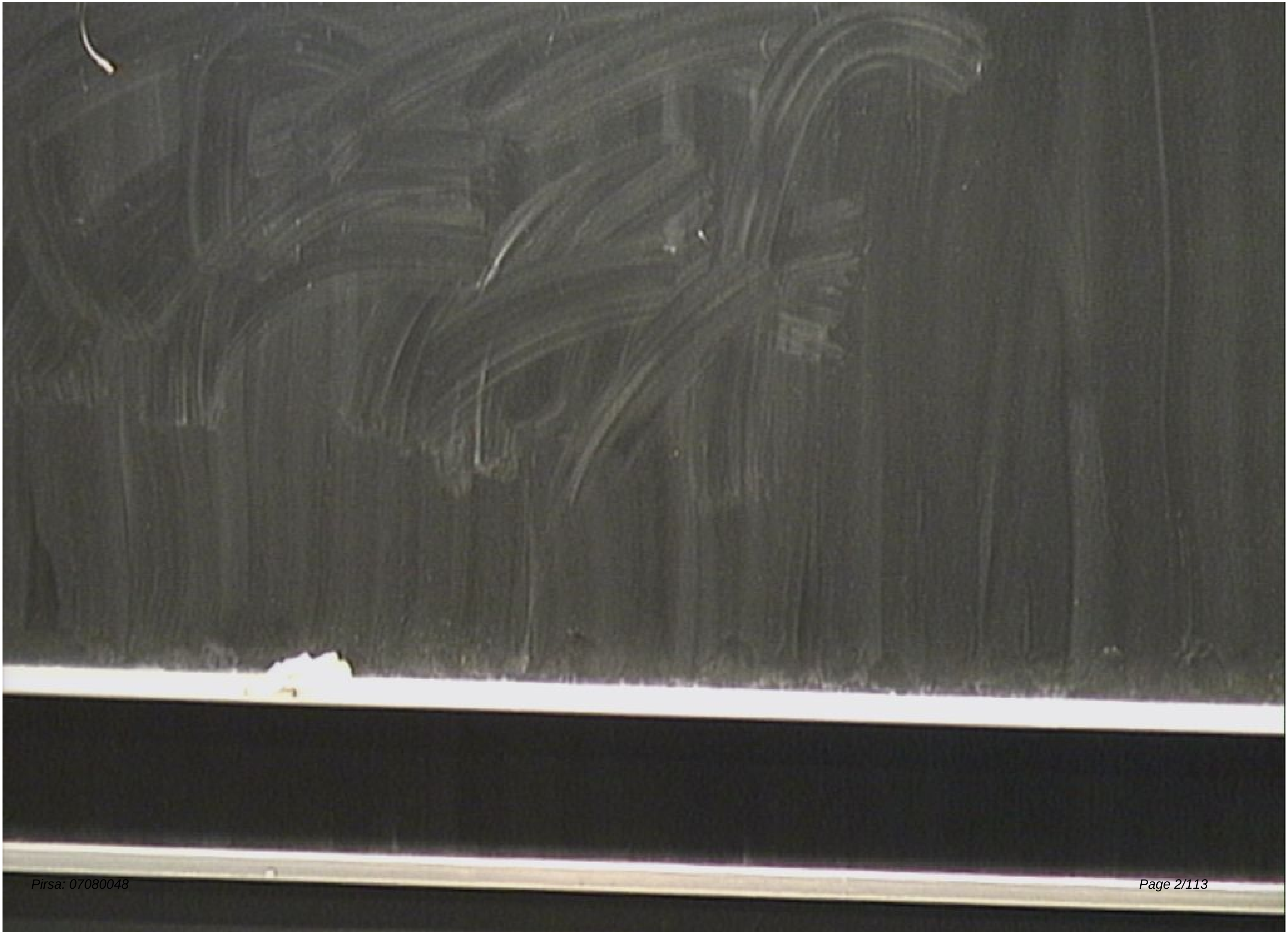
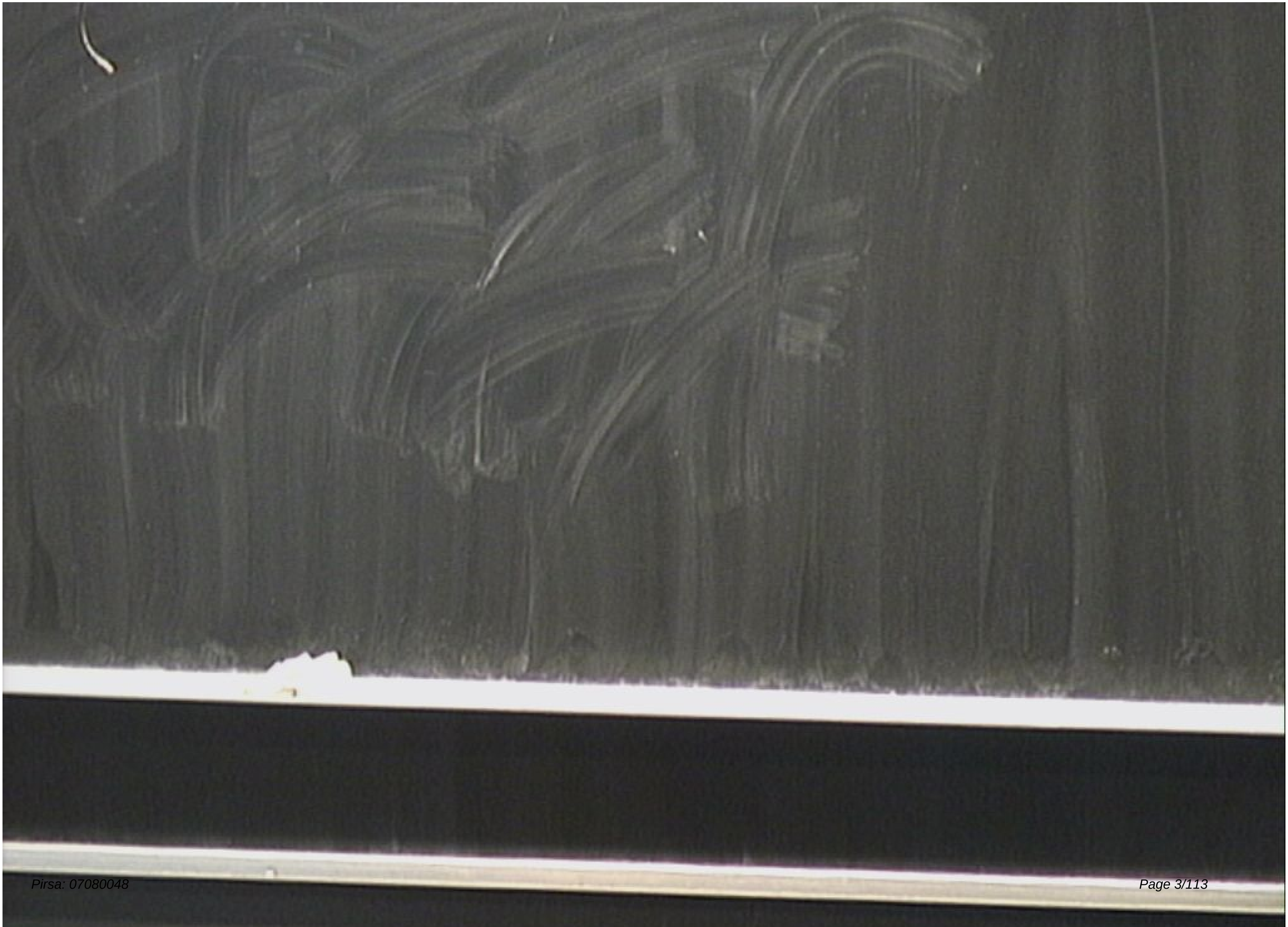
Title: Time symmetric quantum theory, weak measurements, and modular variables (Part 2A)

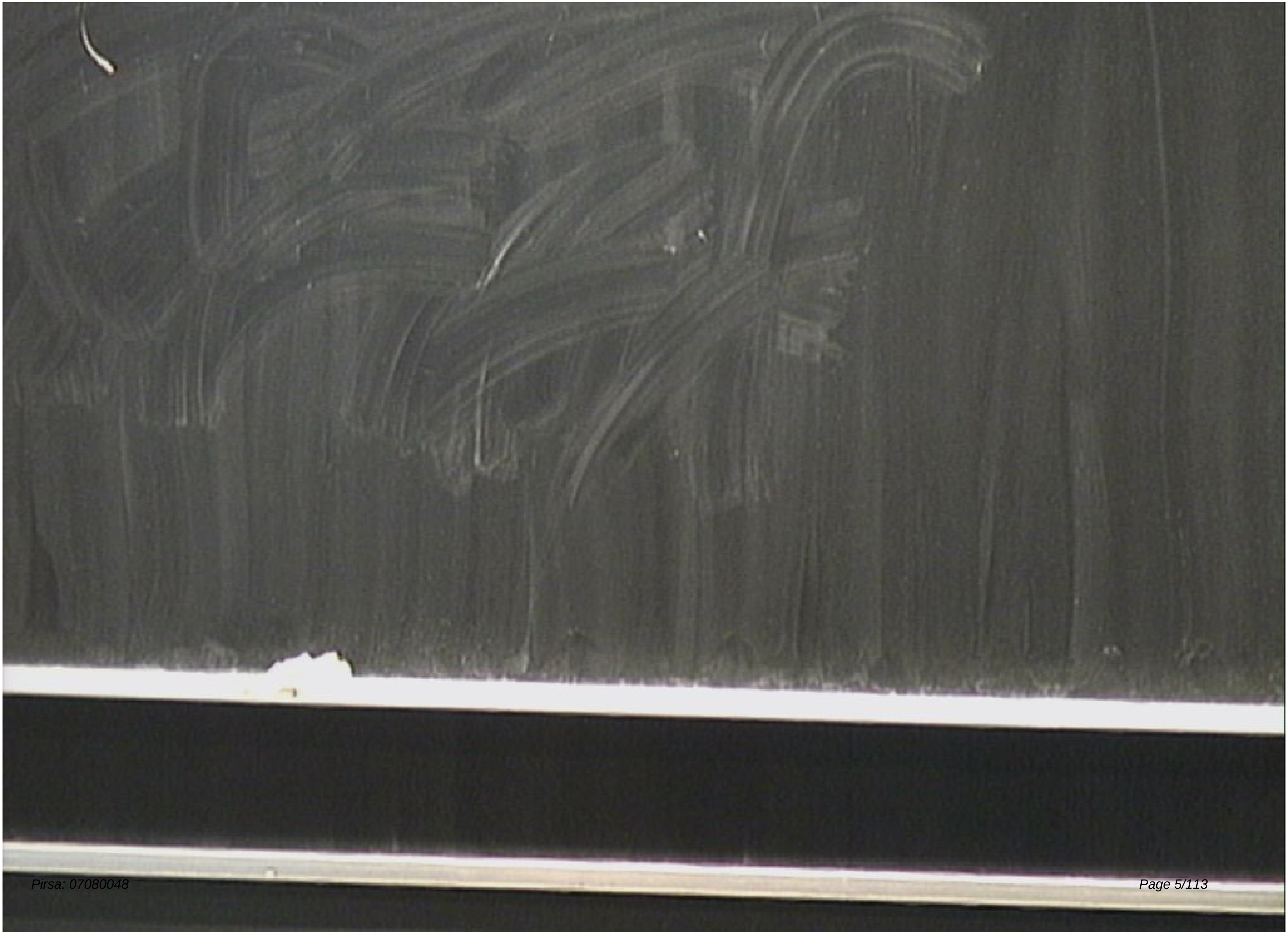
Date: Aug 29, 2007 03:15 PM

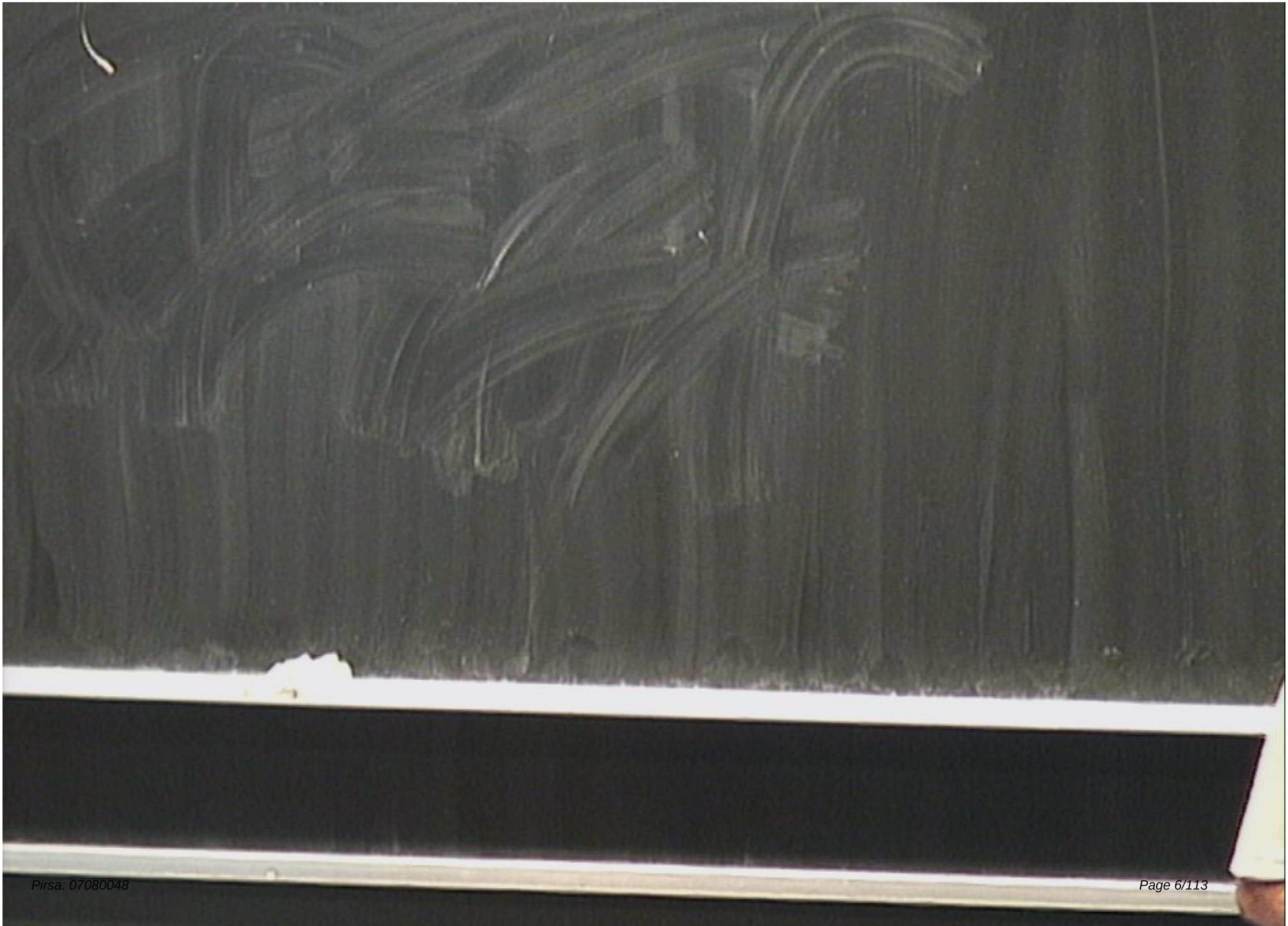
URL: http://pirsa.org/07080048

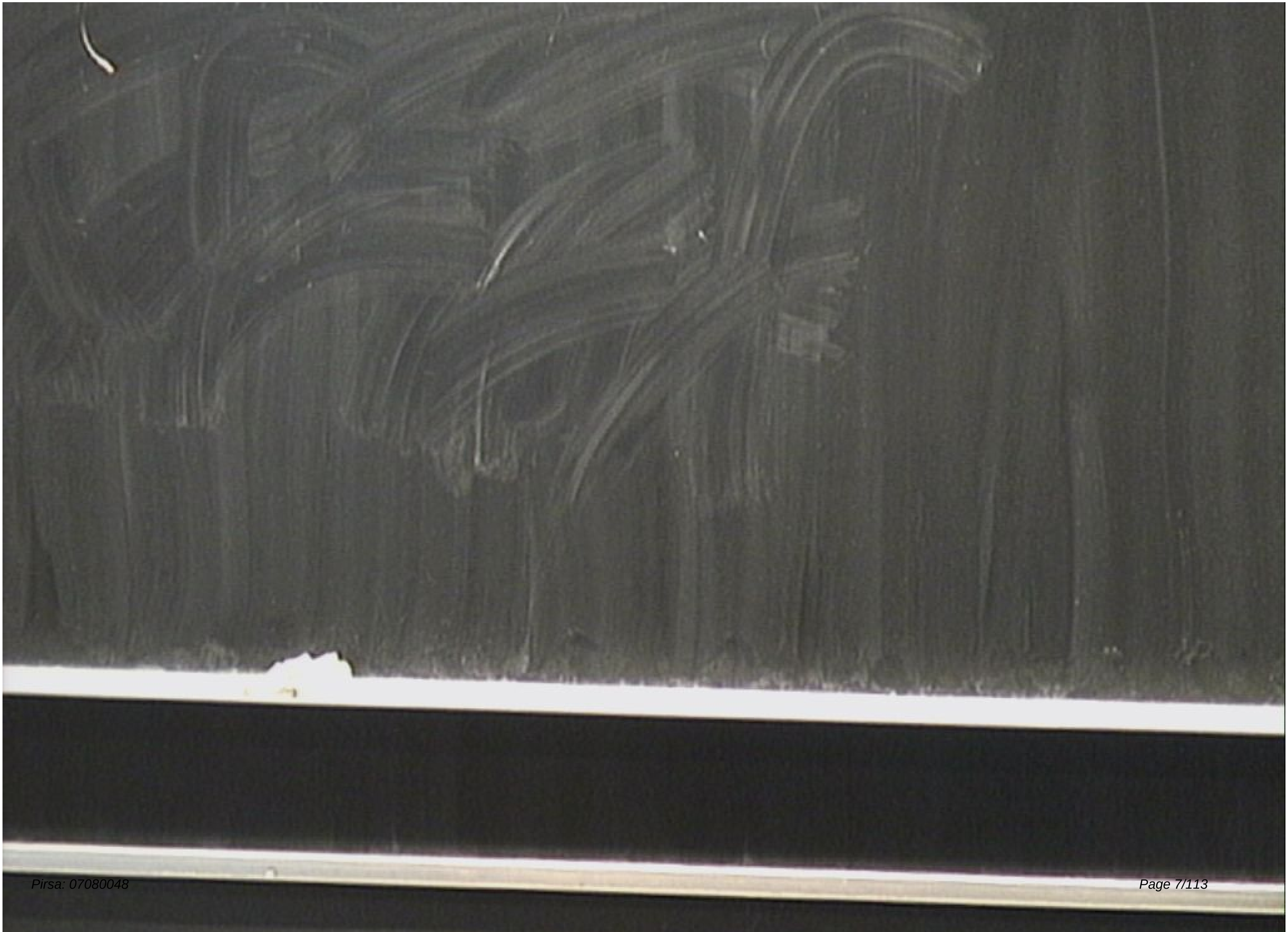
Abstract:

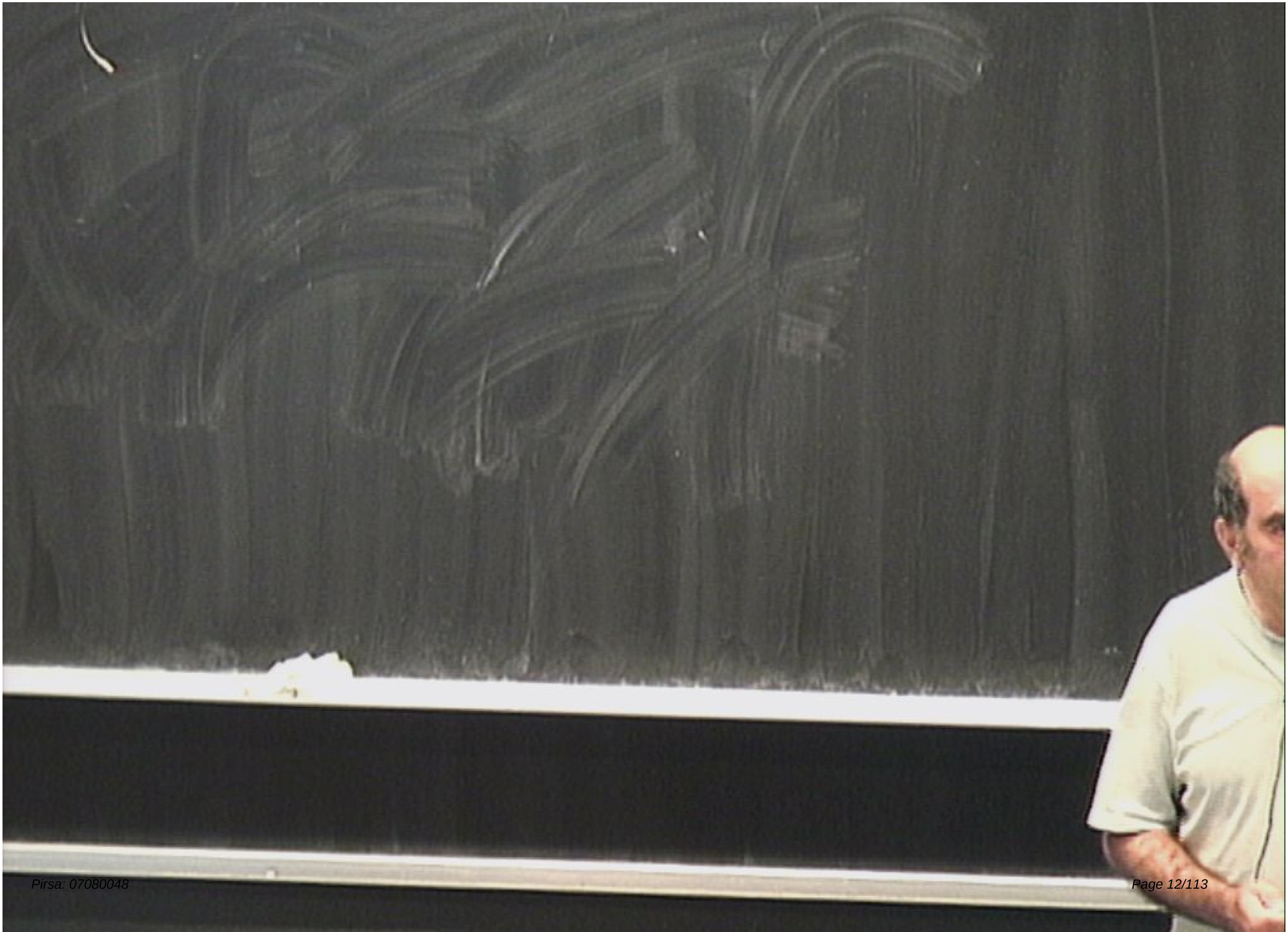


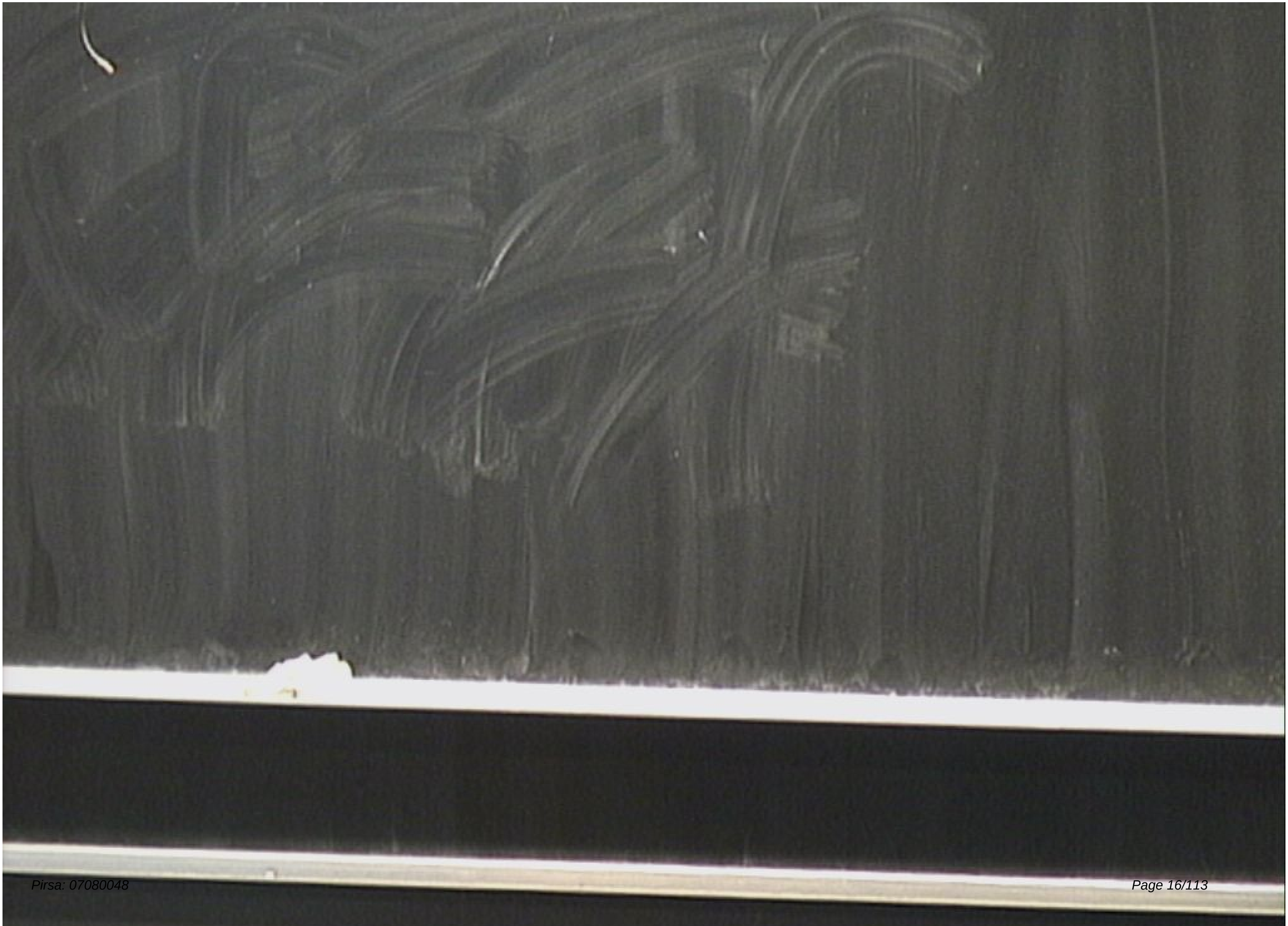


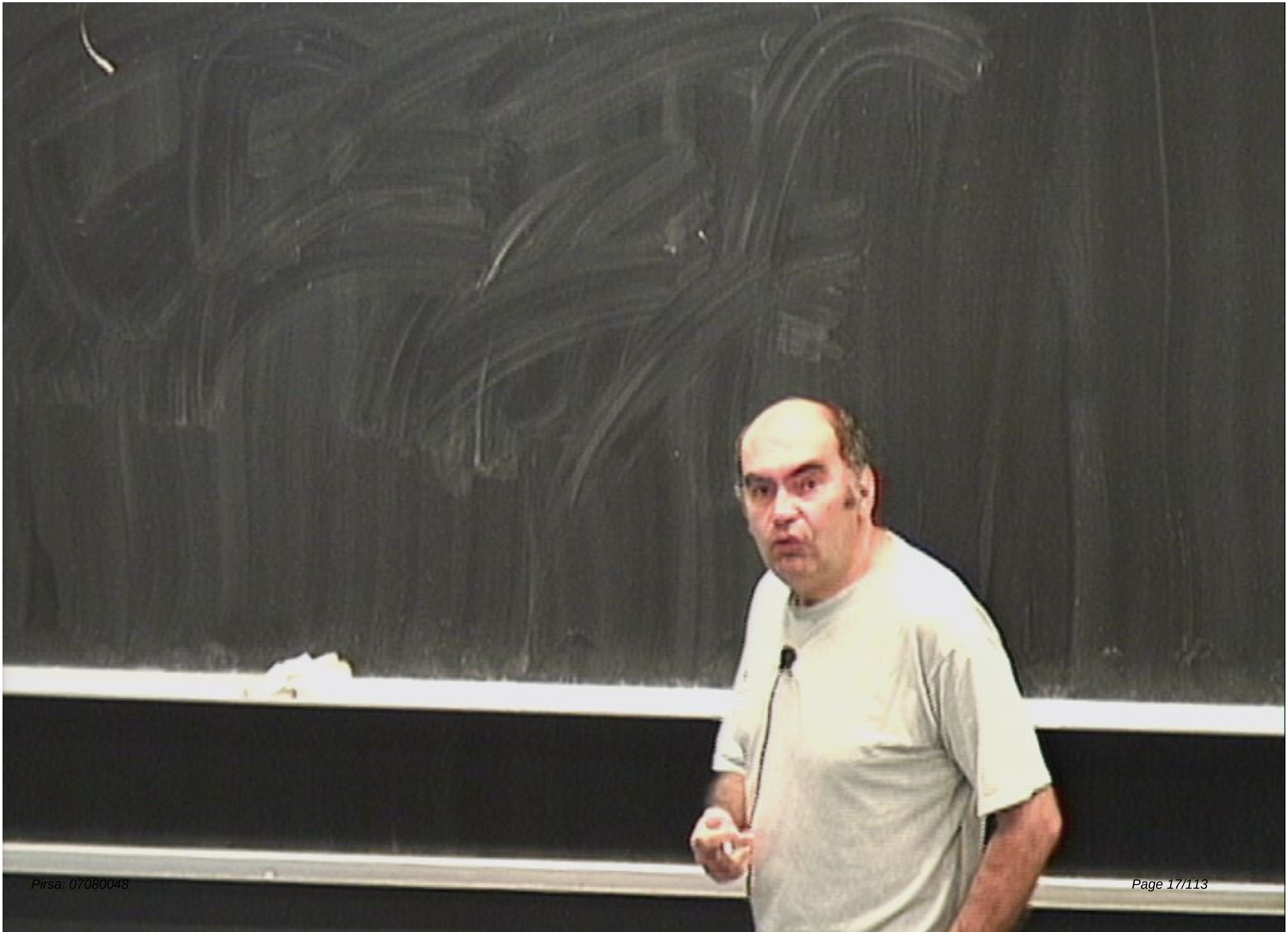


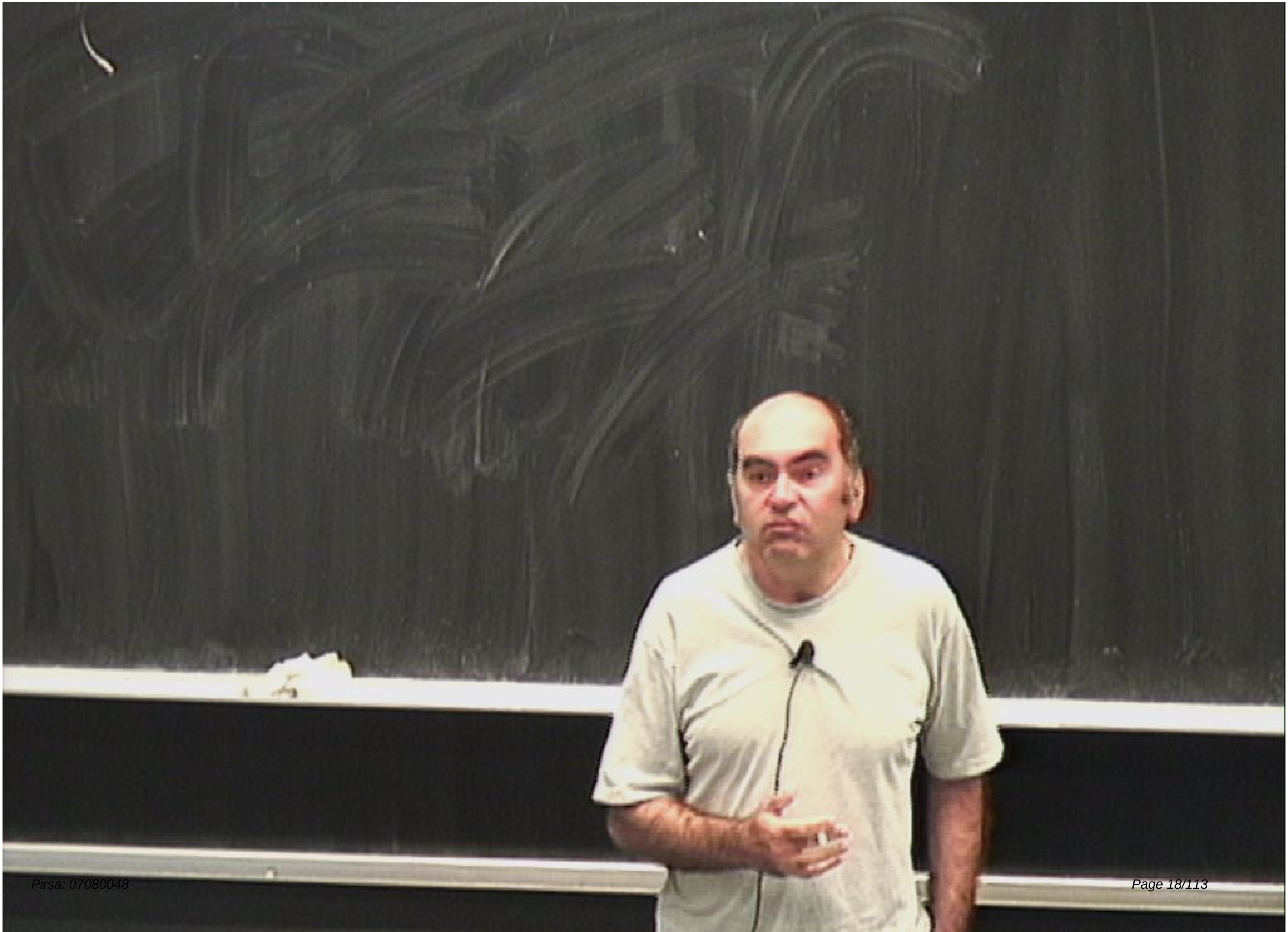


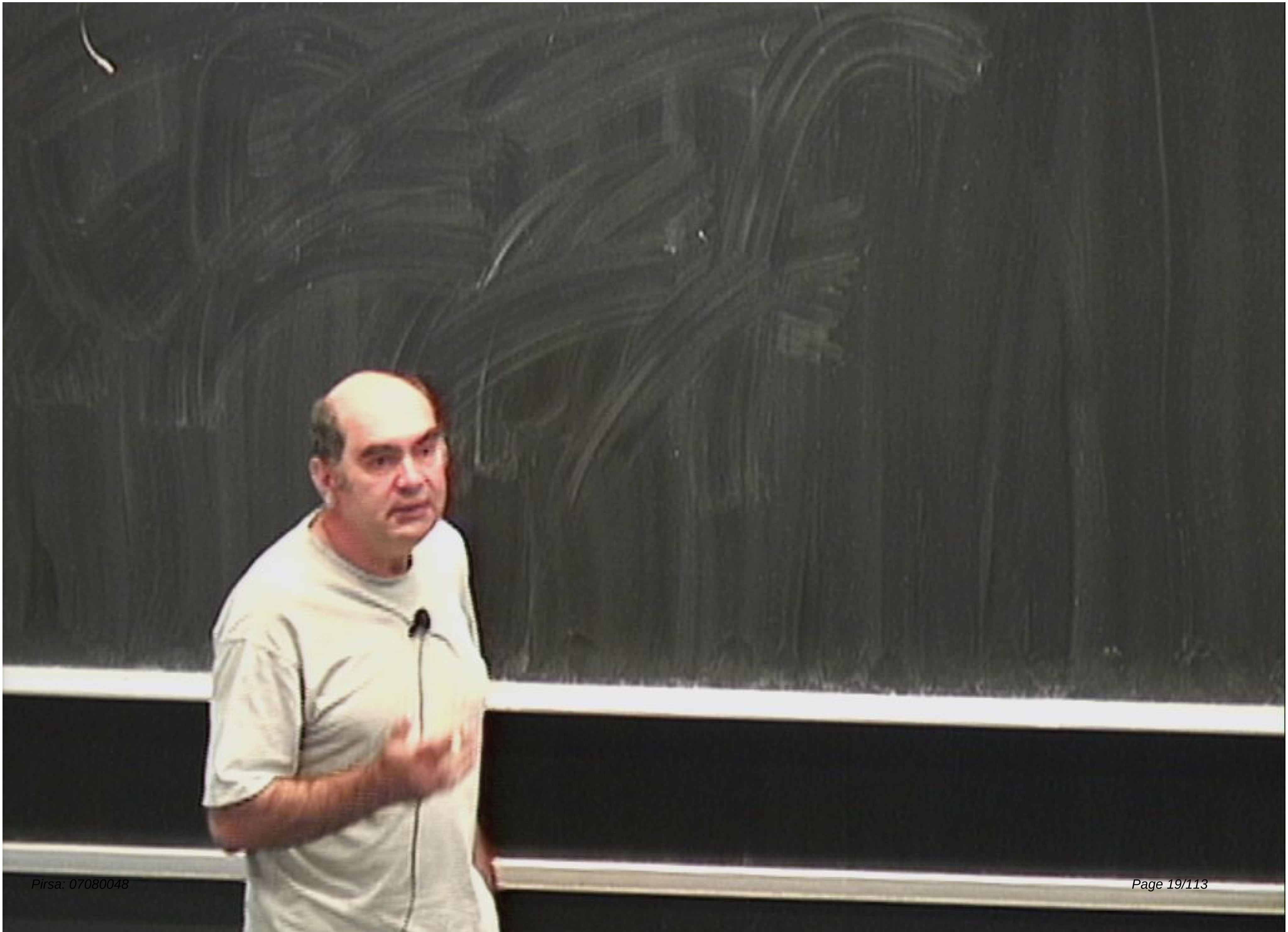


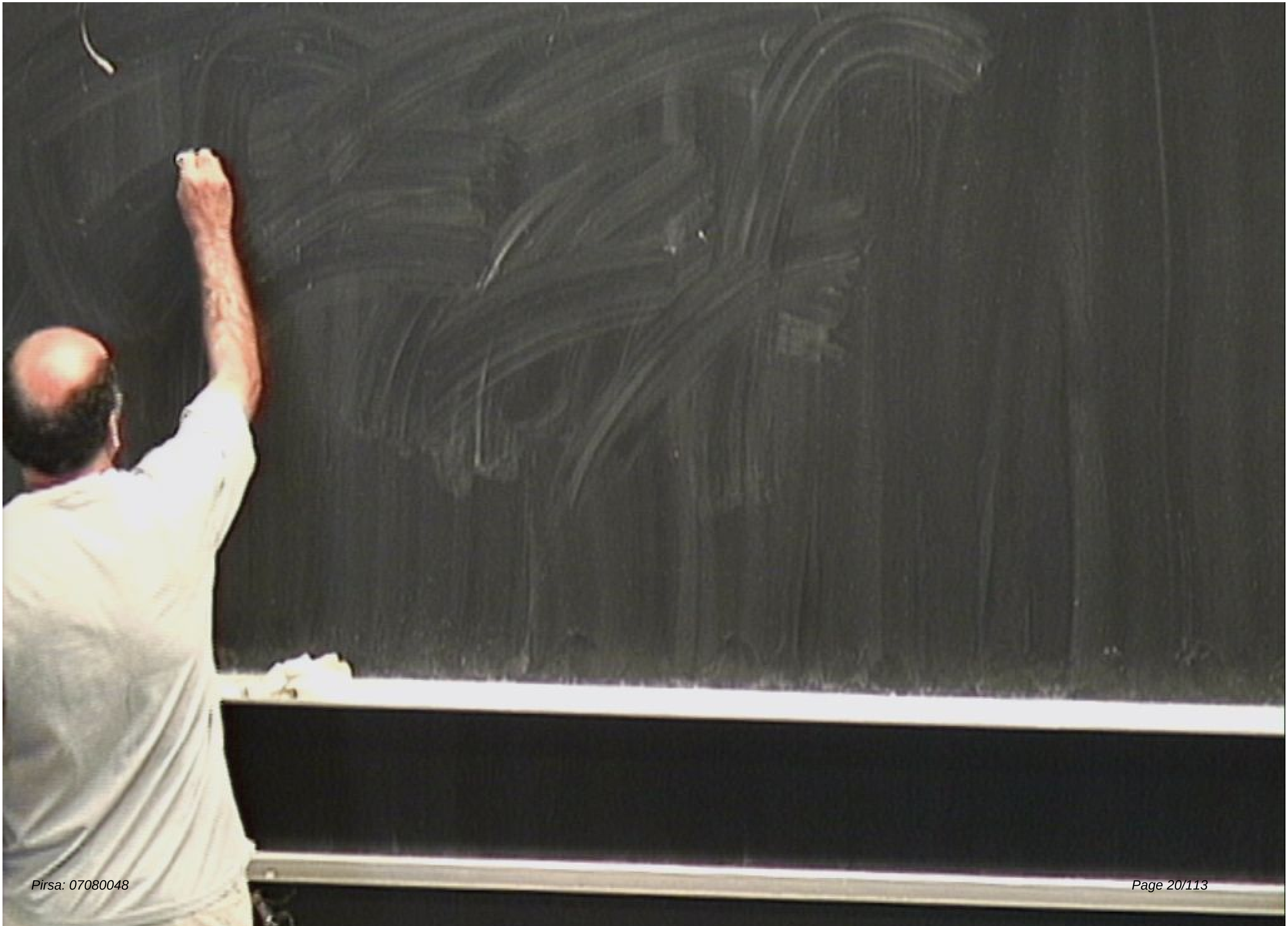


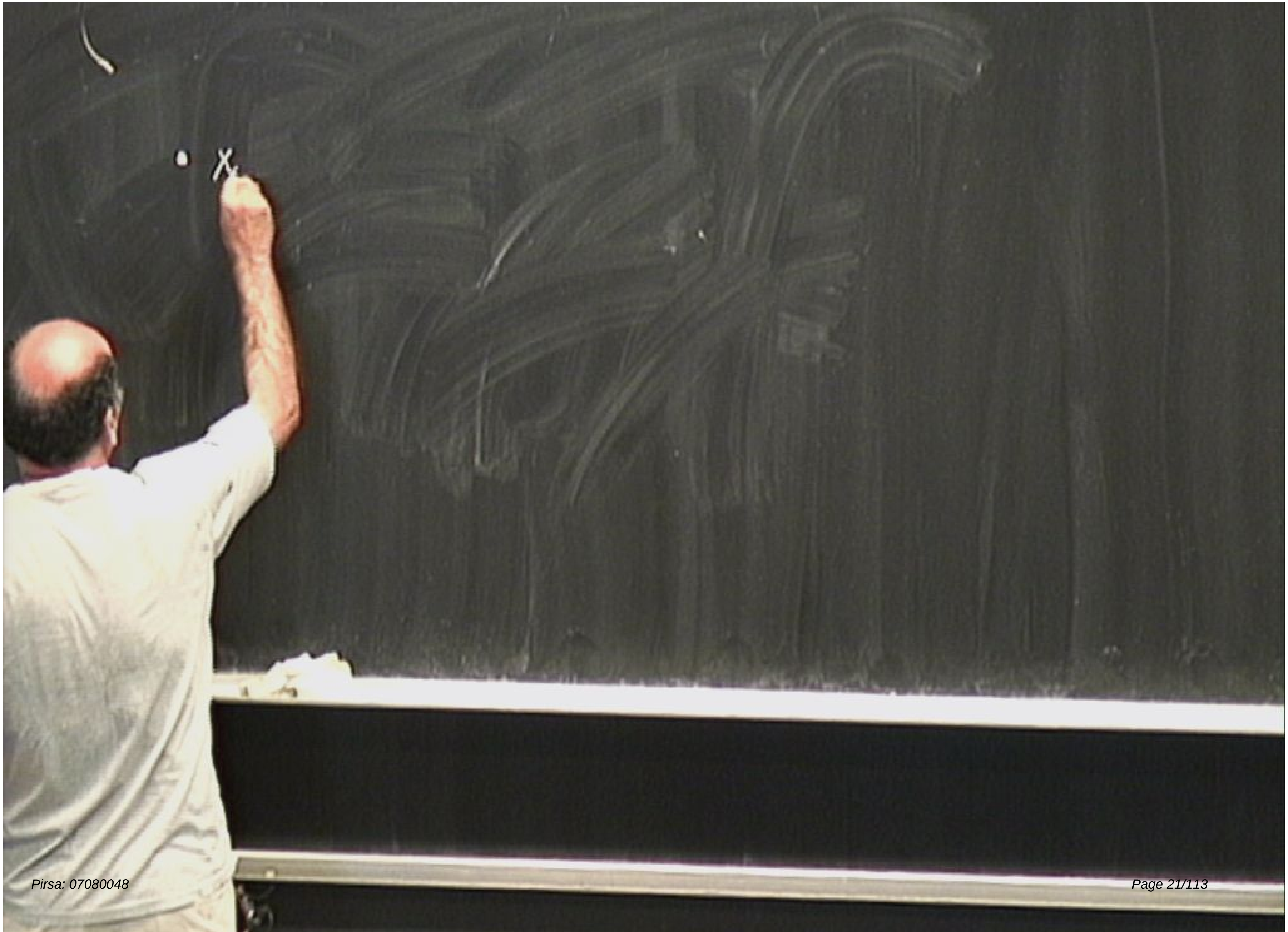


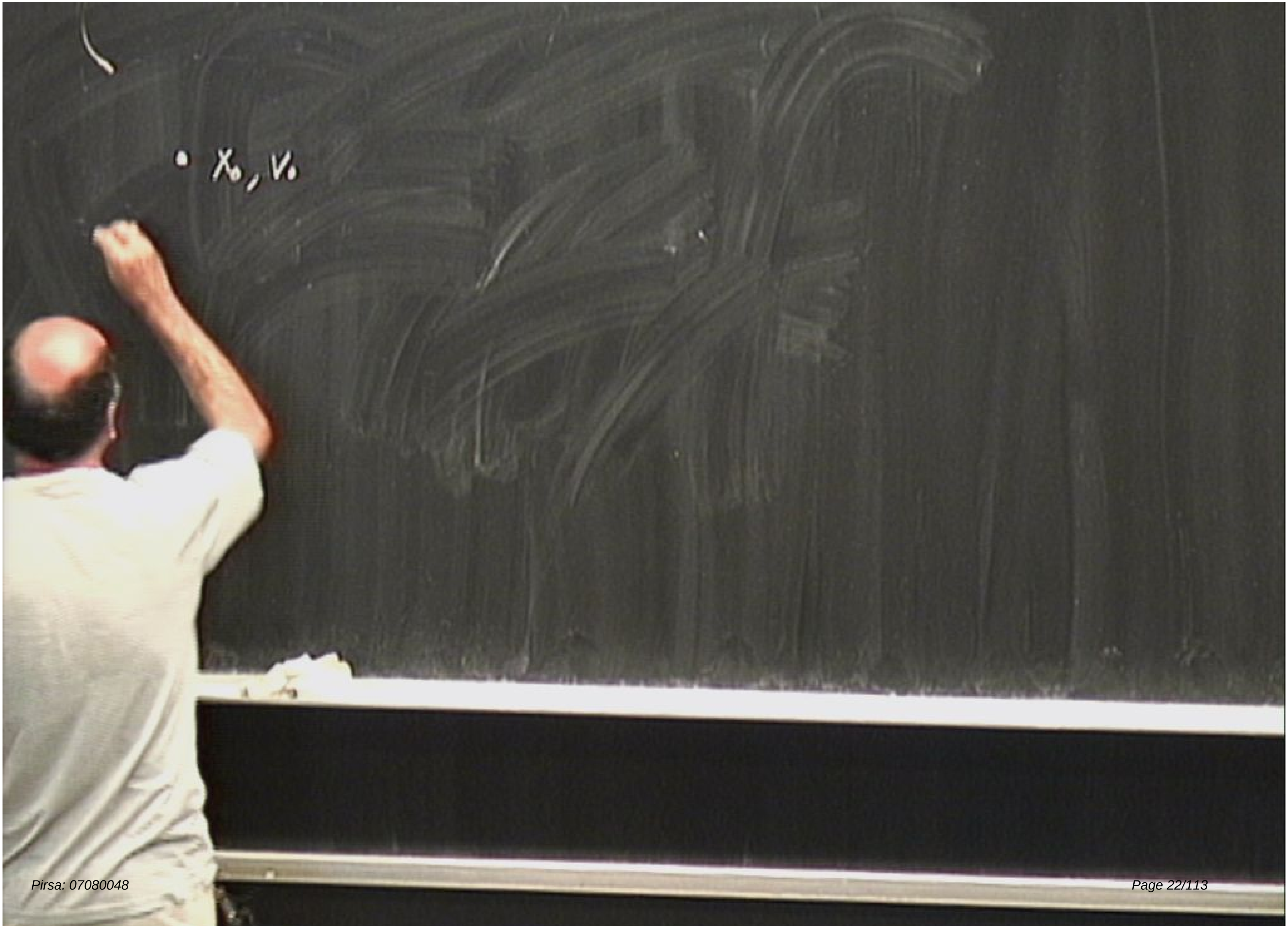


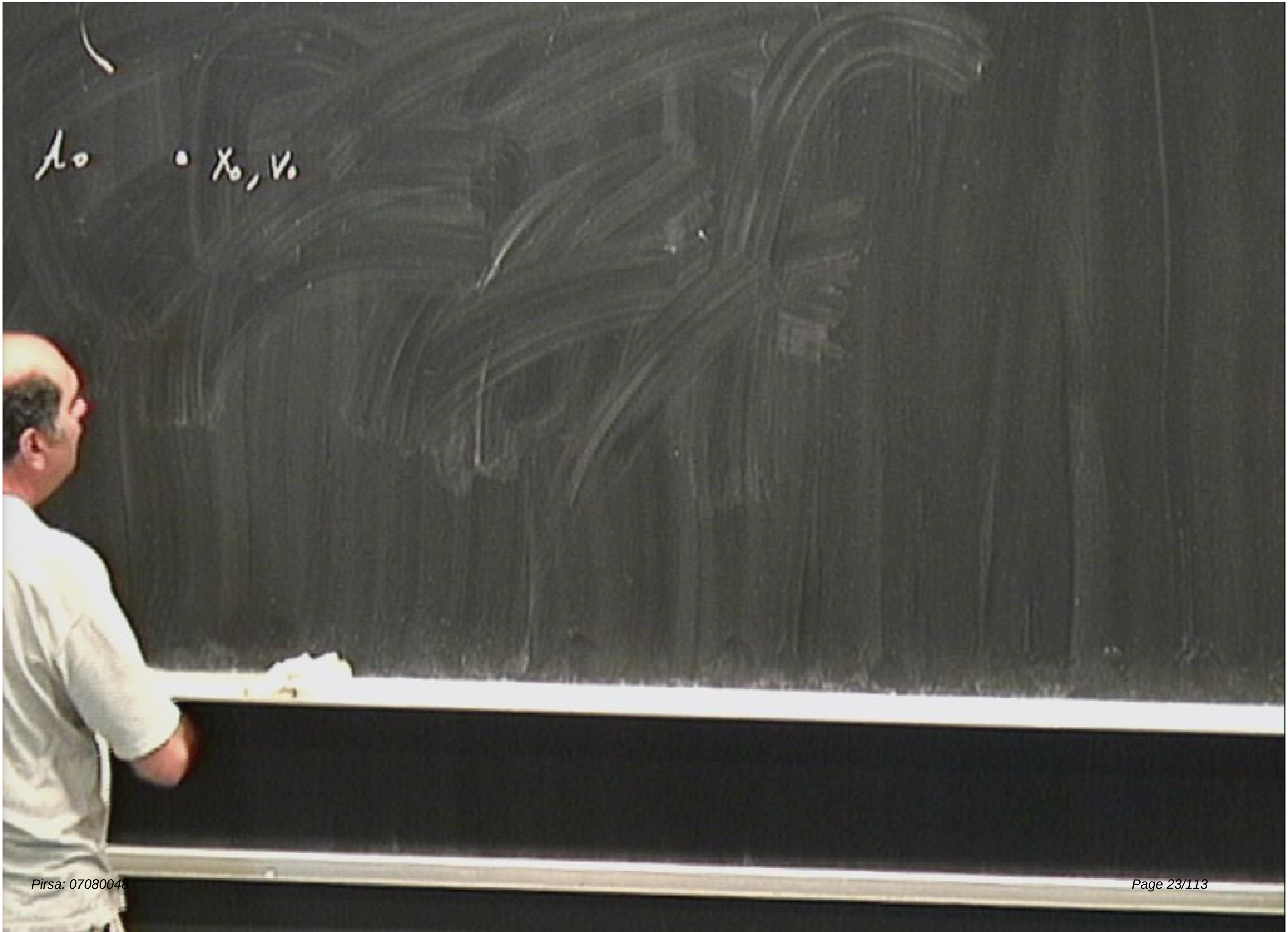


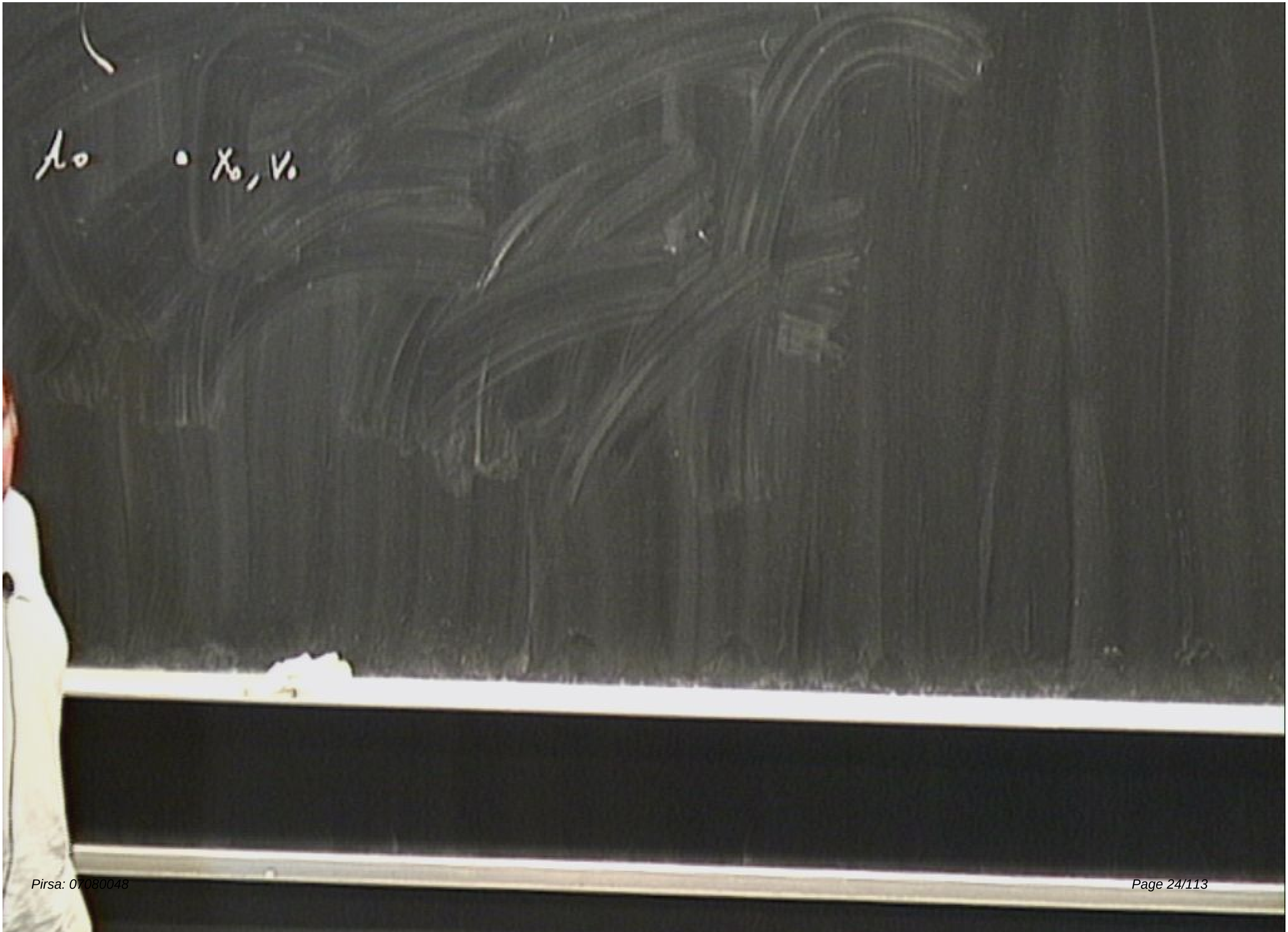




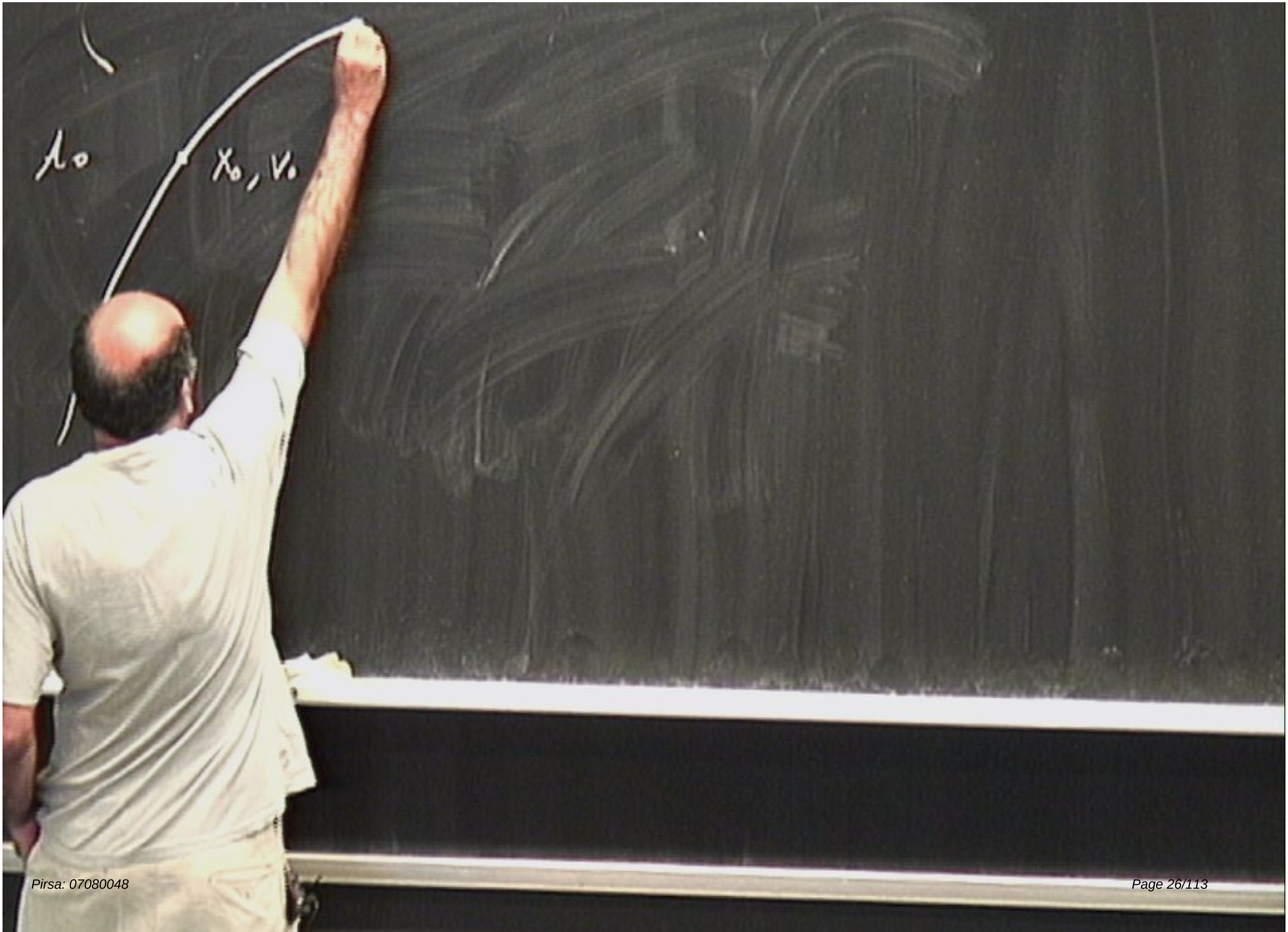

• X

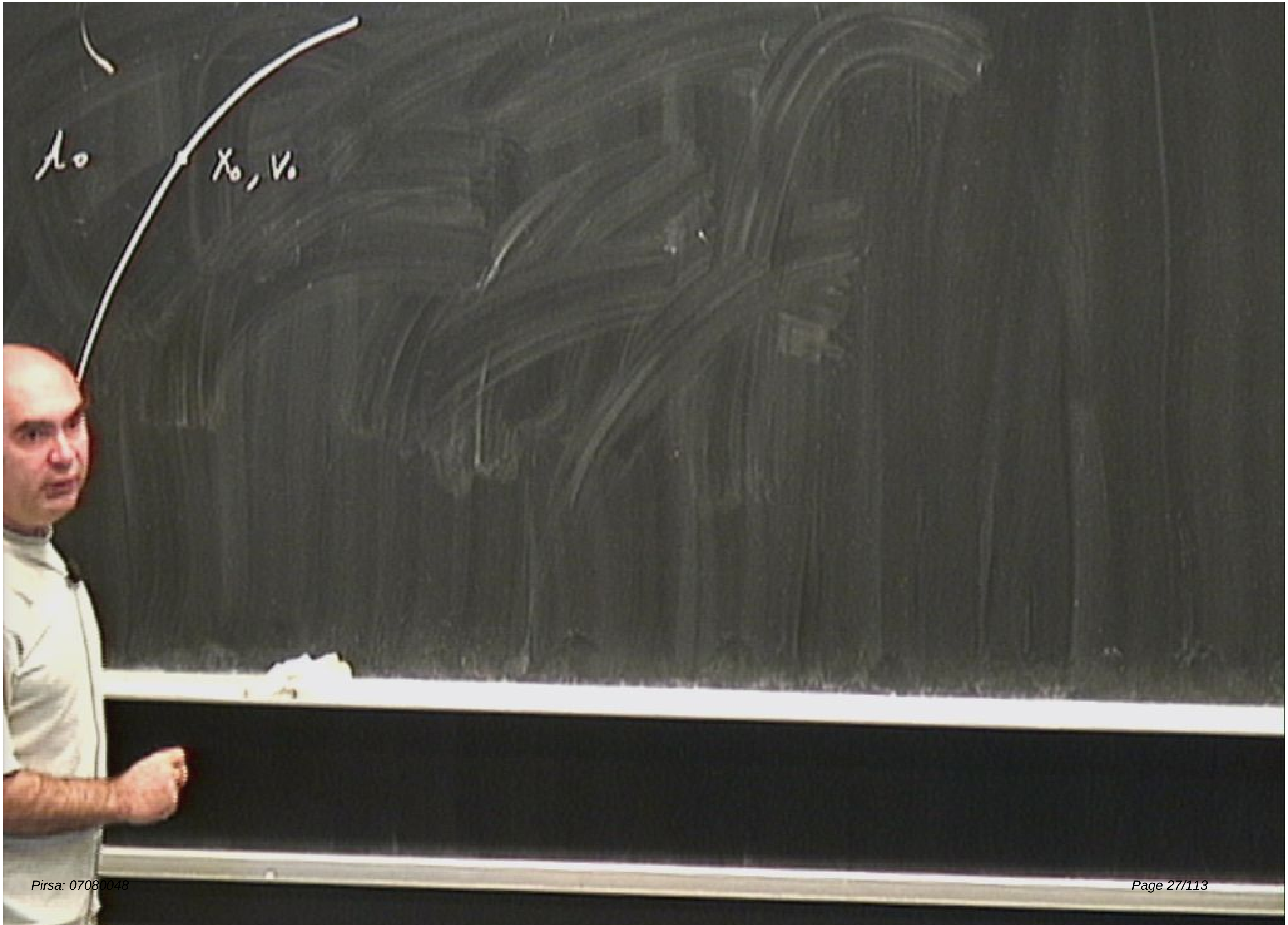

• x_0, v_0


λ_0
$\cdot\ x_0, v_0$


h_0 • x_0, v_0


t_0 • x_0, v_0


λ_0
X_0, V_0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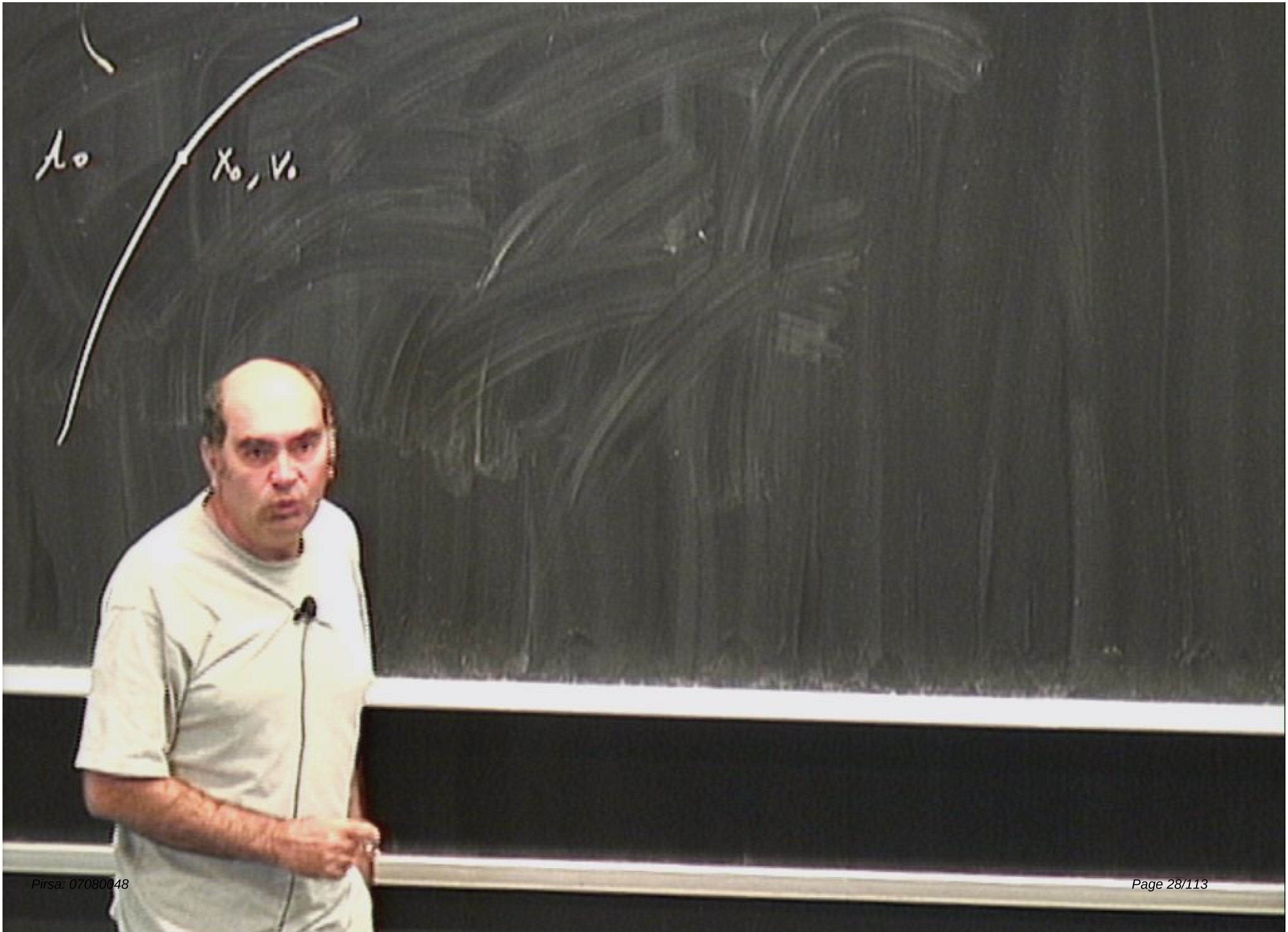
x_0, v_0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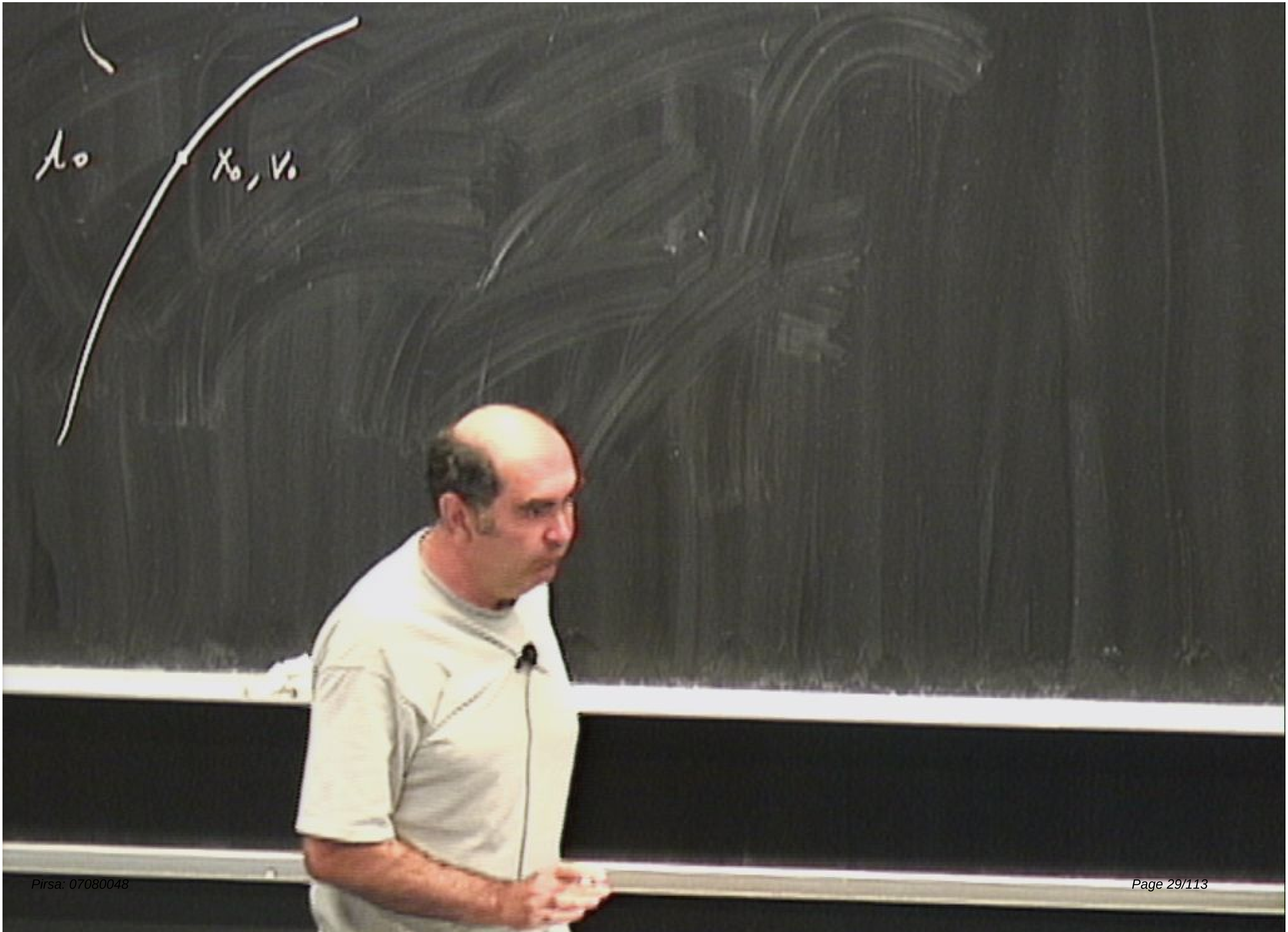
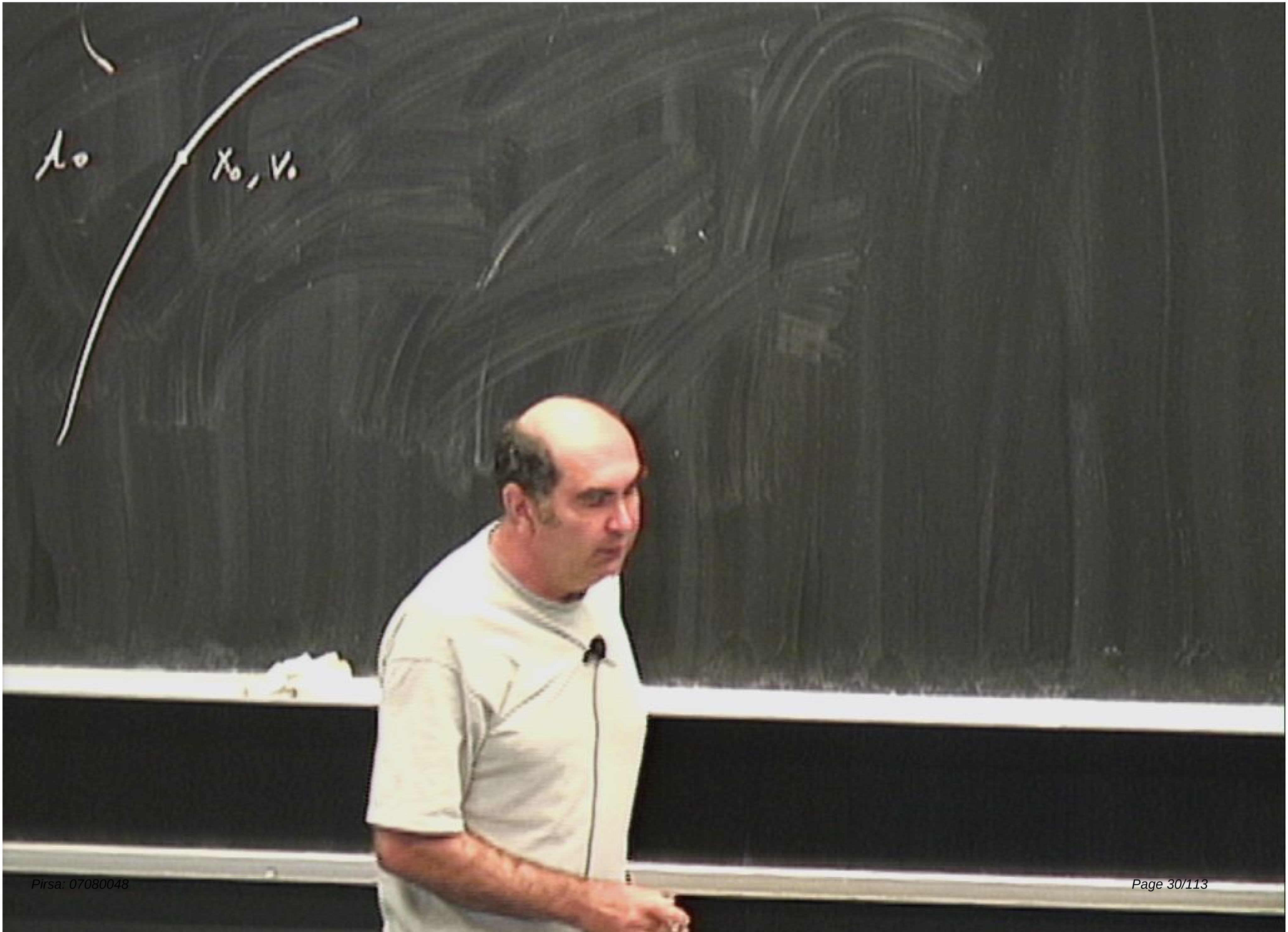
x_0, v_0


λ_0
X_0, V_0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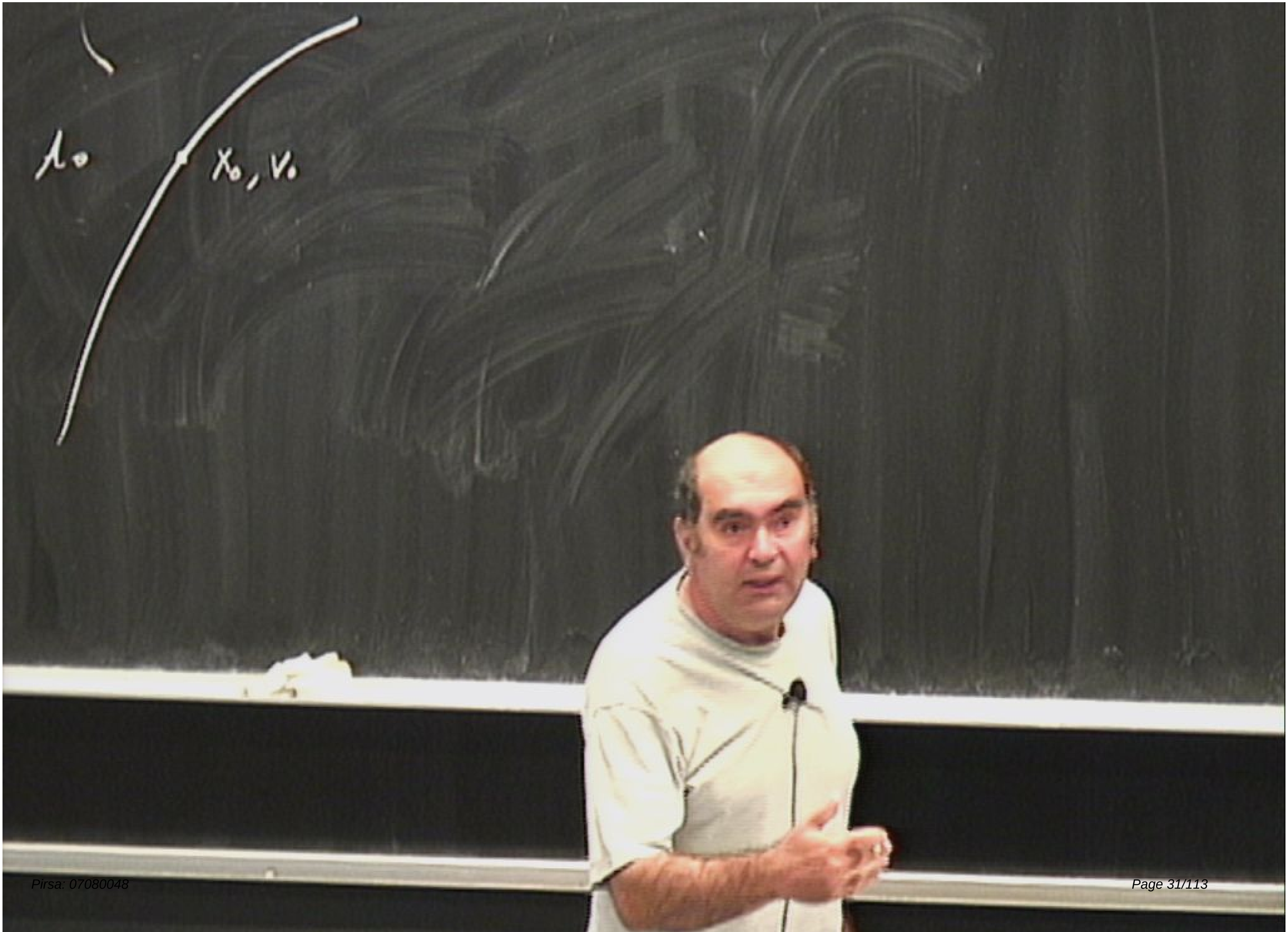
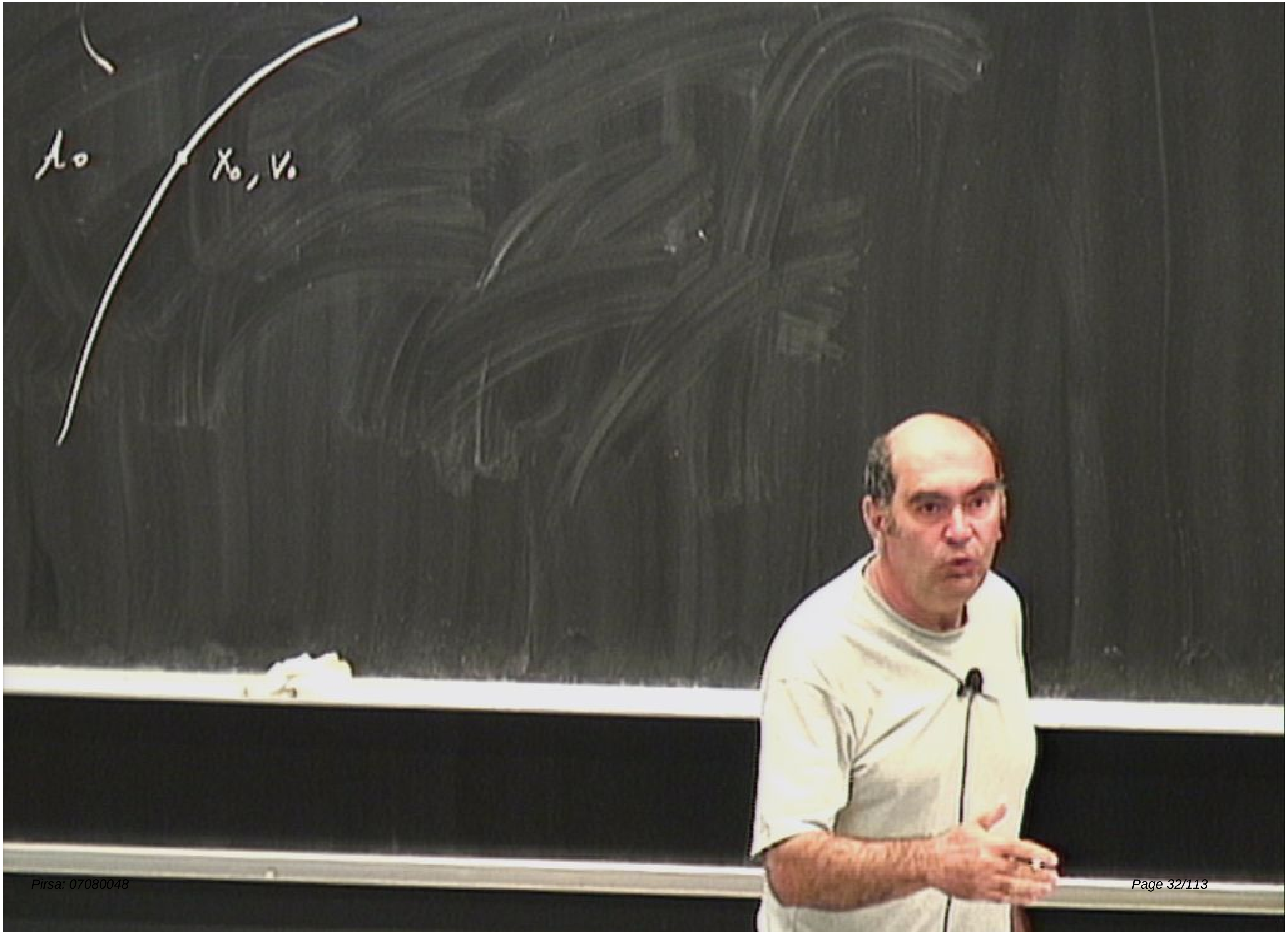
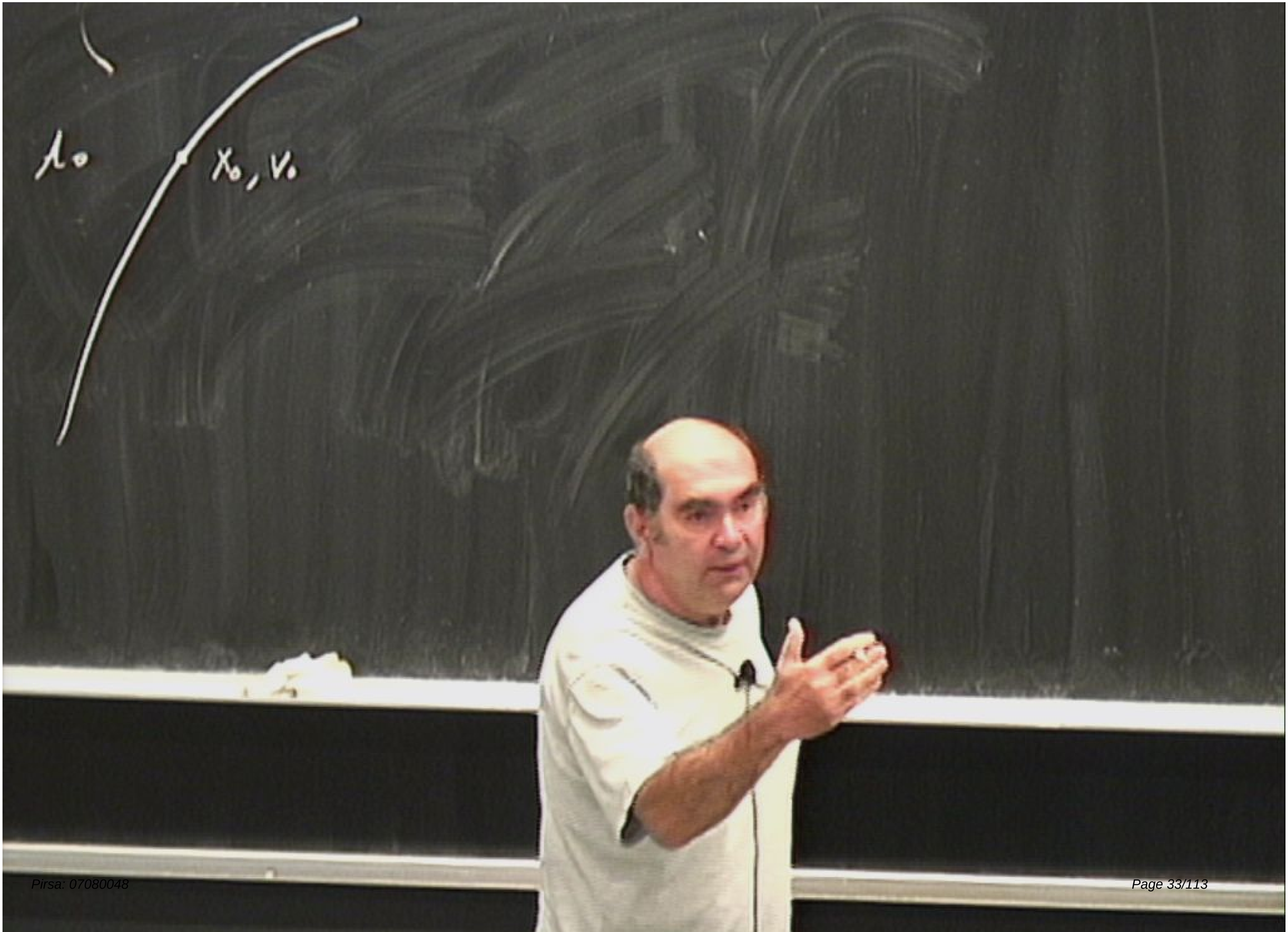
x_0, v_0


λ_0
x_0, v_0


λ_0
x_0, v_0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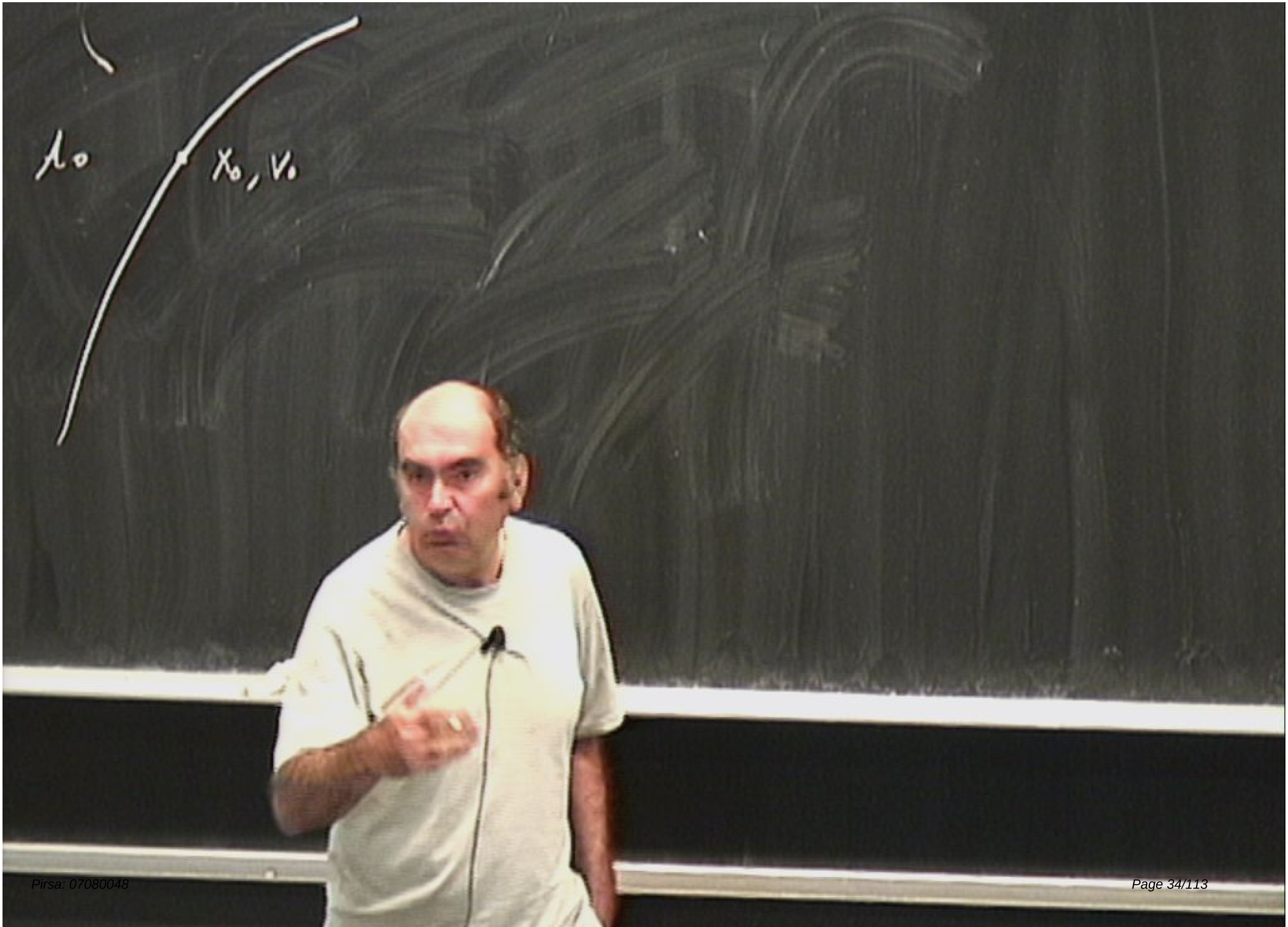
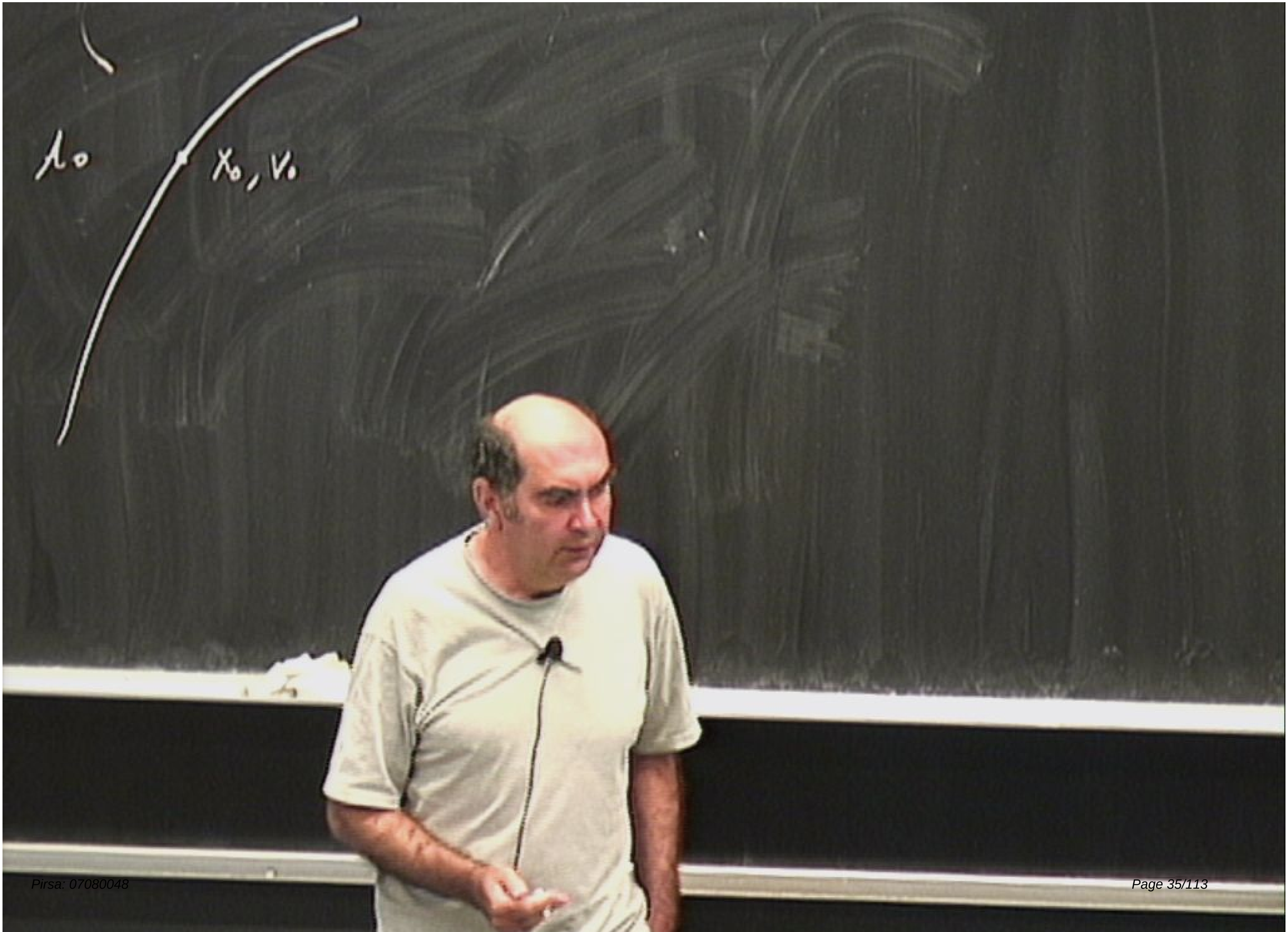
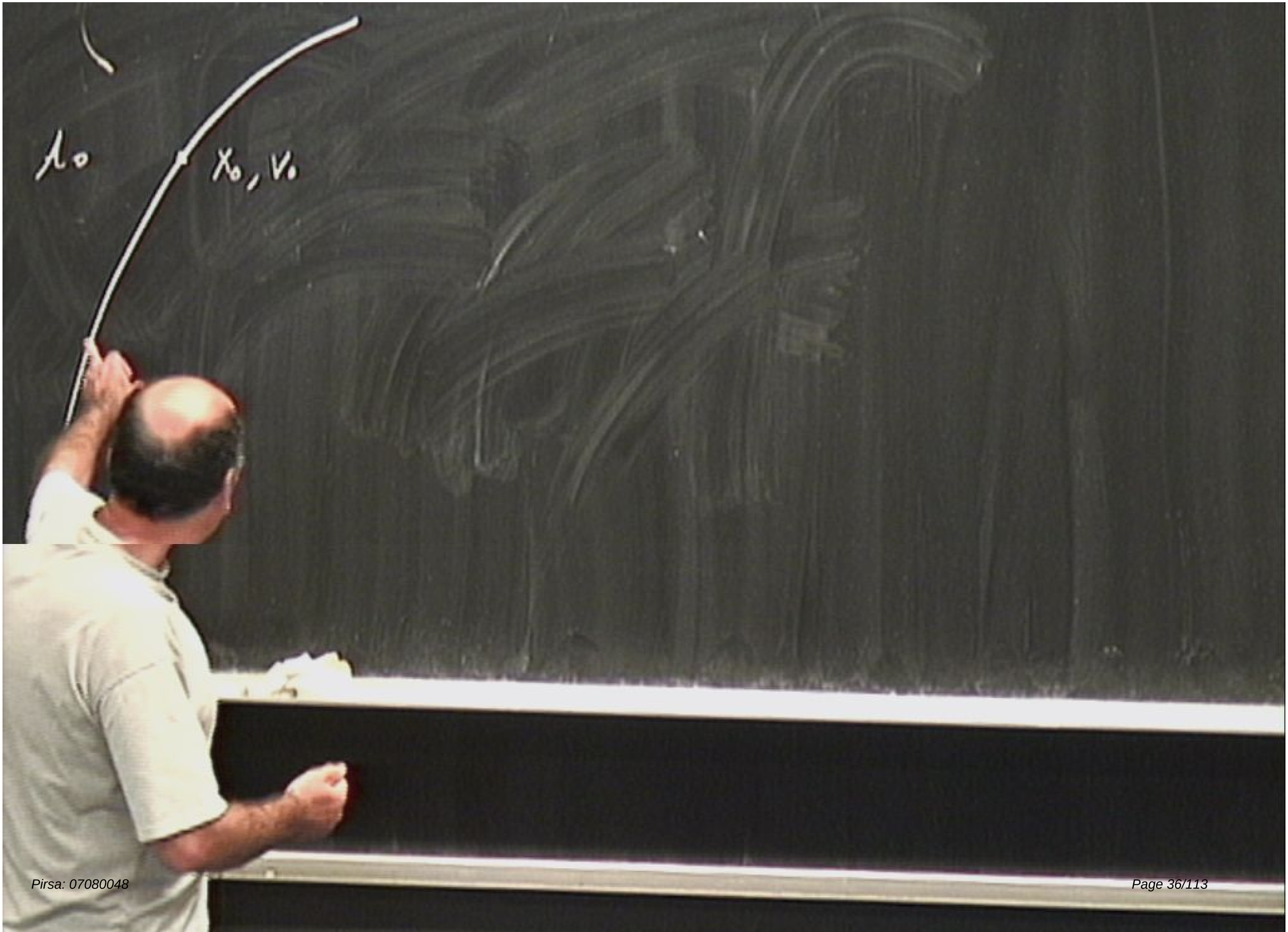
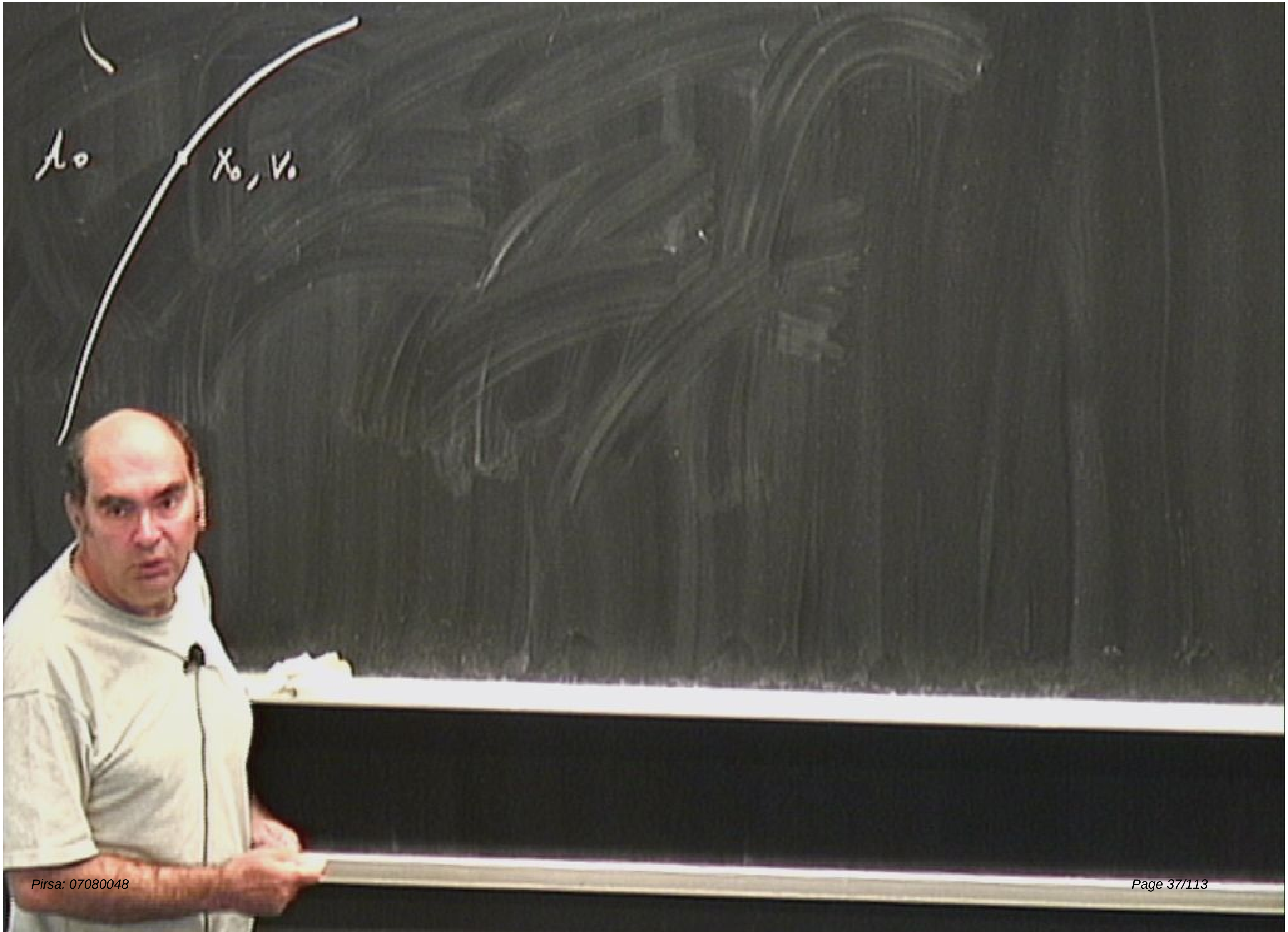
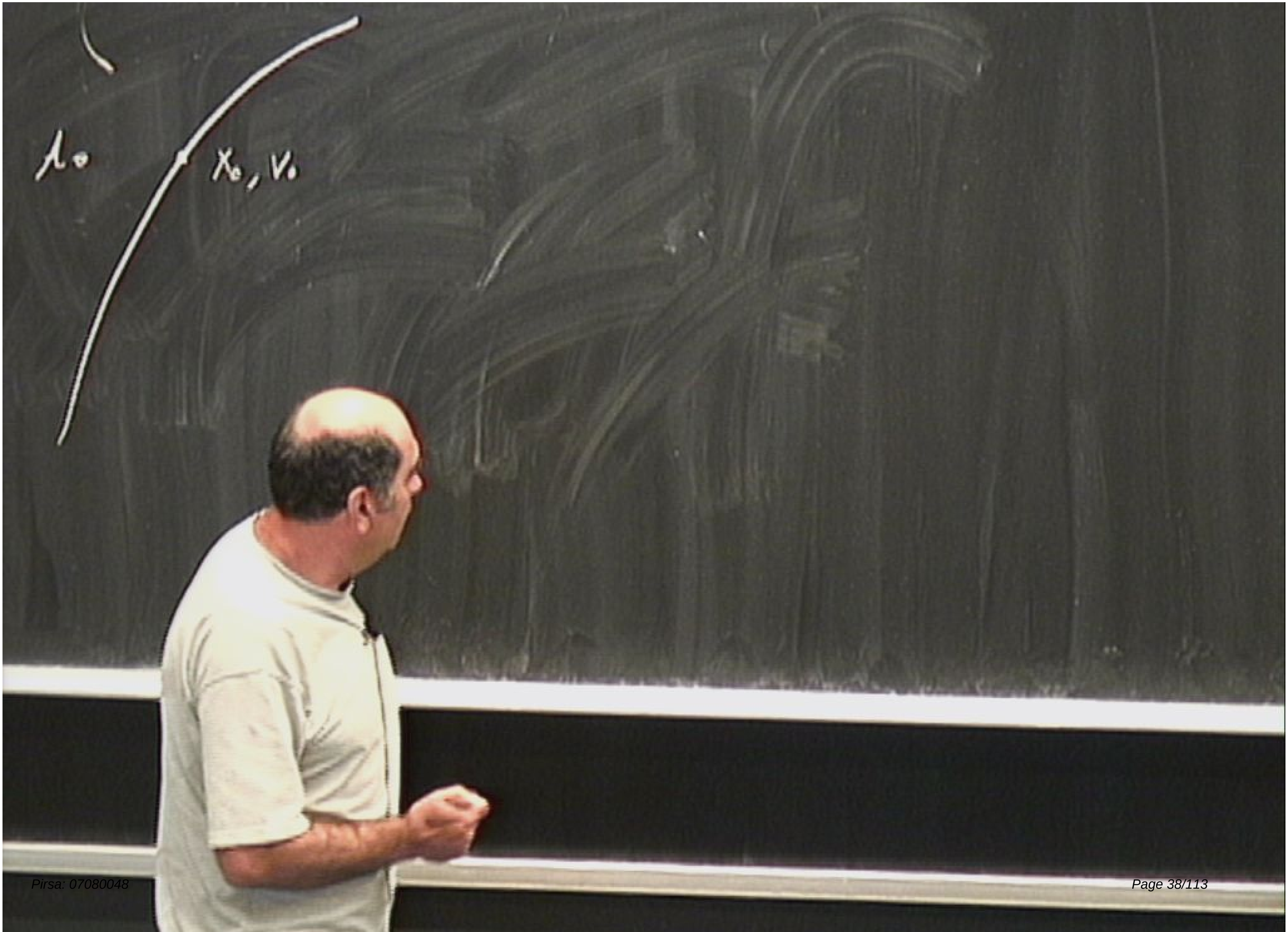
x_0, v_0


λ_0
x_0, v_0


λ_0
x_0, v_0


λ_0
X_0, V_0


λ_0
x_0, v_0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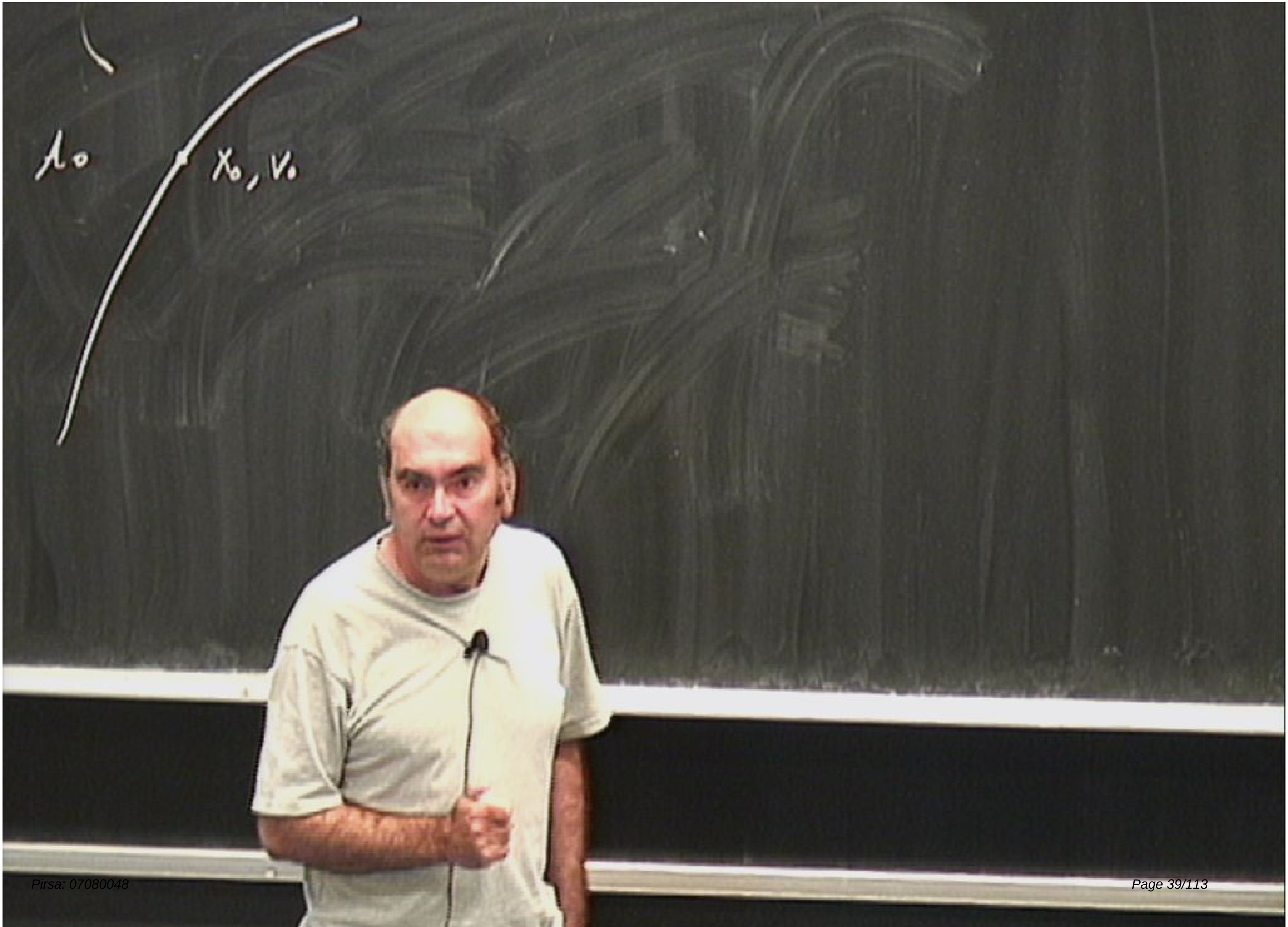
x_0, v_0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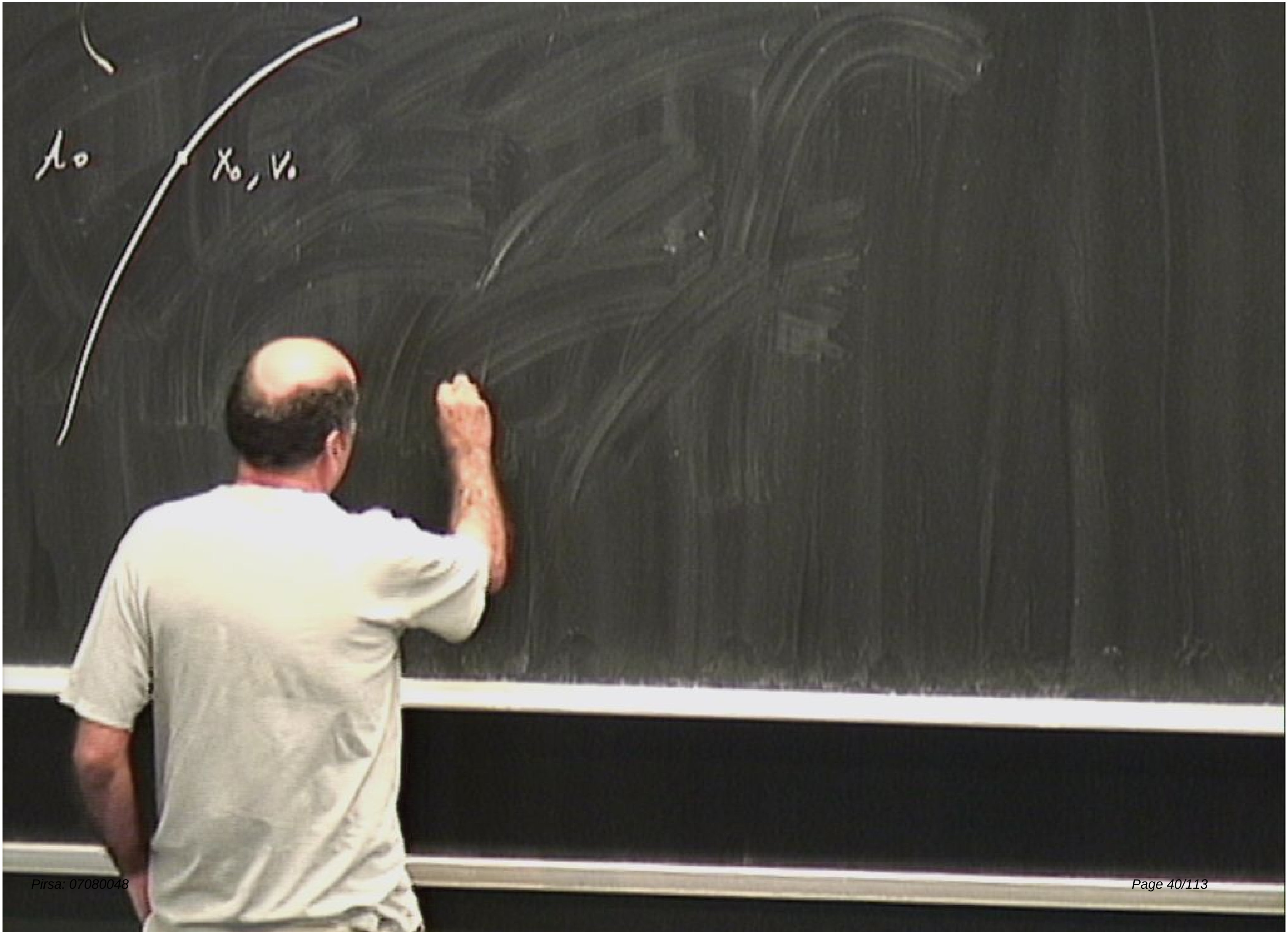
x_0, v_0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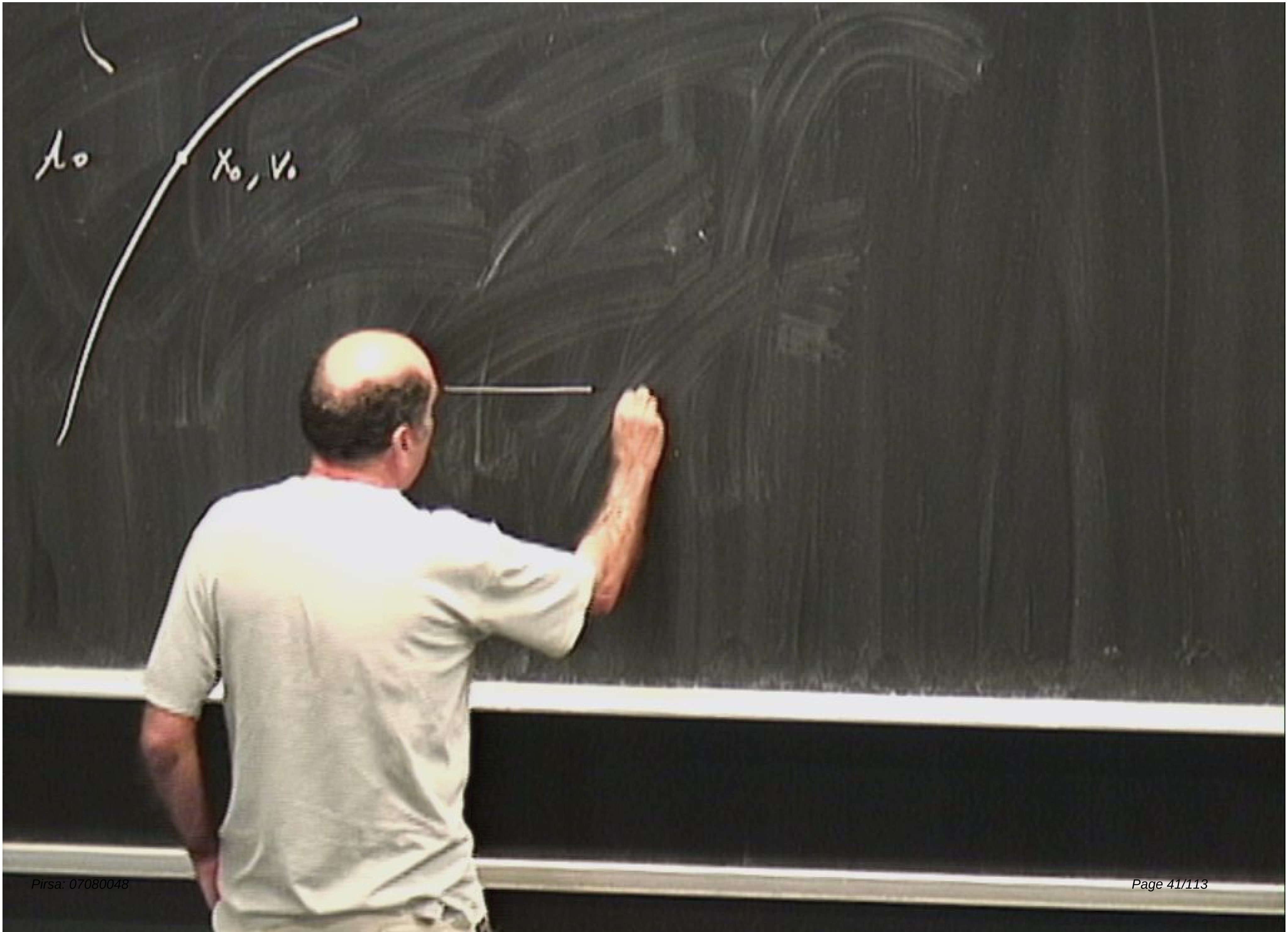
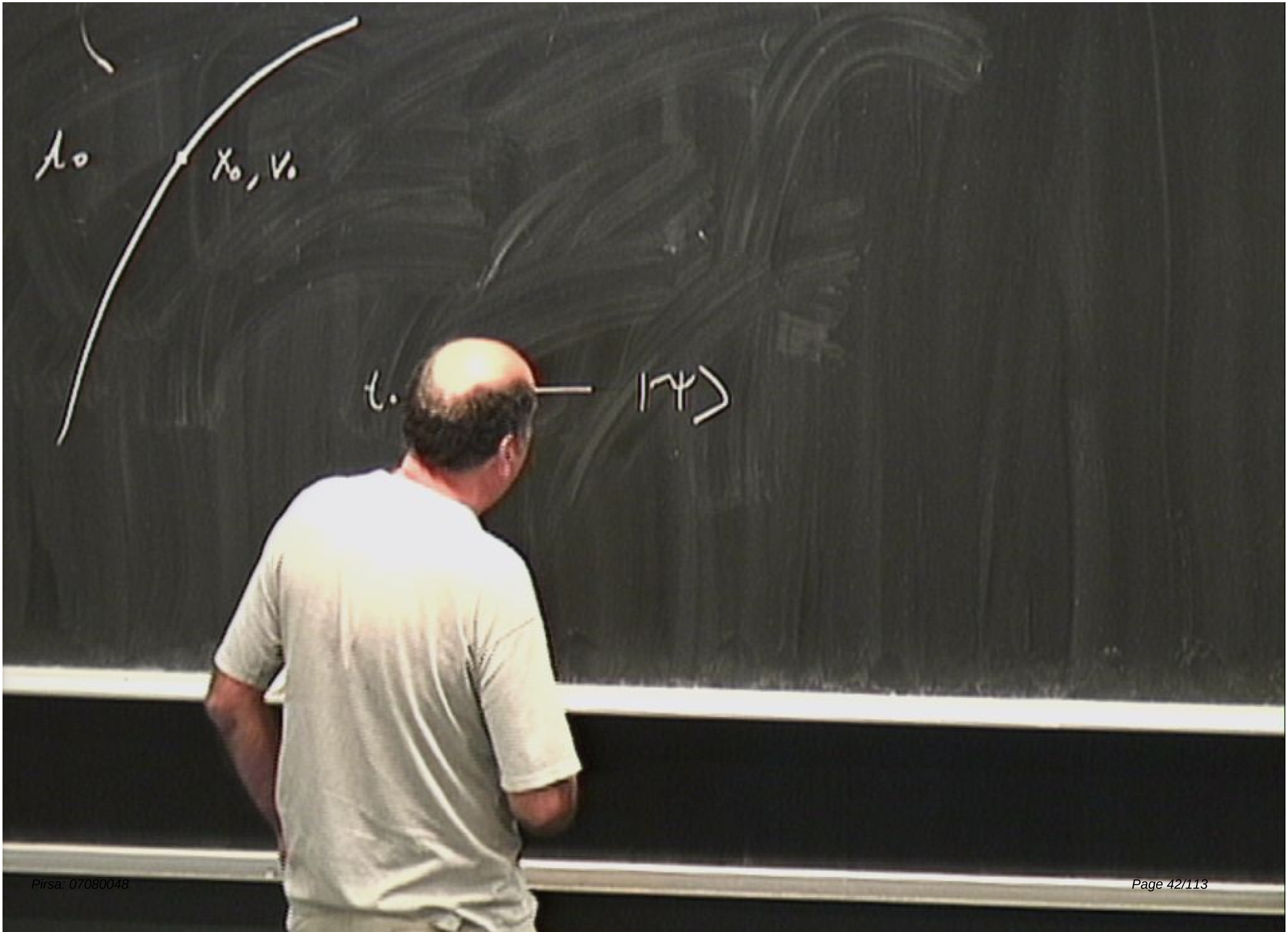
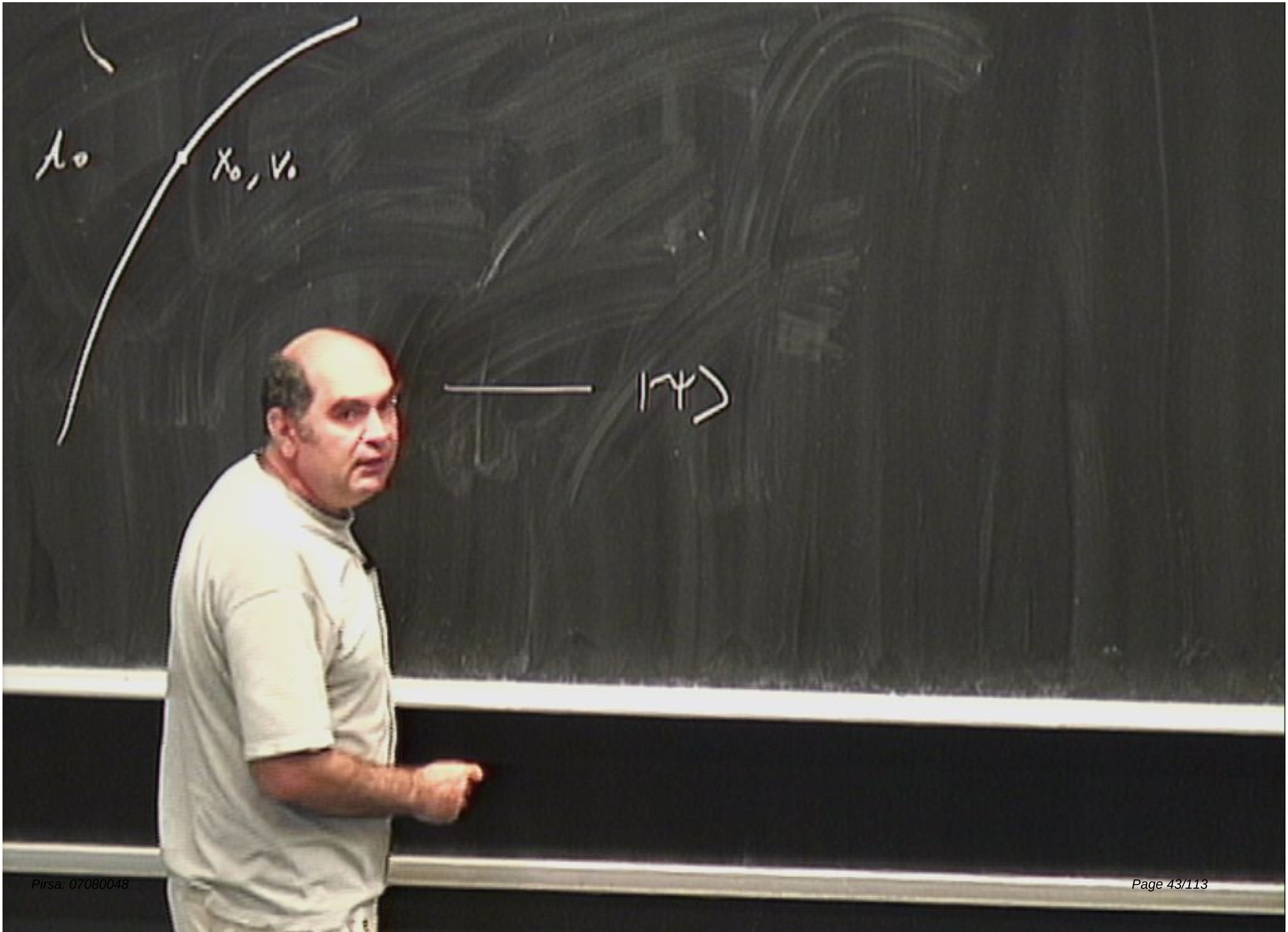
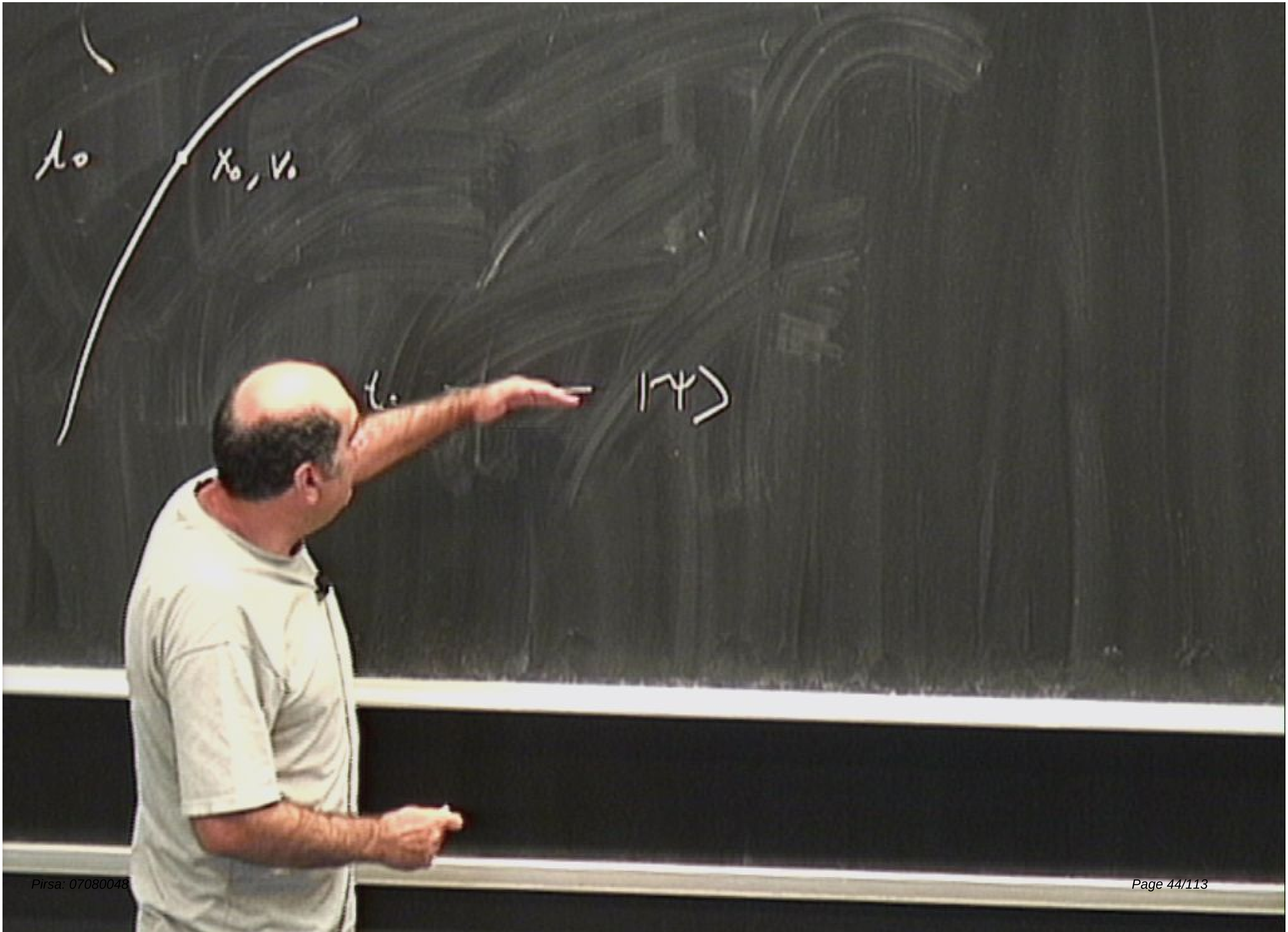
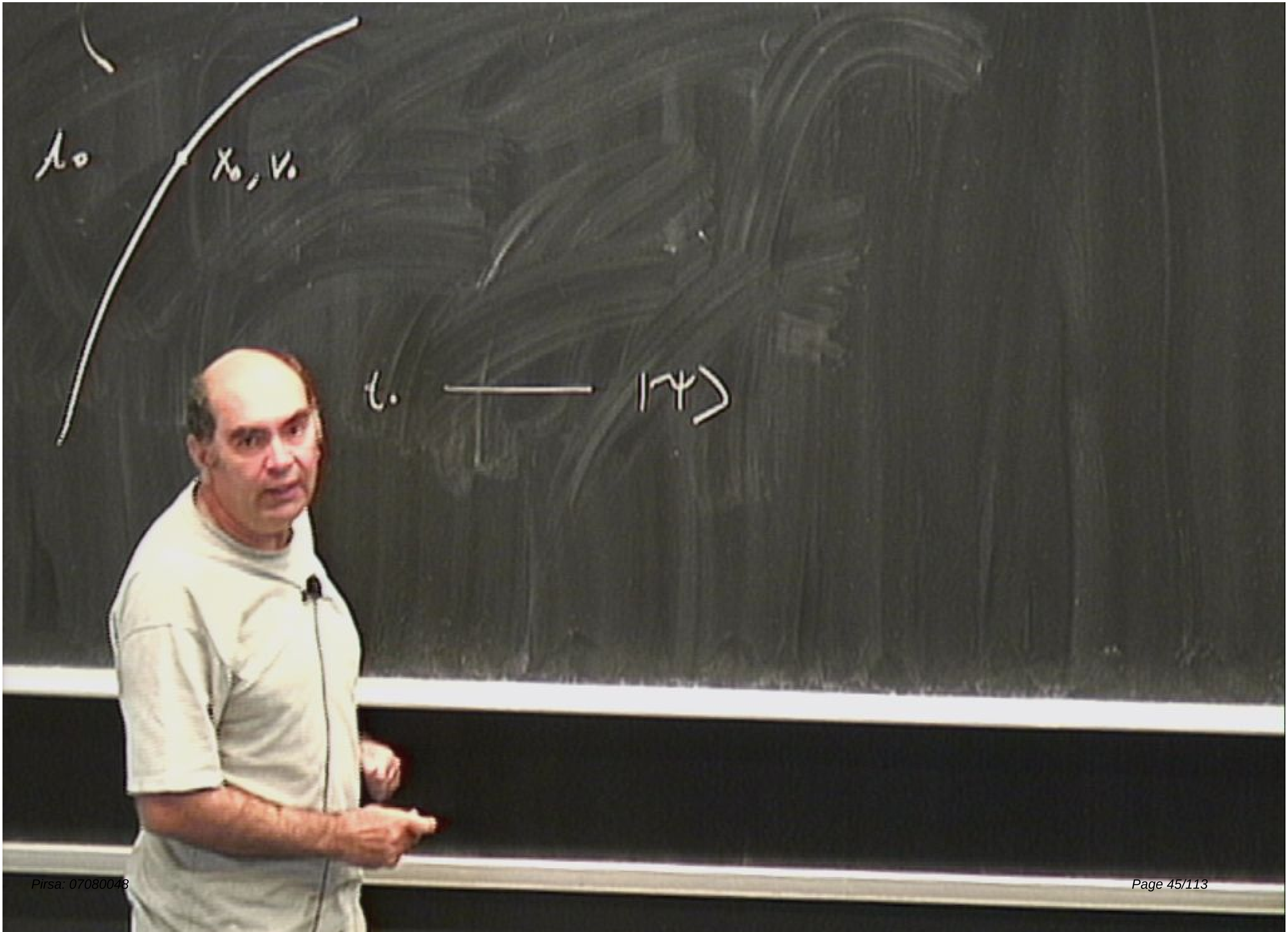
x_0, v_0

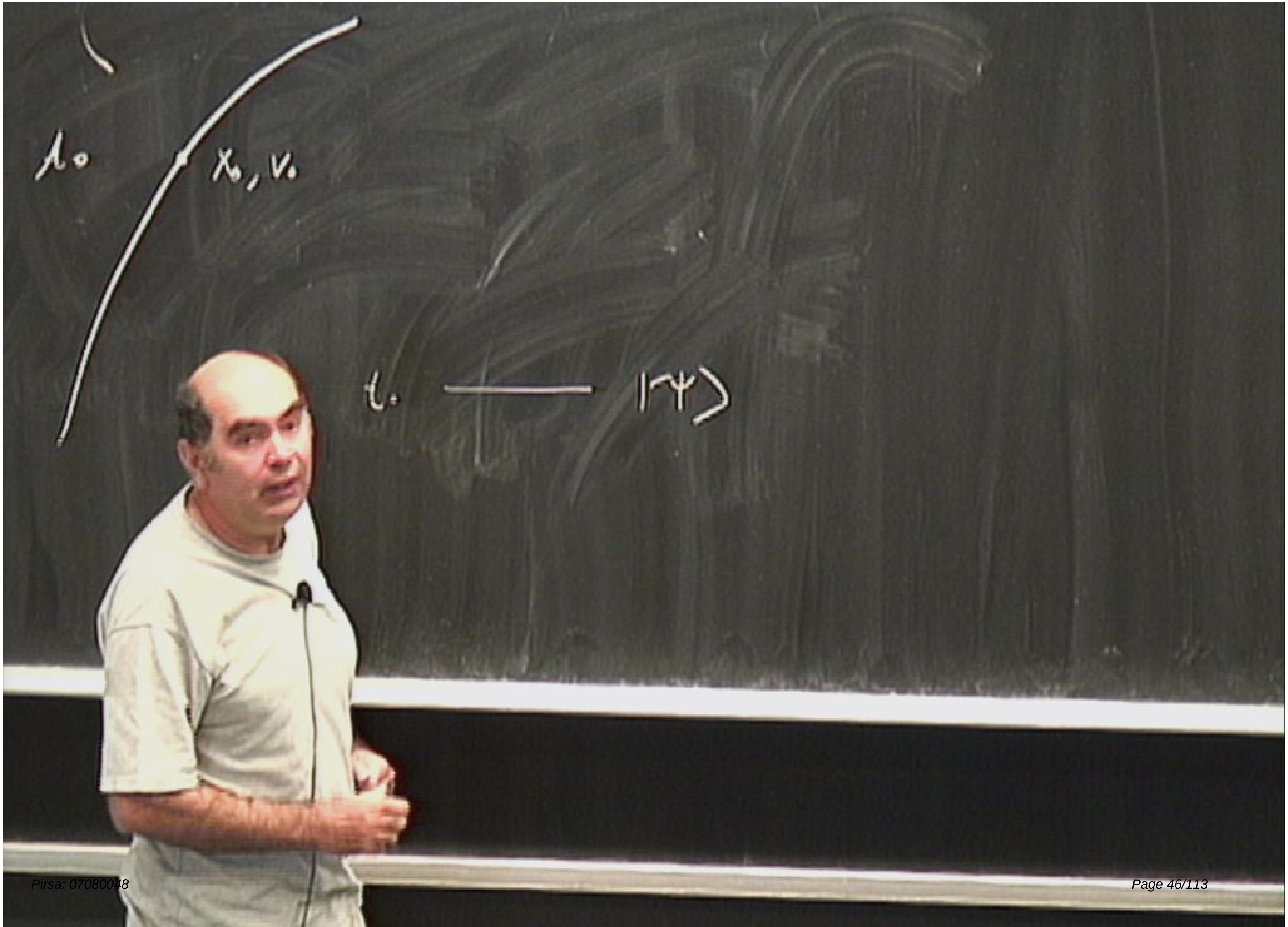

λ_0
x_0, v_0

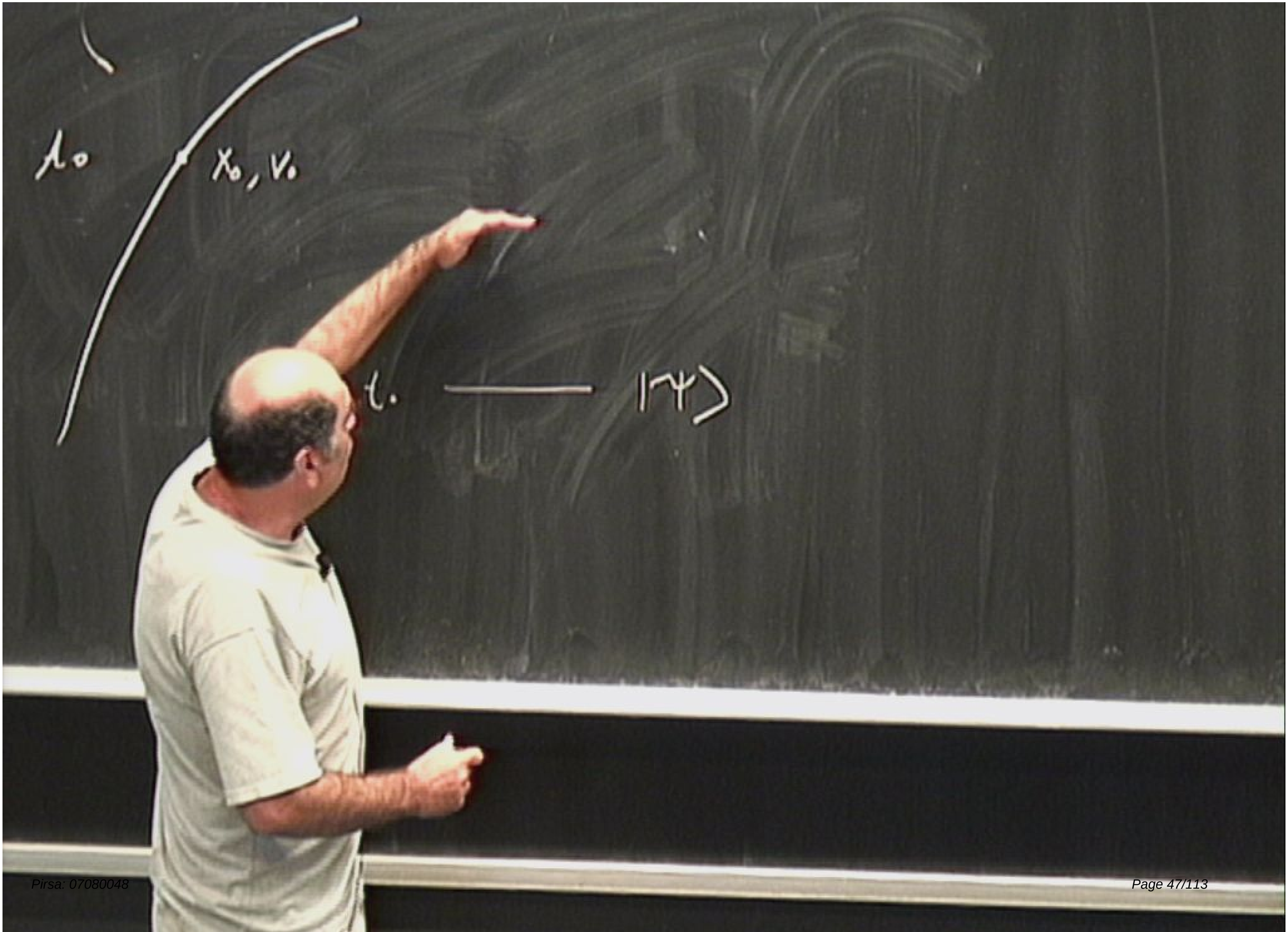

λ_0
x_0, v_0
t_0
$|\psi\rangle$

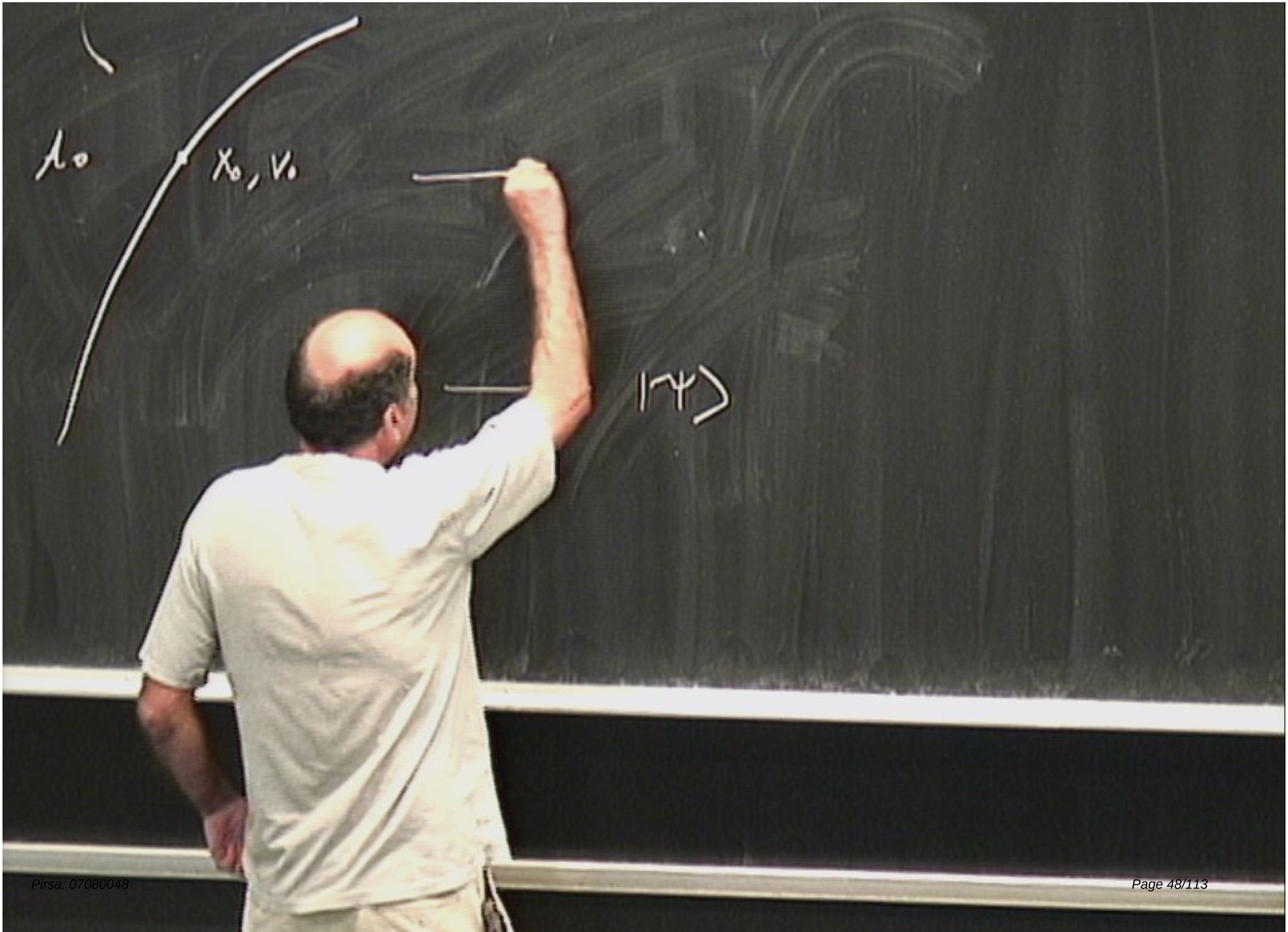

λ_0
x_0, v_0
$|\psi\rangle$

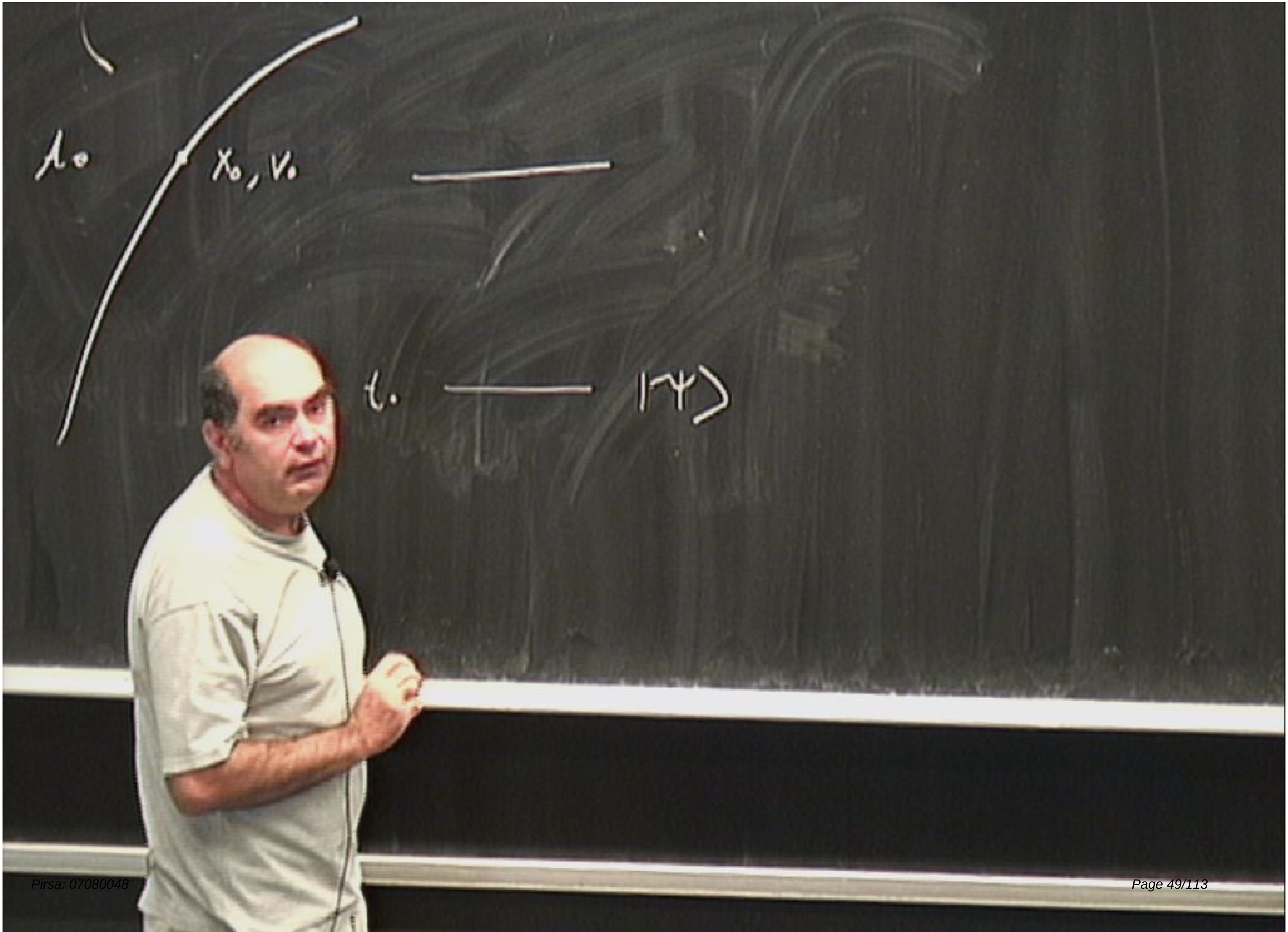

λ_0
x_0, v_0
$|\psi\rangle$

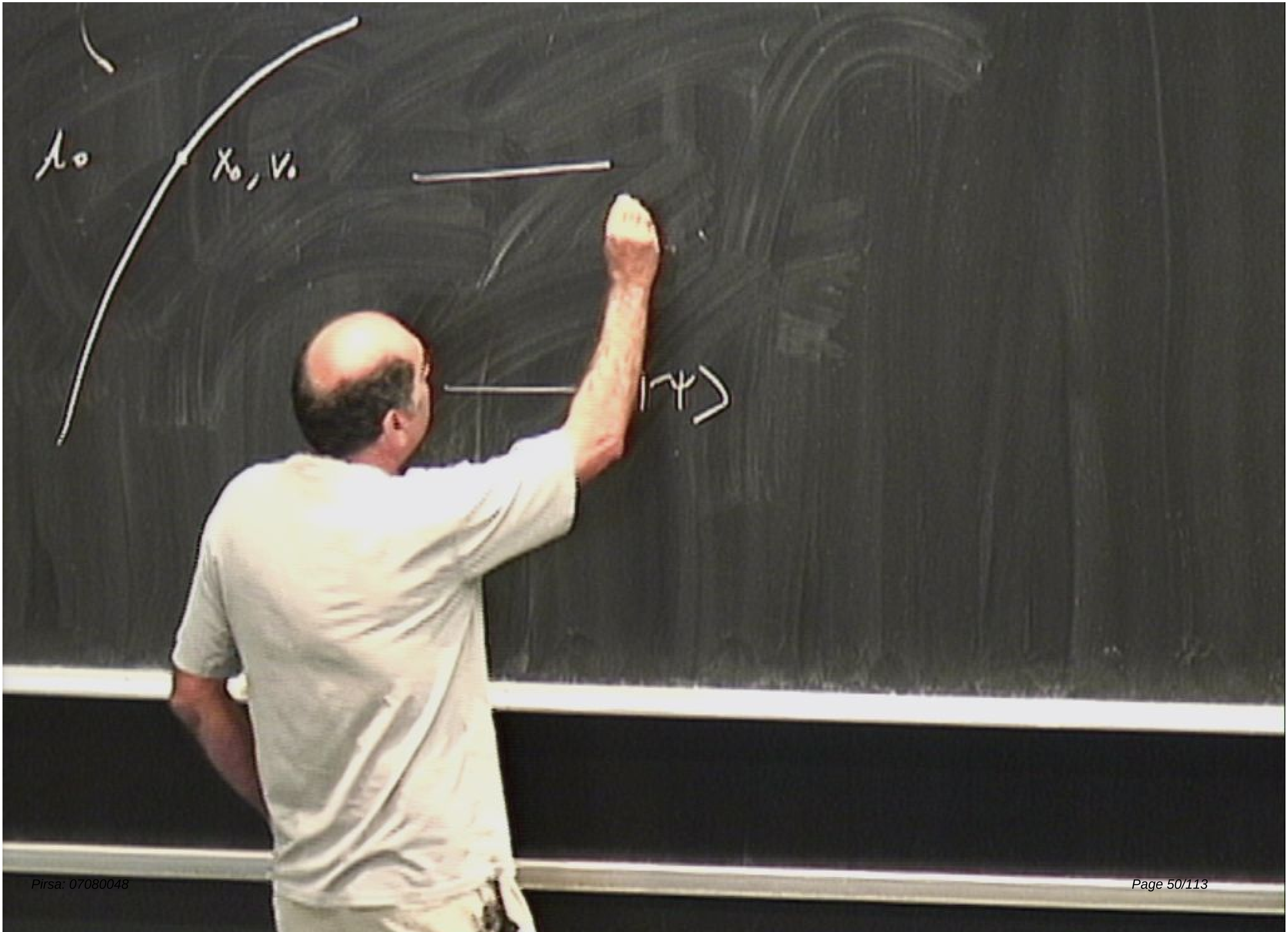

t_0
x_0, v_0
t_0 ——— $|\Psi\rangle$

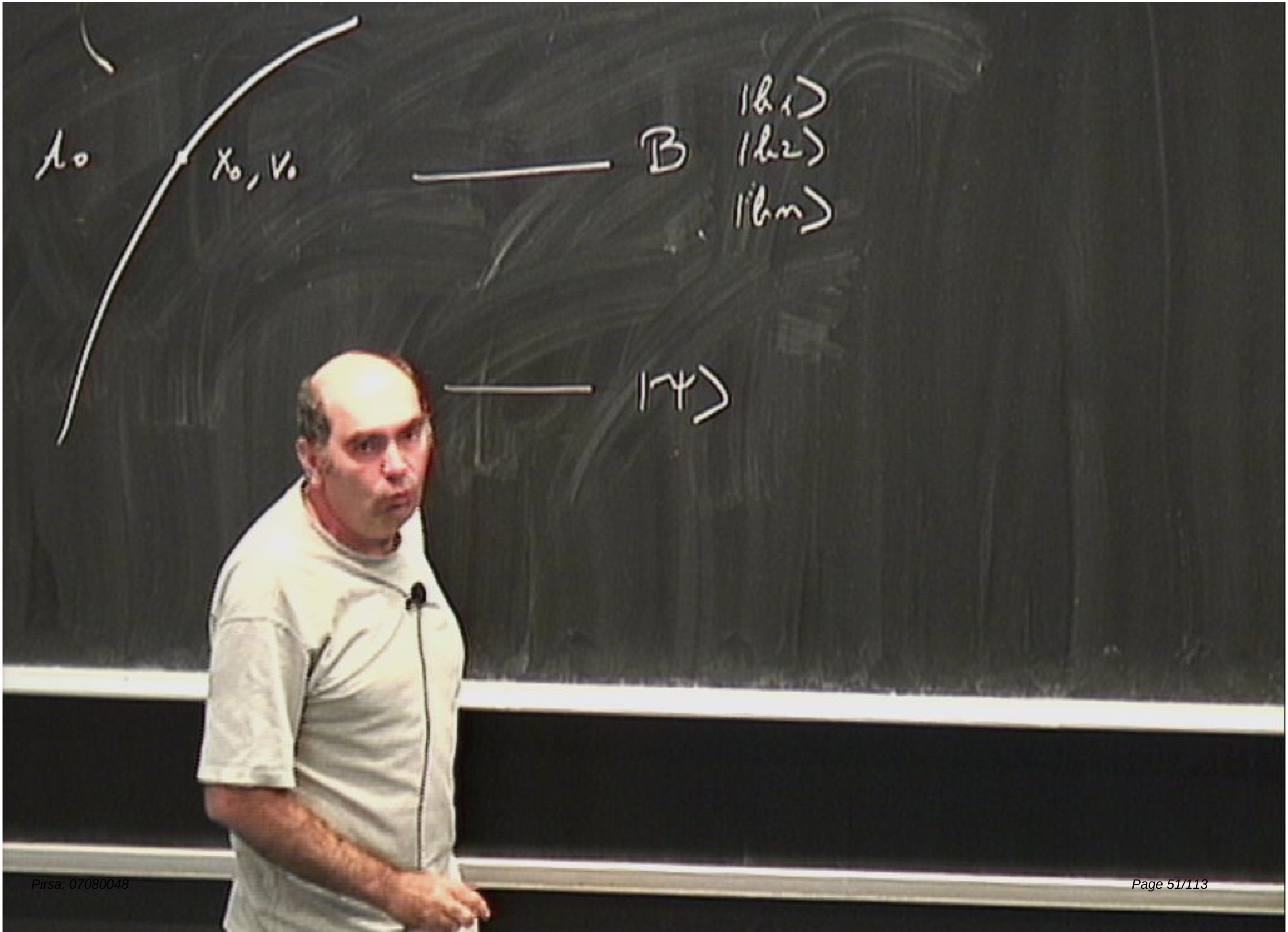

t_0
x_0, v_0
t_0
$|\Psi\rangle$

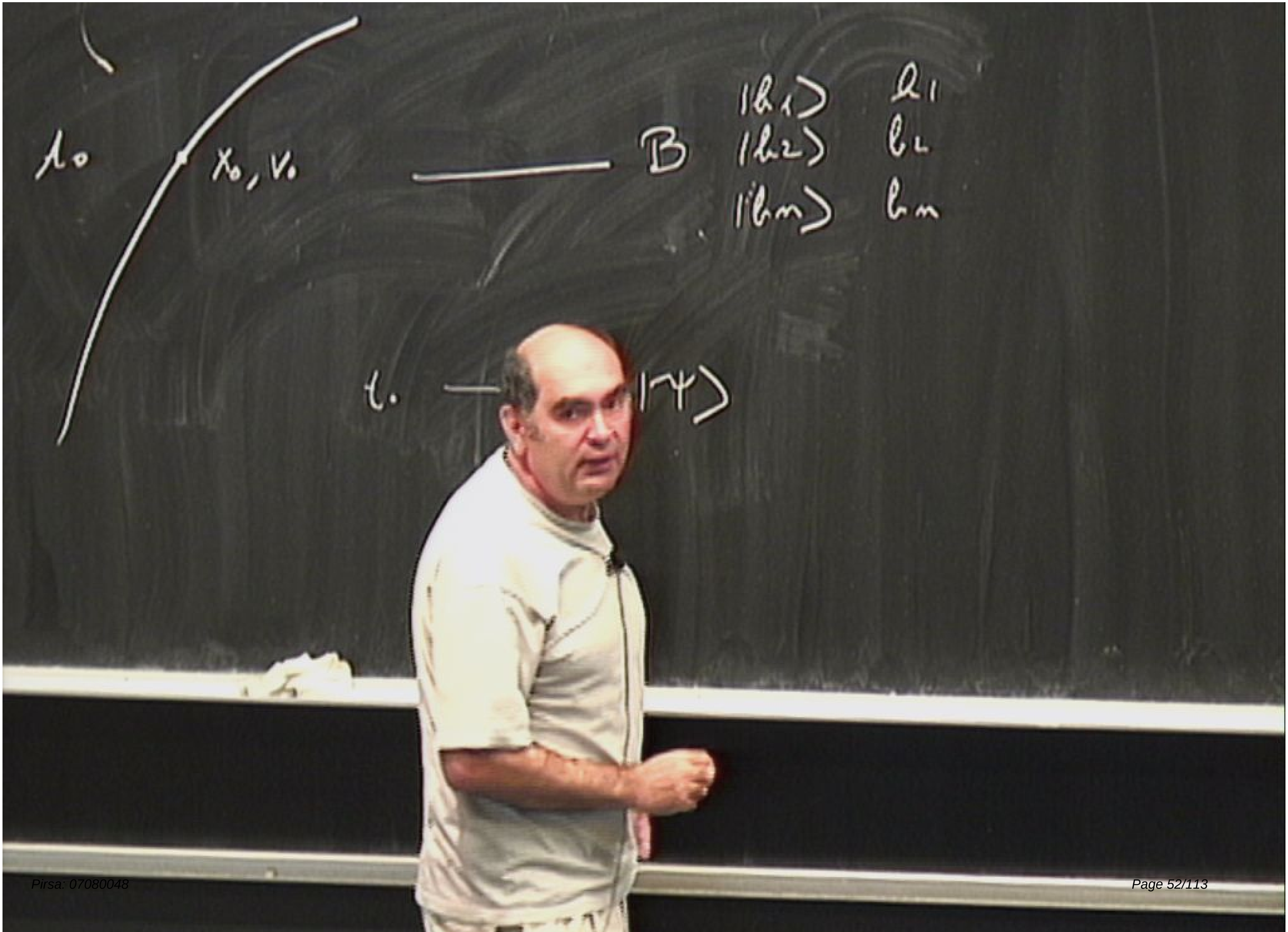

λ_0
x_0, v_0
t_0 —— $|\psi\rangle$


λ_0
x_0, v_0
$|\psi\rangle$

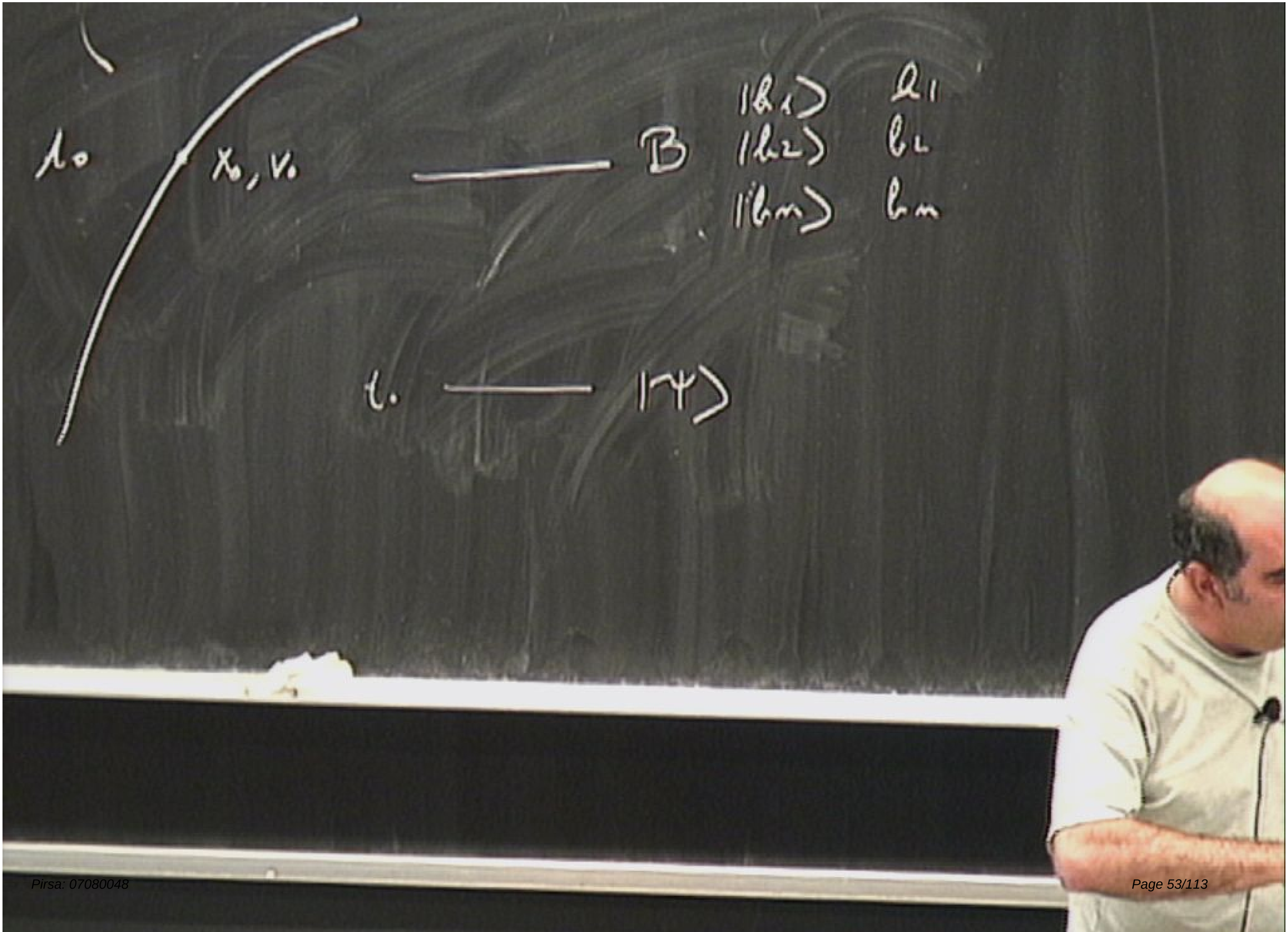

λ₀
x₀, v₀
t₀
|Ψ⟩

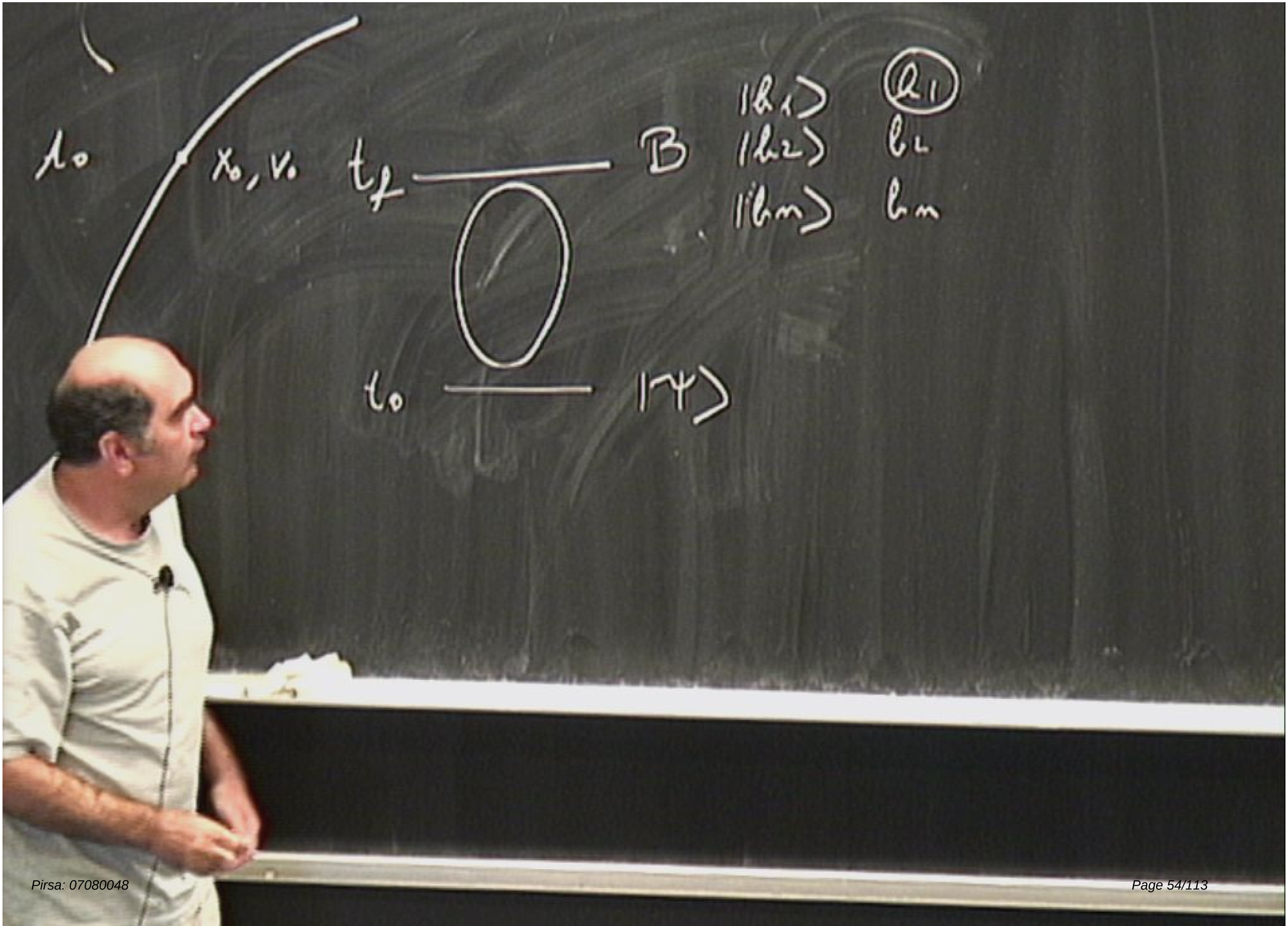

λ_0
x_0, v_0
$|\psi\rangle$

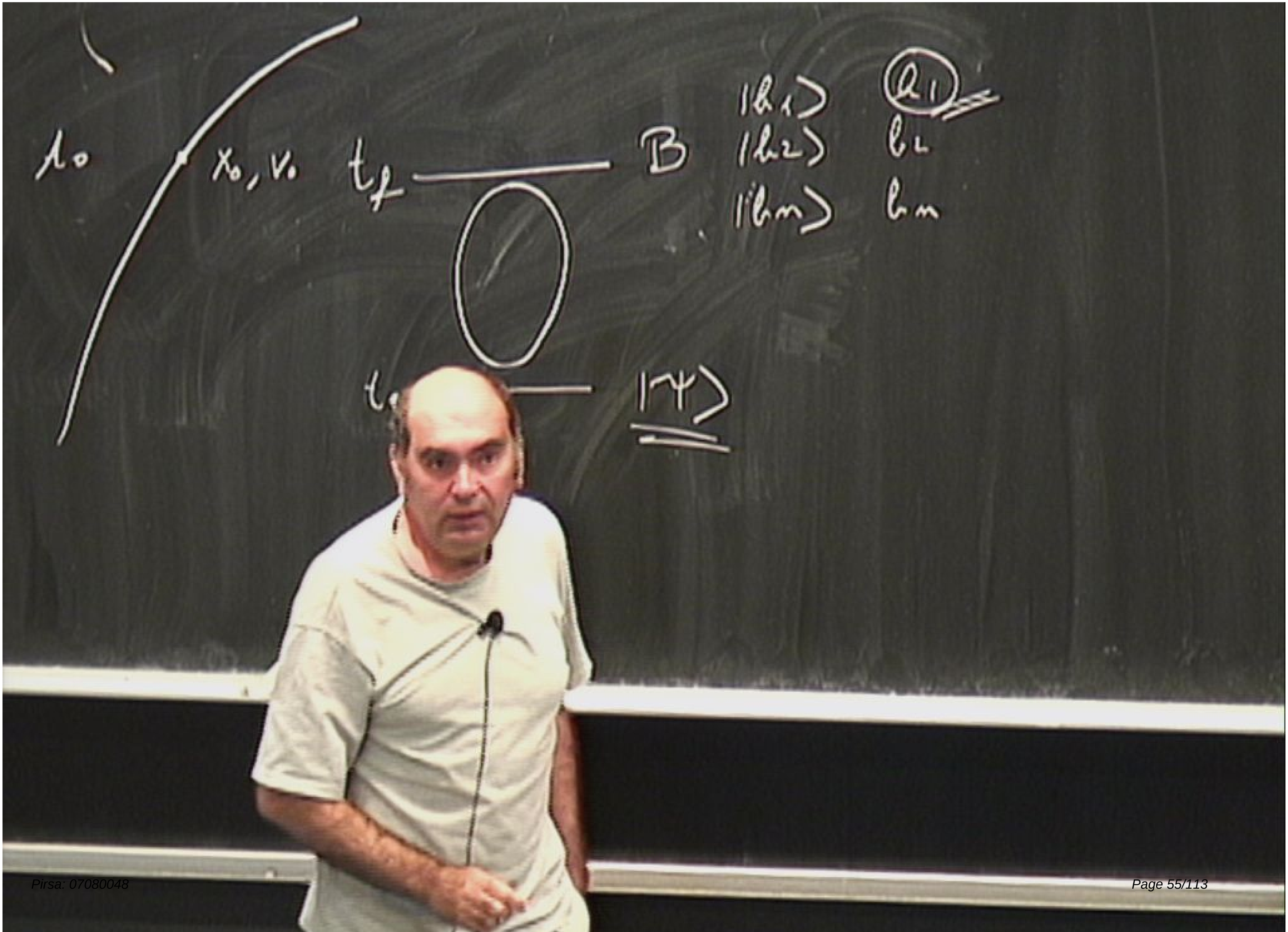

λ₀
x₀, v₀
B
|b₁⟩
|b₂⟩
|bₙ⟩
|Ψ⟩

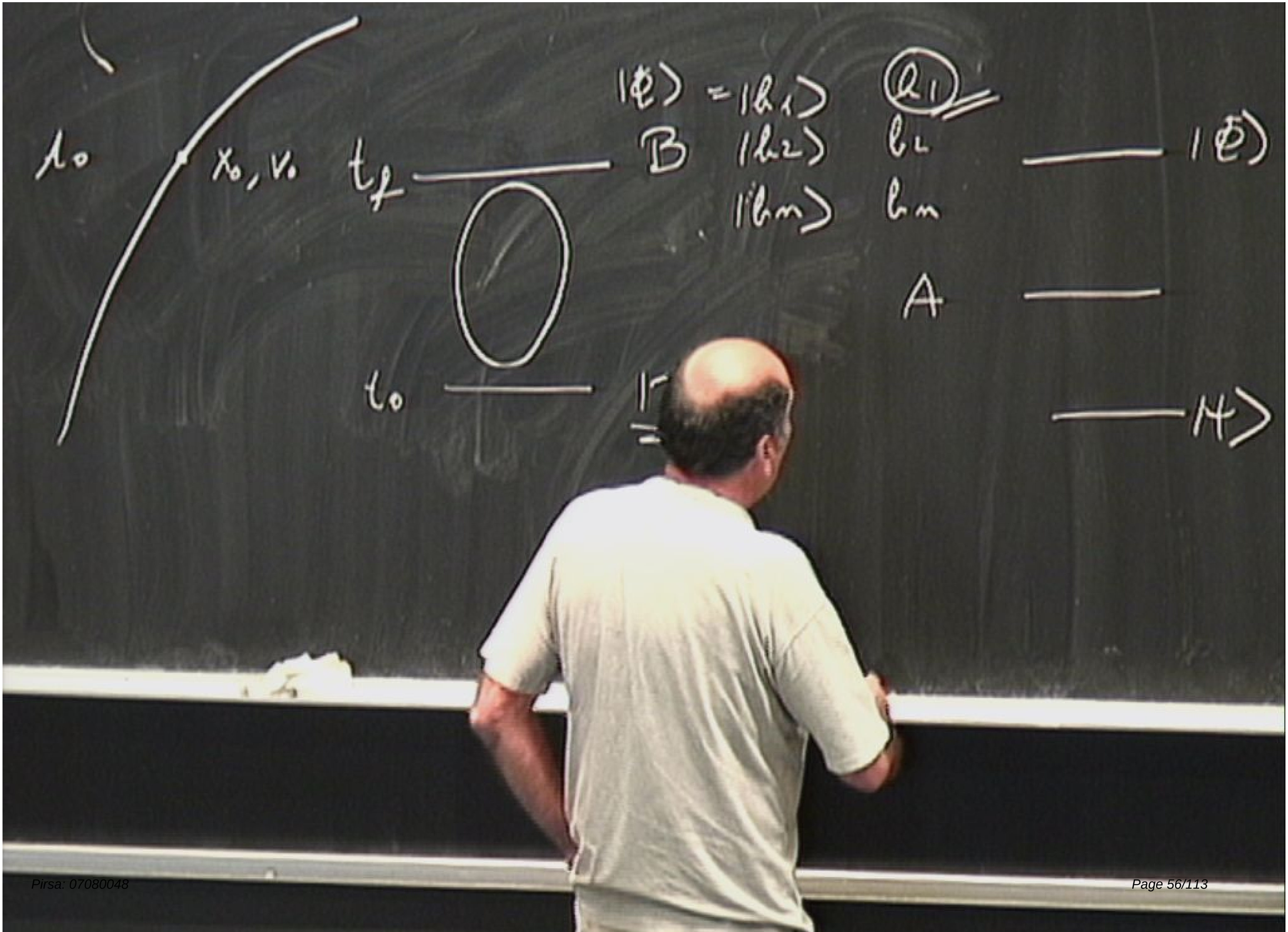


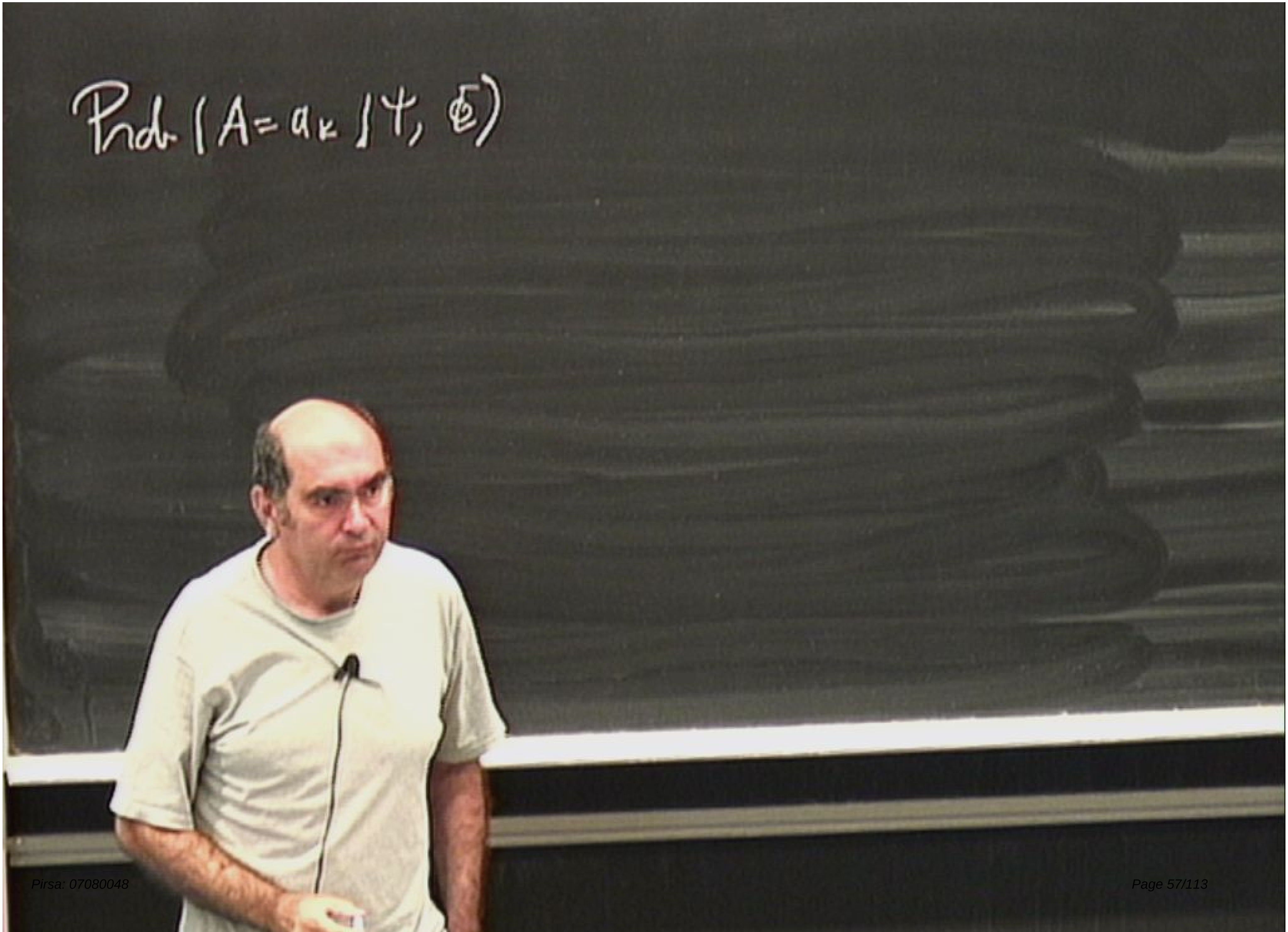
x_0, v_0
B
$|b_1\rangle$ b_1
$|b_2\rangle$ b_2
$|b_m\rangle$ b_m
$|\psi\rangle$


t_0
x_0, v_0
B
$|b_1\rangle$ b_1
$|b_2\rangle$ b_2
$|b_m\rangle$ b_m
t_0 —— $|\psi\rangle$

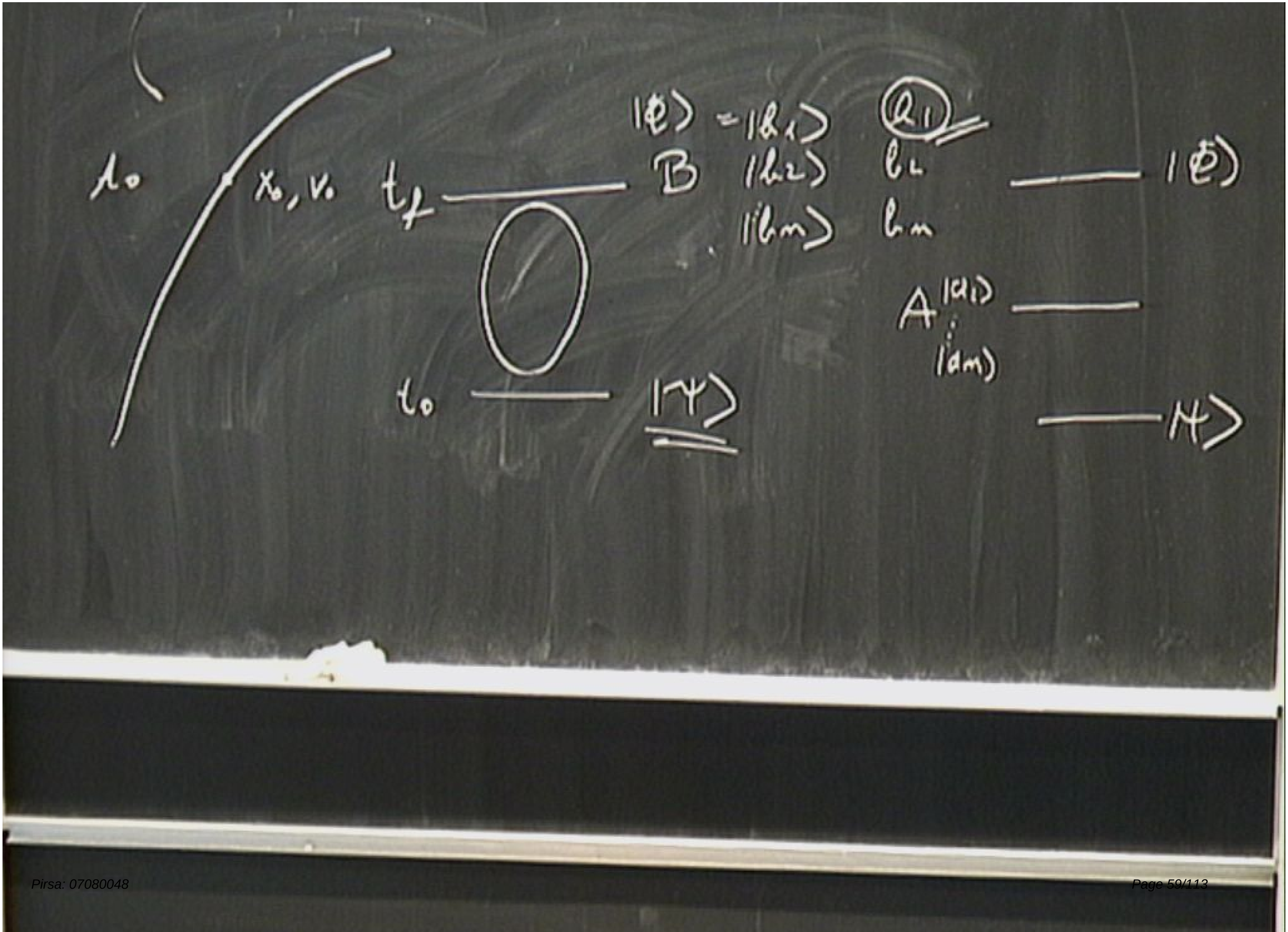

x_0, v_0
t_f
B
$|b_1\rangle$
$|b_2\rangle$
$|b_m\rangle$
b_1
b_2
b_m
t_0
$|\Psi\rangle$

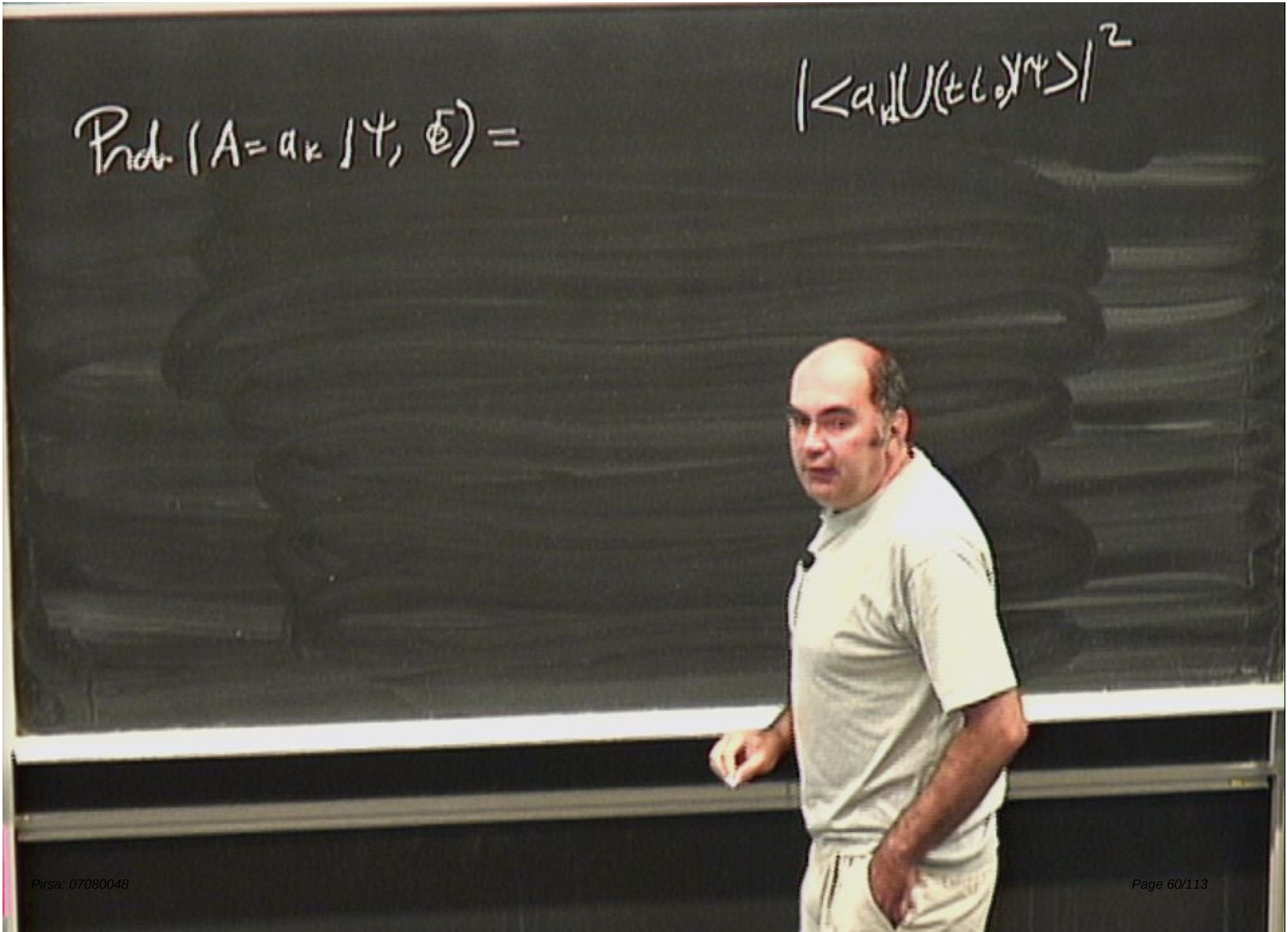

x0, v0
tf
B
|b1⟩ b1
|b2⟩ b2
|bm⟩ bm
|Ψ⟩

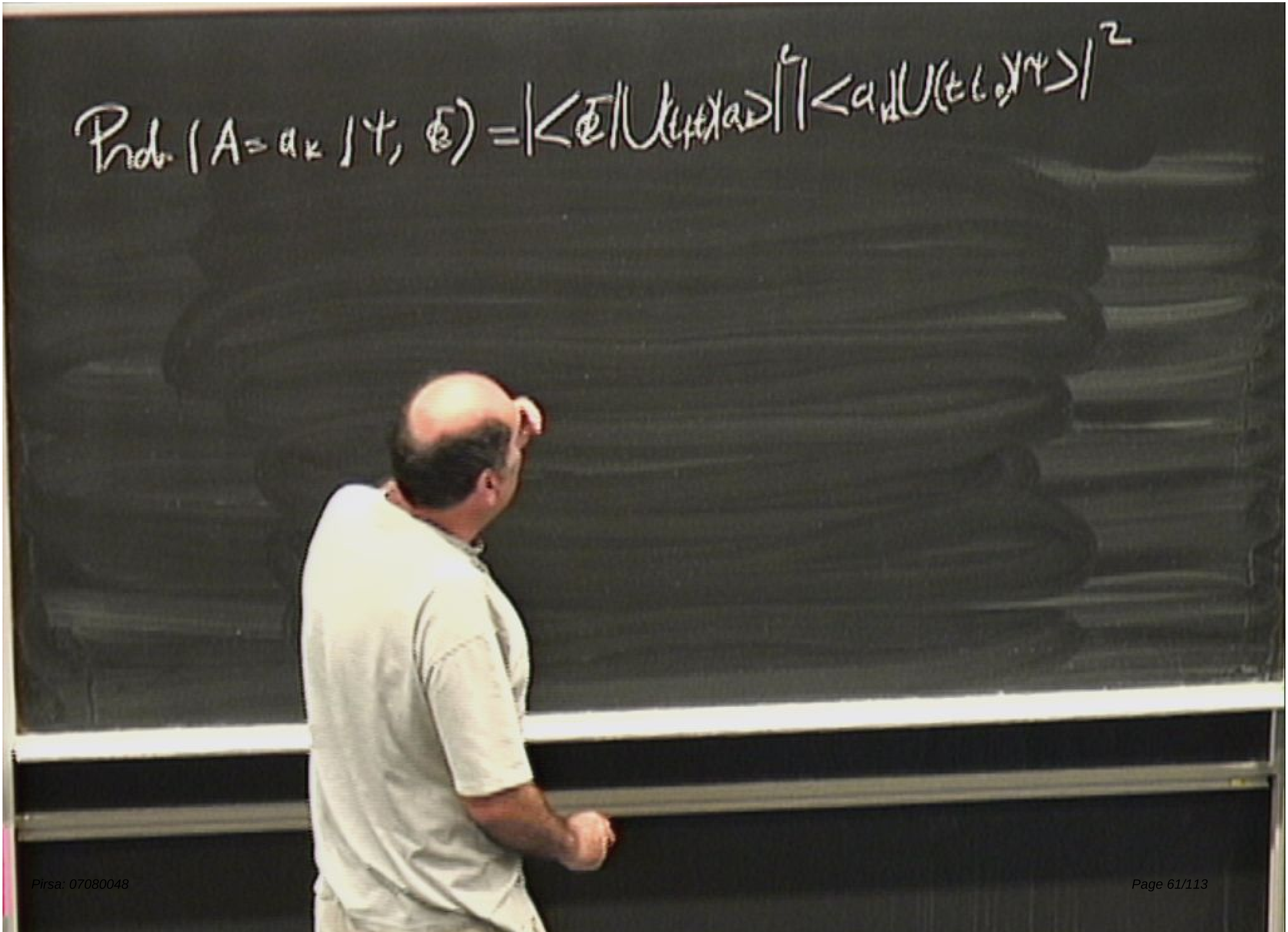


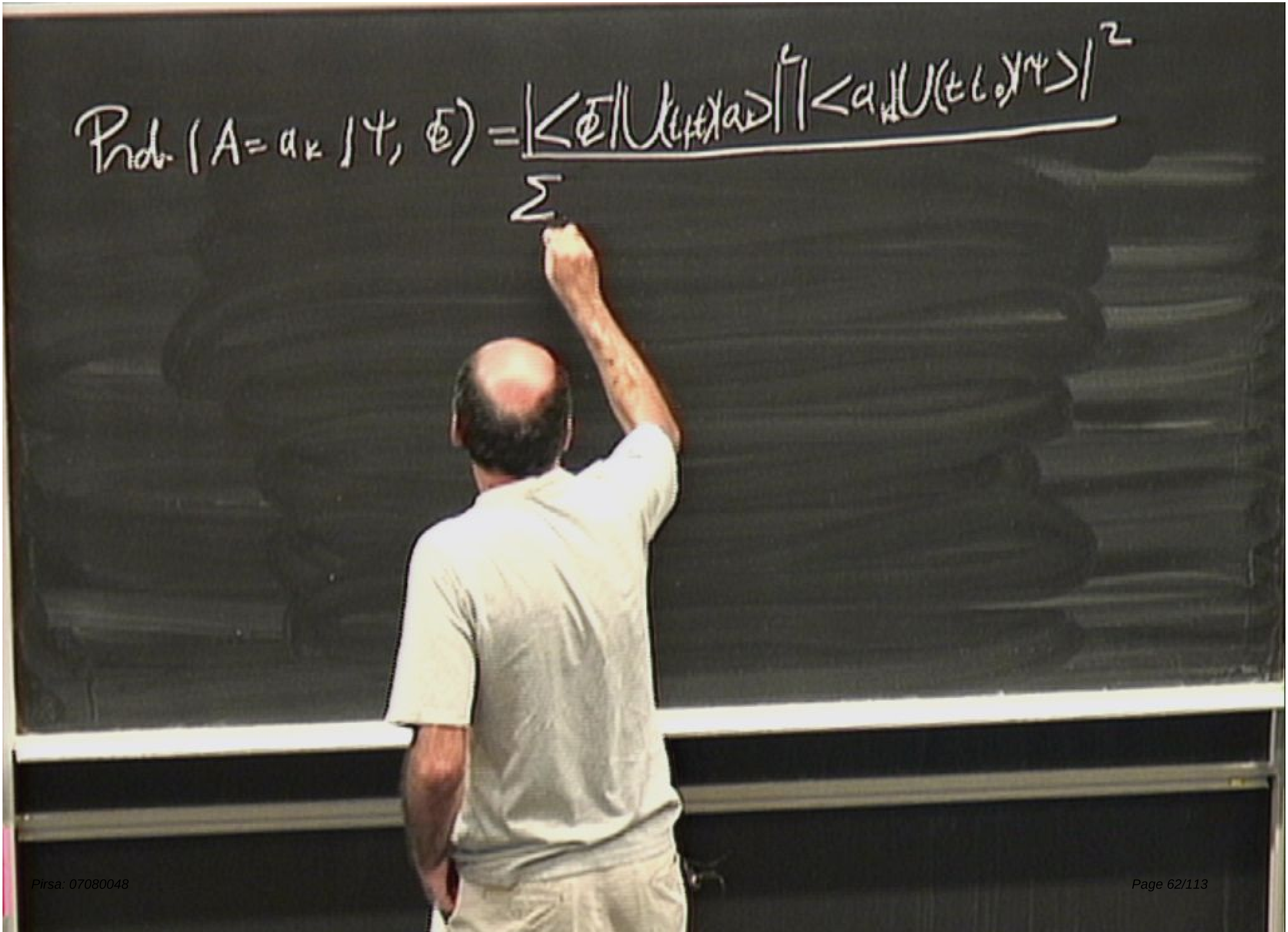

Prob (A = a_k | Ψ, Φ)

$Prob(A = a_k \mid \Psi, \Phi)$


λ₀
x₀, v₀
t_f
t₀
|Ψ>
|Φ> = |b1>
B |b2>
|bm>
A |a1>
|am>
|Φ>
|Ψ>

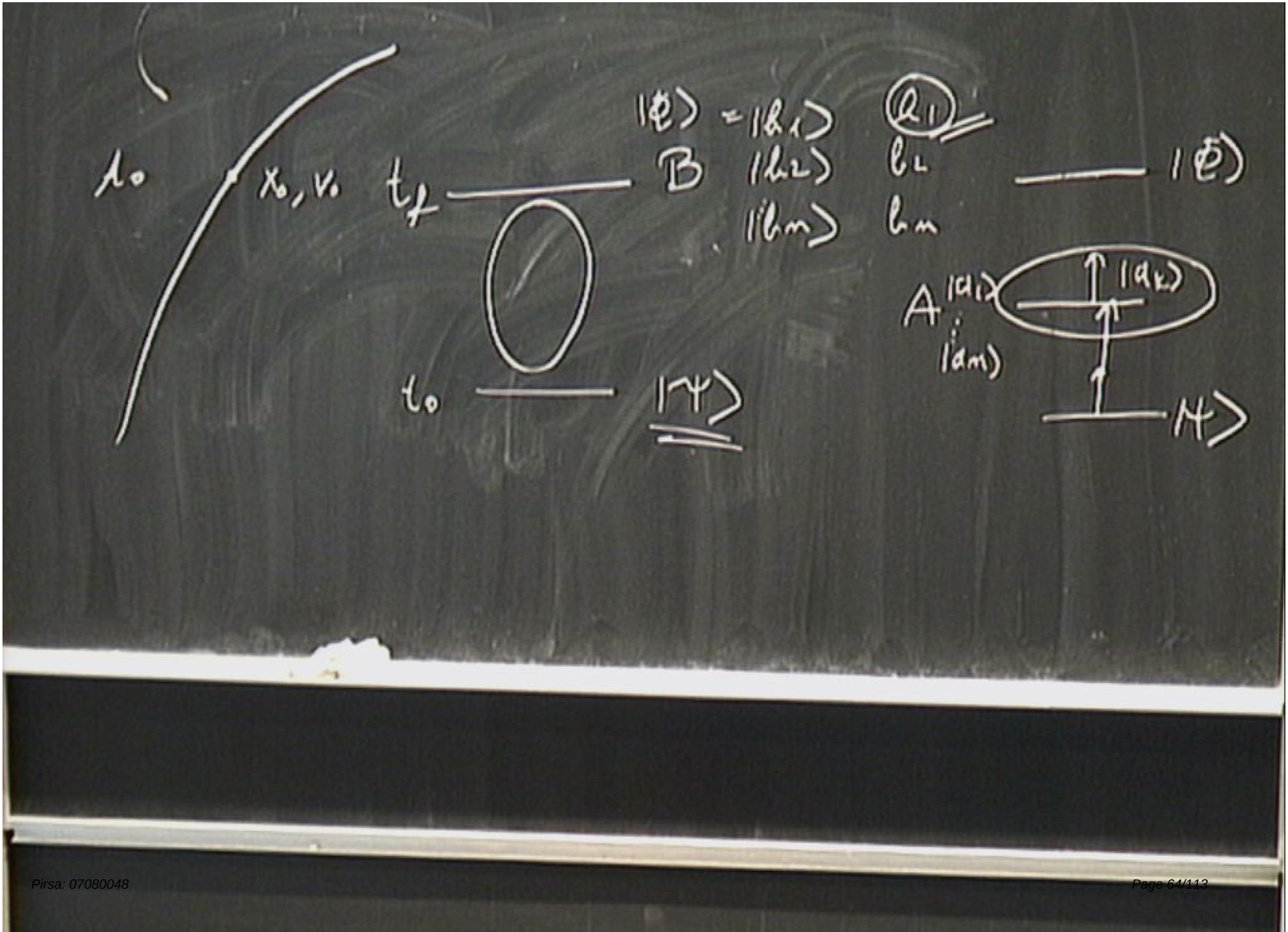

$\mathrm{Prob}(A = a_k \mid \Psi, \Phi) =$
$|\langle a_k | U(t, t_0) | \Psi \rangle|^2$


$\mathrm{Prob.}(A = a_k \mid \Psi, \Phi) = |\langle \Phi | U(t_f, t) | a_k \rangle|^2 \, |\langle a_k | U(t, t_0) | \Psi \rangle|^2$

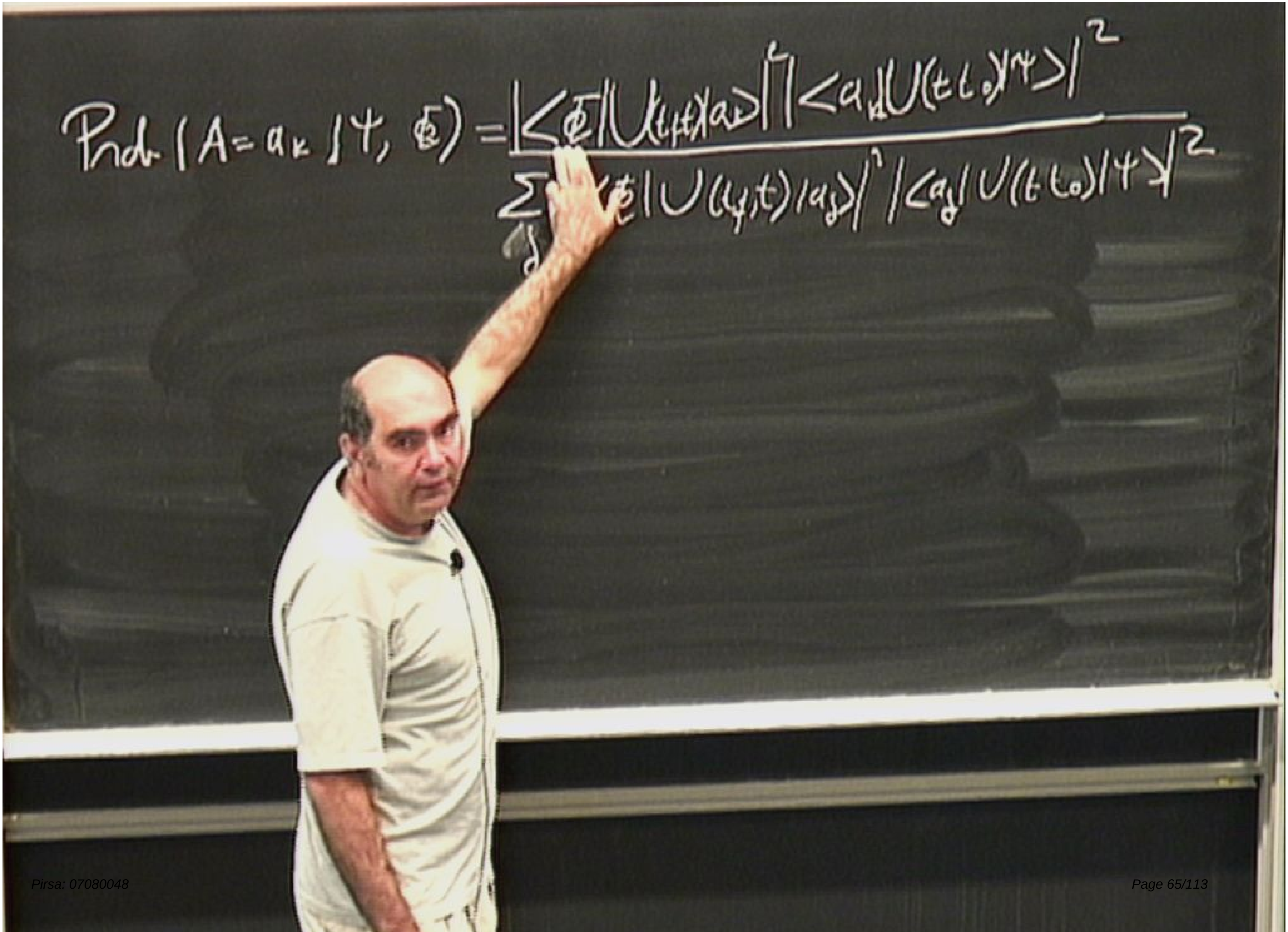


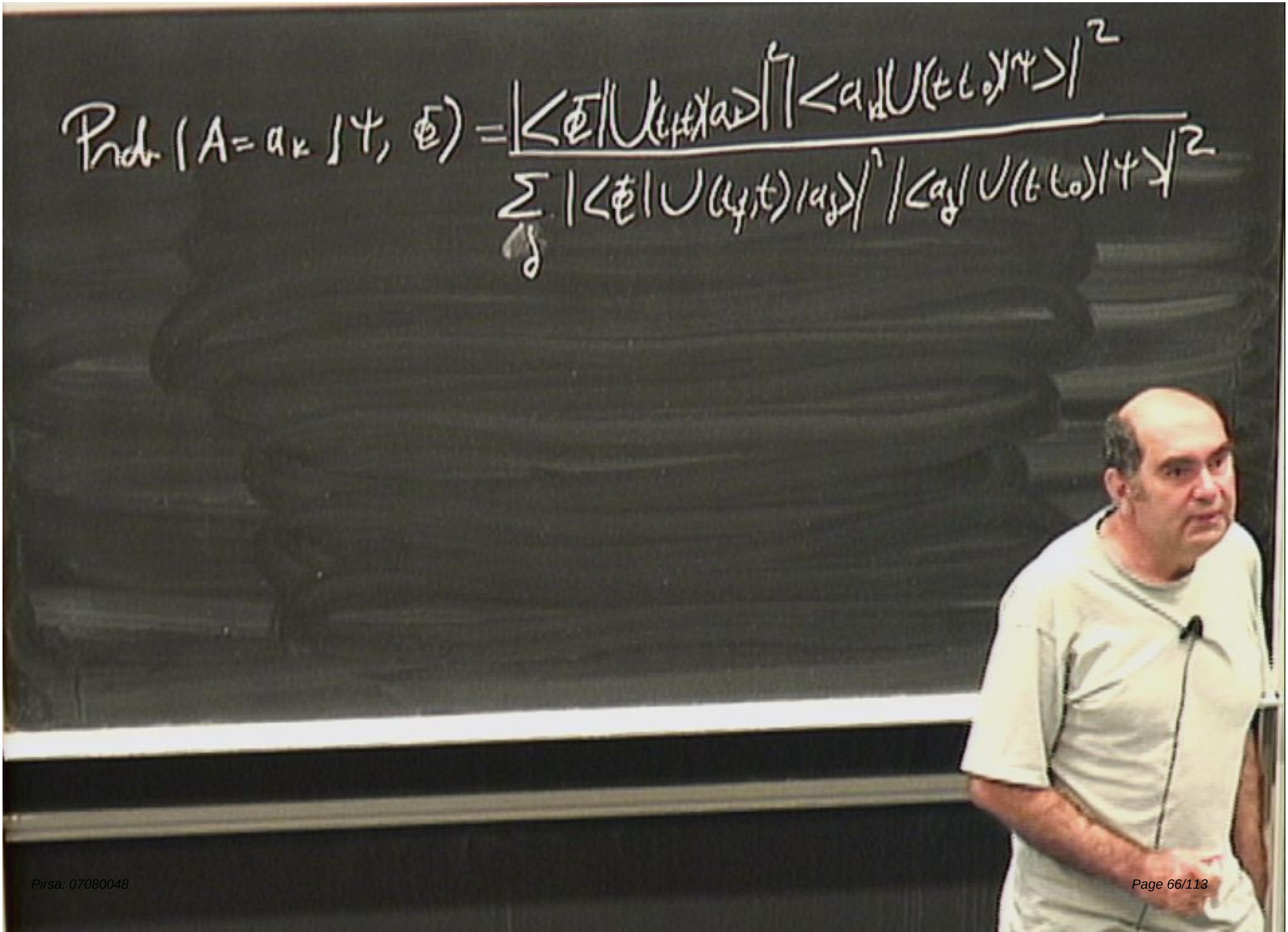
$\text{Prob.}(A = a_k \mid \Psi, \Phi) = \frac{|\langle \Phi | U(t_f,t) | a_k \rangle|^2 \, |\langle a_k | U(t,t_0) | \Psi \rangle|^2}{\Sigma}$

$$\text{Prob}(A = a_k \mid \Psi, \Phi) = \frac{|\langle \Phi | U(t_f, t) | a_k \rangle|^2 \, |\langle a_k | U(t, t_0) | \Psi \rangle|^2}{\sum_j |\langle \Phi | U(t_f, t) | a_j \rangle|^2 \, |\langle a_j | U(t, t_0) | \Psi \rangle|^2}$$

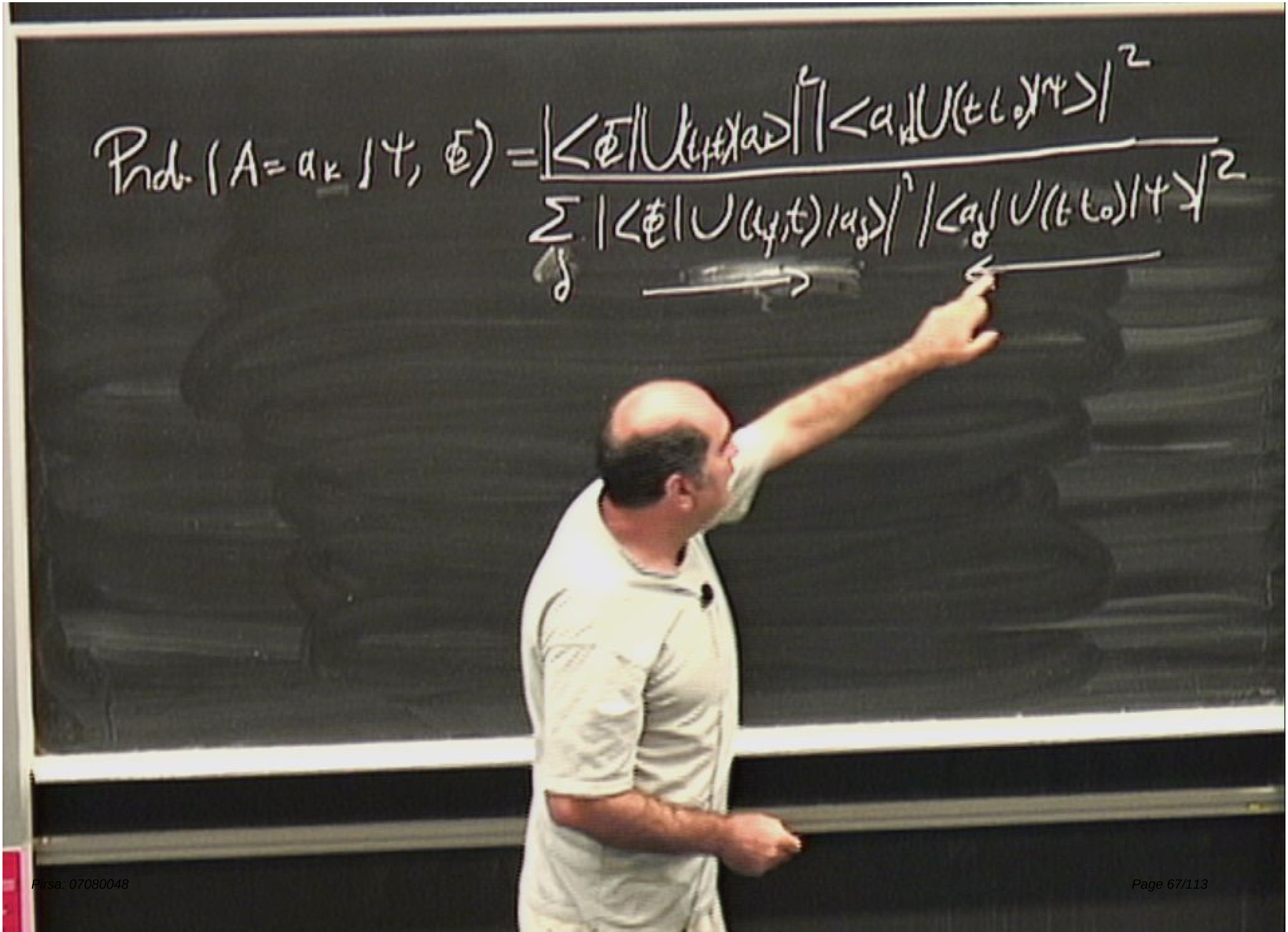


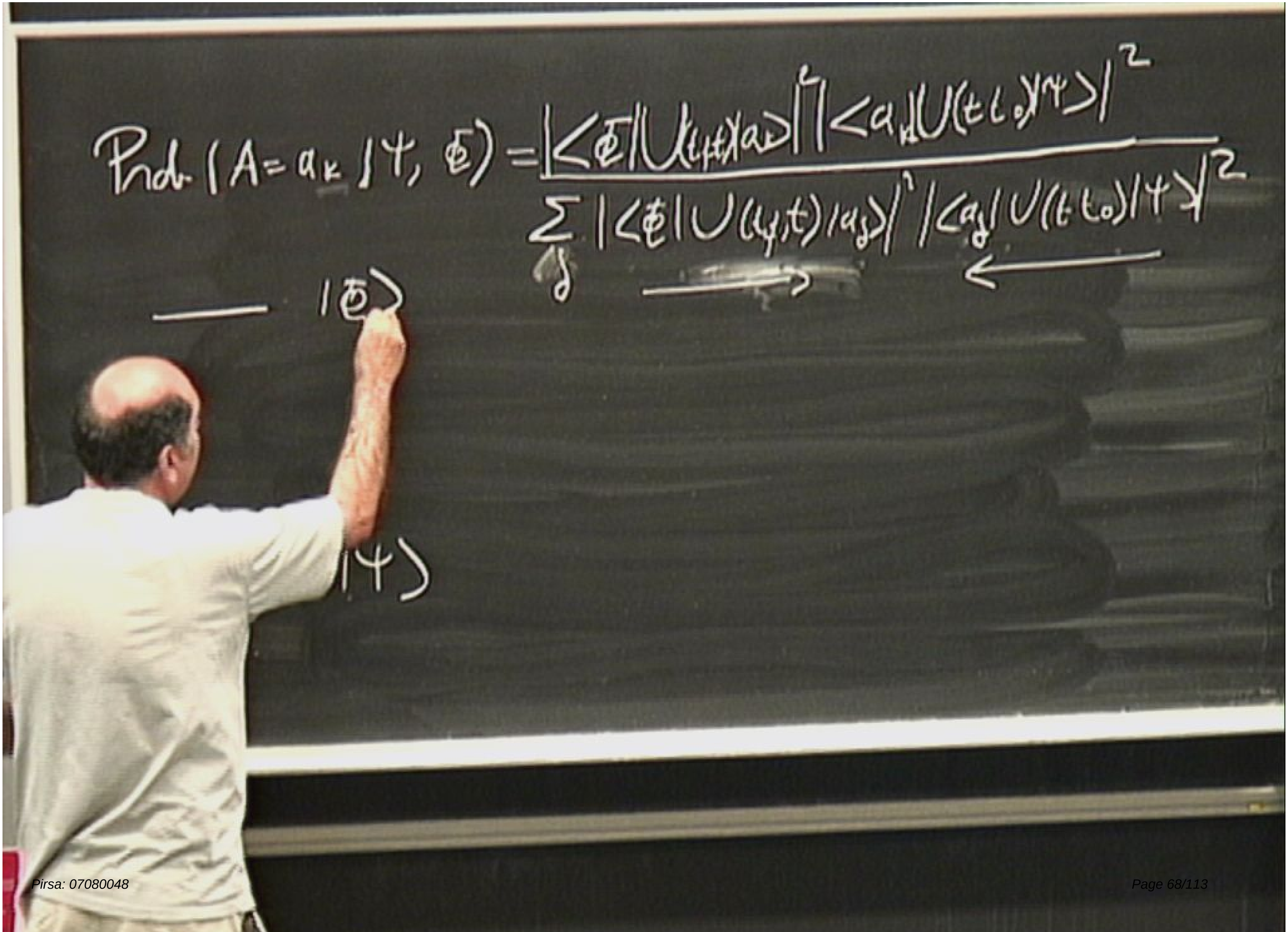
t_0
x_0, v_0
t_f
t_0
$|\Psi\rangle$
$|\ell\rangle = |b_1\rangle$ b_1
B $|b_2\rangle$ b_2
$|b_m\rangle$ b_m
$|\ell\rangle$
A $|a_1\rangle$ $|a_k\rangle$
$|a_m\rangle$
$|\Psi\rangle$


$\mathrm{Prob}(A = a_k \mid \psi, \Phi) = \dfrac{|\langle \Phi | U(t_f,t) | a_k \rangle|^2 \, |\langle a_k | U(t,t_0) | \psi \rangle|^2}{\sum_j |\langle \Phi | U(t_f,t) | a_j \rangle|^2 \, |\langle a_j | U(t,t_0) | \psi \rangle|^2}$



$$\mathrm{Prob}(A = a_k \mid \psi, \phi) = \frac{|\langle\phi|U(t_f,t)|a_k\rangle|^2\,|\langle a_k|U(t,t_0)|\psi\rangle|^2}{\sum_j |\langle\phi|U(t_f,t)|a_j\rangle|^2\,|\langle a_j|U(t,t_0)|\psi\rangle|^2}$$


$\mathrm{Prob}(A = a_k \mid \psi, \Phi) = \dfrac{|\langle \Phi | U(t_f,t) | a_k \rangle|^2 \, |\langle a_k | U(t,t_0) | \psi \rangle|^2}{\sum_j |\langle \Phi | U(t_f,t) | a_j \rangle|^2 \, |\langle a_j | U(t,t_0) | \psi \rangle|^2}$

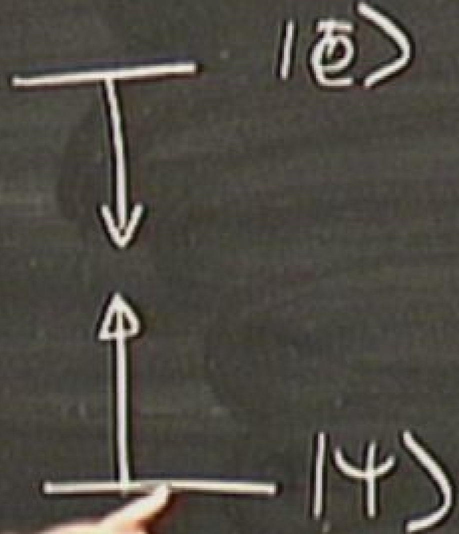

$\text{Prob.}(A = a_k \mid \psi, \Phi) = \dfrac{|\langle \Phi | U(t_f,t) | a_k \rangle|^2 \, |\langle a_k | U(t,t_0) | \psi \rangle|^2}{\sum_j |\langle \Phi | U(t_f,t) | a_j \rangle|^2 \, |\langle a_j | U(t,t_0) | \psi \rangle|^2}$
$|\Phi\rangle$
$|\psi\rangle$

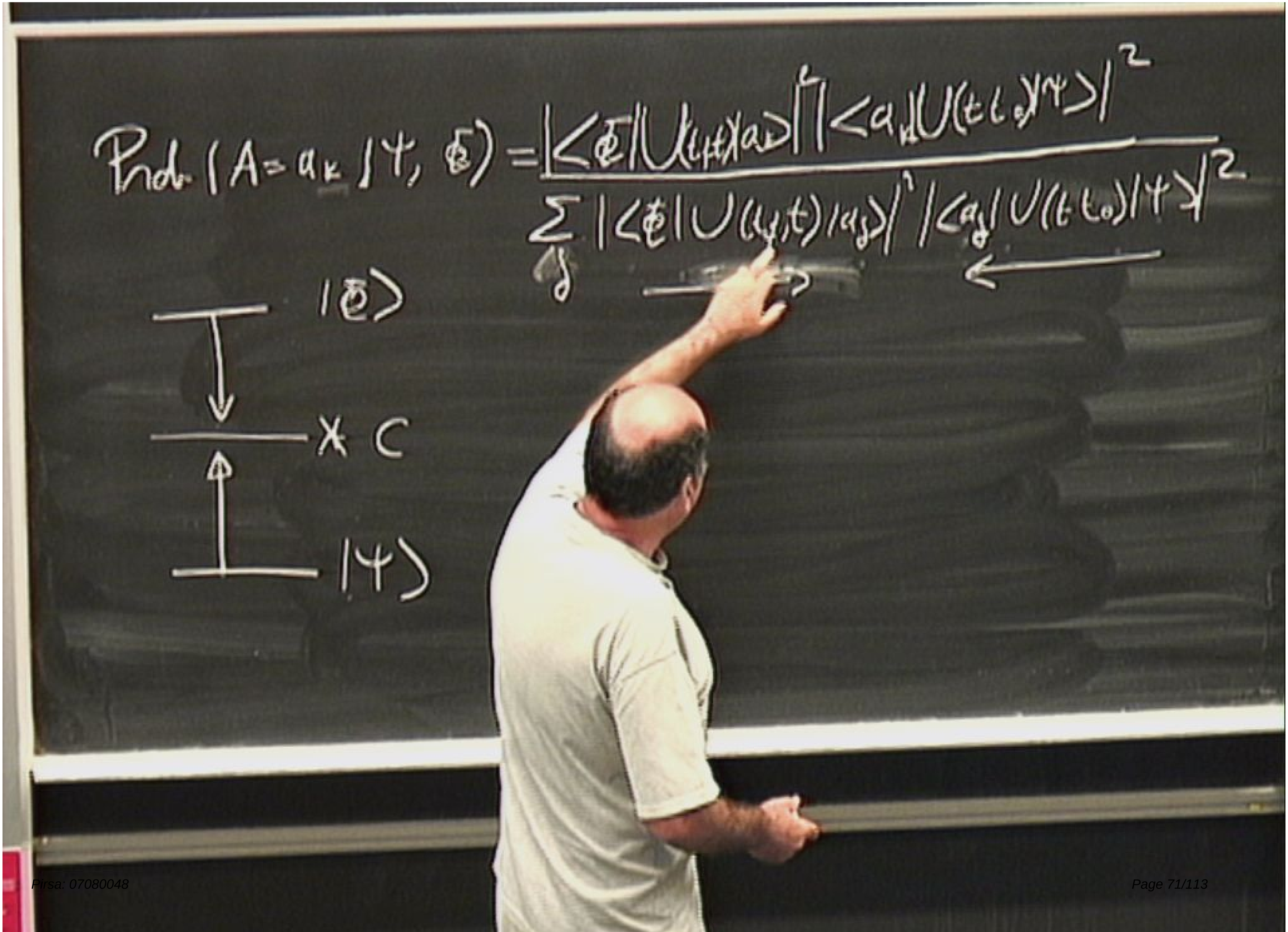
$$\text{Prob}(A=a_k \mid \psi, \Phi) = \frac{|\langle\Phi|U(t_f,t)|a_k\rangle|^2\,|\langle a_k|U(t,t_0)|\psi\rangle|^2}{\sum_j |\langle\Phi|U(t_f,t)|a_j\rangle|^2\,|\langle a_j|U(t,t_0)|\psi\rangle|^2}$$

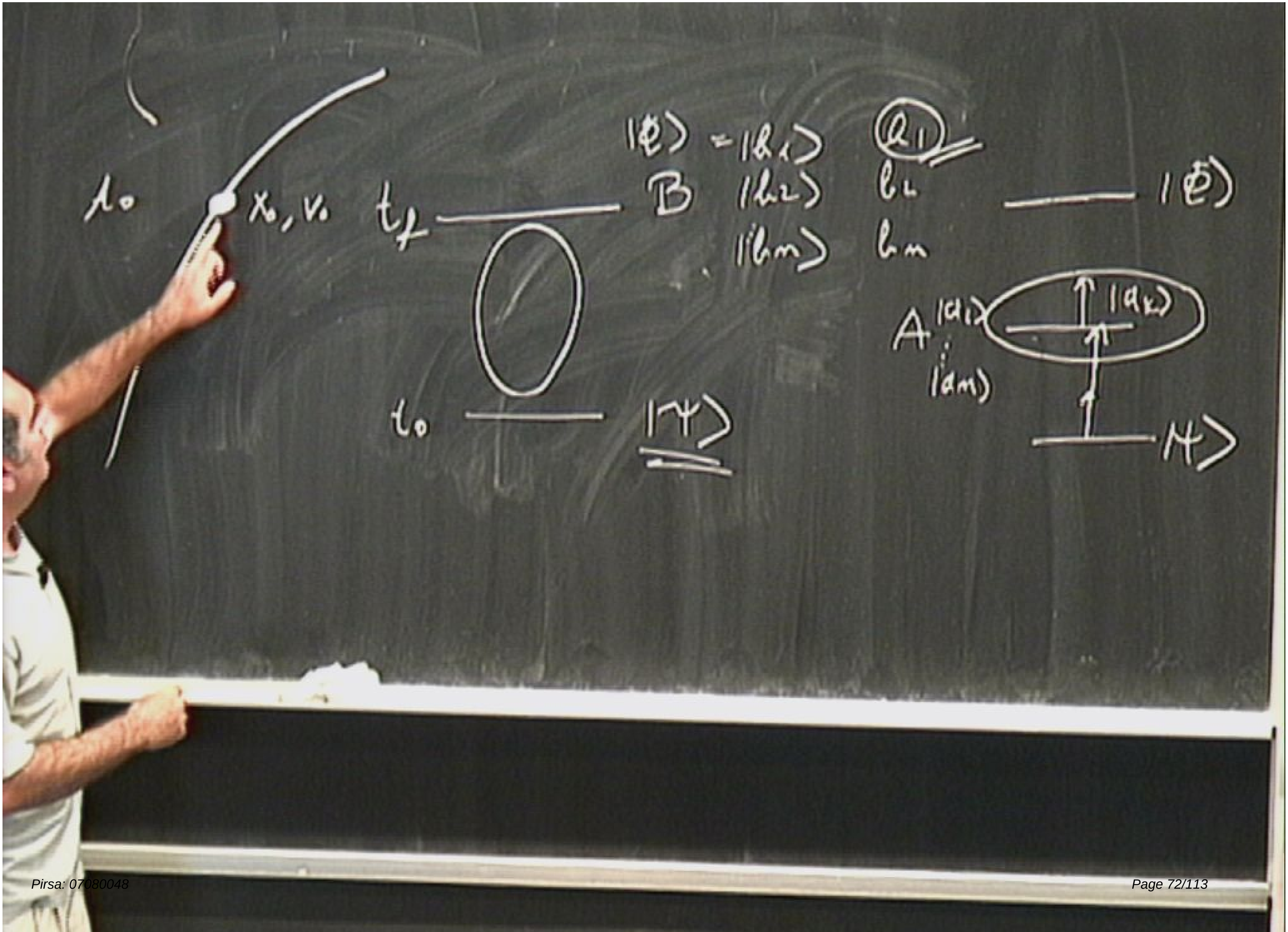
$|\Phi\rangle$

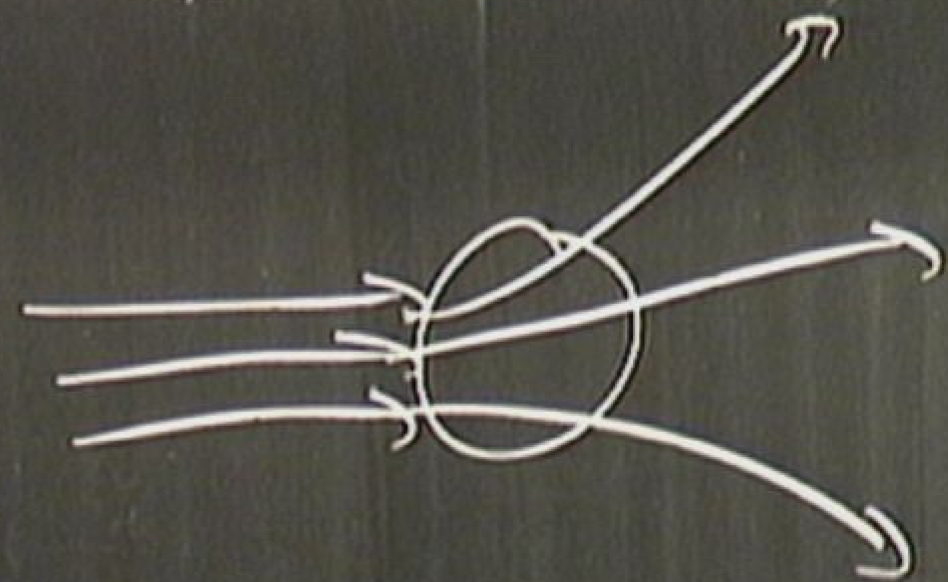
$|\psi\rangle$

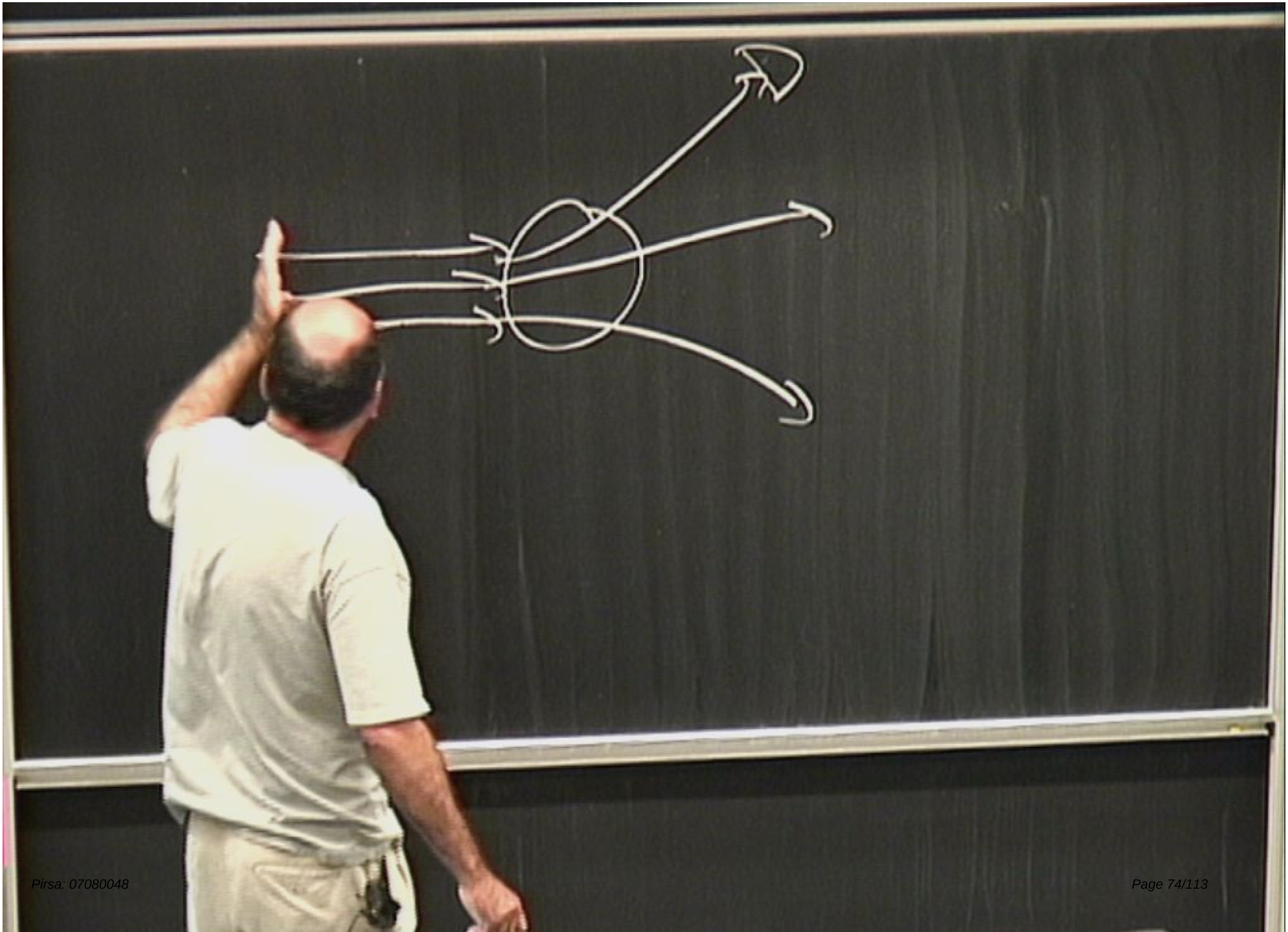
$$\mathrm{Prob}(A = a_k \mid \psi, \Phi) = \frac{|\langle \Phi | U(t_f,t) | a_k\rangle|^2 \, |\langle a_k | U(t,t_0) | \psi\rangle|^2}{\sum_j |\langle \Phi | U(t_f,t) | a_j\rangle|^2 \, |\langle a_j | U(t,t_0) | \psi\rangle|^2}$$

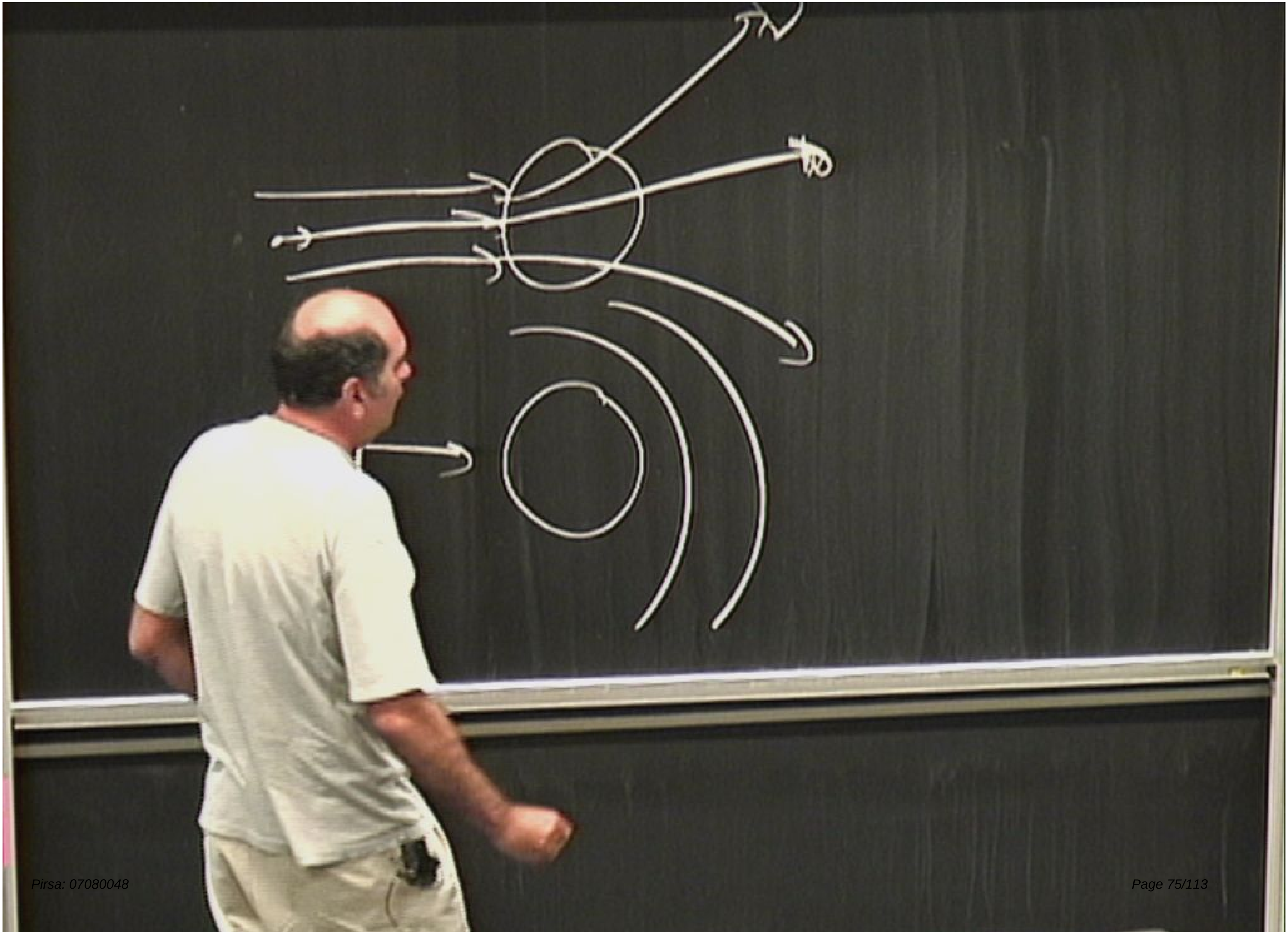


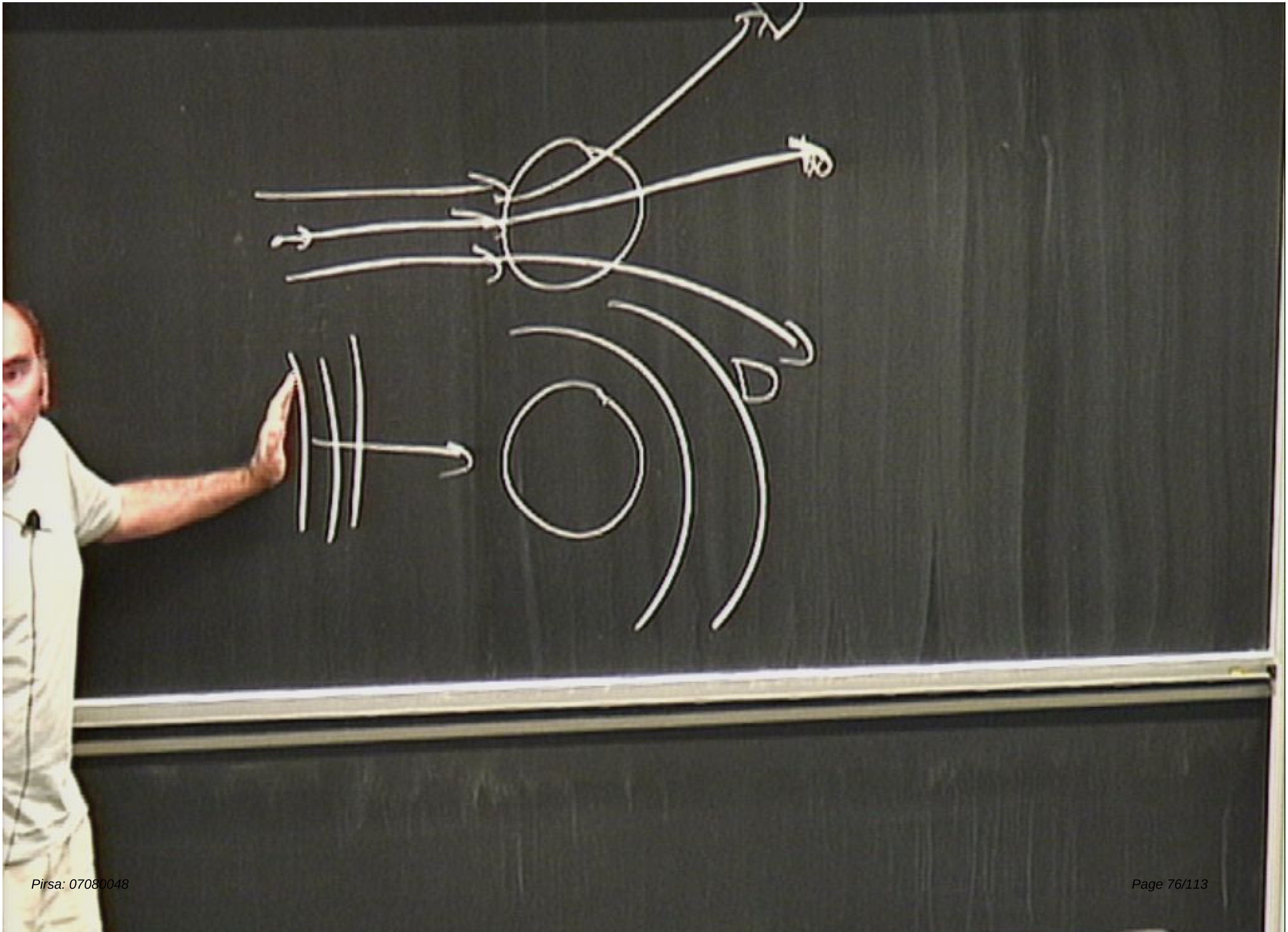

Prob. (A = a_k | ψ, φ) = |<φ|U(t_f,t)|a_k>|² |<a_k|U(t,t_0)|ψ>|² / Σ_j |<φ|U(t_f,t)|a_j>|² |<a_j|U(t,t_0)|ψ>|²
|φ>
C
|ψ>

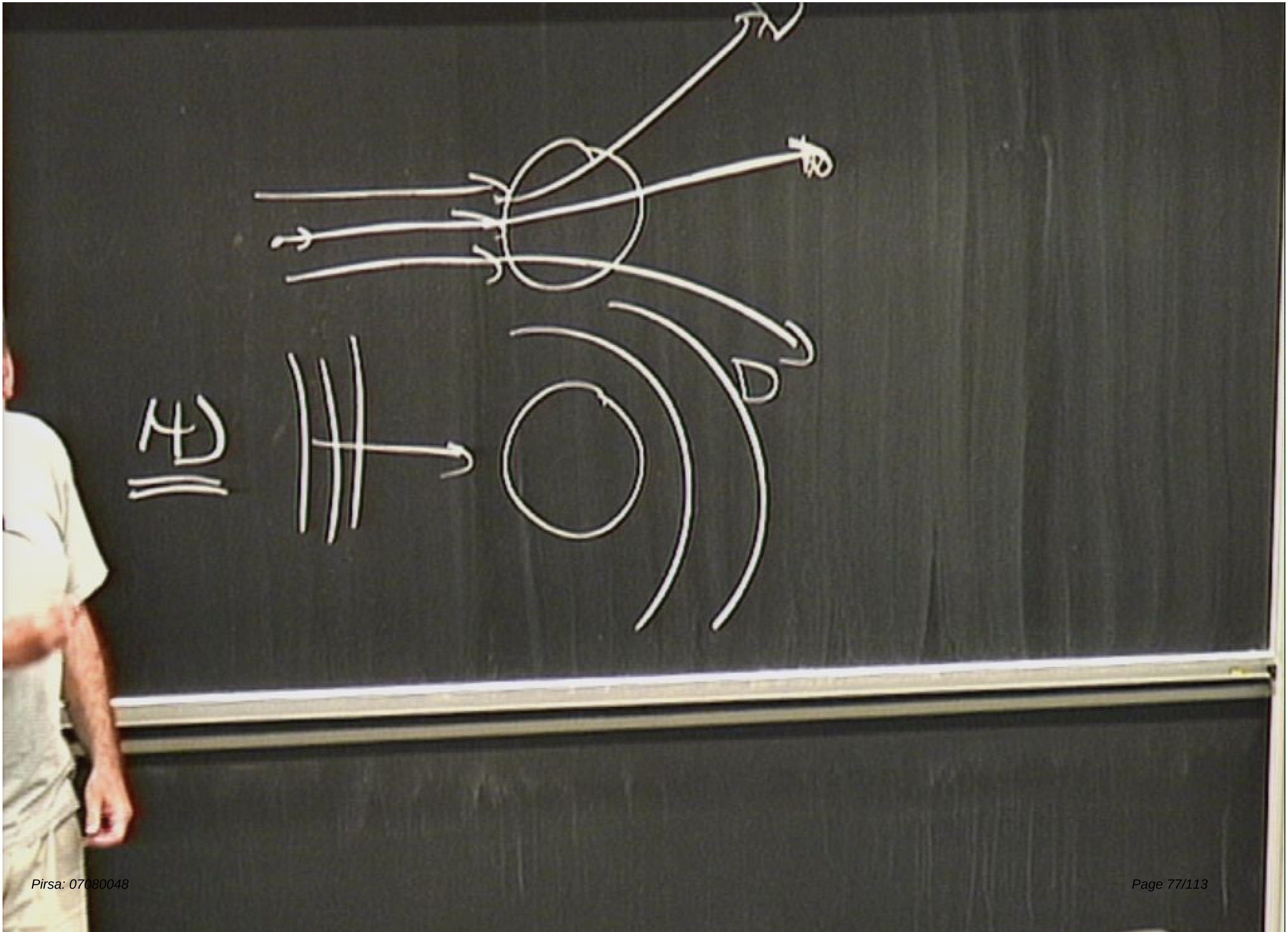

x₀, v₀
B
A

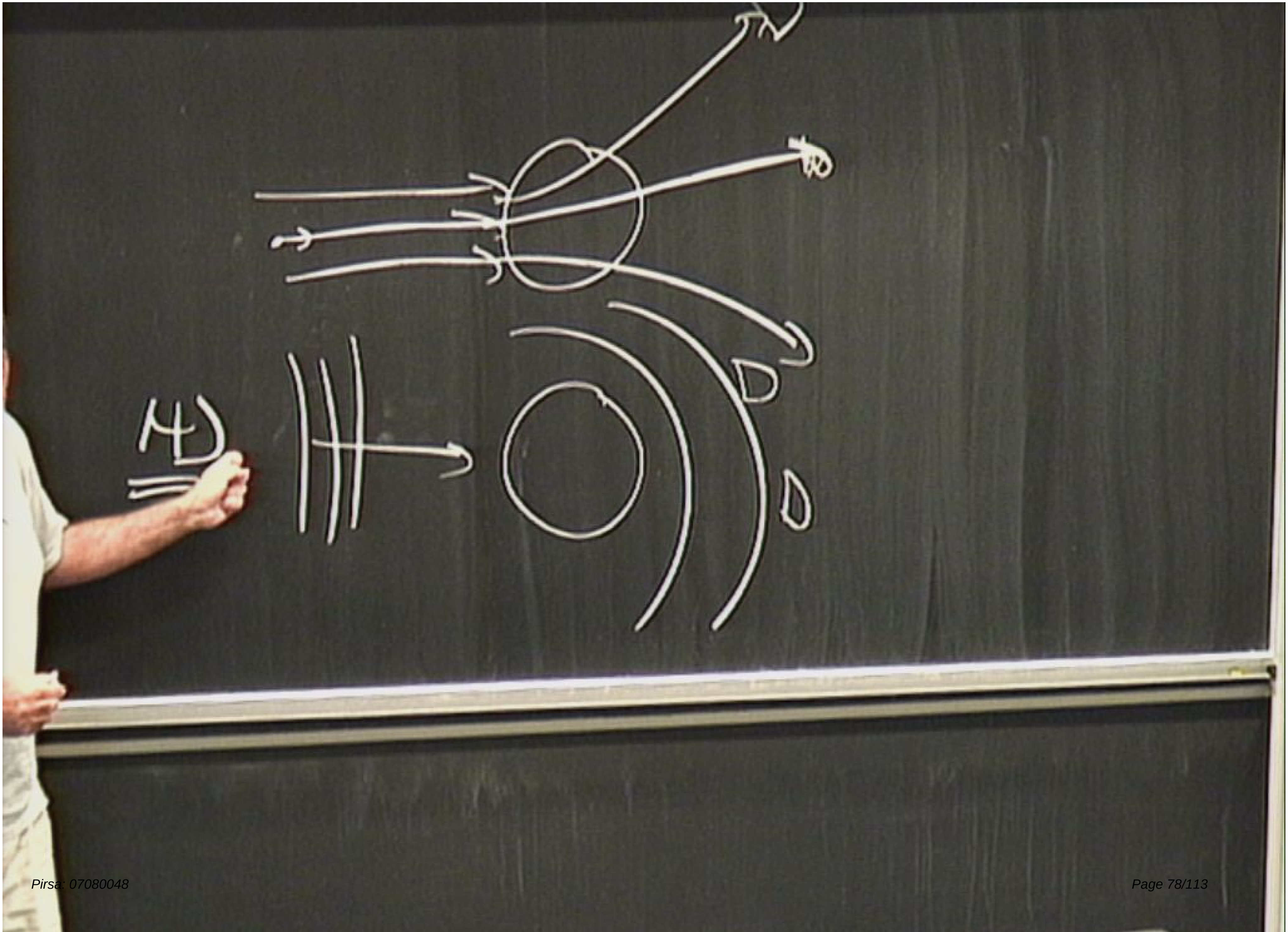


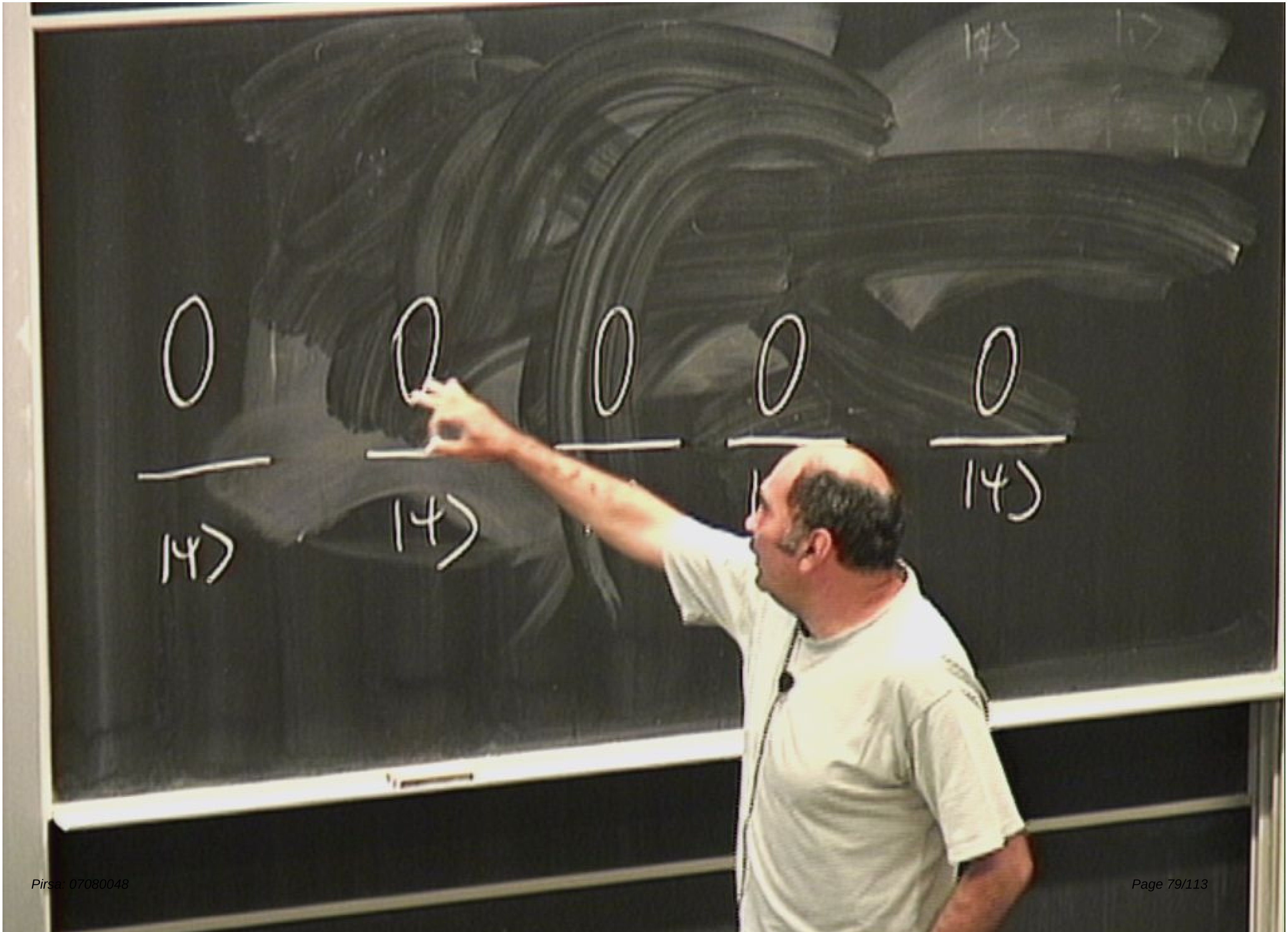


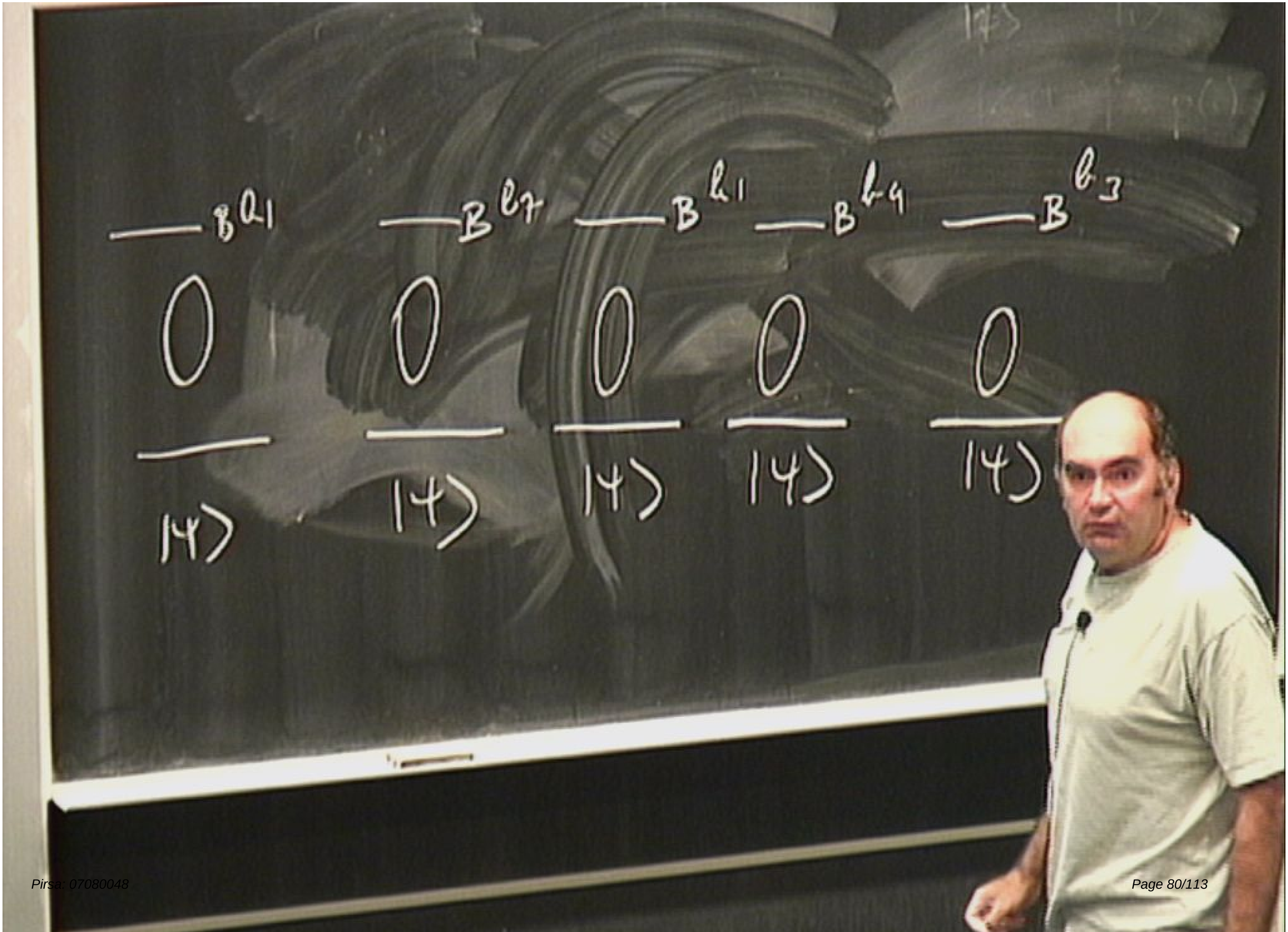


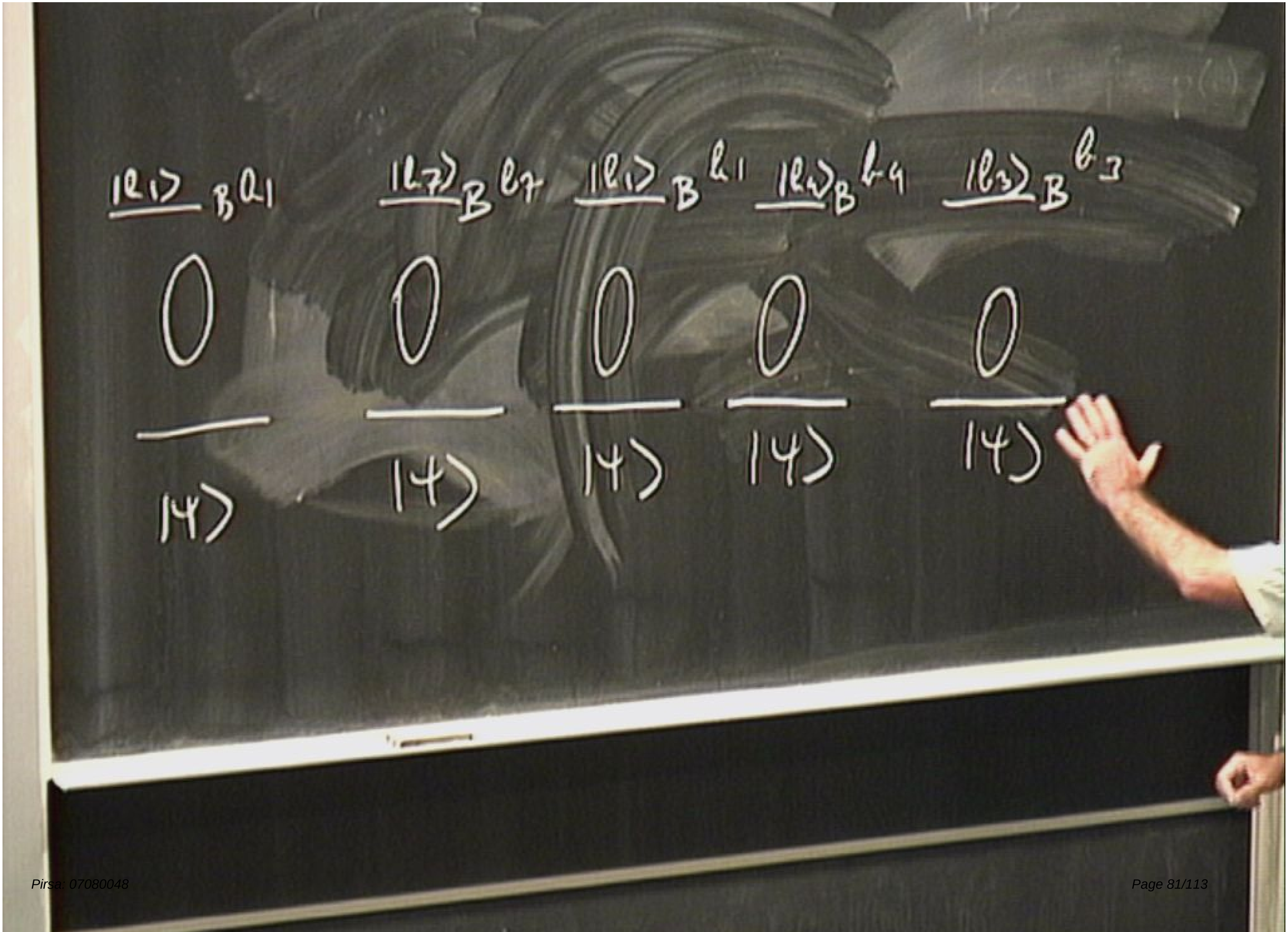




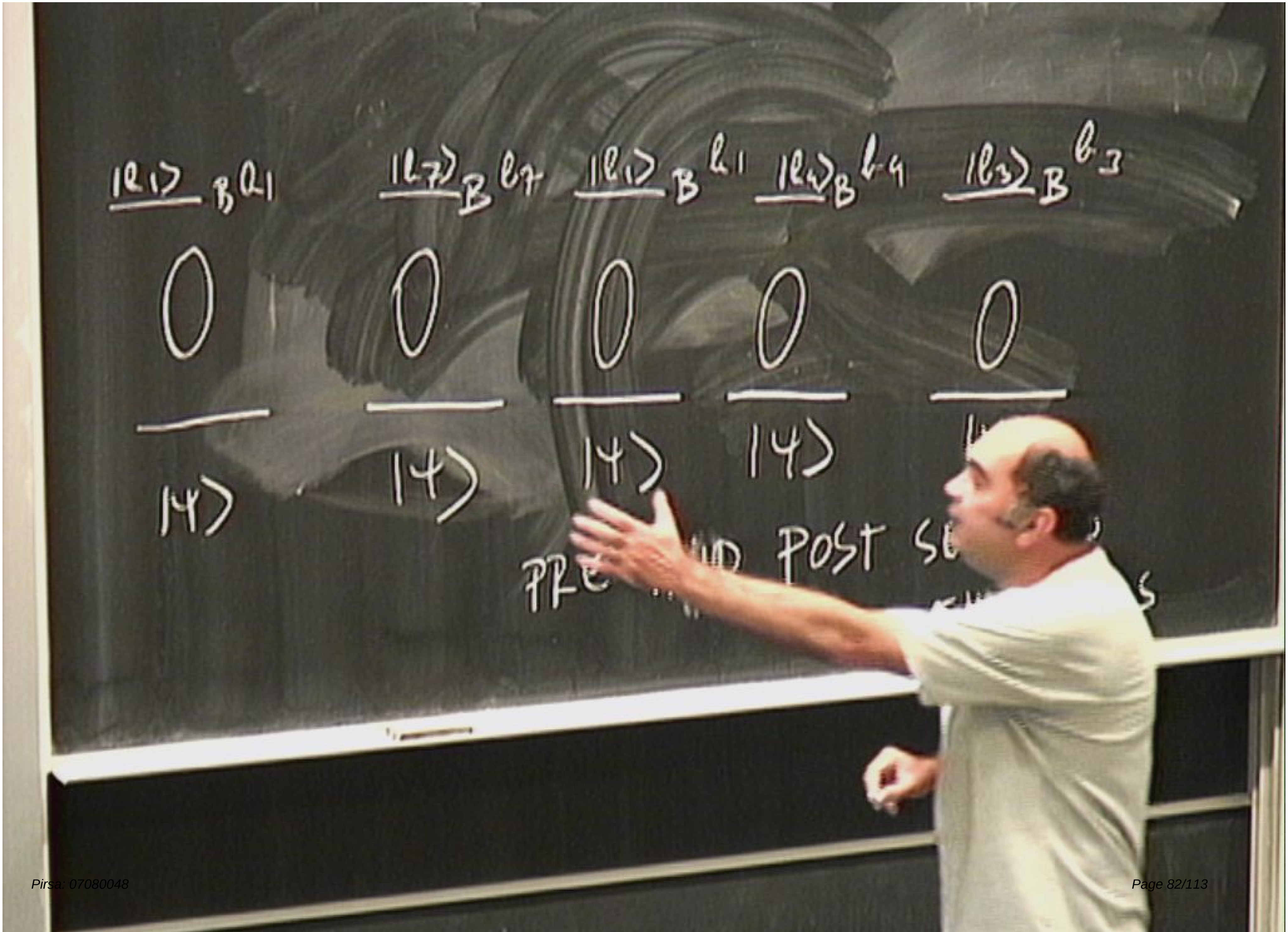


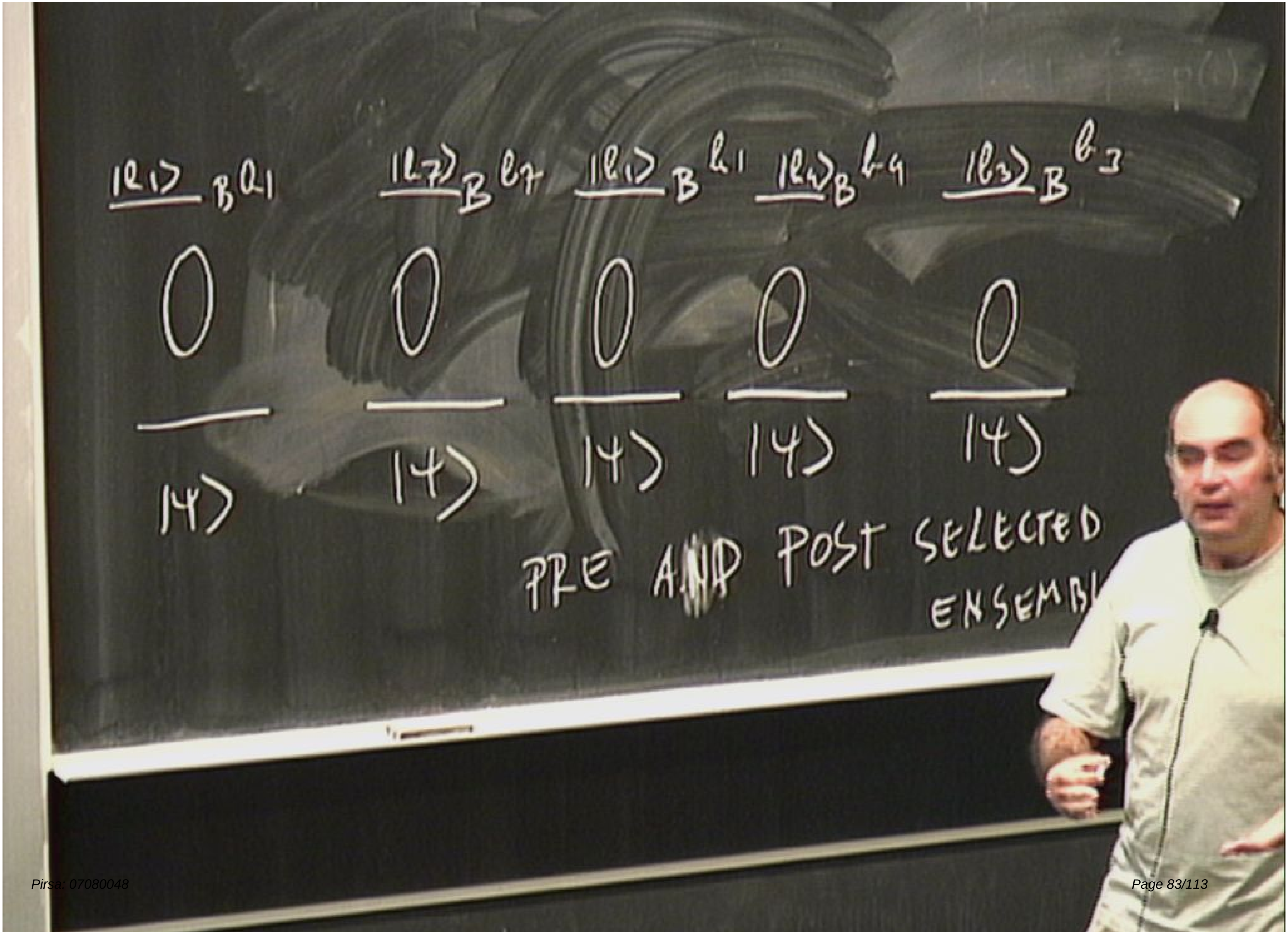

0
|ψ⟩
0
|ψ⟩
0
0
0
|ψ⟩





|e1⟩ B e1
|e7⟩ B e7
|e1⟩ B e1
|e4⟩ B e4
|e3⟩ B e3
0
|ψ⟩


POST
PRE

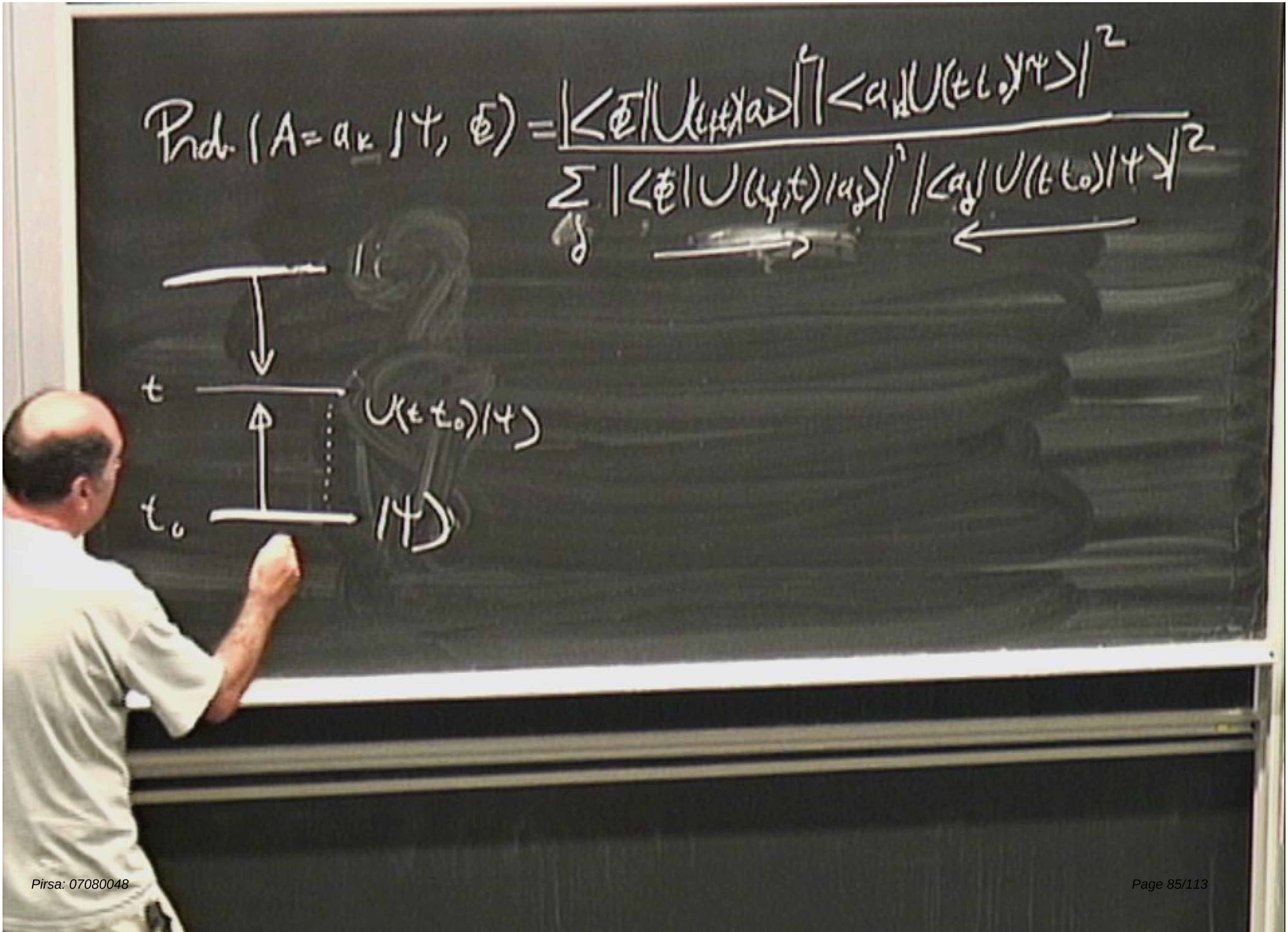

PRE AND POST SELECTED
ENSEMBL

$\underline{|\ell_1\rangle_B}\ \ell_1$ $\quad$ $\underline{|\ell_7\rangle_B}\ \ell_7$ $\quad$ $\underline{|\ell_1\rangle_B}\ \ell_1$ $\quad$ $\underline{|\ell_4\rangle_B}\ \ell_4$ $\quad$ $\underline{|\ell_3\rangle_B}\ \ell_3$

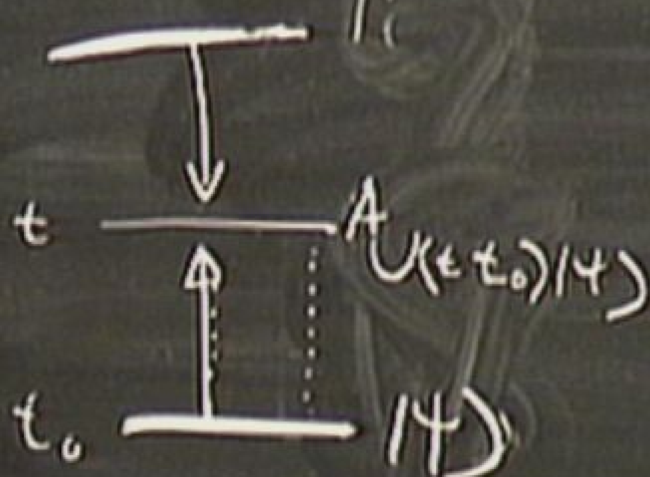
$0 \quad 0 \quad 0 \quad 0 \quad 0$

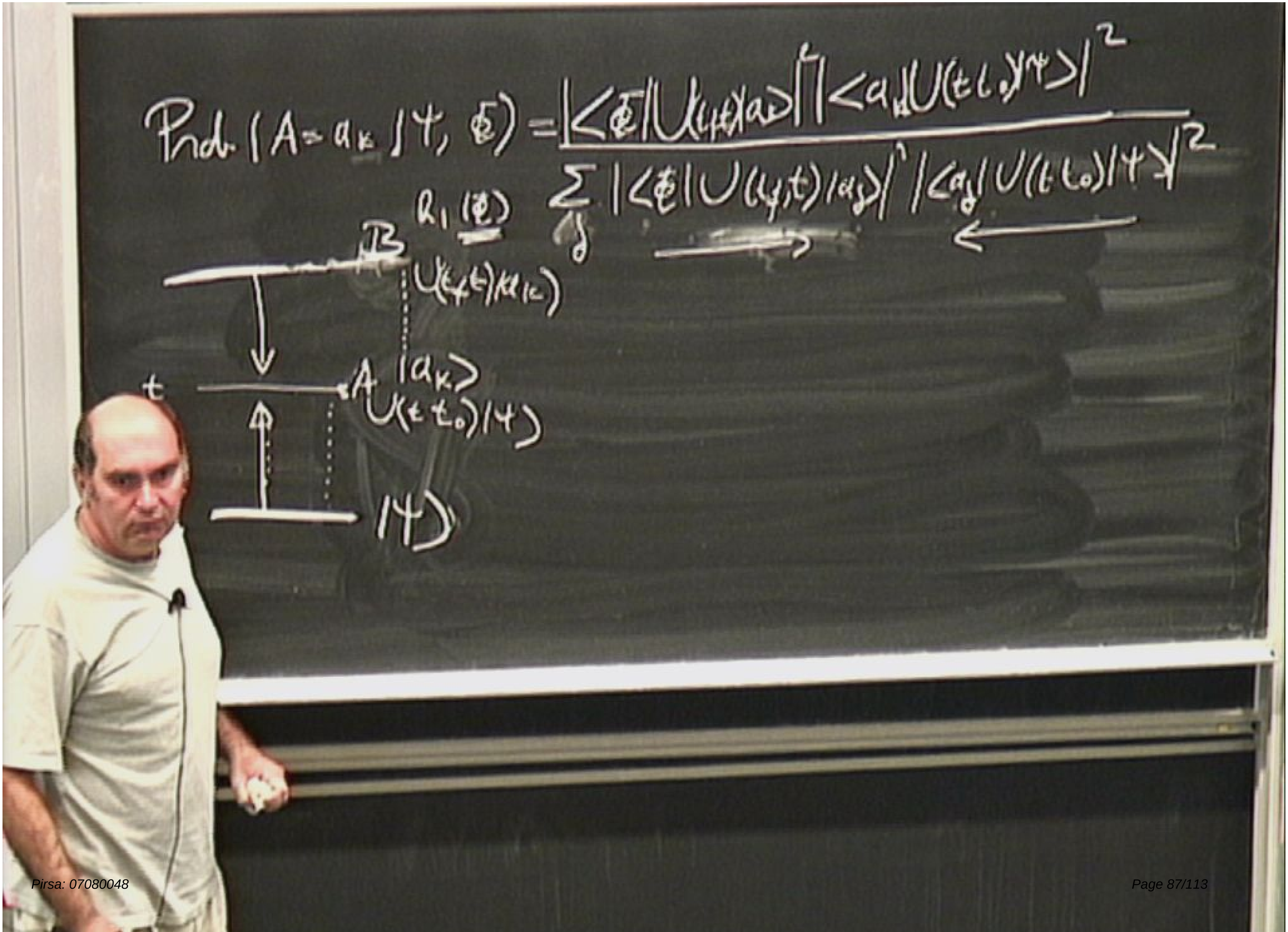
$|\psi\rangle \quad |\psi\rangle \quad |\psi\rangle \quad |\psi\rangle \quad |\psi\rangle$

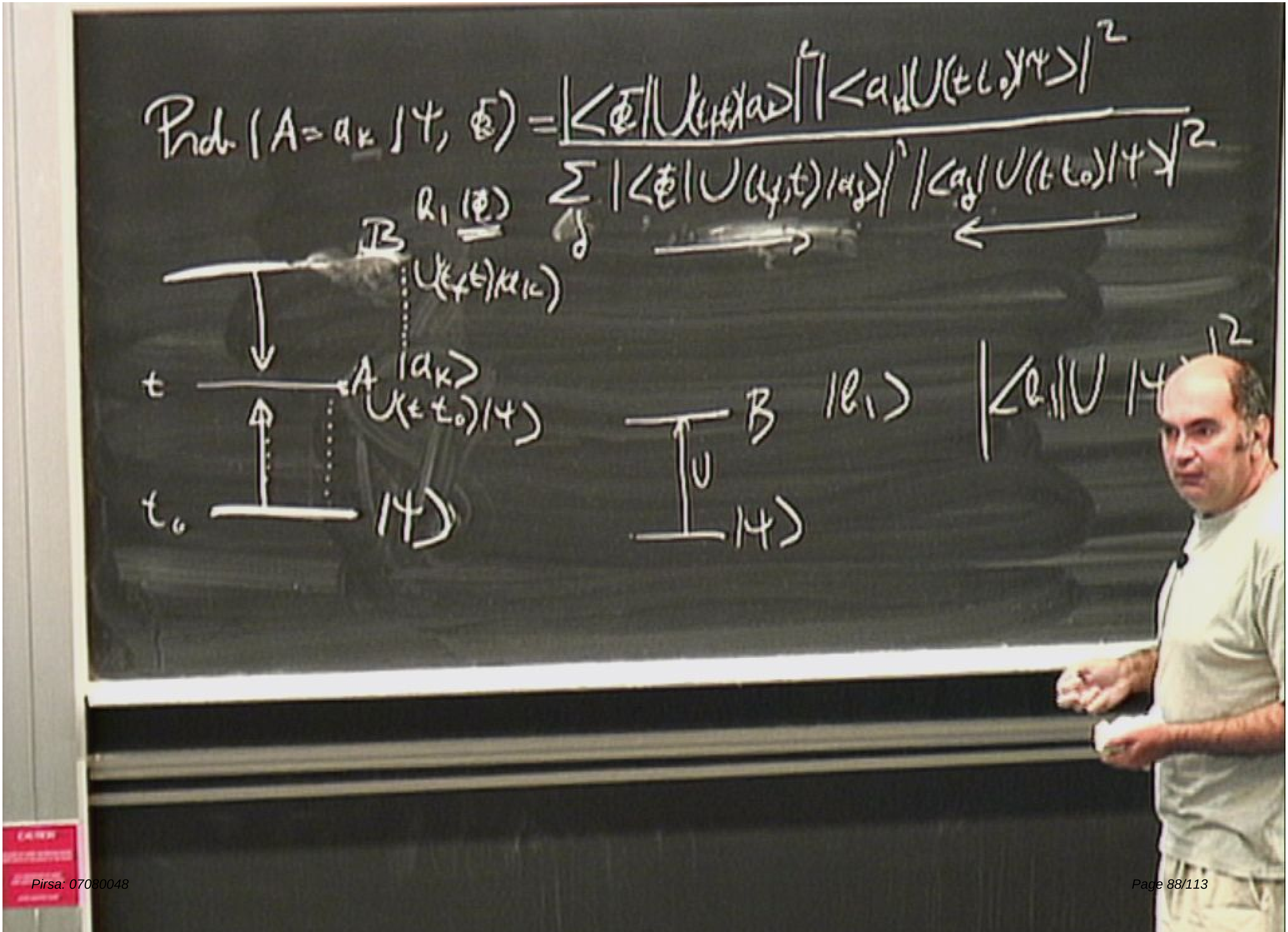
PRE AND POST SELECTED ENSEMBLES


$\text{Prob}(A = a_k \mid \Psi, \Phi) = \dfrac{|\langle \Phi | U(t_f,t) | a_k \rangle|^2 \, |\langle a_k | U(t,t_0) | \Psi \rangle|^2}{\sum_j |\langle \Phi | U(t_f,t) | a_j \rangle|^2 \, |\langle a_j | U(t,t_0) | \Psi \rangle|^2}$
t
$U(t,t_0)|\Psi\rangle$
t_0
$|\Psi\rangle$

$$\text{Prob}(A = a_k \mid \psi, \phi) = \frac{|\langle \phi | U(t_f, t) | a_k\rangle|^2 \, |\langle a_k | U(t, t_0) | \psi \rangle|^2}{\sum_j |\langle \phi | U(t_f, t) | a_j \rangle|^2 \, |\langle a_j | U(t, t_0) | \psi \rangle|^2}$$

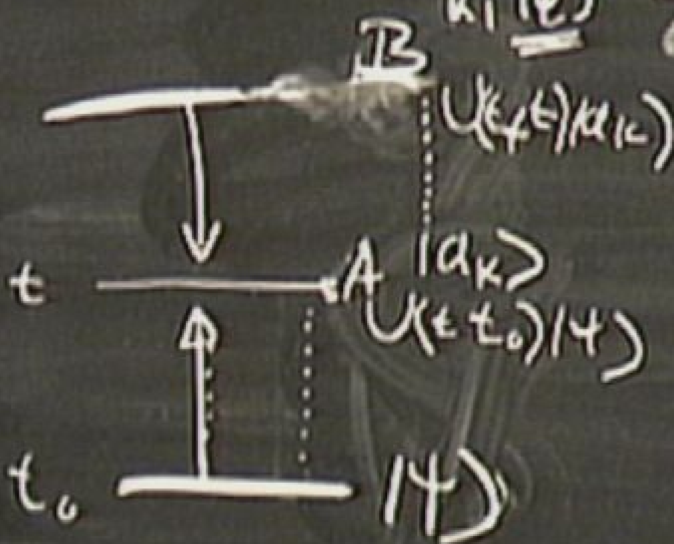


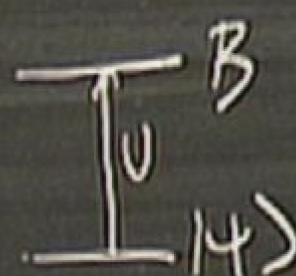

Prob. (A = a_k | Ψ, Φ) = $\frac{|\langle \Phi | U(t_f,t) | a_k \rangle|^2 \, |\langle a_k | U(t,t_0) | \Psi \rangle|^2}{\sum_j |\langle \Phi | U(t_f,t) | a_j \rangle|^2 \, |\langle a_j | U(t,t_0) | \Psi \rangle|^2}$
$R_1(\Phi)$
B
$U(t_f,t)|a_k\rangle$
t
A
$|a_k\rangle$
$U(t,t_0)|\Psi\rangle$
$|\Psi\rangle$



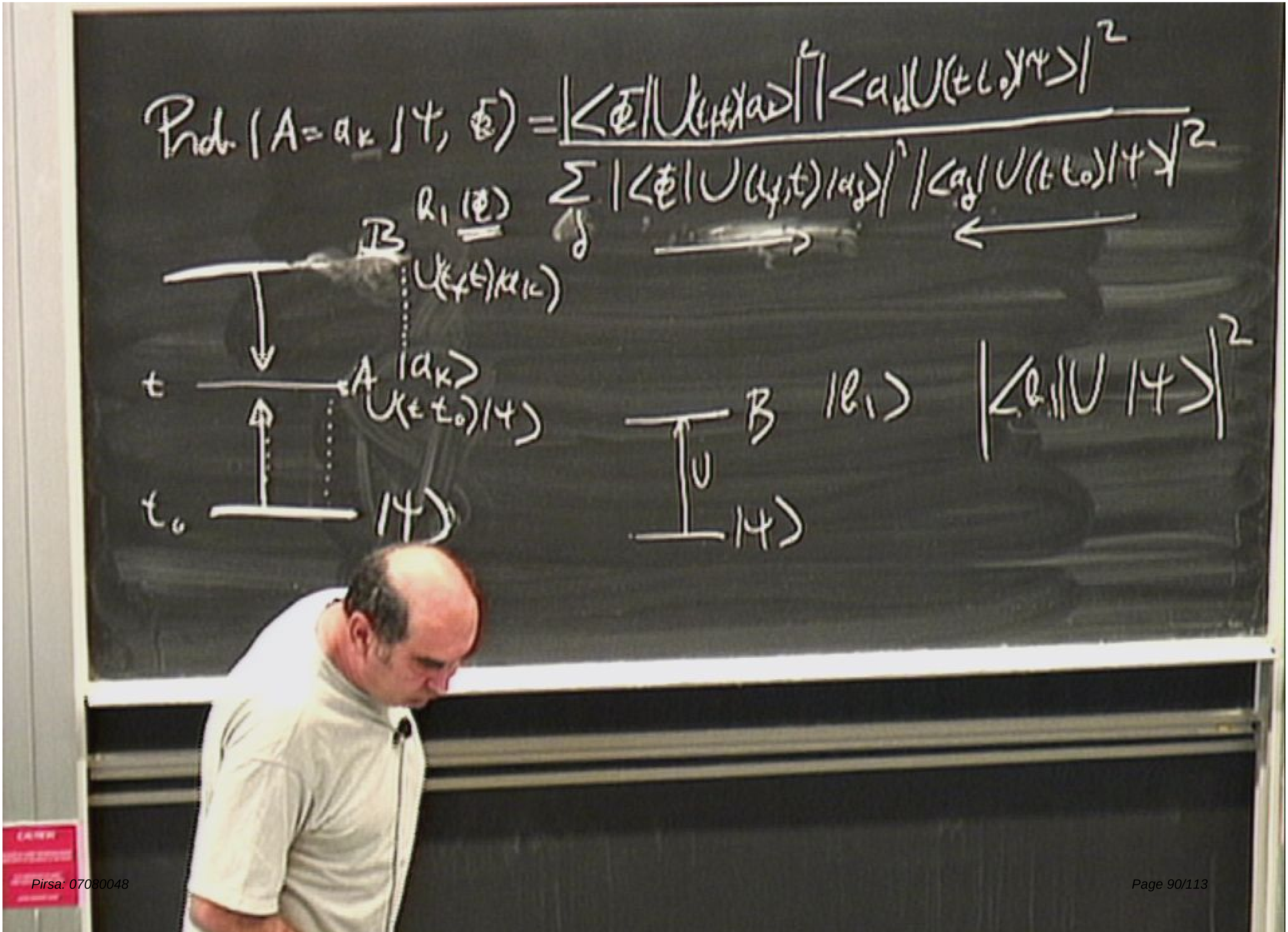
$\mathrm{Prob}(A = a_k \mid \Psi, \Phi) = \dfrac{|\langle \Phi | U(t_f,t) | a_k \rangle|^2 \, |\langle a_k | U(t,t_0) | \Psi \rangle|^2}{\sum_j |\langle \Phi | U(t_f,t) | a_j \rangle|^2 \, |\langle a_j | U(t,t_0) | \Psi \rangle|^2}$
B
$U(t_f,t)|a_k\rangle$
t
A
$|a_k\rangle$
$U(t,t_0)|\Psi\rangle$
t_0
$|\Psi\rangle$
B
$|b_1\rangle$
$|\langle b_1 | U | \Psi \rangle|^2$
U
$|\Psi\rangle$

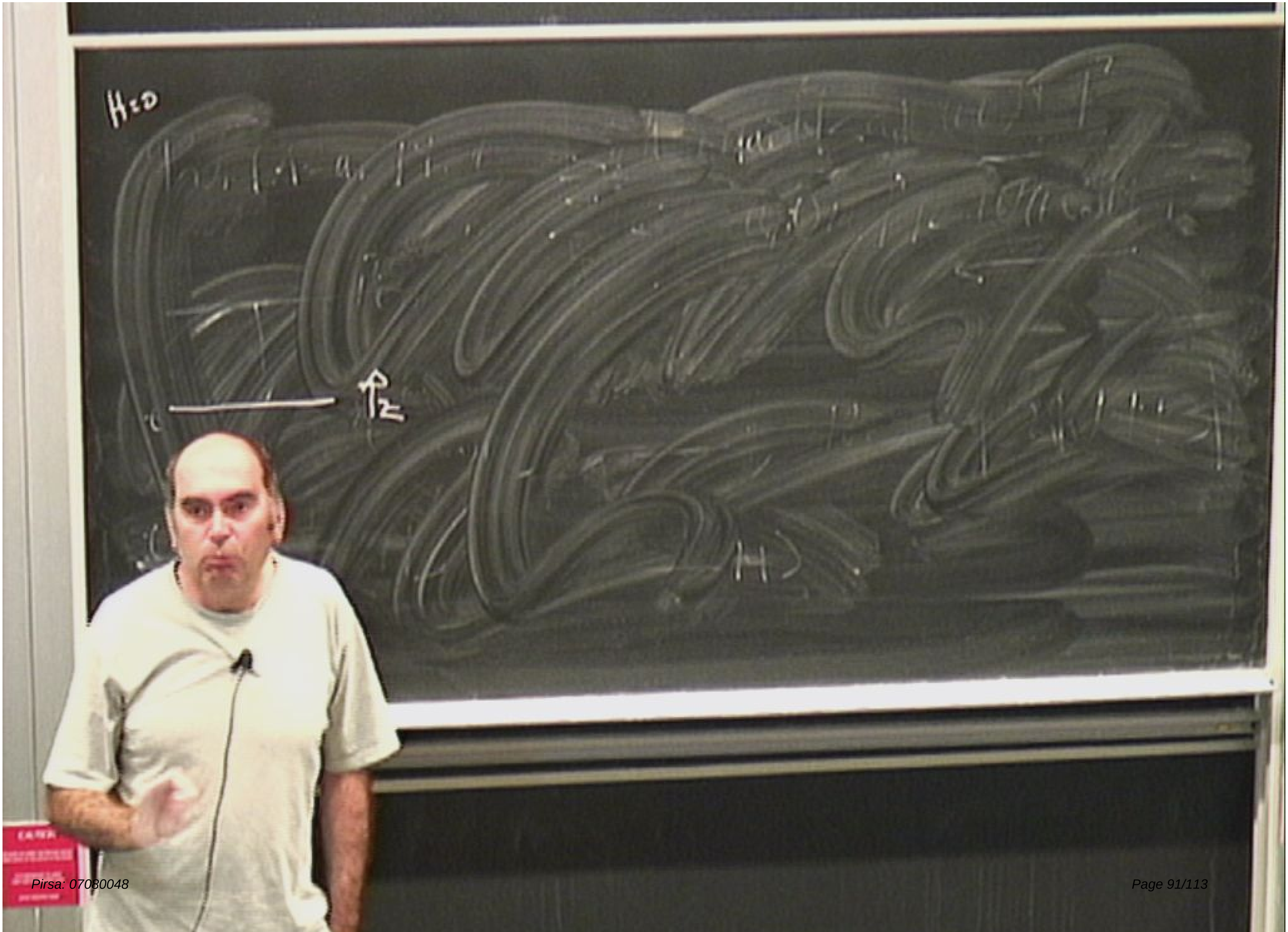
$$\mathrm{Prob}(A = a_k \mid \psi, \Phi) = \frac{|\langle \Phi | U(t_f,t) | a_k \rangle|^2 \, |\langle a_k | U(t,t_0) | \psi \rangle|^2}{\sum_j |\langle \Phi | U(t_f,t) | a_j \rangle|^2 \, |\langle a_j | U(t,t_0) | \psi \rangle|^2}$$

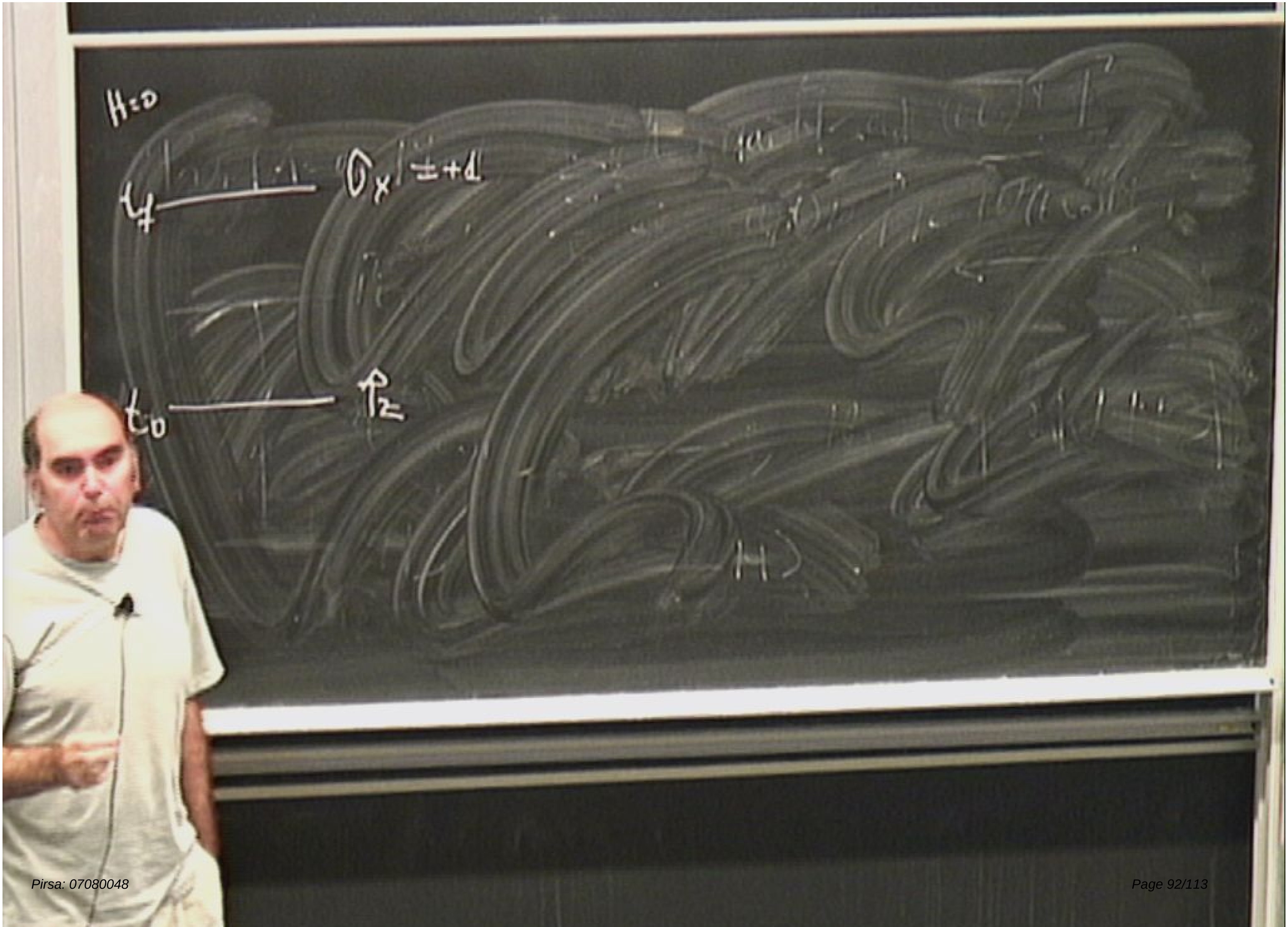


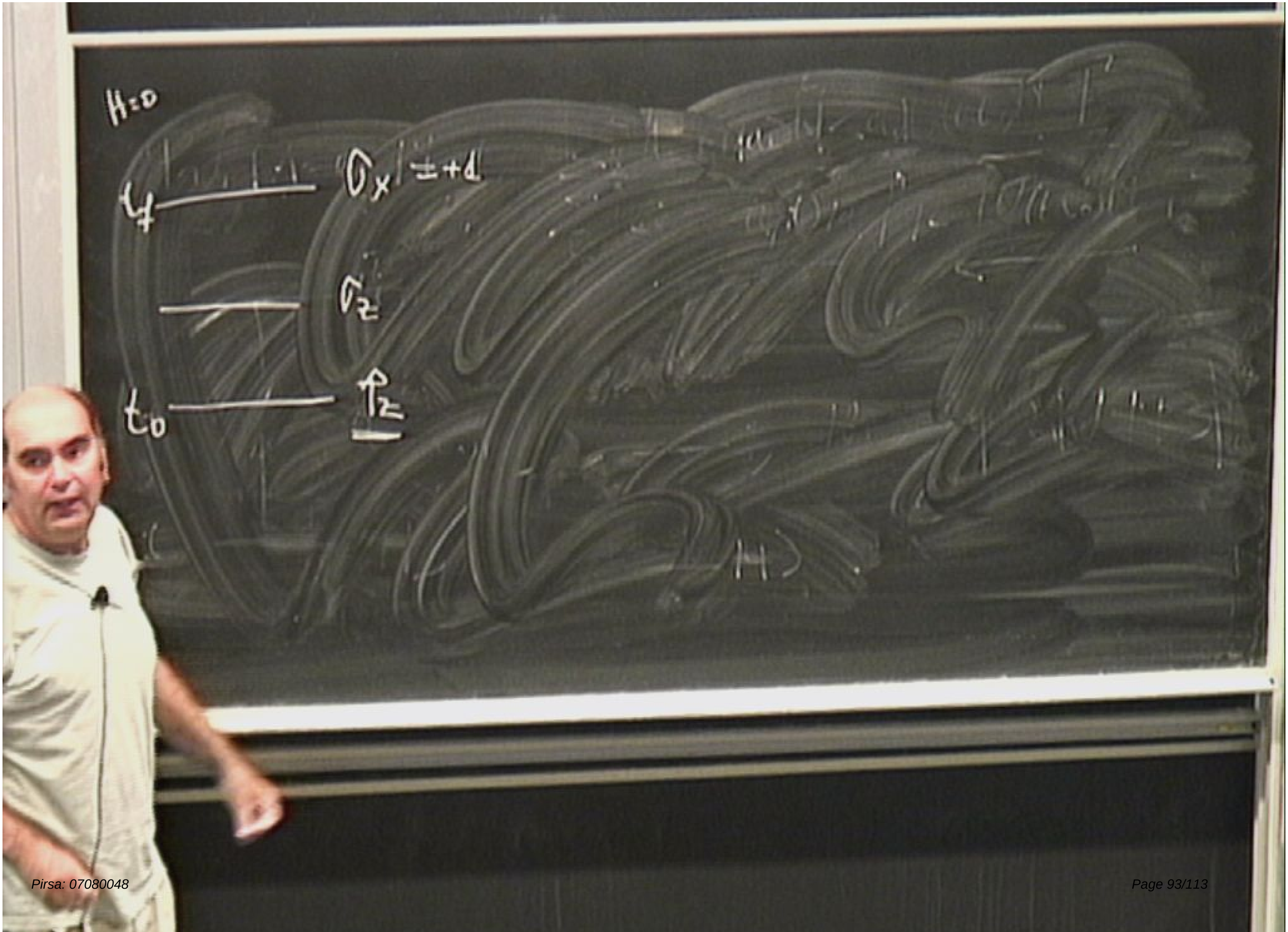


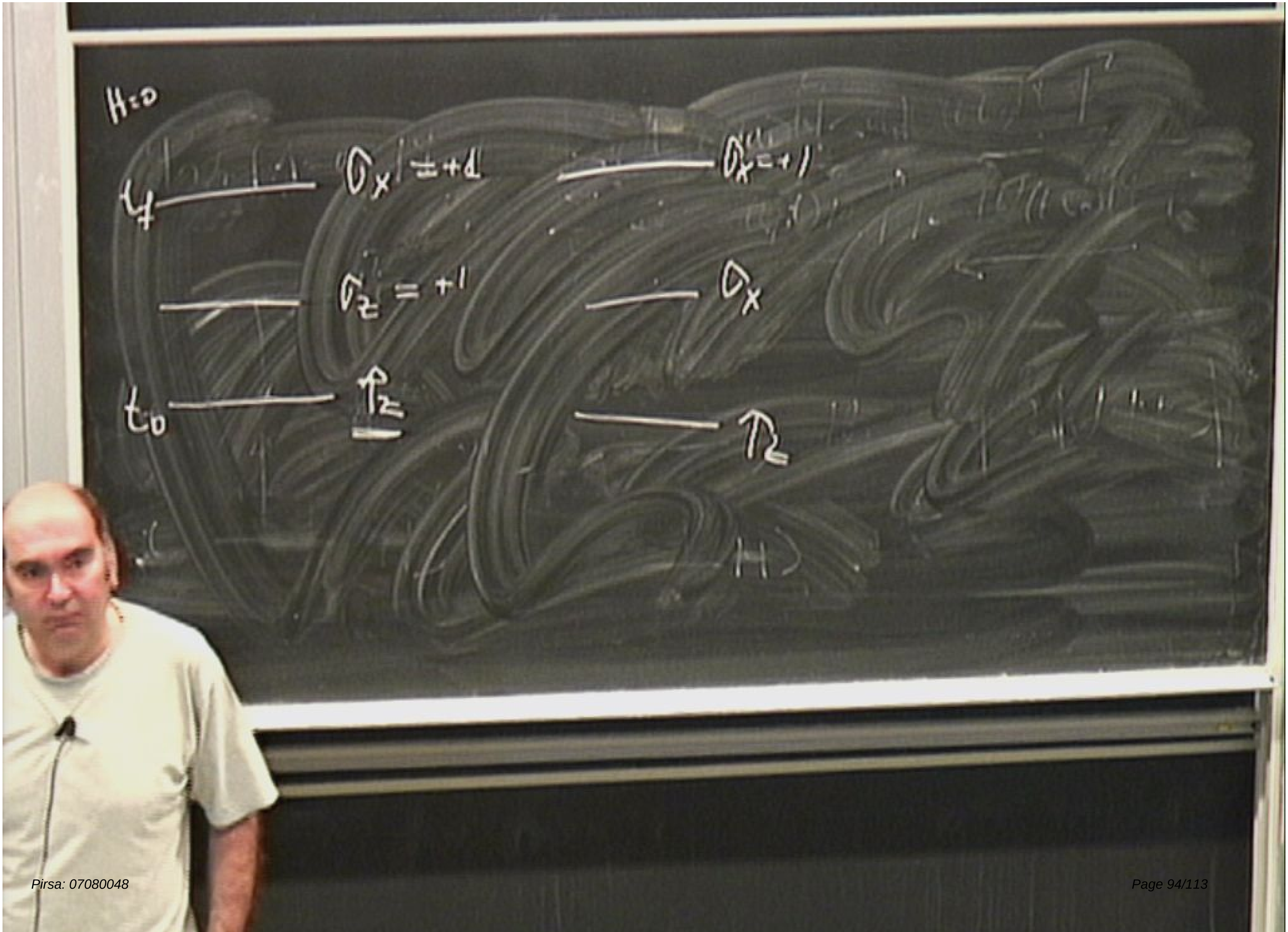
$|b_1\rangle$ $\quad |\langle b_1 | U | \psi \rangle|^2$

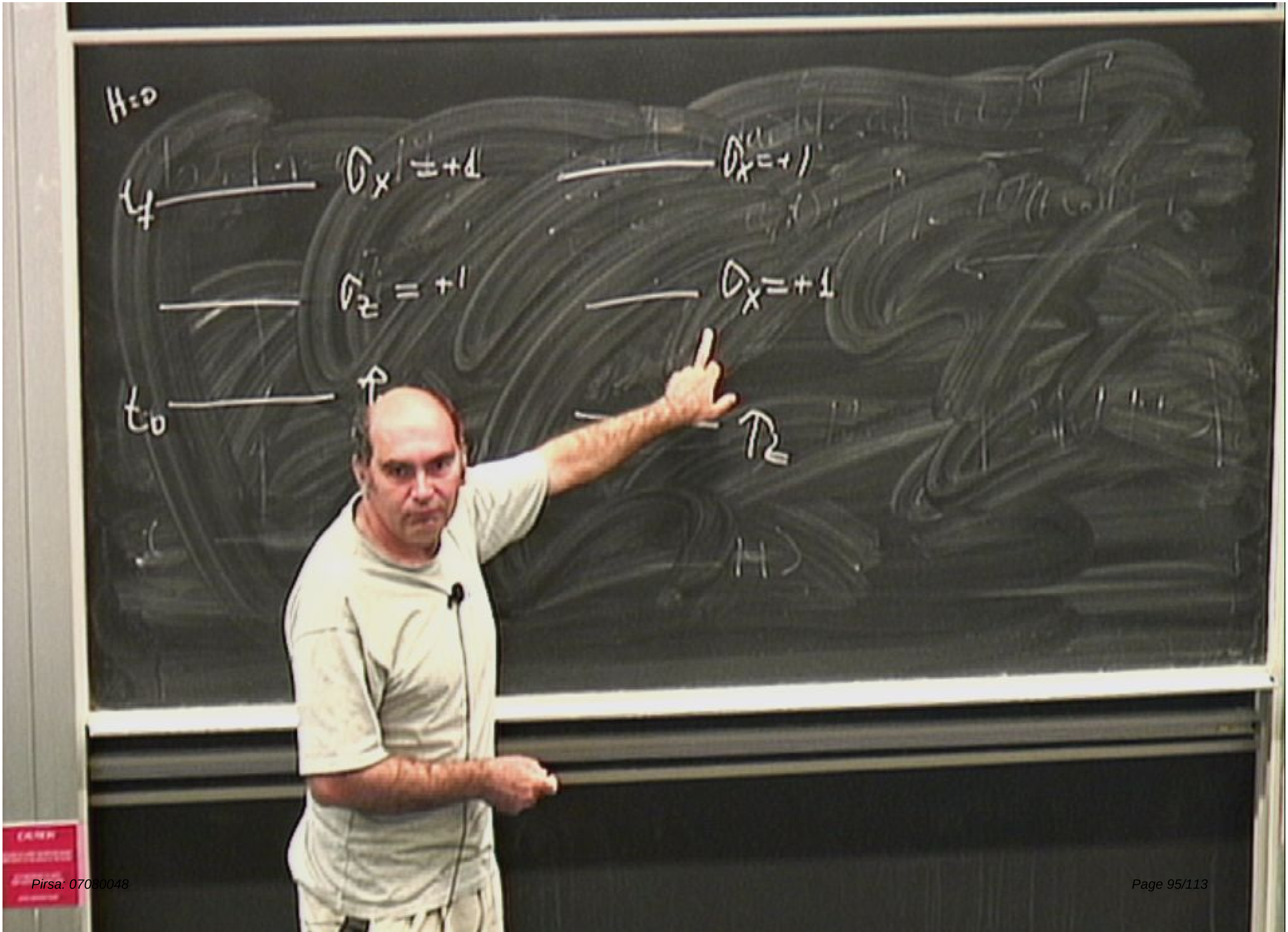

Prob.(A = a_k | ψ, Φ) = |<Φ|U(t_f,t)|a_k>|^2 |<a_k|U(t,t_0)|ψ>|^2 / Σ_j |<Φ|U(t_f,t)|a_j>|^2 |<a_j|U(t,t_0)|ψ>|^2
B
U(t_f,t)|a_k)
t
A |a_k>
U(t,t_0)|ψ)
t_0
|ψ)
B
U
|ψ)
|b_1>
|<b_1|U|ψ>|^2

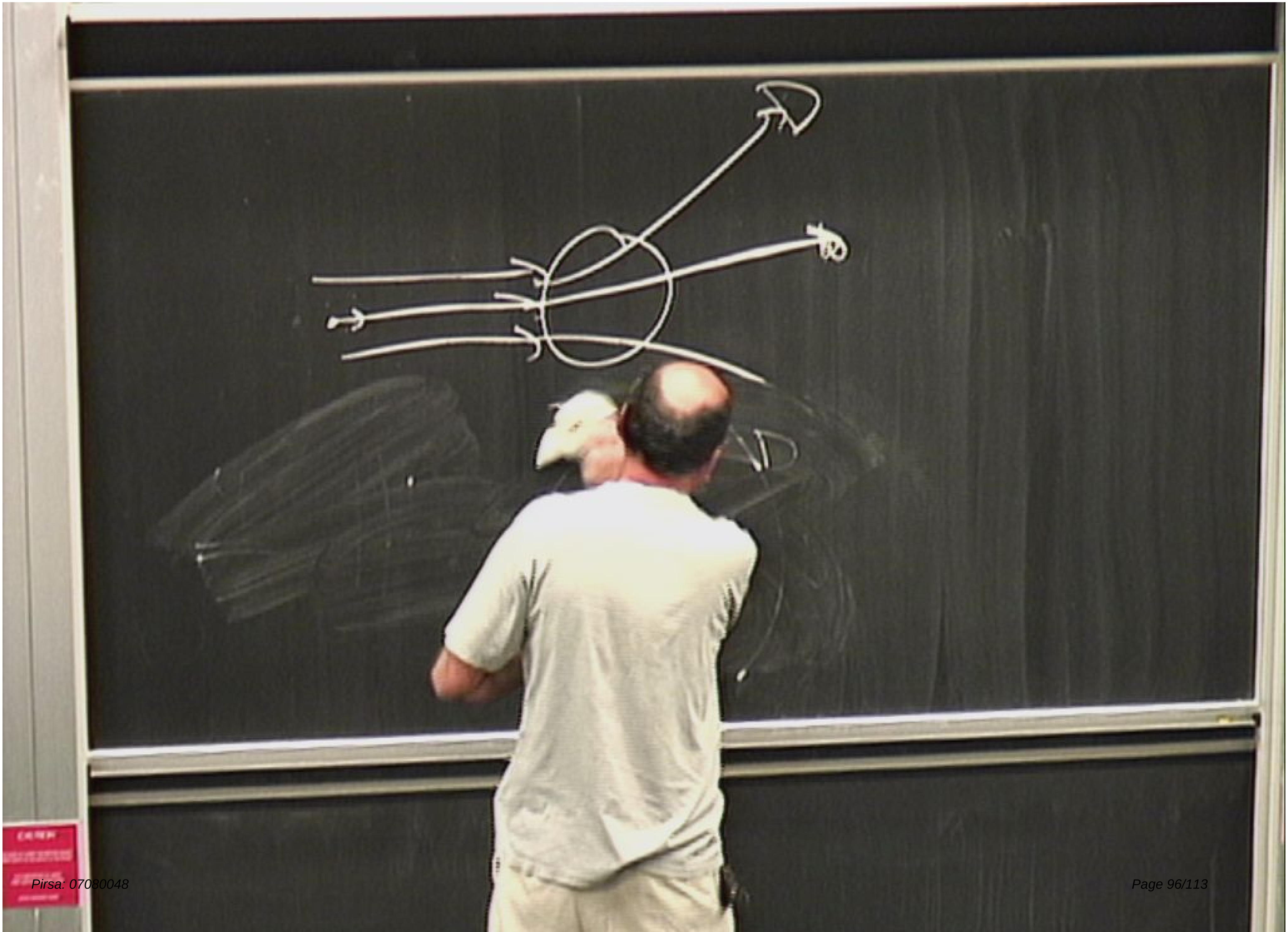

H=0

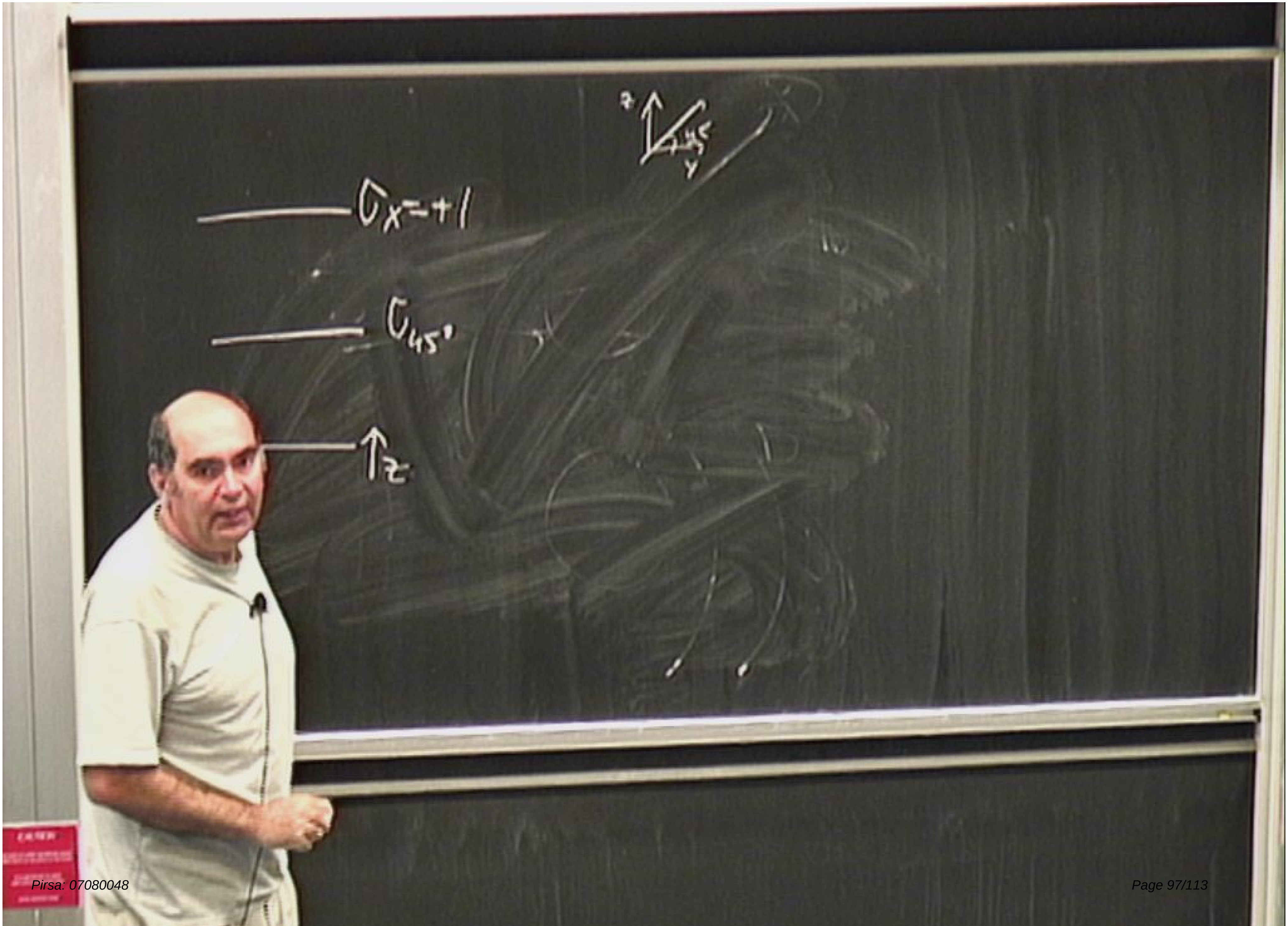

H=0
t_f
t_0


H=0
t_f
σ_x = +1
σ_z
t_0
P_z

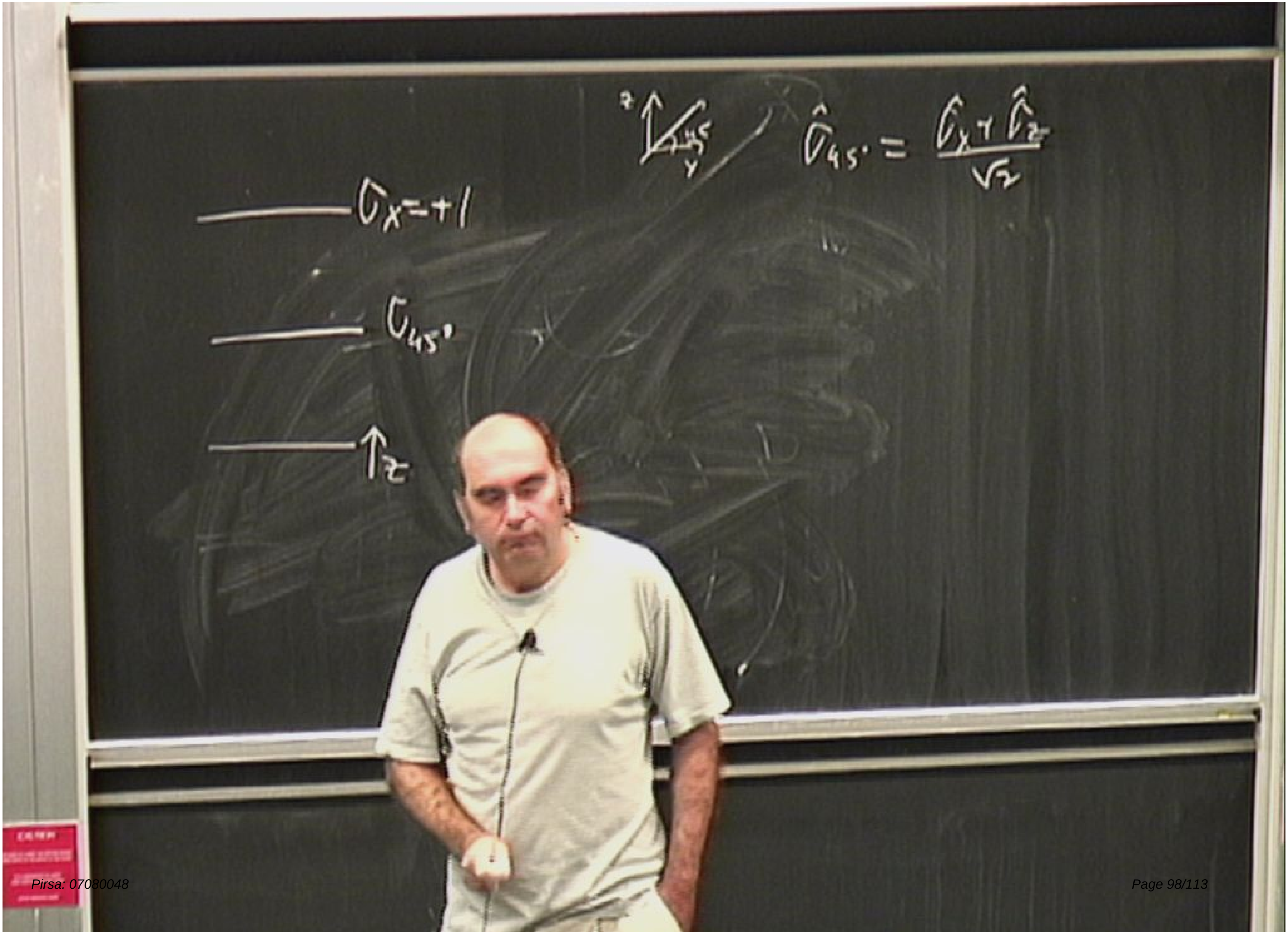

$H=0$
t_f
$\sigma_x = +1$
$\sigma_x = +1$
$\sigma_z = +1$
σ_x
t_0
Π_z
Π_z

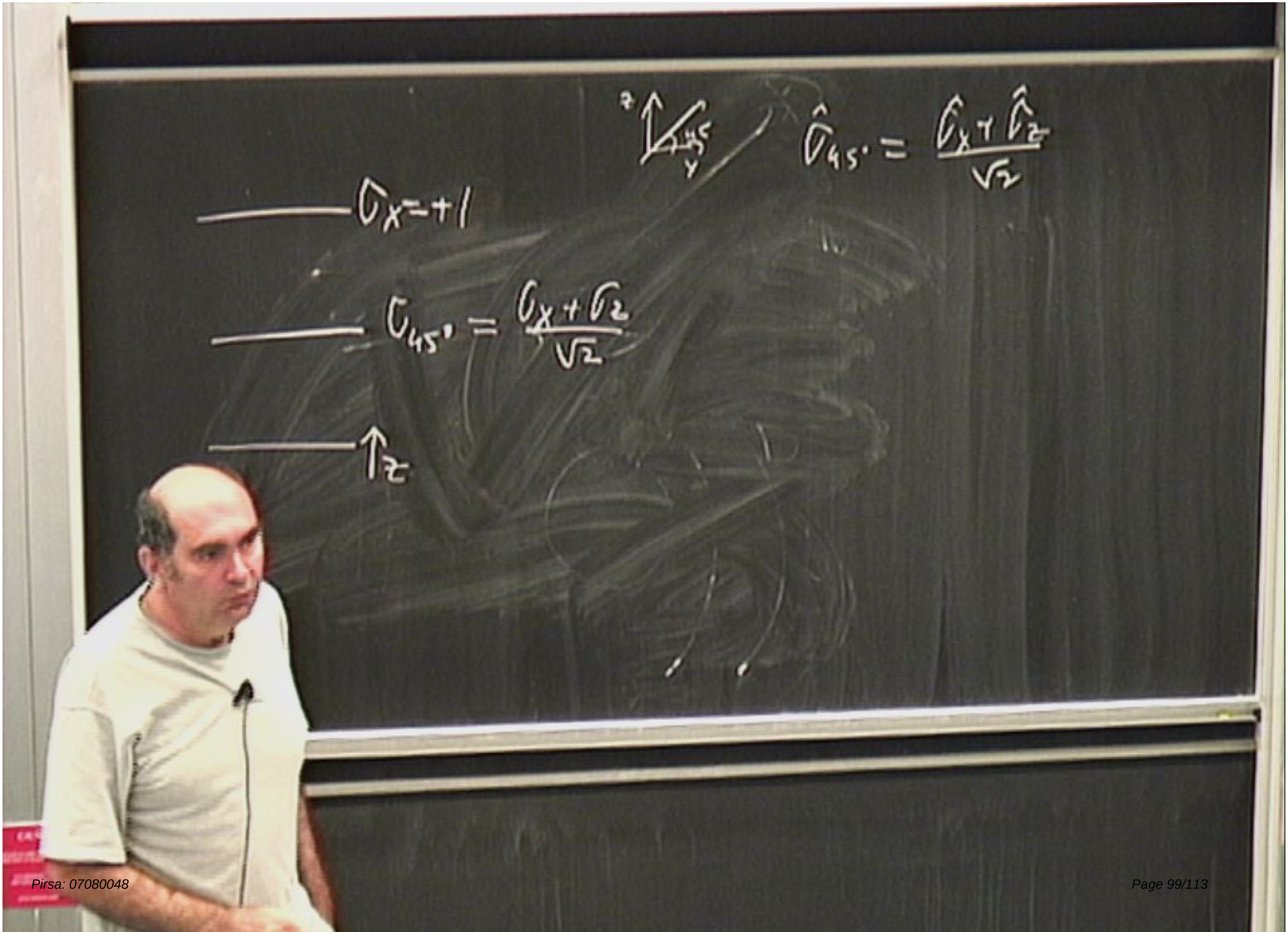

H=0
t_f
$\sigma_x = +1$
$\sigma_x = +1$
$\sigma_z = +1$
$\sigma_x = +1$
t_0



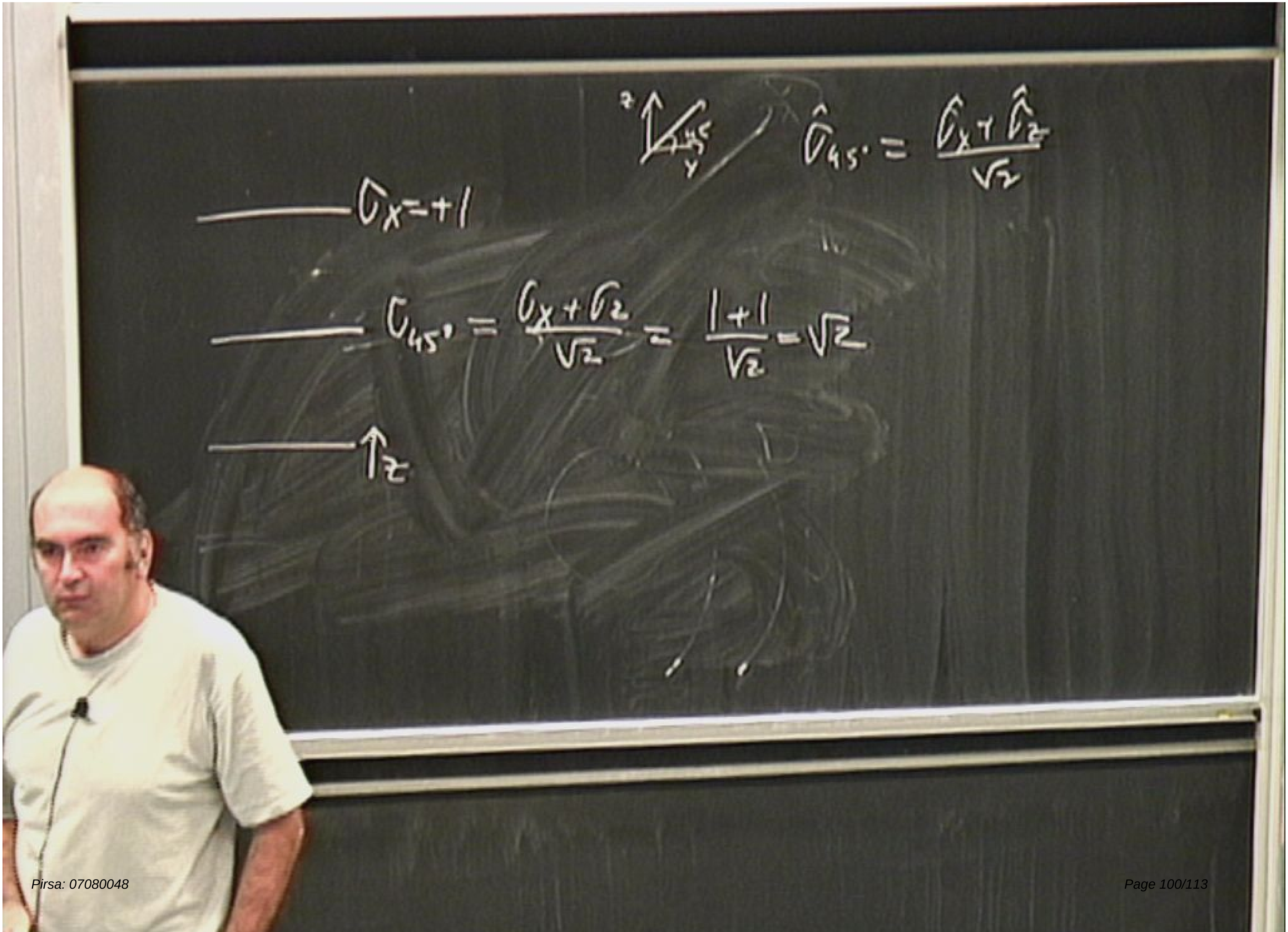


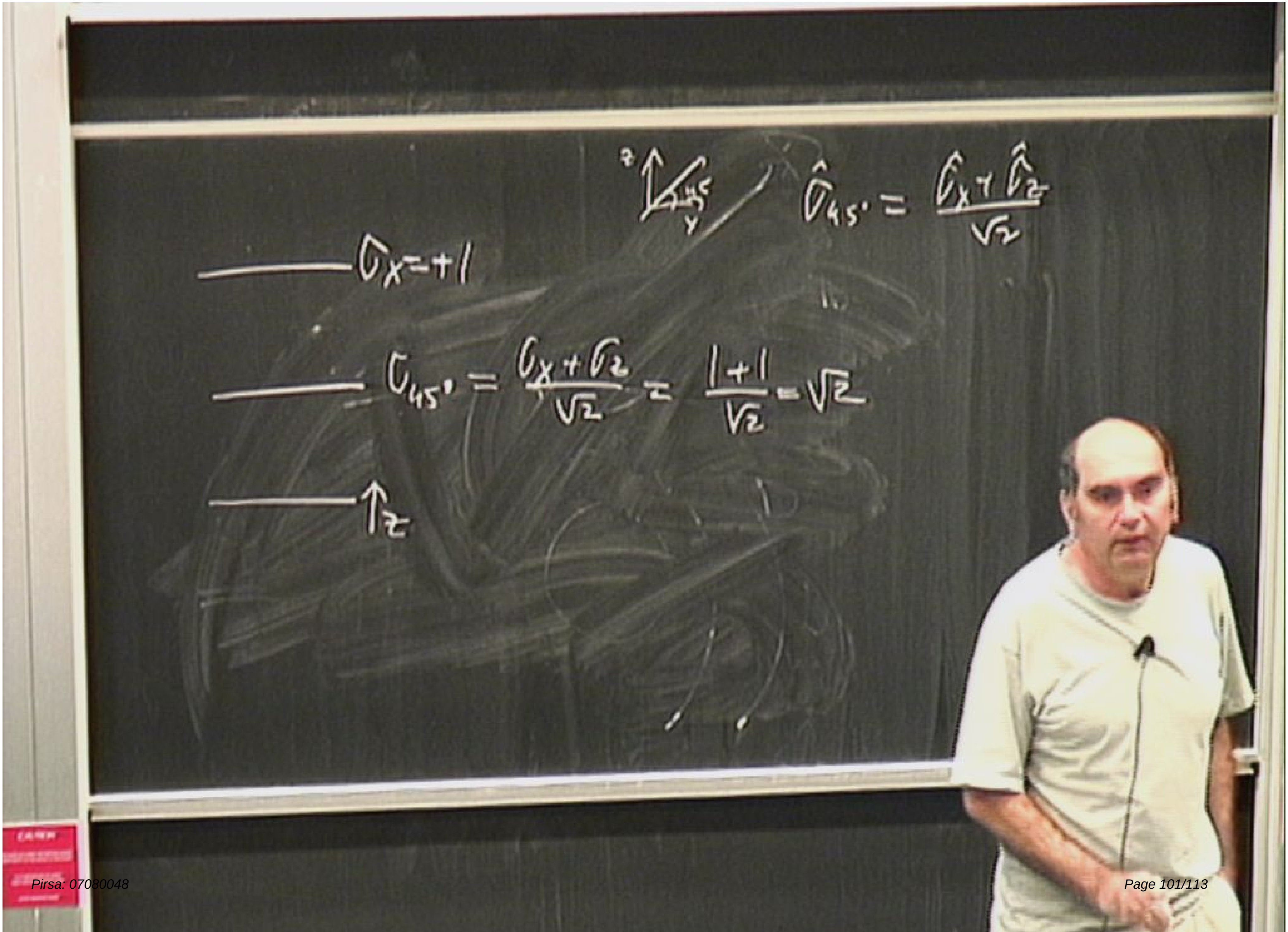
σx=+1
σ45°
↑z

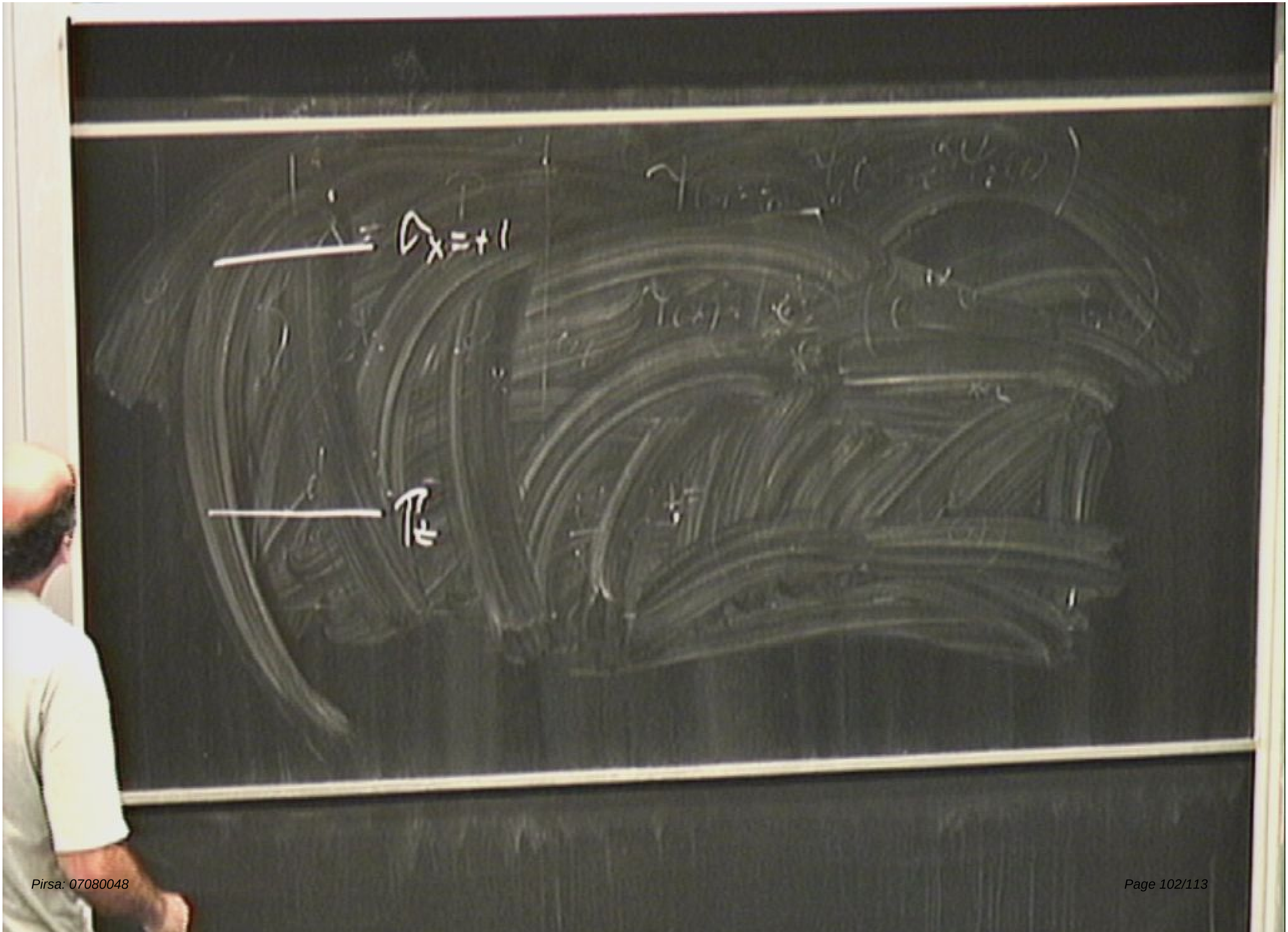

$\sigma_x = +1$
$\sigma_{45°}$
$\uparrow_z$
z
45°
$\hat{\sigma}_{45°} = \frac{\hat{\sigma}_x + \hat{\sigma}_z}{\sqrt{2}}$

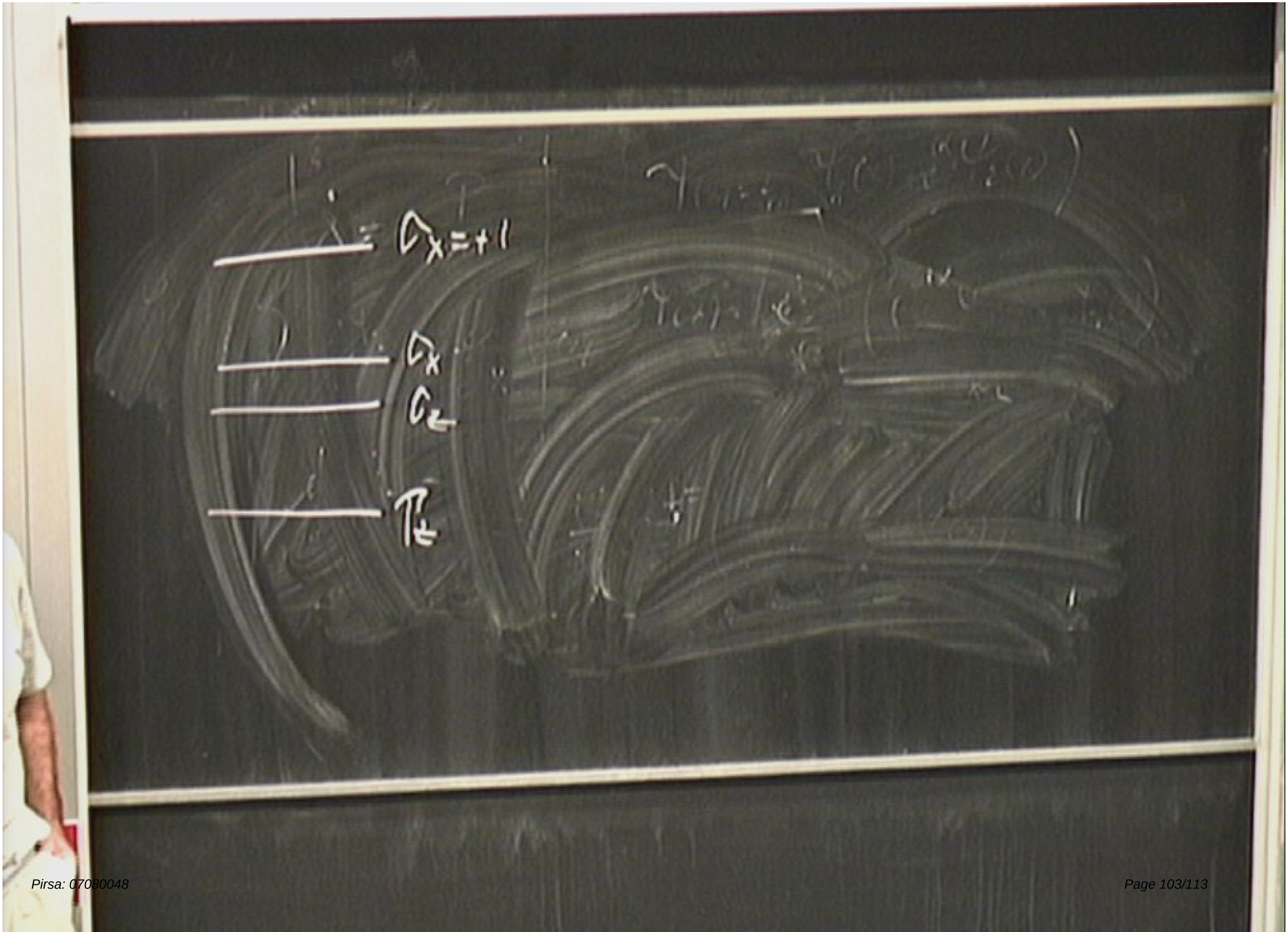


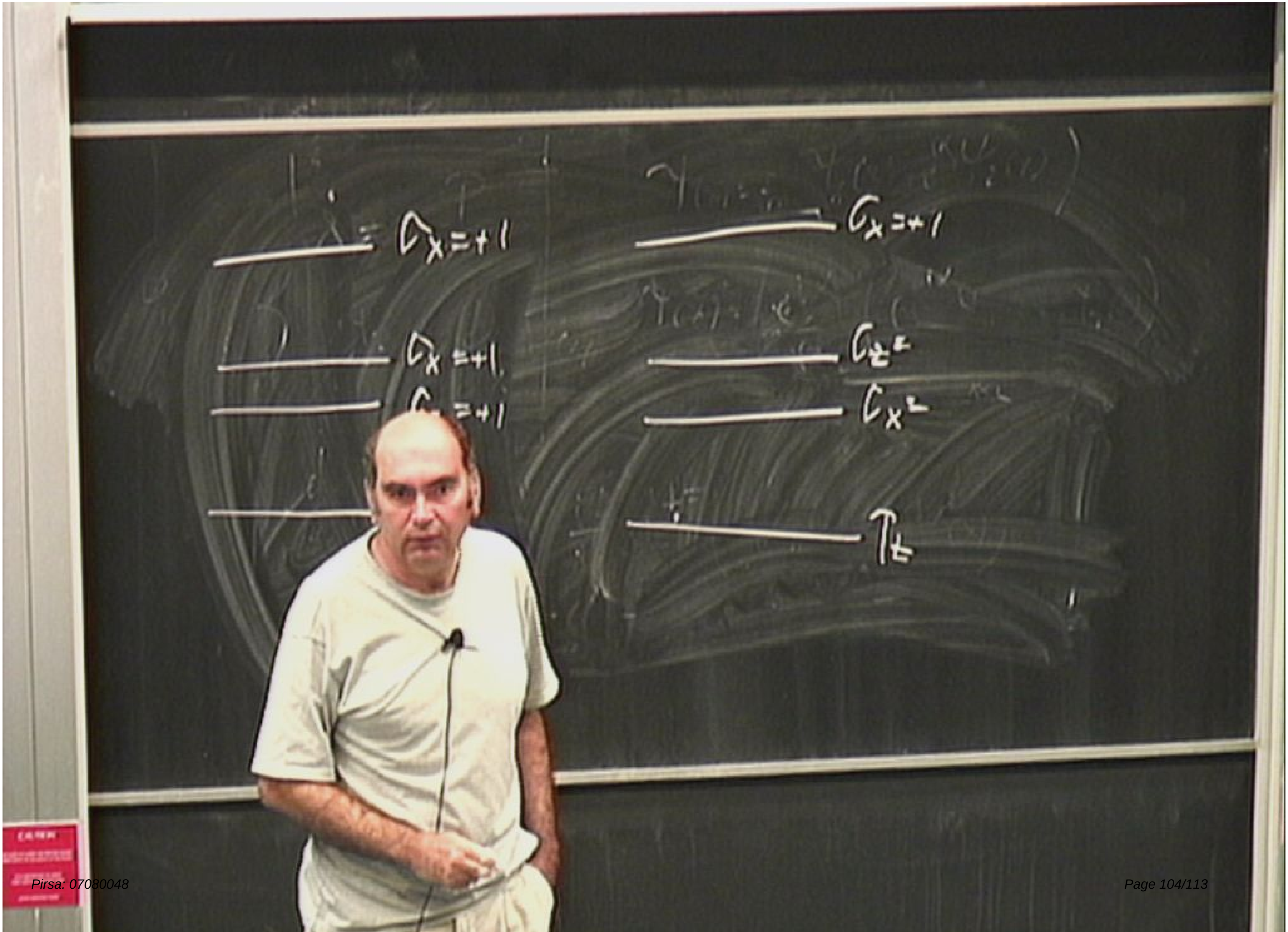
$\hat{\sigma}_{45^\circ} = \frac{\hat{\sigma}_x + \hat{\sigma}_z}{\sqrt{2}}$
$\sigma_x = +1$
$\sigma_{45^\circ} = \frac{\sigma_x + \sigma_z}{\sqrt{2}}$
$\uparrow_z$


$\hat{\sigma}_{45°} = \frac{\hat{\sigma}_x + \hat{\sigma}_z}{\sqrt{2}}$
$\sigma_x = +1$
$\sigma_{45°} = \frac{\sigma_x + \sigma_z}{\sqrt{2}} = \frac{1+1}{\sqrt{2}} = \sqrt{2}$
$\uparrow_z$

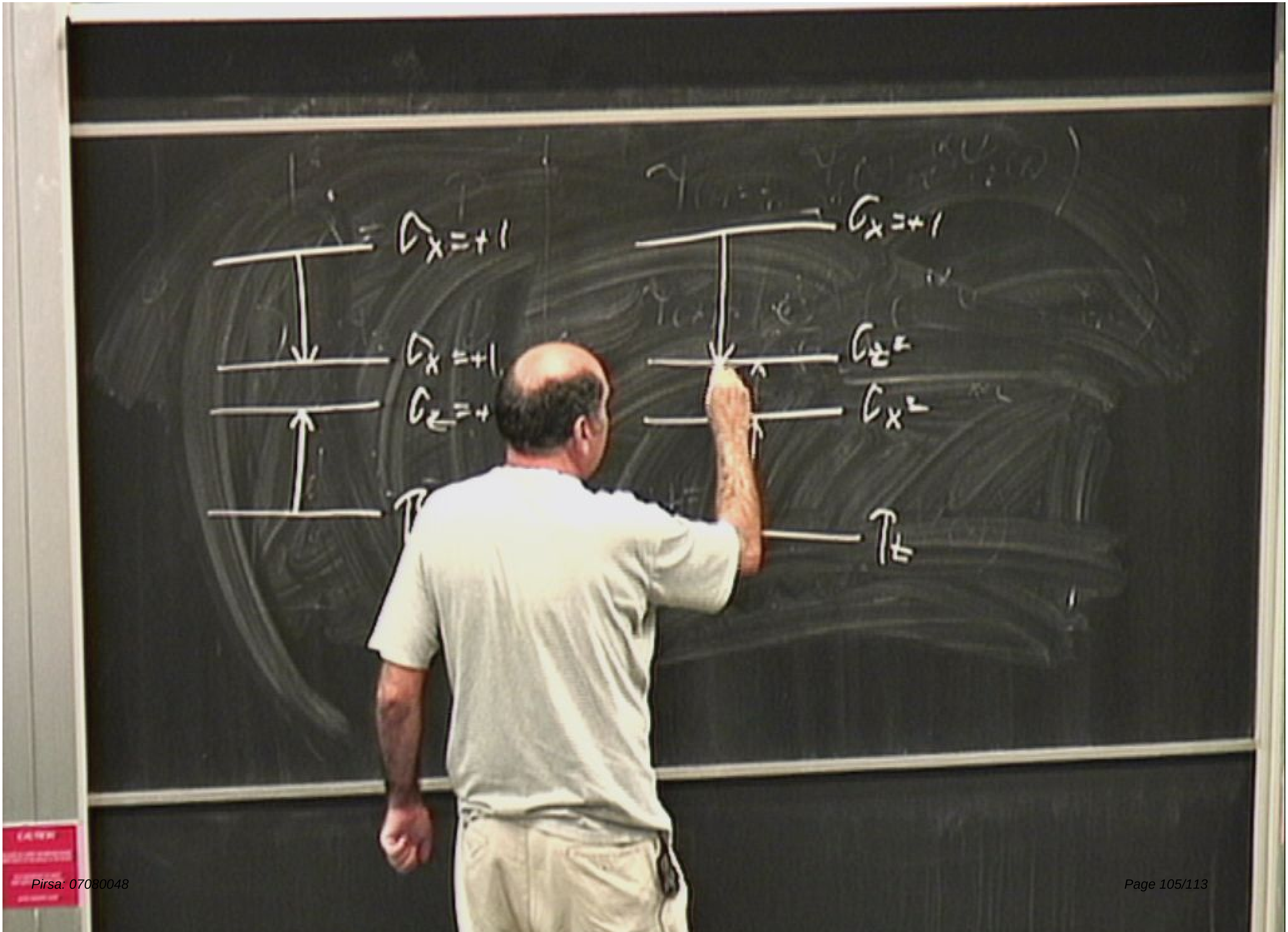

$\hat{\sigma}_{45^\circ} = \frac{\hat{\sigma}_x + \hat{\sigma}_z}{\sqrt{2}}$
$\sigma_x = +1$
$\sigma_{45^\circ} = \frac{\sigma_x + \sigma_z}{\sqrt{2}} = \frac{1+1}{\sqrt{2}} = \sqrt{2}$
$\uparrow z$

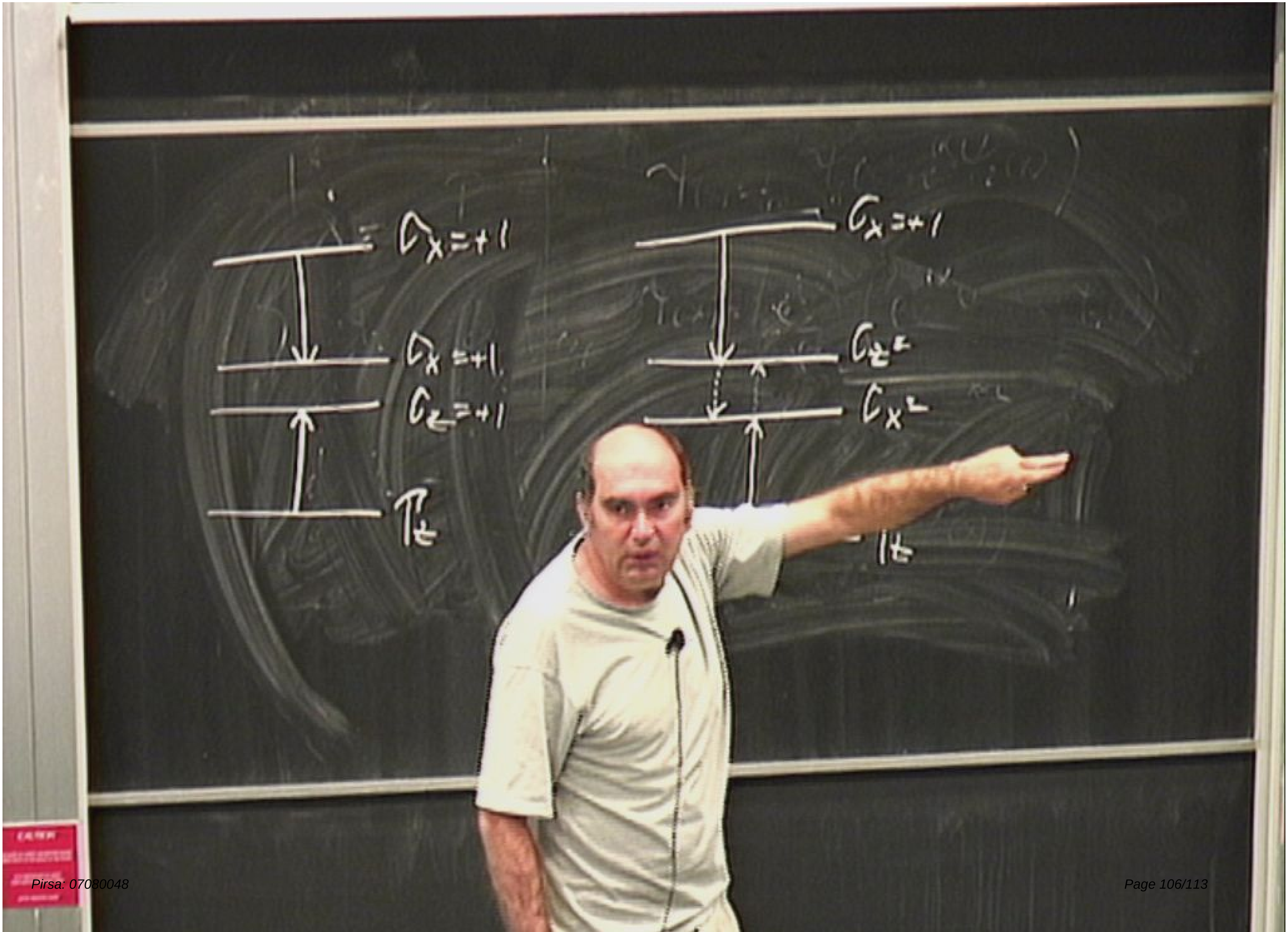

= $\sigma_x = +1$
$\pi_\pm$


$\sigma_x = +1$
σ_x
σ_z
π_z

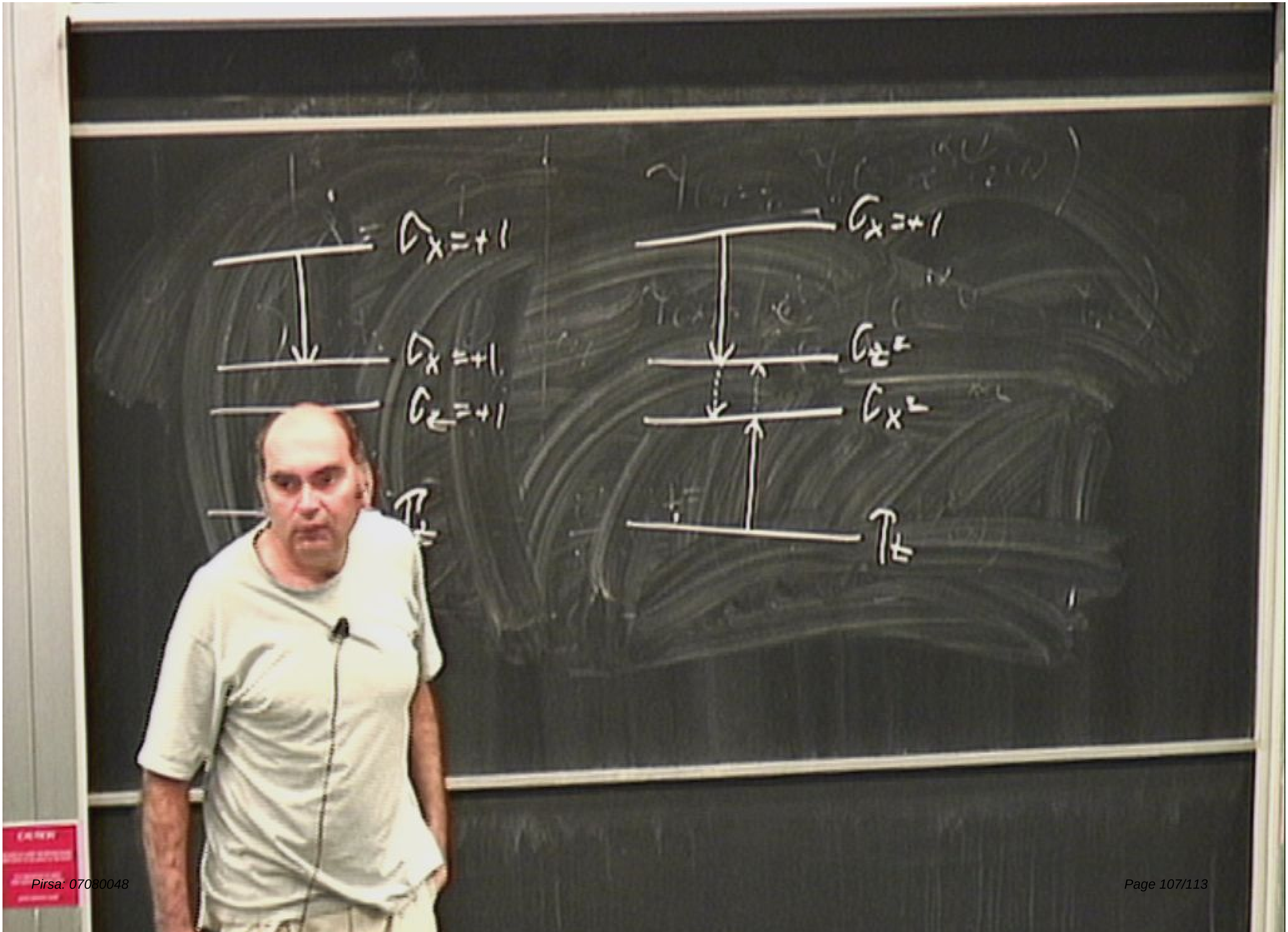


σx=+1
σx=+1
σx=+1
σx=+1

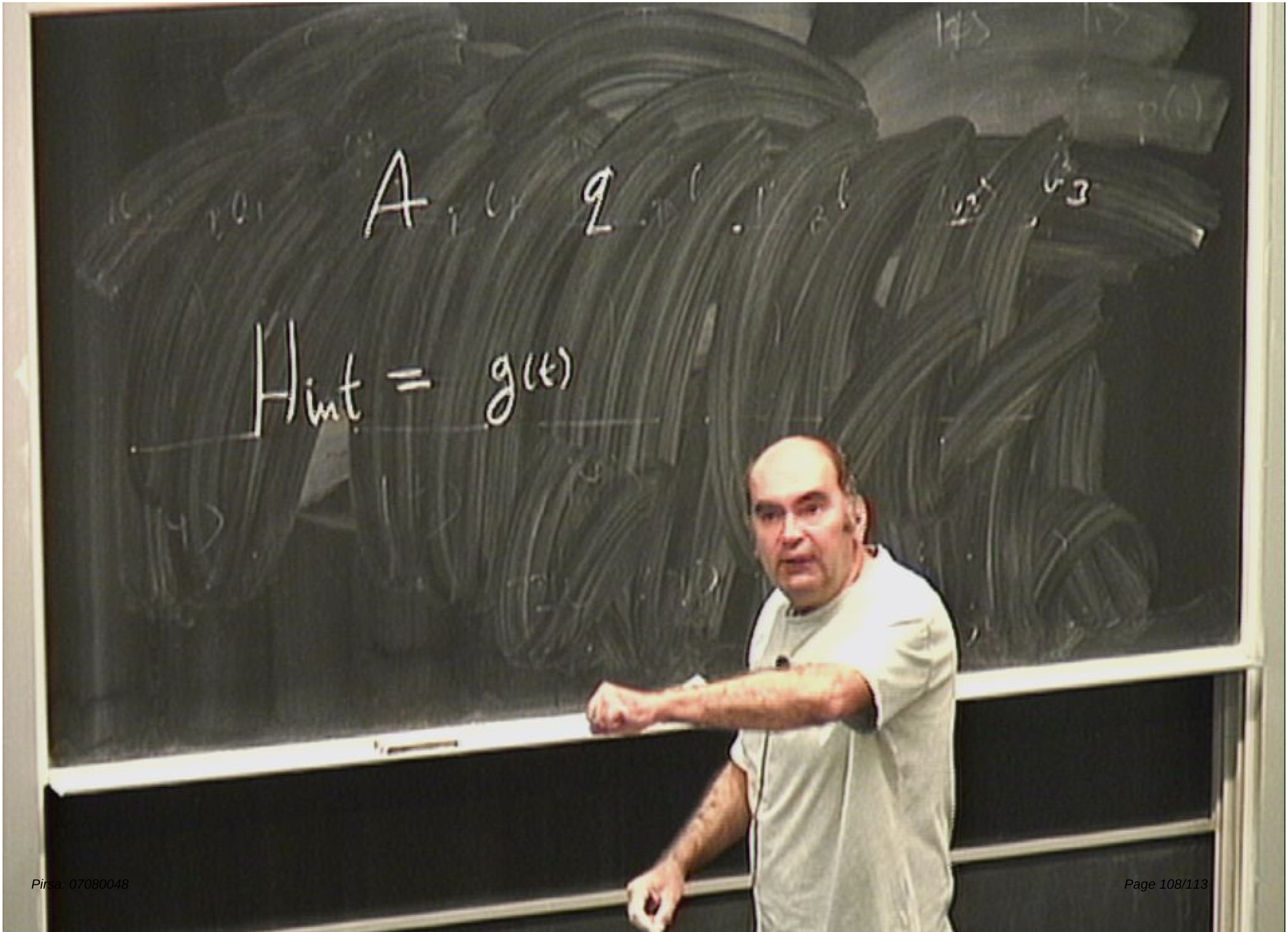

σx=+1
σx=+1
σx=+1
πz

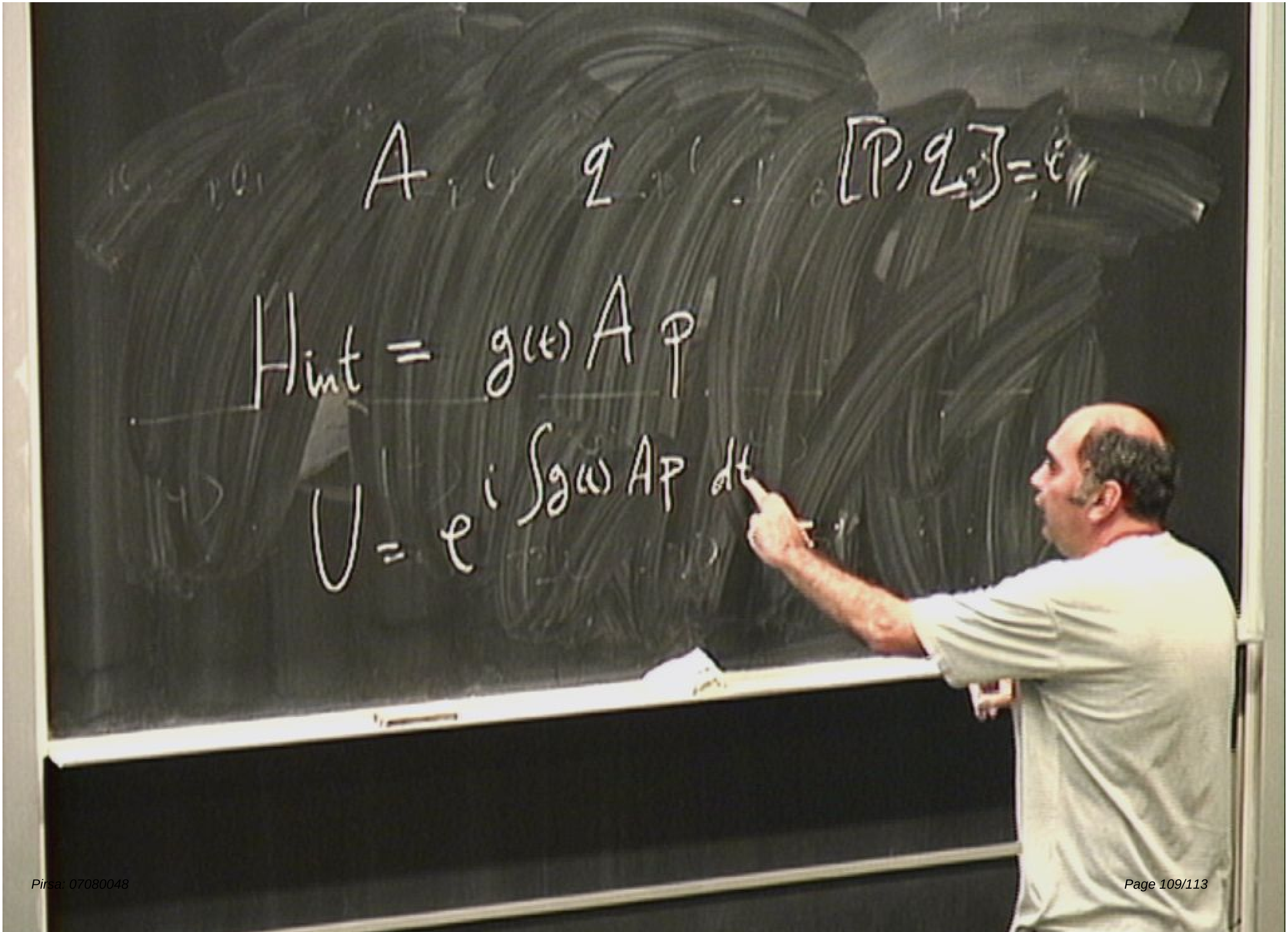


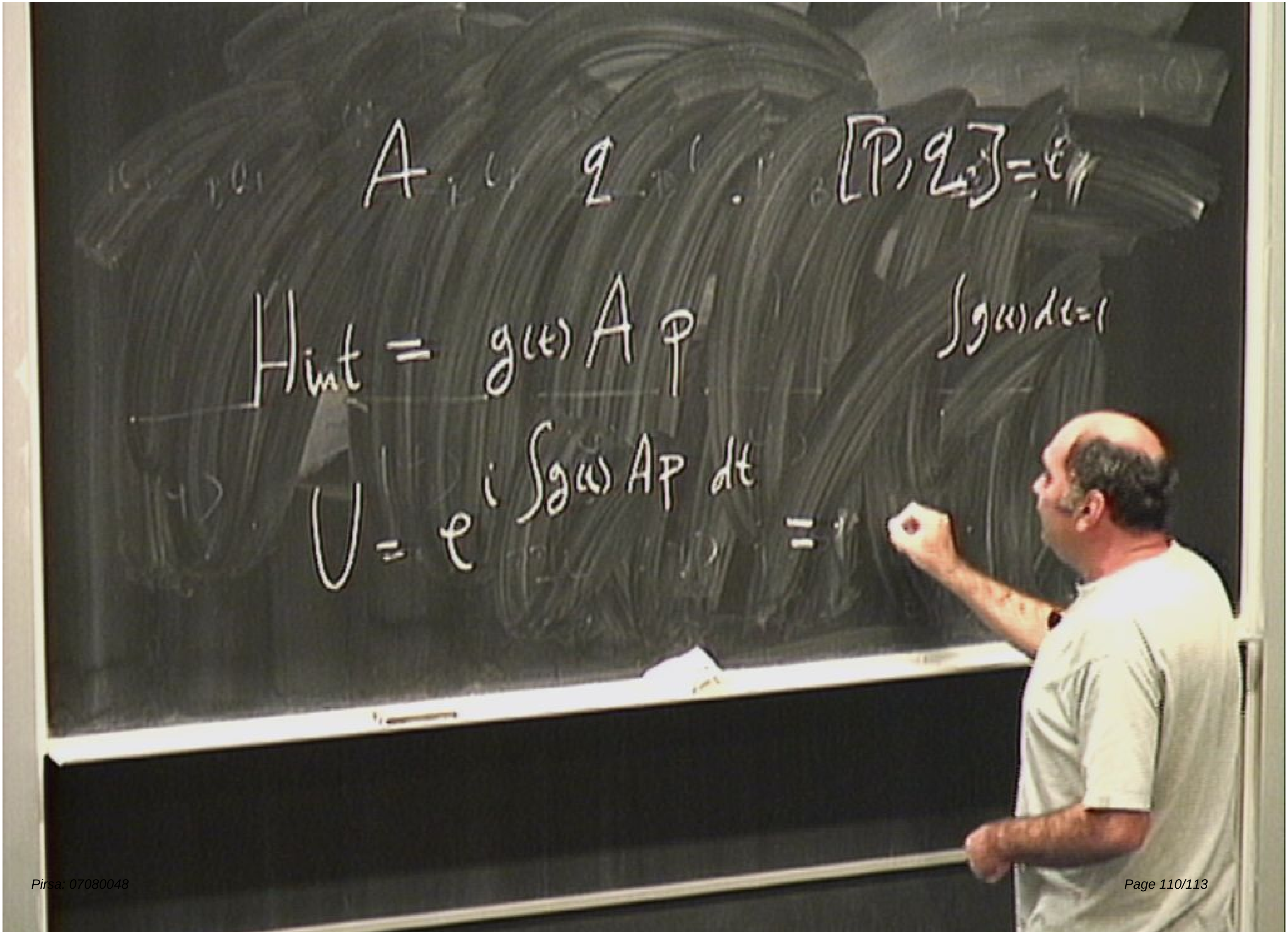
$\sigma_x = +1$
$\sigma_x = +1$
$\sigma_z = +1$
π_z
$\sigma_x = +1$
σ_z^2
σ_x^2
π_z

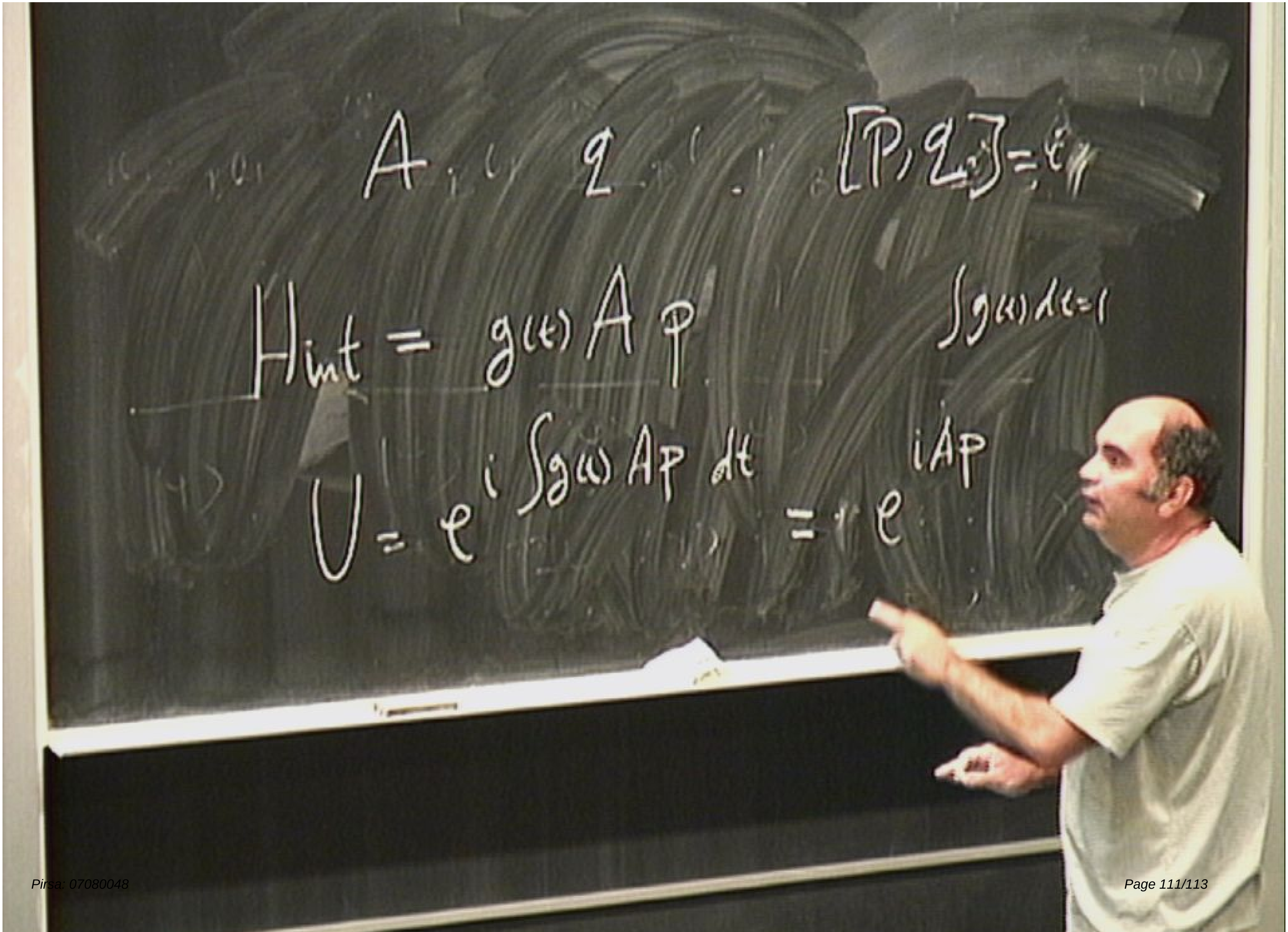


$\sigma_x = +1$
$\sigma_x = +1$
$\sigma_z = +1$
$\sigma_x = +1$
σ_z^2
σ_x^2

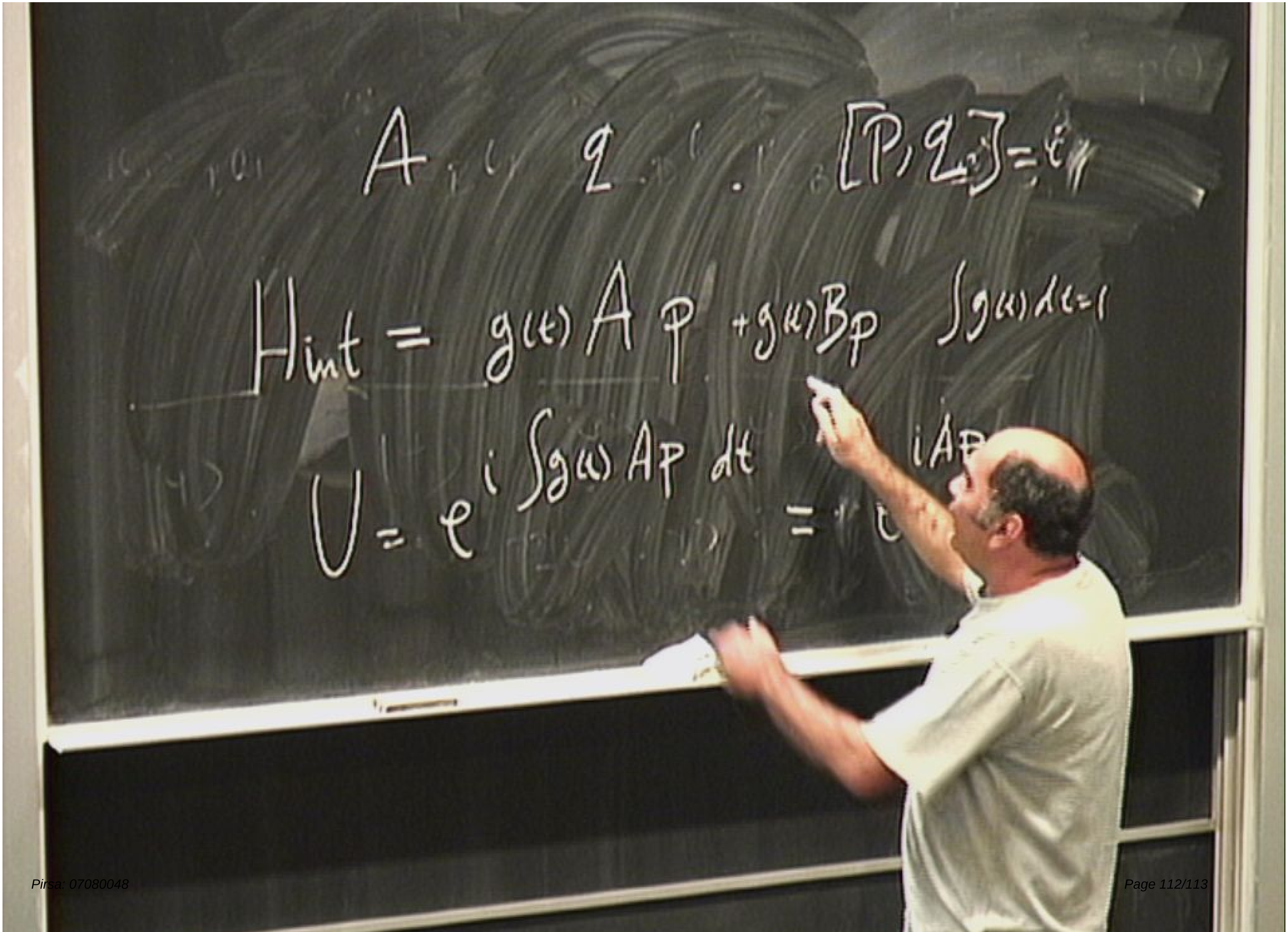

A
q
Hint = g(t)


A q [p, q] = i
H_int = g(t) A p
U = e^{i ∫ g(t) A p dt}


A q [p, q] = i
H_int = g(t) A p
∫g(t) dt = 1
U = e^{i ∫g(t) Ap dt} =



A q $[P, Q] = i$
$H_{int} = g(t) A P$
$\int g(t) dt = 1$
$U = e^{i \int g(t) A p \, dt} = e^{iAp}$


A
q
[P, Q] = i
H_int = g(t) A p + g(t) B p
∫ g(t) dt = 1
U = e^{i ∫ g(t) A p dt}
iAp

$$A \qquad q \qquad [p, q] = i$$

$$H_{int} = g(t)\, A\, p + g(t)\, B\, p \qquad \int g(t)\, dt = 1$$

$$U = e^{i \int g(t)\, A p\, dt} = e^{iAp}$$