

Homework 12

This assignment is optional. You do not turn it in. The problems are intended to give you more practice and experience and insight before the final examination.

1. **The Hubble Law:** Appendix 15 of the textbook lists data for the brightest galaxies, which can be used to test the Hubble Law.
 - a. Make a scatter plot of these galaxies, with distance in Mpc along the x axis and recession velocity in km/s along the y axis.
 - b. Using a ruler or straight-edge, draw the best fitting line that you can which passes through the origin. You can use your own personal judgement to exclude “outlier” points from your fit. Determine the slope of this line, which is your own personal estimate for the Hubble constant. What value do you obtain?
 - c. The accepted value of the Hubble constant is around 72 (km/s)/Mpc. Show this on your graph by putting a dot at 720 km/s and 10 Mpc, and drawing a line from that to the origin. Label this line to distinguish it from the other.
 - d. Comparing the two straight lines, what do you think of the Hubble law and the accepted value of the Hubble constant. (Permission to speak freely is granted.)
2. **Galactic Halo:** According to a recent video on YouTube, the total amount of time everyone who has ever played the video game “Halo” adds up to 85,841,504 days.
 - a. How far would light travel in that time, measured in light years?
 - b. What is that in kiloparsecs (kpc)?
 - c. How does this distance compare to the diameter of the Milky Way galaxy?
 - d. What is wrong with adding up the game playing time that way?
3. **Around the bend:** From observing Type Ia supernovae in distant galaxies it appears that the linear relationship between recession velocity and distance deviates from a straight line at around a red shift of $z = 0.4$. Using the lookback time curve in Fig. 24.4, and assuming that the age of the universe is 13.7 Gyr, how long ago did this change take place?

- 4. Does this black hole make me look fat?** Astronomers think there is a black hole at the center of the Andromeda galaxy with a mass between $10^7 M_{\odot}$ and $10^8 M_{\odot}$.
- What is the size range for the radius (Schwarzschild radius) of the black hole?
 - Which units are more appropriate for reporting the size of the black hole, light years or Astronomical Units?
- 5. Huh?** In 1998 two groups of astronomers used data from Type Ia supernovae in distant galaxies to discover a deviation at large distances from Hubble's Law. One way to summarize their result is the mysterious statement "The Hubble Constant is not constant." Explain the meaning of this apparently incongruous claim.