

Astronomy 2115

Fall 2023

Homework #7

Due Tuesday, October 31 in class

For full credit you must write your solutions neatly and include all work. Do not forget the units.

- 1) What are masers? How can they be used to measure the distances to a galaxy?
- 2) How might you determine what part of a galaxy's redshift is caused by the galaxy's orbital motion about the center of mass of the cluster it is in?
- 3) Some galaxies in the local group exhibit blueshifted spectral lines. Why aren't these galaxies in violation of Hubble's law?
- 4) Describe what "voids" are and what they tell us about the large-scale structure of the Universe?
- 5) What are starburst galaxies and how are they produced?
- 6) Explain why the apparent shape of an elliptical galaxy may be quite different from its real shape.
- 7) Suppose you discover a Type Ia supernova in a distant galaxy. At maximum brilliance the supernova reaches an apparent magnitude of +10. Assume that the absolute magnitude for a Type Ia is -20. How far away is the galaxy?
- 8) The masers that orbit the center of the galaxy M106 have an orbital velocity of about 1000 km/s. Assume that they are observed at 4 month intervals. (a) What distance in meters does a single maser spot move in 4 months? (b) If a maser moves across the line-of sight by an angle of 10 micro-arcsec, calculate the distance to the galaxy.
- 9) You observe a galaxy at the edge of the Coma cluster ($z=0.0232$) to have a velocity of 8310 km/s. Given the diameter of 319 arcminutes for the Coma cluster, use the virial theorem ($M = rv^2/G$) to calculate the total mass of the cluster in solar masses.
- 10) When we observe a quasar at a redshift of 1.0, about how far into the past are we looking assuming $H_0 = 70$ km/s/Mpc? (hint: look in your textbook for a useful figure, or use Ned Wright's Cosmology Calculator on the web). How long has the light been travelling to us?
- 11) What is a radio galaxy?
- 12) Observations of a certain galaxy show that stars at a distance of 16 pc from the center of the galaxy orbit at a speed of 200 km/s. Use Newton's form of Kepler's 3rd law to determine the mass of the central black hole in solar masses.

13) Suppose a blazar at a redshift $z = 1.0$ is observed to have a brightness fluctuation on a timescale of 5 hours as seen from Earth. (a) At what speed does the blazar seem to be moving away from us? (b) Using the idea of time dilation, determine how long this fluctuation lasted as measured by an astronomer in the blazar's host galaxy. (c) What is the maximum size (in AU) of the region from which the blazar emits energy that we observe?

14) Calculate the Schwarzschild radius of a 10^9 solar mass black hole. How does your answer compare with the size of our solar system?