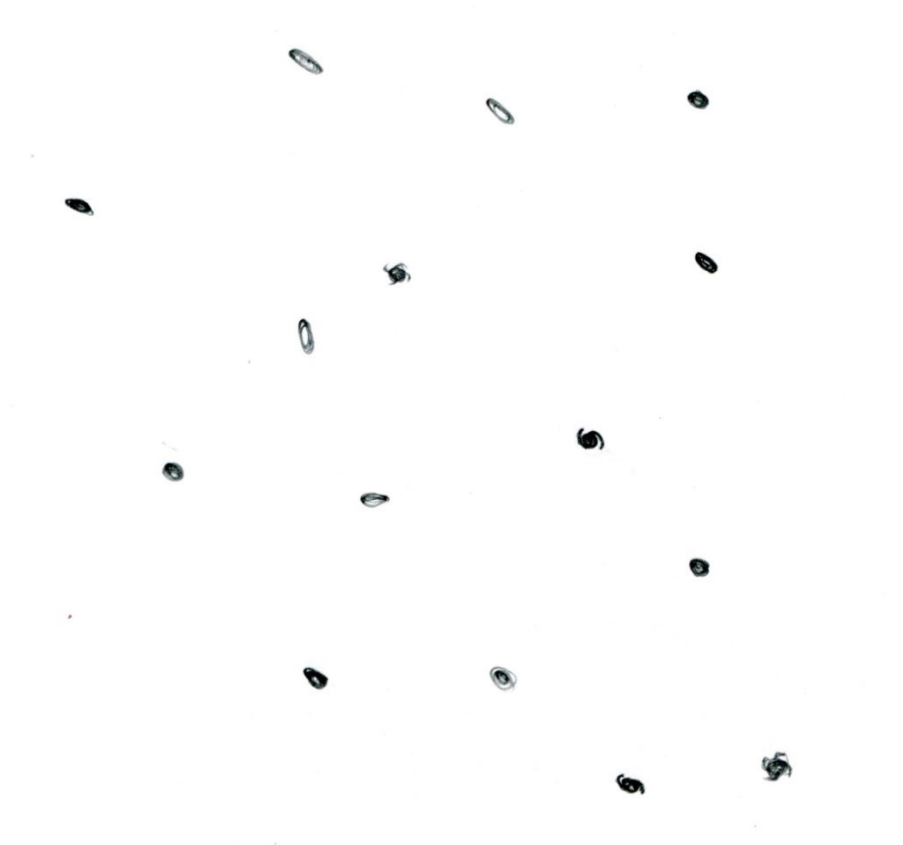


## MGA – How an expanding Universe produces a Hubble Plot

In this assignment, you will make a simple universe of galaxies (on paper). You will then make that universe expand. You will see how that expansion creates a Hubble Plot. Thus this assignment will illustrate to you, not only how an expansion creates a Hubble Plot, but also how such an expansion causes all galaxies to see themselves as being the center of the expansion.

Follow these steps:

- 1) On a blank sheet of paper, draw 15 galaxies, in no particular pattern. Make them small (they do not have to be fancy). Below is an example:



2) Now label each galaxy with a letter:

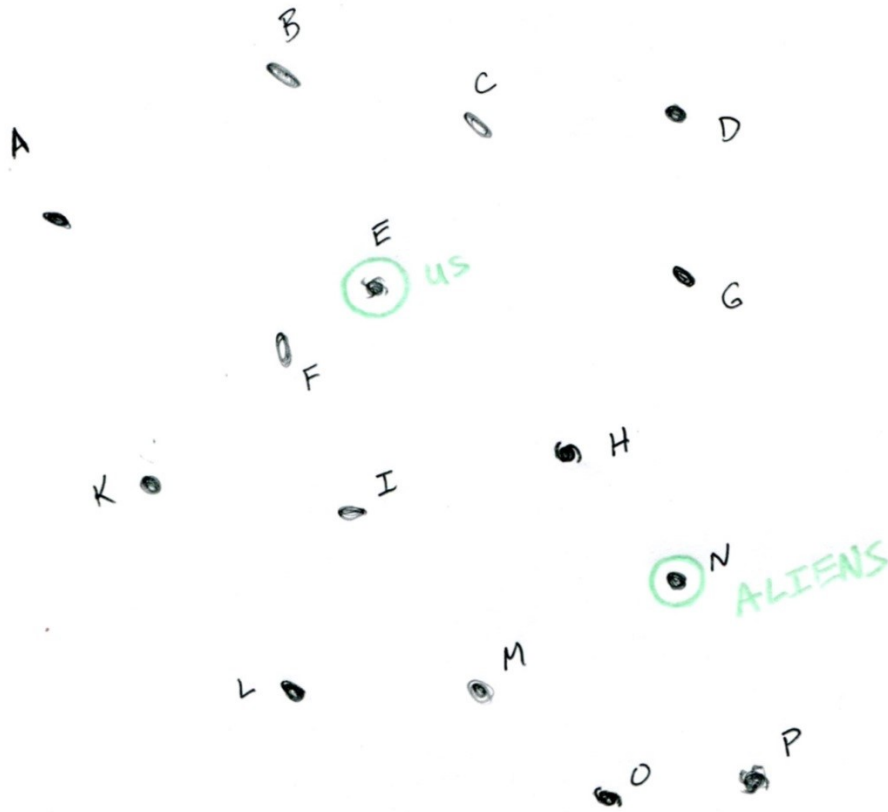


- 3) Now, go to a place that makes photocopies, and have your galaxies page enlarged by at least 20%, and no more than 50% (you want all the galaxies to stay on the enlarged page). This example is enlarged by 25%:



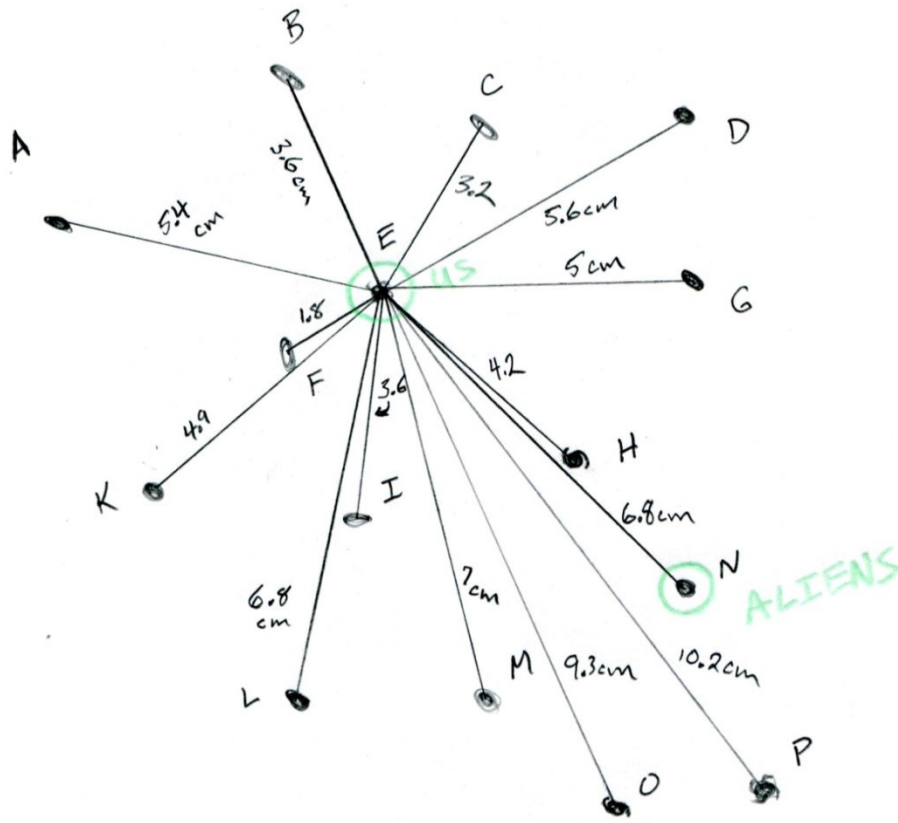
*One flaw in this assignment is that in the real universe, only the distance between galaxies is increasing – the galaxies themselves are NOT enlarging or expanding. However, we can't do that with a copy machine.*

- 4) Go back to your **original (not enlarged)** page of galaxies. Select two galaxies. Circle them. One will be for **us** – our Milky Way, where we live. The other will be a galaxy where some **aliens** live. Note these on the page.

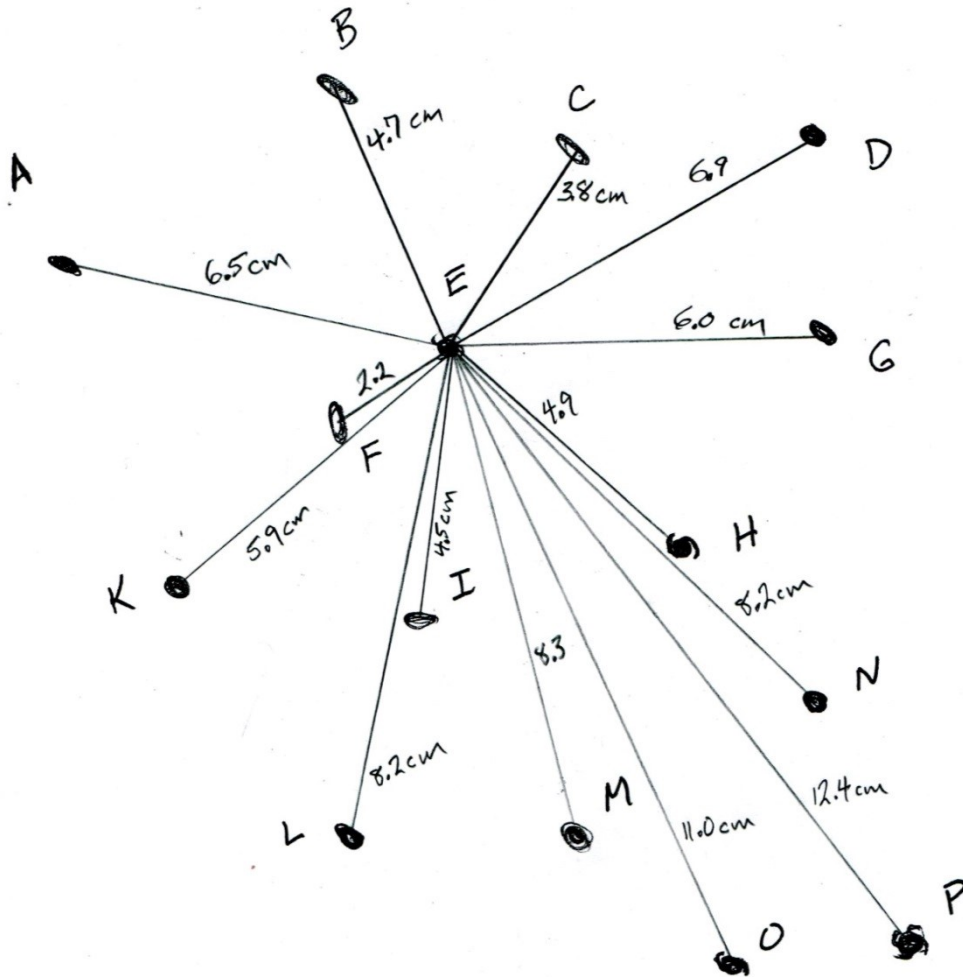


- 5) Now, using the **original (not enlarged)** page of galaxies, measure the distance in centimeters from US (in the Milky Way) to every other galaxy. Measure these distances using the *centers* of every galaxy:

Measure Center to Center



- 6) Next, using the **enlarged** page of galaxies, measure the distance in centimeters from **us** (in the Milky Way) to every other galaxy. Measure these distances from the *centers* of every galaxy:

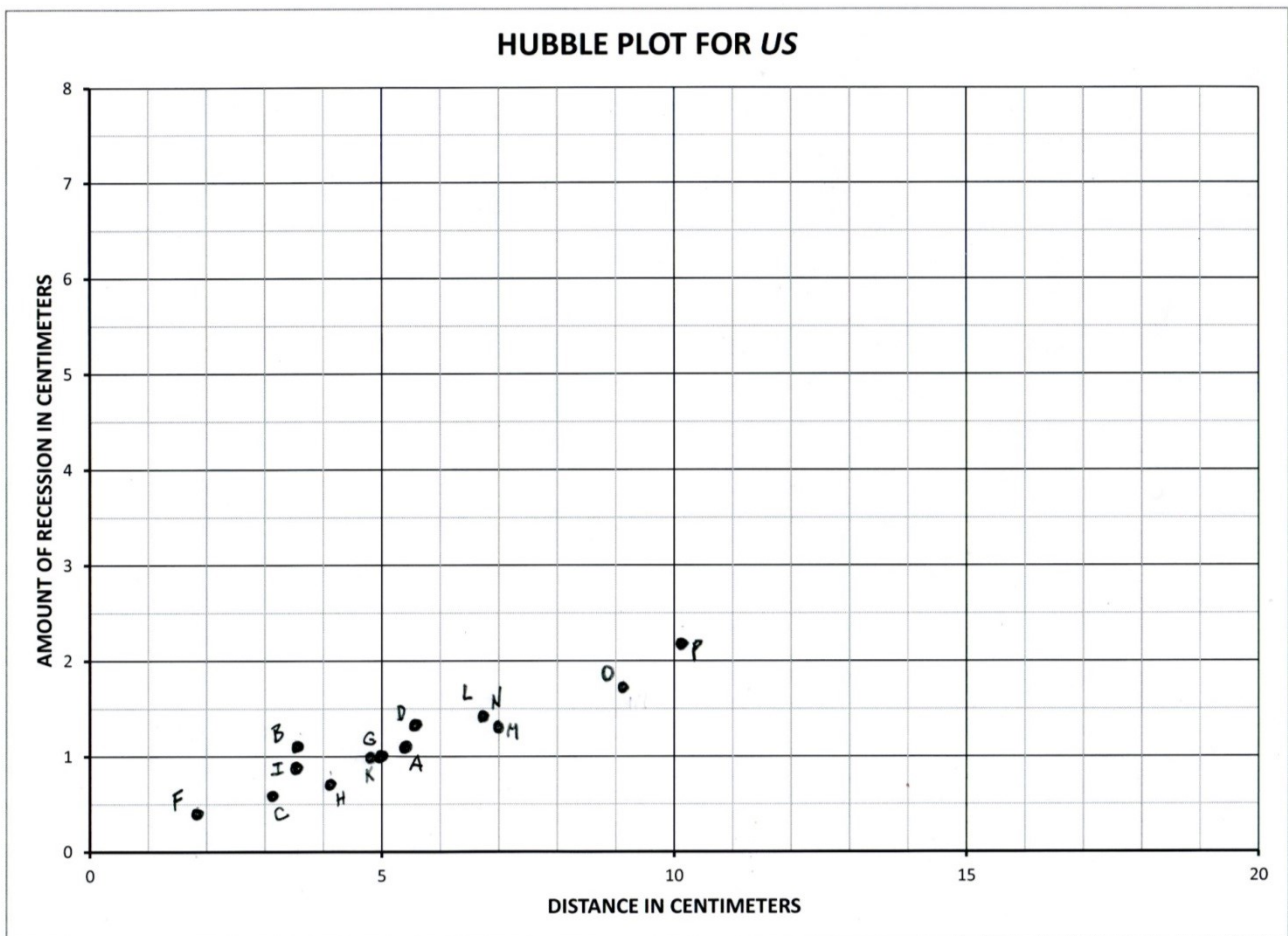




- 8) Now on the **Hubble Plot for US** sheet, plot the distance (first column of the Table) of each galaxy on the horizontal axis of the Hubble Plot, and the amount of recession on the vertical axis. Label each point:

TABLE FOR US IN THE MILKY WAY			
Galaxy	Distance	Distance with Expansion	Amount of Recession
A	5.4	6.5	$6.5 - 5.4 = 1.1$
B	3.6	4.7	$4.7 - 3.6 = 1.1$
C	3.2	3.8	0.6
D	5.6	6.9	1.3
E	This is US		
F	1.8	2.2	0.4
G	5	6.0	1.0
H	4.2	4.9	0.7
I	3.6	4.5	0.9
J	Forgot a J		
K	4.9	5.9	1.0
L	6.8	8.2	1.4
M	7.0	8.3	1.3
N	6.8	8.2	1.4
O	9.3	11.0	1.7
P	10.2	12.4	2.2

Your plot might look quite a bit different than this example:





- 9) Repeat steps 5-9 for the ALIENS instead of for US. You will fill in the section for ALIENS on the **Galaxy Tables** sheet, and fill in the **Hubble Plot for ALIENS**.
- 10) Write a 150-word typed summary of what you learned from this assignment. Did you find that both we and the aliens saw all galaxies receding from us? Did you find that both we and the aliens see a similar Hubble Plot, with the “up-and-to-the-right” pattern?
- 11) Turn in the following, *all stapled together* along with *the cover sheet* on the next page:
- a. Your original page of galaxies
  - b. Your enlarged page of galaxies
  - c. Your tables sheet
  - d. Your Hubble Plot for US
  - e. Your Hubble Plot for ALIENS
  - f. Your typed summary

## **Expanding Universe & the Hubble Plot – COVER SHEET**

Name: \_\_\_\_\_

Turn in:

- Your original page of galaxies**
- Your enlarged page of galaxies**
- Your tables sheet**
- Your Hubble Plot for US**
- Your Hubble Plot for ALIENS**
- Your typed summary**