Homework Set 8

1. [3 pts] You have a telescope that can detect all objects brighter than a minimum flux (or apparent brightness) level F. If you are observing quasars which have luminosity L which is 1800 times larger than the luminosity of a normal (non-active) galaxy, out to how much greater distance can you detect the quasars as compared to the galaxies? Round your answer to 1 decimal place.

Hint. See [Fig. 11.1] and the nearby text.

[ ]

Answer: 42.4 $= 1800^{1/2}$
from $F = L/(4\pi r^2)$, so $r = (L/4\pi F)^{1/2}$

2. [2 pts] Continuing from the previous problem.... But the distance corresponding to the light-travel time since the decoupling of the cosmic microwave background is the greatest distance to which we can ever see in the Universe, using any size of telescope observing at any wavelength. Why is that?

- **A.** This is the distance to the edge of the Universe.
- **B.** There were no photons before the time of decoupling.
- **C.** There were no stars before the time of decoupling.
- **D.** The Universe was opaque at lookback times larger than this.
- **E.** This is the distance to the center of the Universe.

Answer: D

3. [1 pt each] The following is a list of events that happened over the history of the universe. Put them in the correct chronological order, from earliest to most recent.

- **A.** Gravity separates out from the other forces.
- **B.** Decoupling of cosmic background radiation
- **C.** First stars form
- **D.** Original synthesis of hydrogen and helium
- **E.** Giant galaxy clusters finish forming
- **F.** The Universe is a soup of Quarks, before neutrons and protons existed.

G. Inflation (probably happened)

H. Today's massive galaxies finish forming

Answer: A:1, B:5, C:6, D:4, E:8, F:3, G:2, H:7

4. [3 pts] As was shown in class, Newton's form of Kepler's third law, P^2 is proportional to $a^3 / (m_1 + m_2)$, can be solved to show that for circular obits around a central point mass the velocity v is proportional to the square root of 1/r . Suppose that our galaxy had 99.9999% of its mass in a spherical ball of stars (which act as if all of their mass were at one point, at the center). If you found two individual stars or gas clouds that were in orbits outside of this central clump of stars, and star B is 3 times further from the center than is star A, what is the ratio of velocities of star B to star A? Round your answer to 2 decimal places.

Answer: 0.58 = $1/(3^{1/2})$
from v is proportional to $r^{-1/2}$,

5. [2 pts] In the late 1970's, the astronomer Vera Rubin and her colleagues observed galaxies from which almost all of the emitted star light comes from a roughly spherical ball of stars (which act as if all of their mass were at one point, at the center). However, they found that in these galaxies, stars such as A and B from problem 4 were actually moving in their orbits at nearly the same velocities, no matter how far out the stars were from the center of the galaxy. What can we conclude from this?

- **A.** The stars that emit the light were more massive than Rubin thought they were.
- **B.** The observations were wrong.
- **C.** Newton's form of Kepler's third law does not apply to anything besides the Solar System.
- **D.** The outer parts of galaxies contain lots of extra matter that does not emit light.
- **E.** The correct answer to problem 4 must be that stars A and B move at the same speed.

Answer: D