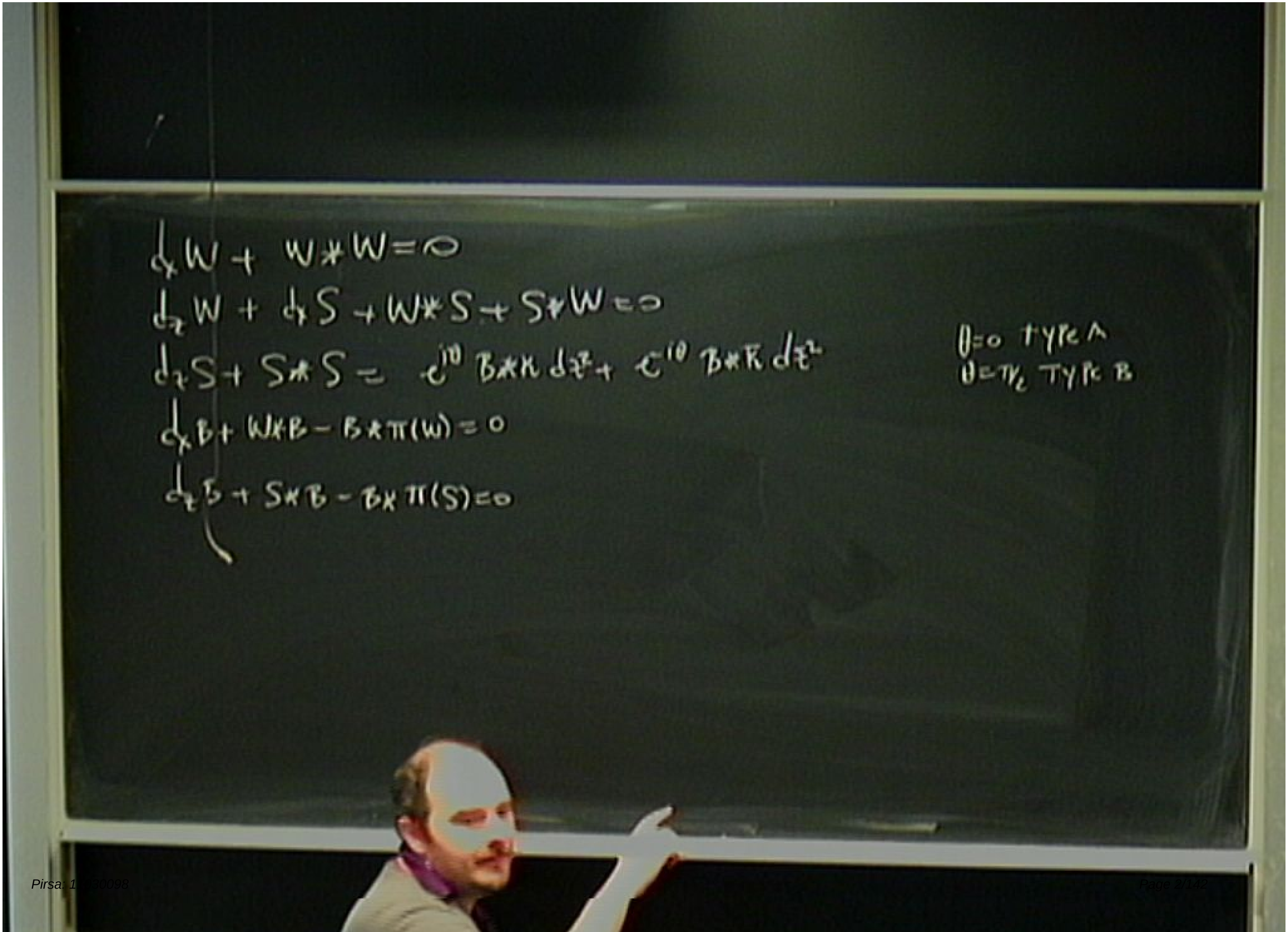
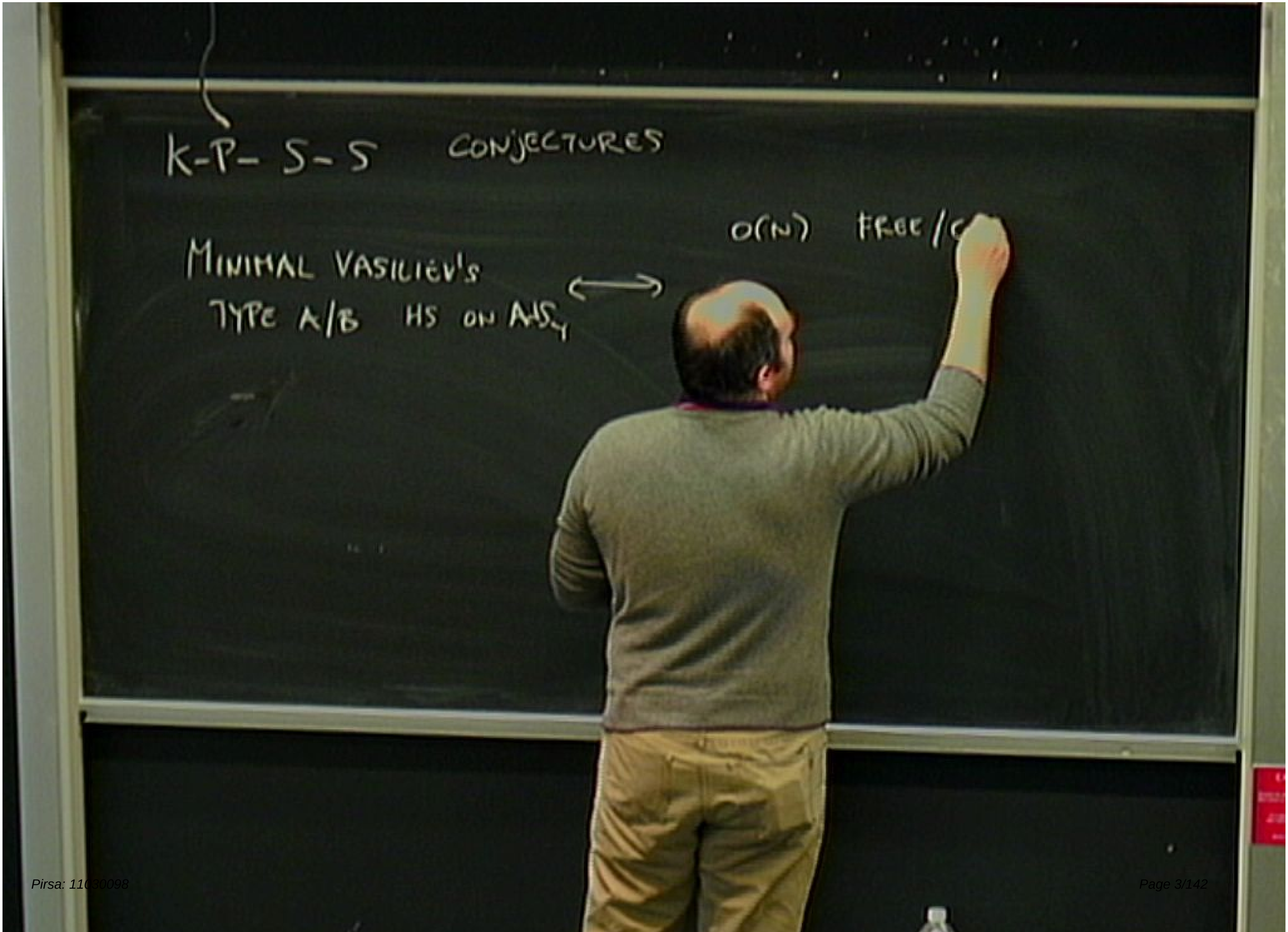
Title: Higher Spin Theories - Lecture 4

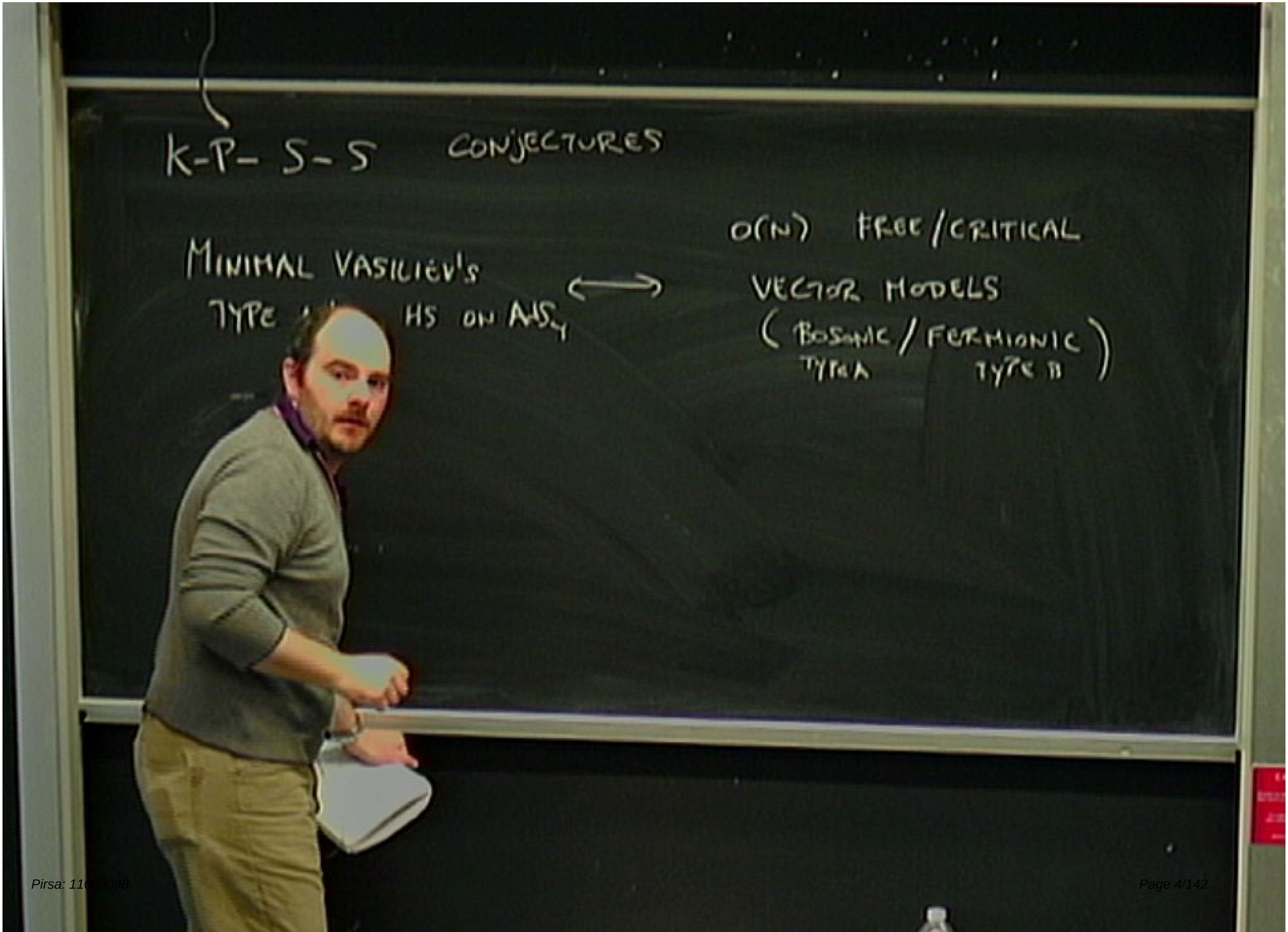
Date: Mar 29, 2011 09:30 AM

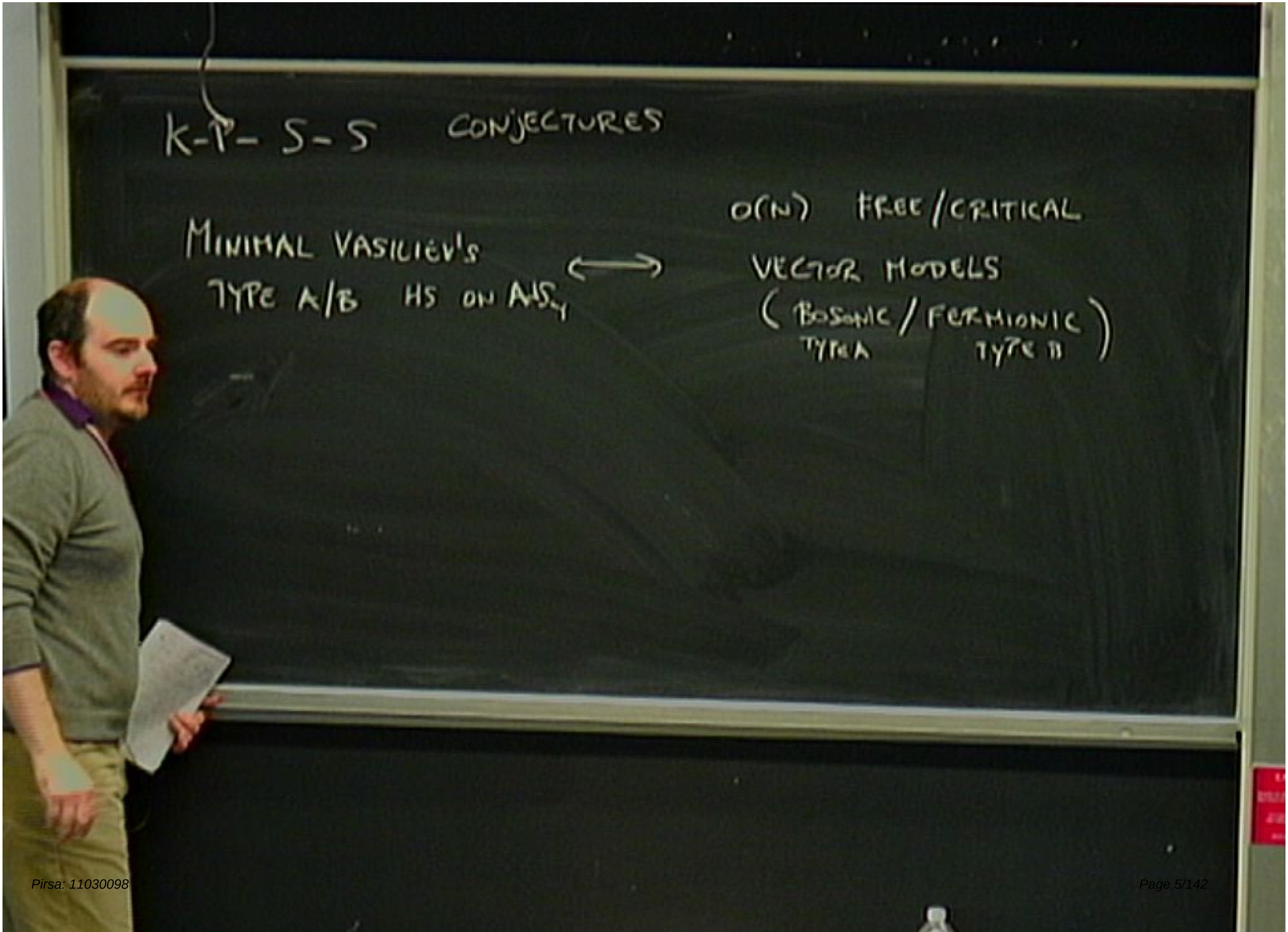
URL: http://pirsa.org/11030098

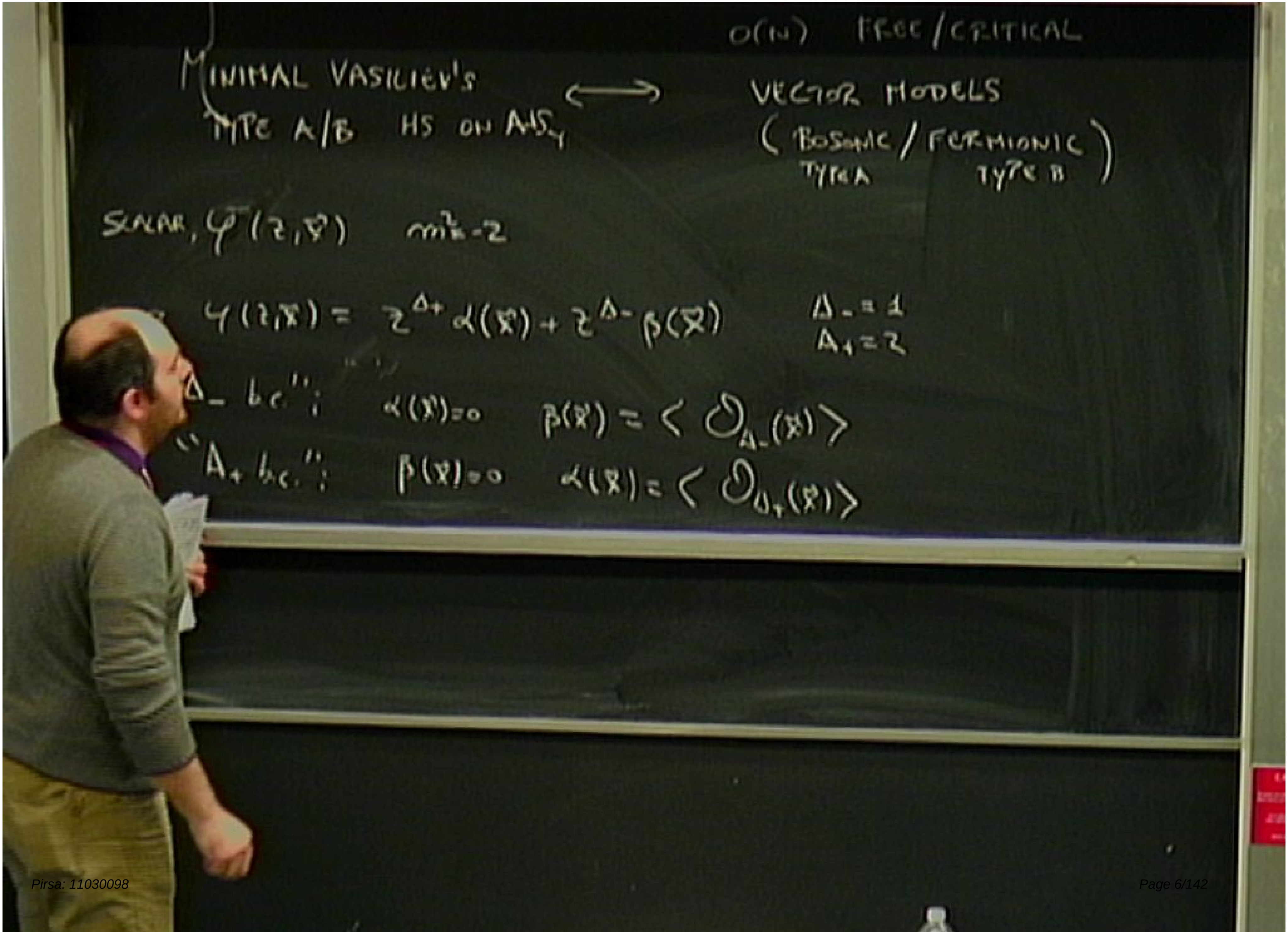
Abstract:

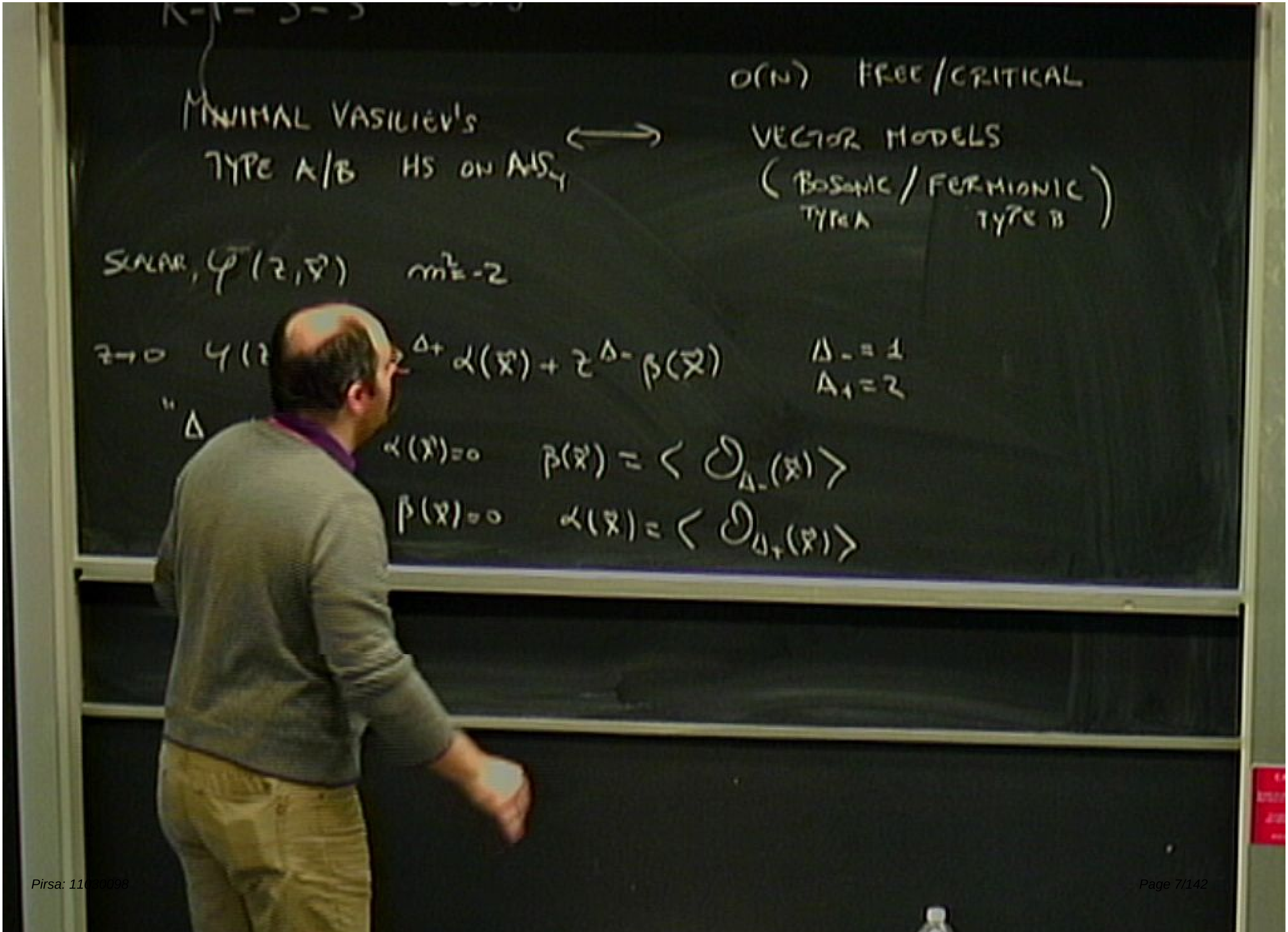

$d_x W + W * W = 0$
$d_z W + d_x S + W * S + S * W = 0$
$d_z S + S * S = e^{i\theta} B * K \, d\bar{z} + e^{i\theta} B * \bar{K} \, d\bar{z}^2$
$\theta = 0$ type A
$\theta = \pi/2$ type B
$d_x B + W * B - B * \pi(W) = 0$
$d_z B + S * B - B * \pi(S) = 0$

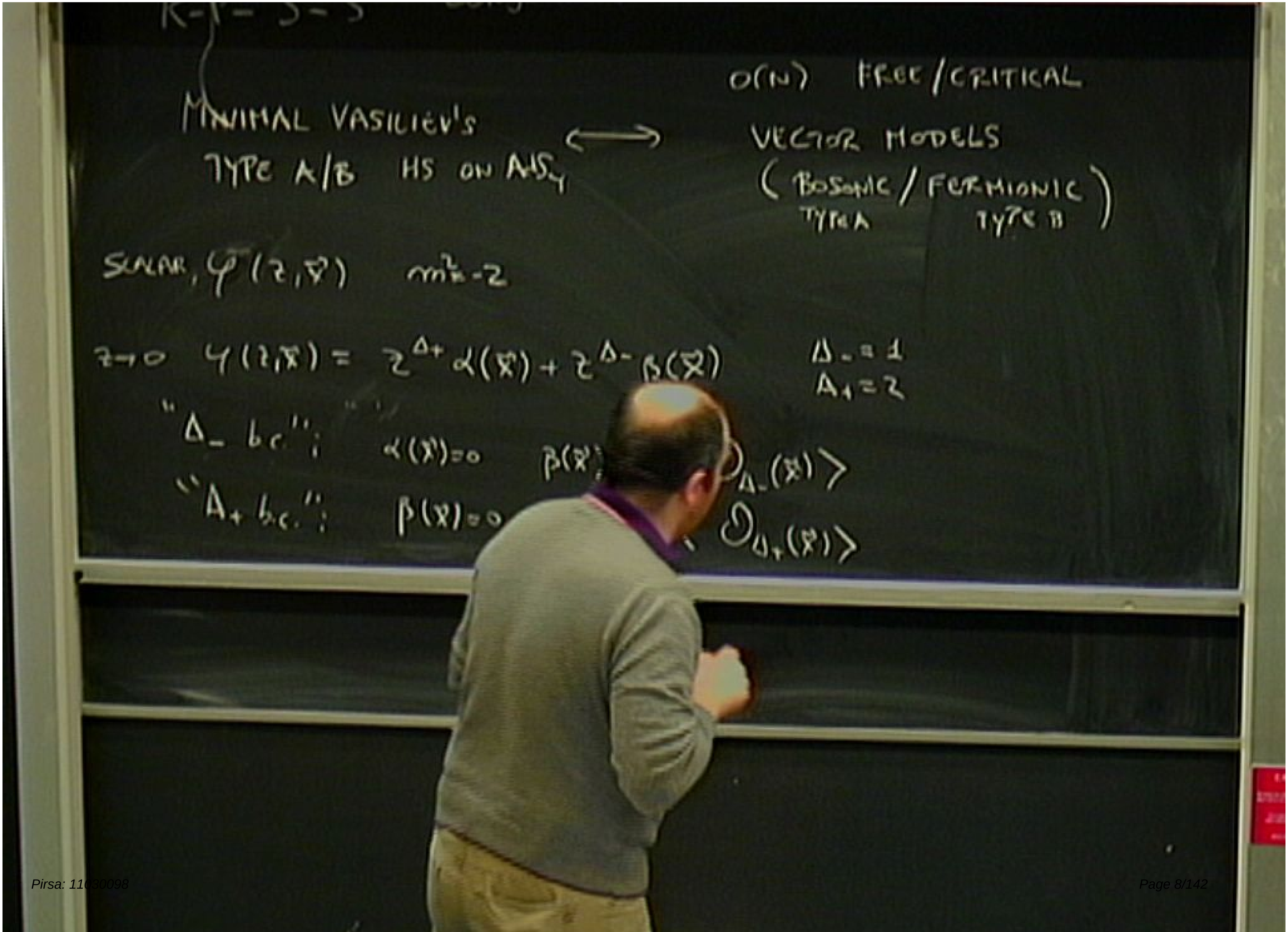

K-P-S-S CONJECTURES
MINIMAL VASILIEV'S
TYPE A/B HS ON AdS4
O(N) FREE/


K-P-S-S CONJECTURES
MINIMAL VASILIEV'S
TYPE
HS ON AdS4
O(N) FREE/CRITICAL
VECTOR MODELS
(BOSONIC / FERMIONIC)
TYPE A
TYPE B


K-P-S-S CONJECTURES
MINIMAL VASILIEV'S
TYPE A/B HS ON AdS_4
$\longleftrightarrow$
O(N) FREE/CRITICAL
VECTOR MODELS
(BOSONIC / FERMIONIC)
TYPE A TYPE B


O(N) FREE / CRITICAL
MINIMAL VASILIEV'S $\longleftrightarrow$ VECTOR MODELS
TYPE A/B HS ON AdS_4
(BOSONIC / FERMIONIC)
TYPE A TYPE B
SCALAR, $\varphi(z, \vec{x})$ $m^2 = -2$
$\varphi(z,\vec{x}) = z^{\Delta_+} \alpha(\vec{x}) + z^{\Delta_-} \beta(\vec{x})$
$\Delta_- = 1$
$\Delta_+ = 2$
"Δ_- b.c.": $\alpha(\vec{x}) = 0$ $\beta(\vec{x}) = \langle \mathcal{O}_{\Delta_-}(\vec{x}) \rangle$
"Δ_+ b.c.": $\beta(\vec{x}) = 0$ $\alpha(\vec{x}) = \langle \mathcal{O}_{\Delta_+}(\vec{x}) \rangle$


O(N) FREE / CRITICAL
MINIMAL VASILIEV'S ⟷ VECTOR MODELS
TYPE A/B HS ON AdS4
(BOSONIC / FERMIONIC)
TYPE A TYPE B
SCALAR, φ(z, x) m² = -2
z→0
Δ- = 1
Δ+ = 2
α(x) = 0 β(x) = ⟨O_Δ-(x)⟩
β(x) = 0 α(x) = ⟨O_Δ+(x)⟩


O(N) FREE/CRITICAL
MINIMAL VASILIEV'S
TYPE A/B HS ON AdS4
VECTOR MODELS
(BOSONIC / FERMIONIC)
TYPE A TYPE B
SCALAR, φ(z, x) m² = -2
z→0 φ(z, x) = z^Δ+ α(x) + z^Δ- β(x)
Δ- = 1
Δ+ = 2
"Δ- b.c.": α(x)=0
"Δ+ b.c.": β(x)=0
O_Δ-(x)>
O_Δ+(x)>

K-P-S-S CONJECTURES

$s=0,2,4,\dots\infty$

MINIMAL VASILIEV'S TYPE A/B HS ON AdS_4 $\longleftrightarrow$ O(N) FREE/CRITICAL VECTOR MODELS (BOSONIC / FERMIONIC)

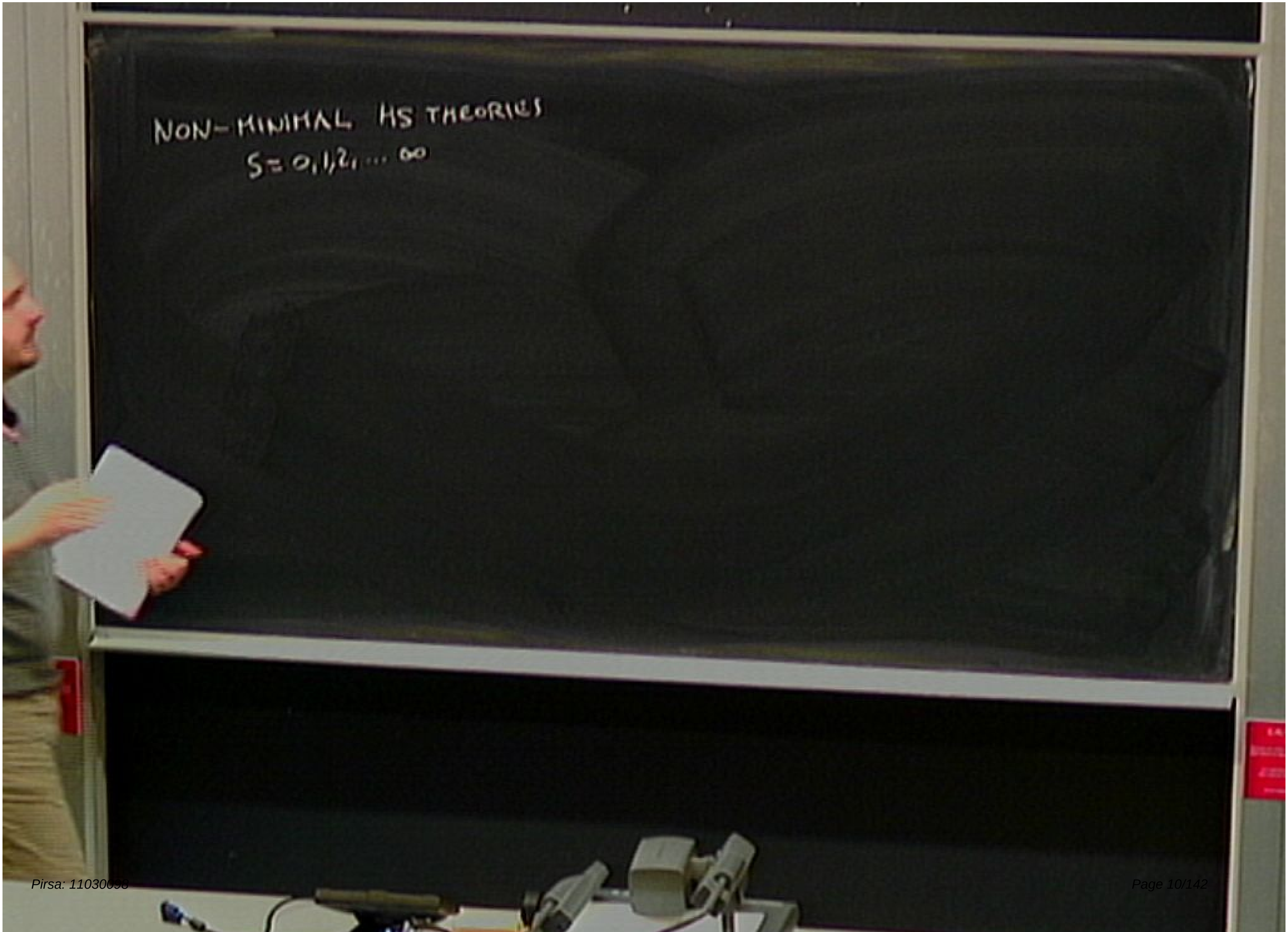
TYPE A TYPE B

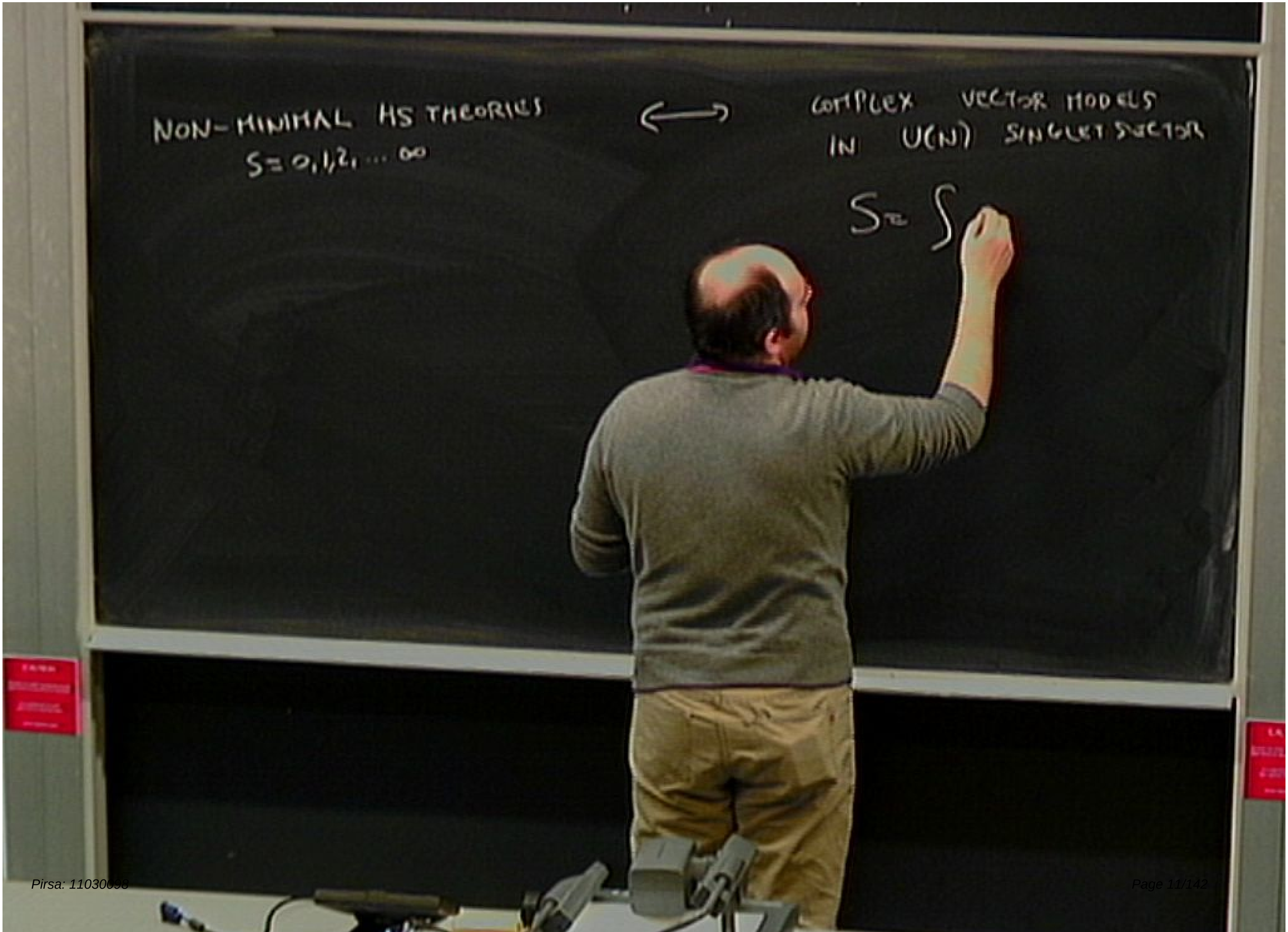
SCALAR, $\varphi(z,\vec{x})$ $m^2=-2$

$z\to 0$ $\varphi(z,\vec{x}) = z^{\Delta_+}\alpha(\vec{x}) + z^{\Delta_-}\beta(\vec{x})$ $\Delta_-=1$ $\Delta_+=2$

"Δ_- b.c.": $\alpha(\vec{x})=0$ $\beta(\vec{x}) = \langle \mathcal{O}_{\Delta_-}(\vec{x})\rangle$

"Δ_+ b.c.": $\beta(\vec{x})=0$ $\alpha(\vec{x}) = \langle \mathcal{O}_{\Delta_+}(\vec{x})\rangle$


NON-MINIMAL HS THEORIES
S=0,1,2,... ∞

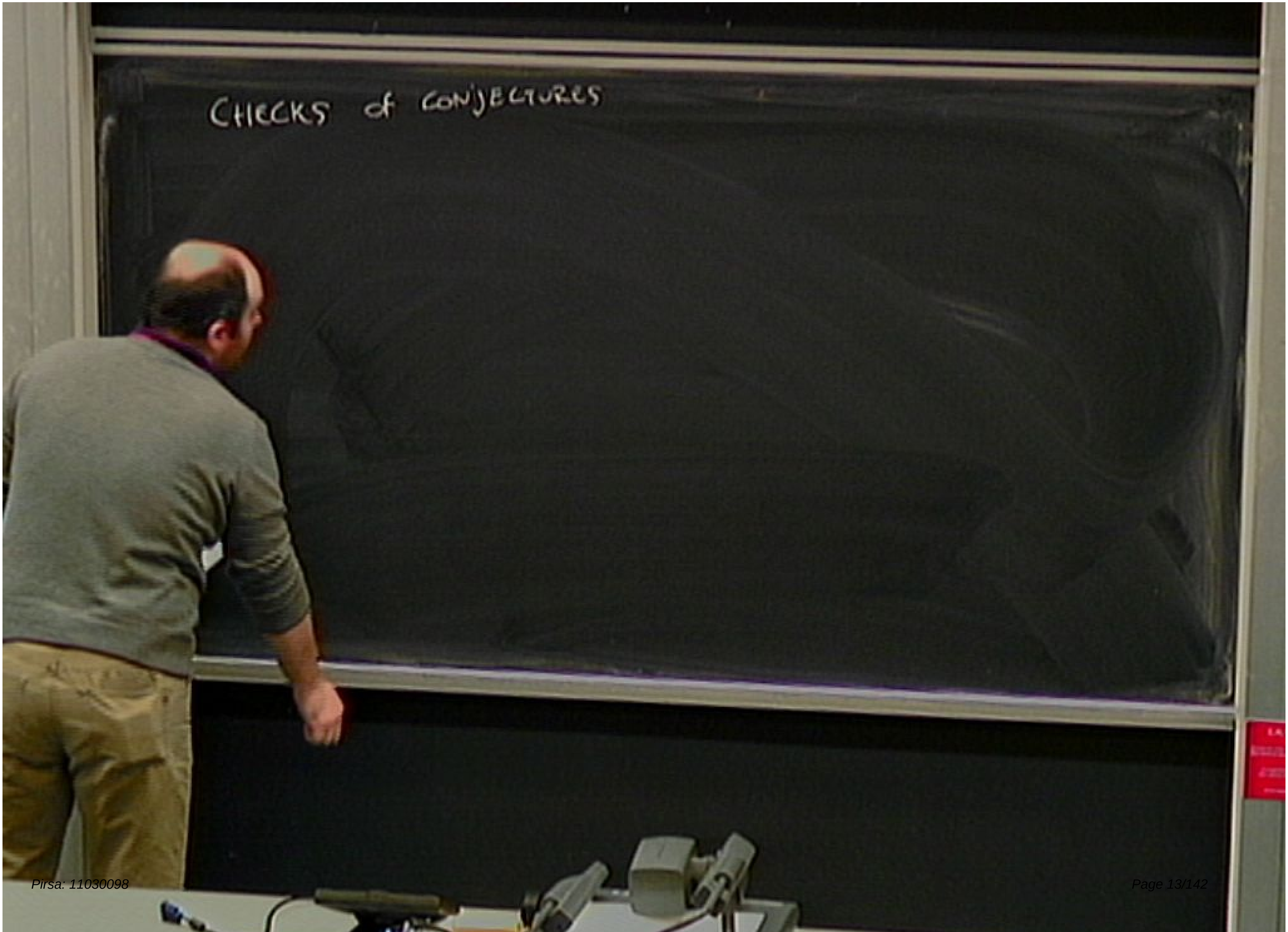

NON-MINIMAL HS THEORIES
S=0,1,2, ... ∞
⟷
COMPLEX VECTOR MODELS
IN U(N) SINGLET SECTOR
S= ∫

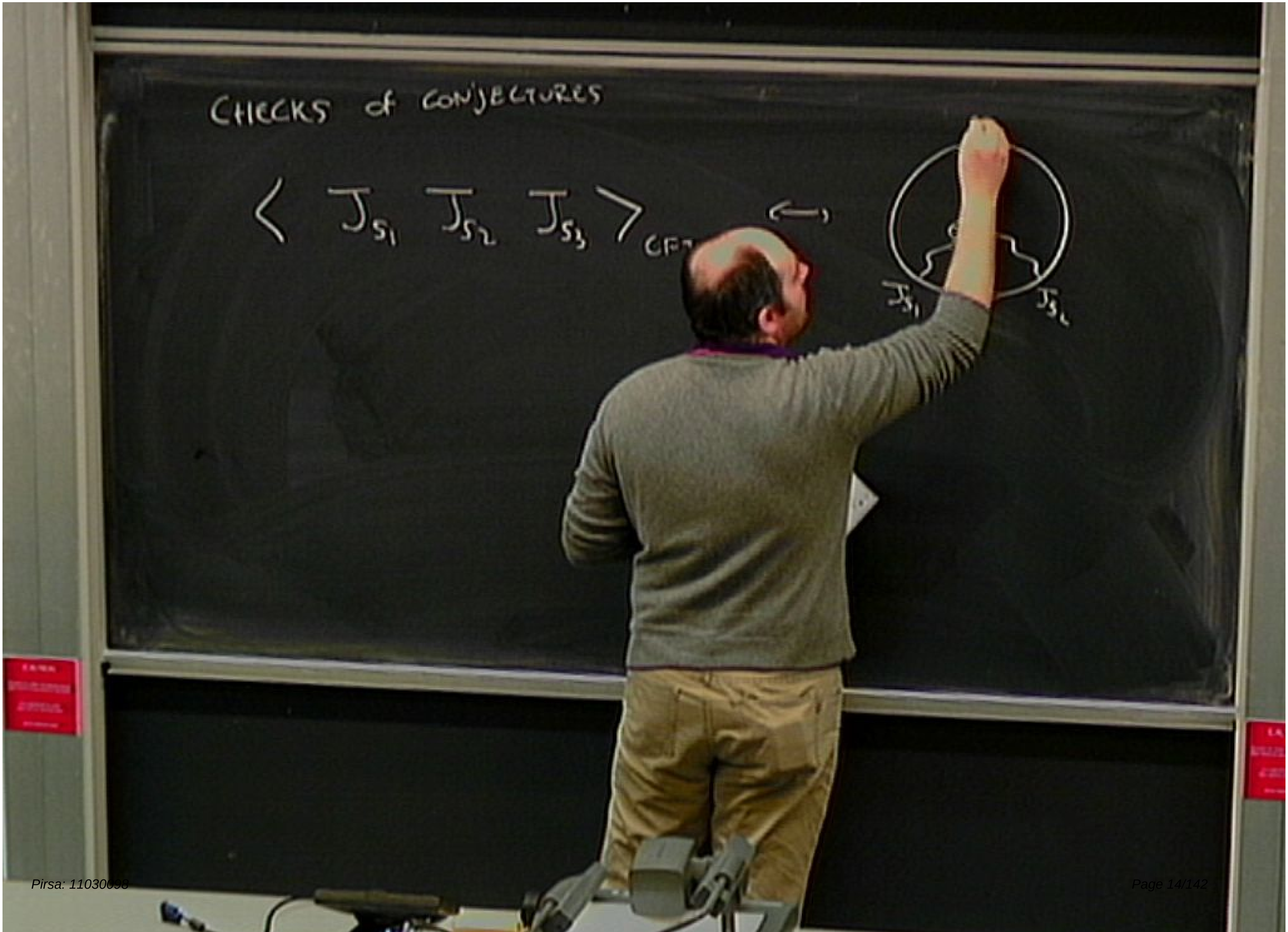
NON-MINIMAL HS THEORIES $\longleftrightarrow$ COMPLEX VECTOR MODELS IN U(N) SINGLET SECTOR

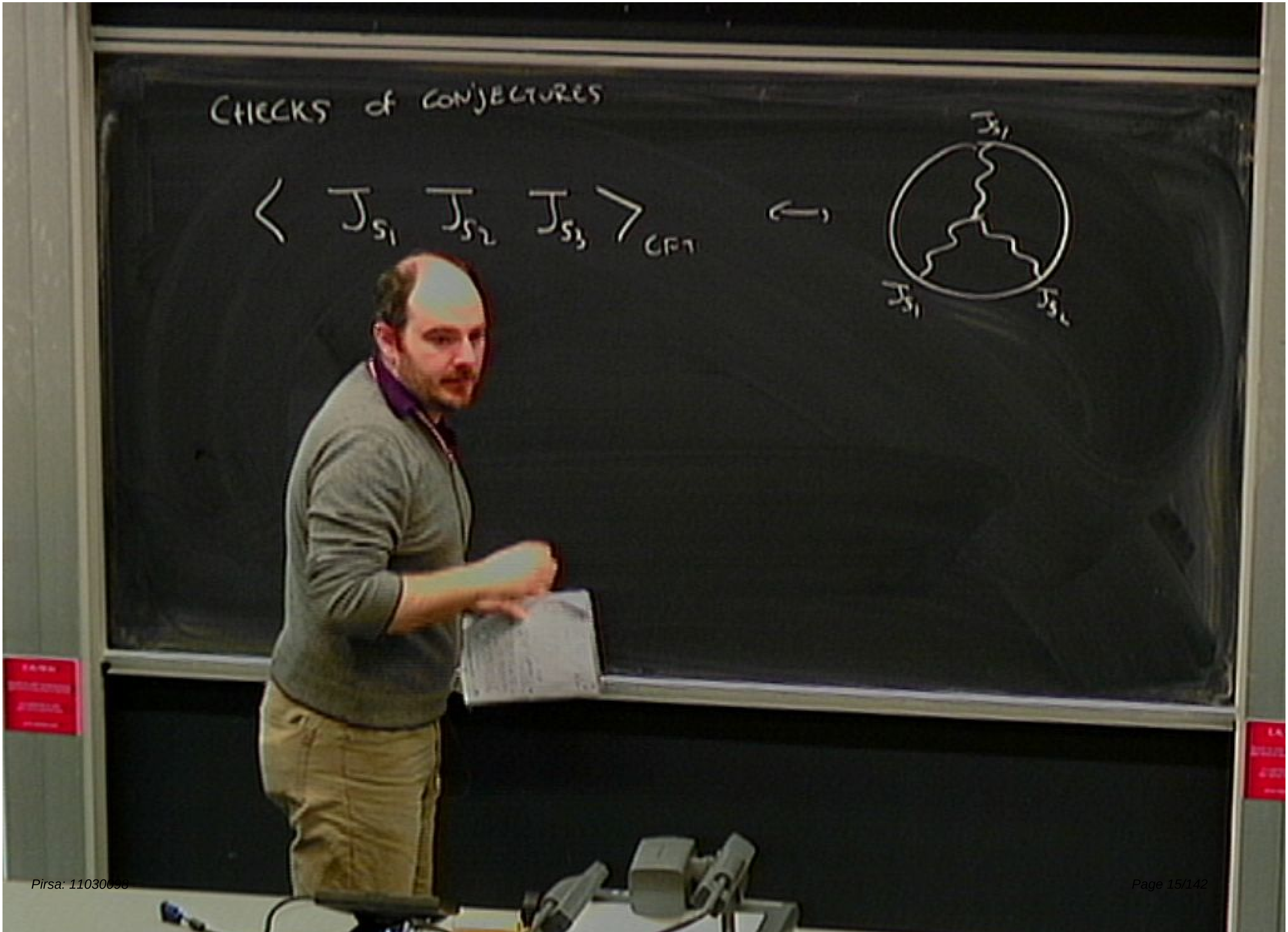
$S = 0, 1, 2, \ldots \infty$

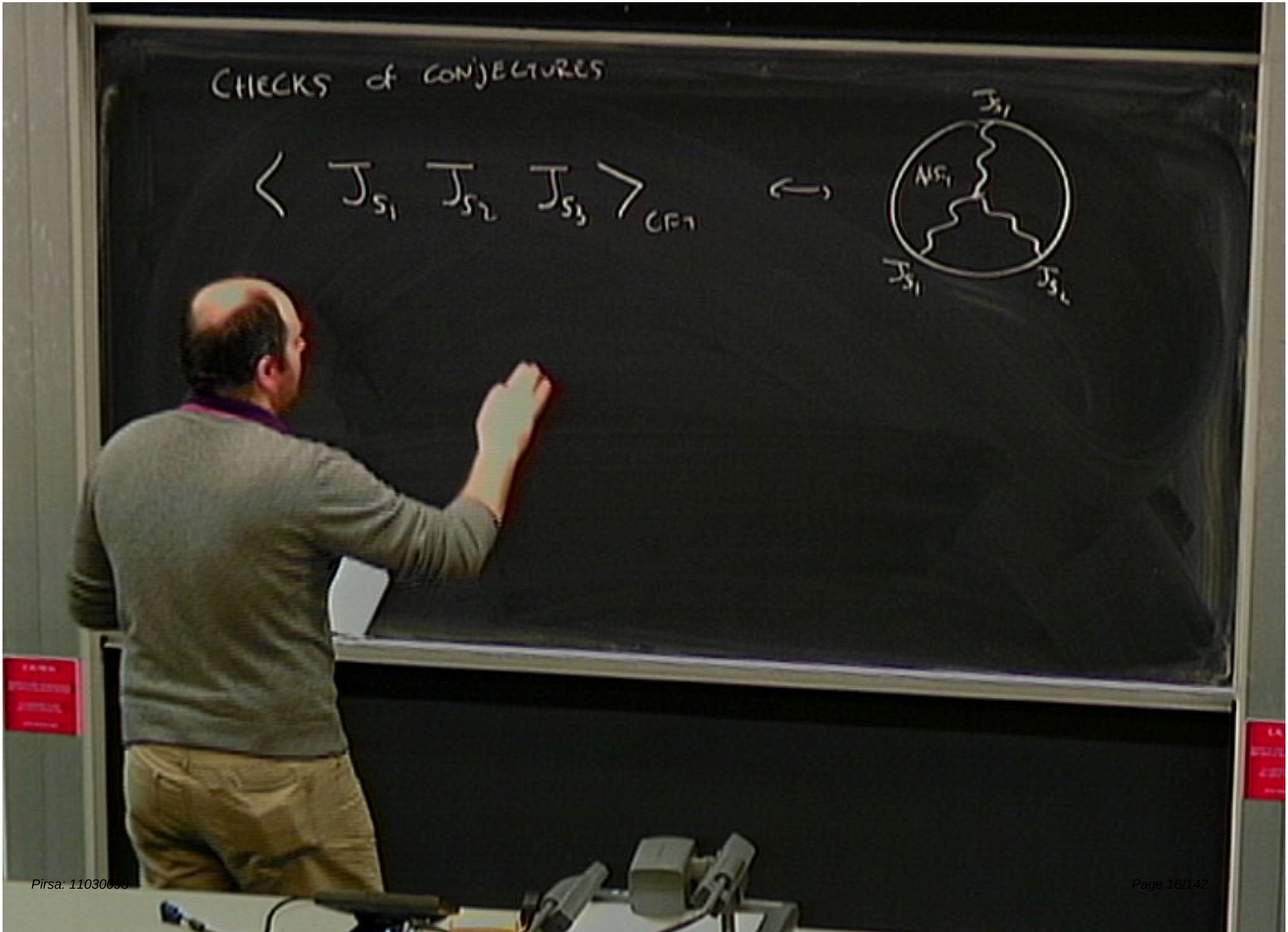
$$S_{free} = \int \partial^\mu \phi_i^* \partial_\mu \phi^i$$

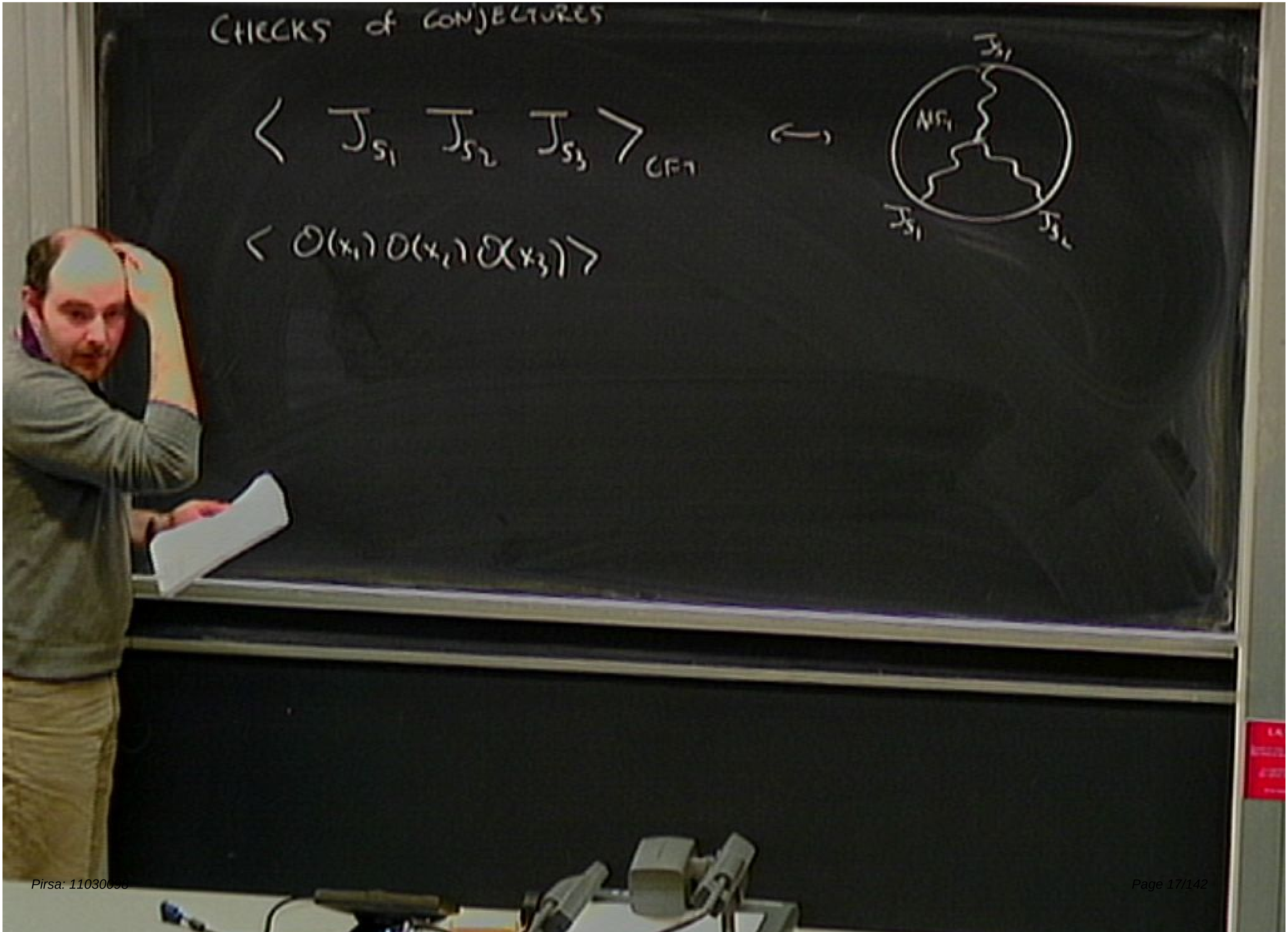
$$J_{(1)} = \phi_i^* (\partial_\mu \phi^i) - (\partial_\mu \phi_i^*) \phi^i$$


CHECKS of CONJECTURES

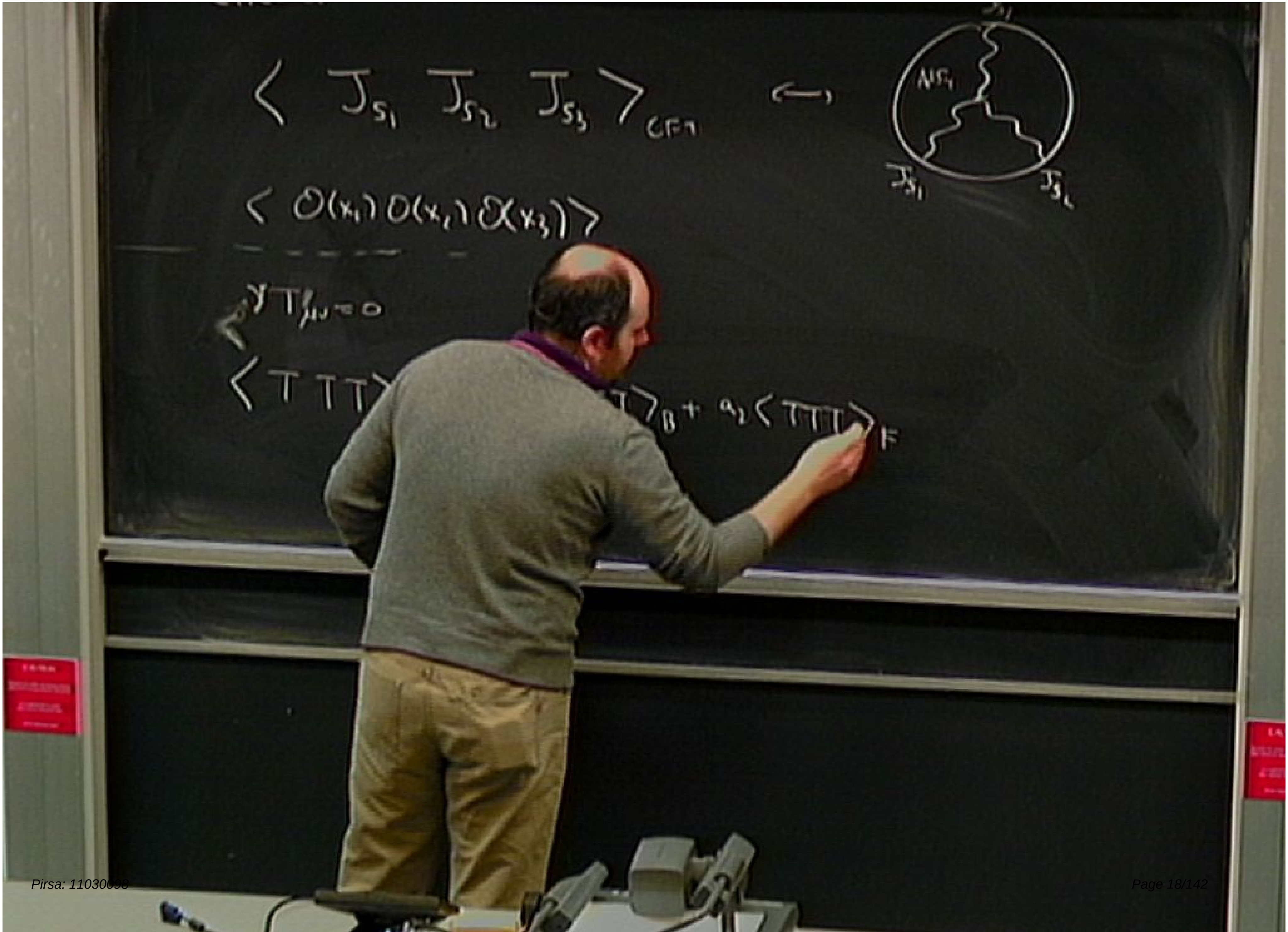

CHECKS of CONJECTURES
$\langle J_{s_1} J_{s_2} J_{s_3} \rangle_{CFT} \longleftrightarrow$
J_{s_1}
J_{s_2}

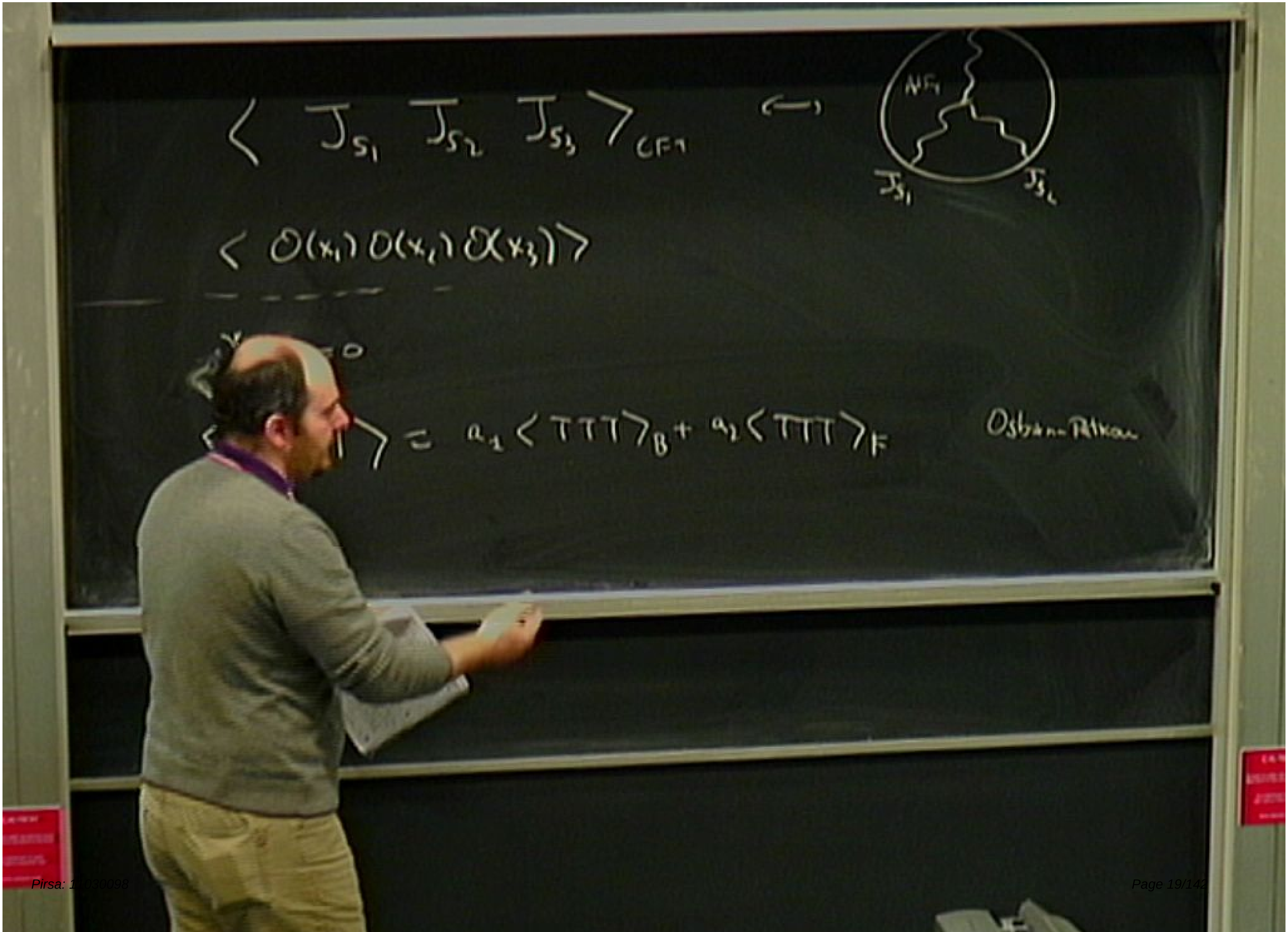

CHECKS of CONJECTURES
$\langle J_{s_1} J_{s_2} J_{s_3} \rangle_{CFT} \longleftrightarrow$
J_{s_1}
J_{s_1}
J_{s_2}

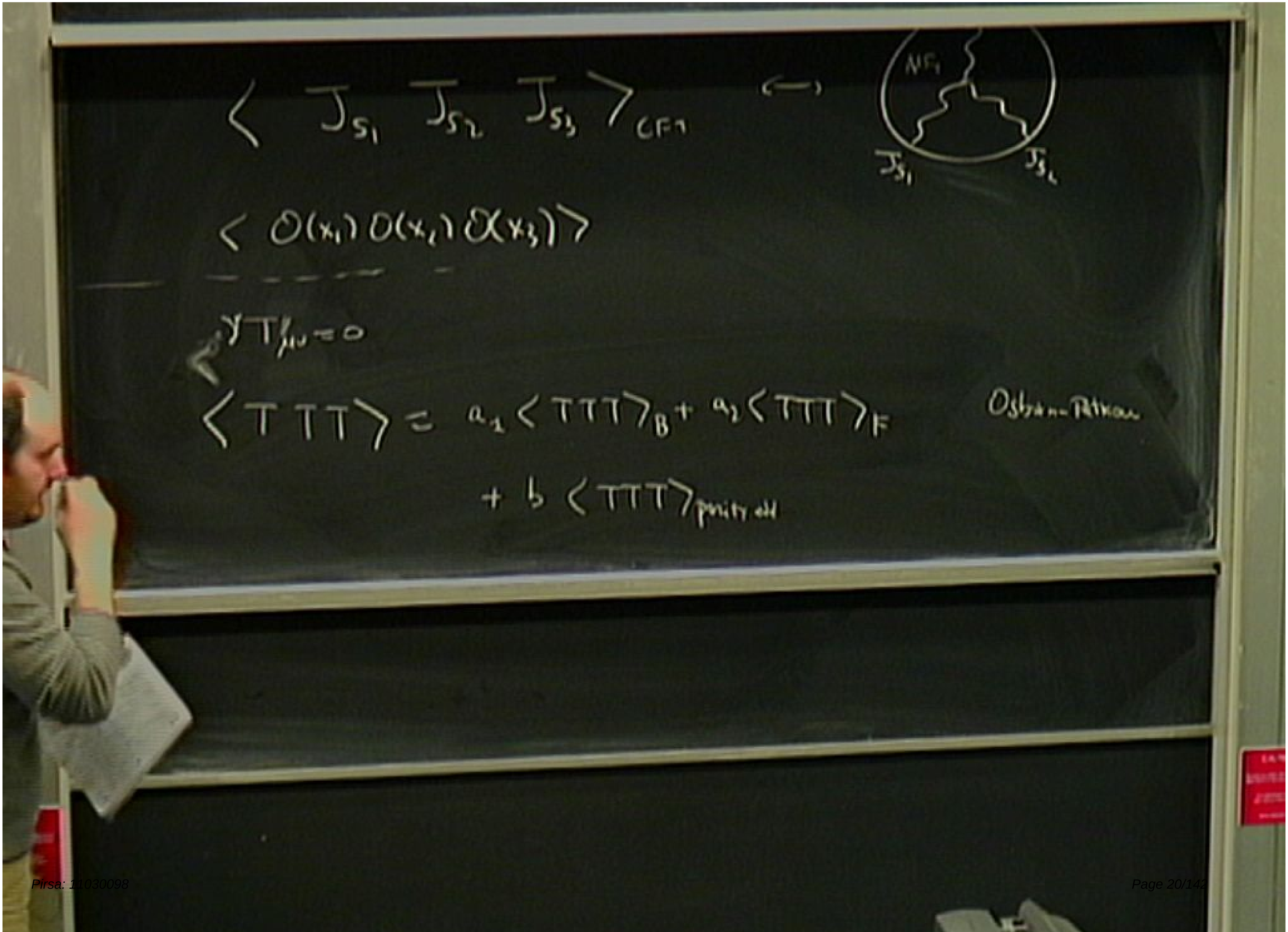

CHECKS of CONJECTURES
$\langle J_{s_1} J_{s_2} J_{s_3} \rangle_{CFT} \longleftrightarrow$
AdS_4
J_{s_1}
J_{s_1}
J_{s_2}

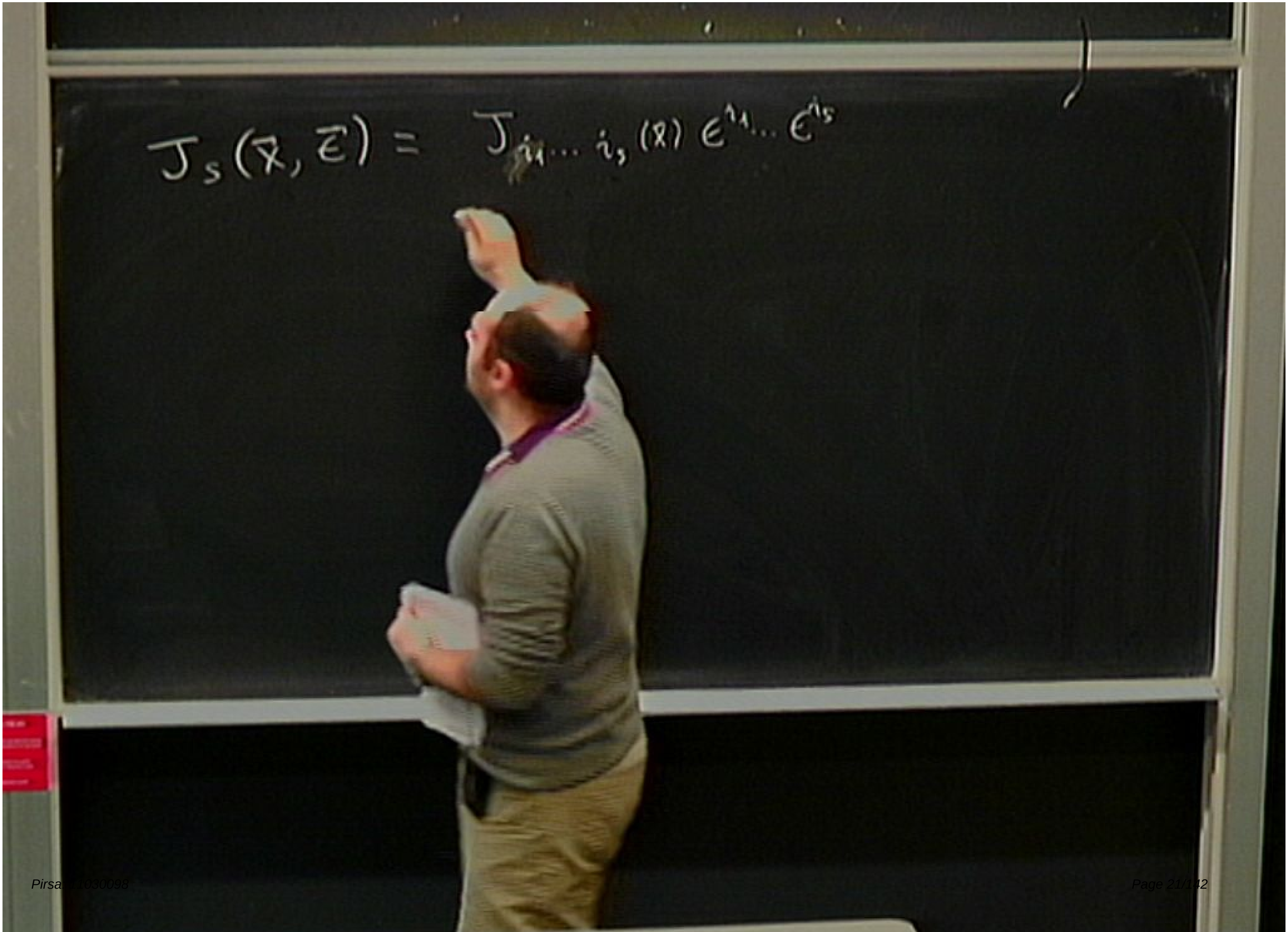


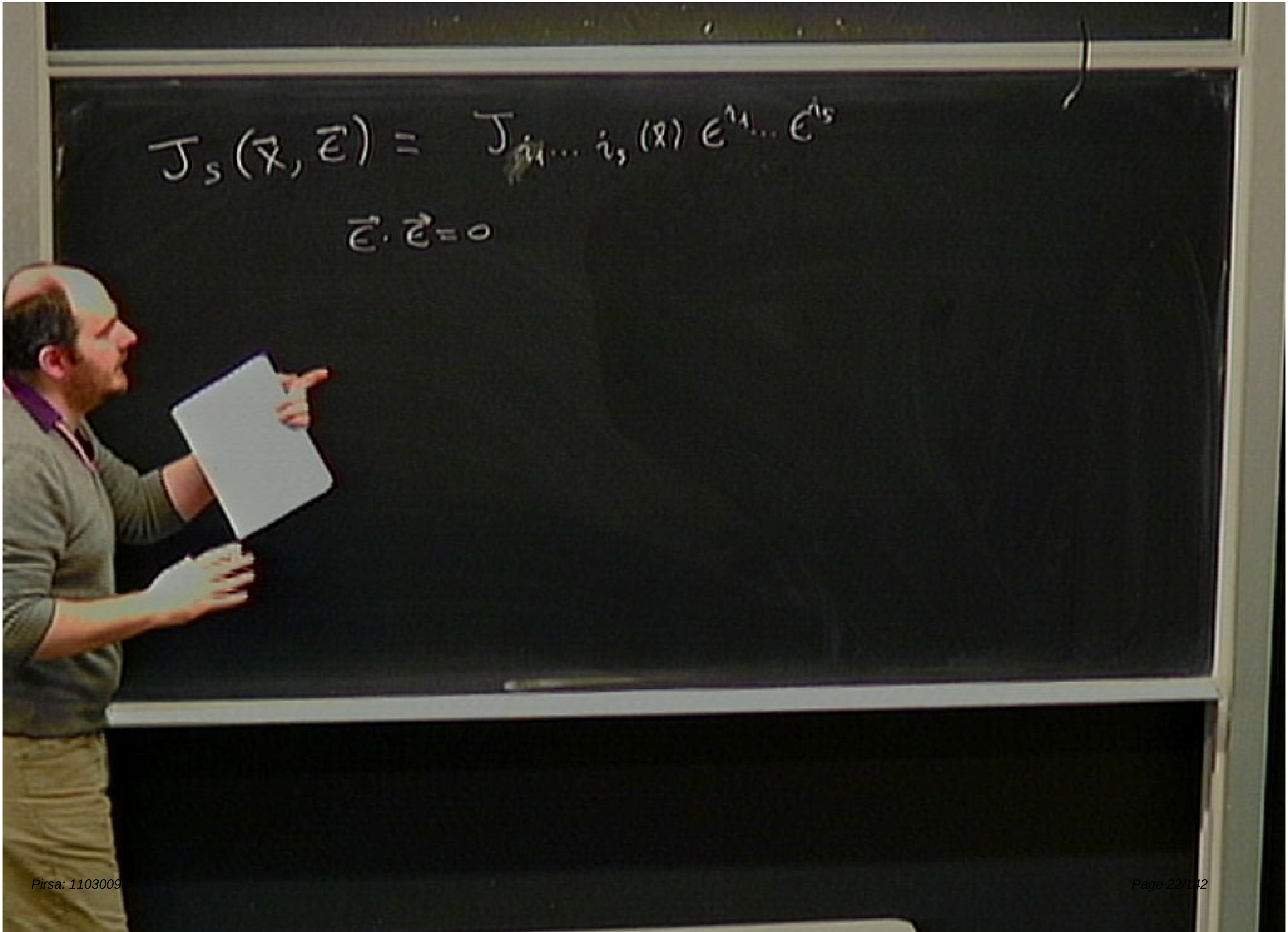
CHECKS of CONJECTURES
$\langle J_{s_1} J_{s_2} J_{s_3} \rangle_{CFT} \longleftrightarrow$
$\langle O(x_1) O(x_2) O(x_3) \rangle$
AdS4

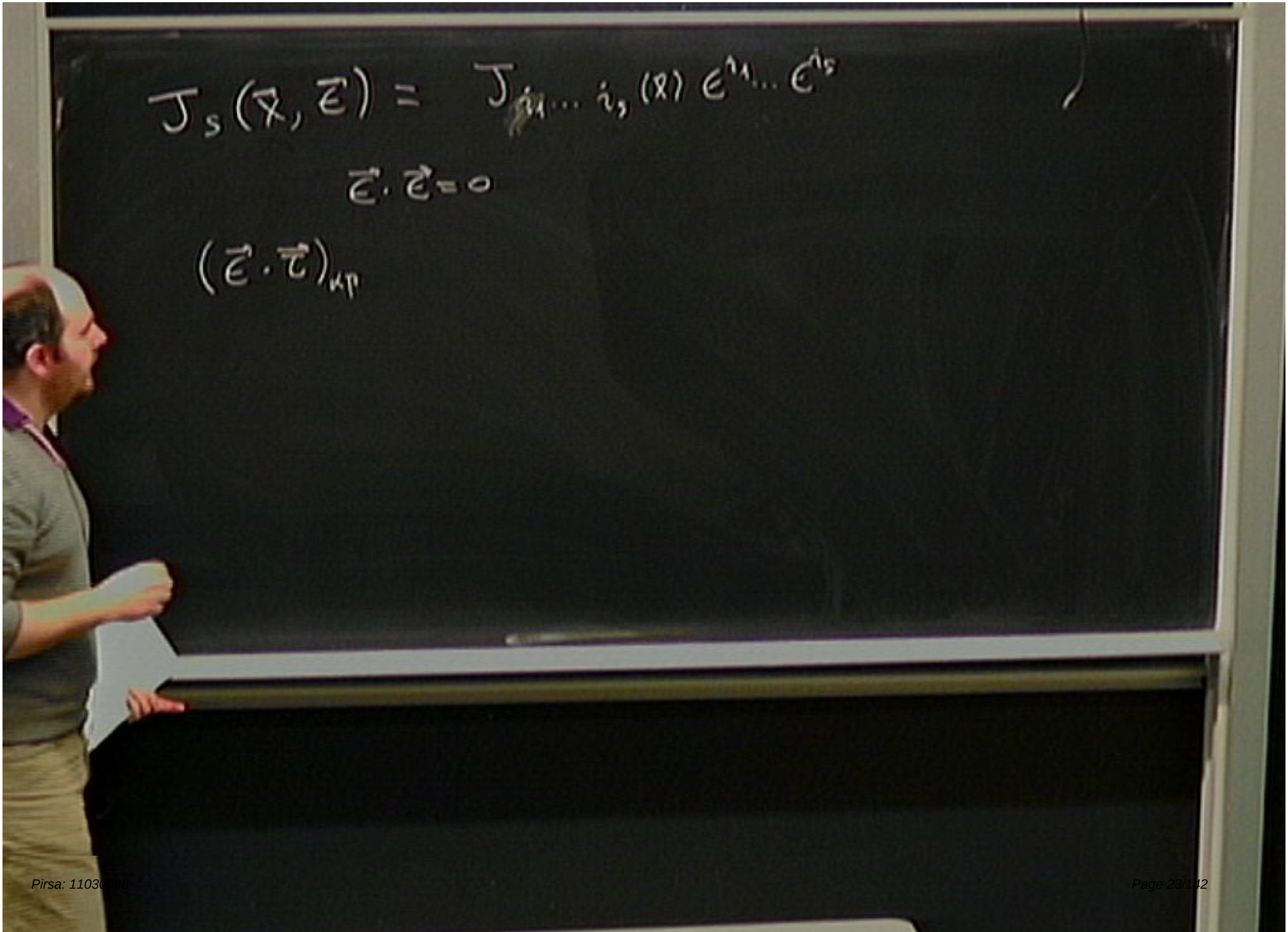

⟨ J_s1 J_s2 J_s3 ⟩_CFT ⟵
AdS4
J_s3
J_s1
J_s2
⟨ O(x1) O(x2) O(x3) ⟩
T^μ_μ = 0
⟨ T T T ⟩
T ⟩_B + a_2 ⟨ T T T ⟩_F

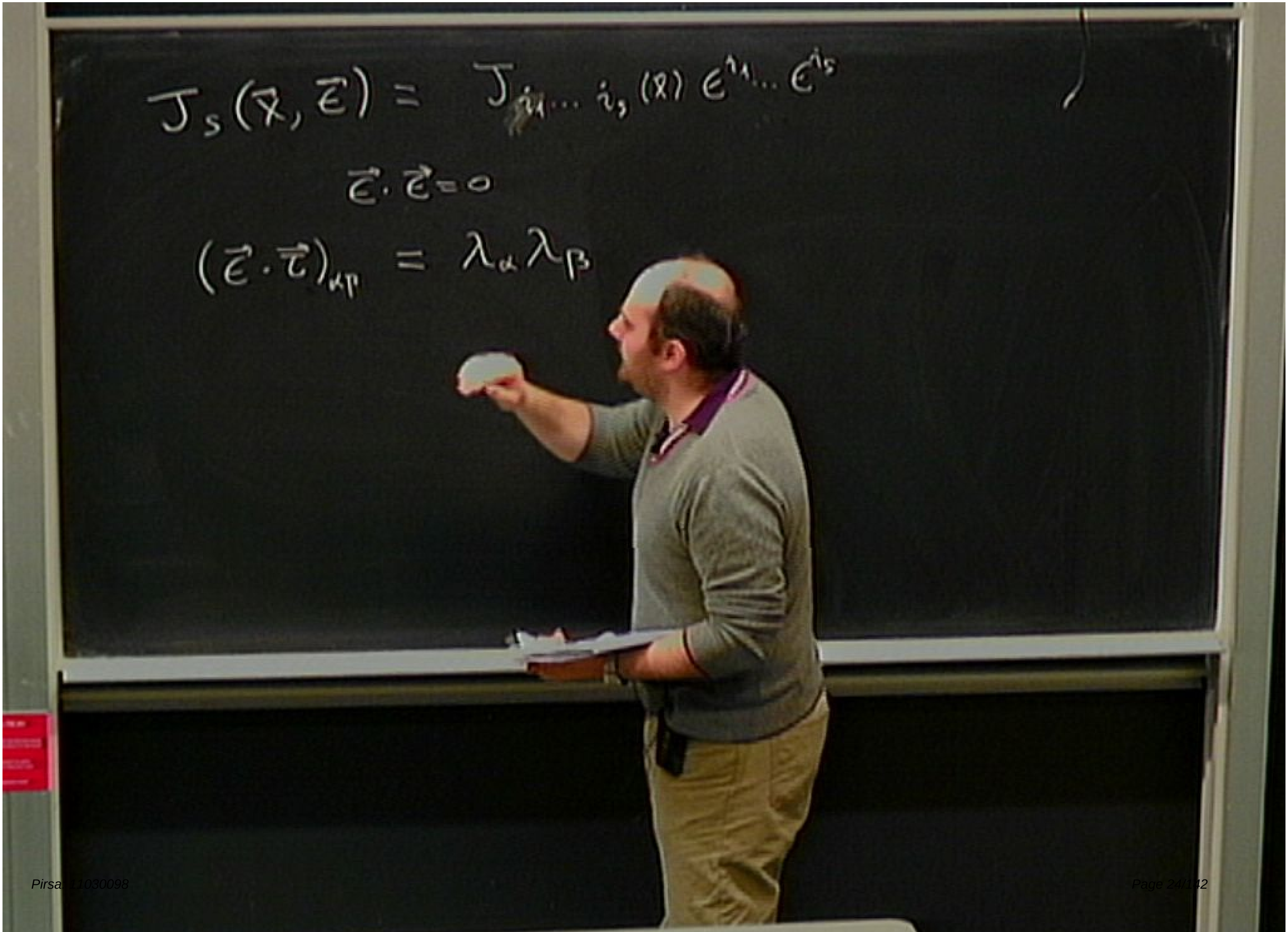

⟨ J_s1 J_s2 J_s3 ⟩_CFT ⟷
J_s1
J_s2
⟨ O(x1) O(x2) O(x3) ⟩
= a_1 ⟨ T T T ⟩_B + a_2 ⟨ T T T ⟩_F
Osborn-Petkou

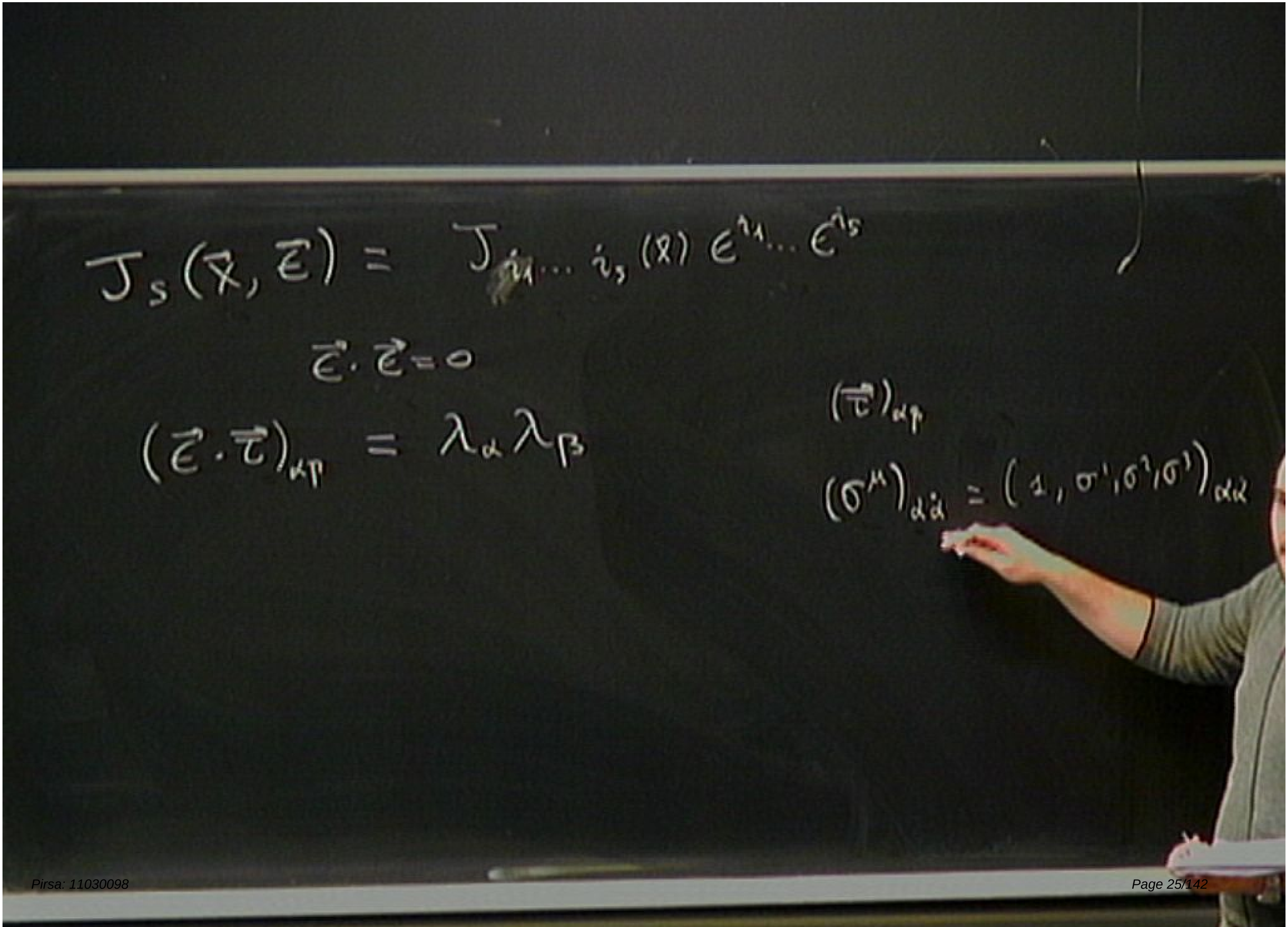

$\langle J_{s_1} J_{s_2} J_{s_3} \rangle_{CFT} \longleftrightarrow$
NF_1
J_{s_1} J_{s_2}
$\langle O(x_1) O(x_2) O(x_3) \rangle$
$T_{\mu\nu} = 0$
$\langle TTT \rangle = a_1 \langle TTT \rangle_B + a_2 \langle TTT \rangle_F$
Osborn–Petkou
$+ b \langle TTT \rangle_{\text{parity odd}}$


$J_s(\vec{x}, \vec{\epsilon}) = J_{i_1 \ldots i_s}(x)\, \epsilon^{i_1} \ldots \epsilon^{i_s}$


$J_s(\vec{x}, \vec{\epsilon}) = J_{i_1 \dots i_s}(x)\, \epsilon^{i_1} \dots \epsilon^{i_s}$
$\vec{\epsilon} \cdot \vec{\epsilon} = 0$


$J_s(\vec{x},\vec{\epsilon}) = J_{i_1\ldots i_s}(\vec{x})\,\epsilon^{i_1}\ldots\epsilon^{i_s}$
$\vec{\epsilon}\cdot\vec{\epsilon}=0$
$(\vec{\epsilon}\cdot\vec{\tau})_{\alpha\beta}$


$J_s(\vec{x}, \vec{\epsilon}) = J_{i_1 \dots i_s}(\vec{x})\, \epsilon^{i_1} \dots \epsilon^{i_s}$
$\vec{\epsilon} \cdot \vec{\epsilon} = 0$
$(\vec{\epsilon} \cdot \vec{\tau})_{\alpha\beta} = \lambda_\alpha \lambda_\beta$


$J_s(\vec{x}, \vec{\epsilon}) = J_{i_1 \ldots i_s}(\vec{x})\, \epsilon^{i_1} \ldots \epsilon^{i_s}$
$\vec{\epsilon} \cdot \vec{\epsilon} = 0$
$(\vec{\epsilon} \cdot \vec{\tau})_{\alpha\beta} = \lambda_\alpha \lambda_\beta$
$(\vec{\tau})_{\alpha\beta}$
$(\sigma^\mu)_{\alpha\dot{\alpha}} = (1, \sigma^1, \sigma^2, \sigma^3)_{\alpha\dot{\alpha}}$

$$J_s(\vec{x}, \vec{\epsilon}) = J_{i_1 \ldots i_s}(\vec{x})\, \epsilon^{i_1} \ldots \epsilon^{i_s}$$

$$\vec{\epsilon} \cdot \vec{\epsilon} = 0$$

$$(\vec{\epsilon} \cdot \vec{\tau})_{\alpha\beta} = \lambda_\alpha \lambda_\beta$$

$$(\vec{\tau})_{\alpha\beta}$$

$$\ldots^{\mu})_{\alpha\dot{\alpha}} = (\mathbb{1}, \sigma^1, \sigma^2, \sigma^3)_{\alpha\dot{\alpha}}$$

$$\ldots_\beta = (\bar{\sigma}^0 \sigma^i)_{\alpha\beta}$$

$$J_s(\vec{x},\vec{\epsilon}) = J_{i_1 \dots i_s}(\vec{x})\, \epsilon^{i_1} \dots \epsilon^{i_s}$$

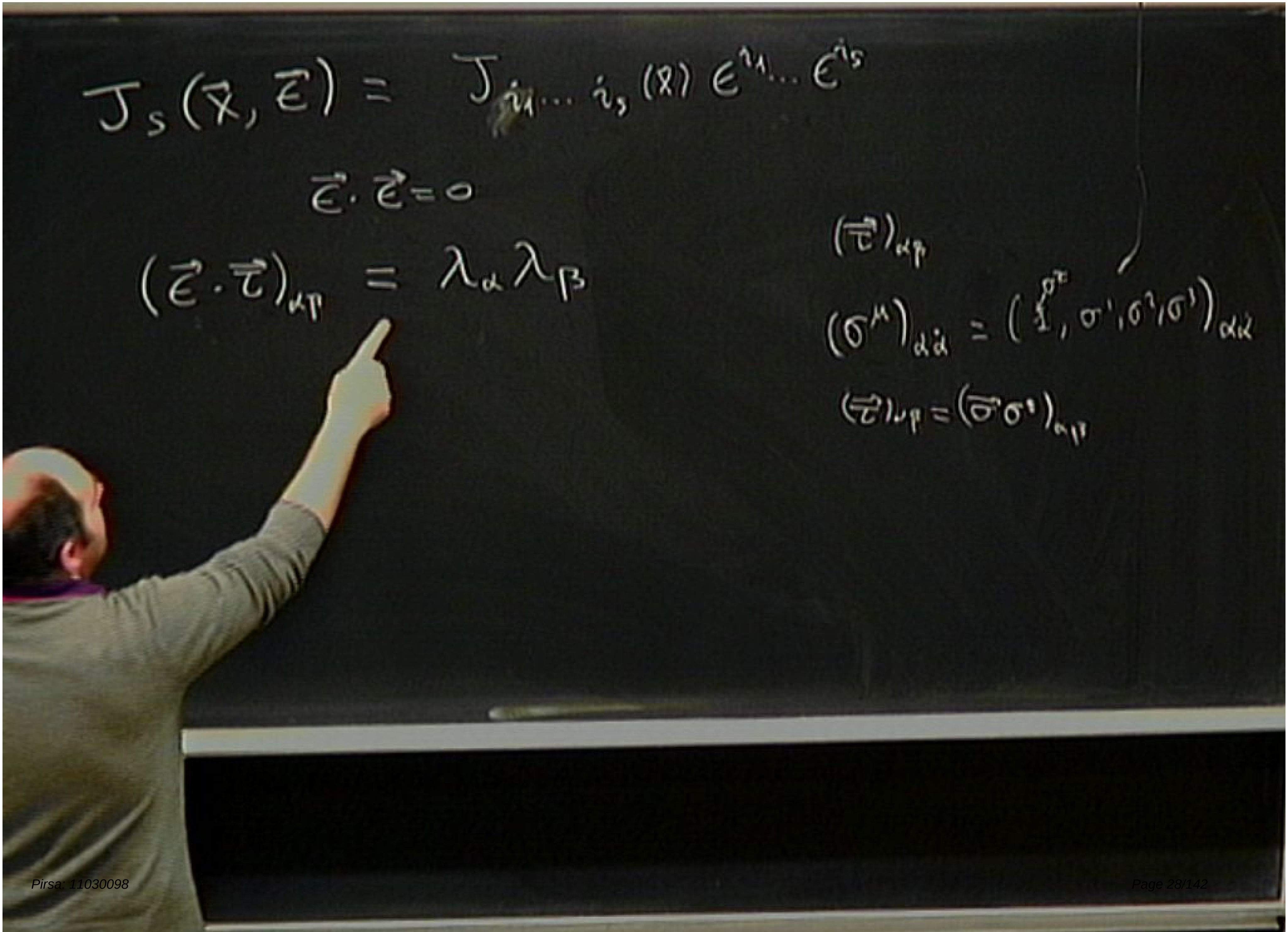
$$\vec{\epsilon} \cdot \vec{\epsilon} = 0$$

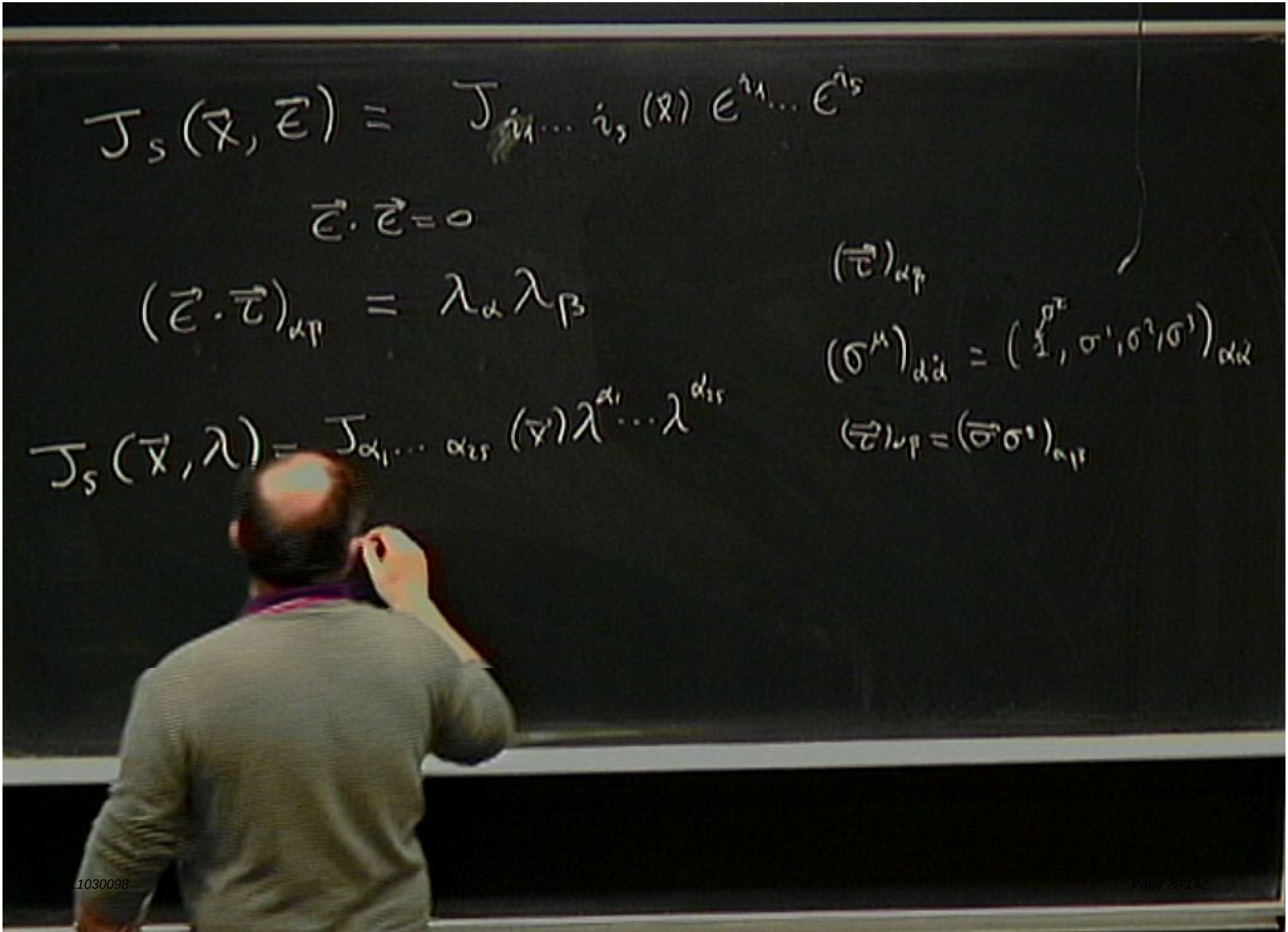
$$(\vec{\epsilon} \cdot \vec{\tau})_{\alpha\beta} = \lambda_\alpha \lambda_\beta$$

$$(\vec{\tau})_{\alpha\beta}$$

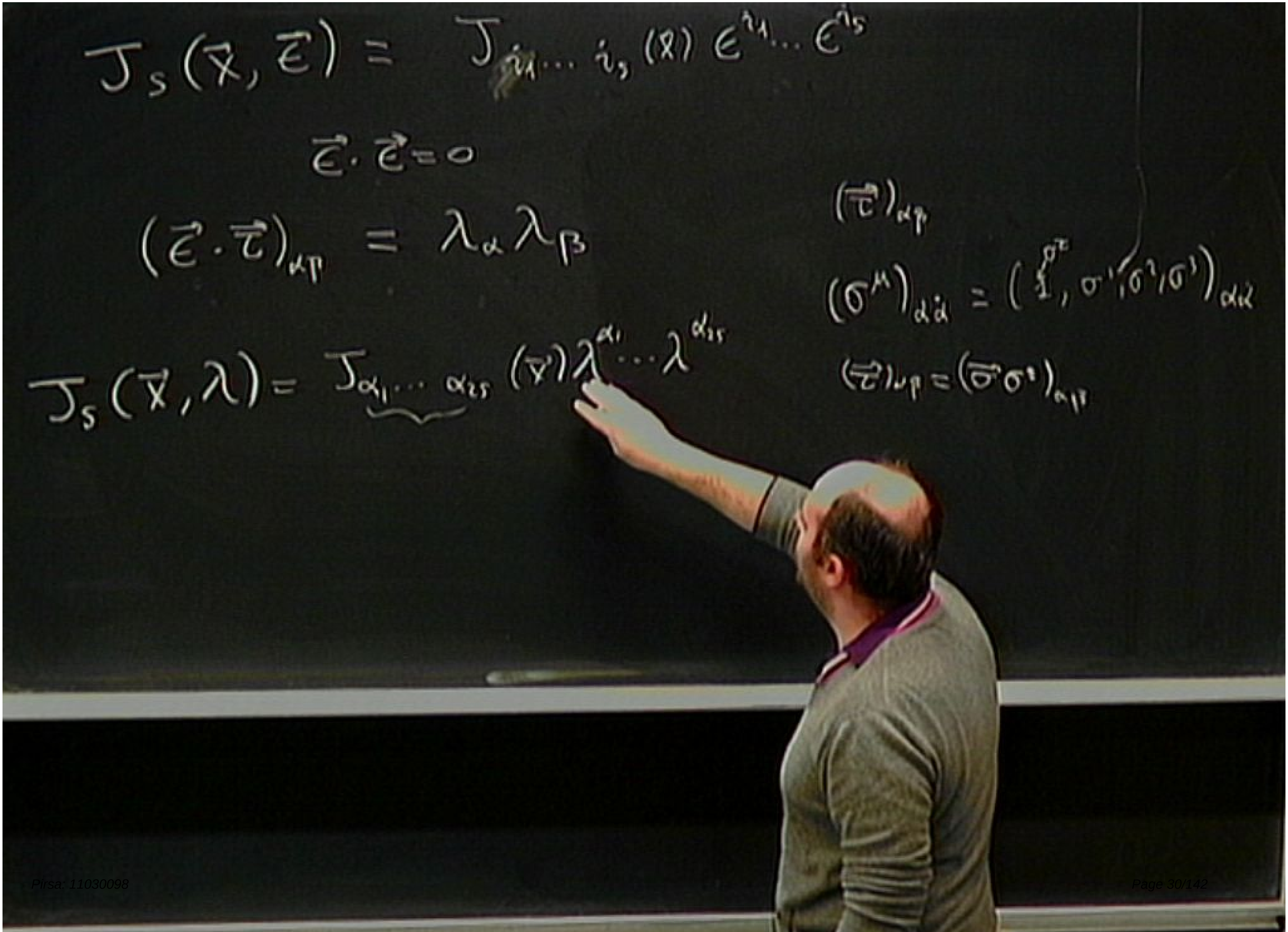
$$(\sigma^\mu)_{\alpha\dot{\alpha}} = (\overset{\sigma^0}{1}, \sigma^1, \sigma^2, \sigma^3)_{\alpha\dot{\alpha}}$$

$$(\vec{\tau})_{\alpha\beta} = (\vec{\sigma}\sigma^0)_{\alpha\beta}$$


$J_s(\vec{x},\vec{\epsilon}) = J_{i_1\dots i_s}(\vec{x})\,\epsilon^{i_1}\dots\epsilon^{i_s}$
$\vec{\epsilon}\cdot\vec{\epsilon}=0$
$(\vec{\epsilon}\cdot\vec{\tau})_{\alpha\beta} = \lambda_\alpha\lambda_\beta$
$(\vec{\tau})_{\alpha\beta}$
$(\sigma^\mu)_{\alpha\dot\alpha} = (\mathbb{1}, \sigma^1,\sigma^2,\sigma^3)_{\alpha\dot\alpha}$
σ^0
$(\vec{\tau})_{\alpha\beta} = (\vec{\sigma}\sigma^0)_{\alpha\beta}$

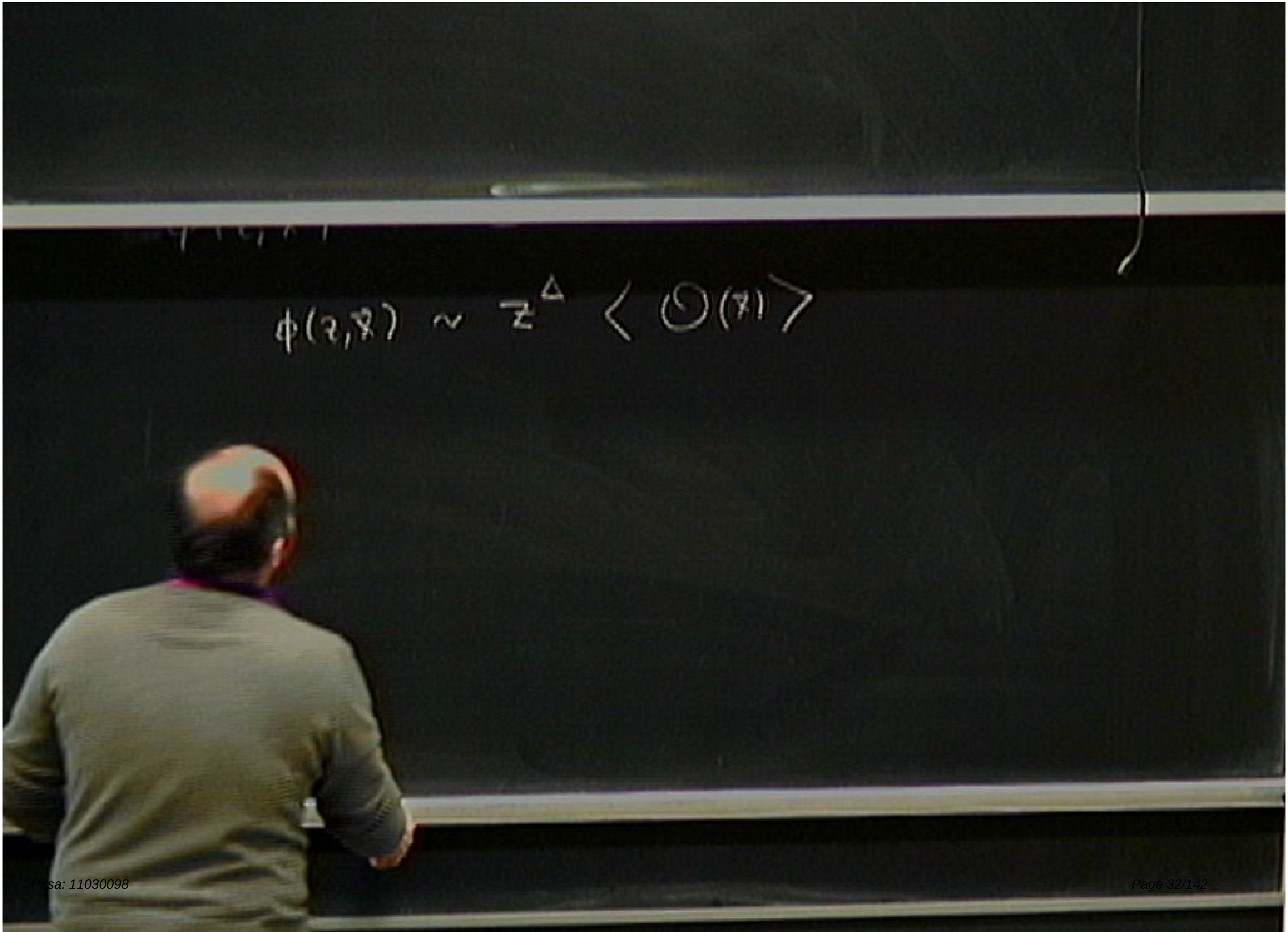


$J_s(\vec{x}, \vec{\epsilon}) = J_{i_1 \dots i_s}(\vec{x})\, \epsilon^{i_1} \dots \epsilon^{i_s}$
$\vec{\epsilon} \cdot \vec{\epsilon} = 0$
$(\vec{\epsilon} \cdot \vec{\tau})_{\alpha\beta} = \lambda_\alpha \lambda_\beta$
$J_s(\vec{x}, \lambda) = J_{\alpha_1 \dots \alpha_{2s}}(\vec{x})\, \lambda^{\alpha_1} \dots \lambda^{\alpha_{2s}}$
$(\vec{\tau})_{\alpha\beta}$
$(\sigma^\mu)_{\alpha\dot{\alpha}} = (1, \sigma^1, \sigma^2, \sigma^3)_{\alpha\dot{\alpha}}$
$(\vec{\tau})_{\alpha\beta} = (\vec{\sigma}\sigma^0)_{\alpha\beta}$



$J_s(\vec{x},\vec{\epsilon}) = J_{i_1\ldots i_s}(\vec{x})\,\epsilon^{i_1}\ldots\epsilon^{i_s}$
$\vec{\epsilon}\cdot\vec{\epsilon}=0$
$(\vec{\epsilon}\cdot\vec{\tau})_{\alpha\beta} = \lambda_\alpha\lambda_\beta$
$J_s(\vec{x},\lambda) = J_{\underbrace{\alpha_1\ldots\alpha_{2s}}}(\vec{x})\,\lambda^{\alpha_1}\ldots\lambda^{\alpha_{2s}}$
$(\vec{\tau})_{\alpha\beta}$
$(\sigma^\mu)_{\alpha\dot\alpha} = (\overset{\sigma^0}{\mathbb{1}}, \sigma^1, \sigma^2, \sigma^3)_{\alpha\dot\alpha}$
$(\vec{\tau})_{\alpha\beta} = (\vec{\sigma}\sigma^2)_{\alpha\beta}$

$$\phi(z, \vec{x}) \longleftrightarrow \mathcal{O}(\vec{x})$$

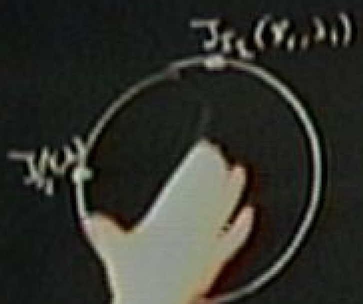

$\phi(z,x) \sim z^{\Delta} \langle O(x) \rangle$

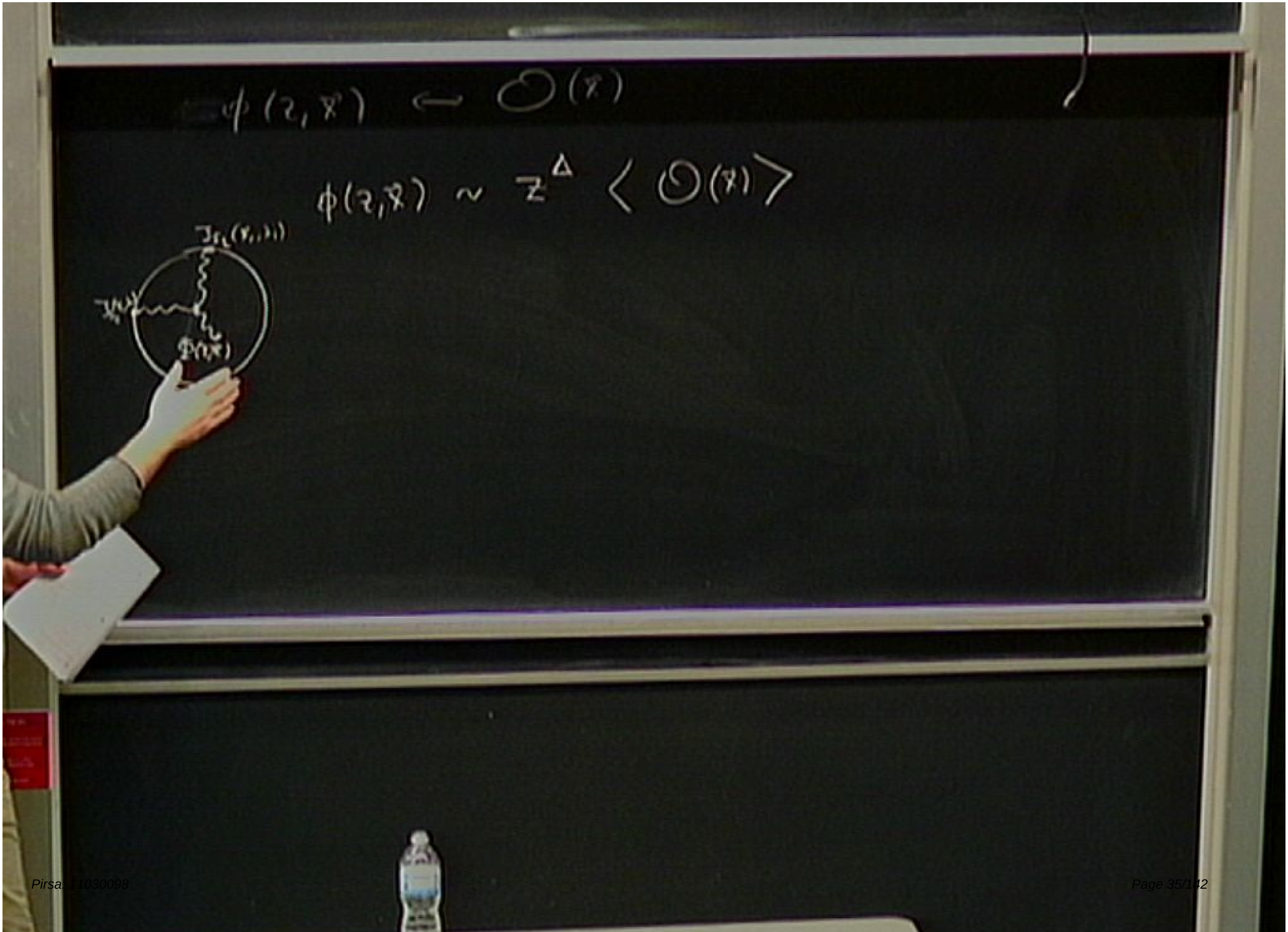
$$\phi(z, \vec{x}) \longleftrightarrow \mathcal{O}(\vec{x})$$

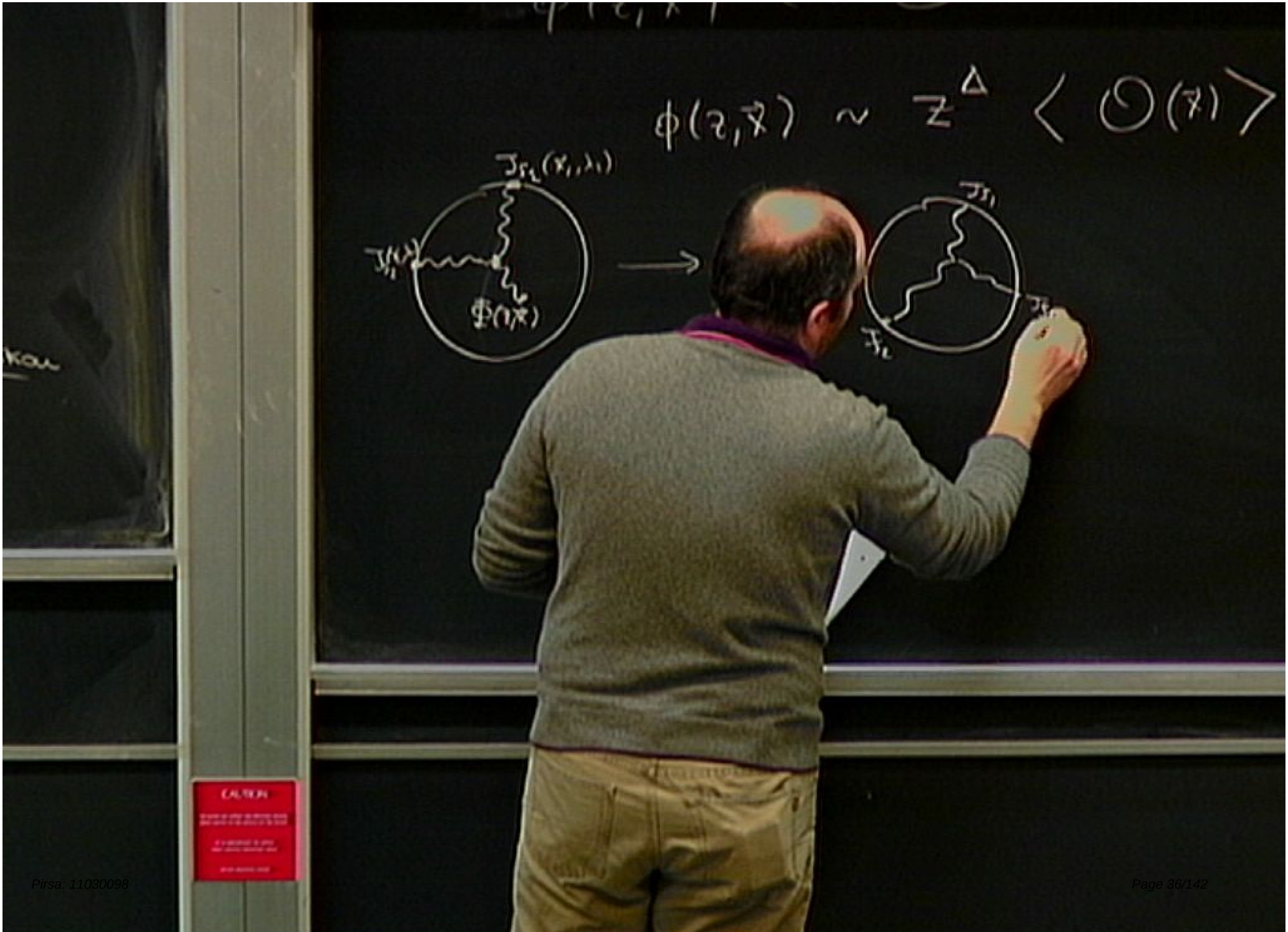
$$\phi(z, \vec{x}) \sim z^{\Delta} \langle \mathcal{O}(\vec{x}) \rangle$$

$$\phi(z, \vec{x}) \longleftrightarrow \mathcal{O}(\vec{x})$$

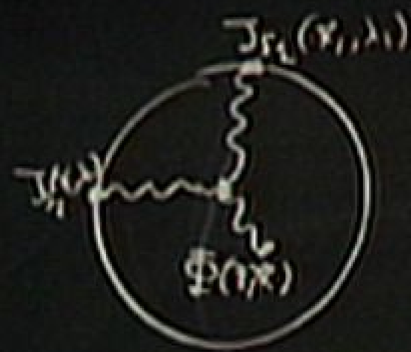
$$\phi(z, \vec{x}) \sim z^{\Delta} \langle \mathcal{O}(\vec{x}) \rangle$$




$\phi(z, \vec{x}) \leftrightarrow \mathcal{O}(\vec{x})$
$\phi(z, \vec{x}) \sim z^{\Delta} \langle \mathcal{O}(\vec{x}) \rangle$

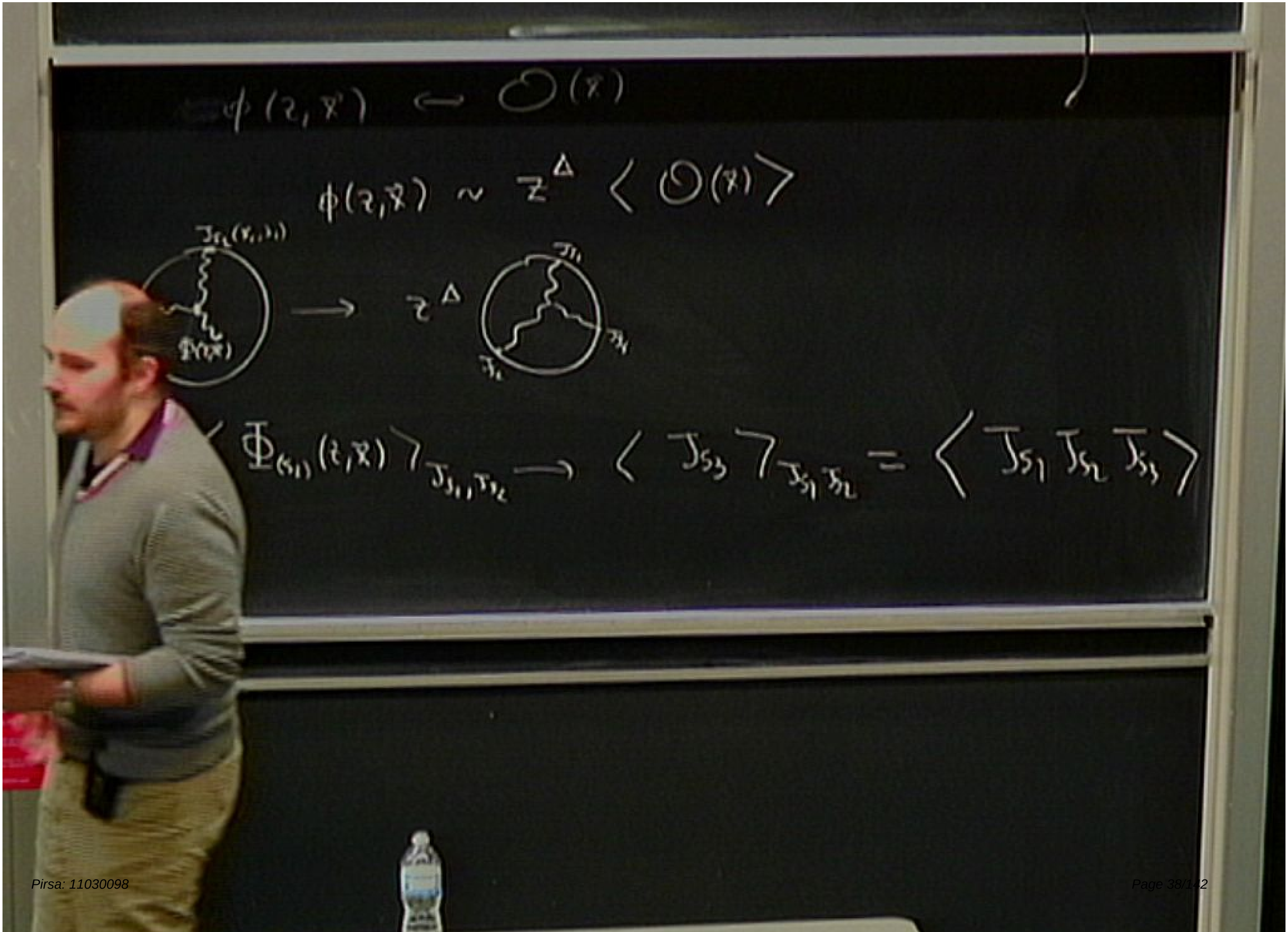

$\phi(z,\vec{x}) \sim z^{\Delta} \langle \mathcal{O}(\vec{x}) \rangle$
$J_{s_1}(x_1,\lambda_1)$
CAUTION

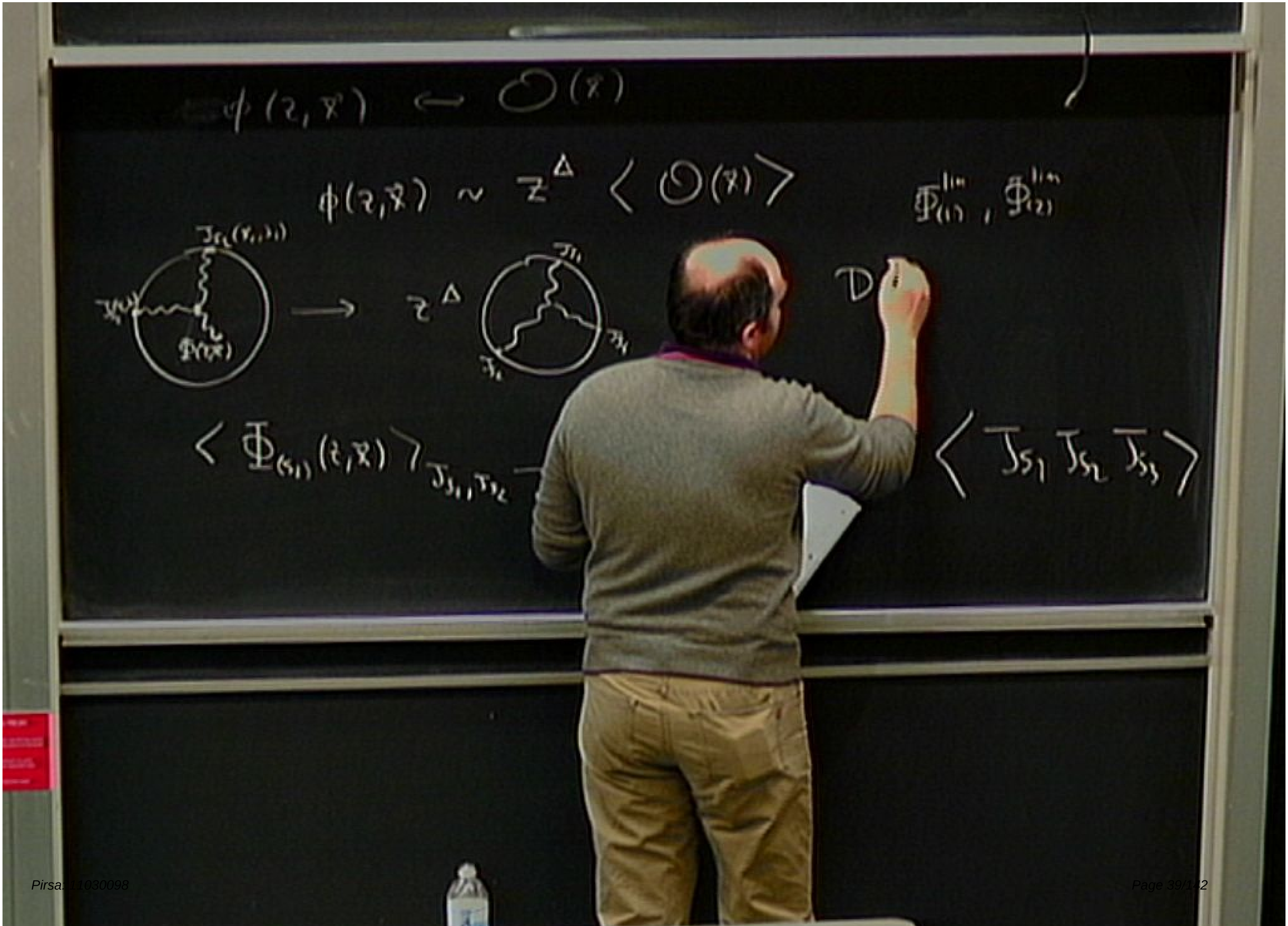
$$\phi(z,\vec{x}) \sim z^{\Delta} \langle \mathcal{O}(\vec{x}) \rangle$$

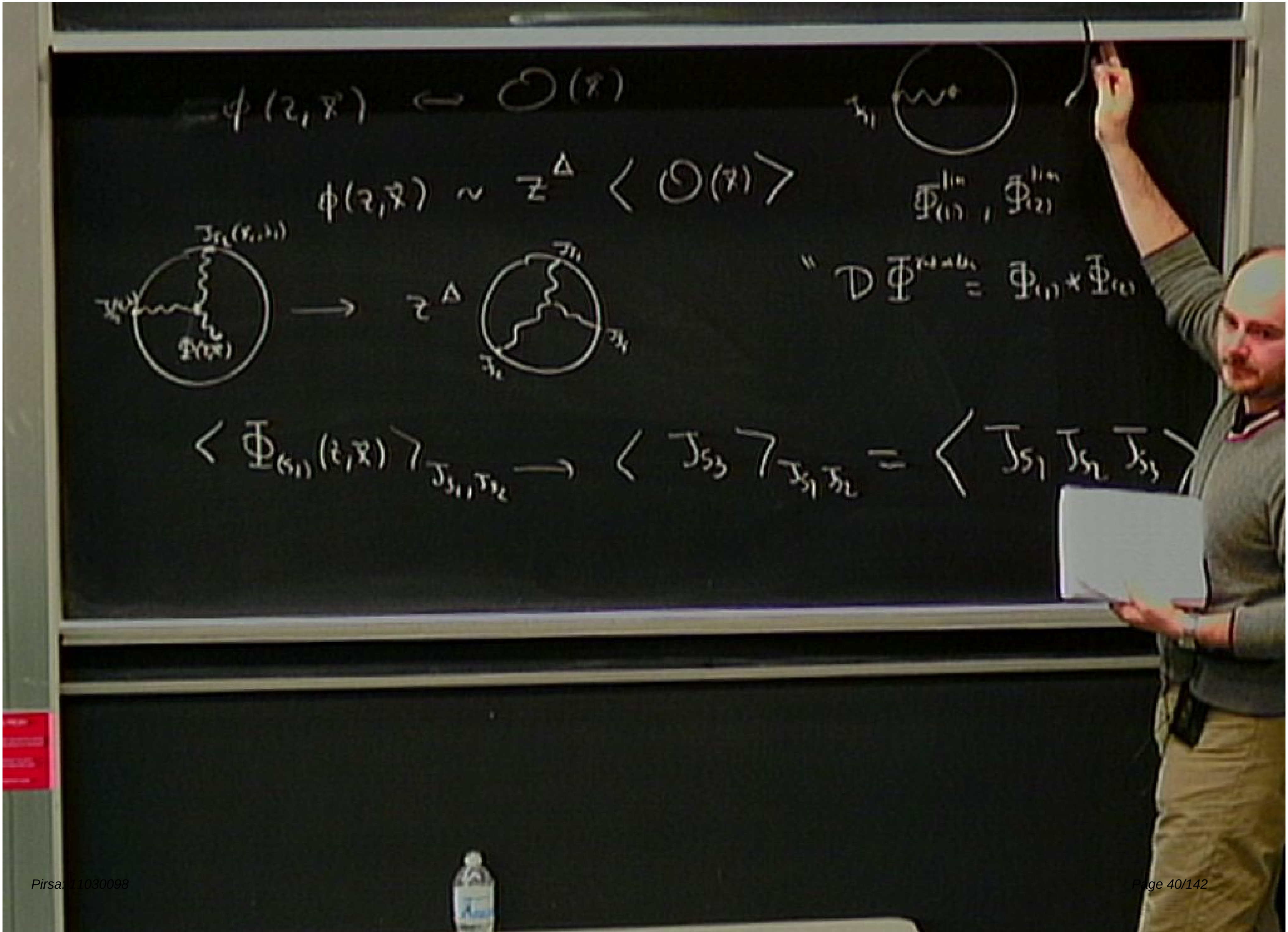


$\longrightarrow \quad z^{\Delta}$

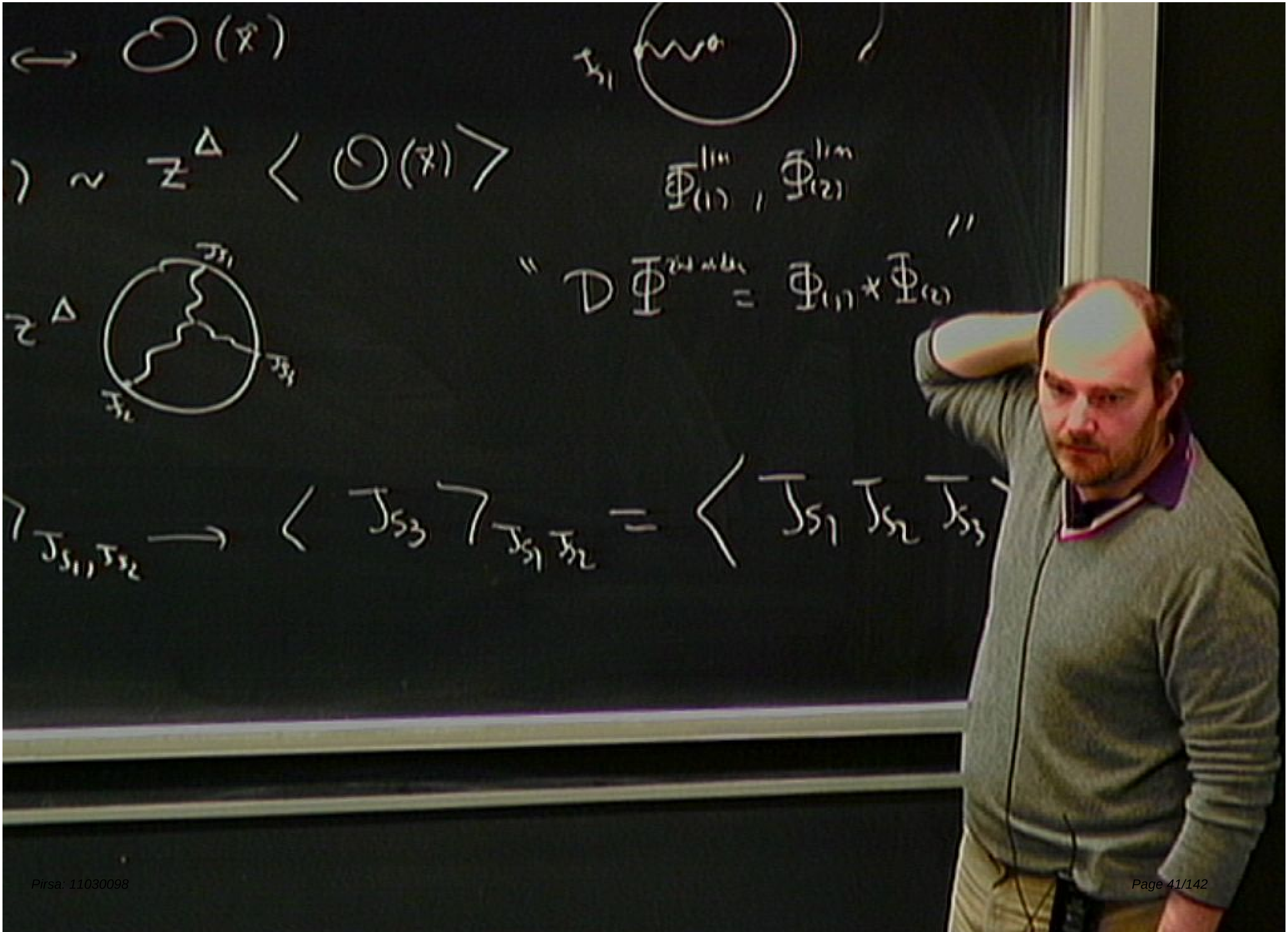
$$\langle \Phi_{(s_1)}(z,\vec{x}) \rangle_{J_{s_1}, J_{s_2}} \longrightarrow \langle J_{s_3} \rangle_{J_{s}}$$


$\phi(z,\vec{x}) \leftrightarrow \mathcal{O}(\vec{x})$
$\phi(z,\vec{x}) \sim z^{\Delta} \langle \mathcal{O}(\vec{x}) \rangle$
$\rightarrow z^{\Delta}$
$\langle \Phi_{(s_1)}(z,\vec{x}) \rangle_{J_{s_1}, J_{s_2}} \rightarrow \langle J_{s_3} \rangle_{J_{s_1} J_{s_2}} = \langle J_{s_1} J_{s_2} J_{s_3} \rangle$


φ(z,x) ↔ O(x)
φ(z,x) ~ z^Δ ⟨O(x)⟩
⟨J_{s1} J_{s2} J_{s3}⟩



φ(z,x) ⟷ O(x)
φ(z,x) ~ z^Δ ⟨O(x)⟩
Φ(1)^lin , Φ(2)^lin
"D Φ" = Φ(1) * Φ(2)
⟨Φ(s1)(z,x)⟩ Js1,Js2 ⟶ ⟨Js3⟩ Js1 Js2 = ⟨Js1 Js2 Js3⟩


$\Phi^{lin}_{(1)}, \Phi^{lin}_{(2)}$
"$D\Phi^{2nd\ order} = \Phi_{(1)} * \Phi_{(2)}$"
$\langle J_{s_3} \rangle_{J_{s_1} J_{s_2}} = \langle J_{s_1} J_{s_2} J_{s_3} \rangle$

$\longleftrightarrow \mathcal{O}(\vec{x})$

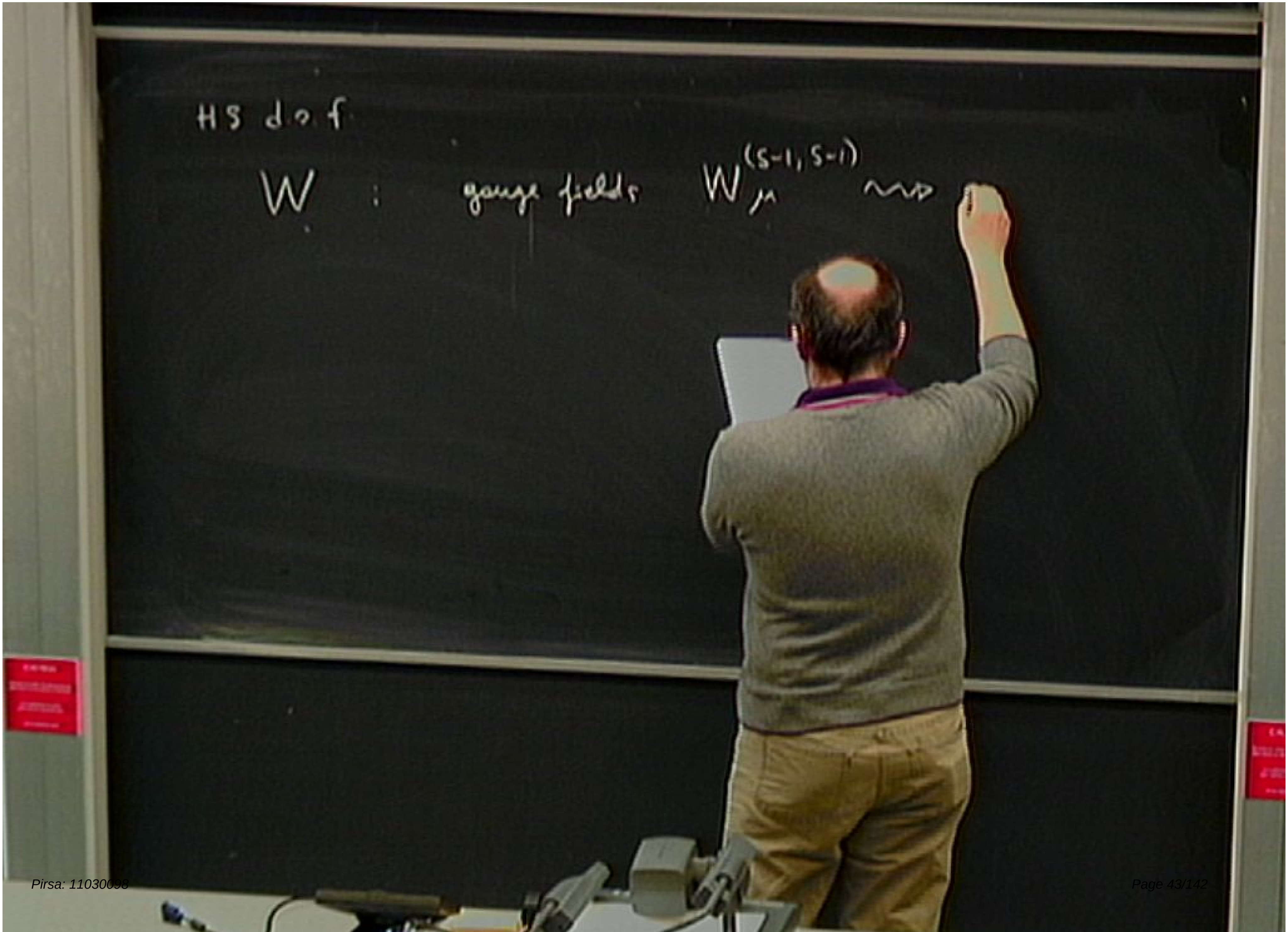
$) \sim z^{\Delta} \langle \mathcal{O}(\vec{x}) \rangle$

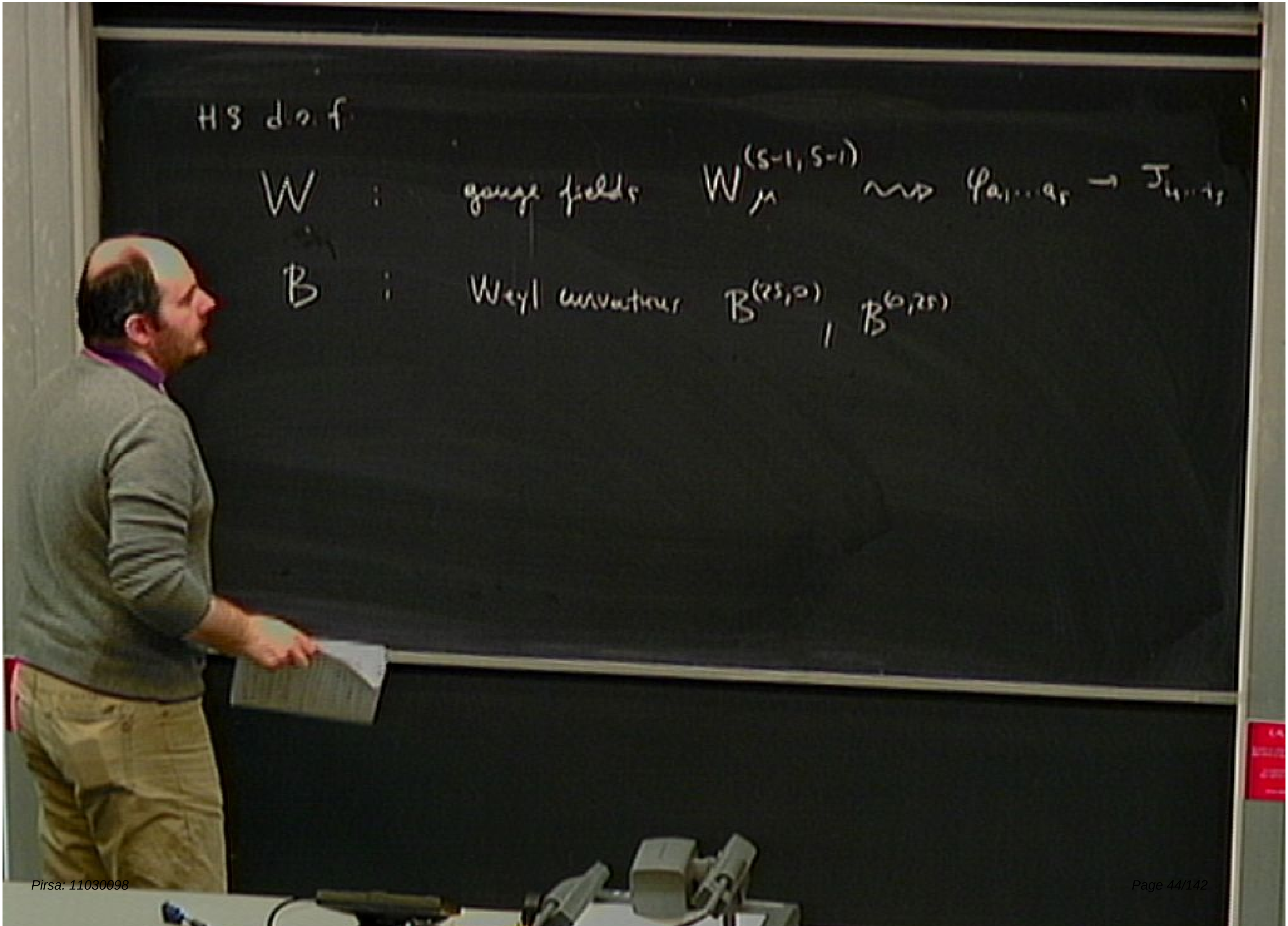
$\Phi^{lin}_{(1)}, \Phi^{lin}_{(2)}$

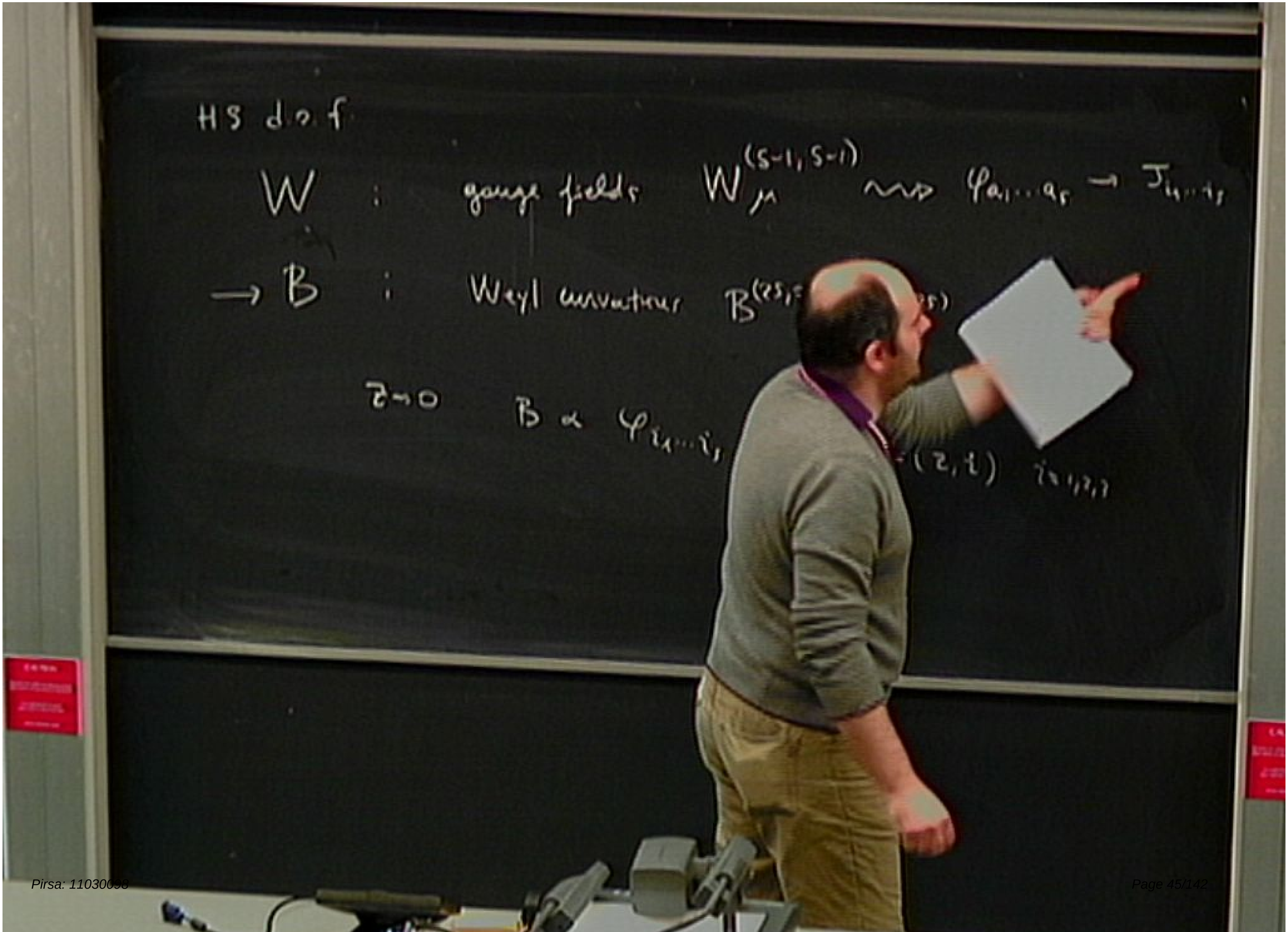
z^{Δ}

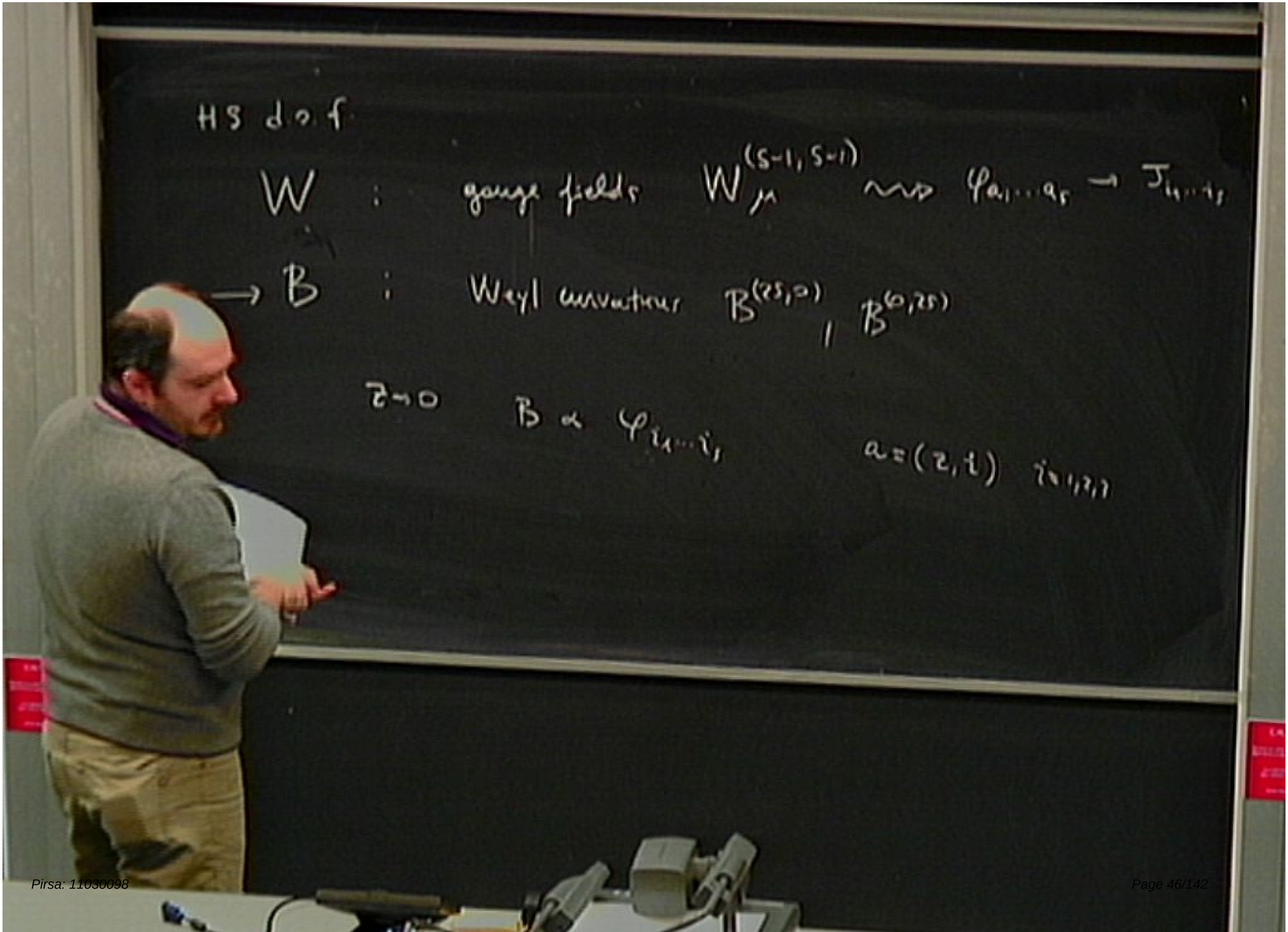
" $D\Phi^{2nd\ order} = \Phi_{(1)} * \Phi_{(2)}$ "

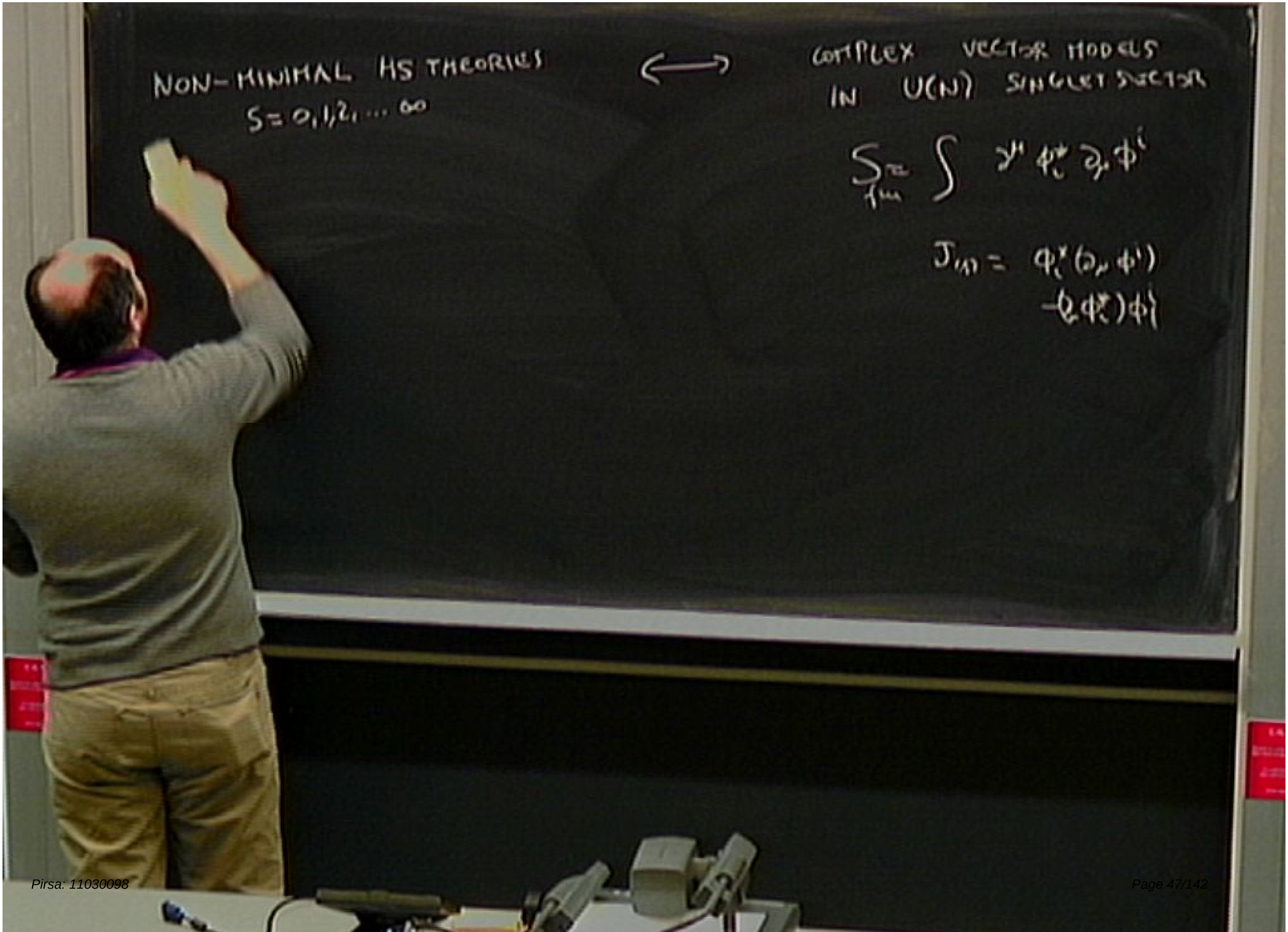
$\rangle_{J_{s_1}, J_{s_2}} \longrightarrow \langle J_{s_3} \rangle_{J_{s_1} J_{s_2}} = \langle J_{s_1} J_{s_2} J_{s_3} \rangle$

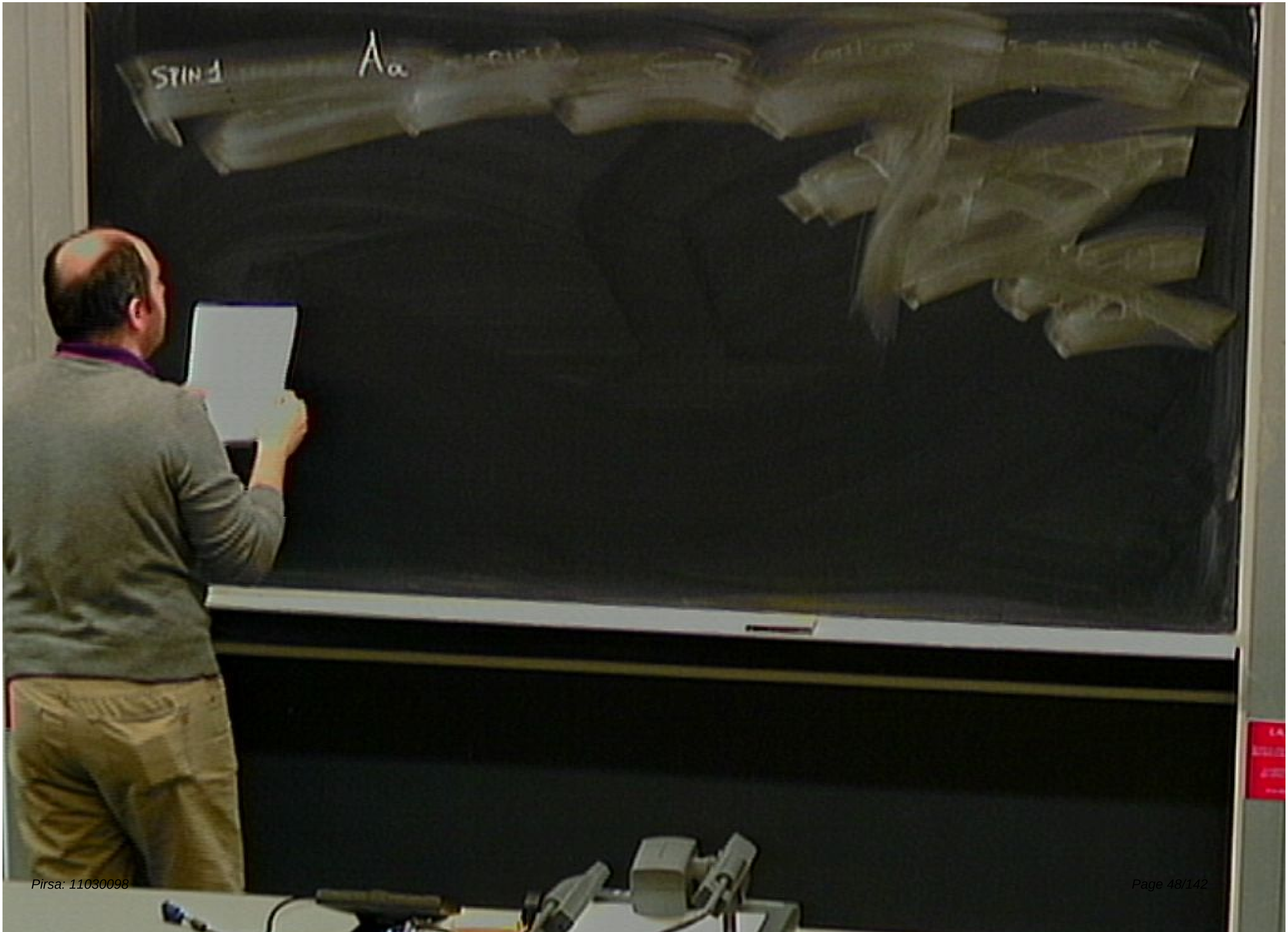

HS d.o.f
W : gauge fields $W_\mu^{(s-1,s-1)}$ ⇝

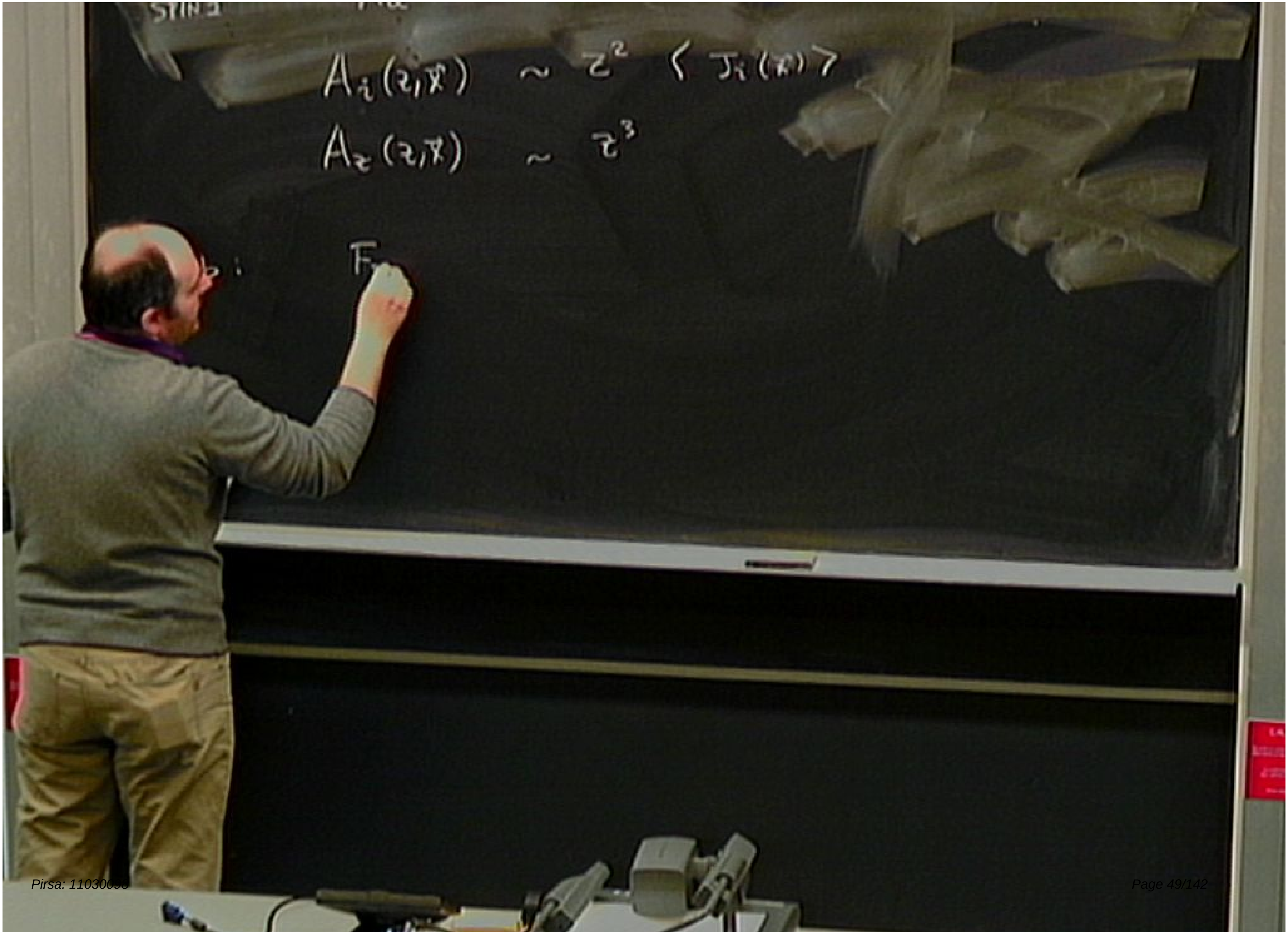

HS d.o.f
W : gauge fields $W_{\mu}^{(s-1,s-1)}$ ⇝ $\varphi_{a_1 \ldots a_s} \to J_{a_1 \ldots a_s}$
B : Weyl curvatures $B^{(2s,0)}$, $B^{(0,2s)}$

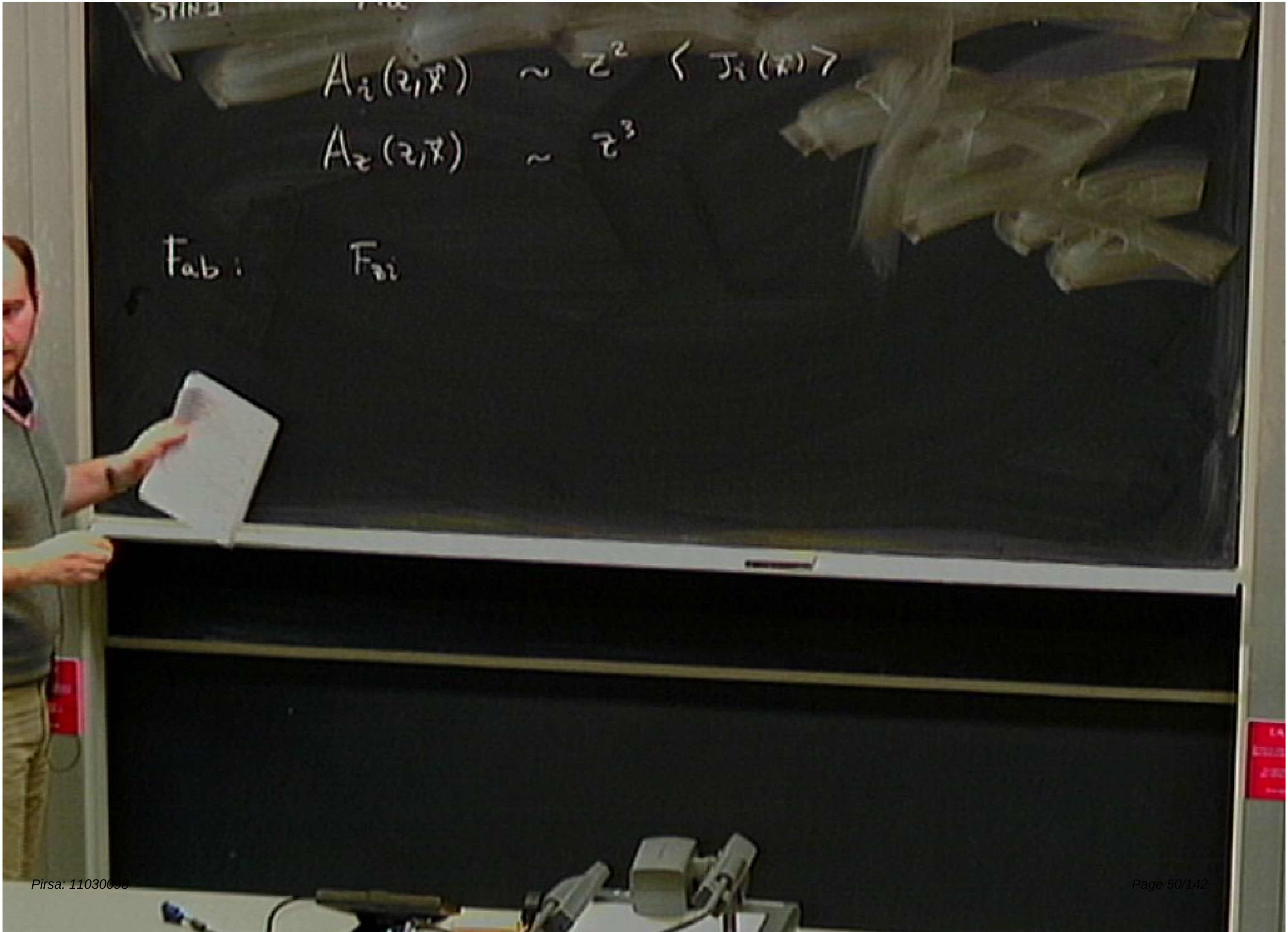

HS d.o.f
W : gauge fields $W_\mu^{(s-1,s-1)}$ ⇝ $\varphi_{a_1 \dots a_s}$ → $J_{i_1 \dots i_s}$
→ B : Weyl curvature
z → 0   B ∝ $\varphi_{i_1 \dots i_s}$

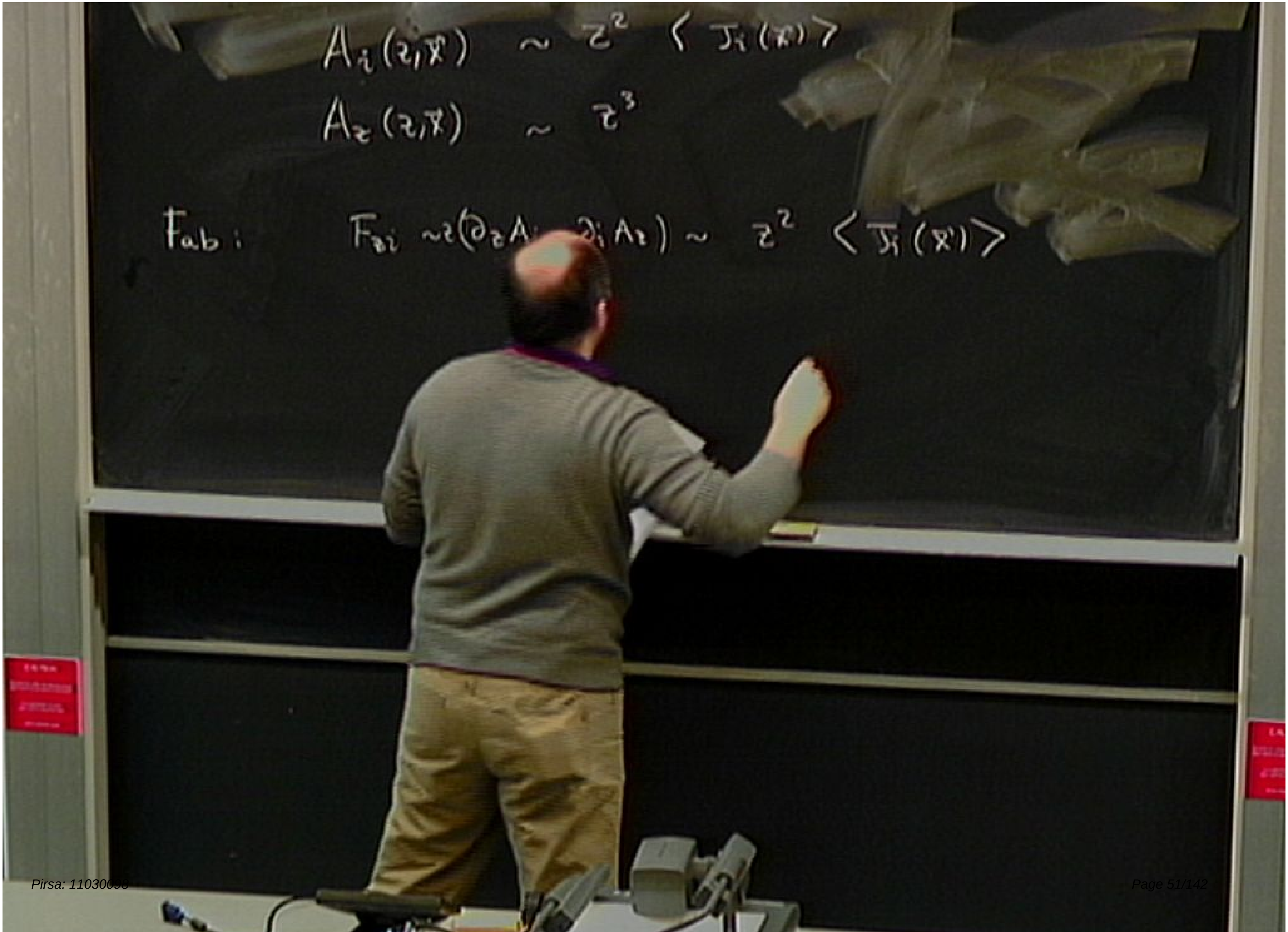

HS d.o.f
W : gauge fields $W_\mu^{(s-1,s-1)} \rightsquigarrow \varphi_{a_1\dots a_s} \to J_{i_1\dots i_s}$
$\to$ B : Weyl curvature $B^{(2s,0)}$, $B^{(0,2s)}$
$z\to 0$ $B \propto \varphi_{i_1\dots i_s}$ $a=(z,i)$ $i=1,2,3$


NON-MINIMAL HS THEORIES
S = 0, 1, 2, ... ∞
⟷
COMPLEX VECTOR MODELS
IN U(N) SINGLET SECTOR
S_free = ∫ ∂^μ φ*_i ∂_μ φ^i
J_(1) = φ*_i (∂_μ φ^i)
− (∂_μ φ*_i) φ^i

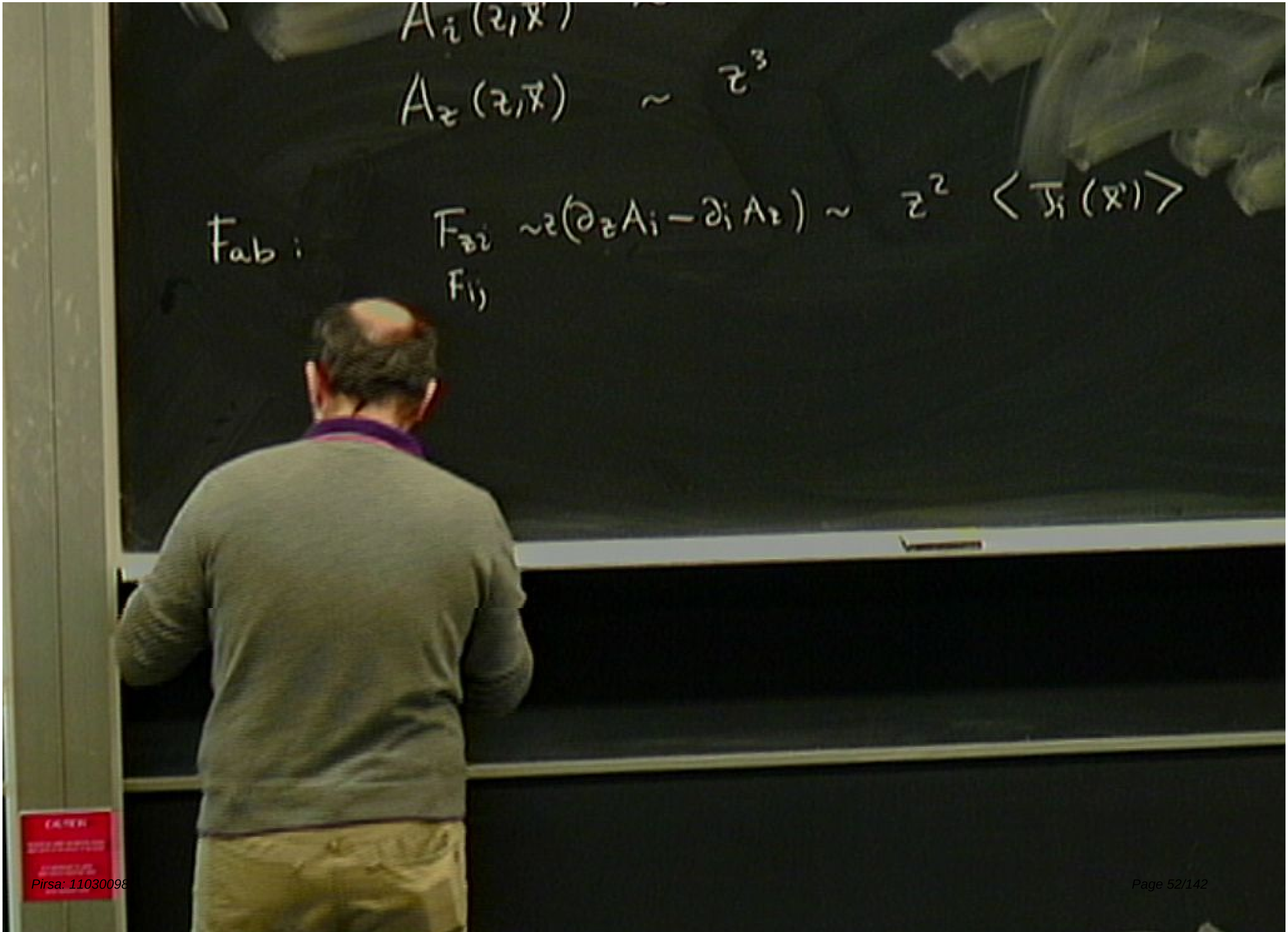


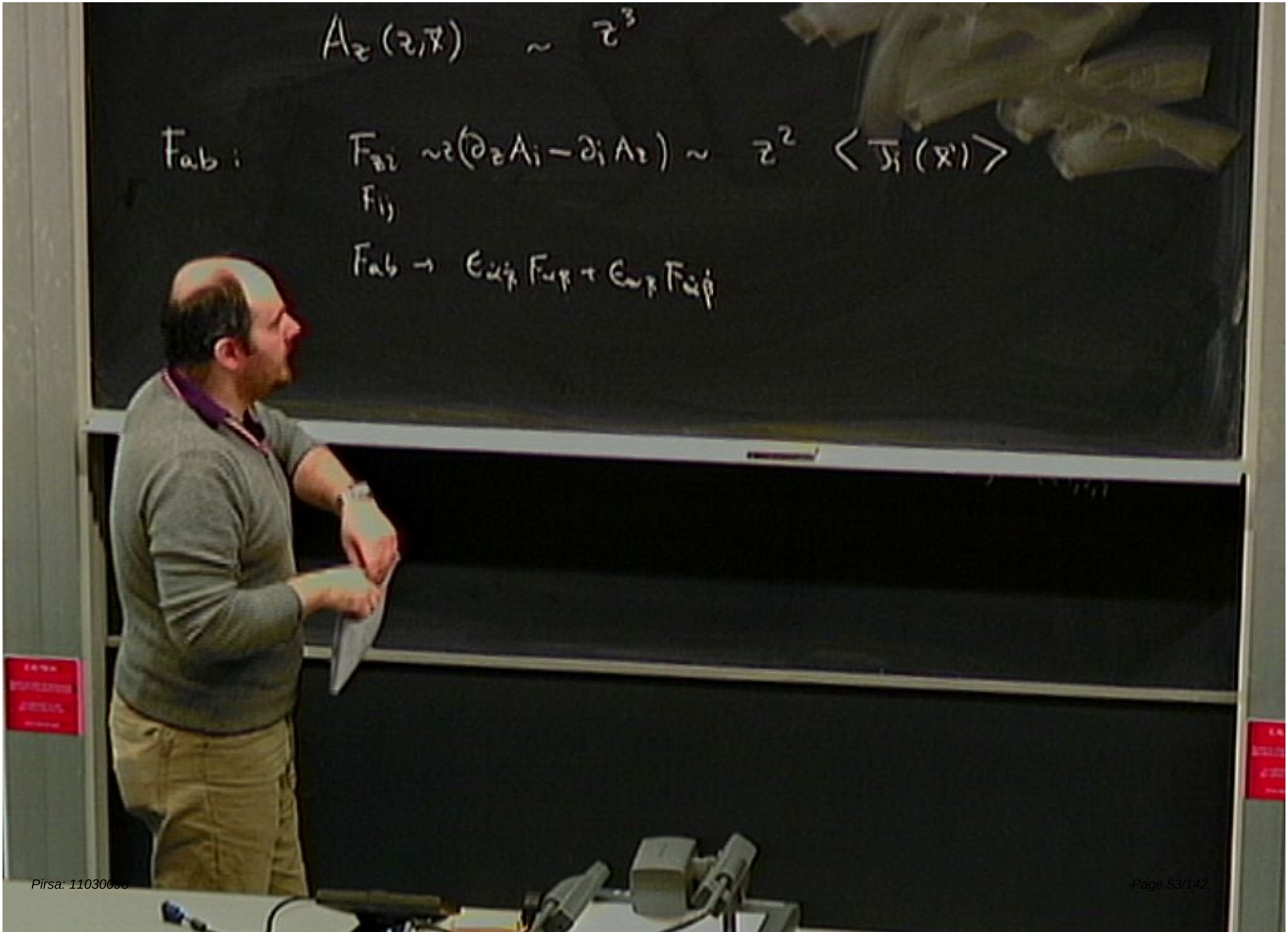

A_i(z,x) ~ z^2 ⟨J_i(x)⟩
A_z(z,x) ~ z^3

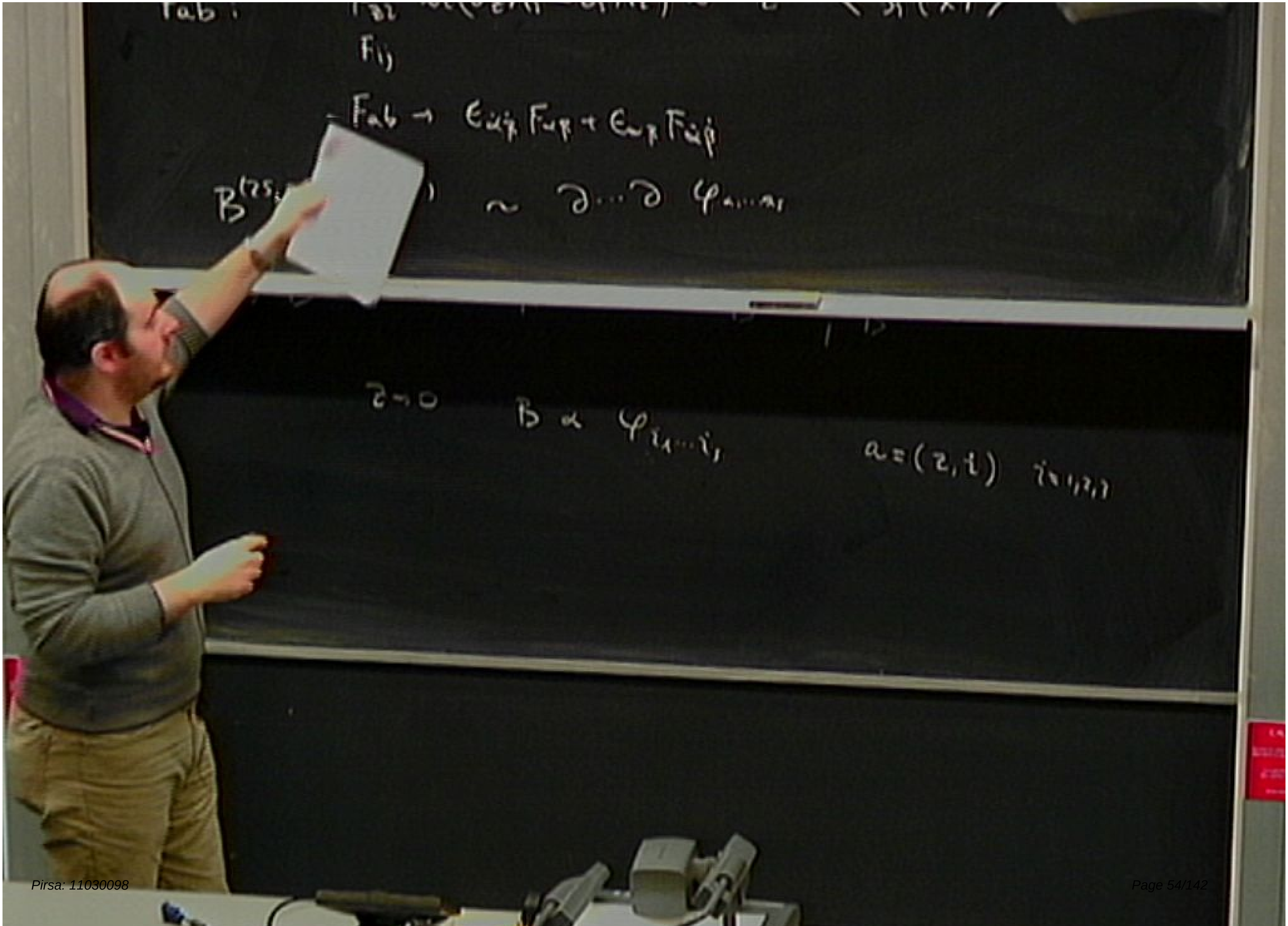

$A_i(z,\vec{x}) \sim z^2 \langle J_i(\vec{x}) \rangle$
$A_z(z,\vec{x}) \sim z^3$
F_{ab} :
F_{zi}



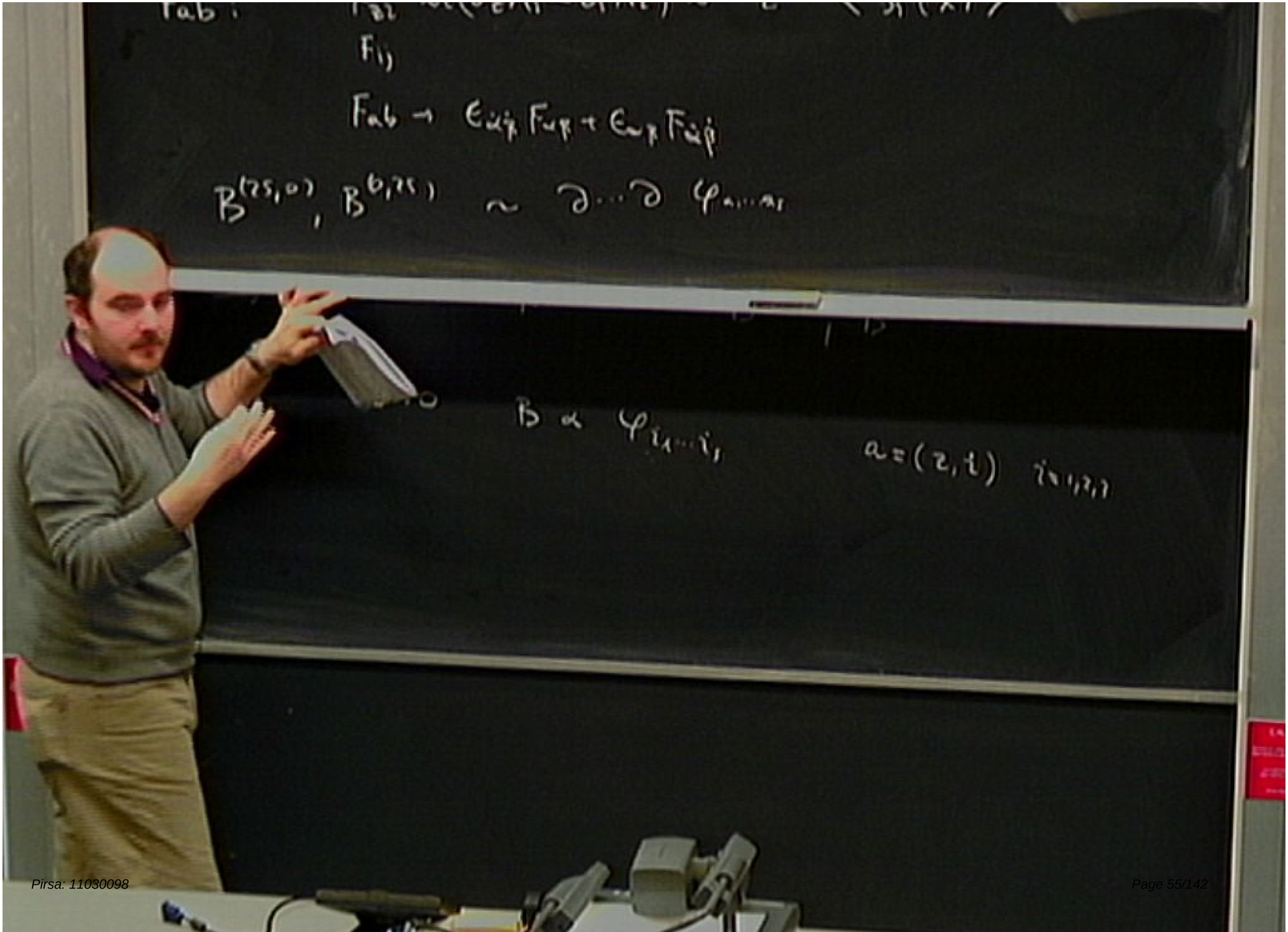
$A_i(z,\vec{x}) \sim z^2 \langle J_i(\vec{x}) \rangle$
$A_z(z,\vec{x}) \sim z^3$
F_{ab} : $F_{zi} \sim z(\partial_z A_i - \partial_i A_z) \sim z^2 \langle J_i(\vec{x}) \rangle$


$A_i(z, \vec{x})$
$A_z(z, \vec{x}) \sim z^3$
F_{ab} :
$F_{zi} \sim z(\partial_z A_i - \partial_i A_z) \sim z^2 \langle J_i(\vec{x}) \rangle$
F_{ij}

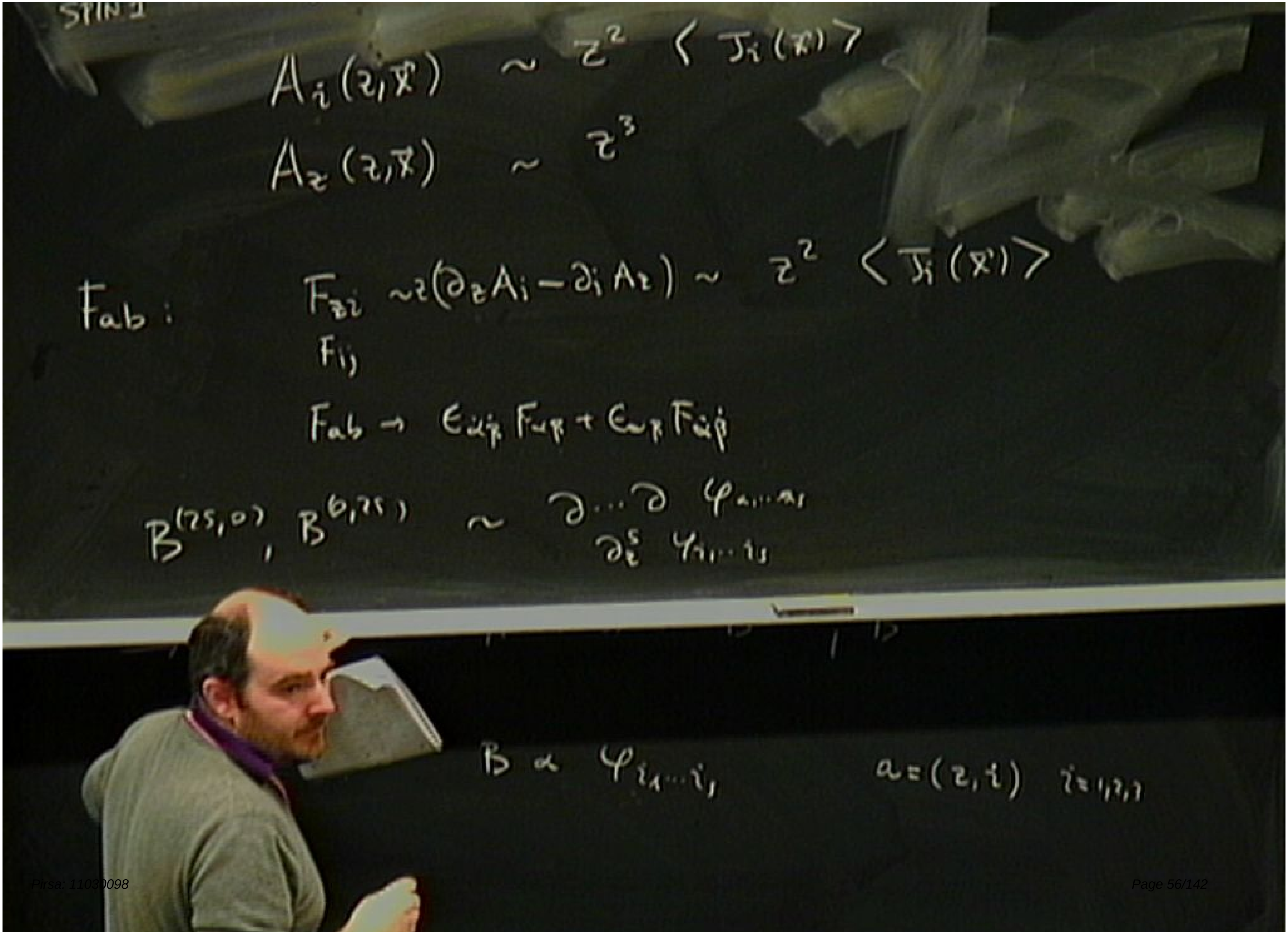

$A_z(z,\vec{x}) \sim z^3$
F_{ab} :
$F_{zi} \sim z(\partial_z A_i - \partial_i A_z) \sim z^2 \langle J_i(\vec{x}) \rangle$
F_{ij}
$F_{ab} \rightarrow$



Fij
Fab → Eαβ Fαβ + Eαβ Fαβ
∼ ∂···∂ φa1···as
z → 0
B ∝ φi1···is
a = (z, i)



F_{ij}
$F_{ab} \to \epsilon_{\dot\alpha\dot\gamma} F_{\alpha\gamma} + \epsilon_{\alpha\gamma} F_{\dot\alpha\dot\gamma}$
$B^{(25,0)}, B^{(0,25)} \sim \partial \cdots \partial \, \varphi_{a_1 \cdots a_5}$
$B \propto \varphi_{i_1 \cdots i_5}$
$a = (z, t)$


SPIN 1
$A_i(z,\vec{x}) \sim z^2 \langle J_i(\vec{x}) \rangle$
$A_z(z,\vec{x}) \sim z^3$
$F_{ab}:$
$F_{zi} \sim z(\partial_z A_i - \partial_i A_z) \sim z^2 \langle J_i(\vec{x}) \rangle$
F_{ij}
$F_{ab} \to \epsilon_{\dot{\alpha}\dot{\beta}} F_{\alpha\beta} + \epsilon_{\alpha\beta} F_{\dot{\alpha}\dot{\beta}}$
$B^{(2s,0)}, B^{(0,2s)} \sim \partial \cdots \partial \varphi_{a_1 \ldots a_s}$
$\partial_z^s \varphi_{i_1 \ldots i_s}$
$B \propto \varphi_{i_1 \ldots i_s}$
$a = (z, i) \quad i = 1,2,3$

SPIN 1 $\quad A_a$

$$A_i(z,\vec{x}) \sim z^2 \langle J_i(\vec{x}) \rangle$$

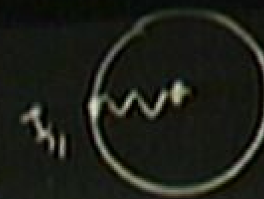
$$A_z(z,\vec{x}) \sim z^3$$

F_{ab} :
$$F_{zi} \sim z(\partial_z A_i - \partial_i A_z) \sim z^2 \langle J_i(\vec{x}) \rangle$$
$$F_{ij}$$

$$F_{ab} \to \epsilon_{\dot{\alpha}\dot{\beta}} F_{\alpha\beta} + \epsilon_{\alpha\beta} F_{\dot{\alpha}\dot{\beta}}$$

$$B^{(2s,0)},\ B^{(0,2s)} \sim \partial \cdots \partial\ \varphi_{a_1 \ldots a_s}$$
$$\partial_z^s\ \varphi_{i_1 \ldots i_s}$$

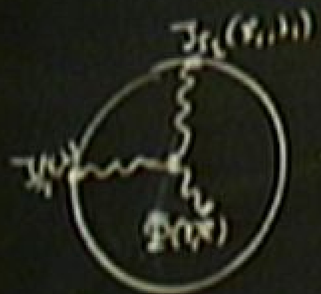
$$B \propto \varphi_{i_1 \ldots i_s} \qquad a = (z, i) \quad i = 1,2,3$$



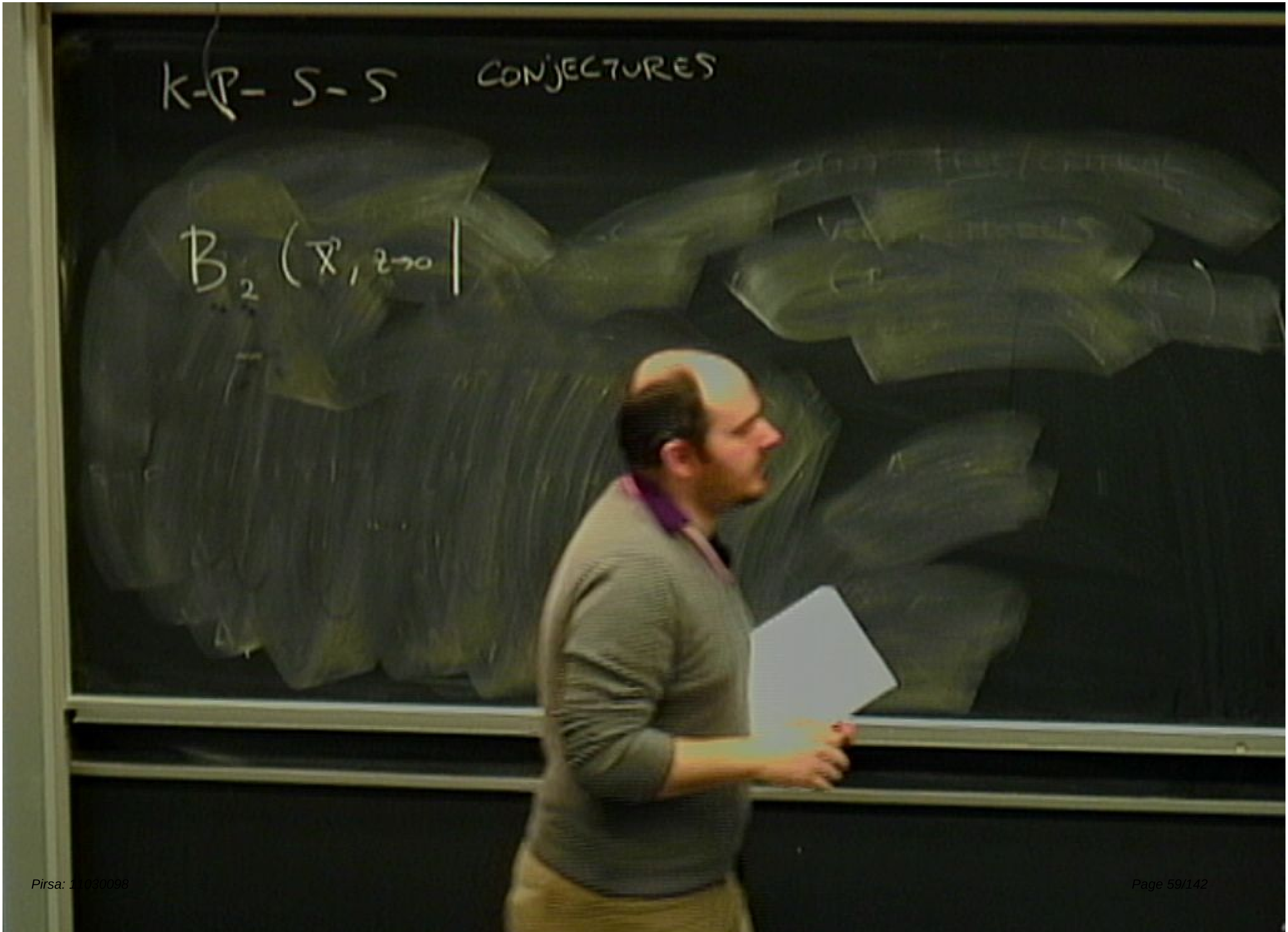
$$\phi(z,\vec{x}) \leftrightarrow \mathcal{O}(\vec{x})$$

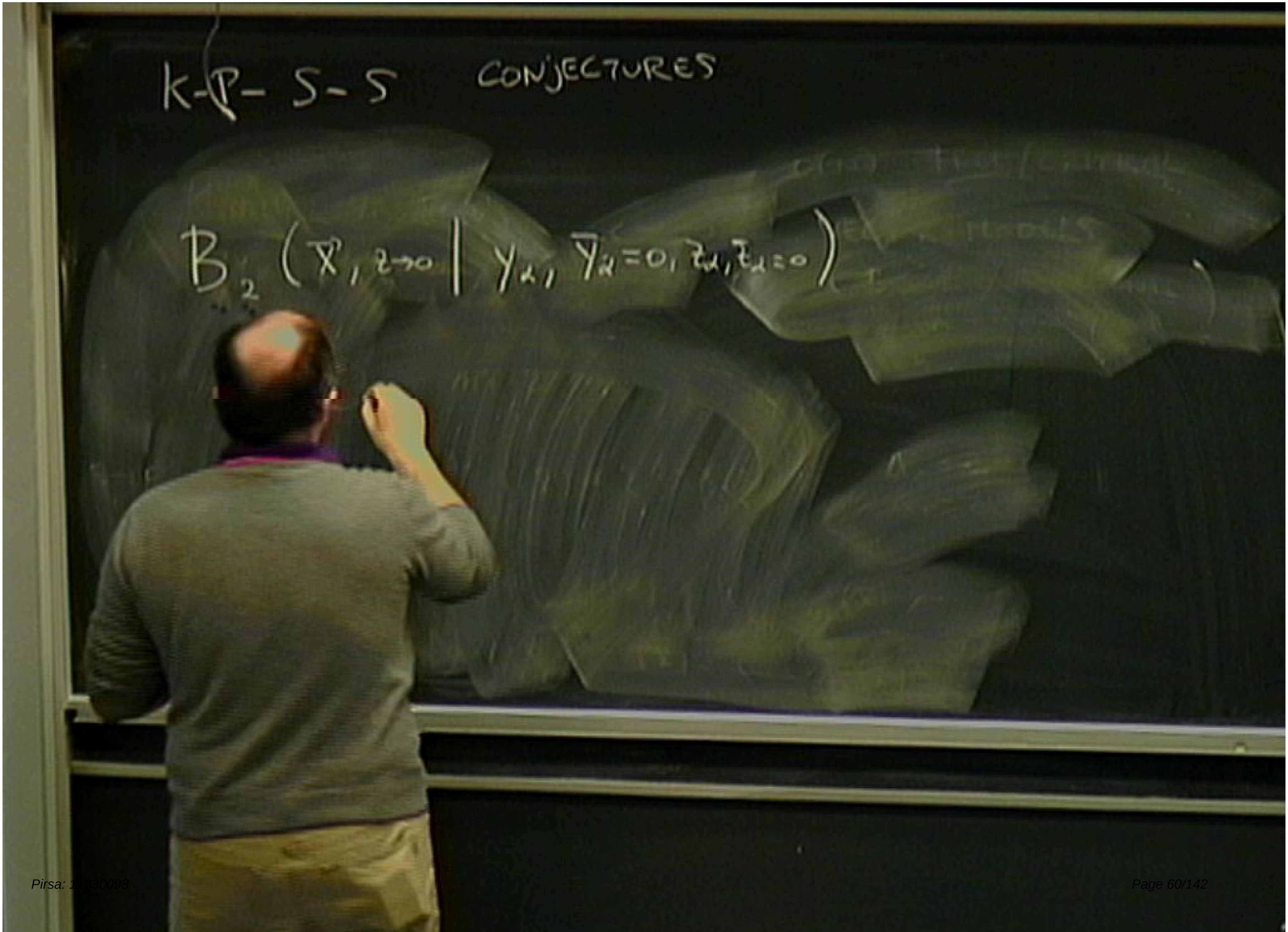
$$\phi(z,\vec{x}) \sim z^{\Delta} \langle \mathcal{O}(\vec{x}) \rangle \qquad \Phi^{lin}_{(1)}, \Phi^{lin}_{(2)}$$

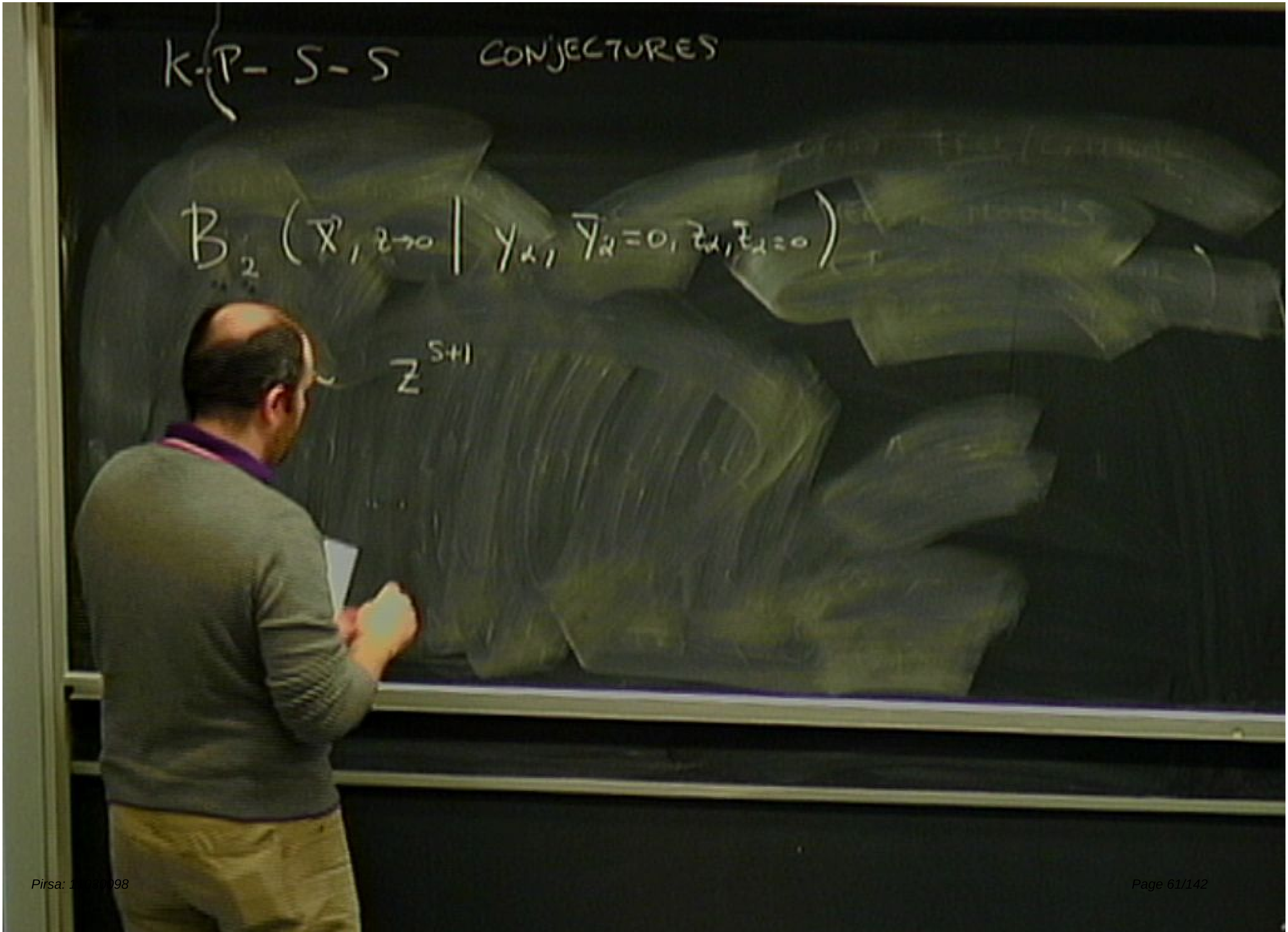
$$\text{"} D\Phi^{non\text{-}lin} = \Phi_{(1)} * \Phi_{(1)} \text{"}$$

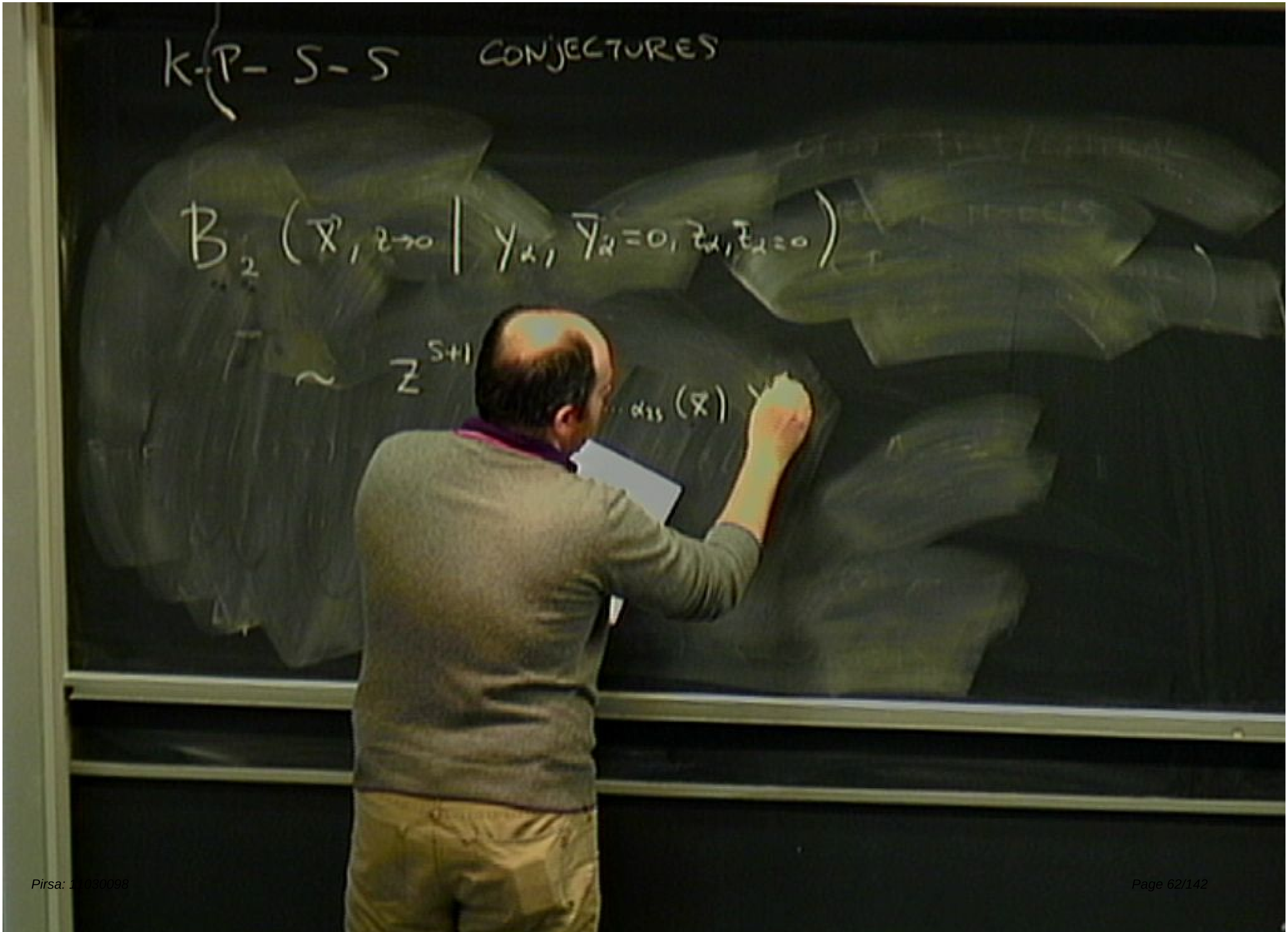
 $\longrightarrow z^{\Delta}$ 

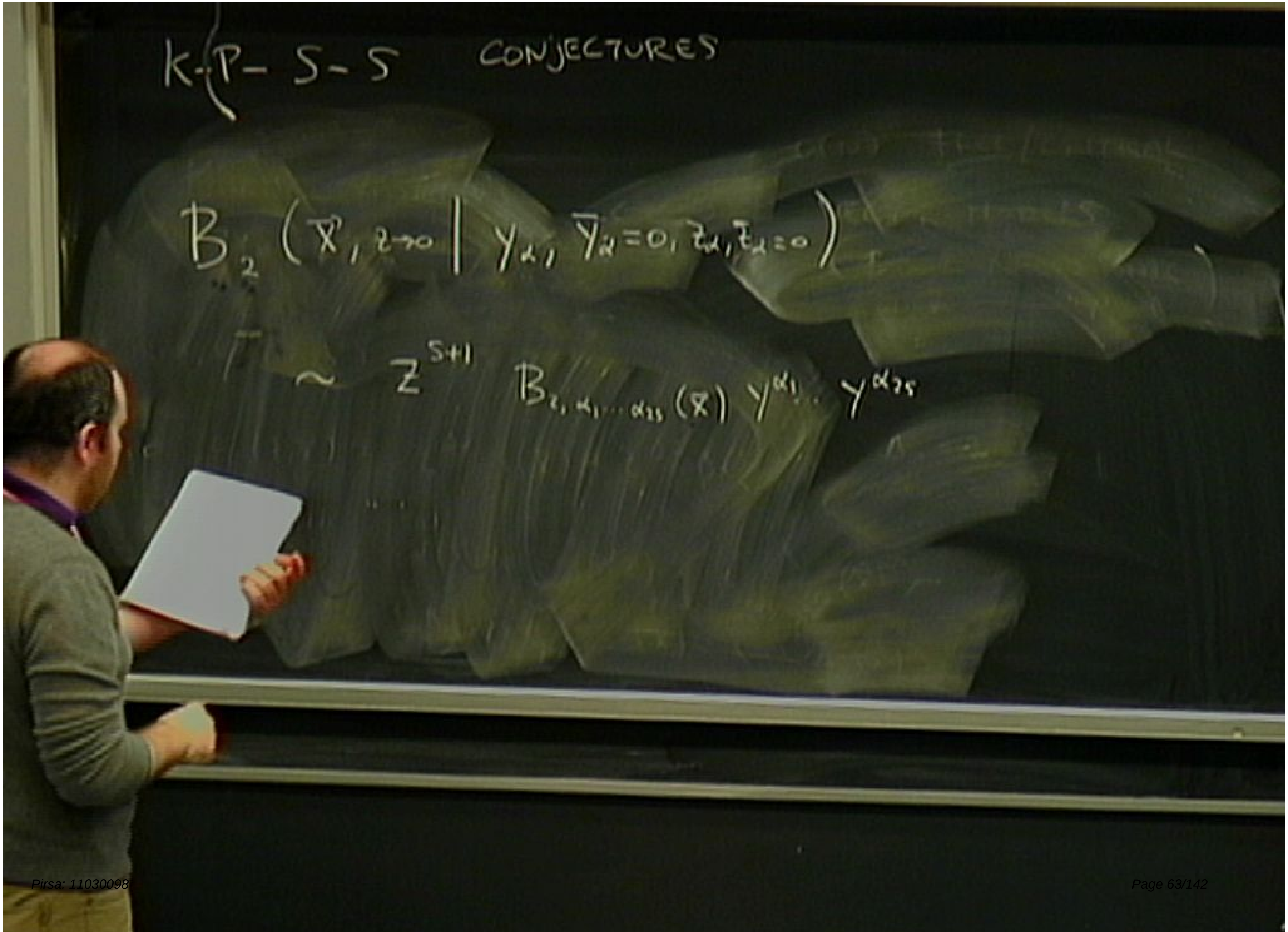
$$\langle \Phi_{(s_3)}(z,\vec{x}) \rangle_{J_{s_1}, J_{s_2}} \longrightarrow \langle J_{s_3} \rangle_{J_{s_1} J_{s_2}} = \langle J_{s_1} J_{s_2} J_{s_3} \rangle$$

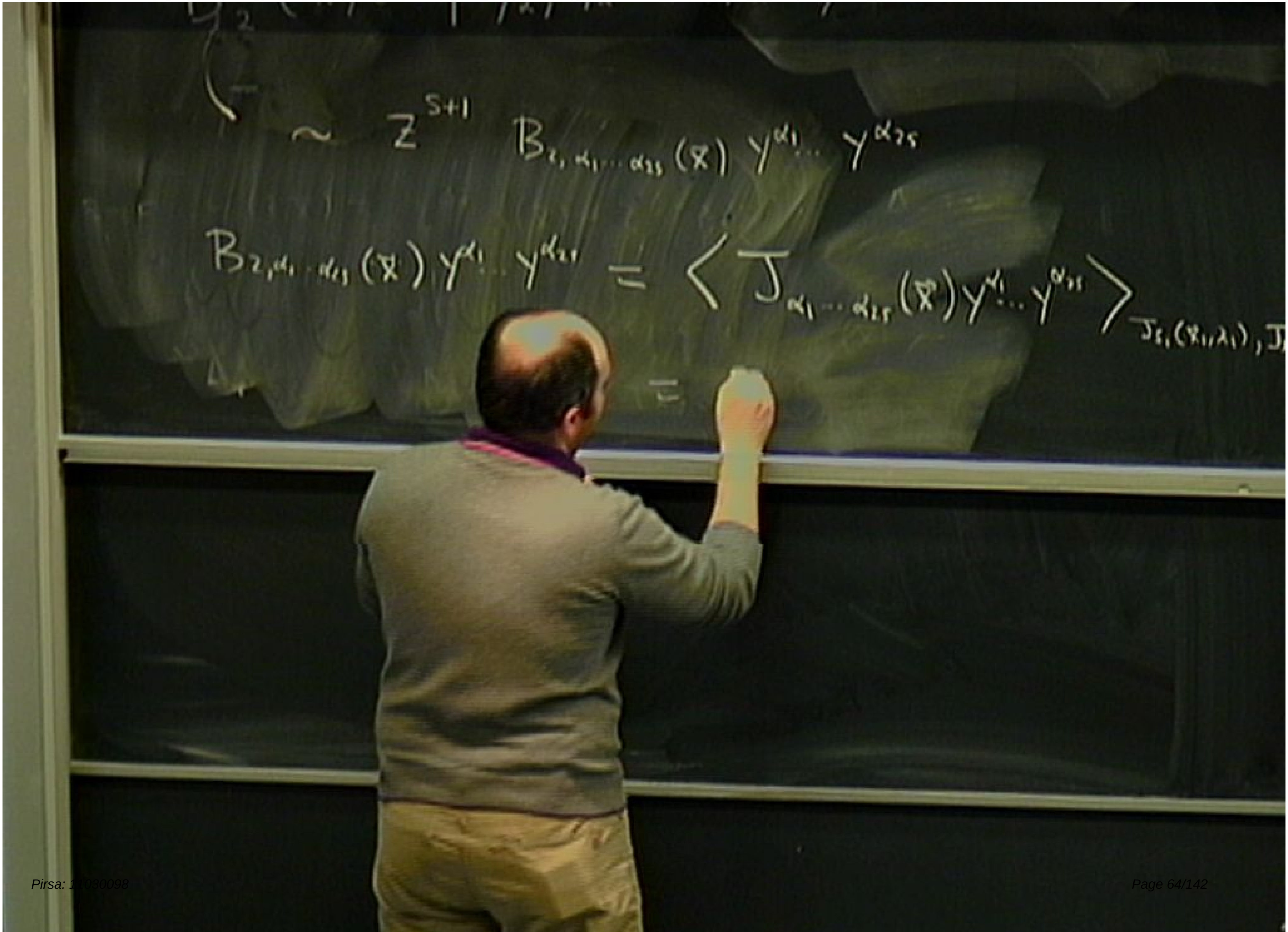

K-P-S-S CONJECTURES


K-P-S-S CONJECTURES
B_2 (x̄, z→0 | y_α, ȳ_α=0, z_α, z̄_α=0)

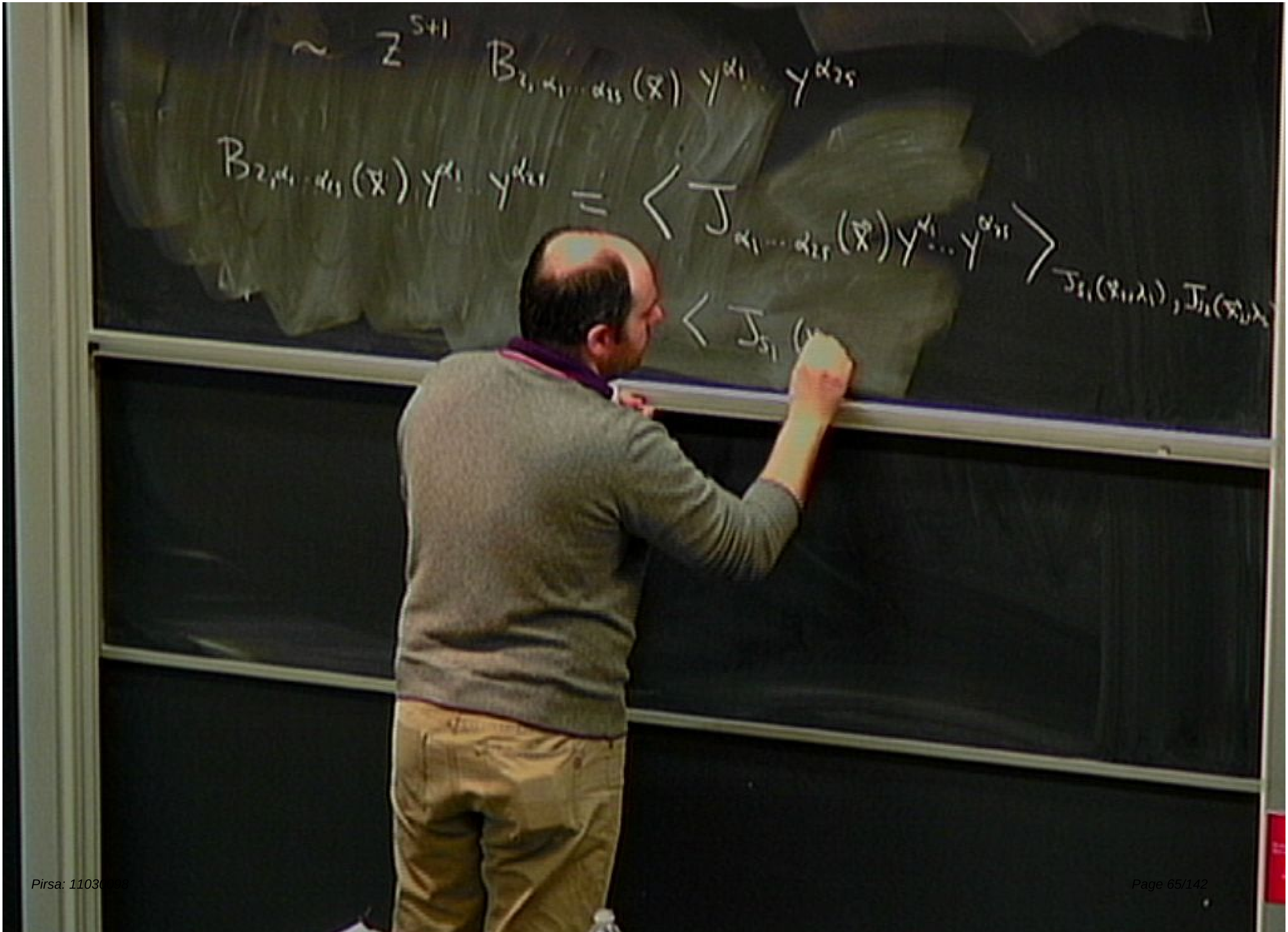

K-P-S-S CONJECTURES
$B_2(\bar{x}, z \to 0 \mid y_\alpha, \bar{y}_\alpha = 0, z_\alpha, \bar{z}_\alpha = 0)$
$\sim z^{s+1}$

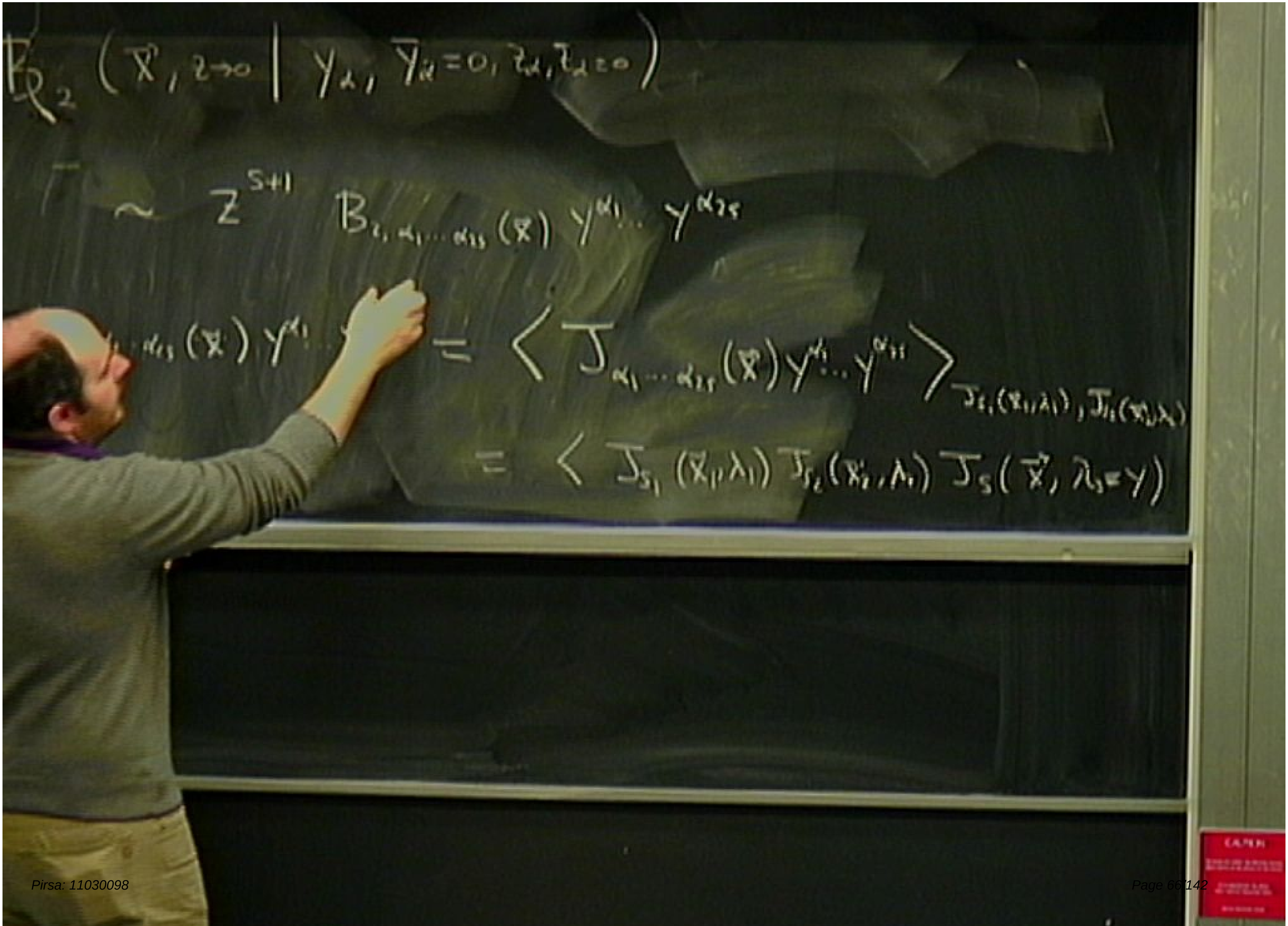

K-P-S-S CONJECTURES
B2 (x, z→0 | yα, ȳα=0, zα, z̄α=0)
~ Z^S+1 ... α2S (x) Y

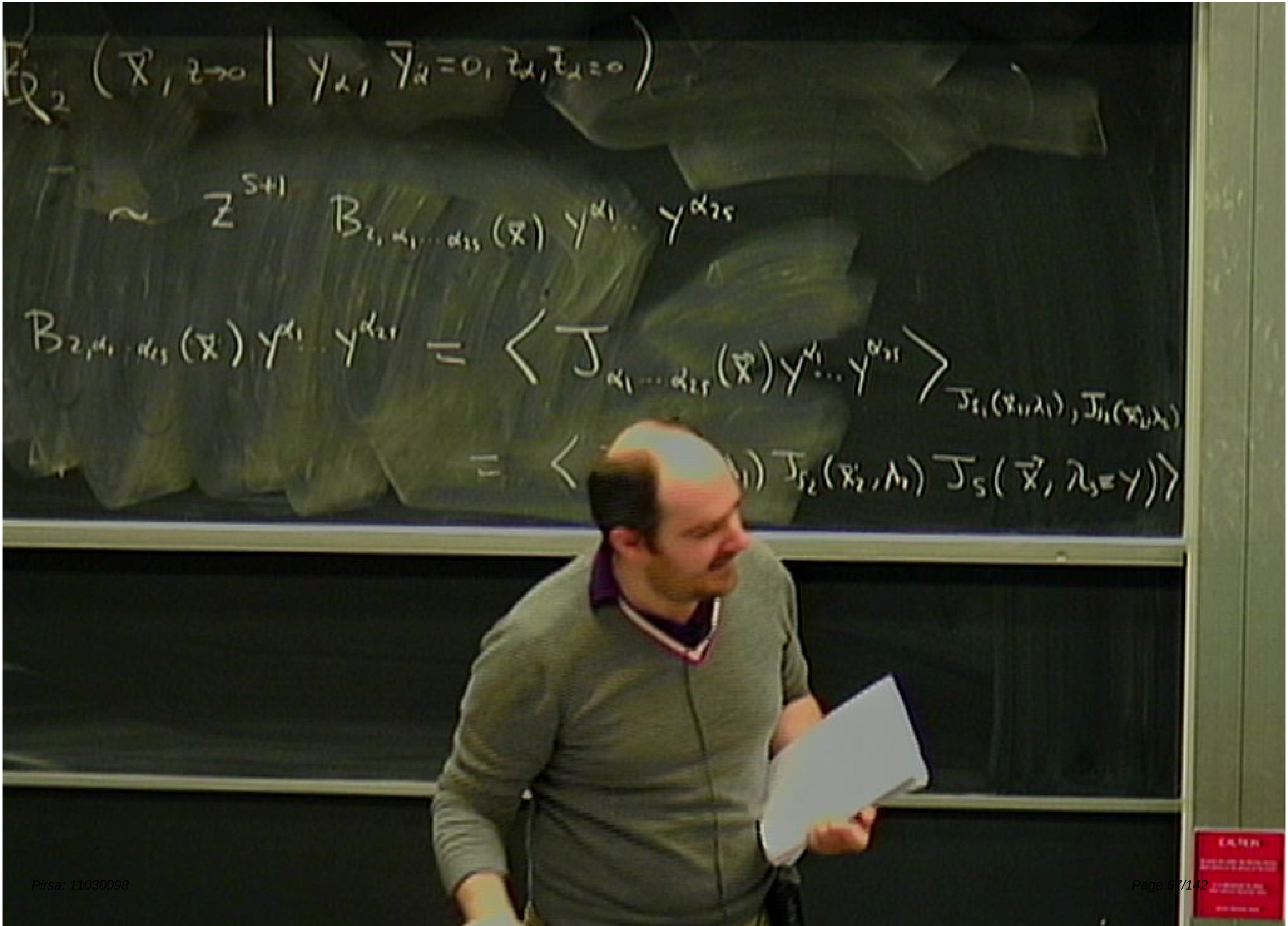

K-P-S-S CONJECTURES
$B_2(\bar{x}, z\to 0 \mid y_\alpha, \bar{y}_\alpha = 0, z_\alpha, \bar{z}_\alpha = 0)$
$\sim z^{S+1} B_{z,\alpha_1\ldots\alpha_{2S}}(\bar{x})\, y^{\alpha_1}\ldots y^{\alpha_{2S}}$



$\sim Z^{S+1} B_{z,\alpha_1\ldots\alpha_{2s}}(x)\, y^{\alpha_1}\ldots y^{\alpha_{2s}}$
$B_{z,\alpha_1\ldots\alpha_{2s}}(x)\, y^{\alpha_1}\ldots y^{\alpha_{2s}} = \langle J_{\alpha_1\ldots\alpha_{2s}}(x)\, y^{\alpha_1}\ldots y^{\alpha_{2s}} \rangle_{J_{s_1}(x_1,\lambda_1),\, J}$
$=$


$\sim Z^{S+1} \; B_{2,\alpha_1\ldots\alpha_{2S}}(x)\, y^{\alpha_1}\ldots y^{\alpha_{2S}}$
$B_{2,\alpha_1\ldots\alpha_{2S}}(x)\, y^{\alpha_1}\ldots y^{\alpha_{2S}} = \left\langle J_{\alpha_1\ldots\alpha_{2S}}(x)\, y^{\alpha_1}\ldots y^{\alpha_{2S}} \right\rangle_{J_{S_1}(x_1,\lambda_1),\, J_{S_2}(x_2,\lambda_2)}$
$\langle J_{S_1}($


$B_2(\vec{x}, z\to 0 \mid y_\alpha, \bar{y}_{\dot\alpha}=0, z_\alpha, \bar{z}_{\dot\alpha}=0)$
$\sim z^{s+1} \; B_{z,\alpha_1\ldots\alpha_{2s}}(\vec{x})\, y^{\alpha_1}\ldots y^{\alpha_{2s}}$
$\ldots\alpha_{2s}(\vec{x})\, y^{\alpha_1}\ldots = \langle J_{\alpha_1\ldots\alpha_{2s}}(\vec{x})\, y^{\alpha_1}\ldots y^{\alpha_{2s}} \rangle_{J_{s_1}(\vec{x}_1,\lambda_1),\, J_{s_2}(\vec{x}_2,\lambda_2)}$
$= \langle J_{s_1}(\vec{x}_1,\lambda_1)\, J_{s_2}(\vec{x}_2,\lambda_2)\, J_s(\vec{x}, \lambda_3 = y)\rangle$

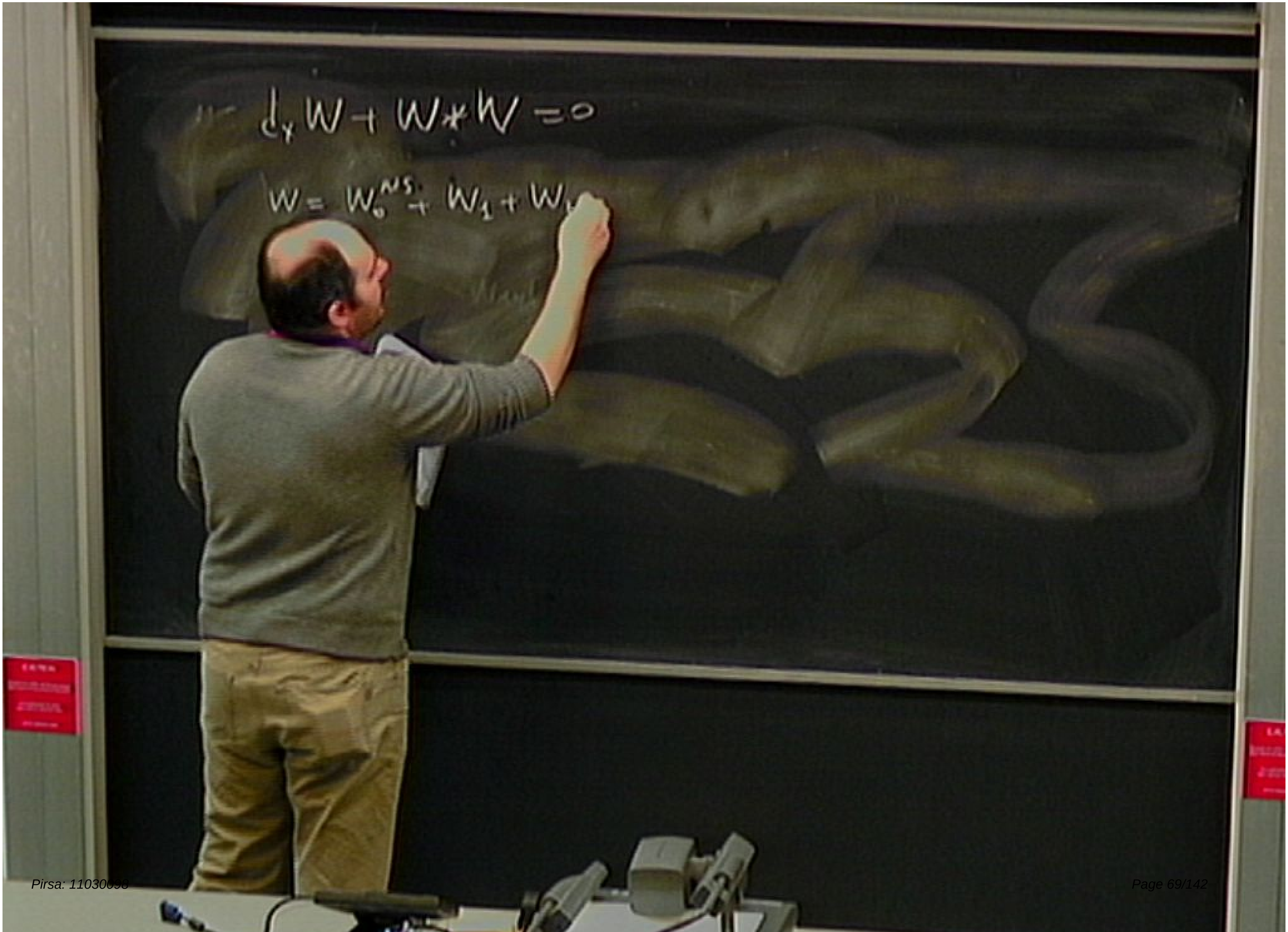

$\Phi_2 (\vec{x}, z \to 0 \mid y_\alpha, \bar{y}_\alpha = 0, z_\alpha, \bar{z}_\alpha = 0)$
$\sim z^{s+1} B_{2,\alpha_1 \dots \alpha_{2s}}(\vec{x})\, y^{\alpha_1} \dots y^{\alpha_{2s}}$
$B_{2,\alpha_1 \dots \alpha_{2s}}(\vec{x})\, y^{\alpha_1} \dots y^{\alpha_{2s}} = \langle J_{\alpha_1 \dots \alpha_{2s}}(\vec{x})\, y^{\alpha_1} \dots y^{\alpha_{2s}} \rangle_{J_{s_1}(\vec{x}_1, \lambda_1), J_{s_2}(\vec{x}_2, \lambda_2)}$
$= \langle \dots \lambda_1)) J_{s_2}(\vec{x}_2, \lambda_1) J_s(\vec{x}, \lambda_s = y) \rangle$

$$F_2\left(\vec{x}, z\to 0 \,\middle|\, y_\alpha, \bar{y}_\alpha = 0, z_\alpha, \bar{z}_\alpha = 0\right)$$

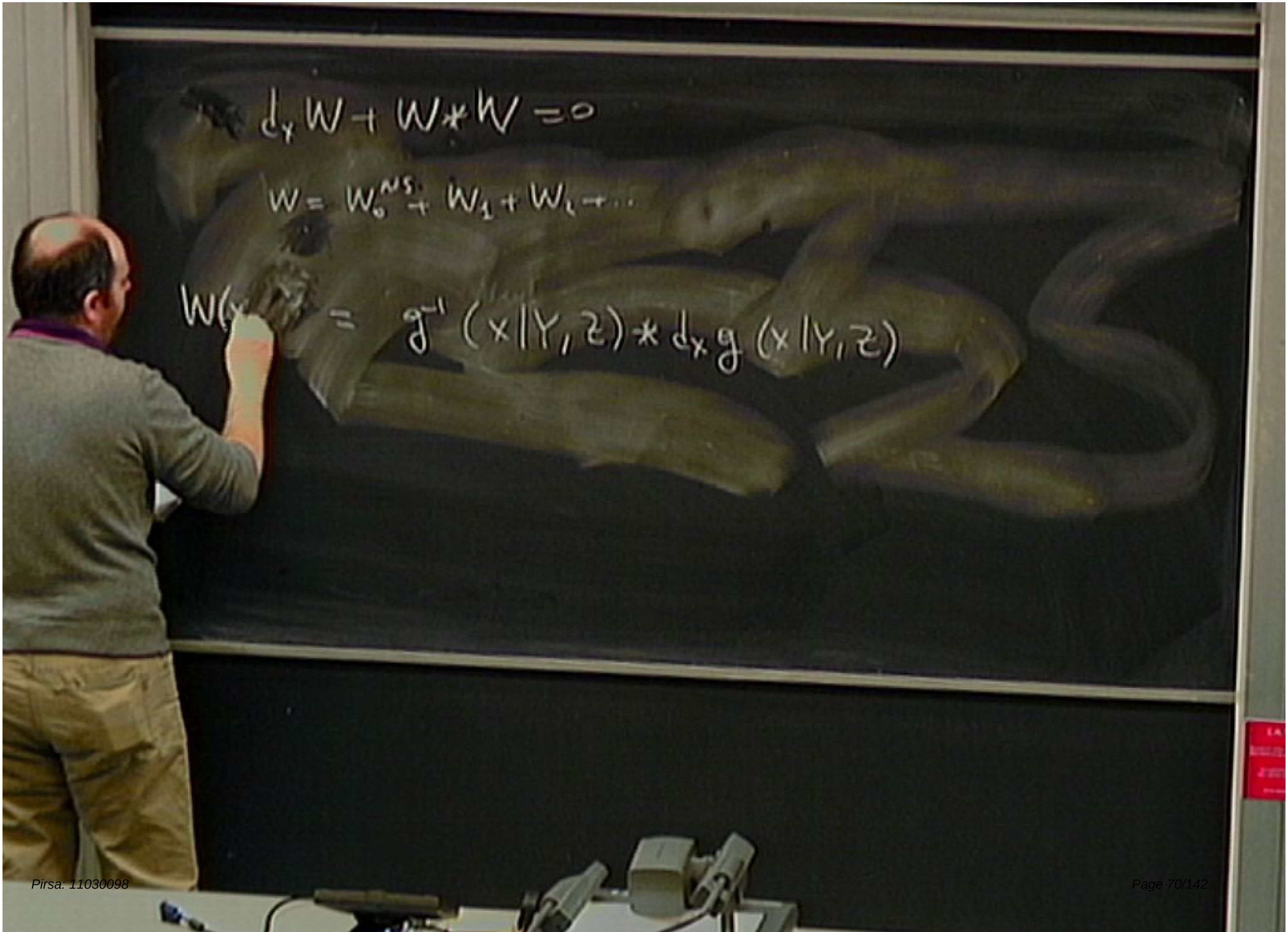
$$\sim z^{s+1} \; B_{z,\alpha_1\ldots\alpha_{2s}}(\vec{x})\, y^{\alpha_1}\ldots y^{\alpha_{2s}}$$

$$B_{z,\alpha_1\ldots\alpha_{2s}}(\vec{x})\, y^{\alpha_1}\ldots y^{\alpha_{2s}} = \left\langle J_{\alpha_1\ldots\alpha_{2s}}(\vec{x})\, y^{\alpha_1}\ldots y^{\alpha_{2s}} \right\rangle_{J_{s_1}(\vec{x}_1,\lambda_1),\, J}$$

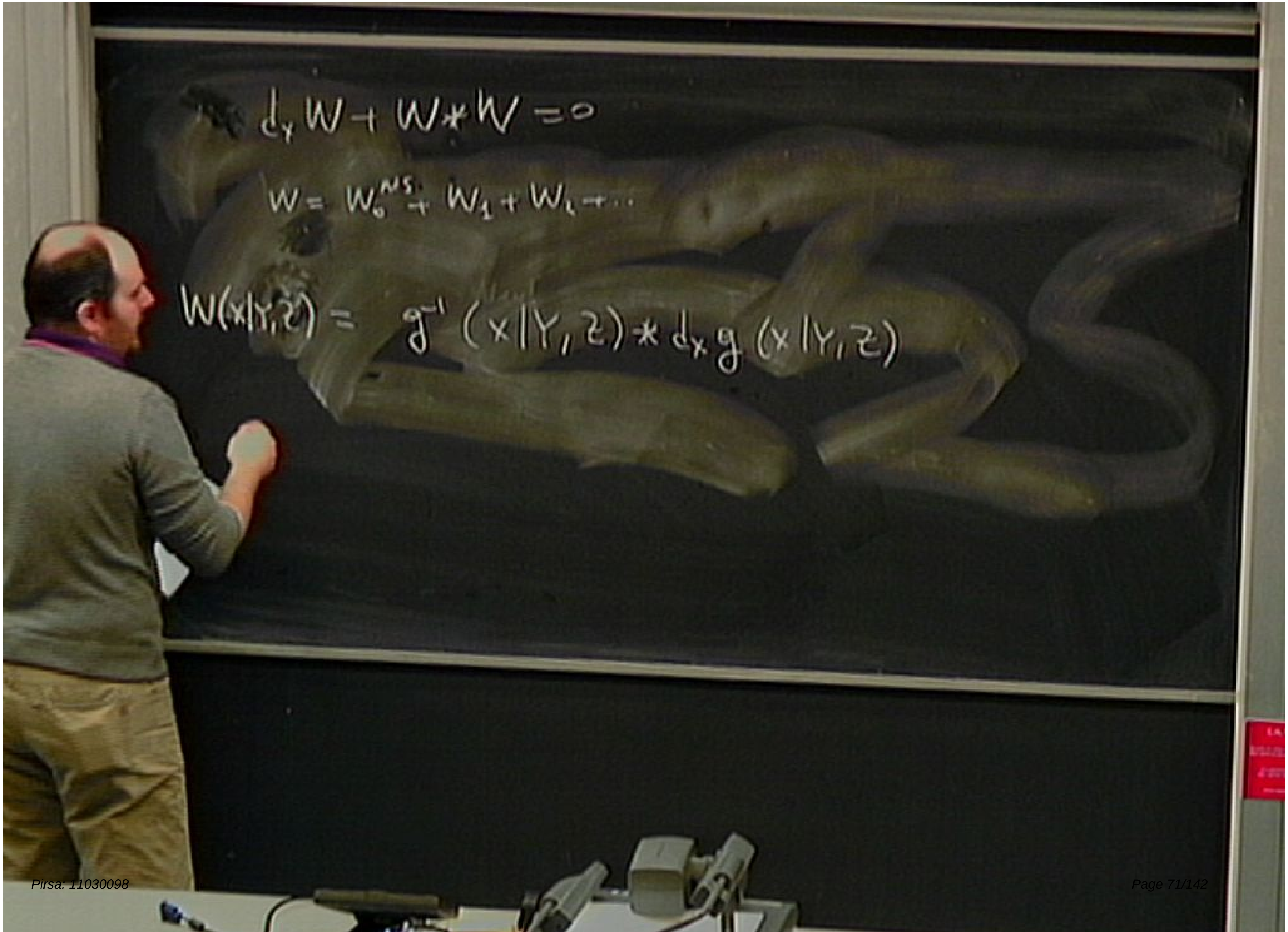
$$= \left\langle J_{s_1}(\vec{x}_1,\lambda_1)\, J_{s_2}(\vec{x}_2,\lambda_1)\, J_s(\vec{x},\lambda_s\right.$$

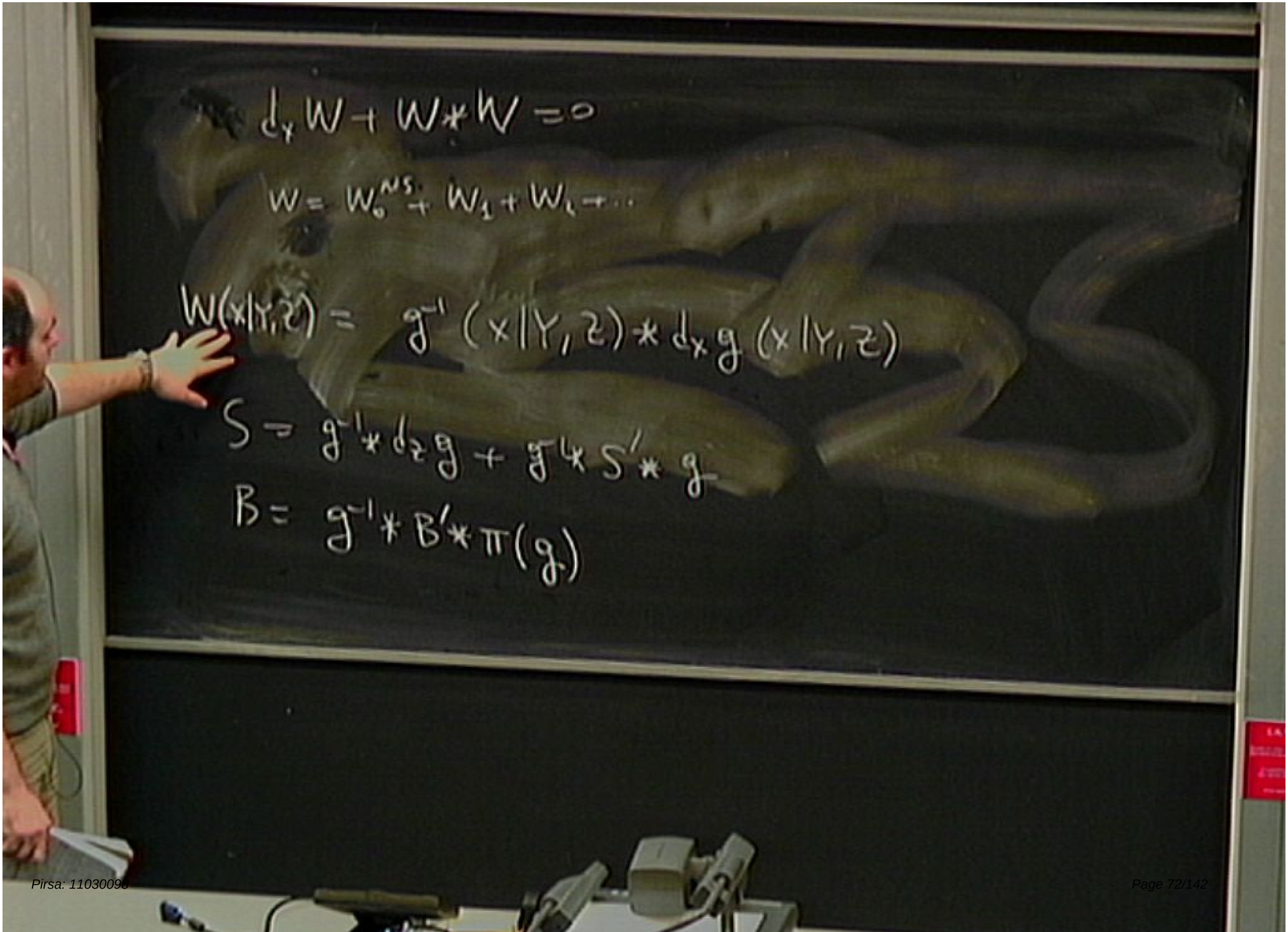


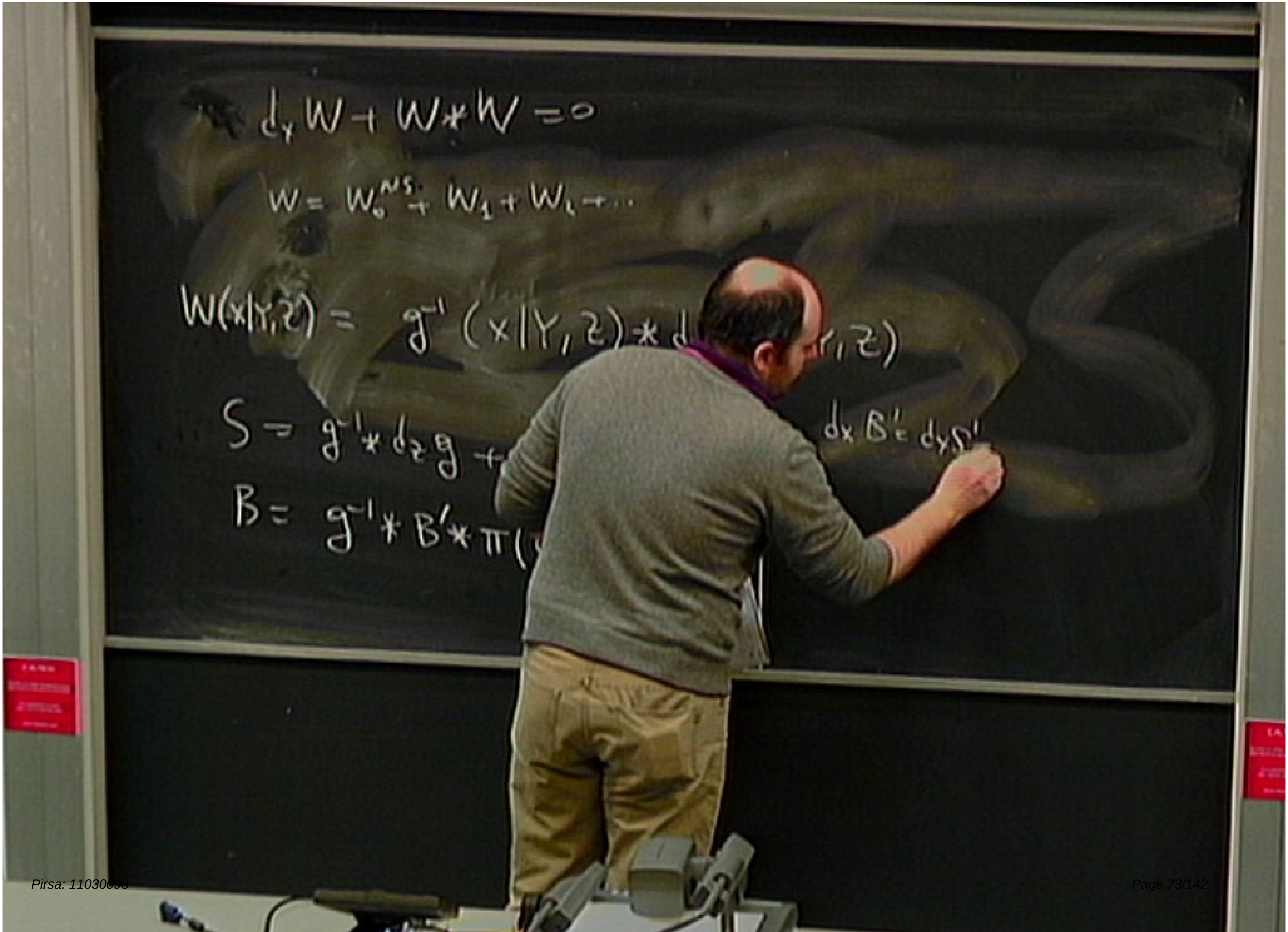
$d_\gamma W + W * W = 0$
$W = W_0^{N.S.} + W_1 + W$

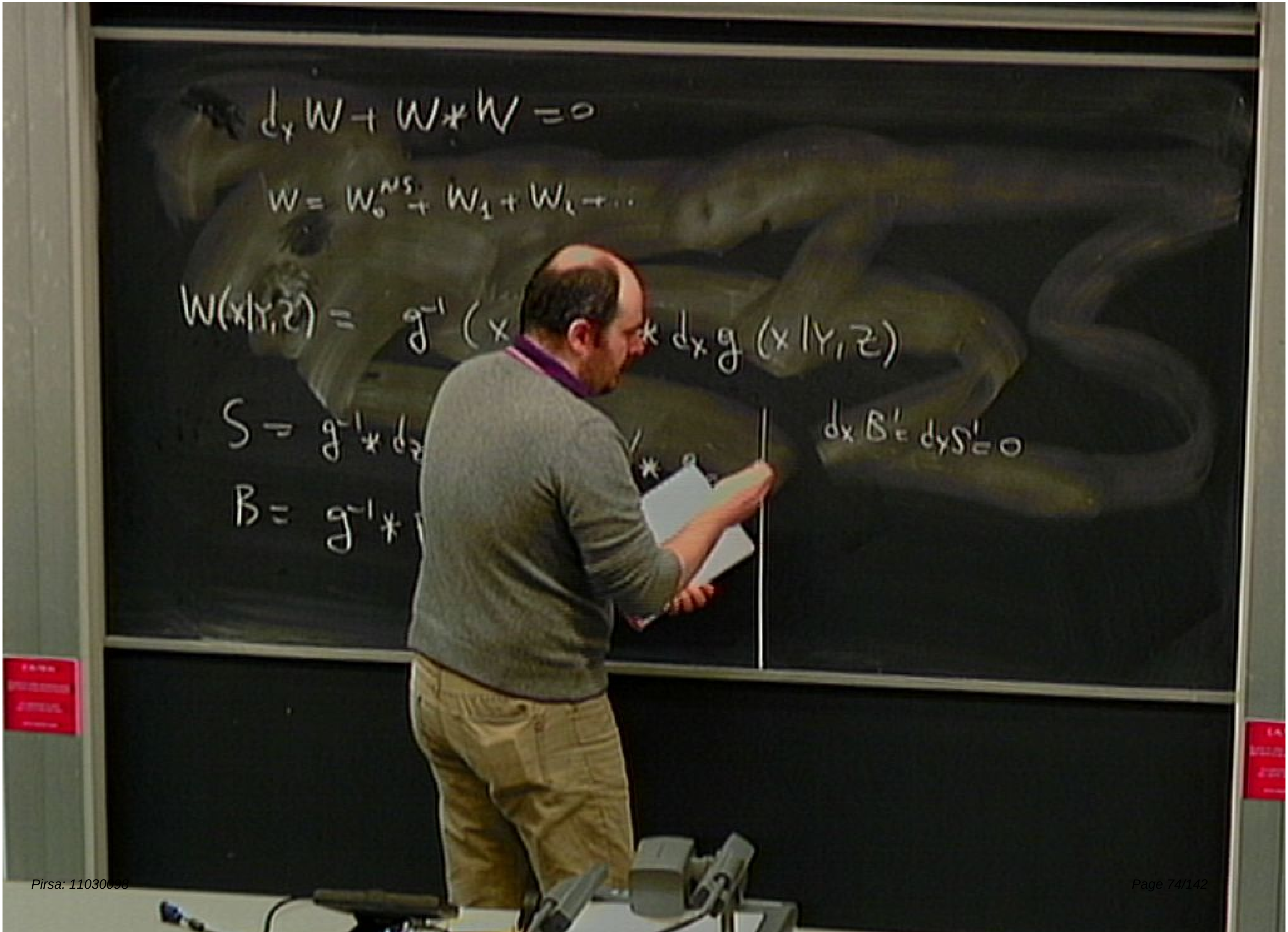


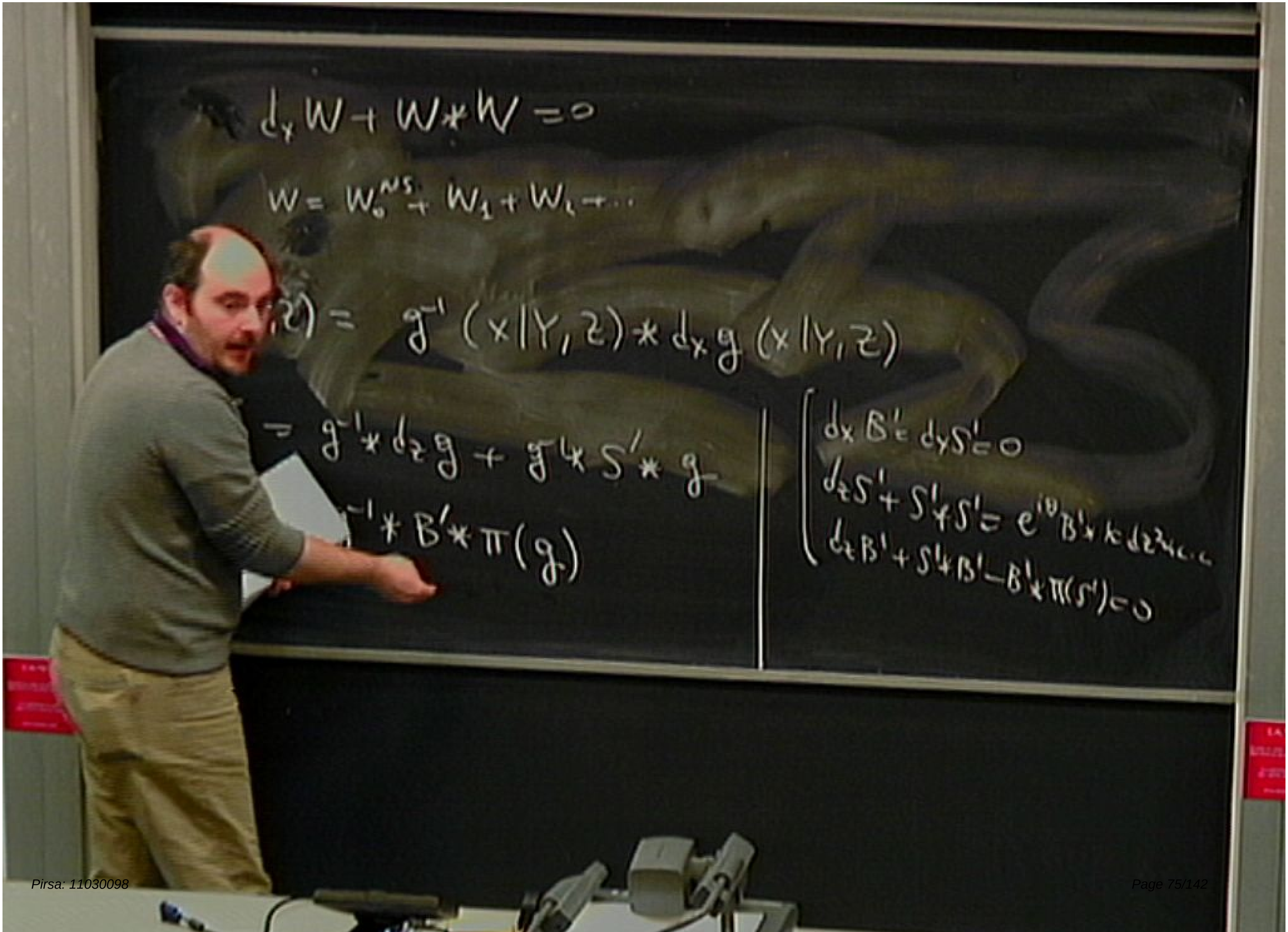
$d_x W + W * W = 0$
$W = W_0^{N.S.} + W_1 + W_2 + \cdots$
$W(x = g^{-1}(x|Y,z) * d_x g(x|Y,z)$

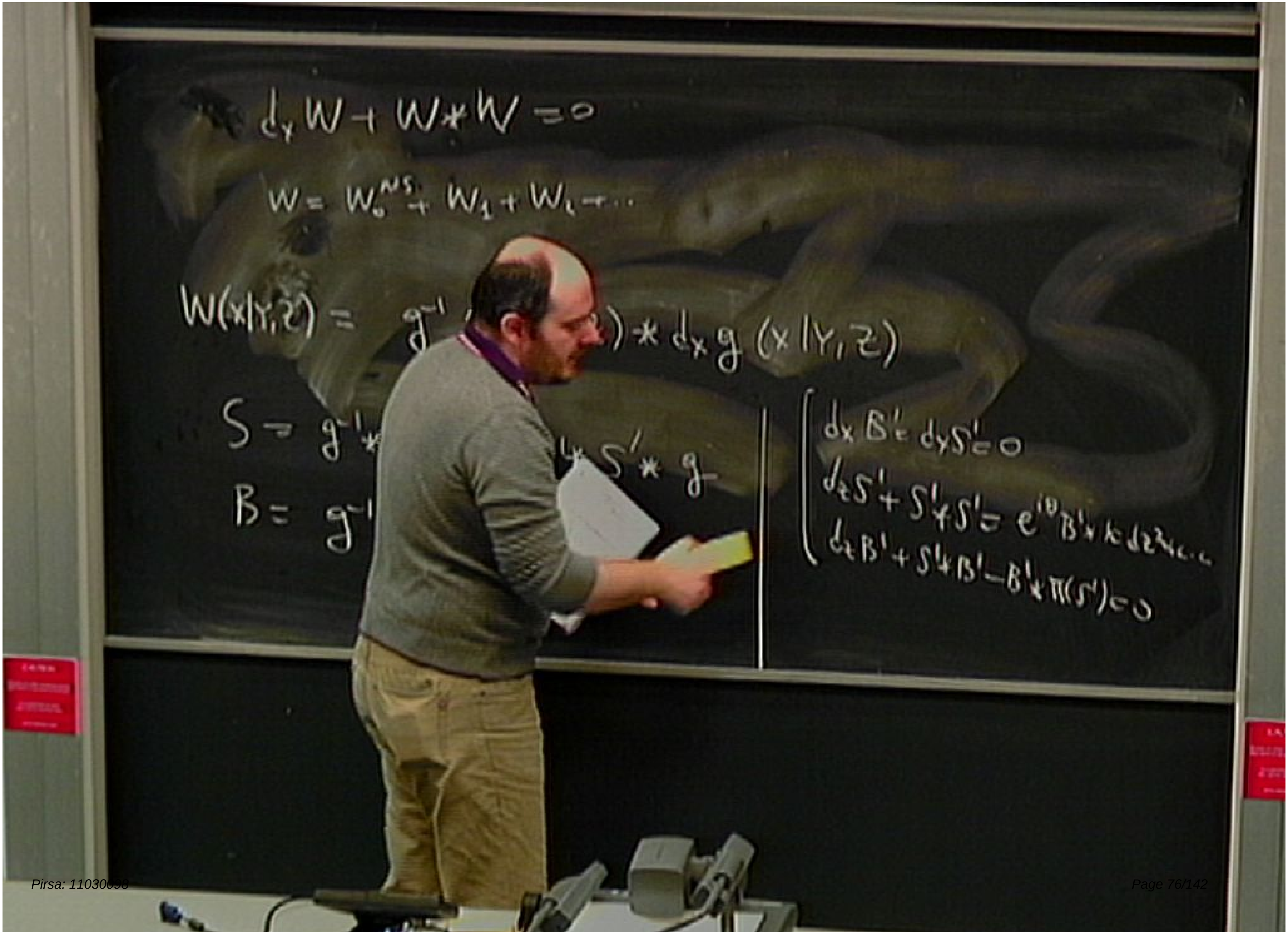

$d_x W + W * W = 0$
$W = W_0^{N.S.} + W_1 + W_2 + \dots$
$W(x|Y,Z) = g^{-1}(x|Y,Z) * d_x g(x|Y,Z)$

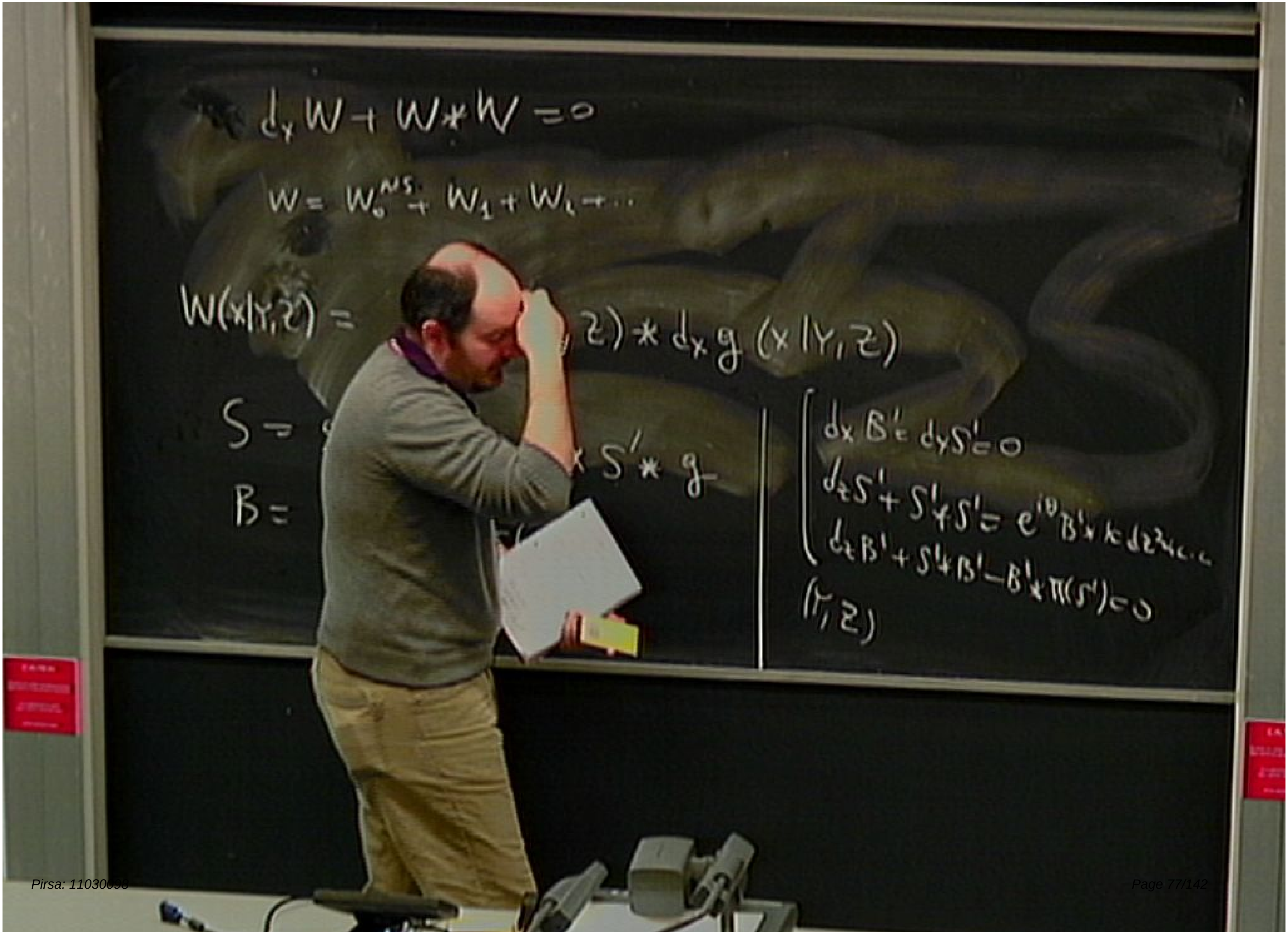

$d_x W + W * W = 0$
$W = W_0^{N.S.} + W_1 + W_2 + \dots$
$W(x|Y,Z) = g^{-1}(x|Y,Z) * d_x g(x|Y,Z)$
$S = g^{-1} * d_Z g + g^{-1} * S' * g$
$B = g^{-1} * B' * \pi(g)$


dY W + W*W = 0
W = W0N.S. + W1 + W2 + ...
W(x|Y,Z) = g-1 (x|Y,Z)*d
S = g-1*dZ g +
dx B' = dY S'
B = g-1 * B' * π(


d_x W + W*W = 0
W = W_0^{N.S.} + W_1 + W_2 + ...
W(x|Y,Z) = g^-1 (x
*d_x g (x|Y,Z)
S = g^-1 * d_z
d_x B' + d_y S' = 0
B = g^-1 *


dx W + W*W = 0
W = W0^N.S. + W1 + W2 + ...
(z) = g^-1 (x|Y, z) * dx g (x|Y, z)
= g^-1 * dz g + g^-1 * S' * g
-1 * B' * π(g)
dx B' = dY S' = 0
dz S' + S' * S' = e^iθ B' * k dz^2 + ...
dz B' + S' * B' - B' * π(S') = 0


d_x W + W*W = 0
W = W_0^{N.S.} + W_1 + W_2 + ...
W(x|Y,Z) = g^{-1}
)*d_x g (x|Y,Z)
S = g^{-1}*
S' g
B = g^{-1}
d_x B' + d_Y S' = 0
d_Z S' + S'*S' = e^{iθ} B'*k dz^2
d_Z B' + S'*B' - B'*π(S') = 0



$d_x W + W * W = 0$
$W = W_0^{N.S.} + W_1 + W_2 + \dots$
$W(x|Y,Z) =$
$Z) * d_x g (x|Y,Z)$
$S =$
$* S' * g$
$B =$
$d_x B' + d_Y S' = 0$
$d_Z S' + S' * S' = e^{i\theta} B' * k\, dz^2 + \dots$
$d_Z B' + S' * B' - B' * \pi(S') = 0$
(Y, Z)

$$d_x W + W * W = 0$$

$$W = W_0^{N.S.} + W_1 + W_2 + \dots$$

$$W(x|Y,z) = g^{-1}(x|Y,z) * d_x g(x|Y,z)$$

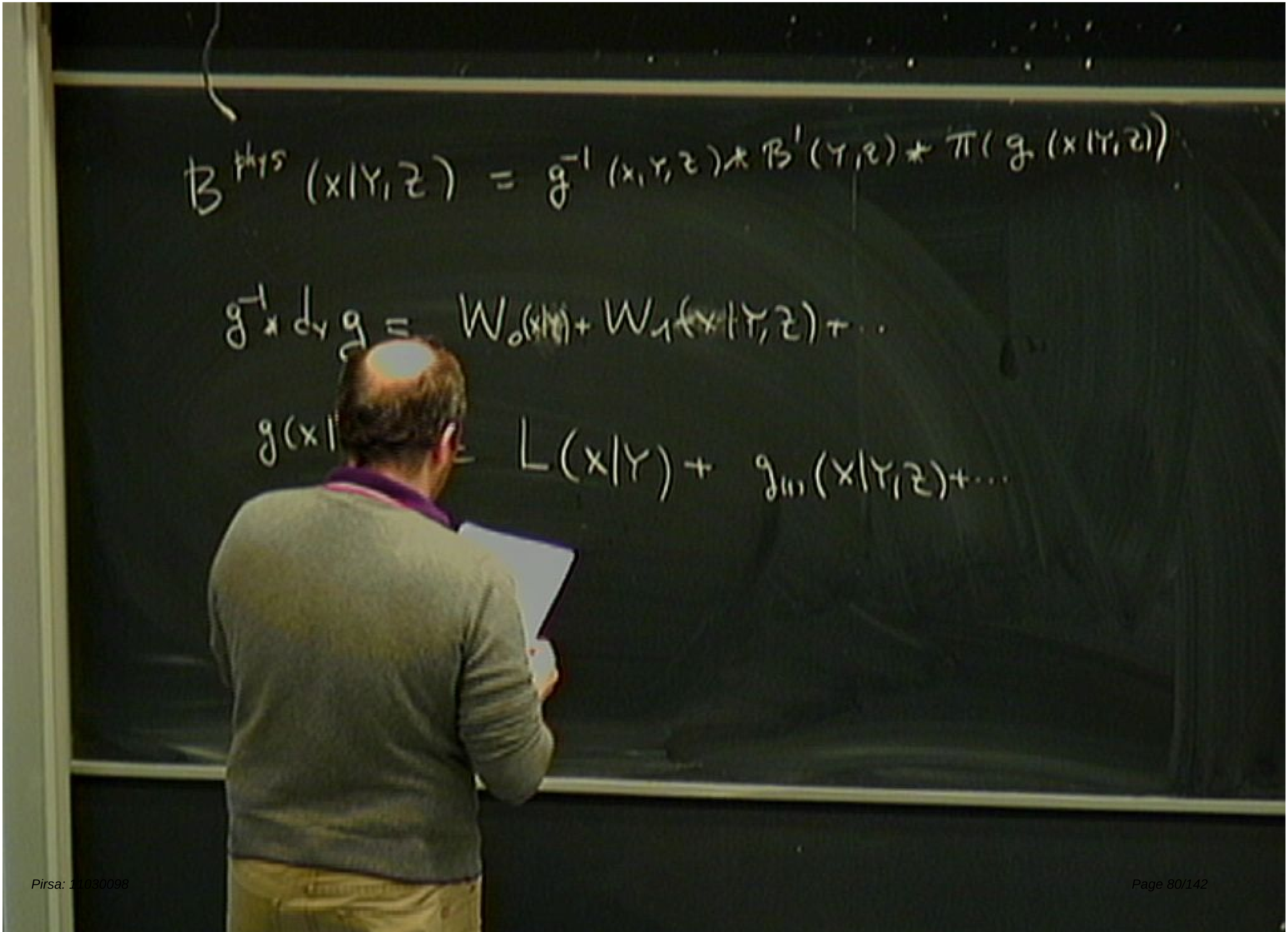
$$S = g^{-1} * d_z g + g^{-1} * S' * g$$

$$B = g^{-1} * B' * \pi(g)$$

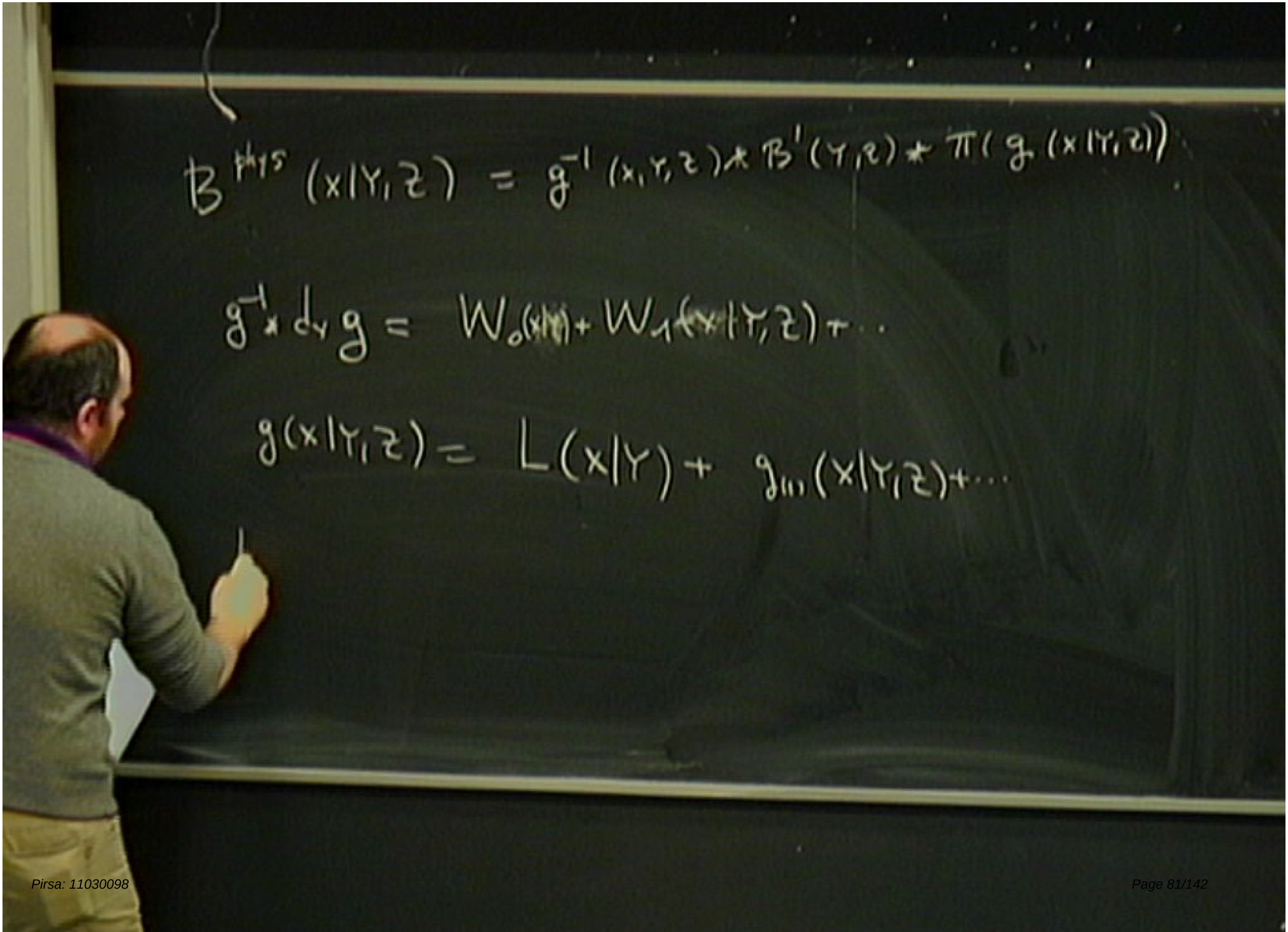
$$\begin{cases} d_x B' = d_x S' = 0 \\ d_z S' + S' * S' = e^{i\theta} B' * k\, dz^2 + \dots \\ d_z B' + S' * B' - B' * \pi(S') = 0 \end{cases}$$

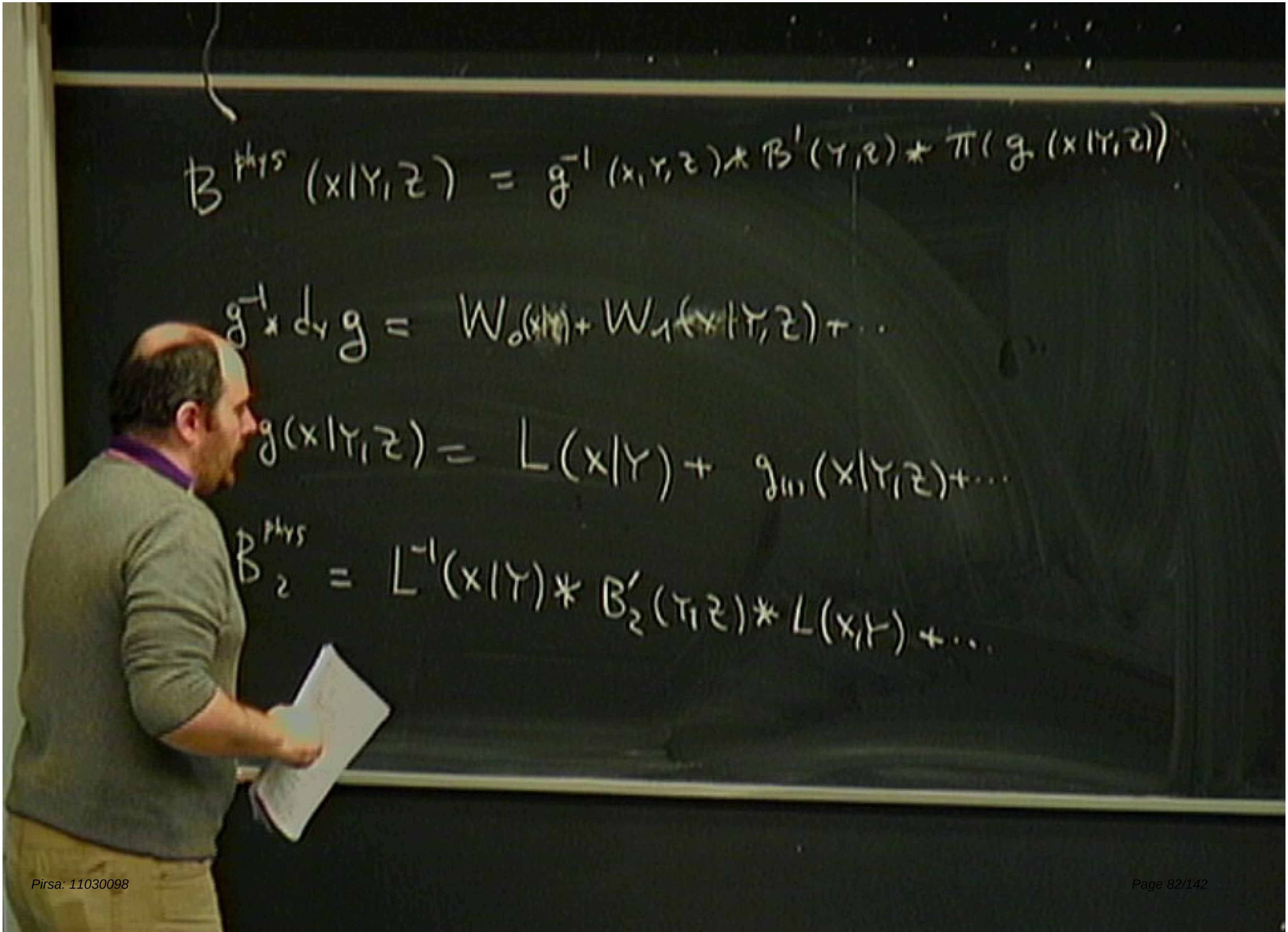
(Y, z)

$$B^{phys}(x|Y,Z) = g^{-1}(x,Y,Z) \star B'(Y,Z) \star \pi(g(x|Y,Z))$$



$B^{phys}(x|Y,Z) = g^{-1}(x,Y,Z) * B'(Y,Z) * \pi(g(x|Y,Z))$
$g^{-1} * d_Y g = W_0(x|Y) + W_1(x|Y,Z) + \cdots$
$g(x|$ … $L(x|Y) + g_{(1)}(x|Y,Z) + \cdots$


$B^{phys}(x|y,z) = g^{-1}(x,y,z) * B'(y,z) * \pi(g(x|y,z))$
$g^{-1} * d_y g = W_0(x|y) + W_1(x|y,z) + \cdots$
$g(x|y,z) = L(x|y) + g_{(1)}(x|y,z) + \cdots$

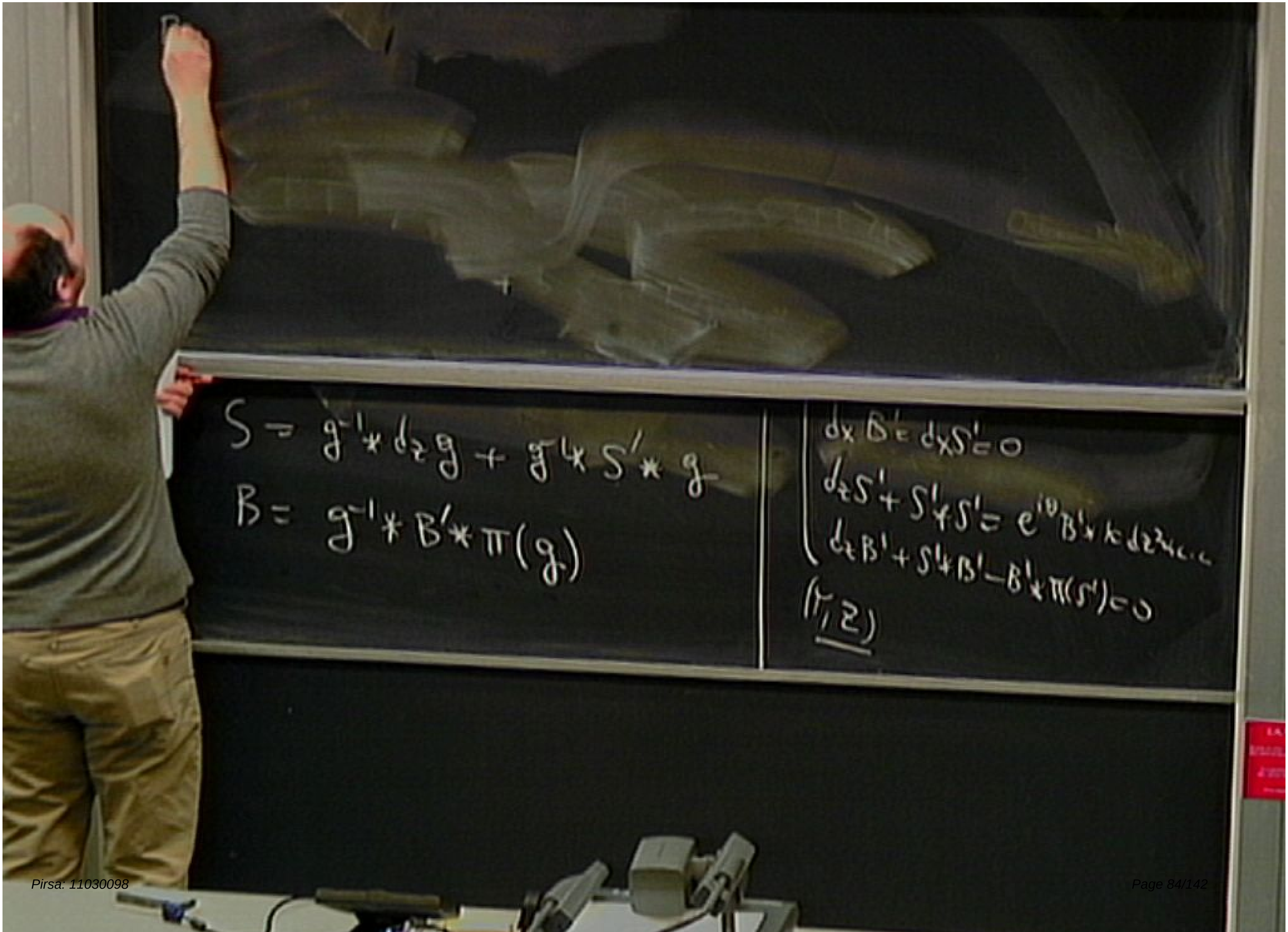

$B^{phys}(x|y,z) = g^{-1}(x,y,z) * B'(y,z) * \pi(g(x|y,z))$
$g^{-1} * d_y g = W_0(x|y) + W_1(x|y,z) + \cdots$
$g(x|y,z) = L(x|y) + g_{(1)}(x|y,z) + \cdots$
$B_2^{phys} = L^{-1}(x|y) * B'_2(y,z) * L(x,y) + \cdots$

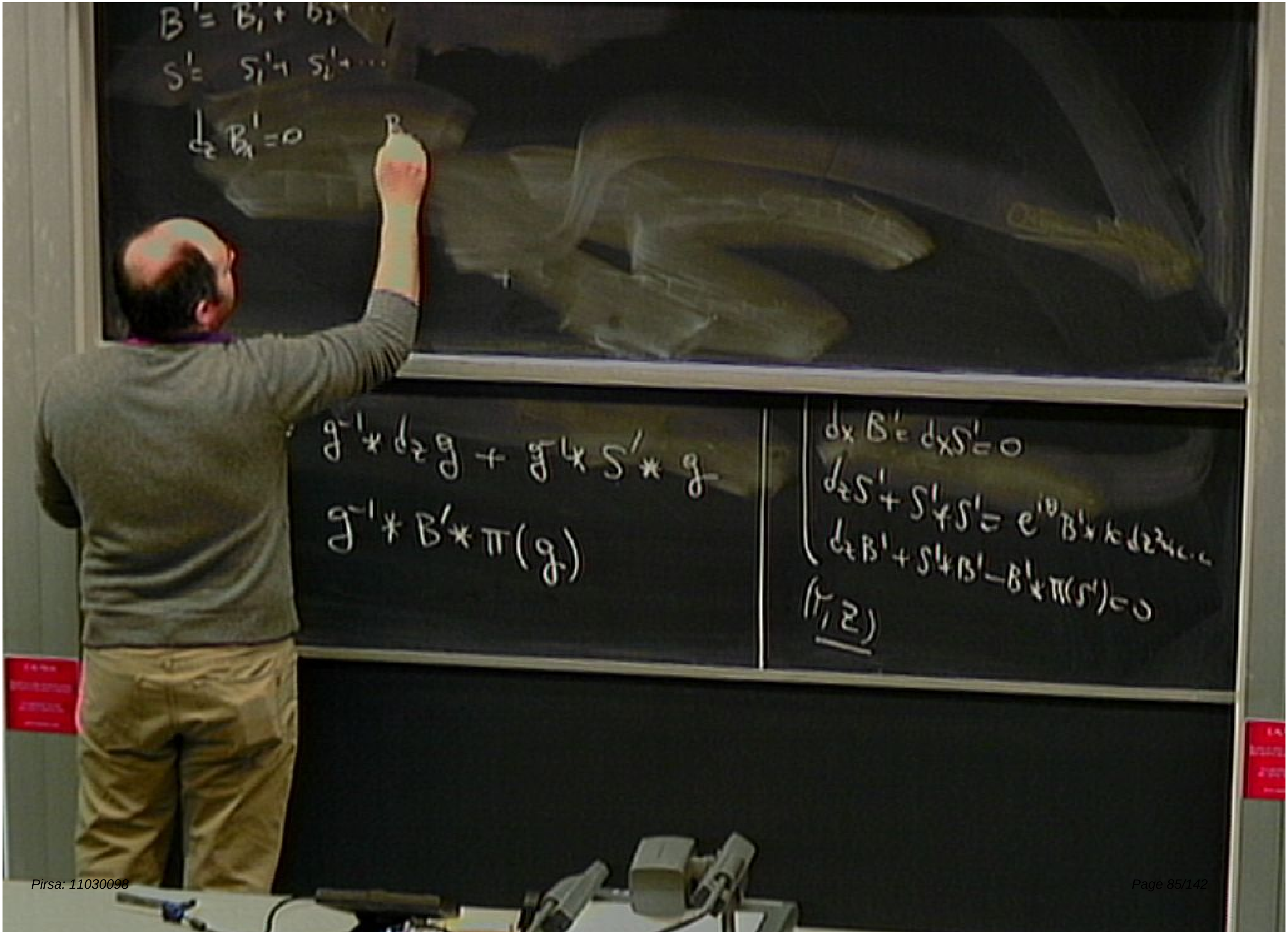
$$B^{phys}(x|Y,Z) = g^{-1}(x,Y,Z) * B'(Y,Z) * \pi(g(x|Y,Z))$$

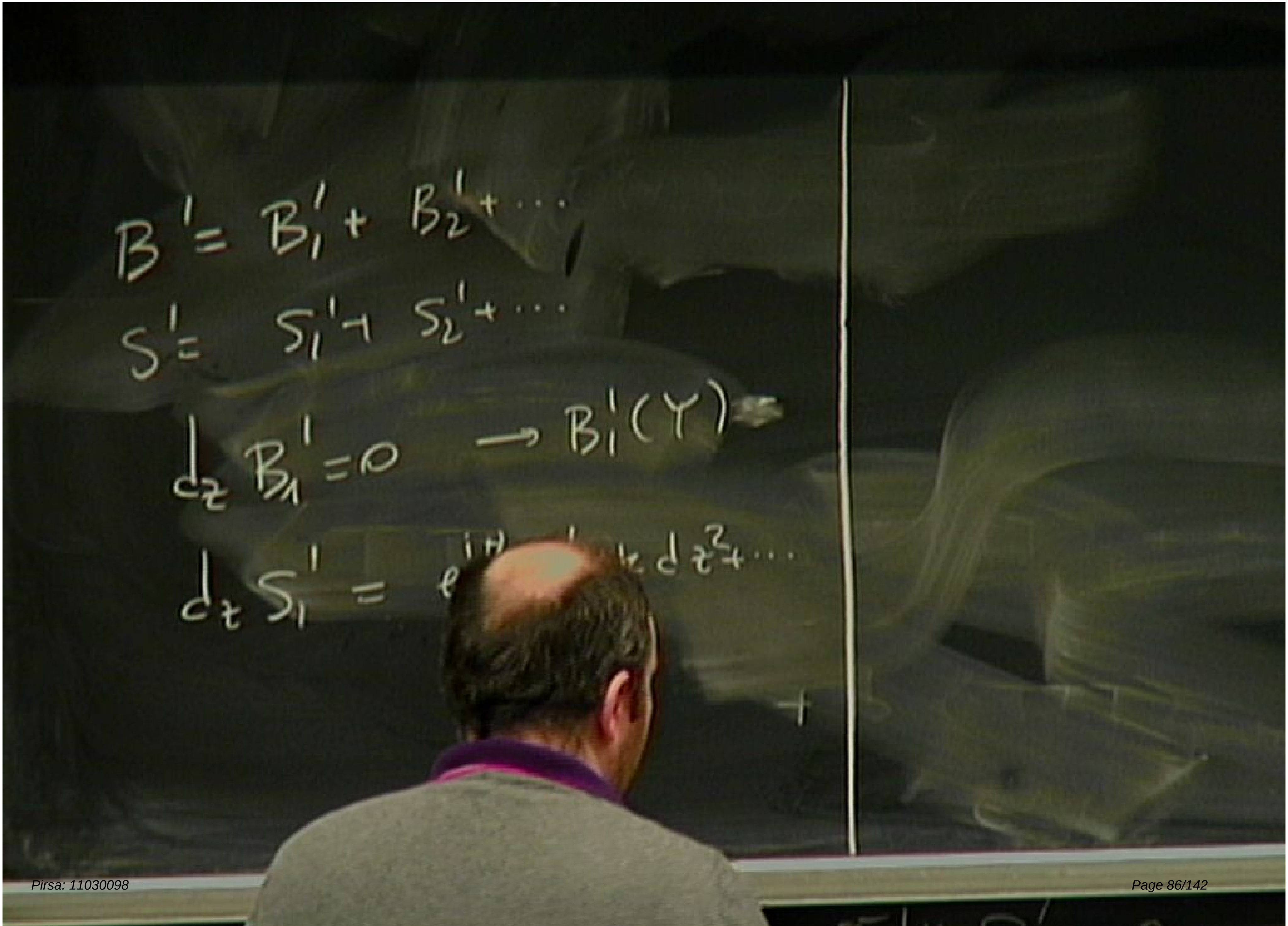
$$g^{-1} * d_Y g = W_0(x|Y) + W_1(x|Y,Z) + \cdots$$

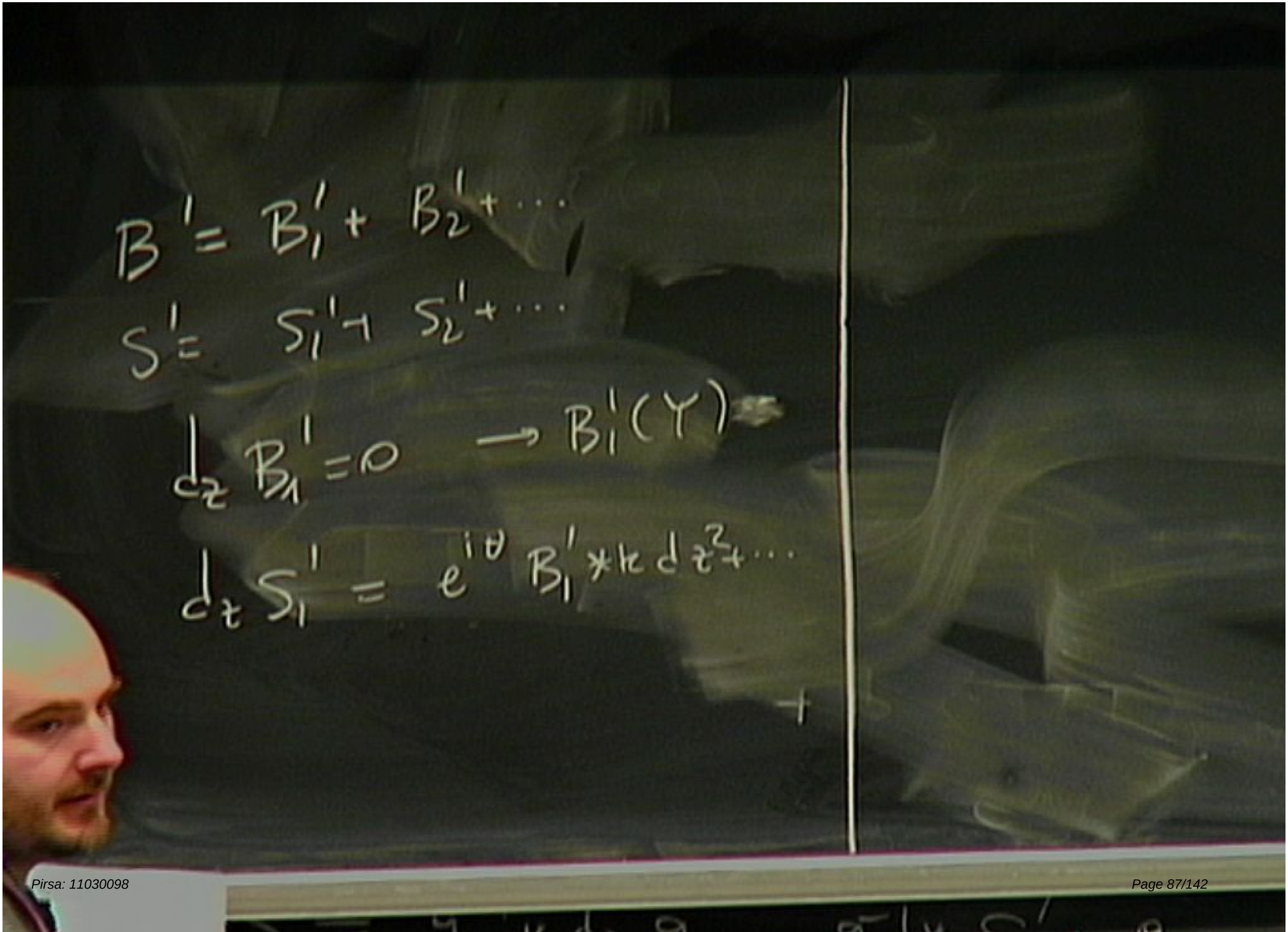
$$g(x|Y,Z) = \underline{L(x|Y)} + g_{(1)}(x|Y,Z) + \cdots$$

$$B_2^{phys} = L^{-1}(x|Y) * B_2'(Y,Z) * L(x,Y) + \cdots$$

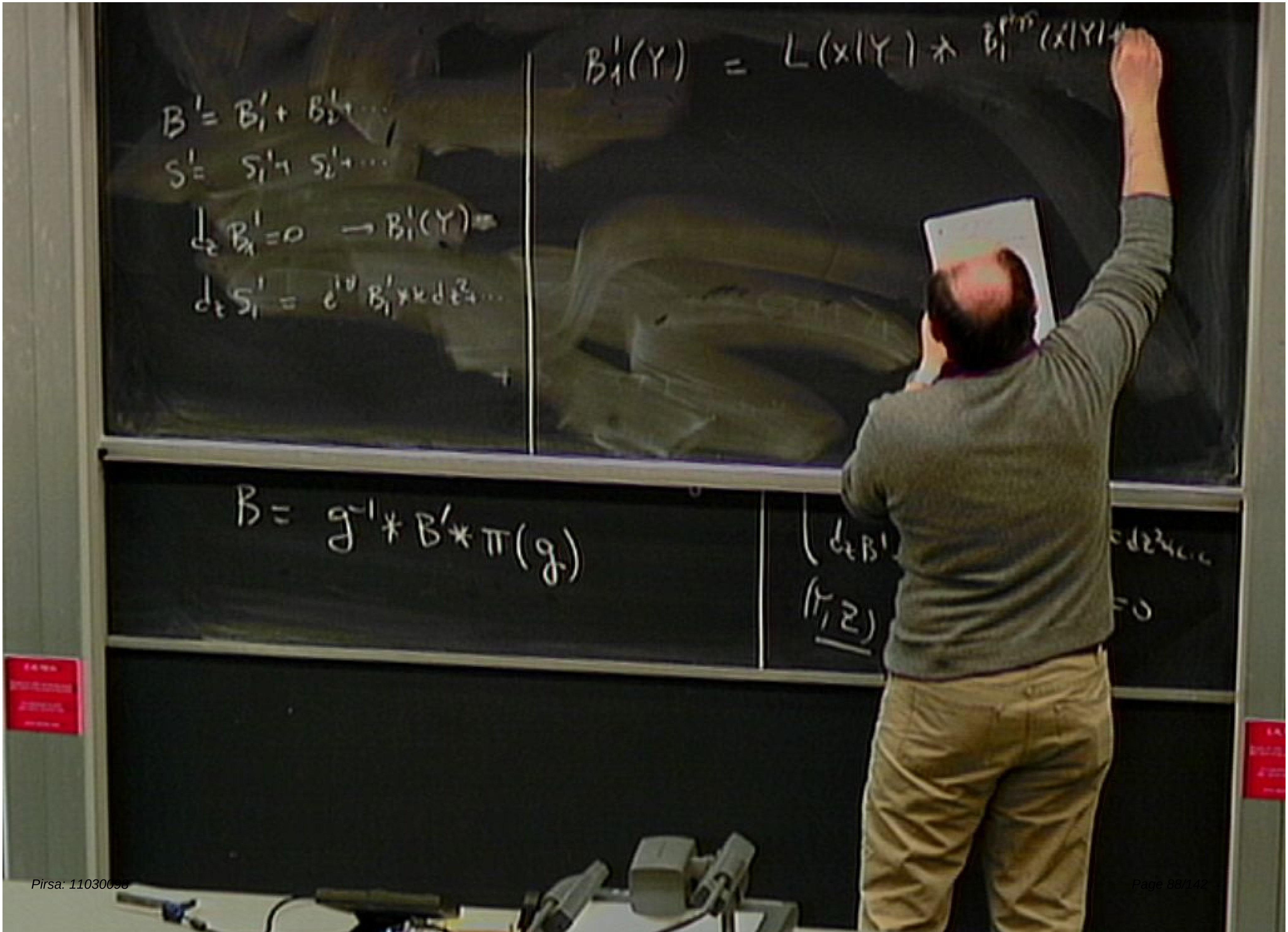

$S = g^{-1} * d_z g + g^{-1} * S' * g$
$B = g^{-1} * B' * \pi(g)$
$d_x B' = d_x S' = 0$
$d_z S' + S' * S' = e^{i\theta} B' * k\, dz^2 + \ldots$
$d_z B' + S' * B' - B' * \pi(S') = 0$
(t, z)


B' = B_1 + B_2 ...
S' = S_1' + S_2' + ...
d_z B_1' = 0
g^-1 * d_z g + g^-1 * S' * g
g^-1 * B' * π(g)
d_x B' = d_x S' = 0
d_z S' + S' * S' = e^iθ B' * k dz^2 + ...
d_z B' + S' * B' − B' * π(S') = 0
(Y, Z)


$B' = B_1' + B_2' + \cdots$
$S' = S_1' + S_2' + \cdots$
$d_z B_1' = 0 \longrightarrow B_1'(Y)$
$d_z S_1' = e$



$B' = B_1' + B_2' + \cdots$
$S' = S_1' + S_2' + \cdots$
$d_z B_1' = 0 \longrightarrow B_1'(Y)$
$d_z S_1' = e^{i\theta} B_1' * k\, dz^2 + \cdots$



$B_1'(Y) = L(x|Y) * B_1'(x|Y)+$
$B' = B_1' + B_2' + \cdots$
$S' = S_1' + S_2' + \cdots$
$d_z B_1' = 0 \rightarrow B_1'(Y)$
$d_t S_1' = \cdots B_1' * dz^2 + \cdots$
$B = g^{-1} * B' * \pi(g)$
(Y, Z)

$\partial \ldots \partial \; \varphi_{a_1 \ldots a_s}$

$\partial_z^s \; \varphi_{i_1 \ldots i_s}$

$$B_1^1(Y) = L(x|Y) * B_1^{phys}(x|Y) * \pi(L^{-1})$$

$$L(x|Y)$$

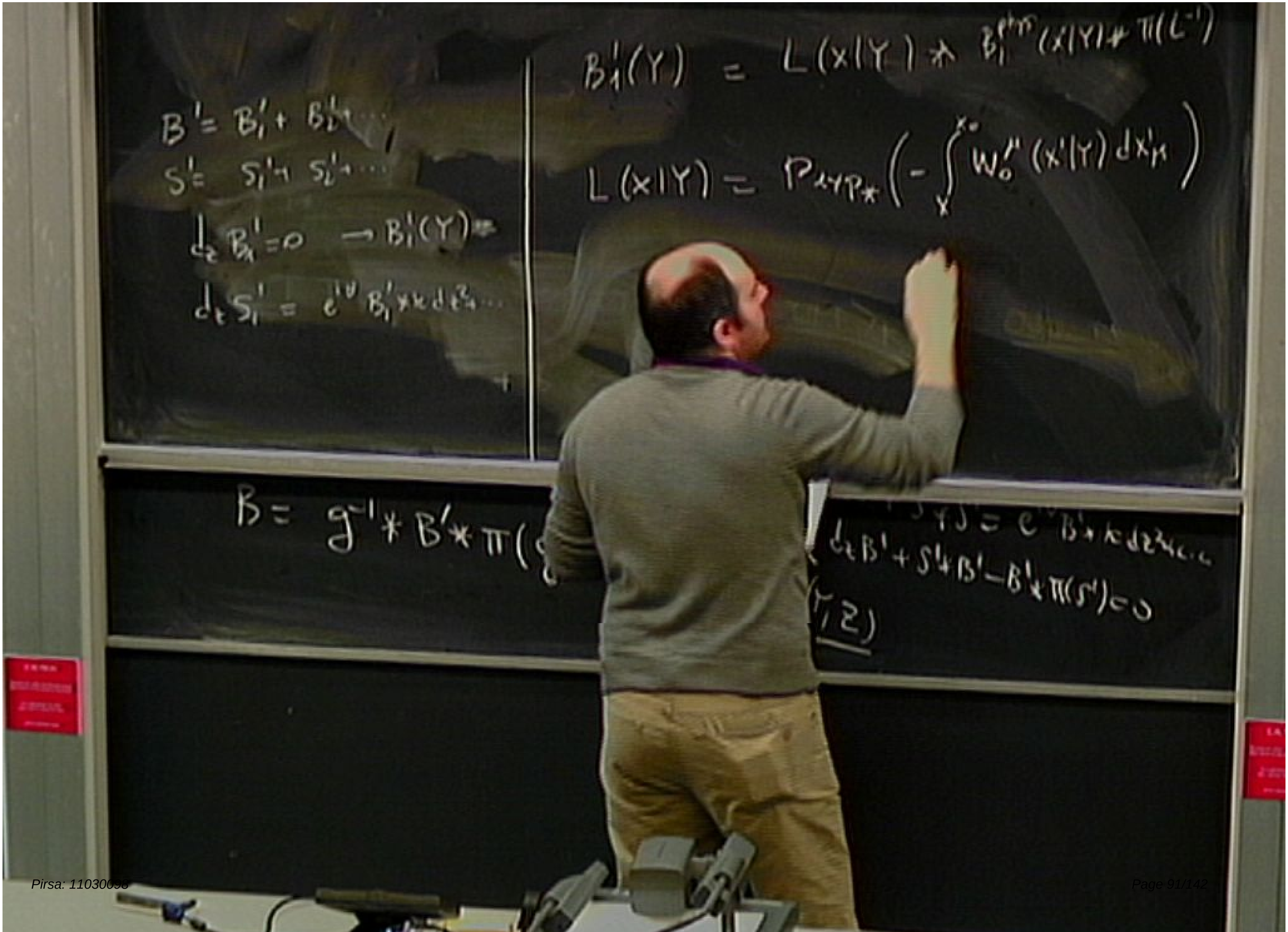
$$B^{phys}(x|Y,Z) = g^{-1}(x,Y,Z) * B'(Y,Z) * \pi(g(x|Y,Z))$$

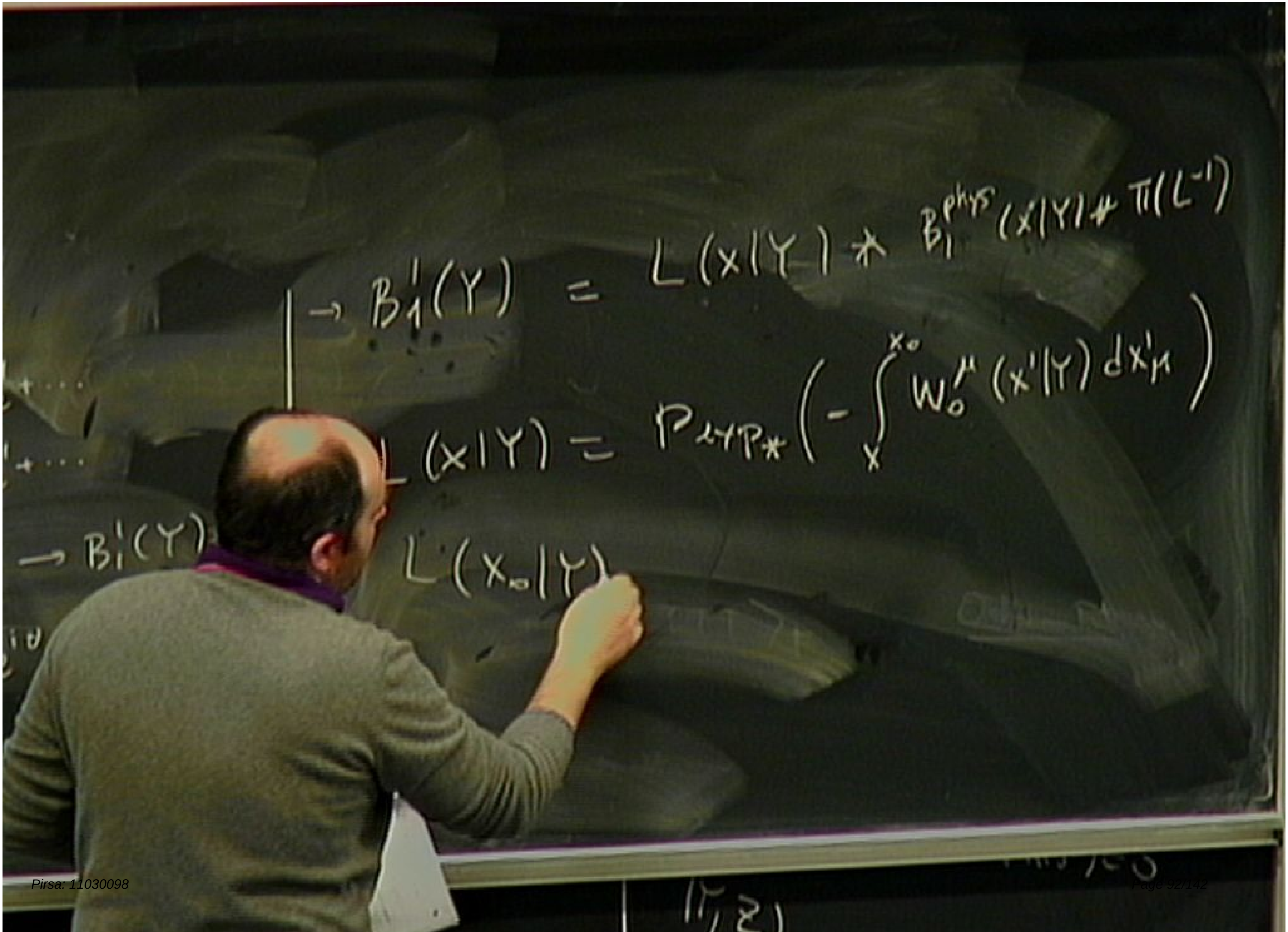
$$g^{-1} * d_Y g = W_0\cancel{(x|Y)} + W_1(x|Y,Z) + \cdots$$

$$g(x|Y,Z) = \underline{L(x|Y)} + \underline{g_{111}}(x|Y,Z) + \cdots$$

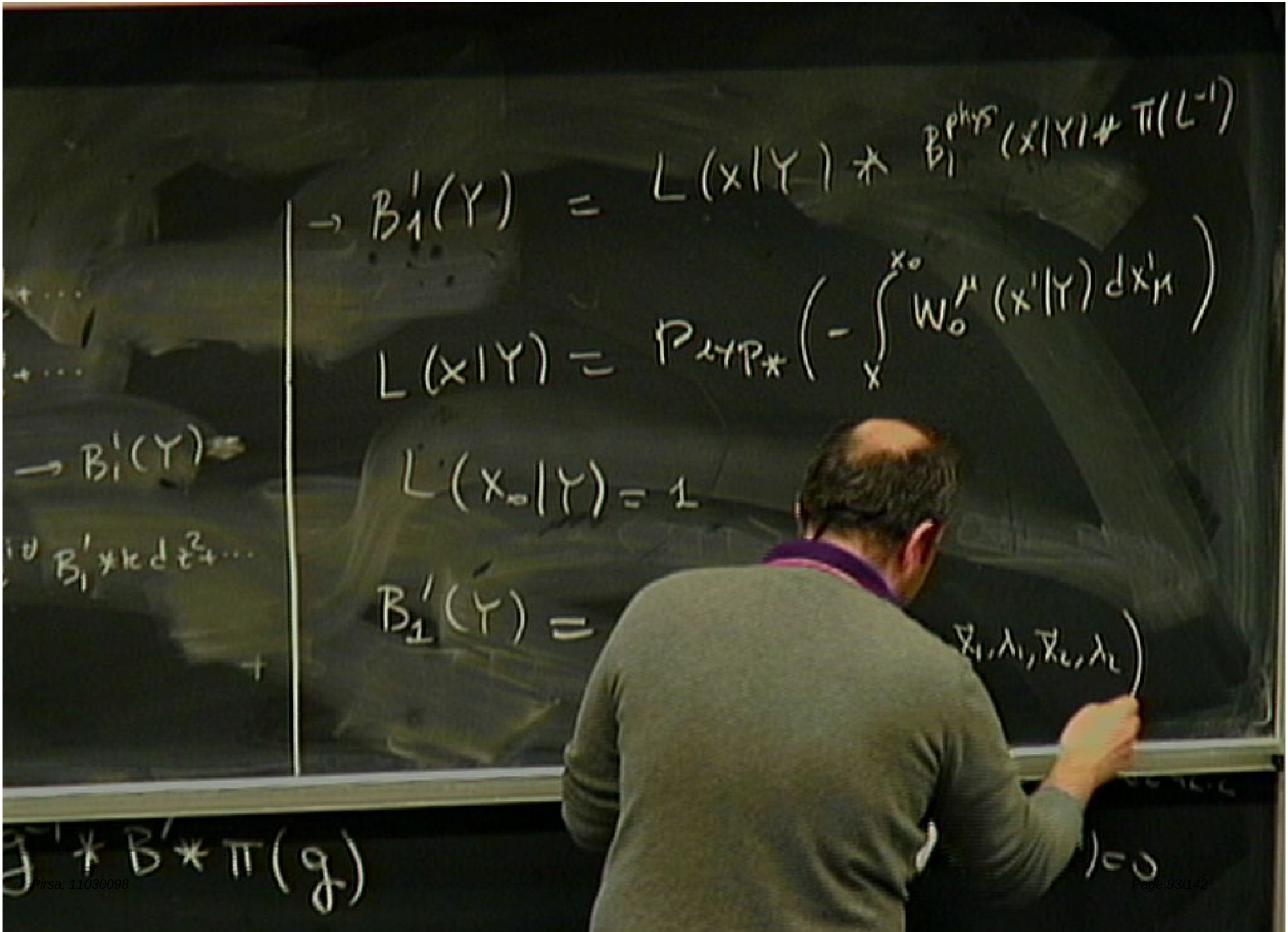
$$\uparrow$$

$$B_2^{phys} = L^{-1}(x|Y) * B_2'(Y,Z) * L(x,Y) + \cdots$$


B'_1(Y) = L(x|Y) * B_1(x|Y) * π(L^{-1})
B' = B'_1 + B'_2 + ...
S' = S'_1 + S'_2 + ...
d_t B'_1 = 0 → B'_1(Y)
d_t S'_1 = e^{iθ} B'_1 * k dt^2 + ...
L(x|Y) = P exp_* (- ∫_x^{x_0} W_0' (x'|Y) dx')
B = g^{-1} * B' * π(
d_t B' + S' * B' - B' * π(S') = 0



$\to B_1^1(Y) = L(x|Y) * B_1^{phys}(x|Y) \# \pi(L^{-1})$
$L(x|Y) = P_{exp_*}\left(-\int_{x}^{x_0} W_0'^{\mu}(x'|Y)\, dx'_\mu\right)$
$\to B_1^1(Y)$
$L(x_0|Y)$


B'1(Y) = L(x|Y) * B1phys(x'|Y) # π(L-1)
L(x|Y) = Pexp*(- ∫ W0μ(x'|Y) dx'μ)
L(x0|Y) = 1
B'1(Y) =
x1, λ1, x2, λ2)
→ B'1(Y)
B'1 * k d t2 + ...
g-1 * B' * π(g)

$$\to B_1'(Y) = L(x|Y) * B_1^{phys}(x|Y) * \pi(L^{-1})$$

$$L(x|Y) = P_{exp_*}\left(- \int_x^{x_0} W_0'^{\mu}(x'|Y)\, dx'_{\mu} \right)$$

$$L(\ldots) = 1$$

$$B_1'(\ldots = B_1^{phys}(X_0|Y;\ \bar{x}_1, \lambda_1, \bar{x}_2, \lambda_2)$$

$+ \cdots$

$+ \cdots$

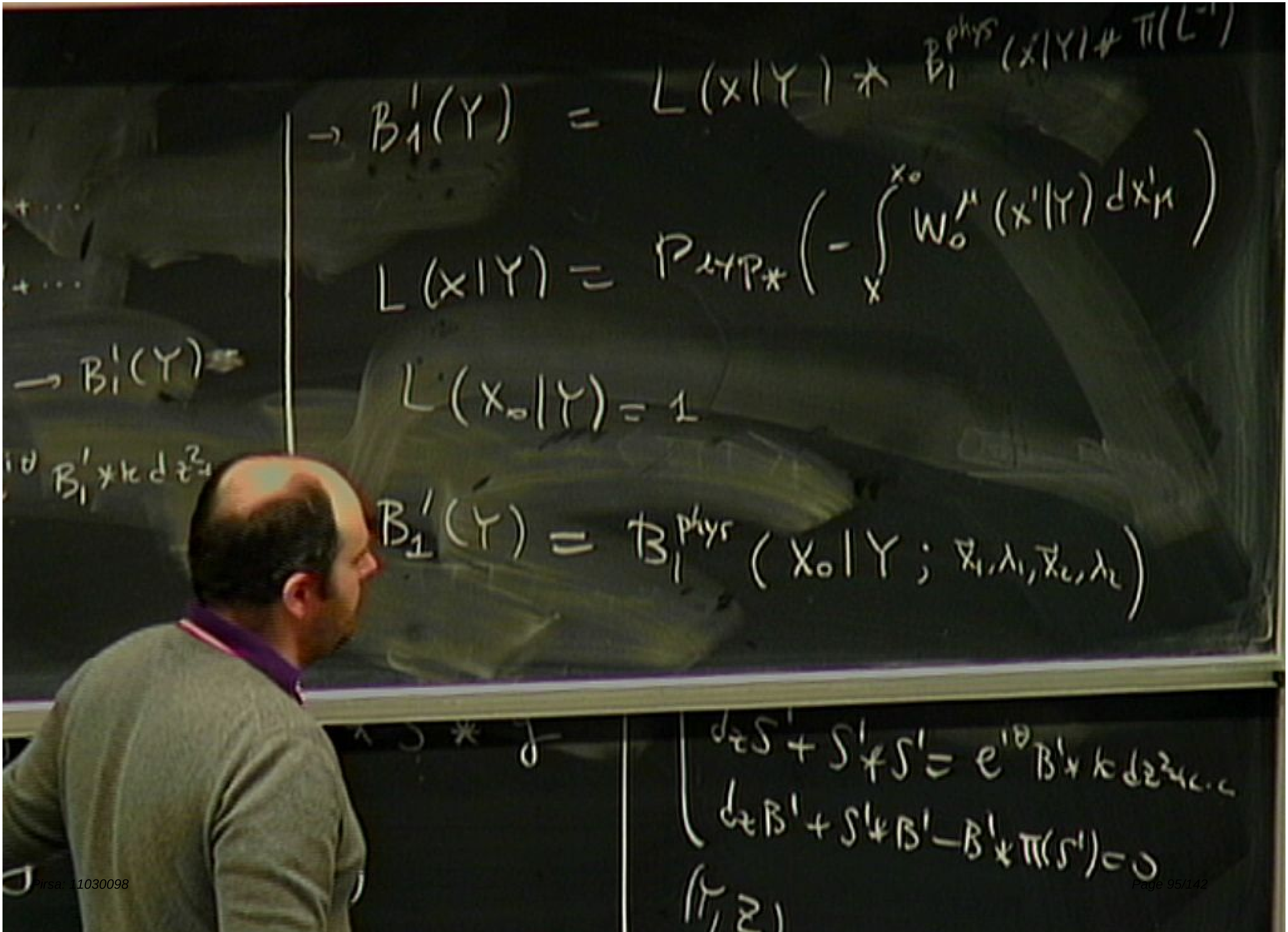
$\to B_1'(Y)$

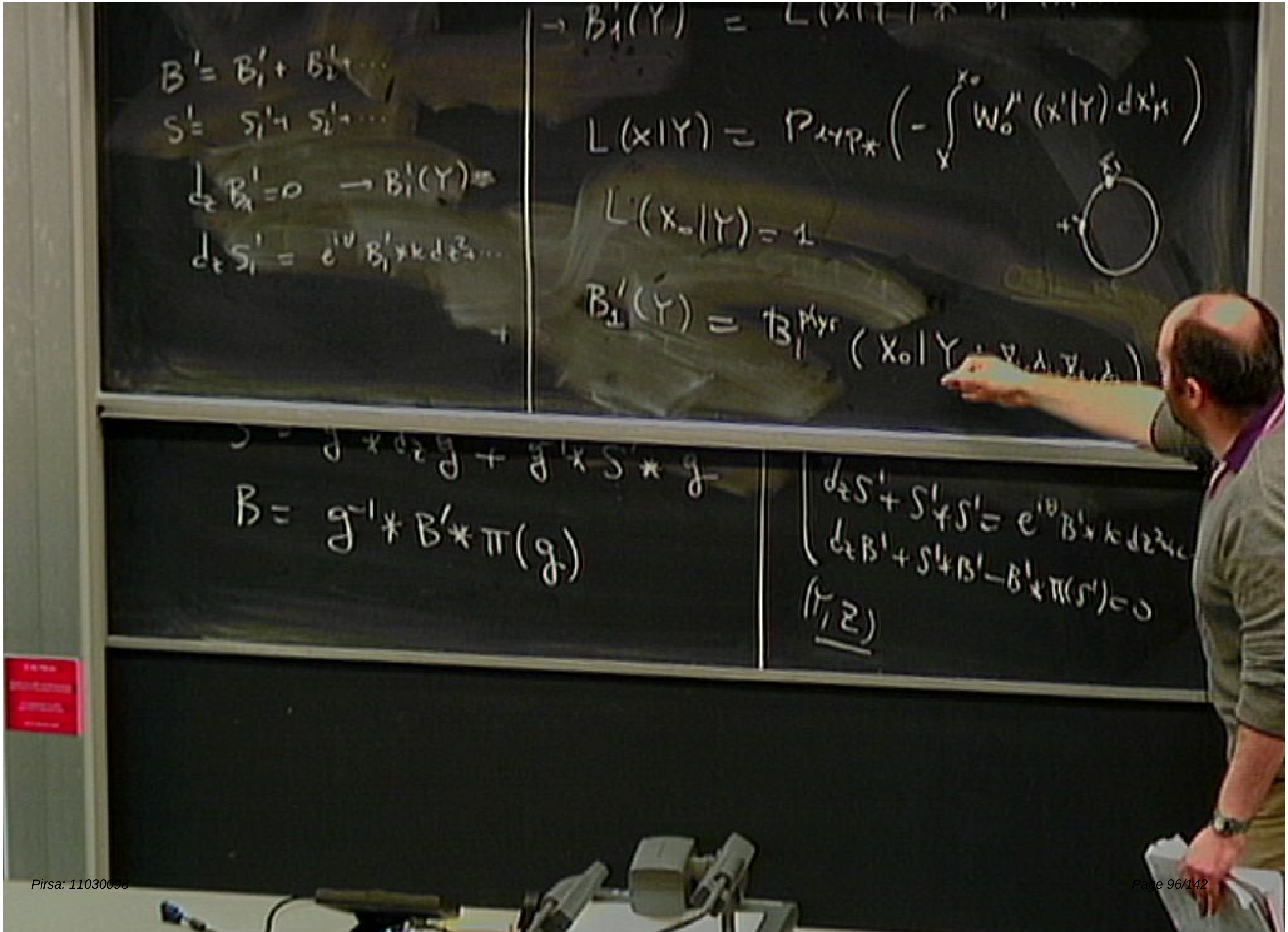
$B_1' * k\, dz^2 + \cdots$

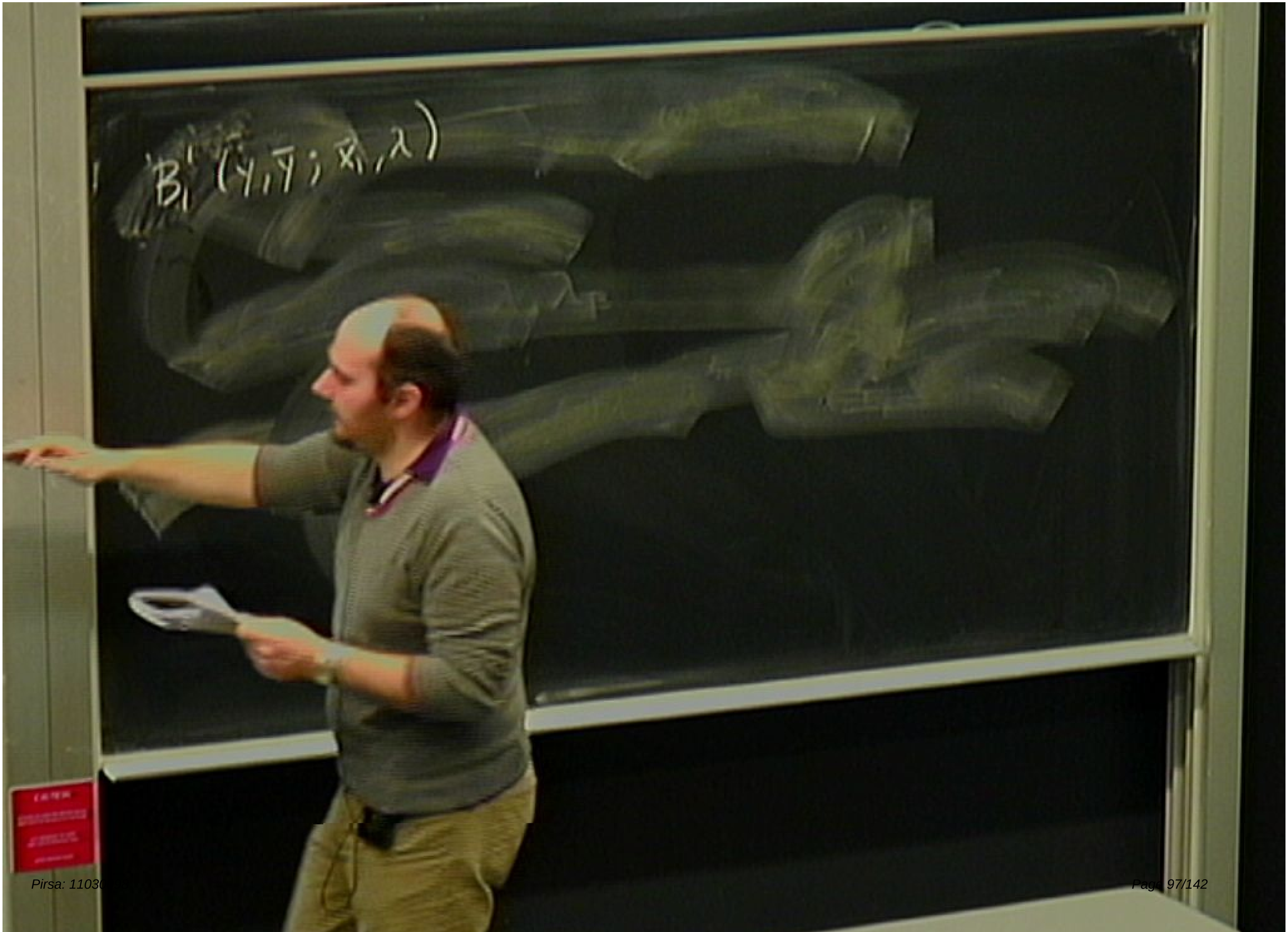
$+$

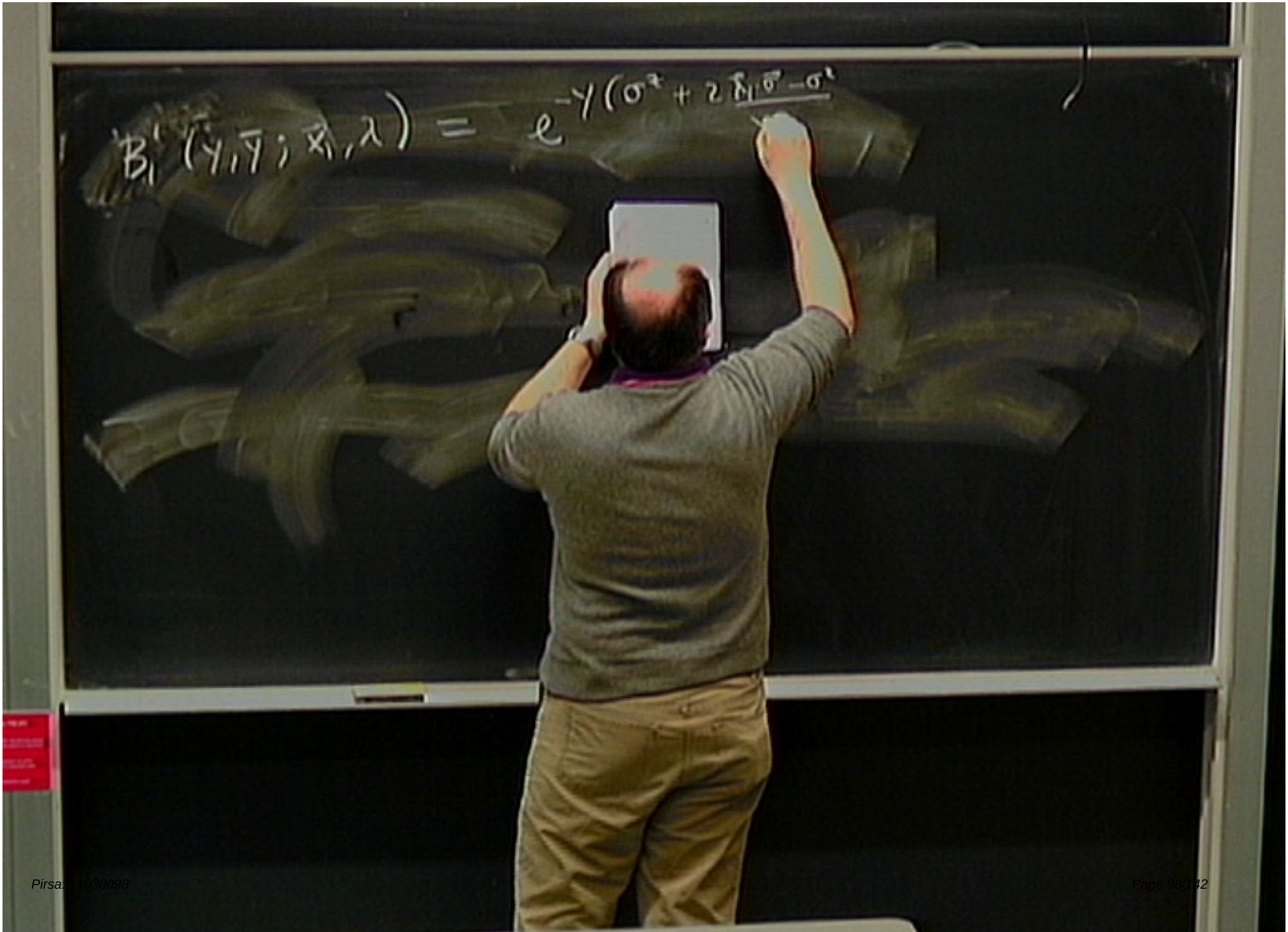
$g^{-1} * B' * \pi(g \ldots$

$\ldots d_t B' + S' * B' - B' * \pi(S') = 0$


$B_1'(Y) = L(x|Y) * B_1^{phys}(x'|Y) * \pi(L^{-1})$
$L(x|Y) = P\exp_*\left(-\int_x^{x_0} W_0'^{\mu}(x'|Y)\, dx'_\mu\right)$
$L(x_0|Y) = 1$
$B_1'(Y) = B_1^{phys}(X_0|Y; \bar{x}_1, \lambda_1, \bar{x}_2, \lambda_2)$
$\to B_1'(Y)$
$d_z S' + S' * S' = e^{i\theta} B' * k\, dz^2 + c.c.$
$d_z B' + S' * B' - B' * \pi(S') = 0$
(Y, Z)


B' = B'1 + B'2 + ...
S' = S'1 + S'2 + ...
dz B'1 = 0 → B'1(Y)
dz S'1 = e^iθ B'1 * κ dz² + ...
L(x|Y) = Pexp* (- ∫ W0^μ (x'|Y) dx'μ)
L(x0|Y) = 1
B = g^-1 * B' * π(g)
dz S' + S' * S' = e^iθ B' * κ dz²
dz B' + S' * B' - B' * π(S') = 0
(Y, Z)





$$B_1^{1}(y,\bar{y};\vec{x}_1,\lambda) = \frac{e^{-y\left(\sigma^2 + 2\frac{\vec{x}_1\cdot\vec{\sigma} - \sigma^2}{x_1^2+1}\right)\bar{y}}}{x_1^2+1}\left\{\exp\left[-2y\,\frac{\vec{x}_1\cdot\vec{\sigma}\,\sigma^{-1}}{x_1^2+1}\lambda_1+\cdots\right\}$$

$$B' = B'_1 + B'_2 + \cdots$$

$$S' = S'_1 + S'_2 + \cdots$$

$$d_z B'_1 = 0 \quad \rightarrow B'_1(Y)$$

$$d_z S'_1 = e^{i\theta} B'_1 * k\, dz^2 + \cdots$$

$$\rightarrow B'_1(Y) = L(x|Y) * B_1^{phys}(x|Y) * \pi(L^{-1})$$

$$L(x|Y) = P_{exp_*}\left(-\int_{x}^{x_0} W_0^{\prime\mu}(x'|Y)\, dx'_\mu \right)$$

$$L(x_0|Y) = 1 \qquad x_0 = (\vec{0}, z=i)$$

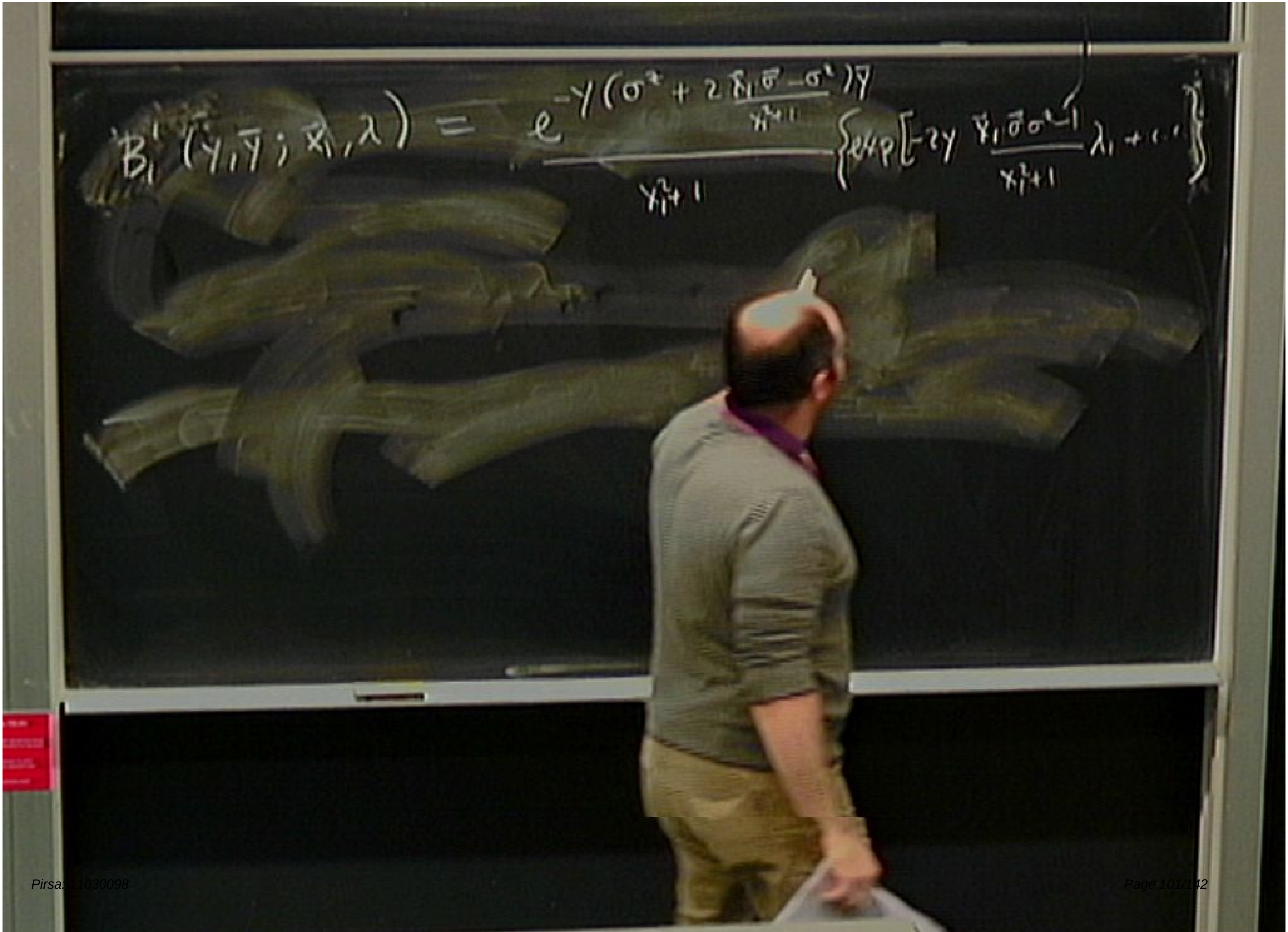
$$B'_1(Y) = B_1^{phys}(X_0|Y; \nu_1, \lambda_1, \nu_2, \lambda_2)$$

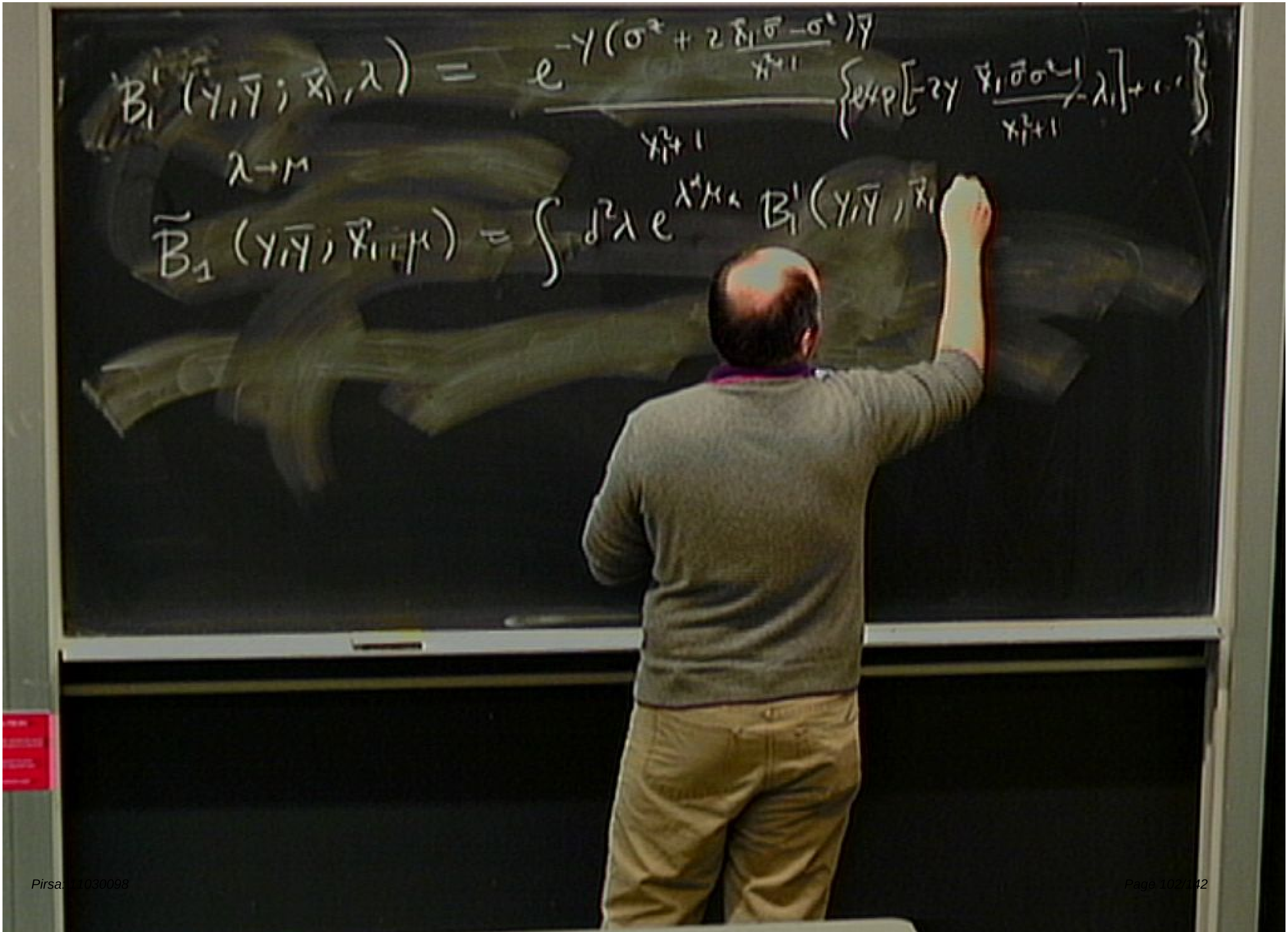
$$S = g^{-1} * d_z g + g^{-1} * S' * g$$

$$B = g^{-1} * B' * \pi(g)$$

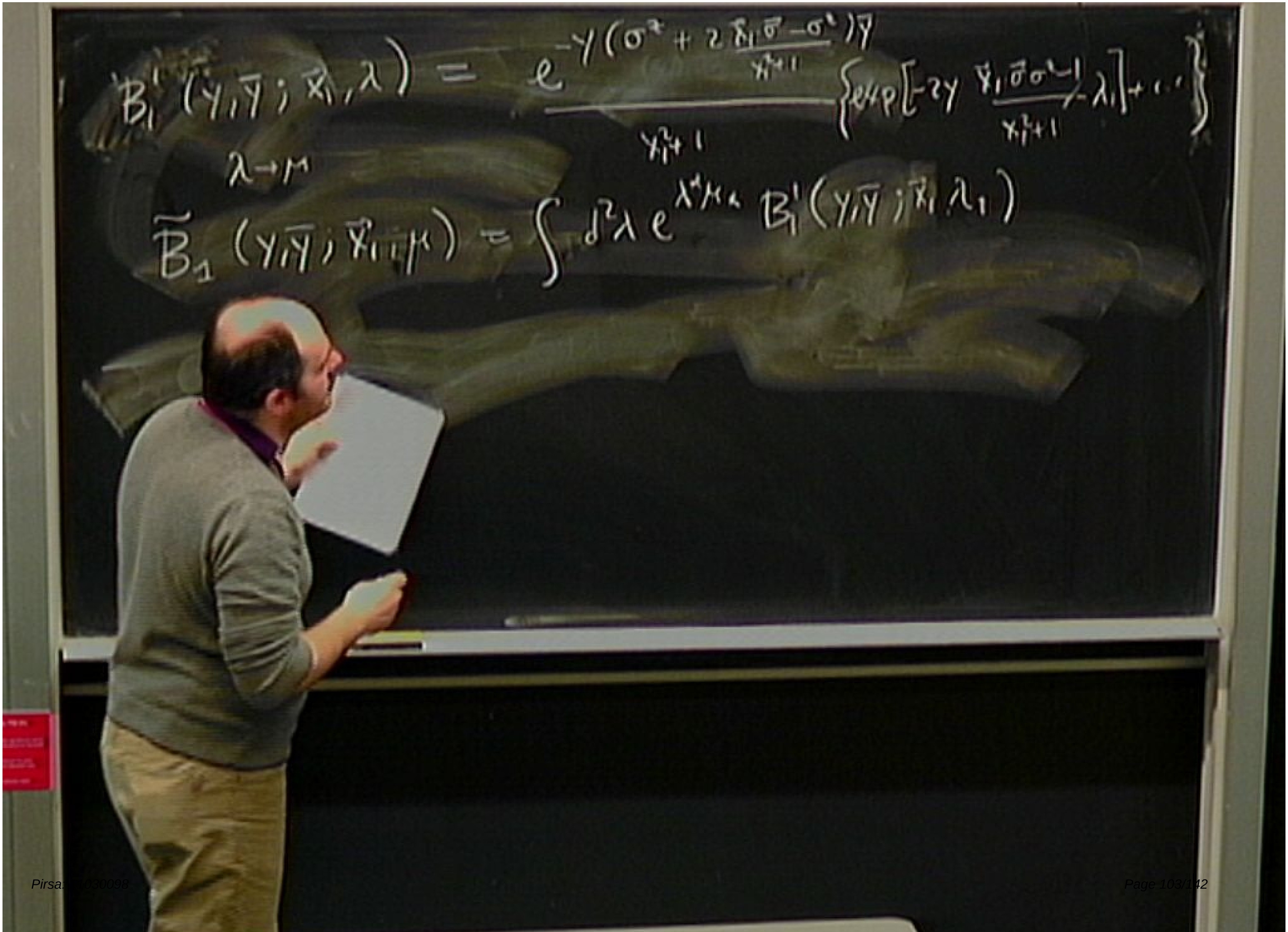
$$\begin{cases} d_z S' + S' * S' = e^{i\theta} B' * k\, dz^2 + \text{c.c.} \\ d_z B' + S' * B' - B' * \pi(S') = 0 \end{cases}$$

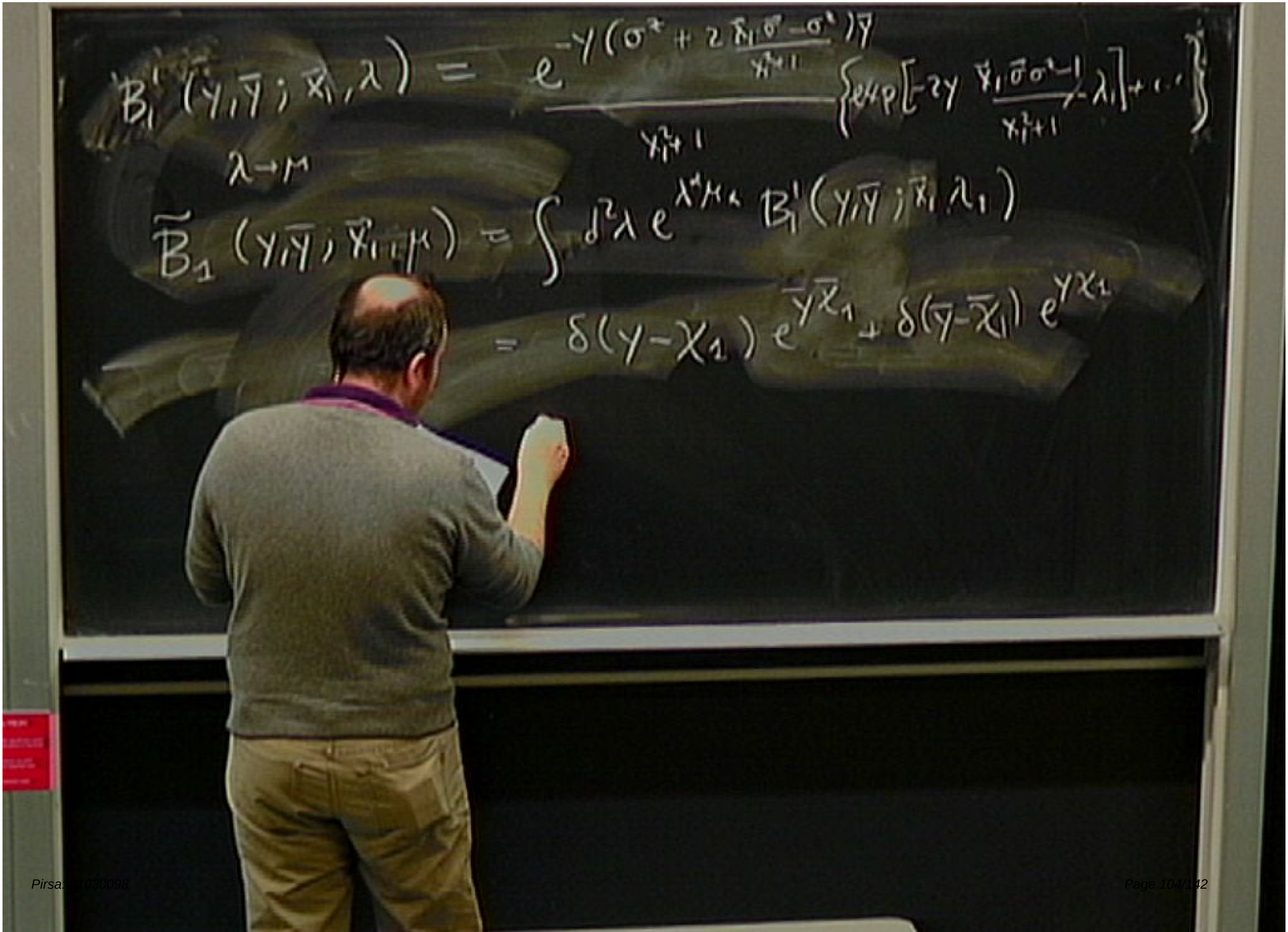
(Y, Z)

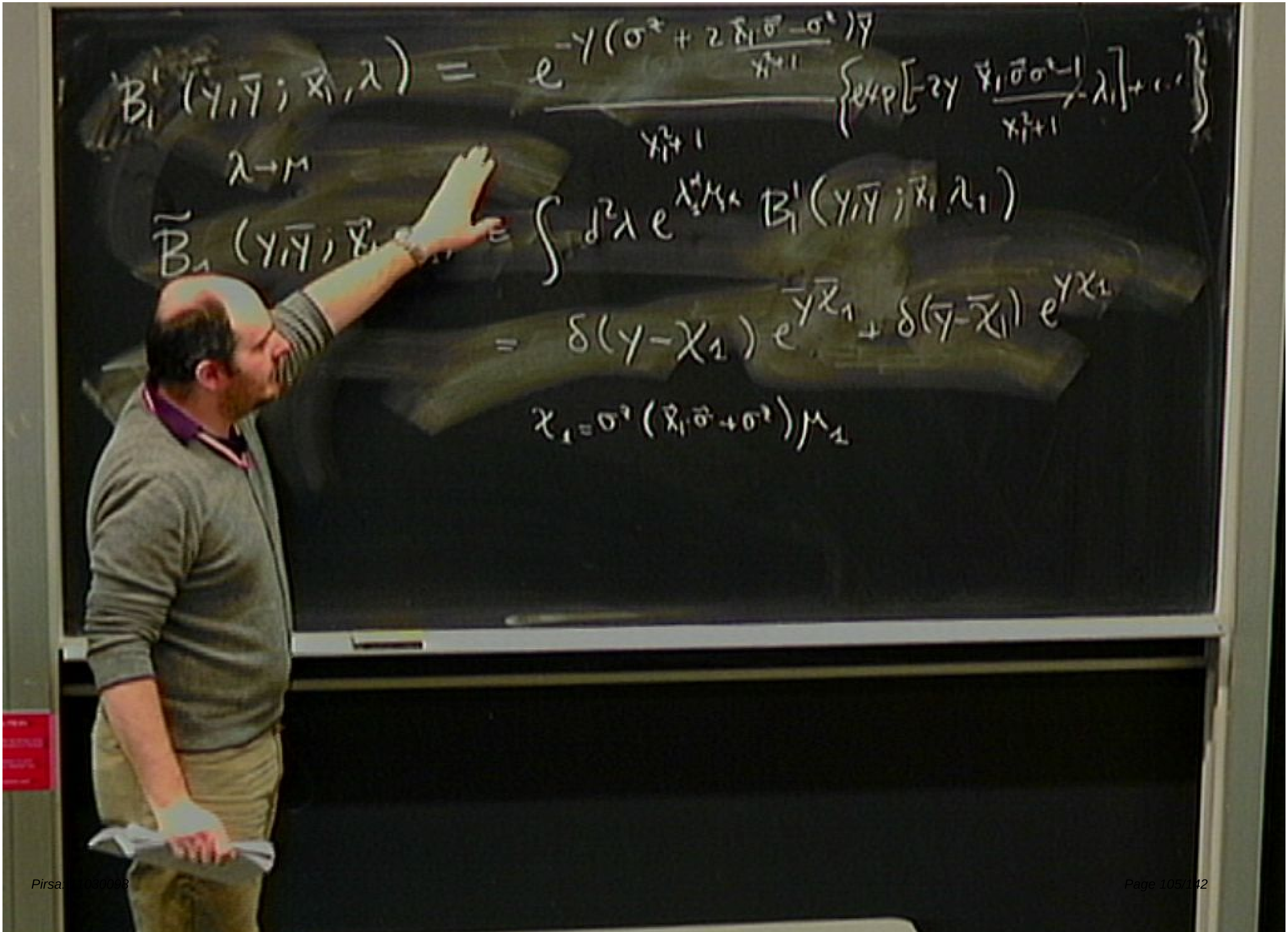

$B_1(y, \bar{y}; \vec{x}_1, \lambda) = \frac{e^{-y(\sigma^2 + 2\frac{\vec{x}_1 \cdot \vec{\sigma} - \sigma^2}{x_1^2+1})\bar{y}}}{x_1^2+1} \left\{ \exp\left[-2y \frac{\vec{x}_1 \cdot \vec{\sigma} \sigma \ldots}{x_1^2+1} \lambda_1 + \ldots \right] \right\}$

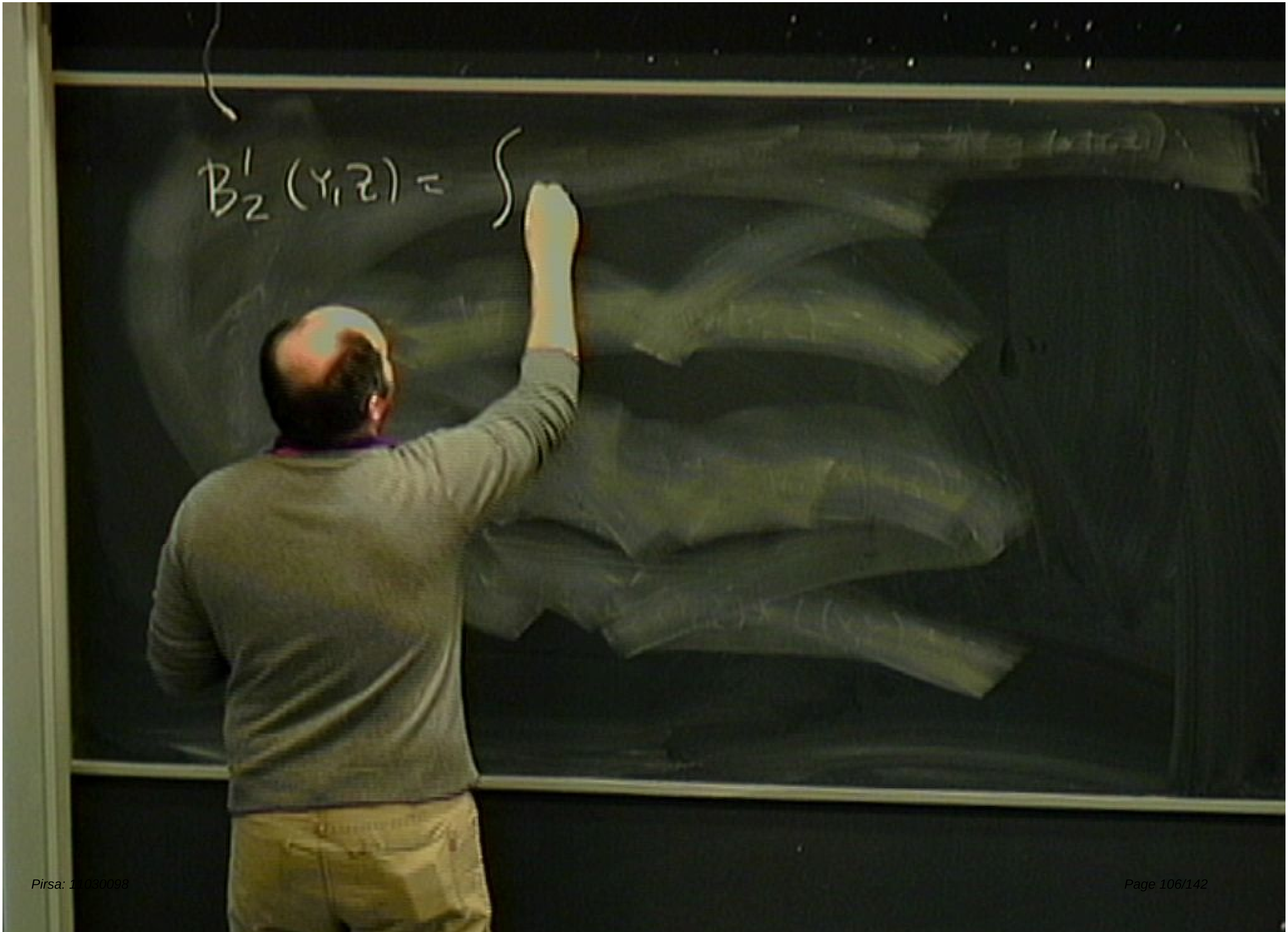


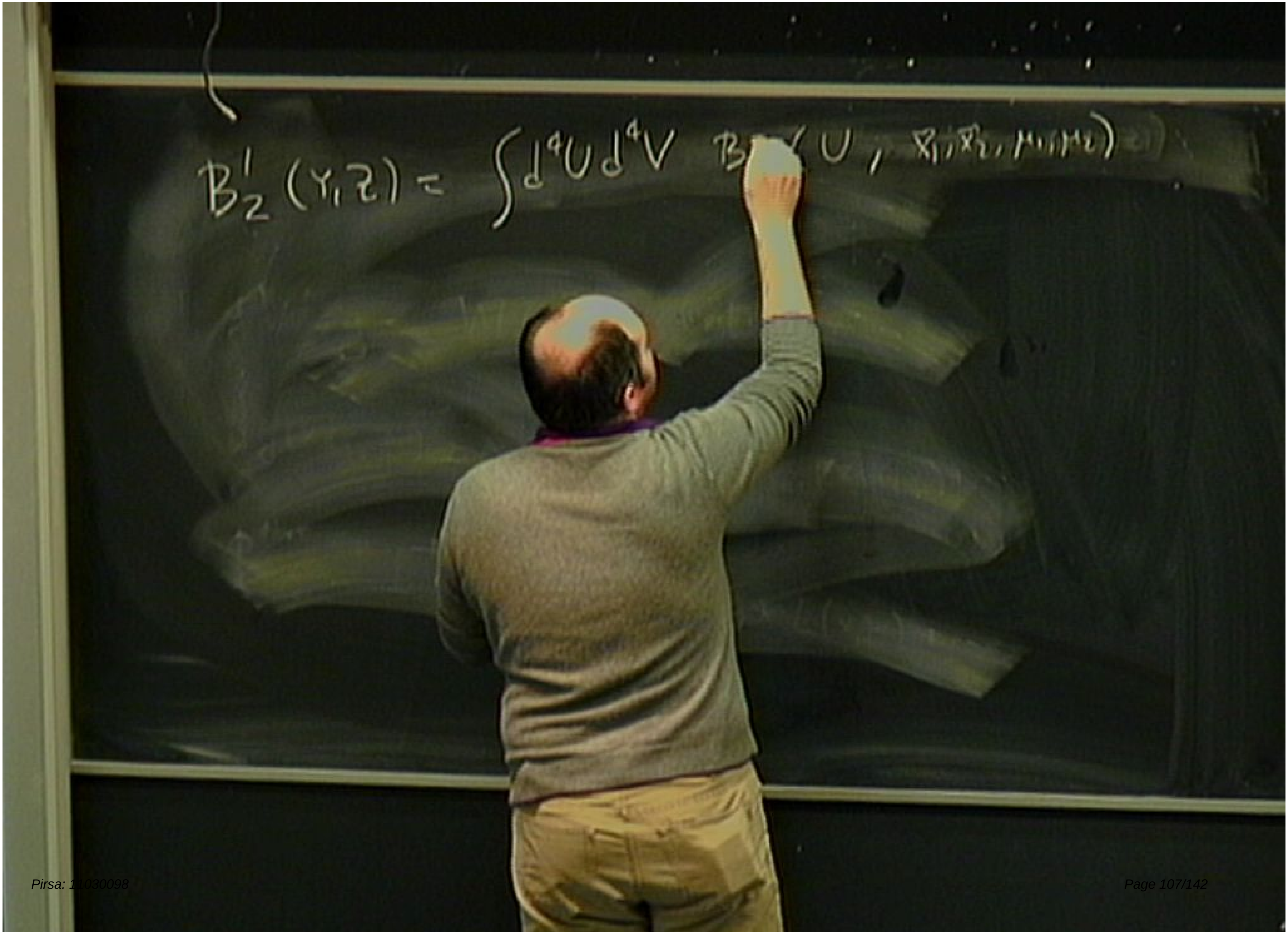
$\lambda \to \mu$
$\tilde{B}_1(y,\bar{y};\vec{x}_1;\mu) = \int d^2\lambda\, e^{\lambda^a \mu_a} B_1'(y,\bar{y},\vec{x}_1$

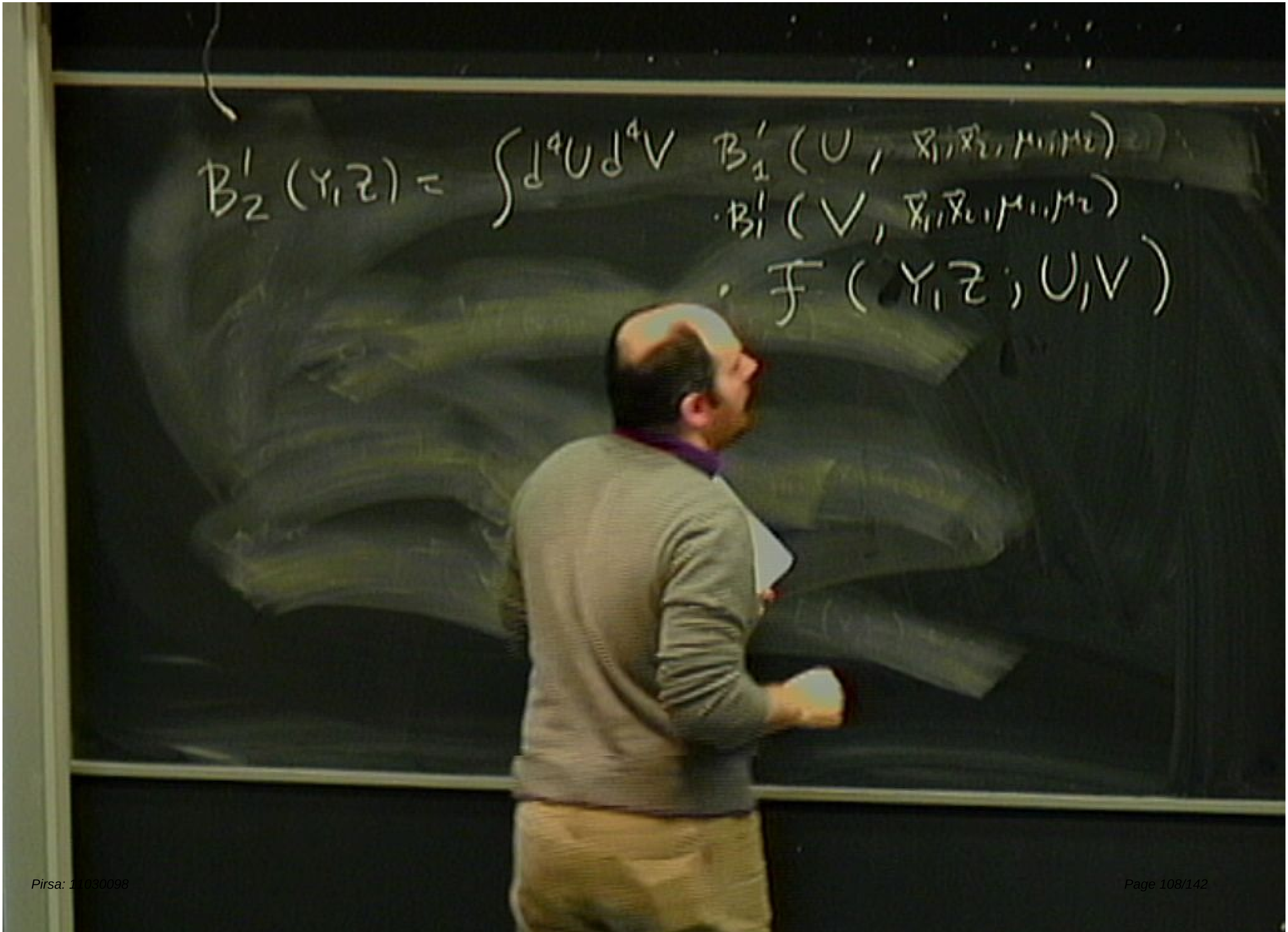

$B_1'(y,\bar{y};\vec{x}_1,\lambda) = \frac{e^{-y(\sigma^2 + 2\frac{\vec{x}_1\cdot\vec{\sigma}-\sigma^2}{x_1^2+1})\bar{y}}}{x_1^2+1}\left\{\exp\left[-2y\frac{\vec{x}_1\cdot\vec{\sigma}\sigma^4}{x_1^2+1}-\lambda_1\right]+\cdots\right\}$
$\lambda \to \mu$
$\tilde{B}_1(y,\bar{y};\vec{x}_1,\mu) = \int d^2\lambda\, e^{\lambda^a\mu_a} B_1'(y,\bar{y};\vec{x}_1,\lambda_1)$

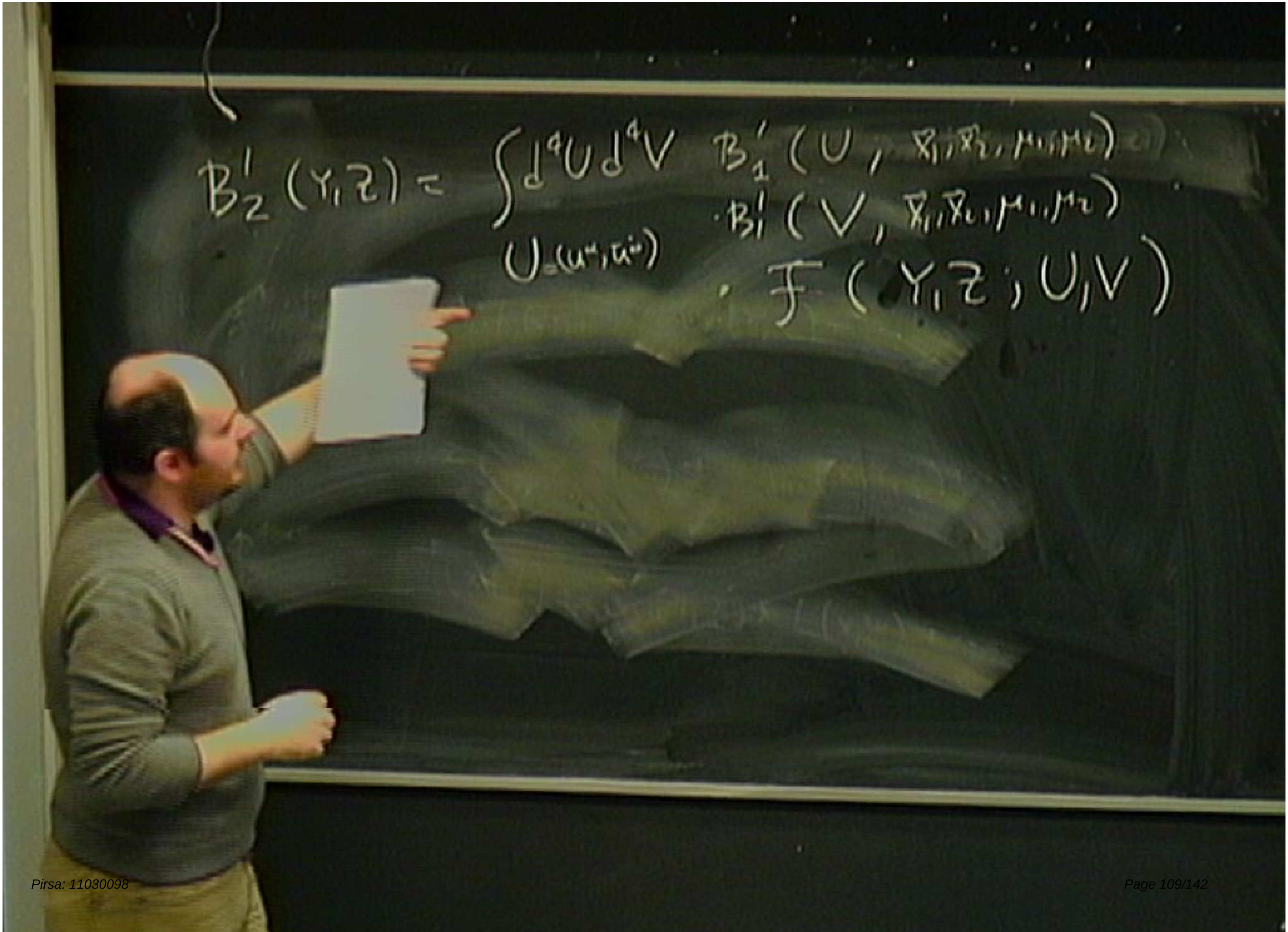

$B_1'(y,\bar{y};\vec{x}_1,\lambda) = \dfrac{e^{-y\left(\sigma^2 + 2\frac{\vec{x}_1\cdot\vec{\sigma} - \sigma^2}{x_1^2+1}\right)\bar{y}}}{x_1^2+1}\left\{\exp\left[-2y\,\dfrac{\vec{x}_1\cdot\vec{\sigma}\,\sigma^2}{x_1^2+1}\lambda_1\right]+\cdots\right\}$
$\lambda\to\mu$
$\tilde{B}_1(y,\bar{y};\vec{x}_1,\mu) = \int d^2\lambda\, e^{\lambda^a\mu_a} B_1'(y,\bar{y};\vec{x}_1,\lambda_1)$
$= \delta(y - X_1)\, e^{-\bar{y}X_1} + \delta(\bar{y}-\bar{X}_1)\, e^{yX_1}$

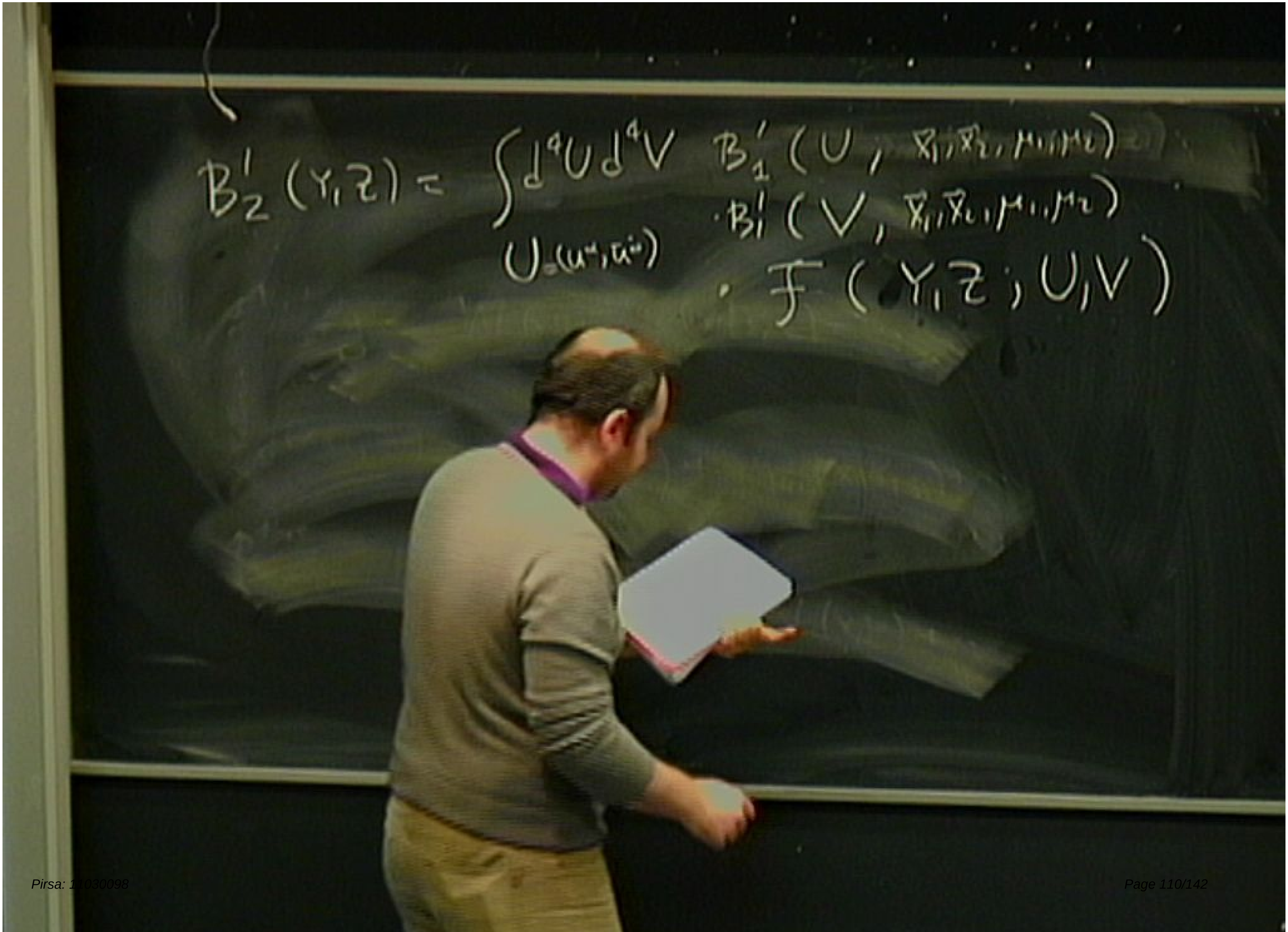

$B_1'(y, \bar{y}; \vec{x}_1, \lambda) = \frac{e^{-y\left(\sigma^2 + 2\frac{\vec{x}_1\cdot\vec{\sigma} - \sigma^2}{x_1^2+1}\right)\bar{y}}}{x_1^2+1}\left\{\exp\left[-2y\,\frac{\vec{x}_1\cdot\vec{\sigma}\sigma^2 - 1}{x_1^2+1}\lambda_1\right] + \cdots\right\}$
$\lambda \to \mu$
$\tilde{B}_1(y, \bar{y}; \vec{x}_1, \mu) = \int d^2\lambda\, e^{\lambda_1^a \mu_a} B_1'(y, \bar{y}; \vec{x}_1, \lambda_1)$
$= \delta(y - \chi_1)\, e^{-\bar{y}\chi_1} + \delta(\bar{y} - \bar{\chi}_1)\, e^{y\chi_1}$
$\chi_1 = \sigma^2(\vec{x}_1\cdot\vec{\sigma} + \sigma^2)\mu_1$


B'_2 (Y, Z) = ∫


$B'_2(Y,Z) = \int d^4U\, d^4V\, B \;(U,\; x_1, x_2, \mu_1, \mu_2)$

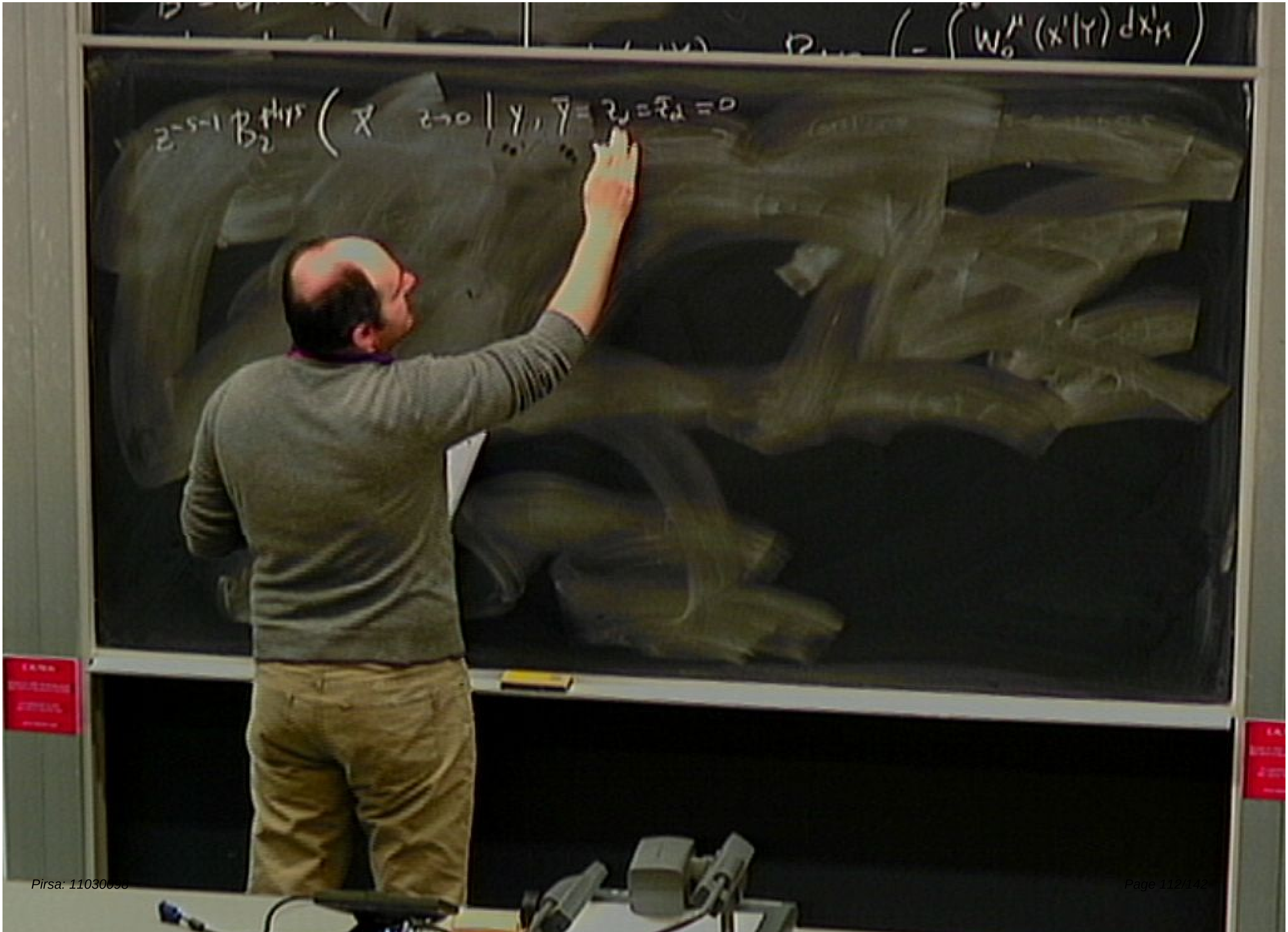

$B'_2(Y,Z) = \int d^4U\, d^4V\; B'_1(U, \bar{x}_1, \bar{x}_2, \mu_1, \mu_2)$
$\cdot B'_1(V, \bar{x}_1, \bar{x}_2, \mu_1, \mu_2)$
$\cdot \mathcal{F}(Y,Z; U,V)$

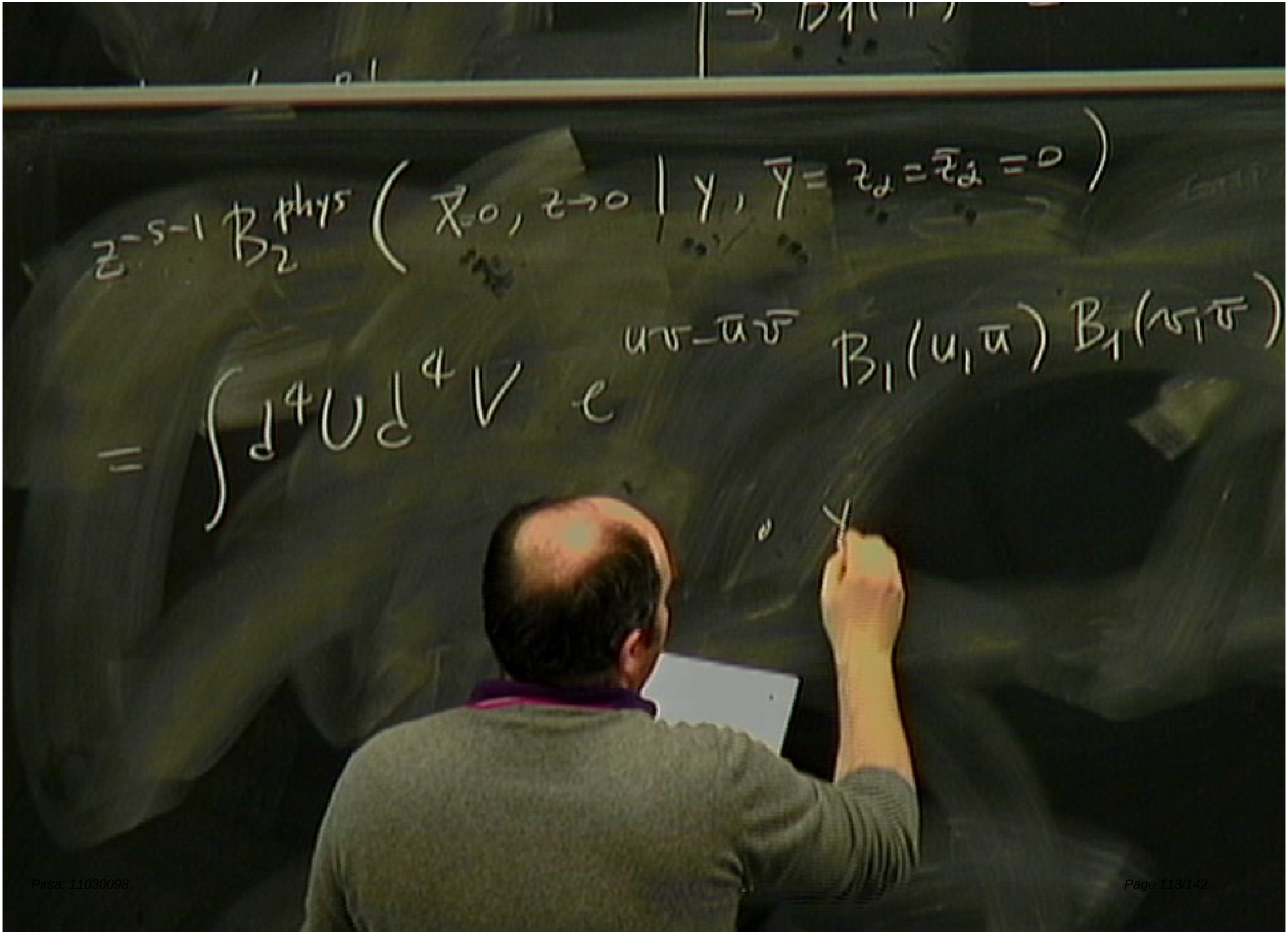

$B'_2(Y,Z) = \int d^4U\, d^4V\; B'_1(U;\bar{x}_1,\bar{x}_2,\mu_1,\mu_2)$
$\cdot B'_1(V,\bar{x}_1,\bar{x}_2,\mu_1,\mu_2)$
$\cdot \mathcal{F}(Y,Z;U,V)$
$U=(u^{\alpha},\bar{u}^{\dot\alpha})$

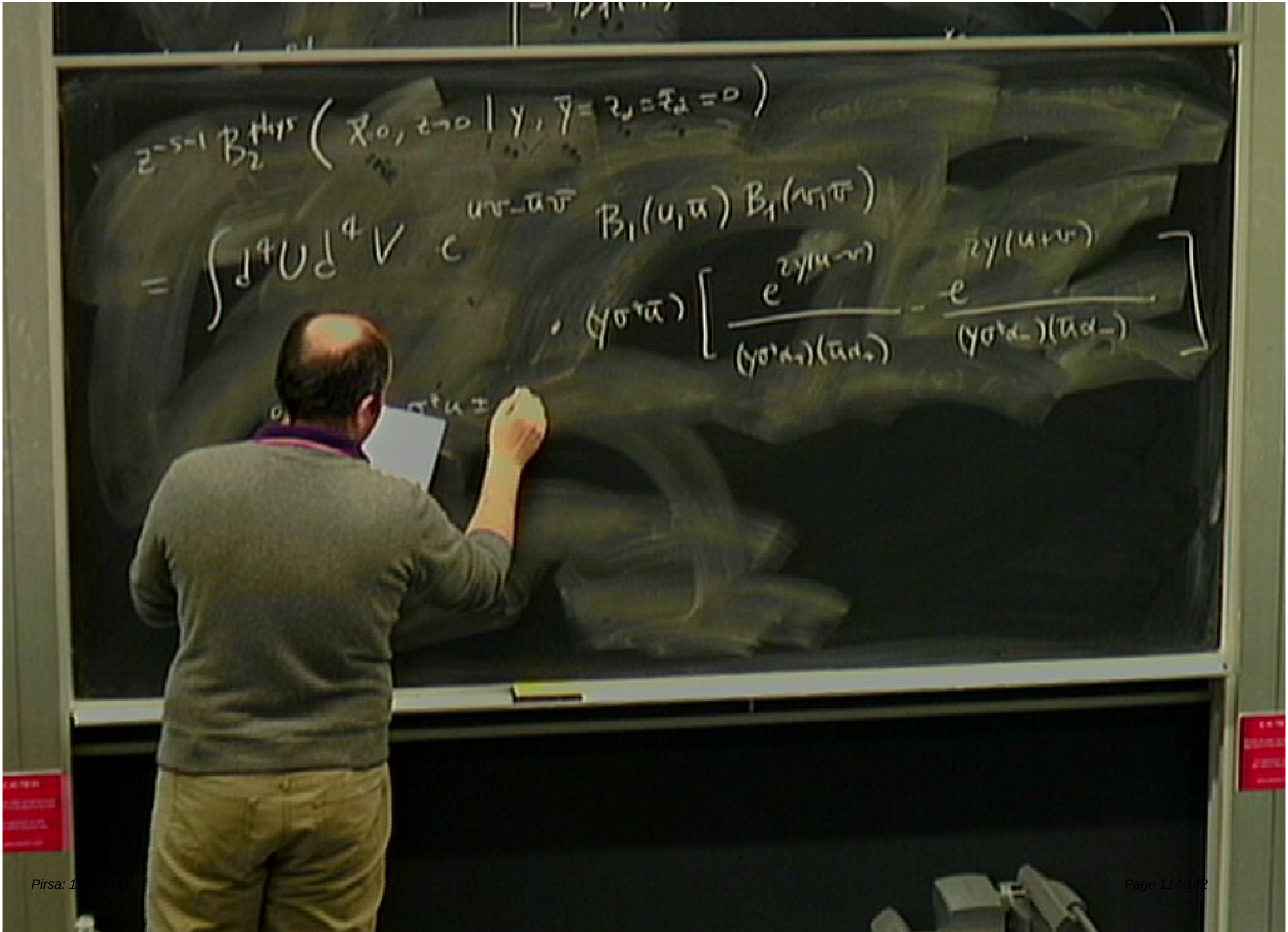

$B'_2(Y,Z) = \int d^4U\, d^4V\; B'_1(U, \ldots)$
$\cdot B'_1(V, \ldots)$
$\cdot F(Y,Z; U,V)$

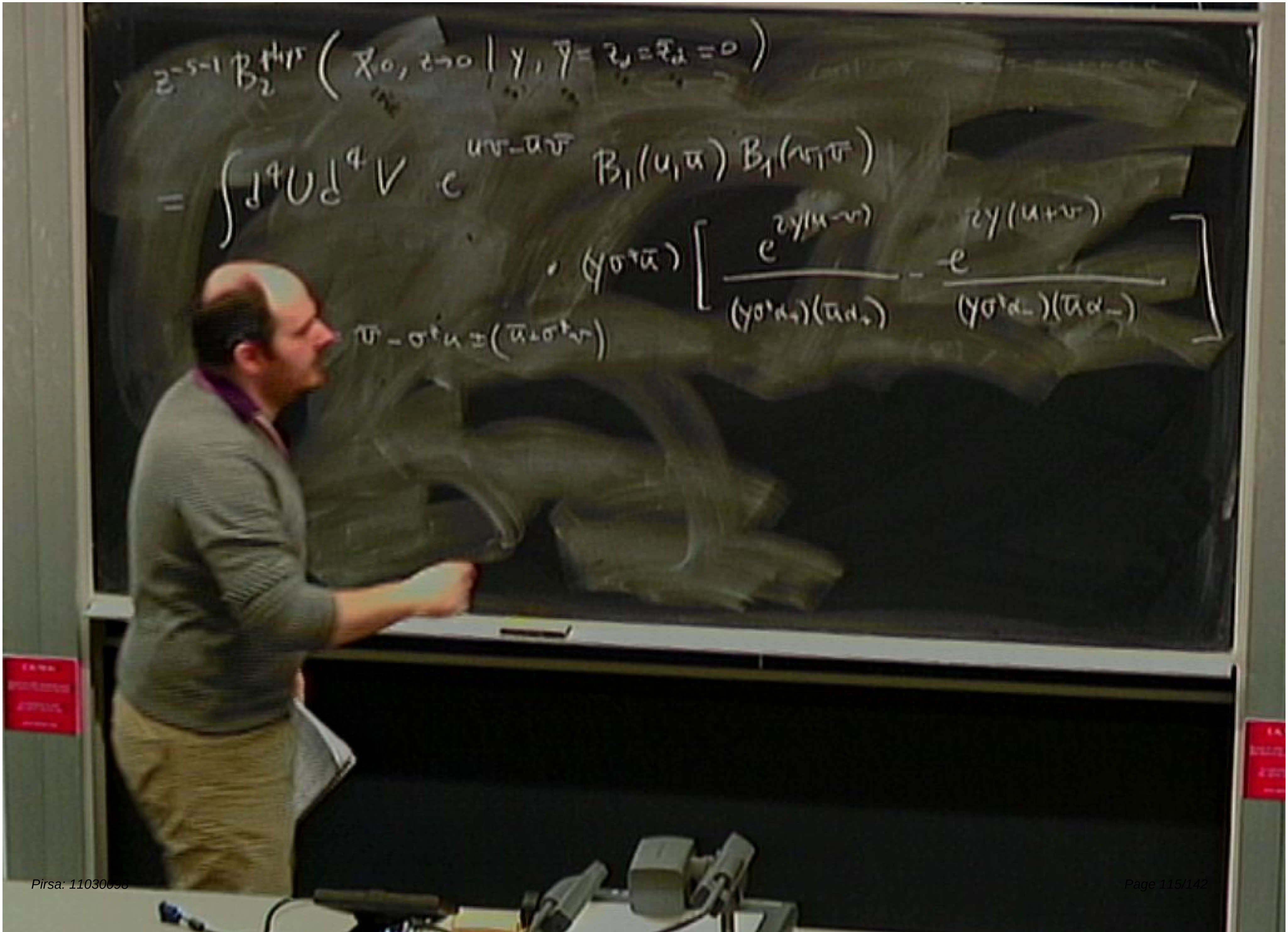
$$B_2'(Y,Z) = \int\limits_{U=(u^\mu,\tilde{u}^\mu)} d^4U\, d^4V \; B_1'(U, \bar{x}_1, \bar{x}_2, \mu_1, \mu_2) \cdot B_1'(V, \bar{x}_1, \bar{x}_2, \mu_1, \mu_2) \cdot \mathcal{F}(Y, Z; U, V)$$

$$B_2^{phys}(x, z | Y, Z) = L^{-1} * B_2'(Y, Z) * \pi(L)$$




$z^{-s-1} B_2^{phys}(\bar{x}=0, z \to 0 \mid y, \bar{y} = z_2 = \bar{z}_2 = 0)$
$= \int d^4U \, d^4V \, e^{uv - \bar{u}\bar{v}} B_1(u,\bar{u}) B_1(v,\bar{v})$


$z^{-s-1} B_2^{phys}(\bar{y}=0, z\to 0 \mid y, \bar{y} = z_\alpha = \bar{z}_\alpha = 0)$
$= \int d^4U\, d^4V\, e^{uv-\bar{u}\bar{v}} B_1(u,\bar{u})\, B_1(v,\bar{v})$
$\cdot (y\sigma^+\bar{u}) \left[\frac{e^{2y(u-v)}}{(y\sigma^+\alpha_+)(\bar{u}\alpha_+)} - \frac{e^{2y(u+v)}}{(y\sigma^+\alpha_-)(\bar{u}\alpha_-)} \right]$



$= \int d^4U\, d^4V\, e^{uv - \bar{u}\bar{v}}\, B_1(u,\bar{u})\, B_1(v,\bar{v})$

$$| \to B_1^1(Y) = L(x|Y) * B_1^{phys}(x|$$

$$B_2^{phys}(\bar{X}=0,\ z\to 0 \mid y,\ \bar{y}=z_\alpha=\bar{z}_\alpha=0)$$

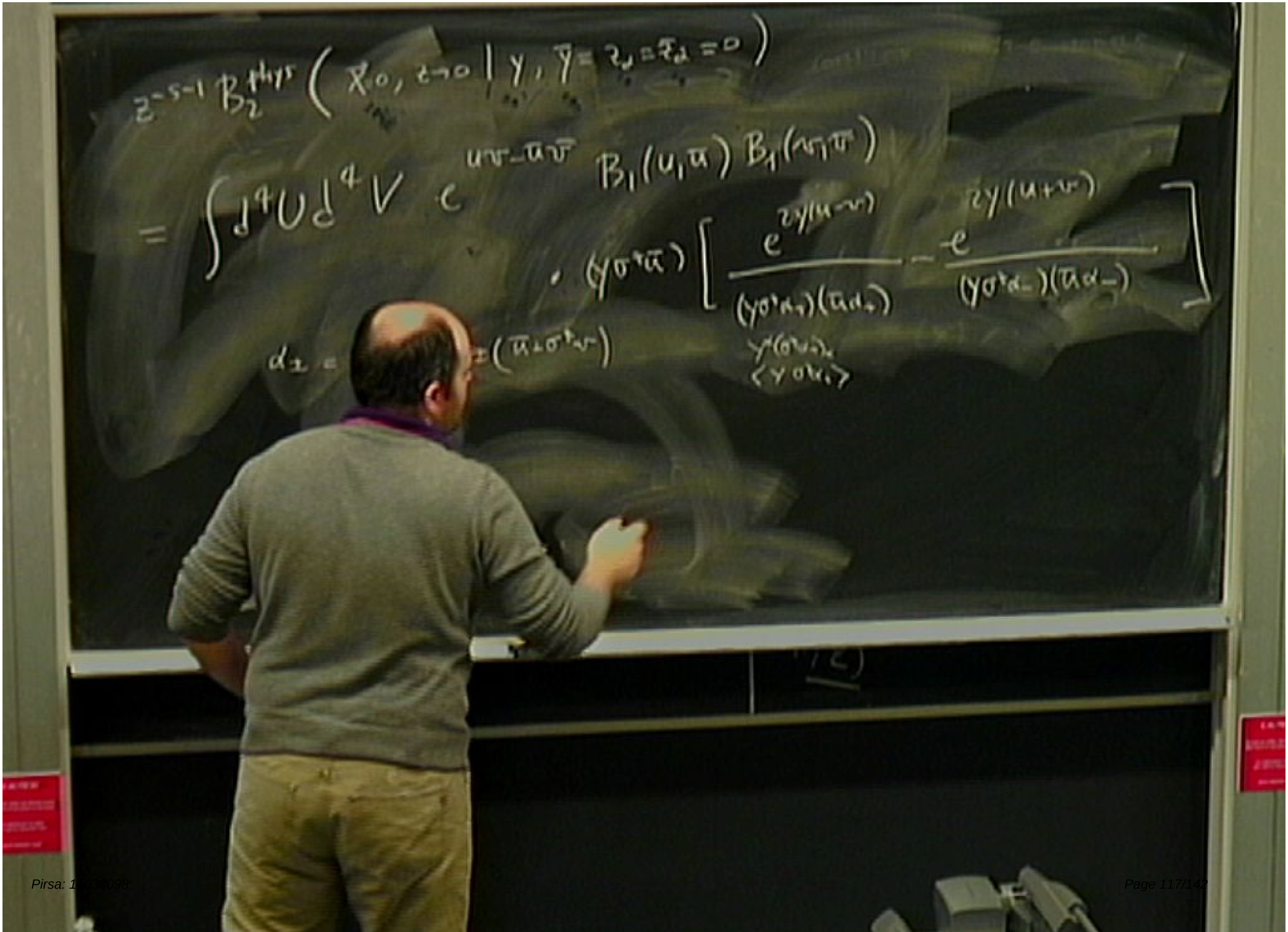
$$d^4U\, d^4V\, e^{uv-\bar{u}\bar{v}}\, B_1(u,\bar{u})\, B_1(v,\bar{v})$$

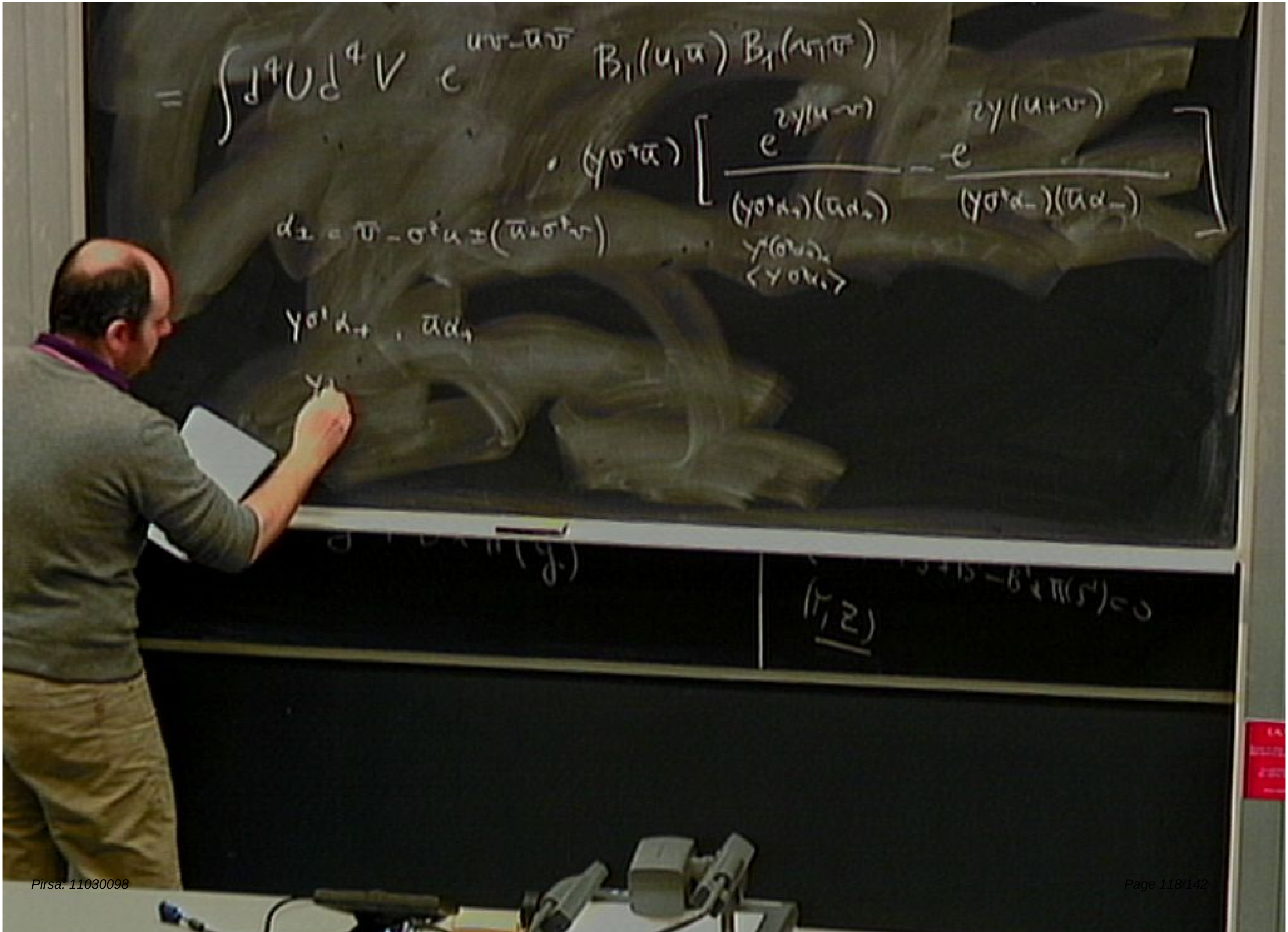
$$\cdot\,(y\sigma^z\bar{u})\Big[\frac{e^{2y(u-v)}}{(y\sigma^z\alpha_+)(\bar{u}\alpha_+)} - \frac{e^{2y(u+}}{(y\sigma^z\alpha_-)(}$$

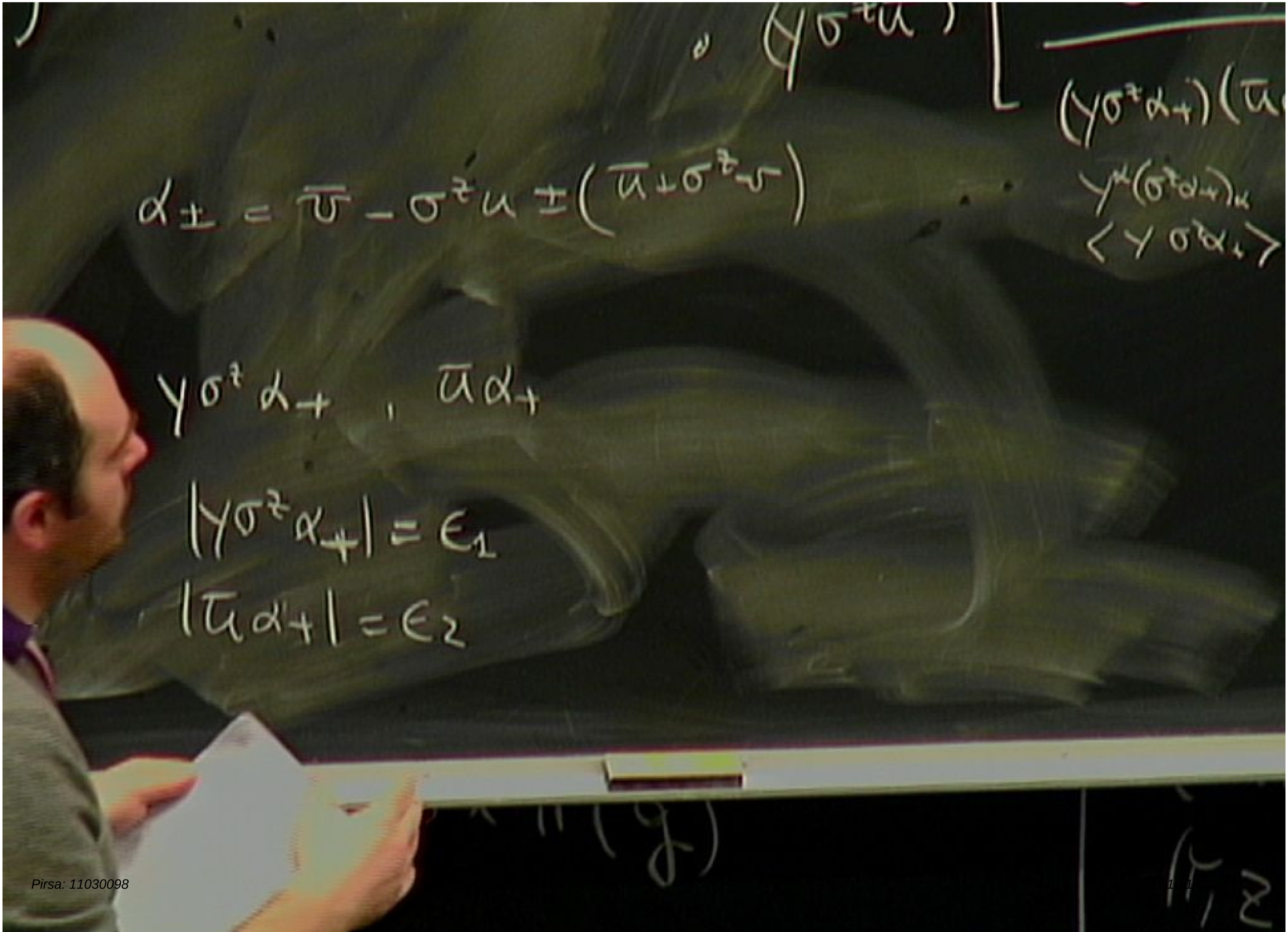
$$\alpha_\pm = \quad (\bar{u}\pm\sigma^z v)$$

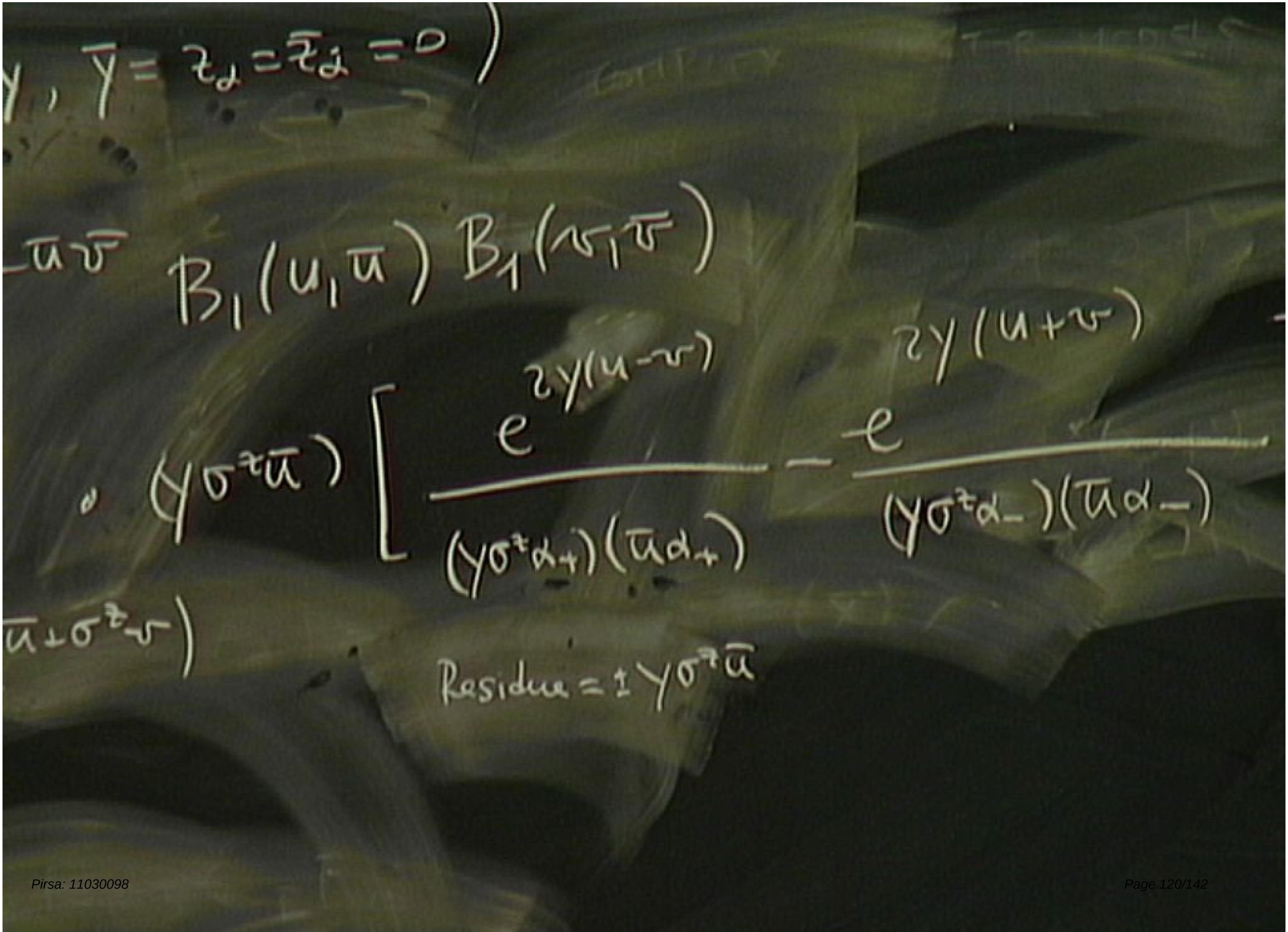
$$y^\alpha(\sigma^z\alpha_+)_\alpha$$

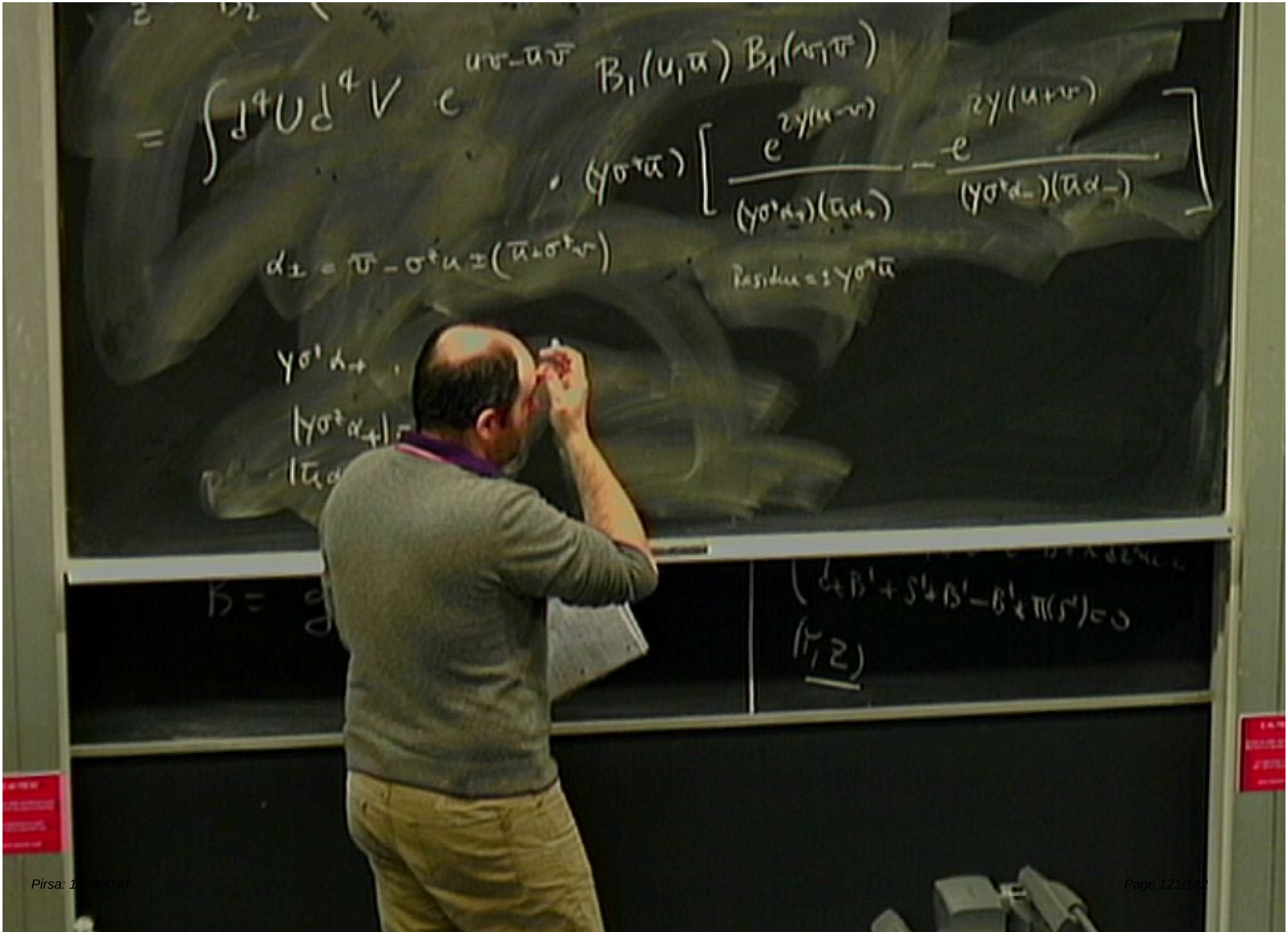
$$\langle y\,\sigma^z\alpha_+\rangle$$

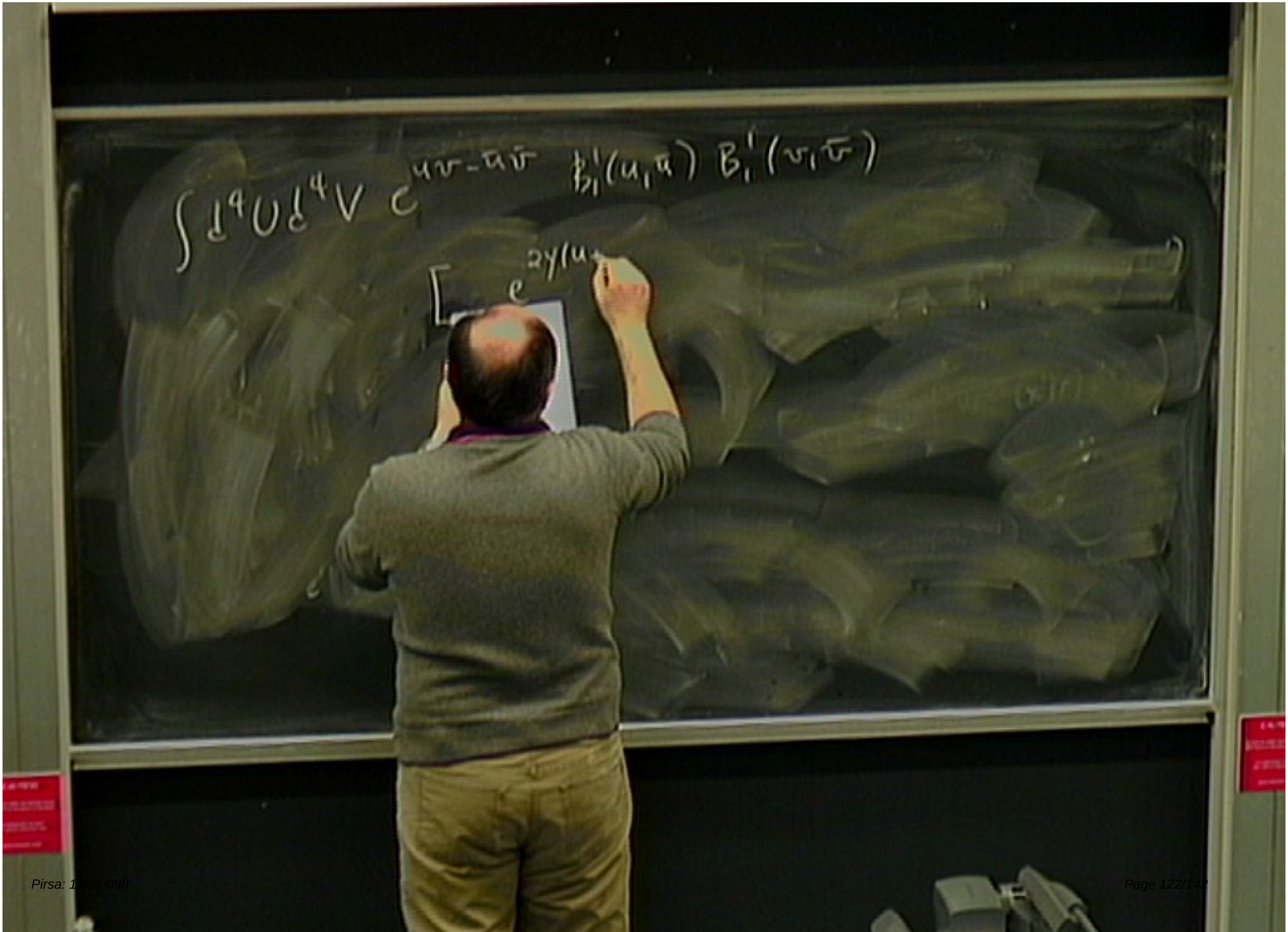


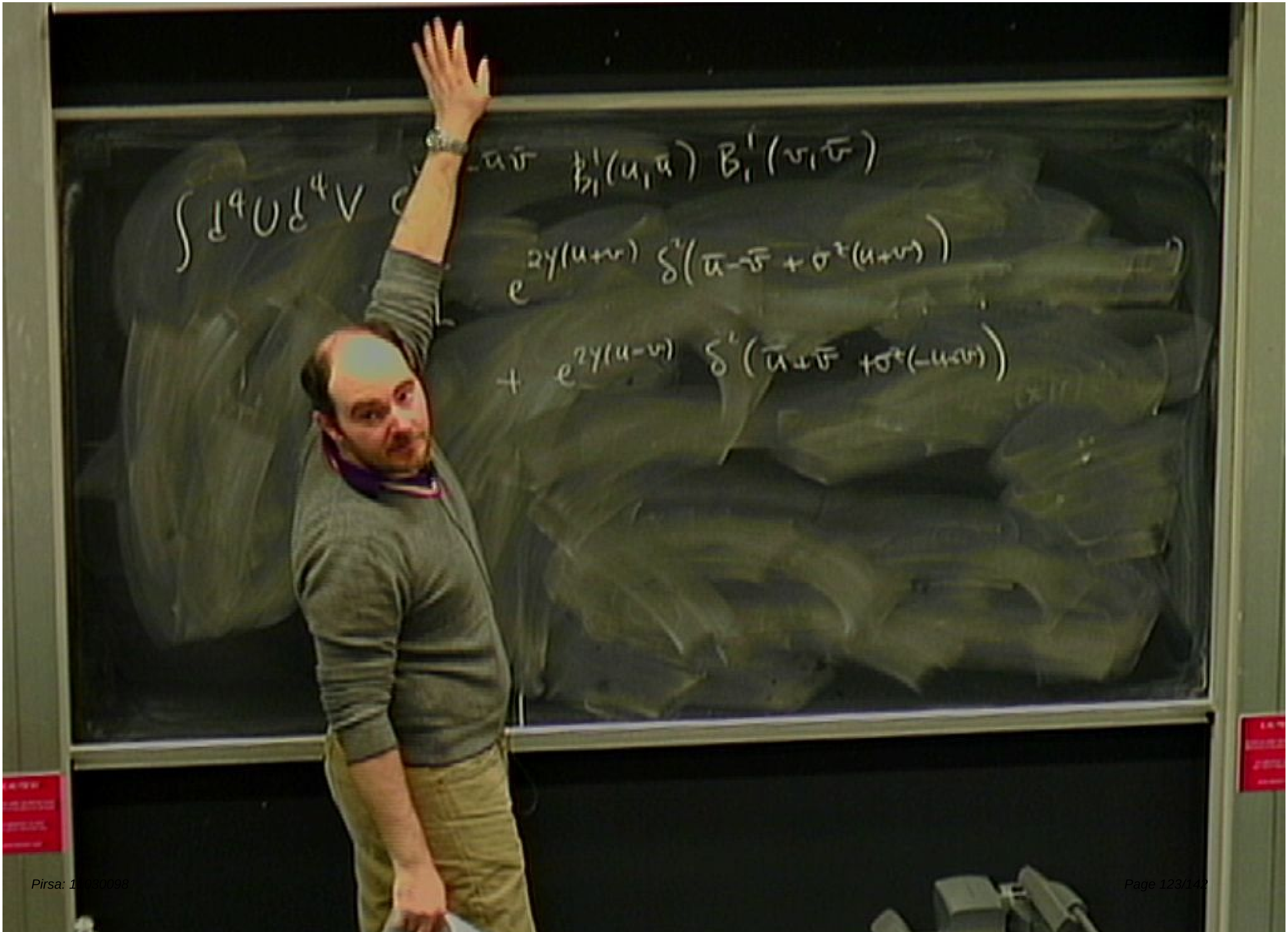


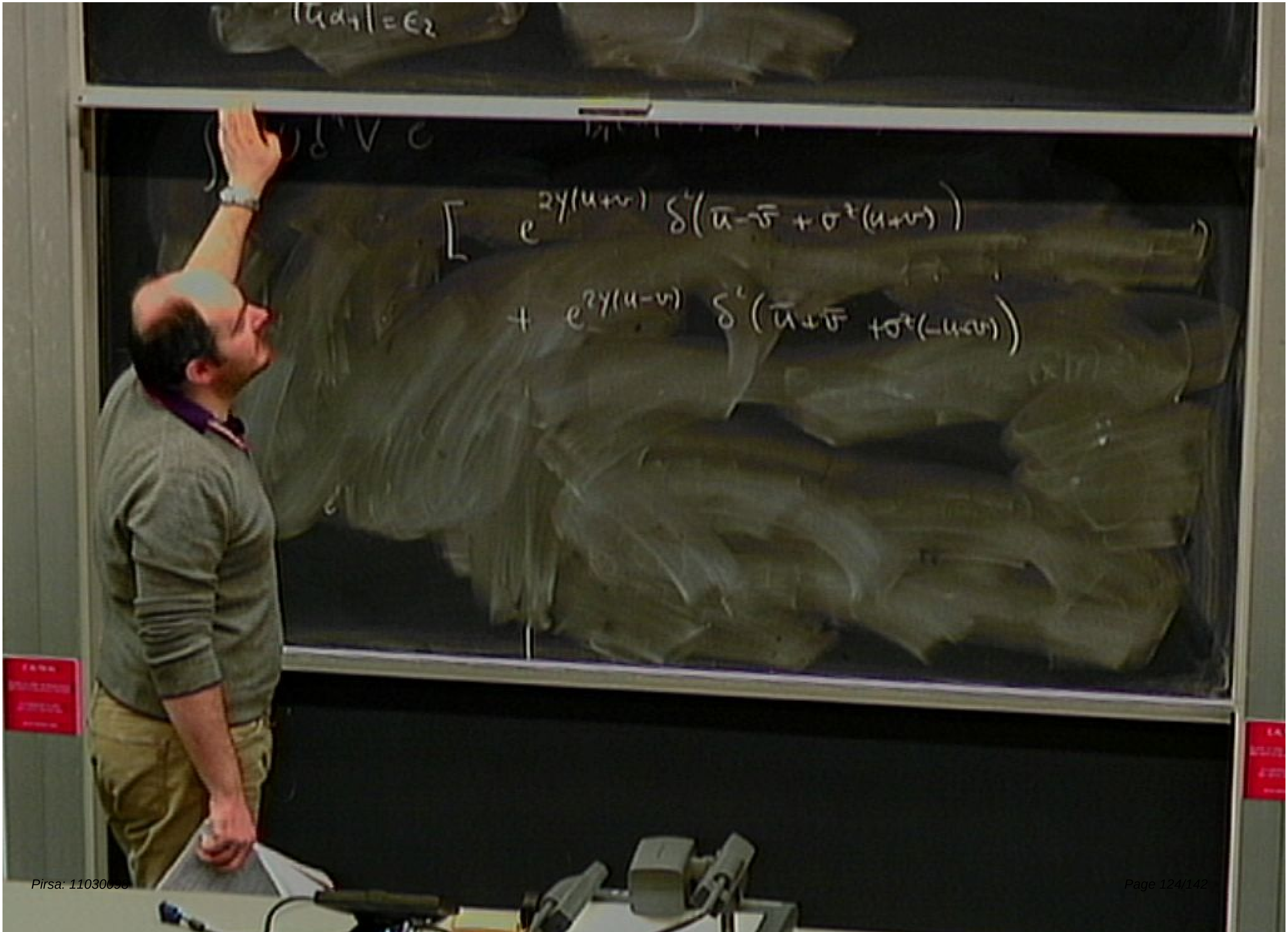

$\alpha_\pm = \bar{v} - \sigma^2 u \pm (\bar{u} + \sigma^2 v)$
$y\sigma^2\alpha_+ \; , \; \bar{u}\alpha_+$
$|y\sigma^2\alpha_+| = \epsilon_1$
$|\bar{u}\alpha_+| = \epsilon_2$
$(y\sigma^2\alpha_+)(\bar{u}$
$\langle y\, \sigma^2\alpha_+ \rangle$


$Y, \bar{Y} = z_2 = \bar{z}_2 = 0$
$B_1(u, \bar{u})\, B_1(v, \bar{v})$
$(y\sigma^z \bar{u}) \left[\frac{e^{2y(u-v)}}{(y\sigma^z \alpha_+)(\bar{u}\alpha_+)} - \frac{e^{2y(u+v)}}{(y\sigma^z \alpha_-)(\bar{u}\alpha_-)} \right.$
Residue = $1\, y\sigma^z \bar{u}$


Residue = i yσ^+ ū
(r, z)


∫ d⁴U d⁴V e^{uv−ūv̄} B₁¹(u,ū) B₁¹(v,v̄)
[e^{2y(u

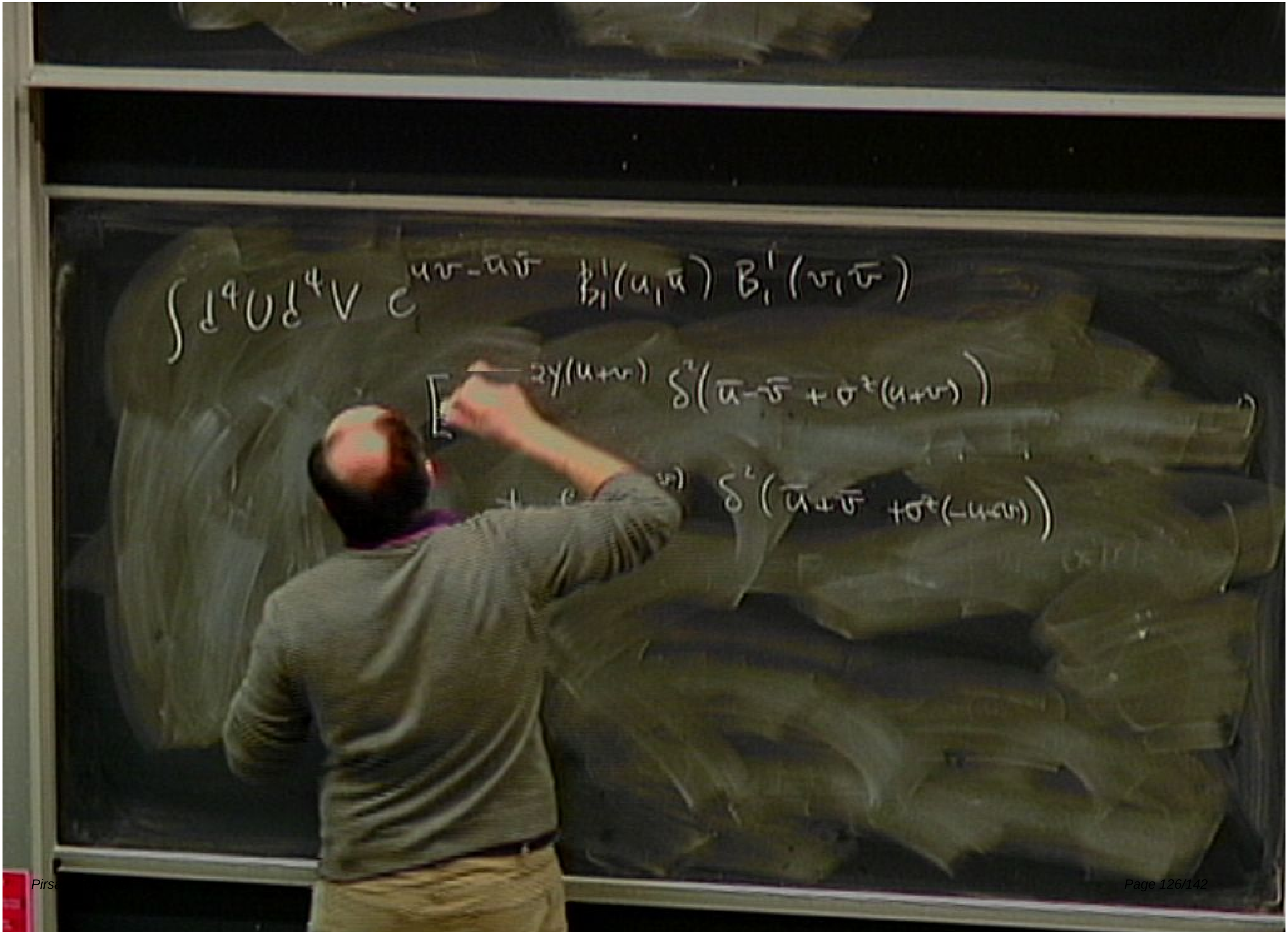

∫ d⁴U d⁴V e^{…−ūv̄} B₁¹(u,ū) B₁¹(v,v̄)
e^{2y(u+v)} δ²(ū − v̄ + σ²(u+v))
+ e^{2y(u−v)} δ²(ū + v̄ + σ²(−u+v))

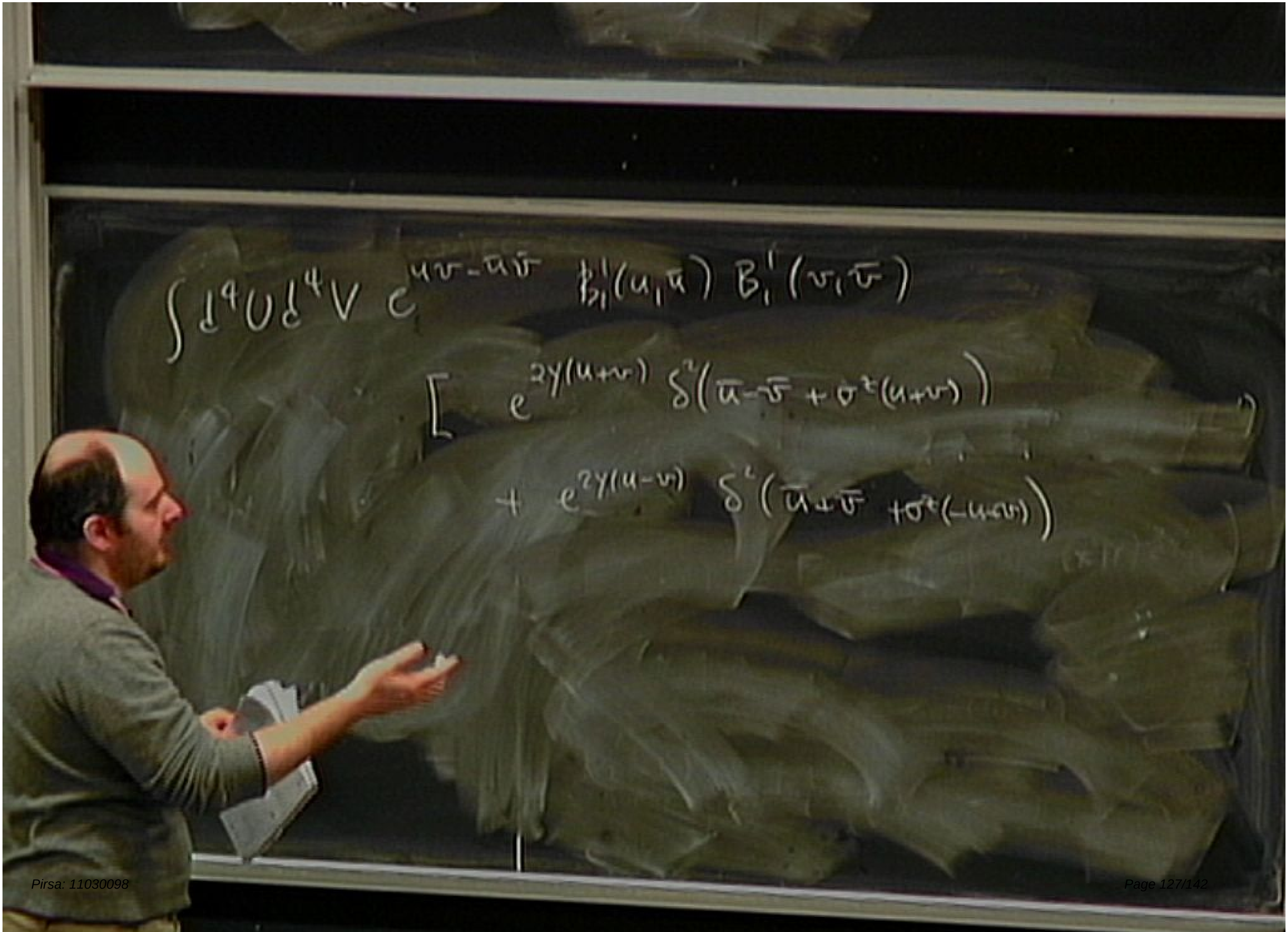

|u α_4| = ε_2
[e^{2y(u+v)} δ^2(ū − v̄ + σ^2(u+v))
+ e^{2y(u−v)} δ^2(ū + v̄ + σ^2(−u+v))

$$\int d^4U\, d^4V\, e^{uv - \bar{u}\bar{v}}\, B_1'(u, \bar{u})\, B_1'(v, \bar{v})$$

$$\Big[e^{2y(u+v)}\, \delta^2\big(\bar{u} - \bar{v} + \sigma^z(u+v)\big)$$

$$+ e^{2y(u-v)}\, \delta^2\big(\bar{u} + \bar{v} + \sigma^z(-u+v)\big)$$

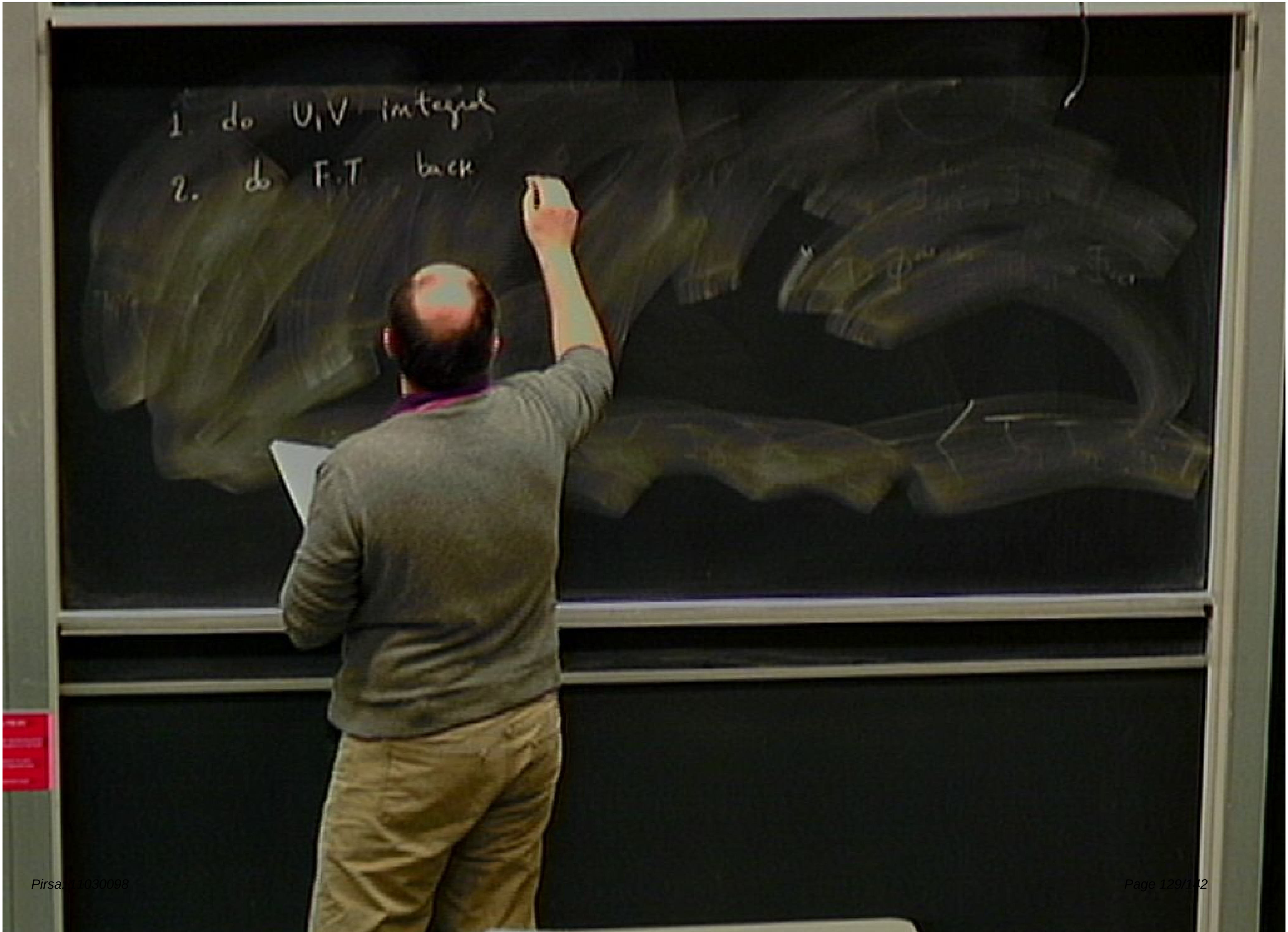

∫ d⁴U d⁴V e^{uv−ūv̄} B₁¹(u,ū) B₁¹(v,v̄)
2y(u+v) δ²(ū−v̄ + σ²(u+v))
δ²(ū+v̄ +σ²(−u+v))

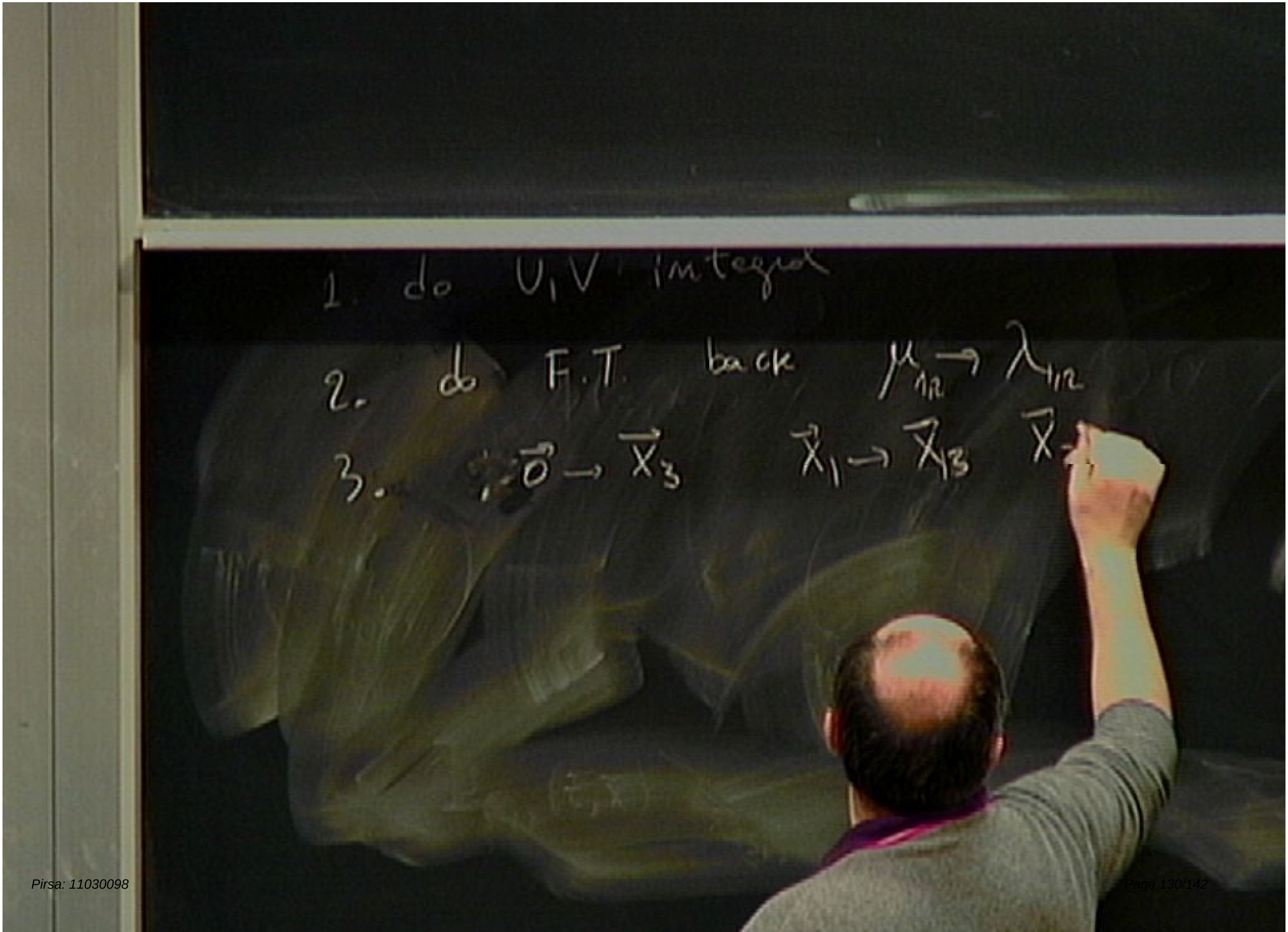

$\int d^4U\, d^4V\, e^{uv - \bar{u}\bar{v}}\, B_1^1(u, \bar{u})\, B_1^1(v, \bar{v})$
$[\; e^{2y(u+v)}\, \delta^2(\bar{u} - \bar{v} + \sigma^2(u+v))$
$+\; e^{2y(u-v)}\, \delta^2(\bar{u} + \bar{v} + \sigma^2(-u+v)))$

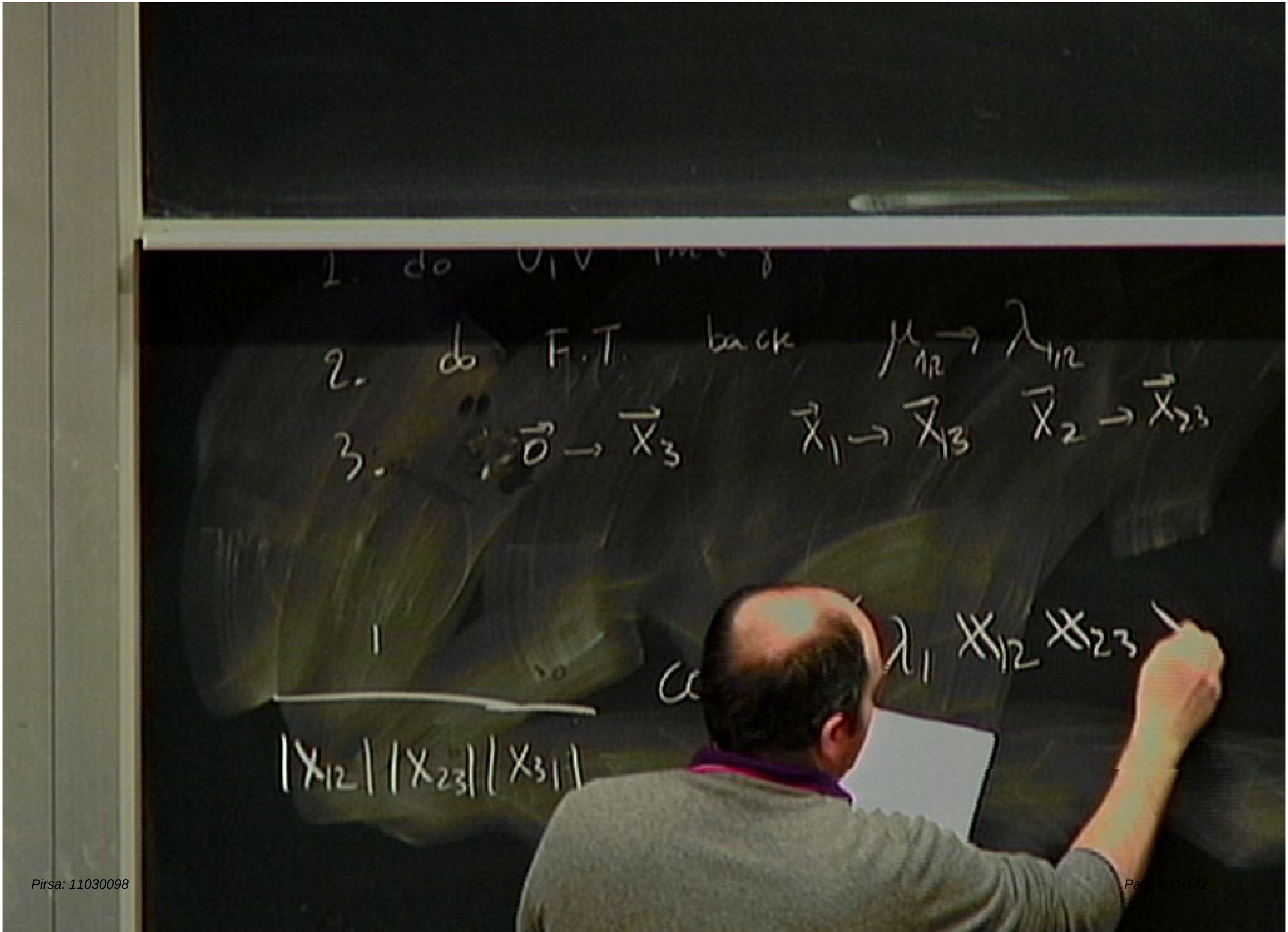
$$\int d^4U\, d^4V\, e^{uv-\bar{u}\bar{v}}\, B_1^1(u,\bar{u})\, B_1^1(v,\bar{v})$$

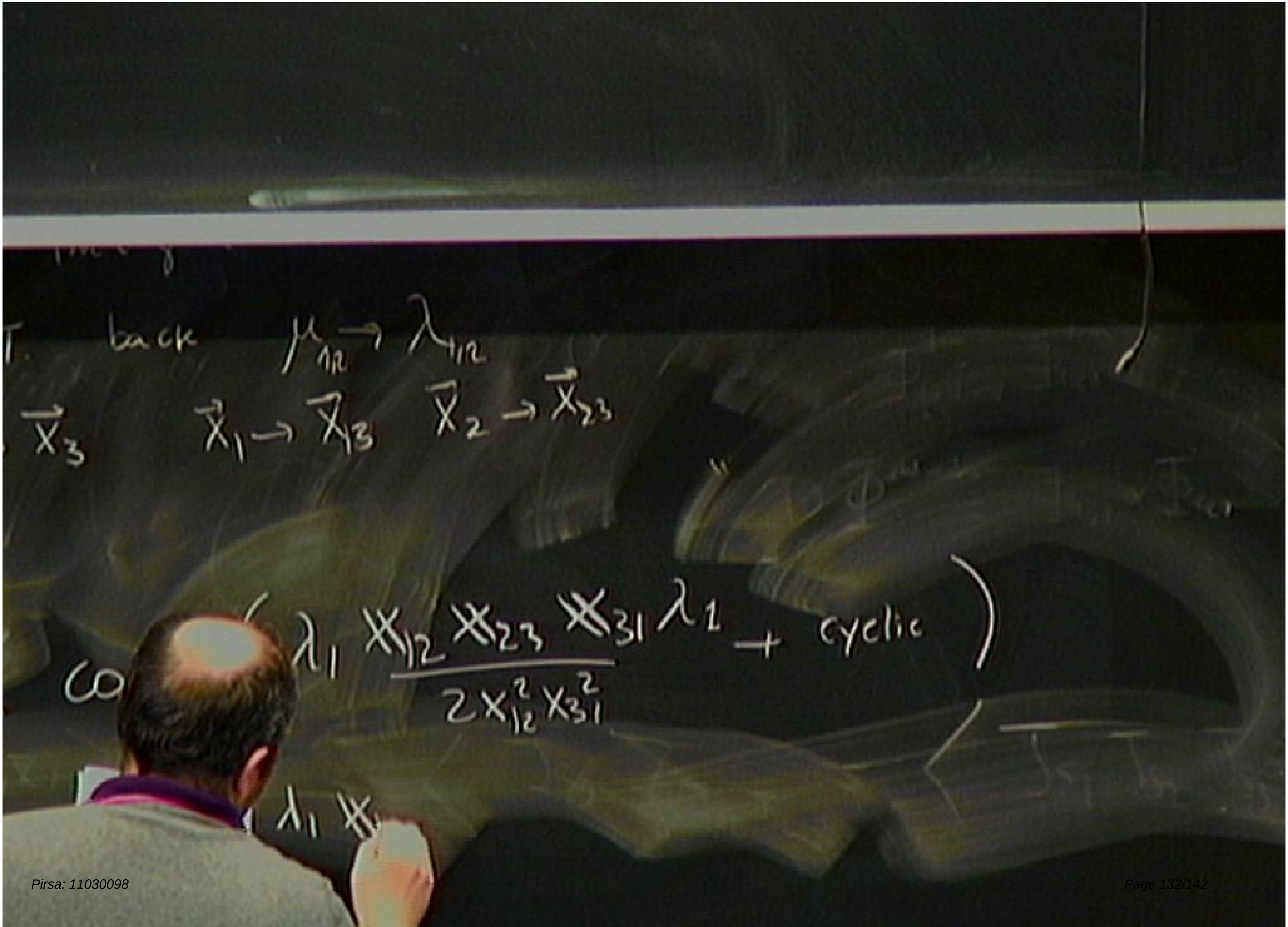
$$\Big[\, e^{2y(u+v)}\, \delta^2\big(\bar{u}-\bar{v}+\sigma^2(u+v)\big)$$

$$+\; e^{2y(u-v)}\, \delta^2\big(\bar{u}+\bar{v}+\sigma^2(-u+v)\big)$$


1. do U,V integral
2. do F.T back


1. do U,V integral
2. do F.T. back $\mu_{12} \to \lambda_{12}$
3. $\vec{0} \to \vec{X}_3$ $\vec{X}_1 \to \vec{X}_{13}$ $\vec{X}$


2. do F.T. back $\mu_{12} \to \lambda_{12}$
3. $\vec{0} \to \vec{x}_3$ $\vec{x}_1 \to \vec{x}_{13}$ $\vec{x}_2 \to \vec{x}_{23}$
$\frac{1}{|x_{12}||x_{23}||x_{31}|}$
$\lambda_1 \mathbb{X}_{12} \mathbb{X}_{23}$


back $\mu_{12} \to \lambda_{12}$
$\vec{X}_3$ $\vec{X}_1 \to \vec{X}_{13}$ $\vec{X}_2 \to \vec{X}_{23}$
$\left(\lambda_1 \frac{X_{12} X_{23} X_{31} \lambda 1}{2 x_{12}^2 x_{31}^2} + \text{cyclic} \right)$

1. do $0,V$ integ...

2. do F.T. back $\mu_{12} \to \lambda_{12}$

3. $\vec{0} \to \vec{x}_3$ $\quad \vec{x}_1 \to \vec{x}_{13}$ $\quad \vec{x}_2 \to \vec{x}_{23}$

$$\frac{1}{|x_{12}||x_{23}||x_{31}|} \quad \frac{\cosh\left(\lambda_1 \frac{x_{12} x_2 \ldots}{2 \ldots} \lambda_2 + \text{cyclic}\right)}{\cosh\left(\lambda \ldots \lambda_1 x_{13} \lambda_3\right.}$$

$$x_1 = \sigma^2 (\vec{x}_1 \cdot \vec{\sigma} + \sigma^2) \mu_1$$

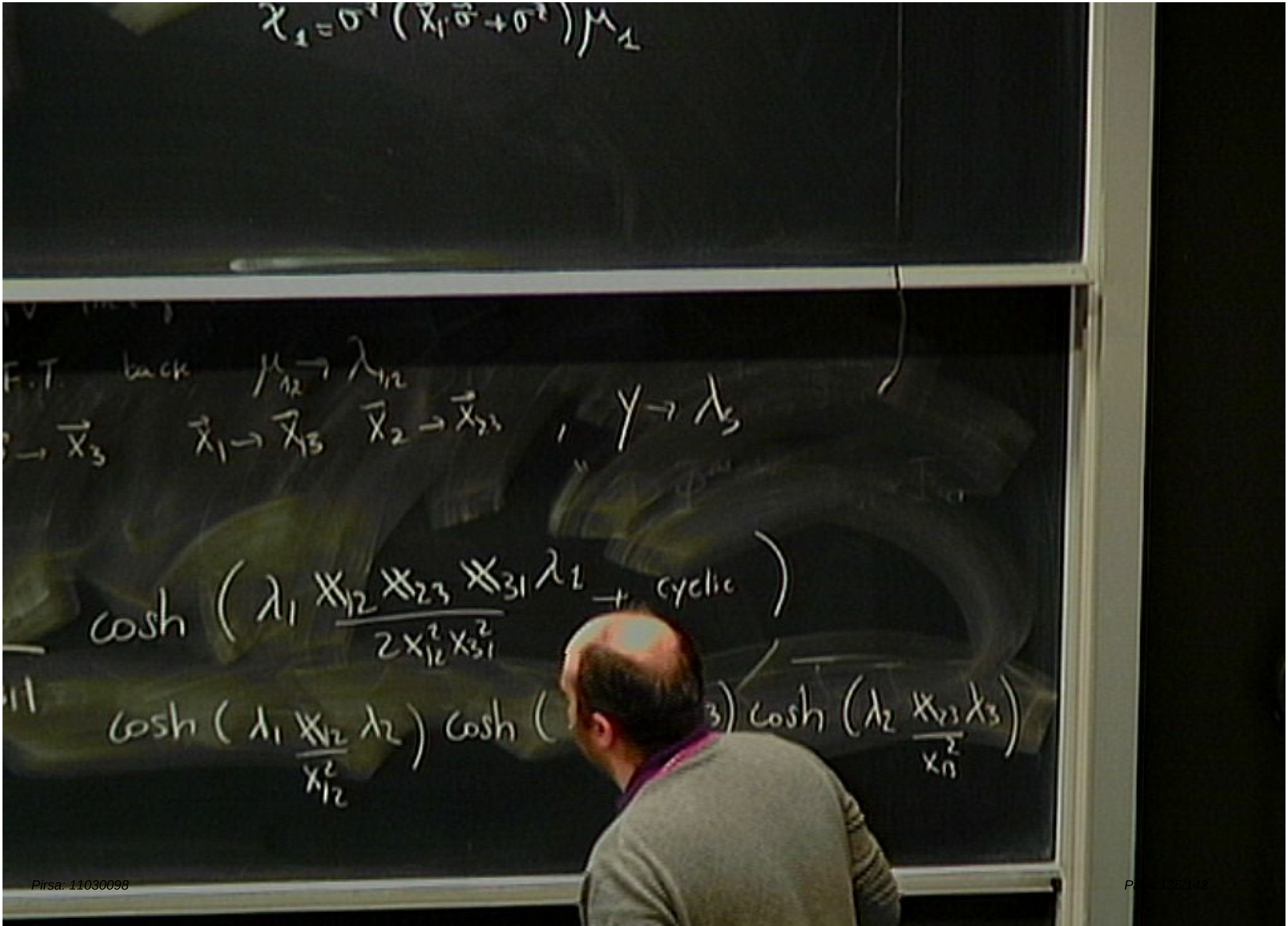
1. do ...

2. do F.T. back $\mu_{12} \to \lambda_{12}$

3. $\vec{0} \to \vec{x}_3$ $\quad \vec{x}_1 \to \vec{x}_{13}$ $\quad \vec{x}_2 \to \vec{x}_{23}$

$$\frac{1}{|x_{12}|\,|x_{23}|\,|x_{31}|} \quad \cosh\left(\lambda_1 \frac{x_{12}\, x_{23}\, x_{31}}{2 x_{12}^2 x_{31}^2} \lambda_1 + \text{cyclic} \right)$$

$$\cosh\left(\lambda_1 \frac{x_{12}}{x_{12}^2} \lambda_2 \right) \cosh\left(\lambda_1 \ldots \right) \lambda_2$$



F.T. back $\mu_{12} \to \lambda_{12}$
$\vec{x}_1 \to \vec{x}_{13}$ $\vec{x}_2 \to \vec{x}_{23}$, $y \to \lambda_3$
$\cosh\left(\lambda_1 \frac{x_{12} x_{23} x_{31} \lambda_1}{2 x_{12}^2 x_{31}^2} + \text{cyclic}\right)$
$\cosh\left(\lambda_1 \frac{x_{12}}{x_{12}^2} \lambda_2\right) \cosh ($
$) \cosh\left(\lambda_2 \frac{x_{23} \lambda_3}{x_{23}^2}\right)$

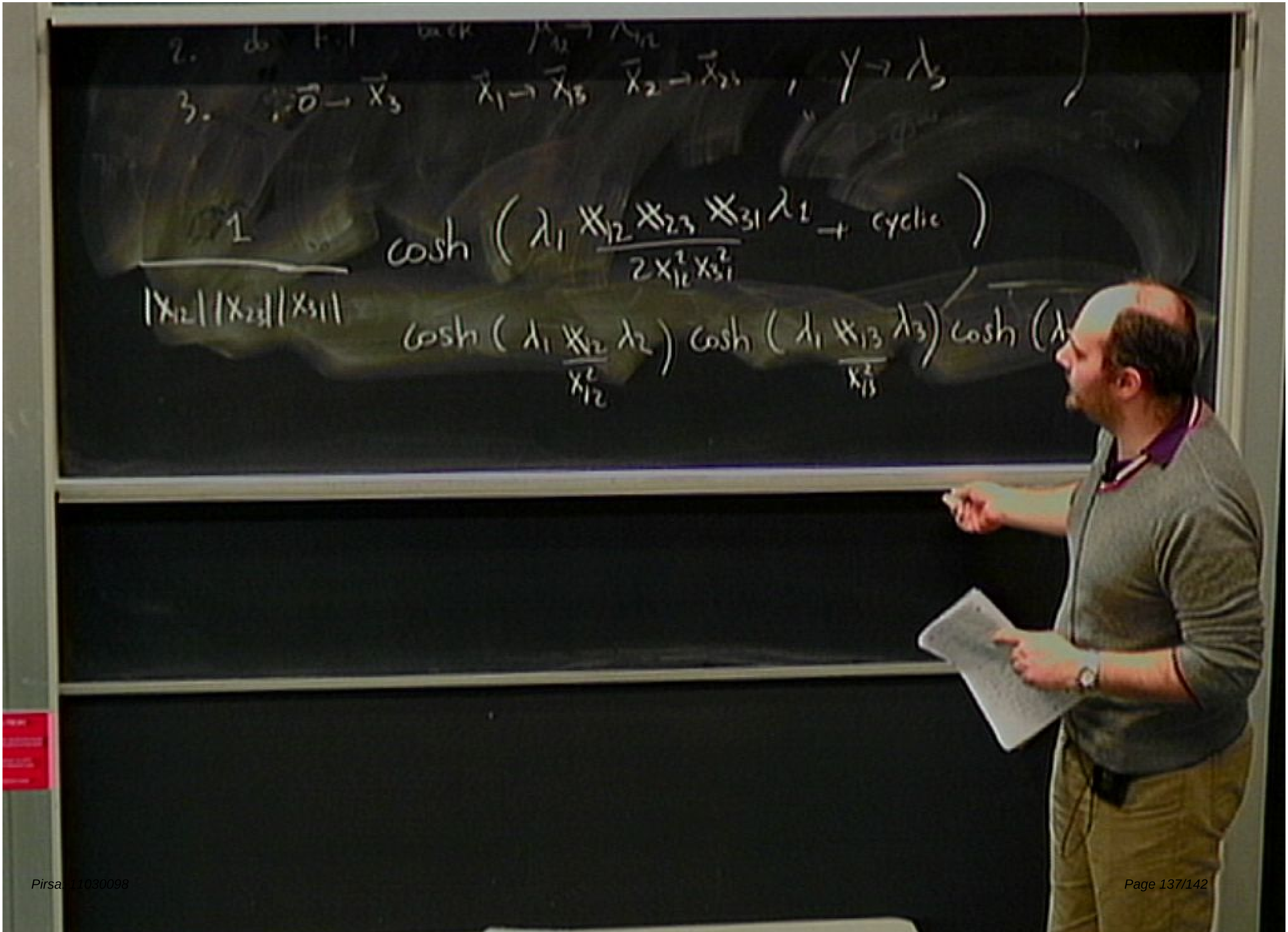
$$\chi_1 = \sigma\left(\vec{x}_1\cdot\vec{\sigma} + \sigma\right)\mu_1$$

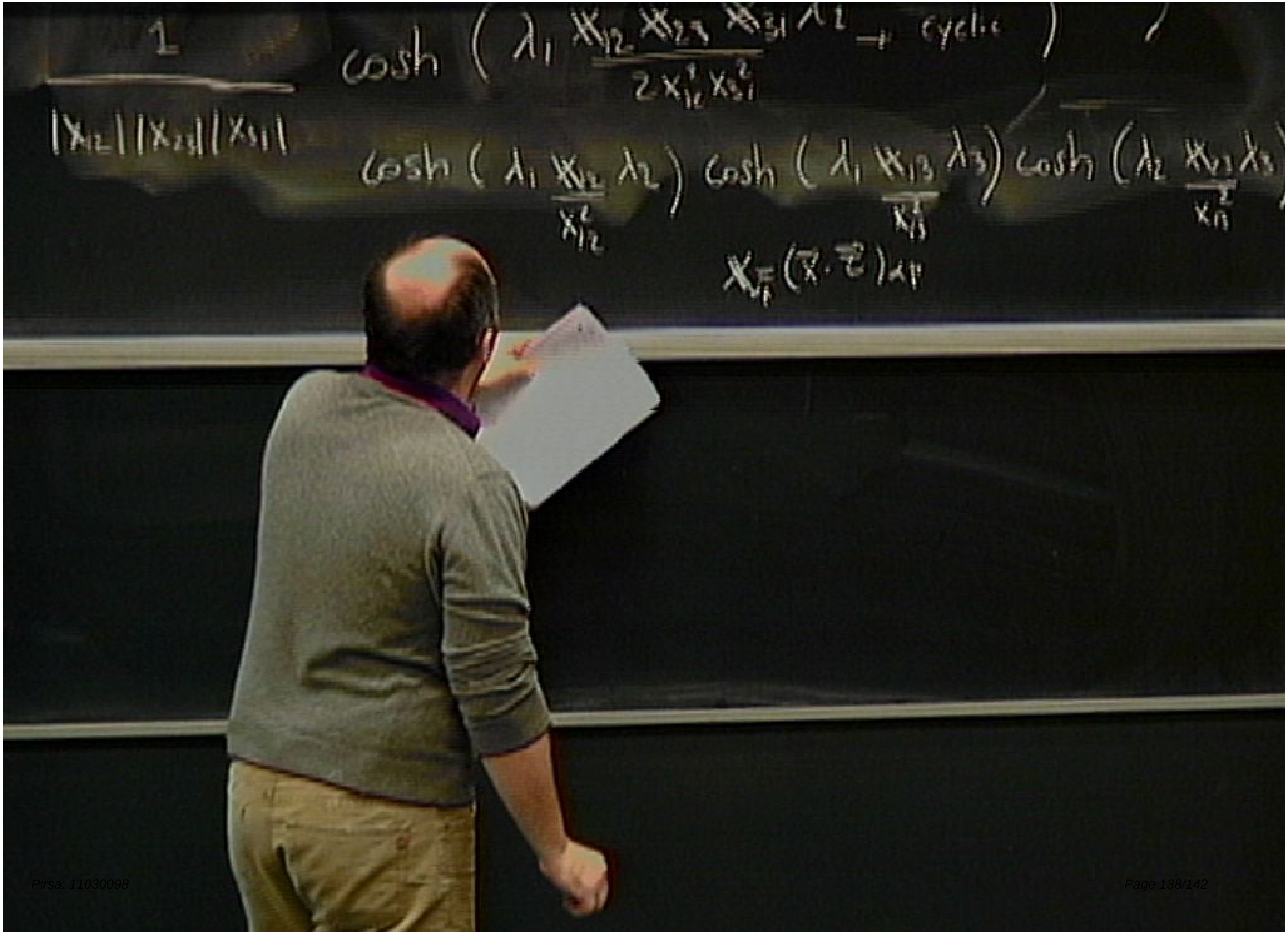
F.T. back $\mu_{12} \to \lambda_{12}$

$\to \vec{x}_3 \quad \vec{x}_1 \to \vec{x}_{13} \quad \vec{x}_2 \to \vec{x}_{23} \quad , \quad y \to \lambda_3$

$$\cosh\left(\frac{\lambda_1 \mathbf{x}_{12}\mathbf{x}_{23}\mathbf{x}_{31}\lambda_1}{2x_{12}^2 x_{31}^2} + \text{cyclic}\right)$$

$$\left(\frac{\lambda_1 \mathbf{x}_{12}\lambda_2}{x_{12}^2}\right)\cosh\left(\frac{\lambda_1 \mathbf{x}_{13}\lambda_3}{x_{13}^2}\right)\cosh\left(\frac{\lambda_2 \mathbf{x}_{23}\lambda_3}{x_{13}^2}\right)$$


3. 0 → x3 x1 → x13 x2 → x23 , y → λ3
1
|x12| |x23| |x31|
cosh (λ1 x12 x23 x31 λ1 / 2 x12² x31² + cyclic)
cosh (λ1 x12 λ2 / x12²) cosh (λ1 x13 λ3 / x13²) cosh (λ


cosh (cyclic)
cosh ( ) cosh ( ) cosh ( )

2. do F.T. back $\mu_{12} \to \lambda_{12}$

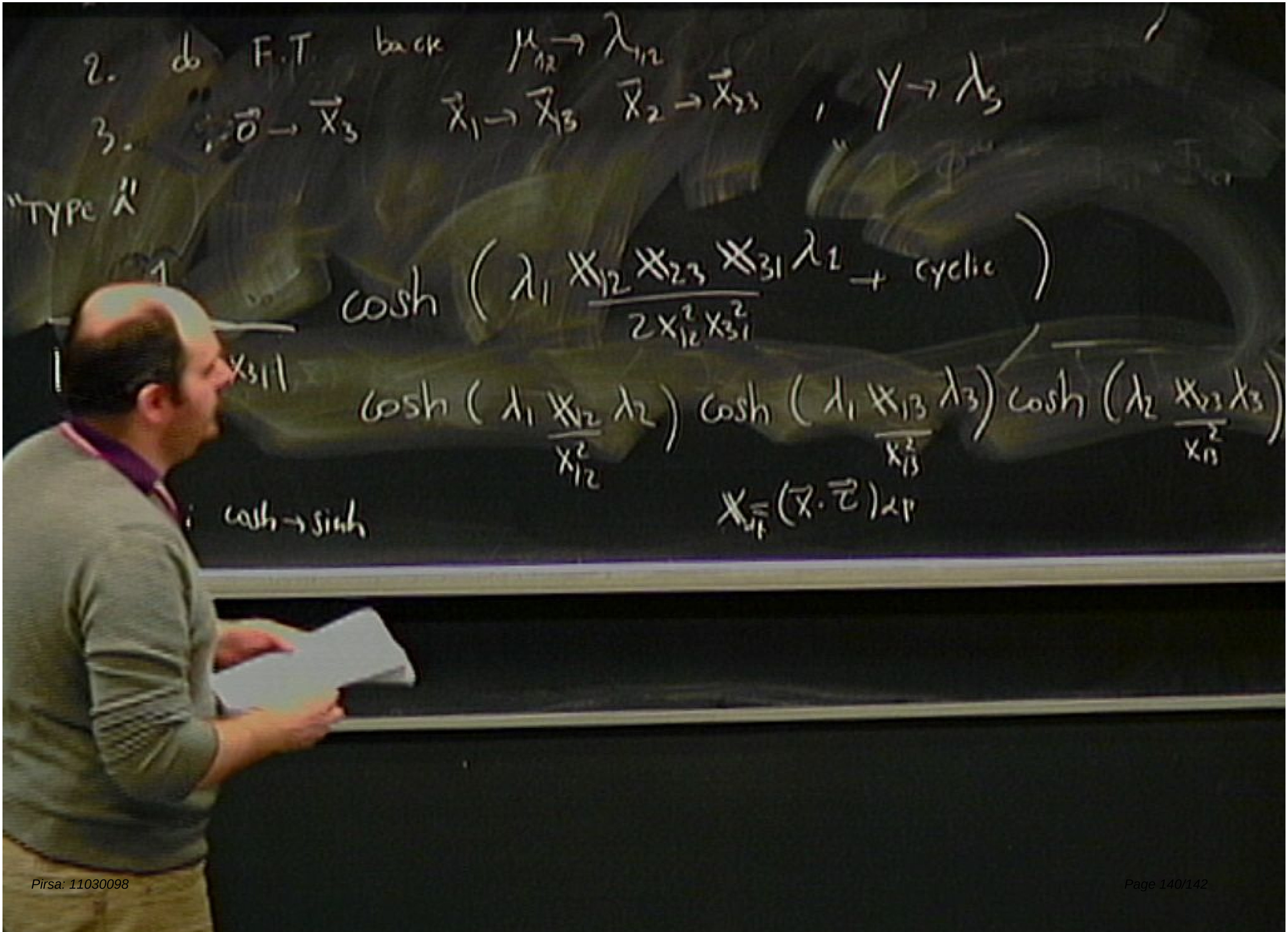
3. $\vec{0} \to \vec{x}_3$ $\quad \vec{x}_1 \to \vec{x}_{13}$ $\quad \vec{x}_2 \to \vec{x}_{23}$, $\quad y \to \lambda_3$

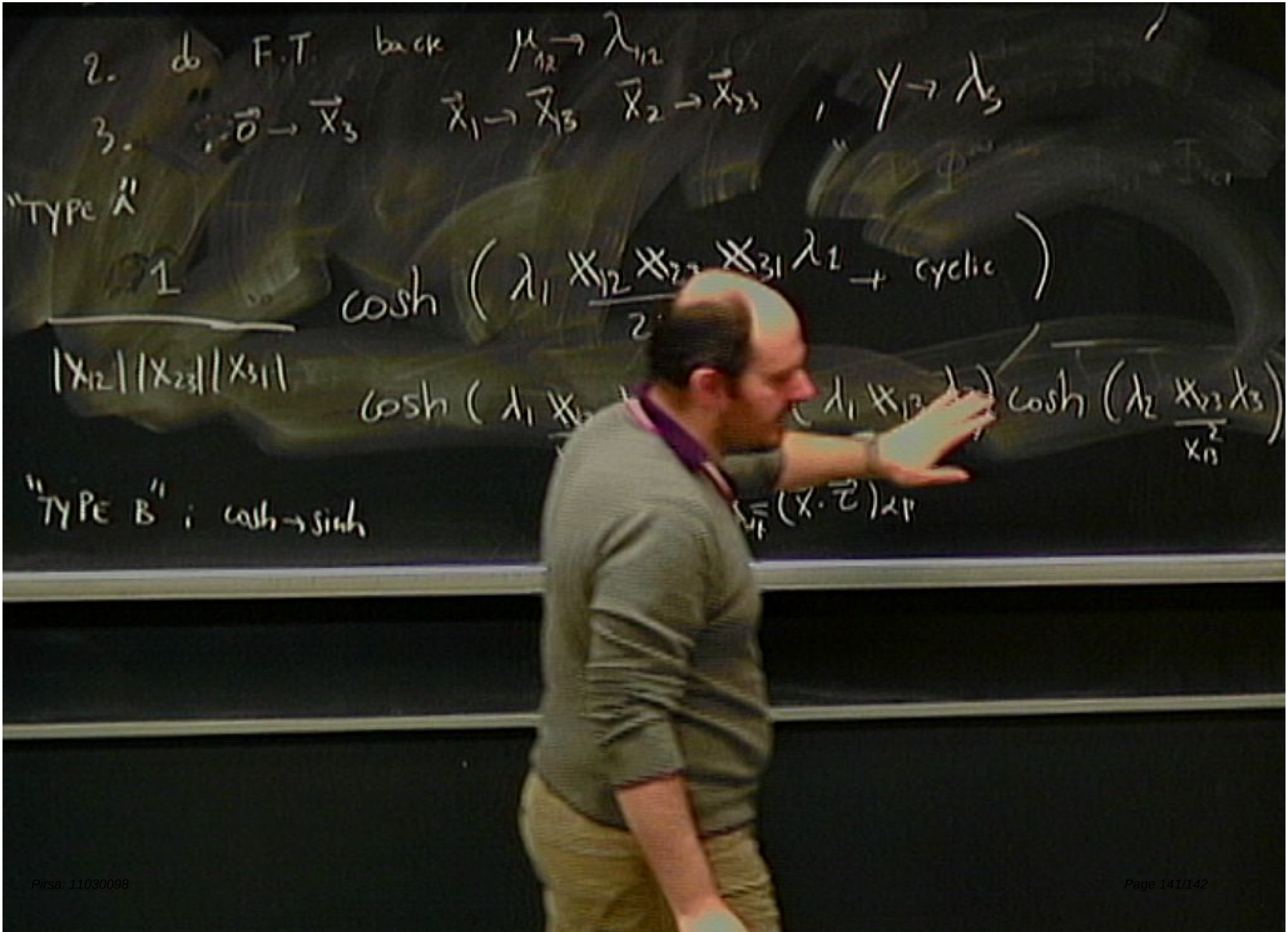
"Type λ"

$$\frac{1}{|x_{12}|\,|x_{23}|\,|x_{31}|}\cosh\left(\lambda_1 \frac{\mathbb{X}_{12}\mathbb{X}_{23}\mathbb{X}_{31}}{2x_{12}^2 x_{31}^2}\lambda_1 + \text{cyclic}\right)$$

$$\cosh\left(\lambda_1 \frac{\mathbb{X}_{12}}{x_{12}^2}\lambda_2\right)\cosh\left(\lambda_1 \frac{\mathbb{X}_{13}}{x_{13}^2}\lambda_3\right)\cosh\left(\lambda_2 \frac{\mathbb{X}_{23}}{x_{13}^2}\lambda_3\right)$$

$$\mathbb{X}_{\mu\nu} = (\vec{x}\cdot\vec{\tau})_{\alpha\beta}$$


2. do F.T. back μ12 → λ12
3. 0 → x3   x1 → x13   x2 → x23 ,   y → λ3
"Type λ"
cosh (λ1 X12 X23 X31 λ2 / 2 x12² x31² + cyclic)
cosh (λ1 X12/x12² λ2) cosh (λ1 X13/x13² λ3) cosh (λ2 X23/x13² λ3)
cosh → sinh


2. do F.T. back μ12 → λ12
3. 0 → X3 X1 → X13 X2 → X23 , Y → λ3
"TYPE A"
cosh
|X12| |X23| |X31|
"TYPE B" : cosh → sinh

1. do U,V integral

2. do F.T. back $\mu_{12} \to \lambda_{12}$

3. $\vec{?}=\vec{0} \to \vec{X}_3$ $\quad \vec{X}_1 \to \vec{X}_{13}$ $\quad \vec{X}_2 \to \vec{X}_{23}$, $\quad Y \to \lambda_3$

"Type A"

$$\frac{1}{|X_{12}|\,|X_{23}|\,|X_{31}|}\;\cosh\left(\lambda_1 \frac{\mathbb{X}_{12}\mathbb{X}_{23}\mathbb{X}_{31}}{2X_{12}^2 X_{31}^2}\lambda_1 + \text{cyclic}\right)\cosh\left(\lambda_1 \frac{\mathbb{X}_{12}}{X_{12}^2}\lambda_2\right)\cosh\left(\lambda_1 \frac{\mathbb{X}_{13}}{X_{13}^2}\lambda_3\right)\cosh\left(\lambda_2 \frac{\mathbb{X}_{23}}{X_{23}^2}\lambda_3\right)$$

"Type B" : cosh → sinh $\qquad \mathbb{X}_{\alpha\beta} = (\vec{X}\cdot\vec{\sigma})_{\alpha\beta}$