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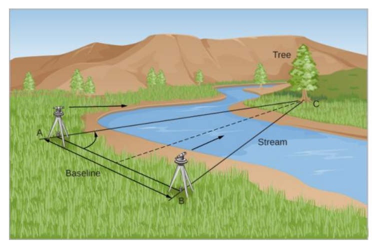
ASTRONOMY

Chapter 19 CELESTIAL DISTANCES
PowerPoint Image Slideshow

19.2 -19.3 SURVEYING THE STARS & THEIR DISTANCES

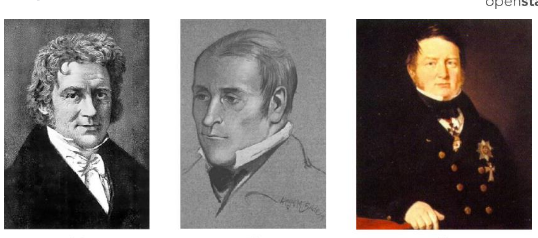
- **Globular Cluster M80.** This beautiful image shows a giant cluster of stars called Messier 80, located about 28,000 light-years from Earth. Such crowded groups, which astronomers call globular clusters, contain hundreds of thousands of stars, including some of the RR Lyrae variables discussed in this chapter. Especially obvious in this picture are the bright red giants, which are stars similar to the Sun in mass that are nearing the ends of their lives. (credit: modification of work by The Hubble Heritage Team (AURA/ STScI/NASA))

Figure 19.4



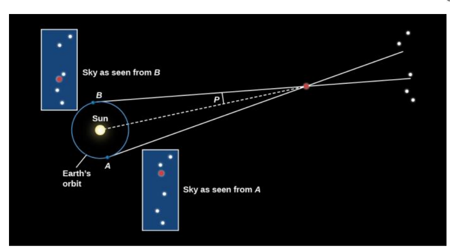
- **Triangulation.** Triangulation allows us to measure distances to inaccessible objects. By getting the angle to a tree from two different vantage points, we can calculate the properties of the triangle they make and thus the distance to the tree.

Figure 19.5



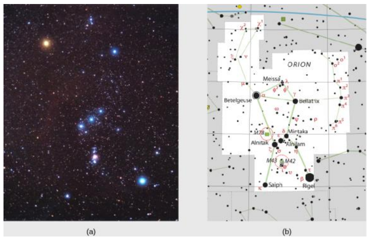
- **Friedrich Wilhelm Bessel (1784–1846), Thomas J. Henderson (1798–1844), and Friedrich Struve (1793–1864).** (a) Bessel made the first authenticated measurement of the distance to a star (61 Cygni) in 1838, a feat that had eluded many dedicated astronomers for almost a century. But two others, (b) Scottish astronomer Thomas J. Henderson and (c) Friedrich Struve, in Russia, were close on his heels.

Figure 19.6



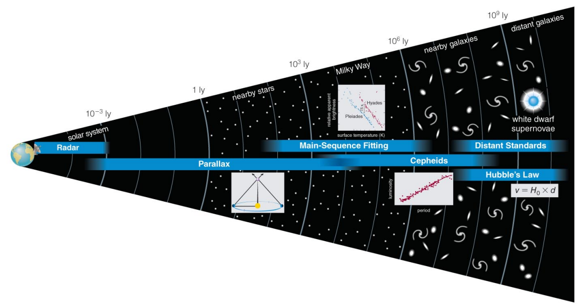
- **Parallax.** As Earth revolves around the Sun, the direction in which we see a nearby star varies with respect to distant stars. We define the parallax of the nearby star to be one half of the total change in direction, and we usually measure it in arcseconds. D= 1/p

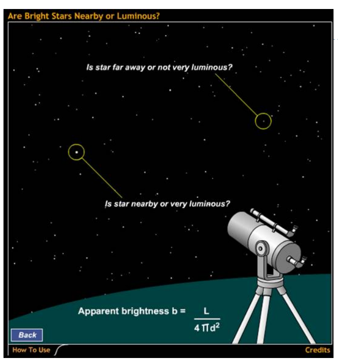
Figure 19.7



- **Objects in Orion.**
  - (a) This image shows the brightest objects in or near the star pattern of Orion, the hunter (of Greek mythology), in the constellation of Orion.
  - (b) Note the Greek letters of Bayer's system in this diagram of the Orion constellation. The objects denoted M42, M43, and M78 are not stars but nebulae—clouds of gas and dust; these numbers come from a list of "fuzzy objects" made by Charles Messier in 1781.

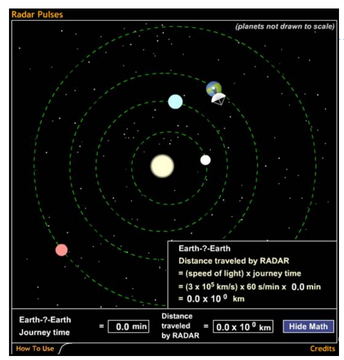
How do we measure the distances?





Brightness alone does not provide enough information to measure distance.

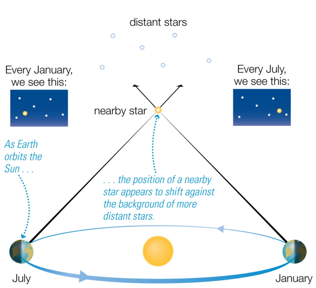
PLAY Are Bright Stars Nearby or Luminous?



Step 1

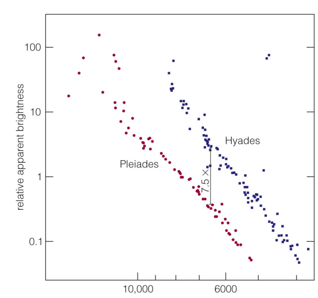
Determine size of solar system using **radar**.

PLAY Radar Pulses



Step 2

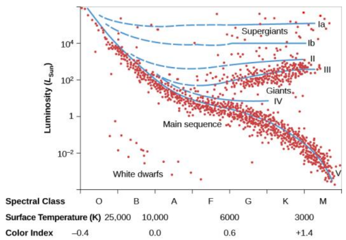
Determine distances of stars out to a few hundred light-years using **parallax**.



Step 3

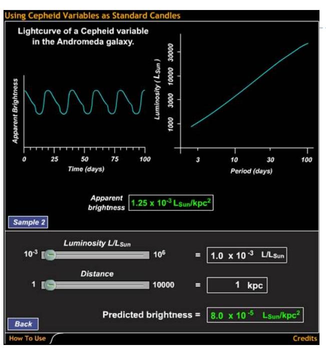
Apparent brightness of star cluster's main sequence tells us its distance. **Main sequence fitting.**

Figure 19.15



- **Luminosity Classes.** Stars of the same temperature (or spectral class) can fall into different luminosity classes on the Hertzsprung-Russell diagram. By studying details of the spectrum for each star, astronomers can determine which luminosity class they fall in (whether they are main-sequence stars, giant stars, or supergiant stars).

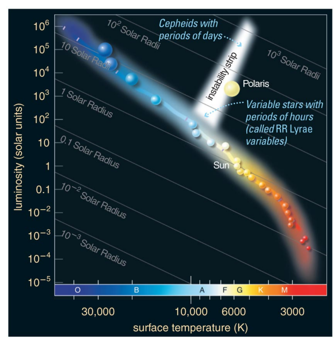
Knowing a star cluster's distance, we can determine the luminosity of each type of star within it.



Step 4

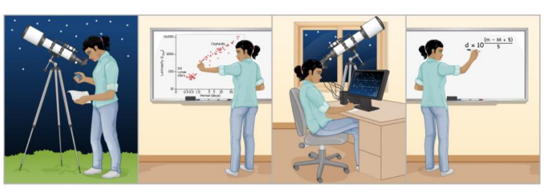
Because the period of a **Cepheid variable** star tells us its luminosity, we can use these stars as standard candles.

PLAY Using Cepheid Variables as Standard Candles



Cepheid variable stars are very luminous.

Figure 19.12



- **How to Use a Cepheid to Measure Distance.**

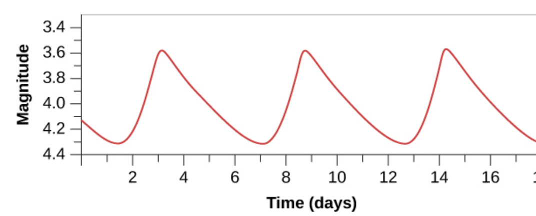
(a) Find a cepheid variable star and measure its period.

(b) Use the period-luminosity relation to calculate the star's luminosity.

(c) Measure the star's apparent brightness.

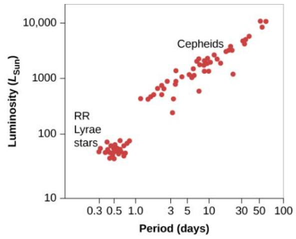
(d) Compare the luminosity with the apparent brightness to calculate the distance.

Figure 19.9



- **Cepheid Light Curve.** This light curve shows how the brightness changes with time for a typical cepheid variable, with a period of about 6 days.

Figure 19.14



- **Period-Luminosity Relation for Cepheid Variables.** In this class of variable stars, the time the star takes to go through a cycle of luminosity changes is related to the average luminosity of the star. Also shown are the period and luminosity for RR Lyrae stars.

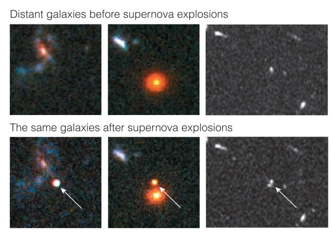
Cepheid variable stars with longer periods have greater luminosities.

Figure 19.10

- **Henrietta Swan Leavitt (1868–1921).** Leavitt worked as an astronomer at the Harvard College Observatory. While studying photographs of the Magellanic Clouds, she found over 1700 variable stars, including 20 cepheids. Since all the cepheids in these systems were at roughly the same distance, she was able to compare their luminosities and periods of variation. She thus discovered a fundamental relationship between these characteristics that led to a new and much better way of estimating cosmic distances. (credit: modification of work by AIP)

Figure 19.11

- **Large Magellanic Cloud.** The Large Magellanic Cloud (so named because Magellan's crew were the first Europeans to record it) is a small, irregularly shaped galaxy near our own Milky Way. It was in this galaxy that Henrietta Leavitt discovered the cepheid period-luminosity relation. (credit: ESO)



Step 5

Apparent brightness of a white dwarf supernova tells us the distance to its galaxy (up to 10 billion light-years). **Distance standards**

Links

- Size universe 6 min

Reading

- 19.2
- 19.3