GALAXIES ELMS Labkey

1. (numeric) Your calculated distance from OP to student B is: **8.4**m

2. (numeric) Your TA tells you the actual distance from OP to student B is **8 m**. How accurate were you as a percentage of the actual distance? **~5%**

3. (MC) Now, your TA has student A bend or kneel to become roughly half the *actual* height of student B. What does the distance to student B seem to be now? **4.2 m**

4. (essay) Why is your new estimate of the distance to student B wrong? **because they are no longer the same actual height the method does not work.**

5. (essay) Suppose you want to make practical use of this method to determine the distance to a person far away, on the other side of a lake, for example. If you compare the *apparent* height of a nearby person with that of the person on the far side of the lake, what critical assumption do you have to make in order to find the distance to the far away person? **That they are roughly the same height**

For each target: **these are the fields students will be entering on table**

a. Find the target name on the **Virgo Galaxies Worksheet**. Enter it in the *Name* field of the *Parameters* box and hit **Resolve**.
b. Zoom (if needed) to a convenient size for identifying the type of galaxy; identify and record the type of galaxy as **S** (spiral), **E** (elliptical), **SB** (barred spiral), **L** (lenticular)under **Type**.
c. If you find it difficult to see the galaxy edges, try checking the box named *Invert Image*; the image will look like a photographic negative and should make things easier to observe.
d. Measure the longest dimension of the galaxy in millimeters and record this under **Major axis** on the Galaxies Worksheet. Galaxies do not come with borders marked like countries on a map—you will have to decide where you think each galaxy ends. *Be as consistent across targets as you can!* Note that a galaxy will not always line up with the crosshairs; often the long axis is tilted in one direction.
e. Do the same with the direction perpendicular to the major axis; record this under **Minor axis**.
f. Measure the **scalebar** of the image from endpoint to endpoint in mm, then record it as arcminutes over mm, e.g., 1′/15mm. *Do not reduce this ratio!* Most of your images will be at the same scale, but a few may not be and you will need this information later to convert

measurements to correct angular size.

g. Record the ratio of major axis to minor axis under **Maj./Min. Ratio**. *Do* reduce the final number as much as possible; calculate to three significant figures.

Virgo Galaxies Worksheet

(for all columns in RED: +1.0 per box, since question is worth 32 points, give 3!)

Obj #	Name	Type	Maj. axis (mm)	Min. axis (mm)	Maj./Min. Ratio	Scale ('/mm)	Ang. Size (')
1	M61	**S**	**130**	**115**	**1.13**	**1/20**	**6.50**
2	NGC4330	**S**	**95.0**	**10.0**	**9.50**	**"**	**4.75**
3	NGC4535	**SB**					
4	NGC4429	**L**					
5	M49	**E**					
6	M59	**E**					
7	M87	**E**					
8	M88	**S**	**140**	**65.0**	**2.15**	**"**	**7.0**
9	M89	**E**					
10	M91	**SB**					
11	M99	**S**	**105**	**95.0**	**1.11**	**"**	**5.25**
12	NGC4527	**S**	**125**	**35.0**	**3.57**	**"**	**6.25**
13	NGC4571	**S**	**60.0**	**55.0**	**1.09**	**1/17**	**3.53**
14	NGC4608	**L[B]**					

6. (essay) 1. Give the largest ratio you found for any spiral galaxy: **9.50**

2. [Info on ellipticals from prior lab.]

3. Do you think there is a significant difference between these two cases? **Y**

4. What can you say about the intrinsic flatness of spirals compared to ellipticals? **should say they are flatter or equivalent**

7. (essay) Please answer the following question about your observations: [Info on ratios for lenticular galaxies: **1.05-4.67]**

2. Is this closer to spirals or ellipticals? **Either; look for their reasoning**

(Thought question: do you see why astronomers have difficulty deciding whether these are some form of spiral, or elliptical?)

8. (essay) For the purposes of the lab there is no good image of Andromeda that you can measure, so we have provided the measurement information you need to continue. (Feel free to find an image of Andromeda on the web; it is a beautiful sight!)

	Type	Maj. Axis (mm)	Scale('/mm)	Angular Size (')
Andromeda	**S**	**160**	**1'/1mm**	**160**

Calculate the angular size of all the galaxies of the *same type* as Andromeda by multiplying the *scale* by the *major axis length* as was done above for Andromeda: *y mm * (x'/mm)*. (If all use the *same* scale you need only calculate the four largest by size in mm.) Enter the angular sizes of the four largest in the form below:

1. #8 M88 7.00': These result from doing the lab, student's will vary

2. #1 M61 6.50'

3. #12 NGC4527 6.25'

4. #11 M99 5.25'

9. (essay) What is the average the angular size of these galaxies: **6.25'**

10. (essay) Now, let's find the distance to the Virgo cluster. Use the formula given earlier (modified); show your work:

$$\frac{160'}{avg.\,angular\;size_{Virgo}} \times 2.5\;Mly \;=\; distance_{Virgo}$$

160'/6.25' X 2.5 Mly = 64.0 Mly (latest figure is 53.8+/- 7.2 Mly)

11. (essay) First use the scale associated with your four galaxies to convert your uncertainty to arcminutes; show your work: **0.4', assuming 1/20: may vary.**

12. (essay) You will also need the uncertainty in the measurement of Andromeda which we will give you as 16mm, at the scale of 1 arcminute/1 mm. Now you can use the following formula to calculate the uncertainty in distance due to the uncertainty in your measurements. (There are other potential sources of uncertainty, but these go well beyond the scope of this lab!) Show your work; use *angular* uncertainty from Question 12. Note that the angular uncertainty in Andromeda as well as its measured size have already been given for you in the equation—it works out to be 1/10th!

$$\left(\frac{ang.uncert.from12}{avg.ang.size_{Virgo}} + \frac{16'}{160'}\right) \times 100\% = \% \, uncert._{distance}$$

(0.4/6.25 + 16/160)*100% = 16.4%;

should get something close to this—although it is probably low!

(+1 per box marked in red; give two points for free!)

Object	**Name**	**Type**	**Maj. axis (mm)**	**Scale**	**Ang. Size (')**
1	NGC6050	**S**	**35.0**	**20"/14mm**	**0.833**
2	IC1173	**S**	**43.0**	"	**1.02**
3	NGC6047	**E**			
4	NGC6057	**E**			
5	PGC57118	**S**	**40.0**	"	**0.952**

14. **(essay)** Find the **three** largest galaxies in Hercules that are the same type you used for Andromeda and convert the linear size to the angular size in arcminutes. If your scale is in *arcseconds* ("), use the conversion factor of 1'/60" to get arcminutes (i.e., *y mm * x"/mm * 1'/60"*). What is the average angular size of these three galaxies?

40.0mm X (20"/14mm) X (1'/60"), etc.

Avg. angular size (') **0.935'**

15. **(essay)** Now, find the distance to the Hercules cluster using the formula for the distance to Virgo, but replacing the average angular size with the one you just calculated for Hercules. Show your work:

$$\frac{160'}{avg.angular\ size_{Hercules}} \times 2.5\ Mly = distance_{Hercules}$$

160/0.935 X 2.5 Mly = 428 Mly (latest figure gives ~508 Mly)

16. (essay) As earlier there is an uncertainty in your measurements for the galaxies in Hercules, but given the smaller images perhaps 6 mm is more reasonable.

And as you did in Question 12, using the proper scale factor from Questions 14 please convert your uncertainty to arcminutes:

0.143'; will vary

17. (essay) There are the same problems with estimating the distance to Hercules as there were with Virgo, but again we can at least estimate our uncertainty in measuring sizes with the same formula as used in Question 13:

$$\left(\frac{16'}{160'} + \frac{ang.uncert.from16}{avg.ang.size_{Hercules}}\right) \times 100\% = \%uncert._{distance}$$

will vary: (16/160 + 0.143/0.935)X100% = 25.3%

Uncertainty of distance in Mly: **108 Mly**

18. (essay) Suppose the actual distance to the Hercules cluster is ~500 Mly. Is this within your distance estimate for Hercules, plus or minus your uncertainty? **varies, but likely to be within margin. Depends on their work, however.**

19. (essay) How does the percentage error in distance to Hercules compare proportionally to the percentage error in distance to student B you got in the experiment at the start of the lab?

should be much larger.

Thought question: Why do you suppose the error you got for student B's distance was larger/smaller than the percentage error you got for the distance to Hercules?

Thought question: If your error percentage was larger than, say, 20%, think about all the different things you measured or assumed that might have gone into making it larger—now you see what astronomers are up against when they measure the universe!