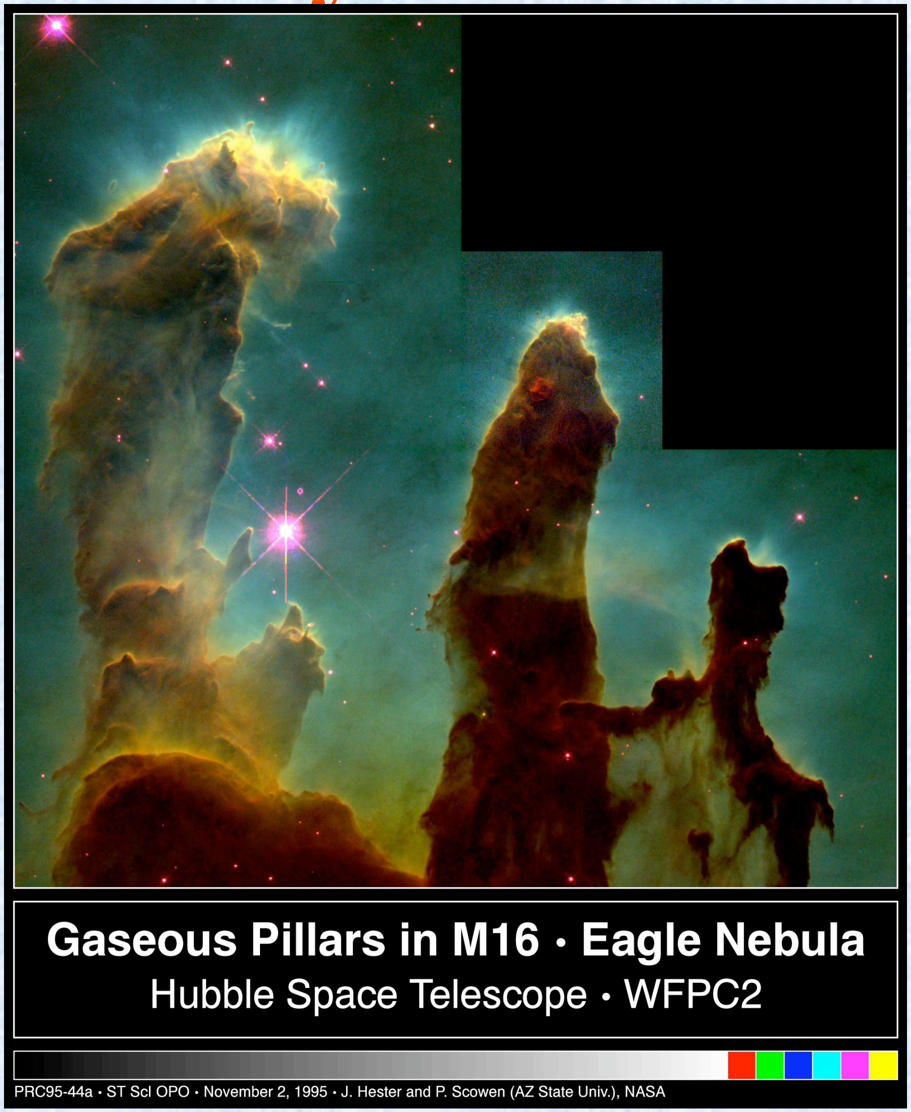
Astronomy 1 – Winter 2011



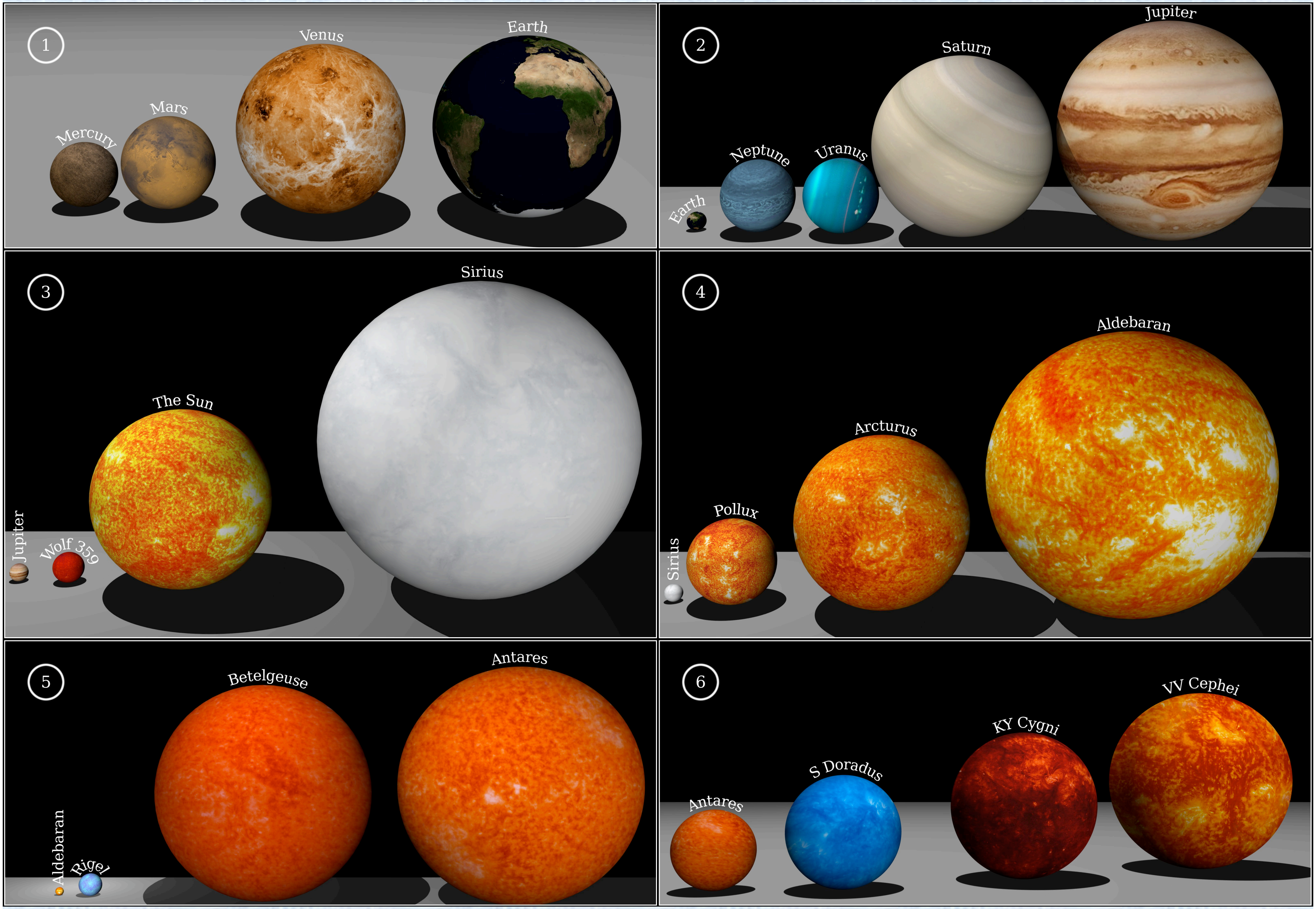
Lecture 20; February 25 2011

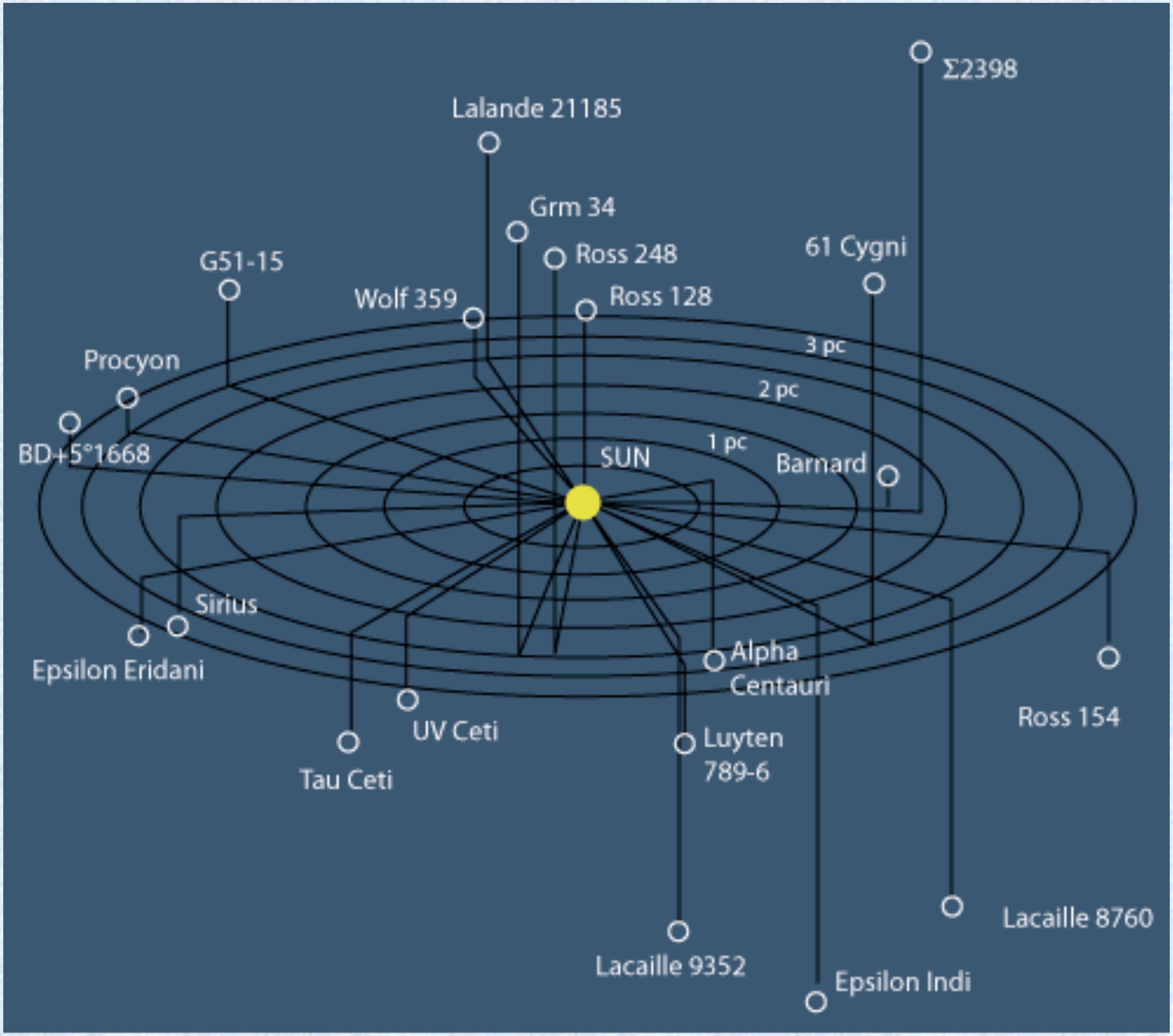
Previously on Astro-1

- The Sun
  - Internal structure
  - Energy source
  - Neutrinos and the solar neutrino problem
  - Sunspots and the sun cycle

Today on Astro-1

- **Introduction to stars**
- **Measuring Distances**
- **Inverse square law: luminosity vs brightness**
- **Colors and spectral types**
- **Masses of stars**


1
Mercury
Mars
Venus
Earth
2
Earth
Neptune
Uranus
Saturn
Jupiter
3
Jupiter
Wolf 359
The Sun
Sirius
4
Sirius
Pollux
Arcturus
Aldebaran
5
Aldebaran
Rigel
Betelgeuse
Antares
6
Antares
S Doradus
KY Cygni
VV Cephei



The closest stars to the sun.

But how do we know the distance to them?

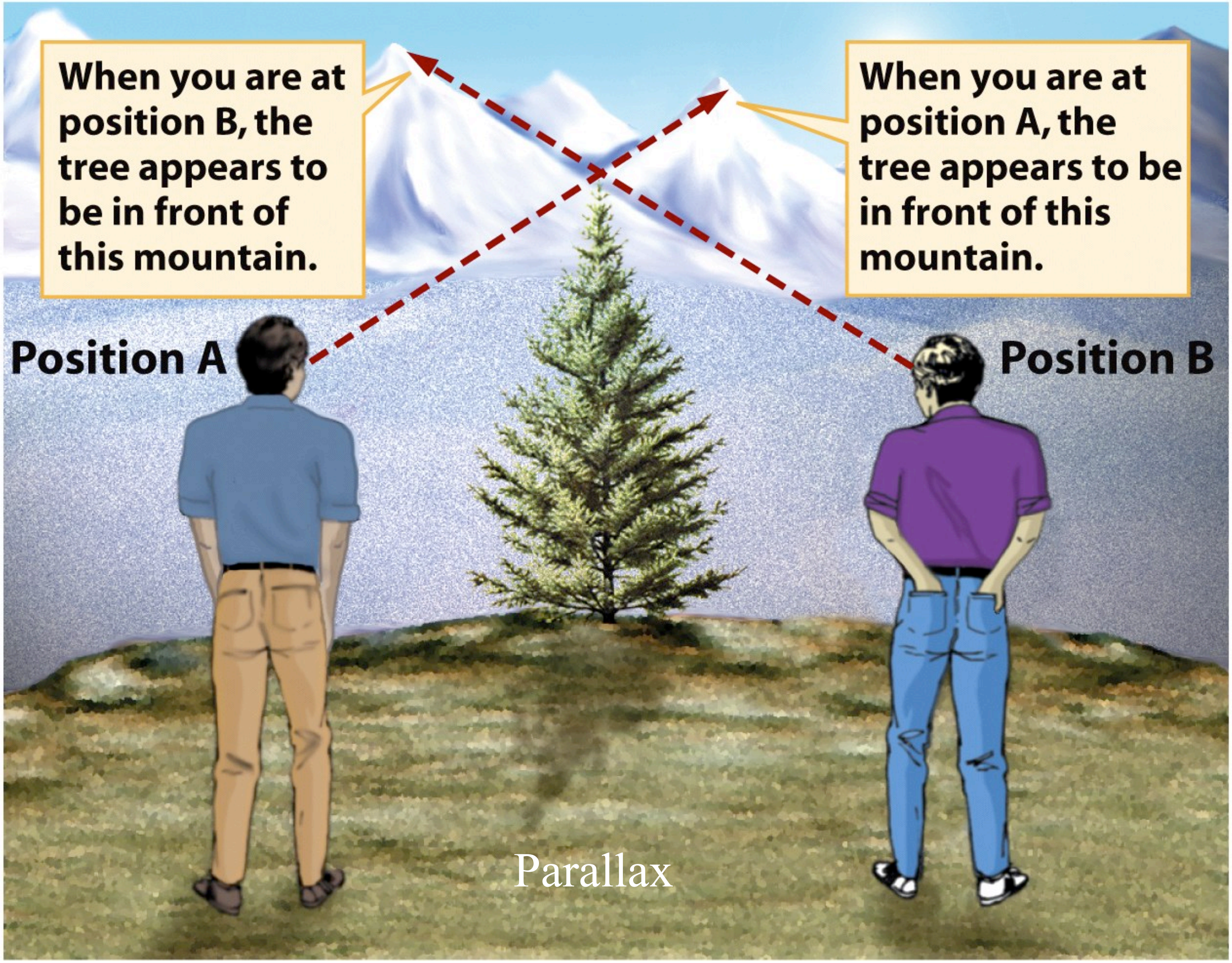


Figure 17-1
Universe, Eighth Edition

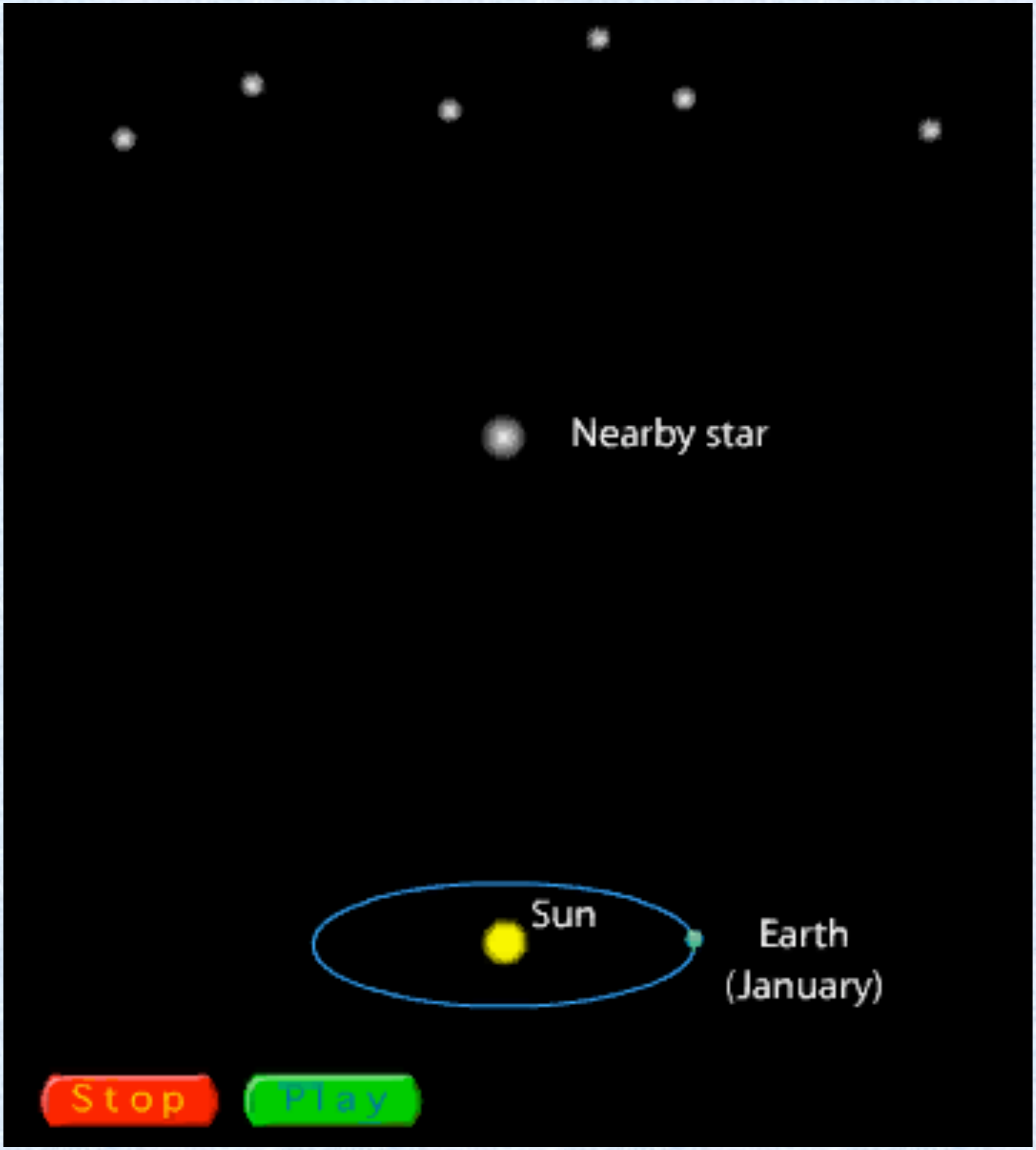
Parallax measuring the distance to a star

$d = 1/p$

p = parallax in arcsec

d = distance in parsecs

1 pc = 3.26 ly



Parallax measuring the distance to a star

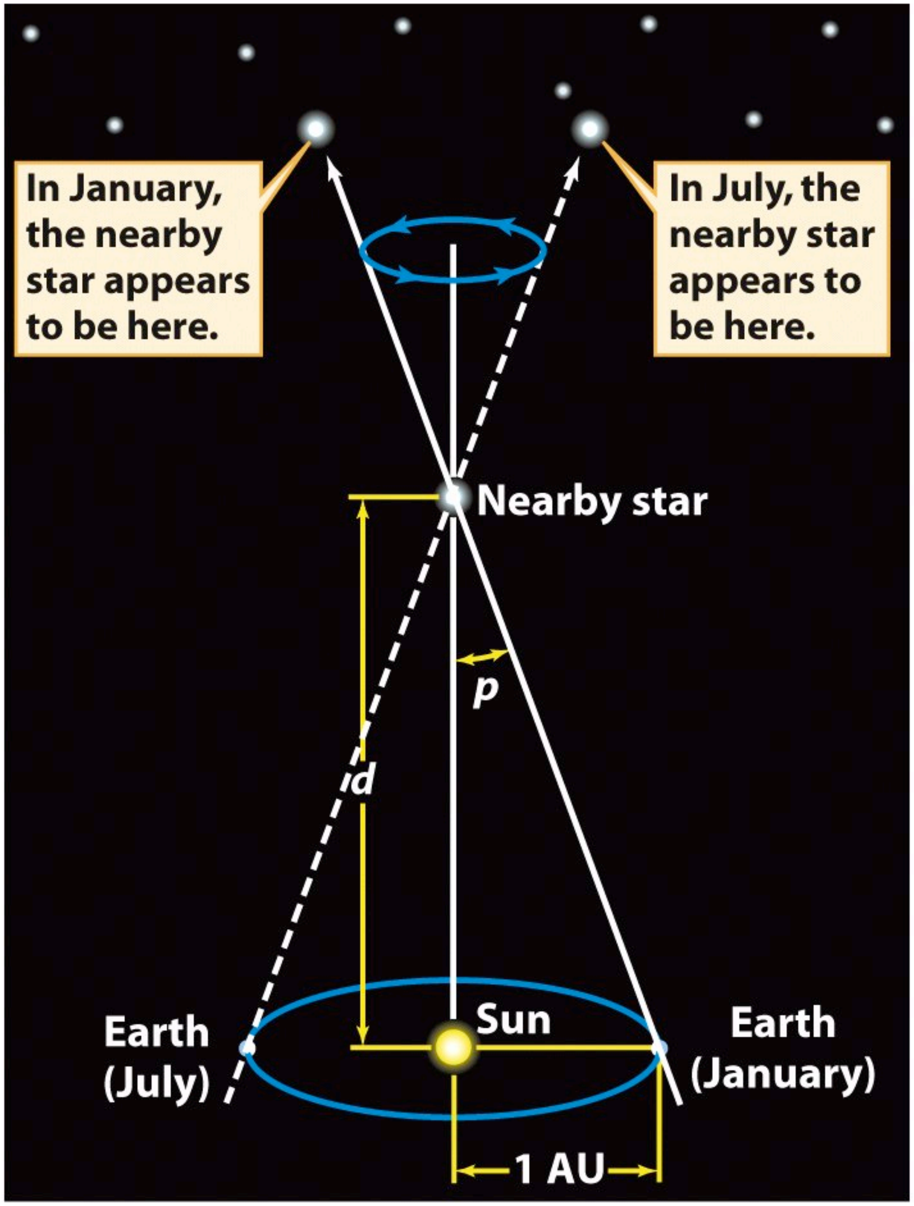
$d = 1/p$

p = parallax in arcsec

d = distance in parsecs

1 pc = 3.26 ly

Remember 1pc is the distance at which 1AU subtends 1 arcsec



Parallax of a nearby star

Figure 17-2a
Universe, Eighth Edition

Example

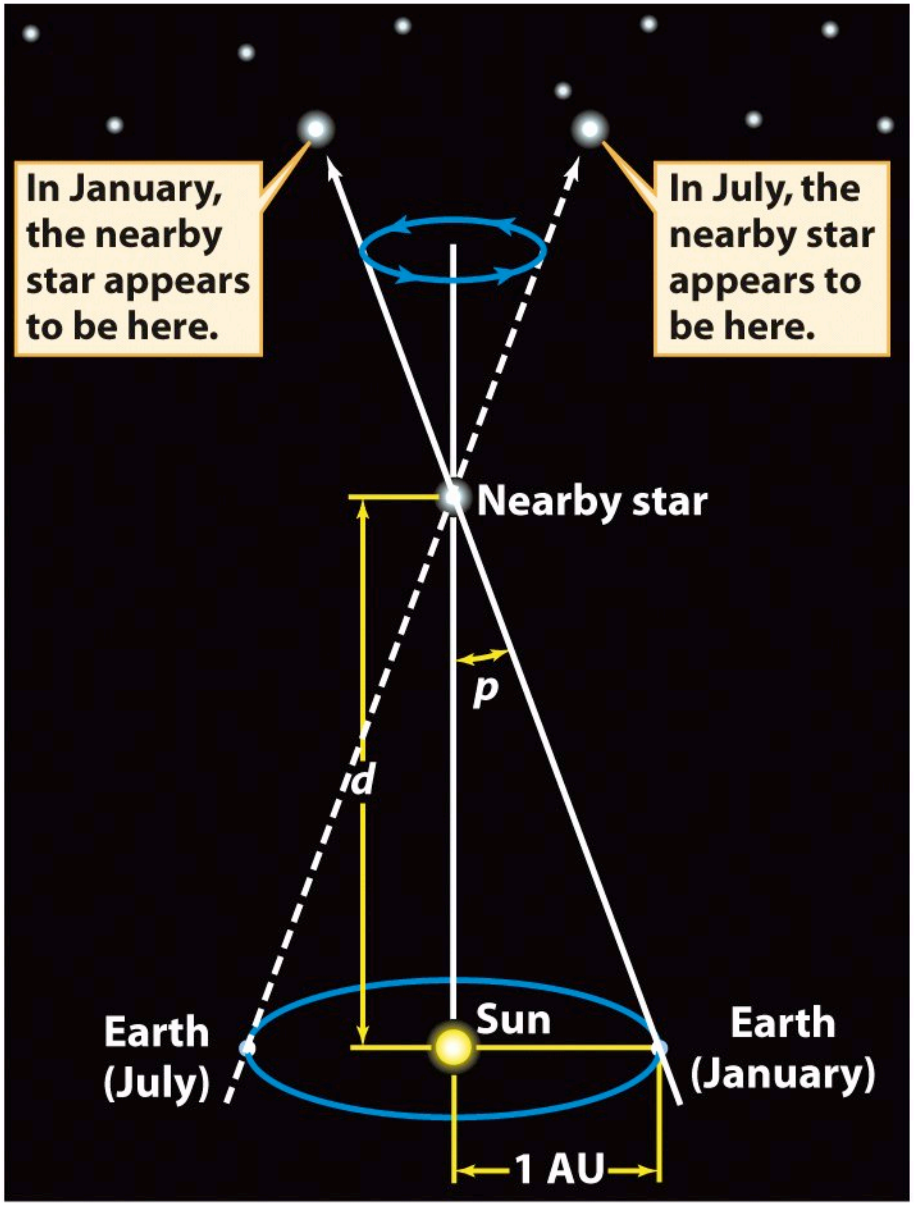
A star has a parallax of 0.1”. What is its distance?

d = 1/p

p = parallax in arcsec

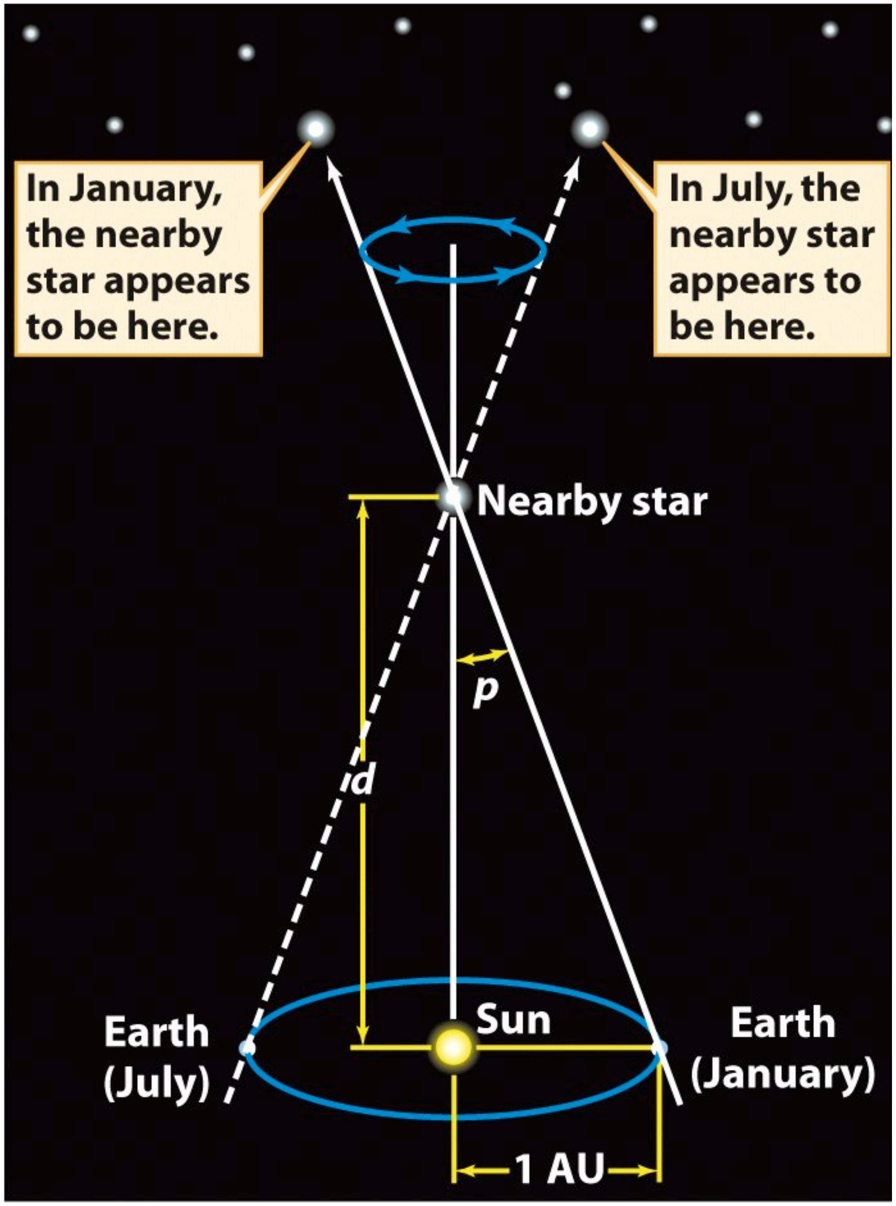
d = distance in parsecs

d = 1/0.1=10 pc



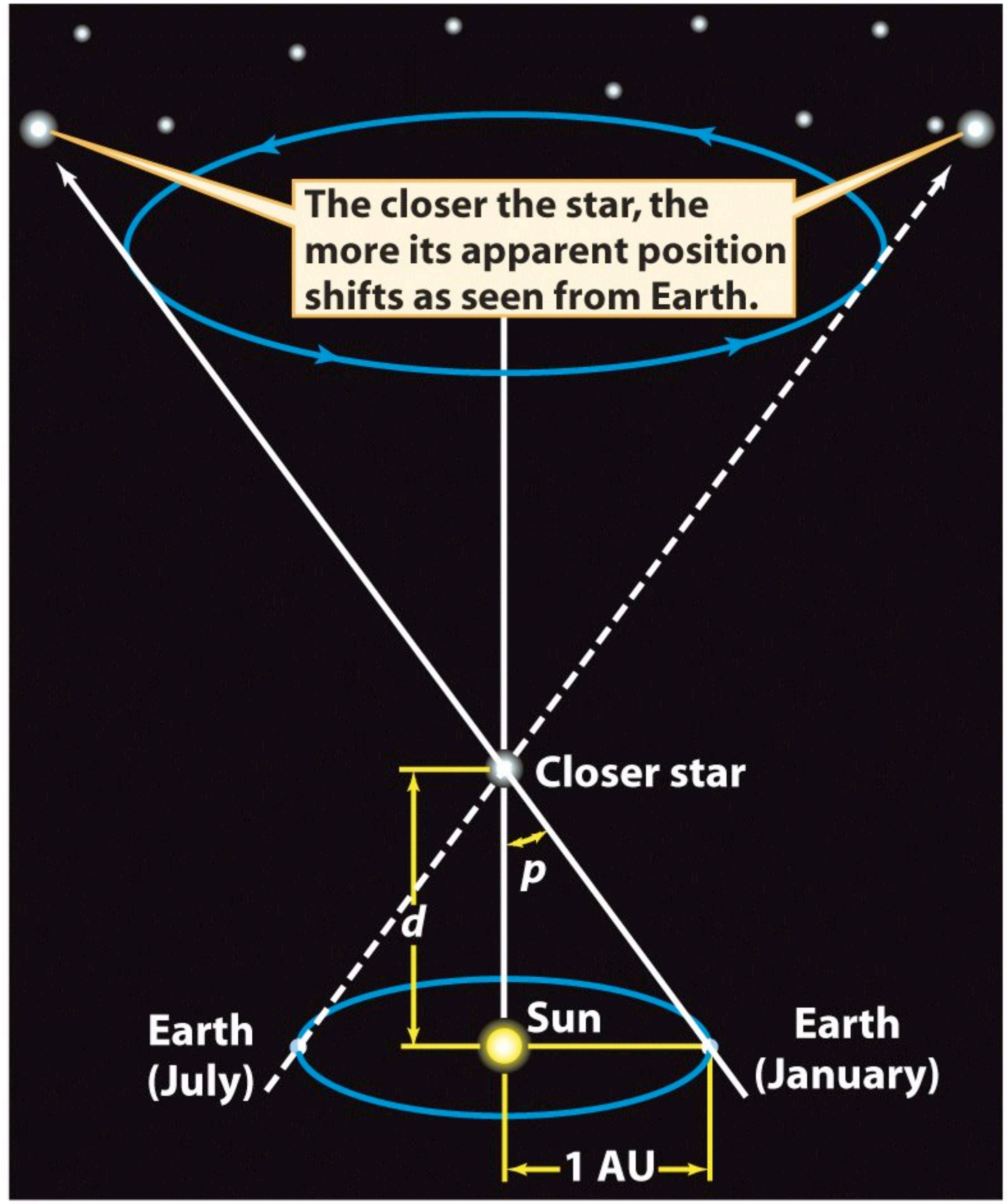
Parallax of a nearby star

Figure 17-2a
Universe, Eighth Edition



Parallax of a nearby star

Figure 17-2a
Universe, Eighth Edition

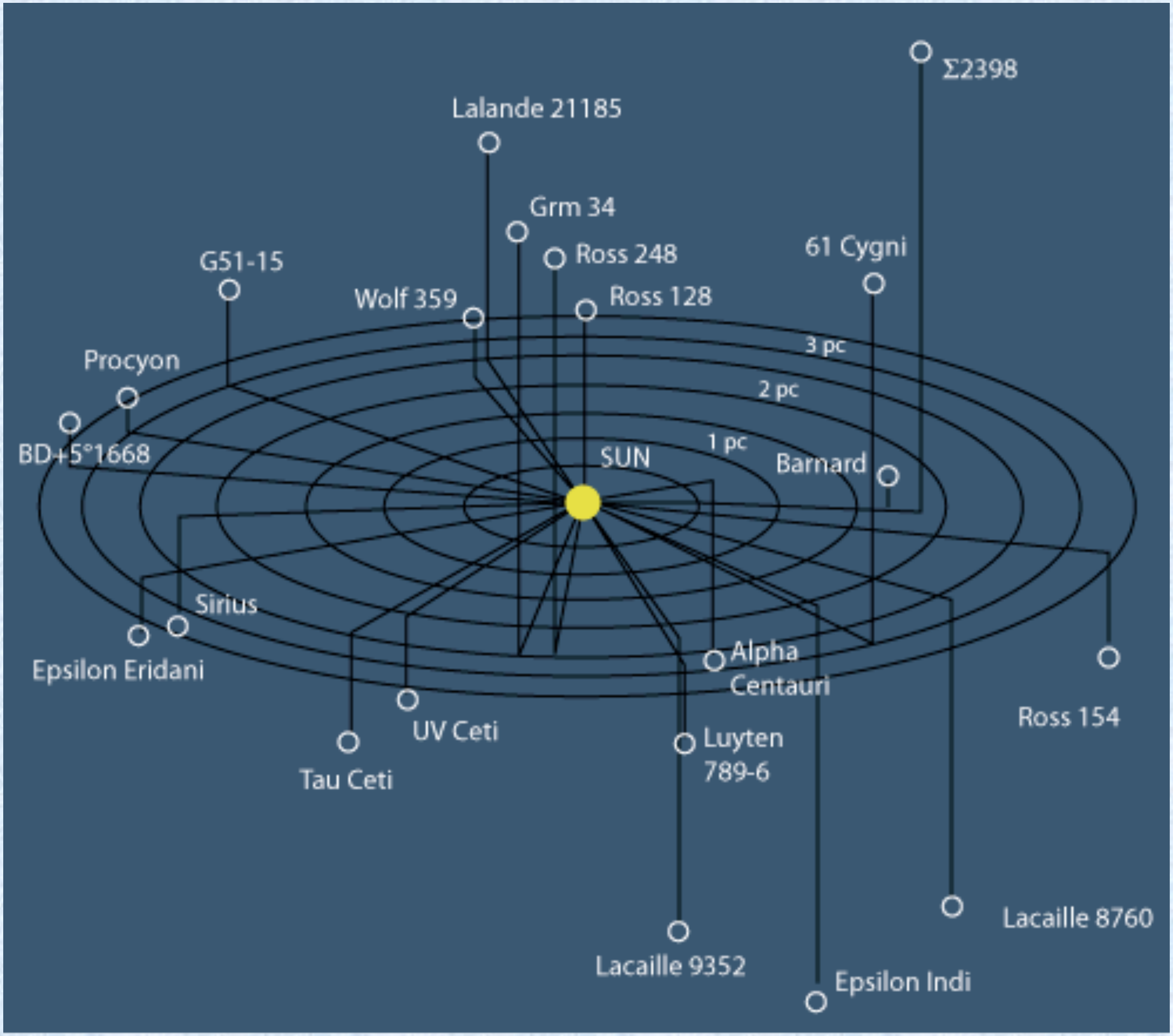


Parallax of an even closer star

Figure 17-2b
Universe, Eighth Edition

Question 20.1 (iclickers!)

- Consider two stars, star 1 and star 2. Star 1 has a parallax of 0.05 arcsec. Star 2 has a parallax of 0.40 arcsec. How far away are the two stars?
    - A) Star 1: 5 pc, Star 2: 40 pc
    - B) Star 1: 1/5 pc, Star 2: 1/40 pc
    - C) Star 1: 10 pc, Star 2: 25 pc
    - D) Star 1: 20 pc, Star 2: 2.5 pc



To put in perspective:
If 1pc = distance from SB to NYC, distance from Sun to Earth ~ 10m! Less than this room!

Inverse square law
determining the luminosity of a star

$b = L/4\pi d^2$

b = brightness of star as we see it

L = luminosity of star (wattage)

d = distance to star

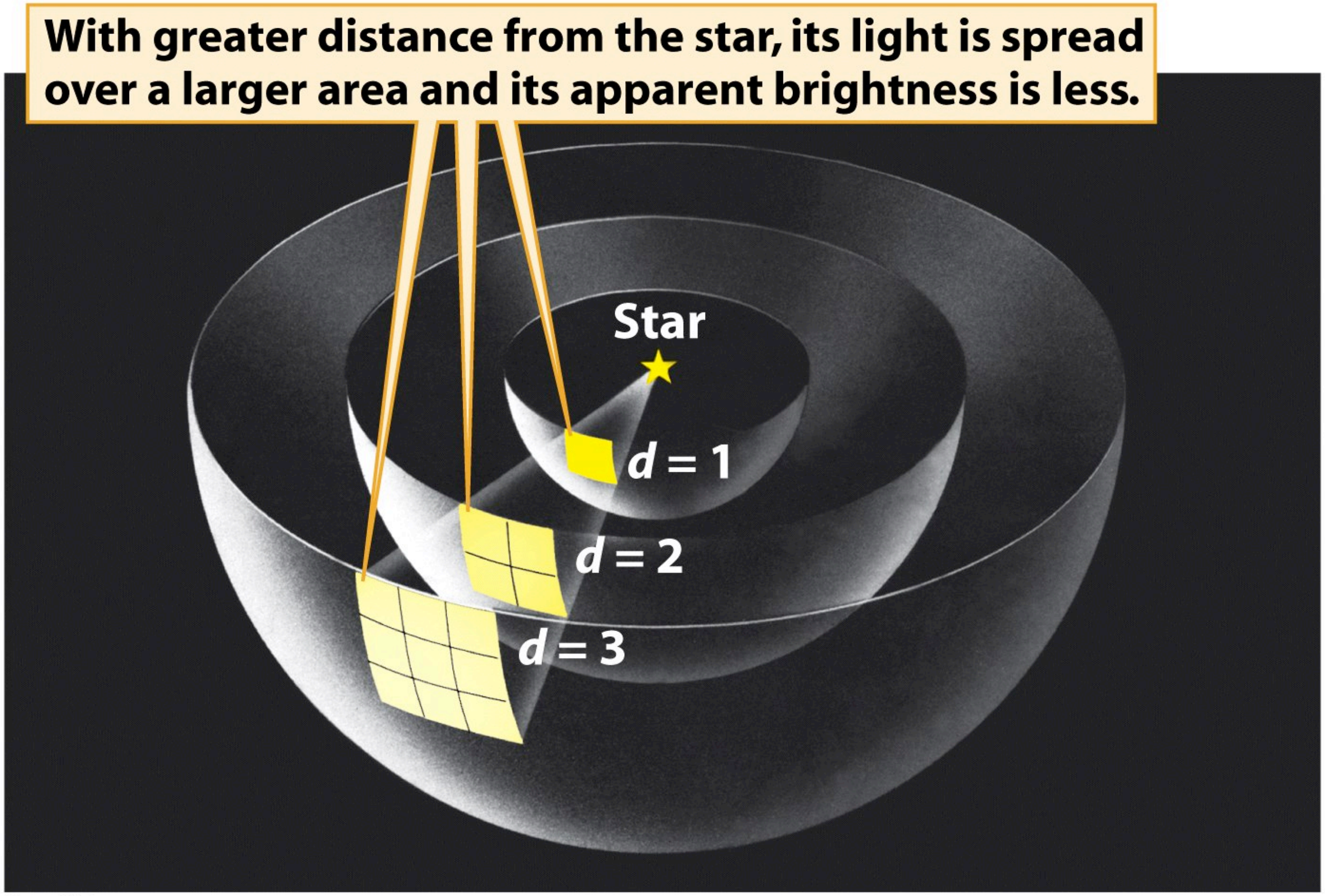


Figure 17-4
Universe, Eighth Edition

The Inverse-Square Law

Radiation from a light source illuminates an area that increases as the square of the distance from the source. The apparent brightness decreases as the square of the distance. The brightness at d = 2 is $1/(2^2)$ = 1/4 of the brightness at d = 1, and the brightness at d = 3 is $1/(3^2)$ = 1/9 of that at d = 1.

Question 20.2 (iclickers!)

- At the distance of the Earth from the Sun (1 AU) the intensity of sunlight is 1370 watts/m^2. What is the intensity at the distance of Saturn from the Sun (10 AU)?

A. 13,700 watts/m^2
B. 1370 watts/m^2
C. 137 watts/m^2
D. 13.7 watts/m^2

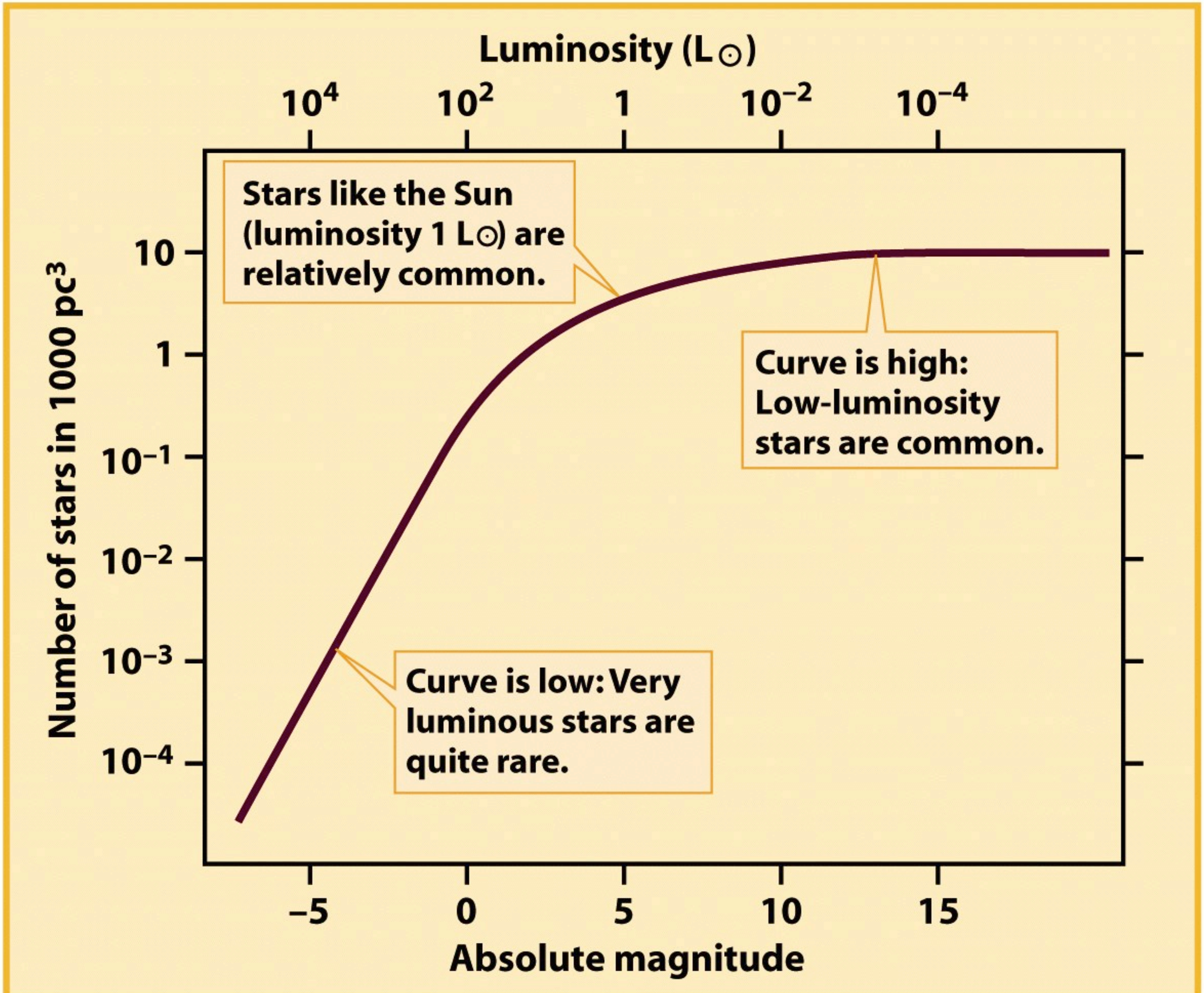
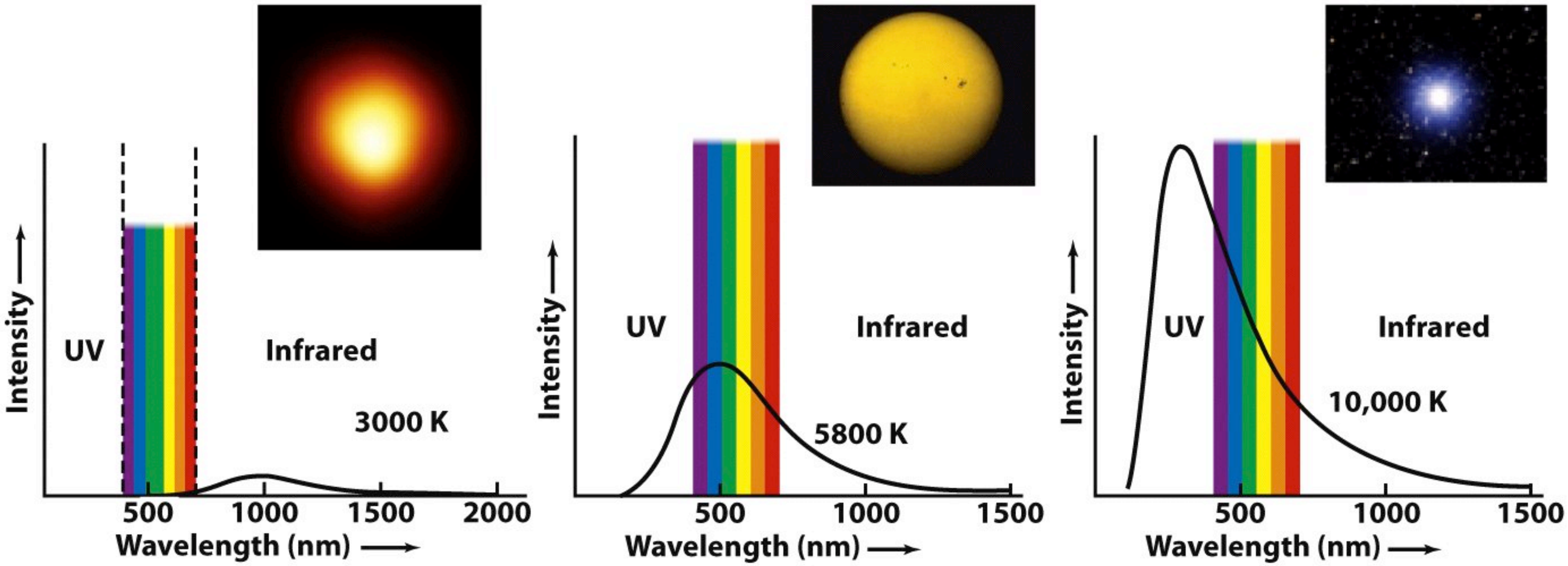


Figure 17-5
Universe, Eighth Edition



(a) A cool star with surface temperature 3000 K emits much more red light than blue light, and so appears red.

(b) A warmer star with surface temperature 5800 K (like the Sun) emits roughly equal amounts of all visible wavelengths, and so appears yellow-white.

(c) A hot star with surface temperature 10,000 K emits much more blue light than red light, and so appears blue.

Figure 17-7
Universe, Eighth Edition

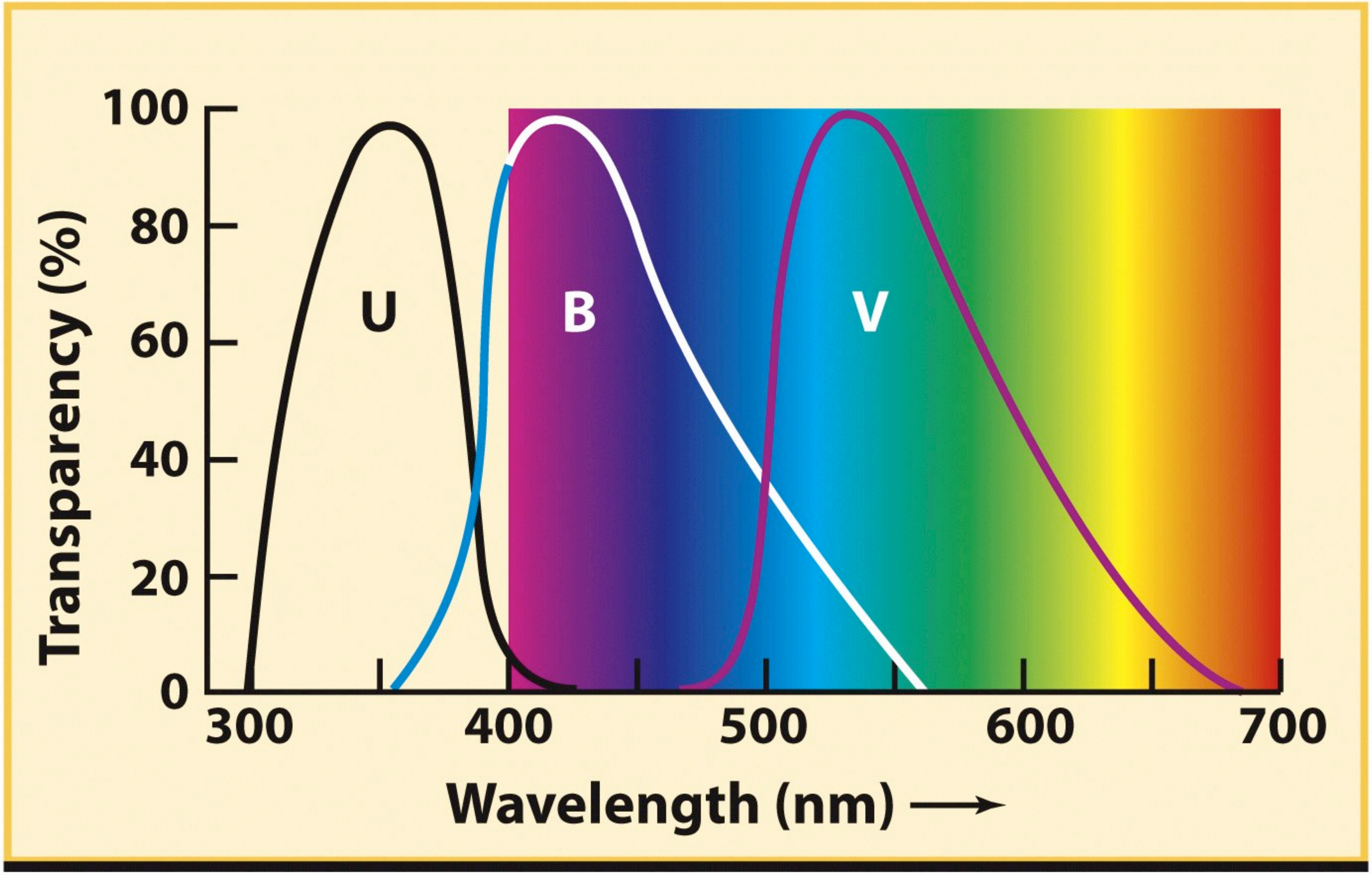


Figure 17-8
Universe, Eighth Edition

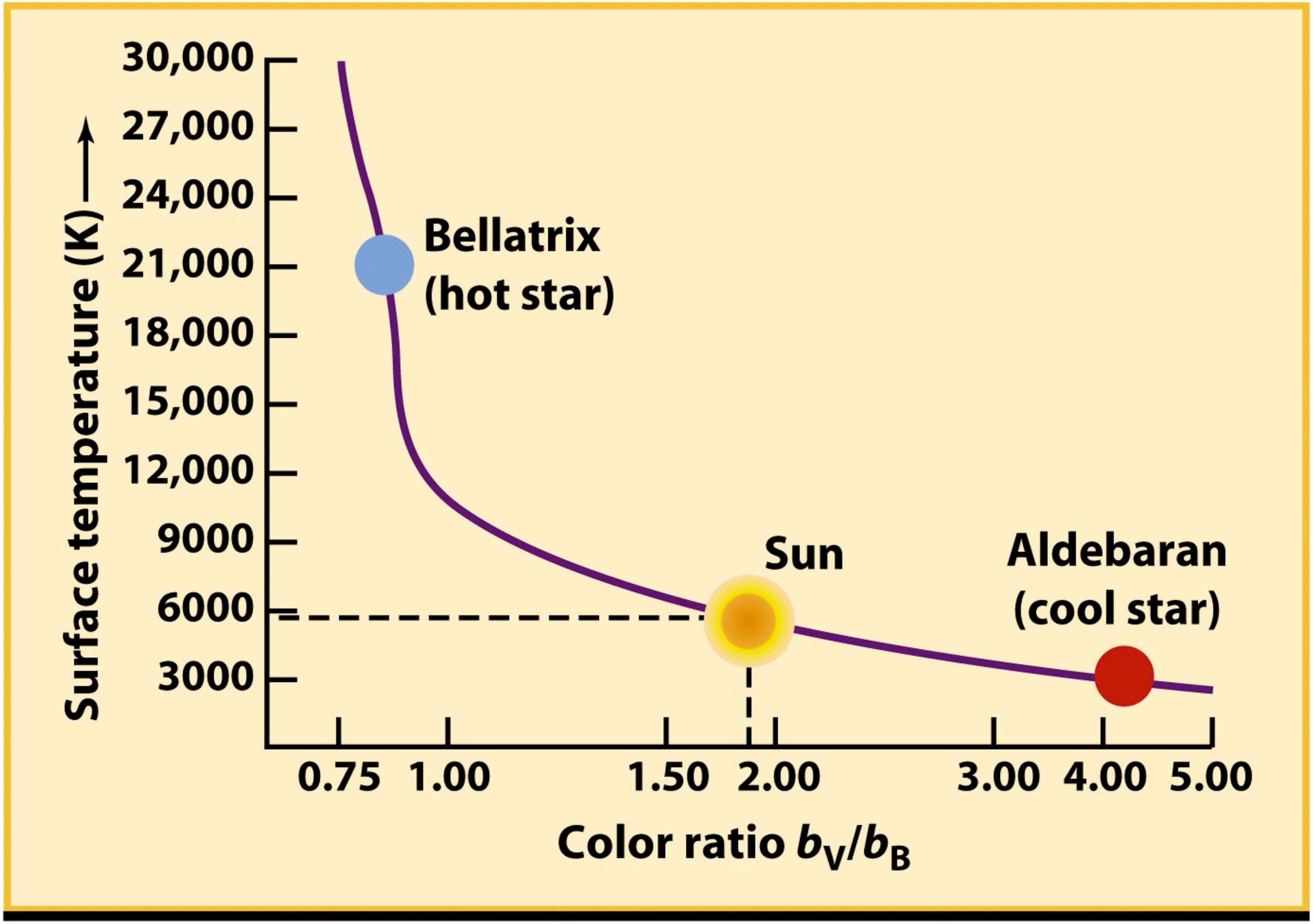


Figure 17-9
Universe, Eighth Edition

Table 17-1 Colors of Selected Stars

Star	Surface temperature (K)	b_V/b_B	b_B/b_U	Apparent color
Bellatrix (γ Orionis)	21,500	0.81	0.45	Blue
Regulus (α Leonis)	12,000	0.90	0.72	Blue-white
Sirius (α Canis Majoris)	9400	1.00	0.96	Blue-white
Megrez (δ Ursae Majoris)	8630	1.07	1.07	White
Altair (α Aquilae)	7800	1.23	1.08	Yellow-white
Sun	5800	1.87	1.17	Yellow-white
Aldebaran (α Tauri)	4000	4.12	5.76	Orange
Betelgeuse (α Orionis)	3500	5.55	6.66	Red

***Source:* J.-C. Mermilliod, B. Hauck, and M. Mermilliod, University of Lausanne**

Table 17-1
Universe, Eighth Edition

The Stars

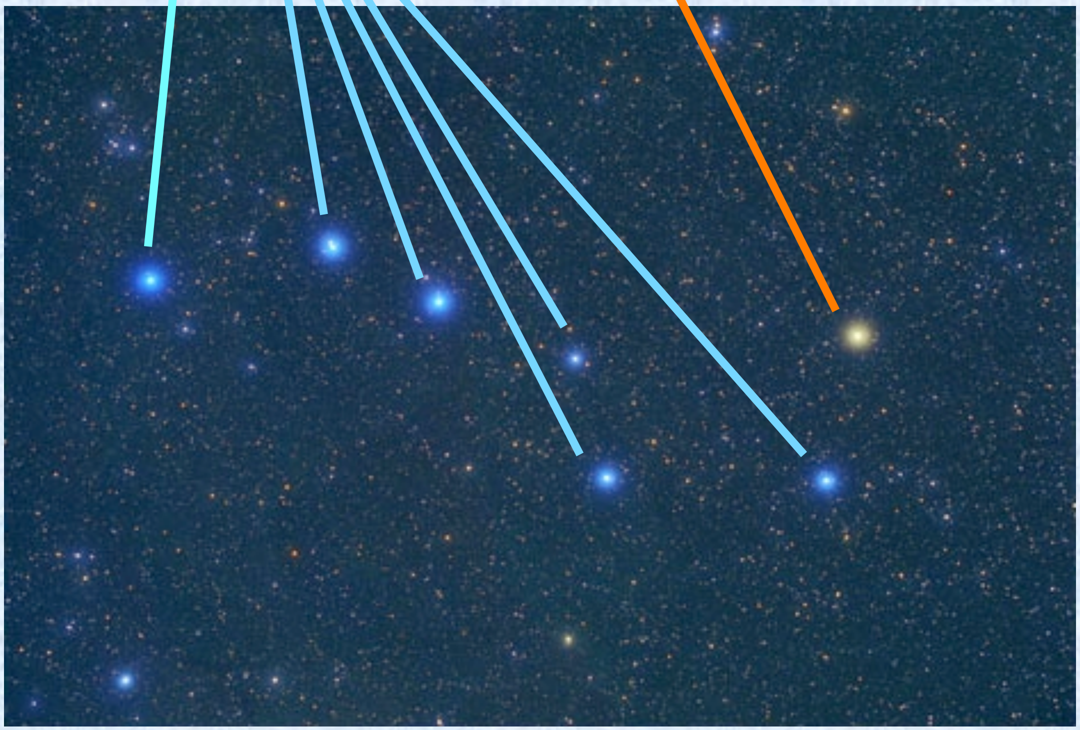
distances – from parallax

luminosites – from $b = L/4\pi d^2$

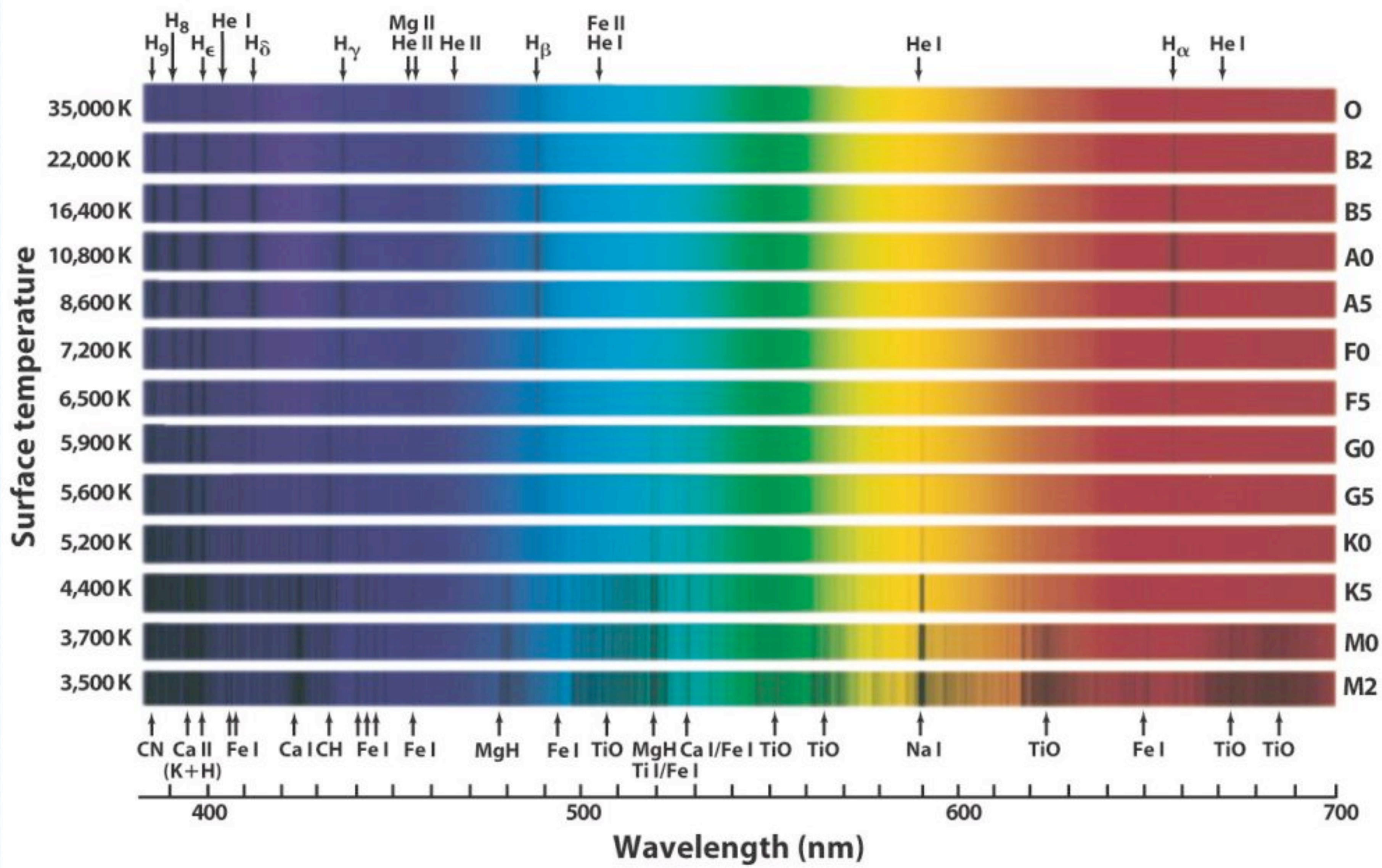
temperatures — from color and spectrum

Hot Cold

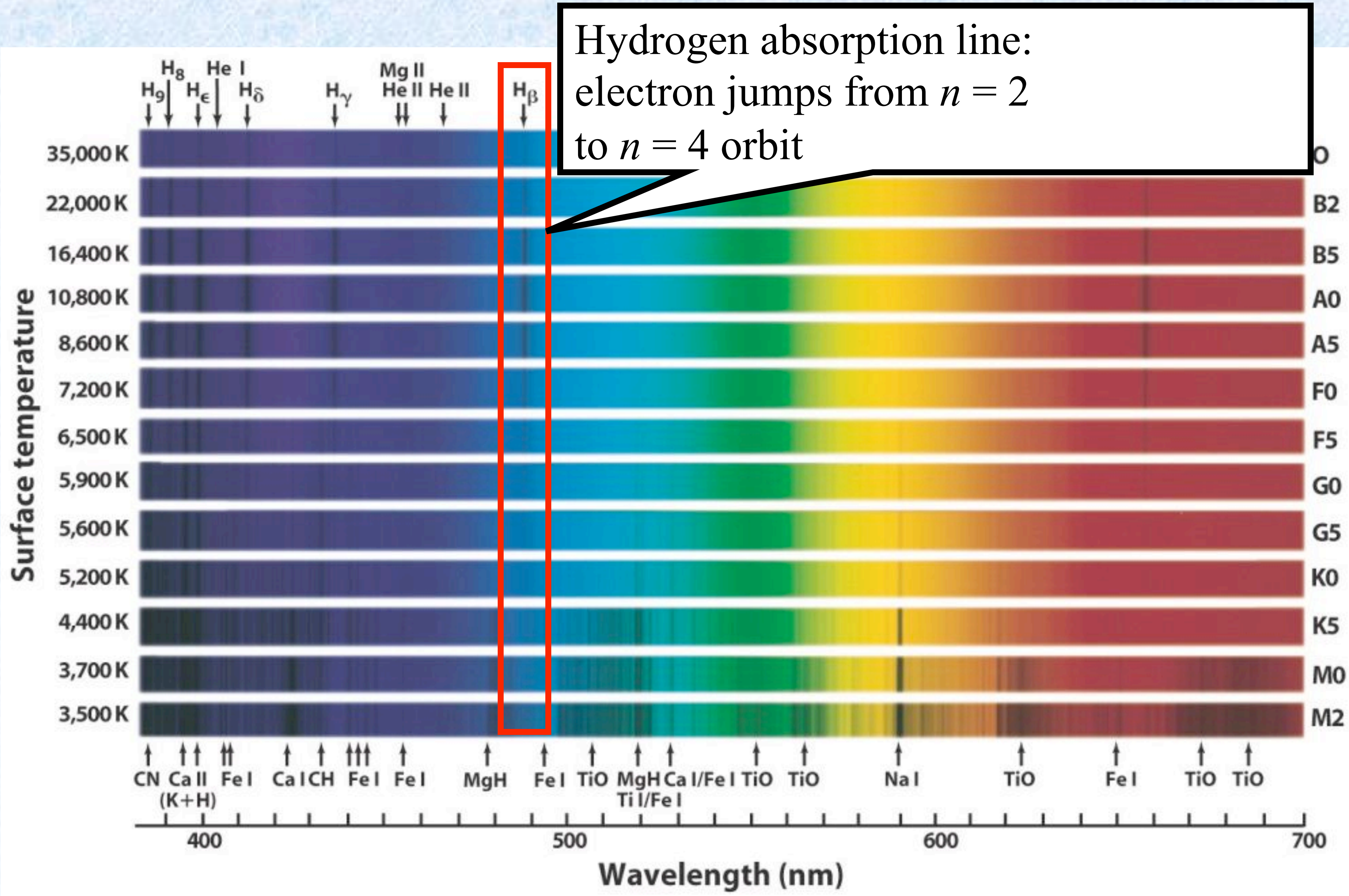
O B A F G K M L T



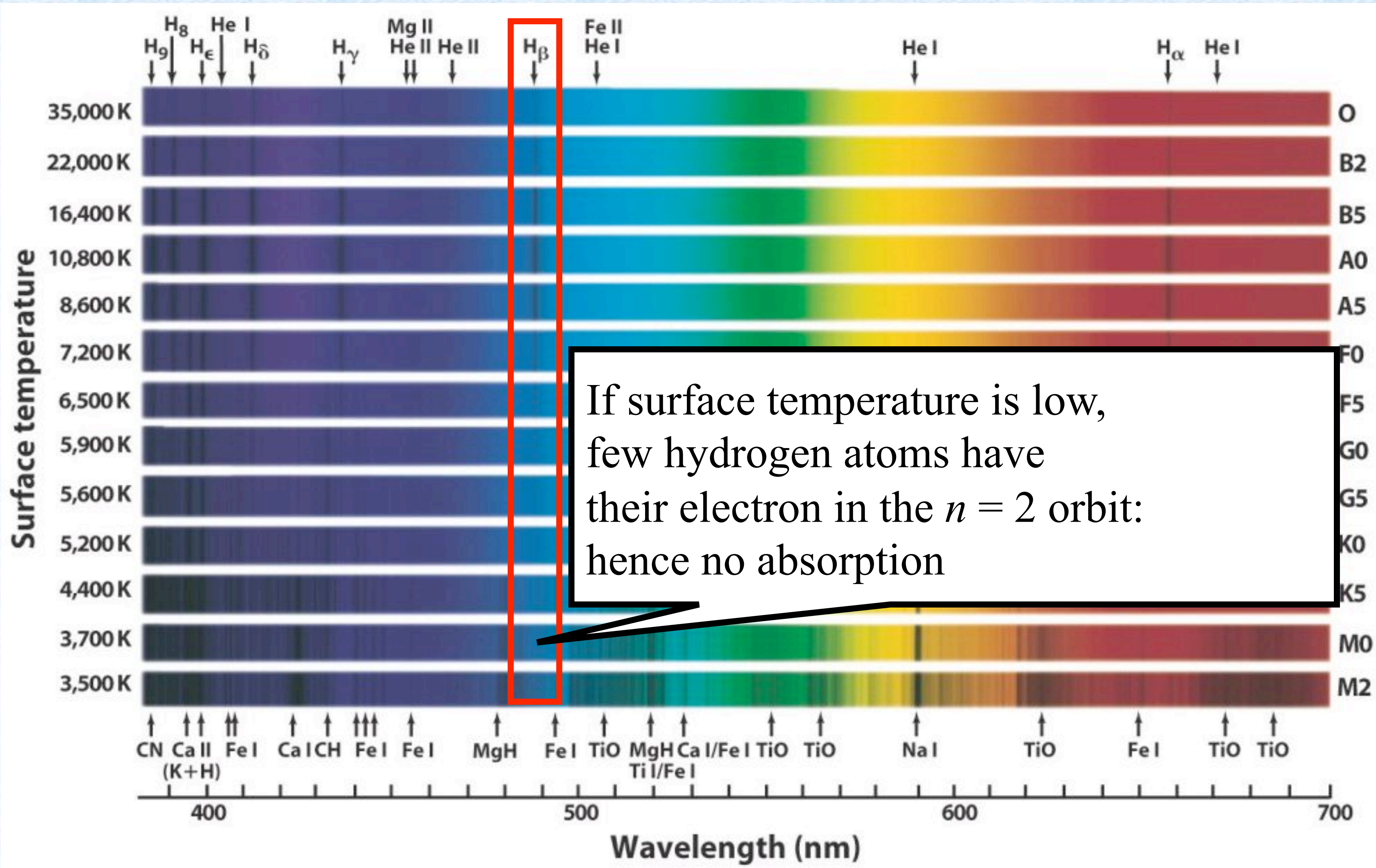
Spectra of stars with different surface temps



Spectra of stars with different surface temps

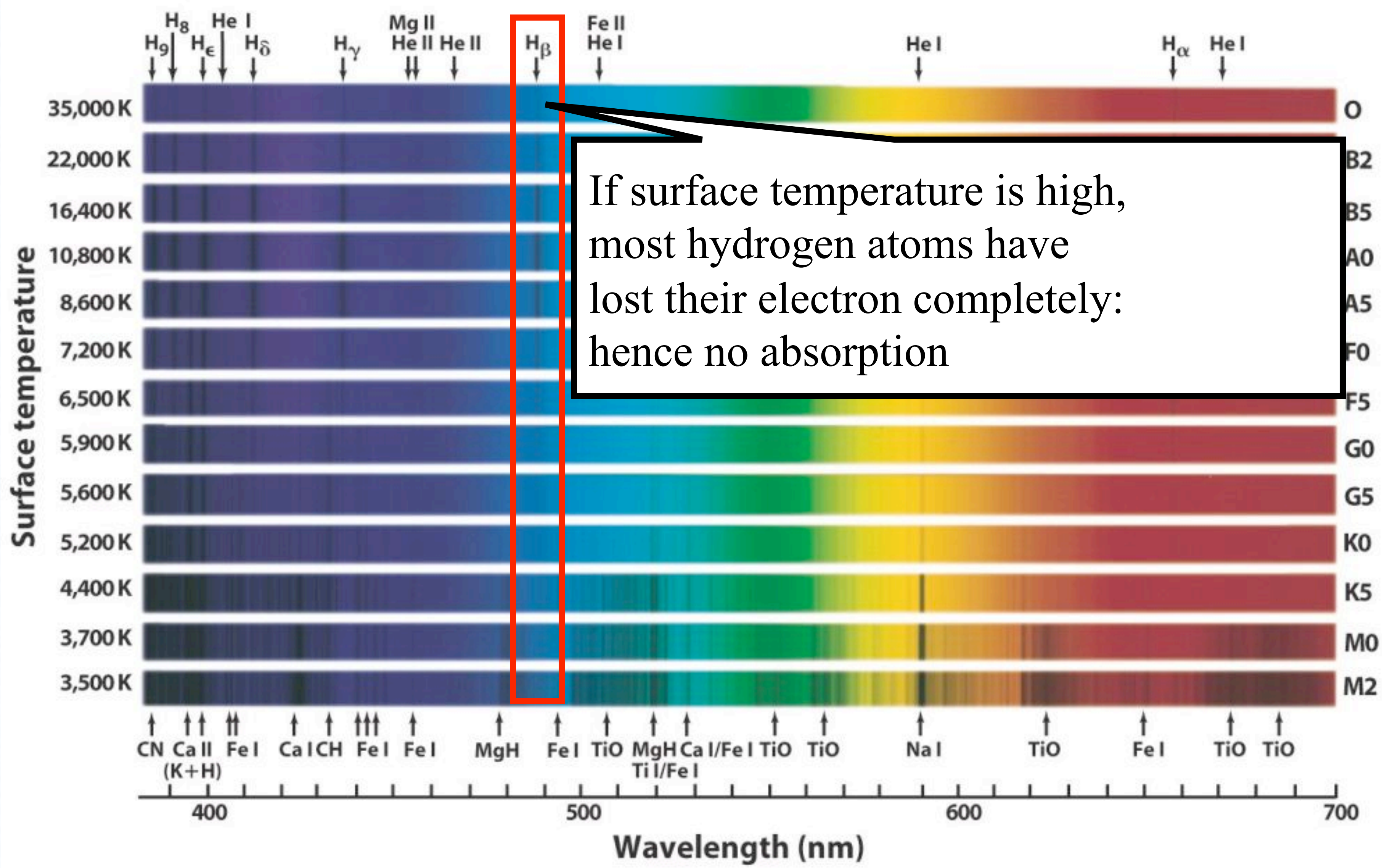


Spectra of stars with different surface temps



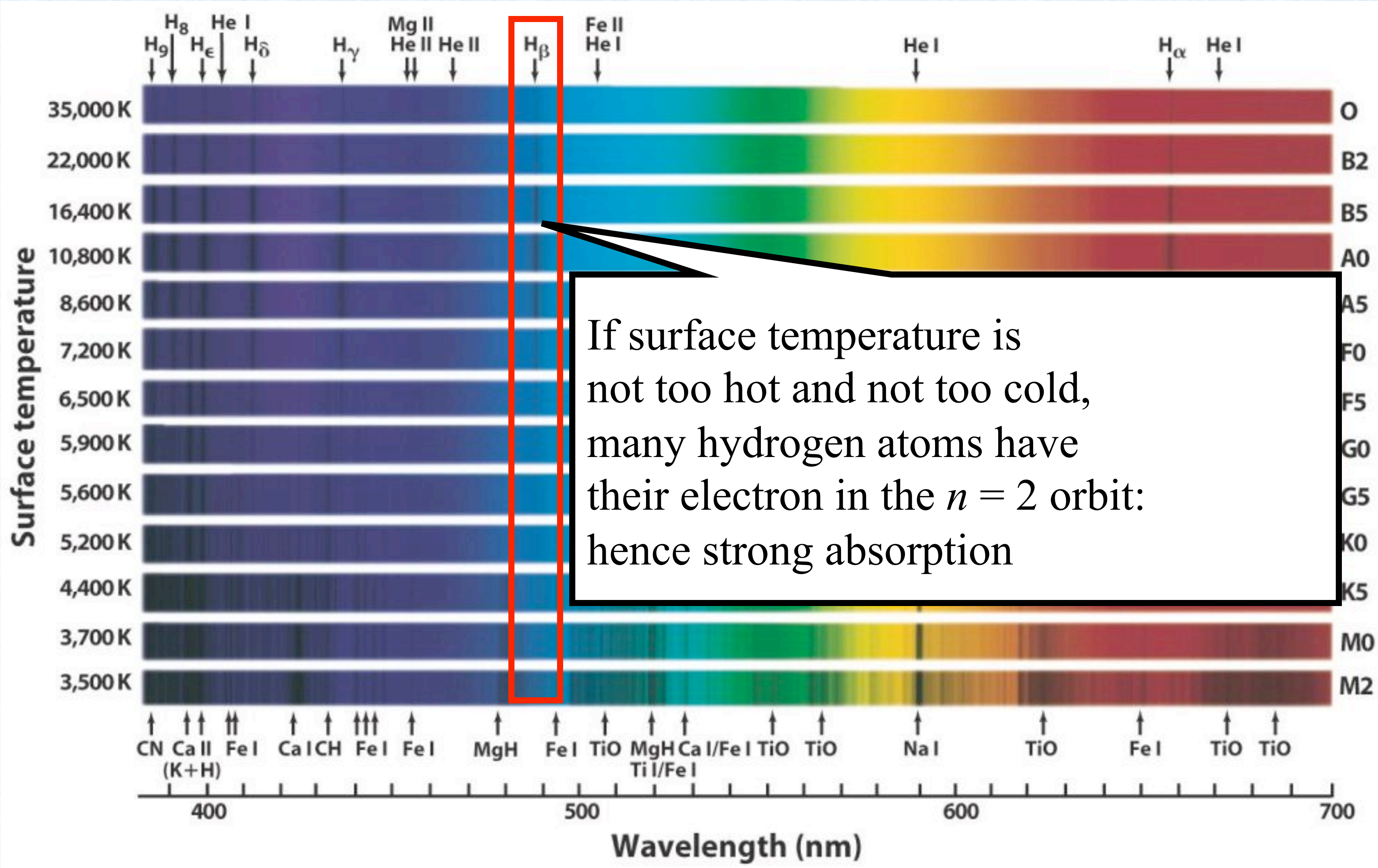
If surface temperature is low,
few hydrogen atoms have
their electron in the n = 2 orbit:
hence no absorption

Spectra of stars with different surface temps



If surface temperature is high,
most hydrogen atoms have
lost their electron completely:
hence no absorption

Spectra of stars with different surface temps



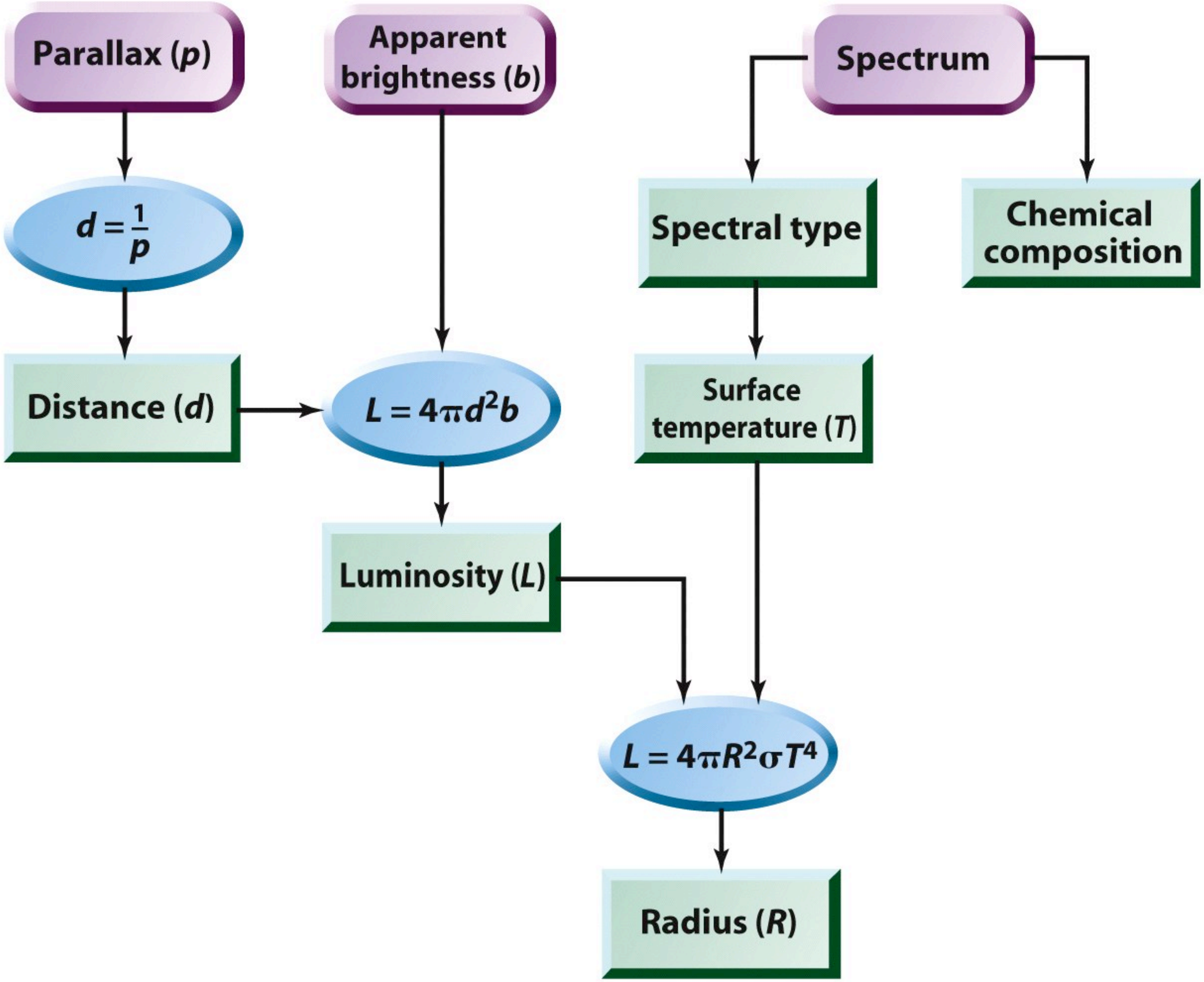


Figure 17-14
Universe, Eighth Edition

Question 20.3 (iclickers!)

- A star has a radius half of that of the Sun and a luminosity equal to 60% of that of the Sun. What's the star's surface temperature? The surface temperature of the Sun is 5800K.

A. 7220 K
B. 6650 K
C. 4660 K
D. 3610 K

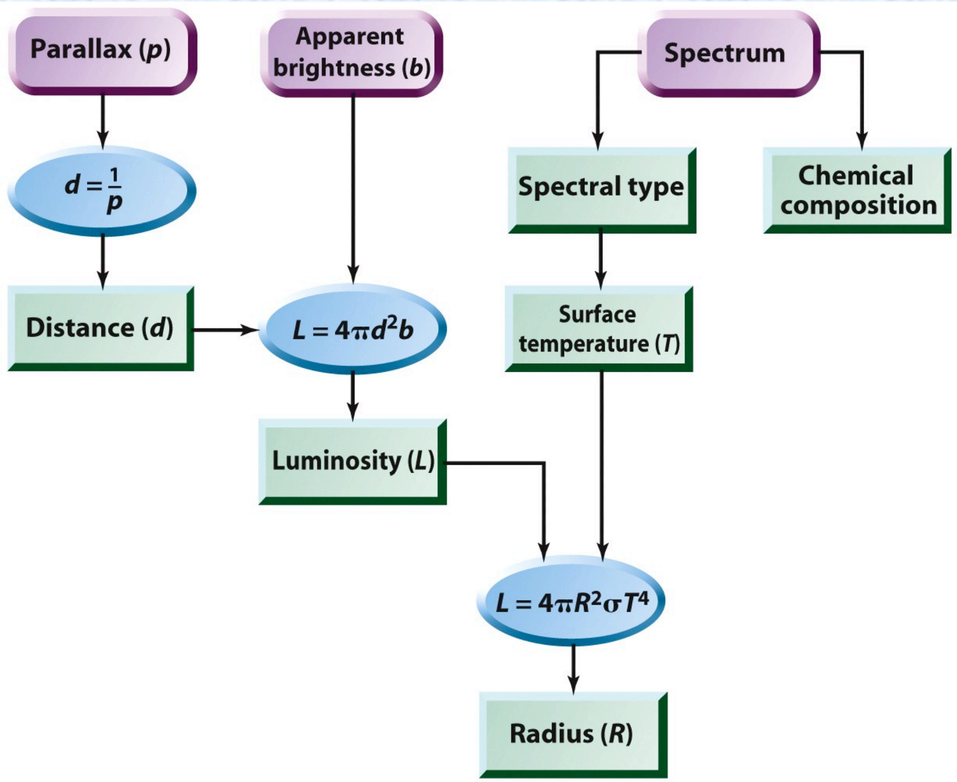


Figure 17-14
Universe, Eighth Edition

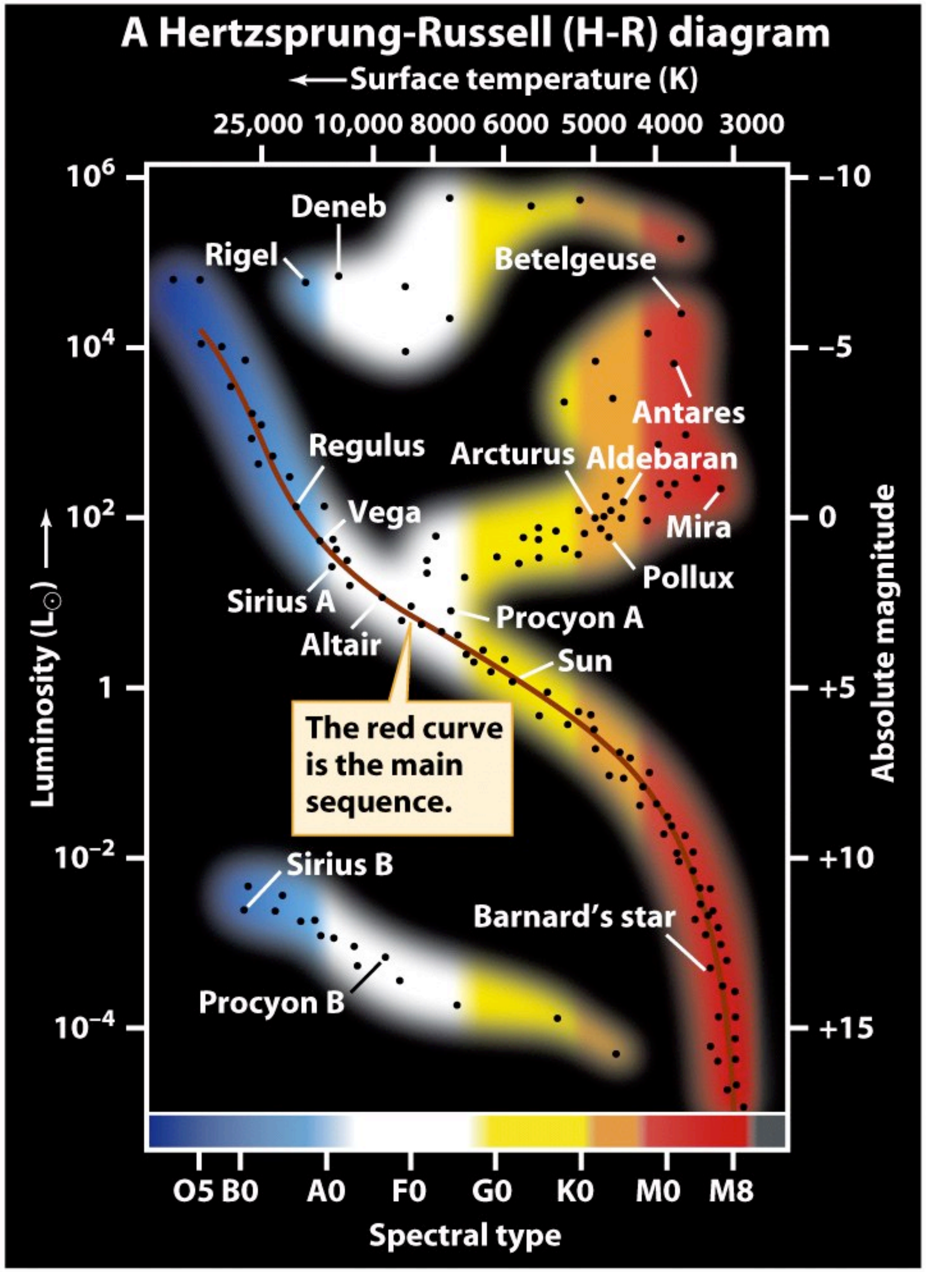
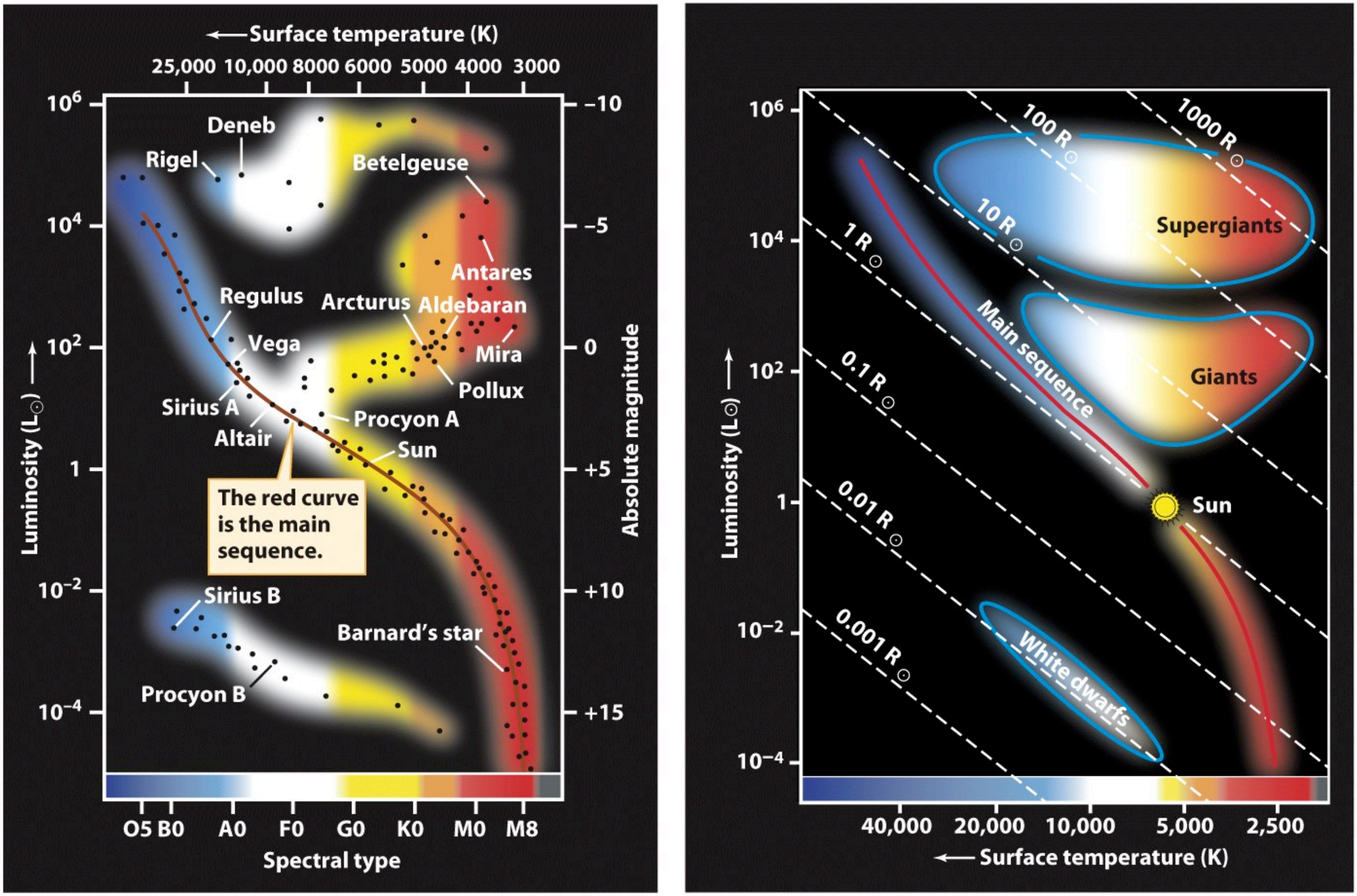


Figure 17-15a

Universe, Eighth Edition



(a) **A Hertzsprung-Russell (H-R) diagram**

(b) **The sizes of stars on an H-R diagram**

Figure 17-15

Universe, Eighth Edition

The mass of stars

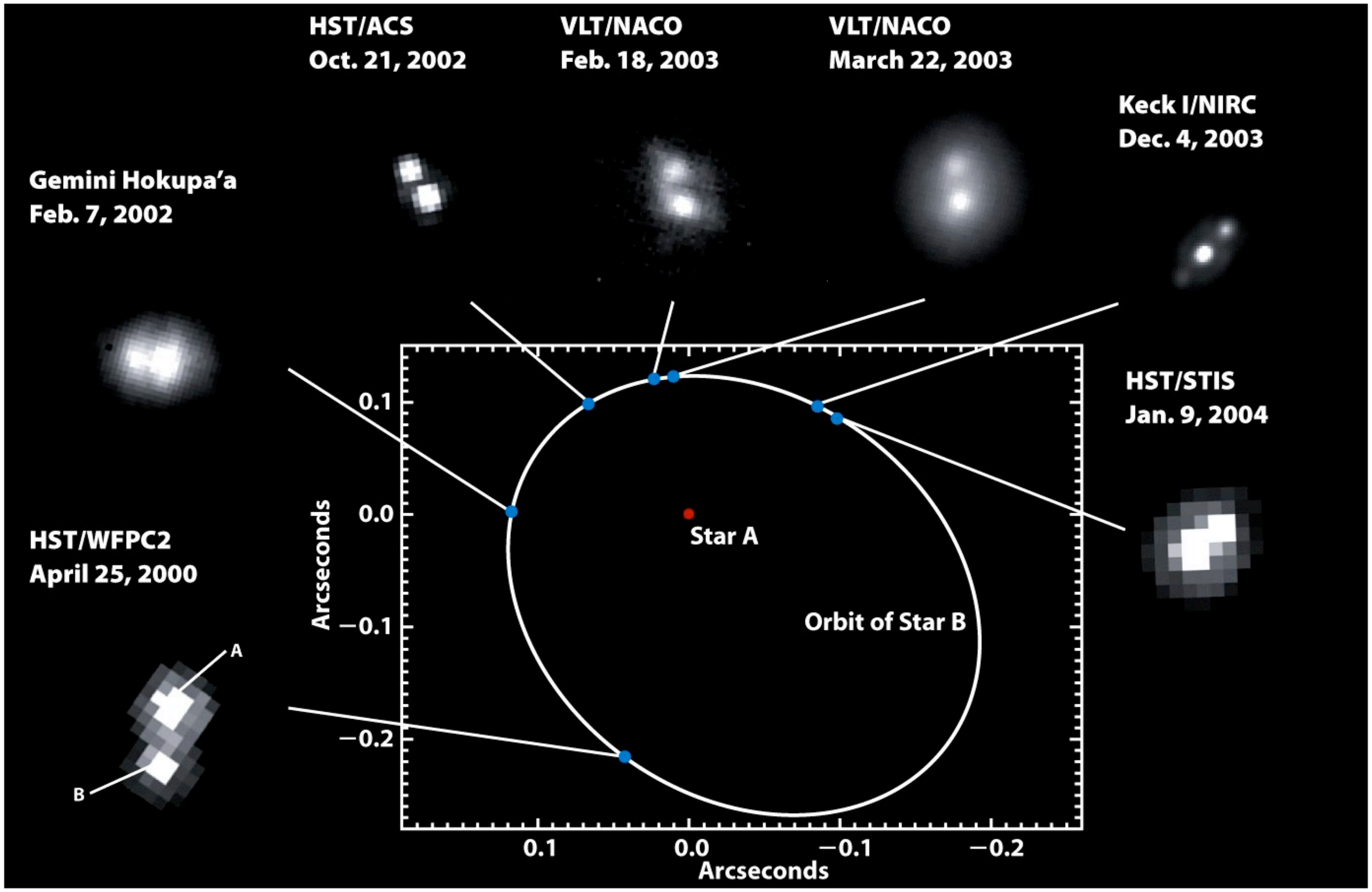
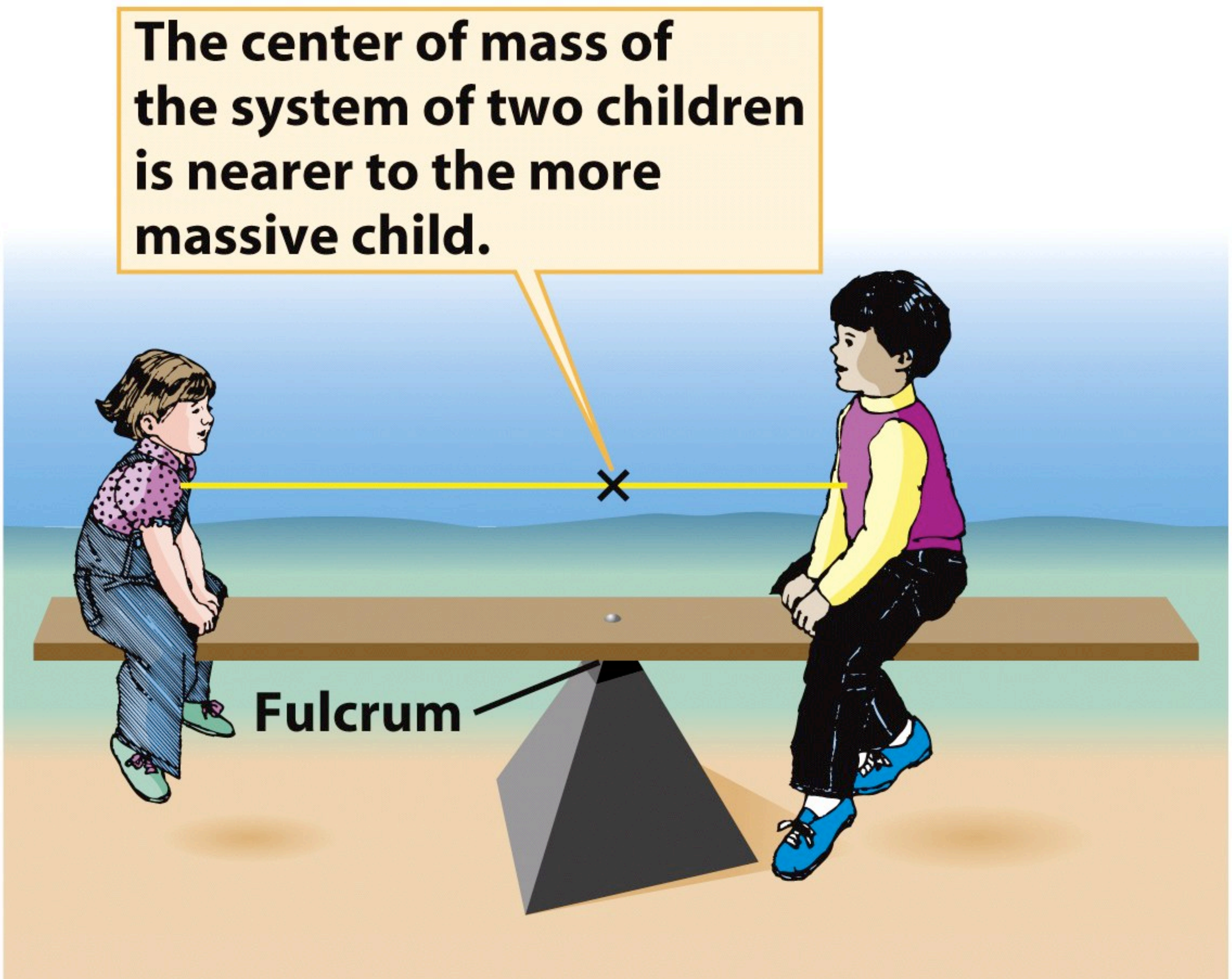


Figure 17-19
Universe, Eighth Edition

To determine stellar mases we rely on binary star systems. As seen from Earth, the two stars that make up this binary system are separated by less than 1/3 arcsecond. For simplicity, the diagram shows one star as remaining stationary; in reality, both stars move around their common center of mass



A “binary system” of two children

Figure 17-20a
Universe, Eighth Edition

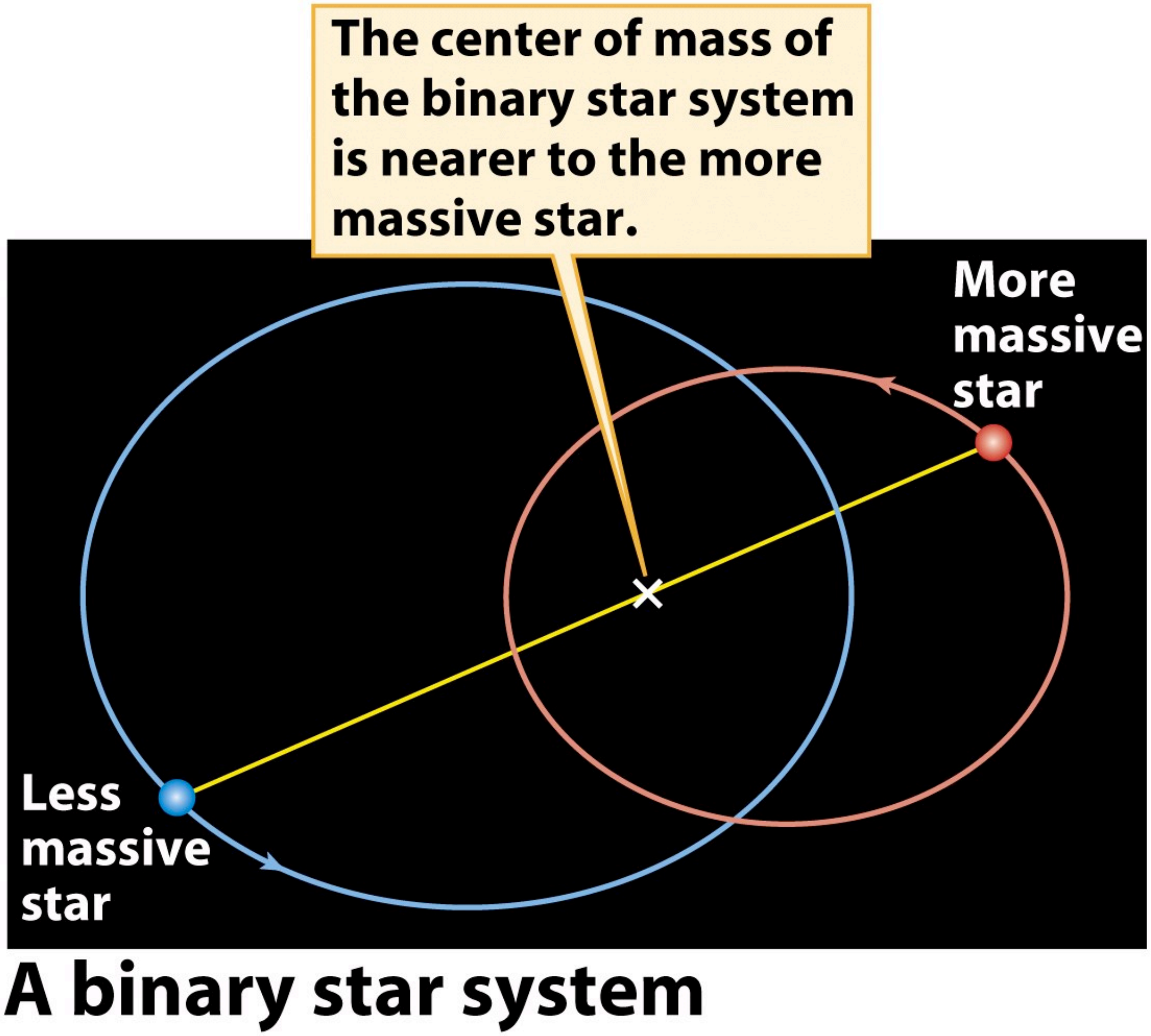
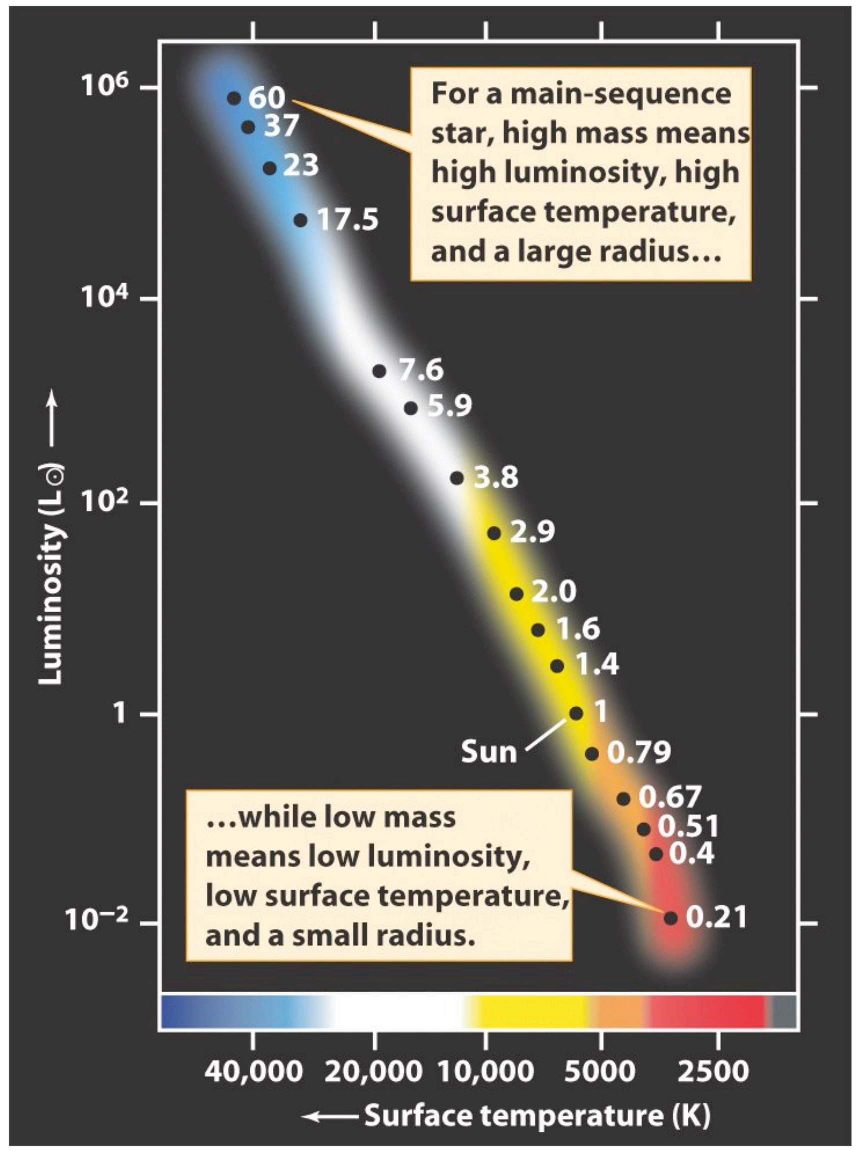


Figure 17-20b
Universe, Eighth Edition

http://astro.ph.unimelb.edu.au/software/binary/binary.htm

H-R diagram with masses

The main sequence is a mass sequence!



Summary

- Parallax is a tool to measure distances
- The Inverse-Square Law relates luminosity and brightness
- Low luminosity stars are more common than more luminous ones
- Colors and spectral types measure a star's temperature
- The Hertzsprung-Russell (H-R) diagram is a graph plotting luminosity vs temperature
- Most stars belong to the main sequence. Other important classes are giants, supergiants and white dwarfs.
- Spectral typing can be used to determine distances
- Masses can be determined for binaries. The main sequence is a mass sequence!!

The End

See you on monday!