Chapter 10
Measuring the Stars

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Units of Chapter 10

The Solar Neighborhood

Luminosity and Apparent Brightness

Stellar Temperatures

Stellar Sizes

The Hertzsprung-Russell Diagram

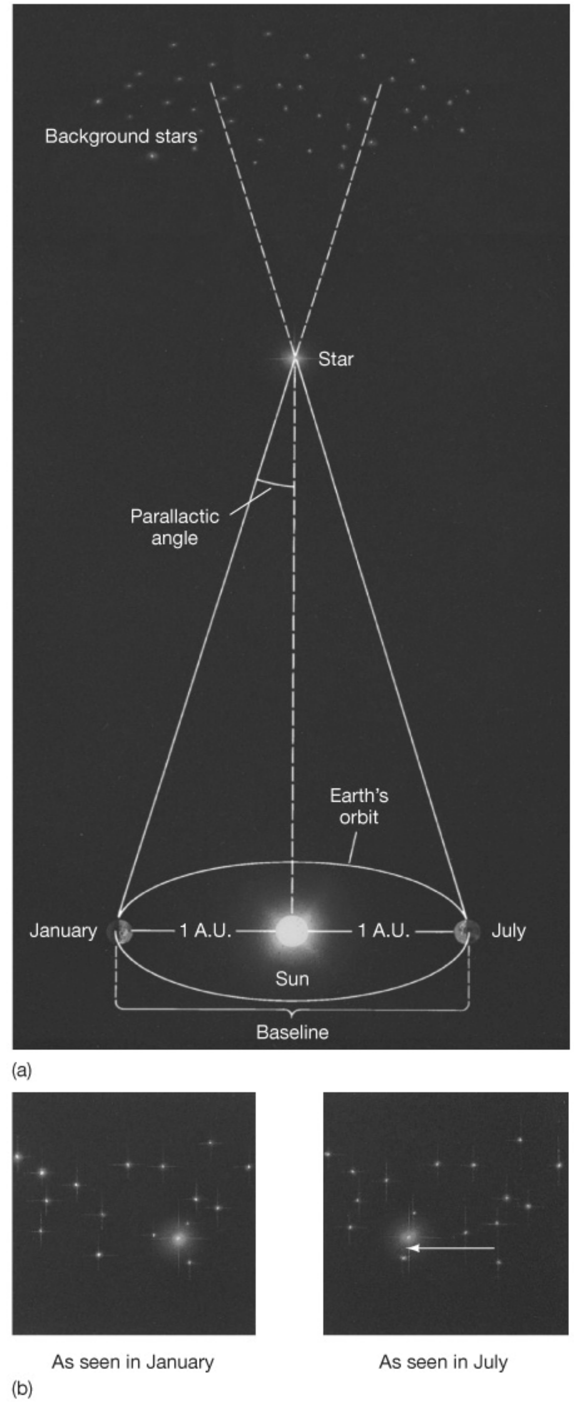
Extending the Cosmic Distance Scale

Stellar Masses

10.1 The Solar Neighborhood

Parallax: look at apparent motion of object against distant background from two vantage points; knowing baseline allows calculation of distance

$$\text{distance (in parsecs)} = \frac{1}{\text{parallax (in arcseconds)}}$$



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10.1 The Solar Neighborhood

Nearest star to the Sun: Proxima Centauri, which is a member of a 3-star system: Alpha Centauri complex

Model of distances:

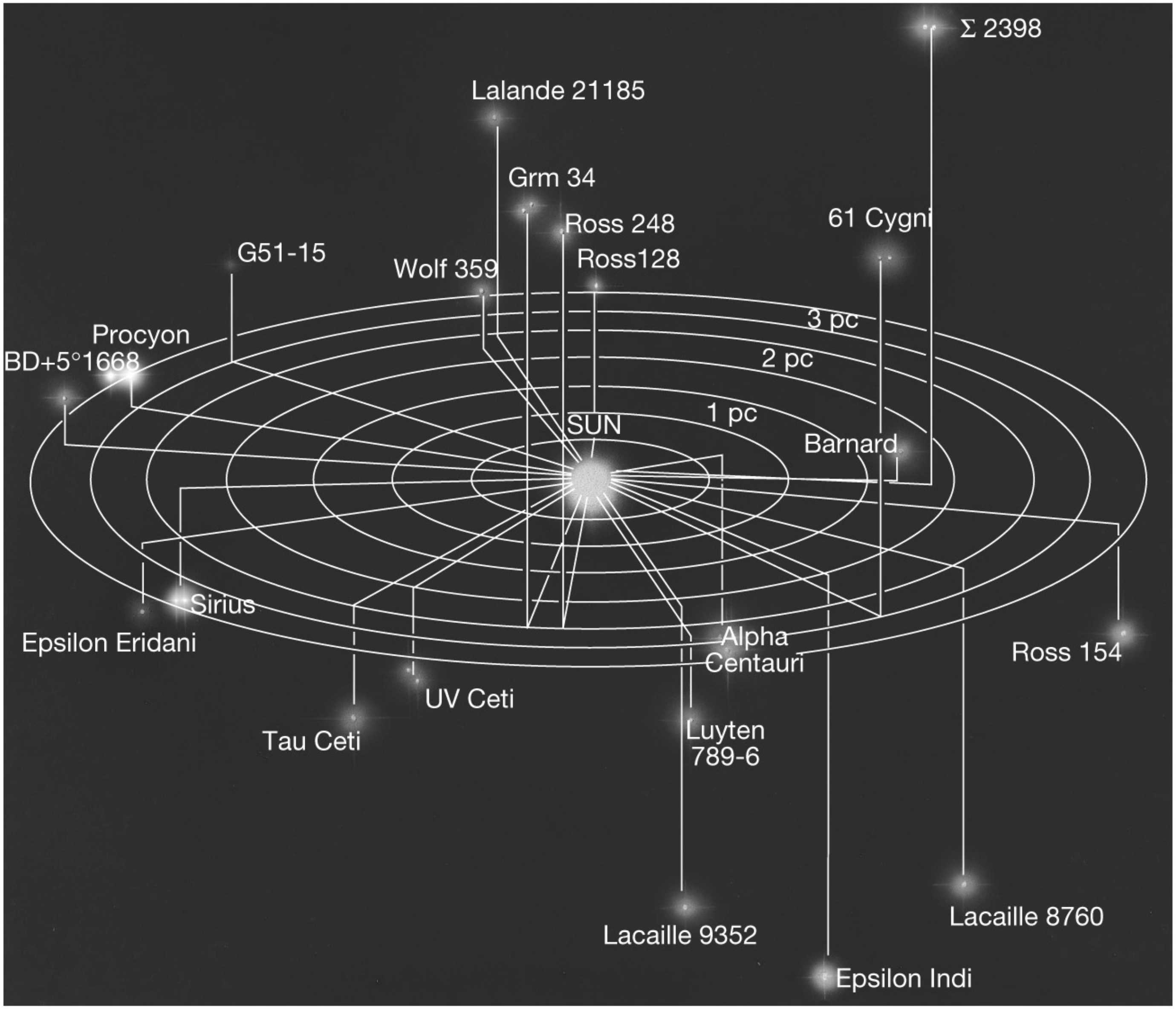
Sun is a marble, Earth is a grain of sand orbiting 1 m away

Nearest star is another marble 270 km away

Solar system extends about 50 m from Sun; rest of distance to nearest star is basically empty

10.1 The Solar Neighborhood

The 30 closest stars to the Sun:



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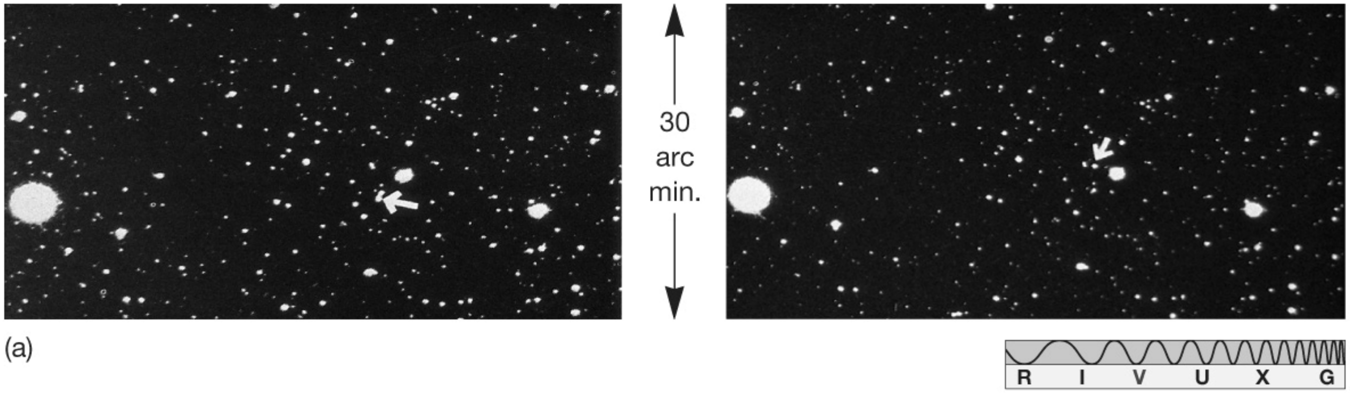
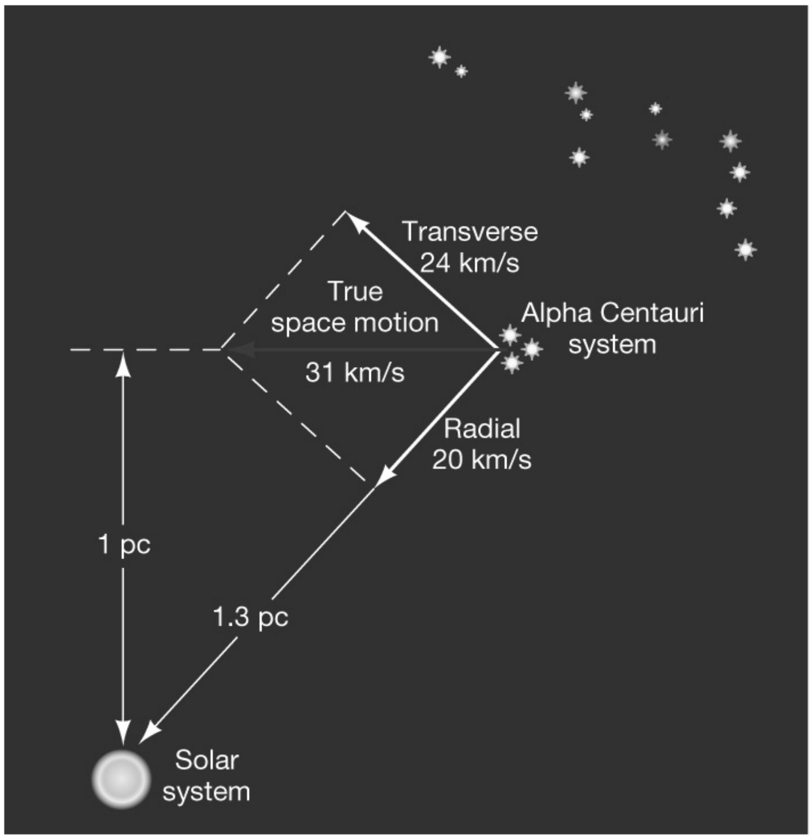
10.1 The Solar Neighborhood



(a)



(b)

Barnard's Star (top) has the largest proper motion of any – proper motion is the actual shift of the star in the sky, after correcting for parallax.

The pictures (a) were taken 22 years apart. (b) shows the actual motion of the Alpha Centauri complex.

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10.2 Luminosity and Apparent Brightness

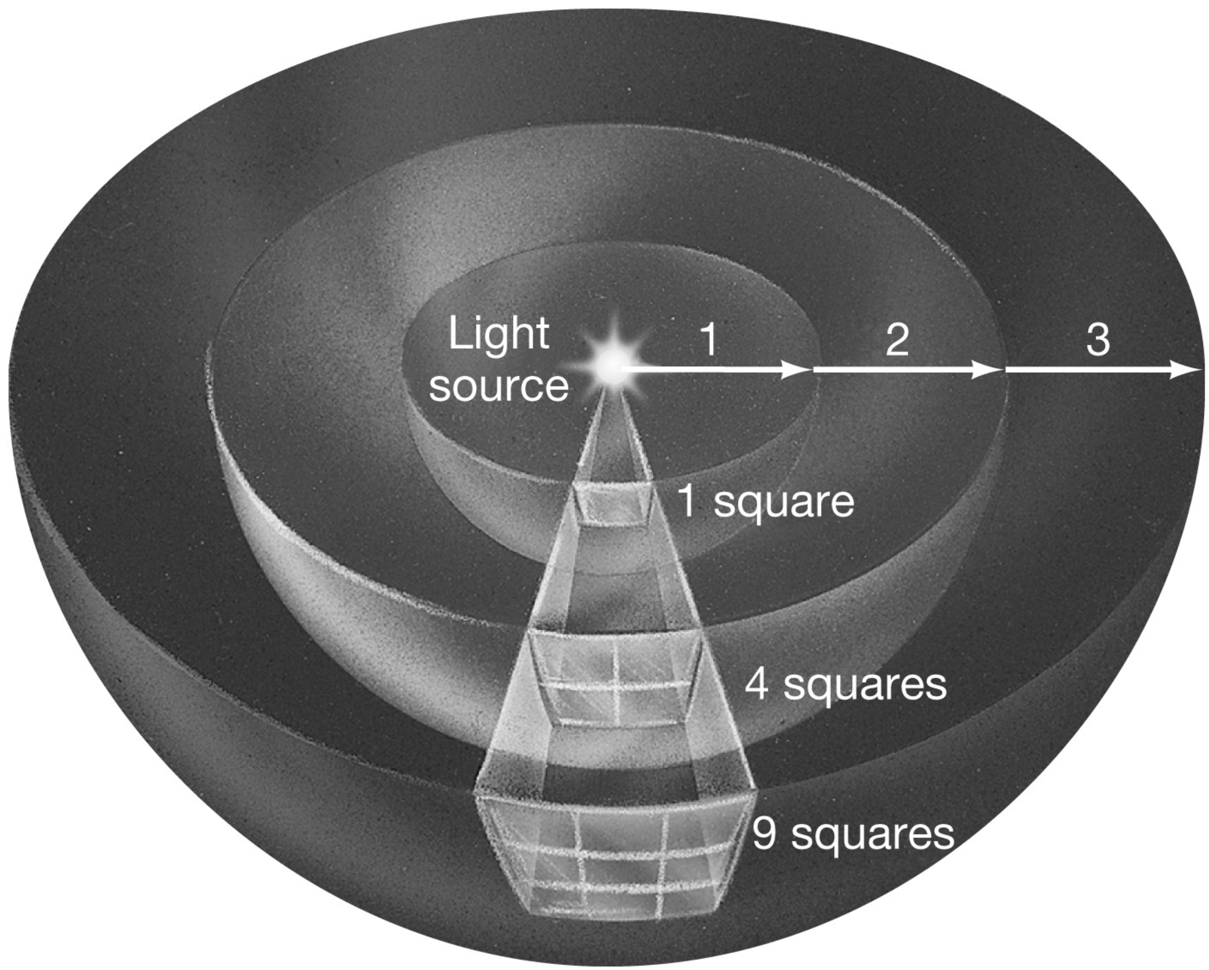
Luminosity, or absolute brightness, is a measure of the total power radiated by a star.

Apparent brightness is how bright a star appears when viewed from Earth; it depends on the absolute brightness but also on the distance of the star:

$$\text{apparent brightness} \propto \frac{\text{luminosity}}{\text{distance}^2}$$

10.2 Luminosity and Apparent Brightness

This is an example of an inverse square law



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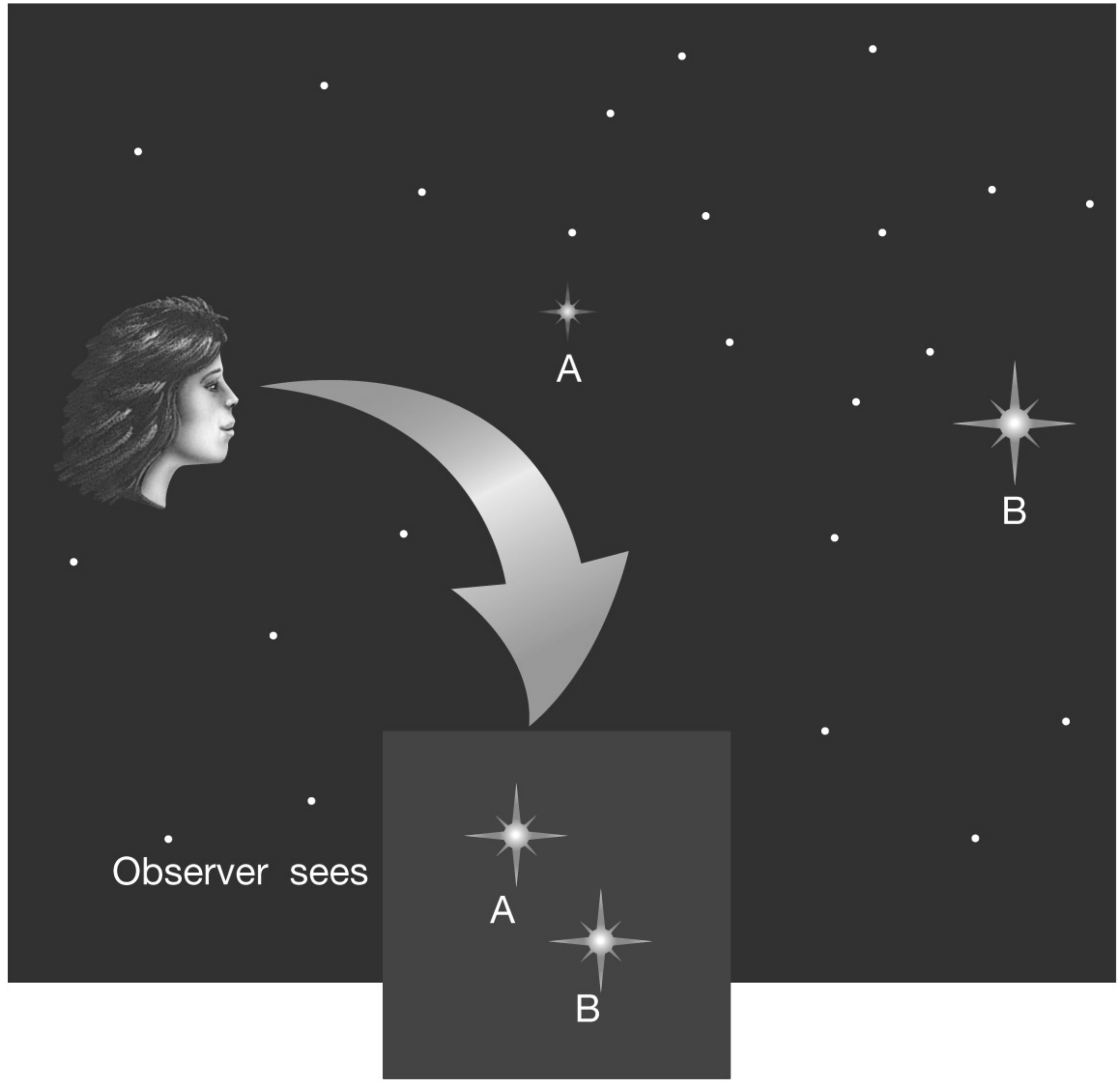
10.2 Luminosity and Apparent Brightness

Therefore, two stars that appear equally bright might be a closer, dimmer star and a farther, brighter one:



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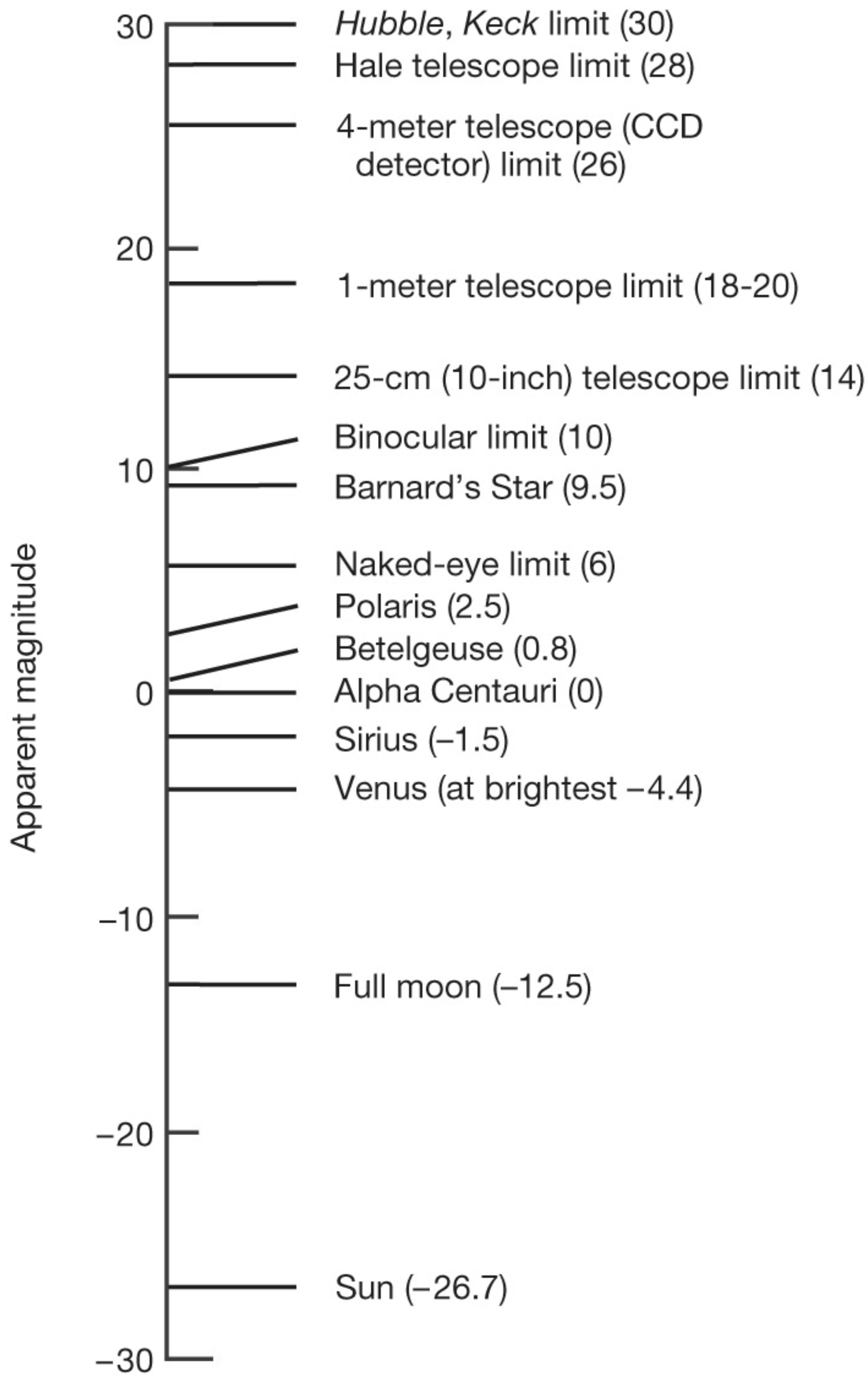
10.2 Luminosity and Apparent Brightness



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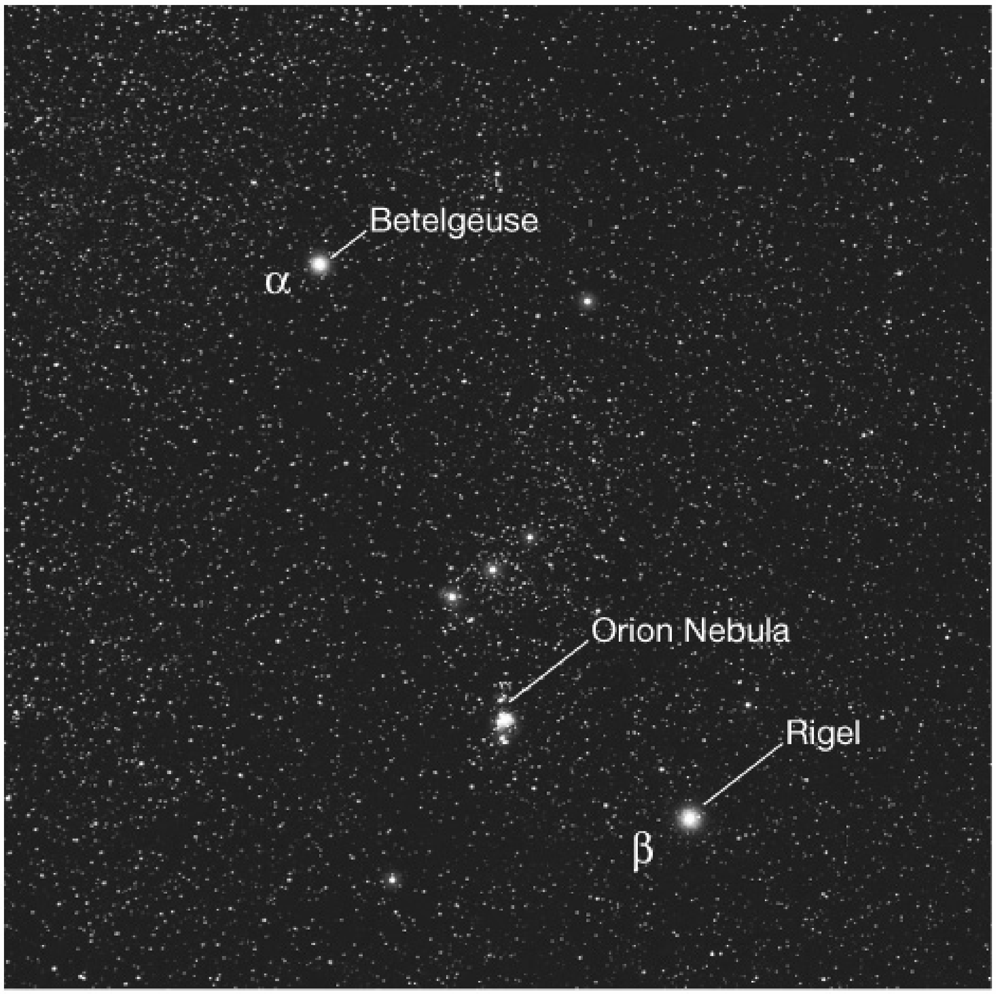
Apparent luminosity is measured using a magnitude scale, which is related to our perception.

It is a logarithmic scale; a change of 5 in magnitude corresponds to a change of a factor of 100 in apparent brightness.

It is also inverted – larger magnitudes are dimmer.

10.3 Stellar Temperatures

The color of a star is indicative of its temperature. Red stars are relatively cool, while blue ones are hotter.



10.3 Stellar Temperatures

The radiation from stars is blackbody radiation; as the blackbody curve is not symmetric, observations at two wavelengths are enough to define the temperature:

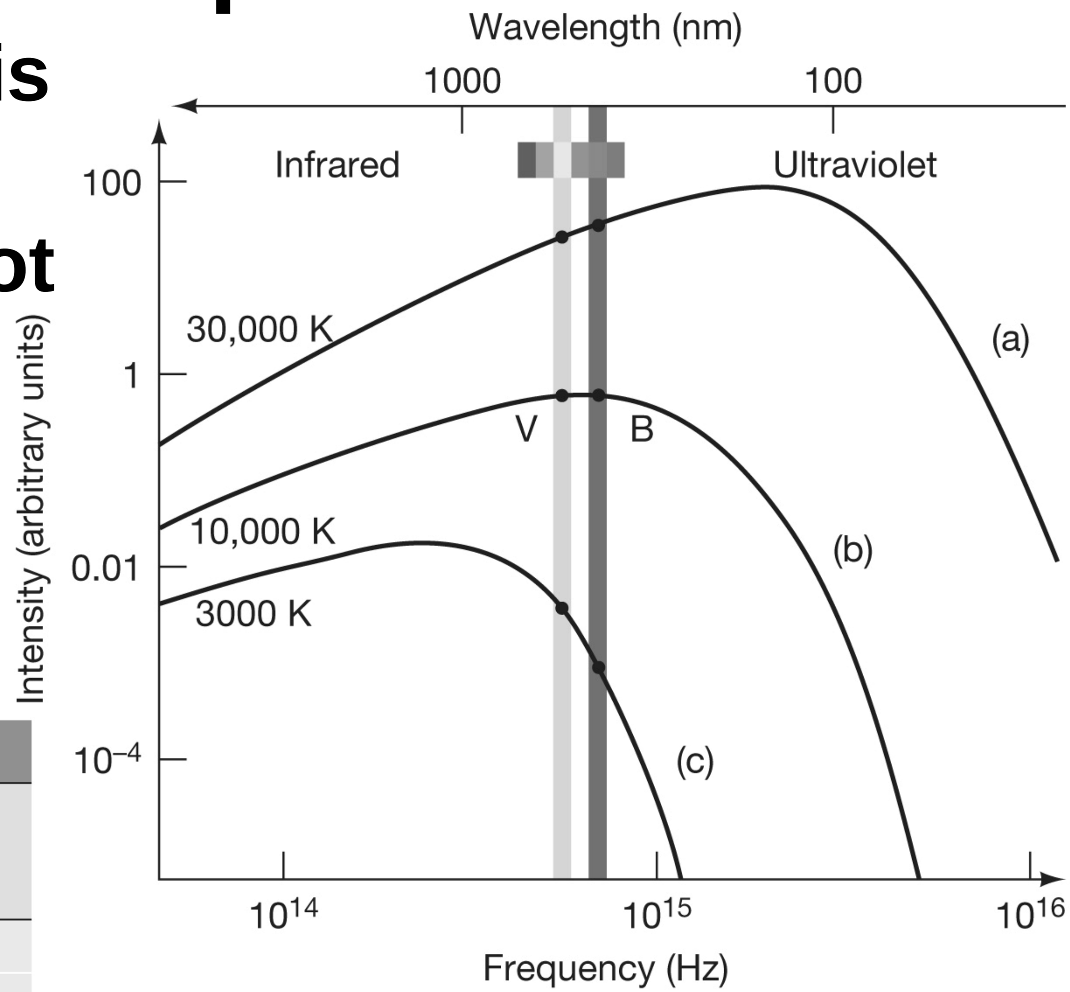


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TABLE 10.1 Stellar Colors and Temperatures

SURFACE TEMPERATURE (K)	COLOR	FAMILIAR EXAMPLES
30,000	electric blue	Mintaka (δ Orionis)
20,000	blue	Rigel
10,000	white	Vega, Sirius
7,000	yellow-white	Canopus
6,000	yellow	Sun, Alpha Centauri
4,000	orange	Arcturus, Aldebaran
3,000	red	Betelgeuse, Barnard's Star

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10.3 Stellar Temperatures

Stellar spectra are much more informative than the blackbody curves.

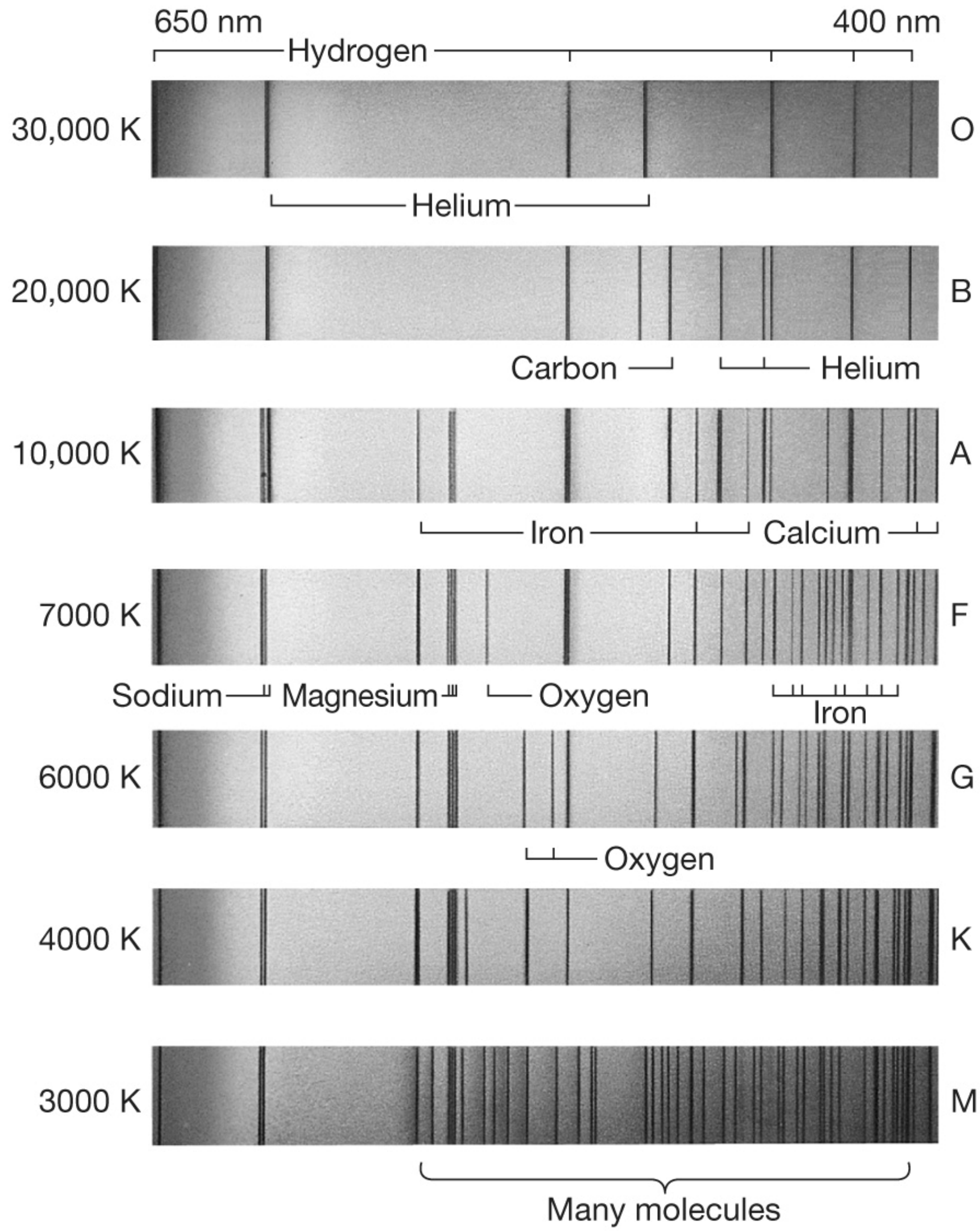
There are seven general categories of stellar spectra, corresponding to different temperatures.

From highest to lowest, those categories are:

O B A F G K M

10.3 Stellar Temperatures

The seven spectral types:



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10.3 Stellar Temperatures

The different spectral classes have distinctive absorption lines.

TABLE 10.2 Spectral Classes

SPECTRAL CLASS	TEMPERATURE (K)	PROMINENT ABSORPTION LINES	FAMILIAR EXAMPLES
O	30,000	Ionized helium strong; multiply ionized heavy elements; hydrogen faint	Mintaka (O9)
B	20,000	Neutral helium moderate; singly ionized heavy elements; hydrogen moderate	Rigel (B8)
A	10,000	Neutral helium very faint; singly ionized heavy elements; hydrogen strong	Vega (A0), Sirius (A1)
F	7000	Singly ionized heavy elements; neutral metals; hydrogen moderate	Canopus (F0)
G	6000	Singly ionized heavy elements; neutral metals; hydrogen relatively faint	Sun (G2), Alpha Centauri (G2)
K	4000	Singly ionized heavy elements; neutral metals strong; hydrogen faint	Arcturus (K2), Aldebaran (K5)
M	3000	Neutral atoms strong; molecules moderate; hydrogen very faint	Betelgeuse (M2) Barnard's Star (M5)

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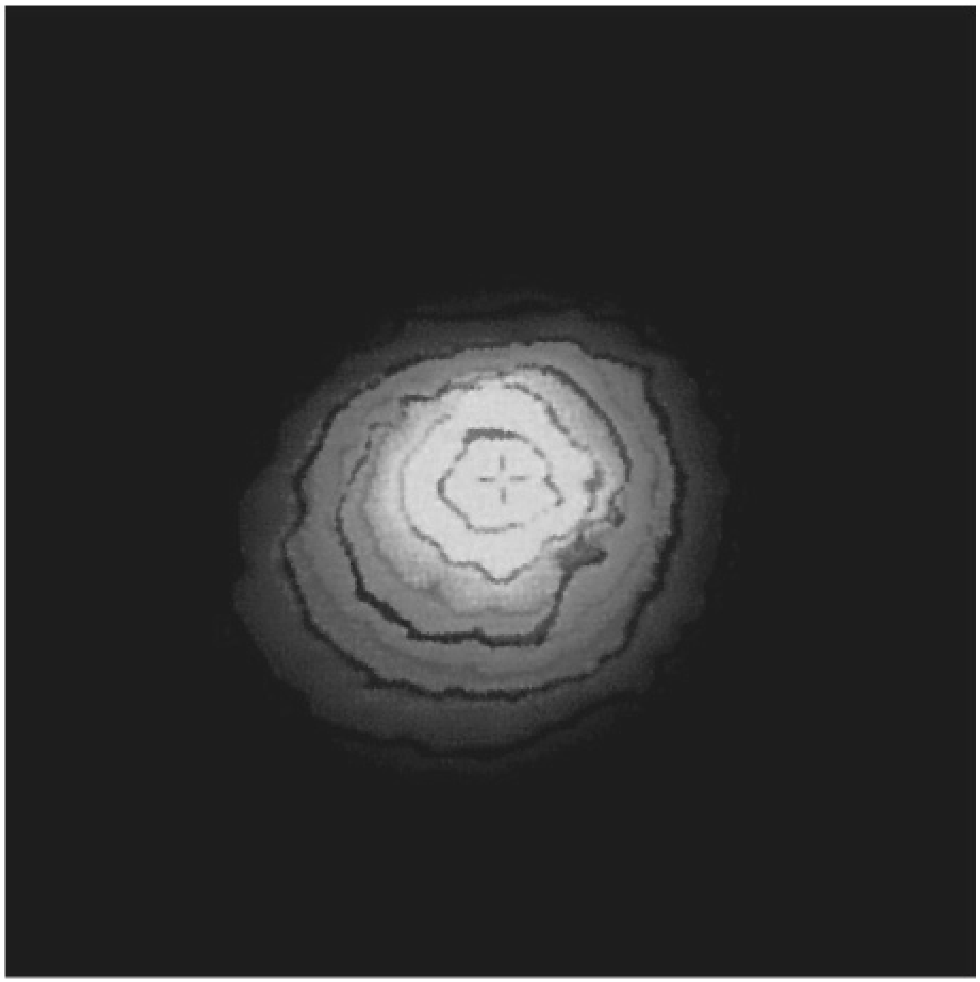
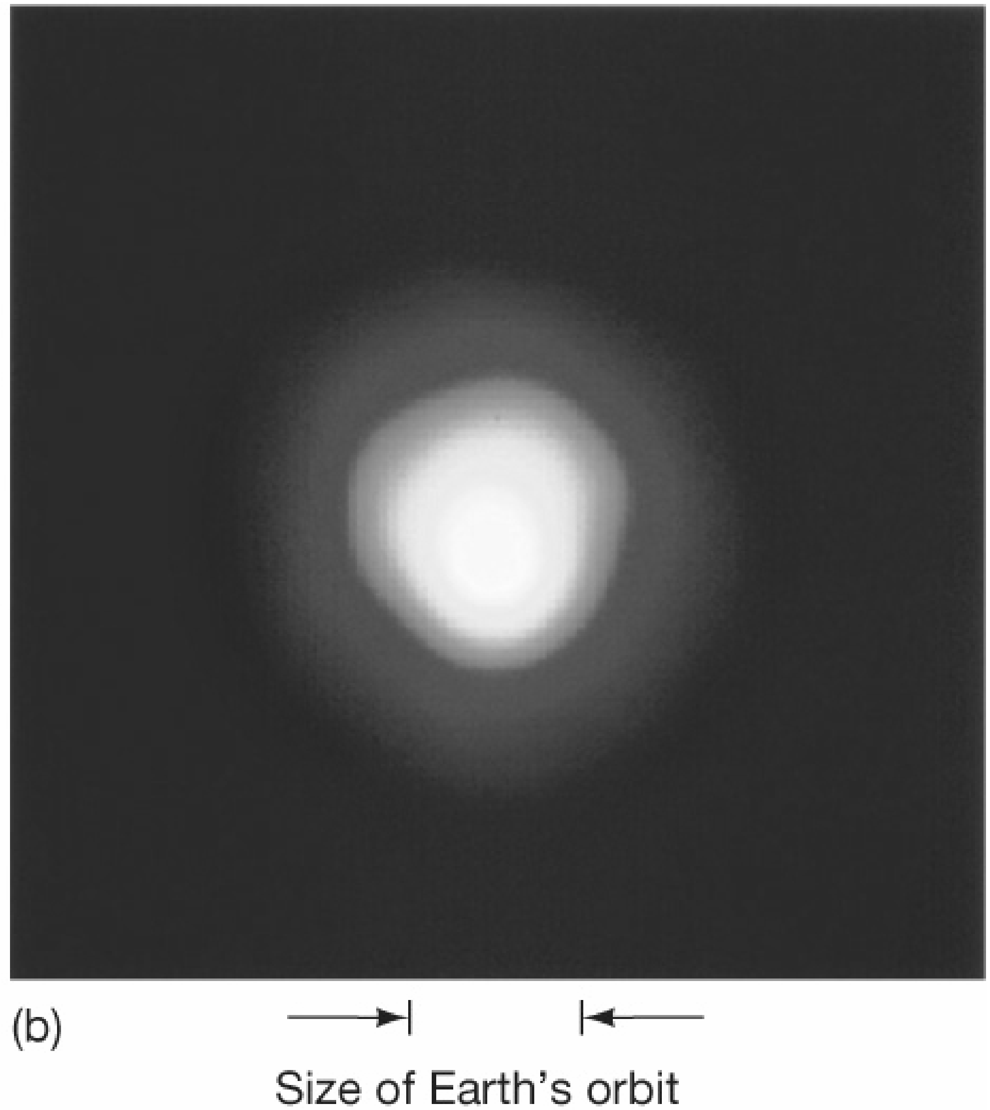
10.4 Stellar Sizes

A few very large, very close stars can be imaged directly using speckle interferometry; this is Betelgeuse:





10.4 Stellar Sizes

For the vast majority of stars that cannot be imaged directly, size must be calculated knowing the luminosity and temperature:

$$\text{luminosity} \propto \text{radius}^2 \times \text{temperature}^4$$

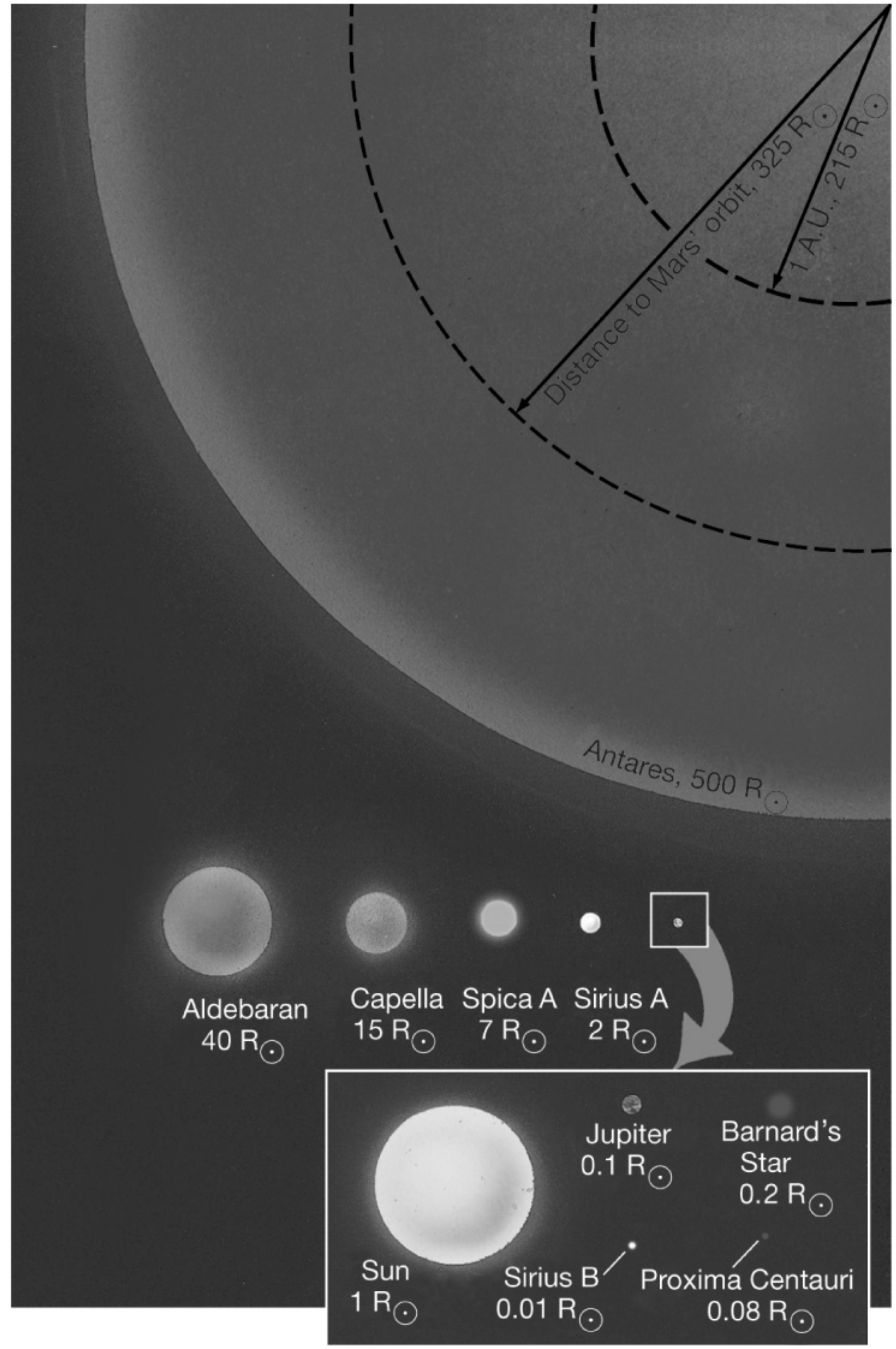
Giant stars have radii between 10 and 100 times the Sun's.

Dwarf stars have radii equal to, or less than, the Sun's.

Supergiant stars have radii more than 100 times the Sun's.

10.4 Stellar Sizes

Stellar radii vary widely:



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