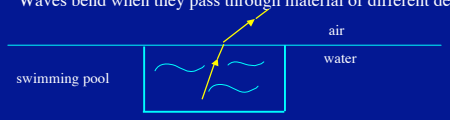
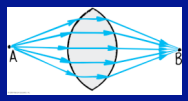
Things that waves do

1. Reflection (last time)
2. Refraction (also covered last time)

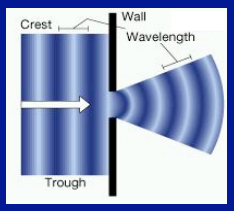
Waves bend when they pass through material of different densities.





3. Diffraction

Waves bend when they go through a narrow gap or around a corner.



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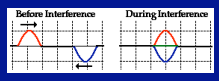
4. Interference

Waves can interfere with each other



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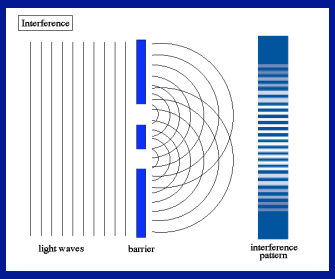
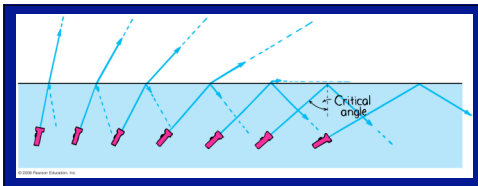
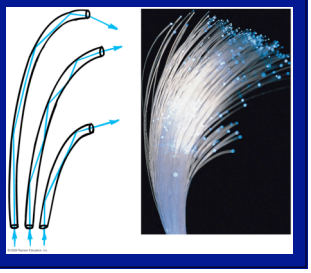


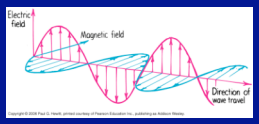


Fiber Optic Cables

Total internal reflection



Polarization of Light



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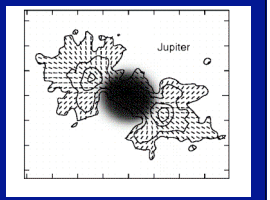
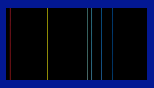


Types of Spectra

1. "Continuous" spectrum - radiation over a broad range of wavelengths (light: bright at every color).

2. "Emission line" spectrum - bright at specific wavelengths only.



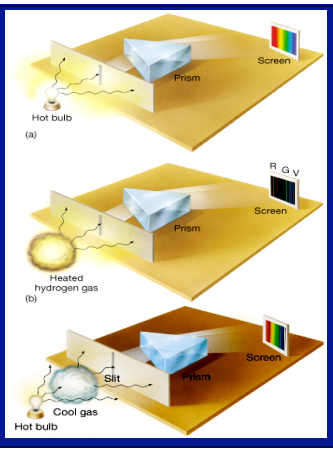
3. Continuous spectrum with "absorption lines": bright over a broad range of wavelengths with a few dark lines.

Kirchhoff's Laws

1. A hot, opaque solid, liquid or dense gas produces a continuous spectrum.

2. A transparent hot gas produces an emission line spectrum.

3. A transparent, cool gas absorbs wavelengths from a continuous spectrum, producing an absorption line spectrum.



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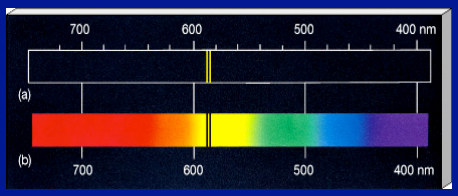
The pattern of emission (or absorption) lines is a fingerprint of the element in the gas (such as hydrogen, neon, etc.)

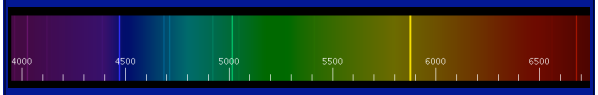
For a given element, emission and absorption lines occur at the same wavlengths.



Sodium emission and absorption spectra

Spectrum of Helium (He) Gas

What kind of gas is this?



Discovered in 1868 by Pierre Jannsen during a solar eclipse
Subsequently seen and named by Norman Lockyer

Clicker Question:

Compared to blue light, red light travels:

A: faster

B: slower

C: at the same speed

Clicker Question:

Which of the following is not an electromagnetic wave:

A: radio waves

B: visible light

C: X-rays

D: sound waves

E: gamma-rays

Clicker Question:

If a star is moving rapidly towards Earth then its spectrum will be:

A: the same as if it were at rest

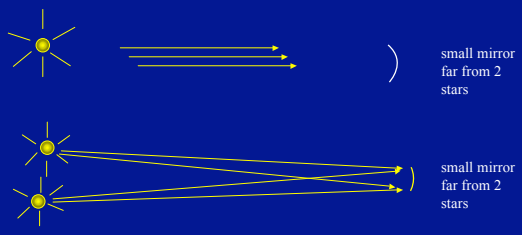
B: shifted to the blue

C: shifted to the red

D: much brighter than if it were at rest

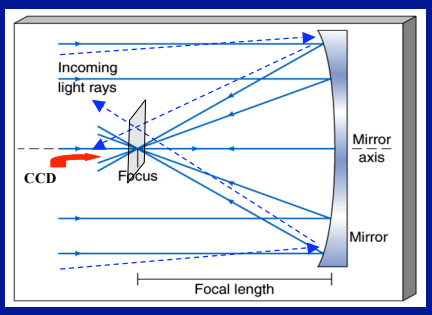
E: much fainter than if it were at rest

Light Hitting a Telescope Mirror



Light rays from any single point of light are essentially parallel. But the parallel rays from the second star come in at a different angle.

Light rays from a distant source, parallel to the "mirror axis" all meet at one point, the focus.

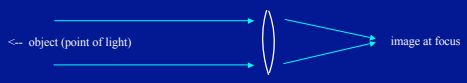


Parallel light rays at another angle meet at another point in same vertical plane, the "focal plane".

Optical Telescopes - Refracting vs. Reflecting

Refracting telescope

Focuses light with a lens (like a camera).



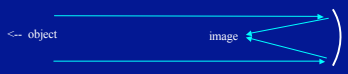
Problems:

- Lens can only be supported around edge.
- "Chromatic aberration".
- Some light absorbed in glass (especially UV, infrared).
- Air bubbles and imperfections affect image quality.

Reflecting telescope

Focuses light with a curved mirror.

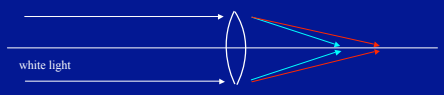
DEMO



- Can make bigger mirrors since they are supported from behind.
- No chromatic aberration.
- Reflects all radiation with little loss by absorption.

Chromatic Aberration

Lens - different colors focus at different places.



Mirror - reflection angle doesn't depend on color.

Refracting Telescope

Yerkes 40-inch (about 1 m).
Largest refractor.

Reflecting Telescope

Cerro-Tololo 4 -m reflector.

Reflector Types

Prime focus

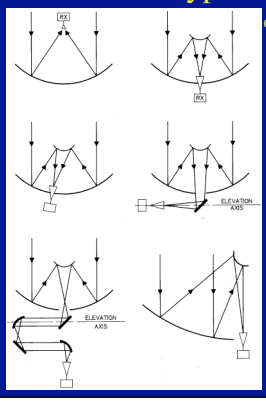
Cassegrain focus

Offset Cassegrain

Naysmith

Beam Waveguide

Dual Offset



Reflector Types

Prime focus (GMRT)

Cassegrain focus (AT)

Offset Cassegrain (VLA)

Naysmith (OVRO)

Beam Waveguide (NRO)

Dual Offset (ATA)

Clicker Question:

An advantage of reflecting telescopes over refracting telescopes is:

A: Big mirrors can be more easily supported.

B: The focus is easy to get to.

C: The resolution is better (for the same aperature).

D: They are more sensitive (for the samer aperature).

Clicker Question:

An advantage of refracting telescopes over reflecting telescopes is:

A: Big lenses are lighter than big mirrors.

B: The focus is easy to get to.

C: They don't suffer from chromatic aberration.

D: They are more sensitive (for the samer aperature).

Clicker Question:

A transparent hot gas produces what sort of spectrum?

A: Emission at specific wavelengths only

B: Emission across a broad range of wavelengths

C: Emission across a broad range of wavelengths with some gaps at specific wavelengths.

D: Very blue emission.