

**Astronomy 16 Modern Astrophysics**  
Fall 2014  
Week 4

*Questions for the week:*

1. What is the surface temperature of the Sun?

By the end of the week, you will be able to answer this question.

*Topics:*

**Three types of spectra**

**Optical depth and the equation of radiation transfer**

**Local thermodynamic equilibrium, Saha equation, Boltzmann equation**

**Blackbody radiation and the Planck function**

*Reading:*

You can skip sec. 5.5 completely, but should read all of sec. 5.4 and 5.6 and 5.7.

To prepare for the beginning of Tuesday's class (class 7), reviewing the material from the beginning of Ch. 5, take a look at color figures 2 (showing some different emission line spectra) and, especially, figure 3, showing, schematically, Kirchoff's three "laws" governing the phenomenology of the three types of spectra. We will begin class by connecting these three types of spectra to atomic processes (electrons moving between energy levels in atoms).

Then we will move on to radiation transfer in the case of pure absorption: How do you compute how much light will be

absorbed as it passes through a medium of a given density, thickness, and optical properties?

*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.*

As you read about radiative transfer, pay special attention to the unitless quantity optical depth. What's the mathematical relationship between optical depth and the fraction of incident light that's transmitted by a given medium? Pay attention also to the quantity called column density. Why does it have the units that it does? Does it make sense to you that column density (rather than number density or mass density) is the measurable "amount of stuff" when we see an absorption line spectrum?

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  $\Delta E/kT$  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  $n_2/n_0$  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?