Announcements

• **Reading Quiz due tonight.** The online Reading Quiz for Weeks 10 and 11 ("Week10_quiz") is due tonight, Tuesday, November 18, by 11:55 PM. Full solutions will be posted 10 minutes after the quiz is due at the textbook web-site (and shortly thereafter at the course web-page as well).

• **Second midterm exam on Thursday:** The second midterm exam will be taken in class this Thursday, November 20, during our regular class time. All of the details about the exam format and content are given in the handout, “Second Midterm Exam Guide” (which is also available at the course web-site: http://sciences.sdsu.edu/~leonard/astro101), and in the Course Reader, pages 225 – 227, and p. 230. Here are the highlights:
  1. The exam consists of 50 multiple choice questions.
  2. You have the full class period (1 hour, 15 minutes) to complete the exam.
  3. No calculators are permitted (or needed).
  4. There will be a seating chart in effect for the exam; please do NOT take your seat until told to do so.
  5. Please bring the following to the exam:
     (a) One ParSCORE FORM No. F-289-PAR-L scantron form. These may be purchased at the campus bookstore and are pink in color. (Note: Many SCAN-TRON forms look similar; *please do NOT purchase the F-288-PAR-L form – it looks similar to the correct form, but is in fact much wider and has different information on it.*
     (b) A number 2 pencil and a good eraser!
     (c) Your official “Exam cheat-sheet” (detached from the end of the Course Reader), with your name at the top, and all the information you want hand-written inside the box.

• **Reminder: Extra question & answer session Wednesday afternoon.** As announced last week, on Wednesday, November 19 (i.e., the day before the exam), from 2:30 – 3:45 PM (note slight change from 4:00 PM ending time announced earlier), I will hold an extra help session in Rm. 216 of the physics-astronomy building. Come armed with all questions that have cropped up during your studying!

Reading Guide and Homework Assignment

This week we continue learning about black holes, and Einstein’s conception of gravity, as embodied in his general theory of relativity. Note that there is no Reading Quiz being assigned for this week.

1. **Text – Chapter 15, Section 15.1.2: The Paths of Light and Matter.**
   Start by finishing up section 15.1 here, by seeing how elegantly Einstein applies the Principle of Equivalence to derive that light should have its path “bent” by gravity.

2. **Text – Chapter 15, Section 15.2: Spacetime and Gravity.**
   In this section, your authors attempt to build up an understanding of “spacetime”, a topic that we only briefly covered in class, so be sure to read this part thoroughly. Then, later on in §15.2.2, comes the description of the distortion of “spacetime” around massive objects that is predicted by the general theory of relativity. Remember, though, that the “embedding diagrams” that are shown, such as the one in Figure 15.6, are just displaying the distortion of space; time is also distorted by the presence of mass, but this distortion cannot be displayed in such a diagram.

3. **Text – Chapter 15, Section 15.3: Tests of General Relativity.**
   As discussed in class, there are a few classic tests of Einstein’s general theory of relativity which, to date, have all been successfully passed. This section describes the first two of them: The advance of the perihelion point of Mercury’s orbit, and the deflection of starlight by the Sun.
4. On-line tutorial: On the “Week12 tutorial” section of the textbook website, look at the *Astronomy Exercise* called “Escape Velocity”. This exercise might seem familiar to you, since you already looked at it way back in Week 4! So, this is basically a refresher on this important concept. Then, look at the *Astronomy Exercise* called “Black Hole”: this lets you see how the mass, radius, and escape velocity are related for stars of different masses and sizes.

5. **Text – Chapter 15, Section 15.4: Time in General Relativity.**

Two more strange predictions of general relativity are that *time should proceed at a slower pace in a strong gravity field*, and that when light leaves a strong gravity field, it experiences a *gravitational redshift*. Both of these predictions have now been verified by experiment, as described in this section.

6. **Text – Chapter 15, Section 15.5.4: A Trip into a Black Hole.**

Having read the first three subsections of section 15.5 on black holes last week, now read what it would be like if you actually fell into such an object.

7. **Text – Chapter 15, Section 15.7: Gravitational Wave Astronomy.**

With this section, we finish off our study of Einstein’s general theory of relativity, and one last (future) test of its truth: The detection of gravitational waves. Pay careful attention to both the *indirect* evidence that we have today that strongly suggests that gravitational waves do exist, and the *direct* evidence that is, at this point, still lacking (although good experiments are underway that should yield an answer soon!).

→ *Optional Astronomy Podcast*, from Astronomycast.com: Episodes 44 and 71: *Einstein’s Theory of General Relativity* and *Gravitational Waves*, available at http://www.astronomycast.com/, as well as through iTunes. The first podcast provides a nice review of the basics of general relativity and covers essentially the same material that we did in class this week, plus a bit more. The second podcast is a really great review of the geometric interpretation of gravity that is provided by General Relativity, and then how experiments coming online in the near future can hope to detect the presence of gravity waves. This second podcast I thought was particularly well done.

(“Do not worry about your difficulties in Mathematics. I can assure you mine are still greater.” – A. Einstein)