

Name:

Date:

Galaxy Zoo

Objectives:

- Distinguish between different types of galaxies
- Identify the various features of each subclass
- Contribute data that will be used by astronomers in their work
- Learn to study galaxies in systematic way

Materials

- Computer
- Internet connection

Introduction

Galaxies evolve on timescales that dwarf human experience. So our best chance at understanding their complex evolution is to observe large samples of galaxies at different points in their lives to try to reconstruct a single galaxy's evolution from the various snapshots.

Thanks to new generations of astronomical surveys we now have images of millions of galaxies. But going through this much data is a time intensive task. We can train computers to do a lot of the work, but human eyes are still better than computer algorithms at picking out subtle galaxy features in many cases.

To this end, Galaxy Zoo was developed to enlist the help of the public. Millions of eyes view each galaxy, analyzing and recording its appearance. Eventually a consensus is reached and the galaxy becomes a part of a catalog that astronomers use in their research projects.

Activity

Part 1: Types of Galaxies

Before we start, what is a galaxy? Write your own definition of a galaxy. Then, draw a sketch of what a galaxy looks like (or draw multiple sketches if necessary):

In general, there are two types of galaxies: spirals and ellipticals (a third category, irregulars, includes everything else). Here are two examples:



Spiral Galaxy

Elliptical Galaxy

Both of these images show galaxies composed of billions of stars, gas and dust. Create two detailed lists of the characteristics of each that will allow you to distinguish one galaxy type from the other:

Observable characteristics of a spiral galaxy	Observable characteristics of an elliptical galaxy

Part 2: Computer Setup

- Go to: www.galaxyzoo.org
- Read through the description of the project
- Click on “Sign up” (on the upper right)
- Create a Zooniverse account
- Go to the bottom of the main page, and click on “Navigator”
- Under the “Select Group” tab, select “Wyoming Workshop”
- Click on “Classify in Group”

Part 3: Classifying Galaxies

Galaxy zoo will show you a galaxy at random, and will ask you a series of questions about what you see. Click the buttons that best describe the galaxy. If you want help with what to look for, click on the “Examples” button. Look carefully at each image! Sometimes using the “invert” button can help bring out details you don’t initially see.

Classify at least 15 galaxies, circling answers in the tables below as you do (Ignore boxes that don’t apply — the line of questioning changes depending on your responses).

Image 1	Smooth	Round	Edge-on	Round	Spiral	Tight arms	Arm #	Bar	No Bulge
	Features/ Disk	In-between	Not edge-on	Boxy	No spiral	Medium		No bar	Noticeable
	Star/ Artifact	Cigar shape		No bulge		Loose			Obvious Dominant

Notes:

Image 2	Smooth	Round	Edge-on	Round	Spiral	Tight arms	Arm #	Bar	No Bulge
	Features/ Disk	In-between	Not edge-on	Boxy	No spiral	Medium		No bar	Noticeable
	Star/ Artifact	Cigar shape		No bulge		Loose			Obvious Dominant

Notes:

Image 3	Smooth	Round	Edge-on	Round	Spiral	Tight arms	Arm #	Bar	No Bulge
	Features/ Disk	In-between	Not edge-on	Boxy	No spiral	Medium		No bar	Noticeable
	Star/ Artifact	Cigar shape		No bulge		Loose			Obvious Dominant

Notes:

Image 4	Smooth	Round	Edge-on	Round	Spiral	Tight arms	Arm #	Bar	No Bulge
	Features/ Disk	In-between	Not edge-on	Boxy	No spiral	Medium		No bar	Noticeable
	Star/ Artifact	Cigar shape		No bulge		Loose			Obvious Dominant

Notes:

Image 5	Smooth	Round	Edge-on	Round	Spiral	Tight arms	Arm #	Bar	No Bulge
	Features/ Disk	In-between	Not edge-on	Boxy	No spiral	Medium		No bar	Noticeable
	Star/ Artifact	Cigar shape		No bulge		Loose			Obvious Dominant

Notes:

Image 6	Smooth	Round	Edge-on	Round	Spiral	Tight arms	Arm #	Bar	No Bulge
	Features/ Disk	In-between	Not edge-on	Boxy	No spiral	Medium		No bar	Noticeable
	Star/ Artifact	Cigar shape		No bulge		Loose			Obvious Dominant

Notes:

Image 7	Smooth	Round	Edge-on	Round	Spiral	Tight arms	Arm #	Bar	No Bulge
	Features/ Disk	In-between	Not edge-on	Boxy	No spiral	Medium		No bar	Noticeable
	Star/ Artifact	Cigar shape		No bulge		Loose			Obvious Dominant

Notes:

Image 8	Smooth	Round	Edge-on	Round	Spiral	Tight arms	Arm #	Bar	No Bulge
	Features/ Disk	In-between	Not edge-on	Boxy	No spiral	Medium		No bar	Noticeable
	Star/ Artifact	Cigar shape		No bulge		Loose			Obvious Dominant

Notes:

Image 9	Smooth	Round	Edge-on	Round	Spiral	Tight arms	Arm #	Bar	No Bulge
	Features/ Disk	In-between	Not edge-on	Boxy	No spiral	Medium		No bar	Noticeable
	Star/ Artifact	Cigar shape		No bulge		Loose			Obvious Dominant

Notes:

Image 10	Smooth	Round	Edge-on	Round	Spiral	Tight arms	Arm #	Bar	No Bulge
	Features/ Disk	In-between	Not edge-on	Boxy	No spiral	Medium		No bar	Noticeable
	Star/ Artifact	Cigar shape		No bulge		Loose			Obvious Dominant

Notes:

Image 11	Smooth	Round	Edge-on	Round	Spiral	Tight arms	Arm #	Bar	No Bulge
	Features/ Disk	In-between	Not edge-on	Boxy	No spiral	Medium		No bar	Noticeable
	Star/ Artifact	Cigar shape		No bulge		Loose			Obvious Dominant

Notes:

Image 12	Smooth	Round	Edge-on	Round	Spiral	Tight arms	Arm #	Bar	No Bulge
	Features/ Disk	In-between	Not edge-on	Boxy	No spiral	Medium		No bar	Noticeable
	Star/ Artifact	Cigar shape		No bulge		Loose			Obvious Dominant

Notes:

Image 13	Smooth	Round	Edge-on	Round	Spiral	Tight arms	Arm #	Bar	No Bulge
	Features/ Disk	In-between	Not edge-on	Boxy	No spiral	Medium		No bar	Noticeable
	Star/ Artifact	Cigar shape		No bulge		Loose			Obvious Dominant

Notes:

Image 14	Smooth	Round	Edge-on	Round	Spiral	Tight arms	Arm #	Bar	No Bulge
	Features/ Disk	In-between	Not edge-on	Boxy	No spiral	Medium		No bar	Noticeable
	Star/ Artifact	Cigar shape		No bulge		Loose			Obvious Dominant

Notes:

Image 15	Smooth Features/ Disk Star/ Artifact	Round In-between Cigar shape	Edge-on Not edge-on	Round Boxy No bulge	Spiral No spiral	Tight arms Medium Loose	Arm #	Bar No bar	No Bulge Noticeable Obvious Dominant
----------	--	---	-------------------------------	--------------------------------------	----------------------------	--	----------	----------------------	--

Notes:

Rate the relative difficulty you had distinguishing the various characteristics.

<i>Rate the difficulty of classifying each of the following:</i>	Nearly Impossible	Challenging	Some easy, some not	Pretty easy	Notes
Presence of spiral arms					
Roundness of galaxies					
Tightness of spiral arms					
Number of spiral arms					
Evidence of central bar					
Dominance of central bulge					

Additional Notes:

Click on the yellow “Group” button to go back to the group page, and then click on “My Galaxies”. Galaxy Zoo will show you the galaxies you have classified so far, and how your initial classification (smooth, spiral, artifact) stacks up to what others have chosen. How did you do, comparatively?

Choose a galaxy where your answers differed from the majority. Why do you think your responses differed?

Part 5: Visualizing data and drawing conclusions

Consider the research question: “How many spiral arms does a typical spiral galaxy have?”

It isn't likely that a large fraction of the galaxies you analyzed in Part 3 were spirals. Go back to classifying galaxies in Galaxy Zoo until you have analyzed at least 15 spirals. Record the number of spiral arms you see in each galaxy (to save time, you can copy over the information from the spirals you already examined earlier):

Spiral galaxy	# of spiral arms
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

A good way to examine the distribution of data is to make a histogram. Open Excel, and in cell 1 enter the number of galaxies with 1 spiral arm, in cell 2 enter the number of galaxies with two spiral arms, etc. In the last cell, enter the number of galaxies for which you couldn't determine the number of arms. Highlight the data, and insert a column chart. This will produce a histogram of your data — each bar shows you how many galaxies there are (y-axis) with a given number of spiral arms (x-axis). Roughly sketch the histogram below:

Based on this histogram, draw some conclusions about the typical number of spiral arms a spiral galaxy has:

Now, compare your histogram to those of others. How are they similar or different? Why do you think differences exist (if they do)?

Based on your analysis of your plot along with several others', draw new conclusions about the typical number of spiral arms in a spiral galaxy. Why did your conclusion change or stay the same?

Part 7 (optional): Formulate a question, pursue evidence, and justify your conclusion

Your task is to design an answerable research question (like the one above). Once you have done this, propose a plan to pursue evidence, collect data using Galaxy Zoo (or another source pre-approved by your instructor), and create an evidence-based conclusion. You are welcome to use other tools in the Galaxy Zoo navigator, such as the plots for our group.

Specific Research Question:

Step-by-step procedure to collect evidence:

Data and/or results:

Evidence based conclusion statement:

Part 8: Summary

Create a 50-word summary, in your own words, that describes the nature and characteristics of galaxies we observe in the Universe. You should cite specific evidence you have collected, not describe what you have learned elsewhere.