

**Homework 7:** Due **Wednesday, Nov 8, 2006**, in class (or turn them in before then to my mailbox, 5th floor, Sterling Hall). Show your work (for partial credit if you make an arithmetic error).

1. You get a traffic ticket for going through a red light (wavelength 700 nm). You tell the judge that because you were moving towards the light, the Doppler shift meant that you saw light of a shorter wavelength. How fast would you have to be going for the light to appear green (wavelength 500 nm)?

How fast is this in kilometers per hour? If the judge believes you, will you get a speeding ticket? Explain.

2. You use a radio telescope to look at a distant galaxy, and observe an emission line at 21.2 cm wavelength. Neutral hydrogen normally emits at 21 cm: why is the line at a longer wavelength instead?

How fast is the galaxy moving in km/sec? Is it moving towards us, or away?

3. An astronomer observing a binary star finds that the stars orbit each other every 5 years, at a distance of 10 AU. One of the stars is much more massive than the other. What is its mass, in units of the Sun's mass  $M_{\odot}$  ?

4. At the center of the Milky Way is a compact object, probably a giant black hole, with a mass of  $4 \times 10^6 M_{\odot}$ . A star follows a circular orbit around it at a radius of 1000 AU: use Kepler's law to show that its orbital period is about 15 years. (Movie at [www.mpe.mpg.de/ir/GC/](http://www.mpe.mpg.de/ir/GC/))

How fast does the star move in its orbit, in km/sec?

The line  $H\alpha$  of hydrogen is normally seen with a wavelength of 656nm. At what wavelength would we see the line in this star, when it moves directly towards Earth in its orbit?

5. A protostar has a temperature of 1000K: at what wavelength does it give out most of its light? What kind of light is this?

Use the Stefan-Boltzmann formula to calculate how many times less light this protostar gives out from every square meter of its surface, compared to the Sun. (What did you assume for the Sun's surface temperature?)

The protostar is 1000 times more luminous than the Sun. Its luminosity is the light from each square meter, multiplied by the number of square meters. How many times more surface area must it have, compared to the Sun?

What is the protostar's radius? (You need to look up the radius of the Sun.)

6. An A star on the main sequence is about 10 times more luminous than the Sun. Use the graph of Figure 13.23 to find its approximate mass.

This star shines by turning mass into energy. Look back at question 2 of homework 5: how many times more mass must this star turn into energy each second, compared to the Sun?

Suppose that the A star turns about 0.1% of its mass into energy while it is on the main sequence, like the Sun: how many times shorter is this phase of its life, compared to the Sun?

In the Pleiades star cluster, Figure 15-14 shows that stars of type A0 (surface temperature 10,000K) are still on the main sequence. But there are no A stars on the main sequence of a globular star cluster (Figure 15-17). Why?