

# Special Relativity

- Historically, motivation was special relativity was **not** *asymptotic velocity* nor *conflict between Newtonian mechanics and electromagnetism*
- **Irony** of the particle-wave conflict regarding light is that both views are correct

# Propagation of Light

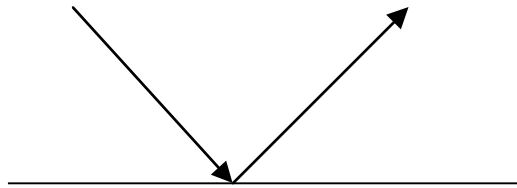
- Propagation of light involves transport of energy away from a source
- The simplest mechanism for such transport is a stream of particles (proposed by Pythagoras in 6th Century B.C.)
- Accounts for propagation in straight lines (shadows) and propagation in vacuum

# Propagation of Light

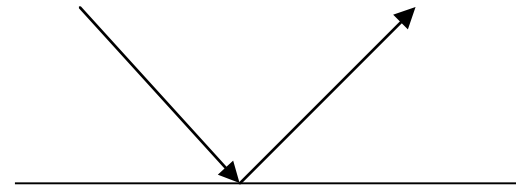
- From the Greeks through Newton, light was regarded as a particle phenomenon
- In late 17th Century, Robert Hooke and Christian Huygens proposed wave theories of light
- Huygens showed in *Treatise on Light* (1690) that wave theory **also** explains reflection and refraction

# Reflection and Refraction

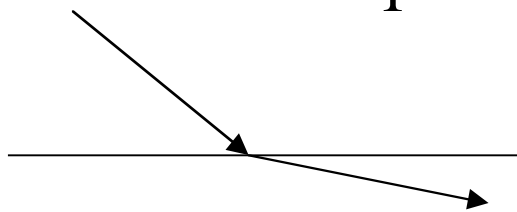
Particles



Waves



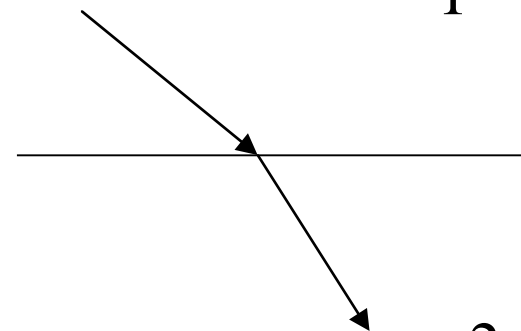
1



$$V_1 > V_2$$

2

1



2

# Particles vs. Waves

- Since the speed of light was unknown, the refraction effect did not settle the controversy
- Because the wave theory also explains diffraction, interference and polarization, from the 17th to the 19th Centuries, the wave theory became more popular

# Problems with the Wave Theory

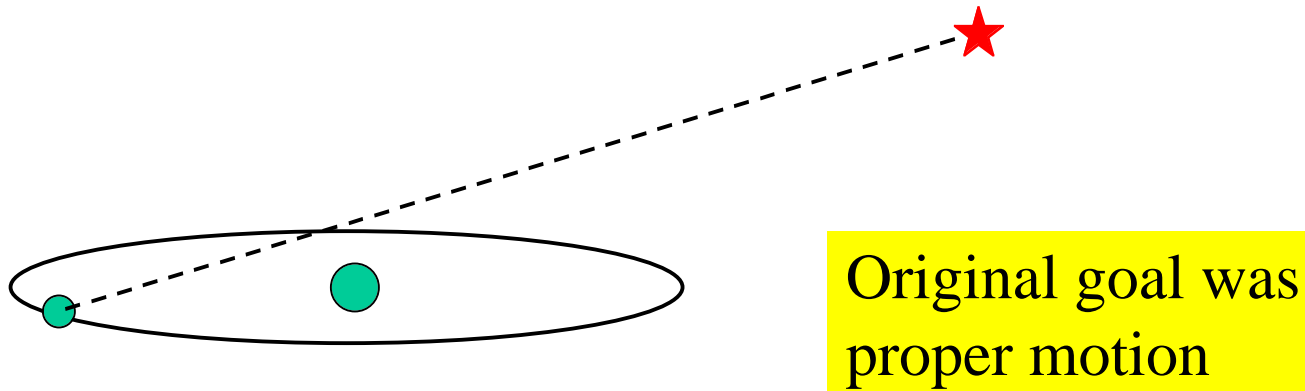
- One problem is that light velocity is much larger than any known mechanical wave velocity (very high “T” but doesn’t interfere with planetary motion)
- No one could devise an experiment to demonstrate the properties of the wave medium, called “lumineferous ether”

# Another Difference Between Particles and Waves

- Particles: velocity is measured relative to the source
- Waves: velocity is measured relative to the medium
- Maxwell's equations predicted velocity of light relative to the ether
- Experiments tried to measure ether velocity relative to the earth

# Stellar Aberration

- An early attempt to measure effect of ether was study of stellar aberration

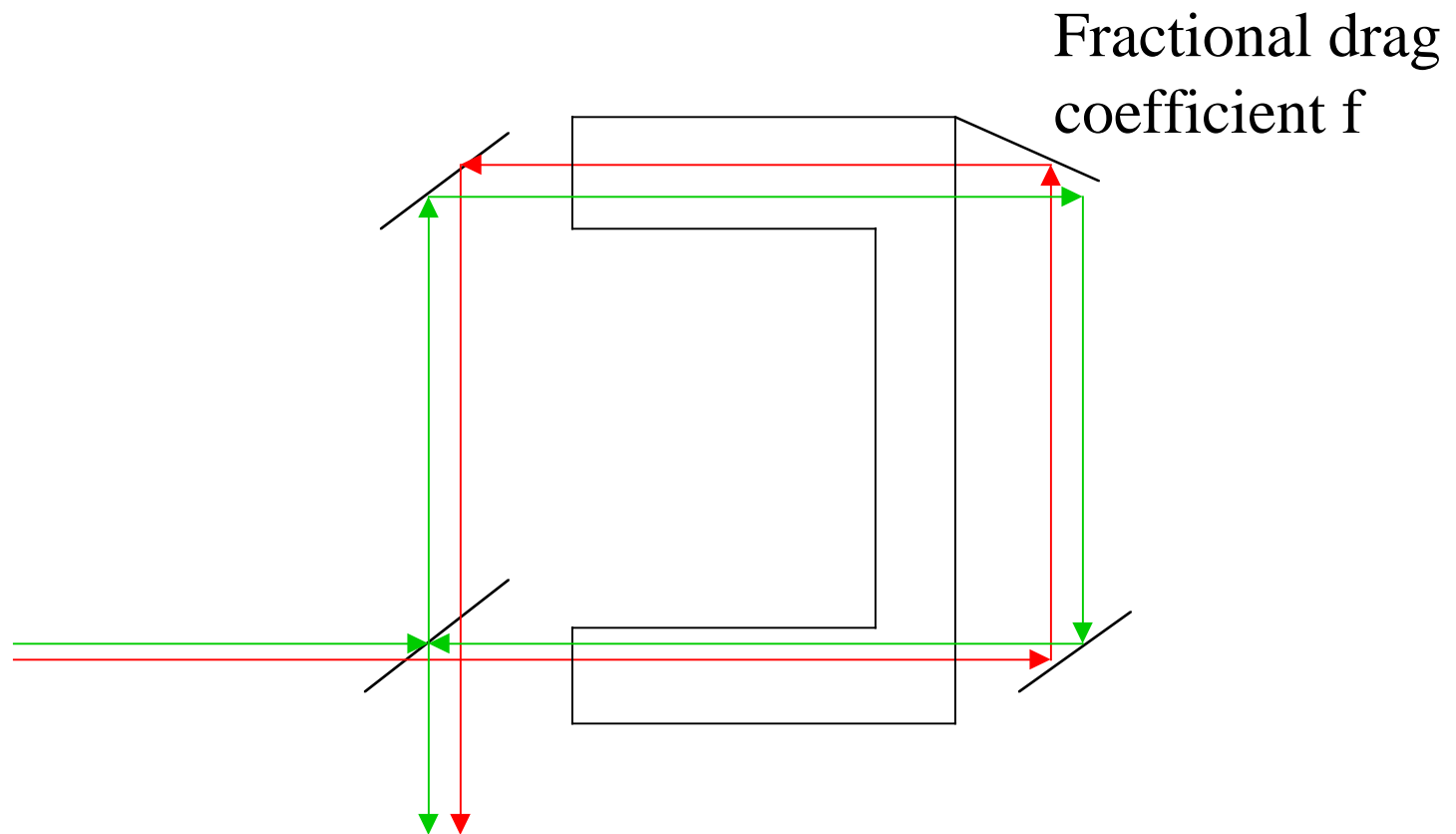


Result was aberration depended on velocity

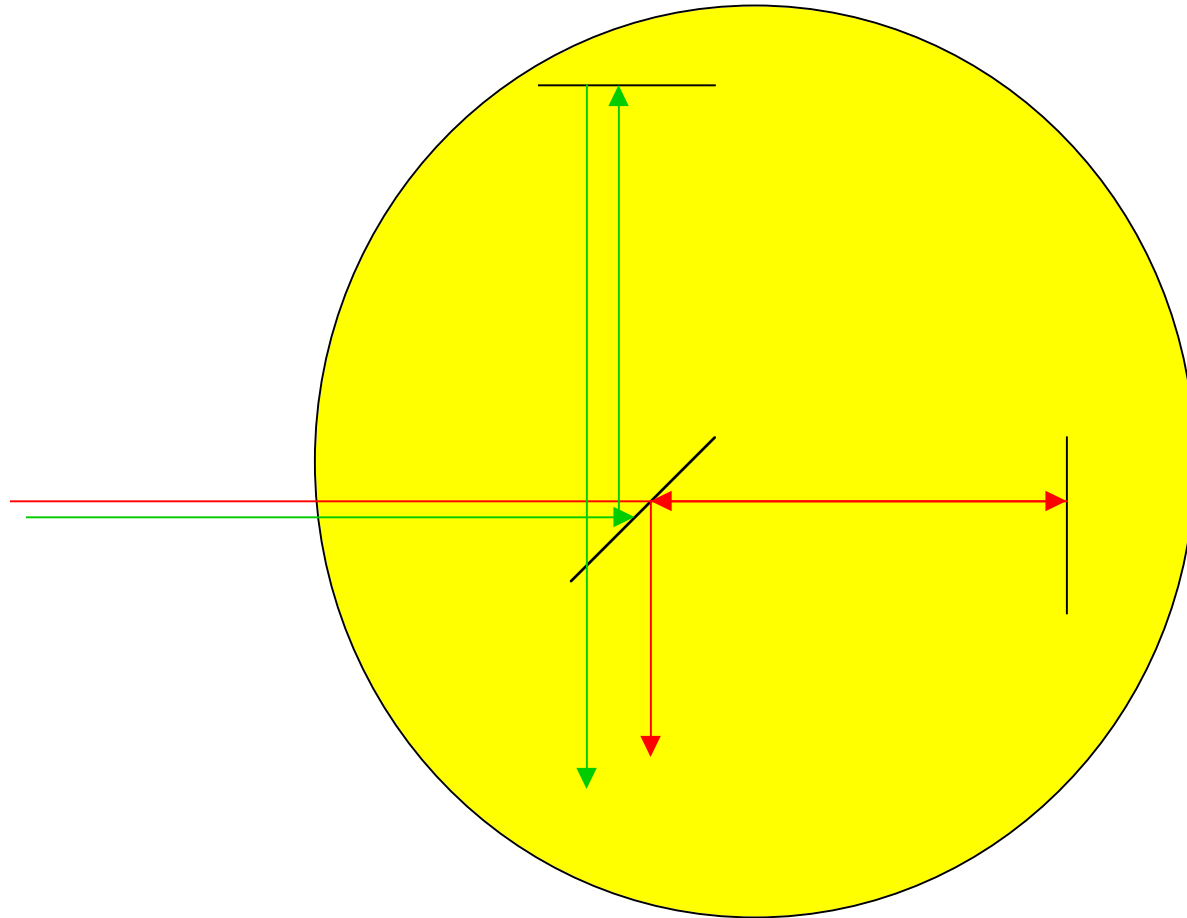
# Stellar Aberration

- Implication of stellar aberration is that earth does not drag ether along with it

# Fizeau's Experiment



# Michaelson-Morley Experiment



# Michaelson-Morley Experiment

- No effect due to earth's motion through the ether

# Einstein's Postulates

- Read Chapter 39.1-3
- Absolute uniform motion cannot be detected
- Speed of light is the same for all observers and is independent of the motion of the source
- Contradicts both particle and wave theories

# Lorentz Vectors and Scalars

- Define a Lorentz vector as a four-component object  $(x, y, z, ct)$
- Define scalar product as follows:

$$(x_1, y_1, z_1, ict_1) \cdot (x_2, y_2, z_2, ict_2) = x_1x_2 + y_1y_2 + z_1z_2 - c^2t_1t_2$$

# Lorentz Transformations

- Transform from one reference frame to another reference frame using Lorentz transformations

$$\begin{pmatrix} x_2 \\ y_2 \\ z_2 \\ ict_2 \end{pmatrix} = \begin{pmatrix} \gamma & 0 & 0 & i\gamma\beta \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -i\gamma\beta & 0 & 0 & \gamma \end{pmatrix} \begin{pmatrix} x_1 \\ y_1 \\ z_1 \\ ict_1 \end{pmatrix}$$

assuming motion  $v$  along the  $x$  axis,

$$\gamma = \sqrt{\frac{1}{1-\beta^2}}, \quad \beta = v/c$$