Astro 102, Fall 2006 — Review Problems #4

1. Suppose you are designing a project for Astronomy 222, Observational Astronomy. You want to measure the distance to a near-earth asteroid using parallax. You have two small small telescopes you can use, one at Dyer Observatory (in Nashville) and one in Arizona. The two telescopes are 2000 km away from each other.

You take a simultaneous picture of the asteroid from each telescope, and compare the position of the asteroid to background stars. This gives you the angular offset between the asteroid as seen from the two locations to a precision of $2''$.

(a) Draw a picture that shows what you've done above. Indicate on this picture what measurement is 2,000 km. Label with d the distance from the Earth to the asteroid.

(b) What is the farthest an asteroid can be without being too far for you to measure its distance given the precision of your parallax measurement? (Hint: if you come up with an answer that is measured in parsecs or tenths of parsecs, you've done something very wrong.)

(c) How does your answer in (c) compare to the distance from the Earth to the Moon, and to 1 AU (the distance from the Earth to the Sun)?

(d) (Bonus.) Where do you want the asteroid to be in the sky as seen from the each observatory so as to make the best possible measurement? (I.e. near rising, near setting, directly overhead, a little east of overhead, or a little west of overhead?) (No, there won't be any "Bonus" questions on the actual test.)

2. Star A has a measured parallax of $0.10''$, and Star B has a measured parallax of $0.025''$. Star B appears twice as bright as Star A. What is L_A/L_B, the ratio of the luminosity of Star A to the luminosity of Star B?

3. An astronomer makes the following observations:

- A Cepheid Variable with a period of 10 days has a parallax of 0.022"
- The Cepheid variable is 3.4×10^{-11} times as bright as the Sun in Earth's sky.
- Another Cepheid variable star in a nearby galaxy also has a period of 10 days, and is 1.1×10^{-21} times as bright as the Sun. (This is a very dim star requiring a lot of, for instance, Hubble Space Telescope time to observe!)
- A thermonuclear supernova in the same nearby galaxy as the second Cepheid is observed to be 1.5×10^{-15} times as bright as the Sun.
- A thermonuclear supernova in another distant galaxy is observed to be 1.3×10^{-19} times as bright as the Sun.

How far away is the more distant galaxy?

HINT: This is a tough problem, tougher than anything I'd ask on the test, but it does take you through a number of things. Perhaps the hardest part is thinking where to start. You can help yourself by working through the following individual questions:

- How far away is the first Cepheid variable?

- How luminous is the first Cepheid variable?
- You know that Cepheids with the same period have the same luminosity; how luminous is the second Cepheid variable?
- How far away is the nearby galaxy?
- How luminous is the thermonuclear supernova?
- Thermonuclear supernovae are "standard candles"; at peak brightness, they all have approximately the same luminosity. How luminous is the thermonuclear supernova?
- How far away is the distant galaxy?

4. Consider the following four methods for measuring distances in astronomy:

- Parallax (Sometimes called "Trigonometric Parallax")
- Main-Sequence Fitting of Clusters
- Cepheid Variables (looking at supergiant variables)
- Thermonuclear Supernovae (looking at supernovae, which are briefly as bright as a whole galaxy).

Answer the following questions for all four methods. You may find it helpful to outline in a couple of sentences how each method works, but this is not necessary.

(a) Under what conditions can you use each method? I.e., do you need to see only luminous stars, or also relative dim stars?

(b) Roughly how far away (nearby stars, galaxy scale, nearby galaxies, or much of the Universe) does each method work?

(c) How does each method depend on other methods to calibrate and verify its results?

5. Sirius is the second brightest star in the sky. It turns out to be a binary system of two stars, although we can only see one with our naked eyes. (Sirius A is 10,000 times brighter than Sirius B.) Both stars are of spectral class A.

(a) Sirius has a measured parallax of $0.38''$. How far away is it?

(b) Sirius A is 1.2×10^{10} times less bright to an Earth-bound observer than the brightest star in the sky. What is the luminosity of Sirius A in both Watts and $L_\odot$?

(c) Is Sirius A a White Dwarf, a Main Sequence star, a Giant, or a Supergiant?

(d) Is Sirius B a White Dwarf, a Main Sequence star, a Giant, or a Supergiant?