13.6: Wrapping It Up 13 - How Well Do We Know the Expansion Rate and Age of the Universe?

Learning Objectives

- You will be able to put everything together to demonstrate your understanding of the expansion and age of the Universe, including determining the accuracy of your measurements for these two important parameters.

You have already determined a best fit value for the expansion rate and age of the Universe based on your measurements of galactic distances and speeds. In this activity, you will use your data to determine how well you know the expansion rate and age. Make sure you have your data available in the *Graphing Tool*.

13.6.1: Part I: Accuracy of the Hubble Constant

13.6.1.1: A. Your Data

You may have noticed when you calculated your best fit line that it does not go through all of the data points on your graph. This is the nature of data; there is always some spread.

1. Plot the best fit line through (0,0) again. Recall that the slope is the Hubble constant, H_0. What is your best fit value for H_0?

km/s/Mpc

One simple way to estimate the accuracy of the value of H_0 is to draw the steepest reasonable line and the shallowest reasonable line on the graph, and measure their slopes. To do this using the *Graphing Tool*, click on the tab for Draw Line and adjust the slider bar for the slope.

2. What is the maximum value you get for the value of H_0?

3. What is the minimum value you get for the value of H_0?

You can express how well you know the value of your measurement in terms of the best fit value ± the accuracy. You calculate the "+" number by subtracting the best fit from the maximum value and you calculate the "–" number by subtracting the minimum value from the best fit. For example, if your measurement of the Hubble constant was 70 ± 10 km/s/Mpc, the minimum would be 60 km/s/Mpc and the maximum would be 80 km/s/Mpc.

4. What is the best fit value ± the accuracy of the Hubble constant for your data set?

You could also express how well you know the value of your measurement in terms of ± a percent. To do this, take your accuracy ("±" number) and divide it by the best fit value. For example, if your measurement of the Hubble constant was 70 ± 10 km/s/Mpc, the accuracy expressed in terms of a percent would be: 10/70 = ± 14%.

5. Express the accuracy of your measurement in terms of a percent.

13.6.1.2: B. Compare to the HST Key Project

The HST Key Project team measured a value of 72 ± 8 km/s/Mpc.

1. What is the maximum value of H_0 according to the HST team?

km/s/Mpc

2. What is the minimum value of H_0 according to the HST team?

km/s/Mpc

3. Does the range of values measured by the HST team overlap with the range that you measured? If the ranges overlap, the measurements are said to be consistent. Explain what factors may or may not contribute to a discrepancy.

4. Who measured the value of H_0 more accurately, the HST team or you? What factors in the *data* may have contributed to a discrepancy? (You are not allowed to use the professional or amateur status of the researchers as a reason.)

13.6.2: **Part II: Accuracy of the Age of the Universe**

13.6.2.1: A. Your Data

1. What is the age of the Universe from your best fit value of H_0 (in billions of years; you calculated this previously)?

billion years

2. How old would the Universe be for your maximum value of H_0 (in billions of years)?

3. How old would the Universe be for your minimum value of H_0 (in billions of years)?

4. Based on your data, does a bigger Hubble constant (faster expansion) correspond to a bigger (older) or smaller (younger) age of the Universe?

a. Bigger (older)

b. Smaller (younger)

5. What is the final best fit value and accuracy for the age of the Universe from your data? (For example, if you get a best fit age of the Universe of 14 billion years, with a range from 13 billion to 15 billion, you could express this as 14 ± 1 billion years.)

6. What is the percent accuracy for your measurement of the age of the Universe? (For example, if your best fit age is 14 ± 1 billion years then your accuracy expressed as a percent is: 1/14 = 7%.)

13.6.2.2: B. Compare to the HST Key Project

The HST Key Project team's measurement of 72 ± 8 km/s/Mpc corresponds to an age of the Universe of $13.6^{+1.7-1.3}$ billion years.

1. What is the maximum value of t according to the HST team?

billion years

2. What is the minimum value of t according to the HST team?

billion years

3. Does the range of values measured by the HST team overlap with the range that you measured? If the ranges overlap, the measurements are said to be consistent. Explain what factors may or may not contribute to a discrepancy.

13.6.2.3: C. Comparing to Other Observations

Measurements that include the HST data, plus other lines of evidence, yield an age of the Universe of 13.8 ± 0.1 billion years.

1. Does this overlap with your range of values for the age? If so, your measurement is said to be consistent with this one.

a. Yes

b. No

2. How does the accuracy of your measurement compare to this one? What factors in the *data* may contribute to the difference?
