Announcements

- **Reading Quiz due tonight!** The Reading Quiz for Week 13 ("Week13_quiz") is due tonight, Tuesday, April 22, by 11:55 PM.

- **Third Midterm Exam:** As stated in the course syllabus, the third midterm exam will be given in class next Thursday, May 1. It will be similar in form to the first two midterm exams; more information about the exam will be given in class on Thursday, April 24 and on Tuesday, April 29.

**Reading Guide and Homework Assignment**

(Week #14 On-Line Reading Quiz Due: Tuesday, April 29, 11:55 PM)

This week is all about galaxies: Their shapes, sizes, and masses, as well as their distances from us. It draws on material from several chapters, so be sure to keep this reading guide handy as you skip through them. Notice also that the suggested order of reading follows how the subjects were introduced in class but, having (hopefully!) heard the class lecture, you could also read the assignments in the order that they are presented by the text.

1. **Text — Chapter 10, Section 10.1: Fundamental Units of Distance.**
   
   This first section covers what should be familiar territory by this point in the course: the definitions of common distances used in astronomy, such as the light-second, and the astronomical unit. It also discusses some of the techniques used to measure distances in the Solar System.

2. **Text – Chapter 10, Section 10.2: Surveying the Stars.**
   
   This section moves outward from our Solar System, and discusses how distances to the nearest stars are measured through the quantitative relation between the parallax of a nearby star and its distance from us:
   
   \[ D = \frac{1}{p} \]
   
   where \( D \) is the distance in parsecs (1 parsec = 3.26 light years), and \( p \) is the parallax of the star, defined to be one-half the angle that a star shifts when seen from opposite sides of Earth’s orbit, in arcseconds. You should be able to work with this equation to derive distances when given measured parallaxes (and vice-versa).

3. On-line tutorial: On the “Week14_tutorial: Part 1” section of the textbook website, look at the Astronomy Exercise called “Parallax II”. We looked at this one in class, and it provides a nice demonstration of just how parallax is used to determine the distances of nearby stars.

4. **Text – Chapter 10, Sections 10.3.1 → 10.3.5: Cepheid Variable stars.**
   
   Section 10.3 (re)introduces the topic of standard candles or, as your book prefers, standard bulbs. The power of standard bulbs for determining distances is vital to the distance scale, and the most accurate class of objects that can be used as standard bulbs in the nearby universe is the Cepheid variable star. Make sure you understand how the period-luminosity relation for Cepheid variables allows us to gauge their distances: The key thing is that the period of oscillation of a Cepheid’s light curve, and the Cepheid’s mean apparent brightness, are relatively easy quantities to measure. Once the luminosity of Cepheids at various periods is known, it is then a relatively simple matter to determine individual Cepheid distances by measuring their periods and mean apparent brightnesses. Since Cepheids are so intrinsically luminous they can be seen out to great distances, which enables us to measure distances out to somewhat beyond 60 million light years (current record holder is a measurement from 2005 of a distance of about 100 million light years). Be sure with this reading to not “miss the forest for the trees”: here’s a capsule summary of the BIG PICTURE importance of Cepheids:
Cepheid variable star: A type of supergiant star that is up to 10,000 times more luminous than the Sun. In 1910, Henrietta Leavitt determined that Cepheids could be used as standard candles. It was Edwin Hubble who, in 1924, used Cepheids to determine the distance to the Andromeda nebula, and found it to be very far away — about 1 million light years (a bit shorter than today’s best estimate of 2 million light years, but nonetheless very far!). Cepheids have now been used to measure distances out to about 100 million light years.

5. On-line tutorial: On the “Week14_tutorial: Part 1” section of the textbook website, look at the Astronomy Exercise called “Cepheid Variable I”; working with this applet should give you a better understanding of how the period of a Cepheid variable star is related to its luminosity (and, also, its mass). Note that the Y-Axis is in these funny astronomy units called “magnitudes”, in which smaller numbers (e.g., more negative) actually represent a brighter object. We didn’t discuss the magnitude system in class, and you are not responsible for knowing it.

6. Text — Chapter 17, Sections 17.1 and 17.2: The Great Nebula Debate and Types of Galaxies. Start by reading the introduction on page 383 as well as the caption to the picture of the Hubble Deep Field on page 382. Section 17.1 opens the chapter by recounting the “Great Nebula Debate”, and how it was resolved by Edwin Hubble’s discovery that the spiral nebulae are, in fact, large stellar systems separate from our Milky Way Galaxy (itself a large spiral galaxy). §17.2 walks you through the different types of galaxies. Focus attention on the differences among the three basic types.

7. On-line tutorial: On the “Week14_tutorial: Part 2” section of the textbook website, look at the Active Figure called “Galaxy Types”. This is a nice interactive applet that allows you to explore the differences among elliptical, spiral, and barred-spiral galaxies. Notice in particular how a spiral galaxy rotates, whereas the stellar motions in an elliptical galaxy are much more randomized.


Read here about the discovery of dark matter, both in our Galaxy (the Milky Way) as well as throughout the Universe. Notice, in particular, that it is the use of Newton’s version of Kepler’s Third Law that provides the main evidence for the existence of dark matter in the Milky Way. The end of §16.3.2 goes into a bit more detail on the possibilities for dark matter than we did in class, but the bottom line is, as of now, we don’t know what it is and a number of seemingly “likely” candidates have been shown to be incorrect. Any ideas?

9. On-line tutorial: On the “Week4_tutorial” section of the textbook website (note: this is the tutorial from Week 4!), look again at the Astronomy Exercise called “Orbital Motion”, and simply do the following: Adjust the mass of the Sun so that it is 0.5 M$\text{Sun}$. Notice how slowly the planet orbits it. Then, increase the Sun’s mass so that it is 2.0 M$\text{Sun}$. Look how Earth’s orbital velocity speeds up! Conclusion: The greater the mass interior to an orbit, the faster that orbit will be. This concept is crucial to an understanding of how dark matter is detected in galaxies.

10. Text — Chapter 17, Section 17.3.1: Masses of Galaxies. Read here about how the masses of galaxies are derived by analyzing the spectra of objects (stars) or material (interstellar gas) in the galaxies. Note that dark matter is inferred to exist in both spiral and elliptical galaxies.

11. On-line reading quiz (Due: 11:55 PM, Tuesday, April 29): Take this week’s reading quiz by clicking on the “Week14_quiz” assignment at the on-line textbook web-site. The reading quiz will become available to you at 12:05 AM, Wednesday, April 23. It consists of 10 multiple choice questions. You must complete this on-line quiz by 11:55 PM Tuesday, April 29. As always, you may take the quiz twice.