Mon 5/6 Physics 132 Prof. W. Losert

Outline

Models of Light: Waves

Office Hours (in course center):

Friday 5/10 2-3pm review questions

3-4pm office hours

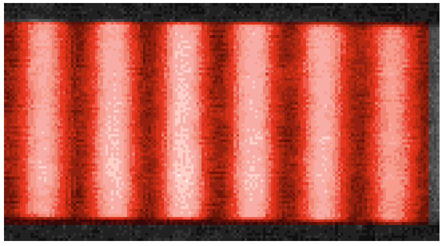
- evalUM (Campus Survey)
  - Donuts if at least 9 of you do it!
- MPEX -> email today
- Surveys in recitation/lab tomorrow
- One page to read for Wed (Fluorescence)
- Practice problems and review slides will be posted by Wednesday

Office Hours (in course center):

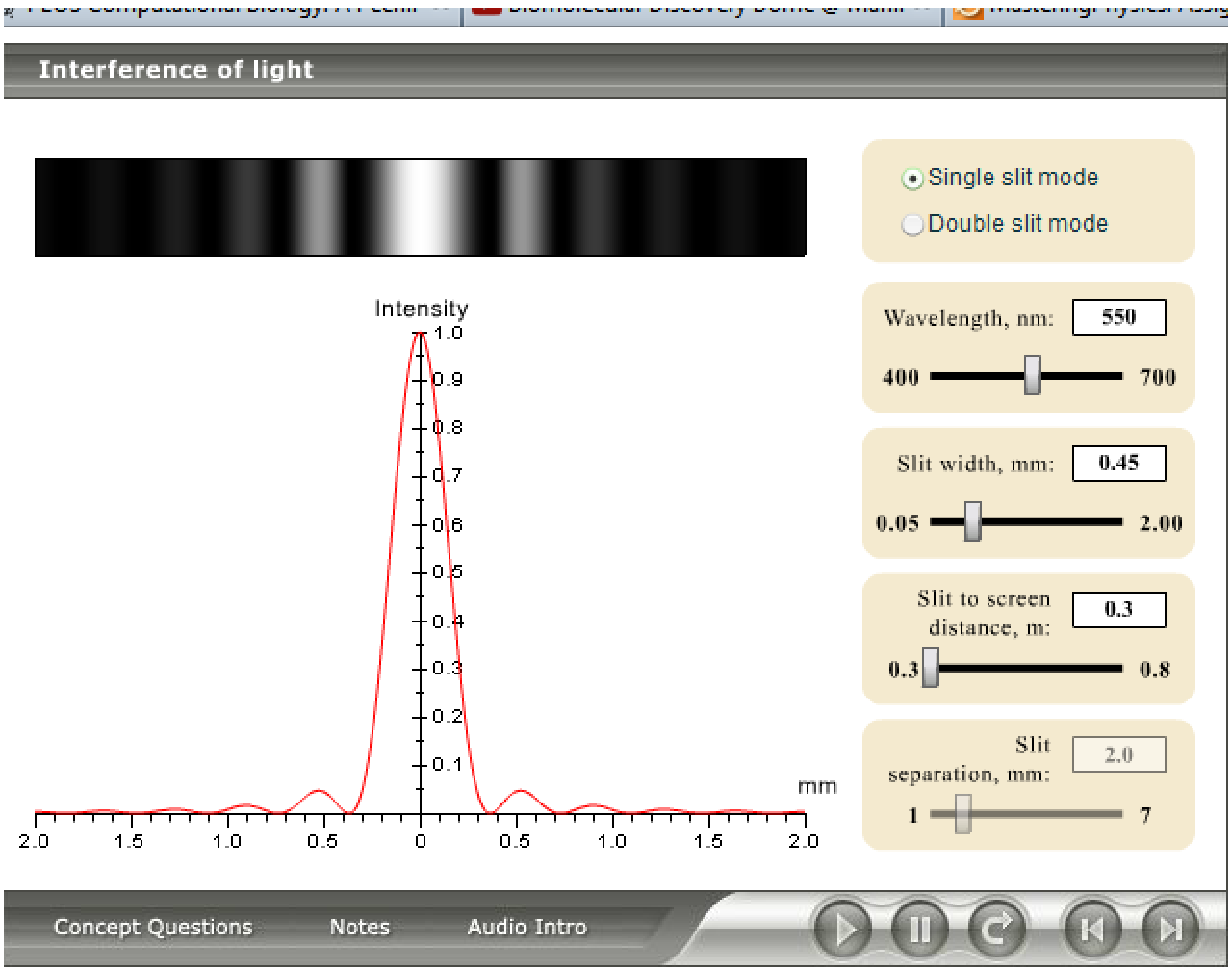
Friday	5/10	2-3pm	review questions
		3-4pm	office hours
Monday	5/13	2.30-4pm	office hours

Go over quiz

When a laser is shone upon a double slit, a closeup of the center of the pattern looks like the figure at the right. If one of the slits is covered (the left one) but the other slit remains open, what will this part of the pattern look like?

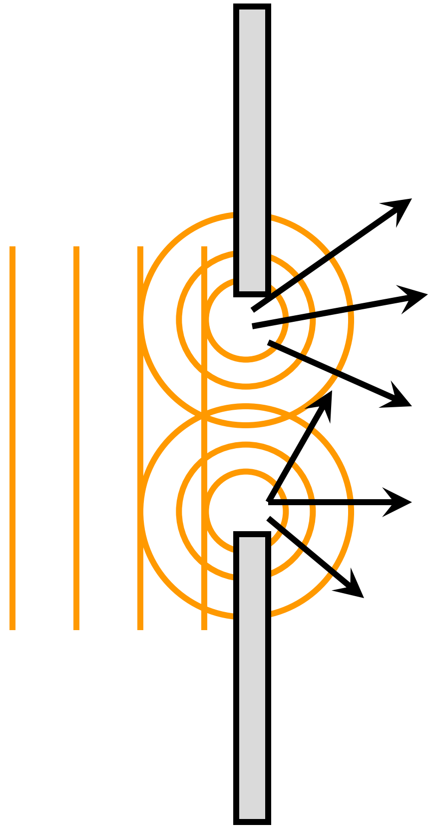


1. The same.
2. The left side will be dark.
3. The right side will be dark.
4. The whole thing will be bright.
5. The whole thing will be bright except for two dark bands at either side.
6. Something else.

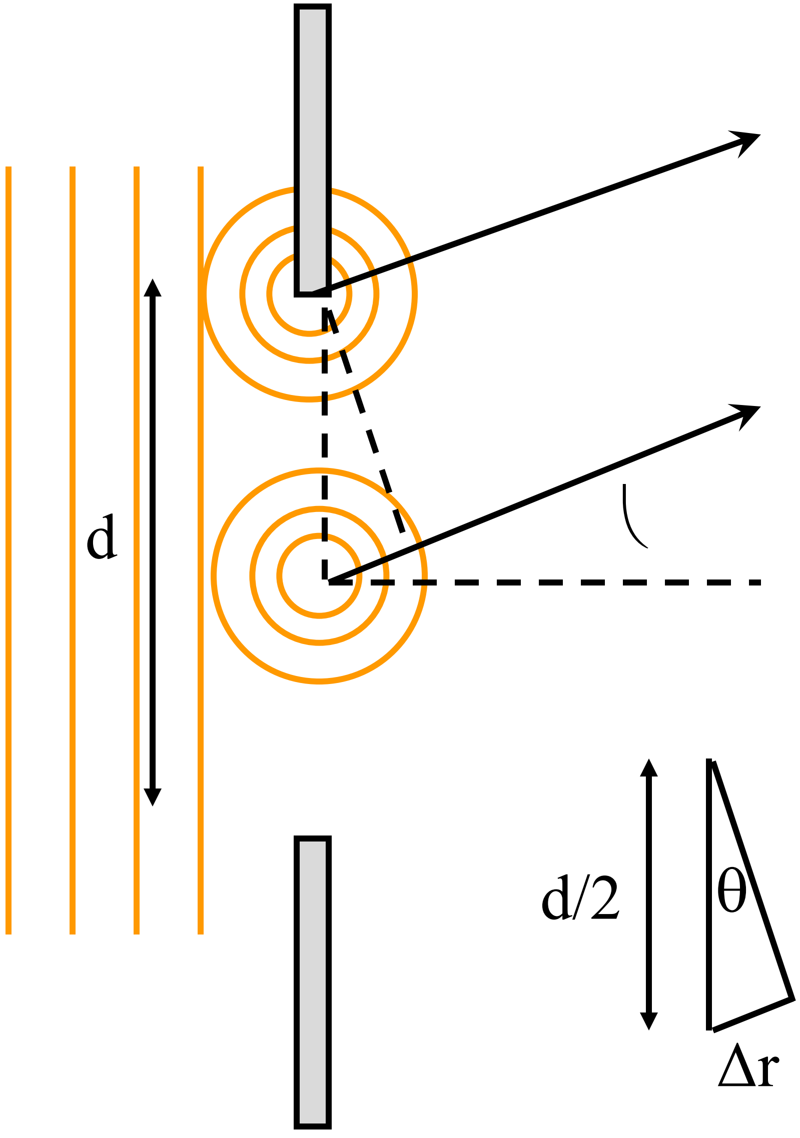


http://www.wiley.com/college/halliday/0470469080/simulations/sim48/sim48.html

Diffraction

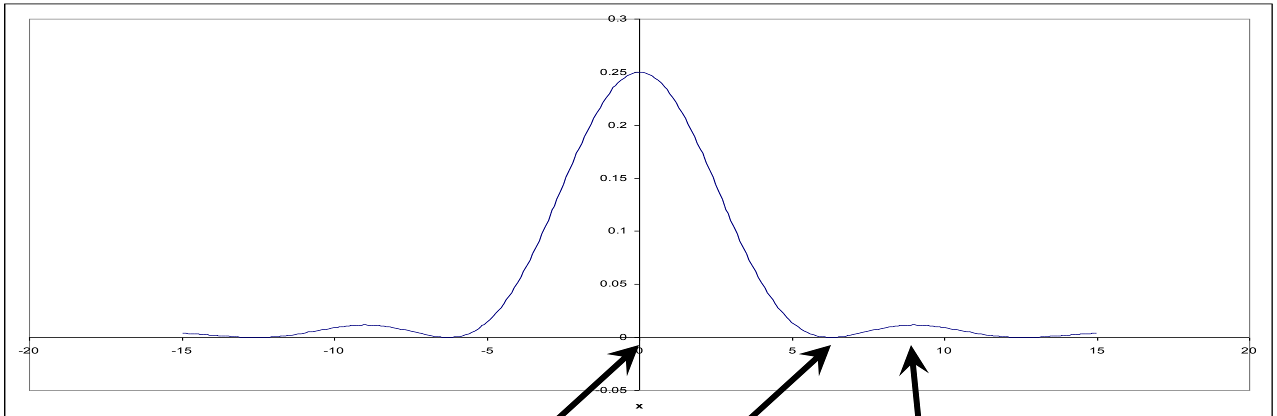


- Every bit of the interior of the slit acts as a source of outgoing spherical Huygens' wavelets.
- The outgoing wavelets from one part of the slit can interferer with the wavelets from another part of the slit.

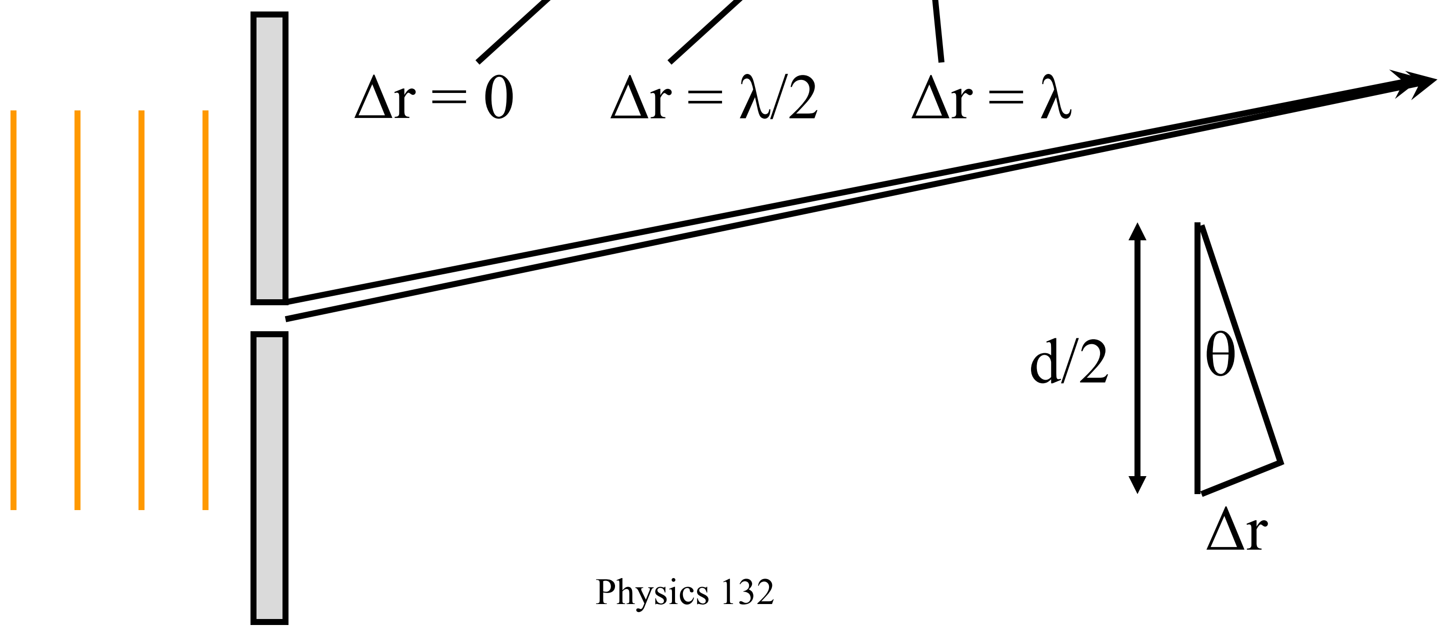


When the distance traveled by the wavelet from the middle of the slit is half a wavelength greater than the distance traveled by the wavelet from the top of the slit every wavelet from the top half of the slit has a canceling wavelet from the bottom half of the slit.

The result is no intensity at that angle.



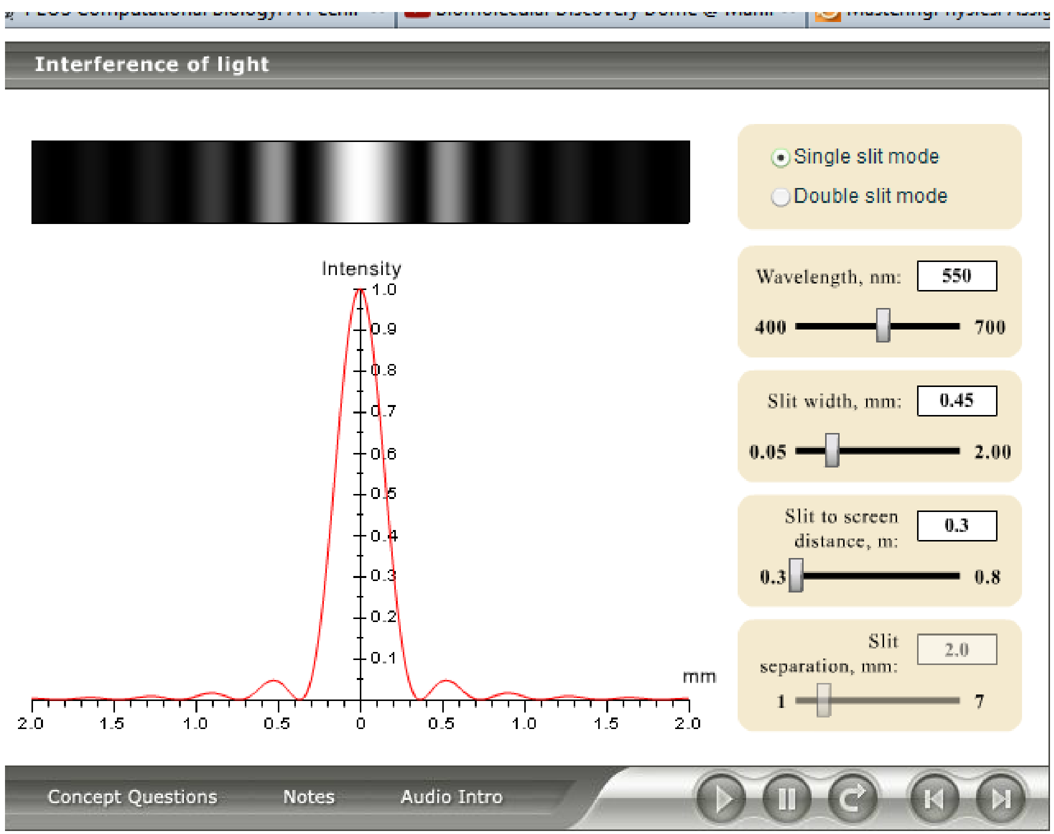
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-20
-15
-10
-5
0
5
10
15
20
x



Δr = 0
Δr = λ/2
Δr = λ
d/2
θ
Δr

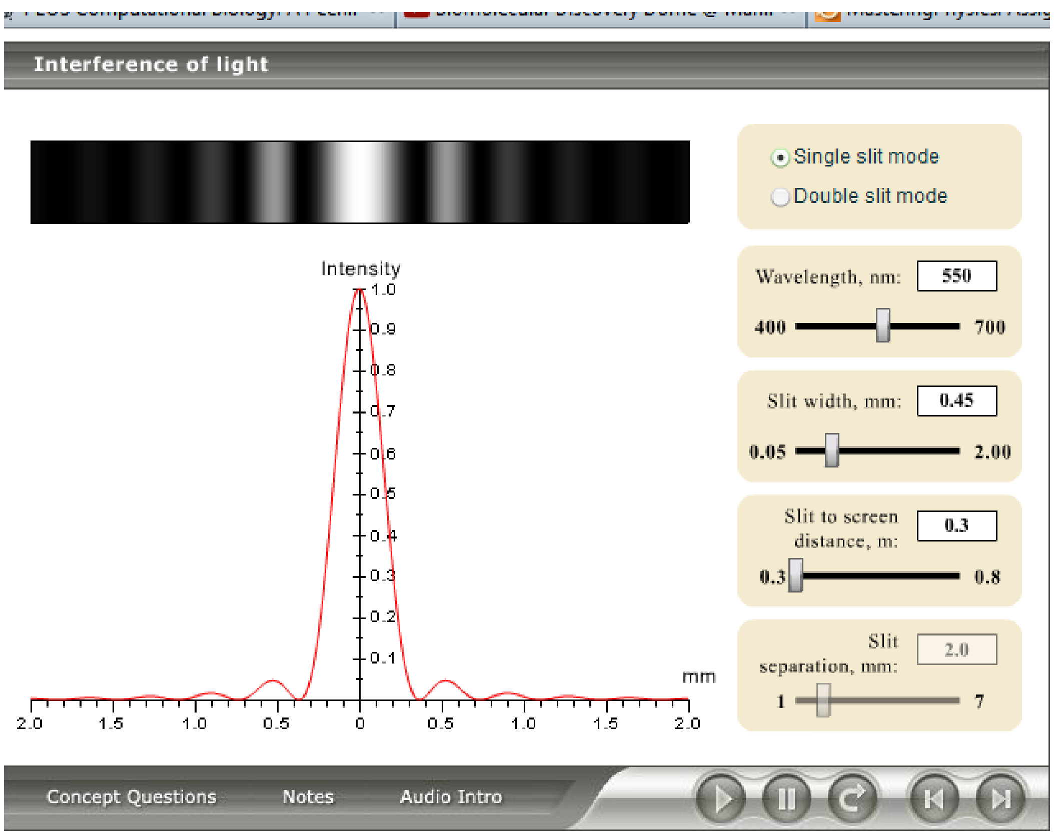
If I make the wavelength longer what will happen to the pattern?

1. Get wider
2. Get narrower
3. Stay the same
4. Something else



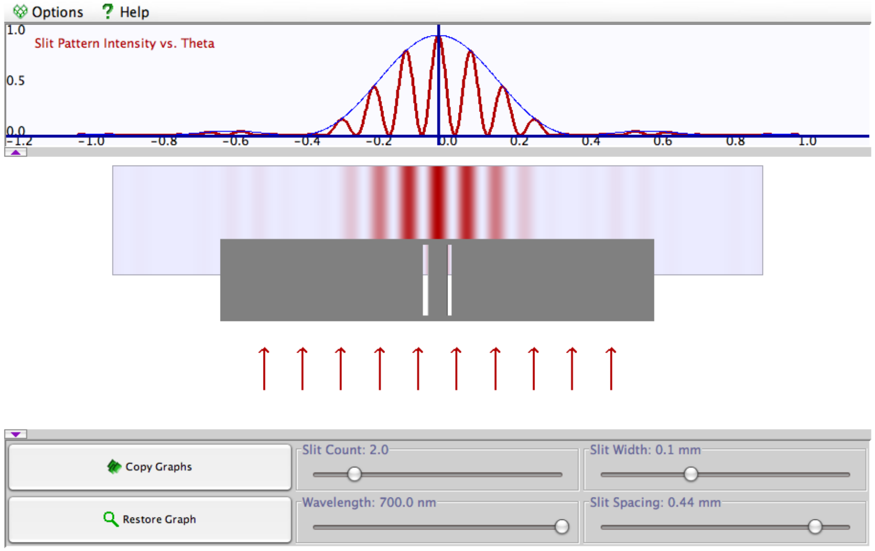
If I make the slit wider
what will happen to the pattern?

1. Get wider
2. Get narrower
3. Stay the same
4. Something else



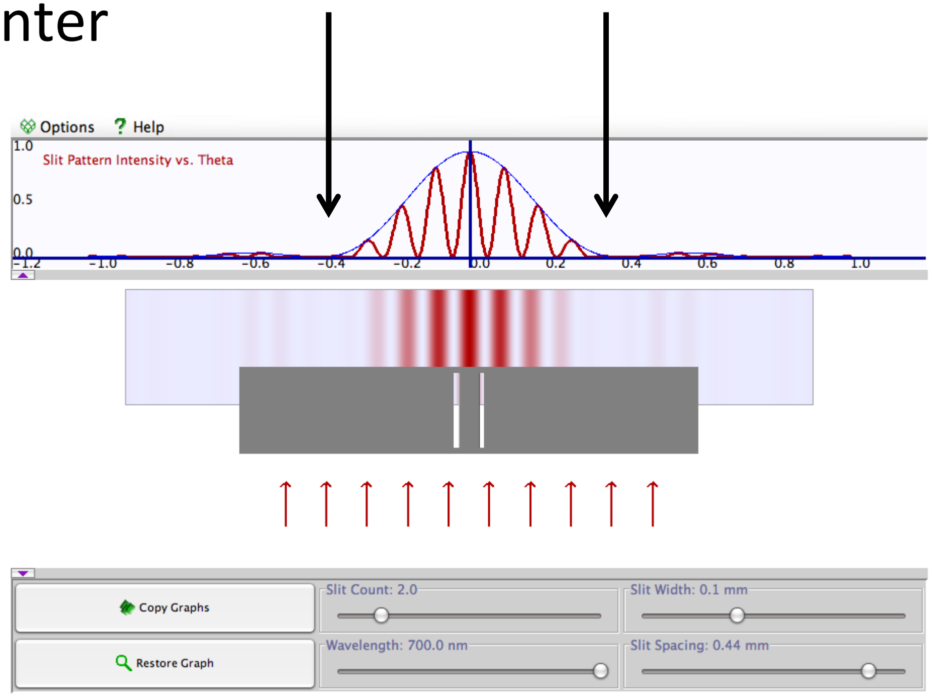
If the wavelength is decreased, what will happen to the fringes (narrow peaks shown in red)?

1. Fringes get wider
2. Fringes get narrower
3. Fringes stay the same
4. Something else



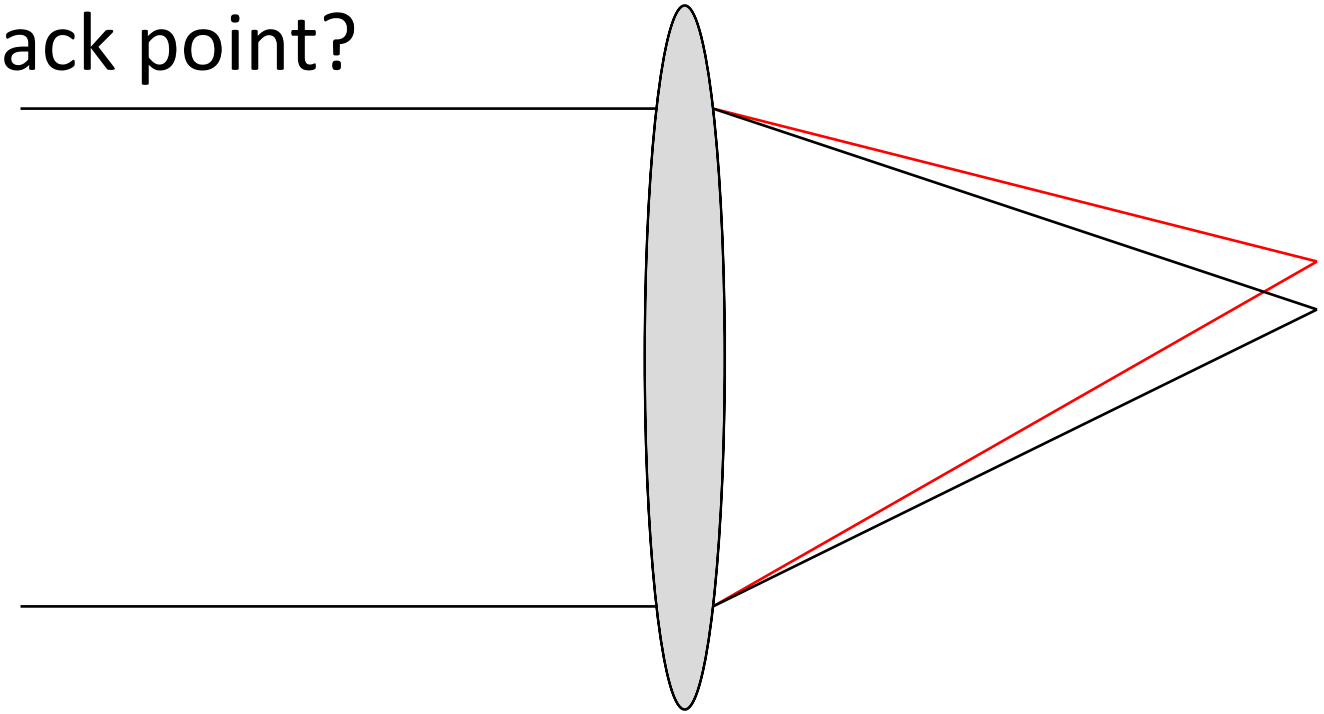
If the wavelength is reduced, what will happen to the squash point (the point where the fringes are driven to zero – shown by the dark arrow)?

1. Move toward the center
2. Move away from the center
3. Stay the same
4. Something else



Reconsidering lenses?
How tightly can we focus light?

- Can we distinguish the red point from the black point?

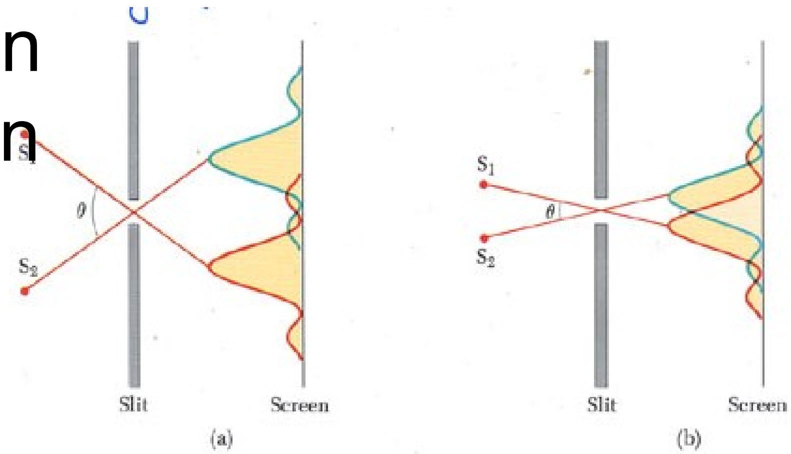


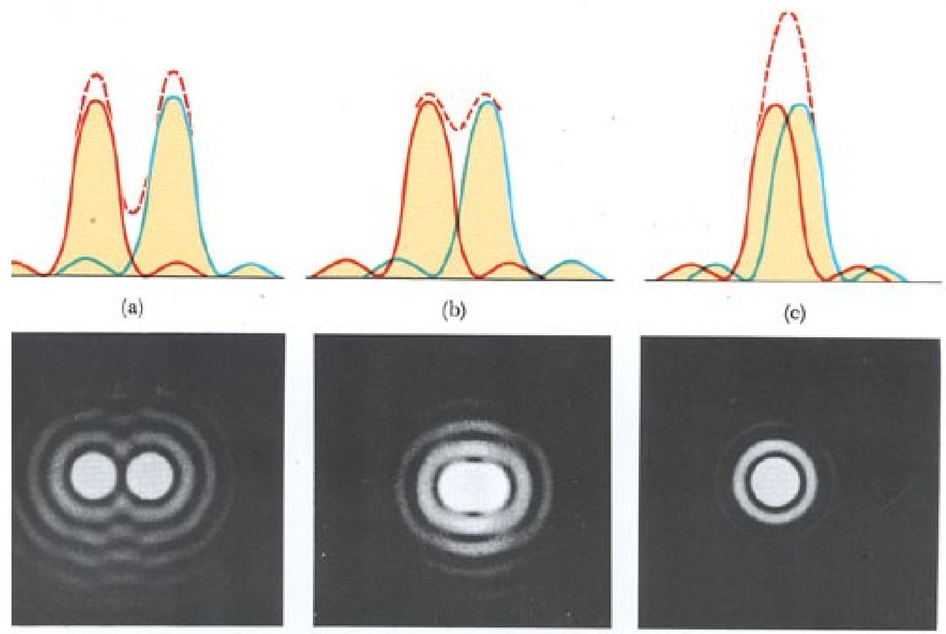
When the angular separation between points is greater than the angle to the first diffraction minimum, the points can be separated.

This is called the Rayleigh resolution criterion.

The minimum of a diffraction pattern occurs at an angle

$$\sin\theta_R = 1.22\frac{\lambda}{d}$$



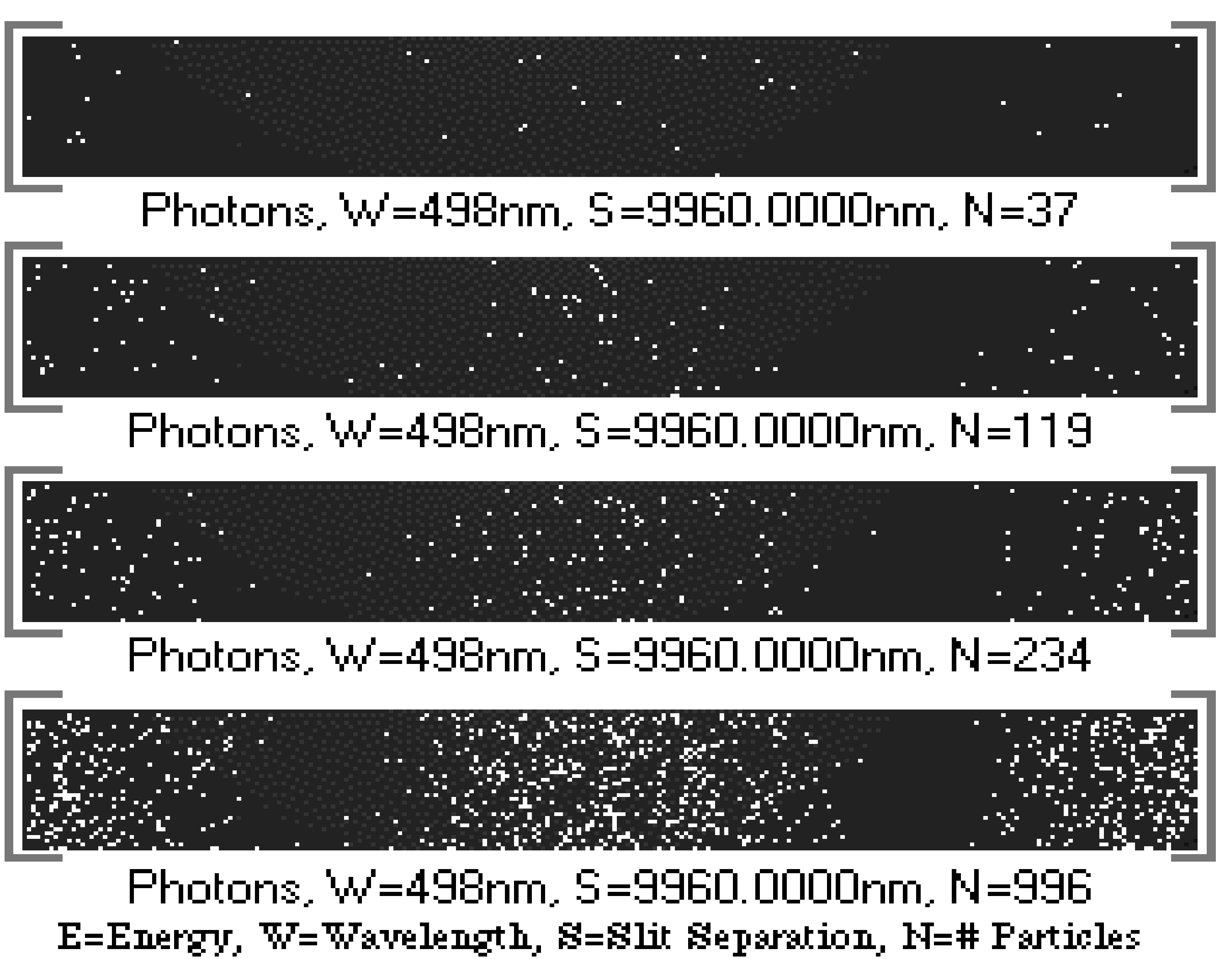


4. Serway Fig. 38.12, Fig. 38.13

Both Particle and Wave Properties are Displayed

- Individual photons strike the target individually and are detected as tiny spots.
- Individual photons still follow an interference pattern – but at random.
- The intensity of an EM wave only tells us the *probability* of finding a photon at a particular place.

Results


Photons, W=498nm, S=9960.0000nm, N=37
Photons, W=498nm, S=9960.0000nm, N=119
Photons, W=498nm, S=9960.0000nm, N=234
Photons, W=498nm, S=9960.0000nm, N=996
E=Energy, W=Wavelength, S=Slit Separation, N=# Particles

Foothold Ideas:
The Probability Framework

- It's clear that both the wave model and th photon have an element of truth. Here's t way we reconcile it:
  - *Maxwell's equations and the wave theory of light yield a function – the electric field – whose square (the intensity of the light) is proportional to the probability of finding a photon.*
  - *No theory of the exact propagation of individual photons exist. This is the best we can do: a theory of the probability function for photons.*

Foothold Ideas:
The Probability Framework for electrons

- Quantum mechanics gives us a wave function of an electron, whose square gives us the probability of finding an electron
  - *Schrödinger's equation is the wave theory of matter. It's solution yields the wave function whose square is proportional to the probability of finding an electron.*
  - *No theory of the exact propagation of individual electrons exist. This is the best we can do: a theory of the probability function for electrons.*