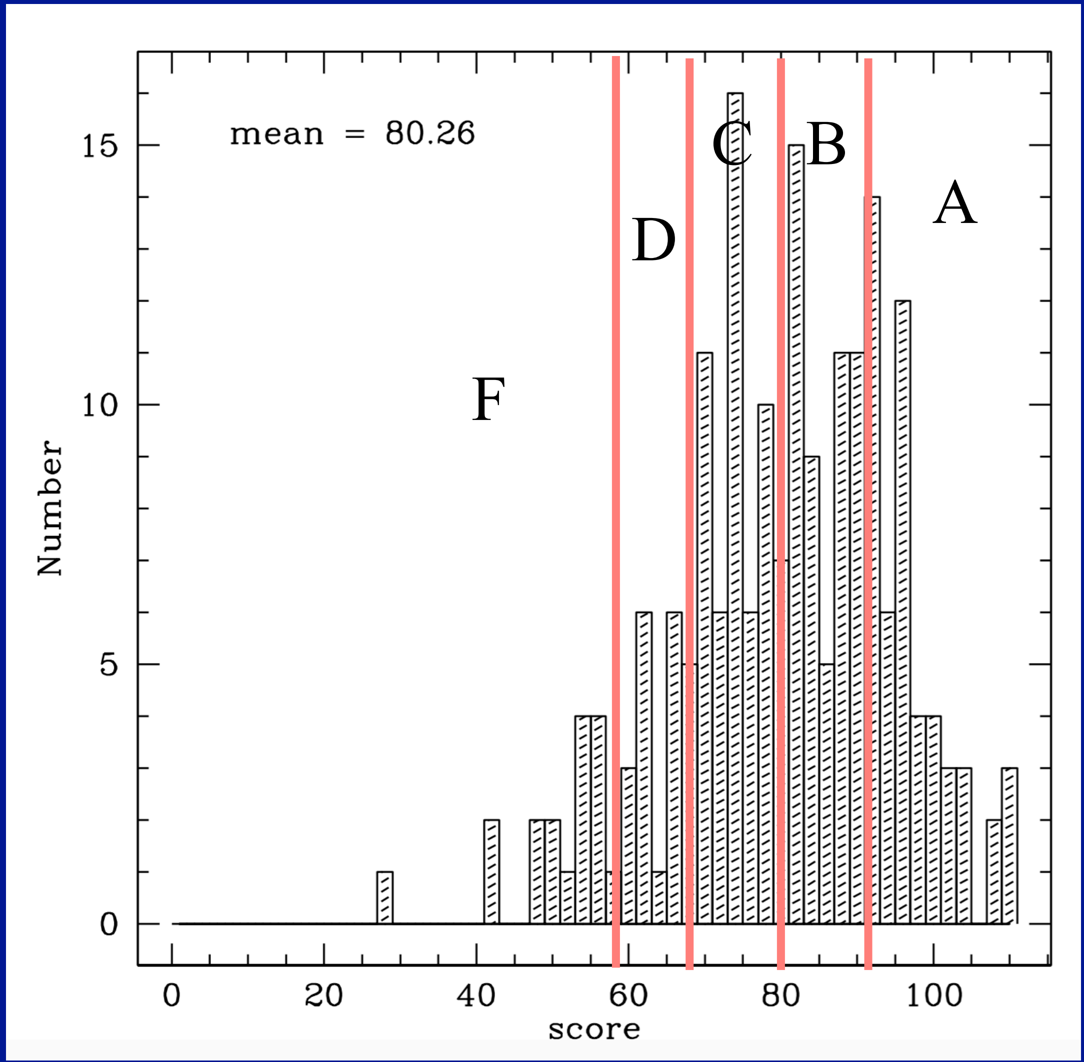
Test #2 results

Grades posted in UNM Learn

Along with current grade in the class



Clicker Question:

If the Earth had no Moon then what would happen to the tides?

A: The tides would not be as strong but would occur with the same frequency

B: There would be no tides

C: The tides would occur less often

D: The tides would occur more often

Clicker Question:

Earth’s rotation is slowing down because of the tidal interaction between Earth and the Moon at a rate of 2 milliseconds/century. If this rate remains constant at the present value, how long will it take for one day on Earth to become 2 seconds longer than it is now:

A: 1000 years

B: 100,000 years

C: 1 million years

D: 100 million years

Clicker Question:

Which of these moons of Jupiter has the highest density?

A: Io

B: Europa

C: Ganymede

D: Callisto

Note: You must take the pre-game survey. Download then enter Group code: **norton.beta.gtaylor1**

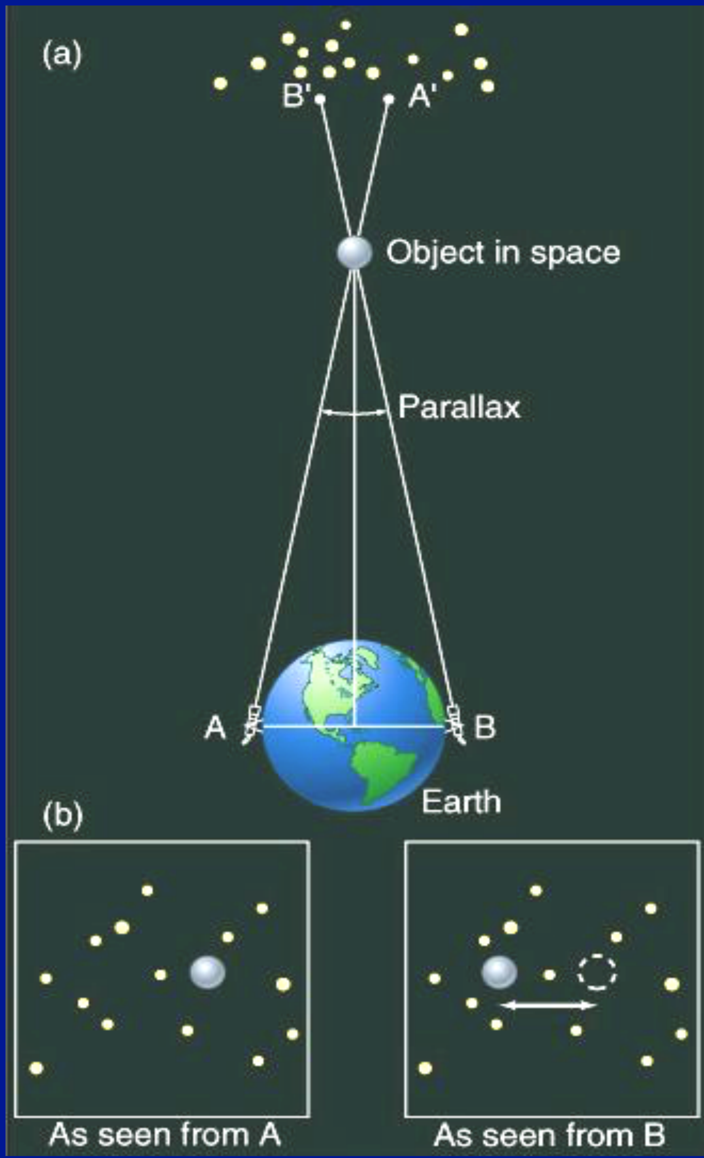
Measuring the Stars

How big are stars?
How far away are they?
How bright are they?
How hot?
How old, and how long do they live?
What is their chemical composition?
How are they moving?
Are they isolated or in clusters?

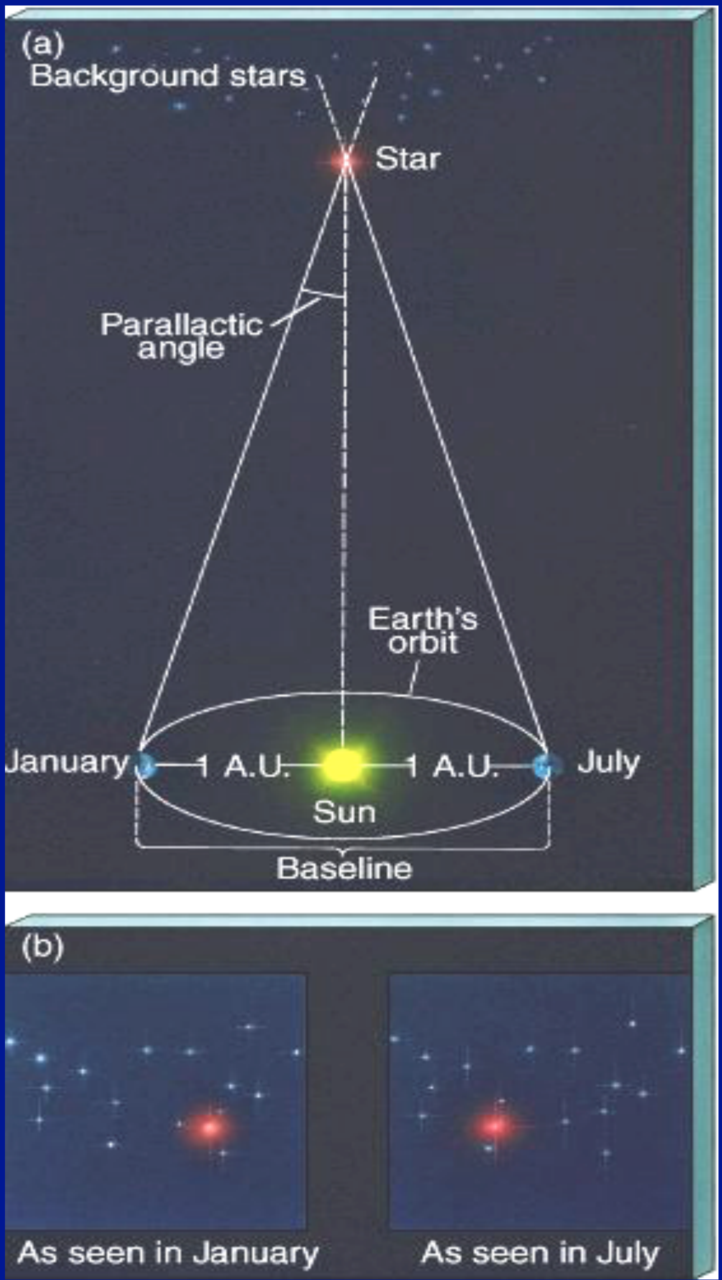
By answering these questions, we not only learn about stars, but about the structure and evolution of galaxies they live in, and the Universe.

How Far Away are the Stars?

Earth-baseline parallax - useful in Solar System



Earth-orbit parallax - useful for nearest stars



Parallax demo

New distance unit: the parsec (pc).

Using Earth-orbit parallax, if a star has a parallactic angle of 1",
it is 1 pc away.

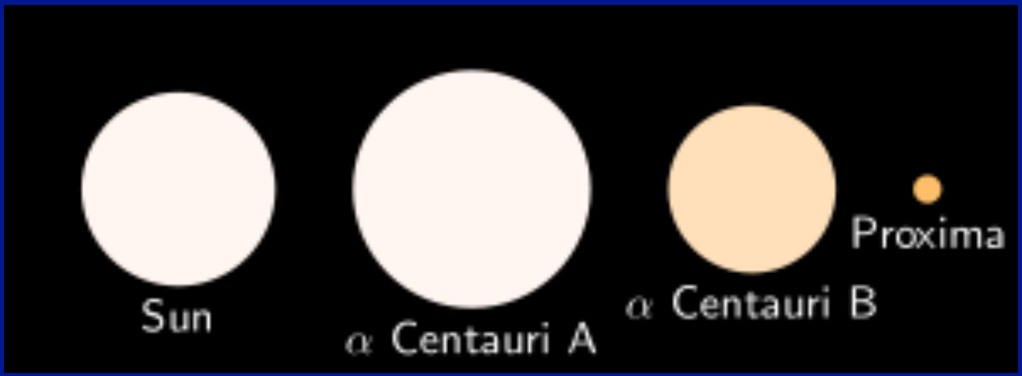
Remember 1" (arcsecond) = 1/60 arcmin = 1/3600 degrees

If the angle is 0.5", the distance is 2 pc.

$$\text{Distance (pc)} = \frac{1}{\text{Parallactic angle (arcsec)}}$$

Closest star to Sun is Proxima Centauri. Parallactic angle is 0.7", so distance is 1.3 pc.

1 pc = 3.3 light years
= 3.1×10^{18} cm
= 206,000 AU



1 kiloparsec (kpc) = 1000 pc
1 Megaparsec (Mpc) = 10^{6} pc

Earth-orbit parallax using ground-based optical telescopes is good for stars within 30 pc (1000 or so). Tiny volume of Milky Way galaxy. Other methods later.

Our nearest stellar neighbors (to 4 pc)

Astrometry of PMS stars

Loinard, Mioduszewski, Rodriguez, et al., 2005, ApJ, 619, 179.

HDE 283572

Proper motion

26.42 milliarcsec/yr

v = 16.9 km/s

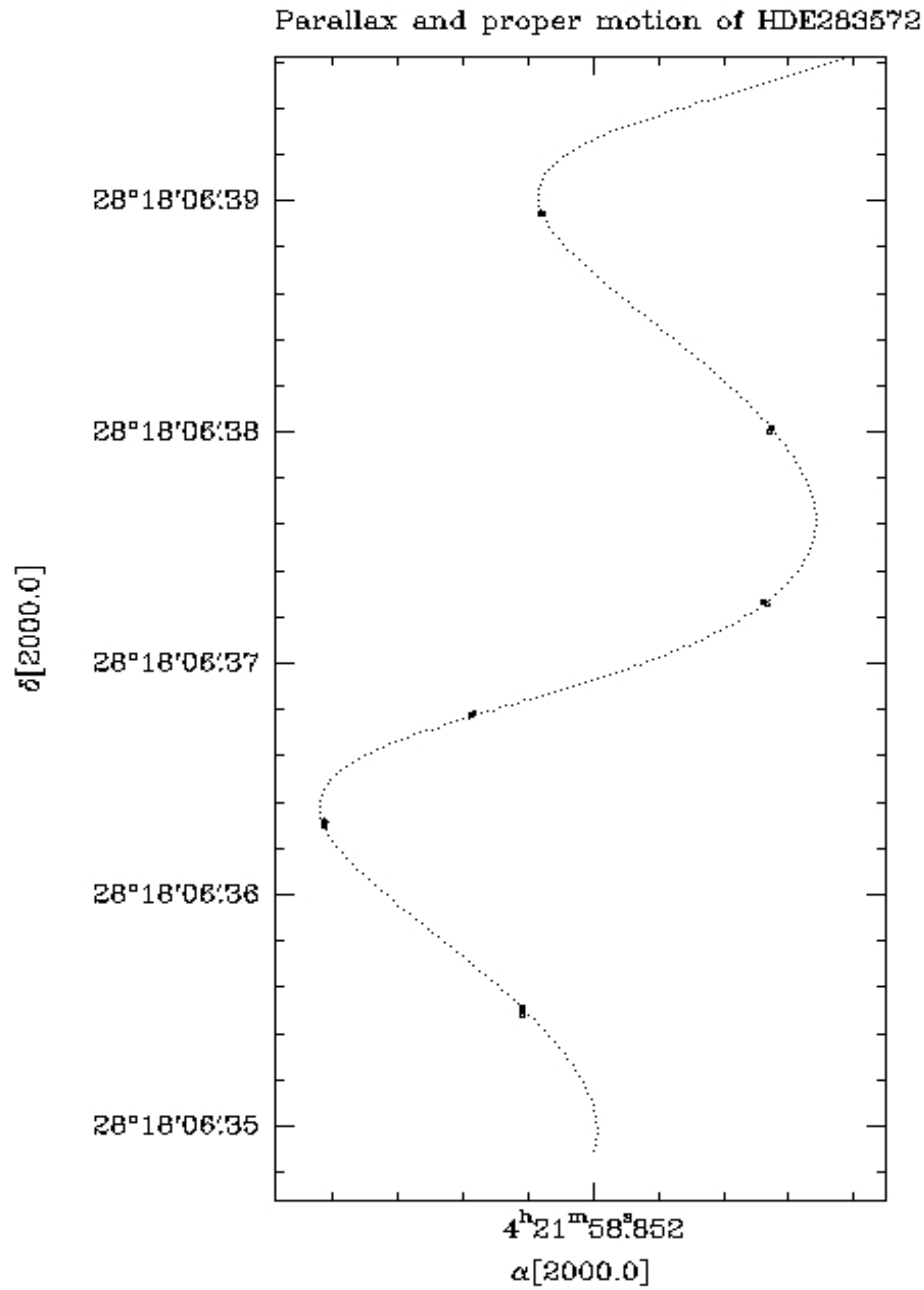
Parallax:

7.794 milliarcsec

Distance

128.3 parsecs

0.5% accuracy



Clicker Question:

Suppose we observe a star with an annual parallax of 667 milliarcseconds, what is its distance in parsecs?

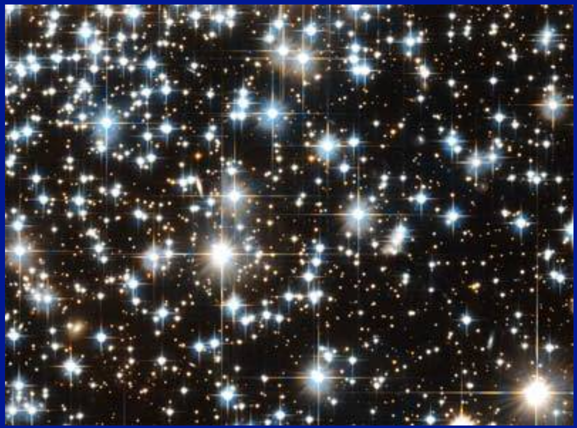
A: 100 parsecs

B: 1.5 parsecs

C: 0.1 parsecs

D: 0.01 parsecs

How Luminous are Stars?



Remember, luminosity of the Sun is

$$L_{Sun} = 4 \text{ x} 10^{33} \text{ erg/s}$$

(amount of energy put out every second in form of radiation).
Luminosity also called "absolute brightness".

How bright a star appears to us is the "apparent brightness", which depends on its luminosity and distance from us:

$$\text{apparent brightness} \quad \alpha \quad \frac{\text{luminosity}}{(\text{distance})^2}$$

So we can determine luminosity if apparent brightness and distance are measured:

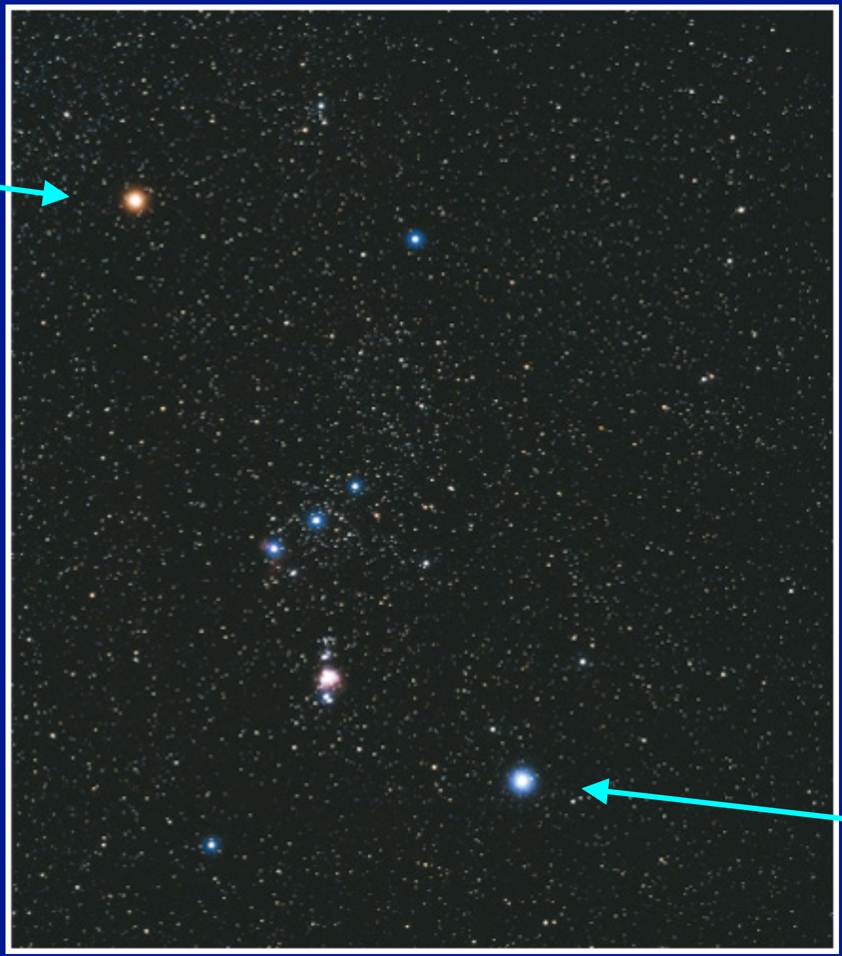
$$\text{luminosity} \quad \alpha \quad \text{apparent brightness x (distance)}^2$$

Please read about magnitude scale.

How Hot are Stars at the Surface?

Stars' spectra are roughly those of blackbodies. Color depends on surface temperature. A quantitative measure of "color", and thus temperature, can be made by observing star through various color filters.

Betelgeuse
T=3000 K
M1



Rigel
T=20,000 K
B8

Spectral Classes

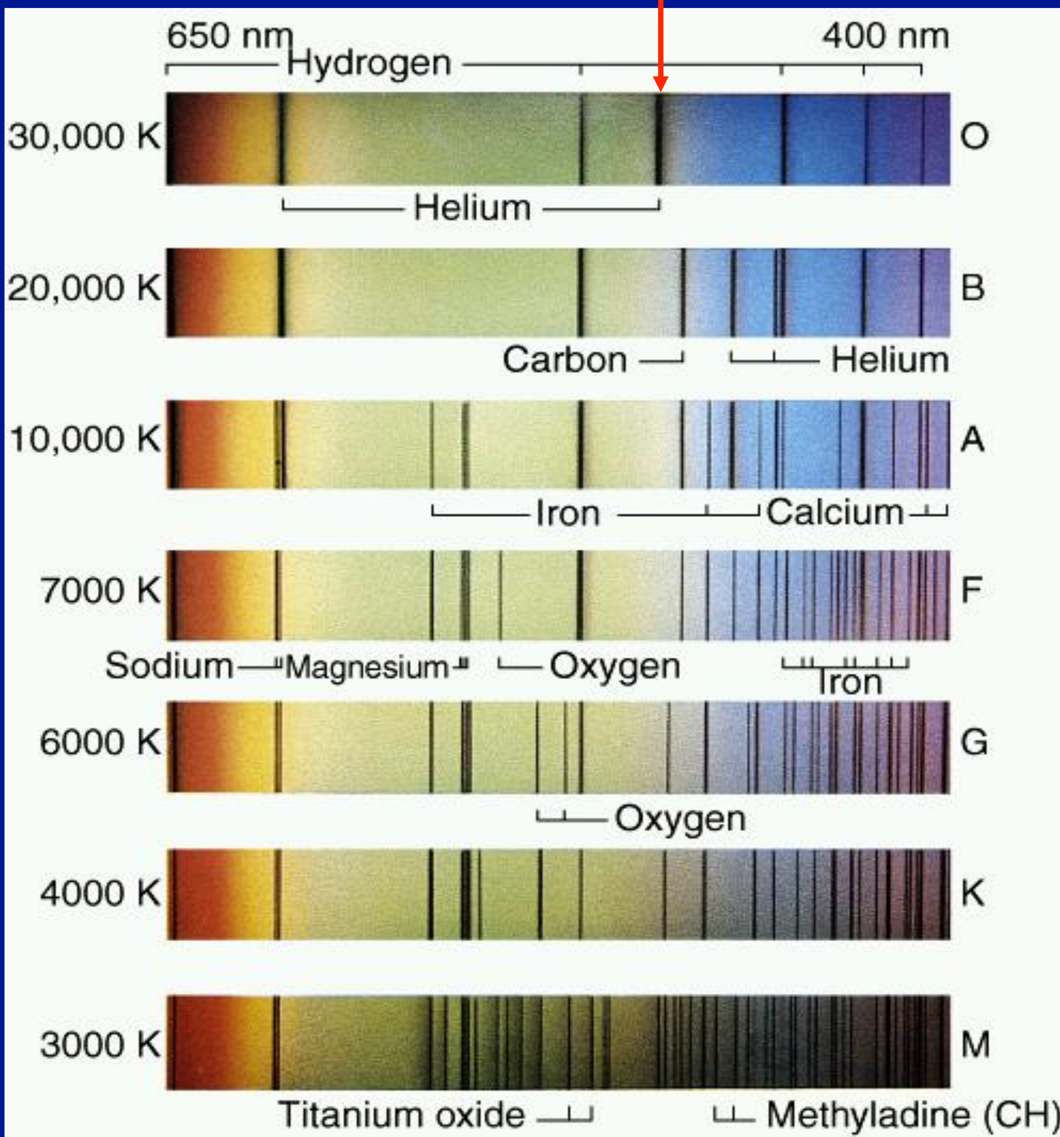
Strange lettering scheme is a historical accident.

Spectral Class	Surface Temperature	Examples
O	30,000 K	
B	20,000 K	Rigel
A	10,000 K	Vega, Sirius
F	7000 K	
G	6000 K	Sun
K	4000 K	
M	3000 K	Betelgeuse

Further subdivision: BO - B9, GO - G9, etc. GO hotter than G9.
Sun is a G2.

Classification of Stars Through Spectroscopy

Ionized helium. Requires extreme UV photons. Only hottest stars produce many of these.



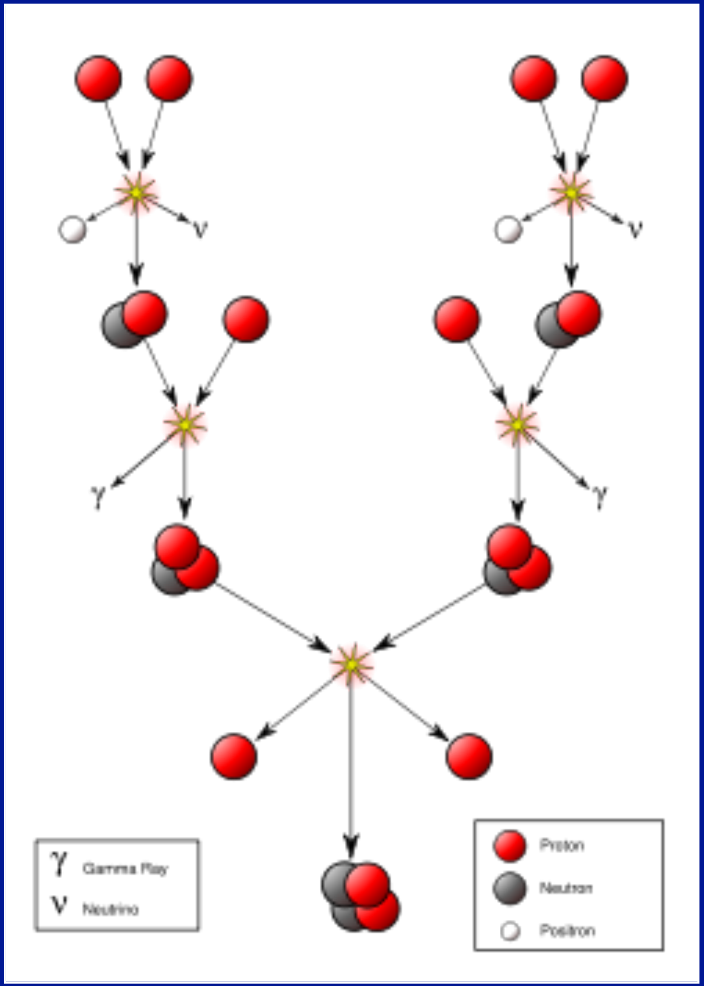
Remember: stellar spectra show black-body radiation and absorption lines.

Pattern of absorption lines depends on temperature (mainly) and chemical composition.

Spectra give most accurate info on these as well as:

density in atmosphere
gravity at surface
velocity of star towards or from us

Nuclear Fusion of H -> He in the Sun



Net result:

4 protons → ^{4}He + 2 neutrinos + energy

Mass of end products is less than mass of 4 protons by 0.7%. Mass converted to energy.

600 millions of tons per second fused. Takes billions of years to convert p's to ^{4}He in Sun's core. Process sets lifetime of stars.

Hydrostatic Equilibrium: pressure from fusion reactions balances gravity. Sun is stable.

Fusion as an Energy Source

Can we build fusion reactors on Earth to generate clean (no carbon dioxide) energy?

Maybe.

$^{2}H + {}^{3}H \rightarrow {}^{4}He$ + neutron + energy

JET tokomak

Trouble is

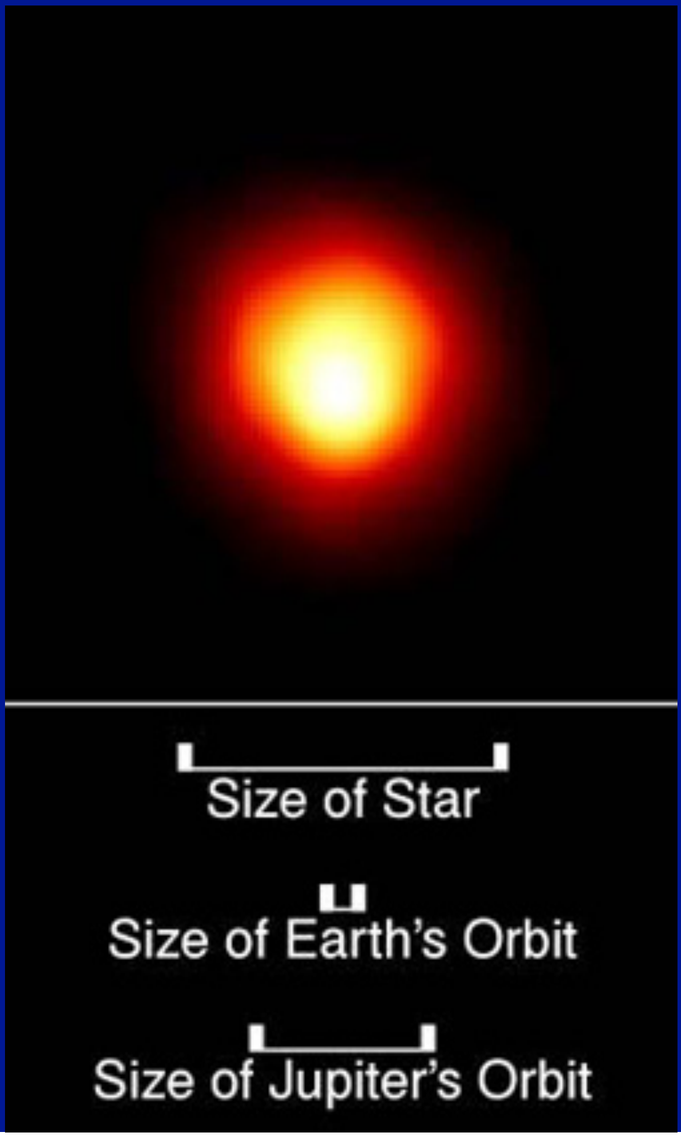
1) Confinement of the reaction
2) safely stopping the neutrons

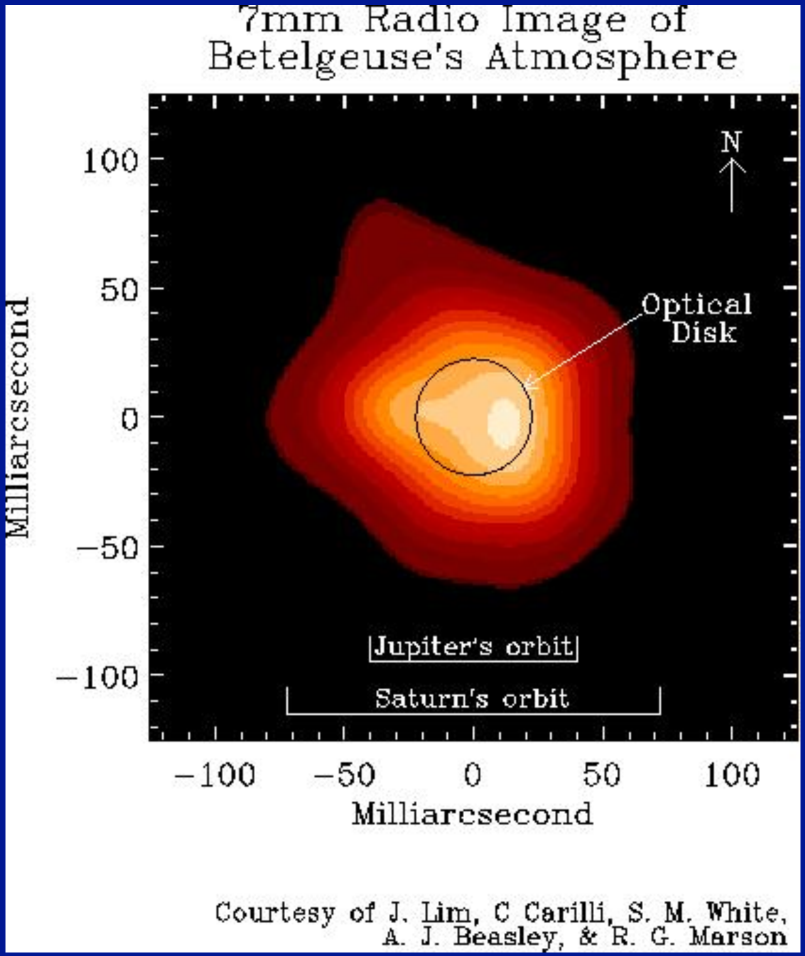
Methods:

1) Magnetic confinement (tokomaks) JET -> ITER -> DEMO
2) Inertial confinement (lasers)
3) Field Reversal Confinement (collision) p – ^{11}B

Stellar Sizes - Direct Measurement

For a few nearby giant stars we can image them directly using HST or the VLA. Almost all other stars are too far away





Stellar Sizes - Indirect Method

Almost all stars too far away to measure their radii directly. Need indirect method. For blackbodies, use Stefan's Law:

Energy radiated per cm^2 of area on surface every second α T^4
(T = temperature at surface)

And:

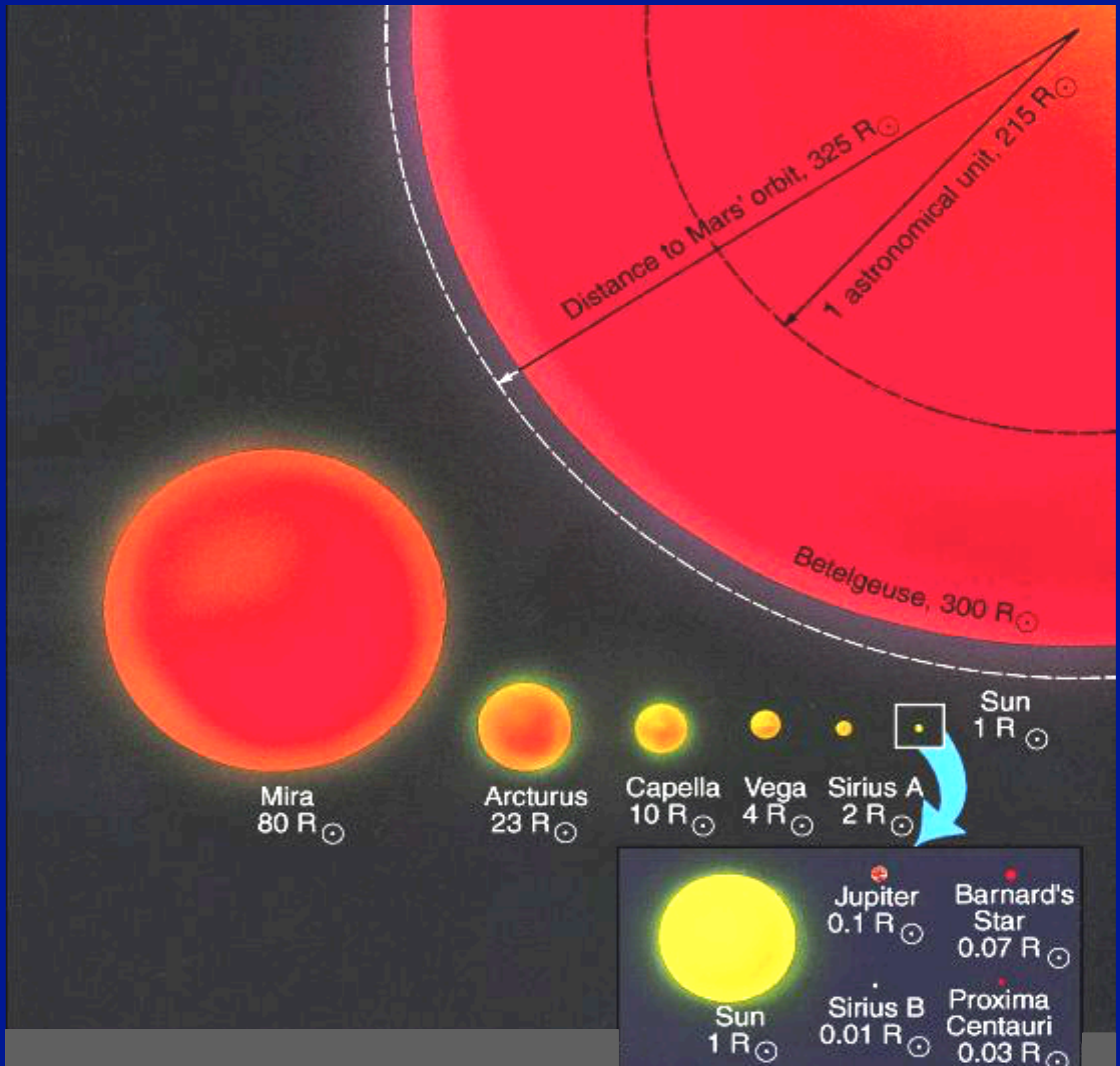
Luminosity = (energy radiated per cm^2 per sec) x (area of surface in cm^2)

So:

Luminosity α (temperature)^4 x (surface area)

Determine luminosity from apparent brightness and distance, determine temperature from spectrum (black-body curve or spectral lines), then find surface area, then find radius (sphere surface area is $4 \pi R^2$)

The Wide Range of Stellar Sizes



Clicker Question:

One parsec is about the same as:

A: 3 km

B: 3 light-years

C: 1 Astronomical Unit

D: The time it takes to make the Kessel Run

Clicker Question:

Suppose two stars (star A and star B) appeared equally bright but we knew that star A was 10 times further away, what do we know about the luminosity of star A?

A: The two stars have equal luminosity.

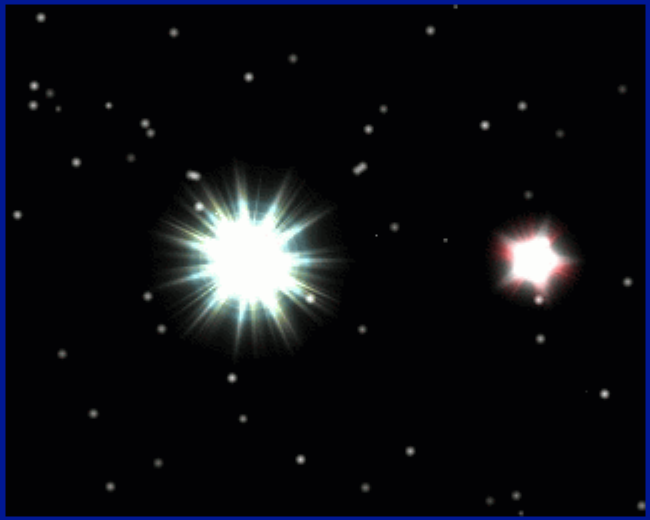
B: Star A is 10 times more luminous than star B.

C: Star A is 100 times more luminous than star B.

D: Star B is 10 times more luminous than star A.

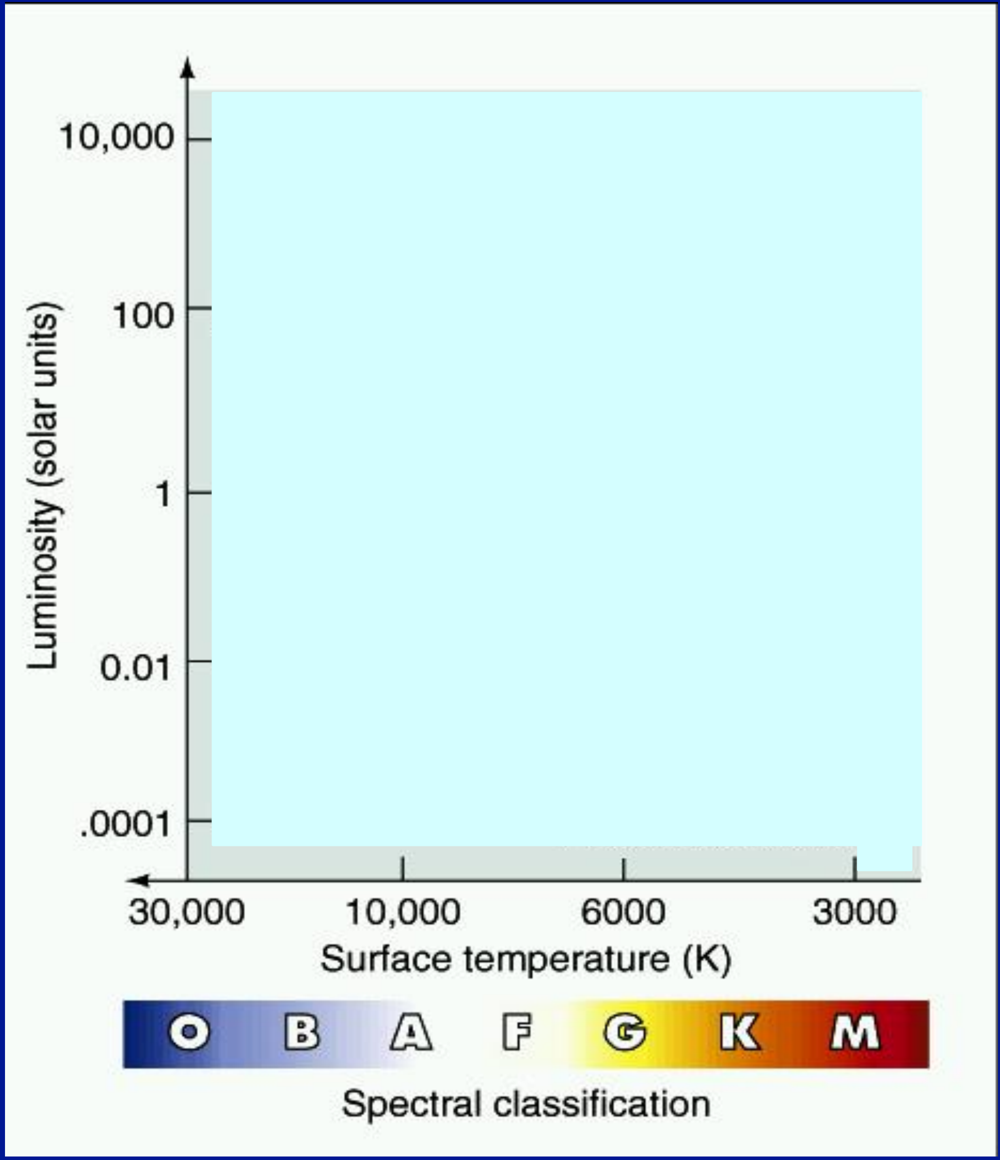
How Massive are Stars?

1. Binary Stars. Orbital period depends on masses of two stars and their separation.

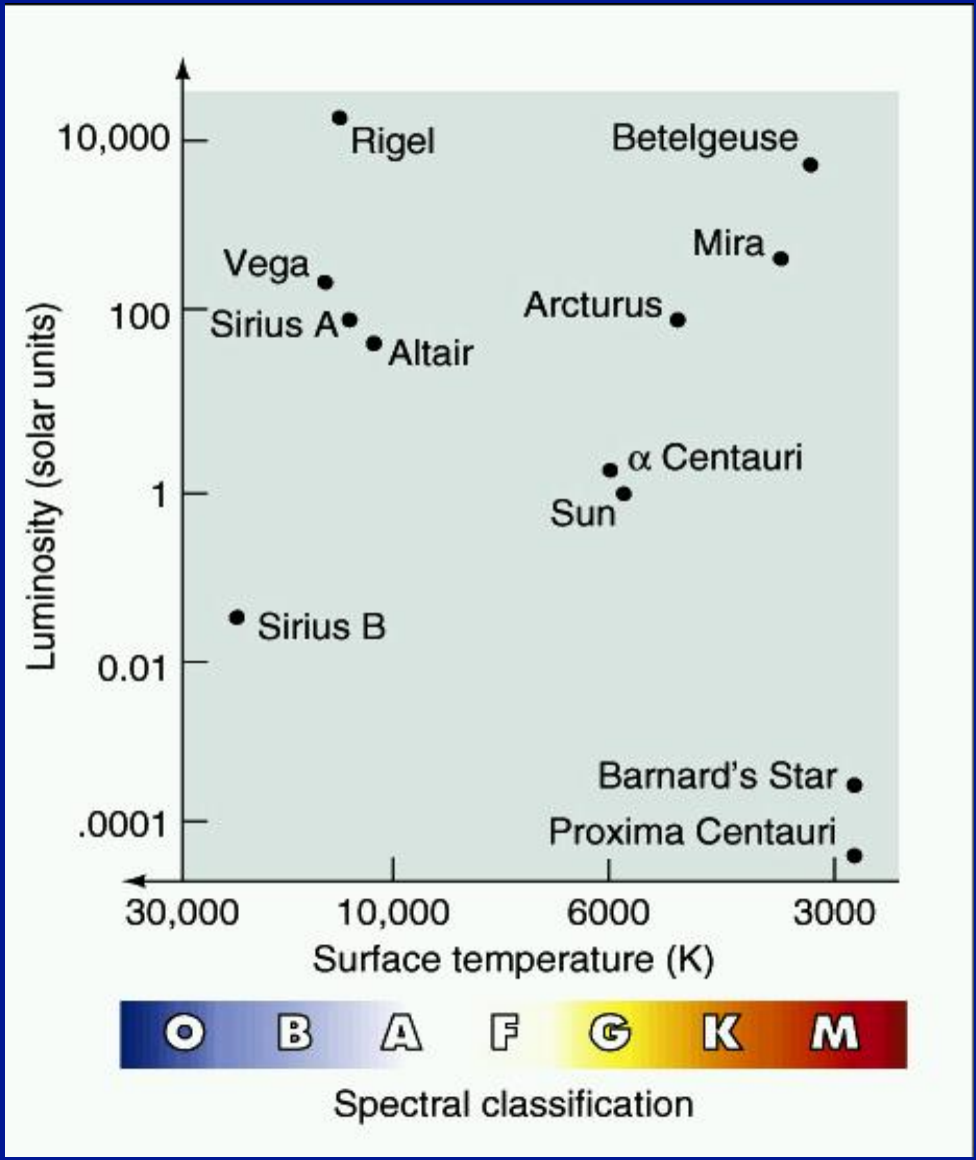


2. Theory of stellar structure and evolution. Tells how spectrum and color of star depend on mass.

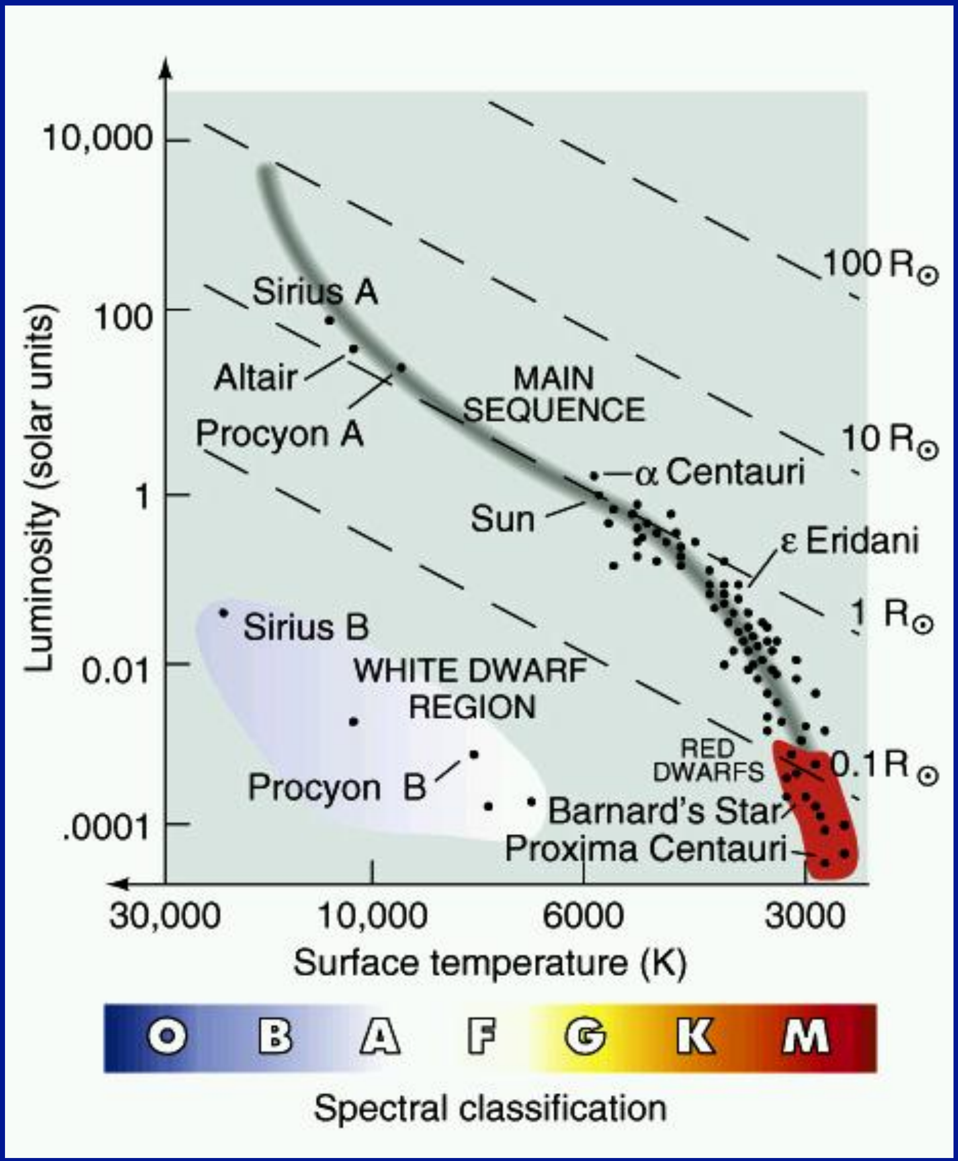
The Hertzsprung-Russell (H-R) Diagram



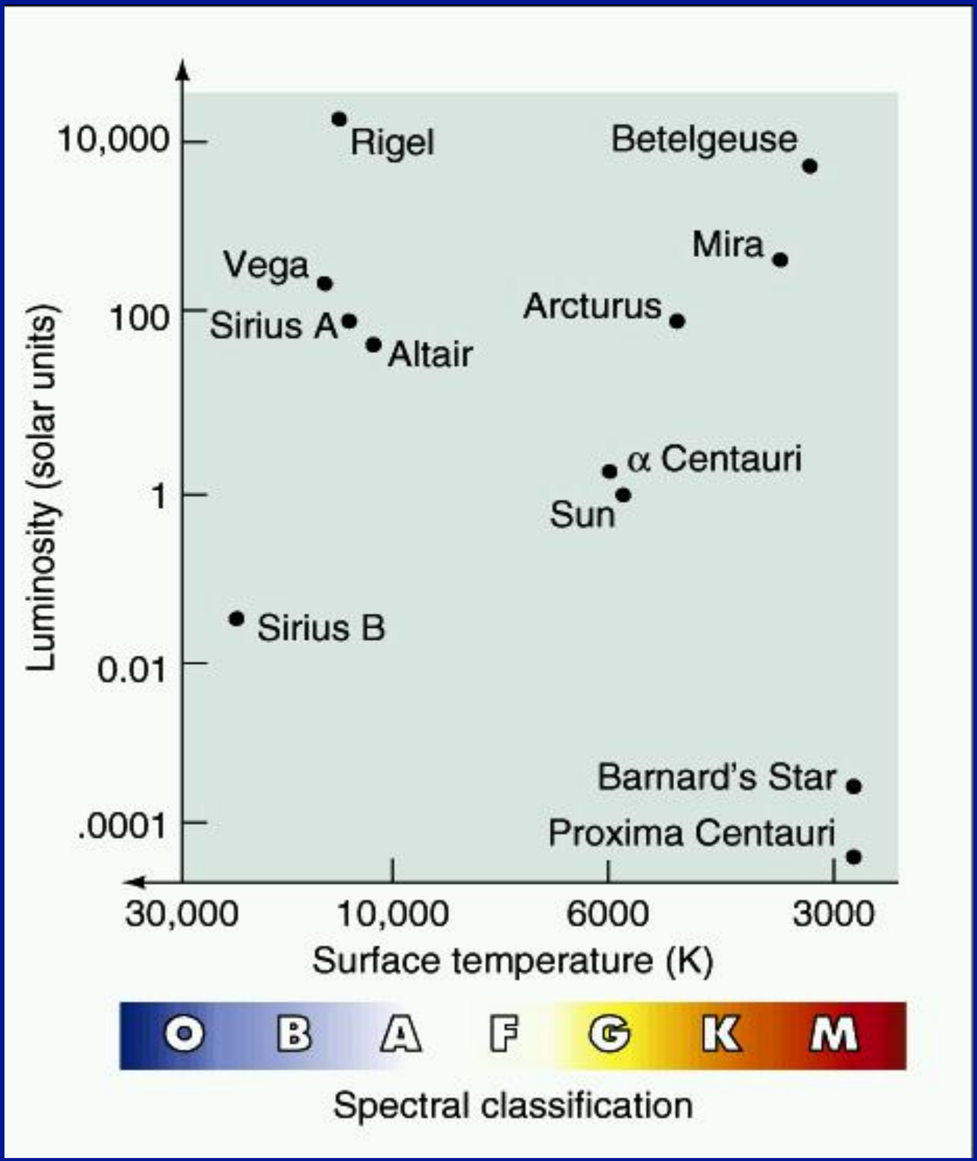
H-R Diagram of Well-known Stars



H-R Diagram of Nearby Stars

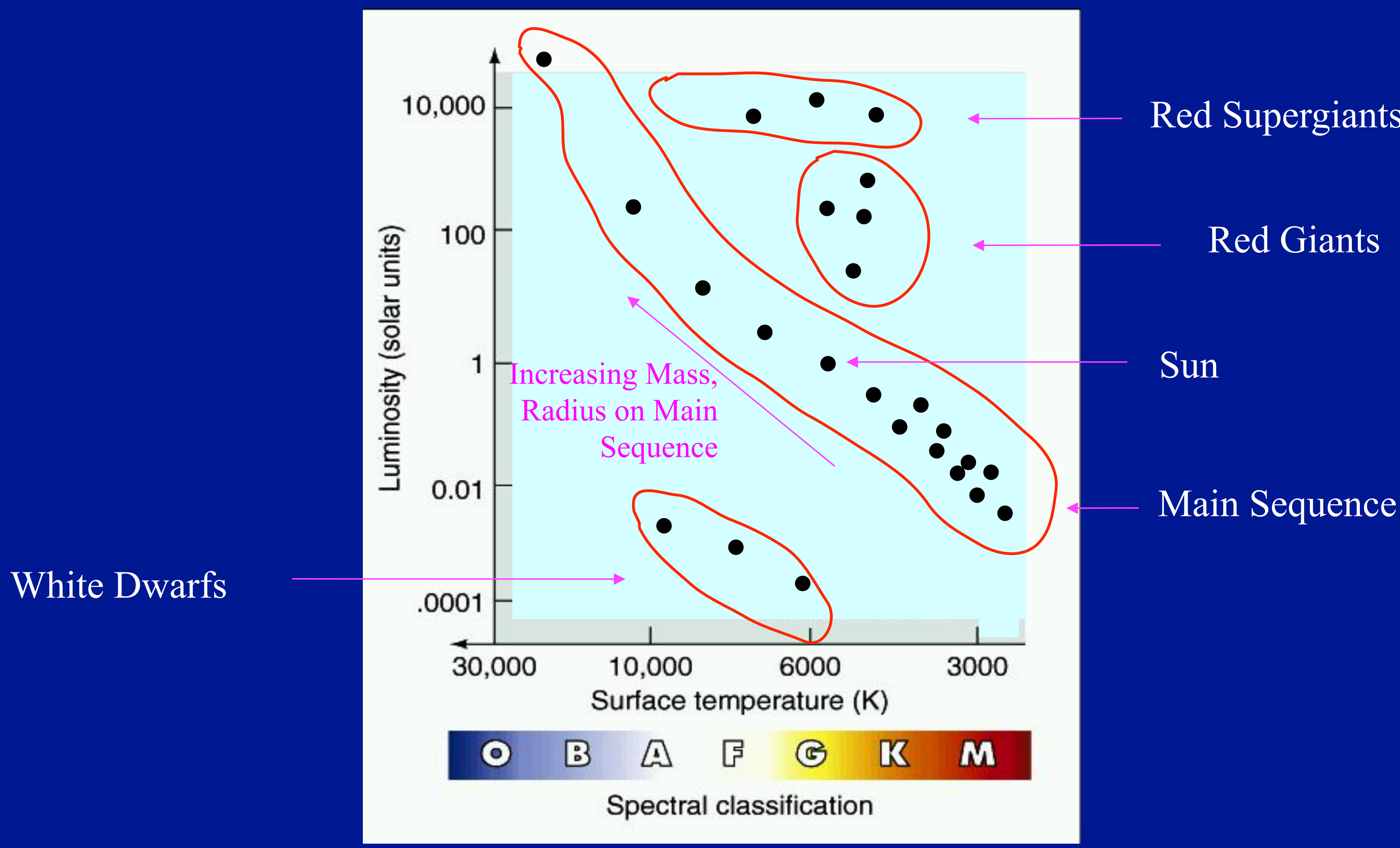


H-R Diagram of Well-known Stars



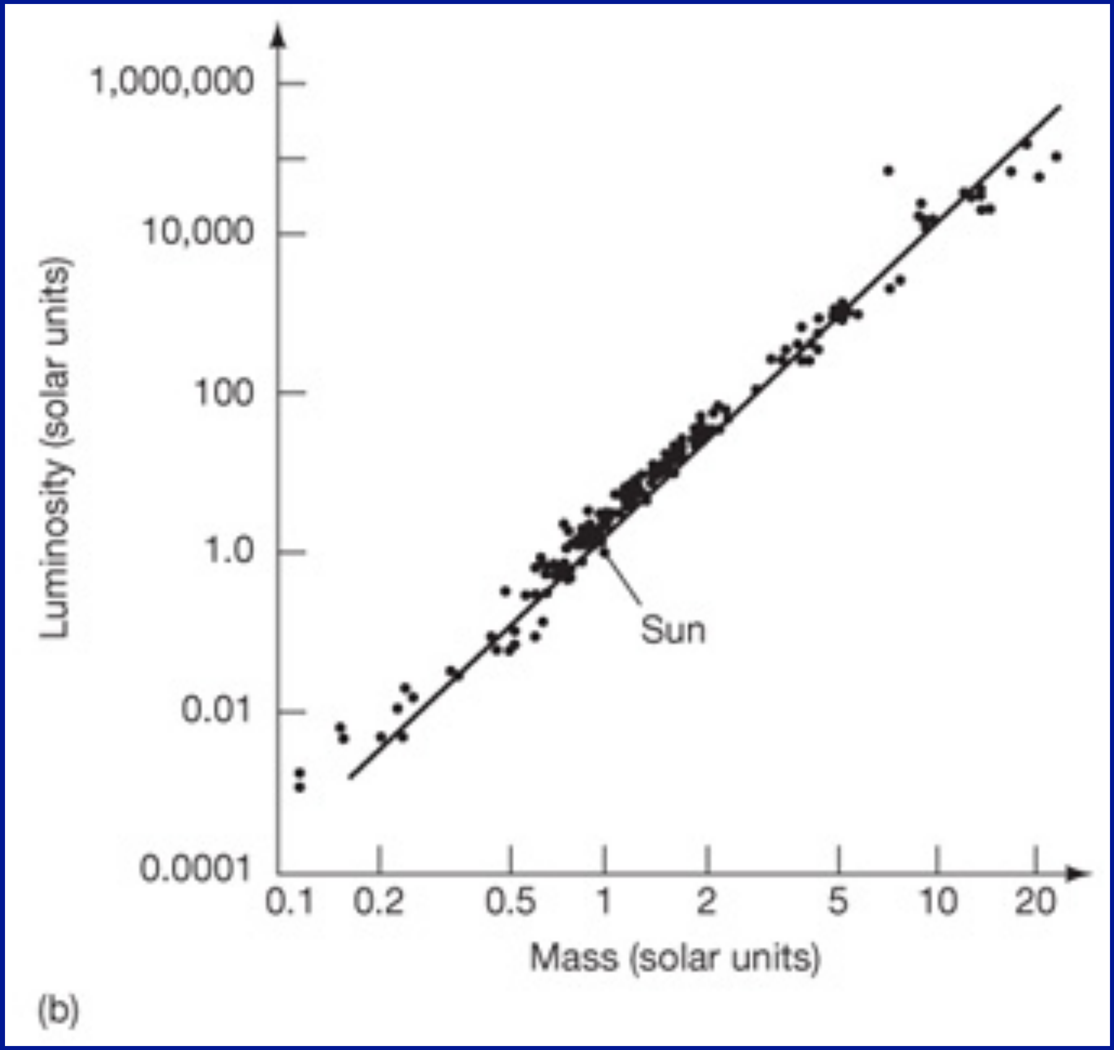
Note lines of constant radius!

The Hertzsprung-Russell (H-R) Diagram



How does a star's Luminosity depend on its Mass?

$$L \propto M^3$$



(Main Sequence stars only!)

How Long do Stars Live (as Main Sequence Stars)?

A star on Main Sequence has fusion of H to He in its core. How fast depends on mass of H available and rate of fusion. Mass of H in core depends on mass of star. Fusion rate is related to luminosity (fusion reactions make the radiation energy).

So,

$$\text{lifetime} \quad \alpha \quad \frac{\text{mass of core}}{\text{fusion rate}} \quad \alpha \quad \frac{\text{mass of star}}{\text{luminosity}}$$

Because luminosity α $(\text{mass})^3$,

$$\text{lifetime} \quad \alpha \quad \frac{\text{mass}}{(\text{mass})^3} \quad \text{or} \quad \frac{1}{(\text{mass})^2}$$

So if the Sun's lifetime is 10 billion years, a 30 M_{Sun} star's lifetime is only 10 million years. Such massive stars live only "briefly".

Clicker Question:

The HR diagram is a plot of stellar

A: mass vs diameter.

B: luminosity vs temperature

C: mass vs luminosity

D: temperature vs diameter

Clicker Question:

What would be the lifetime of a star one tenth as massive as our sun?

A: 1 billion years = 10^9 years

B: 10 billion years = 10^{10} years

C: 100 billion years = 10^{11} years

D: 1 trillion years = 10^{12} years

Star Clusters

Two kinds:

1) Open Clusters

-Example: The Pleiades

-10's to 100's of stars

-Few pc across

-Loose grouping of stars

-Tend to be young (10's to 100's of millions of years, not billions, but there are exceptions)

2) Globular Clusters

- few x 10 ^{5} or 10 ^{6} stars

- size about 50 pc

- very tightly packed, roughly spherical shape

- billions of years old

Clusters are crucial for stellar evolution studies because:

1) All stars in a cluster formed at about same time (so all have same age)

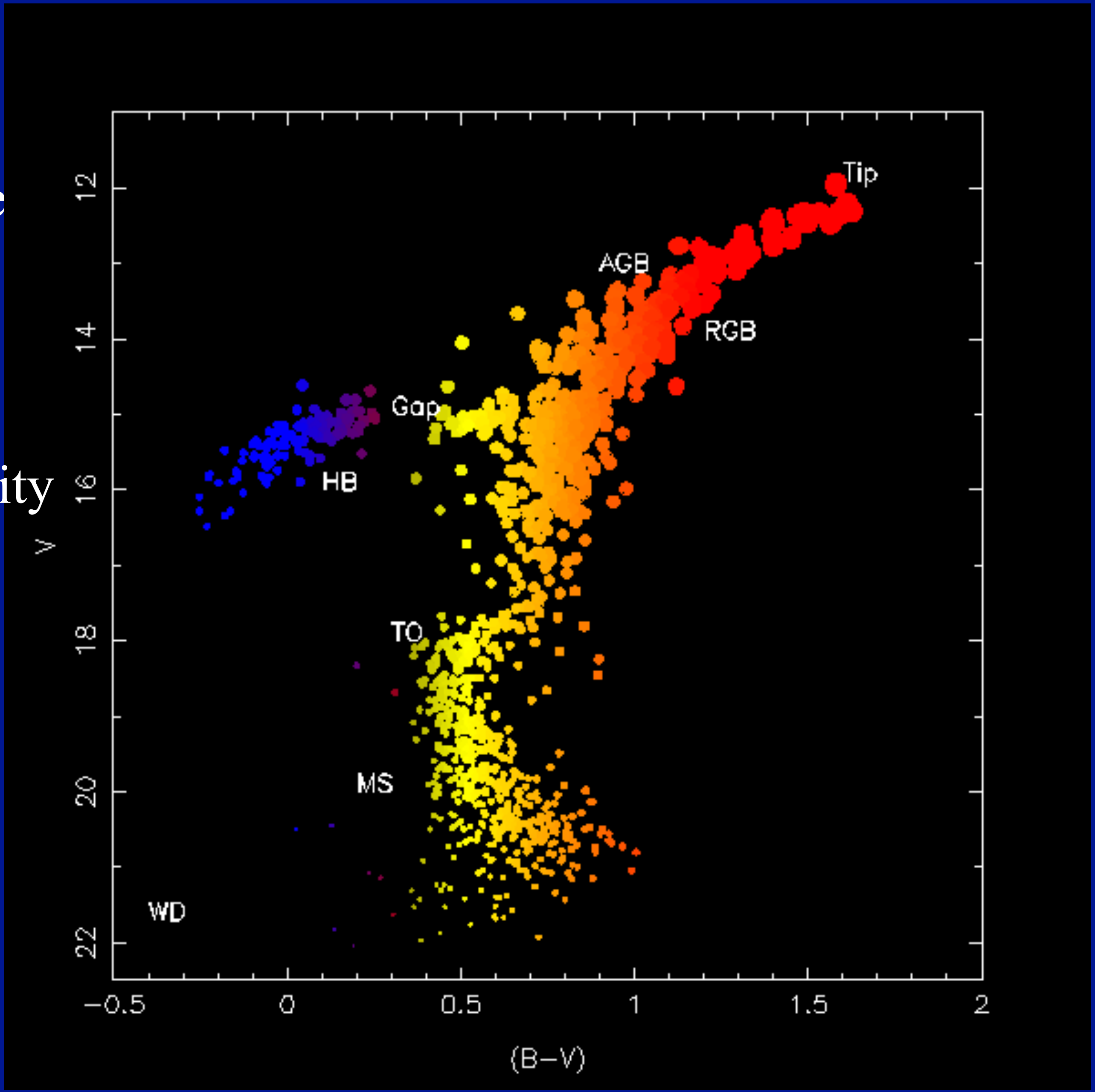
2) All stars are at about the same distance

3) All stars have same chemical composition

2) Globular Clusters

All stars about the same age
Differences all have to do with initial mass

Luminosity



Temperature