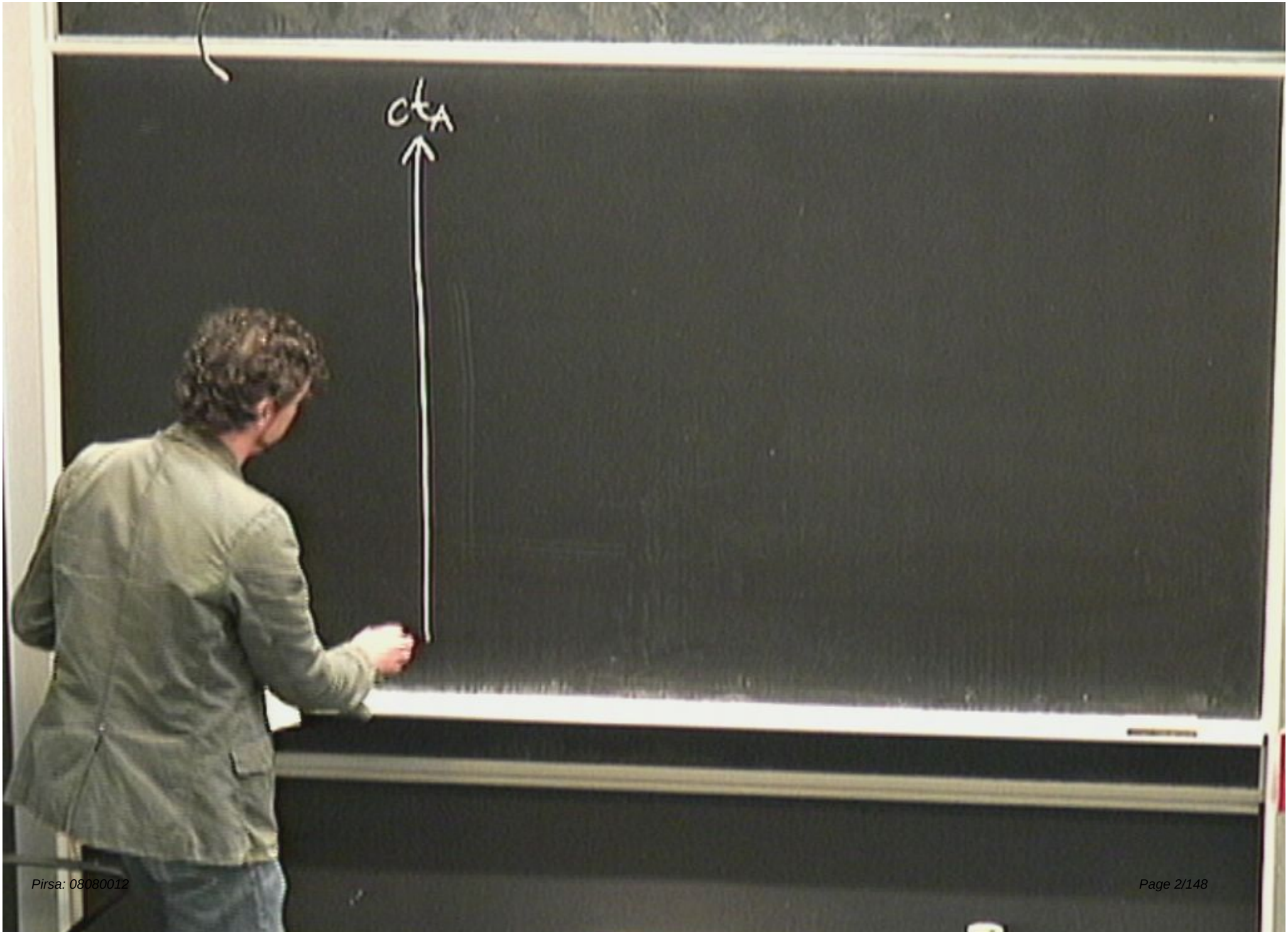
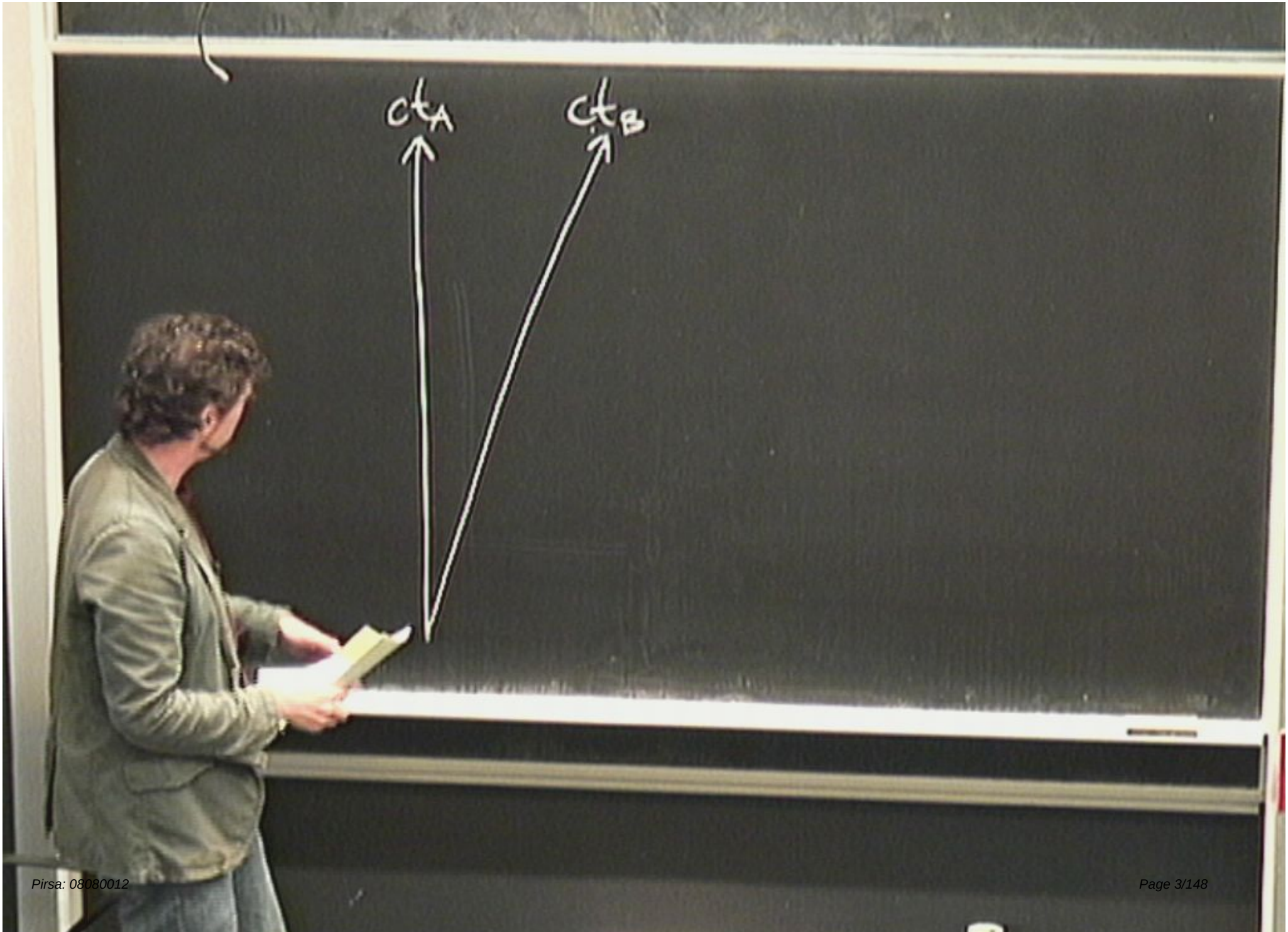
Title: Relativity 2

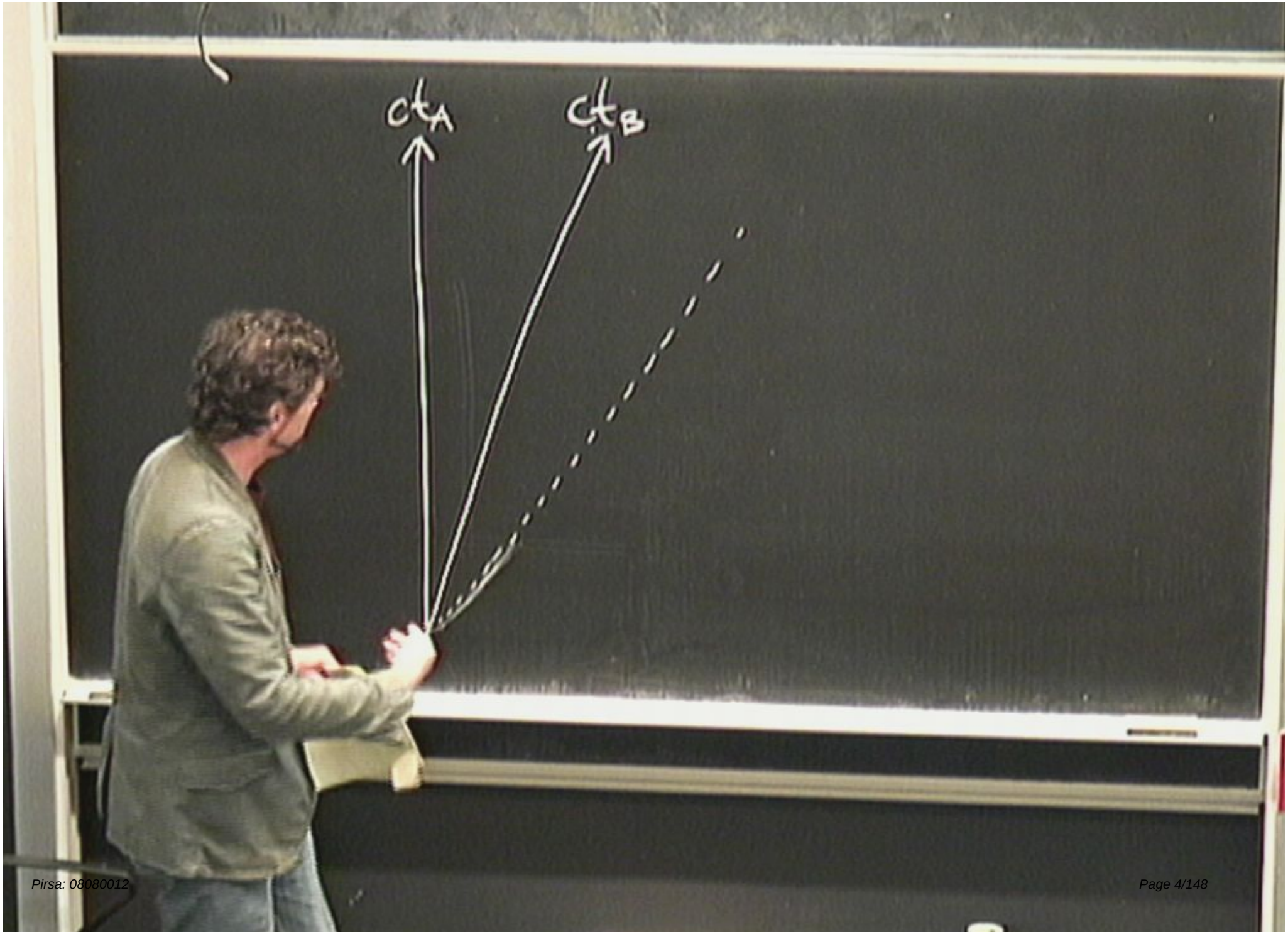
Date: Aug 11, 2008 09:00 AM

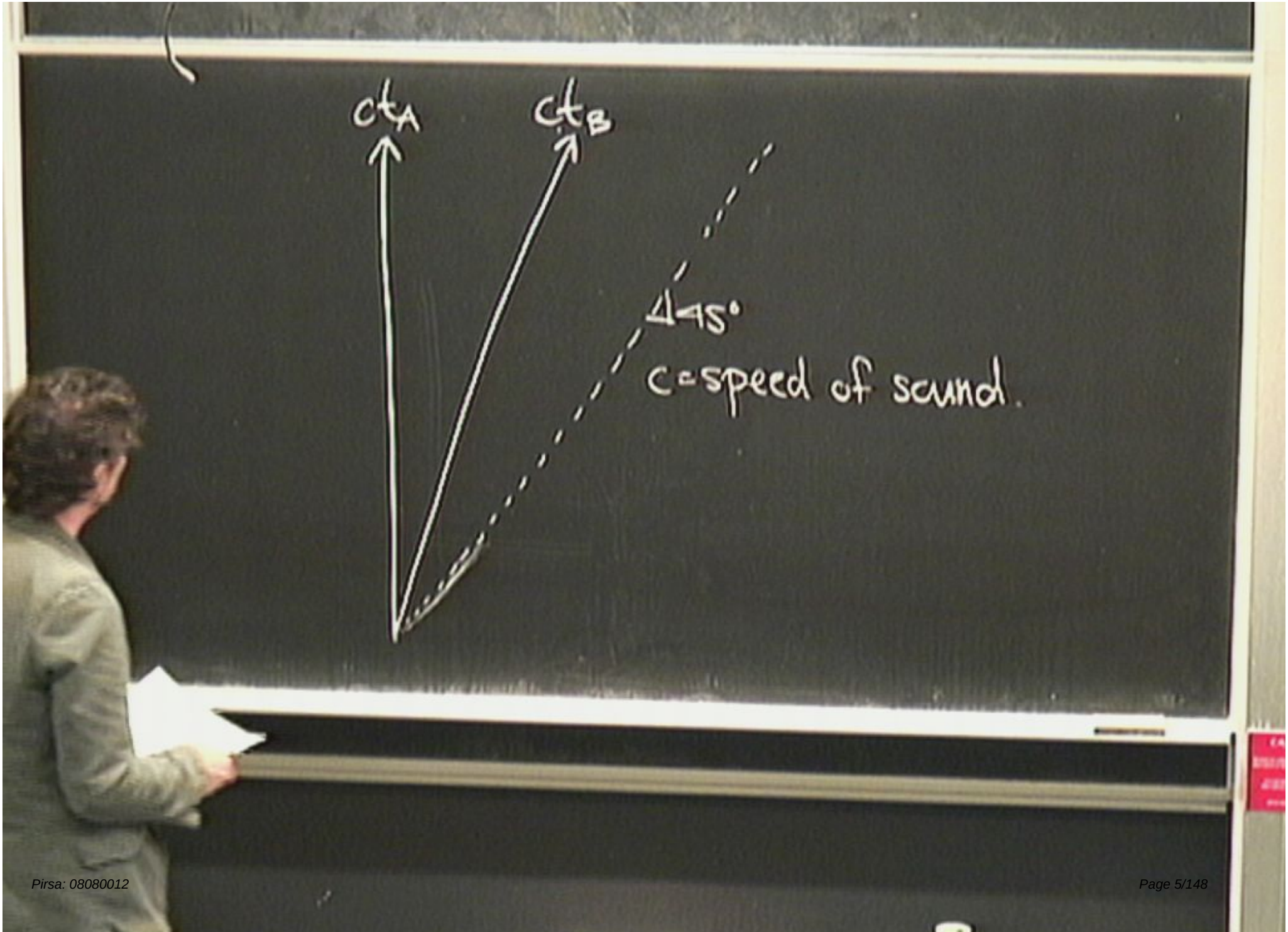
URL: http://pirsa.org/08080012

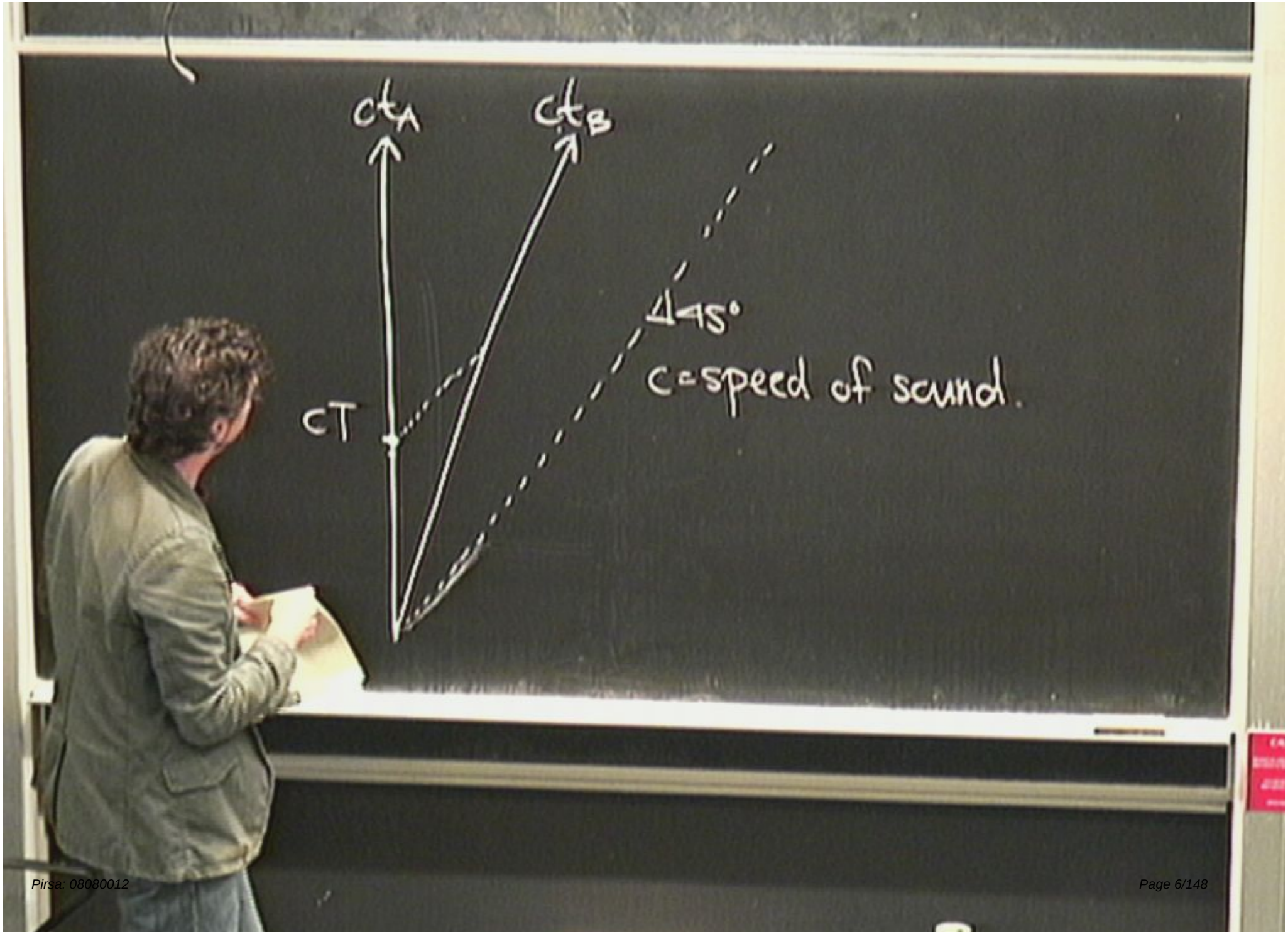
Abstract:

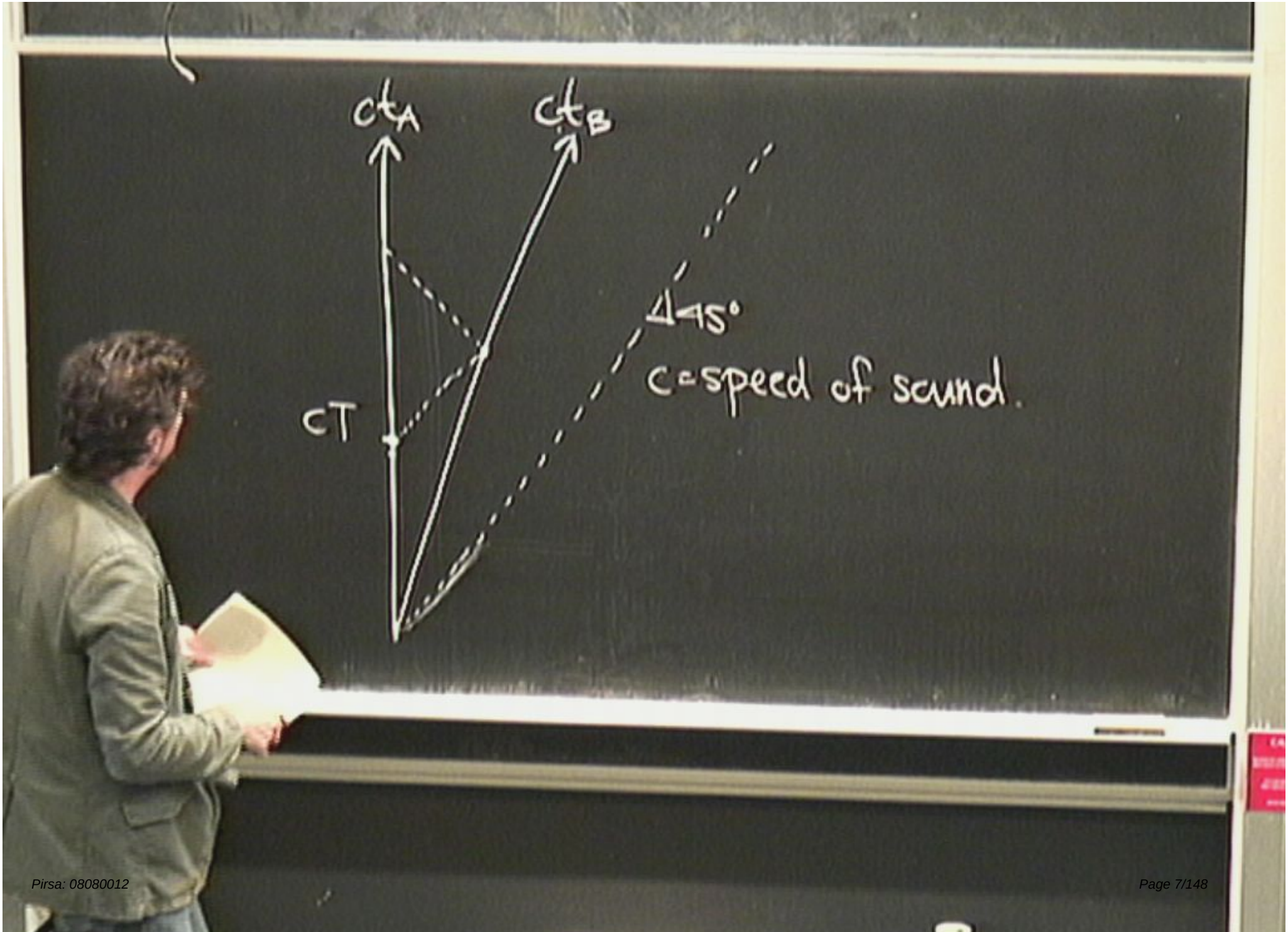

ct_A

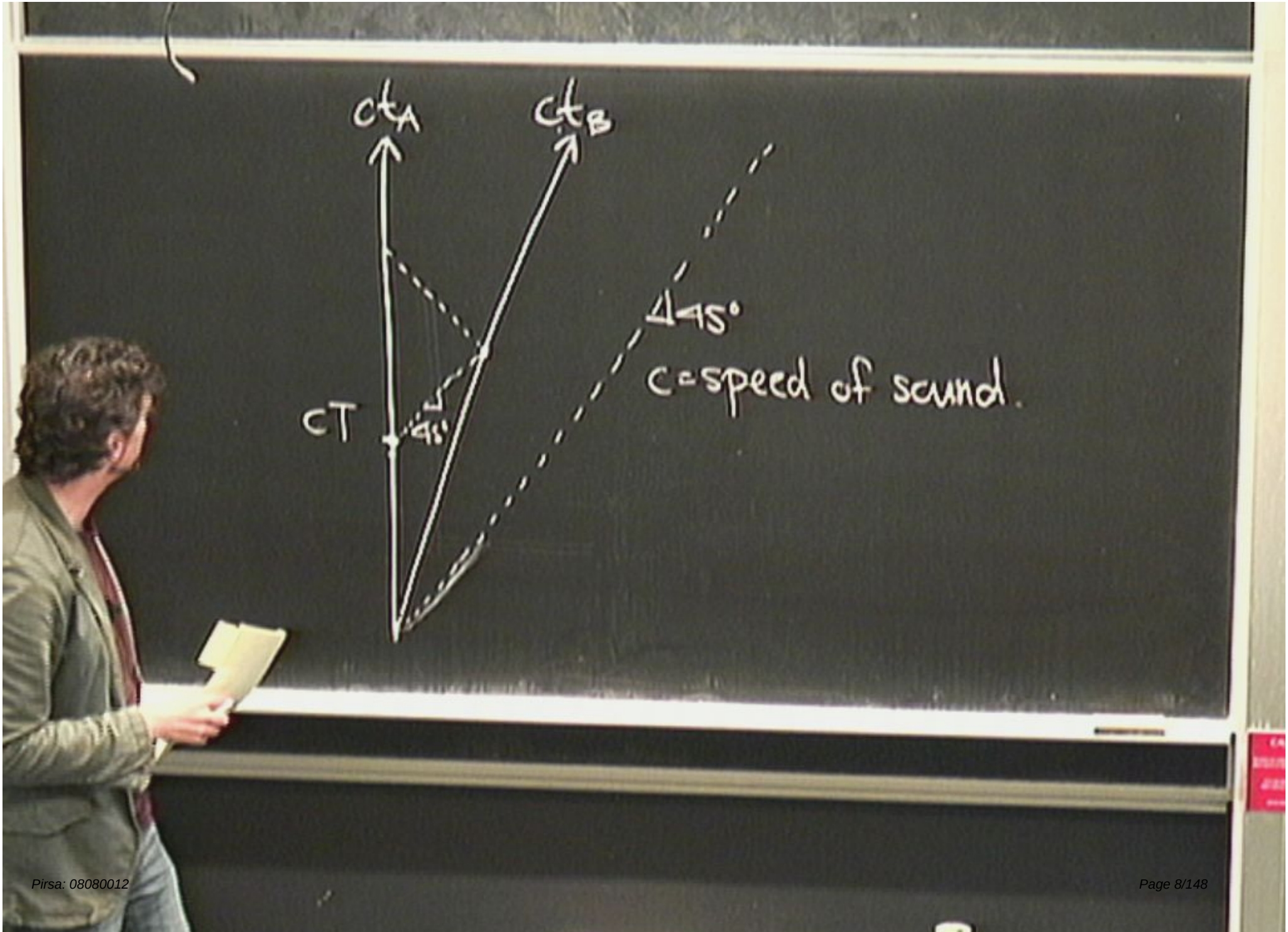

ct_A
ct_B

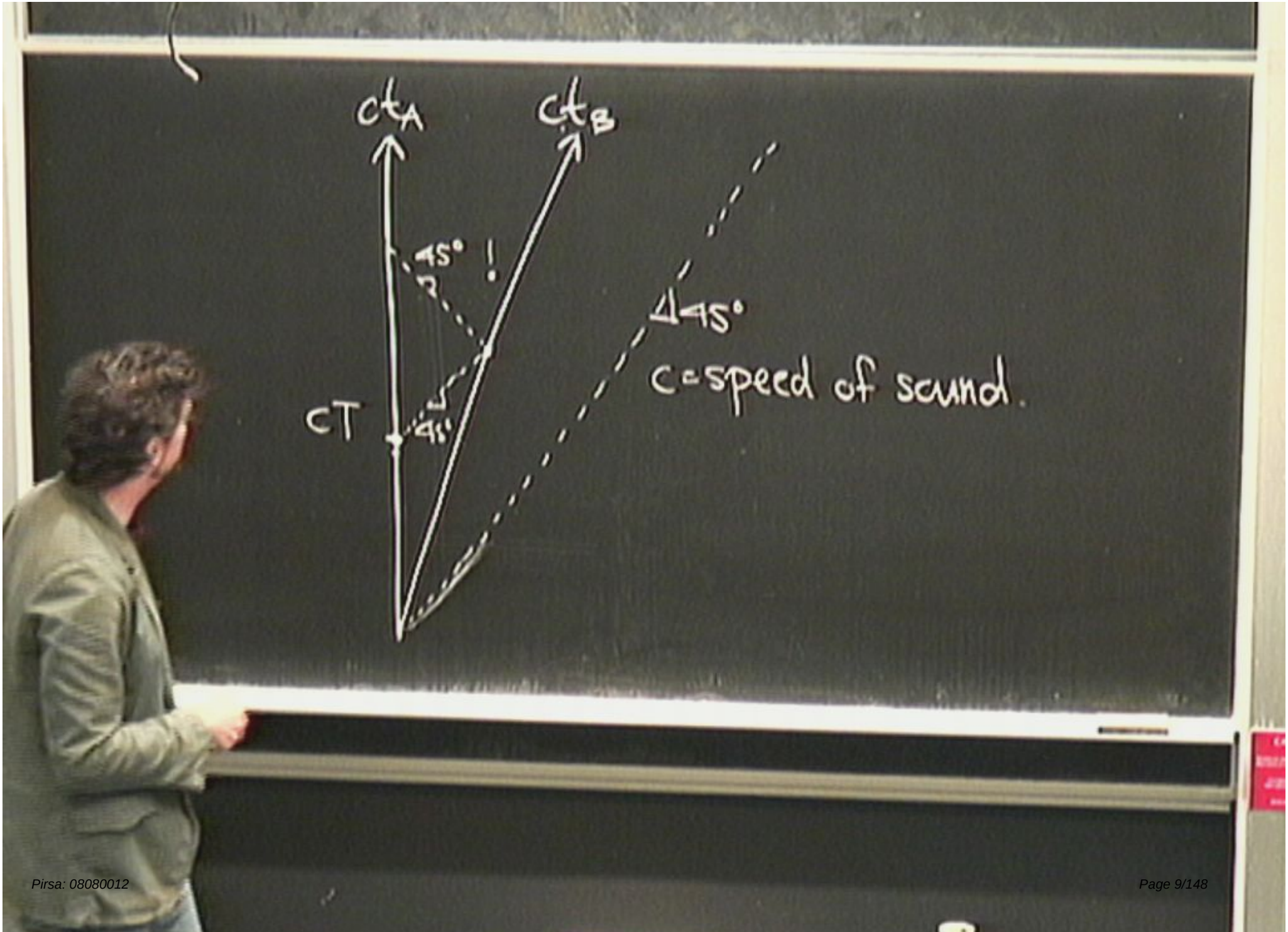

ct_A
ct_B

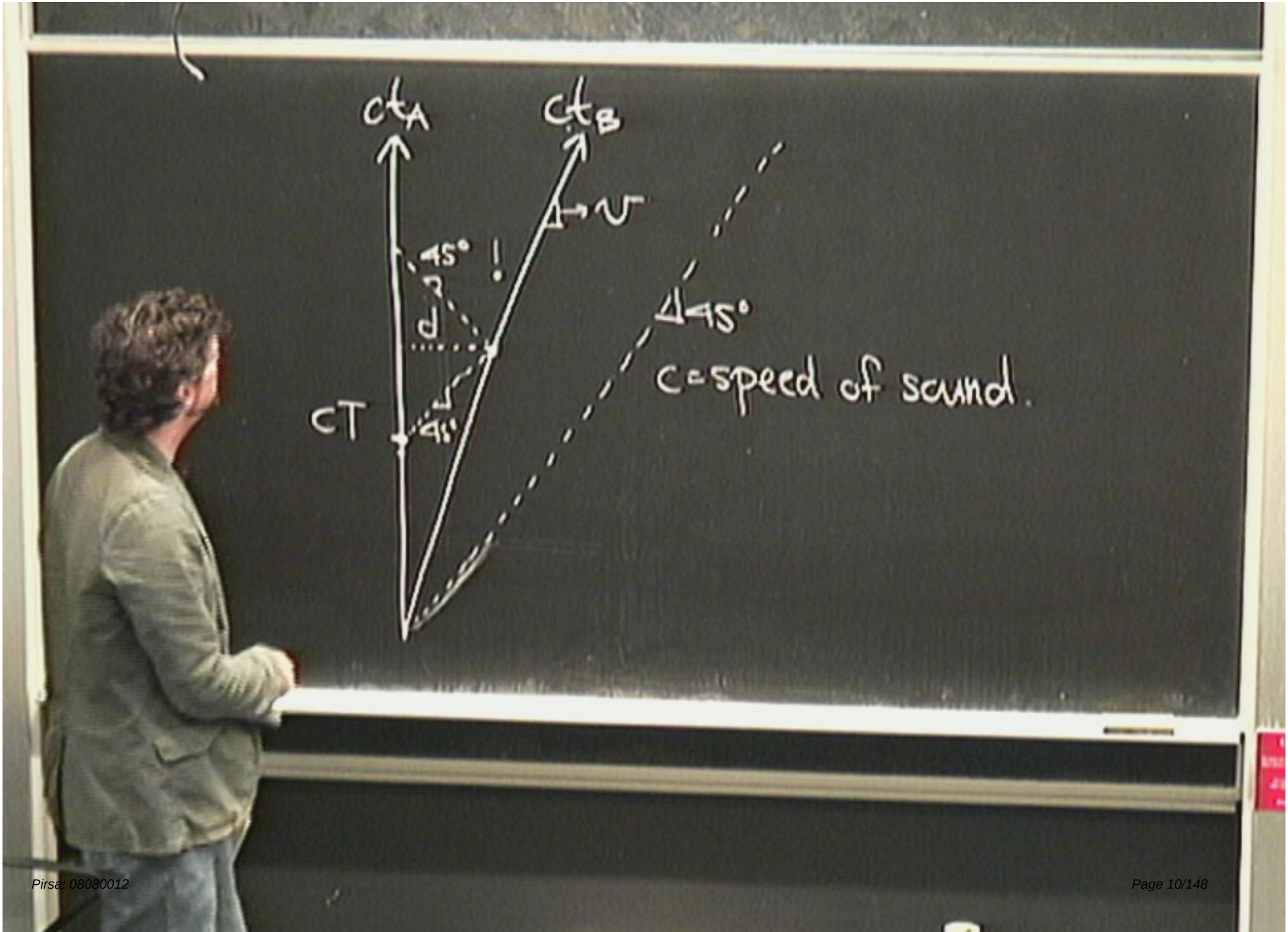

ct_A
ct_B
45°
c=speed of sound.

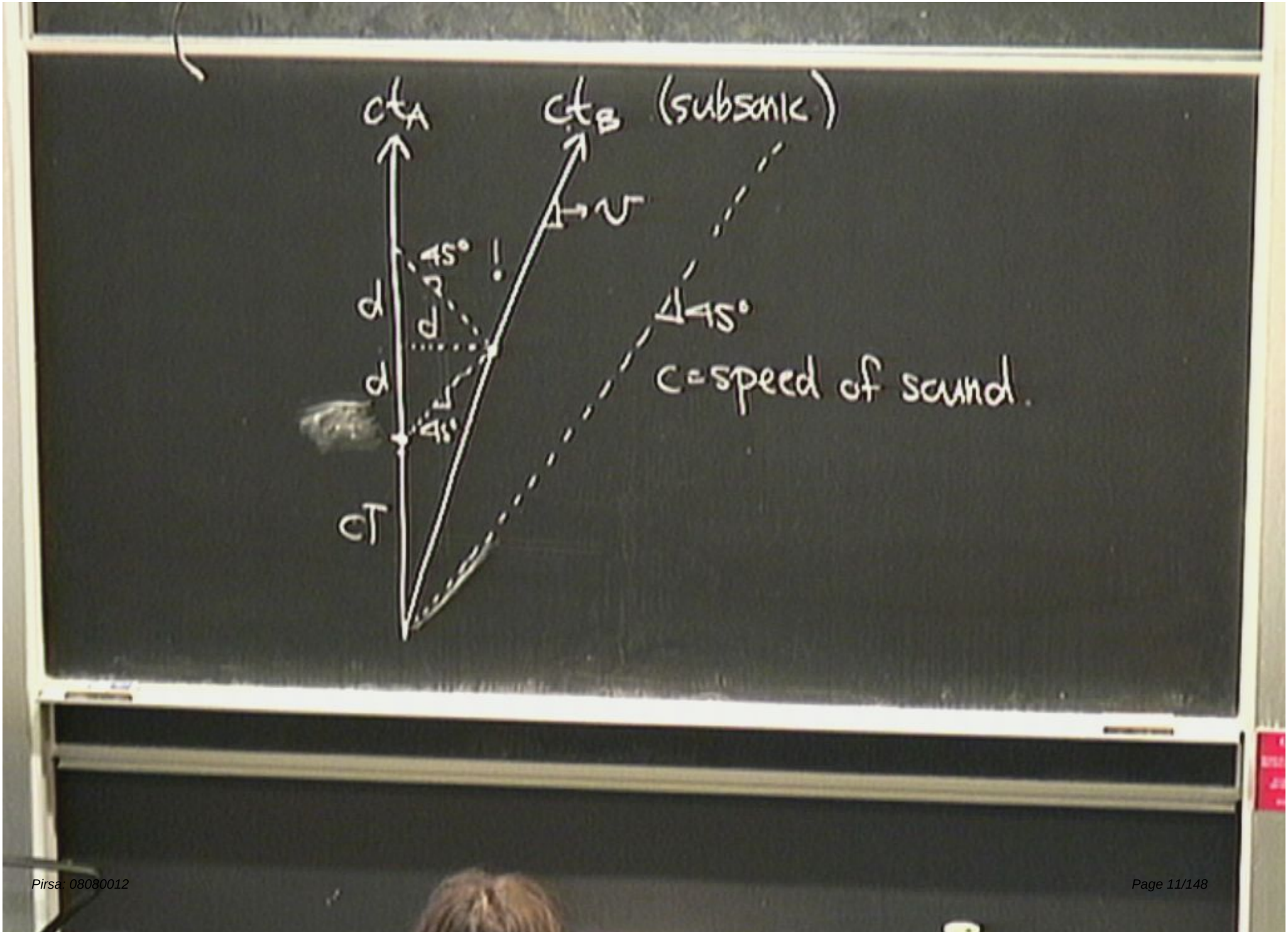

ct_A
ct_B
45°
c=speed of sound.
CT

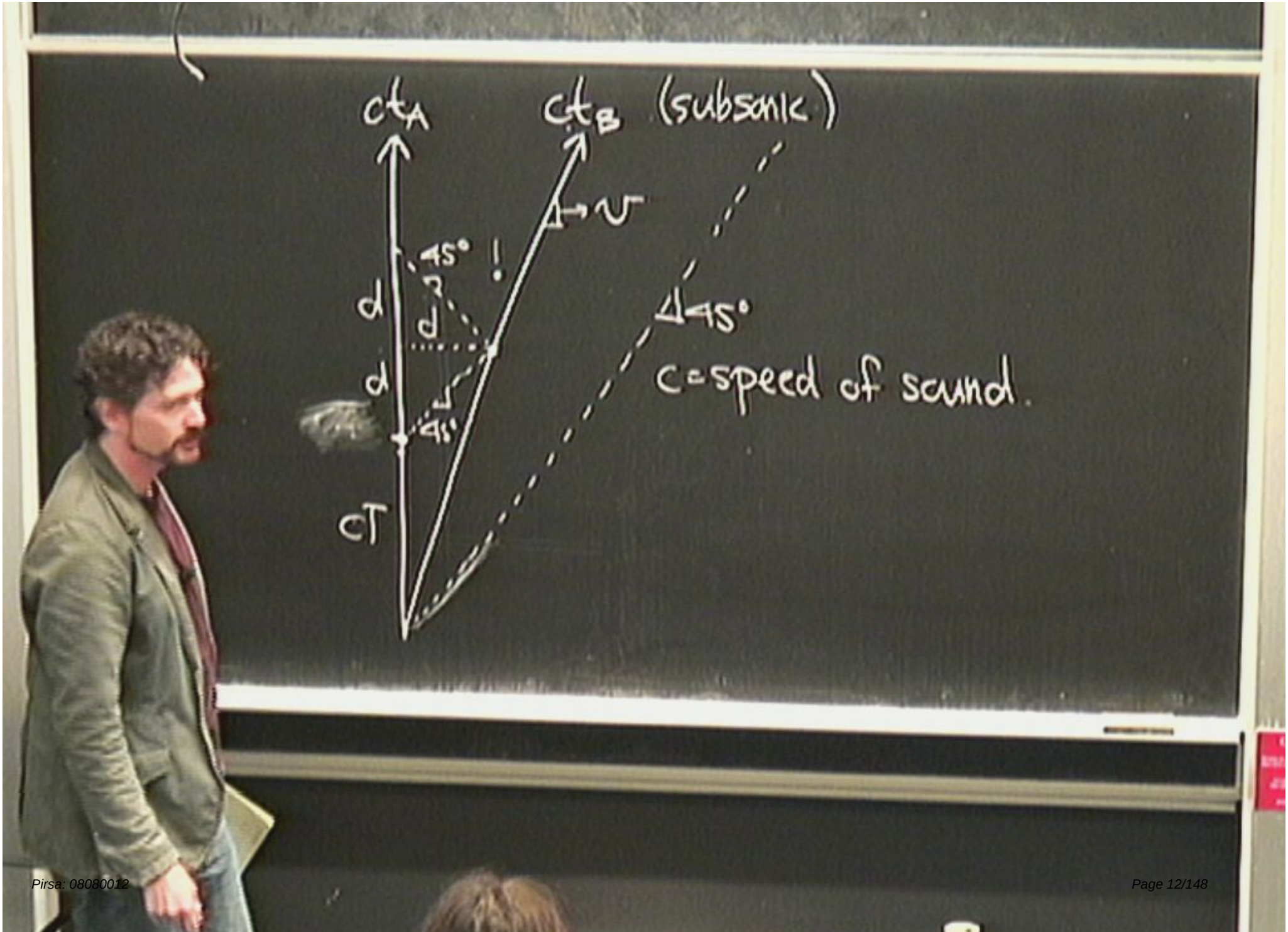

ct_A
ct_B
CT
45°
c=speed of sound.

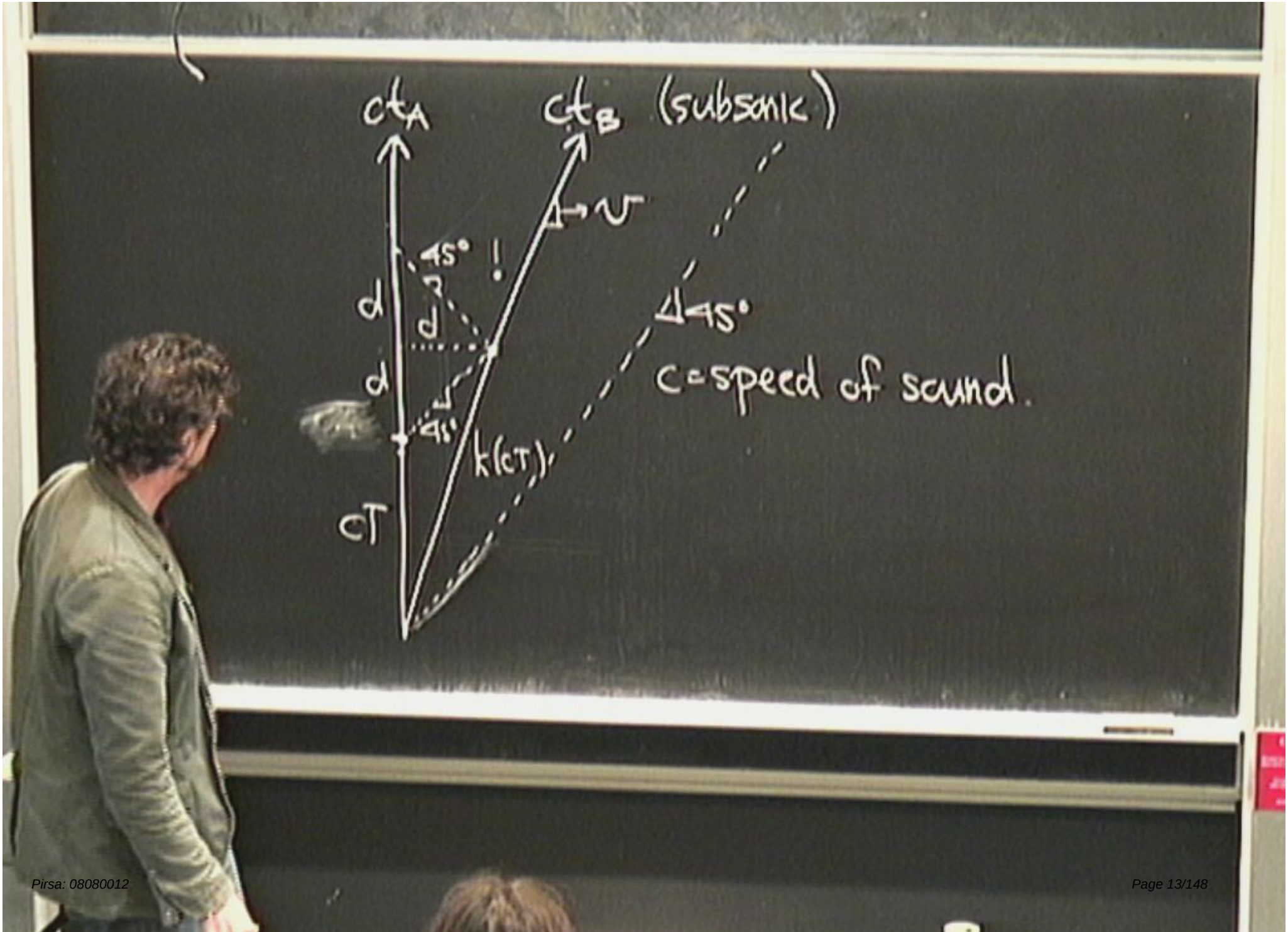

ct_A
ct_B
45°
c=speed of sound.
CT
45°

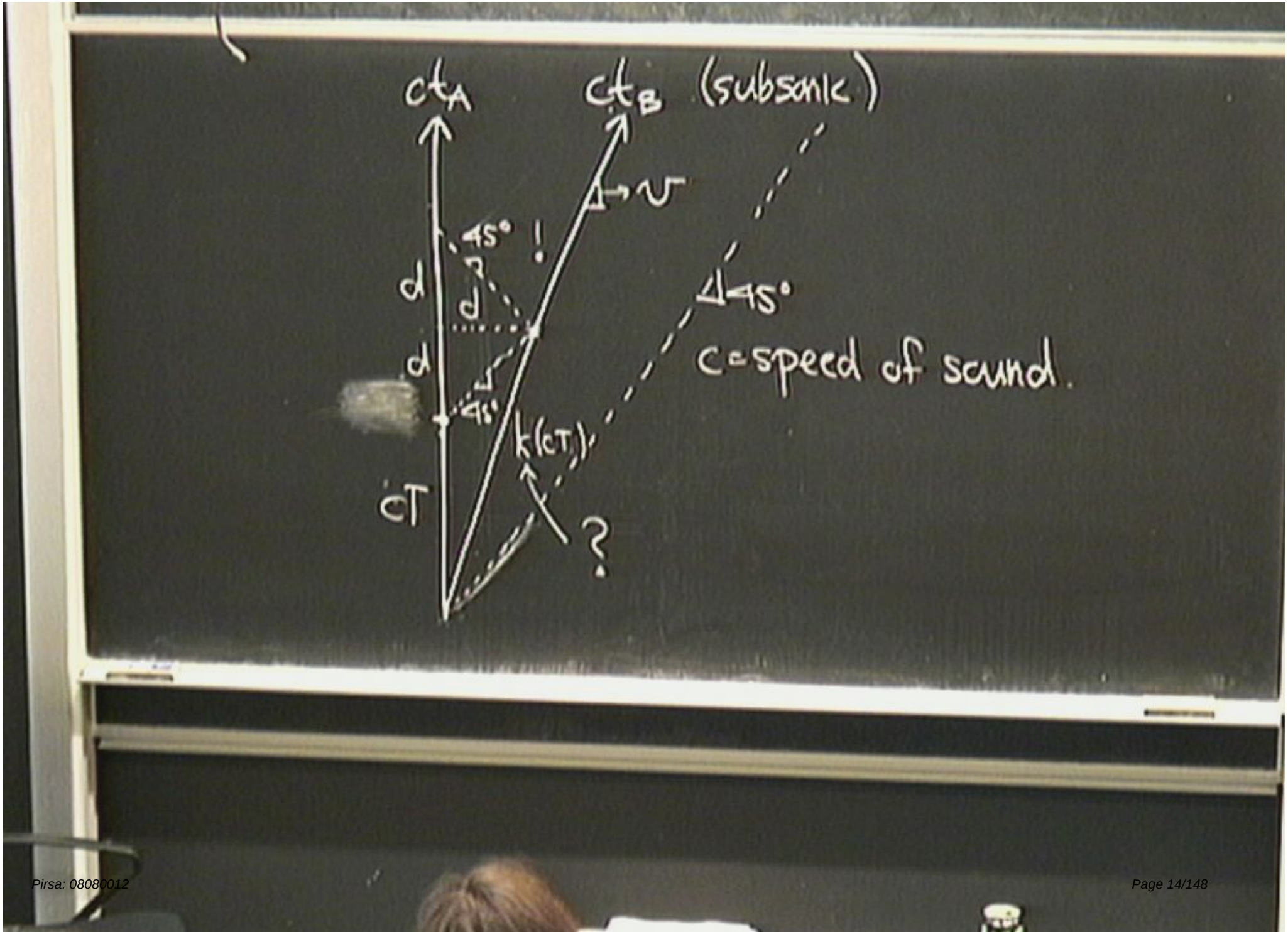

ctA
ctB
45°
!
45°
CT
45°
c=speed of sound.

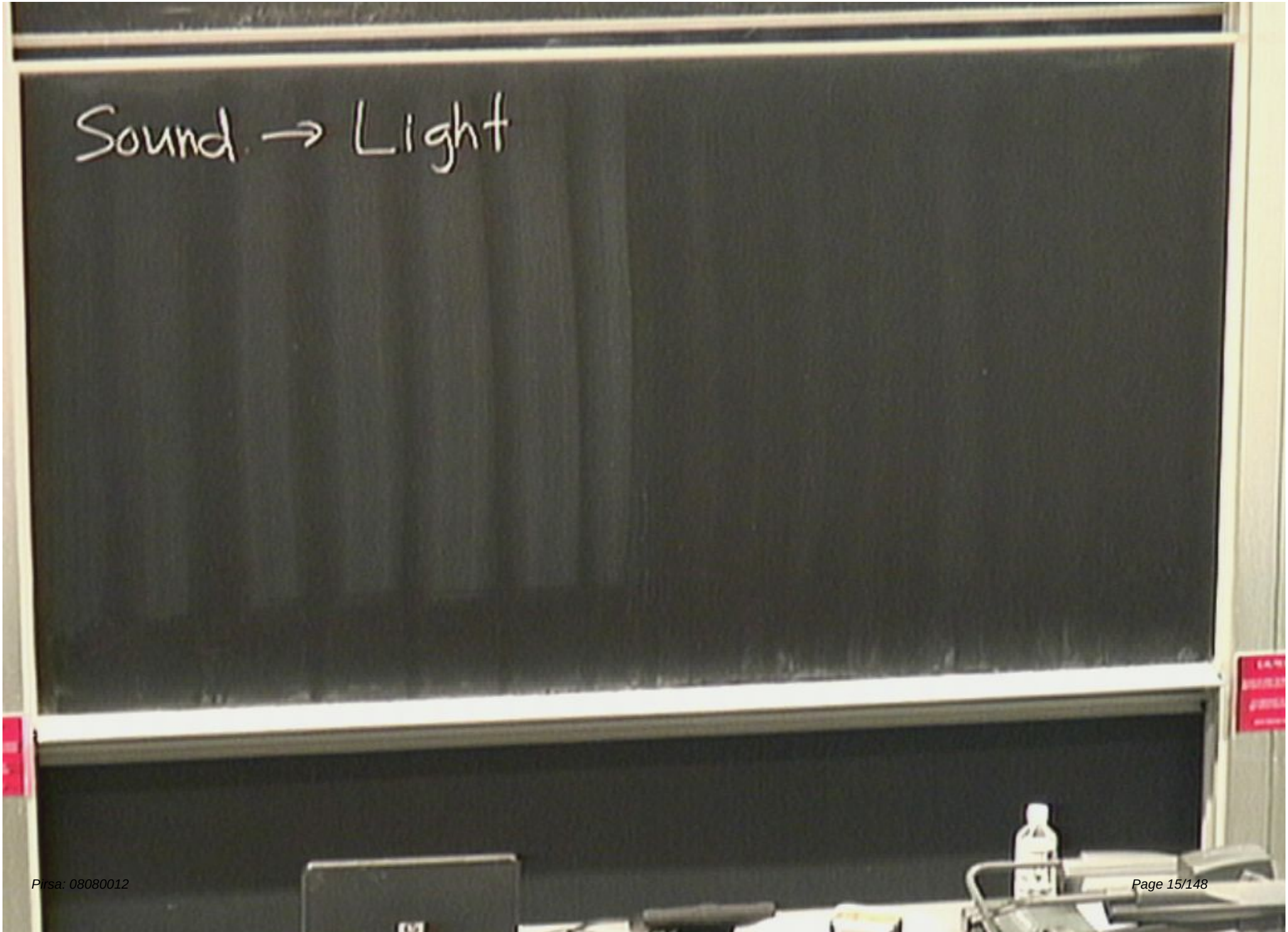

ct_A
ct_B
v
45°
!
d
45°
CT
45°
c=speed of sound.

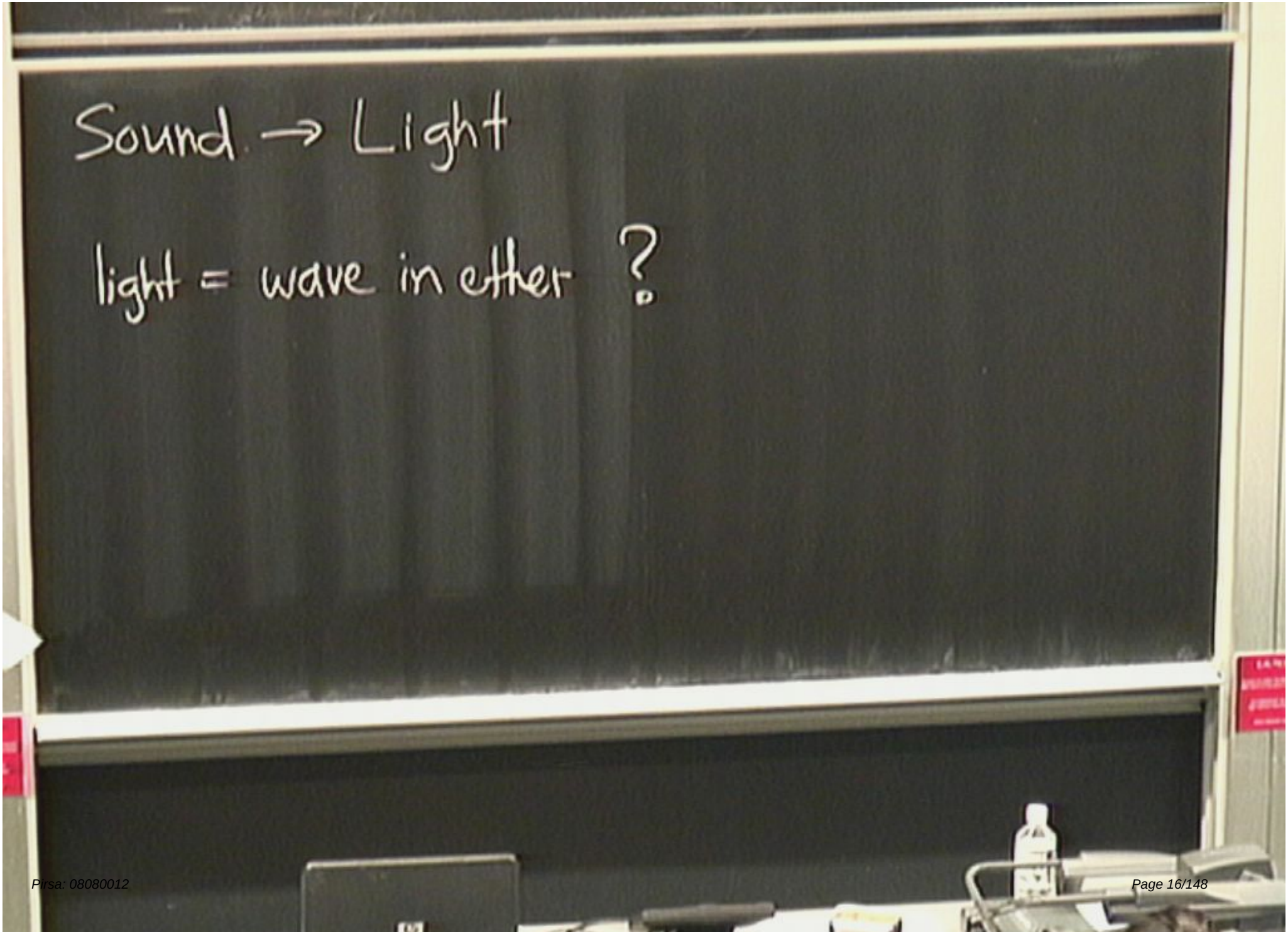

ct_A
ct_B (subsonic)
v
45°
!
d
d
d
45°
ct
Δ < 45°
c = speed of sound.

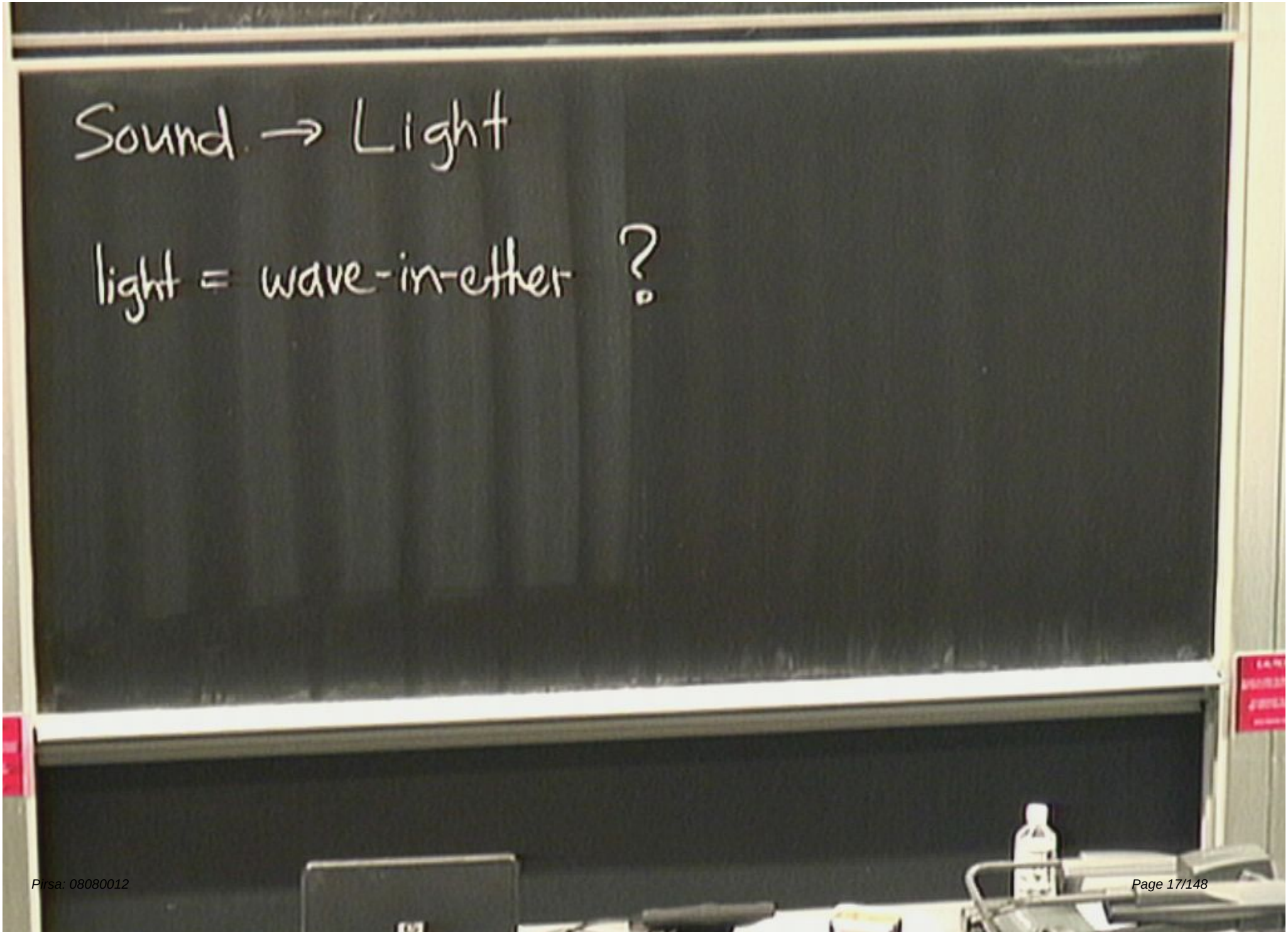

ct_A
ct_B (subsonic)
v
45°
!
d
d
d
45°
CT
∠45°
c=speed of sound.

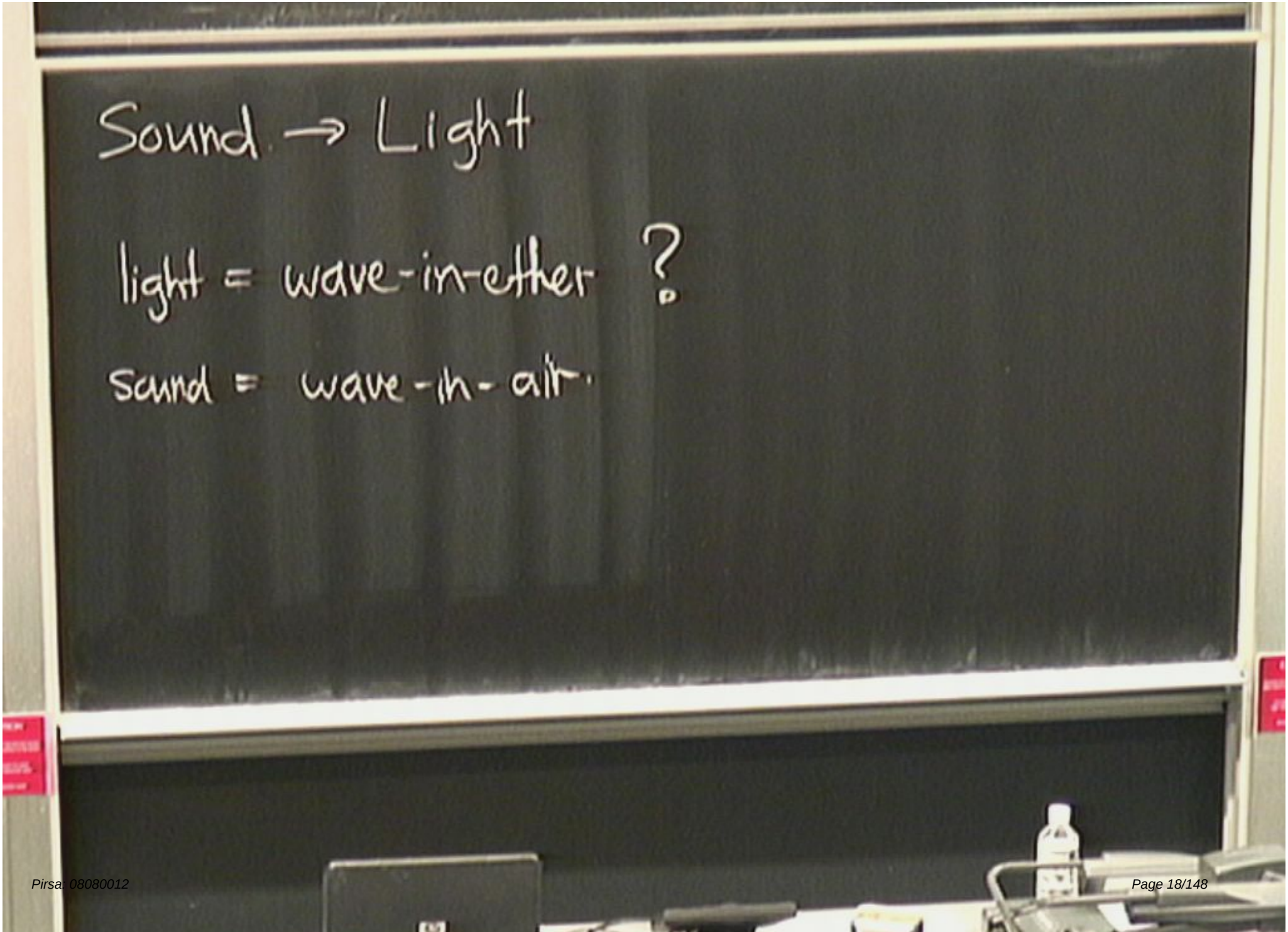

ct_A
ct_B (subsonic)
$\Delta \to v$
45°
!
d
d
d
45°
Δ<45°
c=speed of sound.
v(CT)
CT

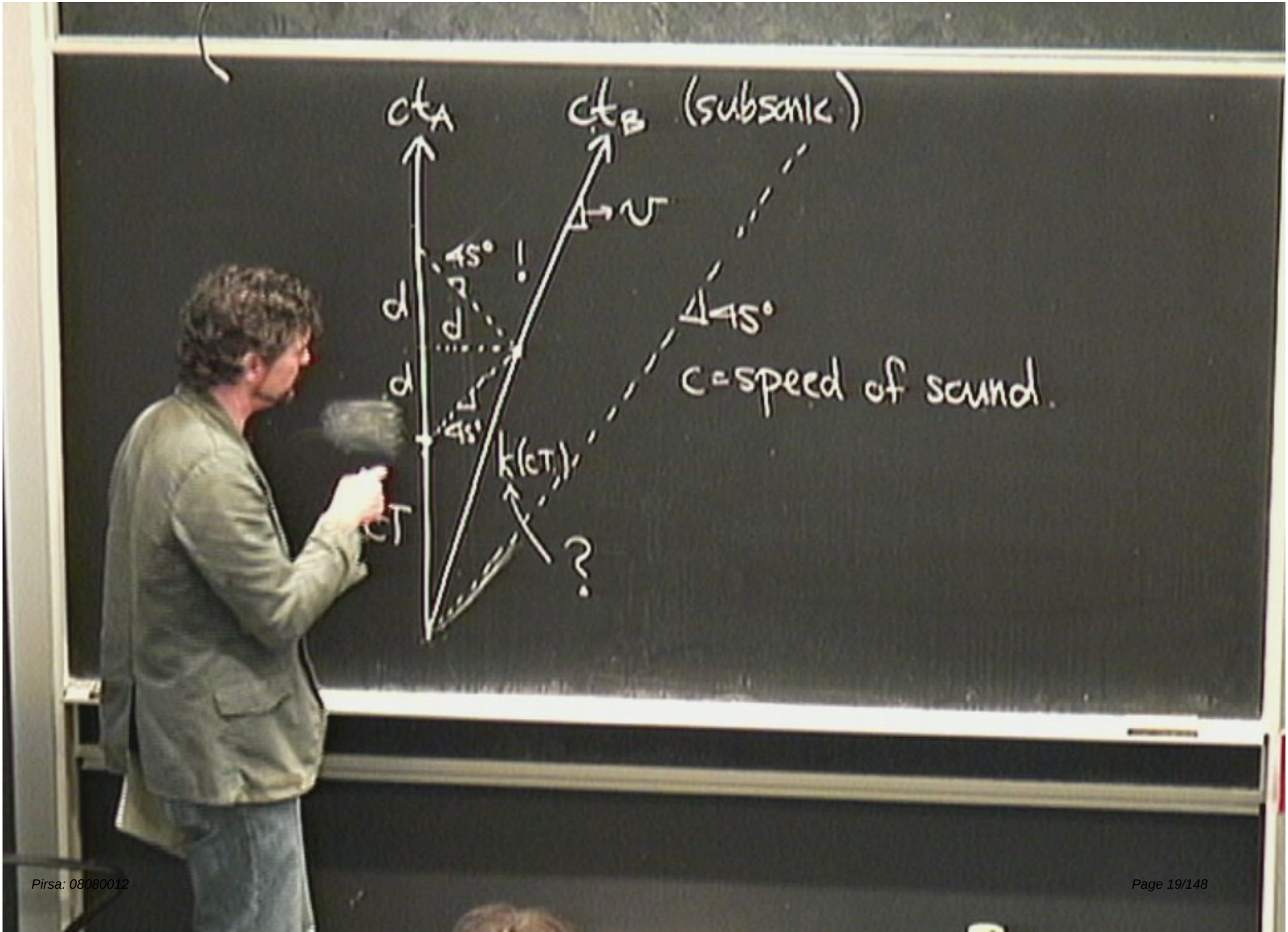

ct_A
ct_B (subsonic)
v
45°
!
d
d
d
45°
$\angle$ 45°
c = speed of sound.
k(cT)
cT
?

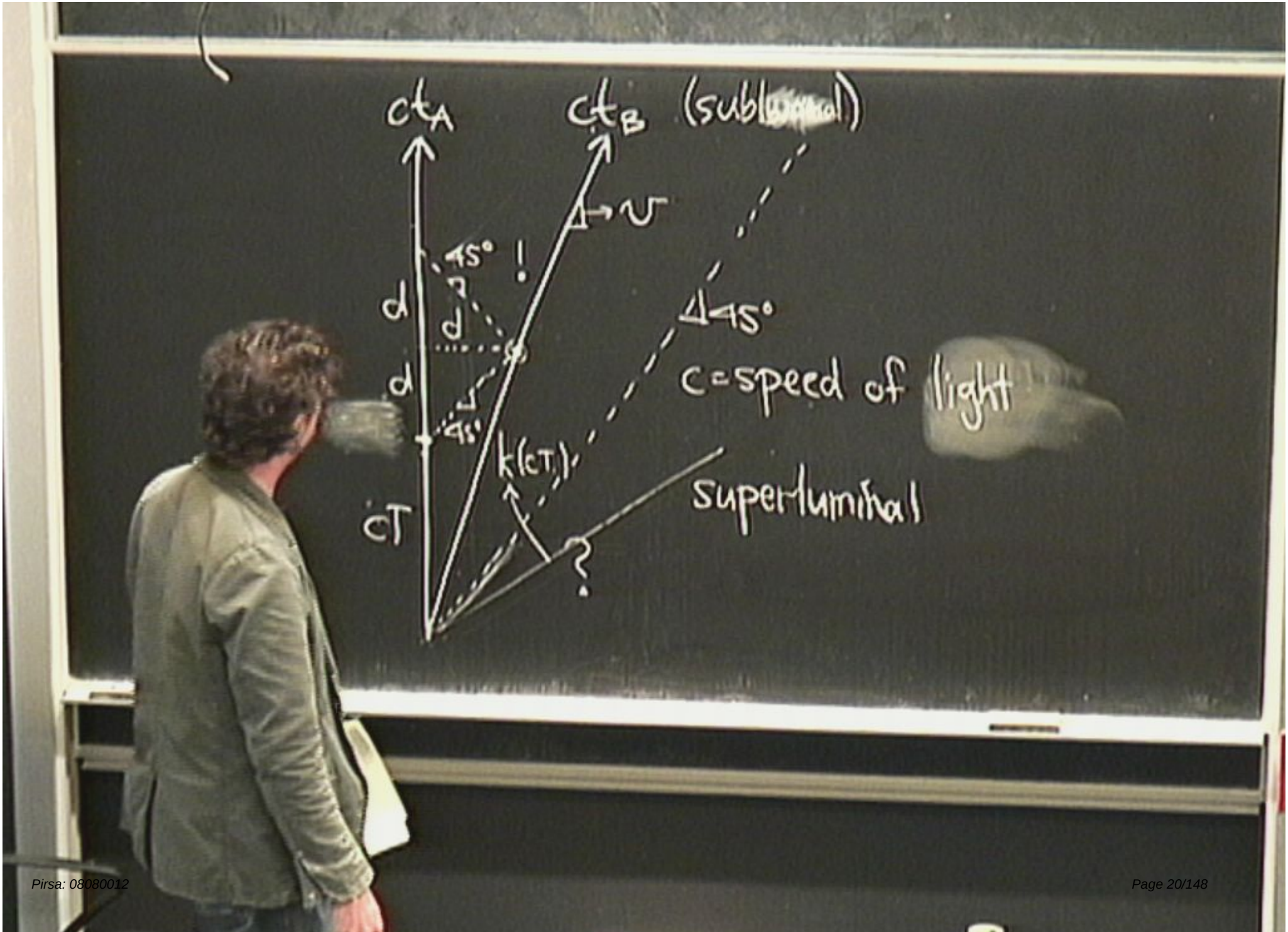

Sound → Light

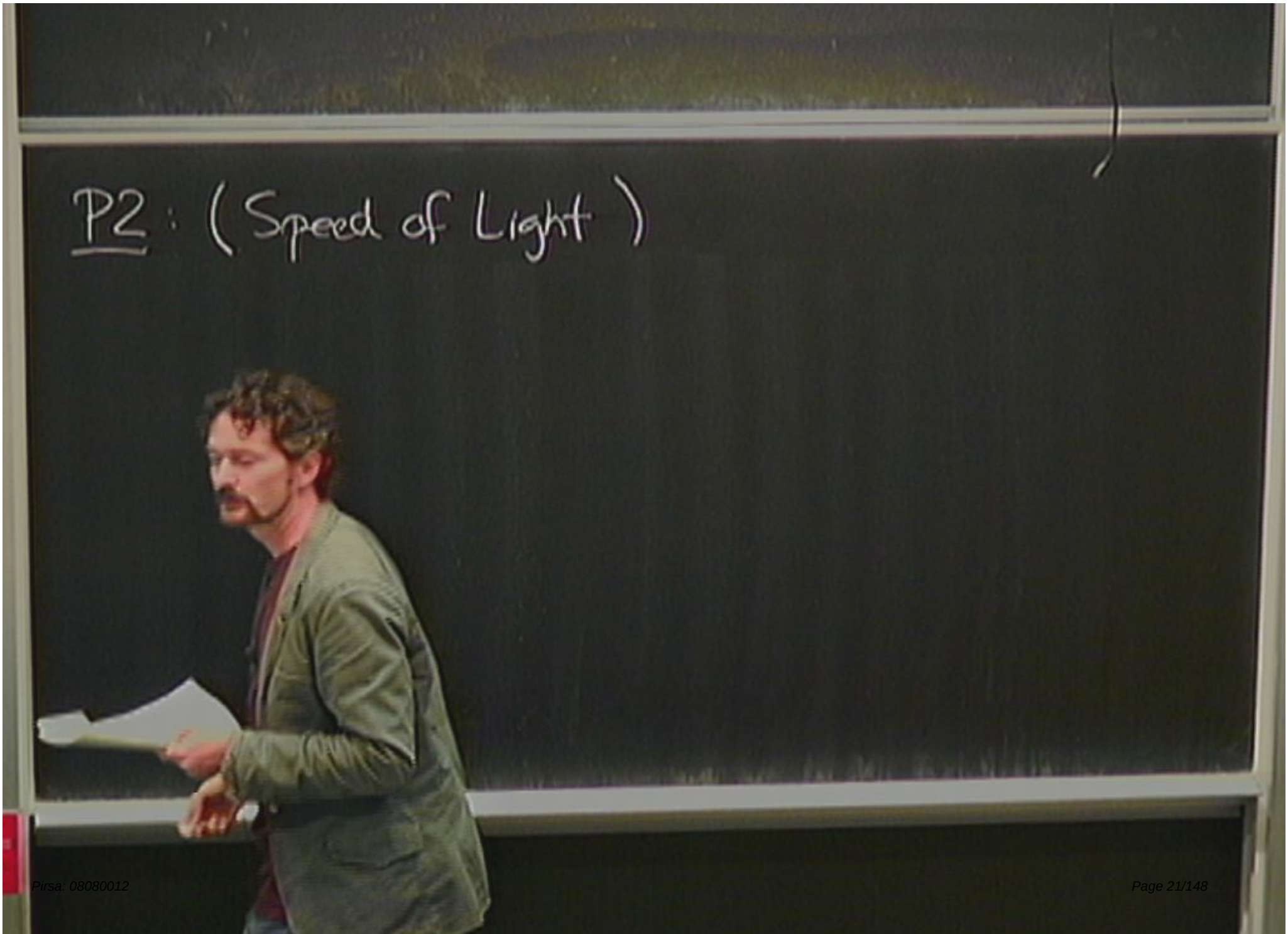

Sound → Light
light = wave in ether ?


Sound → Light
light = wave-in-ether ?


Sound → Light
light = wave-in-ether ?
sound = wave-in-air.


ct_A
ct_B (subsonic)
v
45°
!
d
d
d
45°
45°
c=speed of sound.
$k(cT_1)$
cT
?


ct_A
ct_B
(subluminal)
v
45°
d
d
d
45°
c=speed of light
45°
k(cT)
cT
superluminal
?


P2 : (Speed of Light)

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For an observer "at rest", the speed of light is c, independent of the motion of the source

P2: (Speed of Light)

there exists at least one frame in which this is true.

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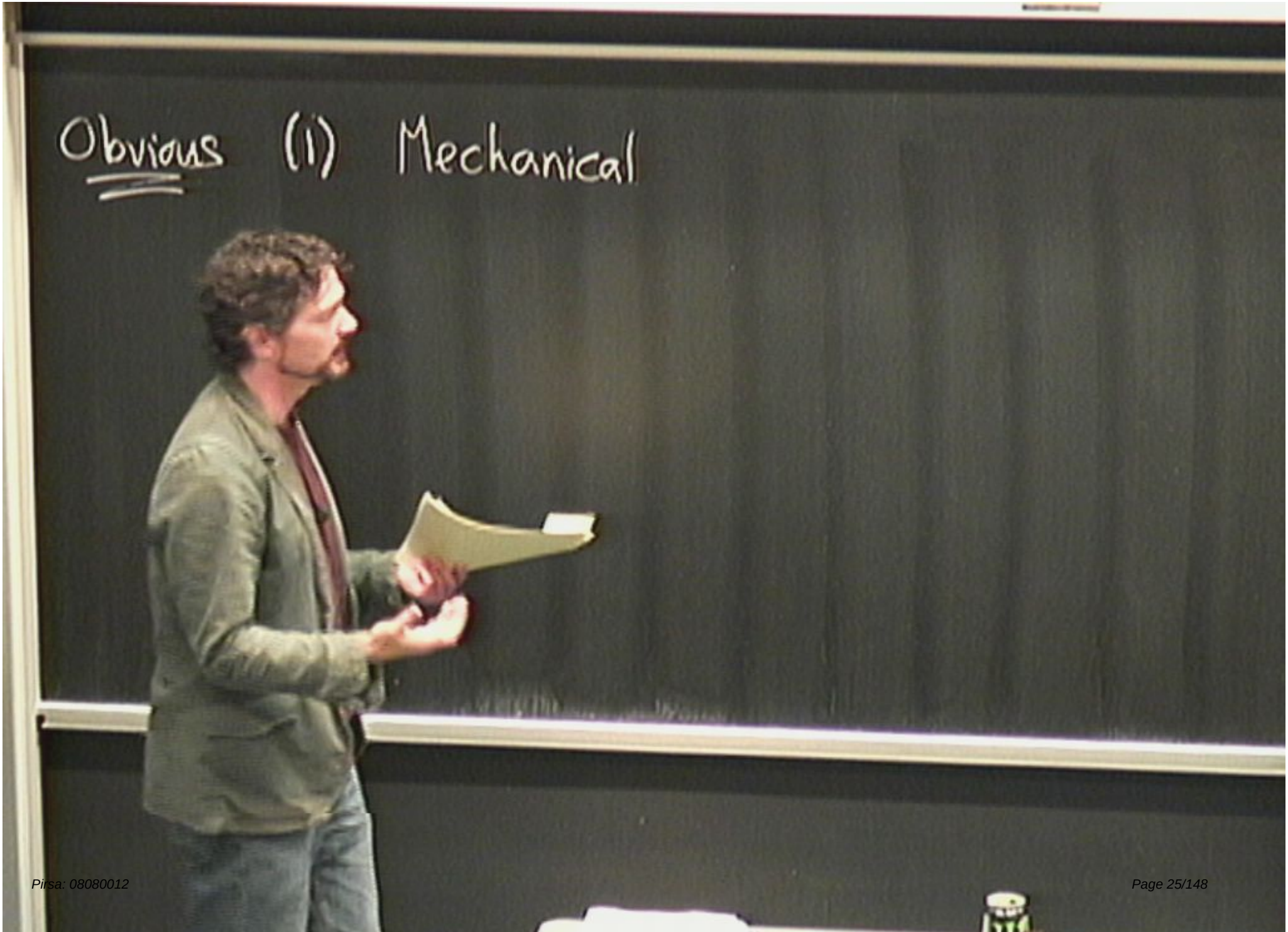
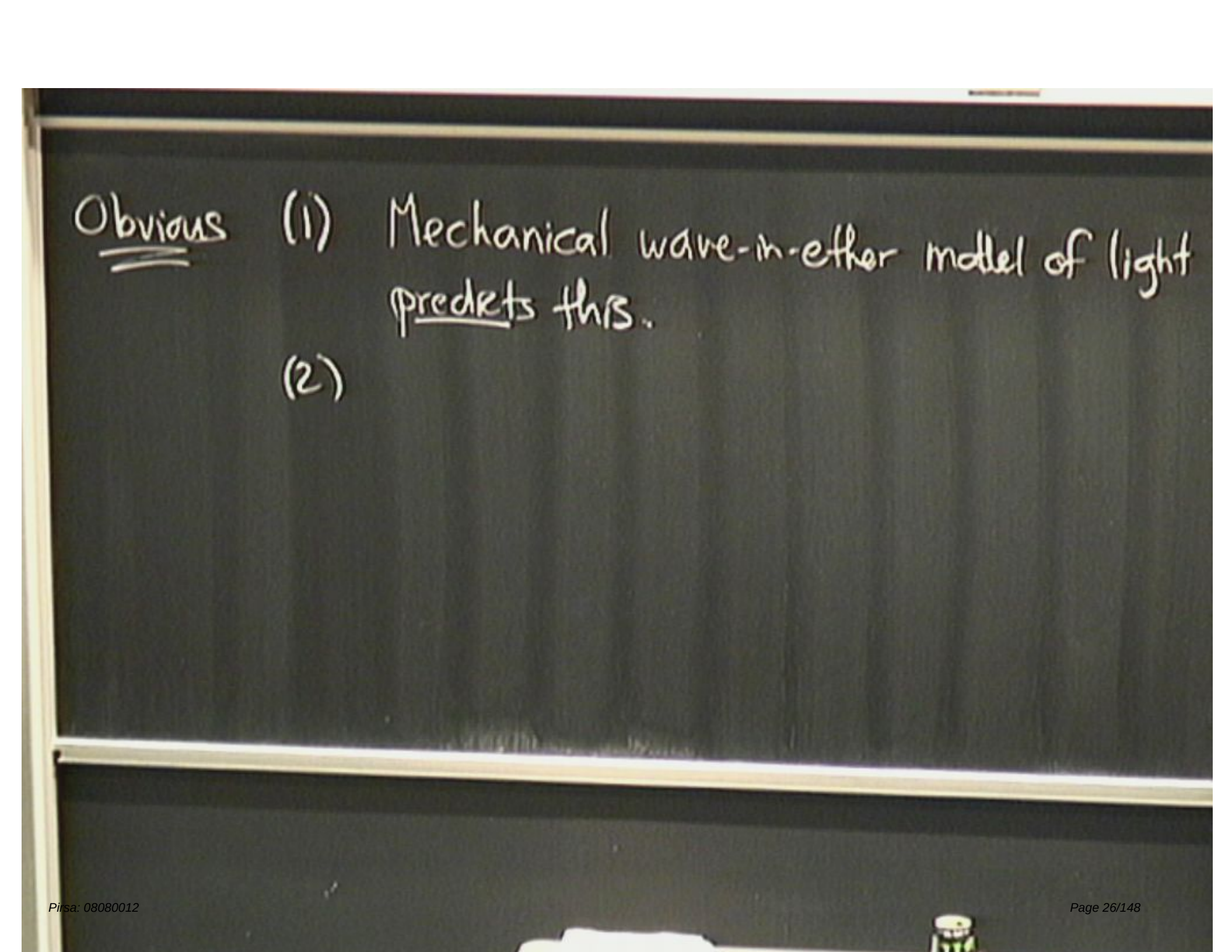
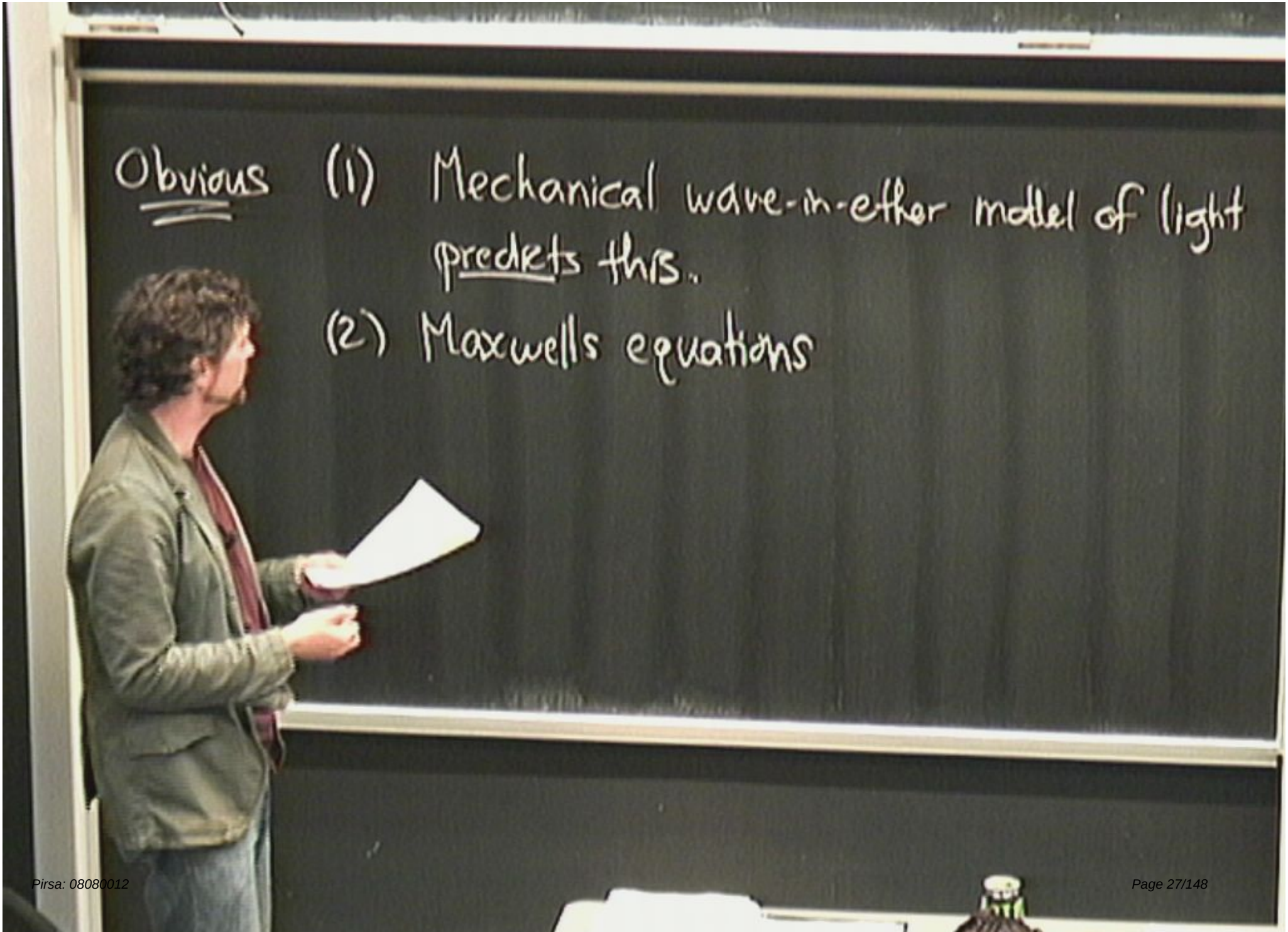

Obvious (1) Mechanical

Obvious (1) Mechanical wave-in-ether model of light predicts this.

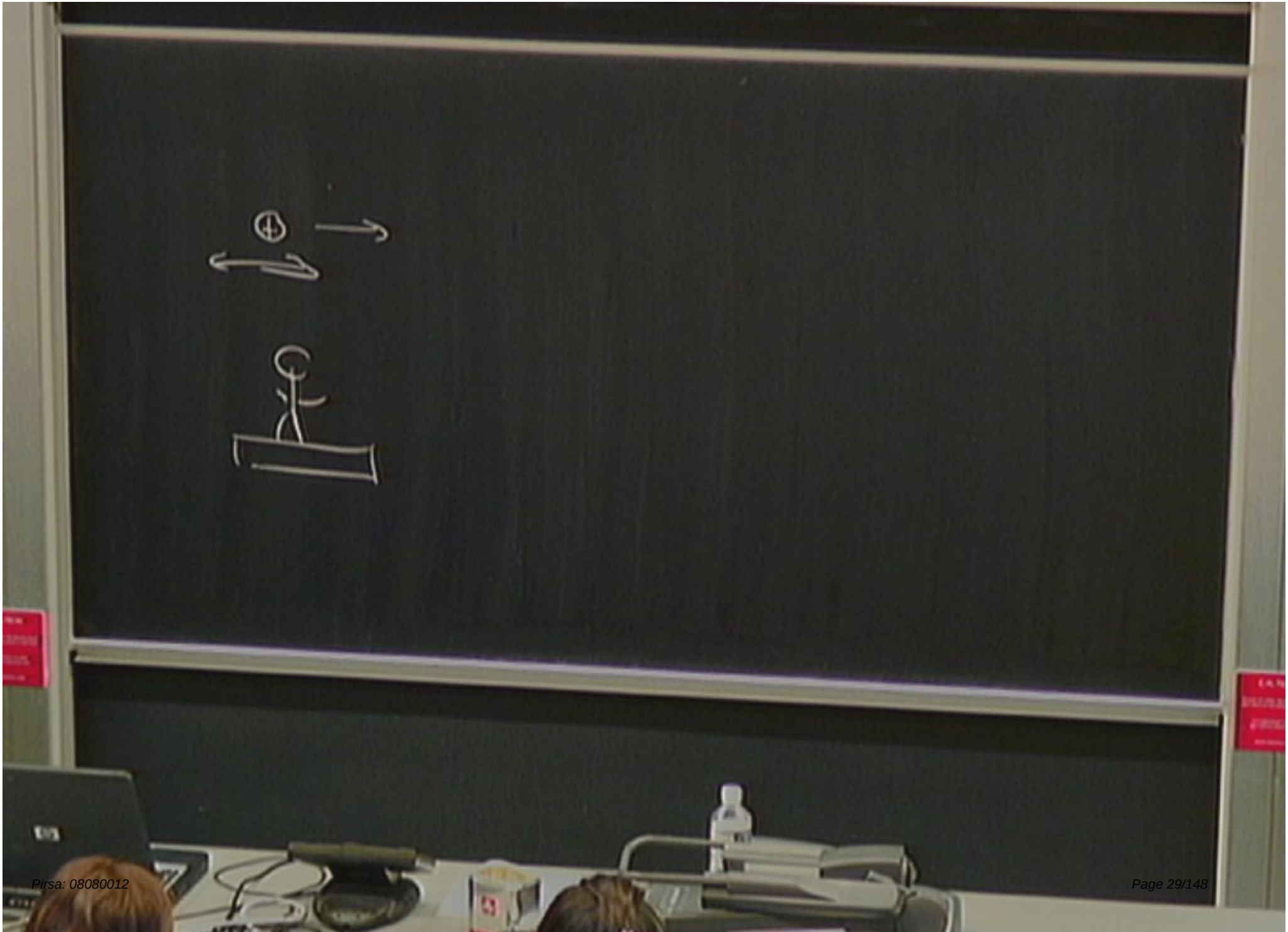
(2)

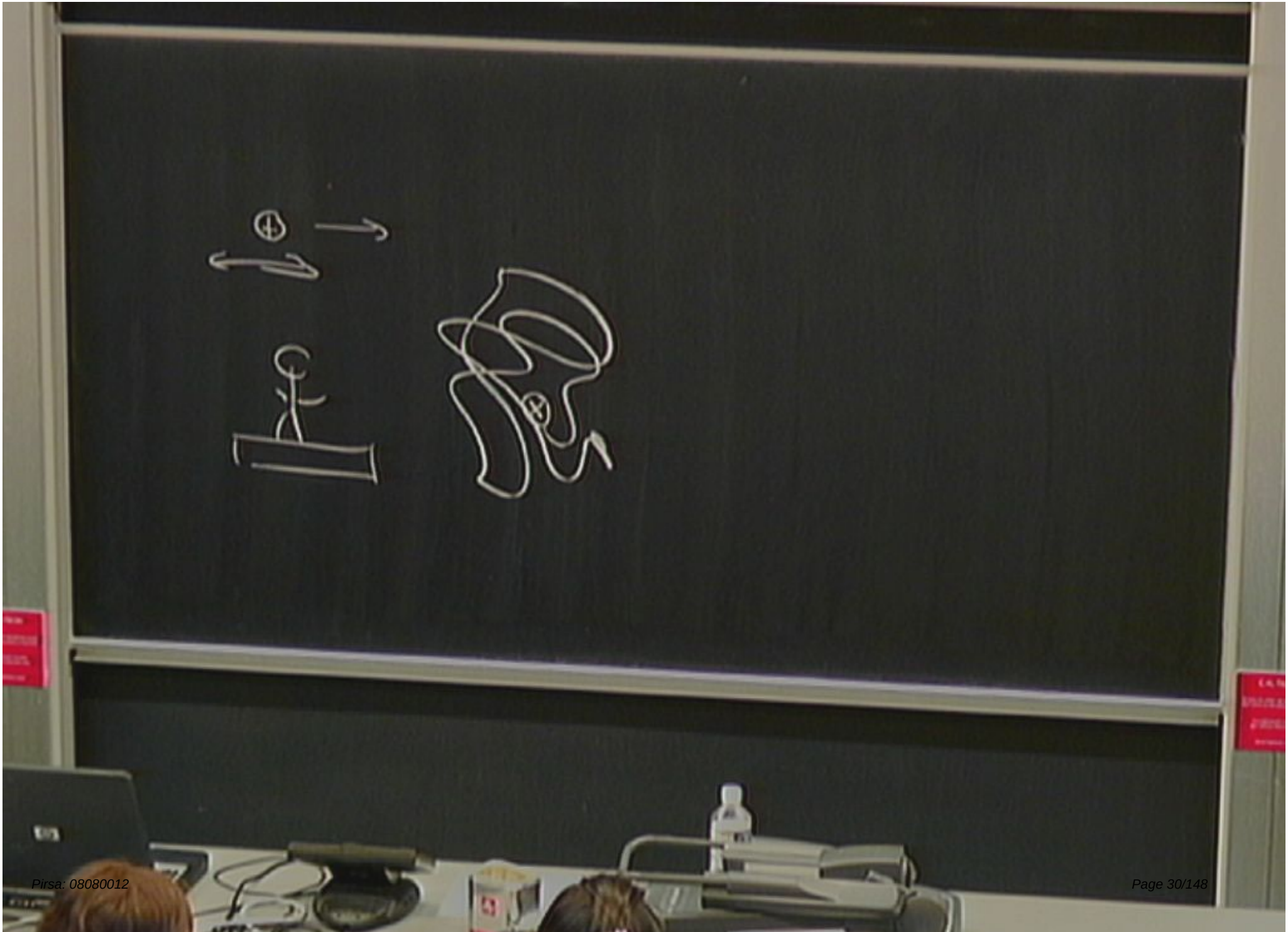


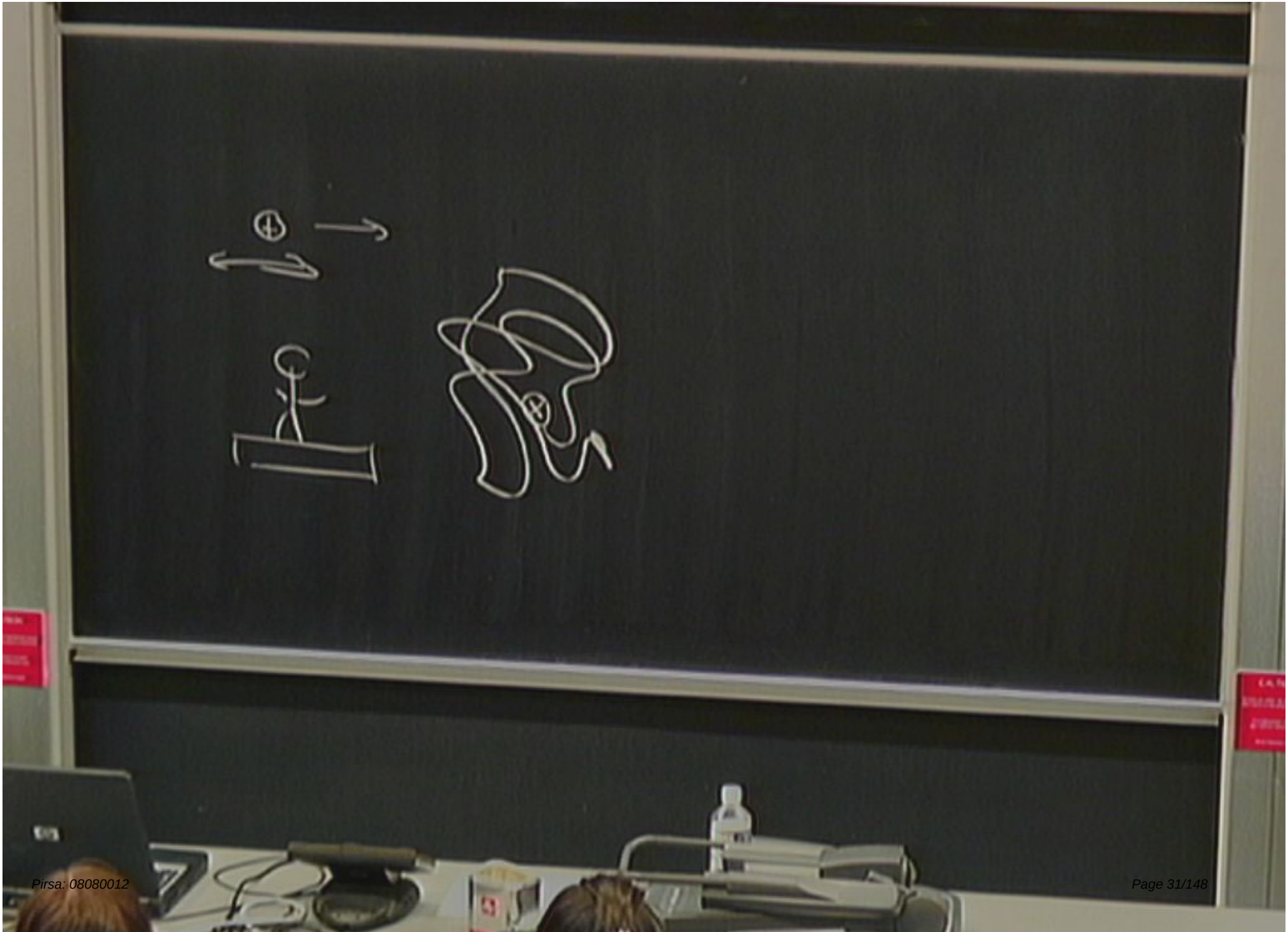

Obvious (1) Mechanical wave-in-ether model of light predicts this.
(2) Maxwells equations

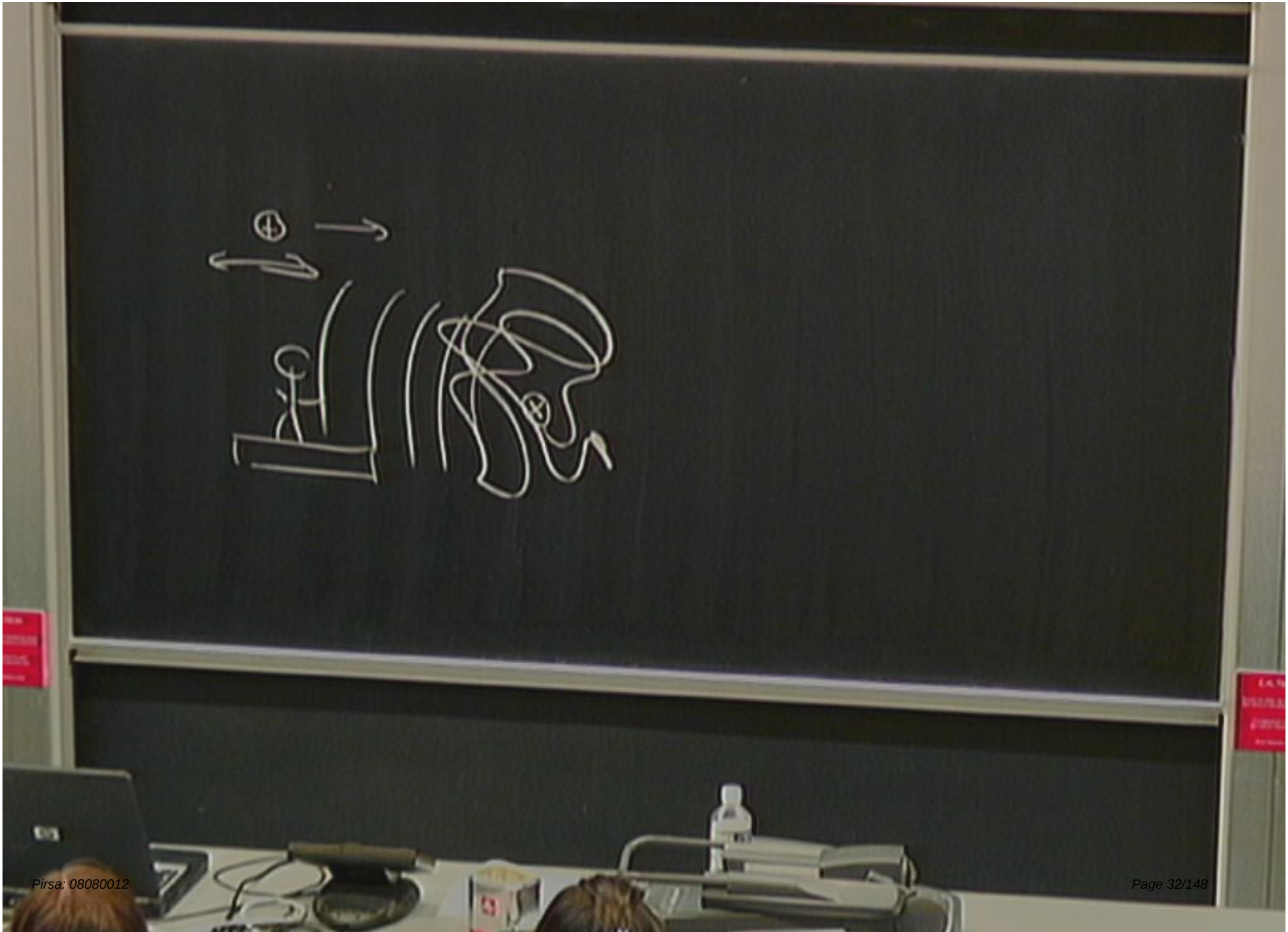
Obvious (1) Mechanical wave-in-ether model of light predicts thrs.

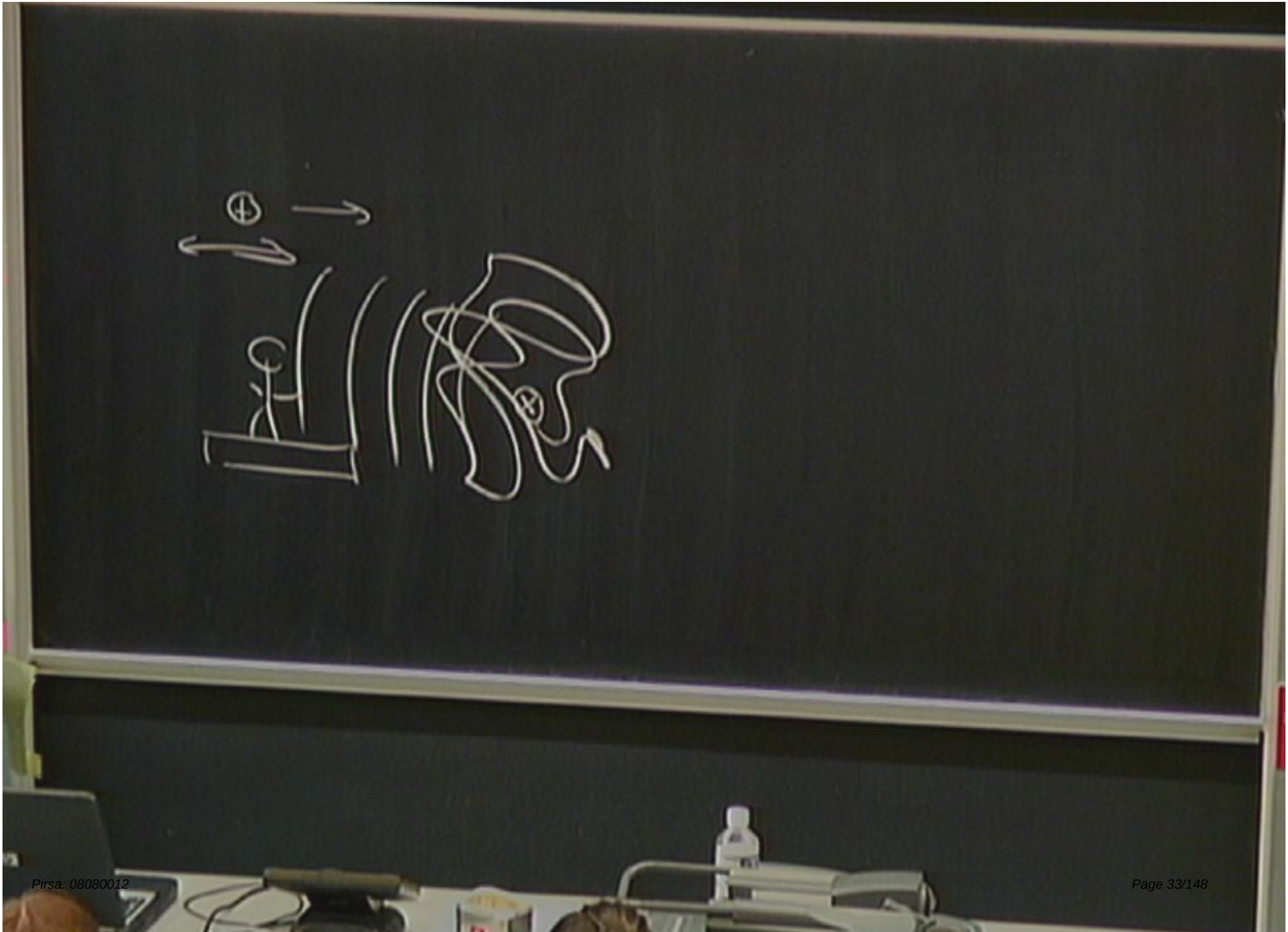
(2) Maxwells equations predict thr?

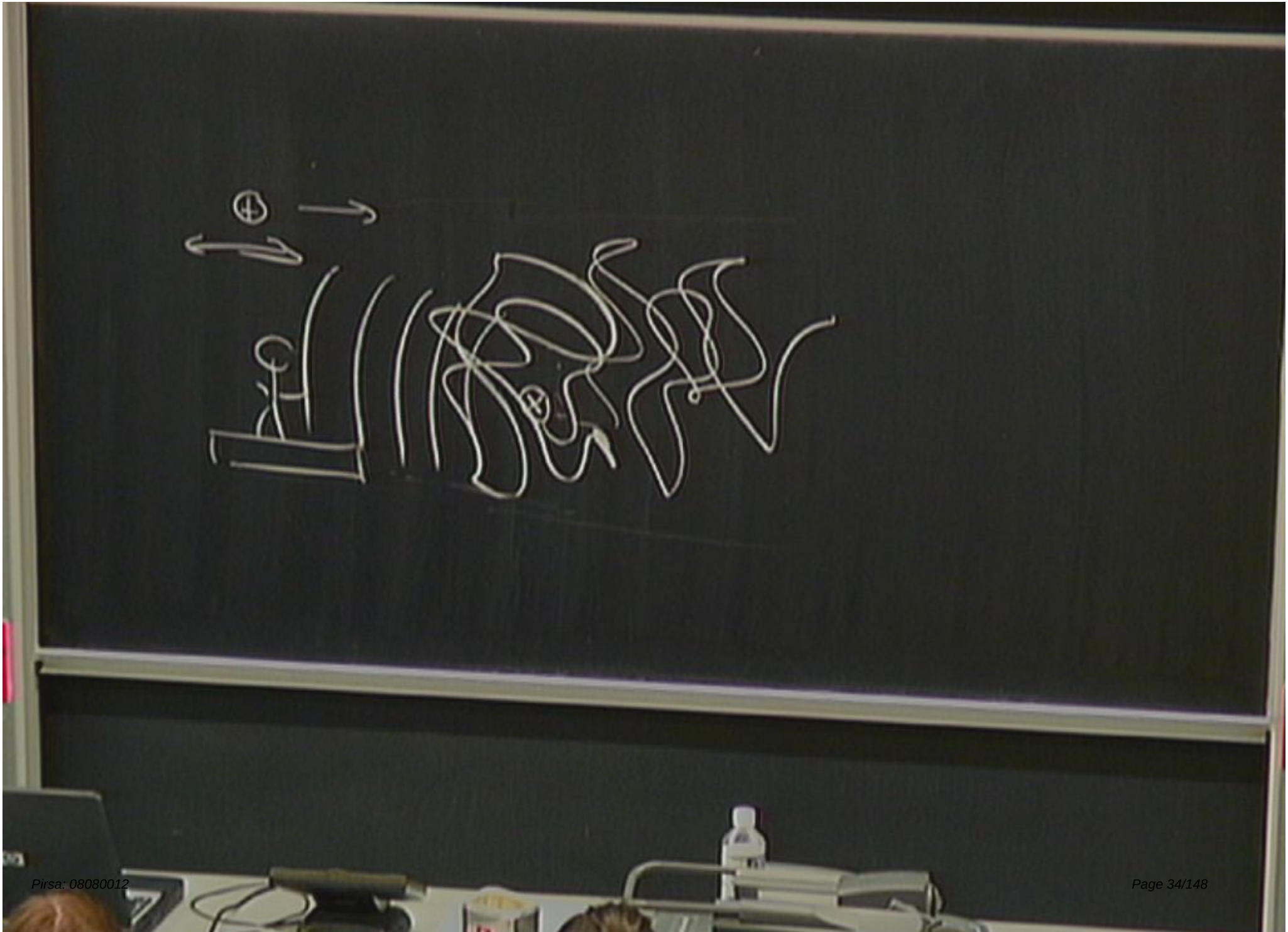


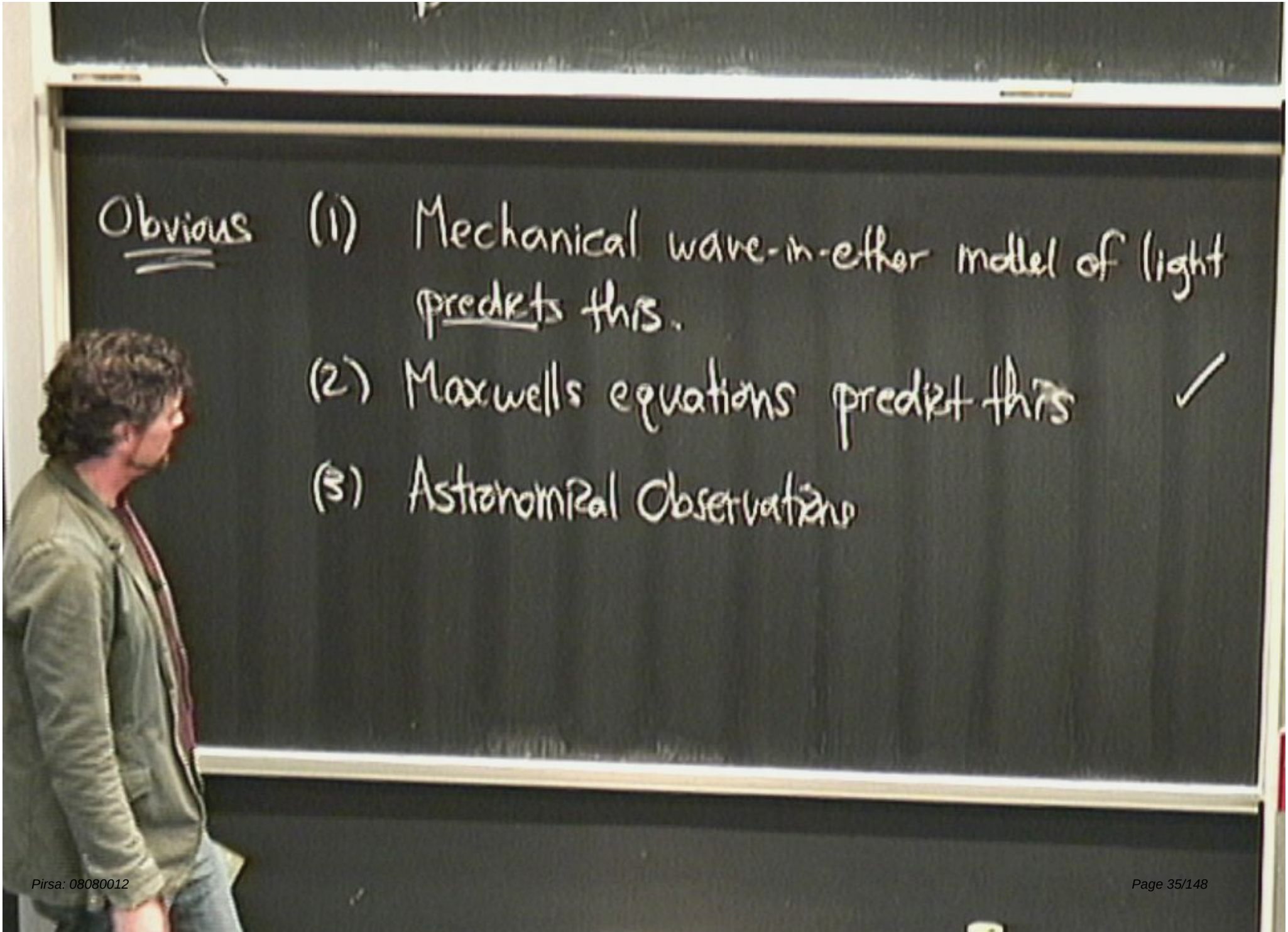











Obvious
(1) Mechanical wave-in-ether model of light predicts this.
(2) Maxwells equations predict this ✓
(3) Astronomical Observations

P2: (Speed of Light)

there exists at least one frame in which this is true.

For an observer "at rest", the speed of light is c, independent of the motion of the source

P2': (Einstein did not say):

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..... source

P2: (Speed of Light)

there exists at least one frame in which this is true.

For an observer "at rest", the speed of light is c, independent of the motion of the source

P2′: (Einstein did not say):

..... source

_ _ . _ _ _ _ _ _ _ _ _ _ . observer

P2: (Speed of Light)

there exists at least one frame in which this is true.

For an observer "at rest", the speed of light is c, independent of the motion of the source

P2': (Einstein did not say):

..... source

- - . - - - - - - - - - - observer

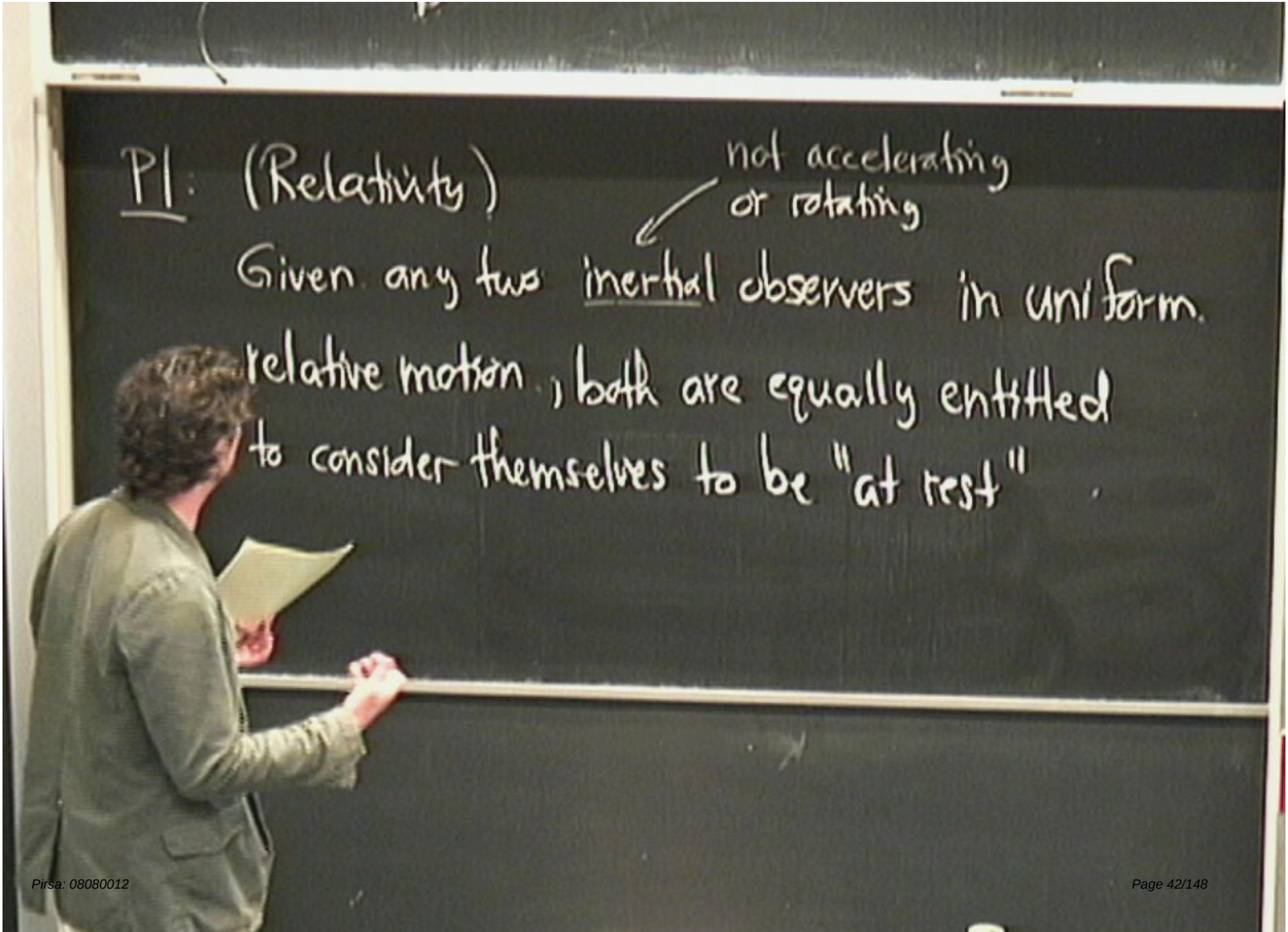
P1: (Relativity)

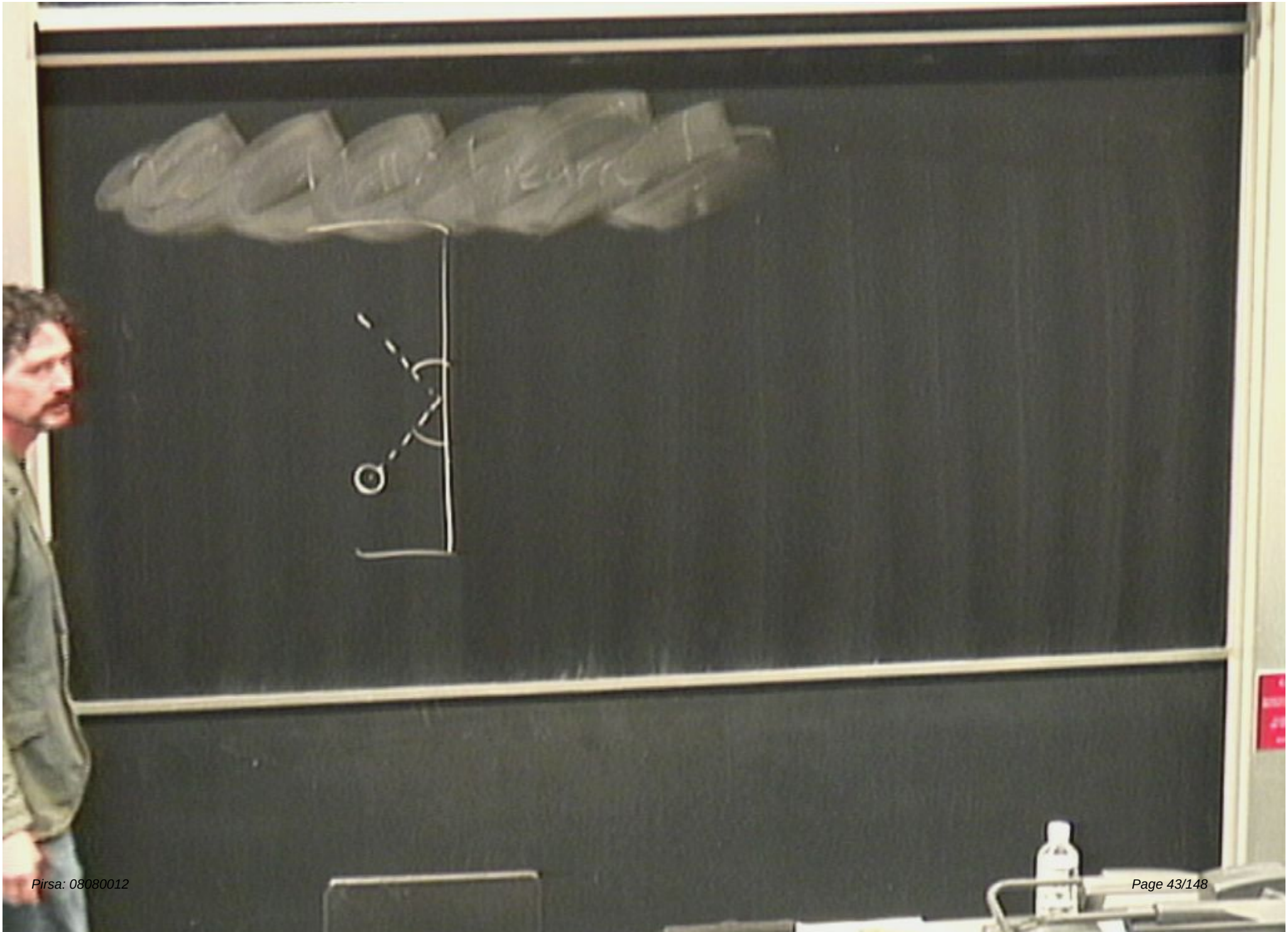
Given any two inertial observers in uniform relative motion, both are equally entitled to consider themselves to be "at rest".

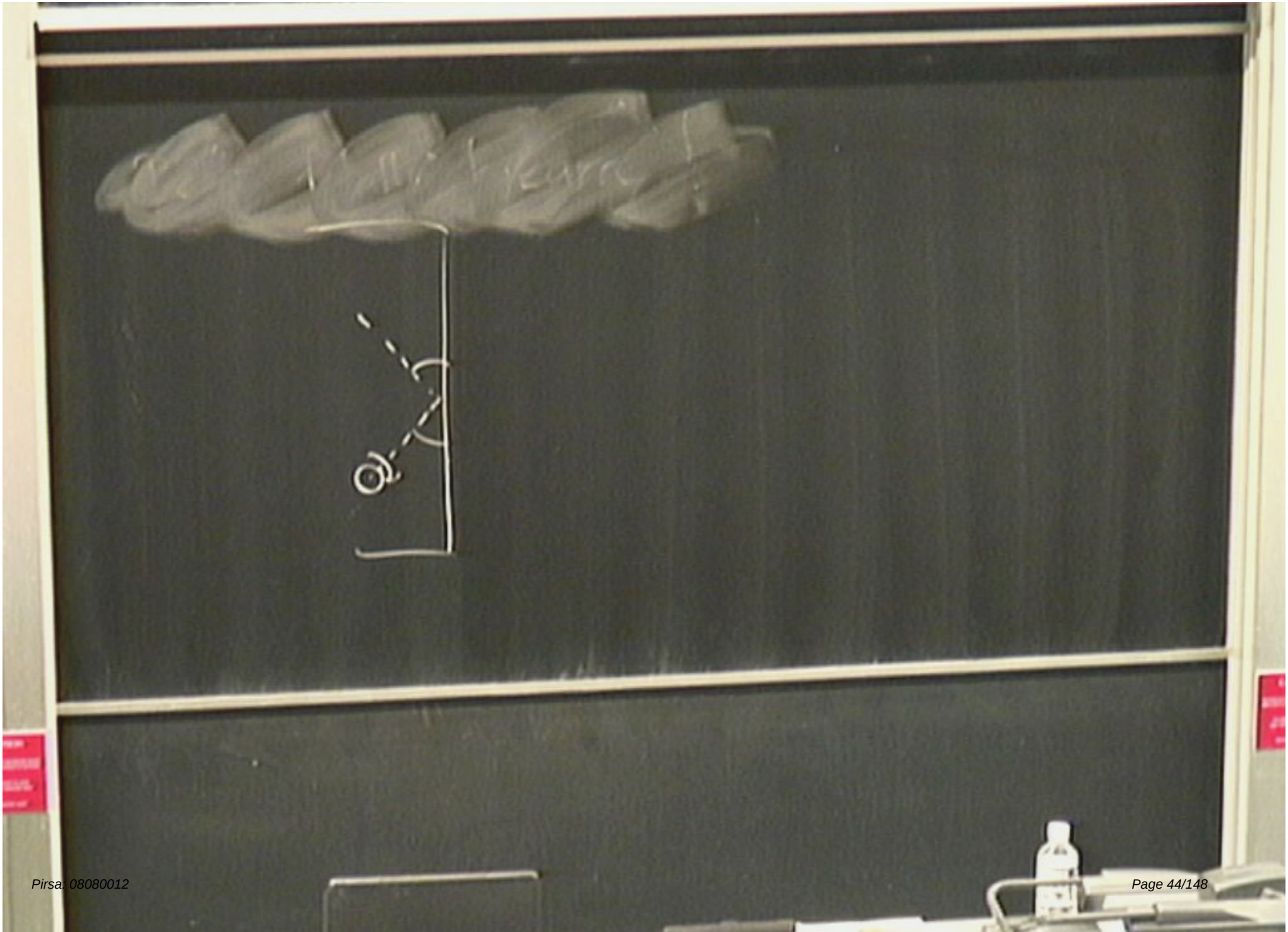
P1: (Relativity)

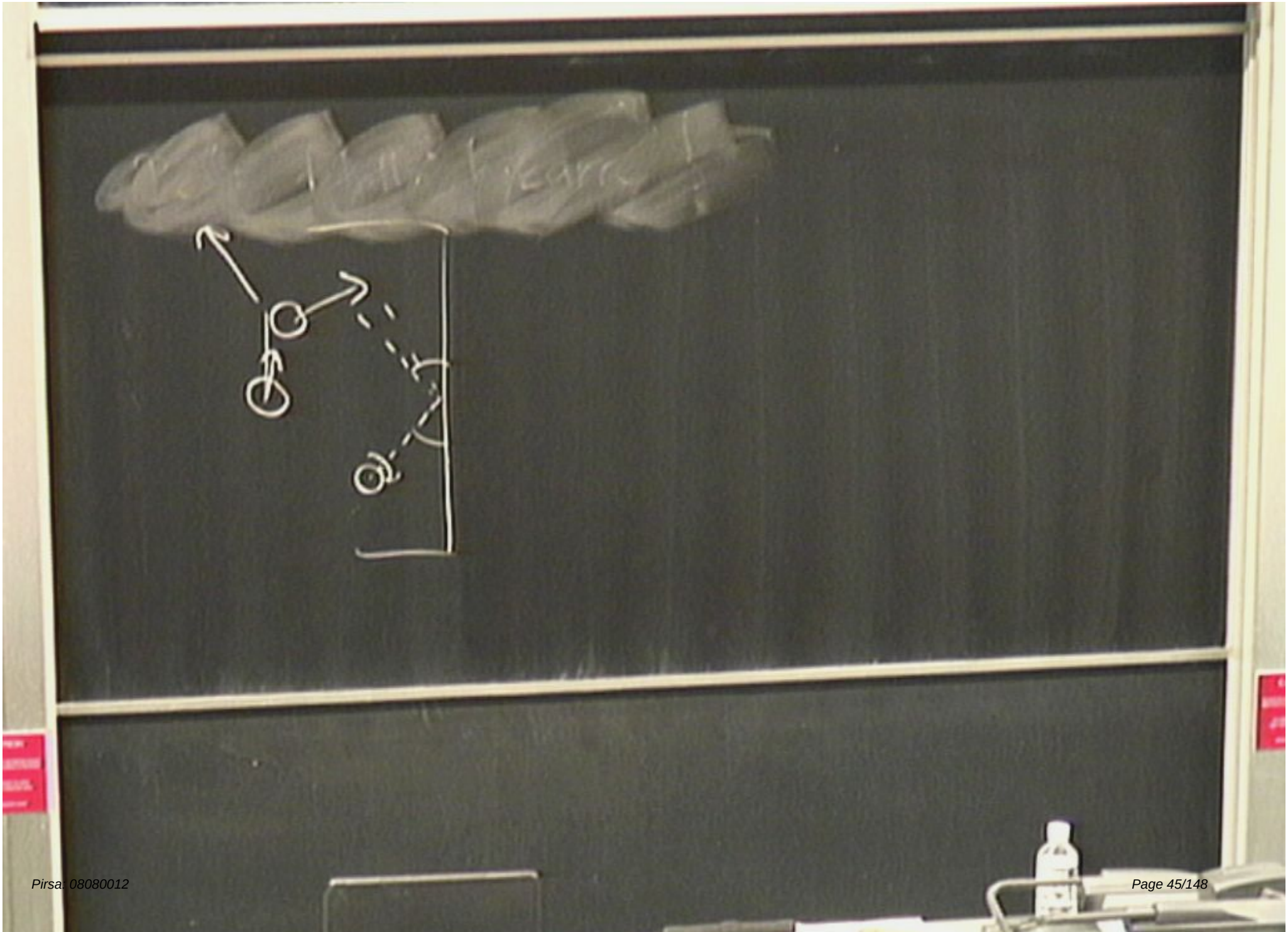
not accelerating or rotating

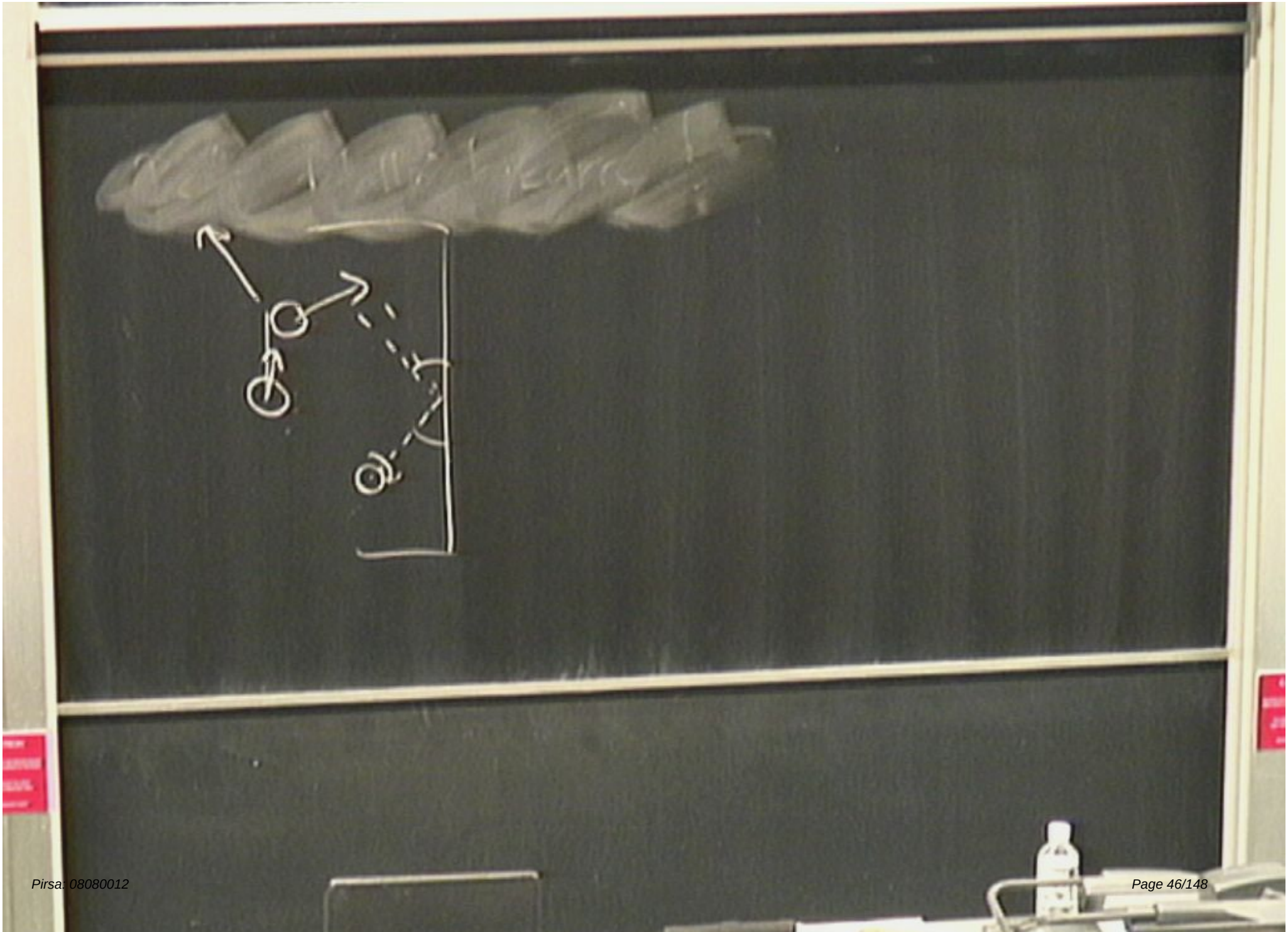
Given any two inertial observers in uniform relative motion, both are equally entitled to consider themselves to be "at rest".

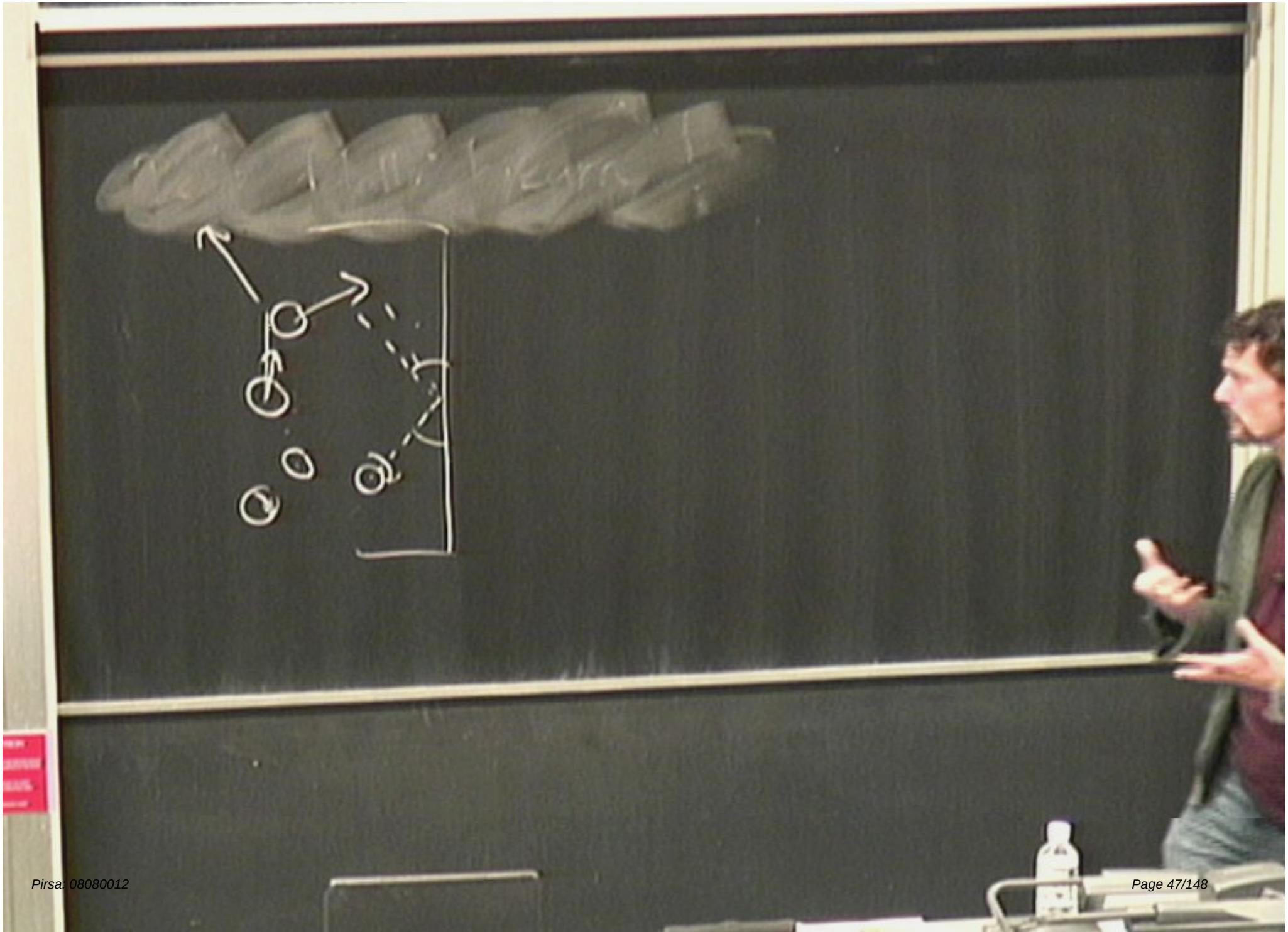

P1: (Relativity)
not accelerating or rotating
Given any two inertial observers in uniform relative motion, both are equally entitled to consider themselves to be "at rest".

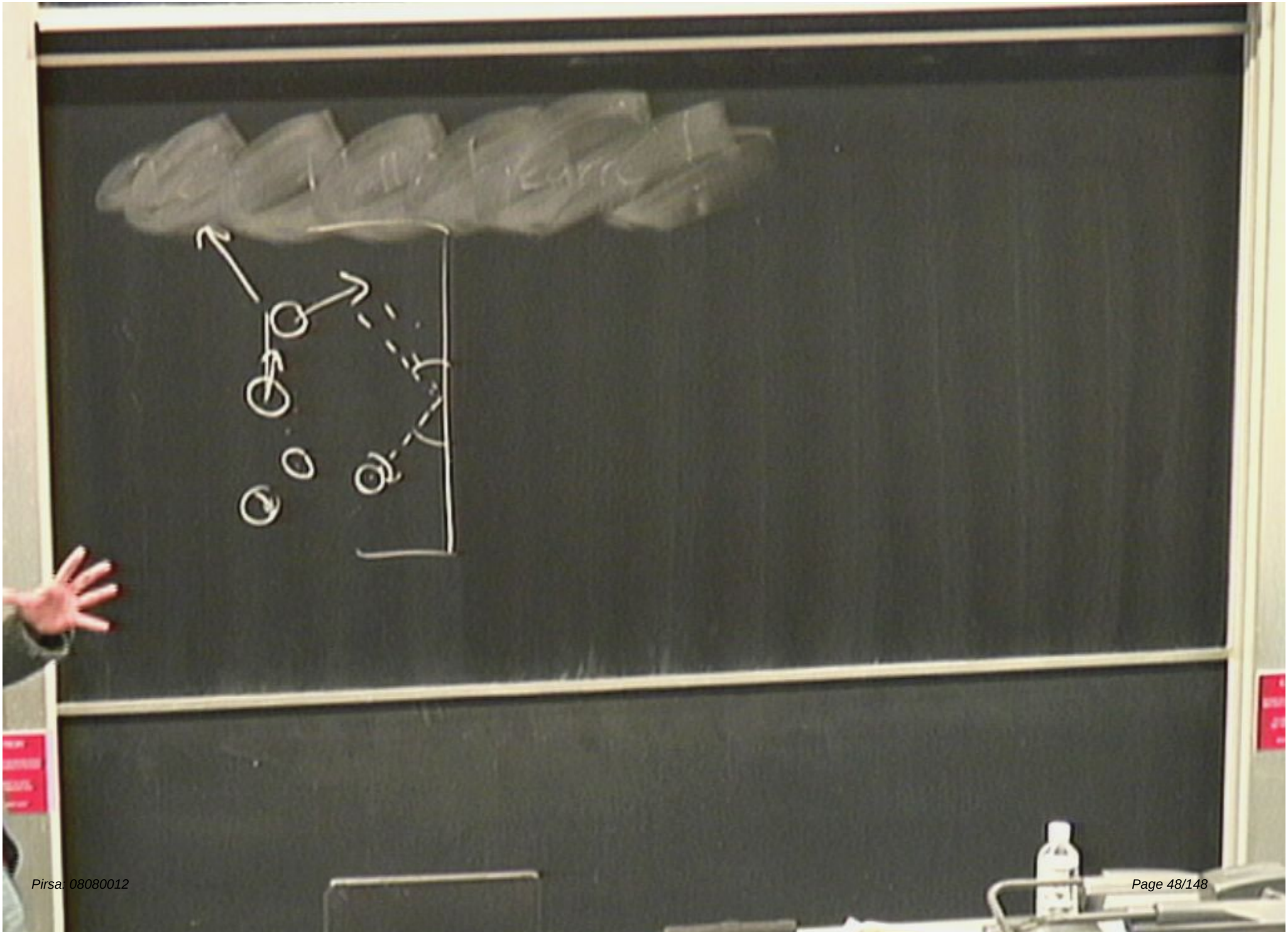


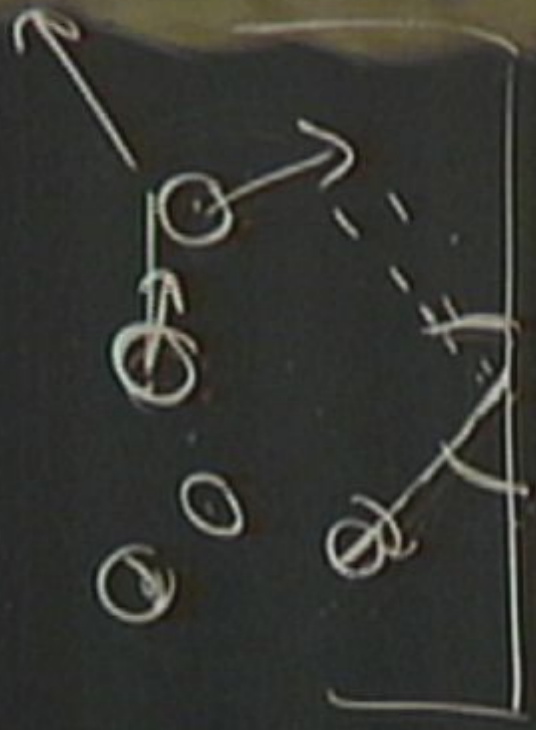




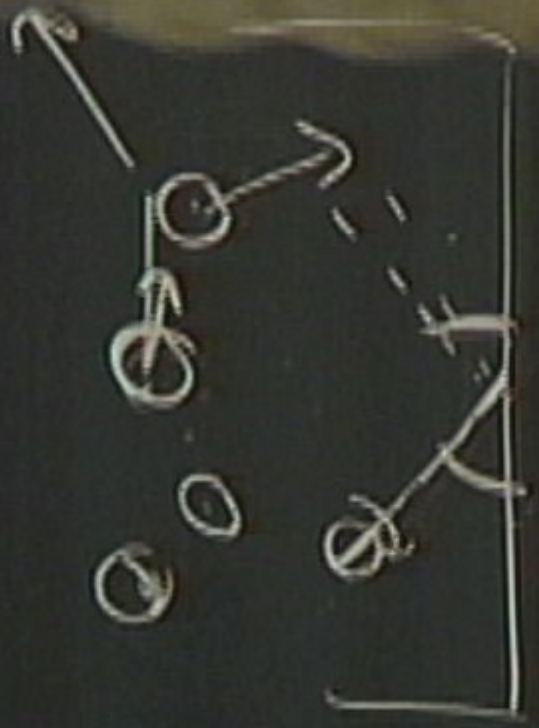








* no way to determine velocity of train based on observing behaviour of balls.



* no way to determine velocity of train based on observing behaviour of balls.

Obvious for mechanical phenomena.

Obvious for mechanical phenomena.

Not obvious for e/m. phenomena.

Obvious for mechanical phenomena.

Not obvious for e/m. phenomena.

e.g. wave-in-ether.
(sound in air.)

Obvious for mechanical phenomena.

Not obvious for e/m. phenomena.

e.g. wave-in-ether.
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Not obvious for e/m. phenomena.

e.g. wave-in-ether.
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Obvious for mechanical phenomena.

Not obvious for elm. phenomena.

e.g. wave-in-ether.
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Obvious for mechanical phenomena.

Not obvious for e/m. phenomena.

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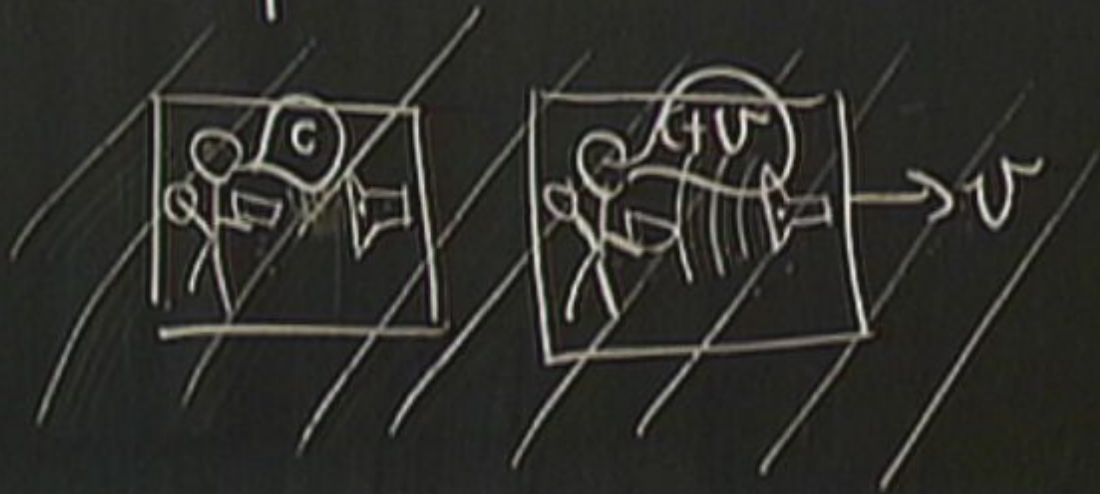

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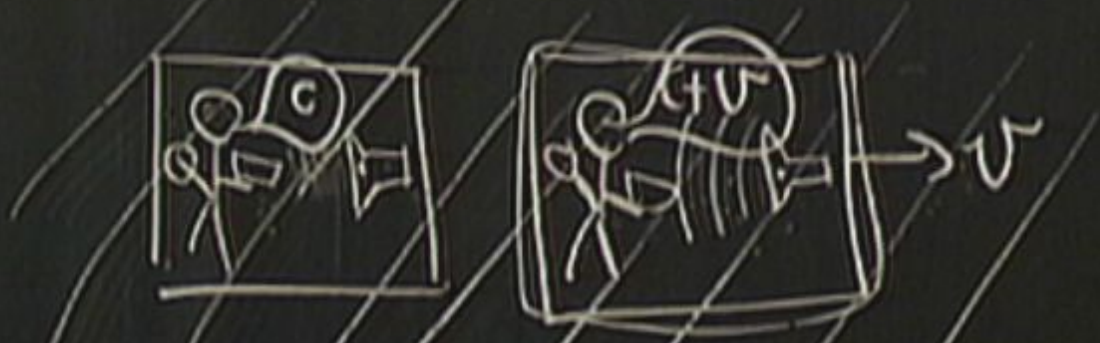

Obvious for mechanical phenomena.

Not obvious for elm. phenomena.

Einstein wanted all physical phenoms

e.g. wave-in-ether.
(sound in air)

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Not obvious for elm. phenomena.

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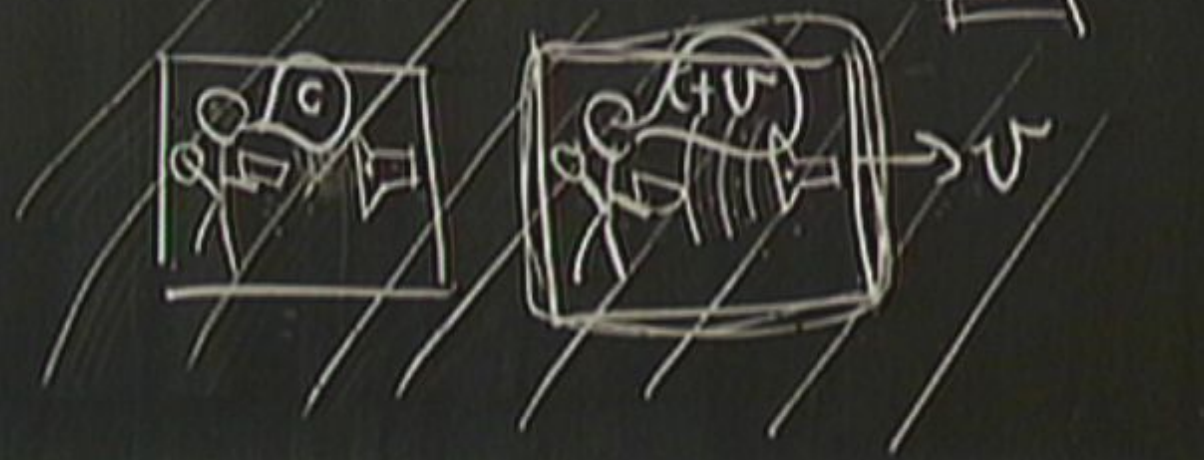
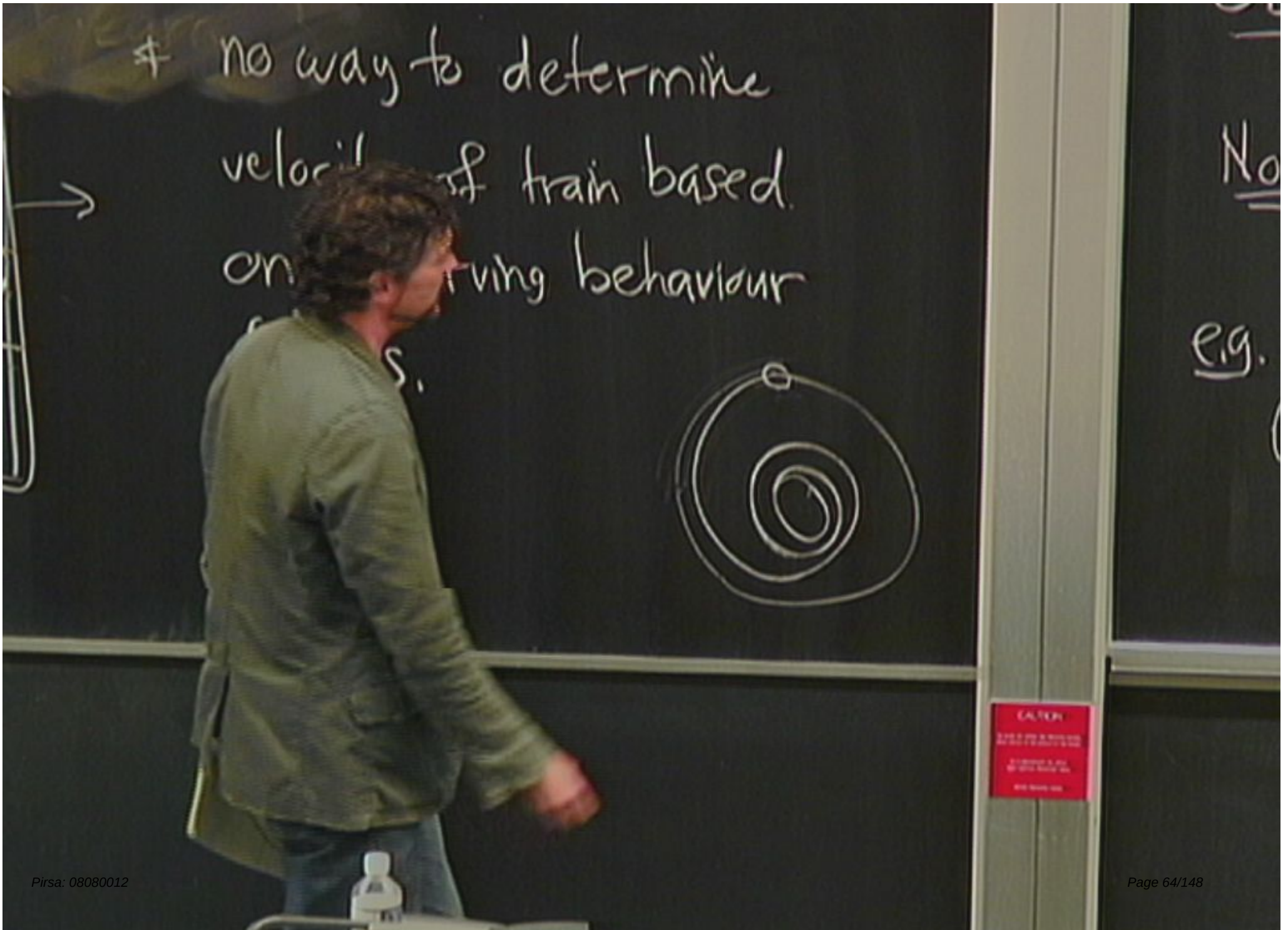


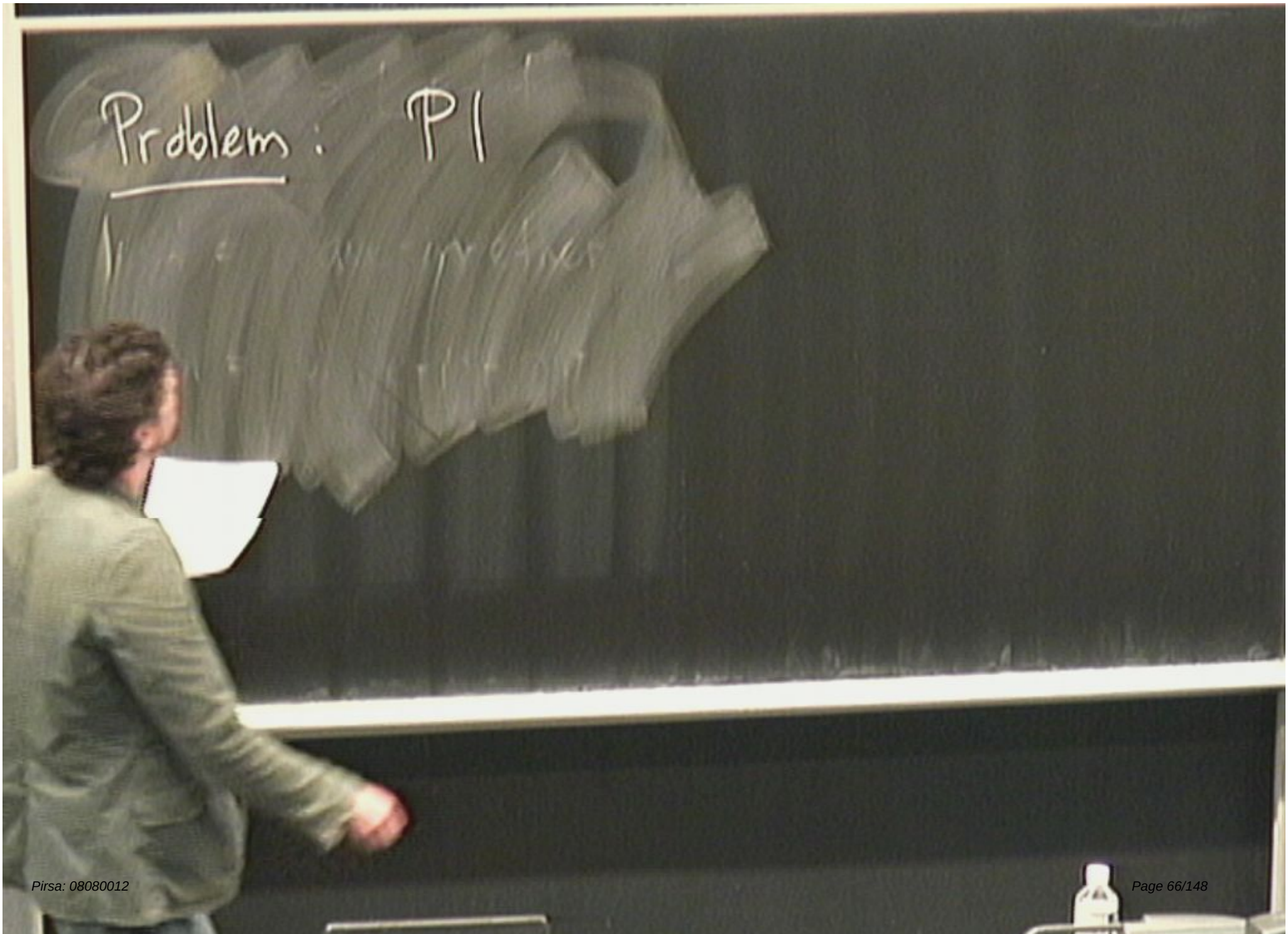

no way to determine
of train based
behaviour
No
e.g.

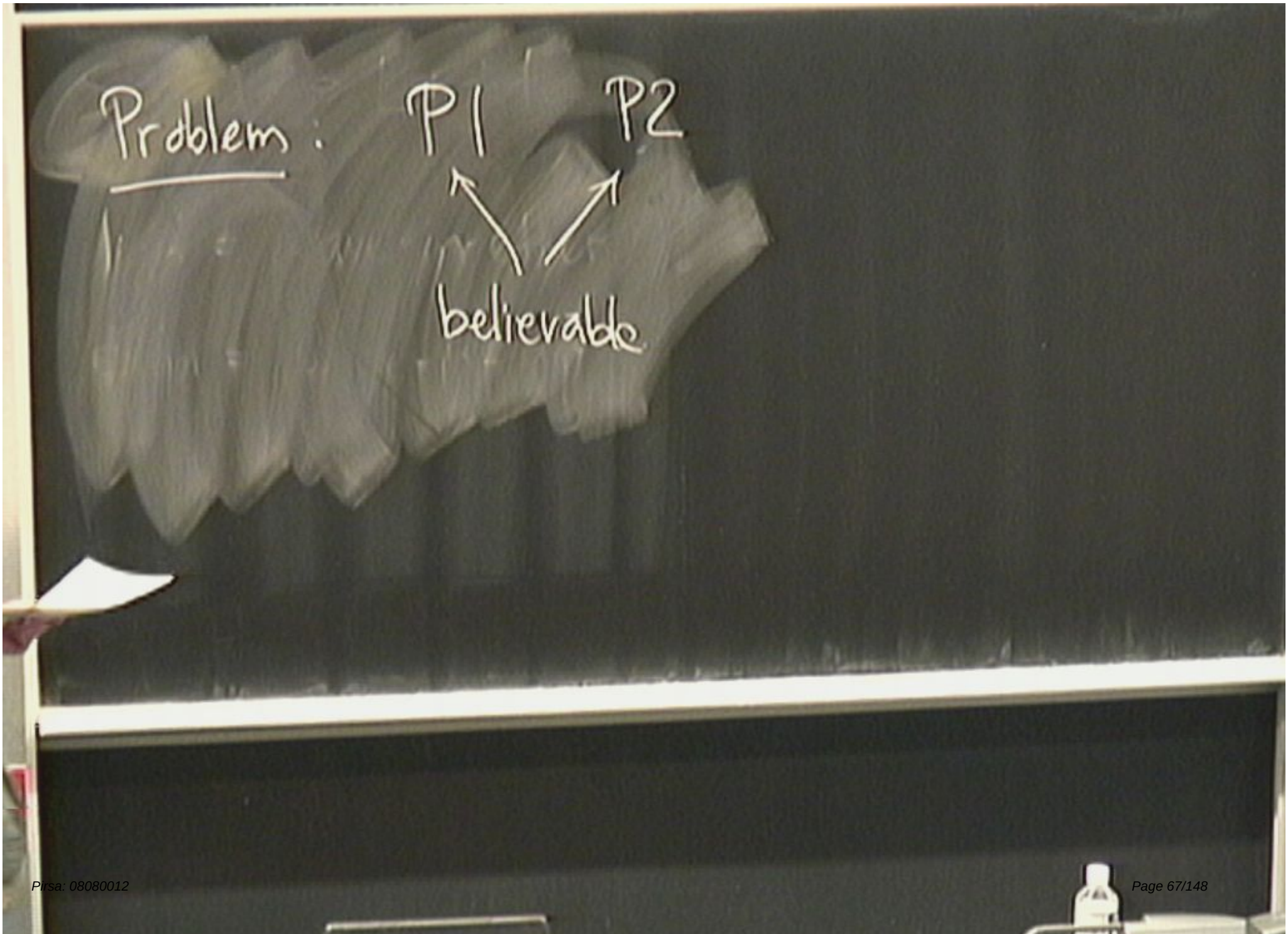
P1: (Relativity)

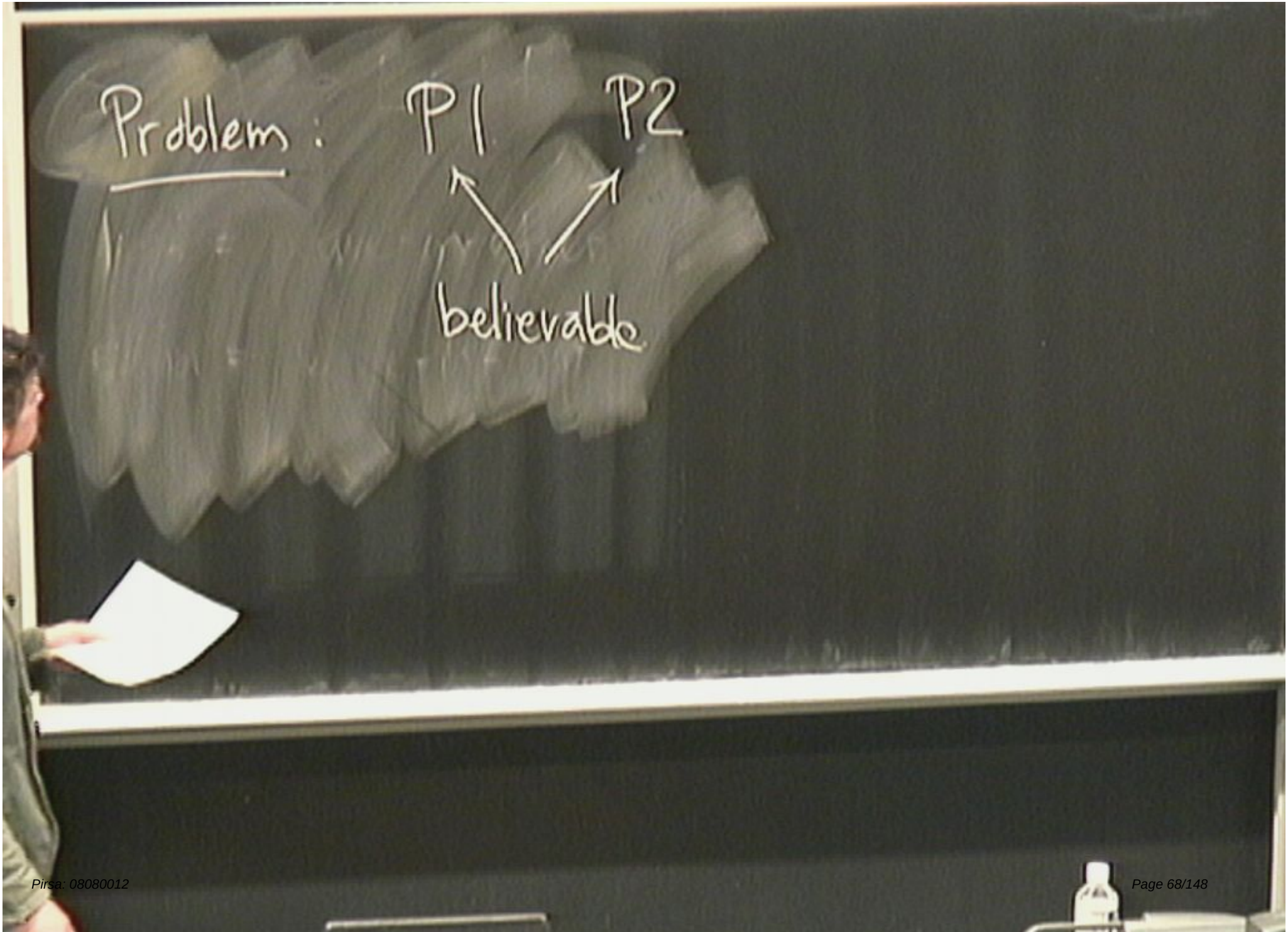
not accelerating or rotating

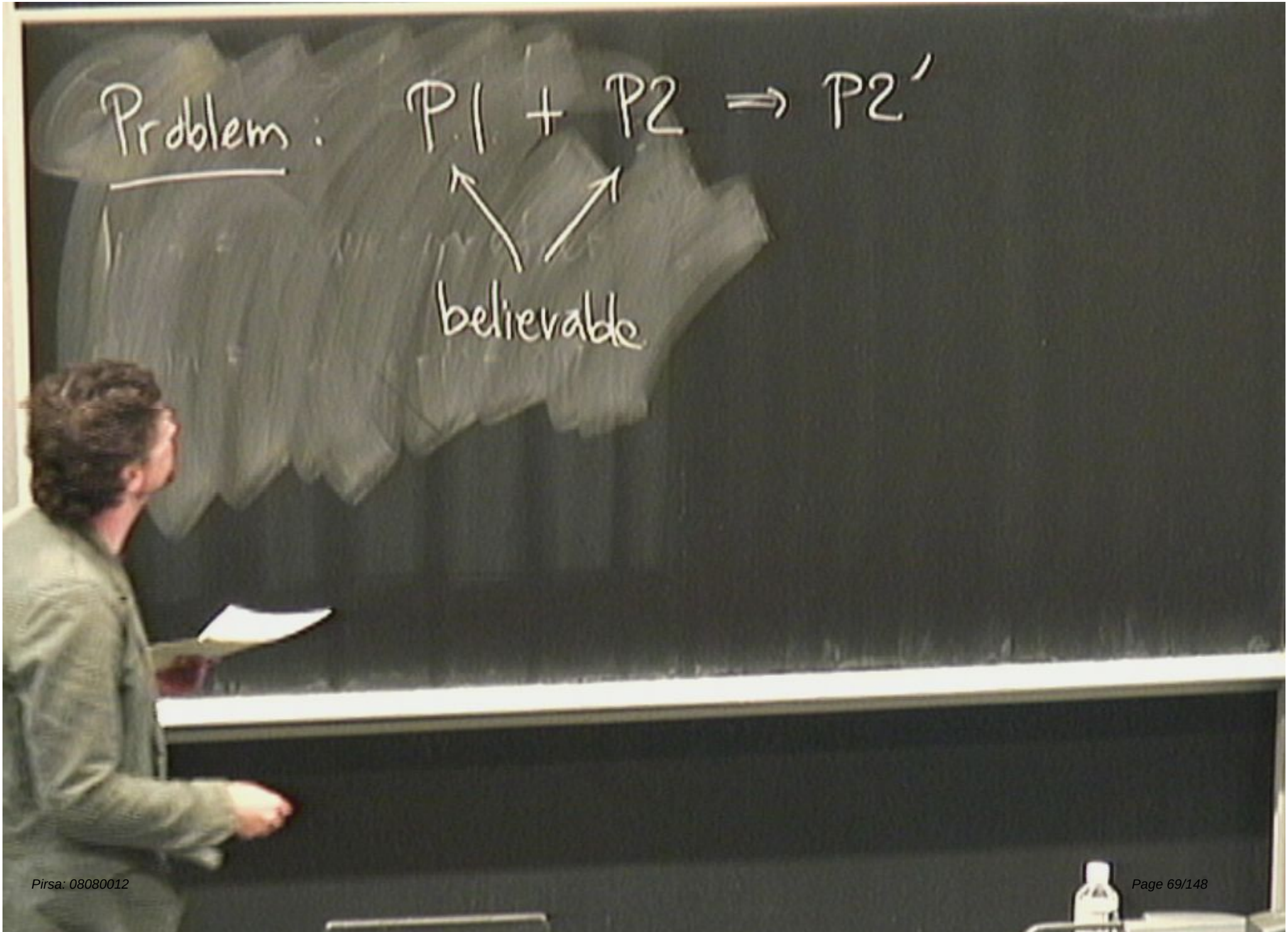
Given any two inertial observers in uniform relative motion, both are equally entitled to consider themselves to be "at rest".

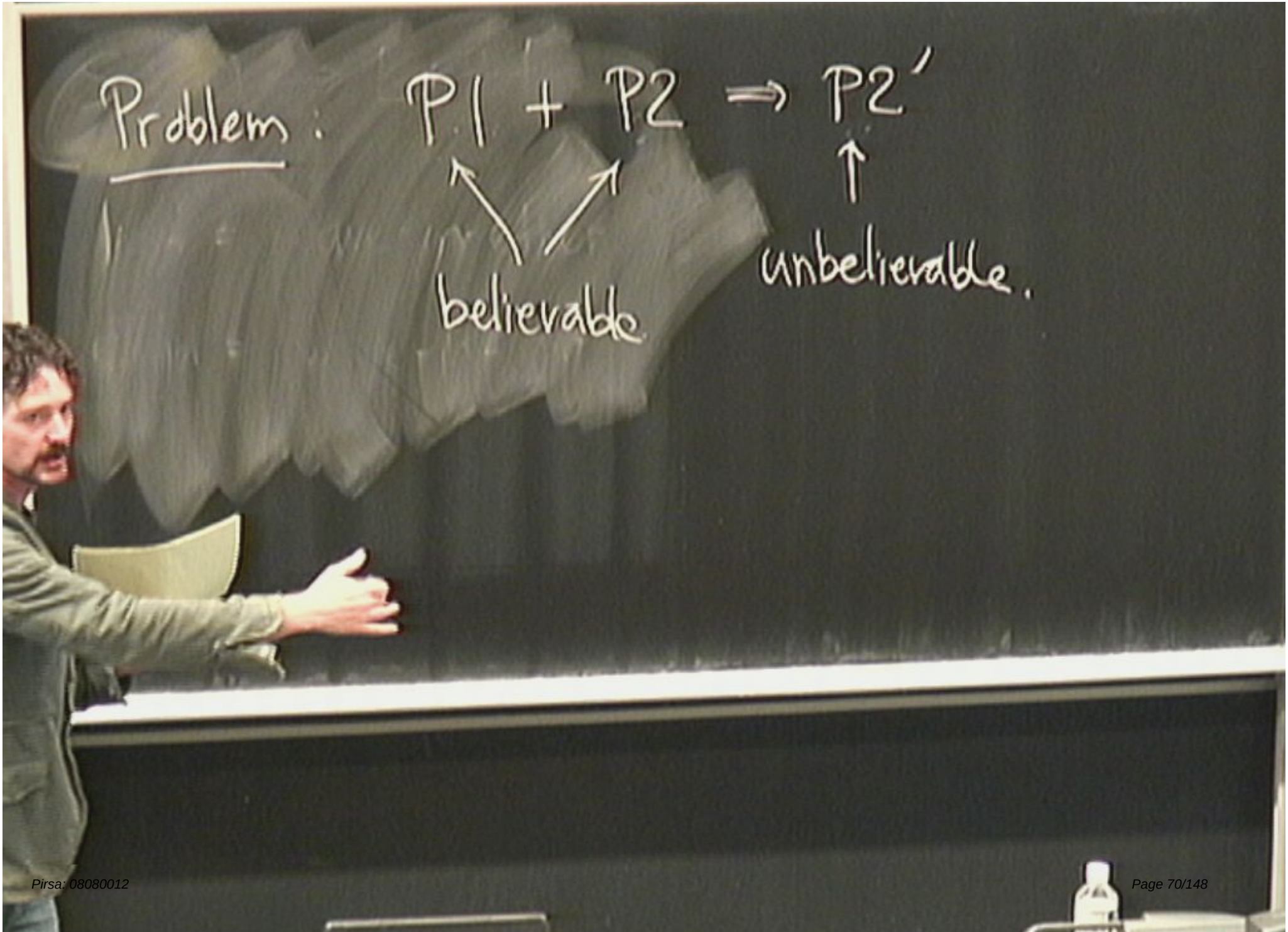
It is reasonable to extend P1 to e/m.

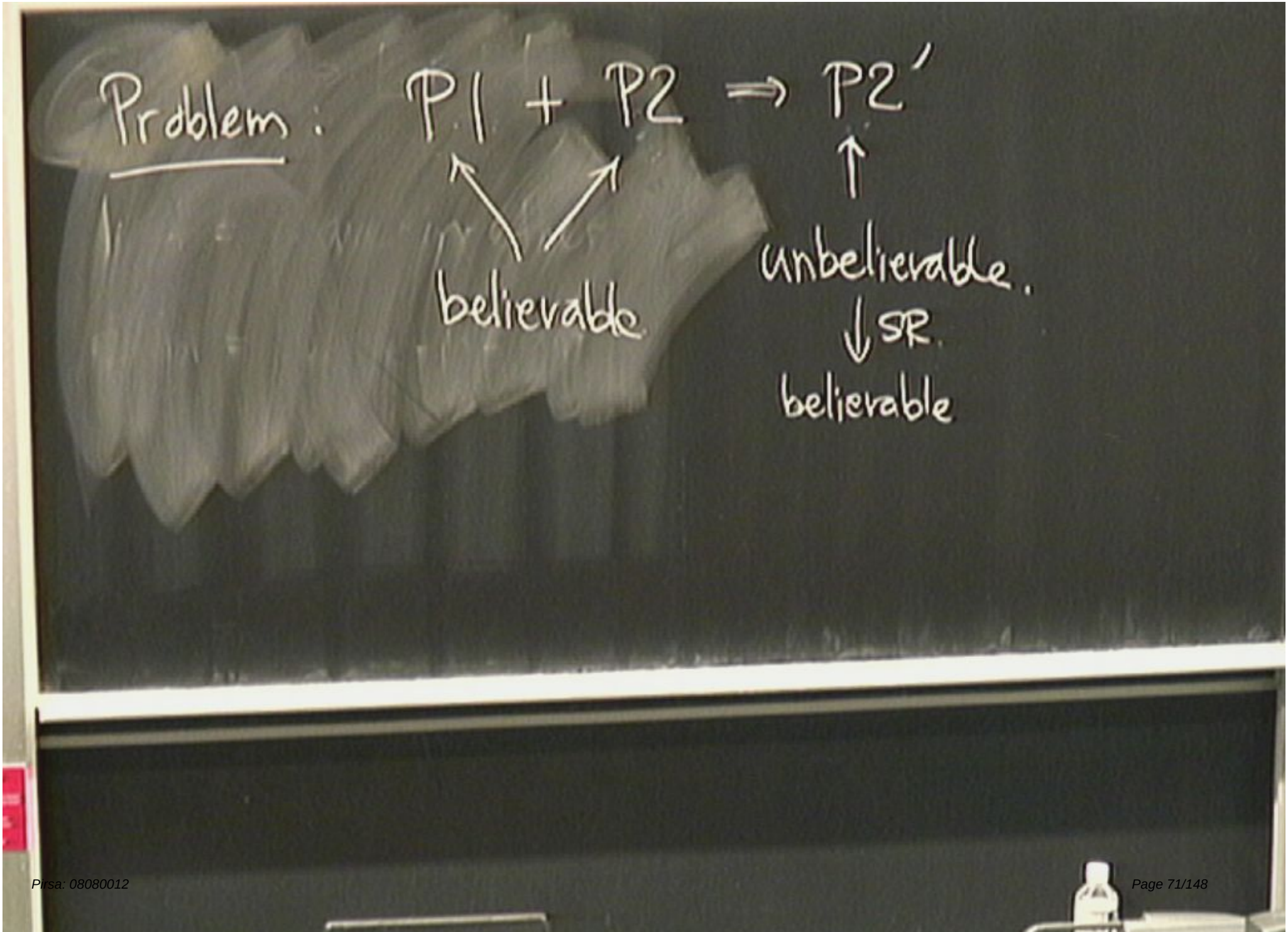

Problem: P1

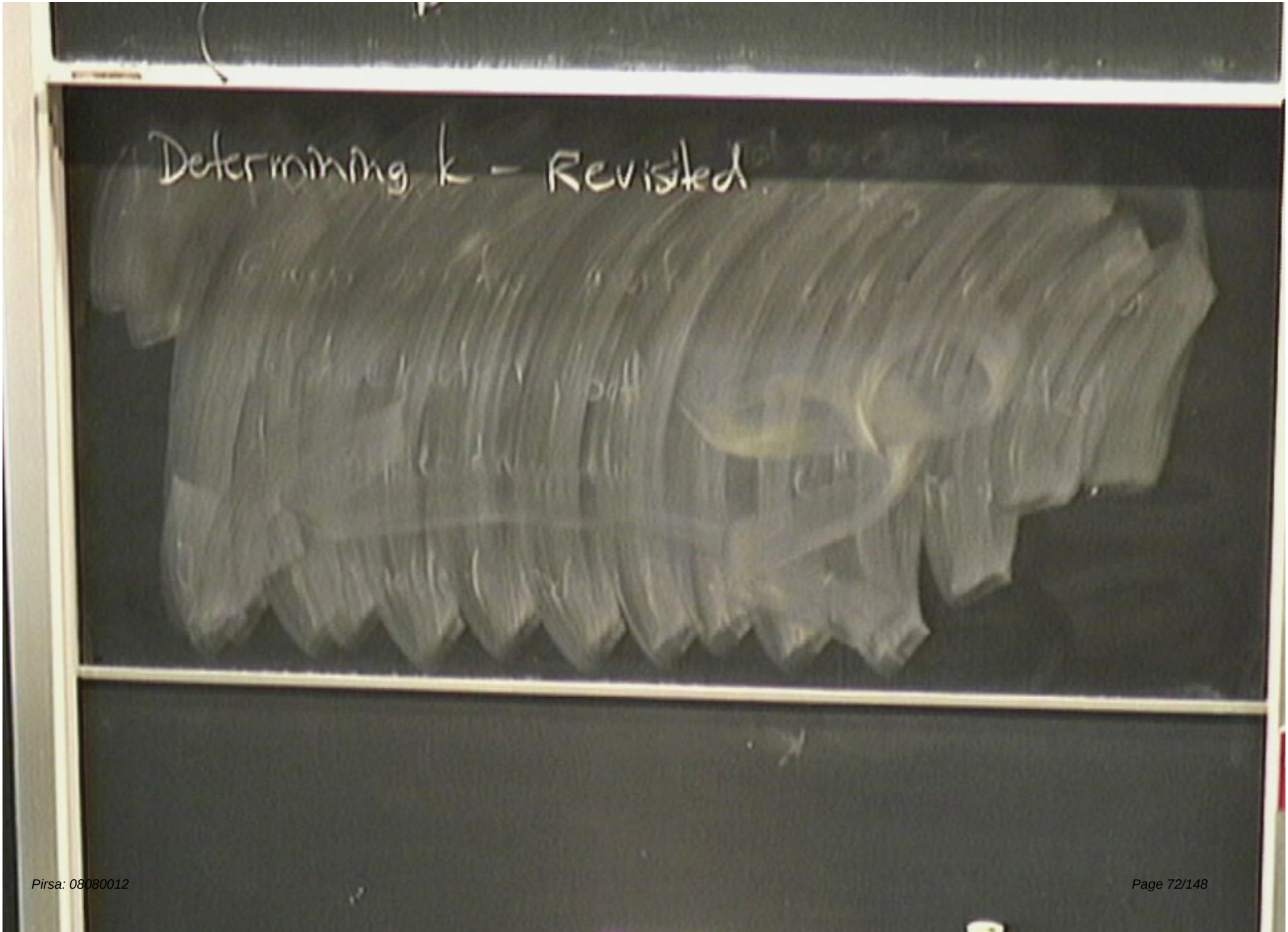

Problem: P1 P2
believable

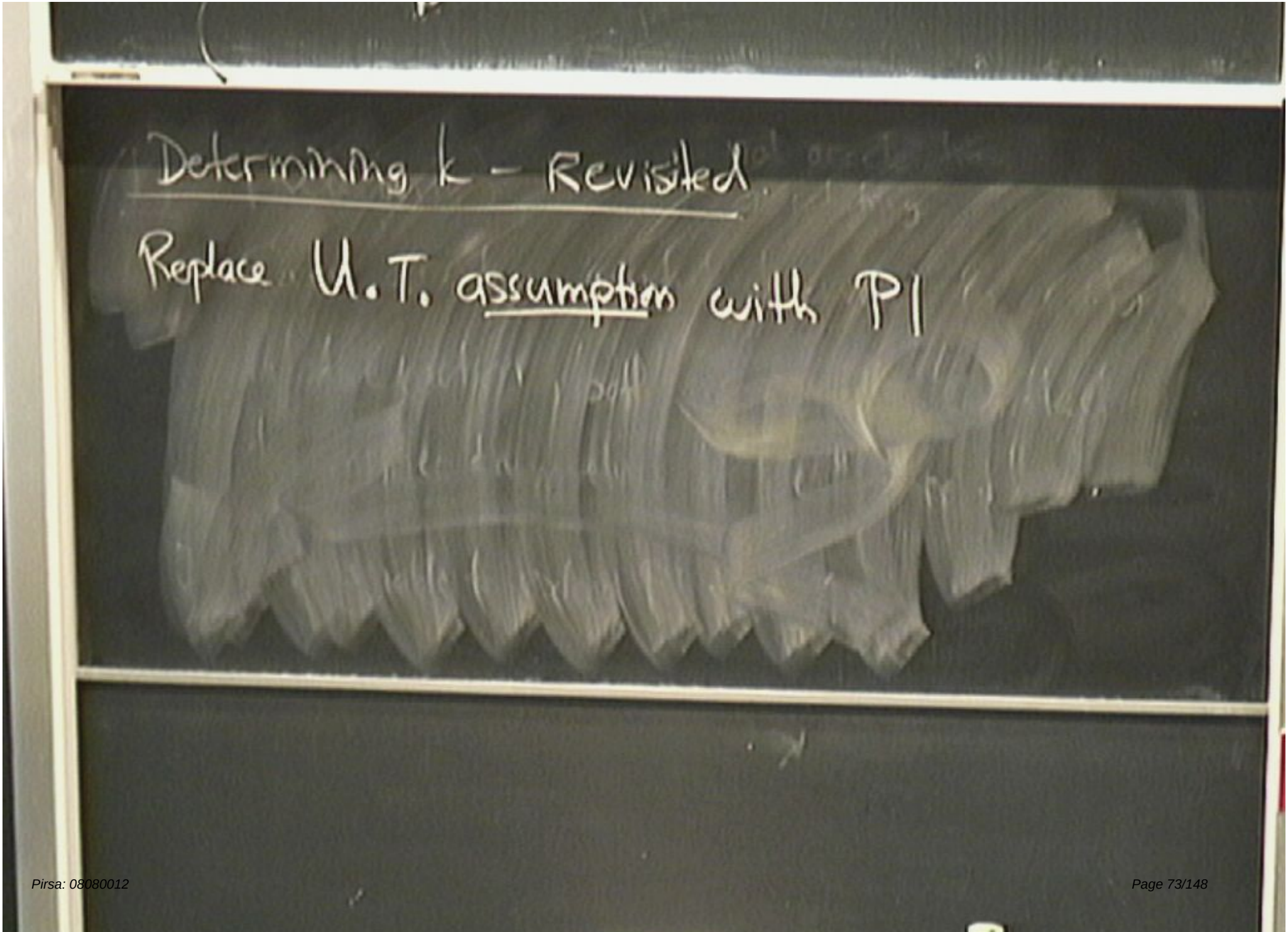

Problem :
P1
P2
believable


Problem: P1 + P2 ⇒ P2'
believable


Problem: P1 + P2 ⇒ P2'
believable
unbelievable.

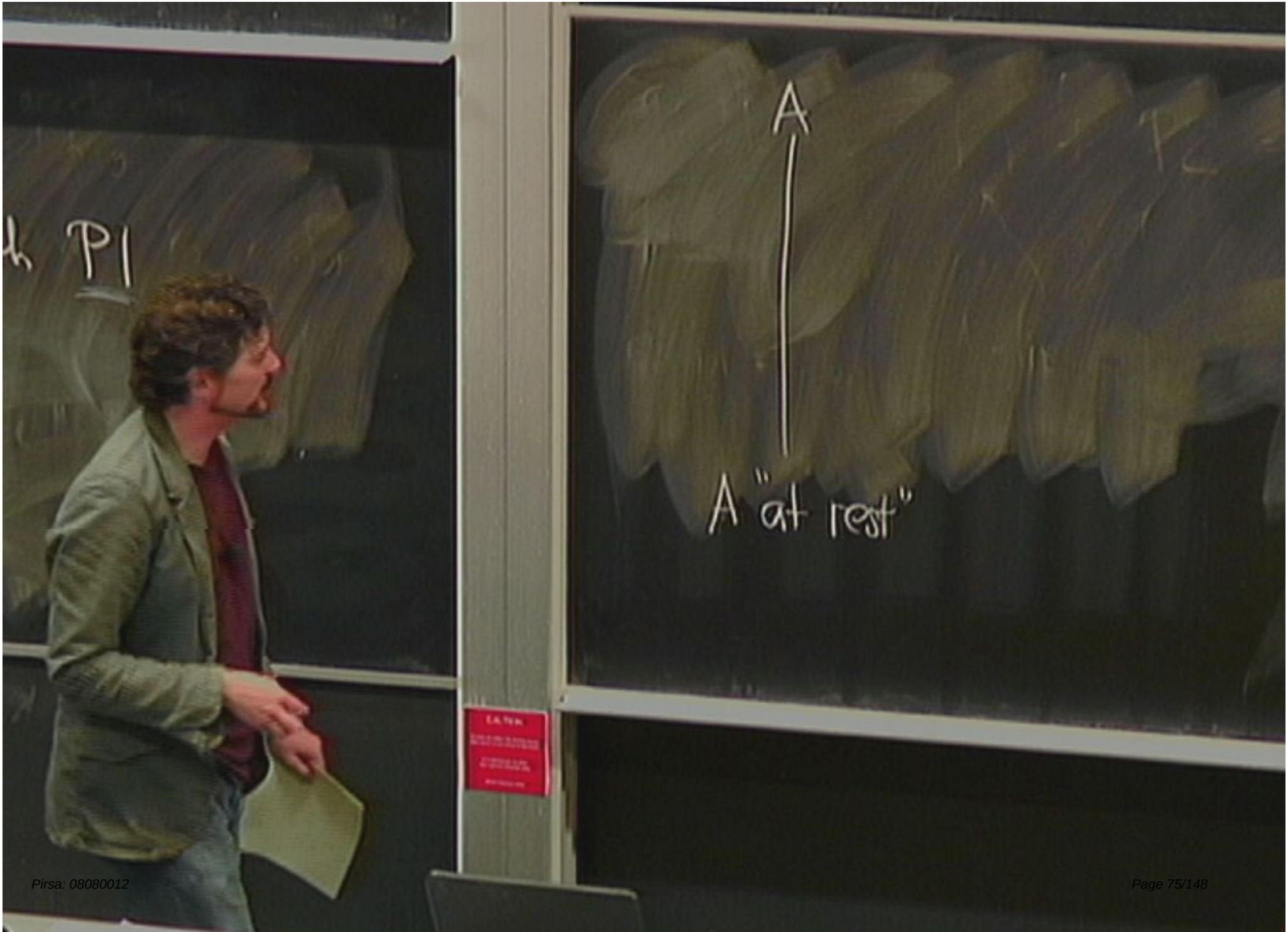

Problem: P1 + P2 ⇒ P2'
believable
unbelievable.
↓ SR
believable

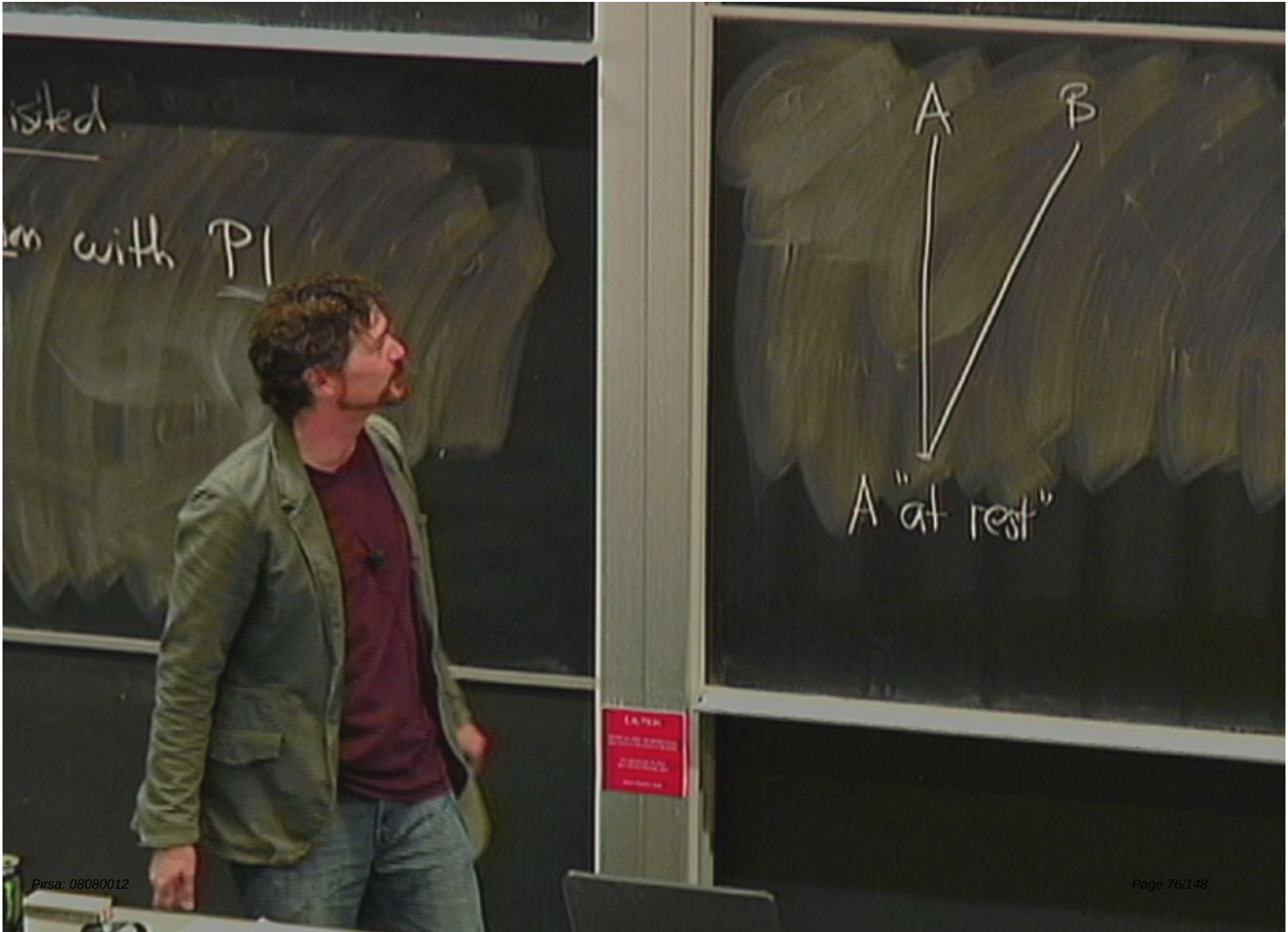

Determining k - Revisited

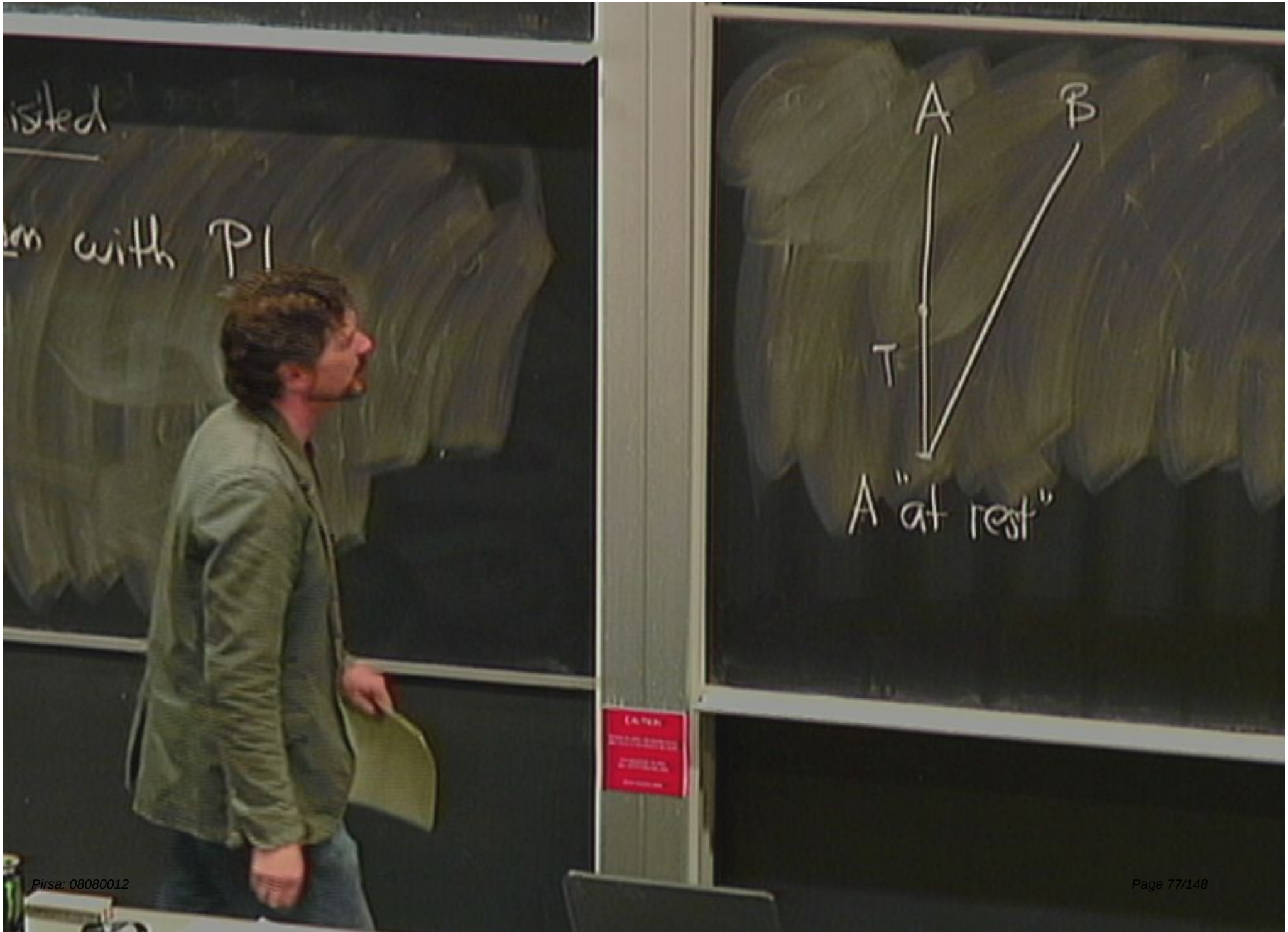

Determining k - Revisited
Replace U.T. assumption with PI

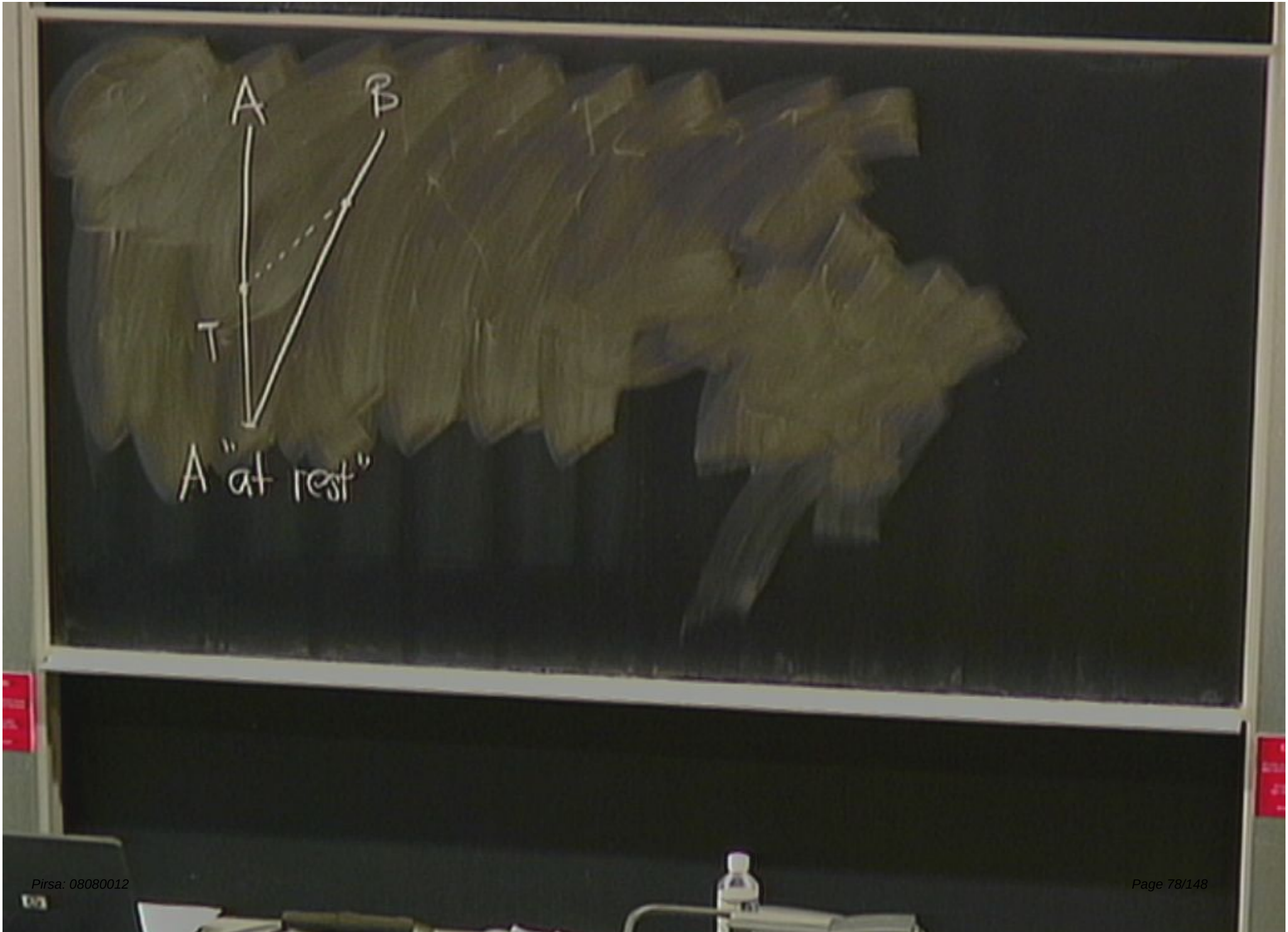
Determining k - Revisited

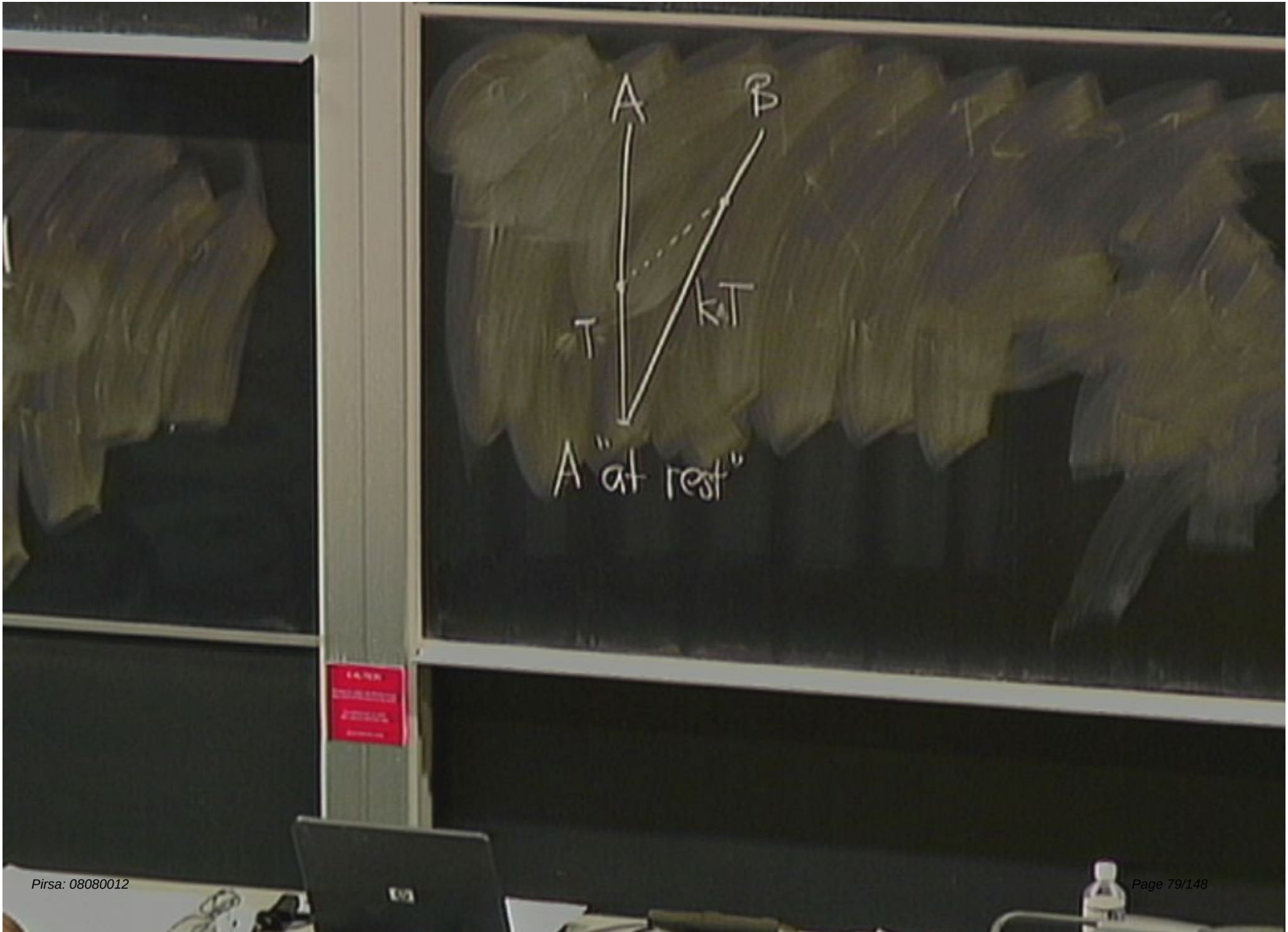
Replace U.T. assumption with PI

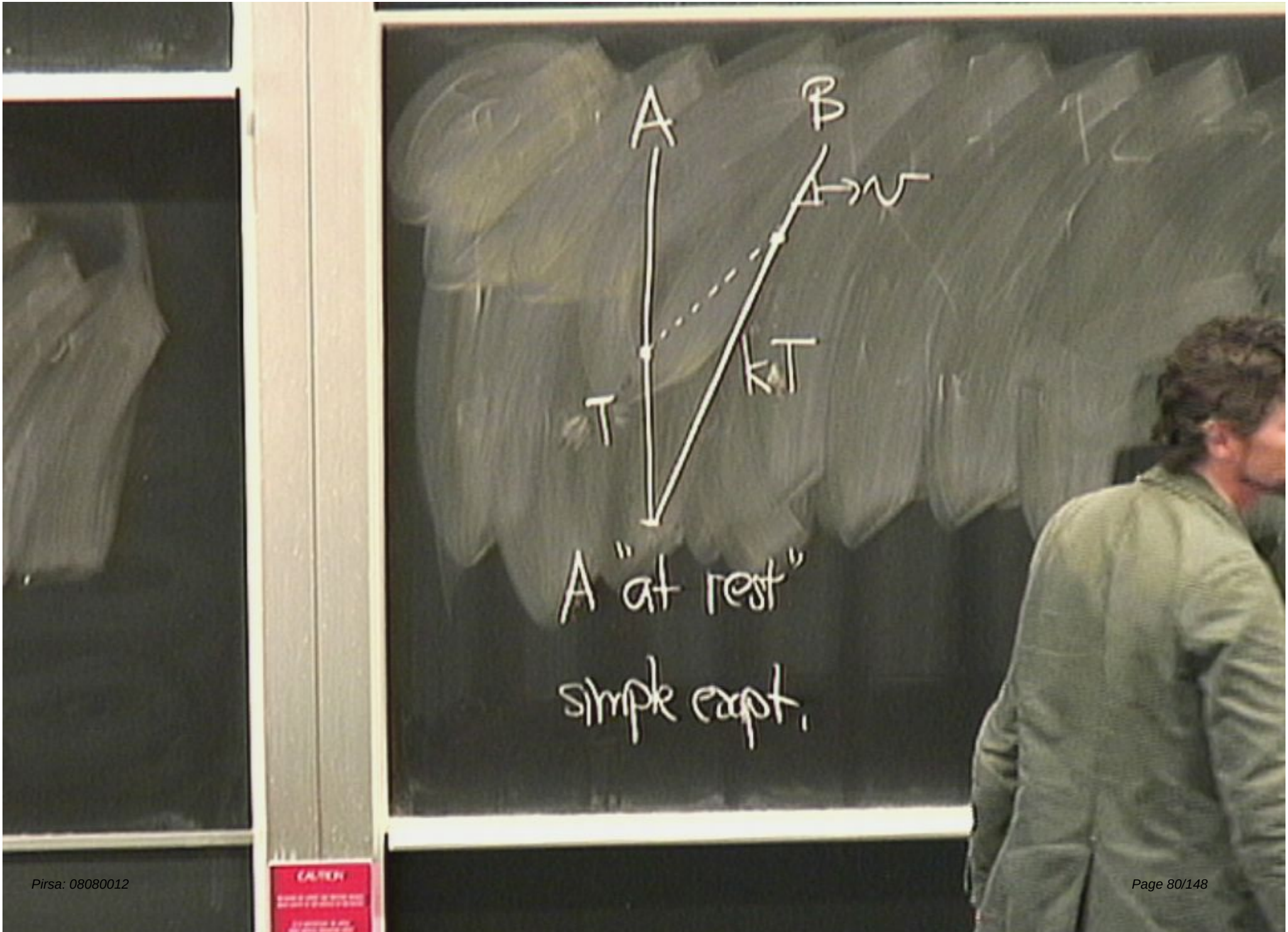

A
A "at rest"

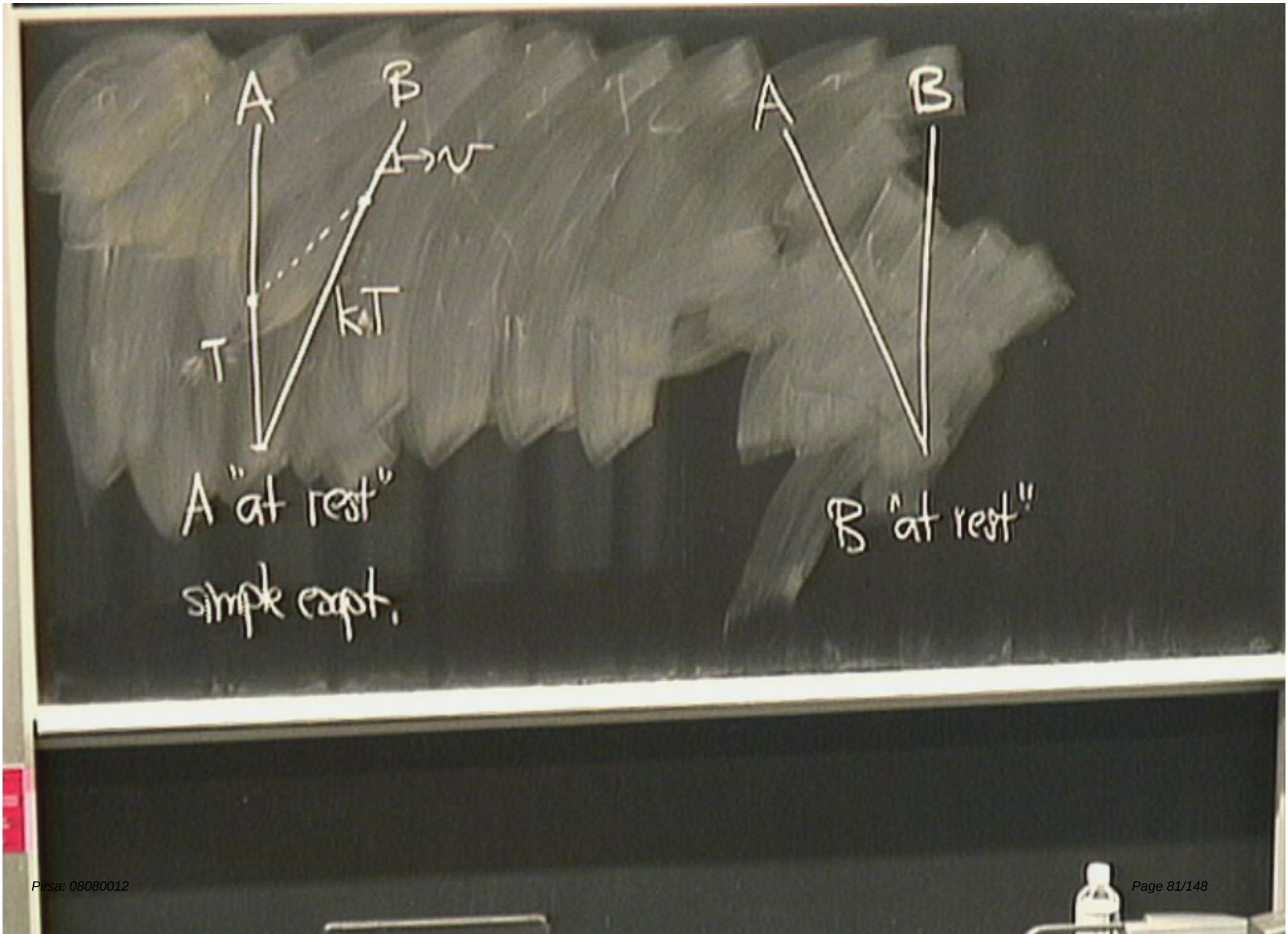

isted
with PI
A
B
A "at rest"

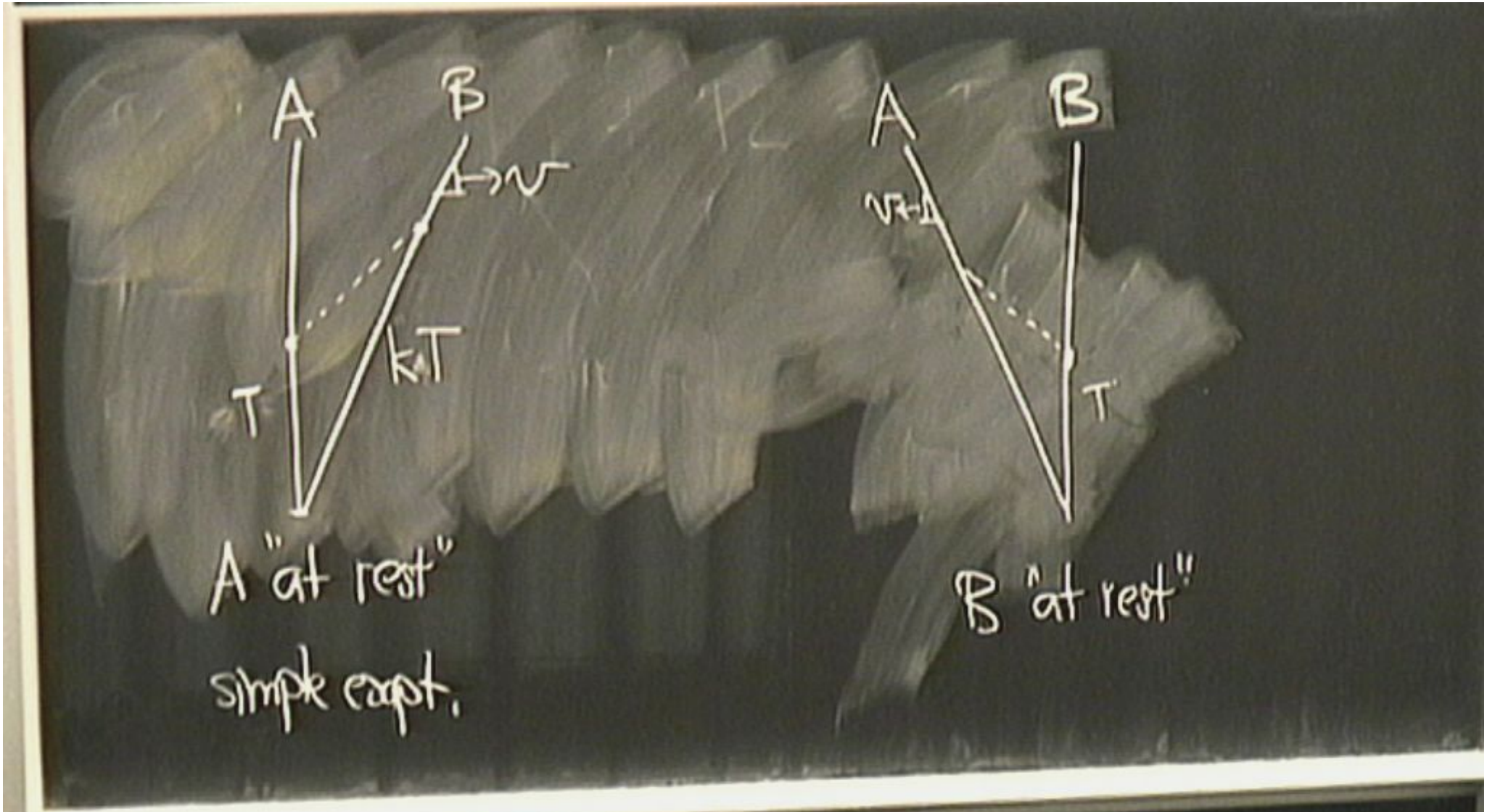

A
B
T
A "at rest"

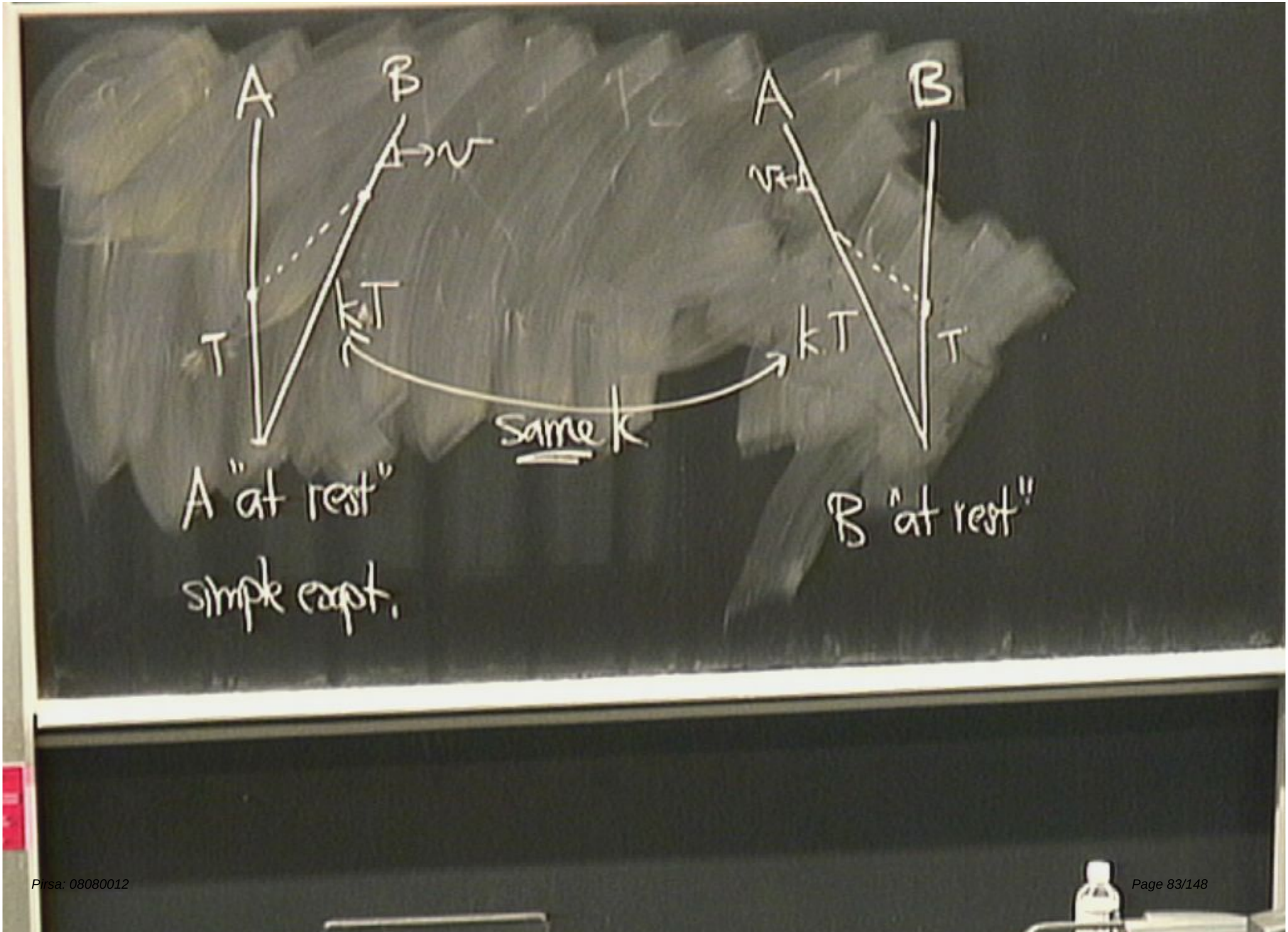

A
B
T
A "at rest"

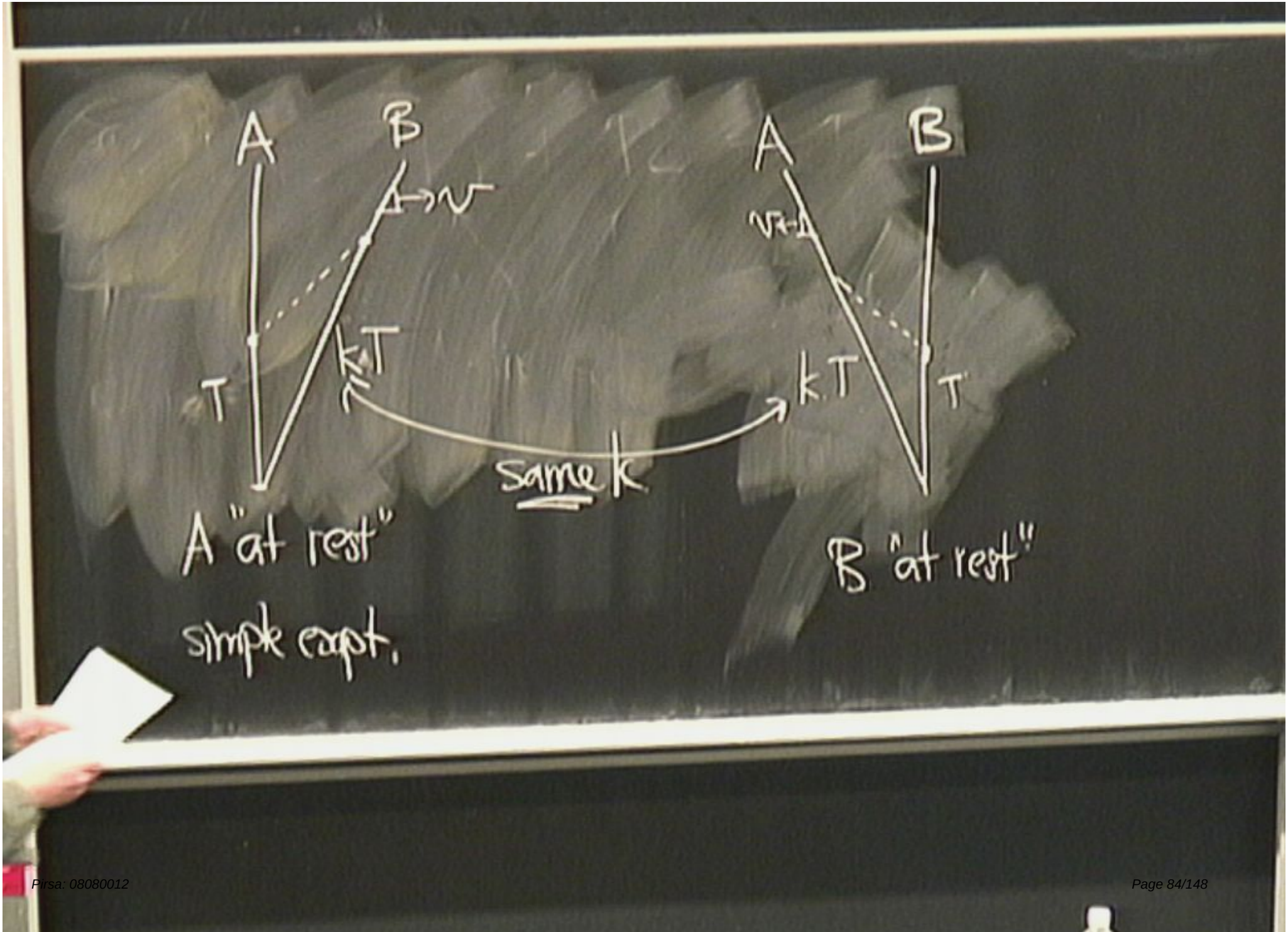

A
B
T
kT
A "at rest"

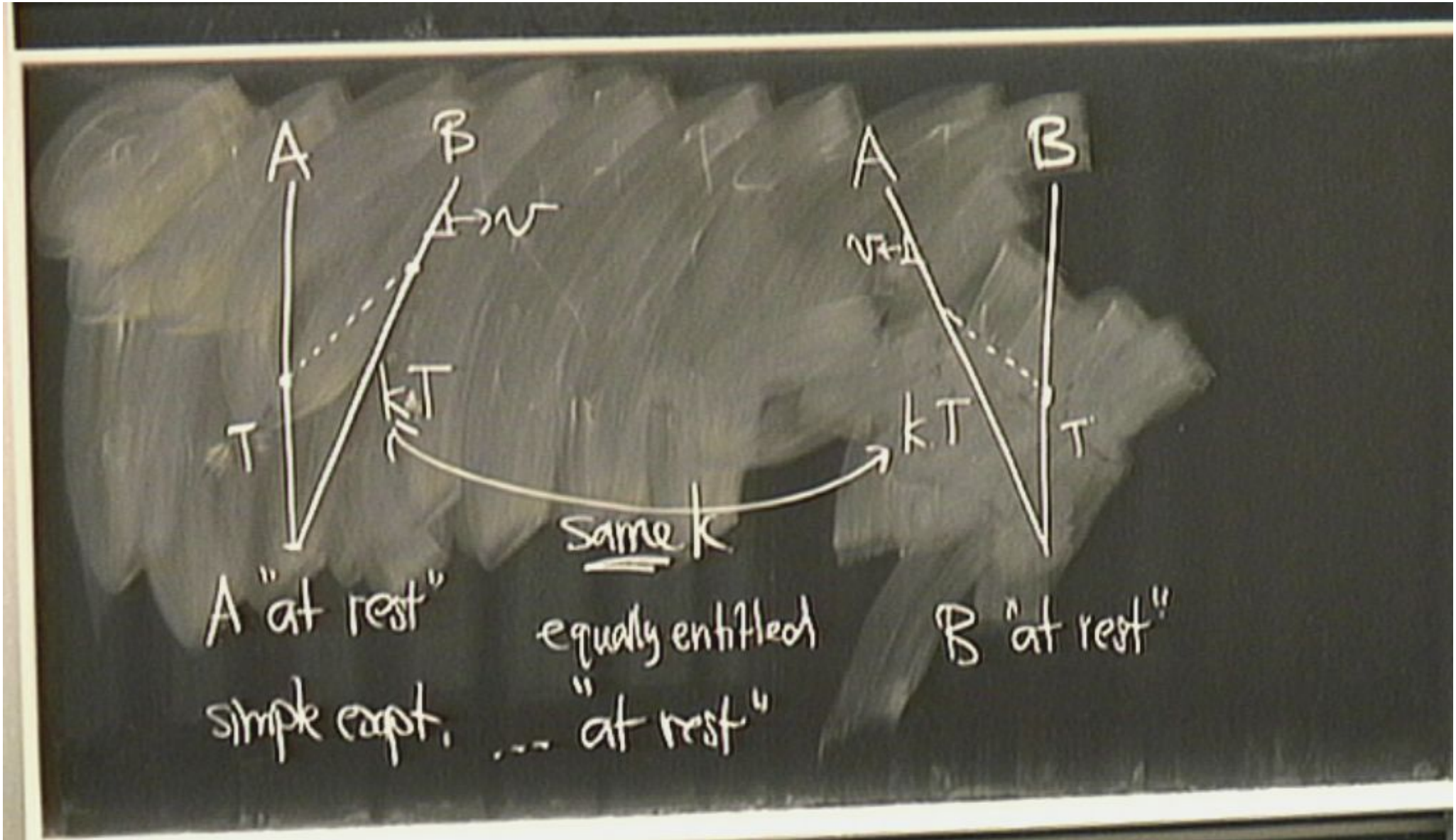

A
B
T
kT
A "at rest"
simple expt.

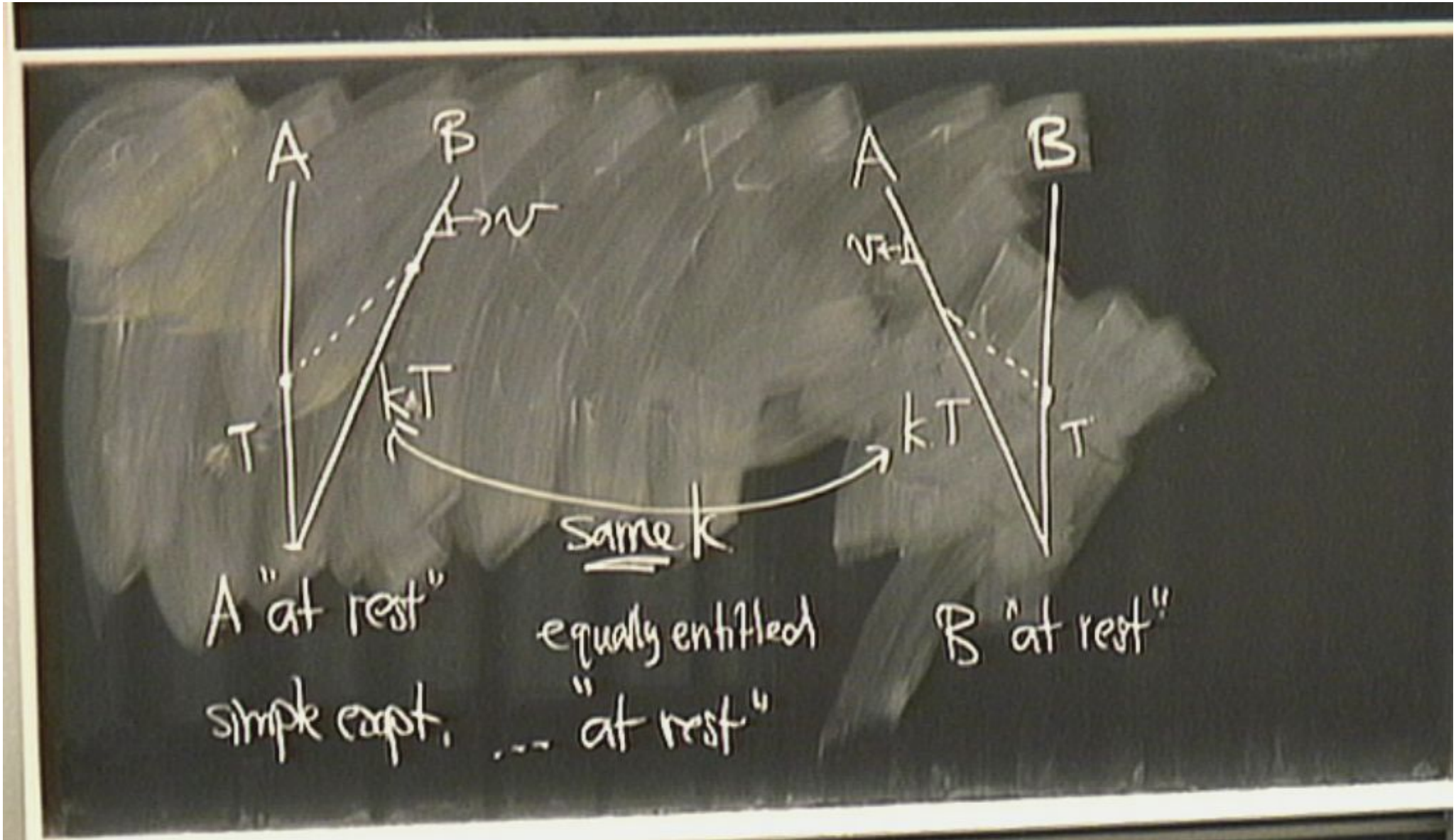

A
B
T
kT
A "at rest"
simple capt.
A
B
B "at rest"

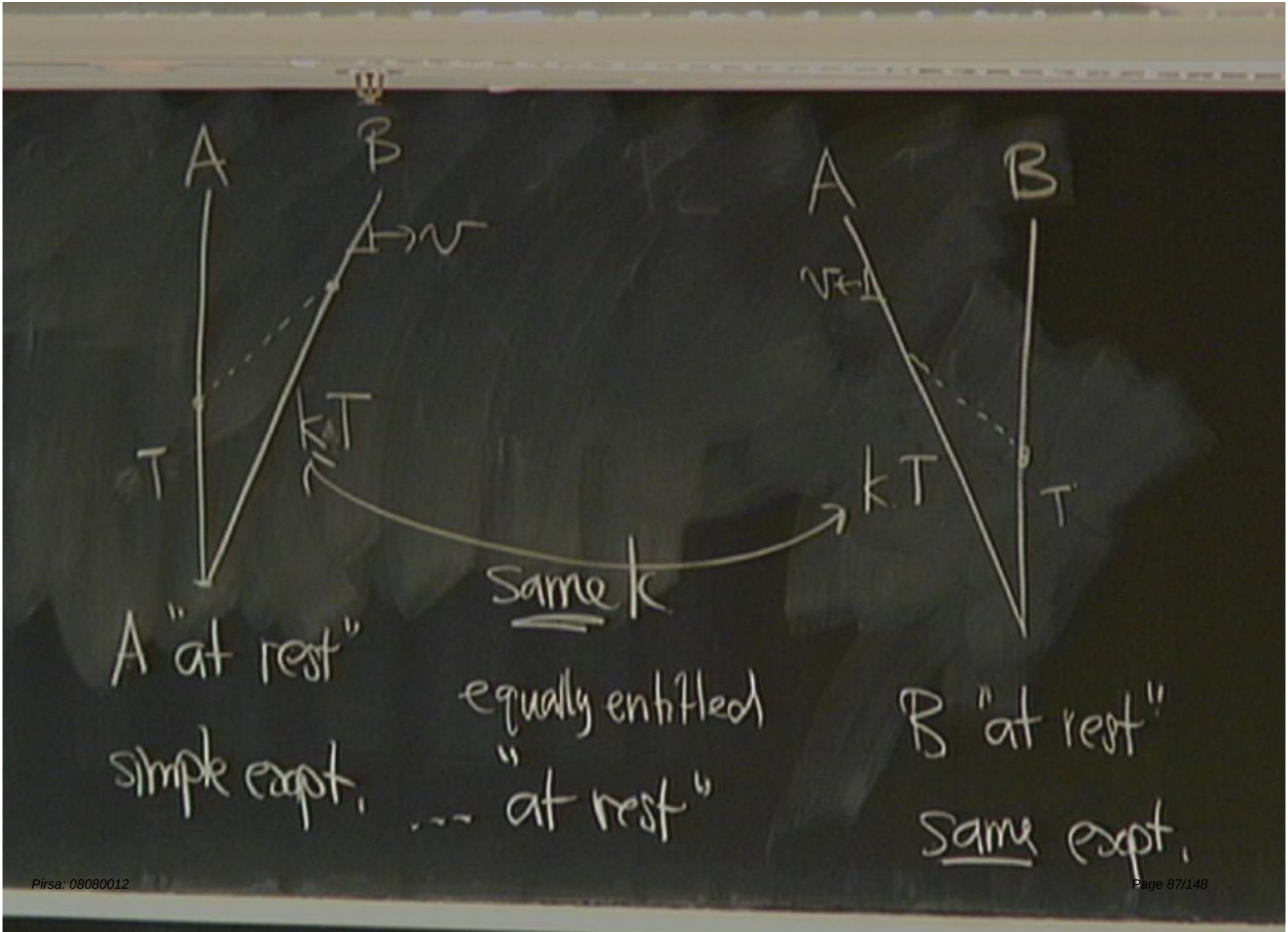

A
B
T
kT
A "at rest"
simple expt.
A
B
T
B "at rest"

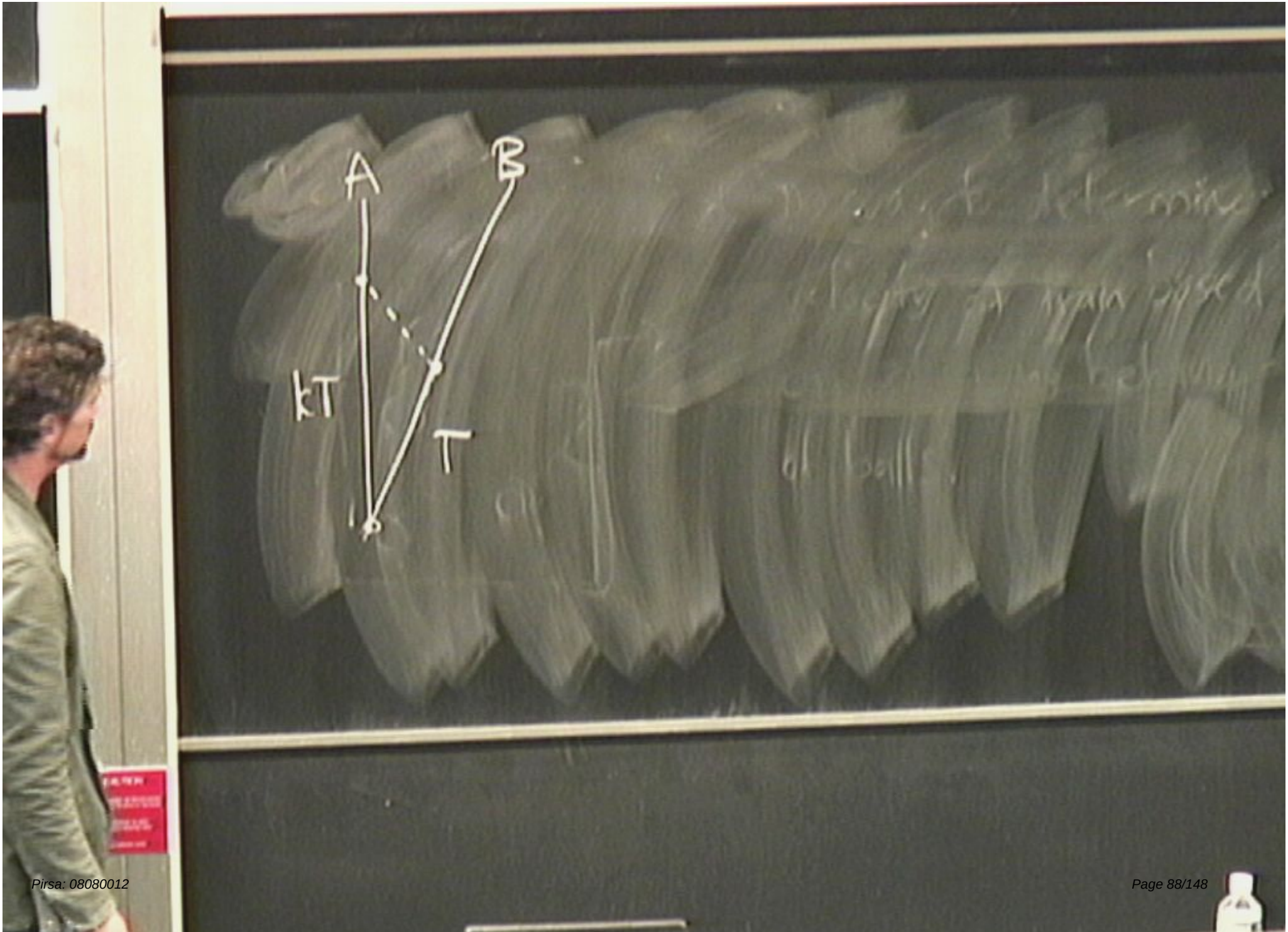

A
B
A
B
T
kT
kT
T
same k
A "at rest"
B "at rest"
simple expt.

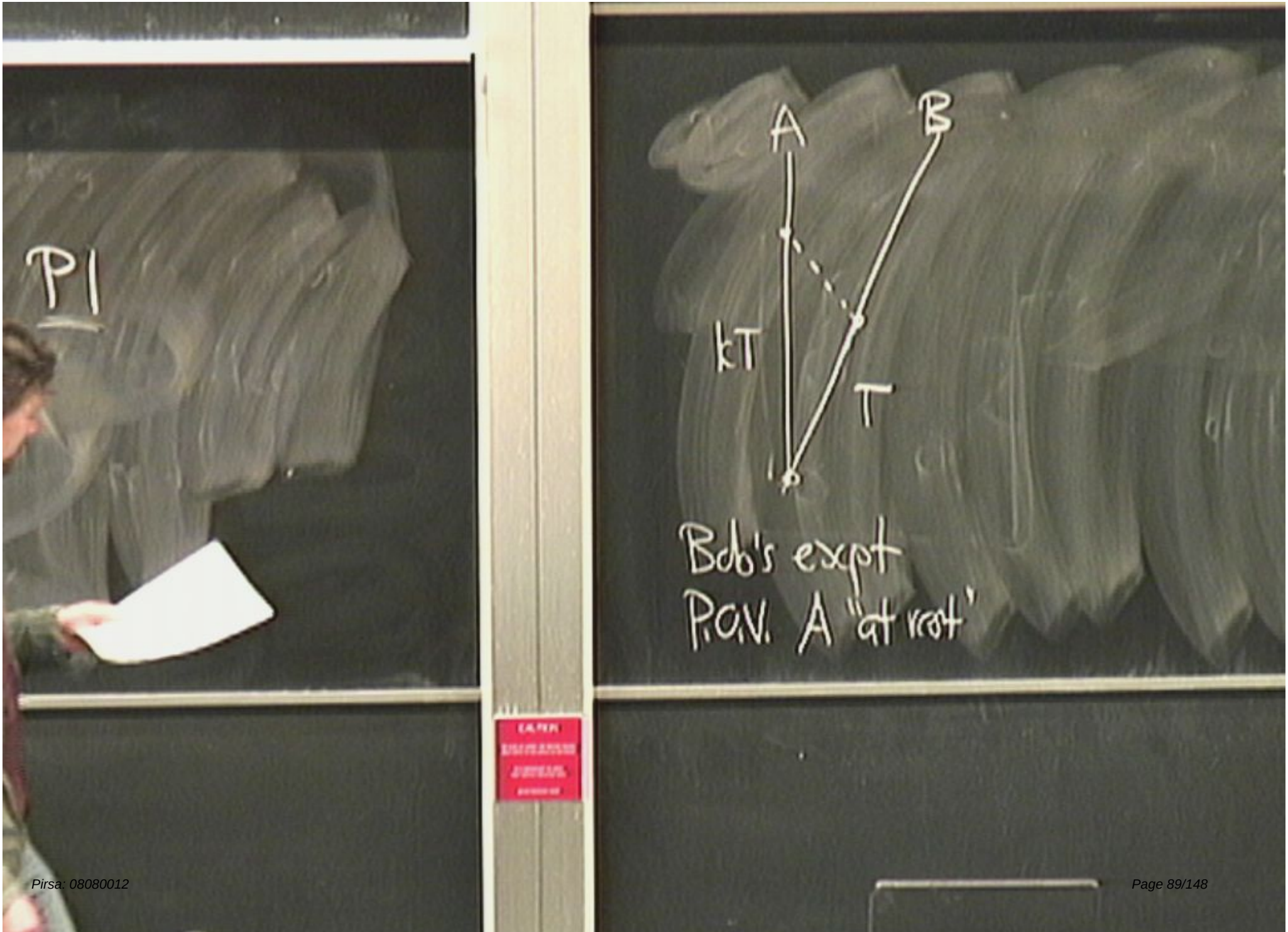

A
B
A → v
T
kT
same k
A "at rest"
simple expt.
A
B
v → 0
kT
T
B "at rest"

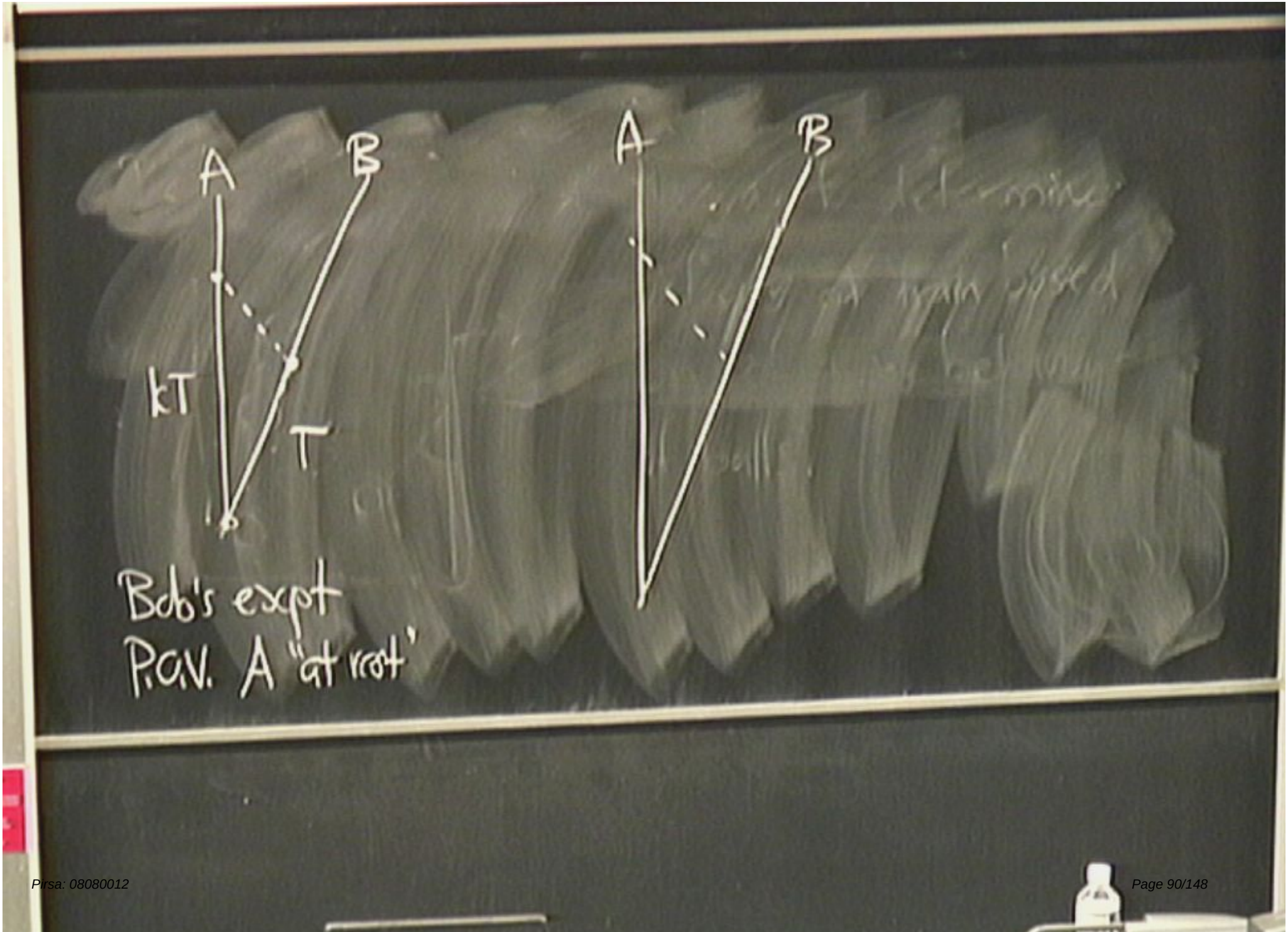

A
B
T
kT
same k
A "at rest"
simple expt.
equally entitled
"at rest"
A
B
kT
T
B "at rest"

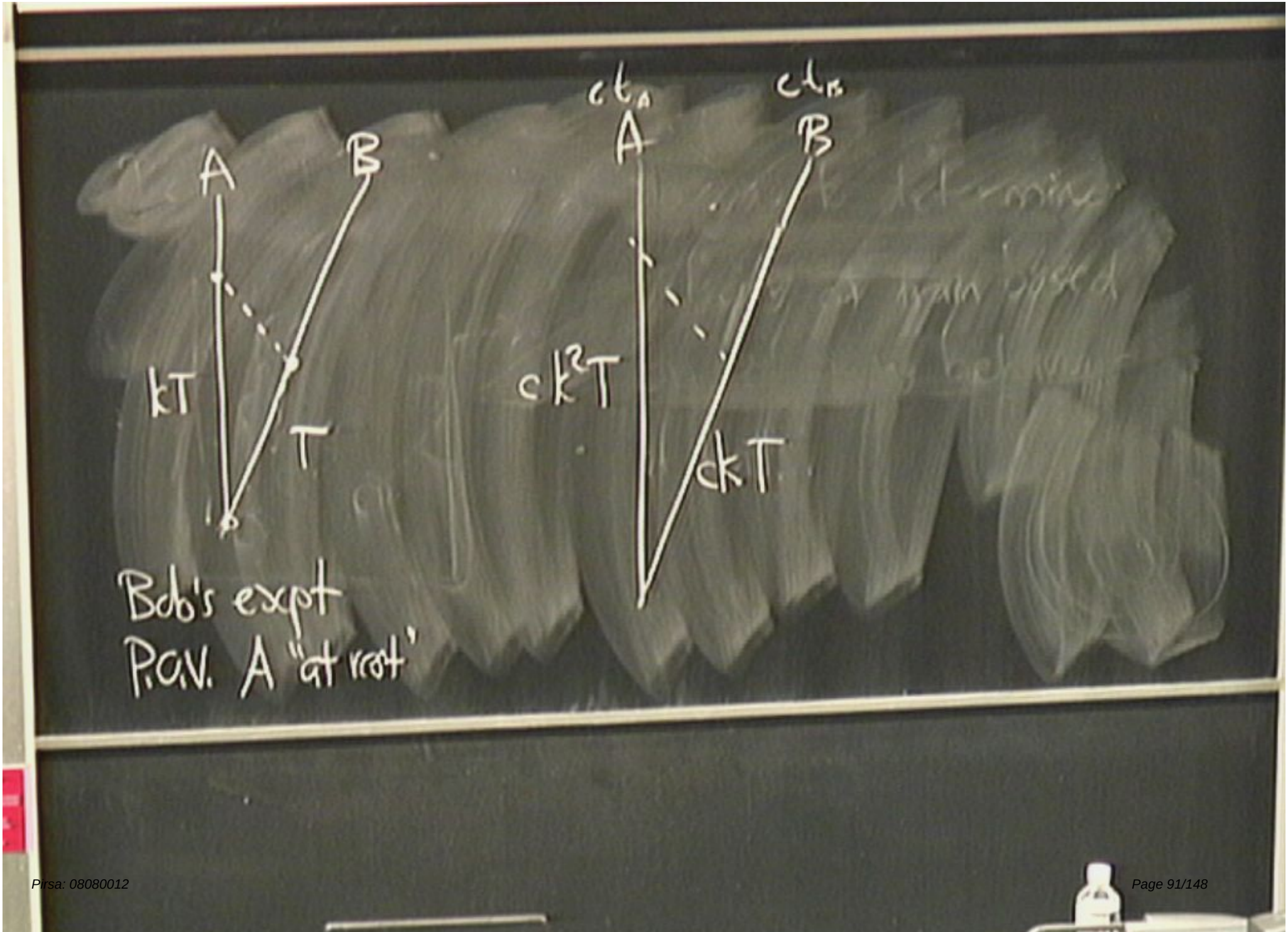

A
B
A
B
T
kT
kT
T
same k
A "at rest"
equally entitled
"
B "at rest"
simple expt. ... "at rest"

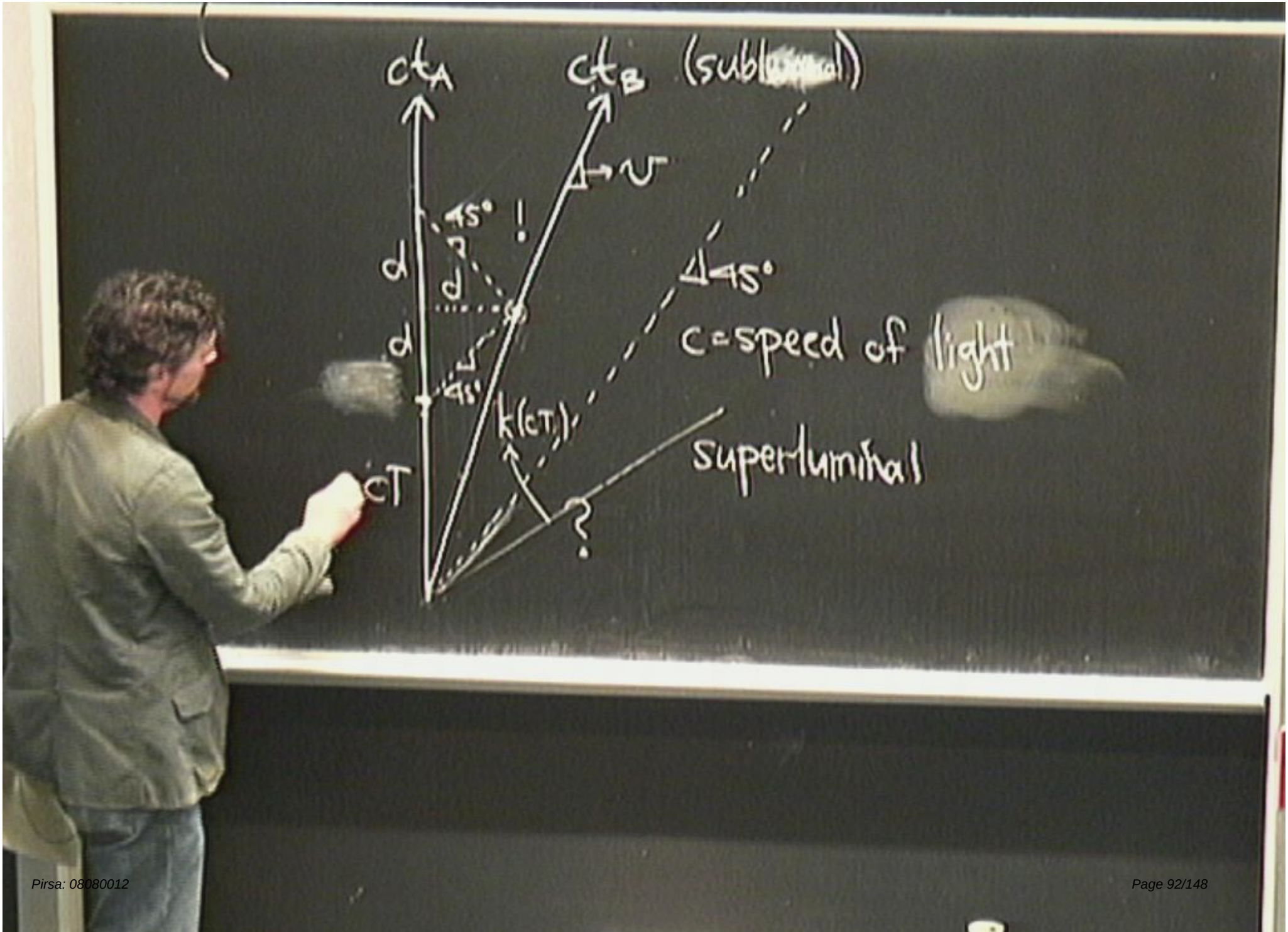

A
B
T
kT
A "at rest"
simple expt.
Same k
equally entitled
"at rest"
A
B
kT
T
B "at rest"
Same expt.

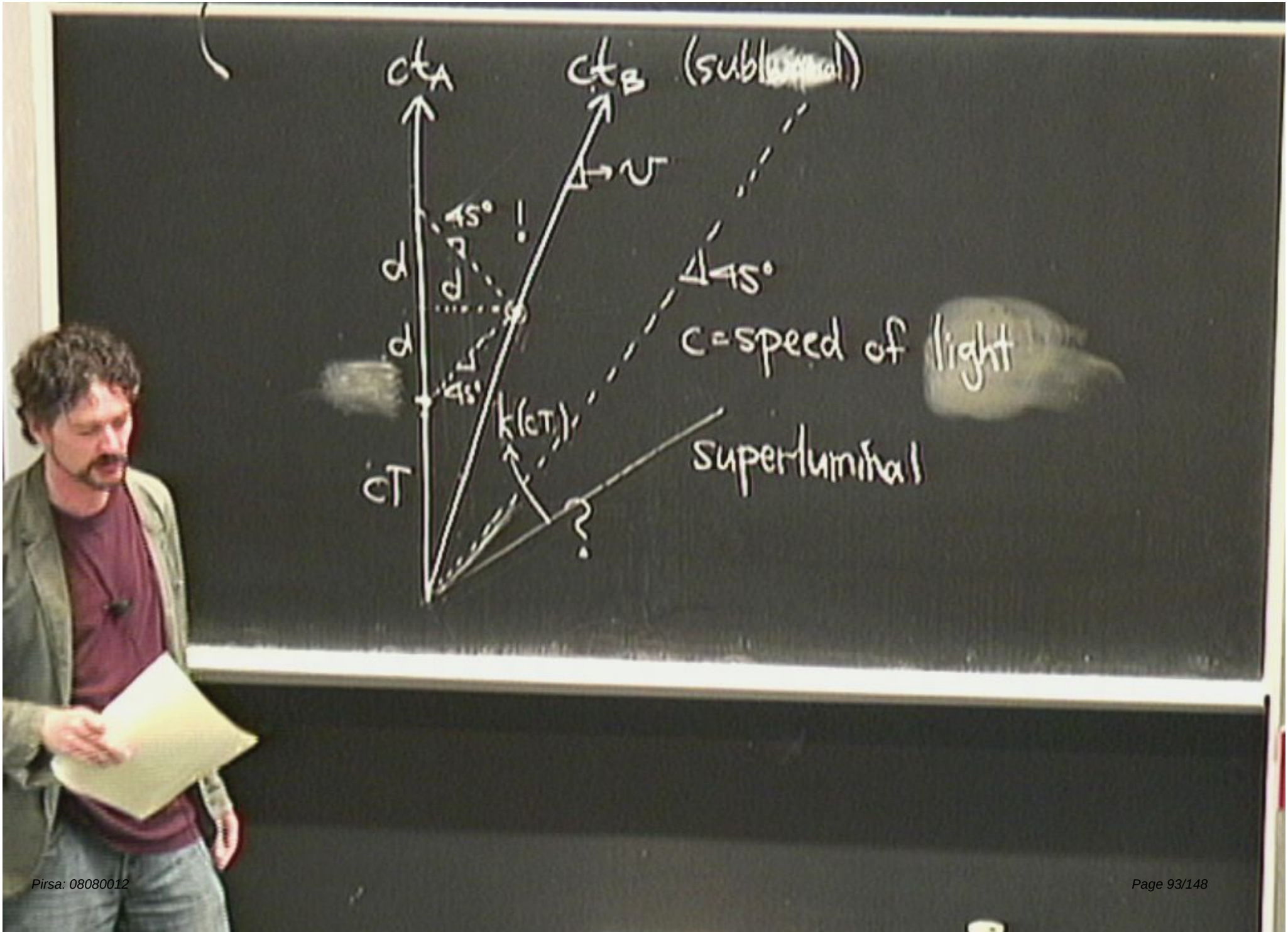

A
B
kT
T


P1
A
B
kT
T
Bdb's expt
P.o.V. A "at rest"


A
B
kT
T
A
B
Bob's expt
P.a.v. A "at rest"

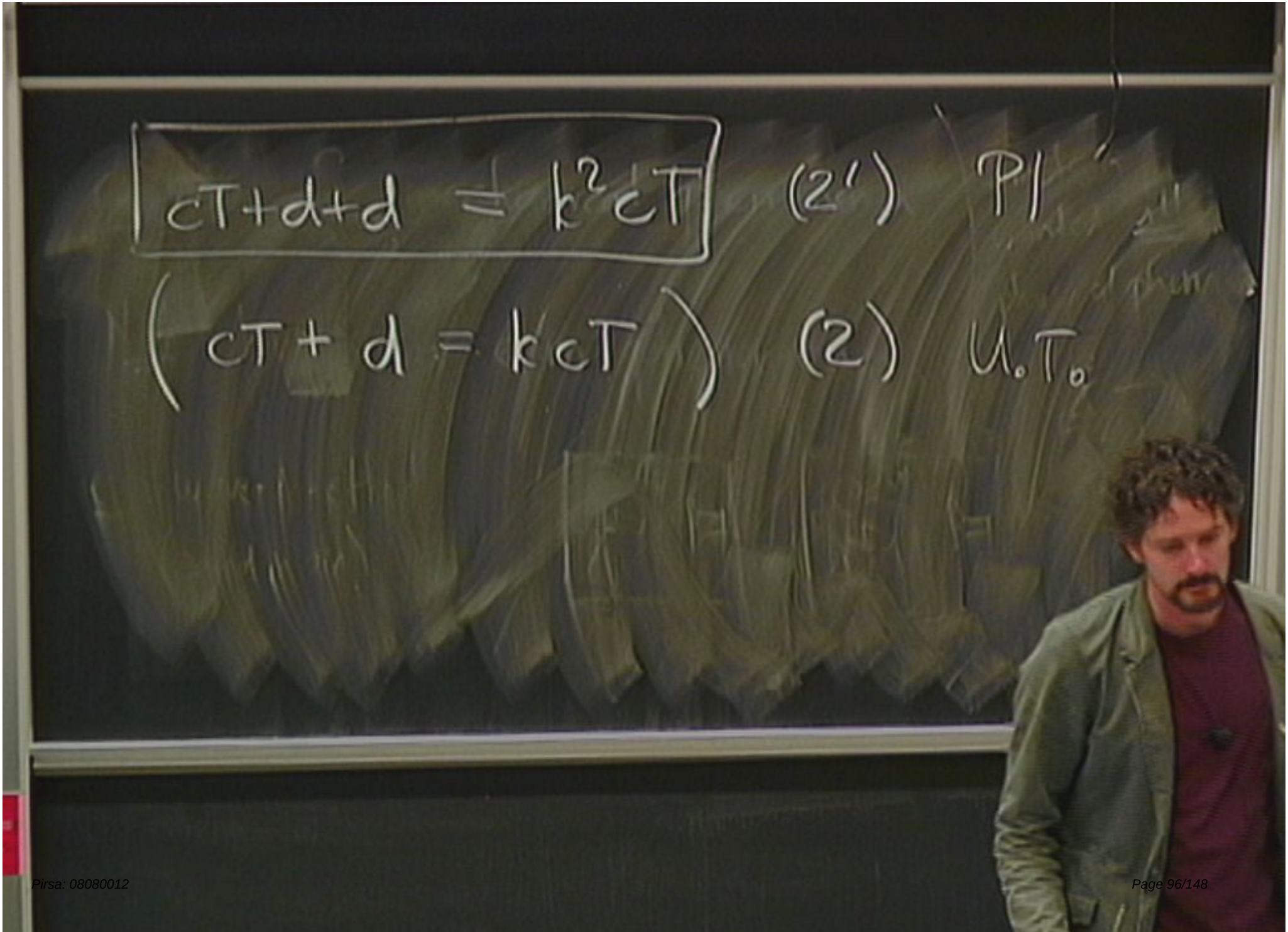

A
B
kT
T
ct_A
ct_B
A
B
ck^2T
ckT
Bob's expt
P.o.V. A "at rest"


ct_A
ct_B
(subl[illegible]al)
v
45°
d
d
d
45°
45°
c=speed of light
k(cT)
cT
superluminal
?


ct_A
ct_B
(subl
45°
d
d
d
45°
cT
k(cT)
c=speed of light
superluminal
?

$$cT + d + d = k^2 cT$$

$$cT + d + d = k^2 cT \qquad (2')$$


cT+d+d = k²cT (2') PI
(cT + d = kcT) (2) U.T.

$$cT + d + d = k^2 cT \quad (2') \quad \text{P.I.}$$

$$\left(cT + d = k\,cT \right) \quad (2) \quad \text{U.T.}_0$$

recall: (1)

$$cT + d + d = k^2 cT \qquad (2') \quad \text{P!}$$

$$\left(cT + d = k\,cT \right) \qquad (2) \quad \text{U.T.}$$

recall: (1) $\dfrac{d}{cT} = \dfrac{v/c}{1 - v/c}$

$$cT + d + d = k^2 cT \qquad (2') \quad \text{PI}$$

$$\left(cT + d = k\,cT \right) \qquad (2) \quad \text{U.T.}_0$$

recall: (1) $\dfrac{d}{cT} = \dfrac{v/c}{1 - v/c}$

$(1)+(2') \Rightarrow$ $\boxed{k = \sqrt{\dfrac{1+v/c}{1-v/c}}}$

$$cT + d + d = k^2 cT \qquad (2') \quad P!$$

$$\left(cT + d = k\,cT \right) \qquad (2) \quad U.T_0$$

recall: (1) $\dfrac{d}{cT} = \dfrac{v/c}{1 - v/c}$

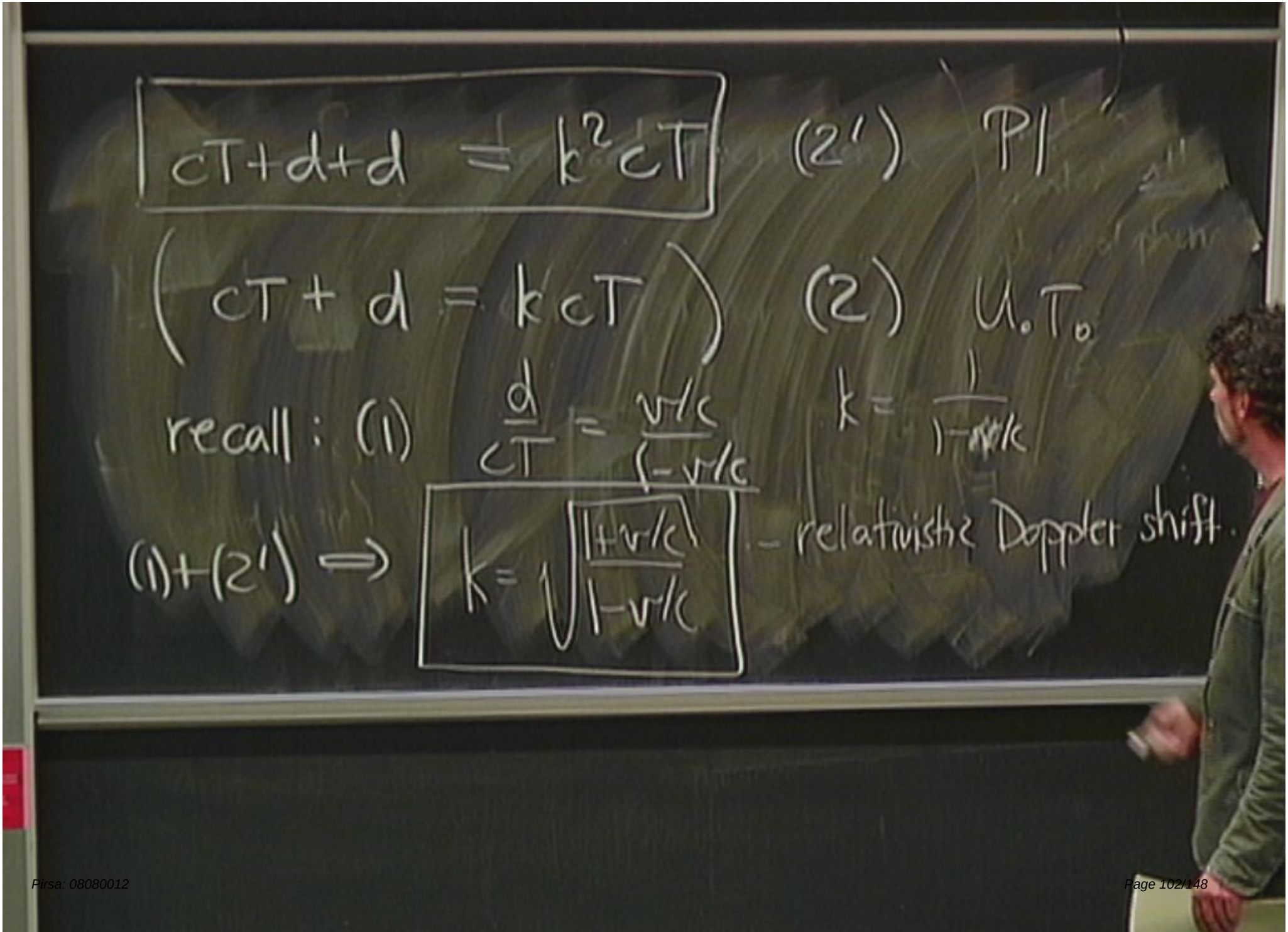
$(1)+(2') \Rightarrow$ $\boxed{k = \sqrt{\dfrac{1+v/c}{1-v/c}}}$ - relativistic Doppler shift.

$$cT + d + d = k^2 cT \qquad (2') \quad P!$$

$$\left(cT + d = k\,cT \right) \qquad (2) \quad U.T.$$

recall: (1) $\dfrac{d}{cT} = \dfrac{v/c}{1 - v/c}$

$(1)+(2') \Longrightarrow$ $\boxed{k = \sqrt{\dfrac{1+v/c}{1-v/c}}}$ - relativistic Doppler shift.


$cT+d+d = k^2cT$ (2′) P1
$(cT + d = kcT)$ (2) U.T.
recall: (1) $\frac{d}{cT} = \frac{v/c}{1-v/c}$ $k = \frac{1}{1-v/c}$
(1)+(2′) $\Rightarrow$ $k = \sqrt{\frac{1+v/c}{1-v/c}}$ - relativistic Doppler shift.

$$cT + d + d = k^2 cT \qquad (2') \quad P!$$

$$\left(cT + d = k\,cT \right) \qquad (2) \quad U.T.$$

recall: (1) $\dfrac{d}{cT} = \dfrac{v/c}{1 - v/c}$ $\qquad k = 1 - v/c$

(1)+(2') $\Rightarrow$ $\boxed{k = \sqrt{\dfrac{1+v/c}{1-v/c}}}$ - relativistic Doppler shift.

$$cT + d + d = k^2 cT \qquad (2') \quad \text{P!}$$

$$\left(cT + d = k\,cT \right) \qquad (2) \quad \text{U.T.}$$

recall: (1) $\dfrac{d}{cT} = \dfrac{v/c}{1 - v/c}$ $\qquad k = \sqrt{1 - v/c}$

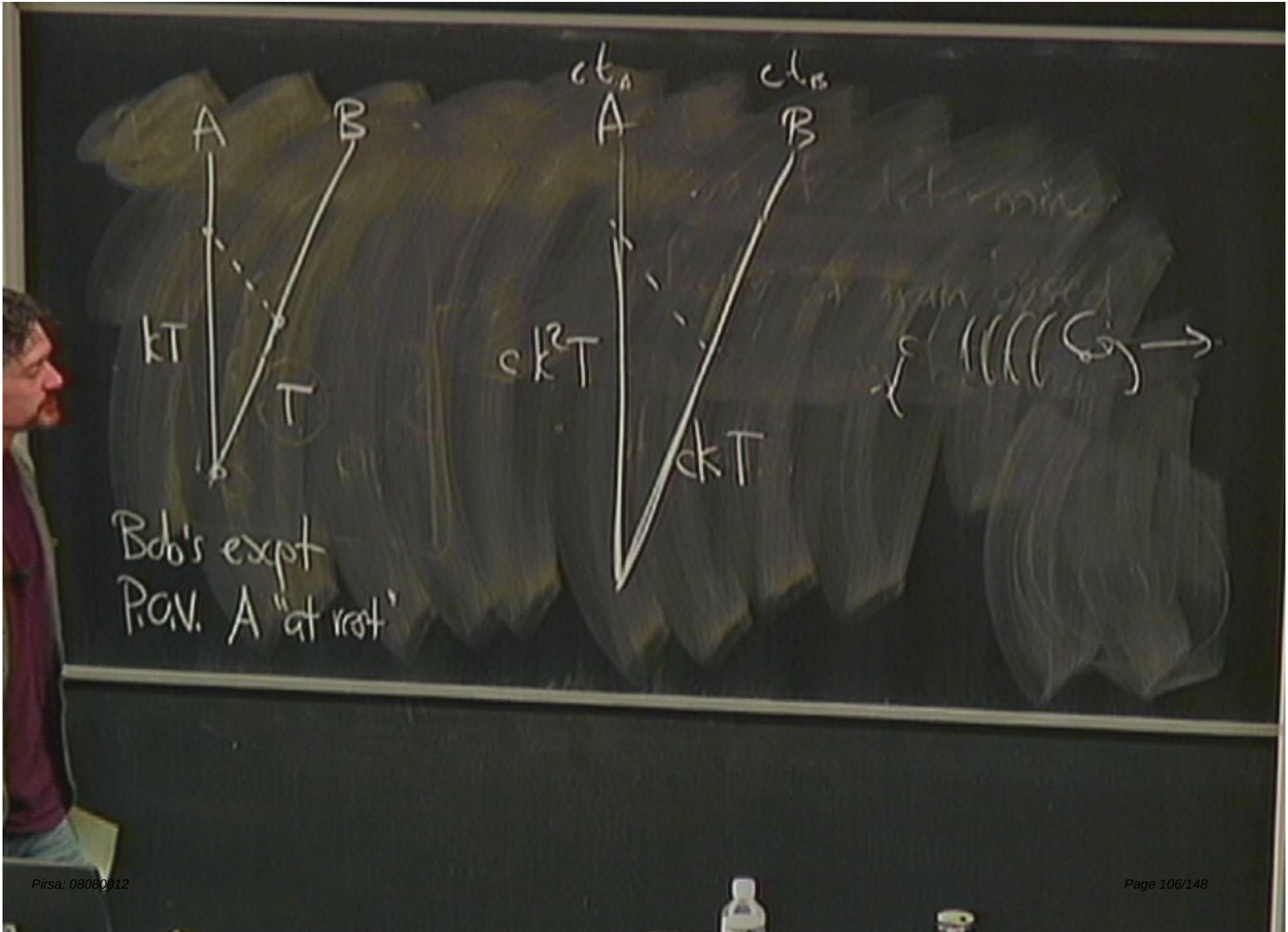
$$(1)+(2') \Rightarrow \boxed{k = \sqrt{\frac{1+v/c}{1-v/c}}}$$ - relativistic Doppler shift.

$$cT + d + d = k^2 cT \qquad (2') \quad \text{P!}$$

$$\left(cT + d = k\,cT \right) \qquad (2) \quad \text{U.T.}$$

recall: (1) $\dfrac{d}{cT} = \dfrac{v/c}{1 - v/c}$ $\qquad \dfrac{1}{k} = 1 - v/c$

$$(1)+(2') \Rightarrow \boxed{k = \sqrt{\frac{1+v/c}{1-v/c}}}$$ - relativistic Doppler shift.

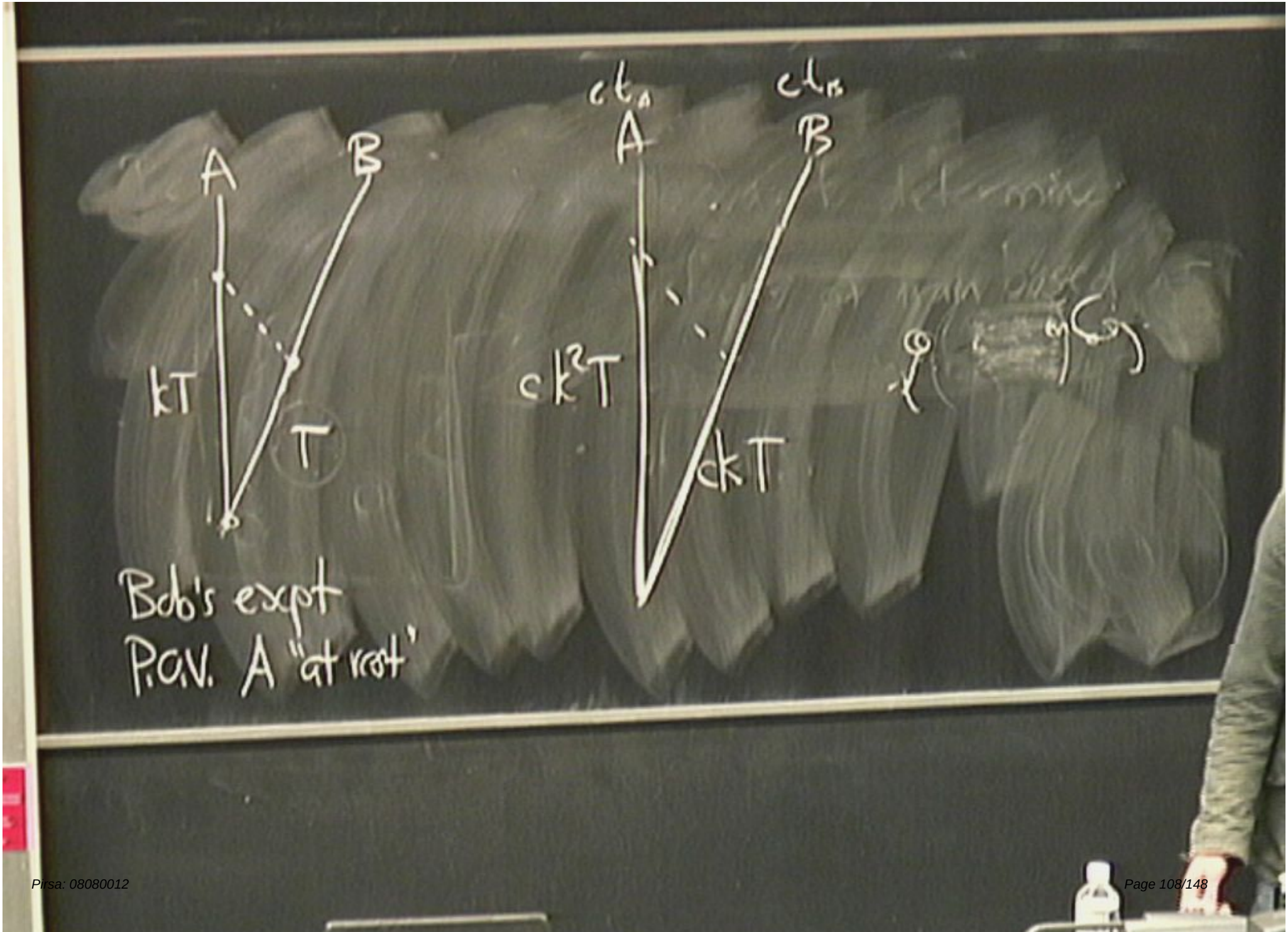

A
B
kT
T
Bob's expt
P.o.V. A "at rest"
A
B
ckT
ckT

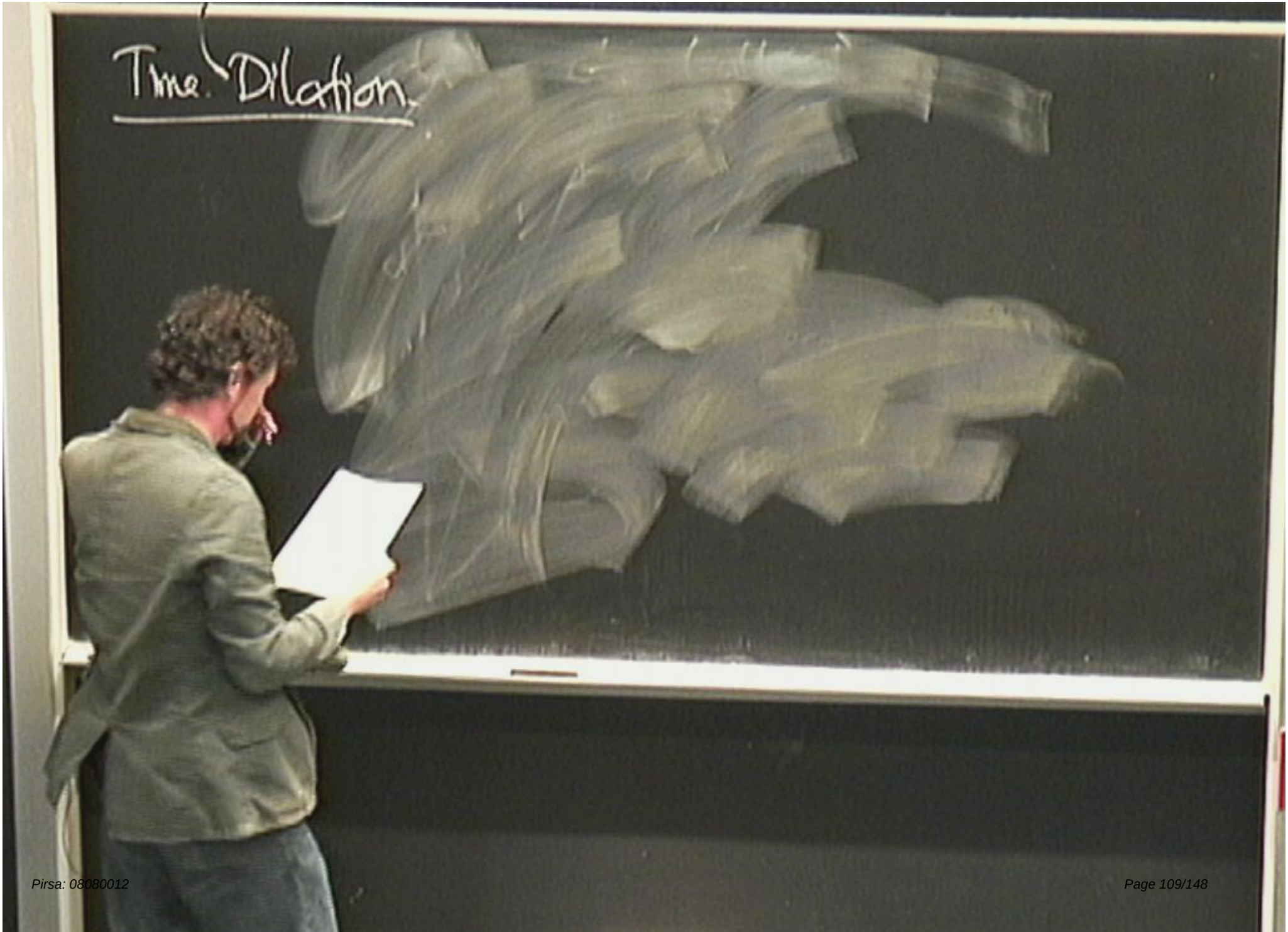
$cT + d + d = k^2 cT$ (2′) PI

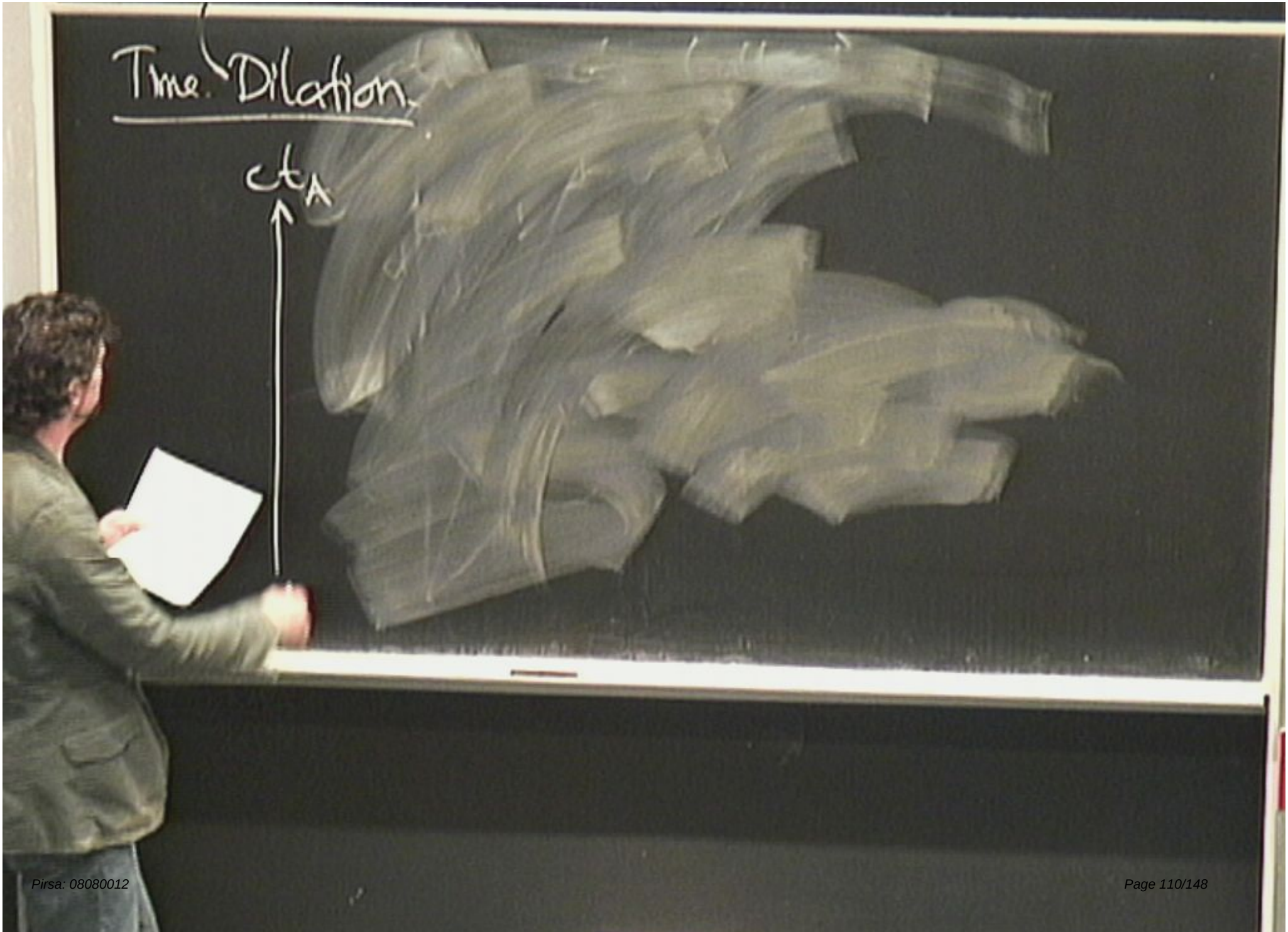
$(cT + d = kcT)$ (2) U.T.

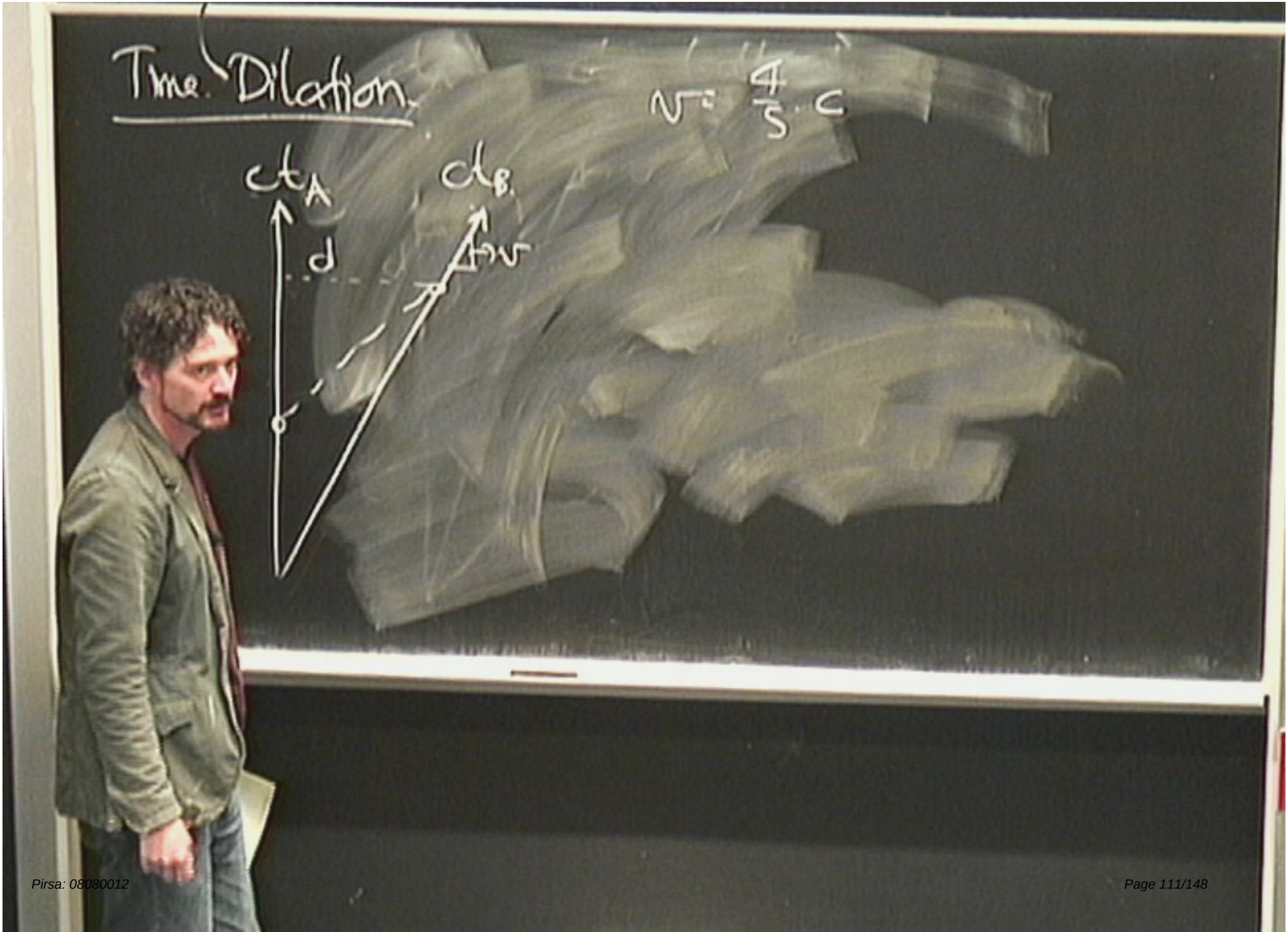
recall: (1) $\frac{d}{cT} = \frac{v/c}{1 - v/c}$ $\frac{1}{k} = 1 - v/c$

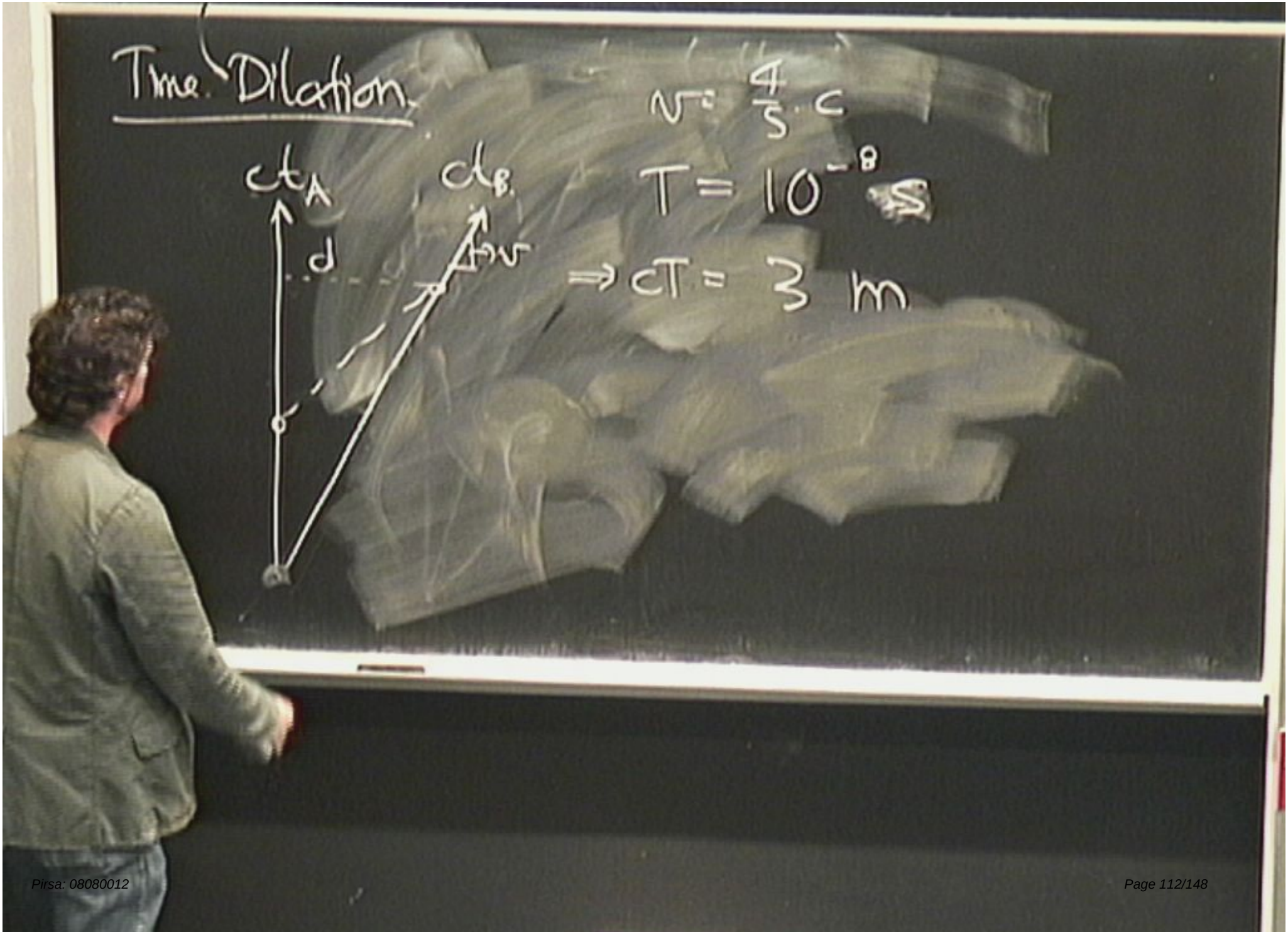
(1)+(2′) $\Rightarrow$ $k = \sqrt{\frac{1+v/c}{1-v/c}}$ – relativistic Doppler shift.


A
B
kT
T
Bob's expt
P.a.v. A "at rest"
A
B
ckT
ckT


Time Dilation


Time Dilation
ct

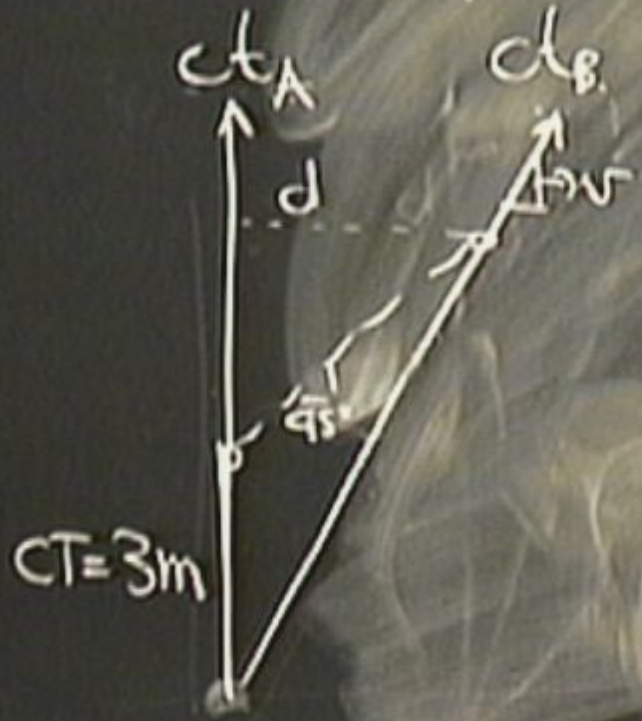

Time Dilation
v = 4/5 · c
ct_A
ct_B
d
vt


Time Dilation
$v = \frac{4}{5} \cdot c$
ct_A
ct_B
d
$T = 10^{-8}$ s
$\Rightarrow cT = 3$ m

Time Dilation

$v = \frac{4}{5} \cdot c$

$T = 10^{-8}$ s



$\Rightarrow cT = 3$ m

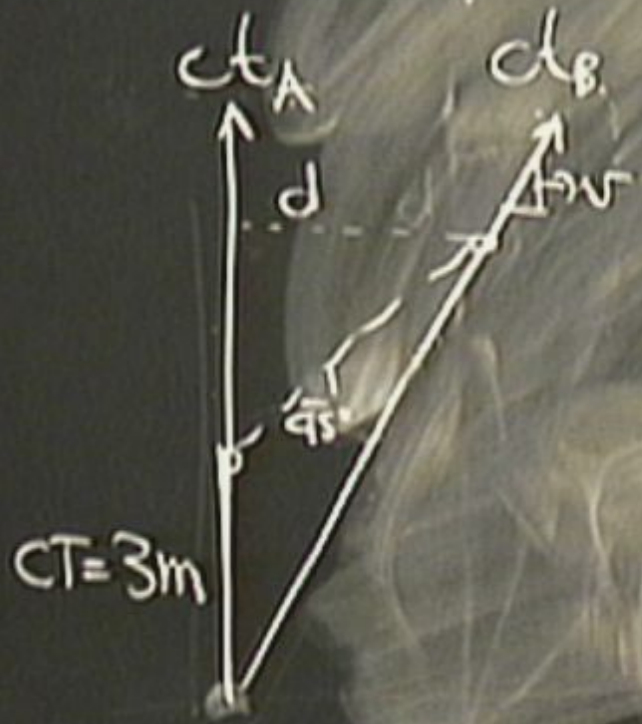
Recall $\frac{d}{cT} = \frac{v/c}{1 - v/c}$

$\Rightarrow d = \frac{4/5}{1 - 4/5}(3\text{m}) =$

Time Dilation

$v = \frac{4}{5} c$

$T = 10^{-8}$ s

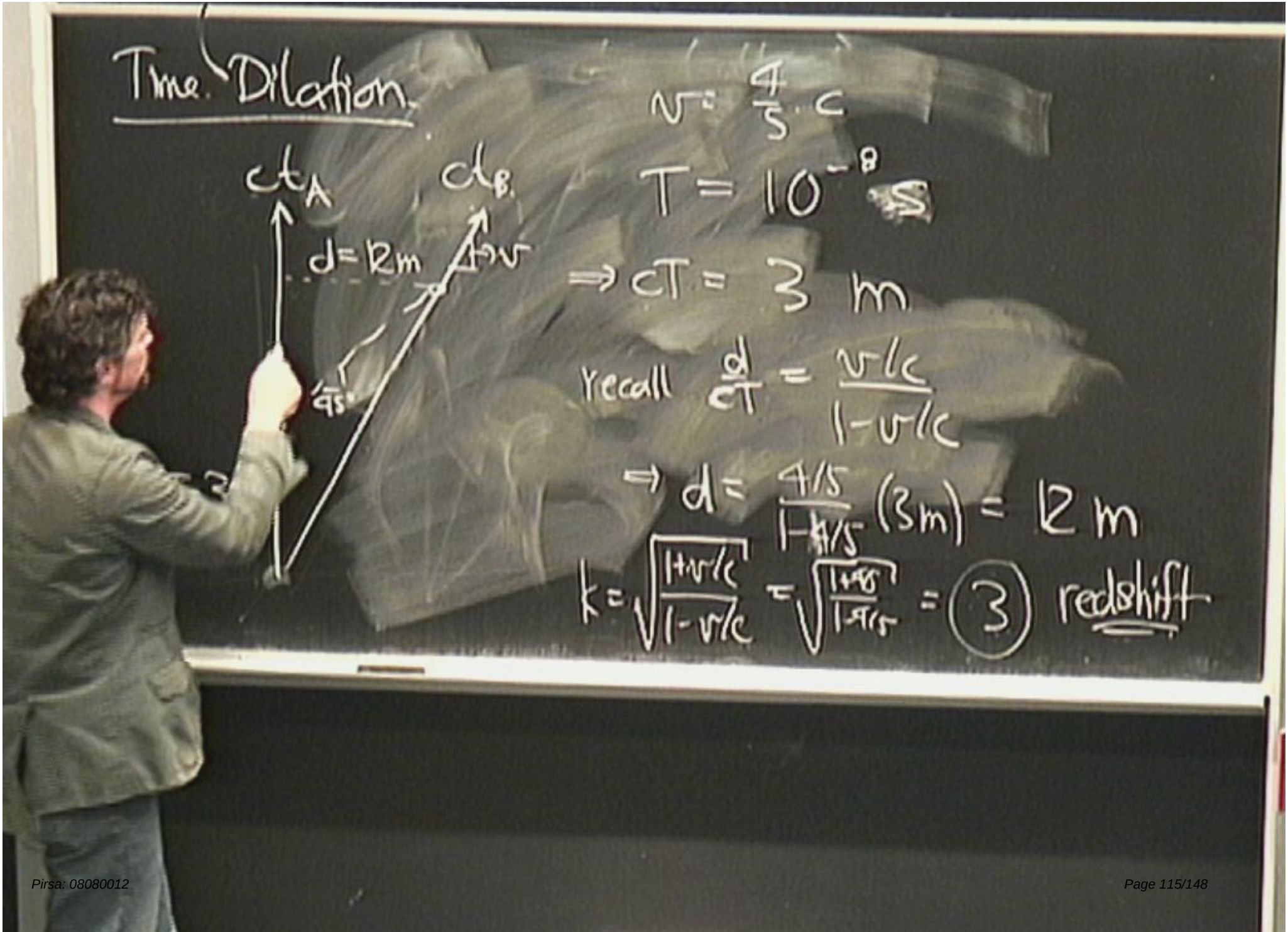


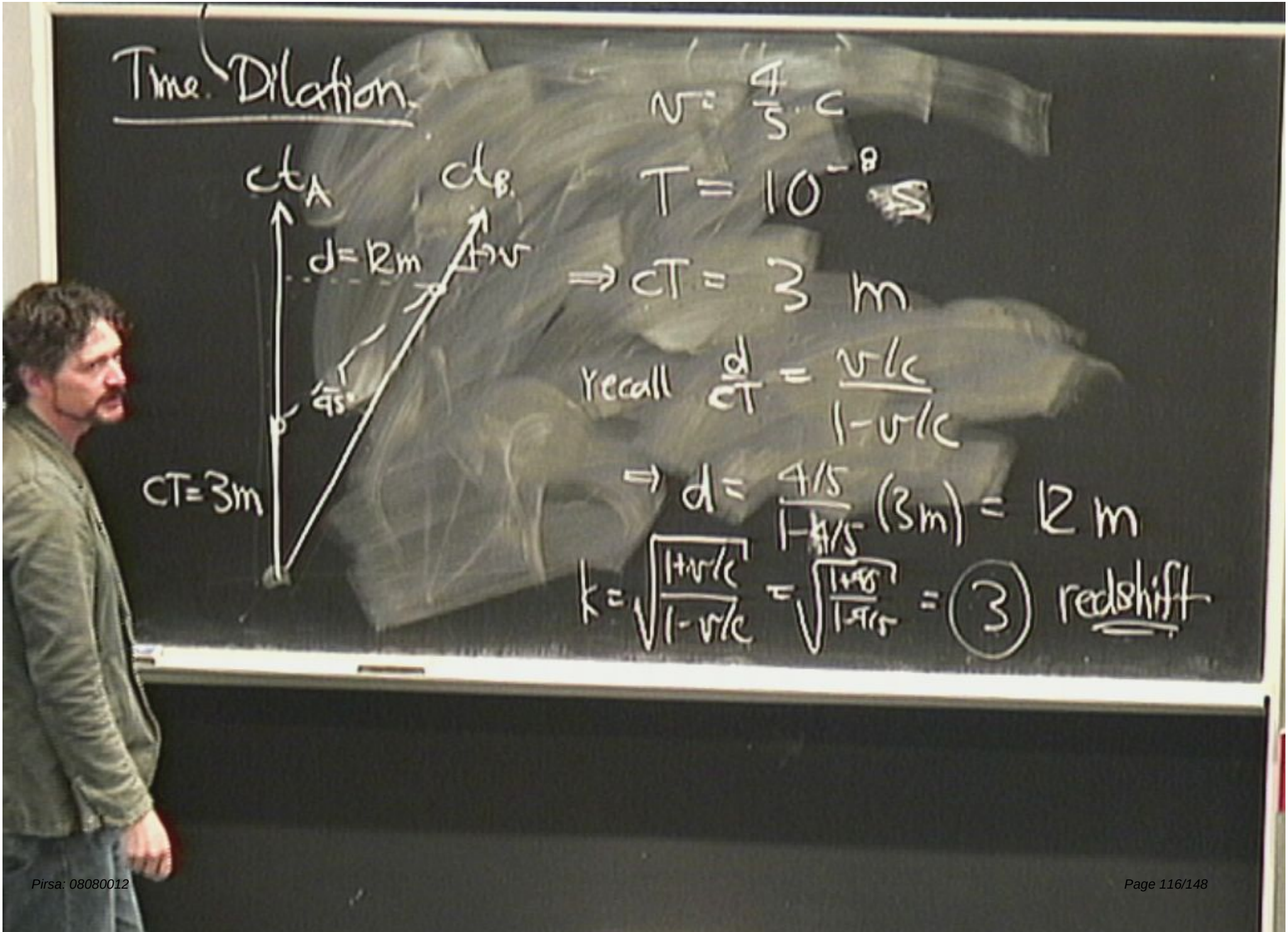
$\Rightarrow cT = 3$ m

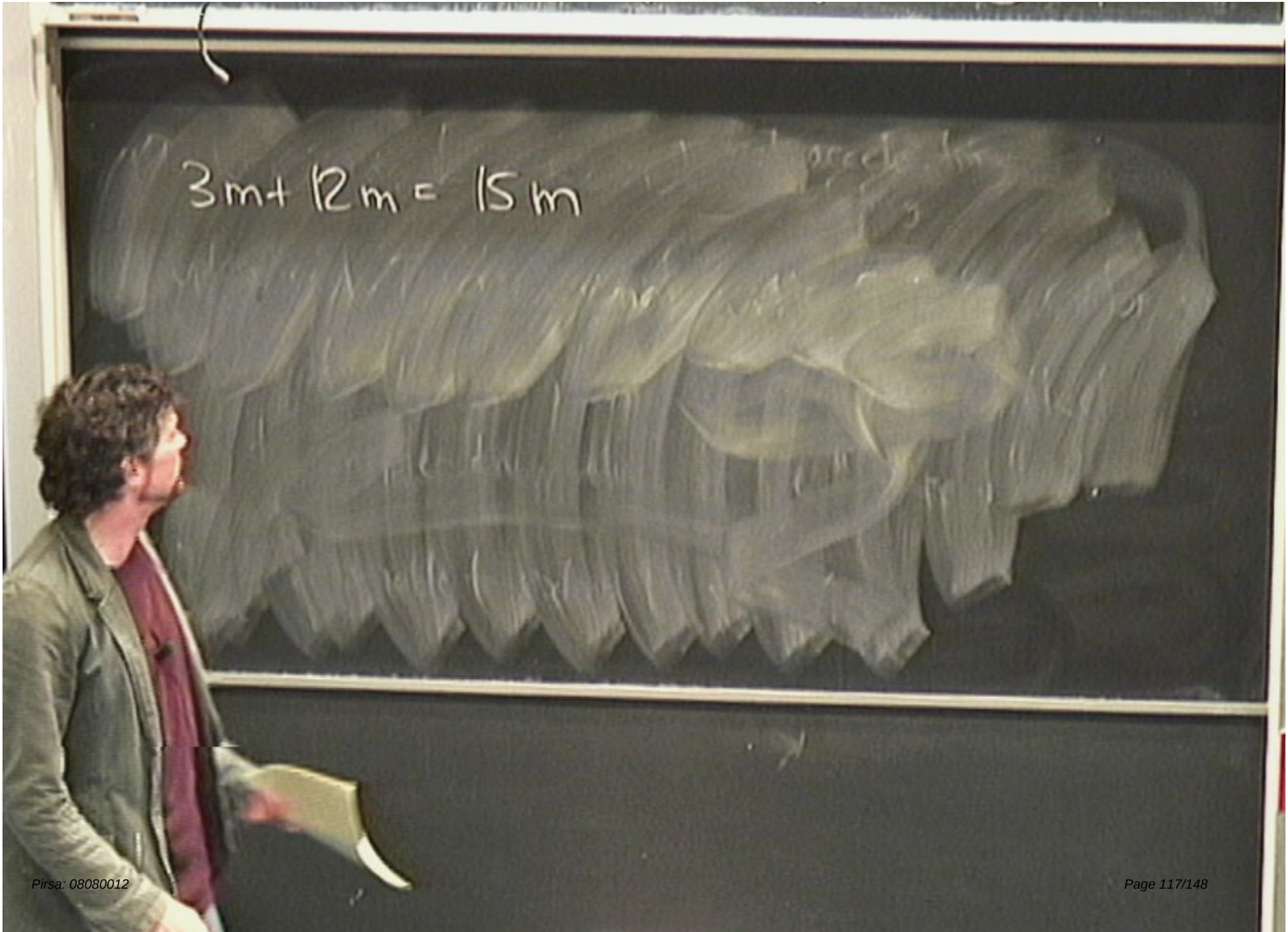
Recall $\frac{d}{cT} = \frac{v/c}{1 - v/c}$

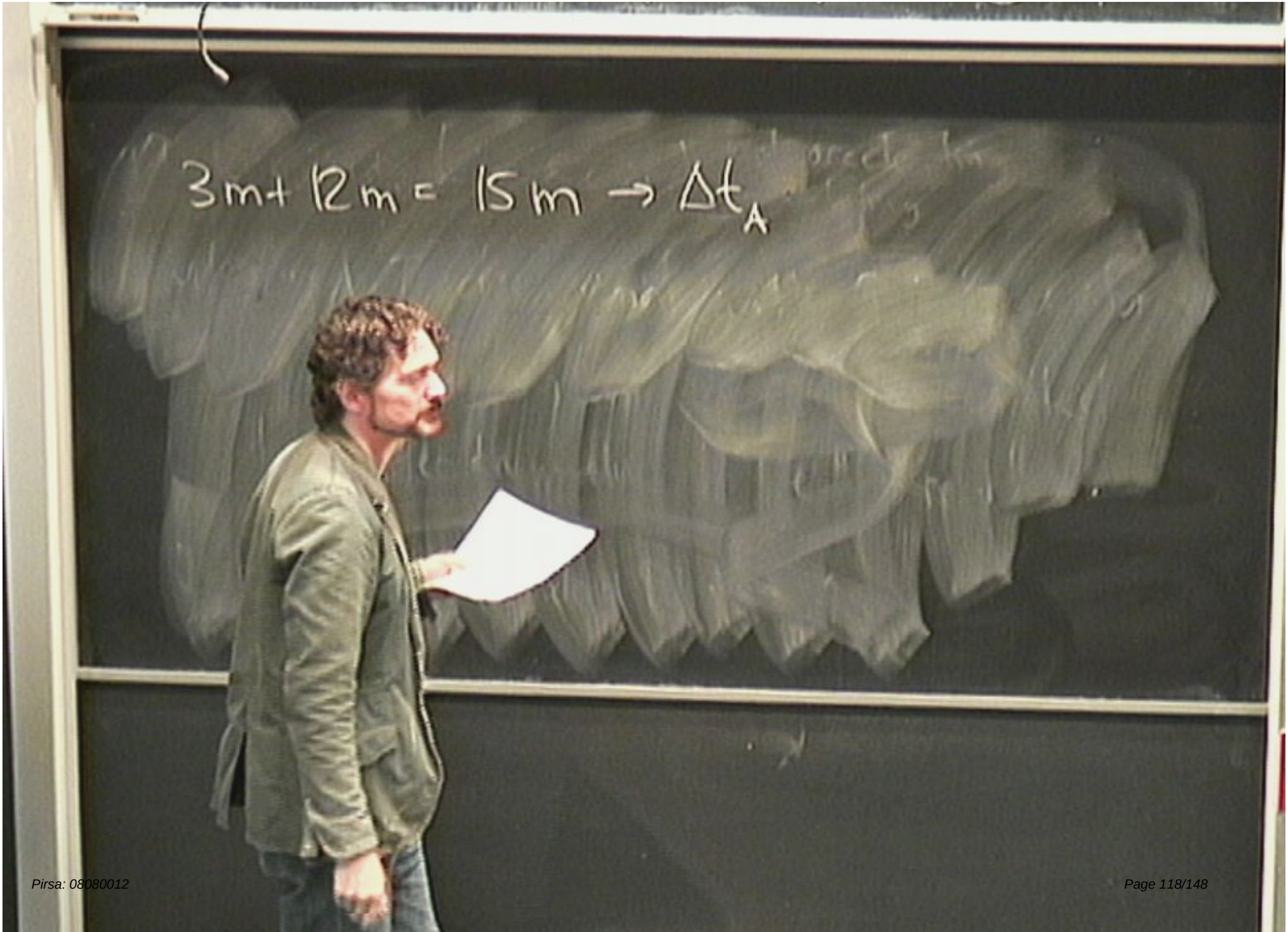
$\Rightarrow d = \frac{4/5}{1 - 4/5}(3\text{m}) = 12$ m

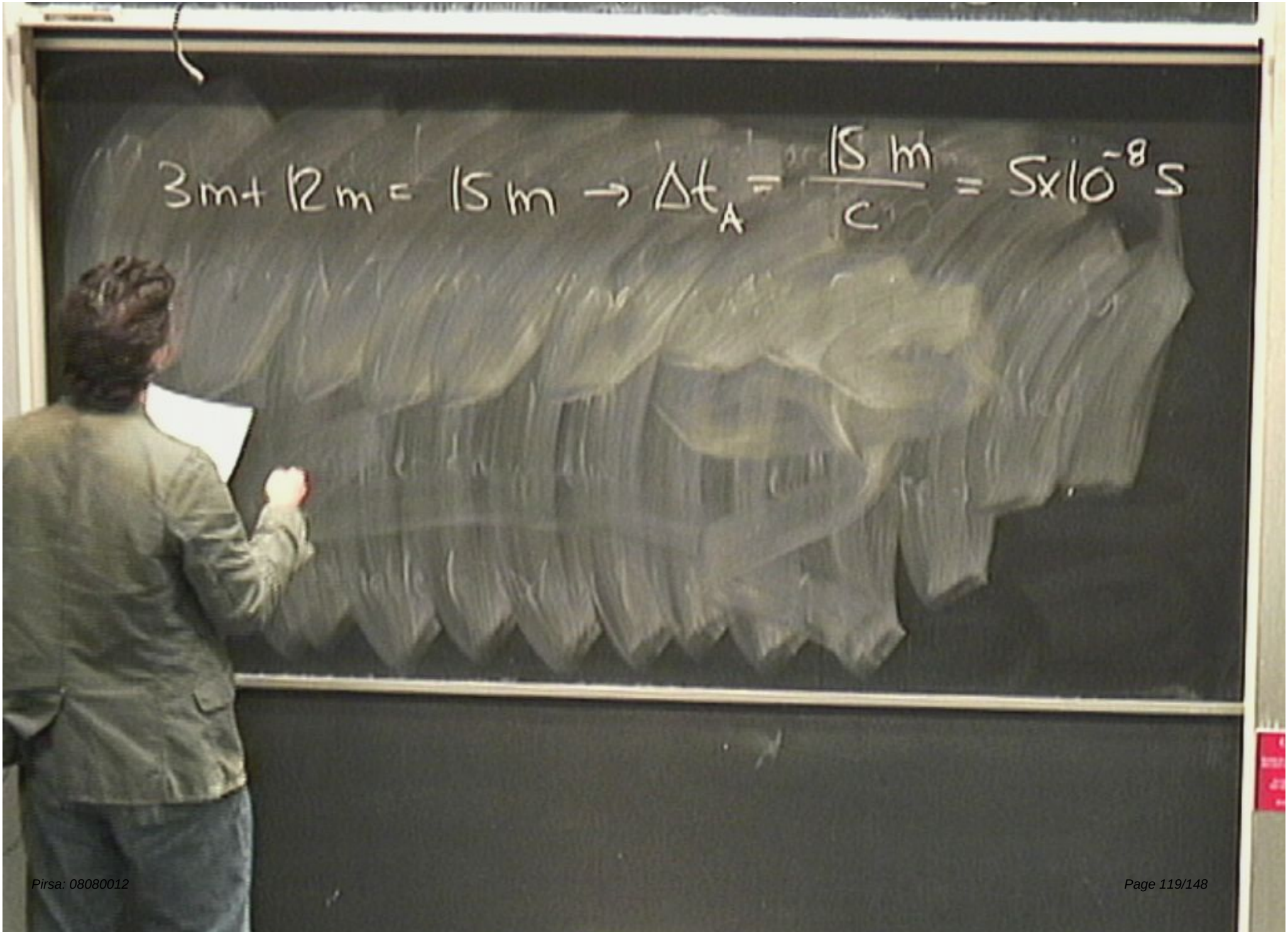
$k = \sqrt{\frac{1+v/c}{1-v/c}} = \sqrt{\frac{1+4/5}{1-4/5}} = 3$

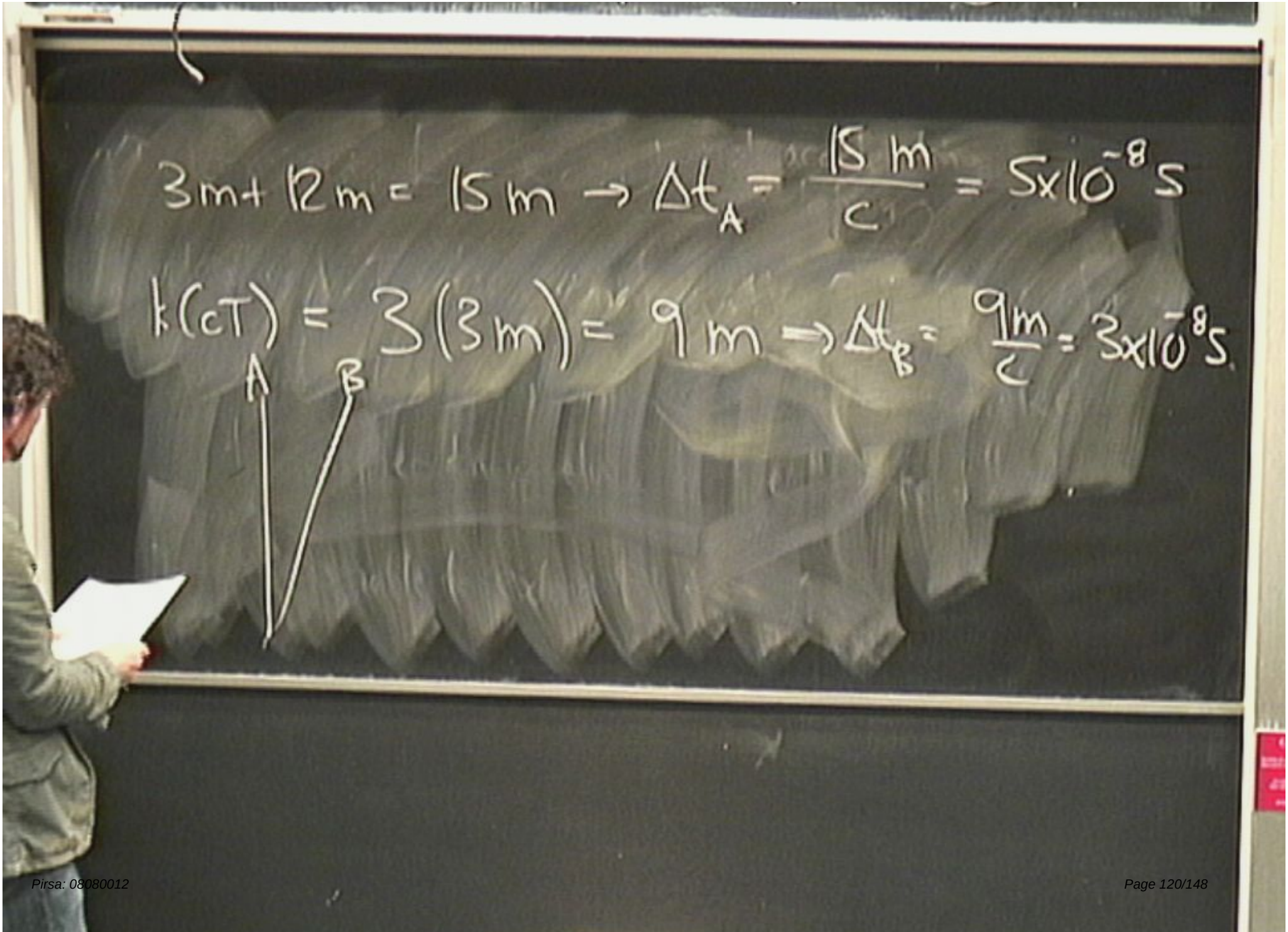

Time Dilation
$v = \frac{4}{5} \cdot c$
$T = 10^{-8}$ s
ct_A
ct_B
$d = 12$ m
$\Rightarrow cT = 3$ m
Recall $\frac{d}{cT} = \frac{v/c}{1 - v/c}$
$\Rightarrow d = \frac{4/5}{1 - 4/5}(3\text{m}) = 12$ m
$k = \sqrt{\frac{1+v/c}{1-v/c}} = \sqrt{\frac{1+\frac{4}{5}}{1-\frac{4}{5}}} = 3$ redshift


Time Dilation
$v = \frac{4}{5} \cdot c$
ct_A
ct_B
$T = 10^{-8}$ s
$d = 12m$
$\Rightarrow cT = 3$ m
45°
Recall $\frac{d}{cT} = \frac{v/c}{1 - v/c}$
$CT = 3m$
$\Rightarrow d = \frac{4/5}{1 - 4/5}(3m) = 12$ m
$k = \sqrt{\frac{1+v/c}{1-v/c}} = \sqrt{\frac{1+\frac{4}{5}}{1-\frac{4}{5}}} = 3$ redshift


3m + 12m = 15m

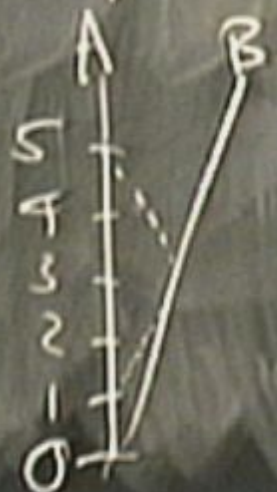

3m + 12m = 15m → Δt_A


3m + 12m = 15m → $\Delta t_A = \frac{15\,m}{c} = 5 \times 10^{-8}\,s$


3m + 12m = 15m → $\Delta t_A = \frac{15\,m}{c} = 5\times10^{-8}\,s$
k(cT) = 3(3m) = 9m → $\Delta t_B = \frac{9m}{c} = 3\times10^{-8}\,s$
A
B

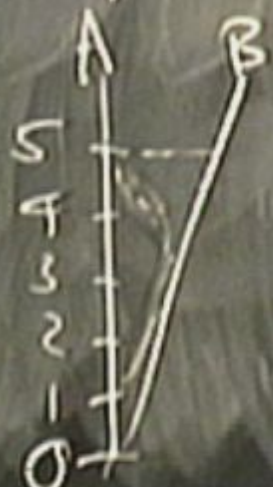
$3m + 12m = 15m \rightarrow \Delta t_A = \frac{15\,m}{c} = 5 \times 10^{-8}\,s$

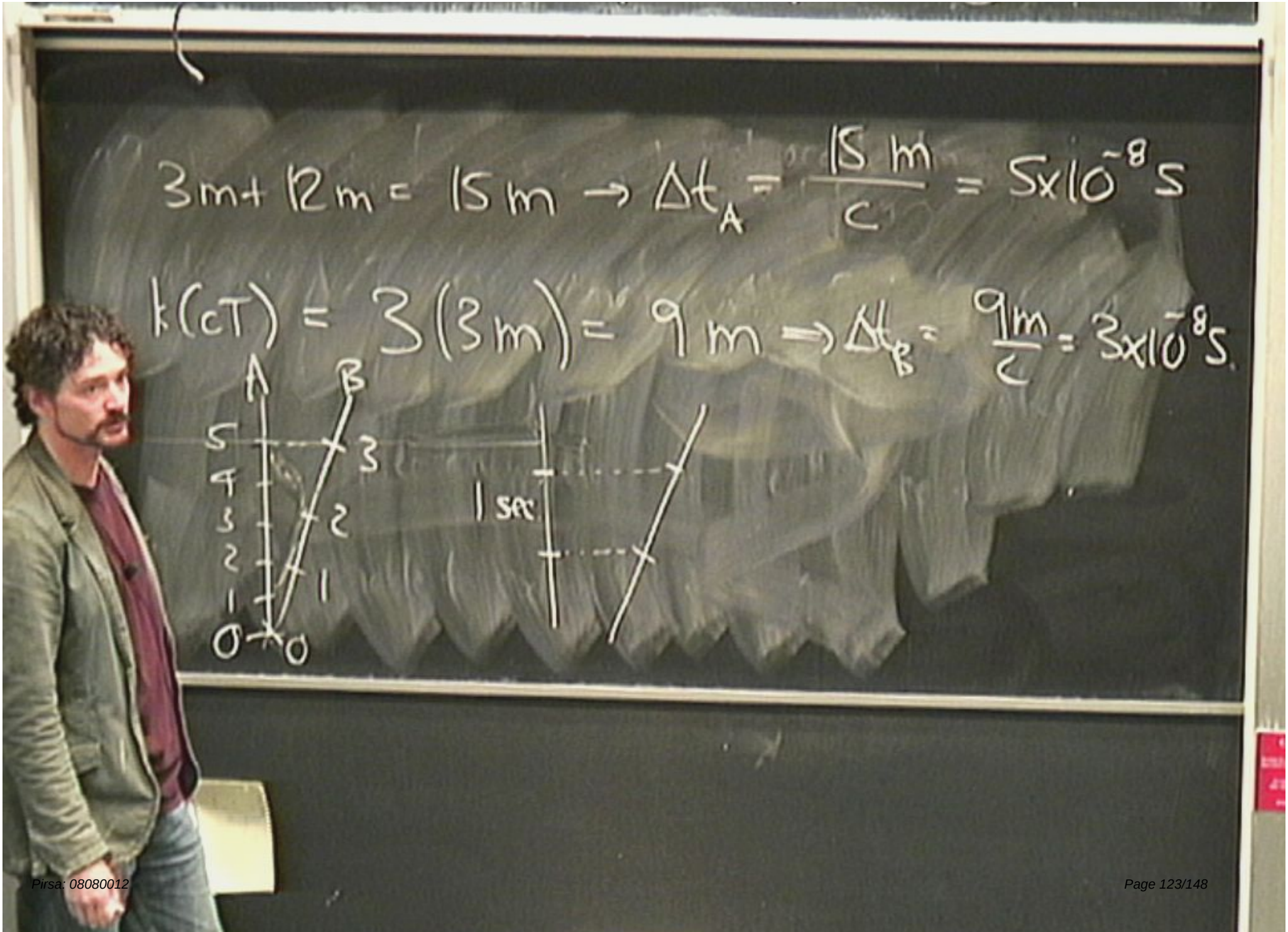
$k(cT) = 3(3m) = 9m \rightarrow \Delta t_B = \frac{9m}{c} = 3 \times 10^{-8}\,s$



$3m + 12m = 15m \rightarrow \Delta t_A = \frac{15\,m}{c} = 5 \times 10^{-8}\,s$

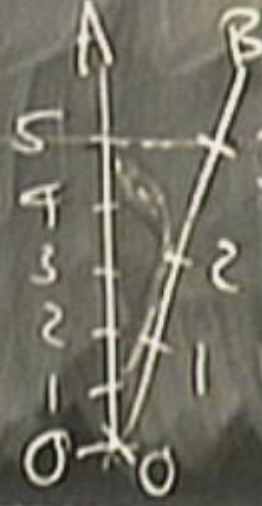
$k(cT) = 3(3m) = 9m \rightarrow \Delta t_B = \frac{9m}{c} = 3 \times 10^{-8}\,s$

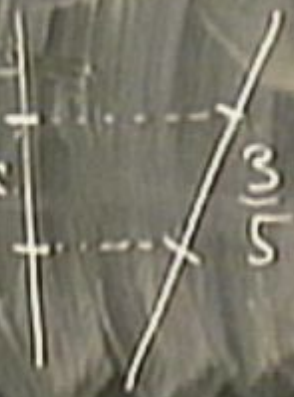



3m + 12m = 15m → Δt_A = 15 m / c = 5x10^-8 s
k(cT) = 3(3m) = 9m → Δt_B = 9m / c = 3x10^-8 s
A
B
5
4
3
2
1
0
3
2
1
0
1 sec

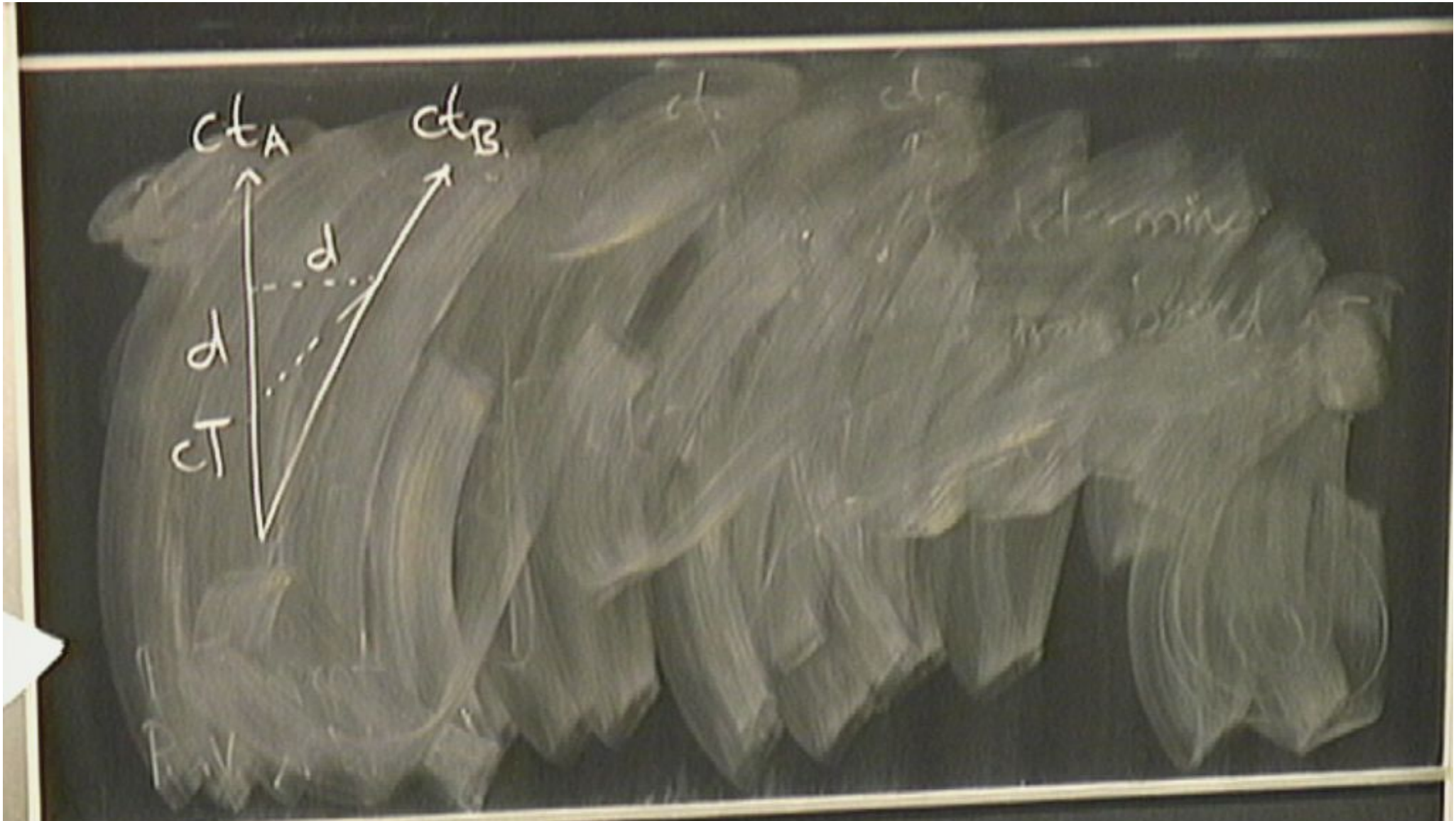
$3m + 12m = 15m \rightarrow \Delta t_A = \frac{15\ m}{c} = 5 \times 10^{-8}\ s$

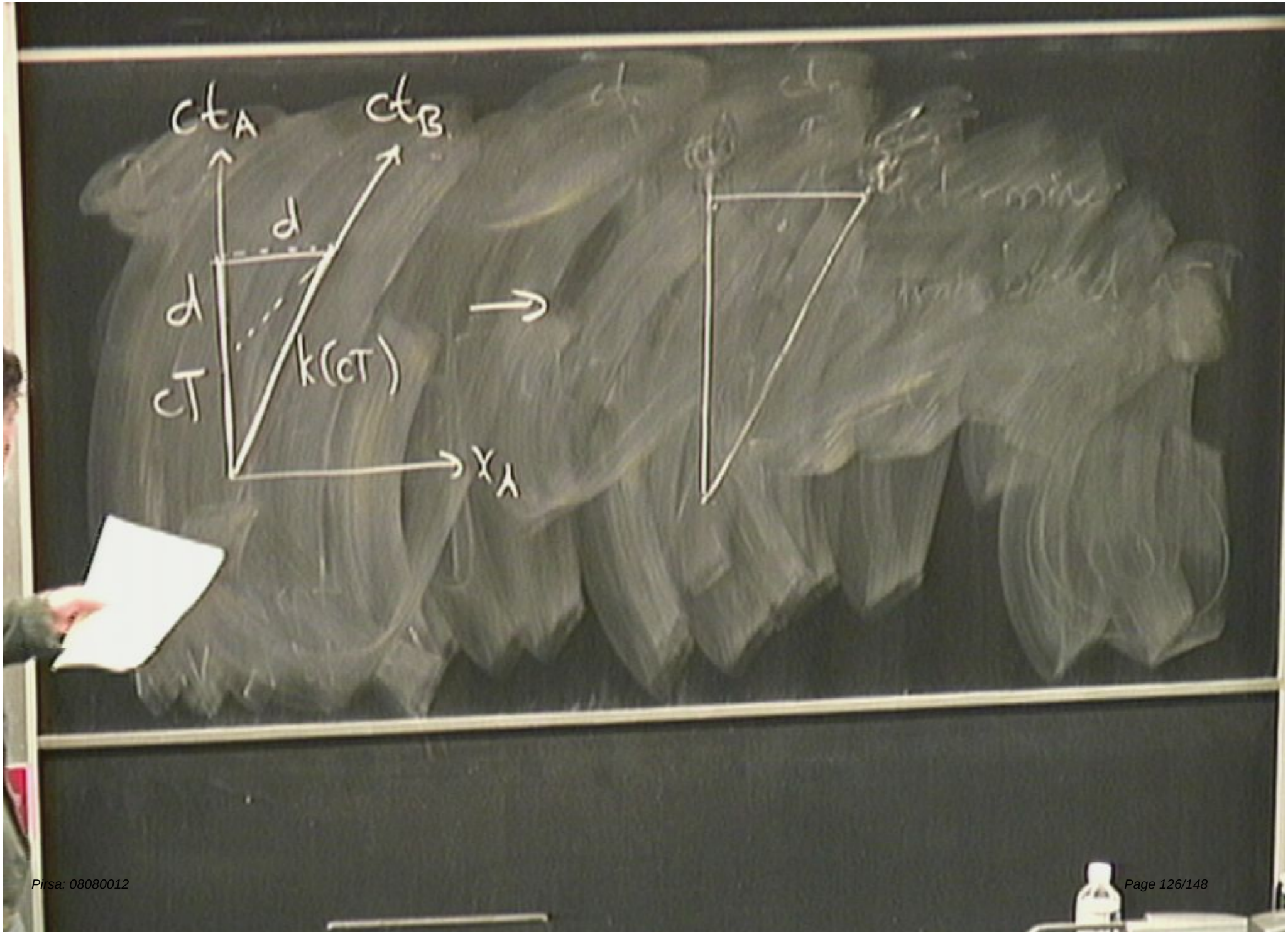
$k(cT) = 3(3m) = 9m \rightarrow \Delta t_B = \frac{9m}{c} = 3 \times 10^{-8}\ s.$

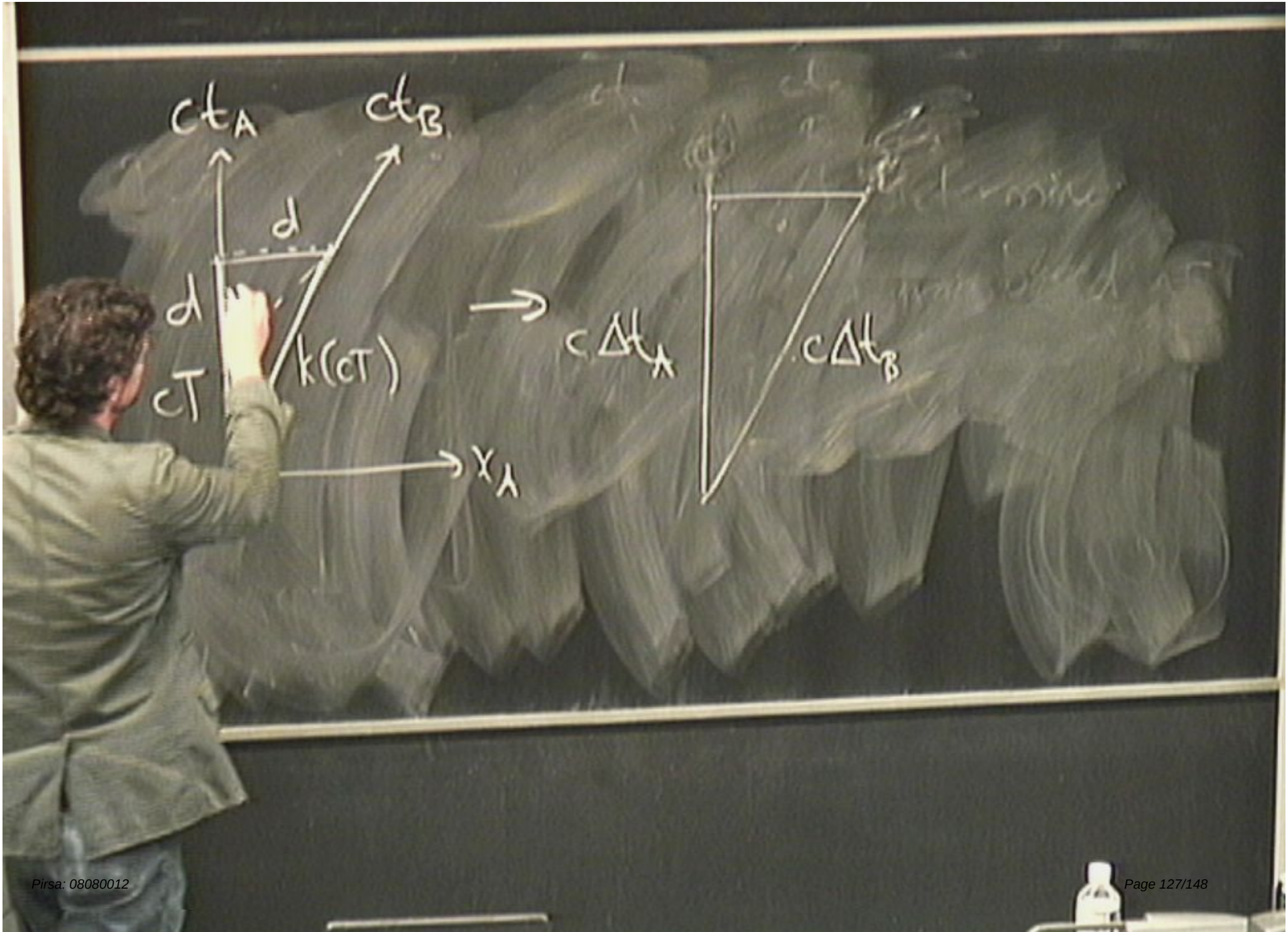


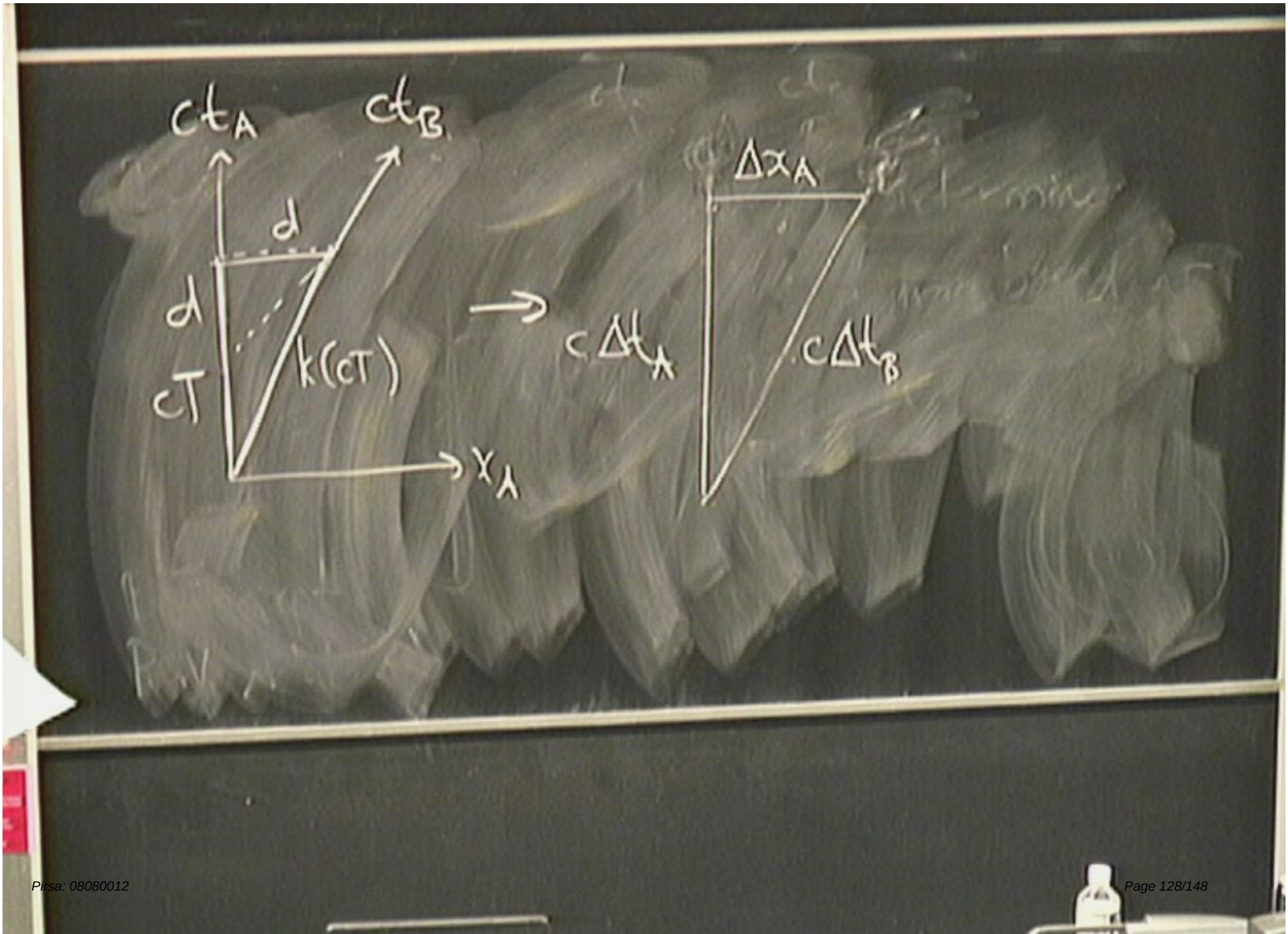


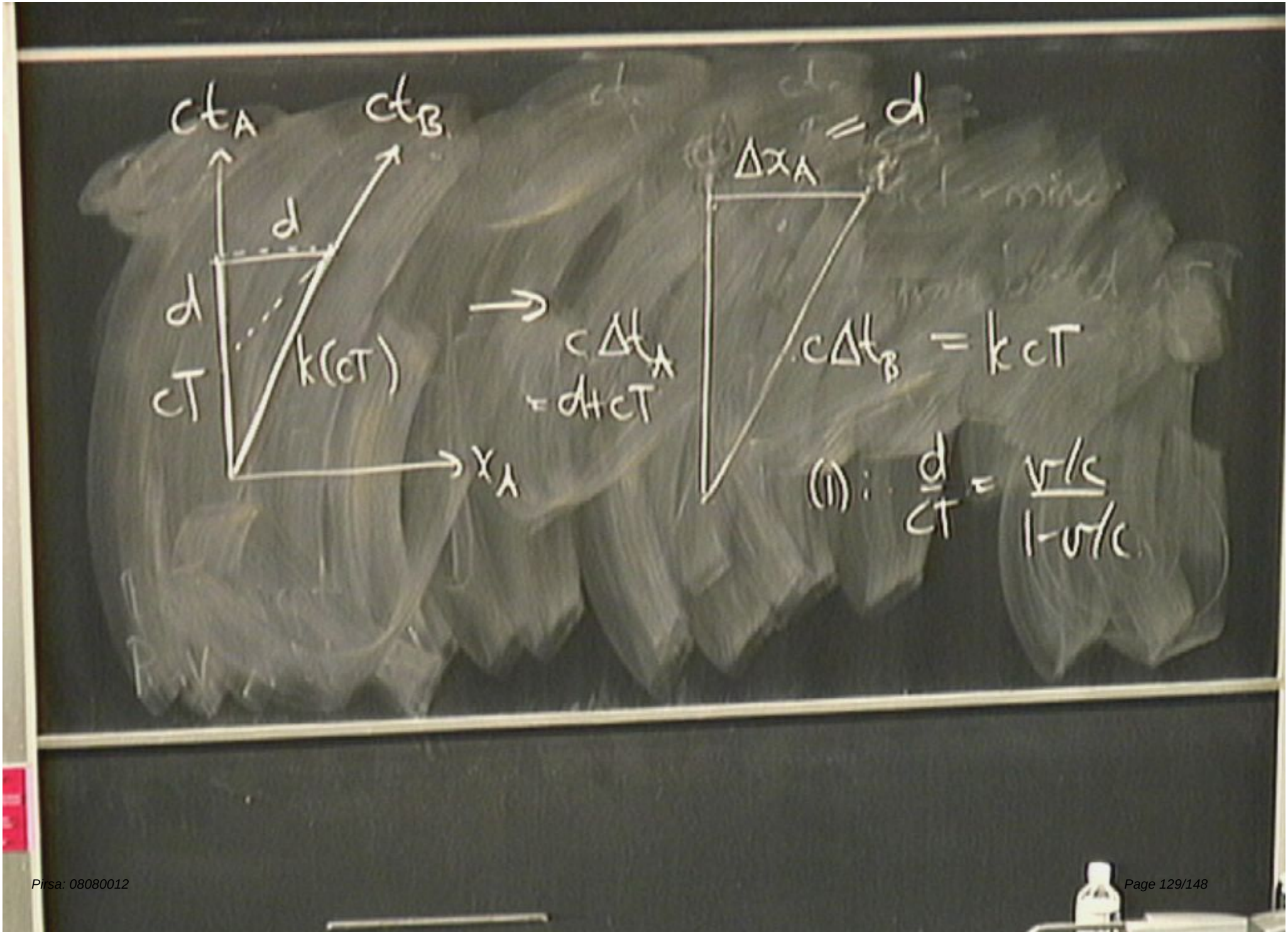
time dilation.

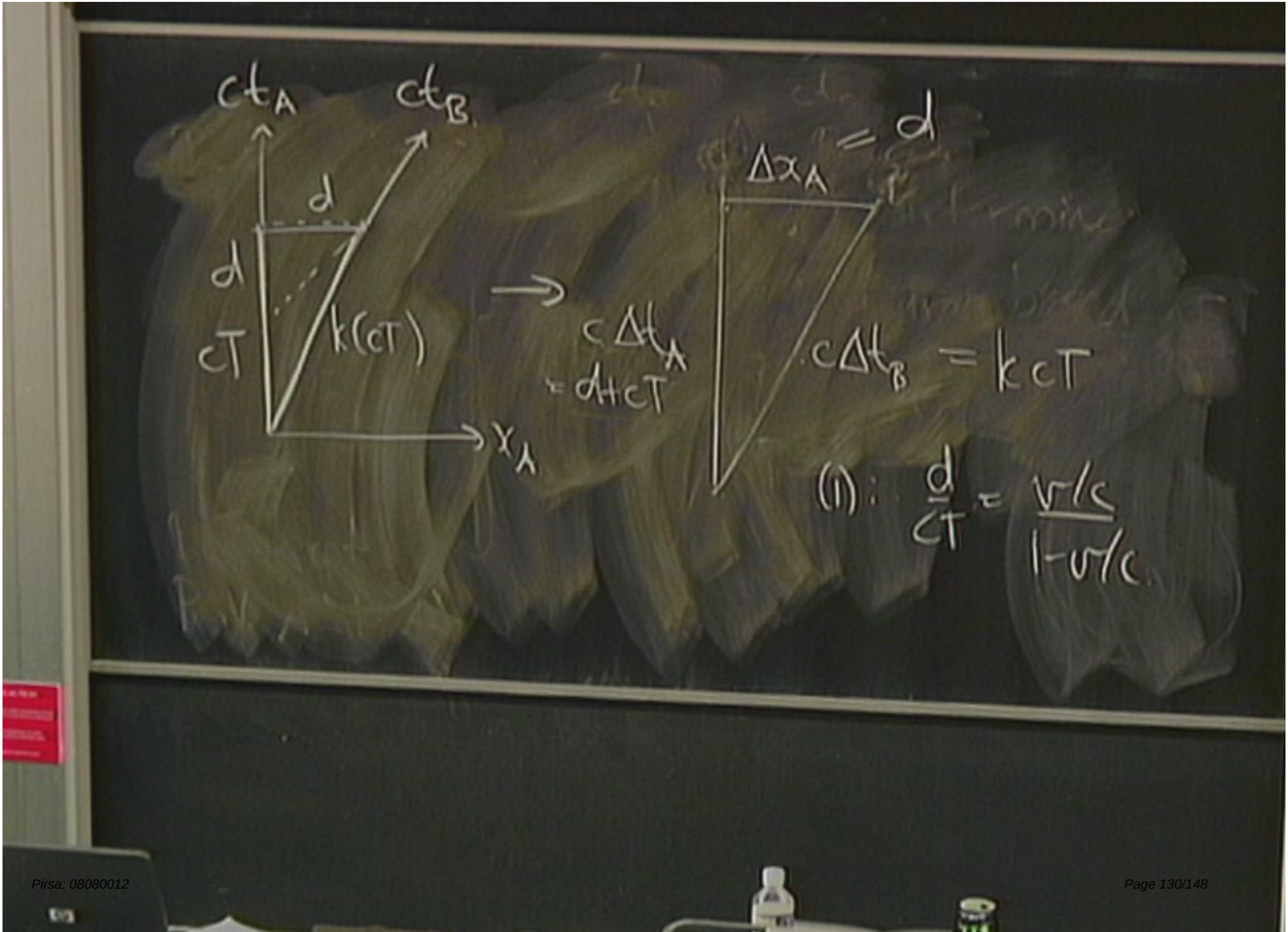

ct_A
ct_B
d
d
cT

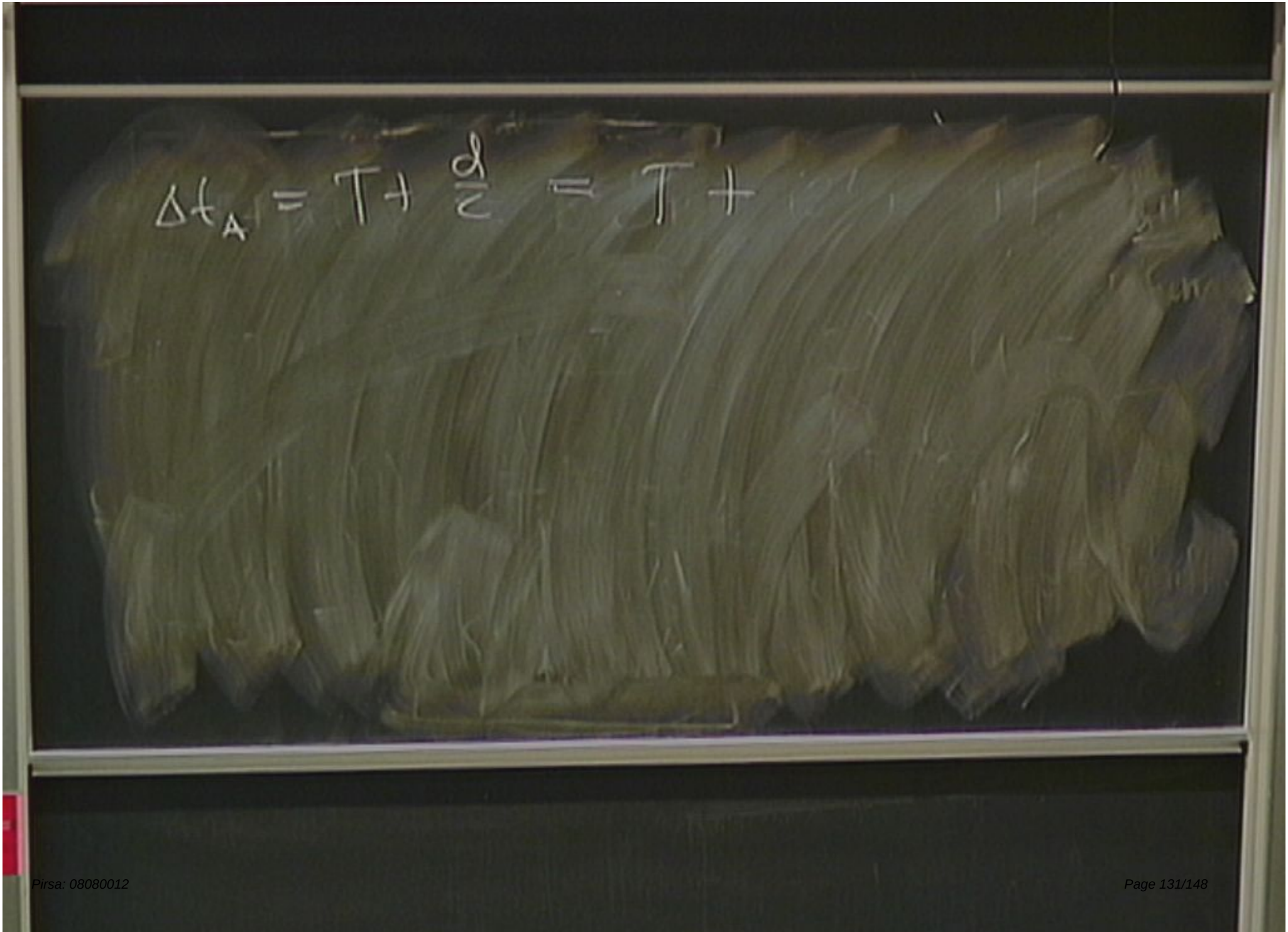

ct_A
ct_B
d
d
cT
k(cT)
x_A

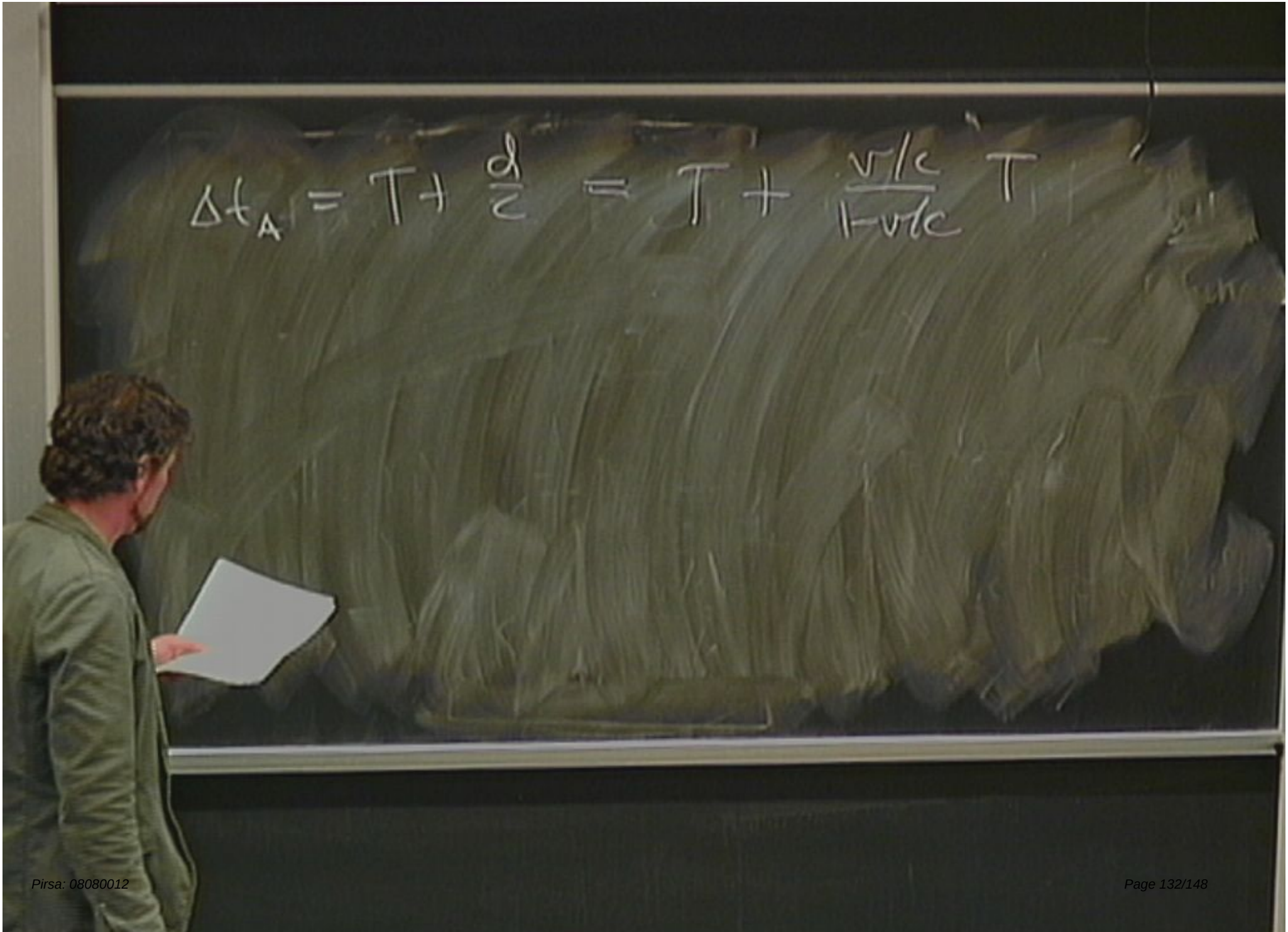

ct_A
ct_B
d
d
cT
k(cT)
X_A
$c\Delta t_A$
$c\Delta t_B$

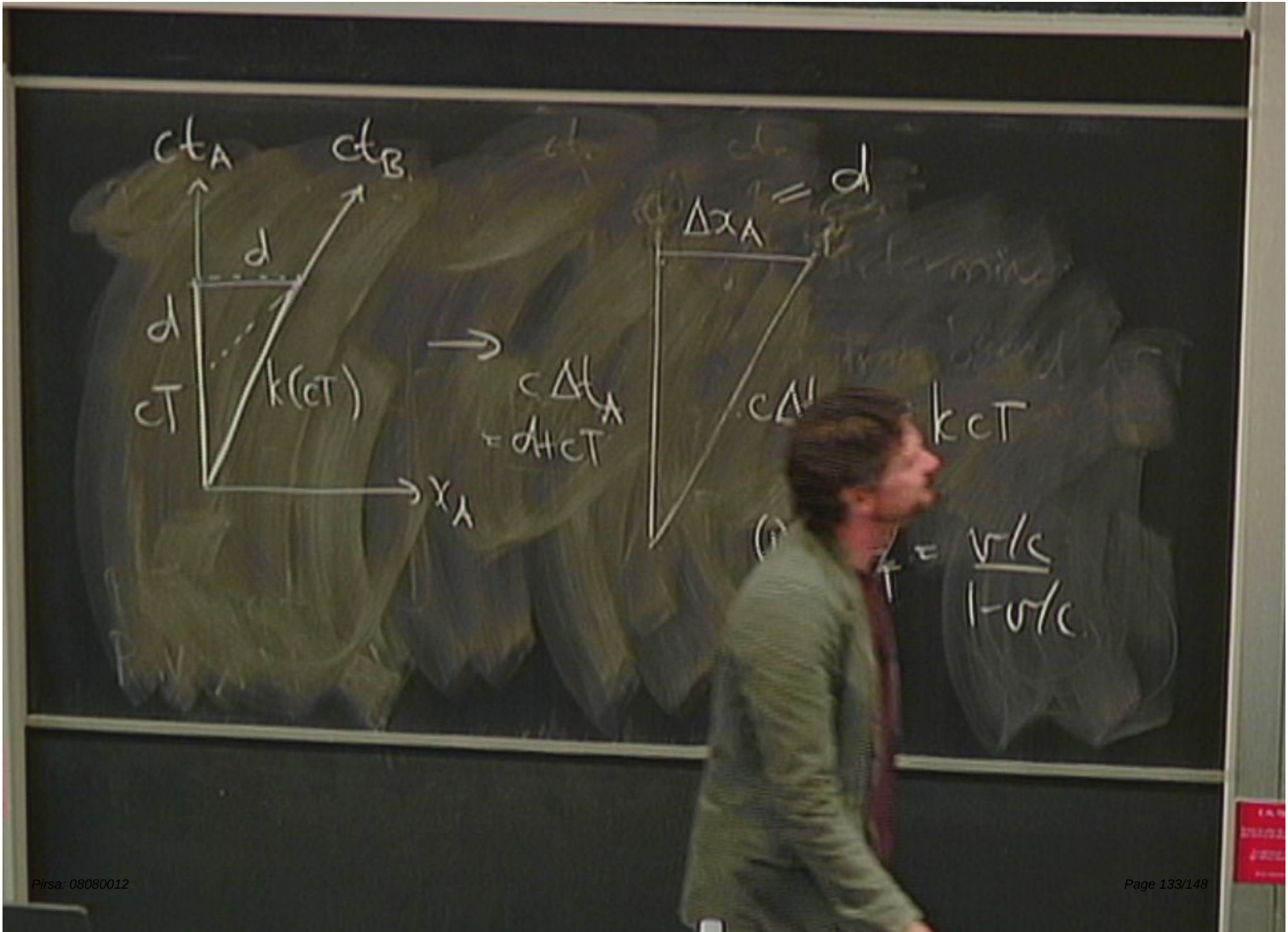

ct_A
ct_B
d
d
cT
k(cT)
x_A
$c\Delta t_A$
Δx_A
$c\Delta t_B$

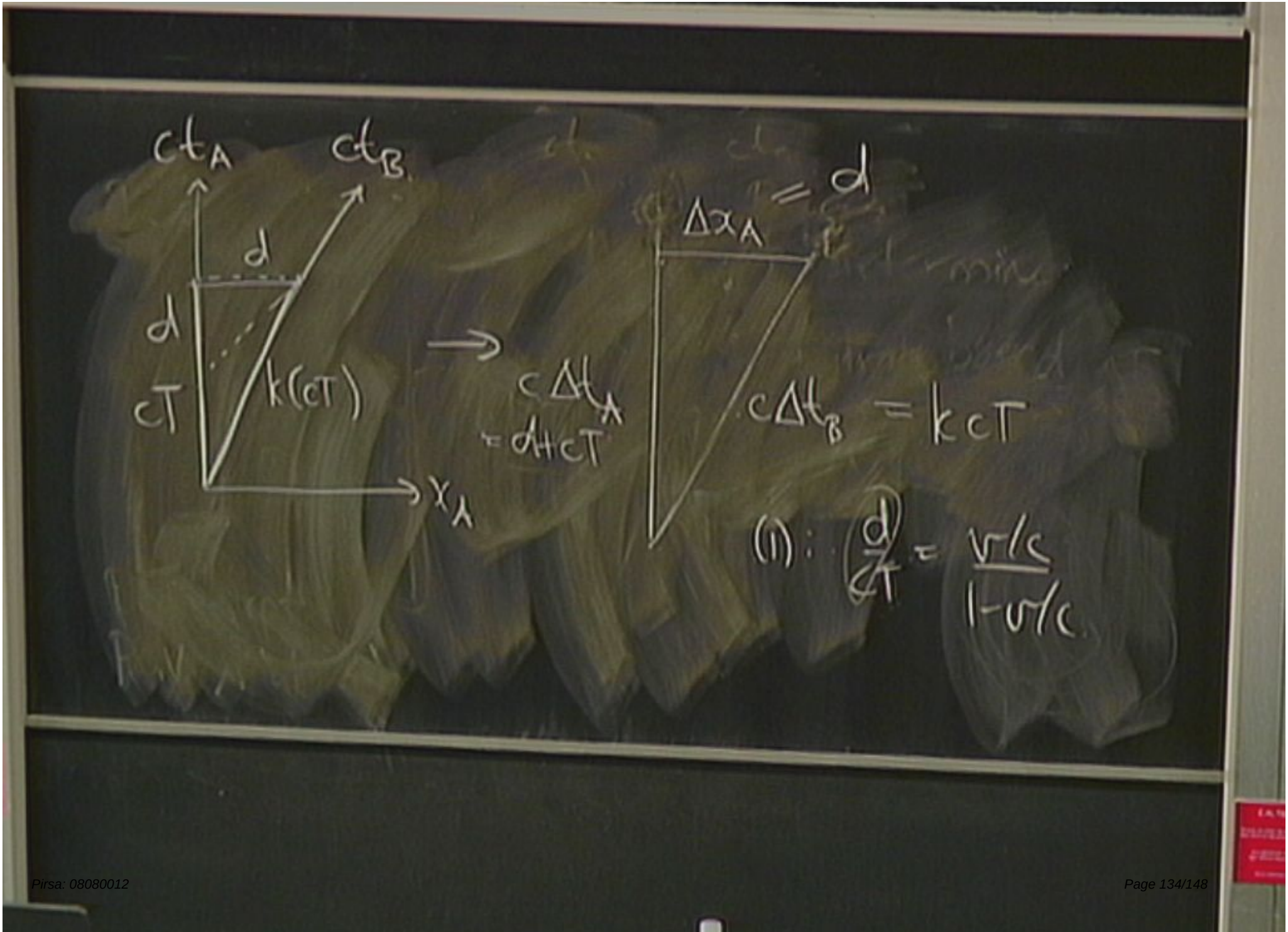

ct_A
ct_B
d
d
cT
k(cT)
x_A
$c\Delta t_A$
$= d + cT$
Δx_A
$= d$
$c\Delta t_B = k\,cT$
(1): $\frac{d}{cT} = \frac{v/c}{1 - v/c}$

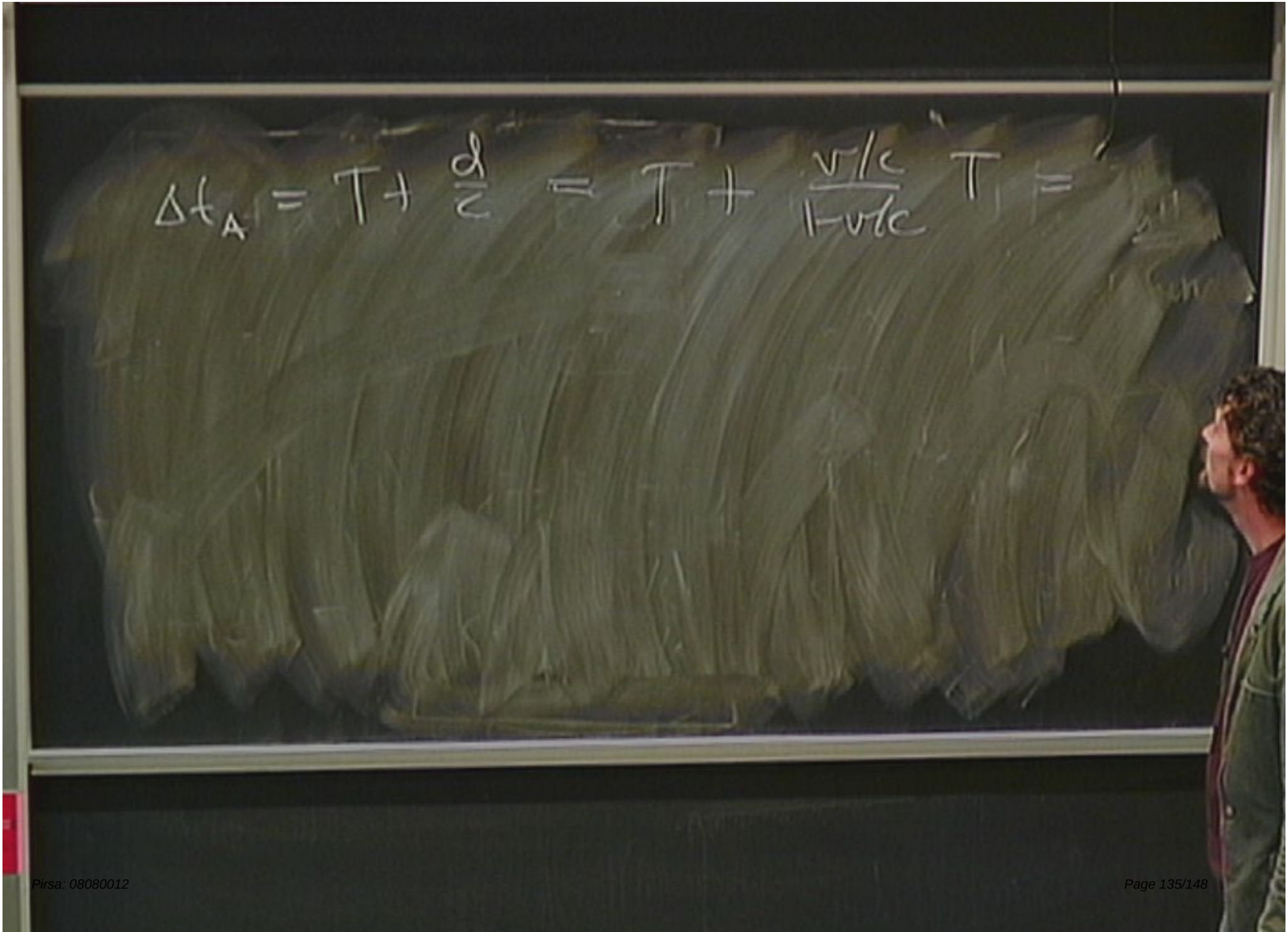

ct_A
ct_B
d
d
cT
$k(cT)$
x_A
$c\Delta t_A = d + cT$
$\Delta x_A = d$
$c\Delta t_B = k\,cT$
(1): $\frac{d}{cT} = \frac{v/c}{1-v/c}$


$\Delta t_A = T + \frac{d}{c} = T +$


$\Delta t_A = T + \frac{d}{c} = T + \frac{v/c}{1-v/c} T$


ct_A
ct_B
d
d
cT
$k(cT)$
x_A
$c\Delta t_A = d + cT$
$\Delta x_A = d$
$c\Delta t$
kcT
$f = \frac{v/c}{1-v/c}$


ct_A
ct_B
d
d
cT
$k(cT)$
x_A
$c\Delta t_A = d + cT$
$\Delta x_A = d$
$c\Delta t_B = k\,cT$
(1): $\frac{d}{cT} = \frac{v/c}{1-v/c}$

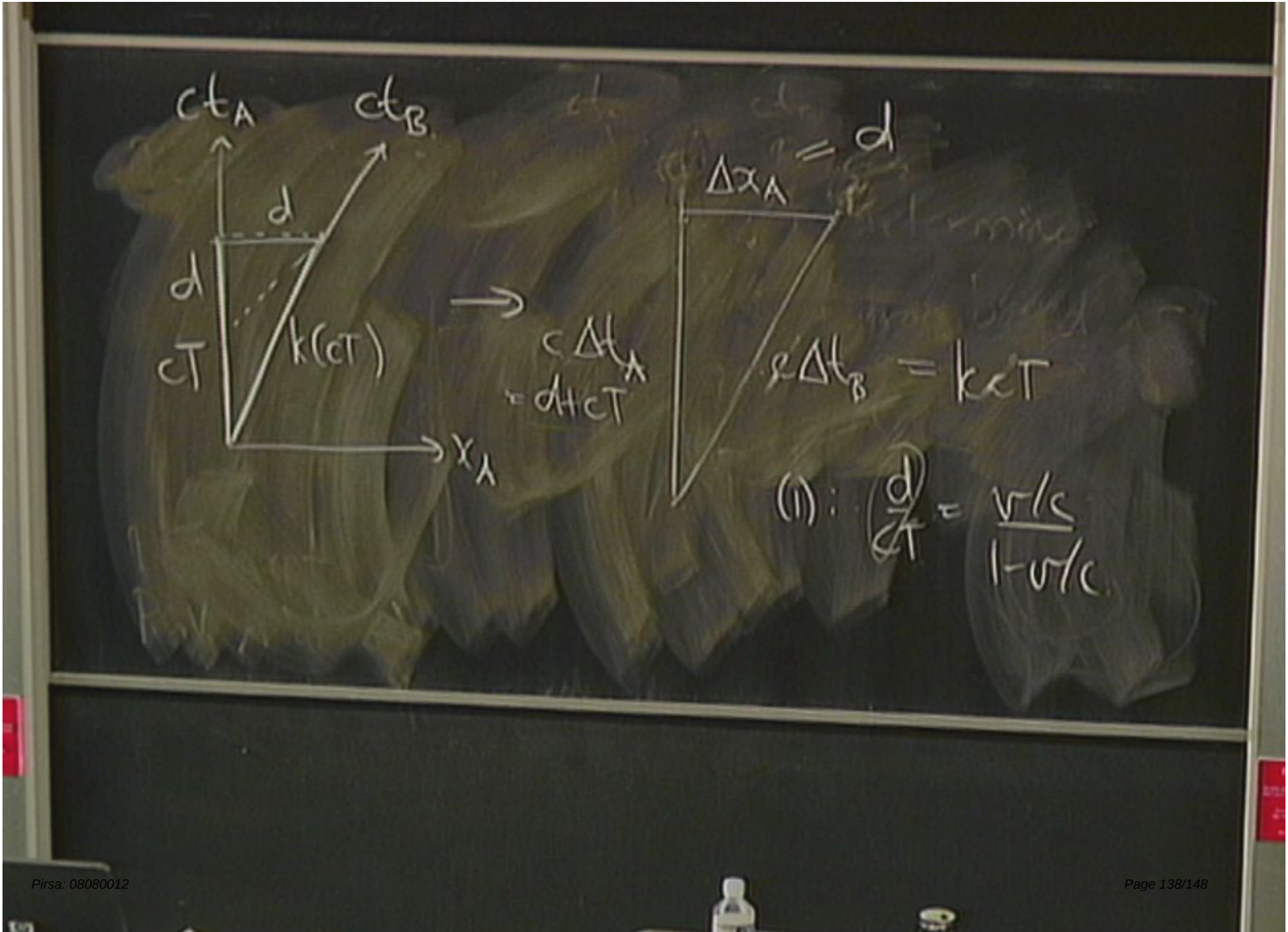

$\Delta t_A = T + \frac{d}{c} = T + \frac{v/c}{1-v/c} T =$

$$\Delta t_A = T + \frac{d}{c} = T + \frac{v/c}{1-v/c} T = \frac{1}{1-v/c} T$$

$$\frac{\Delta t_A}{\Delta t_B} =$$

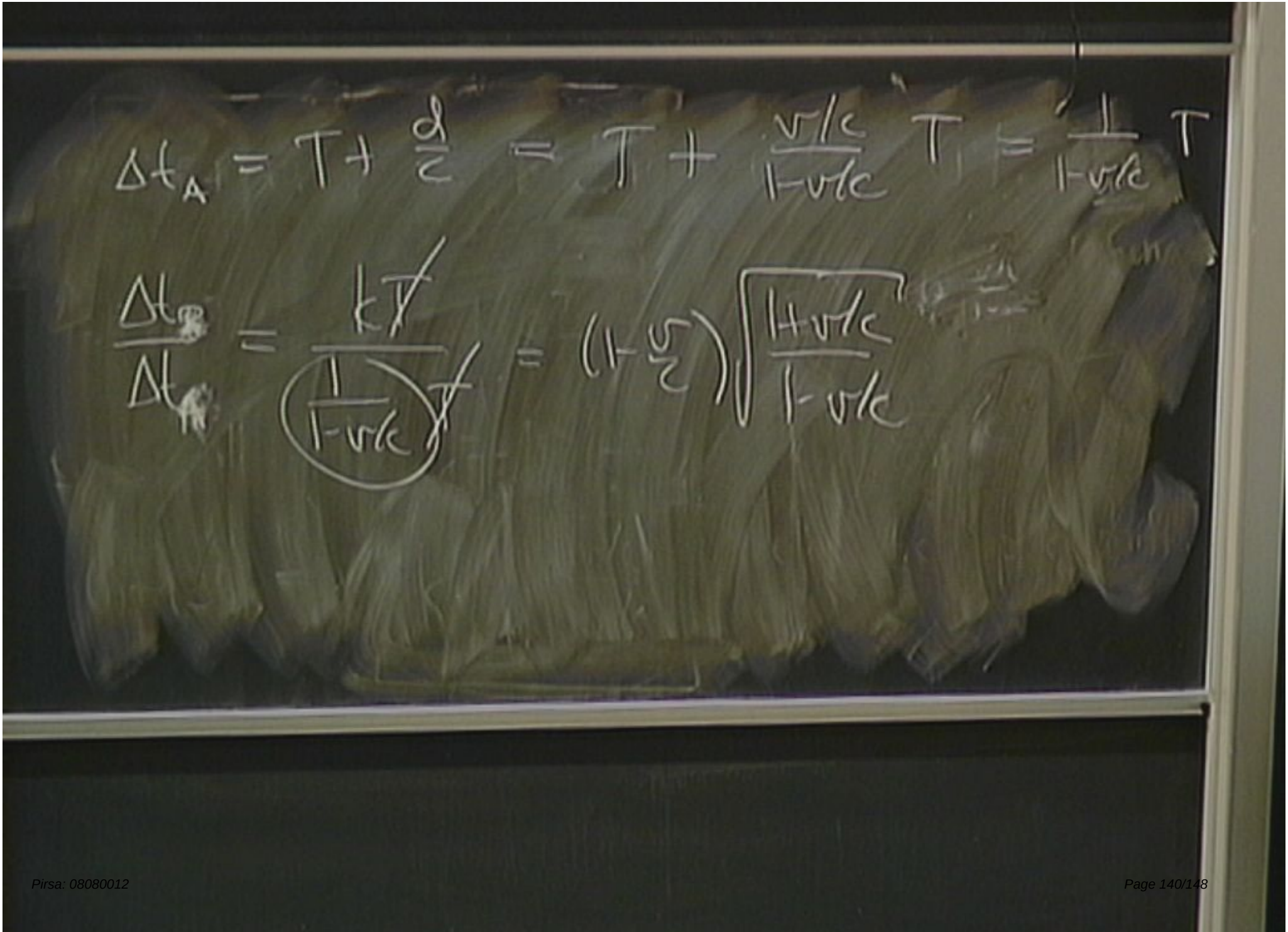
$$\Delta t_A = T + \frac{d}{c} = T + \frac{v/c}{1-v/c}T = \frac{1}{1-v/c}T$$

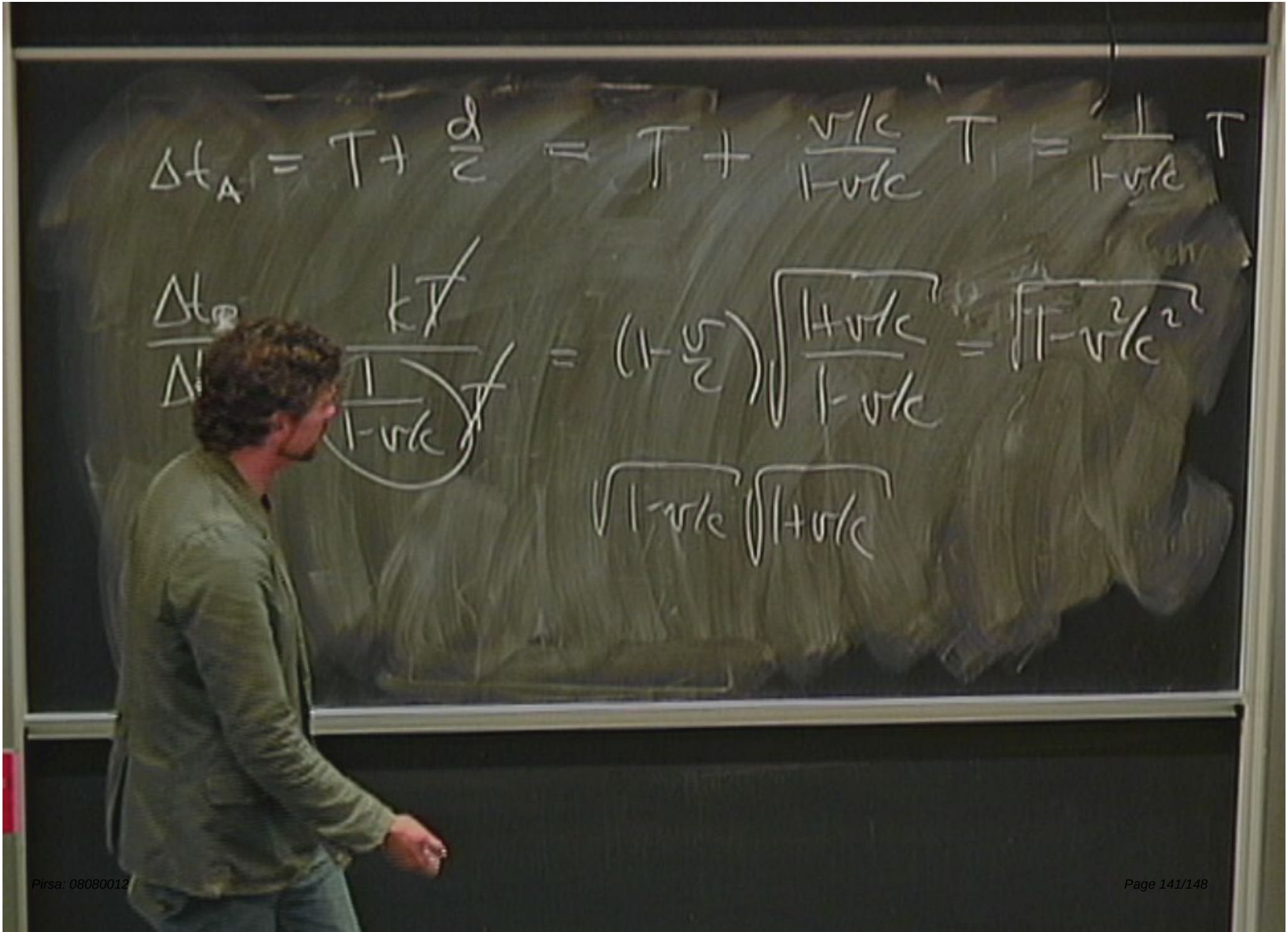
$$\frac{\Delta t_B}{\Delta t_A} =$$


ct_A
ct_B
d
d
cT
k(cT)
x_A
$c\Delta t_A = d + cT$
$\Delta x_A = d$
$c\Delta t_B = k cT$
(1): $\frac{d}{cT} = \frac{v/c}{1 - v/c}$

$$\Delta t_A = T + \frac{d}{c} = T + \frac{vT/c}{1 - v/c} \quad T = \frac{1}{1 - v/c} T$$

$$\frac{\Delta t_B}{\Delta t_A} = \frac{kT}{\frac{1}{1 - v/c} T} =$$

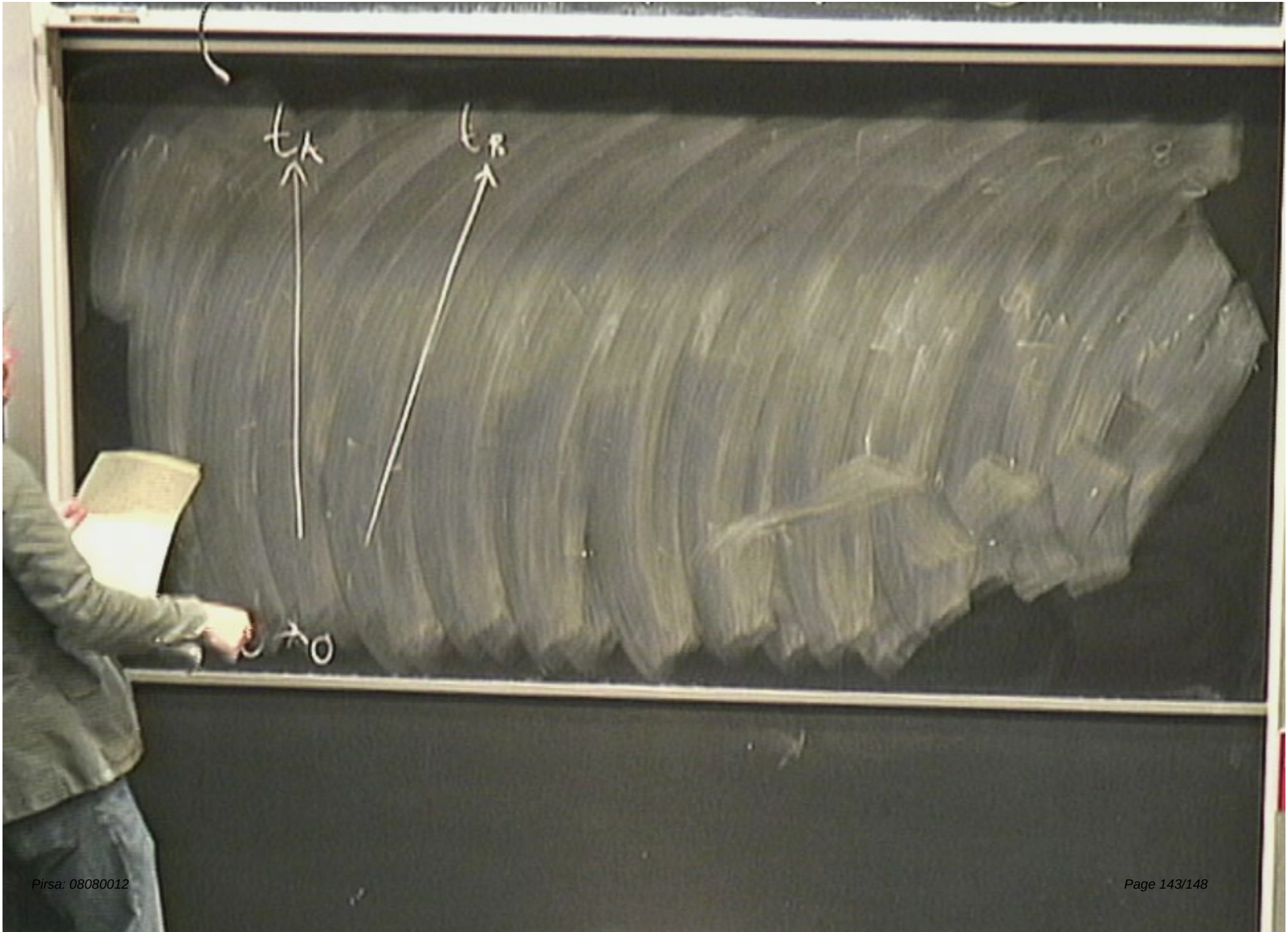

$\Delta t_A = T + \frac{d}{c} = T + \frac{v/c}{1-v/c} T = \frac{1}{1-v/c} T$
$\frac{\Delta t_B}{\Delta t_A} = \frac{kT}{\frac{1}{1-v/c} T} = (1-v/c)\sqrt{\frac{1+v/c}{1-v/c}}$

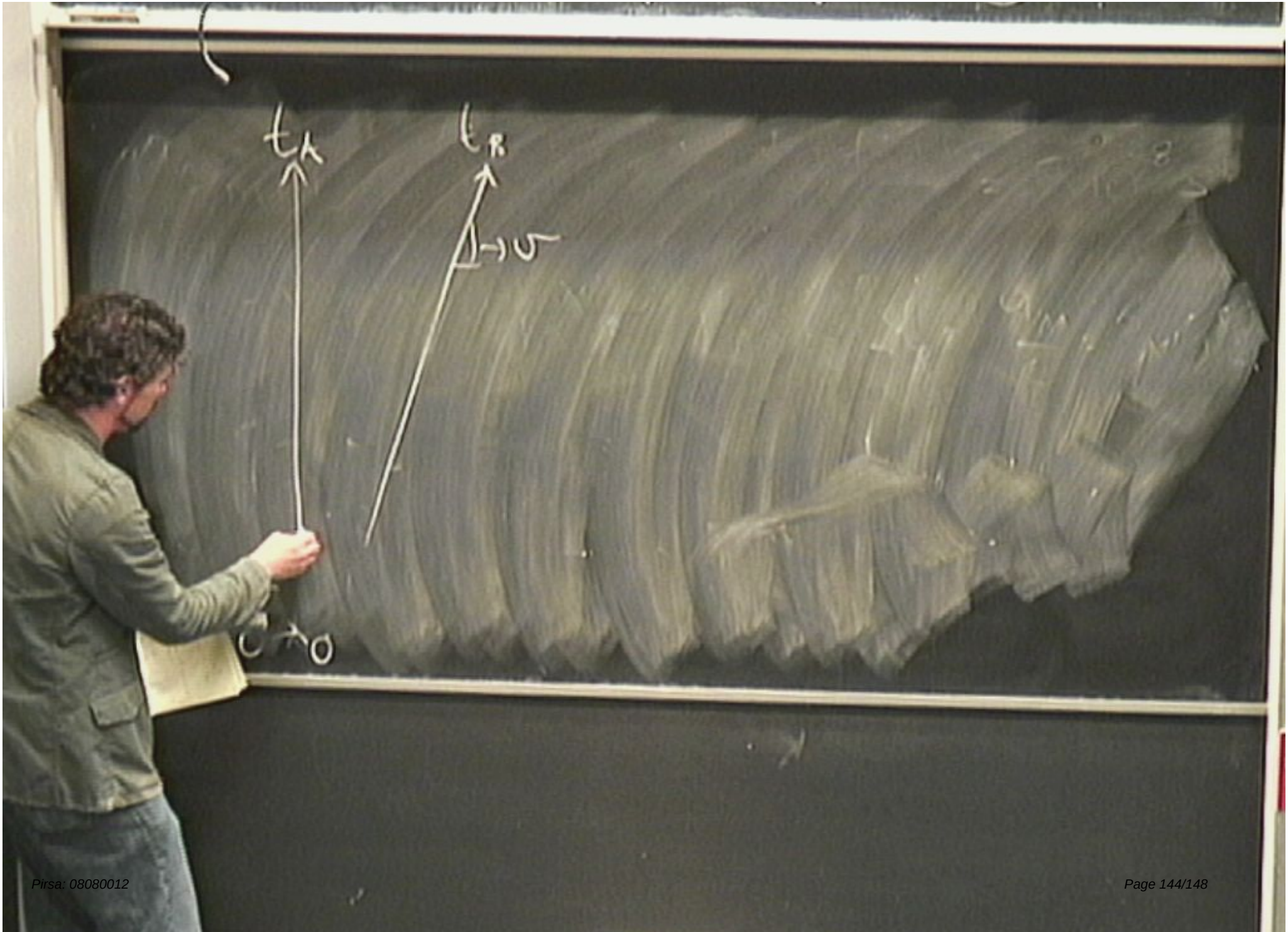

$\Delta t_A = T + \frac{d}{c} = T + \frac{v/c}{1-v/c} T = \frac{1}{1-v/c} T$
$\frac{\Delta t_B}{\Delta t_A} = \frac{kT}{\frac{1}{1-v/c}T} = (1-v/c)\sqrt{\frac{1+v/c}{1-v/c}} = \sqrt{1-v^2/c^2}$
$\sqrt{1-v/c}\sqrt{1+v/c}$

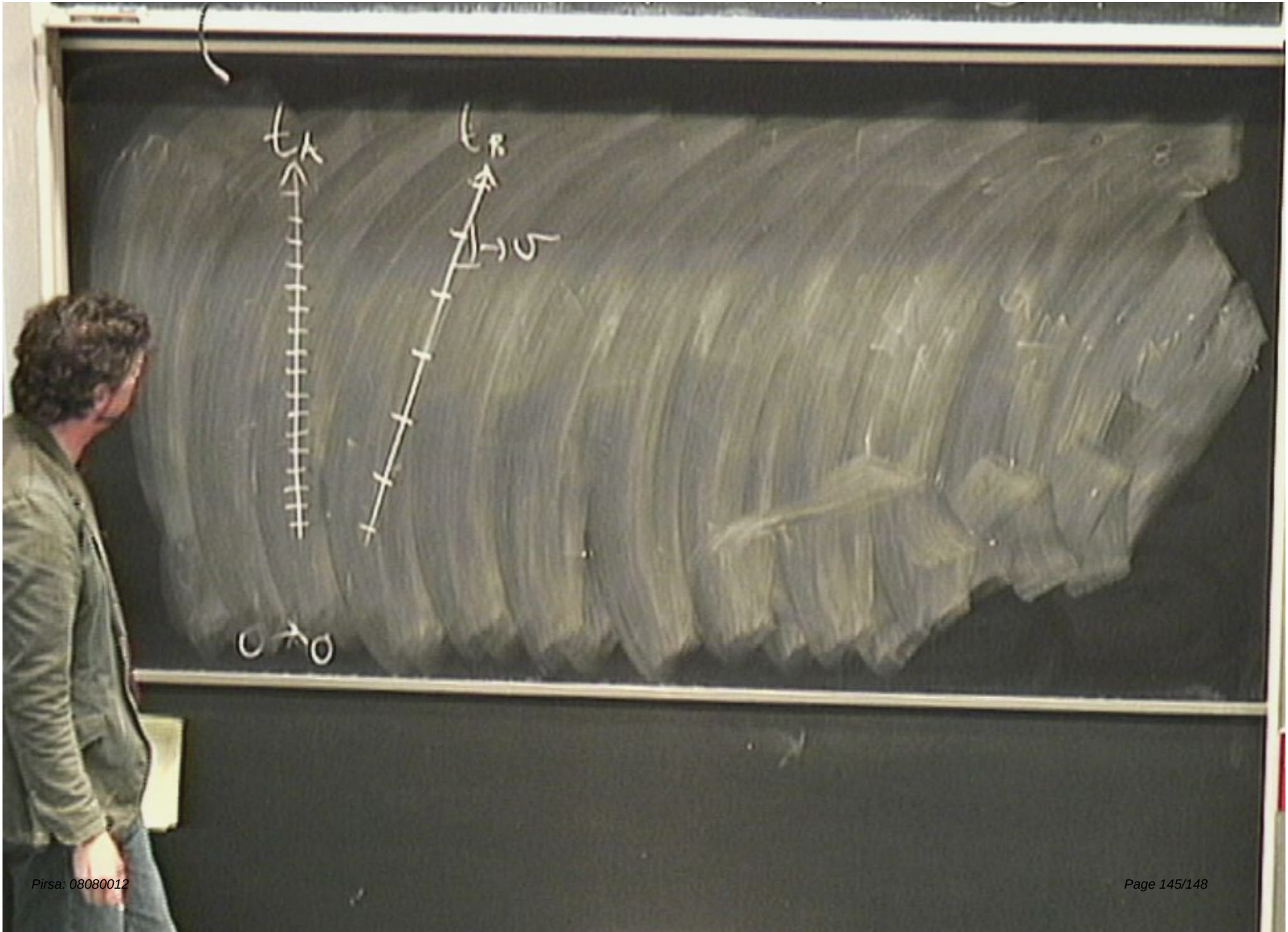
$$\Delta t_A = T + \frac{d}{c} = T + \frac{v/c}{1-v/c}T = \frac{1}{1-v/c}T$$

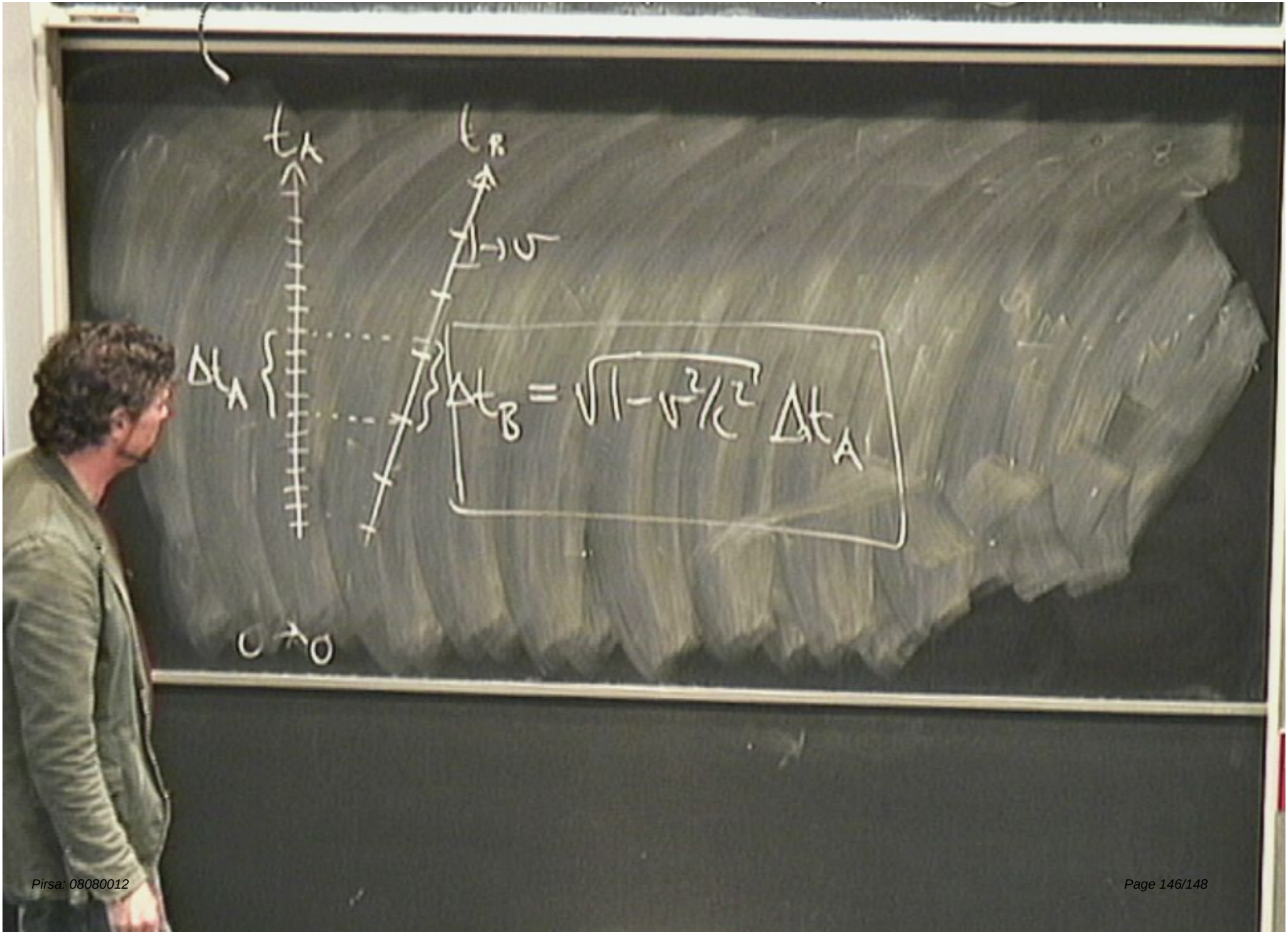
$$\frac{\Delta t_B}{\Delta t_A} = \frac{kT}{\frac{1}{1-v/c}T} = (1-v/c)\sqrt{\frac{1+v/c}{1-v/c}} = \sqrt{1-v^2/c^2}$$

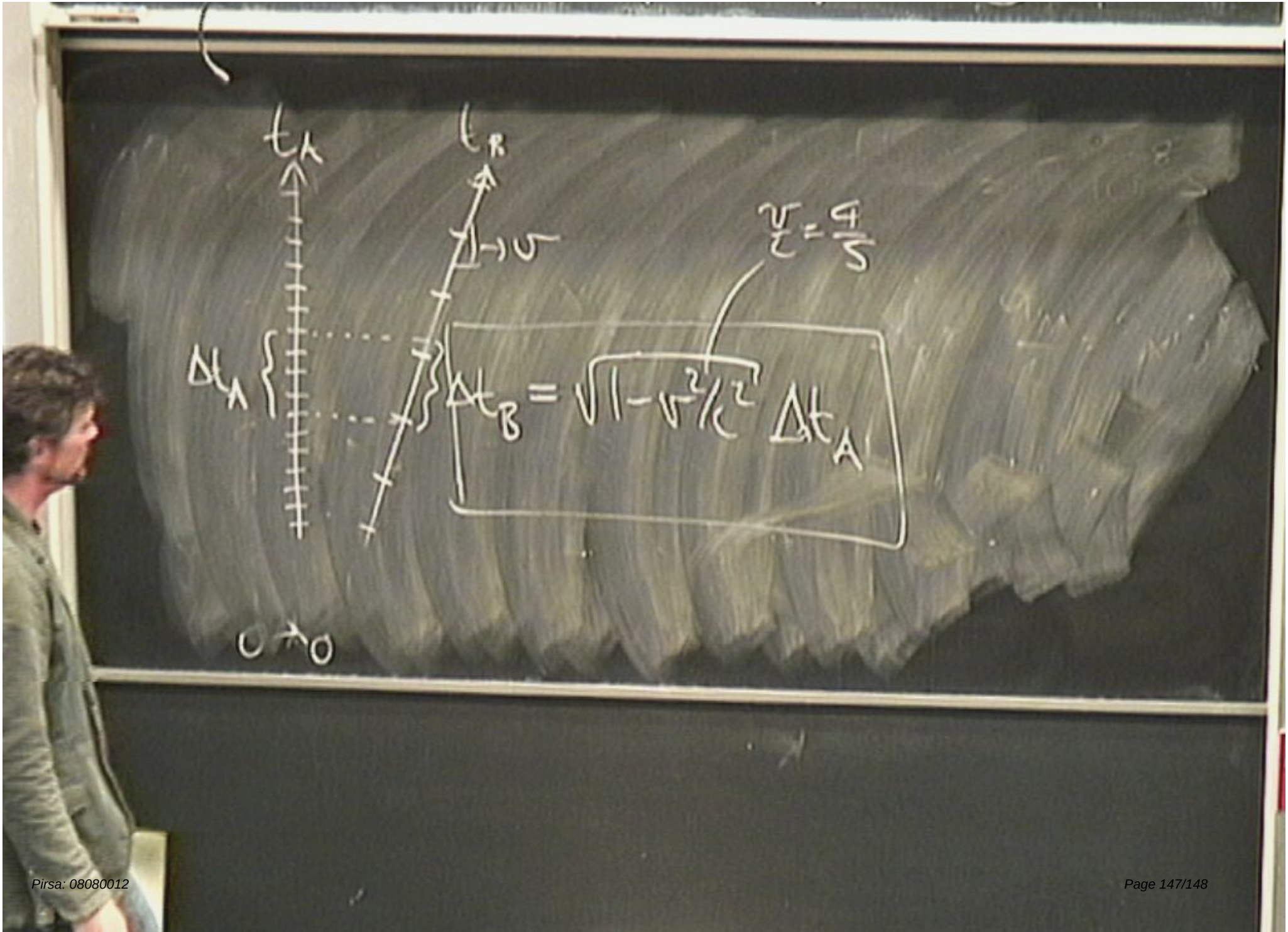
$$\sqrt{1-v/c}\sqrt{1+v/c}$$

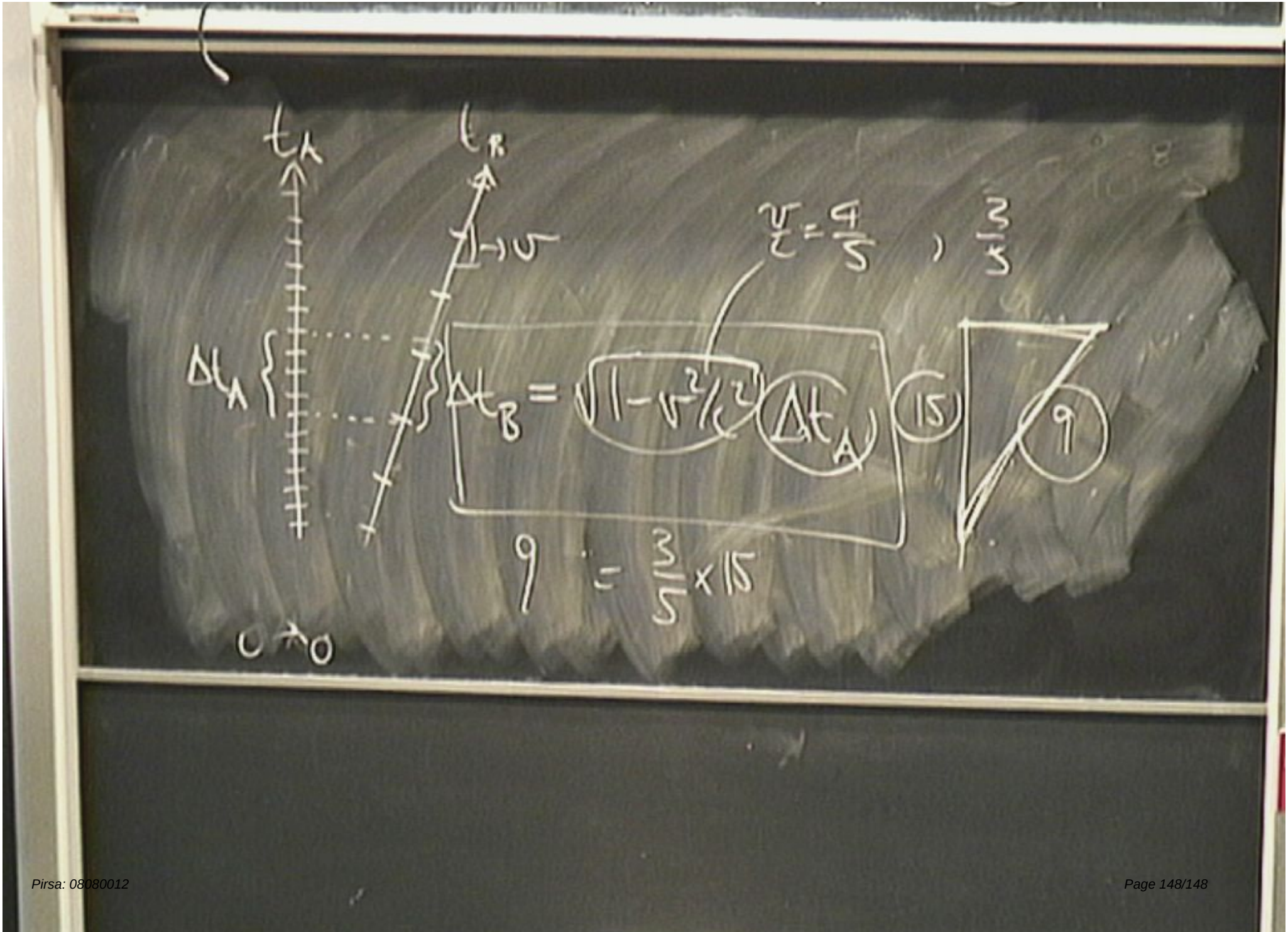

t_A
t_B
τ_0


t_A
t_B
$v \to$
$O \to$


A
B
v
O
O


t_A
t_B
$\to v$
Δt_A
$\Delta t_B = \sqrt{1 - v^2/c^2}\, \Delta t_A$
$v \to 0$


t_A
t_B
$v \to v$
$\frac{v}{c} = \frac{4}{5}$
Δt_A
$\Delta t_B = \sqrt{1 - v^2/c^2}\, \Delta t_A$
$0 \to 0$


t_A
t_B
$v \to 1$
$v = \frac{9}{15}$, $\frac{3}{5}$
Δt_A
$\Delta t_B = \sqrt{1 - v^2/c^2}\,\Delta t_A$
15
9
$9 = \frac{3}{5} \times 15$
$v \to 0$