Astronomy 160b — spring 2007
Problem Set #6 — due April 5 in class

I (12 points). Here are some exercises in using magnitudes. You may want to read the magnitude help-sheet on the classes website first. For many of these problems you'll need to know that the absolute magnitude of the Sun is ≈ 5, while the apparent magnitude of the Sun is ≈ -27.

a) Faint "brown-dwarf" stars have absolute magnitudes of around 17.5. How many times fainter than the Sun are these stars?

b) If one observes a nearby galaxy at a distance of 1 Mpc ($= 10^6$ parsecs) what is the apparent magnitude of Sun-like stars in that galaxy?

c) The magnitude of the full Moon is around -14.5. How much brighter does the Sun appear than the Moon?

d) The brightest stars are around 10^5 times brighter than the Sun. If the apparent magnitude of these bright stars in some galaxy is 22.5, how far away is the galaxy?

e) White dwarfs are 10^4 times fainter than "A-type stars". the nearest example of which is Sirius. Sirius has a distance of 3 parsecs, and an absolute magnitude of $M = 1$. Sirius is orbited by a white dwarf known as Sirius B. What is the apparent magnitude of Sirius B (note that you can assume that the two stars in the Sirius system are at the same distance from Earth).

f) The faintest galaxies observed by the Hubble Space Telescope have apparent magnitudes around 30. Suppose these galaxies are ≈ 3 gigaparsecs away (3×10^9 parsecs). Assuming every star in these galaxies emits about the same amount of light as the Sun (a false assumption, but let's make it just the same), how many stars would these galaxies contain? (Hint, the number of stars in each galaxy will be equal to amount by which the galaxy is intrinsically brighter than the Sun — e.g. a galaxy with 10 Sun-like stars has a brightness 10 times that of the Sun).

II (8 points). When Edwin Hubble first measured Hubble's constant he got a value of 500 km/s/Mpc, about 7 times larger than what we currently believe. The primary reason Hubble got such a wrong answer is that he used the wrong kind of Cepheid variables as a "standard candle". Cepheids are pulsating stars, and there is a relationship between the pulse period and the luminosity that allows one to determine the absolute magnitude of a Cepheid with good precision. Since they are quite bright, Cepheids are often used to determine the distances to nearby galaxies. The problem is that there are two kinds of Cepheids. Hubble turned out to be looking at Type I Cepheids, when he thought he was looking at Type II Cepheids, which have a different absolute magnitude. So he got the distance wrong to all his galaxies, and hence got the wrong value for the Hubble constant. (It may be useful to remember that $\log(2) \approx 0.3$, $\log(3) \approx 0.5$, and $\log(5) \approx 0.7$). *See next page for questions.*

a) Suppose the entire difference between Hubble's measurement of the Hubble constant and the currently known value of 70 km/s/Mpc was due to observing the wrong kind of Cepheid. What is the difference in absolute magnitude between the two types of Cepheids? That is, compute $\Delta \mathrm{Cep} = M_{C1} - M_{C2}$, where M_{C1} and M_{C2} are the absolute magnitudes of the two types of Cepheids.

b) Suppose there had been no problem with the standard candles Hubble used, including the Cepheids, and that the error in the determination of Hubble constant was due to some bizarre mistake in determine the value of an Astronomical Unit (that is, the distance from the Earth to the Sun). Explain why such an error could result in a mistaken value for the Hubble constant. What would the mistaken value of an AU have to be (in meters) to explain Hubble's error?