# Properties of Galaxies

Firstname Lastname

Date

1. Replace the red text at the top of this page with your name and the date.

2. As you enter your work, please make sure that your answers stay red (like this). This will make them easier to see, and thus it will be easier for us to grade them accurately. To convert black text to red, highlight it and then click on the “A” symbol in the menu bar above, to the right of the “**B**”, “*I*”, and “U” symbols. Select the red square to turn your highlighted text red.

3. Delete these 3 initial instructions from this template as soon as you have followed them.

Grouping Galaxies Based on Appearance

1. When you have sorted the galaxies to your satisfaction, save a JPG-format copy of the mosaic and add it to your lab report here.

Place your JPG-format image of the sorted galaxy mosaic here.

2. Add a detailed explanation which describes the key properties of the

galaxies assigned to each row of your mosaic (such as “Row #1: Galaxies have a uniform golden color, no clear features or substructures, and elliptical shapes.”). If there were particular cases which you found most perplexing (such as a galaxy that seemed to belong equally well to two rows), make a note of them as well. (For example, “The last galaxy on the right in row #2 could have gone in row #3 as well, if I prioritized shape over color.”)

Replace this text.

3. Save a JPG-format copy of your partner's mosaic and add it to your lab report.

Place your partner’s JPG-format image of the sorted galaxy mosaic here.

4. Describe your sorting partner. Are they an adult or a child? (If a child, please tell us their age.) Are they engaged in a profession where attention to detail is critical (such as seamstress or electronics technician), or are they Big Picture people? Are they color blind? Have they ever looked at pictures of galaxies before?

Replace this text.

5. Describe the differences and the similarities between your two final galaxy mosaics. Did you agree broadly, or did you focus on very different aspects of the images? Can you each understand what the other did?

Replace this text.

Galaxy Morphology Questions

Please remove incorrect choices, as well as surrounding parentheses and slashes, in the questions below (and delete this instruction).

1. A galaxy emitting lots of blue light must contain many ( hot / cool ), (

high- / low- ) mass ( short- / long- ) lived stars. The stellar classification

of these blue stars is ( O and B / A, F and G / K, M and L ).

2. Galaxies which appear more disturbed tend to have ( higher / lower )

asymmetry indices, and (bluer / redder ) colors.

3. Elliptical galaxies tend to be ( bluer / redder ), ( more / less ) massive,

and contain ( more / less ) gas than spiral galaxies. Their concentration

indices are ( higher / lower ), while their asymmetry indices are ( higher /

lower ).

4. The Milky Way is a replace this text galaxy, with a sub-classification of ( Sa / Sb / Sc / Sd ). It also has a central replace this text.

5. It is much easier to trace the spiral arm structure on a(n) ( face-on /

edge-on ) spiral galaxy than on a(n) ( edge-on / face-on ) one.

6. The force which binds all of the stars and gas in a galaxy together is the

replace this text force.

Imaging Tool Questions

1. Save a copy of the final galaxy data table and include it in your lab report.

Place your JPG-format table of galaxy imaging data here.

2. Note the “ripples” that appear at large radii in the radial counts profile for Galaxy #1. What do you think causes them?

Replace this text.

3. Galaxy #1 Comments: Replace this text.

4. Galaxy #2 is far less luminous than our Milky Way. How many galaxies of this luminosity would you need to match the light output of the Milky Way?

Replace this text.

5. Notice how the light profile (the radial plot of counts) can be divided into

an inner region and an outer region (with a change of slope between them). The names for the two galaxy components that these two regions represent are the replace this text and the replace this text.

6. What do you think causes the patches of blue in the outer regions of this galaxy?

Replace this text.

7. Galaxy #2 Comments: Replace this text.

8. Does Galaxy #3 have a fairly uniform color? ( yes / no )

9. Galaxy #3 Comments: Replace this text.

10. Consider the total B-V color measured across all of Galaxy #4. What value do you find if you reduce the size of the ellipse to contain just the bright golden nucleus of the galaxy? What types of galaxies have this B-V color overall?

Replace this text.

11. Galaxy #4 Comments: Replace this text.

12. What do you think this object (Galaxy #5) might have looked like a few billion years ago?

Replace this text.

13. Galaxy #5 Comments: Replace this text.

14. Note the dark band running along the disk of Galaxy #6, and the bright splotch slightly offset from the center as defined by the rest of the galaxy. These factors will lead to a ( higher / lower ) asymmetry index.

15. Galaxy #6 Comments: Replace this text.

16. Does the edge-on orientation of Galaxy #7 make it more difficult for us to calculate an asymmetry index, and to define a morphological type?

Replace this text.

17. Galaxy #7 Comments: Replace this text.

18. A larger neighboring galaxy above our target (Galaxy #8) scatters light across this entire image. Because of this, the ( left / right ) side of the radial profile is slightly higher than it should be.

19. Galaxy #8 Comments: Replace this text.

20. Galaxy #9 Comments: Replace this text.

21. Galaxy #10 Comments: Replace this text.

22. Which of the ten galaxies posed the largest challenge to fit? Which was the easiest to analyze? Explain your choices.

Replace this text.

Spectral Tool Questions

1. Save a copy of the final galaxy data table and include it in your lab report.

Place your JPG-format table of galaxy spectral data here.

2. The presence of which very strong emission line in the Galaxy #1 spectrum rules out the “E” (for elliptical) morphological class?

Replace this text.

3. Is it the presence or absence of key absorption or emission lines, or the poorly fitting shape of the continuum (the overall shape of the spectrum, ignoring emission and absorption features) which rules out the Sc, Sd, and interacting galaxy types?

Replace this text.

4. Describe the general pattern formed by the galaxy spectrum and the type-specific spectra when the correlation coefficient drops below 0. For which galaxy types does this occur, for this galaxy?

Replace this text.

5. What morphological type yields the second-highest correlation coefficient? Can you point to a feature shown in the accompanying galaxy image which also suggests that this is not the correct type?

Replace this text.

6. Galaxy #1 Comments: Replace this text.

7. More distant galaxies appear ( smaller / larger ) on the images, and their observed spectra are shifted to the ( left / right ) to ( shorter / longer ) wavelengths.

8. If we took a second spectrum of Galaxy #2 and sampled a small region near the galaxy edge rather than the nucleus, how would you expect the spectrum to change? The ( absorption / emission ) lines would become much stronger, indicating ( increased / decreased ) star formation in this region of the galaxy.

9. Galaxy #2 Comments: Replace this text.

10. The redshift measured for Galaxy #3 confirms that it appears so small in the image because it is ( very far away / an intrinsically small galaxy ).

11. Galaxy #3 Comments: Replace this text.

12. Galaxy #4 Comments: Replace this text.

13. Galaxy #5 was very easy to type based on its image, but should give us a different answer based on its core spectra alone. Why is this the case?

Replace this text.

14. Galaxy #5 Comments: Replace this text.

15. Galaxy #6 Comments: Replace this text.

16. Many galaxies of the same morphological type as Galaxy #7 have ( bluer / redder ) disks.

17. Galaxy #7 Comments: Replace this text.

18. Are both of the galaxies in the Galaxy #8 image of the same type? ( yes / no )

19. Galaxy #8 Comments: Replace this text.

20. Galaxy #9 Comments: Replace this text.

21. Can you identify a single feature which is very strong in the observed Galaxy #9 spectrum but much weaker in the reference spectrum for this type of galaxy? How would you expect this to affect the correlation coefficient?

Replace this text.

22. Galaxy #10 Comments: Replace this text.

23. Which of the ten galaxies posed the largest challenges in determining redshifts? Which was the easiest to fit? Explain your choices.

Replace this text.

Final (Post-Lab) Questions

1. Given what you now know, describe how you grouped galaxies together initially. (To what galaxy properties were you most sensitive?)

Replace this text.

2. If you were to resort these galaxies now, what would you change? Are there aspects which you emphasized which you now think are unimportant? Are there properties which you dismissed which now seem more important, in view of what you have learned?

Replace this text.

3. What are the basic observed properties of elliptical galaxies, in images and in spectra? What does this tell us about the distribution of stars and gas in these galaxies?

Replace this text.

4. What are the basic observed properties of spiral galaxies, in images and in spectra? What does this tell us about the distribution of stars and gas in these galaxies?

Replace this text.

5. Which of the ten galaxies in our sample is the best match to the Milky Way galaxy, and why?

Replace this text.

6. Compare your derived morphological types based on images and then from spectra for the ten sampled galaxies. For which galaxies did you estimate different morphological types from the image and from the spectrum? Where your type estimates differed, did they differ by one step (Sb versus Sc), or by several steps (E versus interacting)?

Replace this text.

7. Consider the galaxies for which you found the greatest disagreement between image-based types and spectrum-based types. Discuss the cause(s) of the differences, and explain which type classification you think is the most accurate in each case.

Replace this text.

Summary (300 to 500 words)

Replace this text.

Extra Credit

Replace this text.