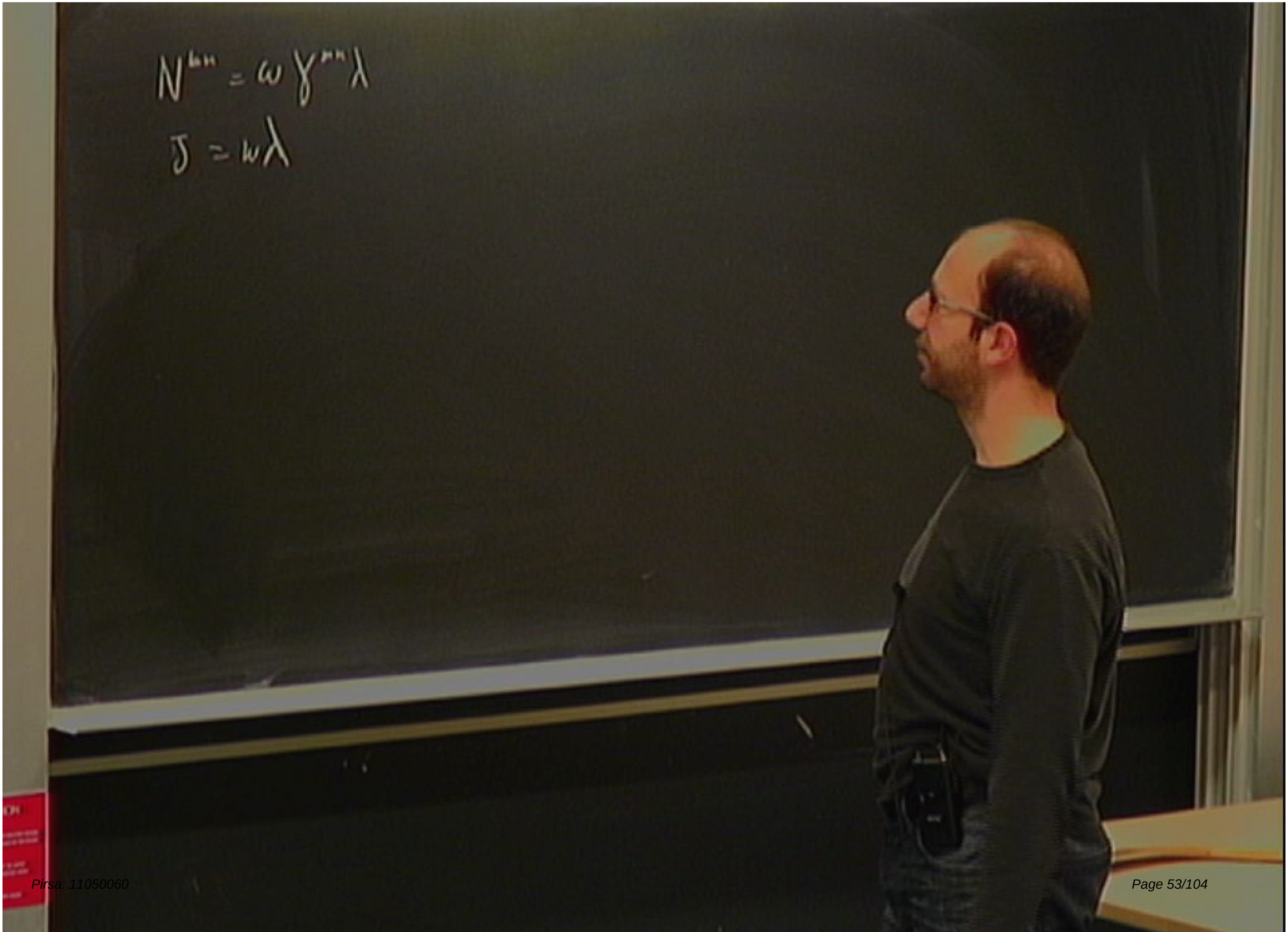

BRST

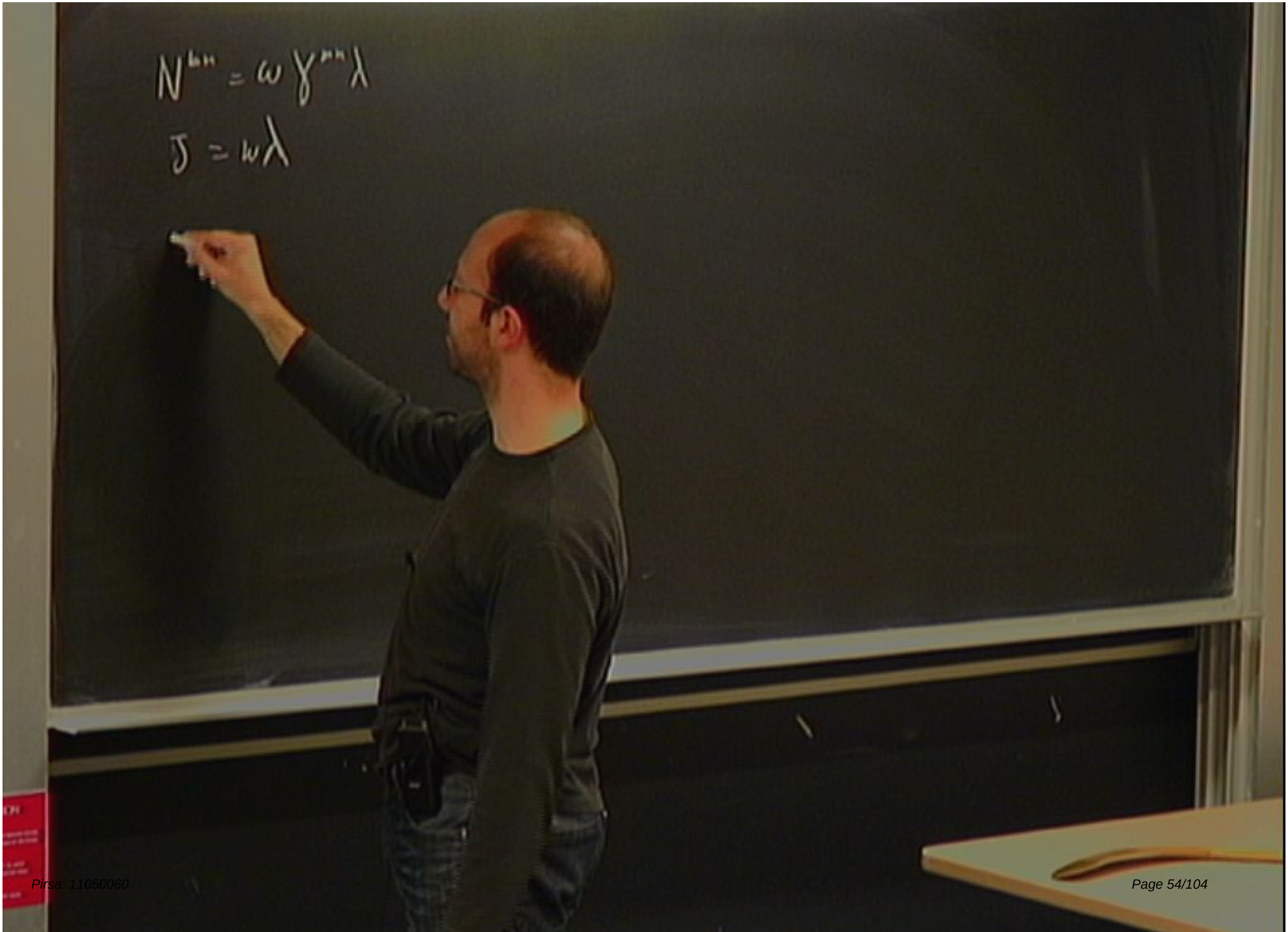

BRST
Q = λ^α D_α
{Q, λ^α A_α} = 0
U ∩ U_45 ∩ U_35

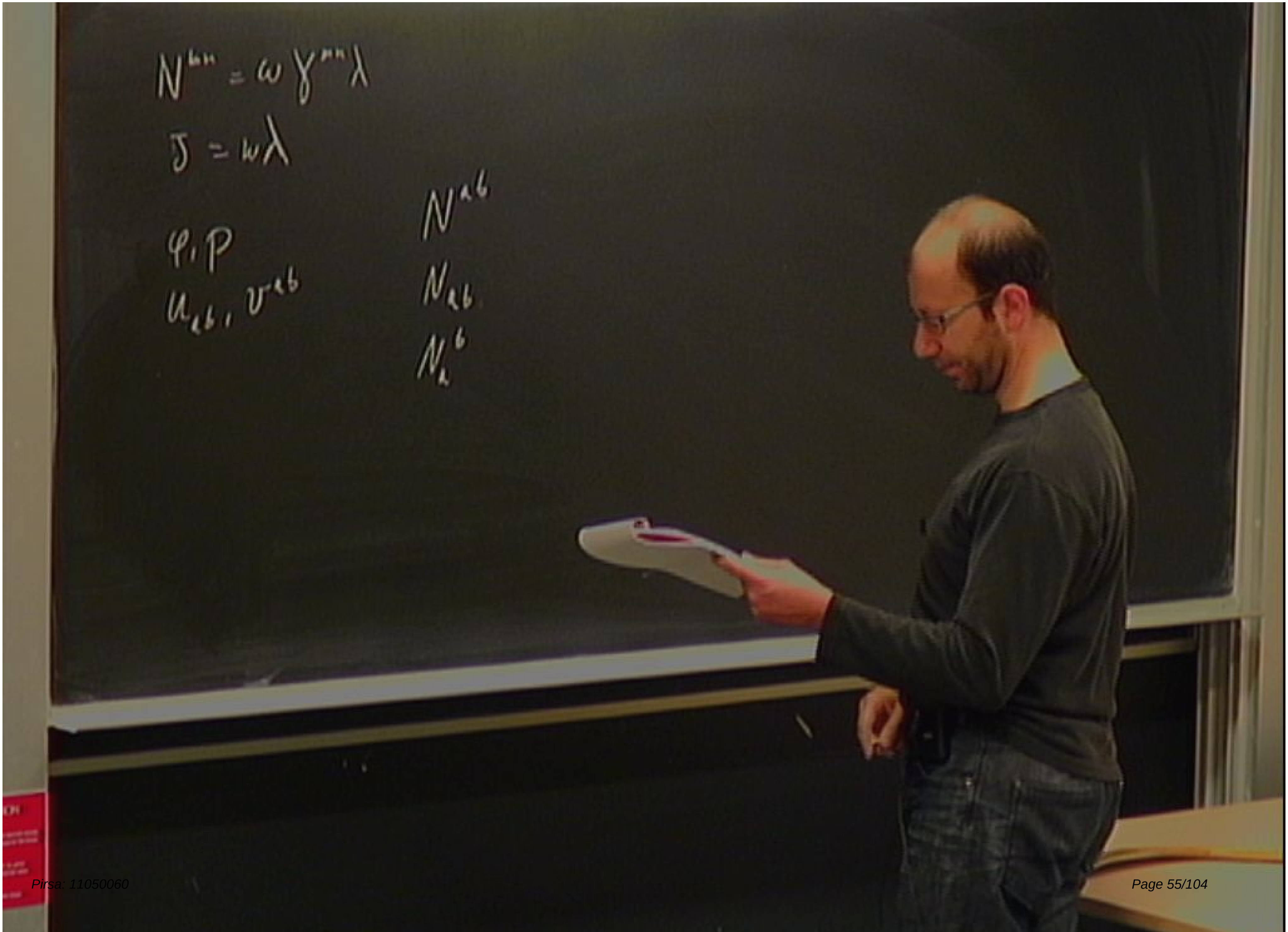

λ = e
λ₂ = λ(u₂₃ u₄₅ − u₂₄ u₃₅ + u₂₅ u₃₄)
U ∩ U₄₅ ∩ U₃₅
φ̃ = φ + log u₄₅
ψ = d log u₄₅ ∧ d log u₃₅

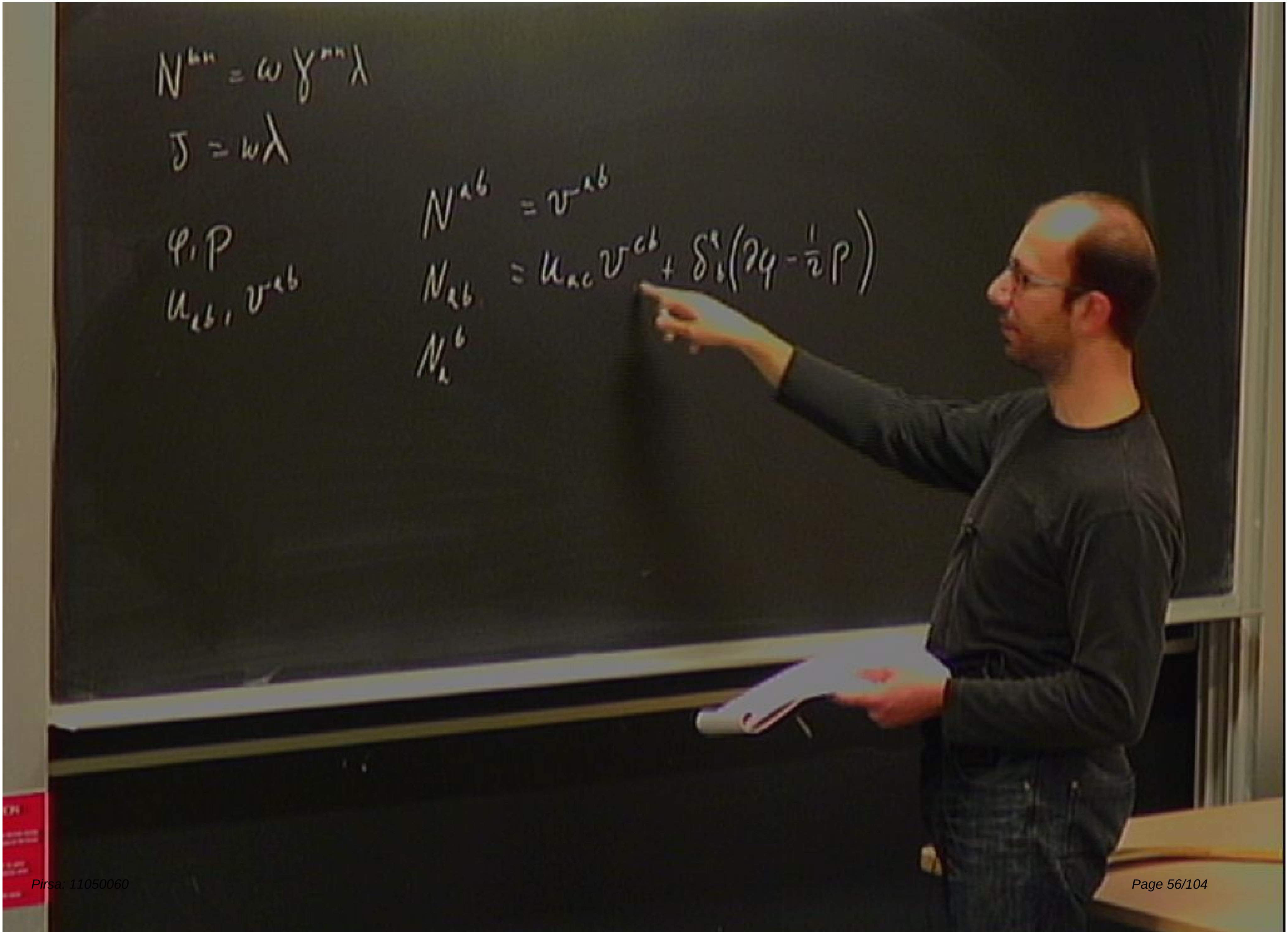


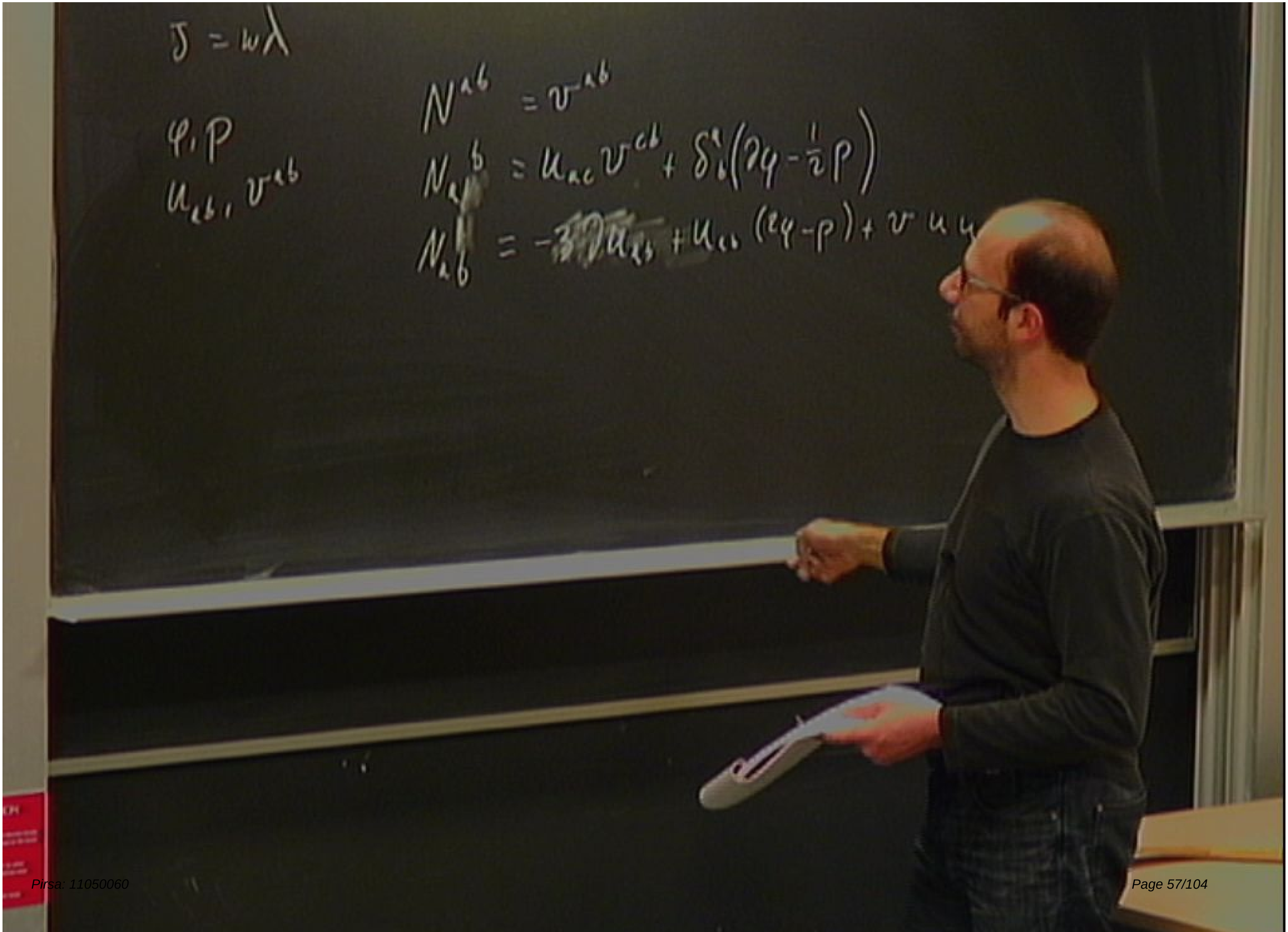


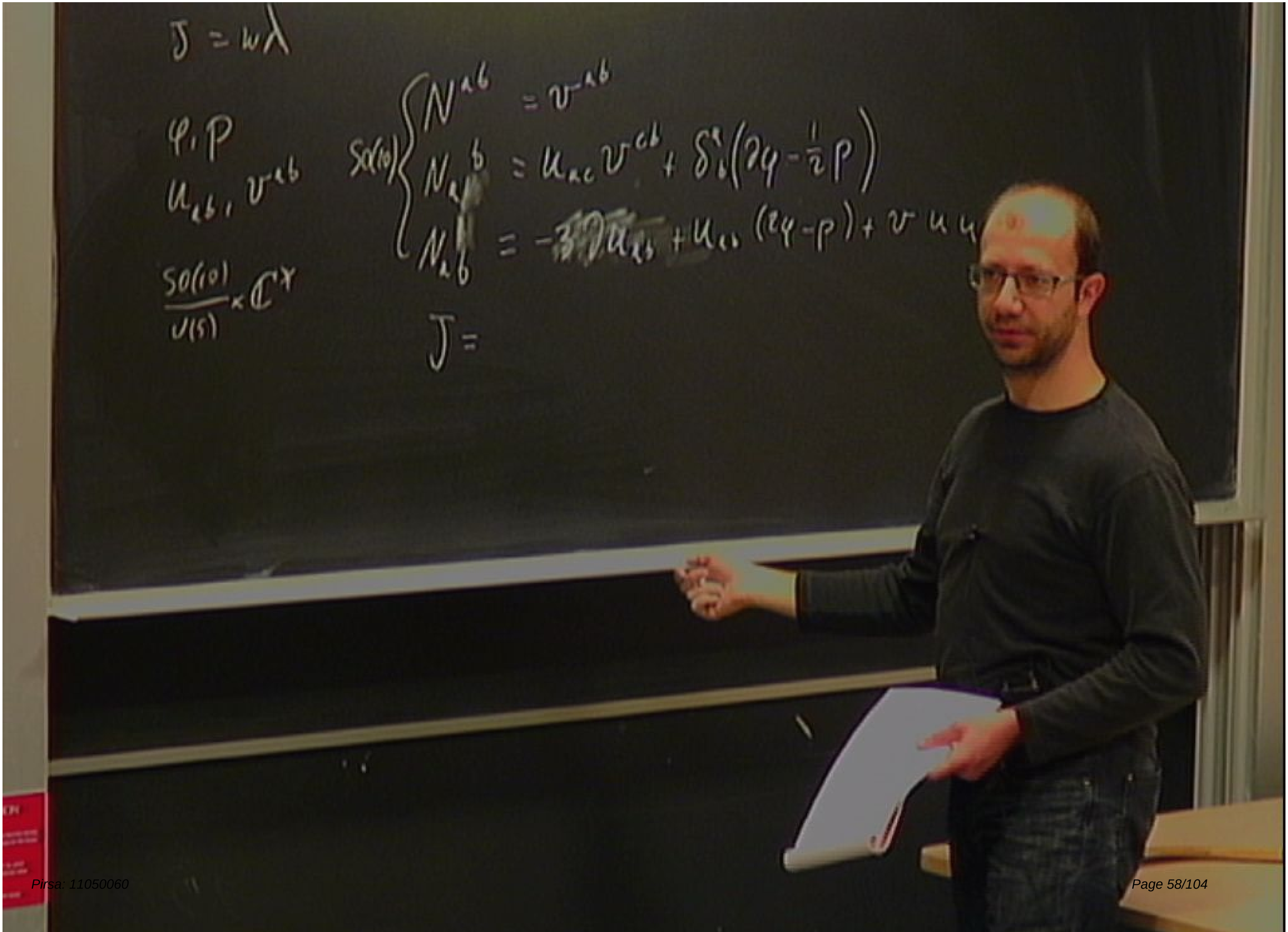

$N^{mn} = \omega \gamma^{mn} \lambda$
$J = \omega \lambda$

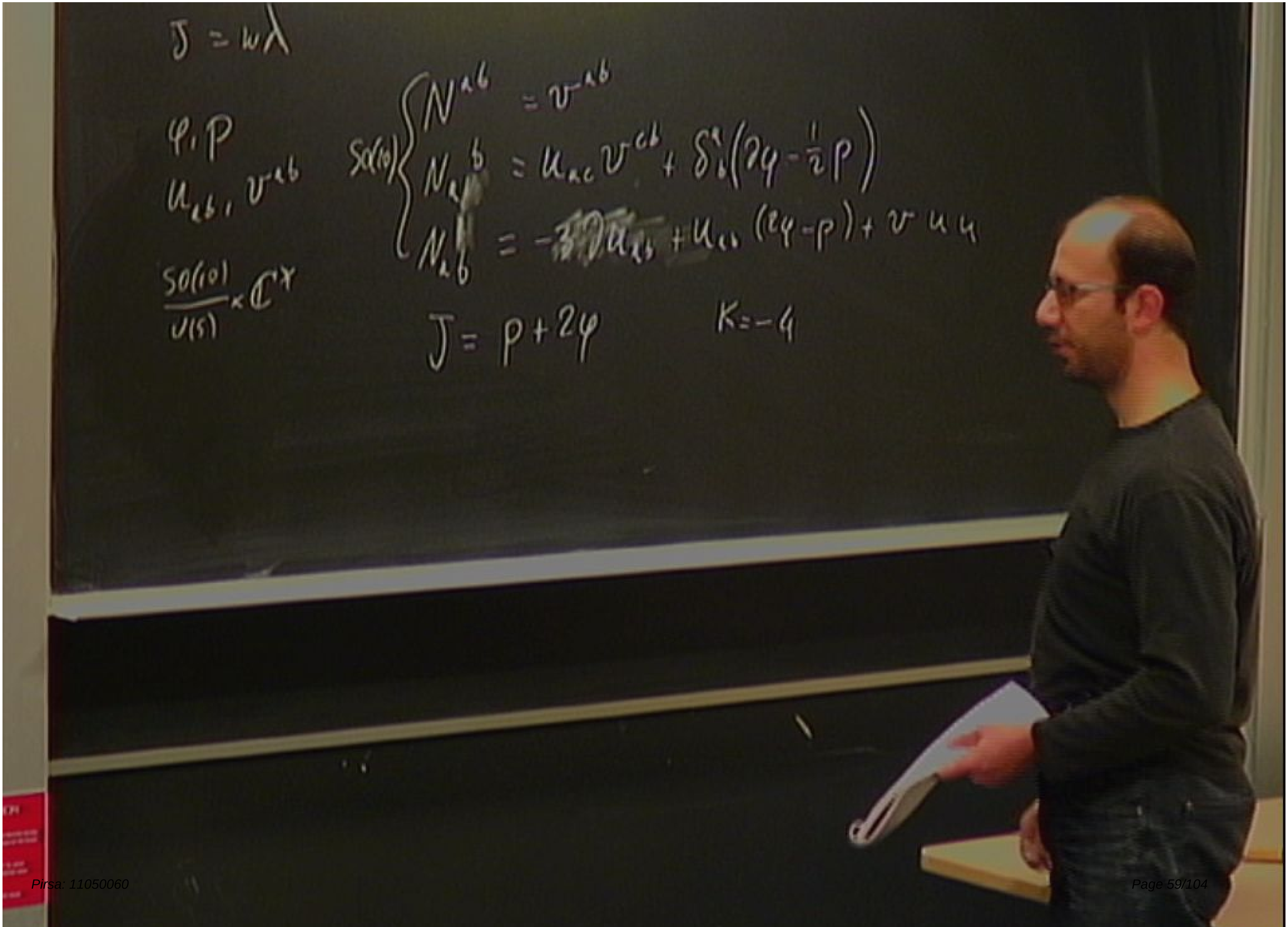

$N^{mn} = \omega \gamma^{mn} \lambda$
$J = \omega \lambda$

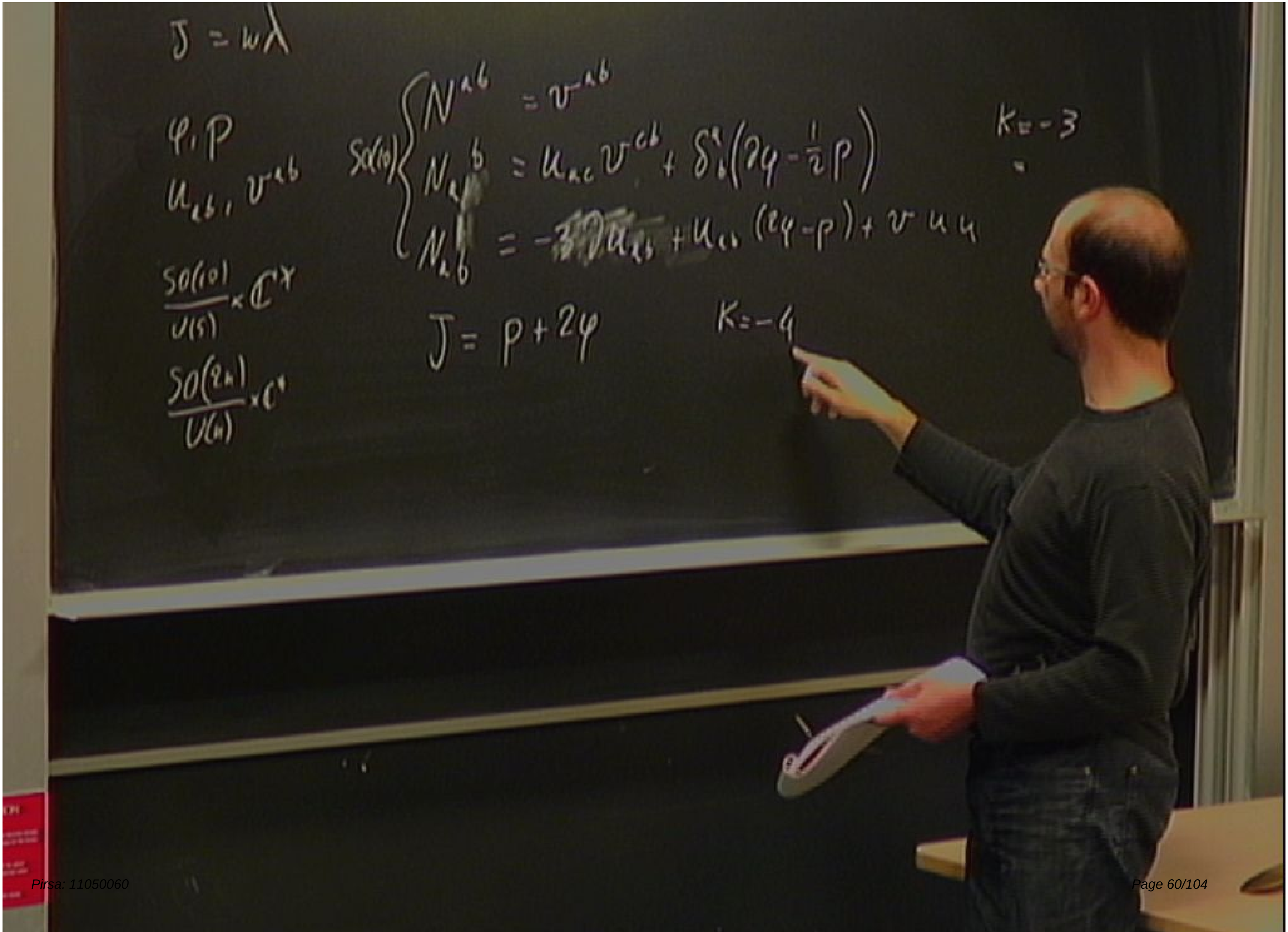

$N^{mn} = \omega \gamma^{mn} \lambda$
$J = \omega\lambda$
φ, P
u_{ab}, v^{ab}
N^{ab}
N_{ab}
$N_a{}^b$


$N^{mn} = \omega \gamma^{mn} \lambda$
$J = w\lambda$
φ, P
u_{ab}, v^{ab}
$N^{ab} = v^{ab}$
$N_{ab} = u_{ac} v^{cb} + \delta^a_b(\partial\varphi - \frac{1}{2}P)$
$N_a^{\ b}$

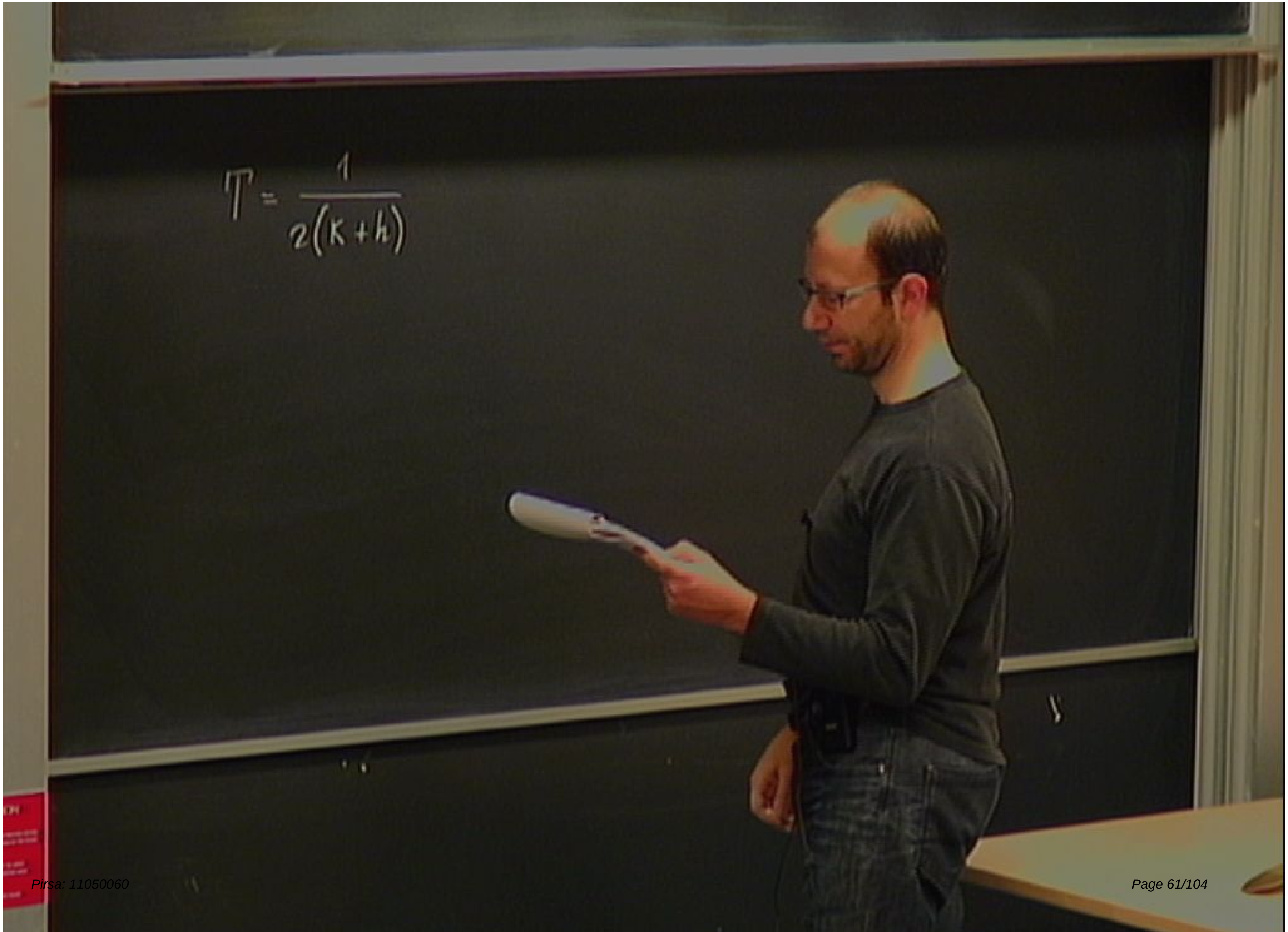

J = ωλ
φ, P
u_ab, v^ab
N^ab = v^ab
N_a^b = u_ac v^cb + δ^a_b (∂φ - ½ P)
N_ab = - … + u_cb (2φ - P) + v u φ

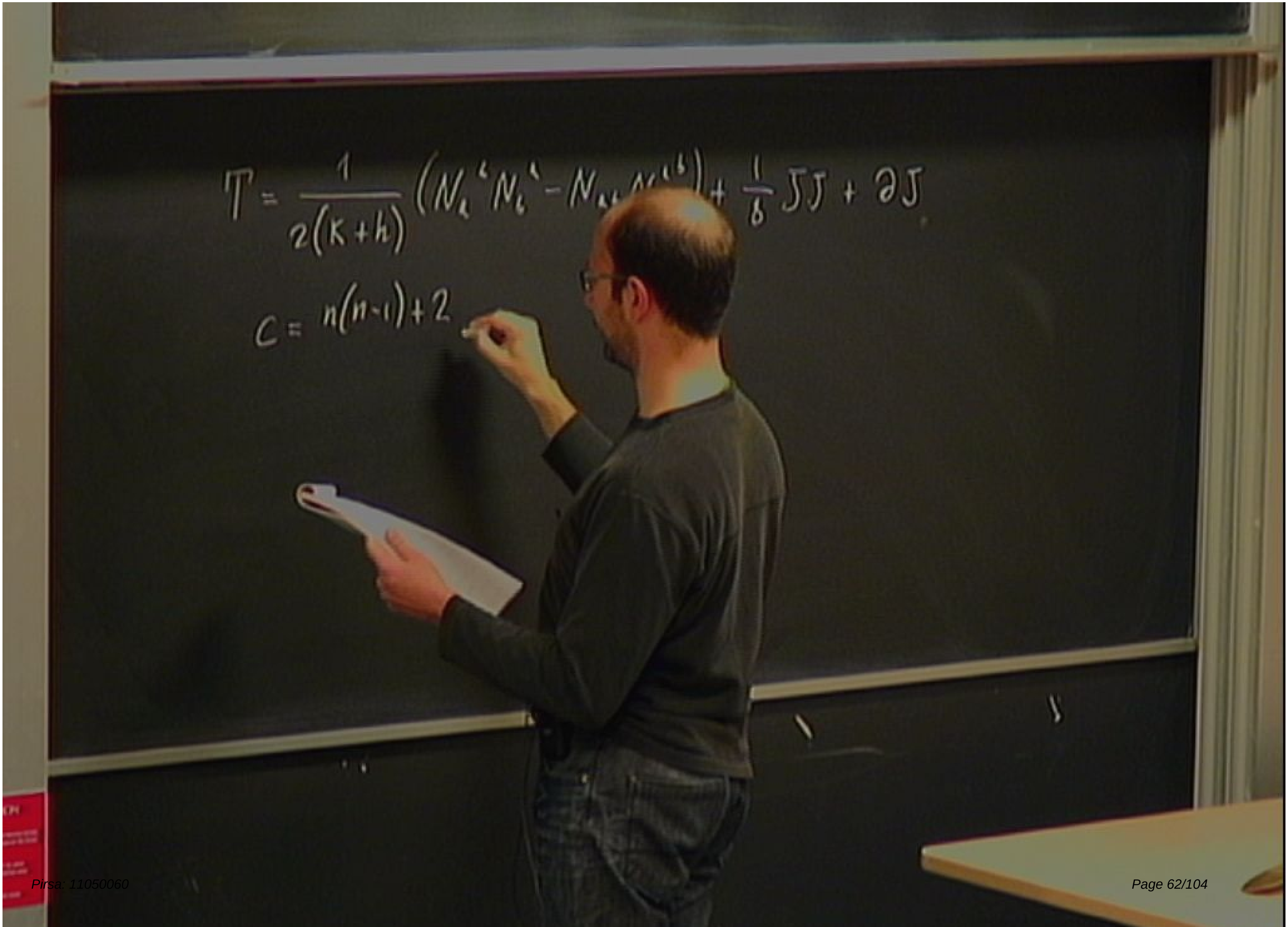


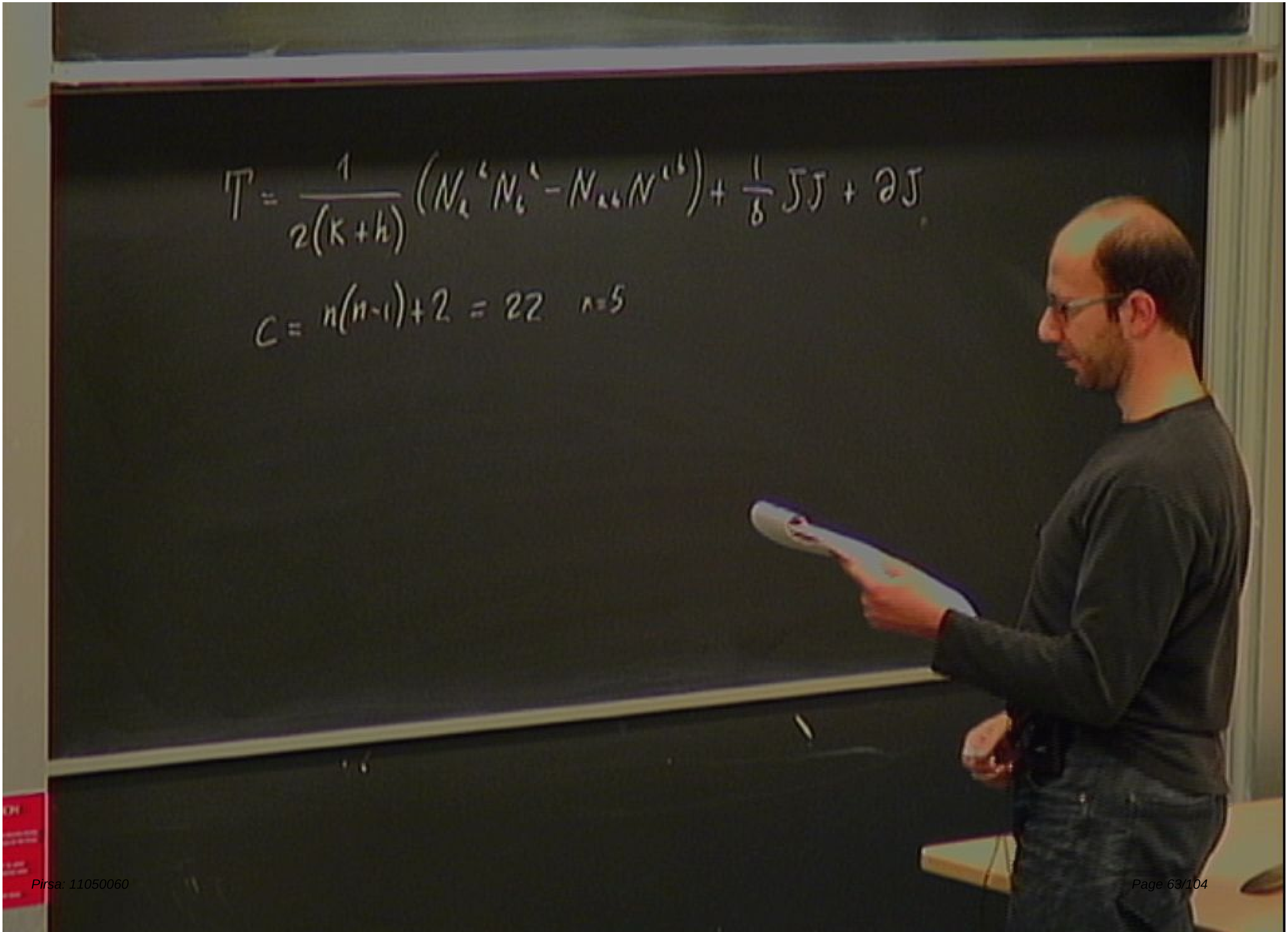

J = wλ
φ, ρ
u_ab, v^ab
SO(10)/U(5) × C*
N^ab = v^ab
J = ρ + 2φ
K = -4

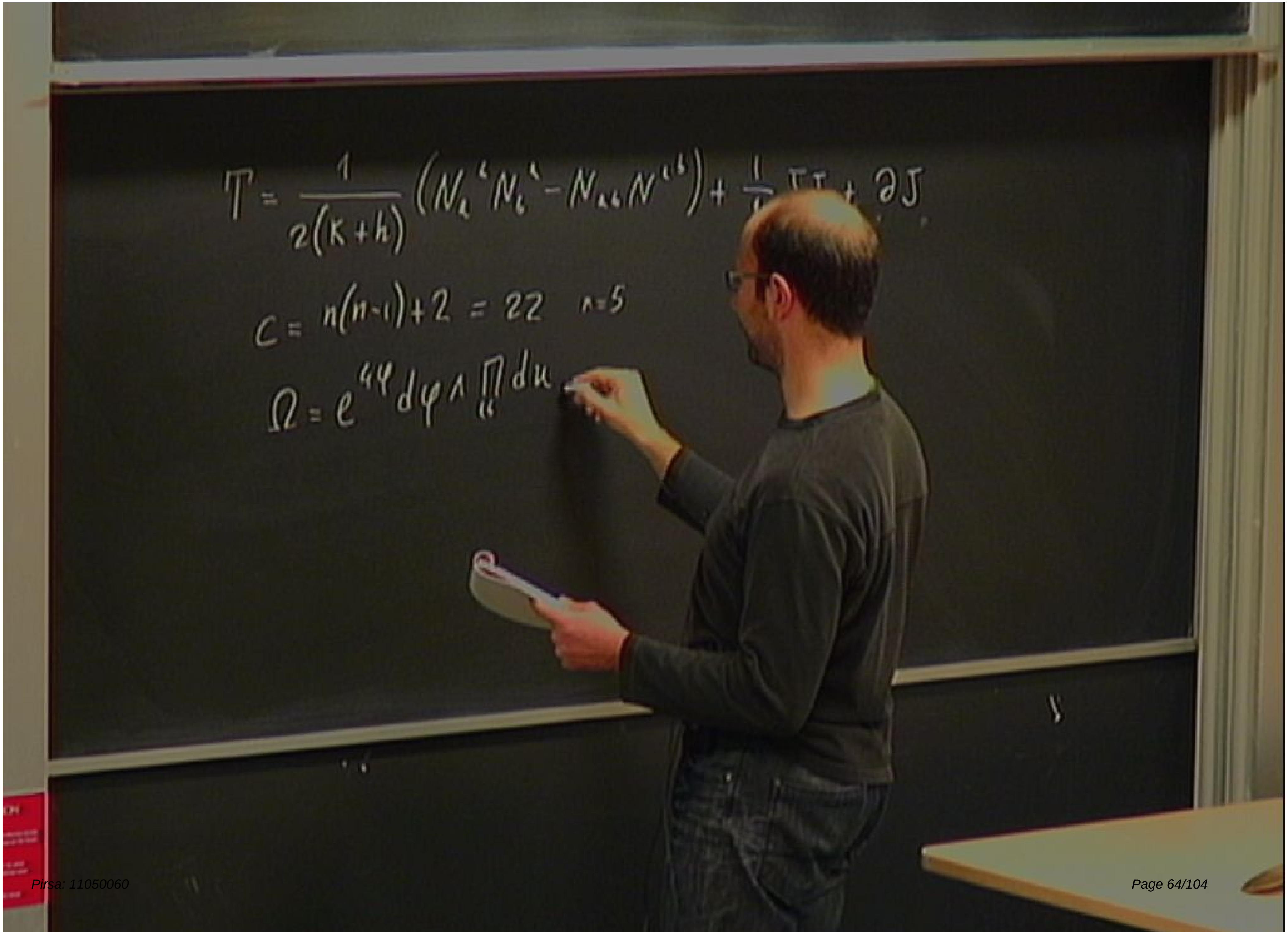


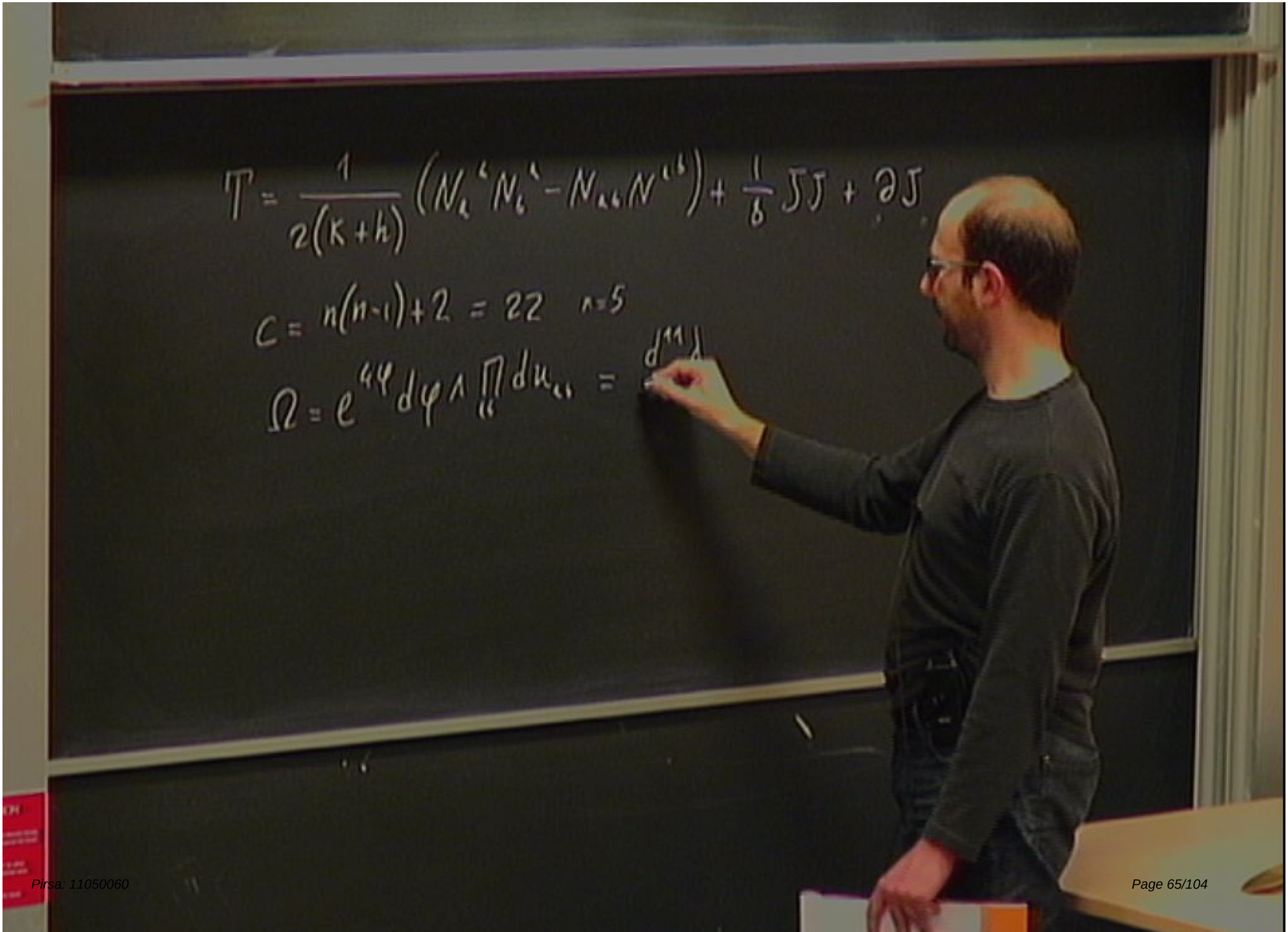
J = wλ
φ, P
K = -3
J = p + 2φ
K = -4


T = 1 / 2(K + h)


T = 1/2(k+h) (+ 1/6 JJ + ∂J
C = n(n-1)+2


$T = \frac{1}{2(K+h)} \left(N_a{}^b N_b{}^a - N_{ab} N^{ab} \right) + \frac{1}{6} JJ + \partial J$
$C = n(n-1) + 2 = 22 \quad n=5$


T = 1/2(K+h) (N_a^b N_b^a − N_ab N^ab) + ∂J
c = n(n−1)+2 = 22   n=5
Ω = e^4φ dφ ∧ ∏ du

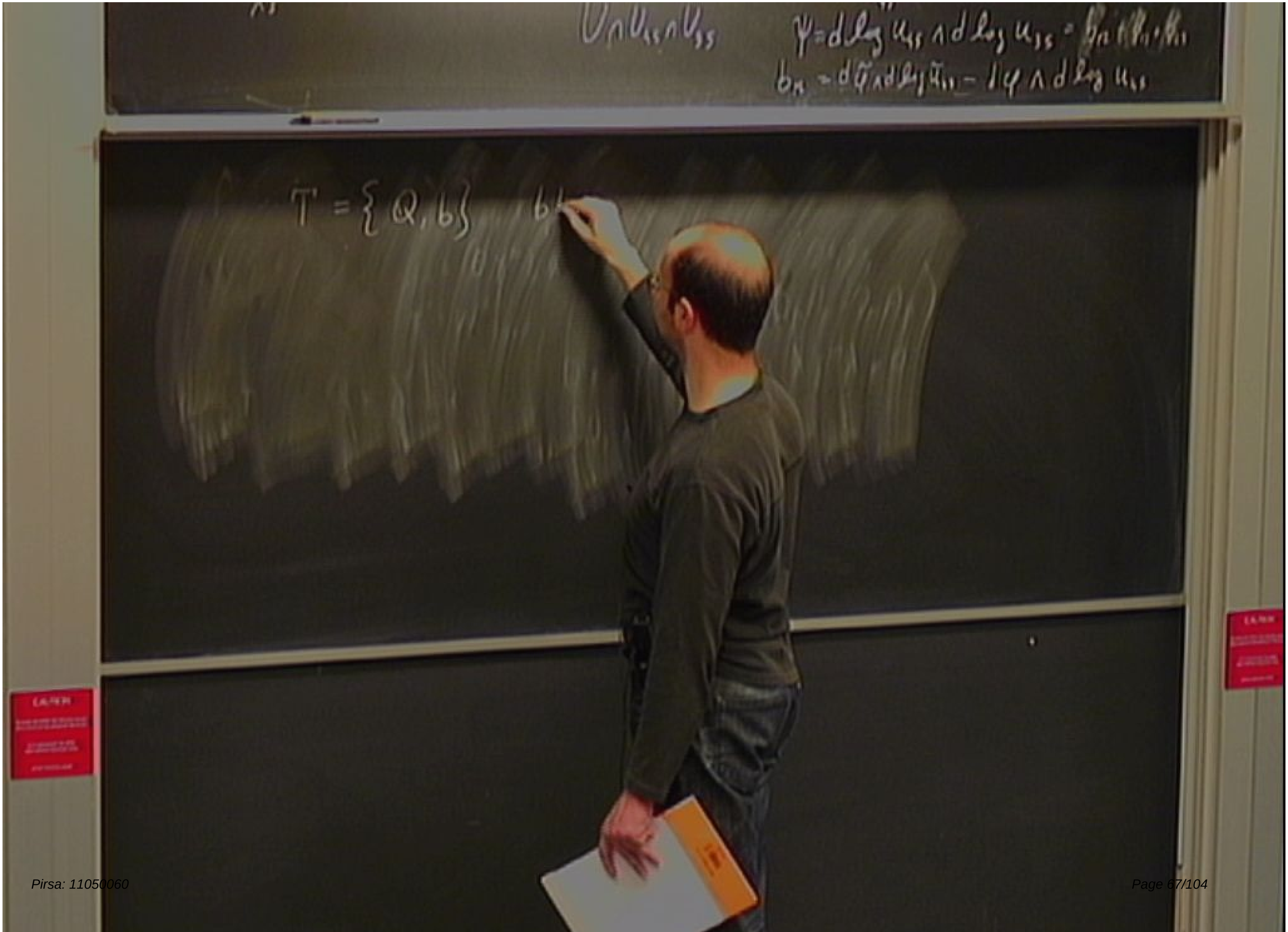


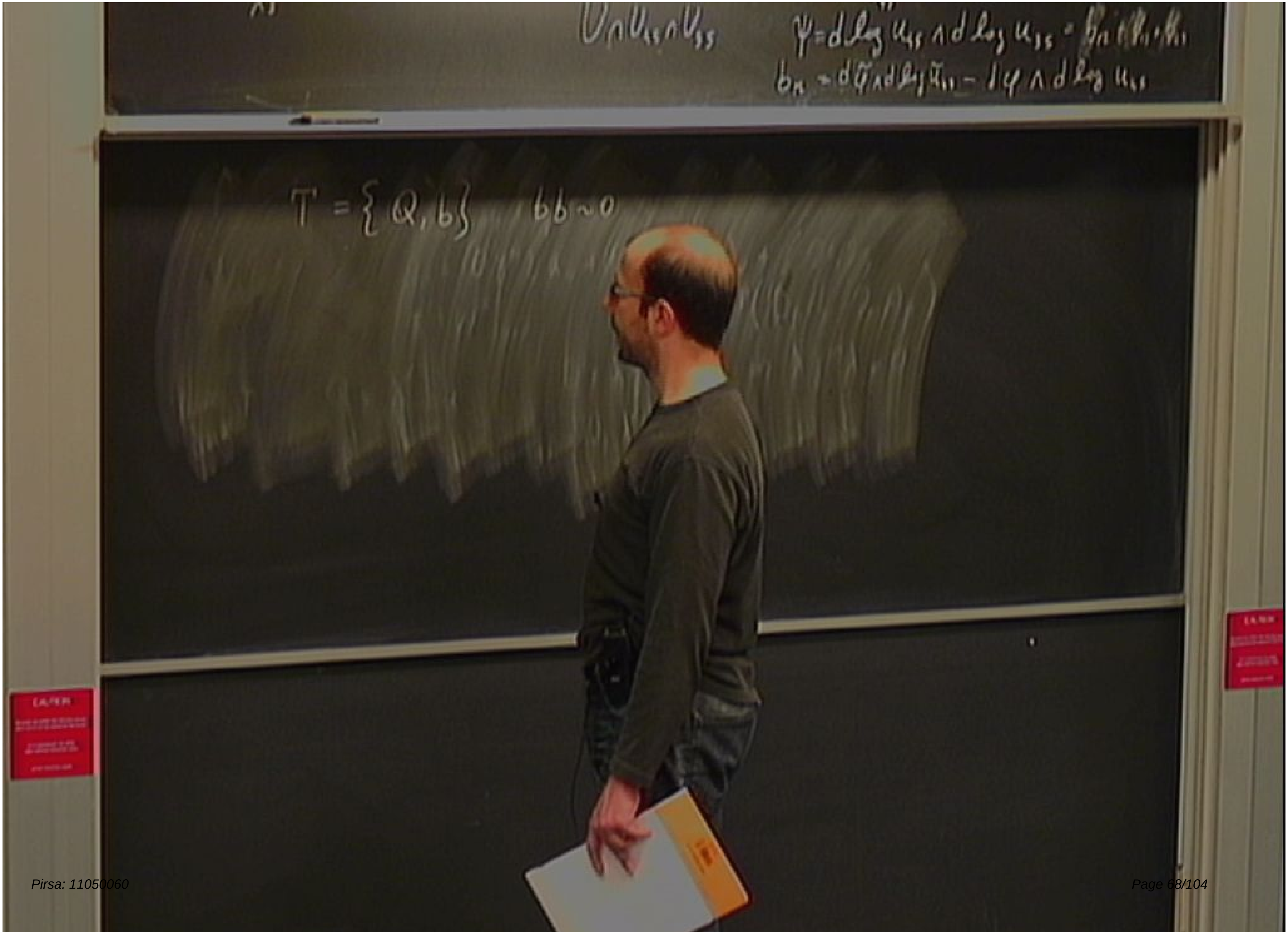
T = 1/2(k+h) (N_a^b N_b^a − N_ab N^ab) + 1/6 JJ + ∂J
c = n(n-1)+2 = 22   n=5
Ω = e^4φ dφ ∧ ∏ du_ab =

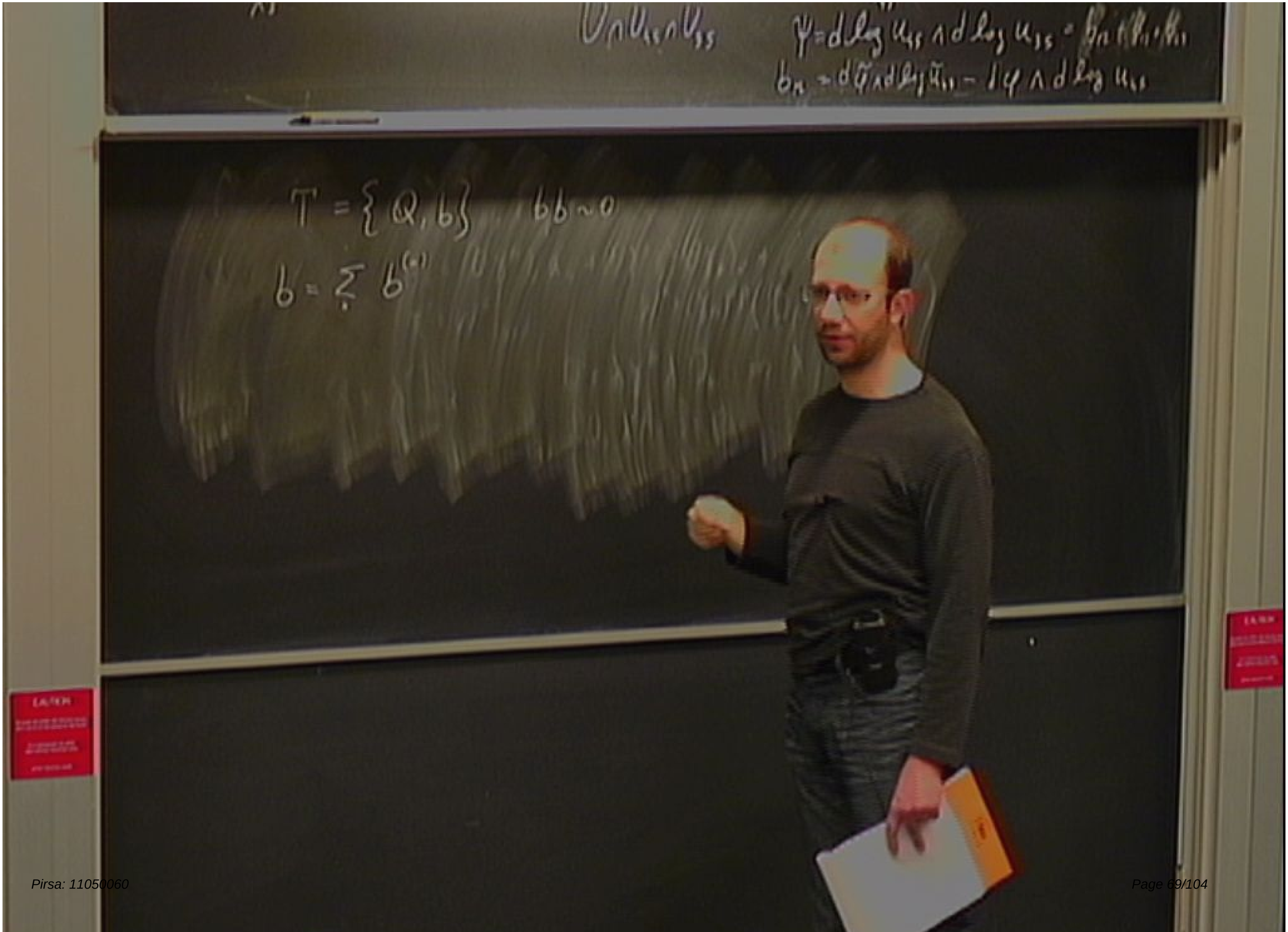
$$T = \frac{1}{2(k+h)}\left(N_a{}^b N_b{}^a - N_{ab}N^{ab}\right) + \frac{1}{6} JJ + \partial J$$

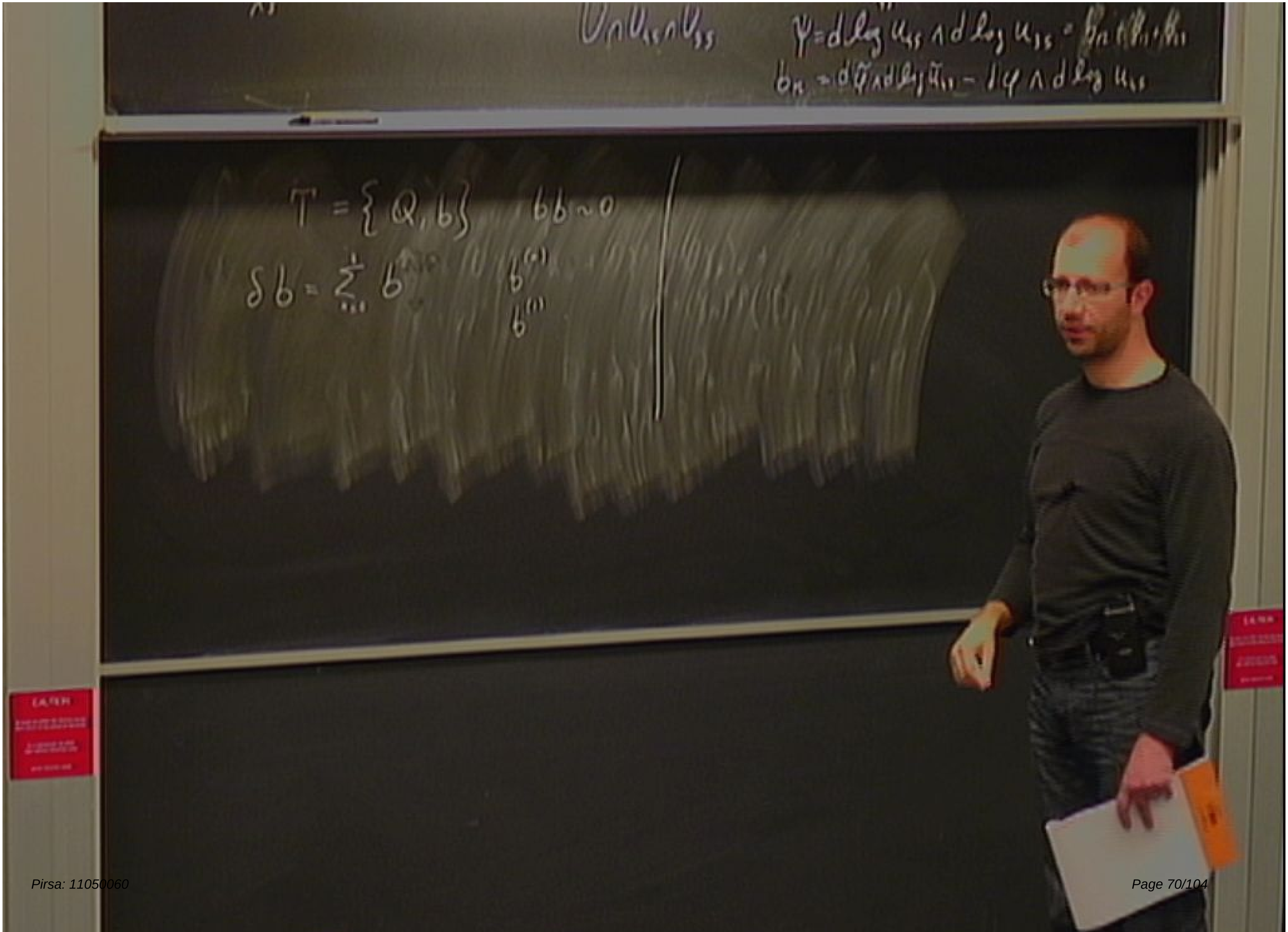
$$c = n(n-1) + 2 = 22 \qquad n=5$$

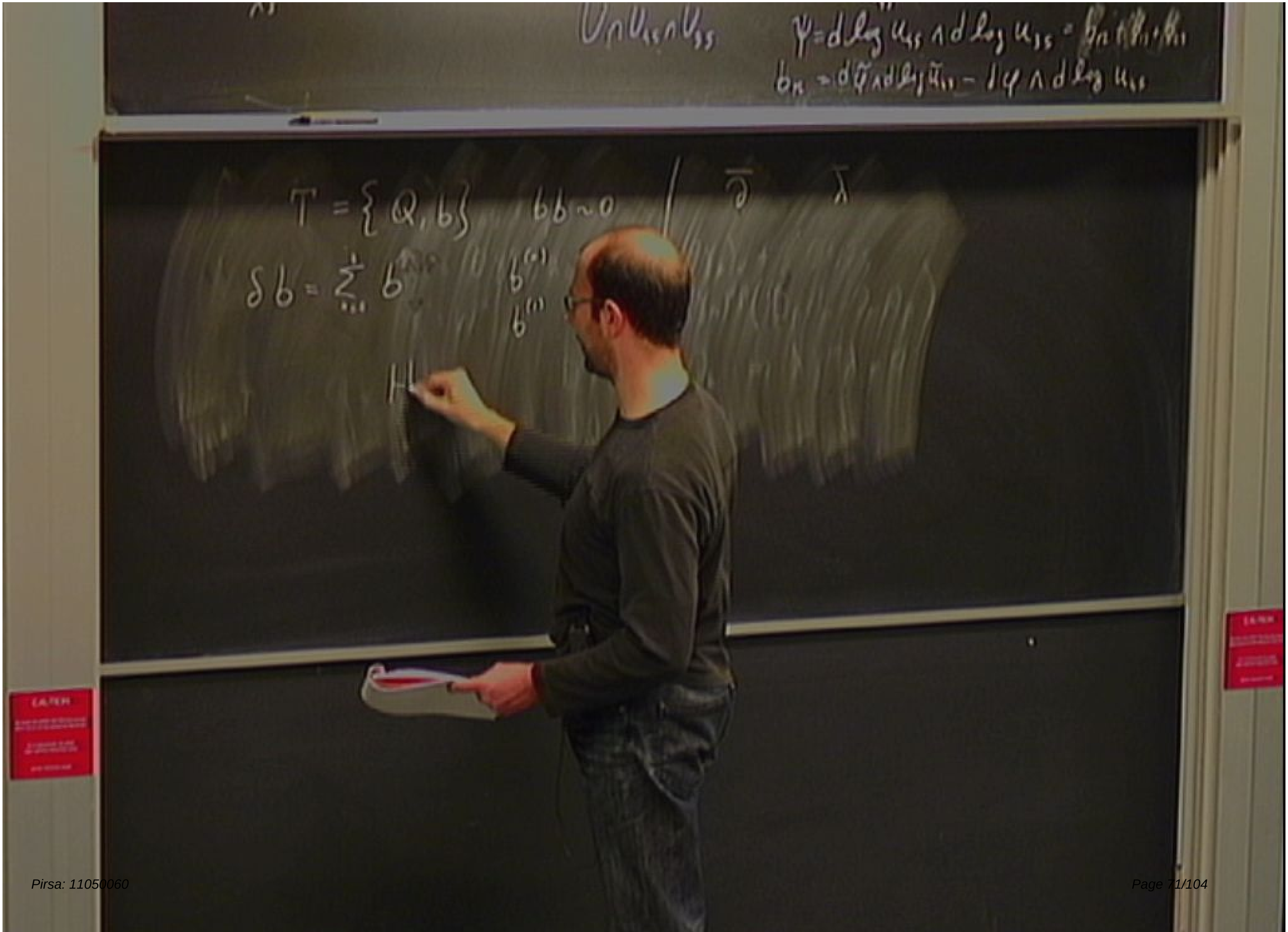
$$\Omega = e^{4\varphi}\, d\varphi \wedge \prod_{ab} du_{ab} = \frac{d^{11}\lambda}{\lambda^3}$$

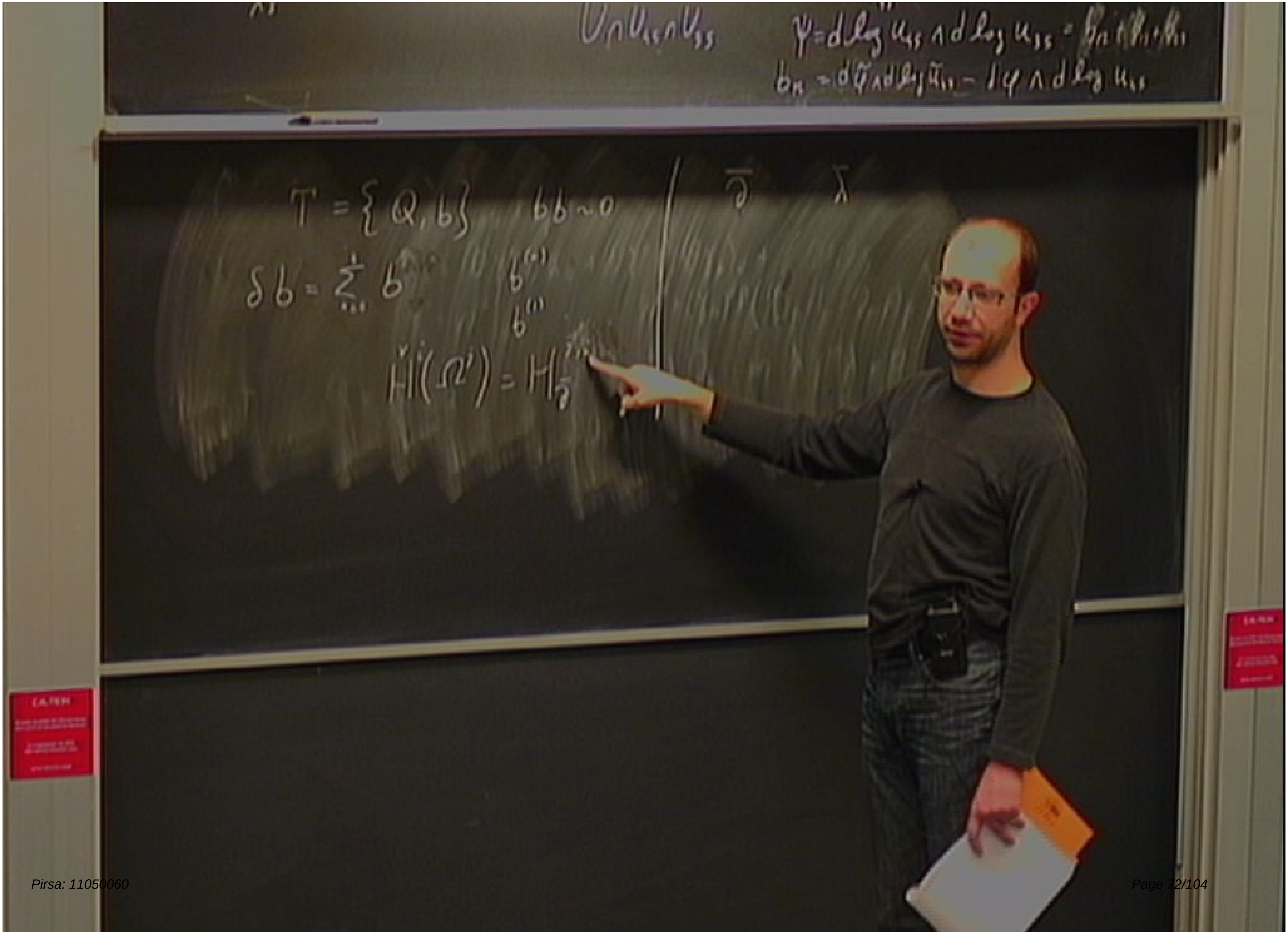

T = {Q, b}

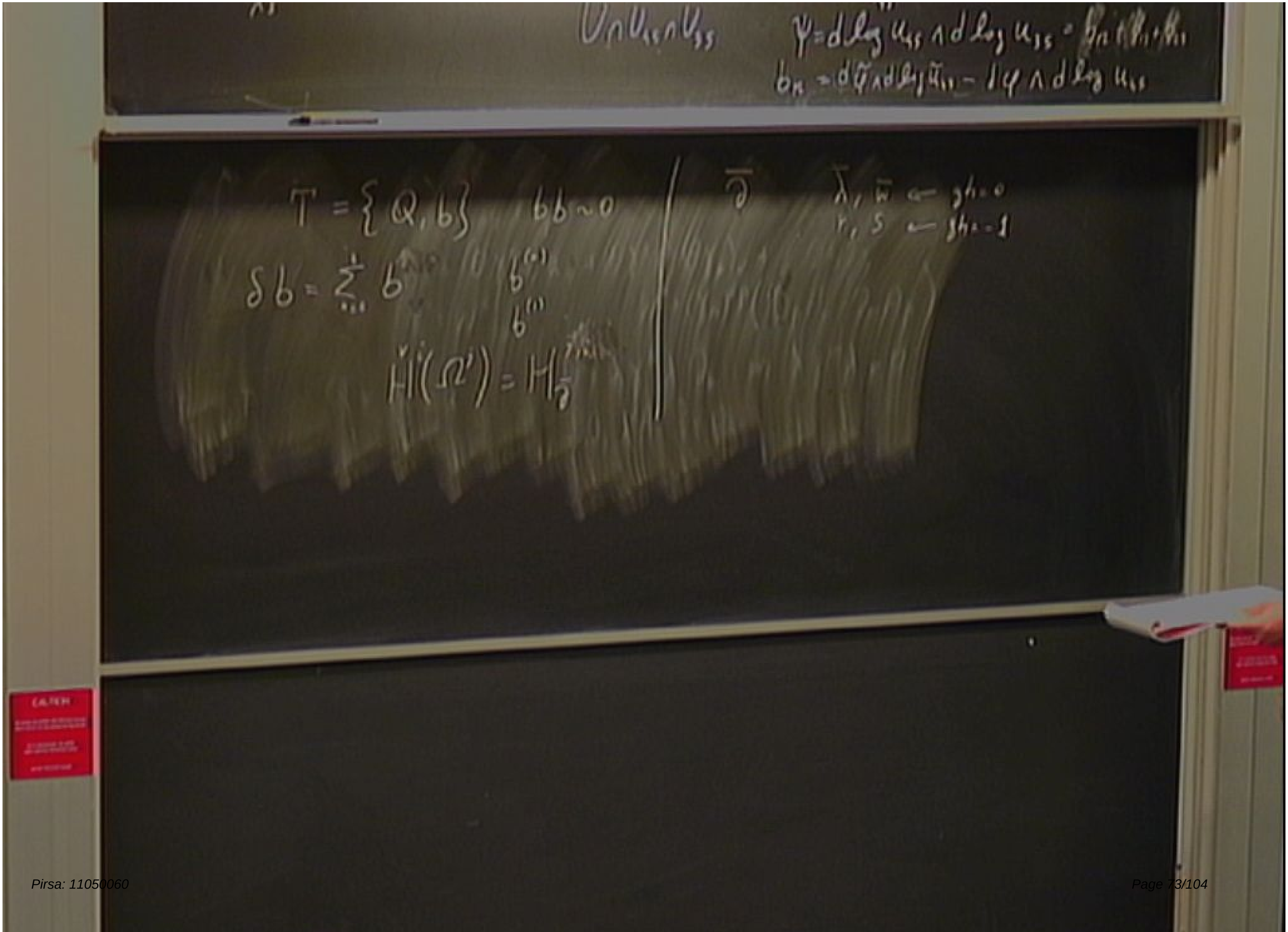

T = {Q, b}
bb ~ 0

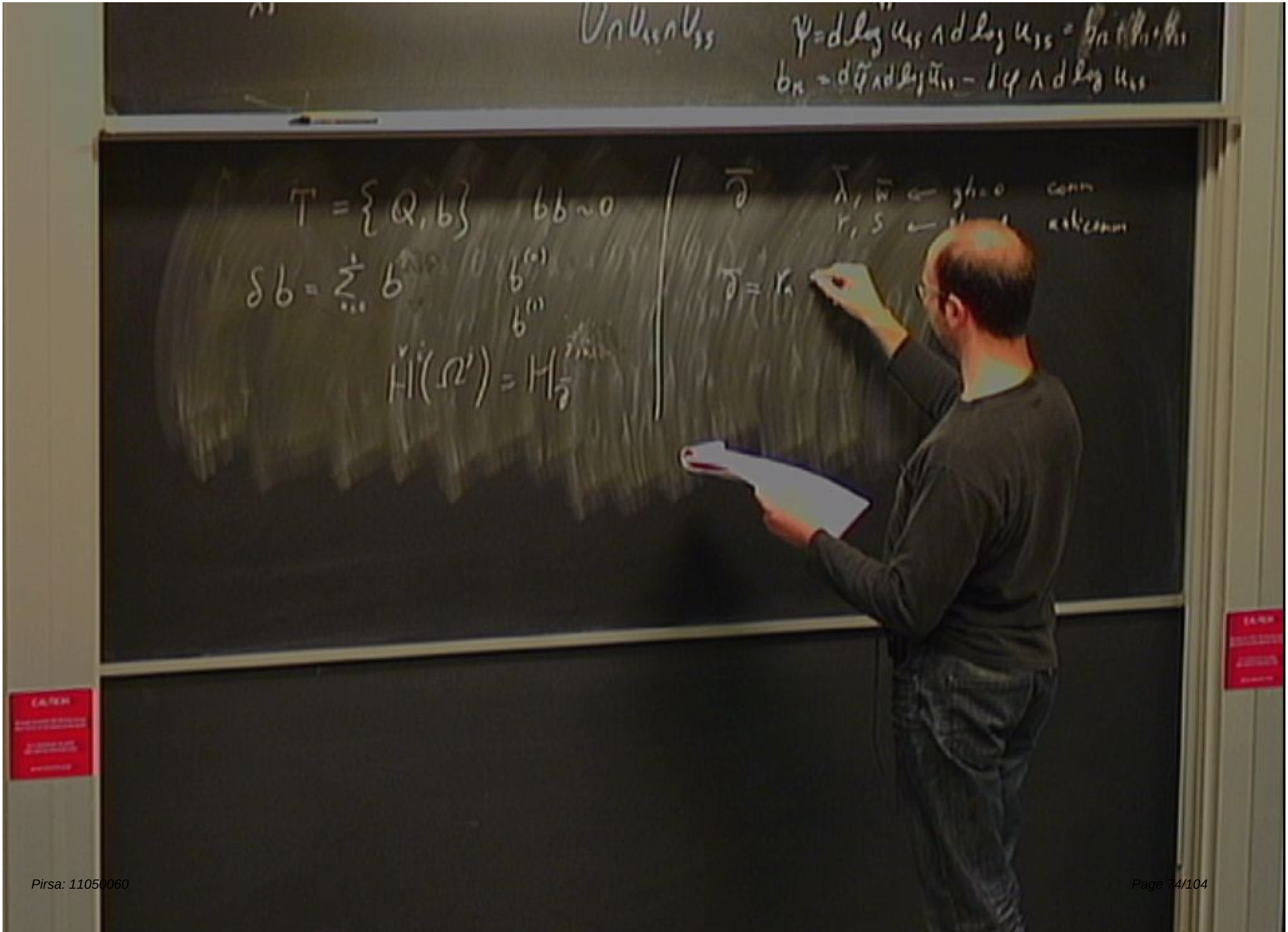

$T = \{Q, b\}$ $bb \sim 0$
$b = \sum b^{(n)}$

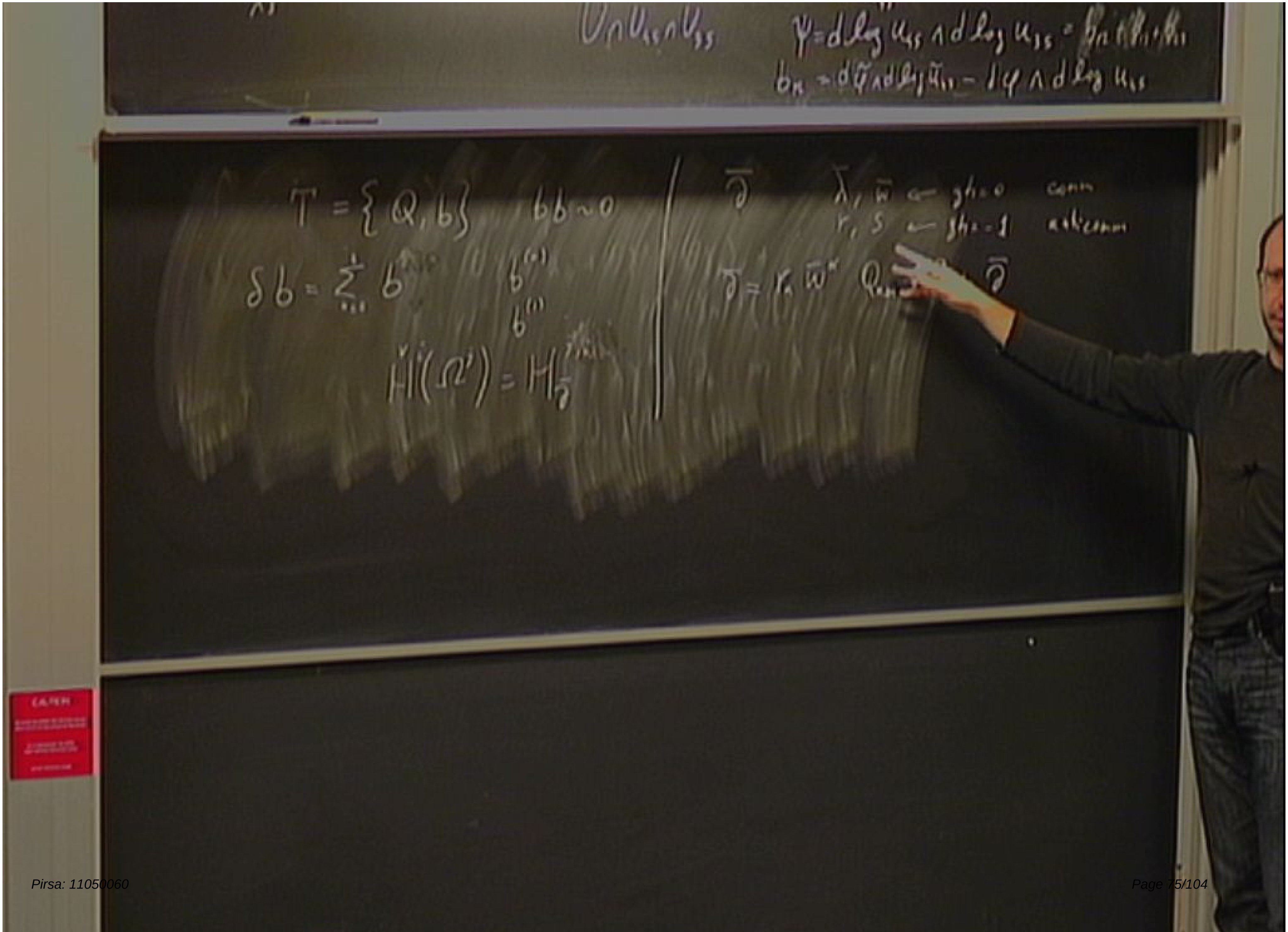

T = {Q, b}   bb ~ 0

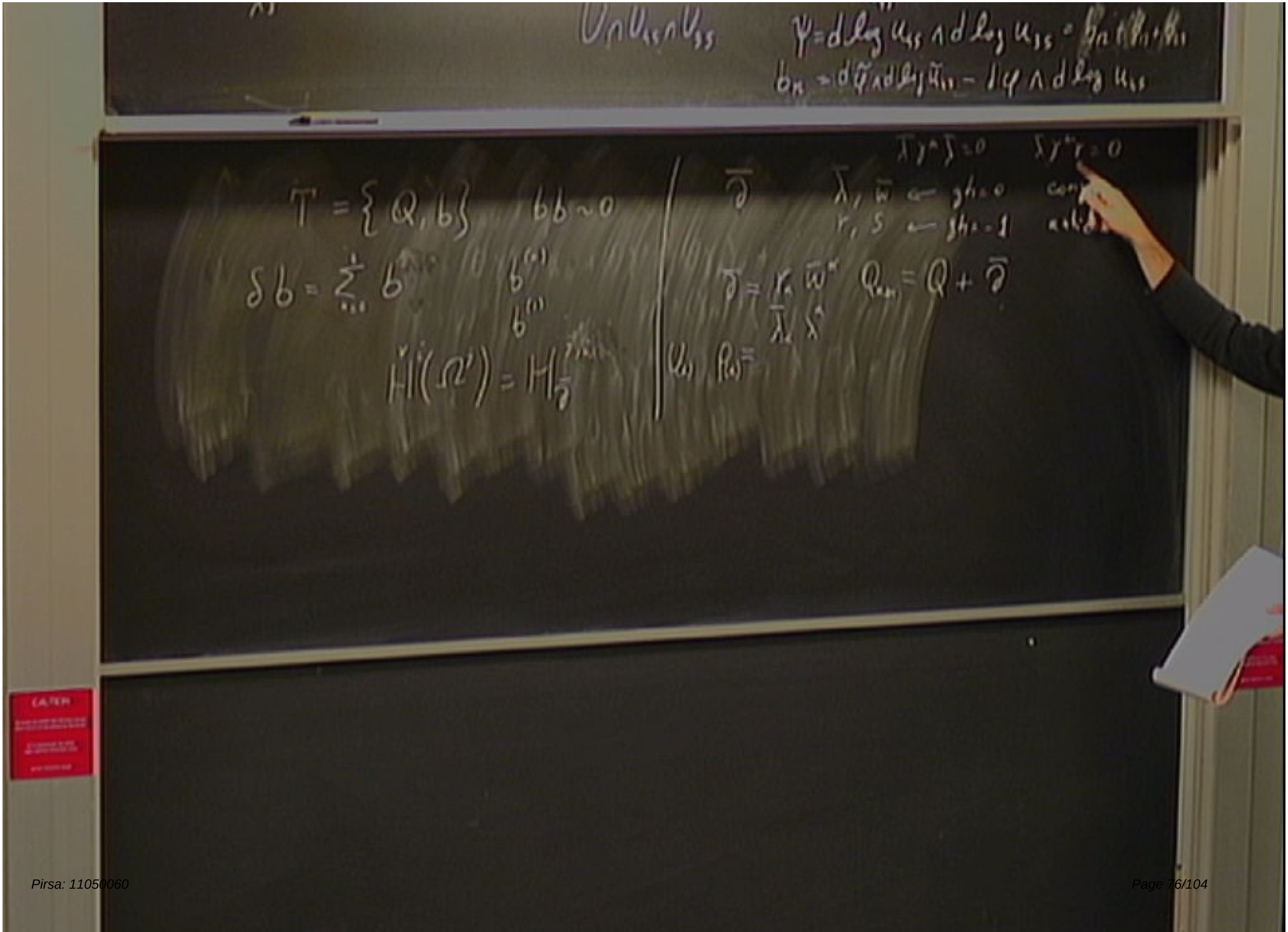

T = {Q, b}
bb ~ 0

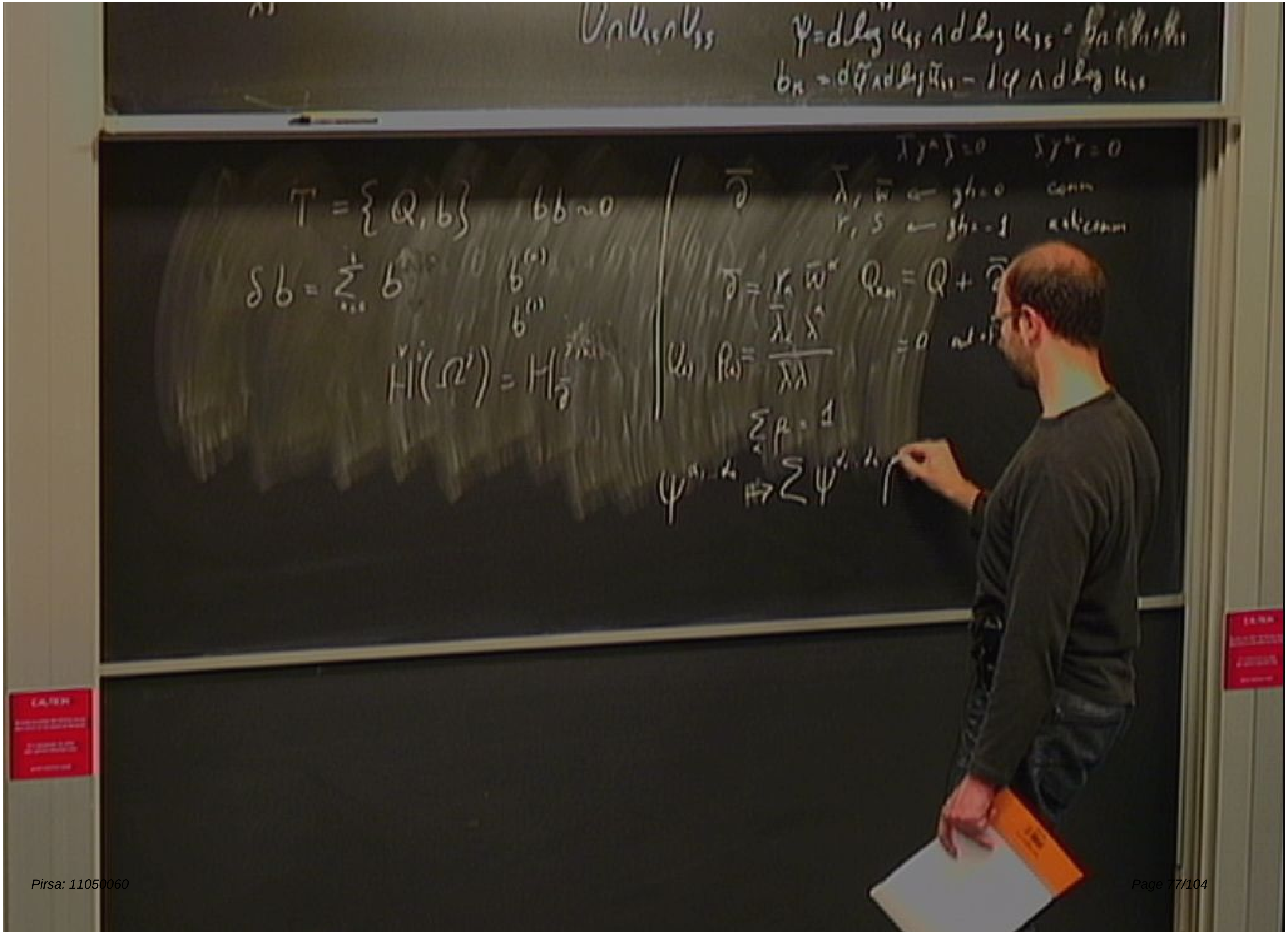

T = {Q, b}
bb ~ 0

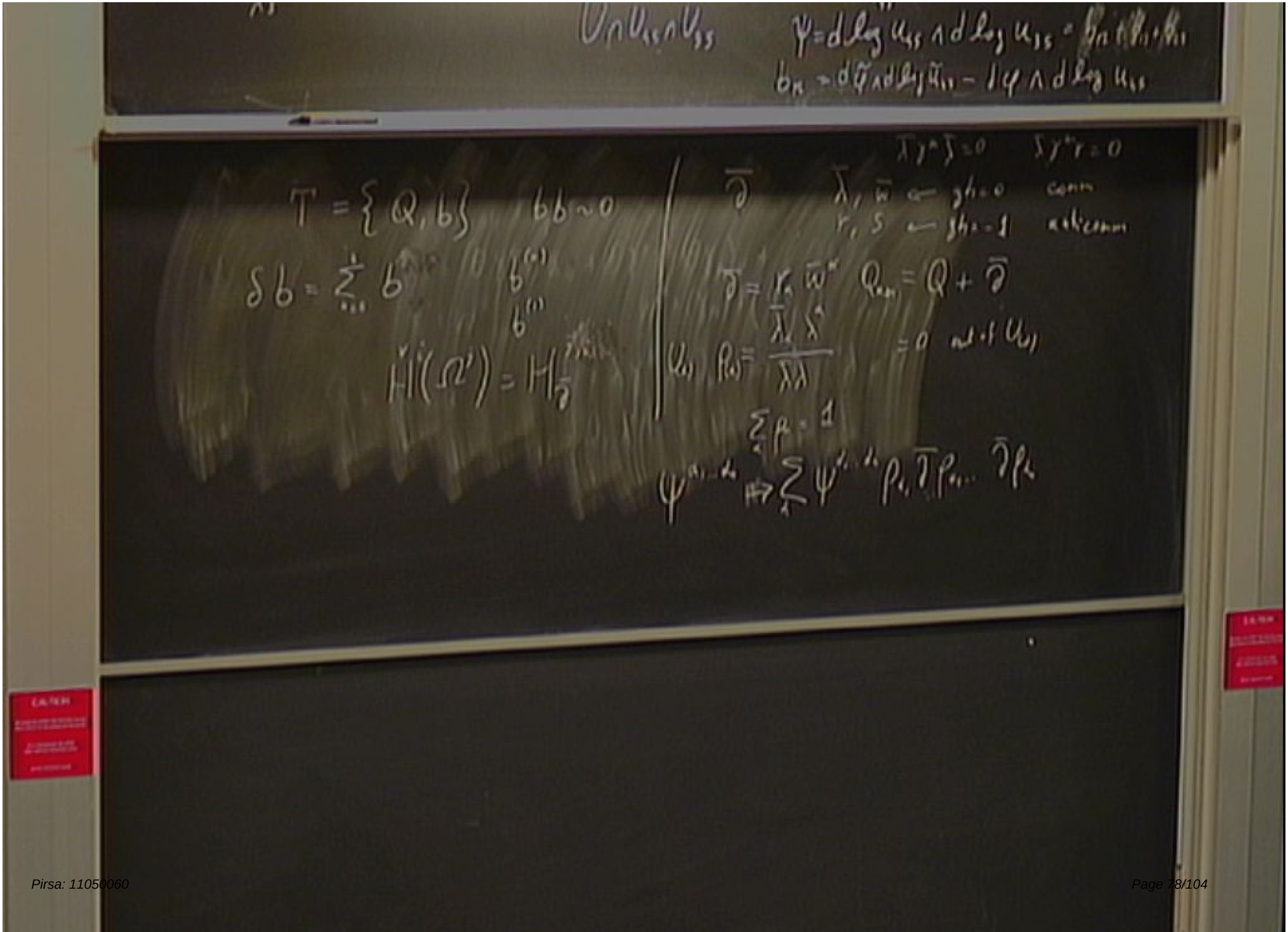

T = {Q, b}   bb ~ 0
δb =
∂̄
λ, w̄ ← gh=0
r, S ← gh=-1
CAUTION

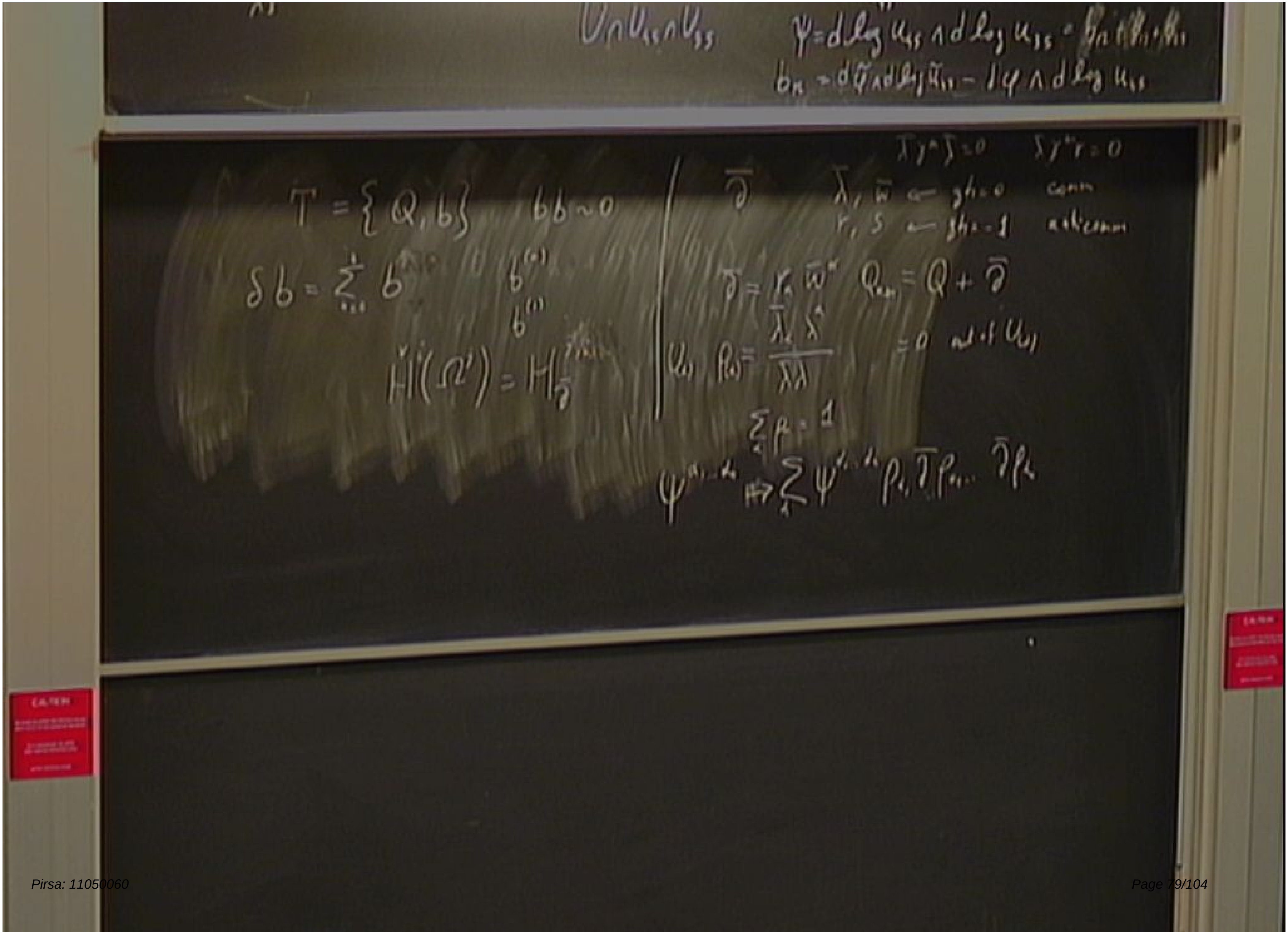

T = {Q, b}
bb ~ 0
ghost
comm
anticomm


T = {Q, b}
bb ~ 0
comm

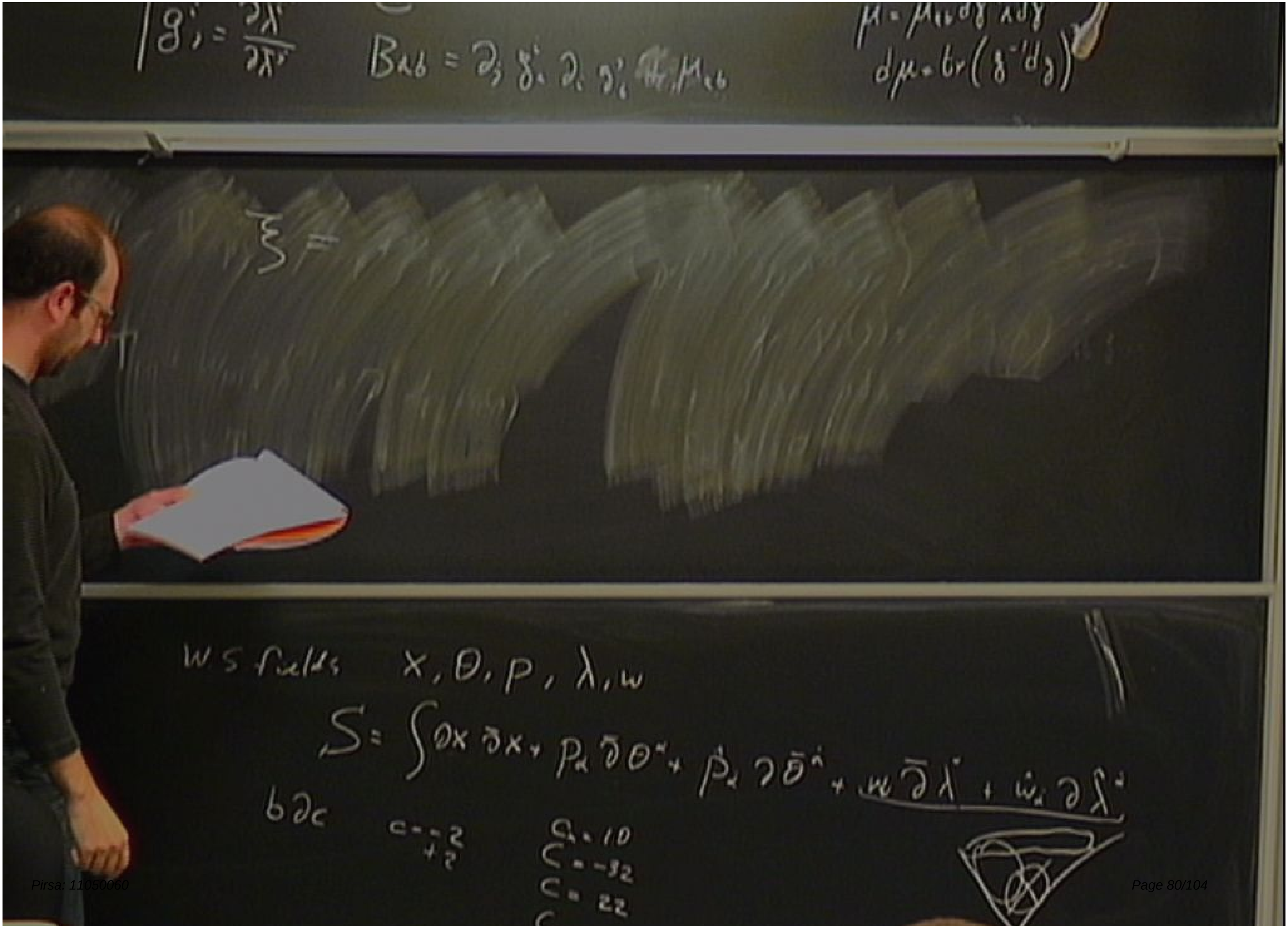

T = {Q, b}
bb ~ 0
r, s ← gh = -1
Q + ∂̄

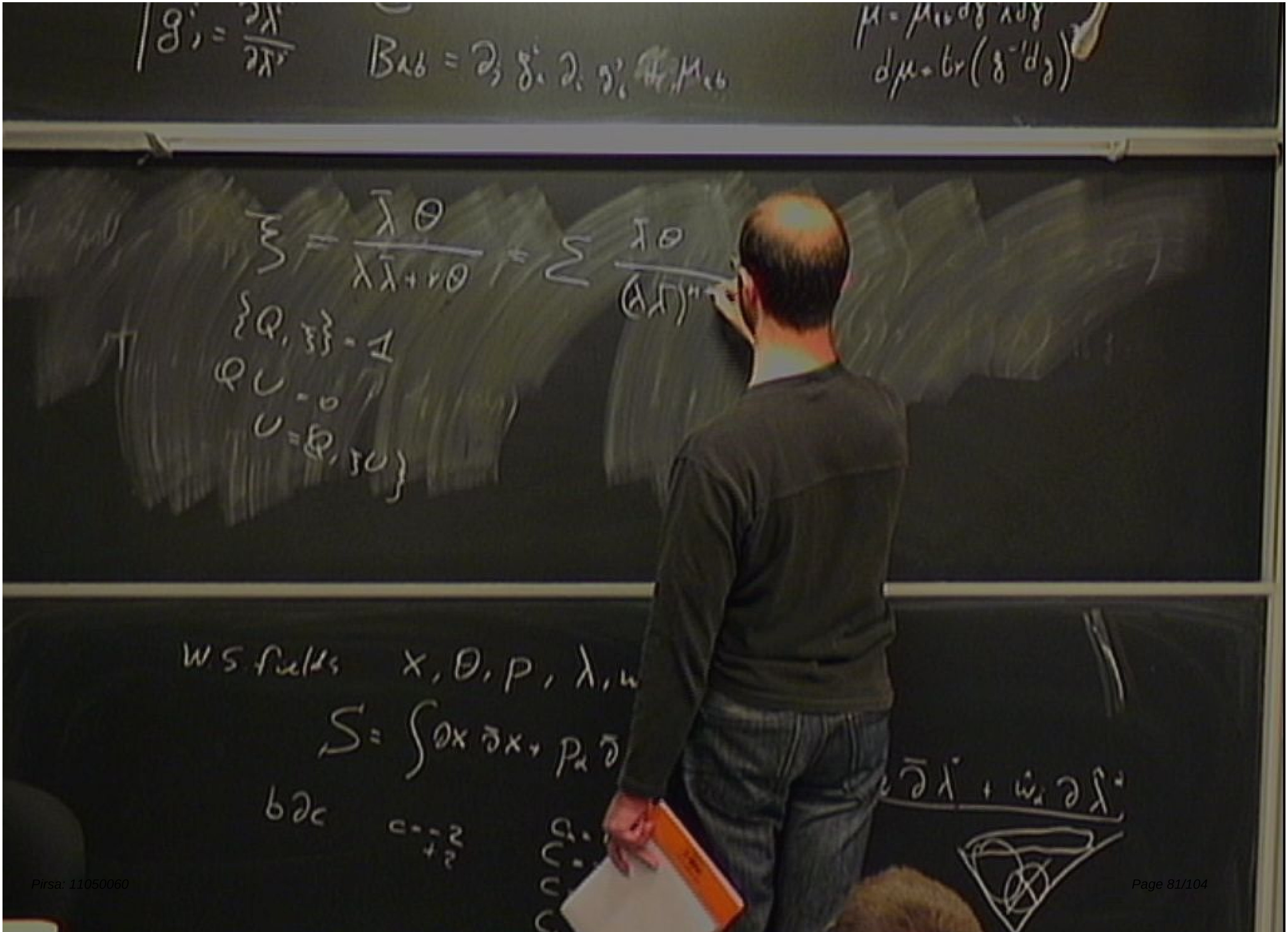

T = { Q, b }   bb ~ 0
δb = Σ b
H(Ω′) = H
conn
anticomm
Σ p = 1


T = { Q, b }
bb ~ 0
gh = 0
gh = -1
comm
anticomm
Q + ∂̄
Σ ρ = 1



T = {Q, b}   bb ~ 0
conn
anticomm
Q_tot = Q + ∂̄


W.S fields X, Θ, p, λ, w
b∂c
c = -2
c = 10
c = -32
c = 22


W.S. fields X, θ, p, λ, w
{Q, ξ} = 1
QU = 0

$$g^i_j = \frac{\partial\lambda^i}{\partial\tilde\lambda^j} \qquad B_{ab} = \partial_j g^j_a\, \partial_i g^i_b\, \mu_{ab}$$

$$\mu = \mu_{ab}\, dg^a \wedge dg^b \qquad d\mu = tr(g^{-1} dg)$$

$$\xi = \frac{\bar\lambda\theta}{\lambda\bar\lambda + r\theta} = \sum \frac{\bar\lambda\theta}{(\lambda\bar\lambda)^{n+1}} (r\theta)^n \qquad \frac{1}{(\lambda\bar\lambda)^n}$$

$\{Q, \xi\} = 1$

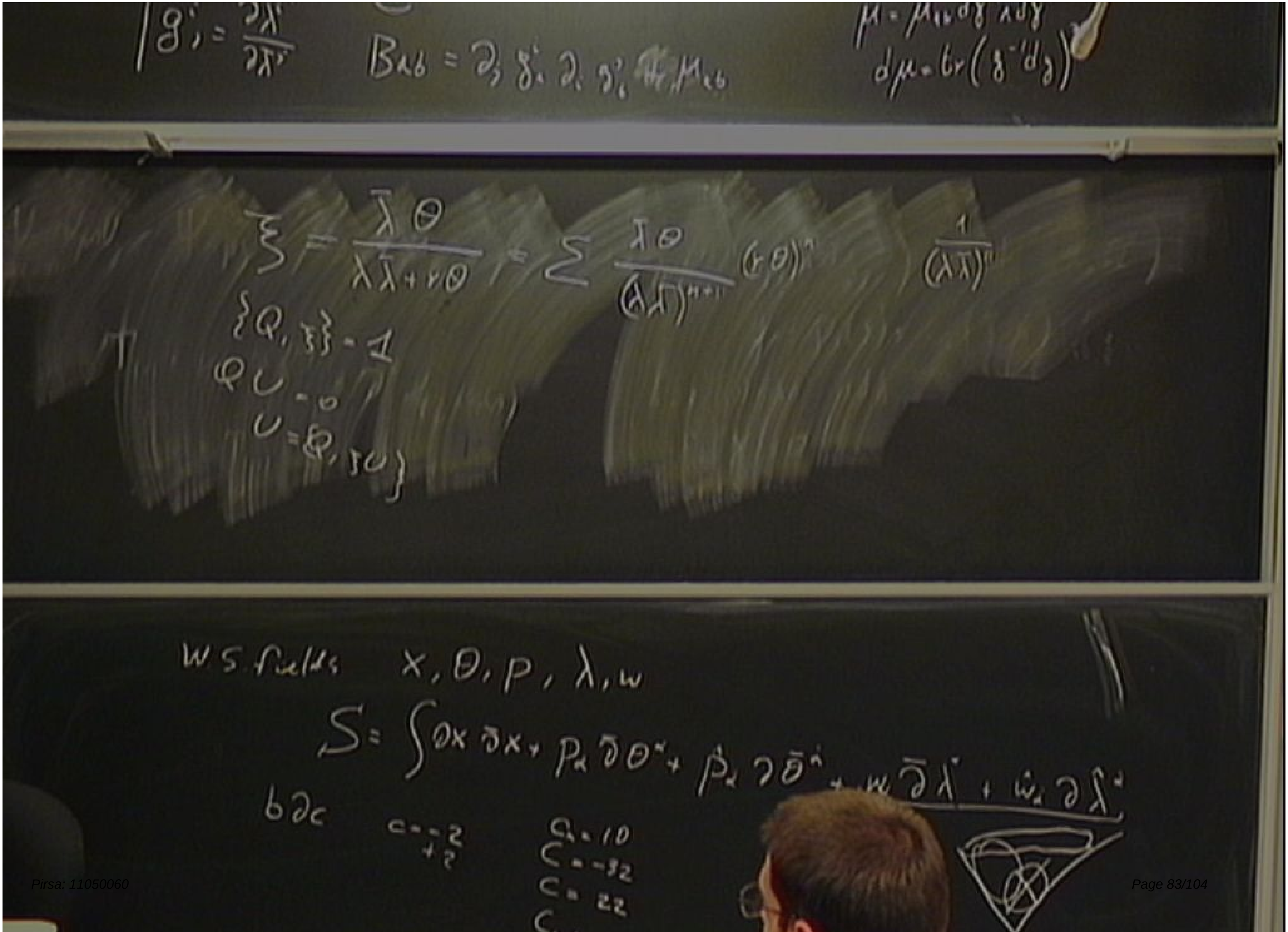
$QU = 0$

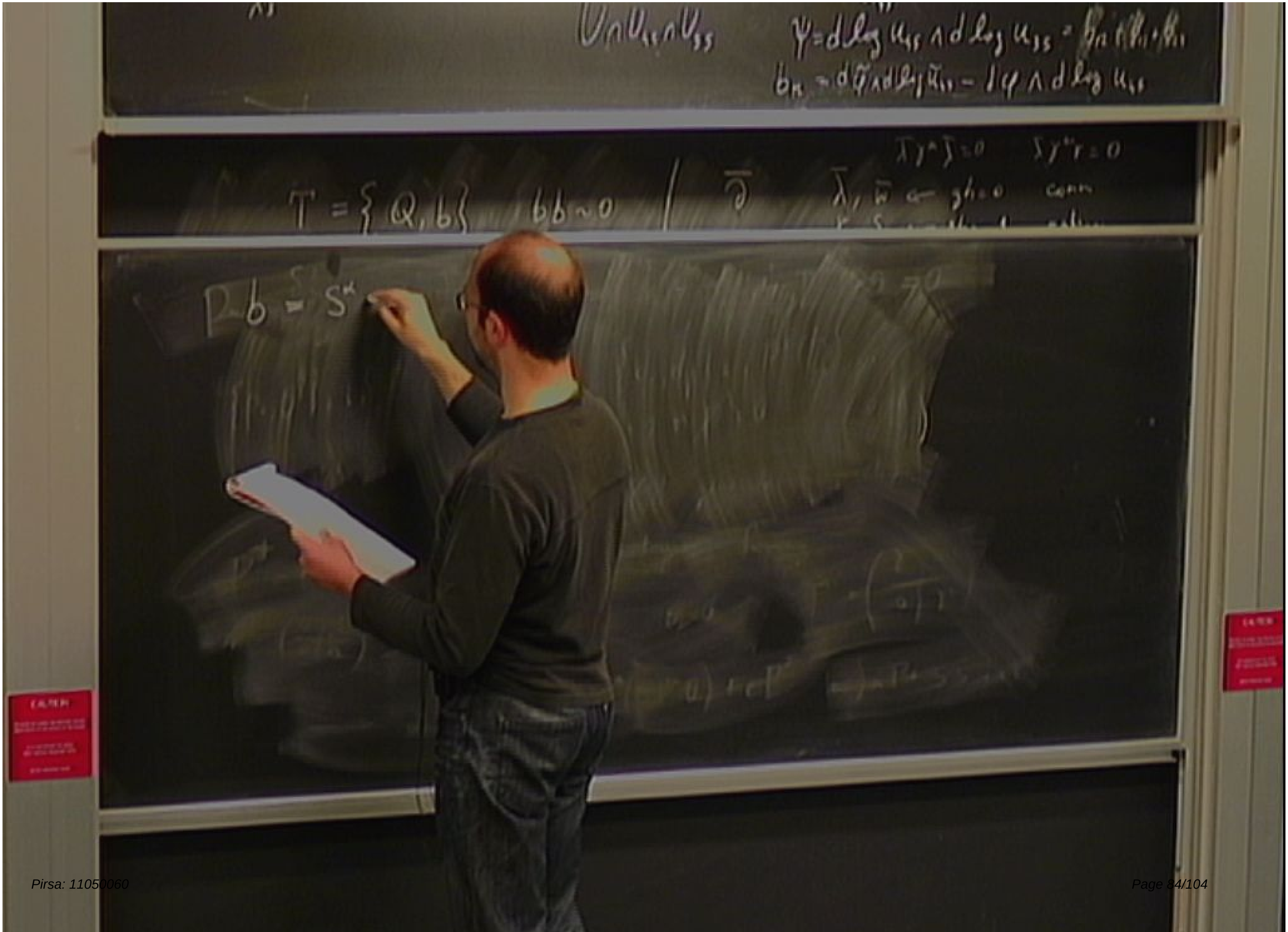
$U = \{Q, \xi U\}$

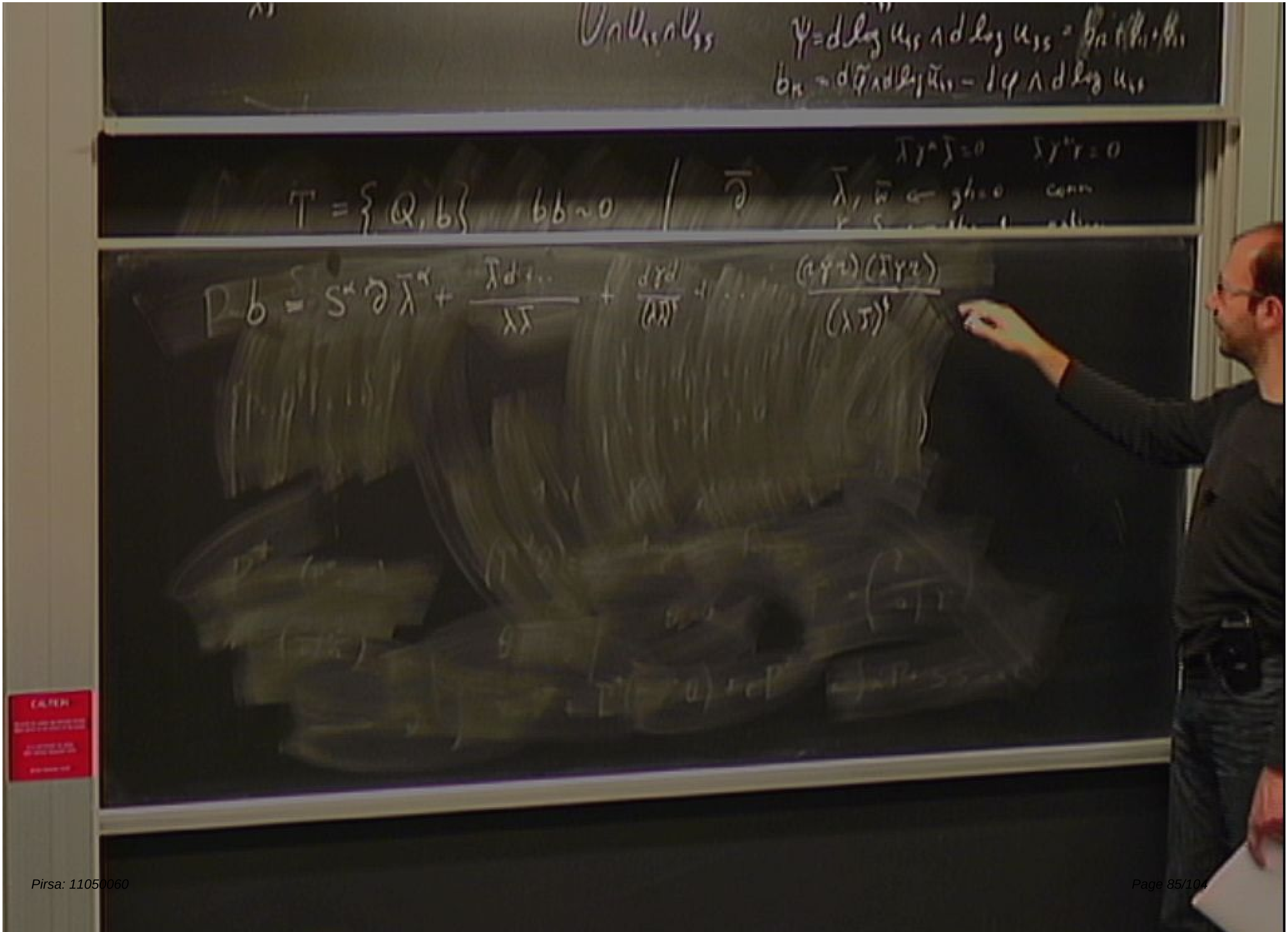
w.s. fields x, θ, p, λ, w

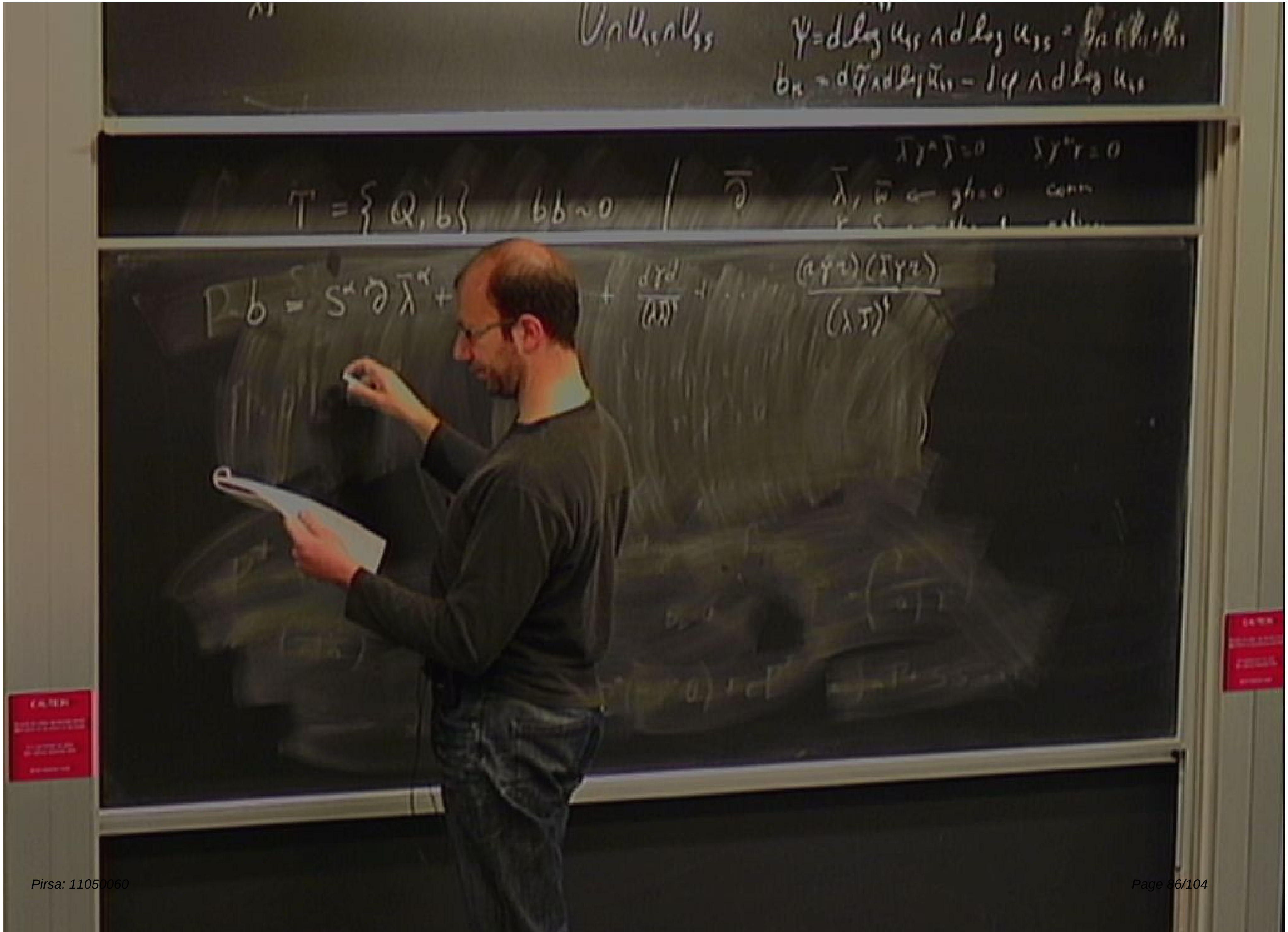
$$S = \int \partial x \bar\partial x + p_\alpha \bar\partial \theta^\alpha + \hat p_\alpha \partial \bar\theta^\alpha + \underline{w \bar\partial \lambda + \hat w_\alpha \partial \hat\lambda^\alpha}$$

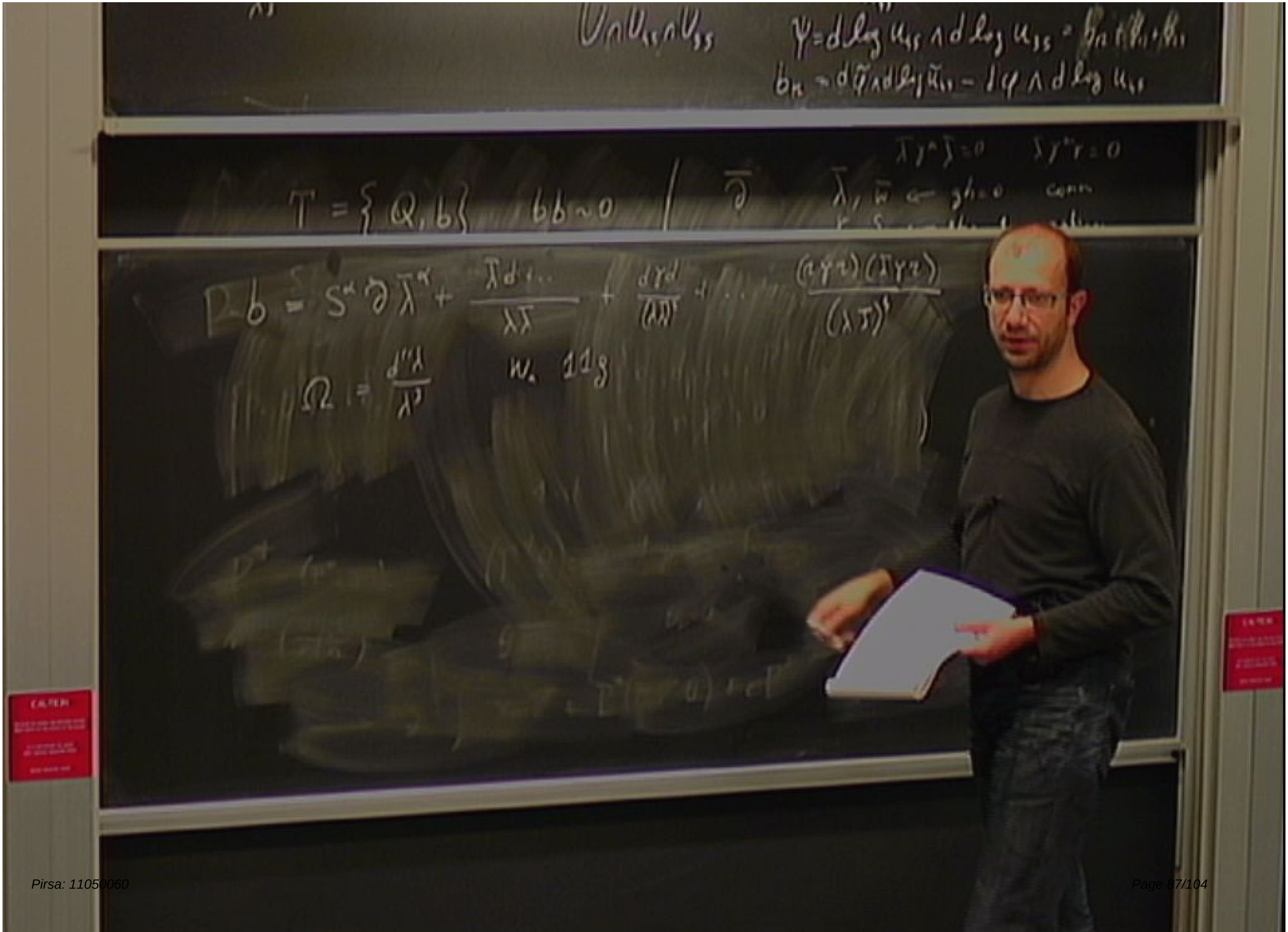
$b\partial c$ $\quad c = -2$, $+2$ $\quad c = 10$, $c = -32$, $c = 22$, c …

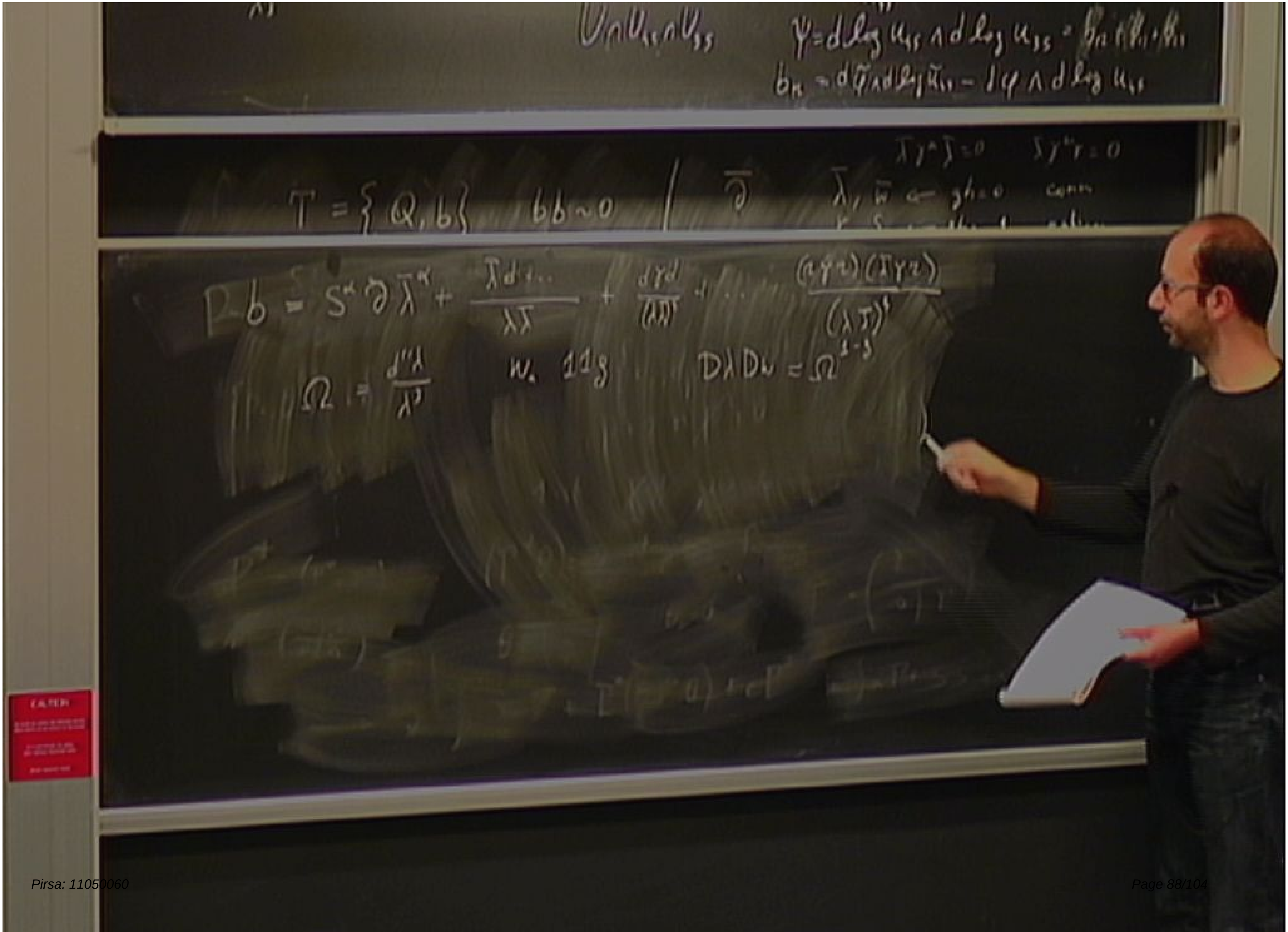

{Q, ξ} = 1
QU = 0
U = {Q, ξU}
W.S. fields X, Θ, p, λ, w
b ∂c

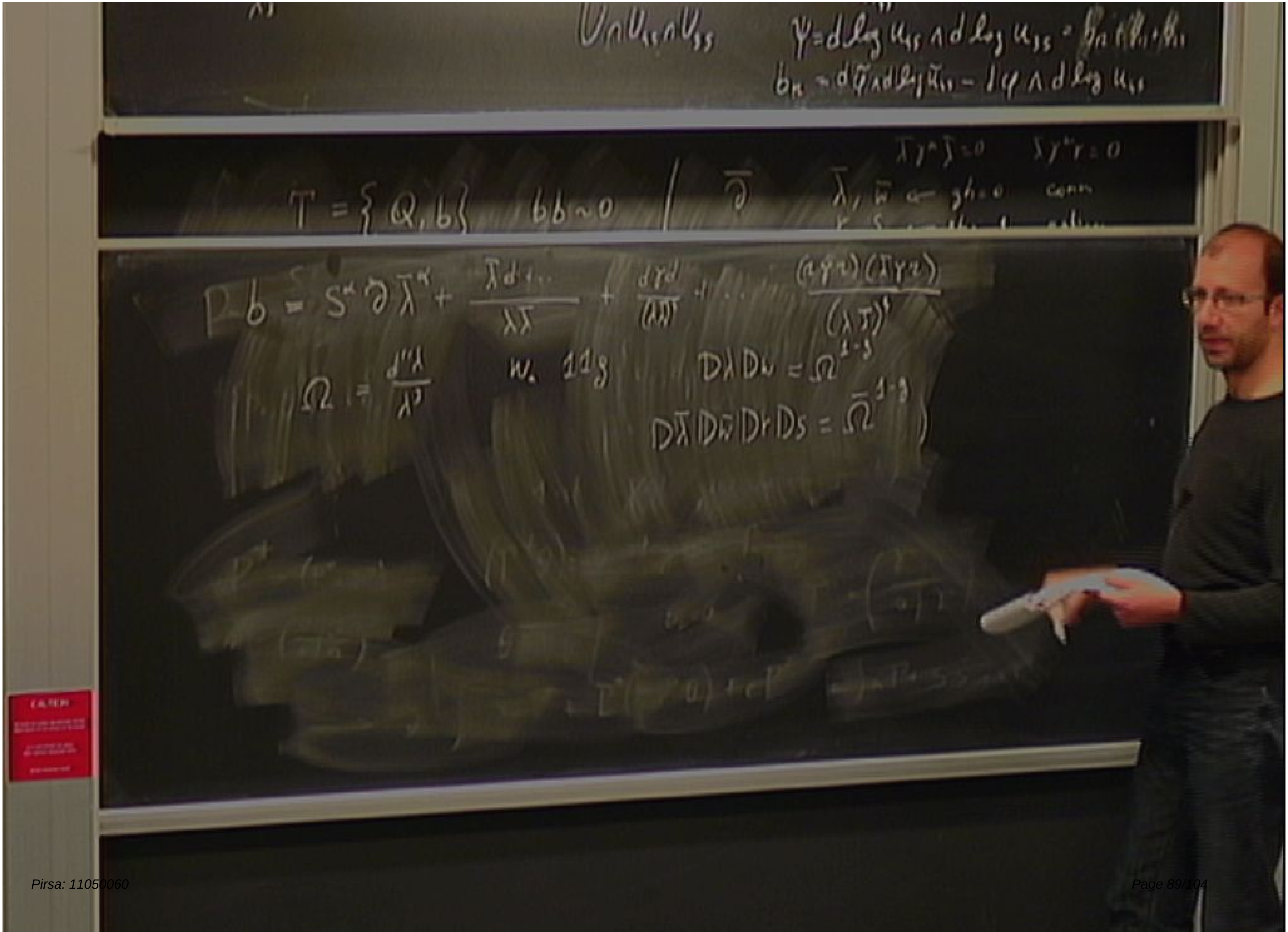


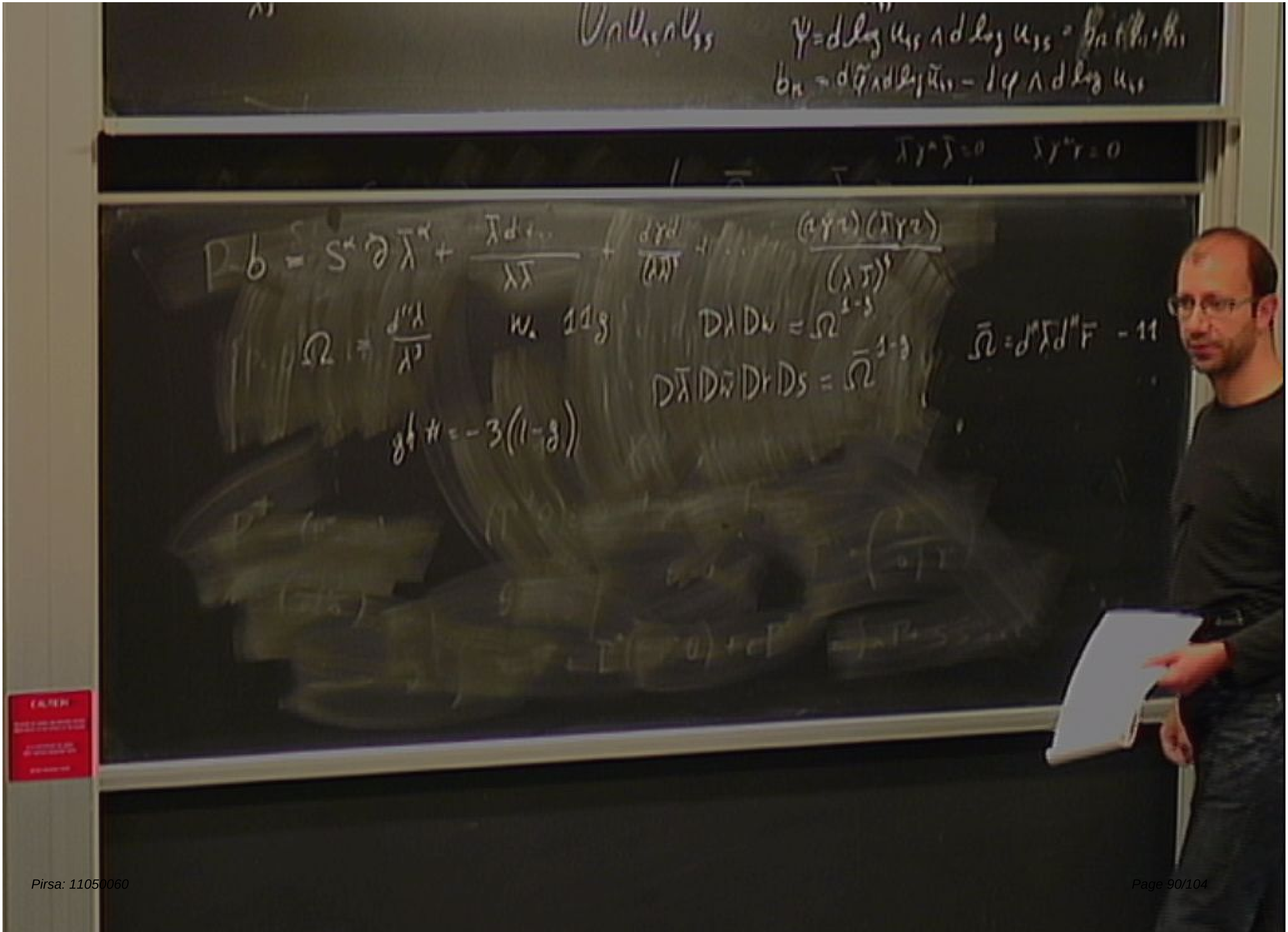

T = { Q, b }
bb ~ 0

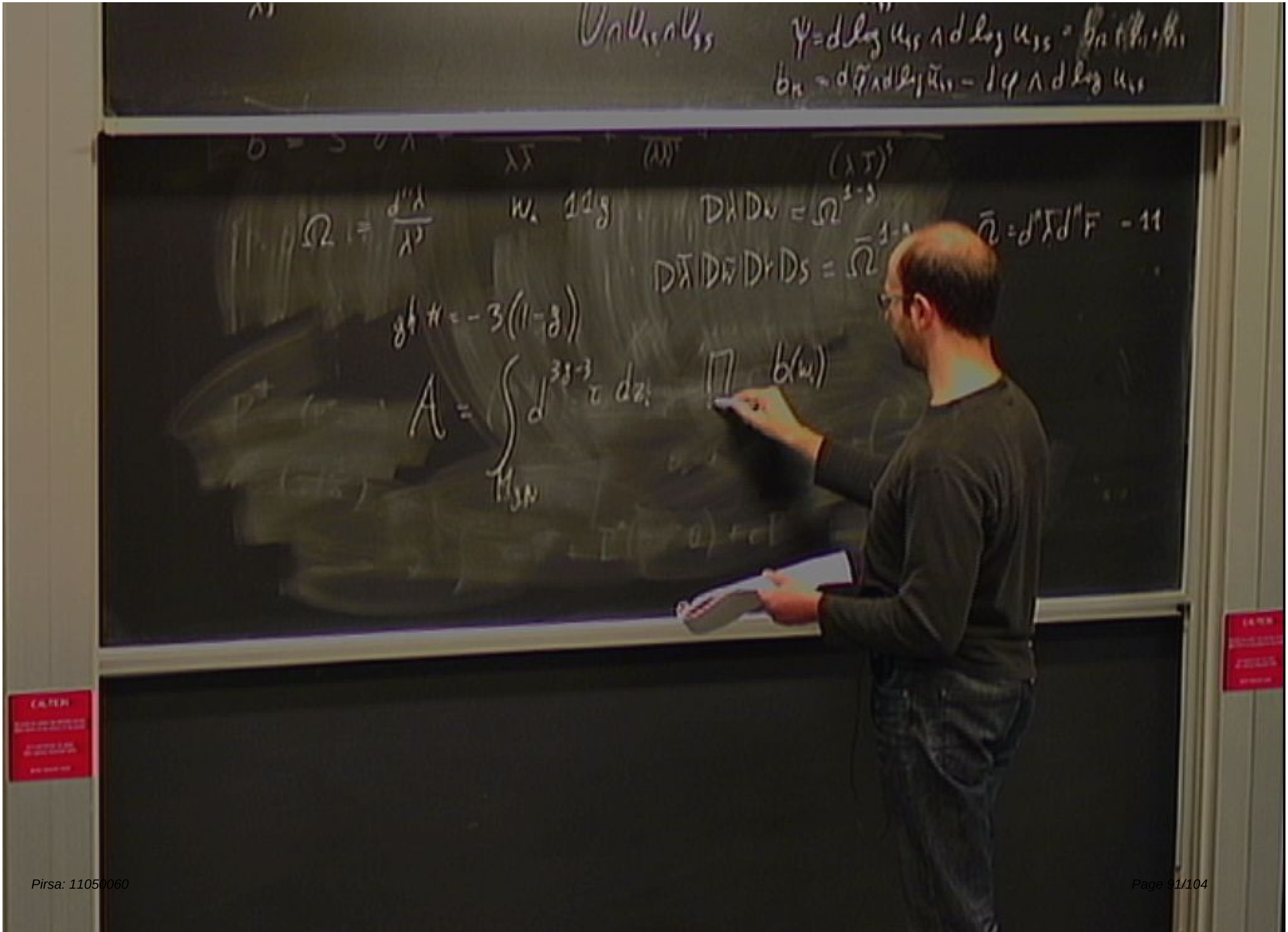

T = { Q, b }
bb ~ 0

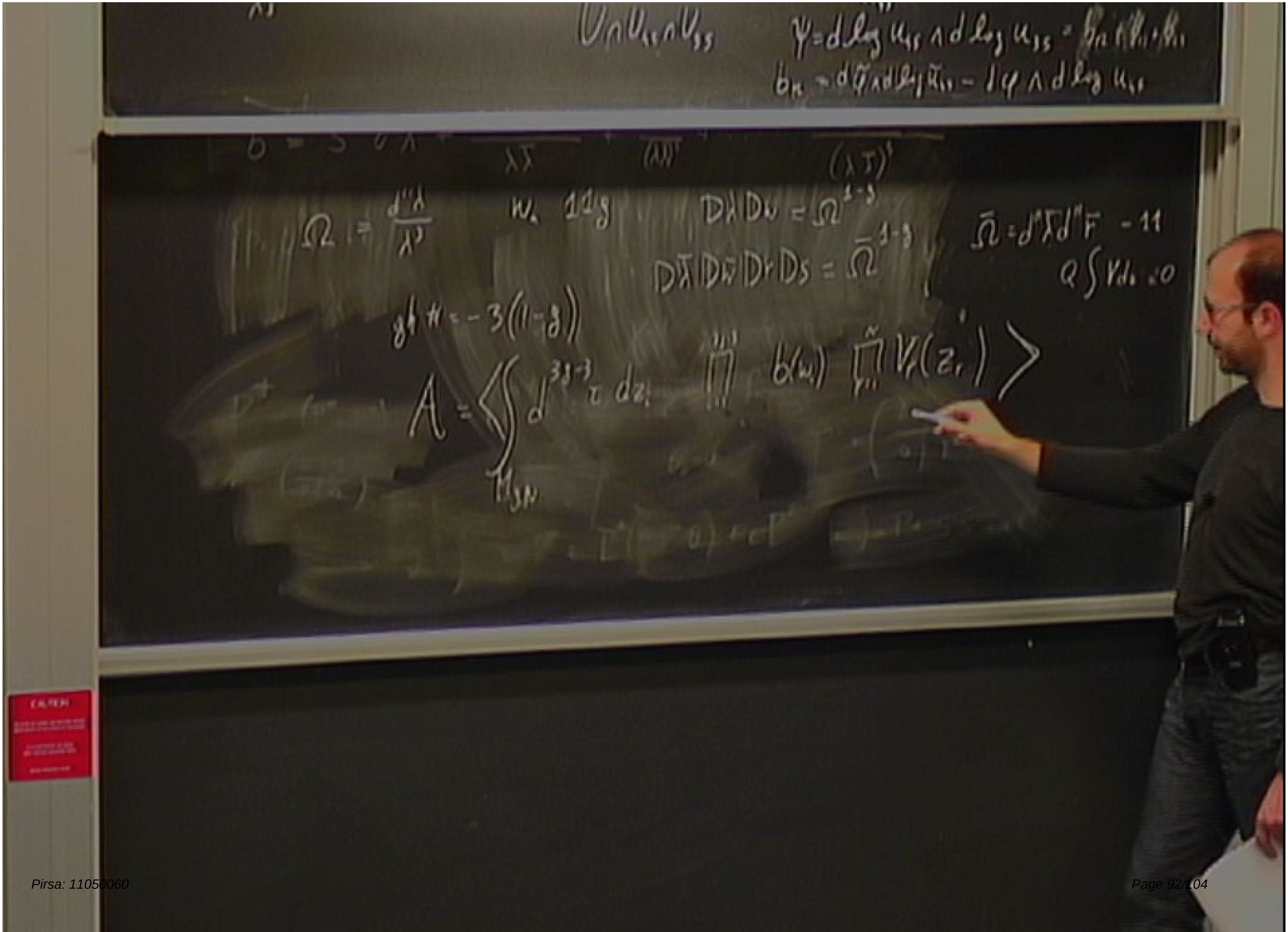


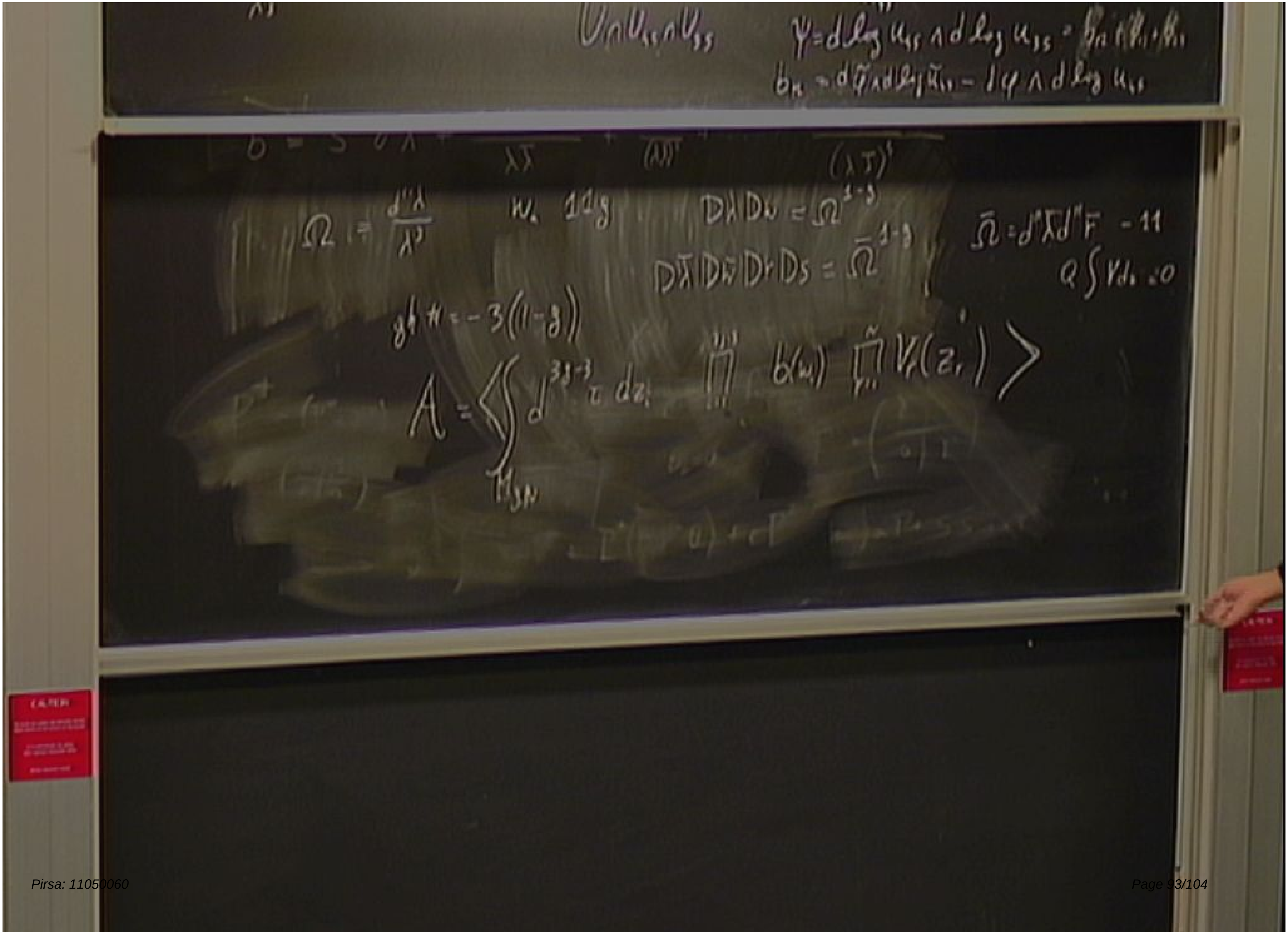

T = { Q, b }
bb ~ 0

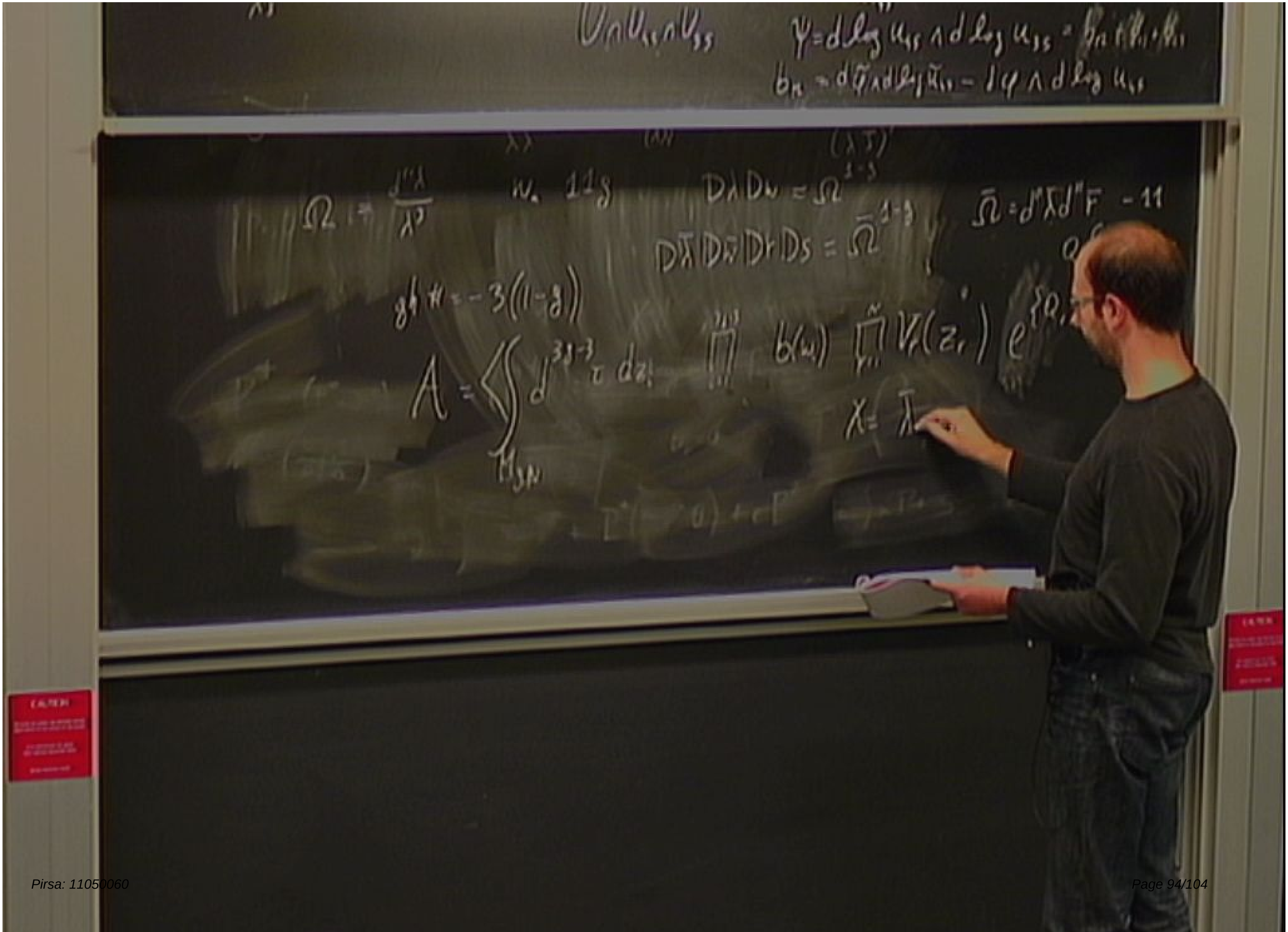

T = { Q, b }
bb ~ 0

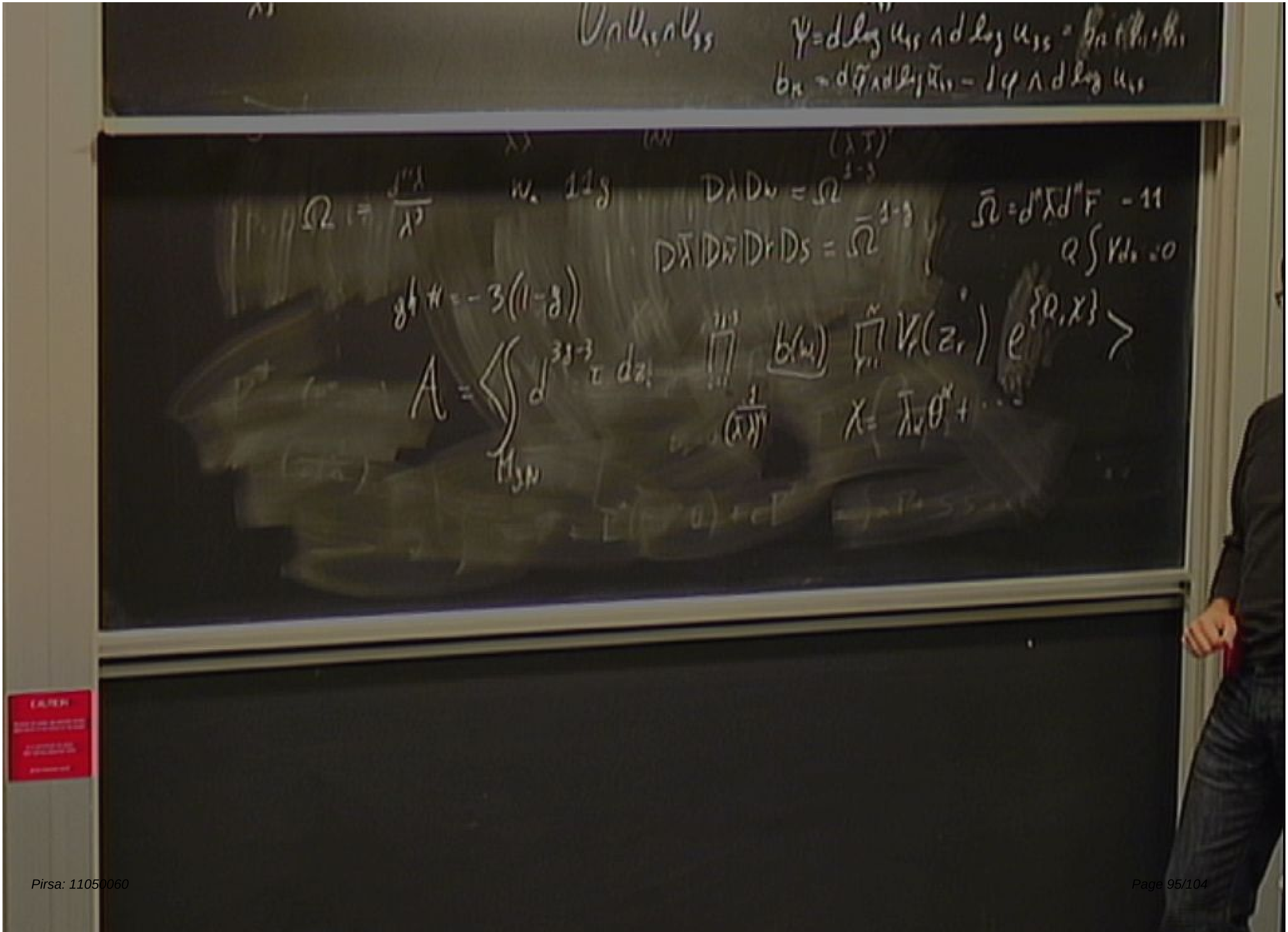


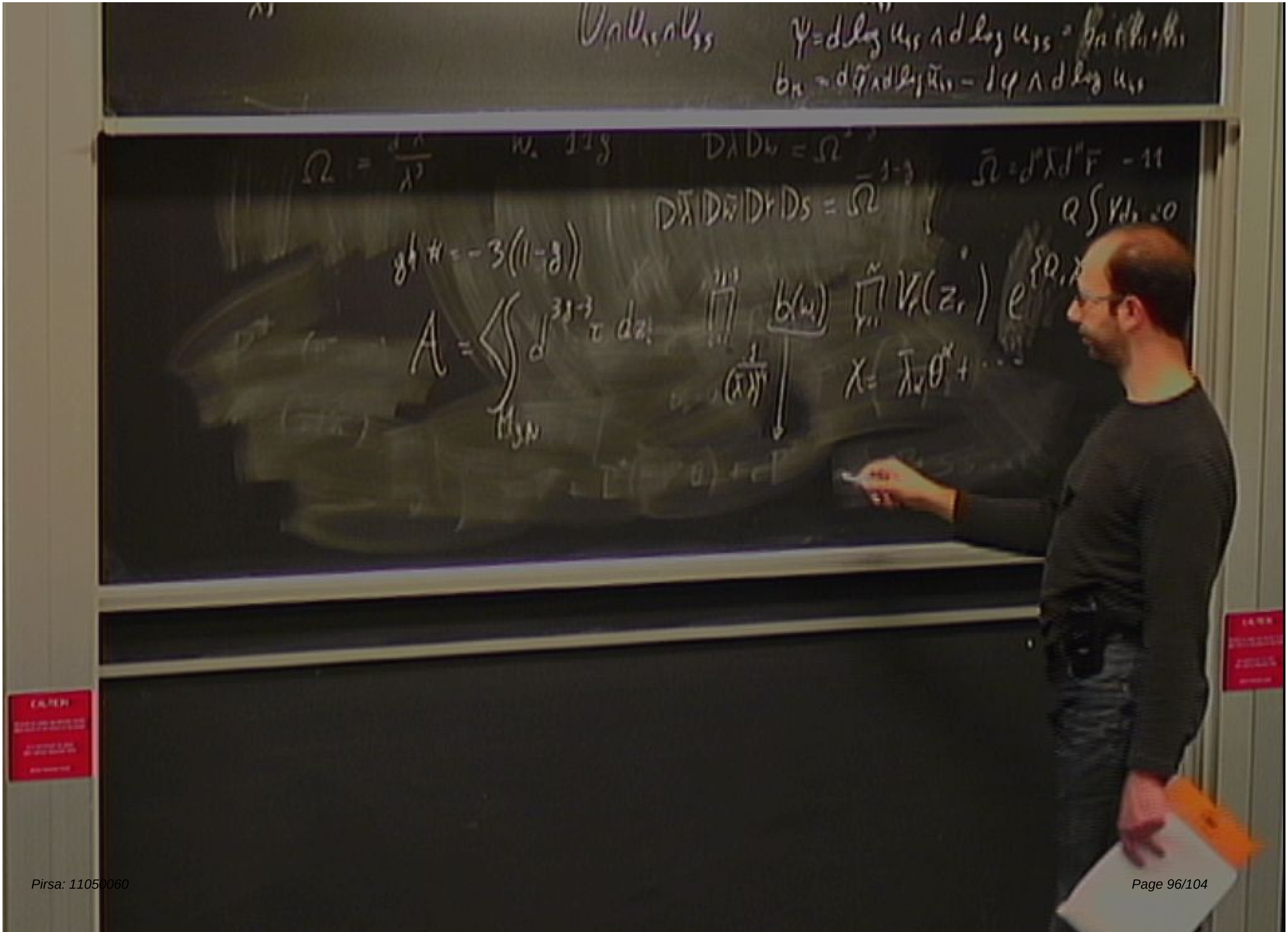


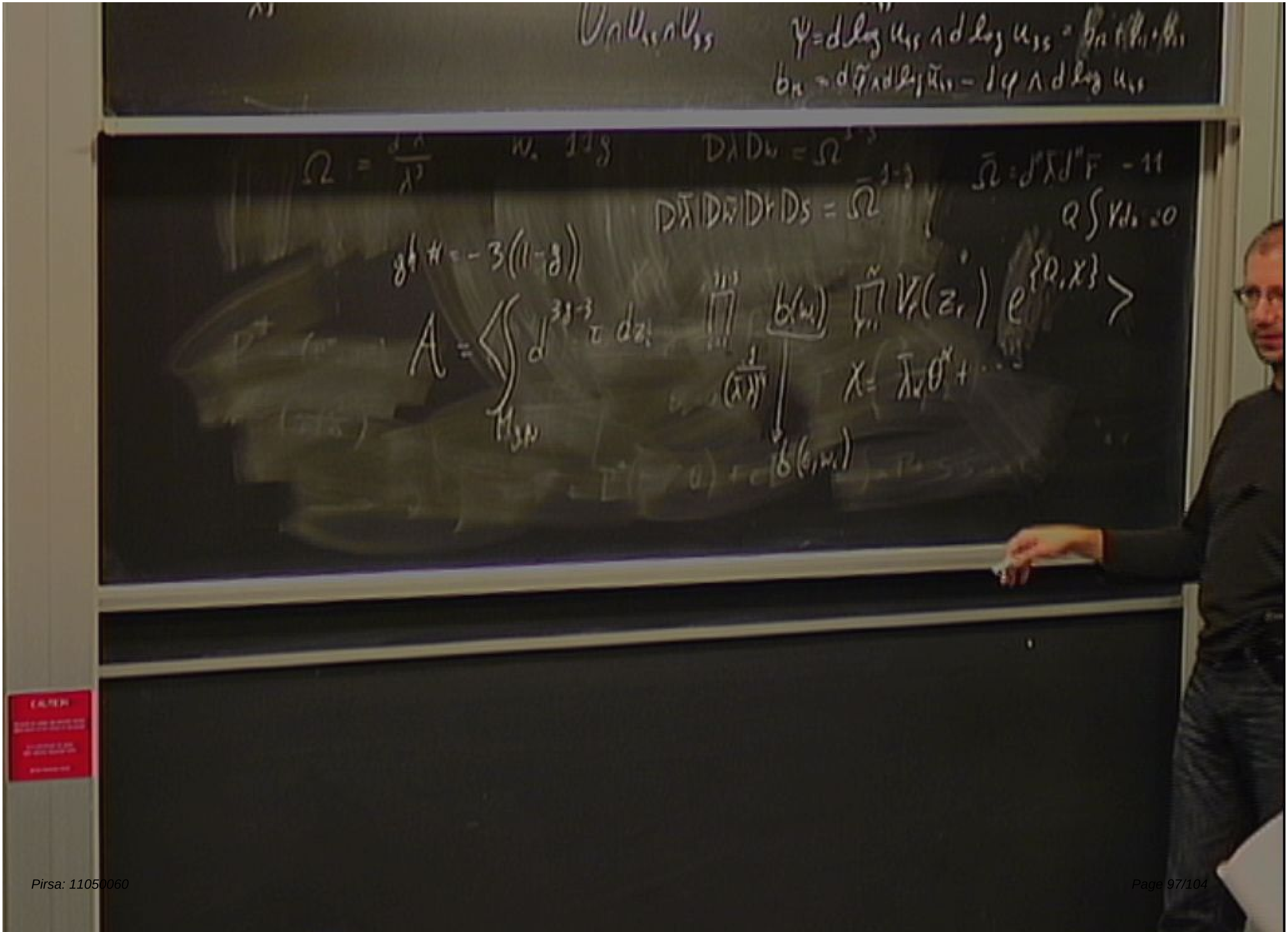


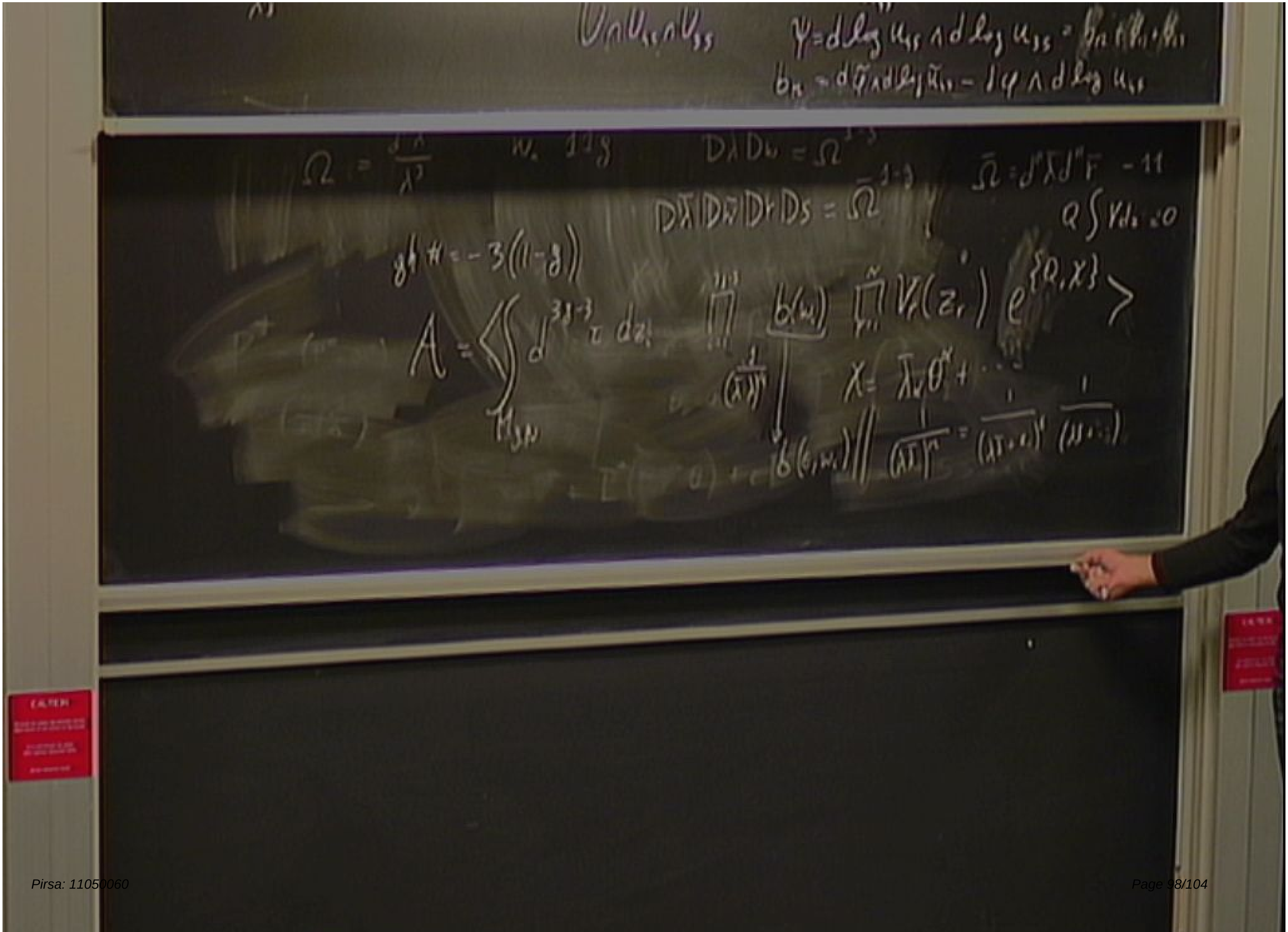


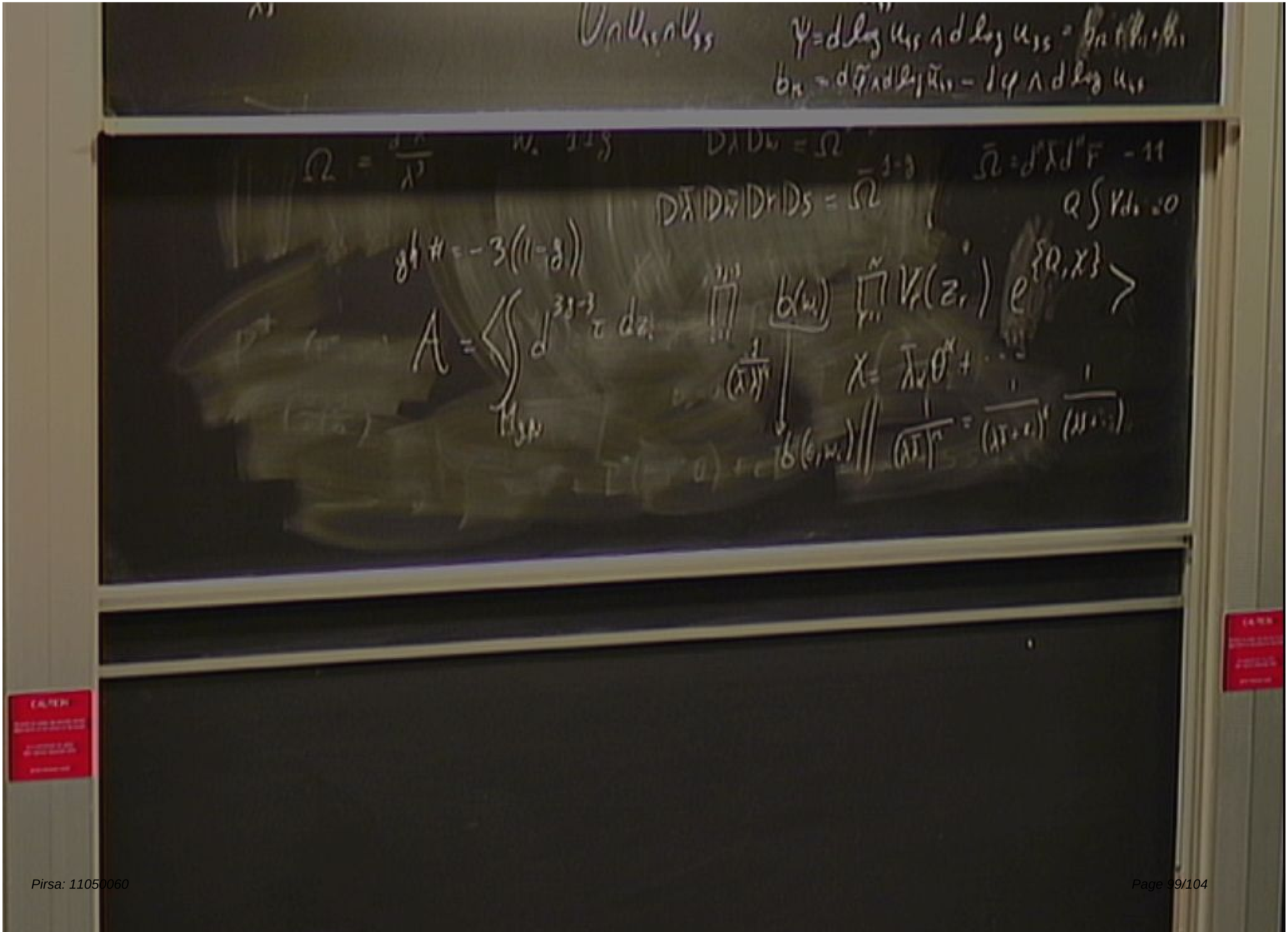


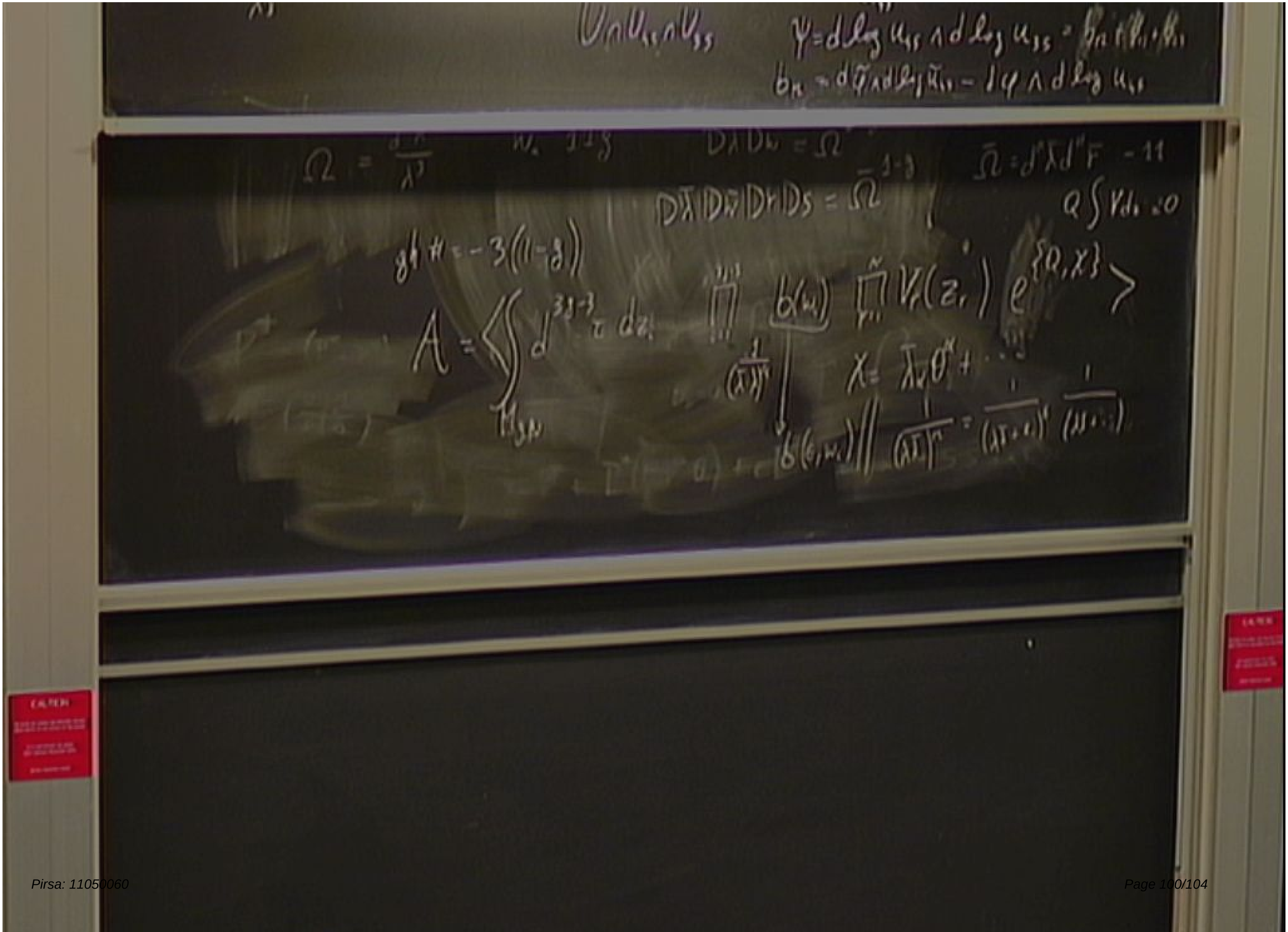


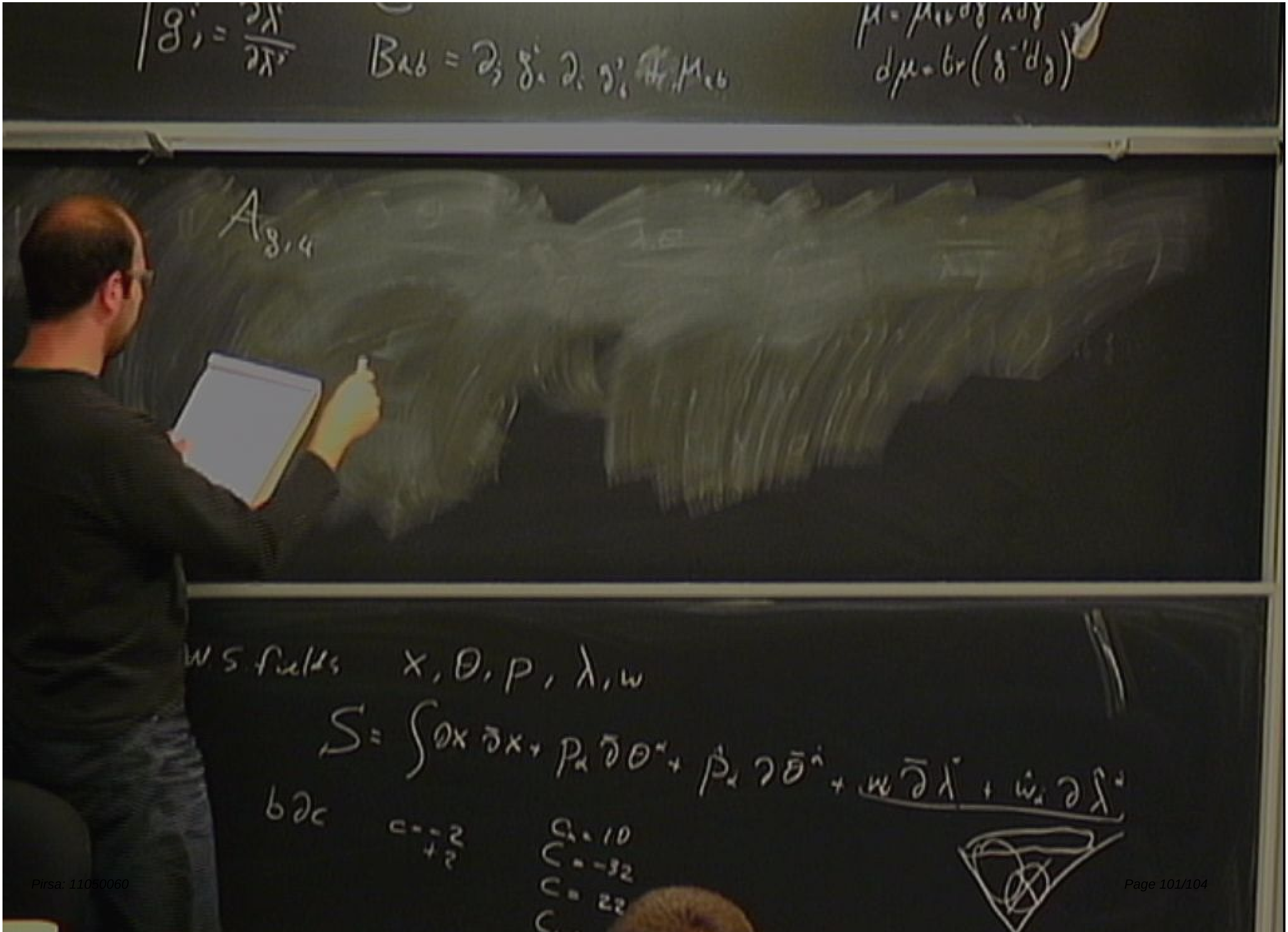


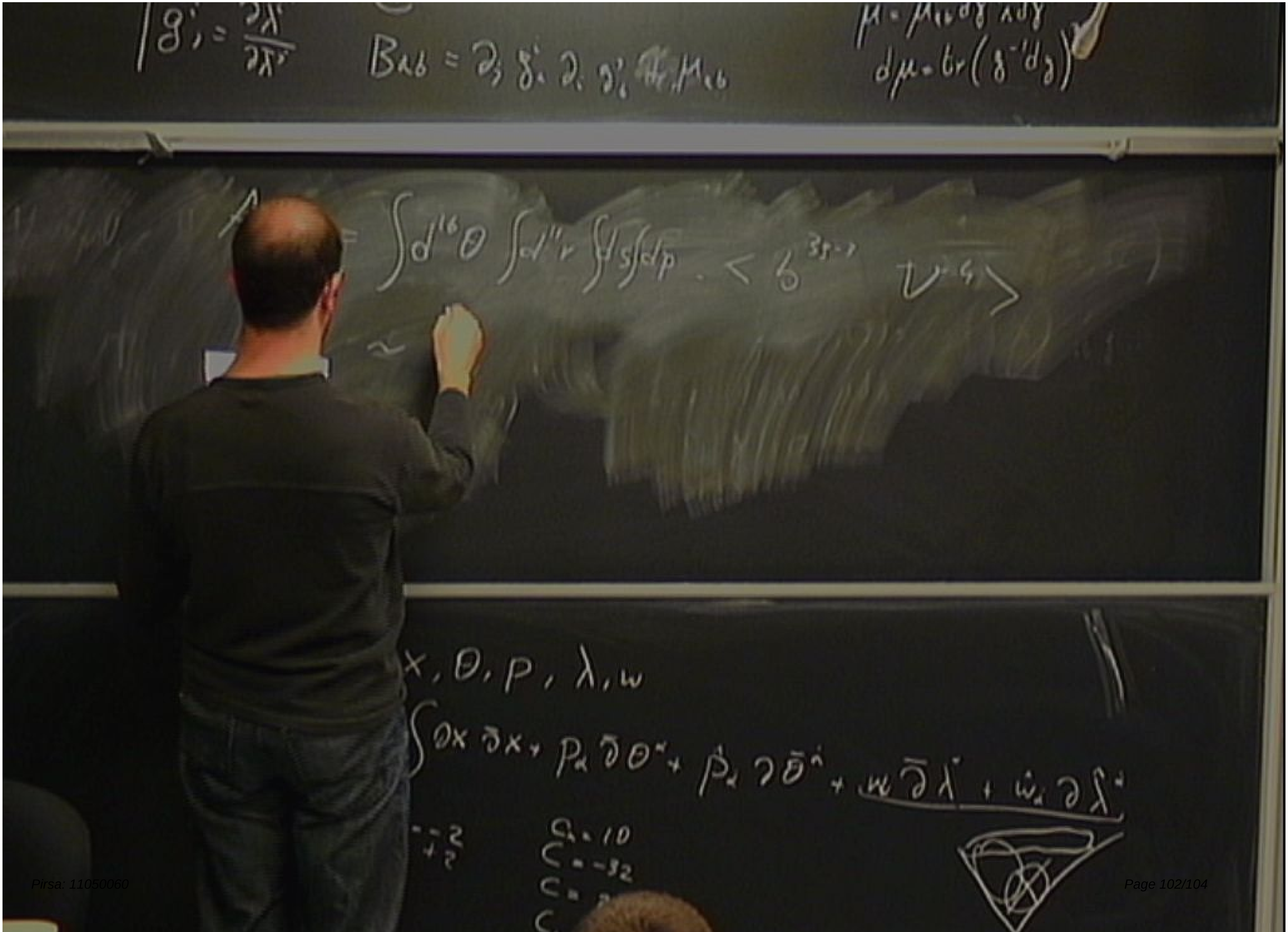


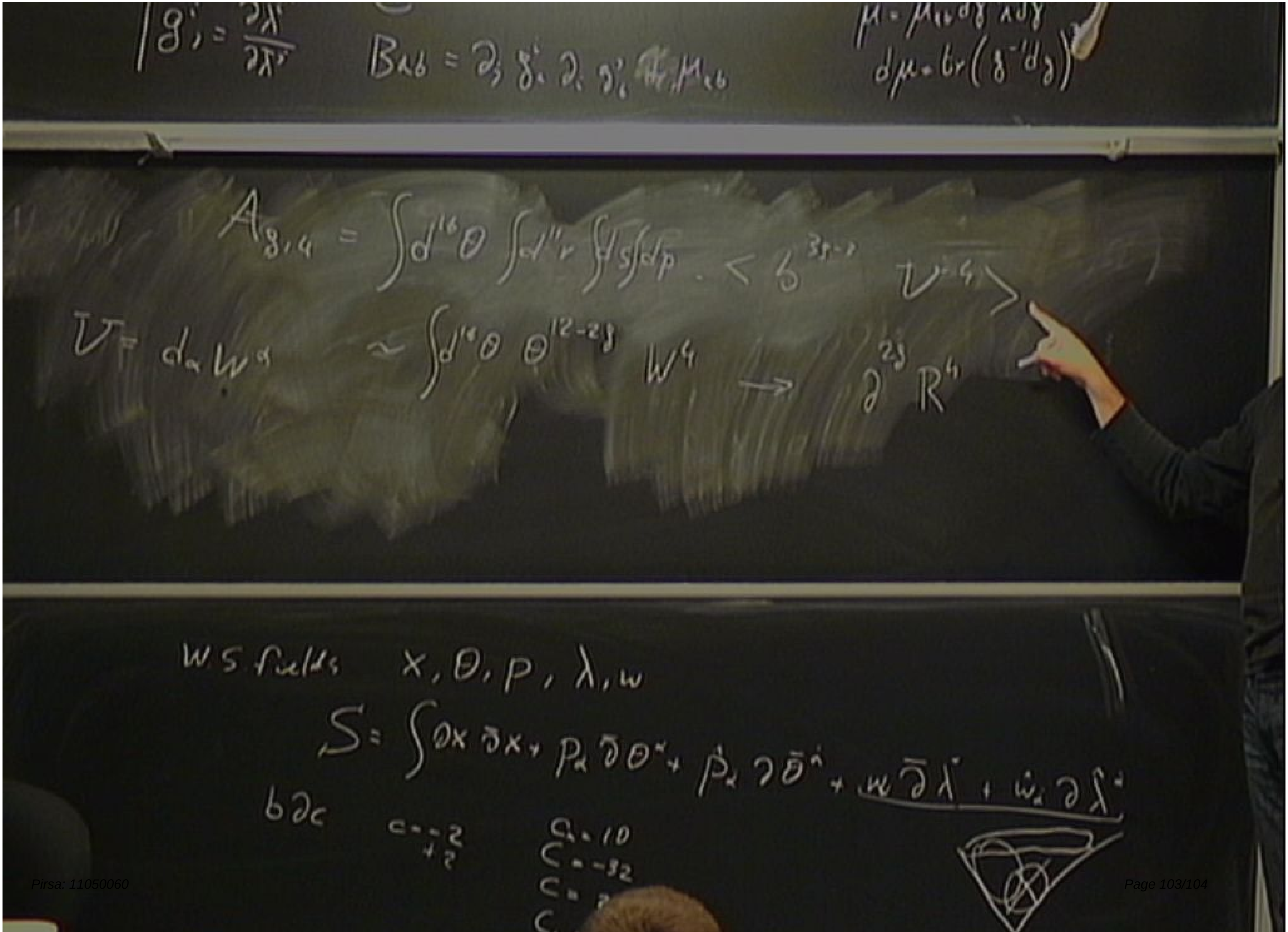









x, θ, p, λ, w


W.S. fields X, θ, p, λ, w

$g^i_j = \frac{\partial \lambda^i}{\partial \lambda^j}$ $B_{ab} = \partial_j g^i_a \partial_i g^j_b \mu_{ab}$ $d\mu = tr(g^{-1} dg)$

$$A_{g,4} = \int d^{16}\theta \int d^{11}r \int ds \int dp \, . \langle b^{3g-3} \quad V^{4} \rangle$$

$$V = d_\alpha W^\alpha \quad \sim \int d^{16}\theta \, \theta^{12-2g} \, W^4 \longrightarrow \partial^{2g} R^4 \qquad \partial^{12} R^4$$

W.S. fields X, θ, p, λ, w

$$S = \int \partial X \bar{\partial} X + p_\alpha \bar{\partial} \theta^\alpha + \hat{p}_\alpha \partial \bar{\theta}^\alpha + w \bar{\partial} \lambda + \hat{w}_\alpha \partial \hat{\lambda}^\alpha$$

$b \partial c$ $c = -2$, $+2$ $c = 10$, $c = -32$, $c = 22$