Lab 12: The Expansion of the Universe and Hubble's Law

Part I: The Nature of the Universe

Watch the following video and answer the following questions in section I, II and III.

There is a lot of information in this video! Take advantage of the fact that you can stop, rewind and replay parts to really try to understand what Phil Plait is saying.

`https://youtu.be/9B7Ix2VQEGo`

Section I: The history of discovering the universe

1. What does it mean to have a "static" universe?

2. When the astronomer, Vesto Slipher, observed the spectra of galaxies in our universe, he noticed that they were red-shifted. What does this mean for the galaxies? Are they moving toward us or away from us? (hint: We answered a question about this during lab 11.)

3. Albert Einstein thought the universe was "static", but two other physicists, Georges Lemaître and Alexander Freidmann, thought differently. Using physics and the observations of the red-shifted galaxies from Vesto Slipher what did Lemaître and Freidmann conclude about the universe?

4. Edwin Hubble (the astronomer for which the space telescope is named) measured distances to the same galaxies that Vesto Slipher had observed. By putting the distances and the redshifts of the galaxies together, he made a very important discovery. What was it?

Section II: The Big Bang and the Expansion of Space

1. What do we call the event at the beginning of the universe where everything was in a single point that suddenly expanded?

2. What is "lookback" time?

As stated in the video, the universe was dense and hot after the Big Bang. It eventually cooled and expanded enough that it became transparent (like we see today). If we look far enough away (which is also looking back in time, see "lookback" time) we can see the edge of that hot dense time of the universe. If we had been there during that time, we would have been able to see it gave off light with our eyes! The wavelength emitted was in the visible part of the spectrum. It is now billions of years in the future and that light has been redshifted to the point that we can no longer see that light with our eyes.

3. The light has been redshifted so much that the two astronomers in 1965 that found the signal of this "cosmic microwave background" had to use what kind of telescope to detect it?

4. When we talk about the expansion of the universe, we don't mean that galaxies are simply moving away from each other, but that space itself is expanding. Phil Plait uses the example of a rubber ruler that expands, the space between tick marks gets bigger. If we replace the tick marks with galaxies, we appear to see them moving away from us. Does this theory explain what Vesto Slipher saw with his redshift measurements? Explain.

5. Astronomers use math to turn the clock backwards to estimate the age of the universe. What is the current best measurement we have on the age of the universe? How does this compare to the age of the Earth?

Section III: Hubble's Law

Watch the following video of Brian Cox explain Hubble's Law and answer the following questions.

`https://youtu.be/PR6wN8ym7SI`

1. What is Hubble's Law?

2. What example did Brian Cox give for the expansion of space? Explain it in your own words.

3. Is there a center of the universe?

4. What is the Hubble constant and what does it mean?