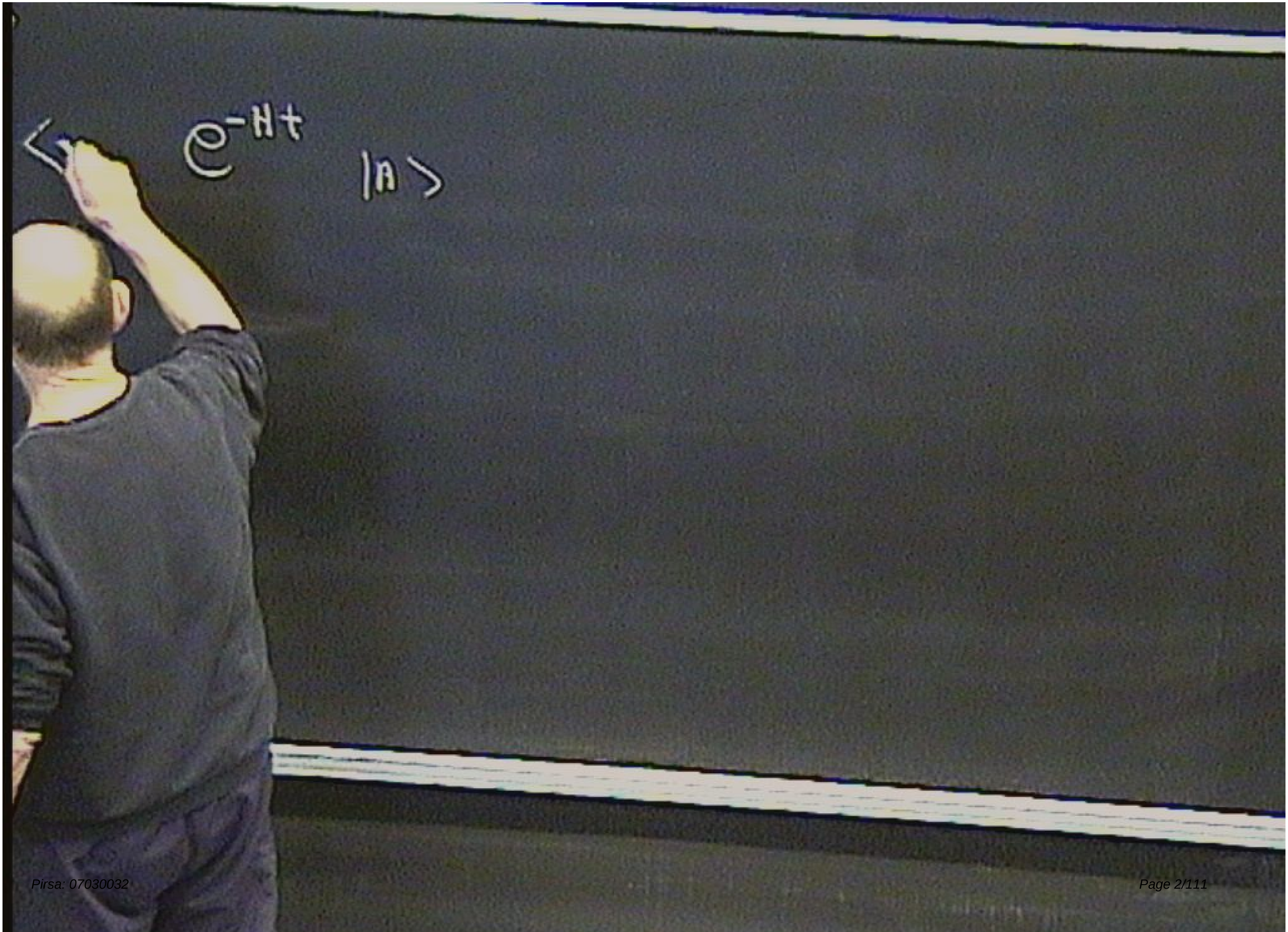
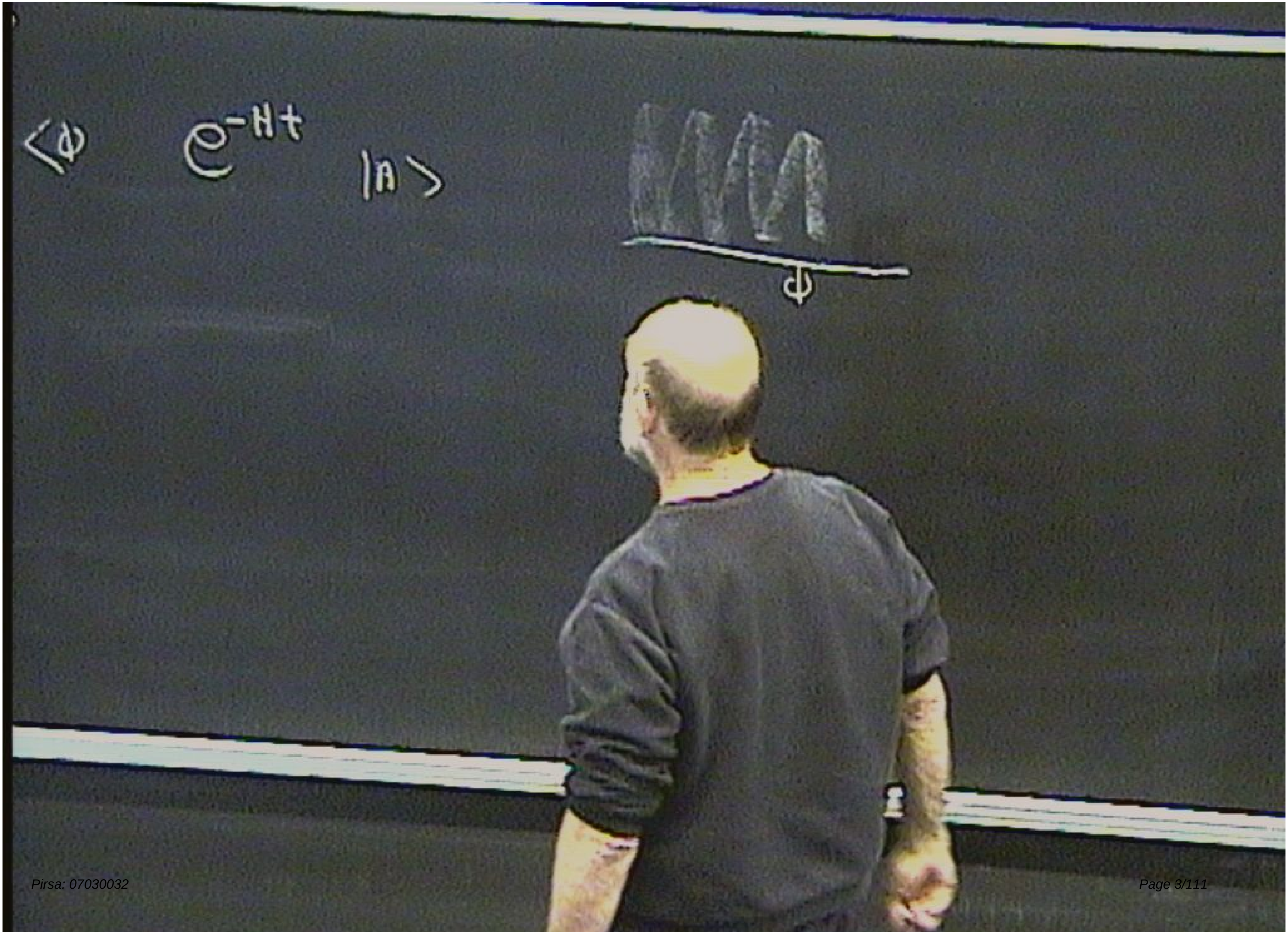
Title: Black Holes and Holography: Mini-Course - Lecture 5

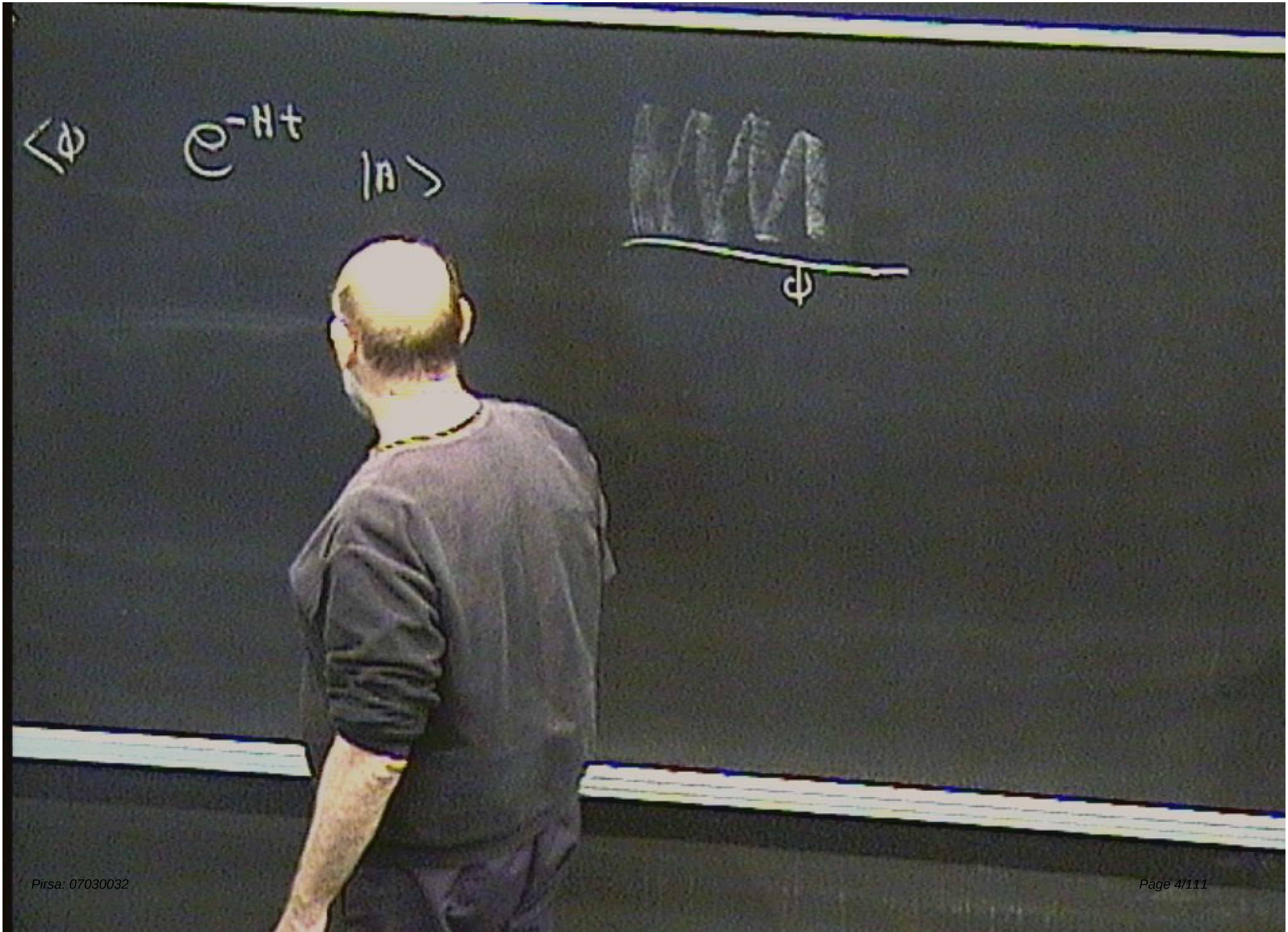
Date: Mar 29, 2007 10:30 AM

URL: http://pirsa.org/07030032

Abstract: <div id="Cleaner">Distinguished theoretical physicist Leonard Susskind, Professor of Physics at Stanford, will give a series of lectures on Black Holes and Holography at Perimeter Institute in Waterloo. This mini-course is open to all university professors and students.


< e^{-Ht} |A>


$\langle \phi \quad e^{-Ht} \quad |A\rangle$
ϕ

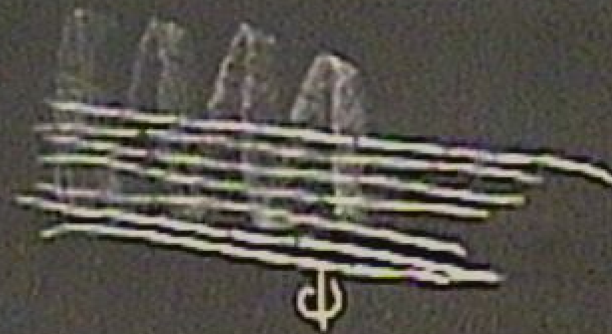

<φ
e^{-Ht}
|n>
φ

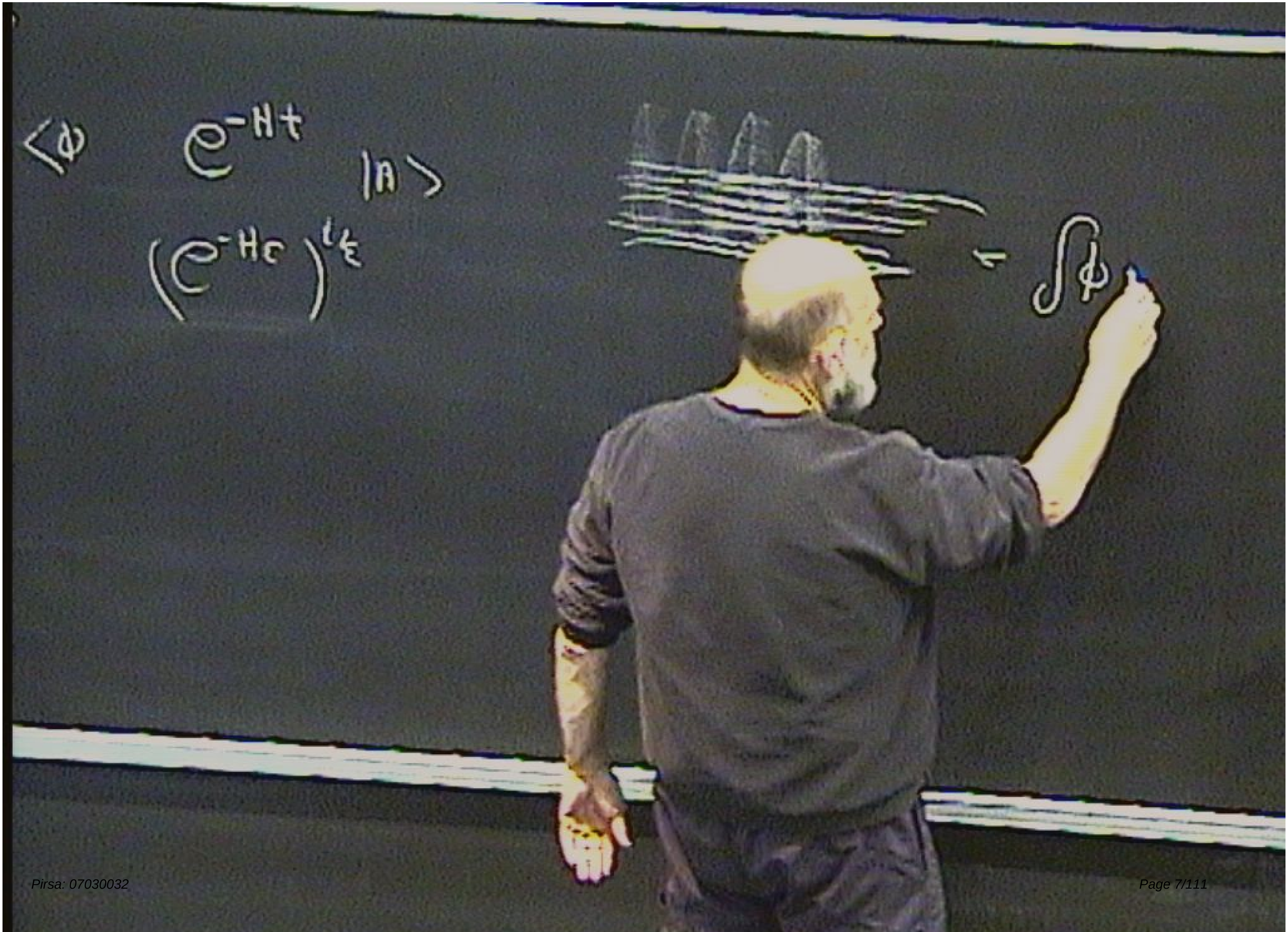
$$\langle \phi | \quad e^{-Ht} \quad | A \rangle$$

$$\left(e^{-H\epsilon} \right)^{t/\epsilon}$$

$\langle \phi | \quad e^{-Ht} \quad | A \rangle$

$\left(e^{-H\epsilon} \right)^{t/\epsilon}$



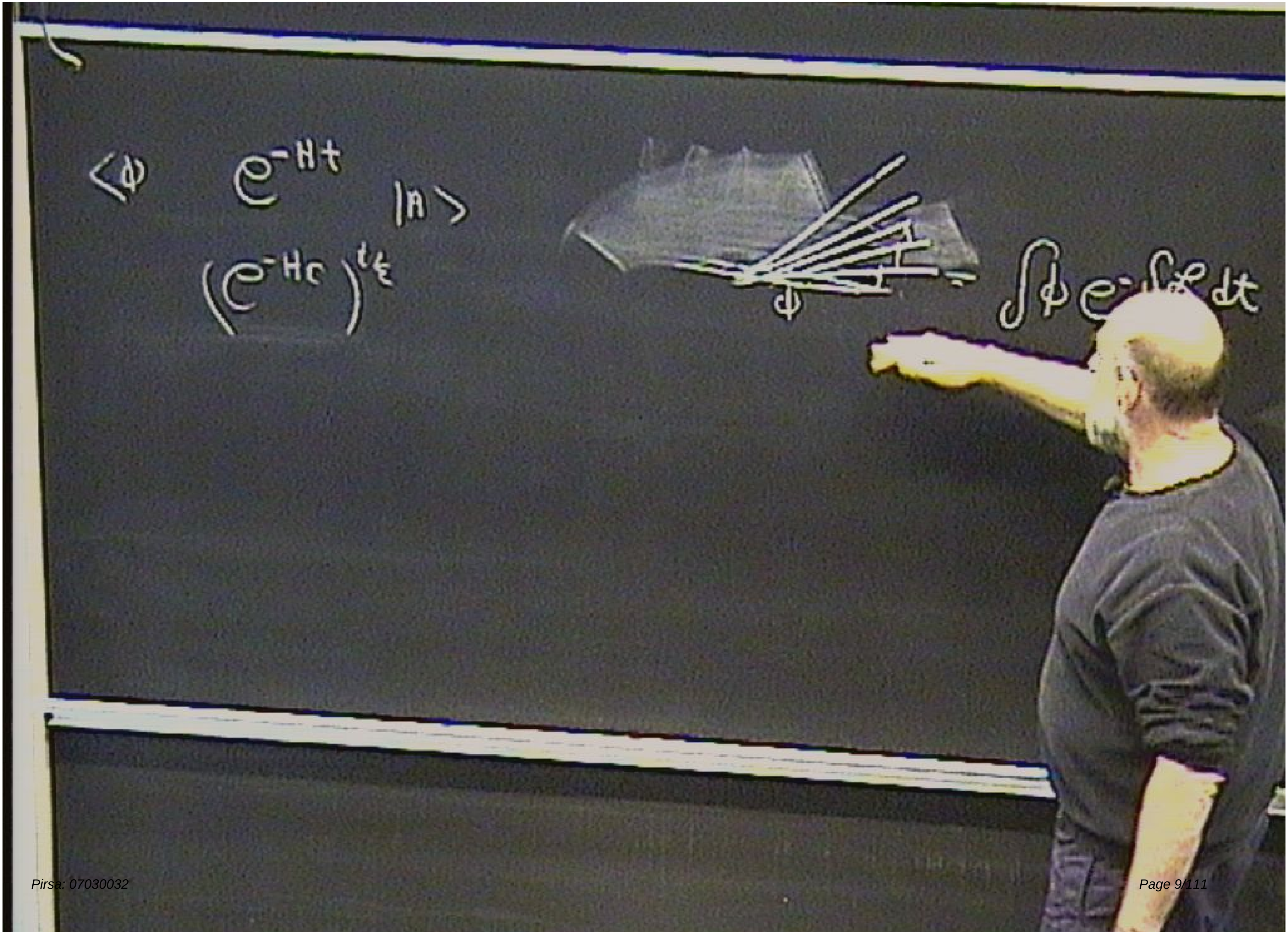

$\langle \phi \quad e^{-Ht} \quad |A\rangle$
$\left(e^{-H\epsilon}\right)^{t/\epsilon}$
$= \int \phi$

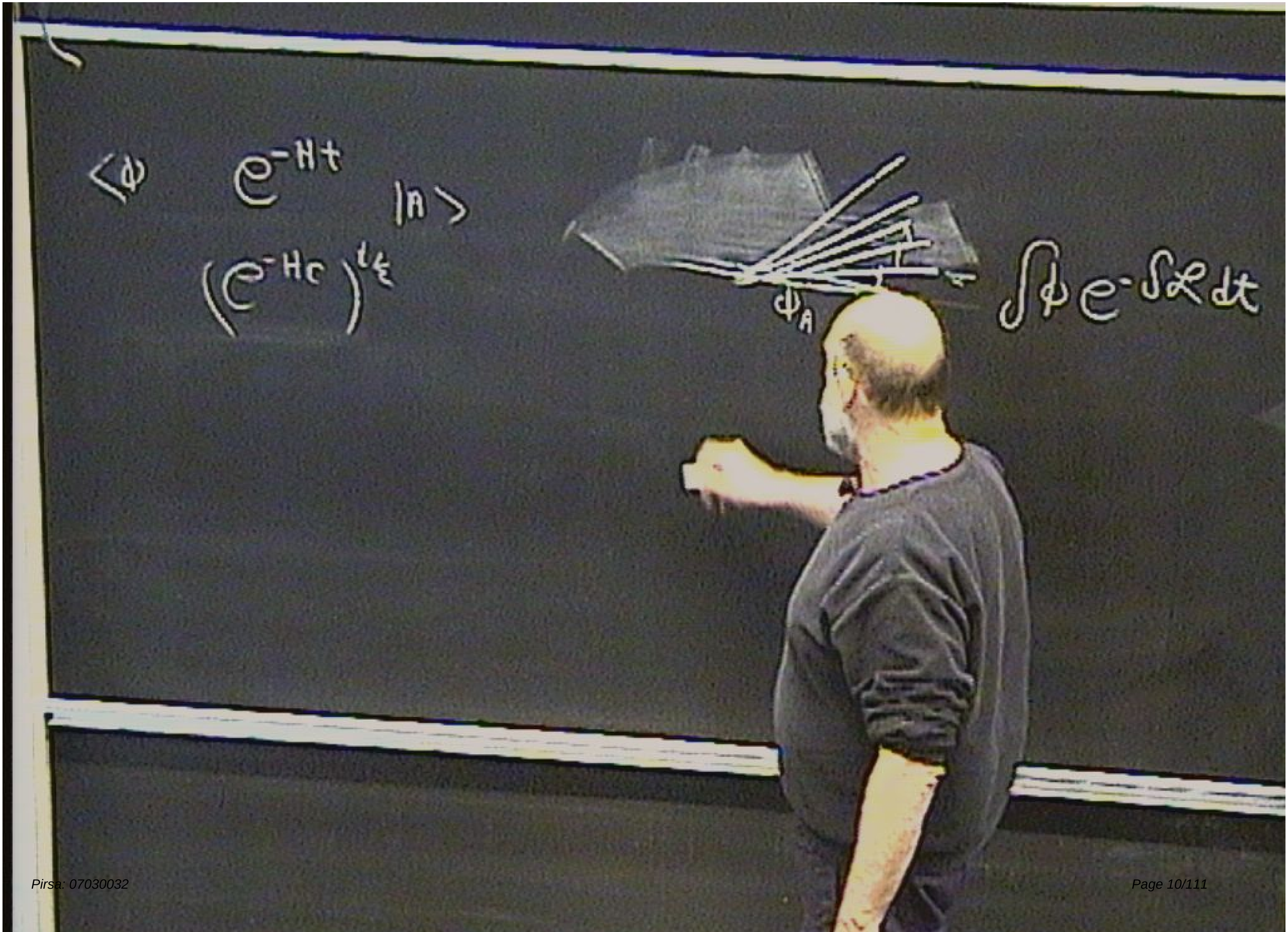
$$\langle \phi | \quad e^{-Ht} \quad |A\rangle$$

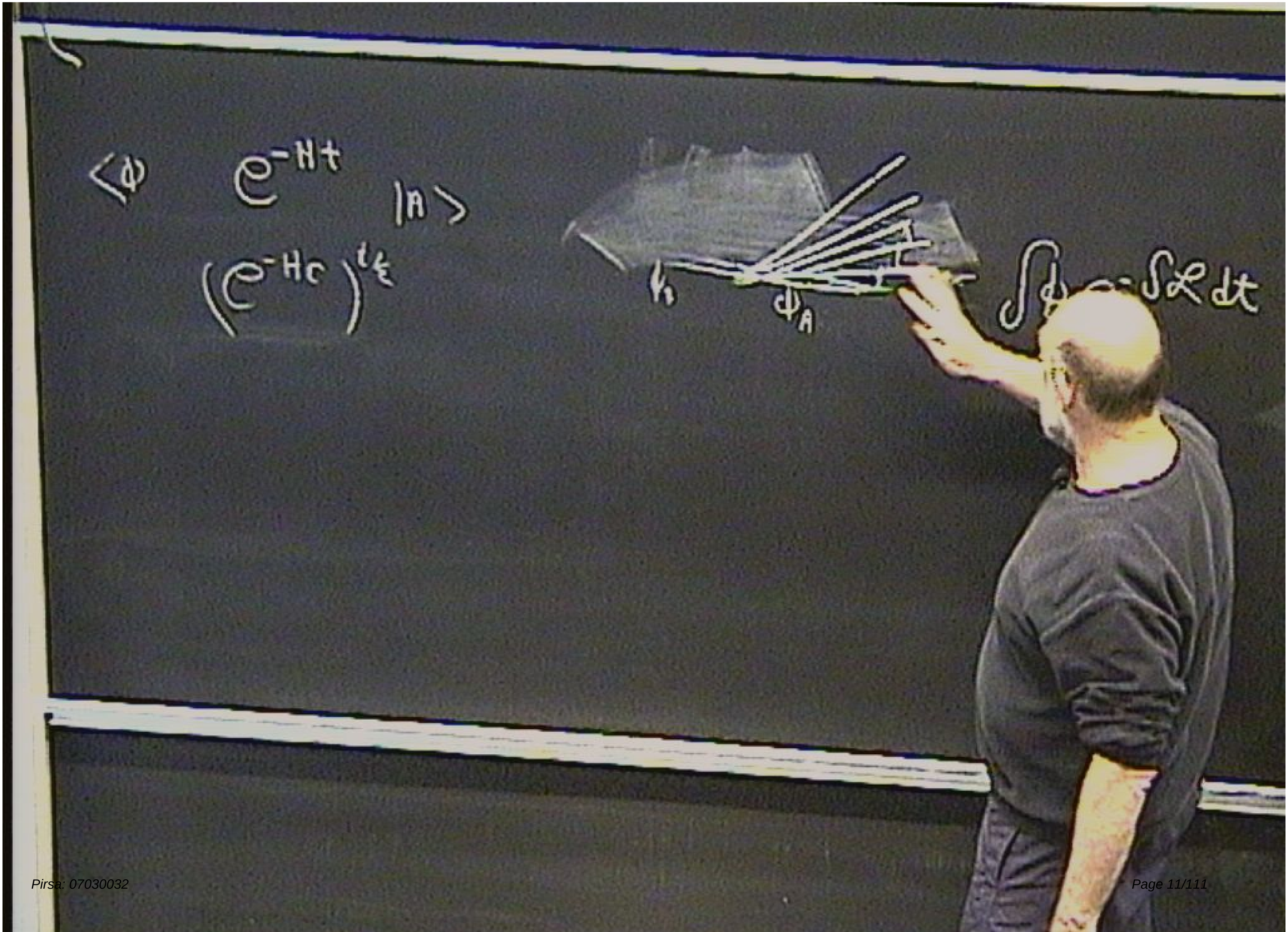
$$\left(e^{-H\epsilon}\right)^{t/\epsilon}$$

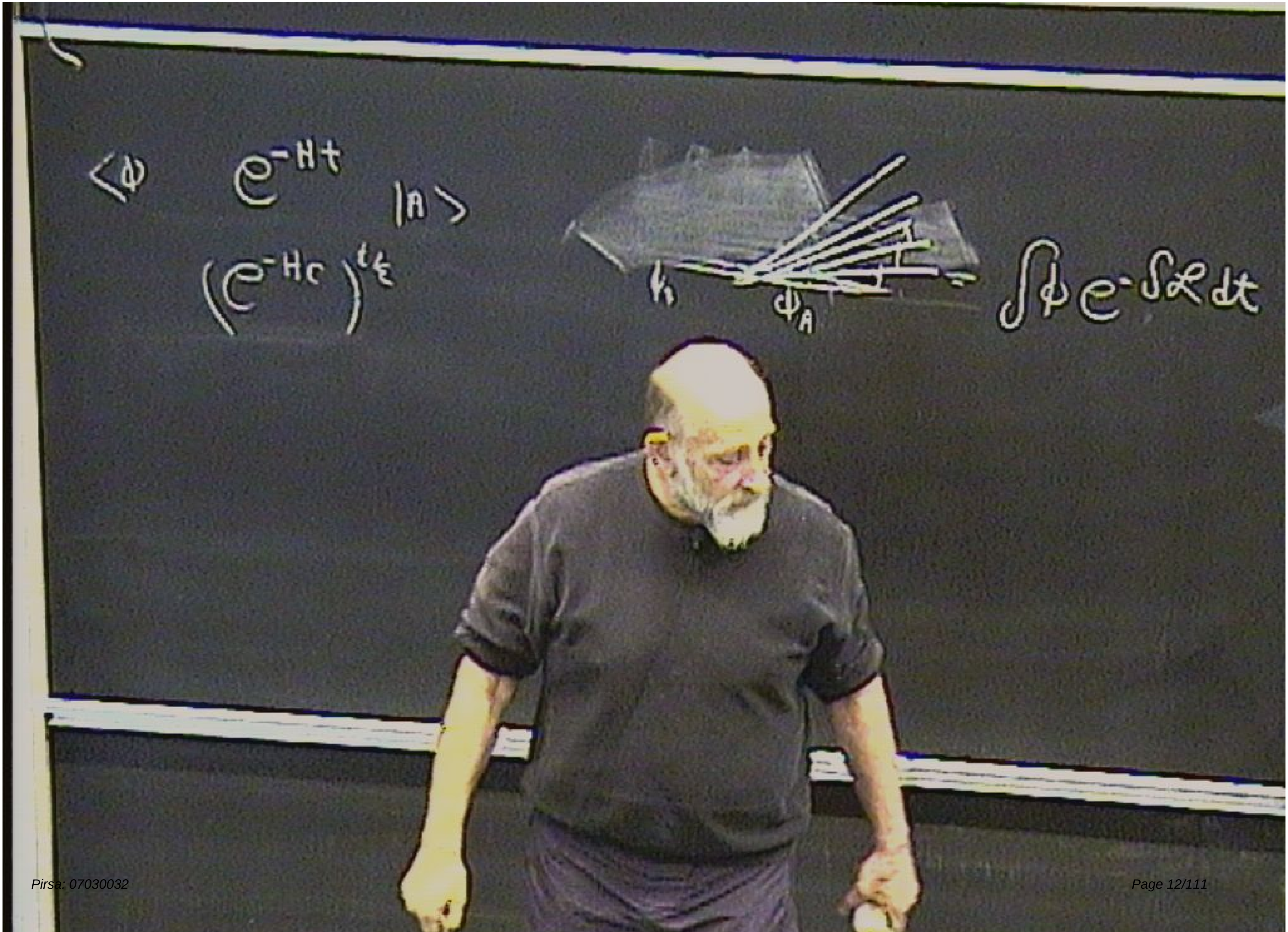
ϕ

$\leftarrow \int \mathcal{D}\phi \, e^{-\int \mathcal{L}\,dt}$


⟨φ e^{-Ht} |A⟩
(e^{-Hε})^{t/ε}
∫Dφ e^{-∫L dt}

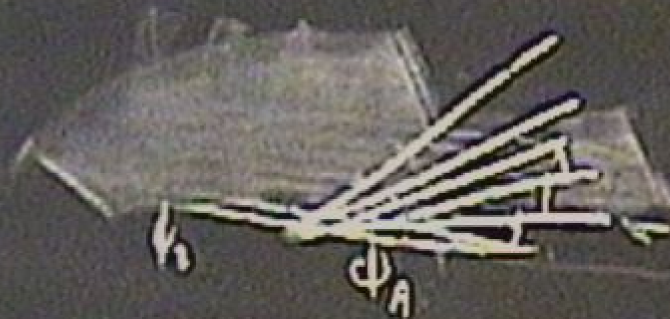

$\langle \phi \quad e^{-Ht} \quad |A\rangle$
$(e^{-H\epsilon})^{t/\epsilon}$
ϕ_A
$\int \phi \, e^{-\int \mathcal{L} dt}$


⟨φ e^{-Ht} |A⟩
(e^{-Hε})^{t/ε}
φ_A


⟨φ e^-Ht |A⟩
(e^-Hε)^t/ε
φ_A
∫dφ e^-∫ℒdt

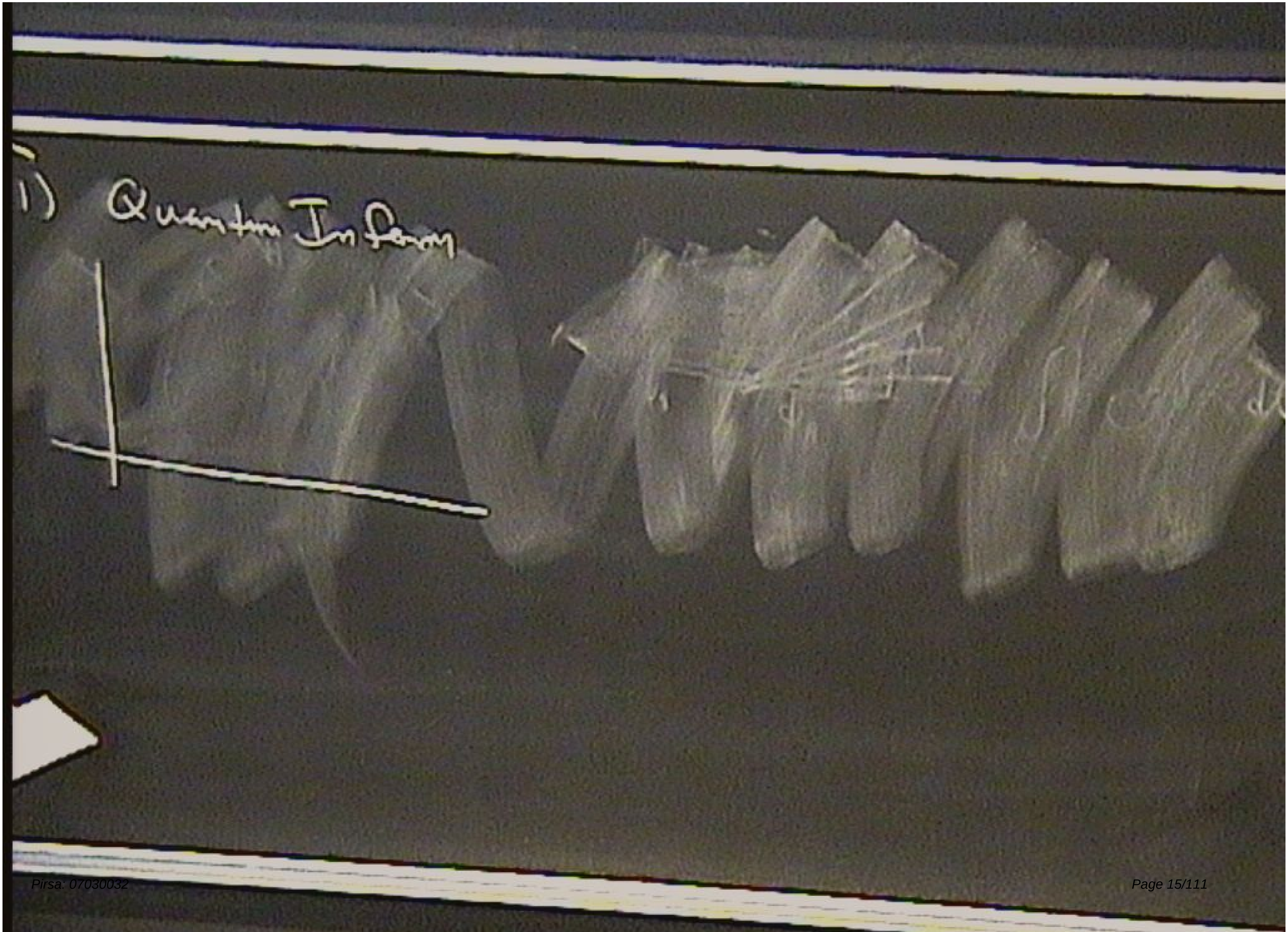
$$\langle \phi | \quad e^{-Ht} \quad |A\rangle$$

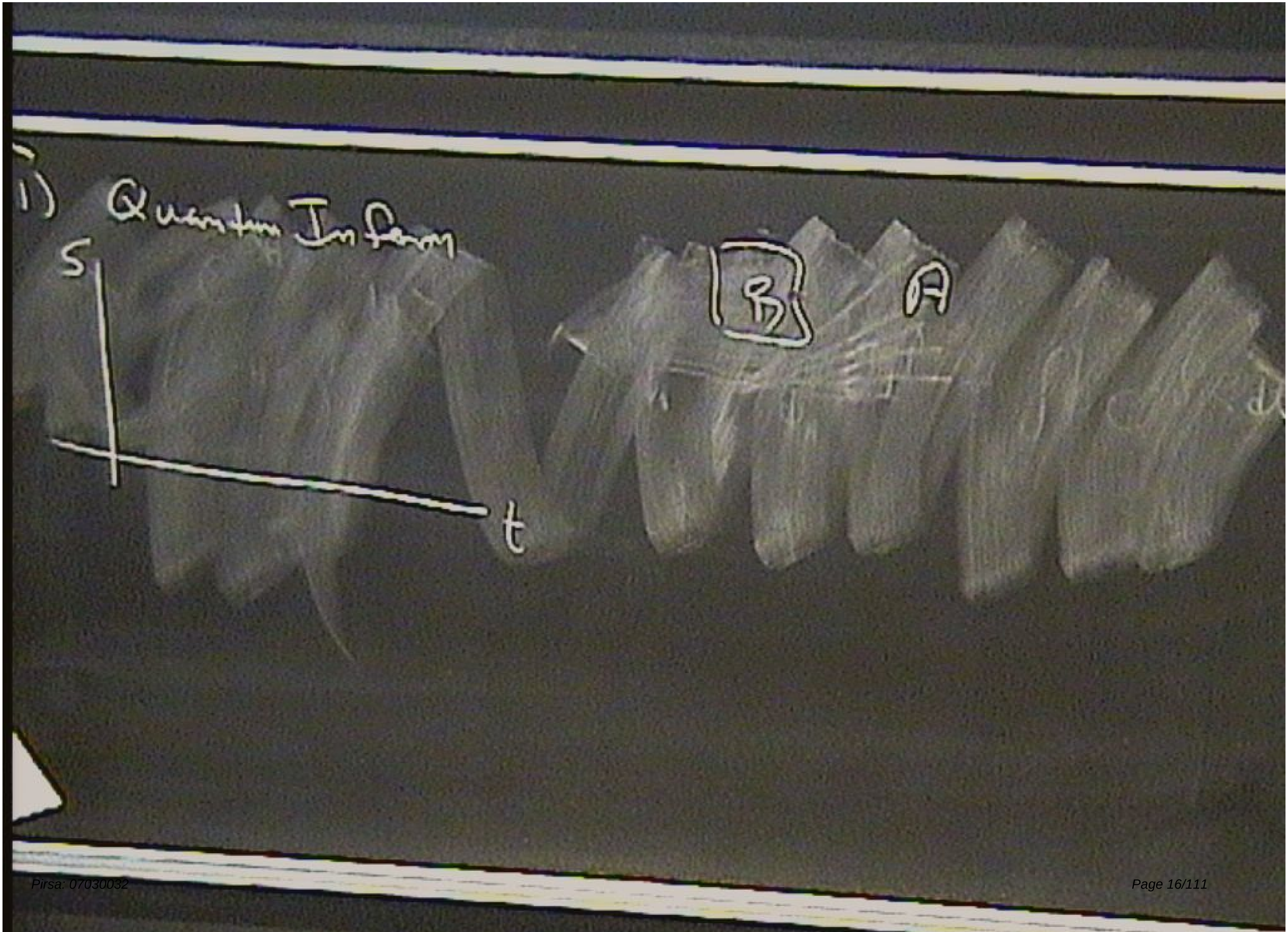
$$\left(e^{-H\epsilon}\right)^{t/\epsilon}$$



$$\int \mathcal{D}\phi \, e^{-\int \mathcal{L}\, dt}$$

1) Quantum Inference


1) Quantum Inference


1) Quantum Inferen
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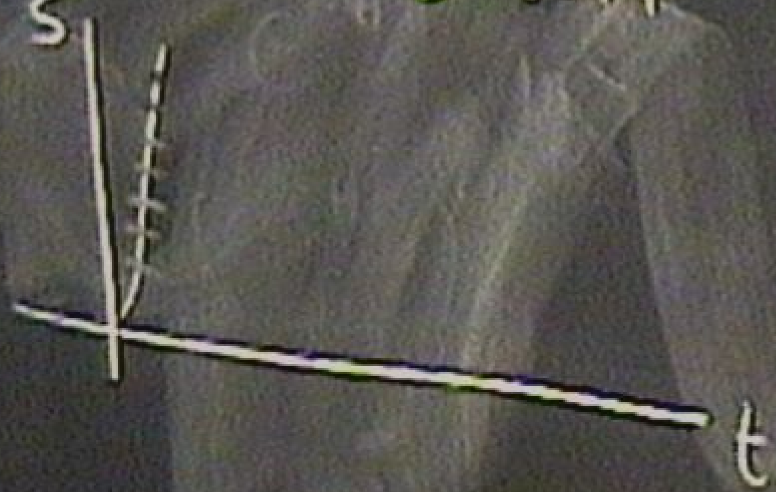
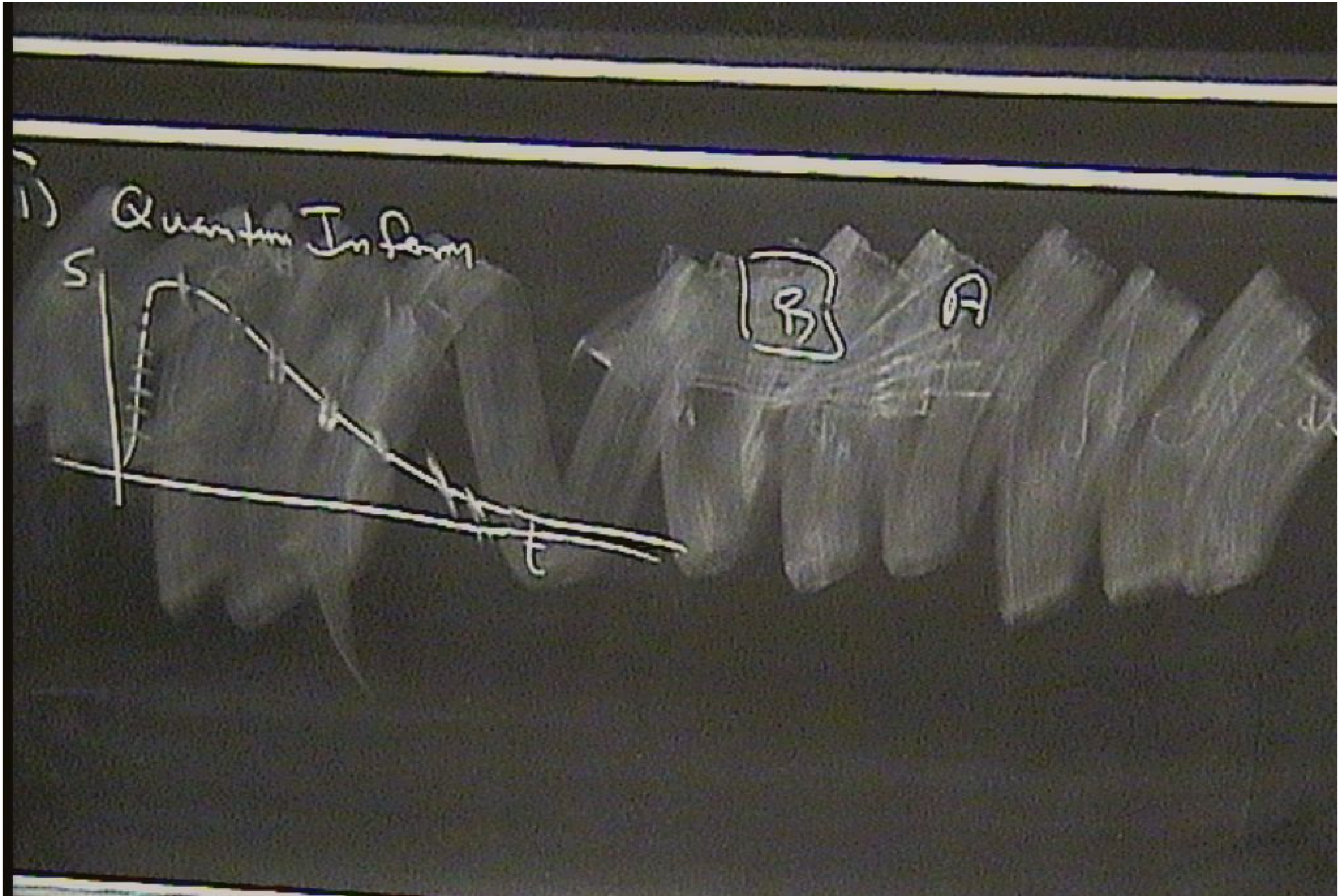
1) Quantum Inference



$\boxed{B}$ A


ii) Quantum Inform
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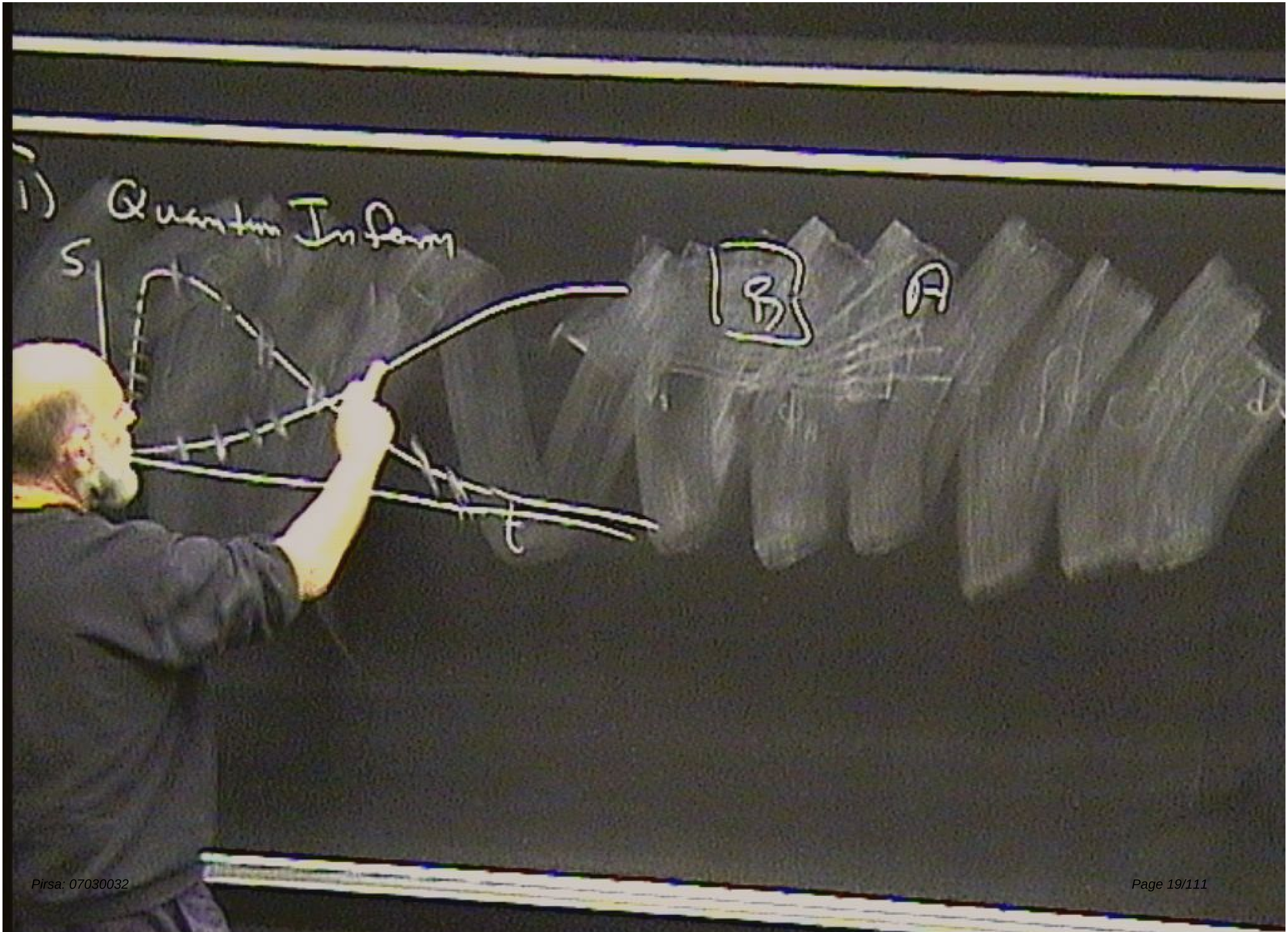
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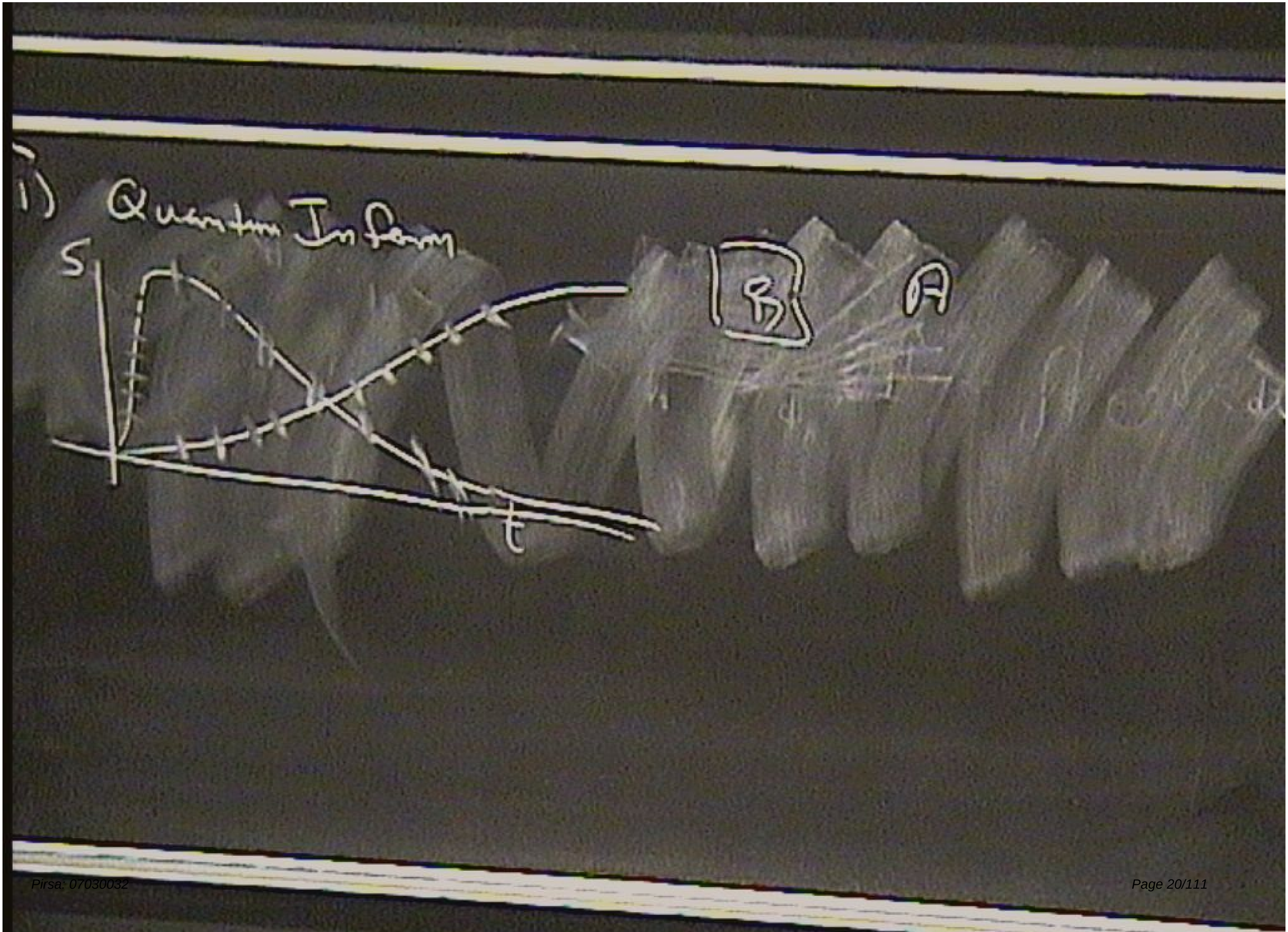
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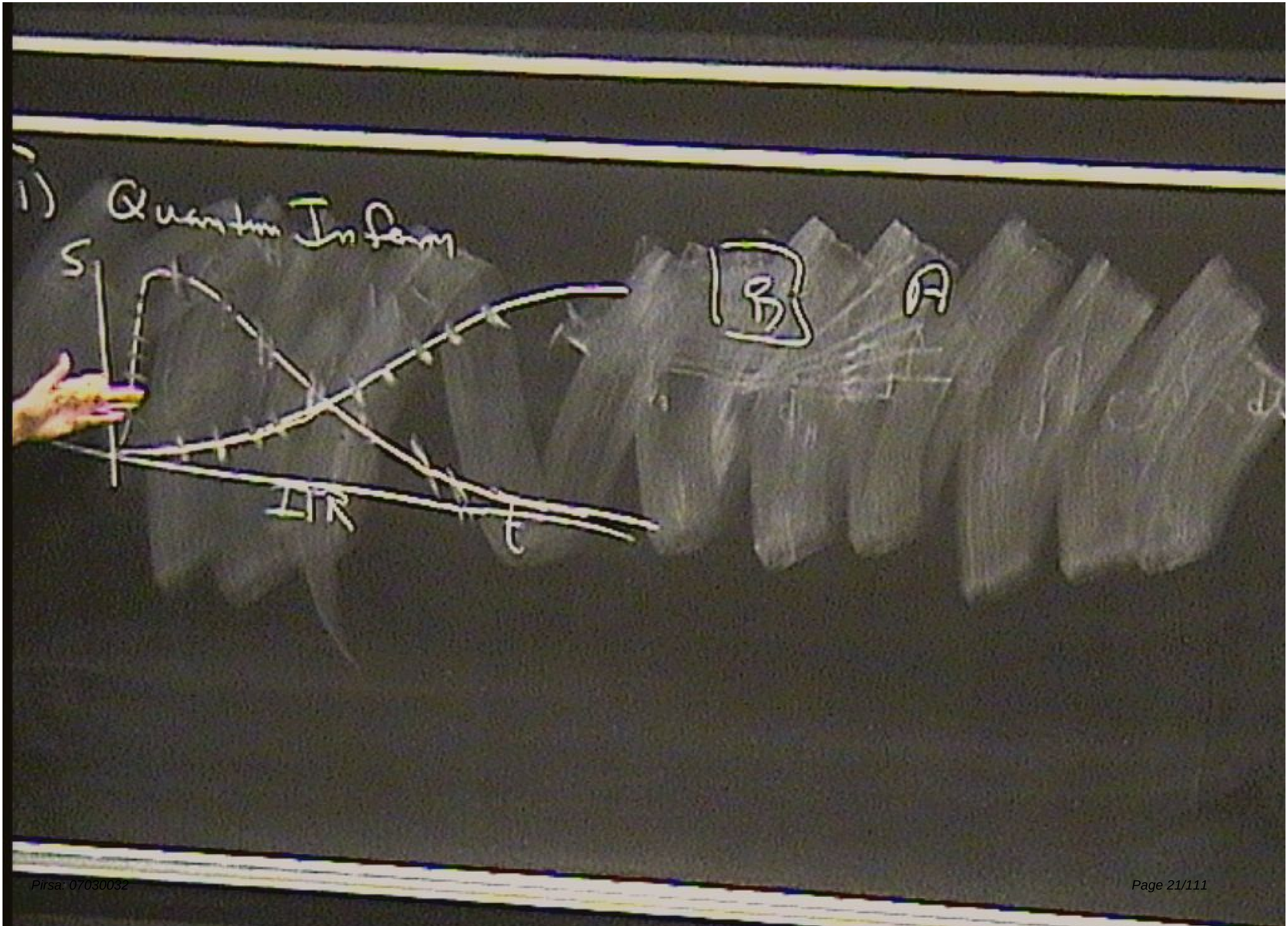
i) Quantum Infancy
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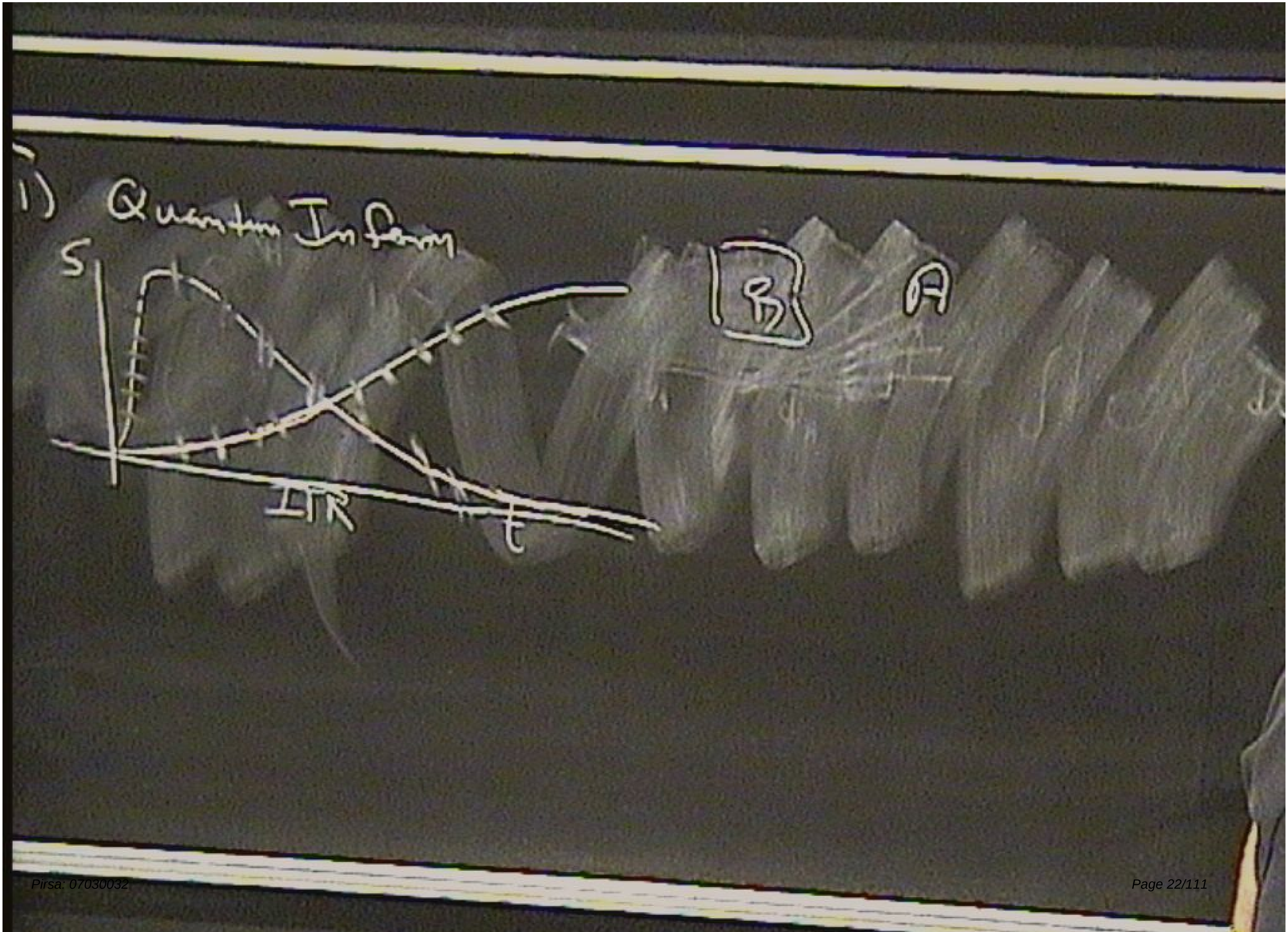
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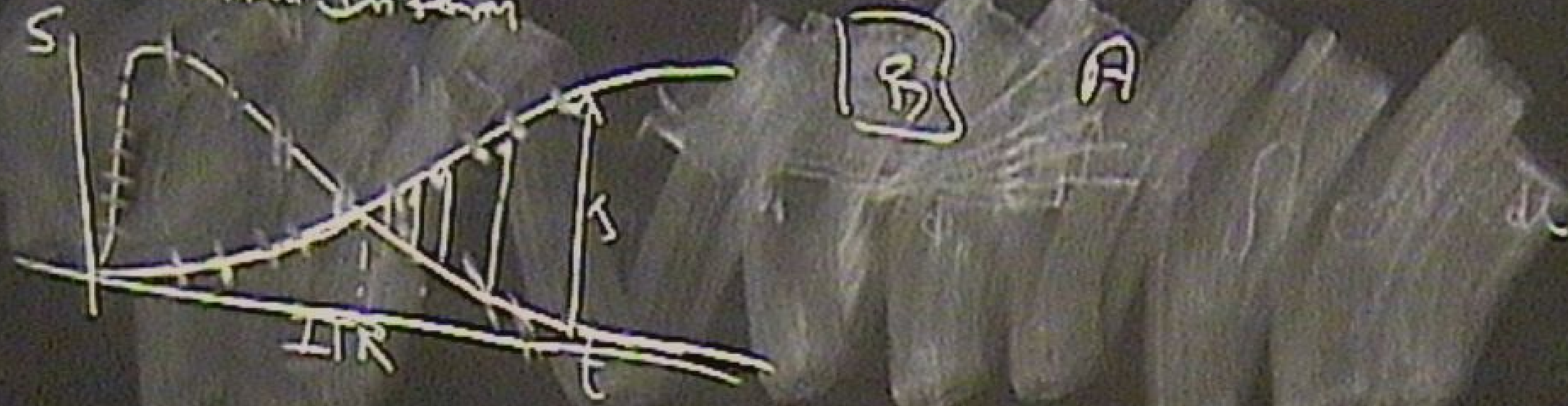
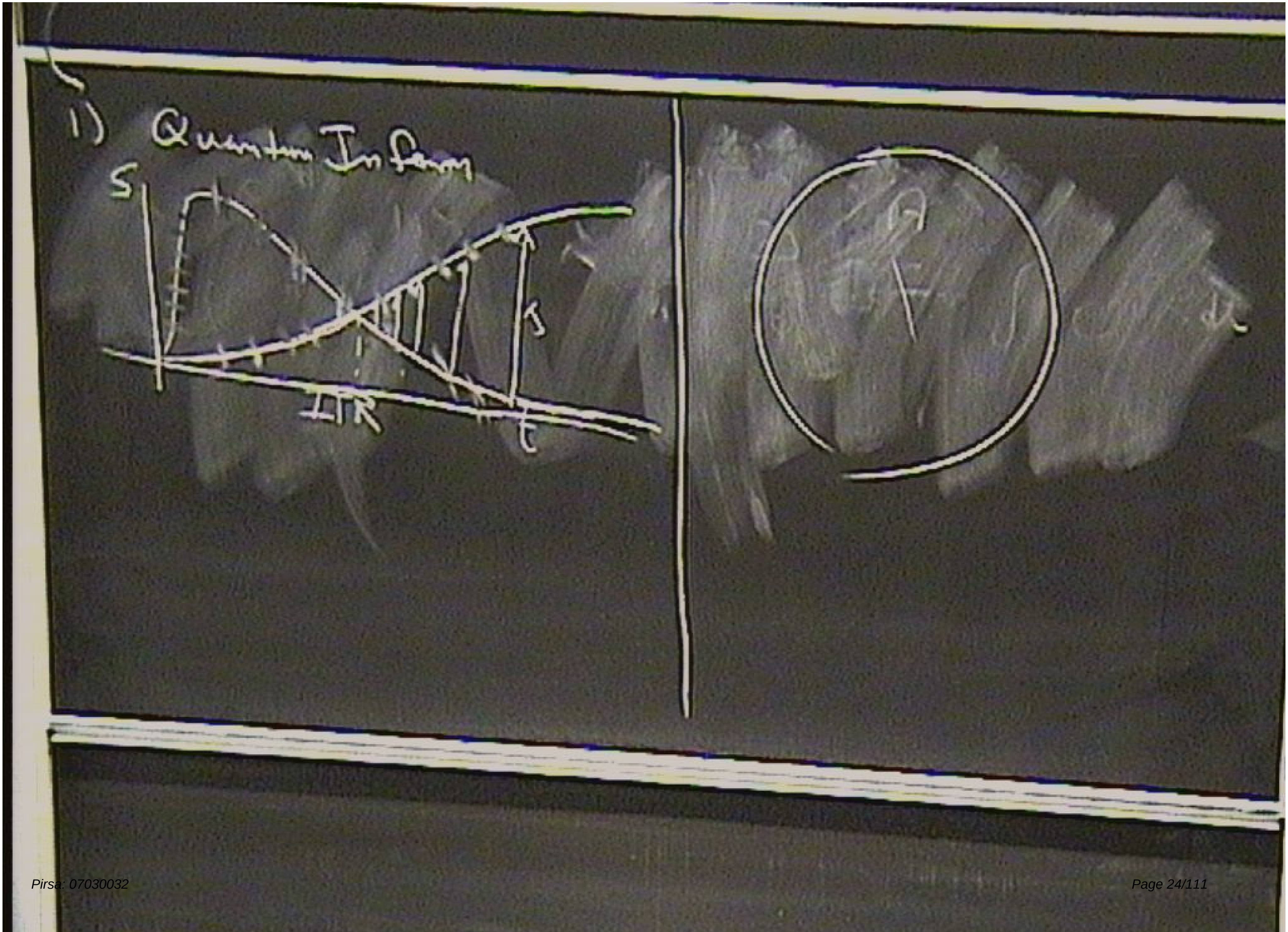
1) Quantum Inform

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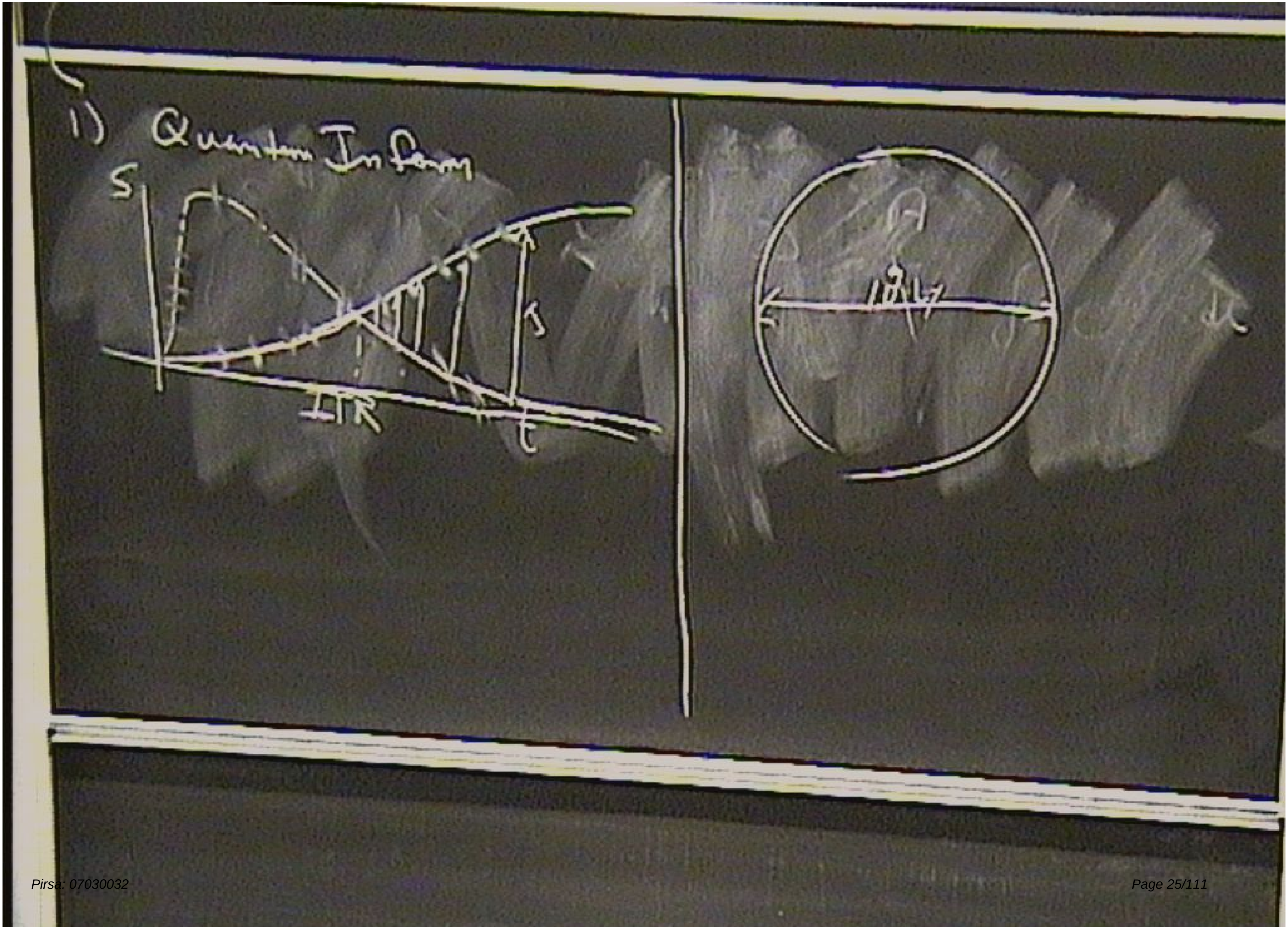
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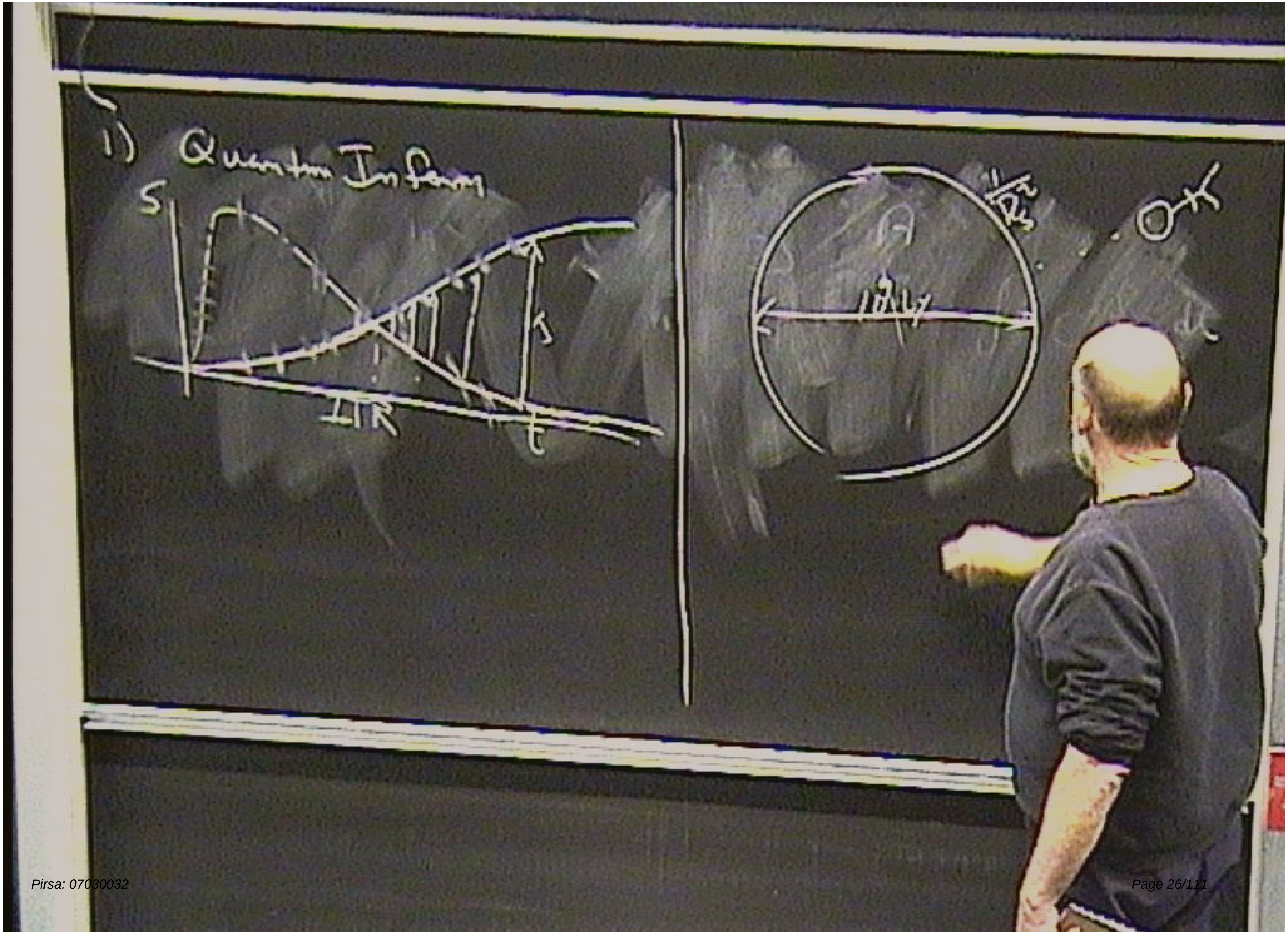
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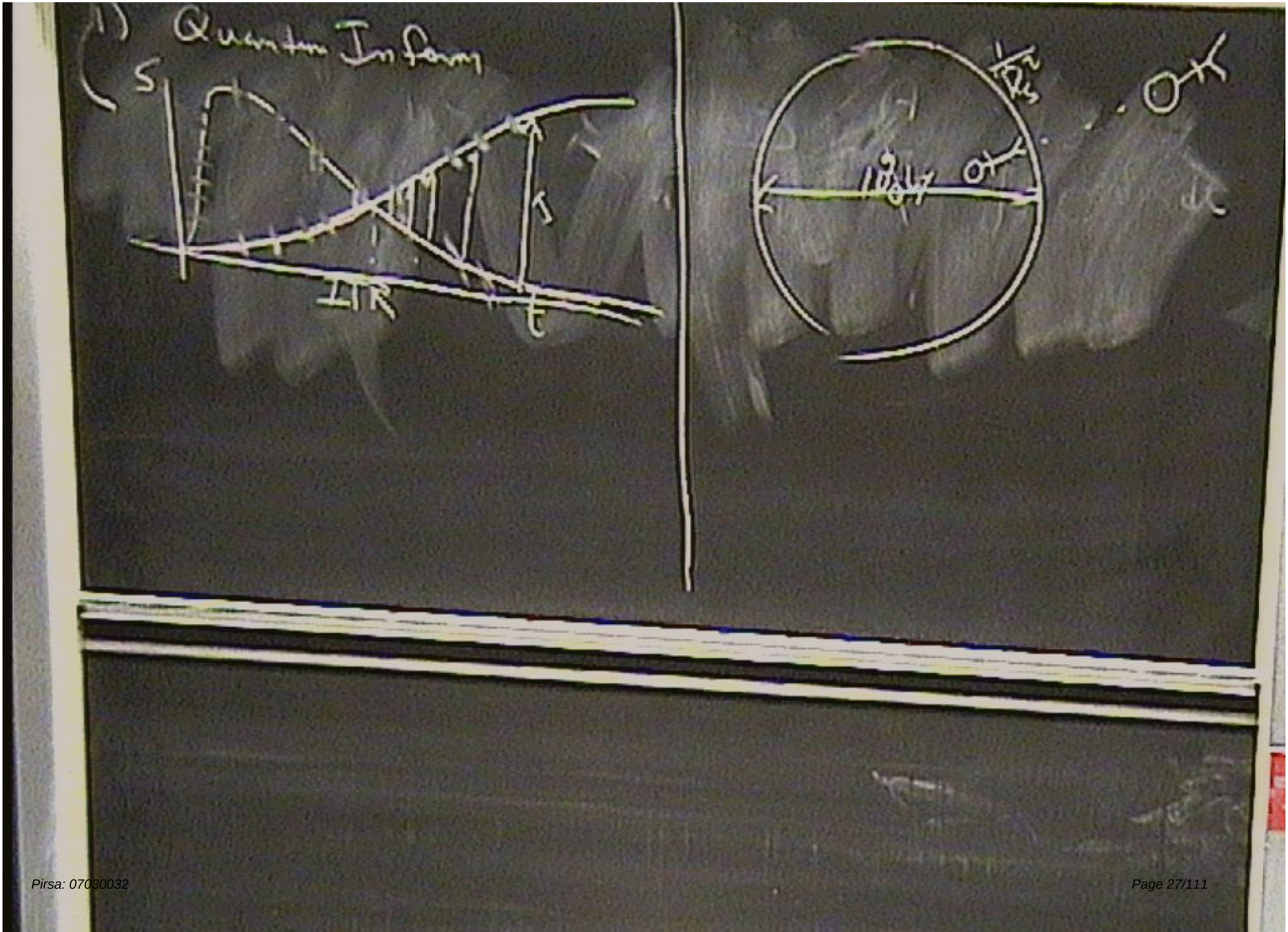

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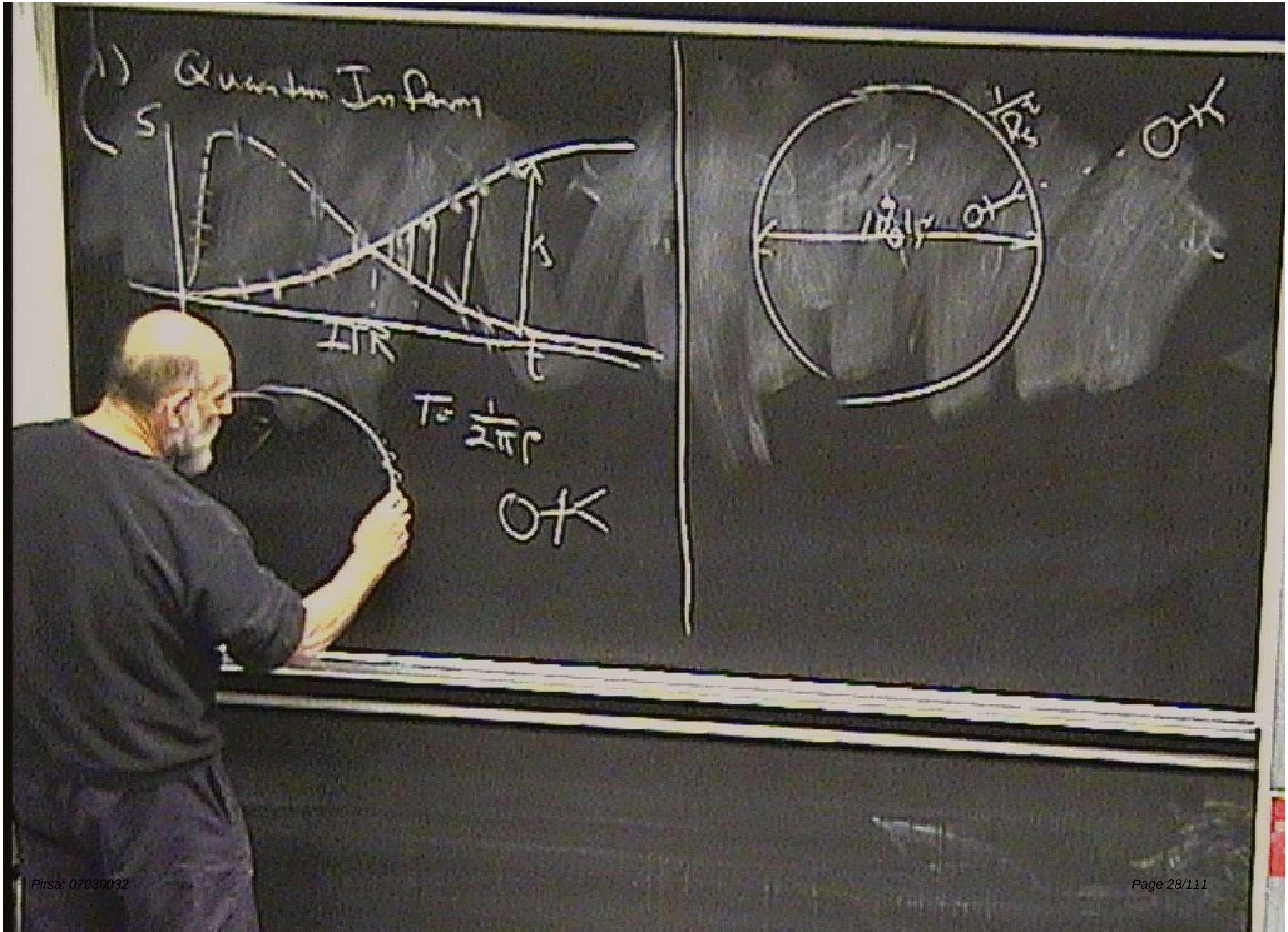
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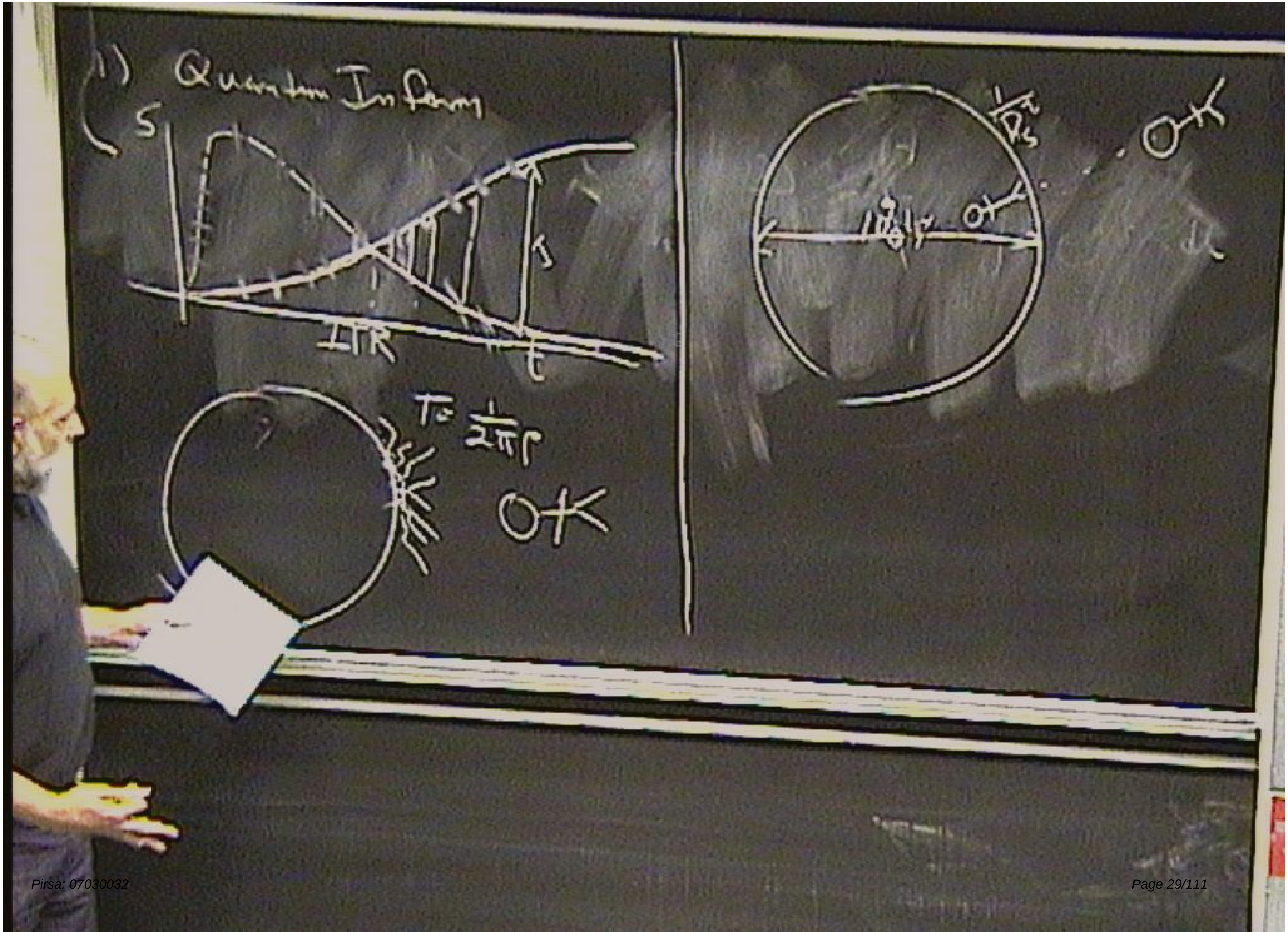
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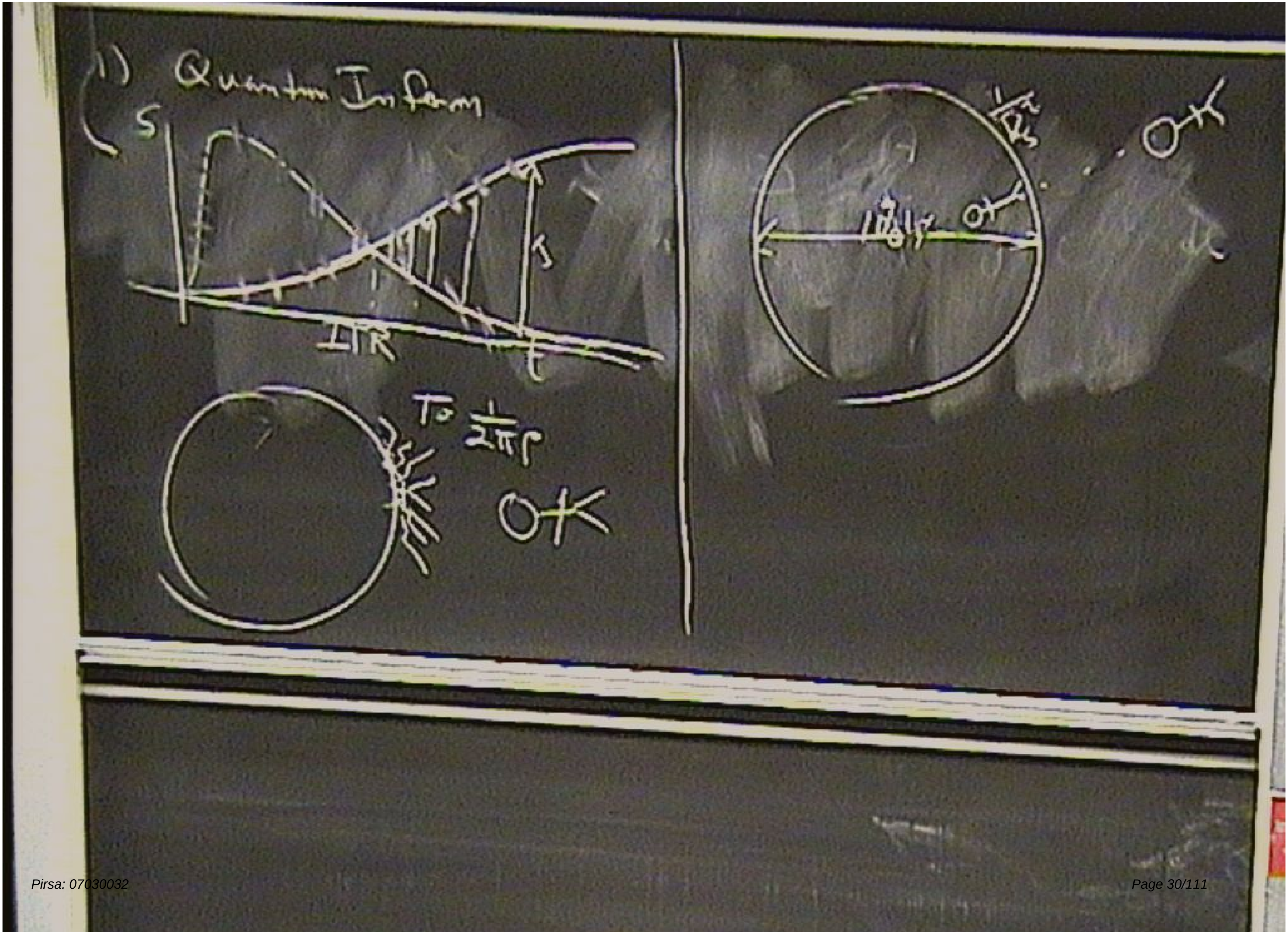
1) Quantum Inform
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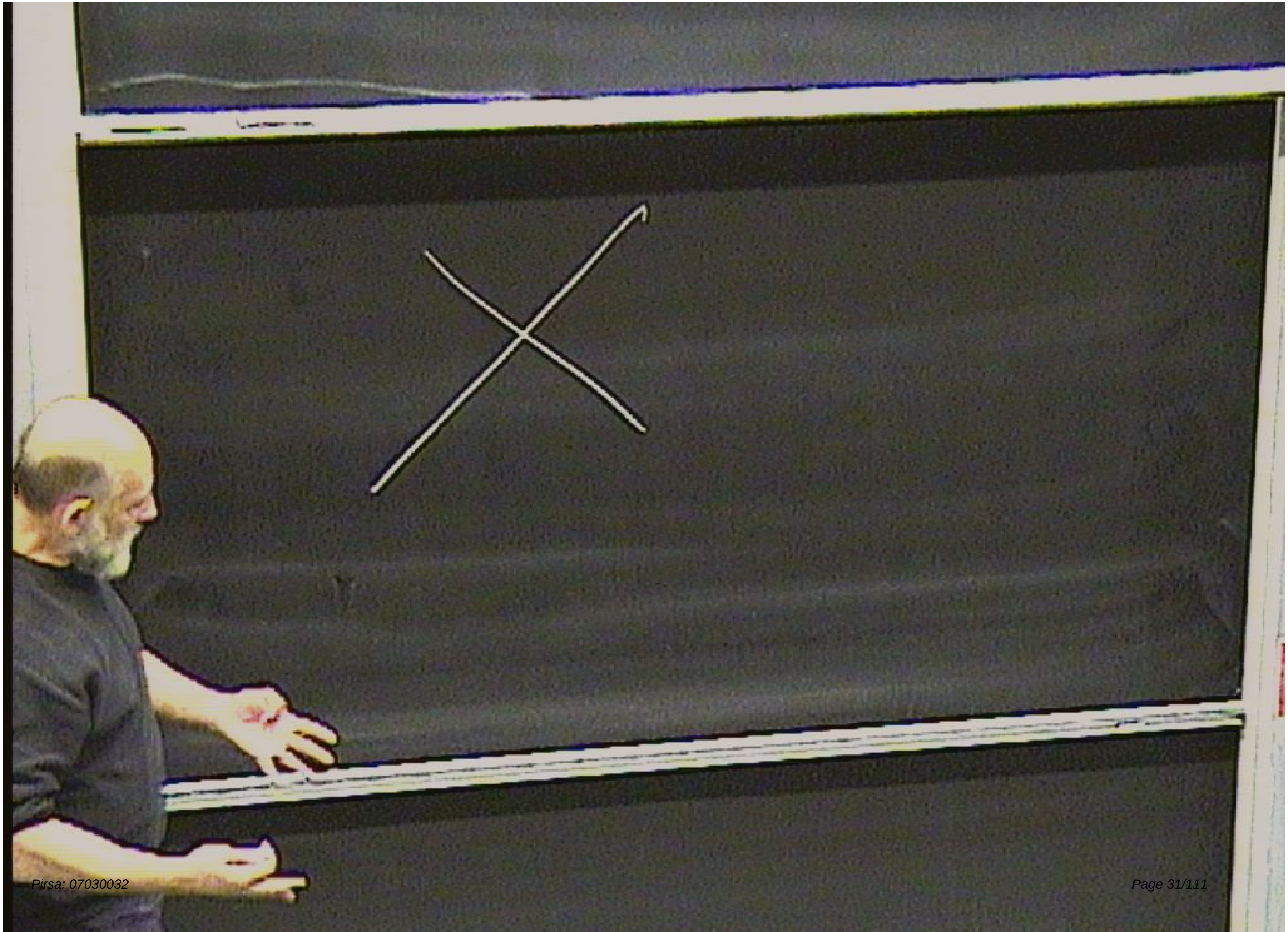

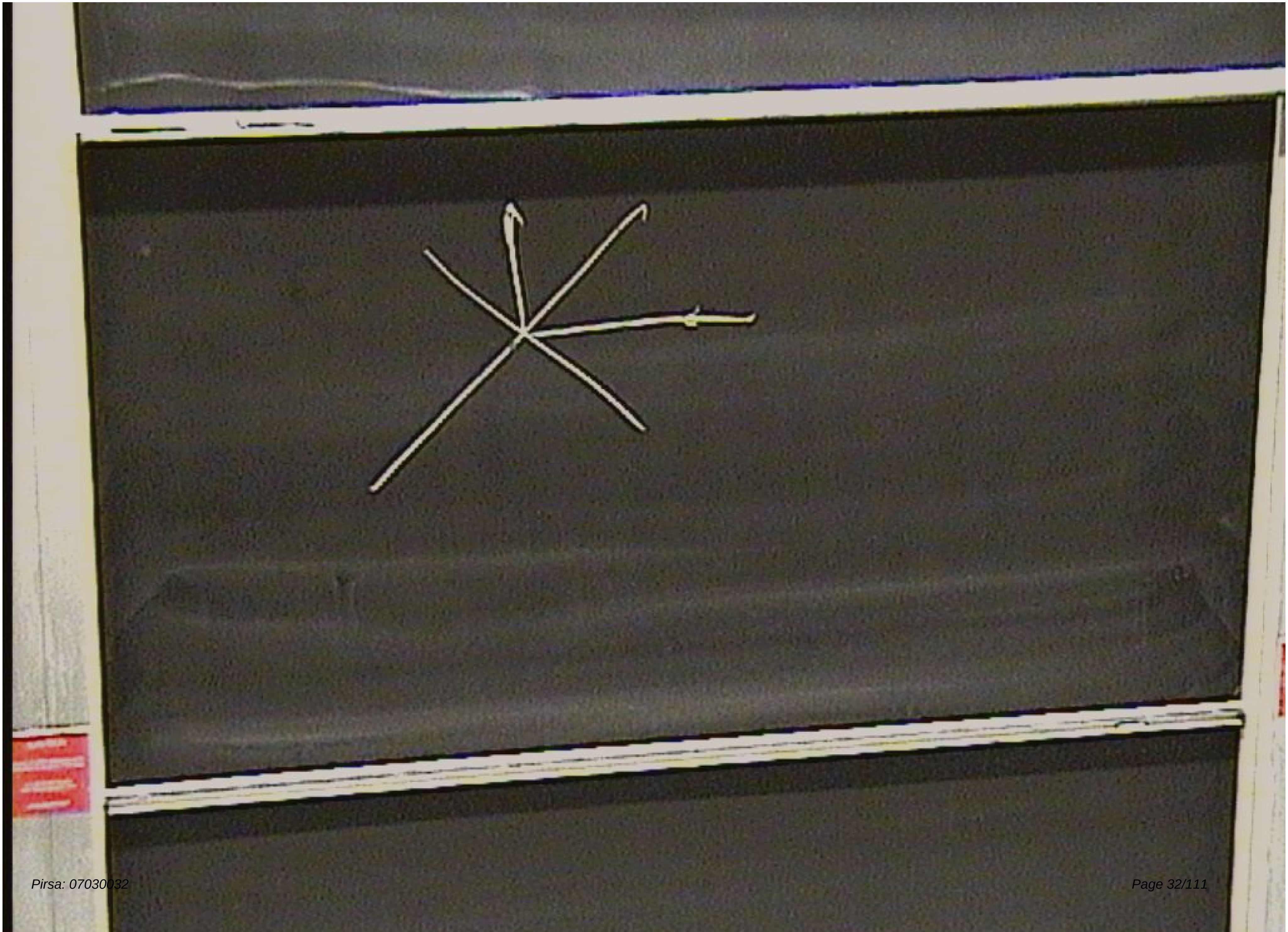

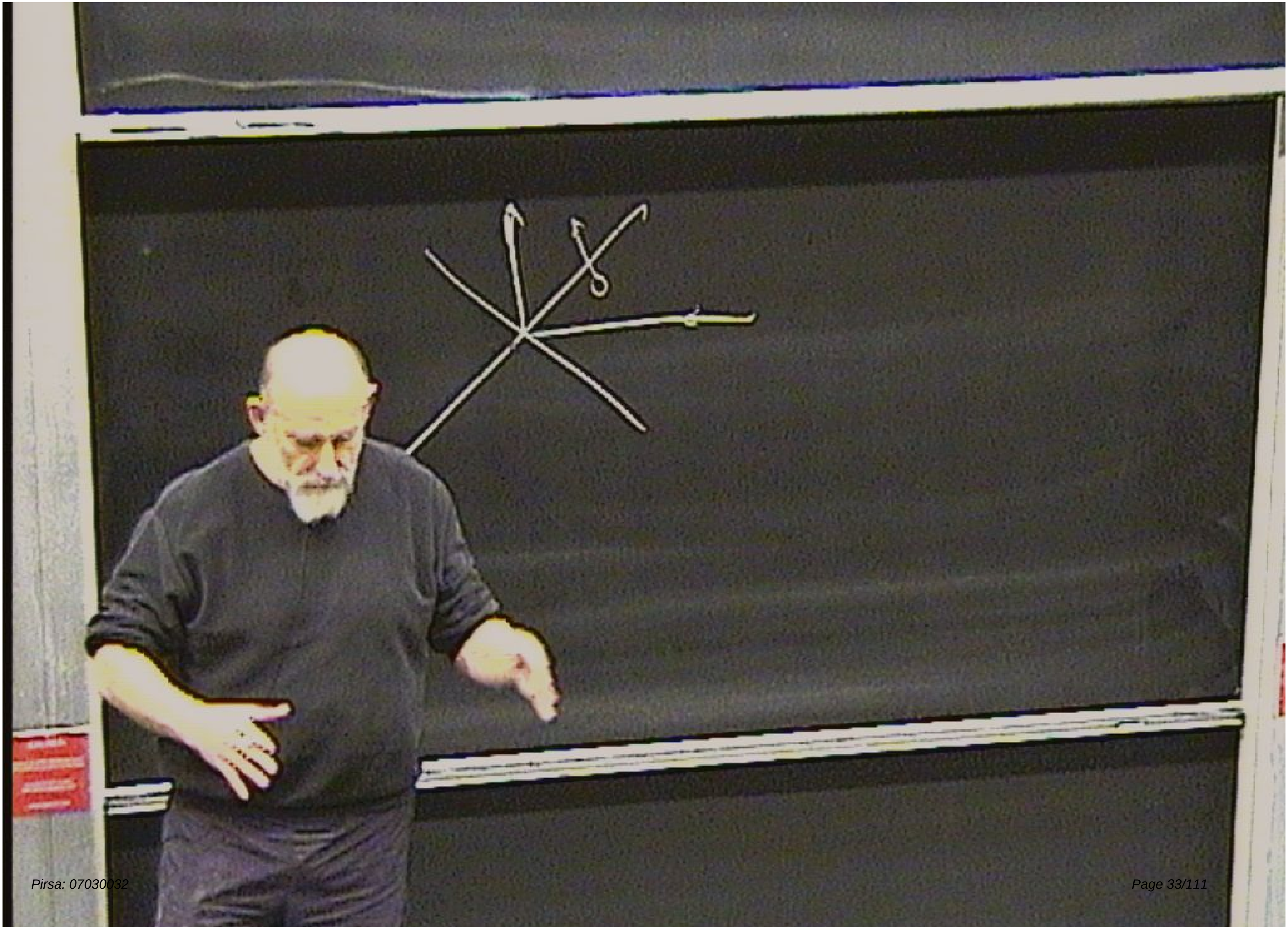

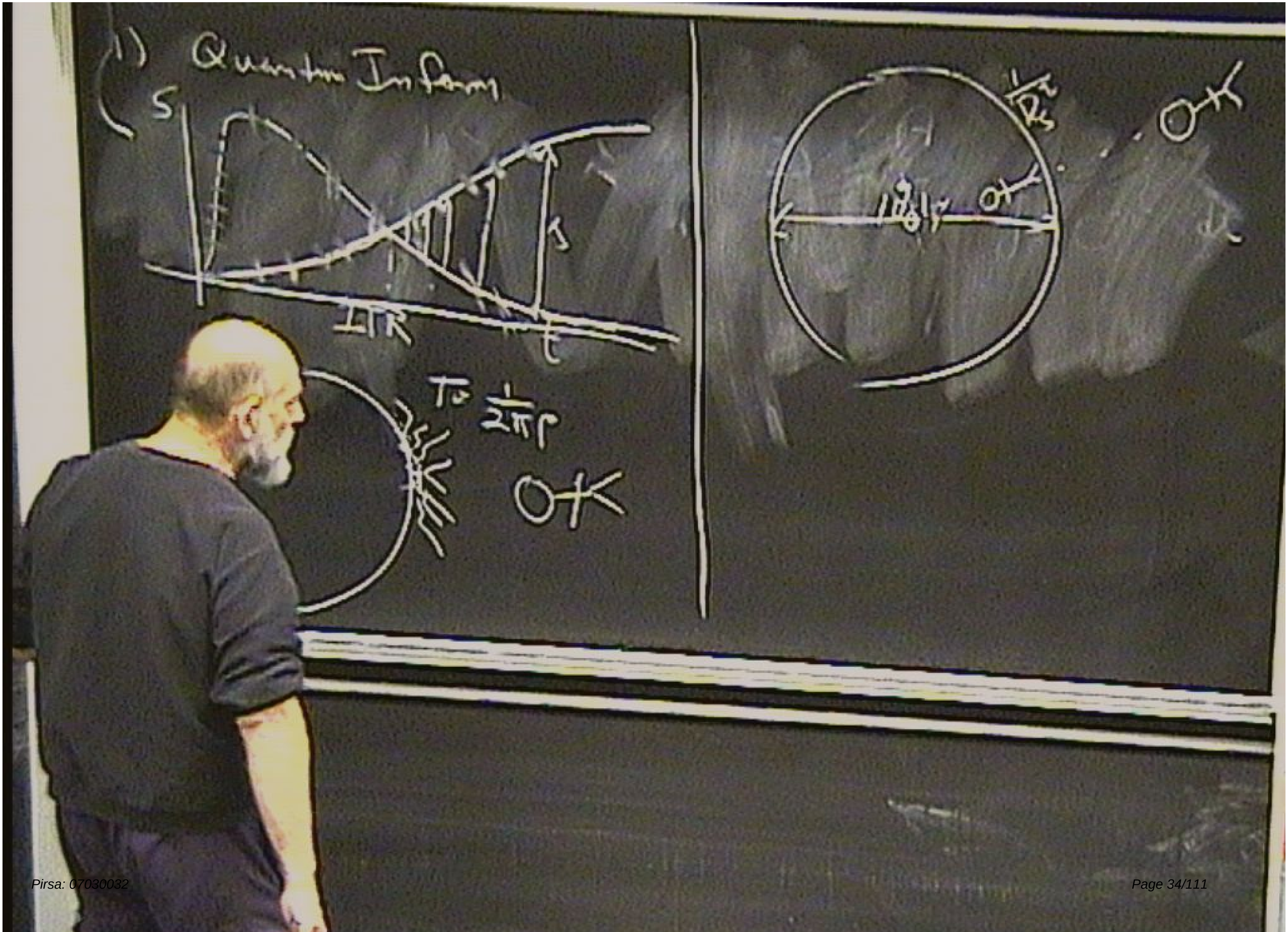
1) Quantum Inform
OK
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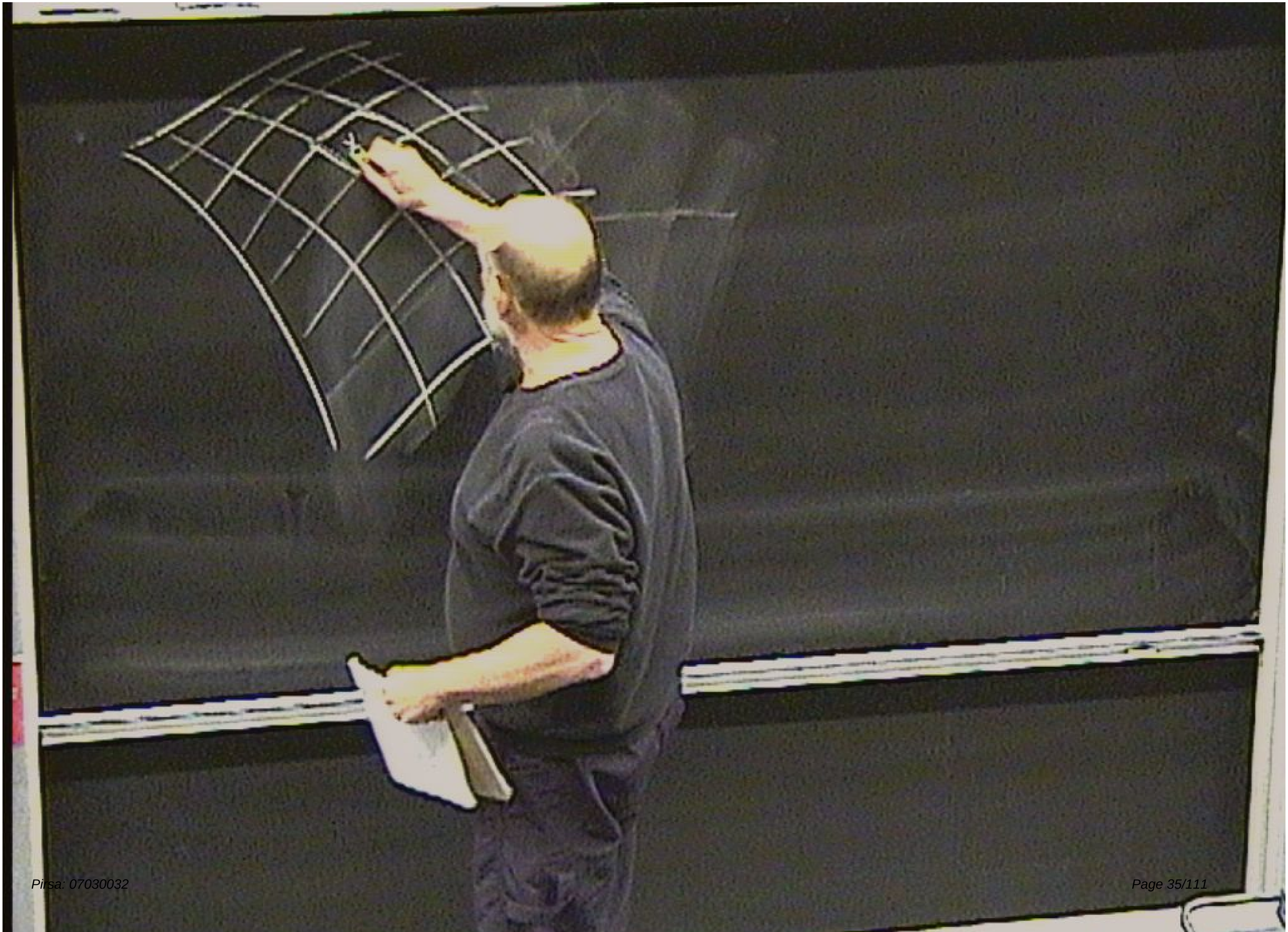

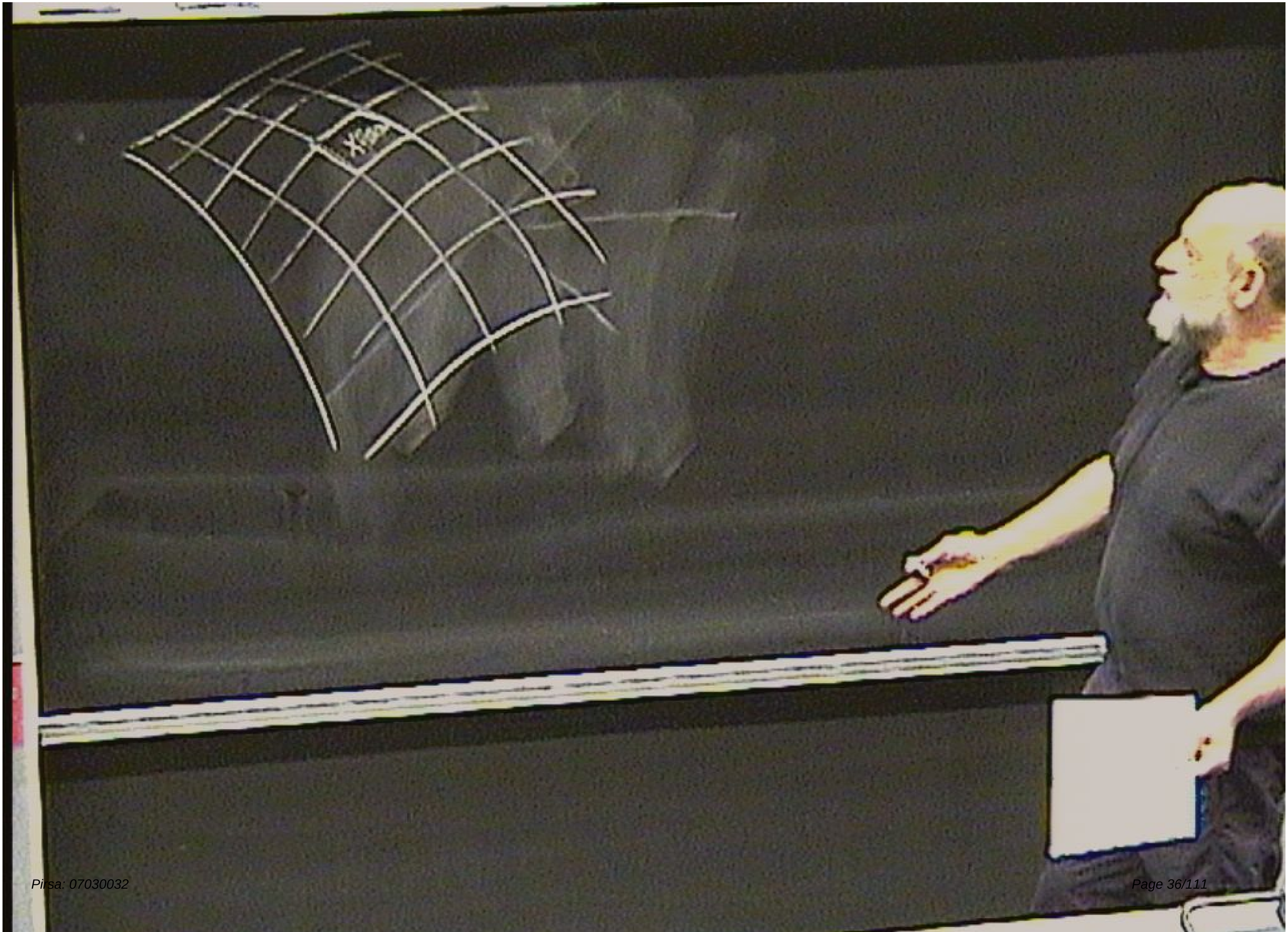

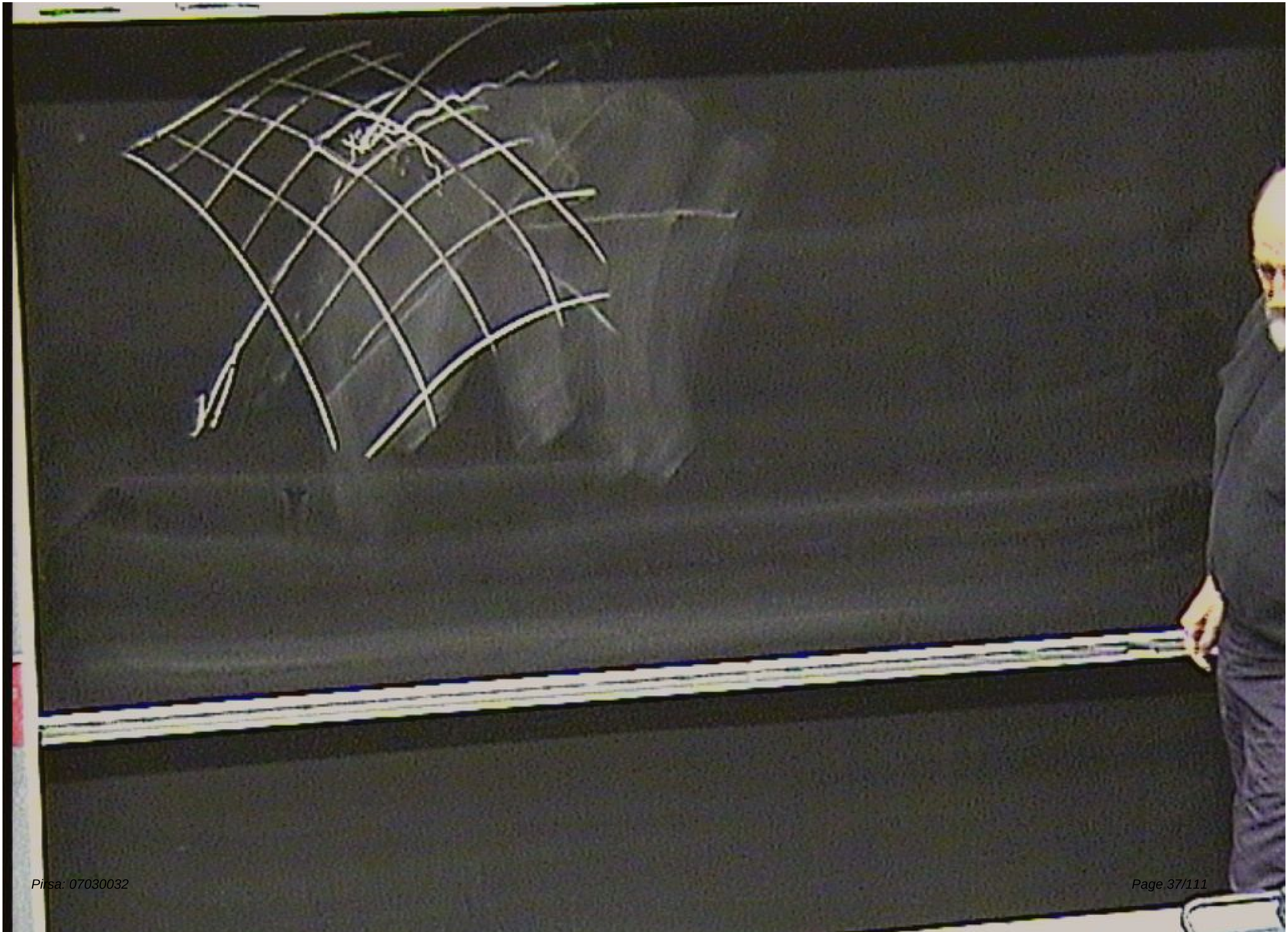

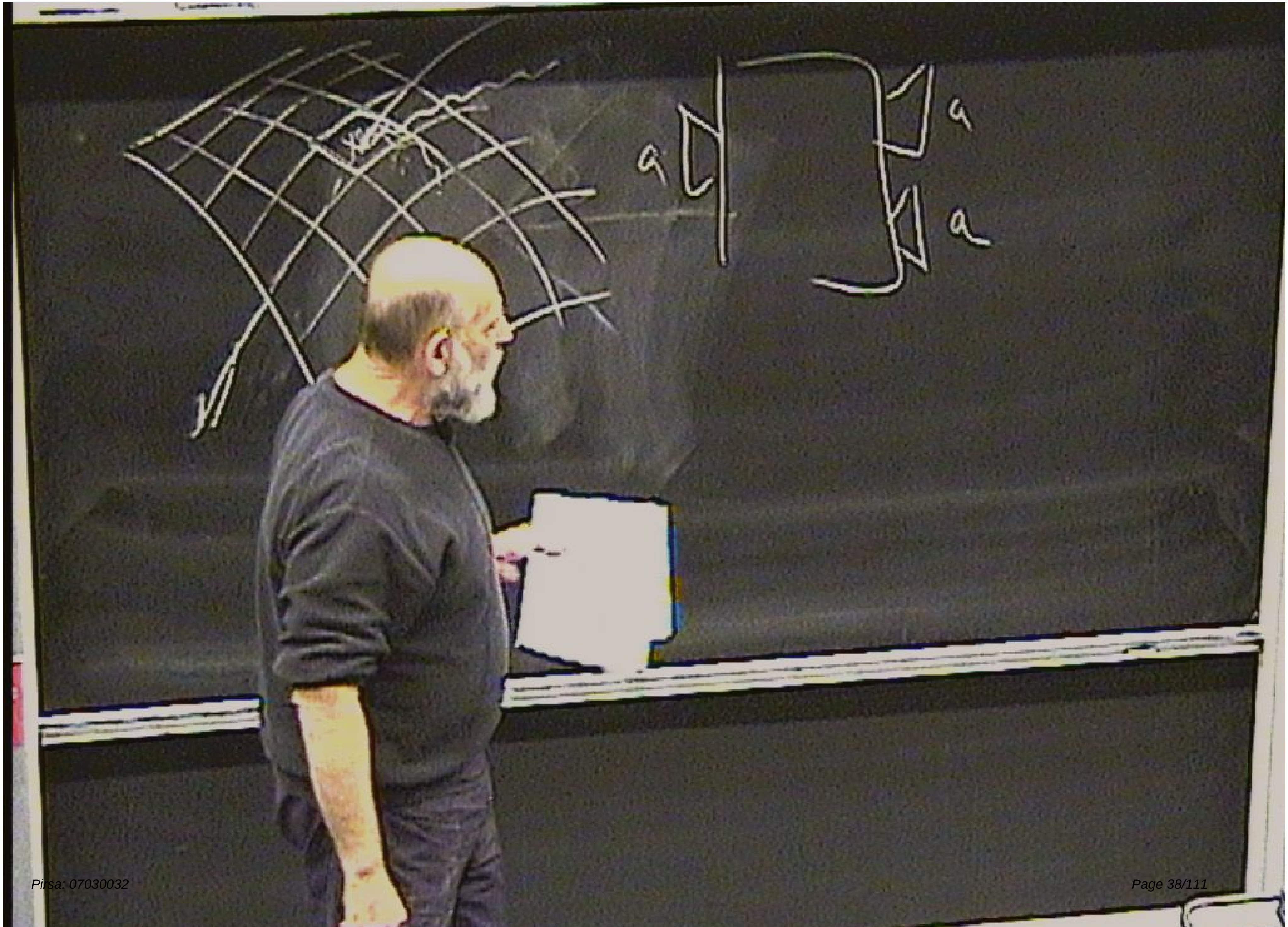
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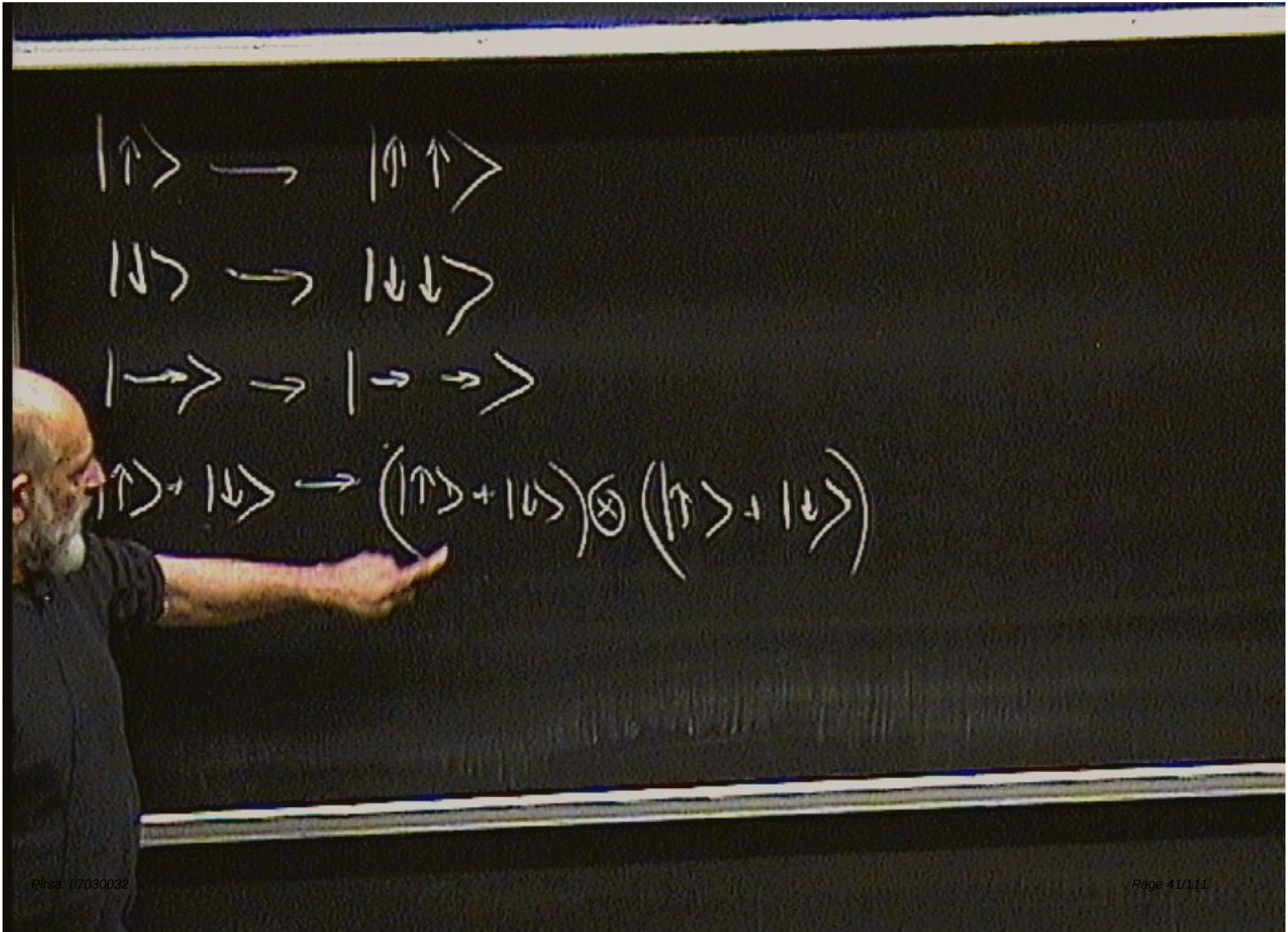
a
a

$$|\uparrow\rangle \longrightarrow |\Uparrow\uparrow\rangle$$

$$|\uparrow\rangle \longrightarrow |\uparrow\uparrow\rangle$$

$$|\downarrow\rangle \longrightarrow |\downarrow\downarrow\rangle$$

$$|\rightarrow\rangle \qquad |\rightarrow\rightarrow\rangle$$

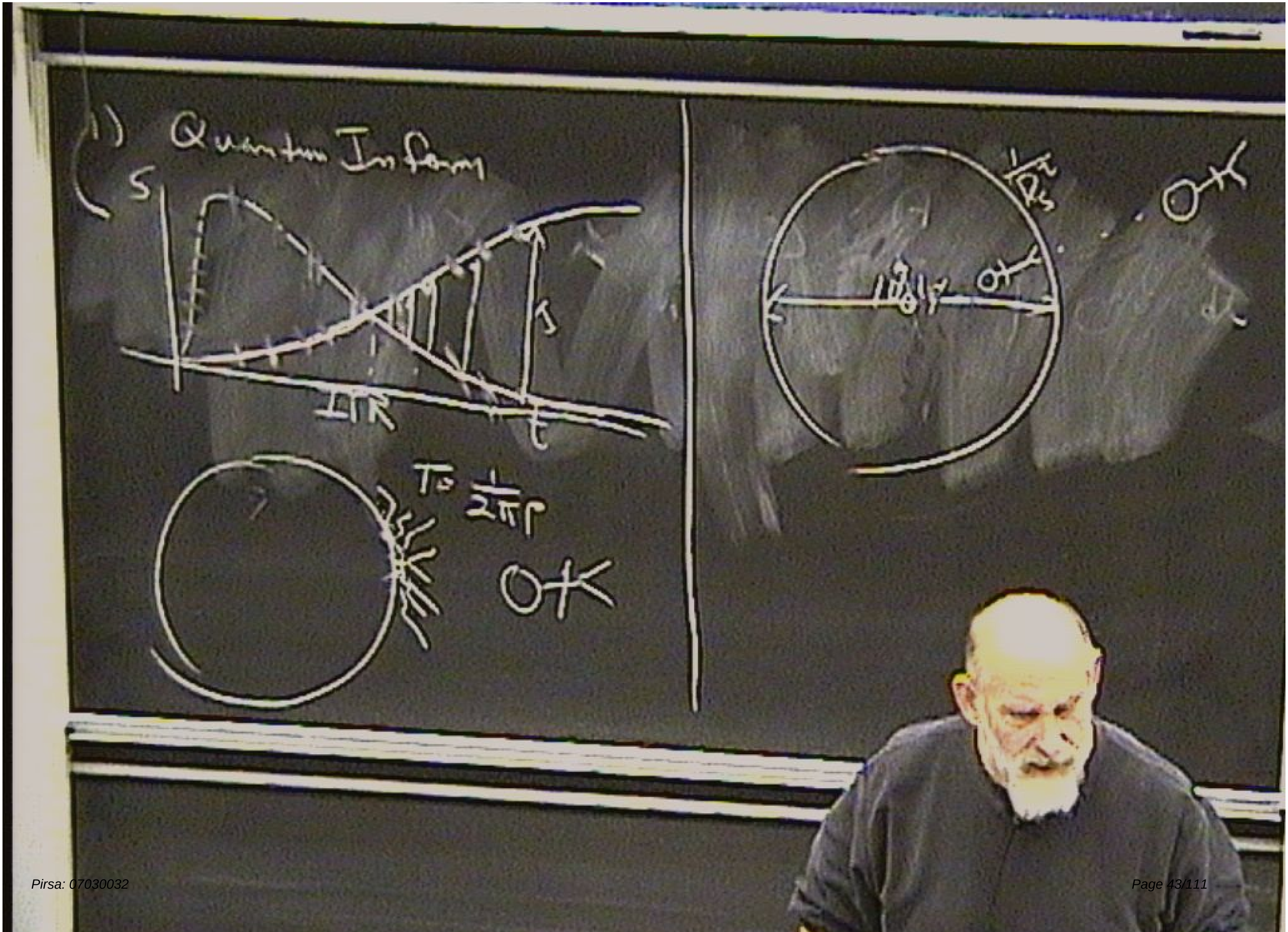

$|\uparrow\rangle \longrightarrow |\uparrow\uparrow\rangle$
$|\downarrow\rangle \longrightarrow |\downarrow\downarrow\rangle$
$|\rightarrow\rangle \rightarrow |\rightarrow\rightarrow\rangle$
$|\uparrow\rangle + |\downarrow\rangle \longrightarrow \left(|\uparrow\rangle + |\downarrow\rangle\right) \otimes \left(|\uparrow\rangle + |\downarrow\rangle\right)$

$$|\uparrow\rangle \longrightarrow |\uparrow\uparrow\rangle$$

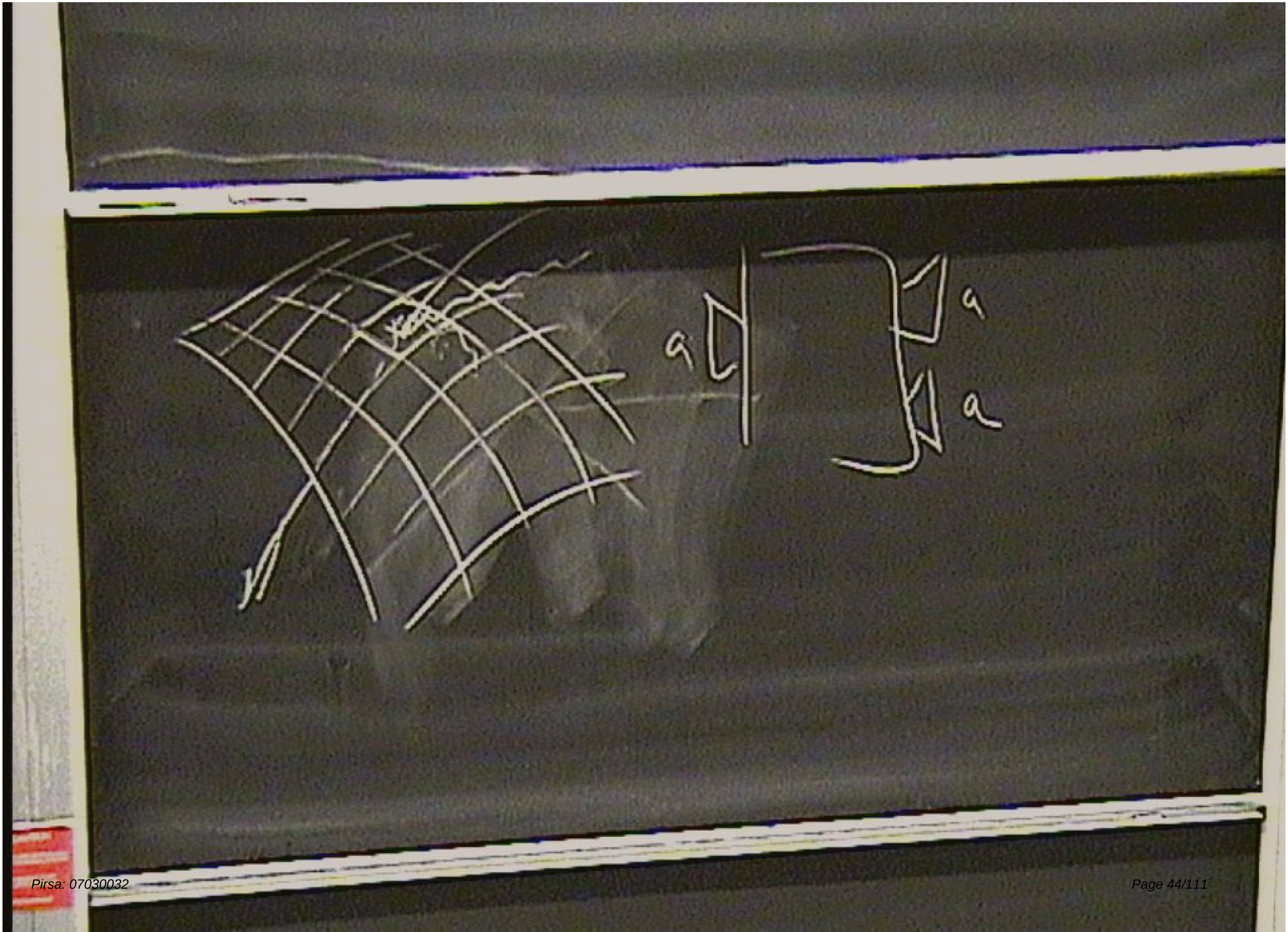
$$|\downarrow\rangle \longrightarrow |\downarrow\downarrow\rangle$$

$$|\rightarrow\rangle \longrightarrow |\rightarrow\rightarrow\rangle$$

$$|\uparrow\rangle + |\downarrow\rangle \longrightarrow \left(|\uparrow\rangle + |\downarrow\rangle\right) \otimes \left(|\uparrow\rangle + |\downarrow\rangle\right)$$



1) Quantum Inform
S
IR
t
T
T = 1/2πρ
OK
OK
OK


a
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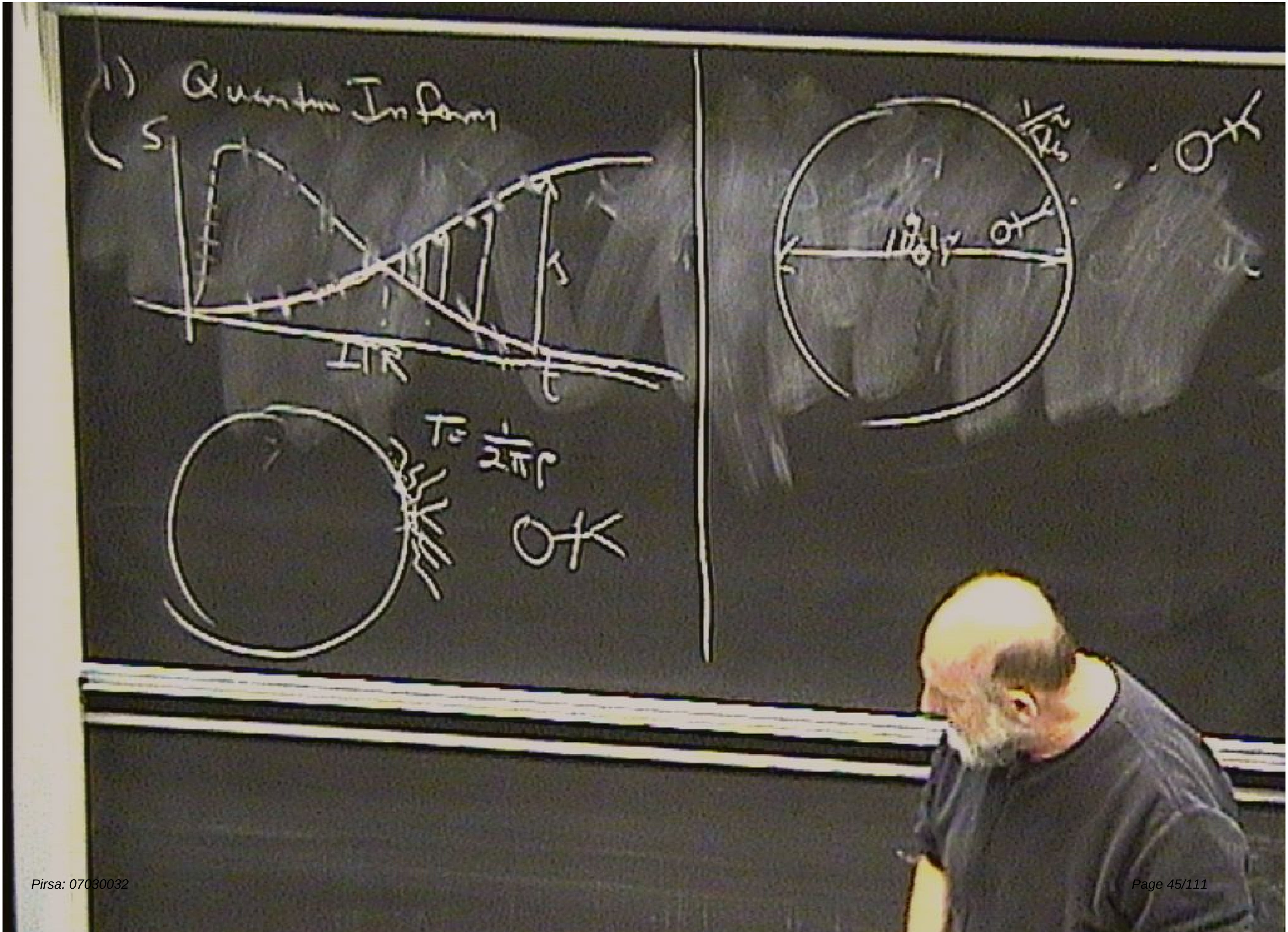
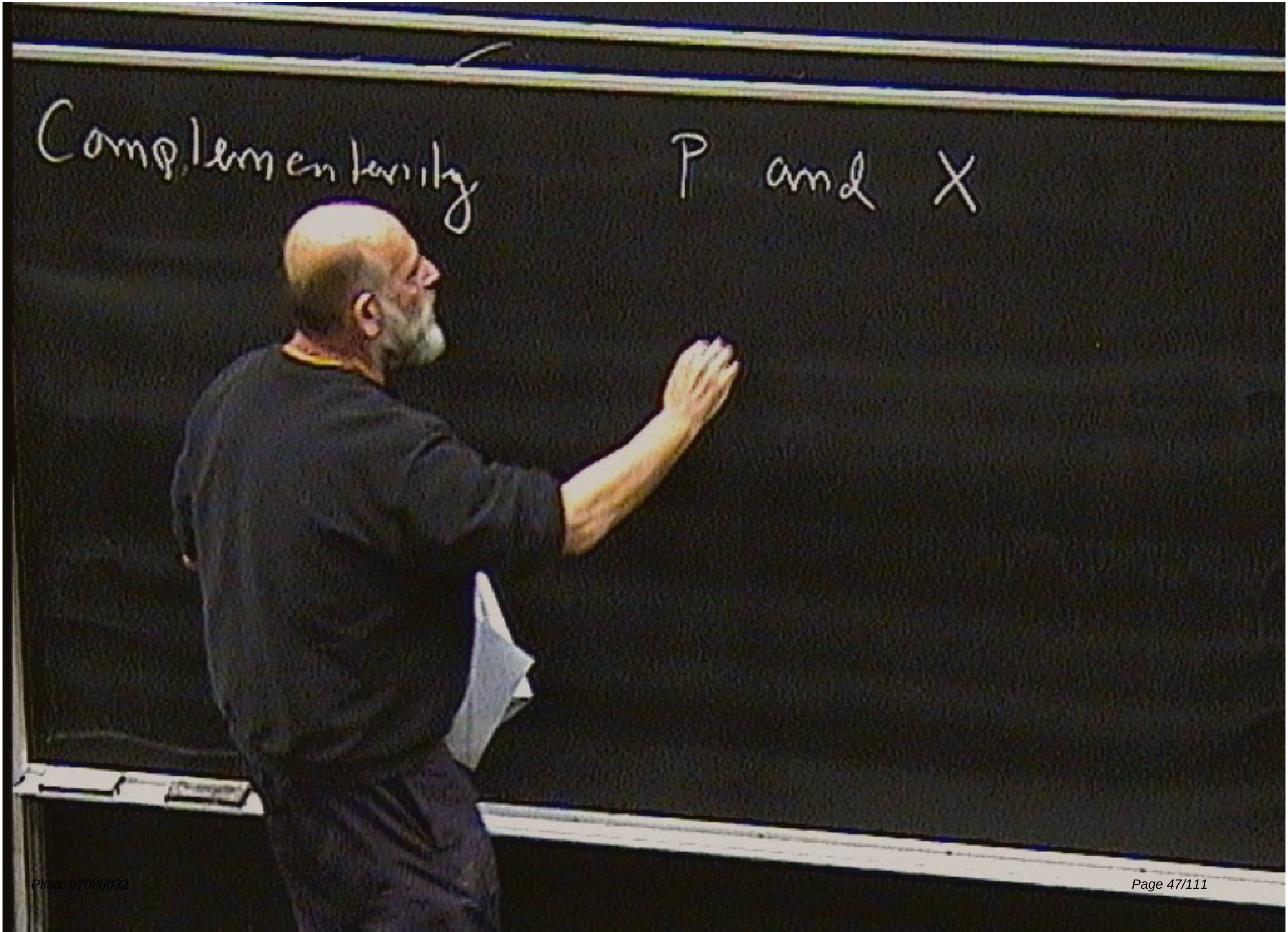
a


1) Quantum Inform
S
IR
t
T = 1/2πρ
OK
OK
OK

Complementarity


Complementarity
P and X

Complementarity

P ~~and~~ X

or

Complementarity

P ~~and~~ X

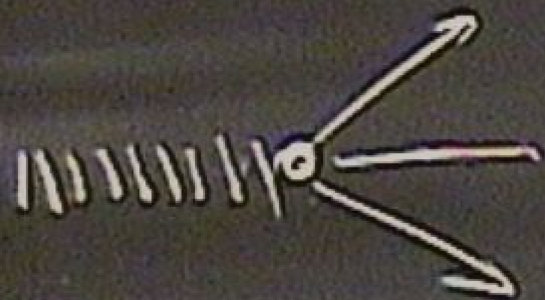
or

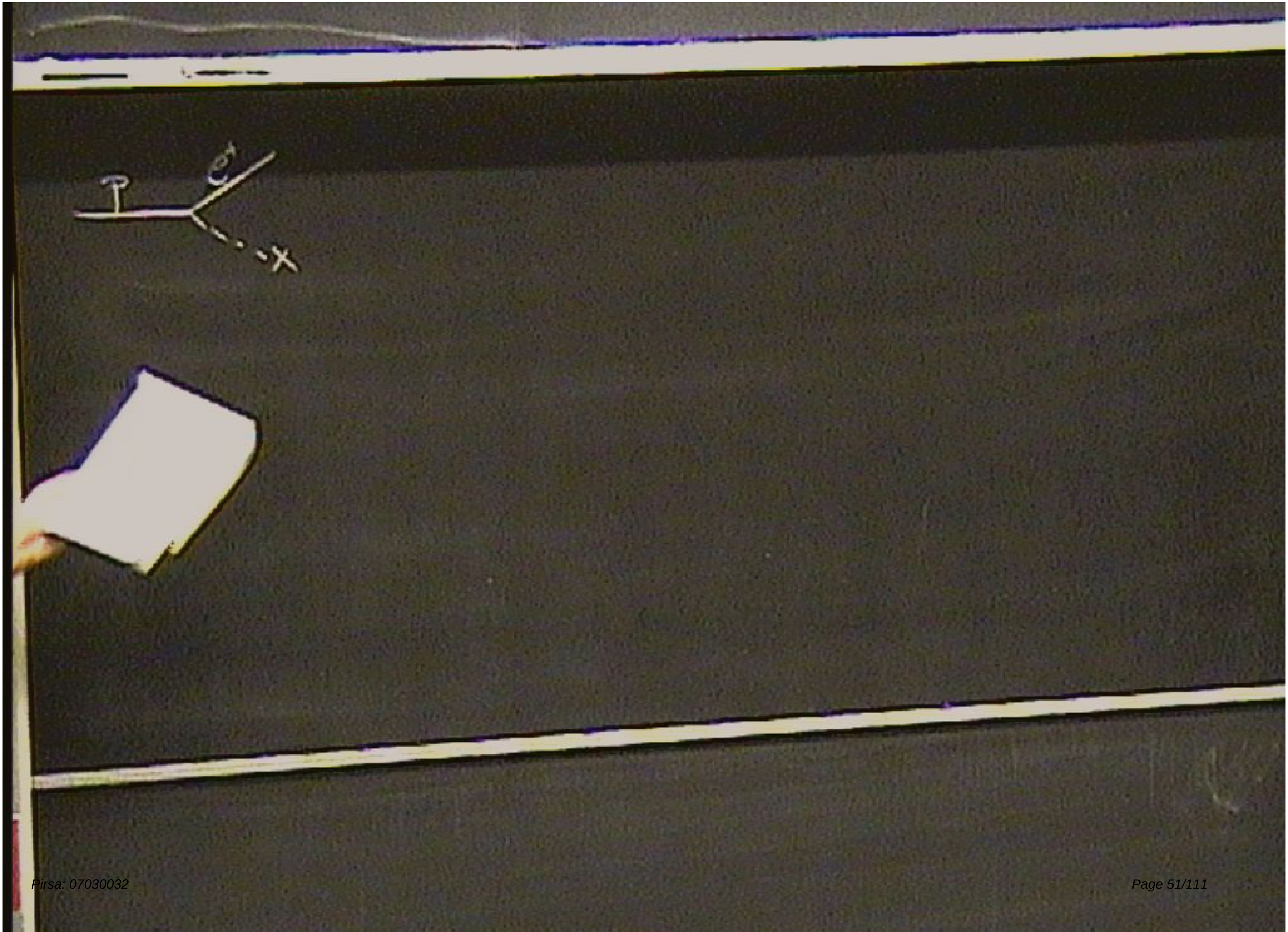
1111111110

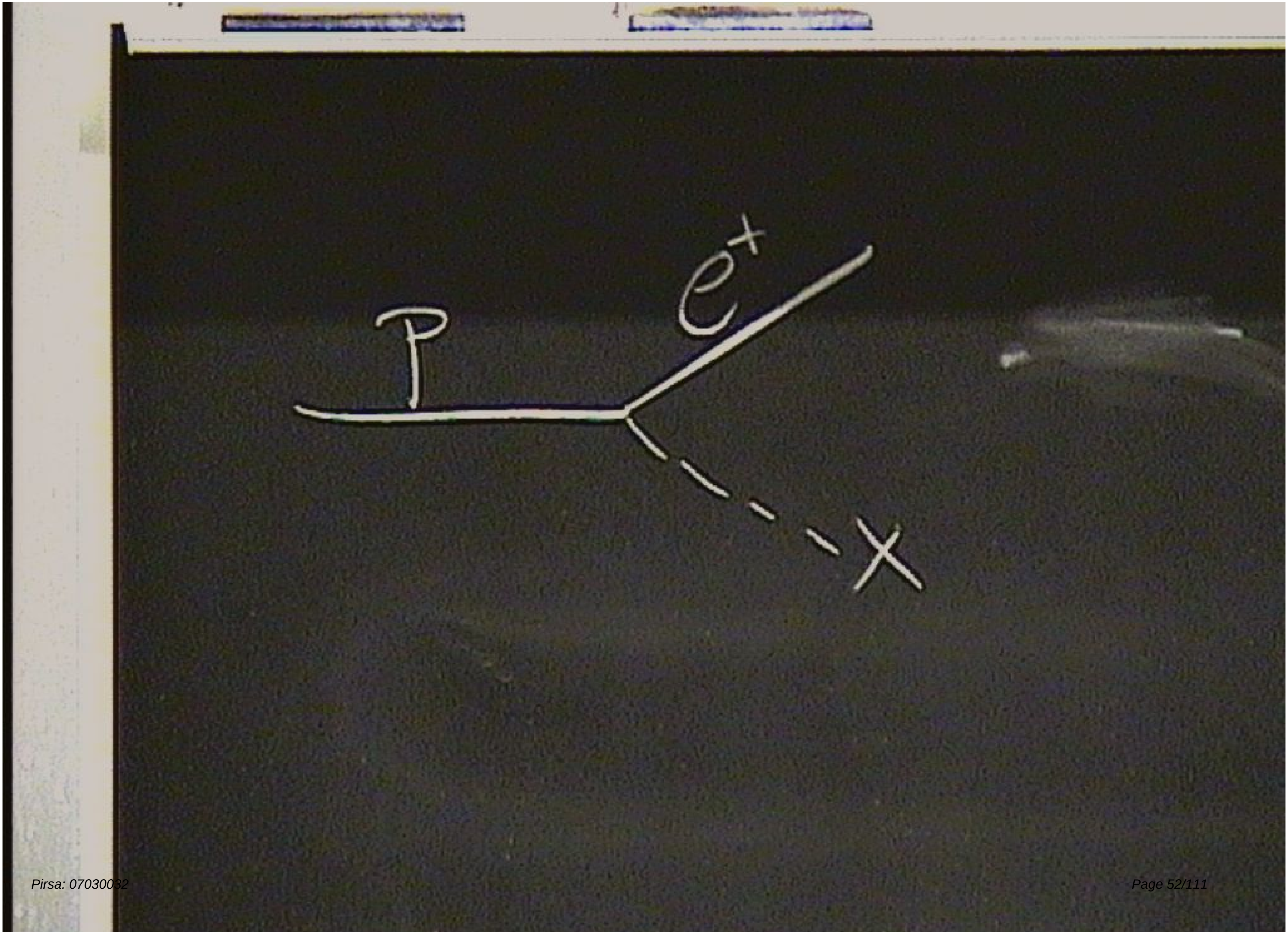
Complementarity

P ~~and~~ X

or






P
e+
X


p
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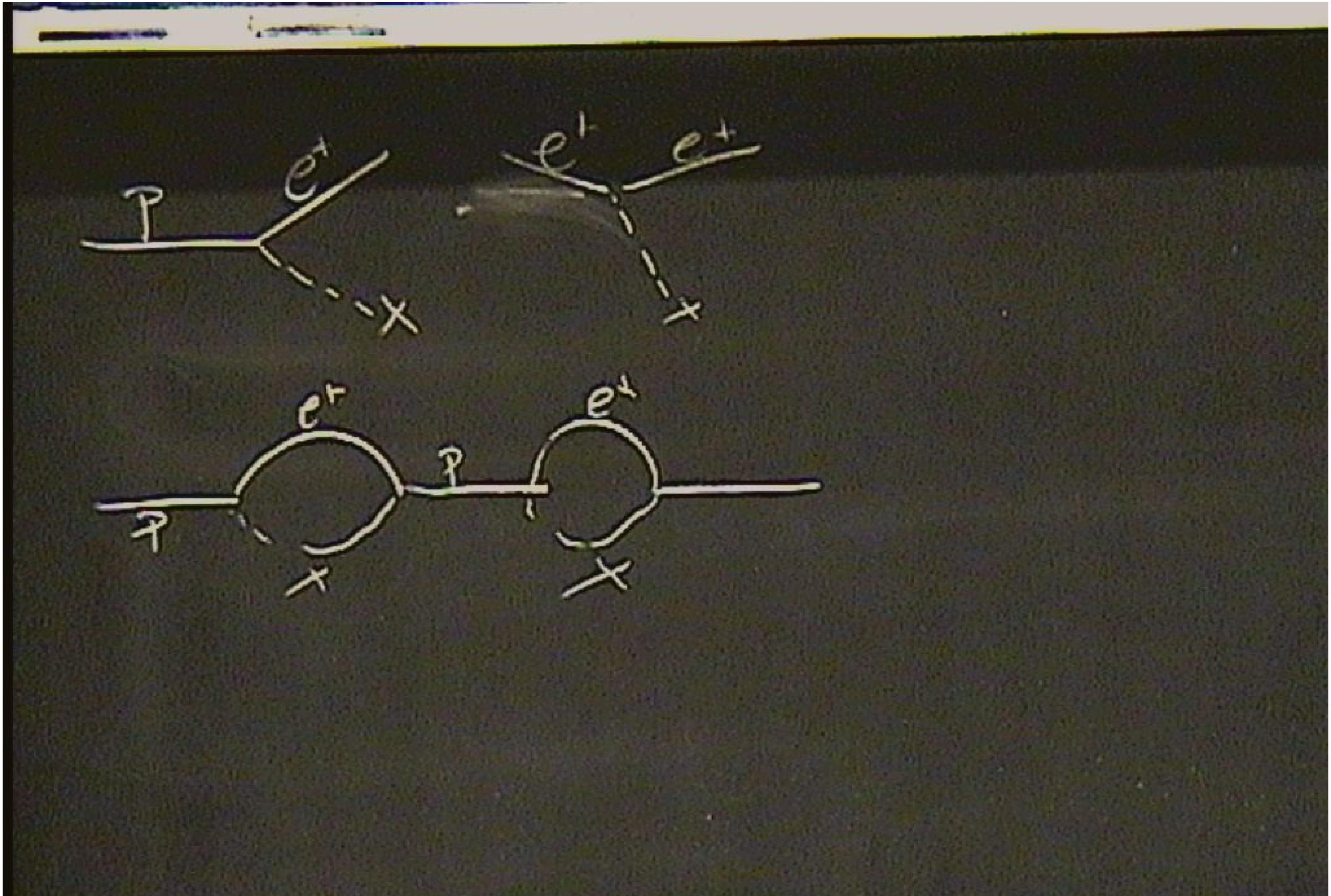
e+
e+


P
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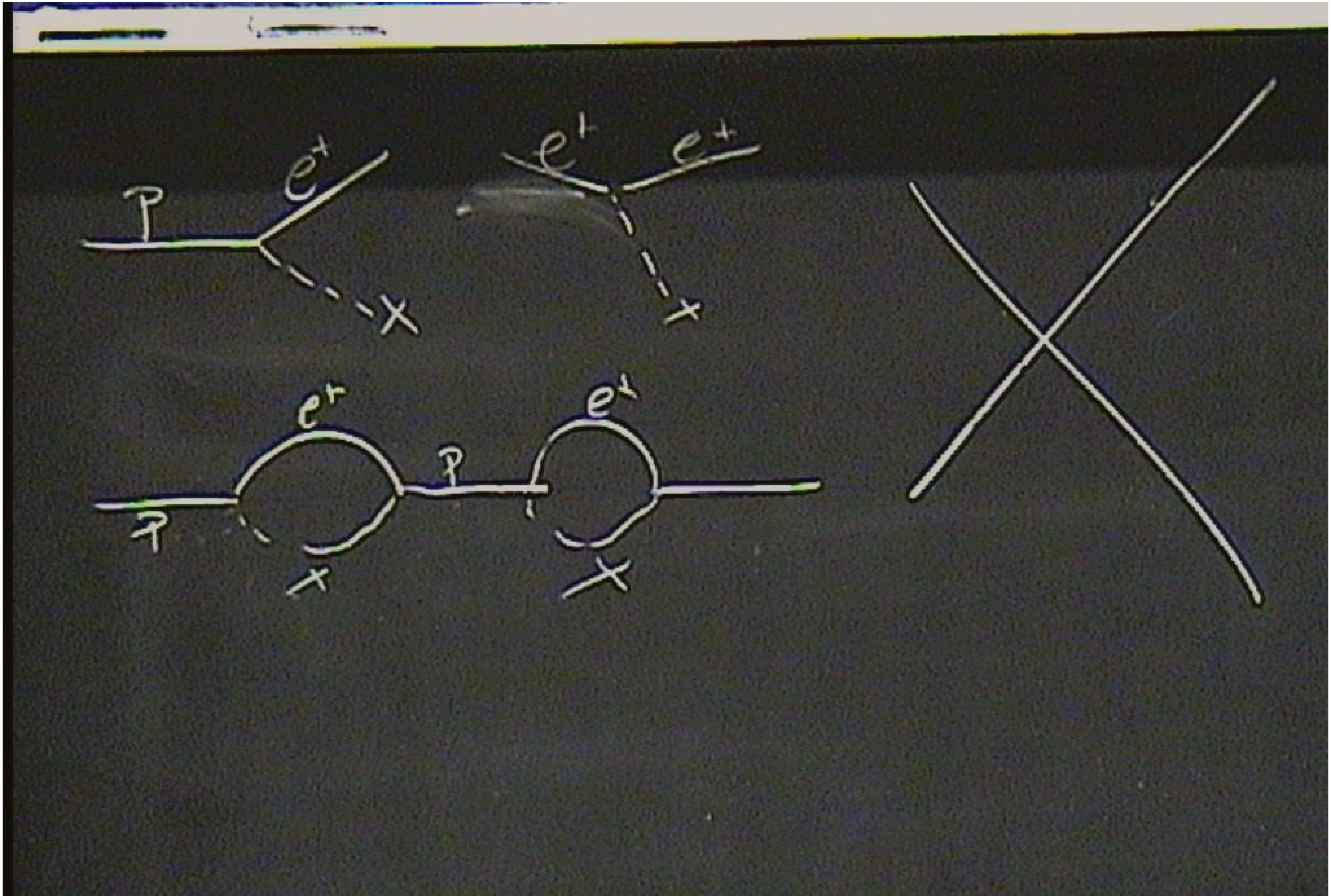
X


P
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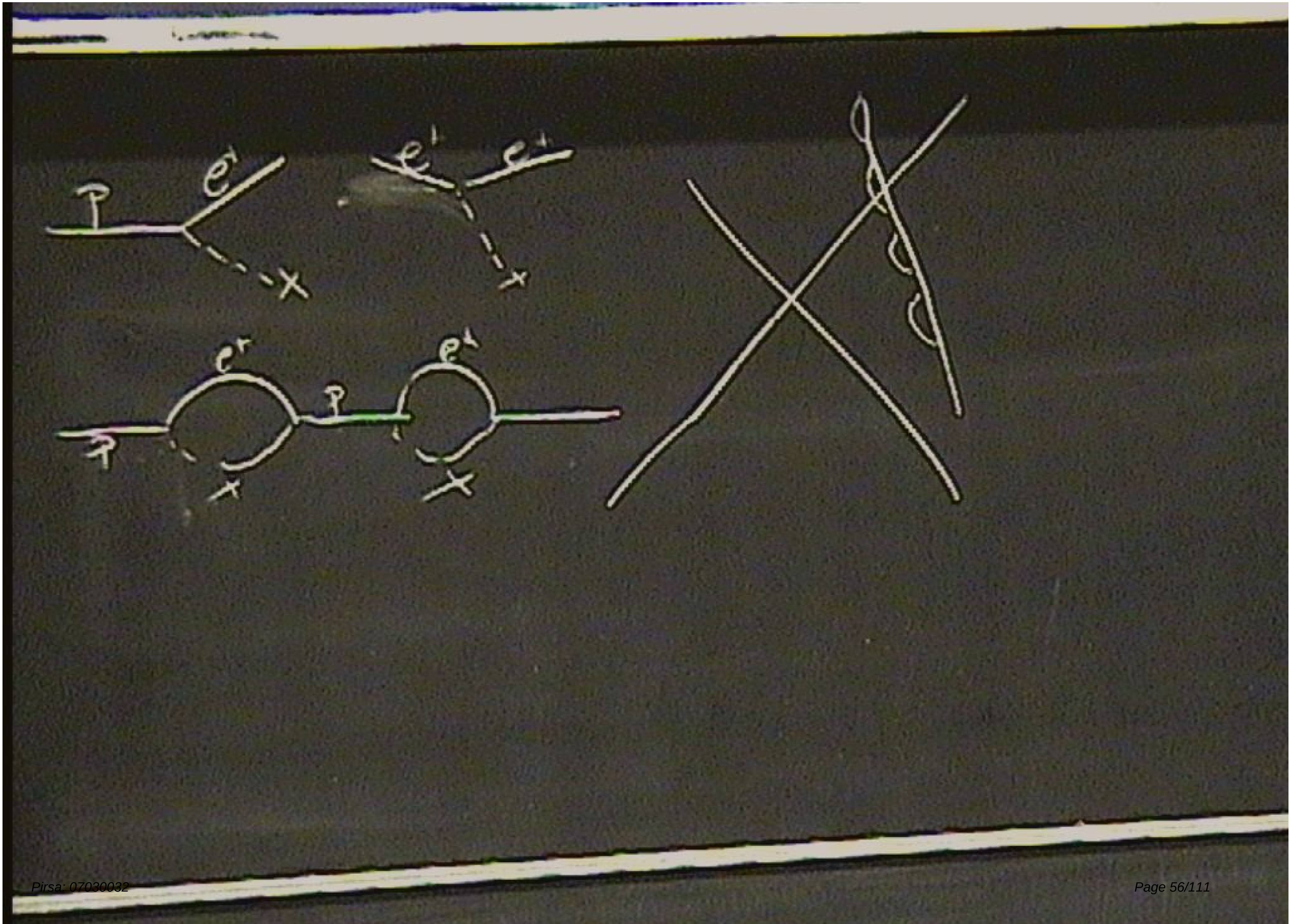
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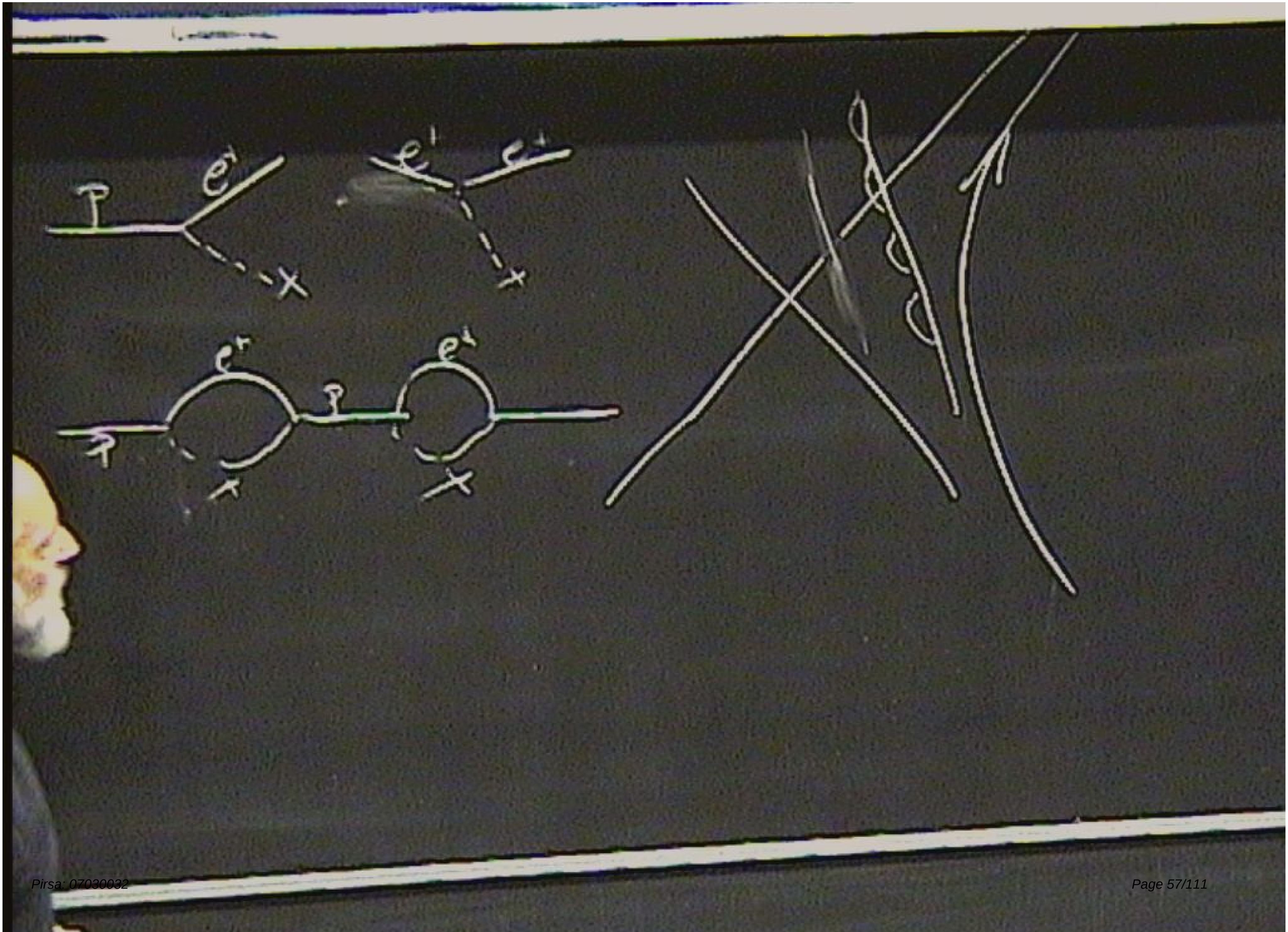

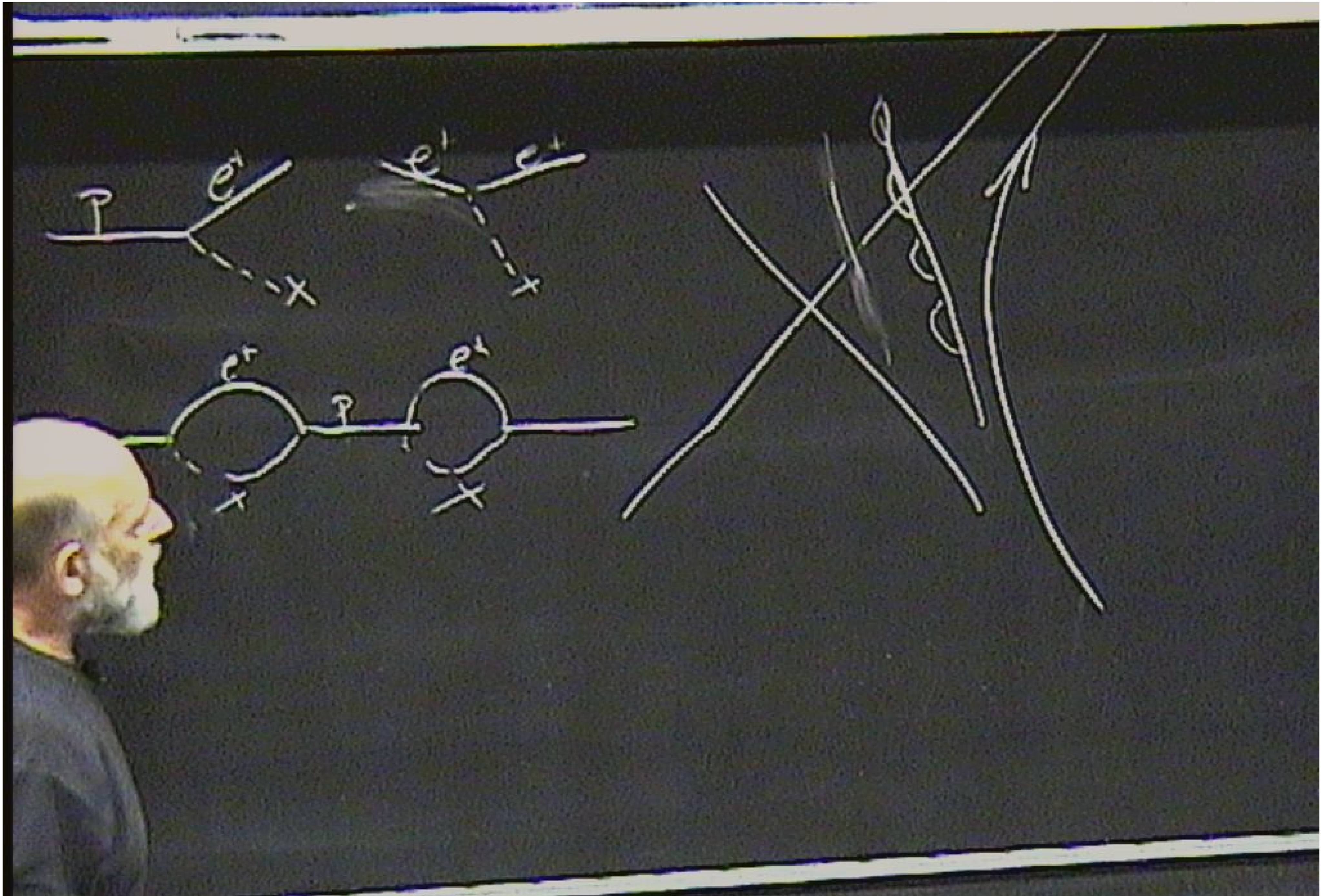
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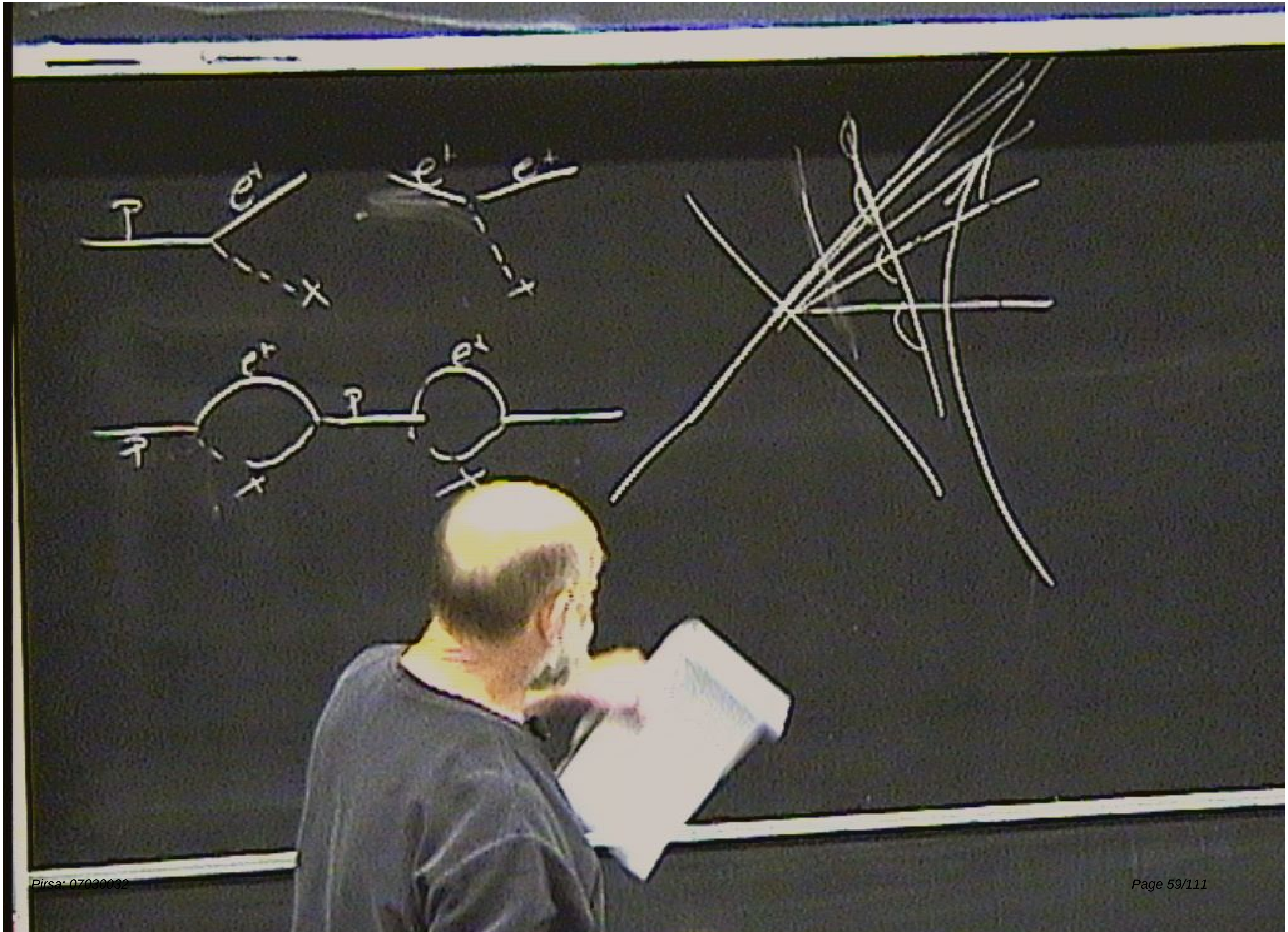
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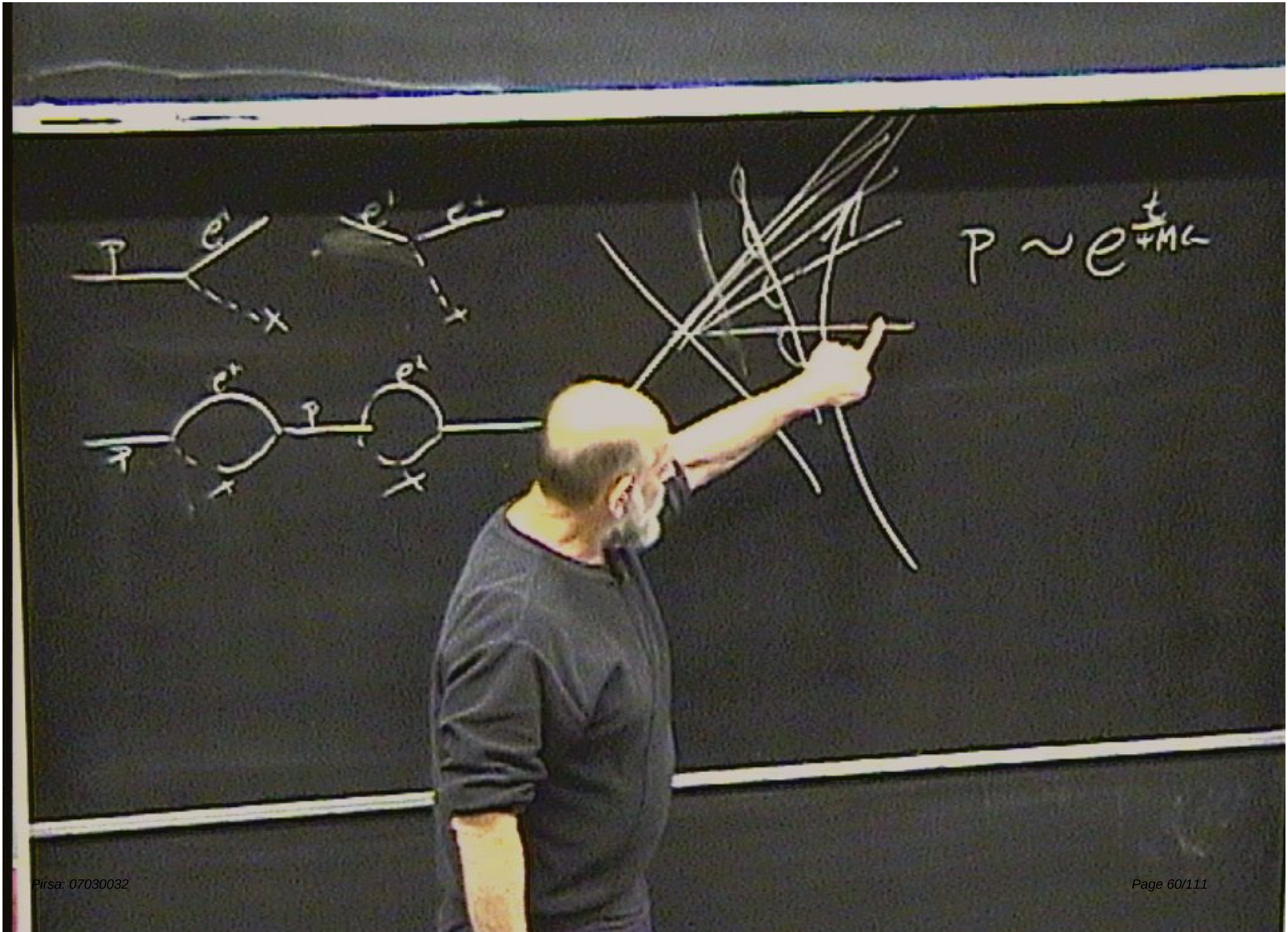
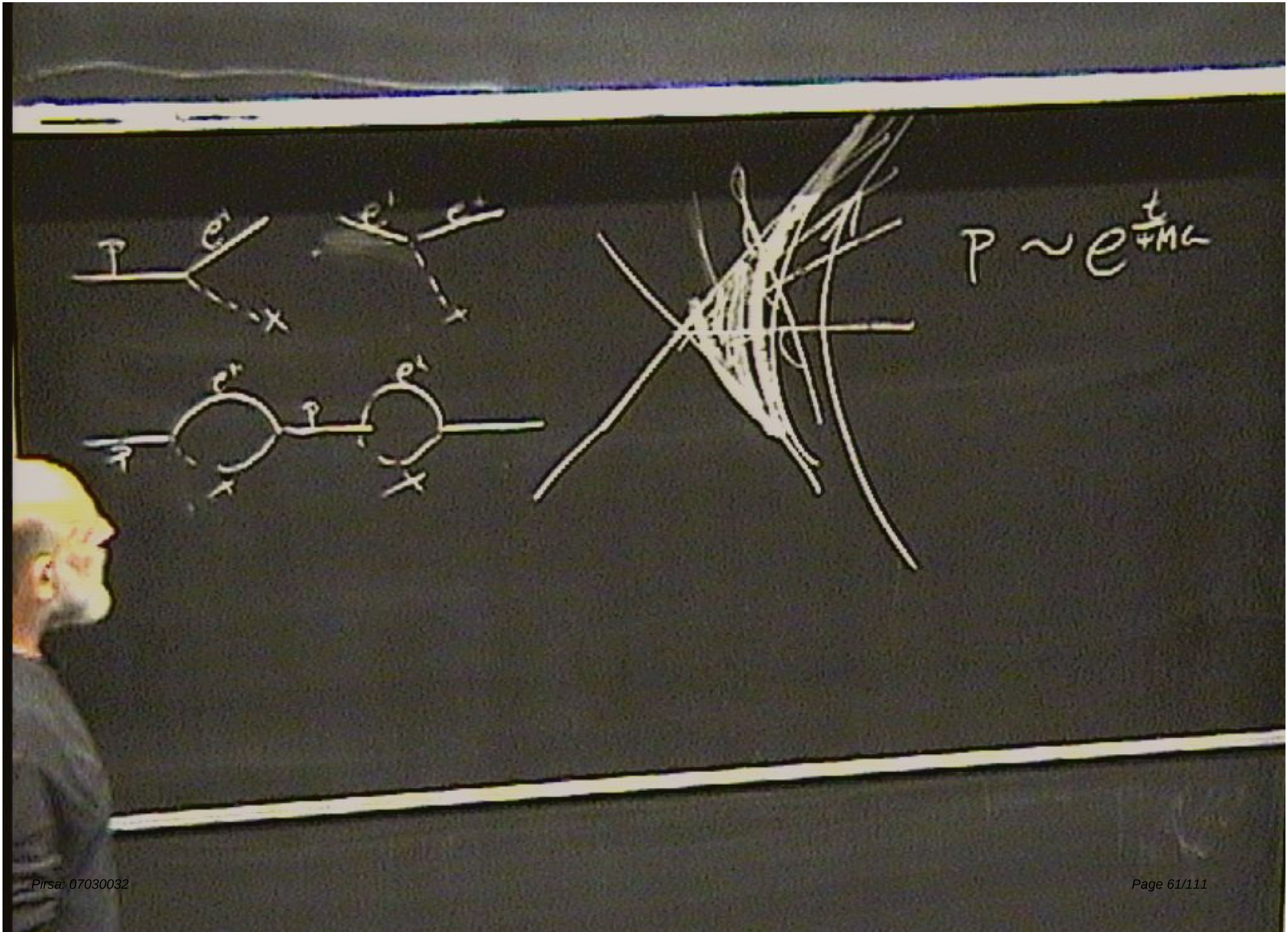
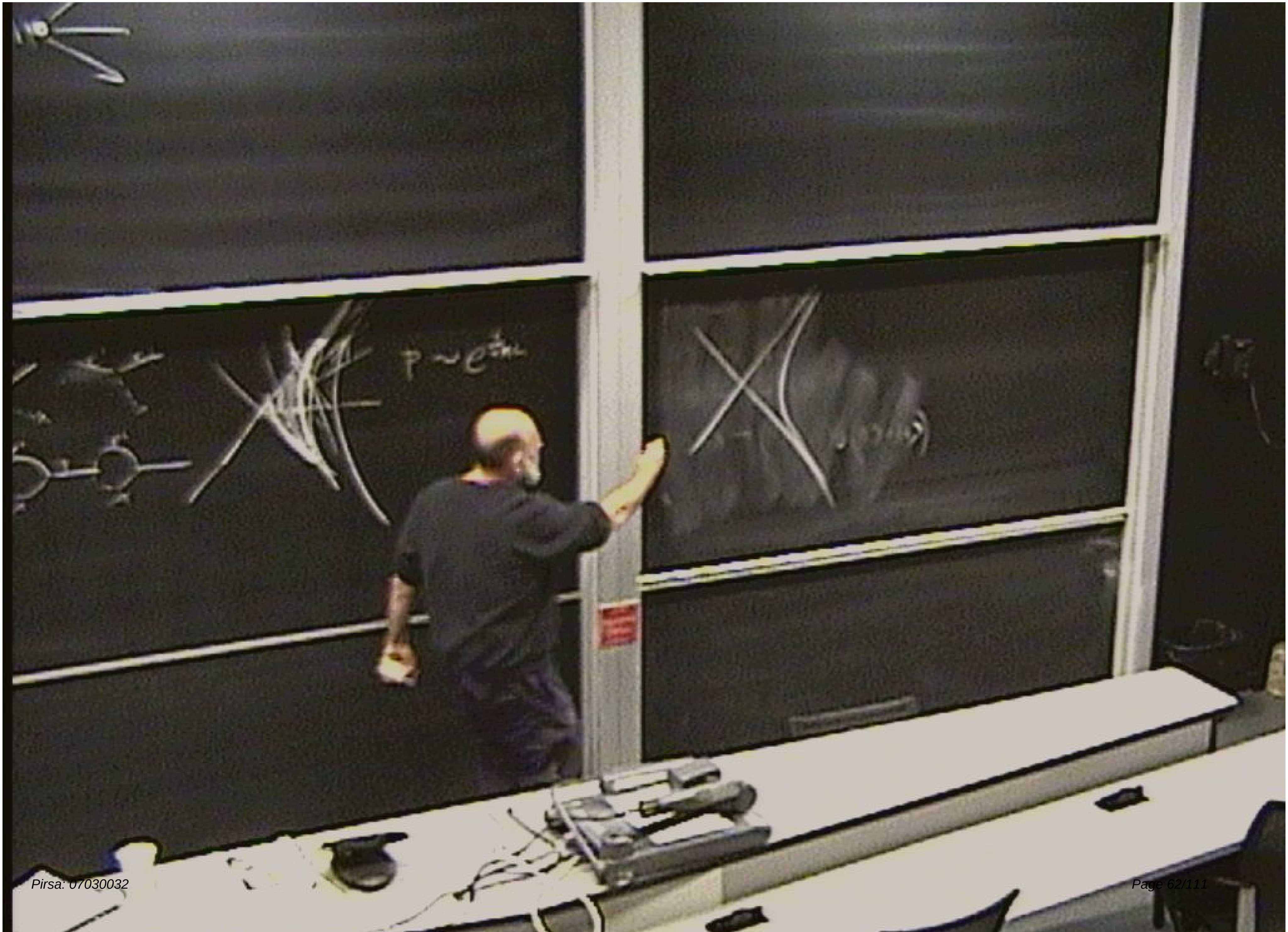
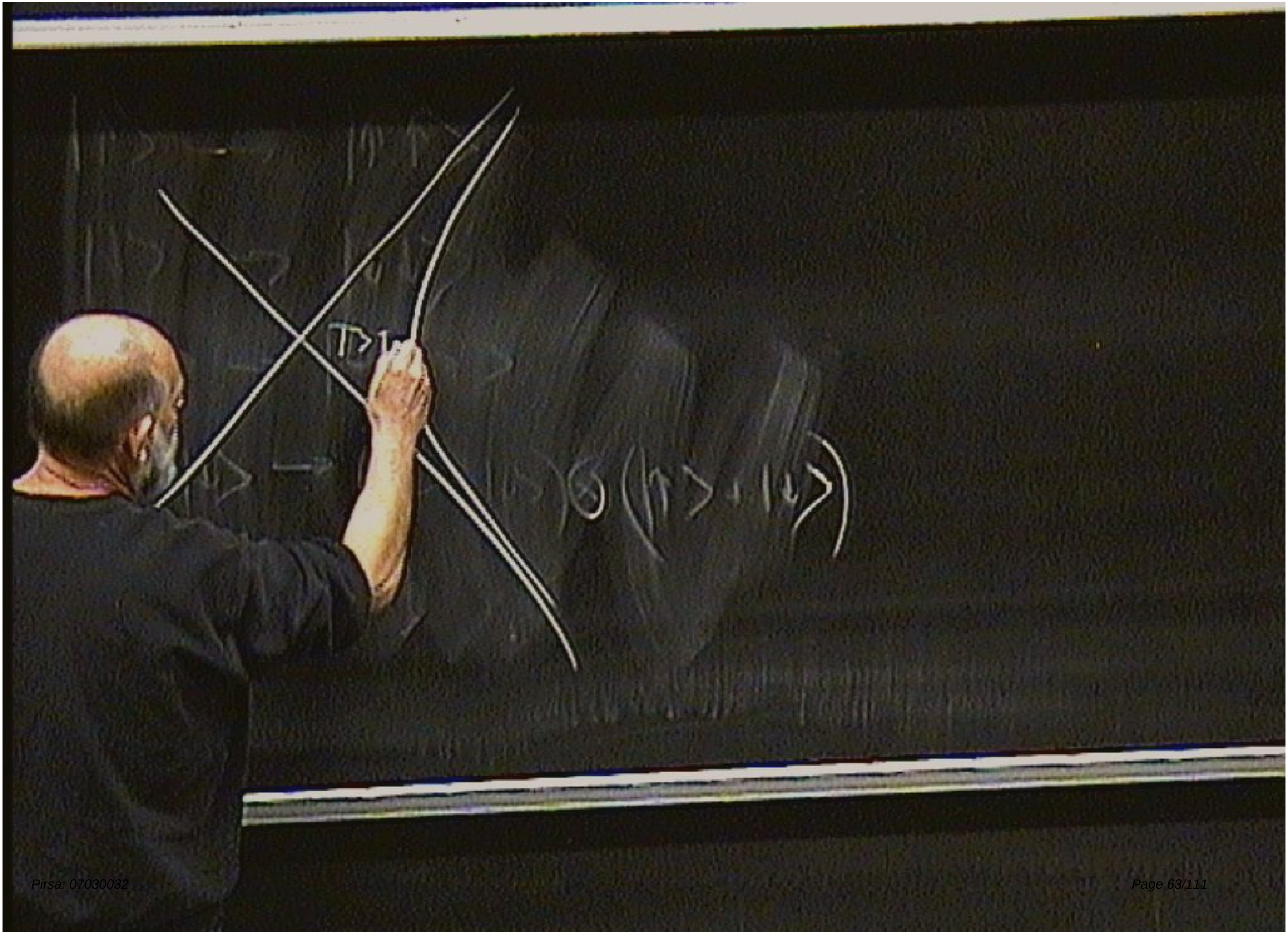


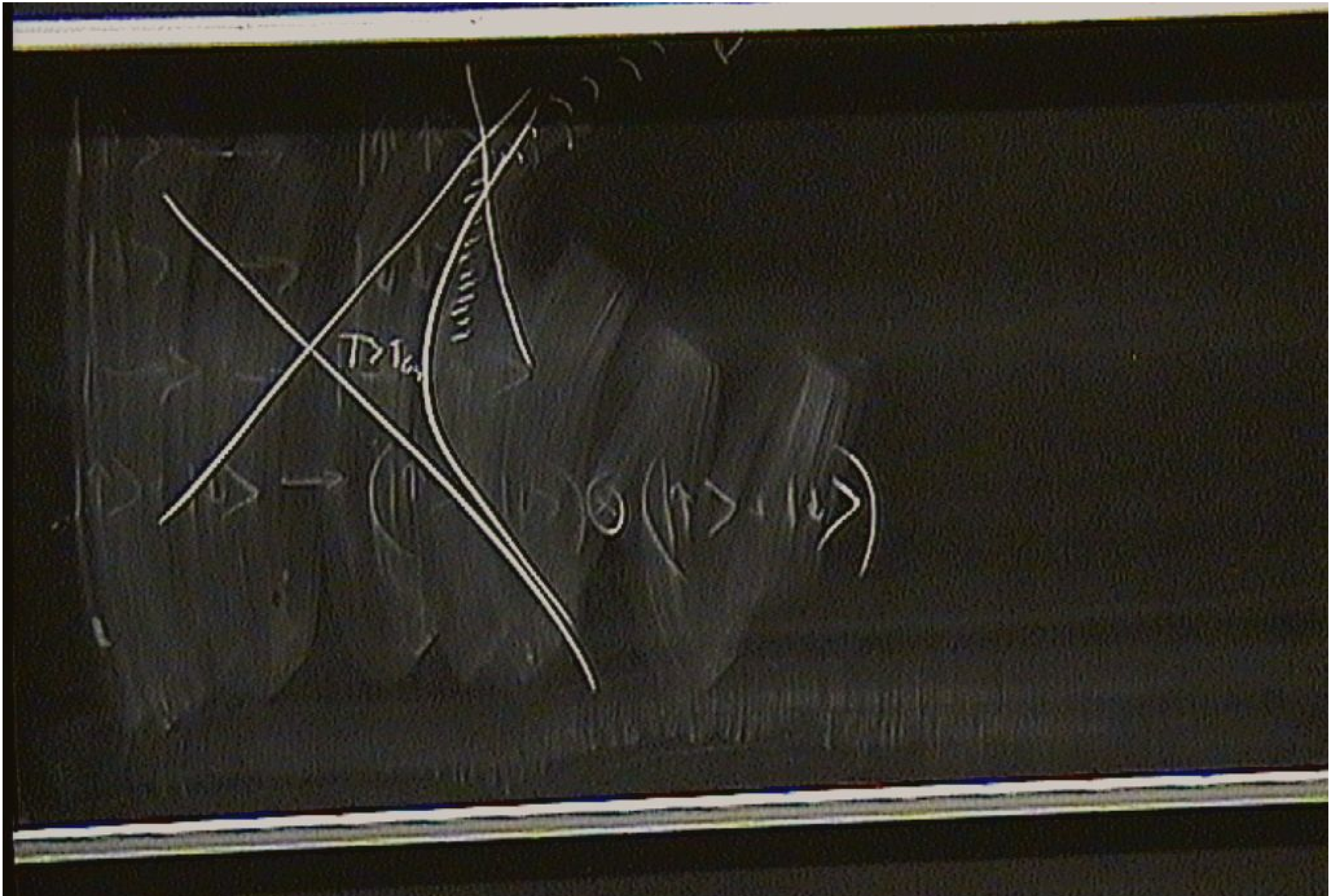


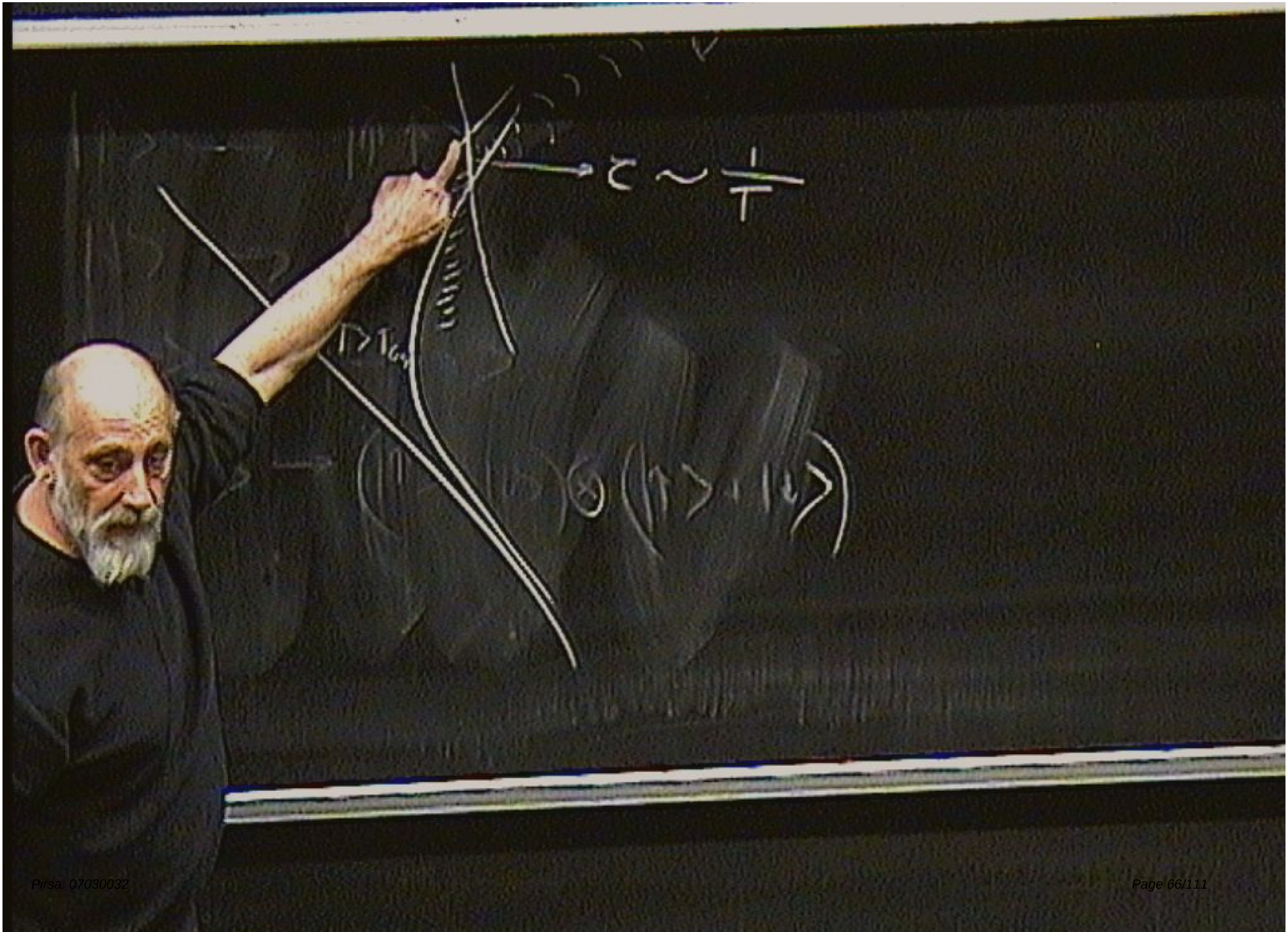


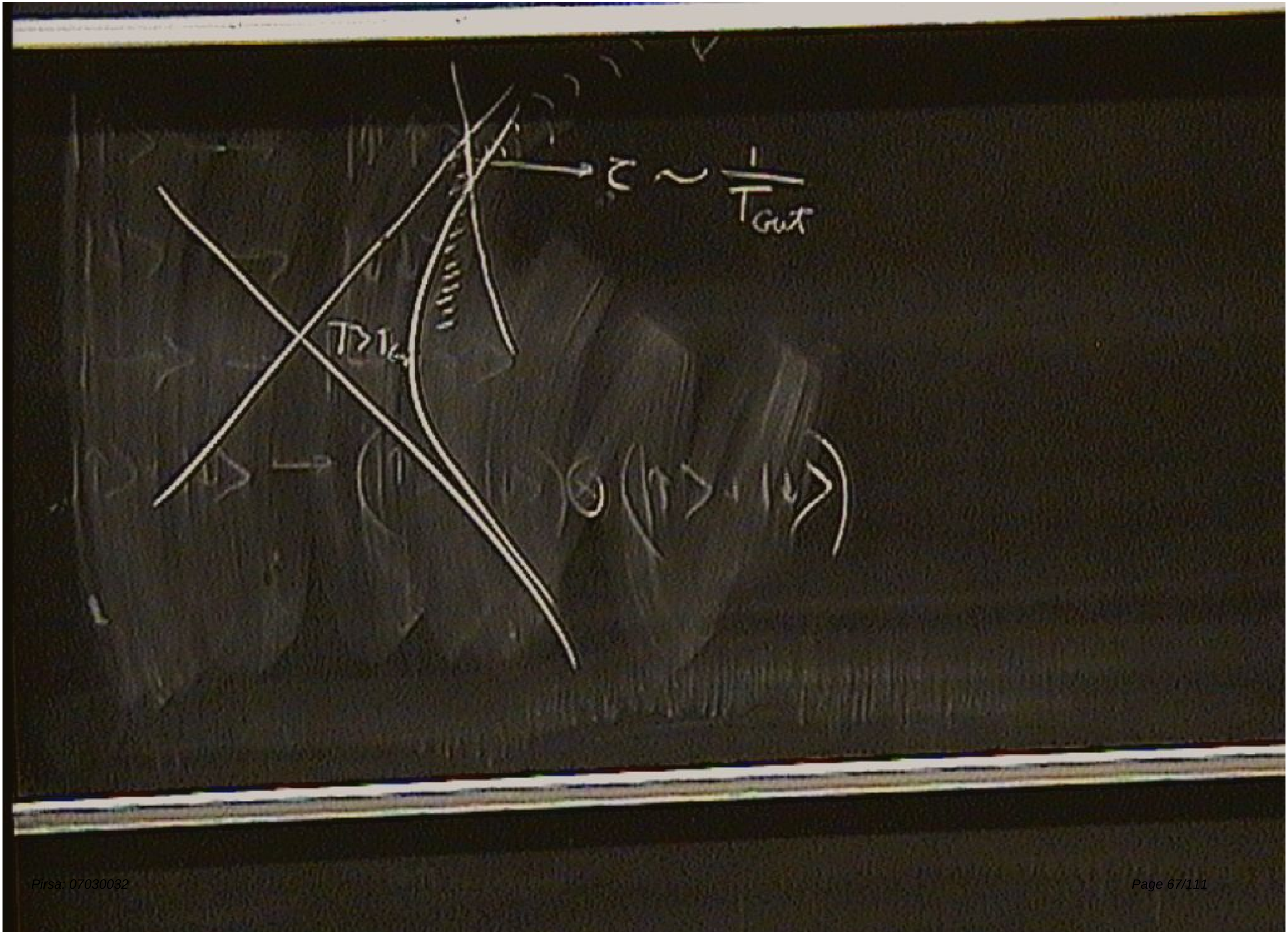


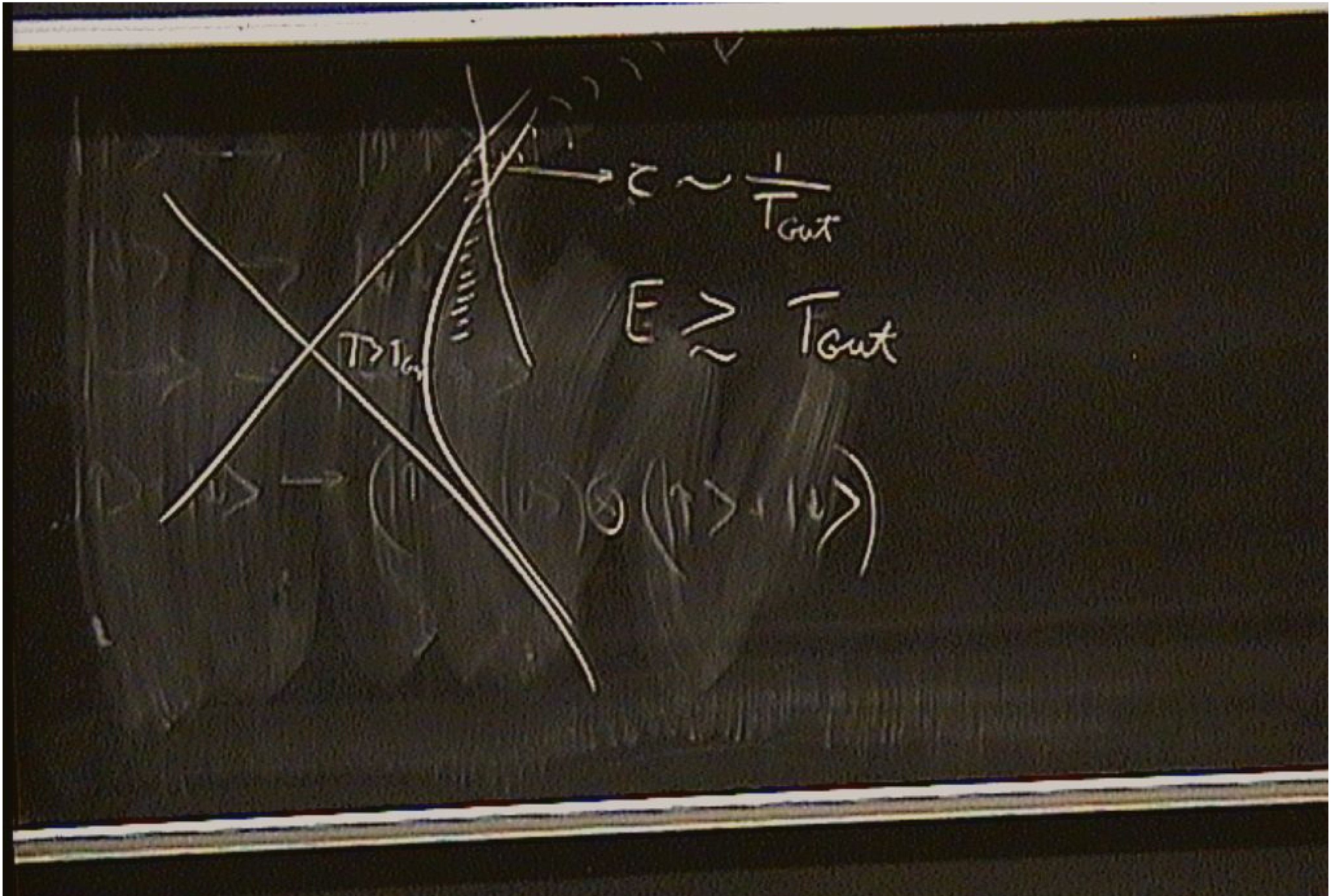
$|\uparrow\rangle_{b}$

$\rightarrow (|\uparrow\rangle \;\; |\downarrow\rangle) \otimes (|\uparrow\rangle + |\downarrow\rangle)$

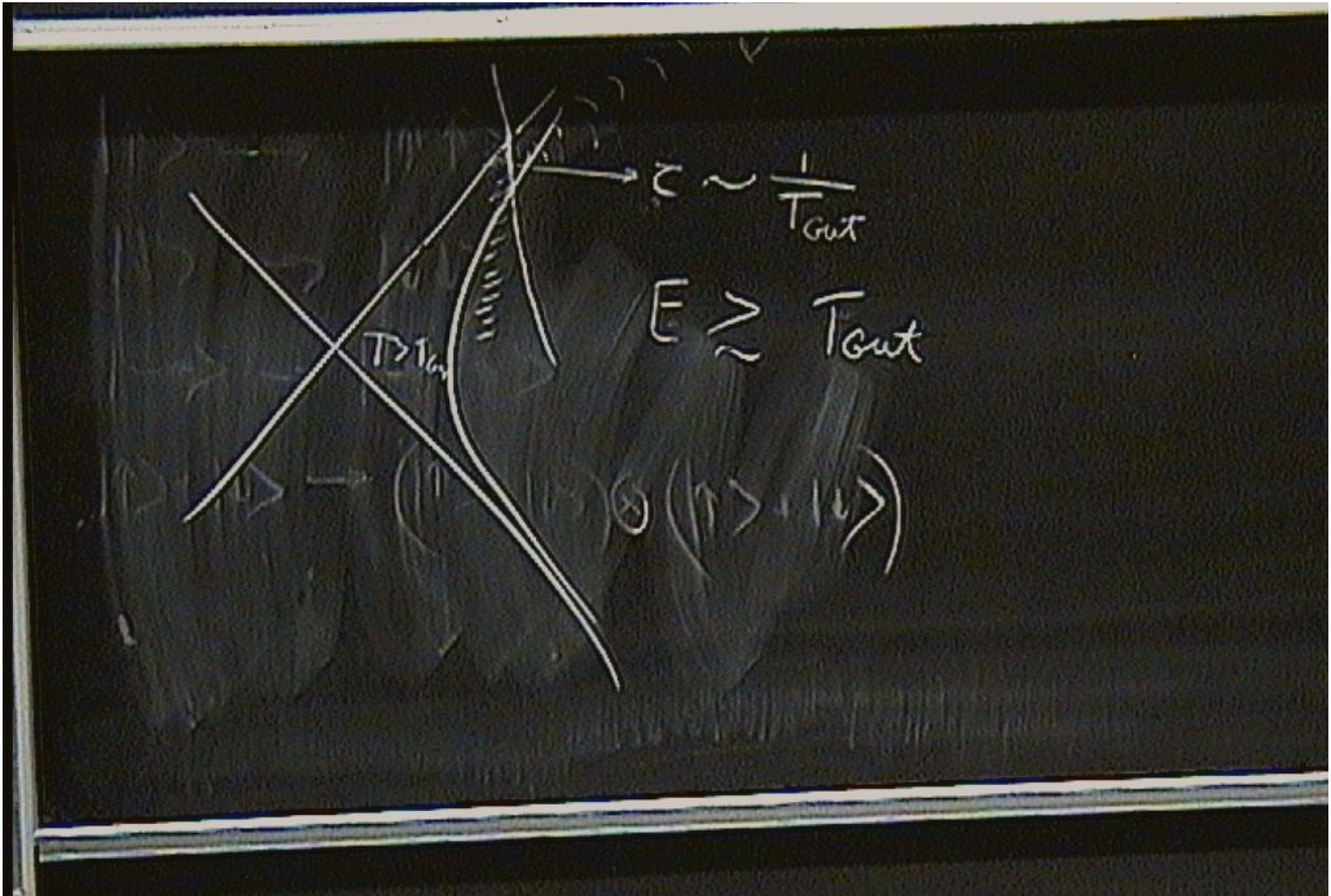



ε ~ 1/T


τ ~ 1/T_Gut

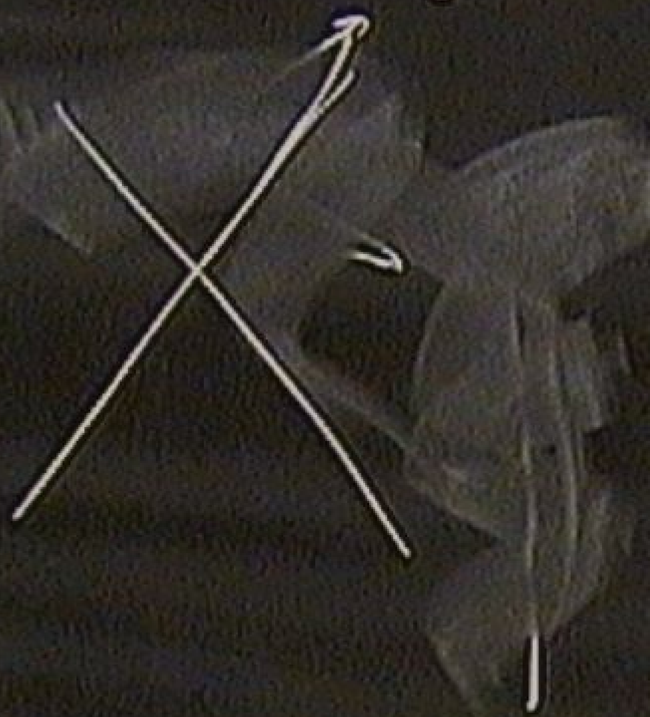


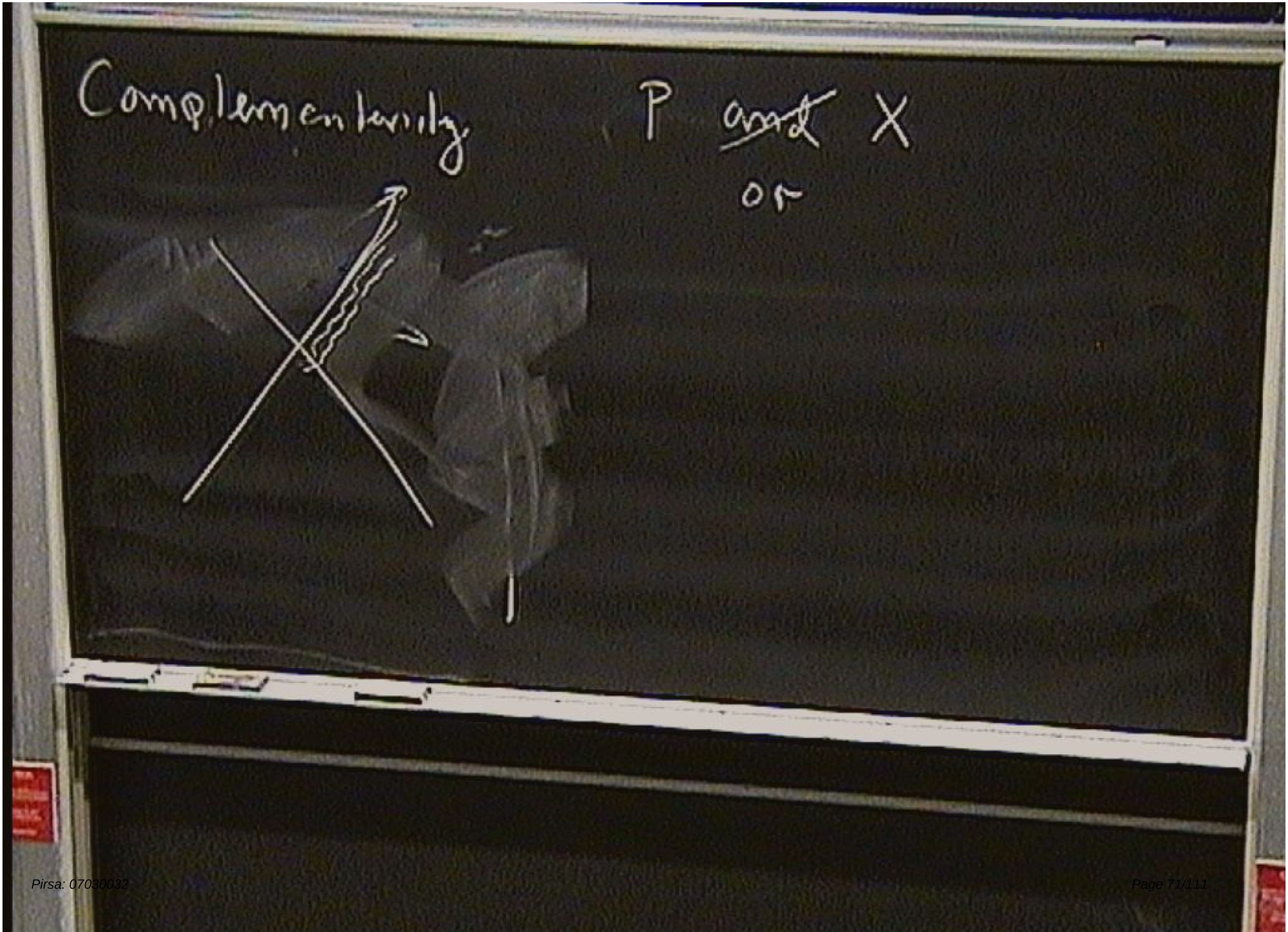
c ~ 1/T_out
E ≳ T_out

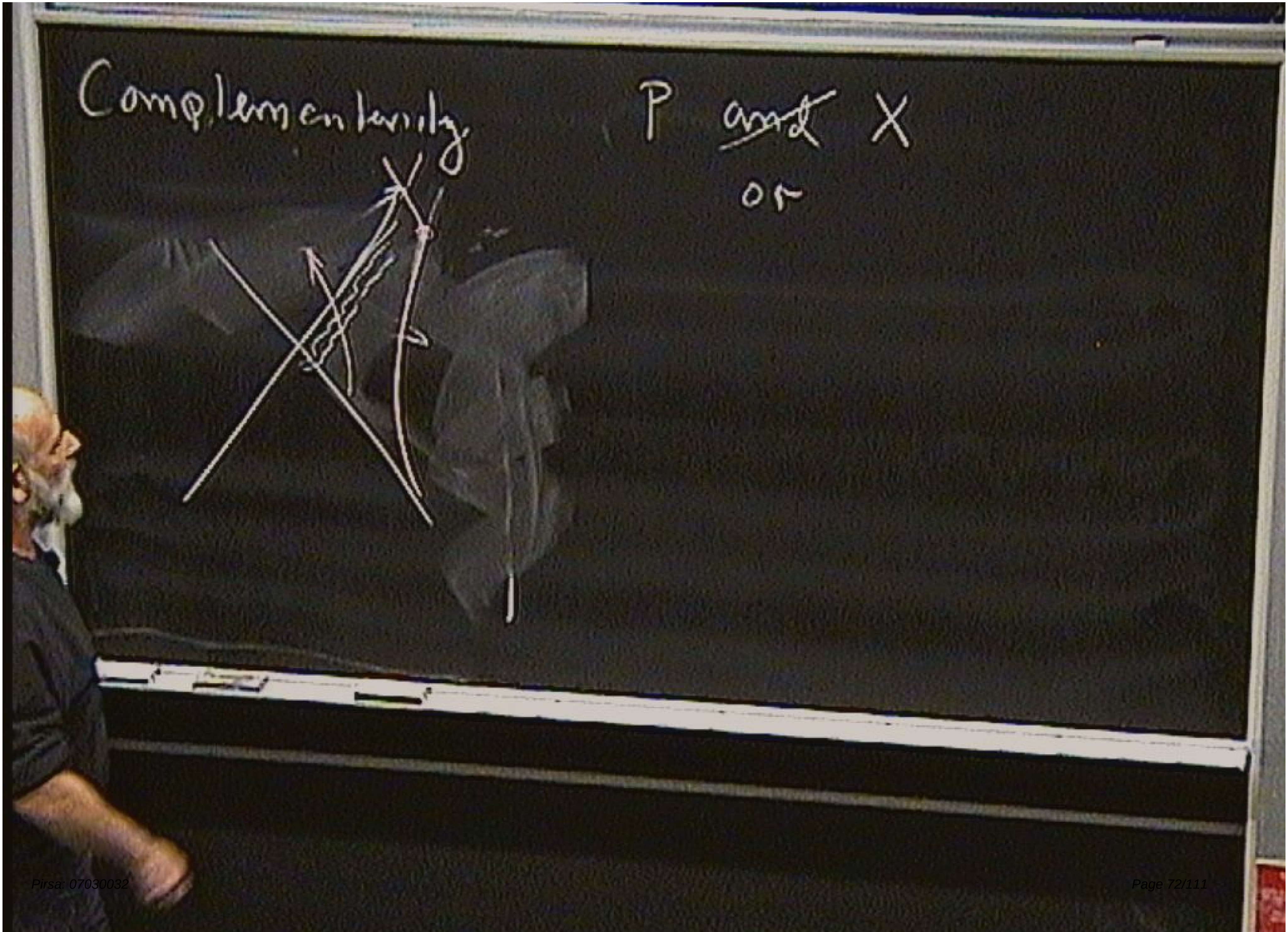

$\tau \sim \frac{1}{T_{out}}$
$E \gtrsim T_{out}$
$T > T_{out}$

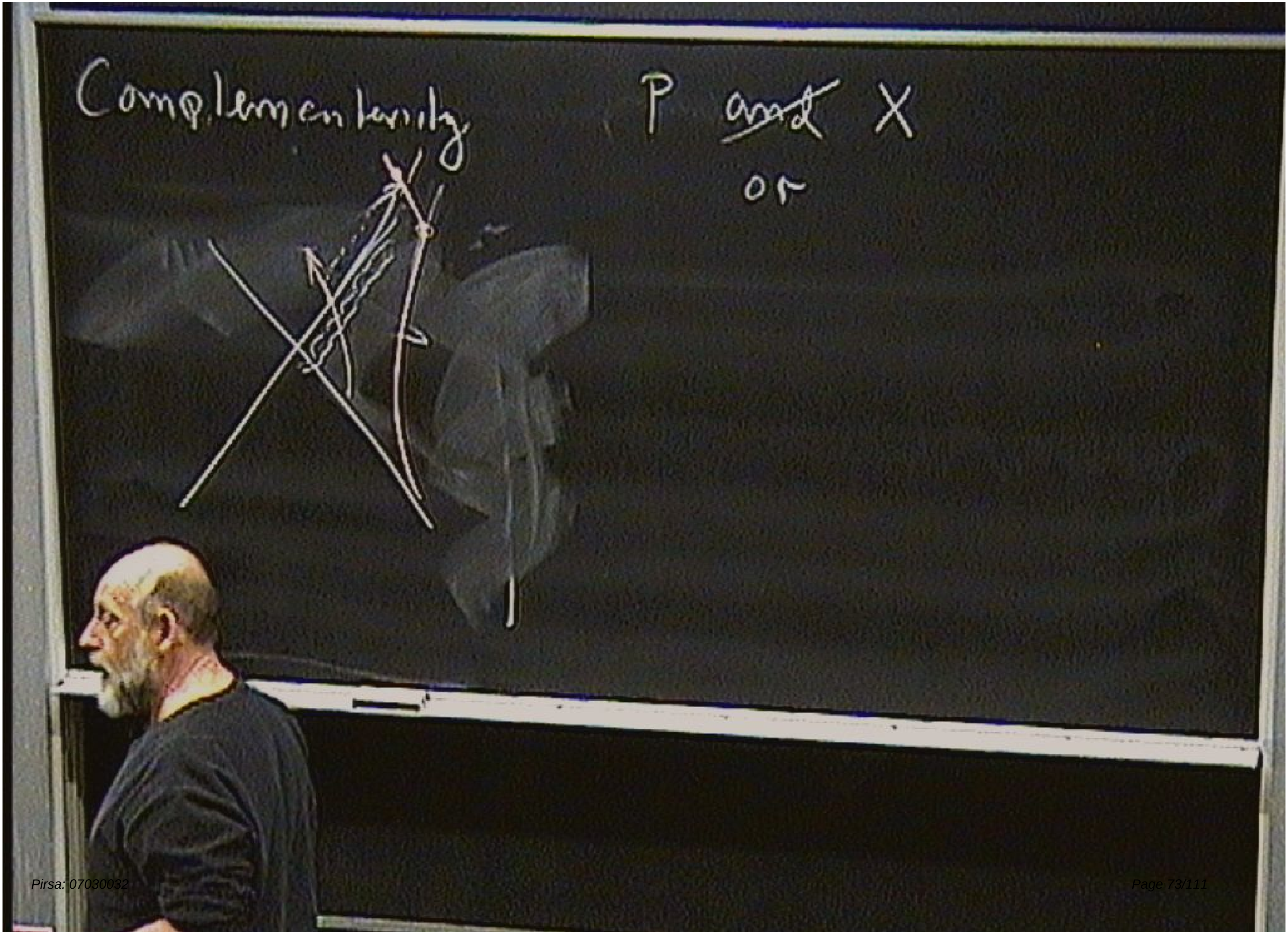
Complementarity

P ~~and~~ X
or



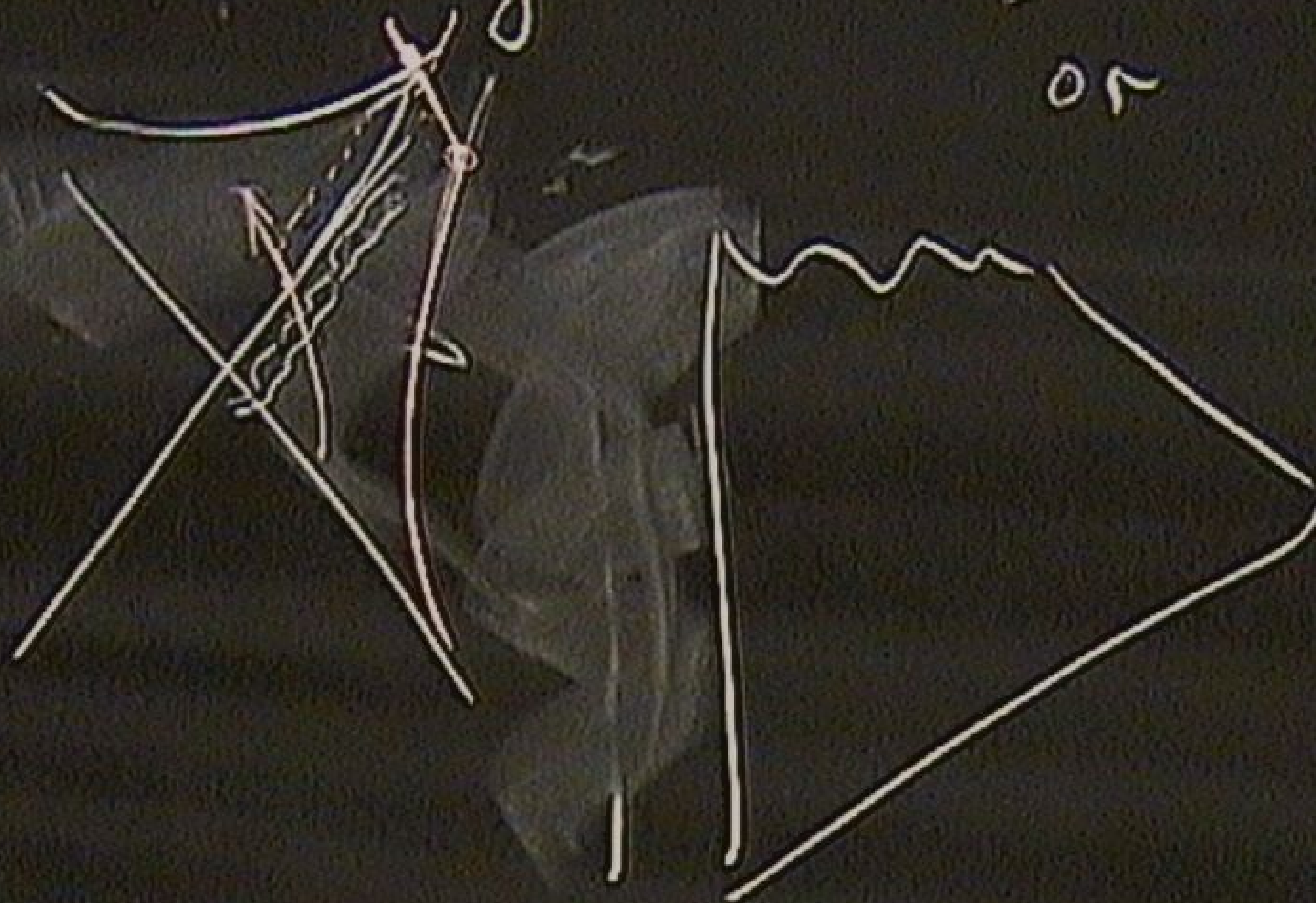

Complementarity
P ~~and~~ X
or

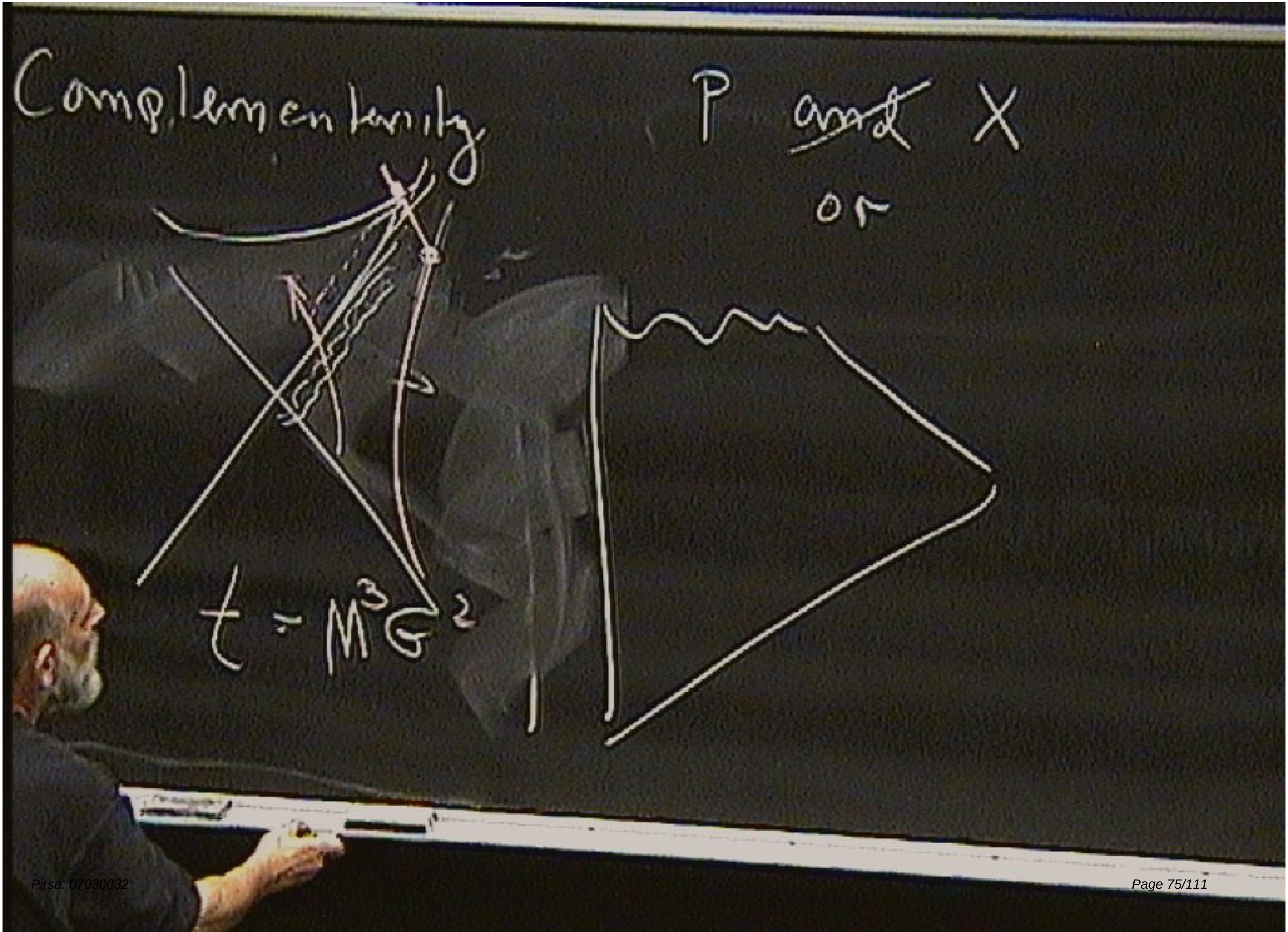

Complementarity
P ~~and~~ X
or

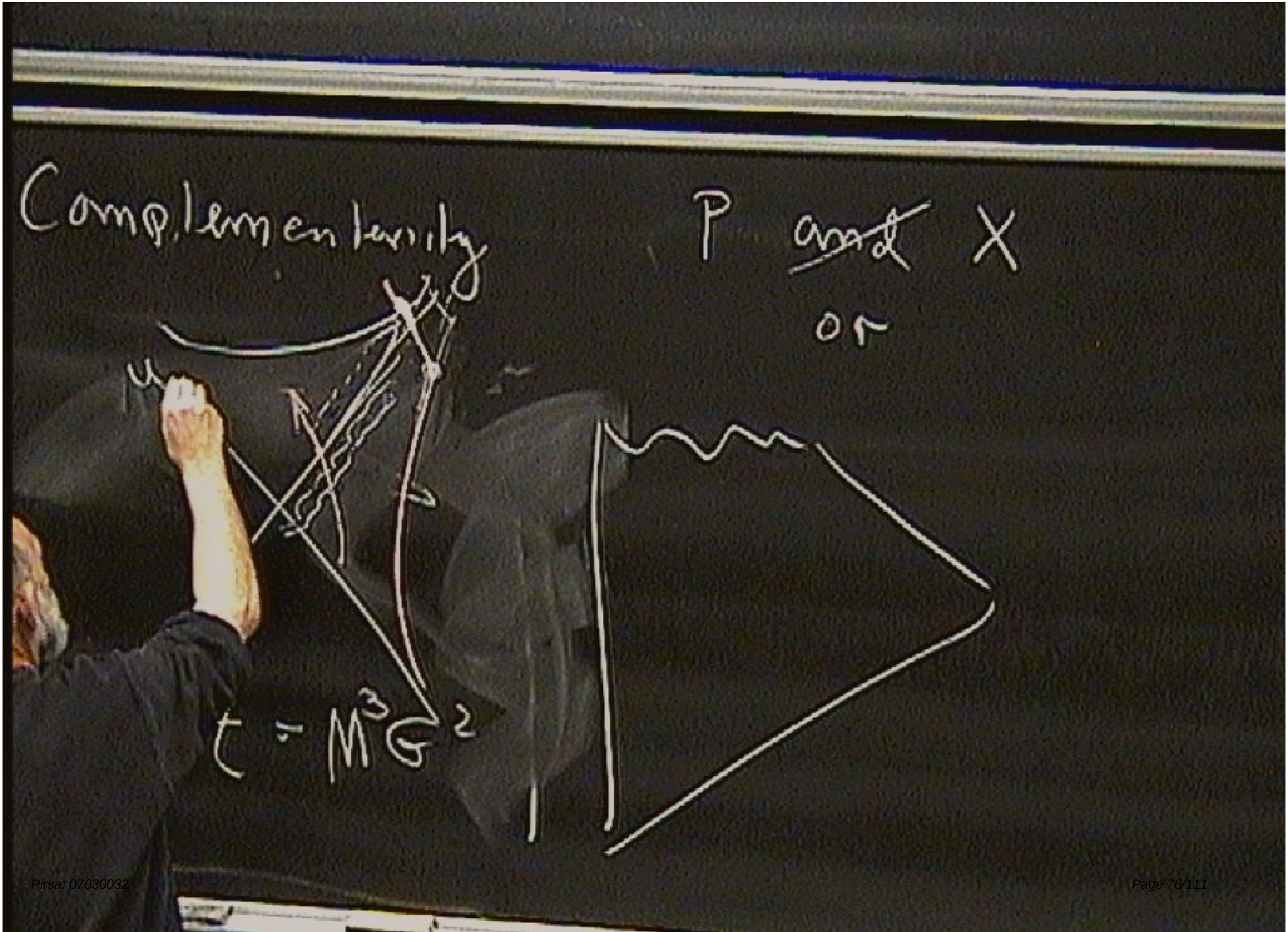

Complementarity
P ~~and~~ X
or

Complementarity

P ~~and~~ X
or



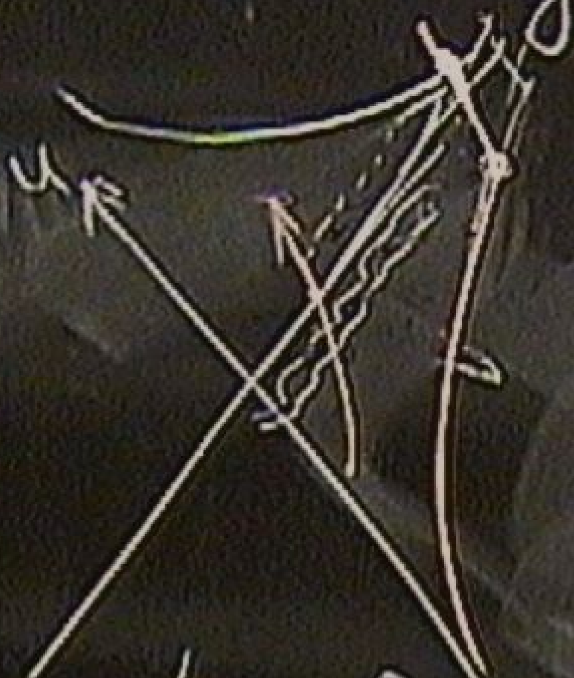

Complementarity
P ~~and~~ or X
t = M³G²


Complementarity
P ~~and~~ X
or
t = M³G²

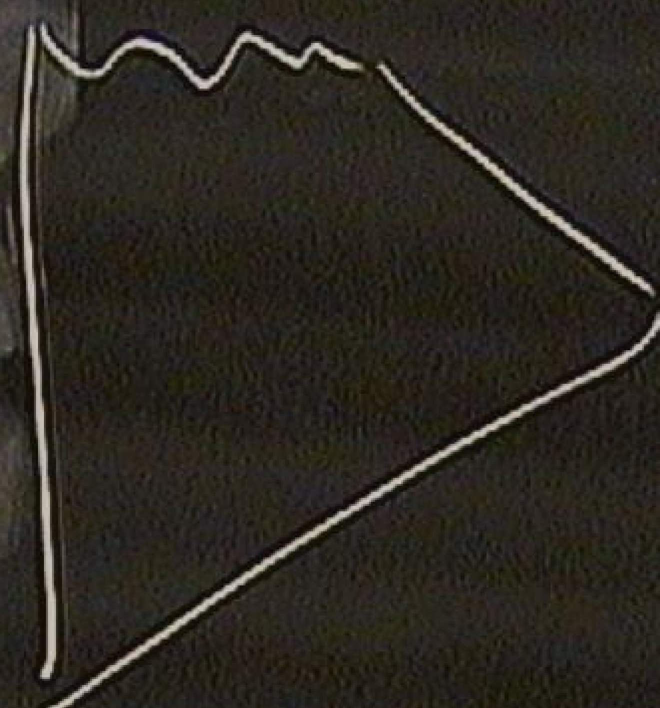
Complementarity

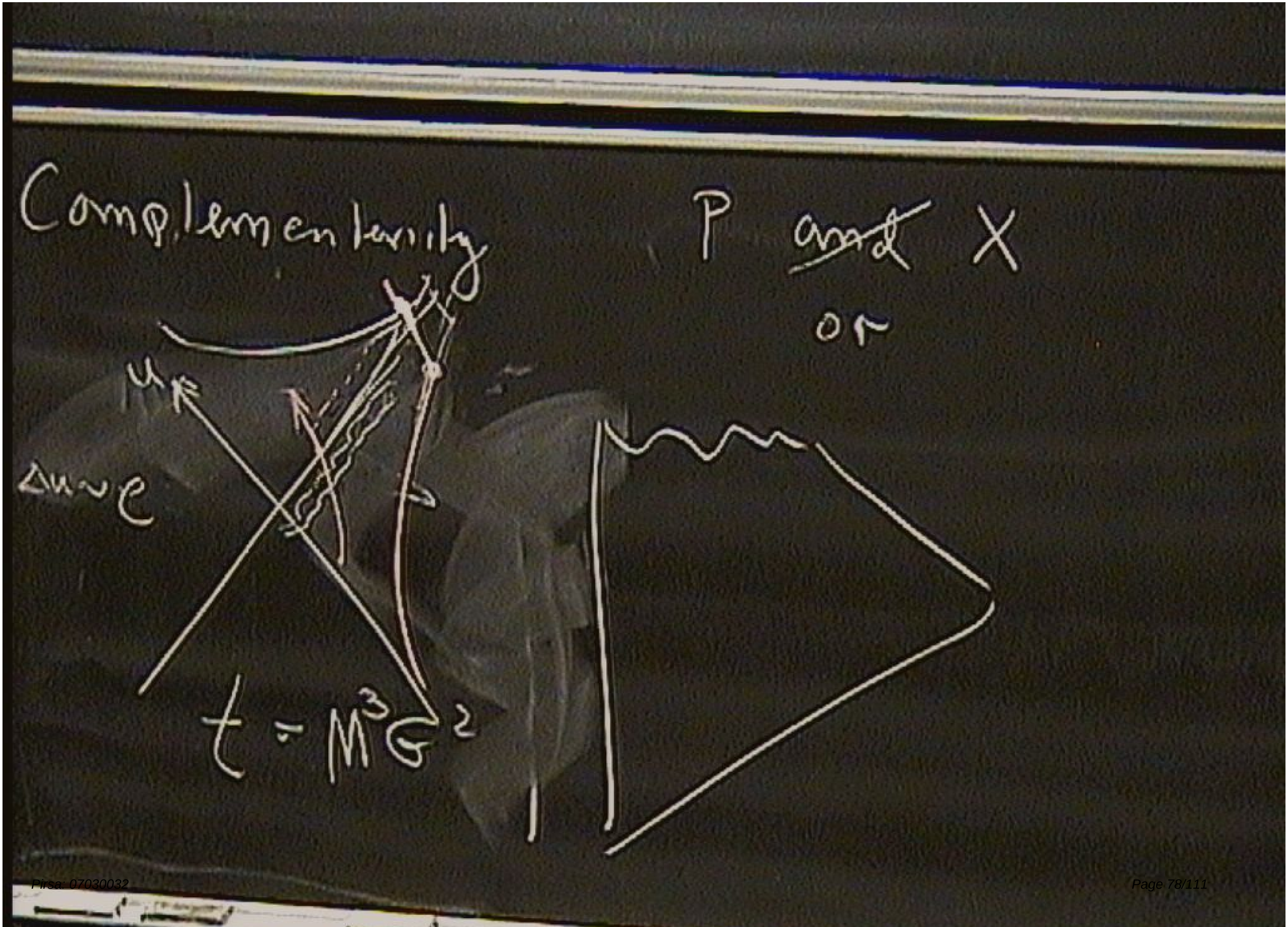
P <u>and</u> X

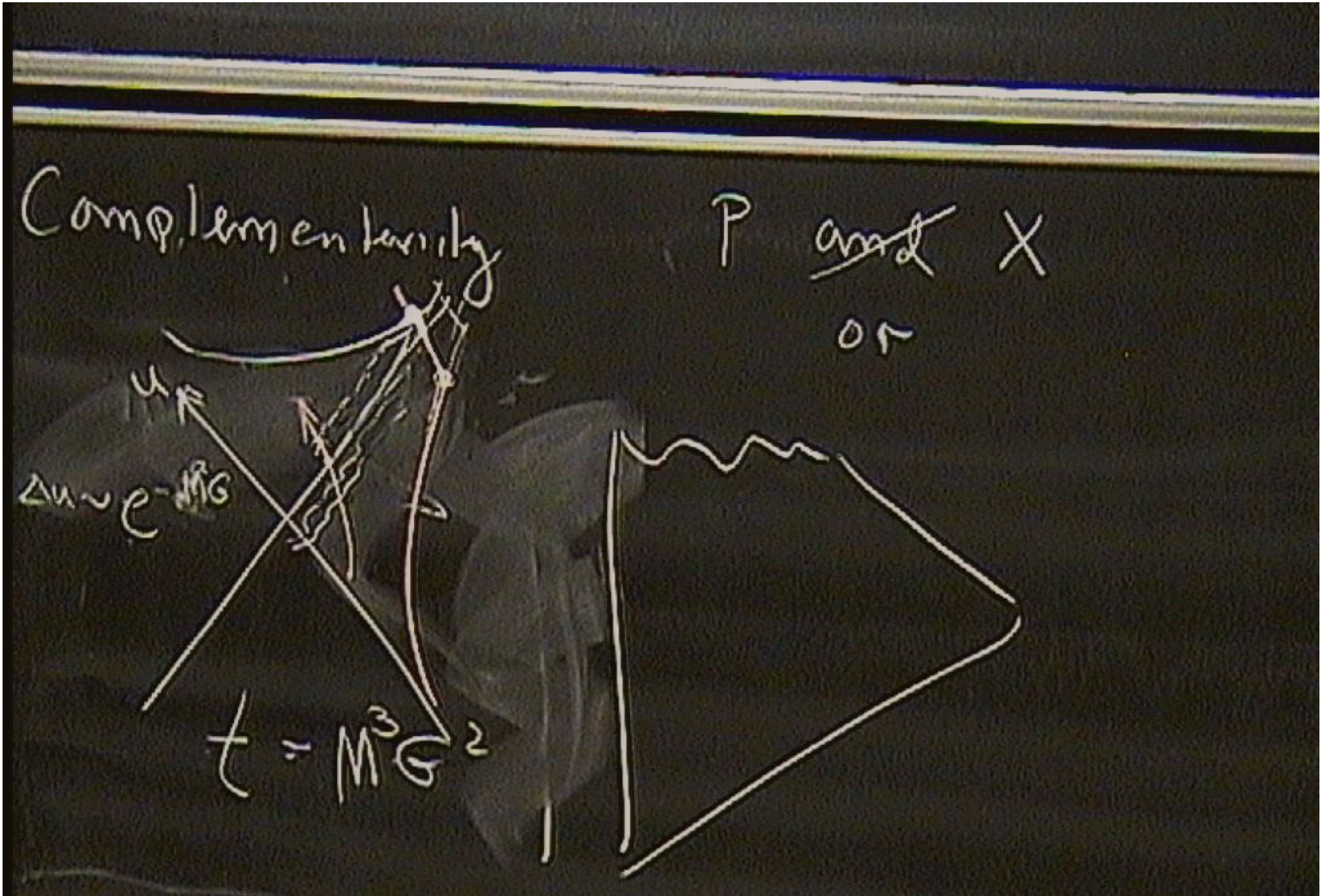
or



$t = M^3 G^2$



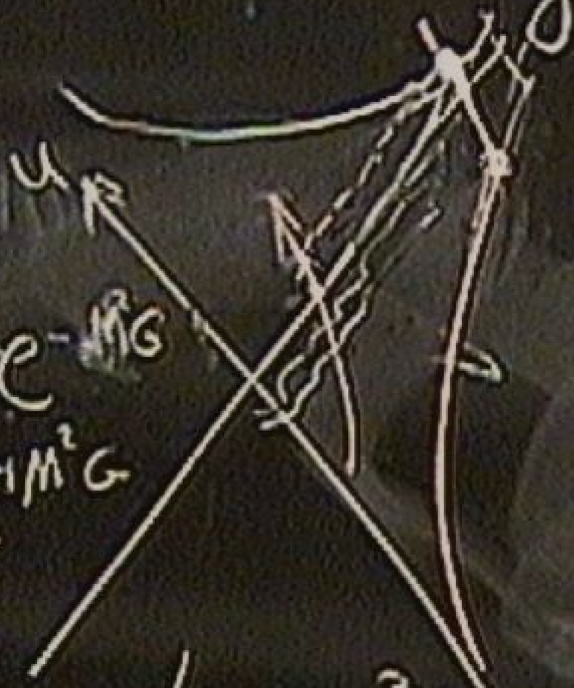

Complementarity
P ~~and~~ X
or
u_F
$\Delta u \sim e$
$t = M^3 G^2$


Complementarity
P ~~and~~ X
or
u_F
$\Delta u \sim e^{-M^2 G}$
$t = M^3 G^2$

Complementarity

P ~~and~~ X

or

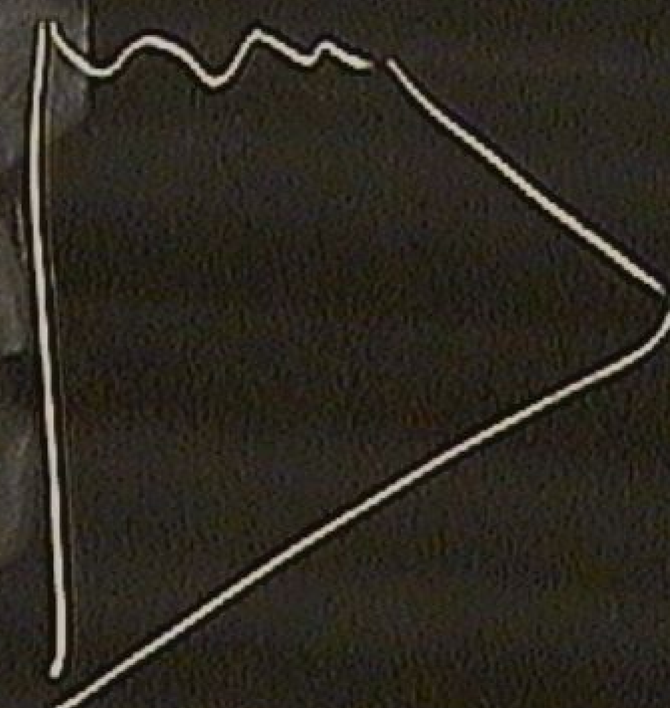


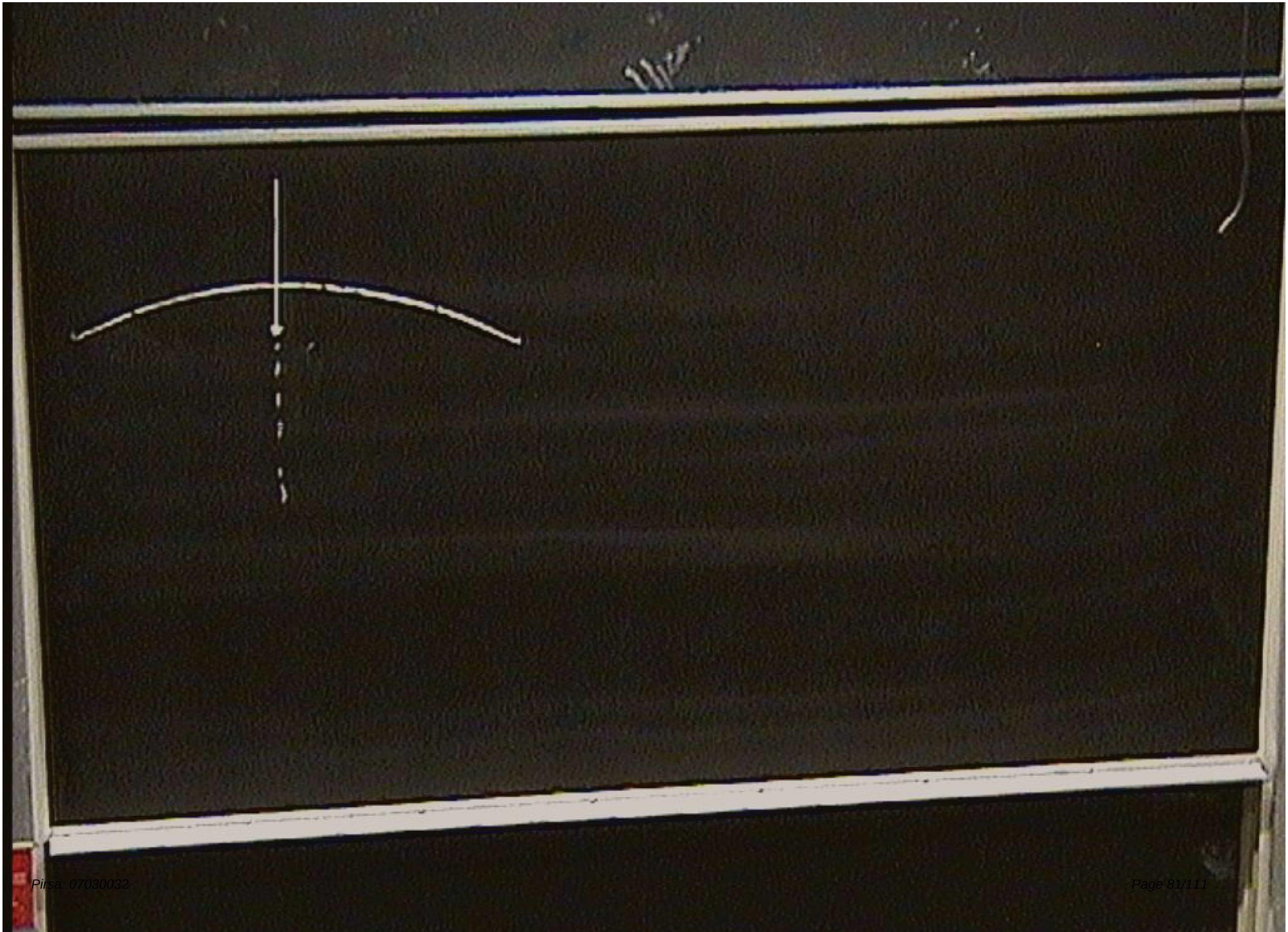
u

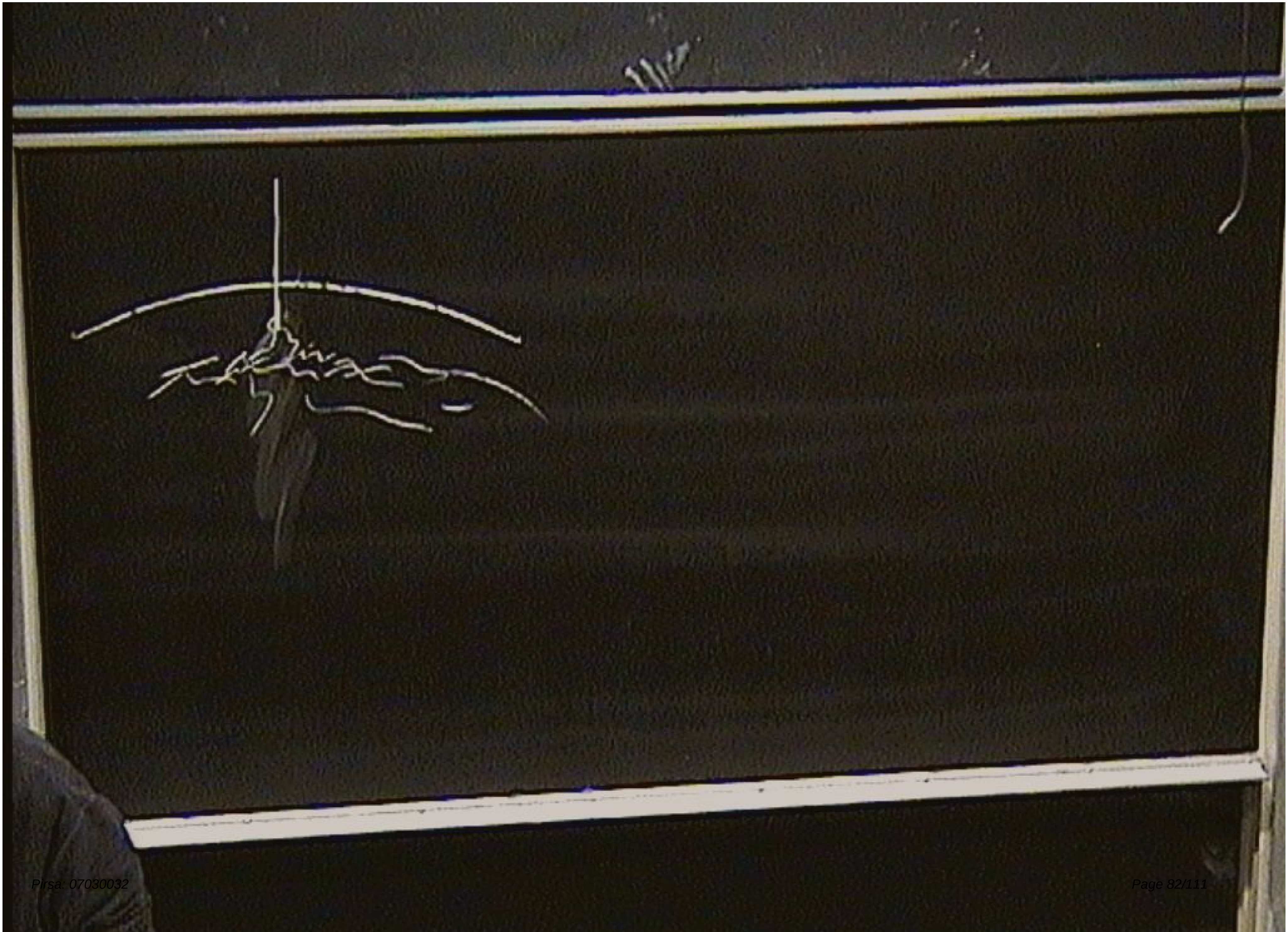
$\Delta u \sim e^{-MG}$

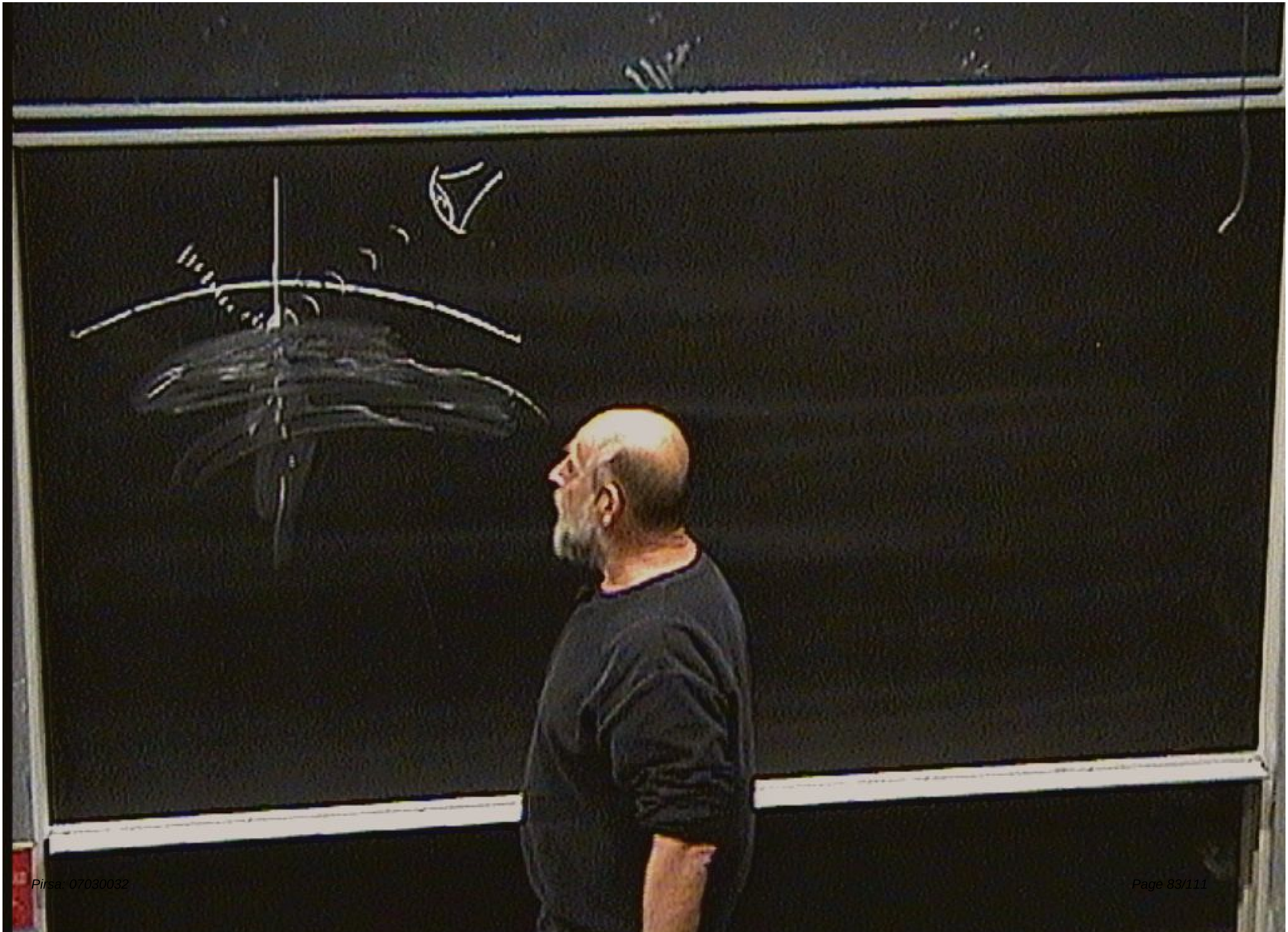
$E \sim e^{-M^2 G}$

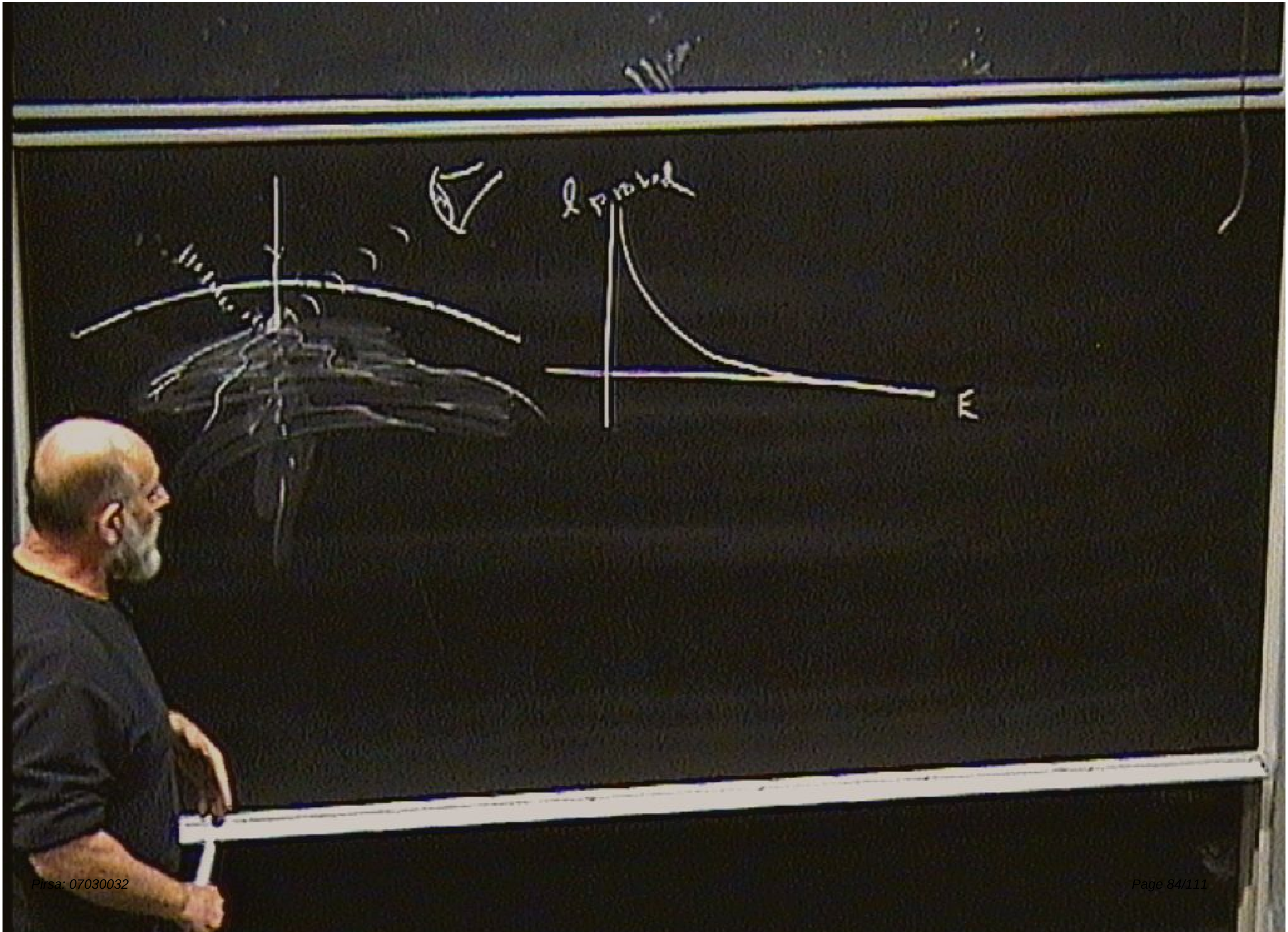
$t = M^3 G^2$







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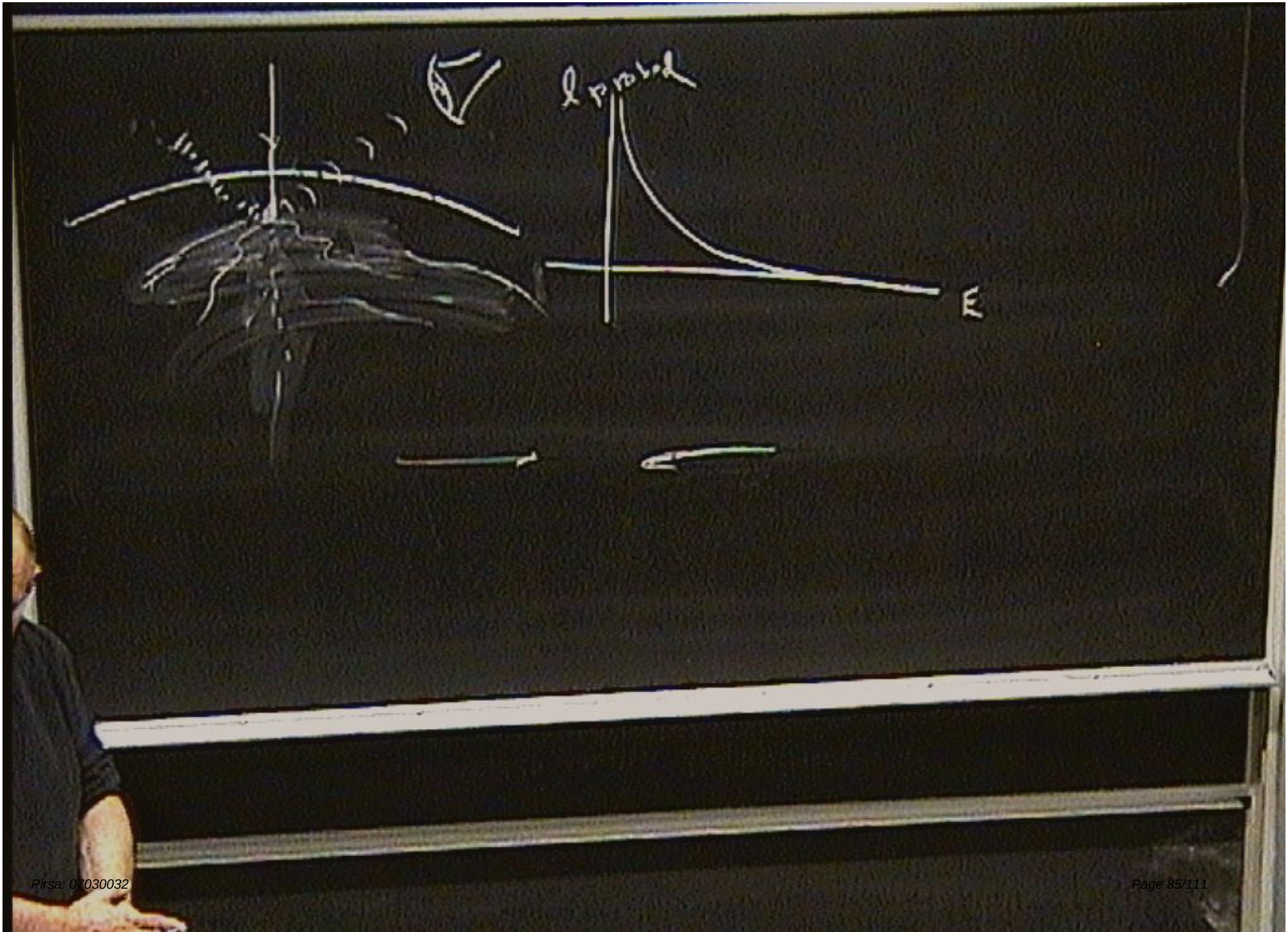
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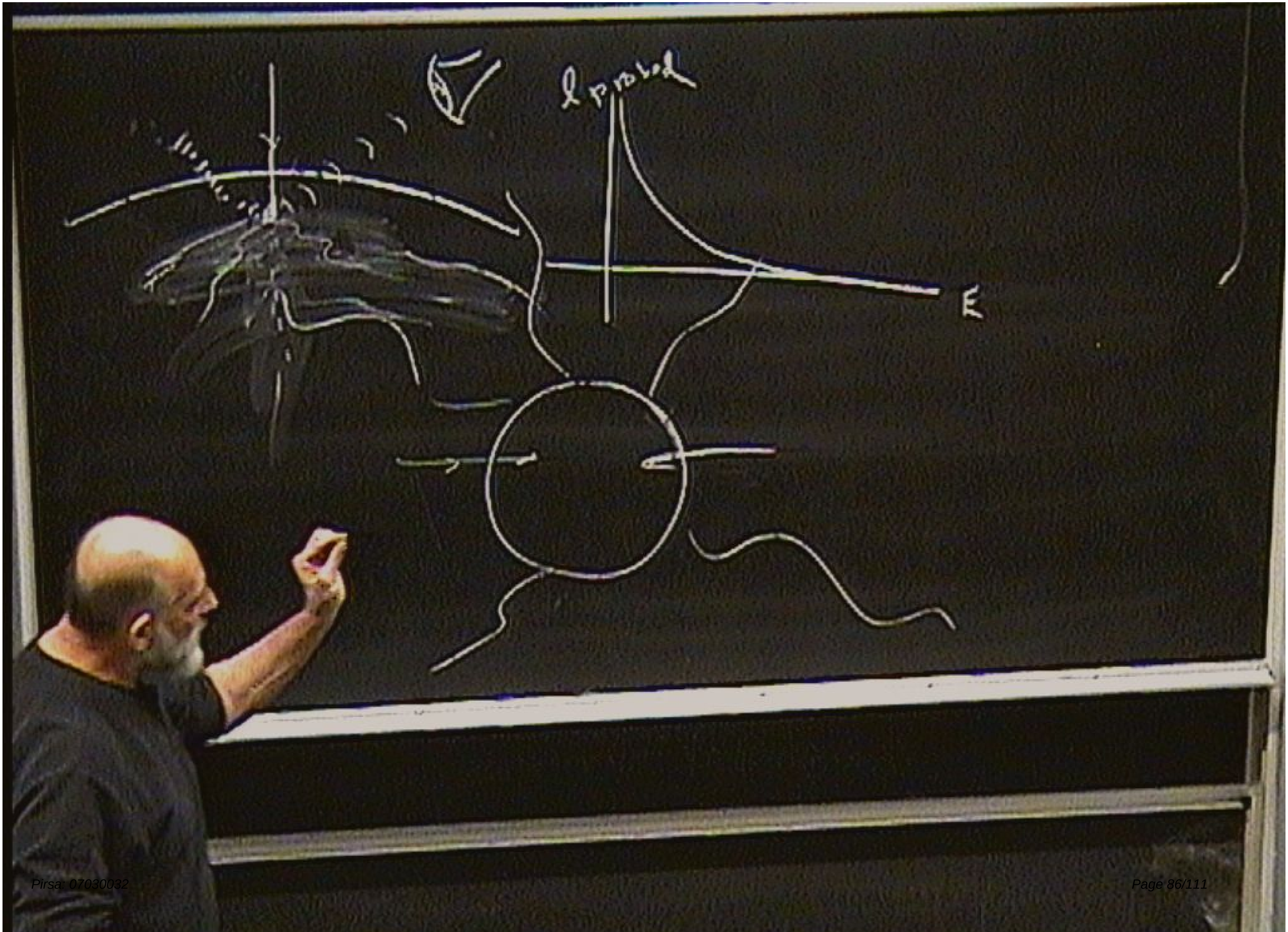
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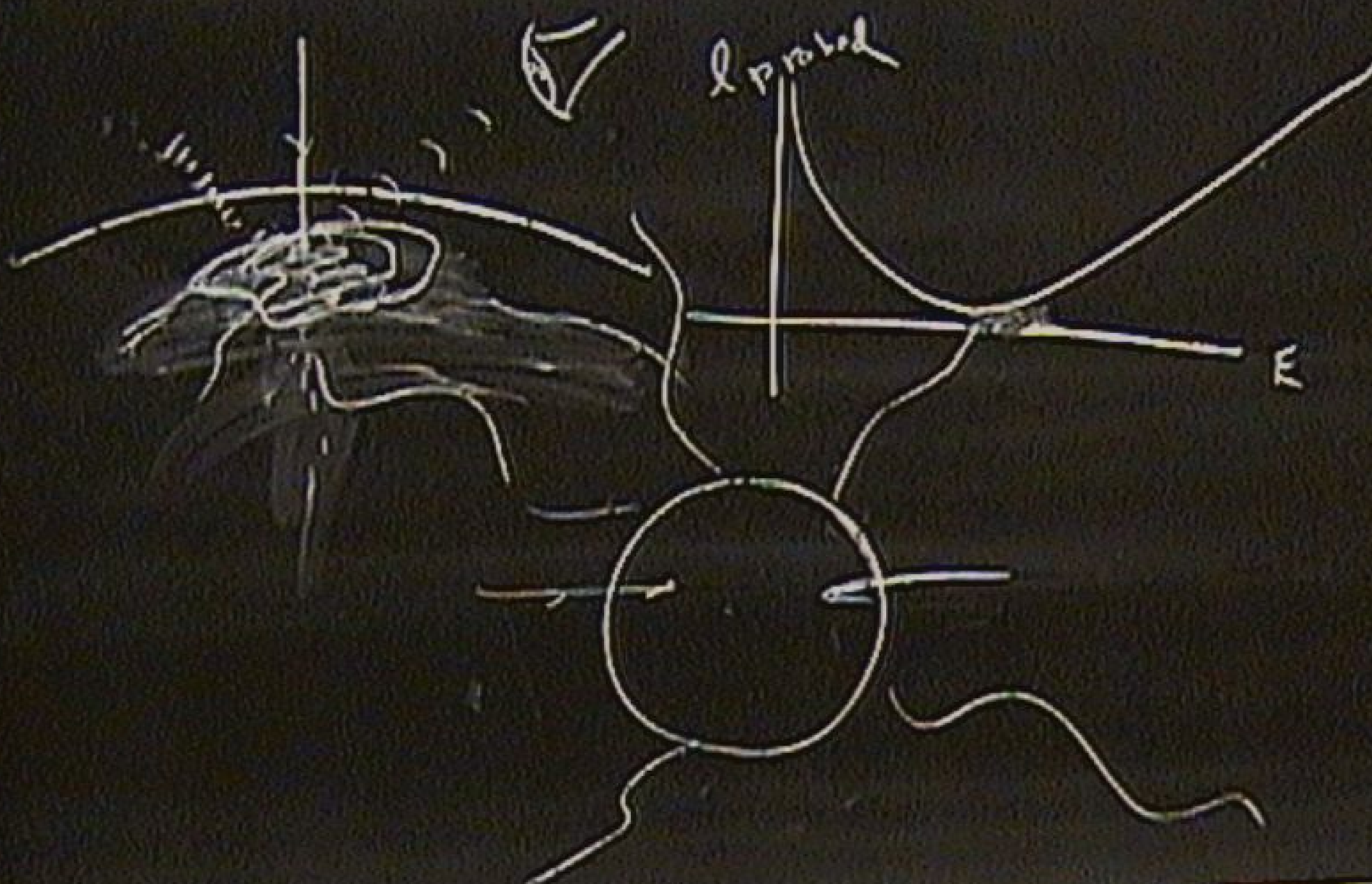
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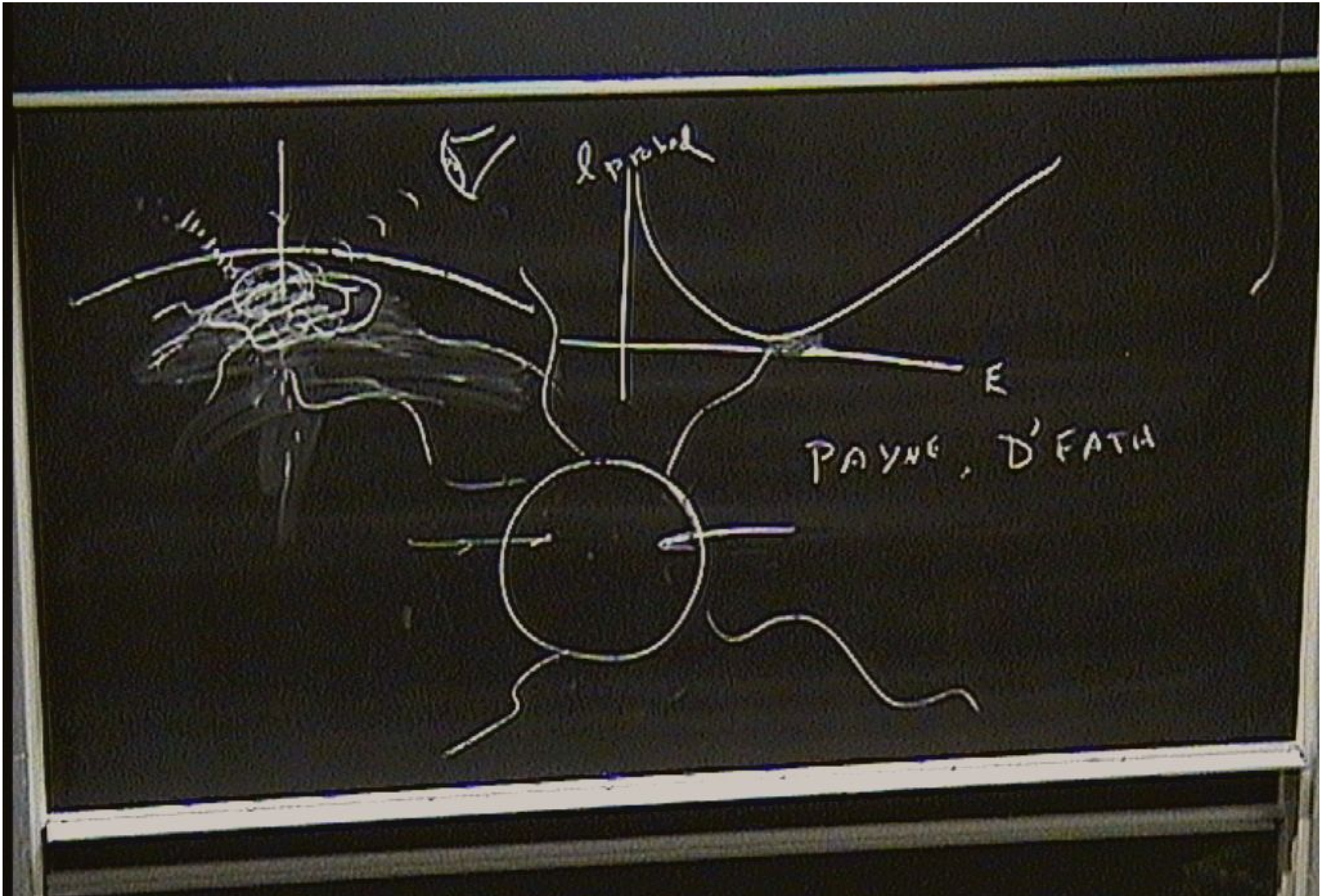
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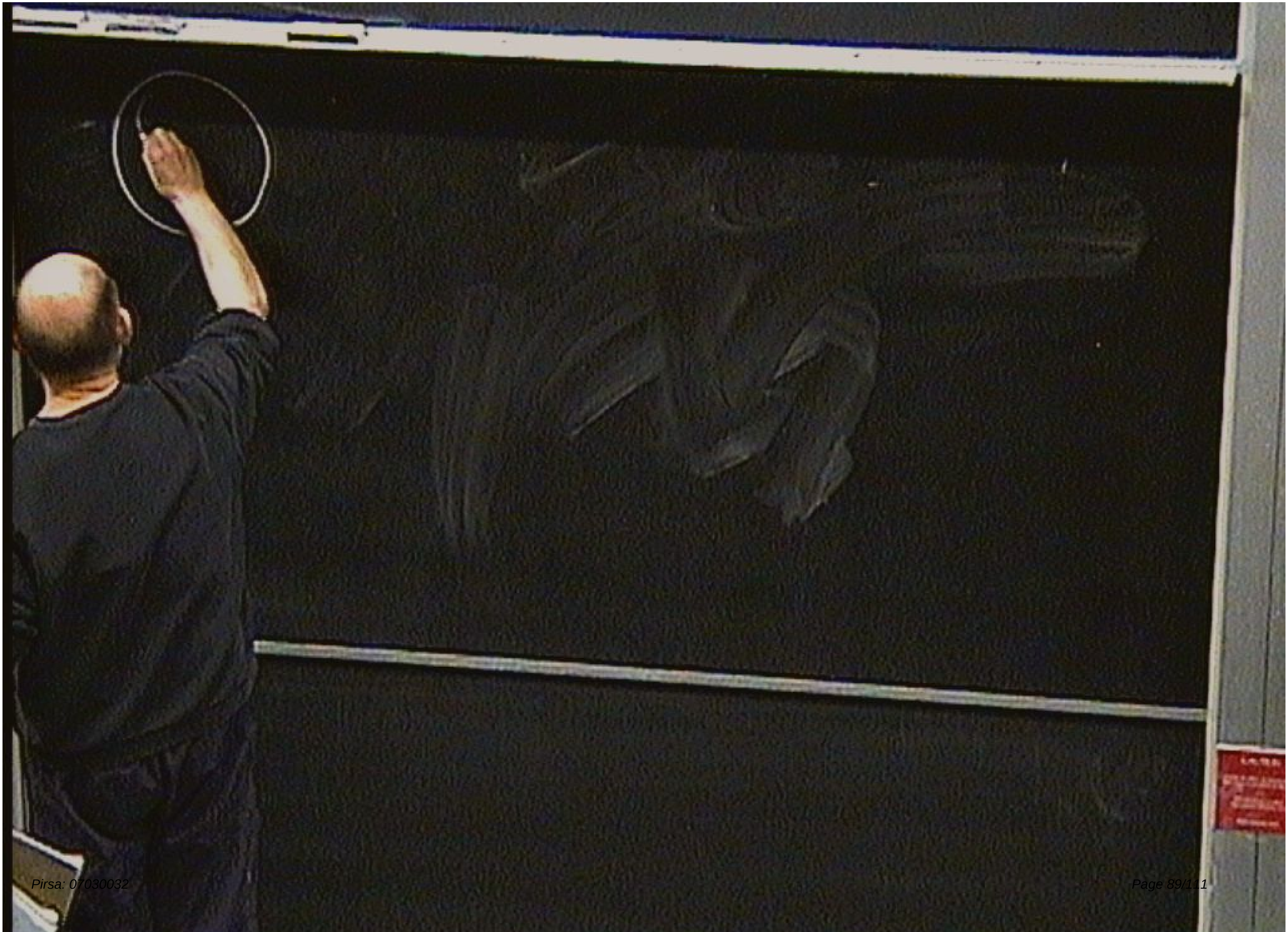
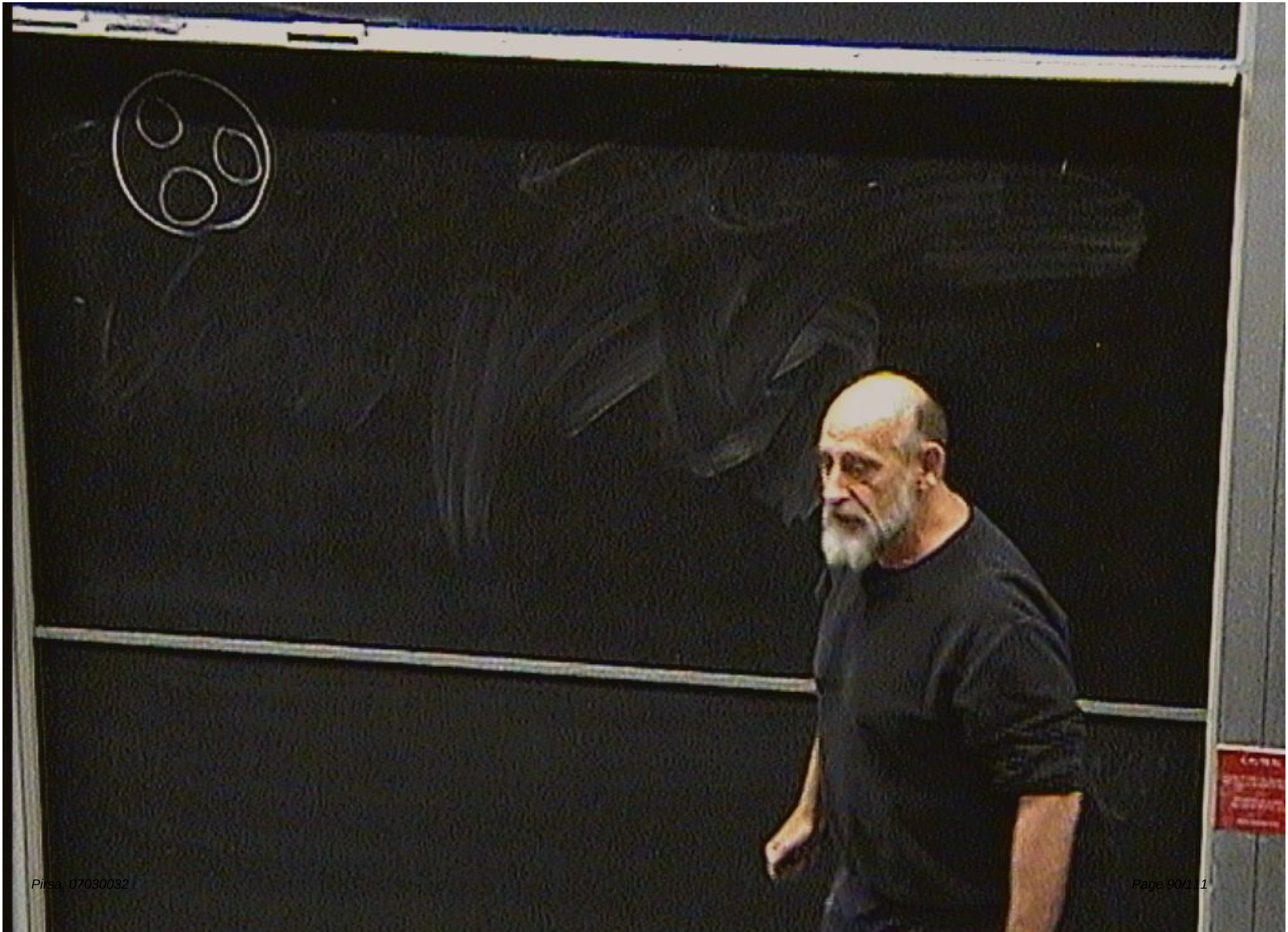
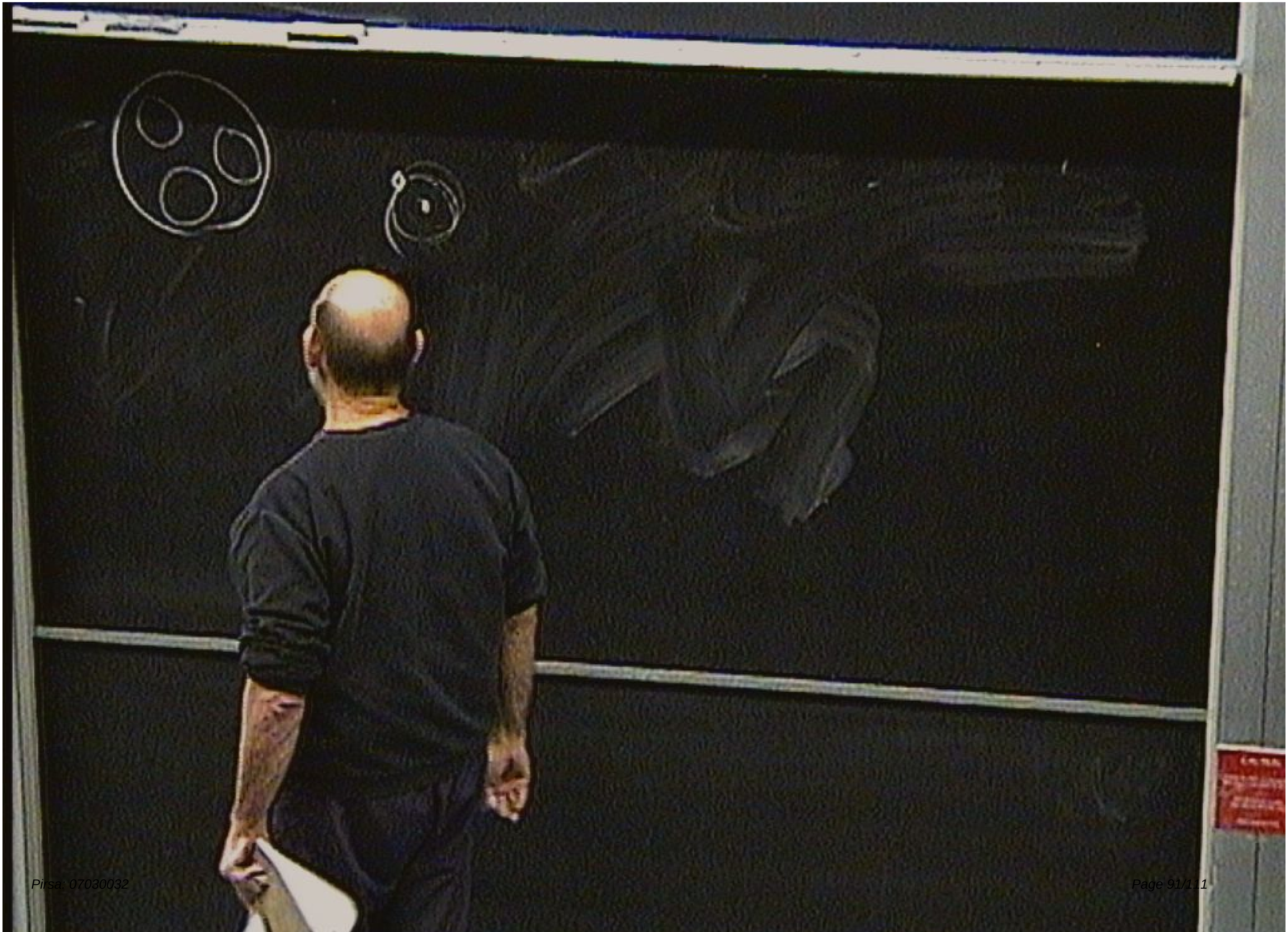
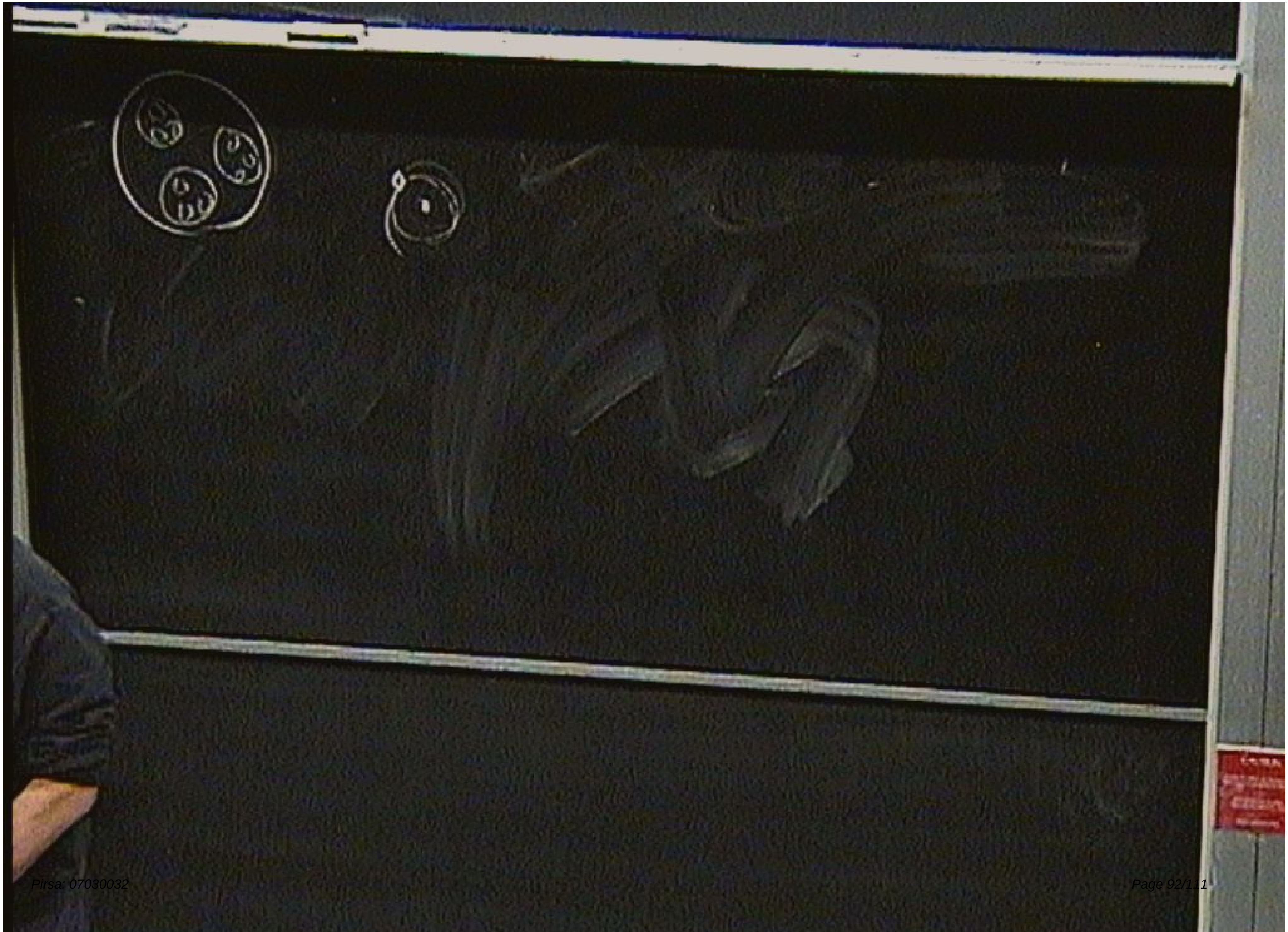
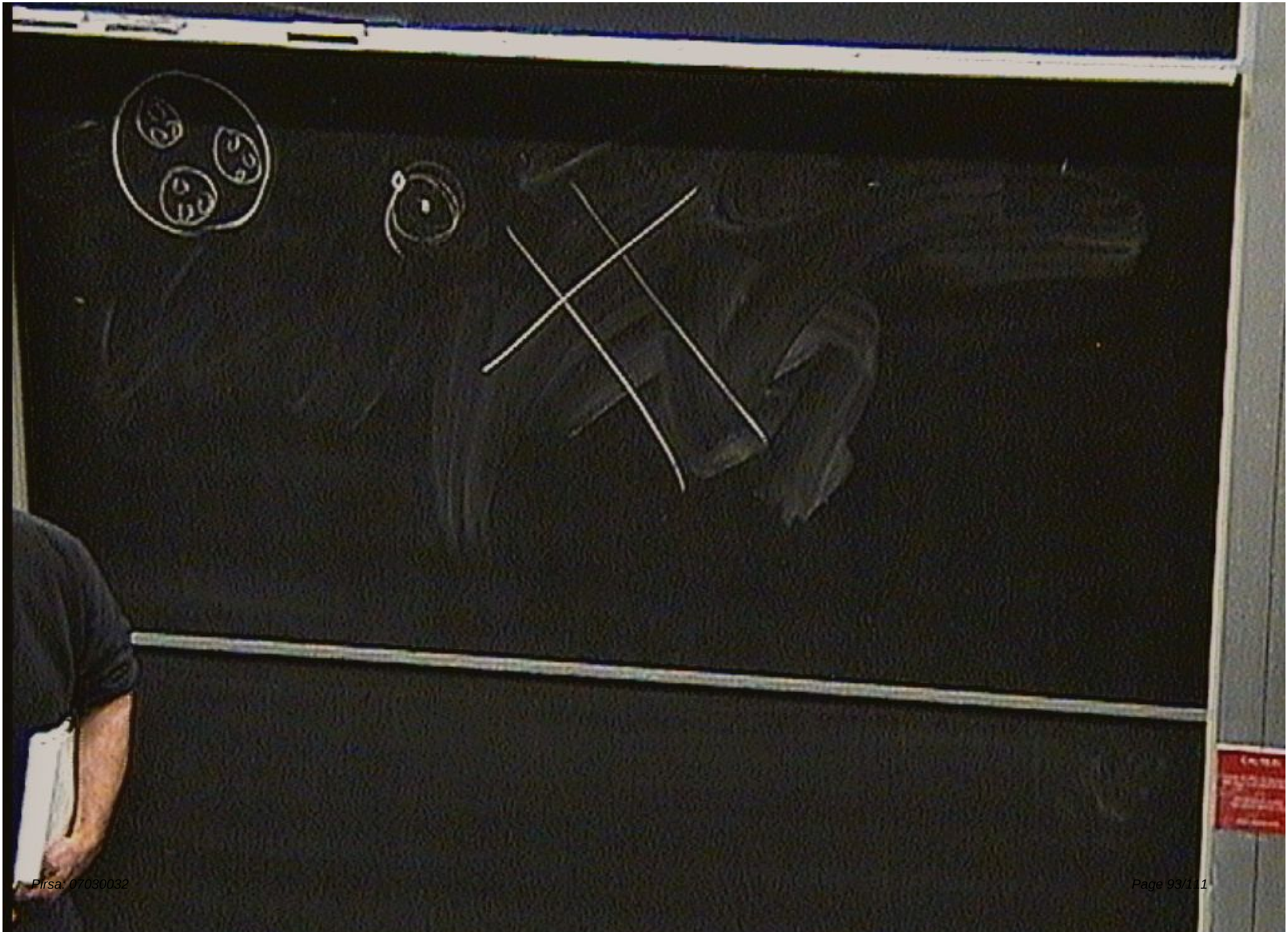
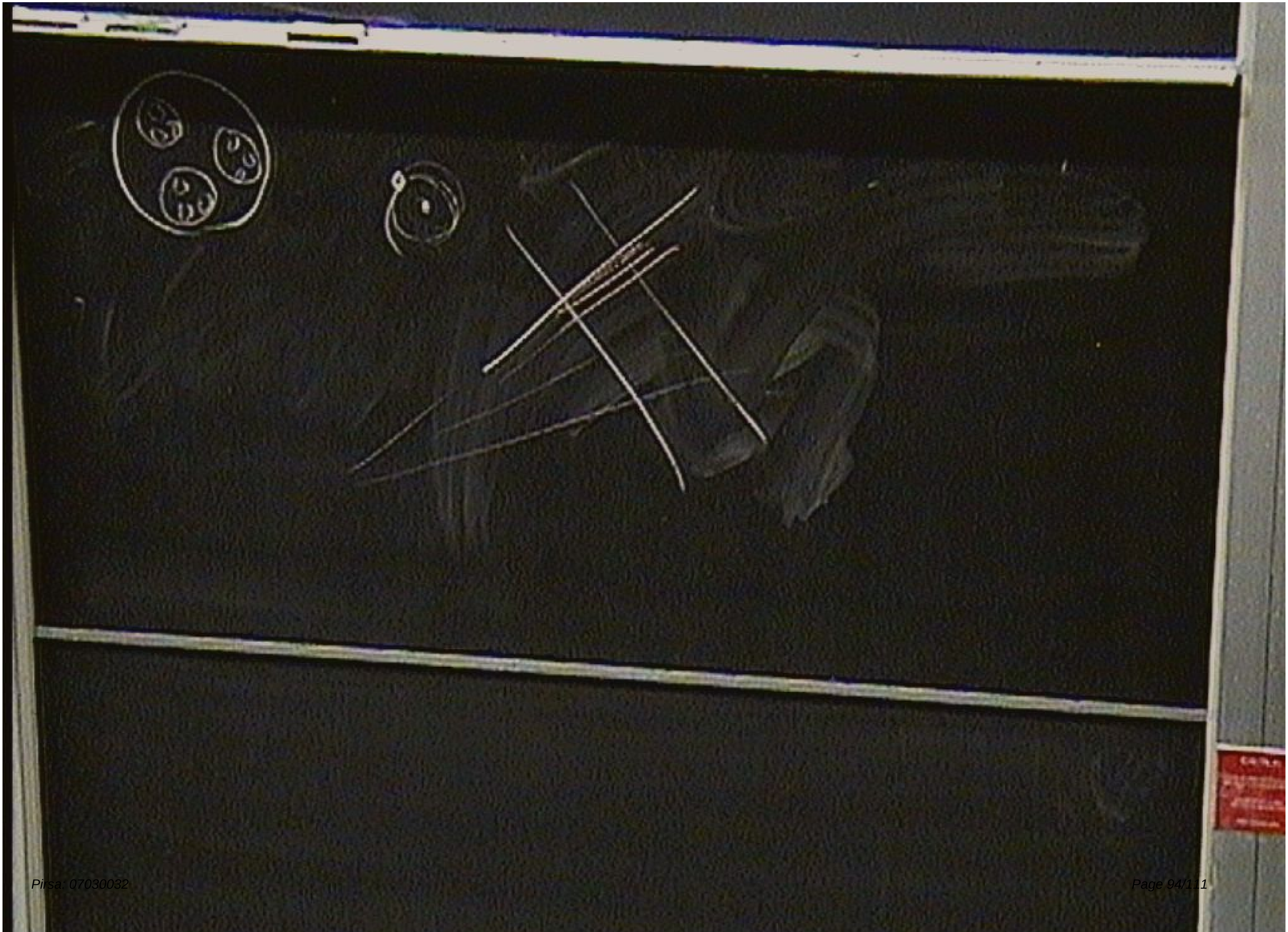


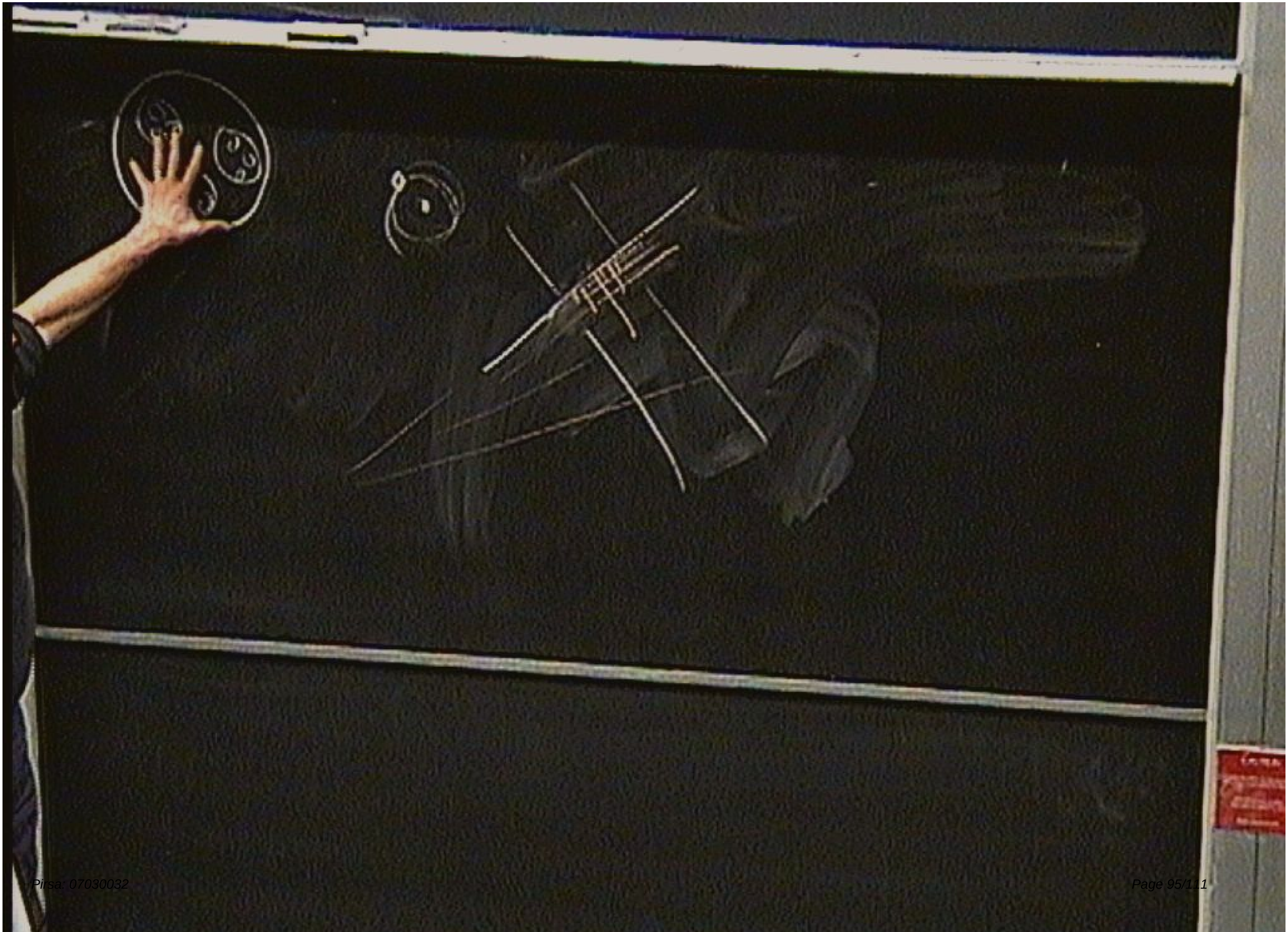


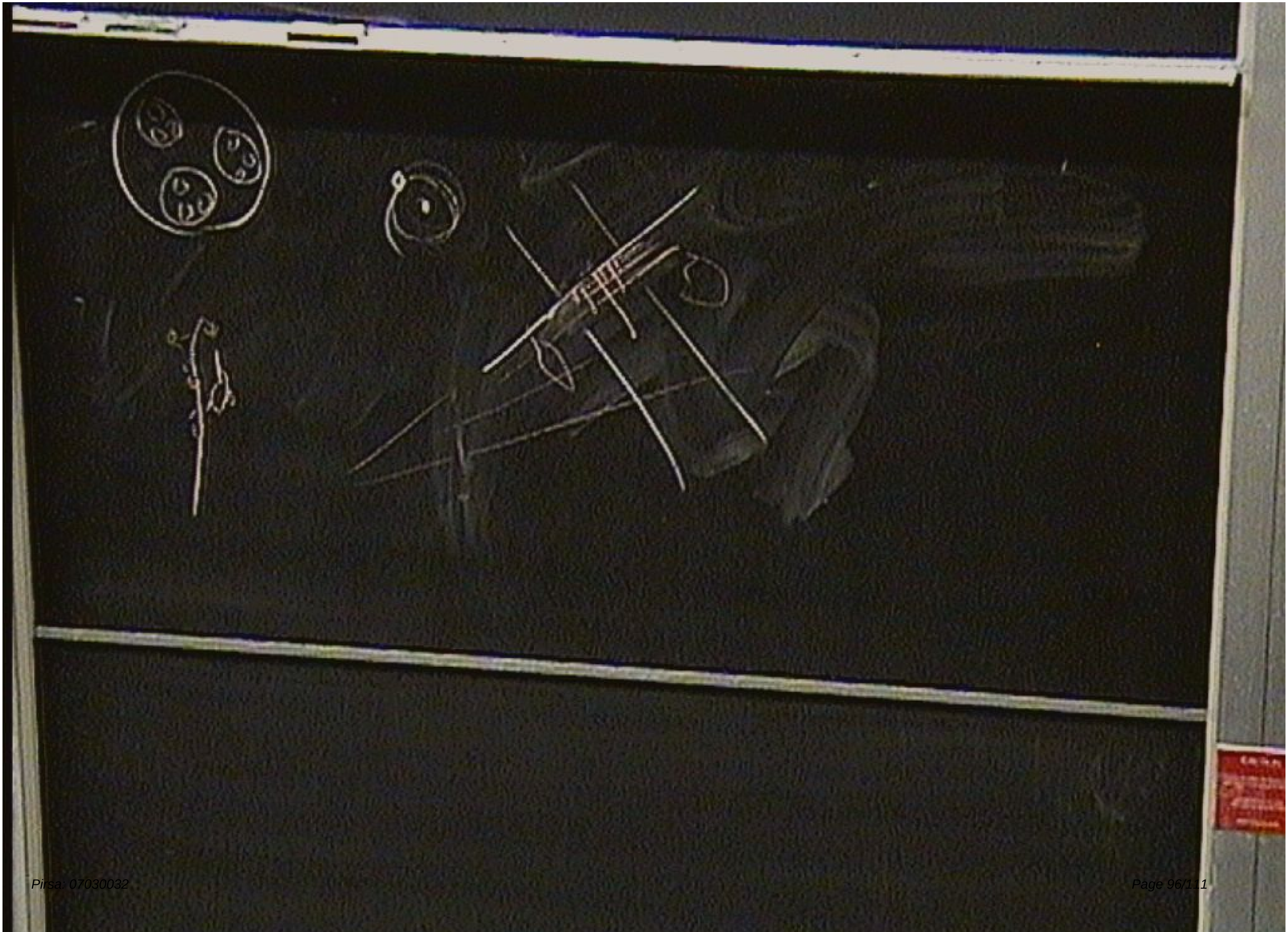


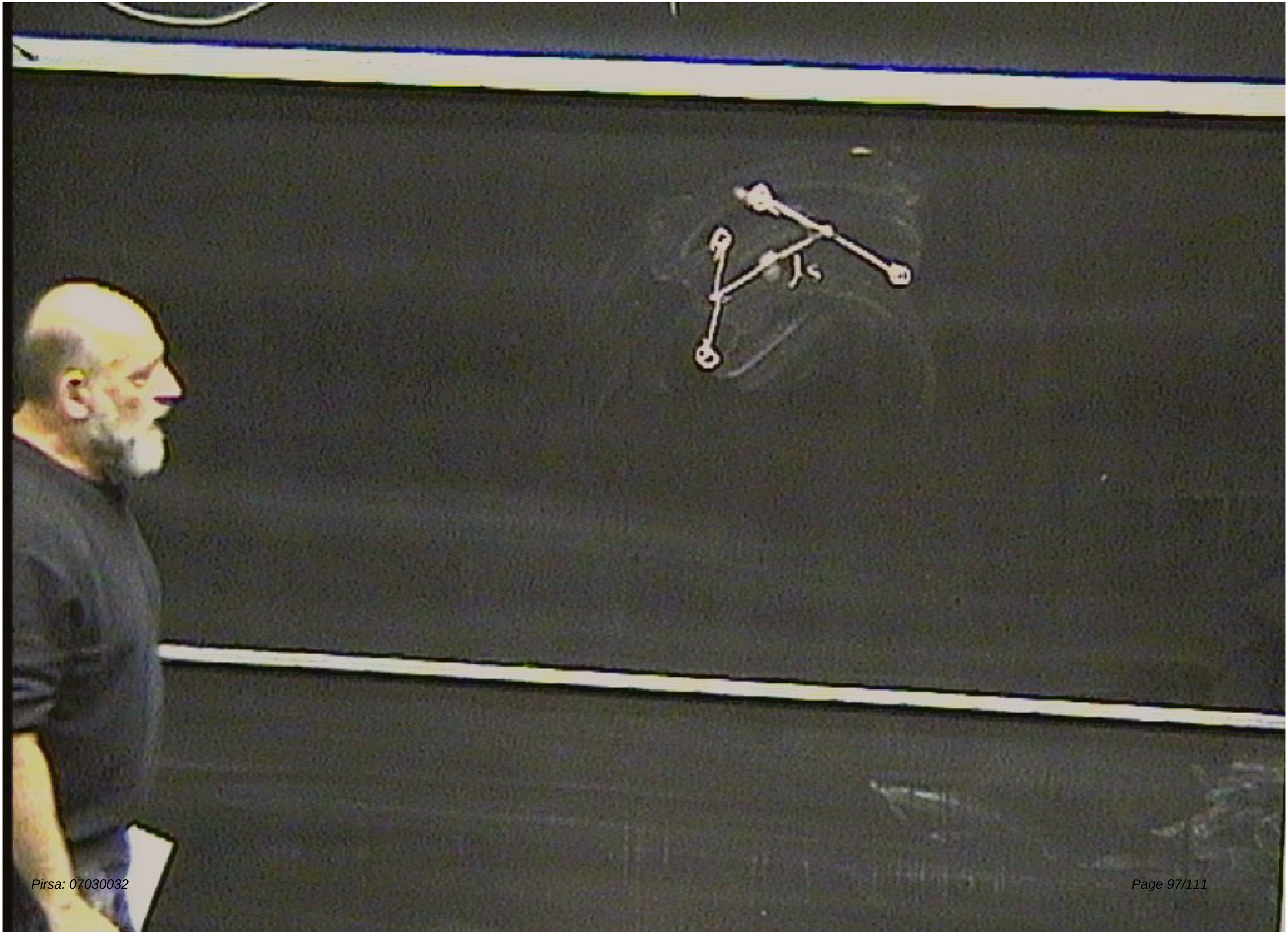


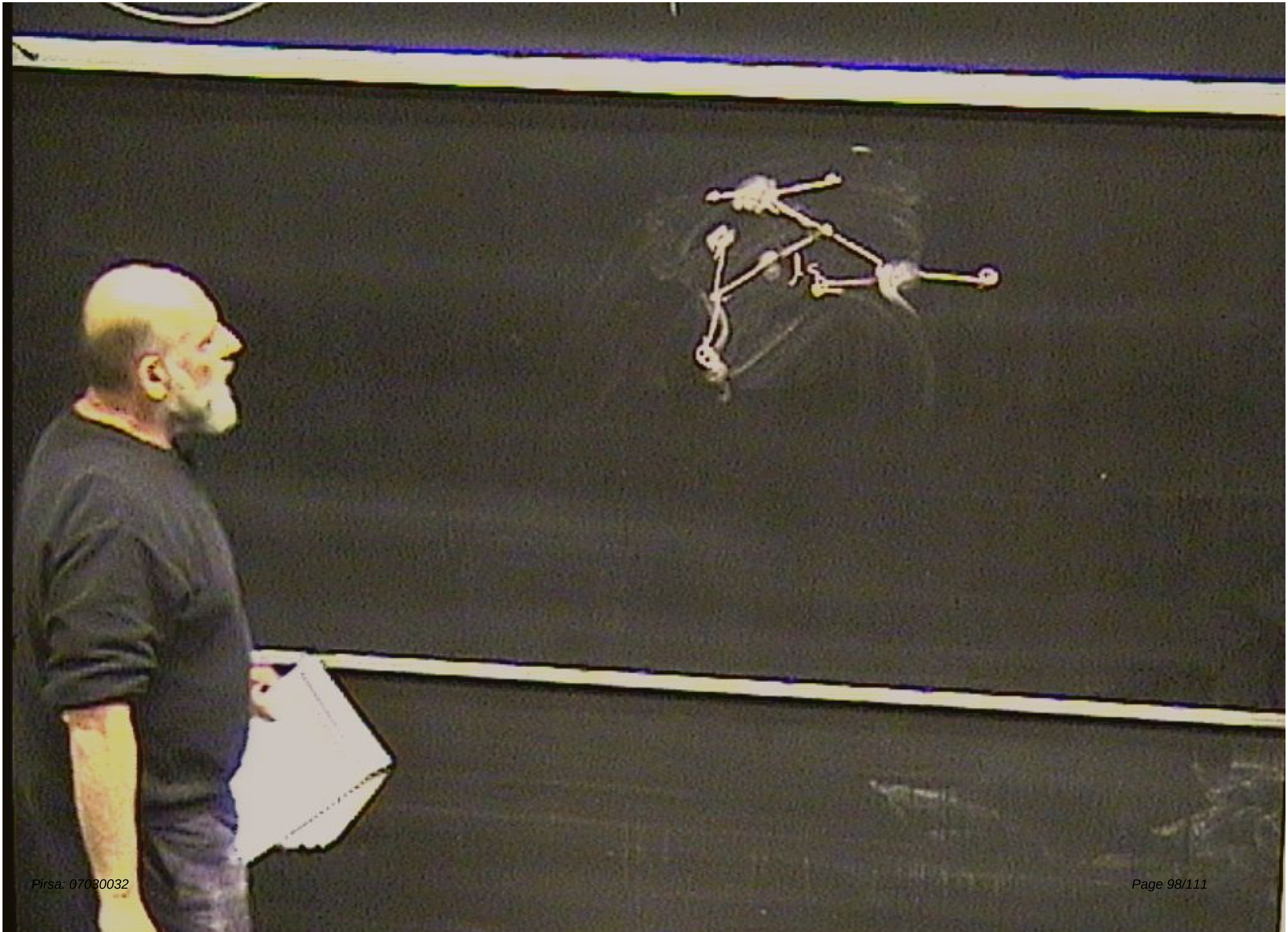


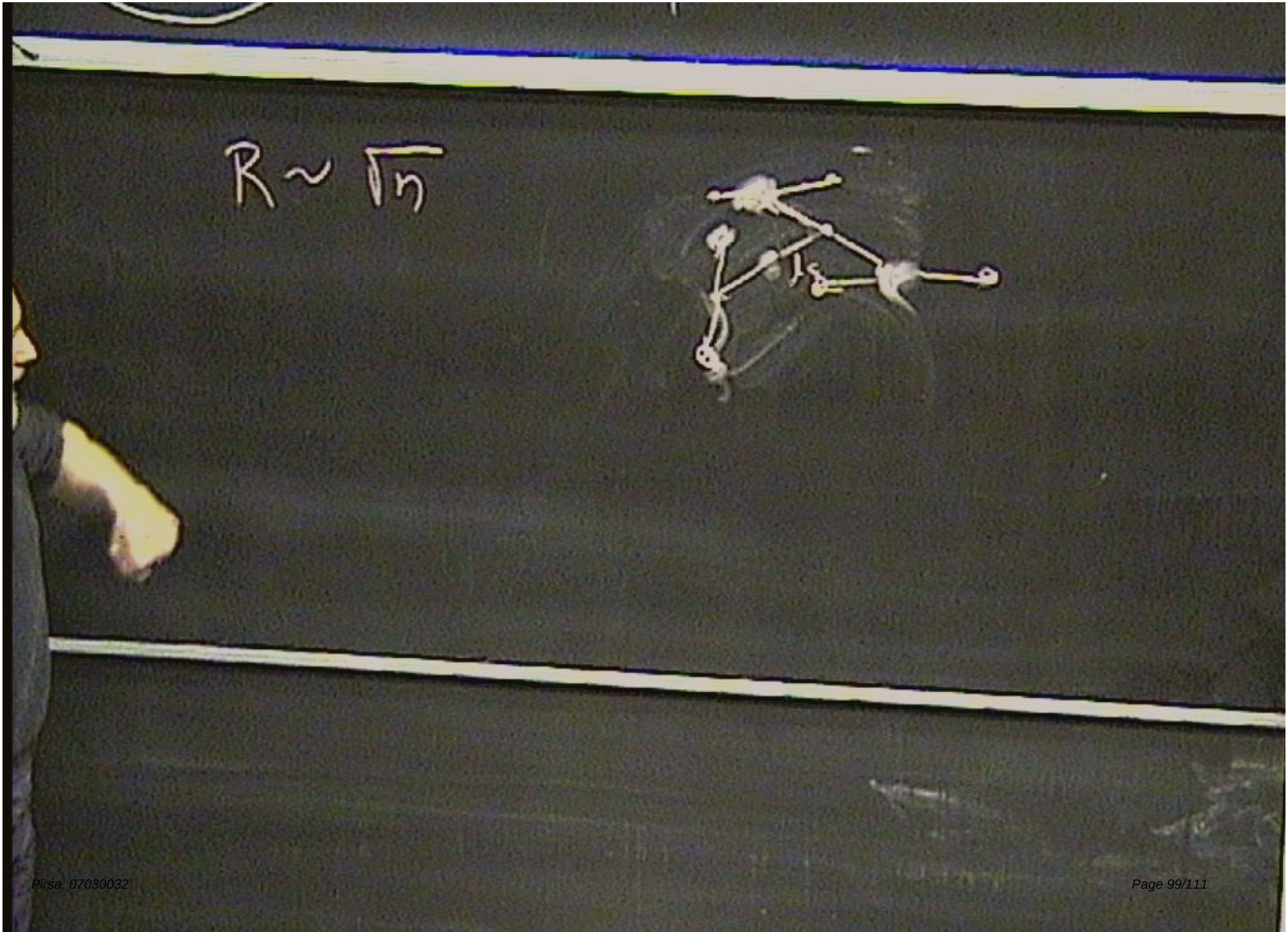






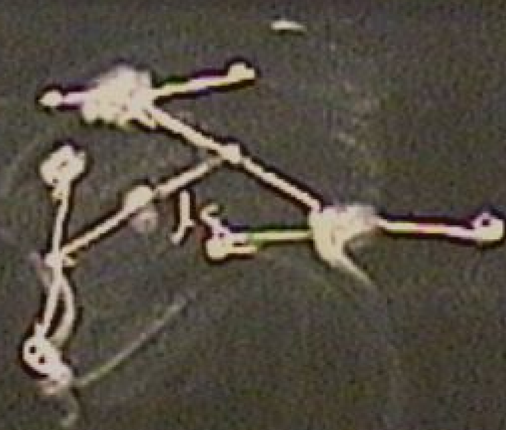




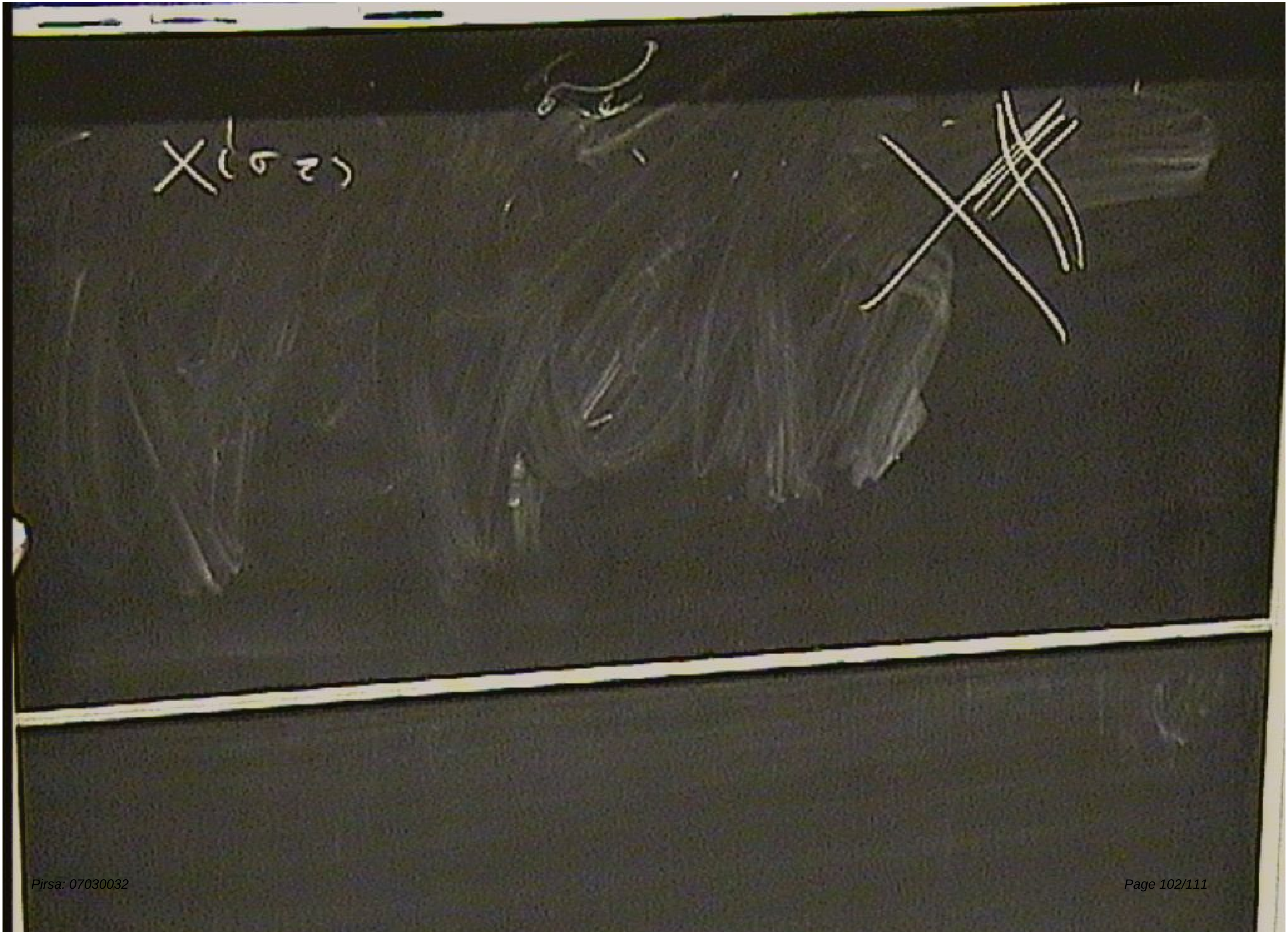

R ~ √n

$R \sim \sqrt{n}$

$2n$

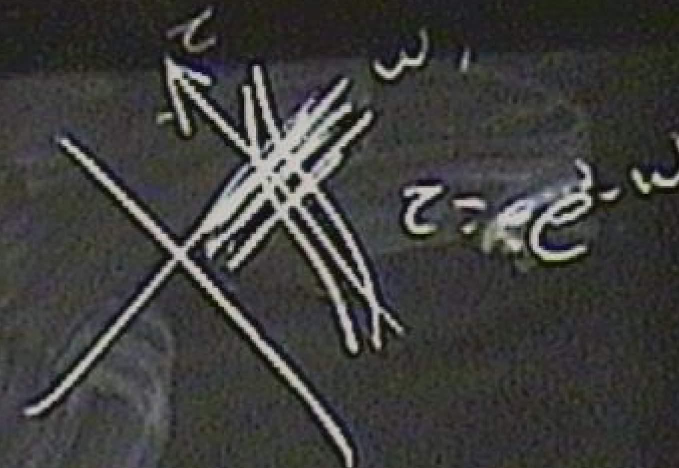


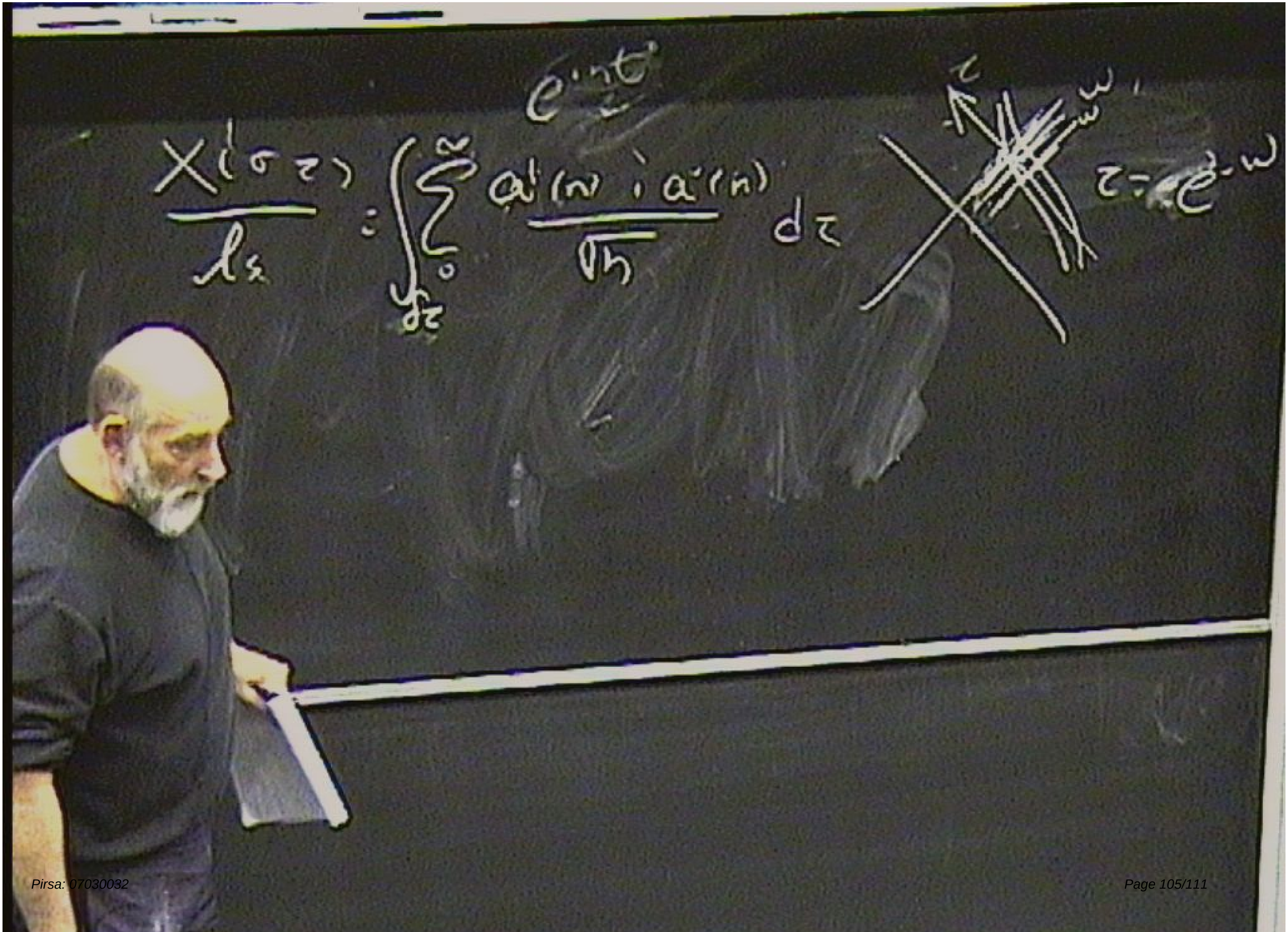
$X(\sigma\,\tau)$


X(σ τ)

$$\frac{X^i(\sigma,\tau)}{l_s} = \sum \frac{a^{i\dagger}(n) + a^i(n)}{\sqrt{n}}$$

$$\frac{X(\sigma,\tau)}{l_s} = \sum_0^{\infty} \frac{a^\dagger(n) + a(n)}{\sqrt{n}}$$



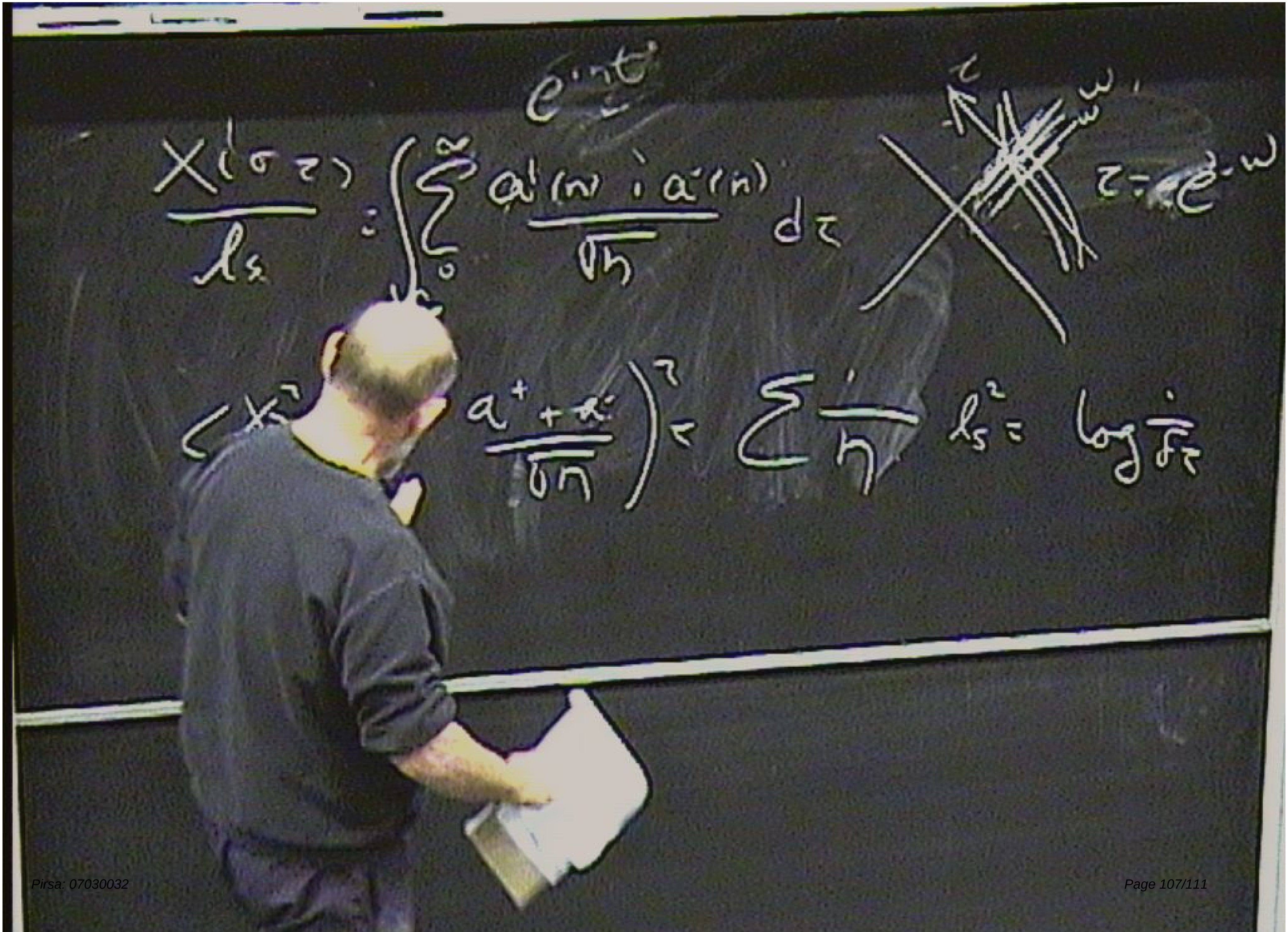

$e^{in\tau}$
$\frac{X(\sigma\tau)}{l_s} = \int \sum_0^\infty \frac{a^\dagger(n) \; a(n)}{\sqrt{n}} d\tau$
$z = e^{-w}$

$$e^{in\tau}$$

$$\frac{X(\sigma,\tau)}{l_s} = \int_{\delta\tau} \sum_0^{\infty} \frac{a^{\dagger}(n)\; i\; a^{-}(n)}{\sqrt{n}}\, d\tau$$

$$\tau = e^{-w}$$

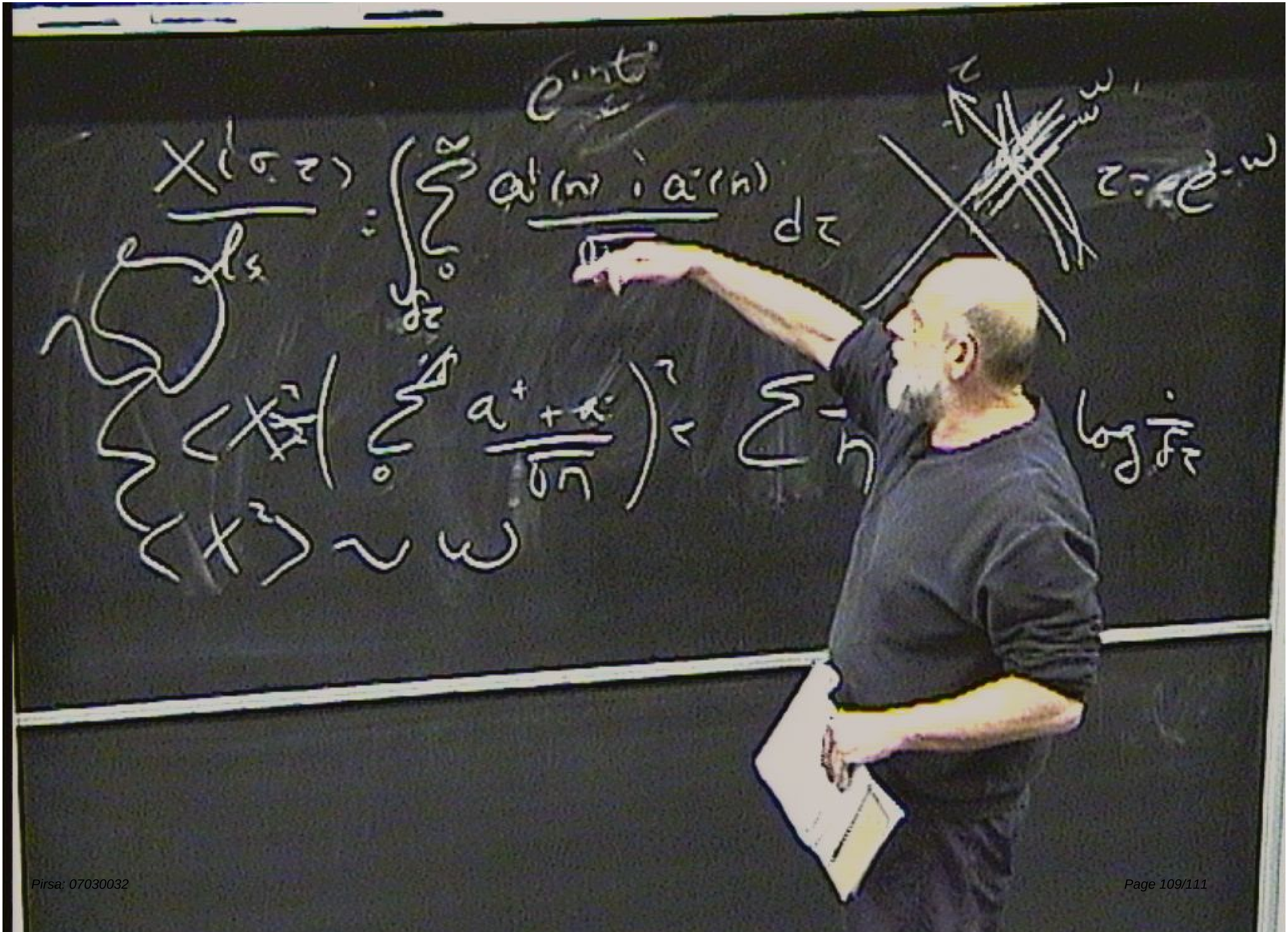
$$X_\tau = \sum_0^{\infty} \frac{a^{+} + a^{-}}{\sqrt{n}}$$

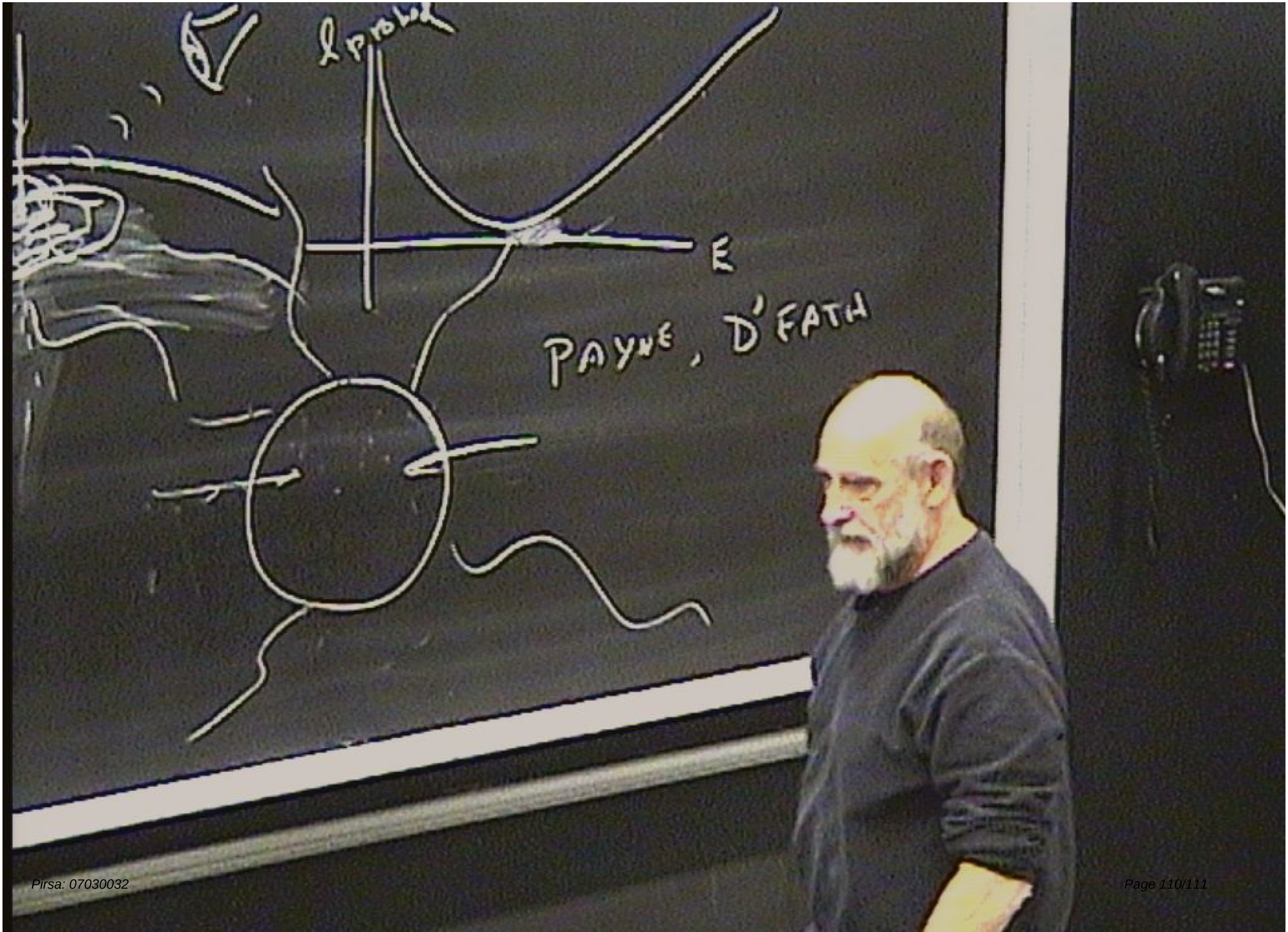

$e^{in\tau}$
$\frac{X(\sigma,\tau)}{l_s} = \int \sum_0^\infty \frac{a^\dagger(n) \; i \; a^-(n)}{\sqrt{n}} d\tau$
$\tau = e^{-w}$
$\left(\frac{a^+ + a^-}{\sqrt{n}}\right)^2 = \sum \frac{1}{n} \, l_s^2 = \log \frac{1}{\delta\tau}$

$e^{in\tau}$

$$\frac{X(\sigma,\tau)}{l_s} = \int_{\delta\tau} \sum_0^\infty \frac{a^\dagger(n) + a^-(n)}{\sqrt{n}} \, d\tau$$

$$\langle X^2 \rangle = \left(\sum_0^{1/\delta} \frac{a^+ + a^-}{\sqrt{n}} \right)^2 = \sum \frac{1}{n} \, l_s^2 = \log \frac{1}{\delta\tau}$$


X(σ,τ)
l_s
dz
z = e^{-w}
<X²> ~ w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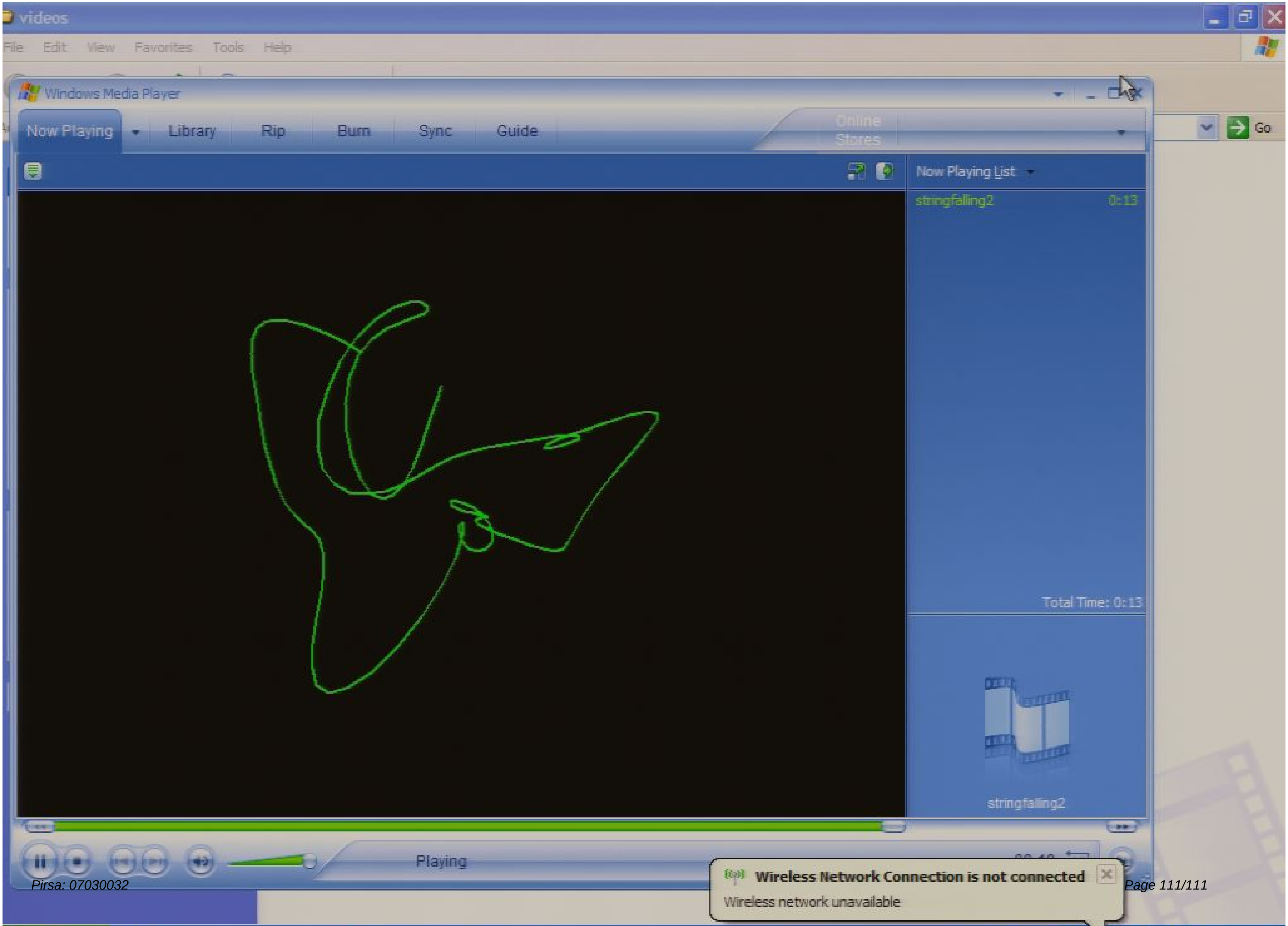
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Library
Rip
Burn
Sync
Guide
Online Stores
Now Playing List
stringfalling2 0:13
Total Time: 0:13
stringfalling2
Playing
Wireless Network Connection is not connected
Wireless network unavailable