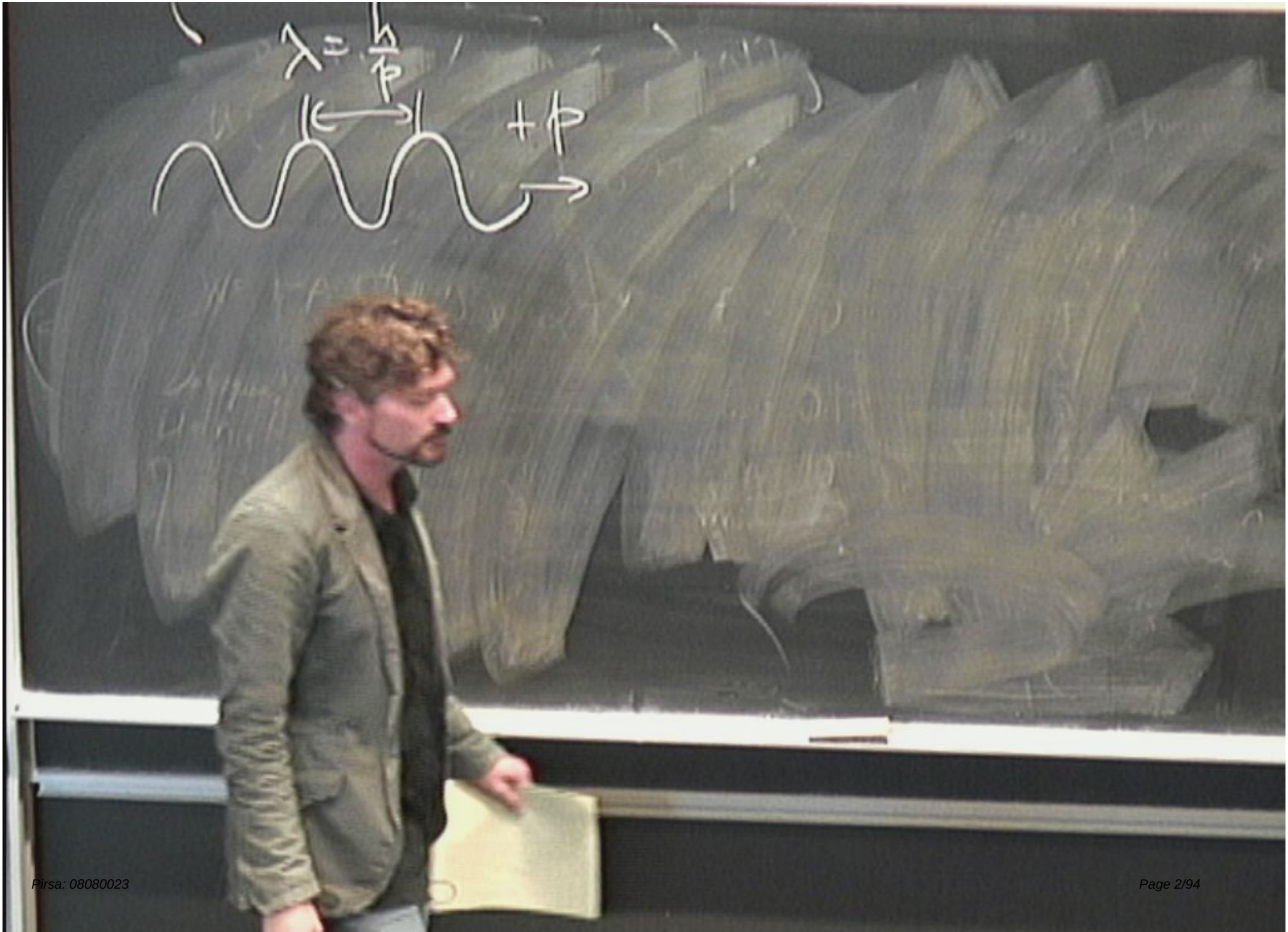
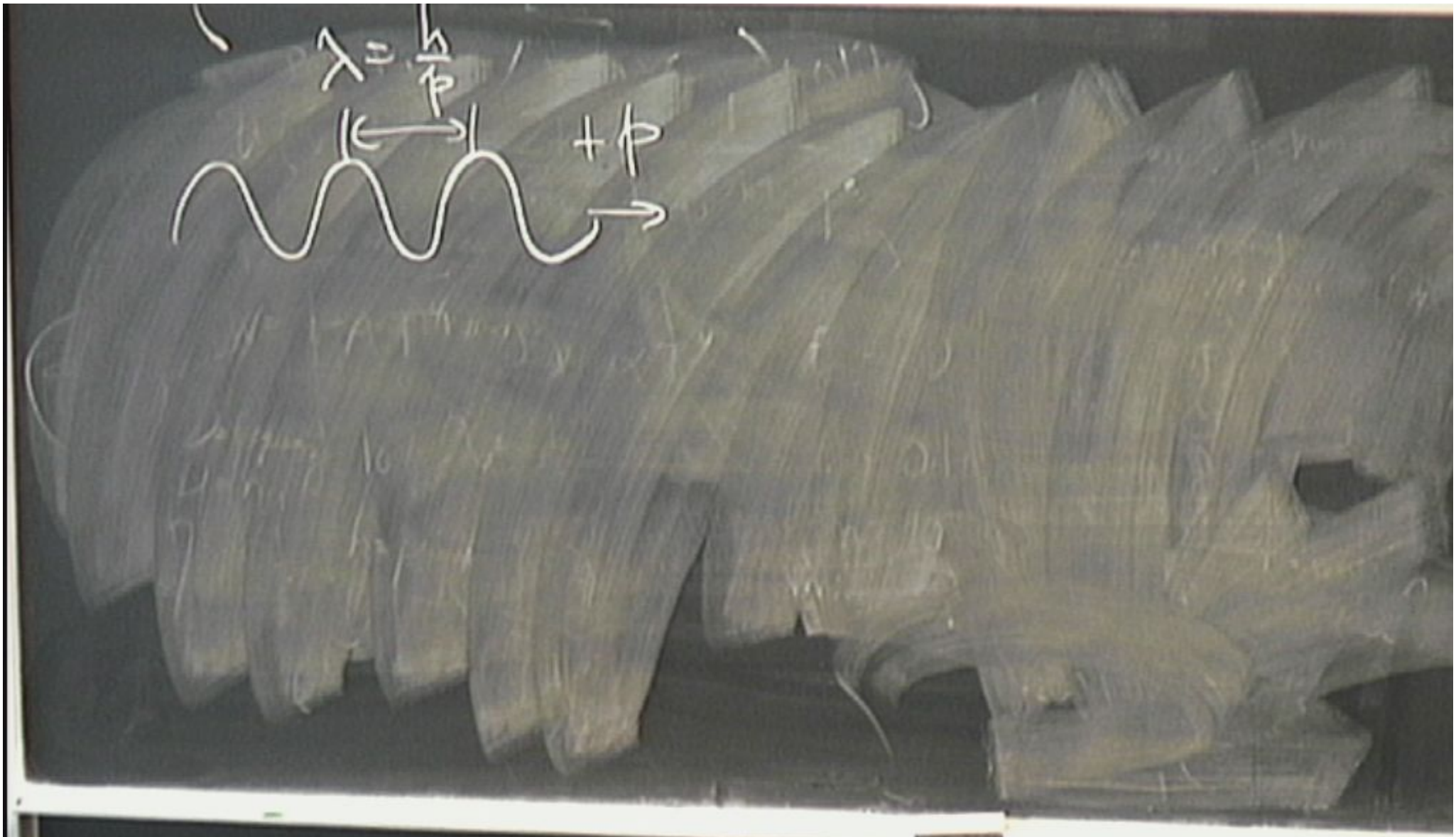
Title: Quantum 5

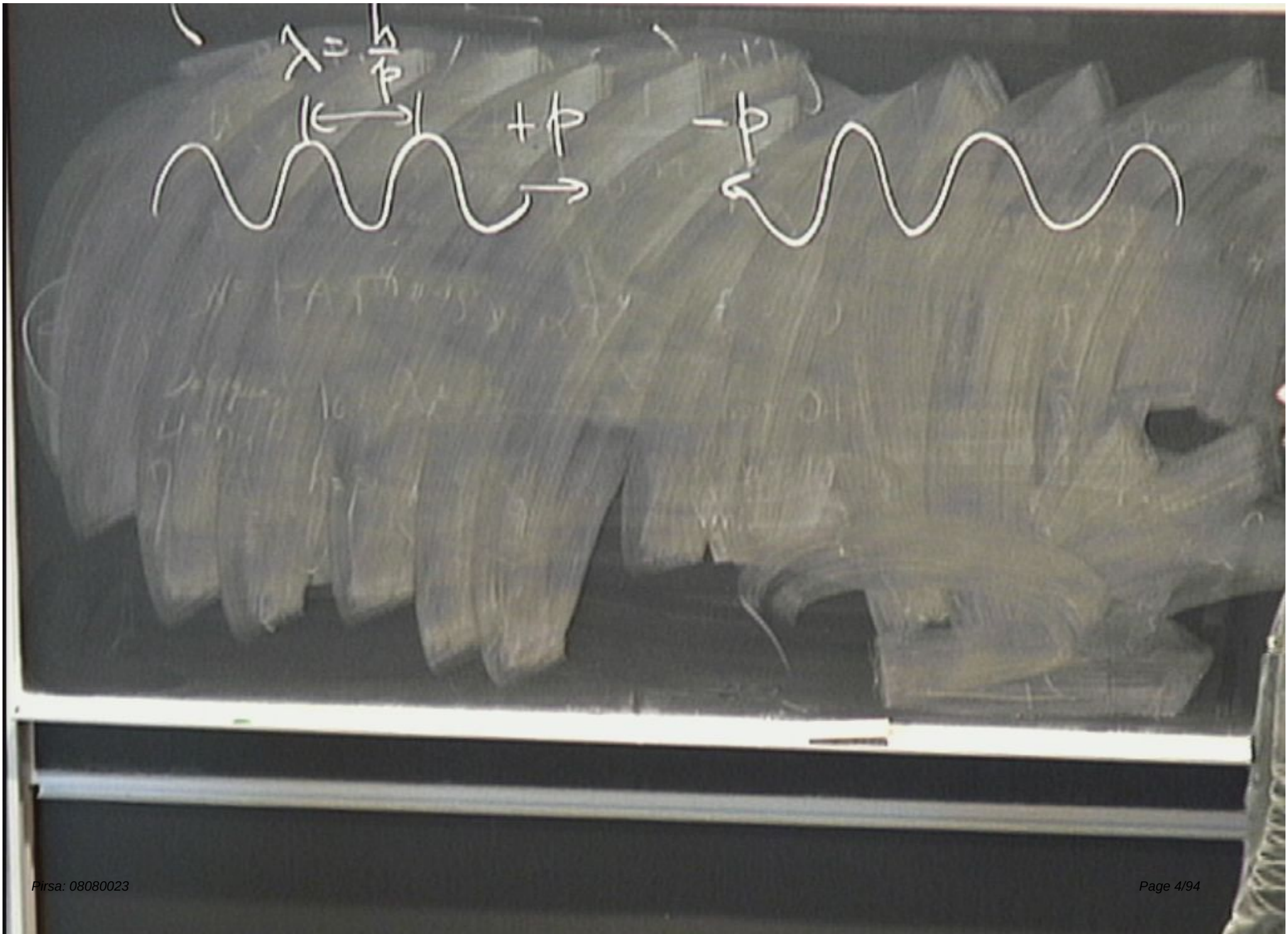
Date: Aug 16, 2008 02:30 PM

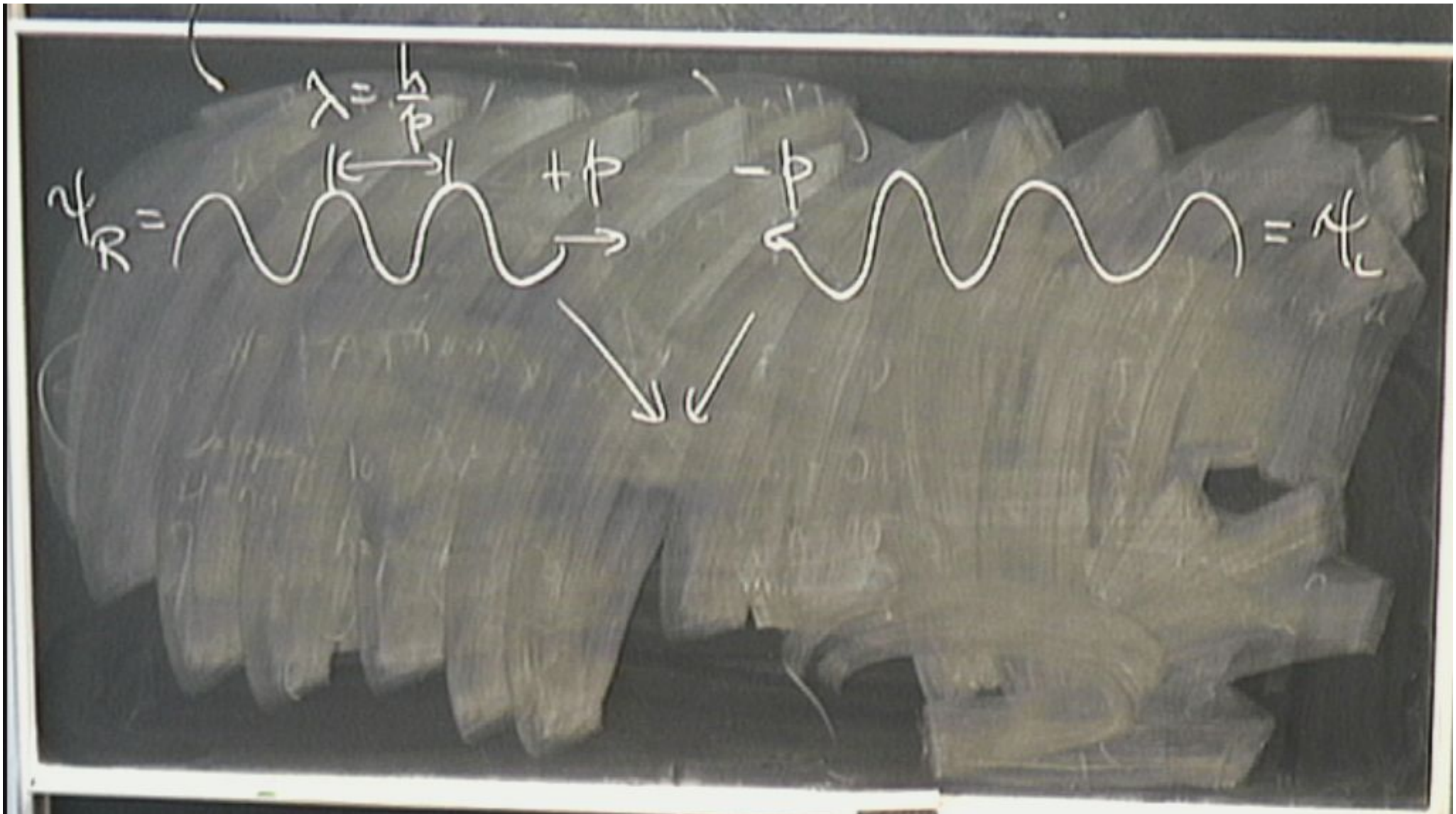
URL: http://pirsa.org/08080023

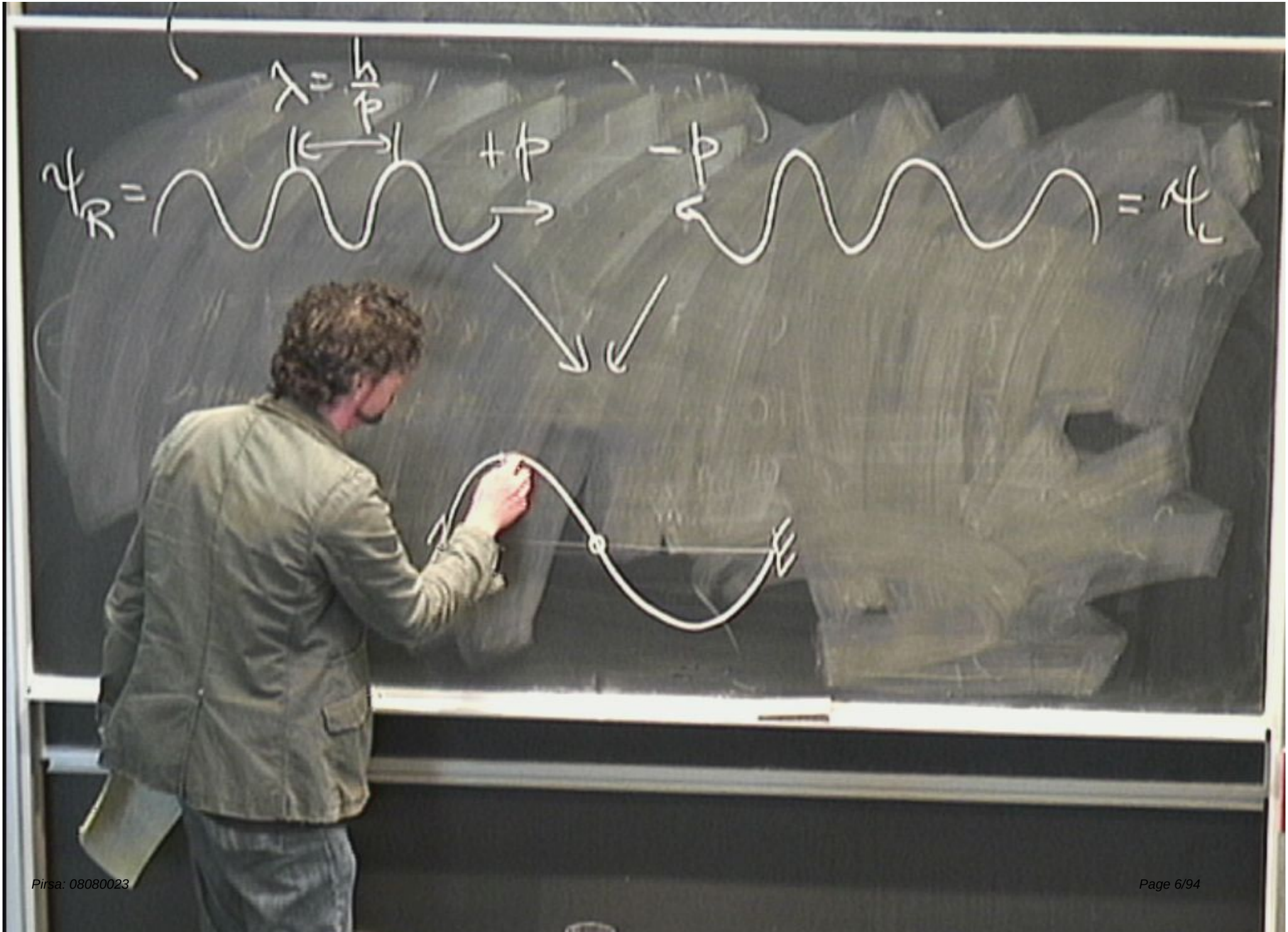
Abstract:

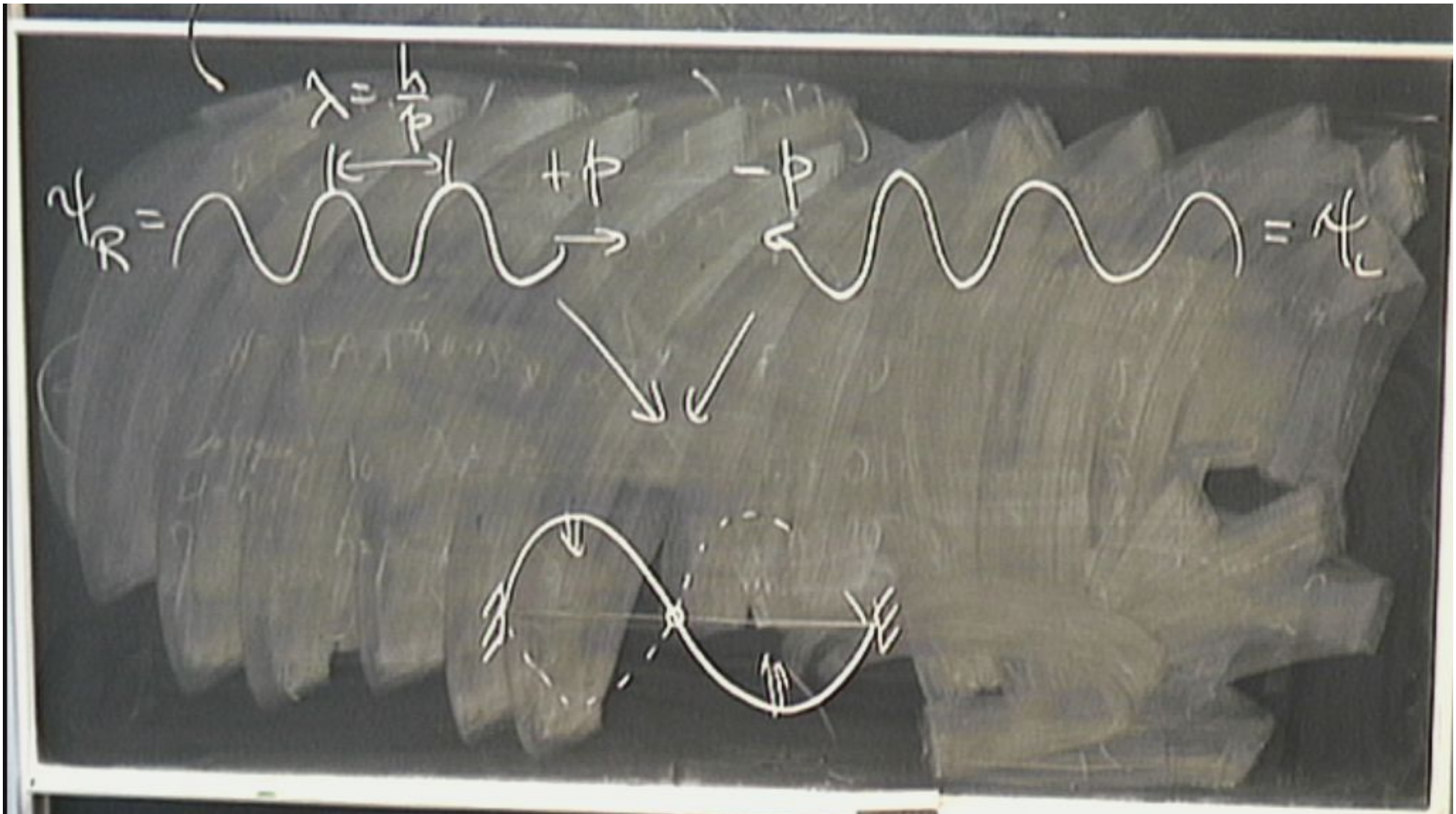

λ = h/p
+p

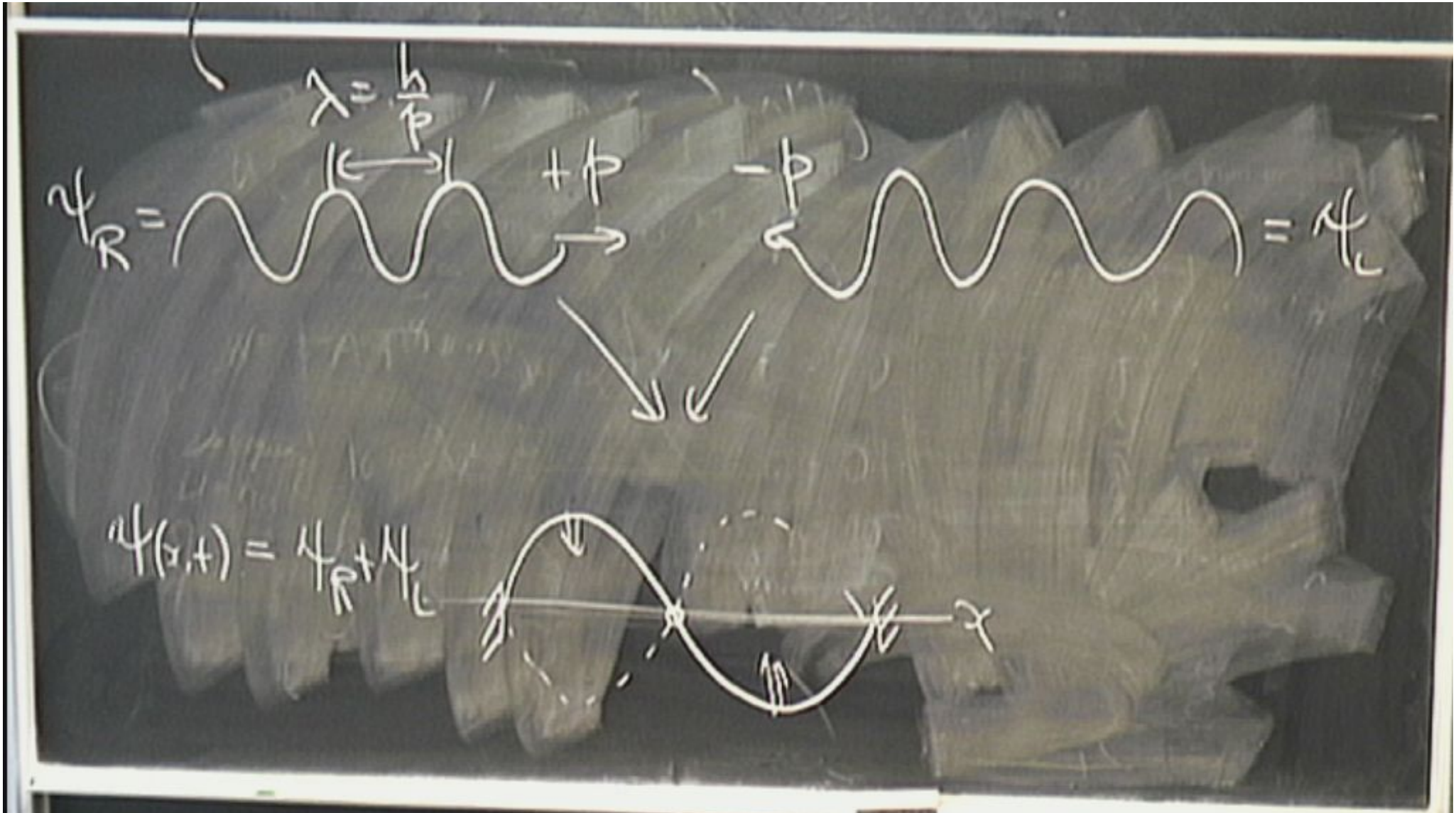

$\lambda = \frac{h}{p}$
$+p$

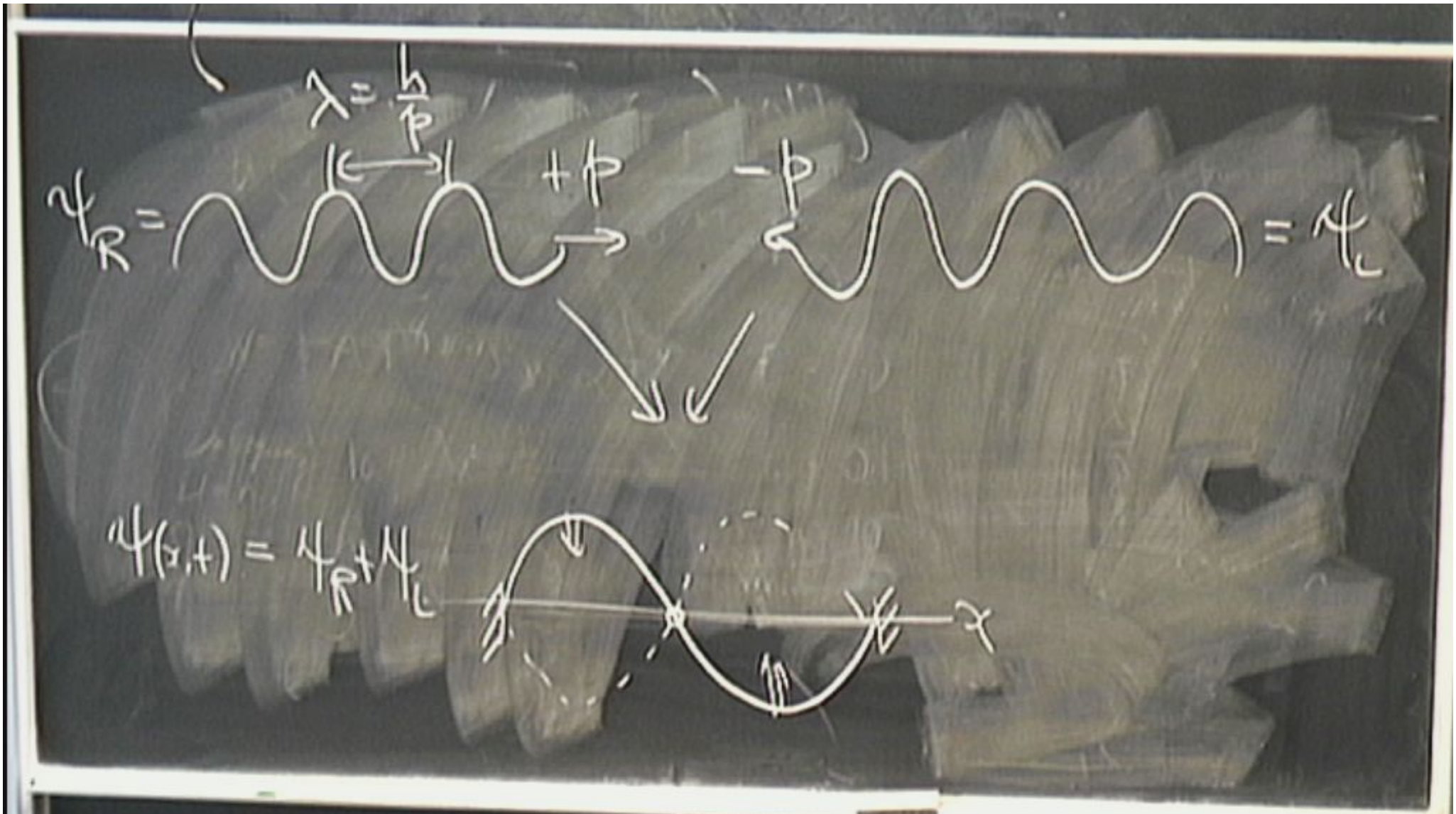

λ = h/p
+p
−p

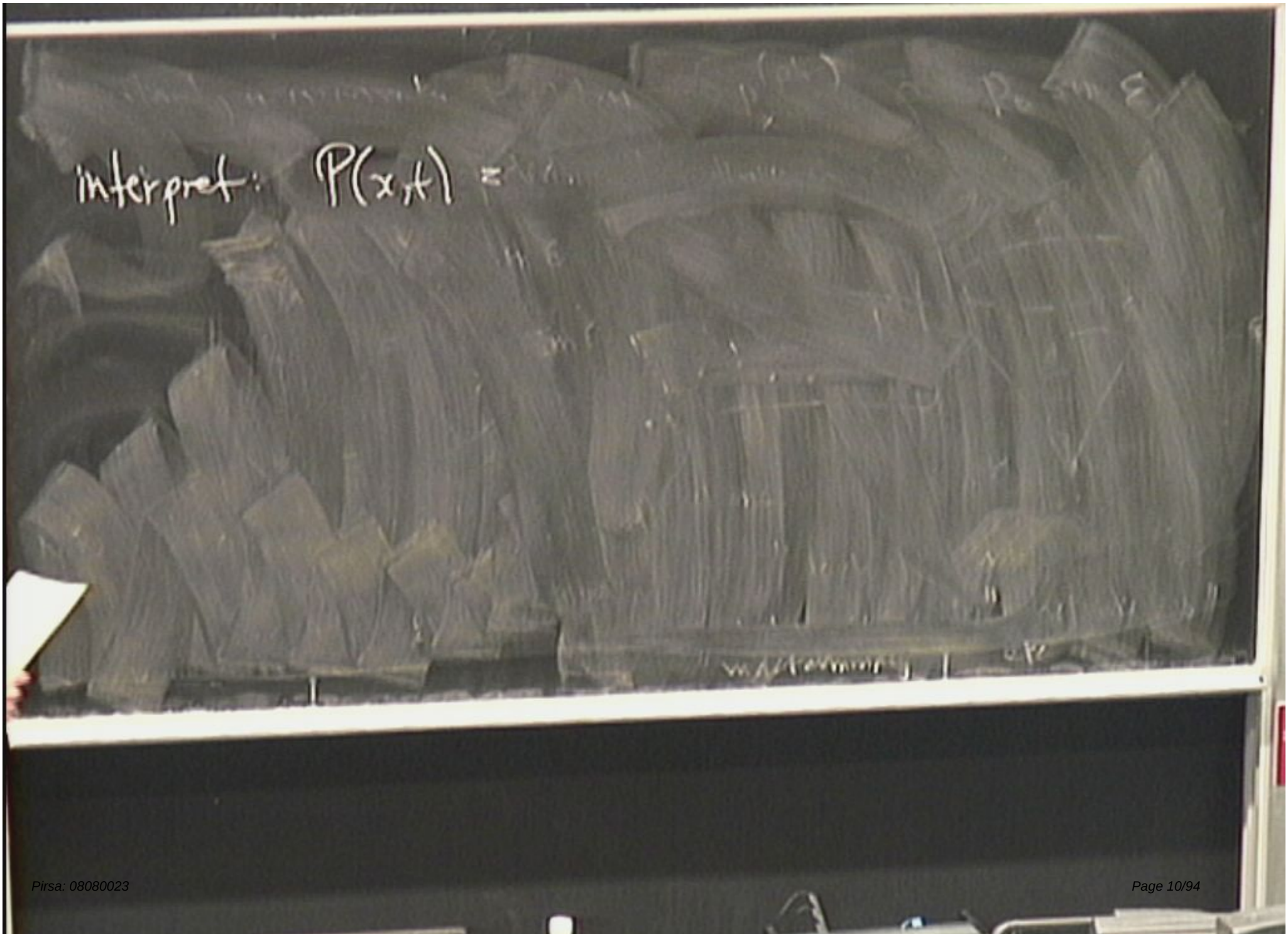

λ = h/p
+p
−p
ψR =
= ψL

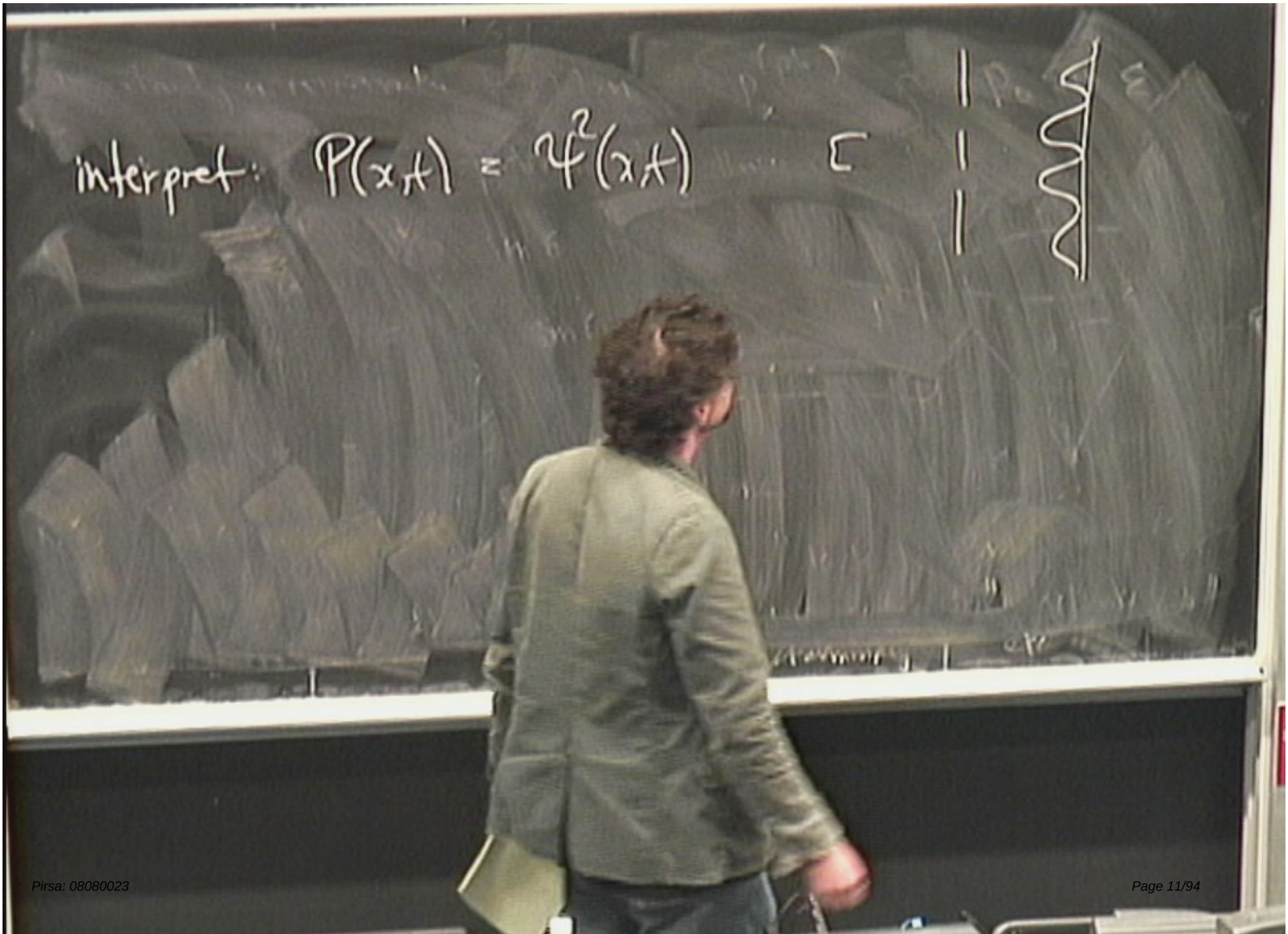

λ = h/p
+p
−p
ψR =
= ψL


λ = h/p
+p
−p


λ = h/p
+p
−p
ψ_R =
= ψ_L
ψ(x,t) = ψ_R + ψ_L
x


$\lambda = \frac{h}{p}$
$+p$
$-p$
$\psi_R =$
$= \psi_L$
$\psi(x,t) = \psi_R + \psi_L$
x


interpret: P(x,t) =


interpret: $P(x,t) = \psi^2(x,t)$

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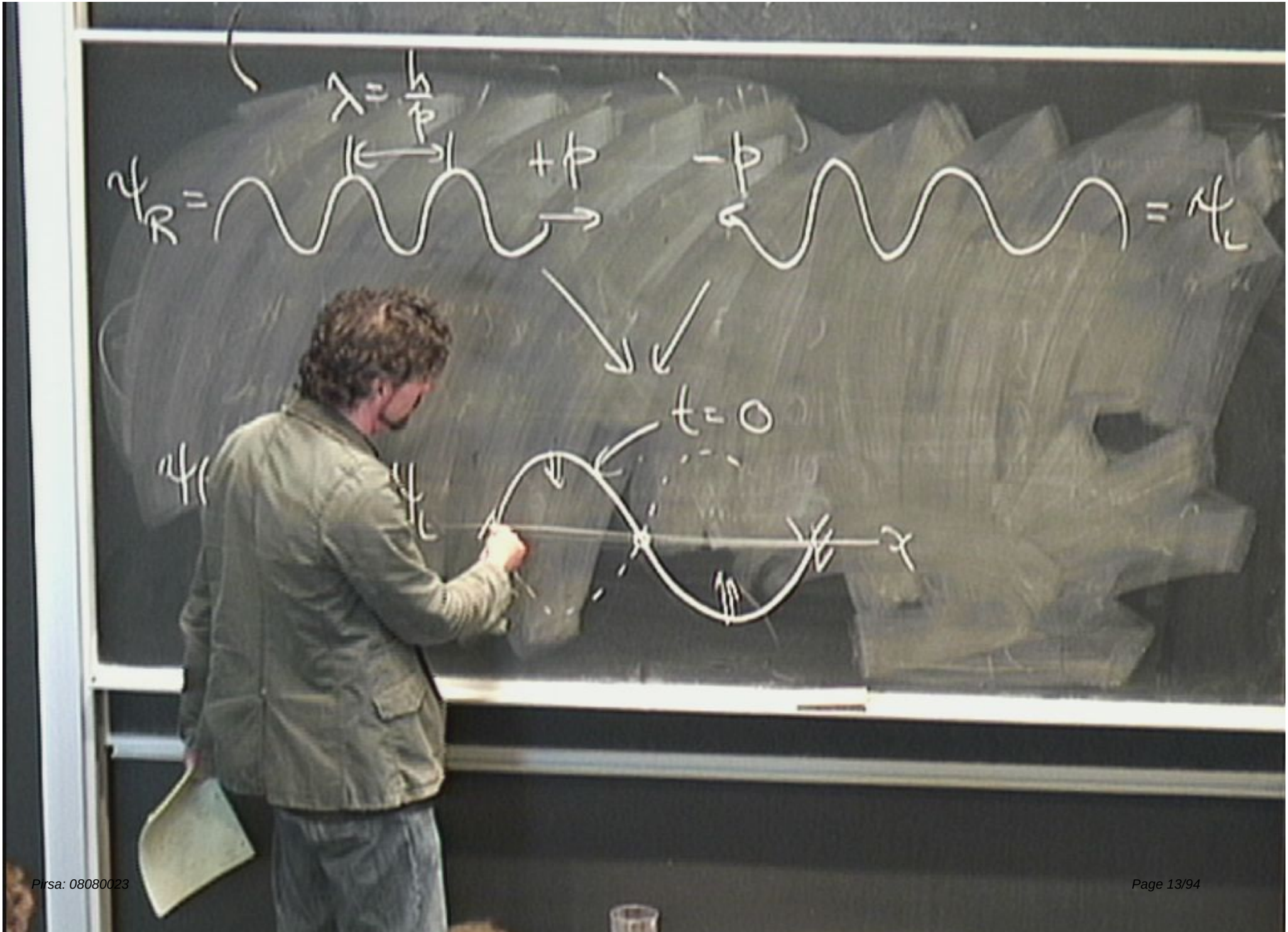
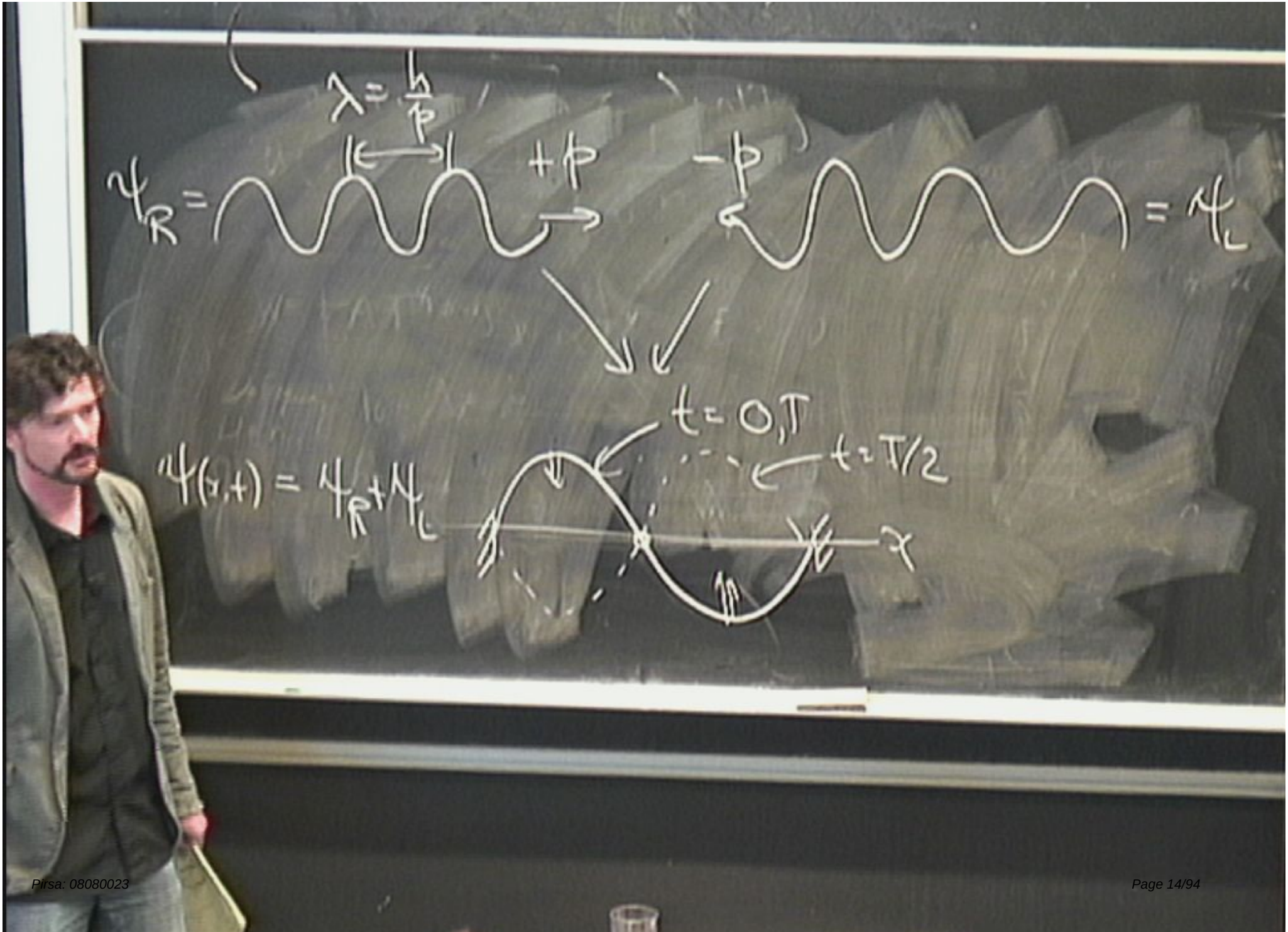
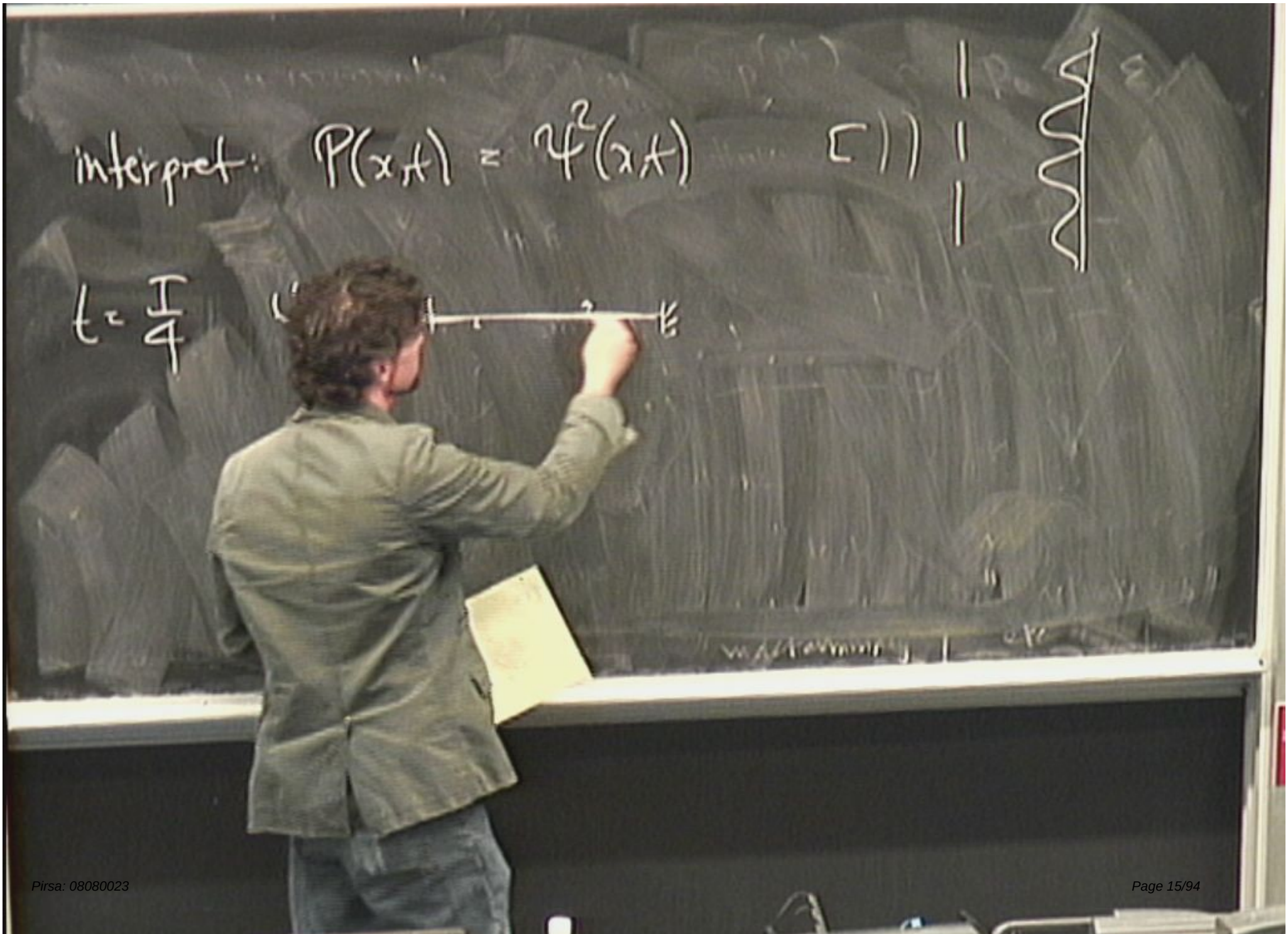
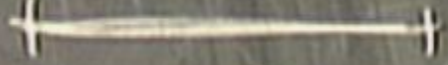
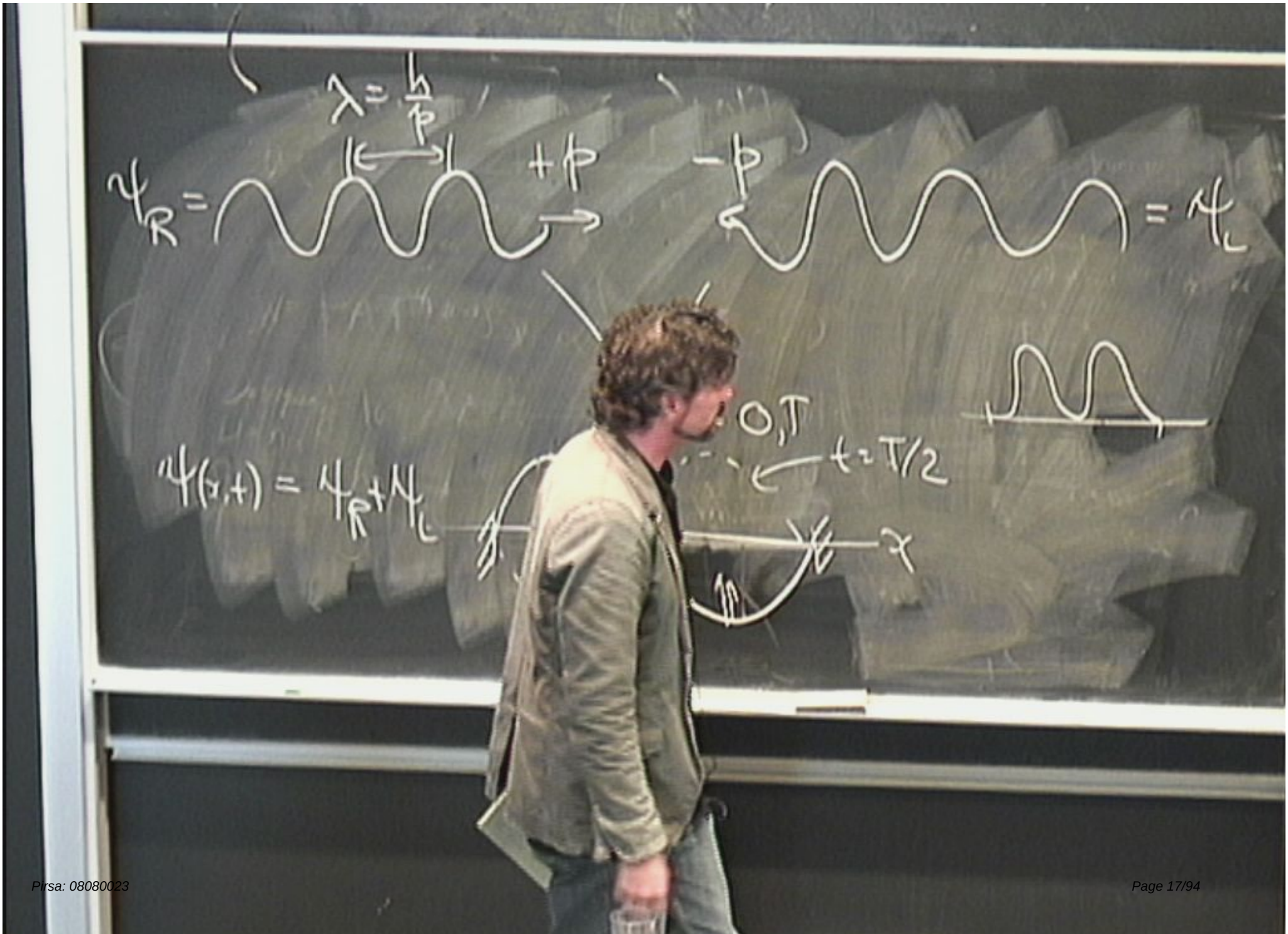

λ = h/p
+p
−p
ψR =
= ψL
t = 0
ψ
ψL
x

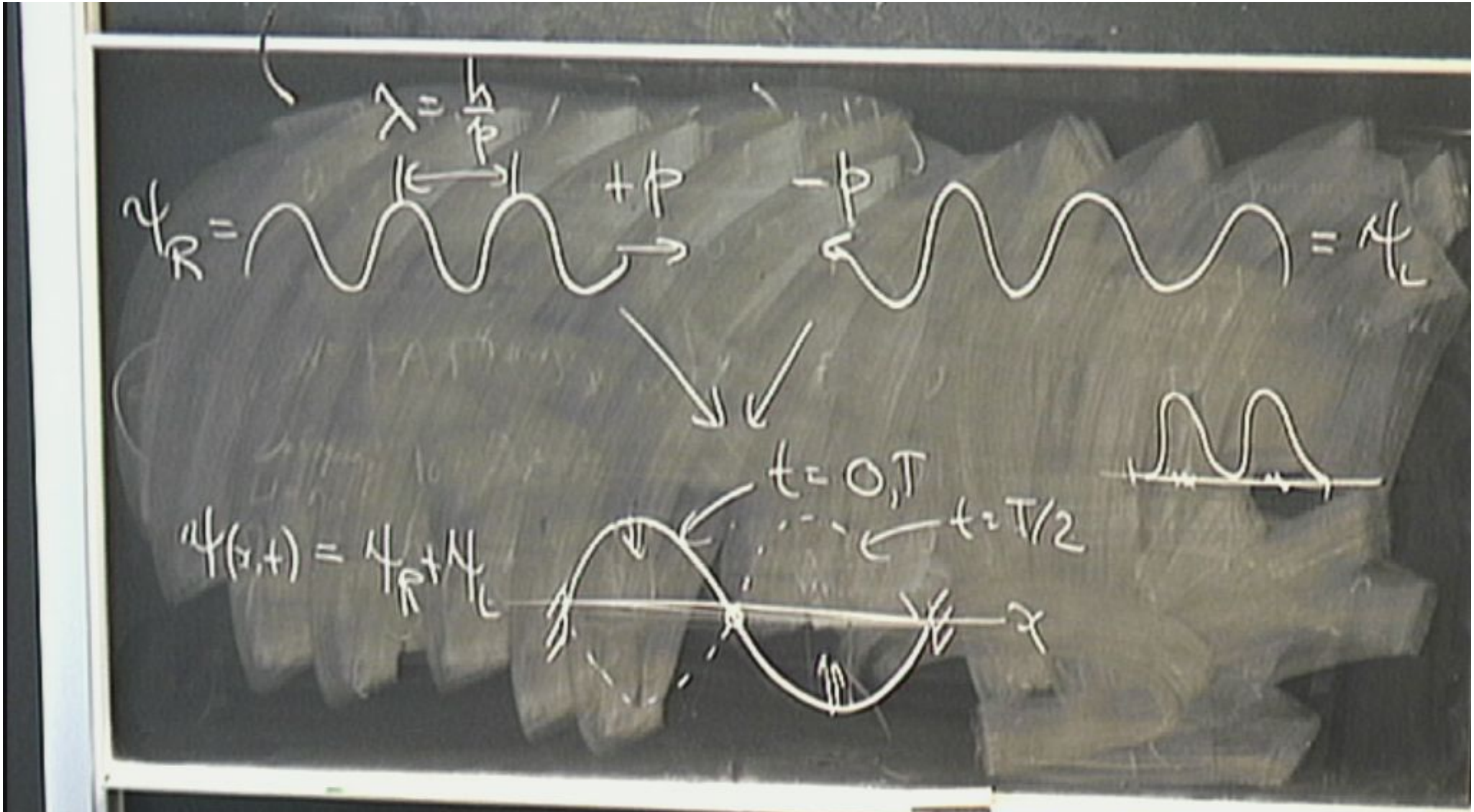

λ = h/p
+p
−p
ψR =
= ψL
t = 0, T
t = T/2
ψ(x,t) = ψR + ψL
x

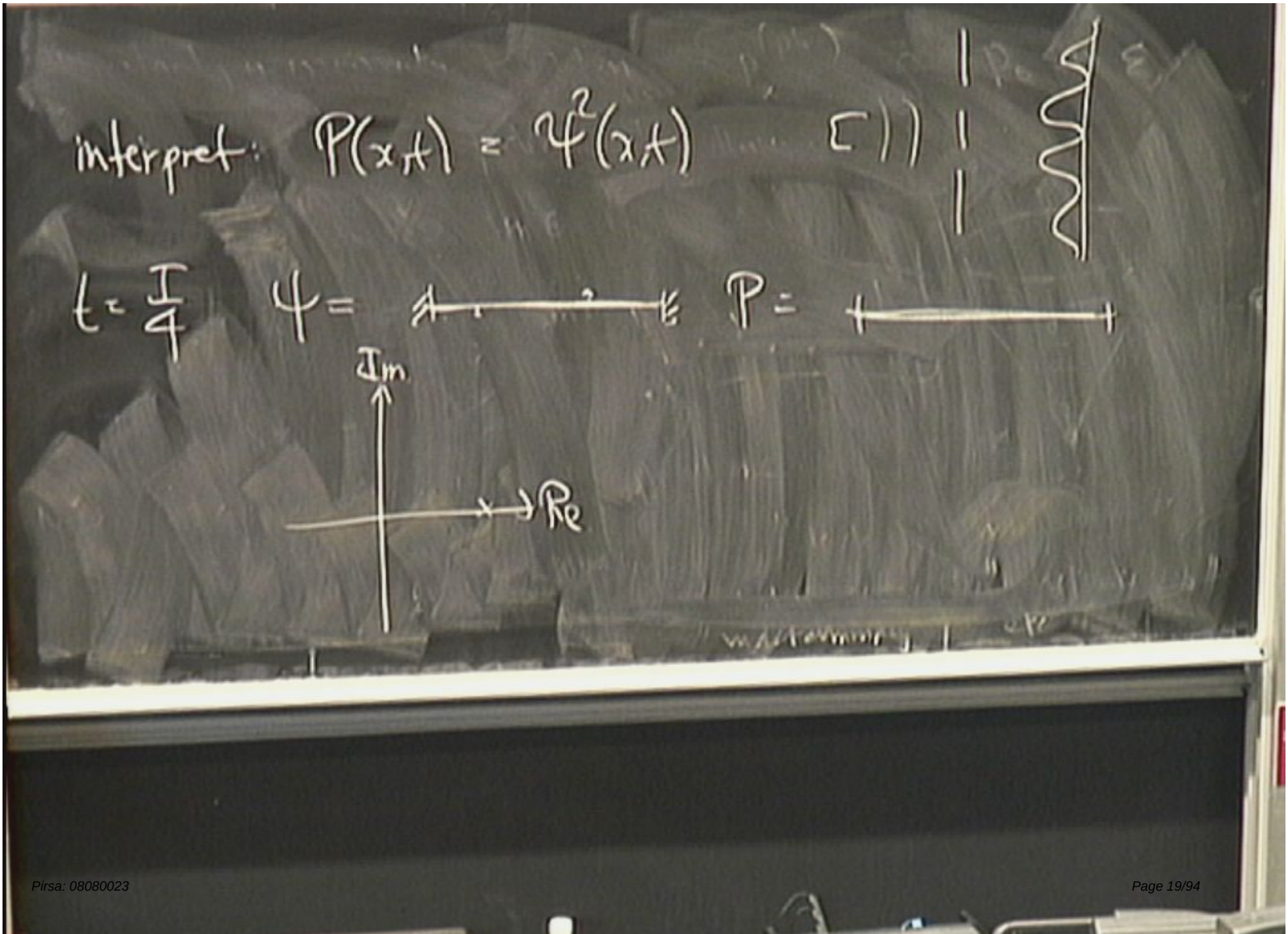

interpret: $P(x,t) = \psi^2(x,t)$
$t = \frac{T}{4}$

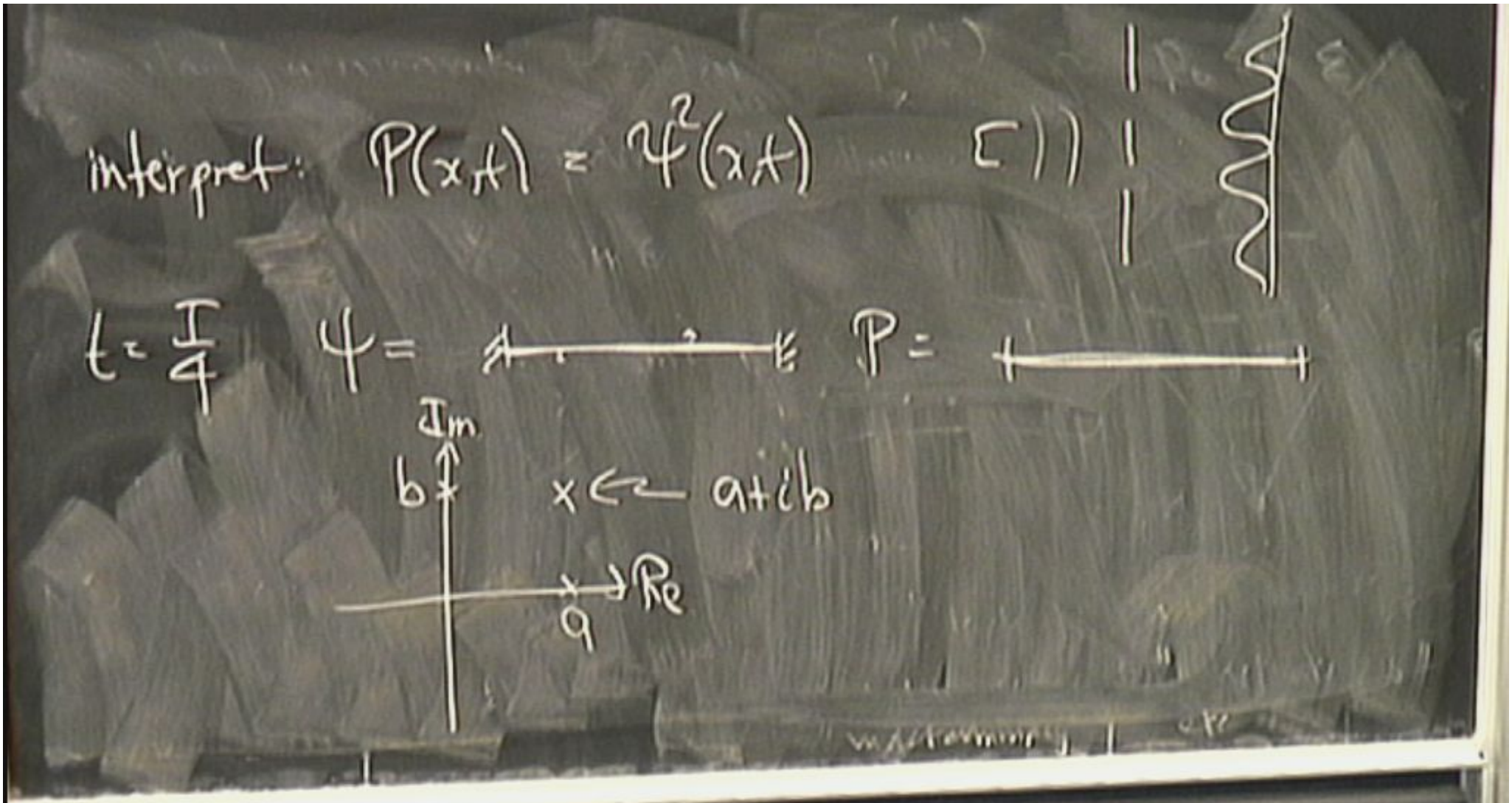
interpret: $P(x,t) = \psi^2(x,t)$

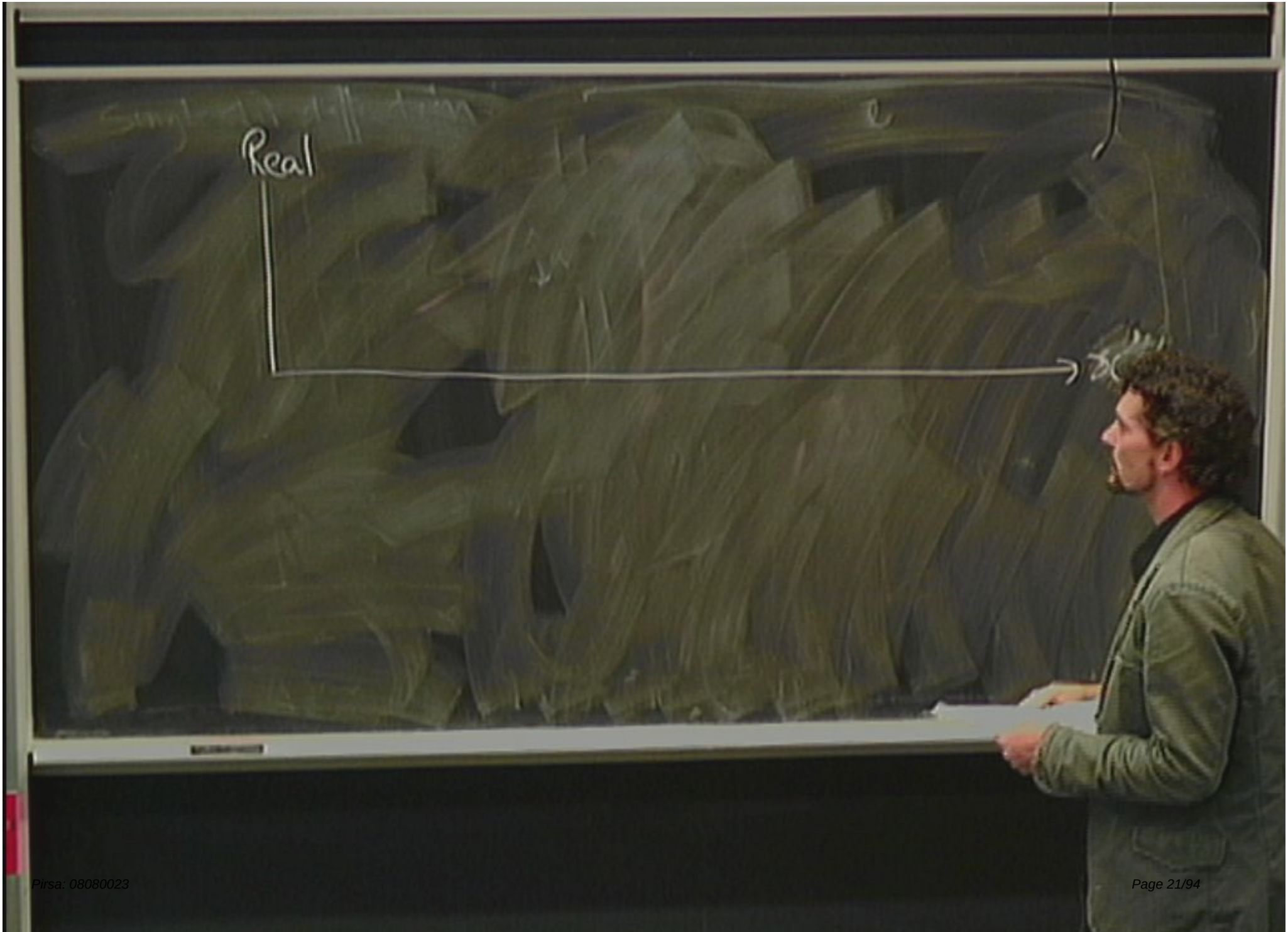
$t = \frac{T}{4}$ $\psi =$  $P =$ 

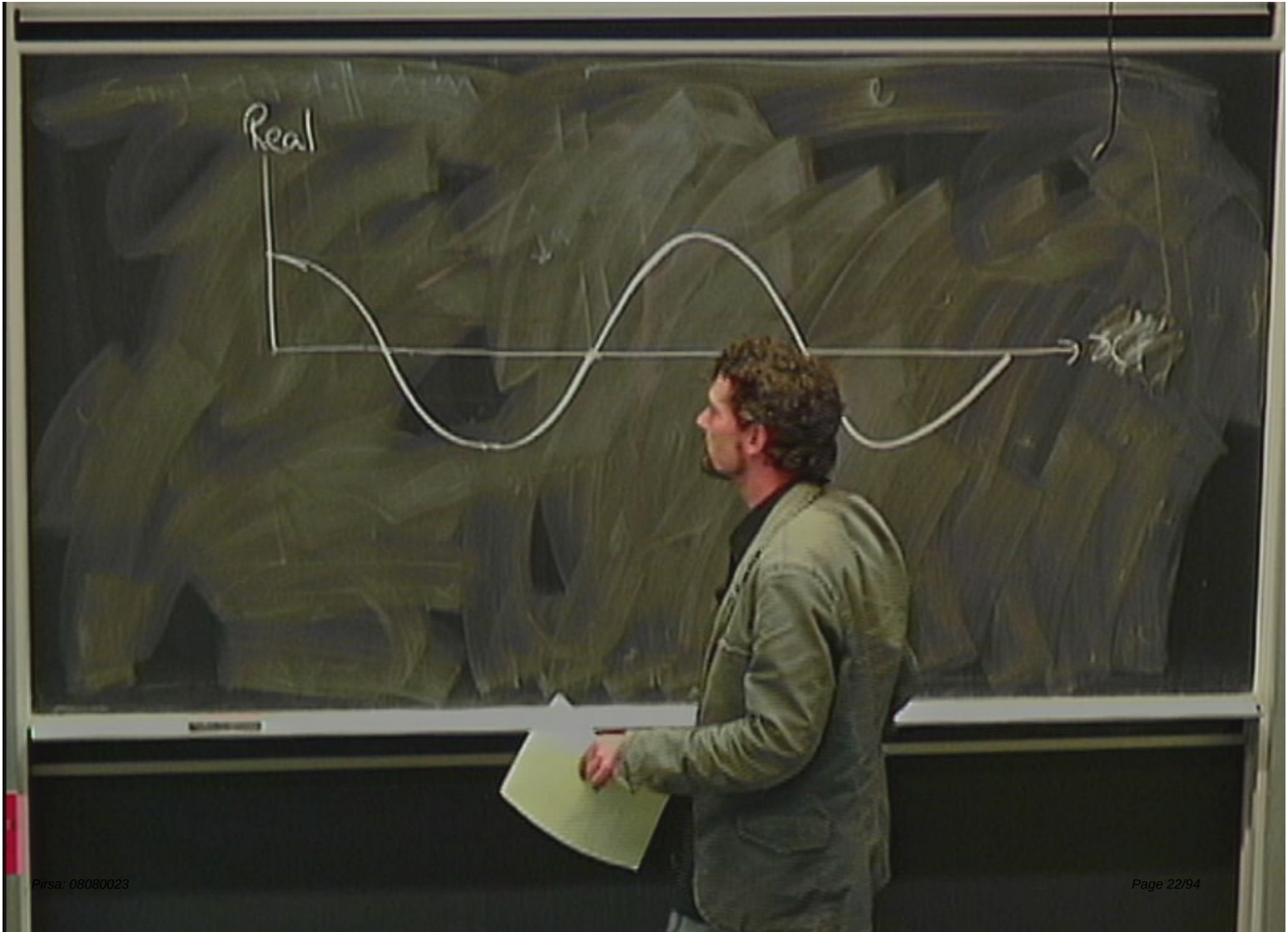

λ = h/p
+p
−p
ψR =
= ψL
ψ(x,t) = ψR + ψL
0, T
t = T/2
x

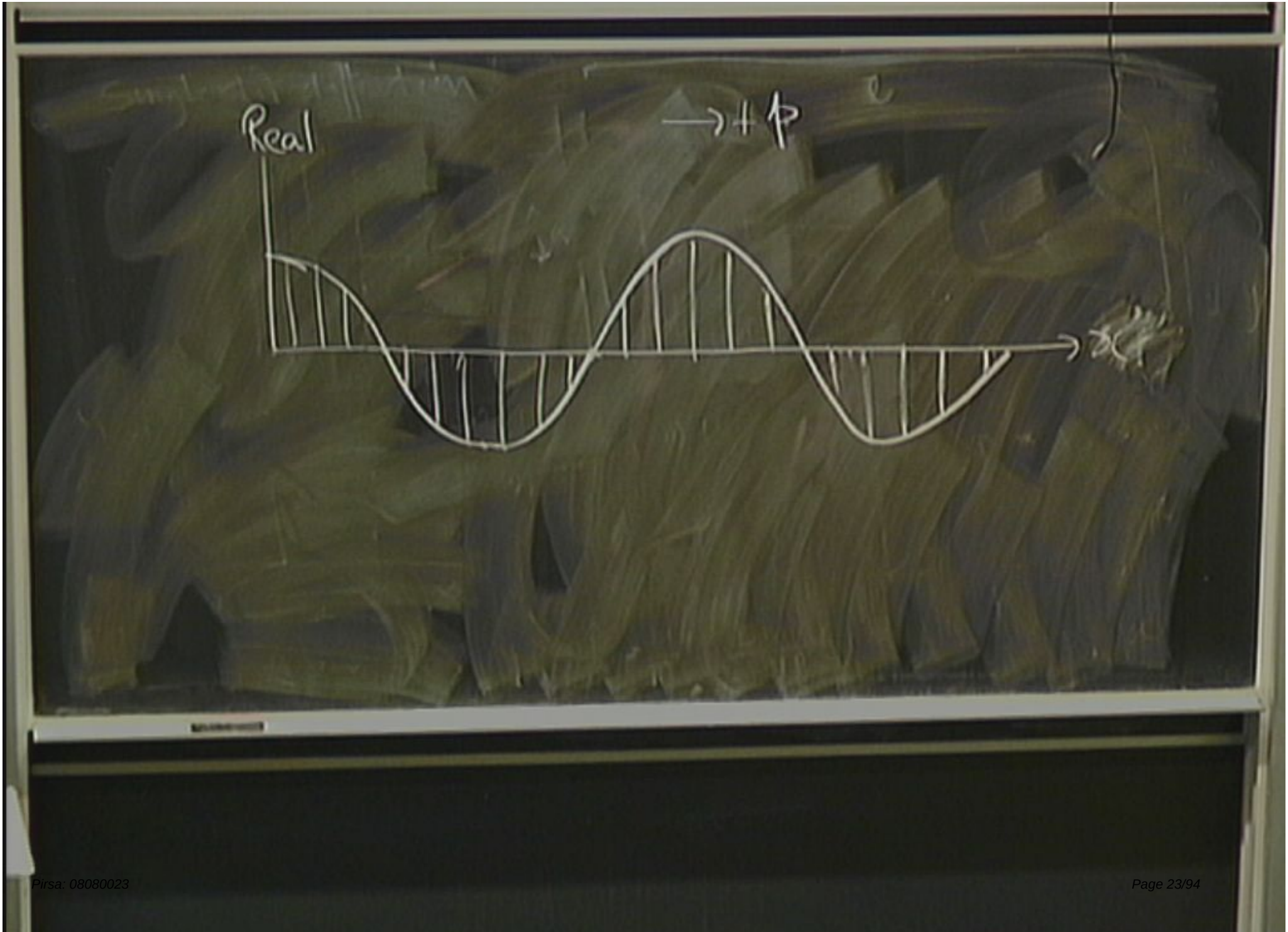

λ = h/p
+p
−p
ψR =
= ψL
t = 0, T
t = T/2
ψ(x,t) = ψR + ψL
x

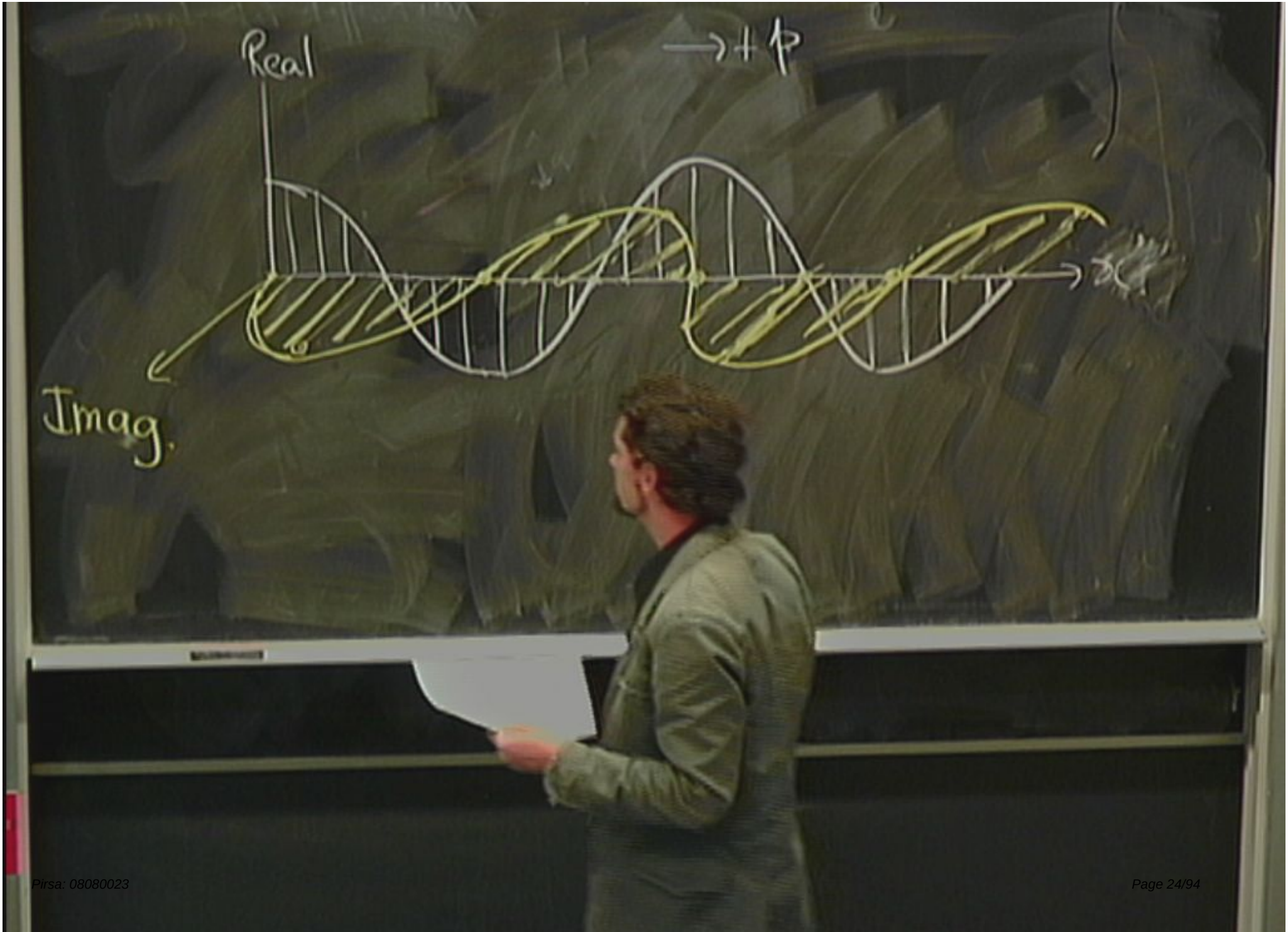

interpret: $P(x,t) = \psi^2(x,t)$
$t = \frac{T}{4}$
$\psi =$
$P =$
Im
Re

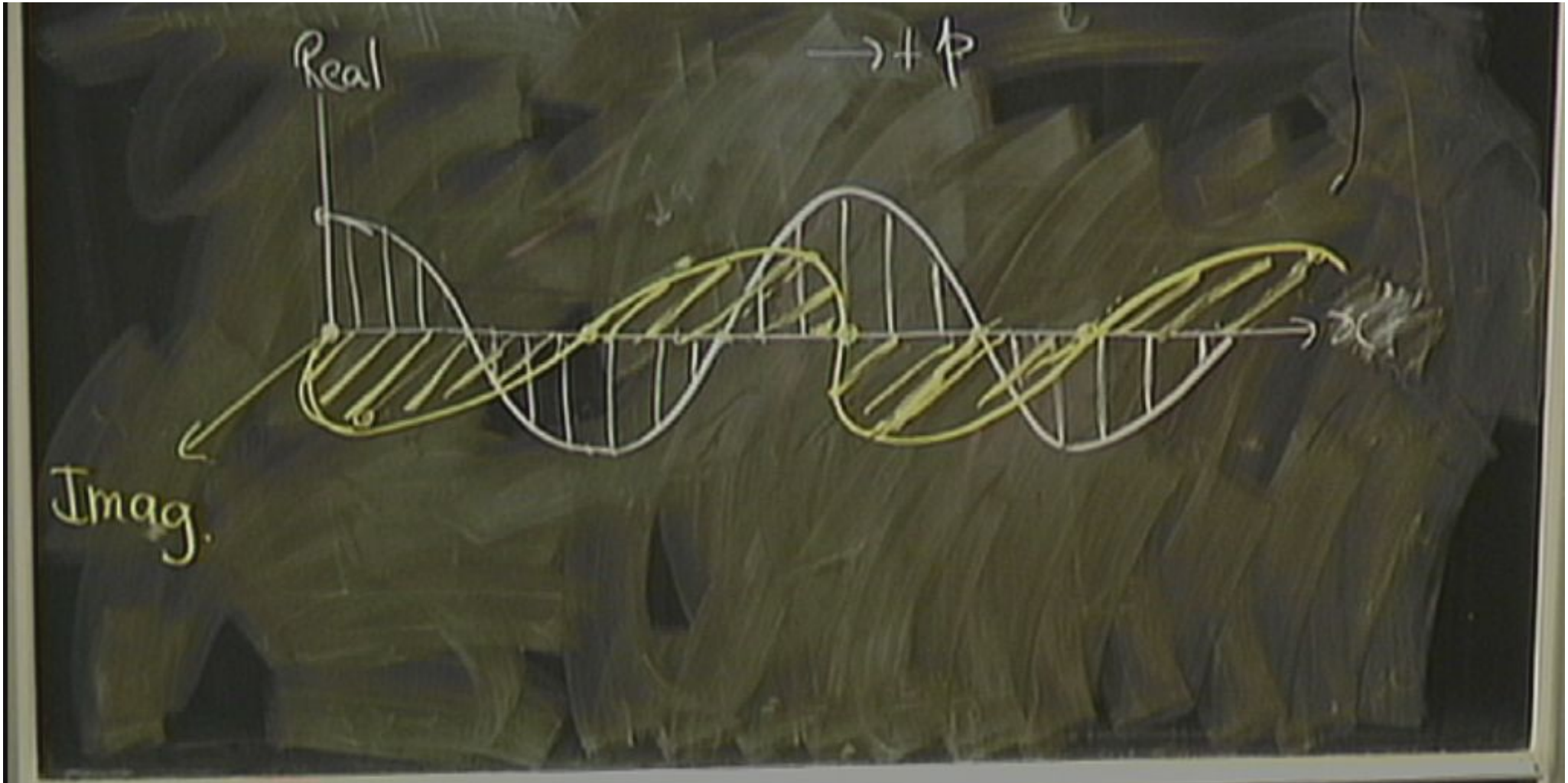

interpret: $P(x,t) = \psi^2(x,t)$
$t = \frac{I}{4}$
$\psi =$
$P =$
Im
b
$x \leftarrow a+ib$
Re
a

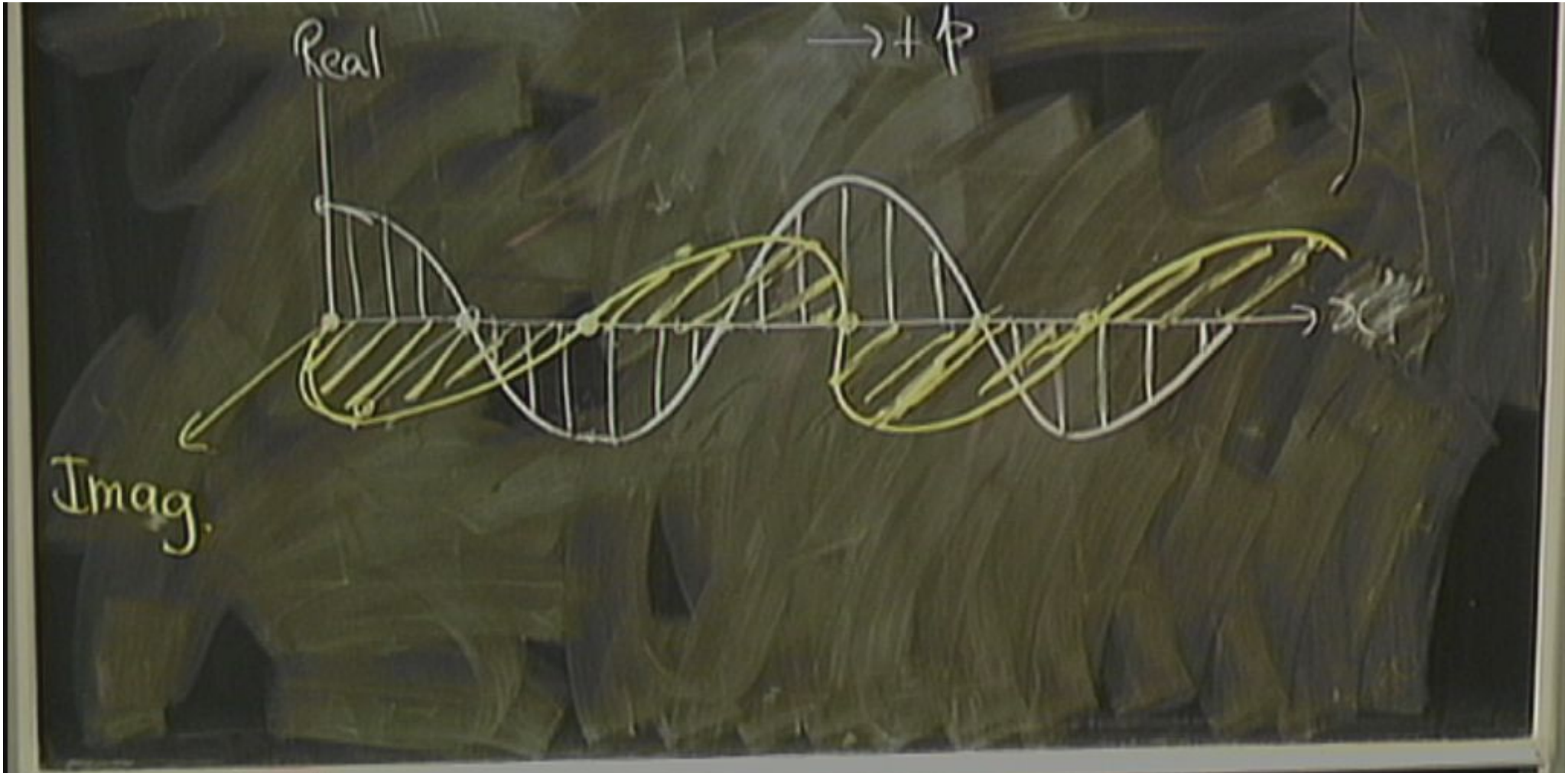

Real


Real


Real
+ p


Real
→ + p
Imag.

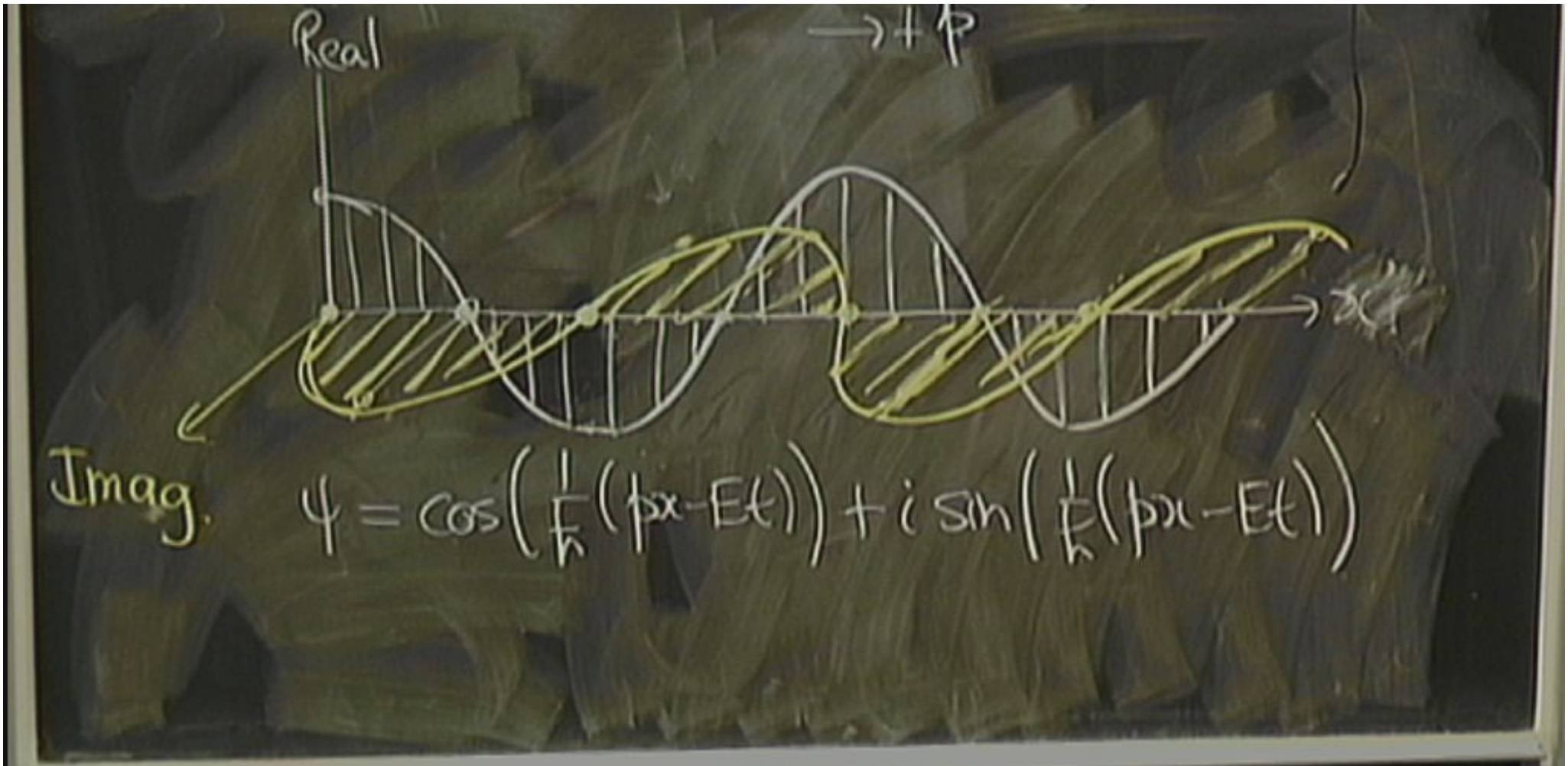

Real
+p
Imag.

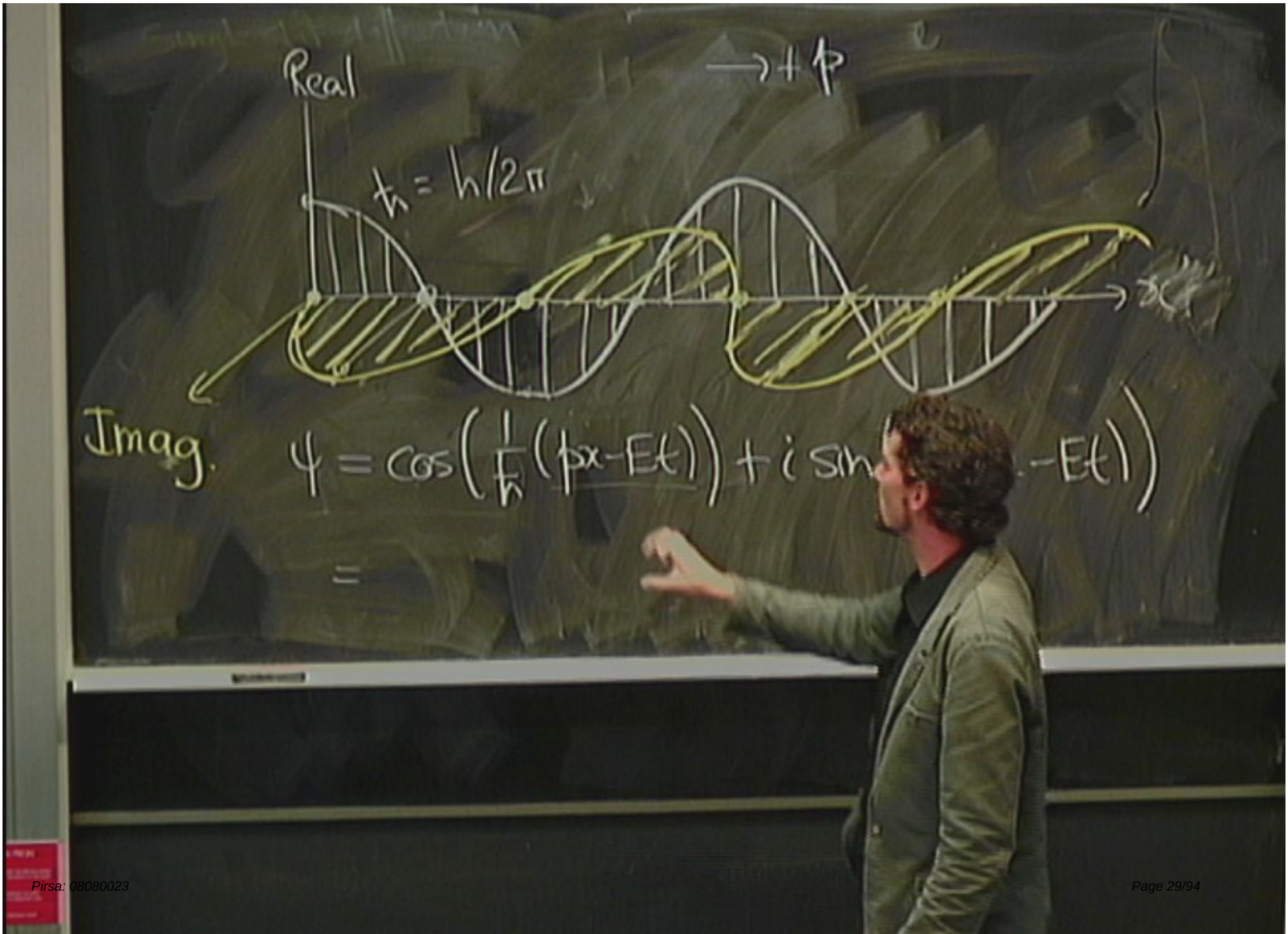

Real
→ + p
Imag.

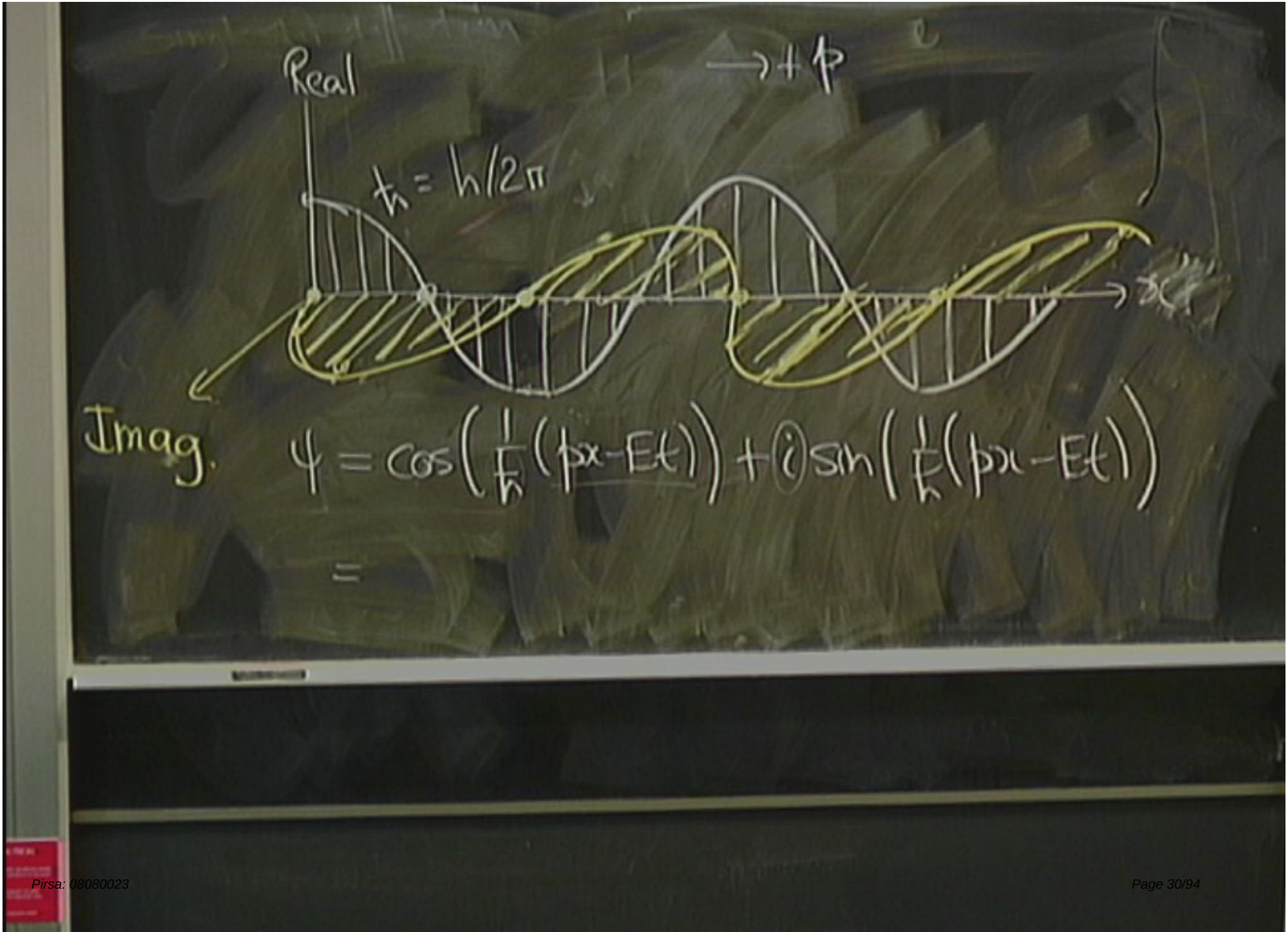
interpret: $P(x,t) = \psi^2(x,t)$

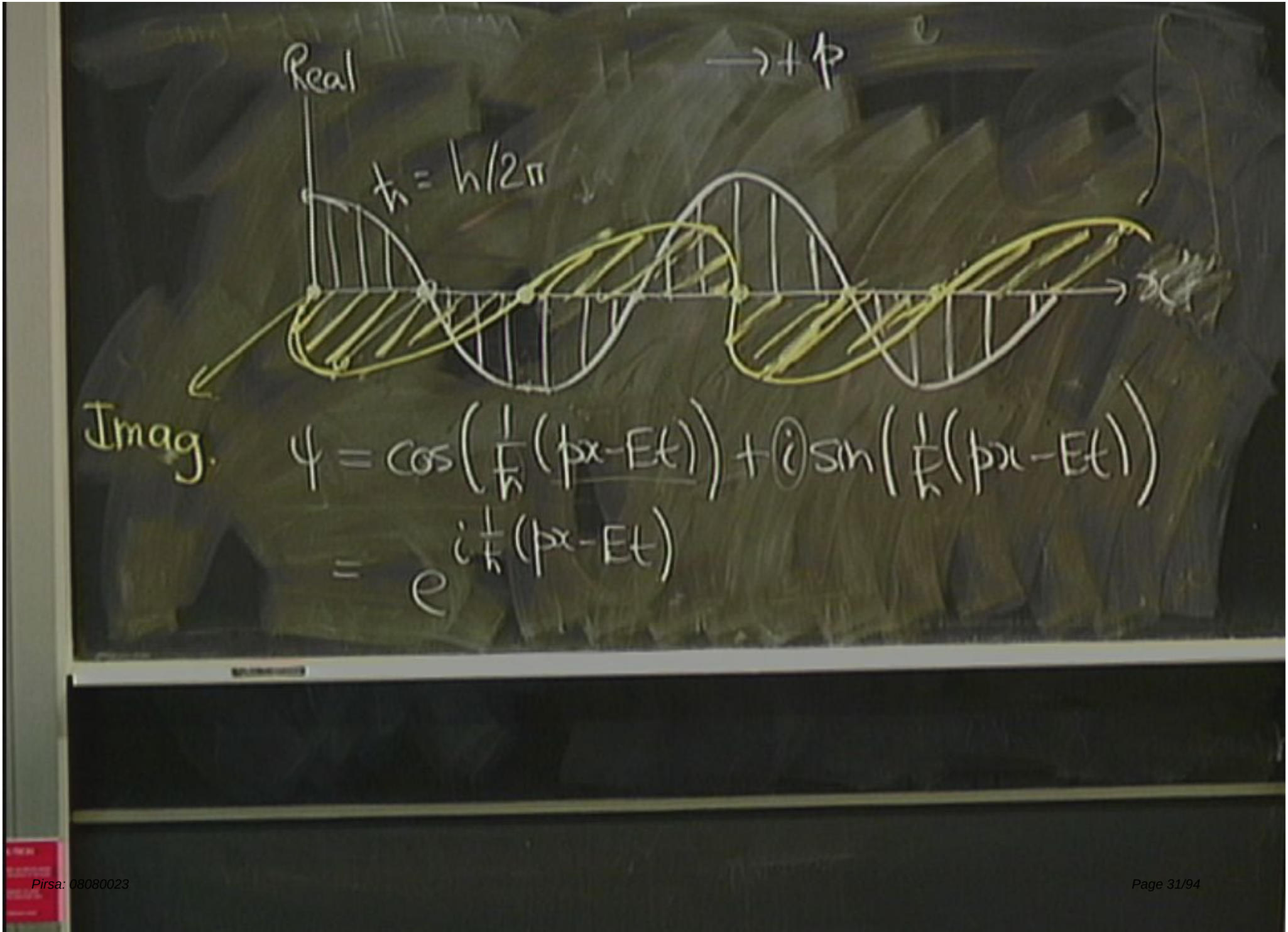
$t = \frac{T}{4}$ $\psi =$  $P =$ 

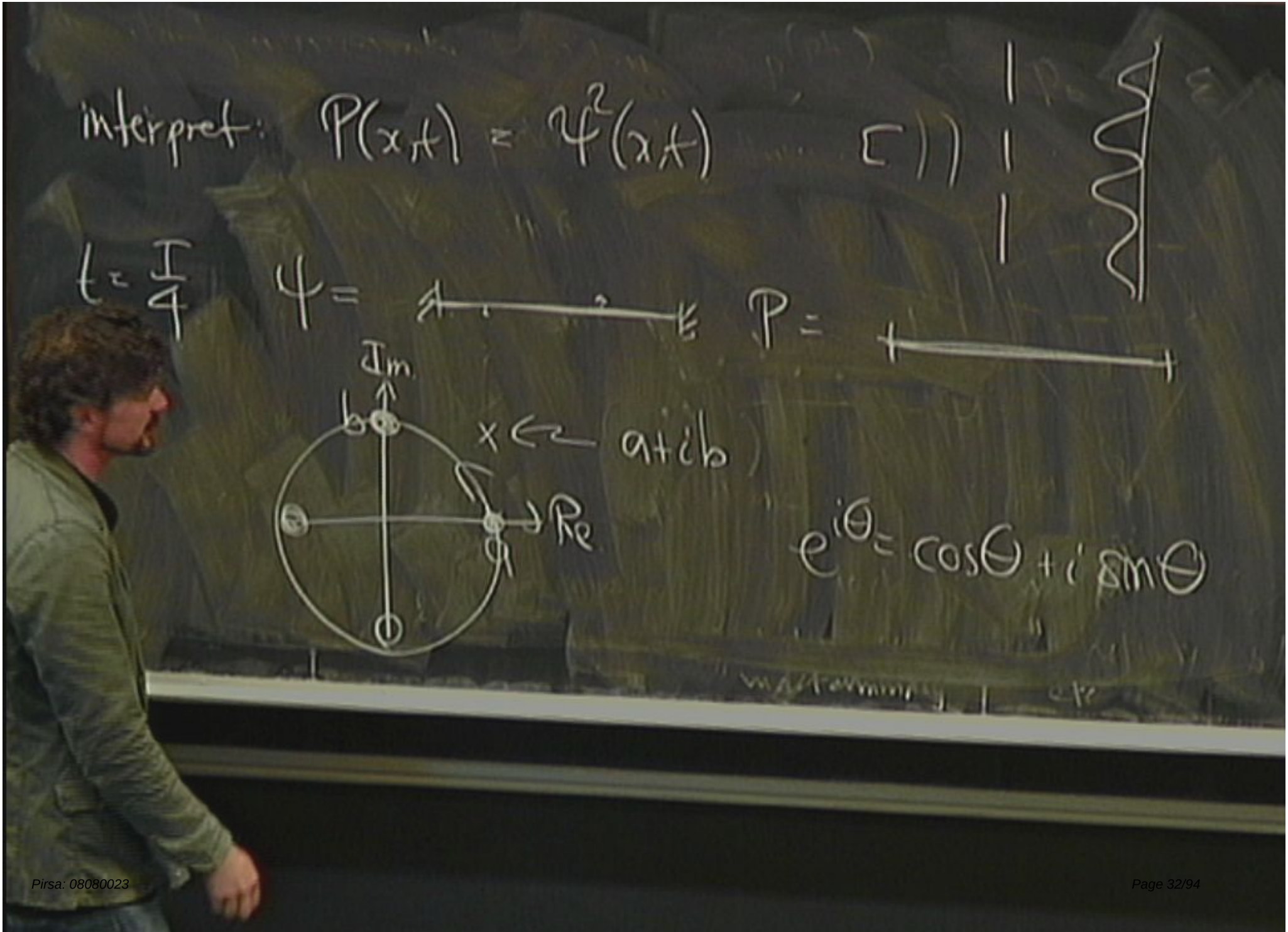
$x \leftarrow a+ib$

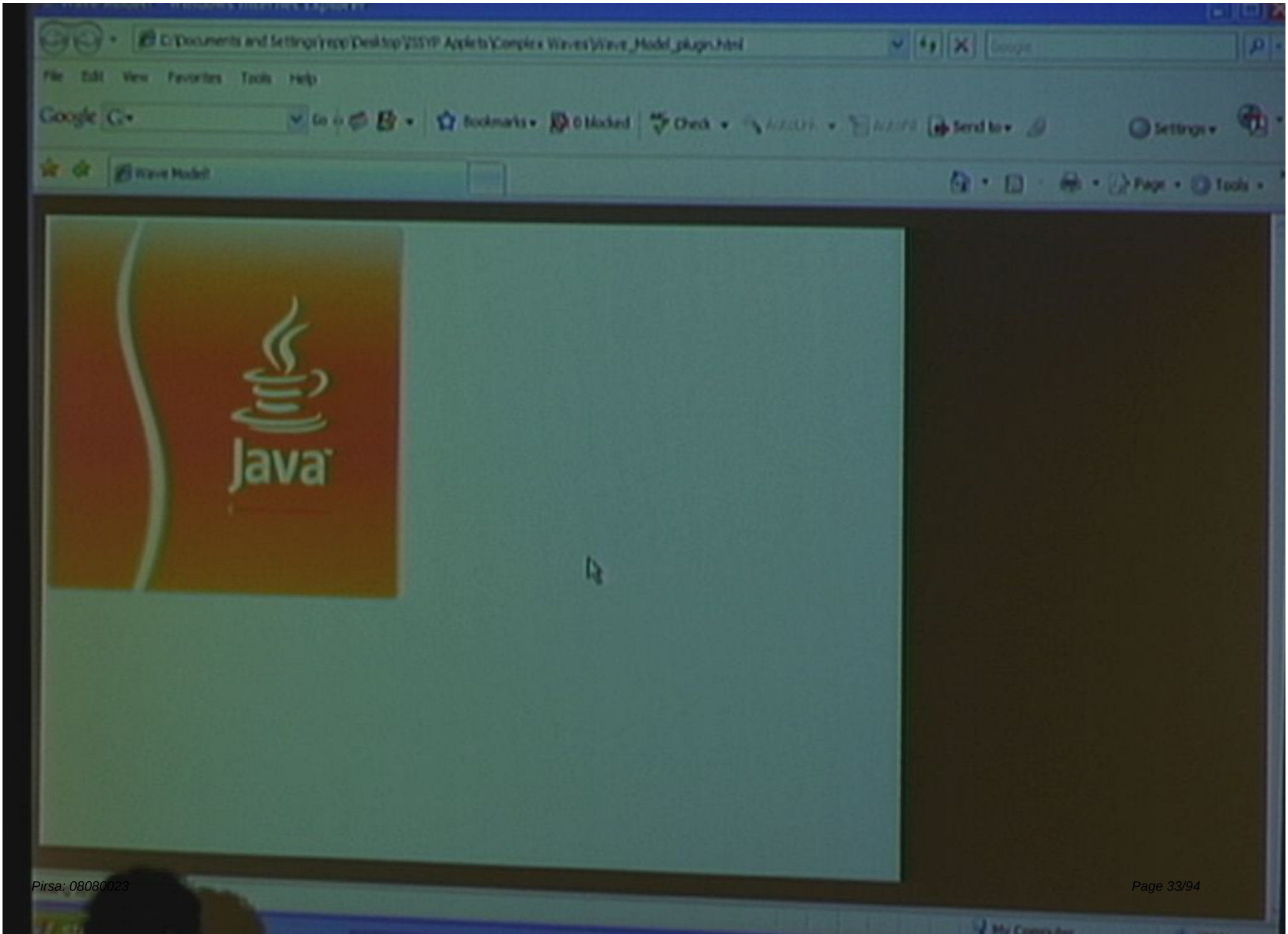

Real
→ + p
Imag.
$\psi = \cos\left(\frac{1}{\hbar}(px - Et)\right) + i \sin\left(\frac{1}{\hbar}(px - Et)\right)$


Real
$\rightarrow +p$
$\hbar = h/2\pi$
Imag.
$\psi = \cos\left(\frac{1}{\hbar}(px - Et)\right) + i \sin$
$-Et)\Big)$
$=$


Real
$\rightarrow +p$
$\hbar = h/2\pi$
$x(t)$
Imag.
$\psi = \cos\left(\frac{1}{\hbar}(px - Et)\right) + i\sin\left(\frac{1}{\hbar}(px - Et)\right)$
$=$


Real
$\rightarrow +p$
$\hbar = h/2\pi$
x
Imag.
$\psi = \cos\left(\frac{1}{\hbar}(px - Et)\right) + i\sin\left(\frac{1}{\hbar}(px - Et)\right)$
$= e^{i\frac{1}{\hbar}(px - Et)}$


interpret: $P(x,t) = \psi^2(x,t)$
$t = \frac{T}{4}$
$\psi =$
$P =$
Im
Re
$x \leftarrow a + ib$
$e^{i\theta} = \cos\theta + i \sin\theta$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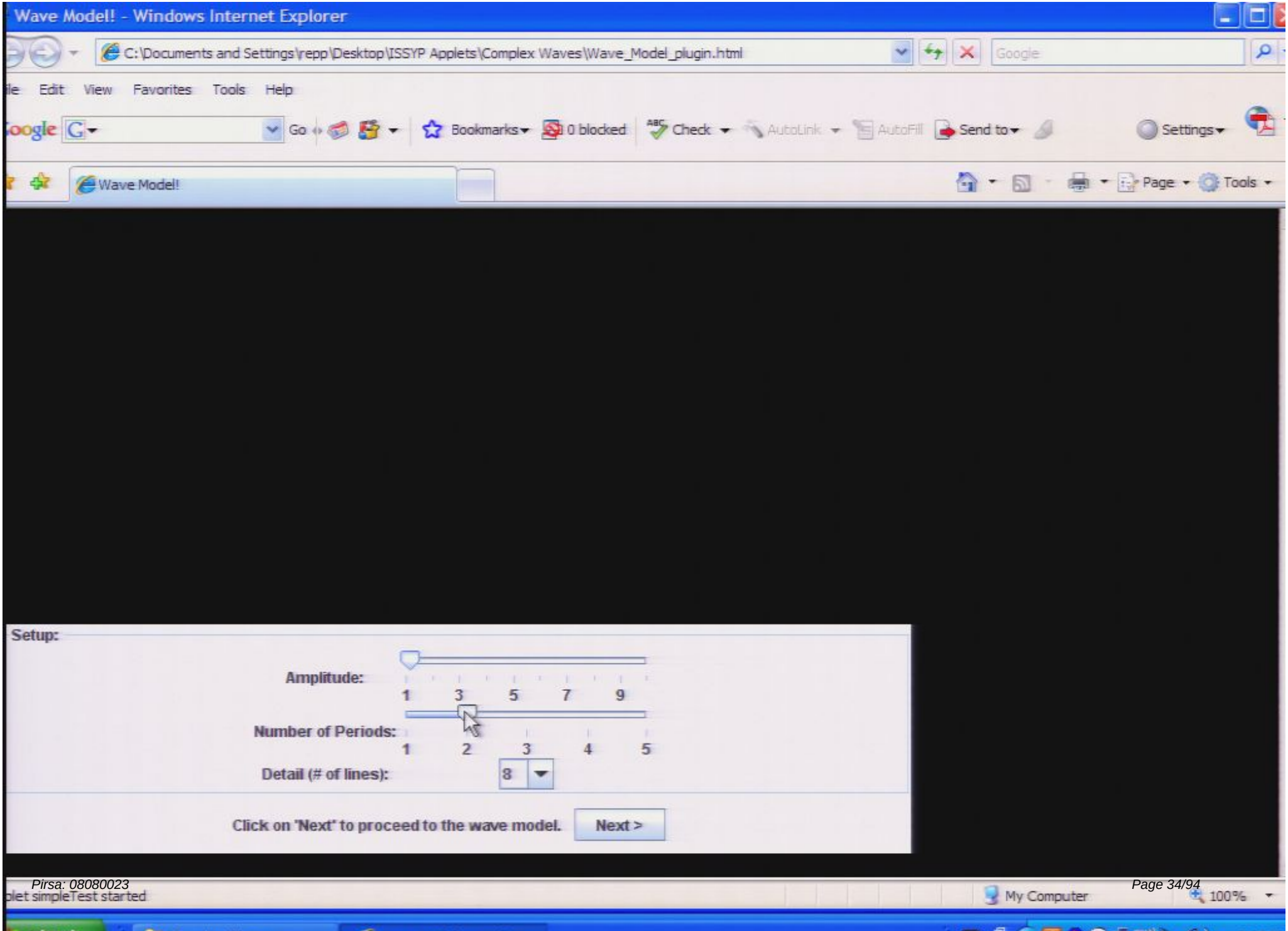
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Edit View Favorites Tools Help
Bookmarks 0 blocked Check AutoLink AutoFill Send to Settings
Wave Model!
Page Tools
Setup:
Amplitude:
1 3 5 7 9
Number of Periods:
1 2 3 4 5
Detail (# of lines):
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Click on "Next" to proceed to the wave model.
Next >
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My Computer
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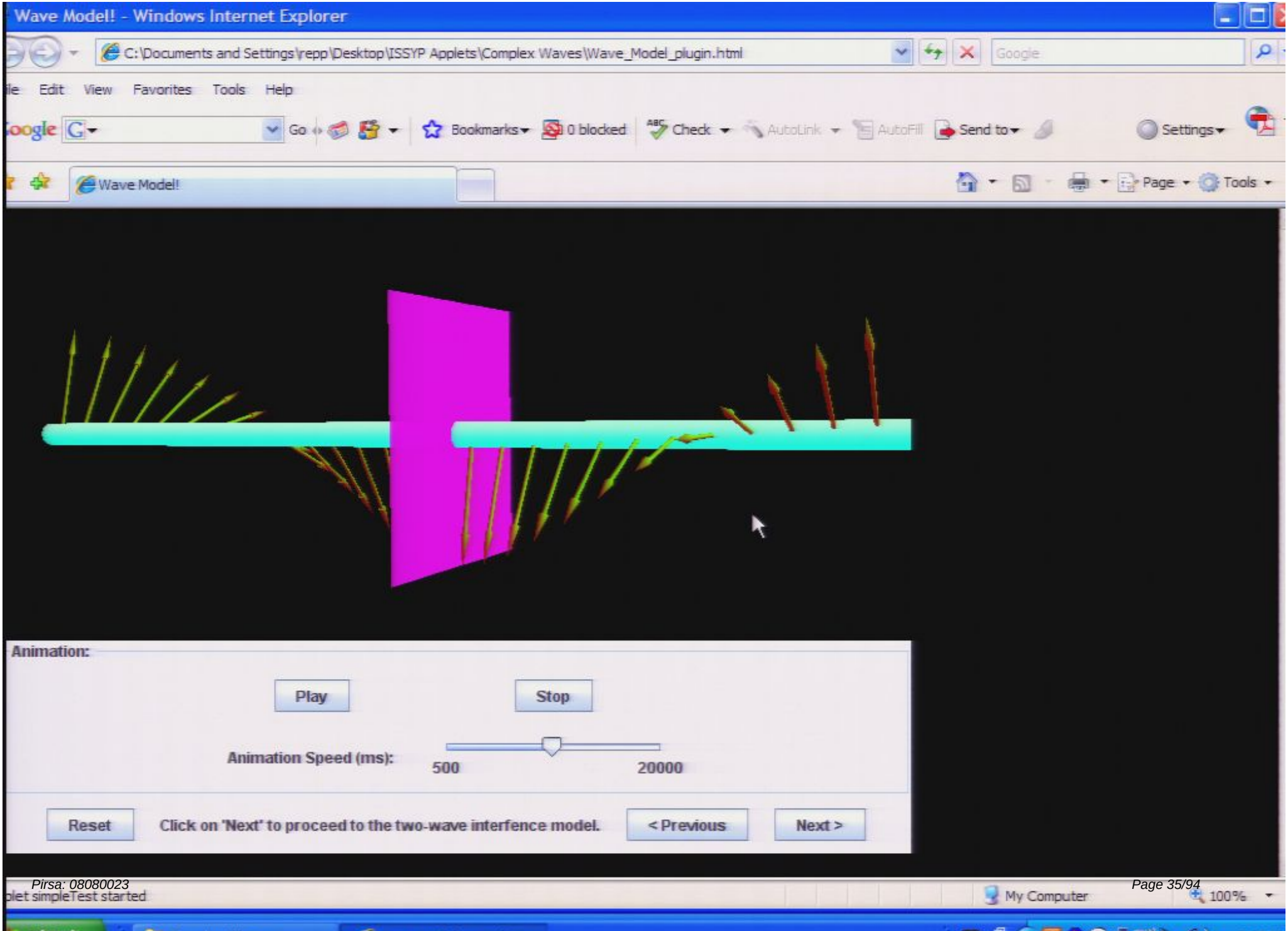
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Wave Model!
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Play
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Click on 'Next' to proceed to the two-wave interfence model.
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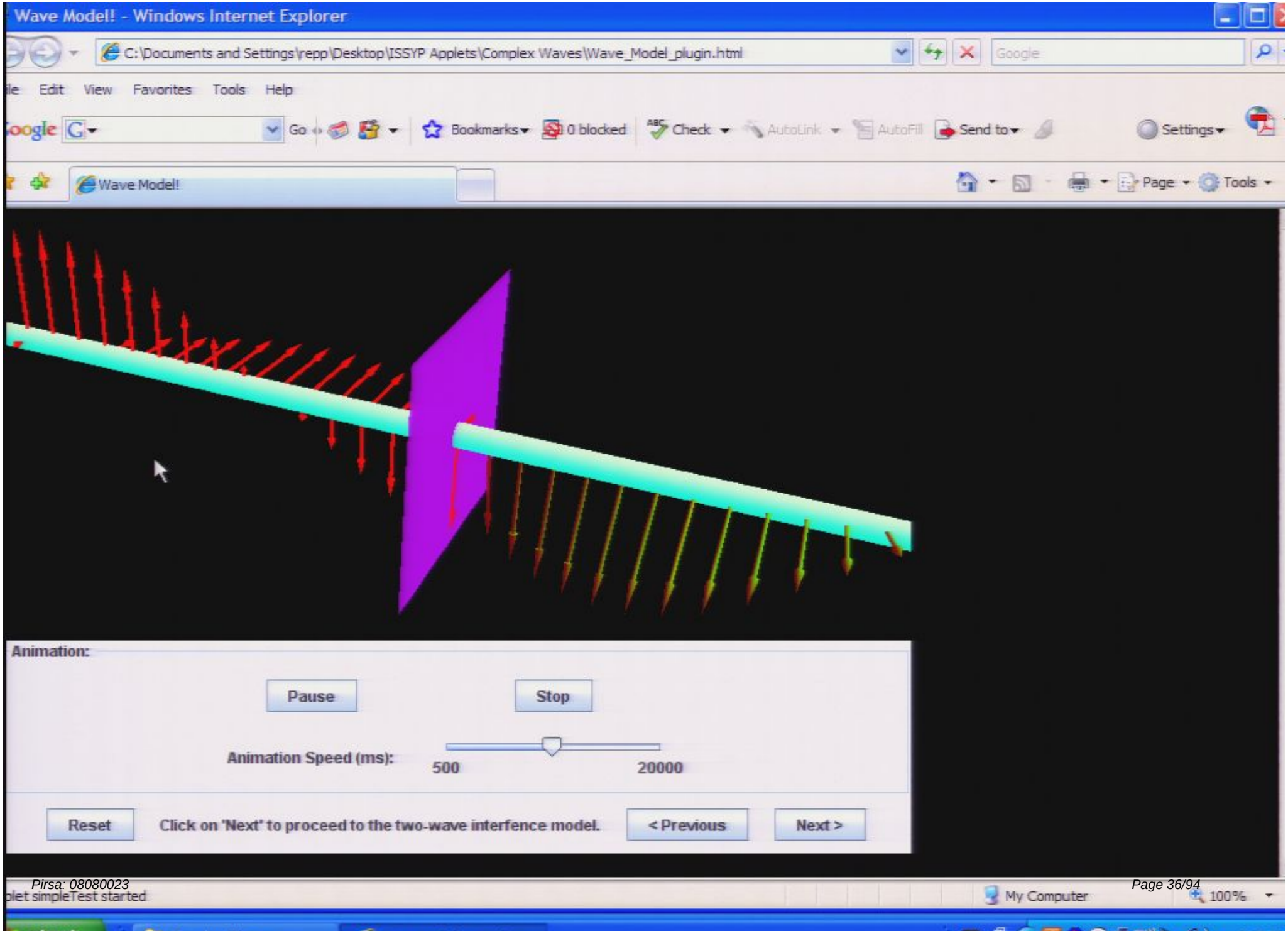
Wave Model! - Windows Internet Explorer
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Wave Model!
Page Tools
Animation:
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Stop
Animation Speed (ms):
500
20000
Reset
Click on 'Next' to proceed to the two-wave interfence model.
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Next >
My Computer
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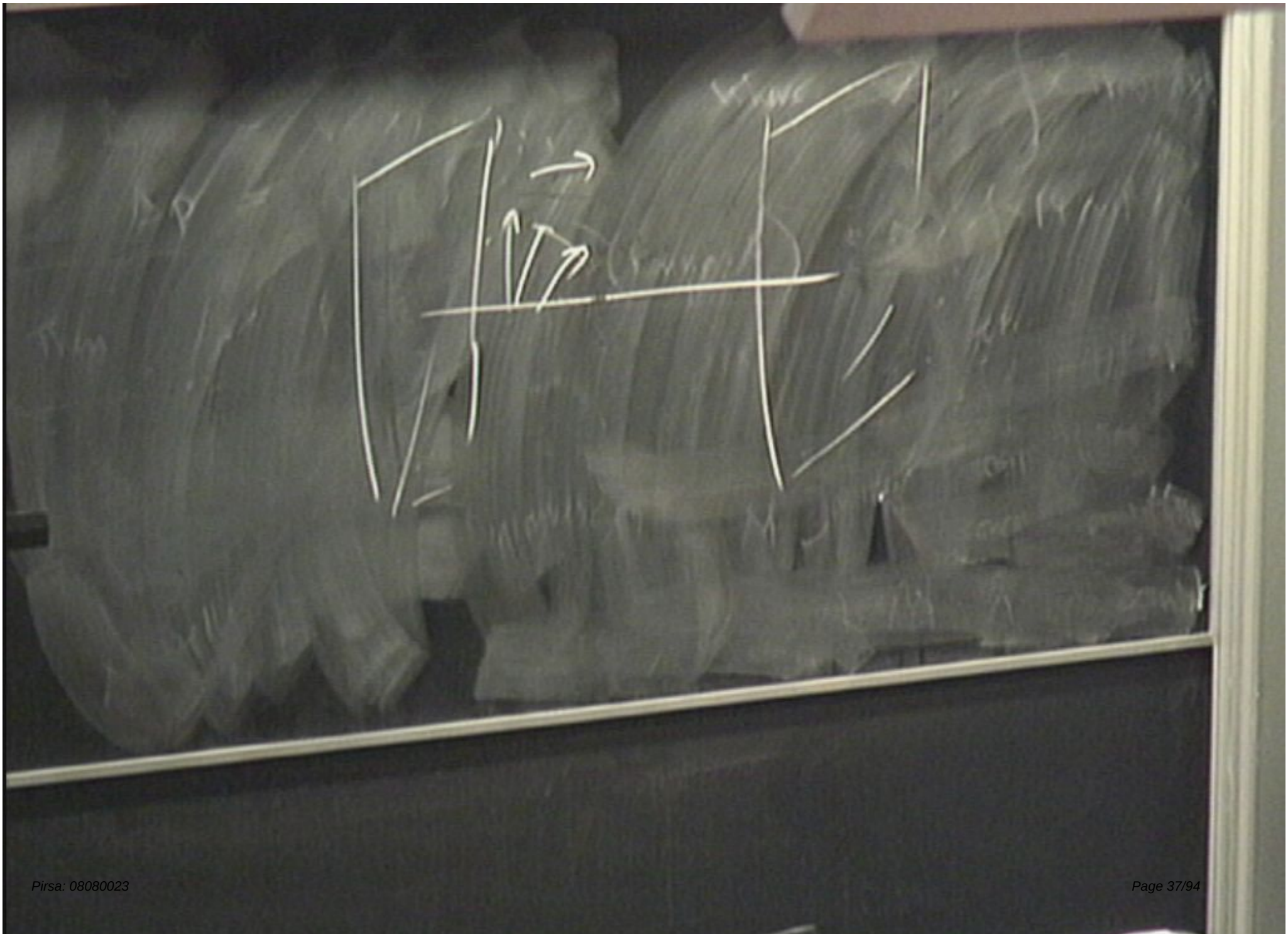

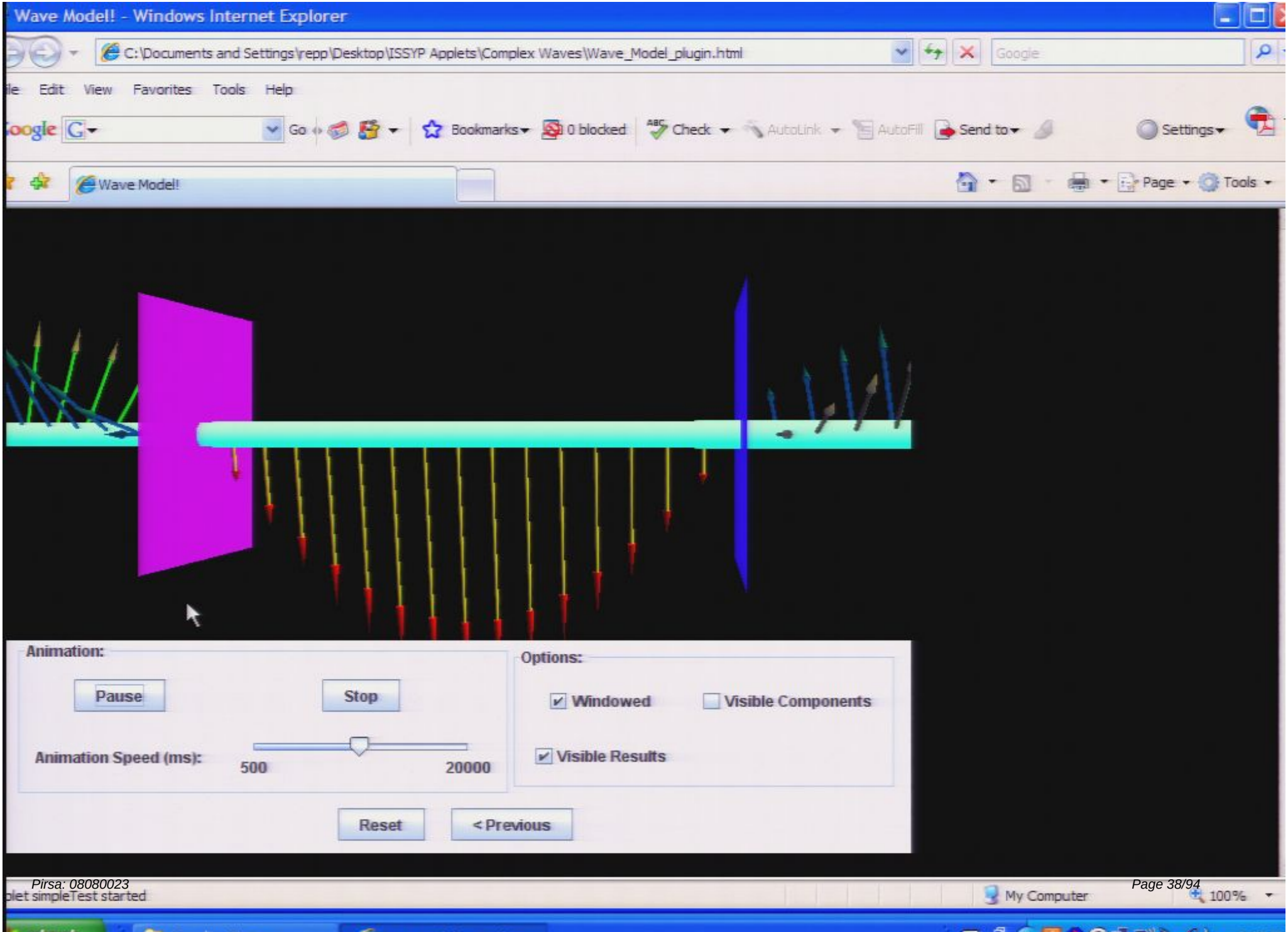
Wave Model! - Windows Internet Explorer
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Edit View Favorites Tools Help
Bookmarks 0 blocked Check AutoLink AutoFill Send to Settings
Wave Model!
Page Tools
Animation:
Pause
Stop
Animation Speed (ms):
500
20000
Options:
Windowed
Visible Components
Visible Results
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< Previous
My Computer
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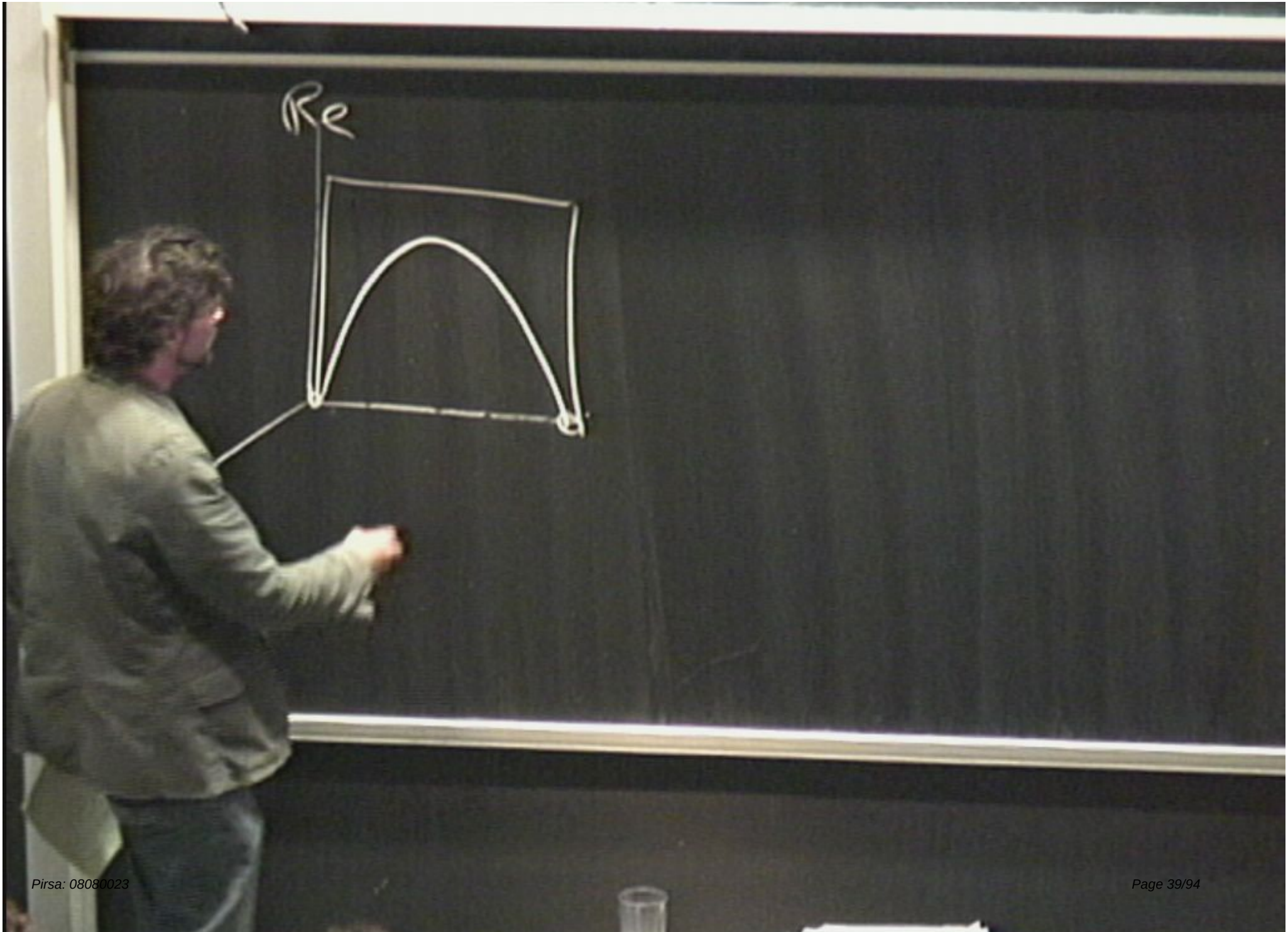
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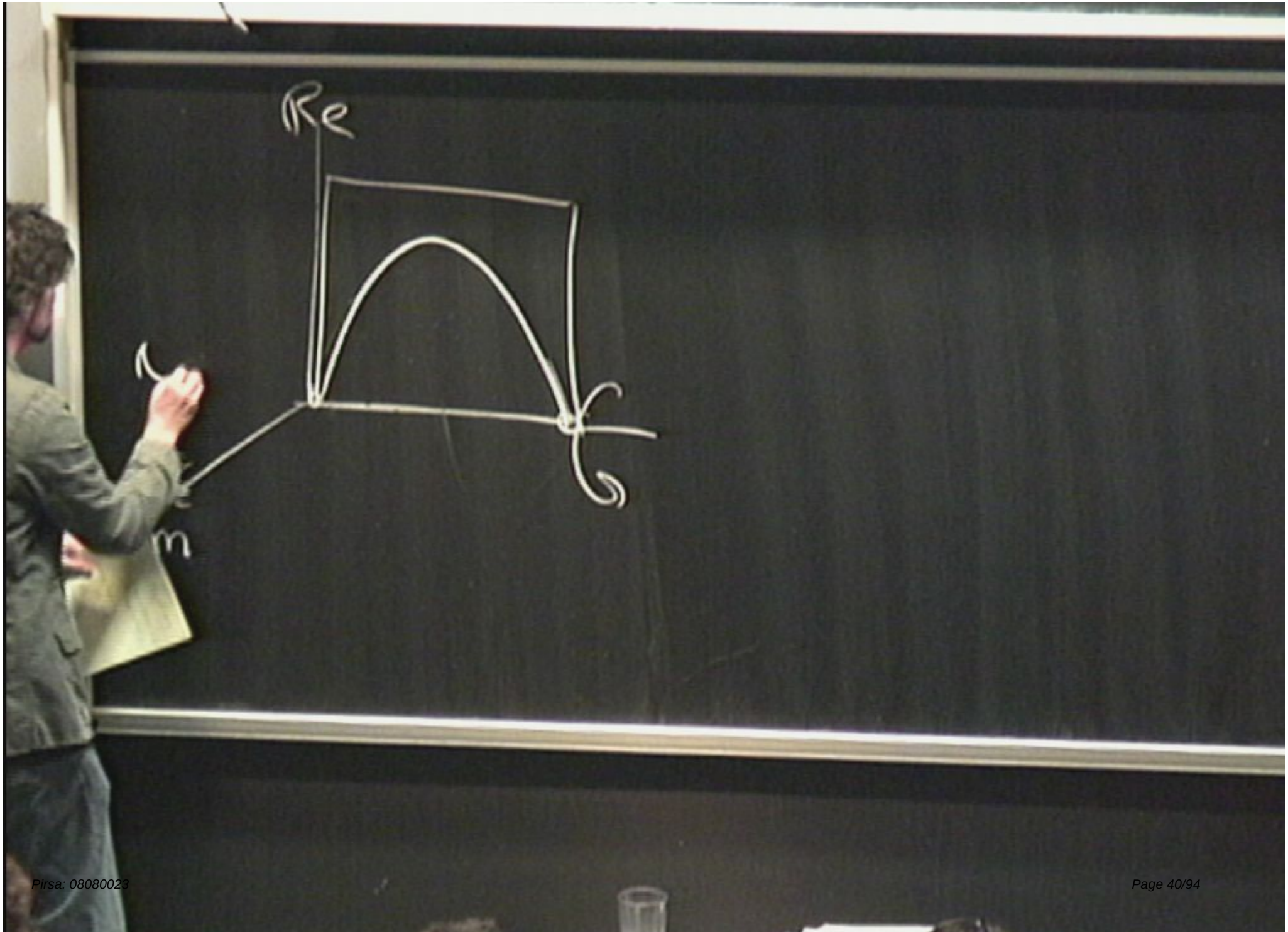
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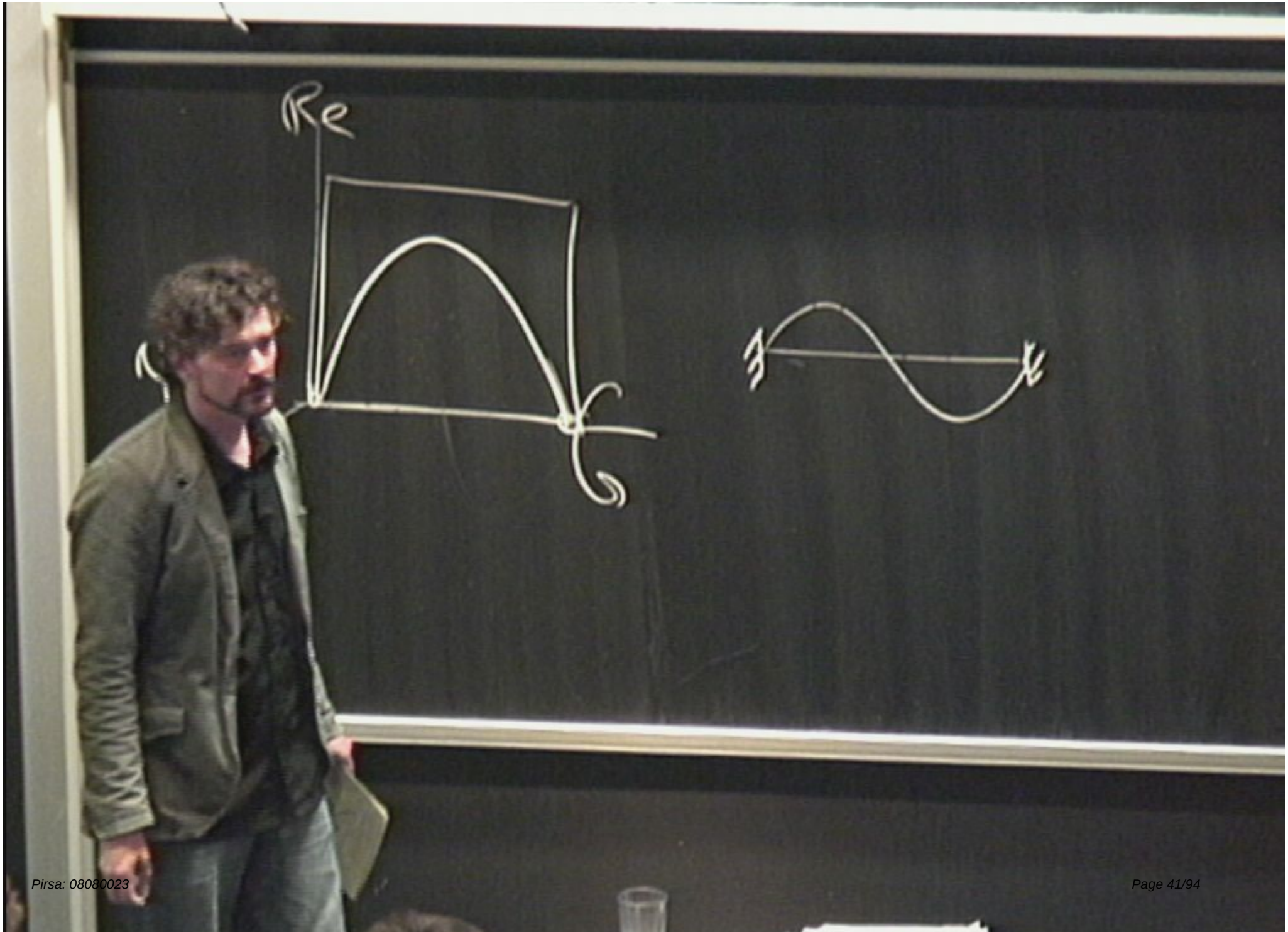
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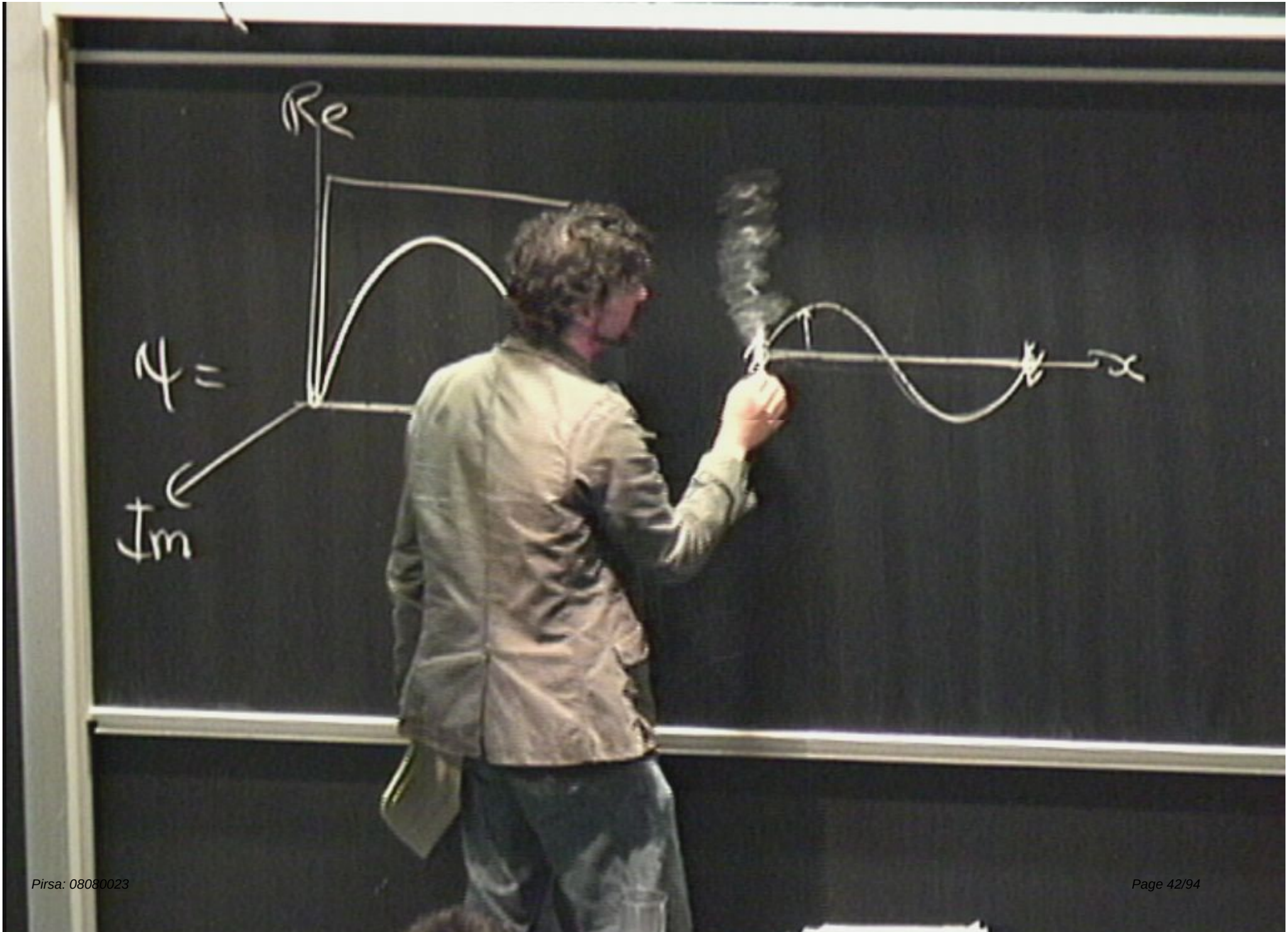
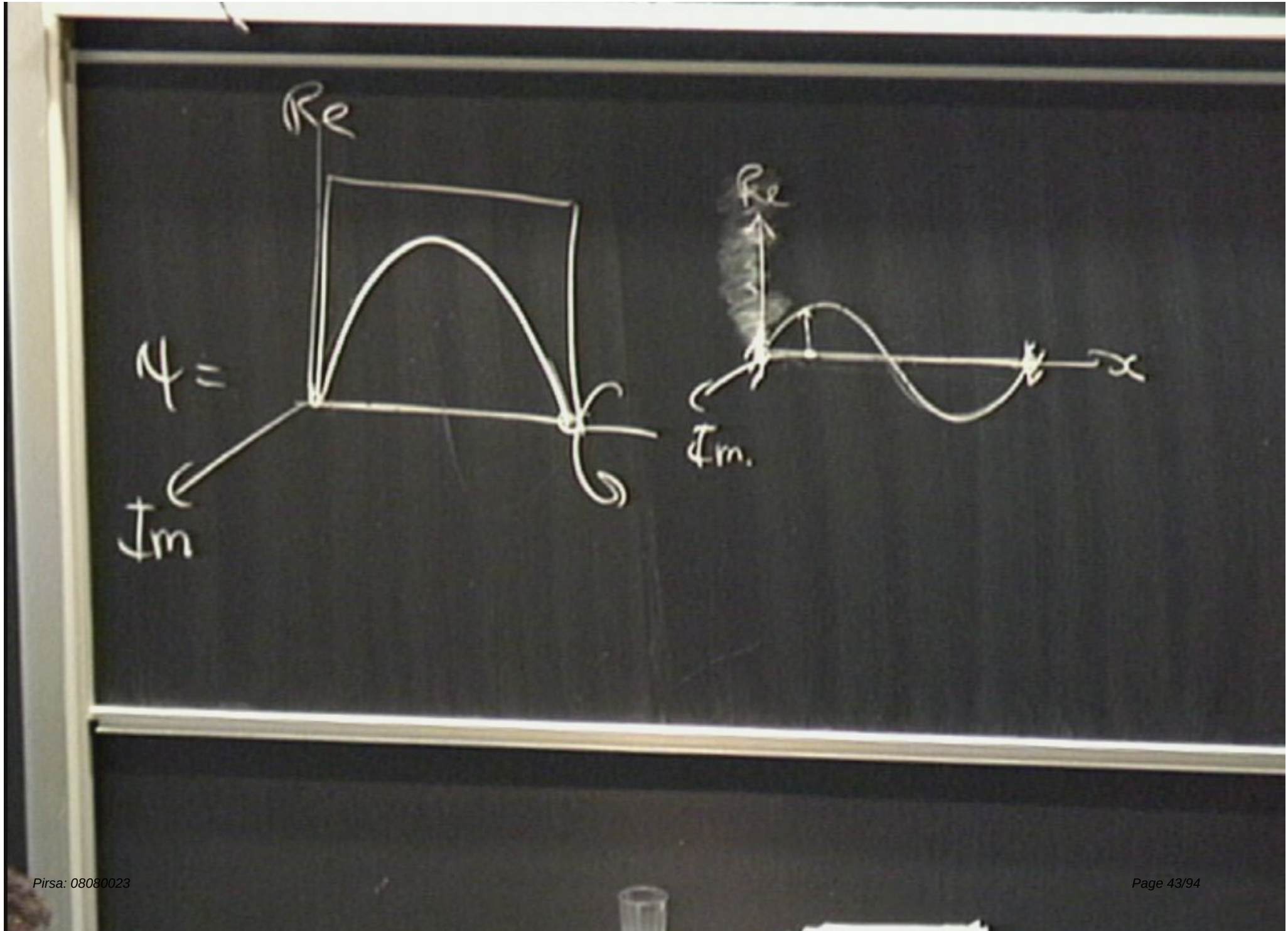
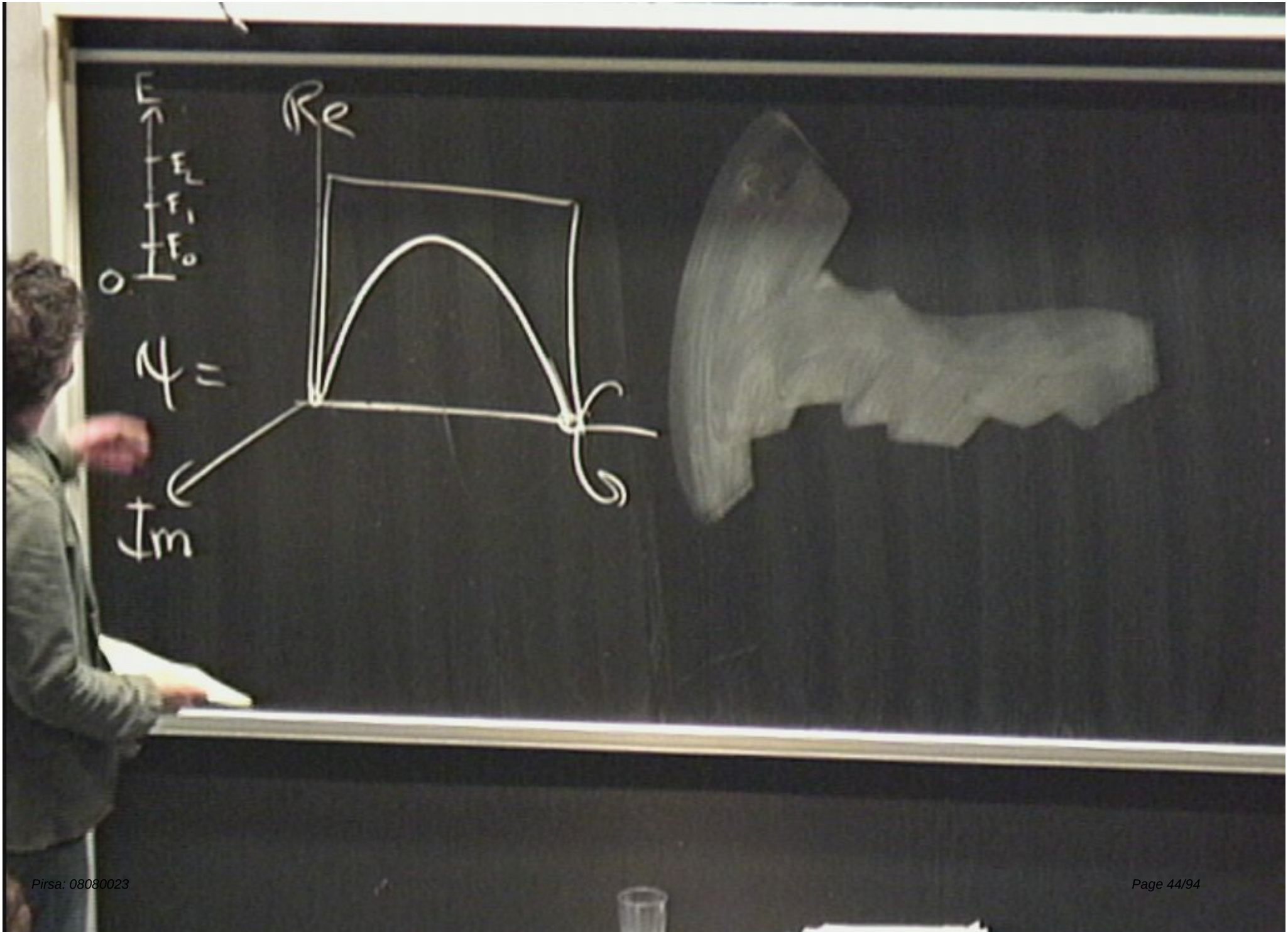
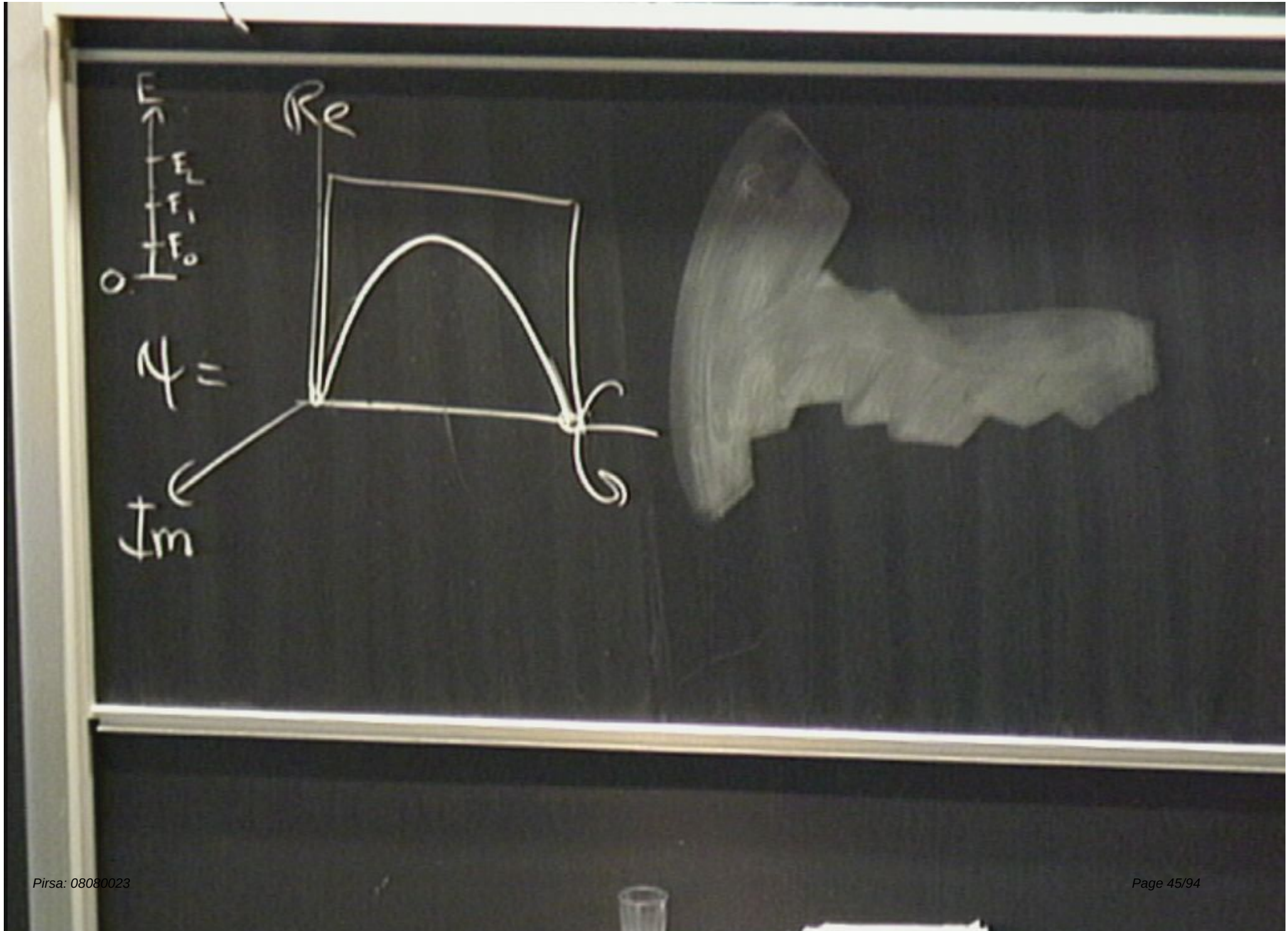
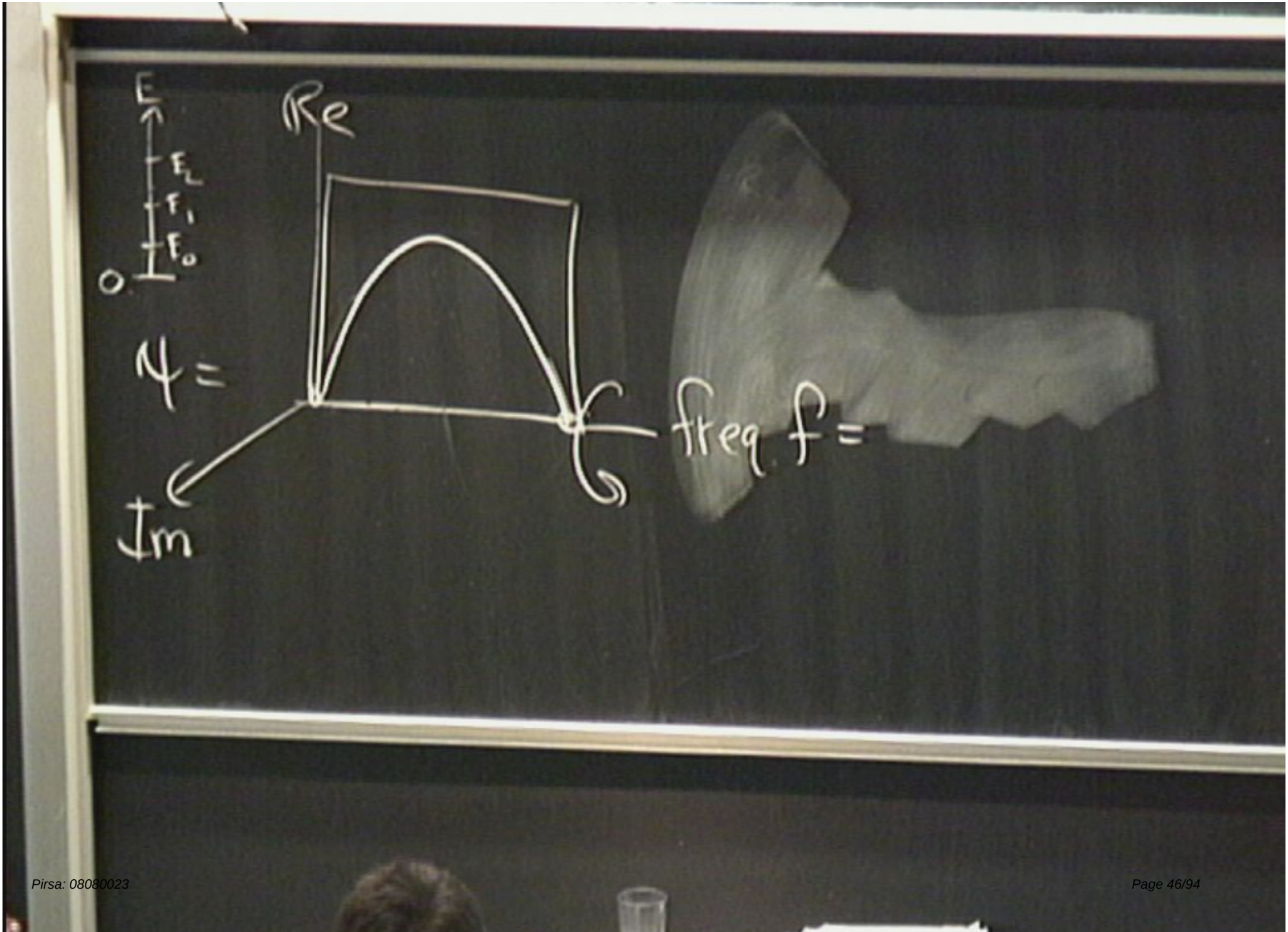
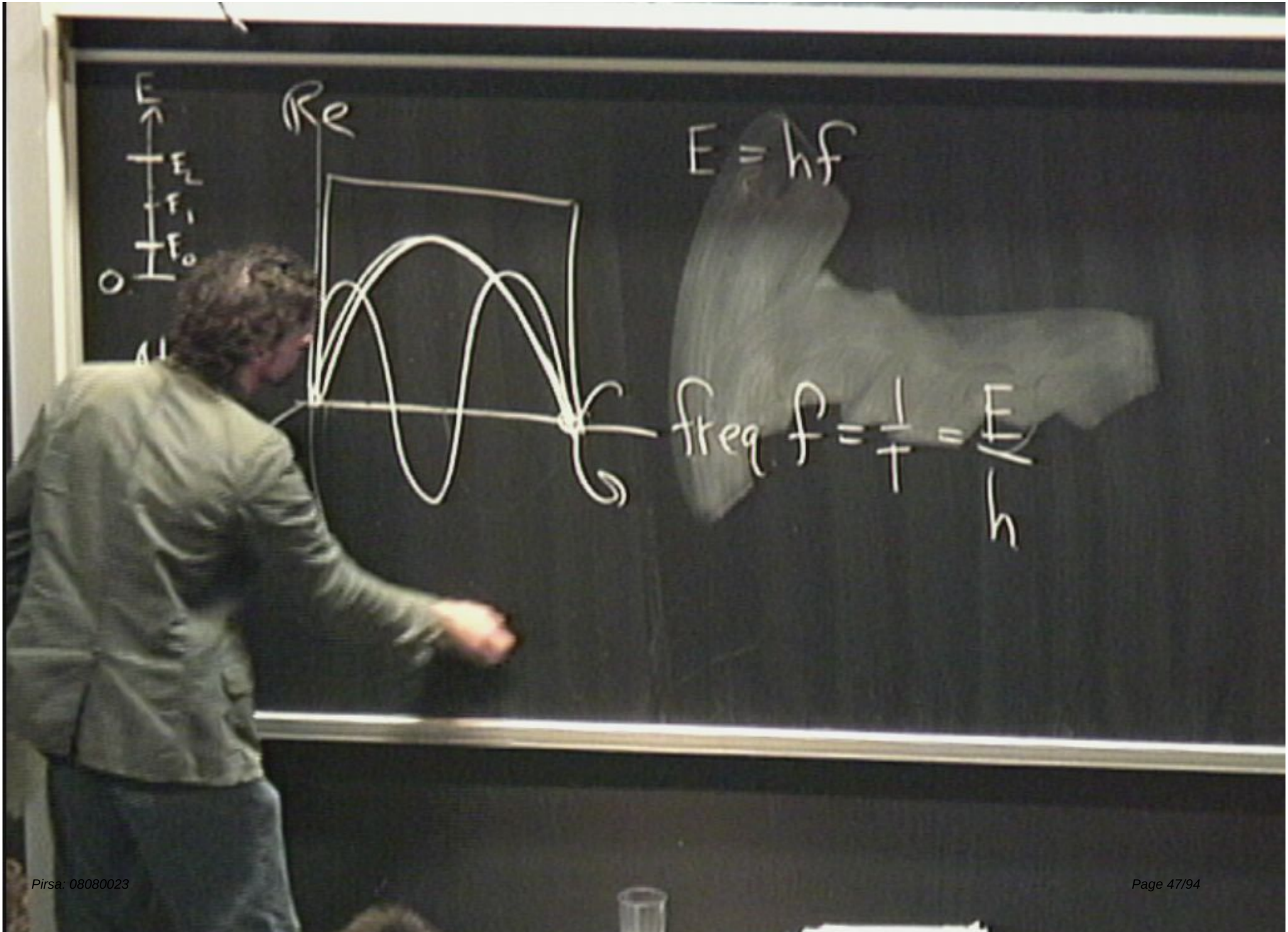

Re
Ψ =
Im
x

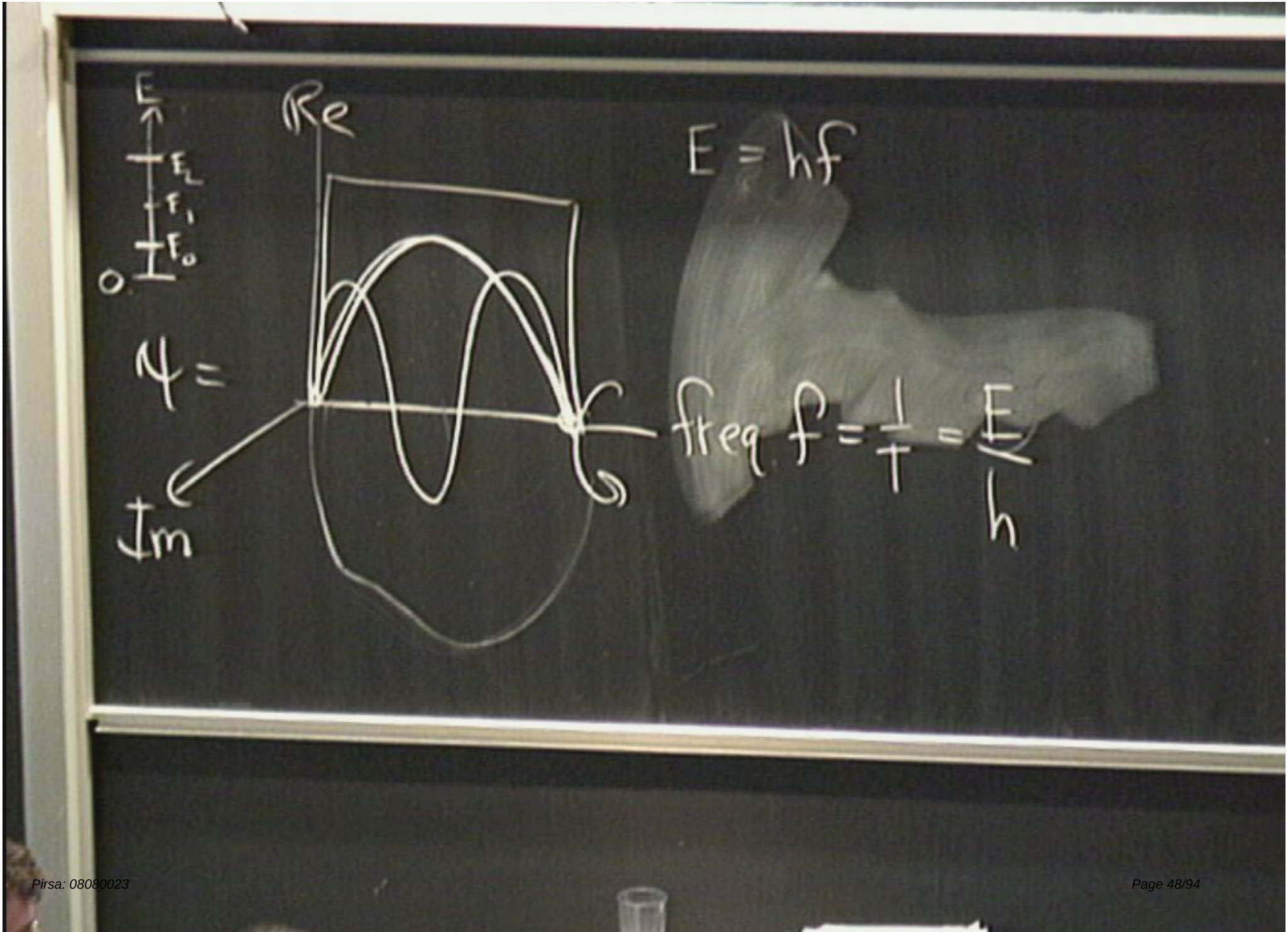

Re
ψ =
Im
Re
x
Im.

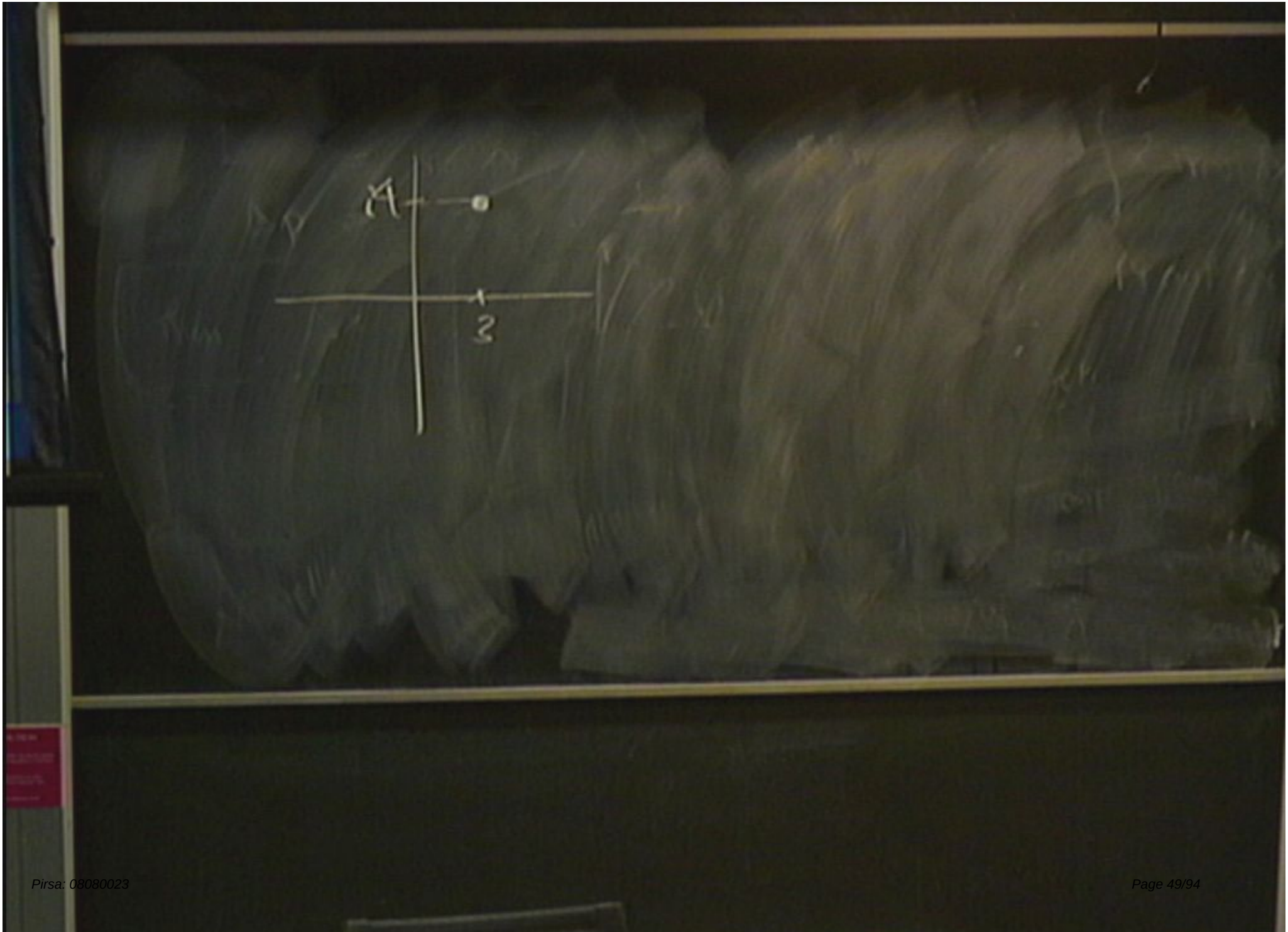

E
E_2
E_1
E_0
0
Re
Im

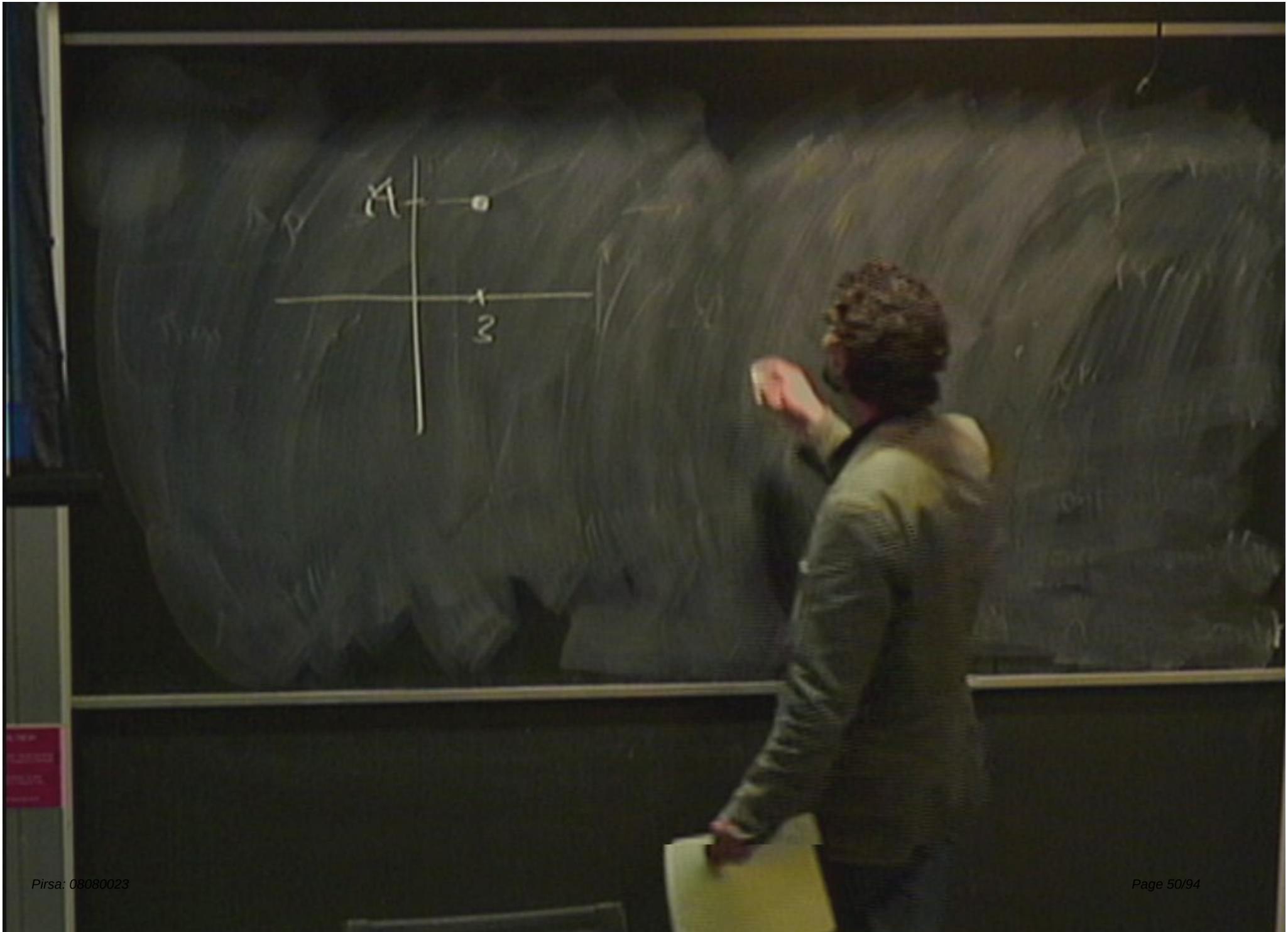

E
E_2
E_1
E_0
0
Re
Im


E
E_2
E_1
E_0
0
Re
Im
freq f =


E
E_2
E_1
E_0
0
Re
E = hf
freq $f = \frac{1}{T} = \frac{E}{h}$


E
E_2
E_1
E_0
0
Re
Im
$\Psi =$
$E = hf$
freq $f = \frac{1}{T} = \frac{E}{h}$


A
3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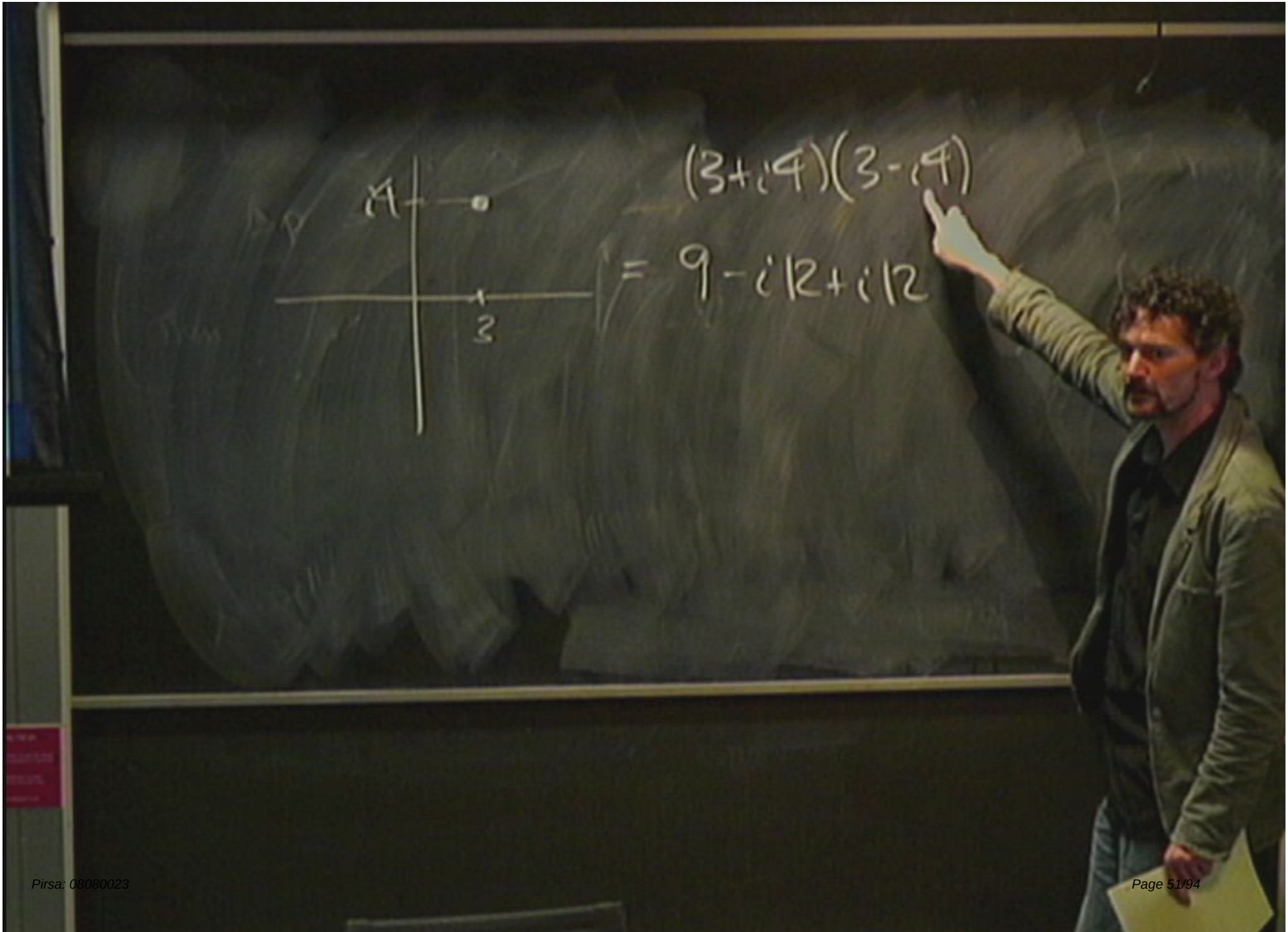
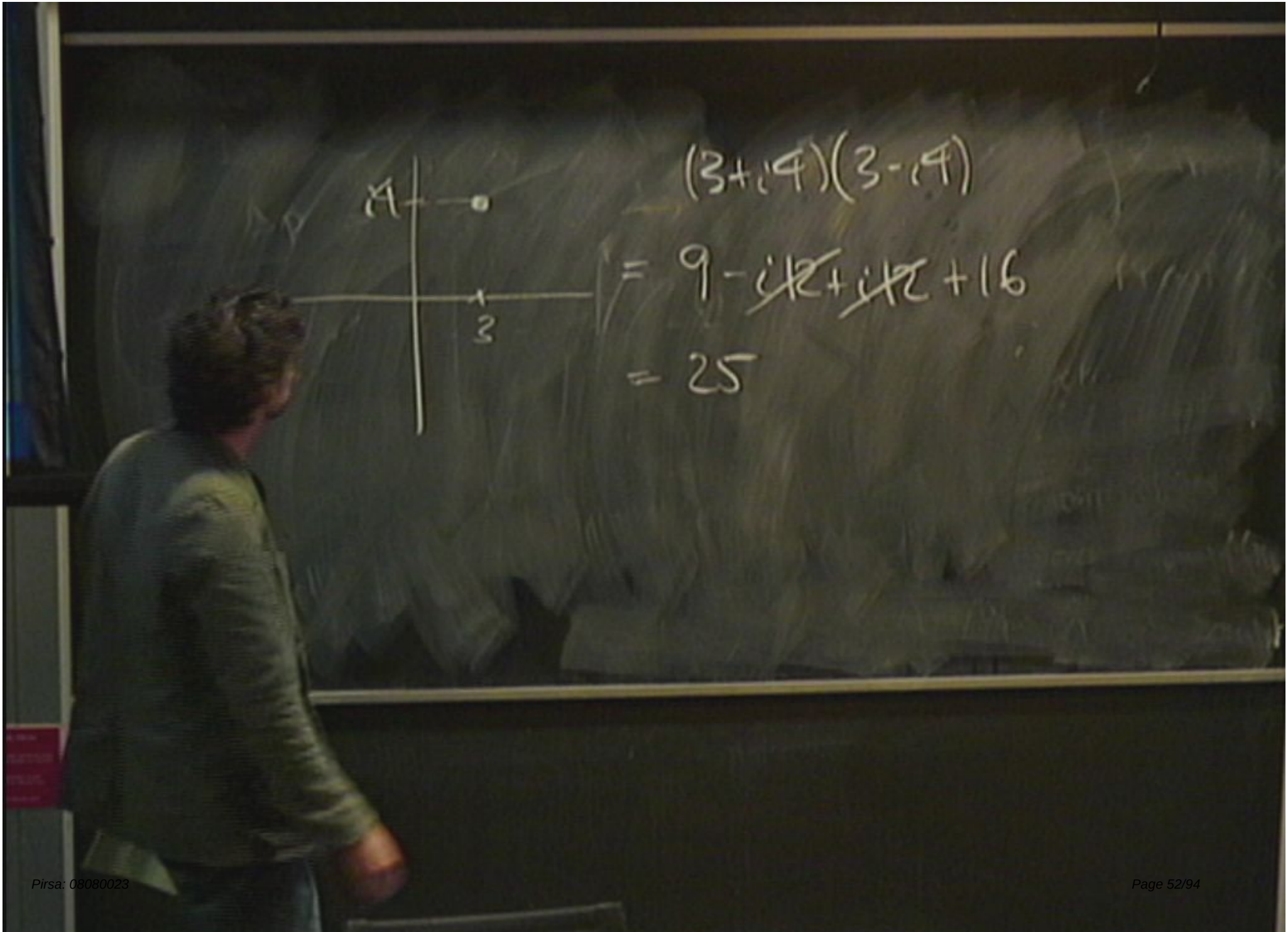
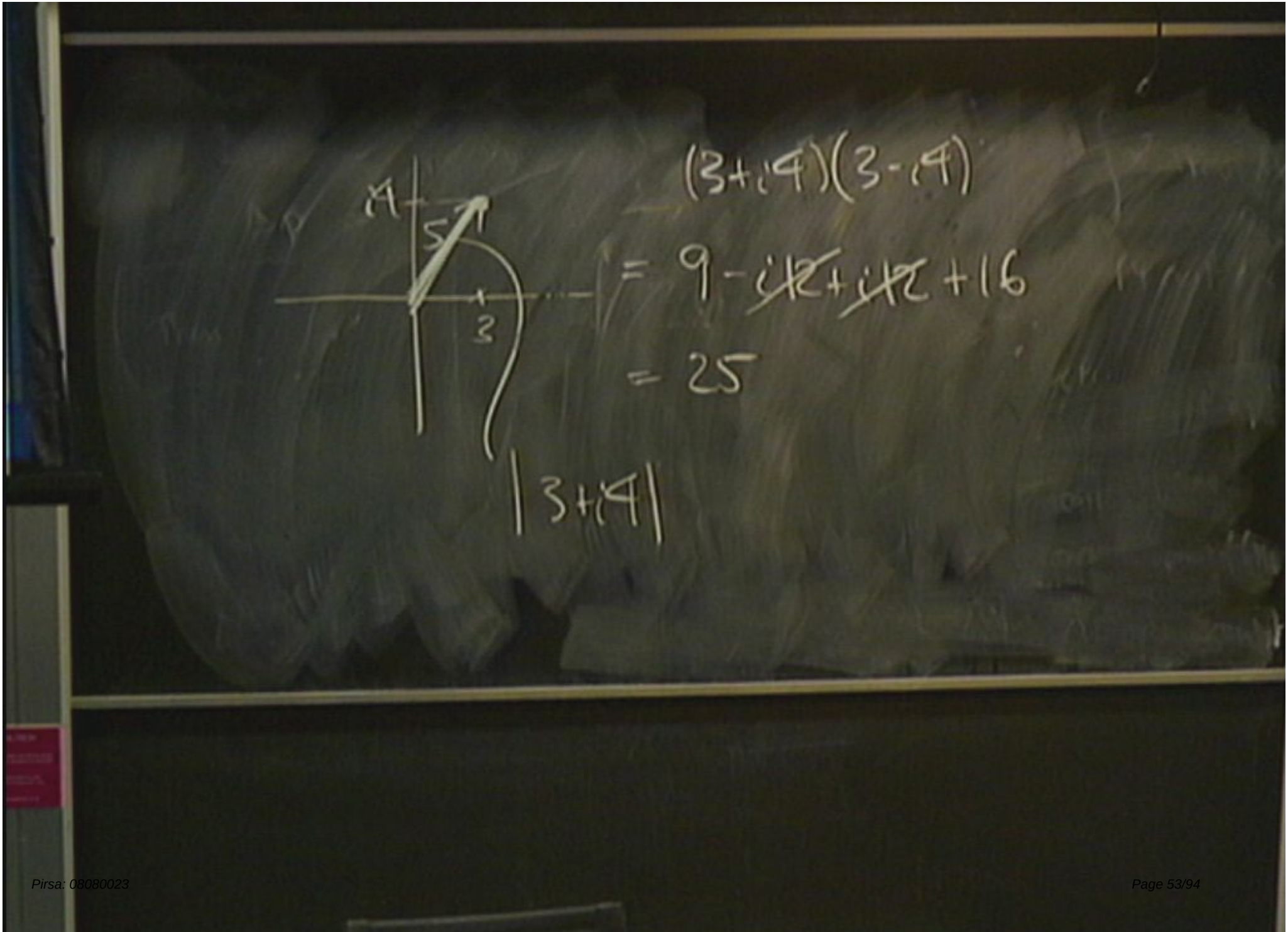
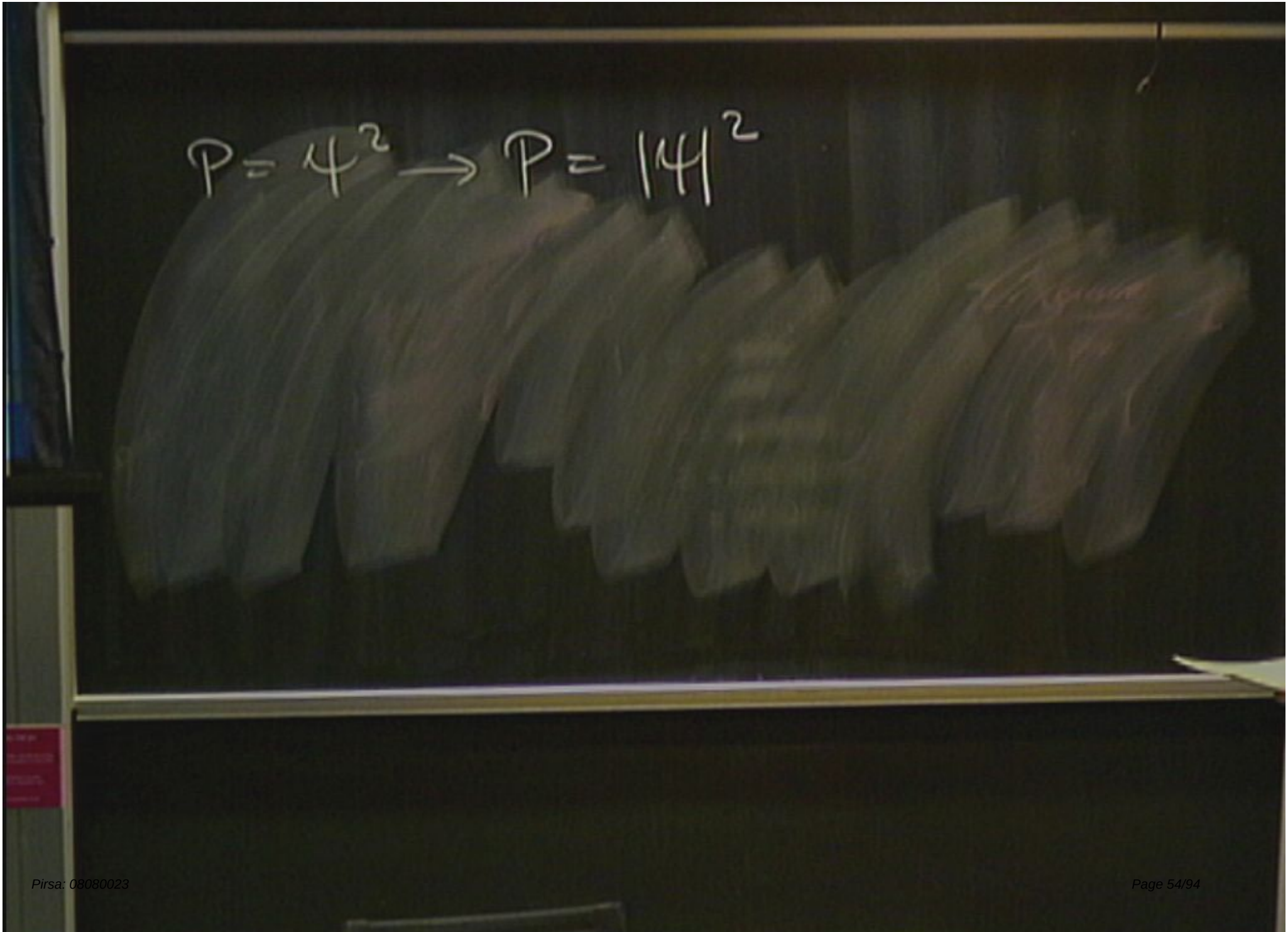
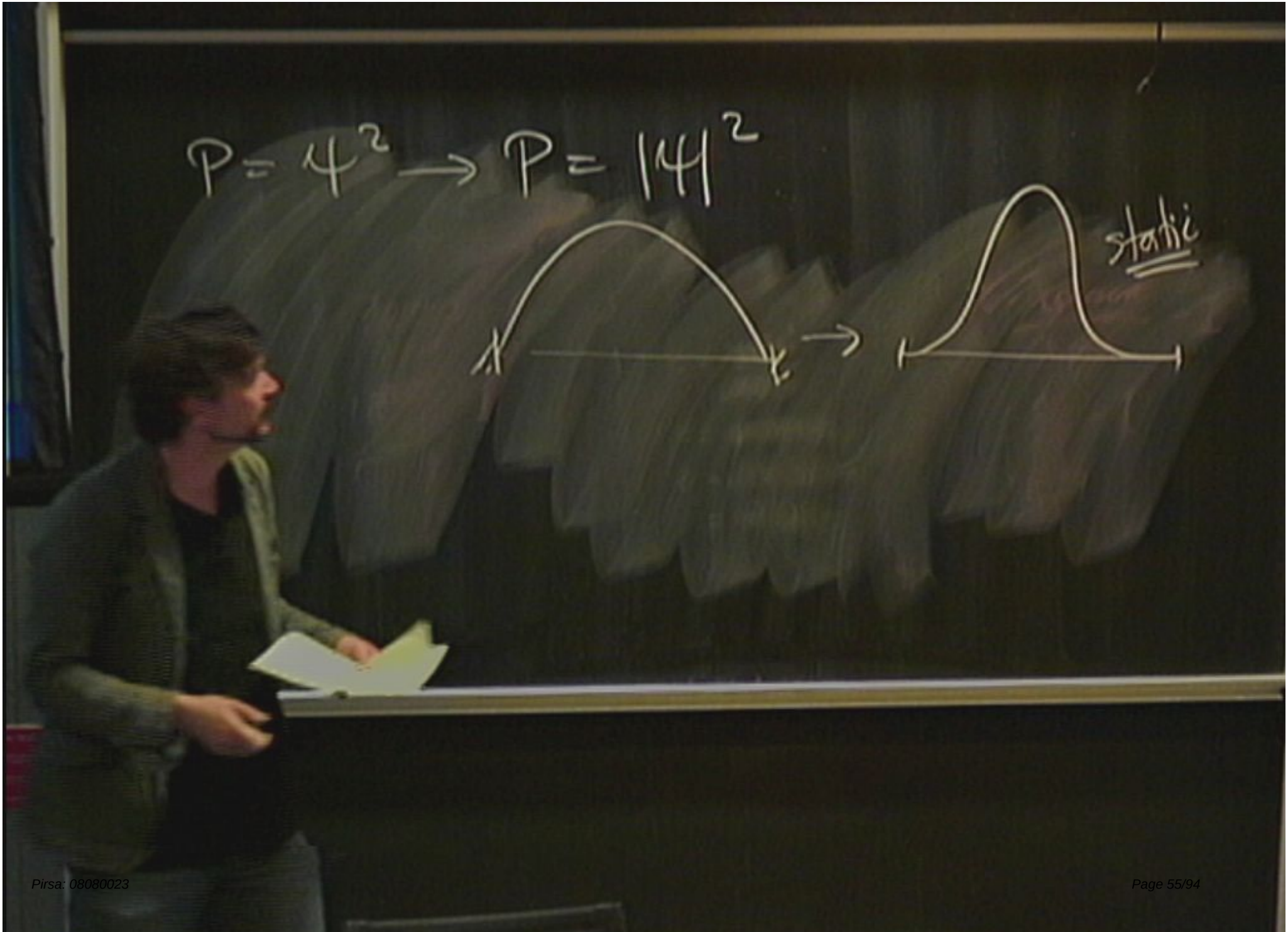
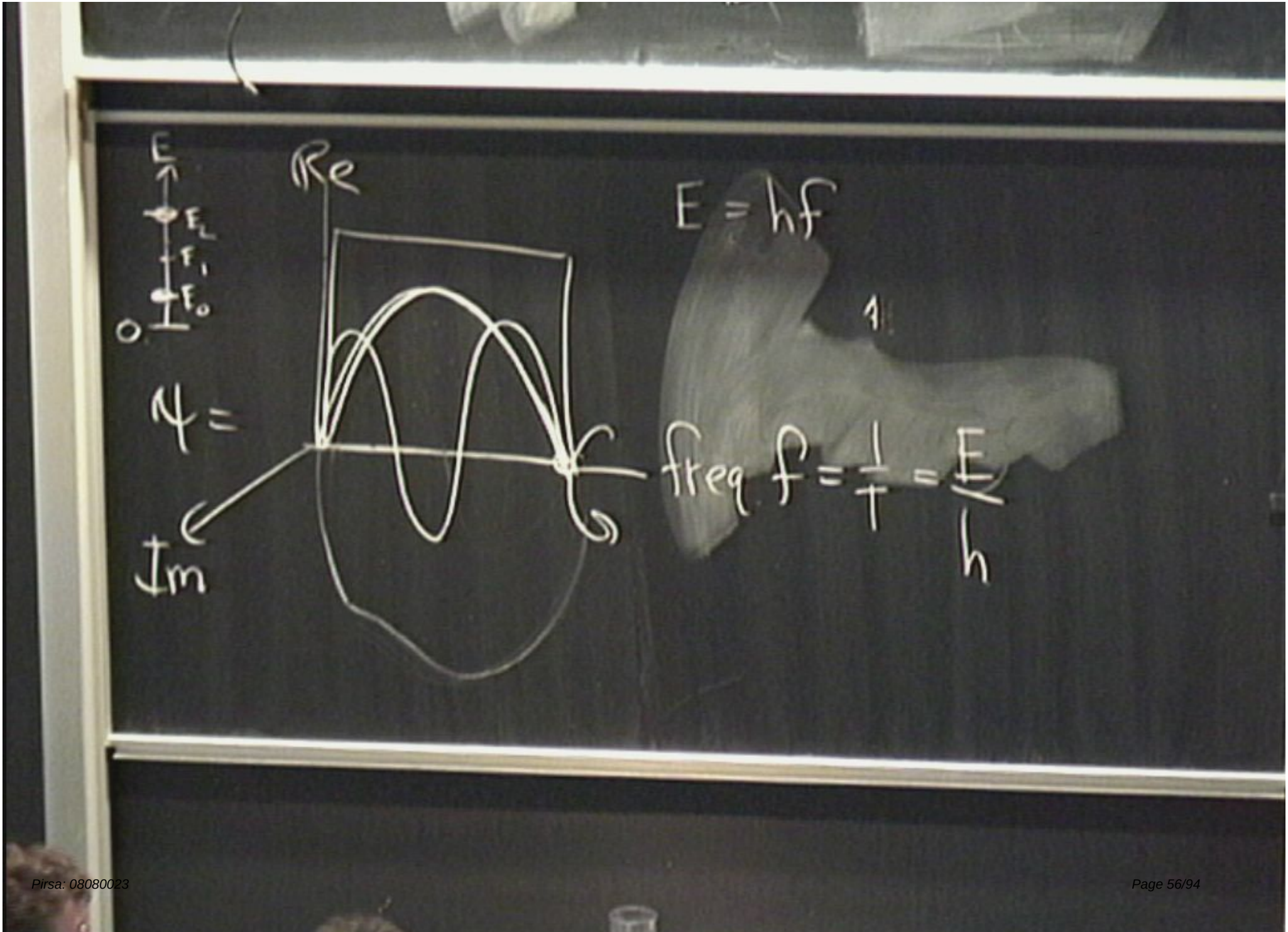

4
3
(3+i4)(3-i4)
= 9 - i12 + i12

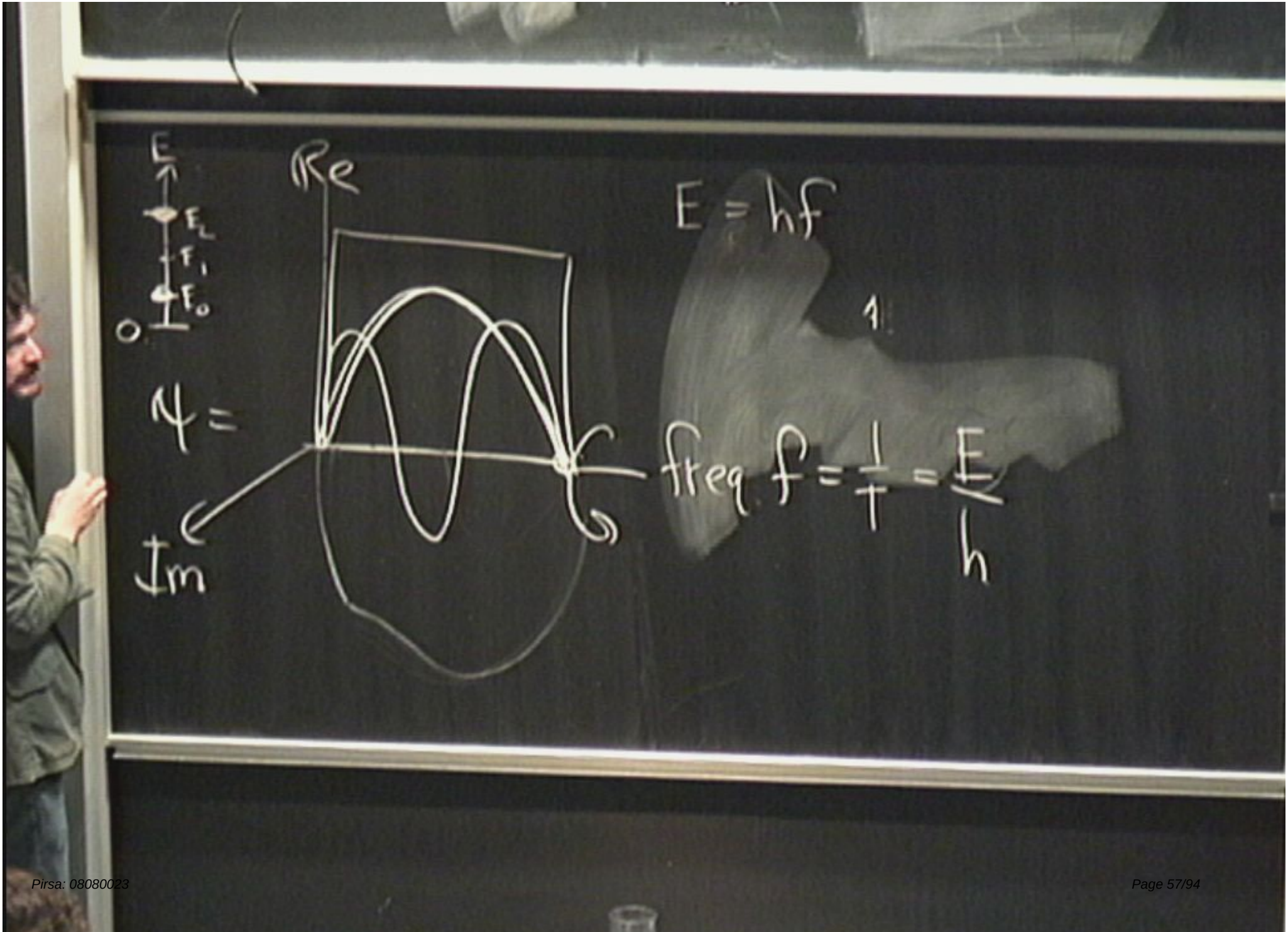

4
3
(3+i4)(3-i4)
= 9 - i12 + i12 + 16
= 25


4
5
3
(3+i4)(3-i4)
= 9 - i12 + i12 + 16
= 25
|3+i4|

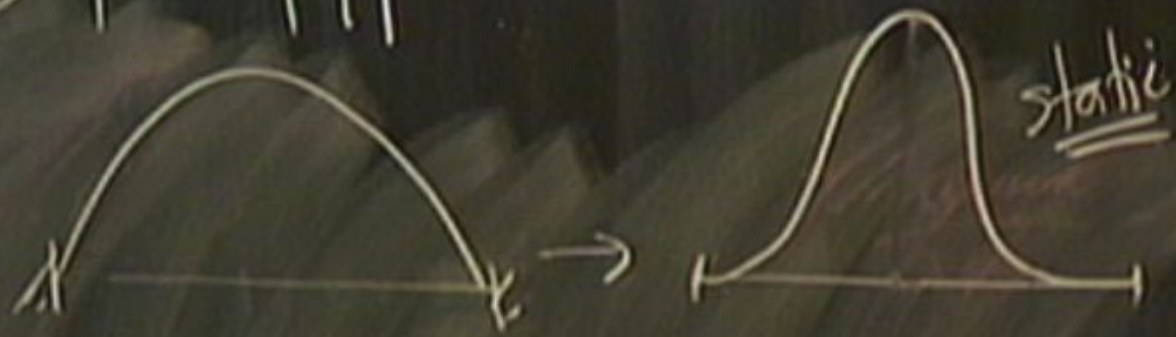

P = 4^2 → P = 141^2


P = 4²
P = 141²
static

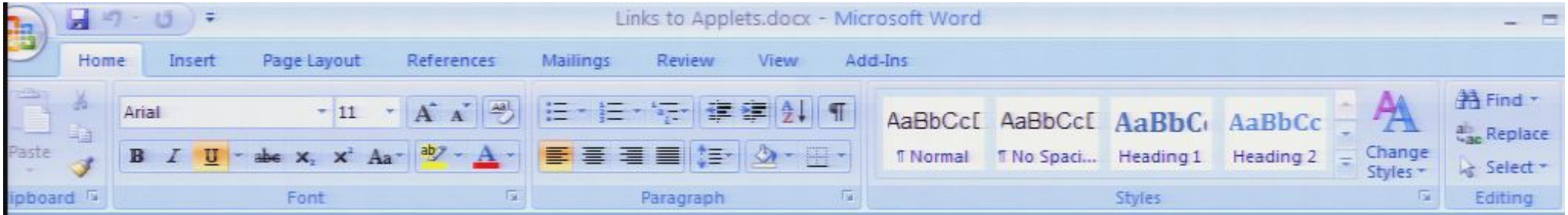

E
E_2
E_1
E_0
0
Re
Im
$\Psi =$
$E = hf$
1
freq $f = \frac{1}{T} = \frac{E}{h}$


E
E_2
E_1
E_0
0
Re
Im
$\Psi =$
$E = hf$
1
freq $f = \frac{1}{T} = \frac{E}{h}$

$P = \psi^2 \rightarrow P = |\psi|^2$



stationary states.

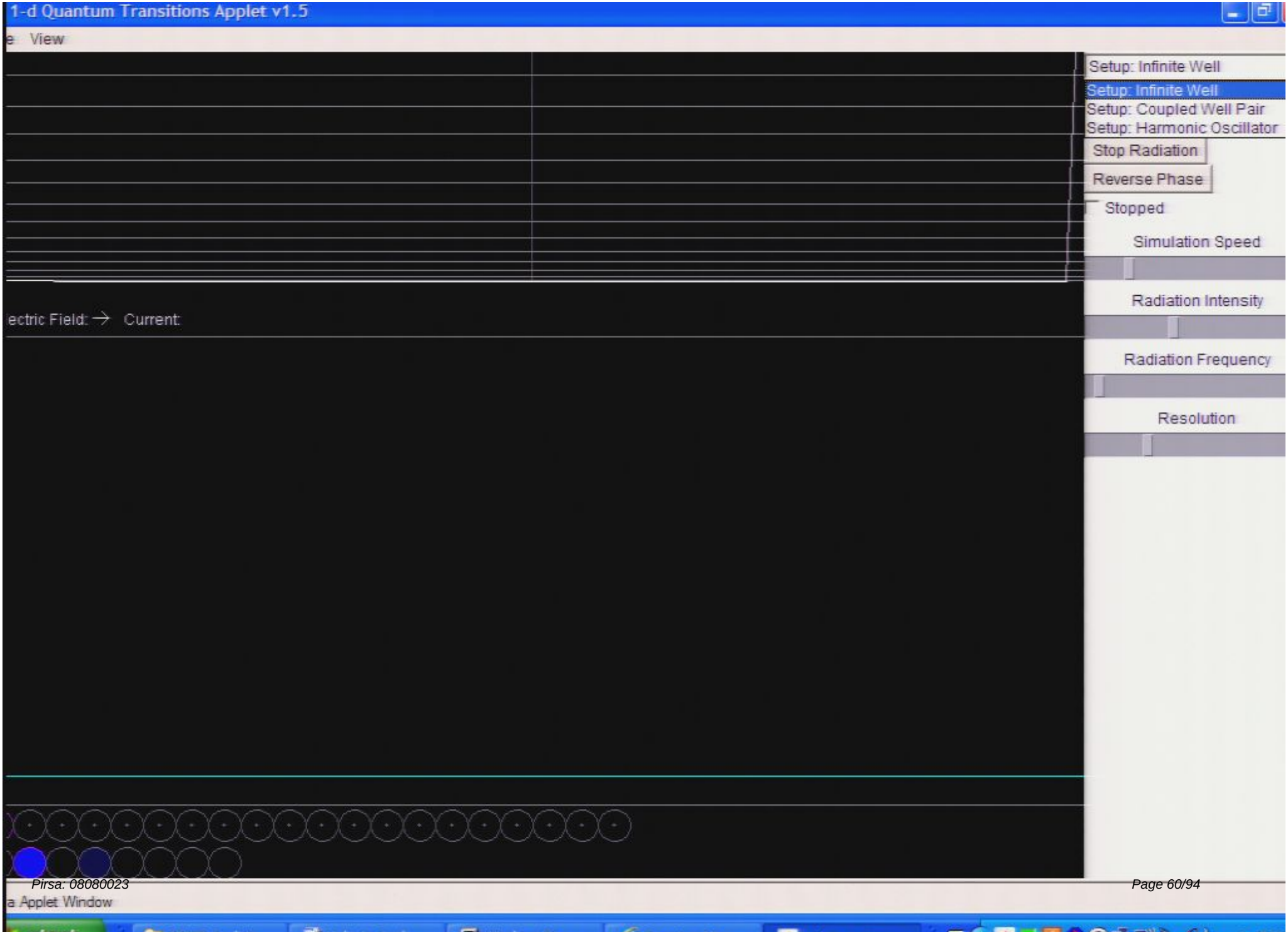


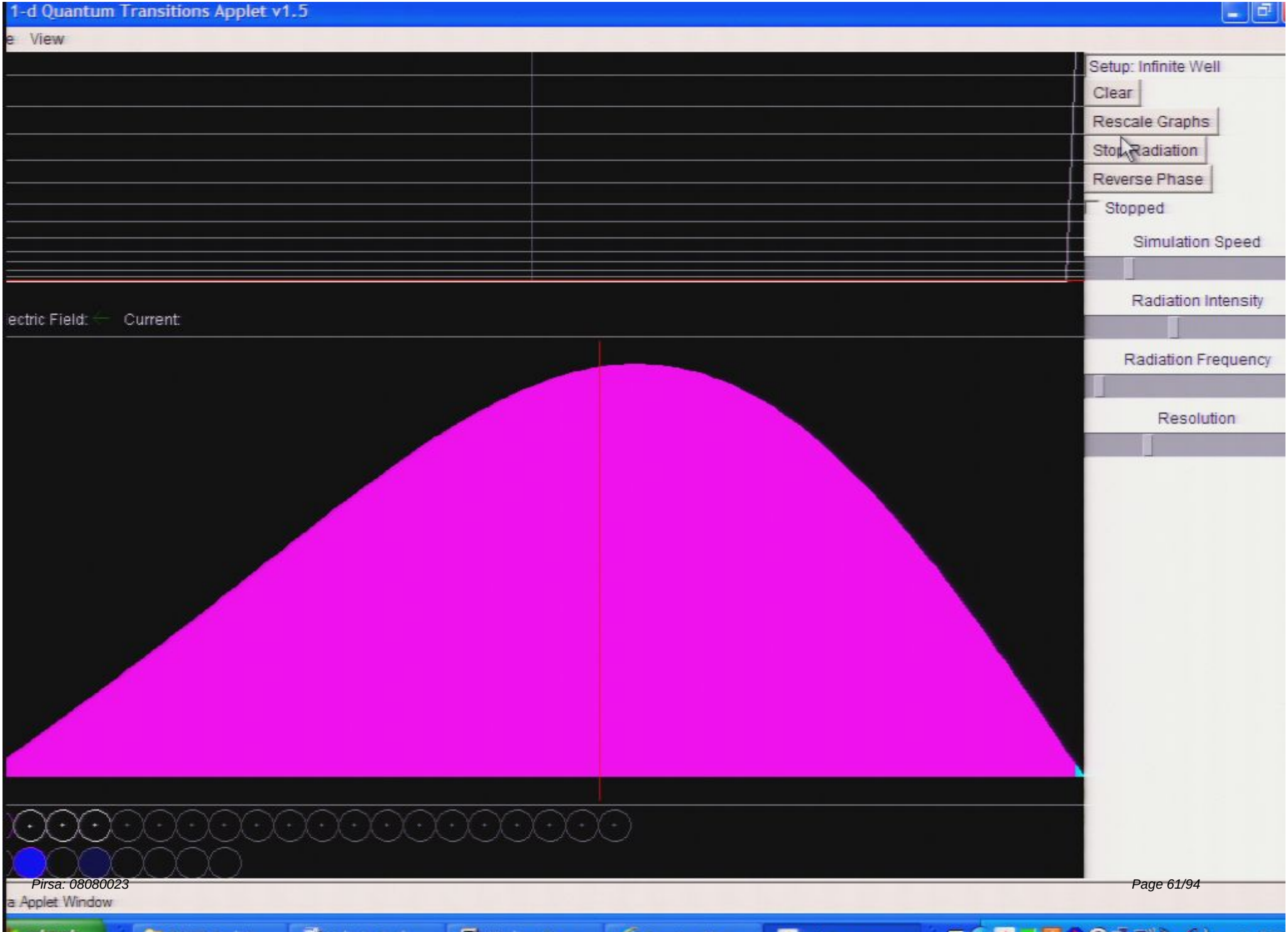
Links to Applets

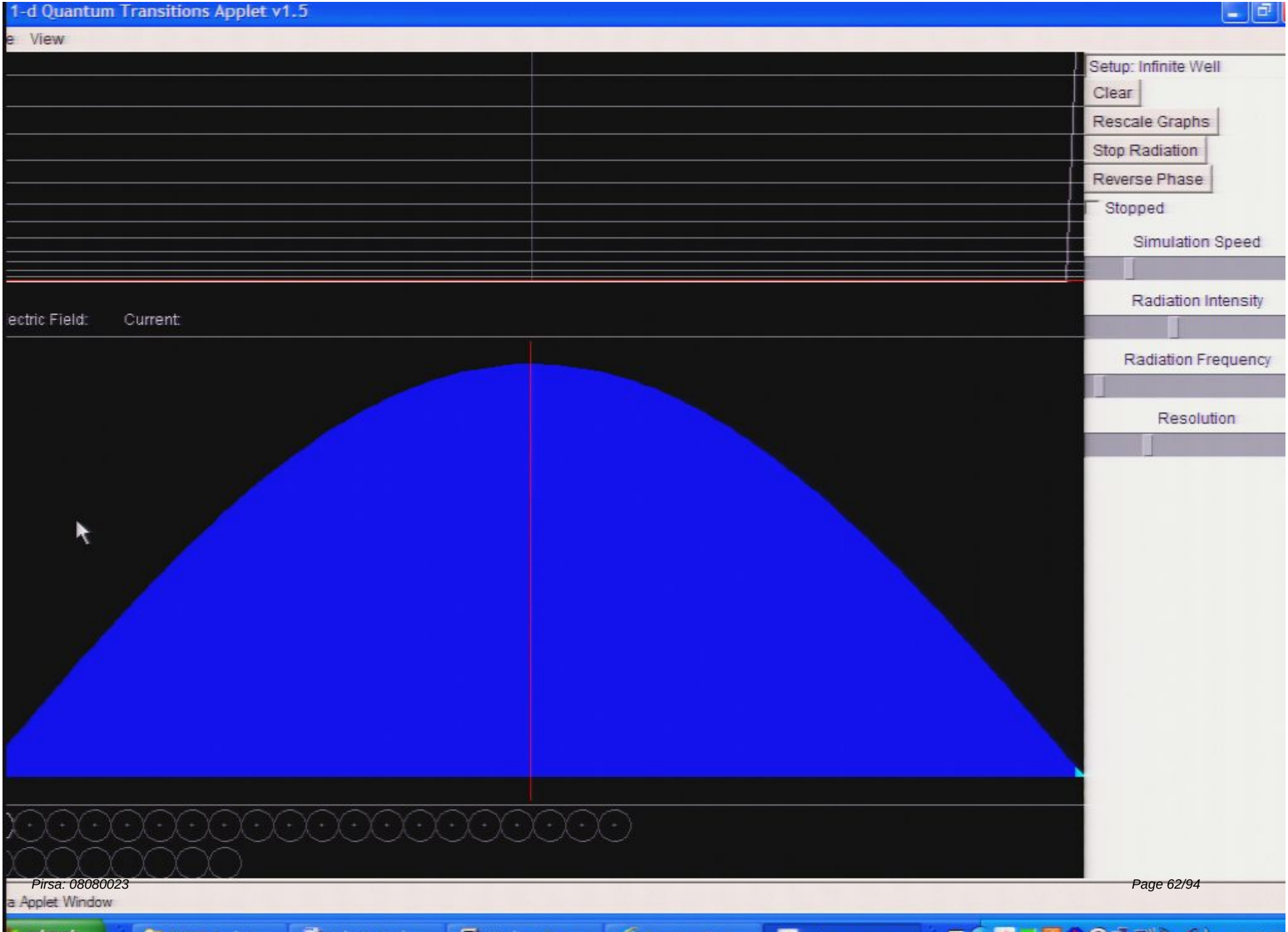
Falstad Applets
http://www.falstad.com/mathphysics.html

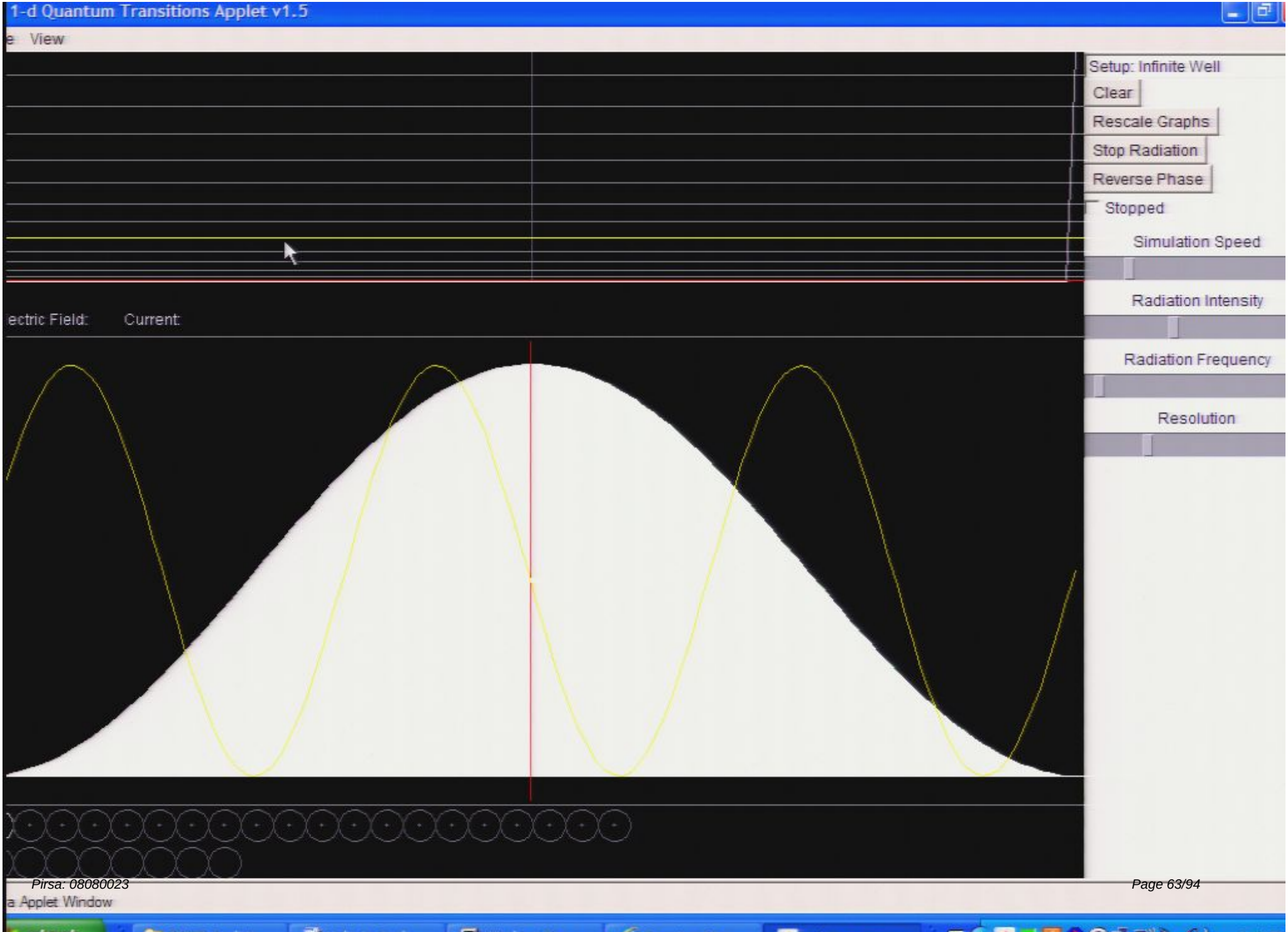
Standing Waves
http://www.ngsir.netfirms.com/englishhtm/StatWave.htm

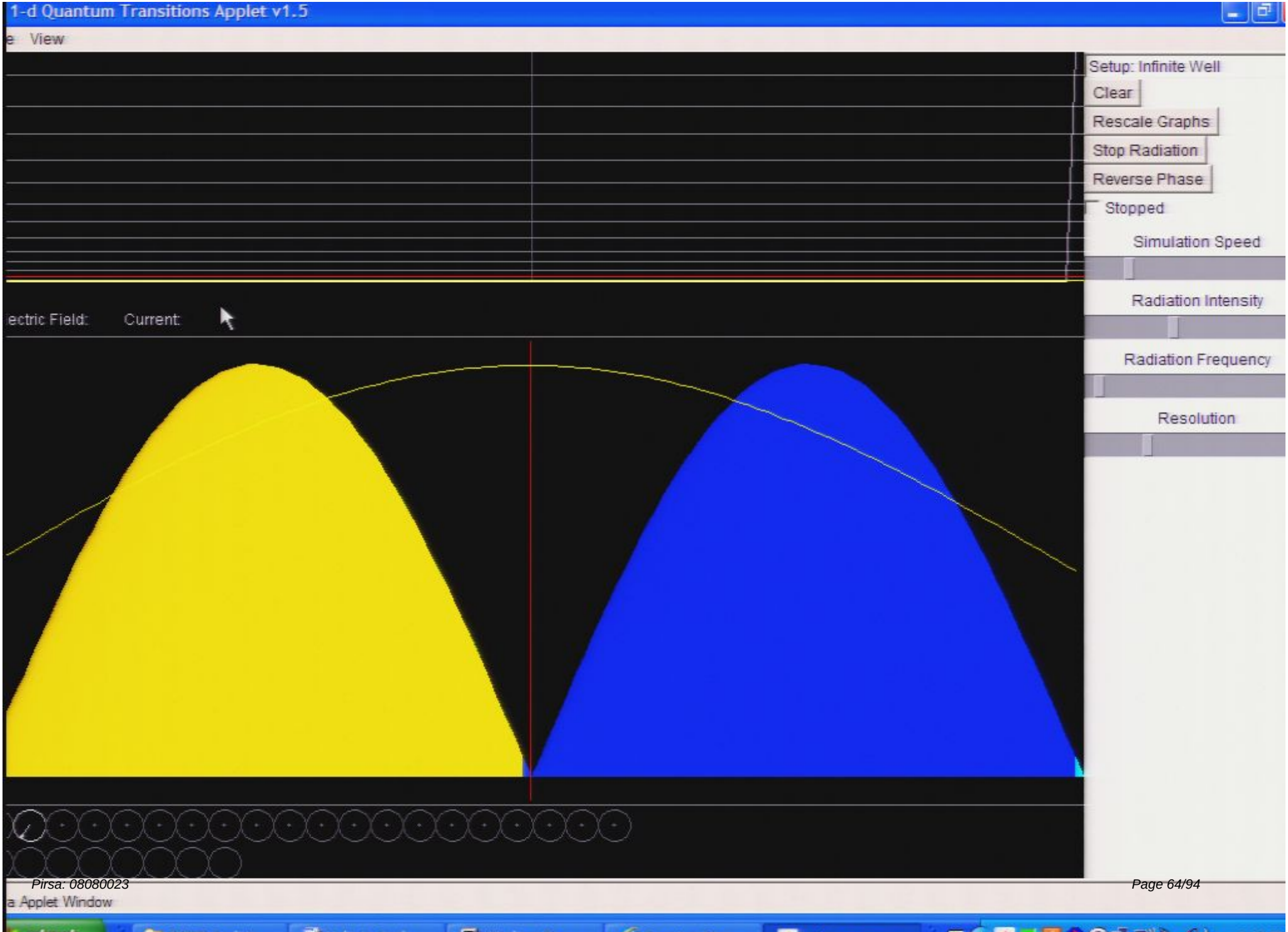
Superposition of Waves:
http://www.phy.ntnu.edu.tw/ntnujava/index.php?topic=19
http://thespoon7.tripod.com/wave.htm
http://kingfish.coastal.edu/physics/physlets/Waves/superposition.html

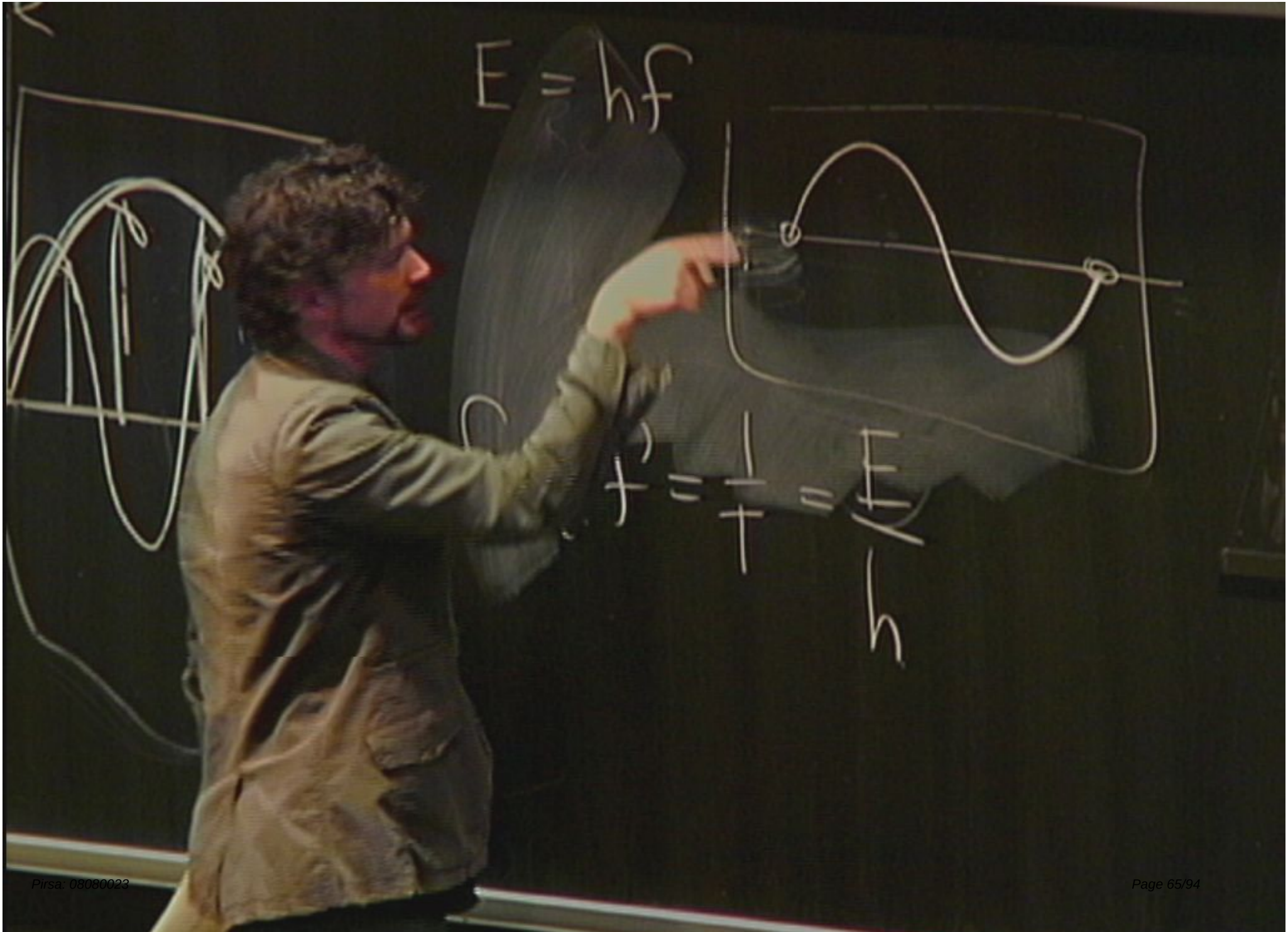

1-d Quantum Transitions Applet v1.5
e View
Setup: Infinite Well
Setup: Infinite Well
Setup: Coupled Well Pair
Setup: Harmonic Oscillator
Stop Radiation
Reverse Phase
Stopped
Simulation Speed
Radiation Intensity
Radiation Frequency
Resolution
ectric Field: → Current:
a Applet Window

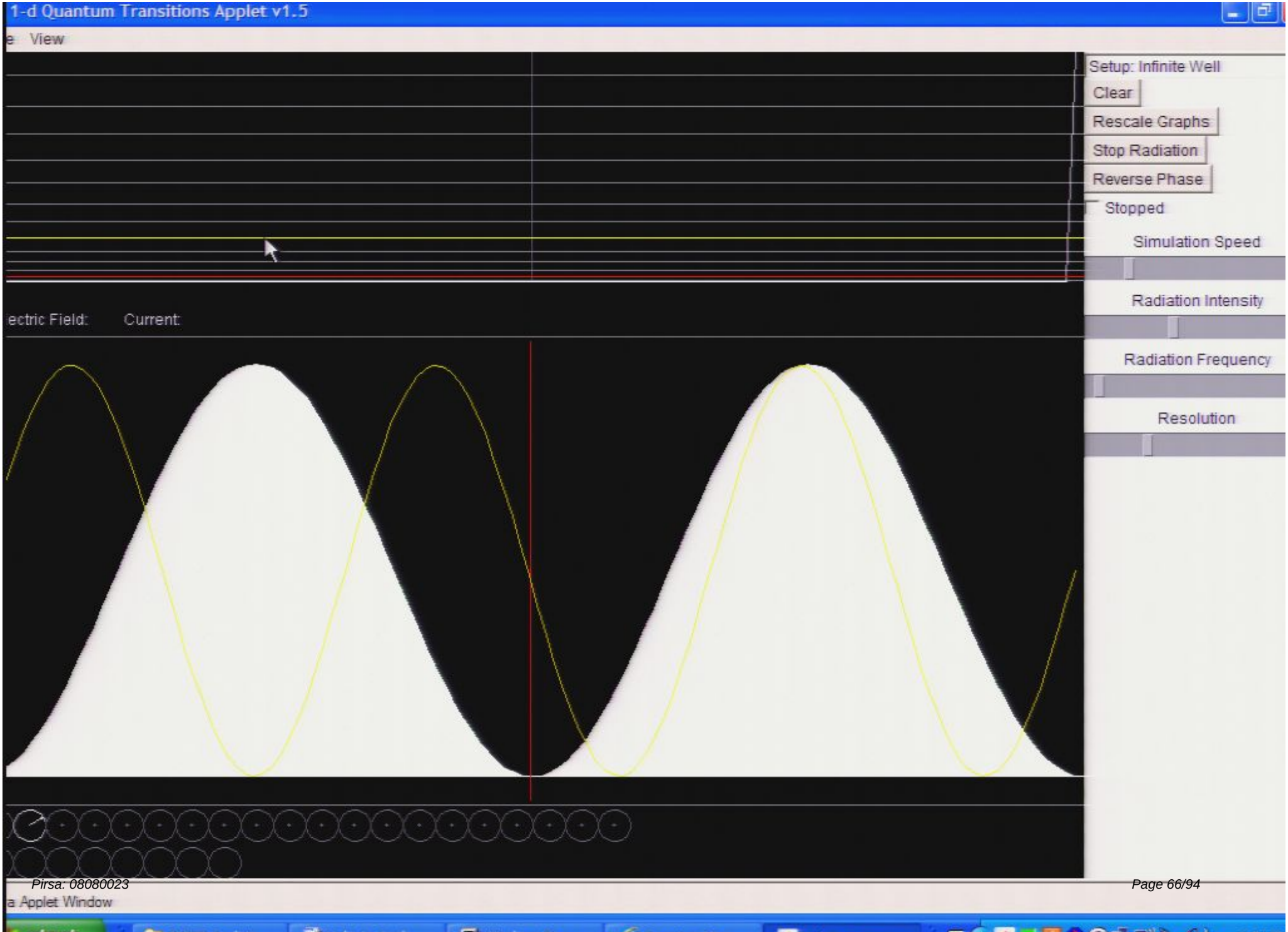

1-d Quantum Transitions Applet v1.5
e View
Setup: Infinite Well
Clear
Rescale Graphs
Stop Radiation
Reverse Phase
Stopped
Simulation Speed
Radiation Intensity
Radiation Frequency
Resolution
ectric Field:
Current:
a Applet Window

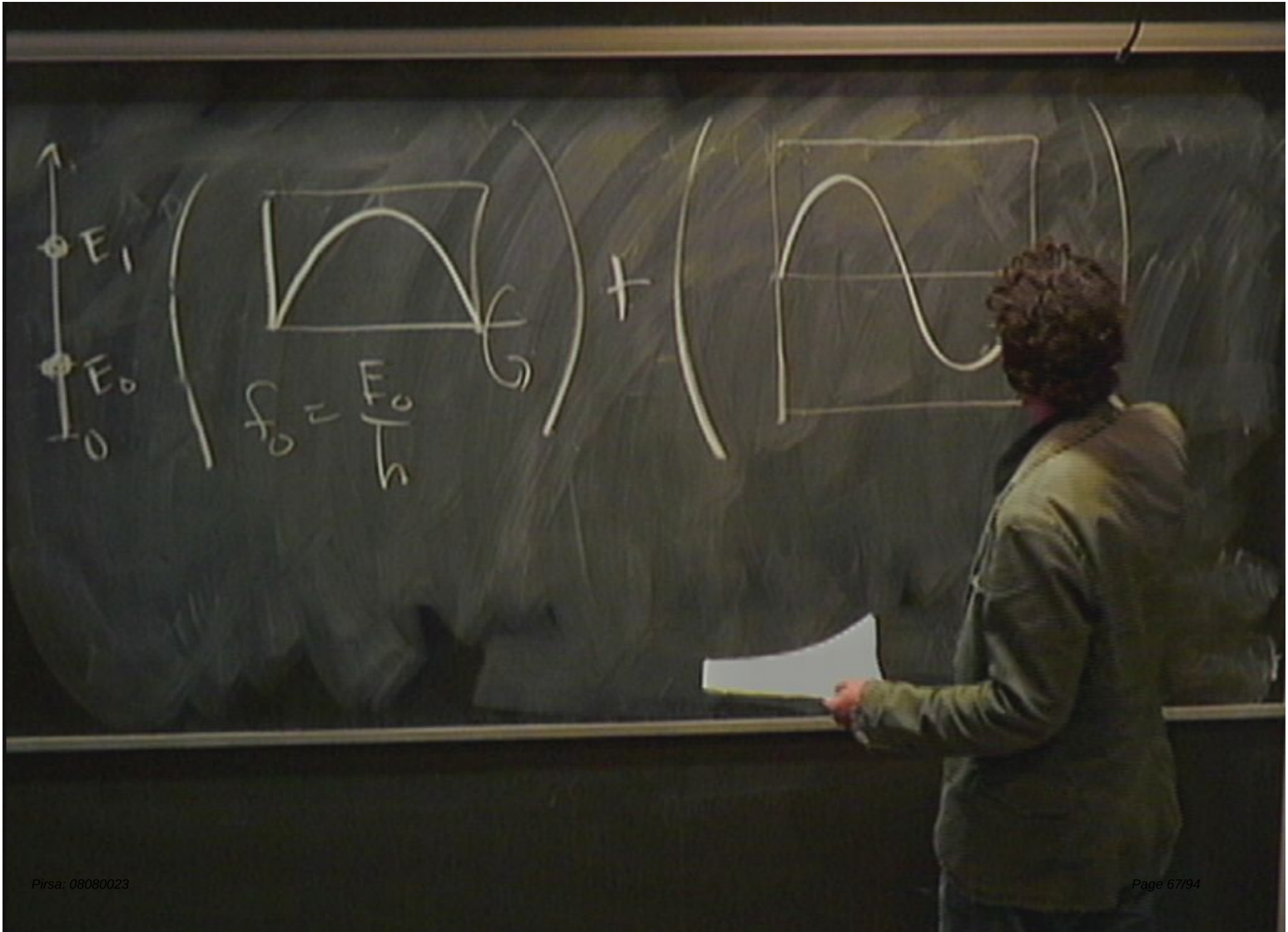

1-d Quantum Transitions Applet v1.5
e View
Setup: Infinite Well
Clear
Rescale Graphs
Stop Radiation
Reverse Phase
Stopped
Simulation Speed
Radiation Intensity
Radiation Frequency
Resolution
ectric Field:
Current:
a Applet Window

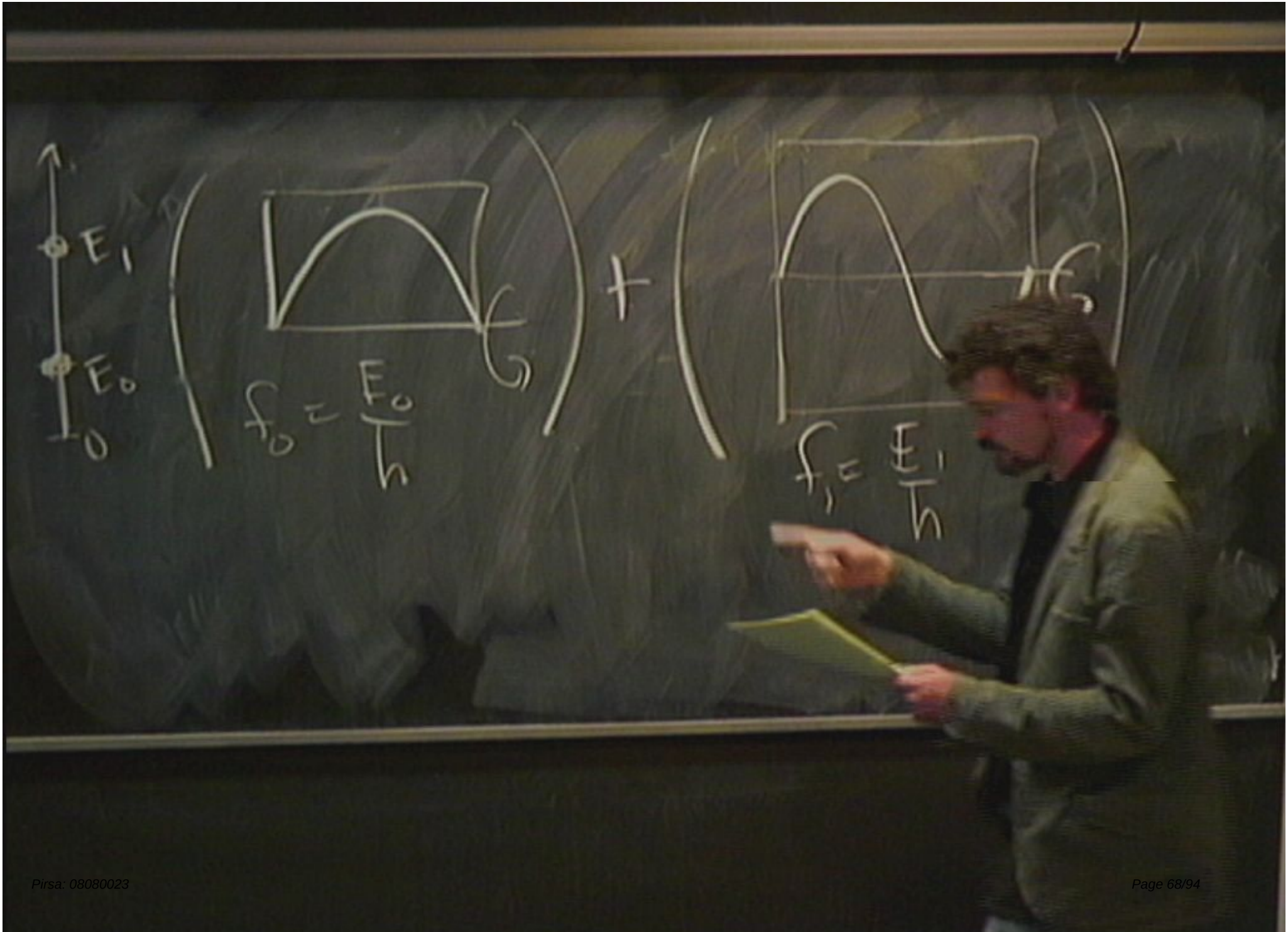

1-d Quantum Transitions Applet v1.5
e View
Setup: Infinite Well
Clear
Rescale Graphs
Stop Radiation
Reverse Phase
Stopped
Simulation Speed
Radiation Intensity
Radiation Frequency
Resolution
ectric Field:
Current:
a Applet Window

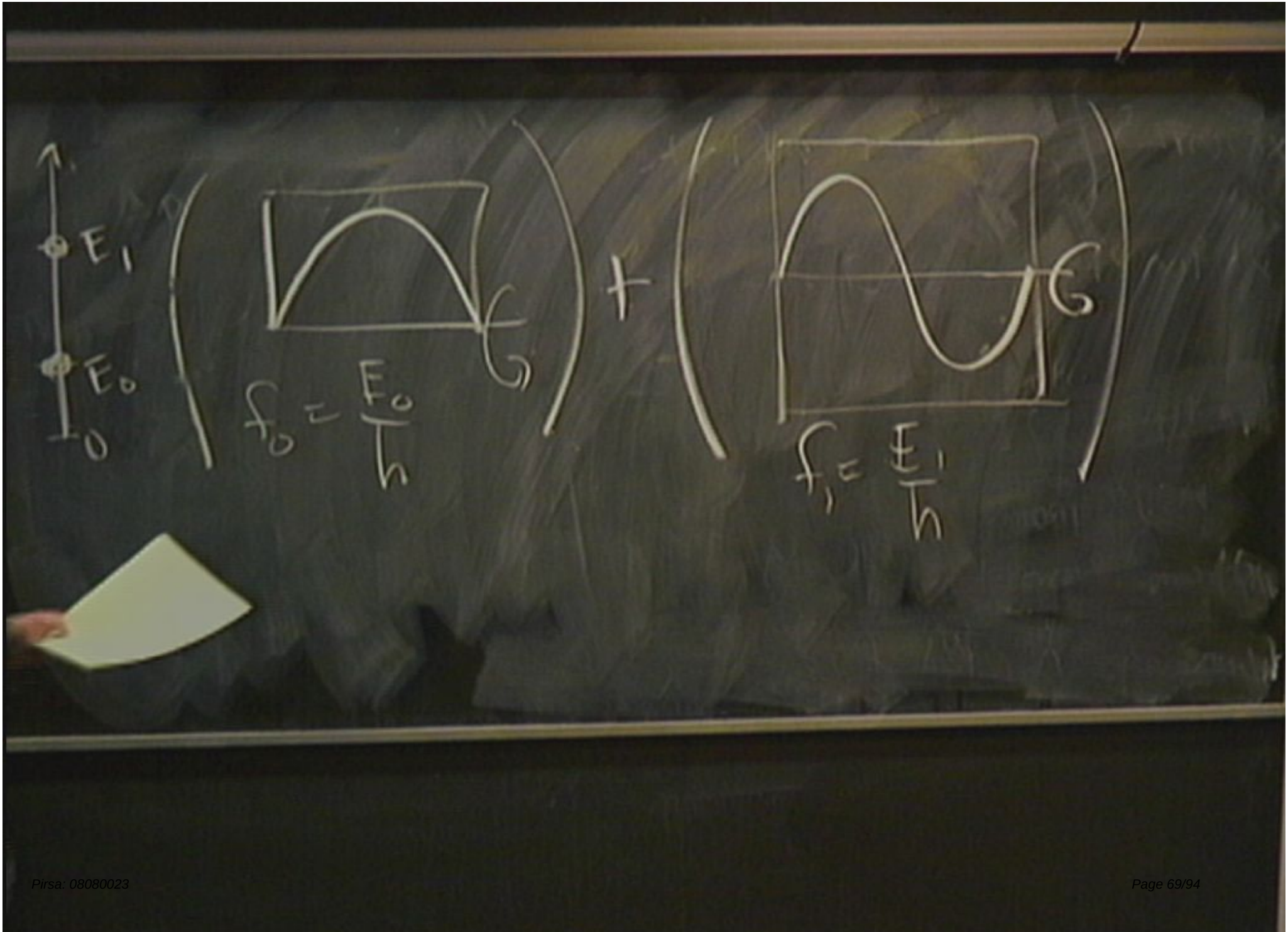

1-d Quantum Transitions Applet v1.5
e View
Setup: Infinite Well
Clear
Rescale Graphs
Stop Radiation
Reverse Phase
Stopped
Simulation Speed
Radiation Intensity
Radiation Frequency
Resolution
ectric Field:
Current:
a Applet Window

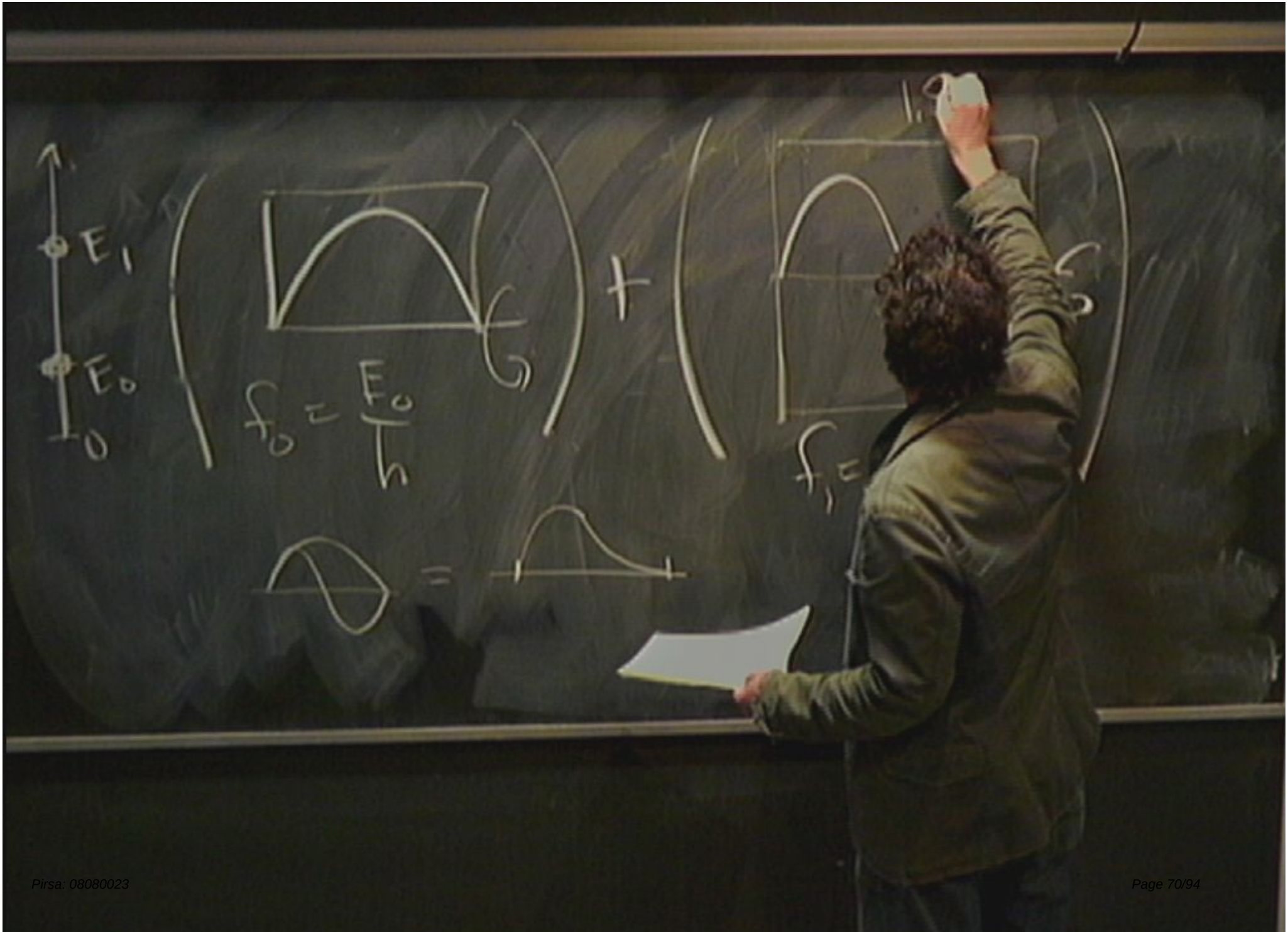

E = hf
f = 1/T = E/h

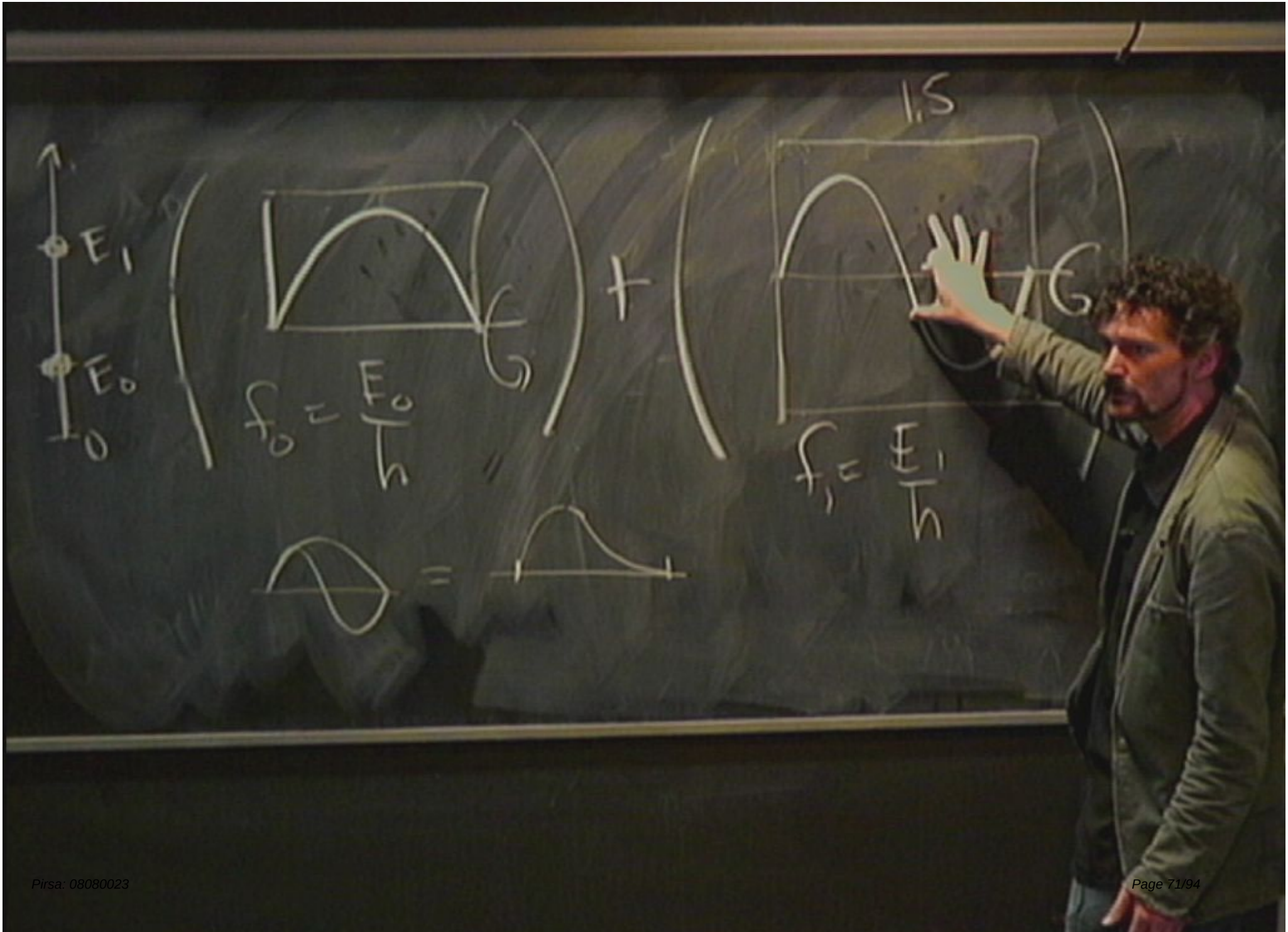

1-d Quantum Transitions Applet v1.5
e View
Setup: Infinite Well
Clear
Rescale Graphs
Stop Radiation
Reverse Phase
Stopped
Simulation Speed
Radiation Intensity
Radiation Frequency
Resolution
ectric Field:
Current:
a Applet Window

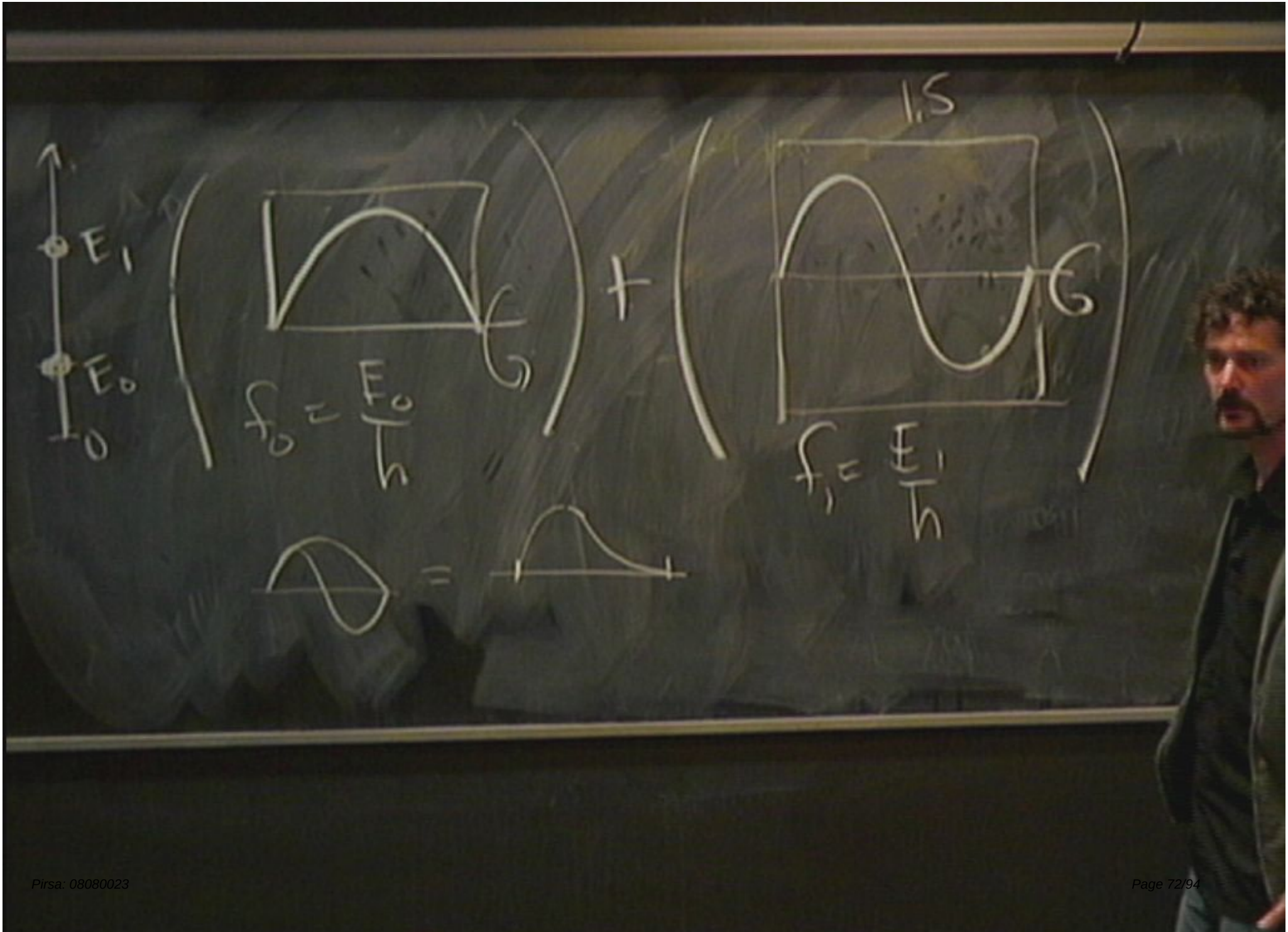

E1
E0
0
f0 = E0/h

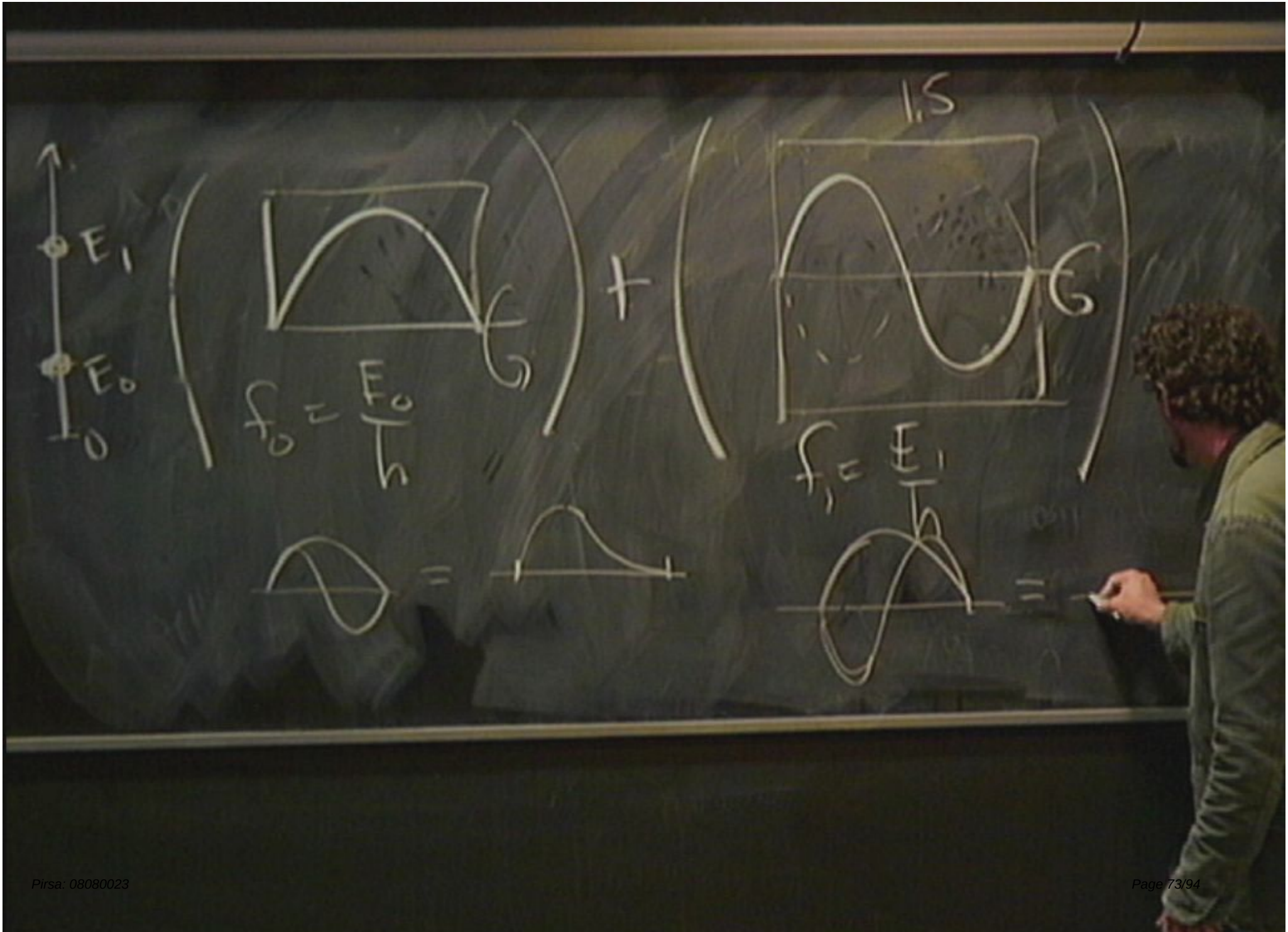

E_1
E_0
0
$f_0 = \frac{E_0}{h}$
$f_1 = \frac{E_1}{h}$

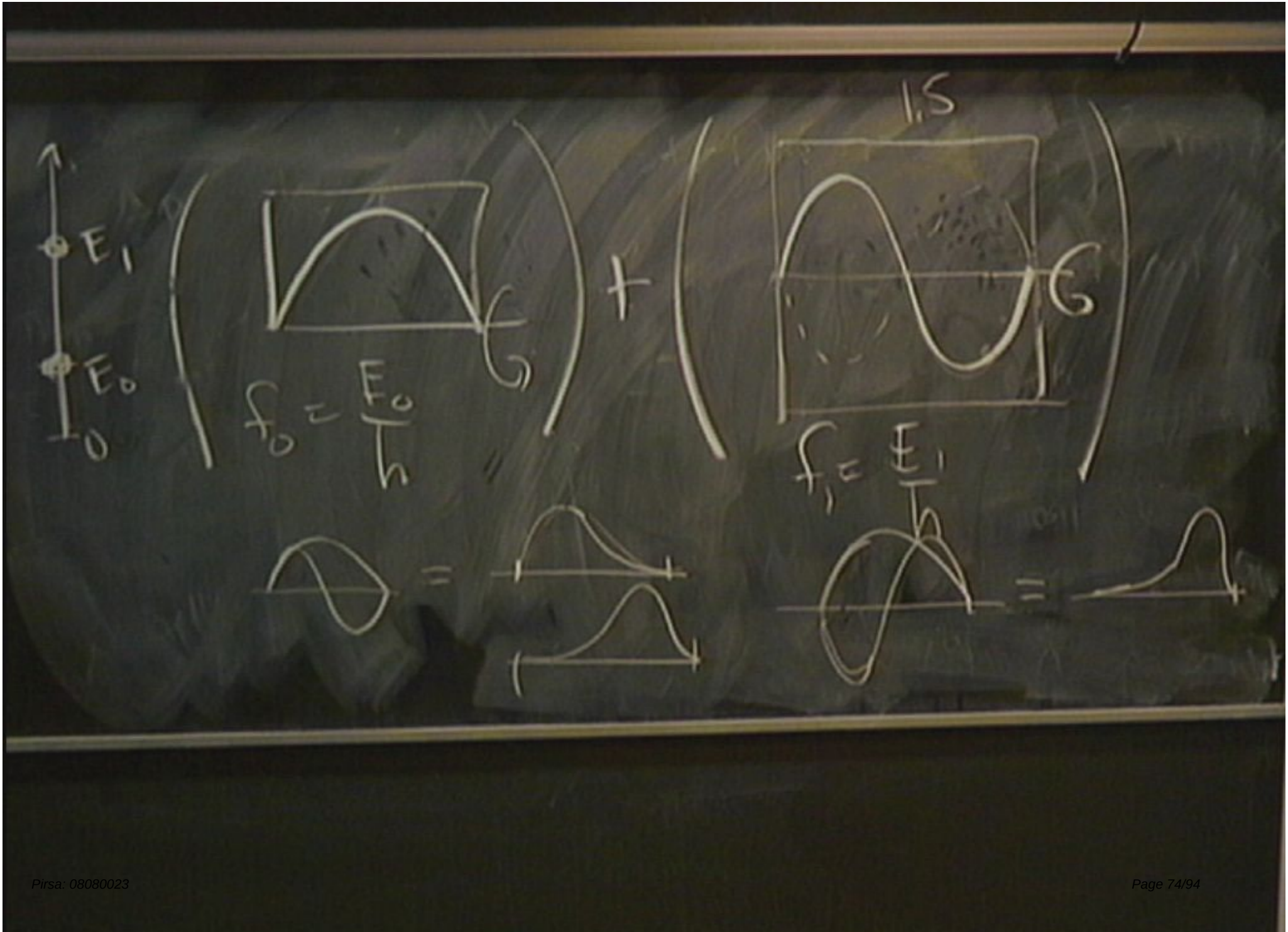

E1
E0
0
f0 = E0/h
f1 = E1/h

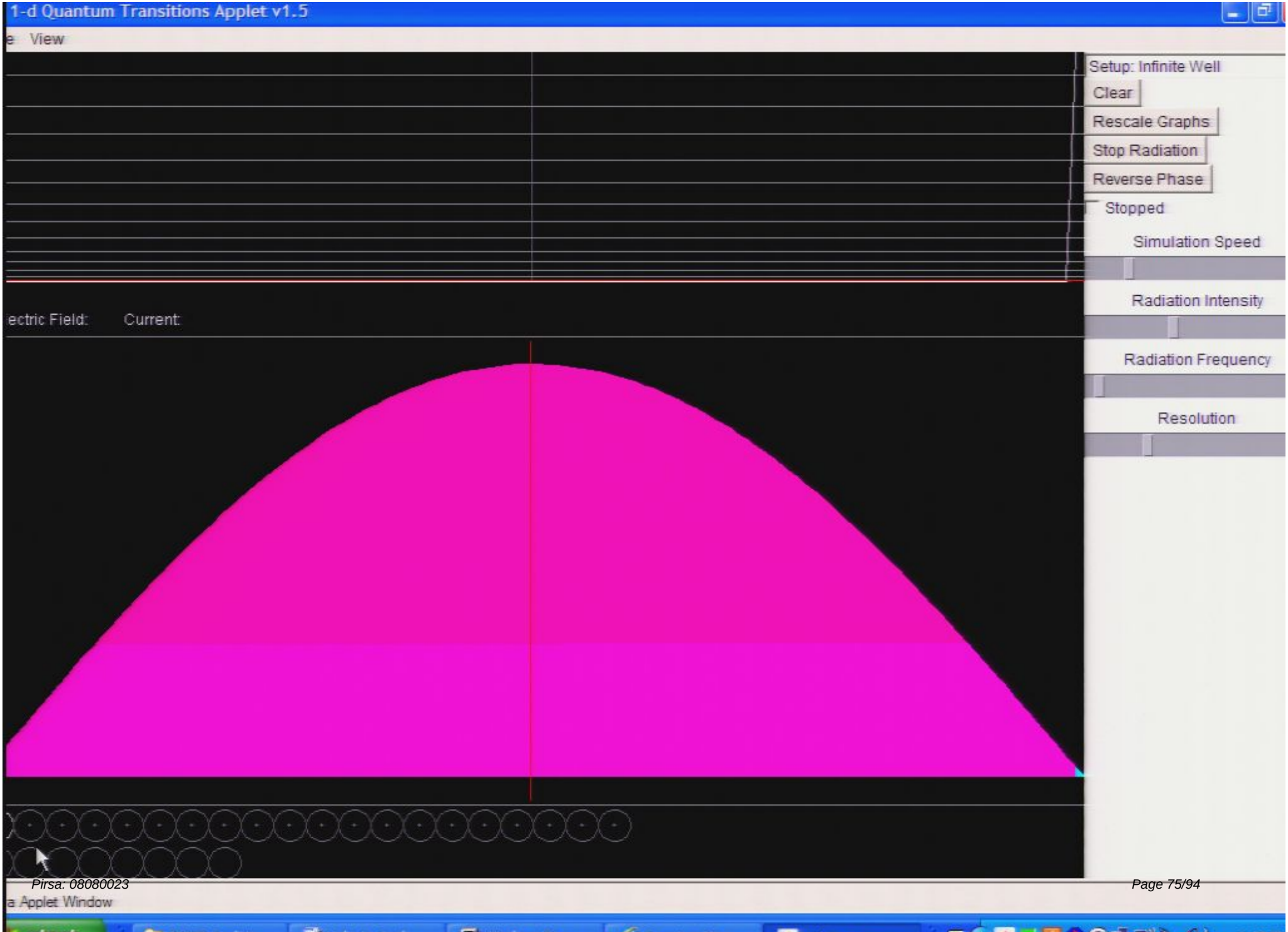

E1
E0
0
f0 = E0/h
f1 =

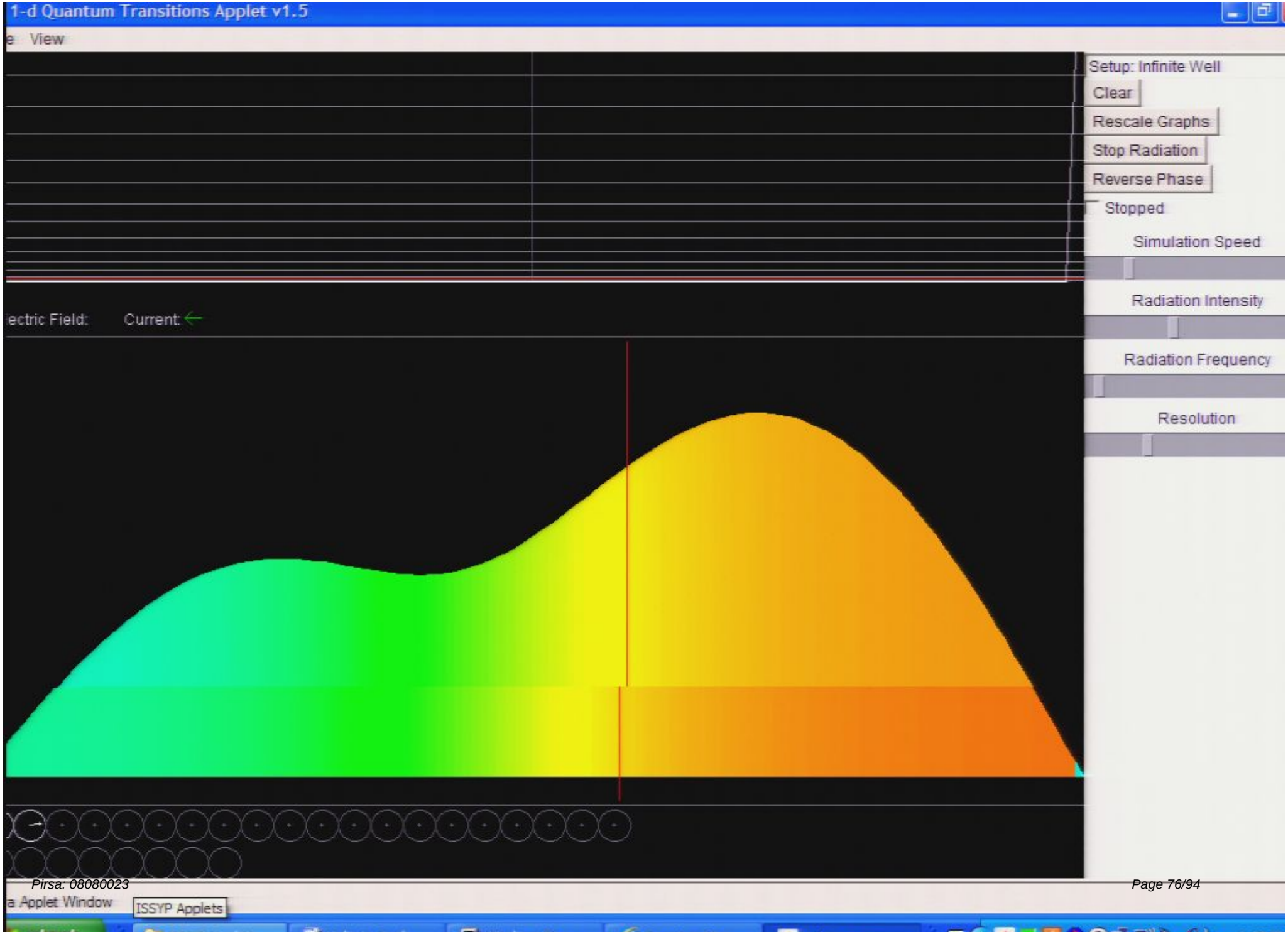

E1
E0
0
f0 = E0/h
1.5
f1 = E1/h

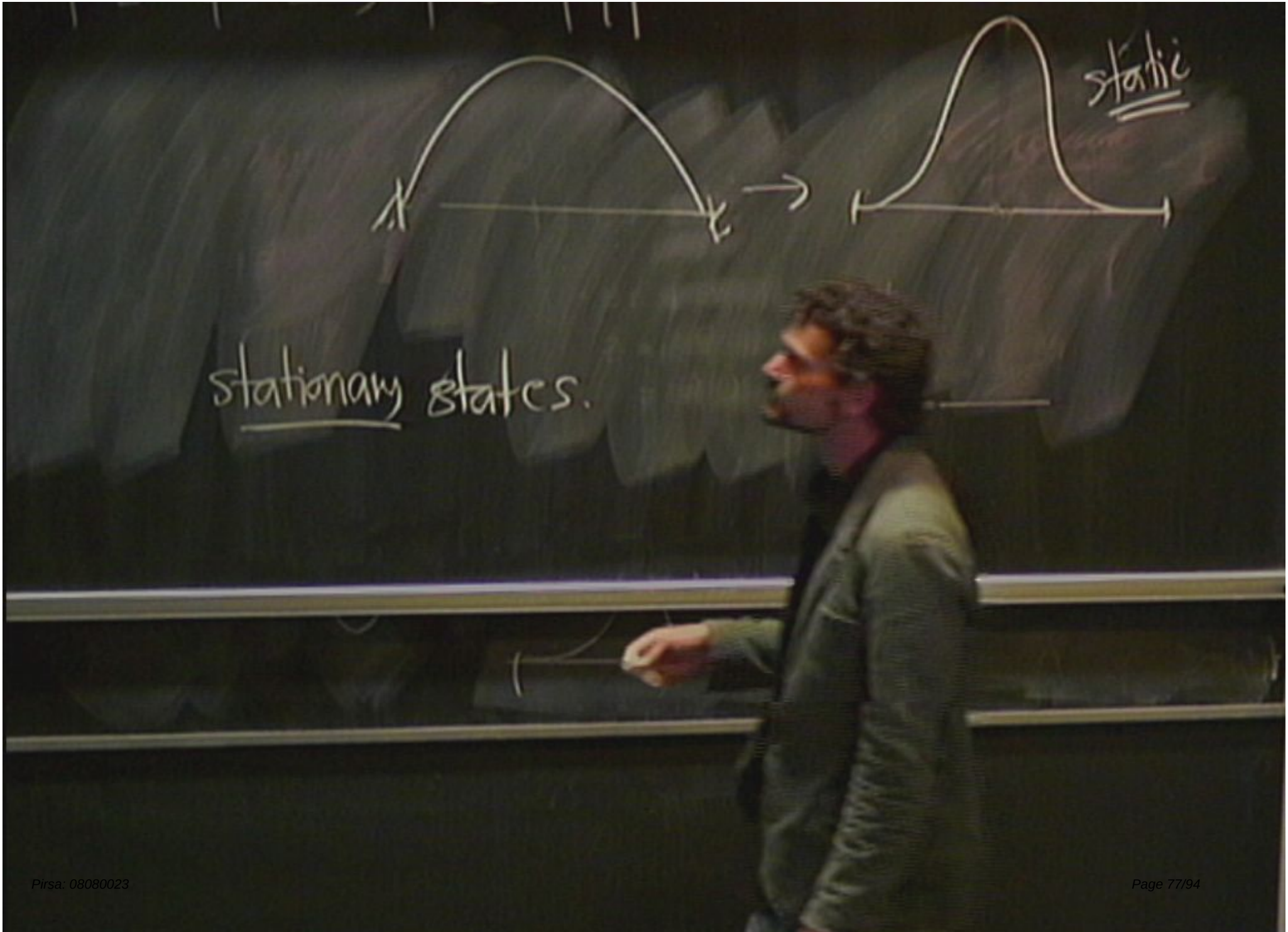

E1
E0
0
1.S
G
G
f0 = E0/h
f1 = E1/h

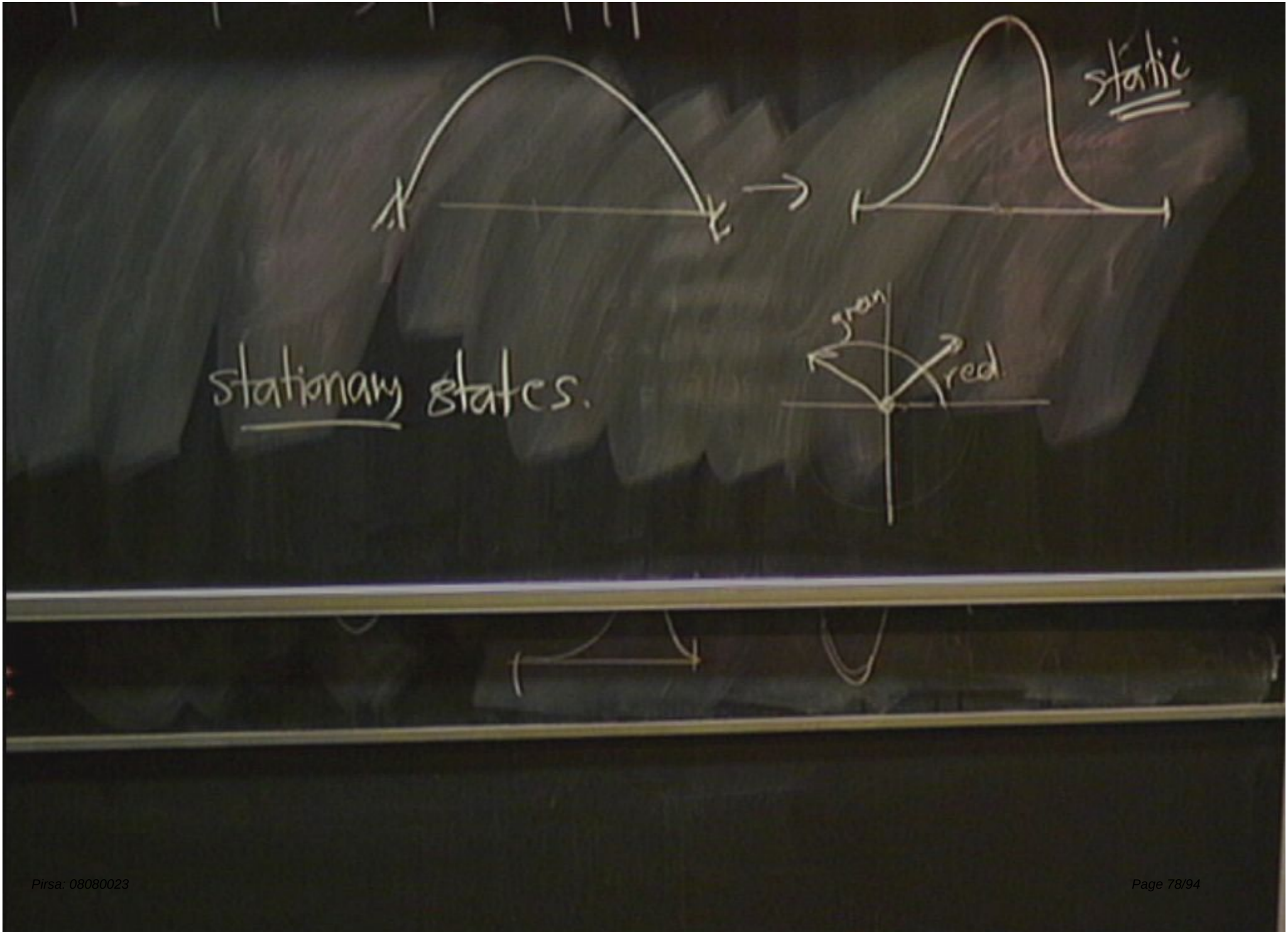

E1
E0
0
f0 = E0/h
1.5
f1 = E1/h

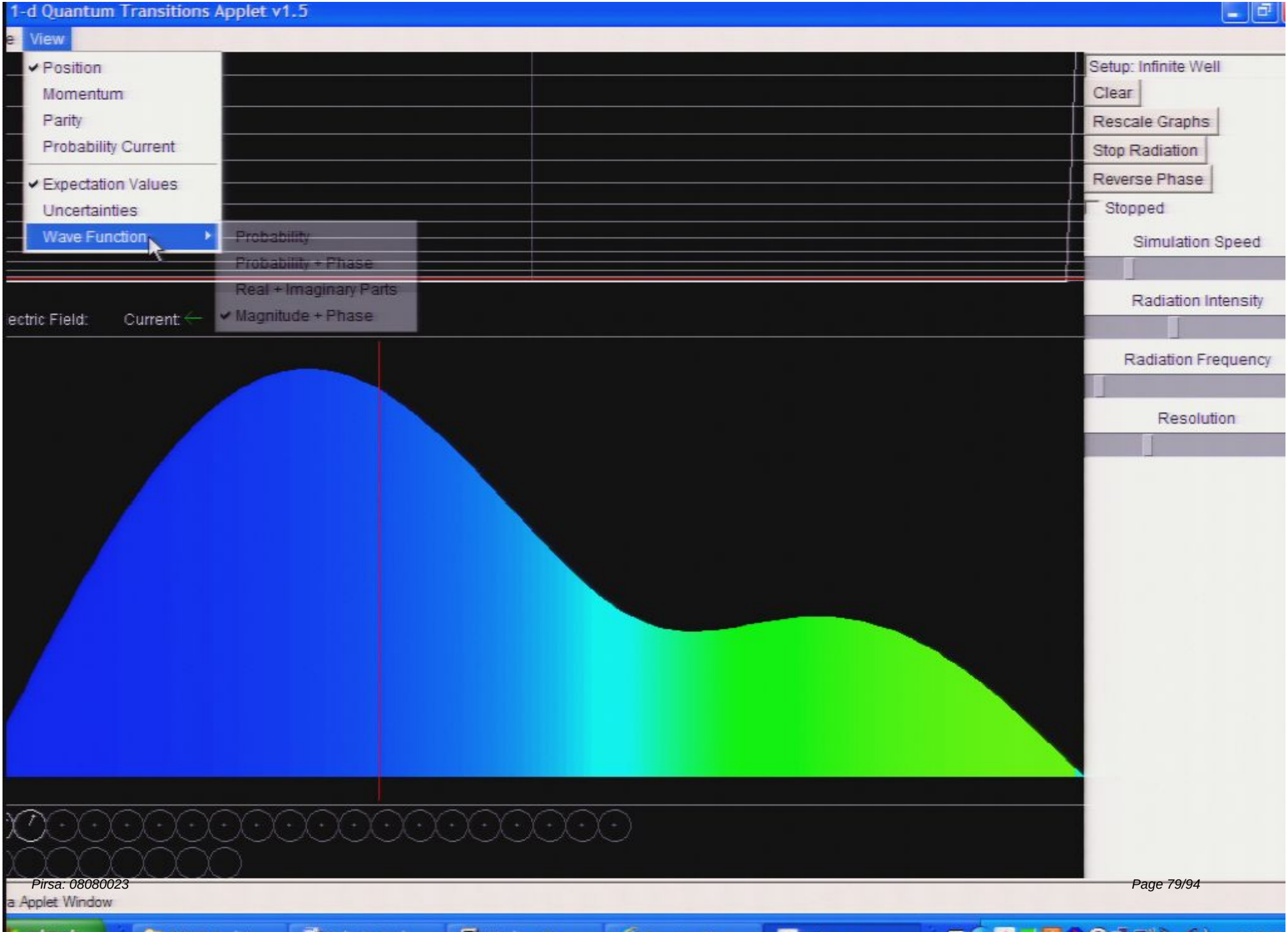

E1
E0
0
1.5
G
G
$f_0 = \frac{E_0}{h}$
$f_1 = E_1$

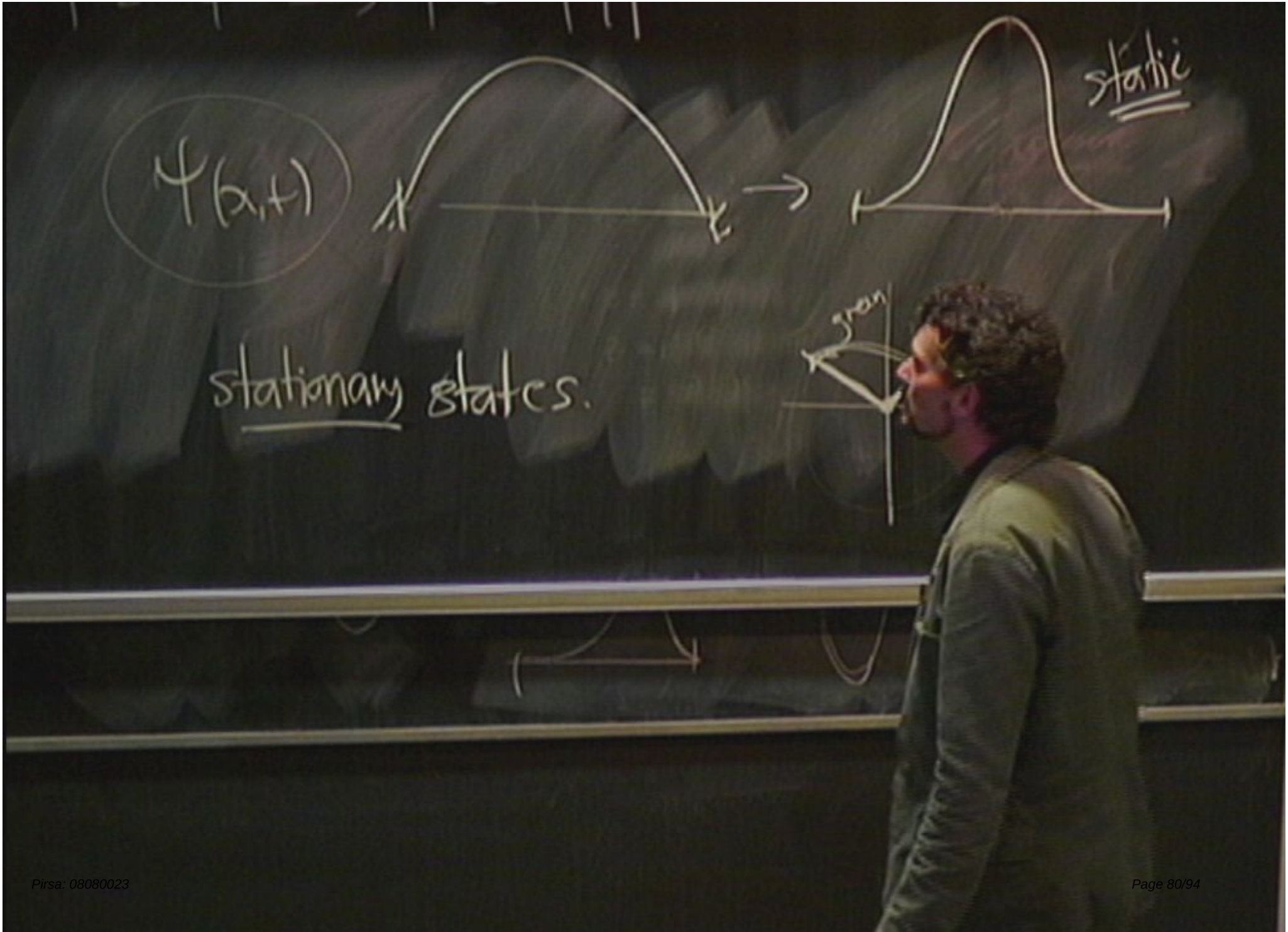

1-d Quantum Transitions Applet v1.5
e View
Setup: Infinite Well
Clear
Rescale Graphs
Stop Radiation
Reverse Phase
Stopped
Simulation Speed
Radiation Intensity
Radiation Frequency
Resolution
ectric Field:
Current:
a Applet Window

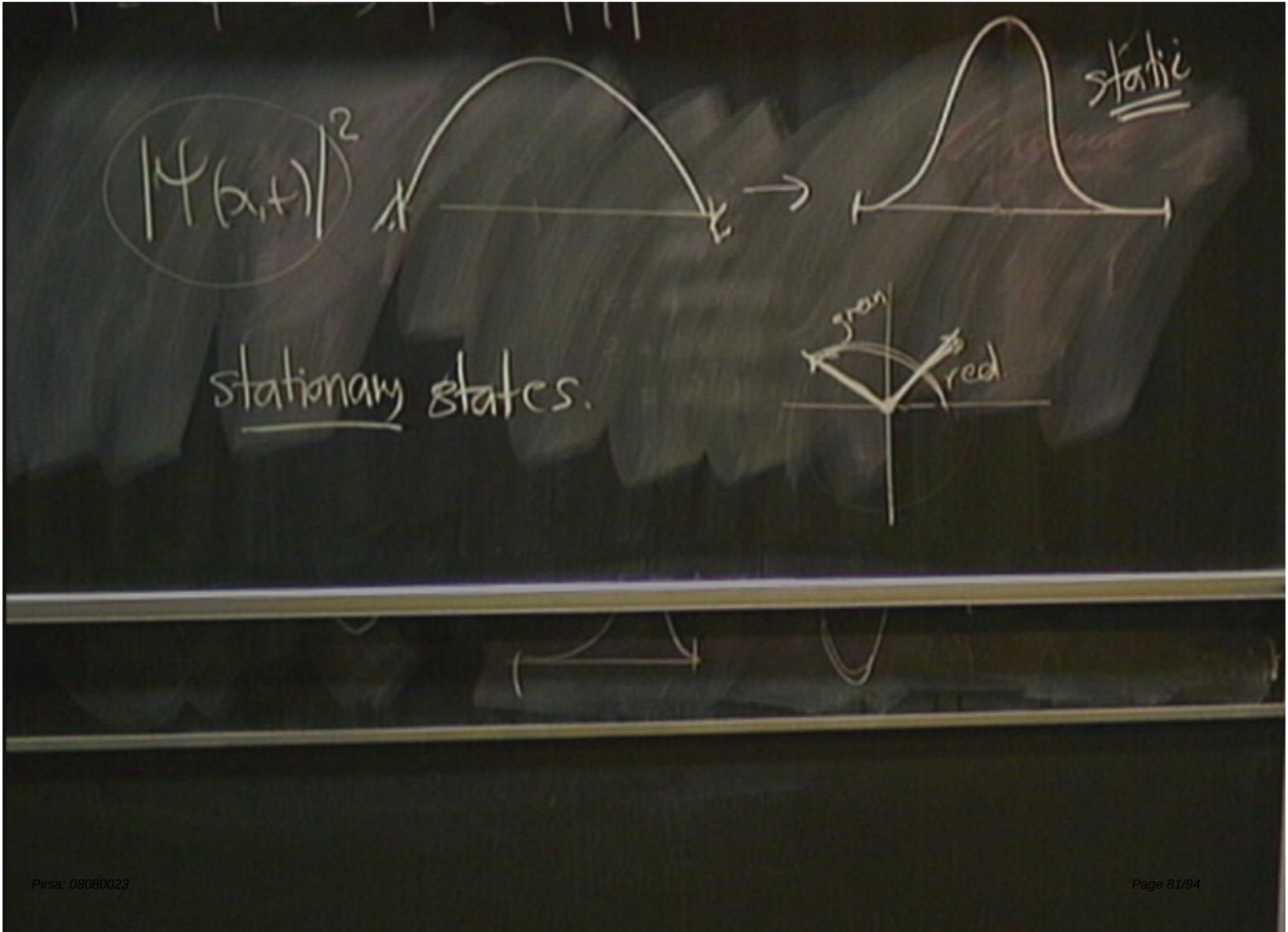

1-d Quantum Transitions Applet v1.5
e View
Setup: Infinite Well
Clear
Rescale Graphs
Stop Radiation
Reverse Phase
Stopped
Simulation Speed
Radiation Intensity
Radiation Frequency
Resolution
ectric Field:
Current:
a Applet Window
ISSYP Applets

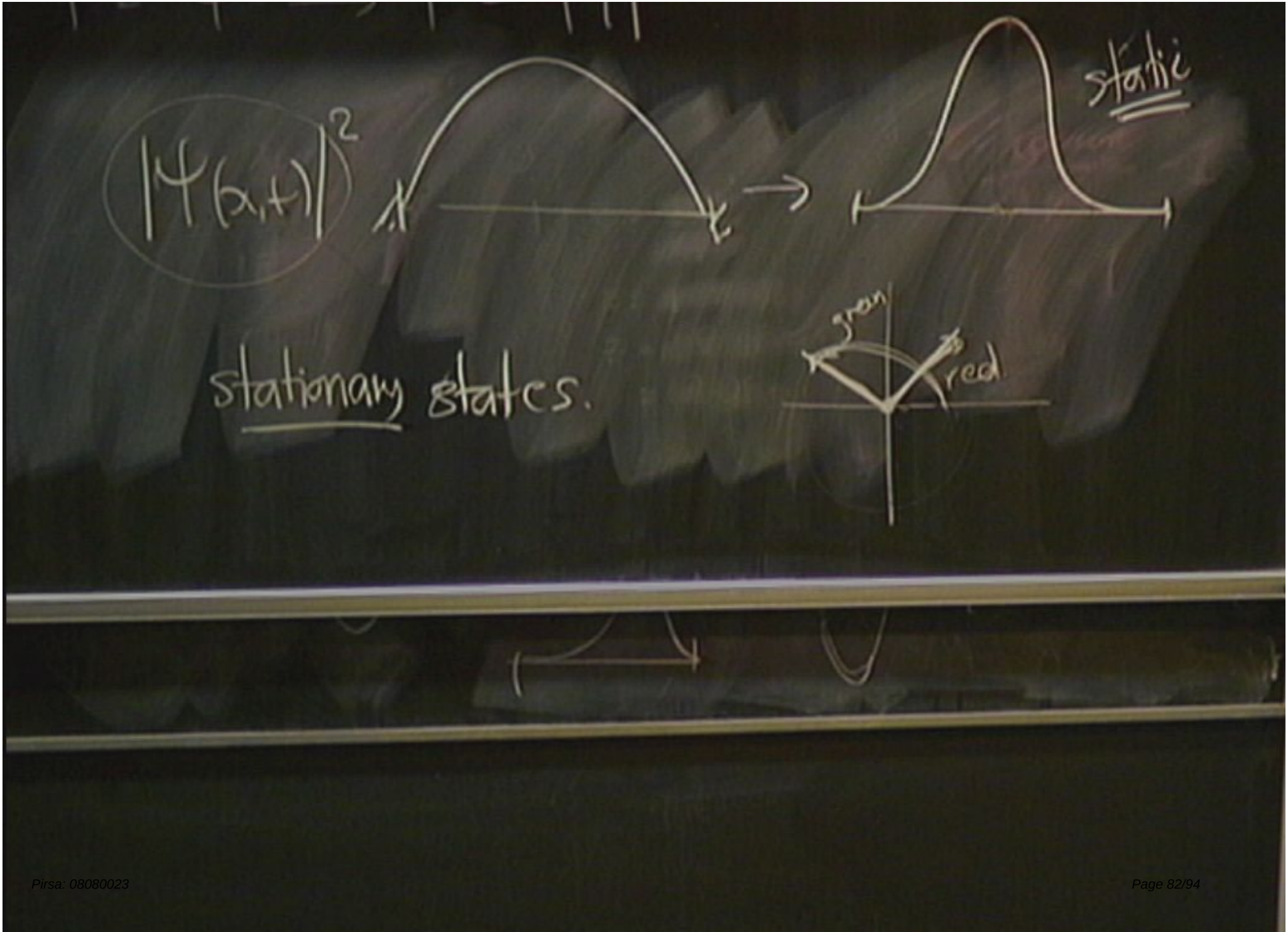

static
stationary states.

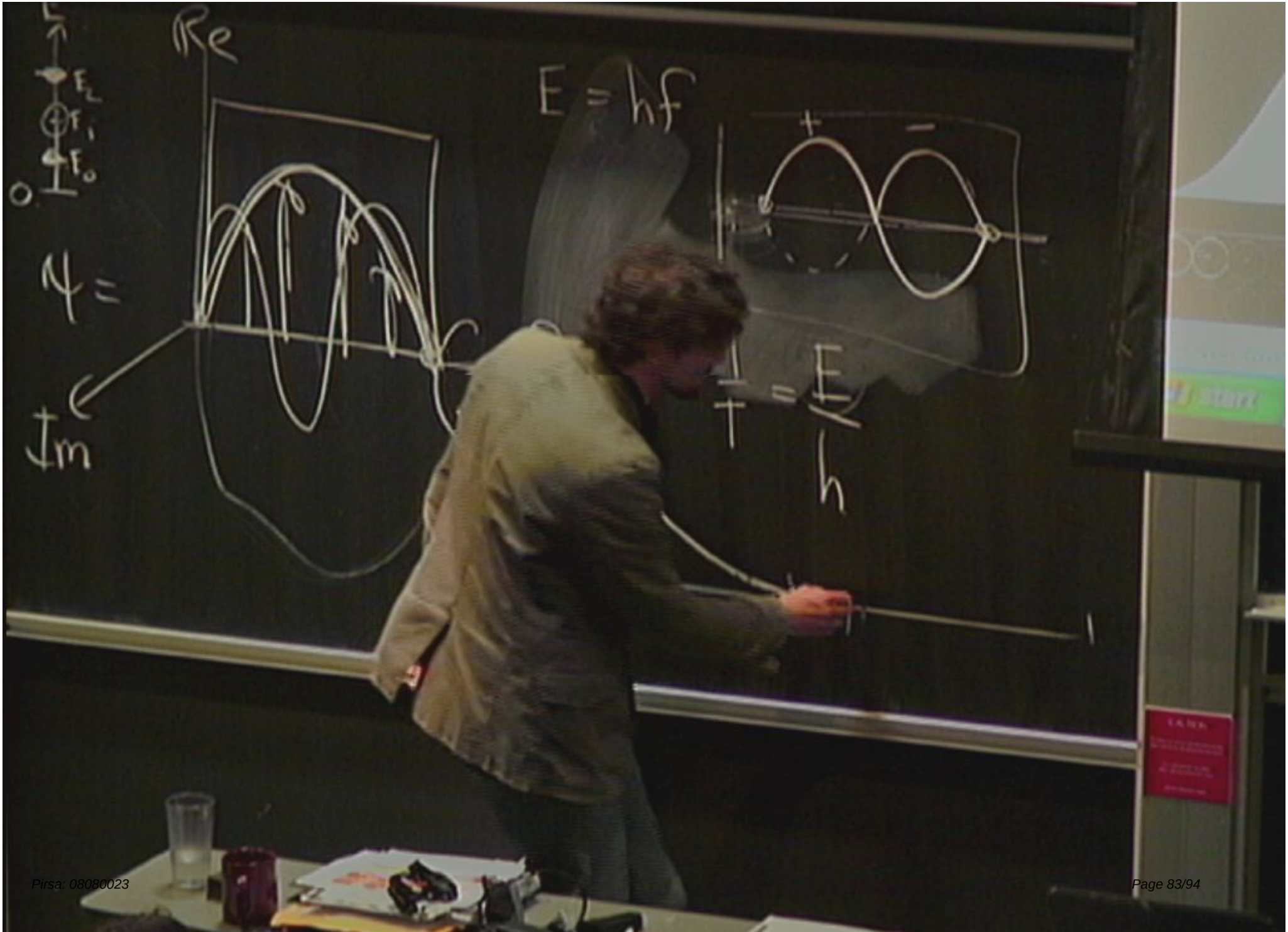

static
stationary states.
green
red

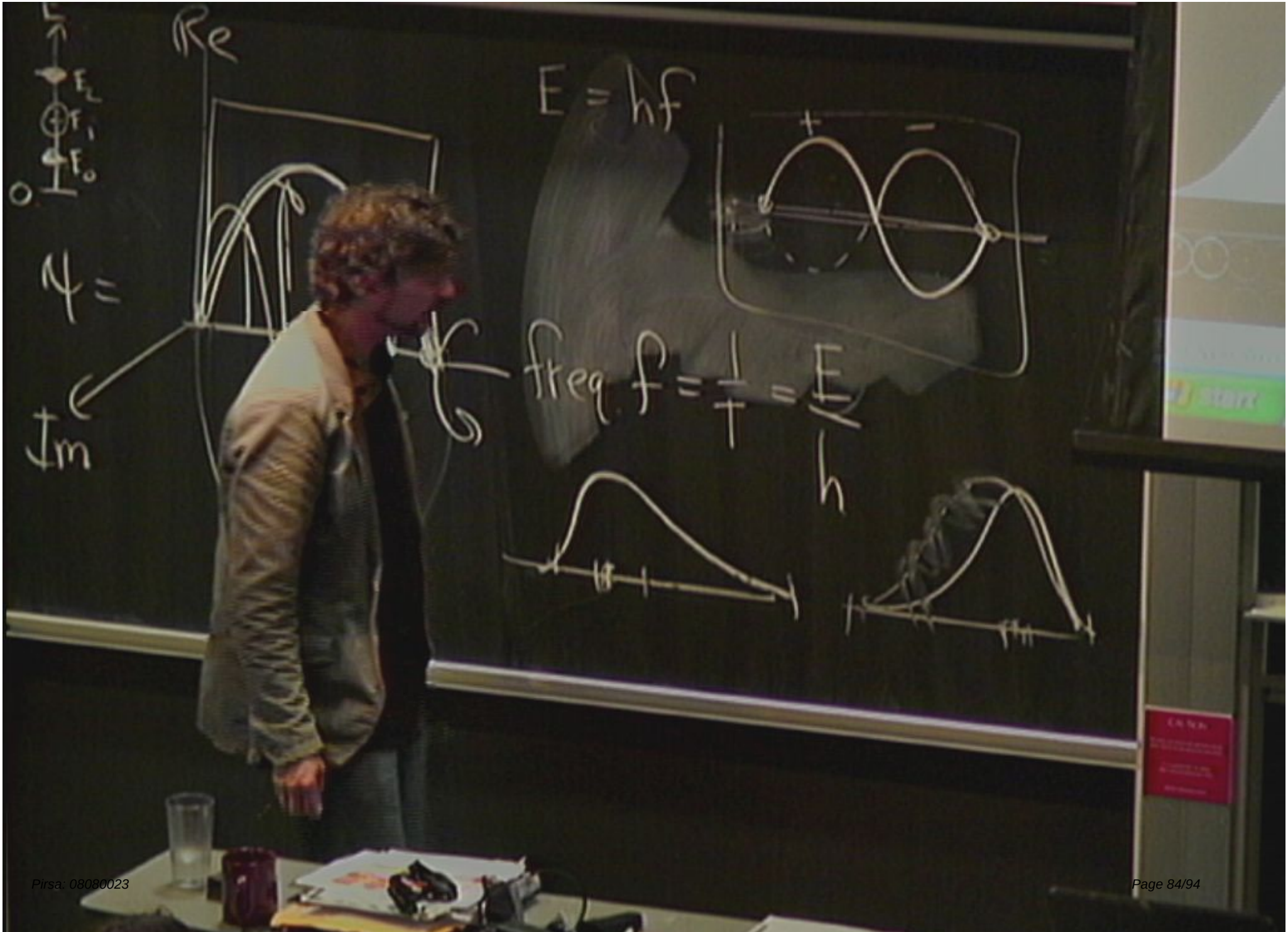

1-d Quantum Transitions Applet v1.5
View
Position
Momentum
Parity
Probability Current
Expectation Values
Uncertainties
Wave Function
Probability
Probability + Phase
Real + Imaginary Parts
Magnitude + Phase
ectric Field:
Current:
Setup: Infinite Well
Clear
Rescale Graphs
Stop Radiation
Reverse Phase
Stopped
Simulation Speed
Radiation Intensity
Radiation Frequency
Resolution
a Applet Window

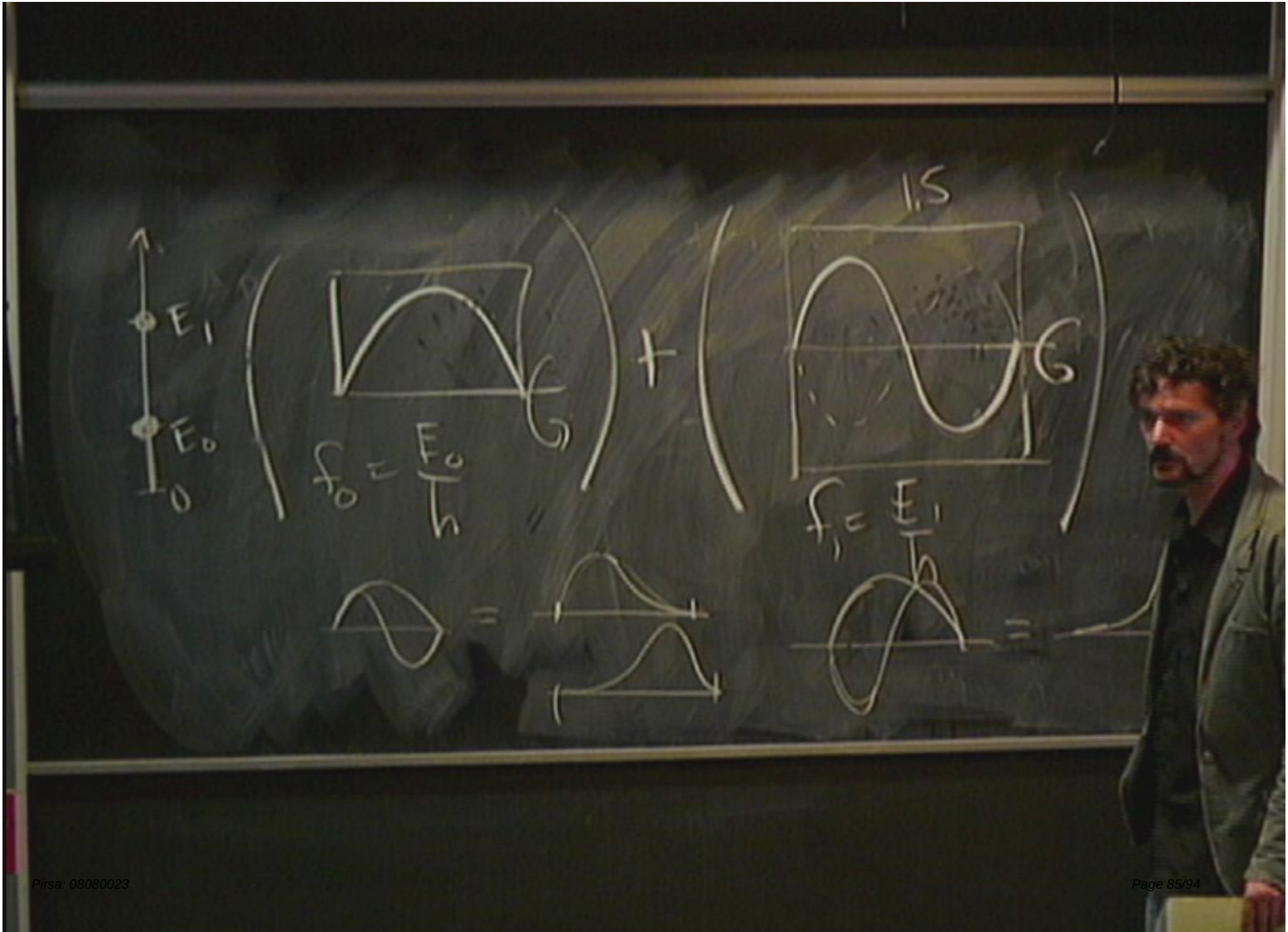

Ψ(x,t)
static
stationary states.

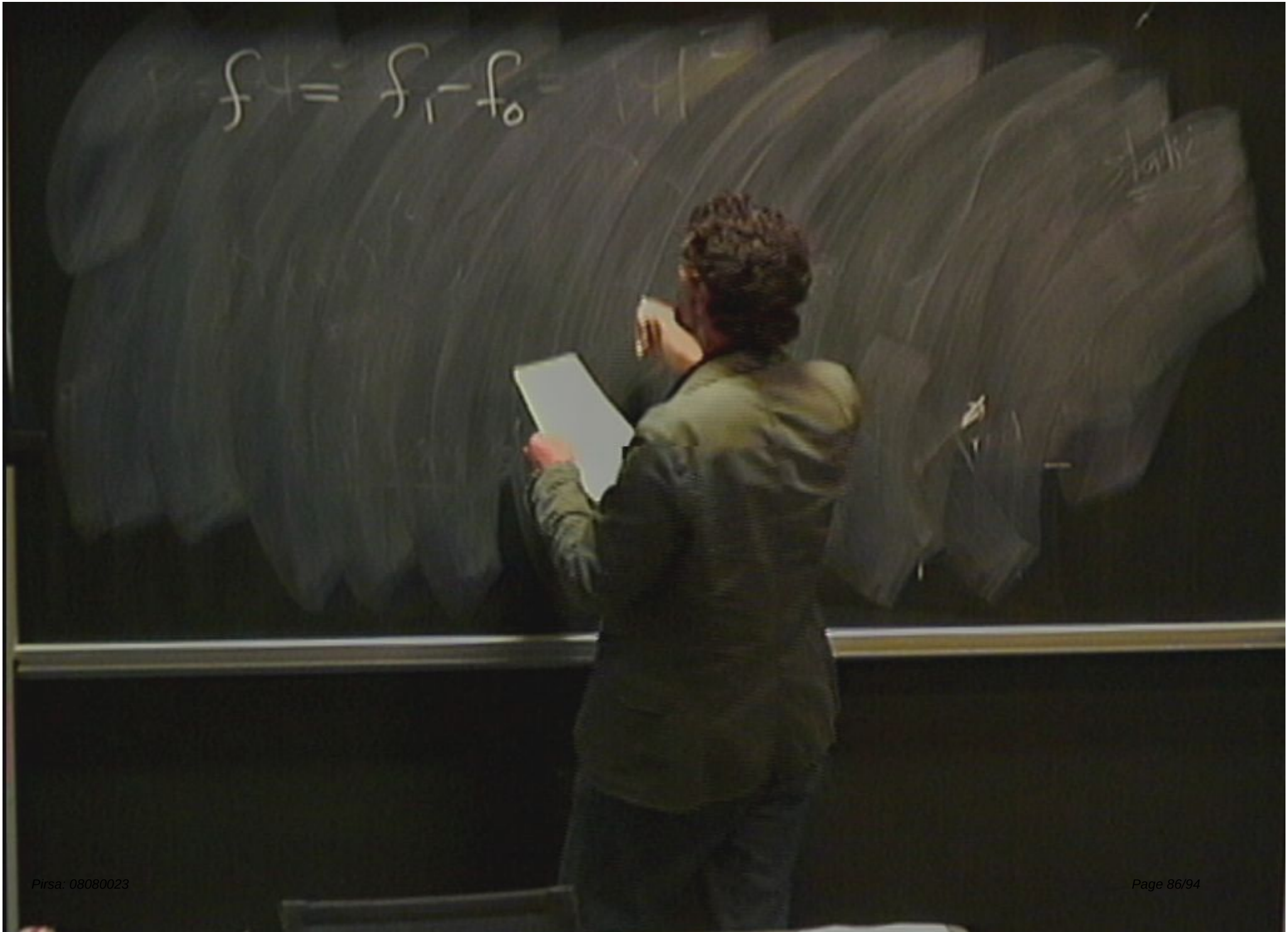

$|\Psi(x,t)|^2$
static
stationary states.
green
red


$|\Psi(x,t)|^2$
static
stationary states.
green
red

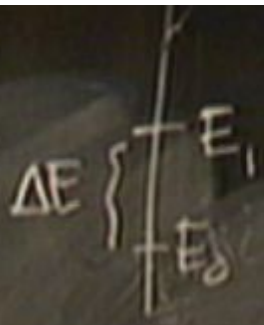

Re
E = hf
Im
h

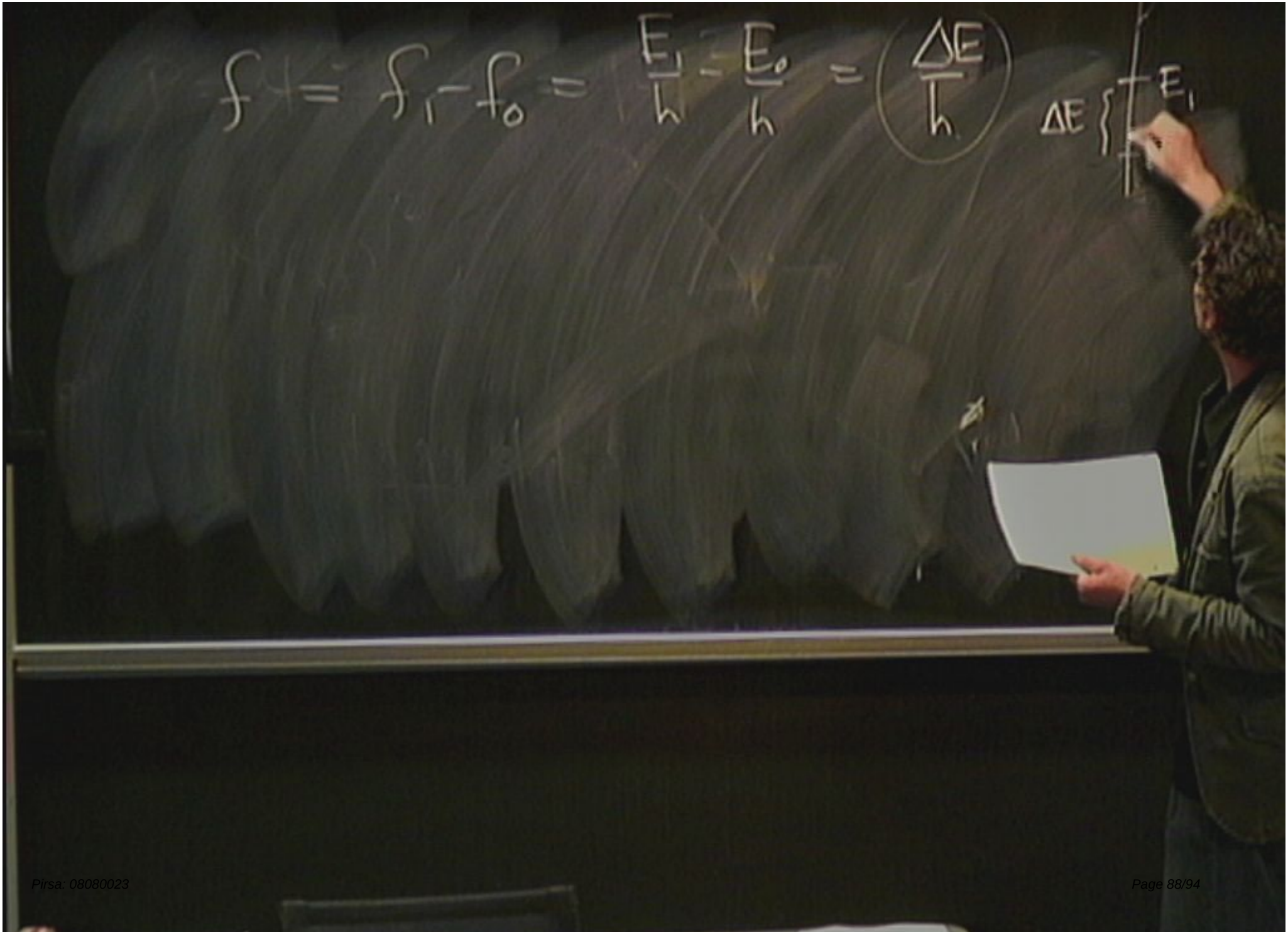

Re
E = hf
Im
freq. f = 1/T = E/h

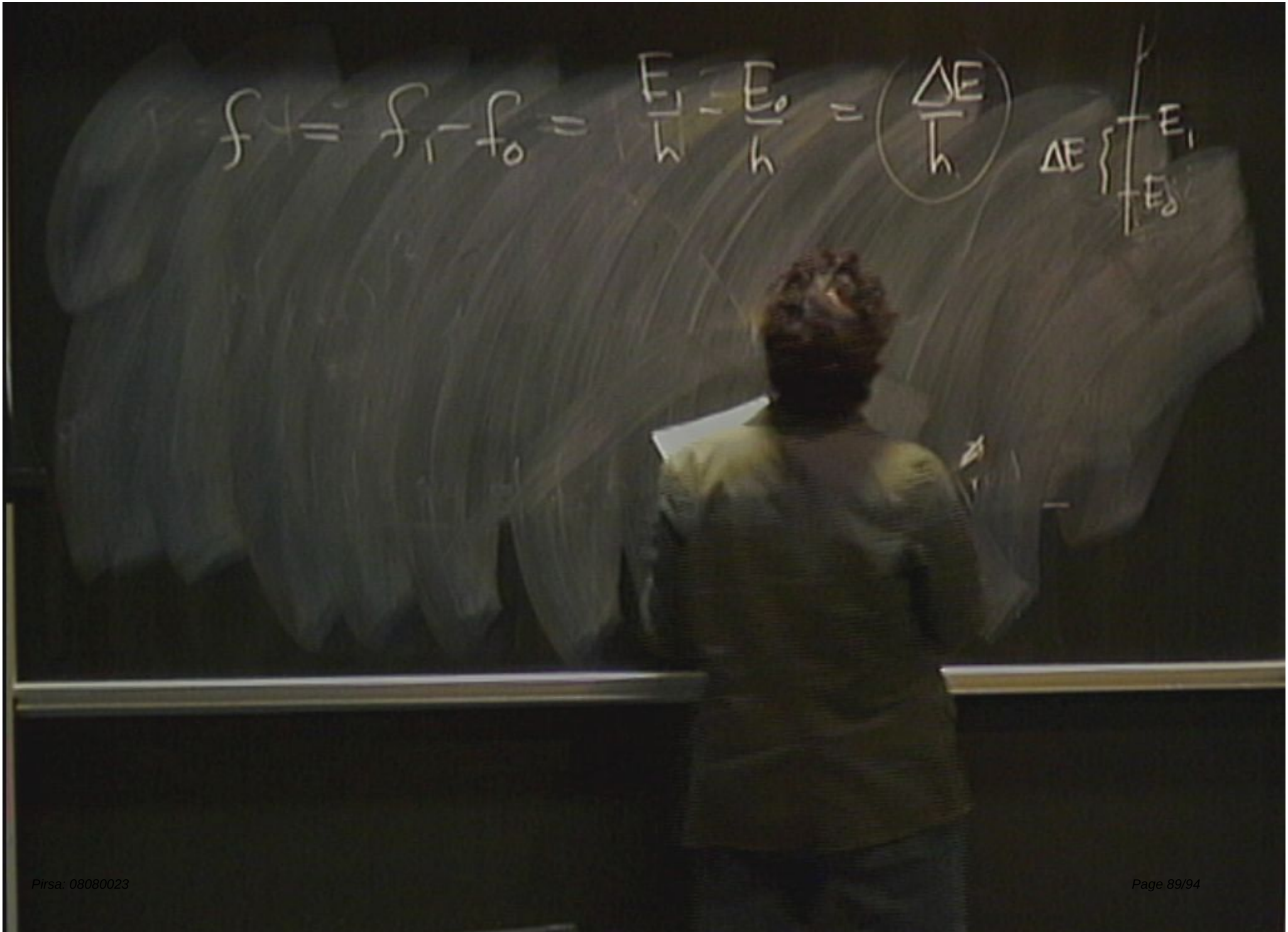

E1
E0
0
f0 = E0/h
1.S
f1 = E1/h

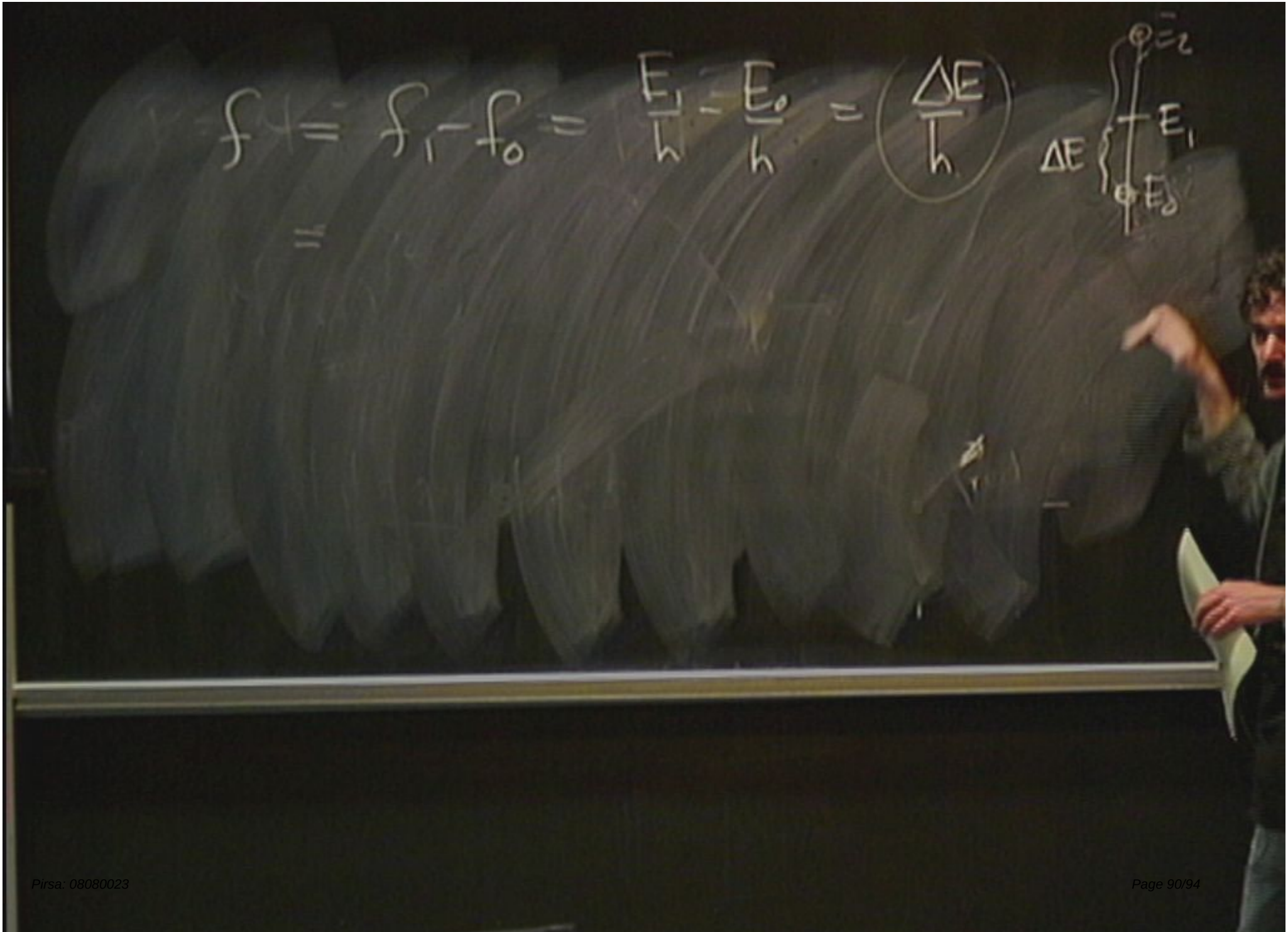

$f_1 = f_1 - f_0$

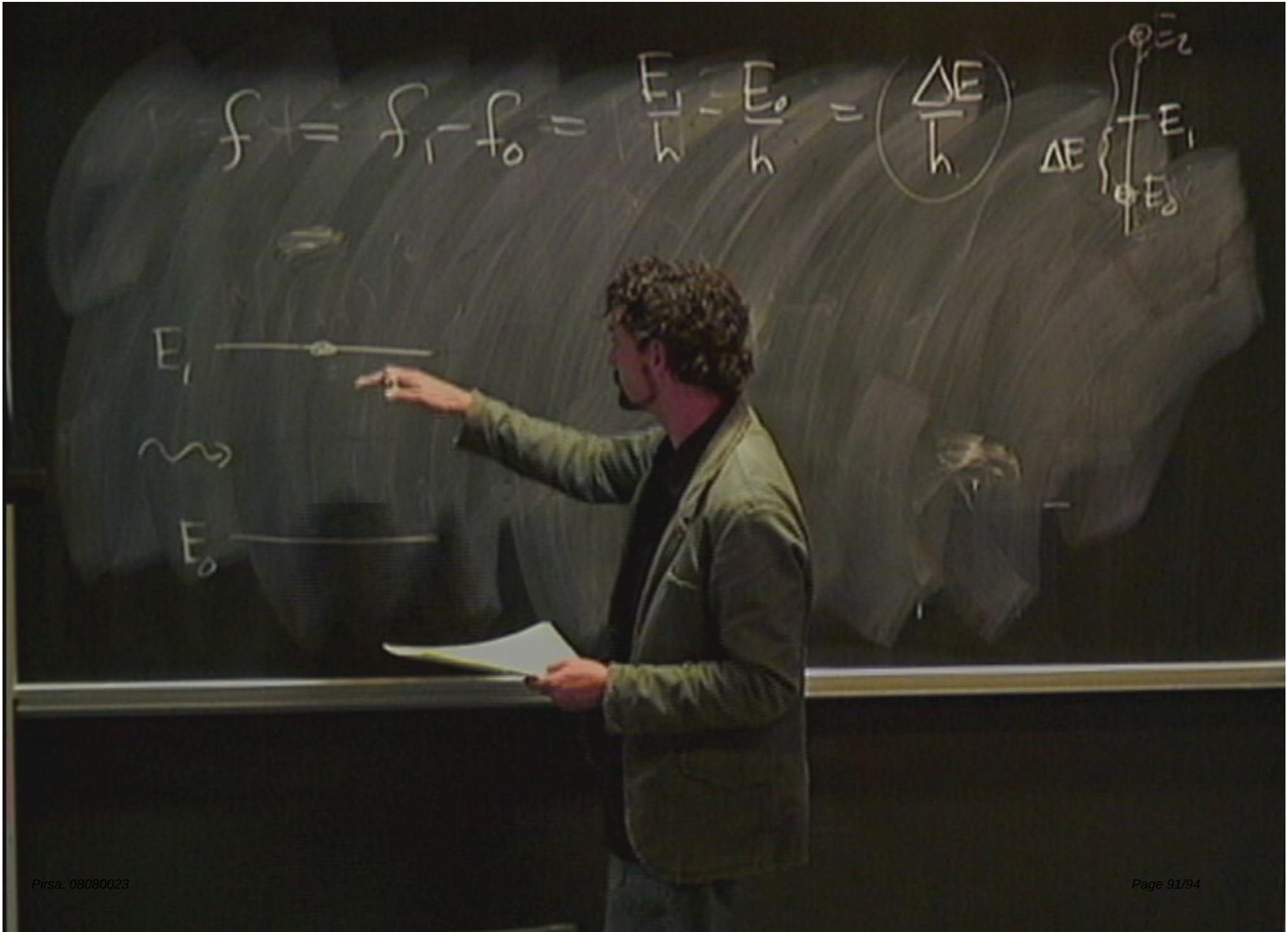
$$f_1 = f_1 - f_0 = \frac{E_1}{h} - \frac{E_0}{h} = \frac{\Delta E}{h}$$

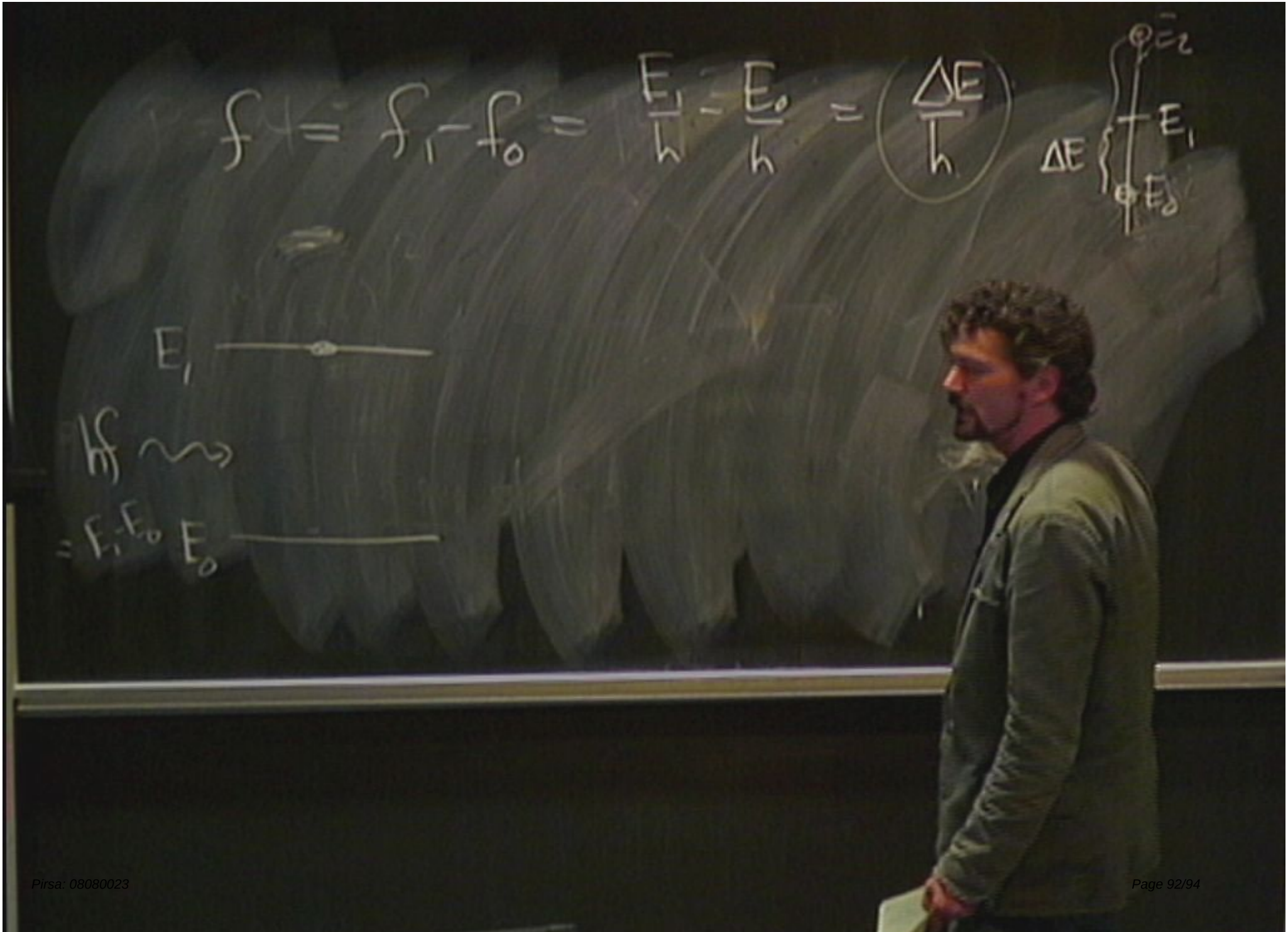



$f = f_1 - f_0 = \frac{E_1}{h} - \frac{E_0}{h} = \frac{\Delta E}{h}$
ΔE
E_1


$f_1 = f_1 - f_0 = \frac{E_1}{h} - \frac{E_0}{h} = \frac{\Delta E}{h}$
ΔE
E_1
E_0


$f_1 = f_1 - f_0 = \frac{E_1}{h} - \frac{E_0}{h} = \frac{\Delta E}{h}$
ΔE
E_1
E_0
=


$f = f_1 - f_0 = \frac{E_1}{h} - \frac{E_0}{h} = \left(\frac{\Delta E}{h}\right)$
ΔE
E_1
E_0

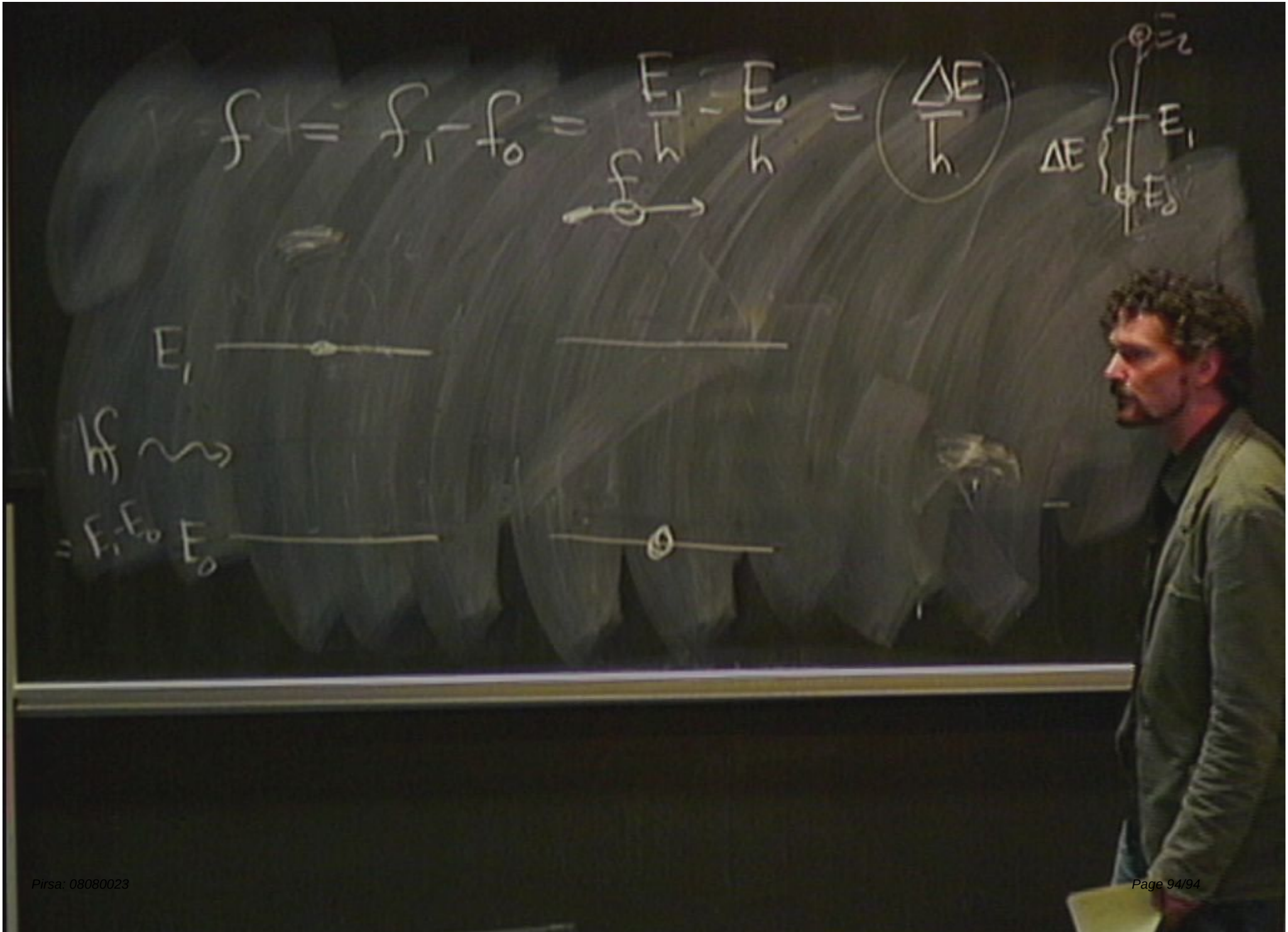

$f_{10} = f_1 - f_0 = \frac{E_1}{h} - \frac{E_0}{h} = \frac{\Delta E}{h}$
ΔE
E_1
E_0
E_1
$hf \rightsquigarrow$
$= E_1 - E_0$

$$f_1 = f_1 - f_0 = \frac{E_1}{h} - \frac{E_0}{h} = \left(\frac{\Delta E}{h}\right)$$

E_1

$hf \rightsquigarrow$

$= E_1 - E_0$ E_0


$f = f_1 - f_0 = \frac{E_1}{h} - \frac{E_0}{h} = \frac{\Delta E}{h}$
f
ΔE
E_1
E_0
E_1
$hf \rightsquigarrow$
$= E_1 - E_0$