10.14: The Stars - A Celestial Census (Exercises)

For Further Exploration

Articles

Croswell, K. “The Periodic Table of the Cosmos.” *Scientific American* (July 2011):45–49. A brief introduction to the history and uses of the H–R diagram.

Davis, J. “Measuring the Stars.” *Sky & Telescope* (October 1991): 361. The article explains direct measurements of stellar diameters.

DeVorkin, D. “Henry Norris Russell.” *Scientific American* (May 1989): 126.

Kaler, J. “Journeys on the H–R Diagram.” *Sky & Telescope* (May 1988): 483.

McAllister, H. “Twenty Years of Seeing Double.” *Sky & Telescope* (November 1996): 28. An update on modern studies of binary stars.

Parker, B. “Those Amazing White Dwarfs.” *Astronomy* (July 1984): 15. The article focuses on the history of their discovery.

Pasachoff, J. “The H–R Diagram’s 100th Anniversary.” *Sky & Telescope* (June 2014): 32.

Roth, J., and Sinnott, R. “Our Studies of Celestial Neighbors.” *Sky & Telescope* (October 1996): 32. A discussion is provided on finding the nearest stars.

Websites

Eclipsing Binary Stars: www.midnightkite.com/index.aspx?URL=Binary. Dan Bruton at Austin State University has created this collection of animations, articles, and links showing how astronomers use eclipsing binary light curves.

Henry Norris Russell: http://www.nasonline.org/publication...ll-henry-n.pdf. A biographic memoir by Harlow Shapley.

Hertzsprung–Russell Diagram: http://skyserver.sdss.org/dr1/en/proj/advanced/hr/. This site from the Sloan Digital Sky Survey introduces the H–R diagram and gives you information for making your own. You can go step by step by using the menu at the left. Note that in the project instructions, the word “here” is a link and takes you to the data you need.

Stars of the Week: http://stars.astro.illinois.edu/sow/sowlist.html. Astronomer James Kaler does “biographical summaries” of famous stars—not the Hollywood type, but ones in the real sky.

Review Questions

1. How does the mass of the Sun compare with that of other stars in our local neighborhood?
2. Name and describe the three types of binary systems.
3. Describe two ways of determining the diameter of a star.
4. What are the largest- and smallest-known values of the mass, luminosity, surface temperature, and diameter of stars (roughly)?
5. You are able to take spectra of both stars in an eclipsing binary system. List all properties of the stars that can be measured from their spectra and light curves.
6. Sketch an H–R diagram. Label the axes. Show where cool supergiants, white dwarfs, the Sun, and main-sequence stars are found.
7. Describe what a typical star in the Galaxy would be like compared to the Sun.
8. How do we distinguish stars from brown dwarfs? How do we distinguish brown dwarfs from planets?
9. Describe how the mass, luminosity, surface temperature, and radius of main-sequence stars change in value going from the “bottom” to the “top” of the main sequence.
10. One method to measure the diameter of a star is to use an object like the Moon or a planet to block out its light and to measure the time it takes to cover up the object. Why is this method used more often with the Moon rather than the planets, even though there are more planets?
11. We discussed in the chapter that about half of stars come in pairs, or multiple star systems, yet the first eclipsing binary was not discovered until the eighteenth century. Why?

Thought Questions

1. Is the Sun an average star? Why or why not?
2. Suppose you want to determine the average educational level of people throughout the nation. Since it would be a great deal of work to survey every citizen, you decide to make your task easier by asking only the people on your campus. Will you get an accurate answer? Will your survey be distorted by a selection effect? Explain.
3. Why do most known visual binaries have relatively long periods and most spectroscopic binaries have relatively short periods?
4. Figure 18.3.2 in Section 18.3 shows the light curve of a hypothetical eclipsing binary star in which the light of one star is completely blocked by another. What would the light curve look like for a system in which the light of the smaller star is only partially blocked by the larger one? Assume the smaller star is the hotter one. Sketch the relative positions of the two stars that correspond to various portions of the light curve.
5. There are fewer eclipsing binaries than spectroscopic binaries. Explain why.
6. Within 50 light-years of the Sun, visual binaries outnumber eclipsing binaries. Why?
7. Which is easier to observe at large distances—a spectroscopic binary or a visual binary?
8. The eclipsing binary Algol drops from maximum to minimum brightness in about 4 hours, remains at minimum brightness for 20 minutes, and then takes another 4 hours to return to maximum brightness. Assume that we view this system exactly edge-on, so that one star crosses directly in front of the other. Is one star much larger than the other, or are they fairly similar in size? (Hint: Refer to the diagrams of eclipsing binary light curves.)
9. Review this spectral data for five stars.

Table A

Star	Spectrum
1	G, main sequence
2	K, giant
3	K, main sequence
4	O, main sequence
5	M, main sequence

   Which is the hottest? Coolest? Most luminous? Least luminous? In each case, give your reasoning.
10. Which changes by the largest factor along the main sequence from spectral types O to M—mass or luminosity?
11. Suppose you want to search for brown dwarfs using a space telescope. Will you design your telescope to detect light in the ultraviolet or the infrared part of the spectrum? Why?
12. An astronomer discovers a type-M star with a large luminosity. How is this possible? What kind of star is it?
13. Approximately 9000 stars are bright enough to be seen without a telescope. Are any of these white dwarfs? Use the information given in this chapter to explain your reasoning.
14. Do 90% of the brightest stars lie on or near the main sequence? Explain why or why not.
15. Which star is more massive—Sirius or Alpha Centauri? Rigel and Regulus have nearly the same spectral type. Which is larger? Rigel and Betelgeuse have nearly the same luminosity. Which is larger? Which is redder?
16. If a visual binary system were to have two equal-mass stars, how would they be located relative to the center of the mass of the system? What would you observe as you watched these stars as they orbited the center of mass, assuming very circular orbits, and assuming the orbit was face on to your view?
17. Two stars are in a visual binary star system that we see face on...one star is very massive whereas the other is much less massive. Assuming circular orbits, describe their relative orbits in terms of orbit size, period, and orbital velocity.
18. Figure 18.2.4 in Section 18.2 shows the velocity of two stars in a spectroscopic binary system. Which star is the most massive? Explain your reasoning.
19. You go out stargazing one night, and someone asks you how far away the brightest stars we see in the sky without a telescope are. What would be a good, general response? (Use Appendix J for more information.)
20. If you were to compare three stars with the same surface temperature, with one star being a giant, another a supergiant, and the third a main-sequence star, how would their radii compare to one another?
21. Are supergiant stars also extremely massive? Explain the reasoning behind your answer.
22. Consider the following data on four stars:

Table B		
Star	Luminosity (in L_{Sun})	Type
1	100	B, main sequence
2	1/100	B, white dwarf
3	1/100	M, main sequence
4	100	M, giant

Which star would have the largest radius? Which star would have the smallest radius? Which star is the most common in our area of the Galaxy? Which star is the least common?
