Sec. 9.4 - Wave or Particle?

Learning Goal: By the end of today I will have a better understanding of the duality of light.

When examining the nature of light, there are several "tests" or phenomena that have to be answered by the given model:

1. reflection,
2. rectilinear propagation (moves in straight lines),
3. diffraction,
4. refraction,
5. dispersion (white light into the spectrum).

If you want to be a famous scientist in the study of light, you have to be able to navigate and explain all of those ideas with your model.

Particle Nature of Light

Isaac Newton was the big supporter of this model. He hypothesized that light travelled as tiny particles, or corpuscles.

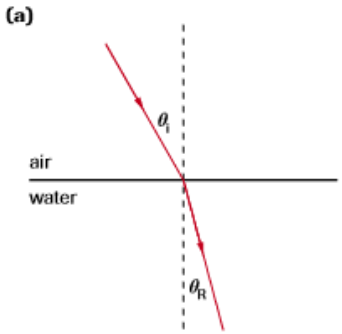
The particle model explains some of the key elements well, but was weak in others.

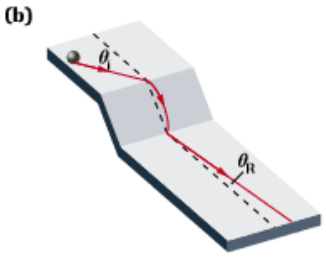
1. reflection,
2. rectilinear propagation (moves in straight lines),
3. diffraction,
4. refraction,
5. dispersion (white light into the spectrum).

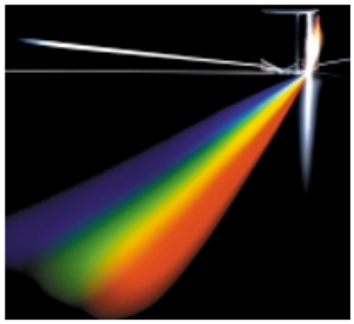
Reflection, rectilinear propagation, the ability to use other mechanics models and formula, and not needing a medium were the strengths of this model.

Diffraction and dispersion explanations involved the collision of light particles and their corresponding change in direction from a momentum stand point. Dispersion was justified via different light particles (colours) had different masses.

Refraction and the explanation of partial-reflection partial refraction were the weak elements.







Wave Nature of Light

Francesco Grimaldi, Robert Hooke, Christian Huygen, and Thomas Young are big players in the wave model theory of light.

As we saw with water waves, a wave model can check off several of the big ideas for light.

1. reflection,
2. rectilinear propagation (moves in straight lines),
3. diffraction,
4. refraction,
5. dispersion (white light into the spectrum).

Reflection, diffraction, refraction, and dispersion are explained well by the wave model of light. Rectilinear propagation and the need for a medium for waves to travel in were obstacles for this model.

Huygen's Wave model set out to change the rectilinear propagation issue.

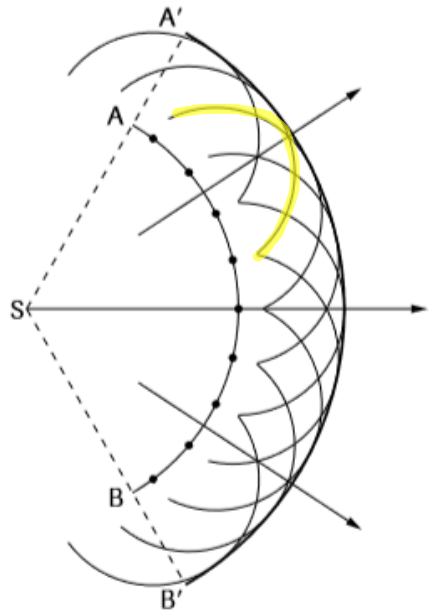
Huygen's Wave Model

Huygens' Principle

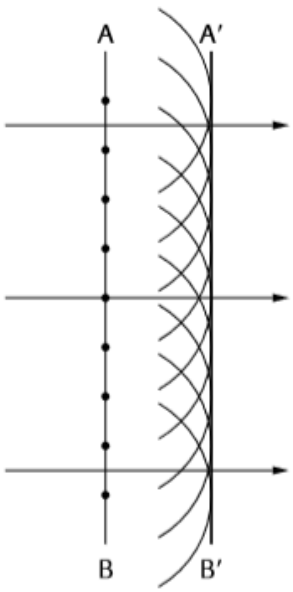
Every point on a wave front can be considered as a point source of tiny secondary wavelets that spread out in front of the wave at the same speed as the wave itself. The surface envelope, tangent to all the wavelets, constitutes the new wave front.

As an illustration of the use of Huygens' principle, consider **Figure 5**, in which the wave front AB is travelling away from the source at some instant. The points on the wave

circular wave front



straight wave front



The greatest challenge to their studies was the incredibly small wavelengths found in light.

The theories were the best possible at the time, but as we learn more and technology advances, we have to revisit old ideas and refresh them.

SUMMARY Light: Wave or Particle?

- Newton's particle theory provided a satisfactory explanation for four properties of light: rectilinear propagation, reflection, refraction, and dispersion. The theory was weak in its explanations of diffraction and partial reflection–partial refraction.
- Huygens' wave theory considered every point on a wave front as a point source of tiny secondary wavelets, spreading out in front of the wave at the same speed as the wave itself. The surface envelope, tangent to all the wavelets, constitutes the new wave front.
- Huygens' version of the wave theory explained many of the properties of light, including reflection, refraction, partial reflection–partial refraction, diffraction, and rectilinear propagation.

Einstein came along and said "It's both.", which lead to an entirely new way of looking at light.

Around the same time Max Planck was introducing the concept of energy packets or quanta (Quantum Theory).

These ideas converged into something called photons, which is part of our current understanding of "light" or electromagnetic energy.

https://youtu.be/m2-UJAEJzcc

https://youtu.be/i1TVZIBj7UA Planck

https://youtu.be/Q_h4IoPJXZw Part 1

https://youtu.be/_rilY-v2Ym8 Part 2

https://youtu.be/Xmq_FJd1oUQ Quantum connection