Outline

Models of Light: Waves

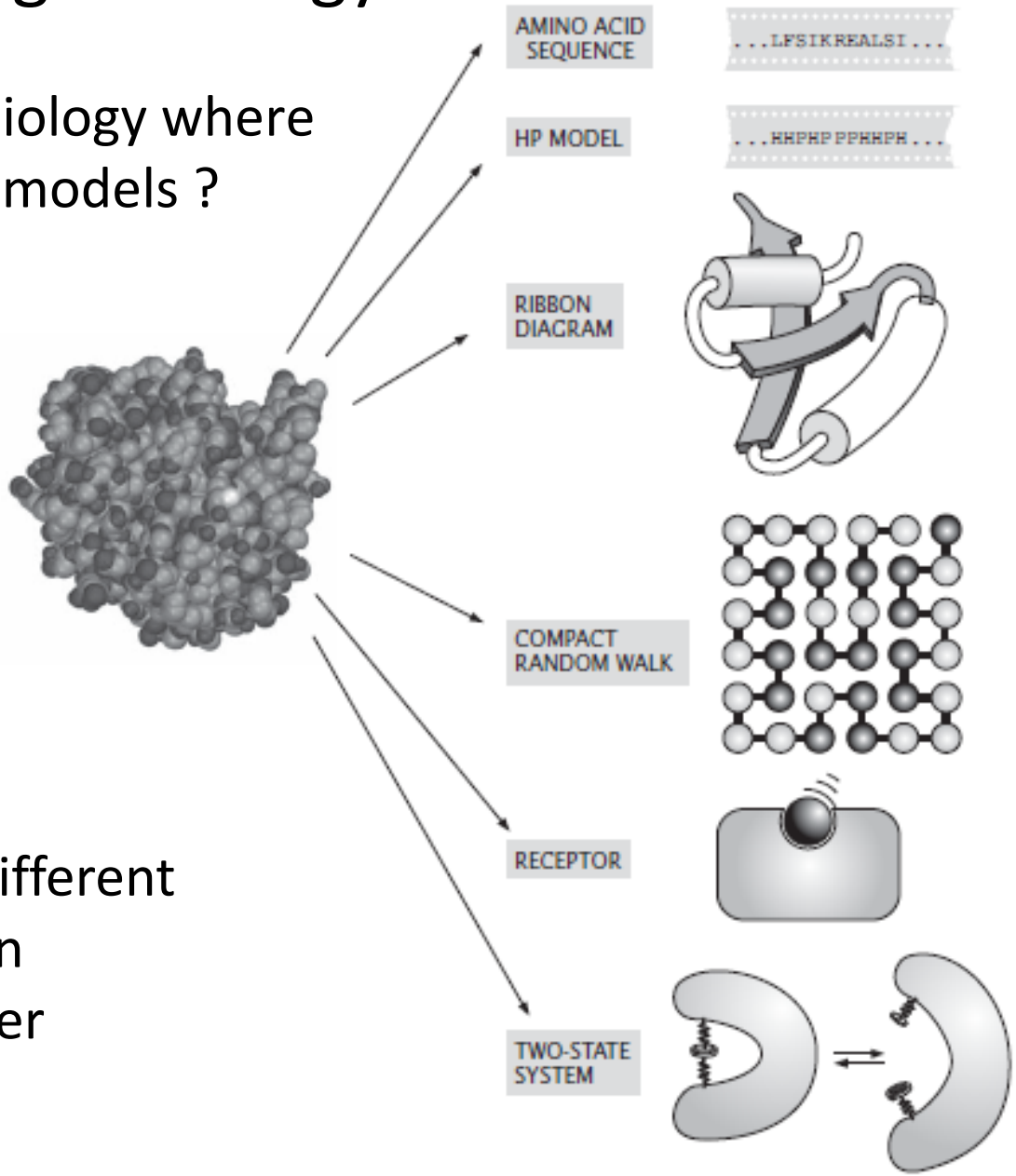
Office Hours (in course center):
Thursday 5/2 5-6.30pm
Friday 5/10 2-3pm review questions
3-4pm office hours

Light: Three models

- Newton's particle model (rays)
  - Models light as bits of energy traveling very fast in straight lines. Each bit has a color. Intensity is the number of bits you get.
- Huygens's/Maxwell wave model
  - Models light at waves (transverse EM waves). Color determined by frequency, intensity by square of a total oscillating amplitude. (Allows for cancellation – interference.)
- Einstein's photon model
  - Models light as "wavicles" == quantum particles whose energy is determined by frequency and that can interferer with themselves.

Modeling in Biology

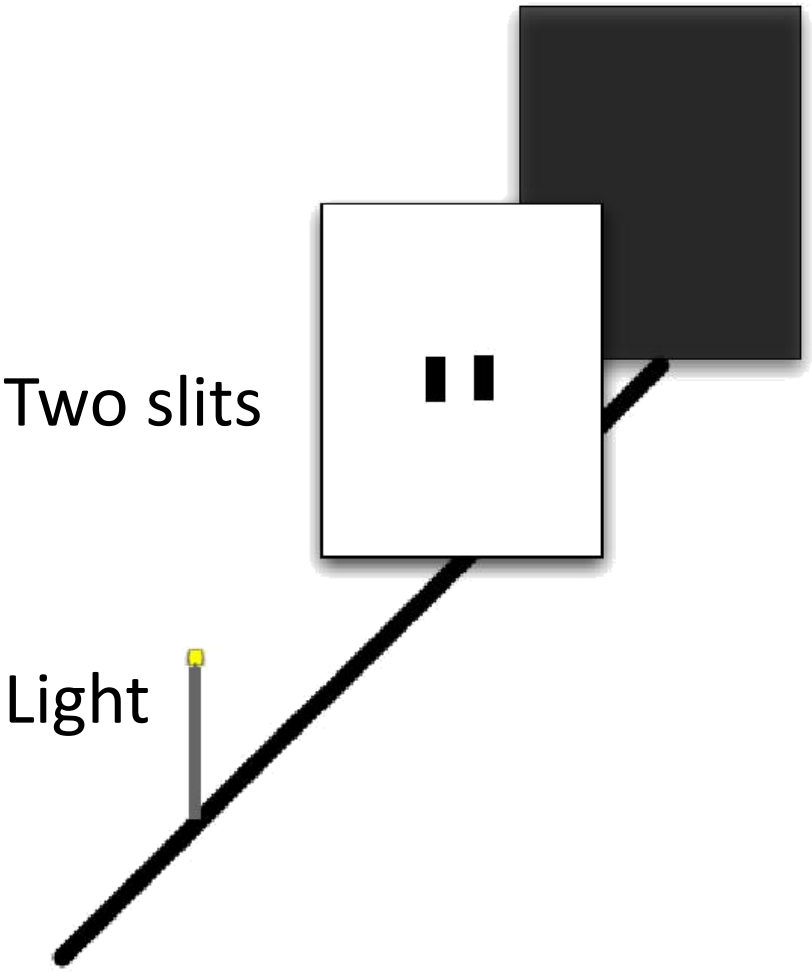
Are there examples in biology where you also need different models ?



Each model highlights different properties of the protein

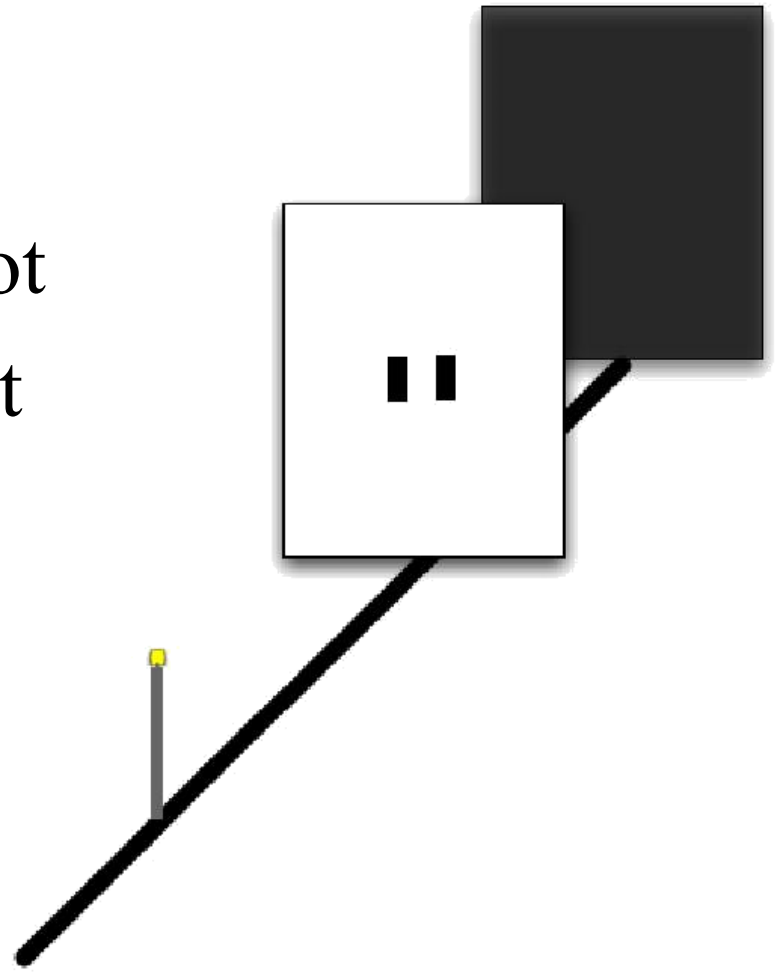
- Hydrophobic character
- Folding property

Our goal: understand how light travels through thin slits



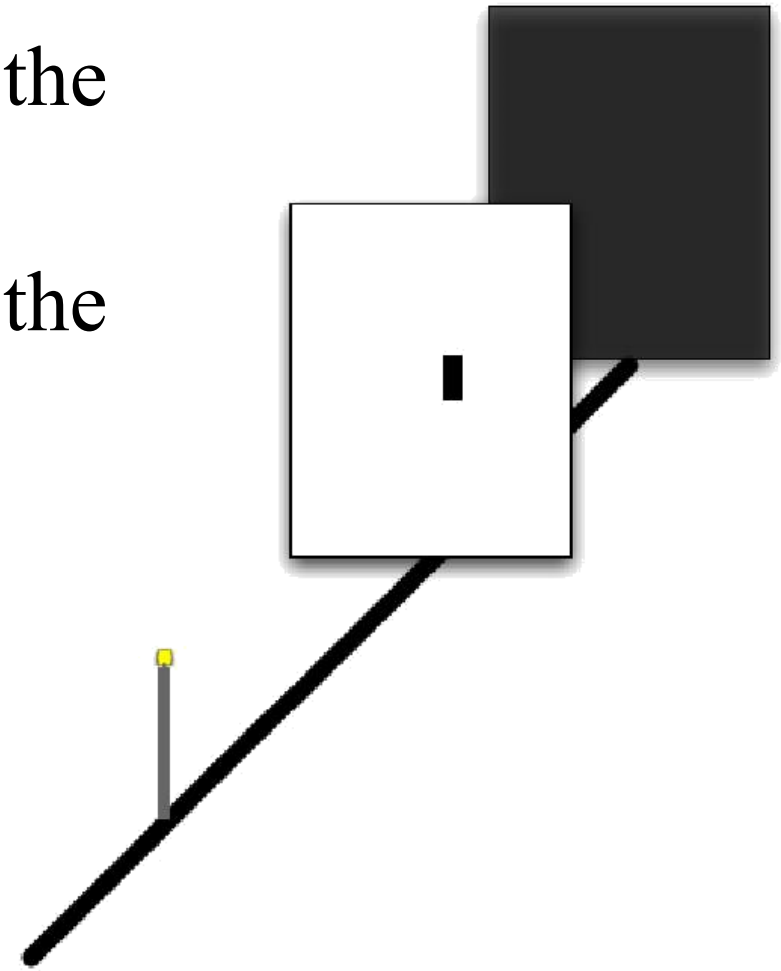
What do we expect from light rays?

1. Two sharp bright spots
2. Two blurry bright spots
3. One wide blurry bright spot
4. One wide sharp bright spot
5. Something else

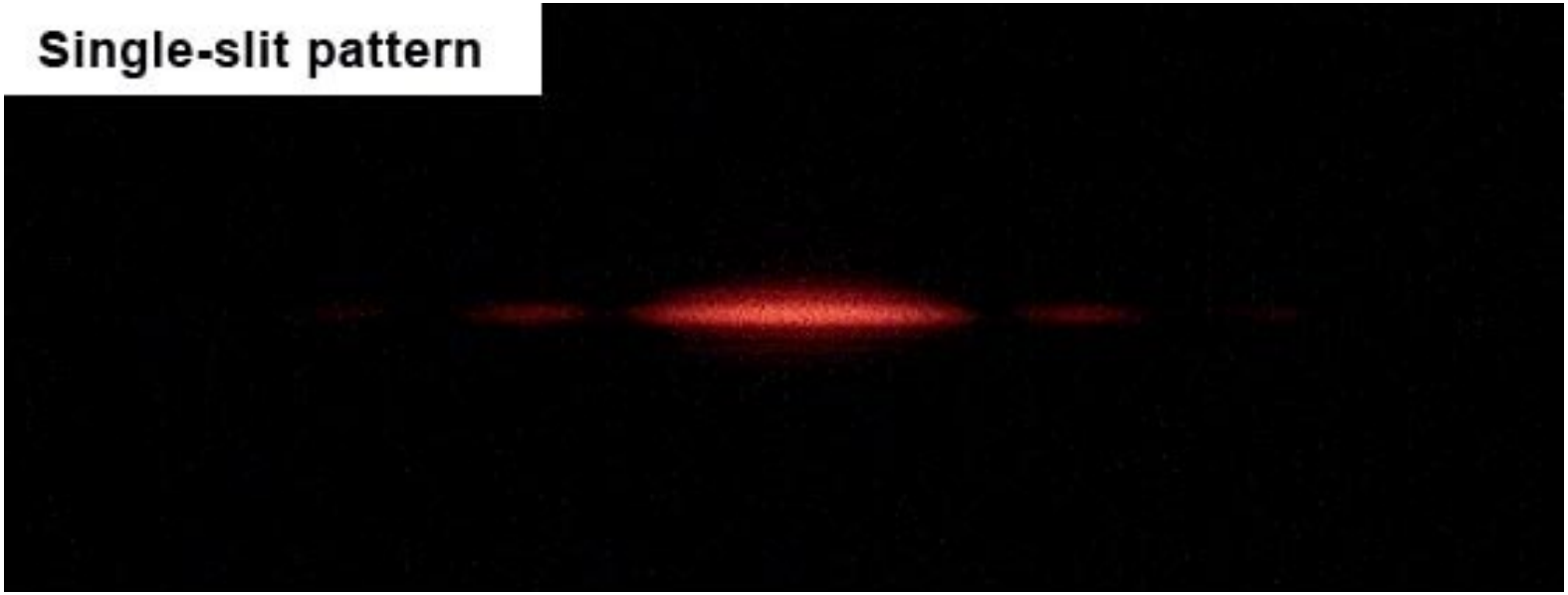


What do we expect from photons going through a single slit?

1. When the slit gets thinner the spot gets thinner
2. When the slit gets thinner the spot gets wider
3. Something else



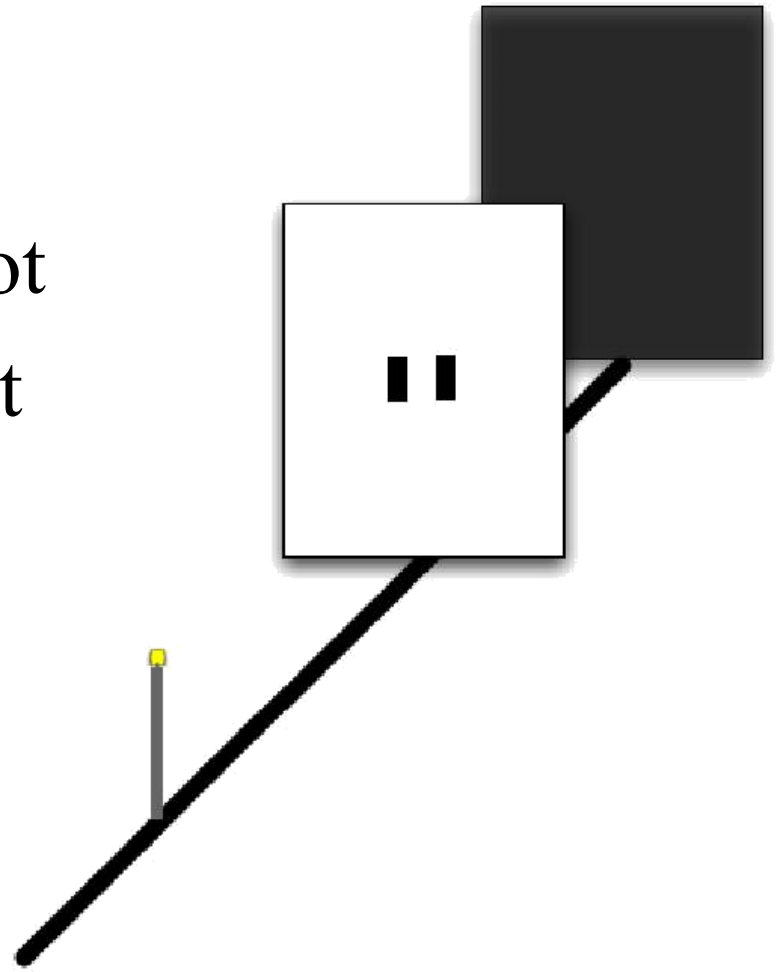
100 micron slit



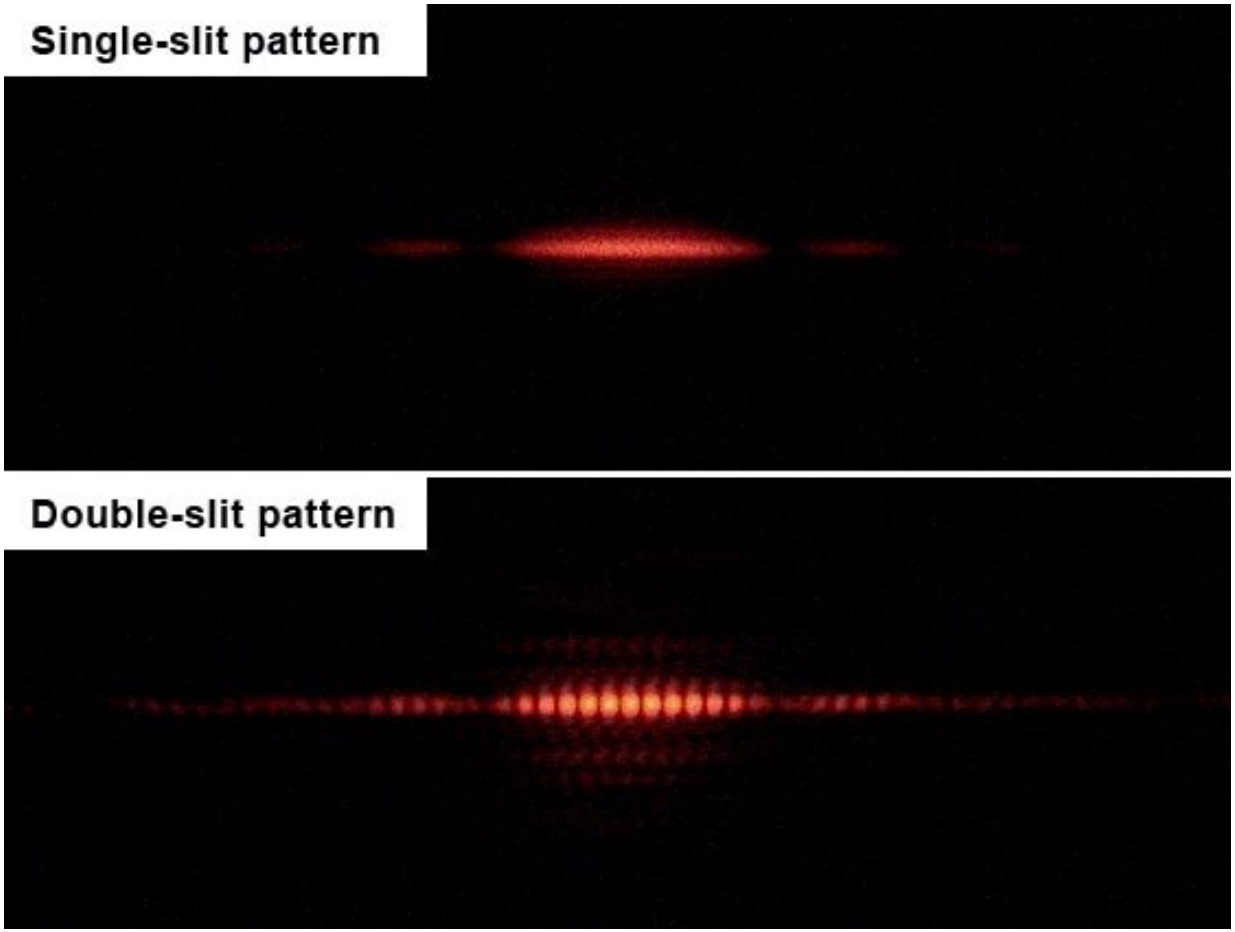
Spot actually gets wider…
Does this mean light has a “size”?

What do we expect from Two waves going through two slits?

1. Two sharp bright spots
2. Two blurry bright spots
3. One wide blurry bright spot
4. One wide sharp bright spot
5. Something else



What a difference a slit makes

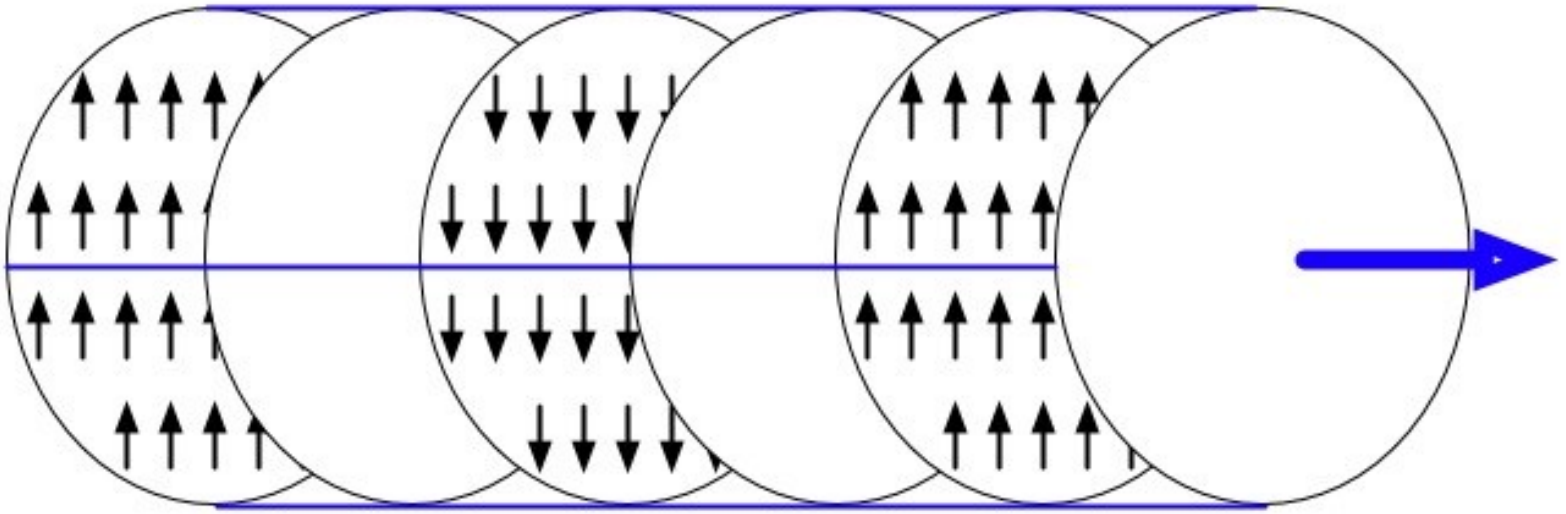


The big deal here is that opening an additional slit makes it *darker* in some places.

No way this happens in either the ray or photon model.

The third model for light: Electromagnetic wave

- Light is an oscillating electromagnetic wave. (Long story)
- A “close-up” of a ray: a plane wave



$$\vec{E}(x,y,z,t) = \vec{E}_0 \sin(kx - \omega t)$$

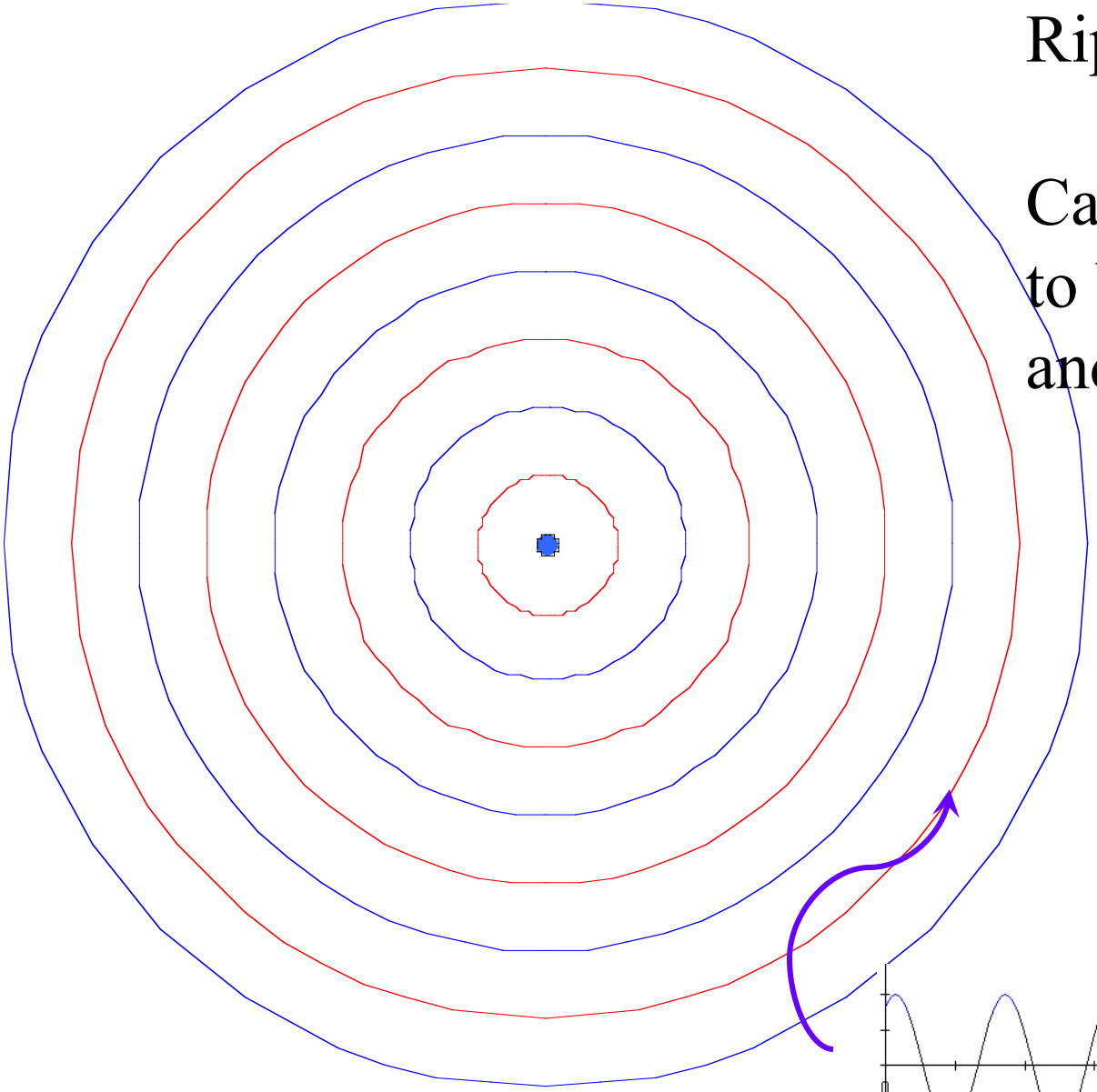
It's hard to picture EM waves in 3D

- Let's build some intuition by working through a simpler example.

Waves on the surface of water

(treating the height of the surface only – that moves up and down – transvers to the wave motion: the actual bits of water move in small circles)

http://www.falstad.com/ripple/



Ripple tank analogy

Can two sources lead to both “bright spots” and “dark spots”?