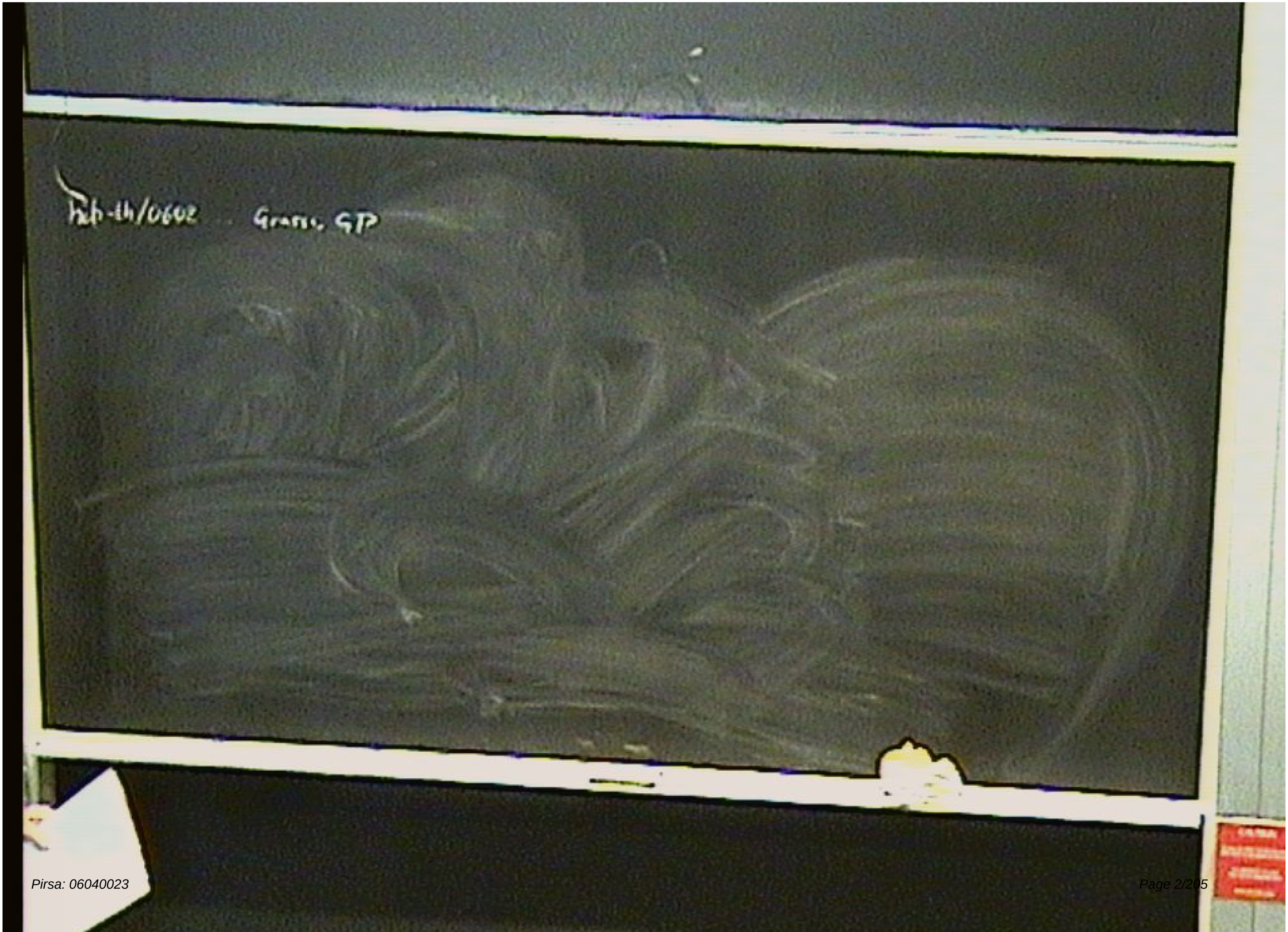
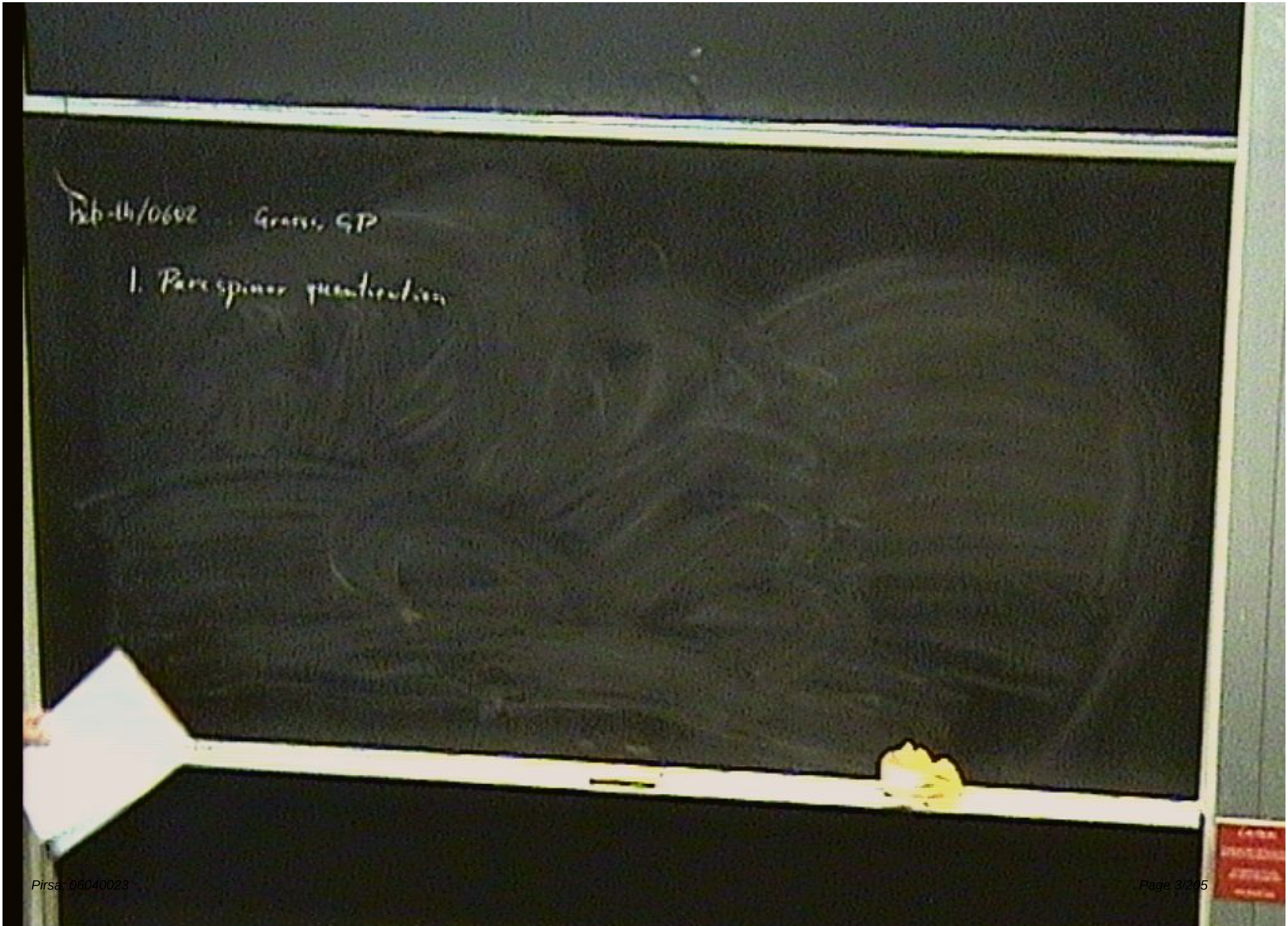
Title: Beta-gamma systems and quantum Koszul resolution

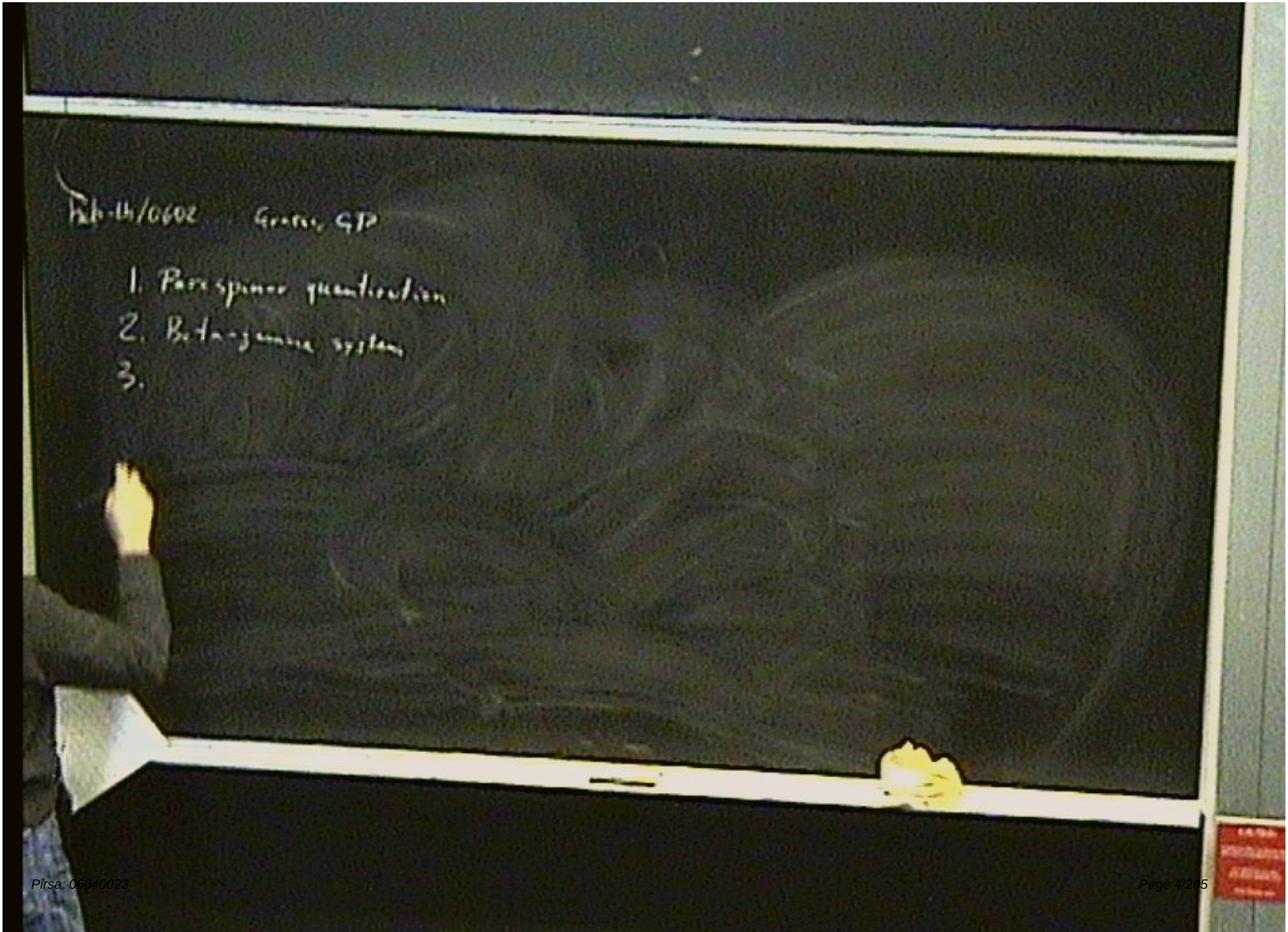
Date: Apr 25, 2006 02:00 PM

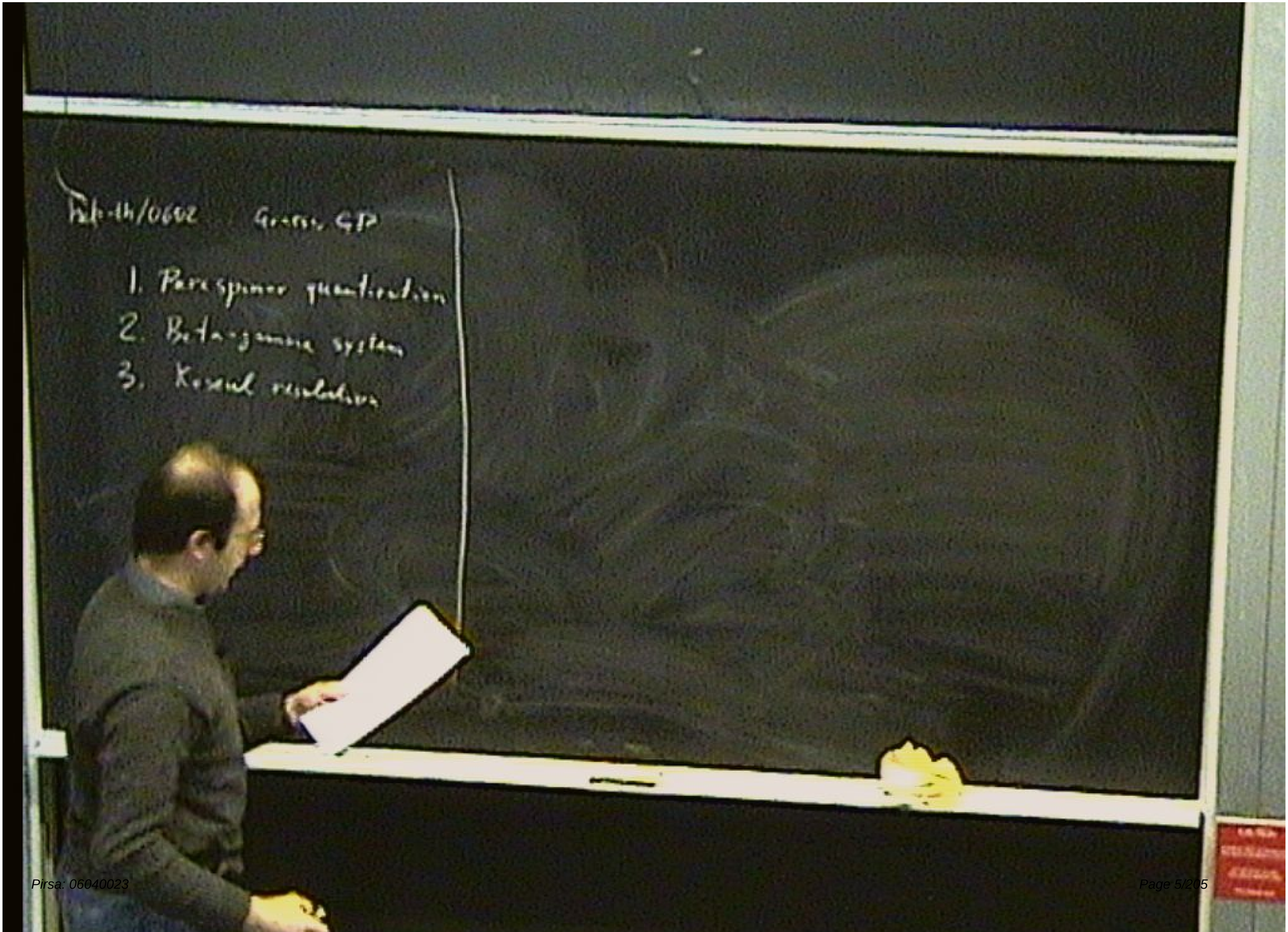
URL: http://pirsa.org/06040023

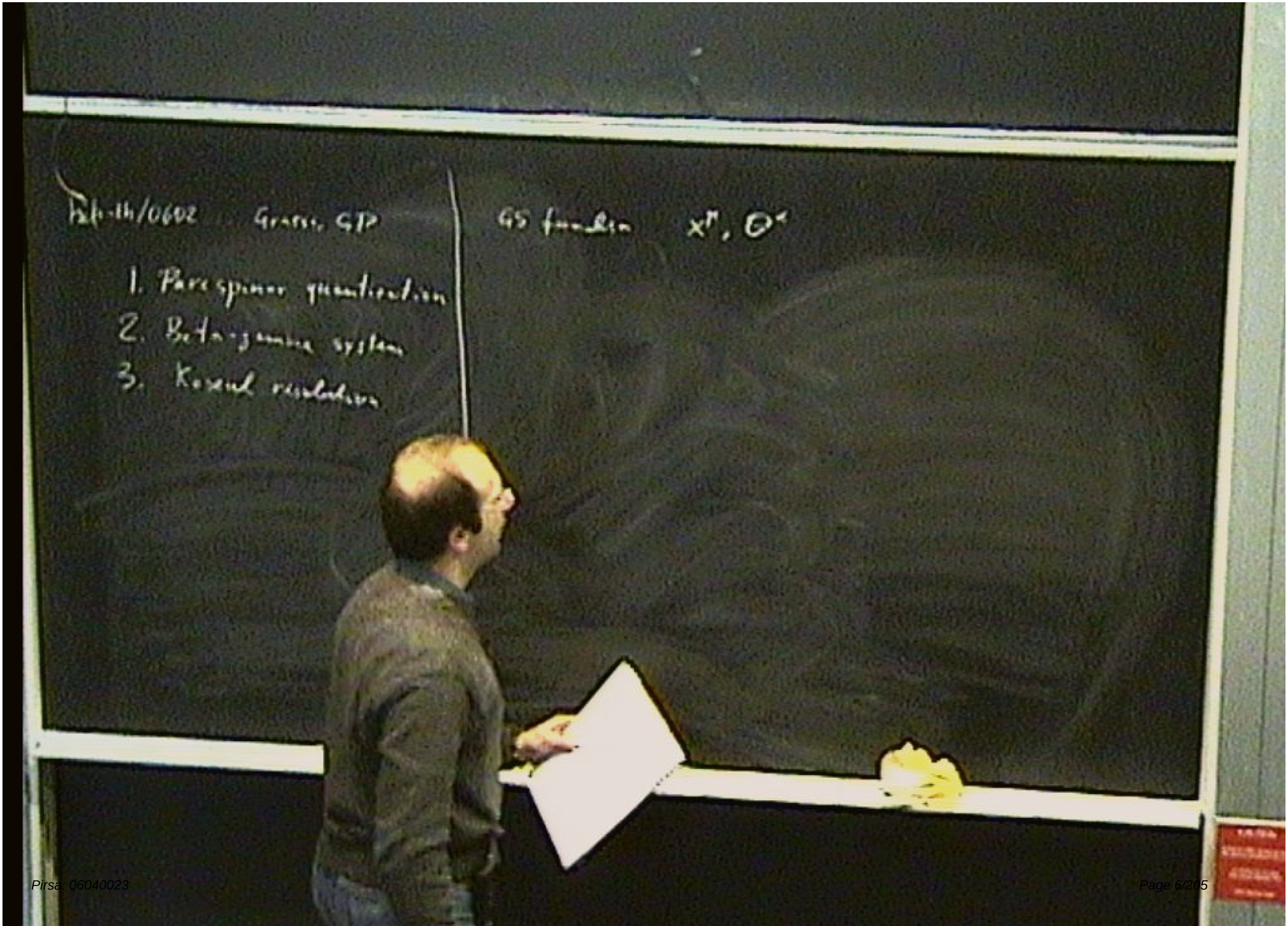
Abstract:

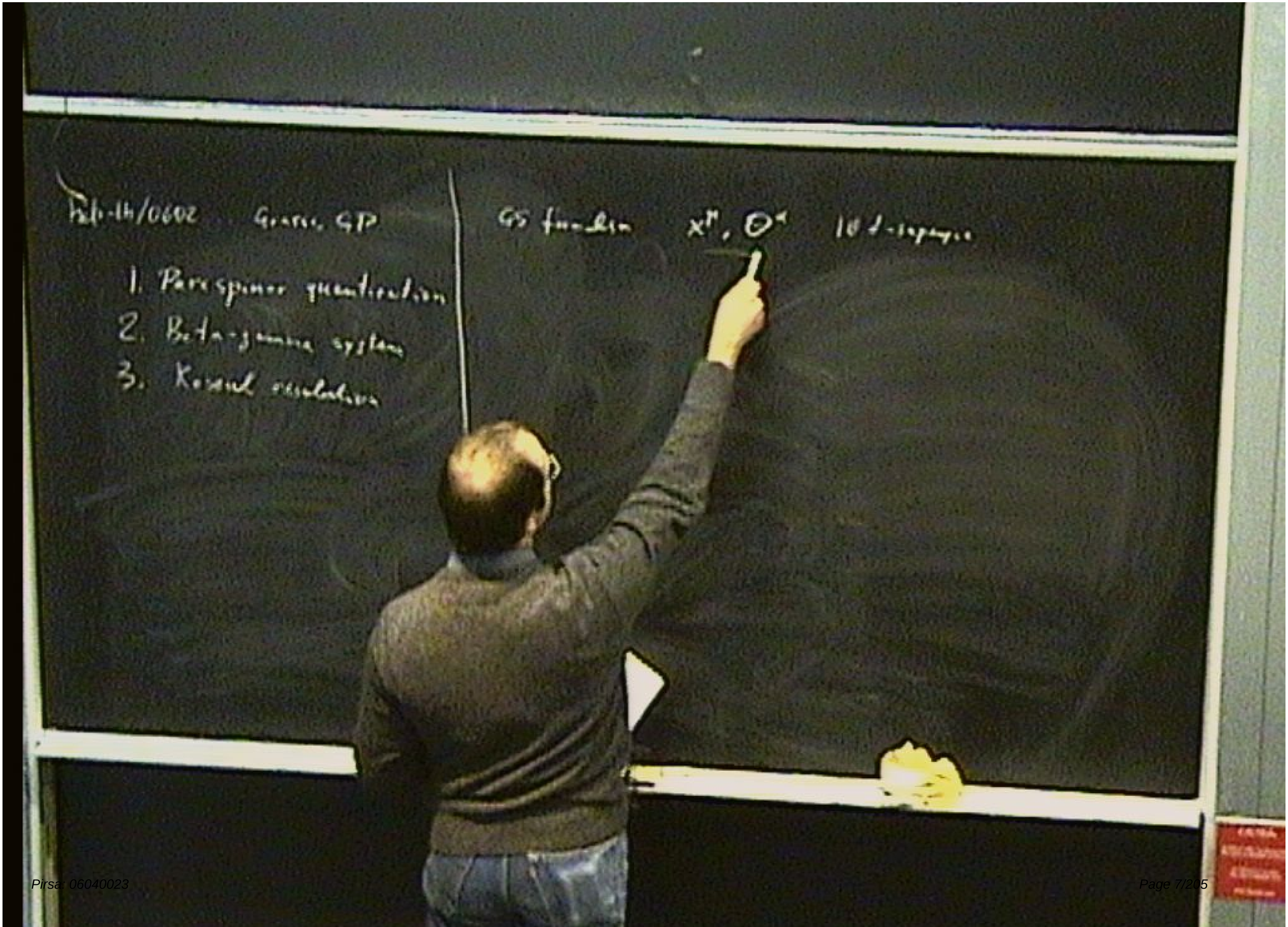

hep-th/0602

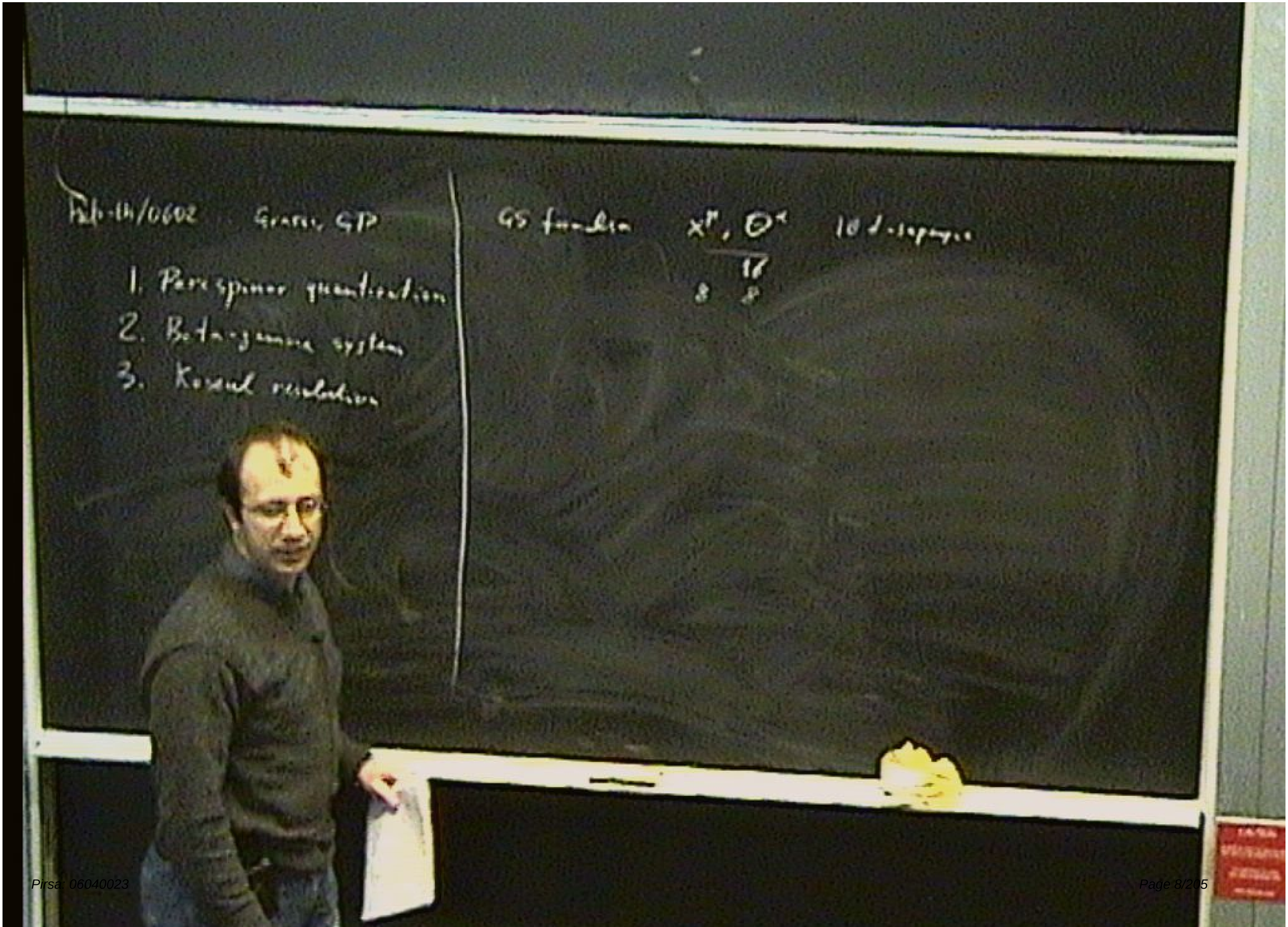

hep-th/0602 Grassi, GP
1. Pure spinor quantization

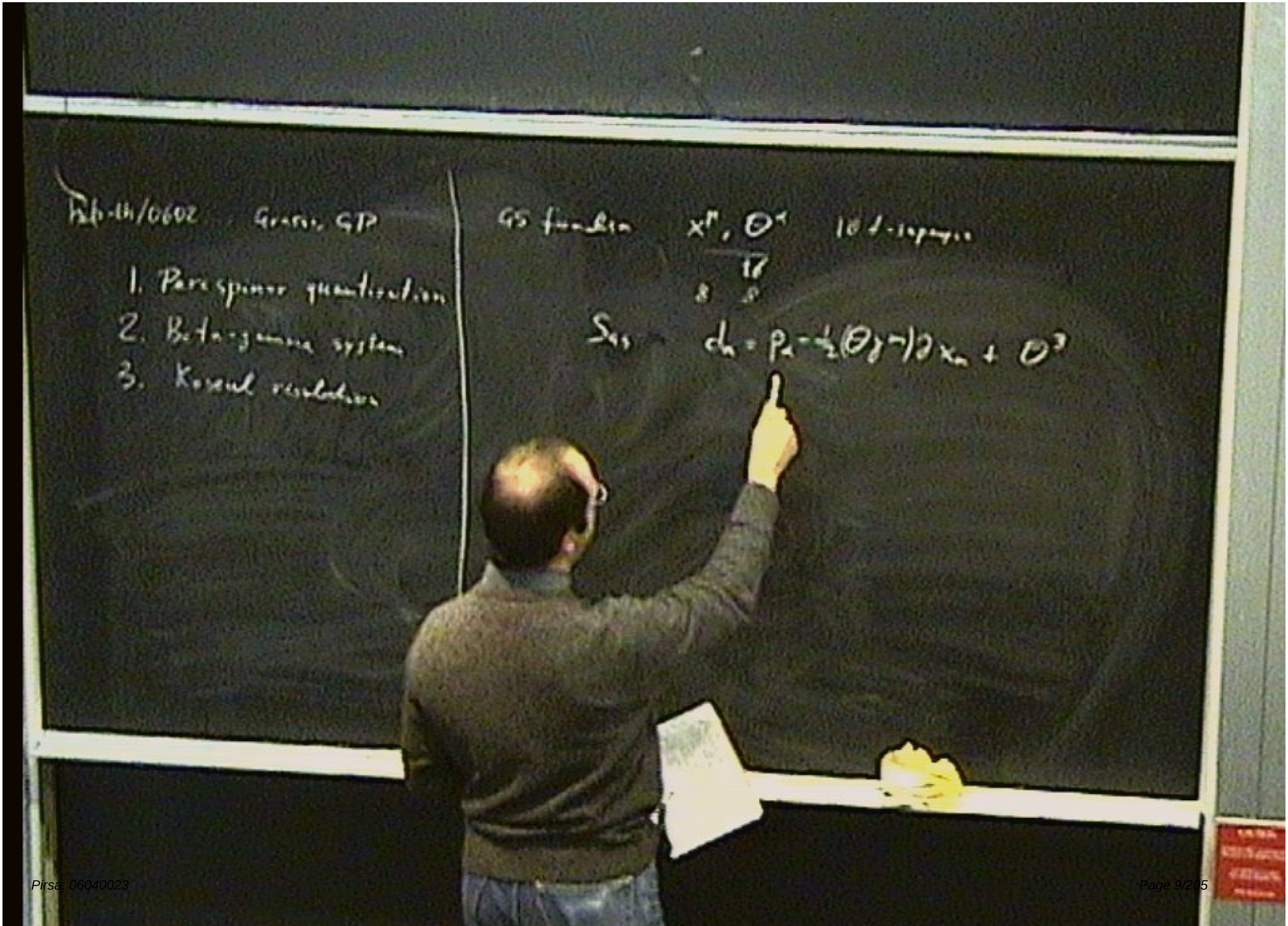

hep-th/0602
1. Paraspinor quantization
2. Beta-gamma system
3.

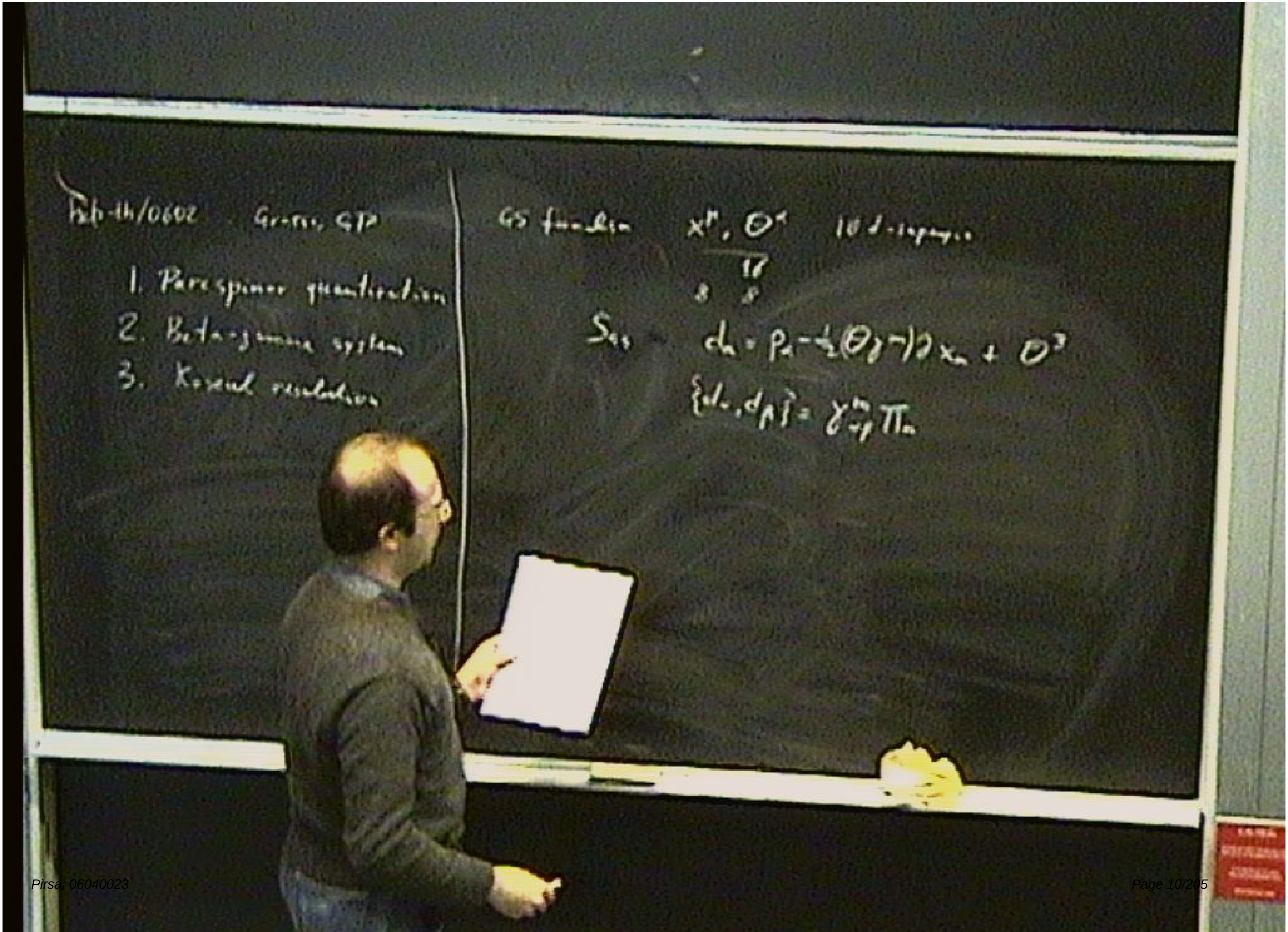

2. Beta-gamma system

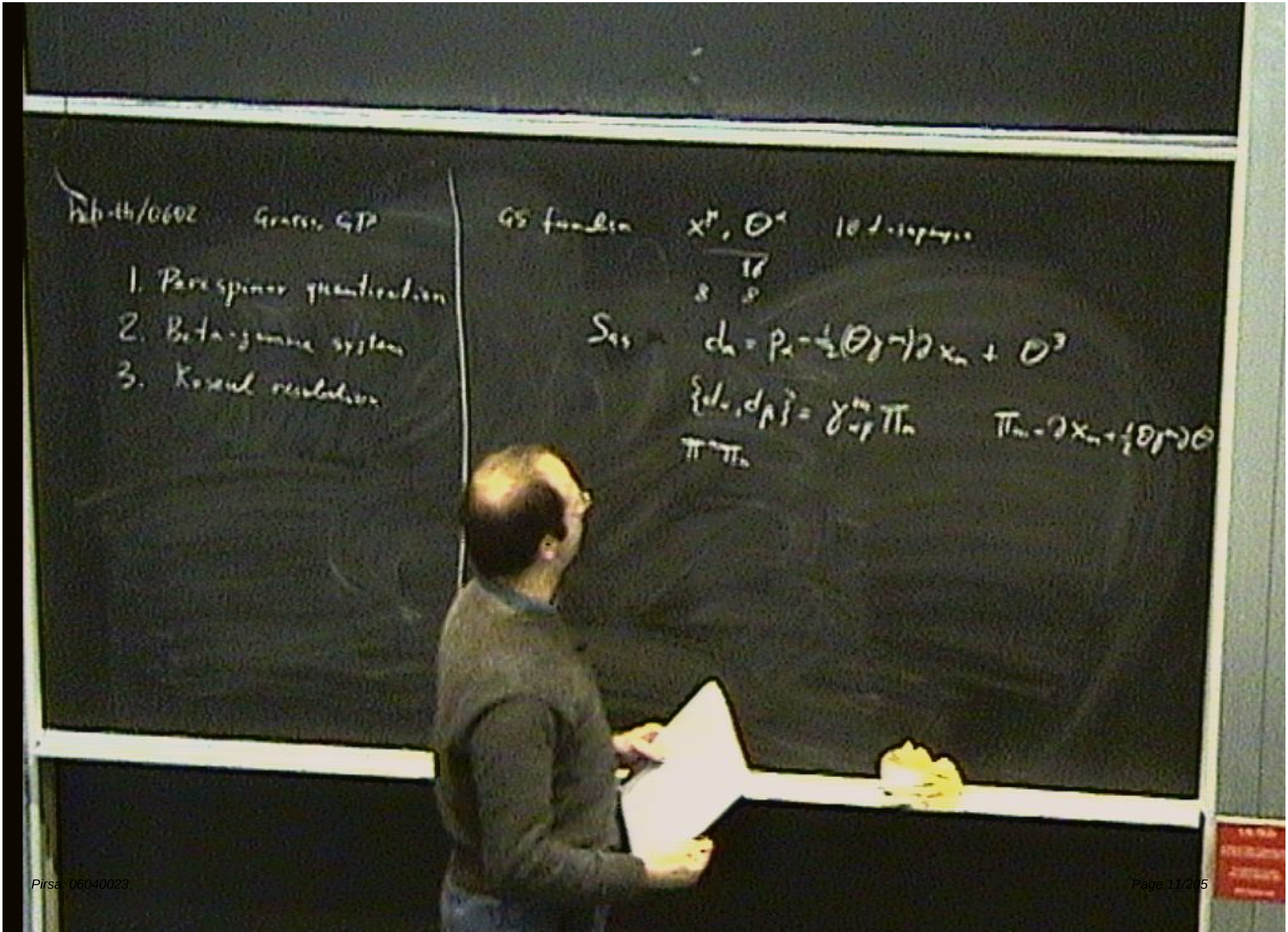

1. Purespinor quantization
2. Beta-gamma system
3. Koszul resolution

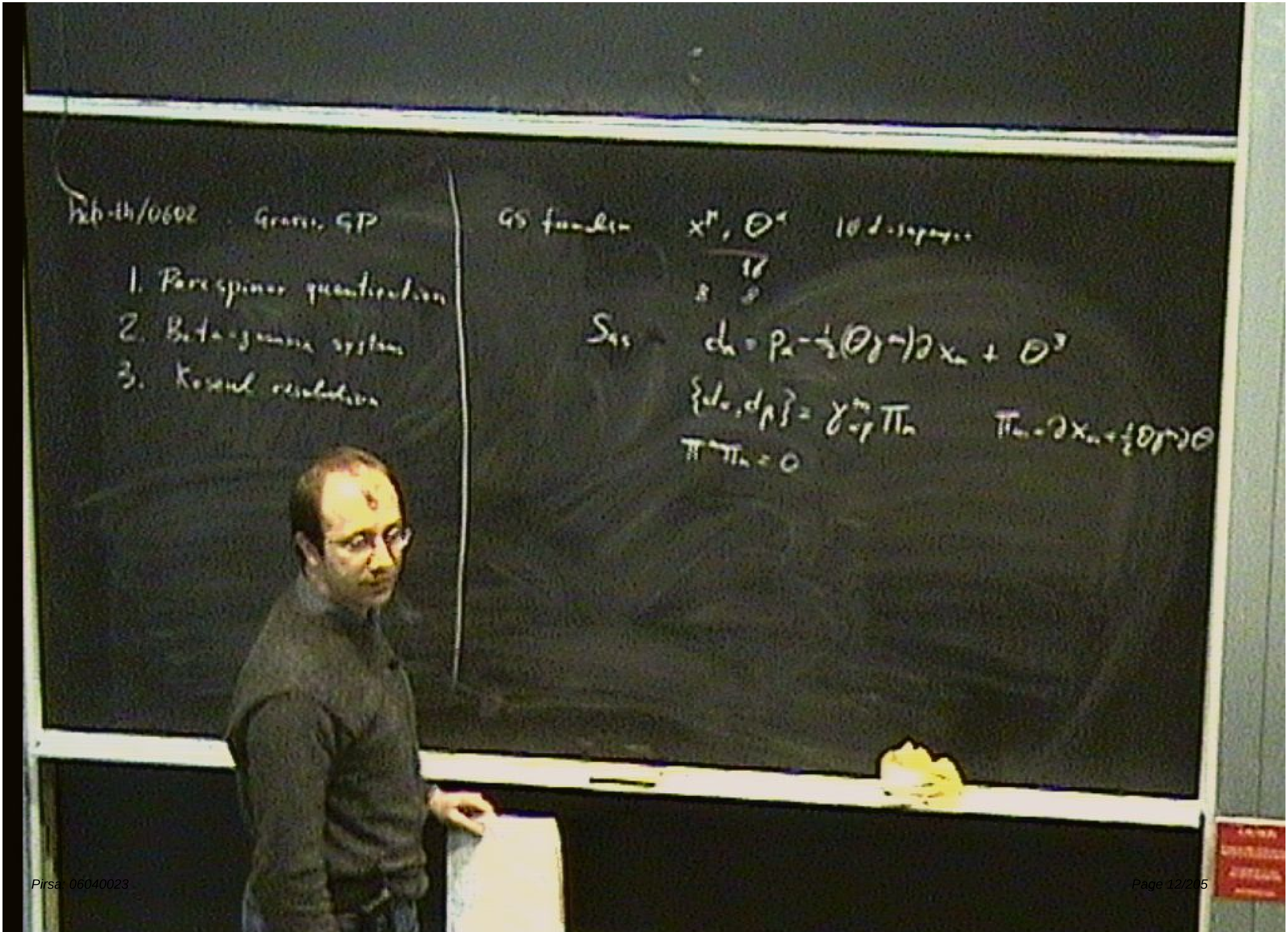

1. Pure spinor quantization
2. Beta-gamma system

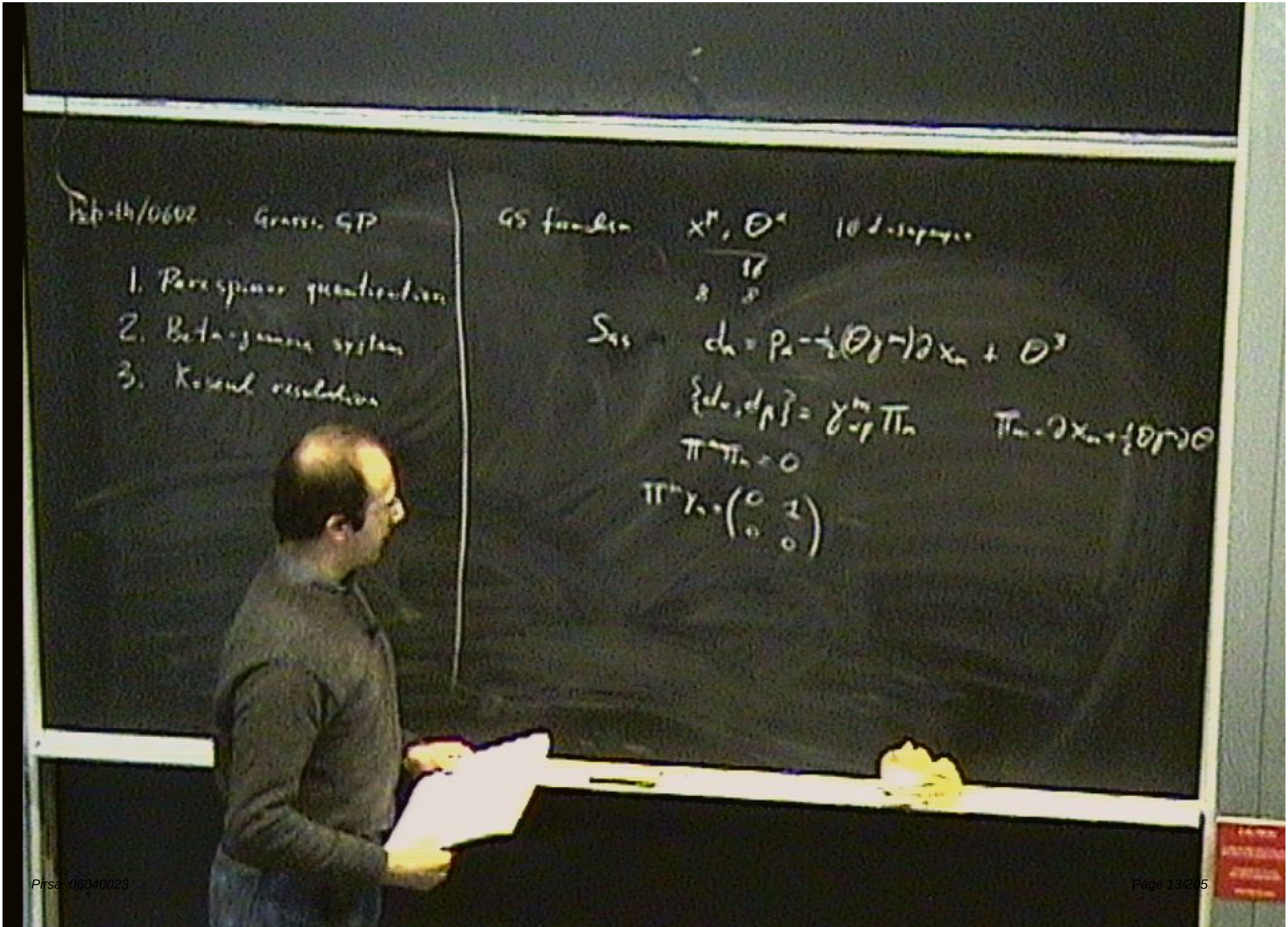

1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution

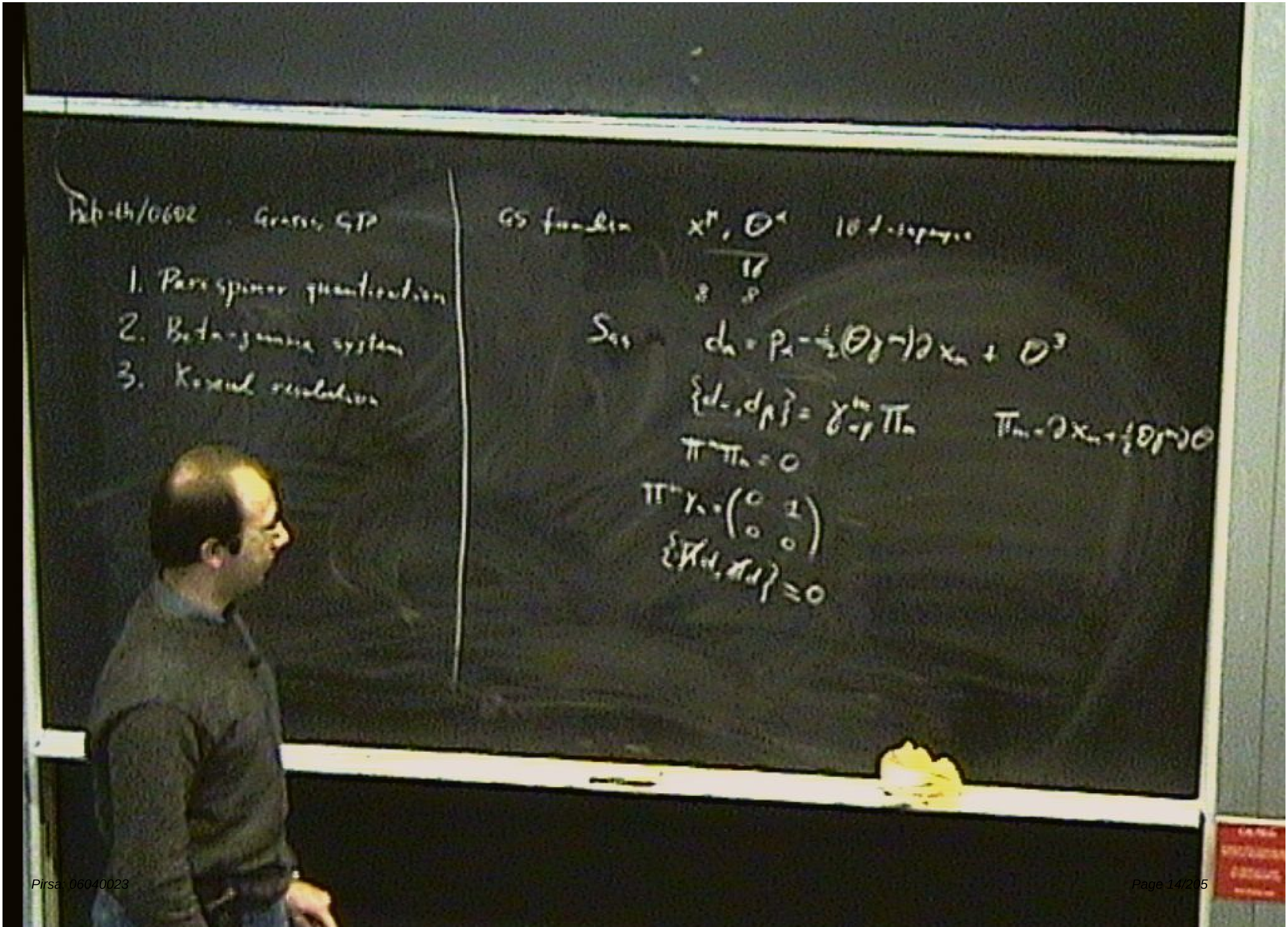

1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution

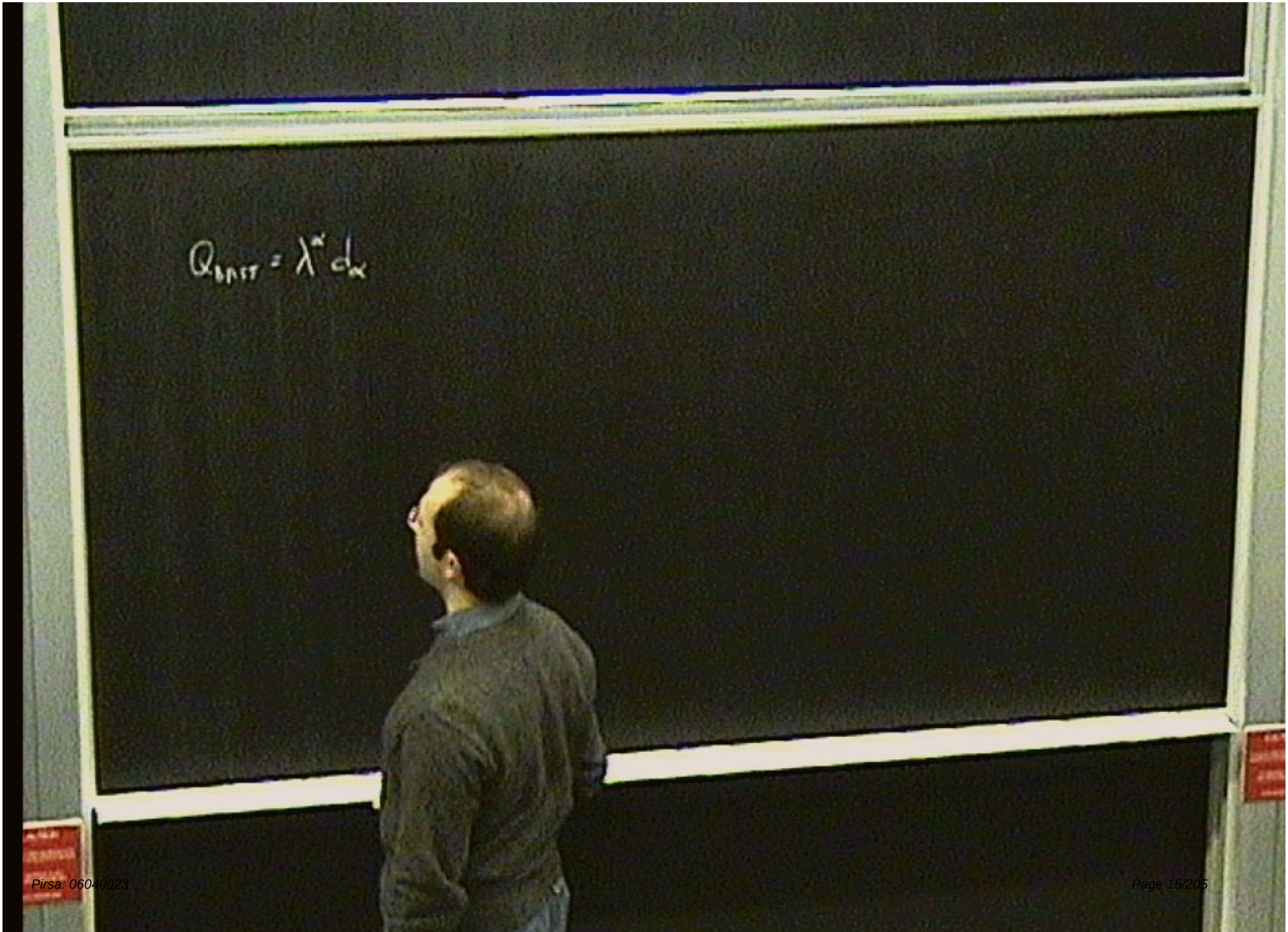

1. Purespinor quantization
2. Beta-gamma system
3. Koszul resolution

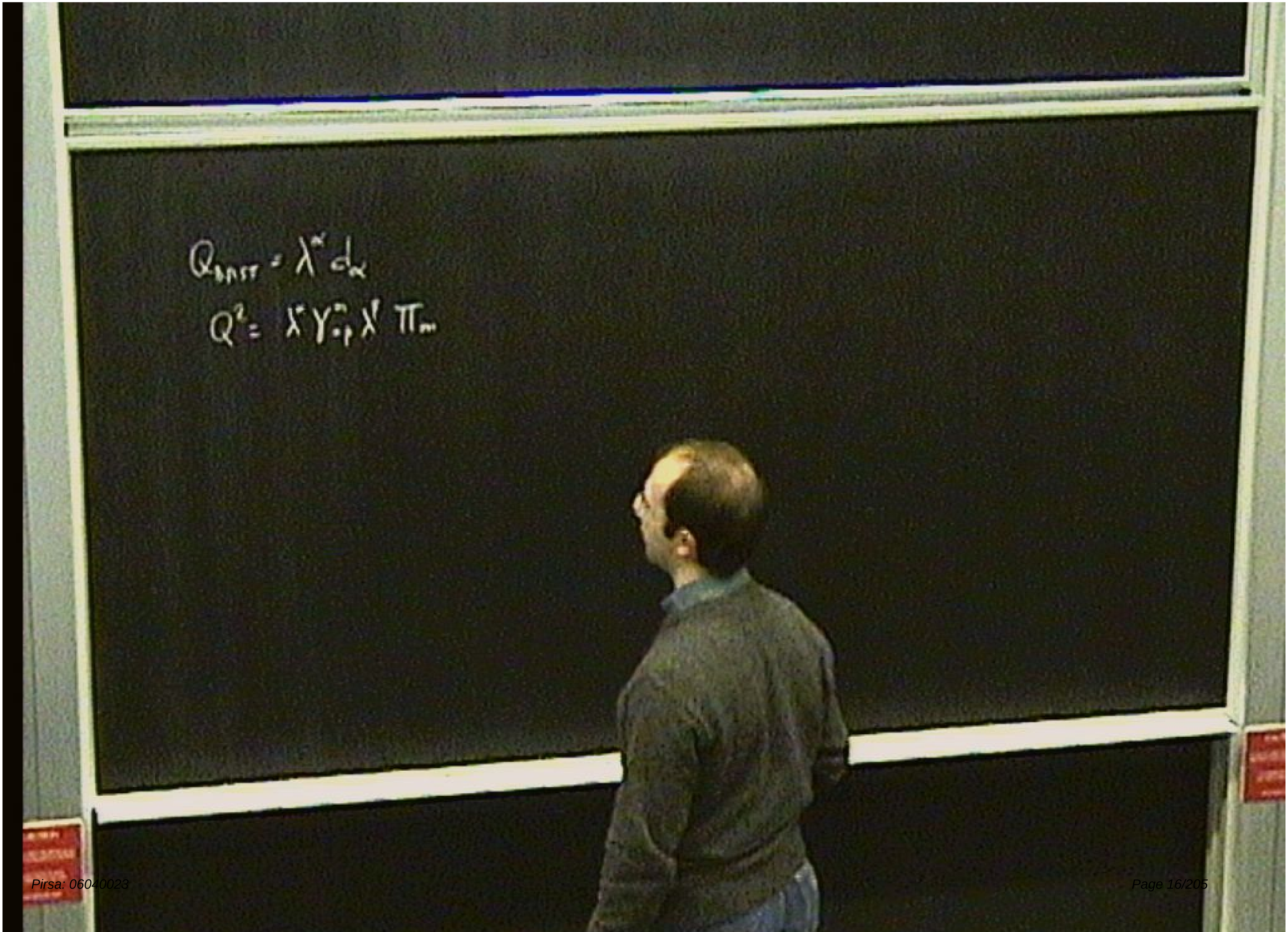

hep-th/0602
1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution
GS formalism
10 d superspace
16
8 8

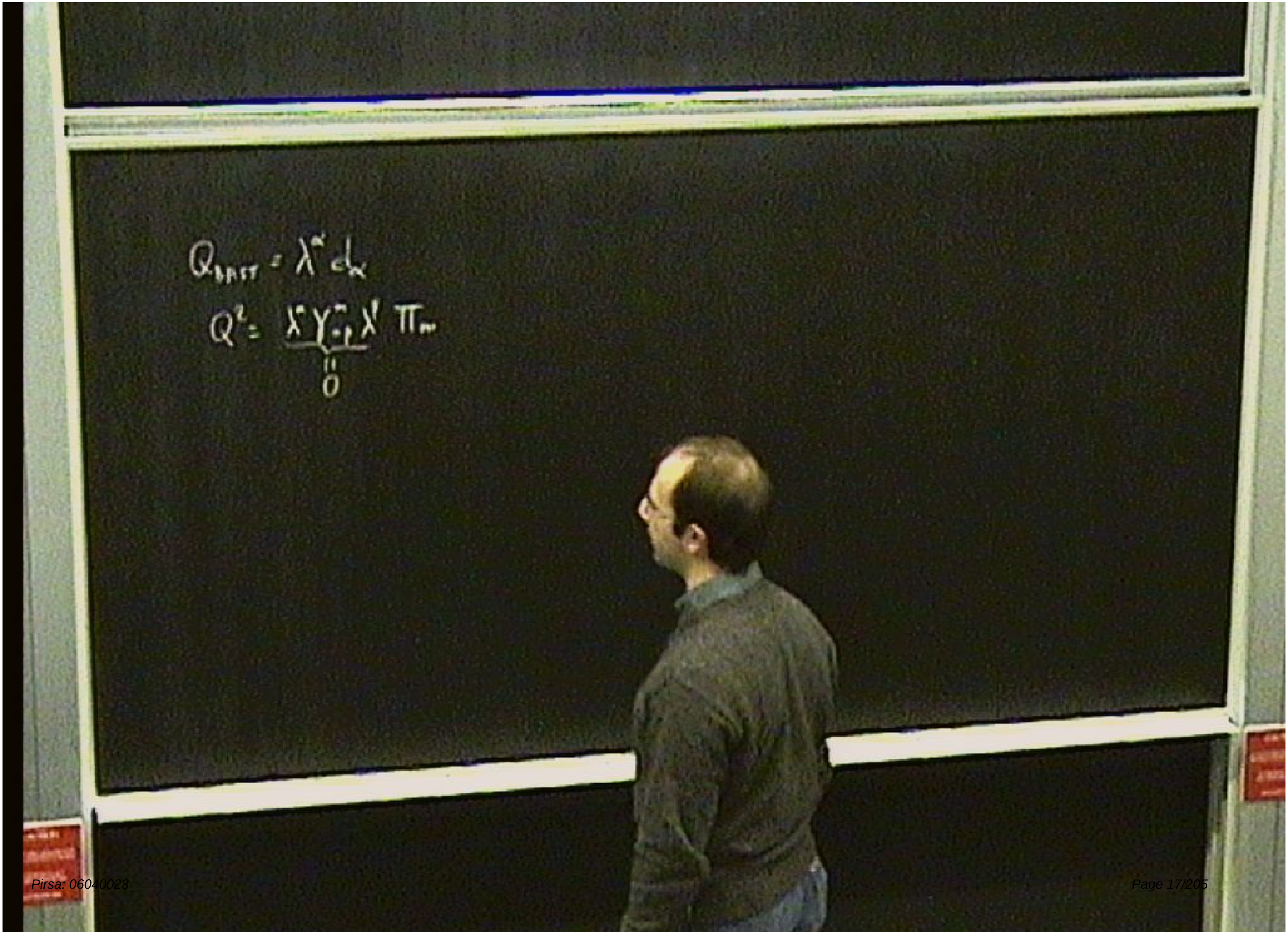

hep-th/0602
1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution
x^m, θ^α
$\Pi^m \Pi_m = 0$

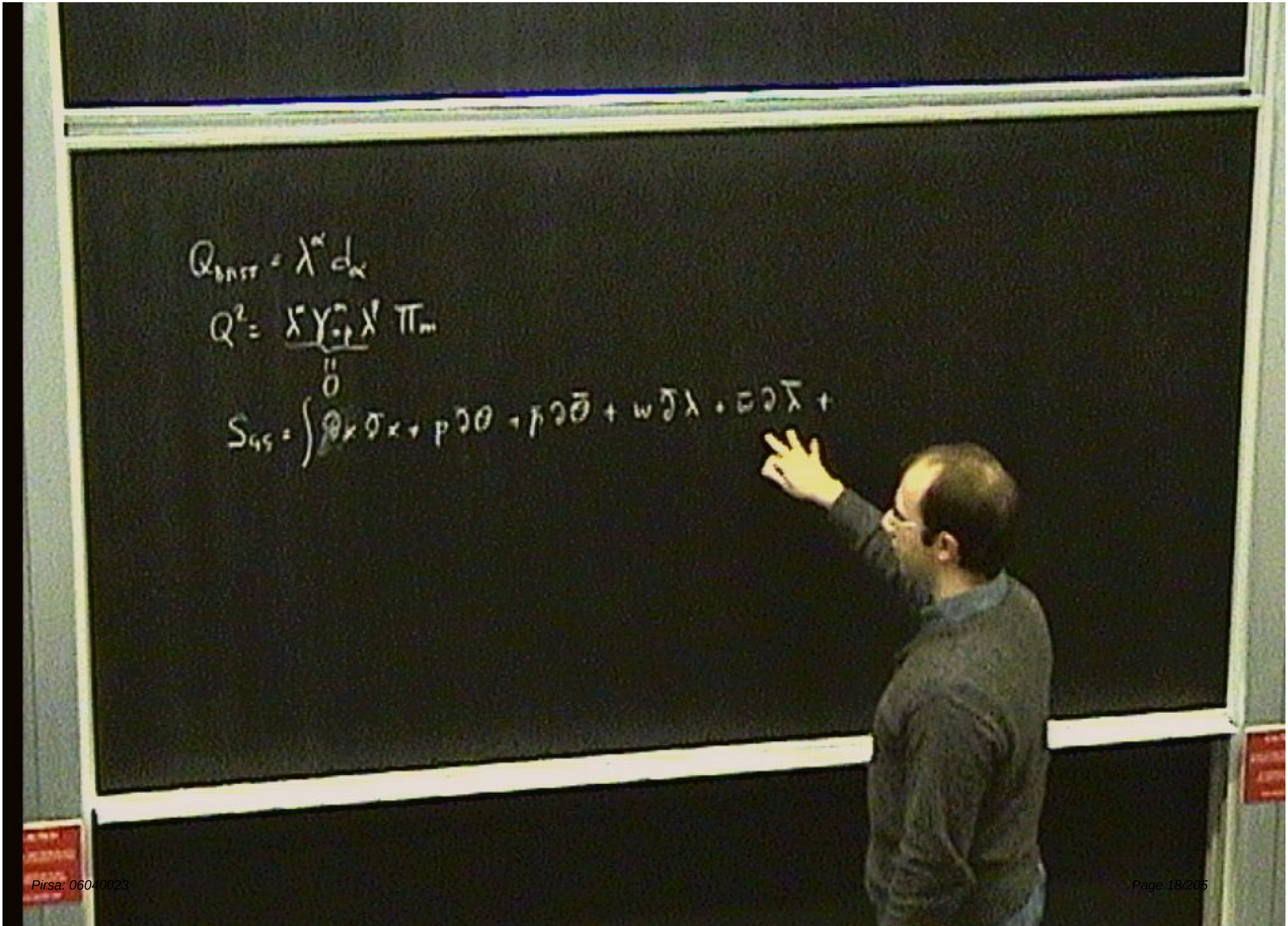

1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution
GS formalism
10 d superspace

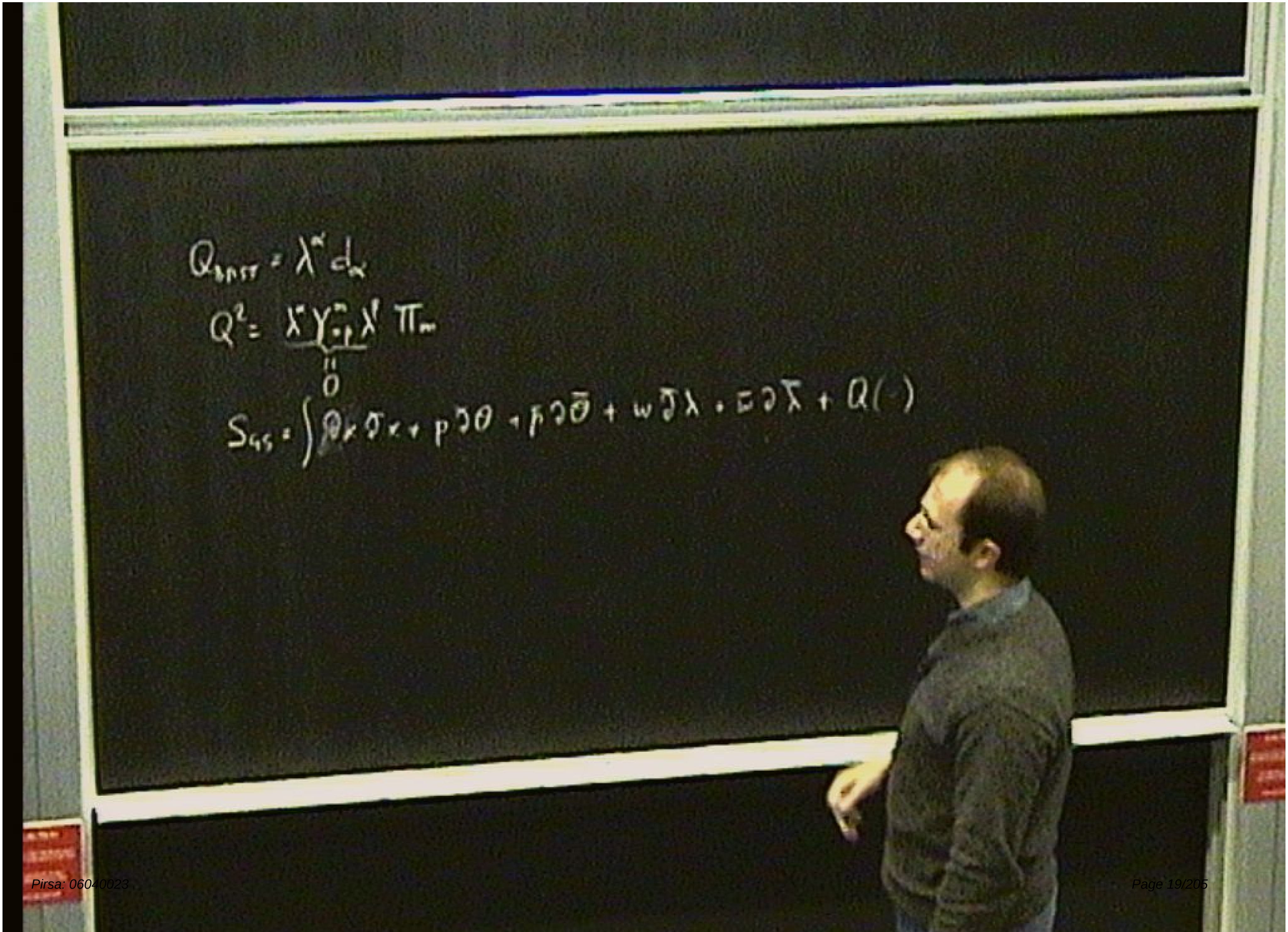

hep-th/0602
1. Pure spinor quantization
2. Beta-gamma system
3. Kernel resolution

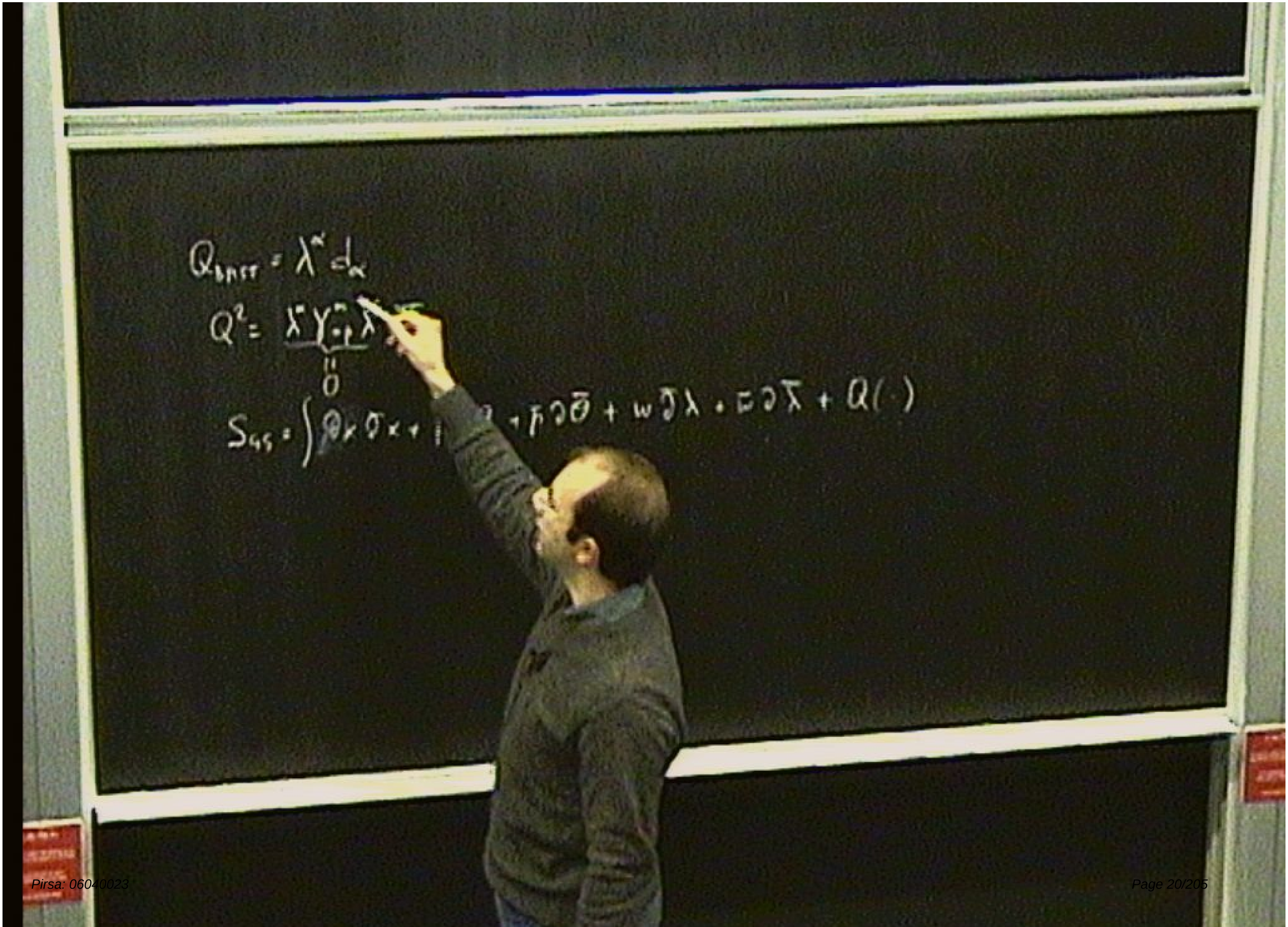

Q_BRST = λ^α d_α

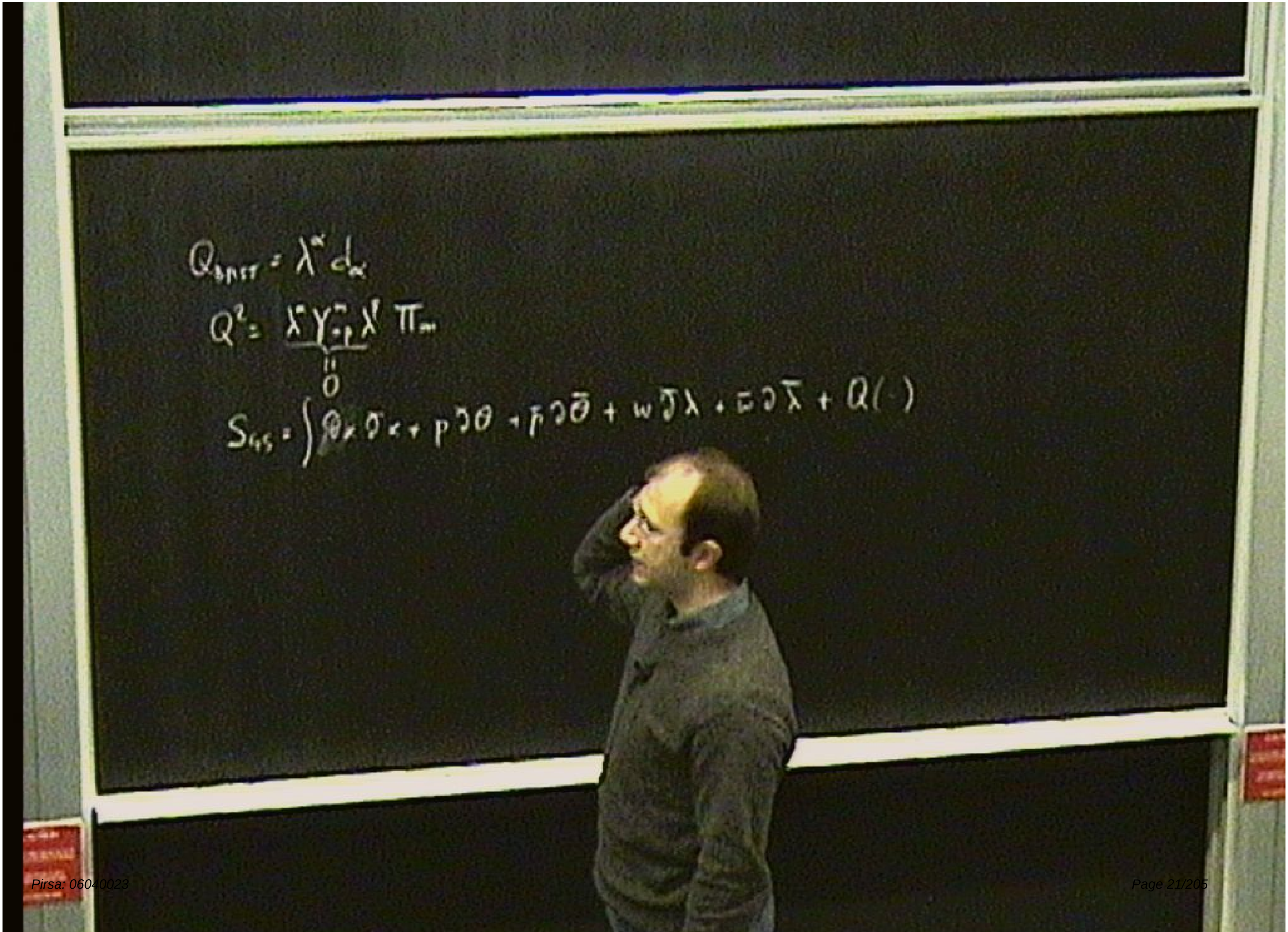

$Q_{BRST} = \lambda^\alpha d_\alpha$
$Q^2 = \lambda^\alpha \gamma^m_{\alpha\beta} \lambda^\beta \Pi_m$

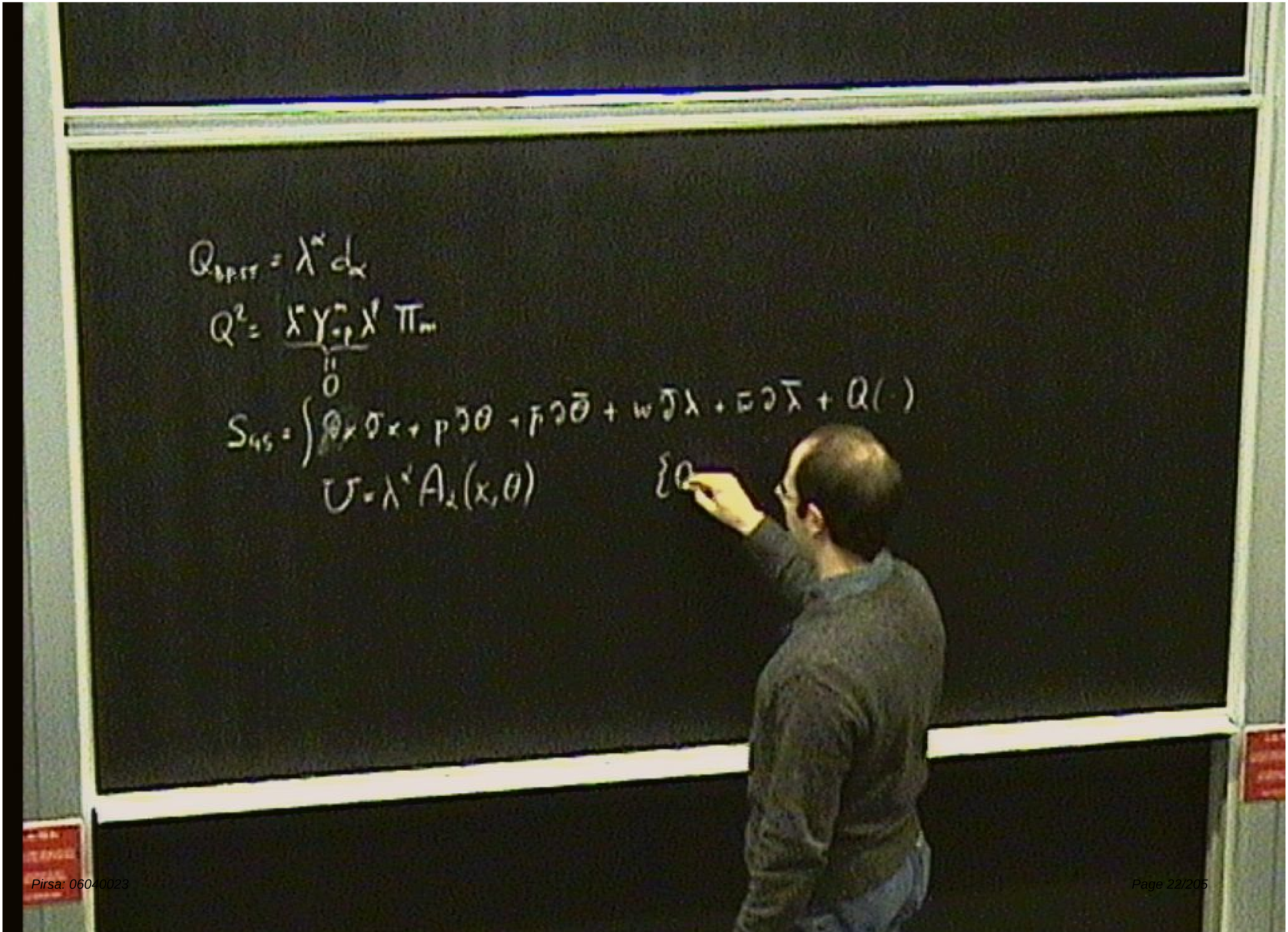

Q_BRST = λ^α d_α
Q^2 = λ^α γ^m_αβ λ^β Π_m
0

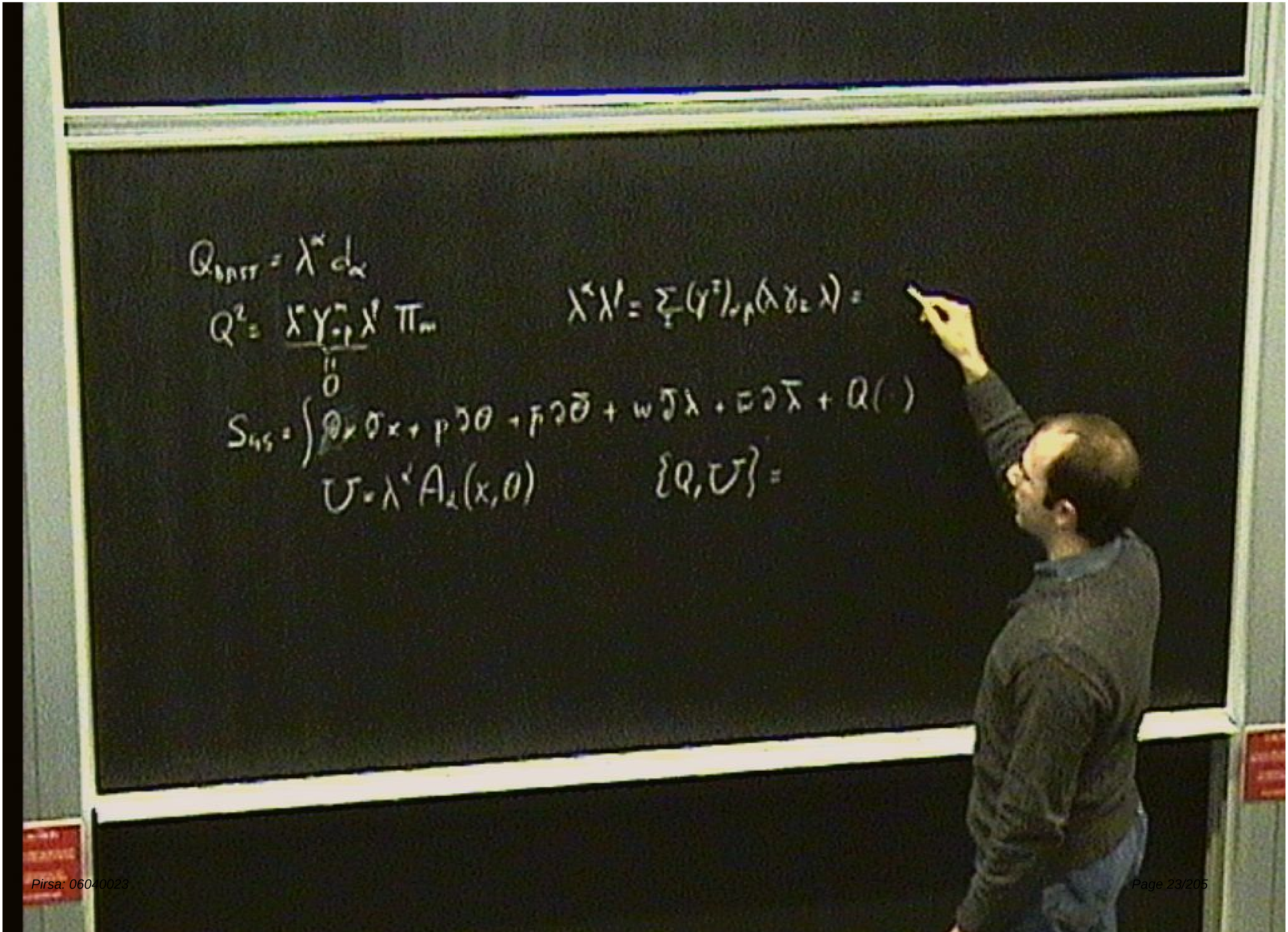

Q_BRST = λ^α d_α
Q² = λ γ^m λ Π_m
0
S_GS = ∫ ∂x ∂̄x + p∂̄θ + p̂∂θ̂ + w∂̄λ + ŵ∂λ̂ +


$Q_{BRST} = \lambda^\alpha d_\alpha$
$Q^2 = \lambda^\alpha \gamma^m_{\alpha\beta} \lambda^\beta \Pi_m$
$= 0$
$S_{GS} = \int \partial x \bar{\partial} x + p \bar{\partial}\theta + \hat{p}\partial\hat{\theta} + w\bar{\partial}\lambda + \hat{w}\partial\hat{\lambda} + Q(\cdot)$

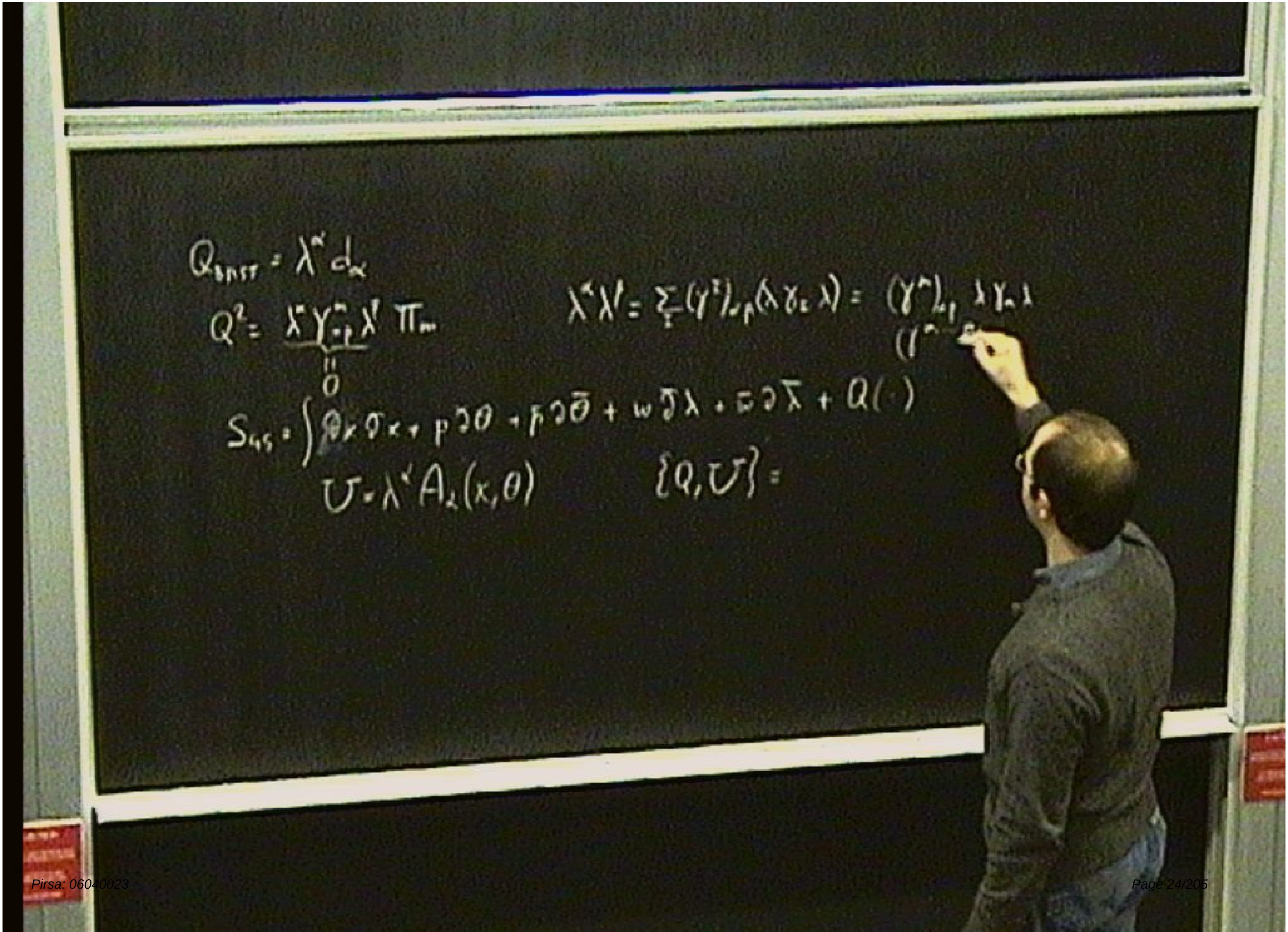

Q_BRST = λ^α d_α
Q² = λ^α γ^m_αβ λ^β
0
S_ws = ∫ θ∂x ∂̄x +
+ p̄∂θ̄ + w∂̄λ + w̄∂λ̄ + Q(·)

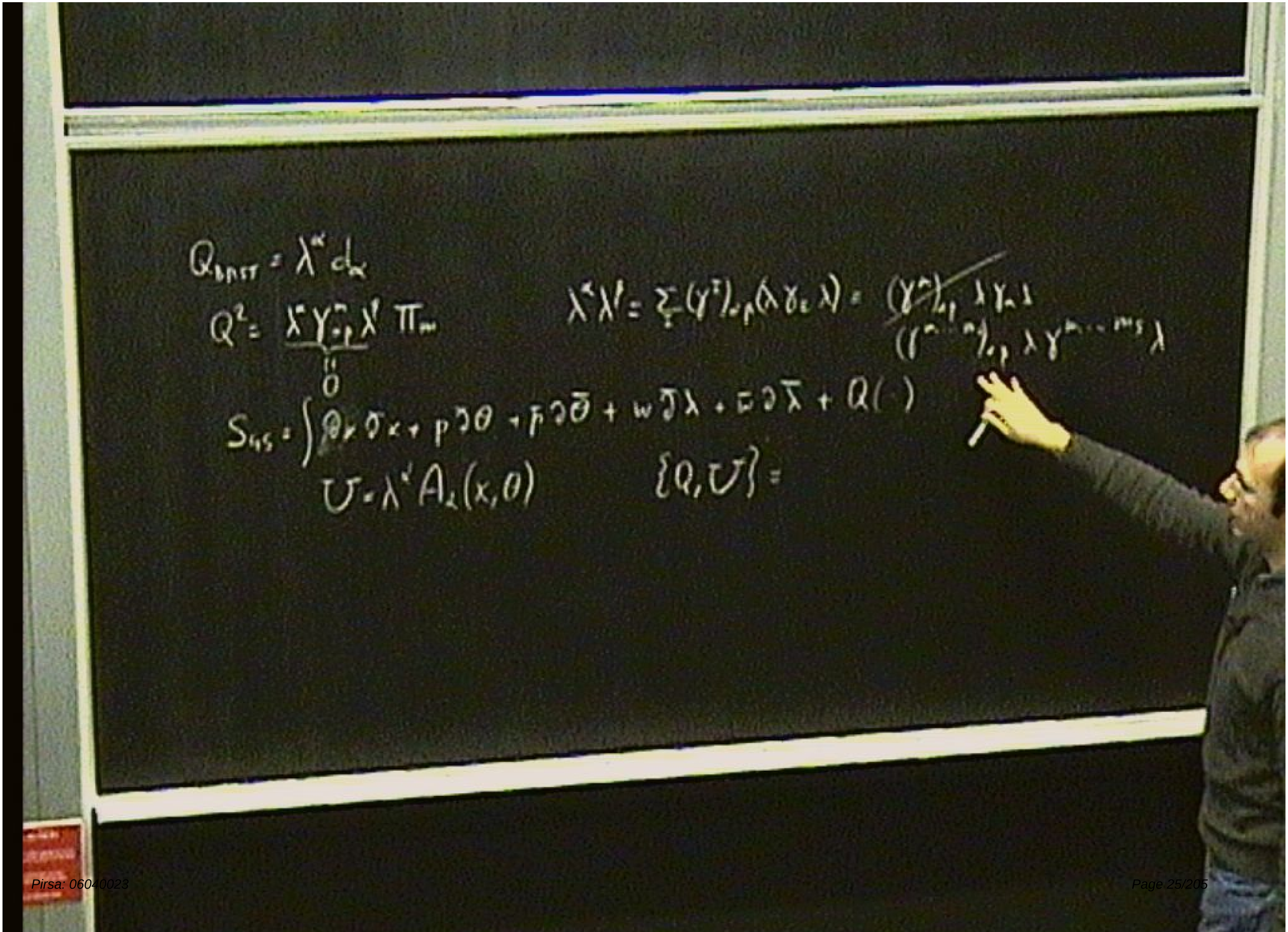

Q_BRST = λ^α d_α
Q² = λ^α γ^m_αβ λ^β Π_m
= 0
S_GS = ∫ θ_α ∂̄x + p ∂θ + p̄ ∂̄θ̄ + w ∂̄λ + w̄ ∂λ̄ + Q( )


Q_BRST = λ^α d_α
Q^2 = λ^α γ^m_αβ λ^β Π_m = 0
S_MS = ∫ ... + p∂θ + p̄∂θ̄ + w∂λ + w̄∂λ̄ + Q( )
U = λ^α A_α(x,θ)



Q_BRST = λ^α d_α
Q^2 = λ^α γ^m_αβ λ^β Π_m
λ^α λ^β = Σ_i (γ^i)_αβ (λ γ_i λ) =
S_WS = ∫ θ ∂̄ x + p ∂̄ θ + p̄ ∂ θ̄ + w ∂̄ λ + w̄ ∂ λ̄ + Q( )
U = λ^α A_α(x,θ)
{Q,U} =


Q_BRST = λ^α d_α
Q^2 = λ^α γ^m_αβ λ^β Π_m
0
λ^α λ^β = Σ_k (γ^k)_αβ (λ γ_k λ) = (γ^m)_αβ λ γ_m λ
S_WS = ∫ ∂x ∂̄x + p∂̄θ + p̄∂θ̄ + w∂̄λ + w̄∂λ̄ + Q(·)
U = λ^α A_α(x,θ)
{Q,U} =



Q_BRST = λ^α d_α
Q² = λ^α γ^m_αβ λ^β Π_m
0
λ^α λ^β = Σ (γ^k)_αβ (λ γ_k λ) = (γ^m)_αβ λ γ_m λ
(γ^m...m5)_αβ λ γ^m...m5 λ
S_HS = ∫ θ x ∂ x + p ∂θ + p̄ ∂θ̄ + w ∂λ + w̄ ∂λ̄ + Q( )
U = λ^α A_α(x,θ)
{Q, U} =

$$Q_{BRST} = \lambda^\alpha d_\alpha$$

$$Q^2 = \underbrace{\lambda^\alpha \gamma^m_{\alpha\beta} \lambda^\beta}_{=\,0} \Pi_m$$

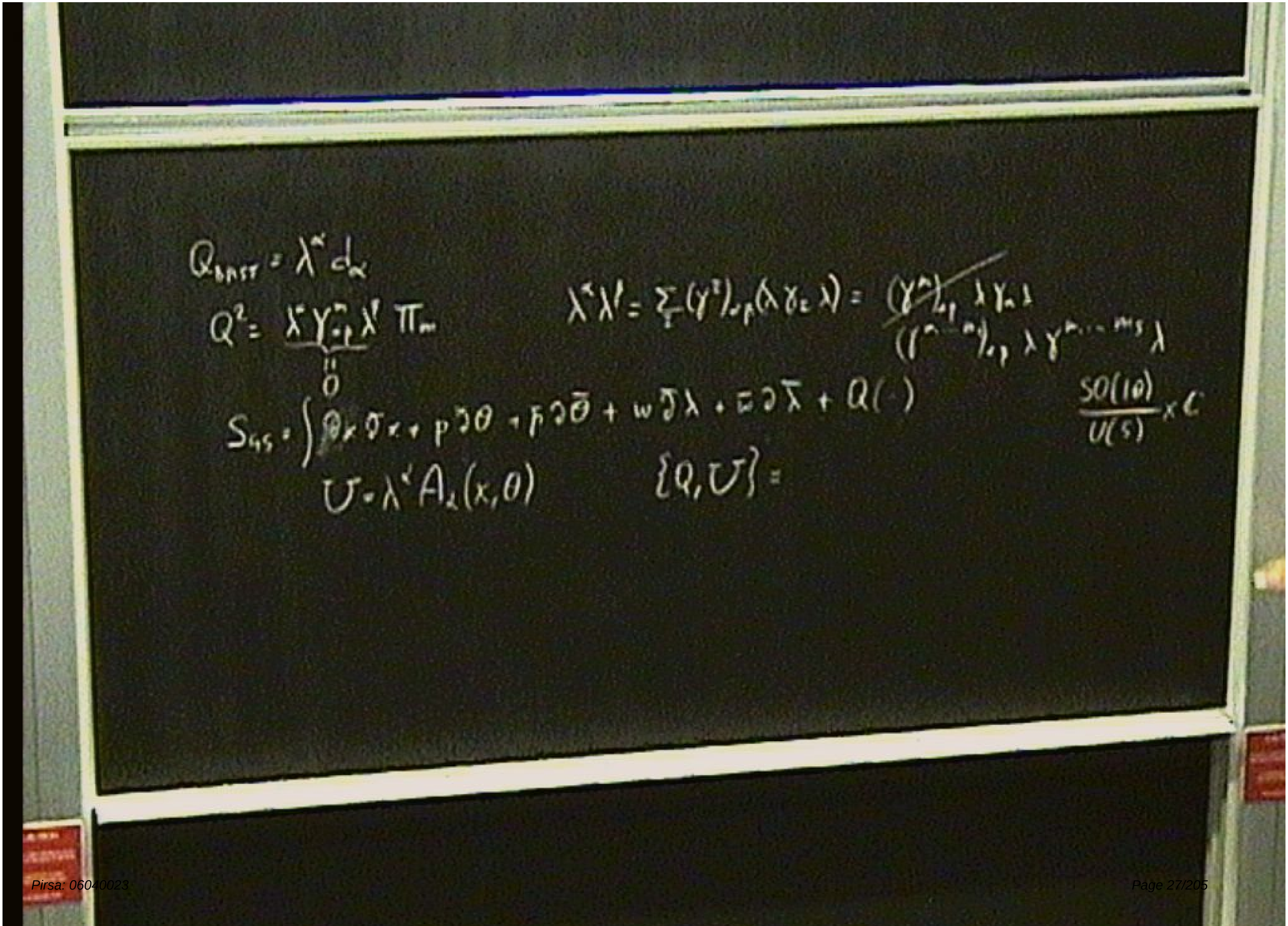
$$\lambda^\alpha \lambda^\beta = \sum_i (\gamma^i)_{\alpha\beta} (\lambda \gamma_i \lambda) = (\gamma^m)_{\alpha\beta}\, \lambda\gamma_m\lambda$$

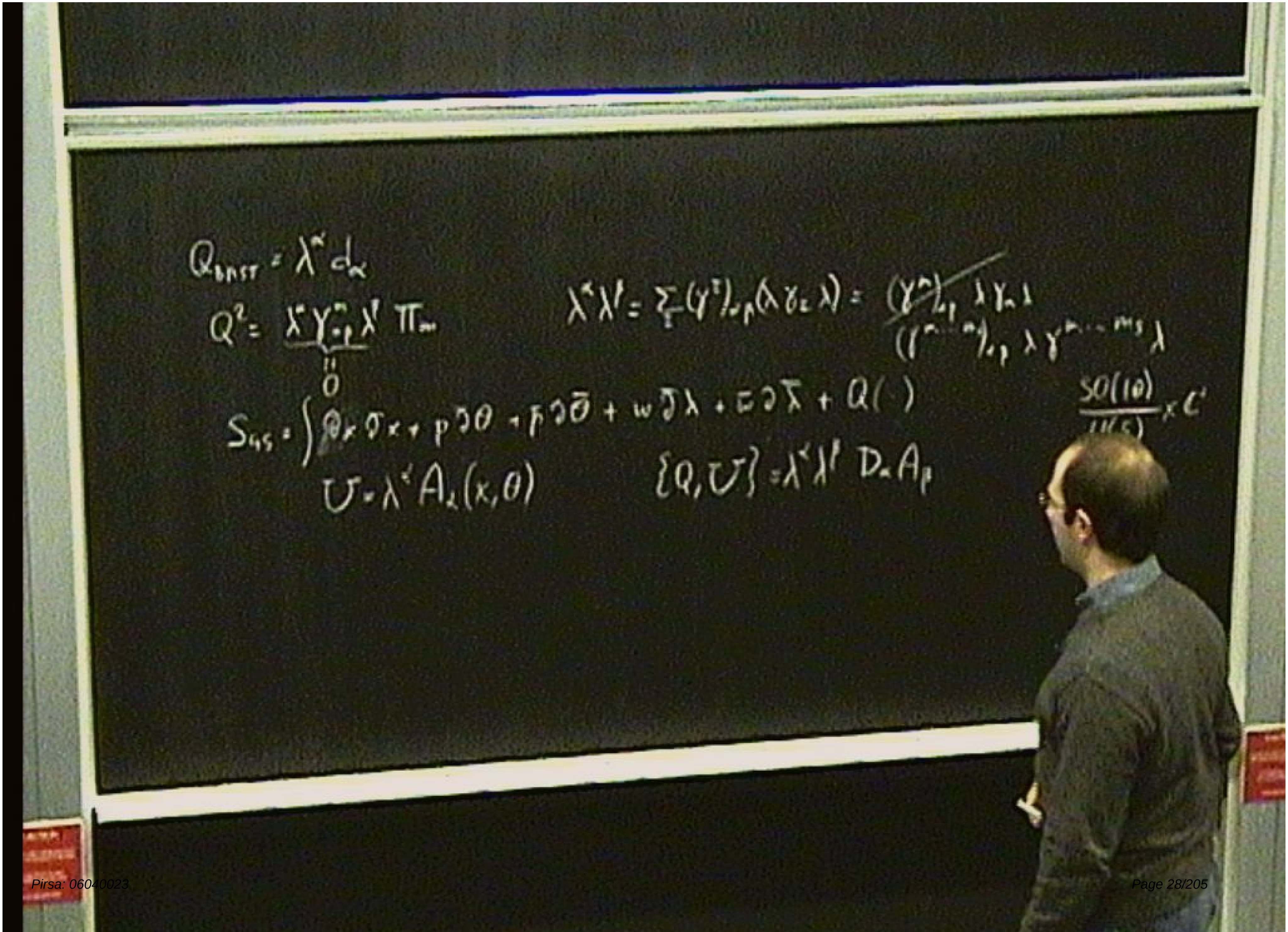
$$(\gamma^{m_1 \dots m_5})_{\alpha\beta}\, \lambda \gamma^{m_1 \dots m_5} \lambda$$

$$\frac{SO(10)}{U(5)}$$

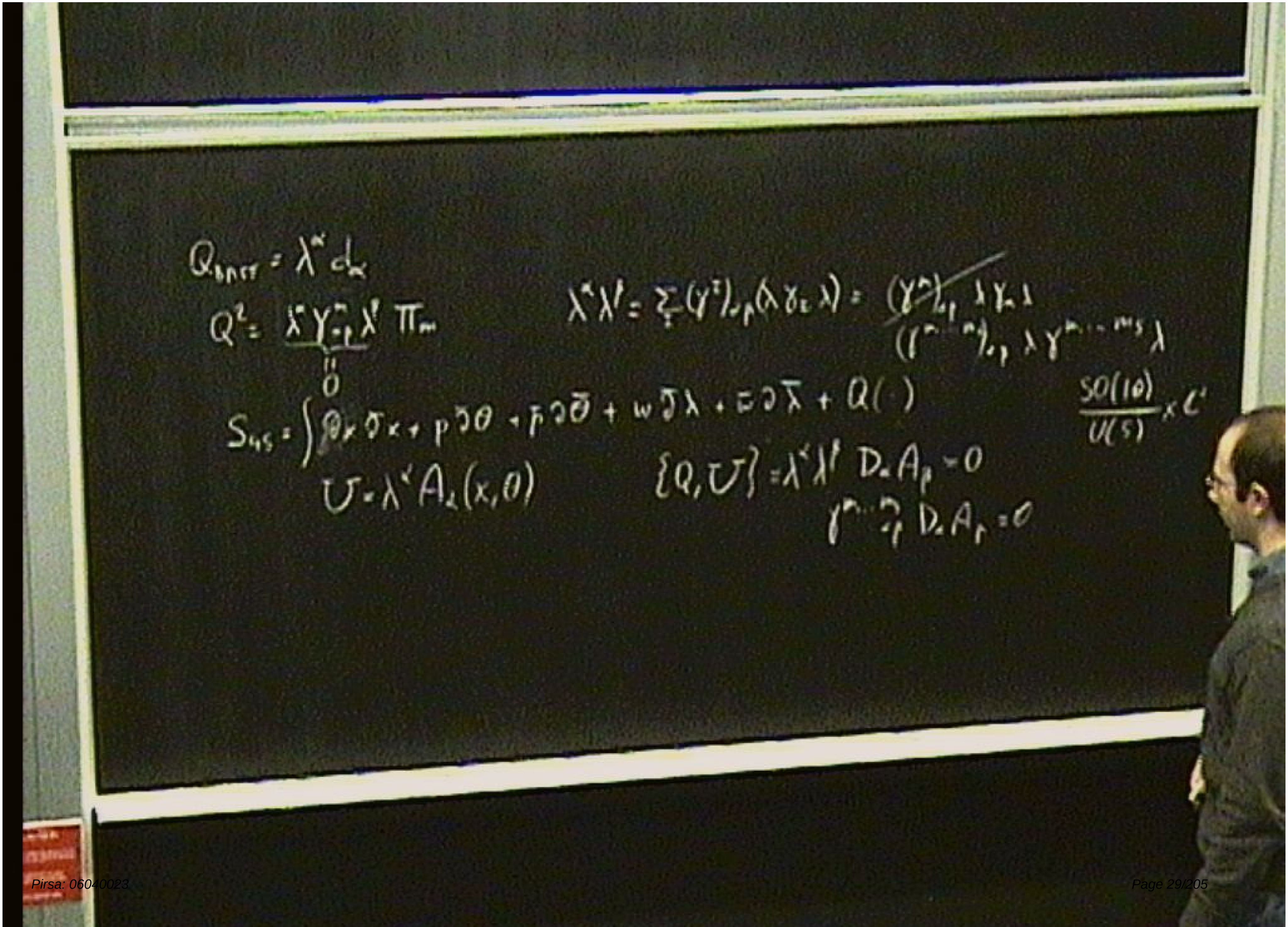
$$S_{ws} = \int \partial x \bar\partial x + p \bar\partial \theta + \bar p \partial \bar\theta + w \bar\partial \lambda + \bar w \partial \bar\lambda + Q(\cdot)$$

$$U = \lambda^\alpha A_\alpha(x,\theta) \qquad \{Q, U\} =$$


Q_BRST = λ^α d_α
Q^2 = λ^α γ^m_αβ λ^β Π_m
0
λ^α λ^β = Σ_s (γ^s)_αβ (λ γ_s λ) = (γ^m)_αβ λ γ_m λ
(γ^m1…m5)_αβ λ γ^m1…m5 λ
S_GS = ∫ ∂x ∂x + p ∂̄θ + p̄ ∂θ̄ + w ∂̄λ + w̄ ∂λ̄ + Q( )
SO(10)/U(5) × C
U = λ^α A_α(x,θ)
{Q, U} =



Q_BRST = λ^α d_α
Q² = λ^α γ^m_αβ λ^β Π_m
U = λ^α A_α(x,θ)
{Q, U} = λ^α λ^β D_α A_β


$Q_{BRST} = \lambda^\alpha d_\alpha$
$Q^2 = \lambda^\alpha \gamma^m_{\alpha\beta} \lambda^\beta \Pi_m$
$\lambda^\alpha \lambda^\beta = \sum (\gamma^z)_{\alpha\beta} (\lambda \gamma_z \lambda) = (\gamma^m)_{\alpha\beta} \lambda \gamma_m \lambda$
$(\gamma^{m_1 \dots m_5})_{\alpha\beta} \lambda \gamma^{m_1 \dots m_5} \lambda$
$S_{NS} = \int \partial x \bar{\partial} x + p \bar{\partial} \theta + \bar{p} \partial \bar{\theta} + w \bar{\partial} \lambda + \bar{w} \partial \bar{\lambda} + Q(\,)$
$\frac{SO(10)}{U(5)} \times C'$
$U = \lambda^\alpha A_\alpha(x, \theta)$
$\{Q, U\} = \lambda^\alpha \lambda^\beta D_\alpha A_\beta = 0$
$\gamma^{m \dots n}_{\alpha\beta} D_\alpha A_\beta = 0$

$$Q_{BRST} = \lambda^\alpha d_\alpha$$

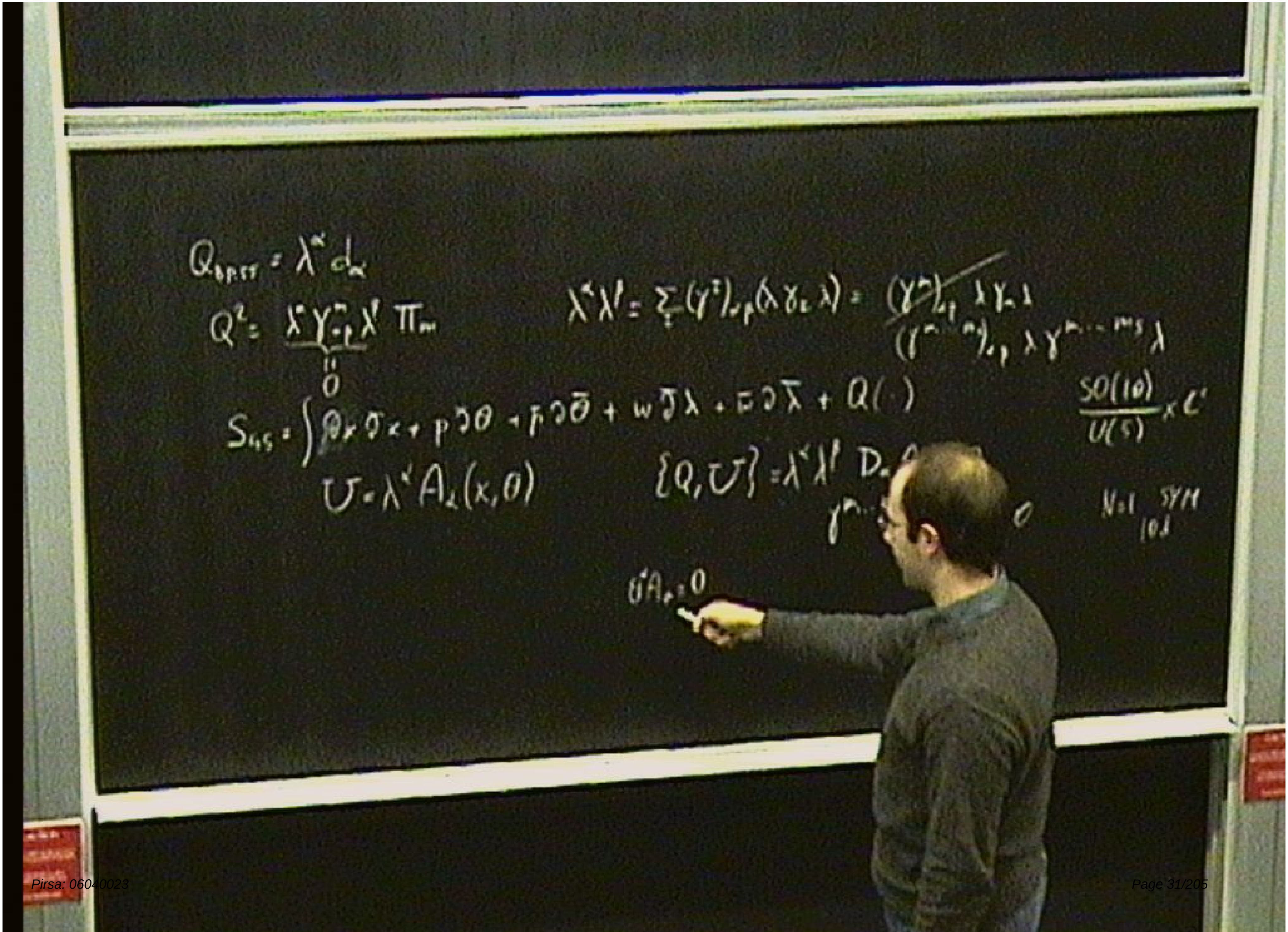
$$Q^2 = \underbrace{\lambda^\alpha \gamma^m_{\alpha\beta} \lambda^\beta}_{= 0} \Pi_m \qquad \lambda^\alpha \lambda^\beta = \sum_k (\gamma^k)_{\alpha\beta} (\lambda \gamma_k \lambda) = (\gamma^m)_{\alpha\beta}\, \lambda \gamma_m \lambda$$

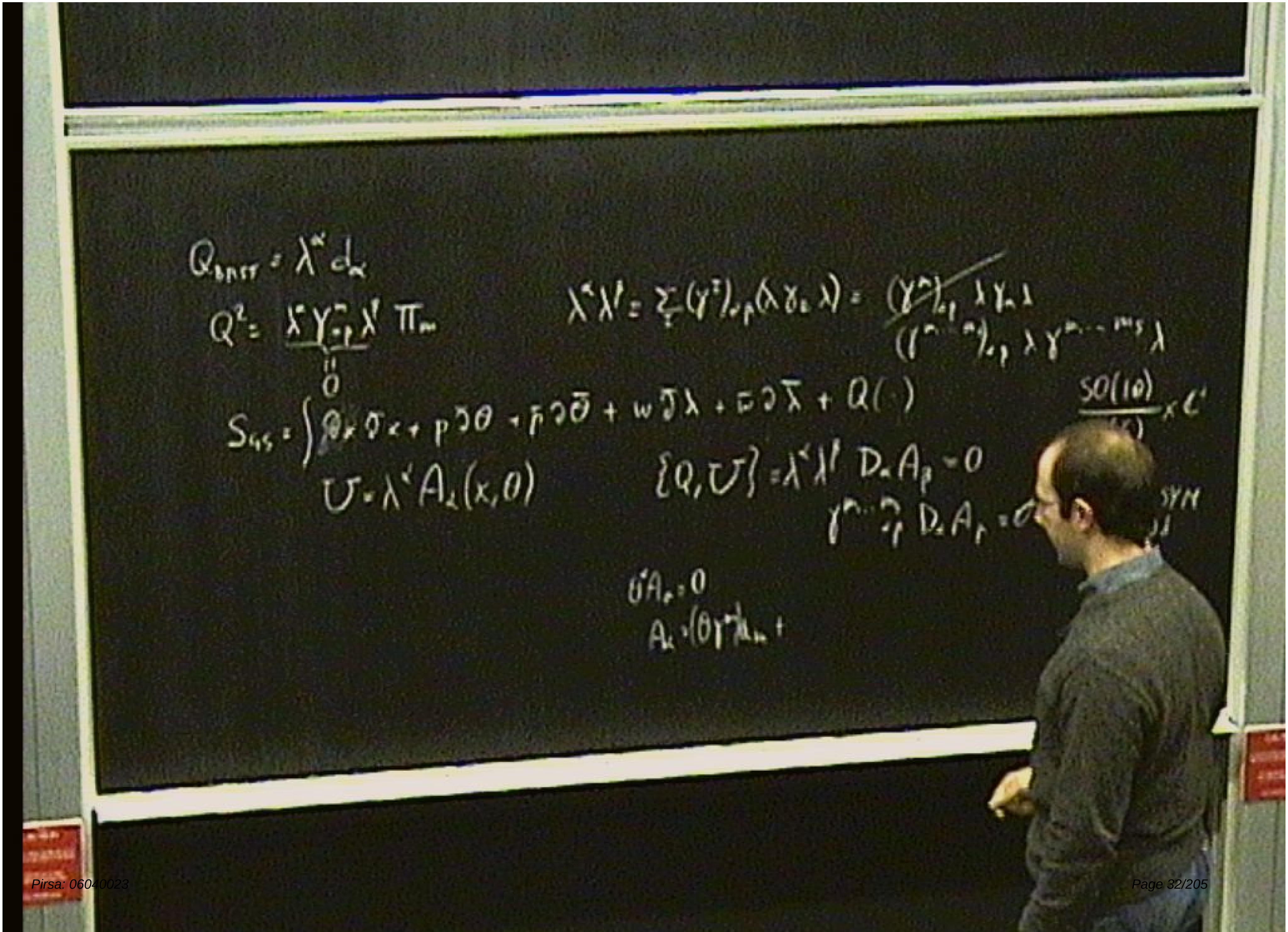
$$(\gamma^{m_1 \dots m_5})_{\alpha\beta}\, \lambda \gamma^{m_1 \dots m_5} \lambda$$

$$S_{WS} = \int \partial x \bar{\partial} x + p \bar{\partial} \theta + \bar{p} \partial \bar{\theta} + w \bar{\partial} \lambda + \bar{w} \partial \bar{\lambda} + Q(\ ) \qquad \frac{SO(10)}{U(5)} \times C^*$$

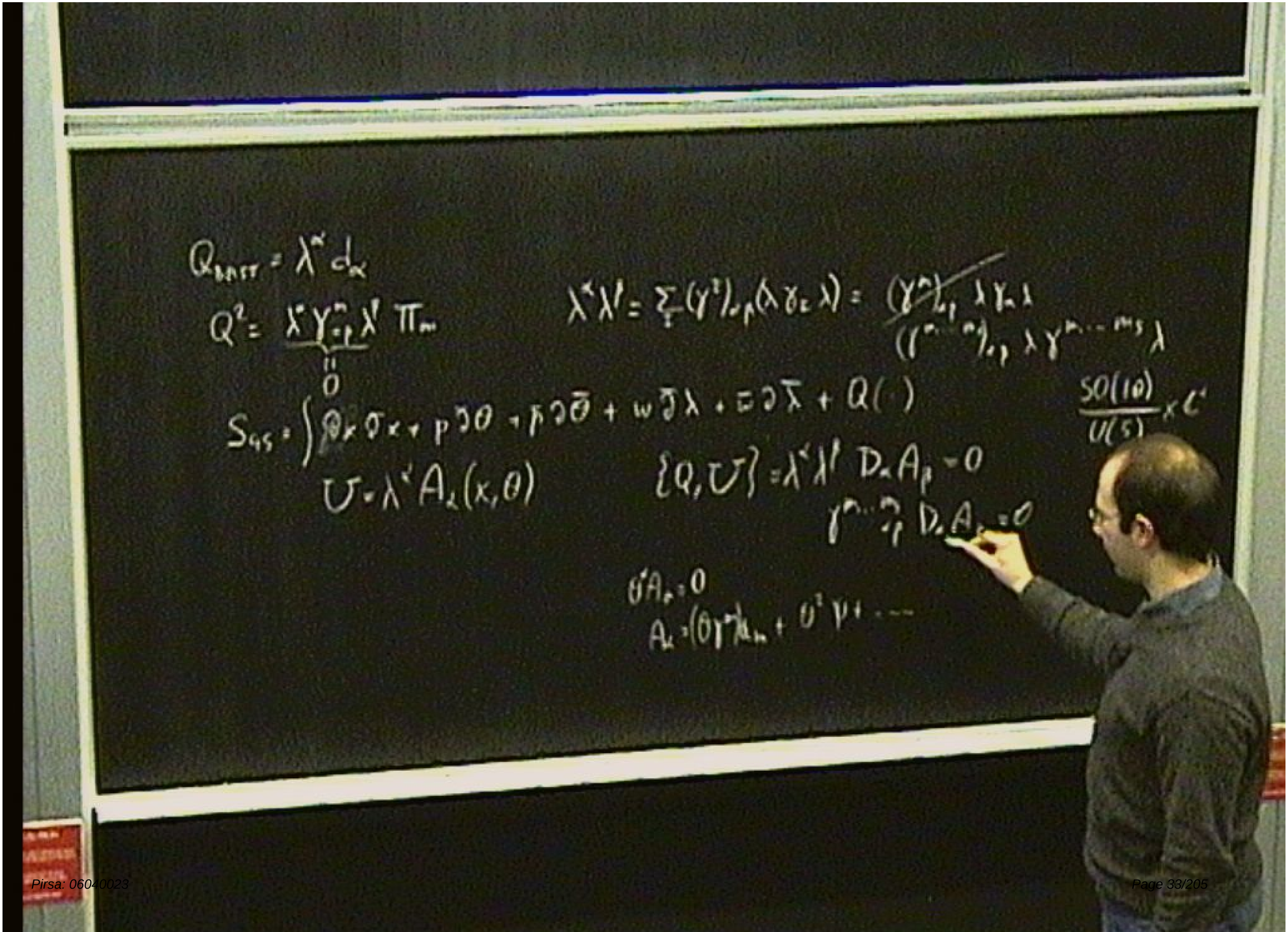
$$U = \lambda^\alpha A_\alpha(x, \theta) \qquad \{Q, U\} = \lambda^\alpha \lambda^\beta D_\alpha A_\beta = 0$$

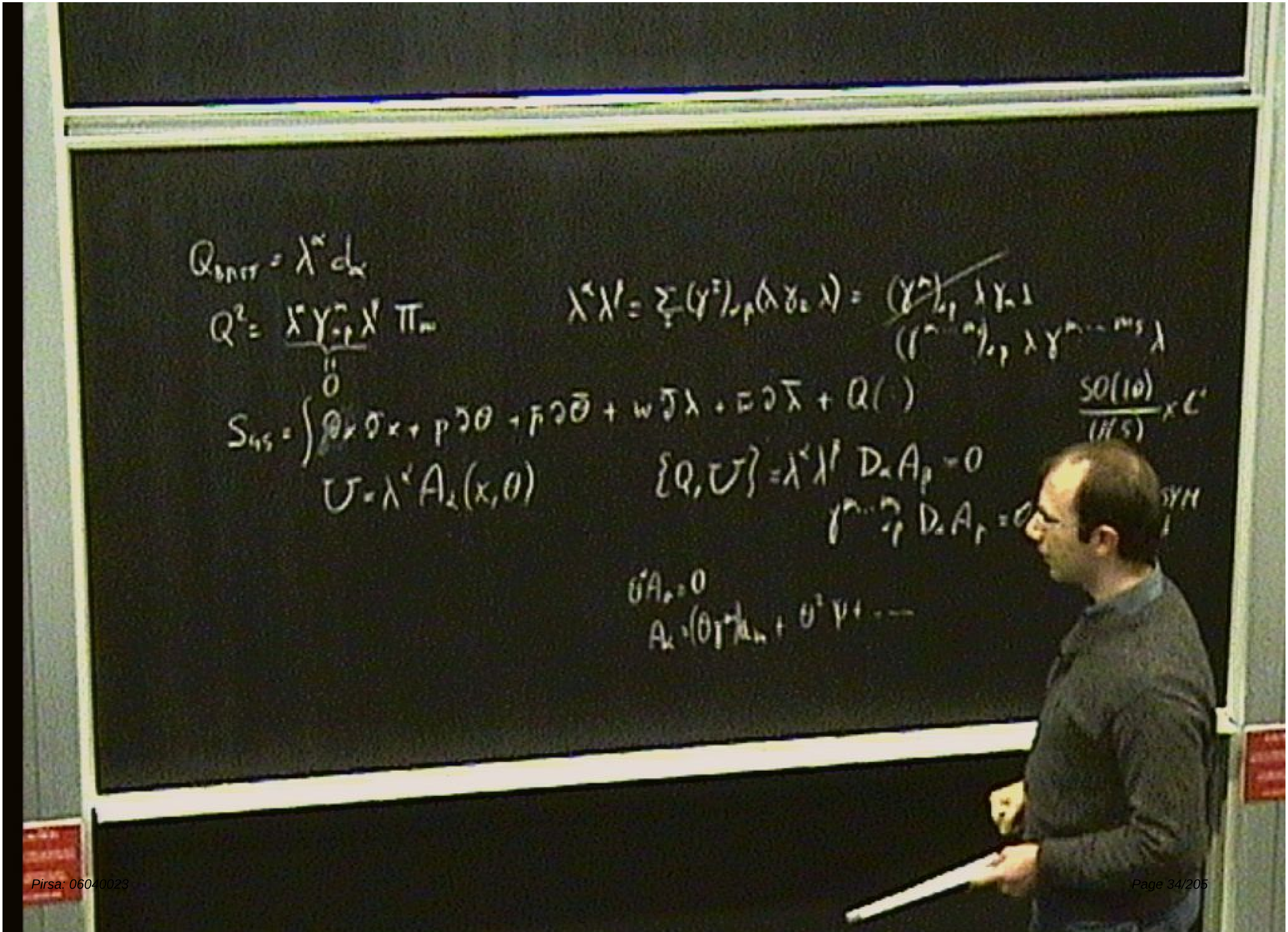
$$\gamma^{m_1 \dots m_5}_{\alpha\beta} D_\alpha A_\beta = 0 \qquad N=1 \text{ SYM } 10d$$

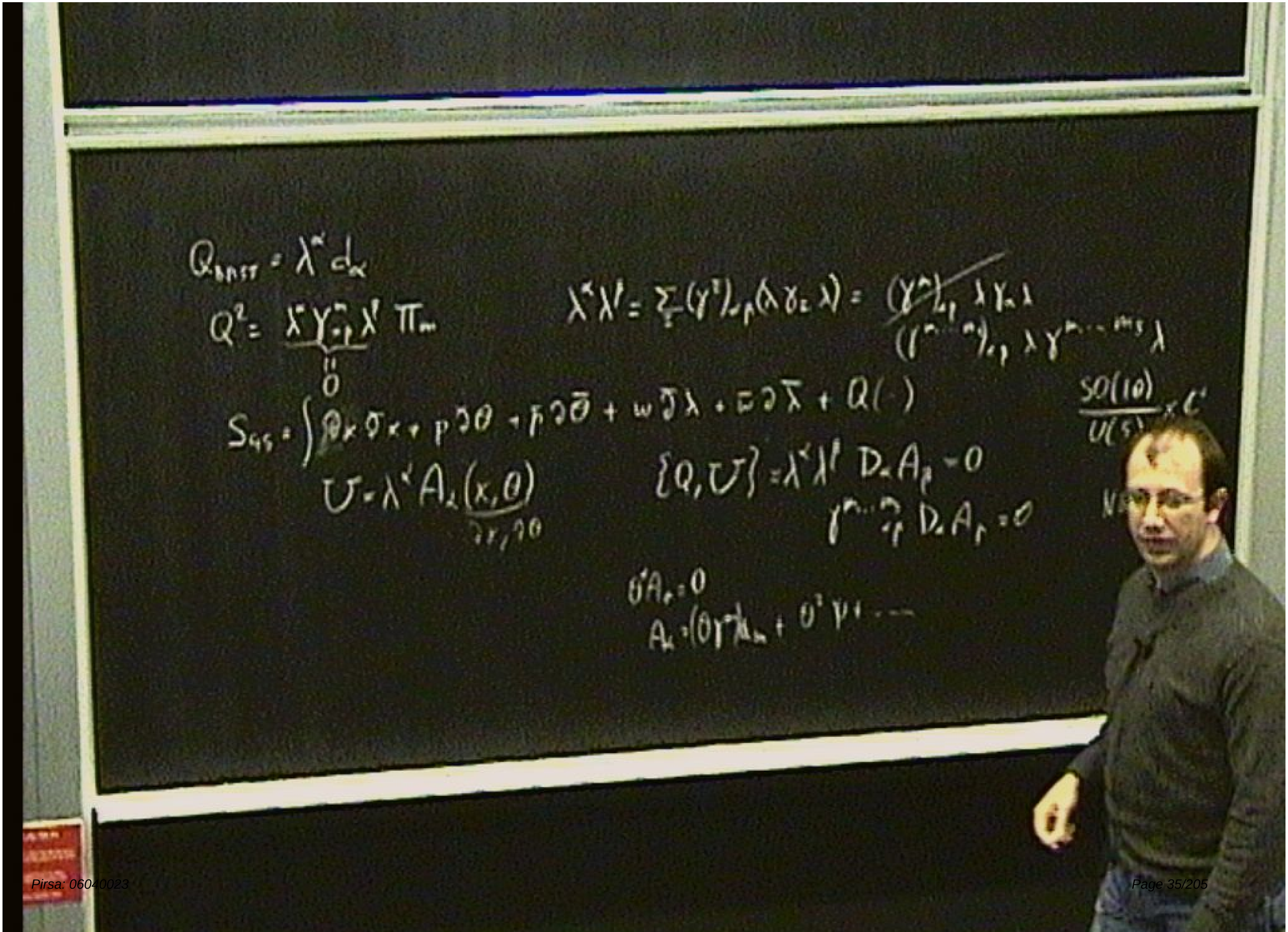

Q_BRST = λ^α d_α
Q² = λ^α γ^m_αβ λ^β Π_m
S_WS = ∫ ∂x ∂̄x + p ∂̄θ + p̂ ∂θ̂ + w ∂̄λ + ŵ ∂λ̂ + Q( )
U = λ^α A_α(x, θ)
λ^α λ^β = Σ (γ^k)^αβ (λ γ_k λ)
{Q, U} = λ^α λ^β D_α
SO(10) / U(5) × C'
N=1 SYM 10d



Q_BRST = λ^α d_α
U = λ^α A_α(x,θ)
SO(10)


Q_BRST = λ^α d_α
Q² = λ^α γ^m_αβ λ^β Π_m
λ^α λ^β = Σ (γ^?)_αβ (λ γ_? λ) = (γ^m)_αβ λ γ_m λ
(γ^m…m)_αβ λ γ^m…m5 λ
SO(10)/U(5) × C*
S_GS = ∫ θ_α ∂̄ x + p ∂θ + p̄ ∂θ̄ + w ∂̄ λ + w̄ ∂ λ̄ + Q( )
U = λ^α A_α(x, θ)
{Q, U} = λ^α λ^β D_α A_β = 0
γ^m…m_αβ D_α A_β = 0
θ^α A_α = 0
A_α = (θ γ^m)_α a_m + θ³ ψ + …


Q_BRST = λ^α d_α
Q² = λ^α γ^m_αβ λ^β Π_m
λ^α λ^β = Σ (γ^β)_αβ (λ γ_β λ) = (γ^m)_αβ λ γ_m λ
(γ^m...m5)_αβ λ γ^m...m5 λ
SO(10) / U(5) × C*
S_WS = ∫ P_x ∂ x + p ∂ θ + p̄ ∂ θ̄ + w ∂̄ λ + w̄ ∂ λ̄ + Q( )
U = λ^α A_α(x, θ)
{Q, U} = λ^α λ^β D_α A_β = 0
γ^m...m5 D_α A_β = 0
θ^α A_α = 0
A_α = (θ γ^m)_α a_m + θ² γ + ...



$Q_{BRST} = \lambda^\alpha d_\alpha$
$Q^2 = \lambda^\alpha \gamma^m_{\alpha\beta} \lambda^\beta \Pi_m$
$S_{GS} = \int \partial x \bar{\partial} x + p \bar{\partial} \theta + \bar{p} \partial \bar{\theta} + w \bar{\partial} \lambda + \bar{w} \partial \bar{\lambda} + Q(\cdot)$
$U = \lambda^\alpha A_\alpha(x, \theta)$
$\{Q, U\} = \lambda^\alpha \lambda^\beta D_\alpha A_\beta = 0$
$\gamma^{m \ldots n}_{\alpha\beta} D_\alpha A_\beta = 0$
$\theta^\alpha A_\alpha = 0$
$A_\alpha = (\theta \gamma^m)_\alpha a_m + \theta^3 \psi + \ldots$
$\frac{SO(10)}{U(5)} \times C^*$

$Q_{BRST} = \lambda^\alpha d_\alpha$

$Q^2 = \underbrace{\lambda^\alpha \gamma^m_{\alpha\beta} \lambda^\beta}_{\overset{\shortparallel}{0}} \Pi_m$

$\lambda^\alpha \lambda^\beta = \sum_k (\gamma^k)_{\alpha\beta} (\lambda \gamma_k \lambda) = \cancel{(\gamma^m)_{\alpha\beta}\, \lambda\gamma_m\lambda}$

$(\gamma^{m_1 \ldots m_5})_{\alpha\beta}\, \lambda \gamma^{m_1 \ldots m_5} \lambda$

$\frac{SO(10)}{U(5)} \times C^*$

$S_{WS} = \int \partial x \bar\partial x + p \bar\partial \theta + \bar p \partial \bar\theta + w \bar\partial \lambda + \bar w \partial \bar\lambda + Q(\cdot)$

$U = \lambda^\alpha A_\alpha \underset{\partial x,\, \partial\theta}{(x, \theta)}$

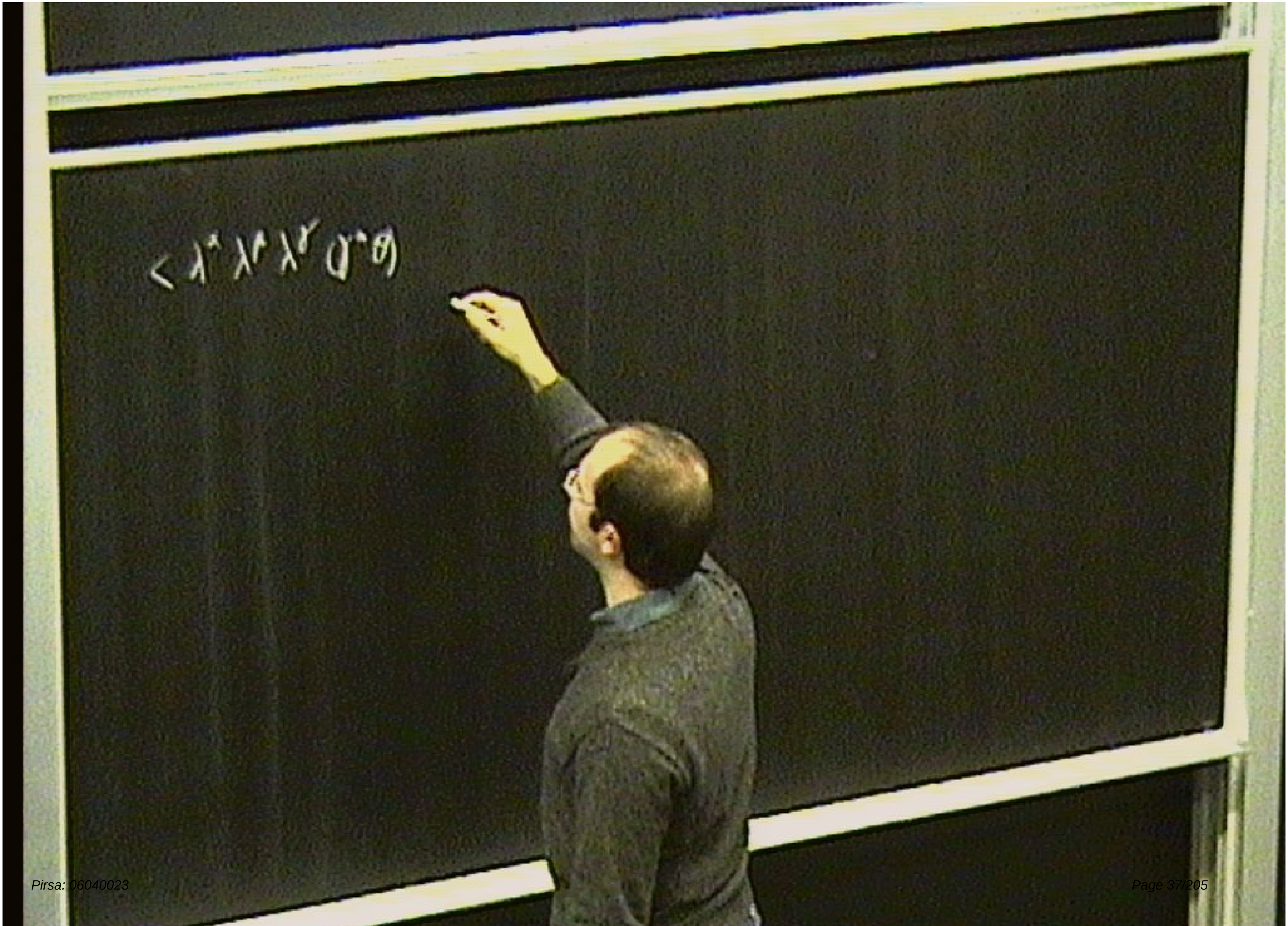
$\{Q, U\} = \lambda^\alpha \lambda^\beta D_\alpha A_\beta = 0$

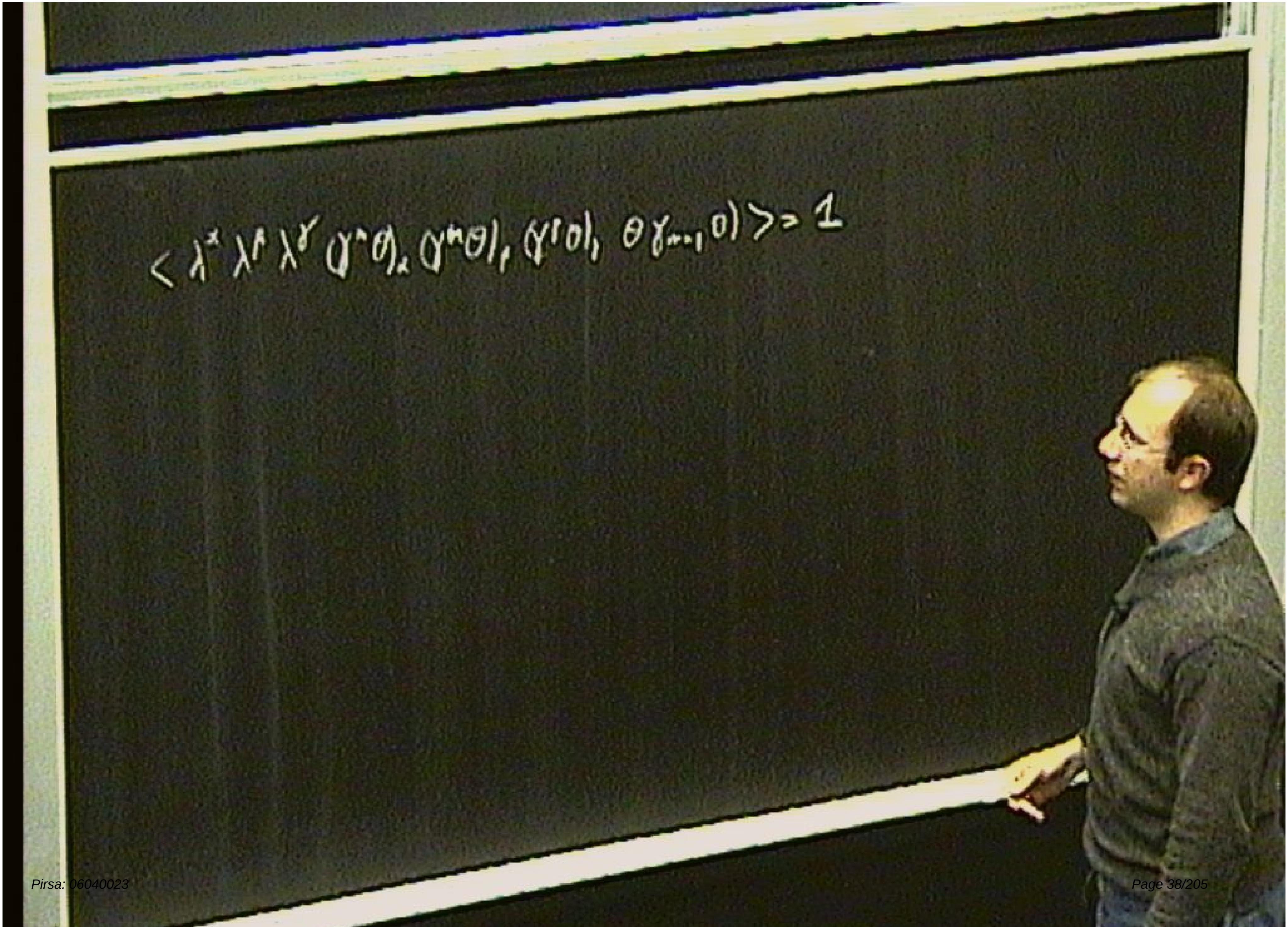
$\gamma^{m \ldots}{}^{\alpha\beta} D_\alpha A_\beta = 0$

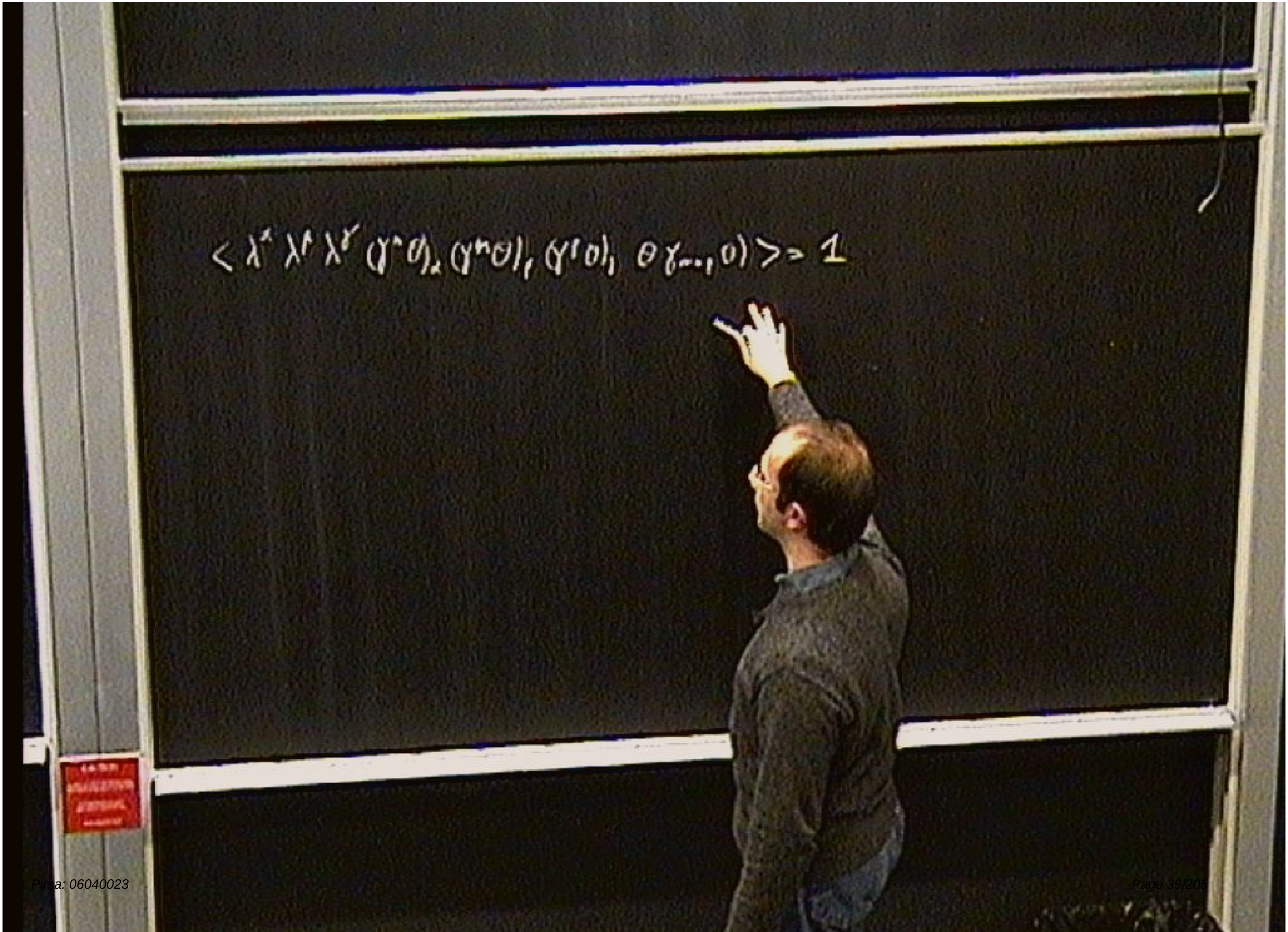
$N=1$ SYM 10d

$\theta^\alpha A_\alpha = 0$

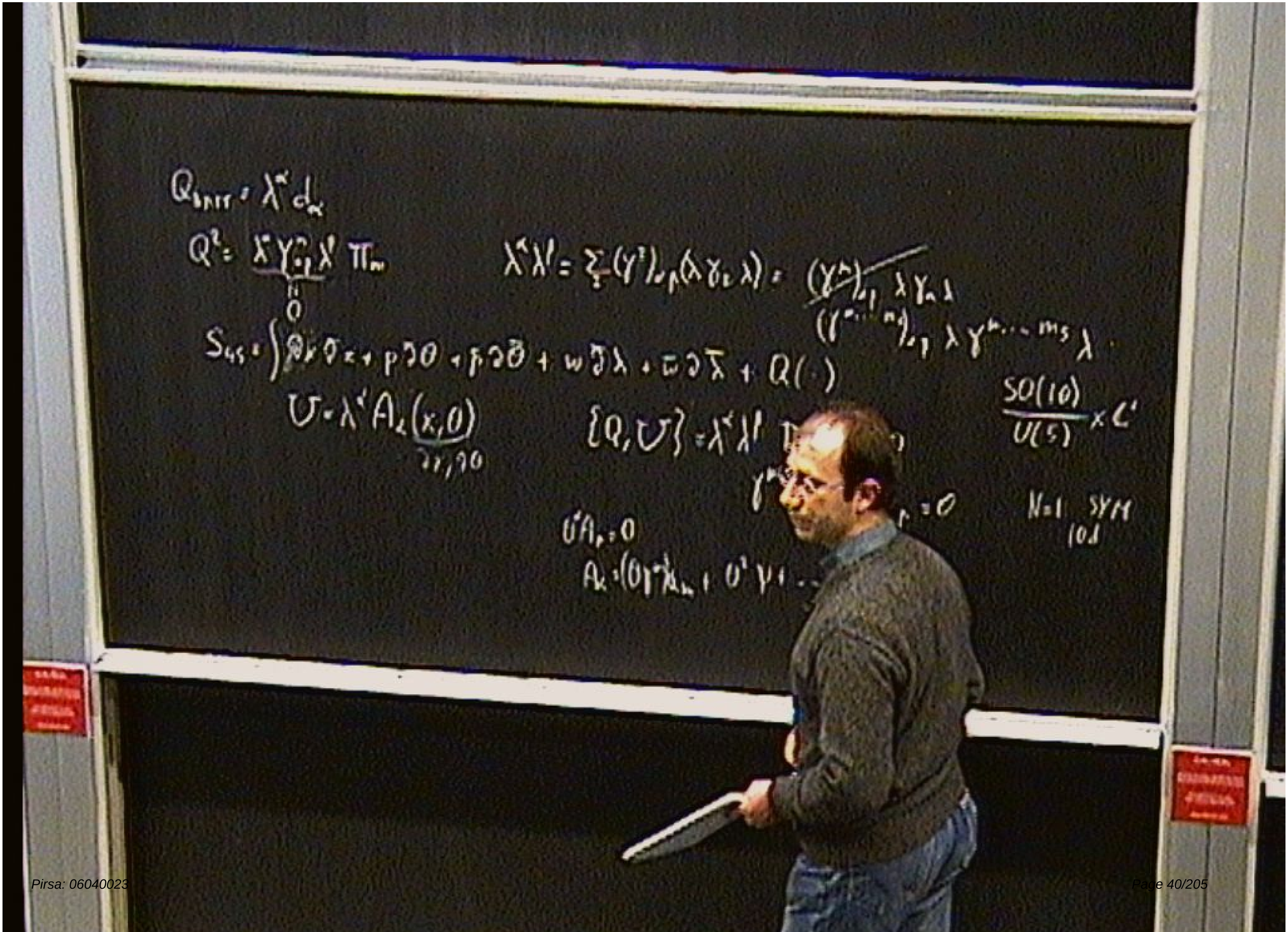
$A_\alpha = (\theta \gamma^m)_\alpha a_m + \theta^2 \psi + \ldots$



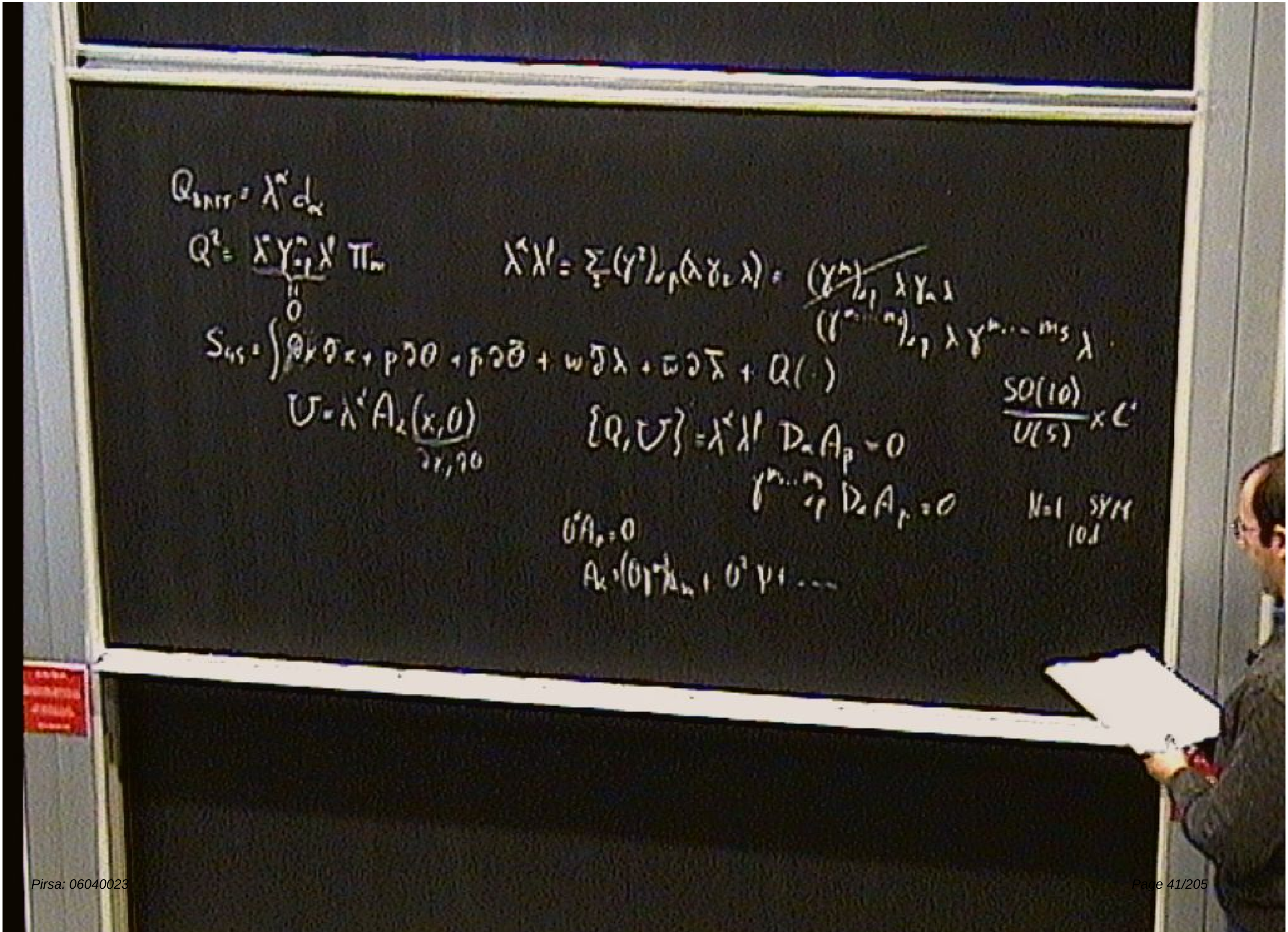

$\langle \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^m\theta)_\alpha (\gamma^n\theta)_\beta (\gamma^p\theta)_\gamma \, \theta\gamma_{mnp}\theta) \rangle = 1$

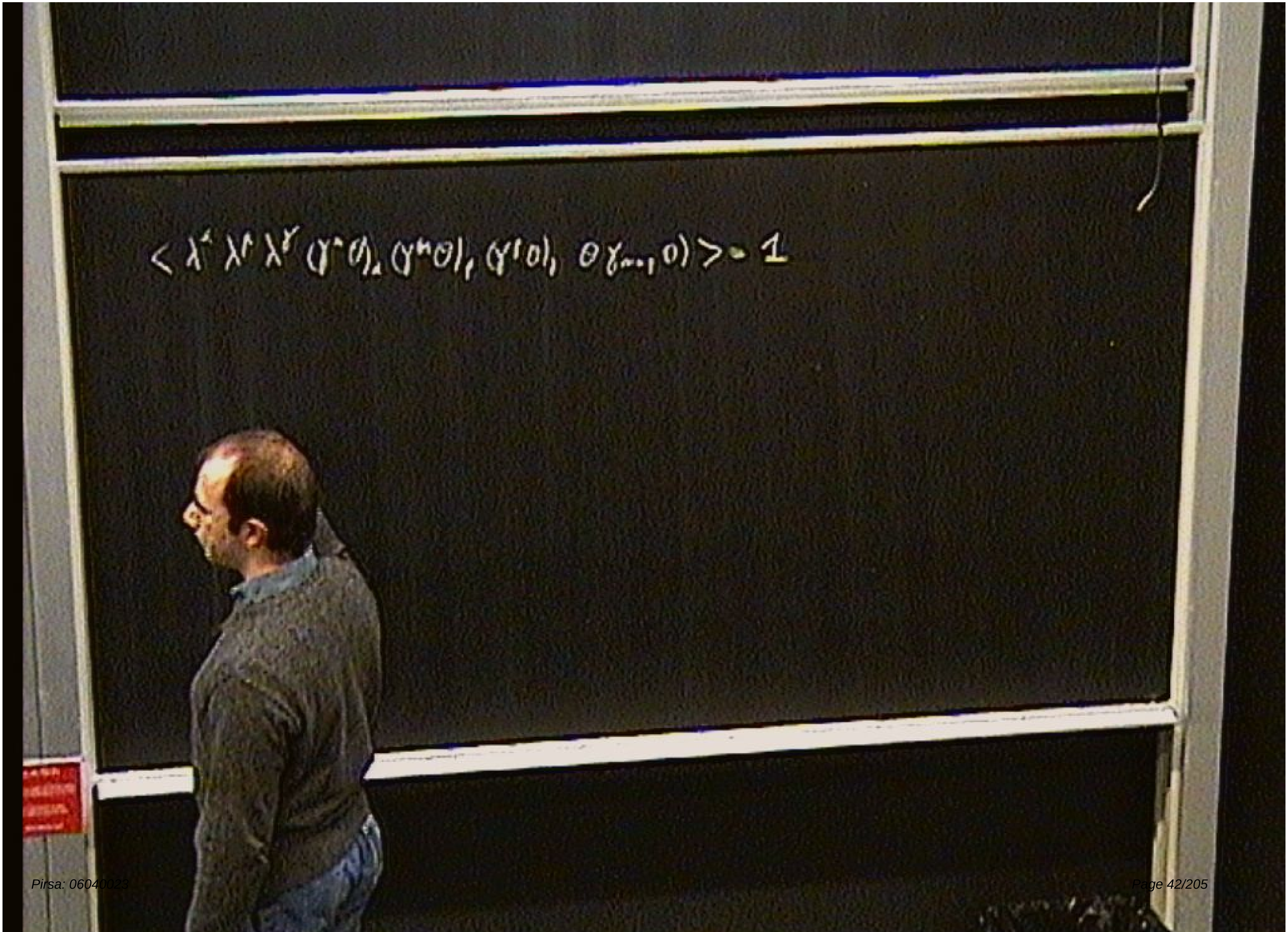


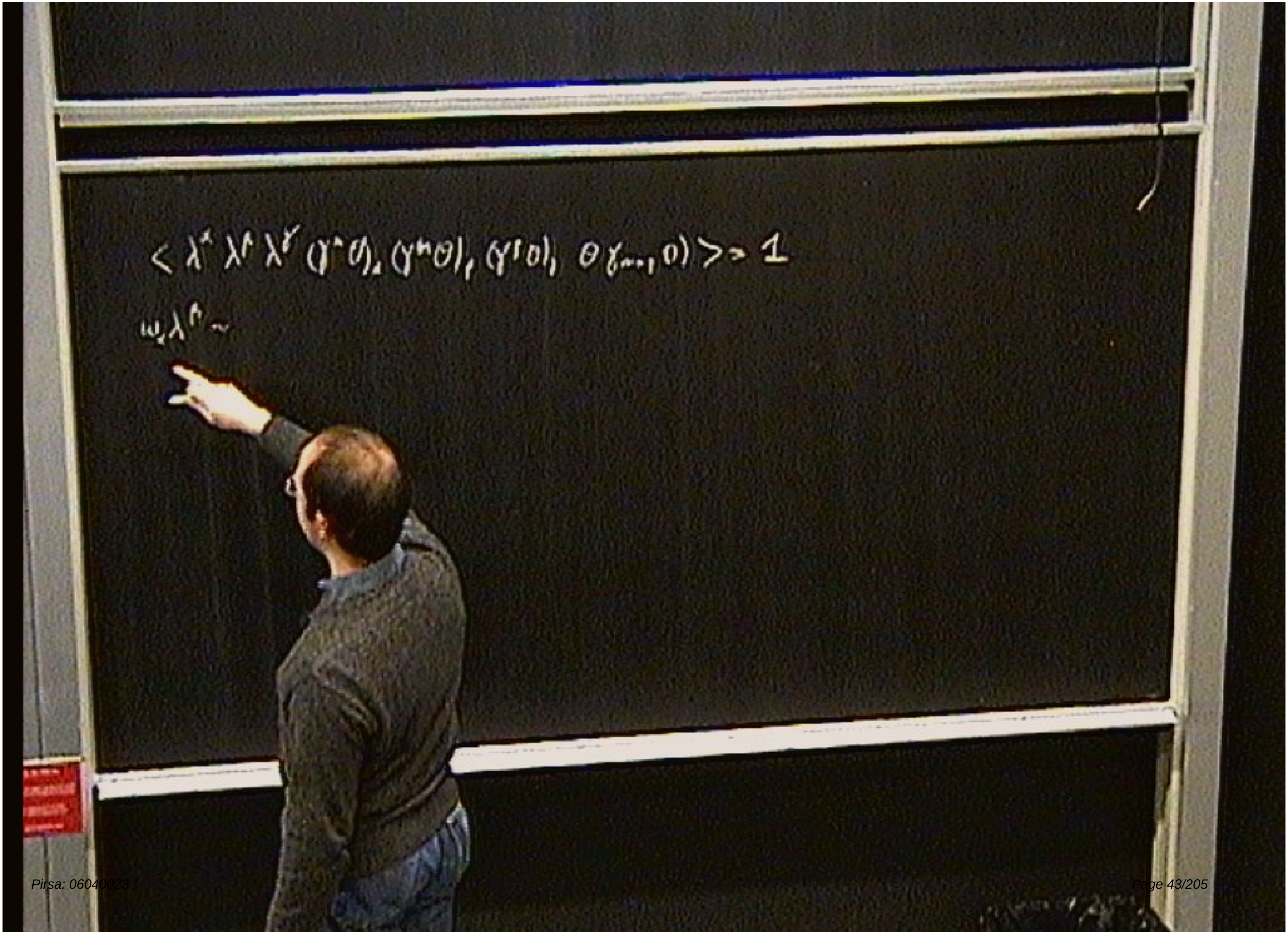
$\langle \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^m \theta)_\alpha (\gamma^n \theta)_\beta (\gamma^p \theta)_\gamma \; \theta \gamma_{mnp} \theta) \rangle = 1$

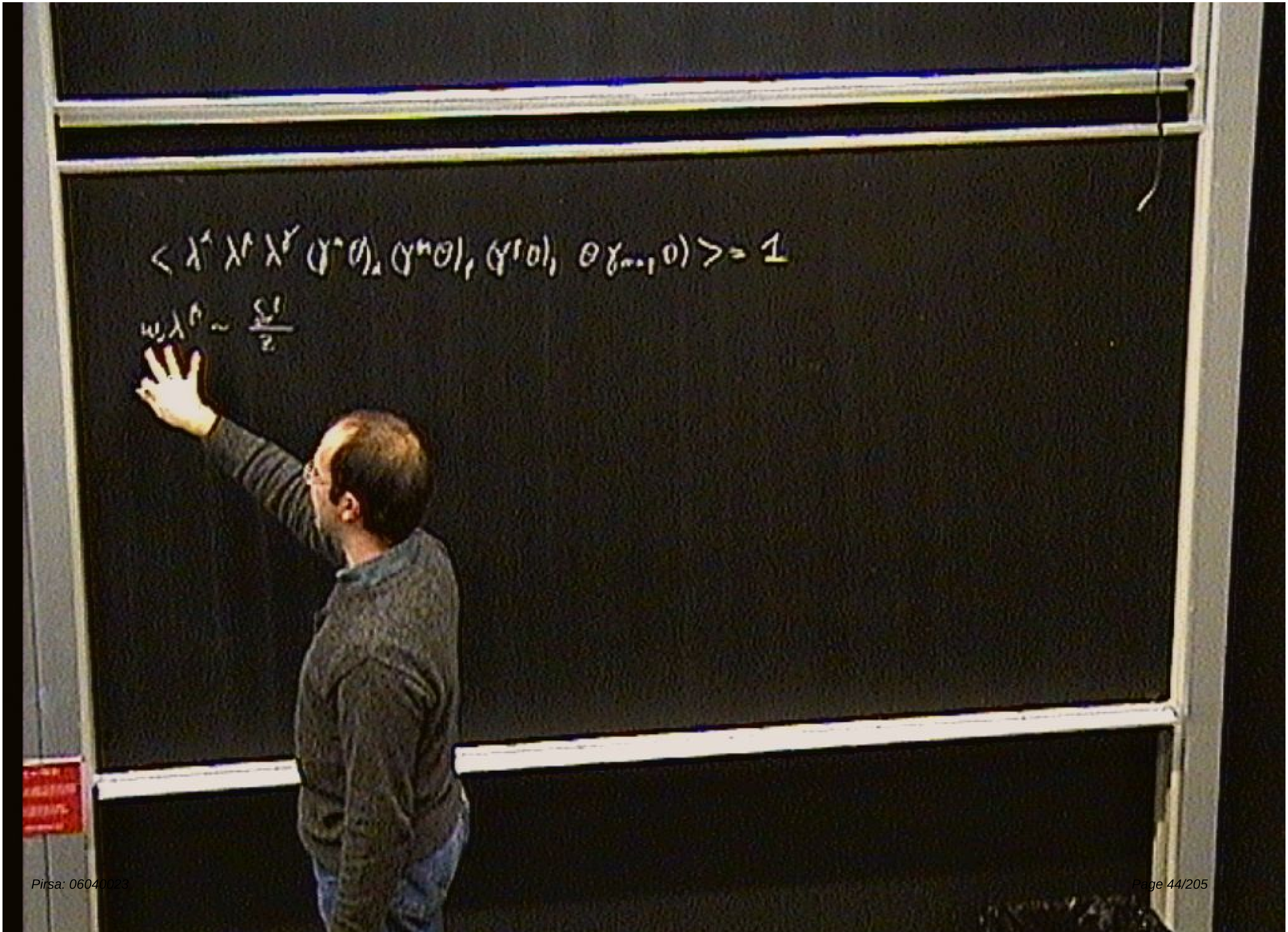


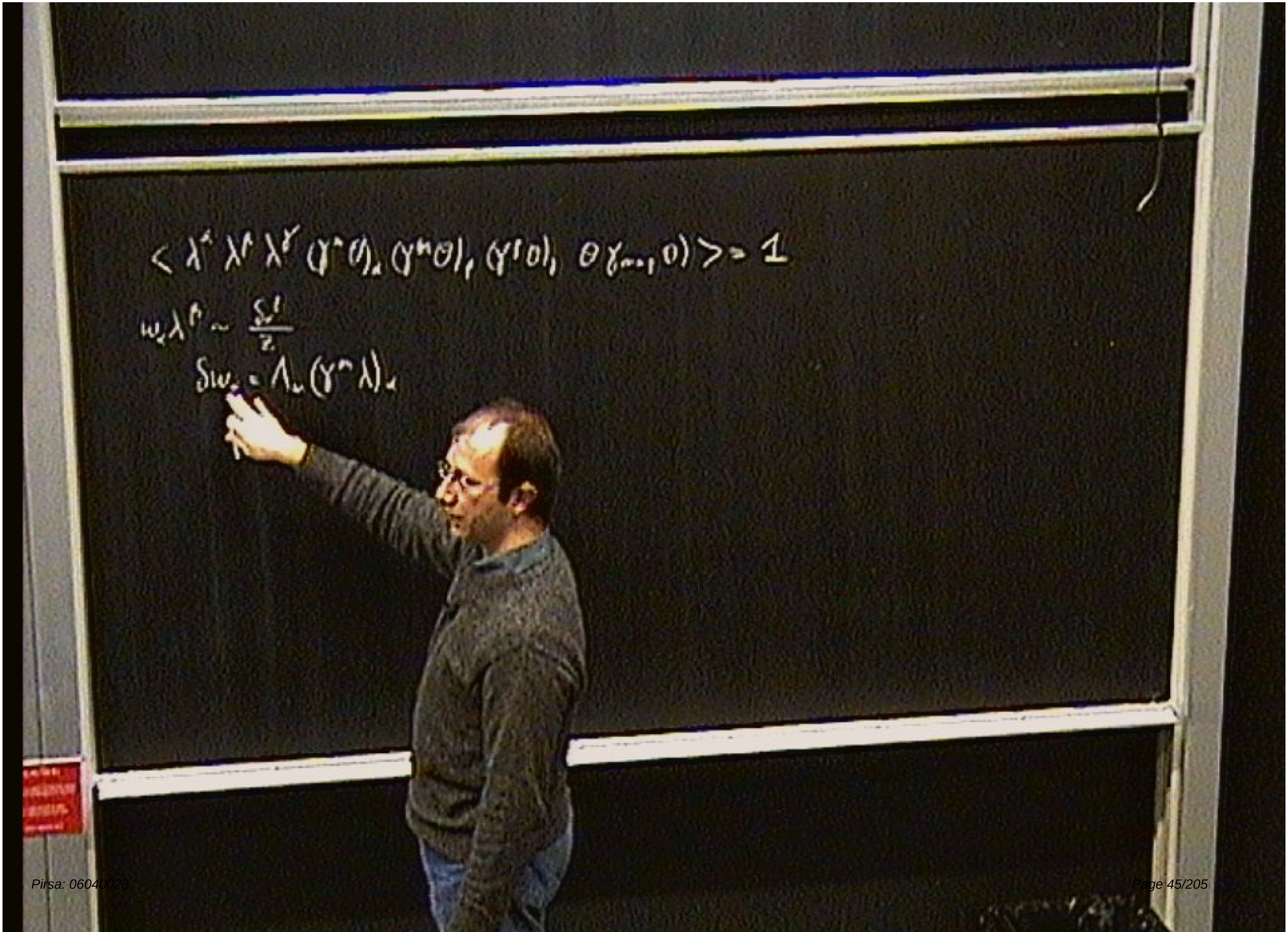
SO(10)/U(5) × C*
N=1 SYM
10d

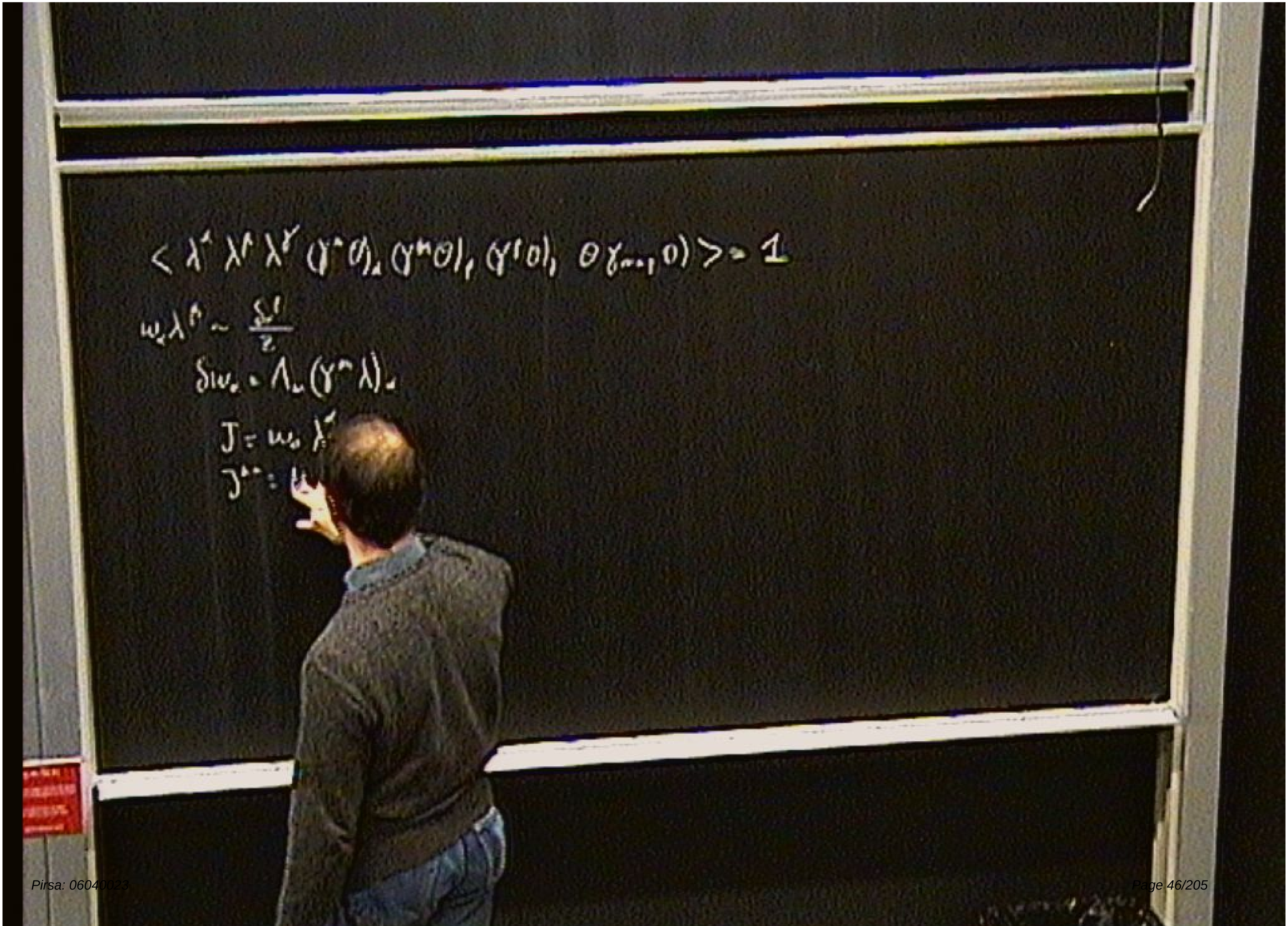

Q_BRST = λ^α d_α
Q² = λγ^m λ Π_m
O
S_WS = ∫ ... + p∂θ + p̄∂θ̄ + w∂λ + w̄∂λ̄ + Q( )
U = λ^α A_α(x, θ)
{Q, U} = λ^α λ^β D_α A_β = 0
SO(10) / U(5) × C
N=1 SYM
10d
A_α = (θγ^m)_α a_m + θ²ψ + ...

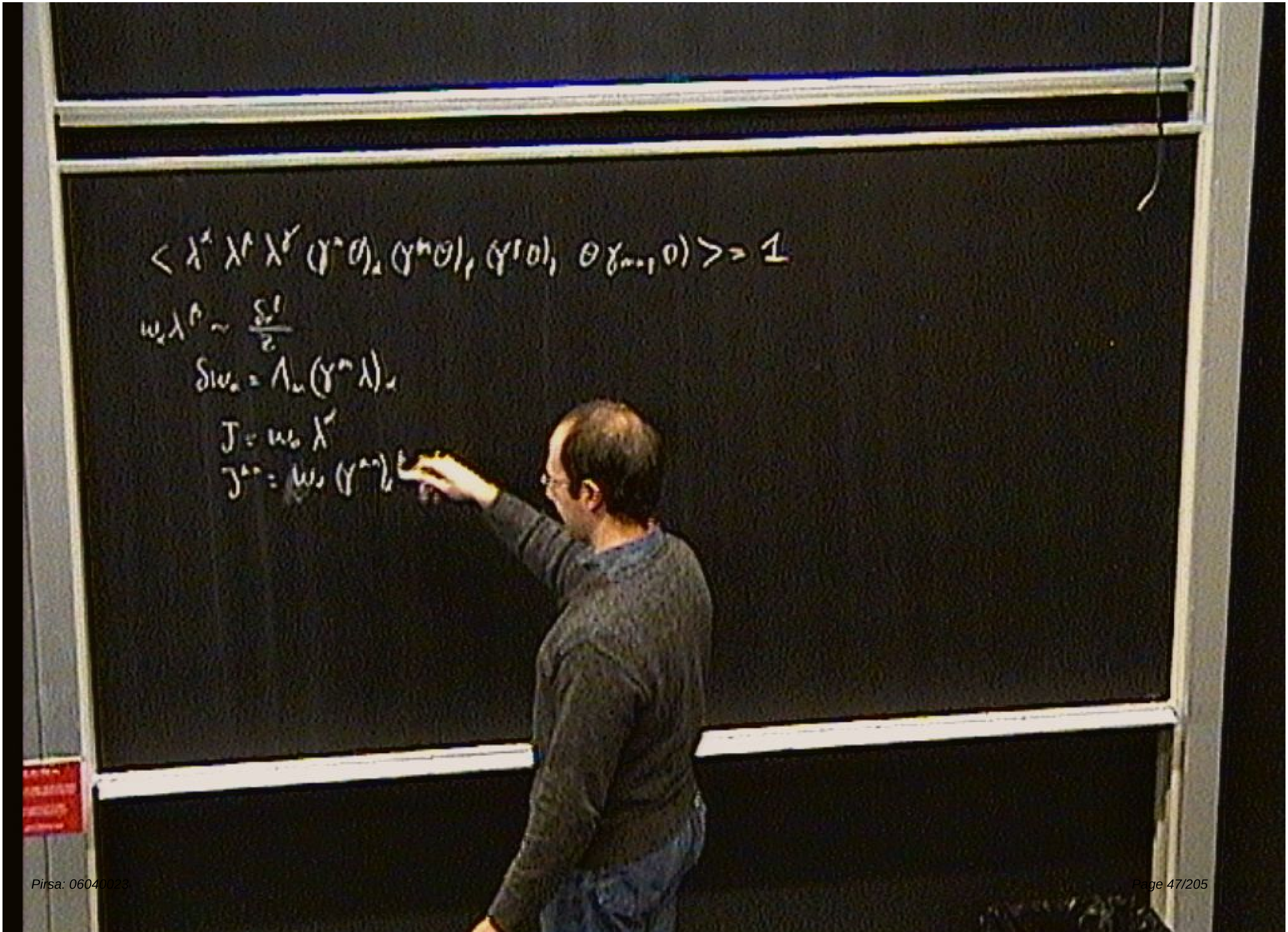

< λ^α λ^β λ^γ (γ^m θ)_α (γ^n θ)_β (γ^p θ)_γ θ γ_{mnp} θ) > = 1

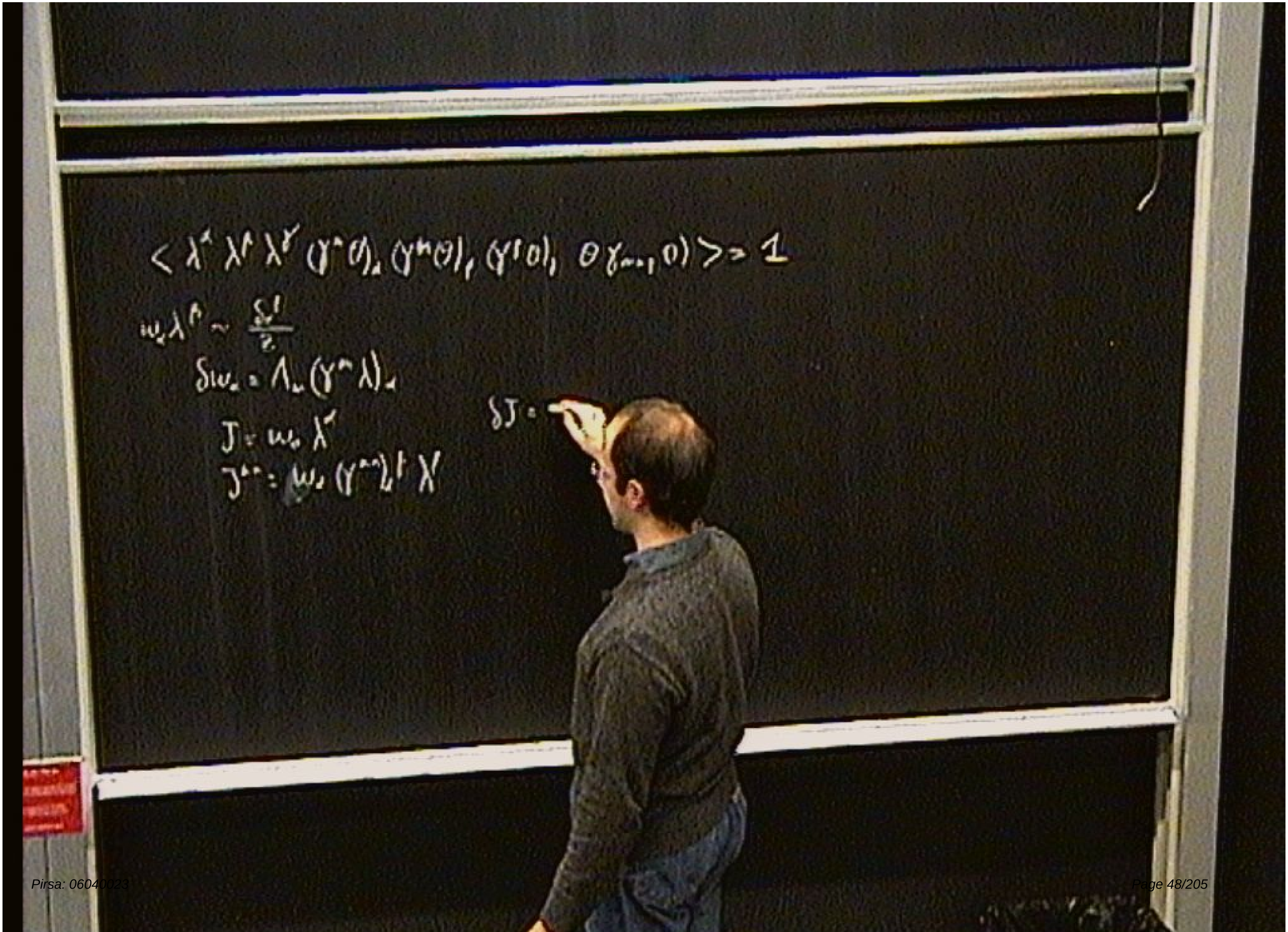

$< \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^m \theta)_\alpha (\gamma^n \theta)_\beta (\gamma^p \theta)_\gamma \, \theta \gamma_{mnp} \theta) > = 1$
$\omega_\alpha \lambda^\alpha \sim$

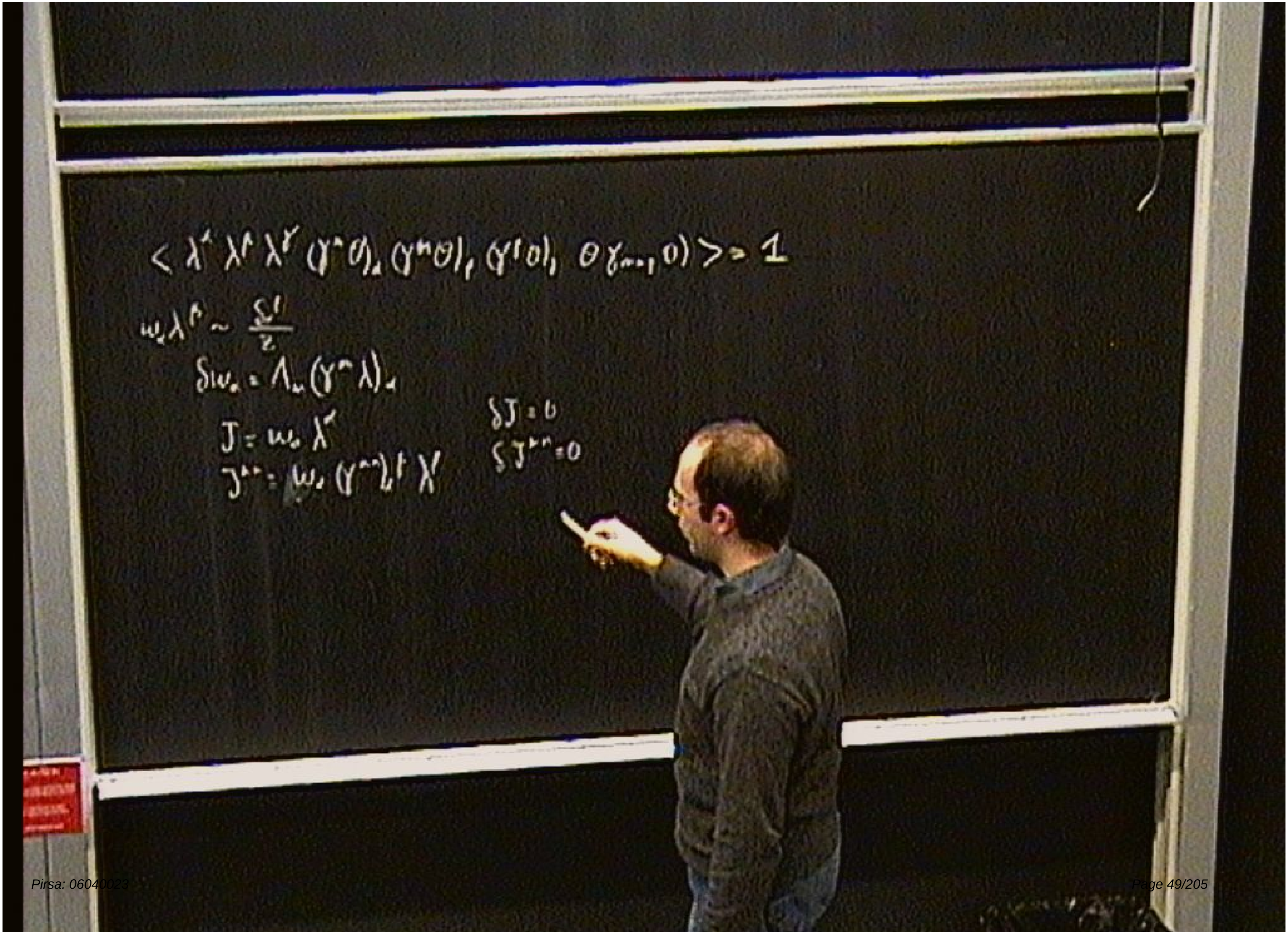


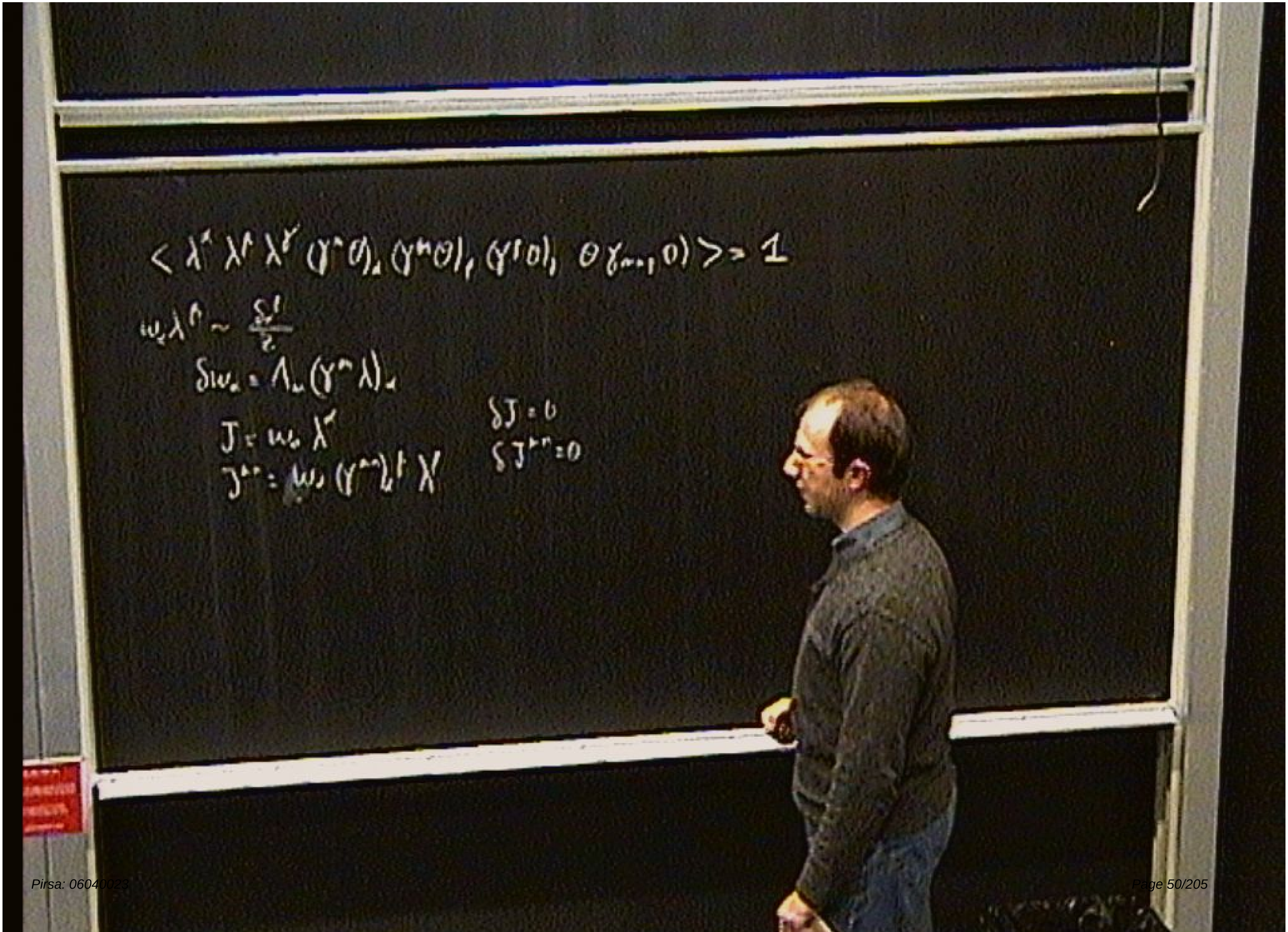

< λ^α λ^β λ^γ (γ^m θ)_α (γ^n θ)_β (γ^p θ)_γ (θ γ_mnp θ) > = 1
w_α λ^α ~
δw_α = Λ_m (γ^m λ)_α


< λ^α λ^β λ^γ (γ^m θ)_α (γ^n θ)_β (γ^p θ)_γ θ γ_{mnp} θ) > = 1
δw_α = Λ_m (γ^m λ)_α

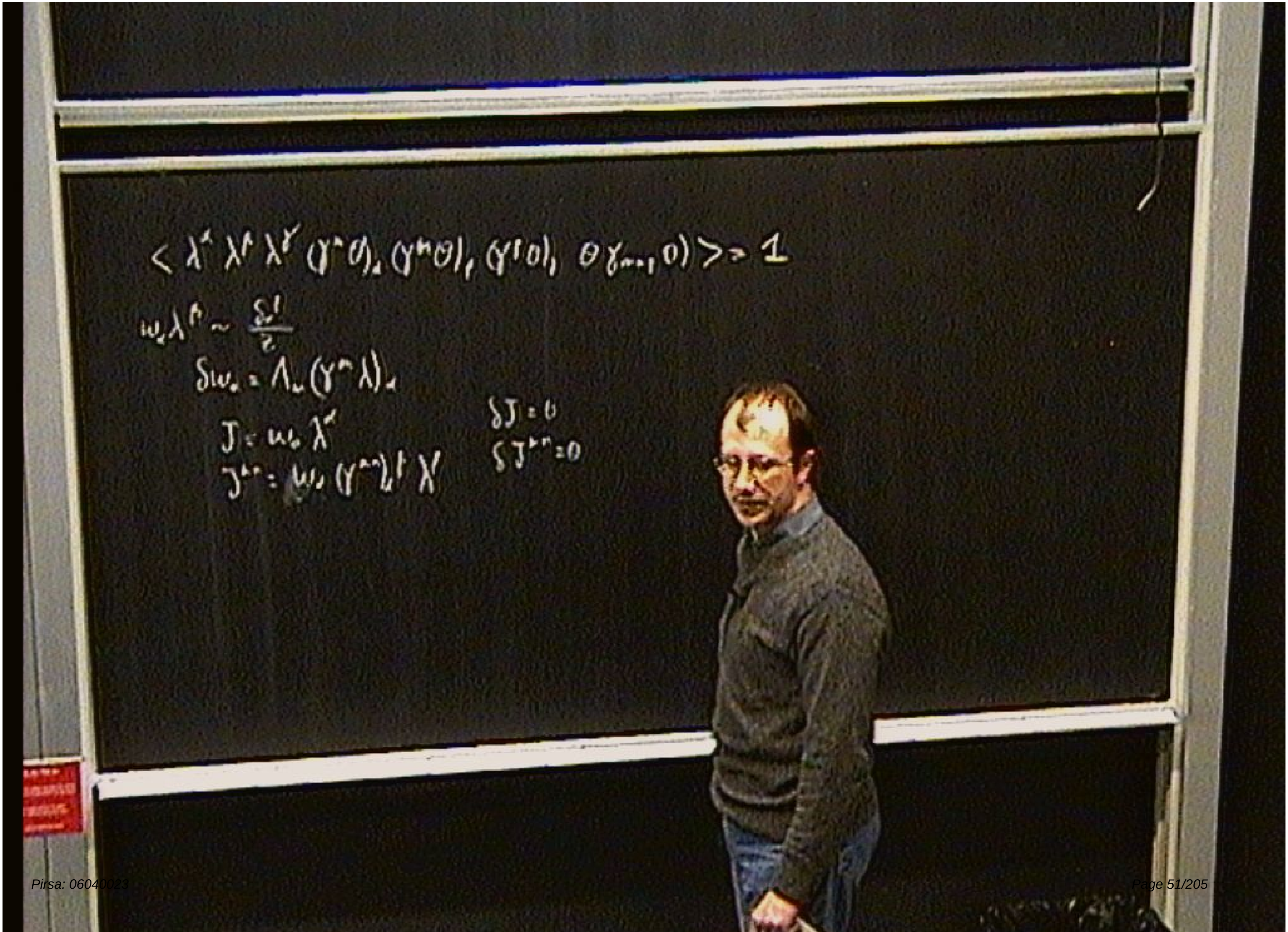


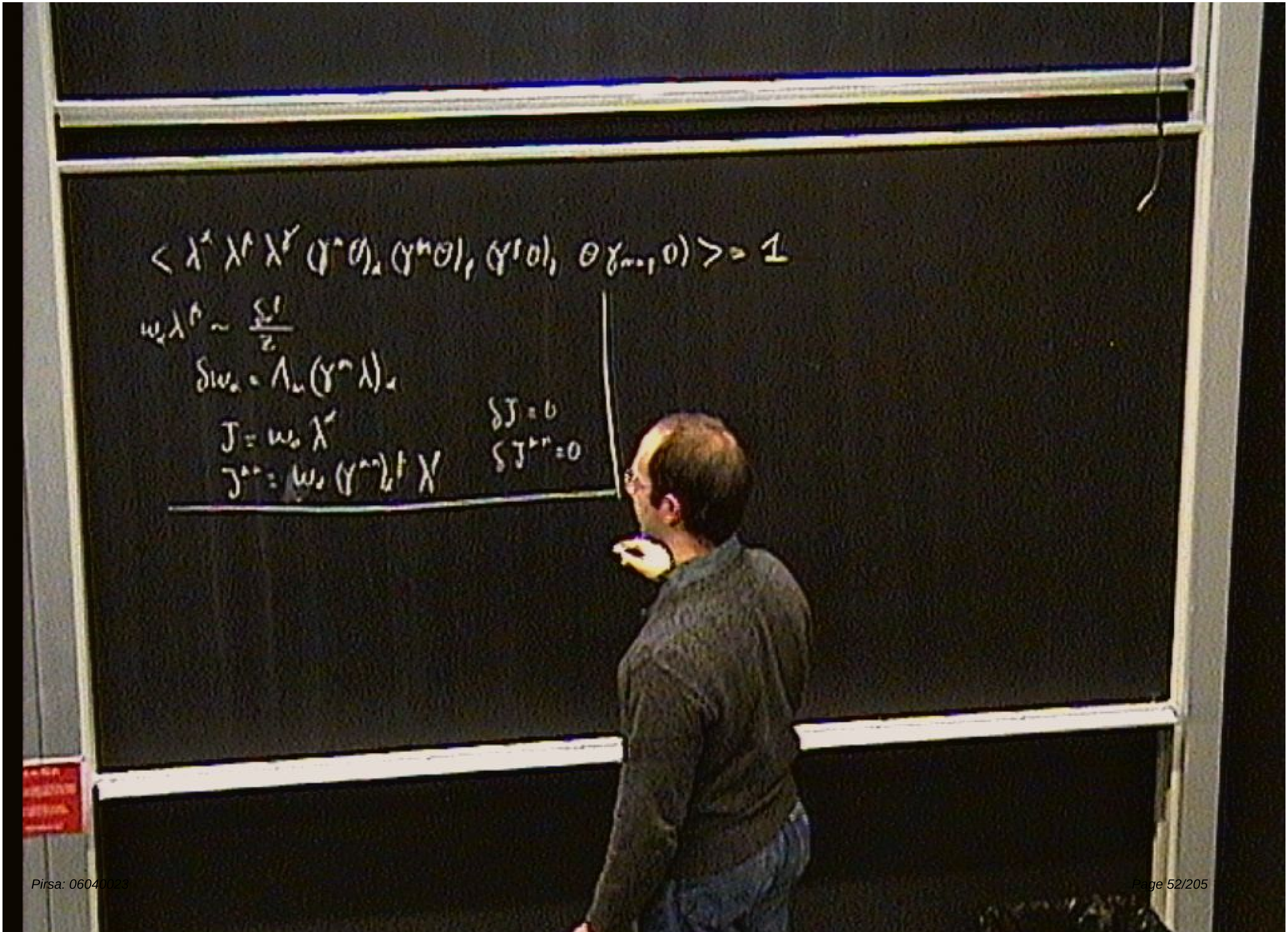

< λ^α λ^β λ^γ (γ^m θ)_α (γ^n θ)_β (γ^p θ)_γ θ γ_mnp θ > = 1
δw_α = Λ_m (γ^m λ)_α
J = w_α λ^α
δJ =

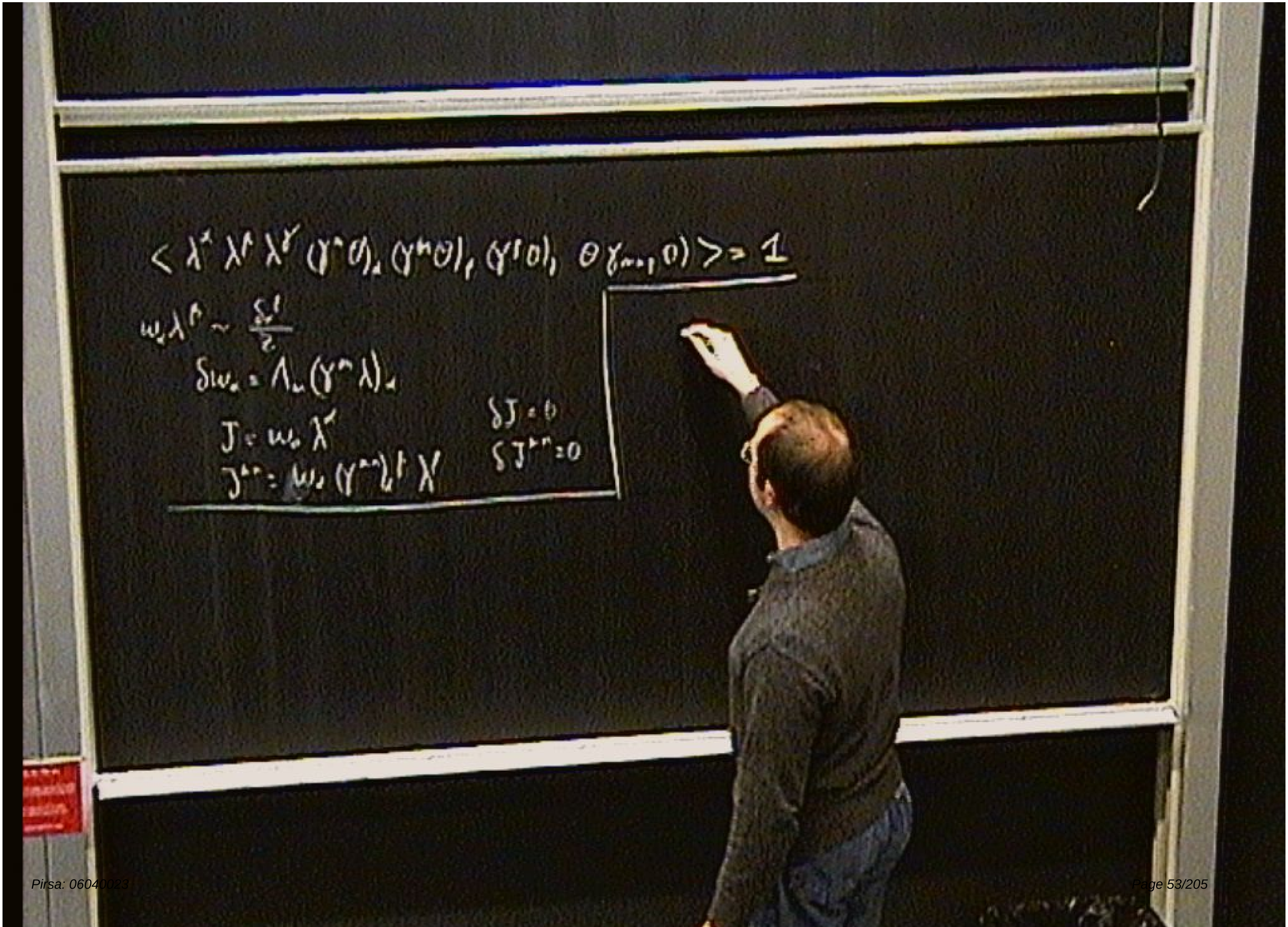

< λ^α λ^β λ^γ (γ^m θ)_α (γ^n θ)_β (γ^p θ)_γ θ γ_{mnp} θ > = 1
δw_α = Λ_m (γ^m λ)_α
J = w_α λ^α
δJ = 0
δJ^{mn} = 0

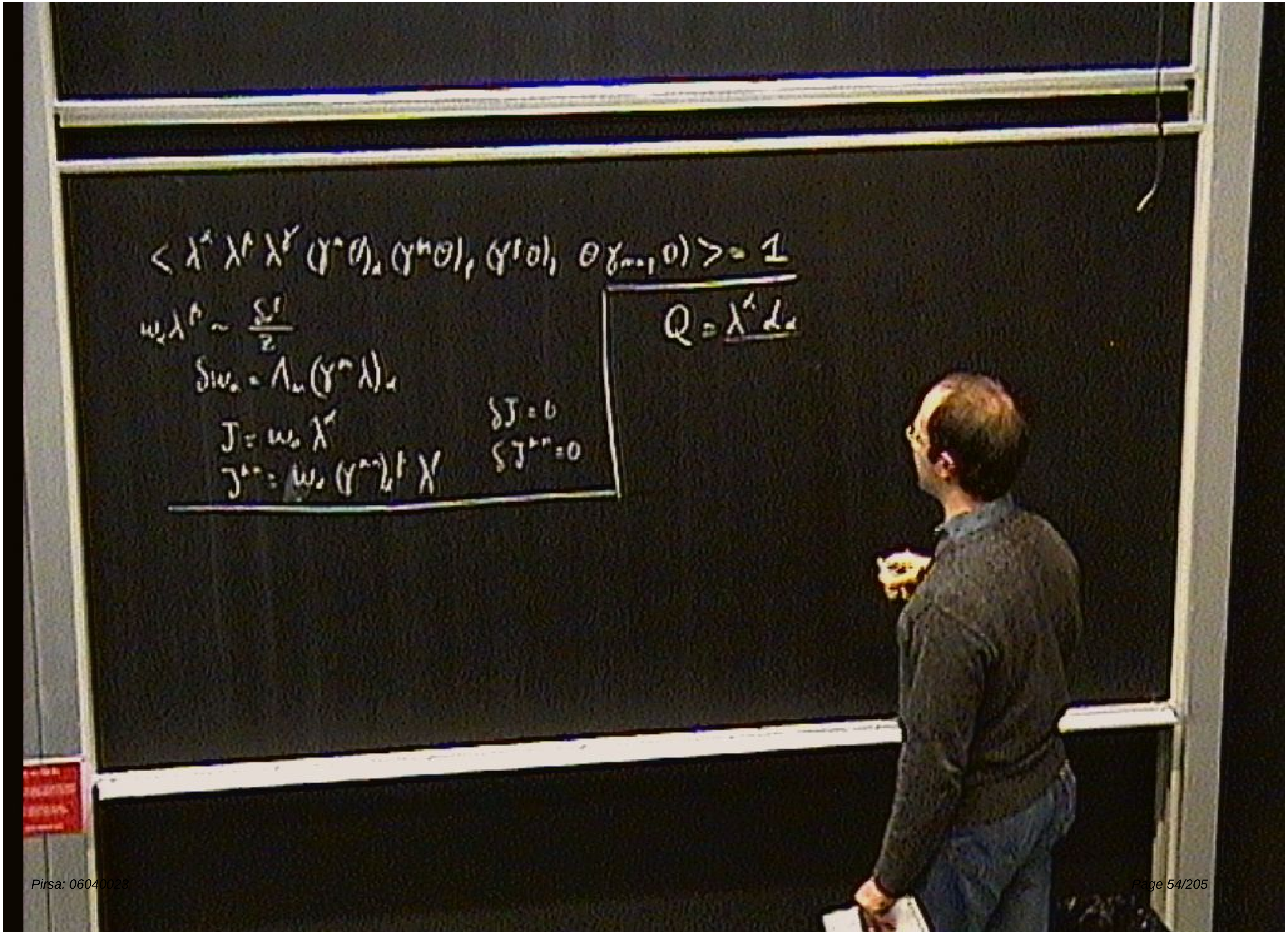


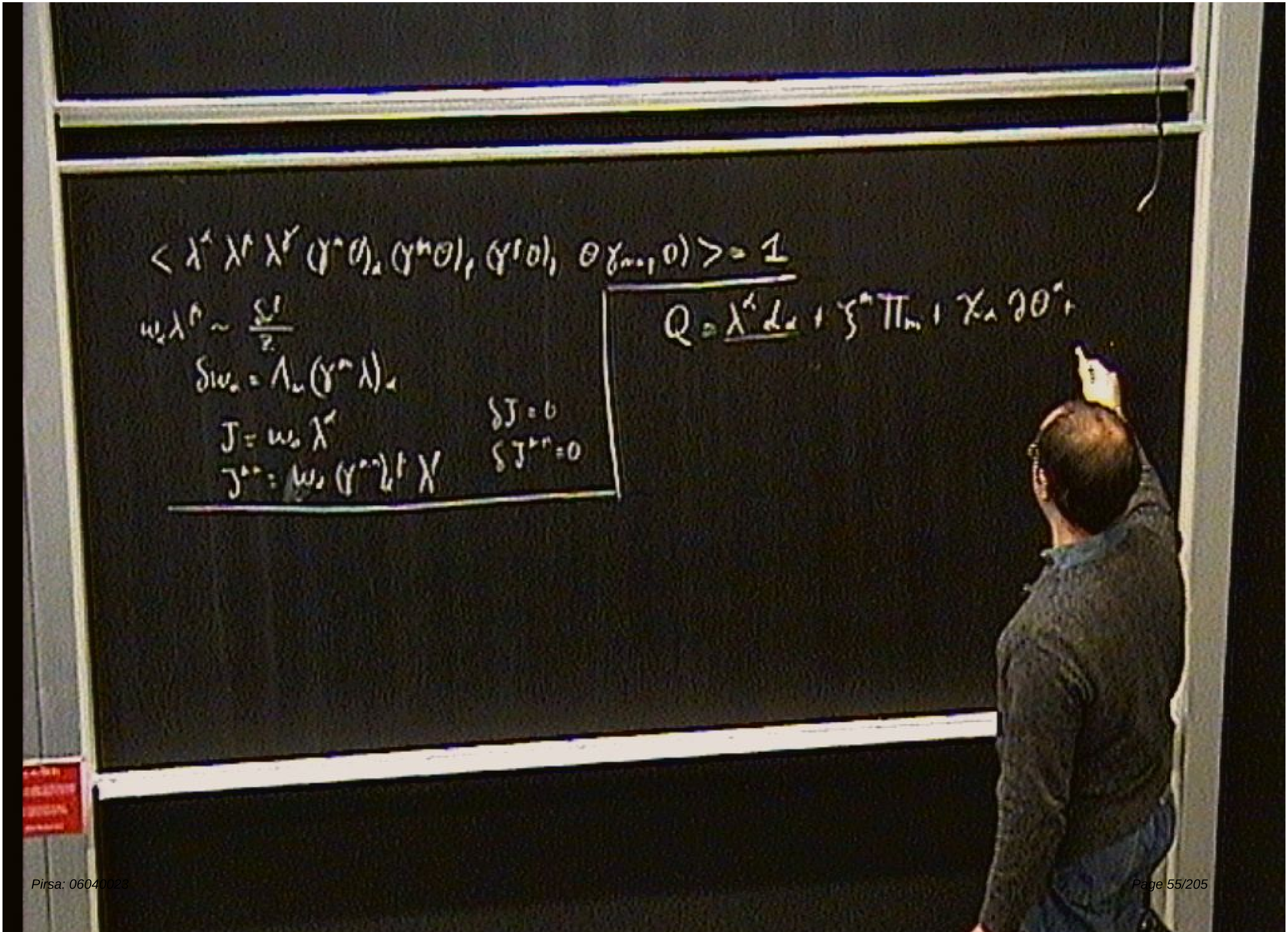
< λ^α λ^β λ^γ (γ^m θ)_α (γ^n θ)_β (γ^p θ)_γ θ γ_mnp θ) > = 1
δJ = 0



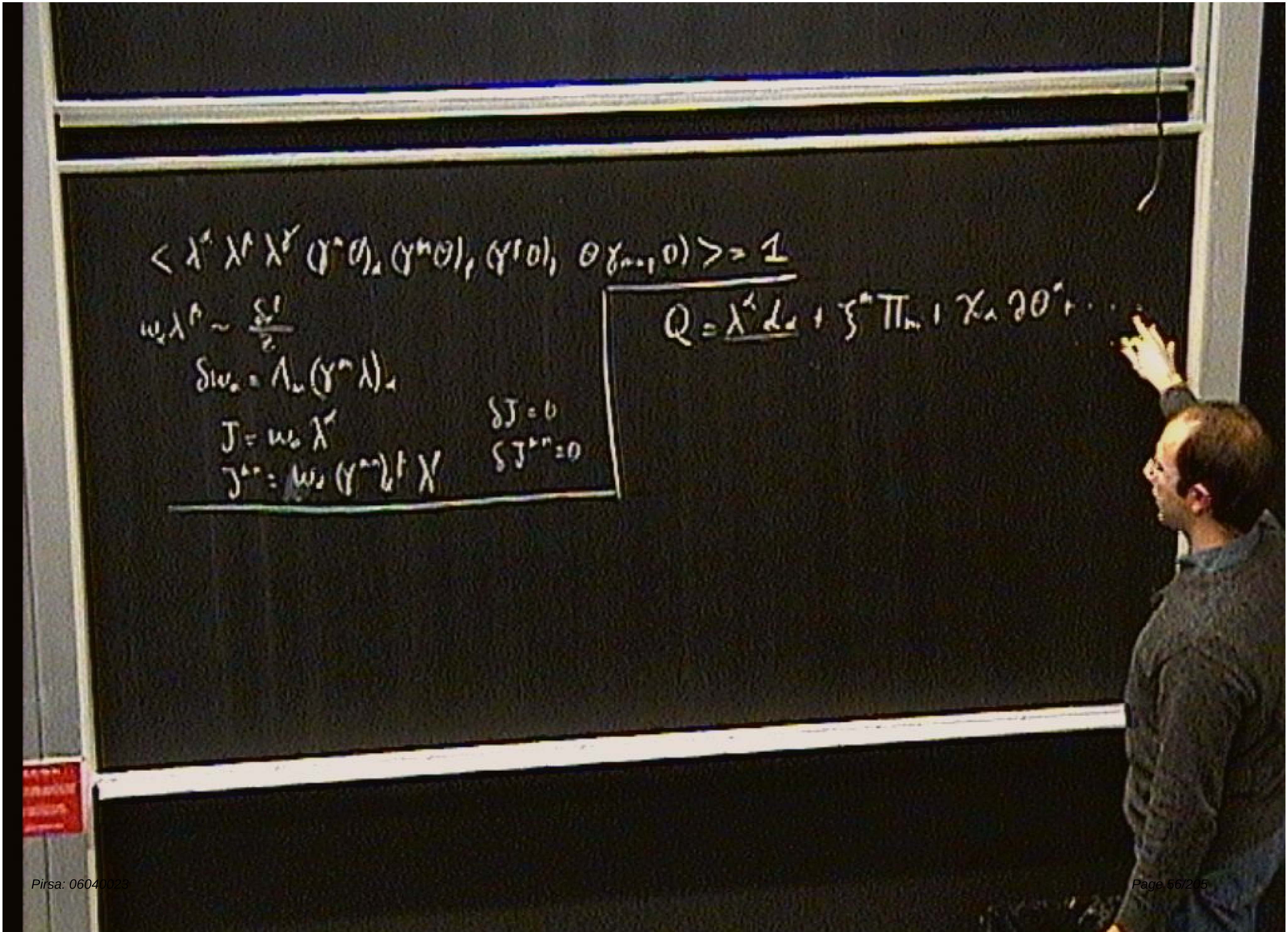



δJ = 0
δJ^{mn} = 0

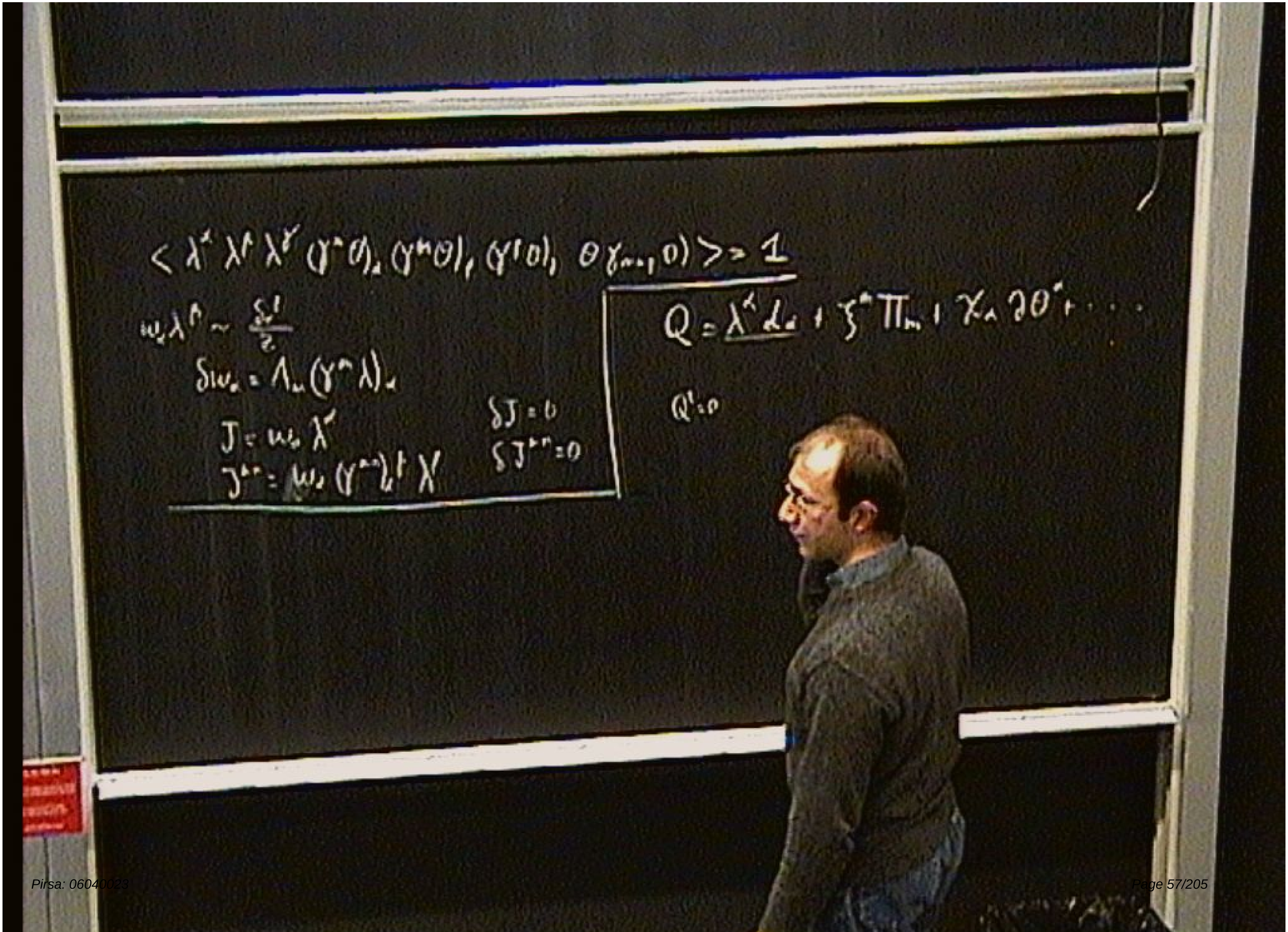

Q = λ^α d_α
δJ = 0

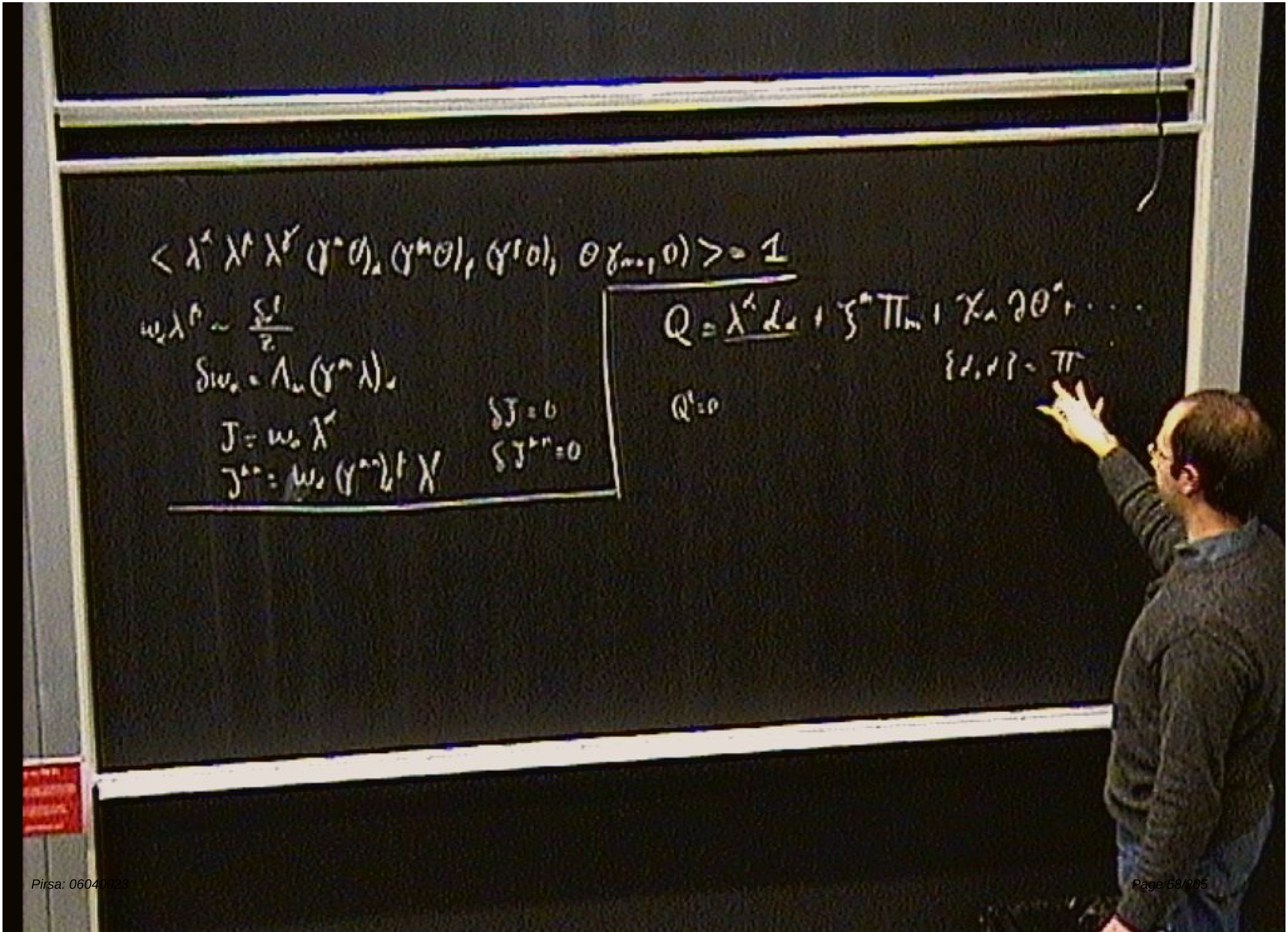


$\langle \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^m\theta)_\alpha (\gamma^n\theta)_\beta (\gamma^p\theta)_\gamma \; \theta\gamma_{mnp}\theta \rangle = 1$
$\delta w_\alpha = \Lambda_m (\gamma^m \lambda)_\alpha$
$J = w_\alpha \lambda^\alpha$
$\delta J = 0$
$J^{mn} = w_\alpha (\gamma^{mn})^\alpha{}_\beta \lambda^\beta$
$\delta J^{mn} = 0$
$Q = \lambda^\alpha d_\alpha + \xi^m \Pi_m + \chi_\alpha \partial\theta^\alpha +$



$< \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^m \theta)_\alpha (\gamma^n \theta)_\beta (\gamma^p \theta)_\gamma \, \theta \gamma_{mnp} \theta) > = 1$
$w_\alpha \lambda^\alpha \sim \frac{\xi'}{\xi}$
$\delta w_\alpha = \Lambda_m (\gamma^m \lambda)_\alpha$
$J = w_\alpha \lambda^\alpha$
$J^{mn} = w_\alpha (\gamma^{mn})^\alpha{}_\beta \lambda^\beta$
$\delta J = 0$
$\delta J^{mn} = 0$
$Q = \lambda^\alpha d_\alpha + \xi^m \Pi_m + \chi_\alpha \partial\theta^\alpha + \cdots$


$< \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^m\theta)_\alpha (\gamma^n\theta)_\beta (\gamma^p\theta)_\gamma \; \theta\gamma_{mnp}\theta) > = 1$
$Q = \lambda^\alpha d_\alpha + \xi^m \Pi_m + \chi_\alpha \partial\theta^\alpha + \ldots$
$\delta w_\alpha = \Lambda_m (\gamma^m \lambda)_\alpha$
$J = w_\alpha \lambda^\alpha$
$\delta J = 0$
$\delta J^{mn} = 0$



δJ = 0
δJ^{mn} = 0
Q^2 = 0

$$< \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^m\theta)_\alpha (\gamma^n\theta)_\beta (\gamma^p\theta)_\gamma \; \theta\gamma_{mnp}\theta) > = 1$$

$$w_\alpha \lambda^\beta \sim \frac{\delta_\alpha^\beta}{z}$$

$$\delta w_\alpha = \Lambda_m (\gamma^m \lambda)_\alpha$$

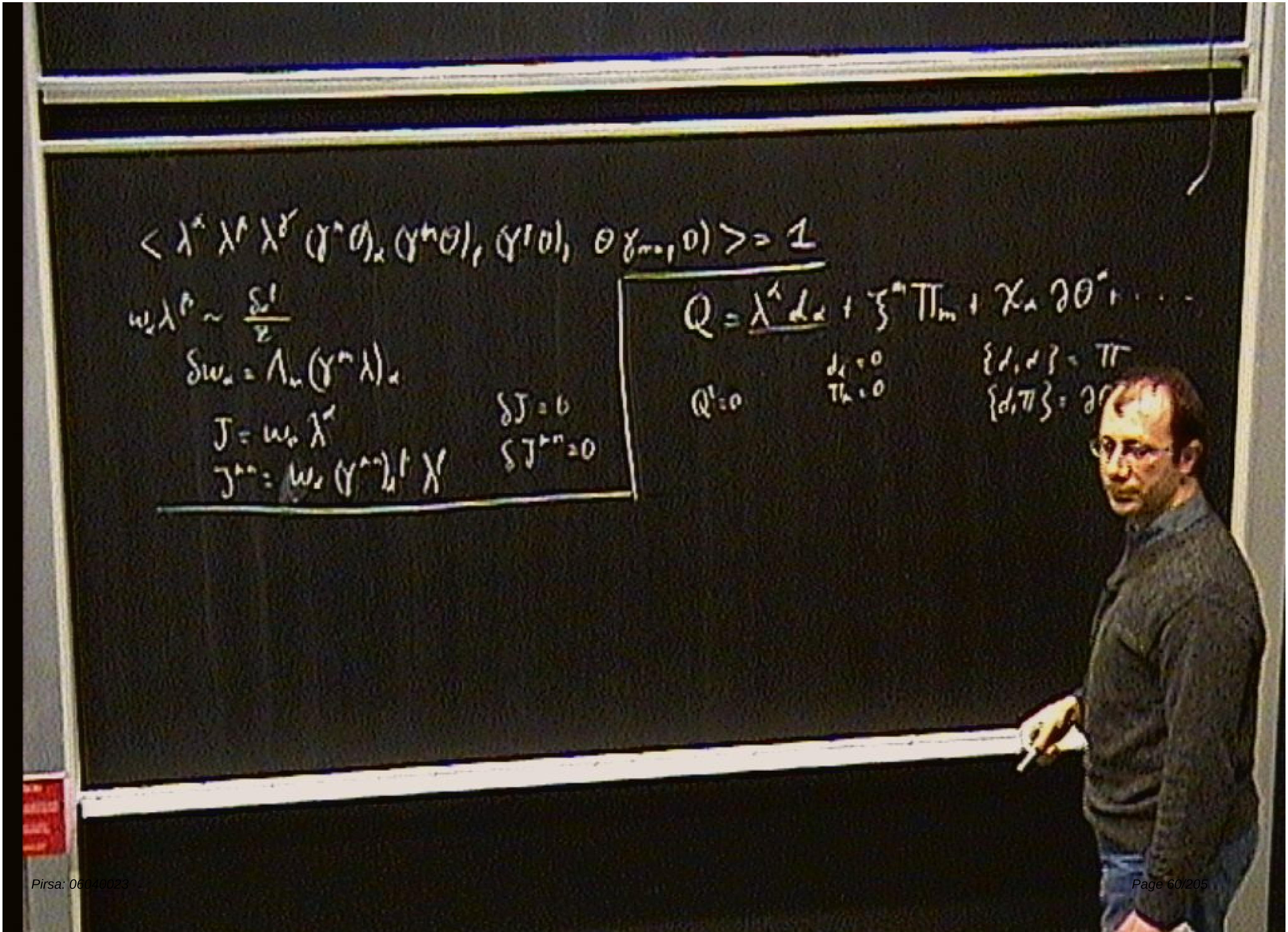
$$J = w_\alpha \lambda^\alpha \qquad \delta J = 0$$

$$J^{mn} = w_\alpha (\gamma^{mn})_\alpha{}^\beta \lambda^\beta \qquad \delta J^{mn} = 0$$

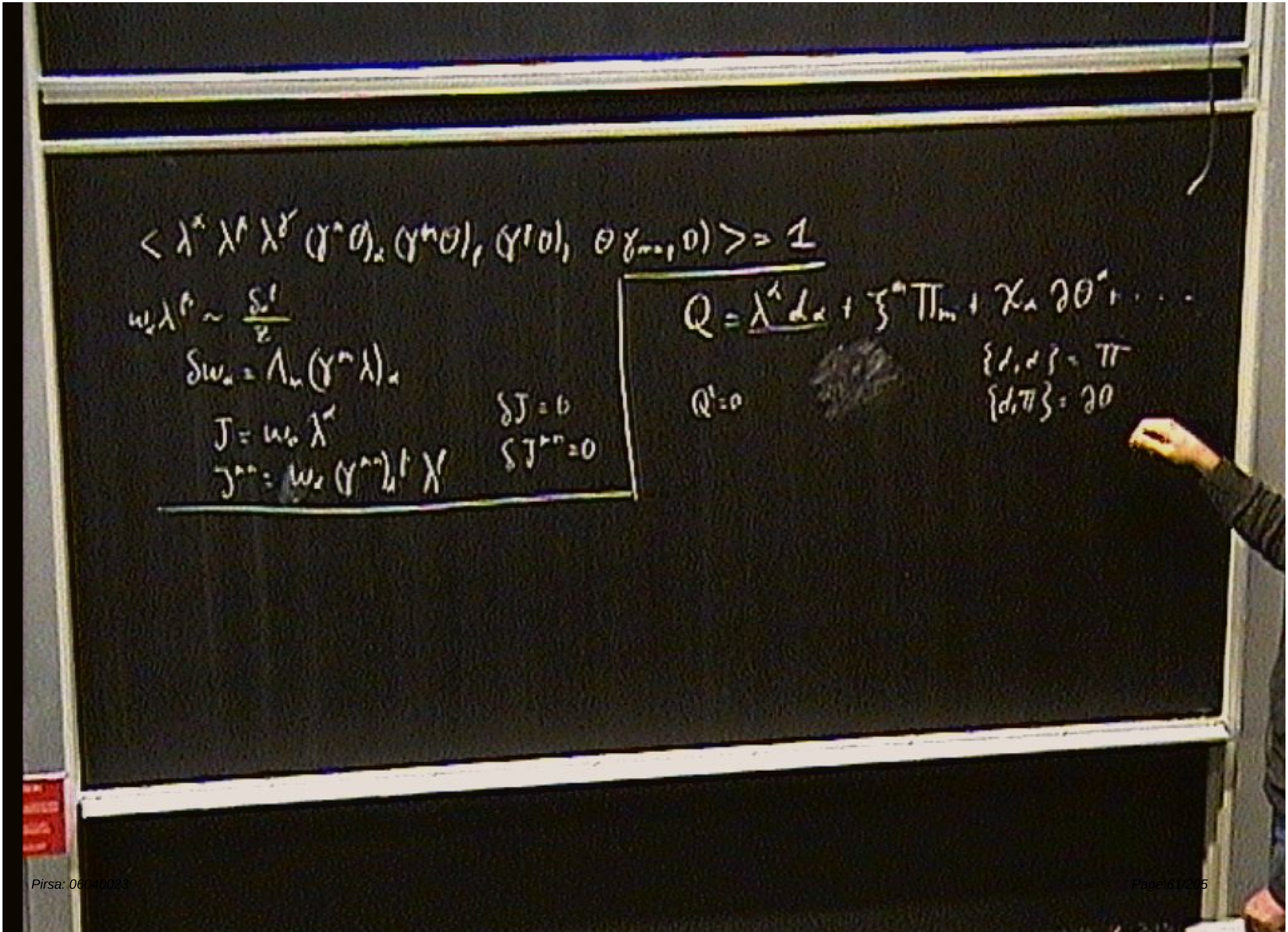
$$Q = \lambda^\alpha d_\alpha + \xi^m \Pi_m + \chi_\alpha \partial\theta^\alpha + \dots$$

$$\{d, d\} = \Pi$$

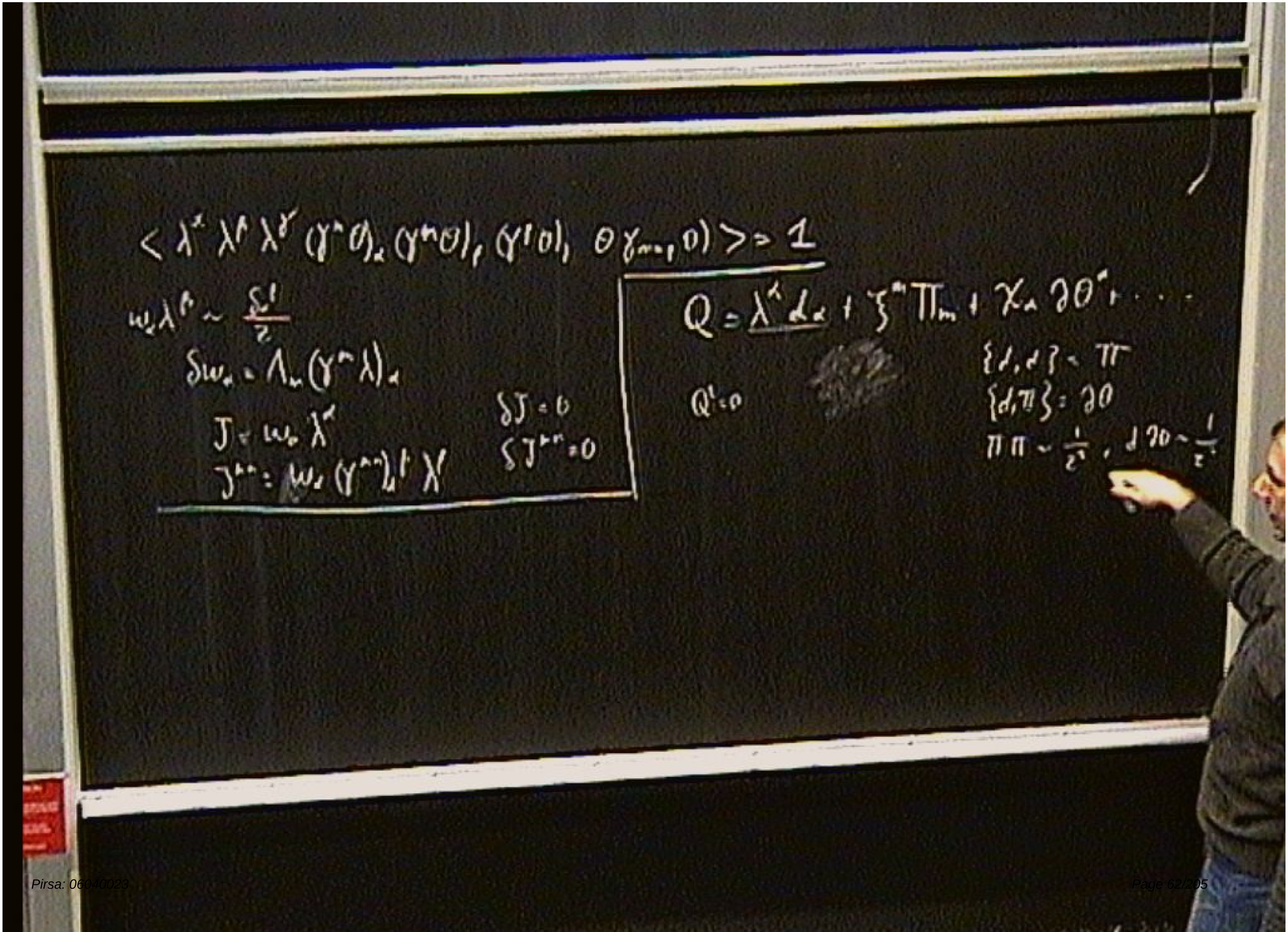
$$Q^2 = 0 \qquad \{d, \Pi\} = \partial\theta$$

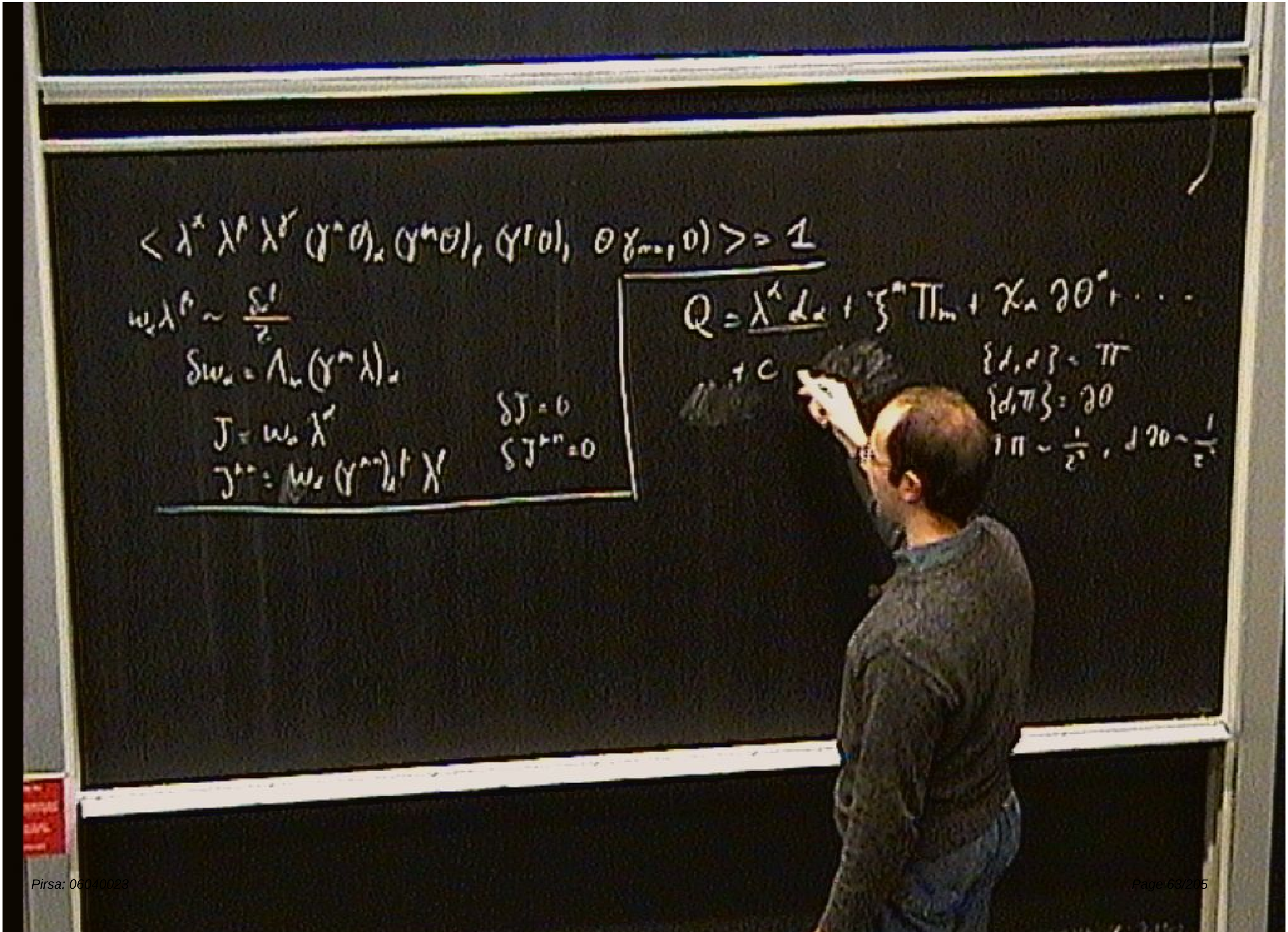


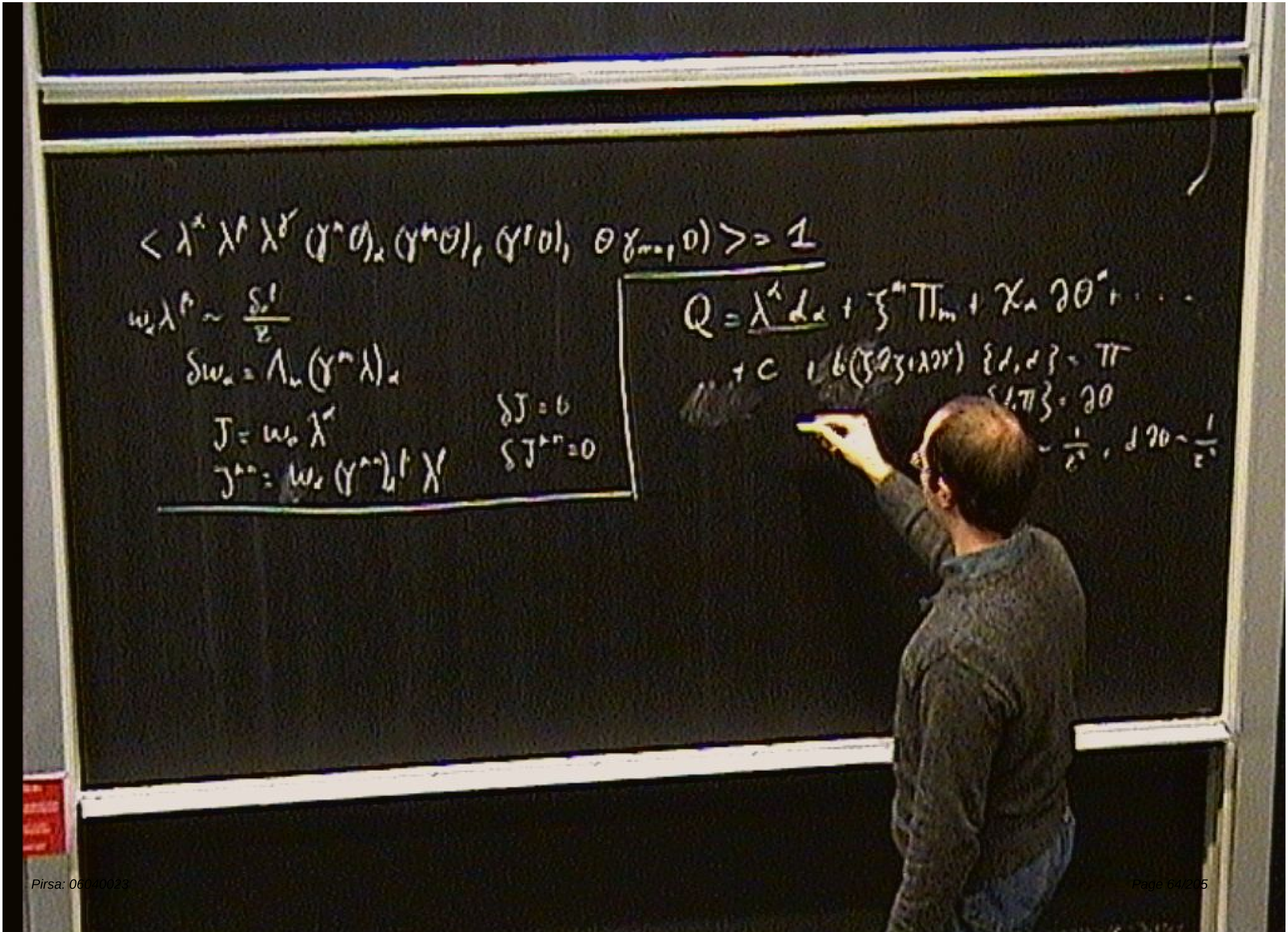
< λ^α λ^β λ^γ (γ^m θ)_α (γ^n θ)_β (γ^p θ)_γ θ γ_mnp θ) > = 1
w_α λ^β ~ δ_α^β / z
δw_α = Λ_m (γ^m λ)_α
J = w_α λ^α
δJ = 0
J^mn = w_α (γ^mn)_β^α λ^β
δJ^mn = 0
Q = λ^α d_α + ξ^m Π_m + χ_α ∂θ^α + . . .
Q² = 0
d_α = 0
Π_m = 0
{d, d} = Π
{d, Π} = ∂θ

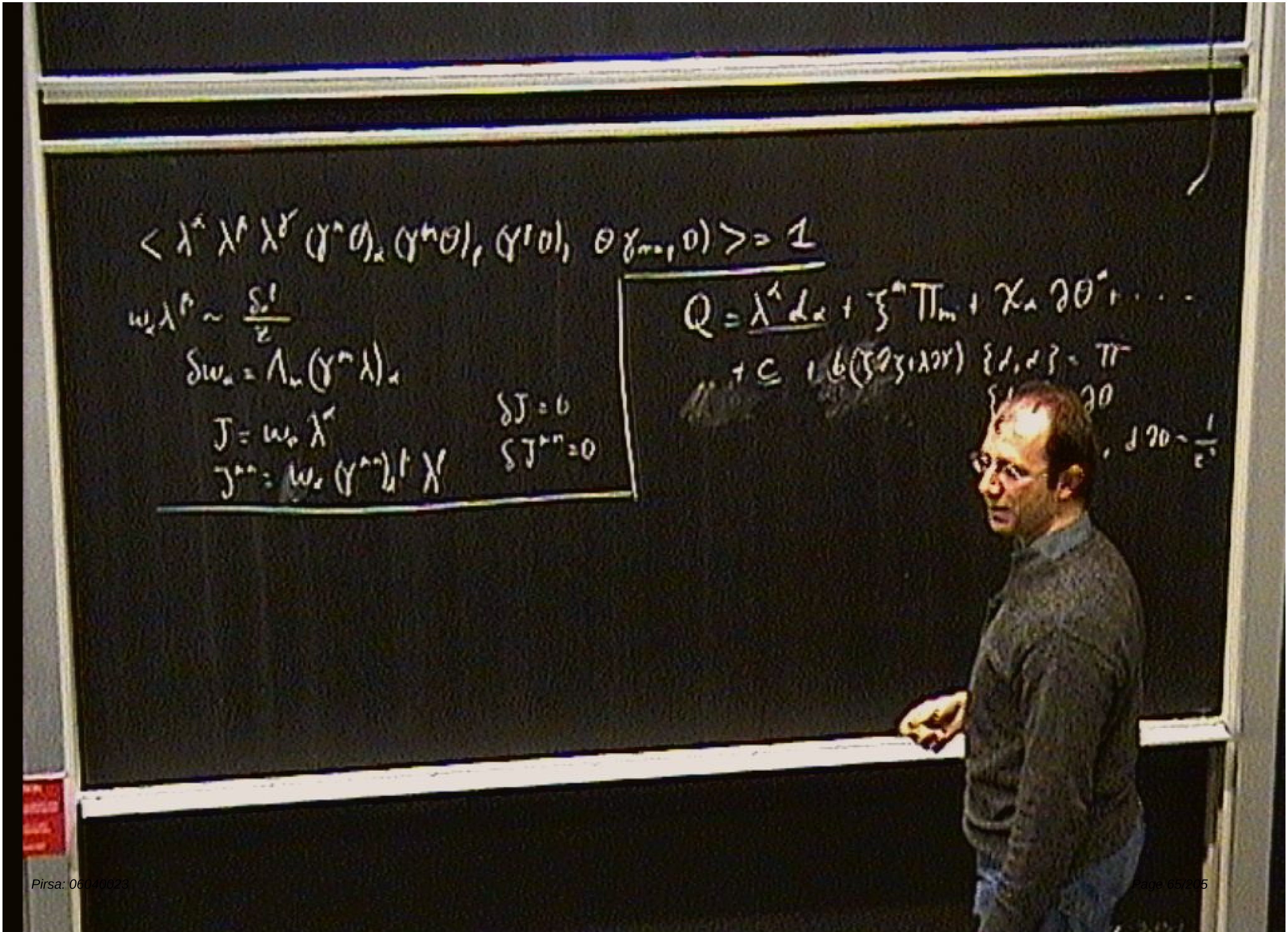


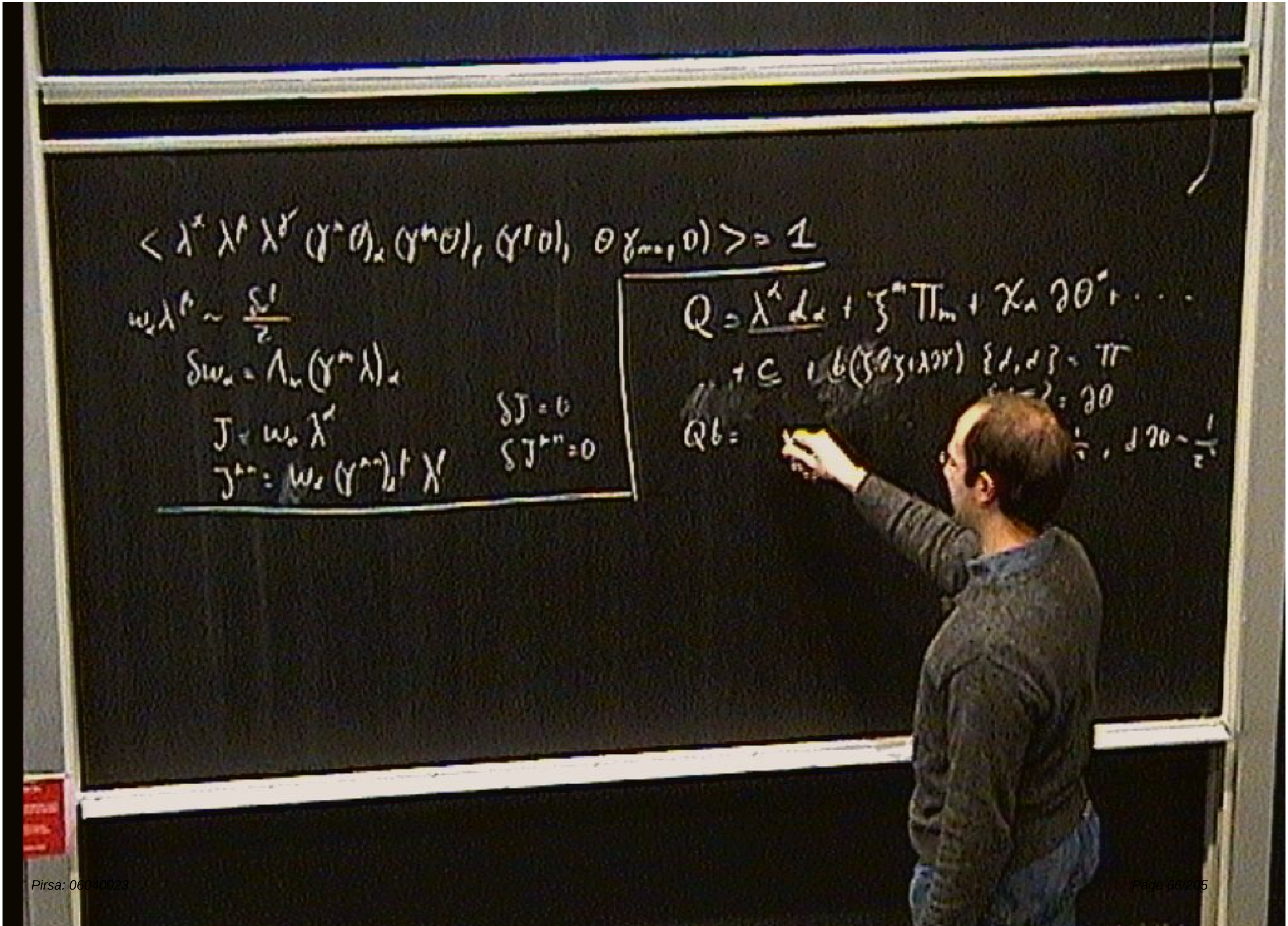
$< \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^m \theta)_\alpha (\gamma^n \theta)_\beta (\gamma^p \theta)_\gamma \; \theta \gamma_{mnp} \theta) > = 1$
$w_\alpha \lambda^\beta \sim \frac{\delta_\alpha^\beta}{z}$
$\delta w_\alpha = \Lambda_m (\gamma^m \lambda)_\alpha$
$J = w_\alpha \lambda^\alpha$
$\delta J = 0$
$J^{mn} = w_\alpha (\gamma^{mn})_\beta^\alpha \lambda^\beta$
$\delta J^{mn} = 0$
$Q = \lambda^\alpha d_\alpha + \xi^m \Pi_m + \chi_\alpha \partial \theta^\alpha + \ldots$
$\{d, d\} = \Pi$
$Q^2 = 0$
$\{d, \Pi\} = \partial \theta$

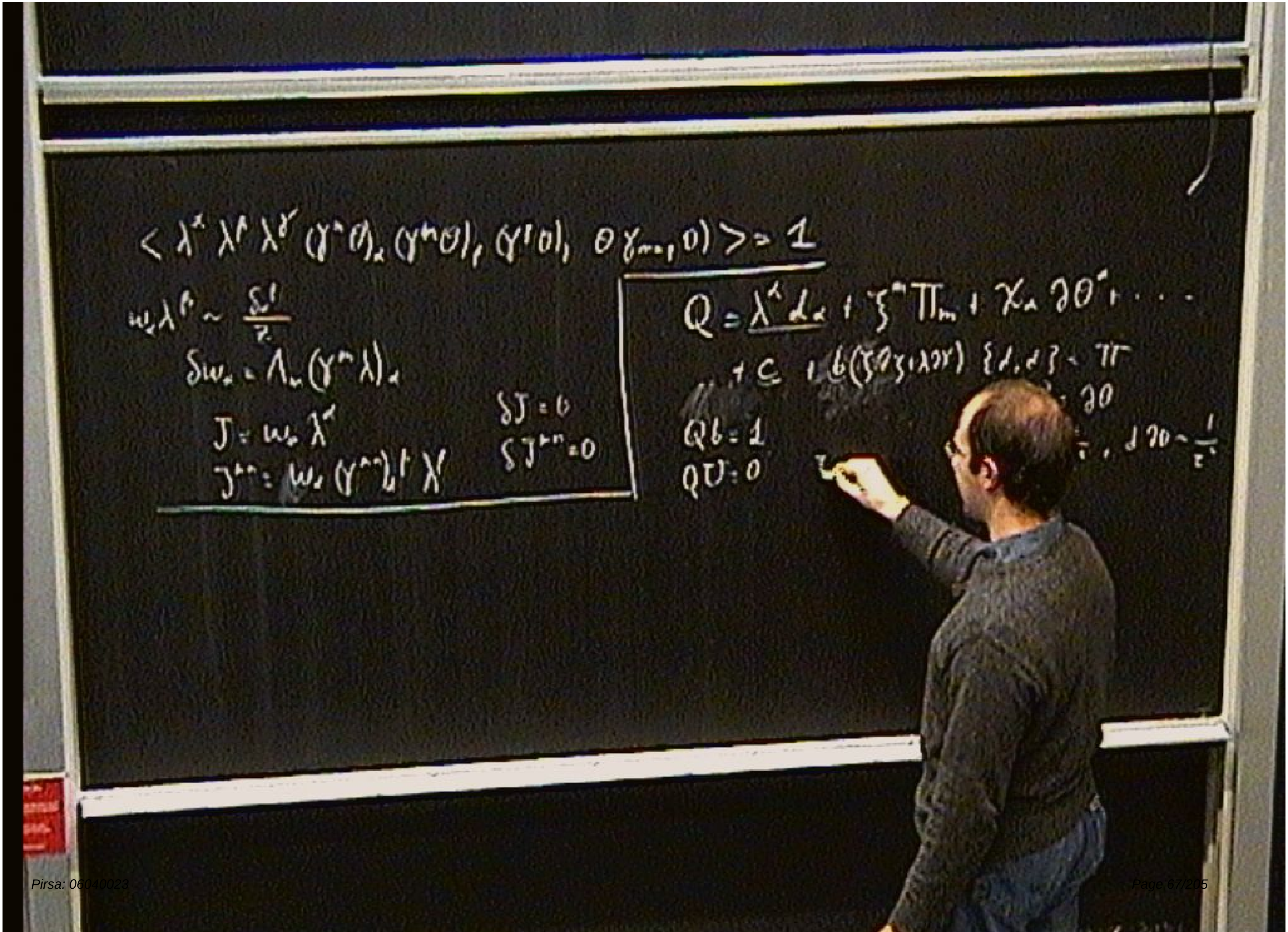

$< \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^m\theta)_\alpha (\gamma^n\theta)_\beta (\gamma^p\theta)_\gamma \, \theta\gamma_{mnp}\theta) > = 1$
$w_\alpha \lambda^\beta \sim \frac{\delta^\beta_\alpha}{z}$
$\delta w_\alpha = \Lambda_m (\gamma^m \lambda)_\alpha$
$J = w_\alpha \lambda^\alpha$
$\delta J = 0$
$J^{mn} = w_\alpha (\gamma^{mn})^\alpha{}_\beta \lambda^\beta$
$\delta J^{mn} = 0$
$Q = \lambda^\alpha d_\alpha + \xi^m \Pi_m + \chi_\alpha \partial\theta^\alpha + \dots$
$Q^2 = 0$
$\{d, d\} = \Pi$
$\{d, \Pi\} = \partial\theta$
$\Pi\Pi \sim \frac{1}{z^2}, \; d\,\partial\theta \sim \frac{1}{z^2}$

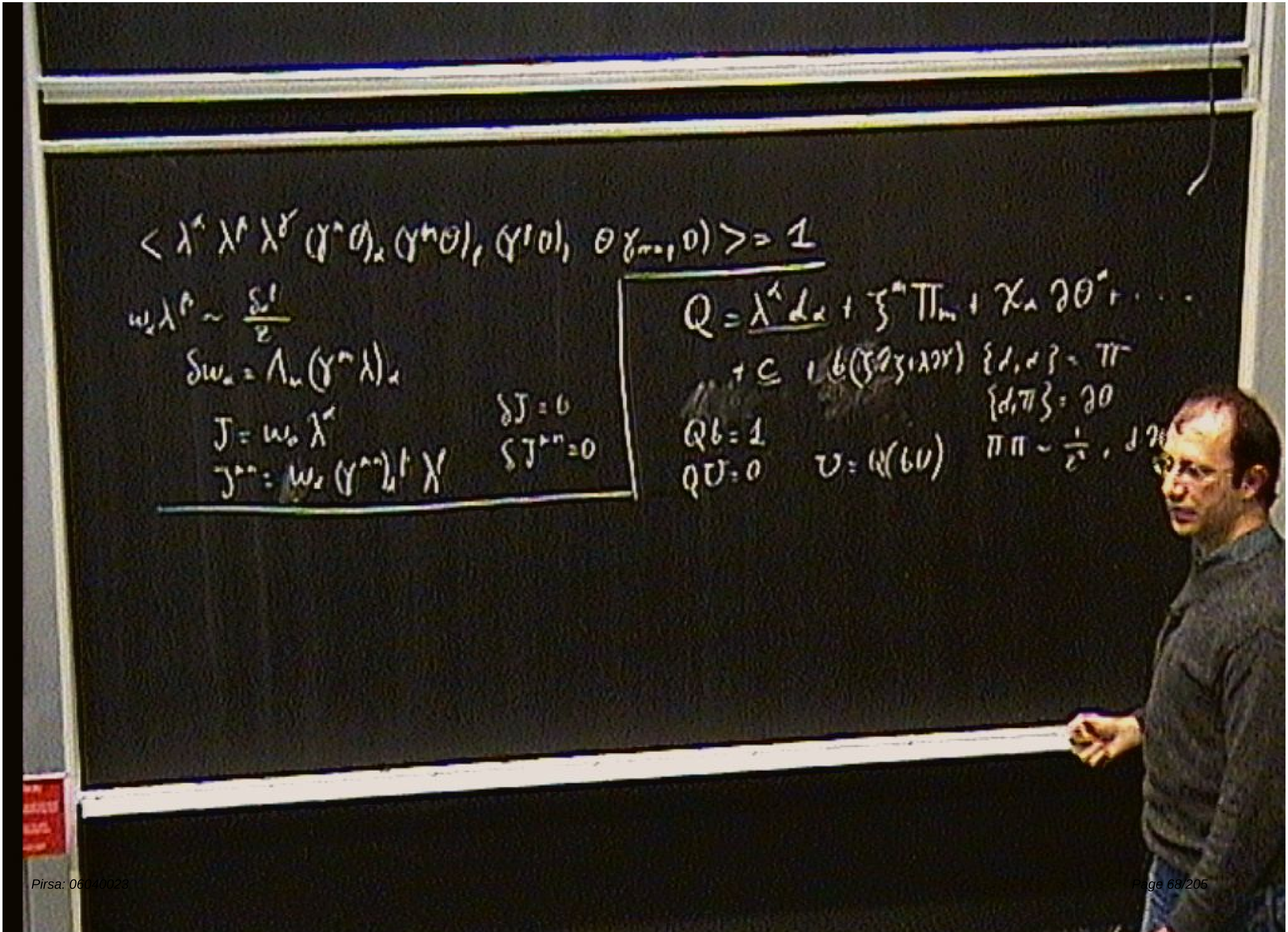

< λ^α λ^β λ^γ (γ^m θ)_α (γ^n θ)_β (γ^p θ)_γ θ γ_mnp θ) > = 1
Q = λ^α d_α + ξ^m Π_m + χ_α ∂θ^α + . . .
δw_α = Λ_m (γ^m λ)_α
J = w_α λ^α
δJ = 0
δJ^mn = 0
{d, d} = Π
{d, Π} = ∂θ


$< \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^m\theta)_\alpha (\gamma^n\theta)_\beta (\gamma^p\theta)_\gamma \; \theta\gamma_{mnp}\theta) > = 1$
$w_\alpha \lambda^\beta \sim \frac{\delta_\alpha^\beta}{z}$
$\delta w_\alpha = \Lambda_m (\gamma^m \lambda)_\alpha$
$J = w_\alpha \lambda^\alpha$ $\delta J = 0$
$J^{mn} = w_\alpha (\gamma^{mn})^\alpha{}_\beta \lambda^\beta$ $\delta J^{mn} = 0$
$Q = \lambda^\alpha d_\alpha + \xi^m \Pi_m + \chi_\alpha \partial\theta^\alpha + \dots$
$+ c + b(\xi\partial\xi + \lambda\partial\chi)$ $\{d, d\} = \Pi$
$\{d, \Pi\} = \partial\theta$
$\sim \frac{1}{z^2}, \; d\,\partial\theta \sim \frac{1}{z}$


< λ^α λ^β λ^γ (γ^m θ)_α (γ^n θ)_β (γ^p θ)_γ θ γ_mnp θ > = 1
δw_α = Λ_m (γ^m λ)_α
J = w_α λ^α
δJ = 0
δJ^mn = 0
Q = λ^α d_α + ξ^m Π_m + χ_α ∂θ^α + . . .






Qb = 1
QU = 0
{d, Π} = ∂θ

$$< \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^m \theta)_\alpha (\gamma^n \theta)_\beta (\gamma^p \theta)_\gamma \; \theta \gamma_{mnp} \theta) > = 1$$

$w_\alpha \lambda^\beta \sim \frac{\delta_\alpha^\beta}{z}$

$\delta w_\alpha = \Lambda_m (\gamma^m \lambda)_\alpha$

$J = w_\alpha \lambda^\alpha \qquad \delta J = 0$

$J^{mn} = w_\alpha (\gamma^{mn})^\alpha{}_\beta \lambda^\beta \qquad \delta J^{mn} = 0$

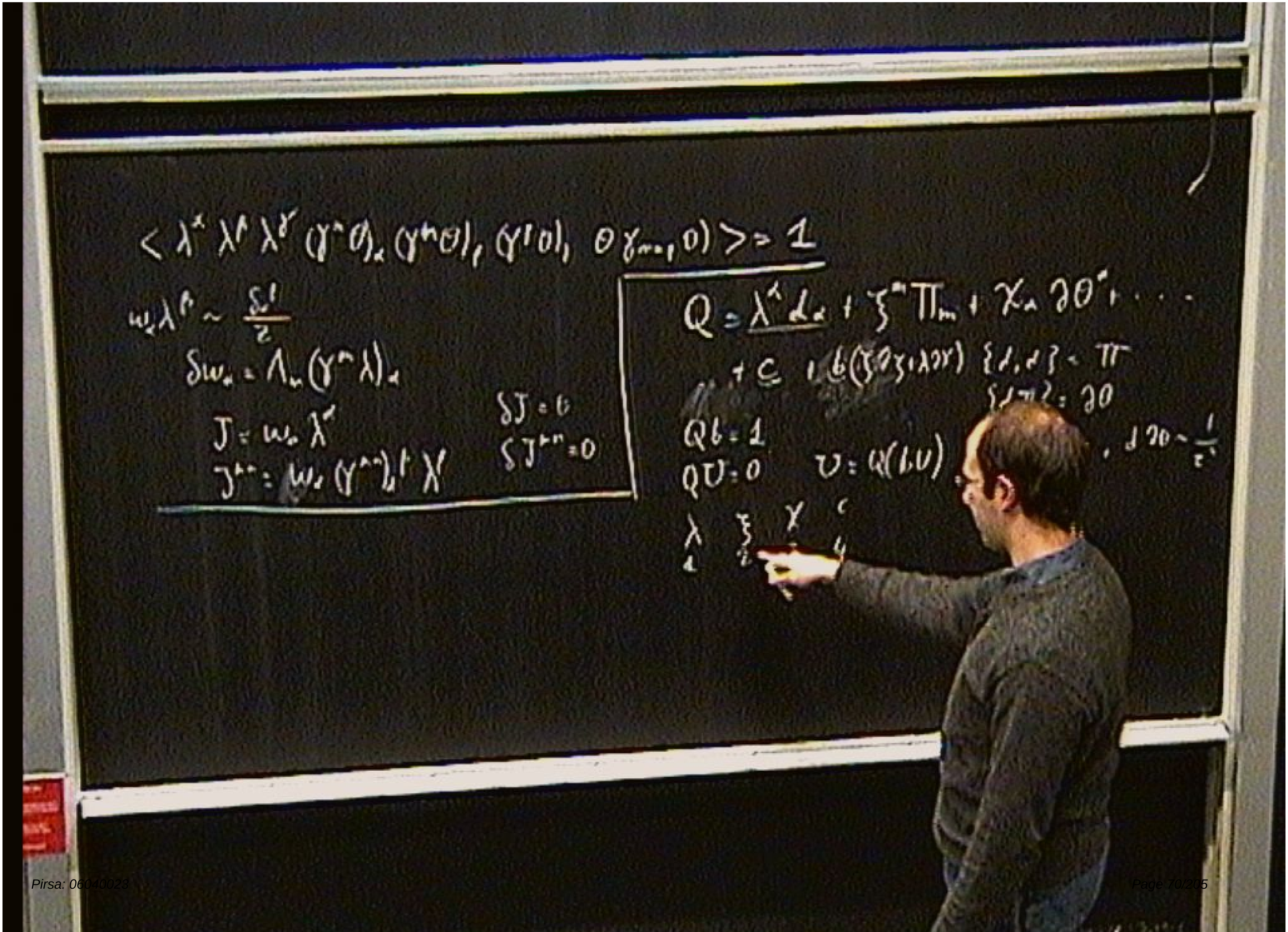
$Q = \lambda^\alpha d_\alpha + \xi^m \Pi_m + \chi_\alpha \partial\theta^\alpha + \cdots$

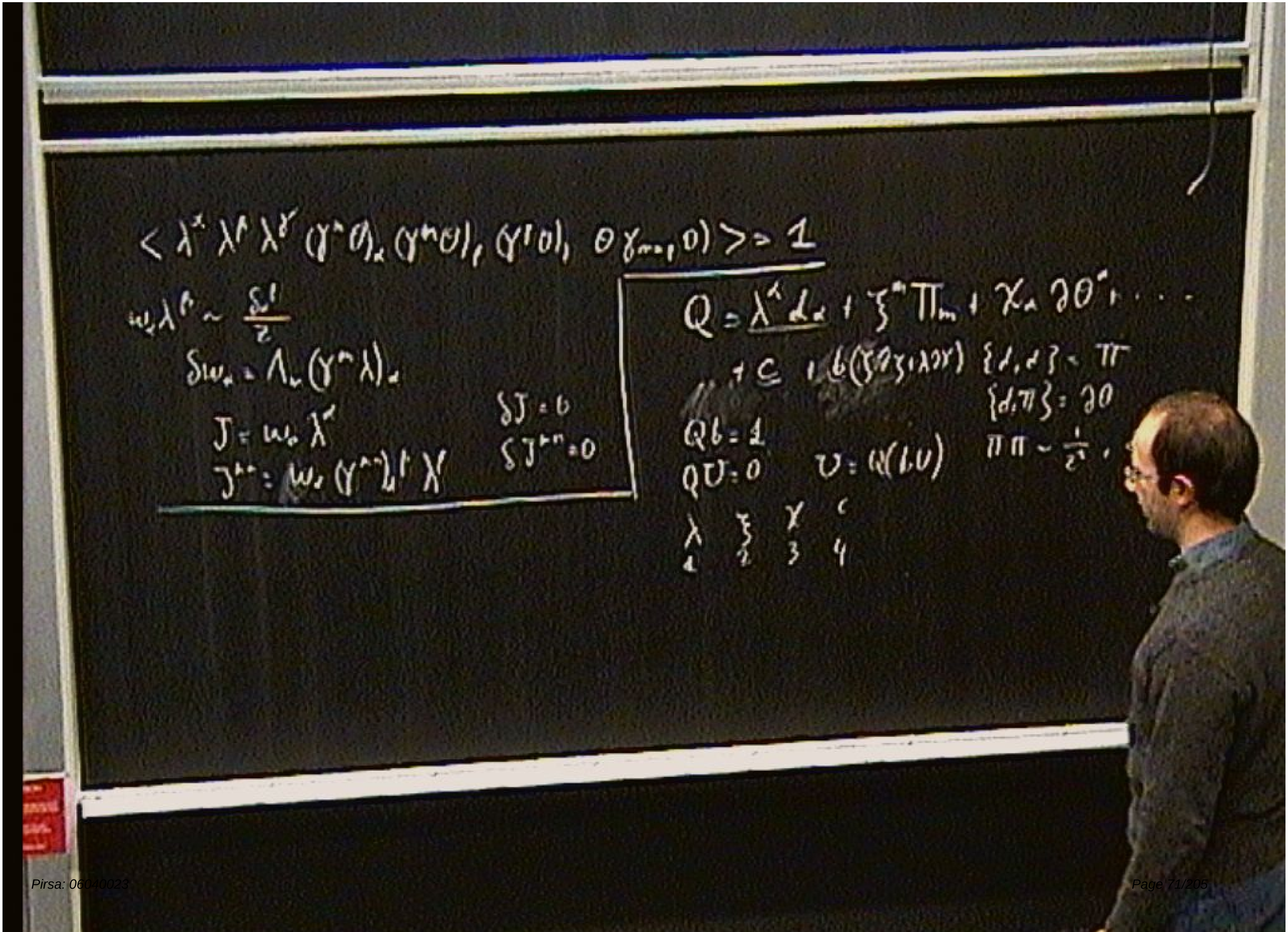
$+ c + b(\xi \partial \xi + \lambda \partial \chi) \qquad \{d, d\} = \Pi$

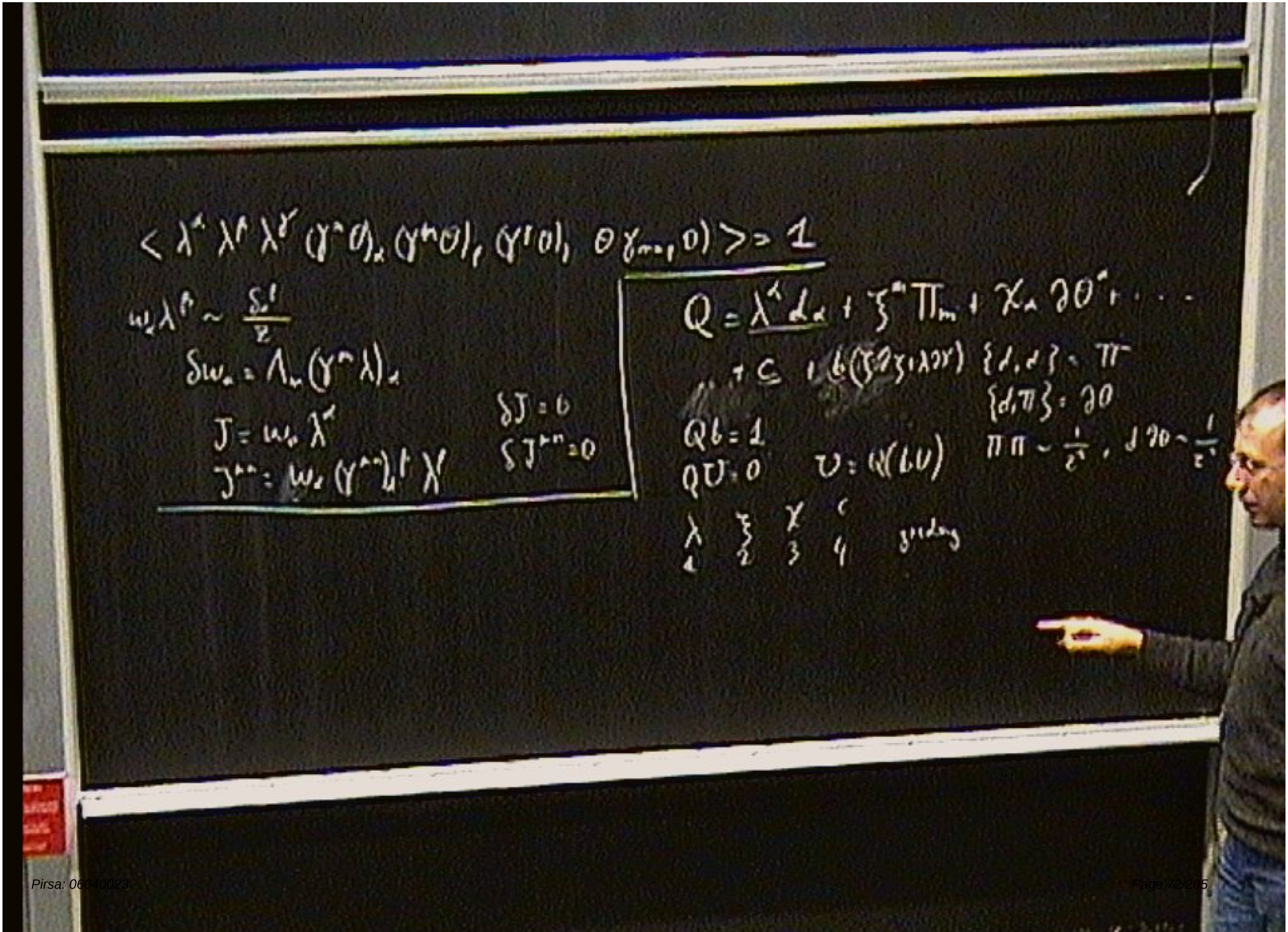
$\{d, \Pi\} = \partial\theta$

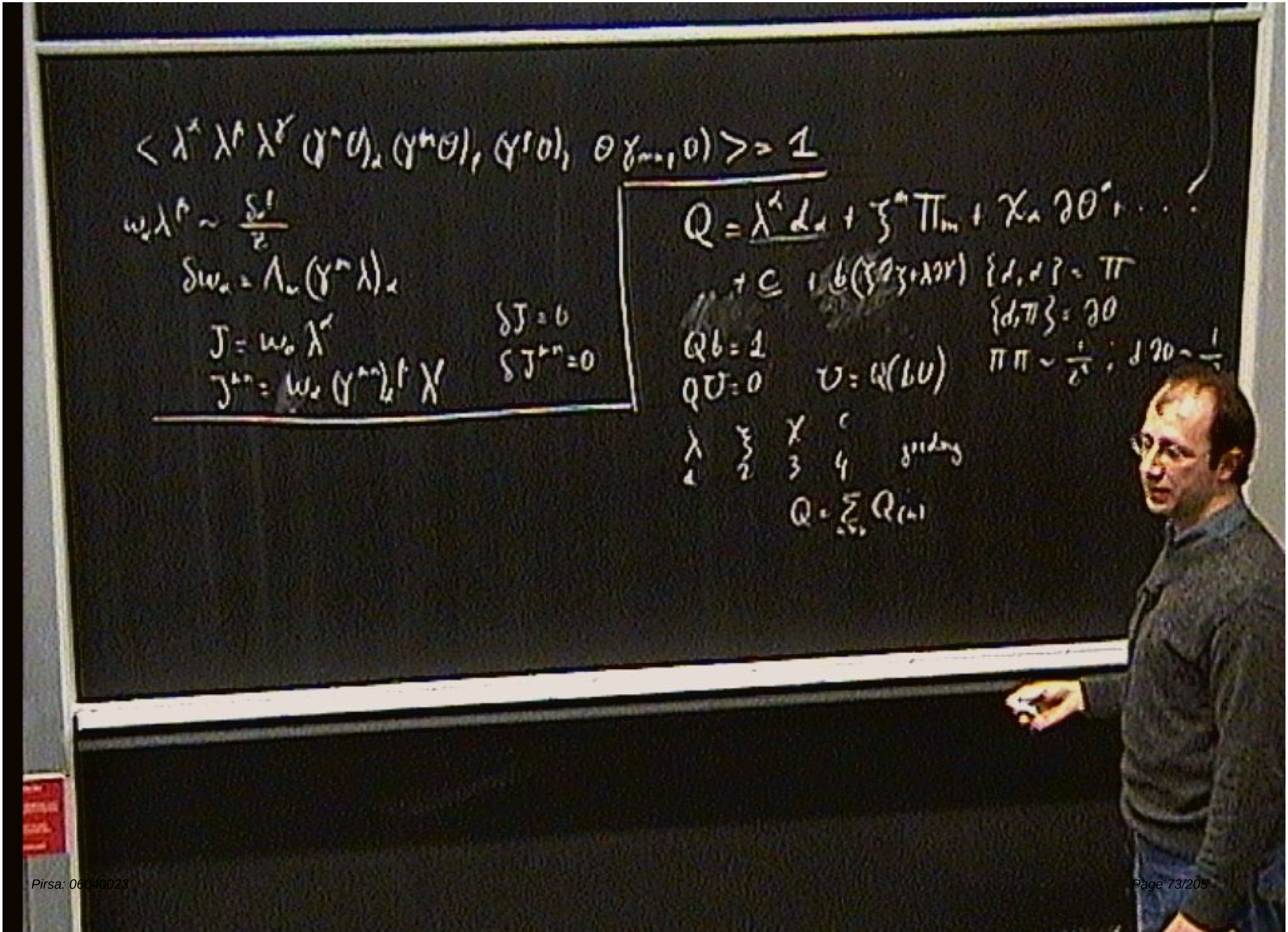
$Qb = 1$

$QU = 0 \qquad U = Q(bU) \qquad \Pi\Pi \sim \frac{1}{z^2}, \; d\,\partial\theta \sim \frac{1}{z^2}$

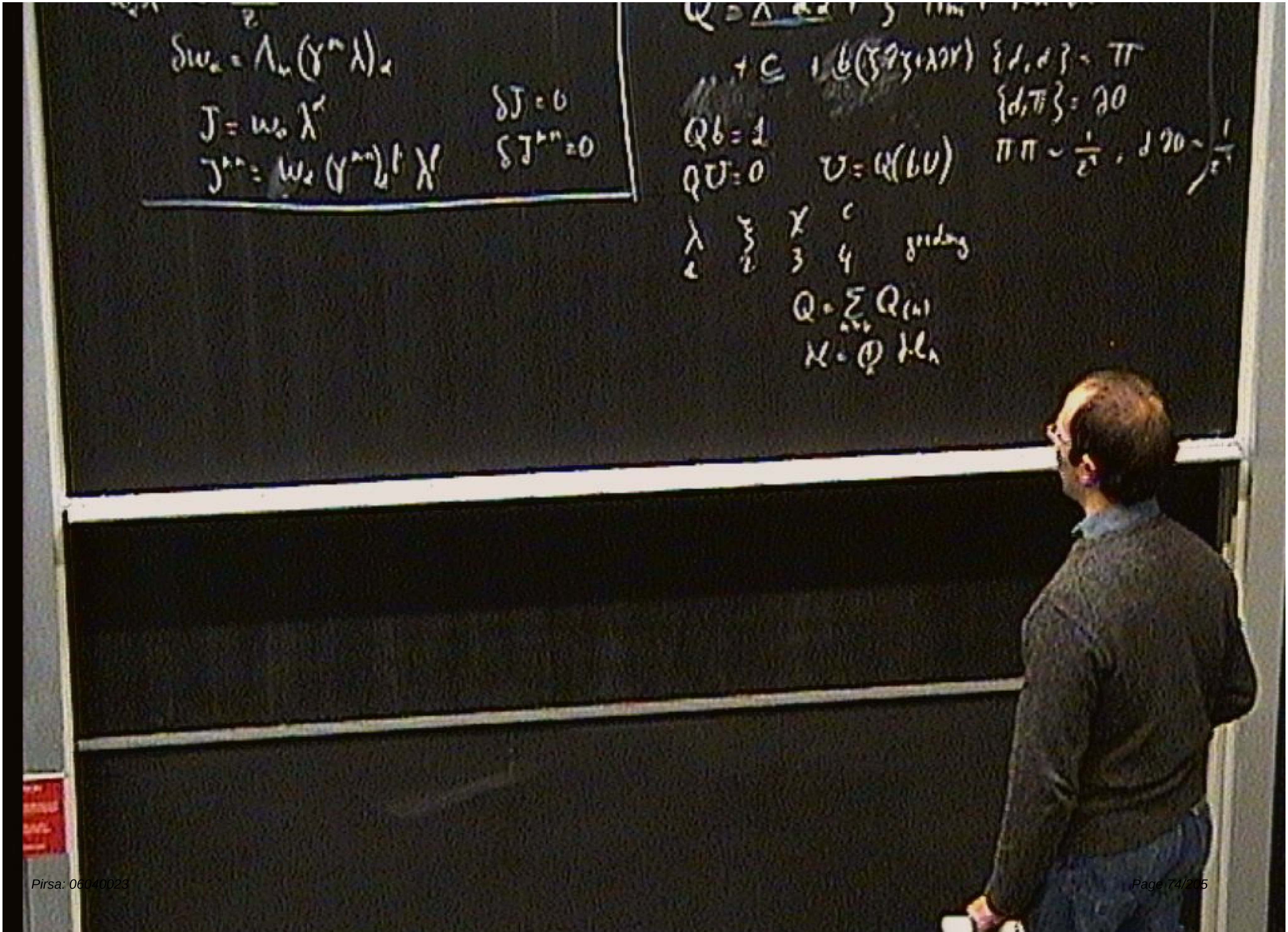

Qb = 1
QU = 0
δJ = 0

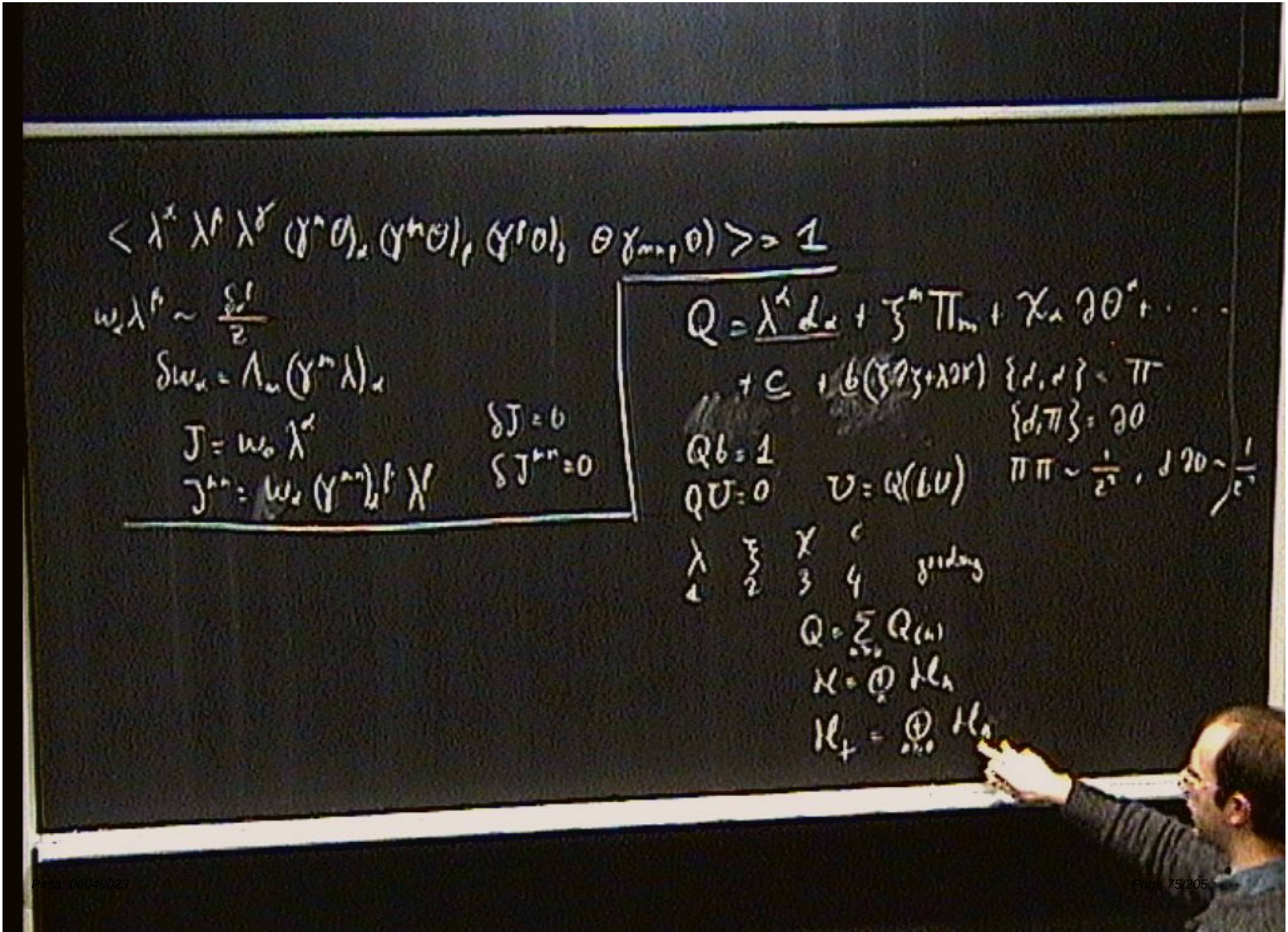

< λ^α λ^β λ^γ (γ^m θ)_α (γ^n θ)_β (γ^p θ)_γ θ γ_mnp θ) > = 1
Q = λ^α d_α + ξ^m Π_m + χ_α ∂θ^α + . . .
{d, d} = Π
{d, Π} = ∂θ
Qb = 1
QU = 0
λ ξ χ c
1 2 3 4
δJ = 0
δJ^+n = 0


< λ^α λ^β λ^γ (γ^m θ)_α (γ^n θ)_β (γ^p θ)_γ θ γ_{mnp} θ > = 1
Q = λ^α d_α + ξ^m Π_m + χ_α ∂θ^α + . . .
{d,Π} = ∂θ
Qb = 1
QU = 0
J = w_α λ^α
δJ = 0
δJ^{mn} = 0
grading

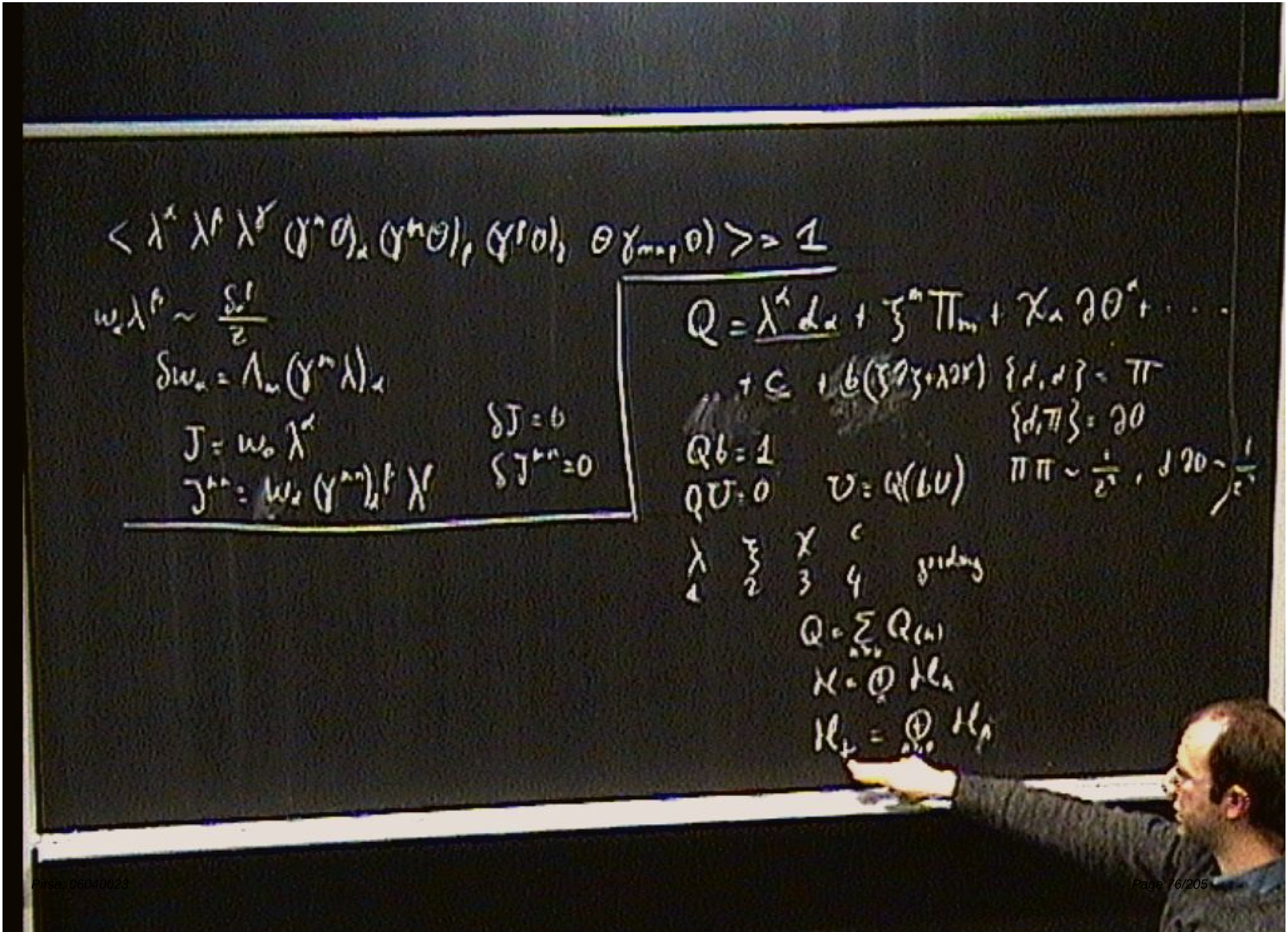


< λ^α λ^β λ^γ (γ^m θ)_α (γ^n θ)_β (γ^p θ)_γ θ γ_mnp θ) > = 1
Q = λ^α d_α + ξ^m Π_m + χ_α ∂θ^α + . . . ?
{d, d} = Π
{d, Π} = ∂θ
Qb = 1
QU = 0
U = Q(bU)
δJ = 0
δJ^mn = 0
grading


Qb = 1
QU = 0
grading



Q = λ^α d_α + ξ^m Π_m + χ_α ∂θ^α + ...
Qb = 1
QU = 0
U = Q(bU)
{d, d} = Π
{d, Π} = ∂θ
δJ = 0
δJ^mn = 0
grading


< λ^α λ^β λ^γ (γ^m θ)_α (γ^n θ)_β (γ^p θ)_γ (θ γ_mnp θ) > = 1
w_α λ^β ~ δ_α^β / z
δw_α = Λ_m (γ^m λ)_α
J = w_α λ^α
δJ = 0
J^mn = w_α (γ^mn)_α^β λ^β
δJ^mn = 0
Q = λ^α d_α + ξ^m Π_m + χ_α ∂θ^α + . . .
+ c + b(ξ∂ξ + λ∂χ)
{d, d} = Π
{d, Π} = ∂θ
Qb = 1
QU = 0
U = Q(bU)
ΠΠ ~ 1/z², d∂θ ~ 1/z
λ ξ χ c
1 2 3 4 grading
Q = Σ Q_(n)
H = ⊕ H_n
H_+ = ⊕ H_p

$$\langle \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^m\theta)_\alpha (\gamma^n\theta)_\beta (\gamma^p\theta)_\gamma \ \theta\gamma_{mnp}\theta \rangle = 1$$

$w_\alpha \lambda^\beta \sim \frac{\delta_\alpha^\beta}{z}$

$\delta w_\alpha = \Lambda_m (\gamma^m \lambda)_\alpha$

$J = w_\alpha \lambda^\alpha \qquad \delta J = 0$

$J^{mn} = w_\alpha (\gamma^{mn})^\alpha{}_\beta \lambda^\beta \qquad \delta J^{mn} = 0$

$Q = \lambda^\alpha d_\alpha + \xi^m \Pi_m + \chi_\alpha \partial\theta^\alpha + \cdots$

$+ c + b(\xi\partial\xi + \lambda\partial\chi) \qquad \{d, d\} = \Pi$

$\{d, \Pi\} = \partial\theta$

$Qb = 1 \qquad \Pi\Pi \sim \frac{1}{z^2}, \ d\,\partial\theta \sim \frac{1}{z}$

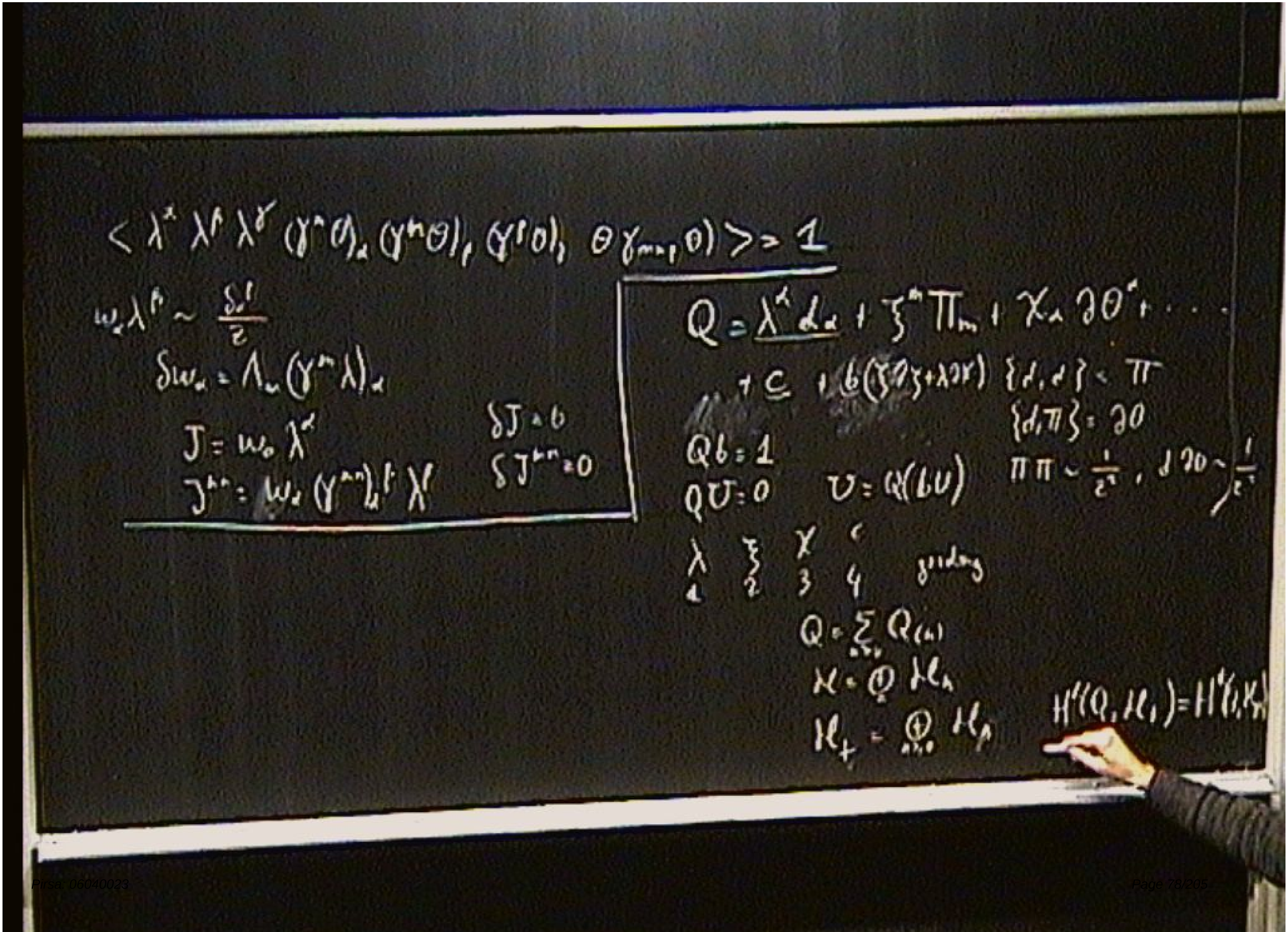
$QU = 0 \qquad U = Q(bU)$

λ	ξ	χ	c	
1	2	3	4	grading

$Q = \sum_{n \geq 1} Q_{(n)}$

$\mathcal{H} = \bigoplus \mathcal{H}_n$

$\mathcal{H}_+ = \bigoplus_{n > 0} \mathcal{H}_n \qquad H^*(Q, \mathcal{H}_+) = H^*($


< λ^α λ^β λ^γ (γ^m θ)_α (γ^n θ)_β (γ^p θ)_γ θ γ_{mnp} θ) > = 1
w_α λ^β ~ δ_α^β / z
δw_α = Λ_m (γ^m λ)_α
J = w_α λ^α
δJ = 0
J^{mn} = w_α (γ^{mn})_α^β λ^β
δJ^{mn} = 0
Q = λ^α d_α + ξ^m Π_m + χ_α ∂θ^α + . . .
+ c + b(ξ∂ξ + λ∂χ)
{d, d} ~ Π
{d, Π} = ∂θ
Qb = 1
QU = 0
U = Q(bU)
ΠΠ ~ 1/z², d∂θ ~ 1/z²
λ ξ χ c
1 2 3 4 grading
Q = Σ Q_(n)
H = ⊕ H_n
H_+ = ⊕ H_p
H^*(Q, H_+) = H^*(Q, H)

$$< \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^m\theta)_\alpha (\gamma^n\theta)_\beta (\gamma^p\theta)_\gamma \, \theta\gamma_{mnp}\theta) > = 1$$

$$w_\alpha \lambda^\beta \sim \frac{\delta^\beta_\alpha}{z}$$

$$\delta w_\alpha = \Lambda_m (\gamma^m\lambda)_\alpha$$

$$J = w_\alpha \lambda^\alpha \qquad \delta J = 0$$

$$J^{mn} = w_\alpha (\gamma^{mn})^\alpha{}_\beta \lambda^\beta \qquad \delta J^{mn} = 0$$

$$Q = \lambda^\alpha d_\alpha + \xi^m \Pi_m + \chi_\alpha \partial\theta^\alpha + \cdots$$

$$+ c + b(\xi\partial\xi + \lambda\partial\chi) \qquad \{d,d\} \sim \Pi$$

$$\{d,\Pi\} = \partial\theta$$

$$Qb = 1 \qquad \Pi\Pi \sim \frac{1}{z^2}, \; d\,\partial\theta \sim \frac{1}{z}$$

$$QU = 0 \qquad U = Q(bU)$$

λ	ξ	χ	c	
1	2	3	4	grading

$$Q = \sum_{n\geq 0} Q_{(n)}$$

$$\mathcal{H} = \bigoplus \mathcal{H}_n$$

$$\mathcal{H}_+ = \bigoplus_{n>0} \mathcal{H}_n$$

$$H^*(Q,\mathcal{H}_+) = H^*(Q,\mathcal{H}$$

$$< \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^m \theta)_\alpha (\gamma^n \theta)_\beta (\gamma^p \theta)_\gamma \; \theta \gamma_{mnp} \theta) > = 1$$

$$w_\alpha \lambda^\beta \sim \frac{\delta_\alpha^\beta}{z}$$

$$\delta w_\alpha = \Lambda_m (\gamma^m \lambda)_\alpha$$

$$J = w_\alpha \lambda^\alpha \qquad \delta J = 0$$

$$J^{mn} = w_\alpha (\gamma^{mn})_\alpha{}^\beta \lambda \qquad \delta J^{mn} = 0$$

$$Q = \lambda^\alpha d_\alpha + \xi^m \Pi_m + \chi_\alpha \partial\theta^\alpha + \cdots$$

$$+ c + b(\xi \partial \xi + \lambda \partial \chi) \qquad \{d, d\} = \Pi$$

$$\{d, \Pi\} = \partial\theta$$

$$Qb = 1$$

$$QU = 0 \qquad U = Q(bU) \qquad \Pi\Pi \sim \frac{1}{z^2}, \; d\,\partial\theta \sim \frac{1}{z}$$

λ	ξ	χ	c	grading
1	2	3	4	

$$Q = \sum Q_{(n)}$$

$$\mathcal{H} = \bigoplus \mathcal{H}_n$$

$$\mathcal{H}_+ = \bigoplus_{n>0} \mathcal{H}_n$$

$$H^*(Q, \mathcal{H}_+) = H^*(Q, \mathcal{H})$$

$$\langle \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^m\theta)_\alpha (\gamma^n\theta)_\beta (\gamma^p\theta)_\gamma \, \theta\gamma_{mnp}\theta \rangle = 1$$

$$w_\alpha \lambda^\beta \sim \frac{\delta_\alpha^\beta}{z}$$

$$\delta w_\alpha = \Lambda_m (\gamma^m \lambda)_\alpha$$

$$J = w_\alpha \lambda^\alpha \qquad \delta J = 0$$

$$J^{mn} = w_\alpha (\gamma^{mn})_\alpha{}^\beta \lambda^\beta \qquad \delta J^{mn} = 0$$

$$Q = \underline{\lambda^\alpha d_\alpha} + \xi^m \Pi_m + \chi_\alpha \partial\theta^\alpha + \cdots$$

$$+ \underline{c} + b(\xi\partial\xi + \lambda\partial\chi)$$

$$\{d, d\} = \Pi$$

$$\{d, \Pi\} = \partial\theta$$

$$Qb = 1$$

$$QU = 0 \qquad U = Q(bU)$$

$$\Pi\Pi \sim \frac{1}{z^2}, \quad d\,\partial\theta \sim \frac{1}{z}$$

λ	ξ	χ	c	
1	2	3	4	grading

$$Q = \sum_{n=0} Q_{(n)}$$

$$\mathcal{H} = \bigoplus \mathcal{H}_n$$

$$\mathcal{H}_+ = \bigoplus_{n>0} \mathcal{H}_n$$

$$\boxed{H^*(Q, \mathcal{H}_+) = H^*(Q, \mathcal{H})}$$

$$\langle \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^m\theta)_\alpha (\gamma^n\theta)_\beta (\gamma^p\theta)_\gamma \, \theta\gamma_{mnp}\theta \rangle = 1$$

$w_\alpha \lambda^\beta \sim \frac{\delta_\alpha^\beta}{z}$

$\delta w_\alpha = \Lambda_m (\gamma^m \lambda)_\alpha$

$J = w_\alpha \lambda^\alpha \qquad \delta J = 0$

$J^{mn} = w_\alpha (\gamma^{mn})^\alpha{}_\beta \lambda^\beta \qquad \delta J^{mn} = 0$

$Q = \lambda^\alpha d_\alpha + \xi^m \Pi_m + \chi_\alpha \partial\theta^\alpha + \cdots$

$+ c + b(\xi\partial\xi + \lambda\partial\chi) \qquad \{d,d\} = \Pi$

$\{d,\Pi\} = \partial\theta$

$Qb = 1$

$QU = 0 \qquad U = Q(bU) \qquad \Pi\Pi \sim \frac{1}{z^2}, \; d\,\partial\theta \sim \frac{1}{z}$

	λ	ξ	χ	c
grading	1	2	3	4

$Q = \sum Q_{(n)}$

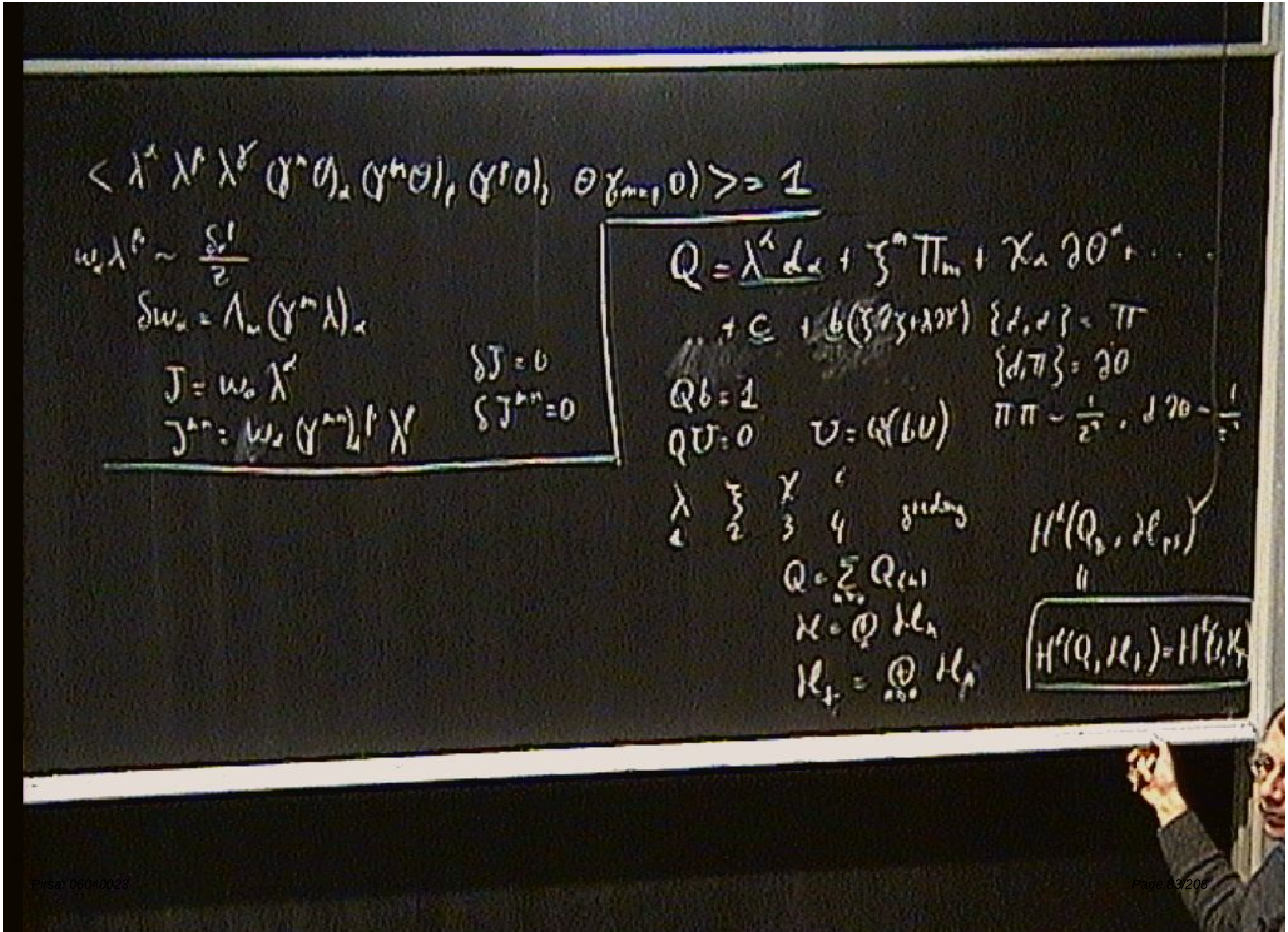
$\mathcal{H} = \bigoplus \mathcal{H}_n$

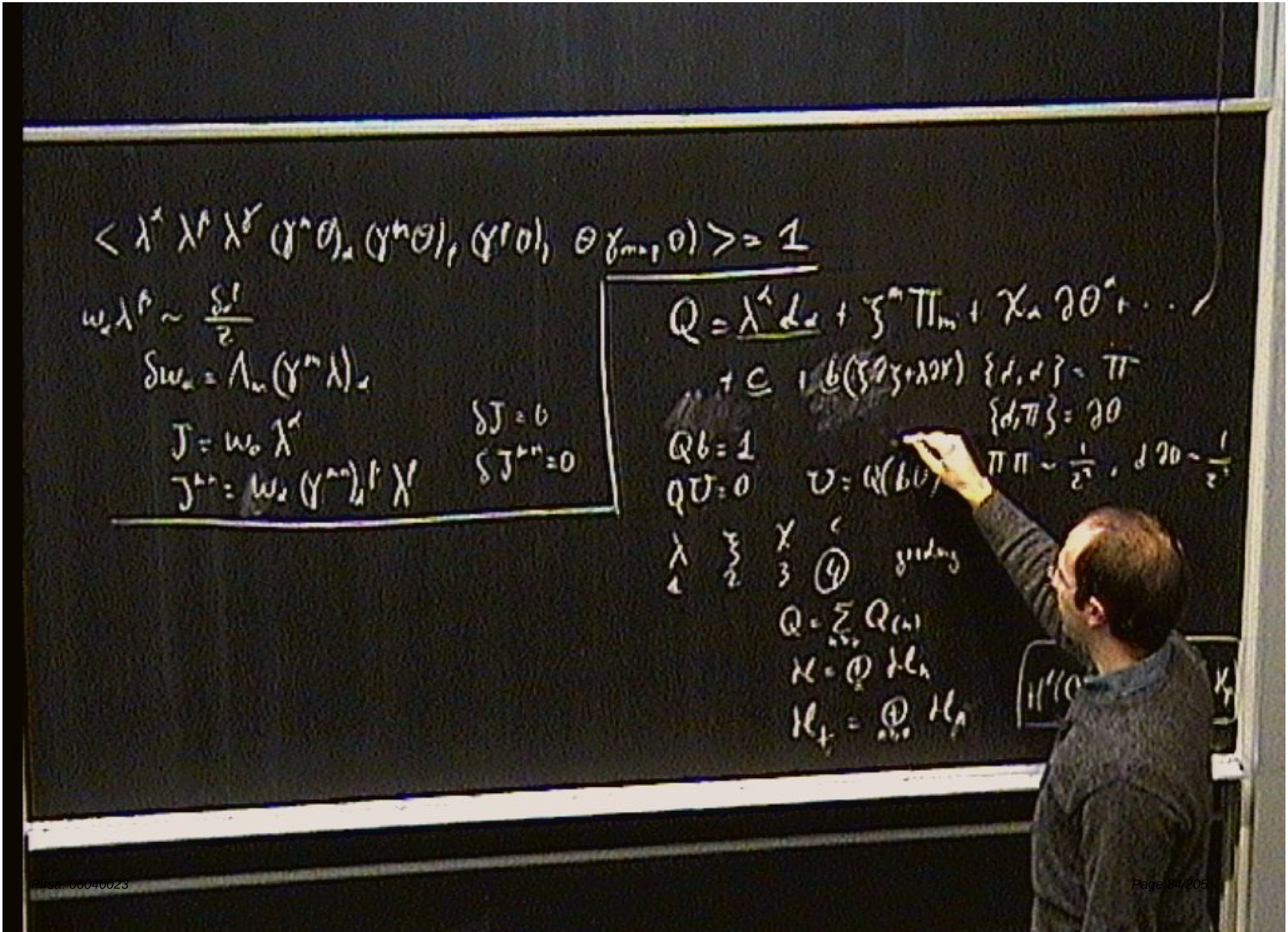
$\mathcal{H}_+ = \bigoplus_{n>0} \mathcal{H}_n$

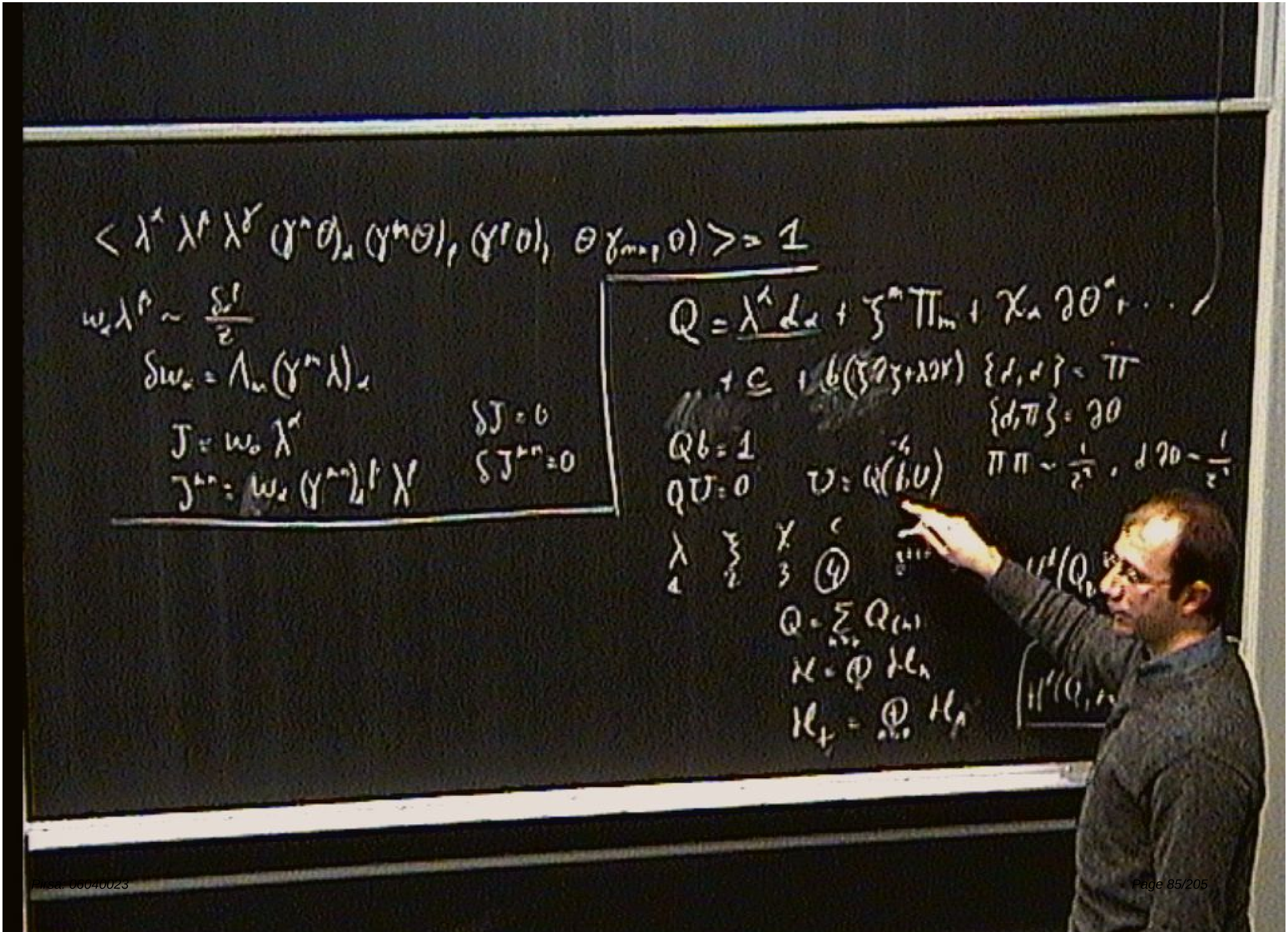
$H^{*}(Q_1, \mathcal{H}_{n})$

$||$

$H^{*}(Q, \mathcal{H}_+) = H^{*}(Q_1 \ldots)$


Q = λ^α d_α + ξ^m Π_m + χ_α ∂θ^α + . . .
Qb = 1
QU = 0
U = Q(bU)
grading


Q b = 1
Q U = 0
grading



Q = λ^α d_α + ξ^m Π_m + χ_α ∂θ^α + ...
Qb = 1
QU = 0
{d, d} = Π
{d, Π} = ∂θ
Q = Σ Q_(n)

$$\langle \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^m\theta)_\alpha (\gamma^n\theta)_\beta (\gamma^p\theta)_\gamma \; \theta\gamma_{mnp}\theta \rangle = 1$$

$w_\alpha \lambda^\beta \sim \frac{\delta_\alpha^\beta}{z}$

$\delta w_\alpha = \Lambda_m (\gamma^m \lambda)_\alpha$

$J = w_\alpha \lambda^\alpha \qquad \delta J = 0$

$J^{mn} = w_\alpha (\gamma^{mn})_\beta{}^\alpha \lambda^\beta \qquad \delta J^{mn} = 0$

$Q = \lambda^\alpha d_\alpha + \xi^m \Pi_m + \chi_\alpha \partial\theta^\alpha + \cdots$

$+ c + b(\xi\partial\xi + \lambda\partial\chi) \qquad \{d, d\} = \Pi$

$\{d, \Pi\} = \partial\theta$

$Qb = 1$

$QU = 0 \qquad U = Q(bU) \qquad \Pi\Pi \sim \frac{1}{z^2}, \; d\,\partial\theta \sim \frac{1}{z}$

$\lambda \;\; \xi \;\; \chi \;\; c$

$4 \;\; 2 \;\; 3 \;\; (4)$ grading

$Q = \sum_{n \geq 0} Q_{(n)}$

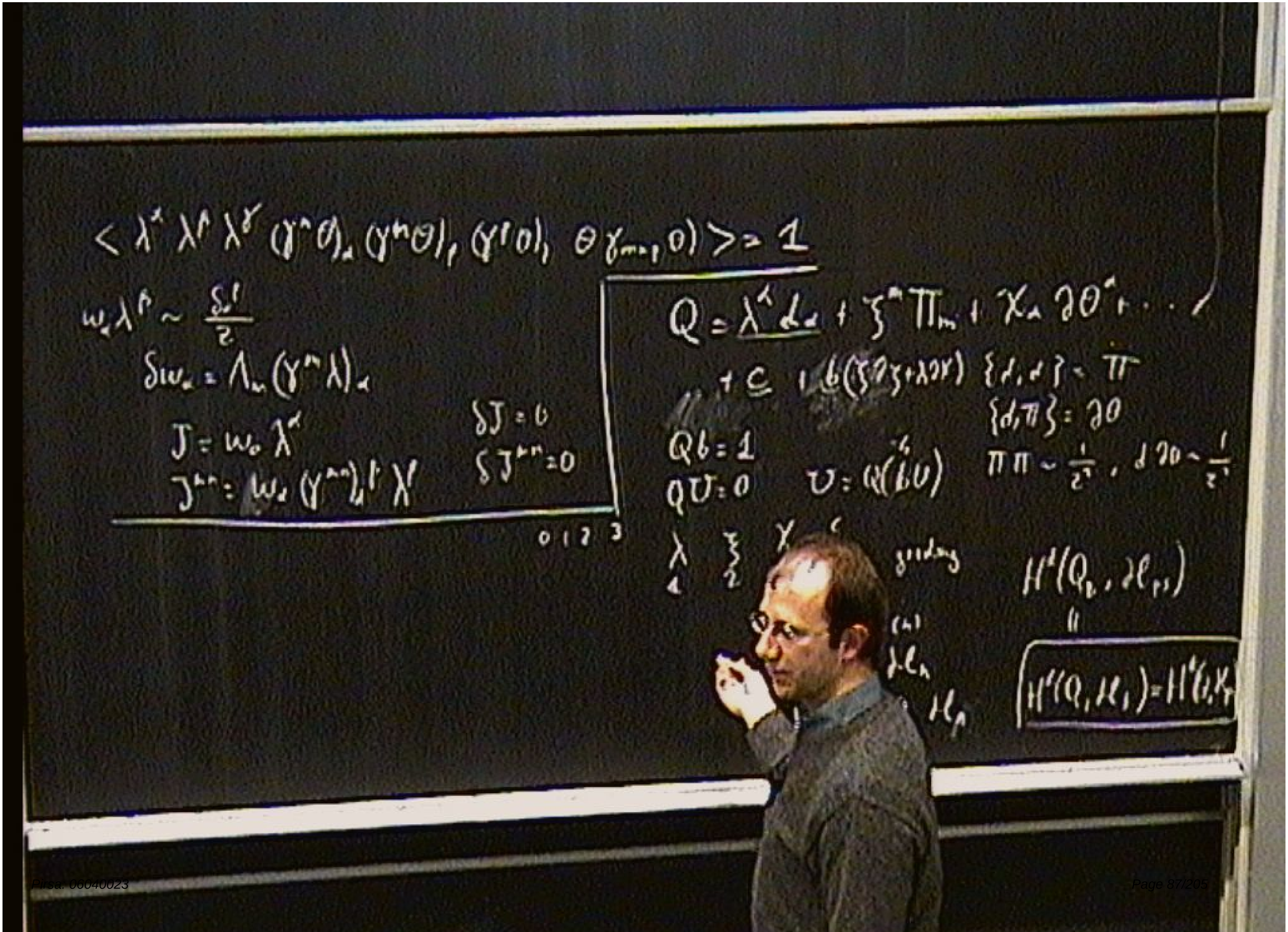
$\mathcal{H} = \oplus \mathcal{H}_n$

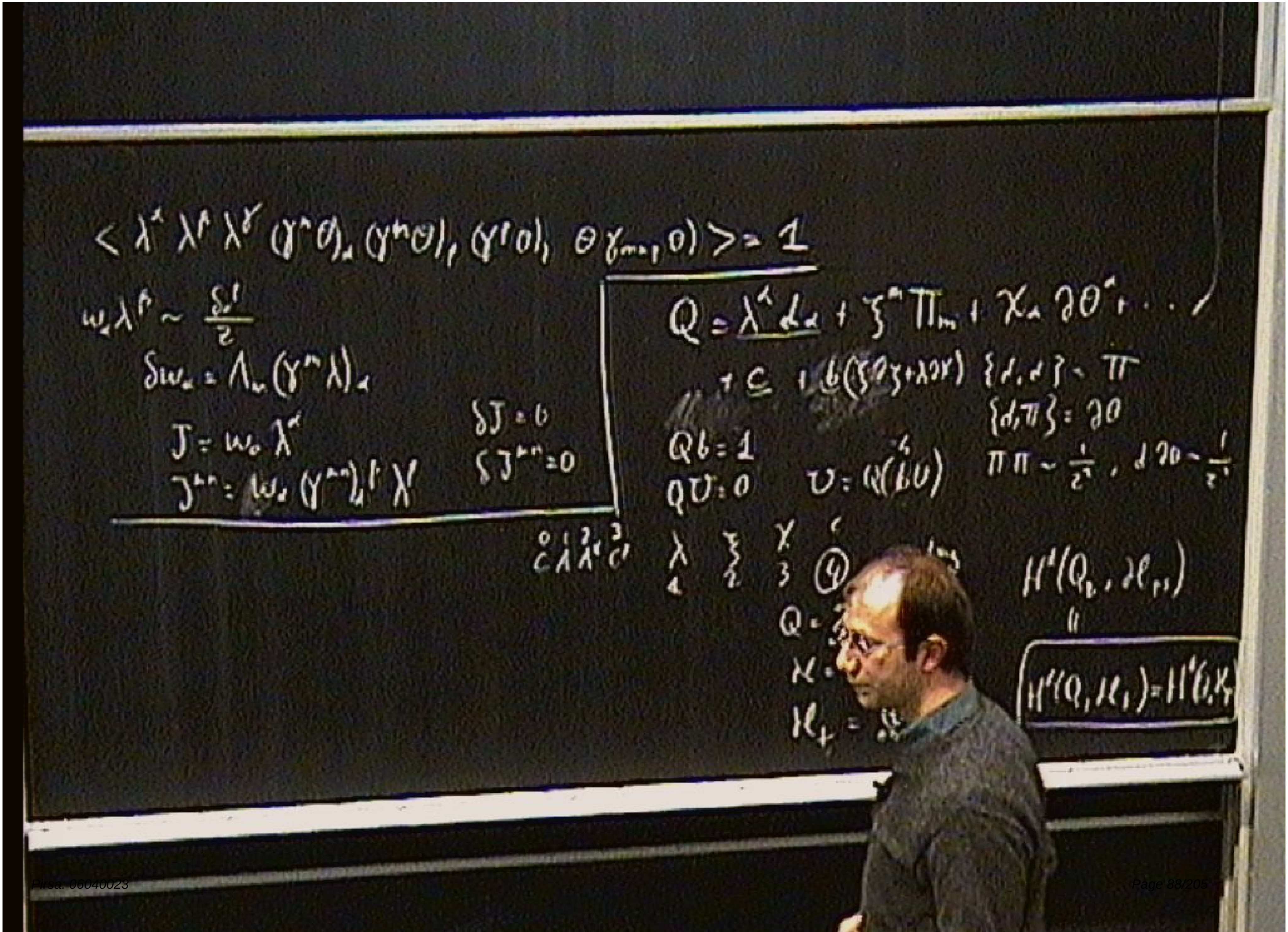
$\mathcal{H}_+ = \oplus_{n>0} \mathcal{H}_n$

$H^*(Q_0, \mathcal{H}_{ps})$

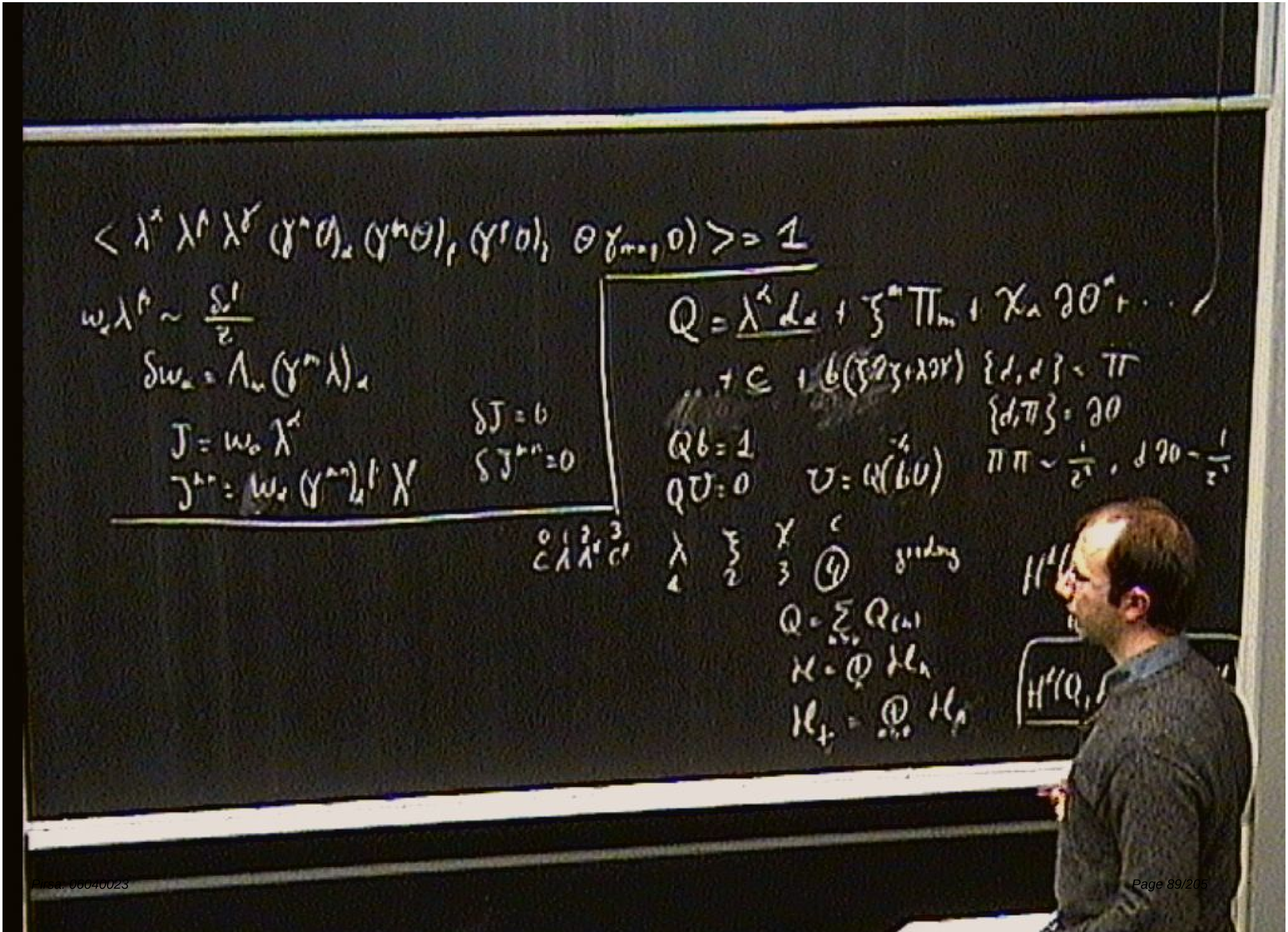
$\parallel$

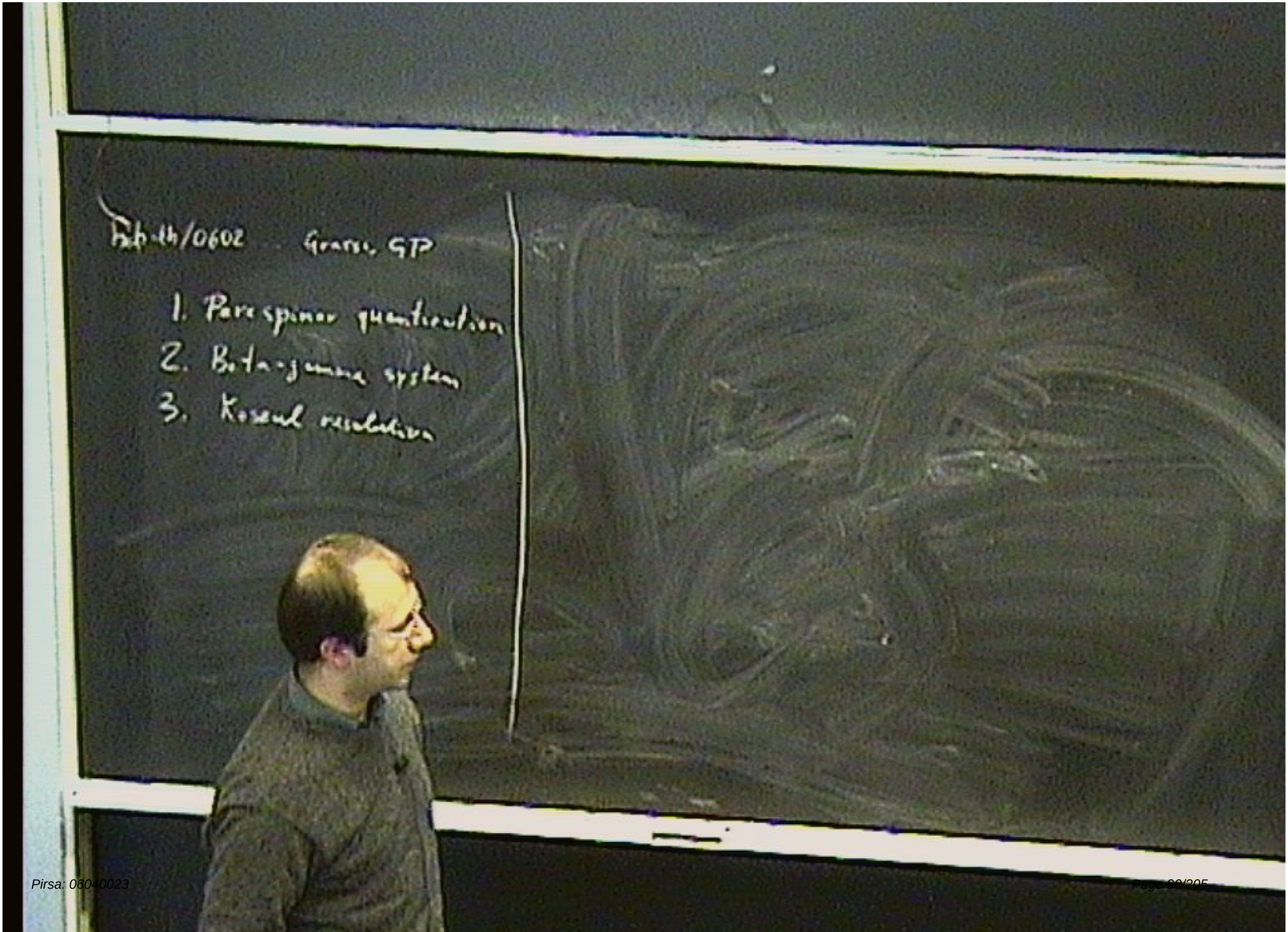
$H^*(Q, \mathcal{H}_+) = H^*(\ldots)$

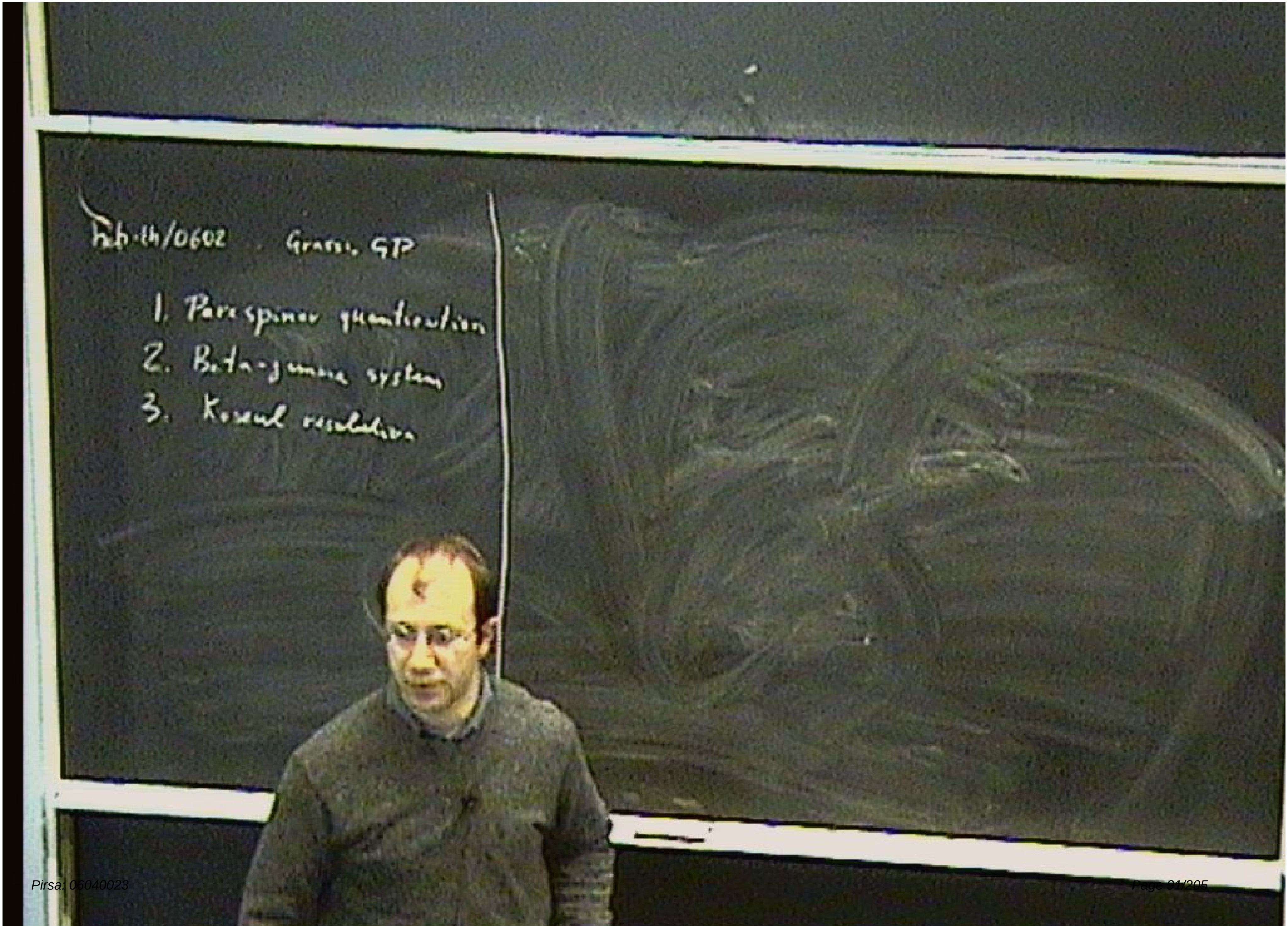

Qb = 1
QU = 0
grading
0 1 2 3

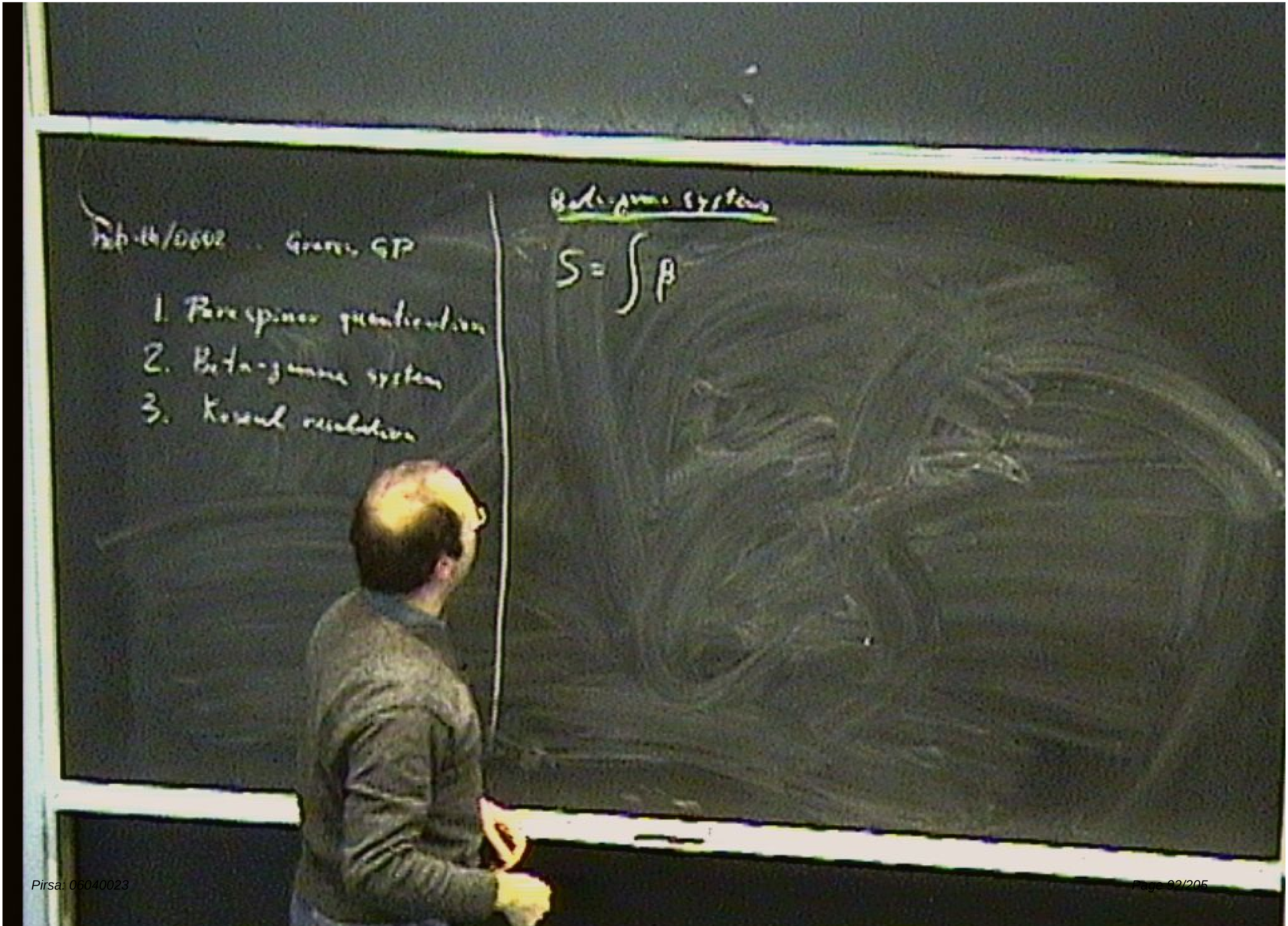


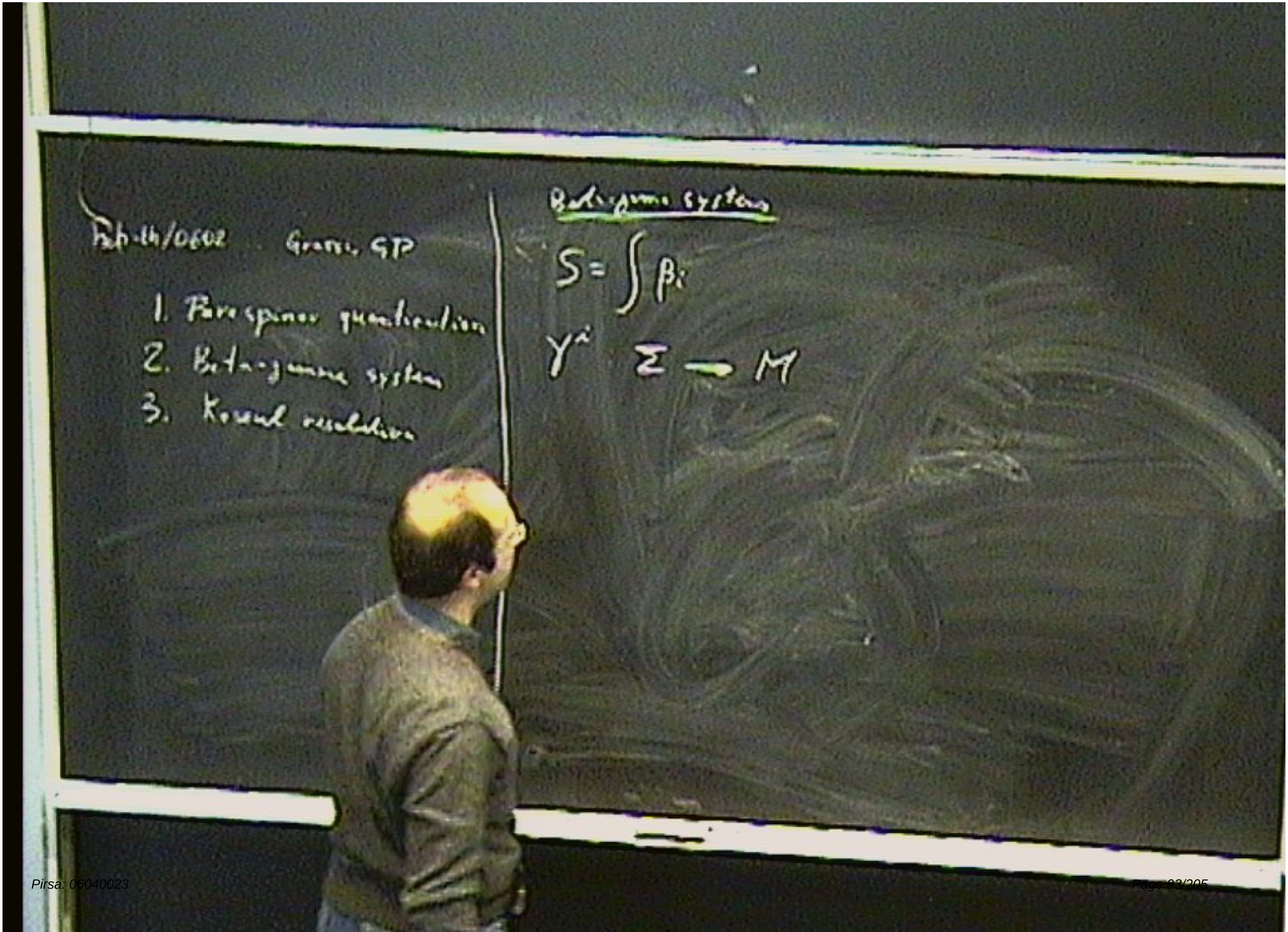
< λ^α λ^β λ^γ (γ^m θ)_α (γ^n θ)_β (γ^p θ)_γ θ γ_mnp θ) > = 1
Q = λ^α d_α + ξ^m Π_m + χ_α ∂θ^α + . . .
{d, d} ~ Π
{d, Π} = ∂θ
Qb = 1
QU = 0
ΠΠ ~ 1/z², dθ ~ 1/z
δw_α = Λ_m (γ^m λ)_α
J = w_α λ^α
δJ = 0
δJ^mn = 0
H^*(Q, H_1) = H^*(Q, K_1)

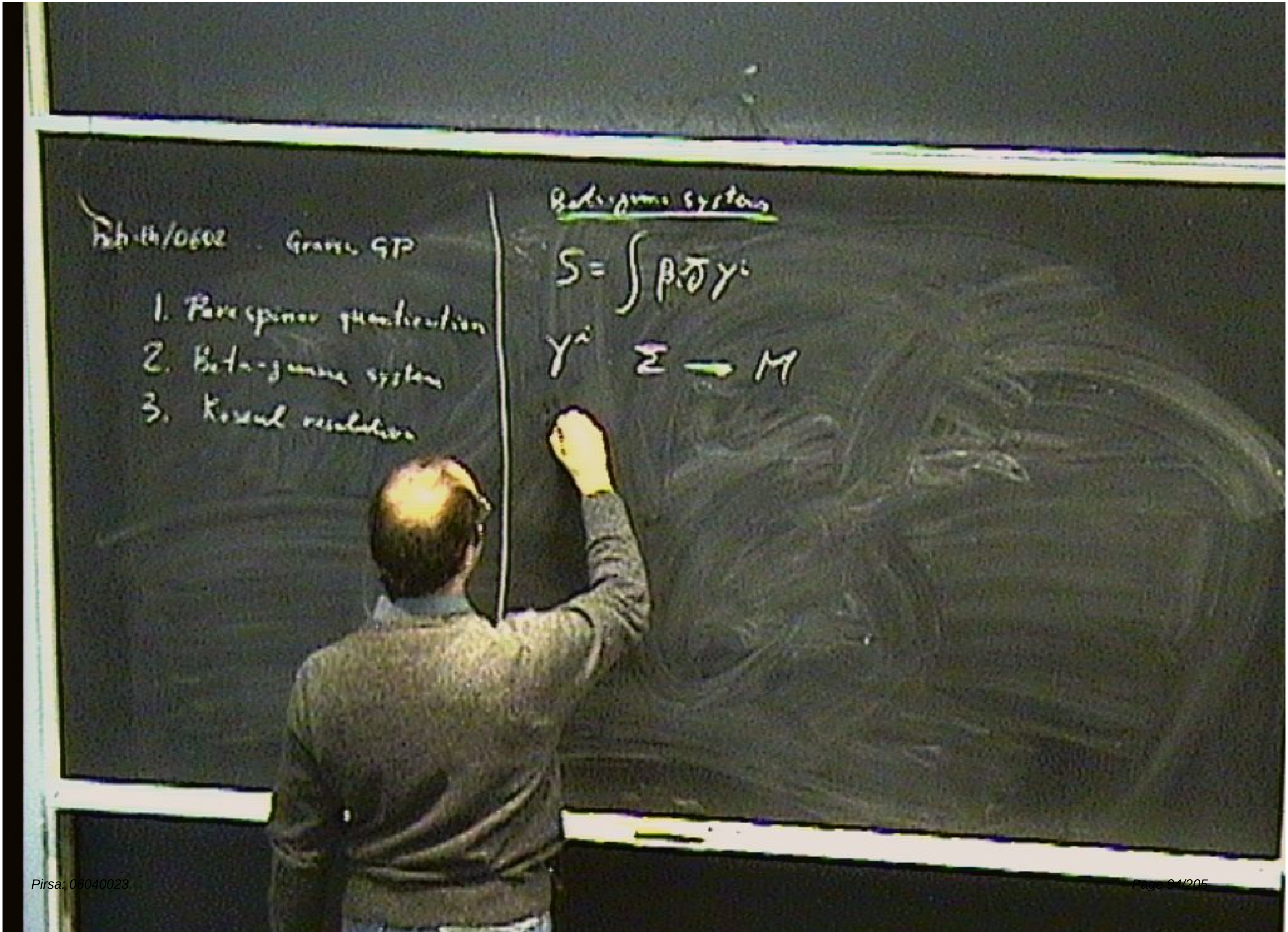

Q b = 1
Q U = 0
{d, d} ~ Π
{d, Π} ~ ∂θ
grading

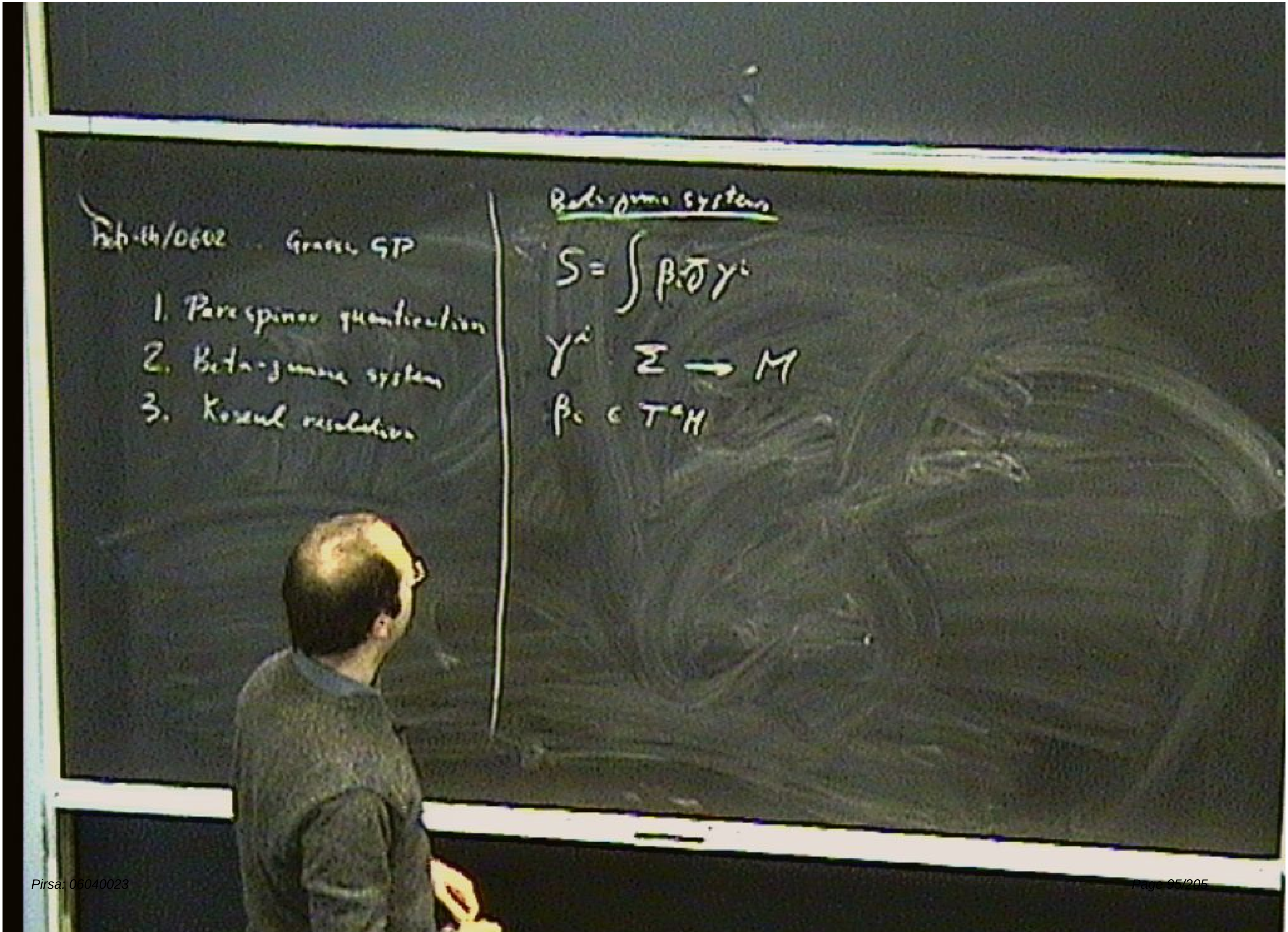

1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution

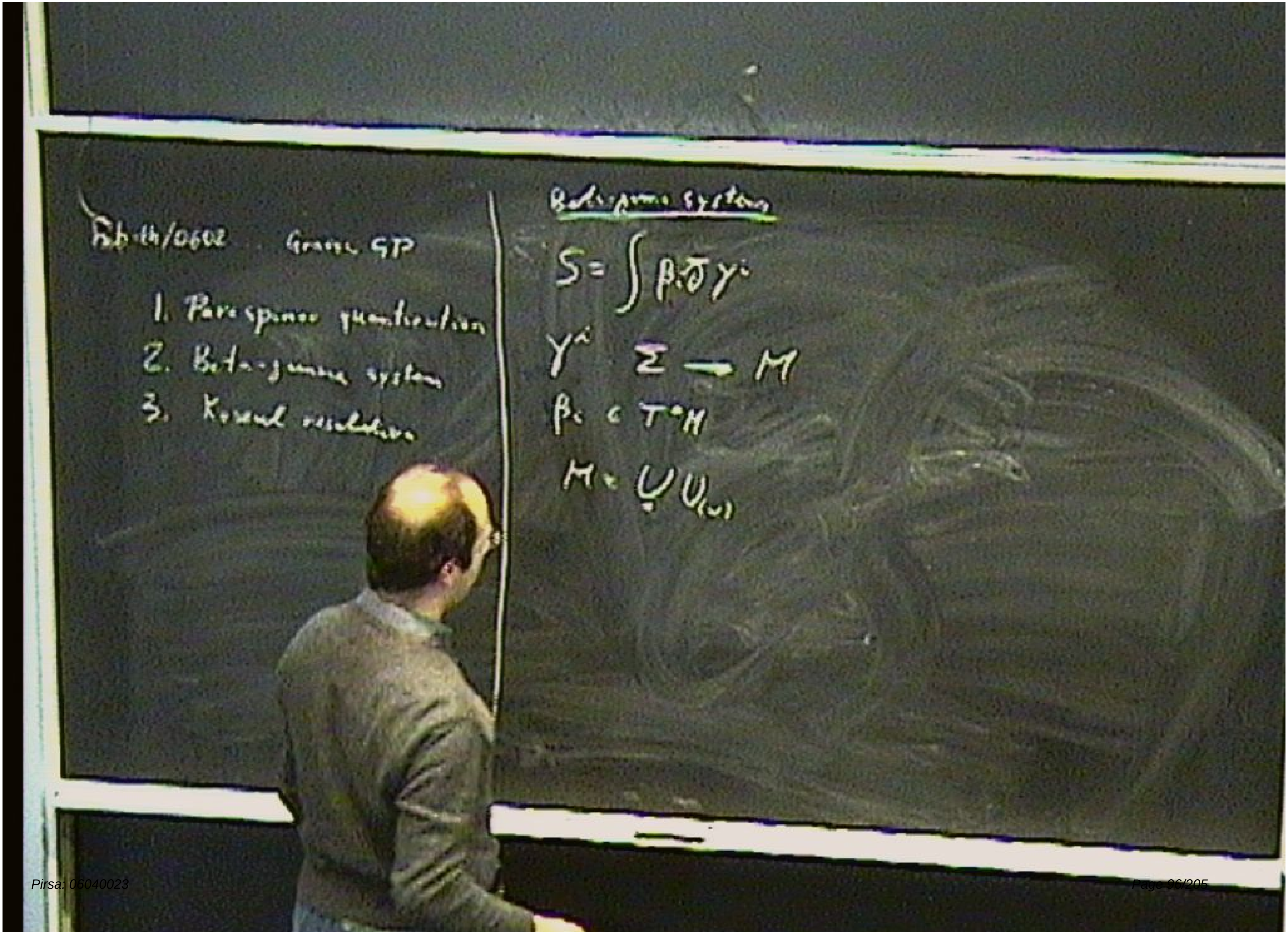

hep-th/0602 Grass. GP
1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution


1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution
Beta-gamma system
S = ∫β

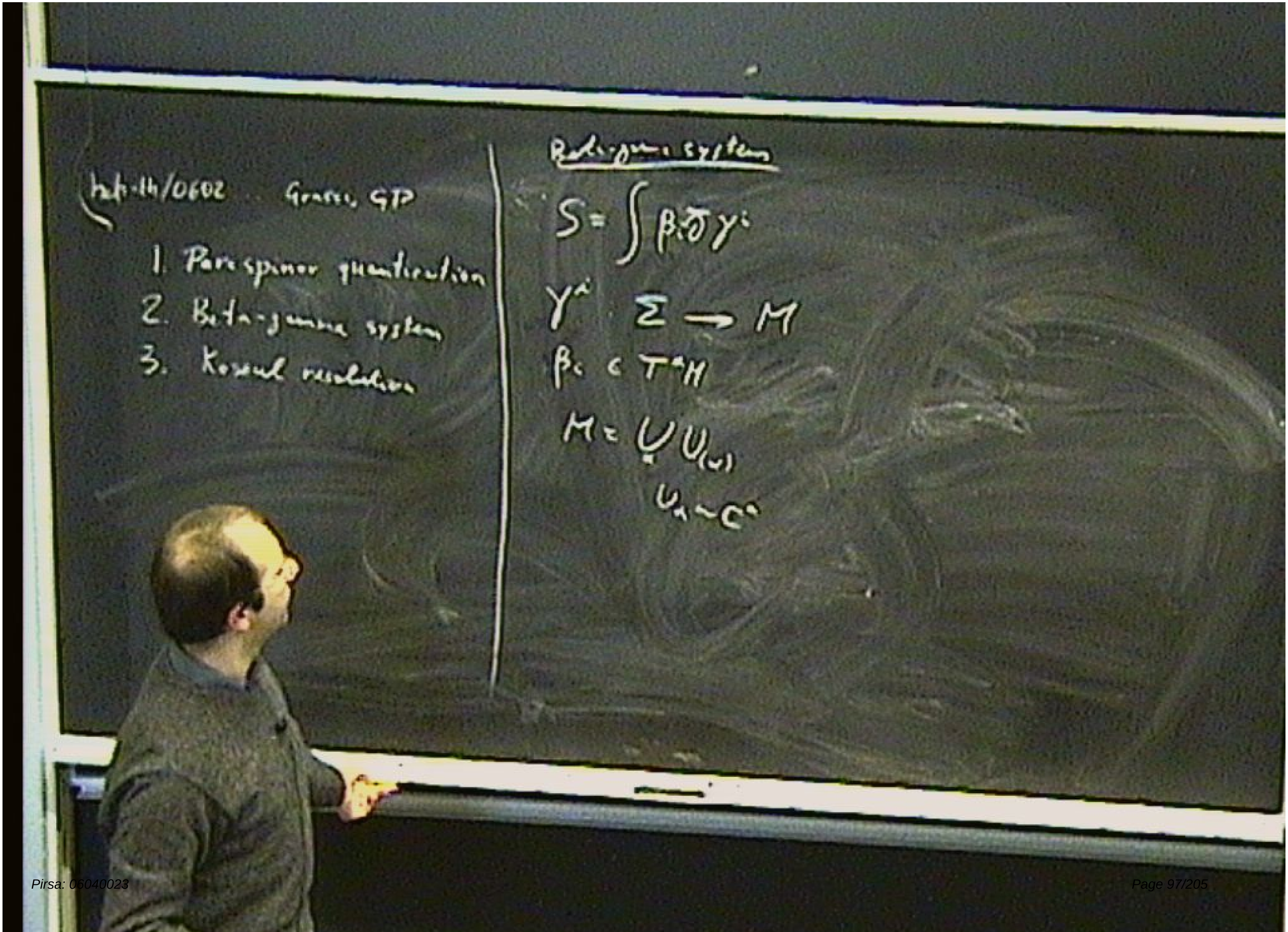

1. Pure spinor quantization
2. Beta-gamma system
3. Kernel resolution
Beta-gamma system
S = ∫ β
γ
Σ → M

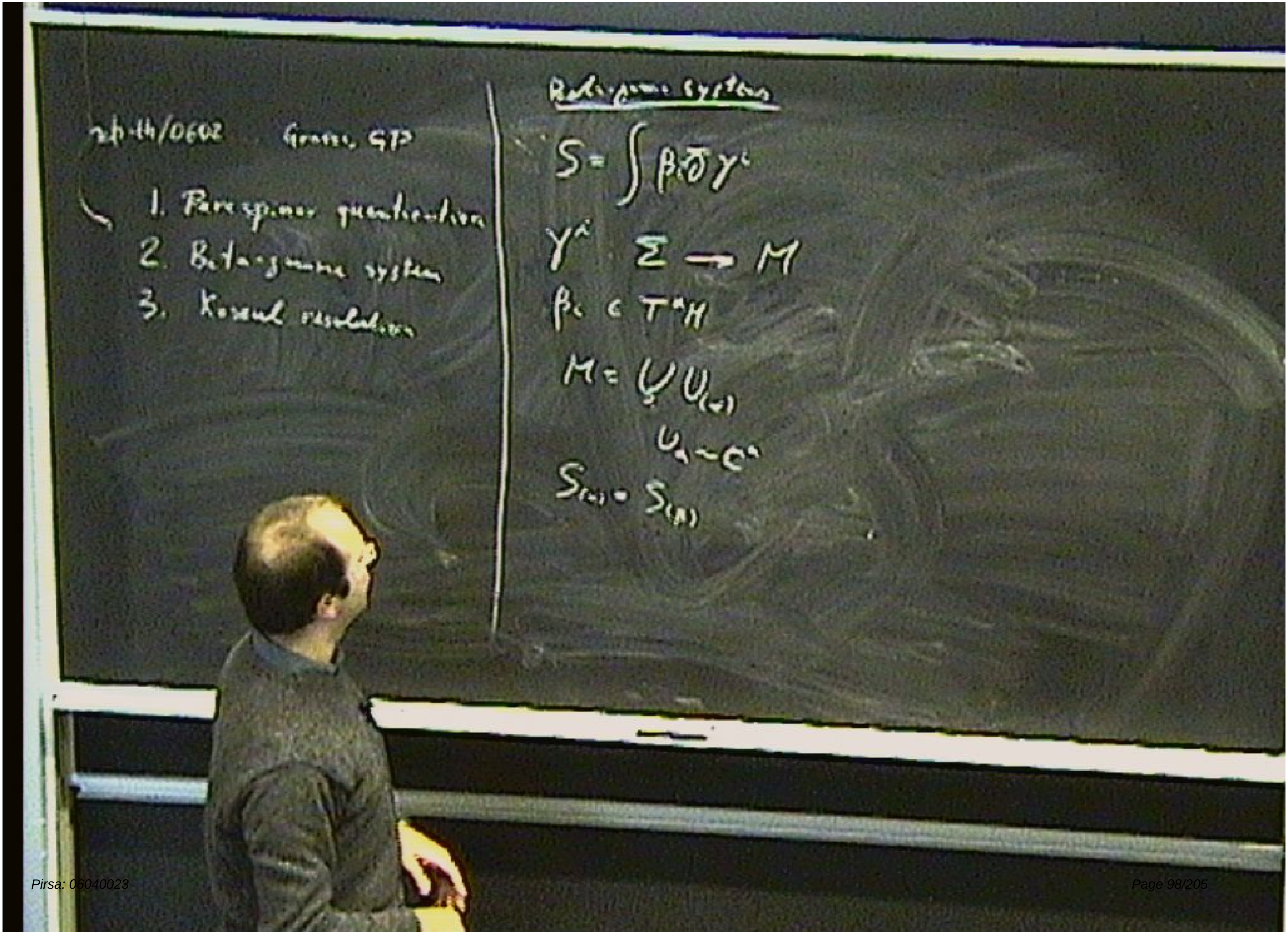

1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution
Beta-gamma system
$S = \int \beta_i \bar{\partial} \gamma^i$
$\gamma^i \quad \Sigma \to M$

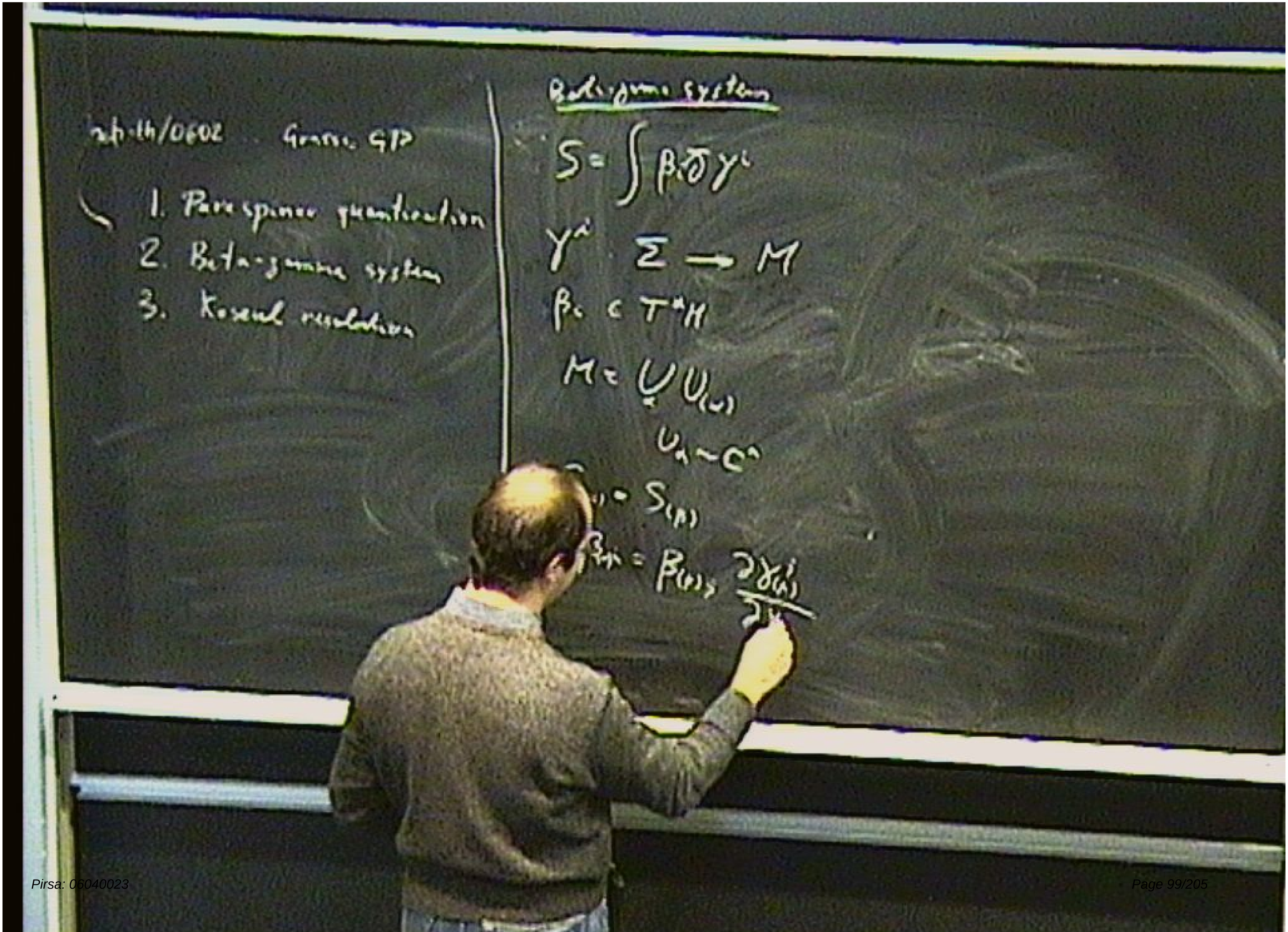

2. Beta-gamma system
3. Koszul resolution
Beta-gamma system
$S = \int \beta_i \bar{\partial} \gamma^i$
$\gamma^i \quad \Sigma \to M$

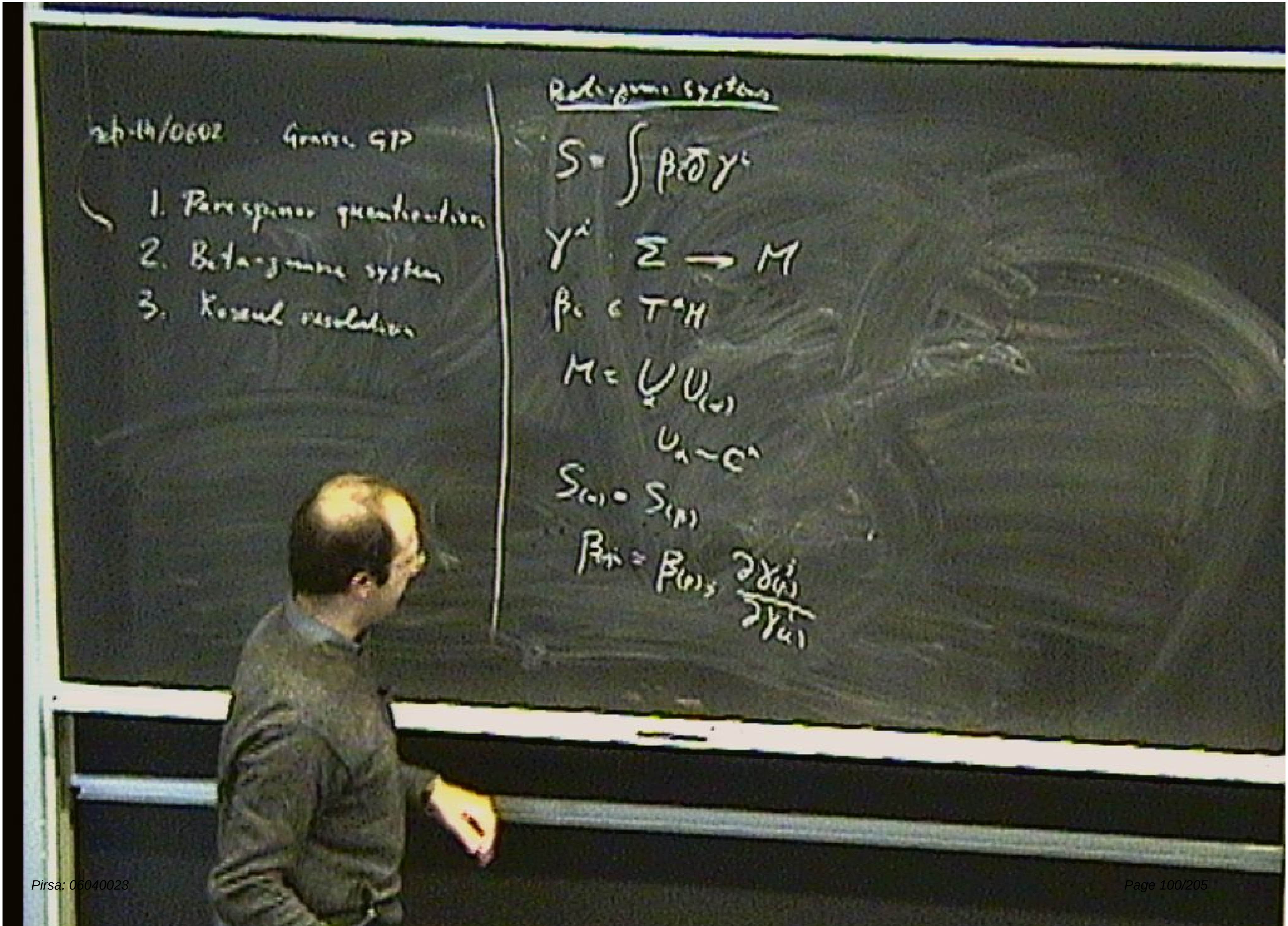


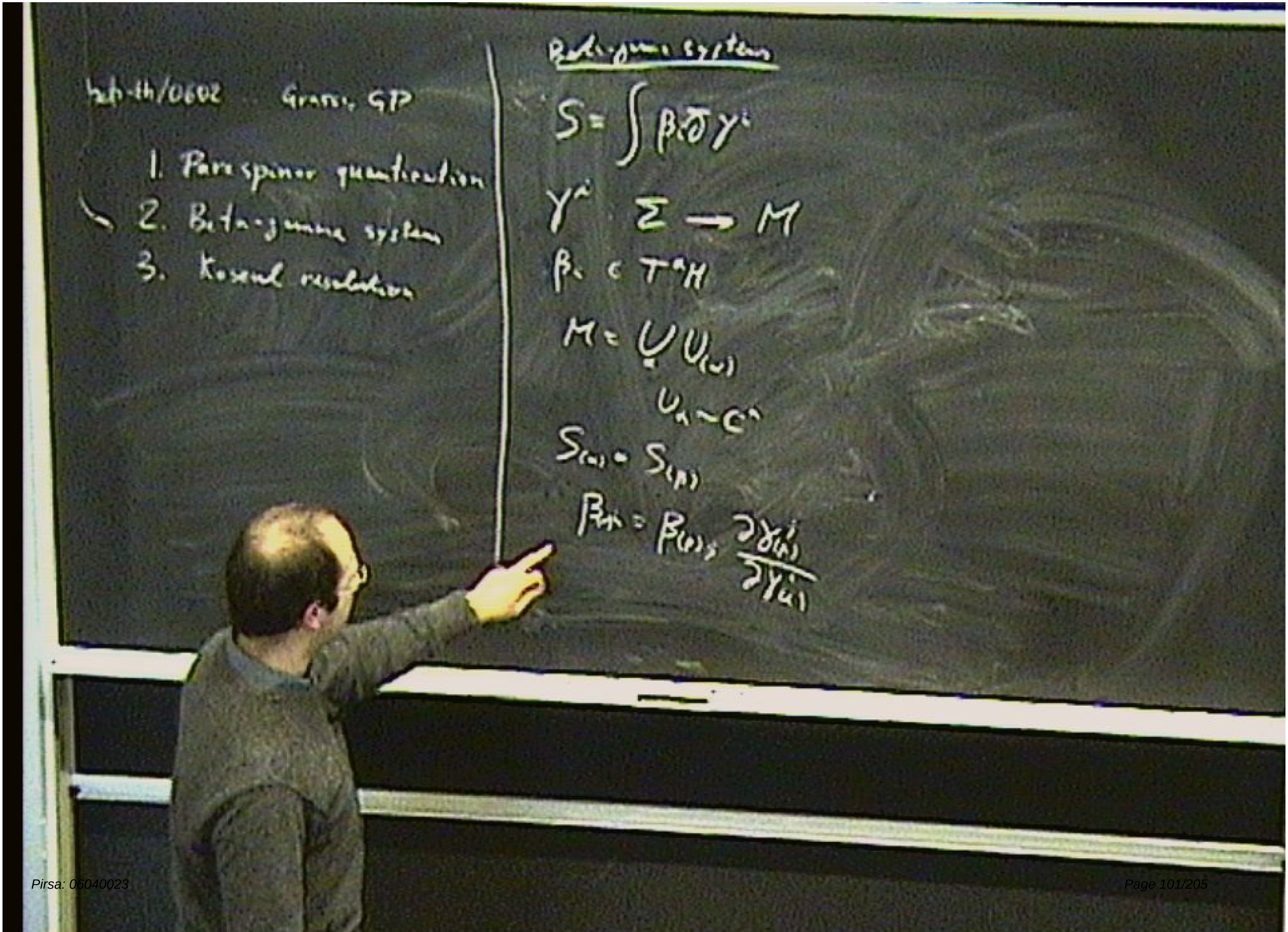
1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution
Beta-gamma system

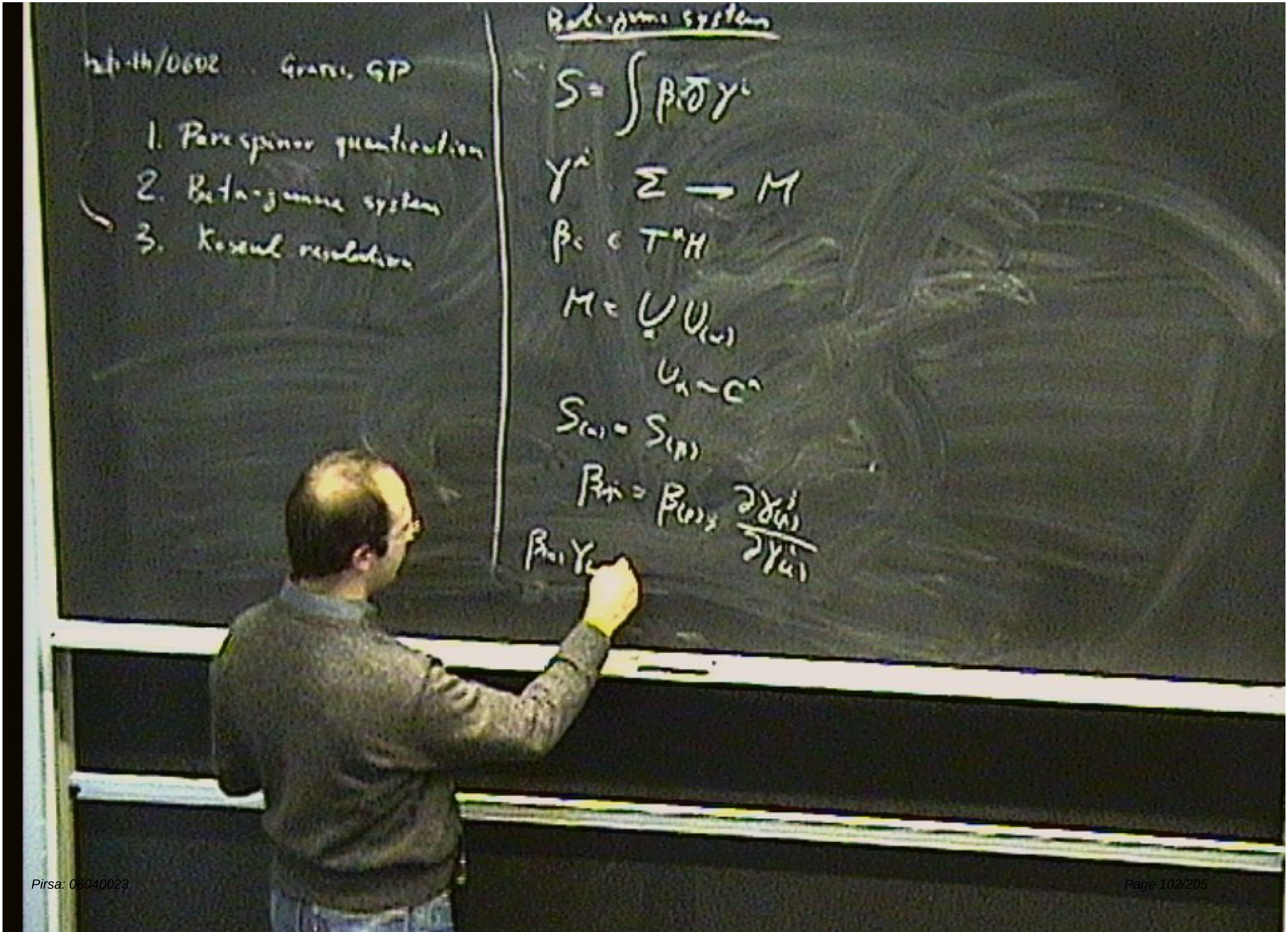

1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution
Beta-gamma system
S = ∫ β_i ∂̄ γ^i
γ^i : Σ → M
β_i ∈ T*M
M = ∪ U_(α)
U_α ~ C^n


Beta-gamma system
1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution

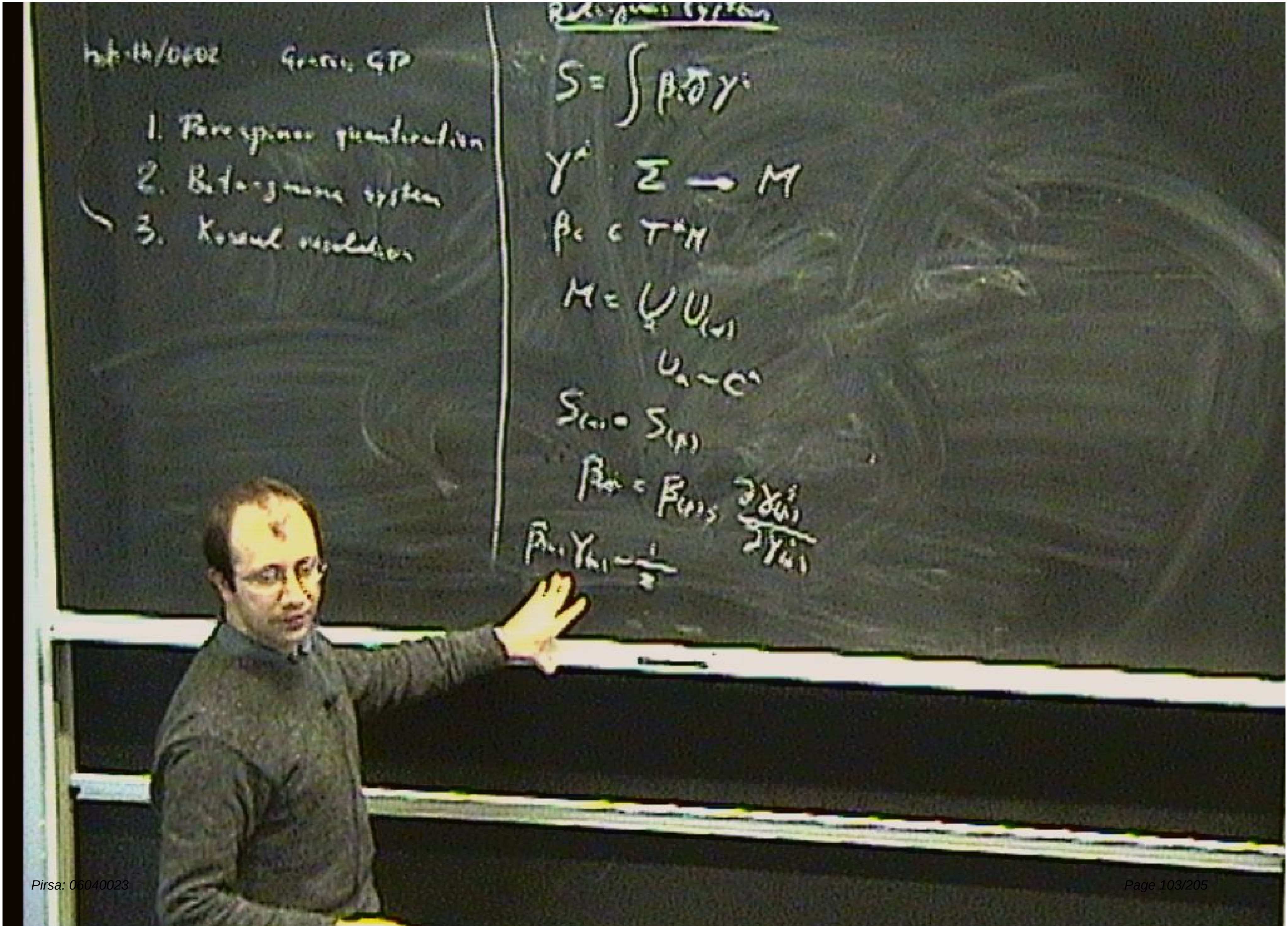

1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution
Beta-gamma system

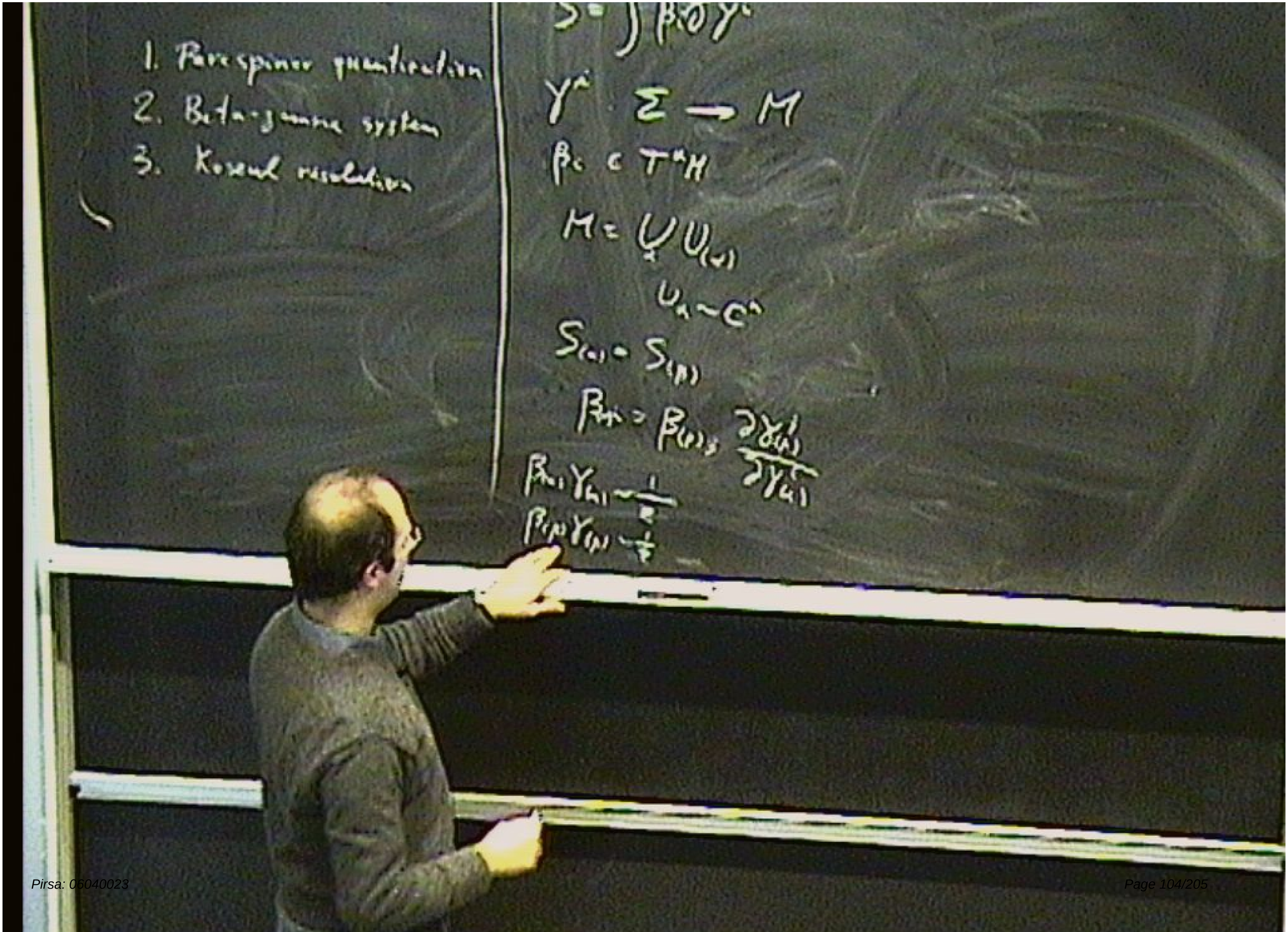

Beta-gamma system
1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution

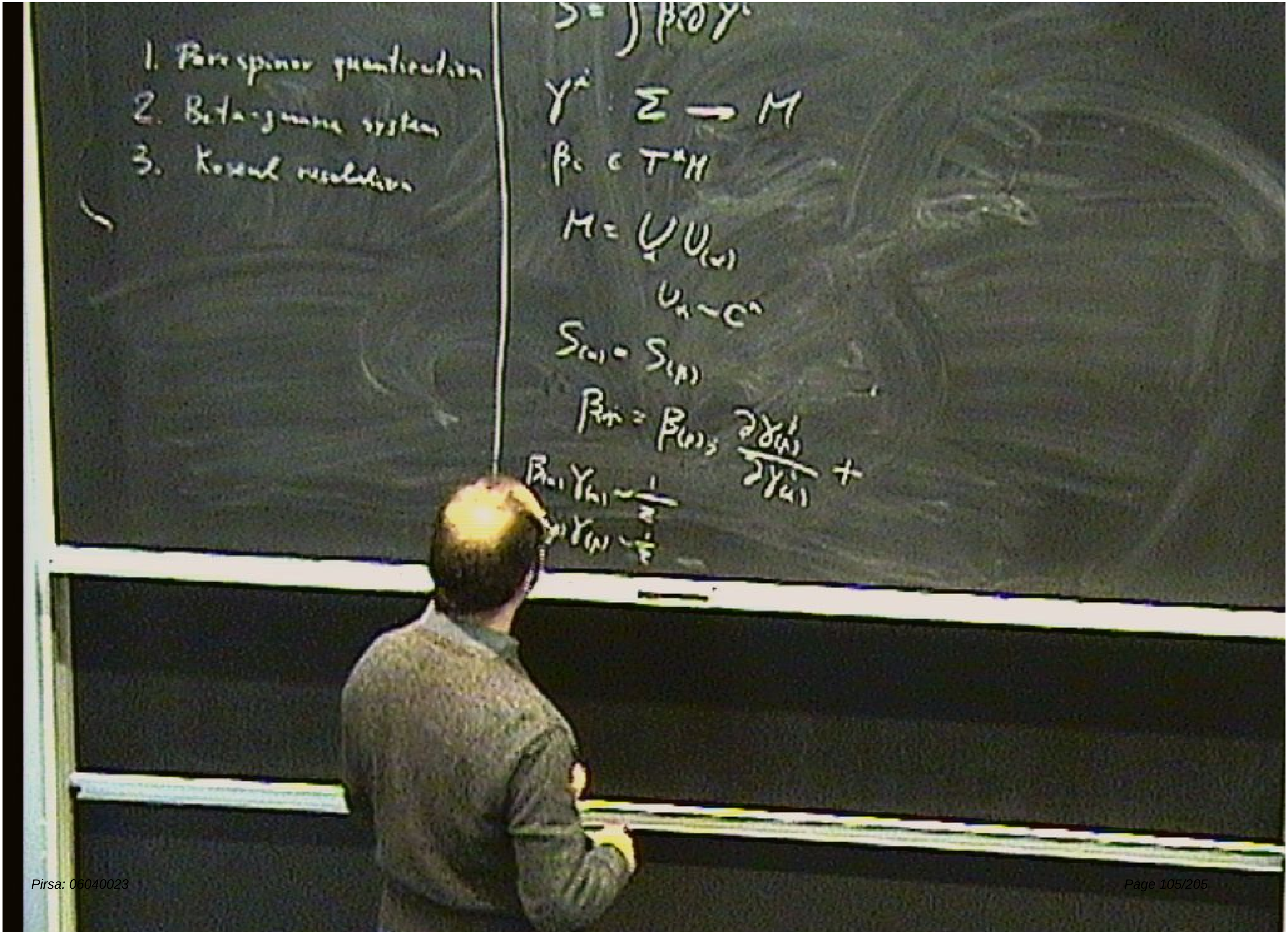

hep-th/0602 Grassi, GP
1. Parraspinor quantization
2. Beta-gamma system
3. Koszul resolution
Beta-gamma system
S = ∫ β ∂̄ γ^i
γ^i Σ → M
β_i ∈ T*M
M = ∪ U_(α)
U_α ~ C^n
S_(α) = S_(β)
β_(α)i = β_(β)j ∂γ^j_(β) / ∂γ^i_(α)

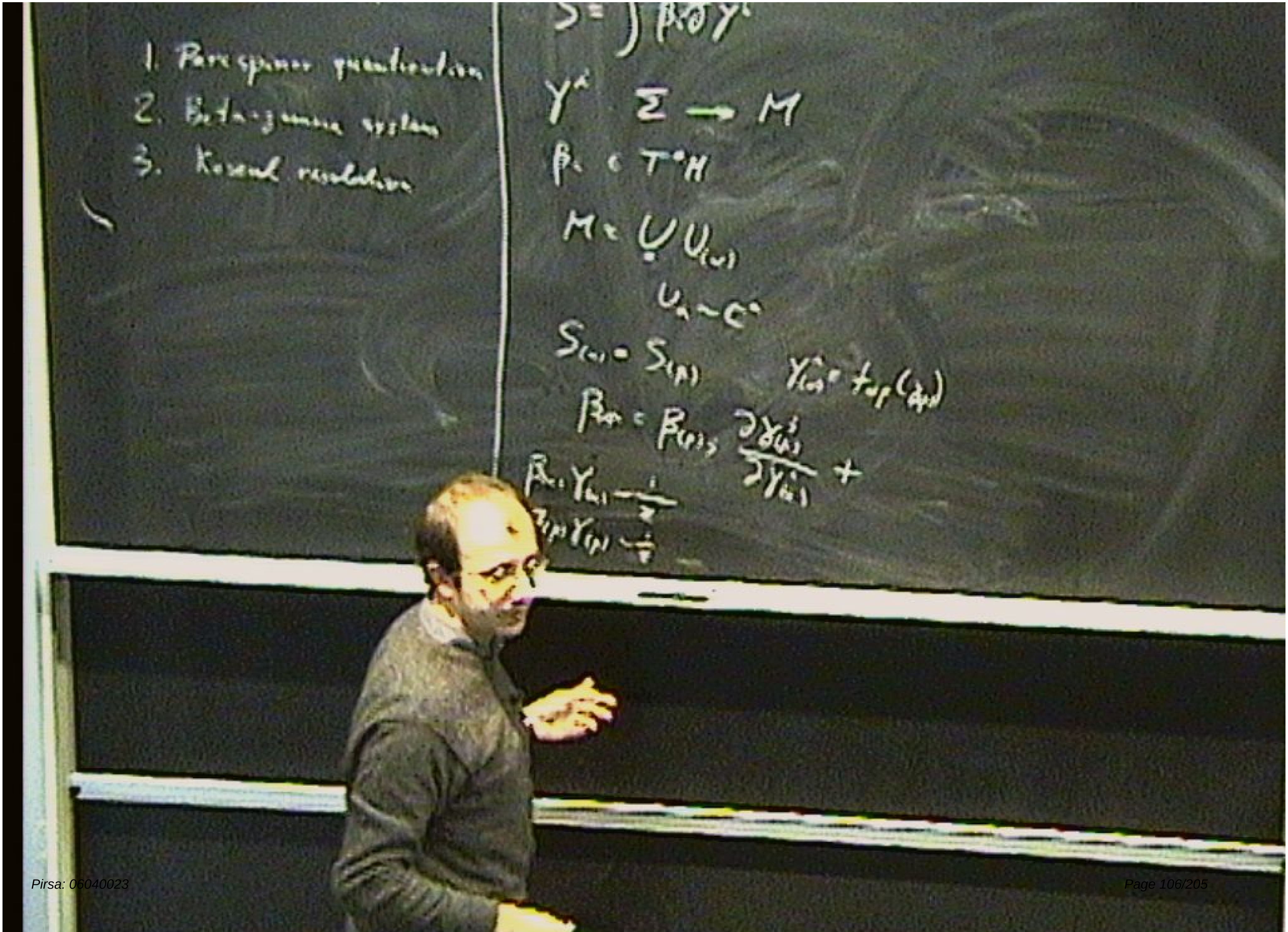


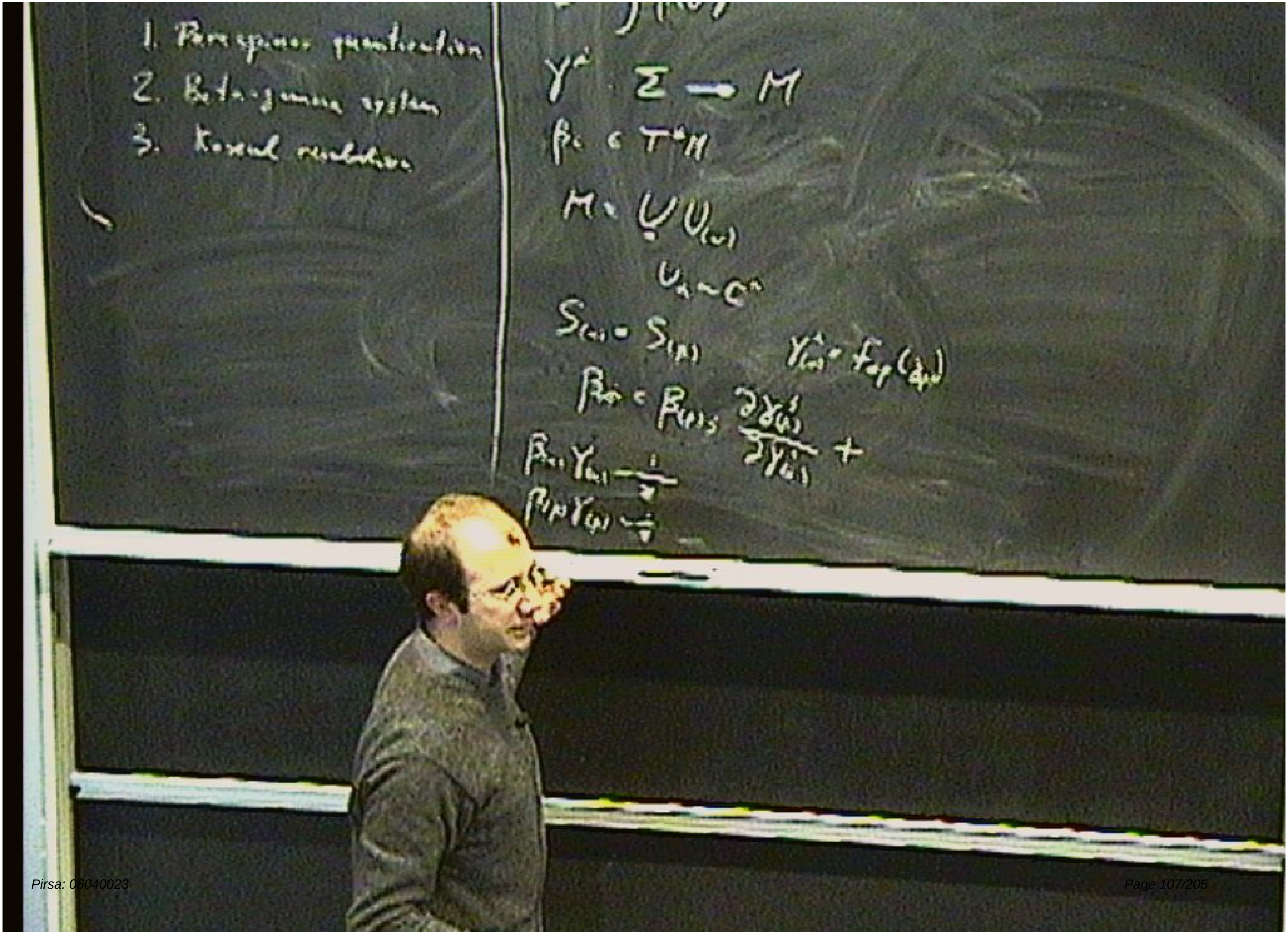
Beta-gamma system
1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution

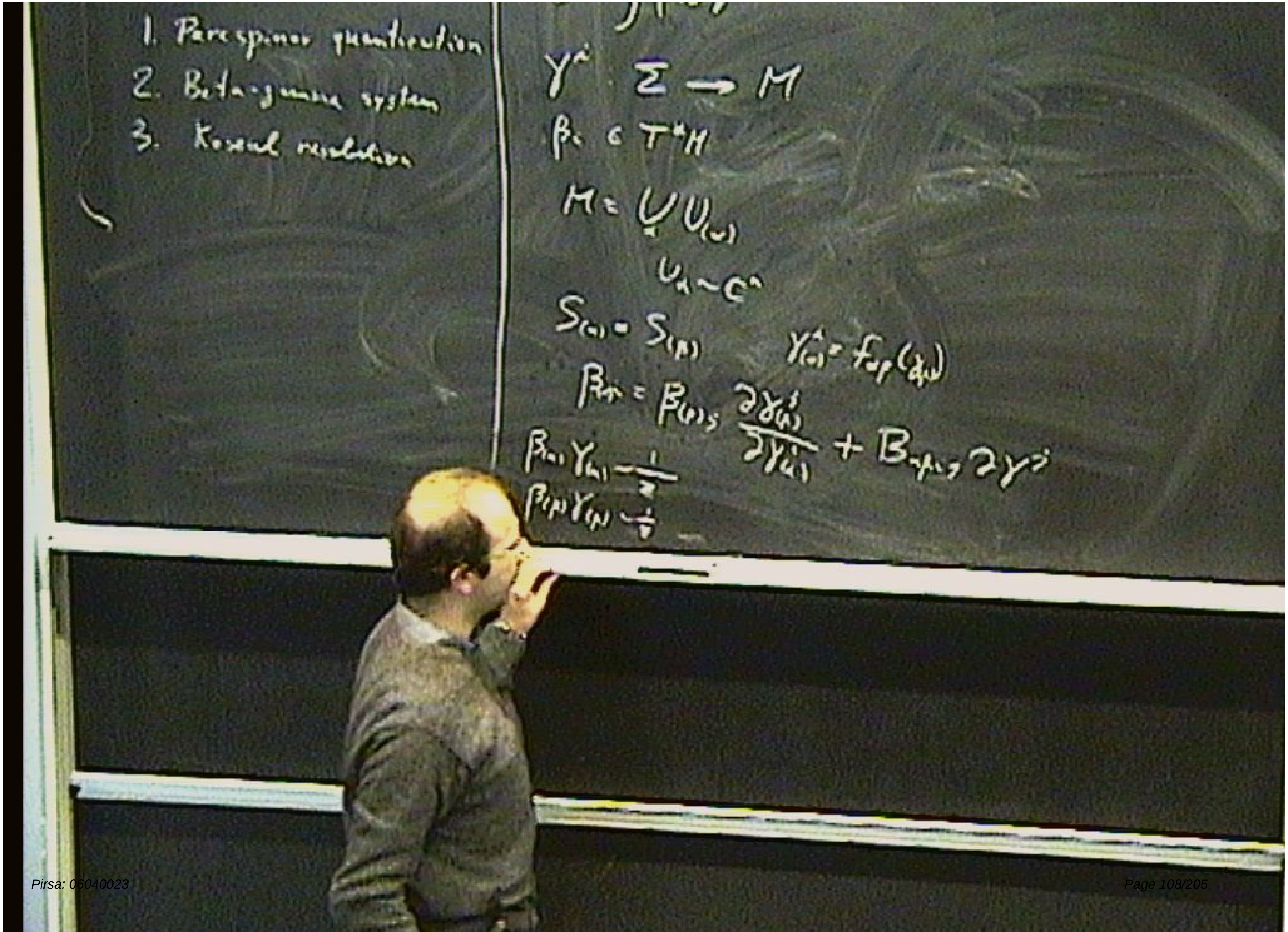

Gratis GTP
1.
2. Beta-gamma system
3. Koszul resolution
S = ∫ β ∂̄ γ
γ Σ → M
β ∈ T*M

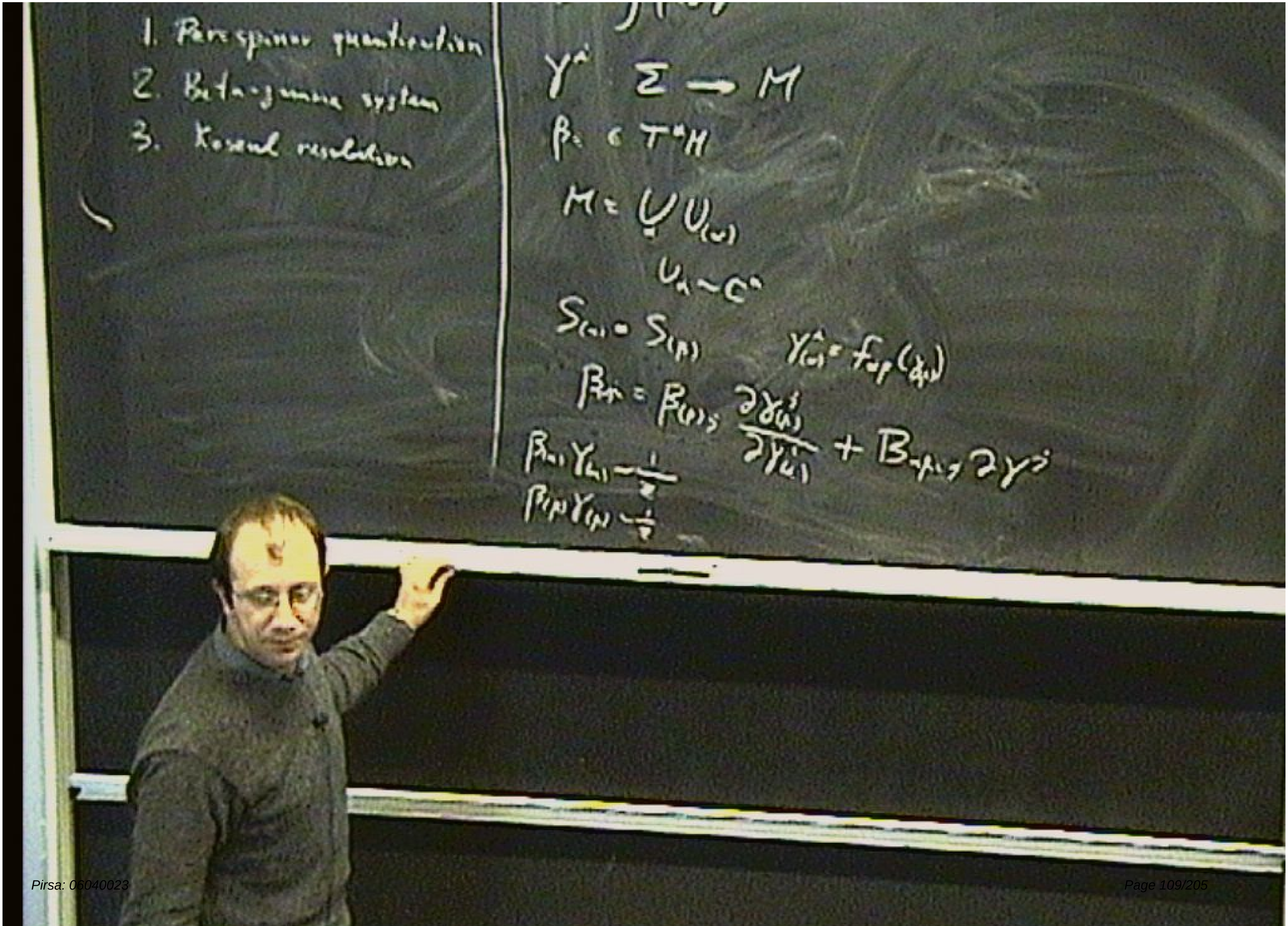

1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution

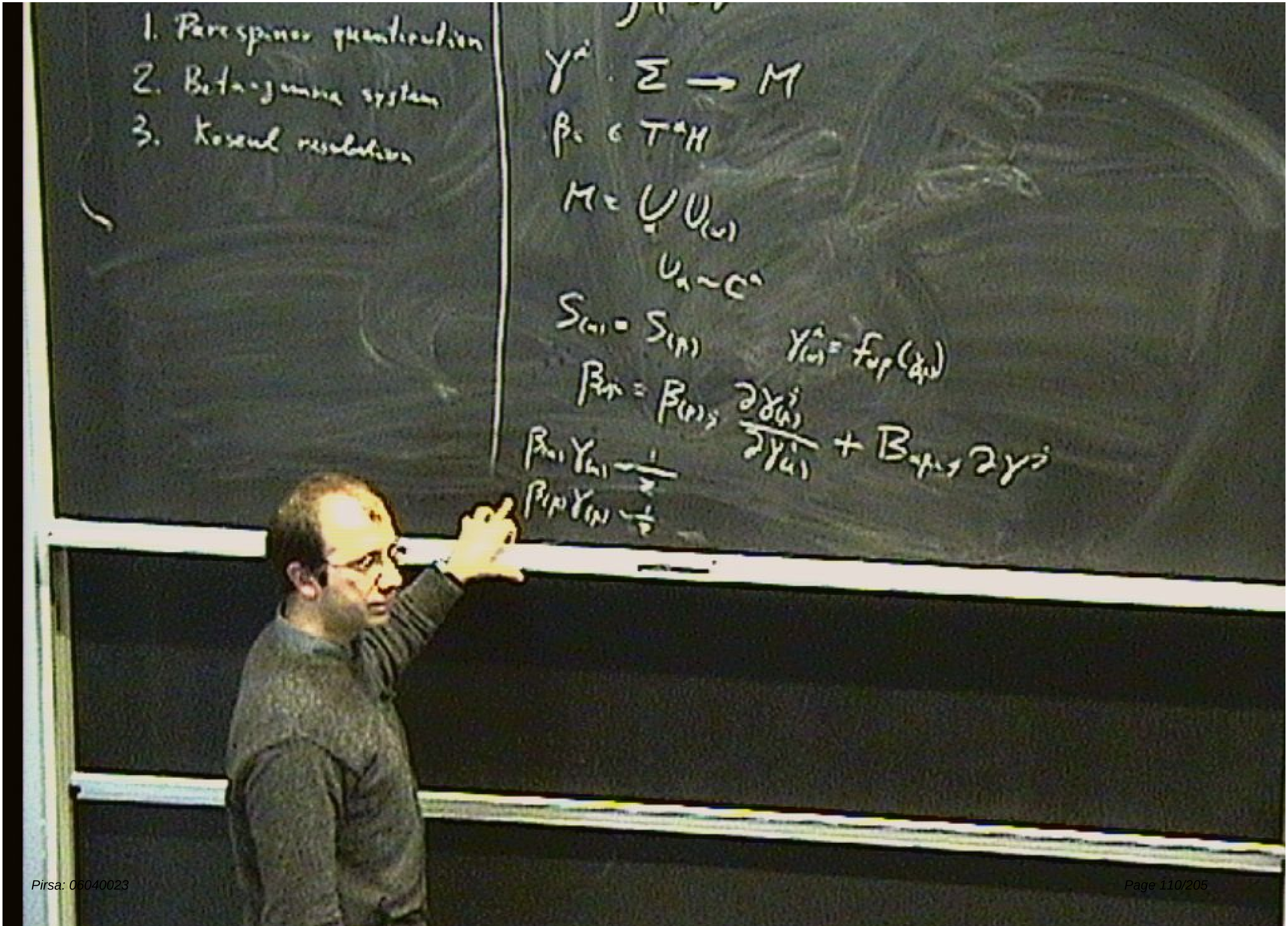

1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution
S = ∫ β∂γ
γ : Σ → M
β ∈ T*M
M = ∪ U(a)
S(a) = S(b)
+

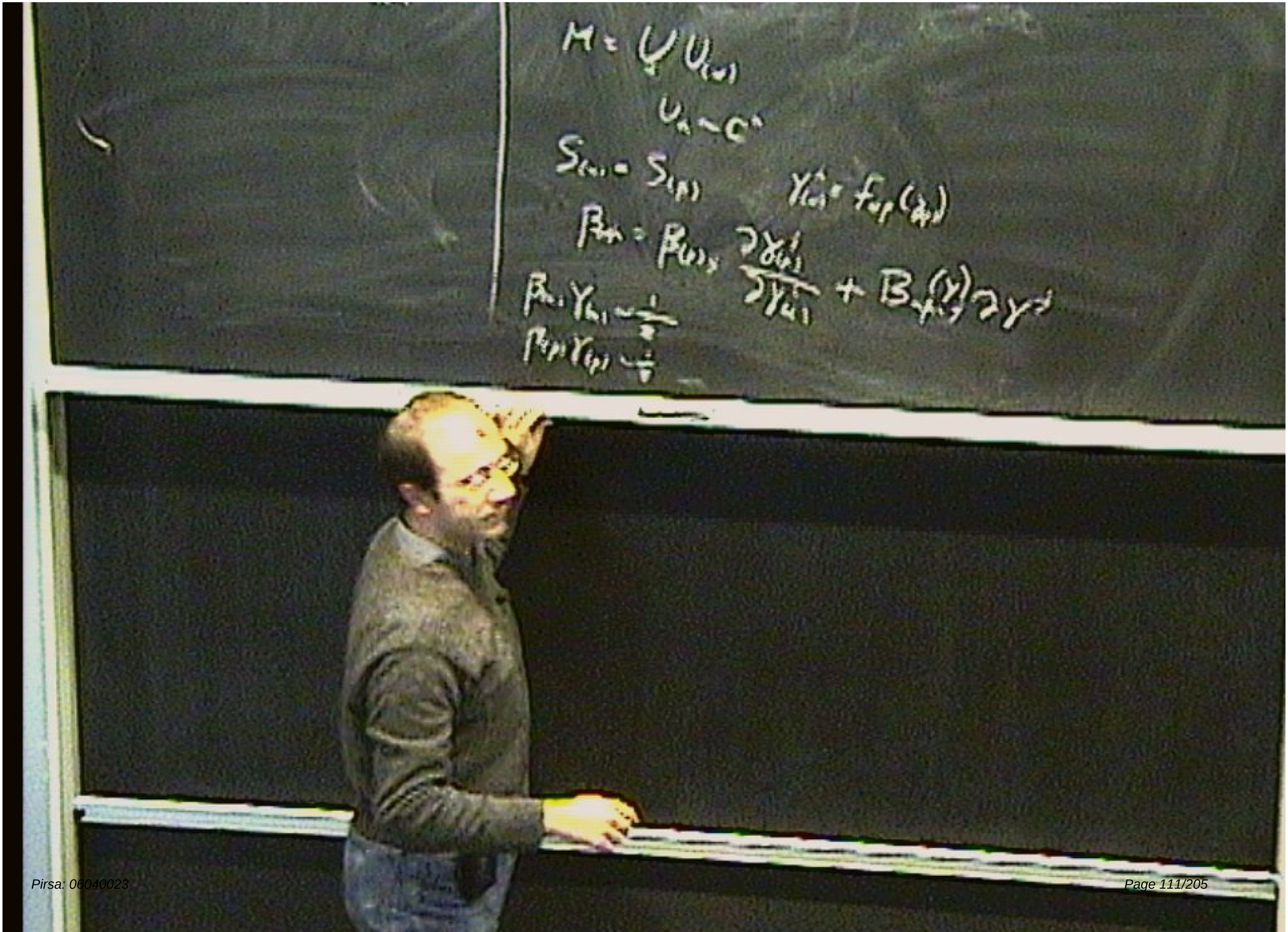

1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution

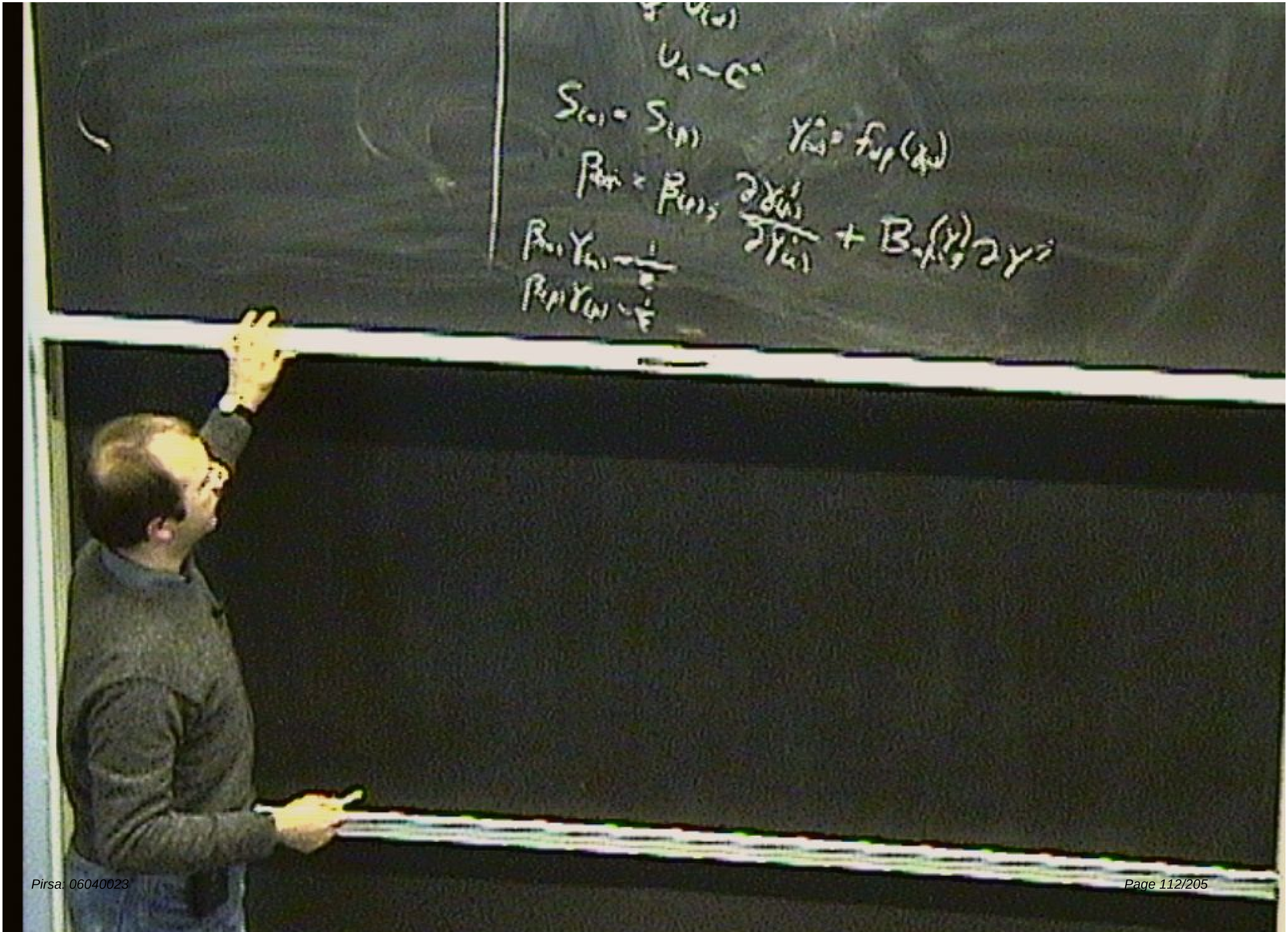

1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution
γ^i : Σ → M
β_i ∈ T*M

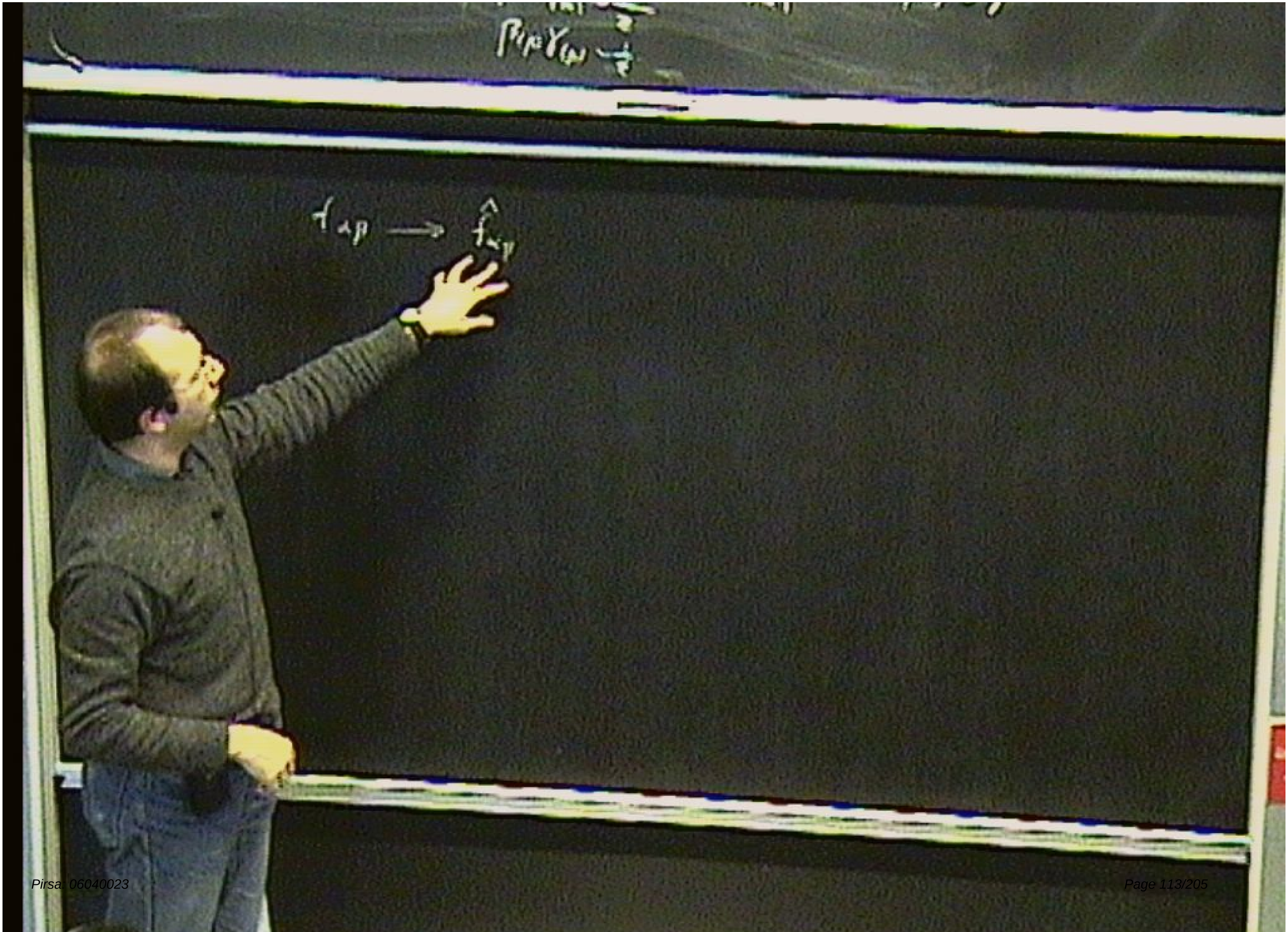

1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution
Σ → M

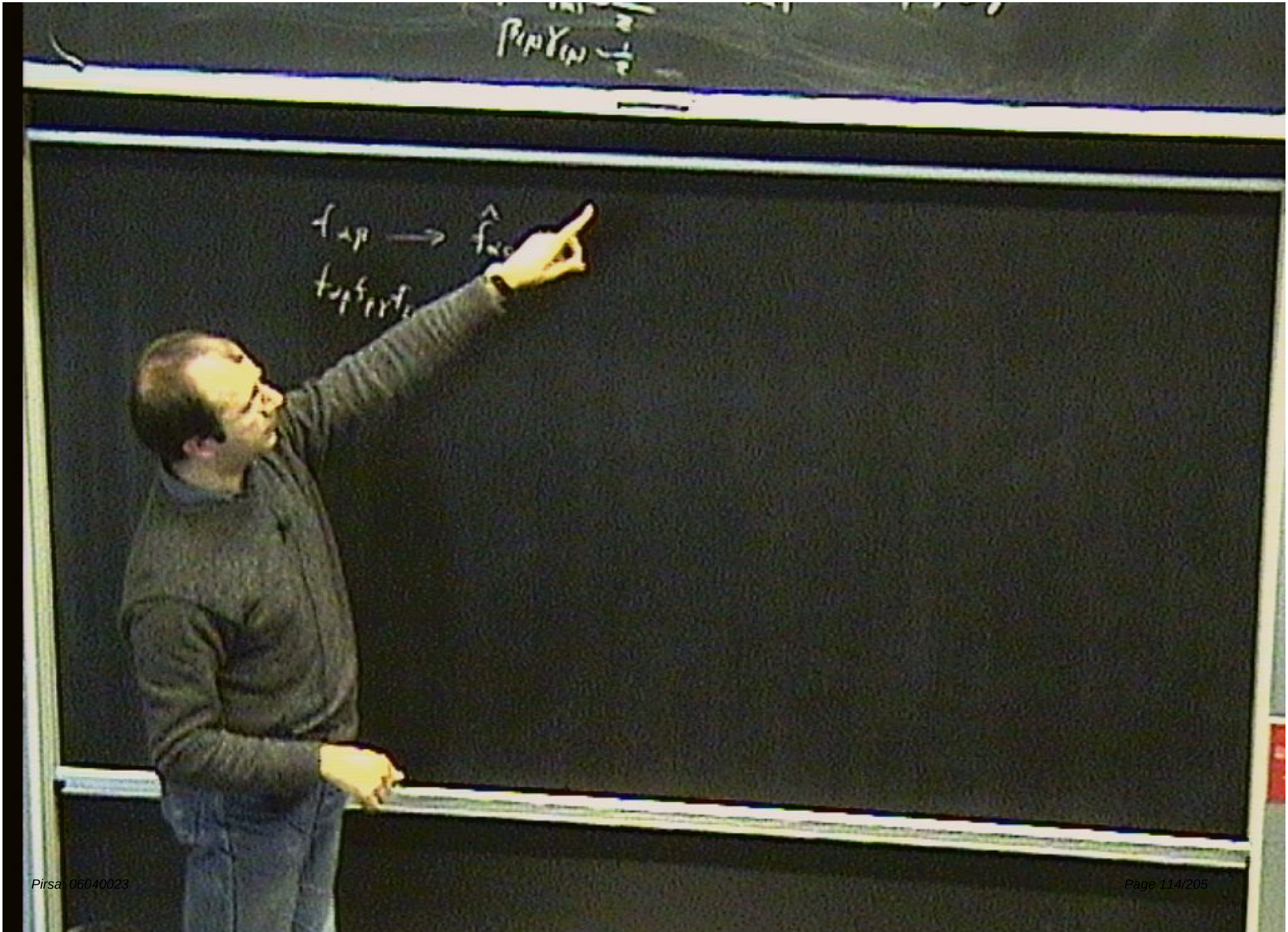

1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution

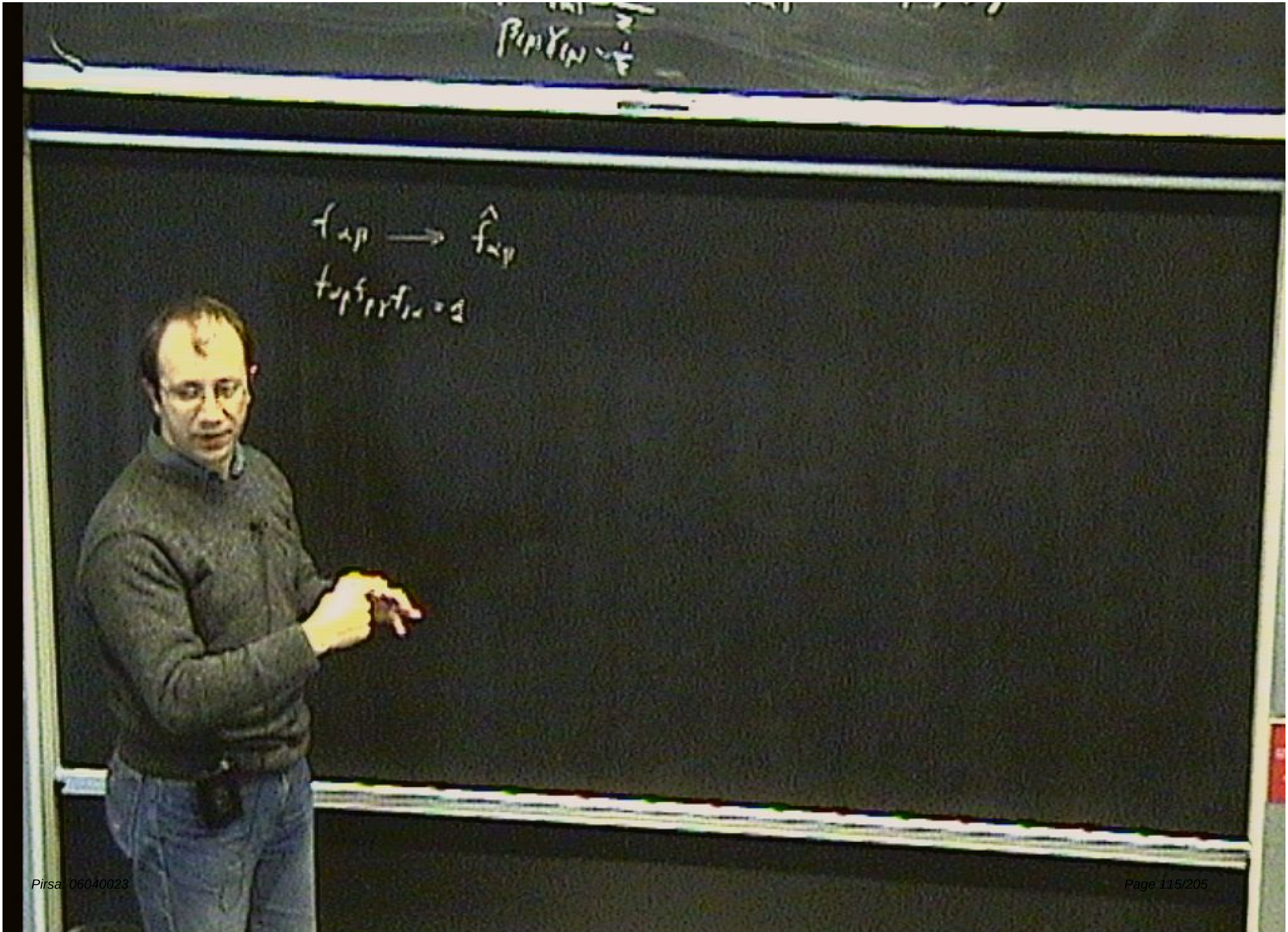

1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution
γ^i : Σ → M
β_i ∈ T*M
M = ∪ U_(α)
U_α ~ C^n
S_(α) = S_(β)



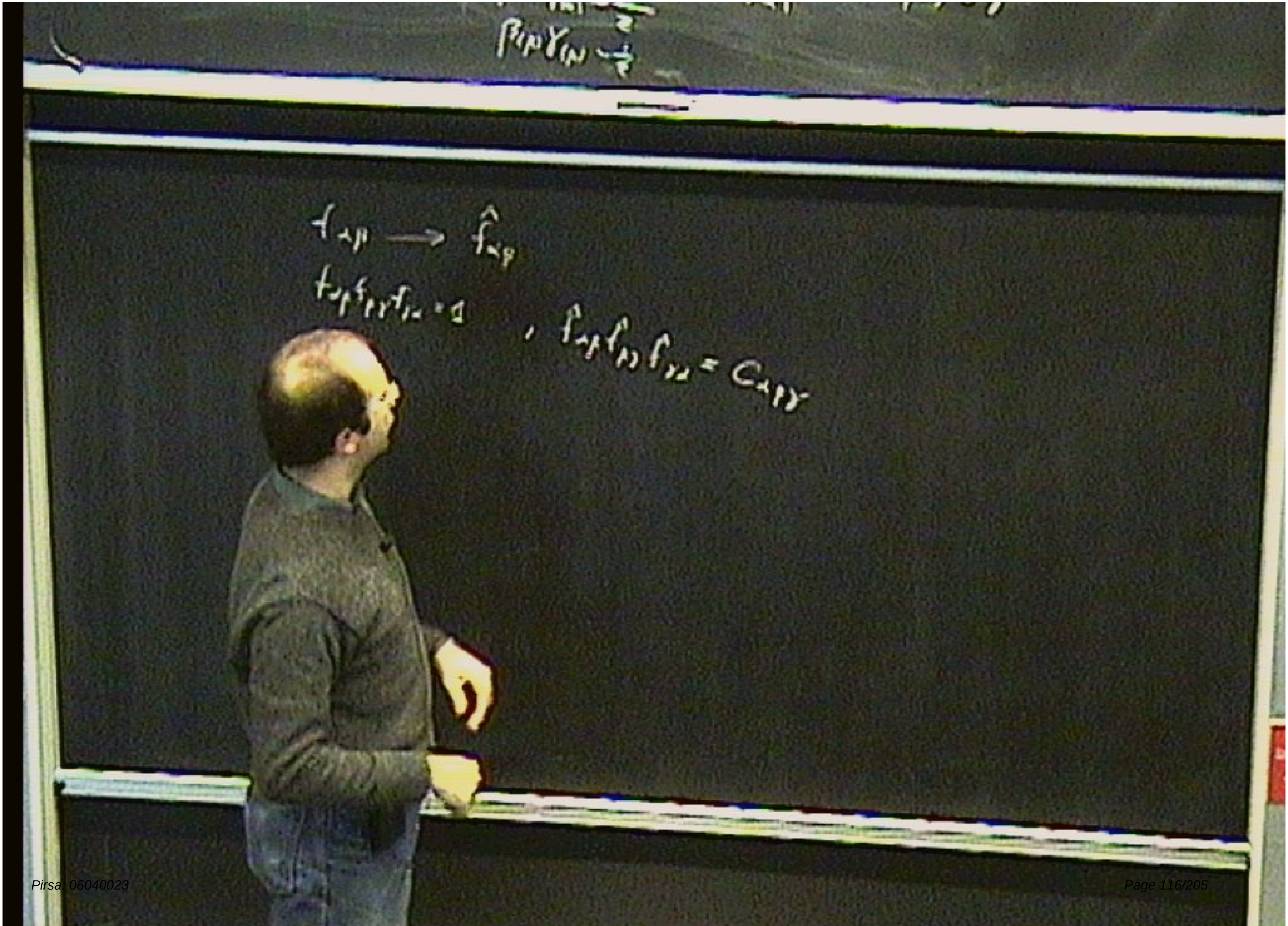


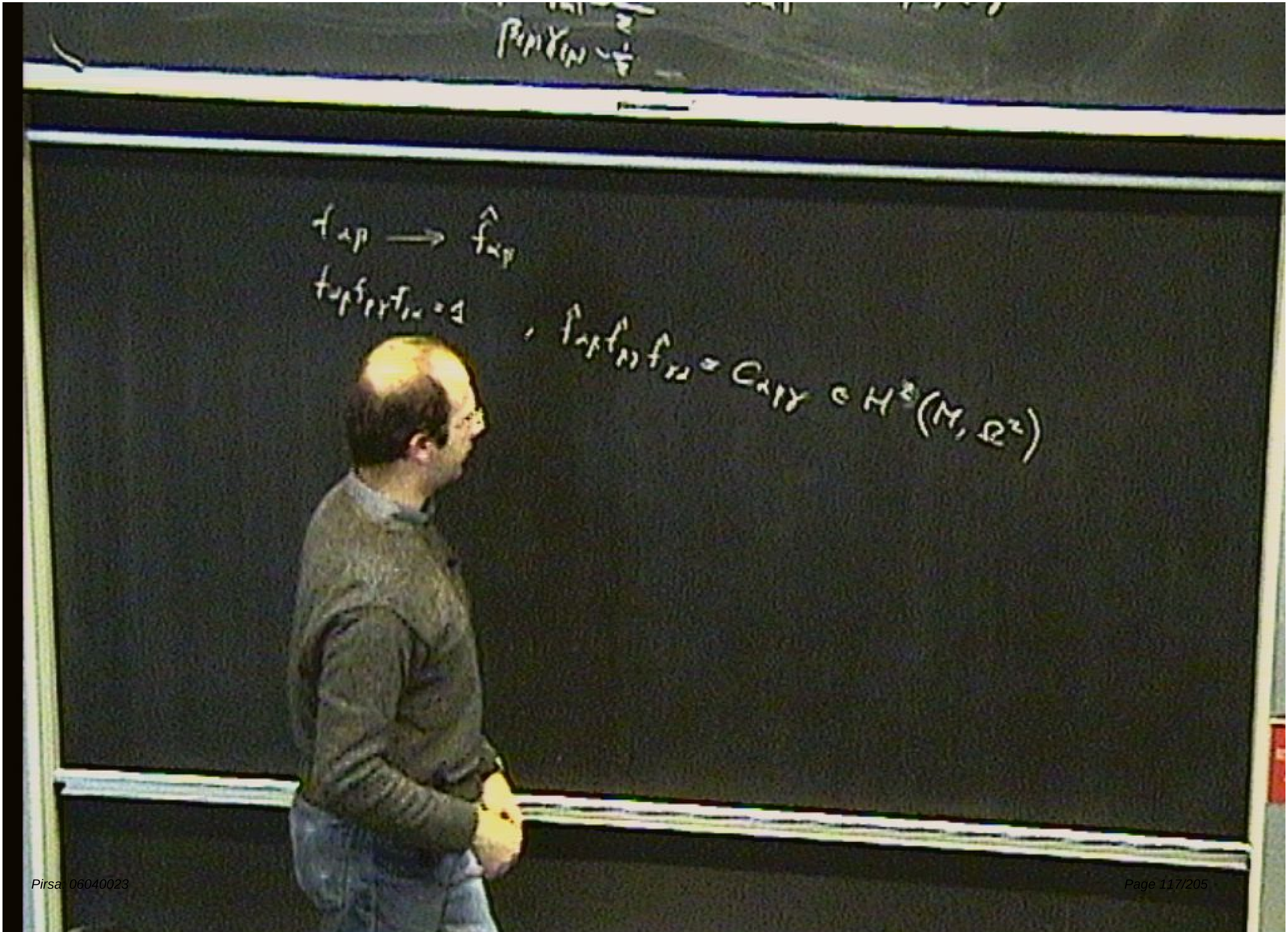

$f_{\alpha\beta} \longrightarrow \hat{f}_{\alpha\beta}$

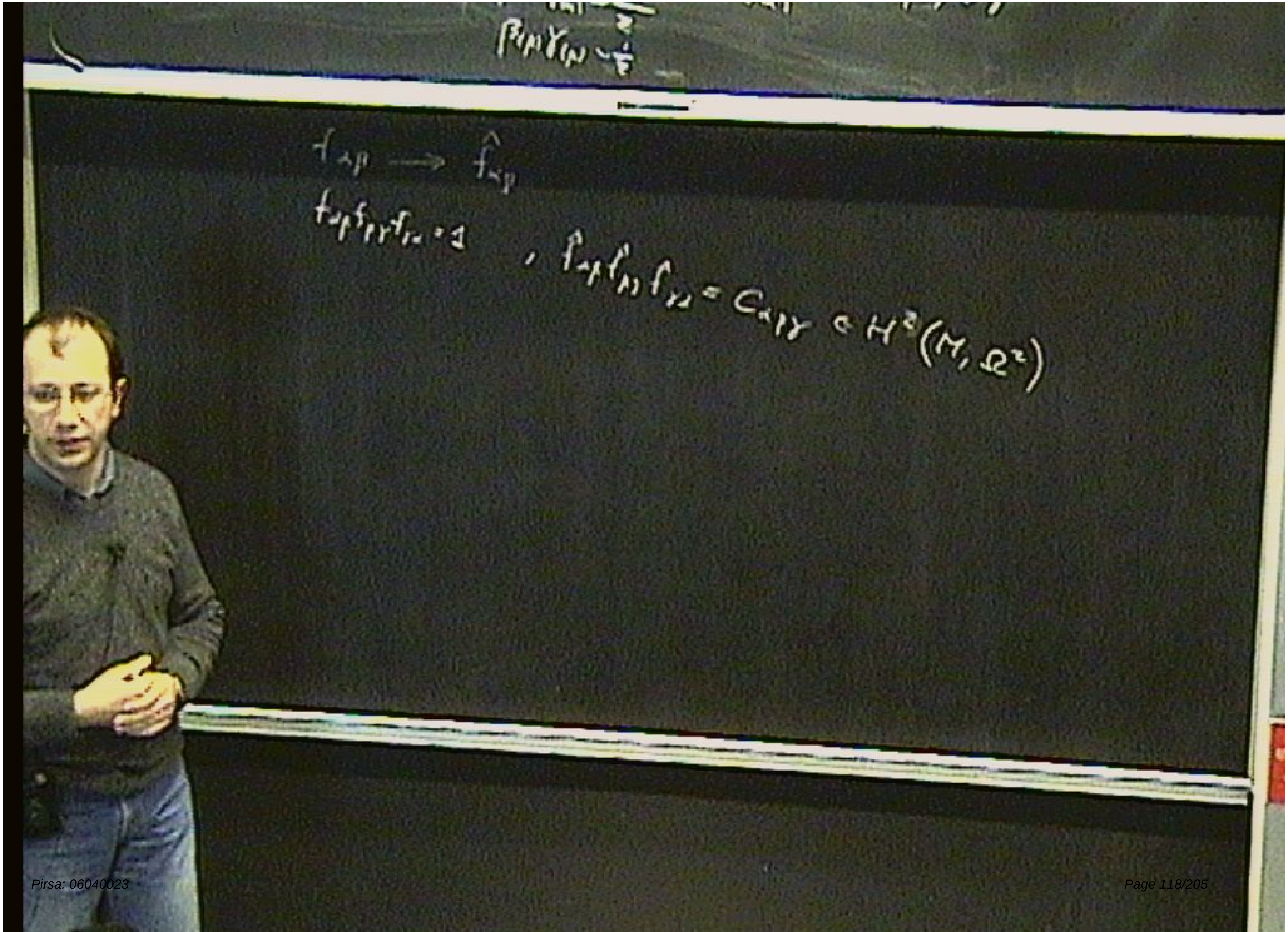


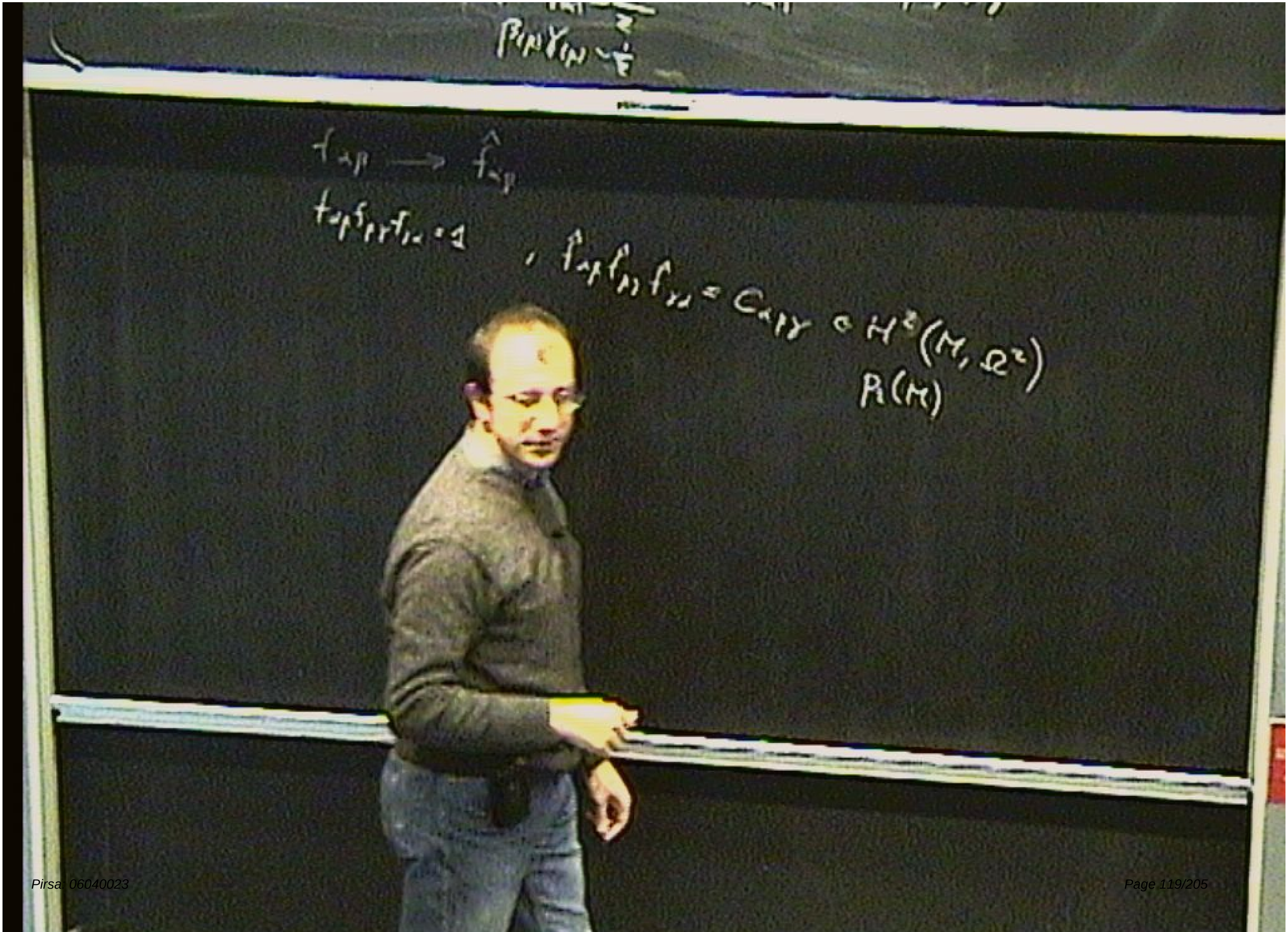


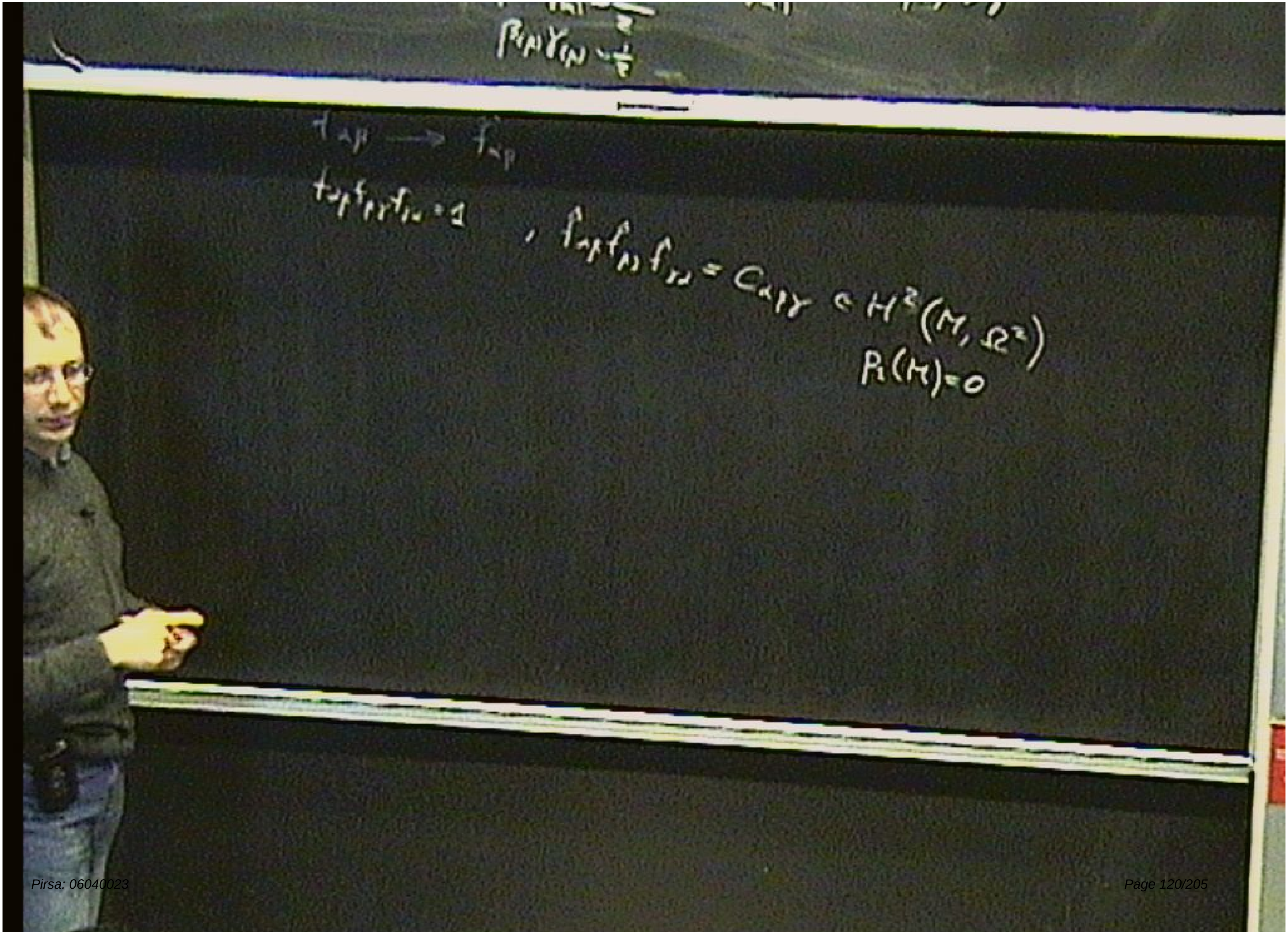
f_{αβ} ⟶ \hat{f}_{αβ}
f_{αβ} f_{βγ} f_{γα} = 1

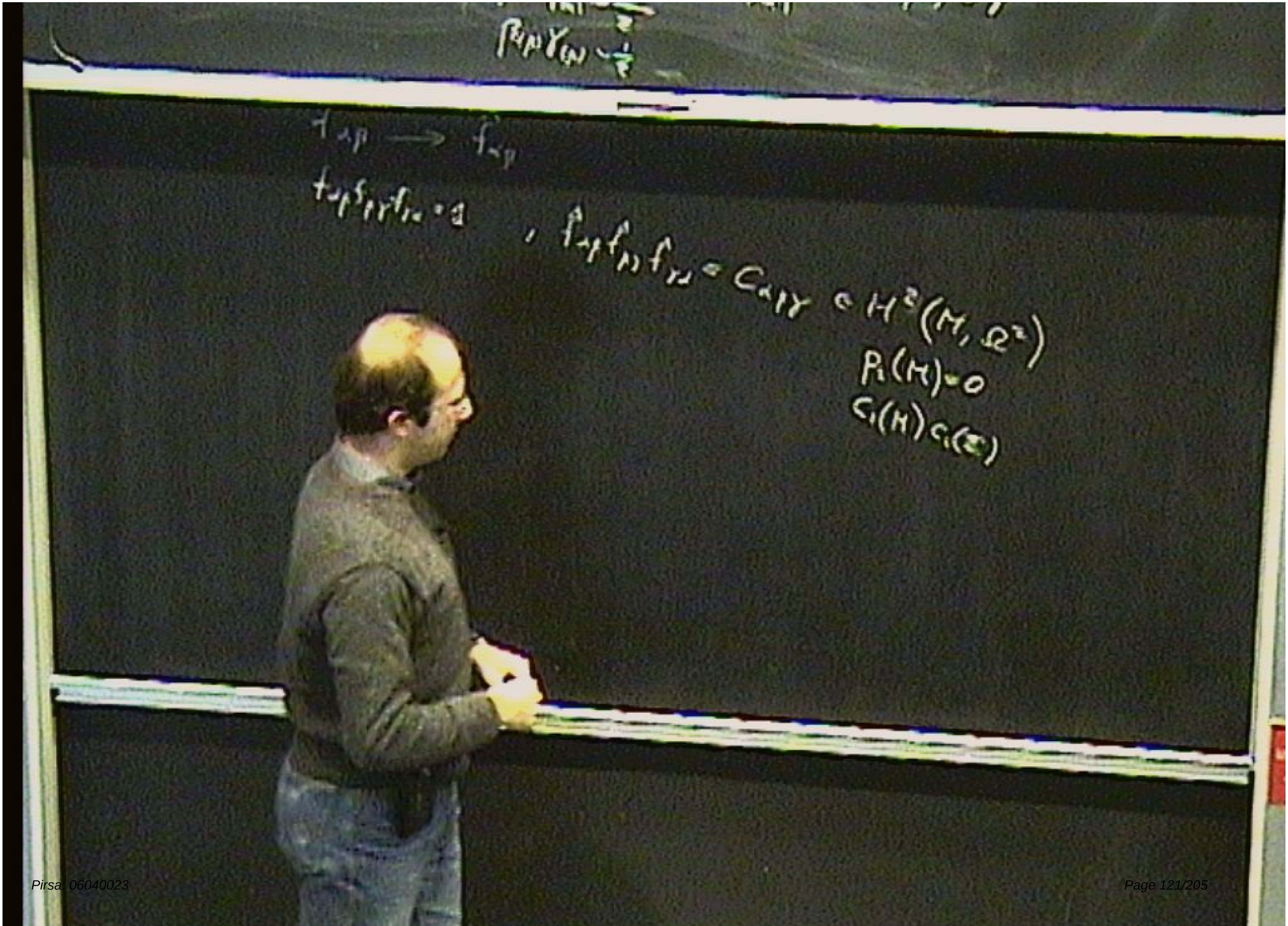


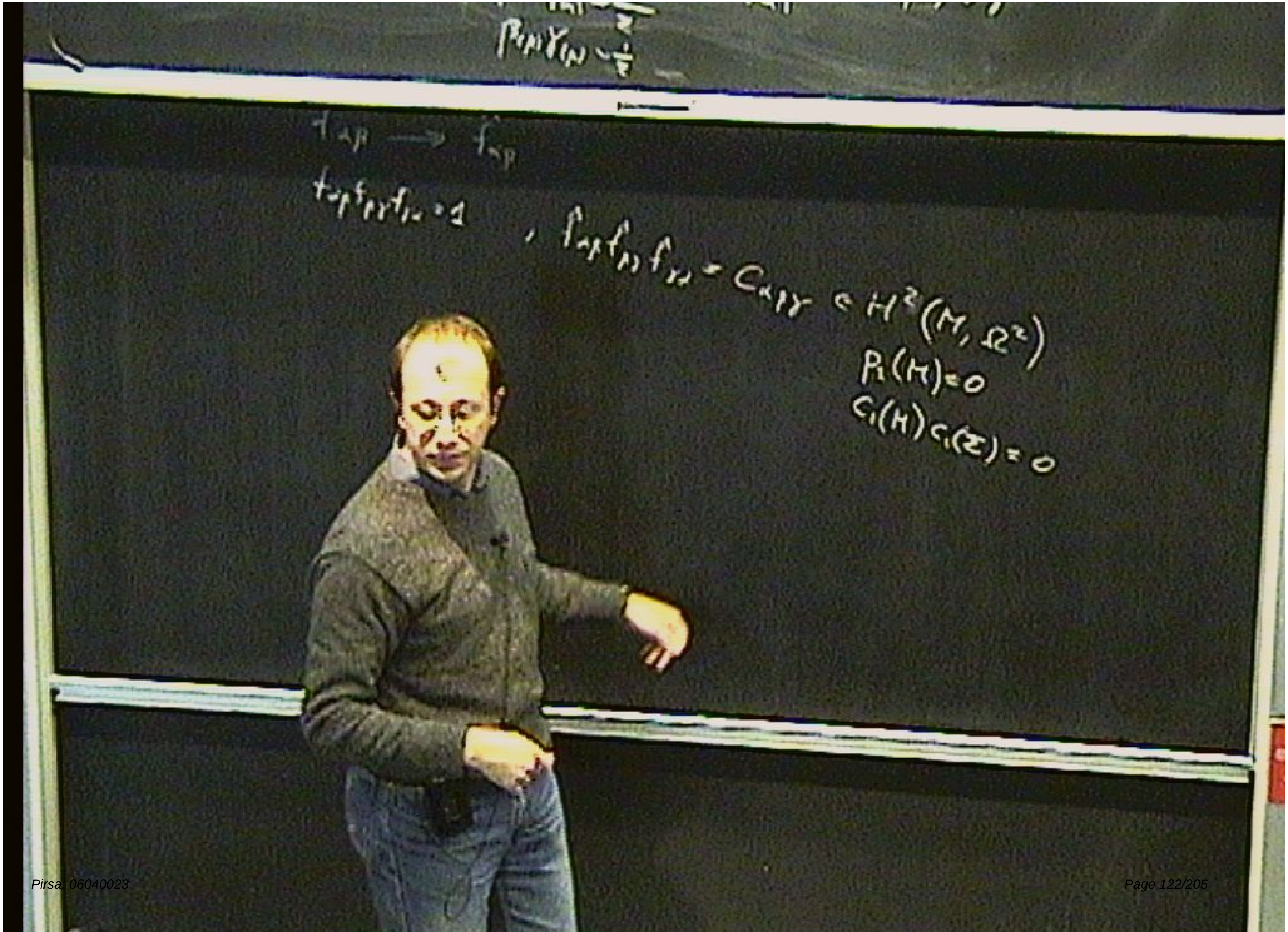

$f_{\alpha\beta} \longrightarrow \hat{f}_{\alpha\beta}$
$f_{\alpha\beta}f_{\beta\gamma}f_{\gamma\alpha} = 1$, $\hat{f}_{\alpha\beta}\hat{f}_{\beta\gamma}\hat{f}_{\gamma\alpha} = C_{\alpha\beta\gamma} \in H^2(M, \Omega^2)$

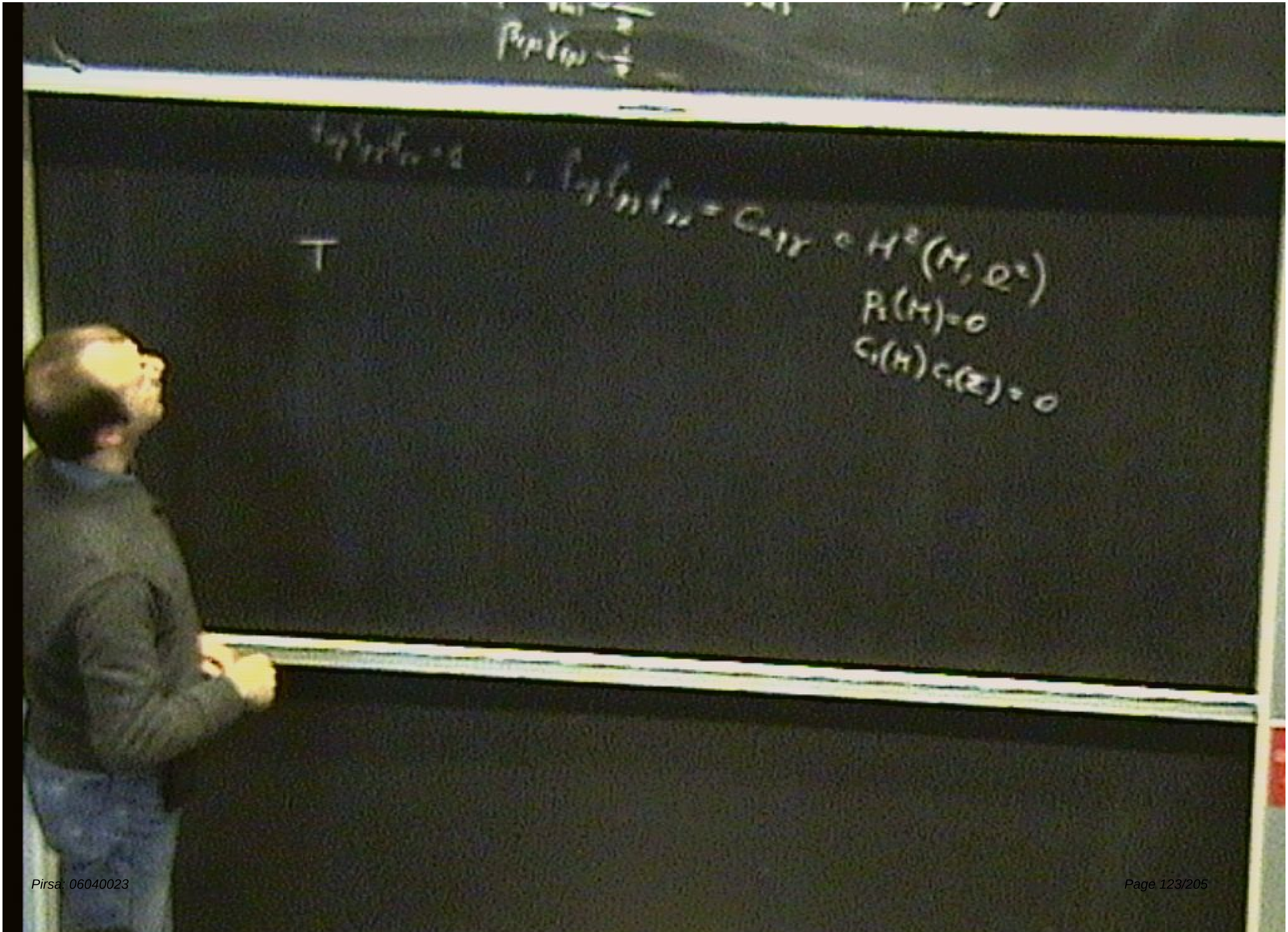

$f_{\alpha\beta} \longrightarrow \hat{f}_{\alpha\beta}$
$f_{\alpha\beta} f_{\beta\gamma} f_{\gamma\alpha} = 1$, $\hat{f}_{\alpha\beta} \hat{f}_{\beta\gamma} \hat{f}_{\gamma\alpha} = C_{\alpha\beta\gamma} \in H^2(M, \Omega^2)$

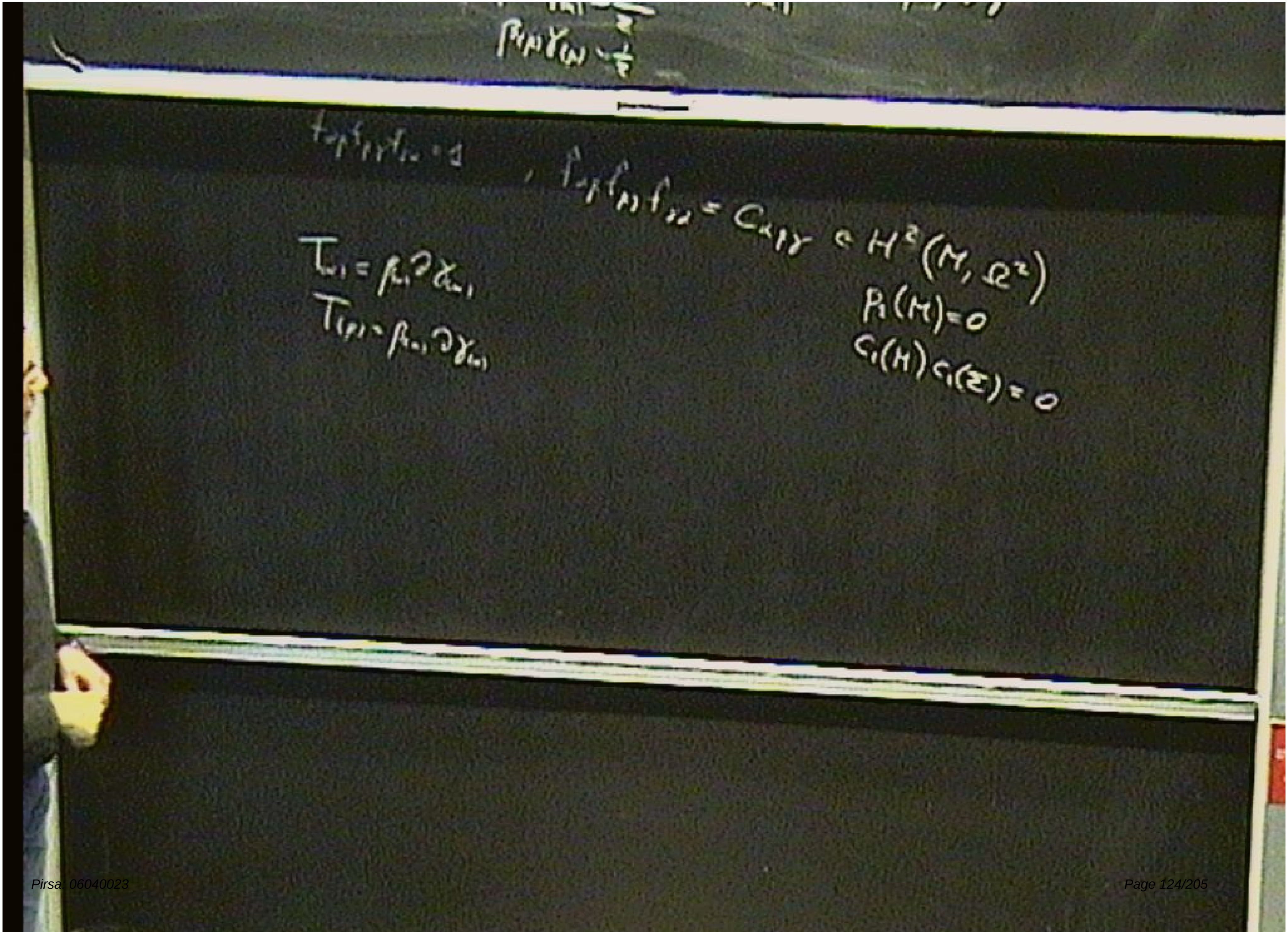


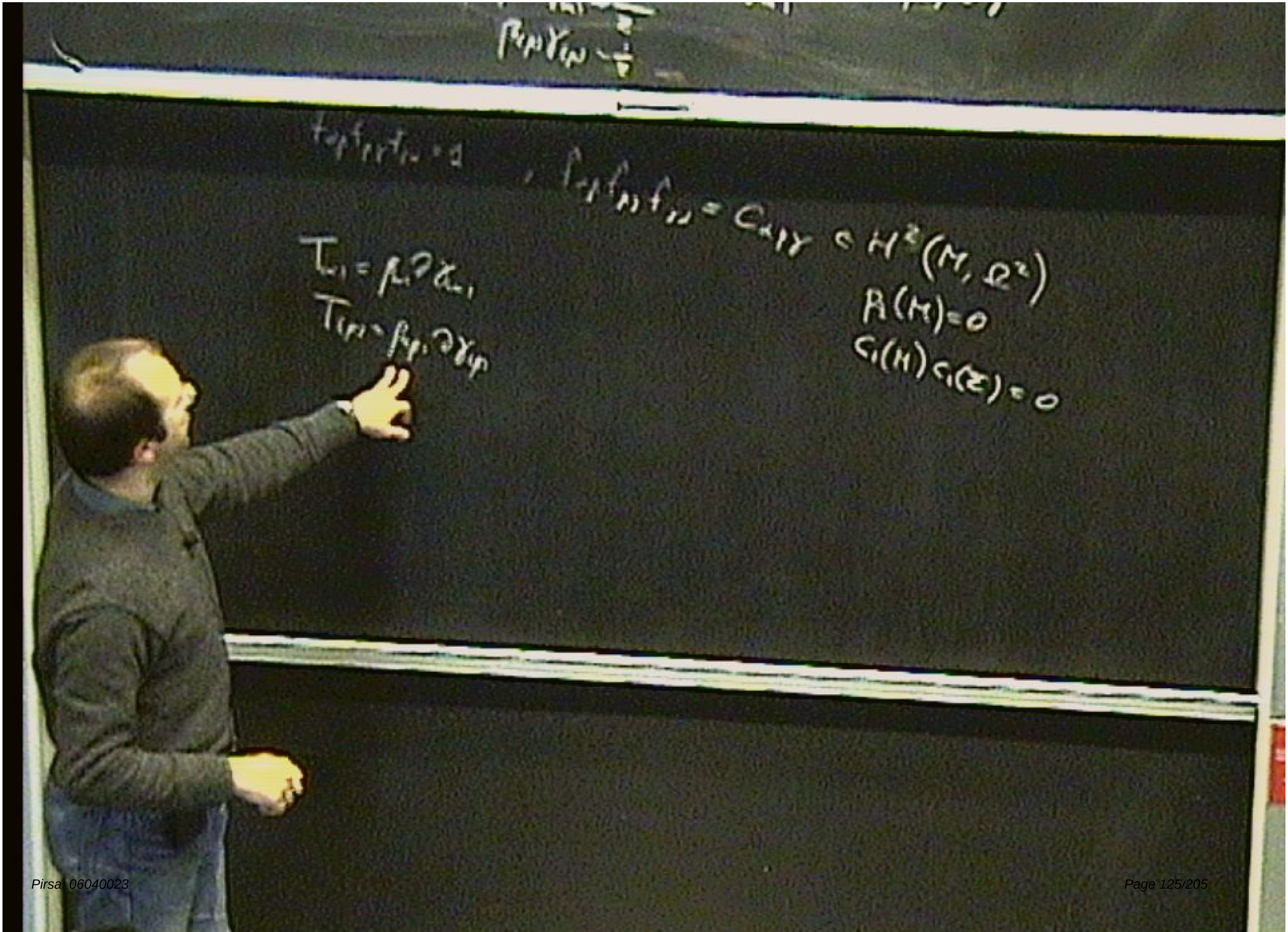

$f_{\alpha\beta} \longrightarrow f_{\alpha\beta}$
$f_{\alpha\beta} f_{\beta\gamma} f_{\gamma\alpha} = 1$, $f_{\alpha\beta} f_{\beta\gamma} f_{\gamma\alpha} = C_{\alpha\beta\gamma} \in H^2(M, \Omega^2)$
$P_1(M) = 0$

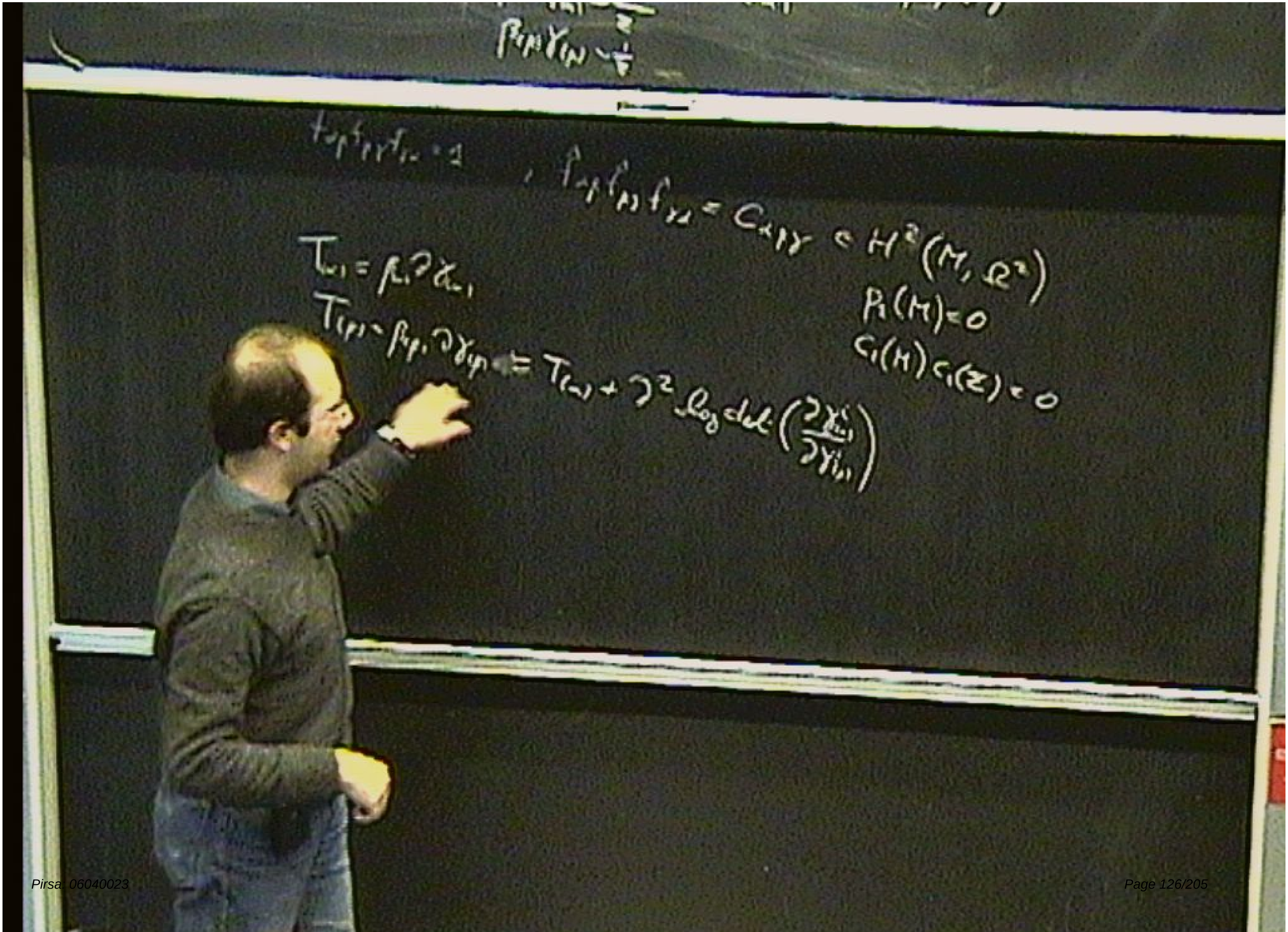

p1(M)=0
c1(M)c1(Σ)

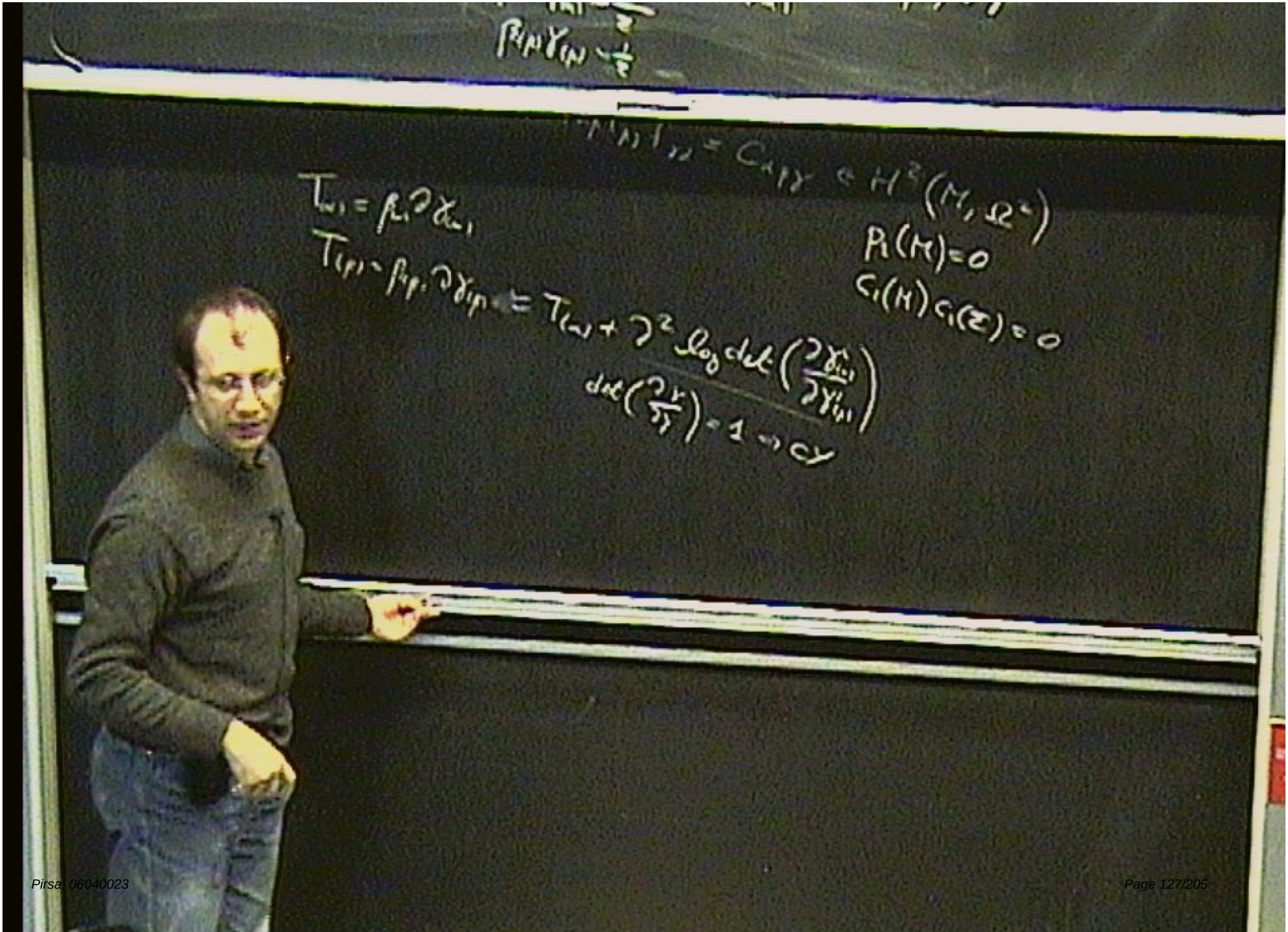

f_αβ → f_αβ
f_αβ f_βγ f_γα = 1 , f_αβ f_βγ f_γα = C_αβγ ∈ H²(M, Ω²)
p₁(M) = 0
c₁(M) c₁(Σ) = 0

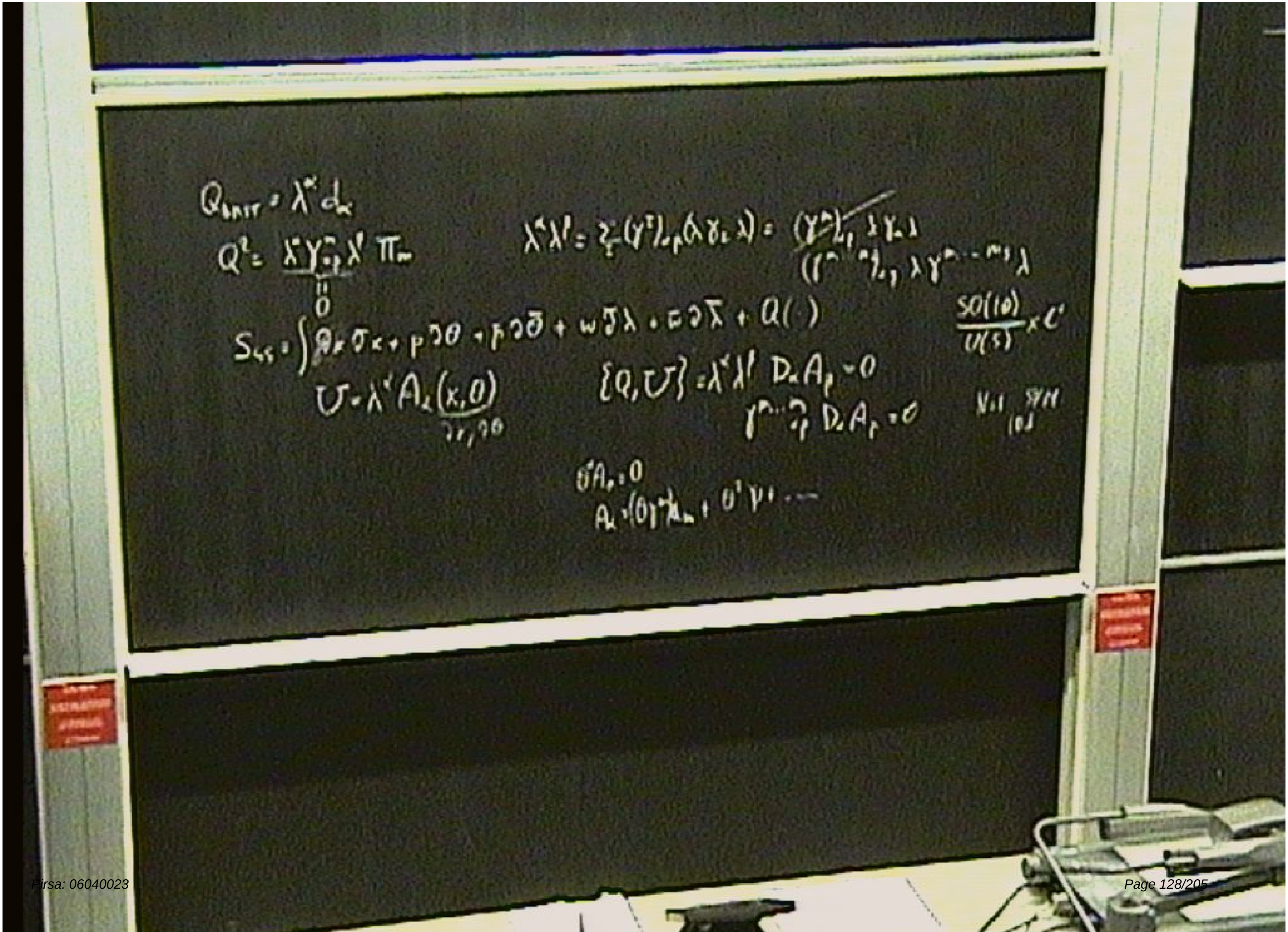

b1(M)=0
c1(M)c1(Σ)=0

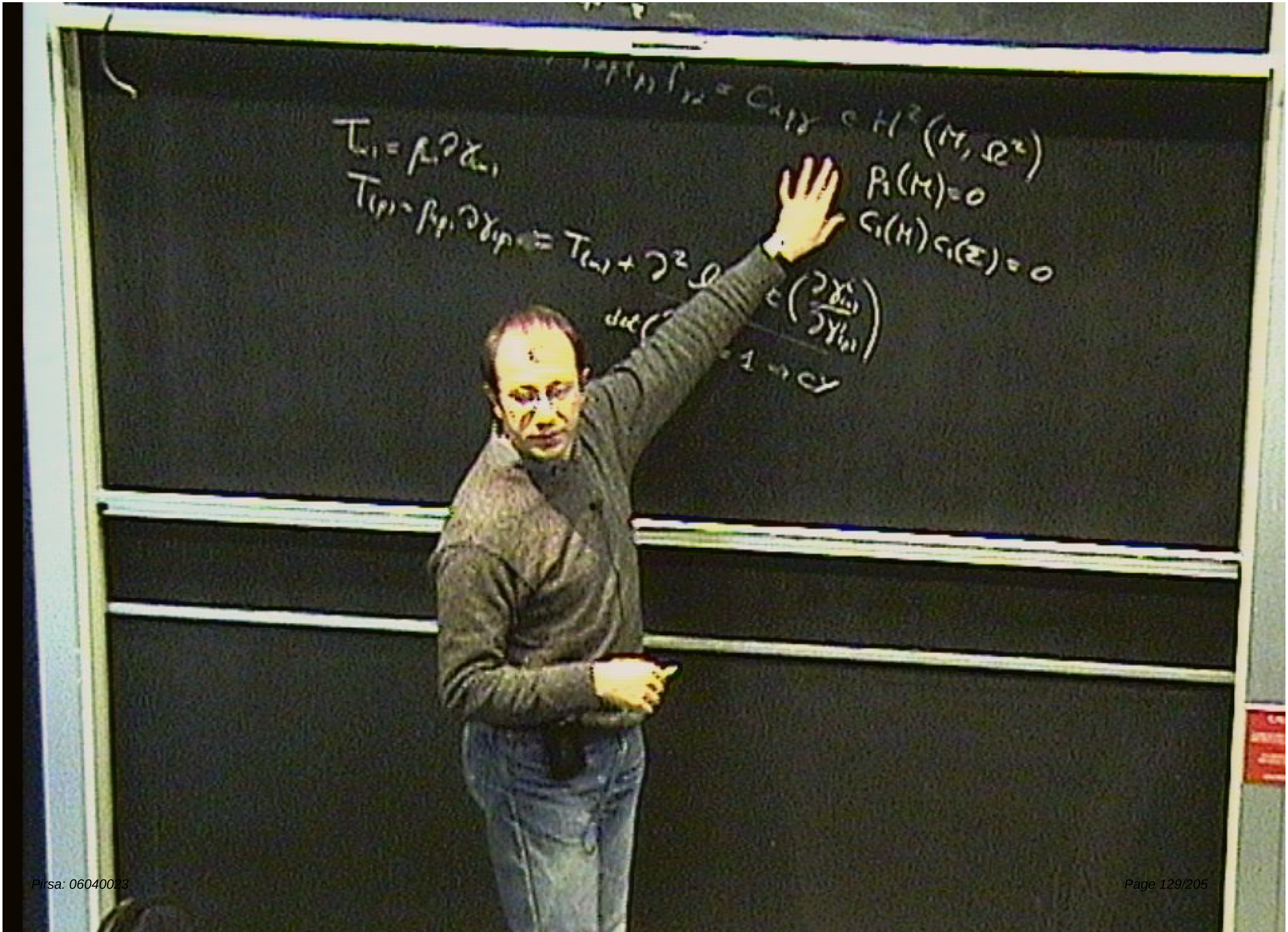

$f_{\alpha\beta}f_{\beta\gamma}f_{\gamma\alpha} = 1$
$f_{\alpha\beta}f_{\beta\gamma}f_{\gamma\alpha} = C_{\alpha\beta\gamma} \in H^3(M, \Omega^2)$
$T_{(\alpha)} = \beta_{(\alpha)}\partial\gamma_{(\alpha)}$
$T_{(\beta)} = \beta_{(\beta)}\partial\gamma_{(\beta)}$
$P_1(M) = 0$
$c_1(M)c_1(\Sigma) = 0$

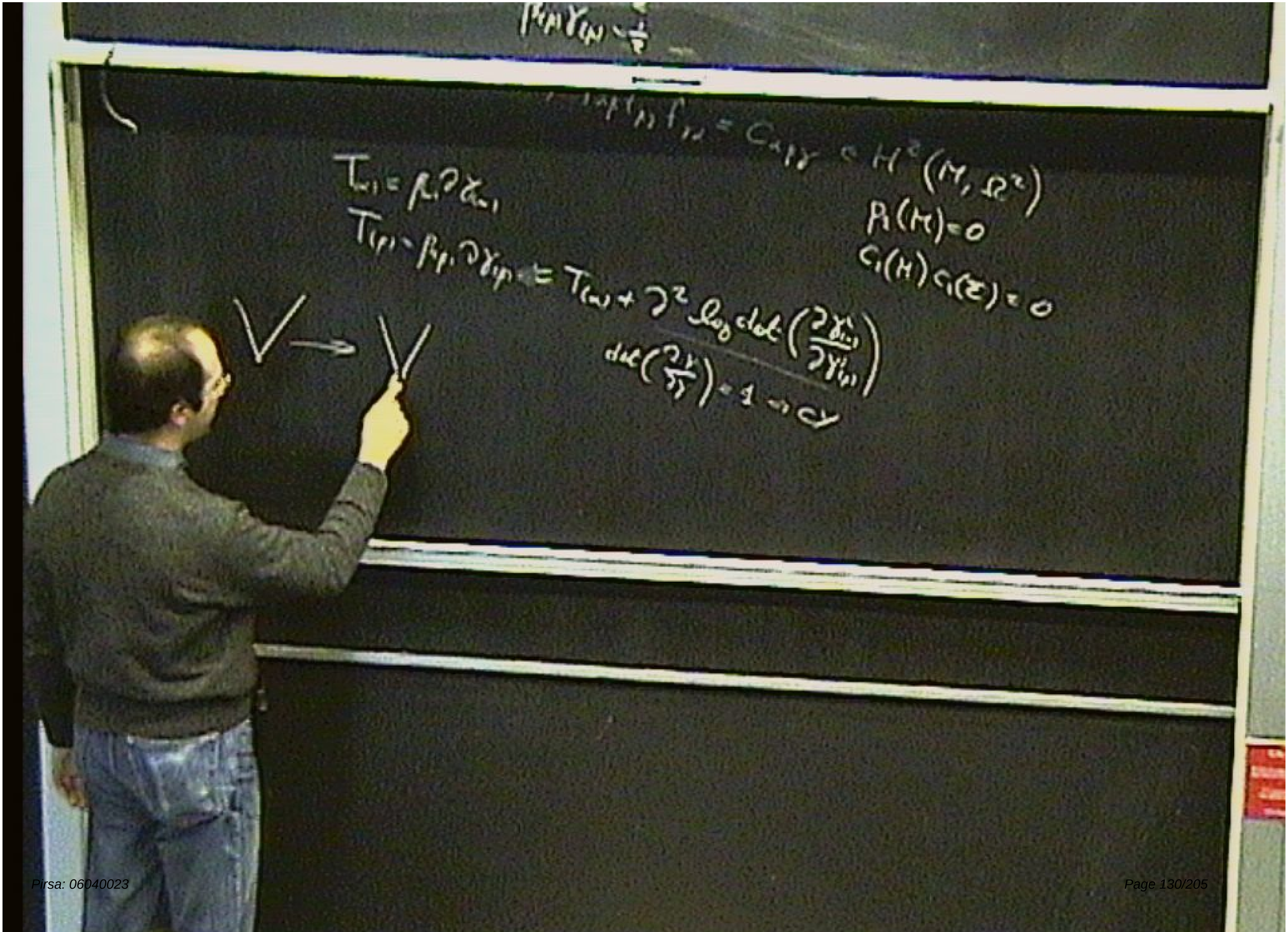





P1(M)=0
c1(M) c1(Σ)=0






$p_1(M)=0$
$c_1(M)c_1(\Sigma)=0$

$\ldots = c_1 \gamma \in H^3(M, \Omega^2)$

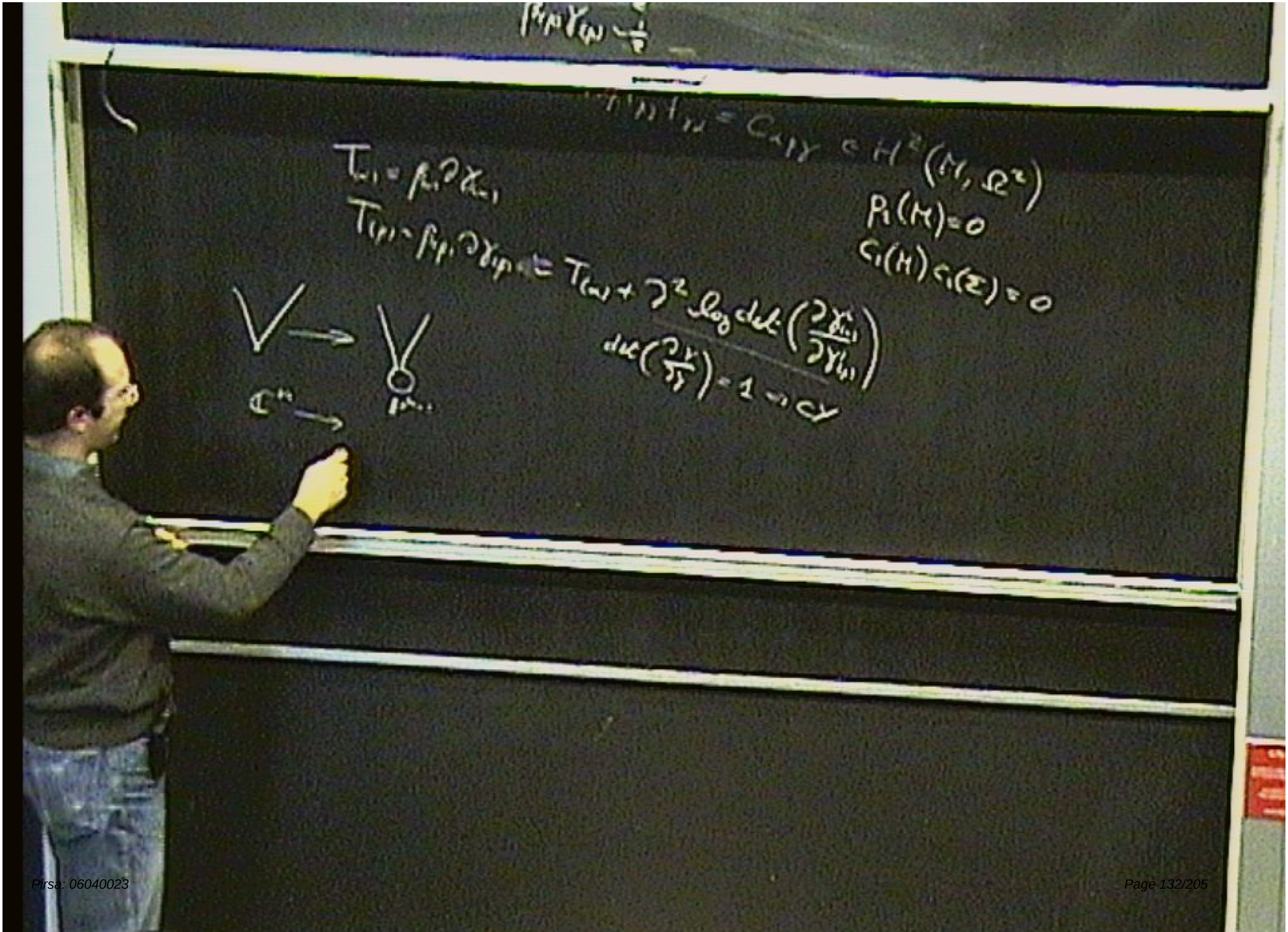
$p_1(M) = 0$

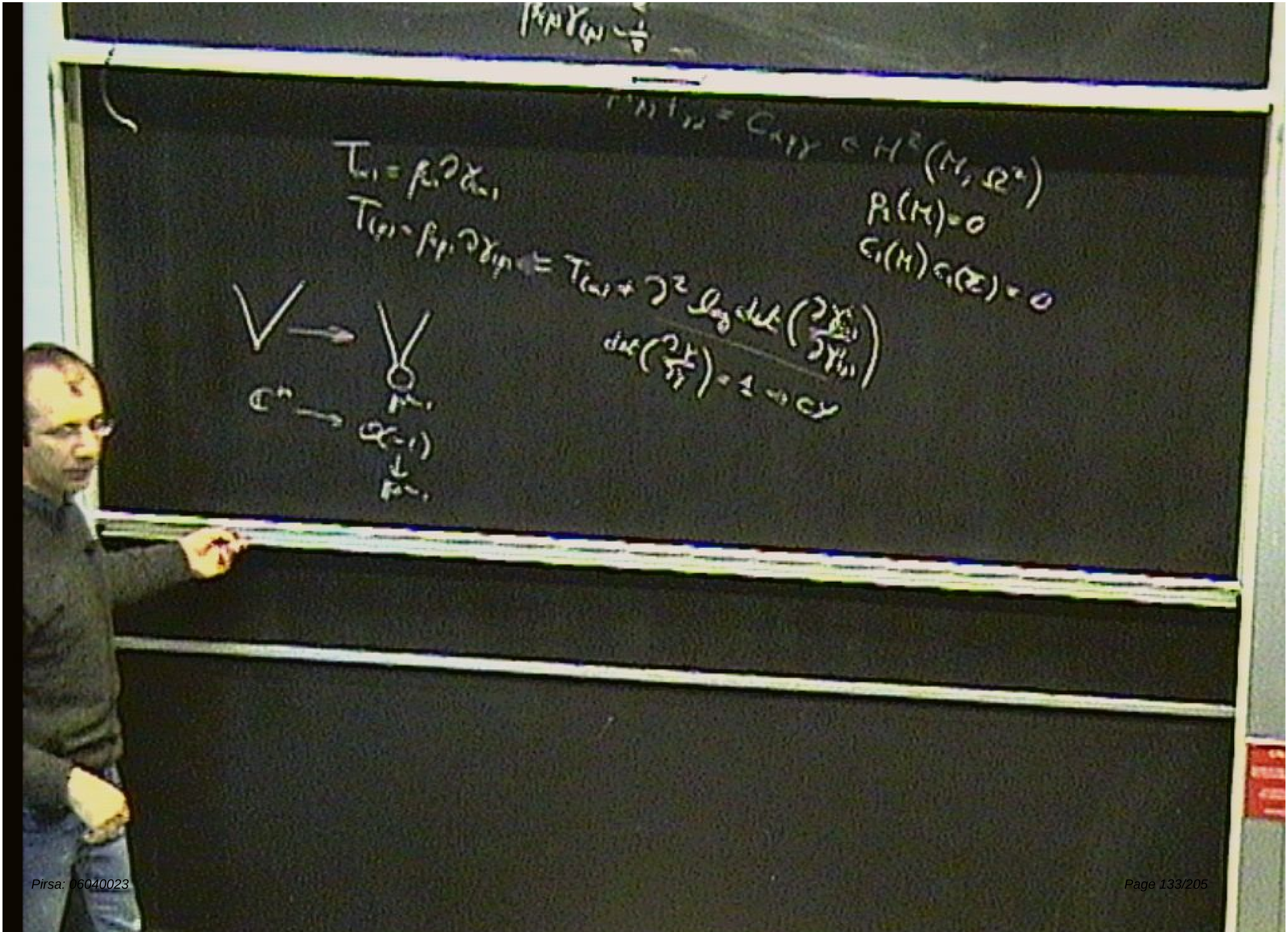
$c_1(M)\, c_1(\Sigma) = 0$

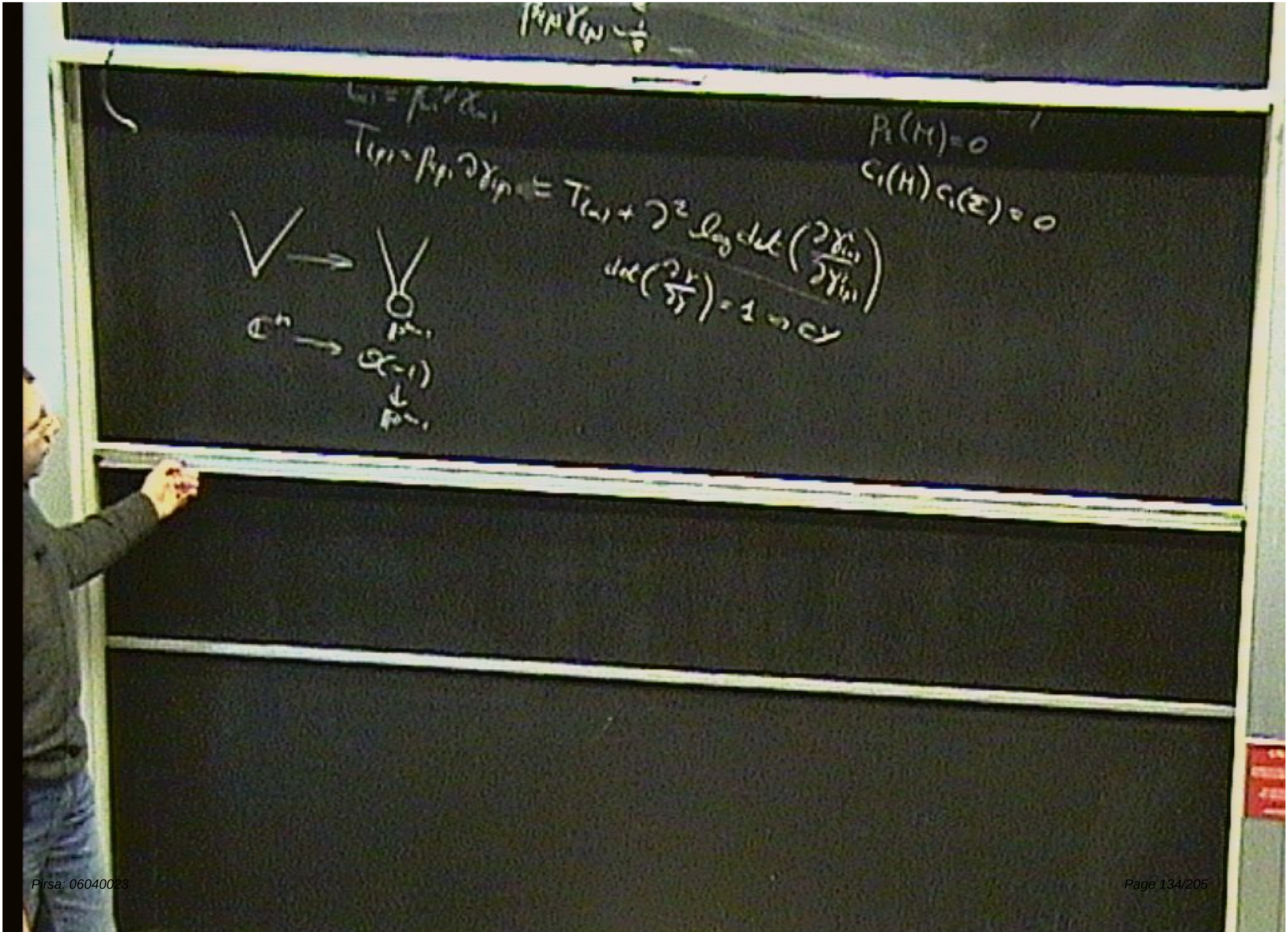
$T_{(\alpha)} = \beta_i \partial \gamma_{(\alpha)}$

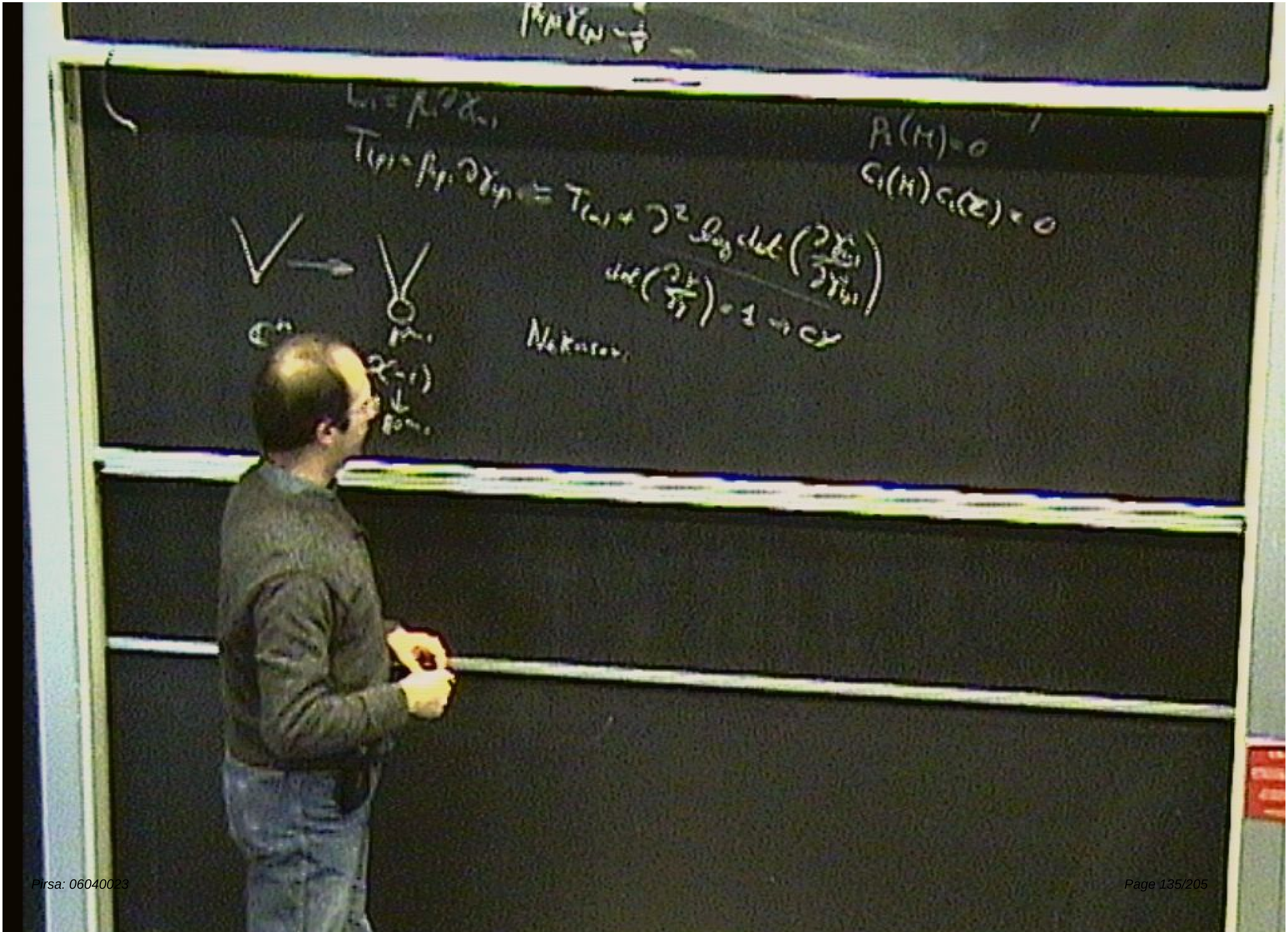
$T_{(\beta)} = \beta_{(\beta)} \partial \gamma_{(\beta)} = T_{(\alpha)} + \partial^2 \log \det\left(\frac{\partial \gamma_{(\alpha)}}{\partial \gamma_{(\beta)}}\right)$

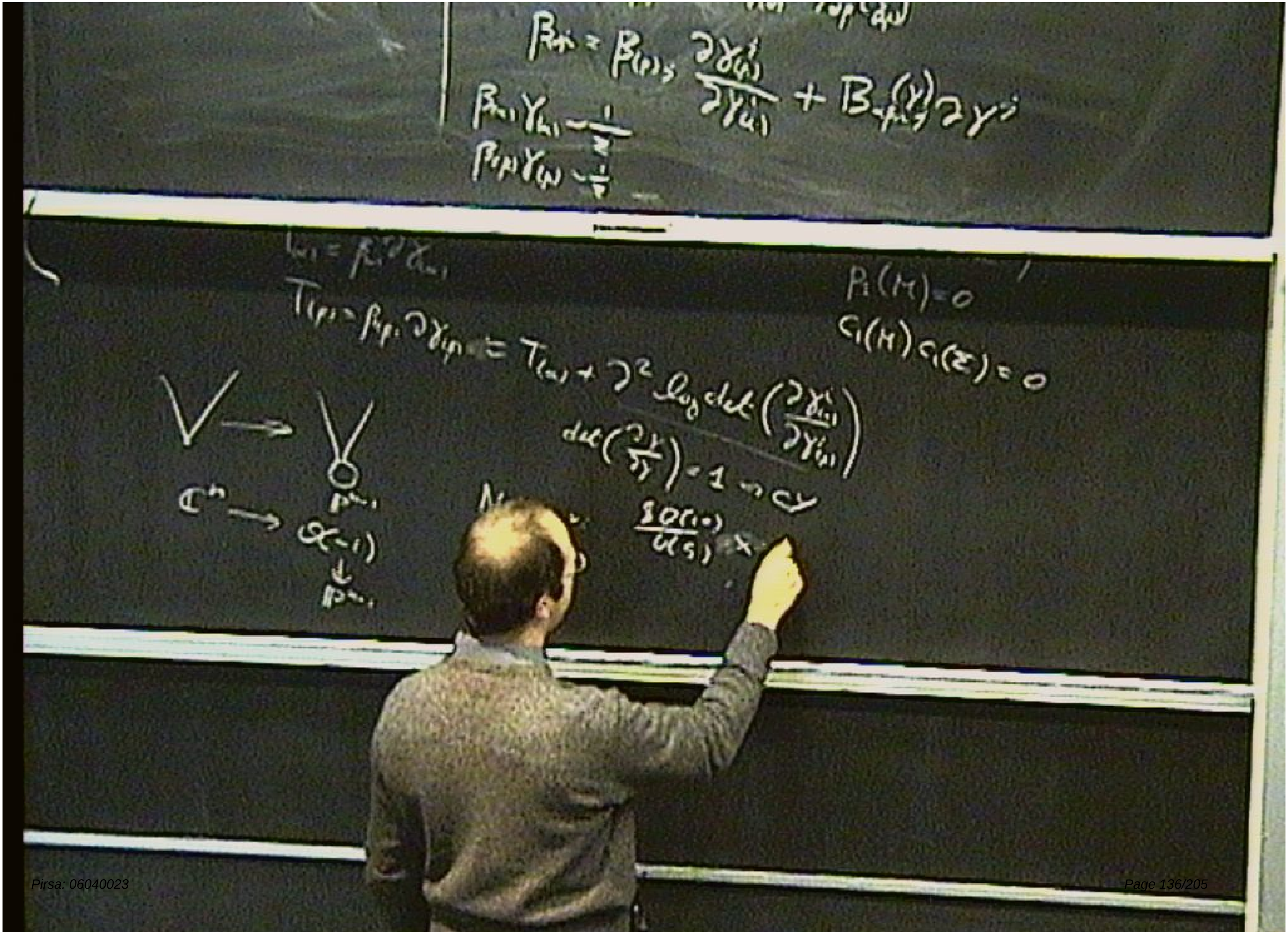
$\det\left(\frac{\partial \gamma}{\partial \gamma}\right) = 1 \Rightarrow c_1$

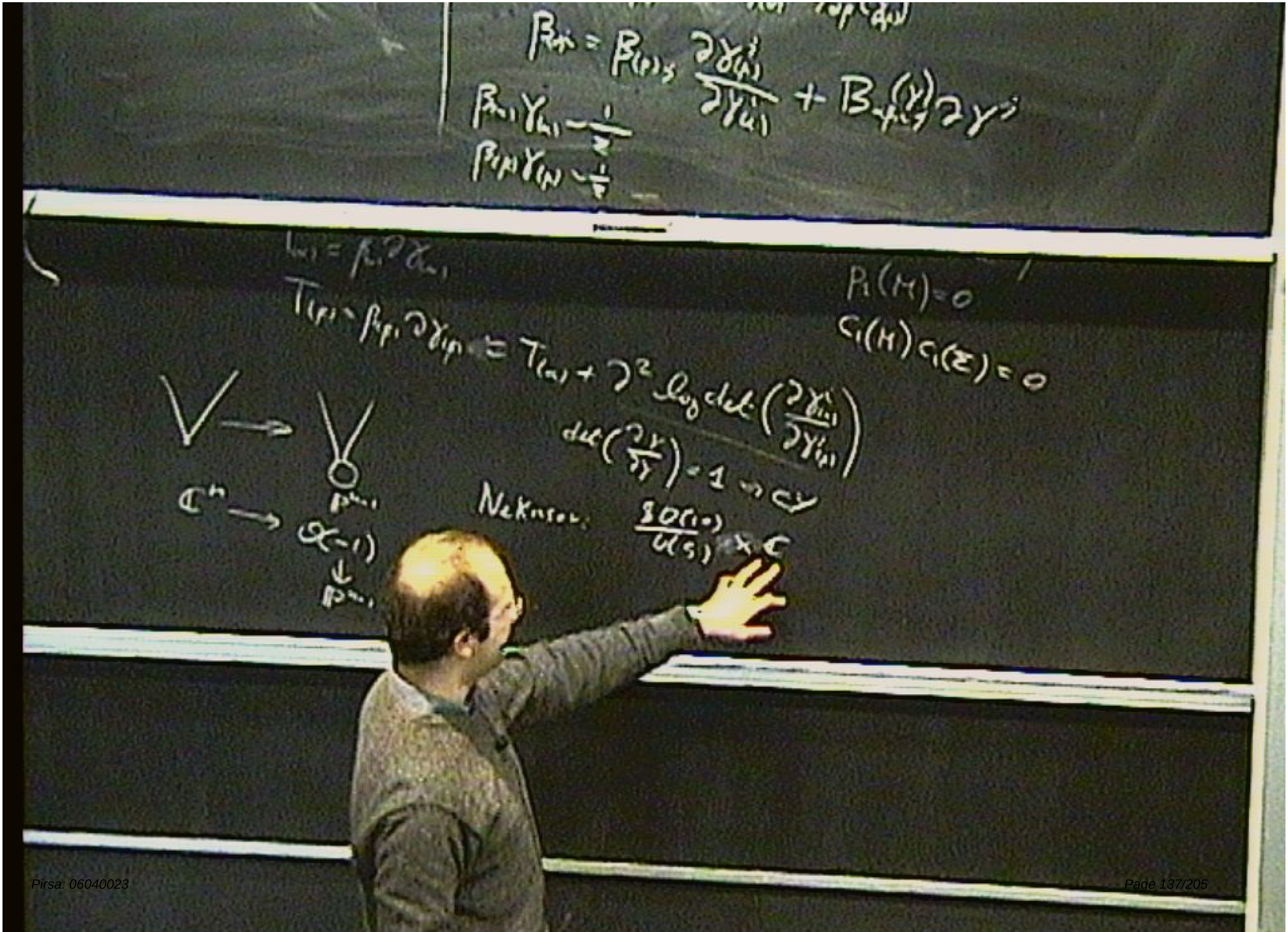

p1(M)=0
c1(M)c1(Σ)=0


$p_1(M) = 0$
$c_1(M)\,c_1(\Sigma) = 0$
$\mathbb{C}^n \to \mathcal{O}(-1)$
$\det\left(\frac{\partial x}{\partial y}\right) = 1 \Rightarrow CY$

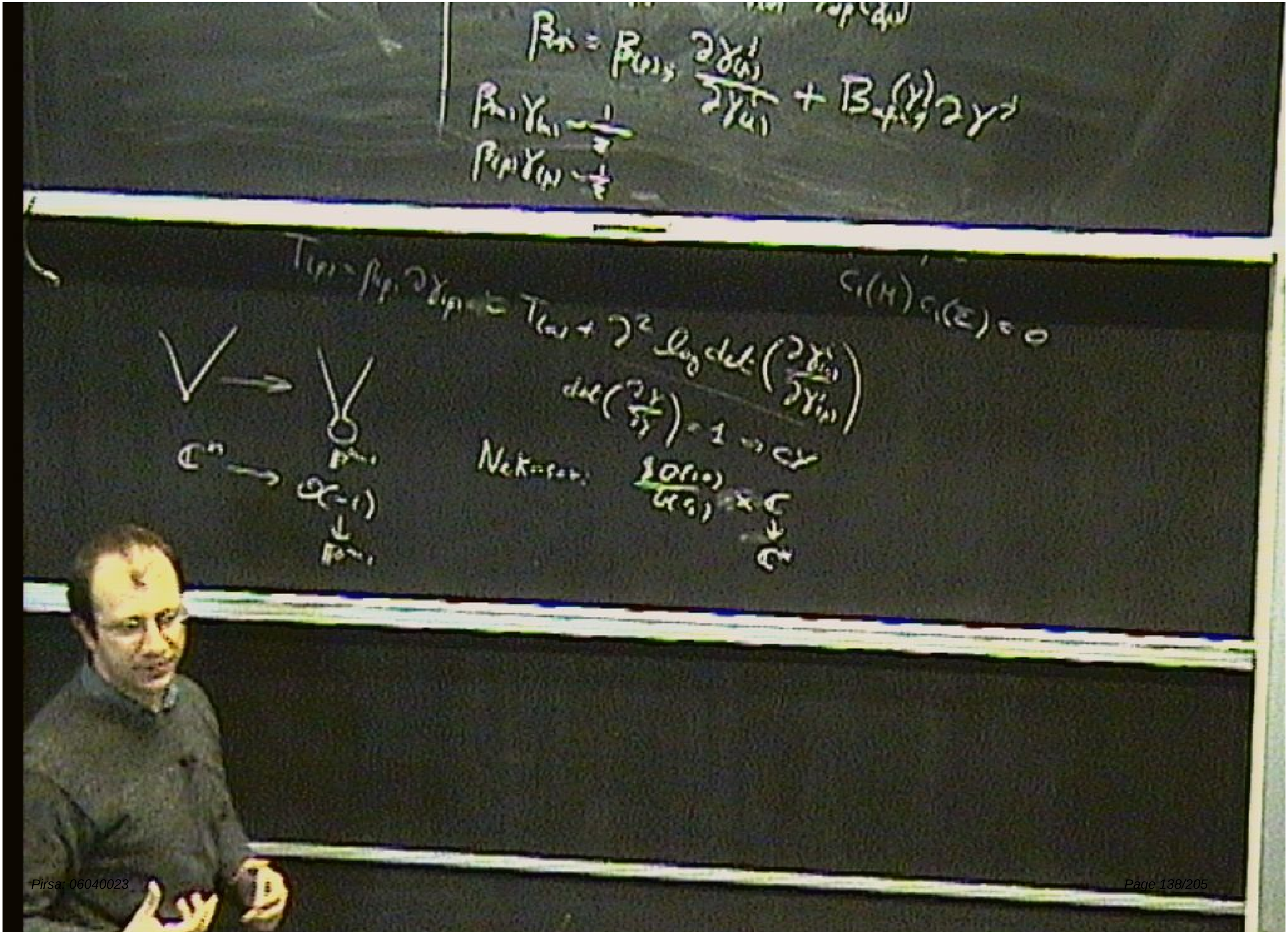

P1(M) = 0
c1(M) c1(Σ) = 0




p1(M) = 0
c1(M) c1(Σ) = 0



p1(M)=0
c1(M)c1(Σ)=0
Nekrasov:



$$\beta_{(n)} = \beta_{(p)j} \frac{\partial\gamma^j_{(p)}}{\partial\gamma^i_{(n)}} + B_{ij}(\gamma)\,\partial\gamma^j$$

$$\beta_{(n)}\gamma_{(n)} \sim \frac{1}{z}$$

$$\beta_{(p)}\gamma_{(p)} \sim \frac{1}{z}$$

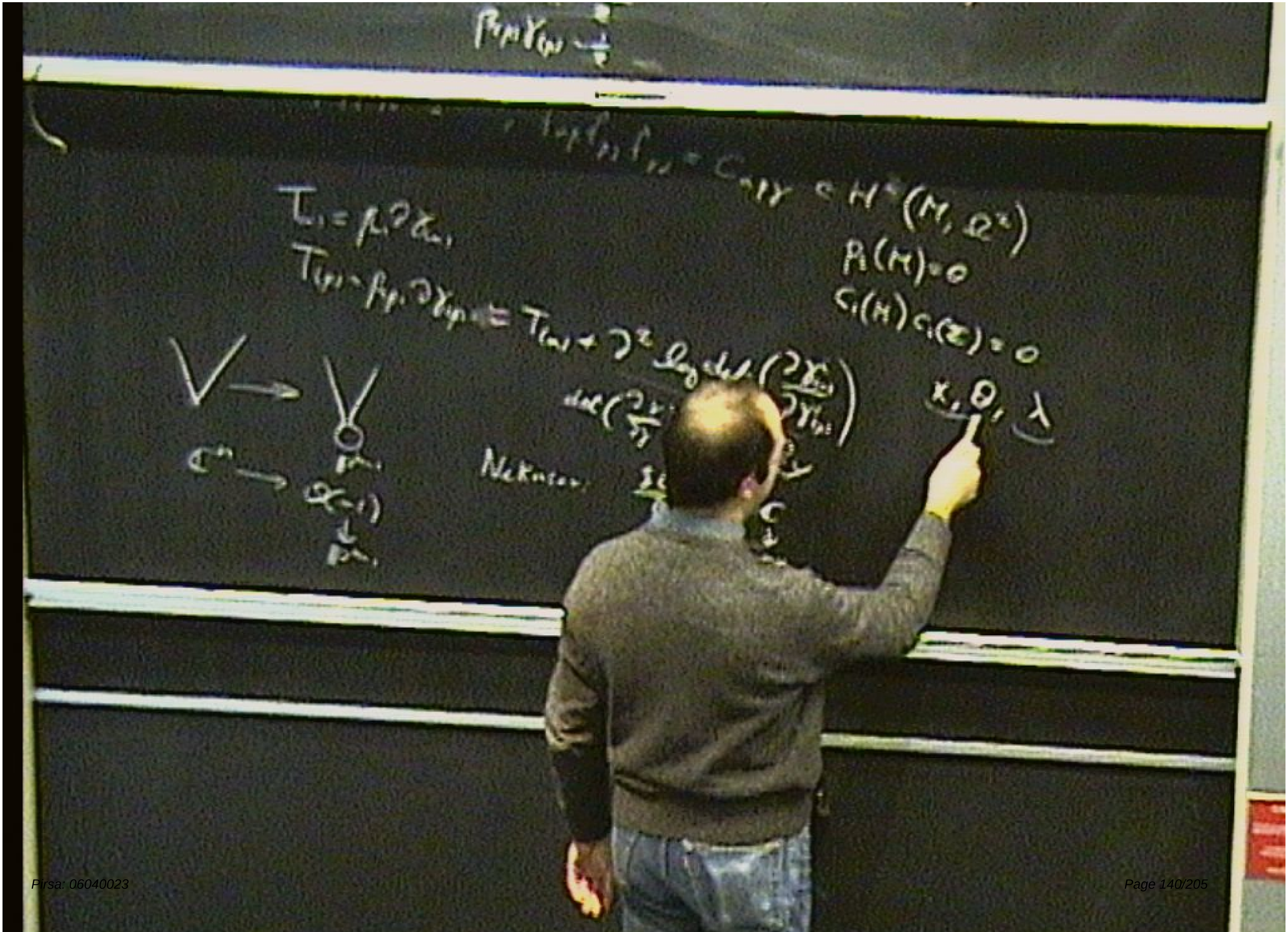
$$T_{(p)} - \beta_{(p)}\partial\gamma_{(p)} = T_{(n)} + \partial^2 \log\det\left(\frac{\partial\gamma^i_{(p)}}{\partial\gamma^j_{(n)}}\right)$$

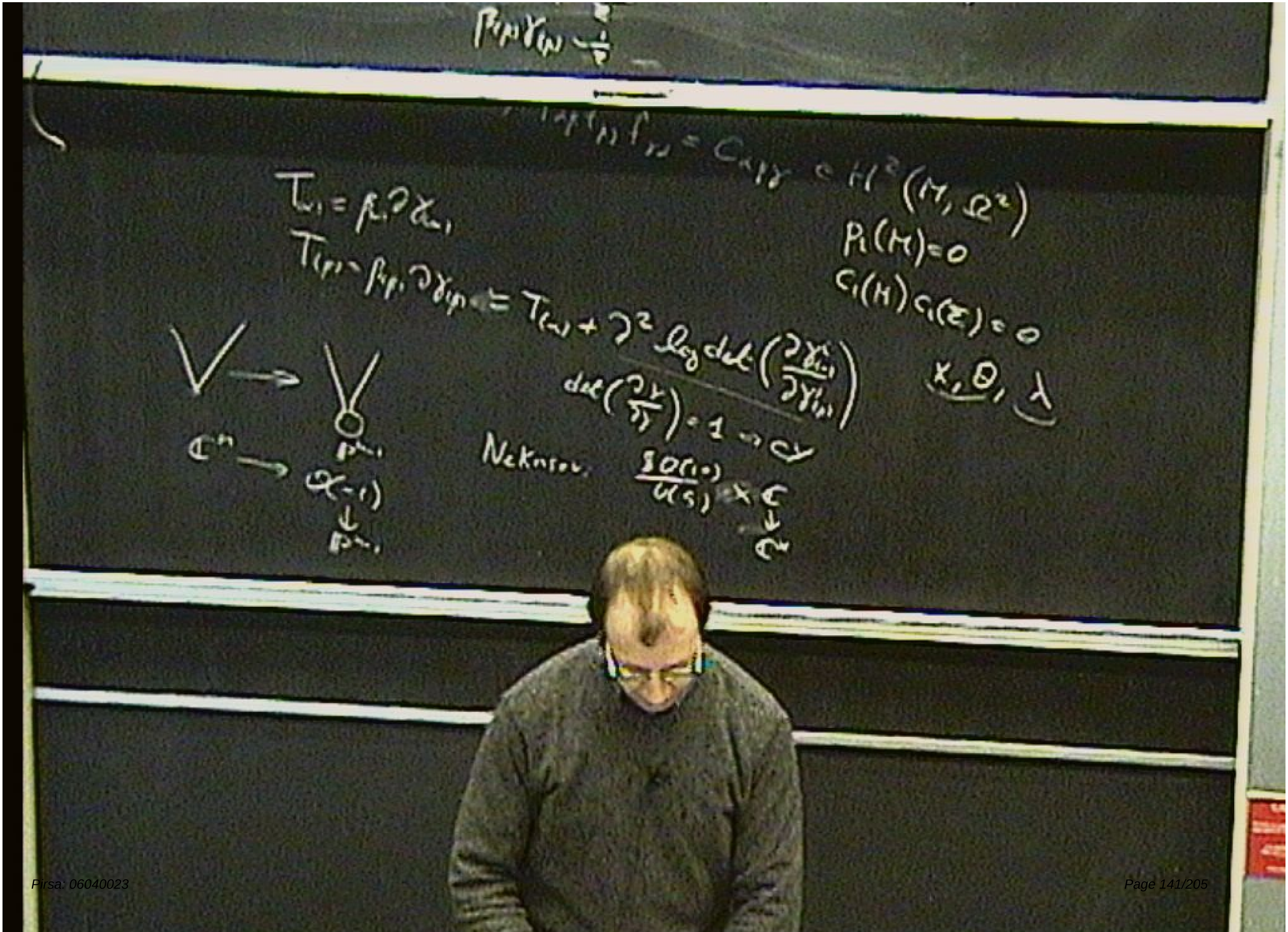
$$c_1(M)\,c_1(\Sigma) = 0$$

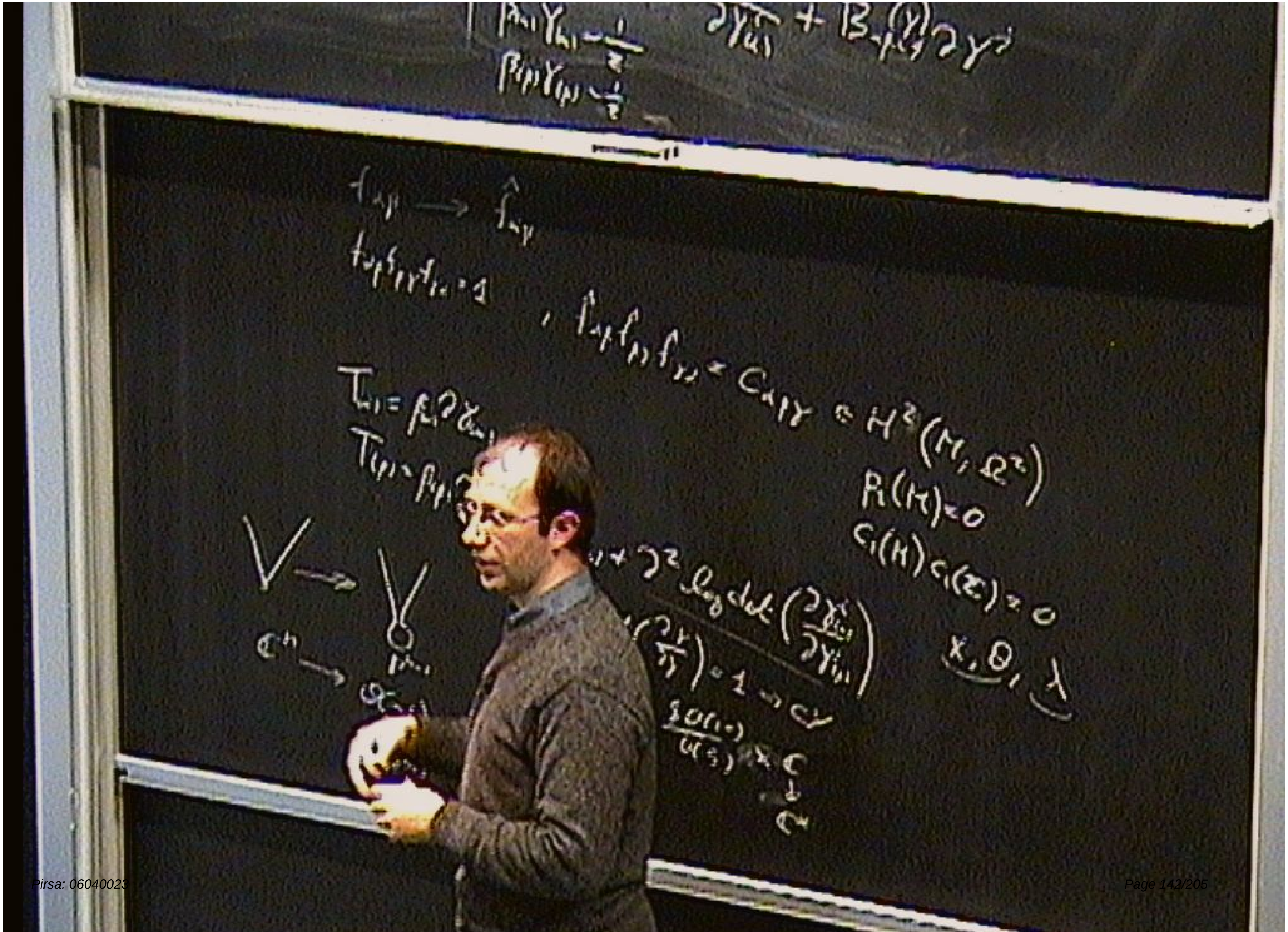
$$\det\left(\frac{\partial\gamma}{\partial\gamma}\right) = 1 \Rightarrow c_1$$

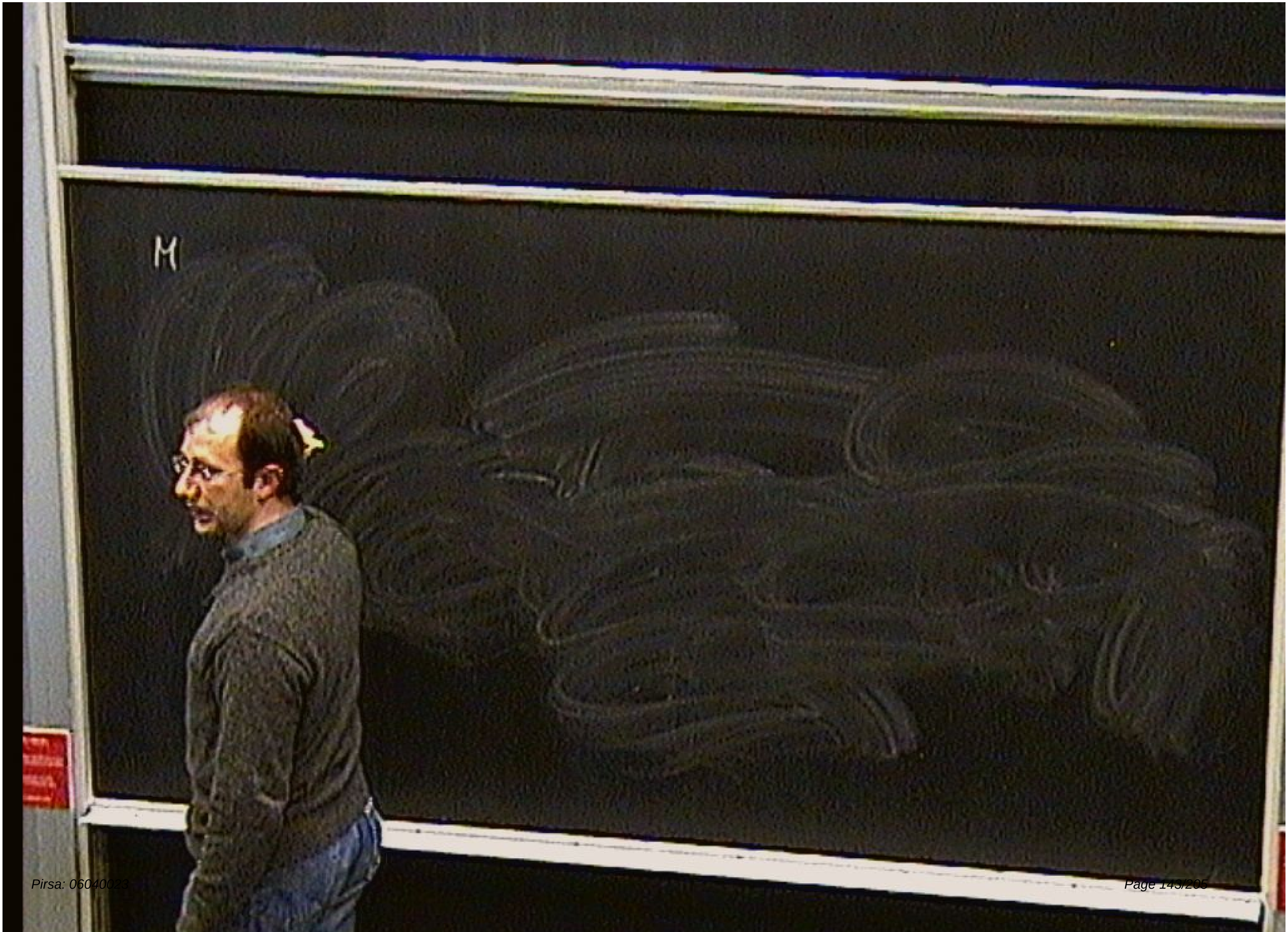
$\mathbb{C}^n \longrightarrow \mathcal{O}(-1)$
$\downarrow$
$\mathbb{P}^{n-1}$

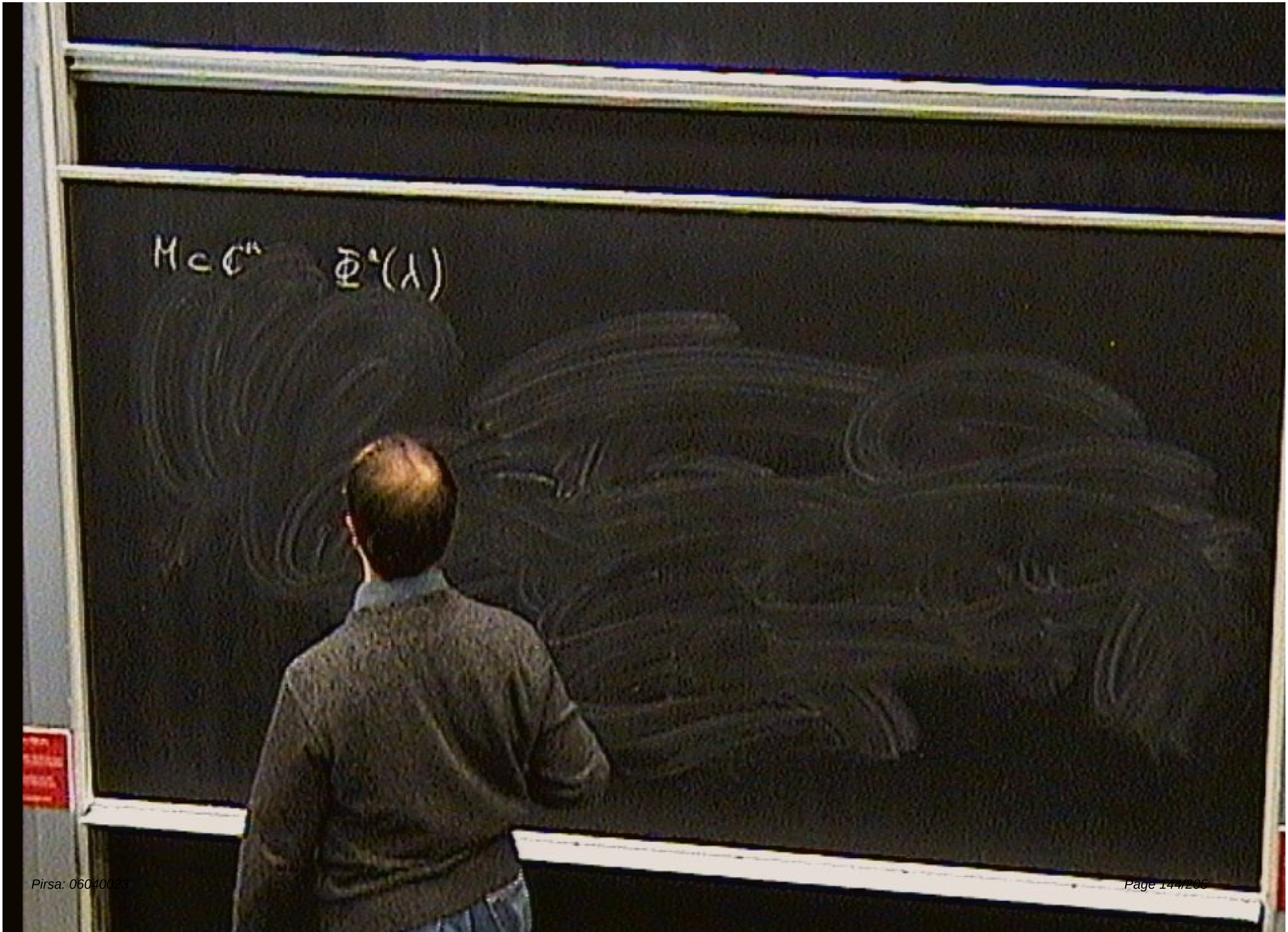
Nekrasov: $\frac{SO(10)}{U(5)} \times \mathbb{C}$
$\downarrow$
$\mathbb{C}^*$

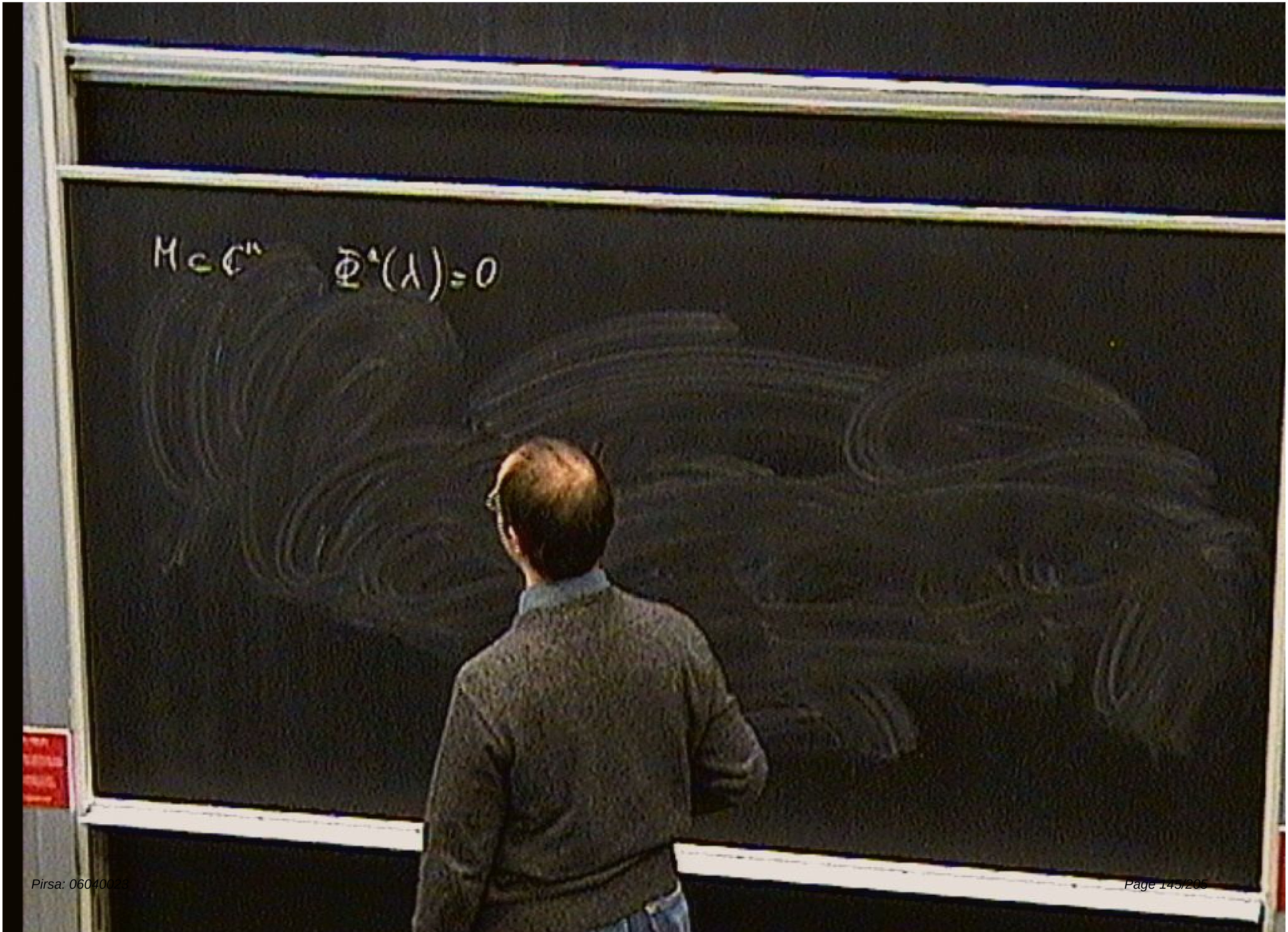


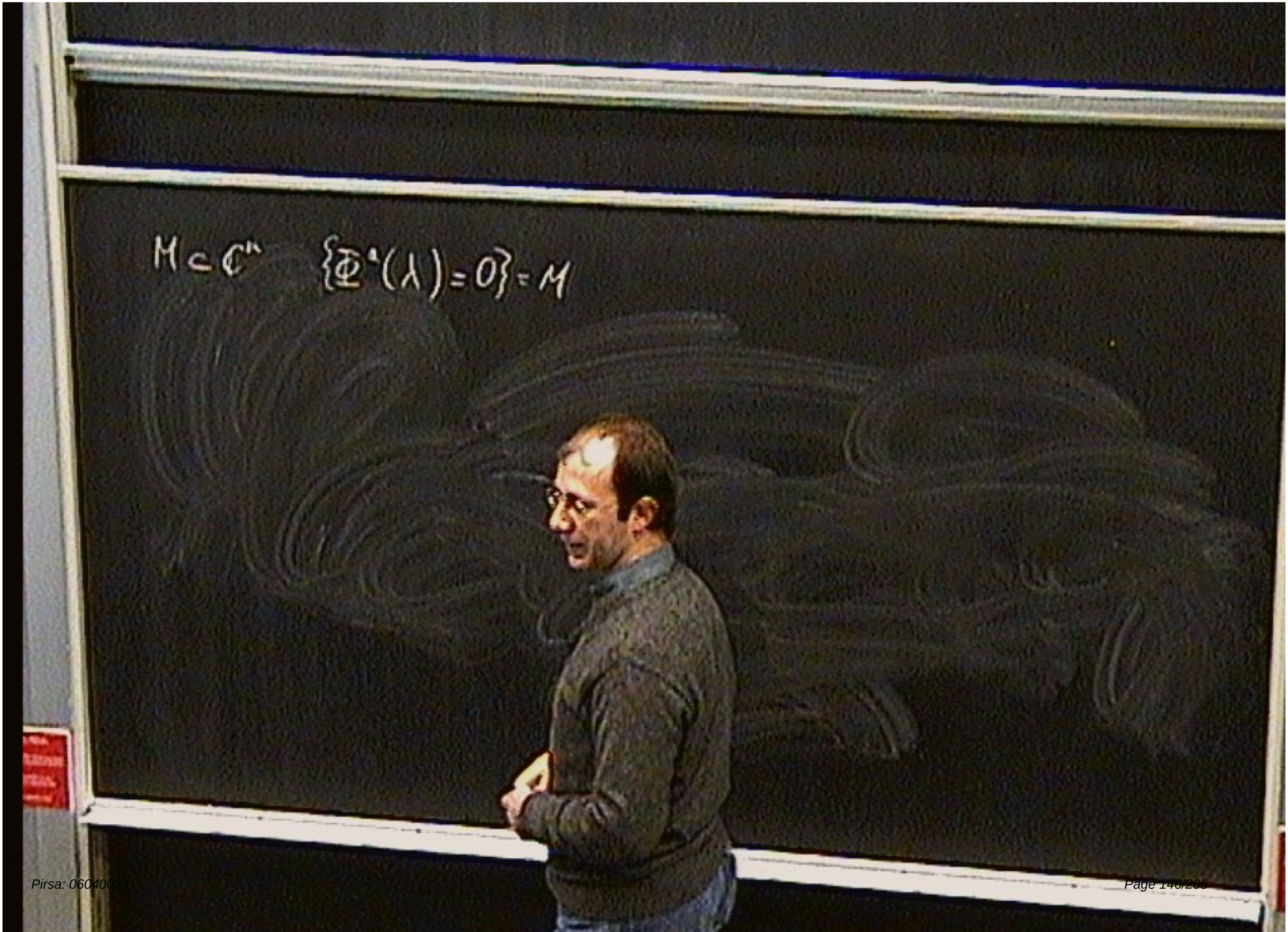

$\in H^2(M, \Omega^2)$
$p_1(M)=0$
$c_1(M)\,c_1(E)=0$
$T_{(n)} + \partial^2 \log\det\left(\frac{\partial \gamma_{(n)}}{\partial \gamma_{(n)}}\right)$
$\det\left(\frac{\partial \gamma}{\partial \gamma}\right) = 1$
$\mathbb{C}^n \to \mathcal{O}(-1)$
Nekrasov
$\frac{SO(10)}{U(5)}$

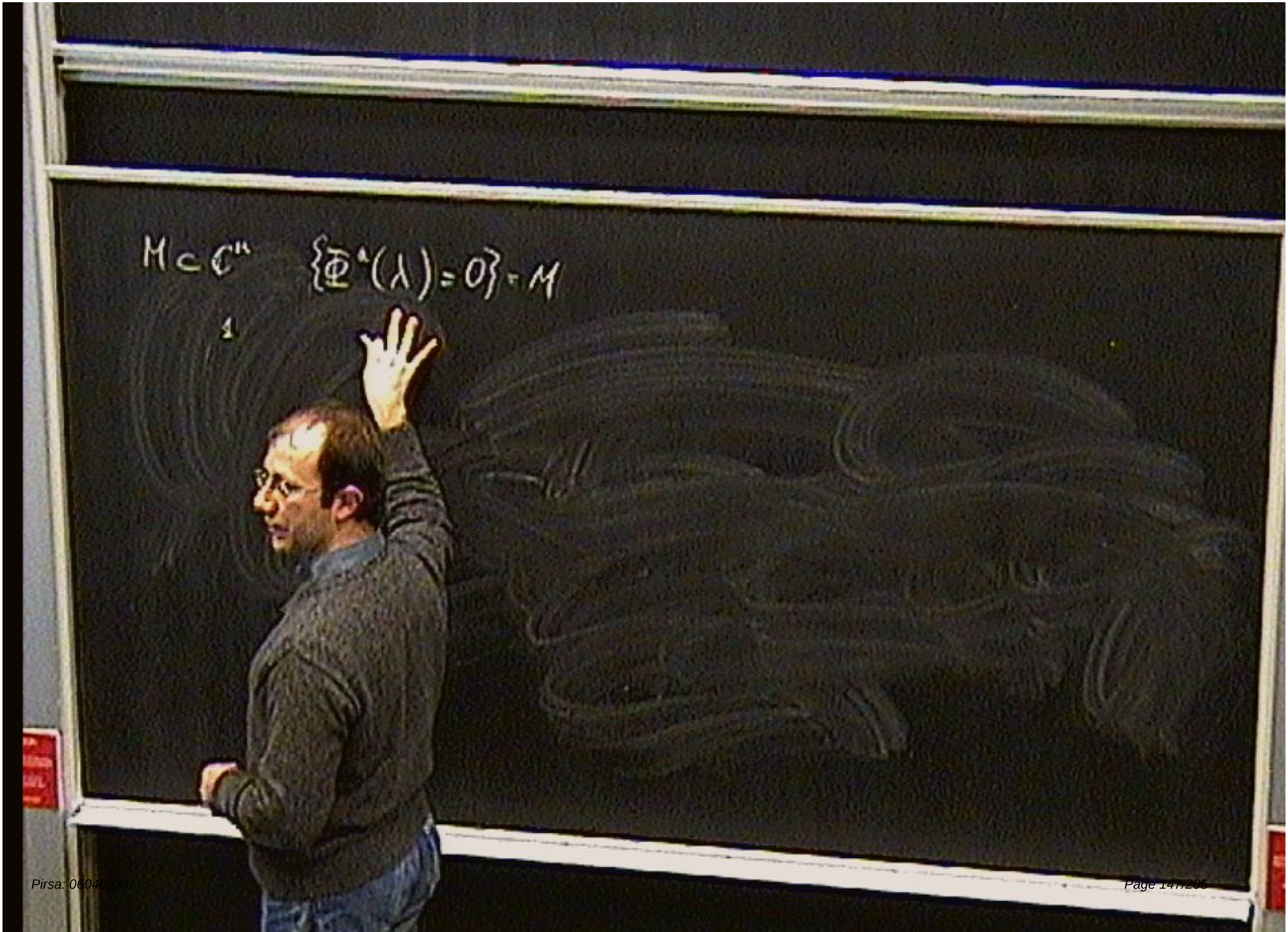


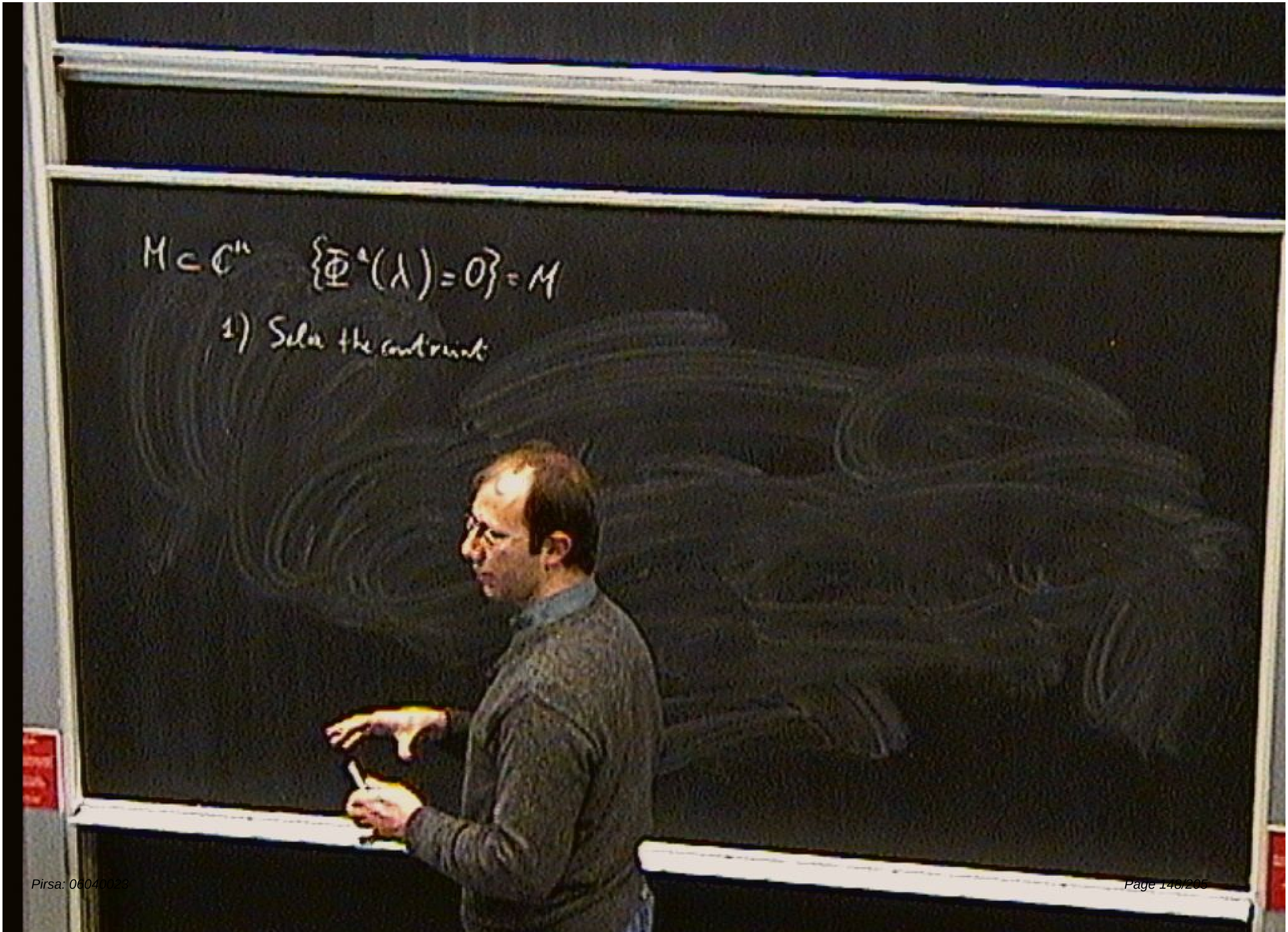

M

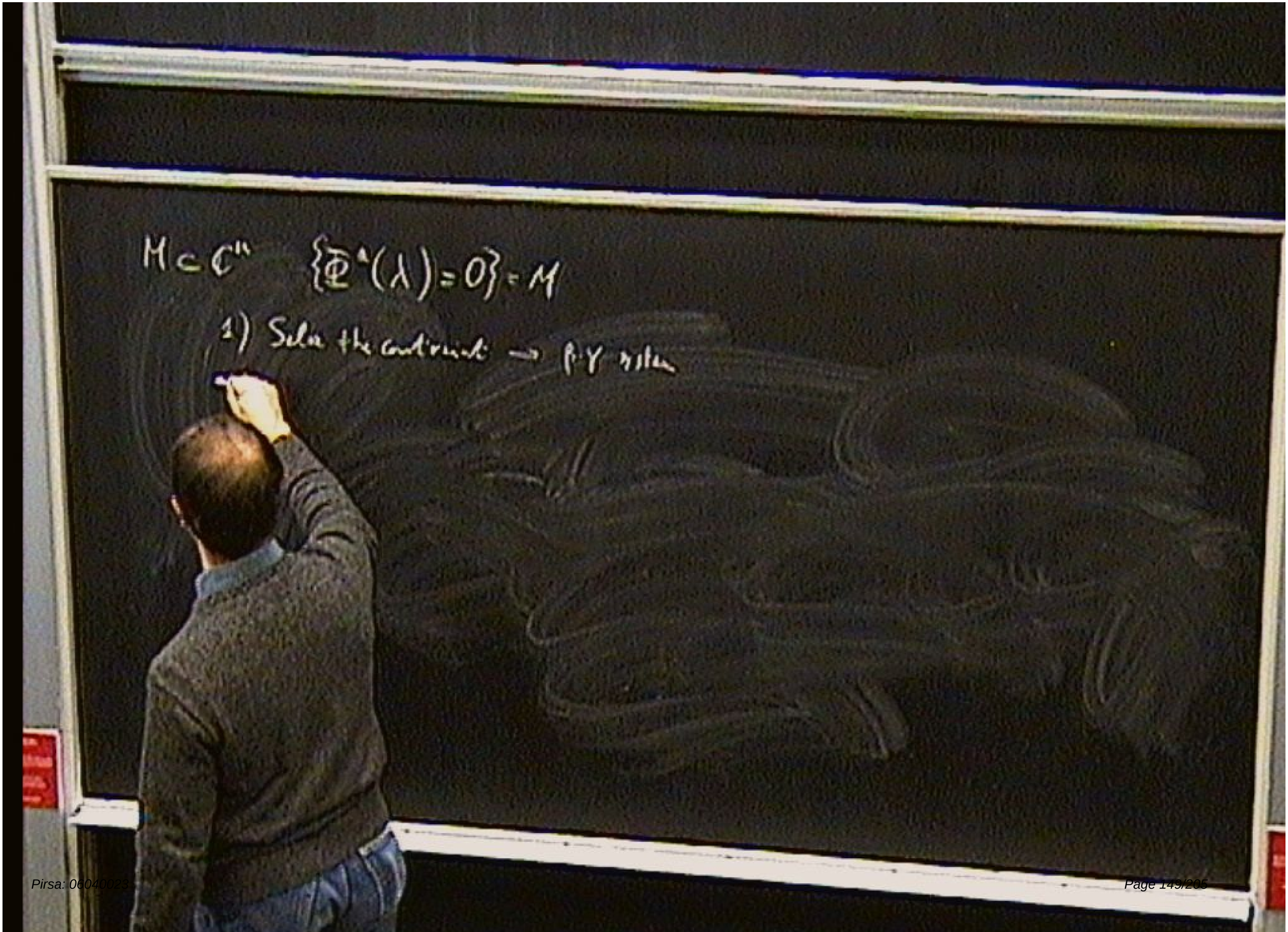

$M \subset \mathbb{C}^n$ $\Phi^a(\lambda)$

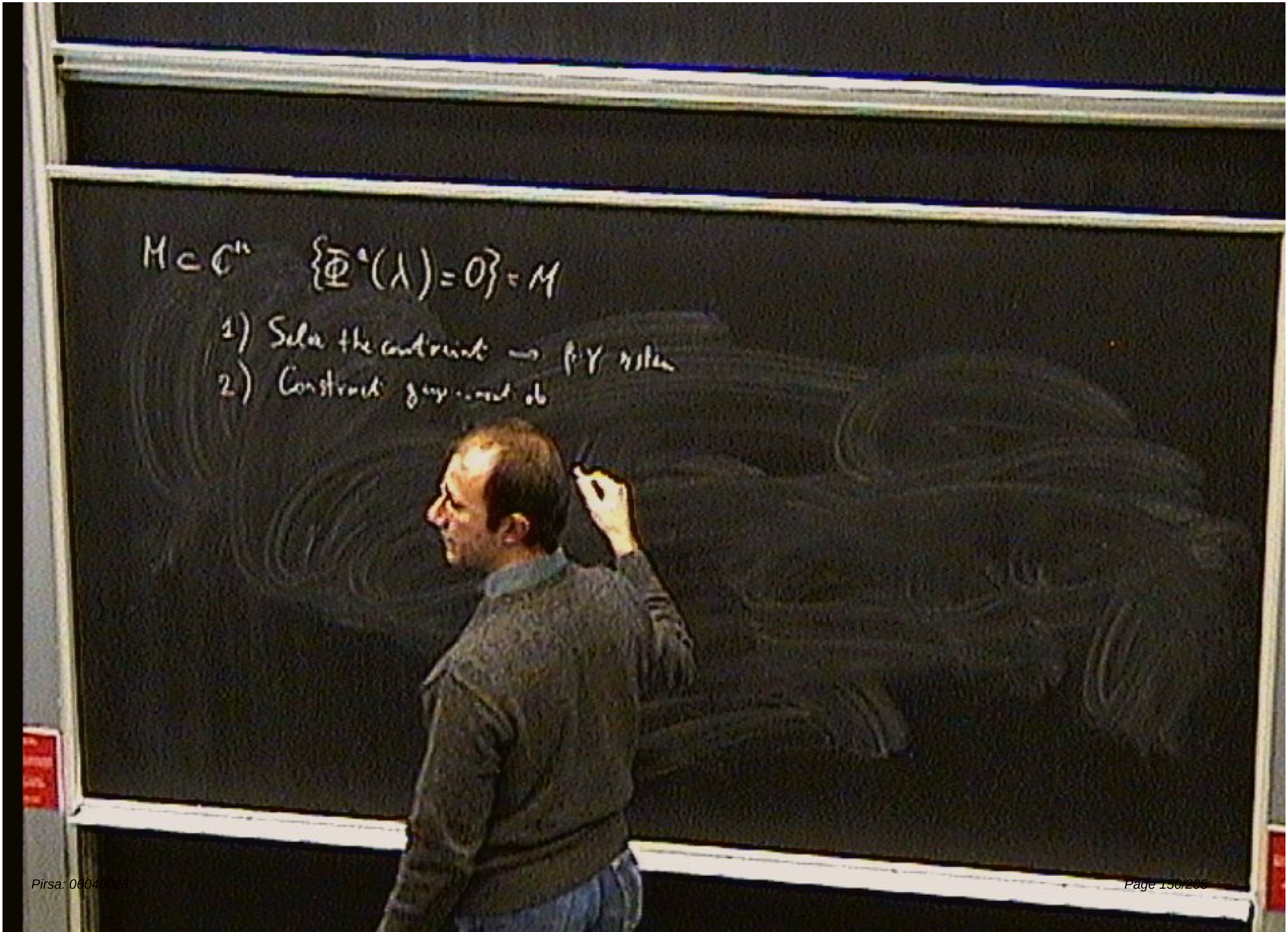

M ⊂ ℂ^n
Φ^a(λ)=0

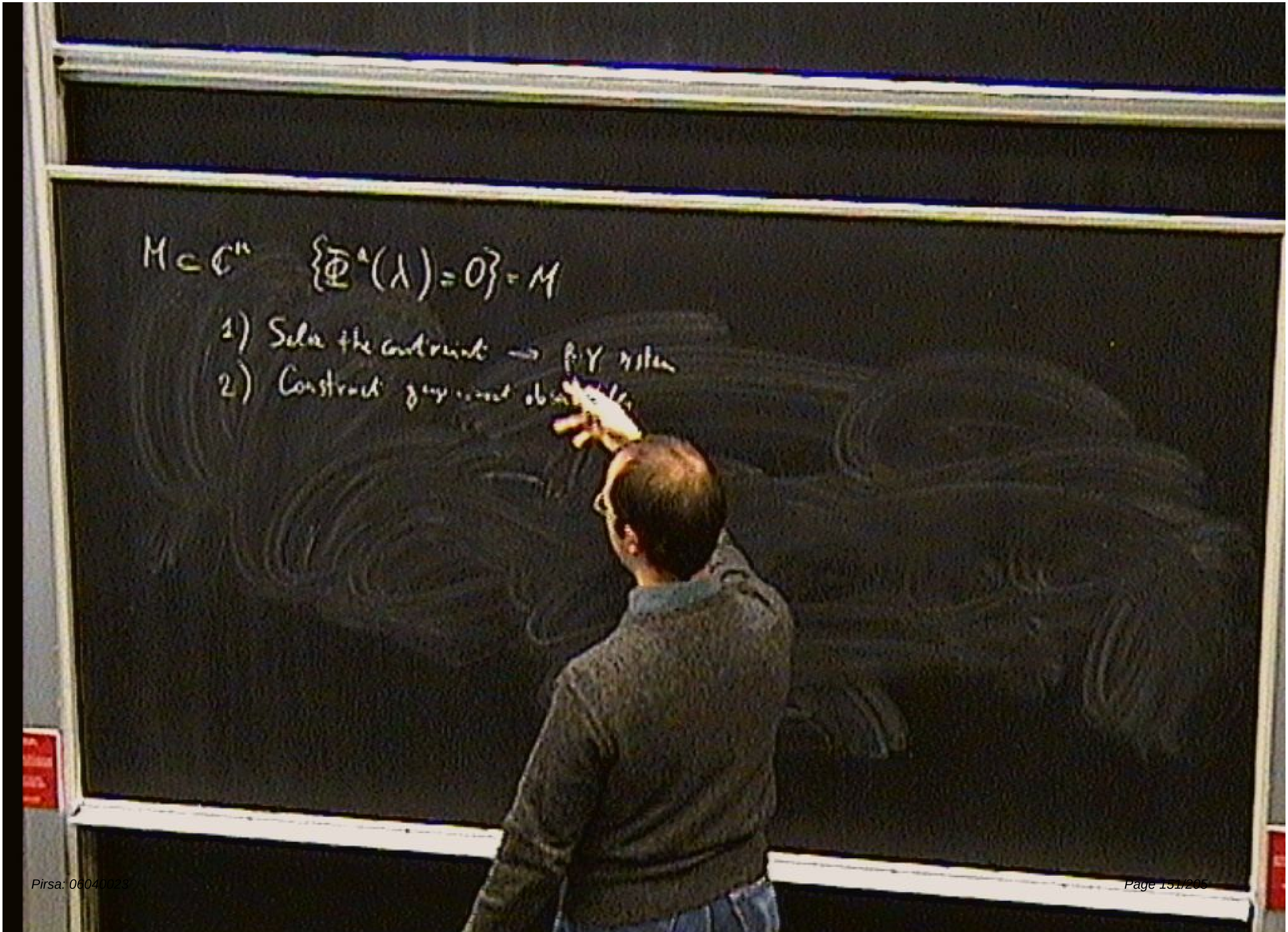

$M \subset \mathbb{C}^n$
$\{\Phi^a(\lambda)=0\}=M$

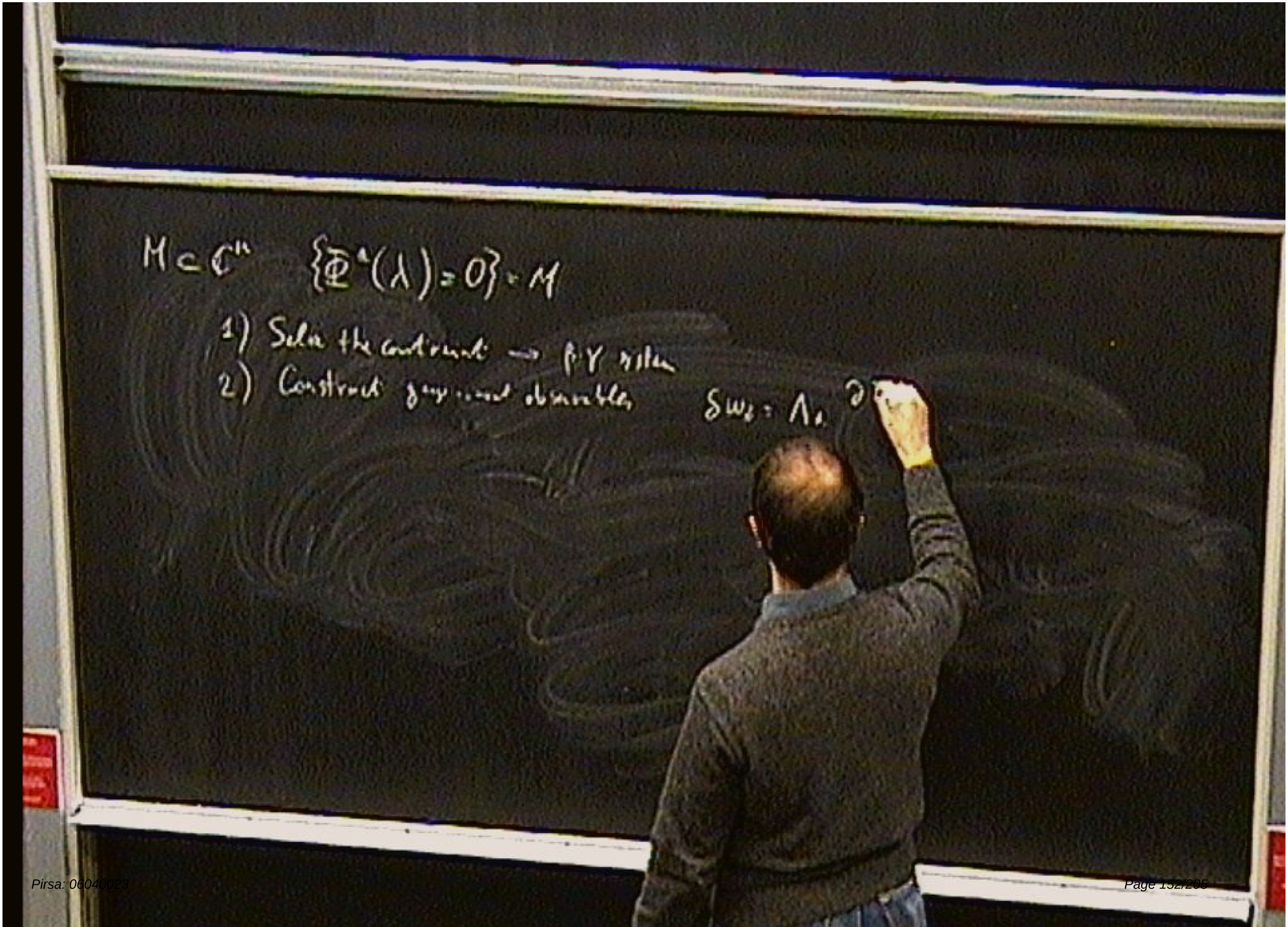

M ⊂ ℂ^n
{Φ^a(λ) = 0} = M

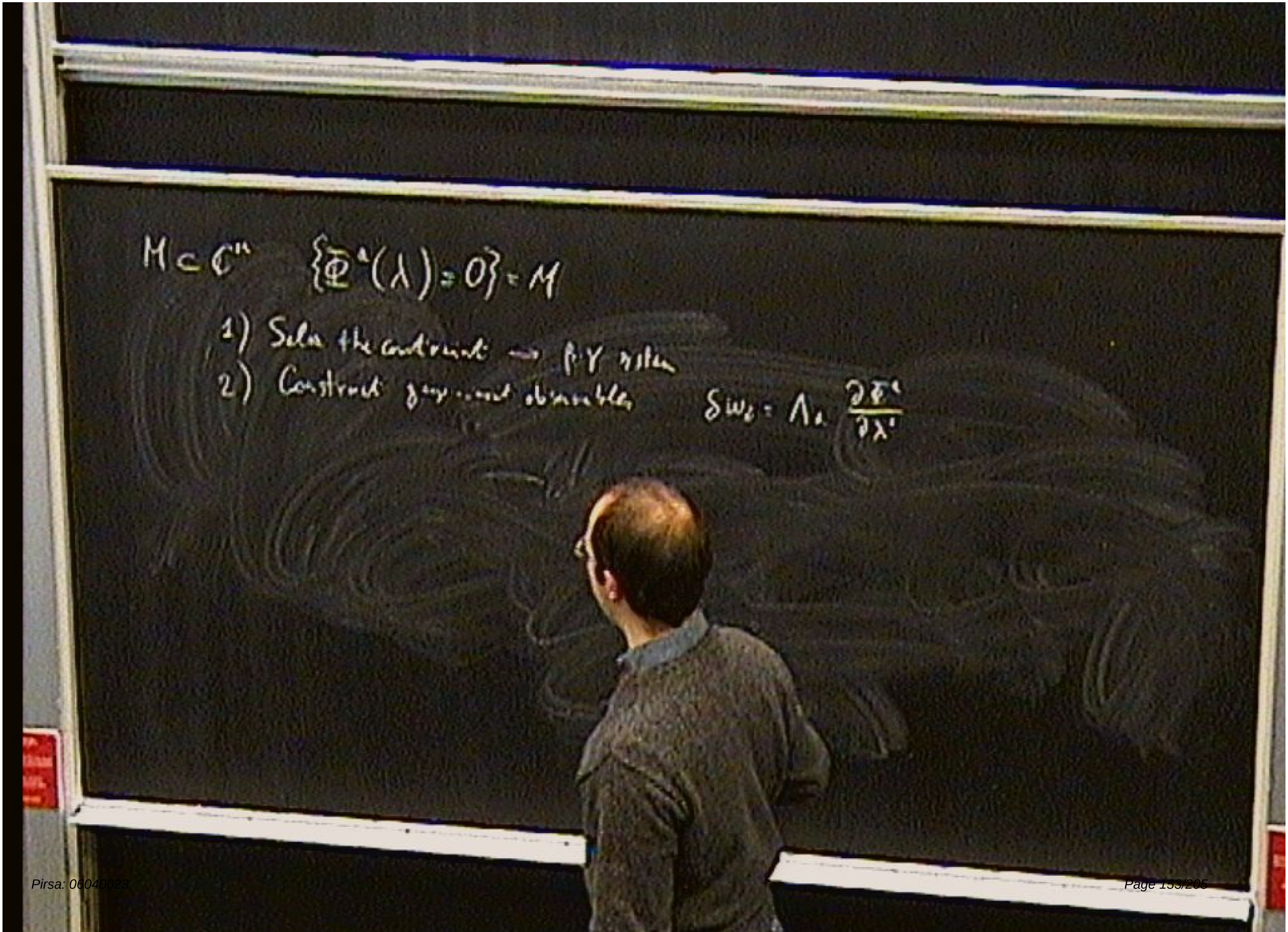

M ⊂ ℂ^n {Φ^a(λ) = 0} = M
1) Solve the constraints

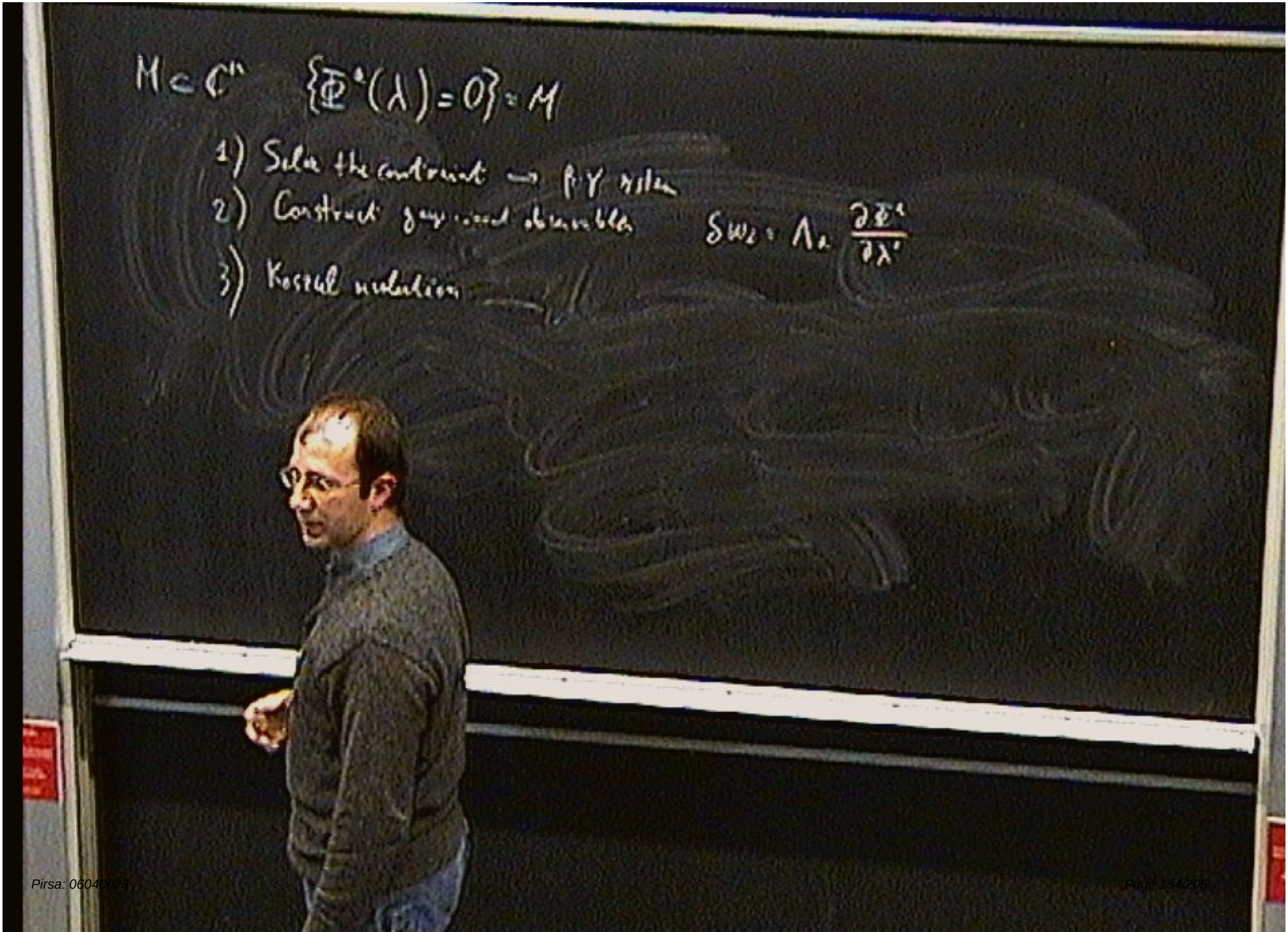

M ⊂ ℂ^n {Φ^a(λ) = 0} = M
1) Solve the constraints

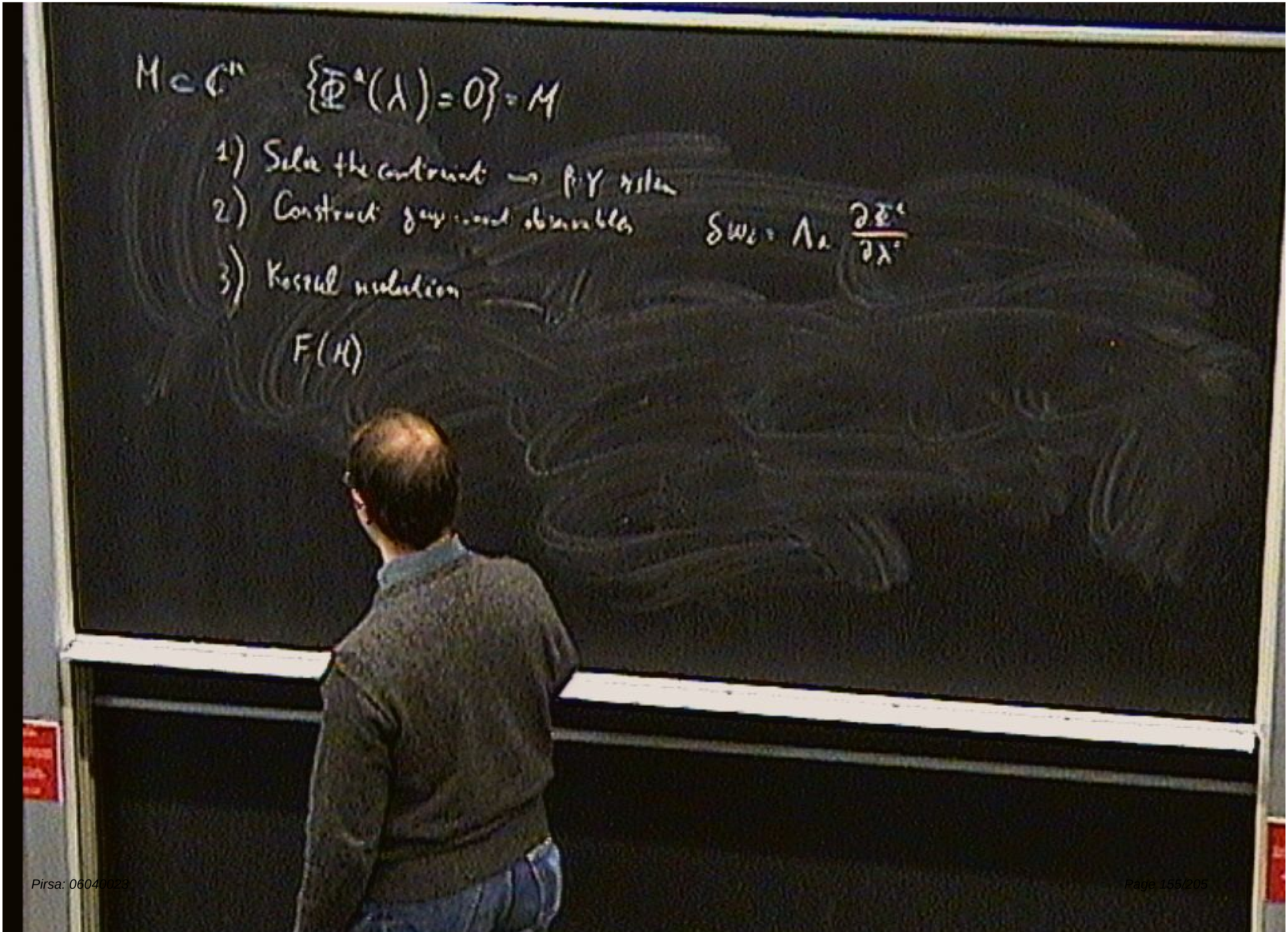

M ⊂ ℂ^n
{Φ^a(λ) = 0} = M
1) Solve the constraints
2) Construct

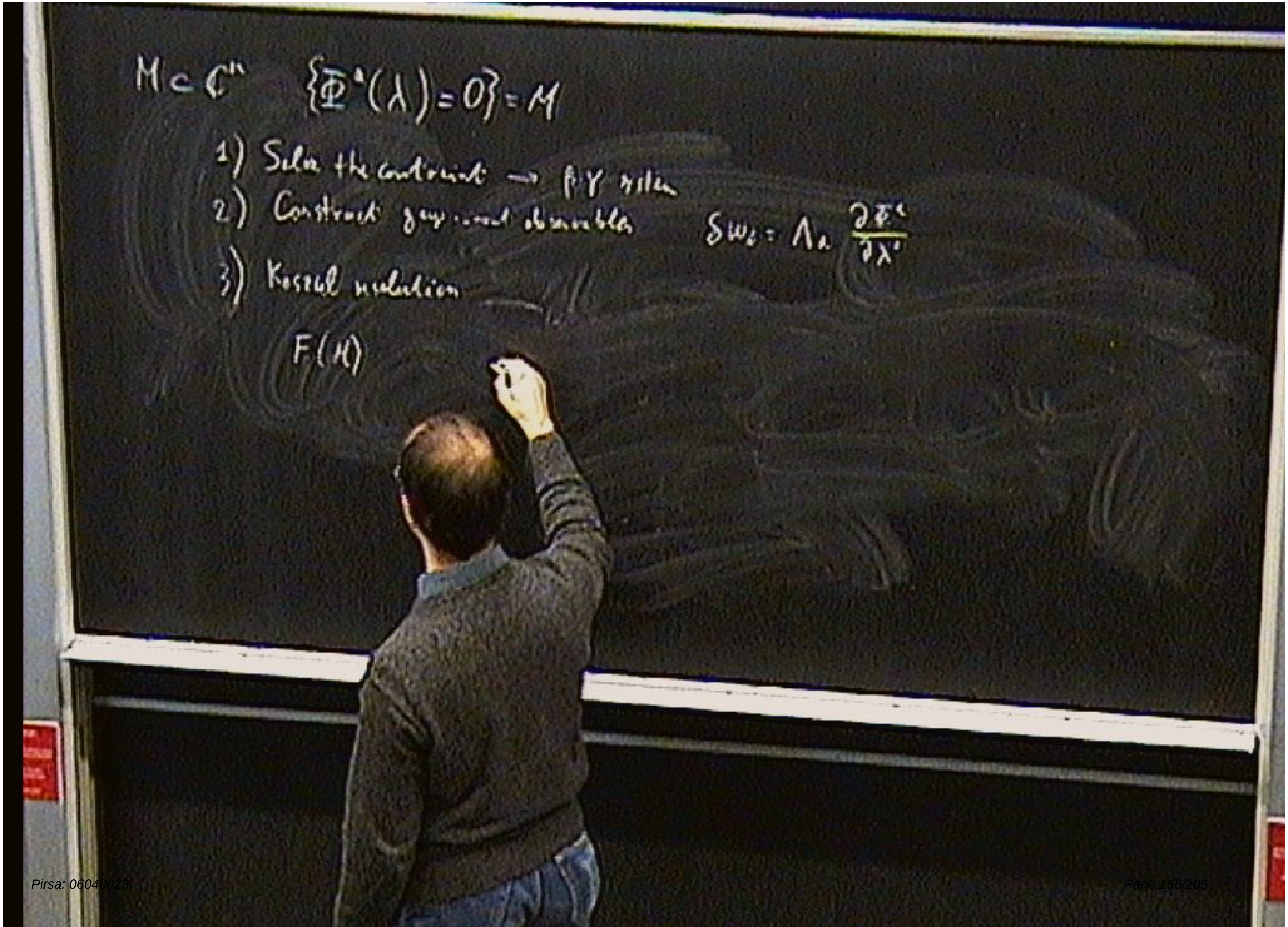

M ⊂ ℂⁿ   {Φᵃ(λ) = 0} = M
1) Solve the
2) Construct

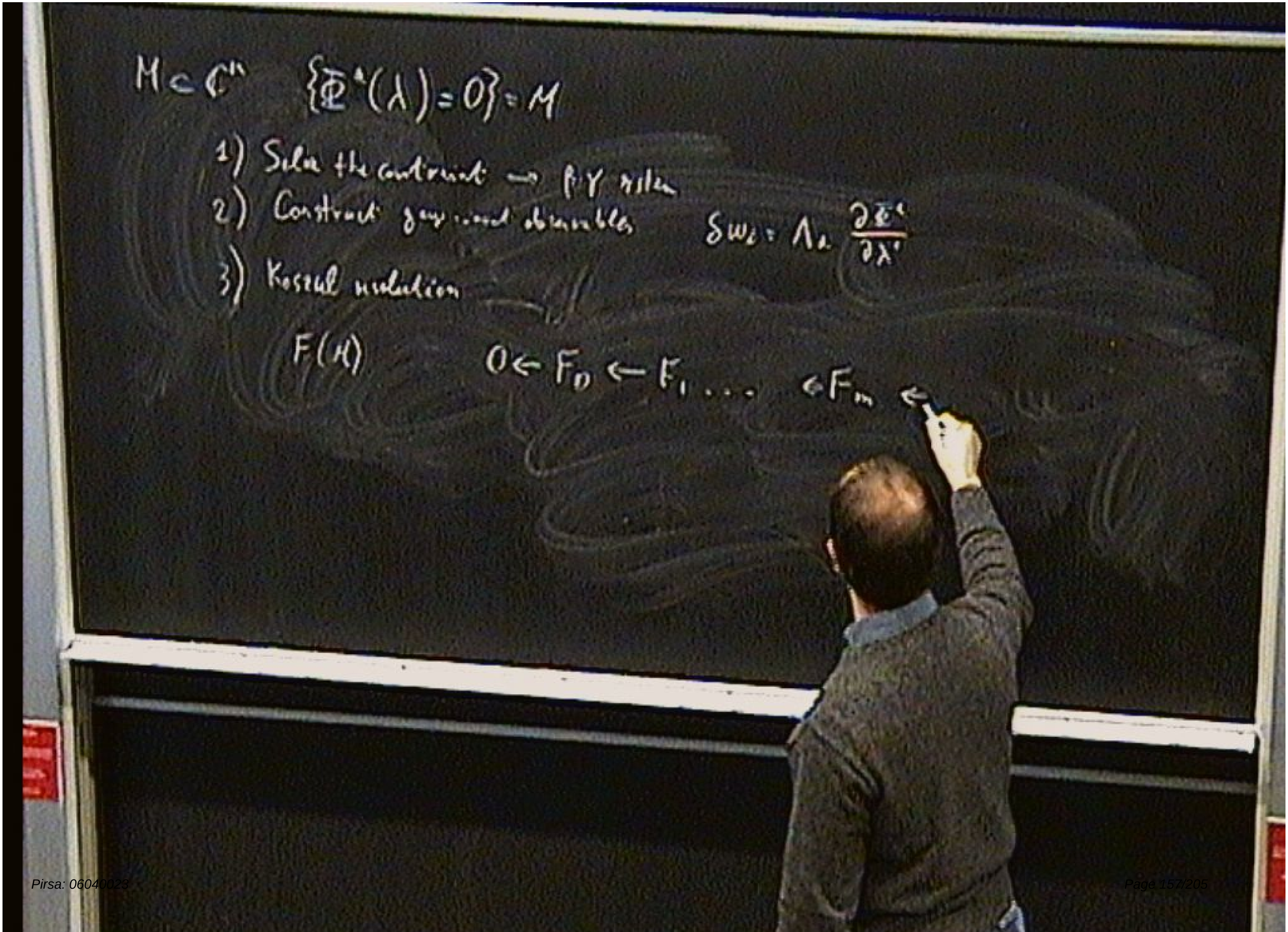

M ⊂ ℂ^n
{Φ^a(λ) = 0} = M
1) Solve the constraints
2) Construct
δw = Λ ∂

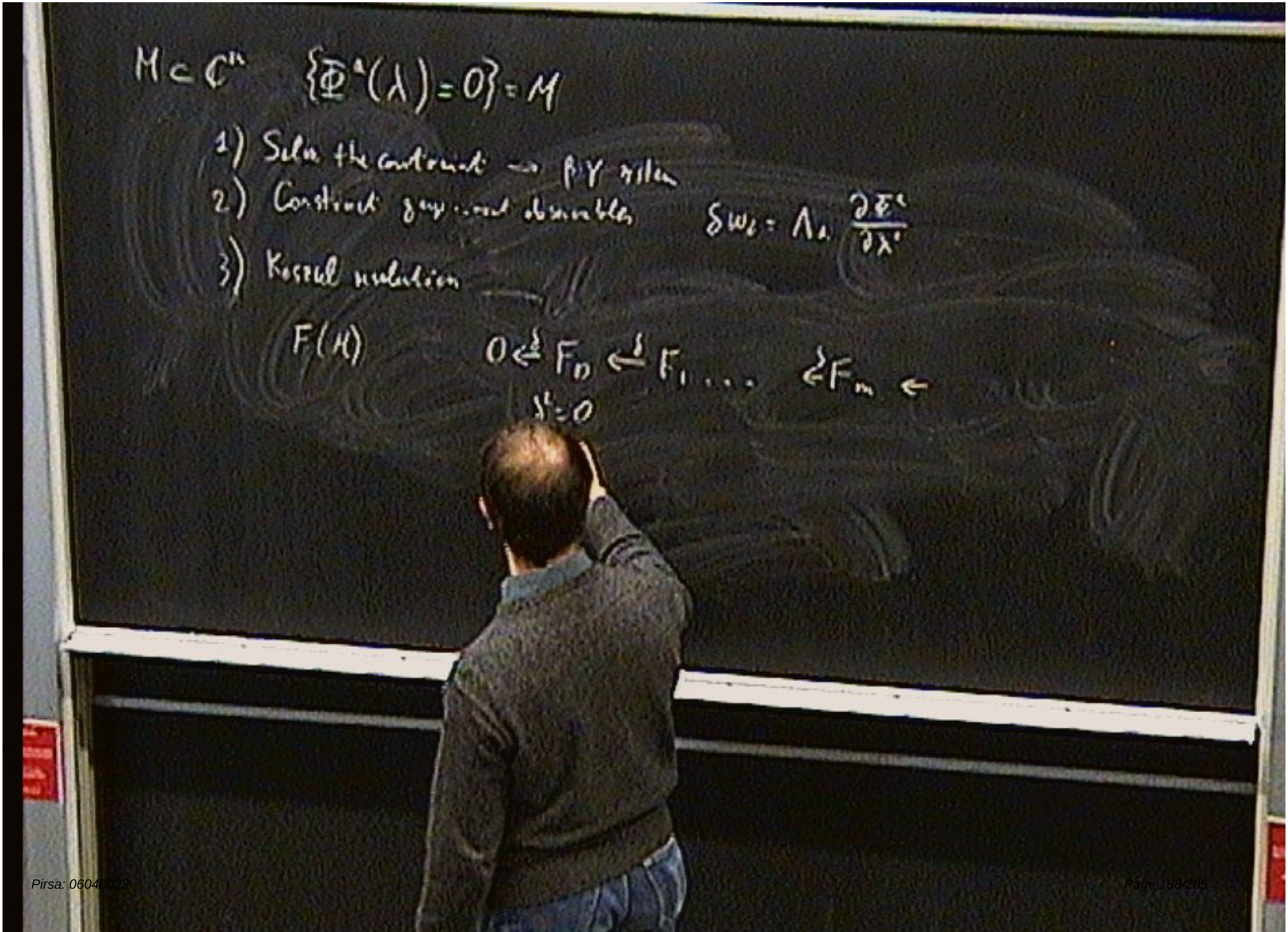

M ⊂ C^n   {Φ^a(λ) = 0} = M
1) Solve the constraint → βγ system
2) Construct gauge-invariant observables
δw_i = Λ_a ∂Φ^a/∂λ^i

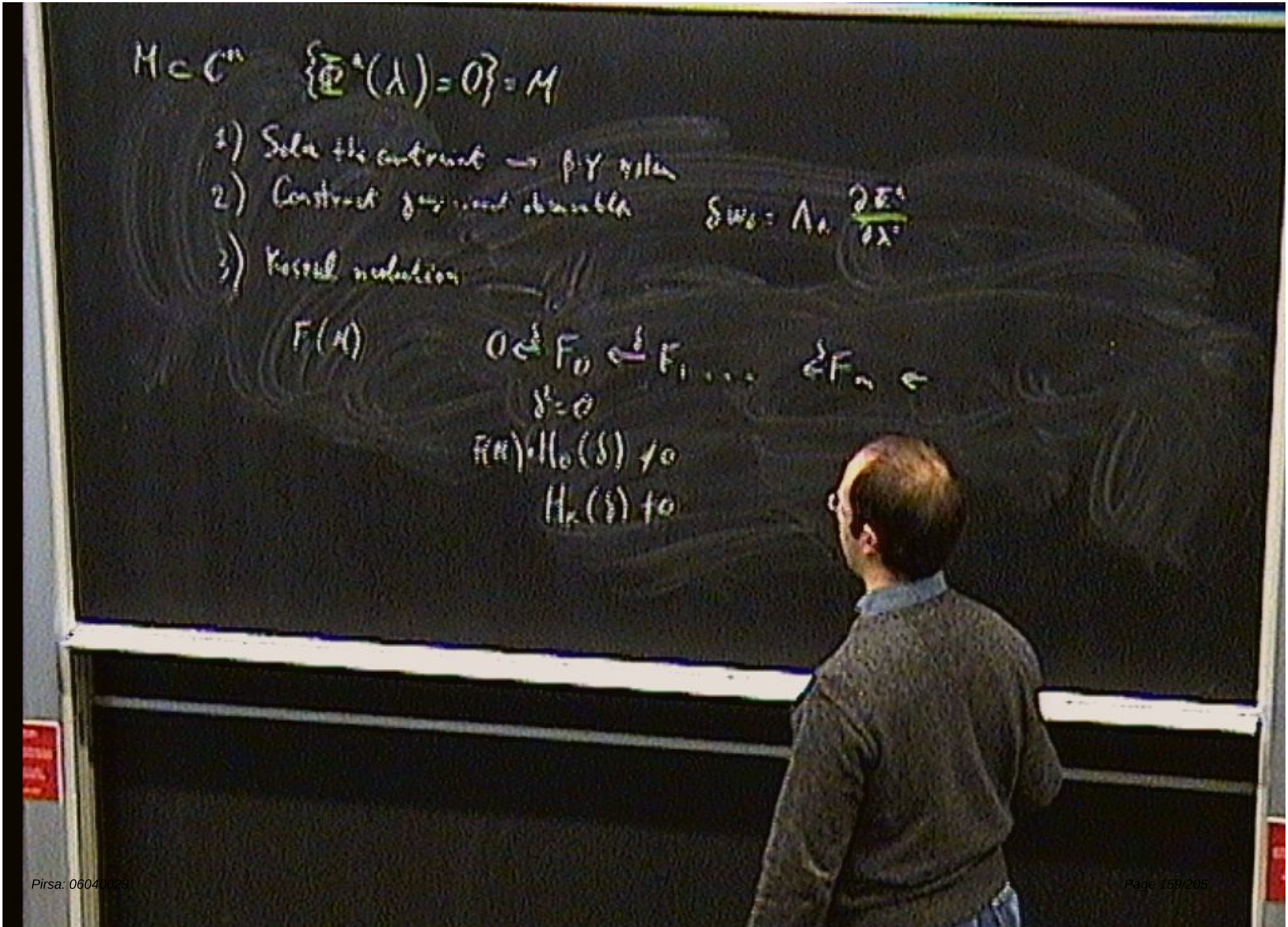

M ⊂ C^n   {Φ^a(λ) = 0} = M
1) Solve the constraint → β-γ system
2) Construct gauge-invariant observables   δw_i = Λ_a ∂Φ^a/∂λ^i
3) Koszul resolution

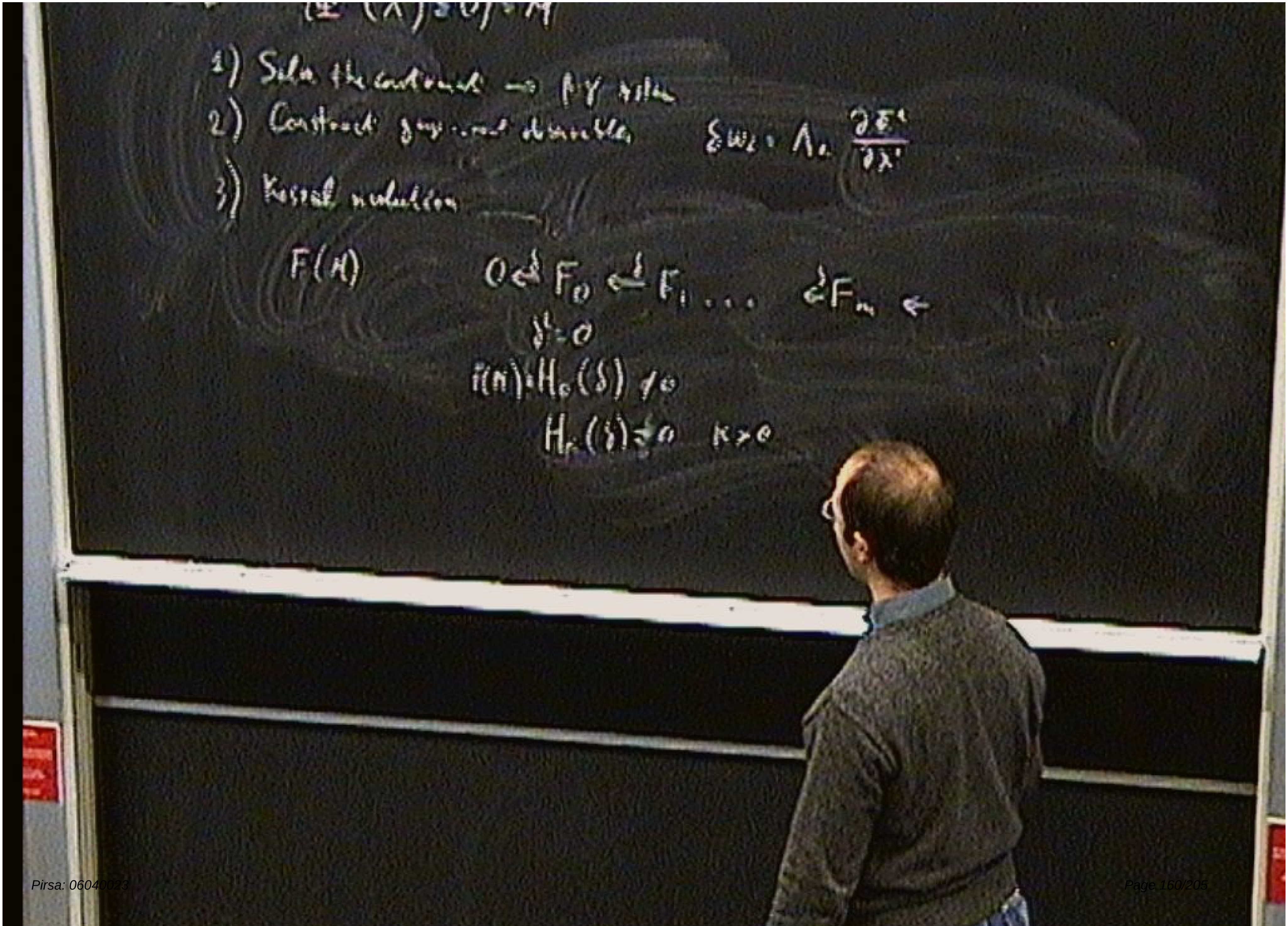

M ⊂ ℂⁿ {Φᵃ(λ) = 0} = M
1) Solve the constraints
2) Construct gauge-invariant observables
δwᵢ = Λₐ ∂Φᵃ/∂λⁱ
3) Koszul resolution
F(M)

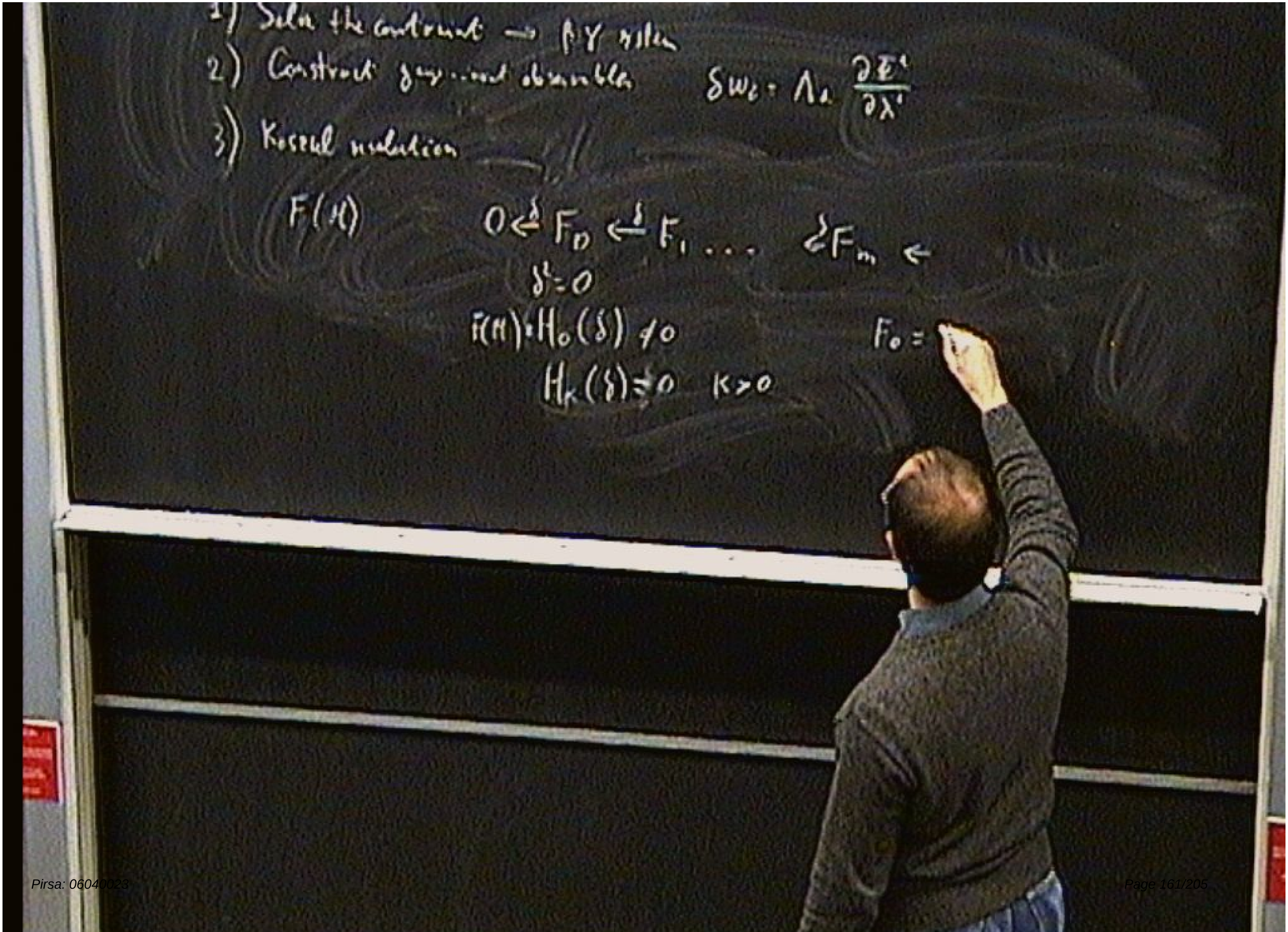

$M \subset \mathbb{C}^n \quad \{\Phi^a(\lambda) = 0\} = M$
1) Solve the constraints
2) Construct gauge-invariant observables
$\delta w_i = \Lambda_a \frac{\partial \Phi^a}{\partial \lambda^i}$
3) Koszul resolution
$F(M)$

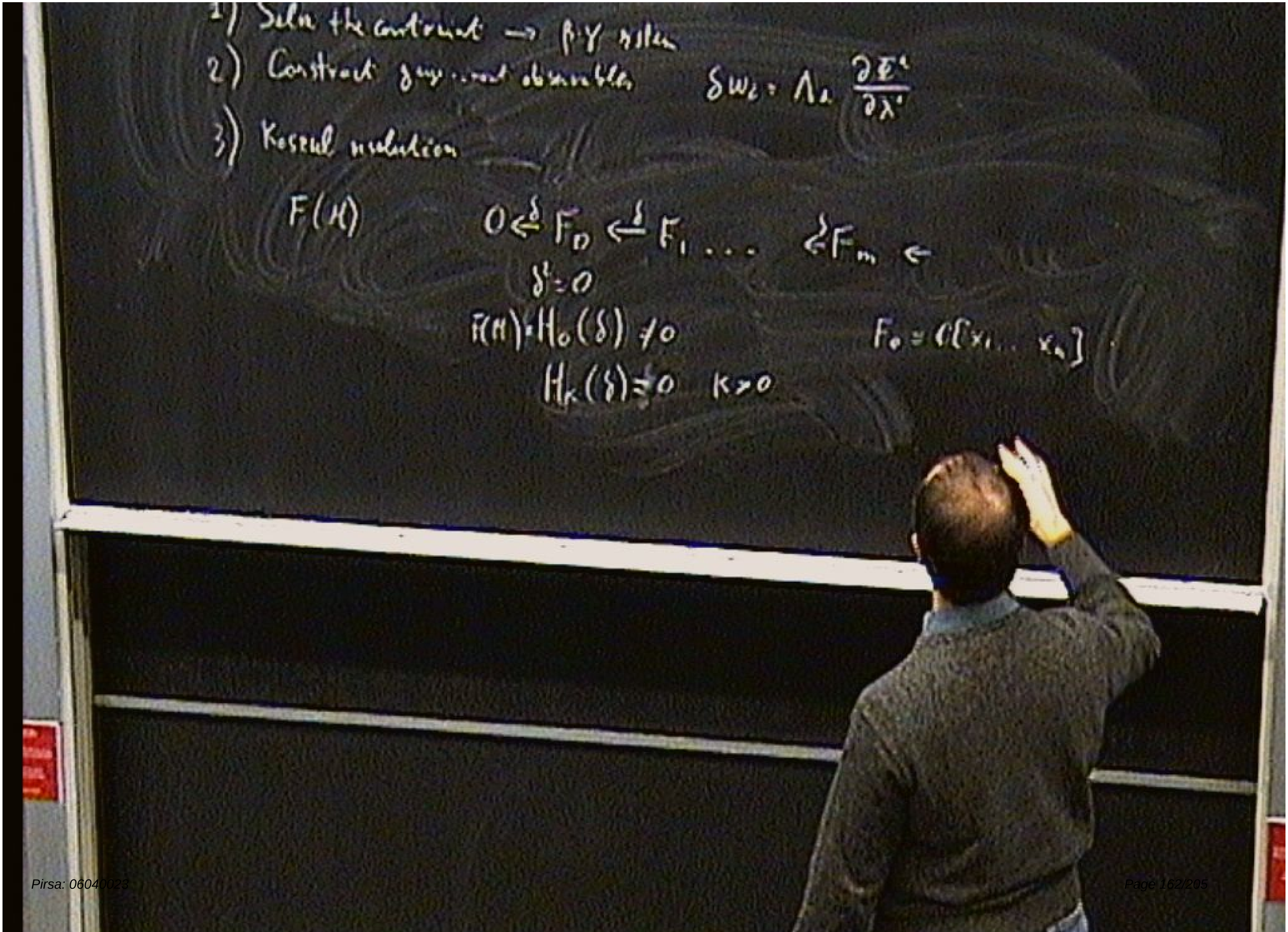

M ⊂ C^n   {Φ^a(λ) = 0} = M
1) Solve the constraints →
2) Construct gauge-invariant observables   δw_i = Λ_a ∂Φ^a/∂λ^i
3) Koszul resolution
F(M)   0 ← F_0 ← F_1 . . . ← F_m ←

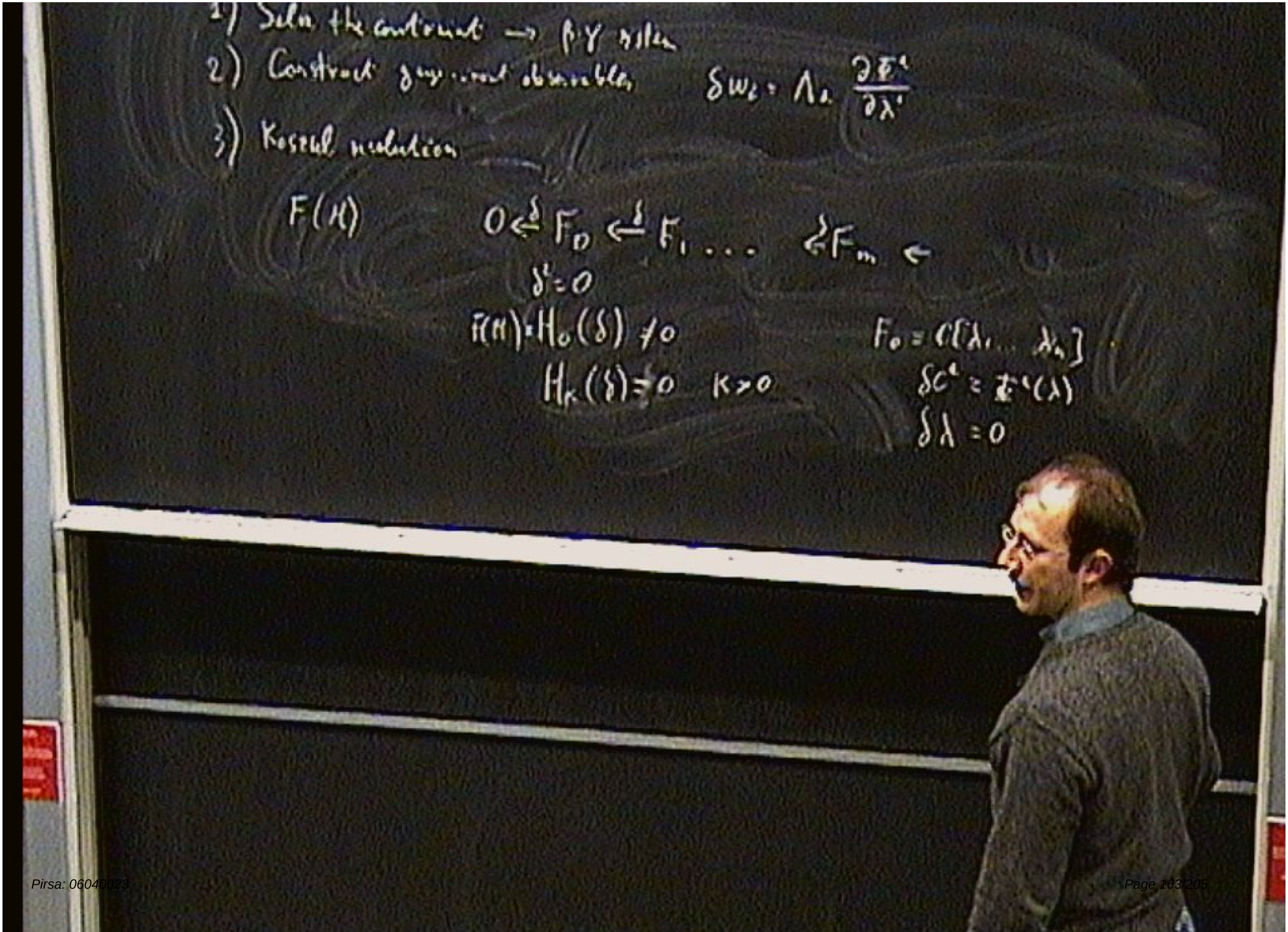

M ⊂ C^n   {Φ^a(λ) = 0} = M
1) Solve the constraints → βγ system
2) Construct gauge-invariant observables
δw_i = Λ_a ∂Φ^a/∂λ^i
3) Koszul resolution
F(M)
0 ←δ F_0 ←δ F_1 . . . ←δ F_m ←
δ² = 0

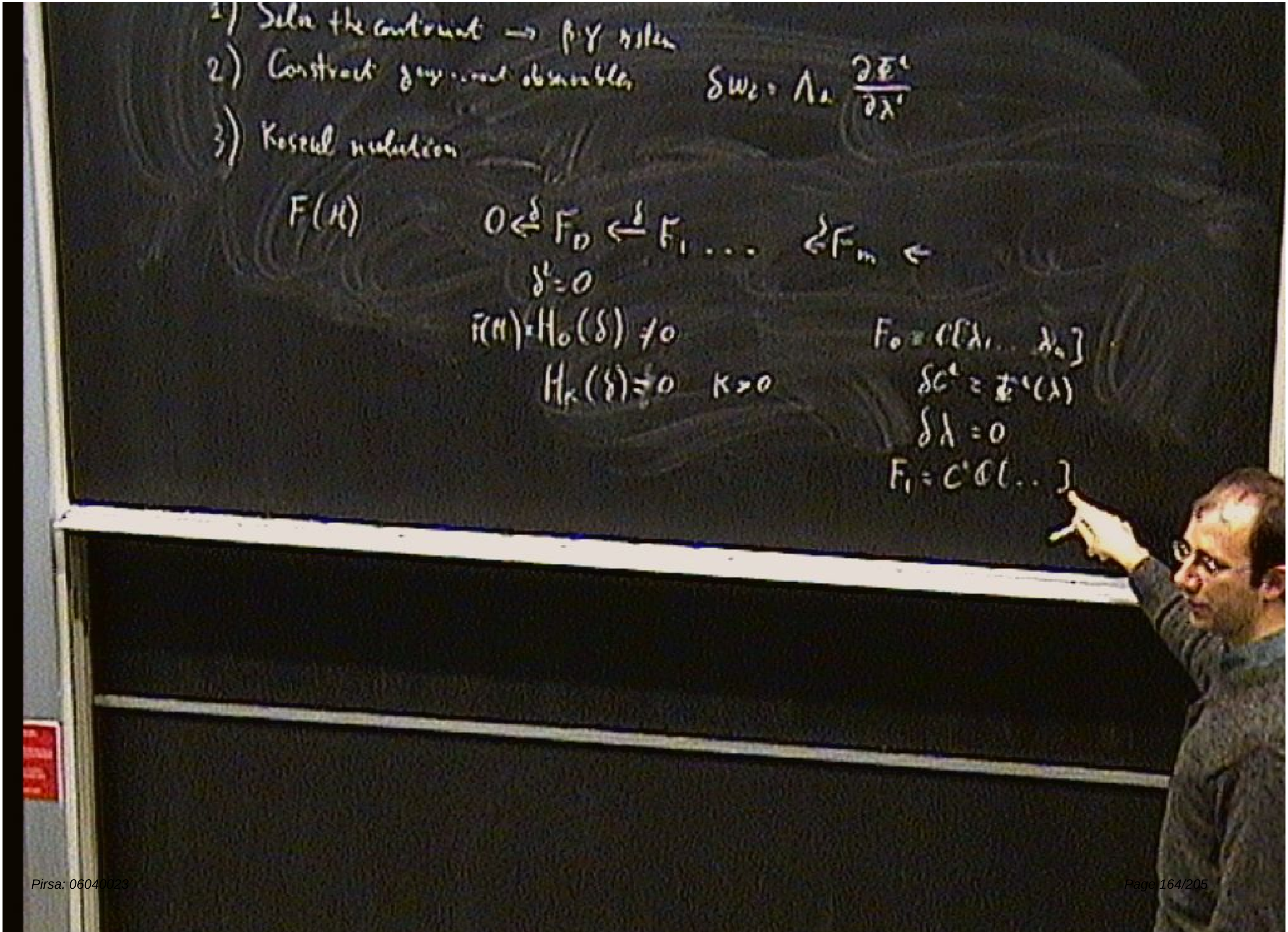

M ⊂ C^n   {Φ^a(λ) = 0} = M
1) Solve the constraint
2) Construct gauge inv. observables
3) Koszul resolution
F(M)
0 ← F_0 ← F_1 ... ← F_n ←
δ² = 0
F(M) = H_0(δ) ≠ 0
H_k(δ) ≠ 0

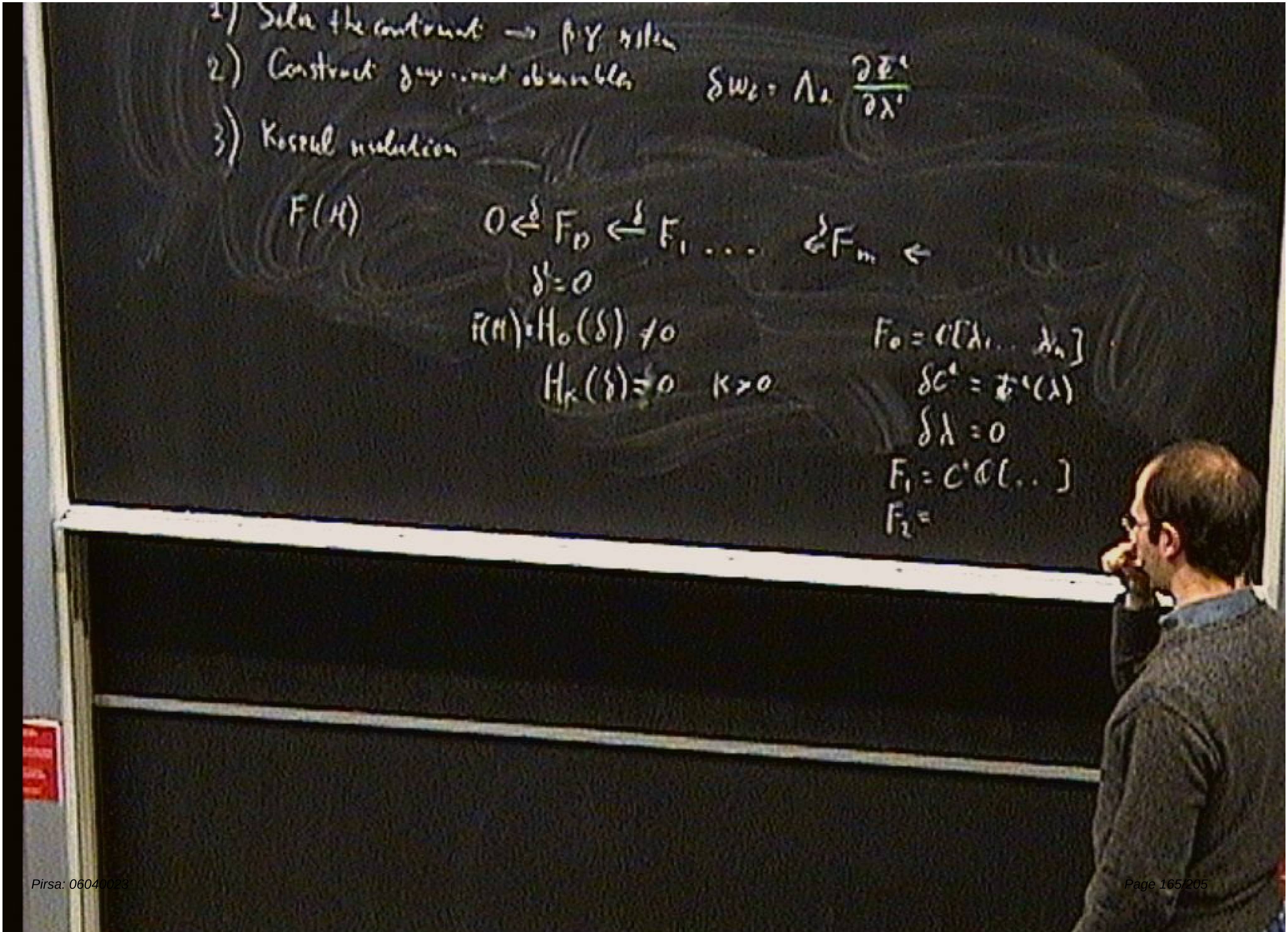


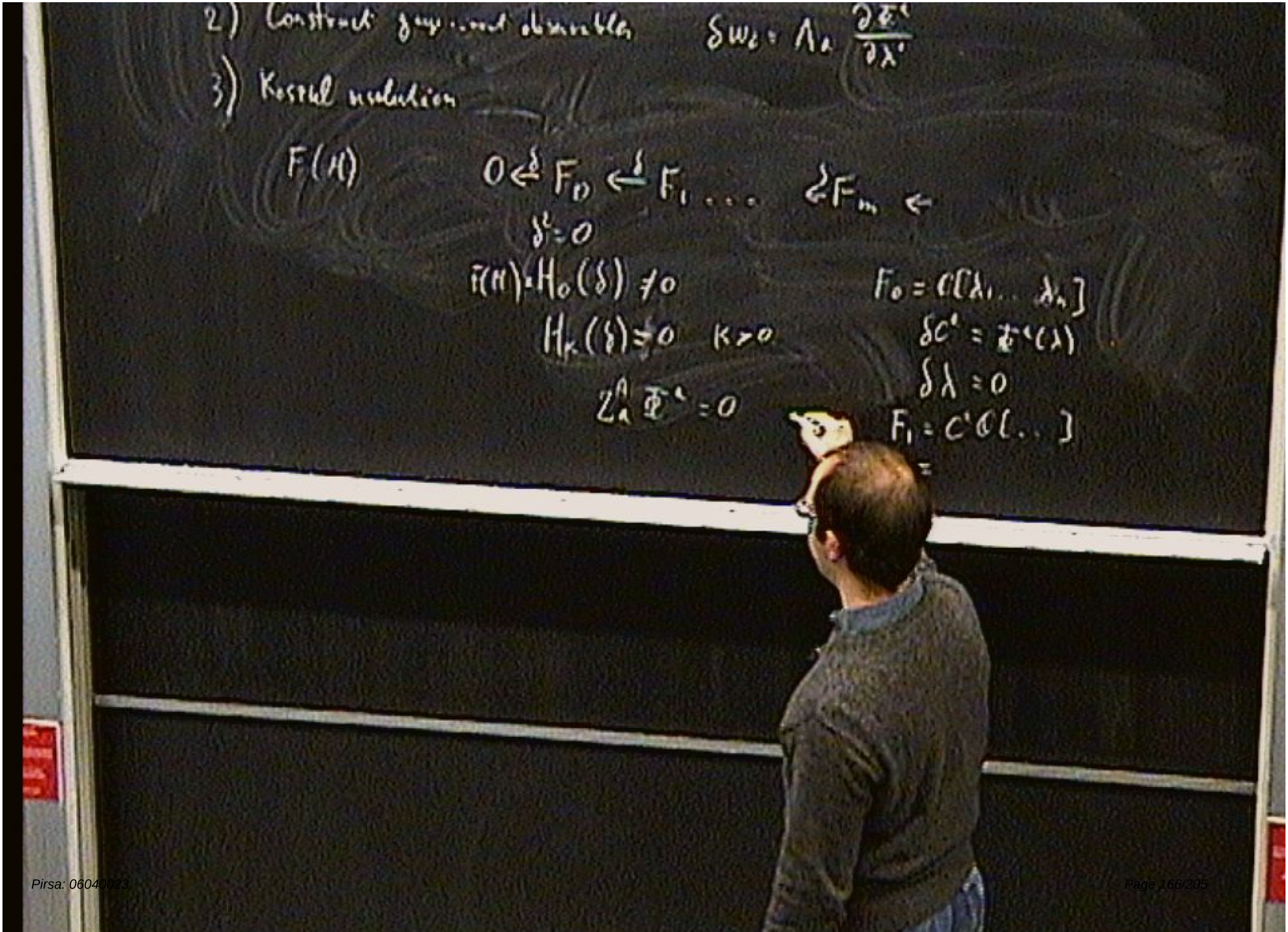

2) Construct gauge-invariant observables
$\delta w_i = \Lambda_a \frac{\partial \Phi^a}{\partial \lambda^i}$
3) Koszul resolution
$F(M)$
$0 \xleftarrow{\delta} F_0 \xleftarrow{\delta} F_1 \ldots \xleftarrow{\delta} F_m \leftarrow$
$\delta^2 = 0$
$F(M) = H_0(\delta) \neq 0$
$H_k(\delta) = 0 \quad k > 0$
$F_0 =$


1) Solve the constraint → B.V system
2) Construct gauge-invariant observables
δw_i = Λ_a ∂Φ^a/∂λ^i
3) Koszul resolution
F(M)
0 ← F_0 ← F_1 . . . ← F_m ←
δ^2 = 0
F(M) = H_0(δ) ≠ 0
F_0 = C[x_1 ... x_n]
H_k(δ) = 0 k > 0

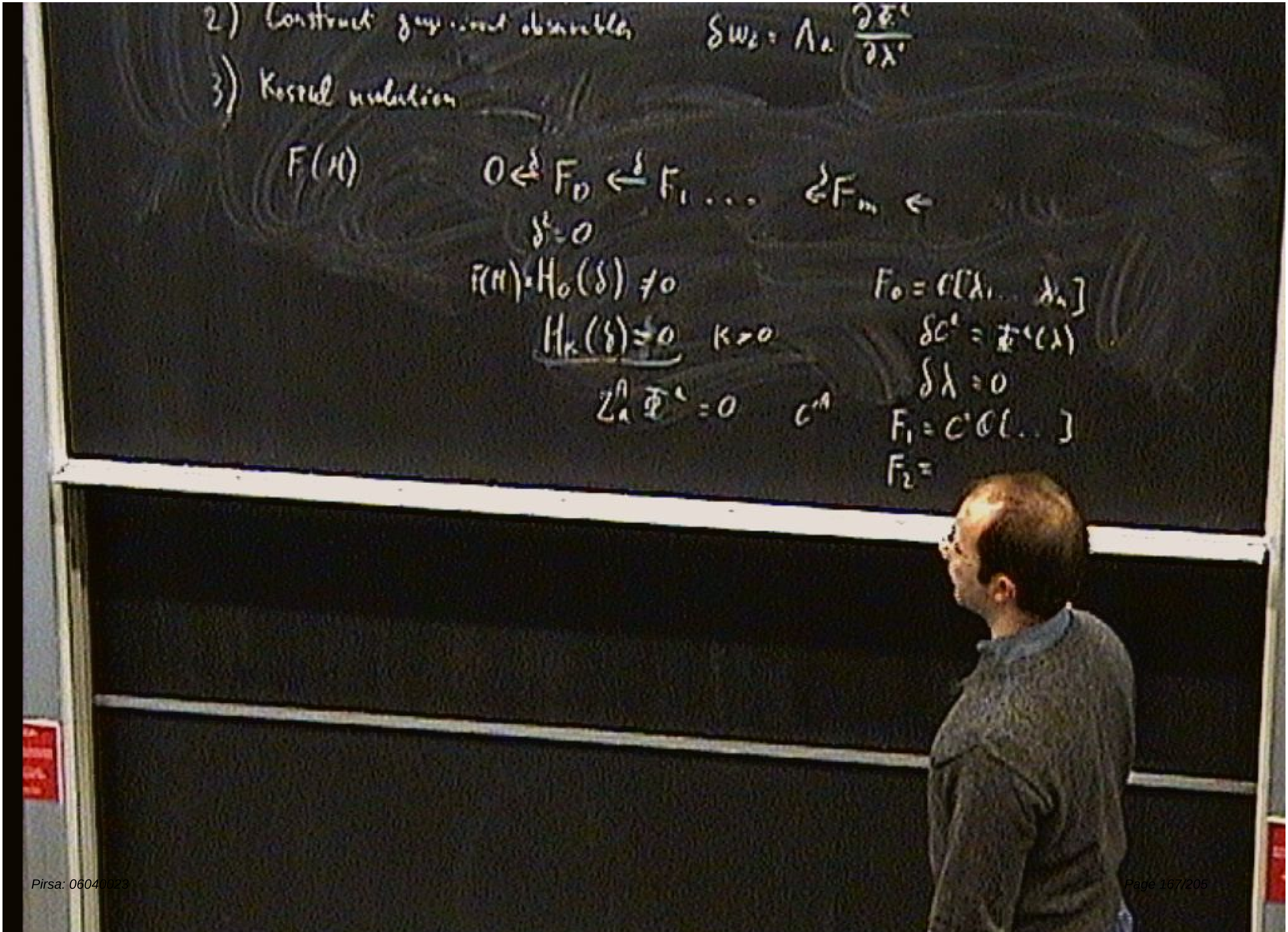

2) Construct gauge-invariant observables
3) Koszul resolution
F(M)
δ²=0
F(M) = H₀(δ) ≠ 0
H_k(δ) = 0 k>0
F₀ = C[λ₁ ... λₙ]
δλ = 0

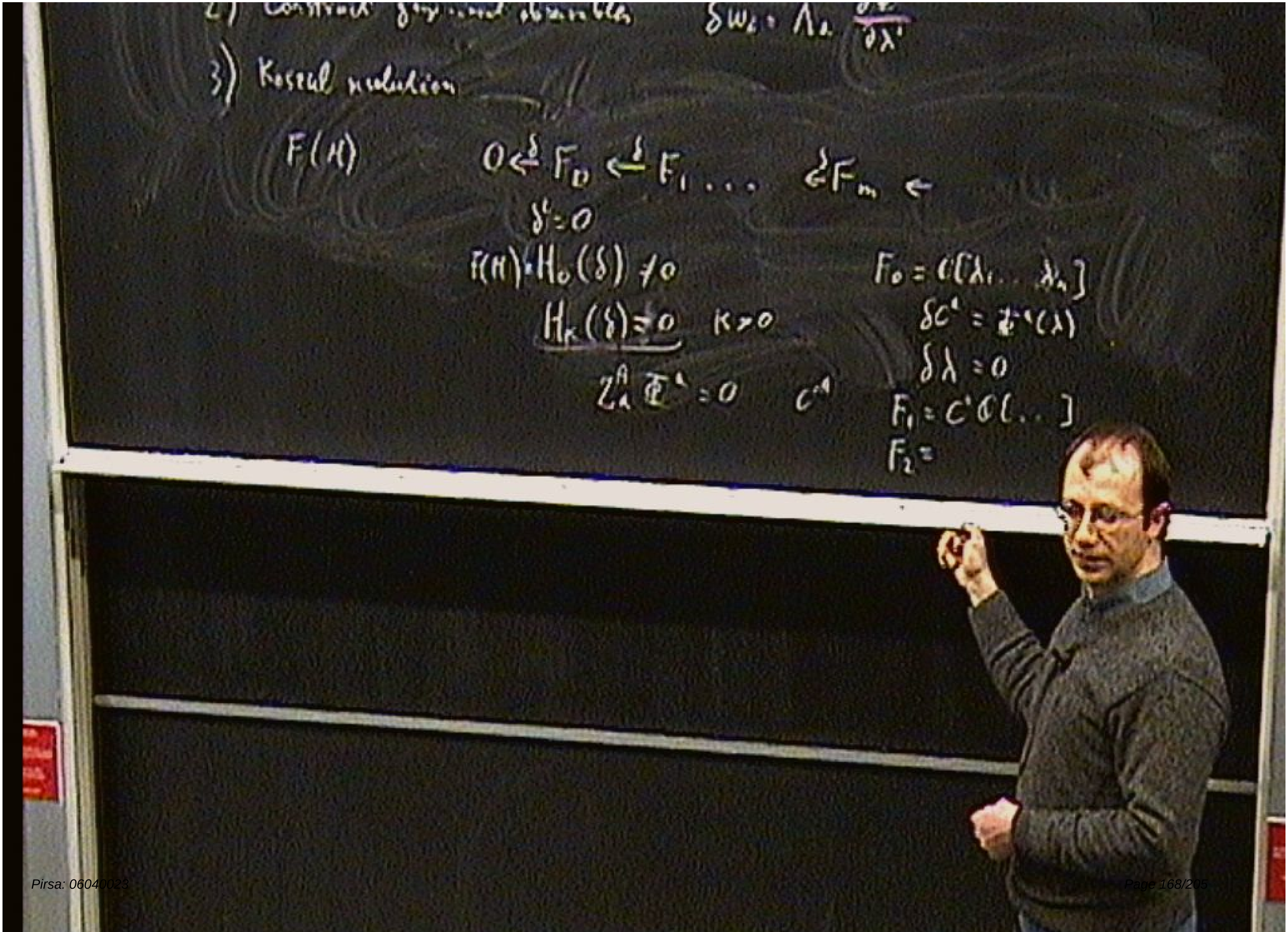

1) Solve the constraint → B.V. system
2) Construct gauge-invariant observables
3) Koszul resolution
F(M)
δ² = 0
K > 0
δλ = 0

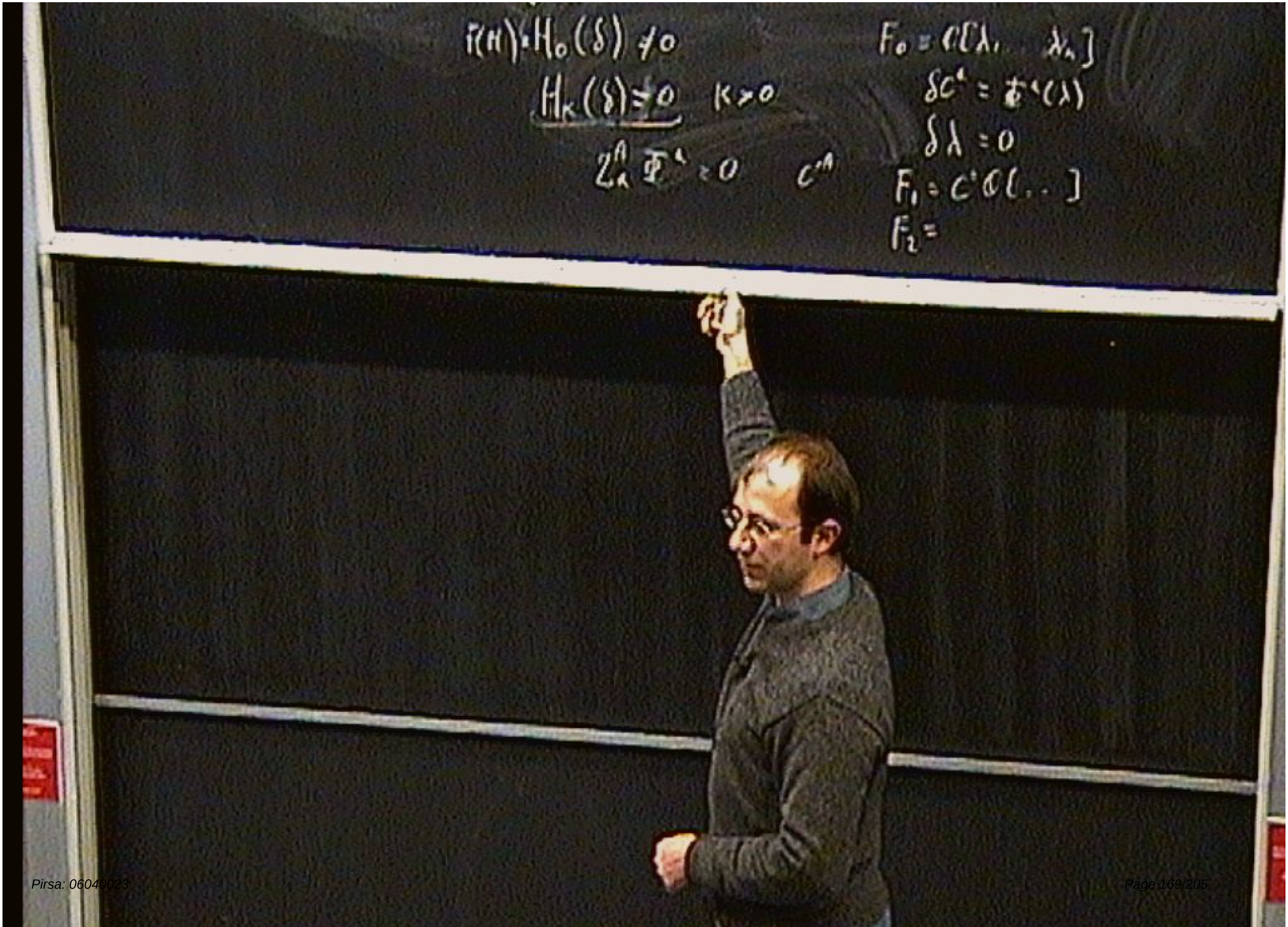

2) Construct
3) Koszul resolution
F(H)



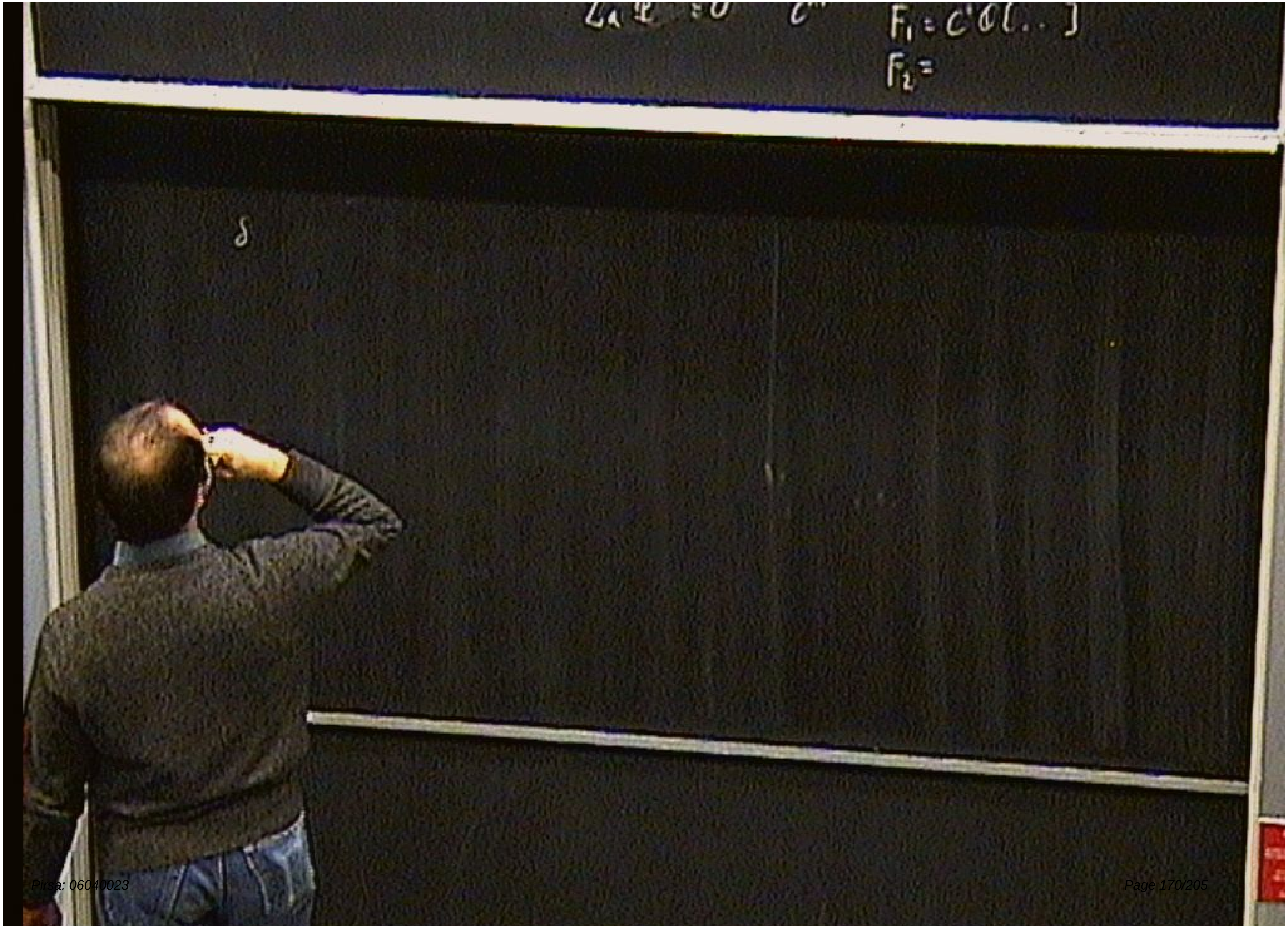
2) Construct gauge-invariant observables
$\delta w_i = \Lambda_a \frac{\partial \Phi^a}{\partial \lambda^i}$
3) Koszul resolution
F(H)
$0 \xleftarrow{\delta} F_0 \xleftarrow{\delta} F_1 \ldots \xleftarrow{\delta} F_m \leftarrow$
$\delta^2 = 0$
$F(H) = H_0(\delta) \neq 0$
$H_k(\delta) = 0 \quad k > 0$
$Z^A_a \Phi^a = 0$
$F_0 = \mathbb{C}[\lambda_1 \ldots \lambda_n]$
$\delta c^a = \Phi^a(\lambda)$
$\delta \lambda = 0$
$F_1 = c^a \mathbb{C}[\ldots]$

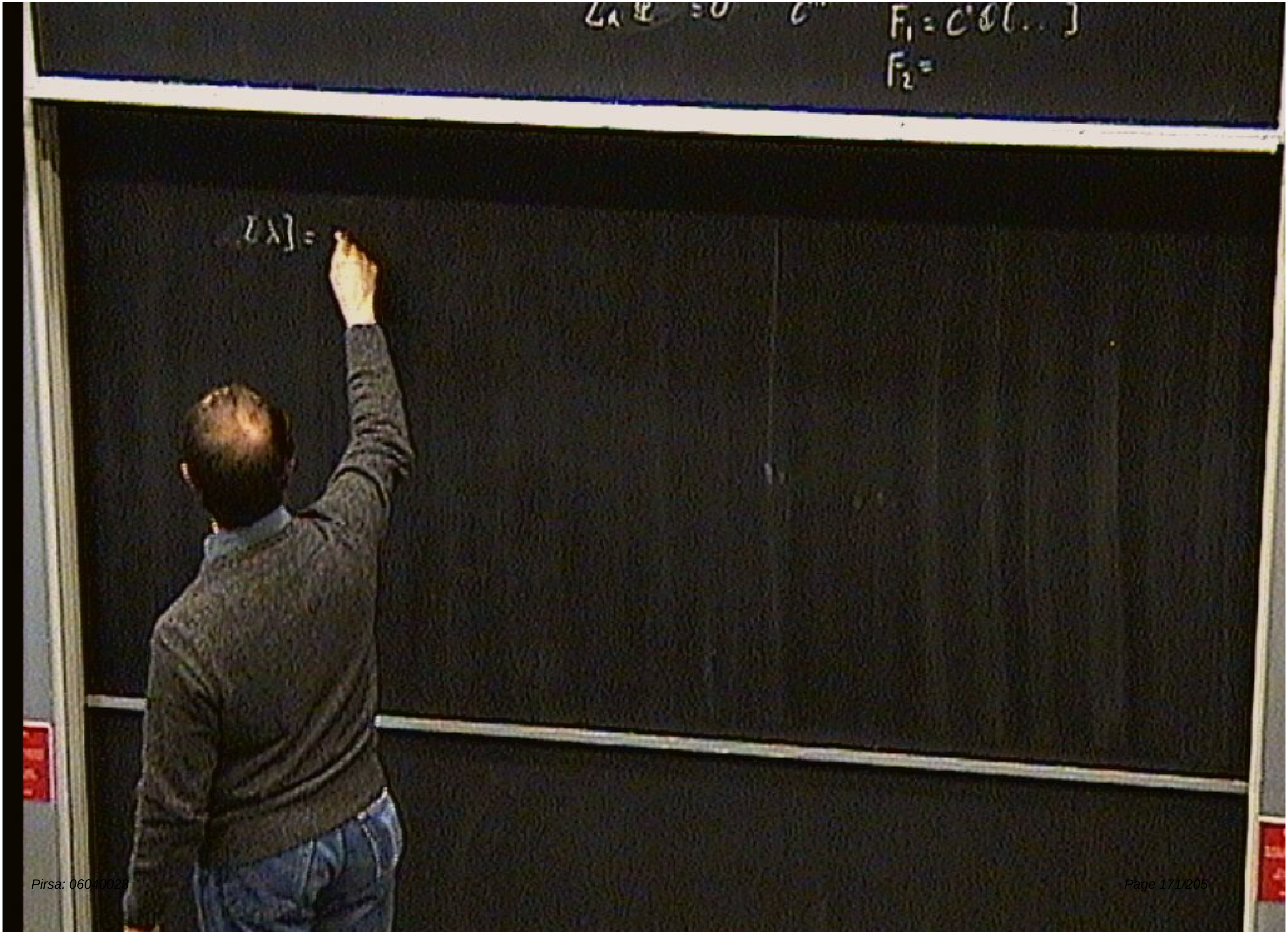

2) Construct
3)
F(M)
δ² = 0
K > 0
F₀ =
δλ = 0
F₁ =
F₂ =

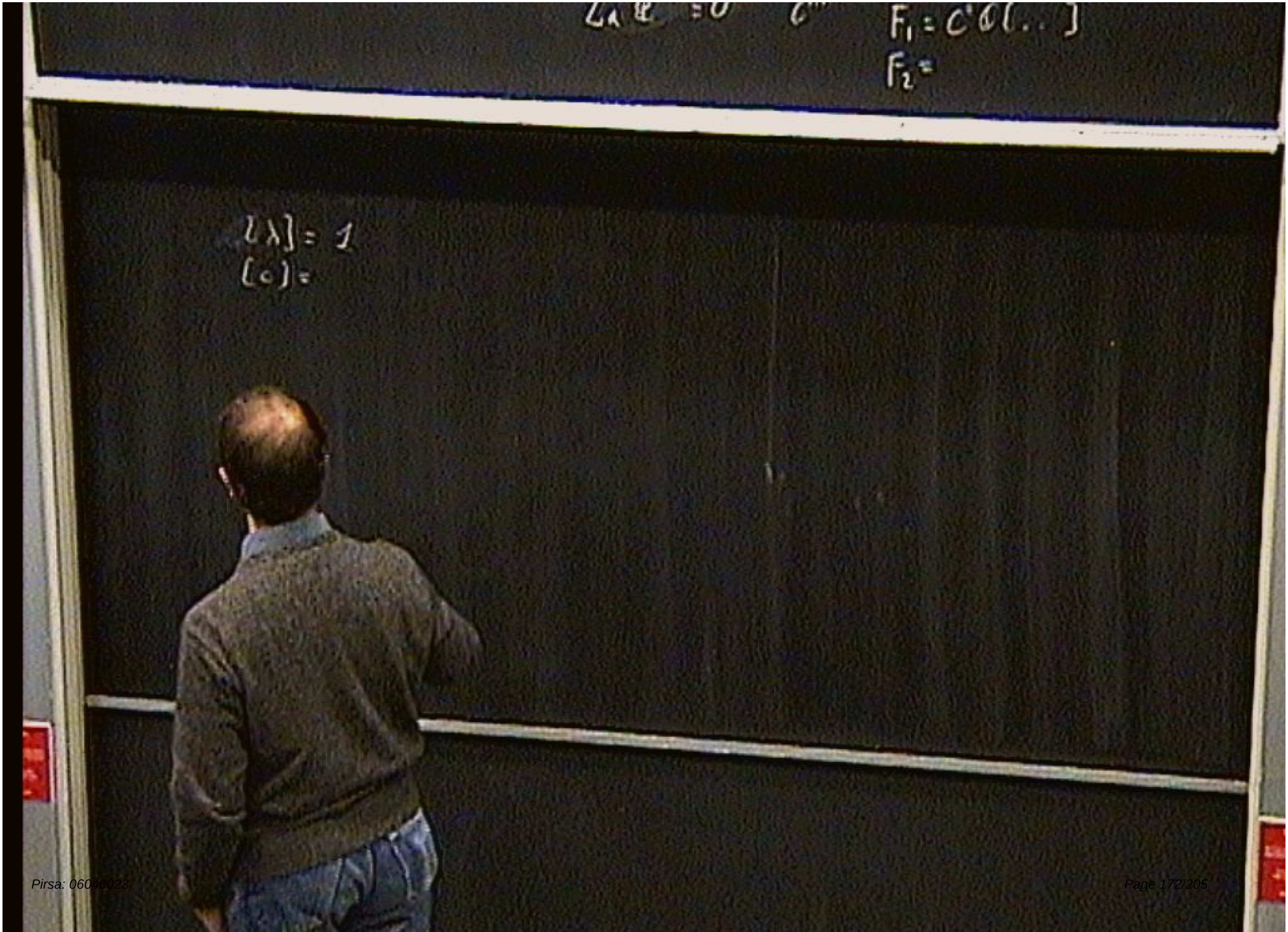

3) Koszul resolution
F(M)
0 ← F_0 ← F_1 . . . ← F_m ←
δ² = 0
F(M) = H_0(δ) ≠ 0
H_k(δ) = 0 k > 0
F_0 = C[λ_1 . . . λ_n]
δλ = 0
F_1 =
F_2 =

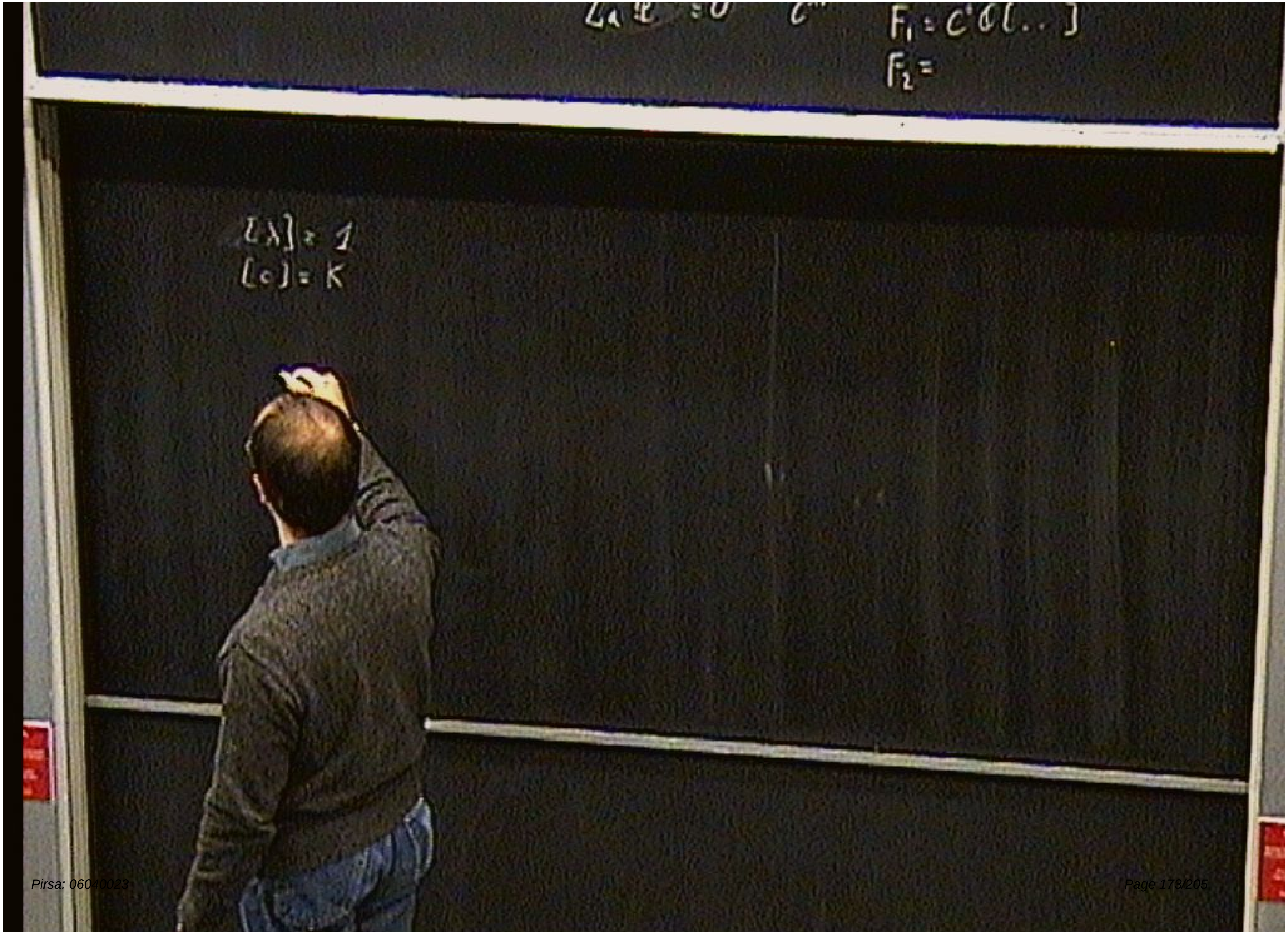


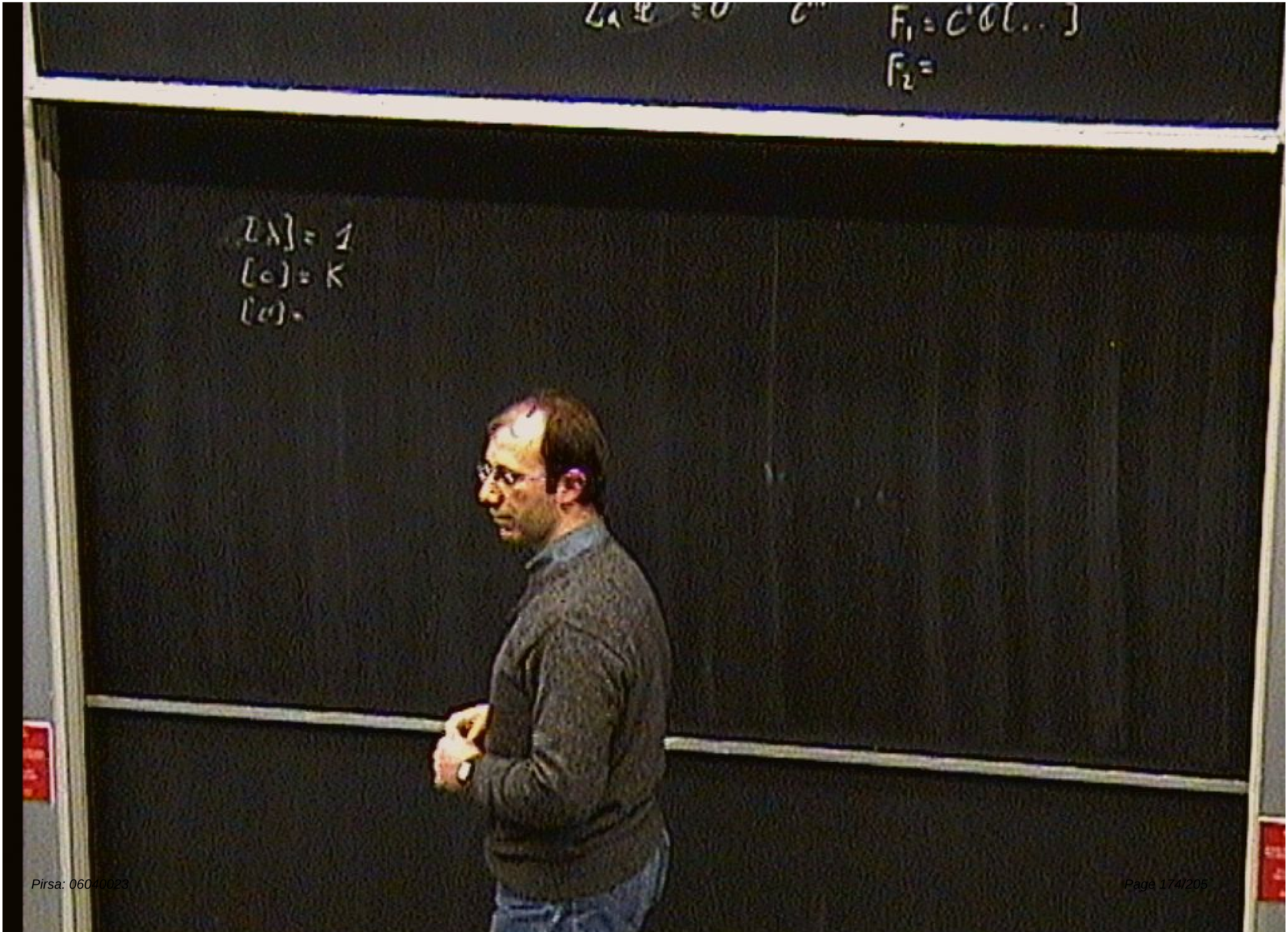
H_0(δ) ≠ 0
H_k(δ) = 0   k > 0
F_0 = C[λ_1 ... λ_n]
δλ = 0
F_1 =
F_2 =

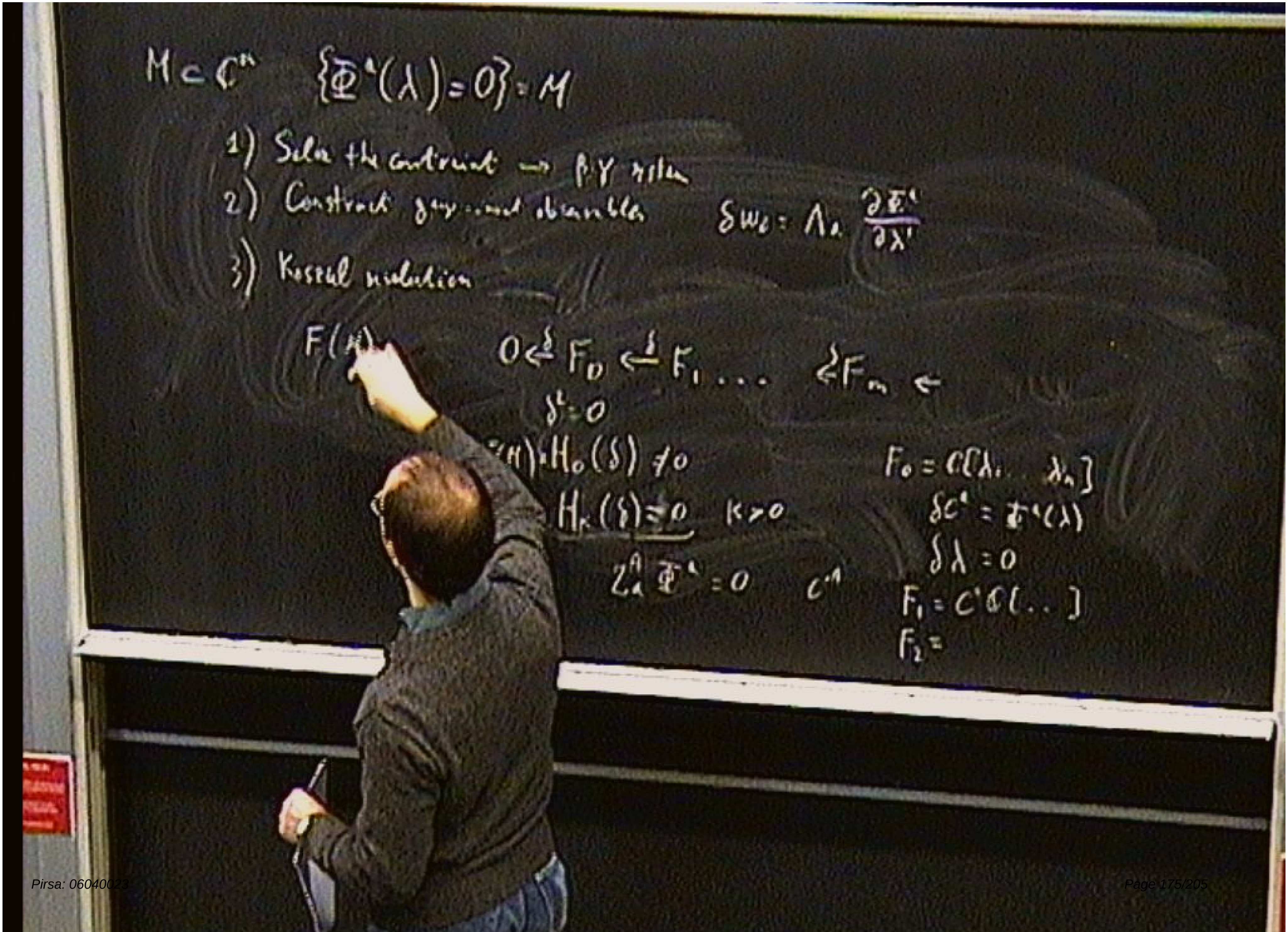

F1 = C'θ[. .]
F2 =

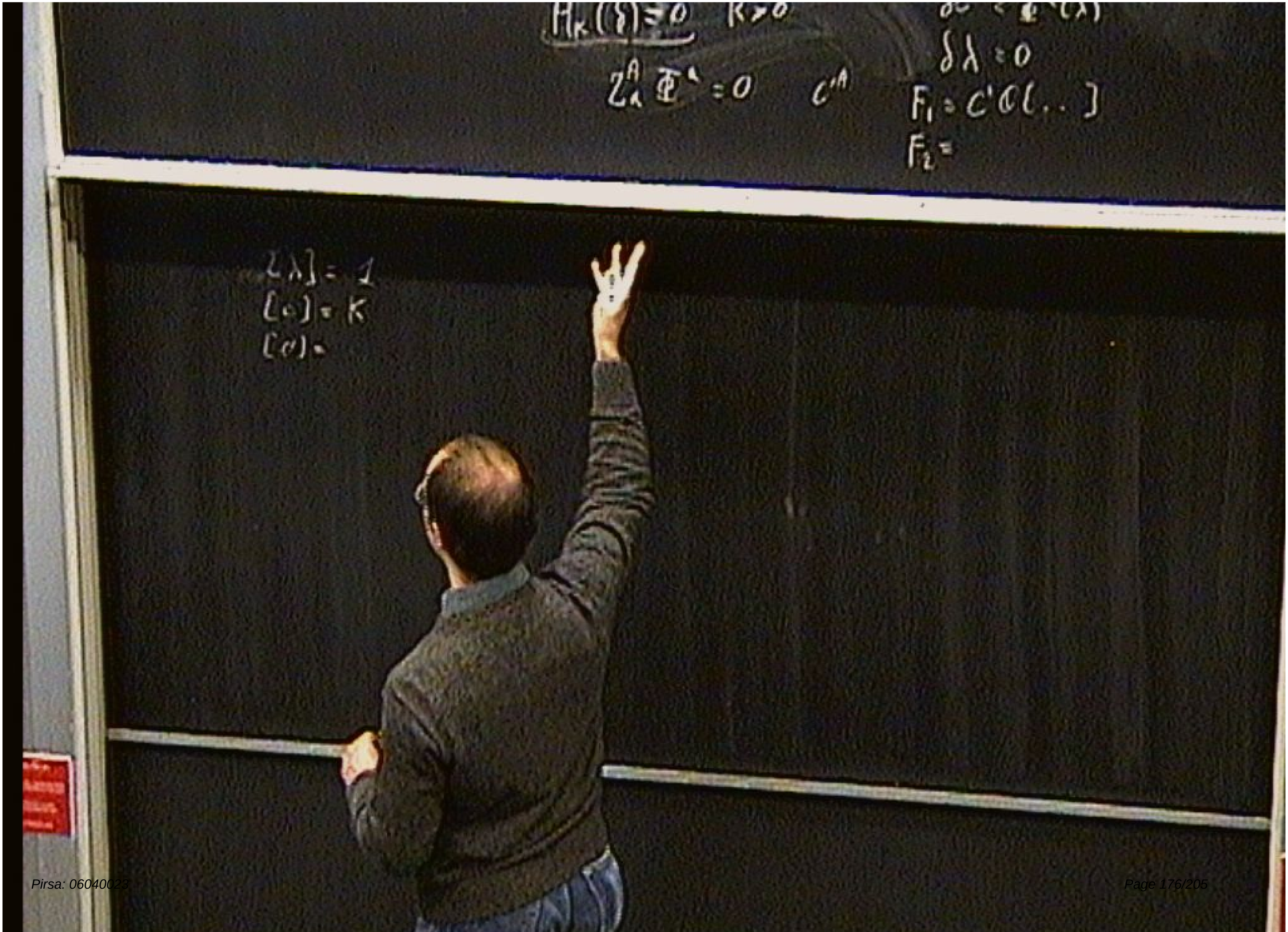


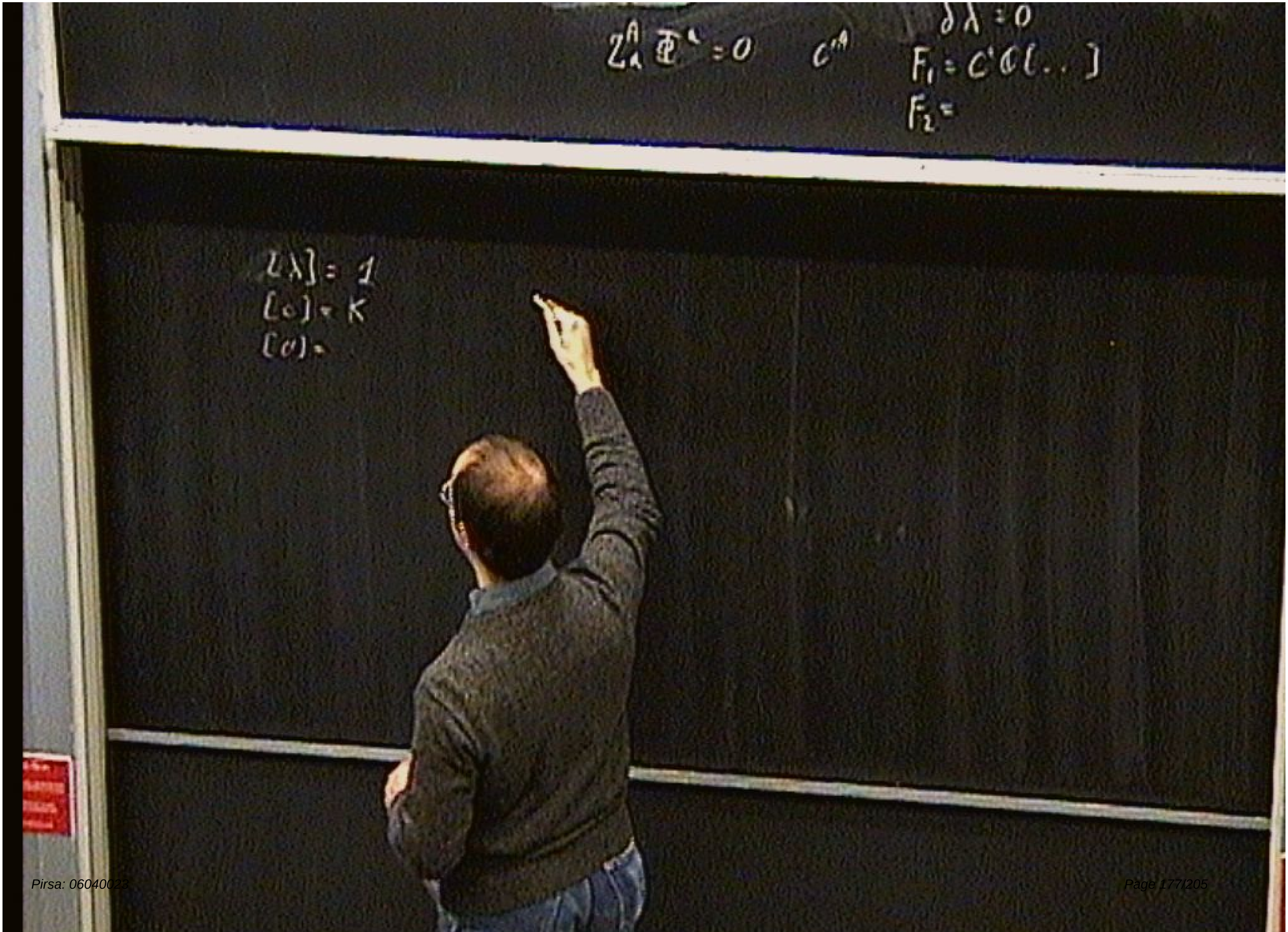

F₂ =
[λ] = 1
[c] =

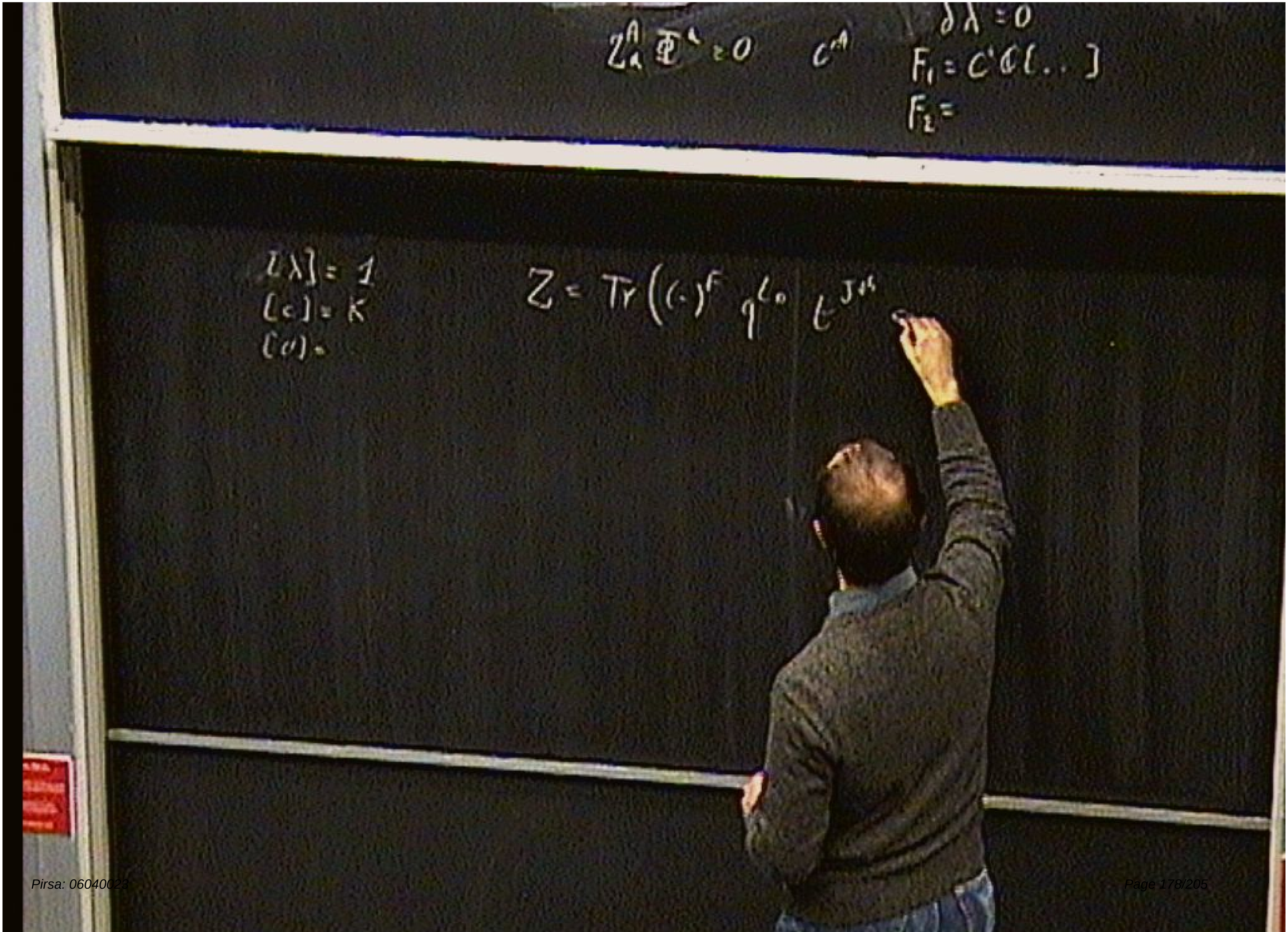

[λ] = 1
[c] = K
F1 = C'C[..]
F2 =

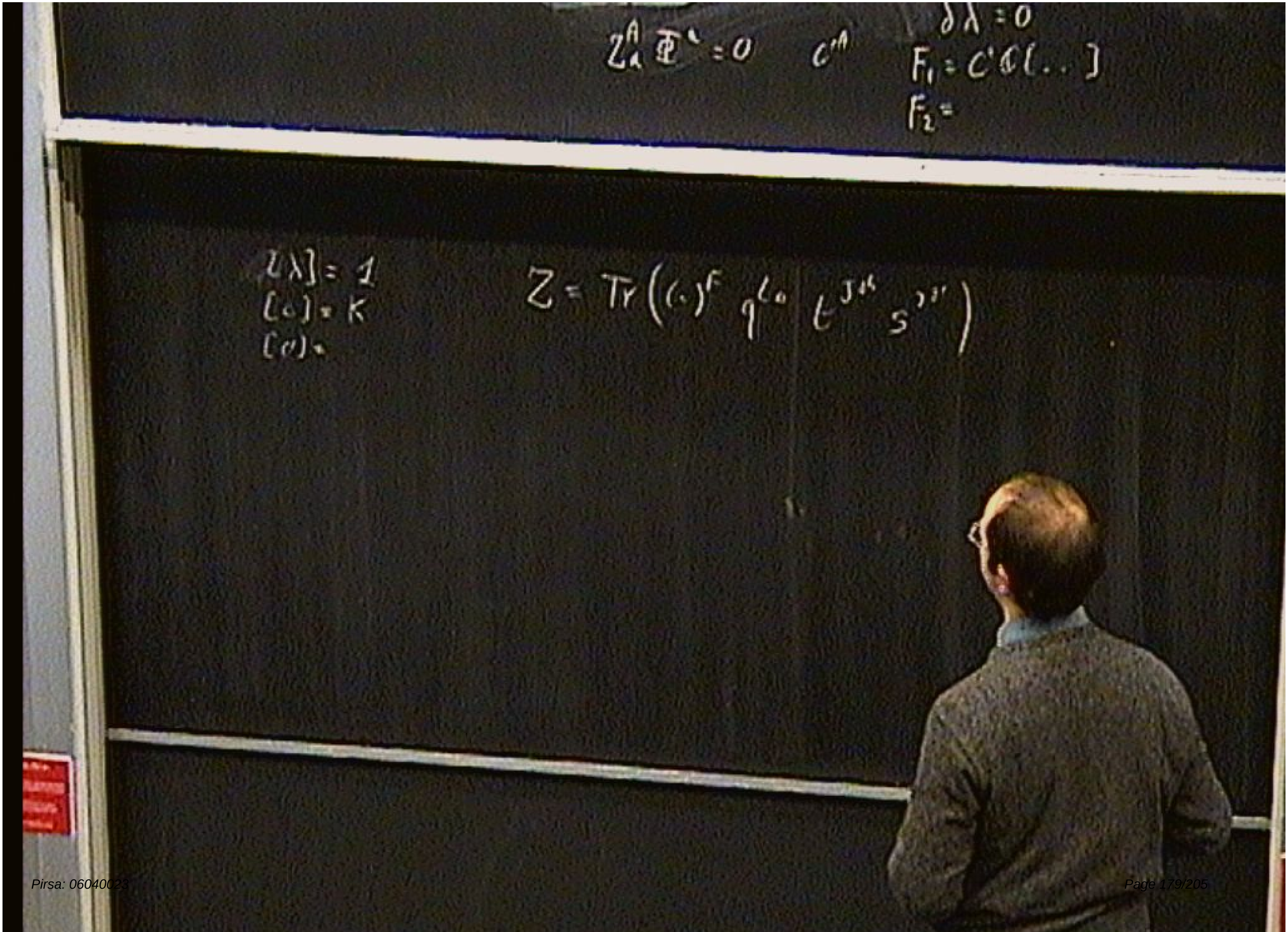

[λ] = 1
[c] = K

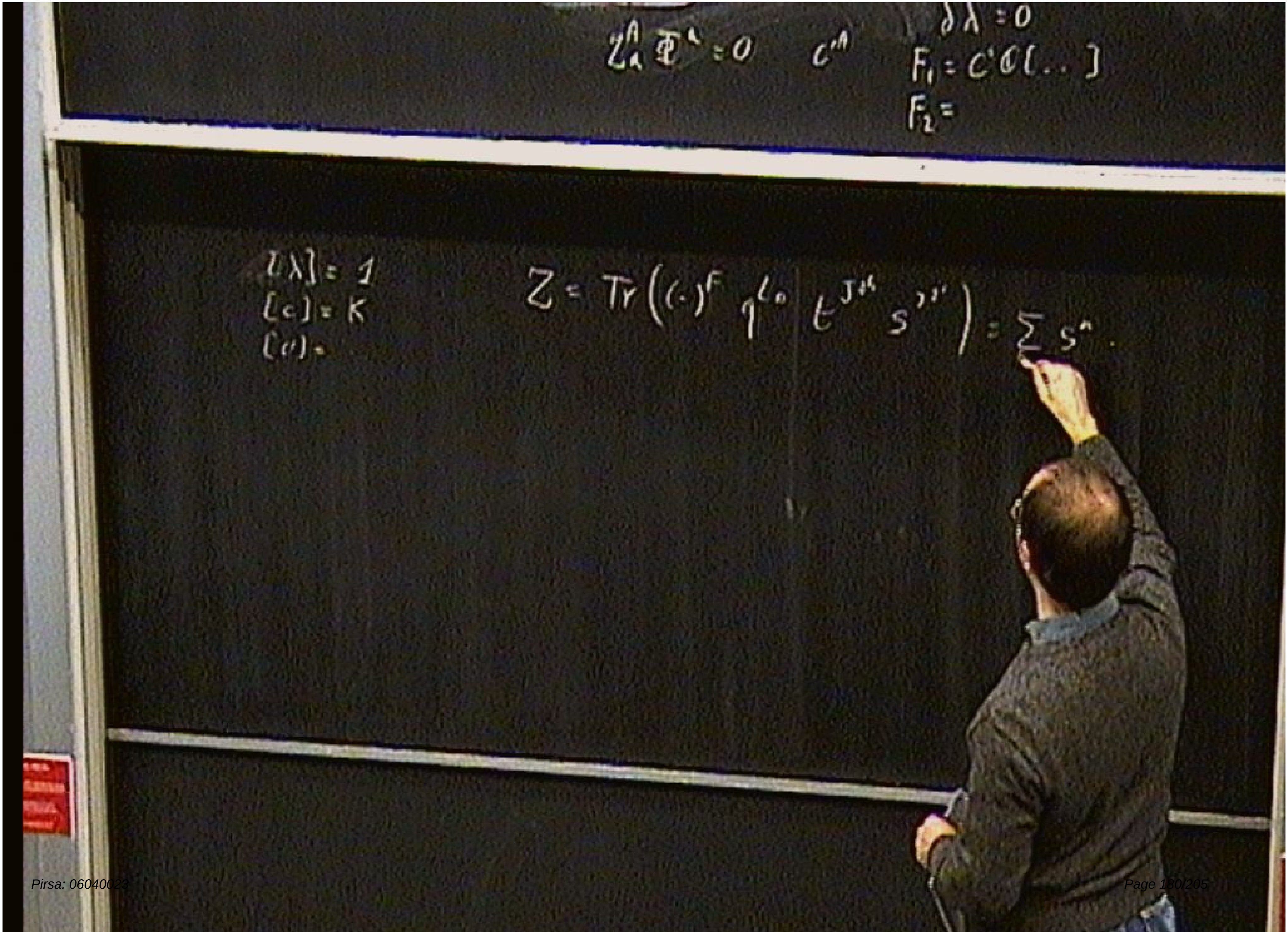

M ⊂ ℂ^n {Φ^a(λ) = 0} = M
1) Solve the constraints → β-γ system
2) Construct gauge-invariant observables
δw_i = Λ_a ∂Φ^a/∂λ^i
3) Koszul resolution
F(M)
0 ← F_0 ← F_1 . . . ← F_m ←
δ^2 = 0
F(M) = H_0(δ) ≠ 0
H_k(δ) = 0 k > 0
Z^A_a Φ^a = 0
c^A
F_0 = ℂ[λ_1 . . . λ_n]
δc^a = Φ^a(λ)
δλ = 0
F_1 = c^a ℂ[. .]
F_2 =

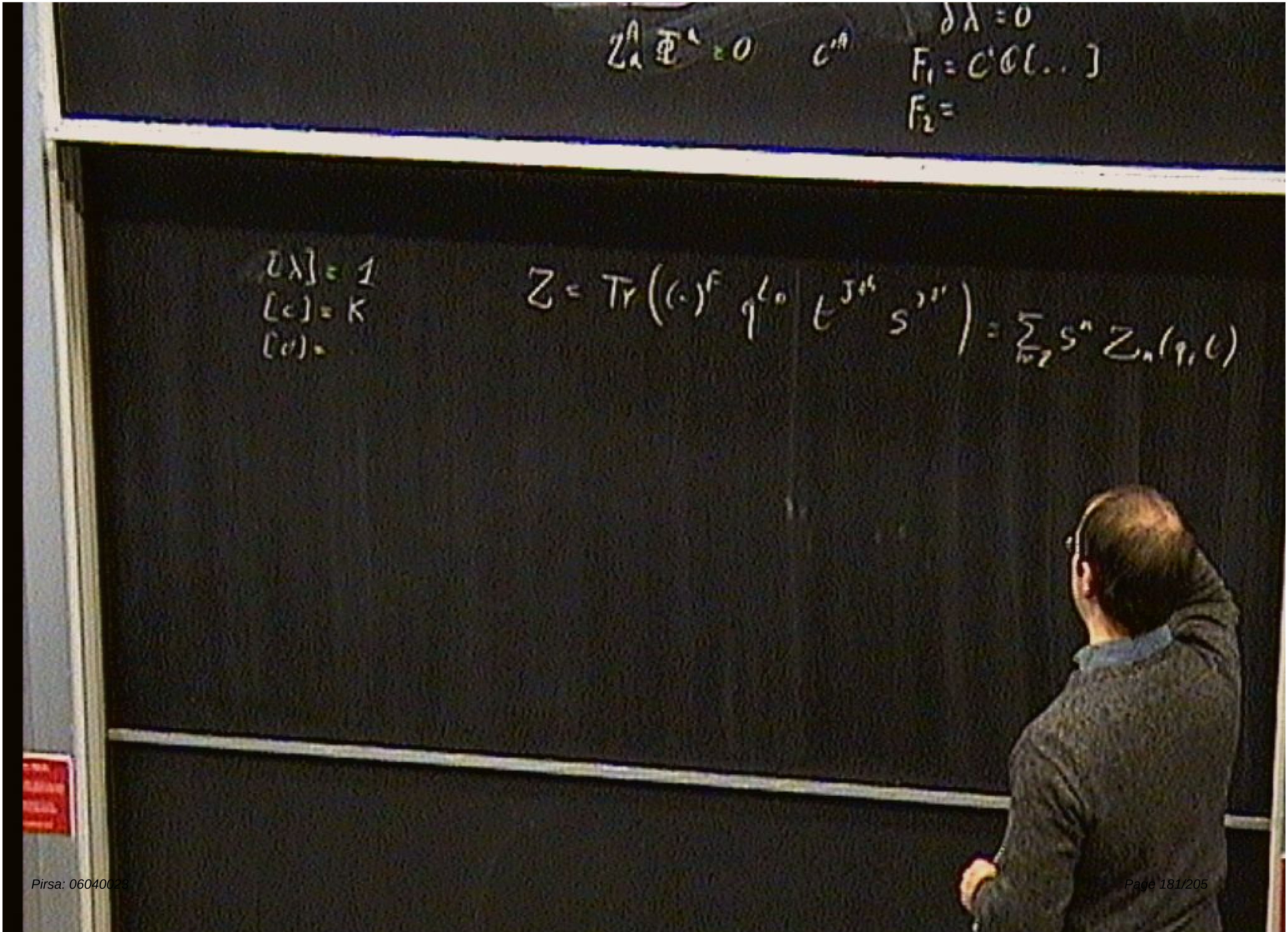

δλ = 0
F₁ = C'C(..]
F₂ =
[λ] = 1
[c] = K

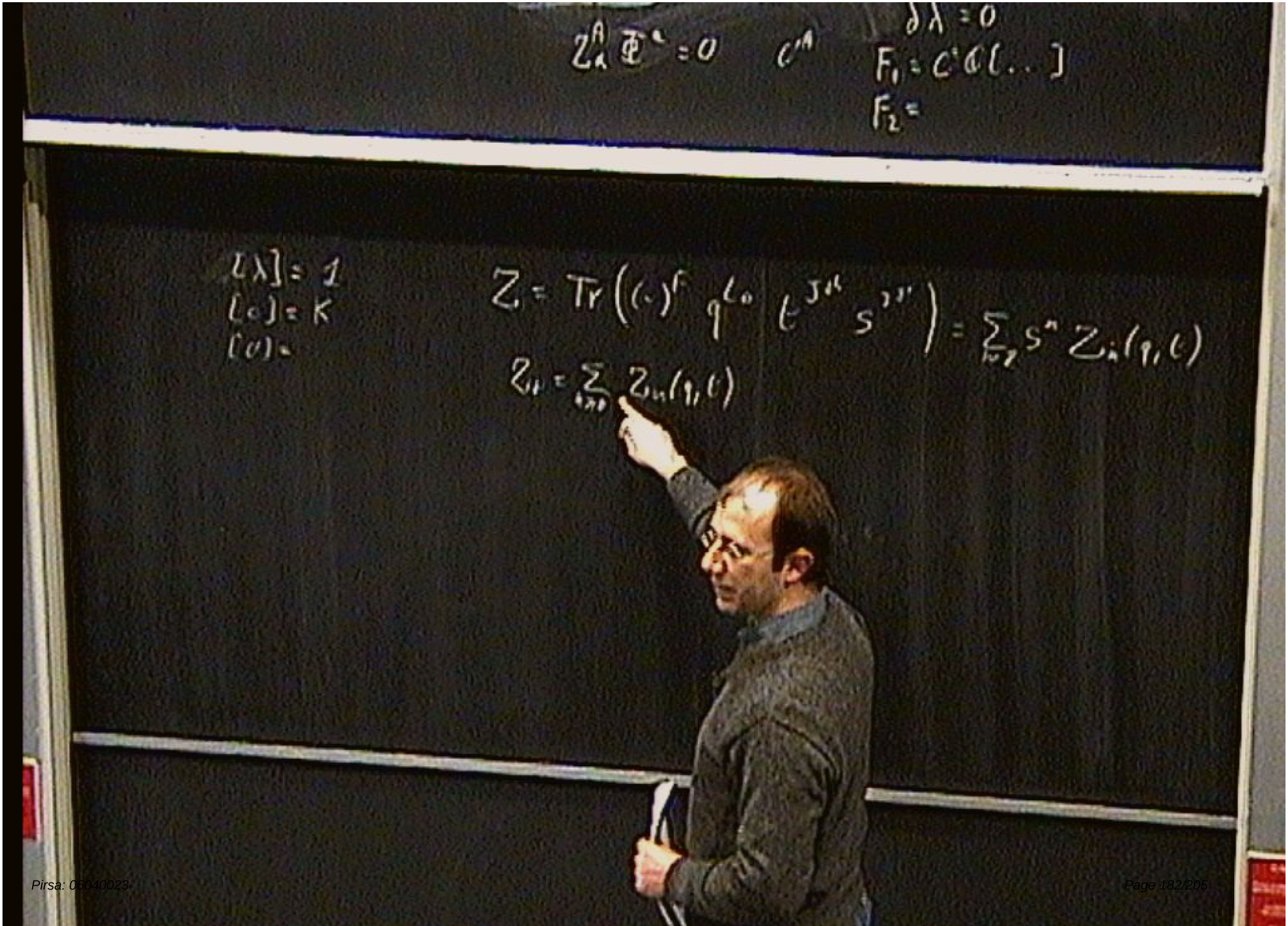

δλ = 0
F2 =
[λ] = 1

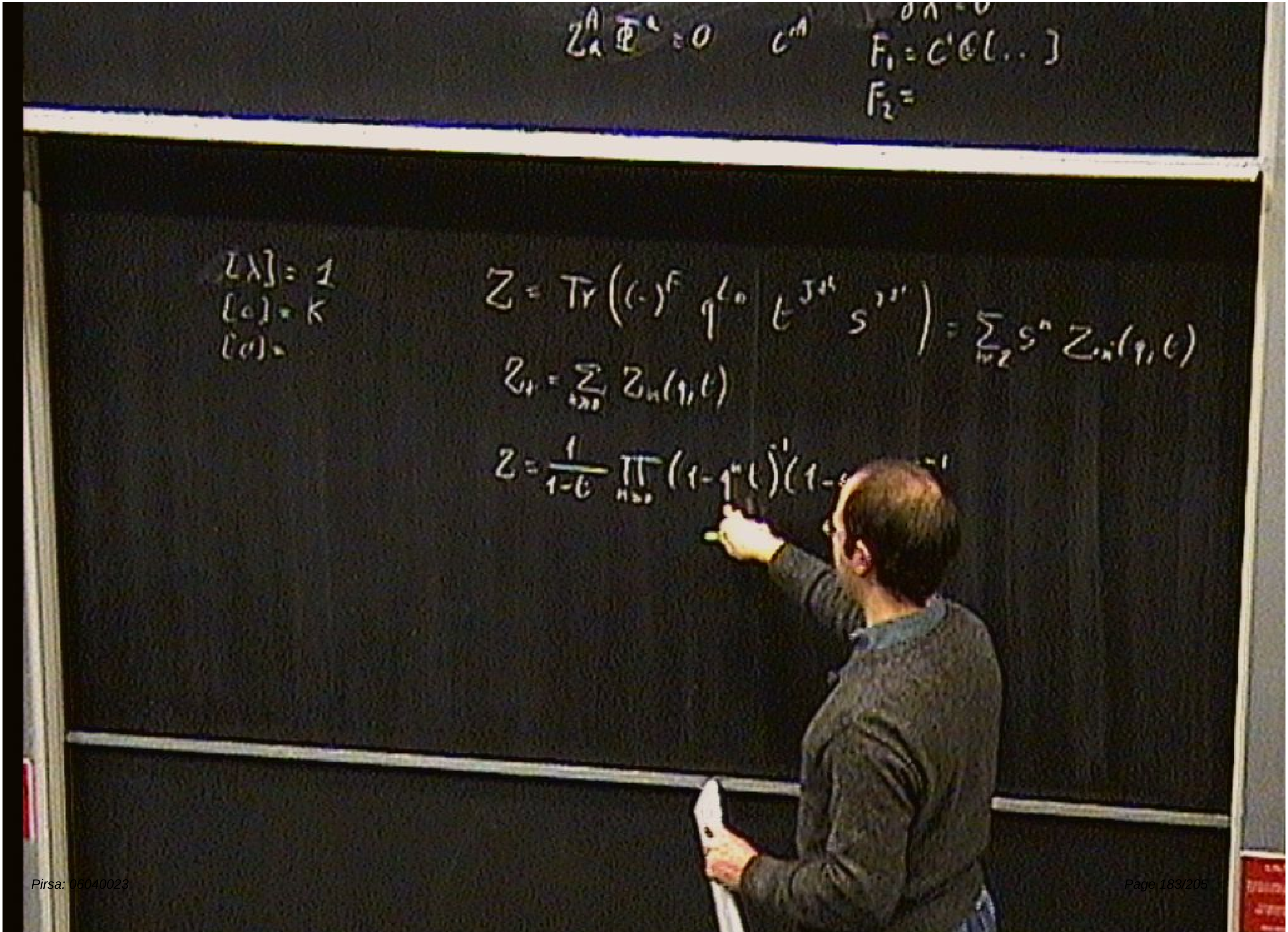

δλ = 0
F1 = C'Φ[. .]
F2 =
[λ] = 1
[c] = K
Z = Tr((-)^F q^L0

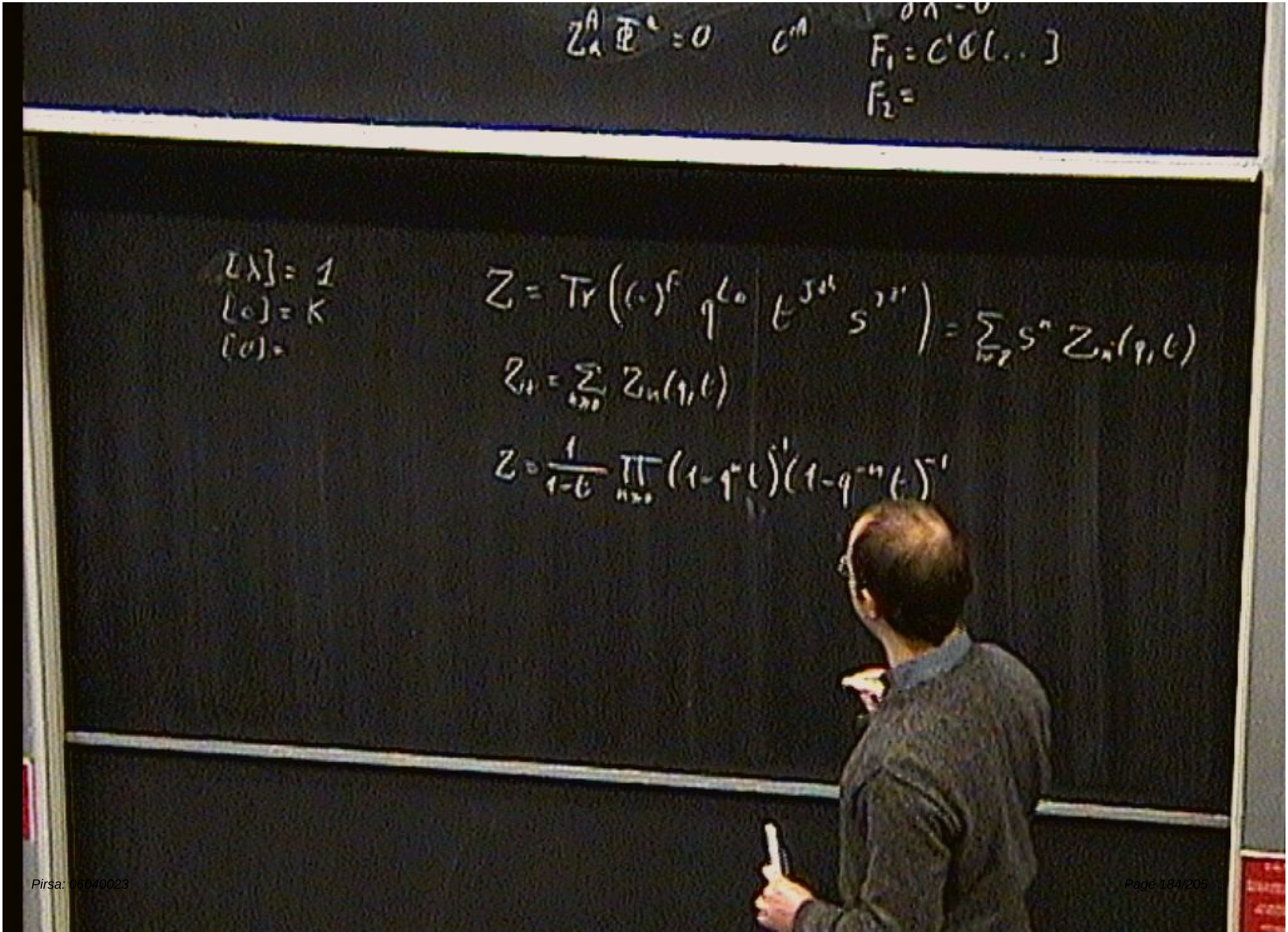

δλ = 0
F₁ = C'Φ[. .]
F₂ =
[λ] = 1
[c] = K
Z = Tr((-)^F q^{L₀} t^{J} s^{J})

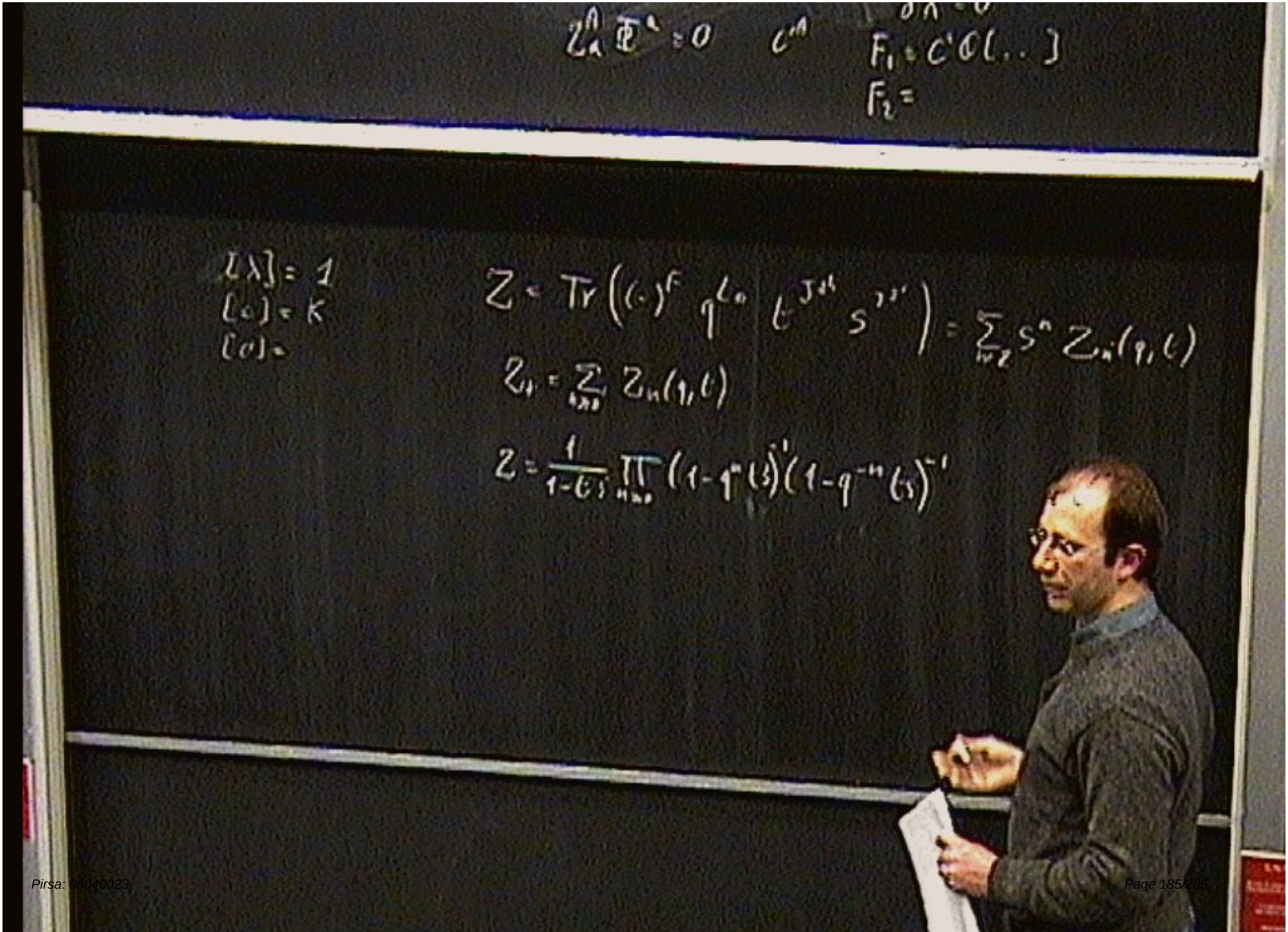

δλ = 0
F₁ = C'Φ[. .]
F₂ =
[λ] = 1
[c] = K
Z = Tr((-)^F q^L₀ t^J s^J) = Σ s^n

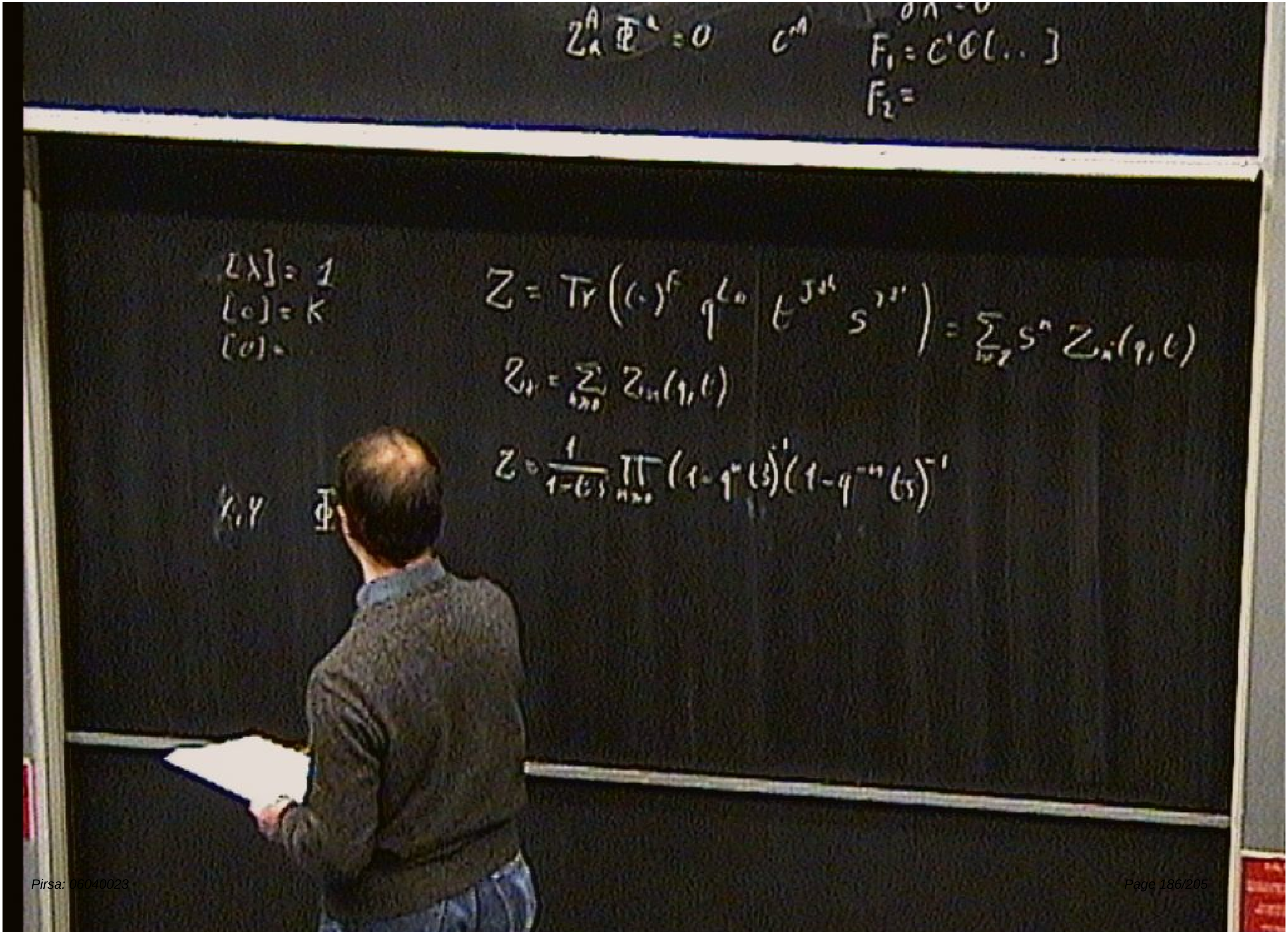

F₁ = C'Φ[. .]
F₂ =
[λ] = 1
[c] = K

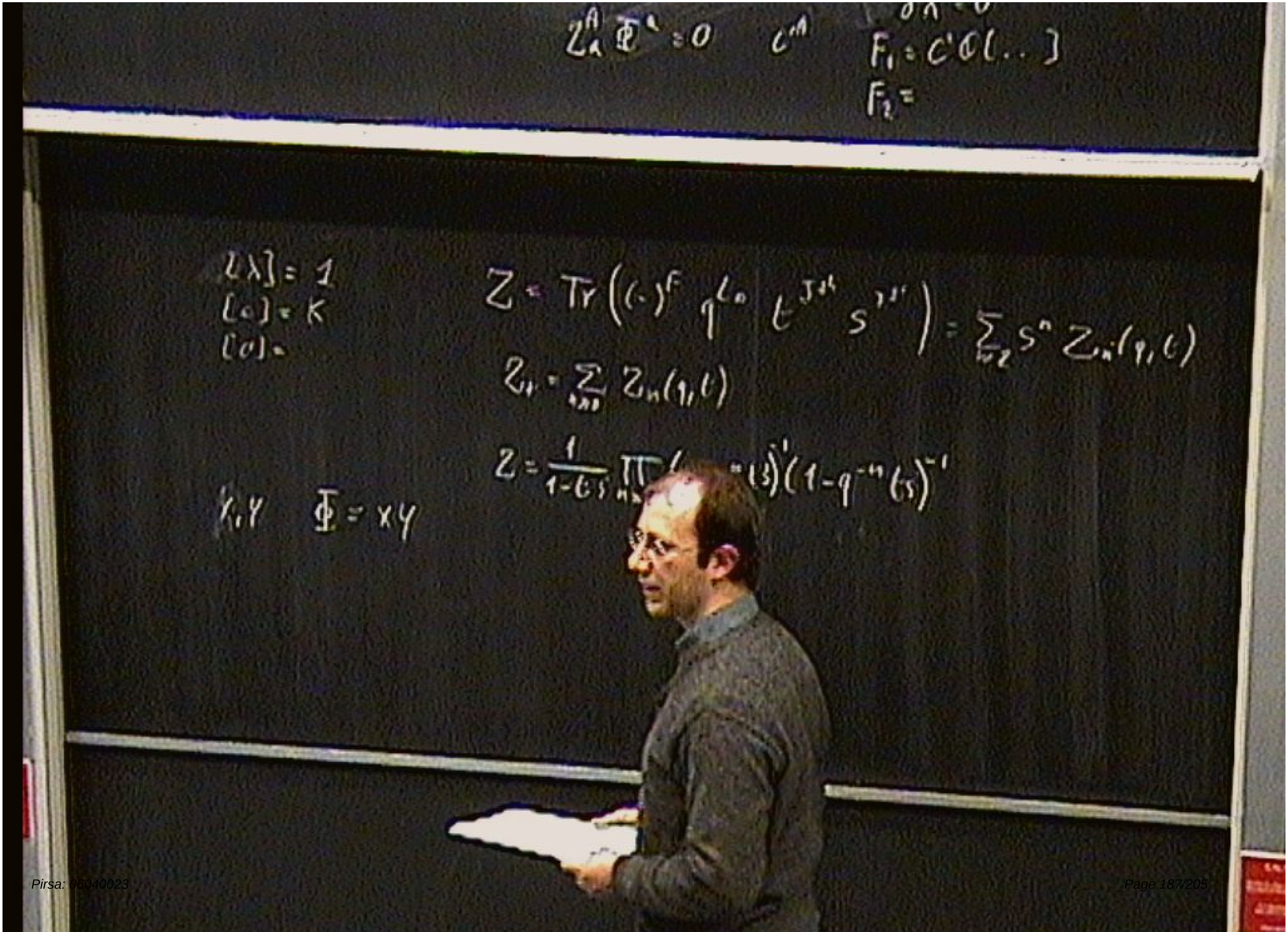

δλ = 0
F₂ =
[λ] = 1

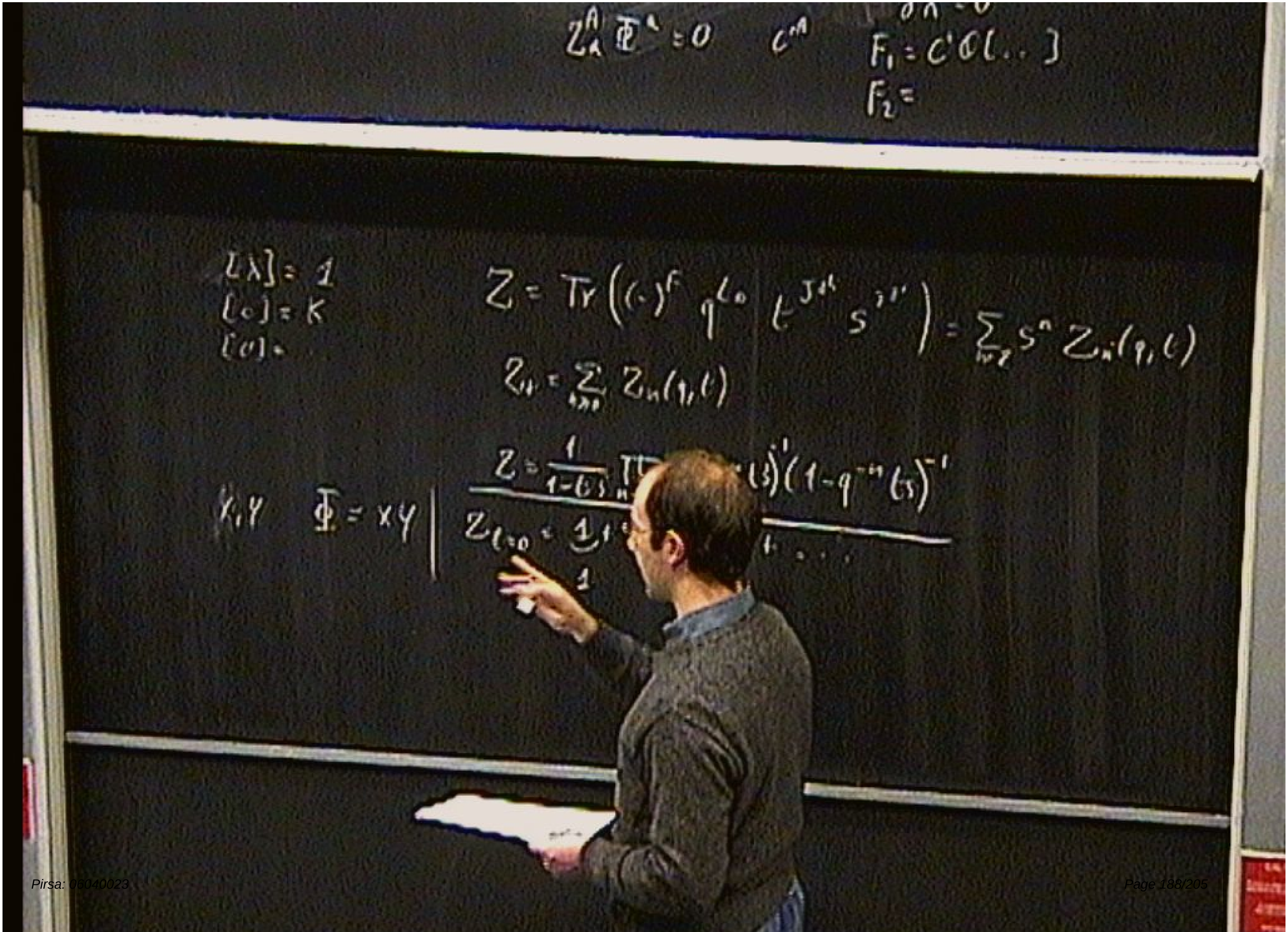

[λ] = 1
F₁ = C'C[...]
F₂ =

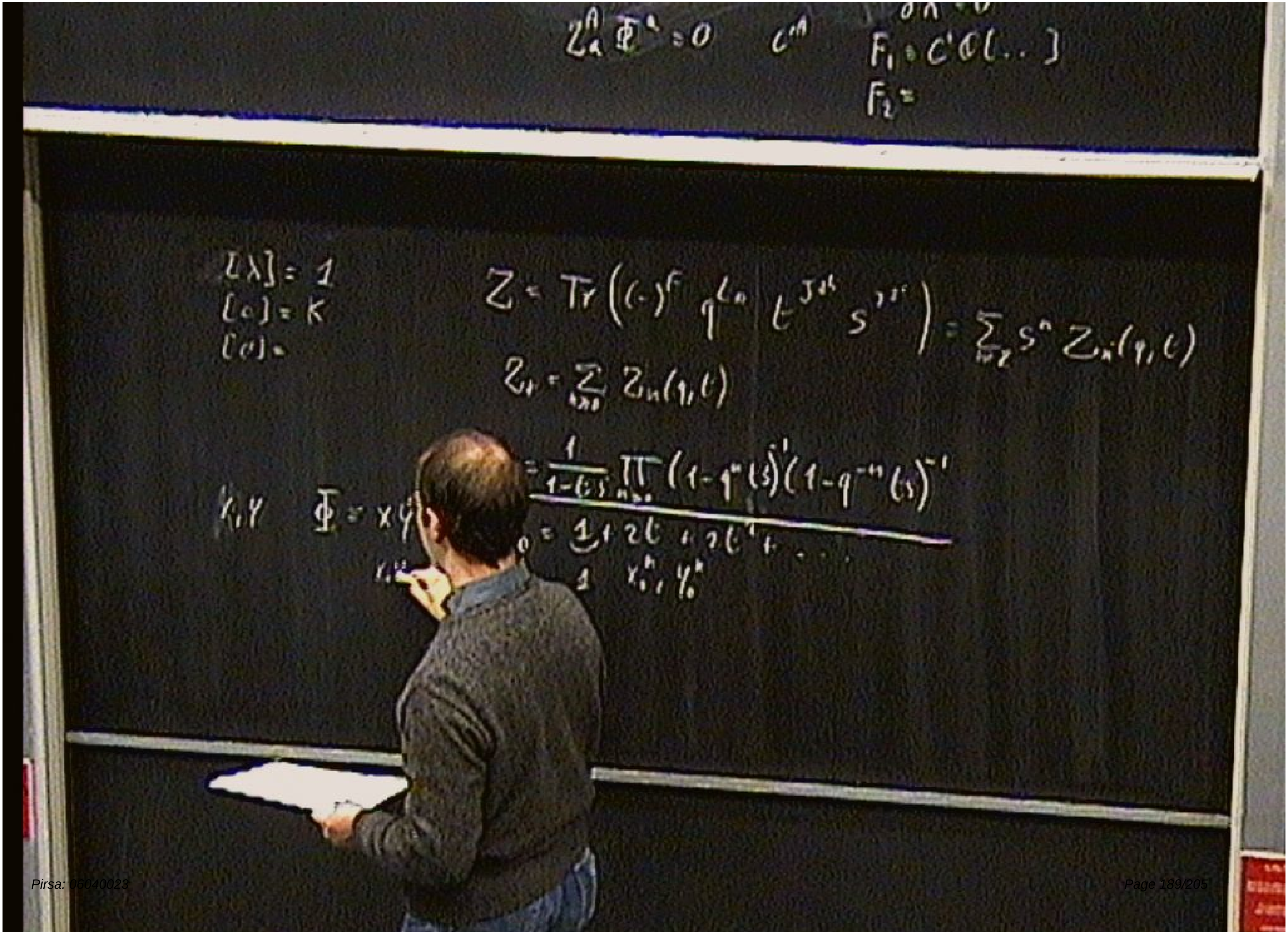

F₁ = C'C[...]
F₂ =
[λ] = 1
[c] = K
Z = Tr((-)^F q^L₀ t^J s^J) = Σ s^n Z_n(q,t)
Z = 1/(1-t) ∏ (1-q^n t)^-1 (1-q^-n t)^-1

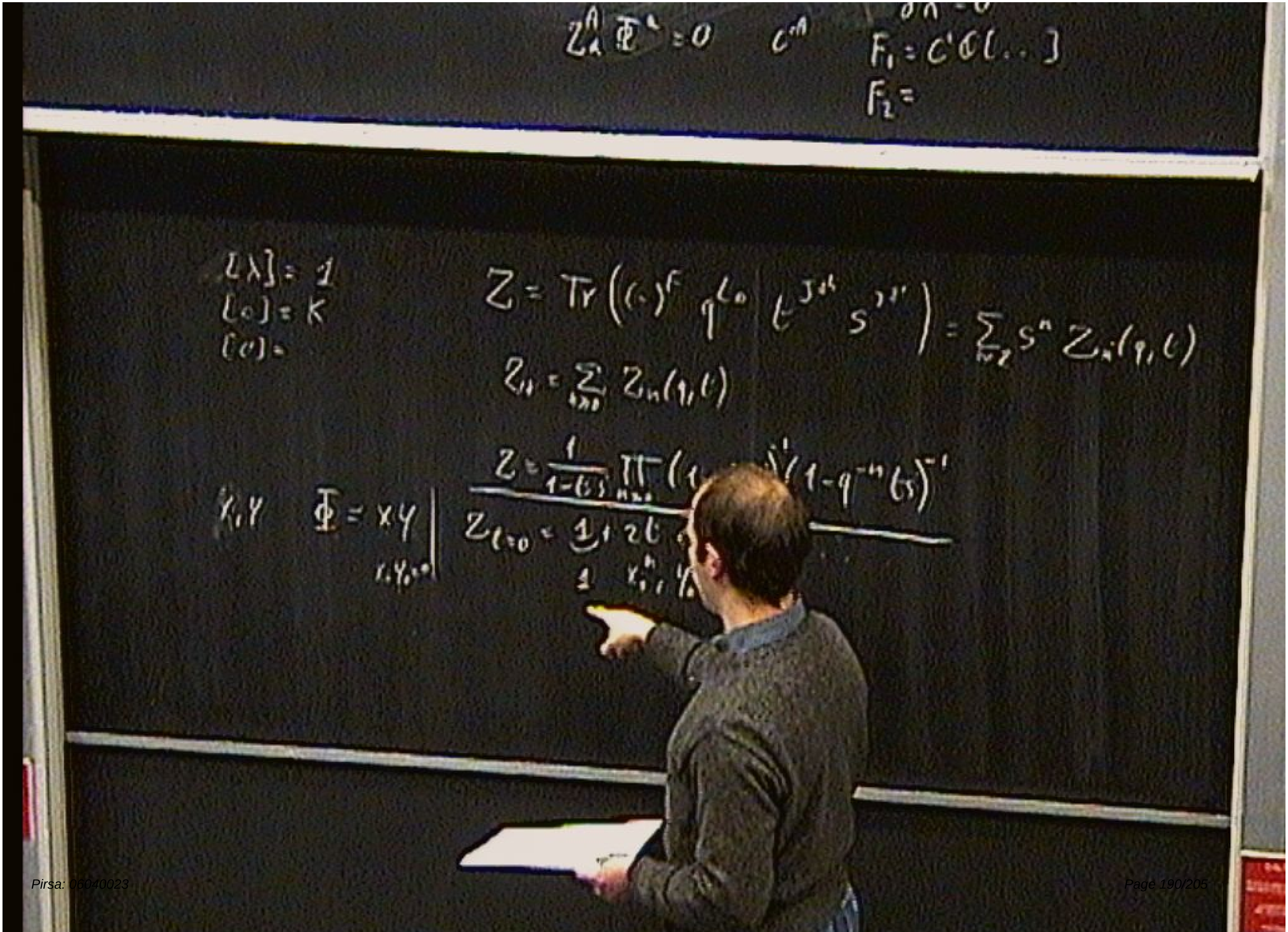

F_1 = C'Φ[...]
F_2 =
[λ] = 1
[c] = K
Z = Tr((-1)^F q^{L_0} t^{J+h} s^{J'}) = Σ_{n∈Z} s^n Z_n(q,t)
Z_+ = Σ_{n≥0} Z_n(q,t)
Z = 1/(1-ts) Π_{n>0} (1-q^n ts)^{-1} (1-q^{-n} ts)^{-1}

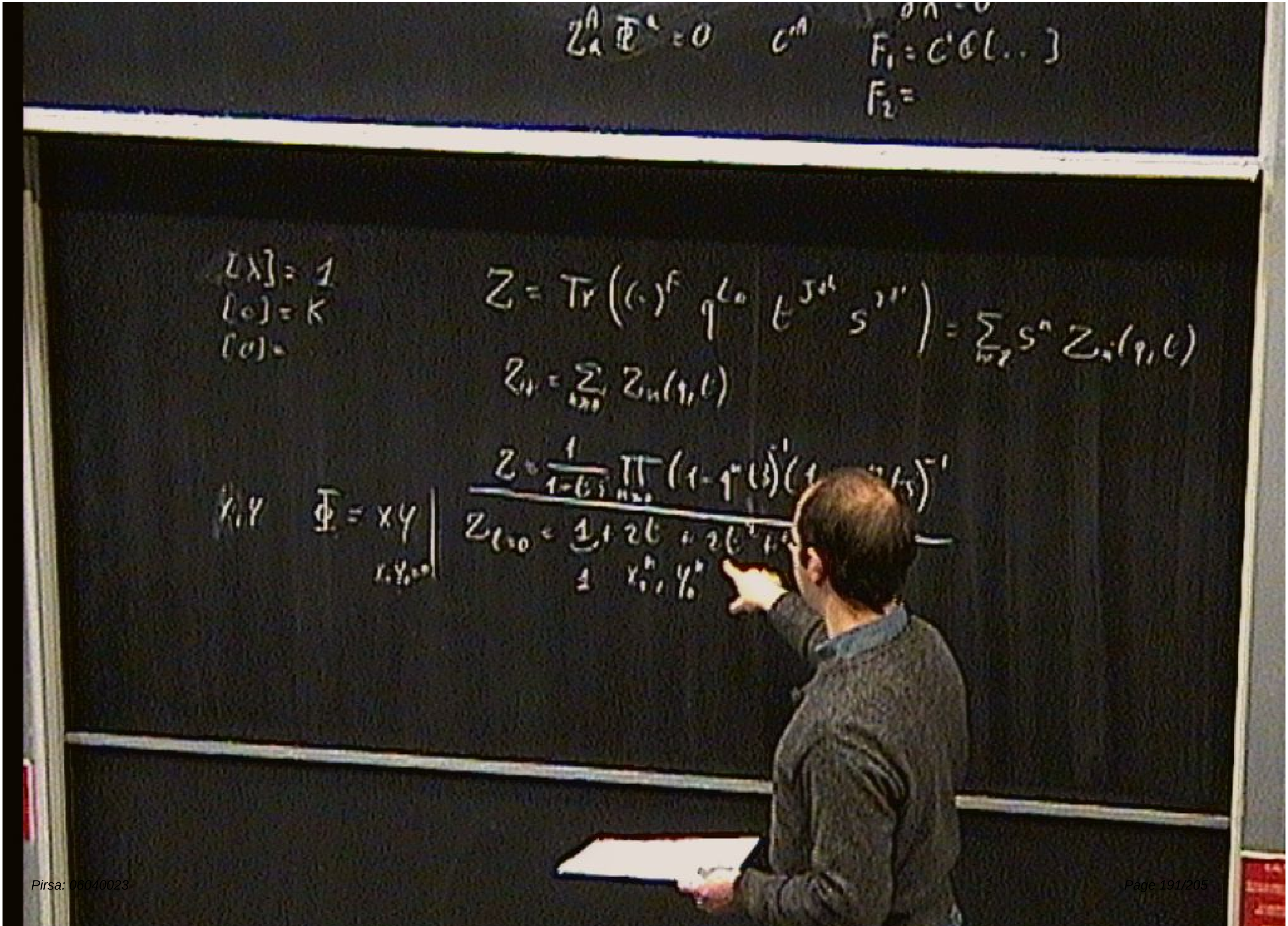

F1 = C'Φ[. .]
F2 =
[λ] = 1
[c] = K

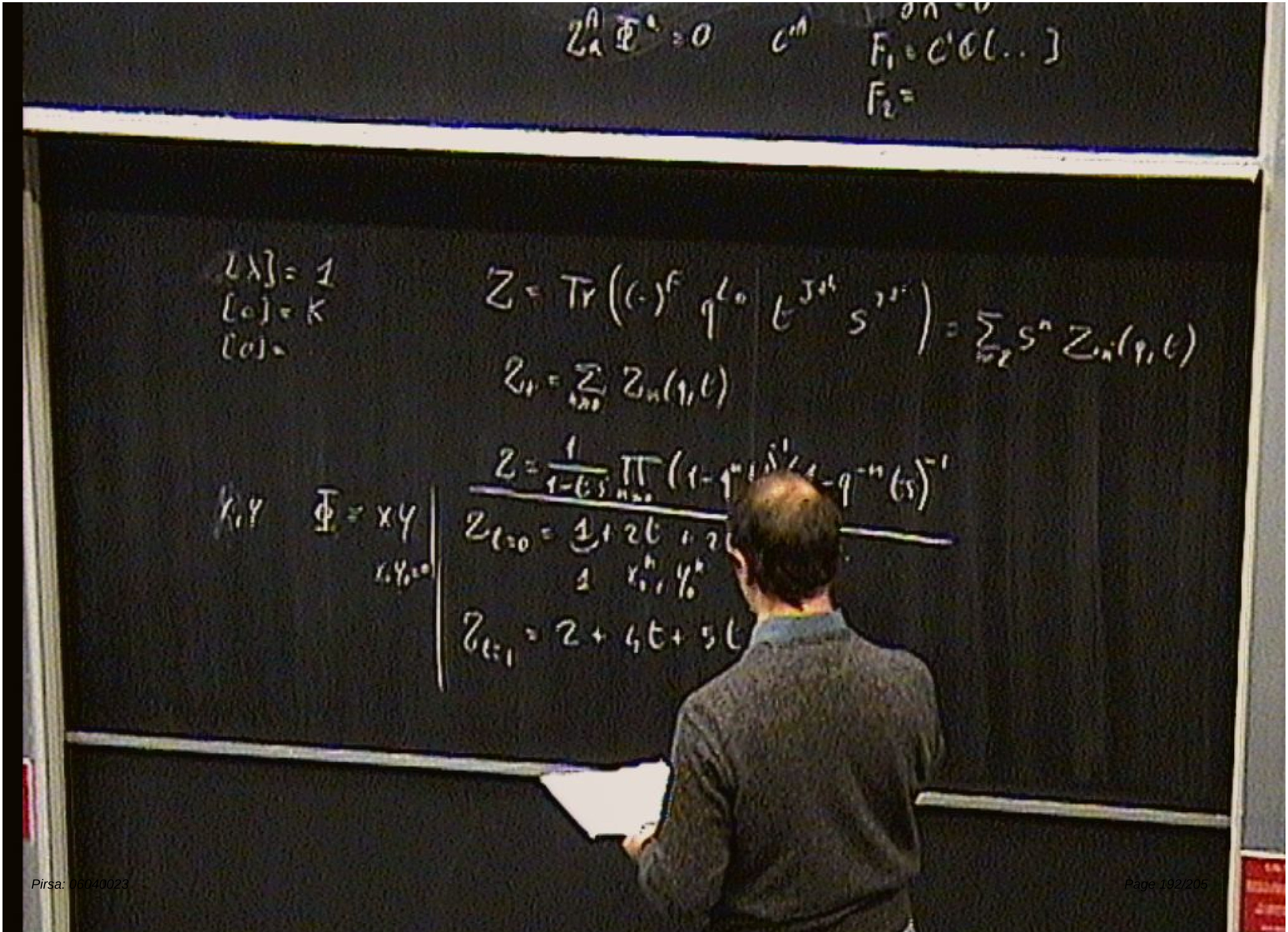

F1 = C'C[...]
F2 =
[λ] = 1
[a] = K
Z = Tr((-)^F q^L0 t^J s^J) = Σ s^n Z_n(q,t)
X, Y   Φ = XY

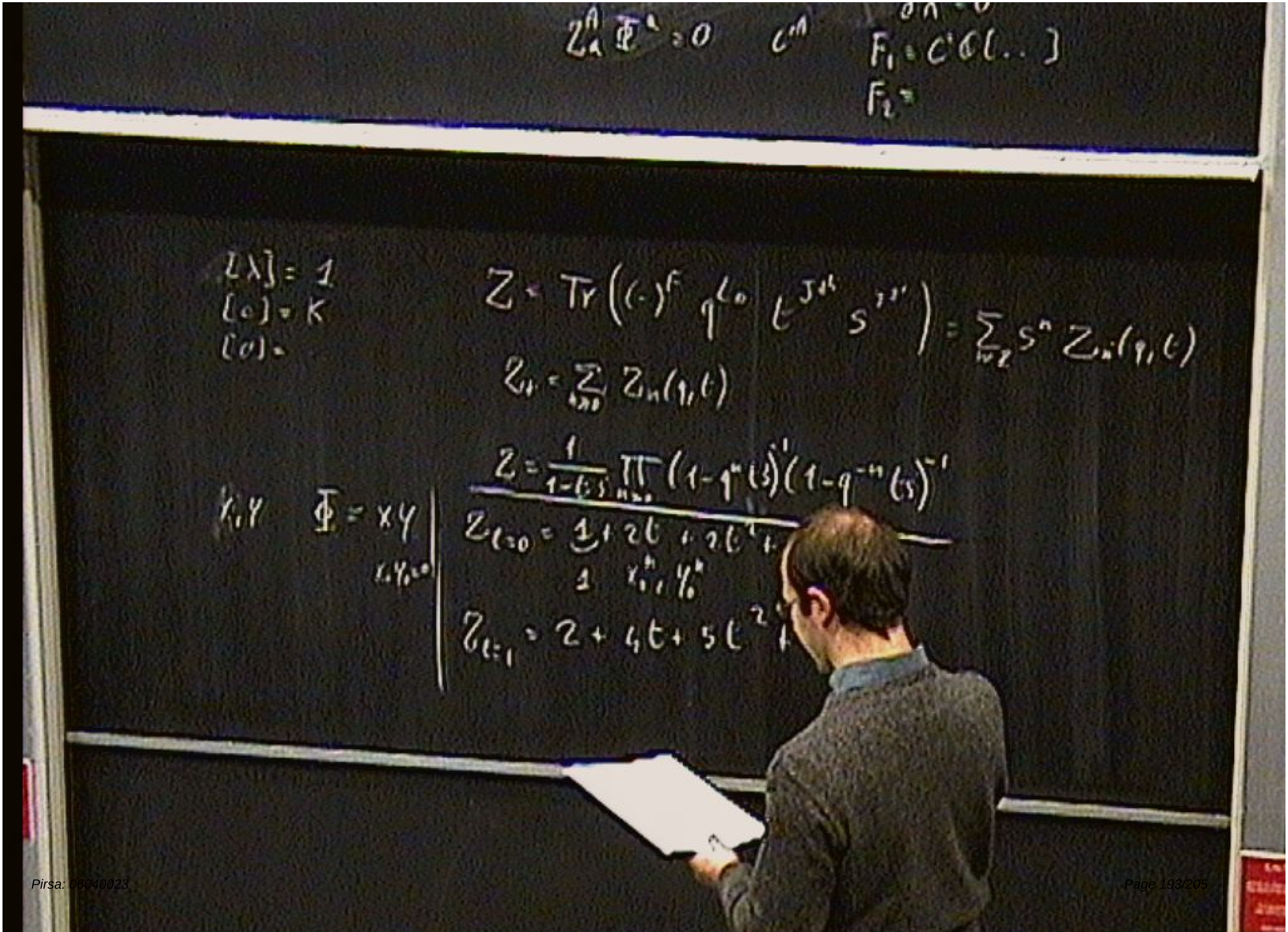

F₁ = C'Φ[. .]
F₂ =
[λ] = 1
[ο] = K
Z = Tr((-)^F q^{L₀} t^{J₃} s^{J'}) = Σ s^n Z_n(q,t)
X, Y   Φ = XY

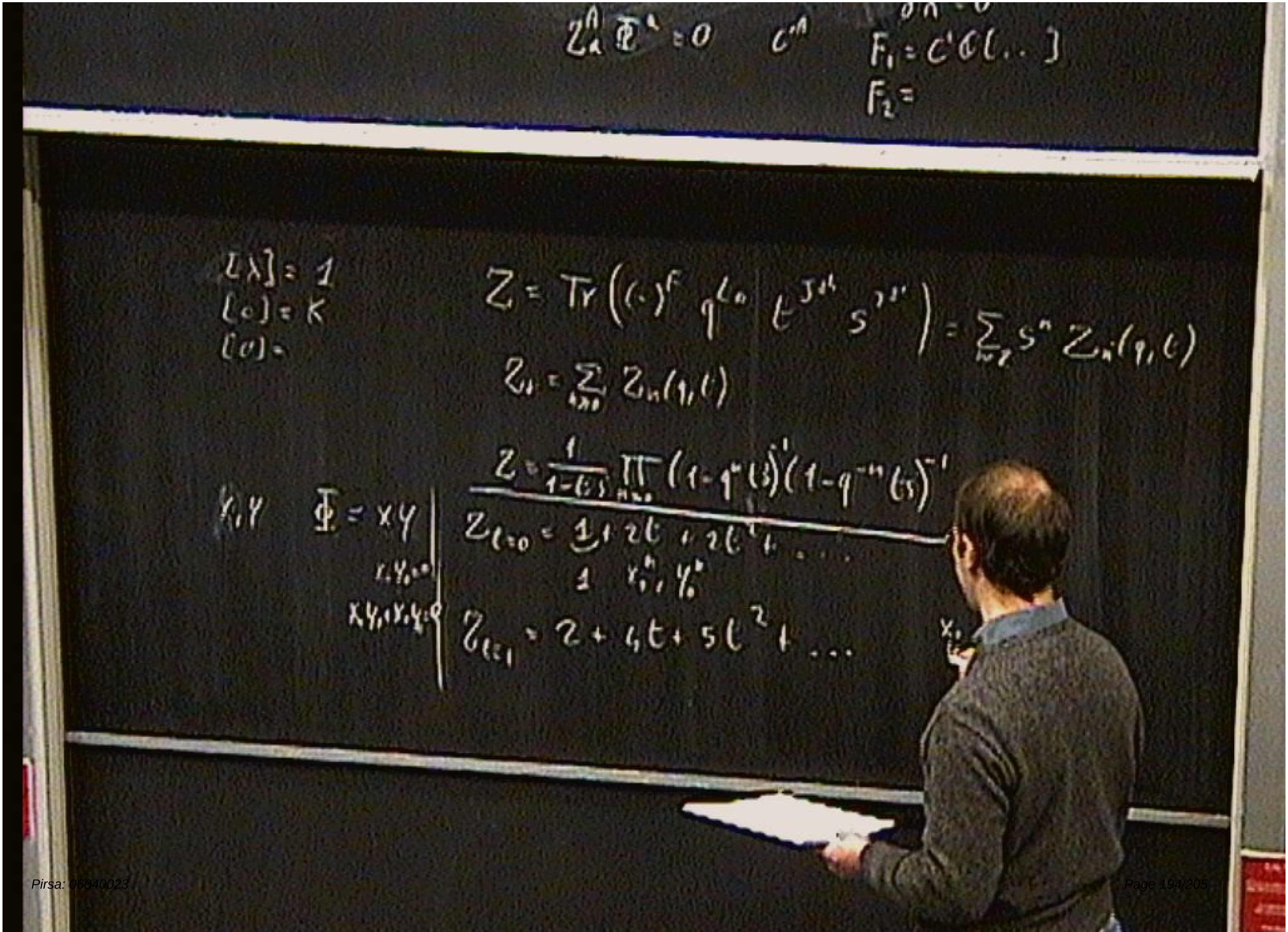

[λ] = 1
[c] = K
F₁ = C'C[..]
F₂ =

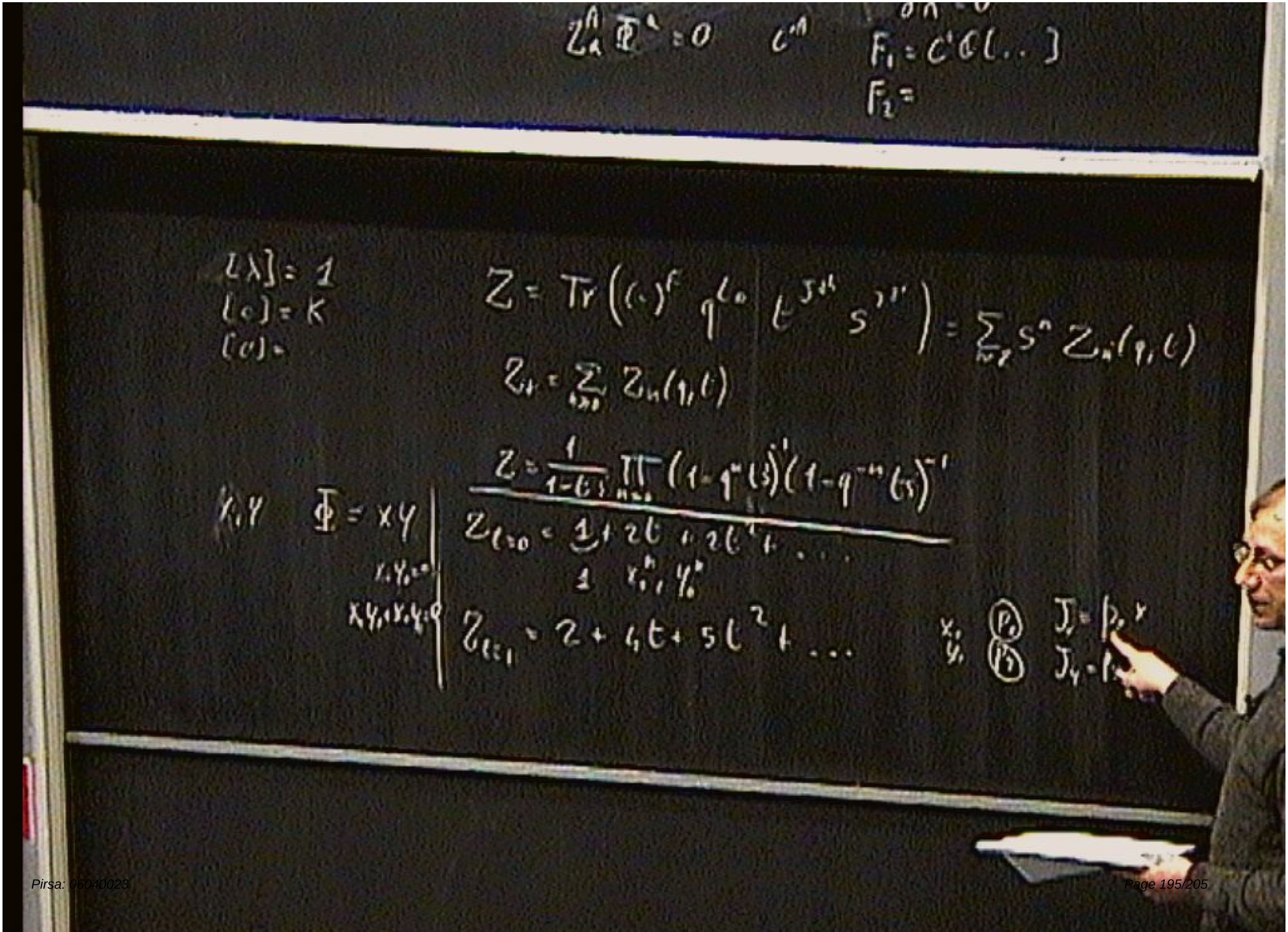

F1 = C'C[...]
F2 =
[λ] = 1
[c] = K
Z = Tr((-)^F q^L0 t^J s^J) = Σ s^n Zn(q,t)
Φ = XY

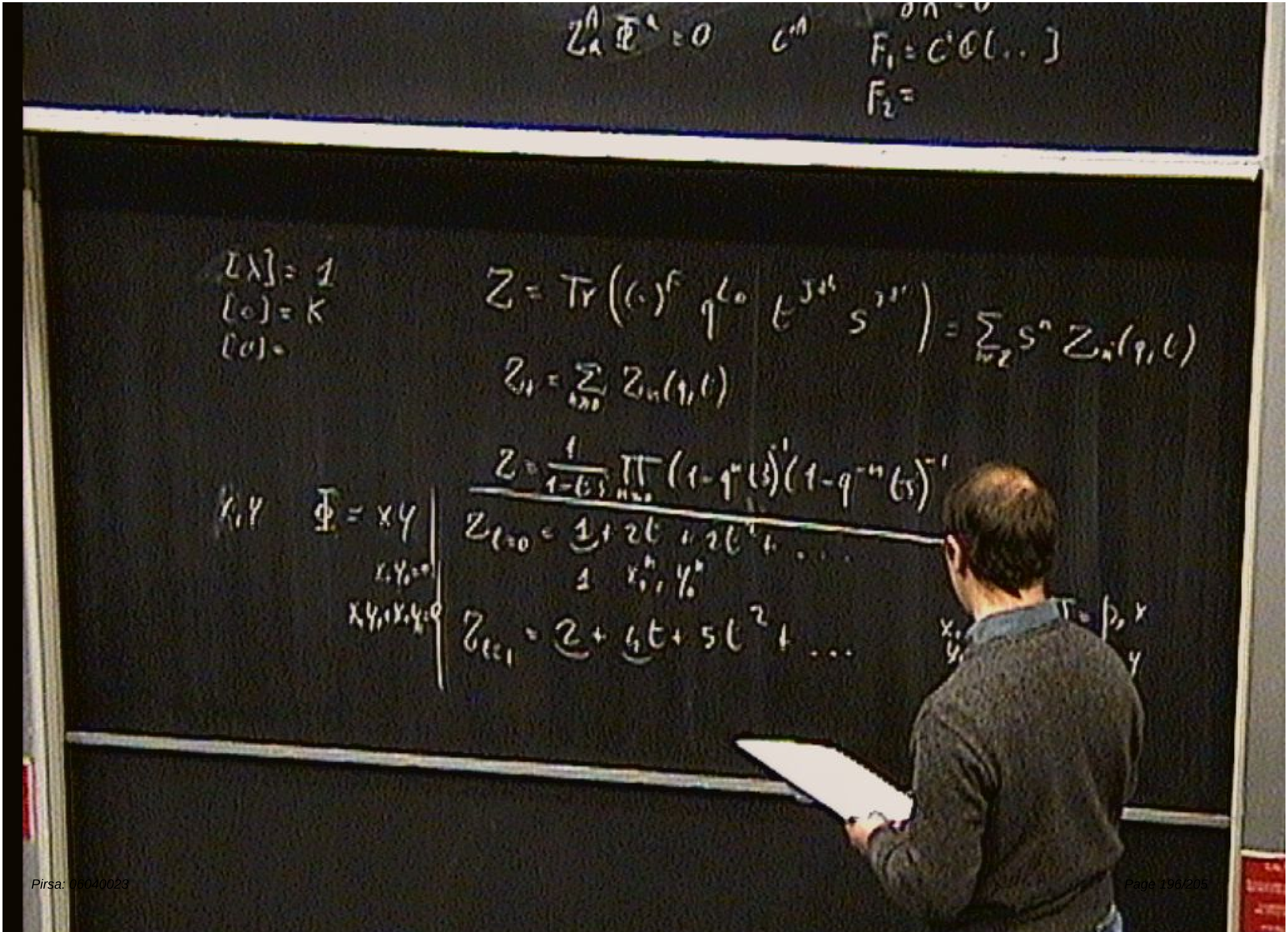

F1 = C'G[..]
F2 =
[λ] = 1
[c] = K
Z = Tr((-)^F q^L0 t^J1 s^J2) = Σ s^n Z_n(q,t)
Φ = XY


[λ] = 1
[σ] = K
Z = Tr((-)^F q^{L_0} t^{J+K} s^{J-K}) = Σ s^n Z_n(q,t)
Φ = XY
Z_{t=0} = 1 + 2t
Z_{t=1} = 2 + 4t + 5t

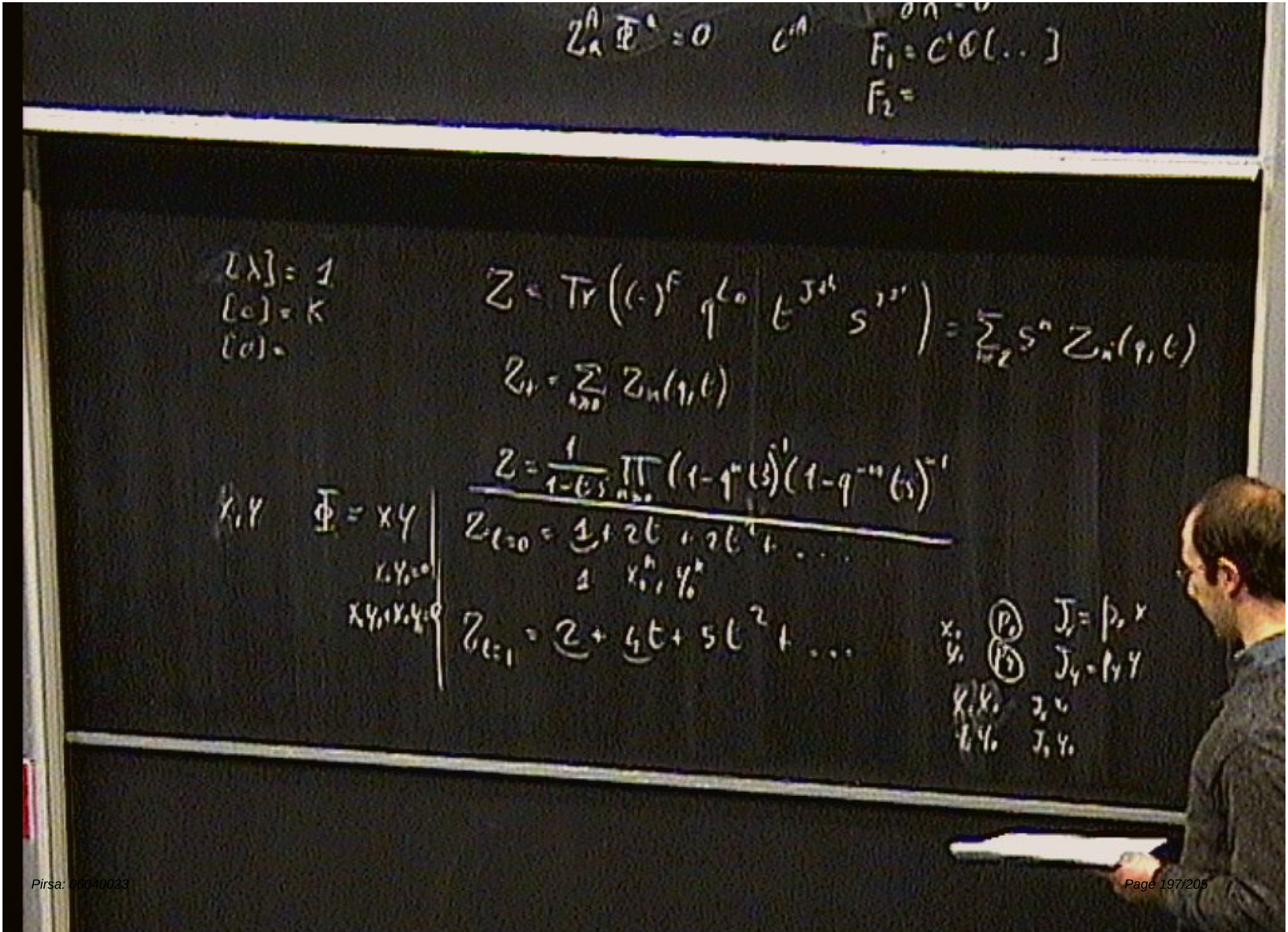

F_1 = C'C[...]
[λ] = 1
[σ] = K
Z = Tr((-)^F q^{L_0} t^{J+K} s^{J+J'}) = Σ_{n∈Z} s^n Z_n(q,t)
Z_+ = Σ_{n≥0} Z_n(q,t)
X, Y
Φ = XY
Z_{t=0} = 1 + 2t + 2t^2
Z_{t=1} = 2 + 4t + 5t^2

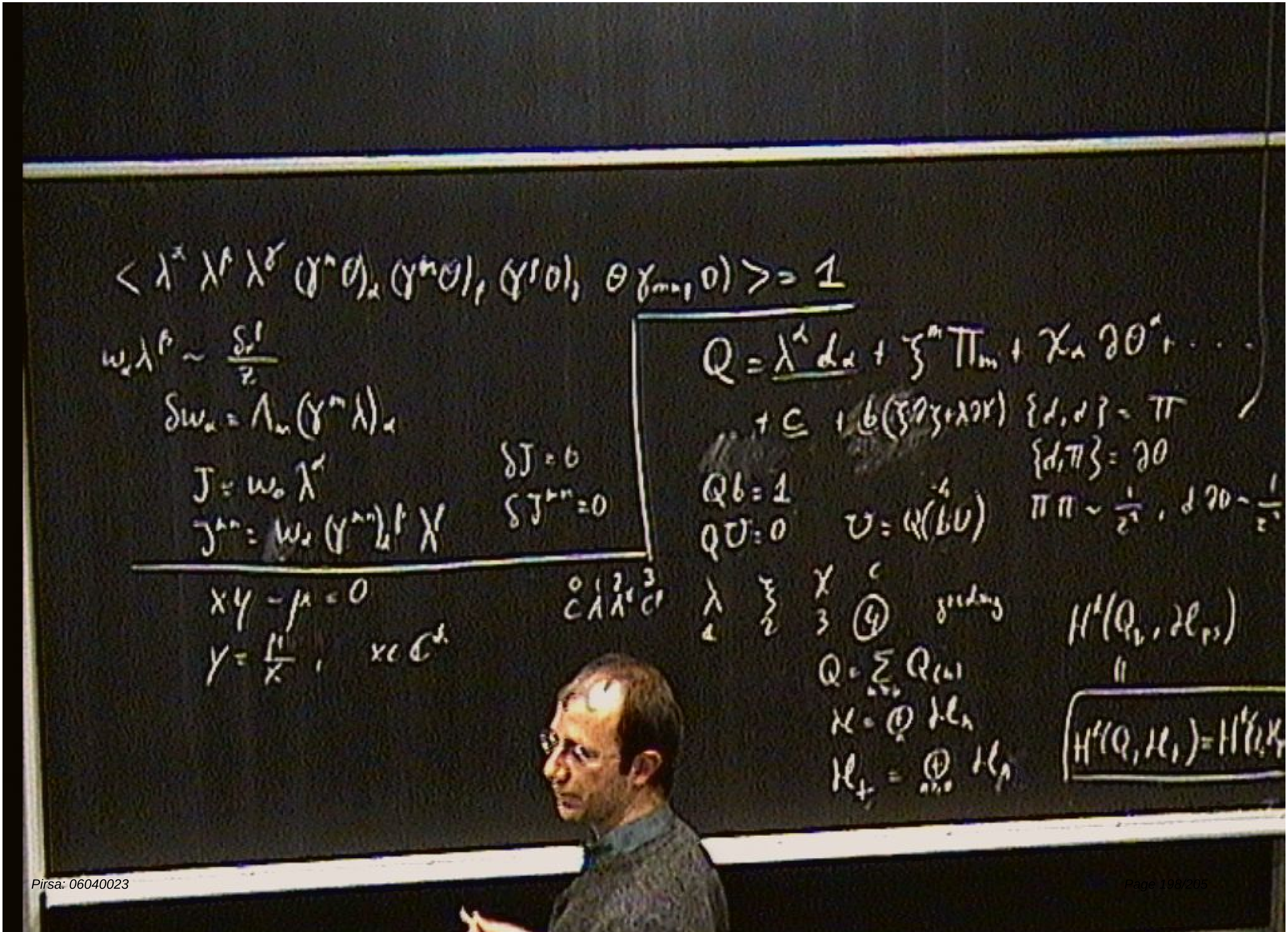

F1 = C'C[...]
F2 =
[λ] = 1
Φ = xy
Z_{t=0} = 1 + 2t + 2t^2 + ...
Z_{t=1} = 2 + 4t + 5t^2 + ...

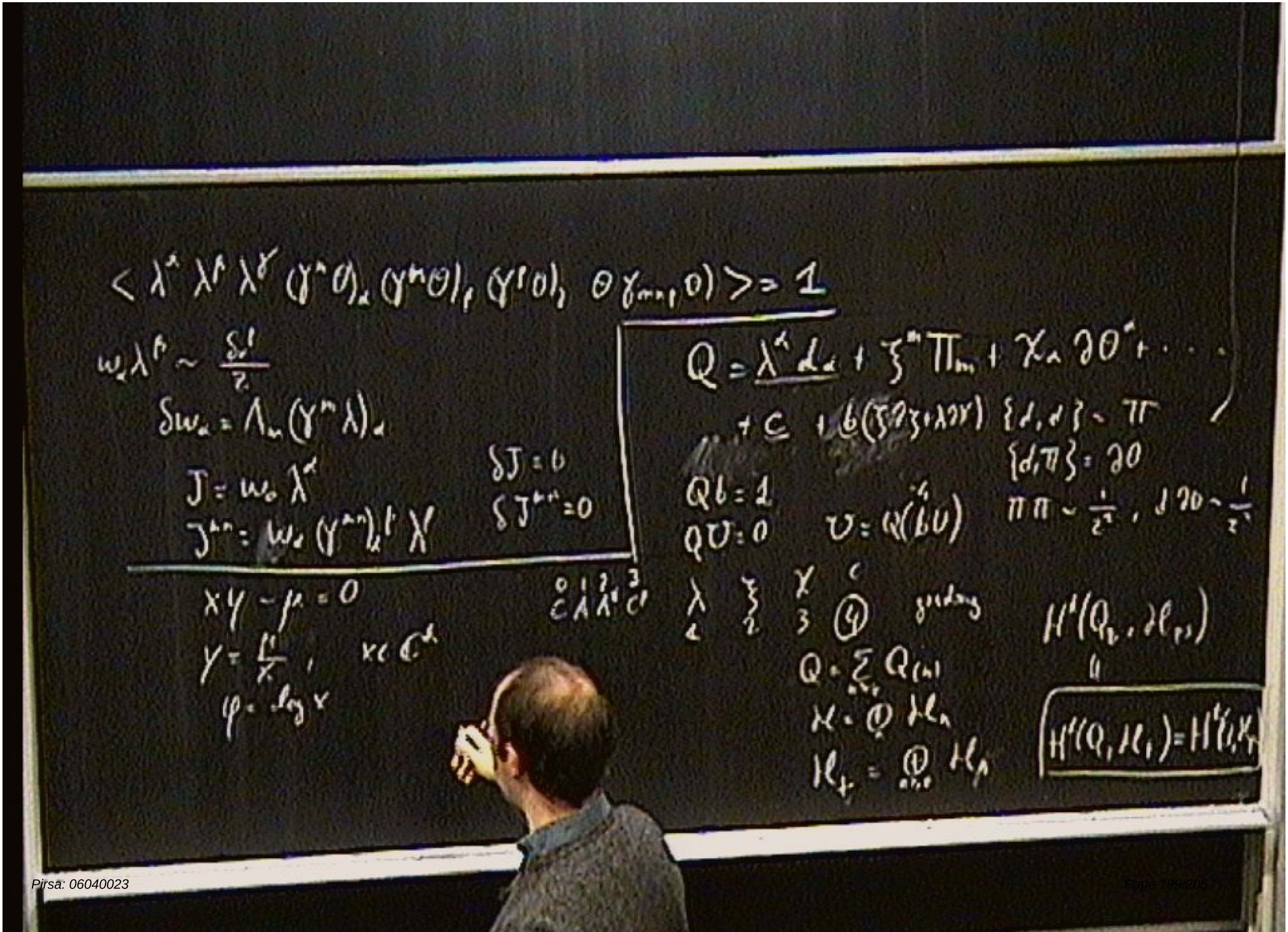

F₁ = C'G[..]
F₂ =
[λ] = 1
[c] = K
Z = Tr((-)^F q^{L₀} t^{J+} s^{J'}) = Σ s^n Z_n(q, t)
Z₊ = Σ Z_n(q, t)
Φ = XY
Z_{t=0} = 1 + 2t + 2t² + ...
Z_{t=1} = 2 + 4t + 5t² + ...
J_x =
J_y =

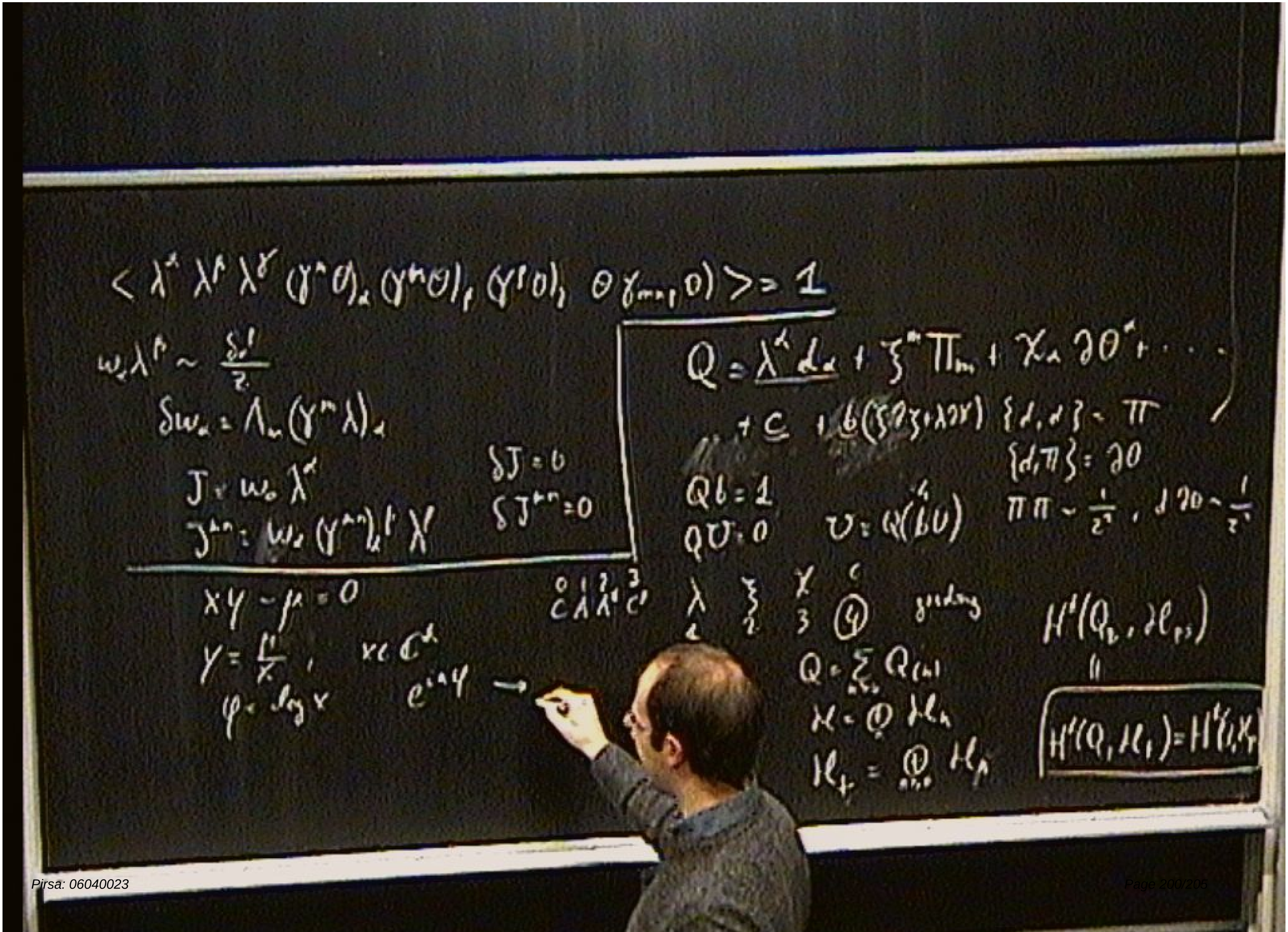


F1 = C'Φ[..]
F2 =
[λ] = 1
Φ = XY
Z = Tr
= 2 + 4t + 5t^2 + ...

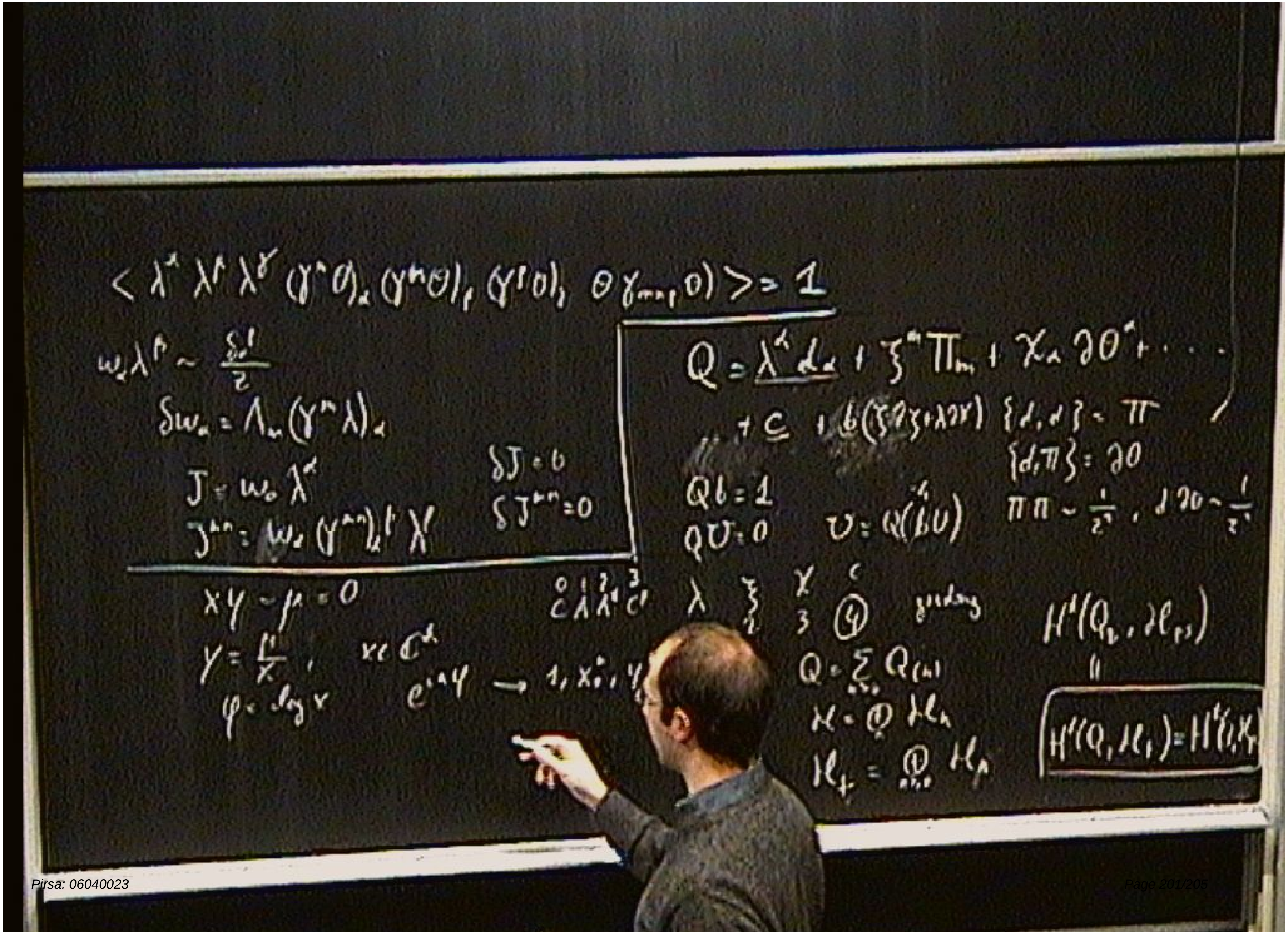

F₁ = C'C[...]
F₂ =
[λ] = 1
[c] = K
Z = Tr((-)^F q^L₀ t^J s^J) = Σ s^n Z_n(q, t)
Φ = XY
Z_t=0 = 1 + 2t + 2t² + ...
Z_t=1 = 2 + 4t + 5t² + ...
J_x = p_x X
J_y = p_y Y


Qb = 1
QU = 0
grading

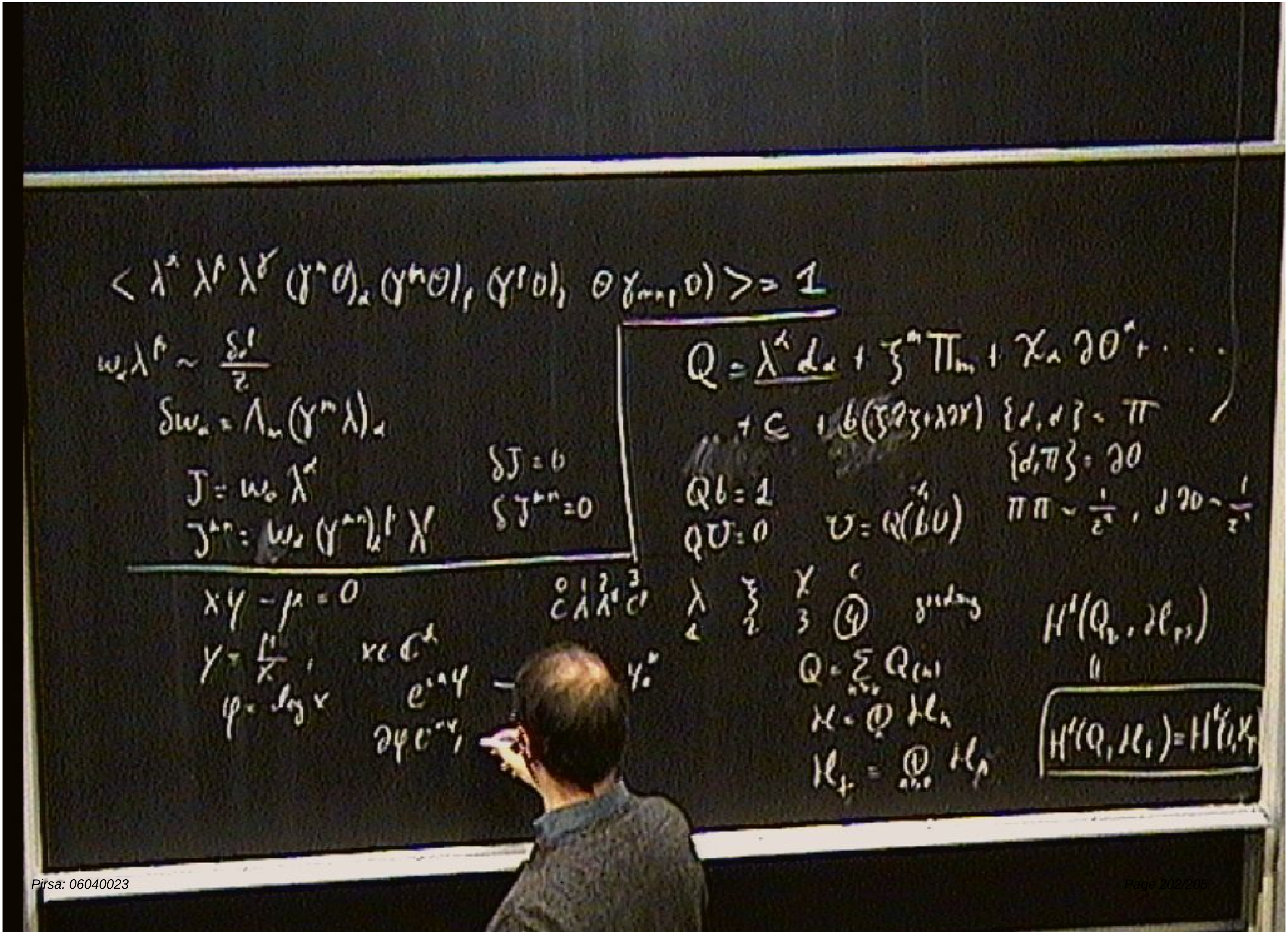

grading

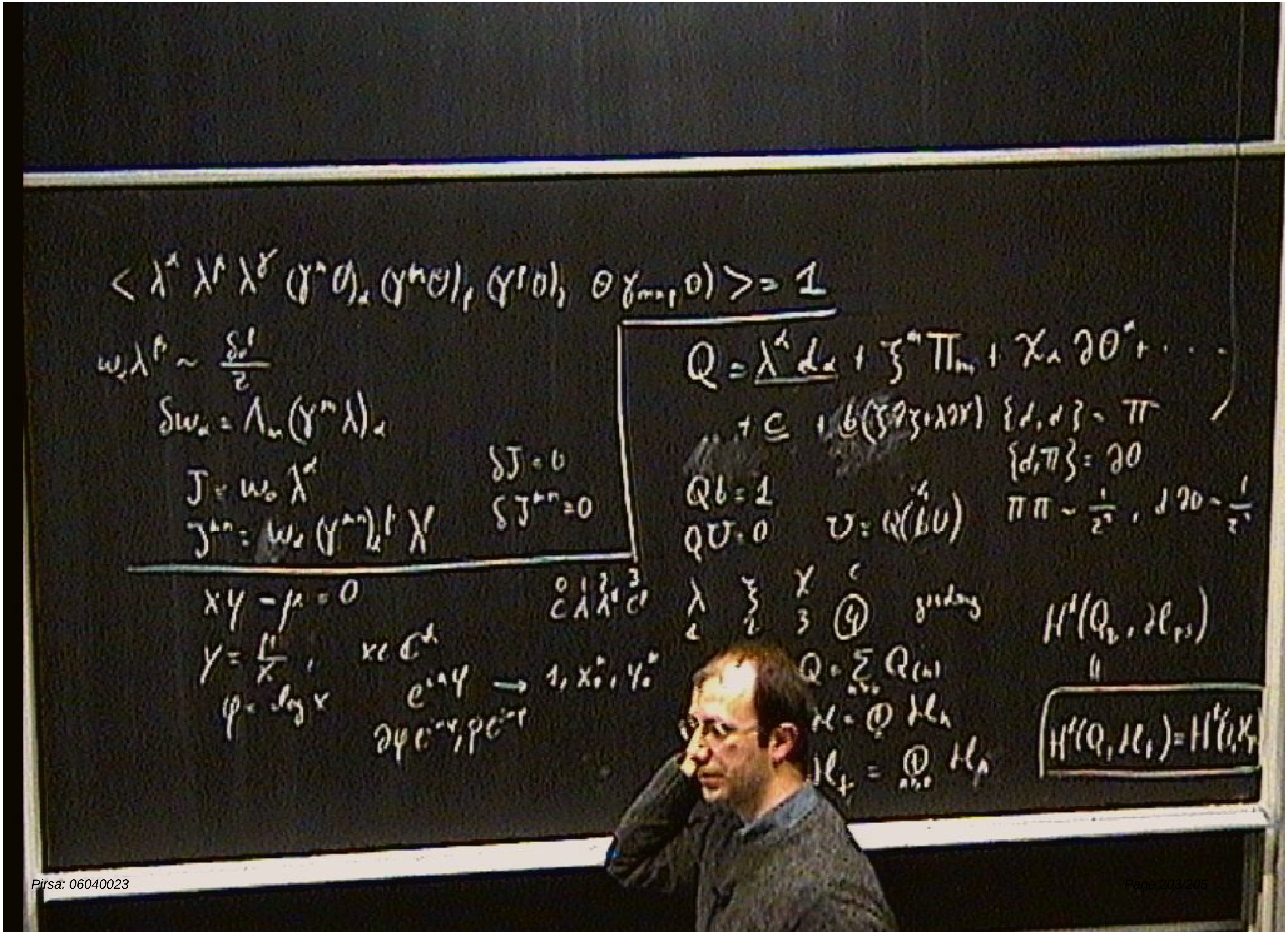


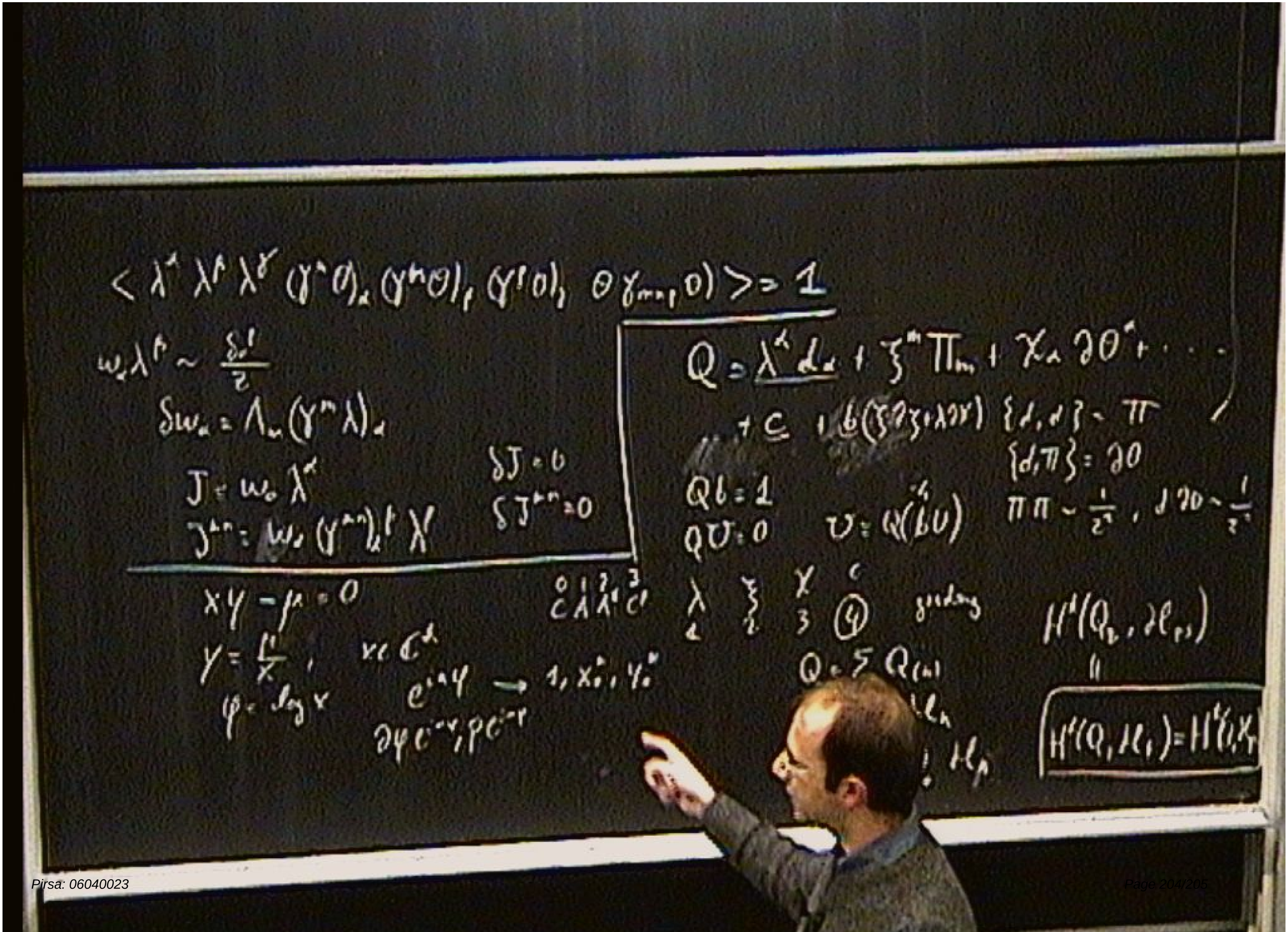
$< \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^m \theta)_\alpha (\gamma^n \theta)_\beta (\gamma^p \theta)_\gamma \; \theta \gamma_{mnp} \theta) > = 1$
$\delta J = 0$
$\delta J^{mn} = 0$
$Q = \lambda^\alpha d_\alpha + \xi^m \Pi_m + \chi_\alpha \partial \theta^\alpha + \cdots$
$Qb = 1$
$QU = 0$
$U = Q(bU)$
$\{d, \Pi\} = \partial \theta$
$xy - \mu = 0$
grading
$Q = \sum Q_{(n)}$



< λ^α λ^β λ^γ (γ^m θ)_α (γ^n θ)_β (γ^p θ)_γ θ γ_{mnp} θ > = 1
Q = λ^α d_α + ξ^m Π_m + χ_α ∂θ^α + . . .
+ c + b(ξ ∂ ξ + λ ∂ χ) {d, d} = Π
{d, Π} = ∂θ
Qb = 1
QU = 0
U = Q(bU)
δJ = 0
δJ^{mn} = 0
J = w_α λ^α
xy − μ = 0
H^i(Q, H_+) = H^i(Q, K_+)


Qb = 1
QU = 0
grading


= 1
δJ = 0
Qb = 1
QU = 0
grading
xy − μ = 0



Q b = 1
Q U = 0
grading