Physics 10263 Lab #7:
Citizen Science - Galaxies

Introduction

Because we live in a galactic disk, our view of the night sky is profoundly affected. For example, the billions of distant, unresolved stars in the disk of our galaxy stretch around us in a ghostly band that rings the sky. We call this the Milky Way. The dust from the disk that surrounds us substantially limits our ability to look for objects outside of our own galaxy, particularly in the direction of the surrounding disk.

Because of this, Astronomers thought that our galaxy was the only large object in the Universe until the first half of the 20th century. Other galaxies were too faint or too obscured by clouds of gas and dust for us to examine closely to determine their distances. Even after other galaxies were discovered outside of our own, we still had trouble seeing objects outside our own galaxy in the direction of the disk. Less than 20 years ago, a huge, faint companion spiral galaxy to our own, Malin 2, was discovered. It hadn't been seen previously due to the fact that it is blocked by the gas and dust in our galaxy and the fact that Malin 2 has a very low surface brightness.

The structure of the Milky Way also affects our observations of objects within the galaxy. For example, even though we know that stars are more or less uniformly distributed around the Milky Way ring, there are places where the star counts vary by factors of hundreds or even thousands. This is due to gas and dust obscuring our line of sight so that only the brightest and/or nearest stars are visible. Without taking this into account, our theories about the structure and dynamics of the Milky Way would be woefully incomplete.

The gas and dust itself has many interesting properties worth exploring. Photometry and spectroscopy of these clouds of gas and dust at varying wavelengths reveals properties such as mass, size, temperature, composition and motion. Often, the thickest clouds along our line of sight harbor forming stars that can only be seen with very long wavelength observations, using radio wavelengths that are less prone to scattering by dust and gas.

Because the sky looks so different near the ring of the Milky Way, we often use a Galactic coordinate system to find our way around the sky. Much like the Earth's equator marks 0 degrees latitude on the Earth while the Earth's north and south poles mark +90 and -90 degrees latitude, we consider the Milky Way in the night sky to mark the galactic equator. So the galactic equator makes a great circle spanning the entire sky, parallel to the faint band of the Milky Way itself.

Objects observed at low galactic latitude (near the galactic equator) tend to be obscured or otherwise affected by the presence of gas and dust along one's line of sight. Conversely, objects near high galactic latitude (near either the North or South galactic poles) are often easily seen, even if they are at enormous distances (like distant galaxy clusters).

Part 1

For helpful background information about what astronomers are hoping to learn by studying bubbles, star forming regions, clusters and other structures in the Milky Way, please read through the February 2010 Scientific American article, "Cloudy with a Chance of Stars."

In order to access this article, just use your browser and go to **http://personal.tcu.edu/dingram/cloudy.pdf** .

Read through the and answer the questions below, which are arranged in the same order that they are covered within the article.

Q1. From the article, “Cloudy with a Chance of Stars,” what four questions about star formation does the author seek to answer with his research?

1.

2.

3.

4.

Q2. When collapsing interstellar clouds reach a density of about 1000 atoms per cubic centimeter, we call them molecular clouds. Why can molecules survive in these clouds and not in other parts of interstellar space?

Q93. Describe two leading ideas that may explain what upsets the balance of pressure and gravity in order to initiate the formation of a star from an interstellar cloud.

1.

2.

Q4. Explain the evidence from the W5 region (described in the photograph on page 39) that radiation pressure from massive stars has triggered the collapse of surrounding dust clouds and subsequent star formation at the rim of the bubble.

Q5. Describe the competitive accretion model for the formation of star clusters.

Q6. Describe the evidence in the Christmas Tree cluster that seems to support competitive accretion as a major influence, at least for some stars.

Q7. Explain how recent theoretical simulations solve the problem of super-massive star formation, allowing stars to form with masses larger than 20 solar masses despite the enormous radiation they emit (which "should" disperse surrounding gas and dust, limiting further growth).

Part 2

We will now move on to the "Citizen Science" part of the lab, In this lab, we will be exploring the structure and interesting features of nearby galaxies. By learning about clumps in these nearby galaxies, we can get a better understanding for similar features in our own galaxy (which are very hard to see from inside the galaxy itself) as well as how galaxies like our own have changed over time.

Close Starry Night. Using a web browser, navigate to **https://bit.ly/2RC31XZ** and from there, sign in to the Zooniverse website if you haven't already (you should have one by now from the Variable Star Zoo or the Zwicky Transient Facility projects). You may need to create an account. This will enable the site to keep a record of your work so that we know how many data sets you have completed.

Now select "About" and read through the short introduction, then answer the questions starting on the next page.

From the “About” section under the first tab (“Research”),

Q14. Describe two ways astronomers think clumps within galaxies may form.

Q15. Describe what two different models say about what will happen to galaxy clumps as time goes on.

Next, click on the “FAQ” tab. Read the answers to these questions and answer:

Q16. Explain why humans are needed to analyze these galaxy images instead of just leaving it all to automated software.

For the next part of the lab, open up the “Classify” tab and click through the brief tutorial. Then, on the right hand side of your browser window, click on the “Field Guide” tab and look at the various examples of what you will be seeing. This will help make your classification tasks proceed much more quickly!

Now proceed to classify 50 images. If you have some uncertainty after looking at a few images, go through the tutorial carefully again. Also, click the “Need some help with this task?” button for some examples of things commonly marked. Many frames (maybe half) have nothing obvious to mark, and that’s fine. Just inspect the image for a few seconds to be sure, then move on to the next.

Once you have completed your contribution to the project, show your lab instructor your profile page (click your username on the top right, then select “Home”). <u>You will need to submit a screen shot showing your progress clearly, like below.</u>

The little ring around the circular icon can be hovered over to indicate how many data sets you have completed for any given project (each part of the ring is color-coded for a different project, so you have to find the right project to hover over). The number below the ring is the total number of data sets for all projects combined. Your TA is looking for a number of at least 50 in the white box with the colored border.