

## Astronomy 301 – Fall 2019

### Homework 12

Due Date: Wednesday, December 4, 2019, 9:00 AM

We encourage you to work together on the homework but you are not allowed to copy from each other. You must write out the answers in your own words.

1. List at least one observation that supports each of the following statements about the universe:
  - (a) The law of gravity holds everywhere.
  - (b) The laws governing electricity and magnetism hold everywhere.
  - (c) The laws governing nuclear energy hold everywhere.
  - (d) The material we observe in the universe using electromagnetic radiation is the same everywhere.
  - (e) The universe is extremely large.
  - (f) The universe is extremely old.
  - (g) The universe is mostly empty.

2. The “Hubble Age” of the universe is given by

$$t = \frac{1}{H}$$

Derive this relation from Hubble’s law assuming the universe has expanded at a constant speed. What would the expansion age of the universe be if the Hubble constant were 140 km/sec/Mpc?

3. Describe the cosmic microwave background radiation. What is the origin of the radiation? The peak of spectrum of the cosmic microwave background is at about 1.1 millimeters ( $= 1.1 \times 10^7 \text{ \AA}$ ). What is the temperature of the radiation? Why is the temperature so low?
4. What elements were present in the universe when the universe was less than about 1 second old? Which elements were present when the very first stars formed and what were their abundances? What was the origin of these elements? Where did all the other elements present in the universe today come from?
5. When the universe was young it went through a phase of extremely rapid expansion called Cosmic Inflation.
  - (a) Approximately when did the cosmic inflation begin? When did it end?
  - (b) During inflation the universe expanded  $10^{25}$  times faster than the speed of light. How can this happen without violating the Special Theory of Relativity, which says nothing can travel faster than light?
6. What part of this course did you like the most? Was there anything you learned in the course that surprised you? What subjects would you have wanted to hear more about? (Any serious answers get credit.)