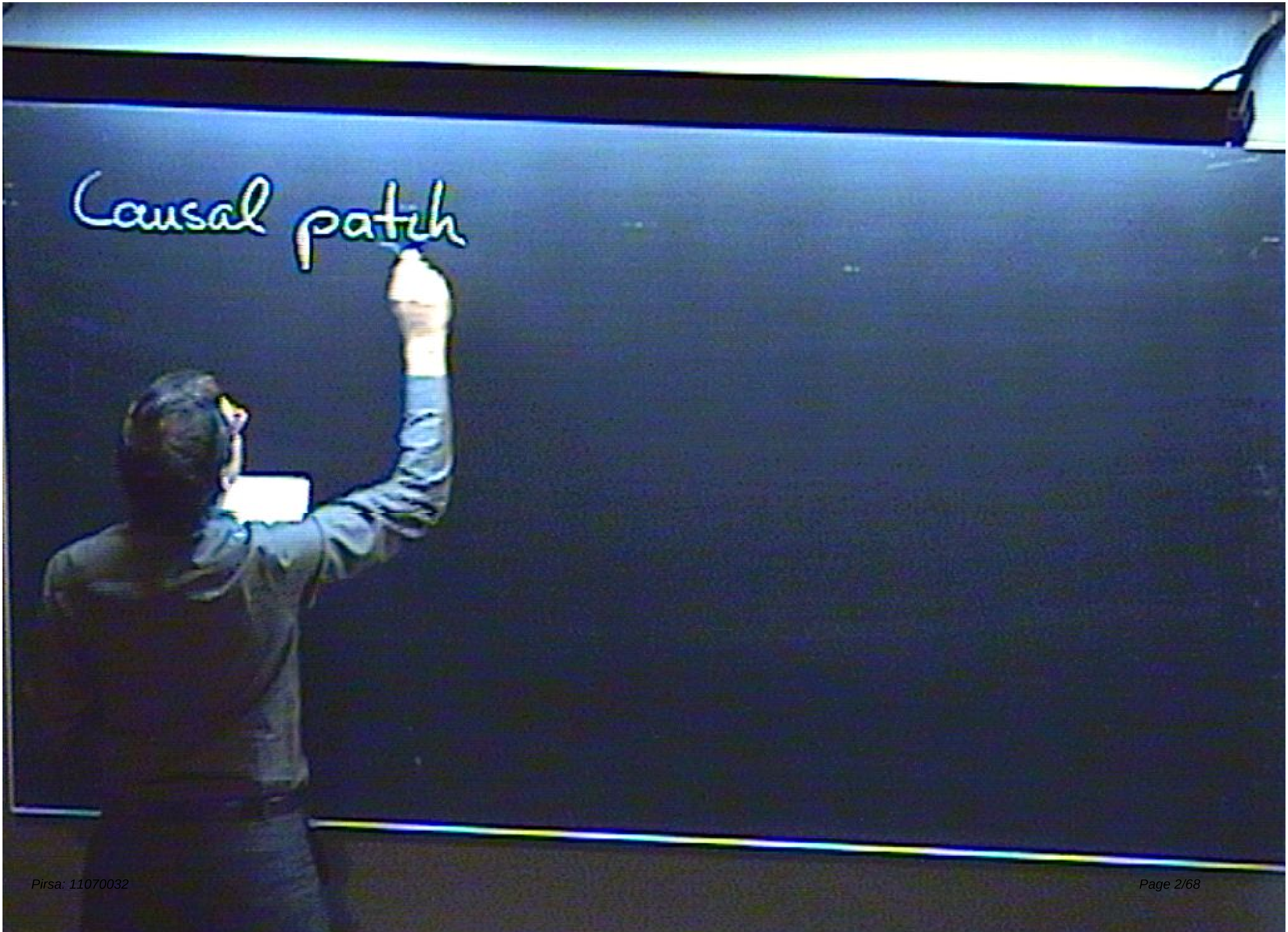
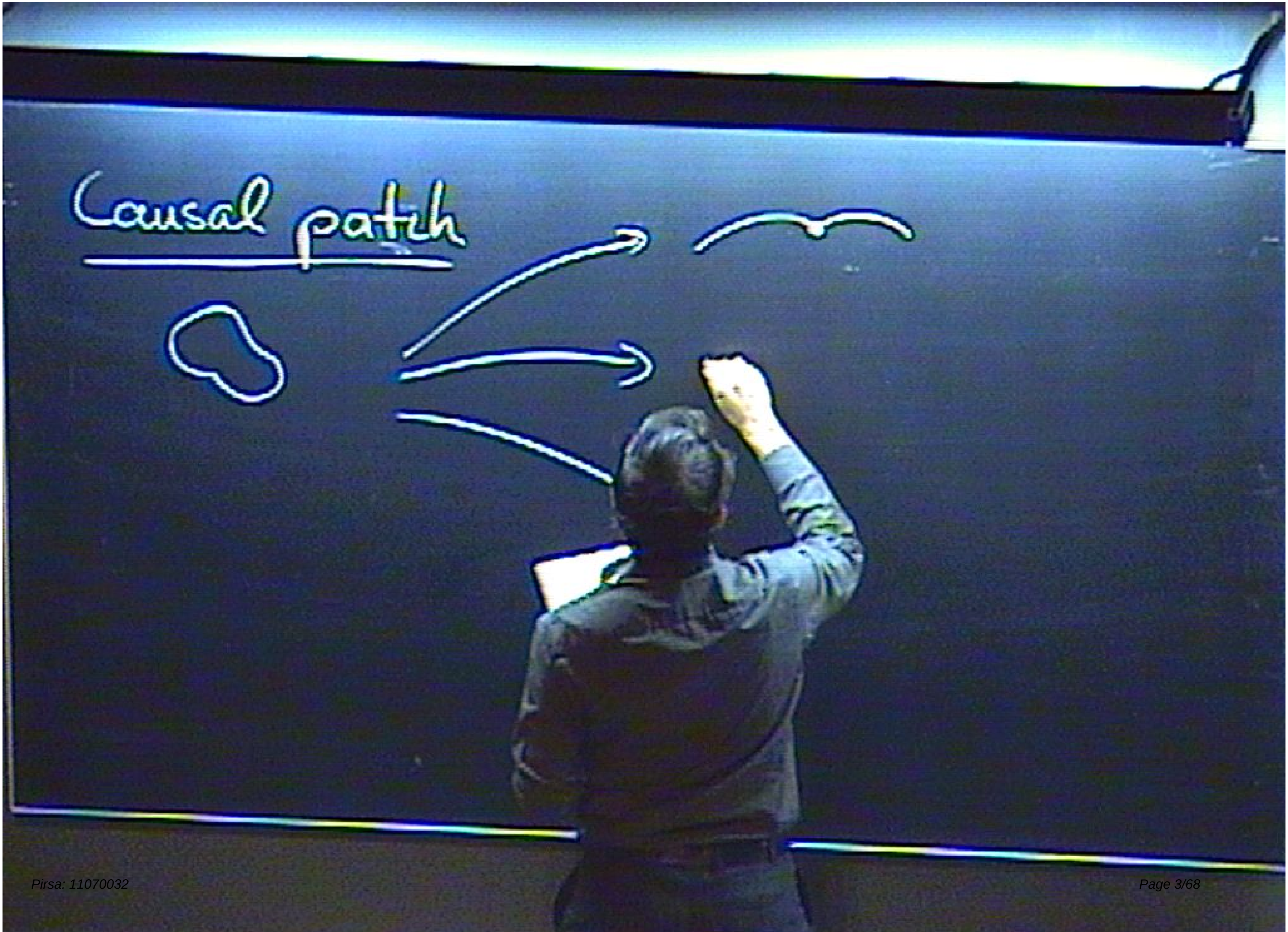
Title: The Measure Problem: Successes and Challenges

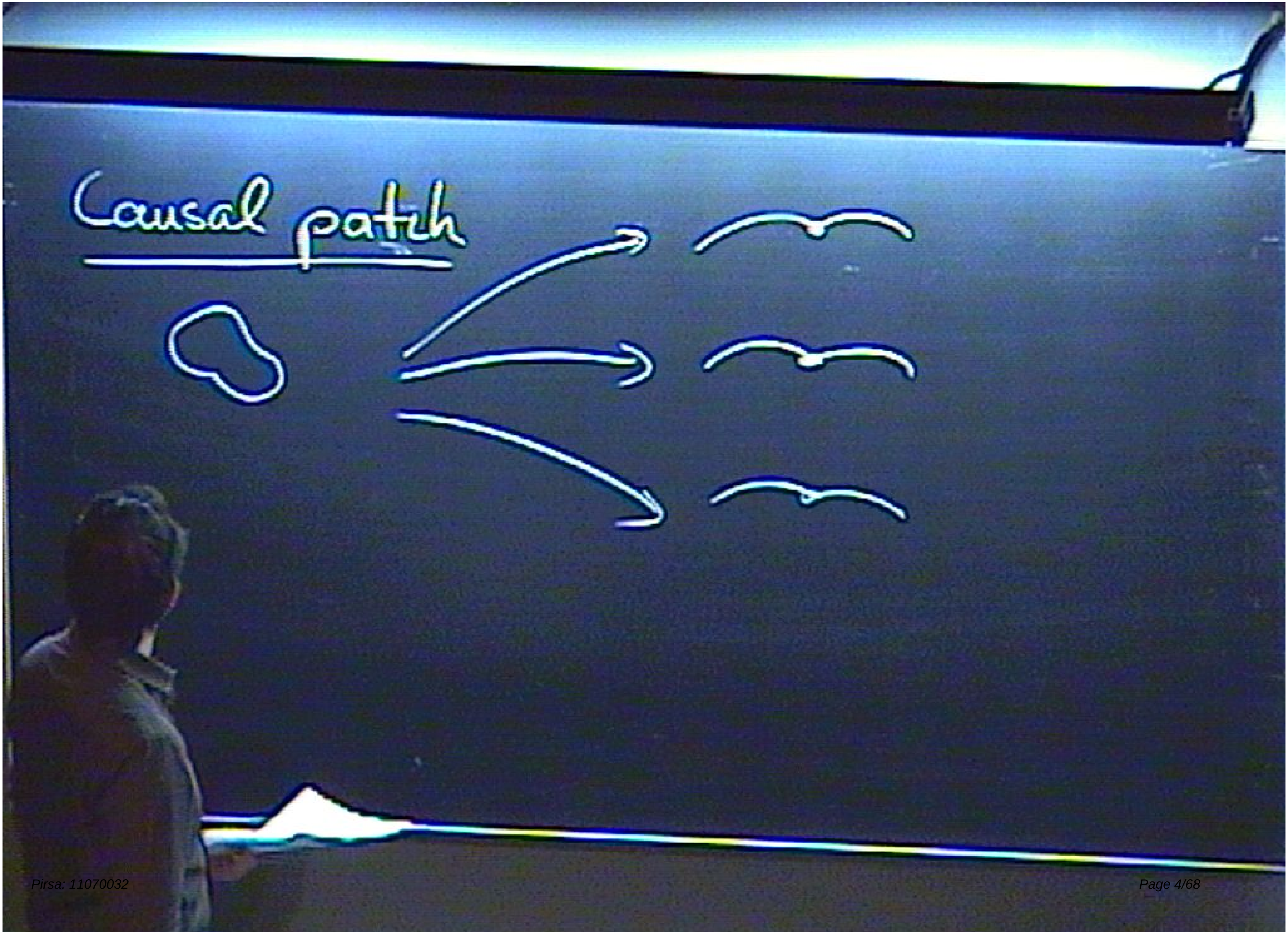
Date: Jul 13, 2011 09:50 AM

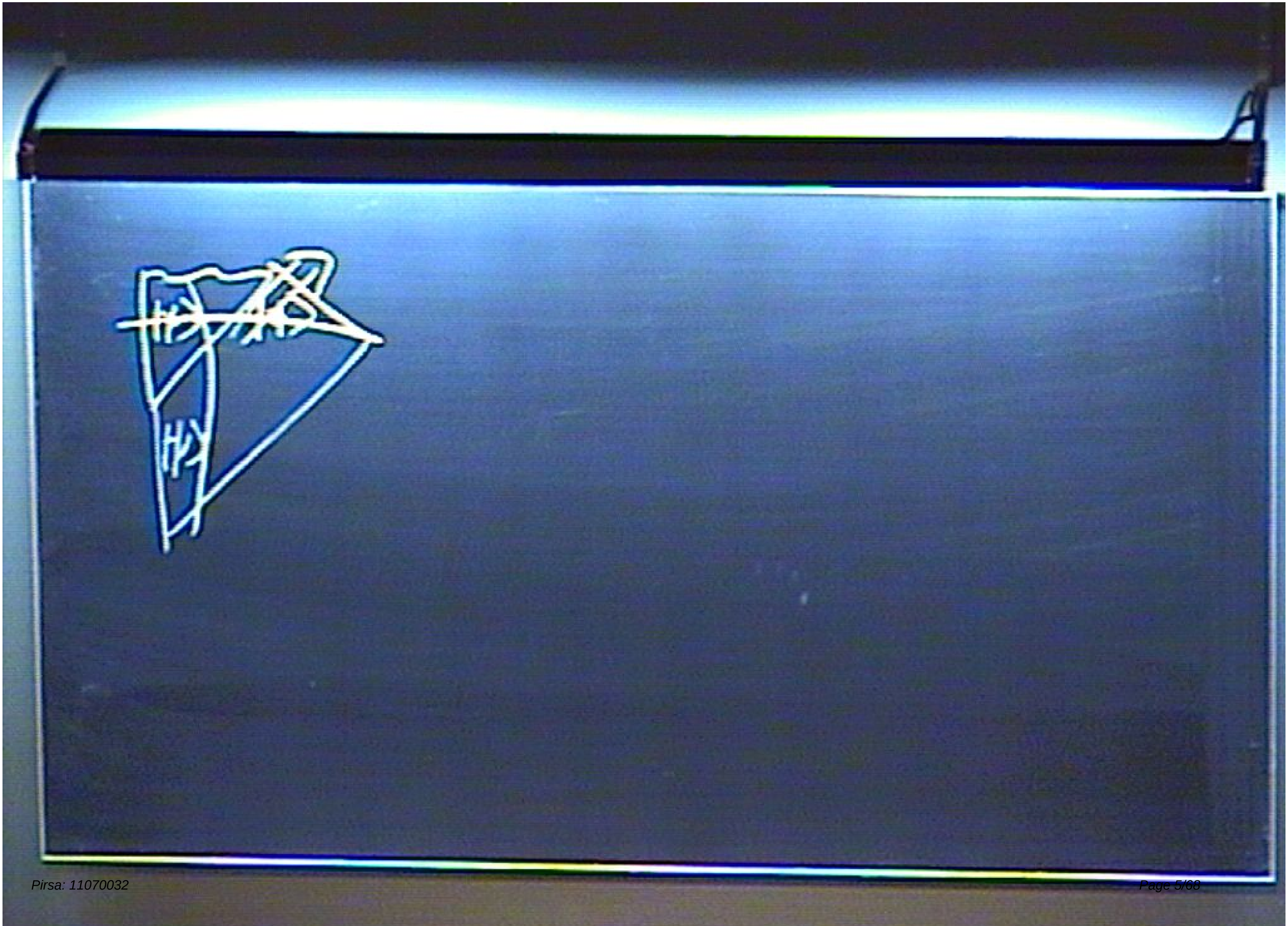
URL: http://pirsa.org/11070032

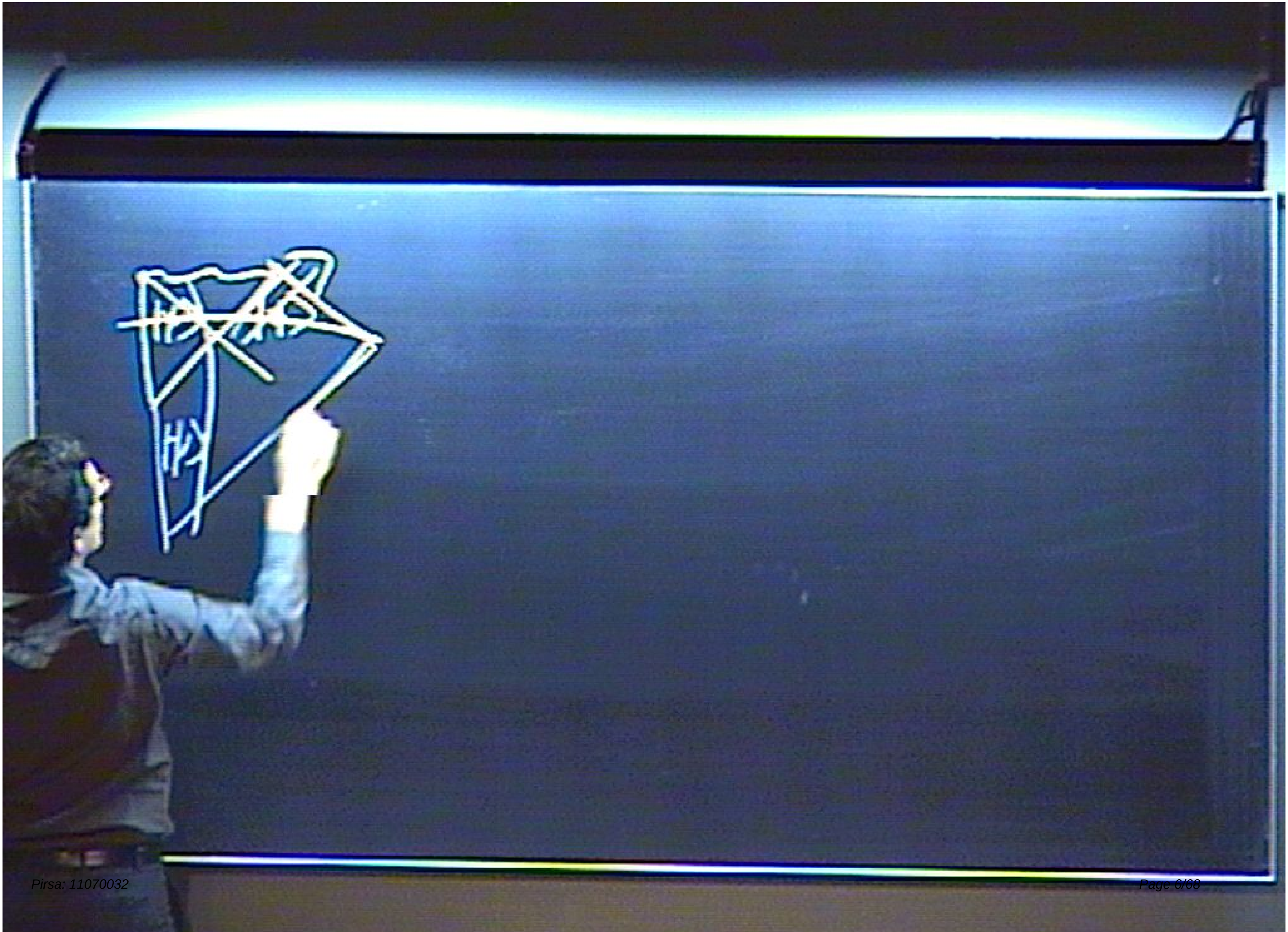
Abstract:

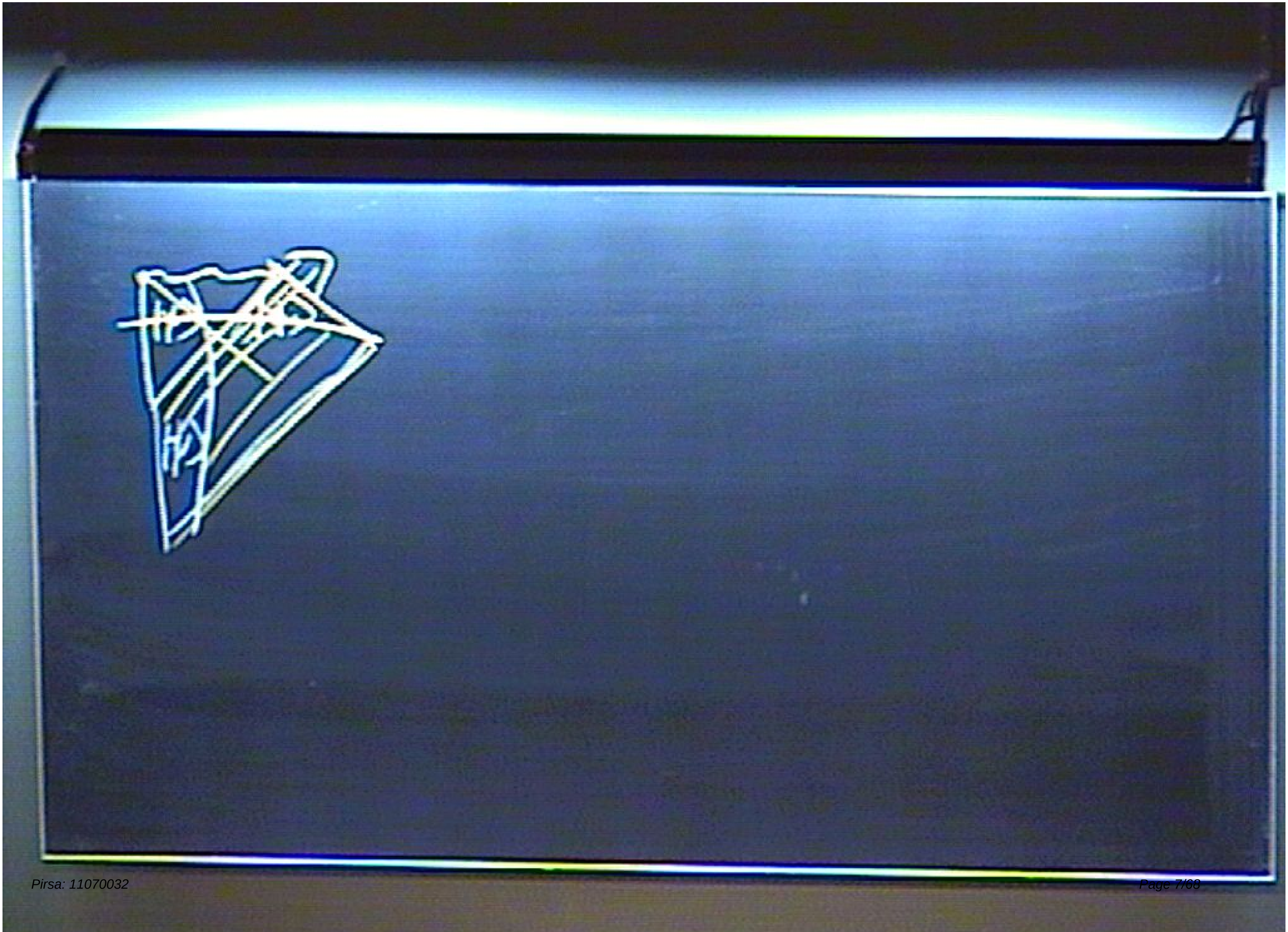

Causal patch

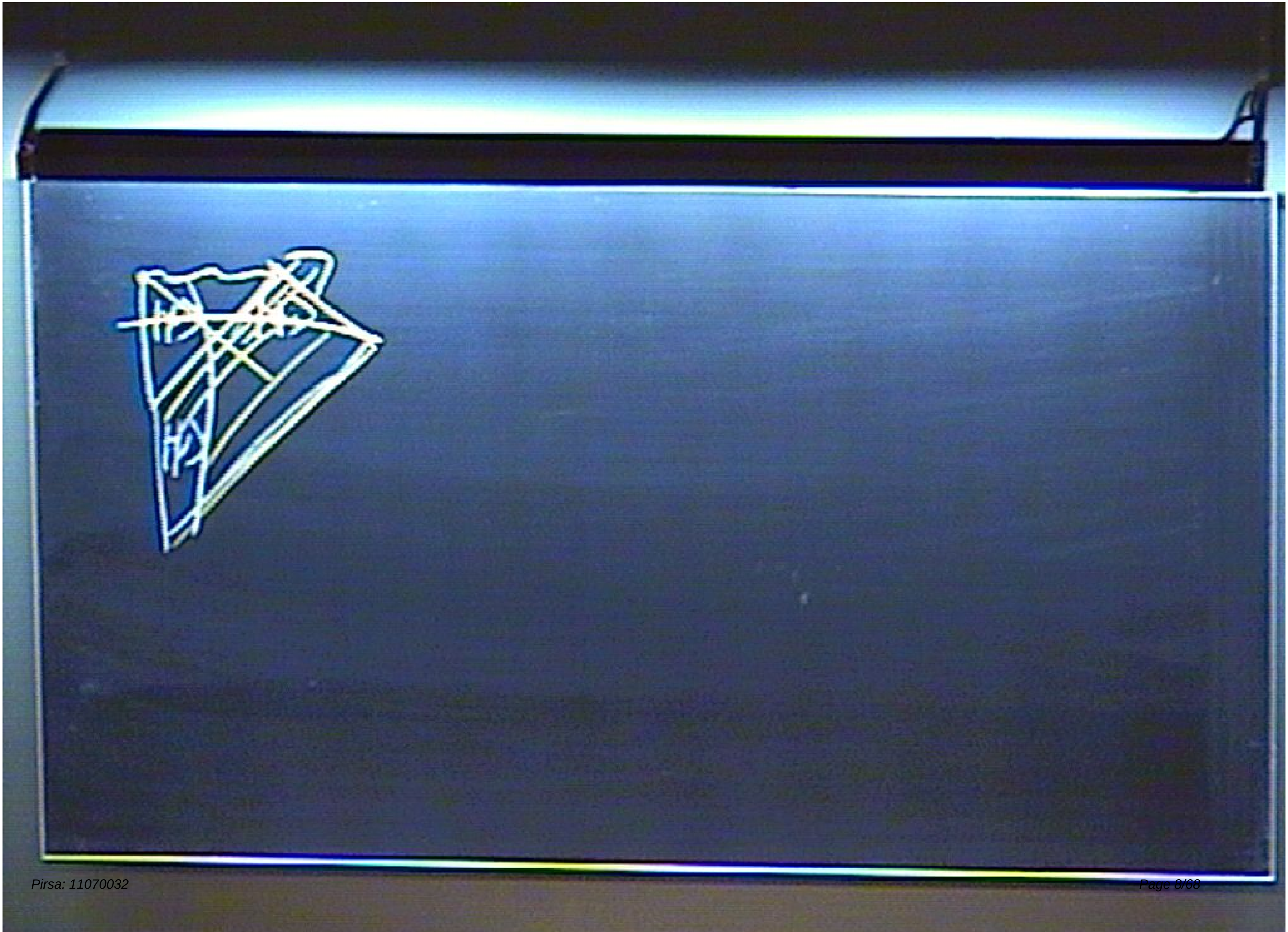

Causal patch

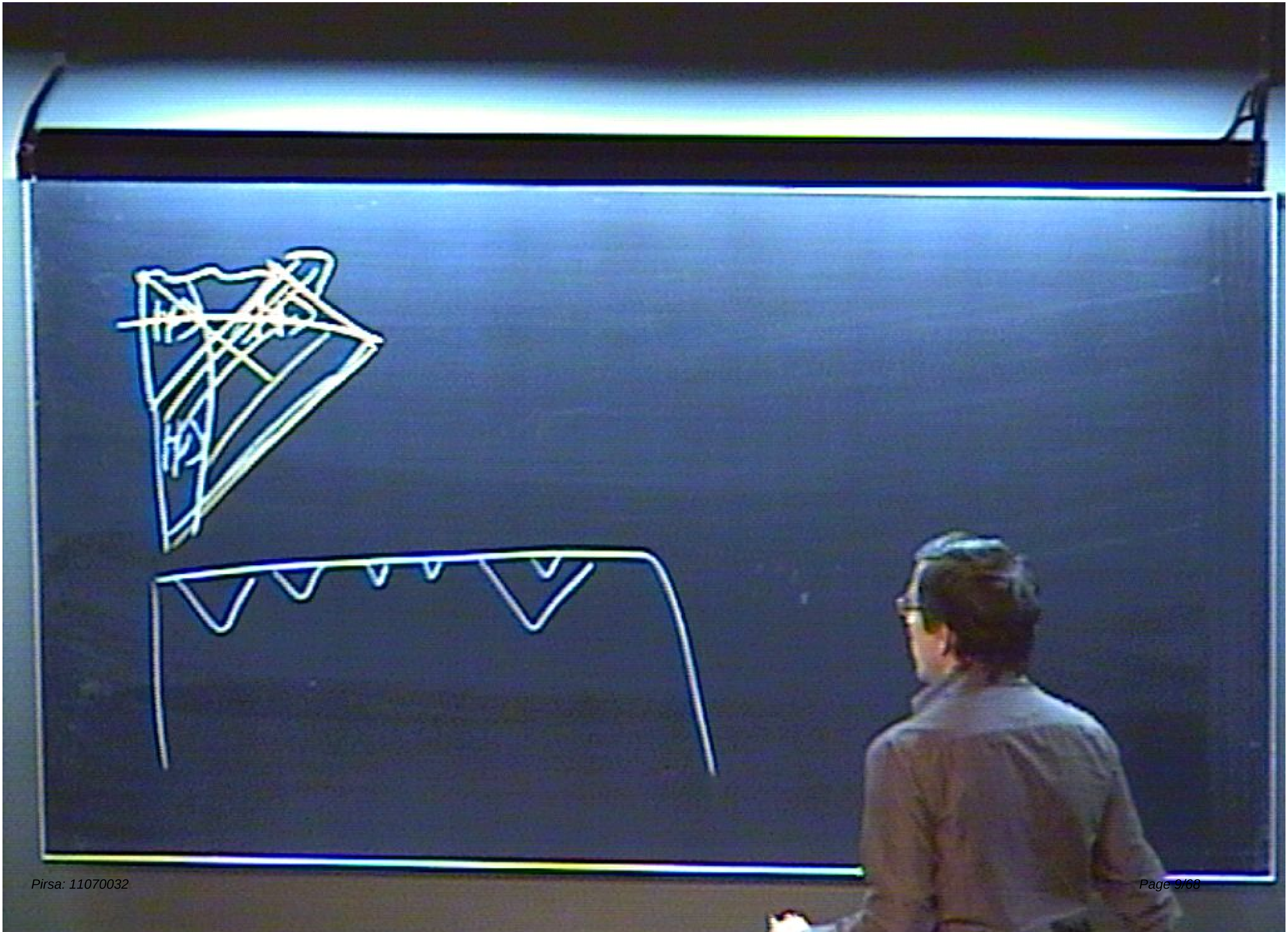

Causal patch

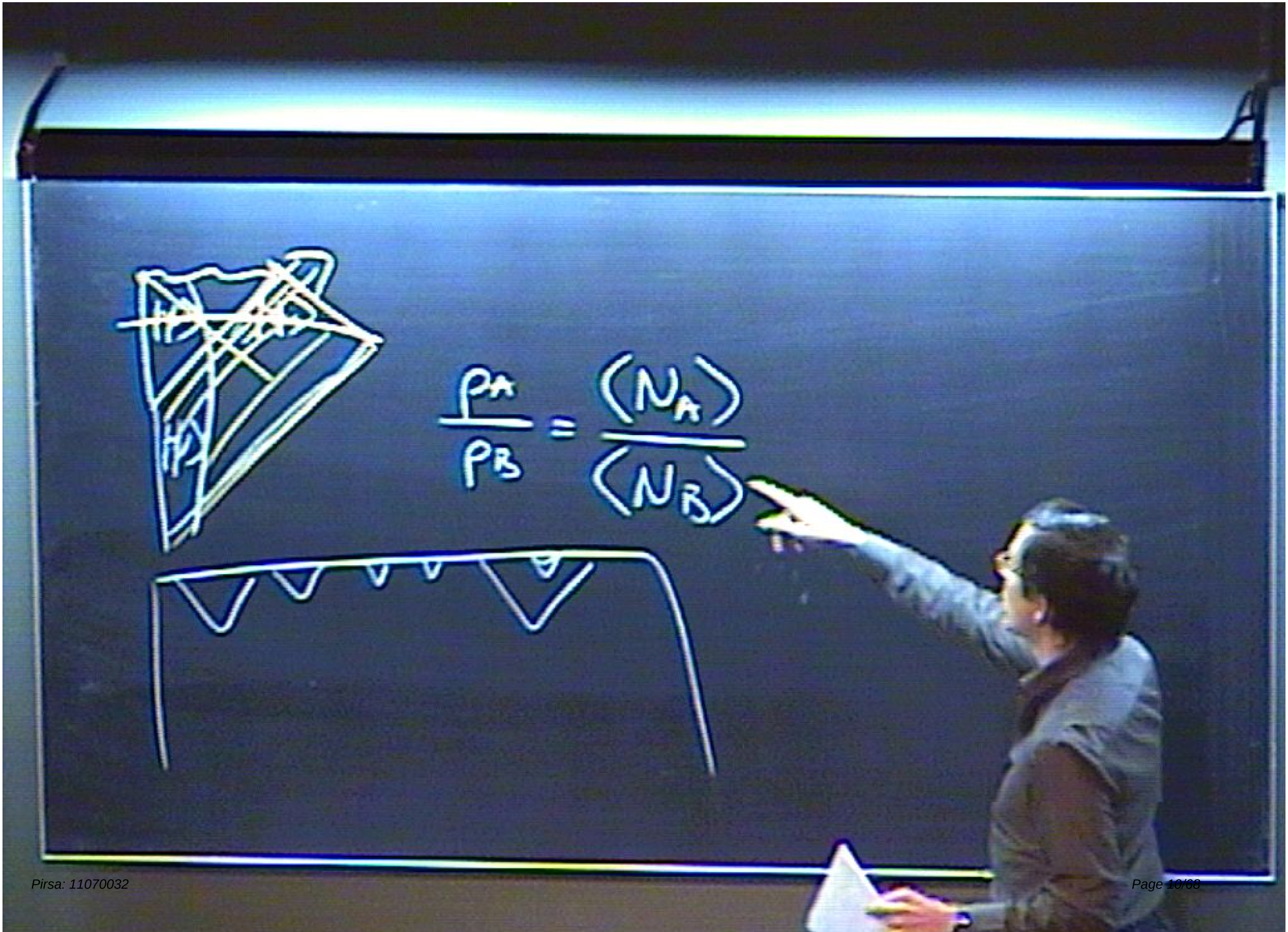


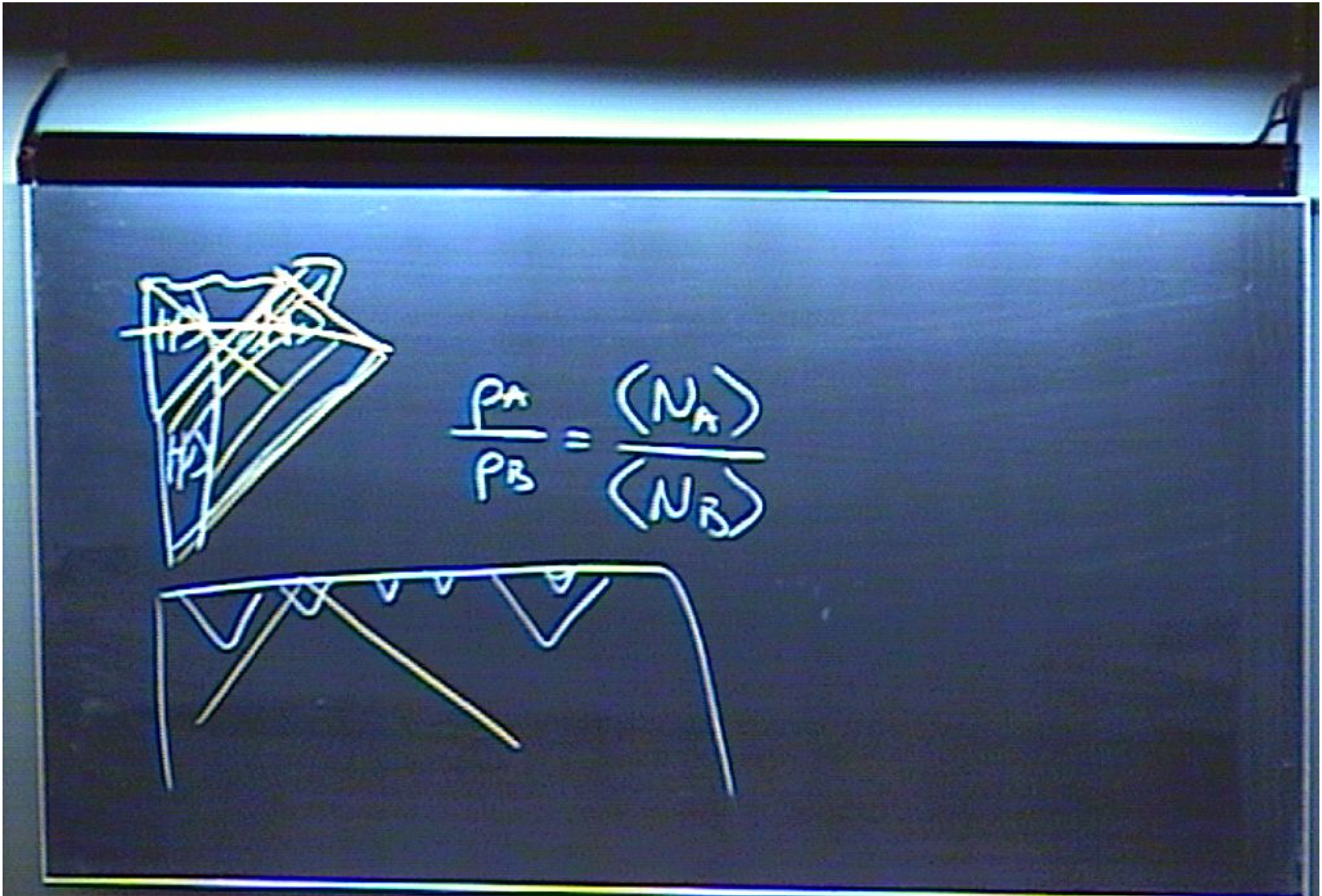









$\frac{\rho_A}{\rho_B} = \frac{\langle N_A \rangle}{\langle N_B \rangle}$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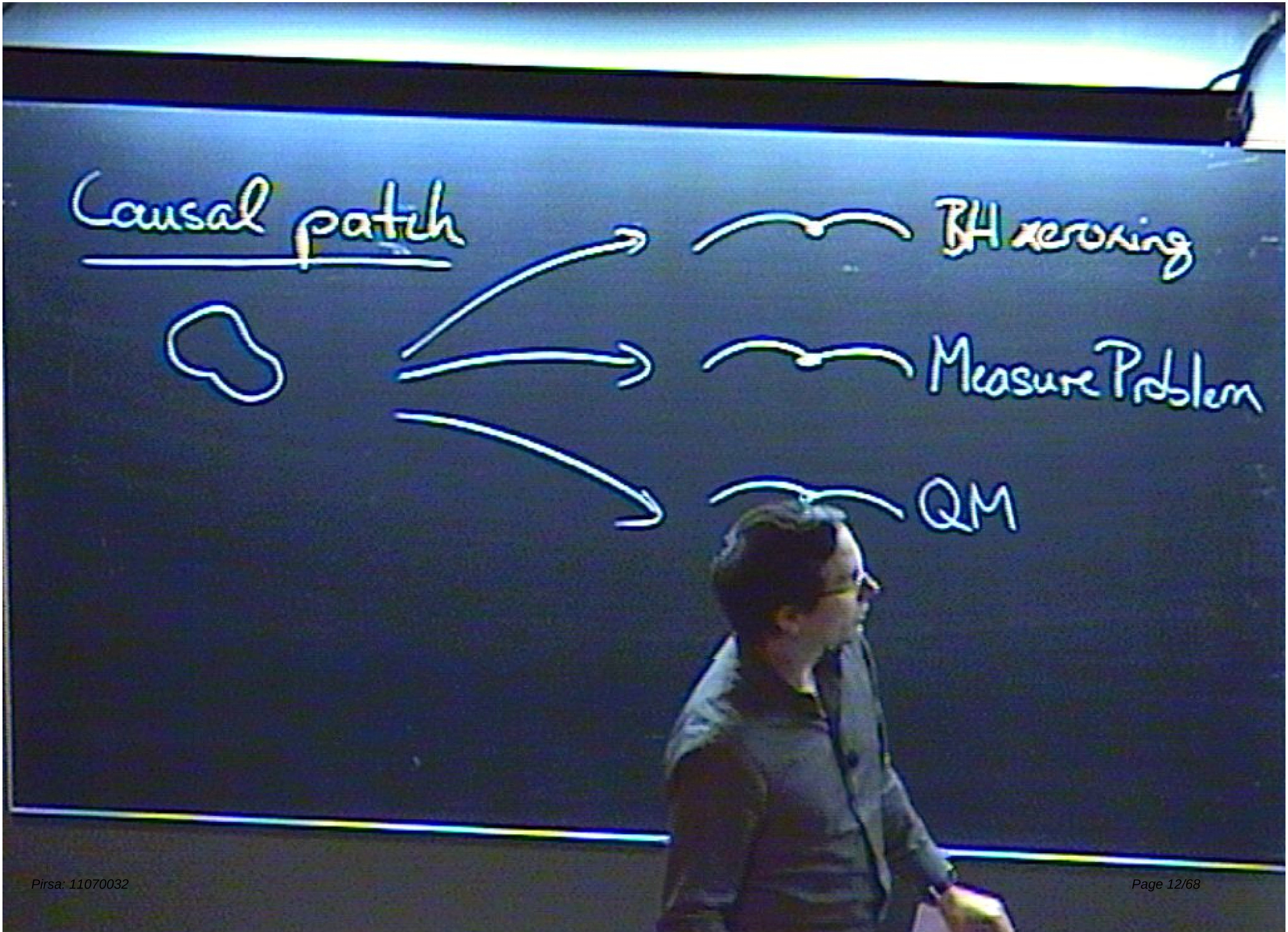
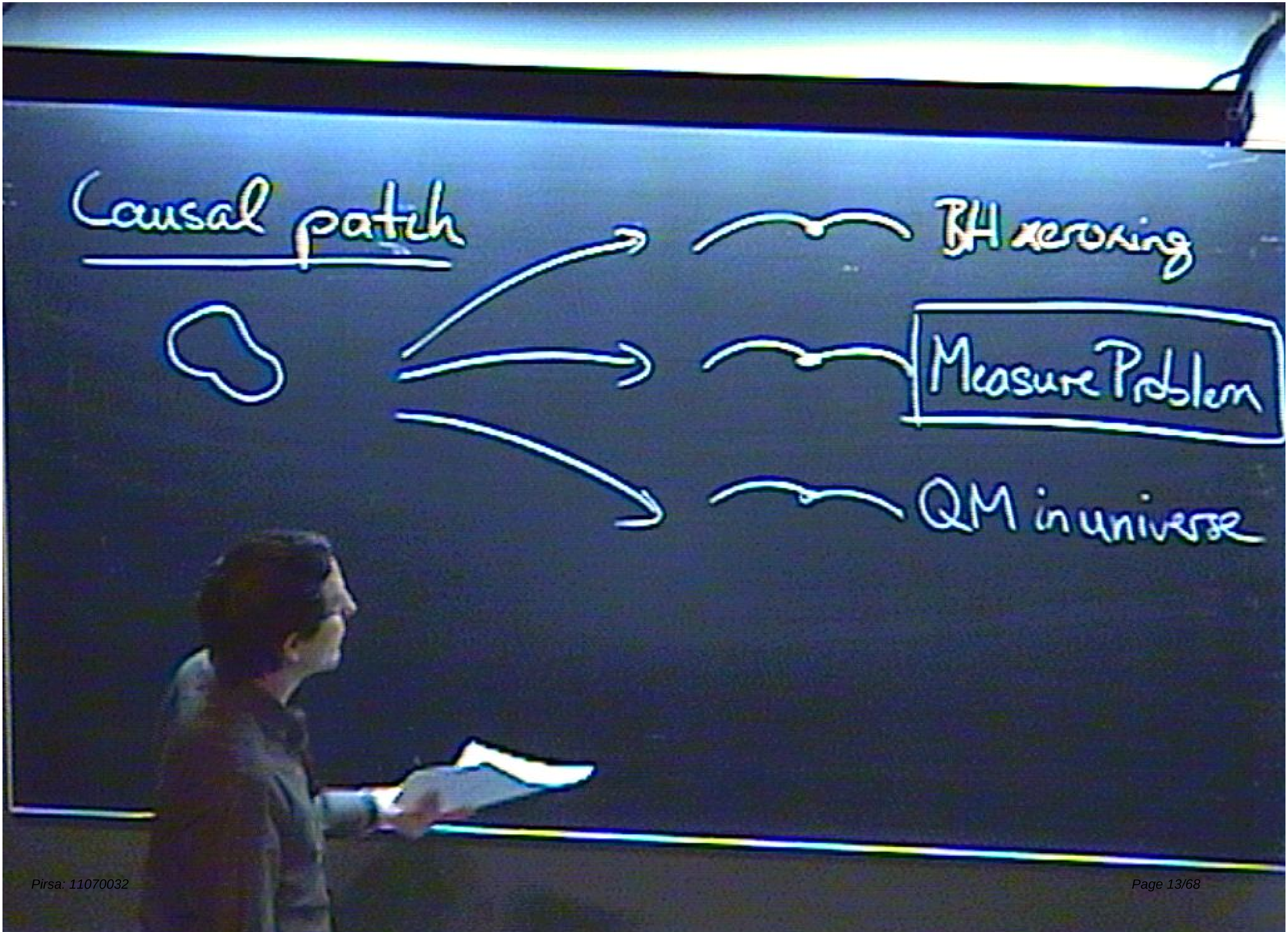

Causal patch
BH xeroxing
Measure Problem
QM


Causal patch
BH xeroxing
Measure Problem
QM in universe

Causal patch

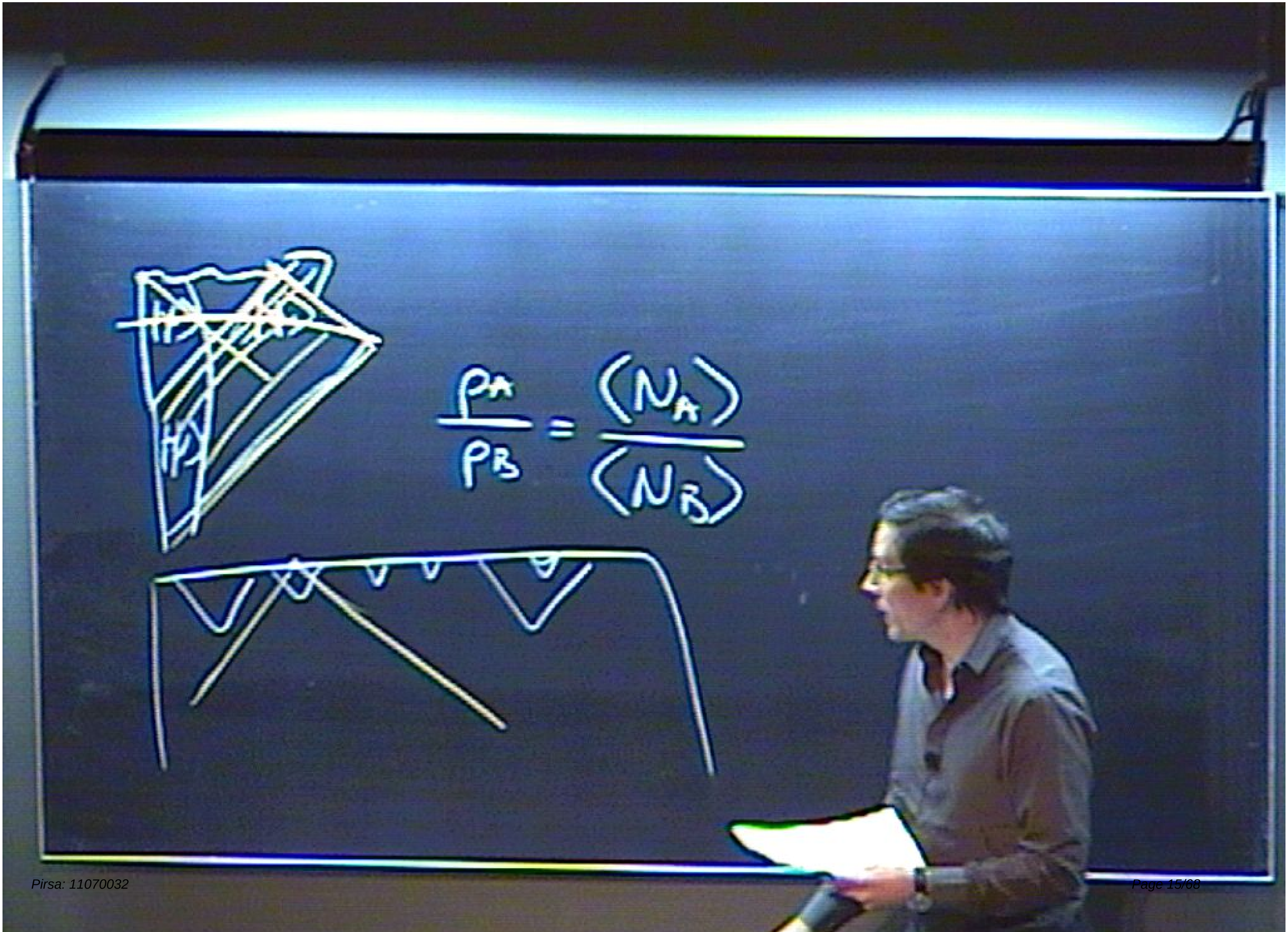
BH xeroxing

Measure Problem

QM in universe

w/ B. Freivogel, S. Leichenauer, V. Rosenhaus

w/ R. Harnik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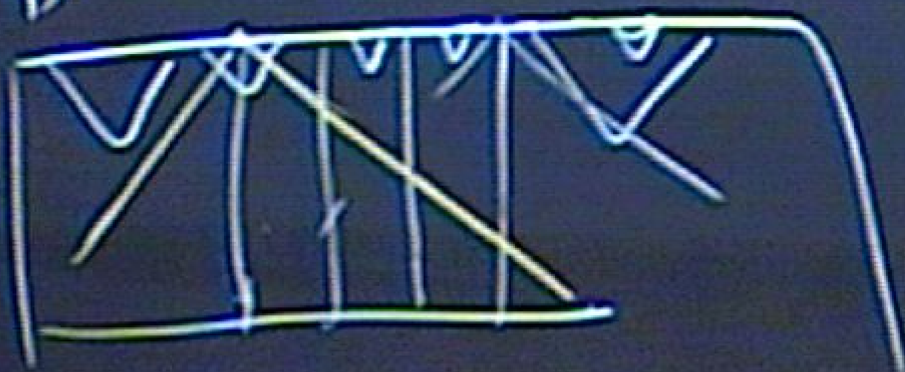

Claim: CP predicts $\log t_\Lambda \sim \log t_c \sim$
$\sim \log t_{obs}$

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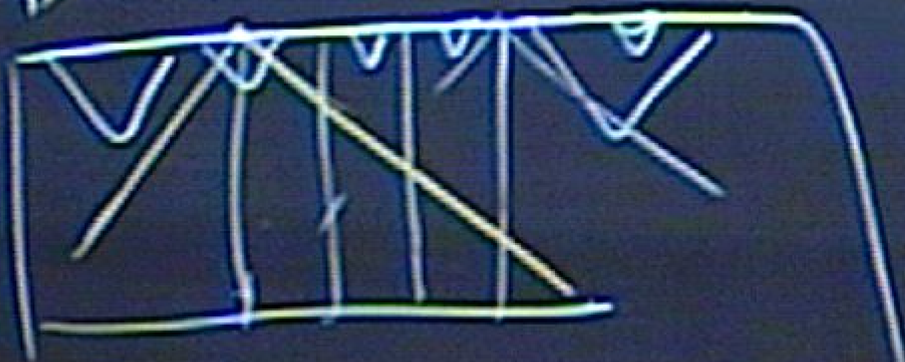

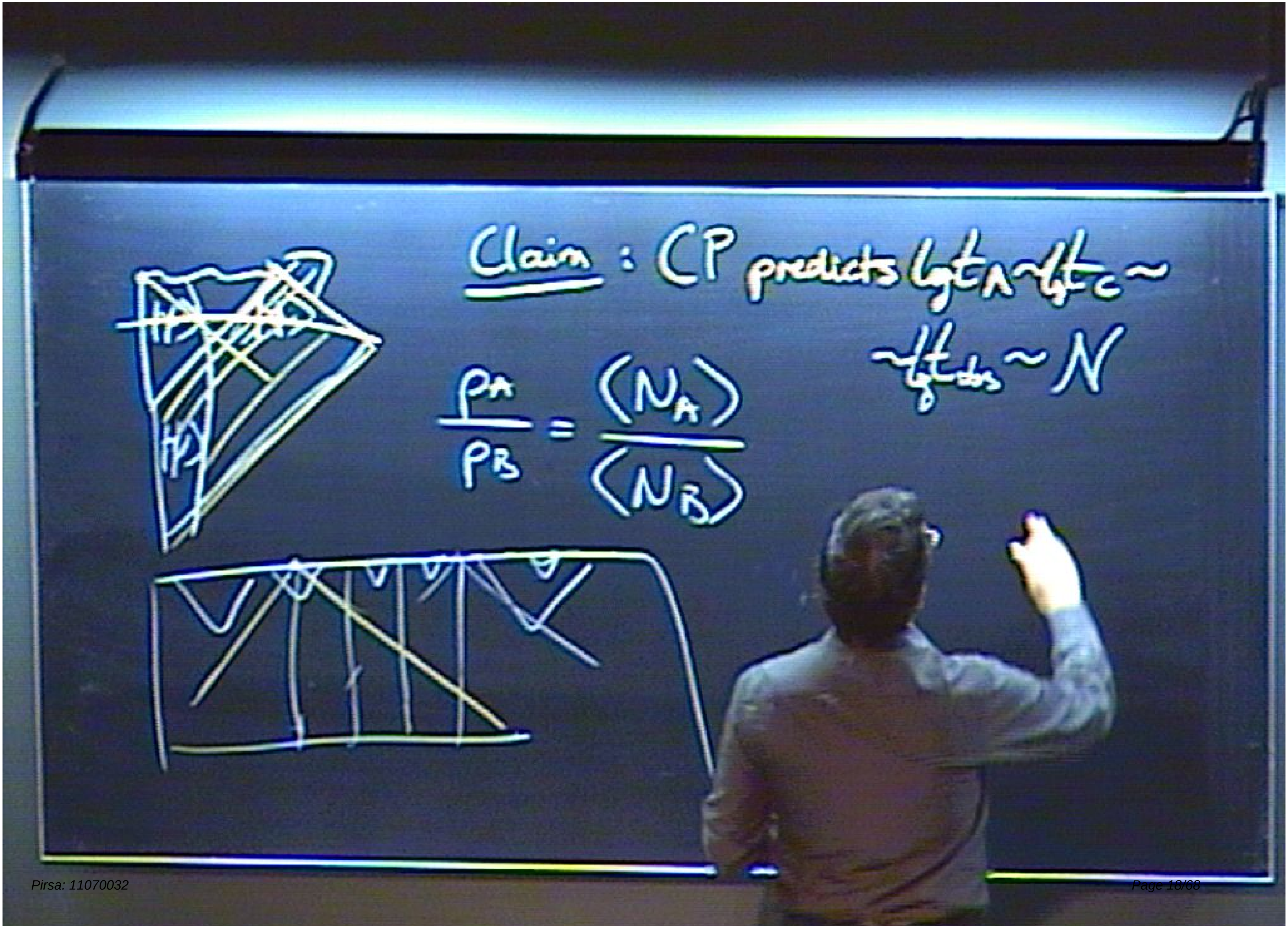
Claim : CP predicts $\log t_\Lambda \sim \log t_c \sim$
$\sim \log t_{obs} \sim N$
$\frac{\rho_A}{\rho_B} = \frac{\langle N_A \rangle}{\langle N_B \rangle}$

Claim: CP predicts $\log t_\Lambda \sim \log t_c \sim \log t_{obs} \sim \frac{1}{2}\log N$

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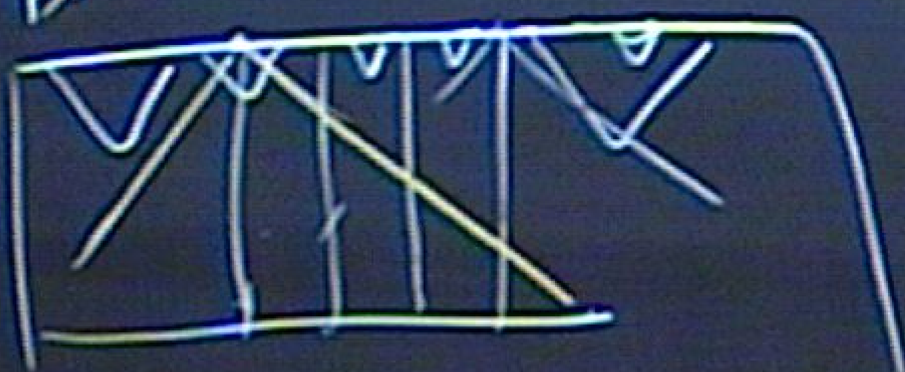
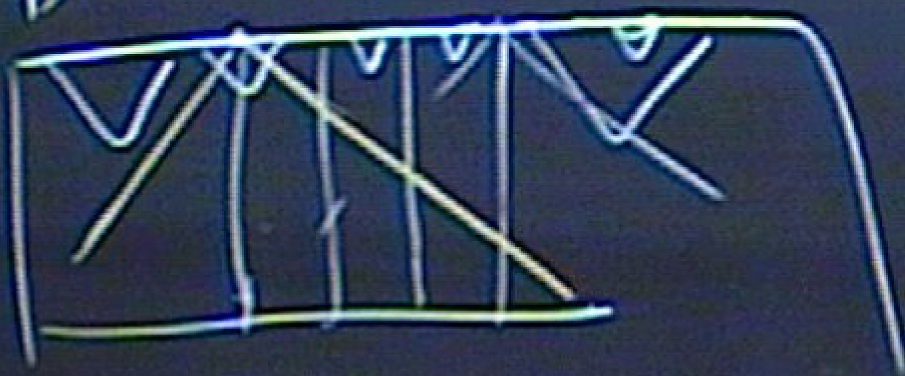


Claim: CP predicts $\log t_\Lambda \sim \log t_c \sim \log t_{obs} \sim \frac{1}{2} \log N$

$$\frac{\rho_A}{\rho_B} = \frac{\langle N_A \rangle}{\langle N_B \rangle}$$

$$\Lambda > 0$$



1) given t_{obs}, compute $\frac{d^2 P}{d\log t_c \, d\log t_\Lambda} = \frac{d^2 \tilde{P}}{d\log t_c \, d\log t_\Lambda}$

Claim: CP predicts $\log t_\Lambda \sim \log t_c \sim$
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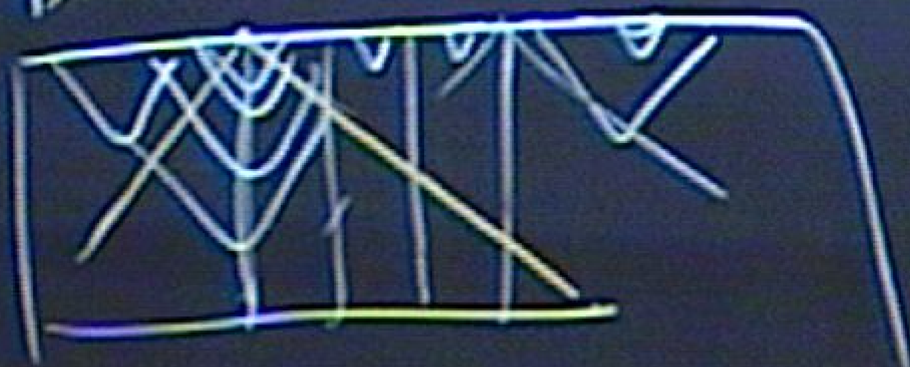

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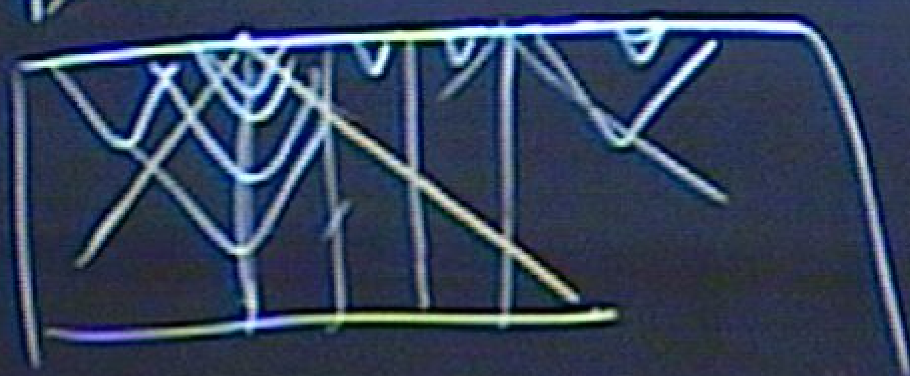
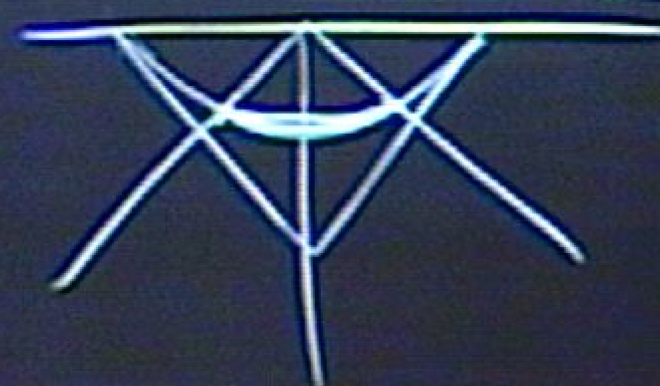
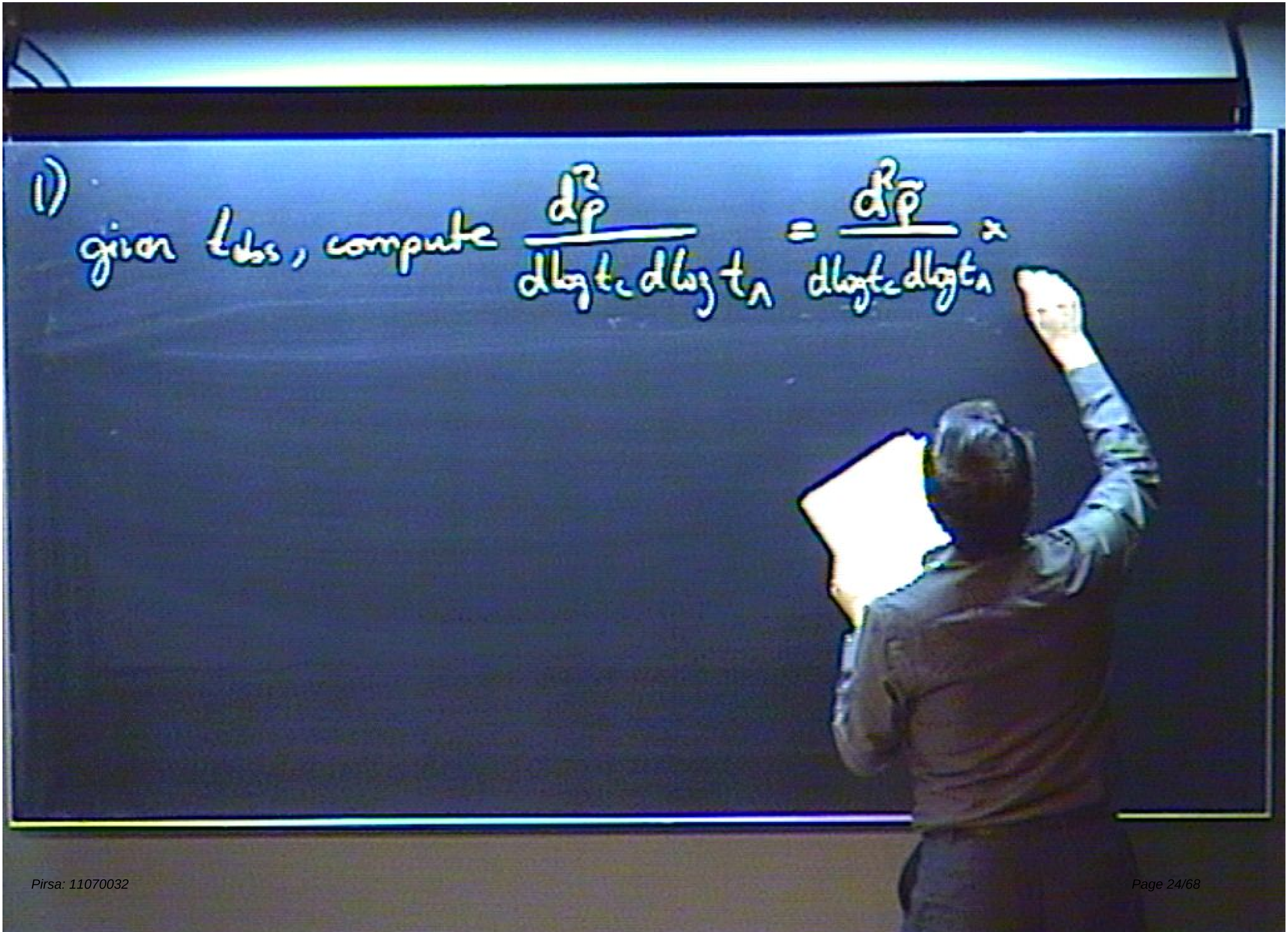
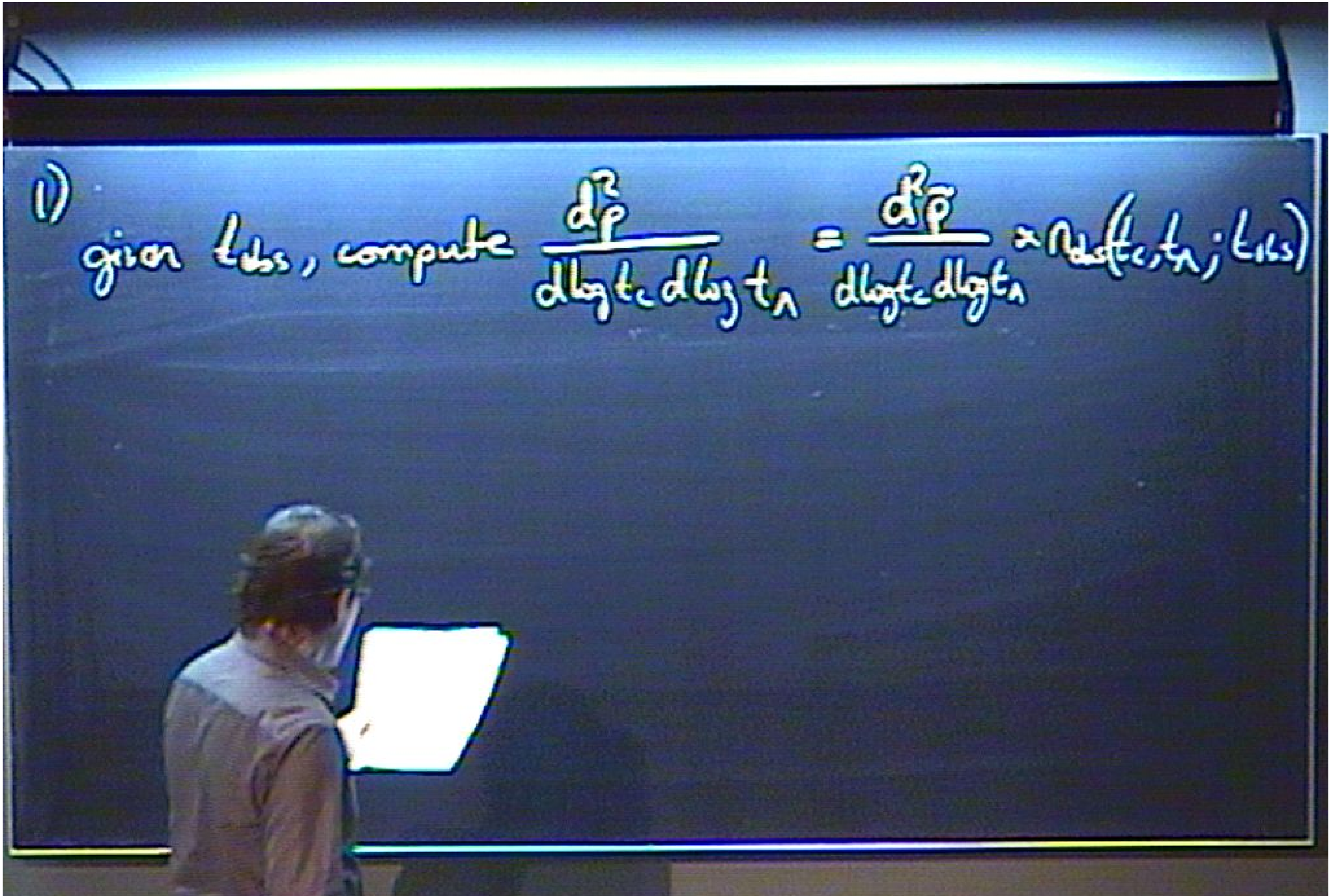





1)
given t_{obs}, compute $\frac{d^2 p}{d\log t_c \, d\log t_\Lambda} = \frac{d^2 \tilde{p}}{d\log t_c \, d\log t_\Lambda} \times$


1) given t_{obs}, compute $\frac{d^2 p}{d\log t_c \, d\log t_\Lambda} = \frac{d^2 \tilde{p}}{d\log t_c \, d\log t_\Lambda} \times n_{obs}(t_c, t_\Lambda; t_{obs})$

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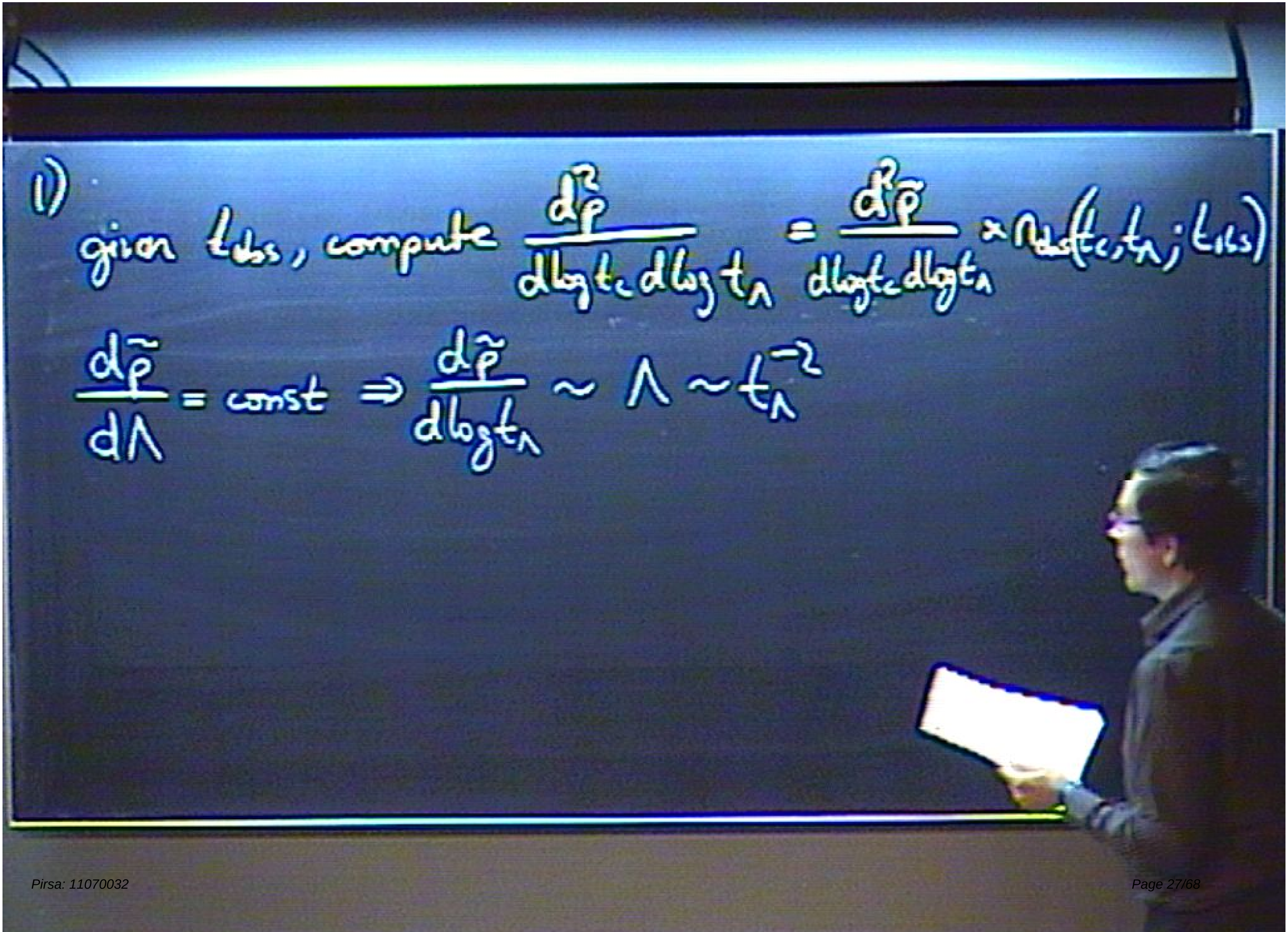
$$\frac{d\tilde{p}}{d\Lambda} = \text{const}$$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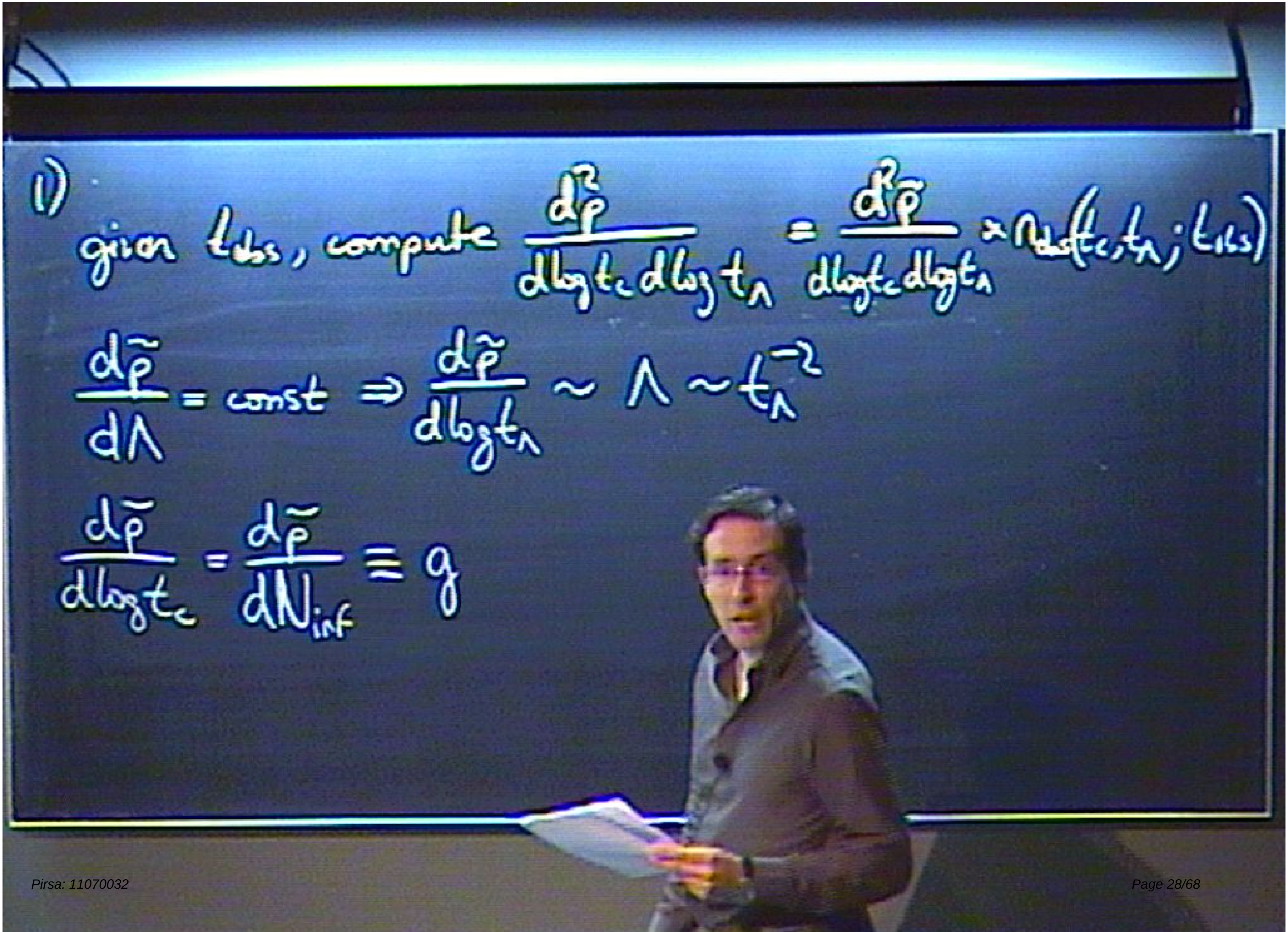
$\frac{d\tilde{p}}{d\Lambda} = \text{const} \Rightarrow \frac{d\tilde{p}}{d\log t_\Lambda} \sim \Lambda \sim t_\Lambda^{-2}$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$\frac{d\tilde{p}}{d\log t_c} = \frac{d\tilde{p}}{dN_{inf}} \equiv g$

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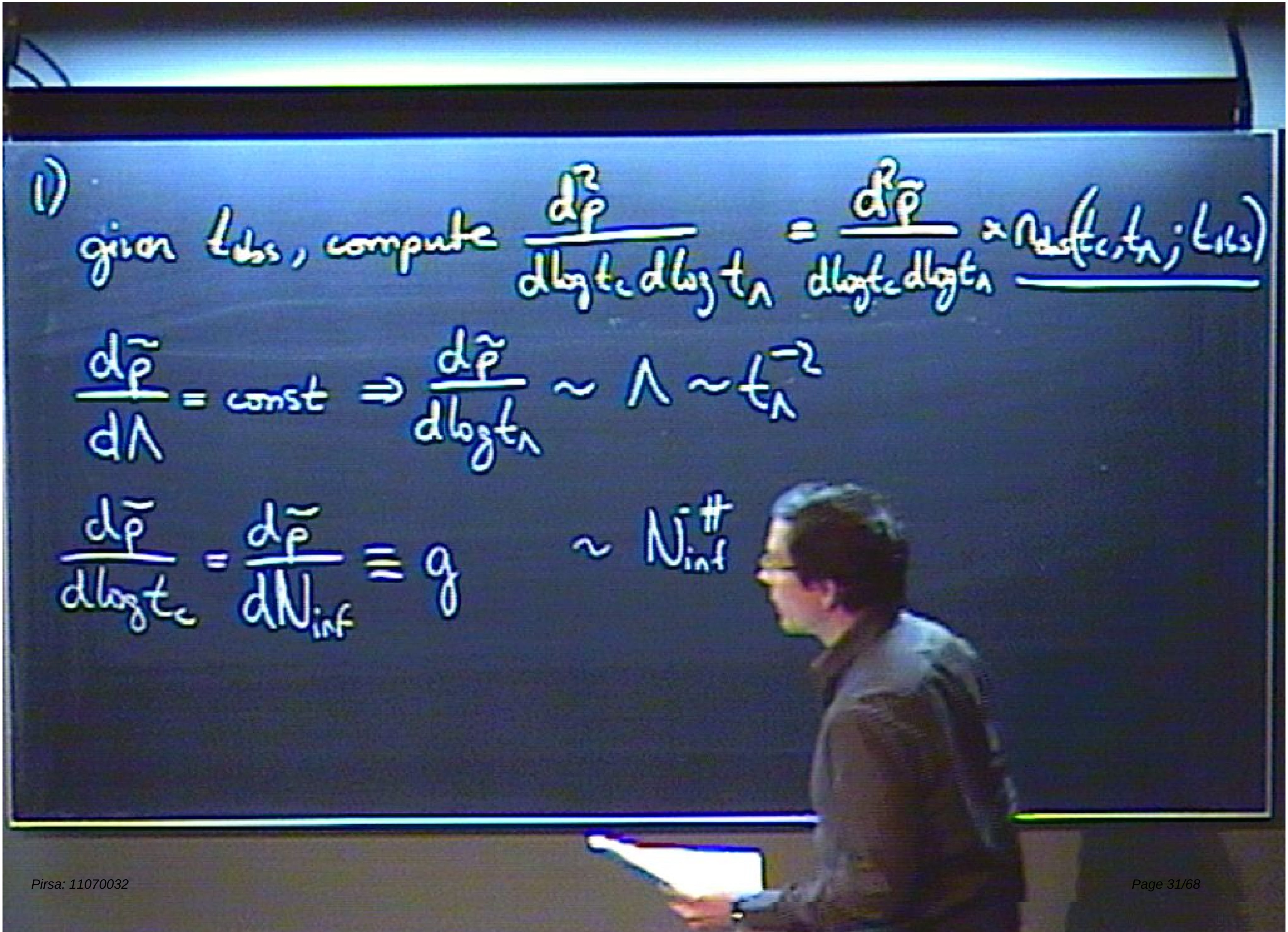
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$n_{obs} = \propto M_{CP}$

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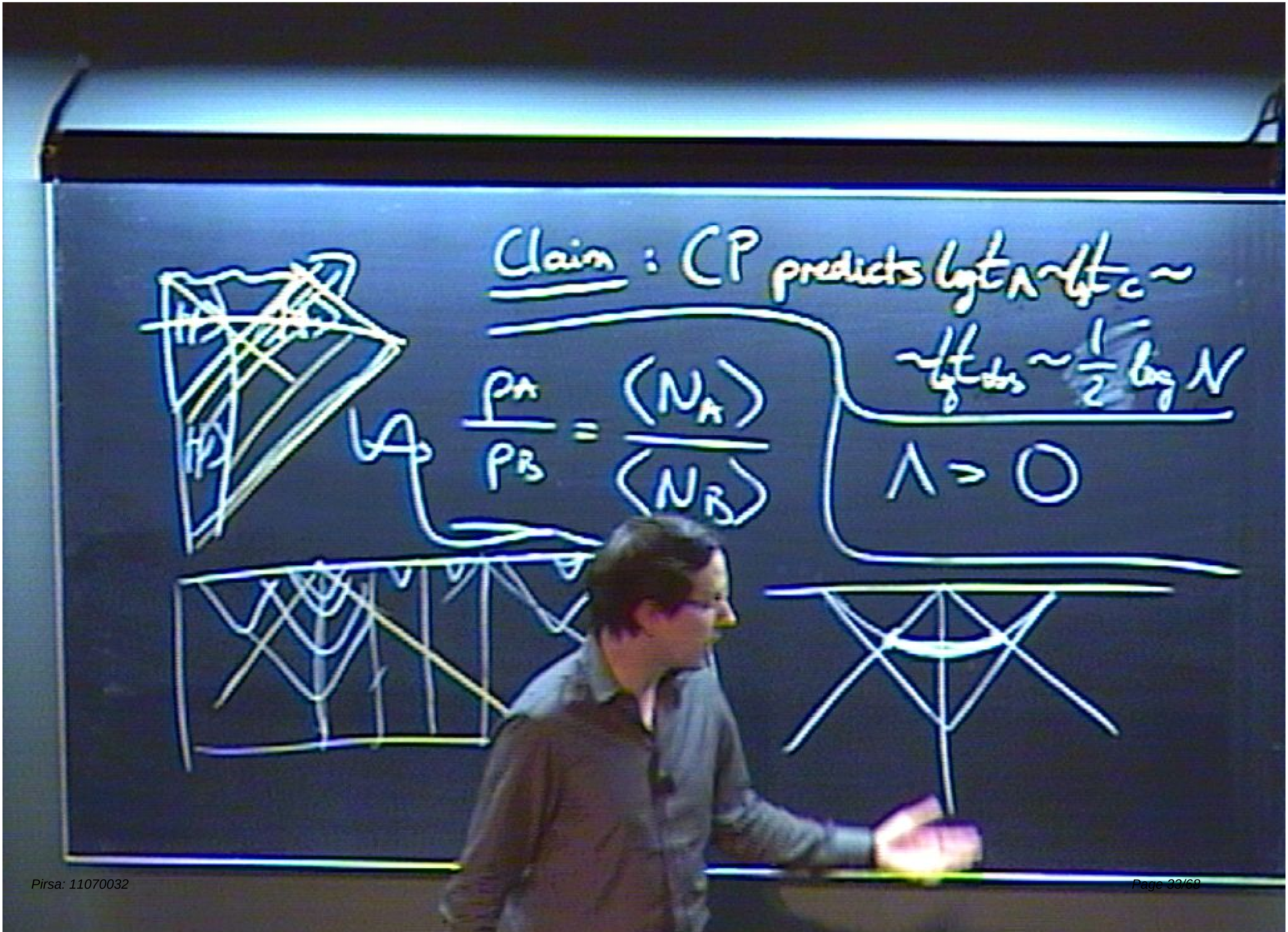

Claim: CP predicts log t_Λ ~ log t_c ~
~ log t_obs ~ 1/2 log N
ρ_A / ρ_B = ⟨N_A⟩ / ⟨N_B⟩
Λ > 0

1)

given t_{obs}, compute $\frac{d^2 p}{d\log t_c \, d\log t_\Lambda} = \frac{d^2 \tilde{p}}{d\log t_c \, d\log t_\Lambda} \propto n_{obs}(t_c, t_\Lambda; t_{obs})$

$n_{obs} = \alpha M_{CP}$

$$\frac{d\tilde{p}}{d\Lambda} = \text{const} \Rightarrow \frac{d\tilde{p}}{d\log t_\Lambda} \sim \Lambda \sim t_\Lambda^{-2}$$

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$\dfrac{d\tilde{p}}{d\log t_c} = \dfrac{d\tilde{p}}{dN_{inf}} \equiv g \quad \sim N_{inf}^{-\#}$

1)

given t_{obs}, compute $\frac{d^2\rho}{d\log t_c \, d\log t_\Lambda} = \frac{d^2\tilde{\rho}}{d\log t_c \, d\log t_\Lambda} \times n_{obs}(t_c, t_\Lambda; t_{obs})$

$$\frac{d\tilde{\rho}}{d\Lambda} = \text{const} \Rightarrow \frac{d\tilde{\rho}}{d\log t_\Lambda} \sim \Lambda \sim t_\Lambda^{-2}$$

$n_{obs} \propto M_{CP}$

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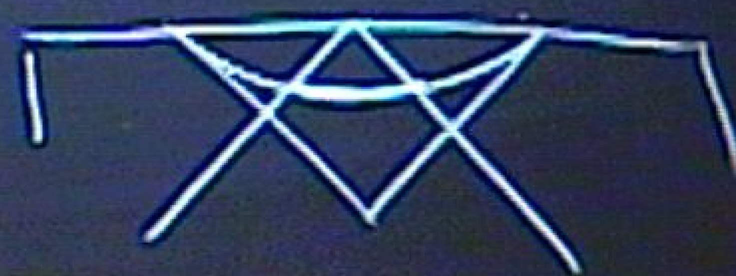

$t_c \ll t_\Lambda$:

$$ds^2 = -dt^2 + a^2(t)\left[d\chi^2 + \sinh^2\chi \, d\Omega_2^2\right]$$

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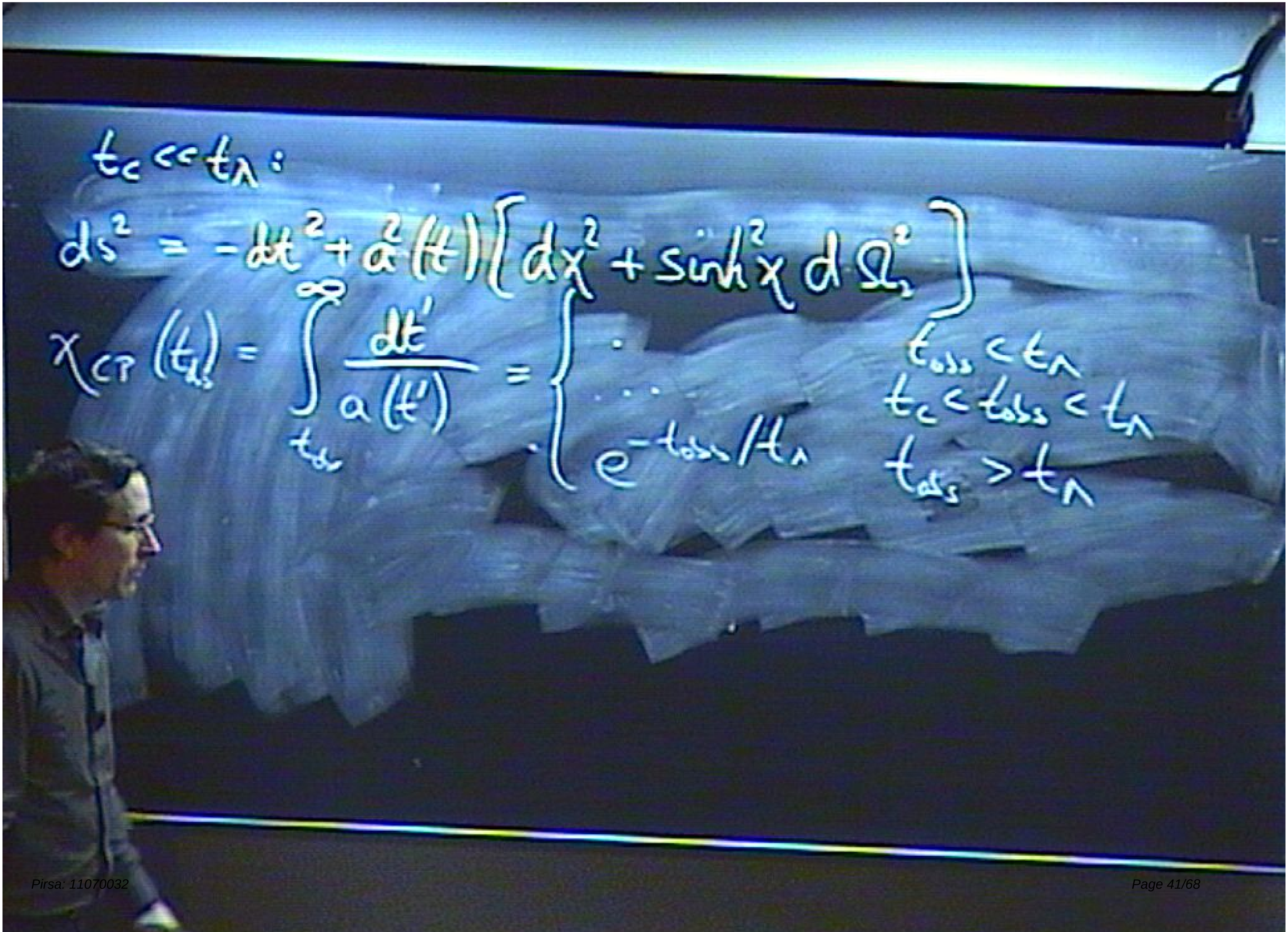
χ_{CP}


$t_c \ll t_\Lambda$:
$ds^2 = -dt^2 + a^2(t)\left[d\chi^2 + \sinh^2\chi \, d\Omega_2^2\right]$
$\chi_{CP}(t_{obs}) = \int_{t_{obs}}^{\infty} \frac{dt'}{a(t')} = \begin{cases} \cdot & t_{obs} < t_\Lambda \\ \cdots & t_c < t_{obs} < t_\Lambda \\ e^{-t_{obs}/t_\Lambda} & t_{obs} > t_\Lambda \end{cases}$

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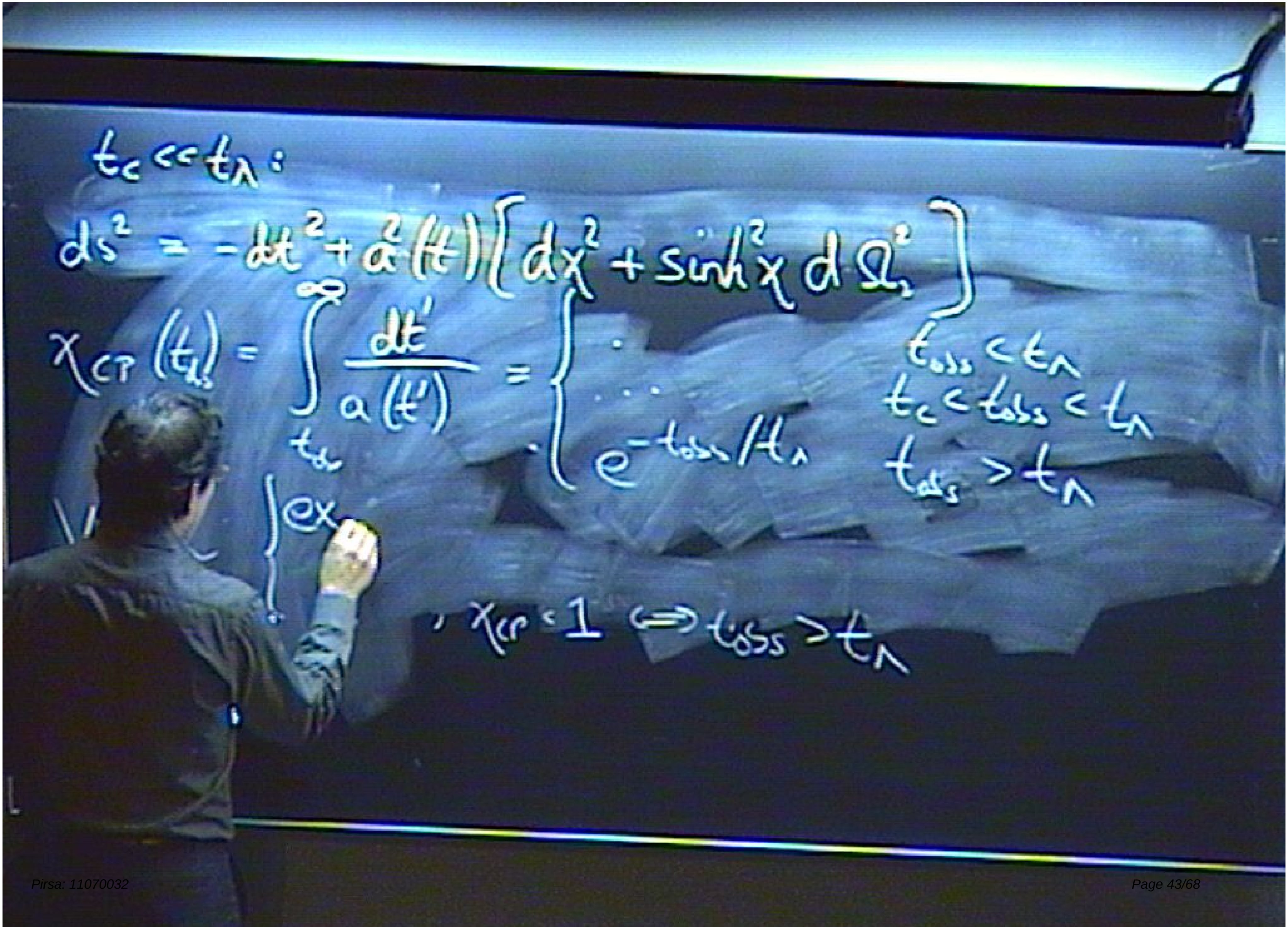
V_{CP}^{com}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ex
$\chi_{CP} < 1 \iff t_{obs} > t_\Lambda$

$t_c \ll t_\Lambda$:

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$$\ldots^{m}_{CP} \sim \begin{cases} \exp(2\chi_{CP}), & \chi_{CP} > 1, \Leftrightarrow t_{obs} < t_\Lambda \\ \chi_{CP}^3, & \chi_{CP} < 1 \Leftrightarrow t_{obs} > t_\Lambda \end{cases}$$

$t_c \ll t_\Lambda$:

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$$V_{CP}^{com} \sim \begin{cases} \exp(2\chi_{CP}), & \chi_{CP} > 1 \Leftrightarrow t_{obs} < t_\Lambda \\ \quad , & \chi_{CP} < 1 \Leftrightarrow t_{obs} > t_\Lambda \end{cases}$$

$$M_{CP}^{com} = V_{CP}^{com} \, a^3(t_{obs}) = t_c V_{CP}^{com}(t_{obs})$$

$t_c \ll t_\Lambda$:

$$ds^2 = -dt^2 + a^2(t)\left[d\chi^2 + \sinh^2\chi \, d\Omega_2^2\right]$$

$$\chi_{CP}(t_{obs}) = \int_{t_{obs}}^{\infty} \frac{dt'}{a(t')} = \begin{cases} \cdot & t_{obs} < t_\Lambda \\ \cdots & t_c < t_{obs} < t_\Lambda \\ e^{-t_{obs}/t_\Lambda} & t_{obs} > t_\Lambda \end{cases}$$

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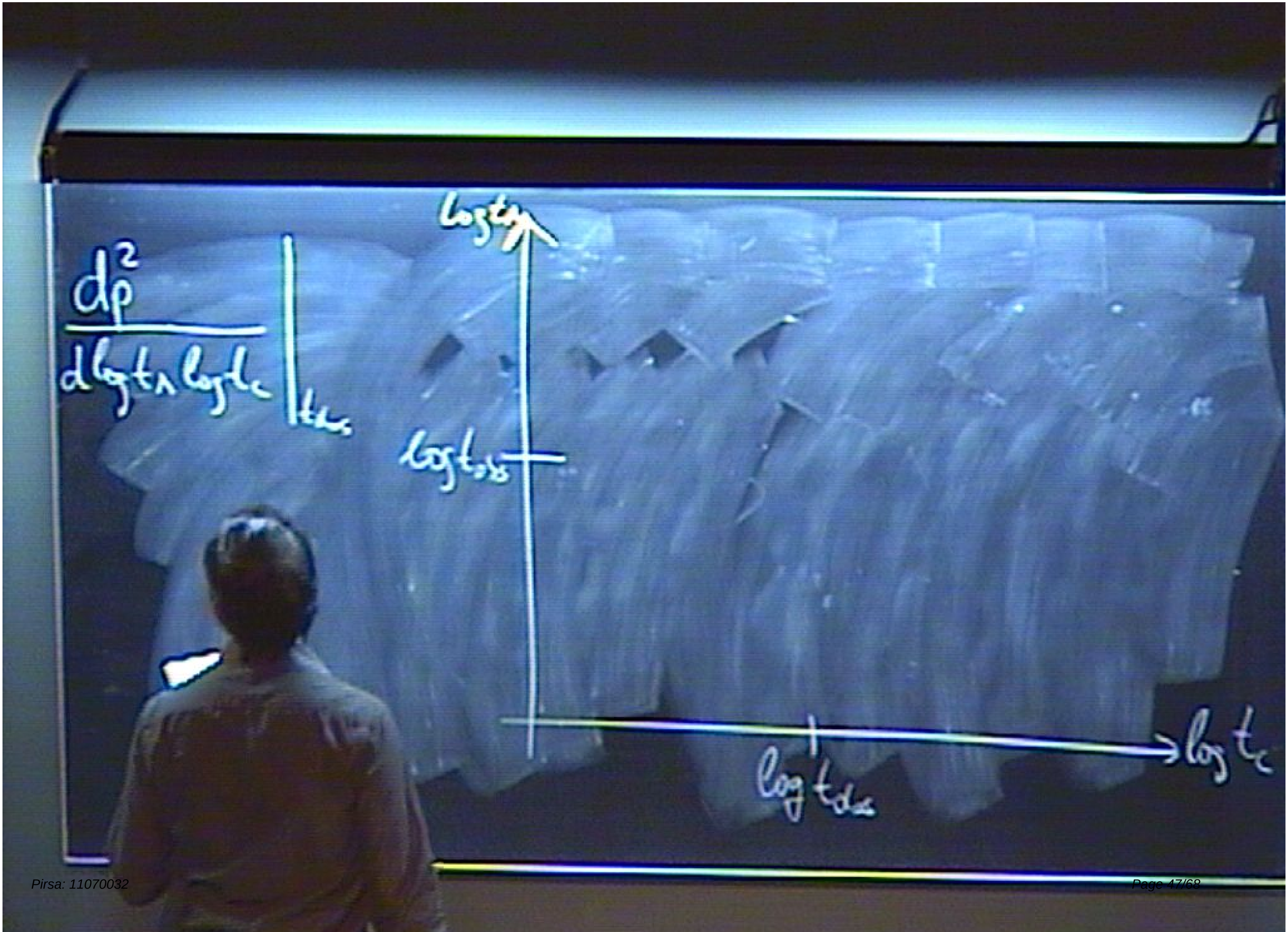
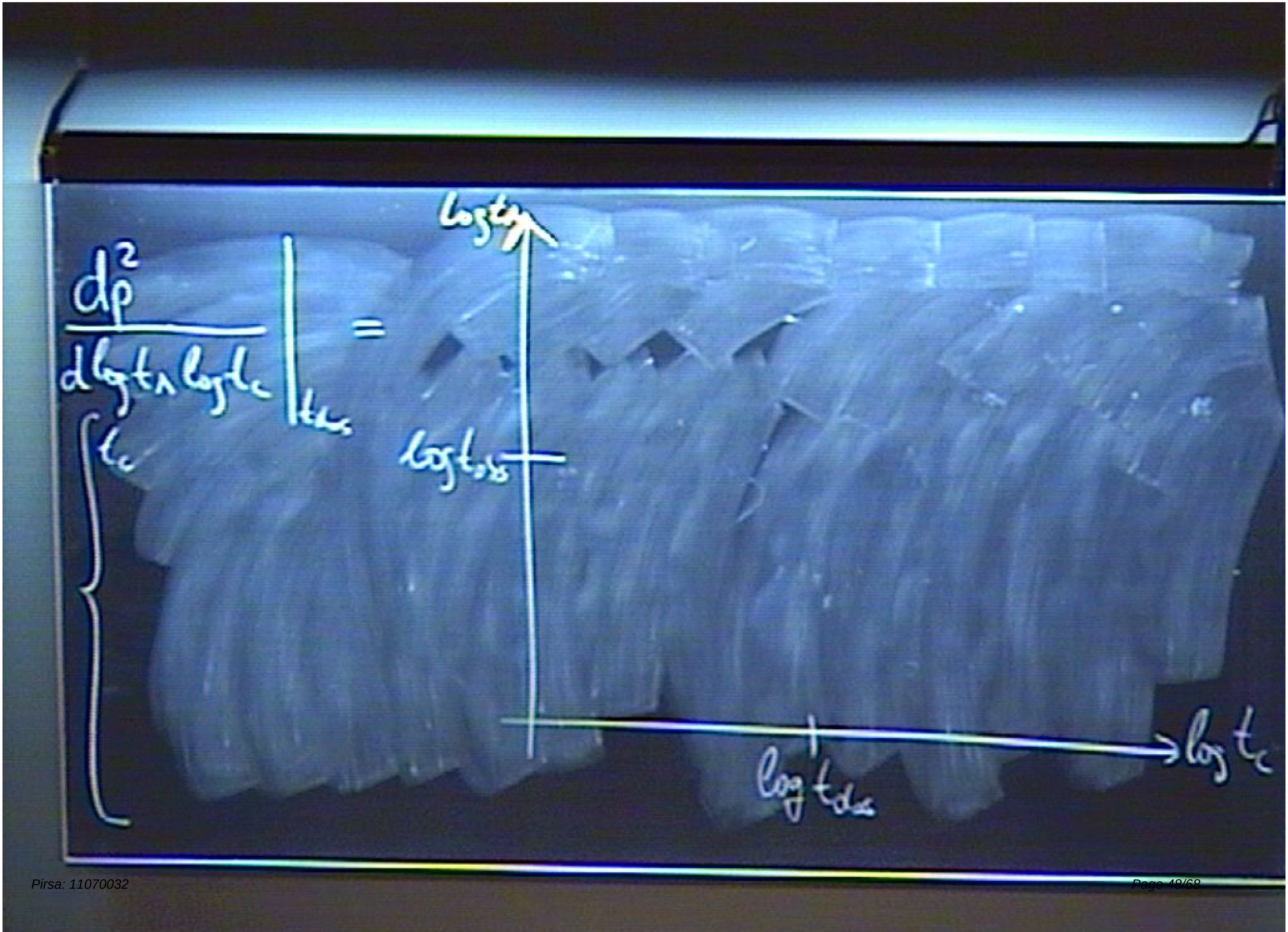
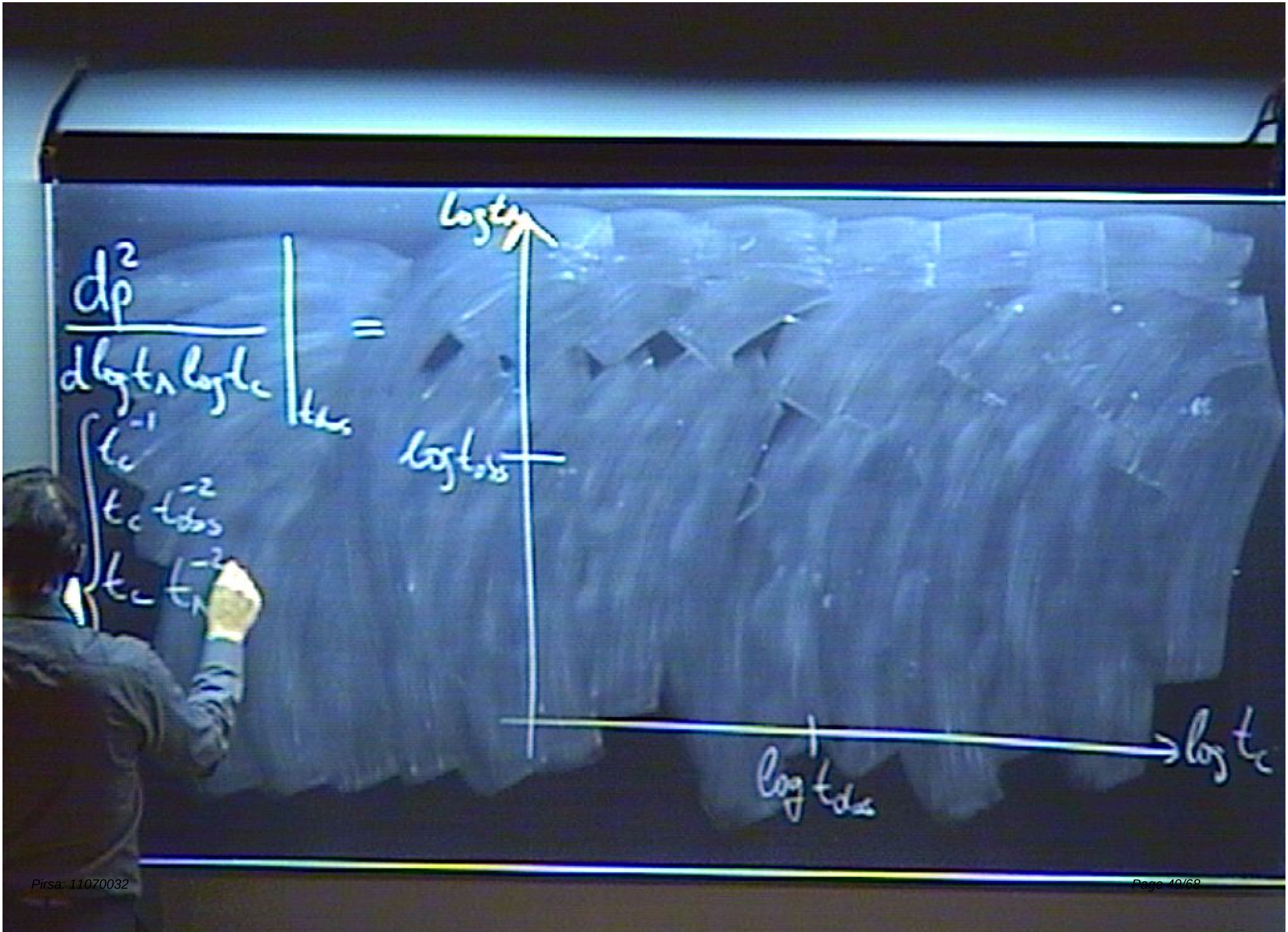
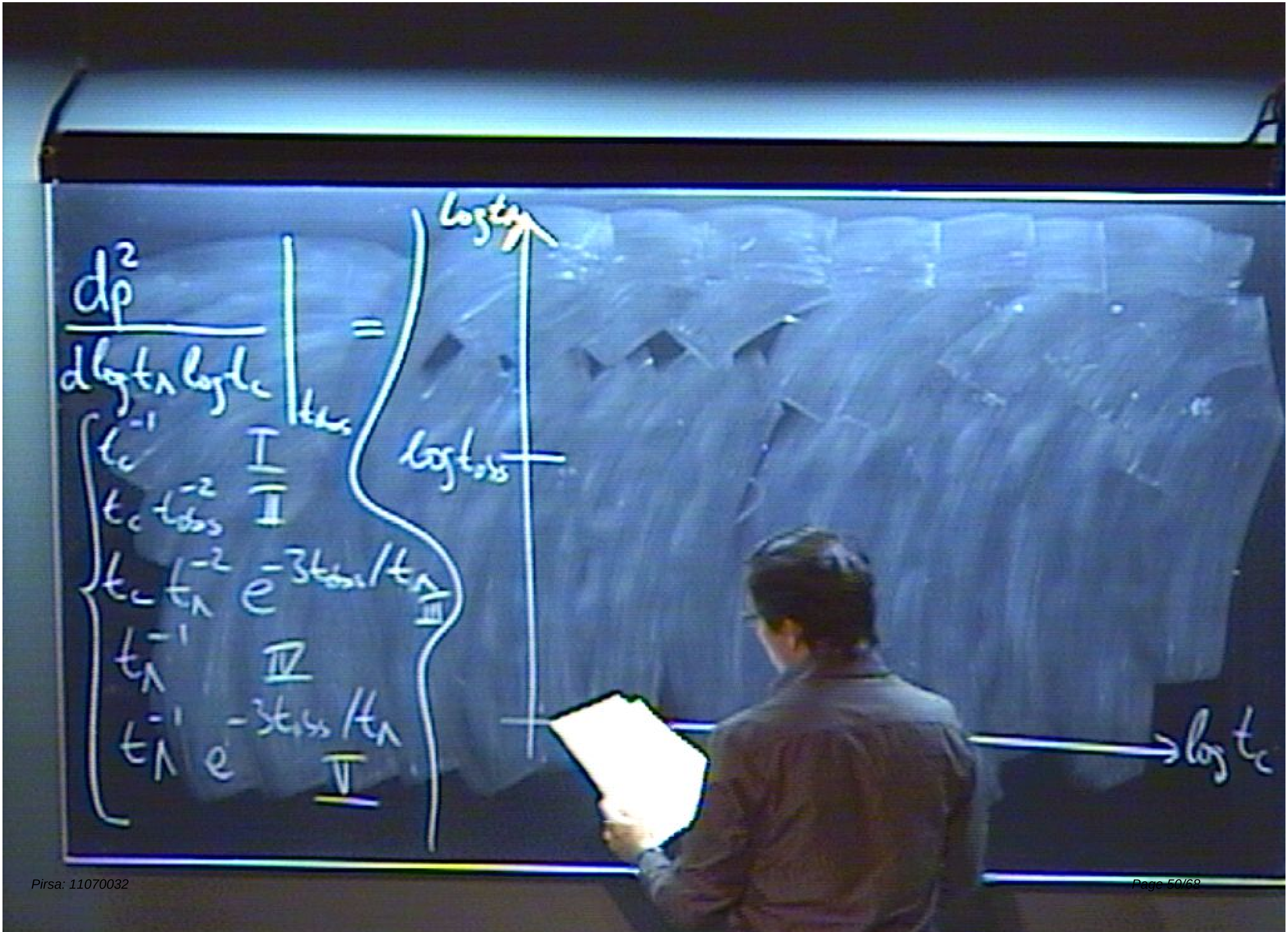
$$M_{CP}^{com} = \rho(t_{obs})\, V_{CP}^{com}\, a^3(t_{obs}) = t_c\, V_{CP}^{com}(t_{obs})$$

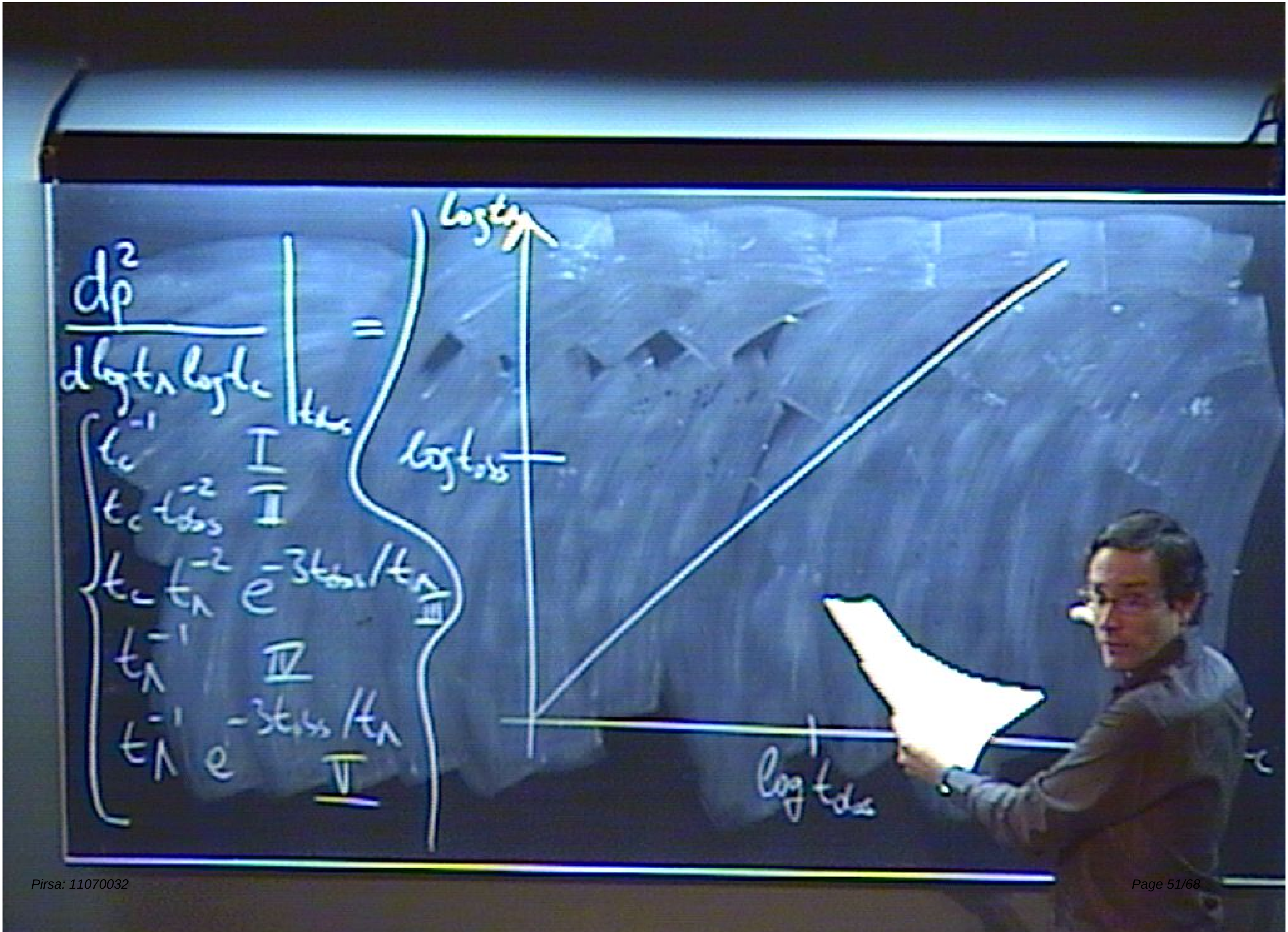

$\frac{dp^2}{d\log t_\Lambda \log t_c}\Big|_{t_{ds}}$
$\log t_\Lambda$
$\log t_{ds}$
$\log t_c$
$\log t_{ds}$

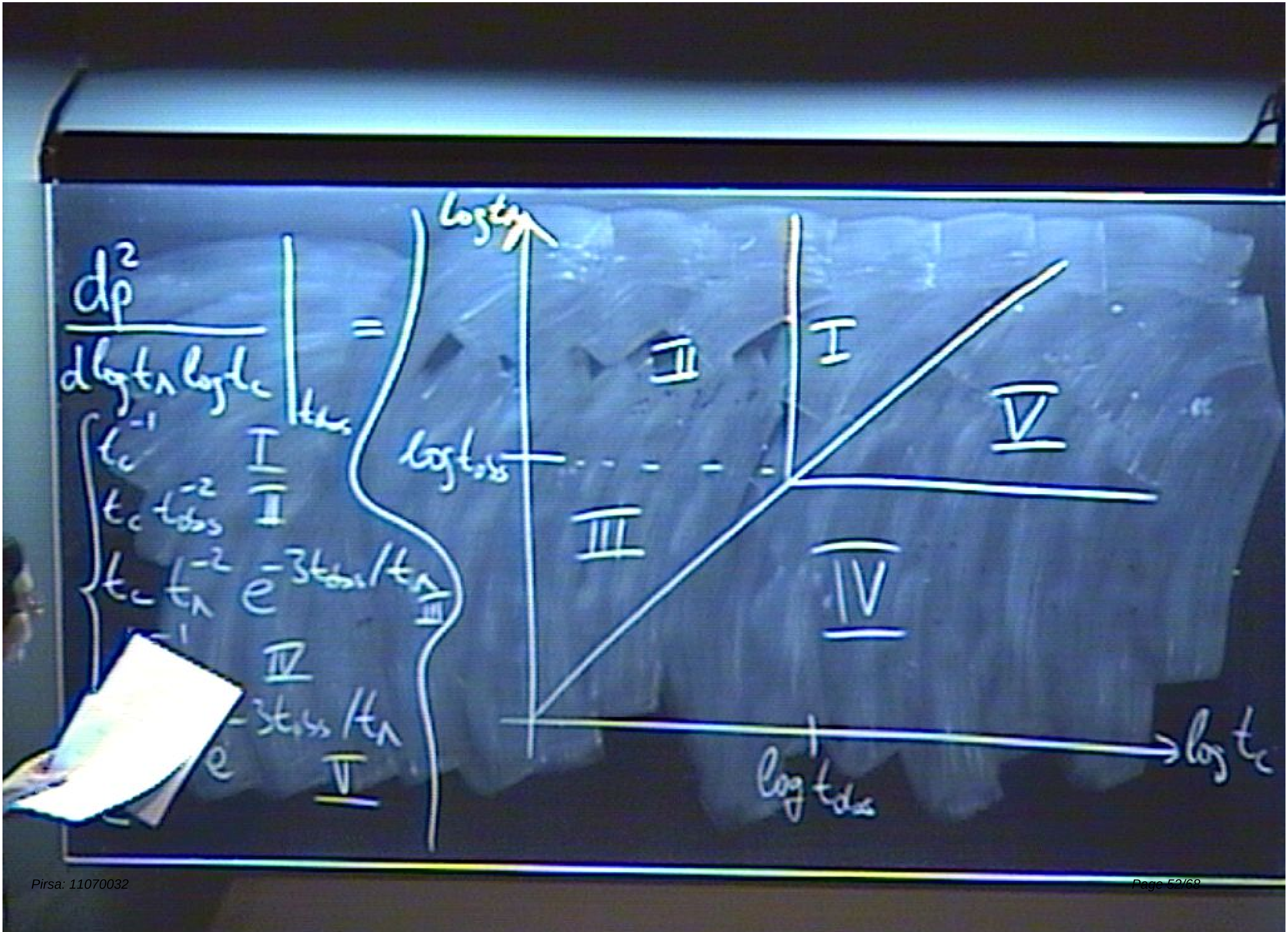

d p^2 / d log t_A log t_c | t_das =
t_c
log t_A
log t_ds
log t_c
log t_das


log t_Λ
d p^2 / d log t_Λ log t_c |_{t_obs} =
t_c^{-1}
t_c t_obs^{-2}
t_c t_Λ^{-2}
log t_obs
log t_obs
log t_c

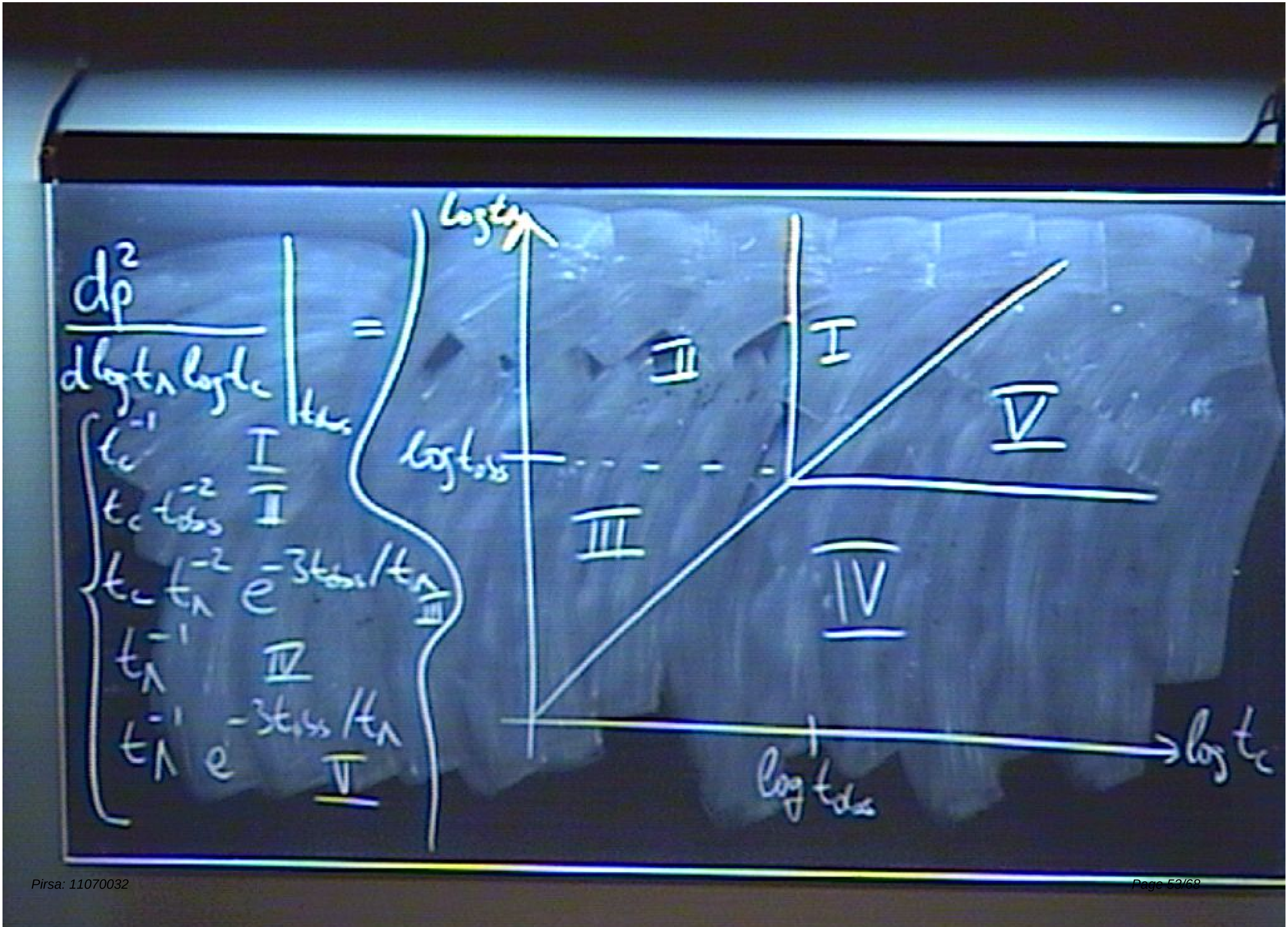


$\frac{dp^2}{d\log t_\Lambda \log t_c}\Big|_{t_{obs}} =$
t_c^{-1} I
$t_c t_{obs}^{-2}$ II
$t_c t_\Lambda^{-2} e^{-3t_{obs}/t_\Lambda}$ III
t_Λ^{-1} IV
$t_\Lambda^{-1} e^{-3t_{obs}/t_\Lambda}$ V
$\log t_\Lambda$
$\log t_{obs}$
$\log t_c$


$\frac{dP^2}{d\log t_\Lambda \log t_c}\Big|_{t_{obs}} =$
t_c^{-1} I
$t_c t_{obs}^{-2}$ II
$t_c t_\Lambda^{-2} e^{-3t_{obs}/t_\Lambda}$ III
t_Λ^{-1} IV
$t_\Lambda^{-1} e^{-3t_{obs}/t_\Lambda}$ V
$\log t_\Lambda$
$\log t_{obs}$
$\log t_{obs}$

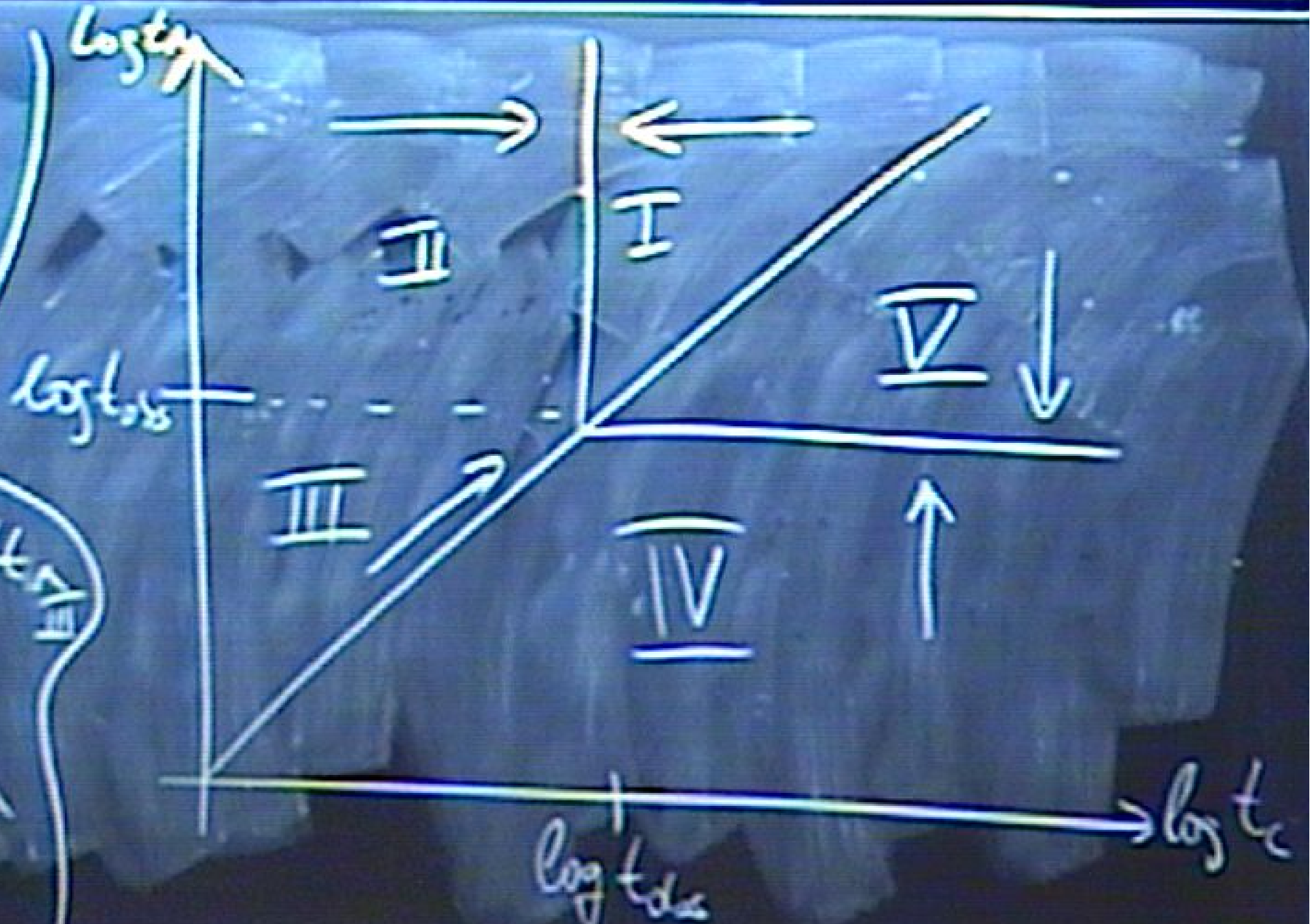


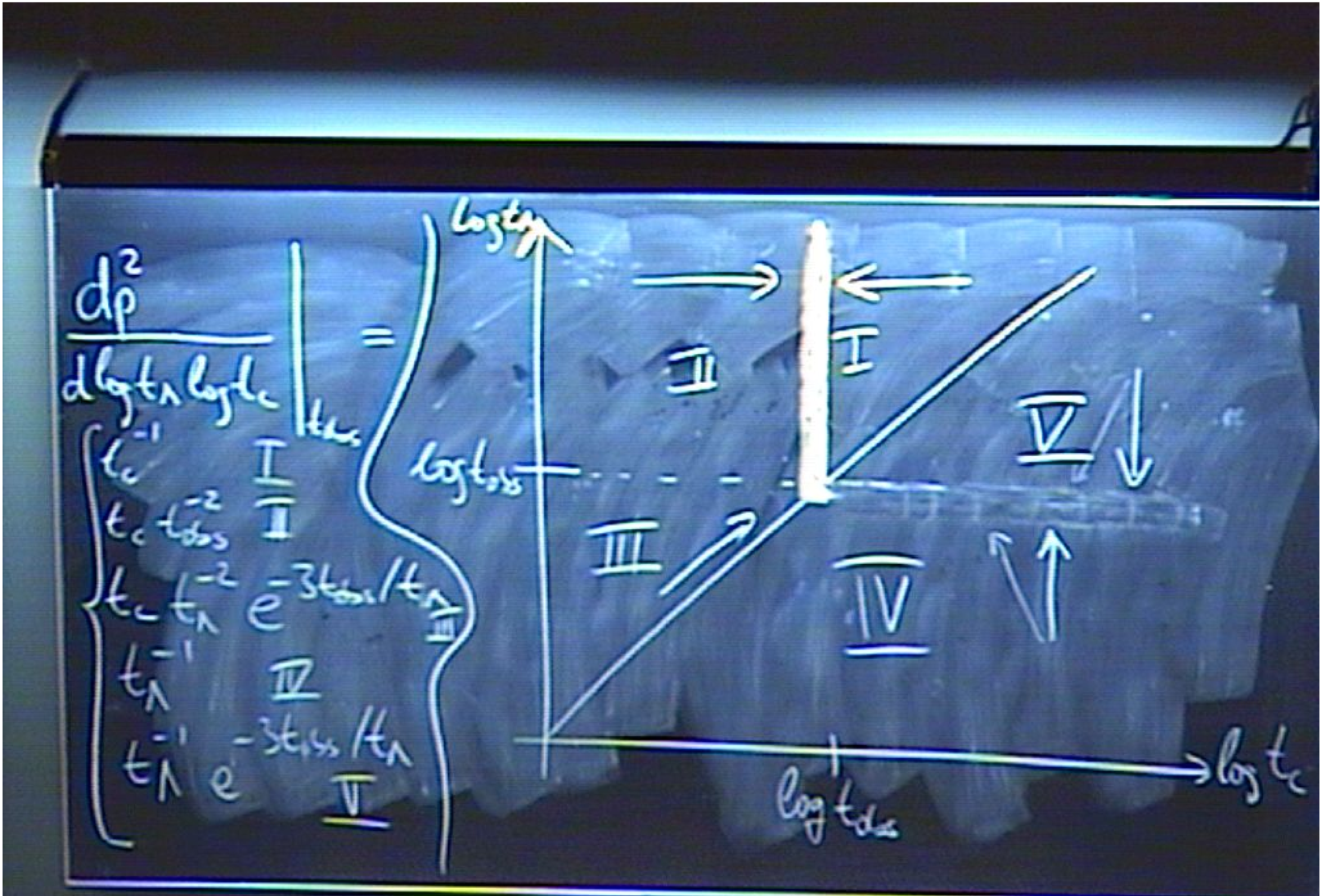
$\frac{dP^2}{d\log t_\Lambda \log t_c}\Big|_{t_{obs}} =$
t_c^{-1} I
$t_c t_{obs}^{-2}$ II
$t_c t_\Lambda^{-2} e^{-3t_{obs}/t_\Lambda}$ III
IV
e^{-3t_{obs}/t_Λ} V
$\log t_\Lambda$
$\log t_{obs}$
$\log t_c$
$\log t_{obs}$
I
II
III
IV
V

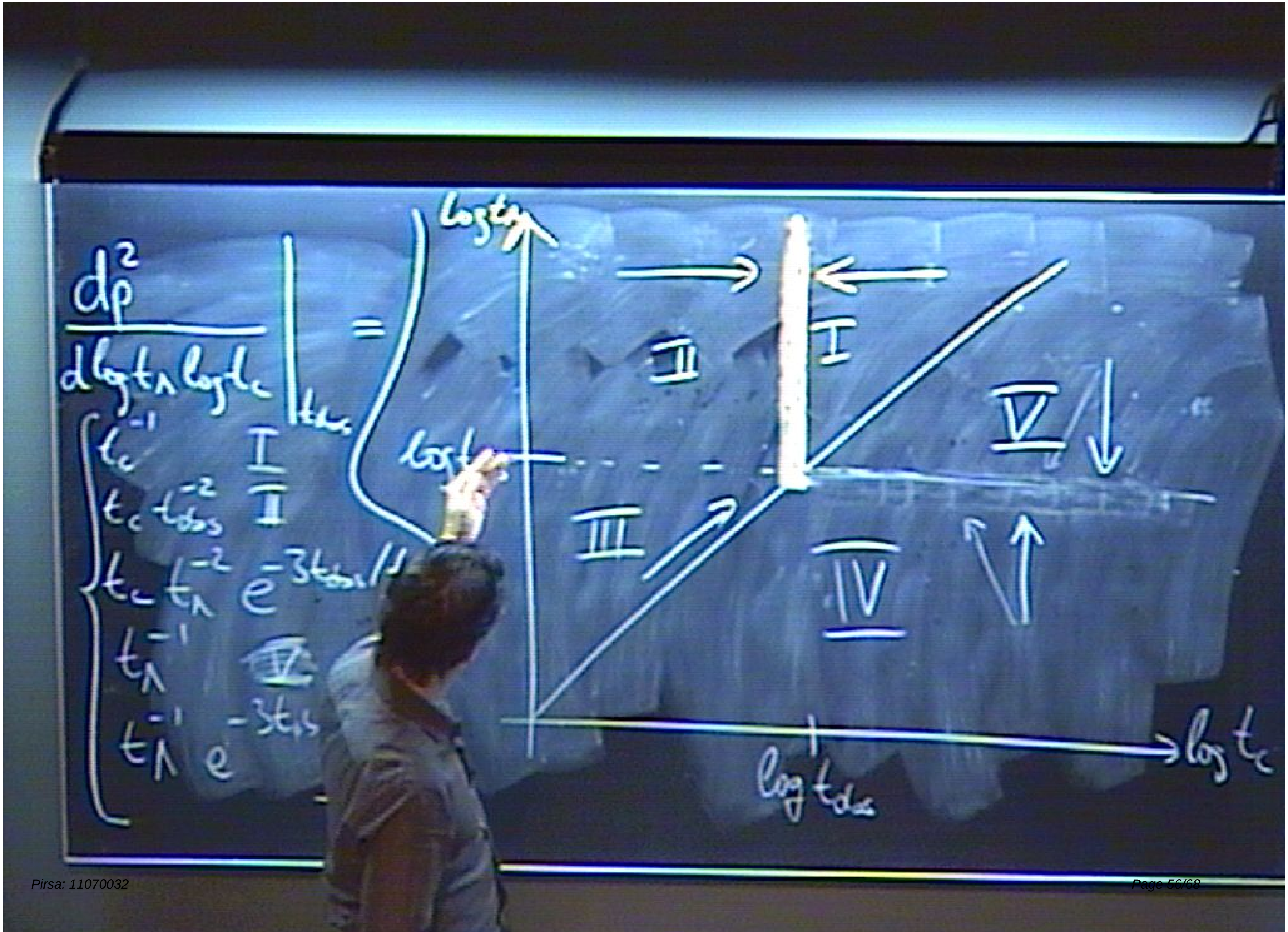


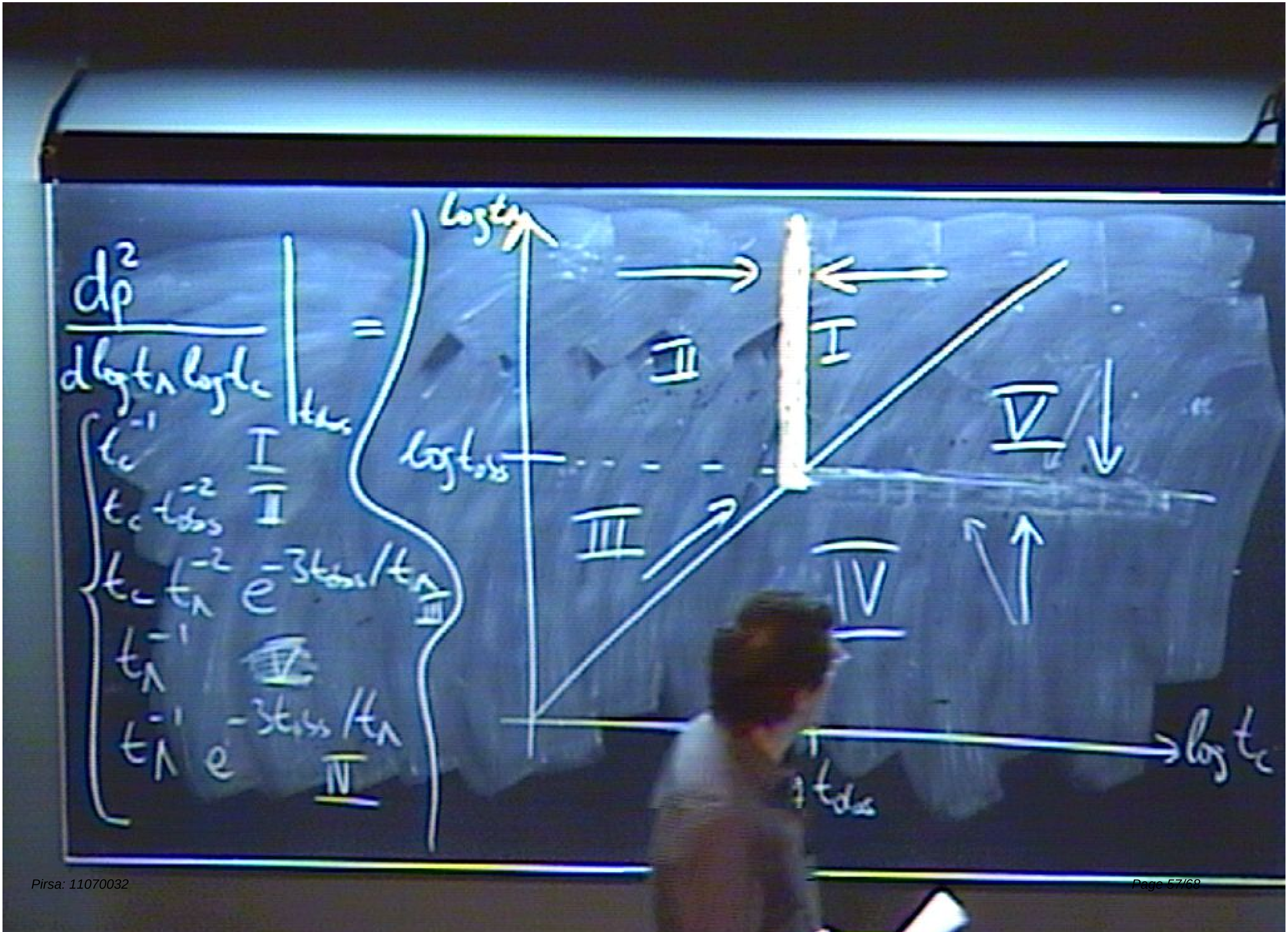
$\left.\frac{dP^2}{d\log t_\Lambda \log t_c}\right|_{t_{dss}} = \begin{cases} t_c^{-1} & \text{I} \\ t_c\, t_{dss}^{-2} & \text{II} \\ t_c\, t_\Lambda^{-2}\, e^{-3t_{dss}/t_\Lambda} & \text{III} \\ t_\Lambda^{-1} & \text{IV} \\ t_\Lambda^{-1}\, e^{-3t_{dss}/t_\Lambda} & \text{V} \end{cases}$
$\log t_\Lambda$
$\log t_{dss}$
I
II
III
IV
V
$\log t_c$
$\log t_{dss}$

$$\frac{dp^2}{d\log t_\Lambda \log t_c}\Bigg|_{t_{dss}} = \begin{cases} t_c^{-1} & \mathrm{I} \\ t_c\, t_{dss}^{-2} & \mathrm{II} \\ t_c\, t_\Lambda^{-2}\, e^{-3t_{dss}/t_\Lambda} & \mathrm{III} \\ t_\Lambda^{-1} & \mathrm{IV} \\ t_\Lambda^{-1}\, e^{-3t_{dss}/t_\Lambda} & \mathrm{V} \end{cases}$$

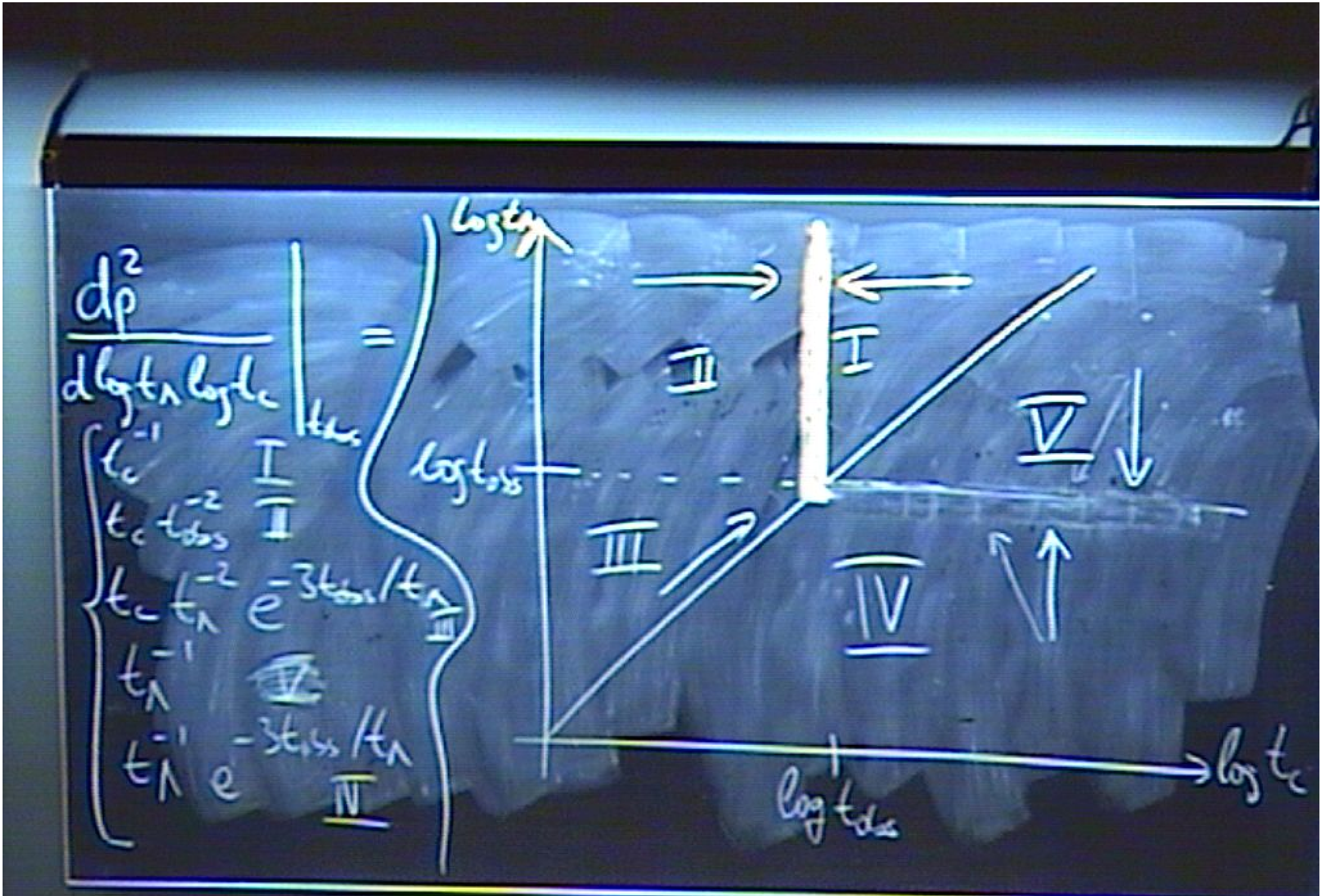



$\frac{dp^2}{d\log t_\Lambda \log t_c}\Big|_{t_{dss}} =$
t_c^{-1} I
$t_c t_{dss}^{-2}$ II
$t_c t_\Lambda^{-2} e^{-3t_{dss}/t_\Lambda}$ III
t_Λ^{-1} IV
$t_\Lambda^{-1} e^{-3t_{dss}/t_\Lambda}$ V
$\log t_\Lambda$
$\log t_{dss}$
$\log t_c$
$\log t_{dss}$
I
II
III
IV
V


d p^2 / d log t_Λ log t_c |_{t_dS} =
t_c^{-1} I
t_c t_dS^{-2} II
t_c t_Λ^{-2} e^{-3t_dS/t
t_Λ^{-1} V
t_Λ^{-1} e^{-3t_dS
log t_Λ
log t
I
II
III
IV
V
log t_c
log t_dS



$\left.\frac{dp^2}{d\log t_\Lambda \log t_c}\right|_{t_{dS}} = \begin{cases} t_c^{-1} & \mathrm{I} \\ t_c\, t_{dS}^{-2} & \mathrm{II} \\ t_c\, t_\Lambda^{-2}\, e^{-3t_{dS}/t_\Lambda} & \mathrm{III} \\ t_\Lambda^{-1} & \mathrm{V} \\ t_\Lambda^{-1}\, e^{-3t_{dS}/t_\Lambda} & \mathrm{IV} \end{cases}$
$\log t_\Lambda$
$\log t_{dS}$
$\log t_c$
t_{dS}
I
II
III
IV
V

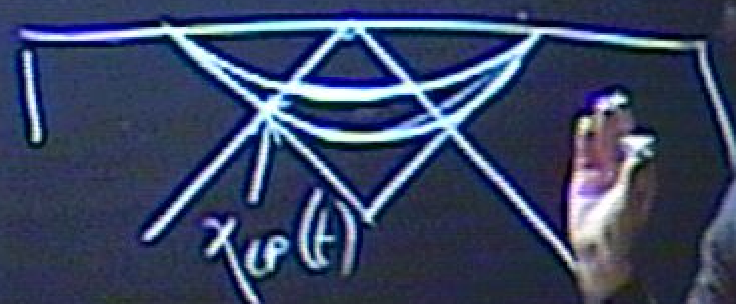

$$\frac{dp^2}{d\log t_\Lambda \log t_c}\Big|_{t_{dss}} = \begin{cases} t_c^{-1} & \mathrm{I} \\ t_c t_{dss}^{-2} & \mathrm{II} \\ t_c t_\Lambda^{-2} e^{-3t_{dss}/t_\Lambda} & \mathrm{III} \\ t_\Lambda^{-1} & \mathrm{V} \\ t_\Lambda^{-1} e^{-3t_{dss}/t_\Lambda} & \mathrm{IV} \end{cases}$$
$\log t_\Lambda$
$\log t_{dss}$
I
II
III
IV
V
$\log t_c$
$\log t_{dss}$

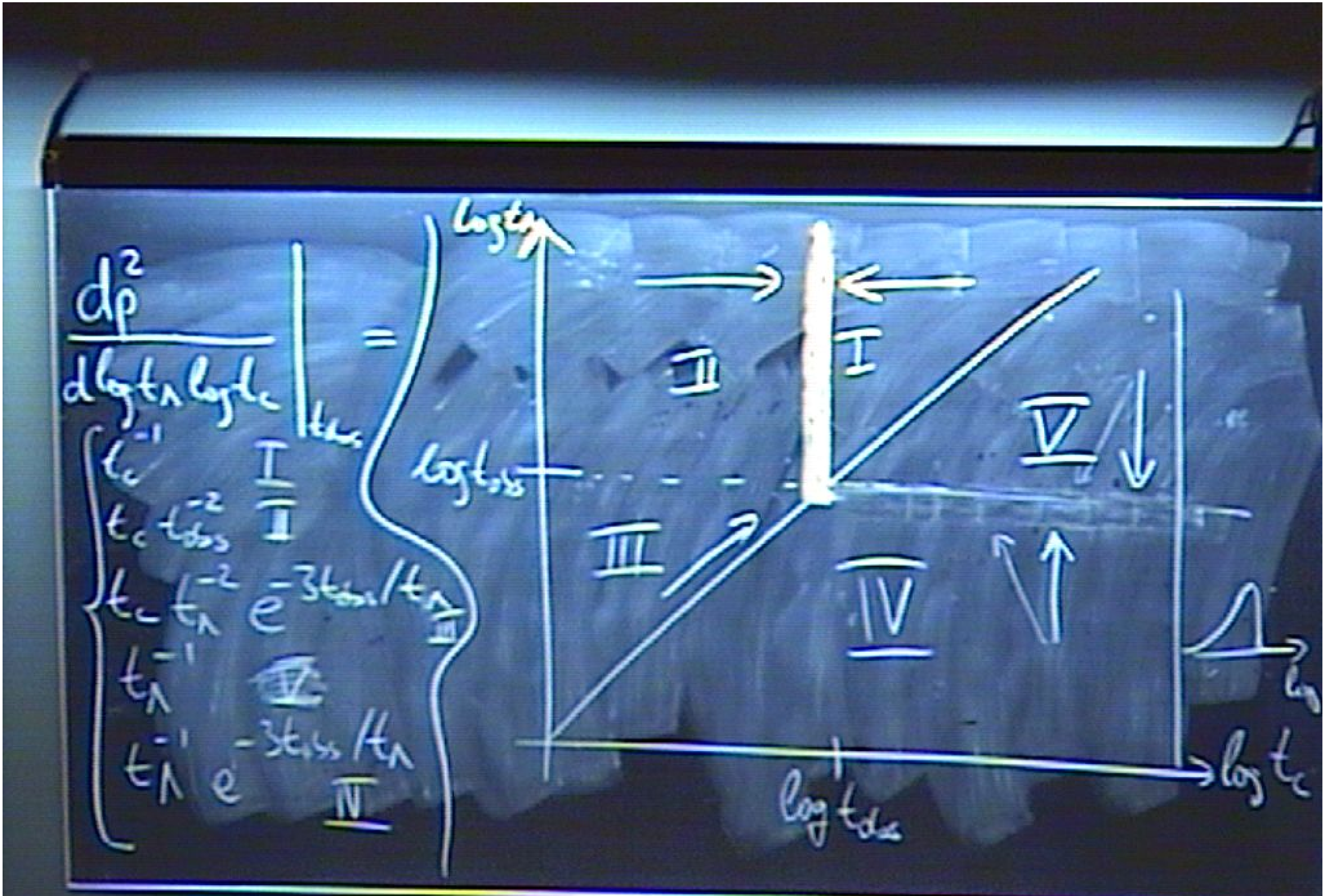
1) given t_{obs}, compute $\frac{d^2 p}{d\log t_c \, d\log t_\Lambda} = \frac{d^2 \tilde{p}}{d\log t_c \, d\log t_\Lambda} \times n_{obs}(t_c, t_\Lambda; t_{obs})$

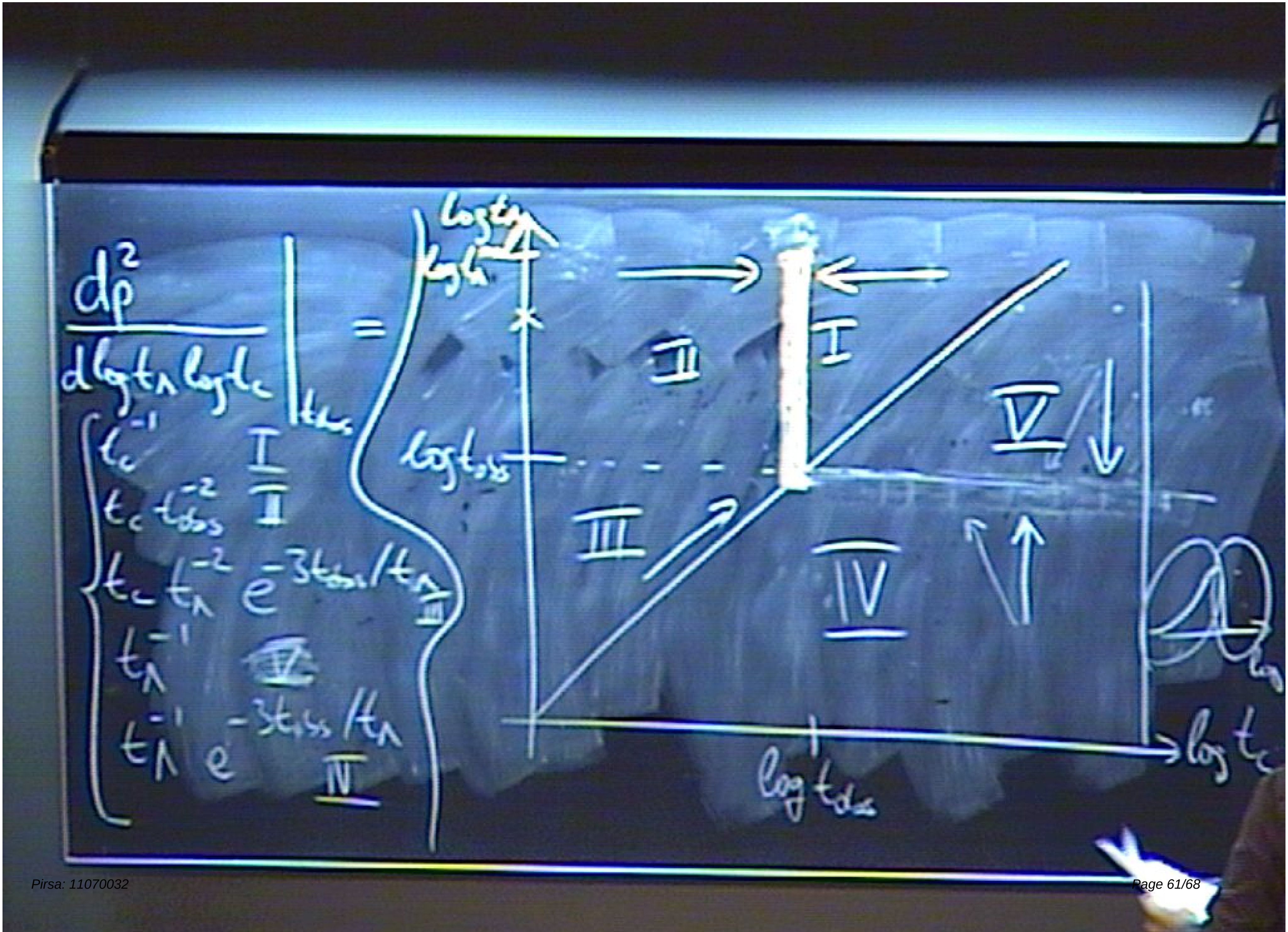
$$\frac{d\tilde{p}}{d\Lambda} = \text{const} \Rightarrow \frac{d\tilde{p}}{d\log t_\Lambda} \sim \Lambda \sim t_\Lambda^{-2}$$

$$n_{obs} = \propto M_{CP}$$

$$\frac{d\tilde{p}}{d\log t_c} = \frac{d\tilde{p}}{dN_{inf}} \equiv g \sim N_{inf}^{-\#}$$

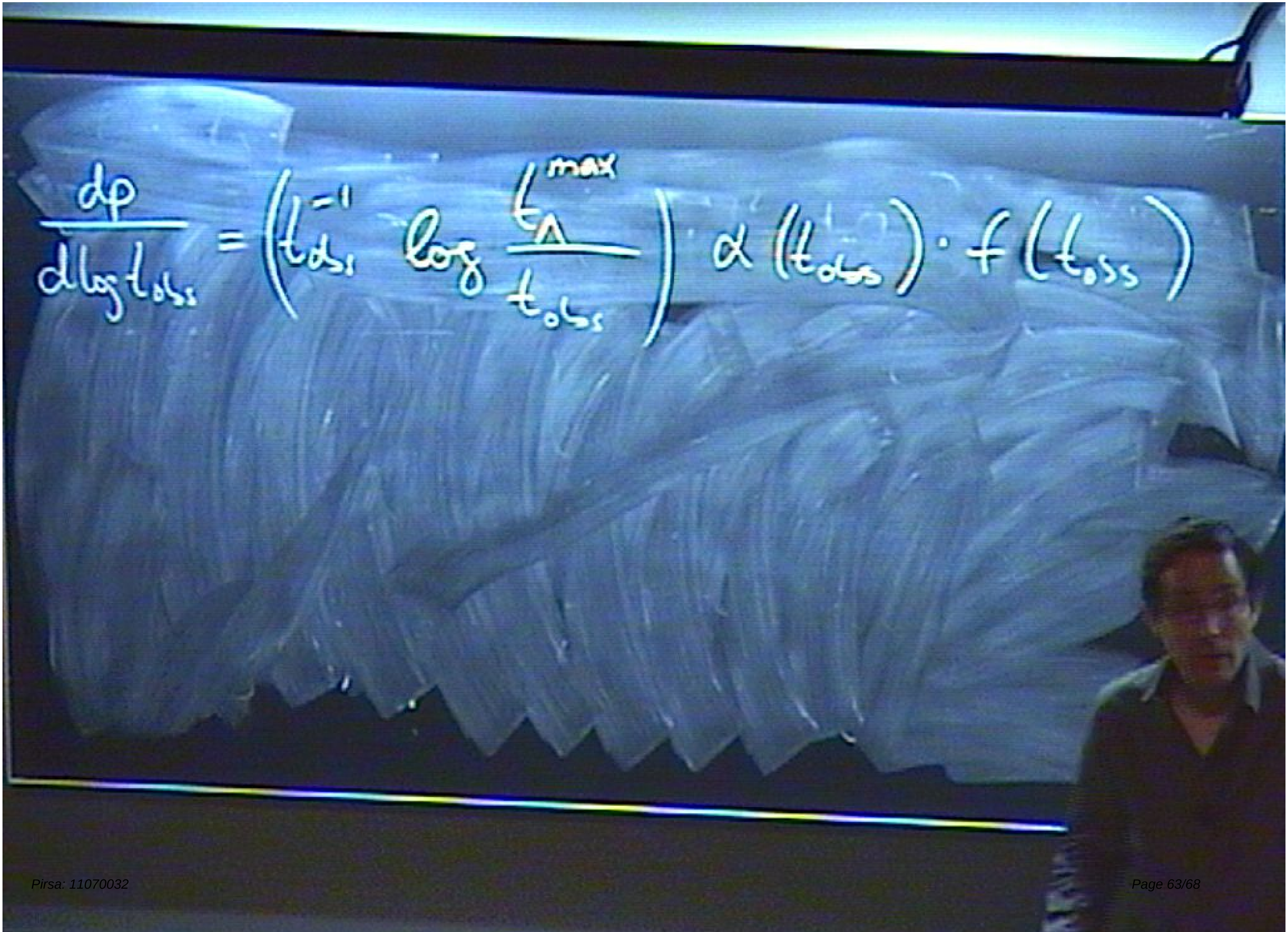


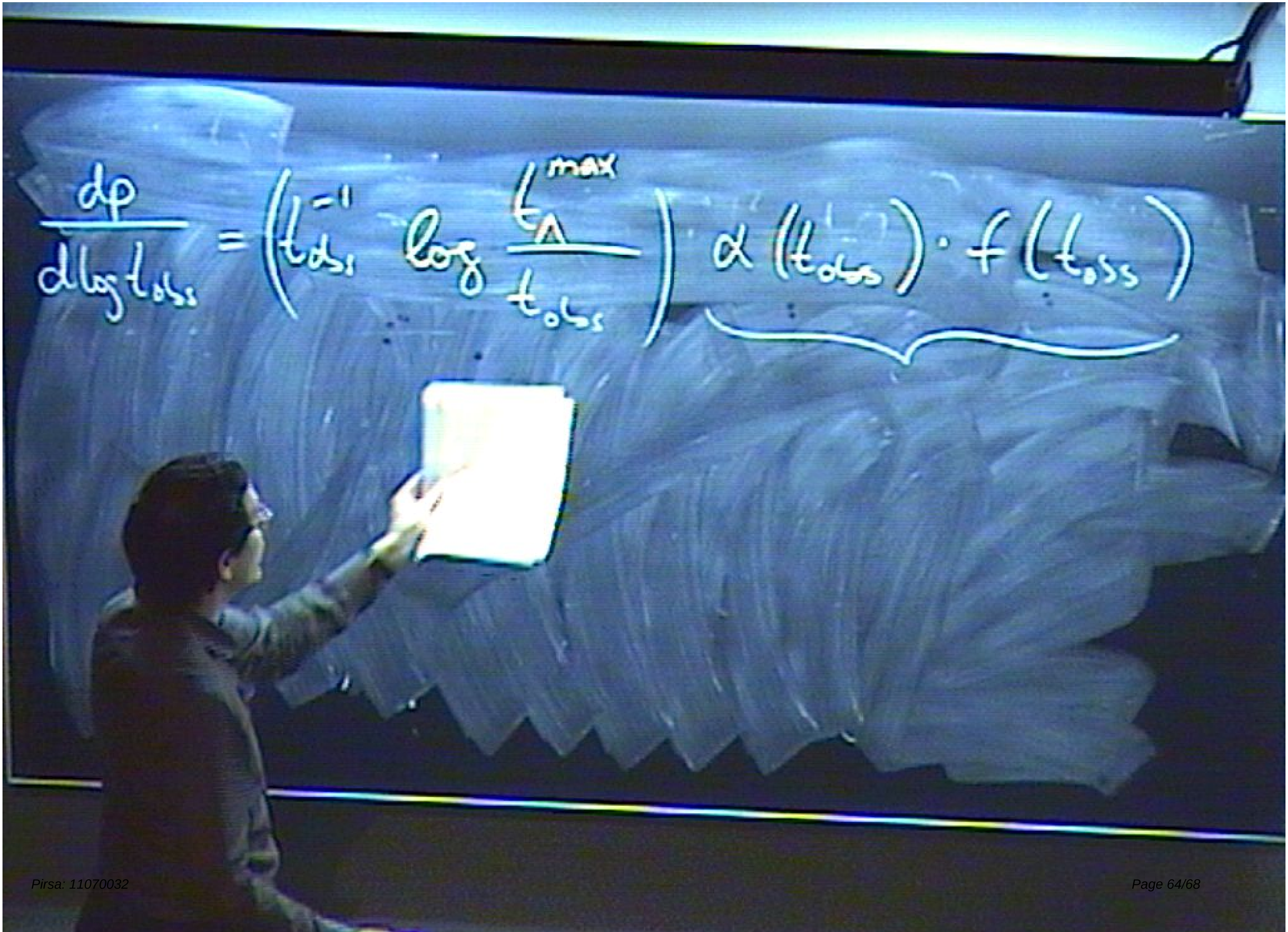

$\frac{dp^2}{d\log t_\Lambda \log t_c}\Big|_{t_{dss}} = \begin{cases} t_c^{-1} & \mathrm{I} \\ t_c t_{dss}^{-2} & \mathrm{II} \\ t_c t_\Lambda^{-2} e^{-3t_{dss}/t_\Lambda} & \mathrm{III} \\ t_\Lambda^{-1} & \mathrm{V} \\ t_\Lambda^{-1} e^{-3t_{dss}/t_\Lambda} & \mathrm{IV} \end{cases}$
$\log t_\Lambda$
$\log t_{dss}$
I
II
III
IV
V
$\log t_{dss}$
$\log t_c$
$\log t_\Lambda$

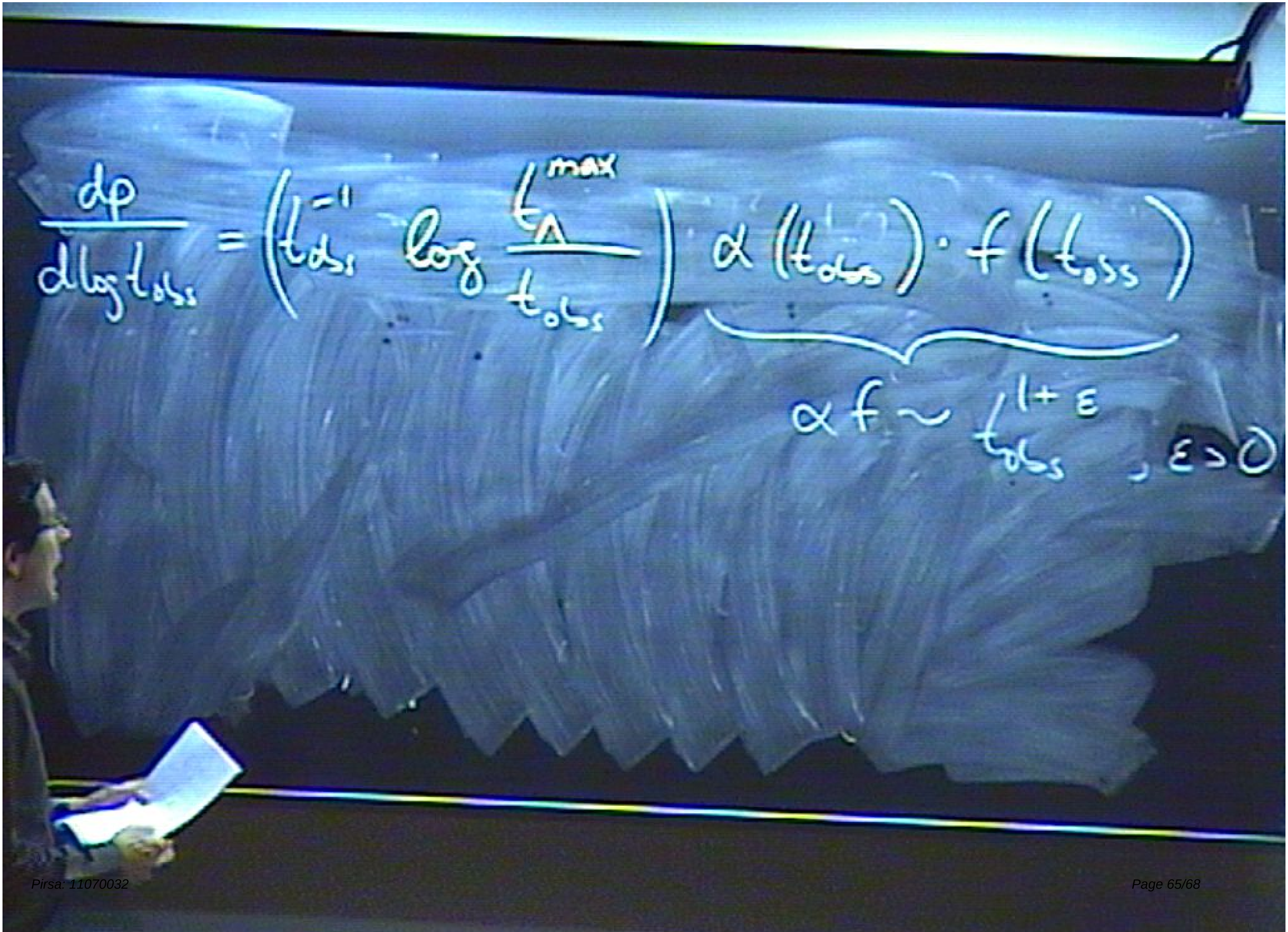


$\frac{dP^2}{d\log t_\Lambda \log t_c}\Big|_{t_{dss}} =$
t_c^{-1} I
$t_c\, t_{dss}^{-2}$ II
$t_c\, t_\Lambda^{-2}\, e^{-3t_{dss}/t_\Lambda}$ III
t_Λ^{-1} V
$t_\Lambda^{-1}\, e^{-3t_{dss}/t_\Lambda}$ IV
$\log t_\Lambda$
$\log t_{dss}$
I
II
III
IV
V
$\log t_c$
$\log t_{dss}$

$$\frac{dp}{d\log t_{obs}} = t_{obs}^{-1} \log \frac{t_\Lambda^{max}}{t_{obs}}$$


$$\frac{dp}{d\log t_{obs}} = \left(t_{obs}^{-1} \log \frac{t_\Lambda^{max}}{t_{obs}}\right) \alpha(t_{obs}) \cdot f(t_{obs})$$


$$\frac{dp}{d\log t_{obs}} = \left(t_{obs}^{-1}\,\log\frac{t_\Lambda^{max}}{t_{obs}}\right)\underbrace{\alpha(t_{obs})\cdot f(t_{obs})}$$


$$\frac{dp}{d\log t_{obs}} = \left(t_{obs}^{-1} \log \frac{t_\Lambda^{max}}{t_{obs}}\right) \underbrace{\alpha(t_{obs}) \cdot f(t_{obs})}_{\alpha f \sim t_{obs}^{1+\varepsilon}, \ \varepsilon > 0}$$

$$\frac{dp}{d\log t_{obs}} = \left(t_{obs}^{-1} \log \frac{t_\Lambda^{max}}{t_{obs}} \right) \underbrace{\alpha(t_{obs}) \cdot f(t_{obs})}_{\alpha f \sim t_{obs}^{1+\varepsilon}, \ \varepsilon > 0}$$

$$\frac{dp}{d\log t_{obs}} = \left(t_{obs}^{-1} \, \log \frac{t_\Lambda^{max}}{t_{obs}} \right) \underbrace{\alpha(t_{obs}) \cdot f(t_{obs})}_{\alpha f \sim t_{obs}^{1+\varepsilon}, \ \varepsilon > 0}$$

$$\frac{dp}{d\log t_{obs}} = \left(t_{obs}^{-1} \log \frac{t_\Lambda^{max}}{t_{obs}}\right) \underbrace{\alpha(t_{obs}) \cdot f(t_{obs})}_{\alpha f \sim t_{obs}^{1+\epsilon},\ \epsilon > 0}$$

$$\sim t_{obs}^{\epsilon} \Rightarrow t_c \sim t_{obs} \sim t_\Lambda^{max} \sim N^{-1/2}$$