ASTR 102
B08
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4: What is the age and size of the universe?

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Objective/Purpose

The objective of the “What is the age and size of the universe?” lab is to further understand approximate age and size of the observable universe. By measuring the distance and recession velocity of some galaxies, the expanse of the universe can be approximated.

Introduction/Theory

Most people don’t really ever stop to consider the vastness that is the universe. Is the universe getting bigger or smaller? This lab uses some software called CLEA which stands for the Contemporary Laboratory Experiences in Astronomy and was developed by Larry Marshall’s group at the Department of Physics at Gettysburg College. By using this software, we will be able to get a rough estimate of the distances of nearby galaxies. We can then plot the Recession Speed of each of the galaxies with their Distance to get a value for the Hubble constant. The Hubble constant will give an approximate idea of whether the universe is expanding and at what rate.

Equipment

The following is the equipment required to complete this lab:

- Computer (with peripherals)
- CLEA Exercise - Hubble Redshift Software

Procedure

The following steps will outline the required procedure to complete this lab. The procedure was fairly simple and repetitive for each galaxy.

Initial Setup

1. We began by opening the CLEA software and selecting Log In on the main menu.
2. Filling in the personal information for both group members, we were then able to start.
3. In order to get started, we had to open the telescope dome. Once the dome was open we were able to see galaxies and adjust the tracking on the telescope view window.

Measuring Galaxies

1. For each cluster of galaxies, approximately two galaxies were examined, and more in the Sagittarius Cluster. To switch to another cluster, the “Change Field” button was pressed.
2. In order to get data from a galaxy we used the tracking buttons and adjusted the slew rate (speed) to get the galaxy we wanted to gather data on to the center.
3. Once the center of the screen is approximately on the galaxy, the “Monitor” button was pressed to get a zoomed in and more exact view of the galaxy. We centered the galaxy even further.
4. Upon properly centering the galaxy, the “Take Reading” button was pressed to then begin gathering data. “Start Resume” was pressed to begin gathering data.
5. Once the Signal/Noise ratio was greater than 15.0, the “Stop/Count” button was pressed to pause data point gathering and put a best-fit line on the points.
6. The left mouse button was pressed to get the value for both the K and H lines. They were recorded along with the galaxy ID and the apparent magnitude.
7. Once these values were recorded, we moved onto the next galaxy.

Observations

There were not very many observations for this lab as it was mostly data collection from pre-existing data. Some of the data points received from CLEA gave conflicting answers with what they should be as they stated that the galaxy was actually moving towards the earth. These points will have to be excluded from the final results in order to obtain an appropriate best-fit graph.

Tables/Measurements

The following measurements are recorded from CLEA and from the following two calculations.

Knowing that the Absolute Magnitude is -22.0

$$10^{\frac{Apparent\ Magnitude - Absolute\ Magnitude - 25}{5}} = Distance(Mpc)$$

and knowing that:
the K base value is: 3934.0
the H base value is: 3968.0

$$\frac{Line - Base}{Base} * 300,000 = Recession\ Speed\ (km/s)$$

			Lambda prime in Angstrom		Recession Speed (km/s)	
Galaxy ID	Apparent Magnitude	Distance (Mpc)	K Line	H Line	K Line	H Line
Coma1	12.30	72.44359601	4013.0	4048.0	6,024.40	6,048.39
Coma2	12.55	81.28305162	4012.0	4048.0	5,948.14	6,048.39
uma1-1	14.62	210.862815	4130.0	4167.0	14,946.62	15,045.36
uma1-3	14.49	198.6094917	4130.0	4167.0	14,946.62	15,045.36
104	6.12	4.207266284	3934.0	3969.0	0.00	75.60
68	6.10	4.168693835	3933.0	3968.0	-76.26	0.00
EDW	13.45	123.0268771	4051.0	4087.0	8,922.22	8,996.98
LAM	11.15	42.65795188	3973.0	4008.0	2,974.07	3,024.19
MKL	13.29	114.2878335	4051.0	4088.0	8,922.22	9,072.58
RFG	12.31	72.77798045	4012.0	4046.0	5,948.14	5,897.18
GAS	10.98	39.44573021	3973.0	4009.0	2,974.07	3,099.80
PRC	13.36	118.0320636	4052.0	4087.0	8,998.47	8,996.98
Boot2	16.76	564.9369748	4446.0	4484.0	39,044.23	39,012.10
196	5.20	2.754228703	3932.0	3968.0	-152.52	0.00
CrBor1	15.08	260.615355	4209.0	4245.0	20,971.02	20,942.54
16	5.26	2.831391996	3933.0	3968.0	-76.26	0.00

Graphs

The graph for this lab is attached at the end of the report. The Recession Speed vs the Distance was plotted to get a best fit straight line. The slope of this line is the Hubble constant.

Calculations

The calculation for the hubble constant is on the graph attached at the end of the report. The equation to calculate it is as follows:

$$Hubble\ constant\ =\ \frac{Recession\ Velocity}{Distance}$$

The approximate age of the universe is on the graph attached at the end of the report and is then calculated using the Hubble constant as follows:

$$Age\ of\ Universe\ (Billions\ of\ years)\ =\ \frac{1000}{Hubble\ Constant}$$

Results

The value for the Hubble constant that was calculated from our best fit line, given points of data, and approximate deviation is 13.67 +/- 0.56 Billion Years. Astronomers are calculating close to 70km/s/Mpc for this value, but the acceptable range is 40-100.

Conclusion/Discussion

The actual calculated Hubble constant currently accepted is approximately 71. When calculating the age of the universe using this constant we receive a value of 14.08 Billion years. The value we calculated falls into the range of the actual value when taking into account our deviation factor. As the objective of this lab was to approximate the age of the universe, and our results fell within the accepted range, this lab was a success. The only possible sources of error from this lab would have been any inconsistencies in data that may have been entered into the CLEA software, however considering our results were rather accurate, I am assuming that the data is sound.

References

No external information was required for the completion of this lab.

Evaluation

Like the stars lab, I think that this experience could be a little bit more in depth. The actual data gathering portion was bland and shallow. This is another report that could easily have been done with a “fill-in-the-blank” type of deal.