Announcements

• **Second Midterm Exam**: As indicated in the *Course Syllabus*, the second midterm exam will be given in class next week on Thursday, March 20. It will be similar in form to the first midterm exam; more information about the exam will be given in class on Thursday, March 13 and on Tuesday, March 18.

• **Reading Quiz due tonight!** The Reading Quiz for last week (“Week7 quiz”) is due tonight, Tuesday, March 11, by 11:55 PM.

• **Advanced notice: Star party next Wednesday evening!** On the evening of Wednesday, March 19, from 7:30 – 8:30 PM, there will be (weather permitting) an optional “Star Party” held on the rooftop of the physics-astronomy building (to make up for the one that was clouded out last month!). Learn your way around the night sky with a star chart and view the moon, Saturn, Mars, the Orion Nebula, and whatever else we feel like looking at through a telescope. More details will be given out in class next Tuesday, March 18.

**Reading Guide and Homework Assignment**
(Week #8 On-Line Reading Quiz Due: Tuesday, March 18, 11:55 PM)

This week we finish our study of light, and continue our investigation of the stars, answering two more fundamental questions about them: (1) What are they made of (in detail!)? (2) What physical process produces the energy by which they shine?

Note that the reading material for this week comes from Chapters 4, 6, and 7. For chapter 4, we have now completed the entire chapter. For chapters 6 and 7, we’ll only be covering parts of them. Note that there is no formal reading assignment from Chapter 5, on astronomical telescopes; for this chapter, you are ONLY responsible for the material that was explicitly presented in class, and is contained on the Powerpoint slide about Astronomical Instruments (slide 159 in your Reader); you do not need to read the chapter (although, of course, you are certainly welcome to!).

1. **Text — Section 4.2.2 and 4.2.3: Radiation and Temperature and Radiation Laws.**

   This is the discussion of how solids, liquids, and hot, dense gasses produce continuous spectra. The key things to pull from this reading are an understanding of exactly what we covered in class: That for a given “blackbody”, the hotter it is, the more energy it will give off at all wavelengths, and the “bluer” its color will be; that is, the peak of the blackbody spectrum will shift to lower and lower wavelengths as the temperature increases. There are two formulas given in section 4.2.3 that quantify these statements mathematically (the Stefan-Boltzmann Law and Wien’s Law), but we will not be using them explicitly in this course. Just know their *qualitative* results, as discussed in class.

2. On-line tutorial: On the “Week8 tutorial: Part 1” section of the textbook website, look at the *Astronomy Exercises* called “Blackbody and Wien’s Law”, and “Stefan-Boltzmann II”. The first exercise should give you a good, intuitive feel for how the color and brightness of a blackbody change with temperature. Note that the wavelength scale given here is in micro-meters (microns), unlike the more typical nano-meters that you are used to. For the second exercise, start by just adjusting the radius of the star, and note that the *luminosity* (the total energy output) of the star increases with increasing radius. Next, increase the temperature of the star, and note how dramatically the luminosity increases with even a small increase in temperature. Having completed these on-line exercises, you have finished your reading of Chapter 4, on light and atoms. Since we covered this entire chapter, you may want to check your understanding by taking the “Post-Test” (available under “What Have I Learned”).

3. **Text — Section 6.1.1: The Composition of the Sun.**

We now commence with our serious study of stars, beginning with the Sun. This is a brief reading that just covers the essential material concerning how we figured out just *what* the Sun is made out of. You should also read the material on pages 134 and 135 that introduce this section. These are the only sections of chapter 6 that we shall be reading.

4. **Text — Chapter 7, Section 7.1: Thermal and Gravitational Energy.**

We shall be reading most of chapter 7: “The Sun: A Nuclear Powerhouse”, and it begins with this section, which discusses the various theories that abounded for just *how* the Sun produces all of the energy that it does. These are interesting from a historical perspective, to just get a sense of how hard it was to figure out what made the Sun (and other stars) shine! Be sure to read the introductory material leading into section 7.1 on pages 161 and 162 as well.

5. **Text — Chapter 7, Section 7.2: Mass, Energy, and the Theory of Relativity.**

This section gives a fair amount of detail about how the Sun generates its energy, laying out all three steps of the *proton-proton chain*. The most important thing to keep your eye on from all of this is the end result: hydrogen nuclei are fused into helium nuclei, releasing energy (photons) and neutrinos; positrons, a form of anti-matter, are also given off in the reaction (but they quickly annihilate with electrons to produce additional photons). Here’s the overall reaction:

\[
4^1\text{H} \rightarrow \frac{3}{2}\text{He} + 2\gamma + 2\nu + 2e^+ 
\]

where \(\gamma\) represents a photon (energy), \(\nu\) represents a neutrino (very light particle), and \(e^+\) represents a positron (one type of anti-matter). Know also that energy is given off through fusion due to the conversion of mass to energy via Einstein’s all-too-famous equation \(E = mc^2\); in this case, about 0.7% of the original hydrogen atoms is converted into energy through the fusion process.

6. On-line tutorial: On the “Week8_tutorial: Part 2” section of the textbook website, look at the Astronomy Exercise called “Nuclear Fusion”. This is a simple little exercise, that should just bring home the fact that as the central temperature of a star increases, its luminous light output increases in a very sensitive way.

7. **Text — Sections 7.3.1 → 7.3.3: The Interior of the Sun: Theory.**

These sections contain one major message: The Sun is a gas in *hydrostatic equilibrium*: the gas pressure exerted outward in the sun exactly balances the gravitational pressure inward, to create a stable equilibrium in which the star is neither expanding nor contracting. The Sun is also *not cooling down*: It is continually generating heat and energy in its core through nuclear fusion.

8. On-line tutorial: On the “Week8_tutorial: Part 2” section of the textbook website, look at the Astronomy Exercise called “Gravity vs. Pressure”. This may help you more fully understand hydrostatic equilibrium in stars. The description of the competition between the inward pull of gravity and the outward push of gas pressure is particularly well done. As you will discover, figuring out just which stars have the highest central pressures is tricky! As usual, keep your eye on the big picture here: gas pressure out = gravity force in!

9. **Text — Section 7.4.2: Solar Neutrinos.**

Skipping over a few sections that concern some details of the Sun’s interior, we finish off chapter 7 with a short reading on neutrinos. Remember, these enigmatic particles stream freely from the sun’s core, making it to Earth in about 8 minutes (i.e., the light travel time from Sun to Earth), whereas the *photons* produced in the core take about a million years for their energy finally be released by the Sun’s surface. The neutrinos thus permit the only *direct* look at what is happening in the Sun’s core right NOW.

10. **On-line reading quiz (Due: 11:55 PM, Tuesday, March 18):** Take this week’s reading quiz by clicking on the “Week8_quiz” assignment at the on-line textbook web-site.