ASTR 300 Stars and Stellar Systems Spring 2011

Homework Set No. 7 Solutions

Go to https://www.courseevalum.umd.edu/ and do the evaluation!

1. Explain how Shapley used globular clusters to determine the distance and direction to the center of our galaxy.

   Shapley noticed that globular clusters were not spread uniformly around the sky but were strongly concentrated towards Sagittarius. He reasoned that they must be concentrated around the center of the galaxy. Shapley used variable stars to find the distances to the globular clusters. He then plotted their distances and directions and was able to locate the direction and distance to the center of their distribution. This was the center of the galaxy.

2. What evidence can you cite that our galaxy has a massive corona?
   (Chapter 15, Review Question 3)

   See p 311 of the text. "the best observations of the rotation curve of the Milky Way show that orbital velocities in the outer disk are constant or even increasing with distance from the center of the galaxy. ... [this implies] that our galaxy has much more mass than is contained within the radius of the sun's orbit... observational evidence ... show[s] that the extra mass lies in an extended halo sometimes called a galactic corona"

3. Why are all spiral tracers young? (Chapter 15, Review Question 9)

   If the tracers were not young, they would have time to move away from the spiral arms (where they formed), and thus would no longer trace out the arms.

4. Why couldn't spiral arms be physically connected structures? What would happen to them? (Chapter 15, Review Question 10)

   Objects at different distances from the center of the galaxy separate, since even at constant rotational velocity the more distant objects must travel further to complete one orbit. Thus a band of stars in the arm will be stretched out, and this would wind up the arms so that soon they would be unrecognizable.

5. If the true distance to the center of the galaxy were 7 (instead of 8) kpc and the orbital velocity of the sun were 220 km/s, what would the mass inside the sun's orbit be?
   (See slide 24 from lecture 22)

   Looking at that slide, if the distance were 7 kpc, then the value of R would be $7000 \times (3.086 \times 10^{18}) = 2.16 \times 10^{22}$ cm.

   Using that value of R we get $M = 1.57 \times 10^{44}\ g\ = 0.79 \times 10^{11}\ M_\odot$

6. If you find that a galaxy has the same size and mass as our Milky Way galaxy and that galaxy has a small satellite galaxy orbiting 60 kpc from the center of the larger galaxy, how long will it take the small galaxy to complete one orbit? What is the orbital velocity of that small satellite galaxy?

   Yet again, we use Kepler's 3rd law: $P^2 = a^3/(M_1 + M_2)$. Your text (p 311) gives the mass of our galaxy as 4×10^{11} M$_\odot$. Since the satellite galaxy is small we can neglect

its mass (M_2). The semi-major axis of the orbit is 60 kpc, but we need this is AU for Kepler's law. Each parsec is 206265 AU, so one kpc = 2.06×10^8 AU. Thus we find $a = 60$ kpc$= 60(2.06 \times 10^8) = 1.236 \times 10^{10}$ AU.
Then $P^2 = (1.236 \times 10^{10})^3/(4 \times 10^{11}) = 4.72 \times 10^{18}$. So the period is $P = \sqrt{4.72 \times 10^{18}} = 2.17 \times 10^9$ yrs.

7. If you find a galaxy that contains globular clusters that are 2 arc seconds in diameter, how far away is the galaxy? (Hints: Assume that a globular cluster is 25 pc in diameter and use the small-angle formula in Chapter 3.) (Chapter 16, Problem 2)

   The *small-angle formula* is given on p 39 of your text. It is (angular diameter)/(206265) = (linear diameter)/(distance) , where the angular diameter is in seconds of arc. Putting in the numbers we know, we get (2")/(206265)=(25)/(distance).

   Solving for the distance yields: distance = $(25 \times 206265)/2 = 2.58 \times 10^6$ pc

   Since one megaparsec is 10^6 pc, the galaxy is about 2.6 Mpc away.

8. How does the unified model explain the two kinds of Seyfert galaxies?
   (Chapter 17, Review Question 7.)

   See your text, p 363-364. "According to the unified model, what you see ... depends on how the black hole's accretion disk is tipped with respect to your line of sight. ... If you view the accretion disk edge on, ... you see gas lying above and below the central disk ... this gas ... is cooler ... and has narrower spectral lines. This might account for type 2 Seyfert galaxies.

   If the accretion disk is tipped slightly, you may be able to see some of the intensely hot gas in the central cavity. ... Type 1 Seyfert galaxies may be explained by this phenomenon."

9. What is the difference between hot dark matter and cold dark matter? What difference does it make to cosmology?
   (Chapter 18, Review Question 10)

   In hot dark matter, the particles would be light and thus be moving so fast that they could not be contained by the gravity of galaxies. Neutrinos would be an example of hot dark matter. In cold dark matter, the particles are thought to be more massive and slow moving. They can thus condense and help form galaxies and hold them together. The hypothetical WIMPS would be an example of cold dark matter.

   It is now thought that cold dark matter is needed to form the galaxies and clusters of galaxies in the time available since the big-bang. Hot dark matter can't do that.

10. What evidence shows that the expansion of the universe is accelerating?
    (Chapter 18, Review Question 11)

    Astronomers have measured the brightness and velocity of distant type Ia supernovae. From their brightness they obtain their distance. Now when we look at distant supernovae, we are looking at the earlier universe. If the universe were slowing down, distant supernovae would show the more rapid past expansion compared to today's rate. So the more distant supernovae should be moving faster than expected. Just the opposite was found: they are moving more slowly. This means that the expansion of the universe is accelerating.