Origins of the Cosmos Workshop - Summer 2022

Pre-Course Assessment

In order to grant credit for the workshop, we do require you to spend some hours learning before arriving at Penn State. We encourage all of you to spend some time prior to the program in the study of astronomy to help set the stage for the week.

Besides the assigned reading detailed separately, there are several great websites that you can use as references. These include:

www.astronomynotes.com

www.teachastronomy.com

map.gsfc.nasa.gov/universe/

We have written a number of multiple-choice and short-answer questions for you to complete. Please provide a sheet with your multiple-choice answers when you arrive at the workshop. Your course grade will not depend on your quiz performance, because many of the concepts reflected in these questions are going to be the focus of instruction during the week. We intend this to be a formative assessment to help guide us in our instruction, so while we encourage you to do your best, we also do not want you to become discouraged at all if you do not know many of the answers.

Short-Answer Questions:

1) Can you explain what measurements are made by astronomers in order to use "Hubble's Law" to measure the distance to a galaxy?

2) When we take "Deep Field" images like the Hubble Deep Field or Hubble Ultra Deep Field, why do many of the smaller galaxies in the image appear to have irregular shapes?

3) In a Universe filled with normal matter, like stars & galaxies, what effect should the matter in the Universe have on the Universe itself?

4) In what way does light limit our view of the entire Universe?

5) Explain the concept of "lookback time".

Multiple-Choice Questions:

1) When we observe the spectra of distant spiral galaxies, what do we find?
A. They look identical to the spectra of distant active galaxies
B. They give off the most radiation in the radio portion of the electromagnetic spectrum
C. All of the absorption lines in the spectrum have been shifted towards redder wavelengths
D. They all show very strong emission lines but no absorption lines

2) What does the correlation between velocity and distance for galaxies tell us about the universe?
A. The Earth is located at the center of the universe.
B. The universe is expanding.
C. The universe is 100 billion years old.
D. The total extent of the universe is about 1 million light years across.

3) Why are active galaxies and quasars so much brighter than the Milky Way?
A. They contain an accretion disk surrounding a central, supermassive black hole, which emits large amounts of electromagnetic radiation.
B. Active galaxies have extremely high magnetic fields, which generate massive amounts of electromagnetic radiation.
C. The cores of these galaxies contain many massive stars, which create multiple supernovae.
D. They contain highly radioactive cores that are generating light via nuclear fission.

4) Galaxy A has an apparent velocity of 5,000 km/sec, and Galaxy B has a velocity of 2,500 km/sec. Which of the following is true:
A. A standard candle in Galaxy A will have a higher luminosity than the same type of standard candle in Galaxy B.
B. A standard candle in Galaxy A will appear fainter than the same type of standard candle in Galaxy B.
C. A standard candle in Galaxy A will appear brighter than the same type of standard candle in Galaxy B.
D. A standard candle in Galaxy A will have a smaller luminosity than the same type of standard candle in Galaxy B.

5) What makes up the majority of the mass in the Milky Way Galaxy?
A. Hydrogen gas in the disk of the Galaxy
B. A black hole in the Galactic Center
C. Young stars in the disk of the Galaxy
D. Dark matter in the halo of the Galaxy

6) When we look at all galaxies within 200 Megaparsecs of the Milky Way, how are they distributed?
A. The galaxies are found in a very regular pattern, like the points on a grid.
B. They appear to be distributed just like the stars in an elliptical galaxy, in a roughly spherical shape.
C. The galaxies are largely found in narrow filaments, surrounding soap-bubble-like voids.
D. All of the galaxies are found in only a few very rich clusters, like Virgo.

7) We can use Cepheid stars to measure distances because:
A. They are all close enough to Earth that we can measure their parallax angles.
B. When they explode, their peak luminosity is always a constant value.
C. The velocity of a Cepheid star is proportional to its distance from Earth.

D. The period of their variation is directly proportional to their luminosity.

8) The central objects in active galaxies can vary in brightness by a large amount in less than one year. What does this tell us about these objects?
A. The object must be less than or about 1 light-year in size.
B. The object must be moving away from us at a high rate of speed.
C. The object must be a variable star like a Cepheid or RR Lyrae.
D. They must be extremely massive; millions or billions of solar masses.

9) Why is the night sky dark?
A. At 10 billion parsecs from Earth, the density of dust is so high the universe becomes opaque.
B. The light from the most distant stars has not had enough time to reach Earth.
C. What we perceive as “darkness” is actually the dark energy the universe emits.
D. The light from the most distant stars is shifted into the gamma-ray part of the spectrum, which we can’t detect with our eyes.

10) How old is the universe, and how do we know?
A. infinitely old; we observe that old galaxies exist at the largest distances we can probe from Earth
B. 8 billion years old; the oldest globular clusters and white dwarfs are all about this age
C. 500 billion years old; the microwave background radiation appears to be 500 billion light years away from us
D. 14 billion years old; the expansion of the universe appears to have started about this long ago

11) What evidence tells us that the Universe does not have a perceptible center or edge?
A. If the edge existed, it would have been seen in the Hubble Ultra Deep Field.
B. If the Universe had a center, it would contain a super-massive black hole, and none has been found.
C. If the Universe had a center or edge, the distribution of galaxies would not appear to be the same in all directions.
D. If the Universe had a center or edge, no quasars would be seen beyond about 10 billion light years from Earth.

12) What evidence is there for dark matter in the Universe?
A. Stars in the outermost parts of spiral galaxies orbit faster than expected
B. The extreme luminosity of quasars is only possible if they are being fed by disks of dark matter
C. The most distant galaxies appear to be decelerating, and some are even starting to come back together in a “Big Crunch”
D. The cosmic microwave background is created by the interactions between different dark matter particles

13) Why can't we see back to the Big Bang?
A. Not enough photons were produced.
B. It would take too long for light to travel that far.
C. The radiation scatters off matter frequently so the Universe is opaque.
D. Radiation is blueshifted out of the visible range.

14) Why couldn't atoms hold together in the earliest moments of the Universe?
A. Gravity was not strong enough at early times.
B. The Universe was expanding.
C. The density was too low.
D. The energy/temperature was too high.

15) By the end of the first hour of the Universe, the distribution of mass was
A. 75% Hydrogen and 25% Helium
B. 75% Hydrogen and 25% Deuterium

C. 50% Hydrogen, 25% Deuterium, and 25% Helium
D. 90% Hydrogen and 10% Carbon

16) In which type of Universe might light launched in one direction eventually return someday from the opposite direction after circling the Universe?
A. closed
B. open
C. flat
D. closed, open, or flat

17) If the Universe is open
A. it will eventually start to re-collapse and it will get hotter and denser.
B. material will get further and further apart, and eventually no new stars will form.
C. its expansion will eventually stop completely but it will never re-collapse.
D. its density exceeds the critical density.

18) A Deuterium nucleus (^2H) consists of
A. one proton and one neutron
B. one proton
C. one neutron
D. two protons and two neutrons

19) The horizon problem is the question of
A. Why the microwave background radiation is so very different in different directions.
B. Why the Universe is so close to having a density close to the critical value (so close to being flat) when it could have any density at all.
C. Whether the Universe has enough dark matter that it will eventually stop expanding and begin to contract again.
D. How two points on opposite sides of the Universe have the same temperature even though communication between them was impossible.

20) What does the Hubble law imply about the history of the Universe?
A. Before the Universe started to expand, it had collapsed and expanded many times before.
B. The Universe has been expanding forever; it is infinitely old.
C. The Milky Way galaxy is at the exact location where the Universe started to expand.
D. The Universe started expanding at some time in the past; the Universe has an age.

21) The cosmic microwave background is important mostly because:
A. It showed that the Universe is open.
B. Its detection represented a major technological advance.
C. It confirmed a major prediction made by the Big Bang theory.
D. It showed that the Universe is flat.

22) Cosmic inflation is
A. Another way of saying that the Universe is expanding at more or less a constant rate since the Big Bang.
B. An idea that dark matter is more important relative to ordinary matter early in the history of the Universe.
C. A proposed change to the Big Bang Model that says there was a short period of extremely rapid expansion at about 10^{-34} seconds after the Big Bang.
D. A theory for how the giant “soap-bubble" surfaces, on which galaxies lie, were formed.

23) As the Universe cools the microwave background radiation changes in the following way:

A. The intensity decreases and the wavelength increases
B. The intensity increases and the wavelength increases
C. The intensity decreases and the wavelength decreases
D. The intensity increases and the wavelength decreases