

ASTR100 HW#6 Solutions

12.9) **C.** There is no “center” of the universe that it is expanding away from. All parts are equally expanding away from all other parts of the universe. Space itself is expanding between the galaxies, the galaxies aren't actually moving.

13.1) **B.** The universe started off being very hot $\sim 10^{15}$ K but through billions of years of expansion, the wavelength of the radiation from the Big Bang increased which means the temperature decreased to the current temperature of ~ 2.7 K.

13.16) From Wien's law we know that the temperature is inversely related to the peak wavelength in a spectrum of radiation. 1 billion years after the Big Bang the temperature was much greater than it is today, therefore the wavelength must have been much shorter than it is today.

14.2) **C.** By plotting the rotation curves of spiral galaxies, we see a discrepancy between what is predicted by Newton and Kepler. Far away from the center of galaxies, the curve should be decreasing but our observations show they are flat which means there must be much more matter than we can see. Also we observe the effects of gravitational lensing which depends on mass and the temperature of gas in clusters of galaxies.

14.6) **A.** Observations from gravitational lensing rule out the possibility that dark matter is large dim objects like planets or red stars, and also black holes. Evidence for WIMPS, comes from analysis of the cosmic microwave background. The temperature fluctuations are best explained by a model which has $\frac{1}{6}$ of the matter in the form of ordinary matter and the rest in the form of WIMPS. This also agrees with our deuterium observations and observations from dark matter in clusters of galaxies.

Extra Credit

15.21)

$$\begin{aligned}\text{Total \# civilizations in Milky Way} &= (\text{\# of stars}) * (\text{\# civilizations per star}) \\ &= (100 \times 10^9 \text{ stars}) * (1/10^6 \text{ civs per star}) \\ &= 10^5 \text{ civilizations}\end{aligned}$$

$$\begin{aligned}\text{Average time between civs} &= (\text{total time})/(\text{total civilizations}) \\ &= (5 \times 10^9 \text{ years})/(10^5 \text{ civilizations}) \\ &= 5 \times 10^4 \text{ yrs/civ} \\ &= 50,000 \text{ yrs/civ}\end{aligned}$$

A civilization only appears once every 50,000 years. Based on this it is not likely that we would make radio contact with another civilization since so much time passes between the rise of civilizations.