

Title: Quantum Mechanics 12 - How Atoms Emit and Absorb Photons

Date: Aug 16, 2008 02:30 PM

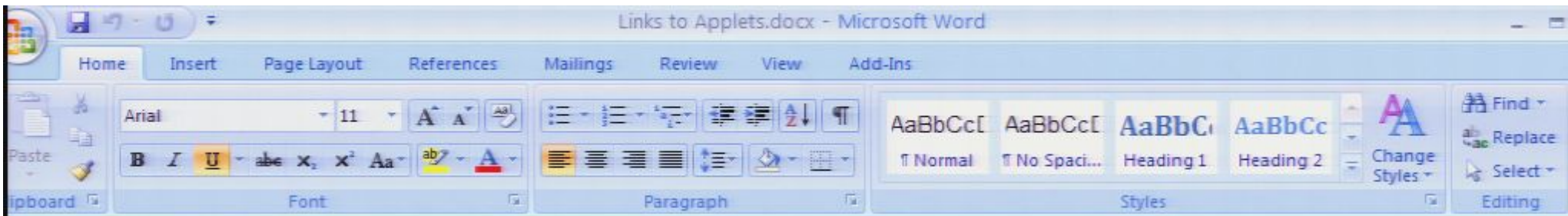
URL: <http://pirsa.org/08080087>

Abstract: Learning Outcomes:

• How the complex standing wave states of an electron in a one-dimensional box are "stationary states" in that the electron probability pattern is static (not changing with time).

• However, if the electron is put in a superposition of two such stationary states (with different energies), its probability pattern is not static, but rather oscillates back and forth; understanding how this oscillation is connected with photon emission and absorption.

• Understanding how these ideas apply to the atom, and how a LASER works (Light Amplification by Stimulated Emission of Radiation).



Links to Applets

Falstad Applets

<http://www.falstad.com/mathphysics.html>

Standing Waves

<http://www.nqsir.netfirms.com/englishhtm/StatWave.htm>

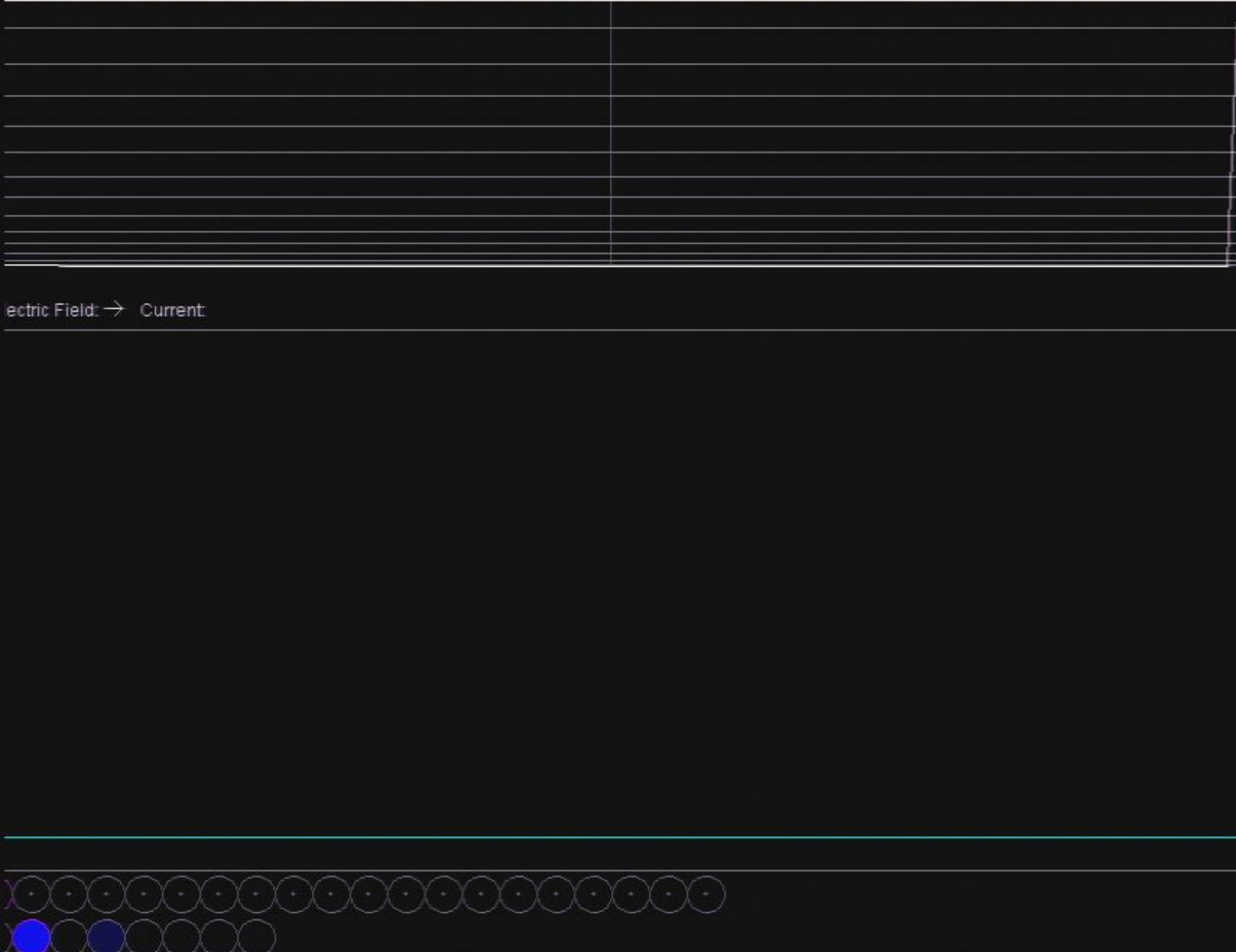
Superposition of Waves:

<http://www.phy.ntnu.edu.tw/ntnujava/index.php?topic=19>

<http://thespoon7.tripod.com/wave.htm>

<http://kingfish.coastal.edu/physics/phslets/Waves/superposition.html>

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

Electric Field: → Current:

View

Setup: Infinite Well

Clear

Rescale Graphs

Stop Radiation

Reverse Phase

Stopped

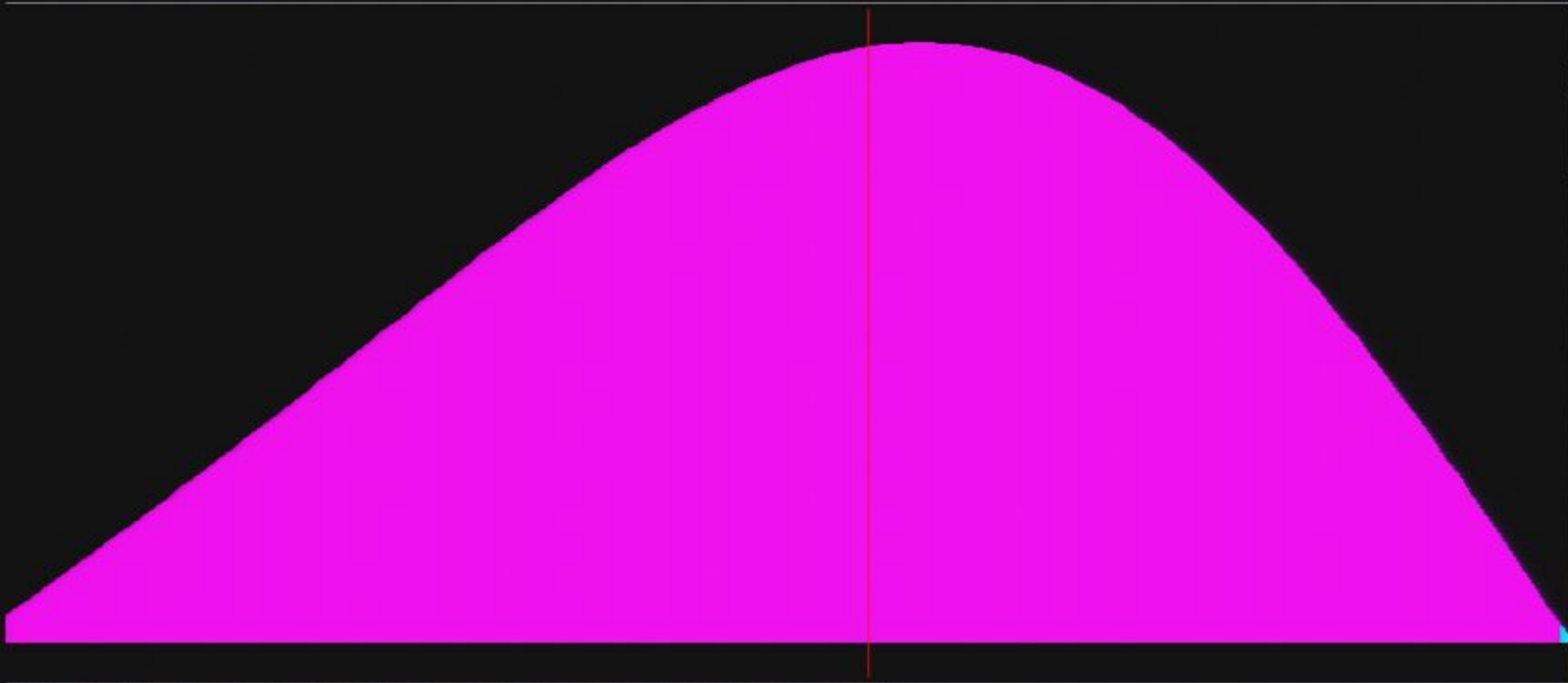
Simulation Speed

Radiation Intensity

Radiation Frequency

Resolution

Electric Field: ← Current:



View

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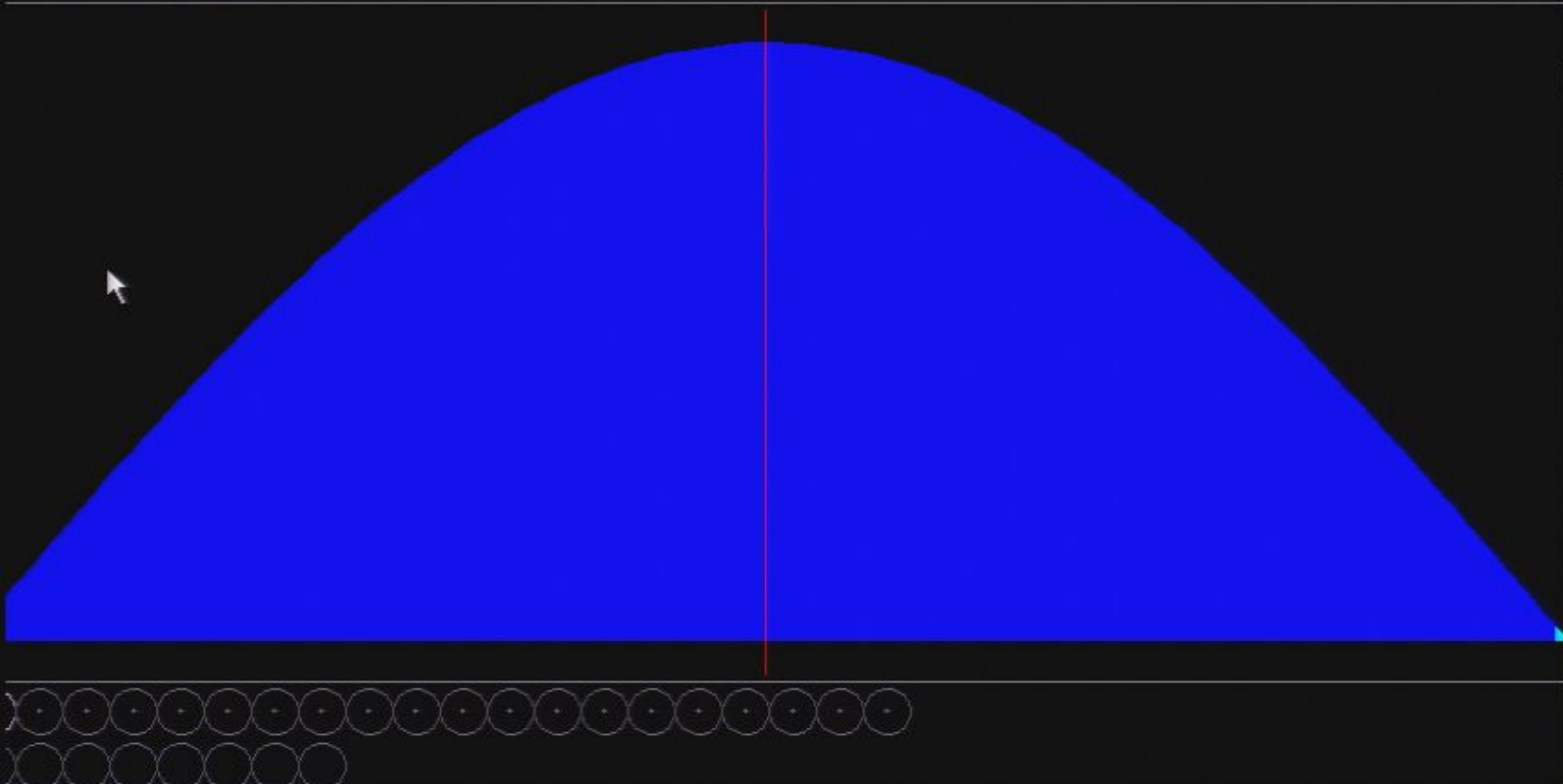
Simulation Speed

Radiation Intensity

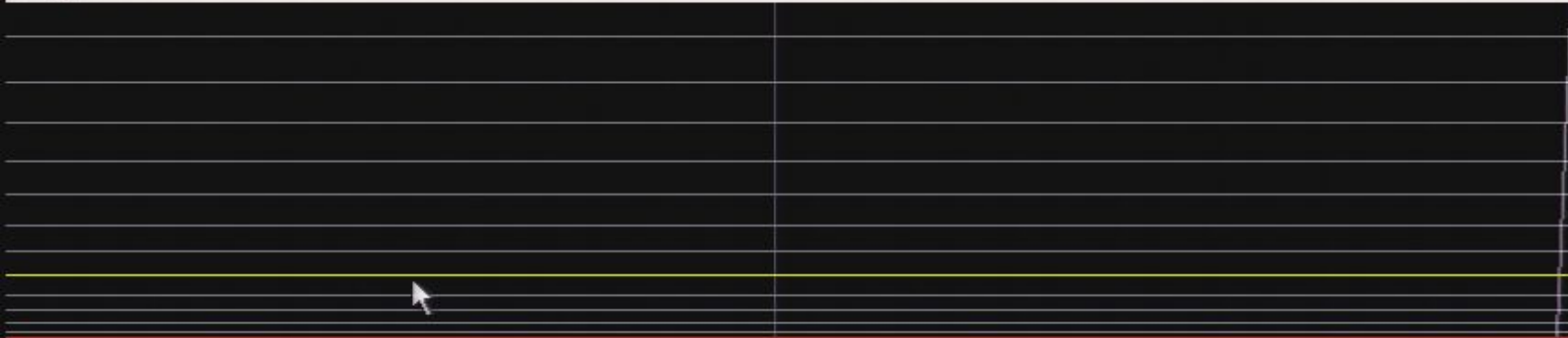
Radiation Frequency

Resolution

Electric Field: Current:



View



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Reverse Phase

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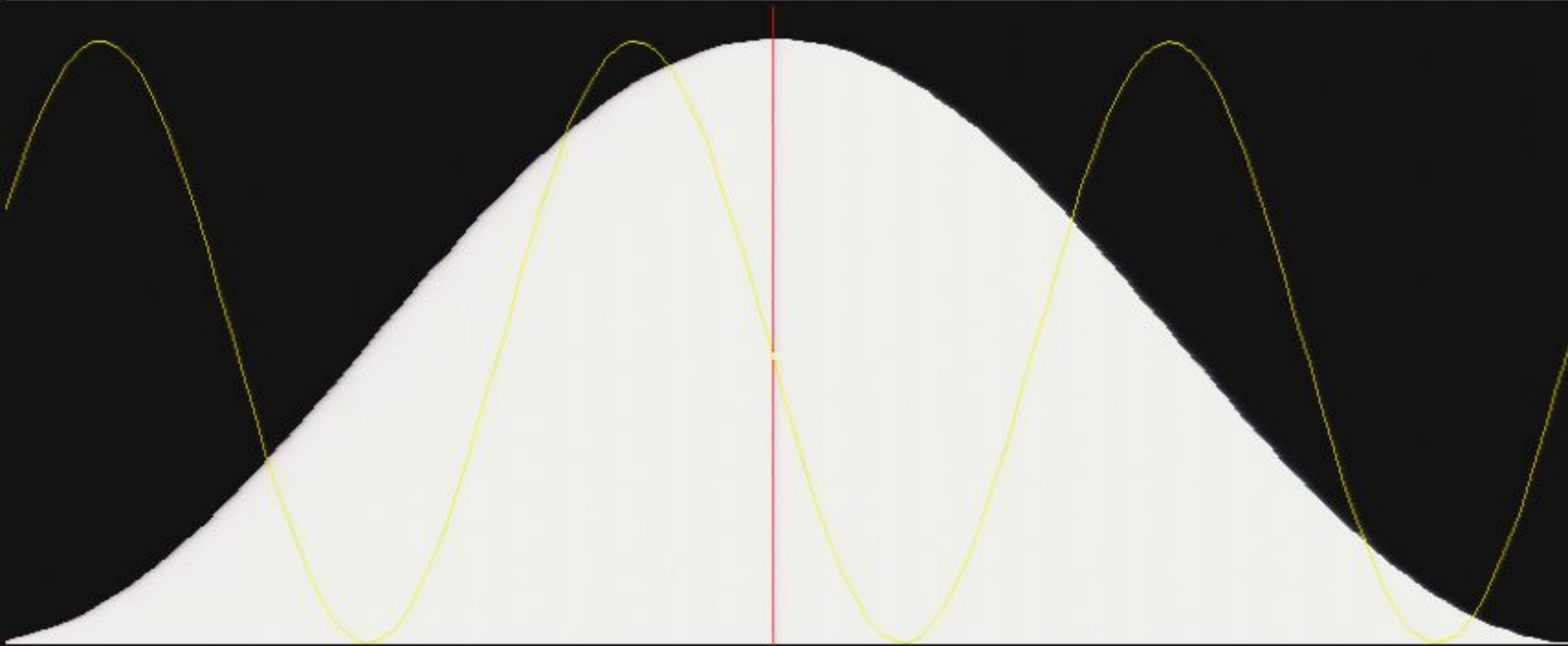
Simulation Speed

Radiation Intensity

Radiation Frequency

Resolution

Electric Field: Current:



Setup: Infinite Well

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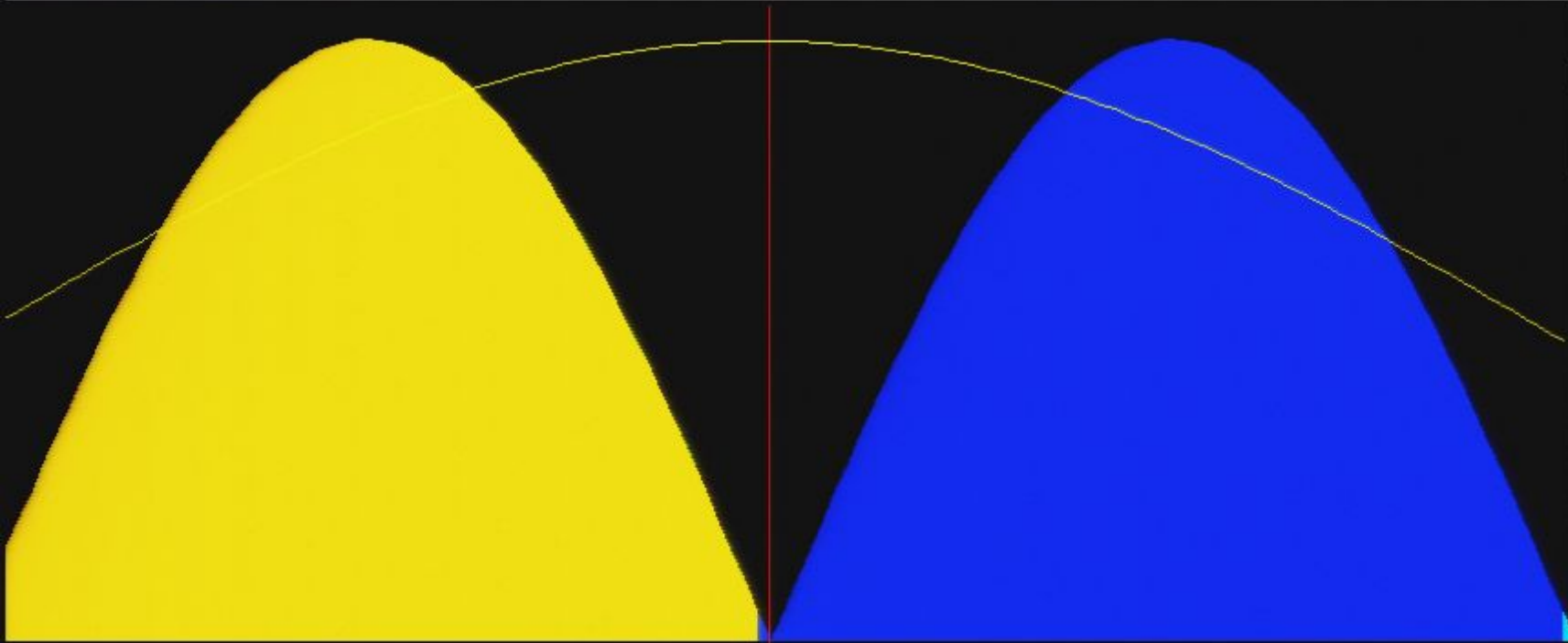
Simulation Speed

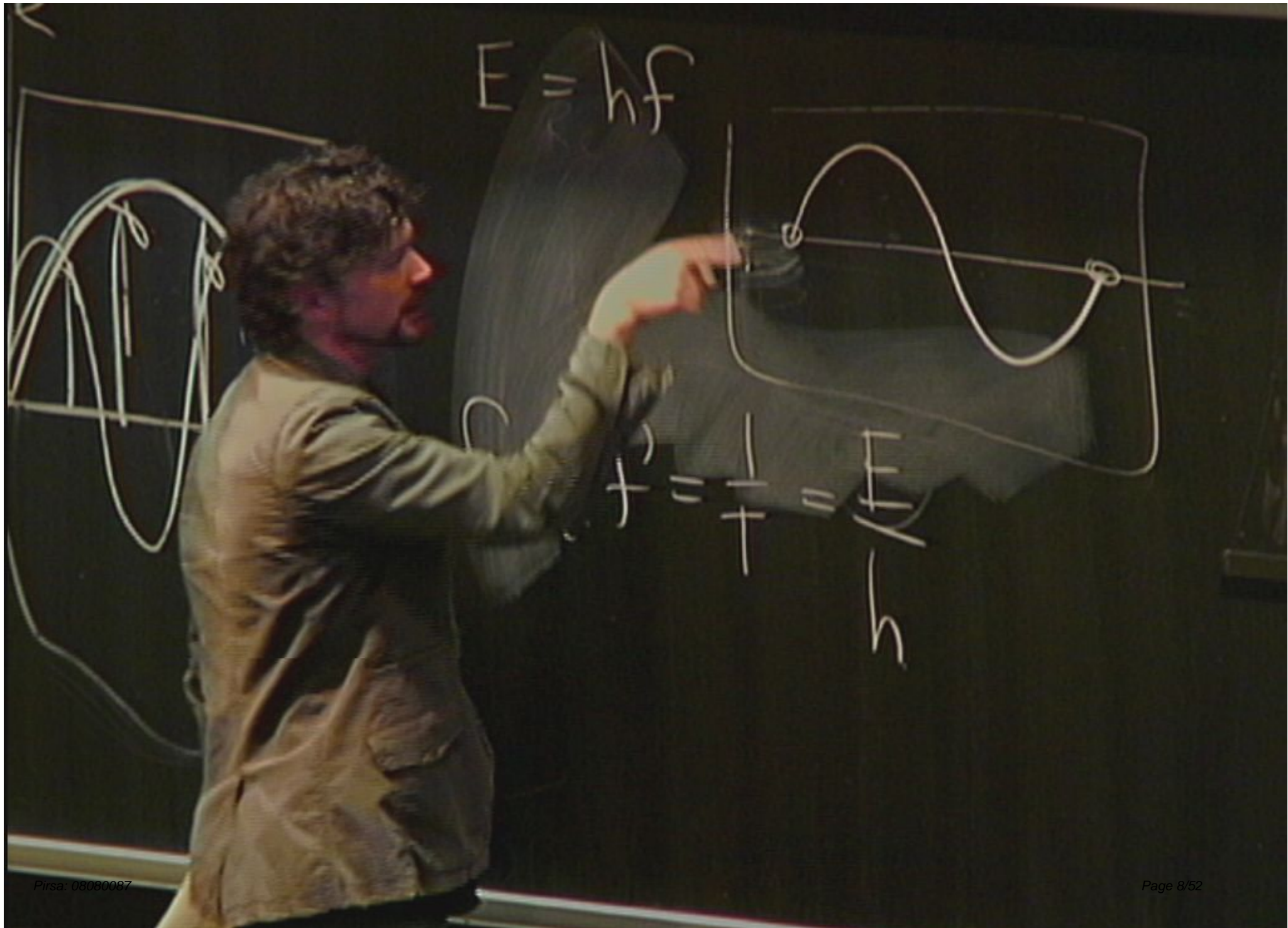
Radiation Intensity

Radiation Frequency

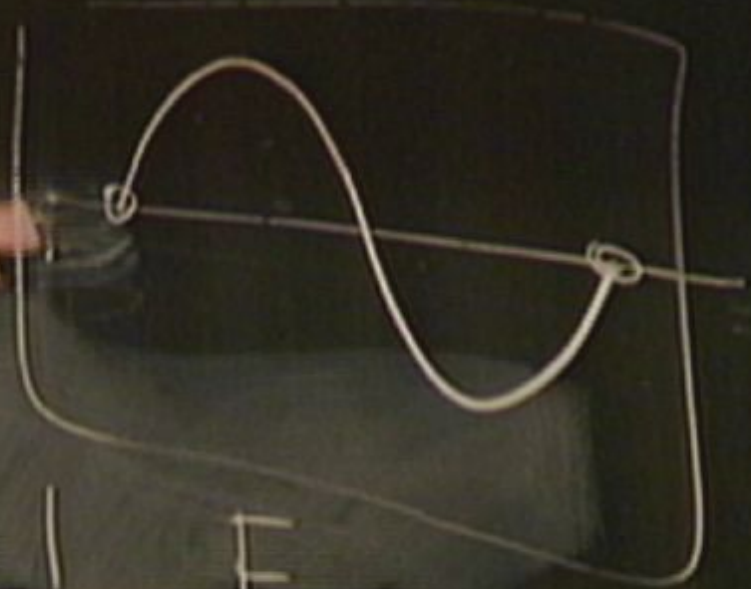
Resolution

Electric Field: Current:





$$E = hf$$



$$f = \frac{1}{T}$$
$$\lambda = \frac{v}{f}$$

View



Setup: Infinite Well

Clear

Rescale Graphs

Stop Radiation

Reverse Phase

Stopped

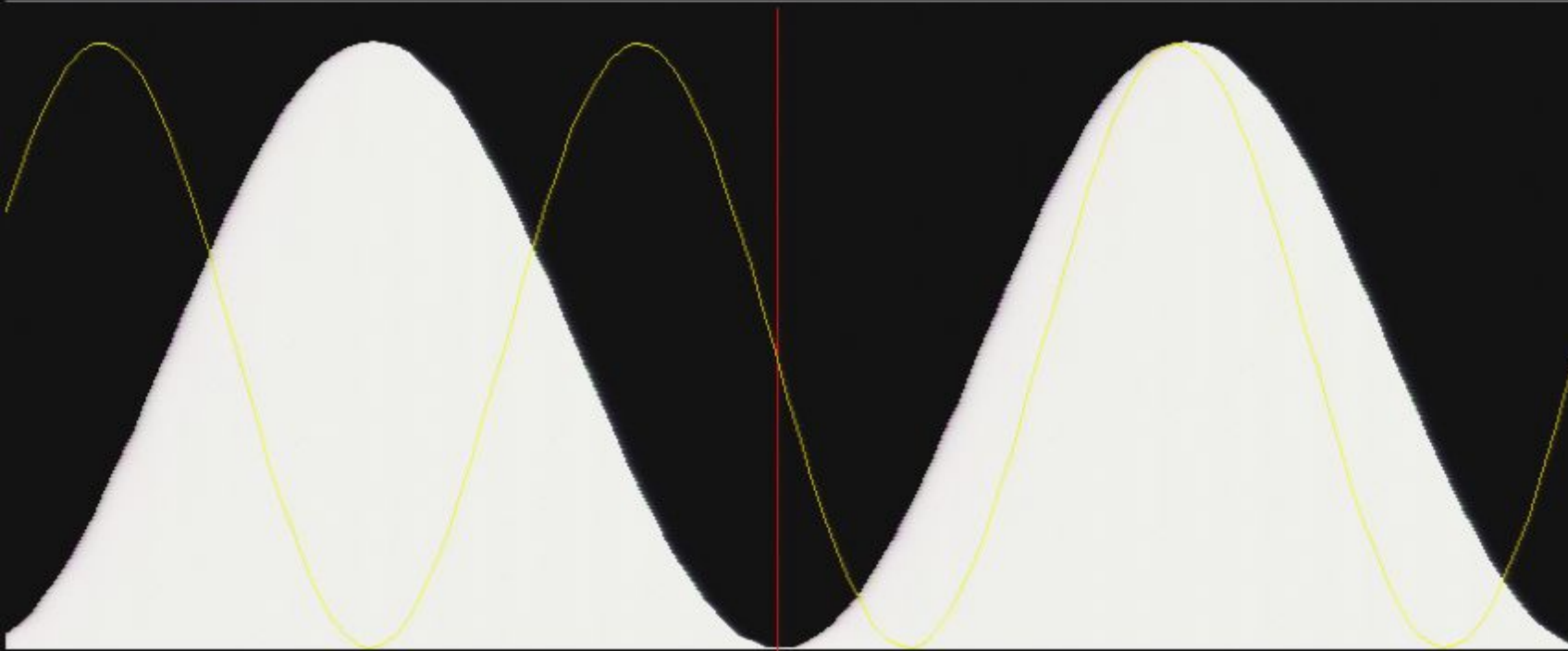
Simulation Speed

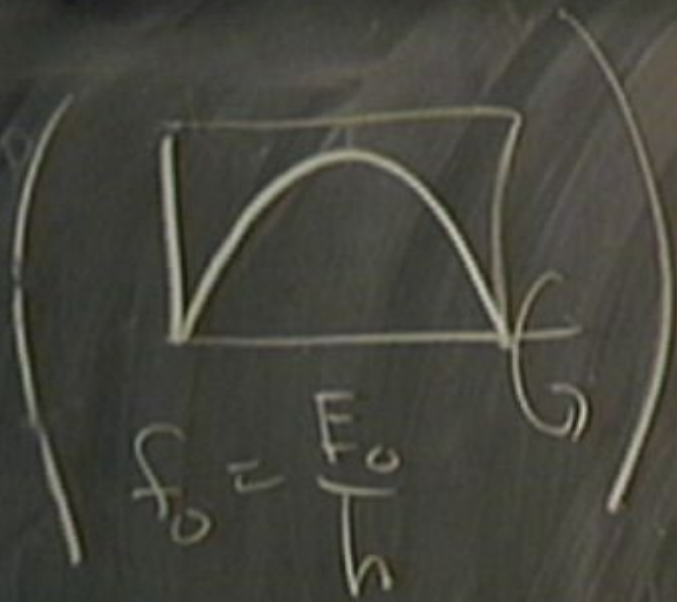
Radiation Intensity

Radiation Frequency

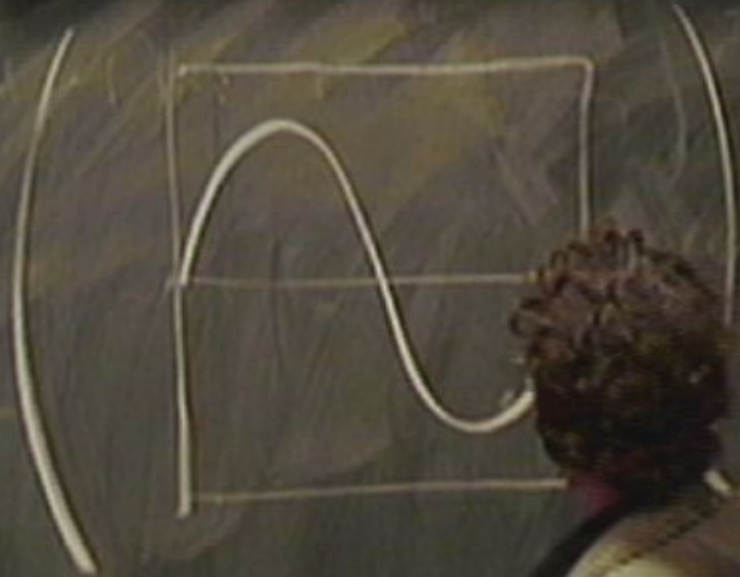
Resolution

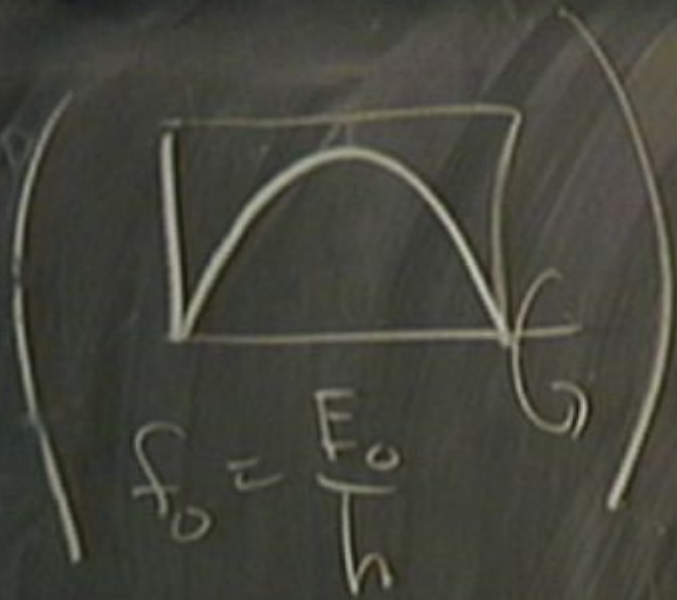
Electric Field: Current:



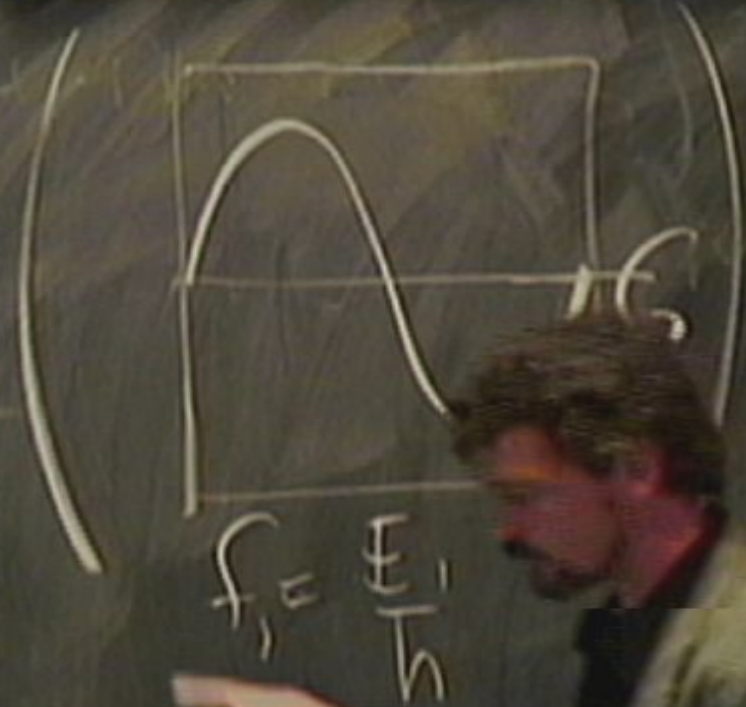


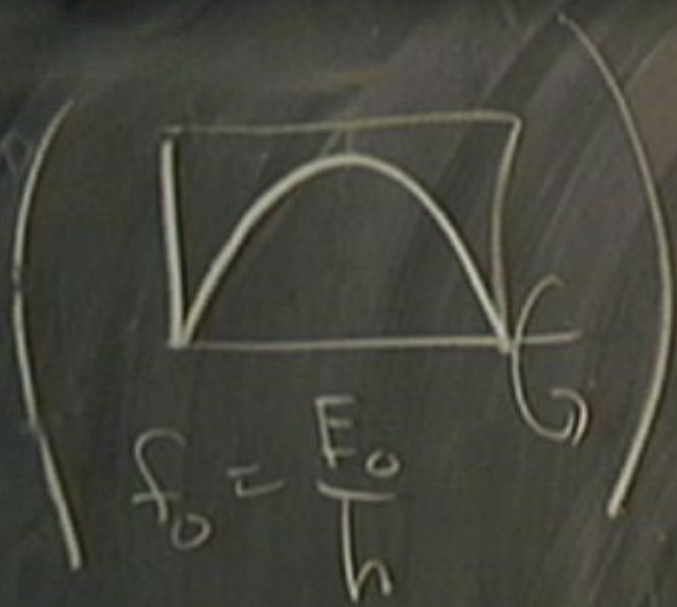
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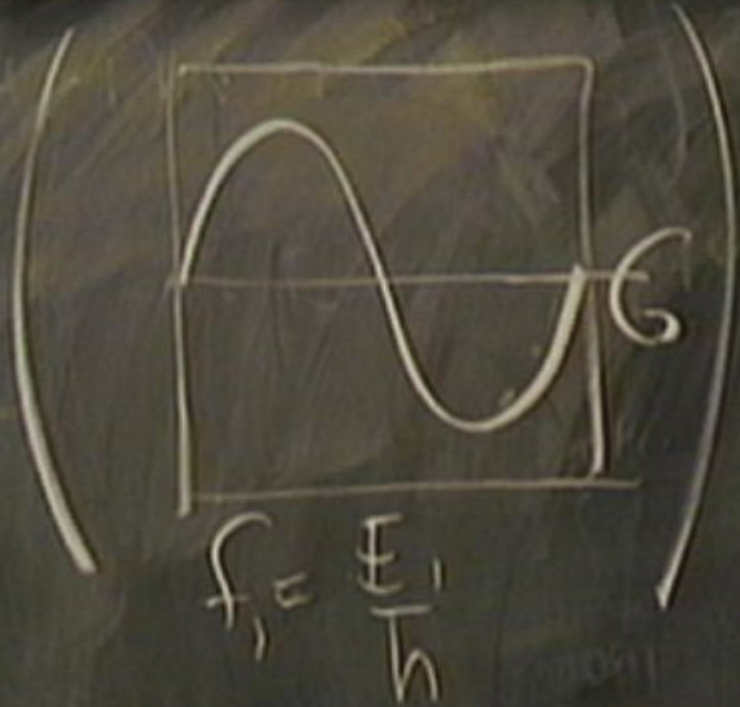


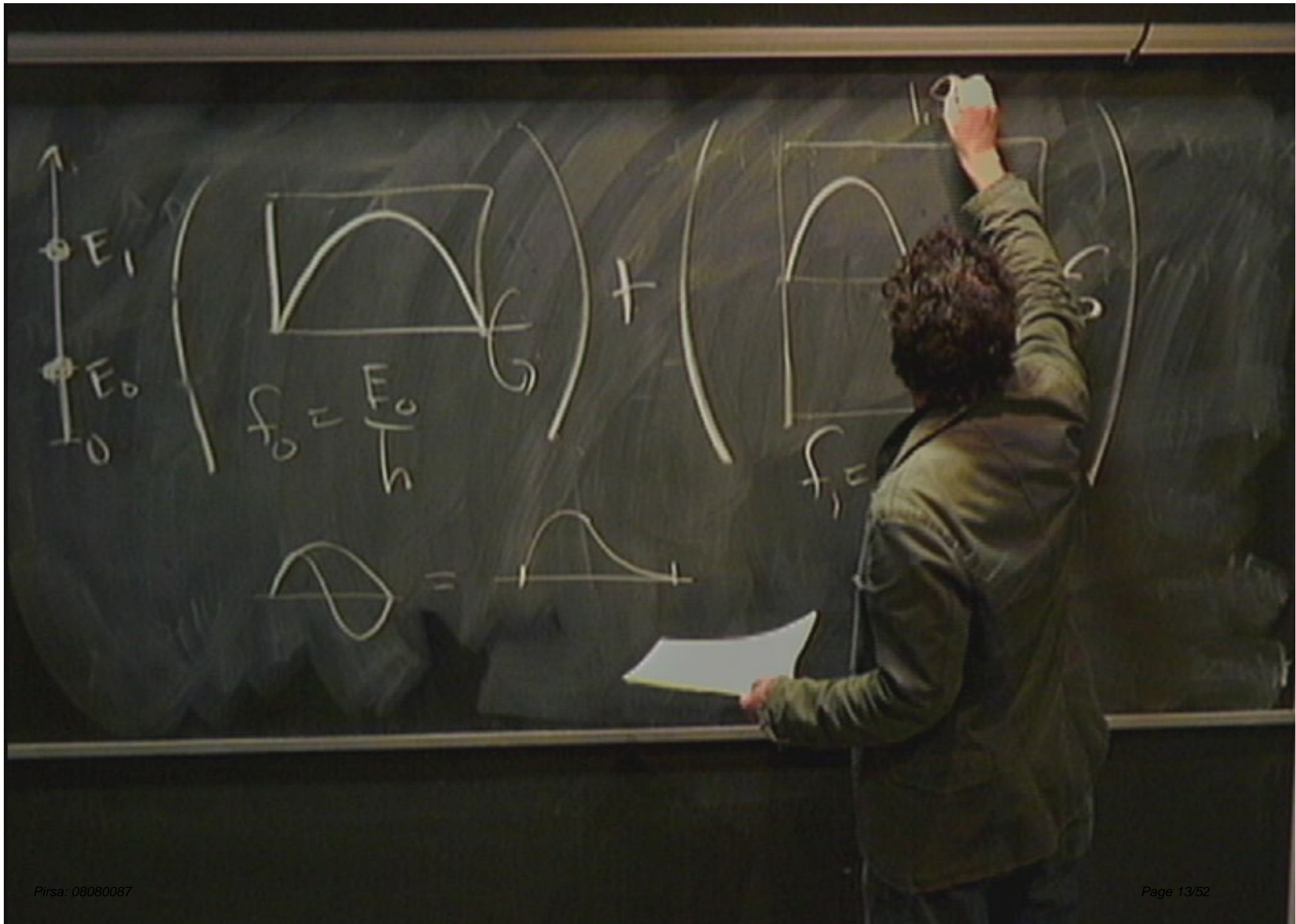
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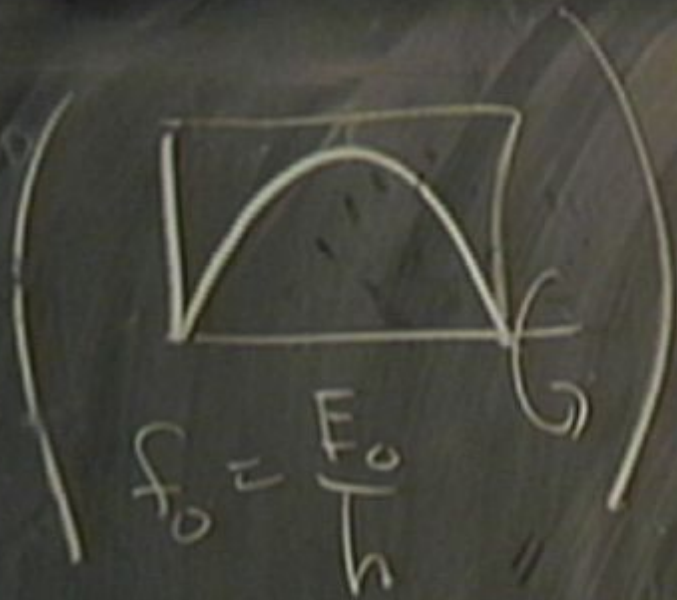




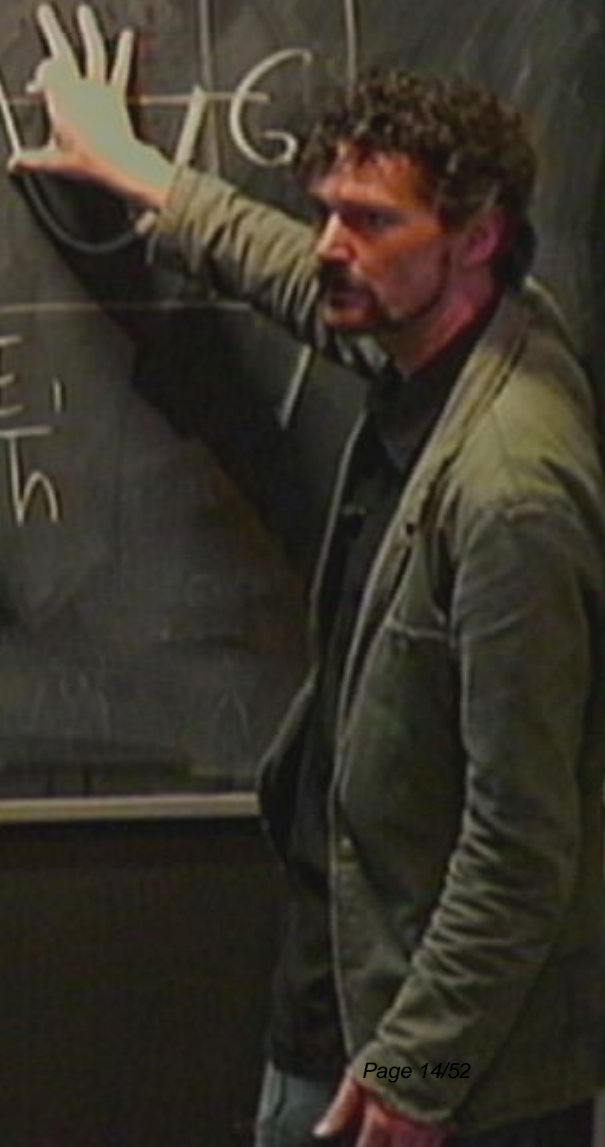
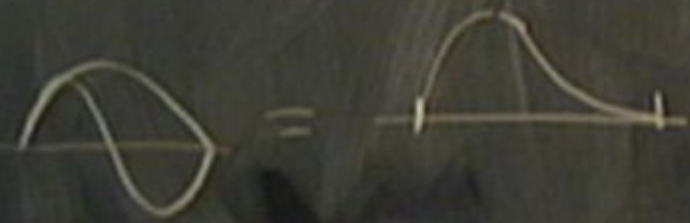
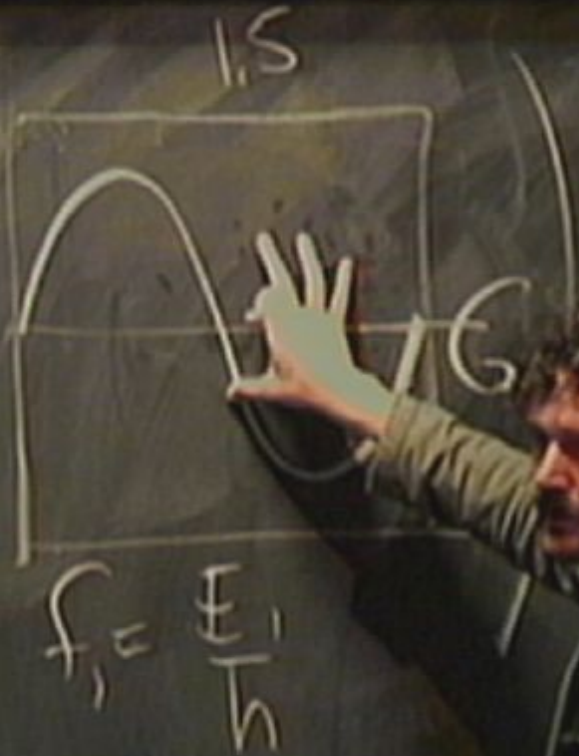
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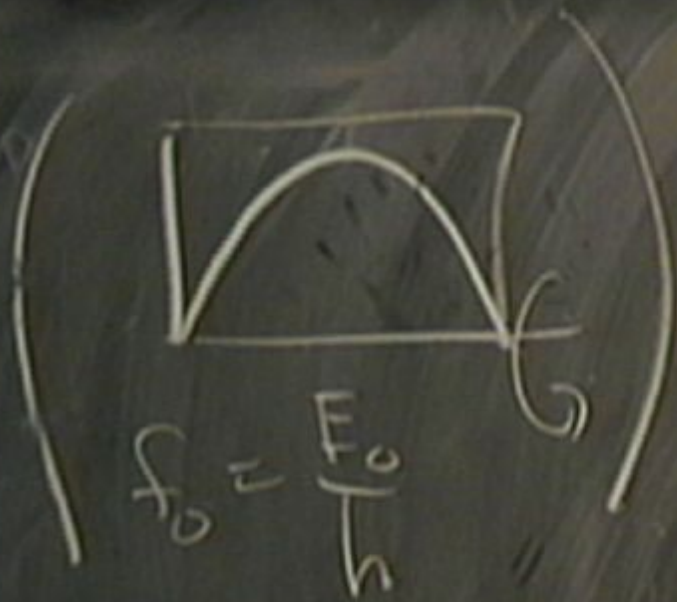




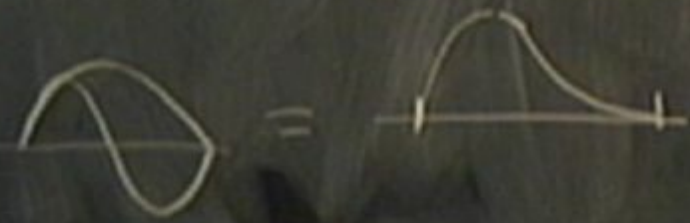
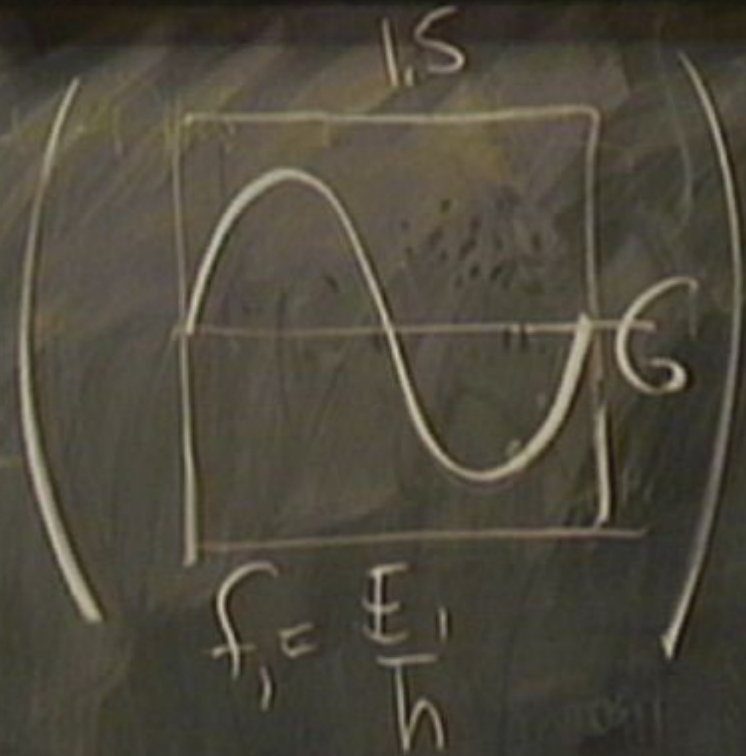


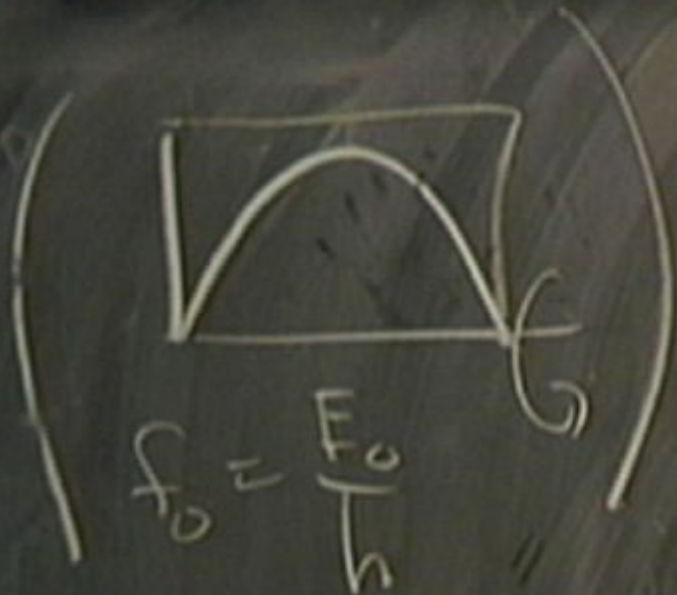
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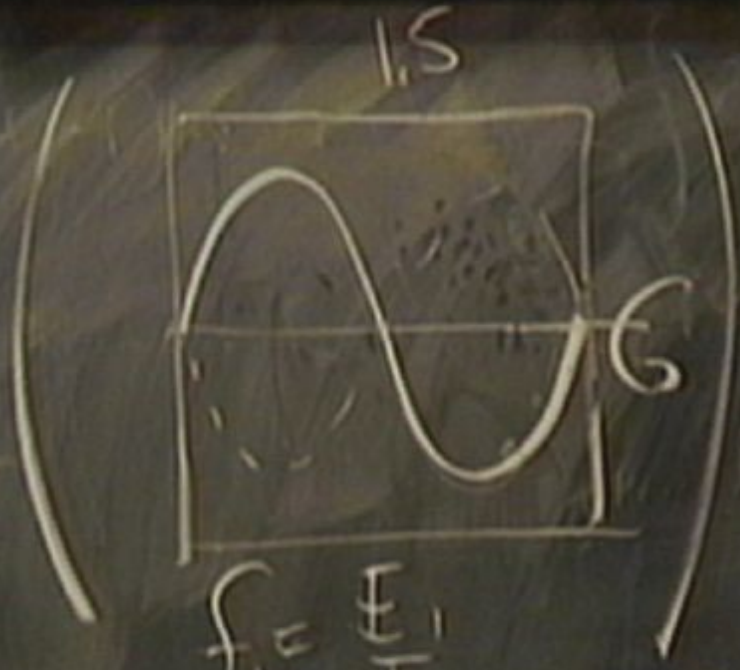
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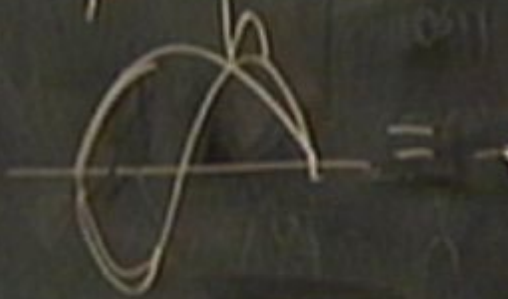


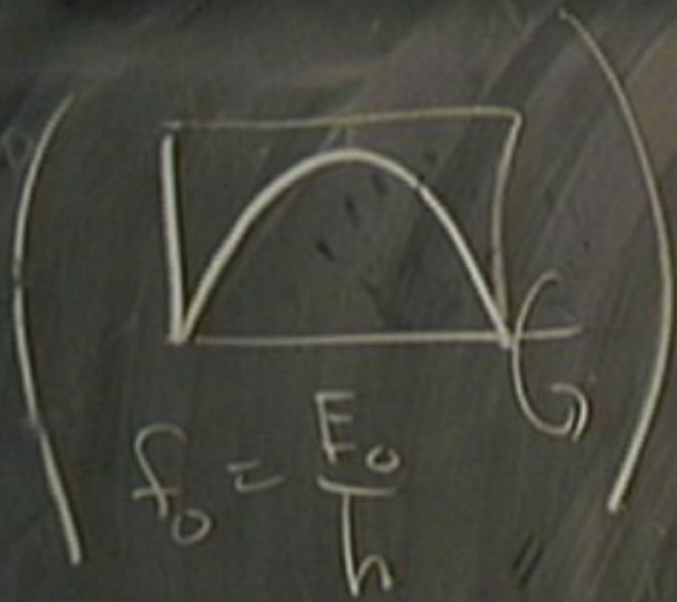
$$f_0 = \frac{E_1 - E_0}{h}$$

+

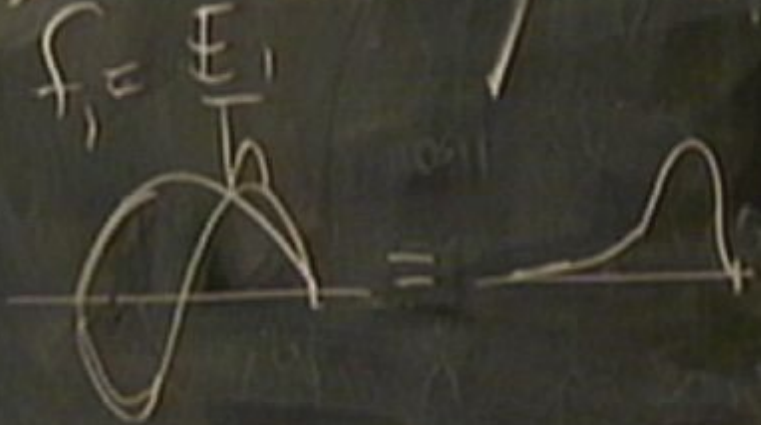
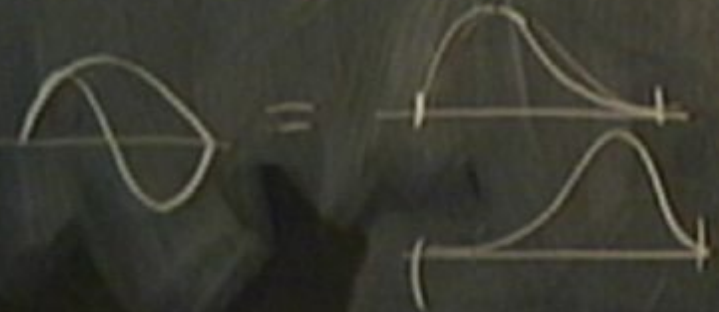
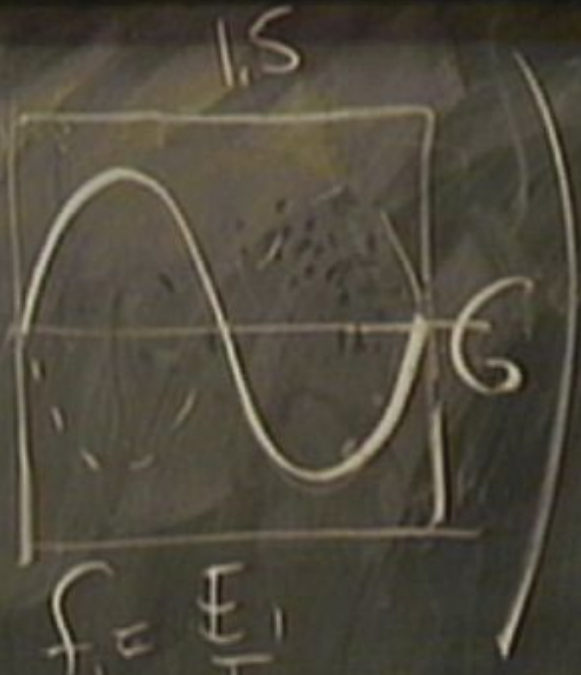


$$f_0 = \frac{E_1 - E_0}{h}$$





+



View

Setup: Infinite Well

Clear

Rescale Graphs

Stop Radiation

Reverse Phase

Stopped

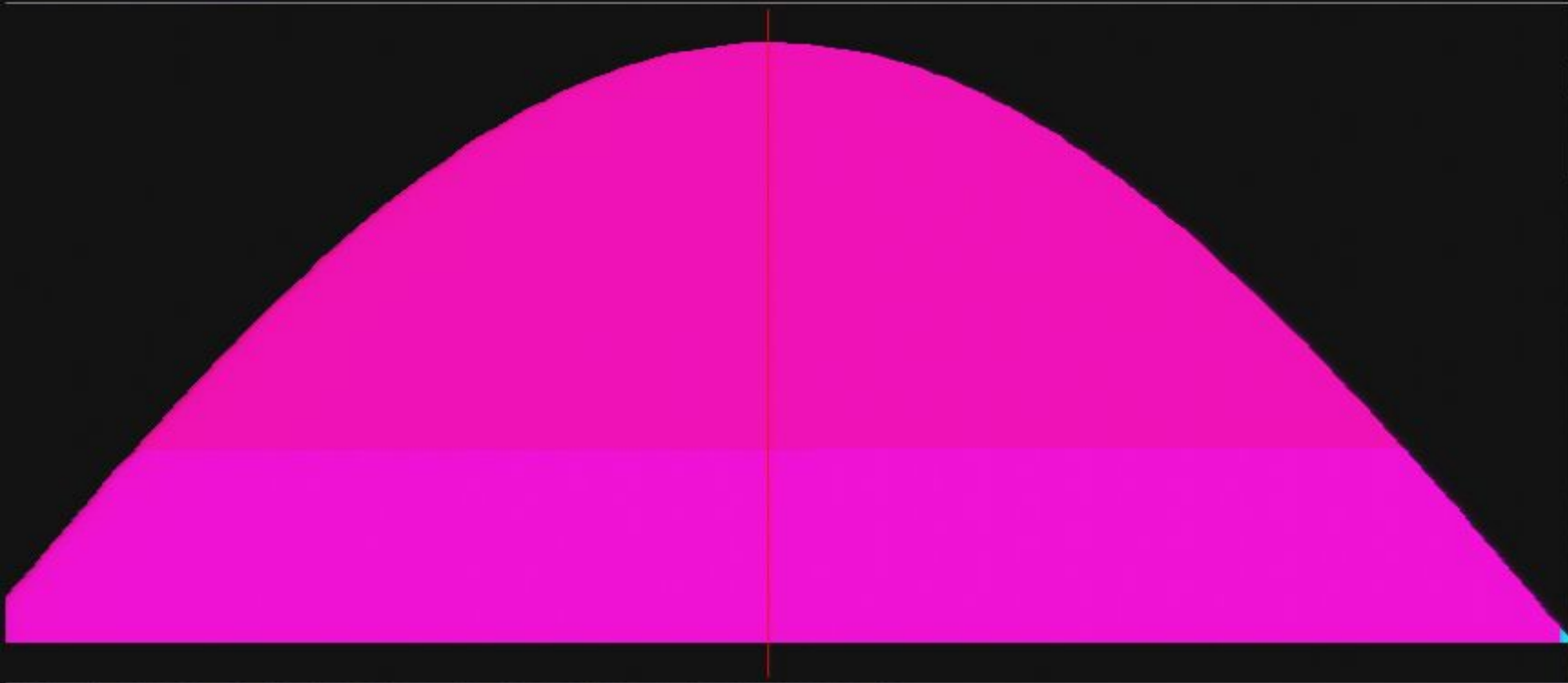
Simulation Speed

Radiation Intensity

Radiation Frequency

Resolution

Electric Field: Current:



View

Setup: Infinite Well

Clear

Rescale Graphs

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Stopped

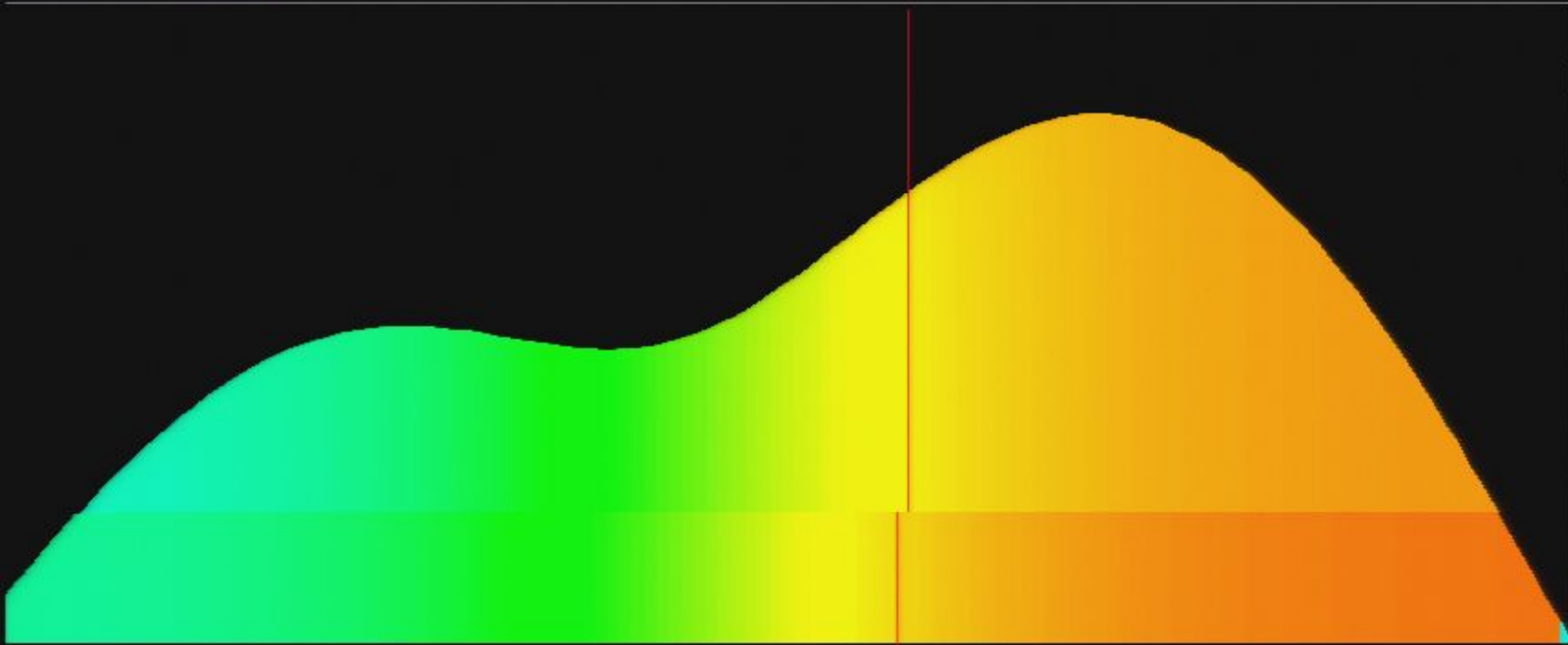
Simulation Speed

Radiation Intensity

Radiation Frequency

Resolution

Electric Field: Current ←



stationary states.



stationary states.



- View
 - ✓ Position
 - Momentum
 - Parity
 - Probability Current
 - ✓ Expectation Values
 - Uncertainties
 - Wave Function
 - Probability
 - Probability + Phase
 - Real + Imaginary Parts
 - ✓ Magnitude + Phase
- Electric Field: Current: ←

Setup: Infinite Well

Clear

Rescale Graphs

Stop Radiation

Reverse Phase

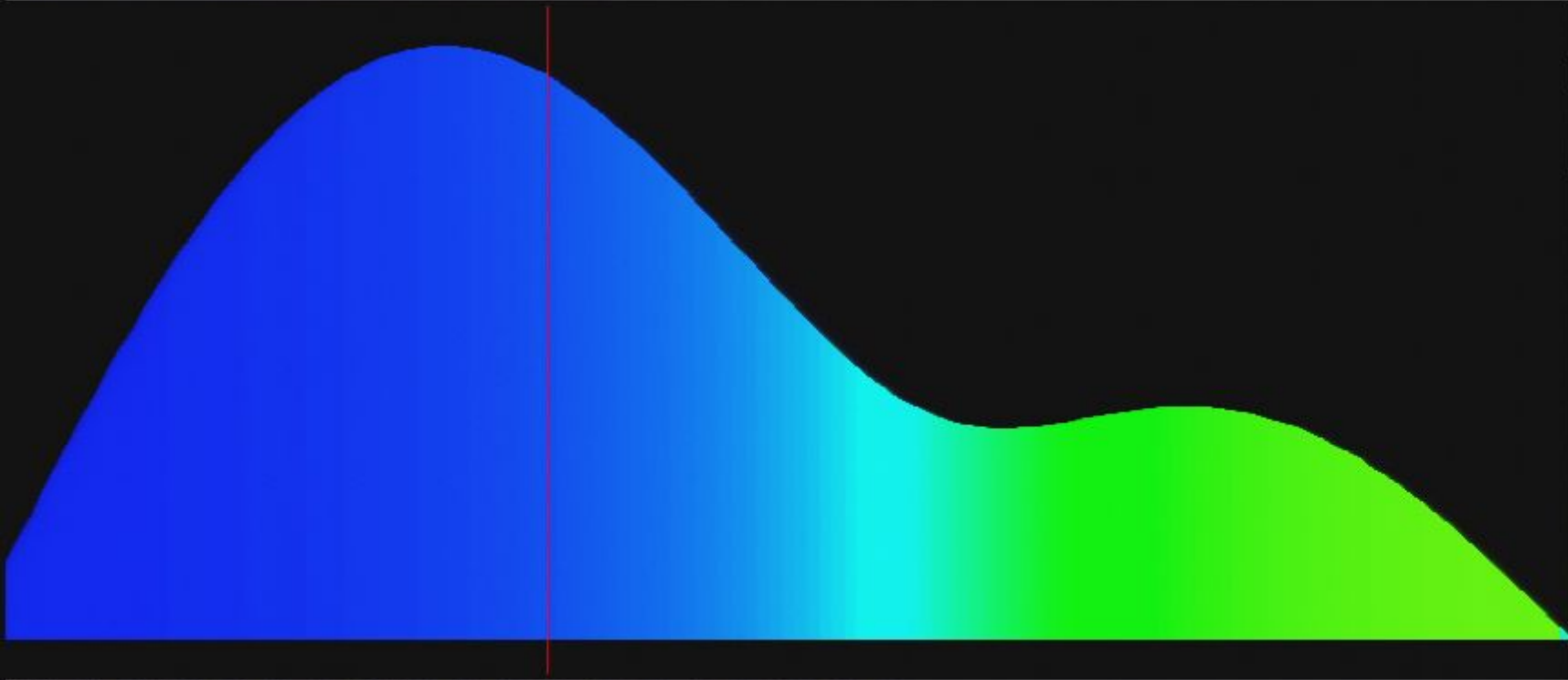
Stopped

Simulation Speed

Radiation Intensity

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Resolution



$\psi(x,t)$



stationary states.

gran

$$|\psi(x,t)|^2$$



stationary states.

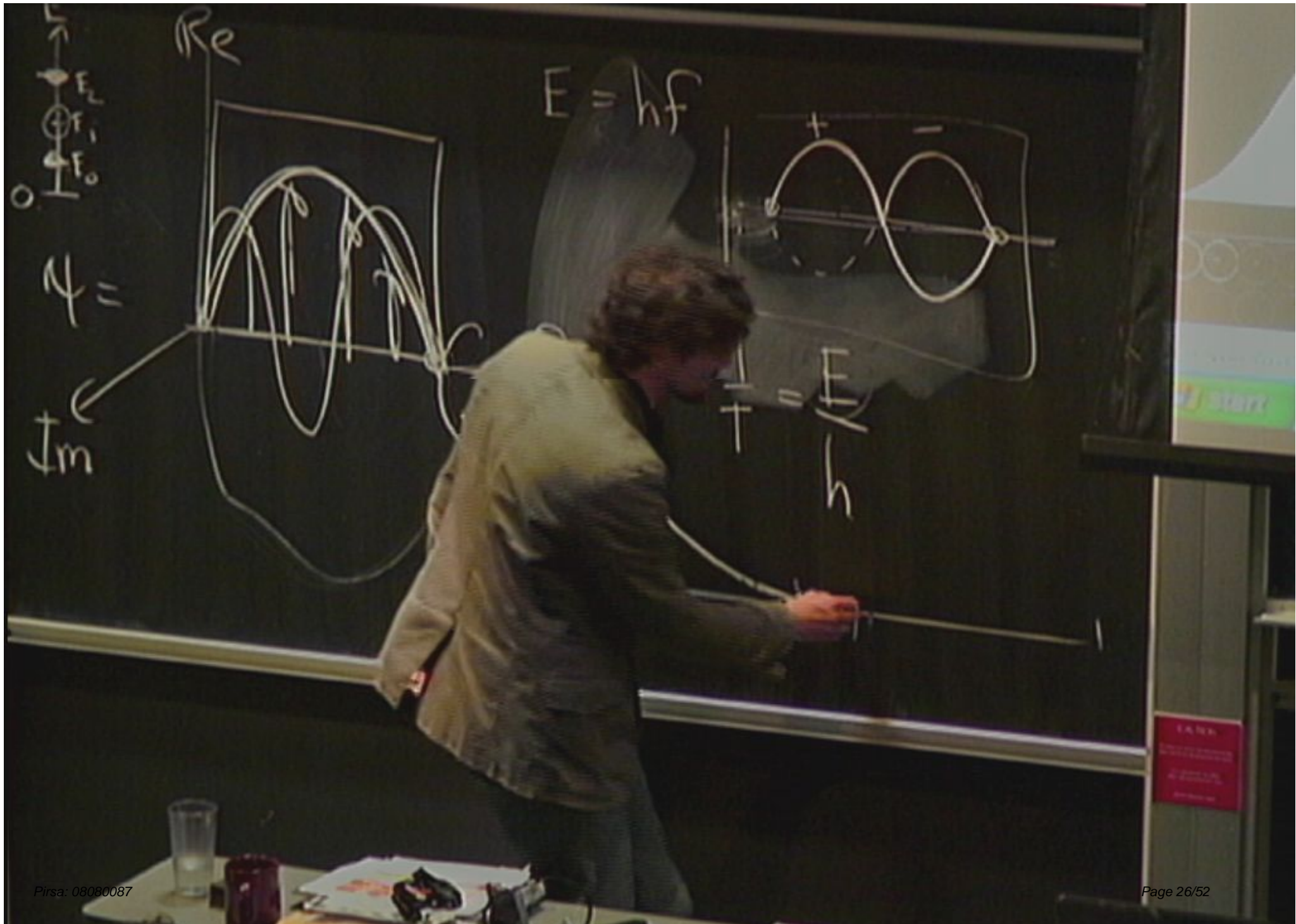


$$|\psi(x,t)|^2$$

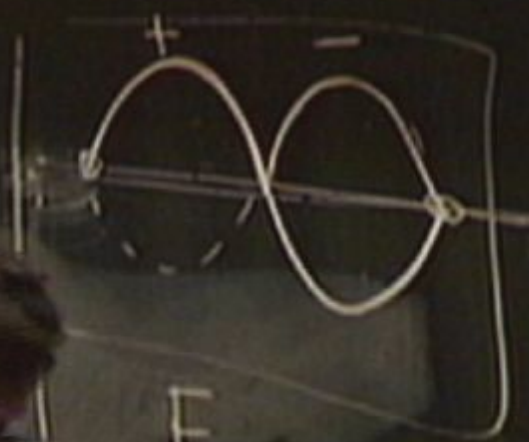


stationary states.





$$E = hf$$



$$\psi = A \sin(kx)$$

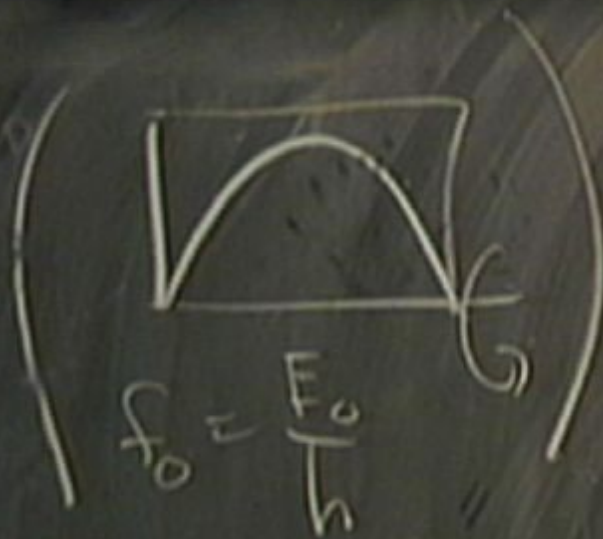
$E = hf$

$f_{\text{freq}} f = \frac{1}{T} = \frac{1}{\Delta t}$

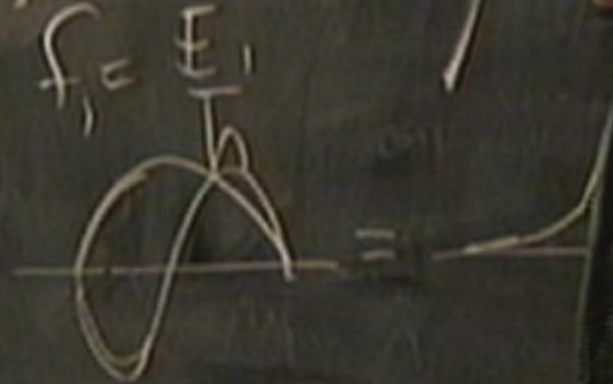
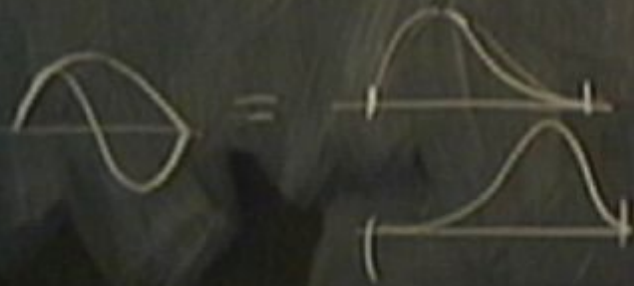
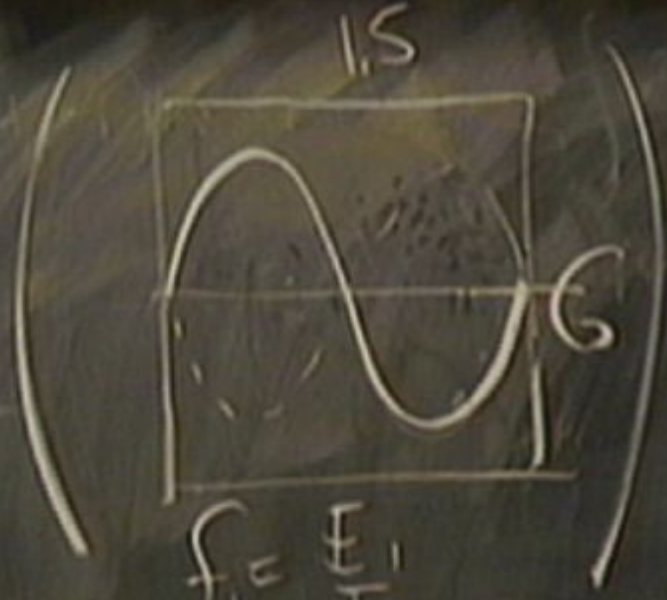
$\psi =$

Re

Im

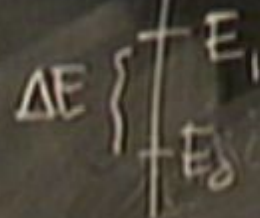


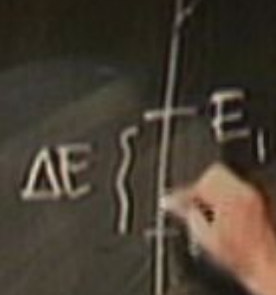
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$$f = f_1 - f_0$$

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



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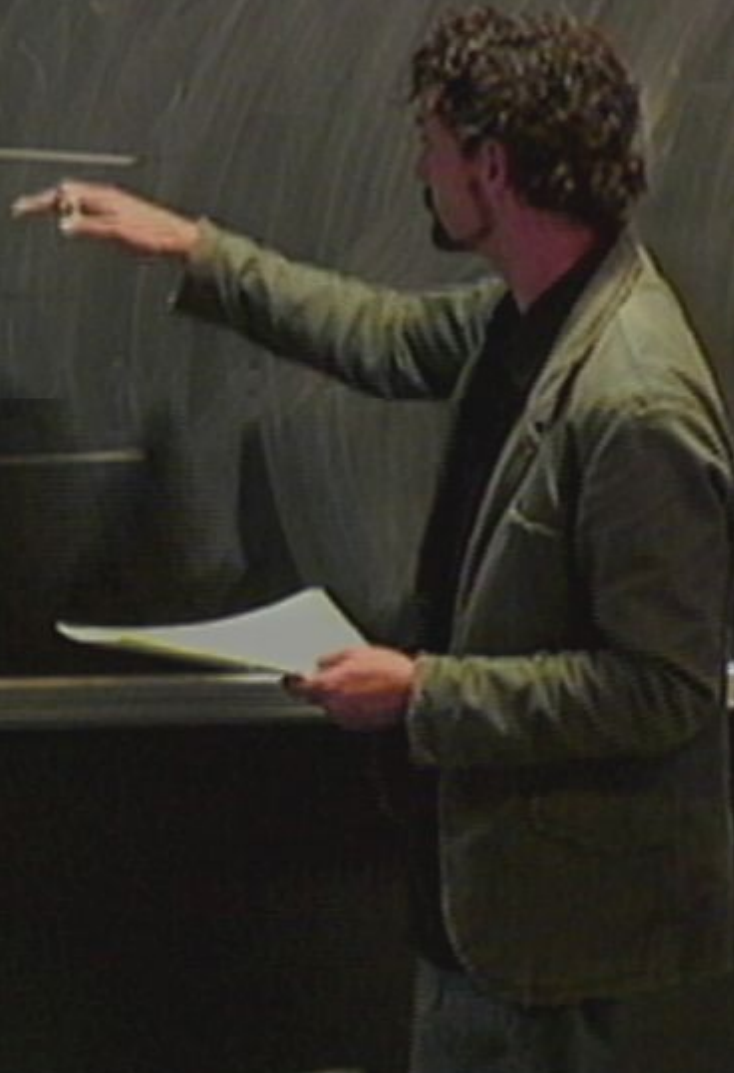
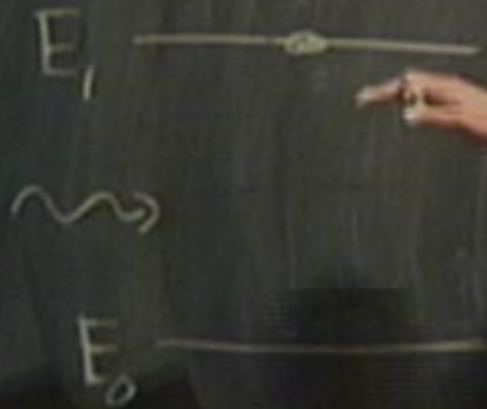
$$f = f_1 - f_0 = \frac{E_1}{h} - \frac{E_0}{h} = \frac{\Delta E}{h}$$



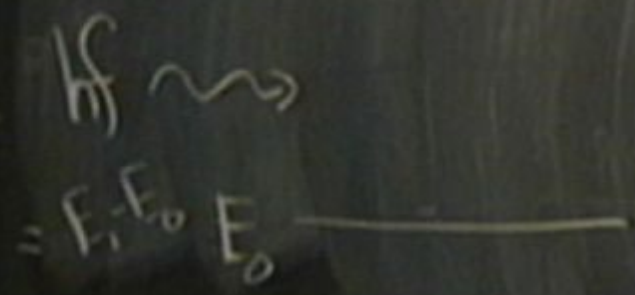
$$f = f_1 - f_0 = \frac{E_1}{h} - \frac{E_0}{h} = \frac{\Delta E}{h}$$



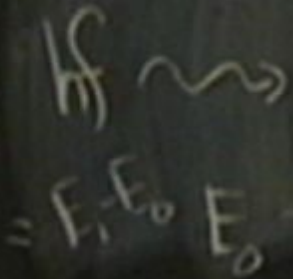
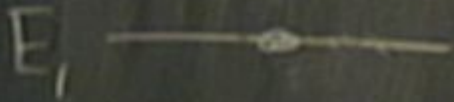
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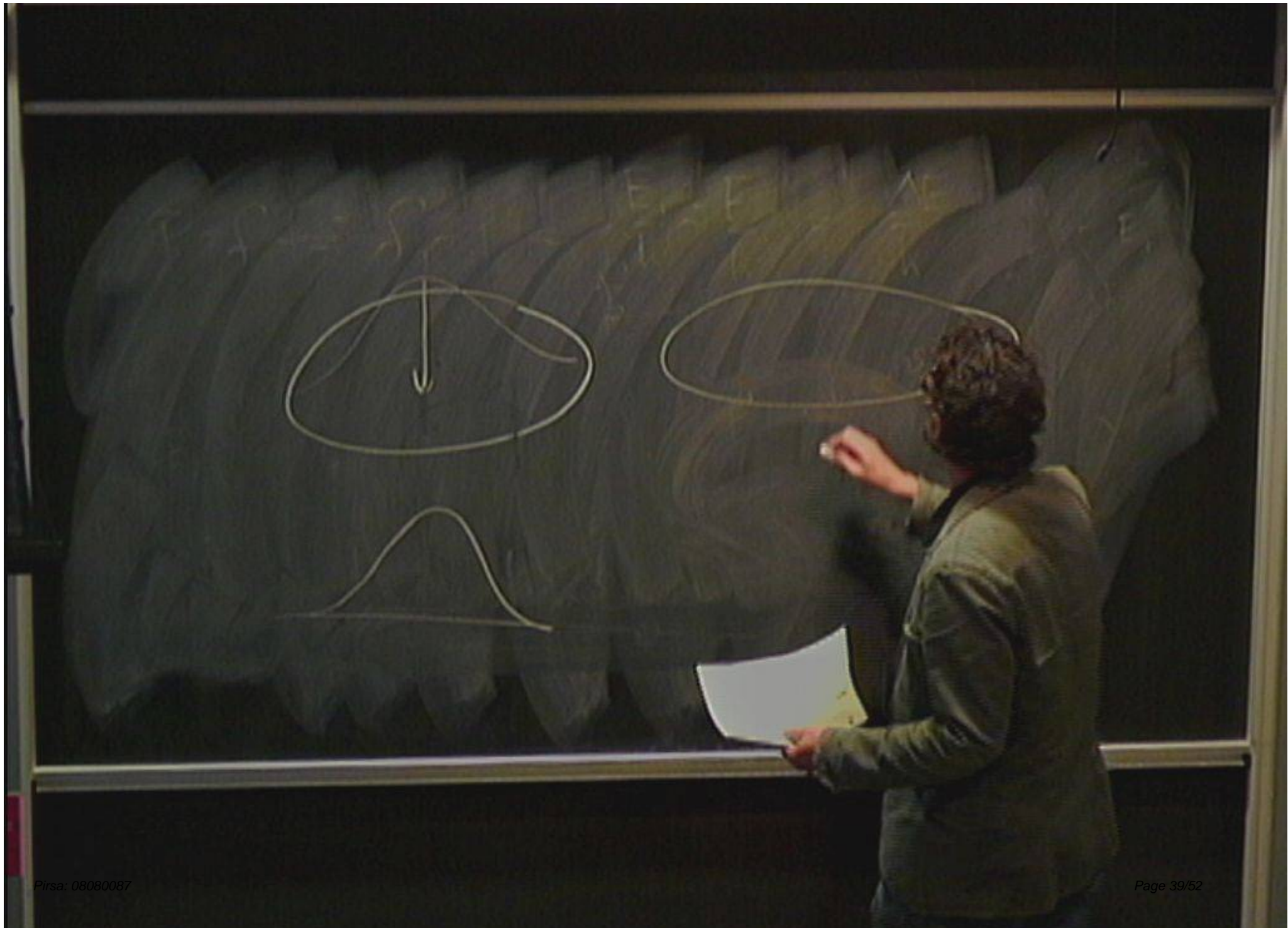
$$f = f_1 - f_0 = \frac{E_1}{h} - \frac{E_0}{h} = \frac{\Delta E}{h}$$



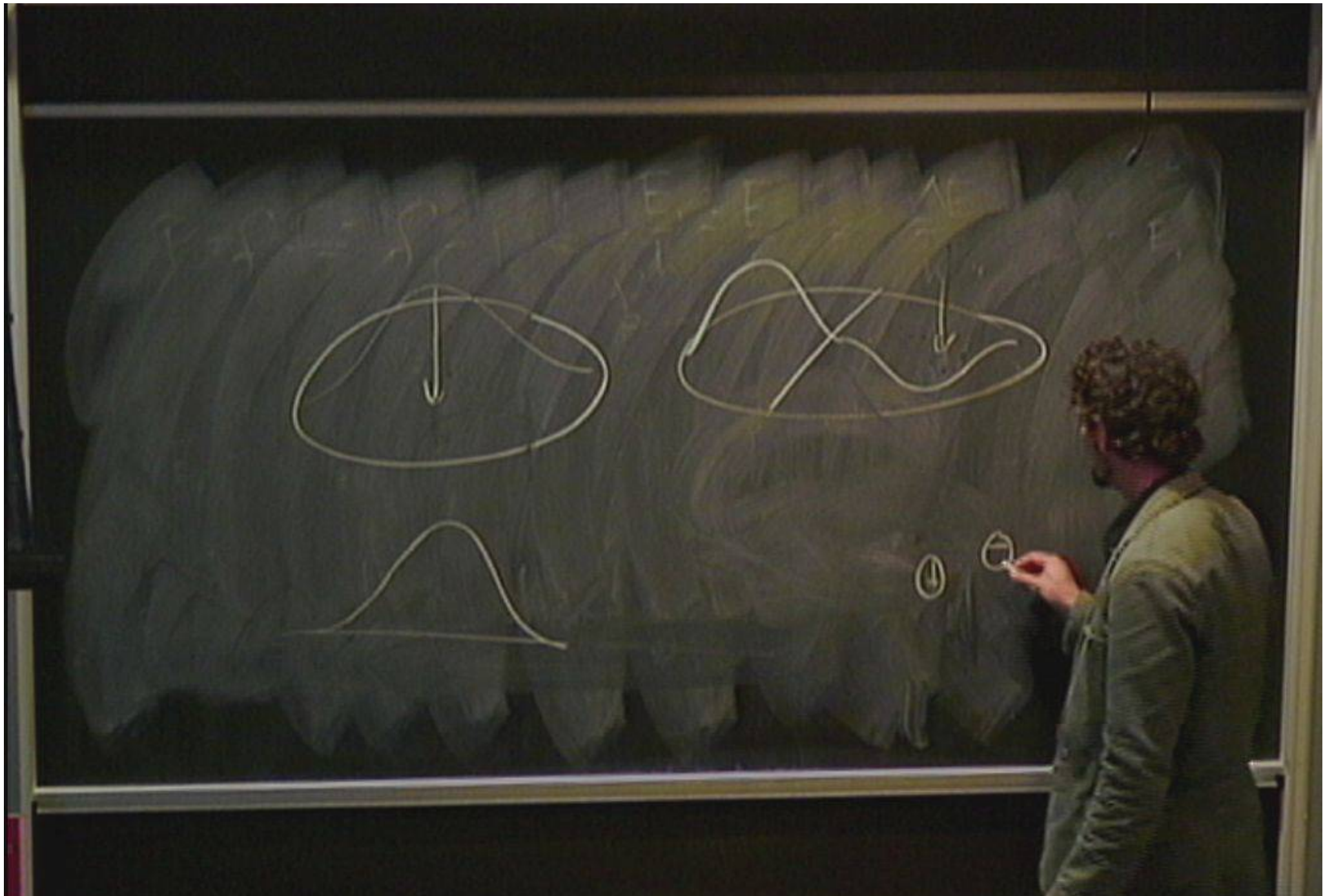
$$hf \rightsquigarrow E_1 - E_0$$

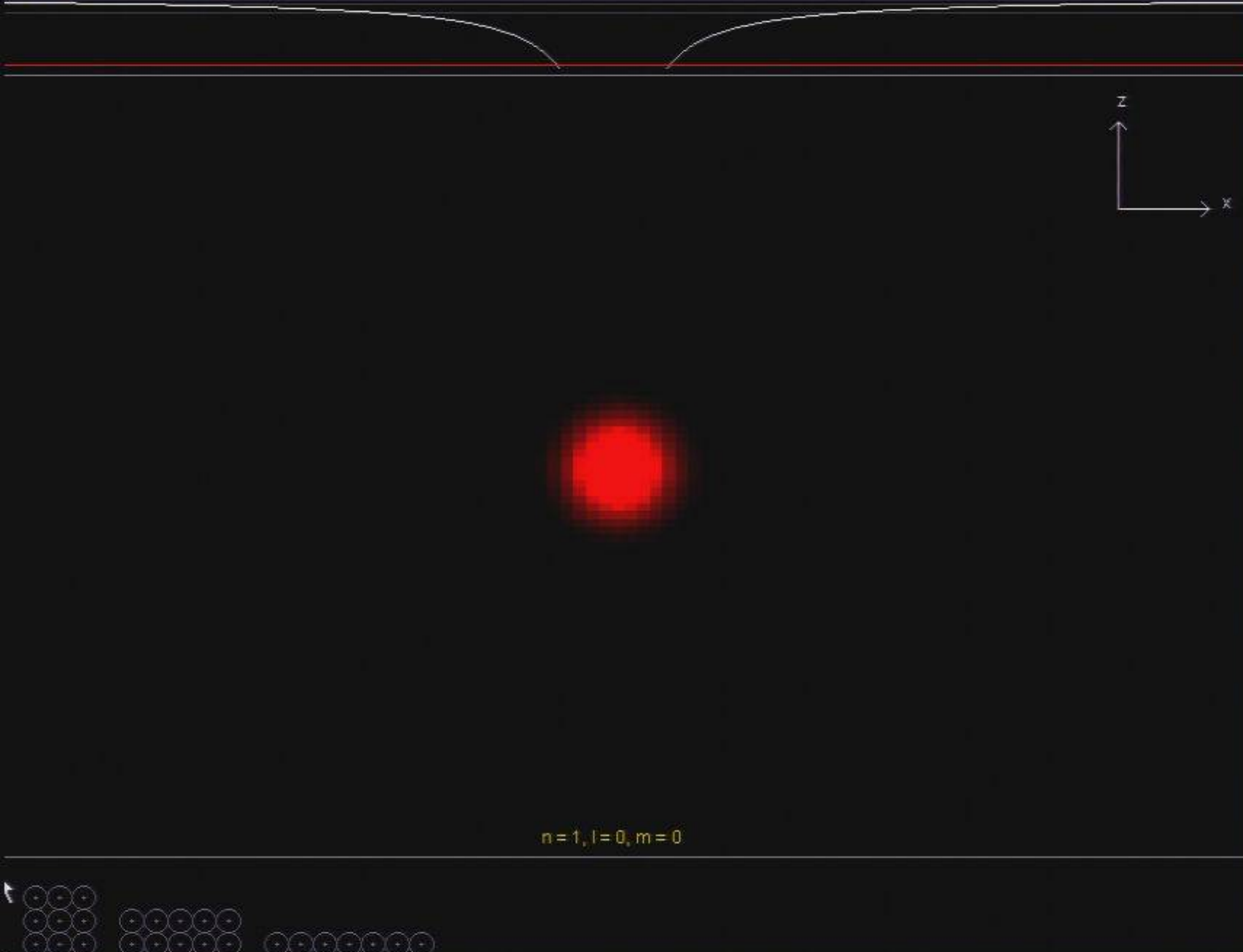










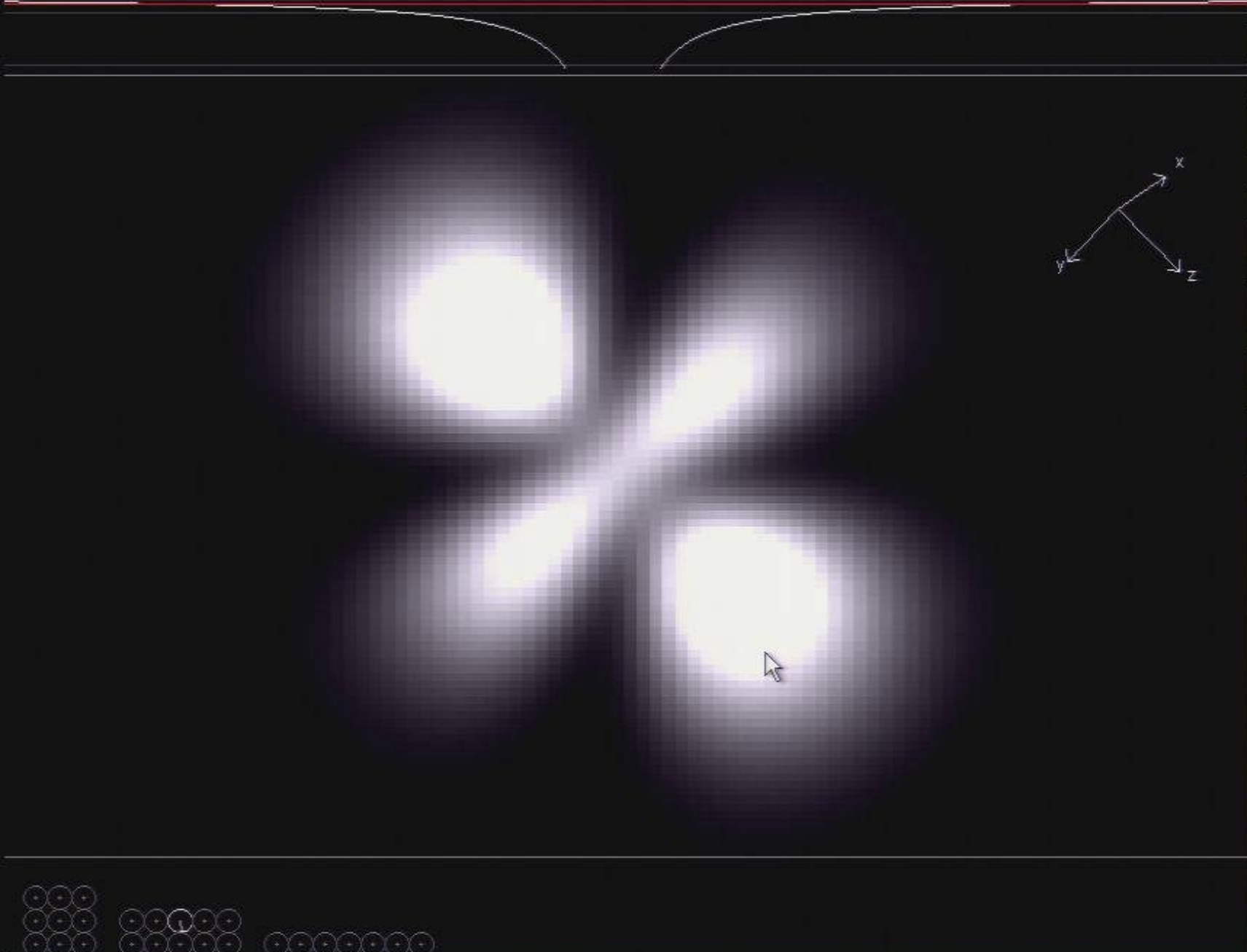


Complex Combos (n=1-4)
No Slicing
Mouse = Adjust View
 Stopped

Simulation Speed
Brightness
Image Resolution
Scale
<http://www.falstad.com>

$n = 1, l = 0, m = 0$





Complex Combos (n=1-4)

No Slicing

Mouse = Adjust View

Stopped

Simulation Speed

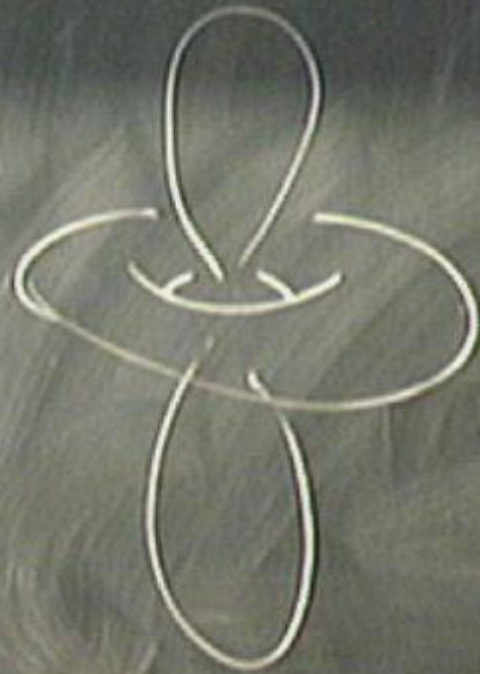
Brightness

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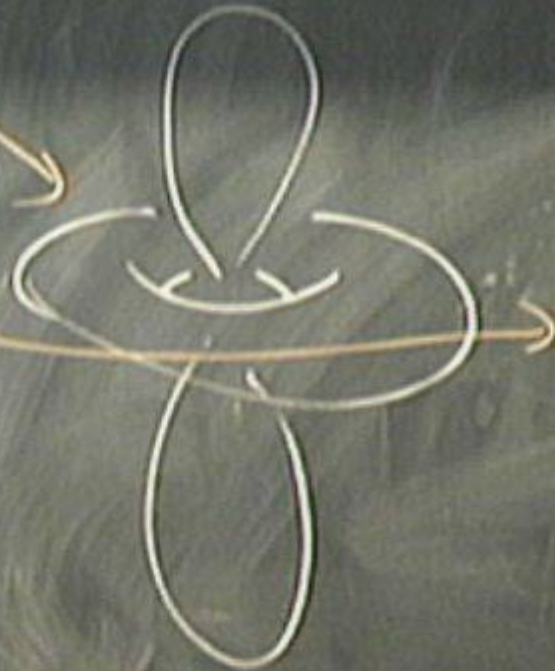


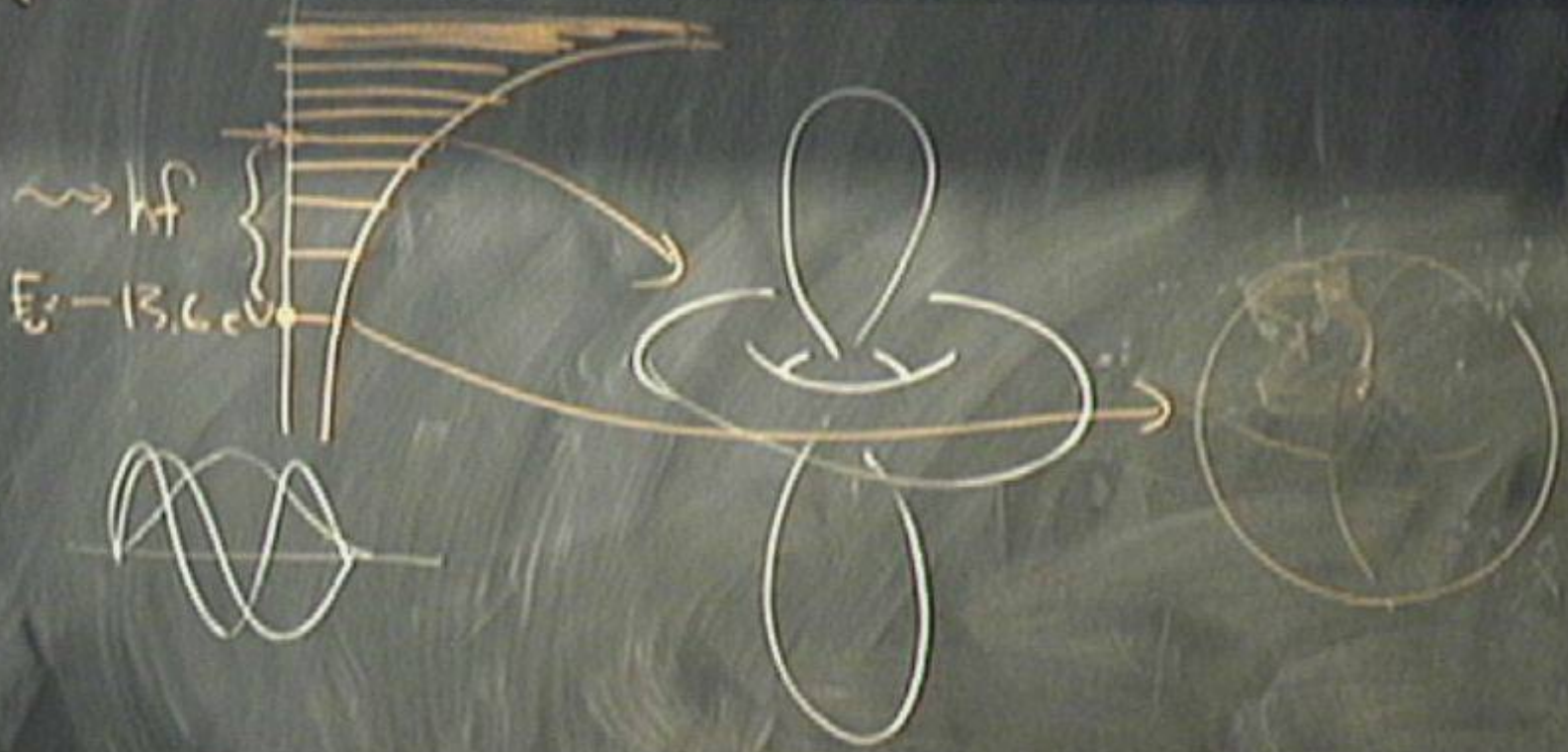


$$E_2 = 13.6 \text{ eV}$$



$$E_2 = 13.6 \text{ eV}$$





- ✓ Energy
- ✓ Position
- Angular Momentum
- Angular Momentum²
- Radial Distribution
- ✓ Phase as Color

Complex Combos (n=1-4)

No Slicing

Mouse = Adjust View

Stopped

Clear

Normalize

Maximize

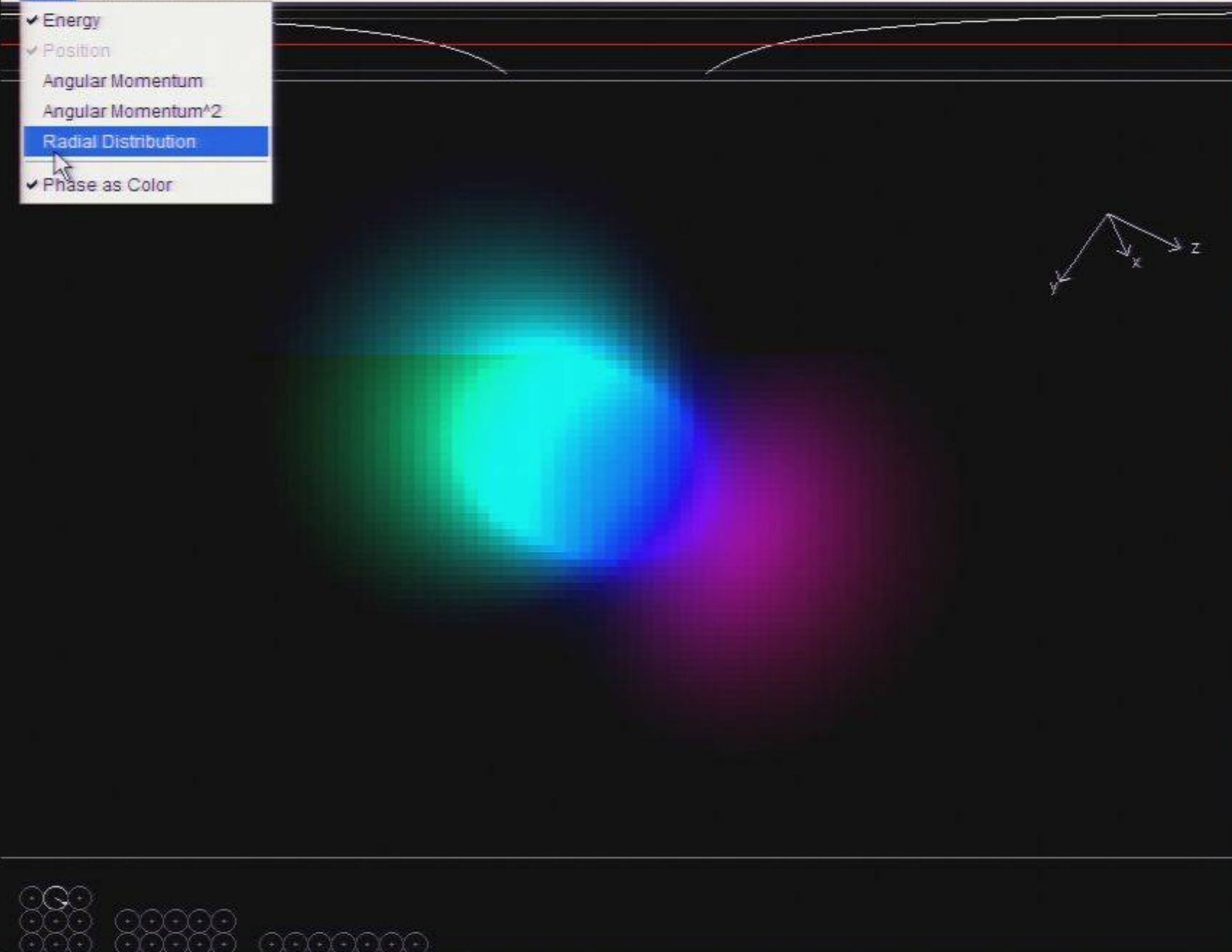
Simulation Speed

Brightness

Image Resolution

Scale

<http://www.falstad.com>





Complex Combos (n=1-4)

No Slicing

Mouse = Adjust View

Stopped

Simulation Speed

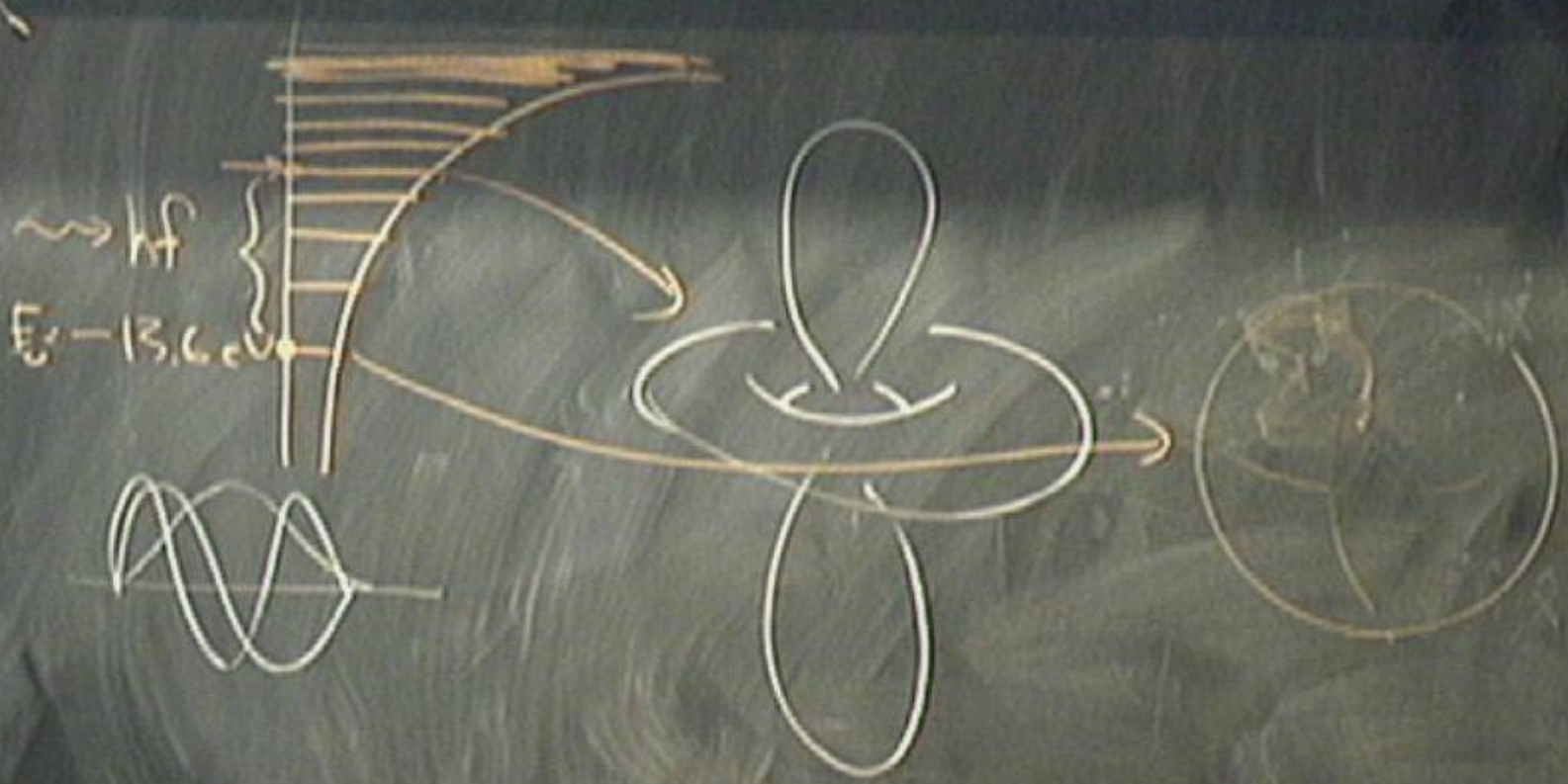
Brightness

Image Resolution

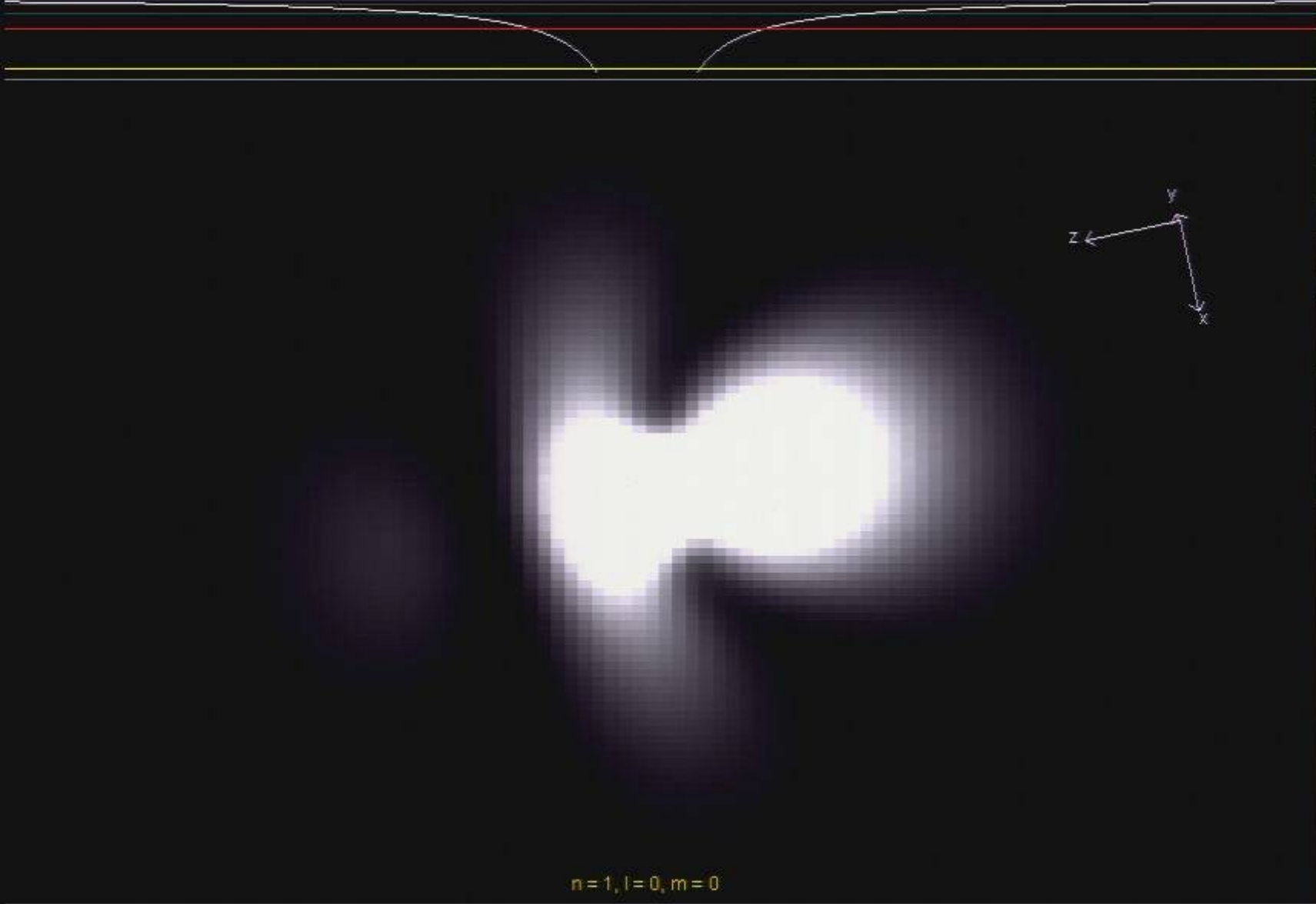
Scale

<http://www.falstad.com>









Complex Combos (n=1-4)
No Slicing
Mouse = Adjust View
 Stopped

Simulation Speed

Brightness

Image Resolution

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