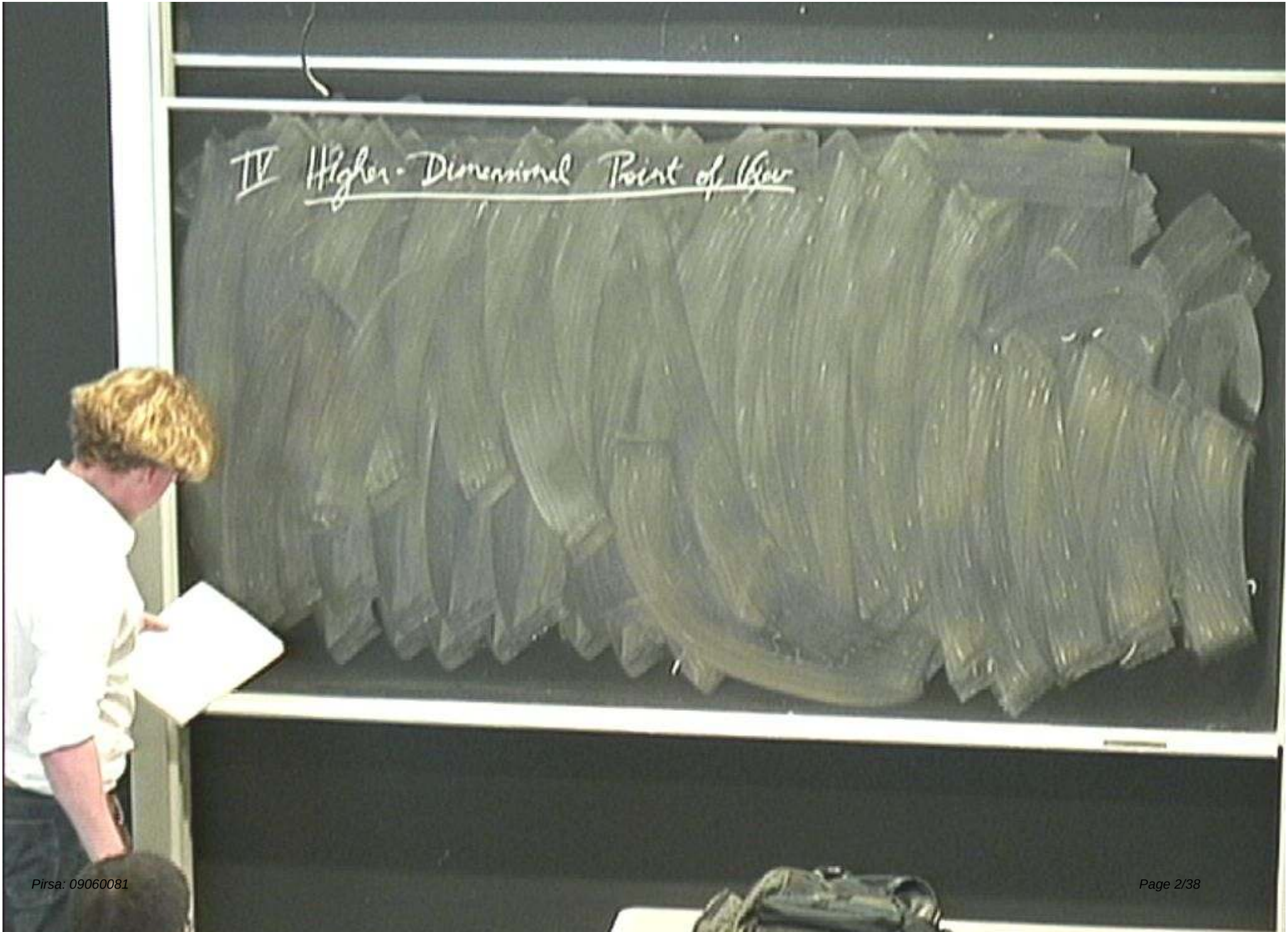
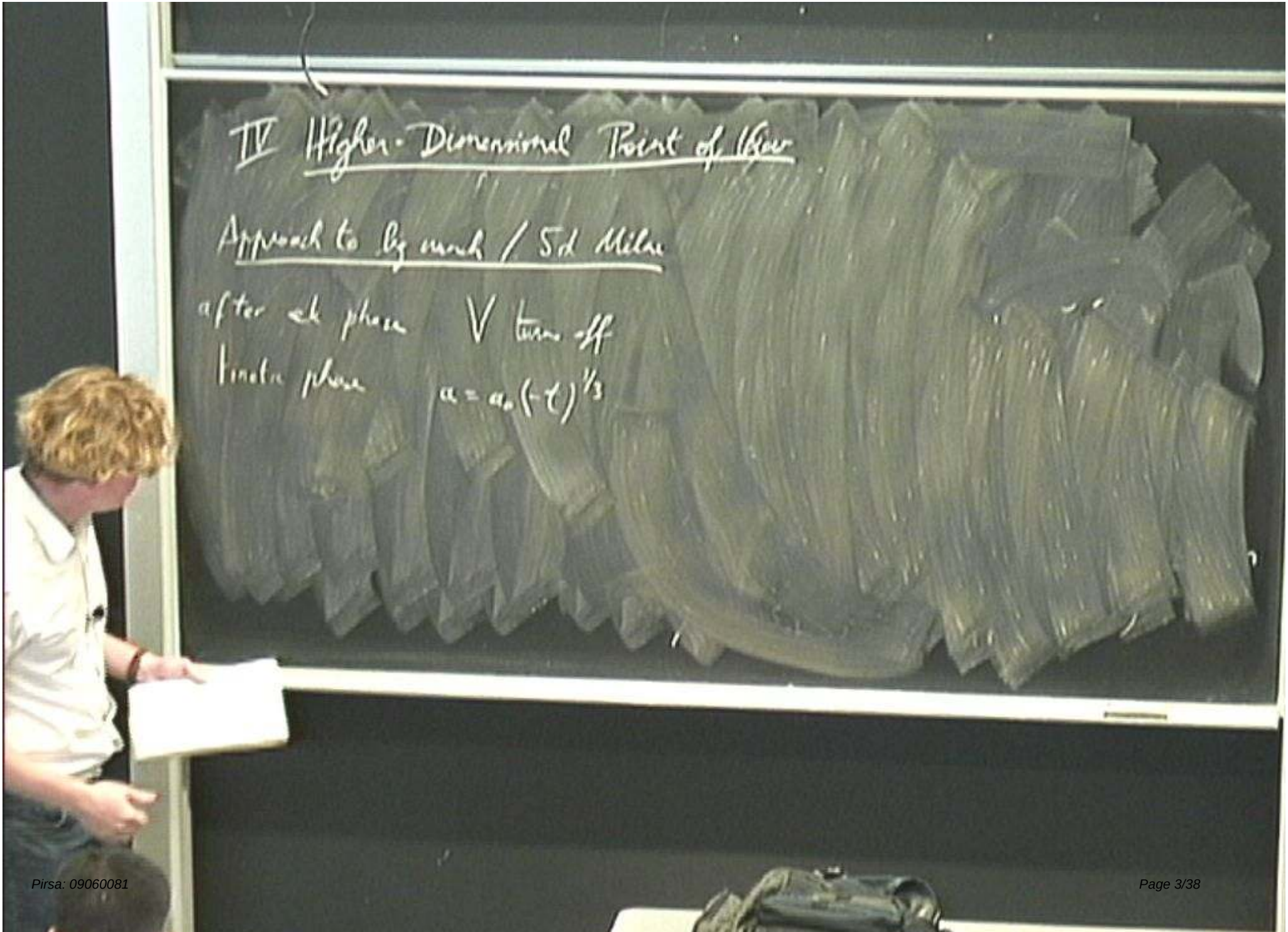
Title: Ekpyrotic/Cyclic Cosmology - Lecture 4

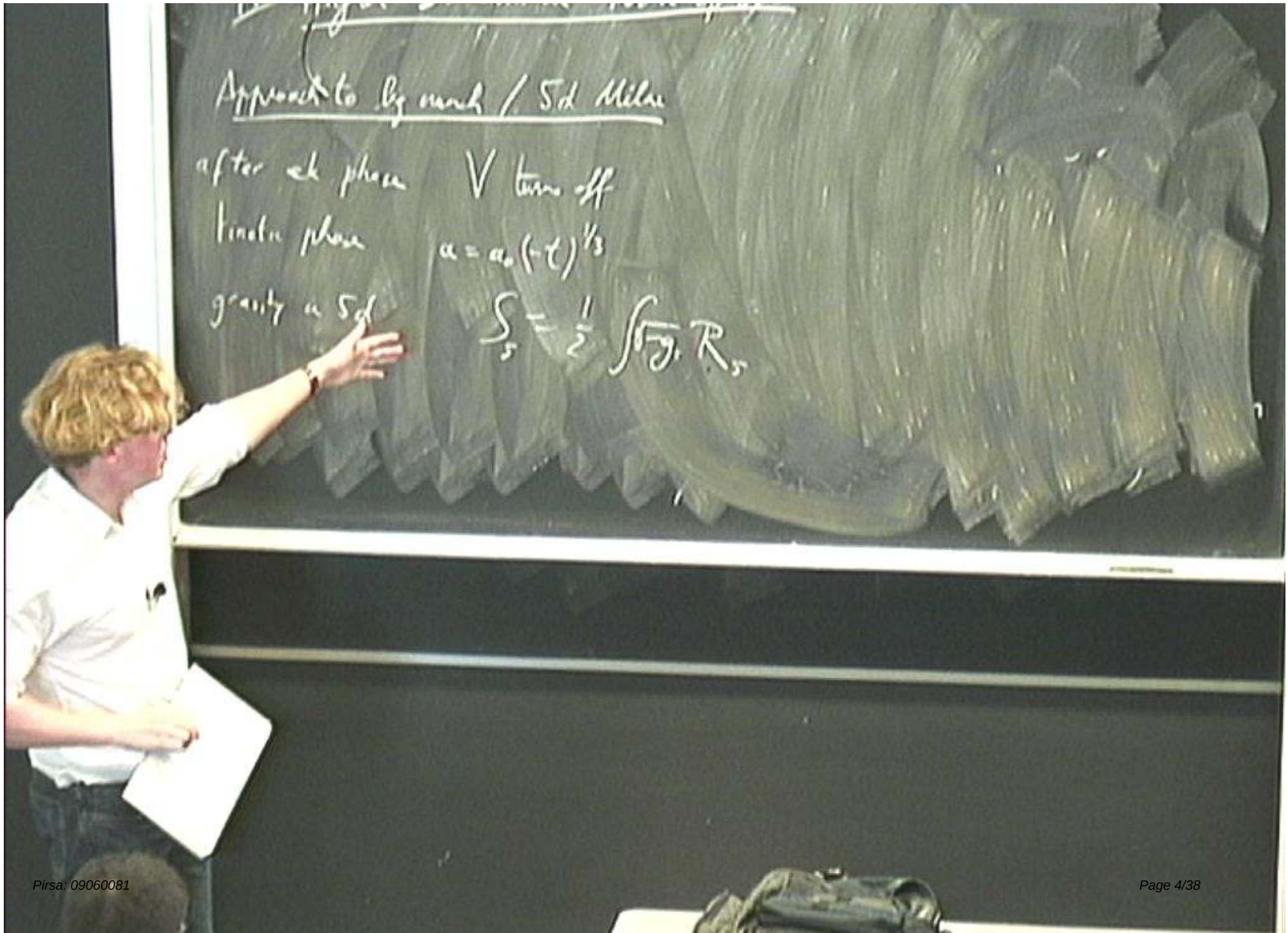
Date: Jun 29, 2009 11:30 AM

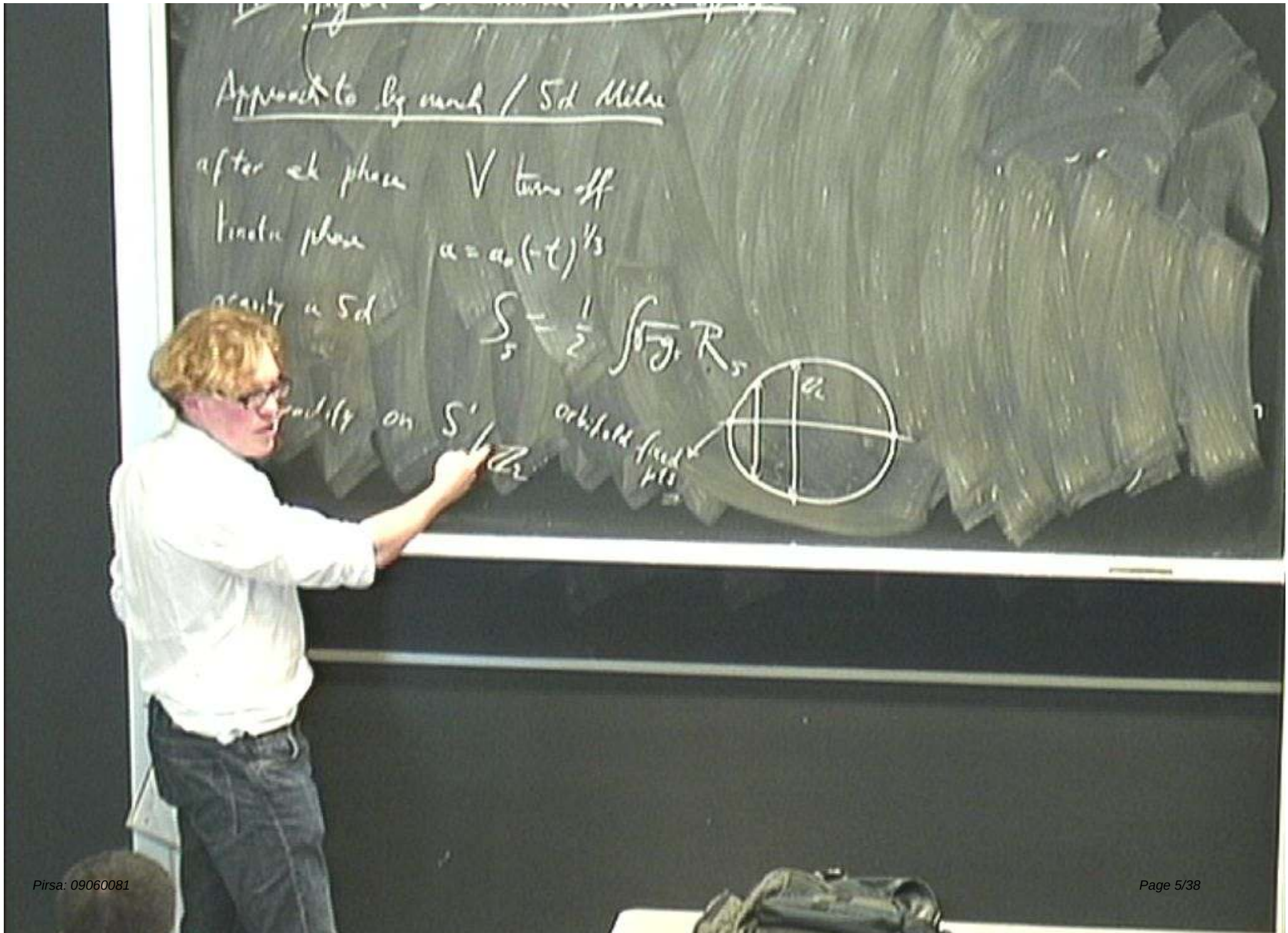
URL: http://pirsa.org/09060081

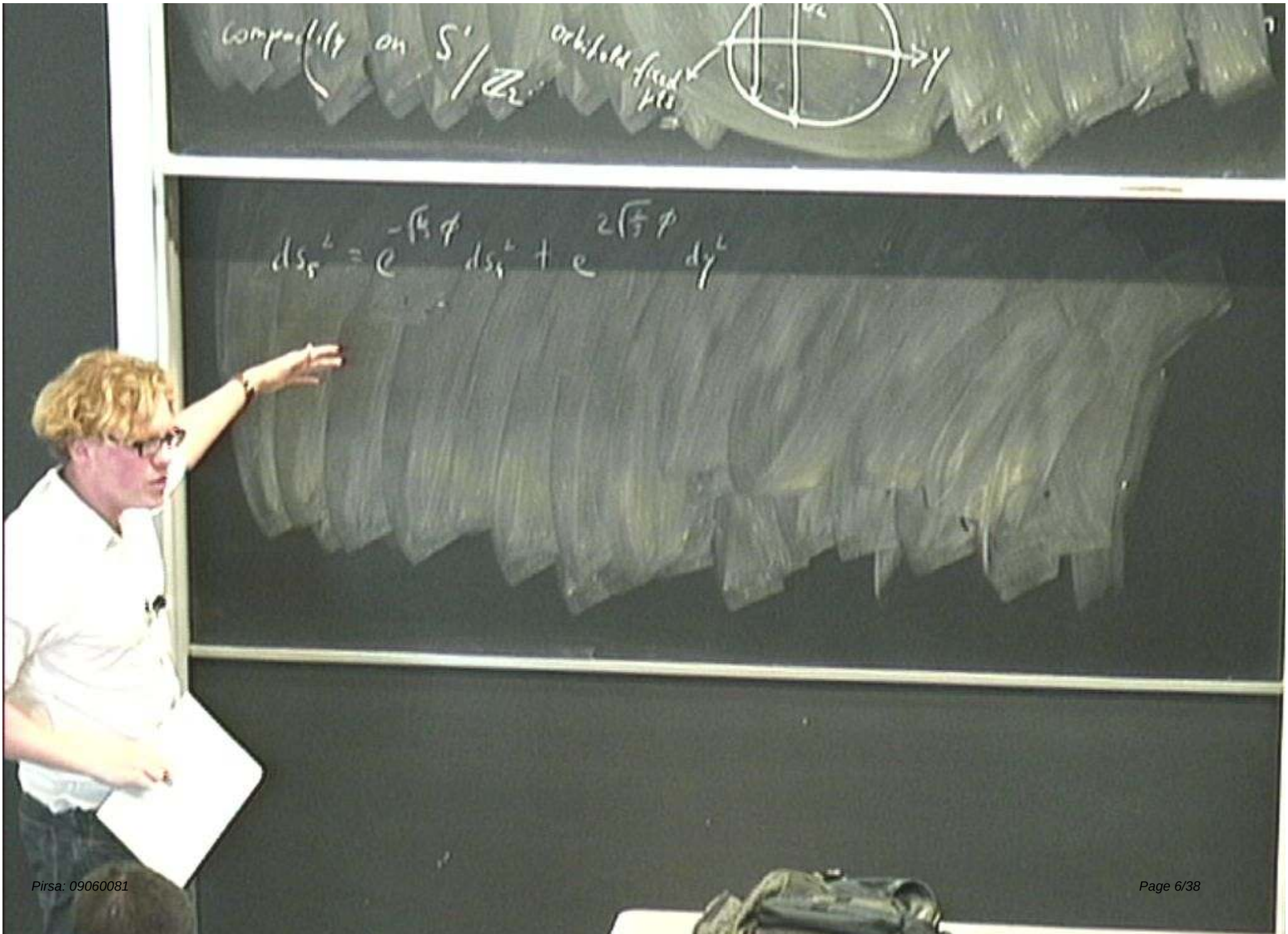
Abstract: TBA

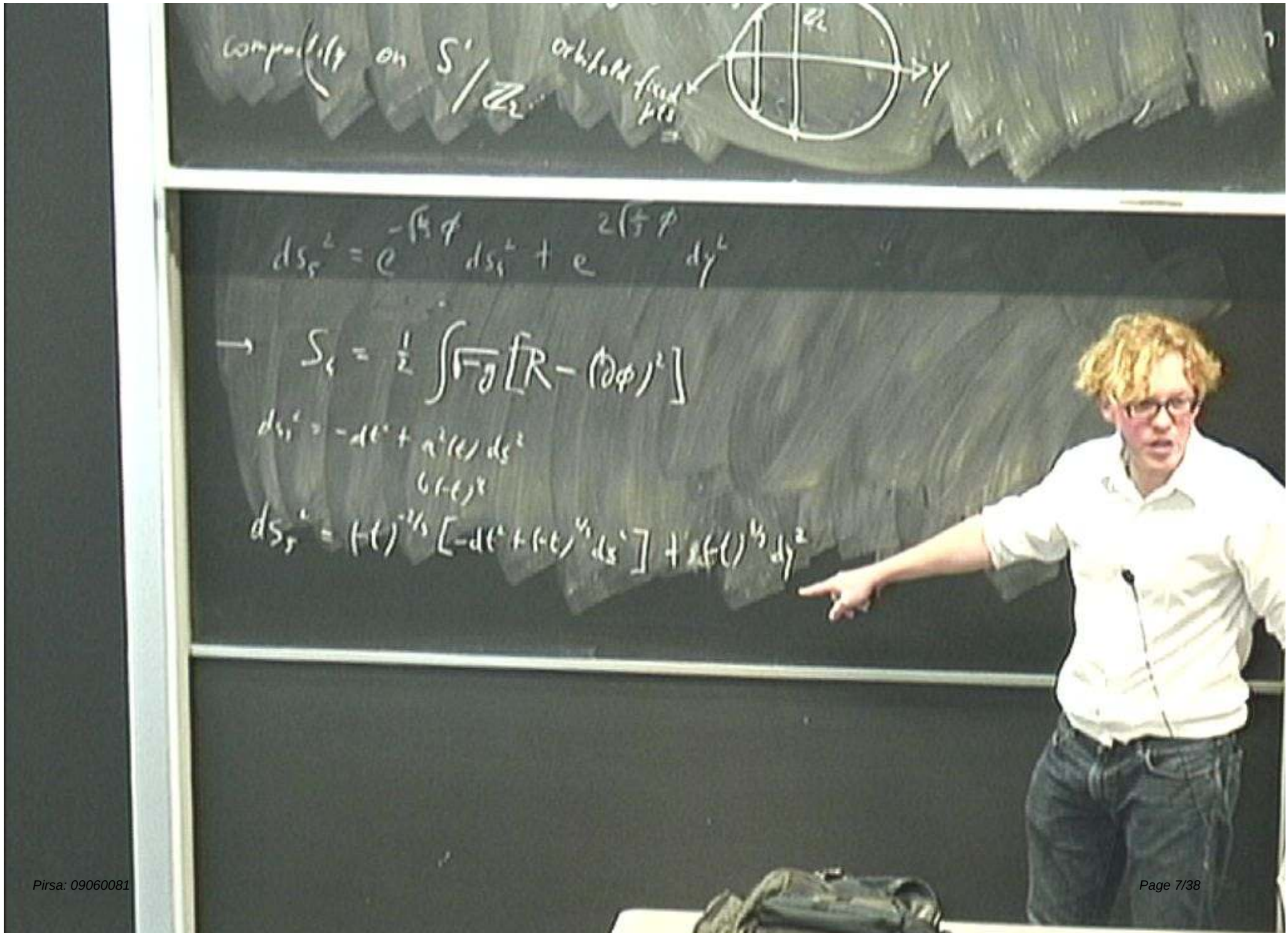

IV Higher-Dimensional Point of View

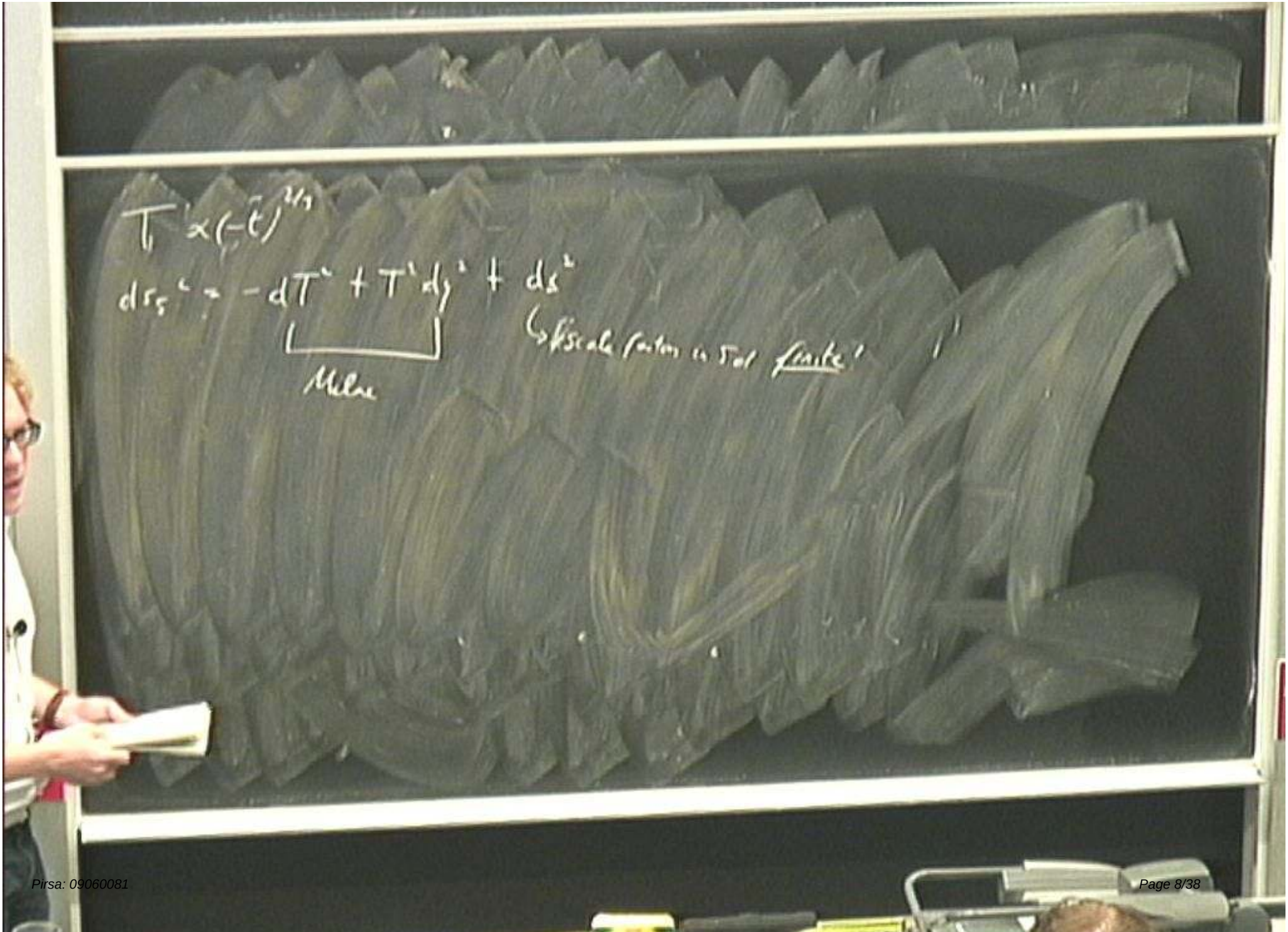

IV Higher-Dimensional Point of View
Approach to big crunch / 5d Milne
after ek phase V turns off
kinetic phase $a = a_0(-t)^{1/3}$

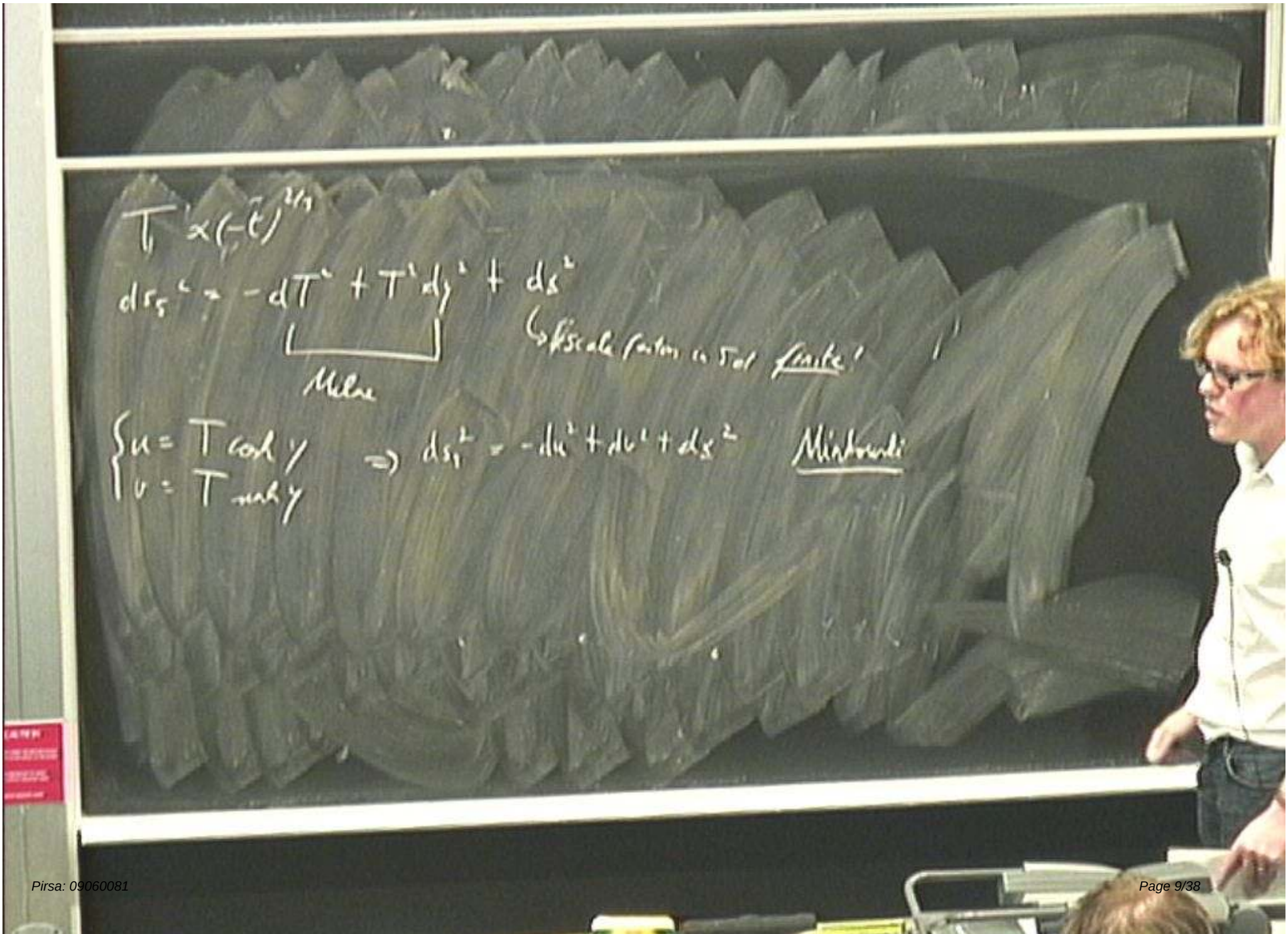

Approach to Big crunch / 5d Milne
after ek phase
V turns off
kinetic phase
$a = a_0 (-t)^{1/3}$
gravity in 5d
$S_5 = \frac{1}{2} \int \sqrt{-g_5} R_5$


Approach to Big crunch / 5d Milne
after ek phase V turns off
linear phase $a = a_0(-t)^{1/3}$
$S_5 = \frac{1}{2}\int \sqrt{-g}\, R_5$
orbifold fixed pts


compactify on $S^1/\mathbb{Z}_2$
orbifold fixed pts
y
$ds_5^2 = e^{-\frac{1}{\sqrt{3}}\phi} ds_4^2 + e^{2\sqrt{3}\phi} dy^2$


Compactify on $S^1/\mathbb{Z}_2$
orbifold fixed
$\mathbb{Z}_2$
y
$ds_5^2 = e^{-\frac{1}{\sqrt{3}}\phi} ds_4^2 + e^{2/\sqrt{3}\phi} dy^2$
$\rightarrow S_4 = \frac{1}{2}\int \sqrt{-g}[R - (\partial\phi)^2]$
$ds_4^2 = -dt^2 + a^2(t)\, ds^2$
$6(1-\epsilon)^2$
$ds_5^2 = (1-\epsilon)^{-1/3}[-dt^2 + (1-\epsilon)^{1/3} ds^2] + A(1-\epsilon)^{1/3} dy^2$


$T \propto (-t)^{2/3}$
$ds_5^2 = -dT^2 + T^2 dy^2 + ds^2$
Milne
↳ fiscale factors in 5d finite!


$T \propto (-t)^{2/3}$
$ds_5^2 = -dT^2 + T^2 dy^2 + ds^2$
Milne
↳ fiscale factors in 5d finite!
$\begin{cases} u = T \cosh y \\ v = T \sinh y \end{cases} \Rightarrow ds_5^2 = -du^2 + dv^2 + ds^2$
Minkowski

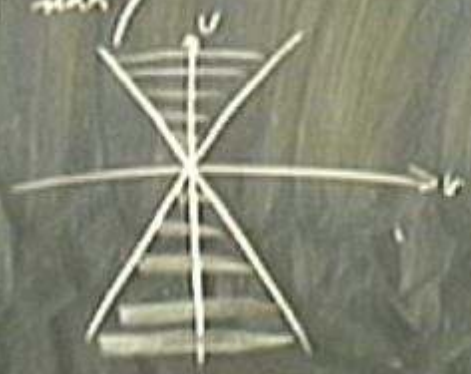
$T_1 \propto (-\bar{t})^{2/3}$

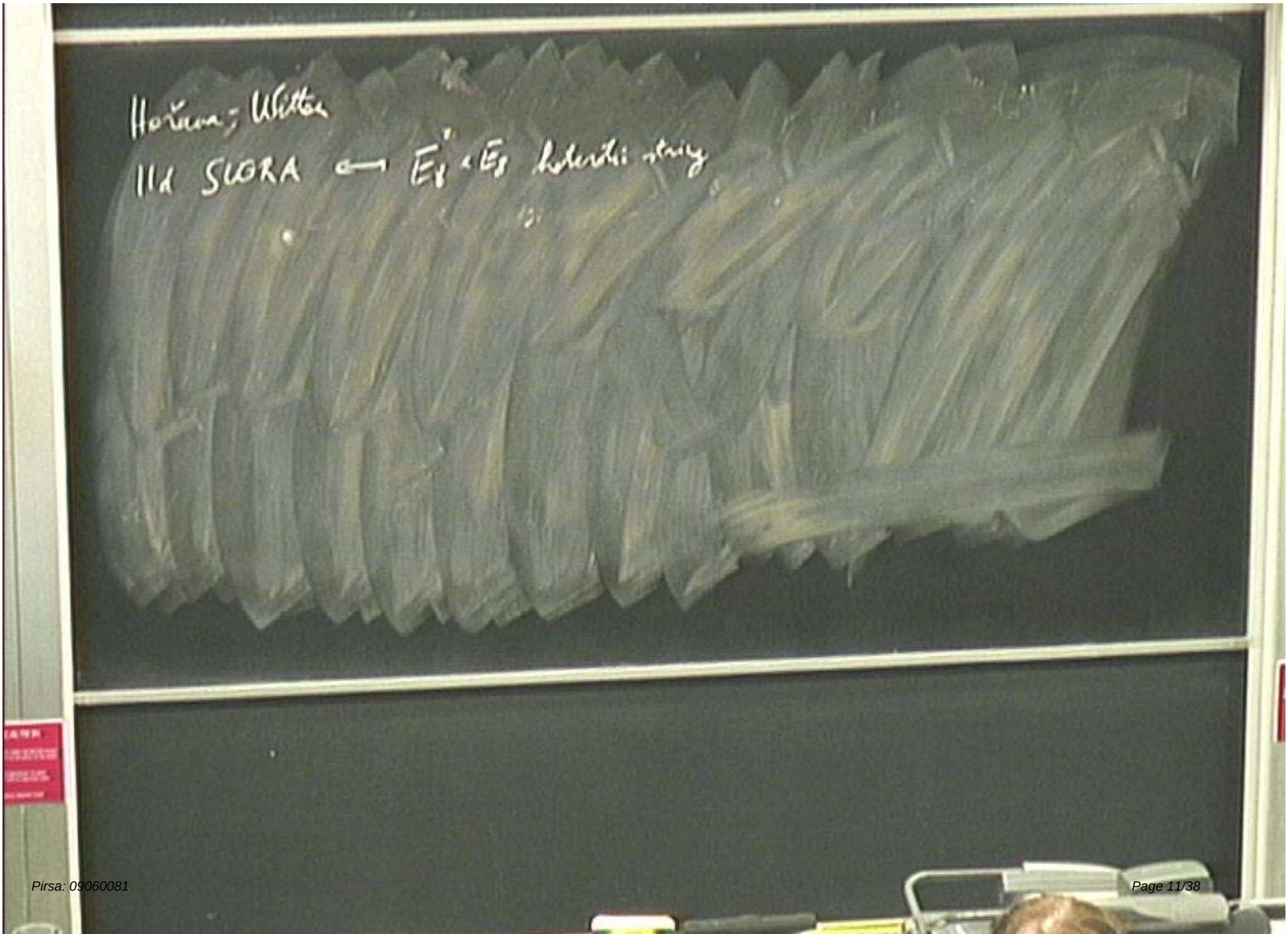
$ds_5^2 = -dT^2 + T^2 dy^2 + ds^2$

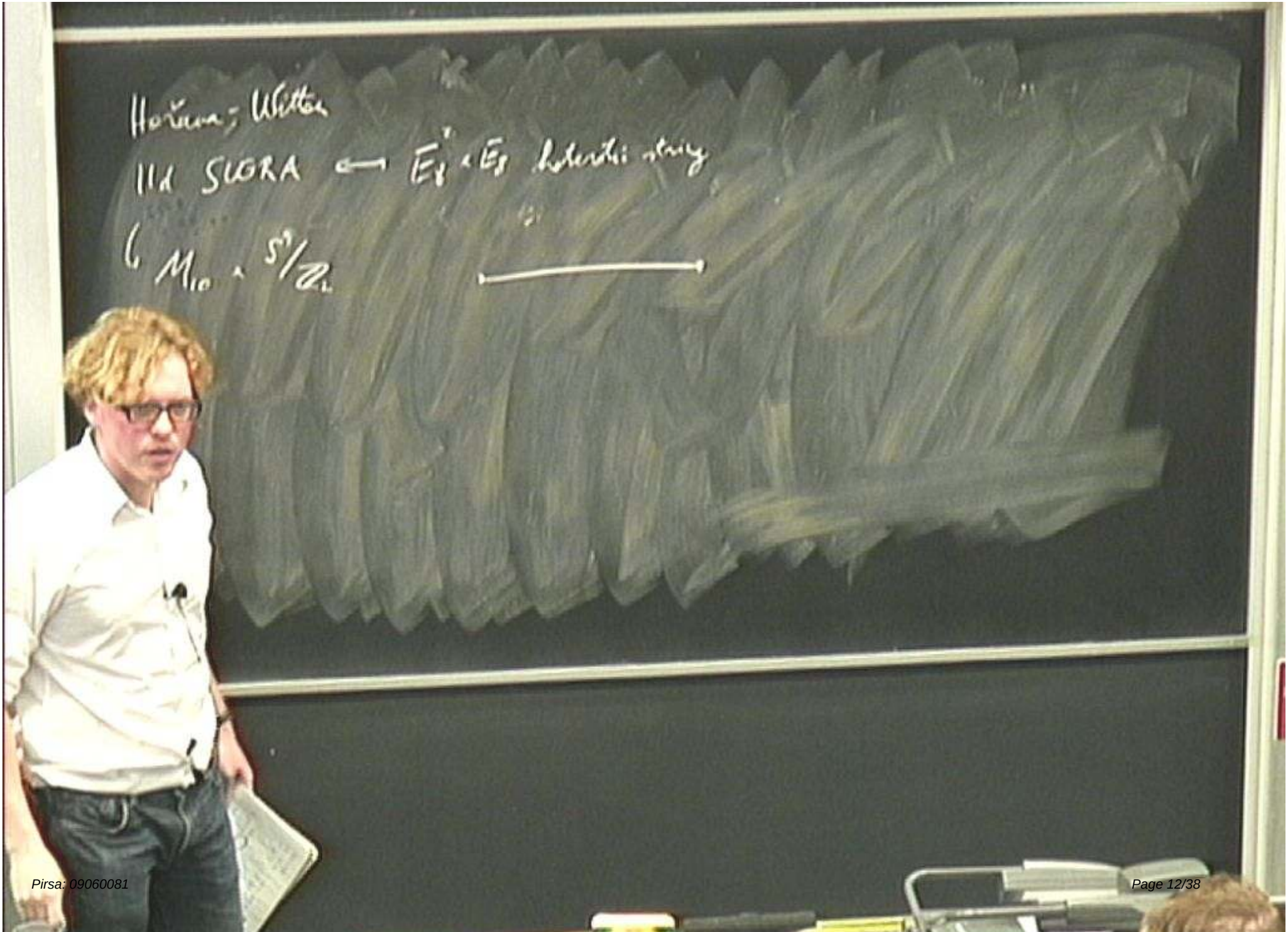
Milne

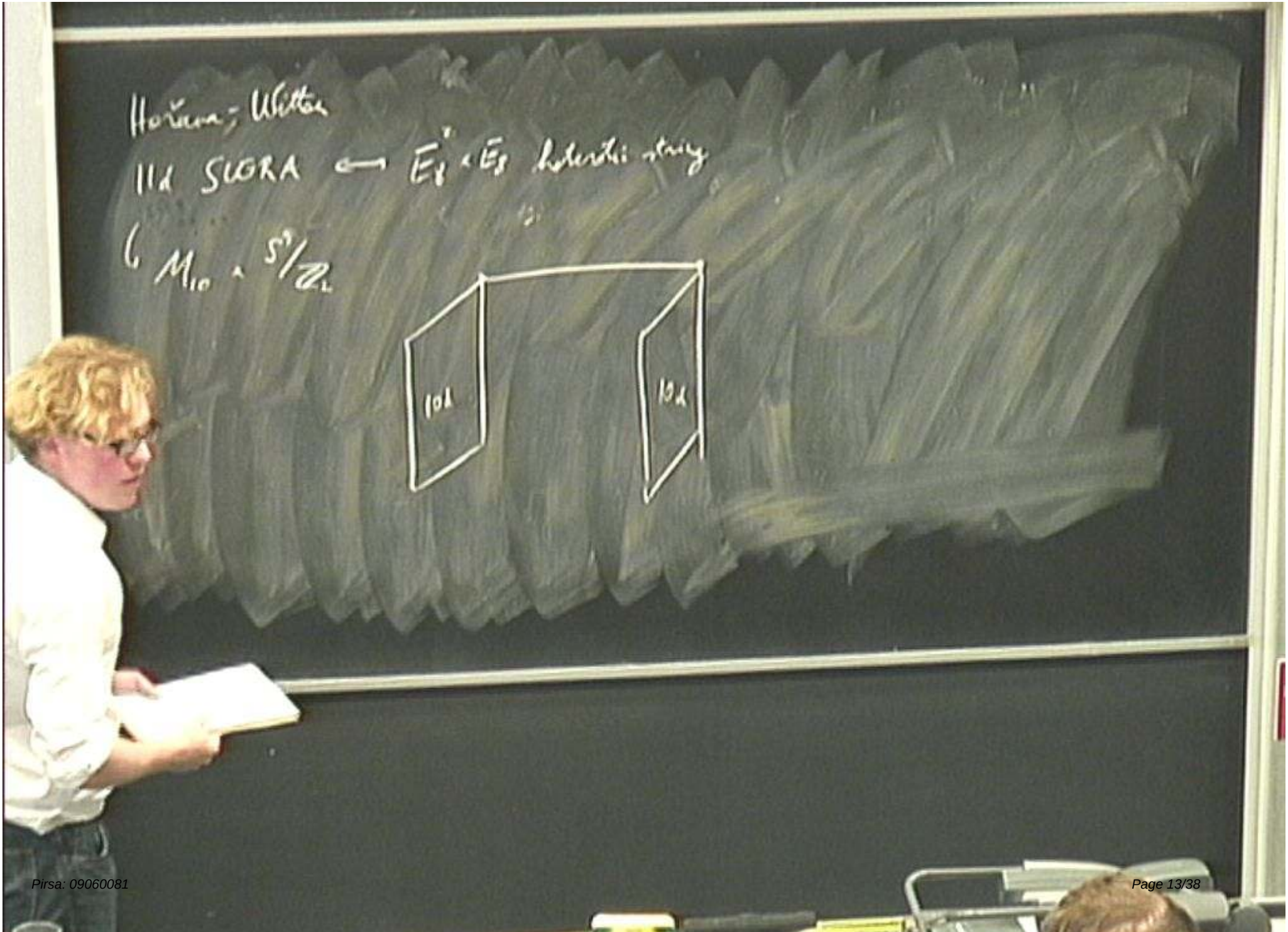
↳ fiscale factors is for finite!

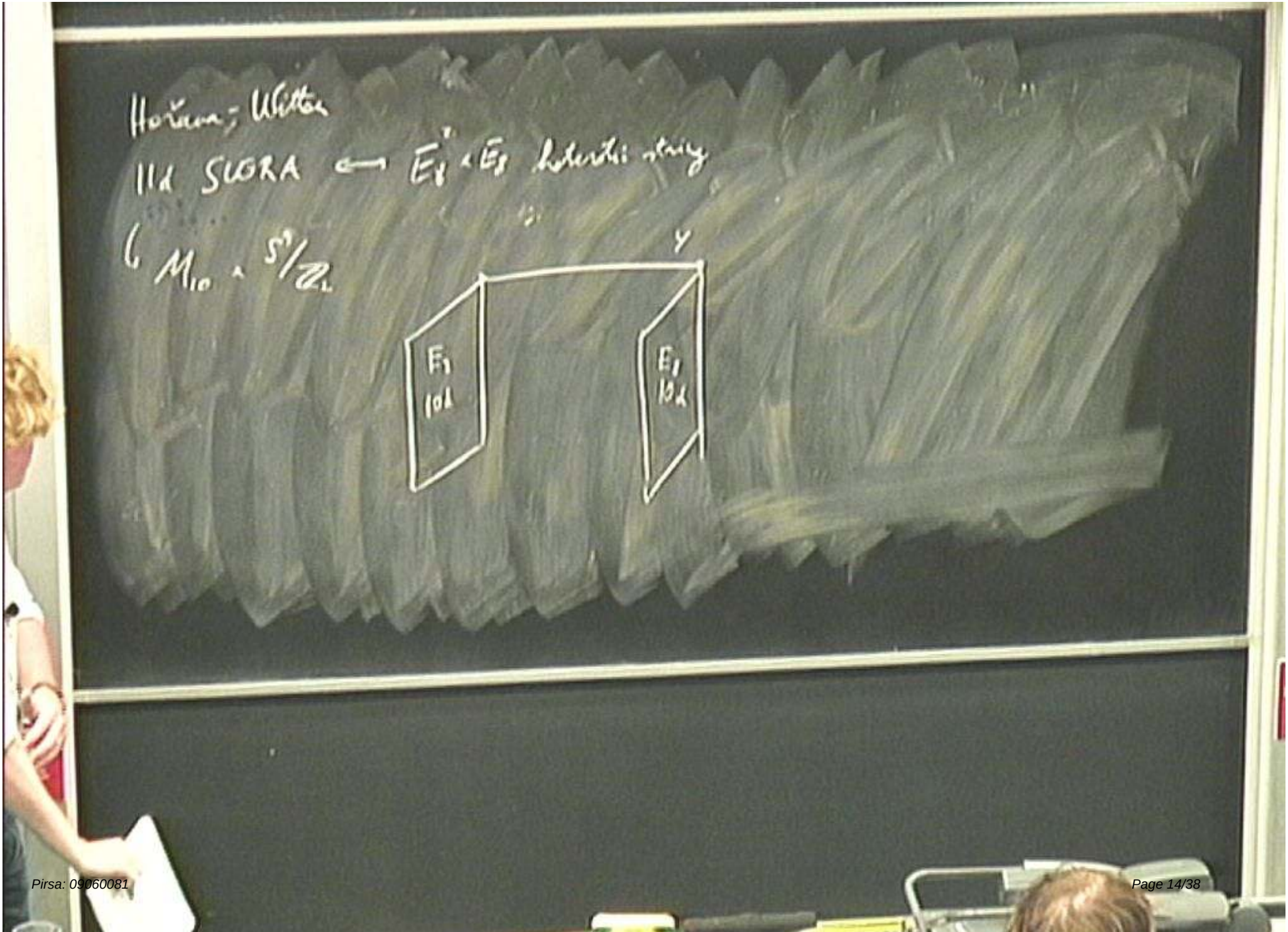
$\begin{cases} u = T \cosh y \\ v = T \sinh y \end{cases} \Rightarrow ds_1^2 = -du^2 + dv^2 + ds^2$ Minkowski

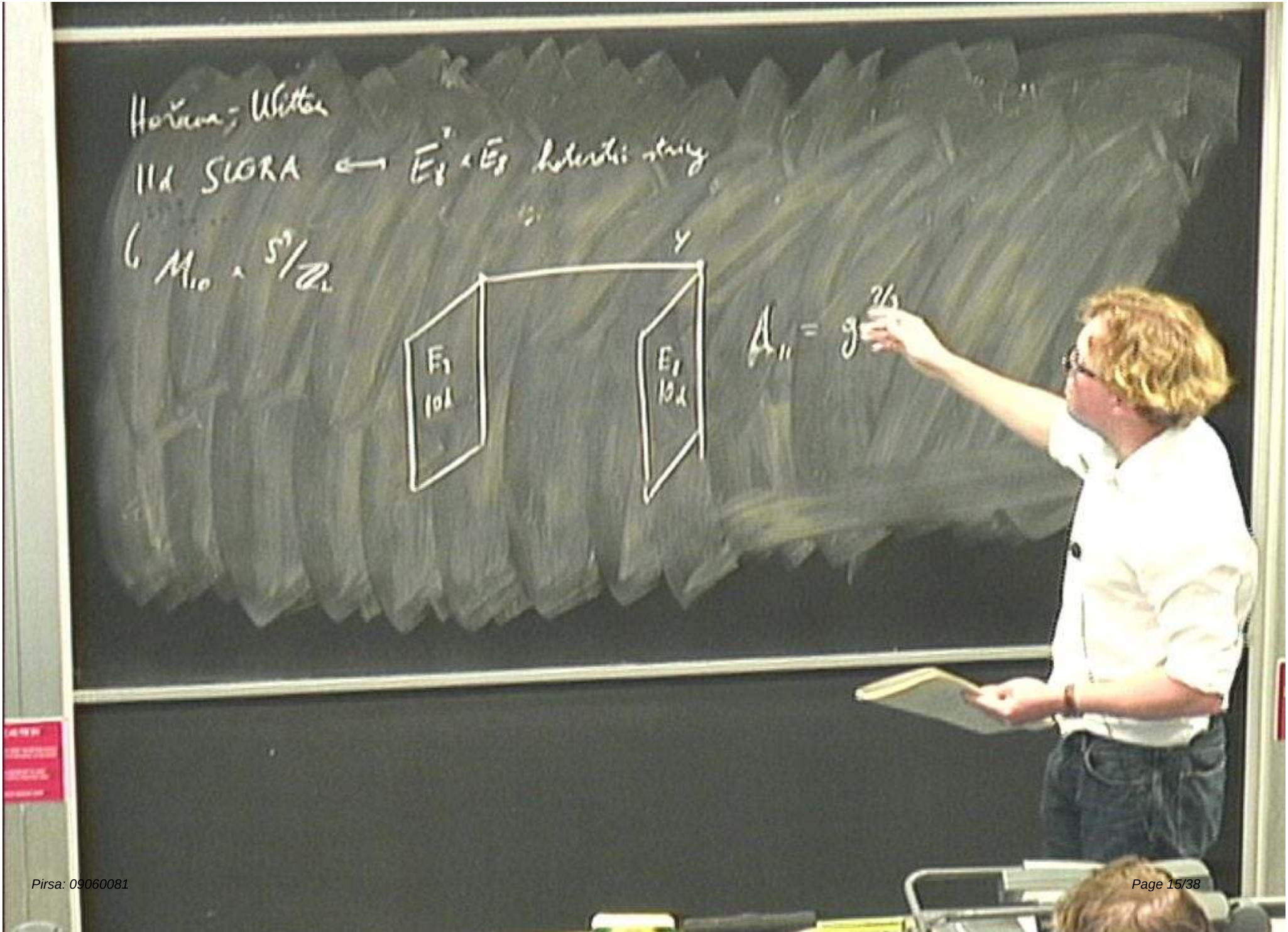


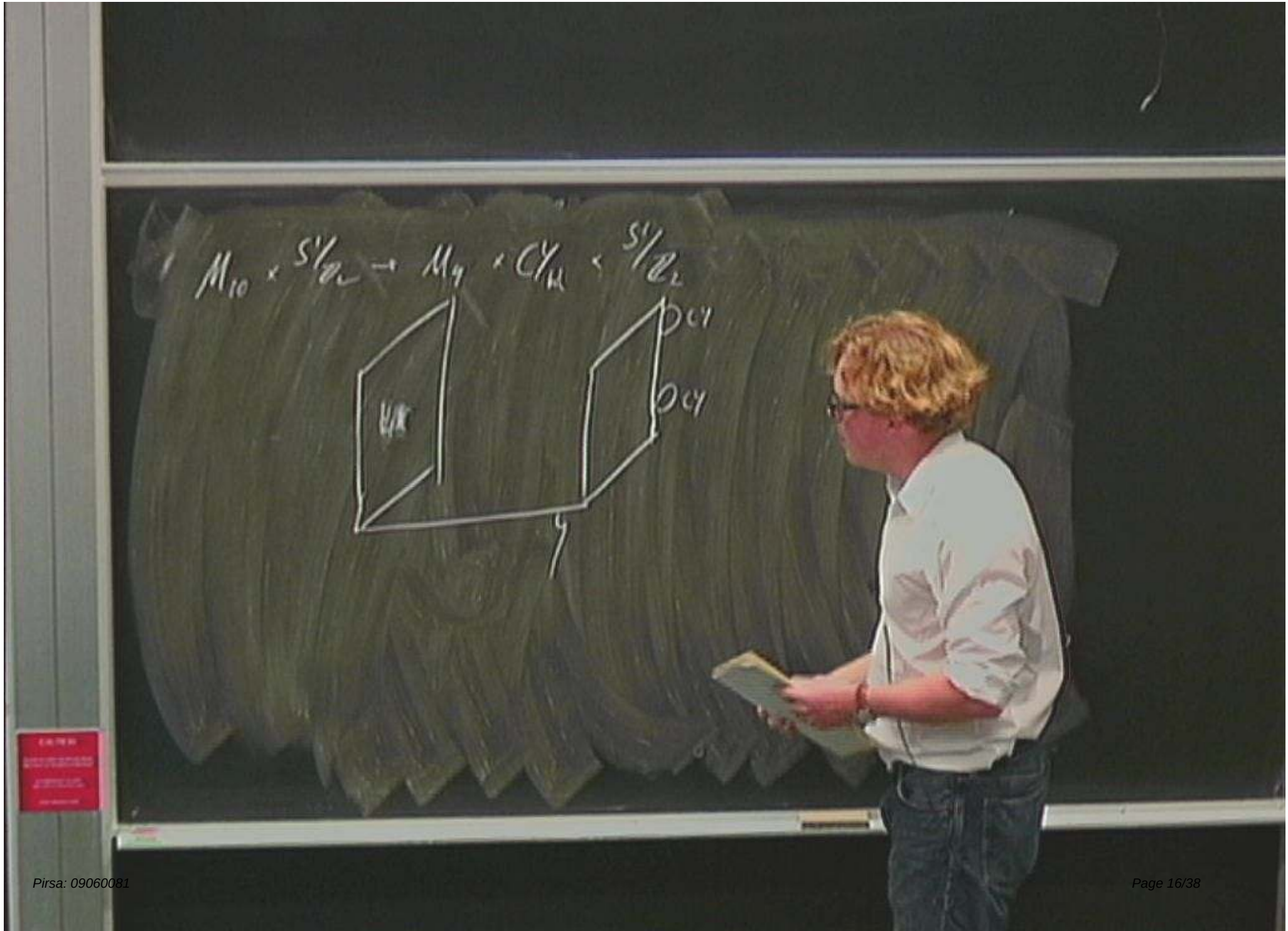

Hořava; Witten
11d SUGRA ⟷ $E_8^{\times} \times E_8$ heterotic string

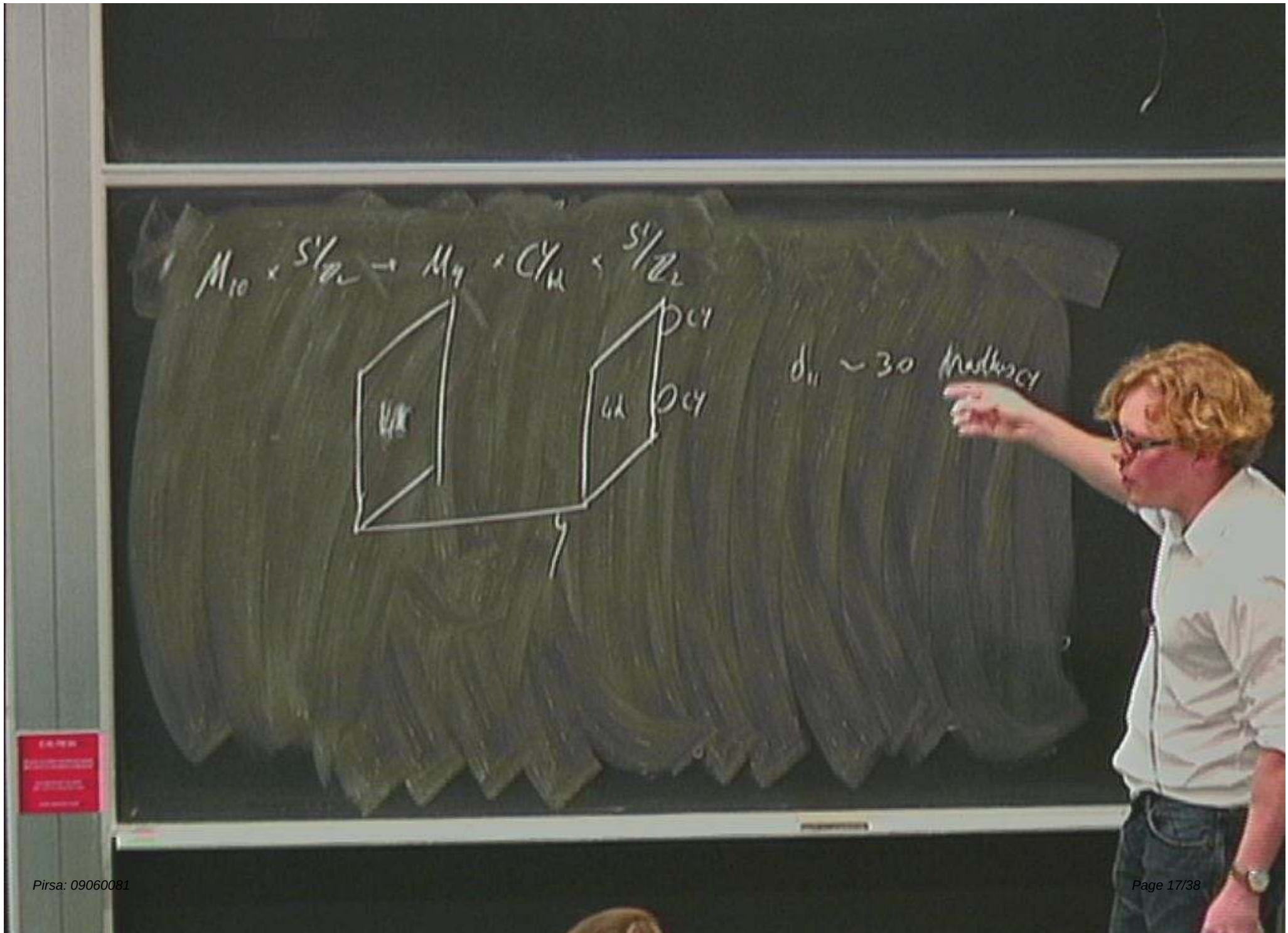

Horava; Witten
11d SUGRA
6 M10 x S1/Z2

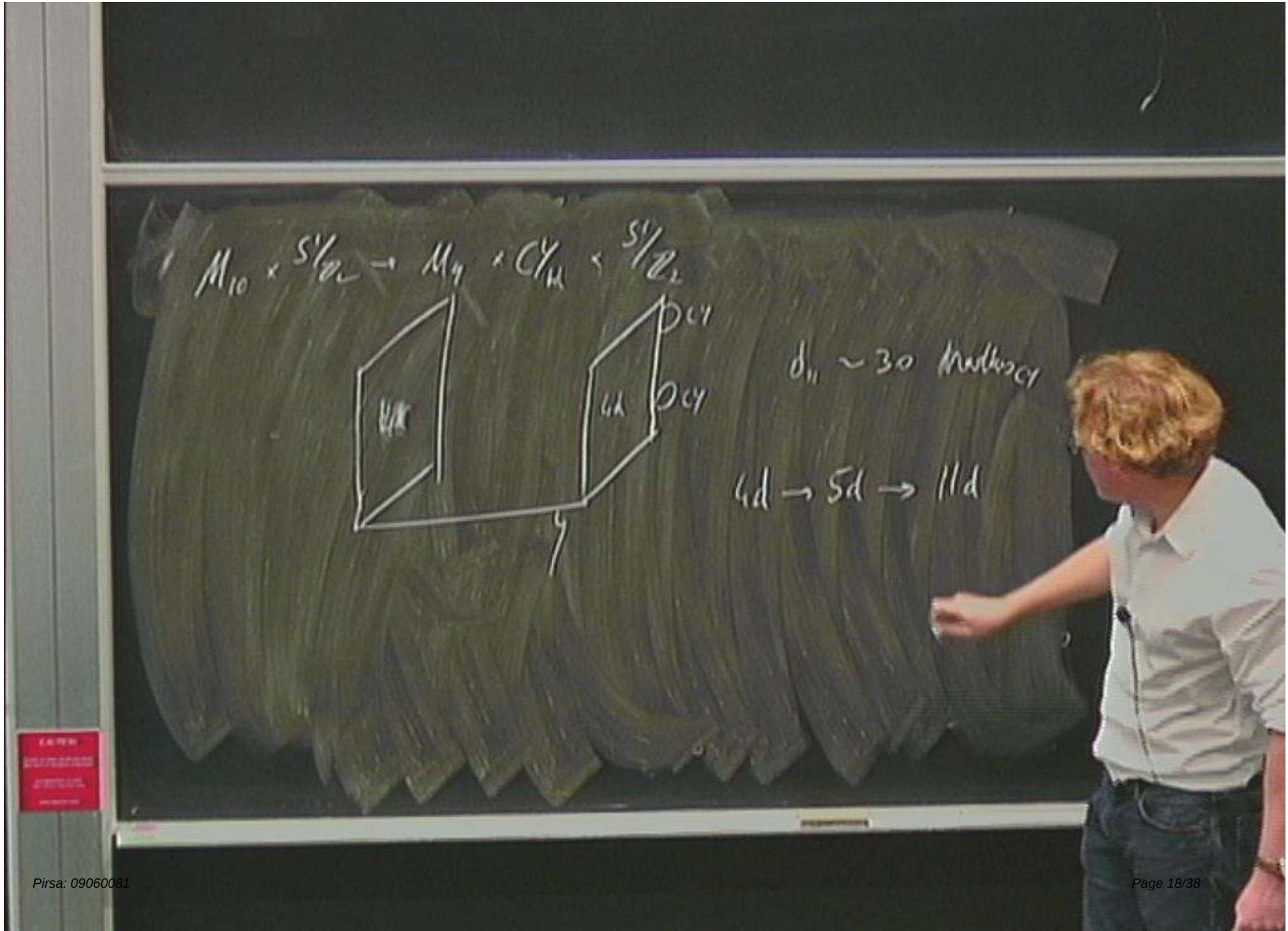

Hořava-Witten
11d SUGRA ⟷ E8 × E8 heterotic string
M10 × S9/Z2
10d
10d

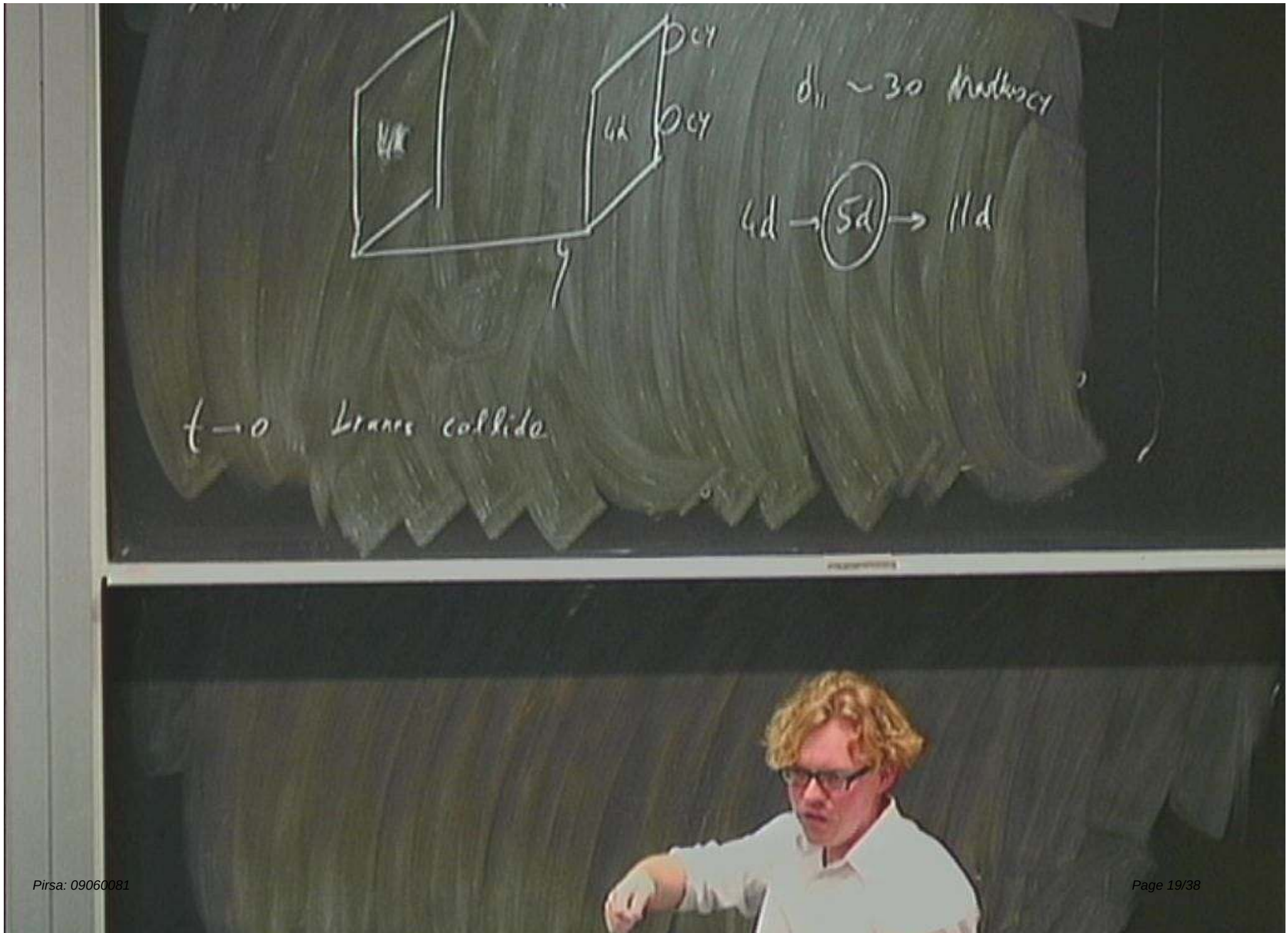

Hořava; Witten
11d SUGRA ⟷ E8 × E8 heterotic string
↳ M10 × S1/Z2
y
E8
10d
E8
10d

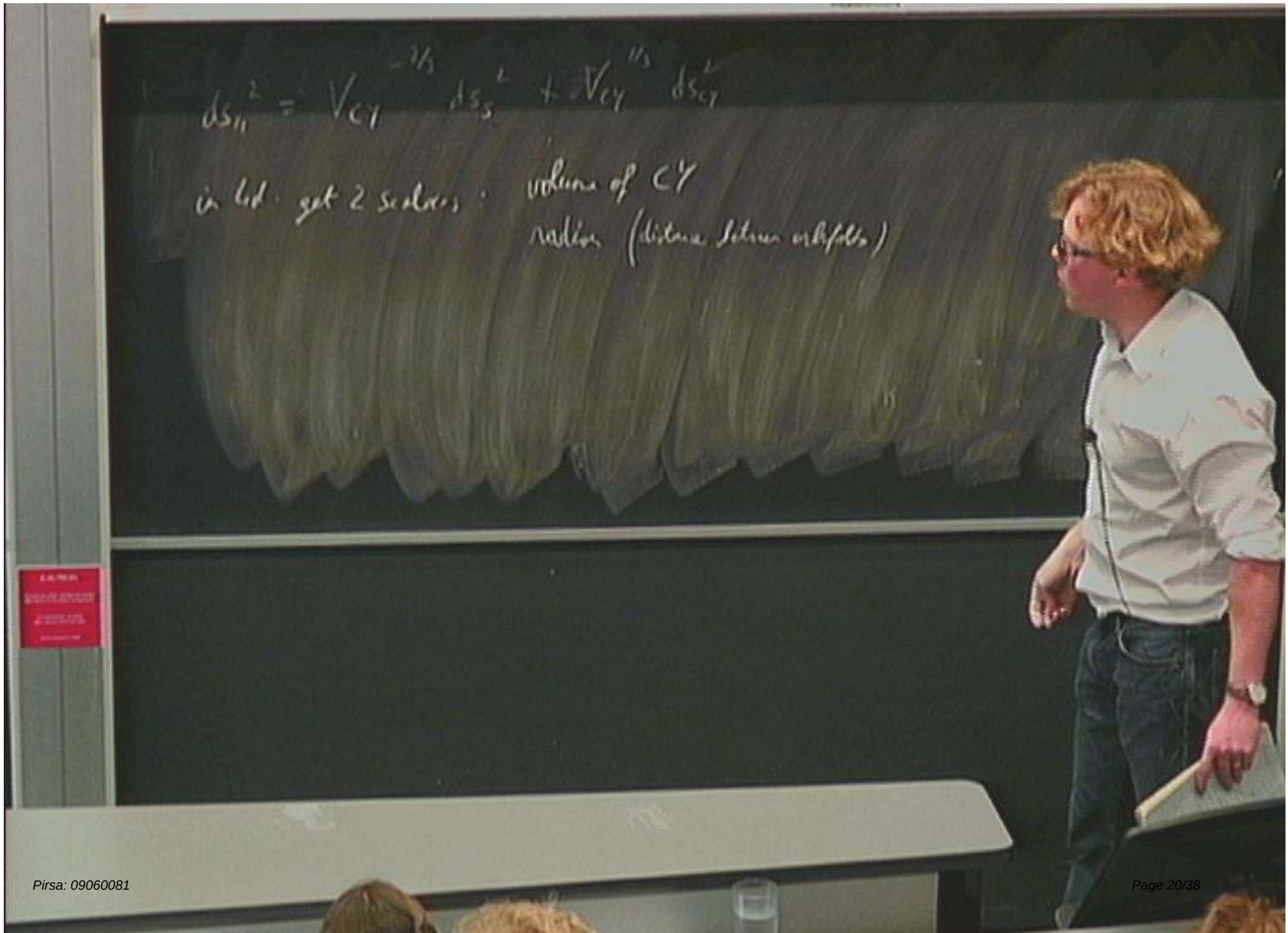

Hořava-Witten
11d SUGRA ⟷ E8 × E8 heterotic string
M10 × S9/Z2
E8
10d
E8
10d
A11 = g

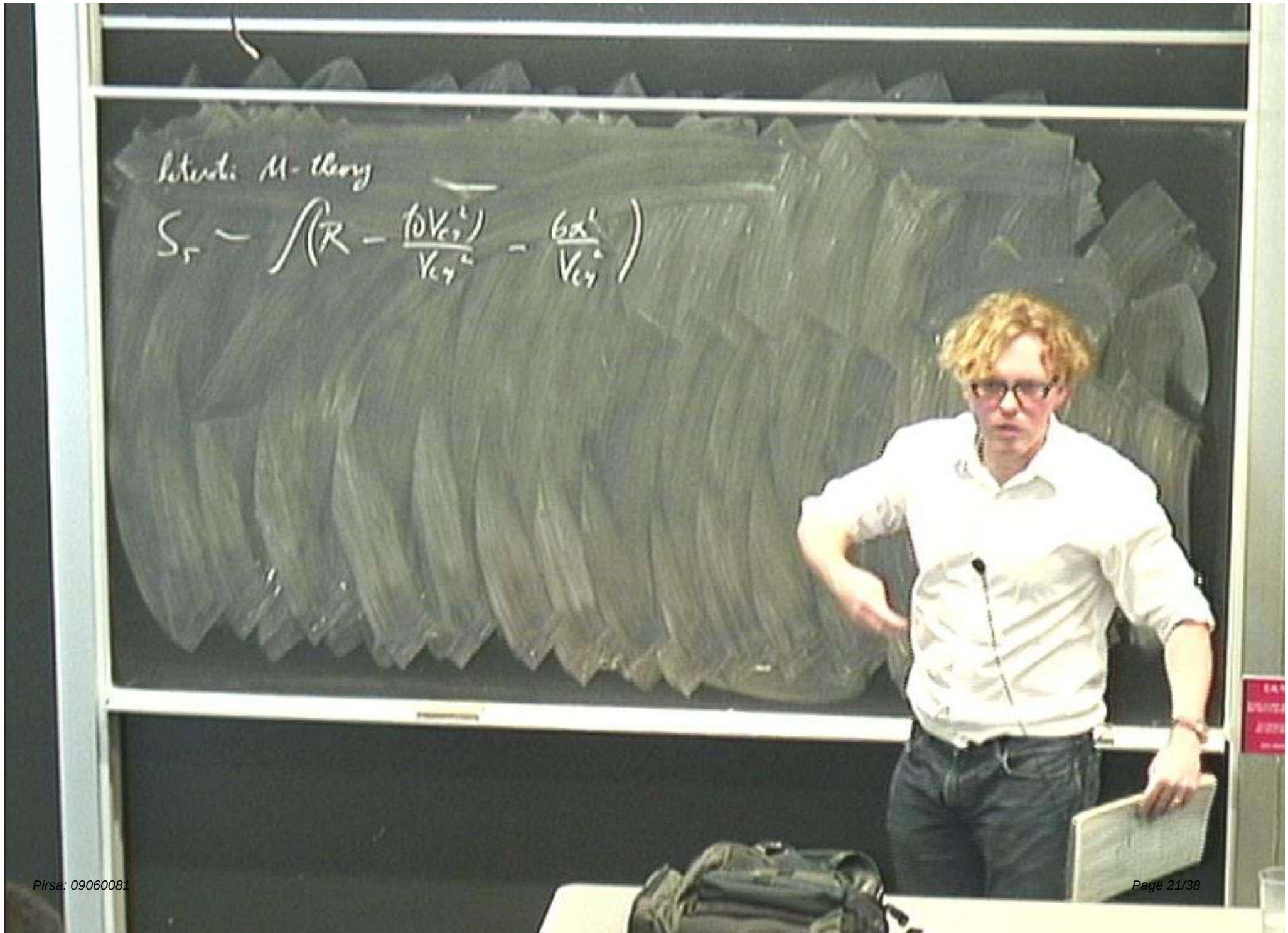


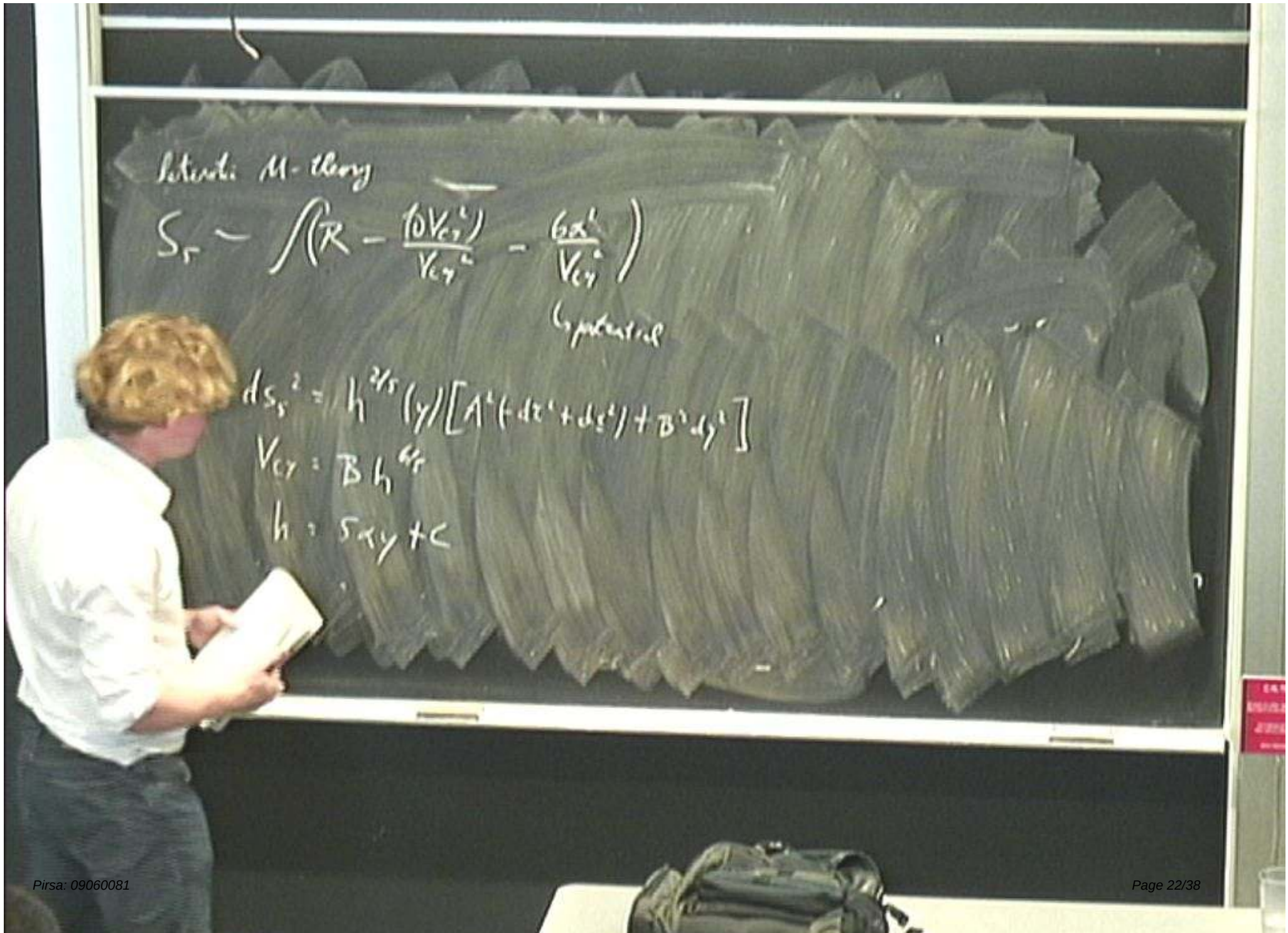

$M_{10} \times S^1/\mathbb{Z}_2 \to M_4 \times CY_{11} \times S^1/\mathbb{Z}_2$
CY
CY
$d_{11} \sim 30$


$M_{10} \times S^1/\mathbb{Z}_2 \to M_4 \times CY_{4d} \times S^1/\mathbb{Z}_2$
CY
CY
4d
$d_{11} \sim 30$ Modulus CY
$4d \to 5d \to 11d$


4d
4d
CY
CY
d_11 ~ 30 Mathes CY
4d → 5d → 11d
t → 0 branes collide


$ds_{11}^2 = V_{CY}^{-2/3} ds_5^2 + V_{CY}^{1/3} ds_{CY}^2$
in 6d get 2 scalars: volume of CY
radion (distance between orbifolds)


Potential M-theory
$S_F \sim \int \left(R - \frac{(\partial V_{CY}^4)}{V_{CY}^4} - \frac{G\alpha'}{V_{CY}^4} \right)$


Heterotic M-theory
$S_5 \sim \int \left(R - \frac{(\partial V_{CY}^2)}{V_{CY}^2} - \frac{G_4^2}{V_{CY}^2} \right)$
4-potential
$ds_5^2 = h^{2/3}(y)\left[A^2(-dt^2 + dx_1^2 + dx_2^2) + B^2 dy^2\right]$
$V_{CY} = B h^{4/3}$
$h = 5Ay + C$

Lateral M-theory

$$S_5 \sim \int \left(R - \frac{(\partial V_{cy}^2)}{V_{cy}^2} - \frac{6\alpha^2}{V_{cy}^2} \right)$$

↳ potential

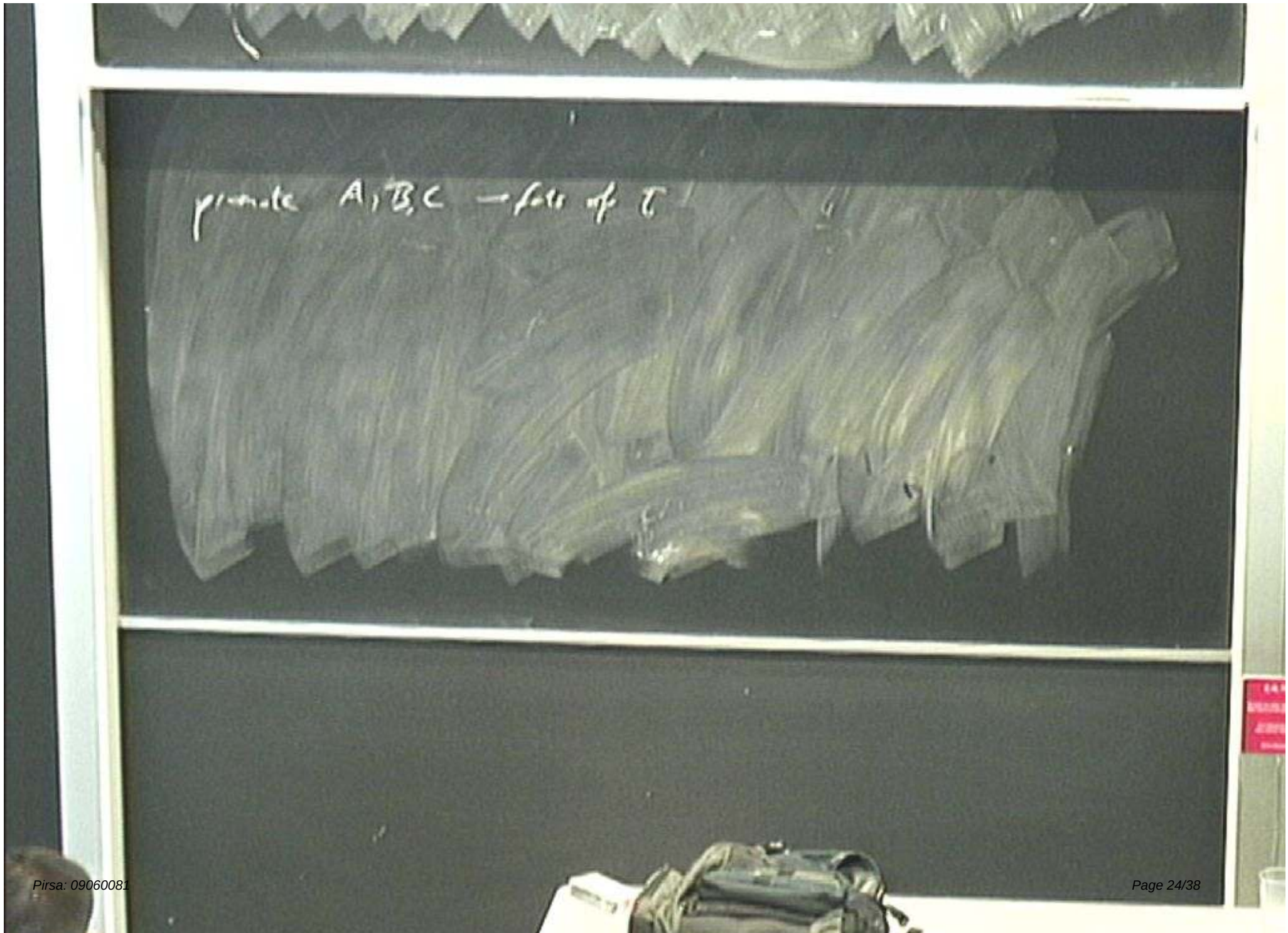
Sol

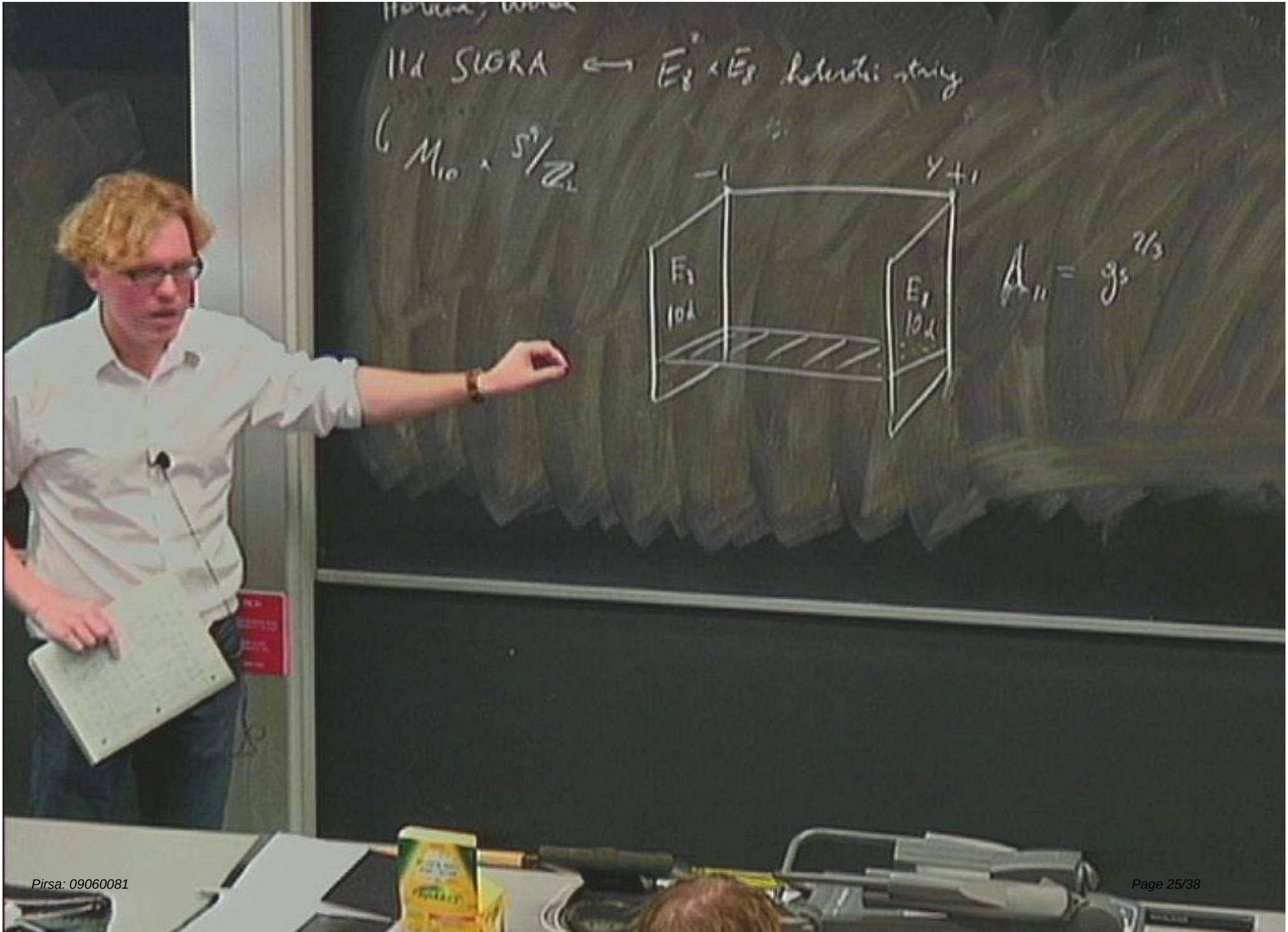
$$ds_5^2 = h^{2/5}(y)\left[A^2(-d\tau^2 + d\xi^2) + B^2 dy^2\right]$$

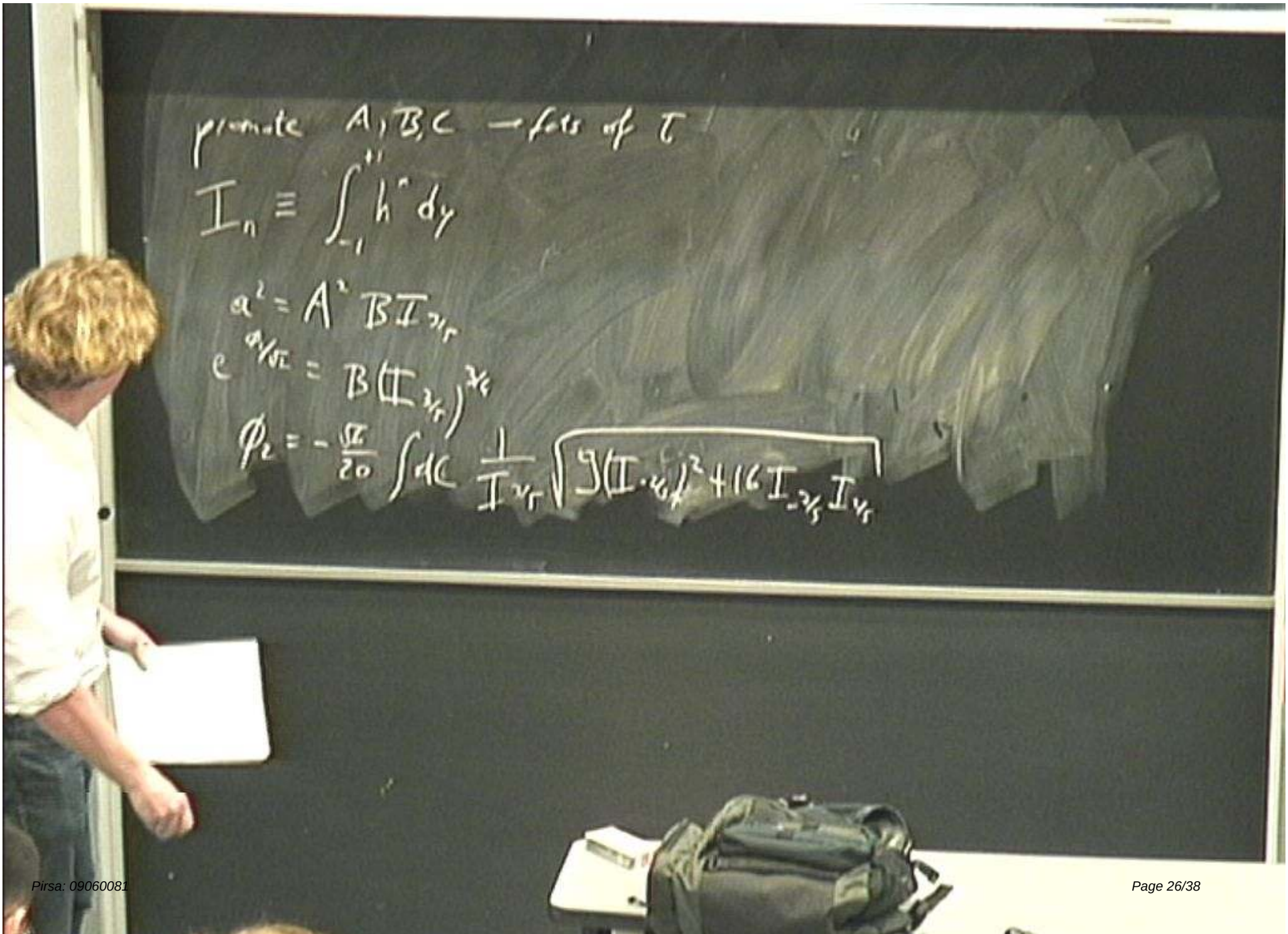
$$V_{cy} = B h^{6/5}$$

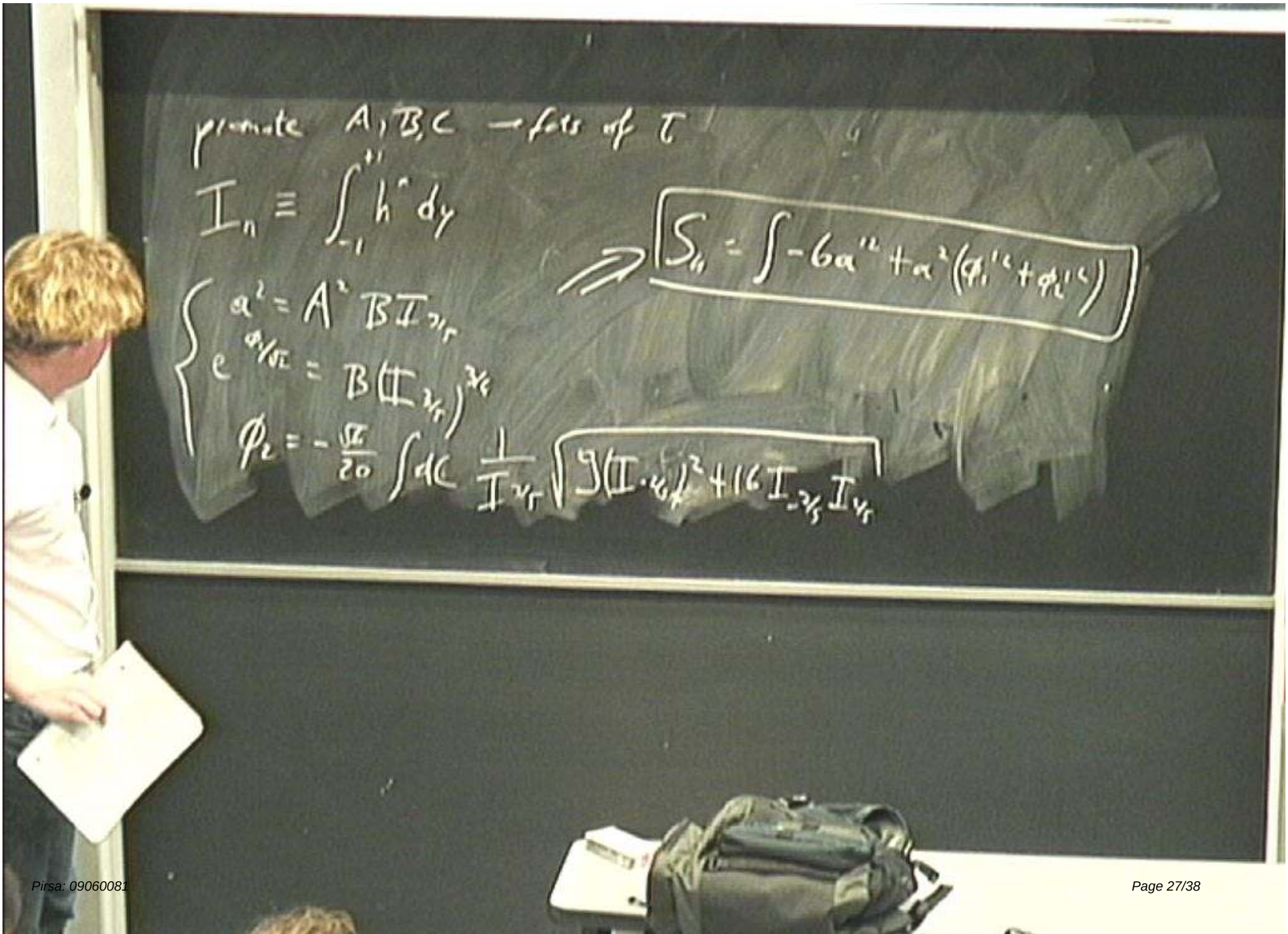
$$h = 5\alpha y + C$$

A, B, C constants


primate A, B, C — fold of C


11d SUGRA ⟷ $E_8 \times E_8$ heterotic string
$M_{10} \times S^1/\mathbb{Z}_2$
-1
$y+1$
E_8
10d
E_8
10d
$M_{11} = g_s^{2/3}$


promote A, B, C — fcts of τ
$I_n \equiv \int_{-1}^{+1} h^n \, dy$
$a^2 = A^2 B I_{1/2}$
$e^{\Phi/\sqrt{2}} = B (I_{1/2})^{3/2}$
$\Phi_2 = -\frac{\sqrt{2}}{20} \int d\zeta \, \frac{1}{I_{1/2}} \sqrt{9(I_{-1/2})^2 + 16 I_{-3/2} I_{1/2}}$

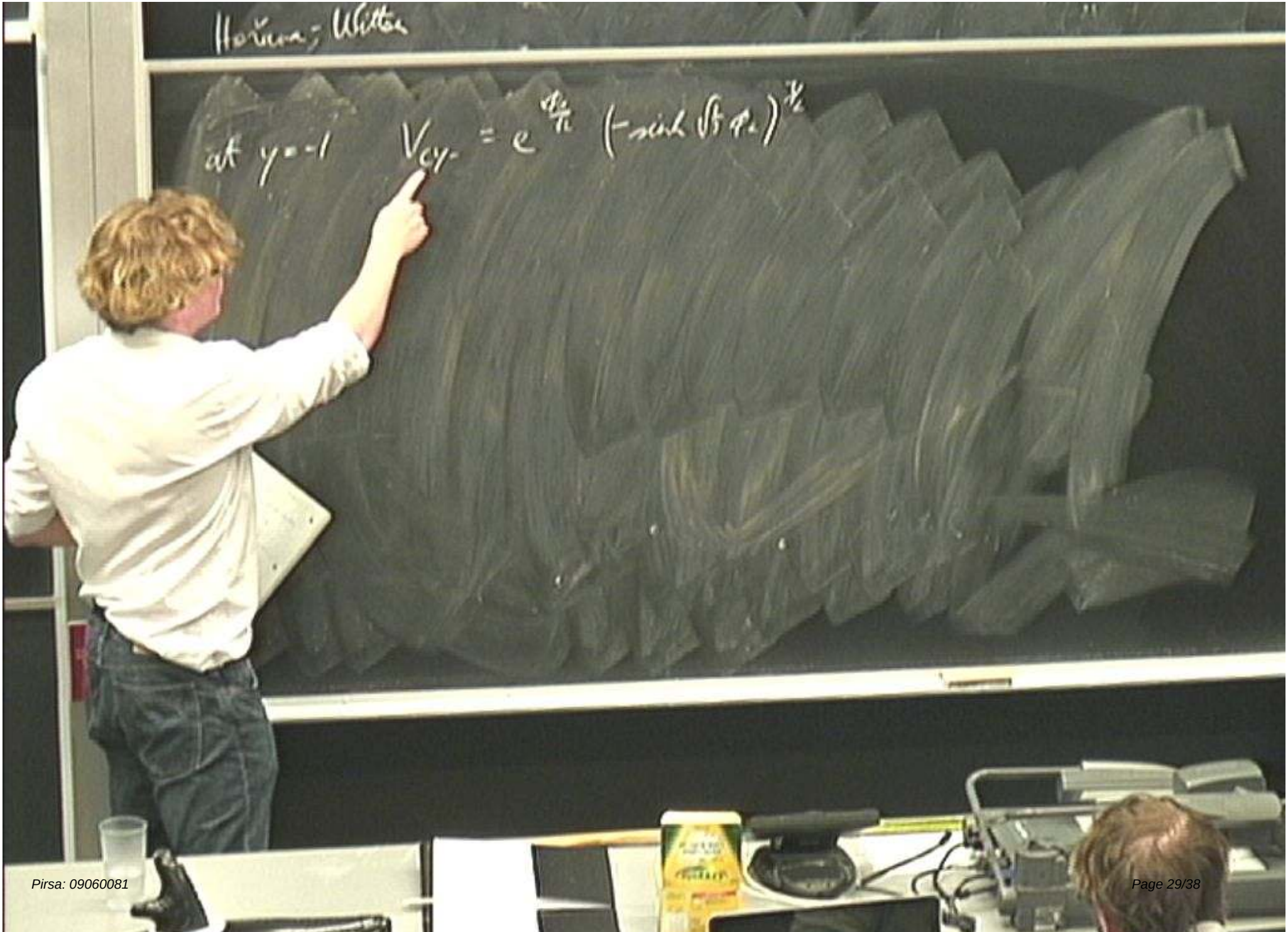

promote A, B, C → fcts of τ
$I_n \equiv \int_{-1}^{+1} h^n \, dy$
$a^2 = A^2 B I_{3/5}$
$e^{\phi_2/\sqrt{2}} = B (I_{3/5})^{3/5}$
$\phi_2 = -\frac{\sqrt{6}}{20} \int dC \frac{1}{I_{3/5}} \sqrt{9 (I_{-2/5})^2 + 16 I_{-3/5} I_{1/5}}$
$\Rightarrow \boxed{S_4 = \int -6a'^2 + a^2 (\phi_1'^2 + \phi_2'^2)}$

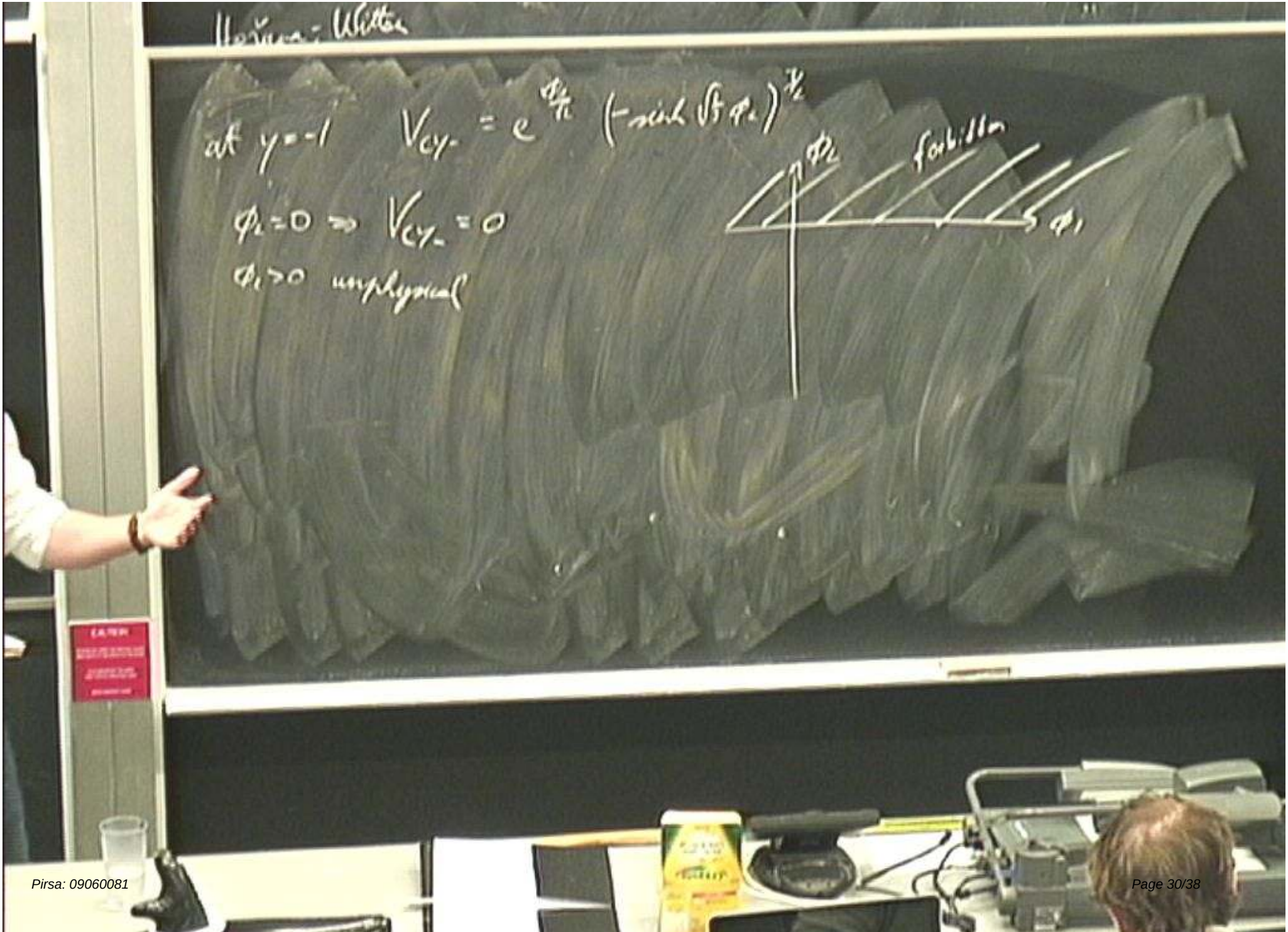
promote $A, B, C \to$ fcts of τ

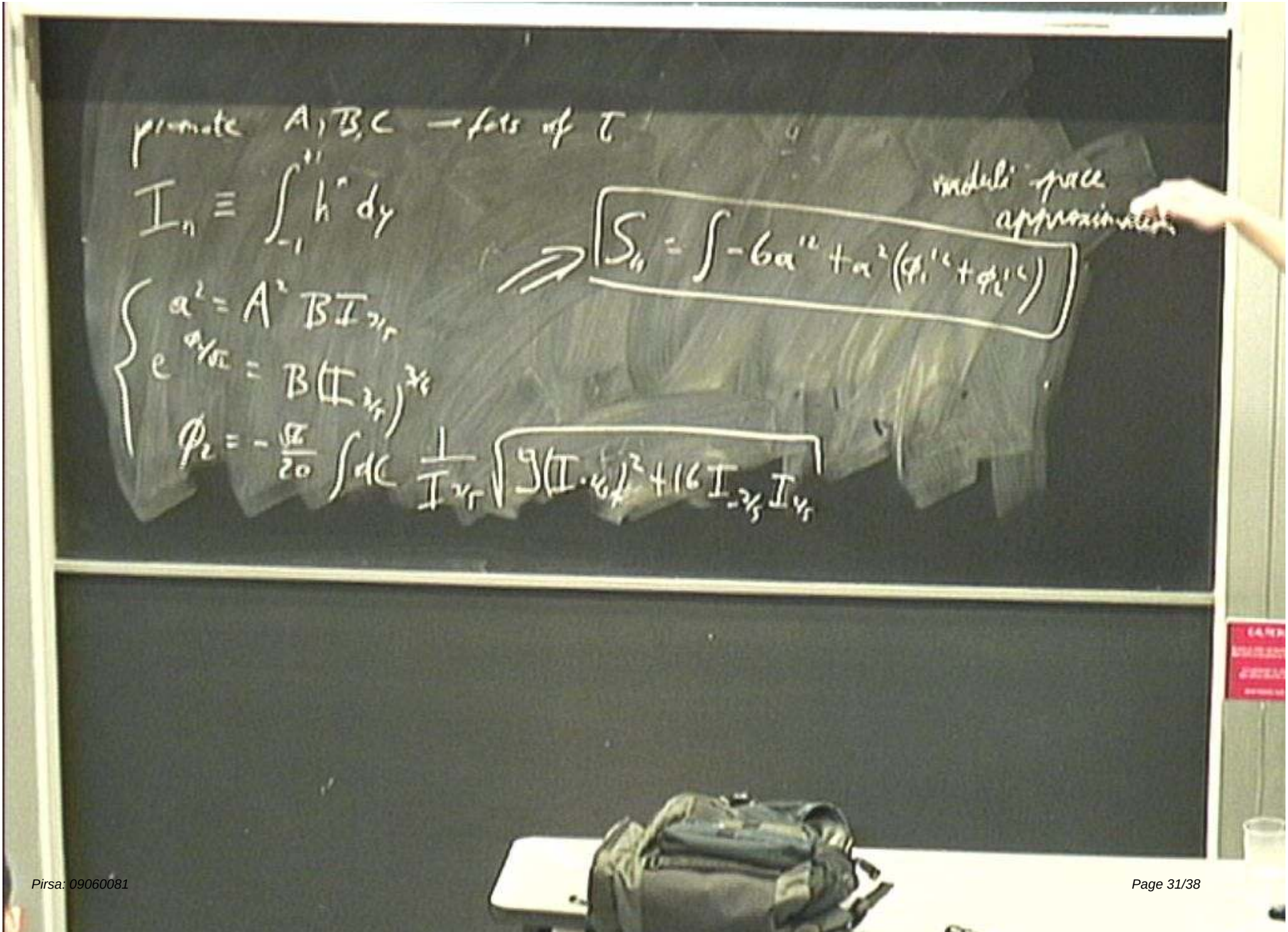
$$I_n \equiv \int_{-1}^{+1} h^n \, dy$$

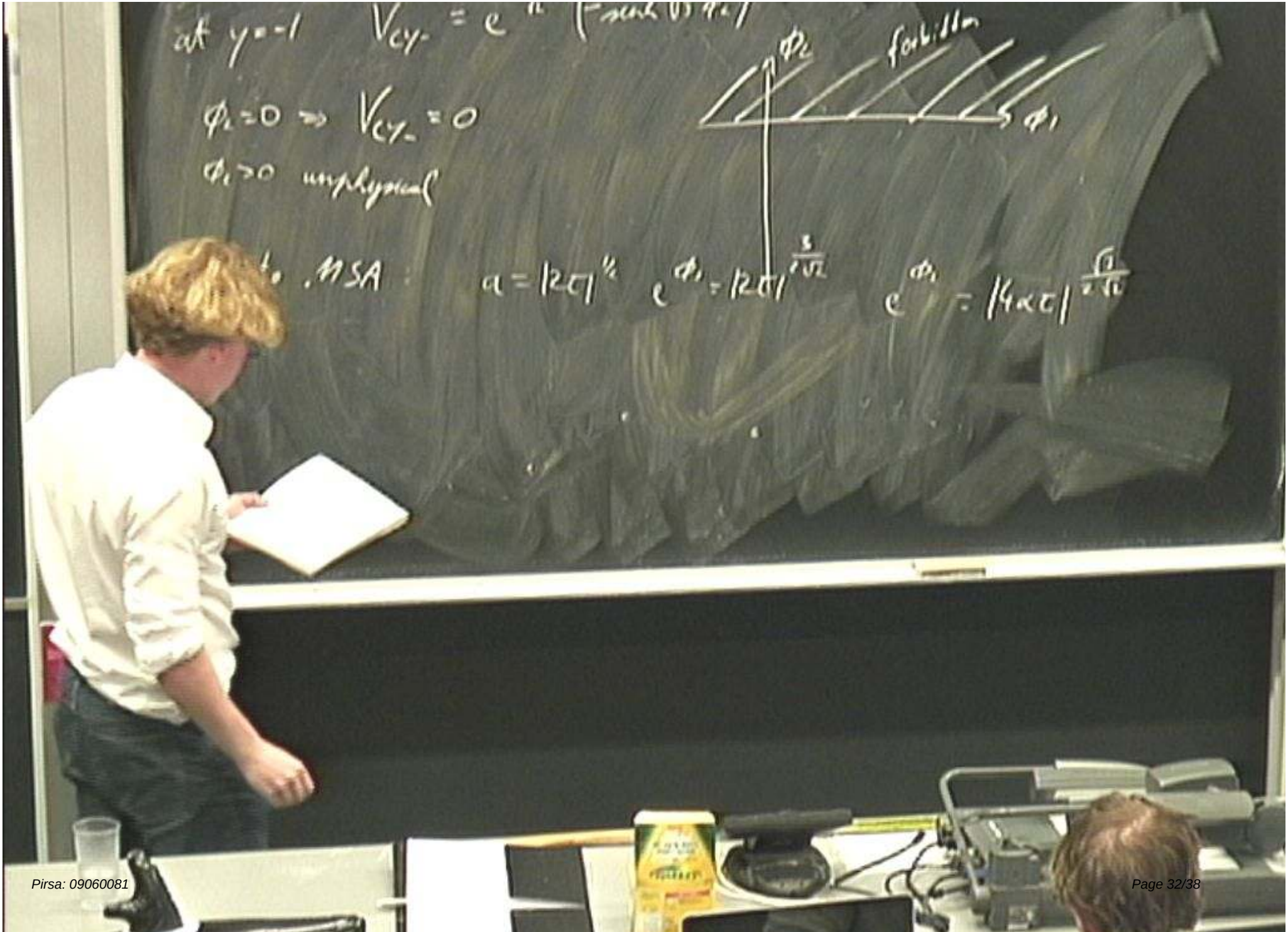
$$\begin{cases} a^2 = A^2 B I_{3/5} \\ e^{\phi_1/\sqrt{2}} = B (I_{3/5})^{3/5} \\ \phi_2 = -\frac{\sqrt{6}}{20} \int dC \, \frac{1}{I_{3/5}} \sqrt{9 (I_{-2/5})^2 + 16 I_{-3/5} I_{3/5}} \end{cases}$$

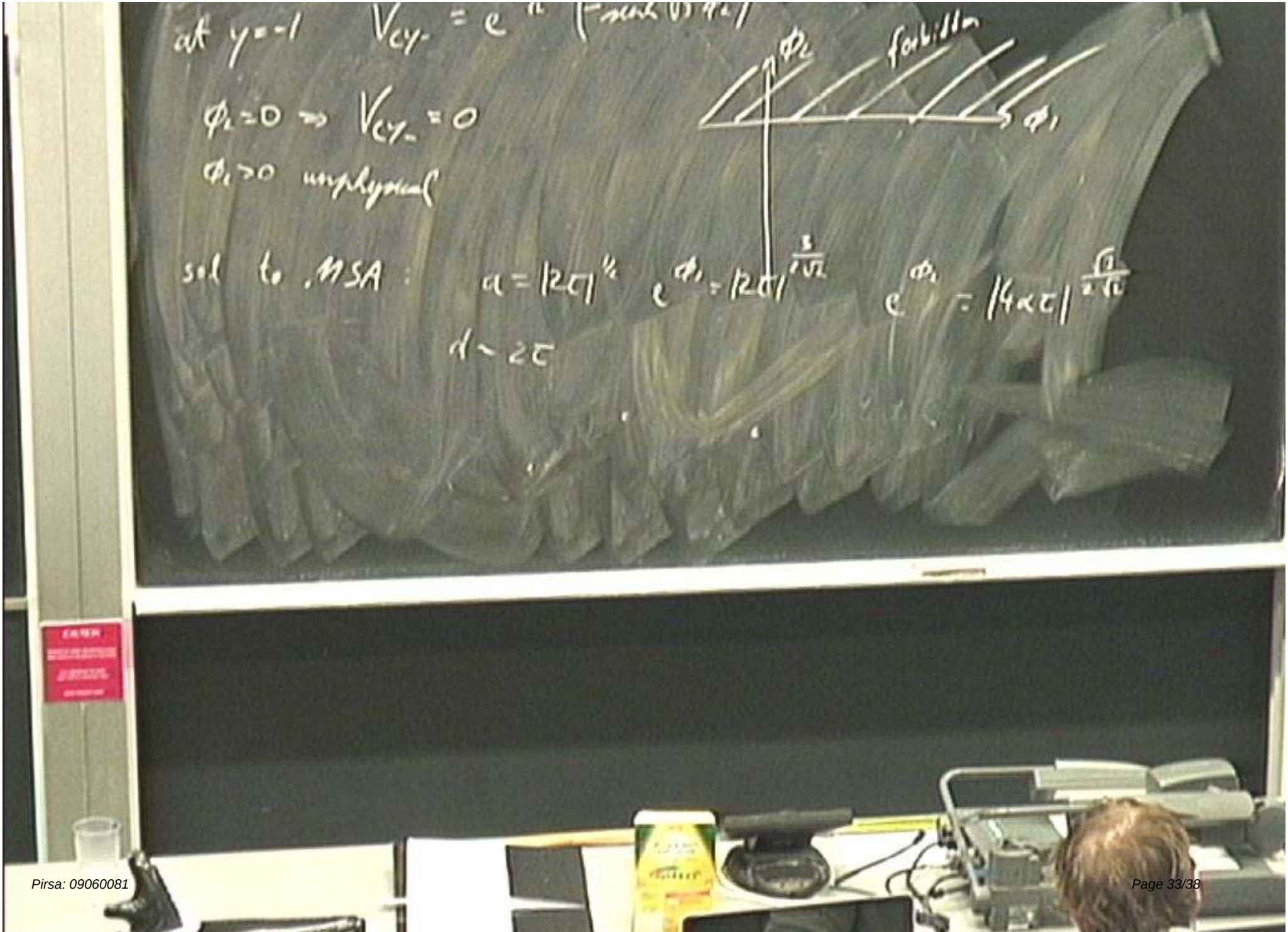
$$\Rightarrow \boxed{S_4 = \int -6a'^2 + a^2 (\phi_1'^2 + \phi_2'^2)}$$

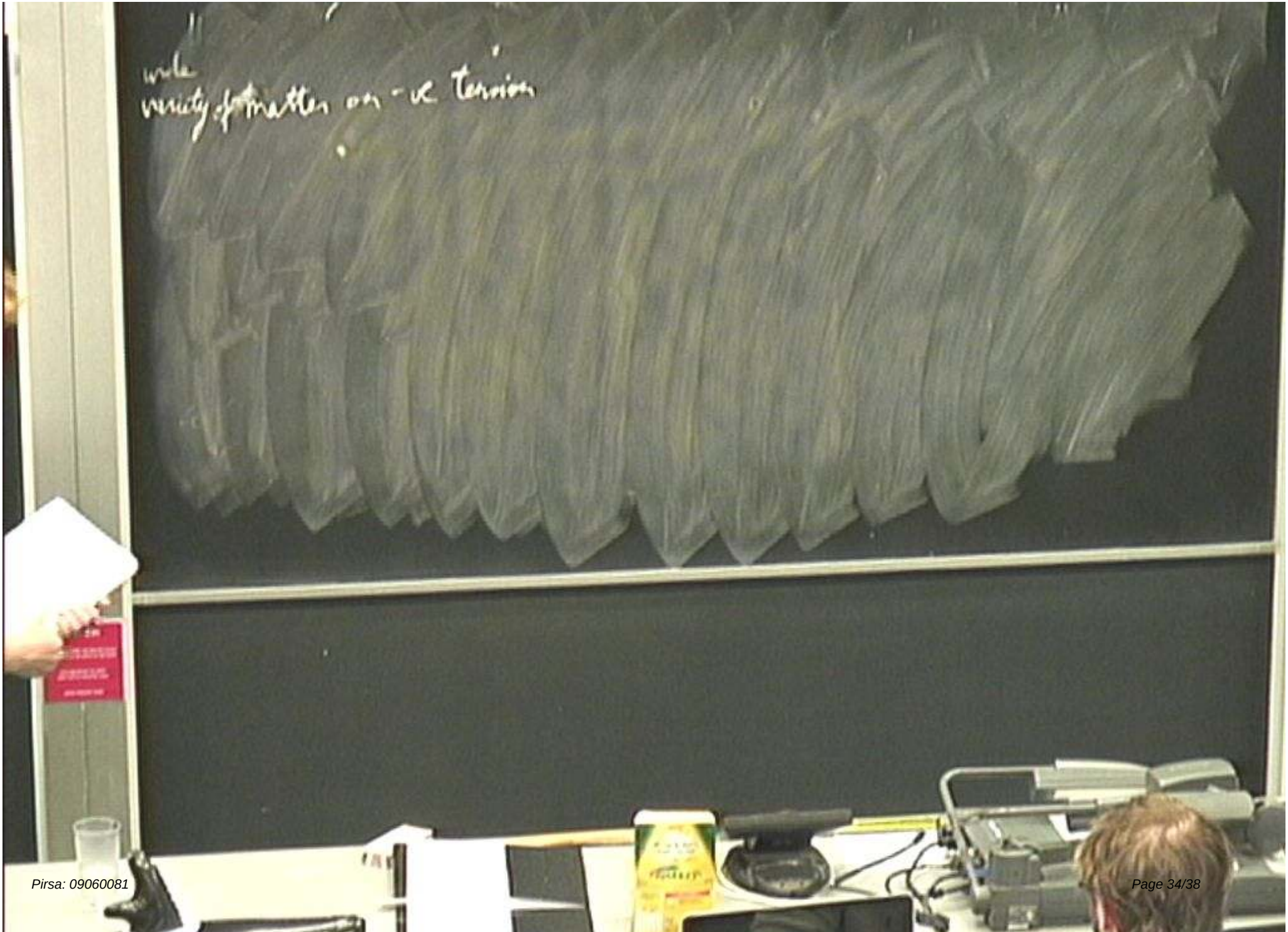

Hořava; Witten
at y=-1

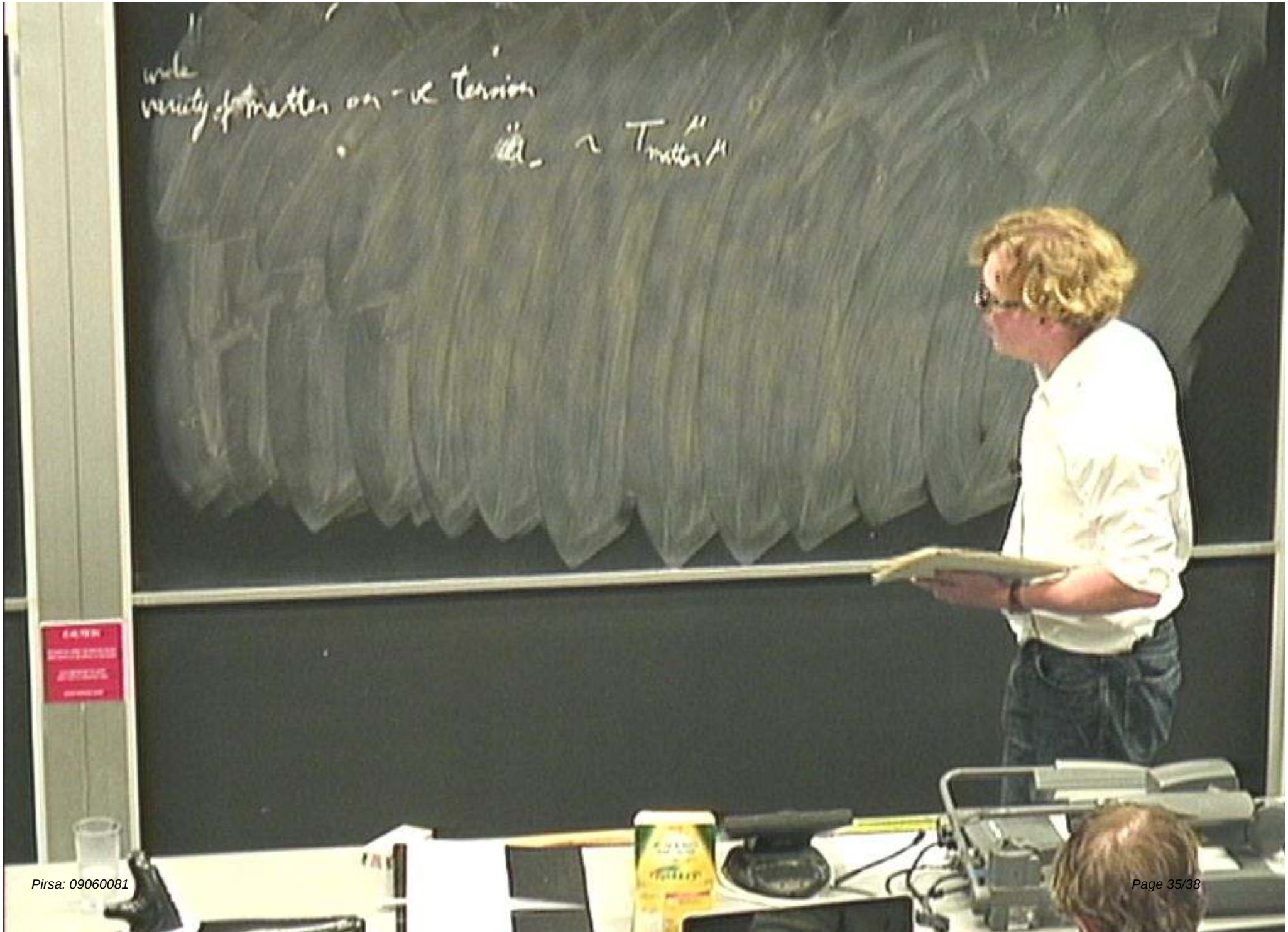

at y=-1
φ2=0 ⇒ Vcy- = 0
φ2>0 unphysical
forbidden
φ2
φ1

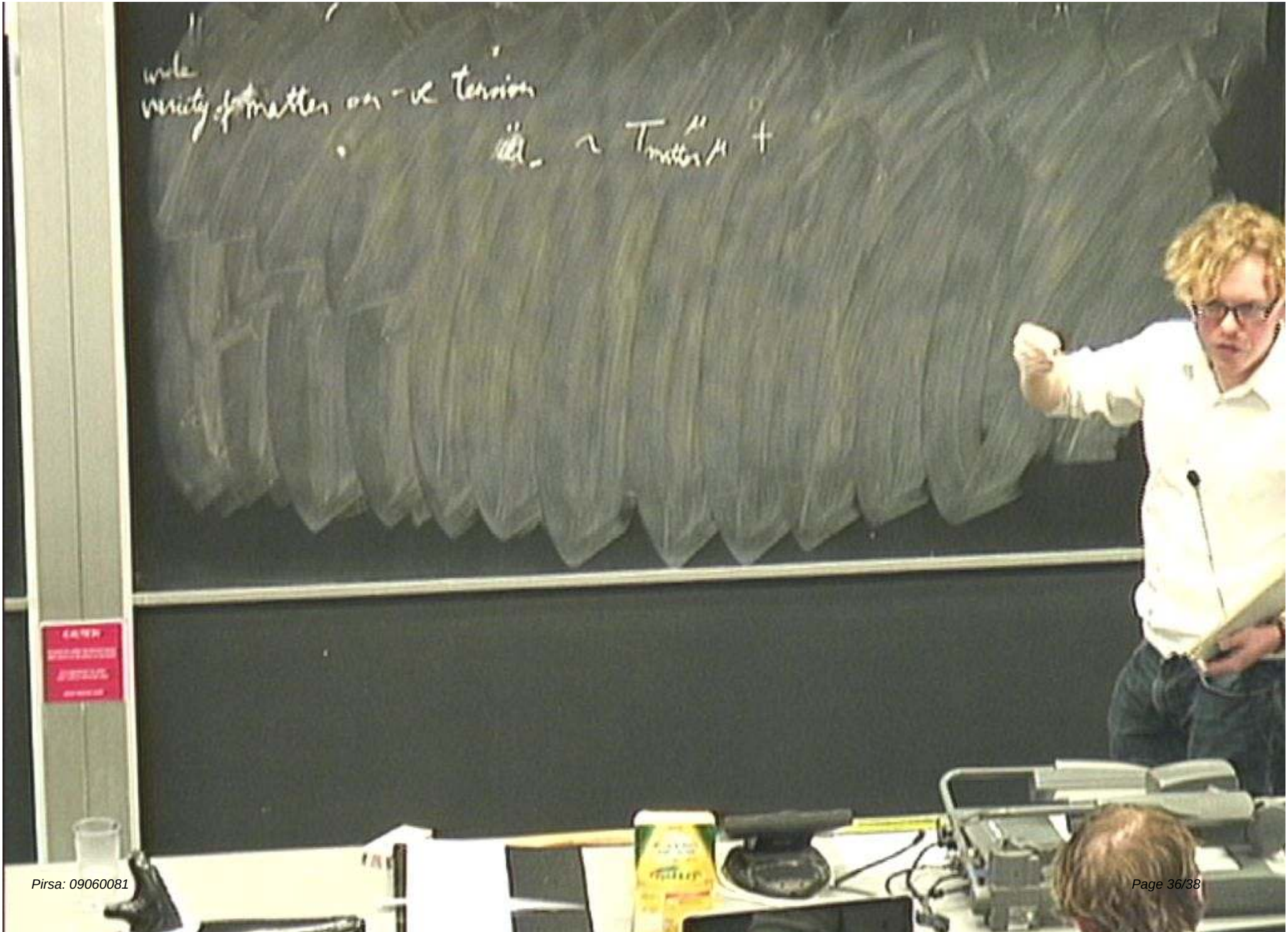

promote A, B, C → fcts of τ
$I_n \equiv \int_{-1}^{+1} h^n \, dy$
$\begin{cases} a^2 = A^2 B I_{1/2} \\ e^{\phi/\sqrt{12}} = B (I_{1/2})^{3/2} \\ \phi_2 = -\frac{\sqrt{12}}{20} \int d\tau \frac{1}{I_{1/2}} \sqrt{9 (I_{-1/2})^2 + 16 I_{-3/2} I_{1/2}} \end{cases}$
moduli space approximation
$S_{11} = \int -6a'^2 + a^2 (\phi_1'^2 + \phi_2'^2)$


at y=-1
$\phi_2 = 0 \Rightarrow V_{cy-} = 0$
$\phi_2 > 0$ unphysical
ϕ_2
ϕ_1
$a = |2c|^{1/2}$
$e^{\phi_1} = |2c|^{\frac{3}{2\sqrt{2}}}$
$e^{\phi_1} = |4\alpha c|^{\frac{\sqrt{3}}{2\sqrt{\alpha}}}$


at y=-1
$\phi_1 = 0 \Rightarrow V_{cy-} = 0$
$\phi_1 > 0$ unphysical
ϕ_2
ϕ_1
sol to MSA:
$d \sim 2\sigma$


wide
variety of matter on - ve tension


wide
variety of matter on - ve tension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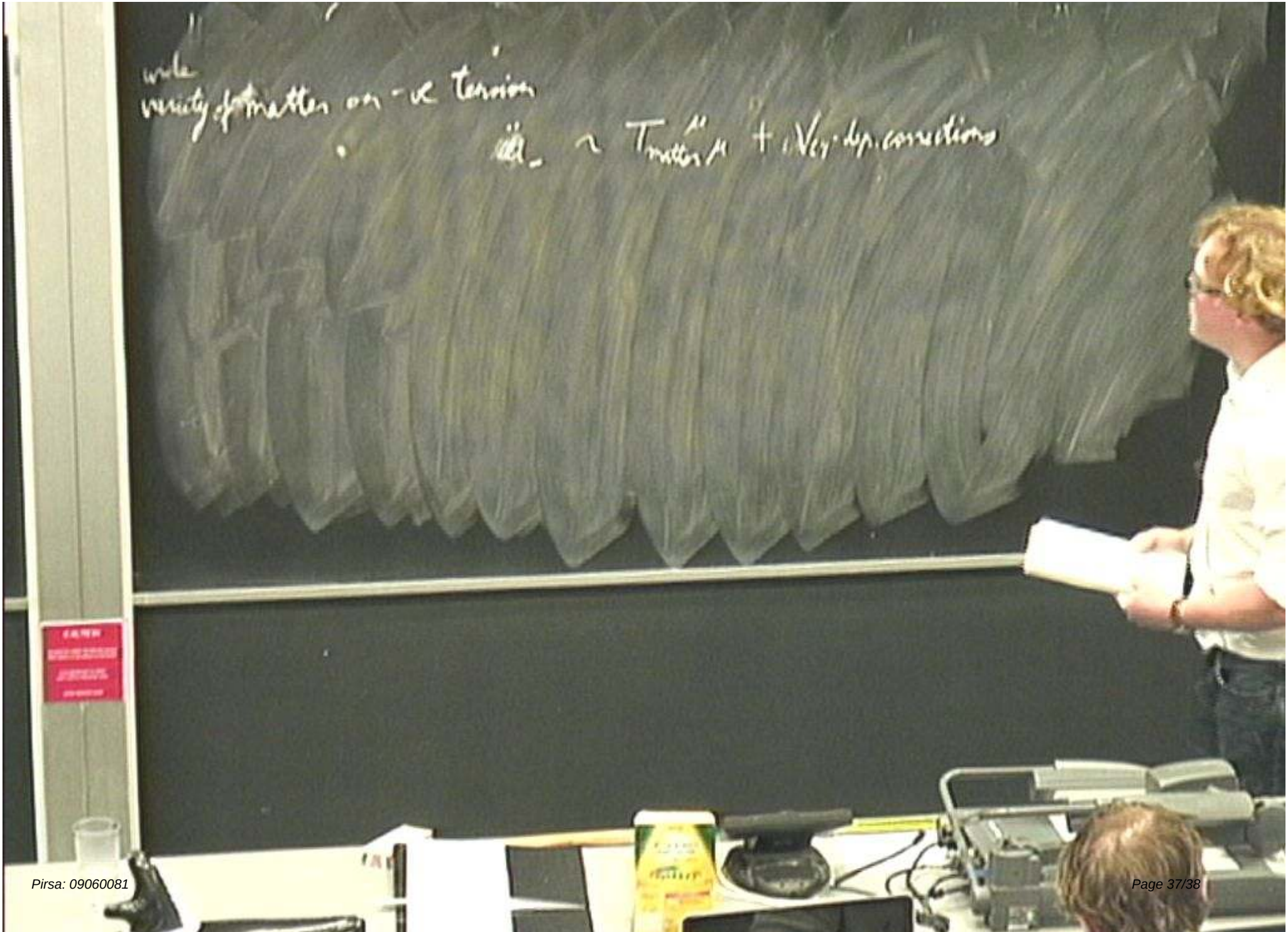
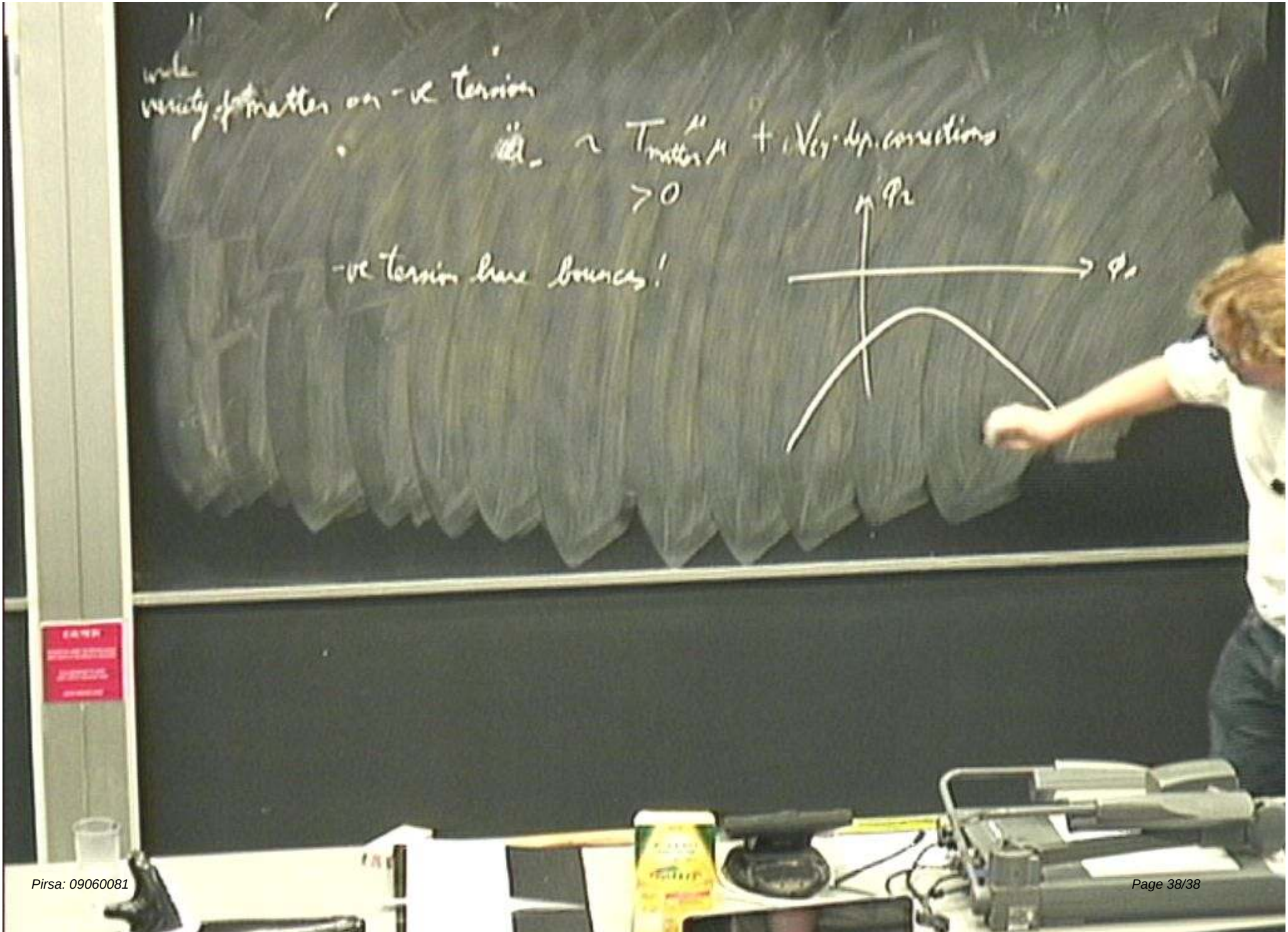
variety of matter on - ve tension


wide
variety of matter on -ve tension
$\ddot{a}_- \sim T^{\mu}_{matter\,\mu}$ + N_{eq}-dep. corrections


-ve tension branes bounce!