

Astronomy 2115

Fall 2023

Homework #9

Due Tuesday, Nov. 14 in class

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

- 1) Explain the difference between a Doppler shift and a cosmological redshift.
- 2) What is meant by the phrase “the observable universe”?
- 3) Describe two ways in which the cosmic microwave background is not isotropic.
- 4) The host galaxy of the supernova HST04Sas has a redshift of $z=1.390$. At what wavelength will we detect Lyman-alpha (rest wavelength 121.6 nm)? What part of the electromagnetic spectrum is this?
- 5) Estimate the age of the universe for a Hubble constant (a) $H_0 = 50$ km/s/Mpc and (b) $H_0 = 75$ km/s/Mpc and (c) $H_0 = 100$ km/s/Mpc. (d) On the basis of your answers explain how the ages of globular clusters can be used to place a limit on the value of the Hubble constant.
- 6) The quasar HS 1946+7658 has a redshift of $z=3.02$. At the time when the light we see from HS 1946+7658 left the quasar, how many times more dense was the matter in the universe on average than it is today?
- 7) If a photon from the CMB had a wavelength λ_0 when it was emitted at redshift z , its wavelength today is greater by a factor $(1+z)$. (a) Let T_n be the temperature of the CMB now. Show that the temperature when the photon was emitted was $T = T_n (1+z)$. (b) What was the radiation temperature at $z=1$? (c) At what redshift would the radiation temperature have been equal to 293 K?
- 8) Some people claim that the universe came into being about 6000 years ago. Find the value of the Hubble constant for such a universe. Is this a reasonable value for H_0 ? Explain your answer.
- 9) What was the epoch of reionization and at roughly what redshift did it take place?
- 10) If gravity is intrinsically so weak compared to the strong force, why do we say that gravity is what keeps the planets in orbit around the Sun?
- 11) What is the difference between an electron and a positron?

12) How does the currently observed abundance of H and He provide strong support for the Big Bang hypothesis?

13) What are Population III stars? Why are they so hard to detect?

14) Suppose that an electron and a positron meet and annihilate each other producing a pair of photons. What will the energy of these photons be? At what part of the electromagnetic spectrum would you find this emission line?