Astronomy 16 – Modern Astrophysics
Fall 2014
Week 5

Questions for the week:

1. What is the surface temperature of the Sun?
2. What is the equilibrium temperature of an object heated by Sunlight and re-radiating thermal energy, that's 1 AU from the Sun?

By the end of the week, you will be able to answer these questions.

Topics:

Local thermodynamic equilibrium, Saha equation, Boltzmann equation
Blackbody radiation and the Planck function
Hydrostatic equilibrium (what holds stars up?)
Stellar structure equations and two-point solutions to estimate central properties
Radiation transport and energy generation in stars

Reading:

The first part of the week, the material we cover will be that in sections 5.6 and 5.7.

This is material assigned over the last two weeks, but which we haven't gotten to yet in class. I will copy in the study topics/notes, below, from last week's assignment.

To prepare for the second half of the week, read about hydrostatic equilibrium in sec. 9.2 (only p. 213 up through the middle of p. 216, right after the *scale height* concept is introduced and the value for the Earth's atmosphere is computed), and read the first two sections of Ch. 15 (you can *skim* sub-sections 15.1.2 and 15.1.3).

Important concepts and related facts to keep in mind as you re-read, and make sure you can answer while/after you've done the reading. We will discuss all of these in class this week.

What quantities (ratios) can we compute with the Saha equation? With the Boltzmann equation? How does each depend on temperature? More specifically, why is the quantity DeltaE/kT or chi/kT so critical (answer from a qualitative, physics point of view, not a mathematical point of view). All the important concepts in sec. 5.6 are summarized in Fig. 5.13. You should be able to explain what that figure is showing and – qualitatively explain why the peak of the n_2^0 fraction represents and why it occurs at some particular temperature but decreases at both lower and higher temperatures.

Blackbody emission discussed in sec. 5.7 is hugely important. You can skim (but don't skip) the derivation of the Planck function on pp. 138-39, but you should study its properties (Fig. 5.14 and the text on pp. 140-42) carefully. The derivation of the surface flux (p. 142) might be hard to follow, but the result (eq. 5.96) is very important. Pay special attention to the version in eq. 5.98. And spend some time thinking about the physical requirements for having blackbody emission. Under what circumstances should we expect a light-emitting object to have a spectrum that's close to the Planck spectrum?

OK – for the new reading: 9.2, 15.1, 15.2

Does pressure necessarily have a force associated with it? Remember, force is a vector quantity; if a force exists, you should be able to state in what direction it points.

What holds up the Earth's atmosphere and keeps it from collapsing into a very thin, very dense layer right along the ground?

Do the various dependencies of the scale height on physical properties make (physical) sense? E.g., why should the scale height of an atmosphere be proportional to its temperature?

Study the form of the perfect gas law shown in eq. (15.7) carefully. You might be familiar with a different form (perhaps from chemistry class). Try to figure out how the version you're familiar with relates to this one.

Given the gravitational potential energy formula for the potential energy between two masses, does the formula in eq. (15.48) make sense to you?

And does it make sense that the ratio of an energy supply to the rate at which the energy is used up gives the time the energy supply will last?