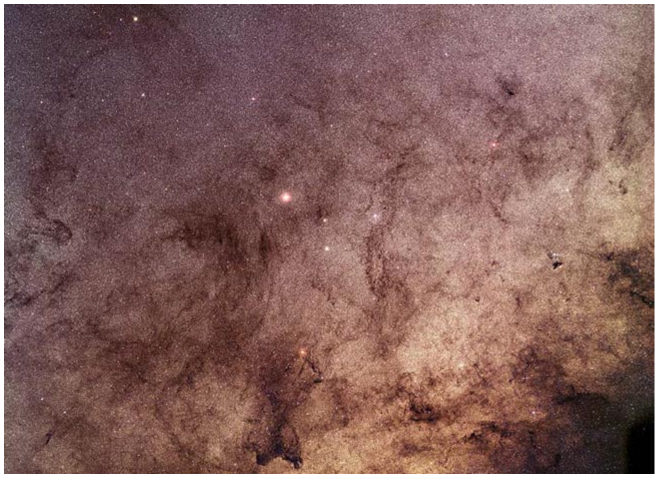
STARS!!

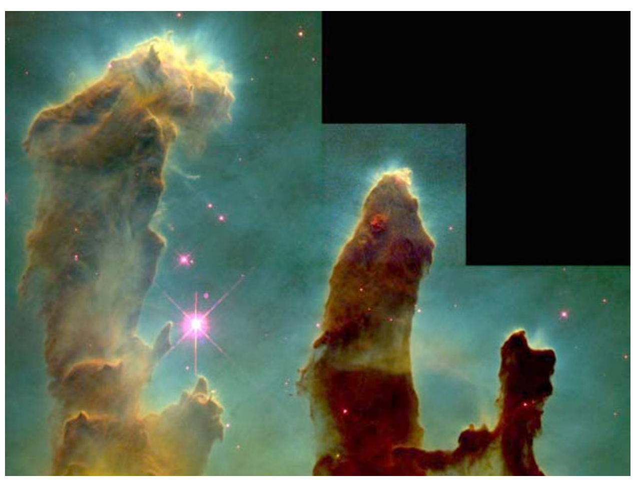
"Astrology is Bogus"

In the constellation of Scorpio

Stars in the Milky Way

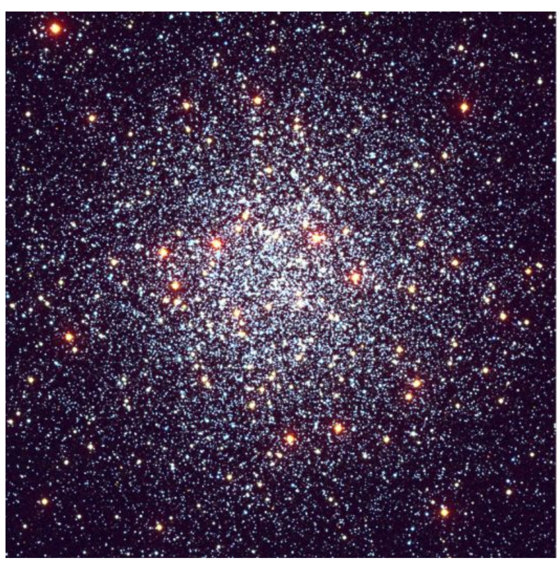


Where Stars are Born



Young Stars

Cluster of Stars



Dying Stars

STARS

- Luminosity
  Total light energy emitted over full surface of star in each second (energy/s)

→ *Brightness*
  Measured light energy collected by telescope (also called FLUX);
  the telescope is some distance away from star (energy/s/cm^2)

- Mass
  Total amount of material star making up the star (kilograms)

- Surface Temperature
  Temperature of the photosphere (Kelvin)

- Diameter (Size)
  The physical size (kilometers)

STARS

Intrinsic Properties	***Observed Properties***
Luminosity Mass Temperature Size	*Brightness* *Distance*

Objectives are to obtain the intrinsic properties of stars. You already learned the Balmer Thermometer to obtain Temperature.

Here we learn about getting Luminosity and Masses.

STARS (how do you learn about them?)

Astronomers want to know their intrinsic properties and compare them to one another to learn about them as a class of object

Want *intrinsic* energy output: luminosity

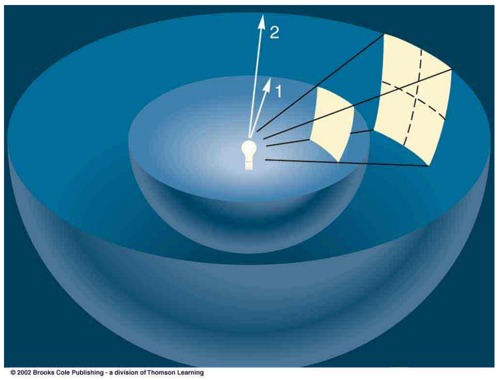
But we only measure is their *observed* *brightness*

But *distance* can convert *brightness* into luminosity

We measure brightness and distance and to get luminosity

Inverse Square Law of Light

The amount of light collected varies with the square of the distance between the collector and the source.



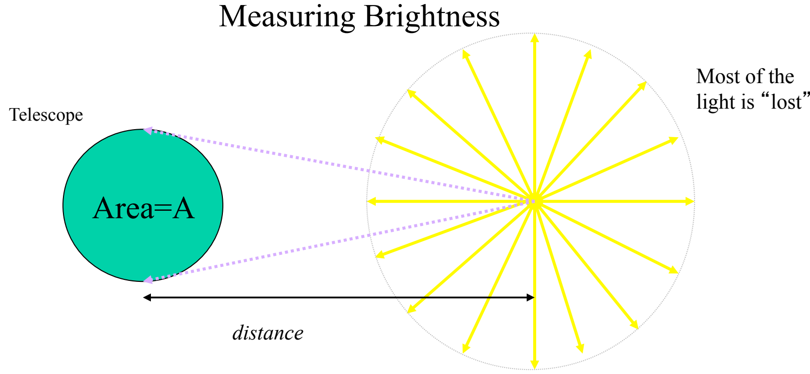
Distance	Light Collected	
1	1	1.00
2	1/4	0.25
3	1/9	0.11
4	1/16	0.06
5	1/25	0.04
10	1/100	0.01
1/2	4	4.00
1/3	9	9.00

The amount of light collected varies with the square of the distance between the collector and the source.

A given telescope (shown as a unit square) will collect less of the light the further away it is from the source. If it is twice as far, it collects ¼ as much of the light.

This is why brightness is distance dependent.

Measuring Brightness

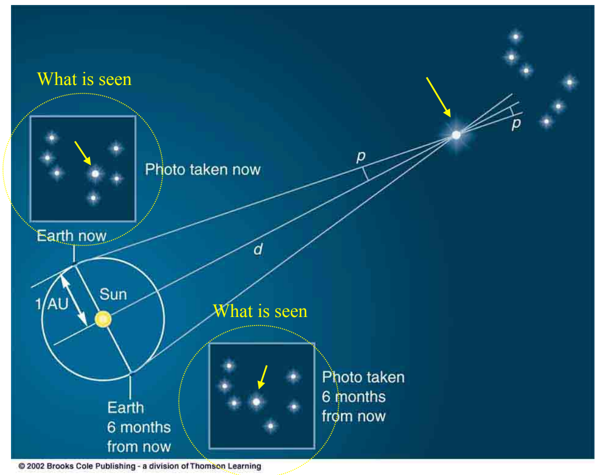


- Collect light from star in telescope with size (area), A.
- Collect that light for given amount of time, say 1 hour.
- Correct for size of telescope and amount of time you were adding up the light

$$\text{Brightness} = \frac{\text{Total Light Energy Collected}}{(\text{Time Collected}) * (\text{Area of Telescope})}$$

Getting the Distances to Stars: Stellar Parallax

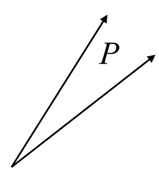
The baseline is the diameter of the Earth's orbit.
The measurements are taken six months apart.



The ½ of the angle between the *now* location and the *6-month* location is called the stellar parallax. = *P*

Parallax Distance

$$d = \frac{1}{P} \quad \text{[parsecs]}$$



P, the parallax angle, is measured in arcseconds

60 arcseconds = 1 arcminute
60 arcminutes = 1 degree
There are 3600 arcseconds in a degree

The larger *P*, the closer the star (smaller *d*)
The smaller *P*, the further the star (larger *d*)

1 parsec = parallax second = 3.26 light years

Putting it all Together

Getting Luminosity from Brightness and Distance

1. **Measure star's brightness**. Use a telescope and add up all the **light energy**. Correct for the size of the telescope and how much time you added the light to get the brightness, ***B***.

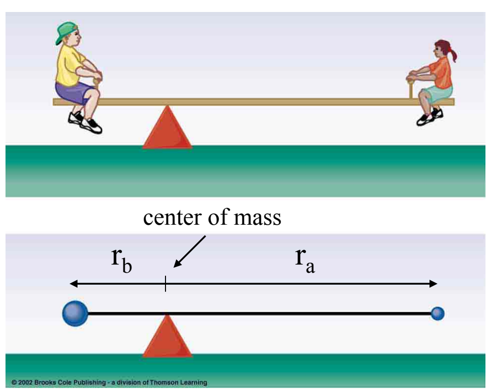
2. **Measure the star's distance, *d*.** Use parallax.

3. **Compute star's luminosity, *L***. Apply the **inverse square law of light** by solving for luminosity in the relation equating brightness and the square of the distance …

measured brightness → $$B \sim \frac{L}{d^2}$$ ← *solve for L, luminosity*; ← *measured distance*

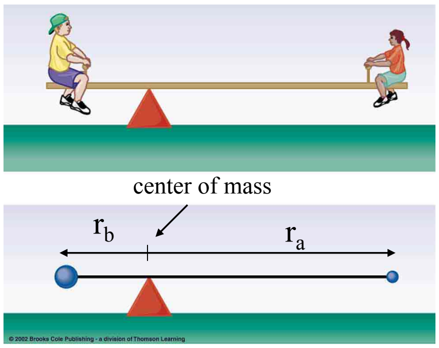
Weighing Stars

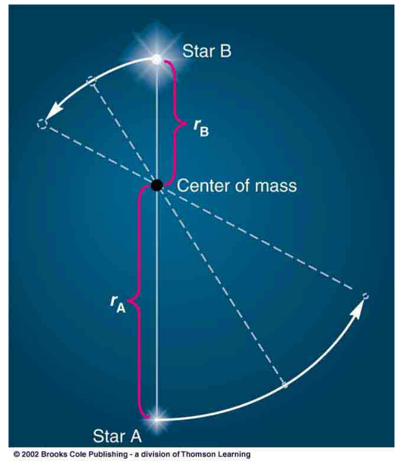
We can only directly measure the masses of stars in binary systems.



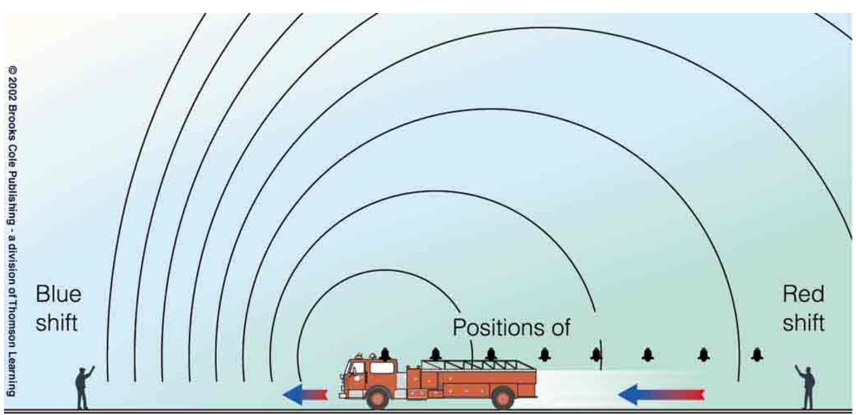
Orbiting stars are balanced around their center of mass, like two kids on a see-saw. If we can measure the dynamics of this balance, we can measure the masses of the stars. But how….?

Weighing Stars





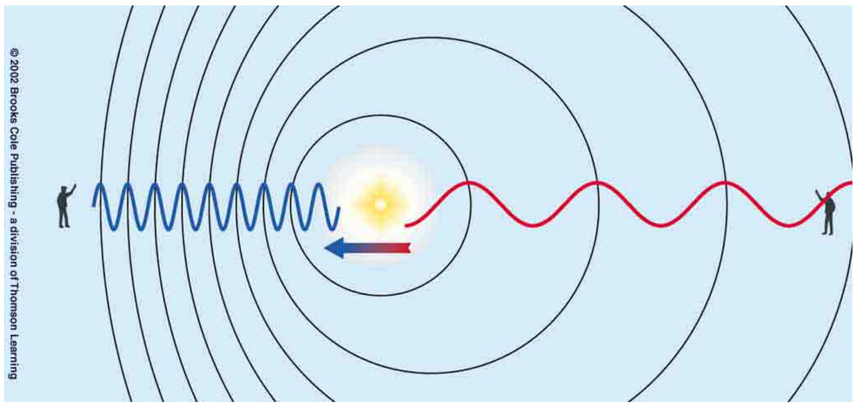
The Doppler Shift (sound).



Higher pitch

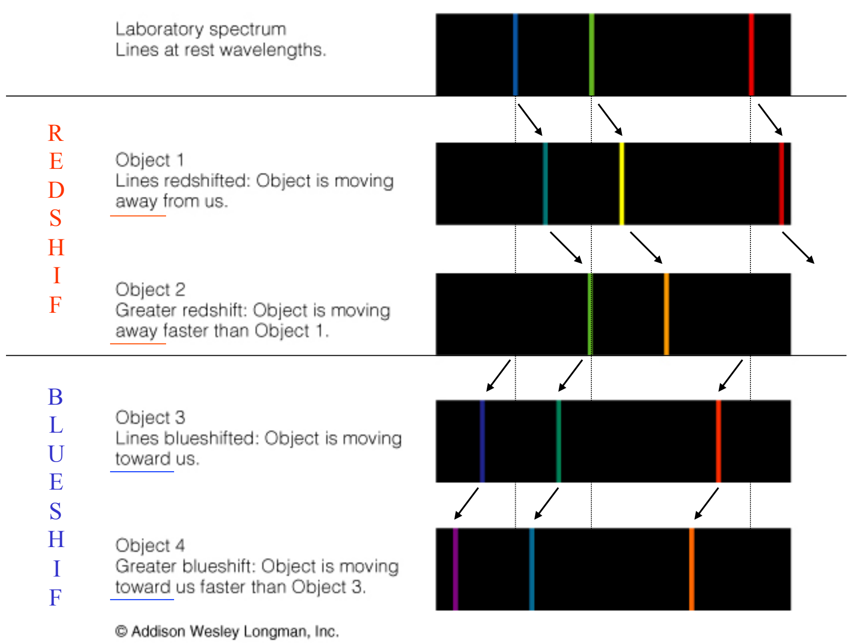
Lower pitch

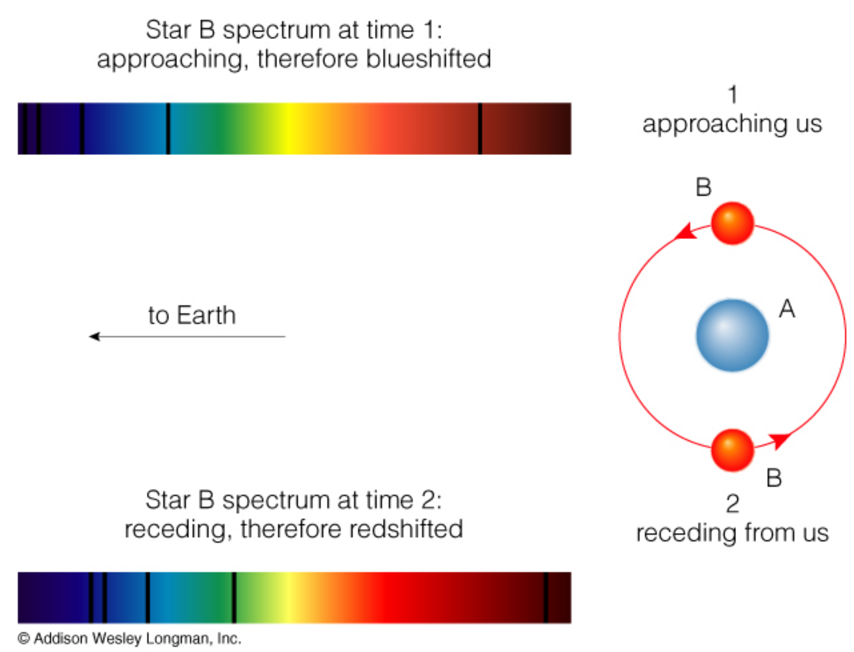
The Doppler Shift (light).

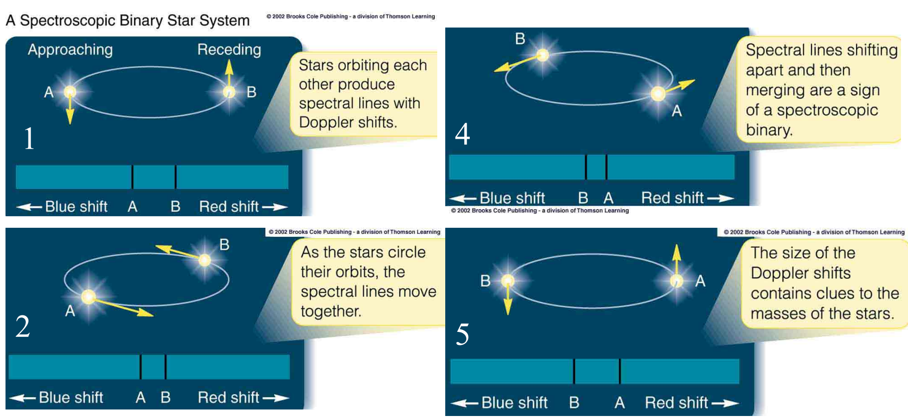


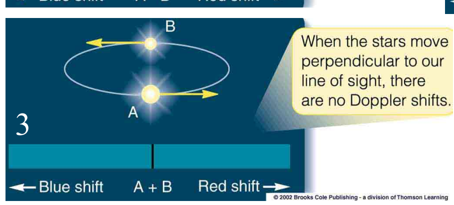
BLUE SHIFT
Higher frequency
Higher energy
Shorter wavelength

RED SHIFT
Lower frequency
Lower energy
Longer wavelength









This is How…

1. Masses, periods, and velocities are related through Kepler's 3rd Law
2. We use binary stars to measure star masses, and then use comparison methods to estimate masses of individual stars

Recall: ***Doppler Shift*** tells only if it is moving toward or away

Measuring Intrinsic Star properties:

Luminosity – measure the brightness of a star and then measure the distance to the star. Compute luminosity from inverse square law.

Brightness is measured by adding up light energy measured and correcting for telescope size and length of exposure. Distance is determined using the method of parallax. (Brightness and distance are apparent properties, not intrinsic)

Masses of stars are measured by measuring their velocities and periods in binary systems. We use the Doppler Effect to measure the star's velocities and the periods of the orbits. We then compute the masses from Kepler's 3rd Law.