Stars, Galaxies & the Universe Announcements

- **HW#3 – due Tuesday (Tomorrow) at 3 pm**
- **Lab Observing Trip – Tues (9/28) & Thurs (9/30)**
- First Exam – next Wed. (9/22) in class

- will post review sheet, practice exam on website

Stars, Galaxies & the Universe Observing Highlights

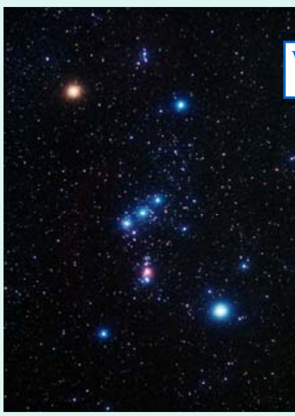
Stars, Galaxies & the Universe Lecture Outline

- Reading Quiz (Quiz 3)

-Basic Properties of Stars!
  - Names
  - Distances
  - Brightness
  - Color/Temperature/Spectra (Wed)

Measuring stars:

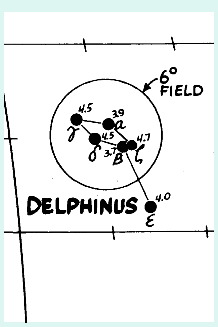
Luminosity, size, distance,
Temperature, age, composition



What properties might we want to know about stars?

- **luminosity**
- **distance**
- **radius**
- **temperature**
- **velocity through space**
- **companion or alone?**

Properties of Stars: Star Names



- refer to Greek, Latin, Arabic names of constellations

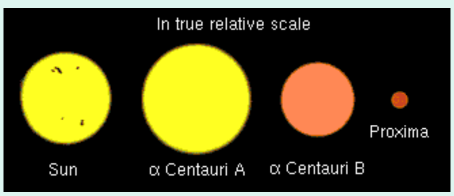
- pair a Greek letter with name representing the brightness *(alpha, beta, gamma, delta…)*

- “catalog” names from various space missions
  (e.g. IRAS 06429-1639)

- stars often have multiple names

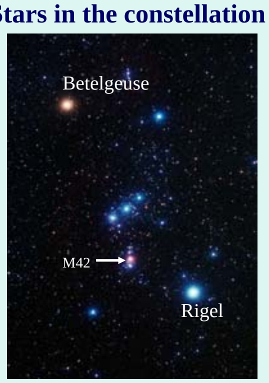
Astronomers do not use “name a star” services!

Stellar Properties: Distance



distance: 1 AU 4.35 ly 4.22 ly

Stars in the constellation Orion

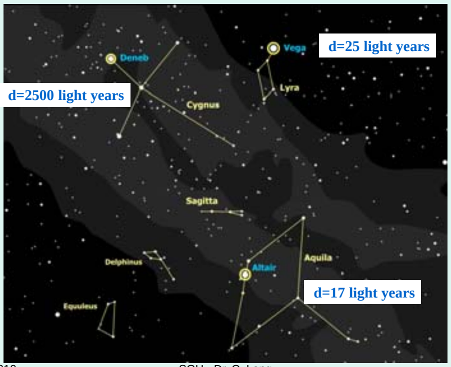


Rigel d = 773 ly
- B8
- 700,000x more LUMINOUS than Sun
- 0.2x as bright as Sirius

Betelgeuse d=427 ly
- very red
- “red giant”
- 135,000x L_{sun}
- cooler than Sun
- radius past ~5 AU

Stars in constellations are not necessarily at the same distance

Stars in the constellation Orion



Properties of Stars: Distances

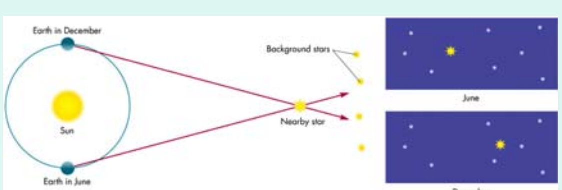
DISTANCE is the fundamental piece of information to know about an astronomical object!

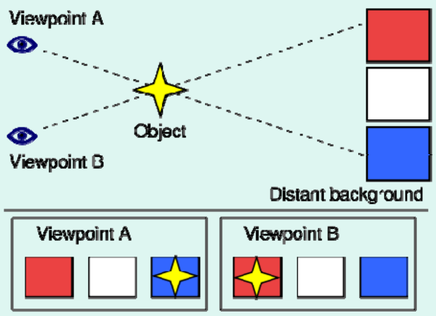
WHY?

- to convert angular size into physical size
- in order to know the intrinsic energy output (or "Luminosity") of a star, you need its distance
- "flux" is what we measure, need to convert that into Luminosity

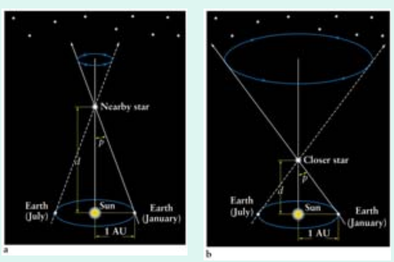
Parallax

• as Earth orbits the Sun, stars appear to change positions against "fixed" background stars
• due to our motion around the Sun
• eye sees about 1' in resolution, so not apparent to naked-eye observers (early Greek astronomers)





Parallax



- all parallaxes are less than 1 arcsecond
- LARGER parallaxes for closer stars
- SMALLER parallaxes for distant stars

The nearest star has a distance of 4.2 light years, which is 1.3 pc. Its parallax angle is 0.77" --small!

Parallax

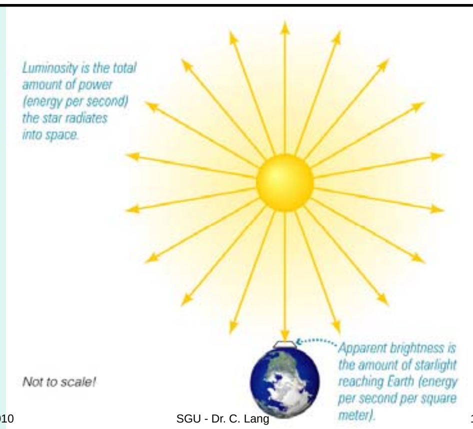
- Very tiny parallax angles difficult to measure from Earth due to smearing of the atmosphere
- *HIPPARCOS* satellite able to measure parallaxes for 118,000 stars. this group only represents the very closest stars !
- However, MOST stars in our Galaxy are TOO distant to see any noticeable parallax and for distant galaxies, can't use parallax!

Measuring stars:

Brightness, parallax

What we'd like to know:

Luminosity, size, distance, Temperature, age, composition



Properties of Stars: Brightness

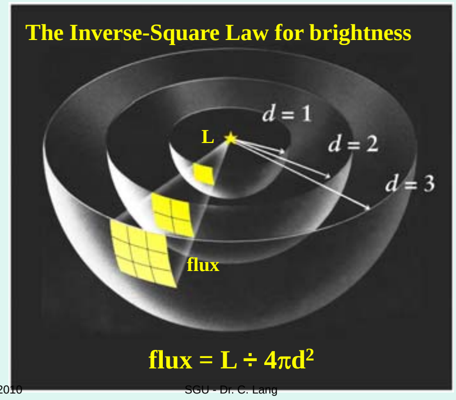
- the brightness we observe from a star or a galaxy is known as "flux"

- "flux" depends on the objects' **distance**

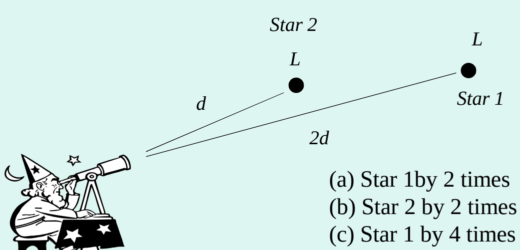
→ the more distant the object, the less bright
→ the closer the object, the more bright

- *The object's **intrinsic energy** does not change!*

→ if the Sun were at the distance of a nearby star (~10 pc) it would *barely* be visible with the naked eye !!

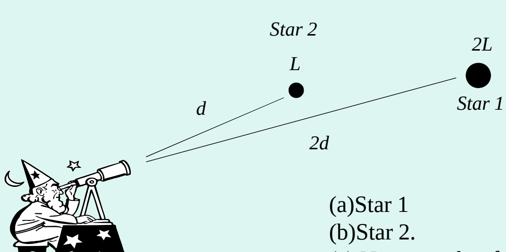


Distance-Luminosity relation:
Which star appears brighter to the observer
and by how much?



(a) Star 1by 2 times
(b) Star 2 by 2 times
(c) Star 1 by 4 times
(d) Star 2 by 4 times

Trickier: Distance-Luminosity relation:
Which star appears brighter to the observer?



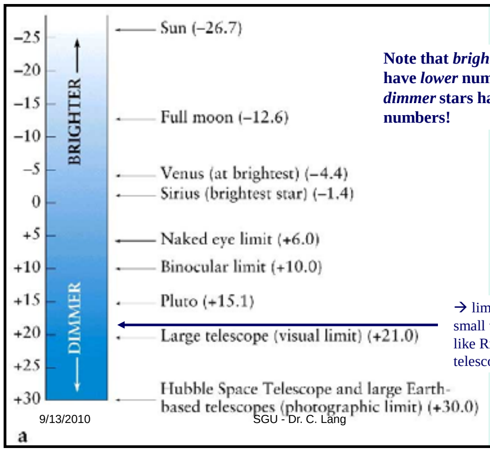
(a)Star 1
(b)Star 2.
(c) Not enough info.

Brightness of stars

- The brightness of a star is a measure of its flux.
- Ptolemy (150 A.D.) grouped stars into 6 `magnitude' groups according to how bright they looked to his eye. Human eyes have a logarithmic response to light.

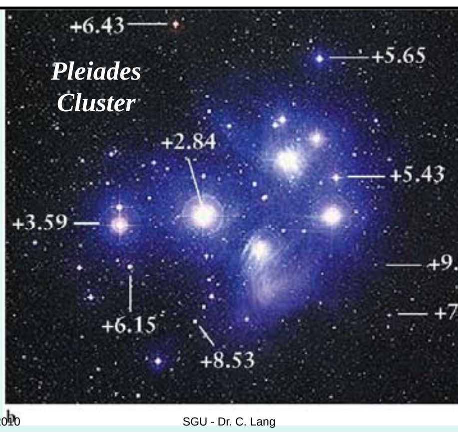
→ Range of eye is magnitude 1 (brightest) to 6 (limit!)
→ Change in magnitude of 1 means 2.5 brighter/dimmer

- Herschel (1800s) first measured the brightness of stars quantitatively and matched his measurements onto Ptolemy's magnitude groups and assigned a number for the magnitude of each star.



Note that *brighter* stars have *lower* numbers, and *dimmer* stars have *higher* numbers!

→ limit of +19 small telescope like Rigel, robotic telescope in AZ



Flux and Apparent Magnitude

Consider two stars, 1 and 2, with apparent magnitudes m_1 and m_2 and fluxes F_1 and F_2. The relation between apparent magnitude and flux is:

$$m_1 - m_2 = -2.5\log_{10}\left(\frac{F_1}{F_2}\right)$$

$$\frac{F_1}{F_2} = 10^{(m_2 - m_1)/2.5}$$

For m_2 - m_1 = 5, F_1/F_2 = 100.

Absolute magnitude

- To talk about the properties of star, independent of how far they happen to be from Earth, we use “absolute magnitude”.
- Absolute magnitude is the magnitude that a star would have viewed from a distance of 10 parsecs.
- Absolute magnitude is directly related to the luminosity of the star.

Star	Apparent magnitude	Distance (parsecs)	Absolute magnitude	Luminosity (relative to Sun)
Sun	-26.8		4.8	
Full Moon	-12.6			
Venus	-4.4			
Sirius	-1.44	2.64	1.45	22.5
Arcturus	-0.05	11.25	-0.31	114
Vega	0.03	7.76	0.58	50.1
Spica	0.98	80.40	-3.55	2250
Barnard's Star	9.54	1.82	13.24	1/2310
Proxima Centauri	11.01	1.30	15.45	1/17700

How do Spica and Sirius compare:

(a)as observed from Earth [apparent magnitude]

(b) Intrinsically [luminosity]?

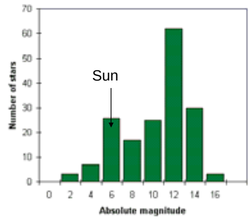


Figure 2. The frequency distribution of the absolute magnitudes of all stars within 10 parsecs of the Sun (from the Hipparcos database).

Stars come in a wide variety of temperatures and sizes

- Stellar temperatures: ~2500 K – 75,000 K!
- Small stars will have low luminosities unless they are very hot.
- Stars with low surface temperatures must be very large in order to have large luminosities.

Stars come in a wide variety of sizes

Stefan-Boltzmann law relates POWER to temperature
→ very strongly related to temperature

POWER per area ~ σT^4

Star's LUMINOSITY =
→ POWER per area * surface area

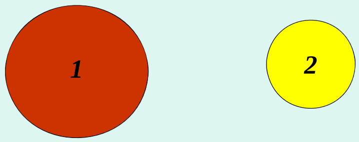
Star's LUMINOSITY can be related to its temperature and size.

LUMINOSITY = $4\pi R^2 \sigma T^4$

LUMINOSITY *is measured in joules per square meter of a surface per second and* $\sigma = 5.67 \times 10^{-8}\ W\ m^{-2}\ K^{-4}$

or in cgs: $\sigma = 5.67 \times 10^{-5}$ *erg* cm^{-2} *sec* K^{-4}

Luminosity - Radius –Temperature Law



R = 2 Rsun

T = ½ T sun

R = Rsun

T = T sun

Which star is more luminous?

(Emits the most energy every second)

(a) Star 1
(b) Star 2

9/13/2010 SGU - Dr. C. Lang 31