General Astronomy (29:61)
Fall 2012
Lecture 21 Notes, October 19, 2012

1 The Sun as a Solar System Object

There are two ways to view the Sun; as the nearest example of a star, which gives us an unequalled opportunity to study a star, and as the dominant object in the solar system. The preface to this chapter gives an interesting discussion on the first of these two considerations. In this semester we will emphasize the second, i.e. the Sun's role in the Solar System.

1.1 "Just the Facts, Ma'am"

Let's start with the basic numbers describing the Sun.

- Distance: 1 astronomical unit (average)
- Radius: 696,000 km (109 times that of the Earth)
- Mass: 1.989×10^{30} kg (330,000 time that of Earth)
- Chemical composition: Nearly exclusively hydrogen and helium

2 The Solar Photosphere

The Sun is a ball of extremely hot gases, so it is remarkable that we see it as a sharp disk in the sky (*Aten*, the defied solar disk of the pharaoh Akhenaton). $\longrightarrow$ See pictures in online notes.

The light we see comes from a layer in the Sun's atmosphere where the gases become opaque. In technical terminology of physics and astronomy, we speak of the gas as becoming *optically thick*. The meaning of this term is as follows.

If we transmit light with intensity I through a medium (air, a piece of glass, etc), the intensity when it leaves the medium is

$$I = I_0 e^{-\tau} \tag{1}$$

where I_0 is the intensity that was incident on the medium, and τ is the *optical depth*. An optically thick gas is one for which $\tau > 1$.

The solar photosphere is the layer that is responsible for sunlight. The atmospheric gases of the Sun become opaque in a very short distance, about 400 km, relative to the radius of the Sun. We will talk about what causes this opacity next time.

2.1 Temperature Structure of the Photosphere

We can tell that the temperature in the photosphere declines with increasing altitude. The reason for this is that the spectrum of the Sun shows absorption lines ($\longrightarrow$ see spectrum in online plots and diagrams). The same statement applies to most other stars. We can apply Kirchoff's 3rd Law (know what it is) to infer that $\frac{dT}{dz} < 0$ in the photosphere.

2.2 The Temperature in the Solar Photosphere

It is remarkable that we can determine the temperature in the solar photosphere, when we have never sent an instrument there. We can do this by comparing the solar spectrum to the Planck function and applying Wien's Law ($\longrightarrow$ see spectrum in online plots and diagrams). From this, we infer a temperature of about 5800K.