ASTR101 A02 B16

Lab 1 - Night Lab

A Photo of the Milky Way from Mount Tolmie taken by me :)

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NIGHT LAB OBJECTIVE:

Becoming familiar with the parts and features of the telescope and how to use them. Additionally, to be aware of the mythology behind the constellations from various cultures and religions. To acquire knowledge about star and solar system object observing and deep-sky phenomena by oneself via the 4 parts of this lab.

PROCEDURE:

Part I: Parts of a Telescope

- The instructor discussed the roles of optical telescopes, understanding how they function as "spaceships" and "time machines," allowing us to observe distant objects and look back in time.
- Learn about refracting and reflecting telescopes, their advantages, disadvantages, and components, including the light-gathering power and how it relates to the primary mirror size.

Part II: Constellations

- Use Stellarium to explore the night sky and identify constellations, focusing on their shapes, stars, and associated myths from various cultures.
- Sketch at least three constellations, label their main stars, and record their positions using cardinal directions as shown on Stellarium. Answer related questions in the lab manual.

Part III: Stars and Solar System Objects

- Learn about the use of 8-inch Celestron Schmidt-Cassegrain telescopes for observing stars and planets. Understand their field of view and magnification capabilities.
- Use Stellarium and other resources to research designated celestial objects visible in the Spring sky from Victoria, and answer the questions in the lab manual.

Part IV: Deep Sky Objects

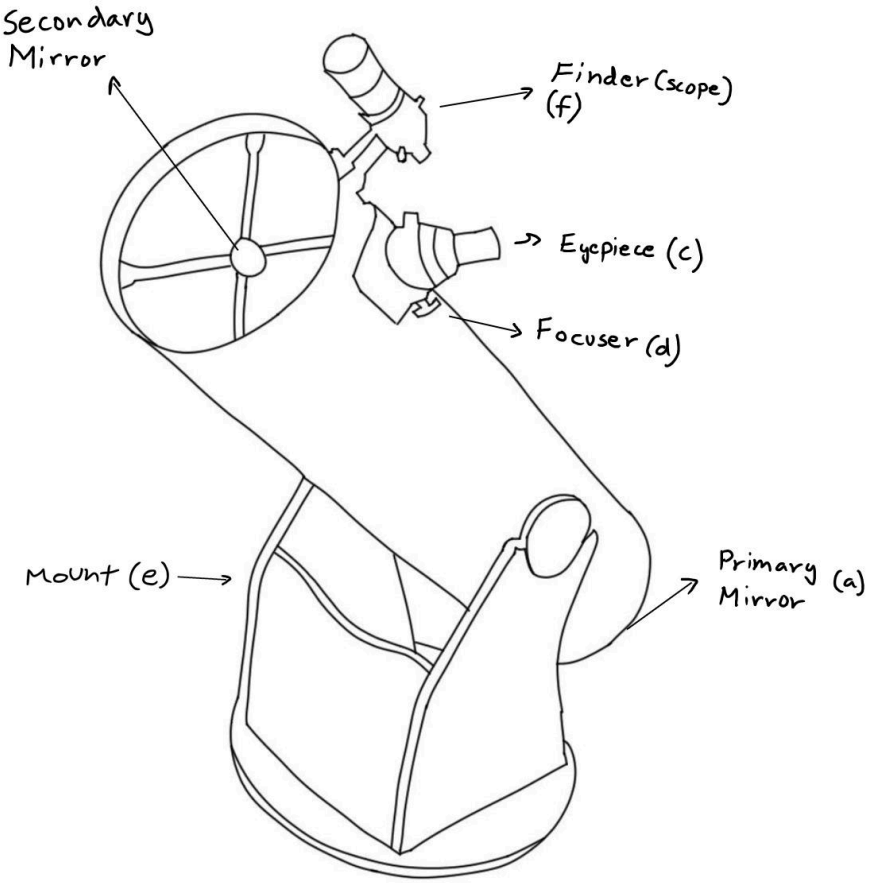
- Explore the features of the 32-inch DFM Telescope at the UVic Observatory, including its use in observing deep sky objects like star clusters, nebulae, and galaxies.
- Study the Messier catalogue and sketch and describe each assigned Messier object as observed through the telescope.

PART I: PARTS OF A TELESCOPE

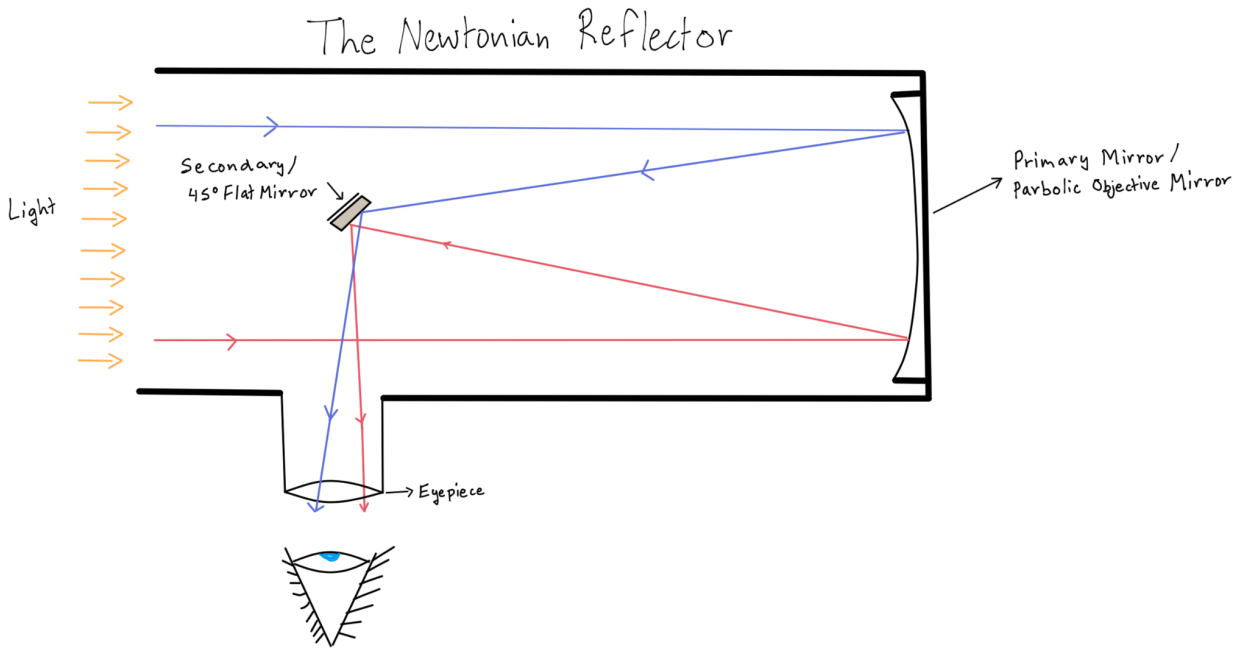
Objective Statement: Understanding the parts of a telescope, its functions and benefits of different types of telescopes.

Questions

1. **Sketch a diagram of the telescope (use a full page), label each of the following parts:**
   a. **Primary Mirror**
   b. **Secondary Mirror**
   c. **Eyepiece**
   d. **Focuser**
   e. **Mount**
   f. **Finder**



2. **Sketch the path of a light ray through the telescope.**



3. **In a sentence or two describe and explain the function of these parts.**

   Primary Mirror:

   Located at the base of the telescope optical tube, the primary mirror is a large, curved mirror that collects light from distant objects and focuses it into an image.

   Secondary Mirror:

   The secondary mirror is a smaller mirror placed at an angle inside the telescope's optical tube; it redirects the focused light from the primary mirror to the eyepiece for viewing.

   Eyepiece:

   The eyepiece is the part you look through; it contains lenses that magnify the image so you can see distant objects in detail.

   Focuser:

   The focuser holds the eyepiece and allows you to adjust its position to get a sharp, clear image by moving it closer or further from the telescope's optics.

Mount:

The mount is the support structure that holds the telescope steady and lets you point it smoothly at different parts of the sky.

Finder:

The finder, or finder scope, is a small telescope attached to the main one; it helps you locate objects more easily by providing a wider field of view.

4. **How much brighter will this Celestron telescope (primary mirror radius = 10cm) make the stars appear relative to your unaided eye?**
We can find the increase in brightness by comparing the areas that gather light in our eye and the telescope:

Area of Pupil:

In the dark our pupils dilate to a radius of $r_e = 0.5\ cm$.

Therefore the area is (using formula for area of a circle):

$$A_e = \pi r_e^2 = \pi(0.5\ cm)^2 \sim 0.8\ cm^2$$

Area of the telescope's primary mirror:

The telescopes mirror has a radius of $r_t = 10\ cm$

Therefore the area is (using formula for area of a circle):

$$A_t = \pi r_t^2 = \pi(10\ cm)^2 \sim 314\ cm^2$$

Brightness Increase is the ratio of the telescope's area to the pupil's area:

$$Brightness\ Increase = \frac{A_t}{A_e} = \frac{314\ cm^2}{0.8\ cm^2} = 392.5$$

Thus we calculated that the Celestron telescope makes stars appear 392.5 times brighter than they do to the unaided eye.

5. **What is a refractor telescope?**

   A refractor telescope is recognized by its use of a series of lenses that collect and focus light from distant objects. It consists of a long tube with a large convex objective lens at the front (the end pointed towards the object being observed). Light entering the telescope passes through this lens, which bends (refracts) the light rays to converge at a focal point. An eyepiece lens at the opposite end of the tube magnifies this focused image for observation. These telescopes are best known for production of high contrast images that are often useful for planetary and lunar observations. By reflecting light through a mirror, a refracting telescope magnifies and focuses light with the help of primary and secondary lenses.

6. **In the early days of observational astronomy (circa early 20th century), most major telescopes were refractor telescopes. However, all modern-day, major telescopes are reflector types. Briefly explain the difference between these two types, and why this change to the reflector type may have happened?**

   Refractor telescopes use lenses to collect and focus light, utilising a large convex objective lens at the front of the telescope, while reflector telescopes gather and focus light with mirrors, specifically a concave primary mirror. The shift from refractors to reflectors occurred because reflector telescopes eliminate chromatic aberration, a distortion where lenses separate light into different colours since mirrors reflect all wavelengths equally. Moreover, mirrors can be constructed much larger than lenses and supported from behind, preventing them from bending under their own weight which is a major limitation for large lenses, which can only be supported at the edges. This capability enables reflector telescopes to have larger apertures, boosting their ability to gather light and making them more practical and economical for observing faint and distant celestial objects in modern astronomy.

PART II: CONSTELLATIONS

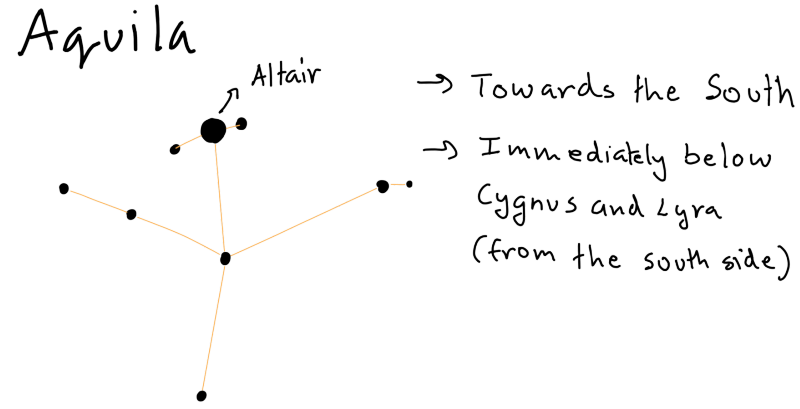
Objective Statement: To research, understand and identify constellations along with their mythological understandings in various religions.

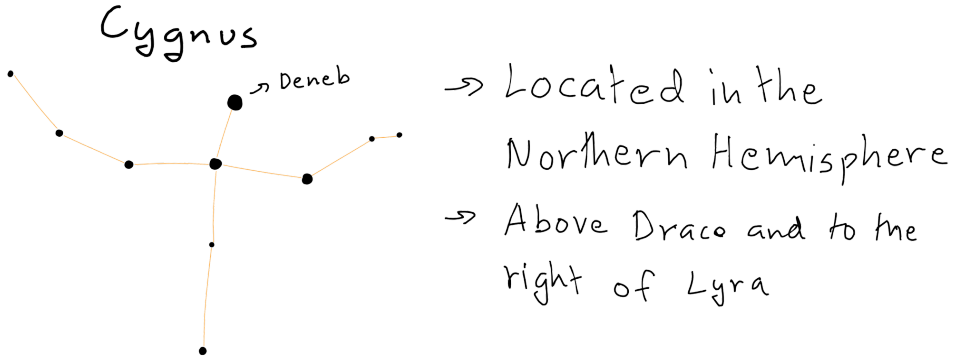
7. **Sketch at least three (3) constellations that you learned in this lab exercise. Note their approximate positions in the sky, and the time and date of the observations. These constellations should be above the horizon in the evening on today's date.**
8. **Learn the names of at least three stars in these constellations and mark them on your sketches.**
   Questions 7 and 8 are below:

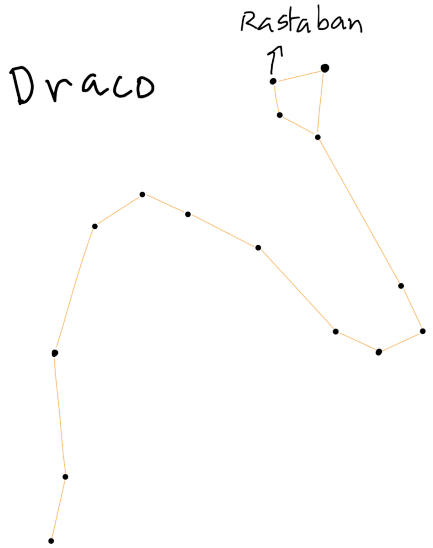
Stellarium Time and Date

20:52:09 on 2024-09-12

(All Sketches were recorded at the same time and date by pausing)

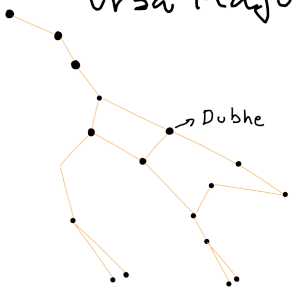






→ Located in the Northern Hemisphere

→ Just above Ursa Major



→ Located in the Northern Hemisphere

→ Just above the horizon line, above Lynx

9. **What is the mythology associated with these constellations? Research and write about these stories. Instead of just Greco-Roman myths, find stories from other cultures such as Arabic, Chinese, Indian, etc., and at least one that the First Nations of North America associated with these constellations. Note that constellations between cultures are not identical. In such cases, find a story that shares at least the bright star you have labelled.**

Aquila

In Hinduism or Indian Mythology, the eagle shape is representative of the god Garuda who is considered to be the god of Strength and Vigilance. This is because the eagle shape of the constellation corresponds with the half human and half eagle deity. **(Source 13)**

Cygnus

According to a Chinese legend, Cygnus is associated in some cultures with the story of Qi Xi, a love story told during the Qi Xi Festival. This tells the story of Zhinü (Vega), a goddess who is a weaver, and a cowherd named Niulang (Altair). “Silver River” is what the Chinese call the Milky Way and it serves to keep the two lovers apart all year. However, once every year, a bridge of magpies (stars belonging to Cygnus) is created by the view that helps them meet each other. The Cygnus stars are believed to represent the magpies that help the two lovers meet once in a year.

To the Lakota of North America’s First Nations, Cygnus looks like a goose or a swan. To them, the star formation is associated with their Star Nation beliefs as the point through which souls come to the earth and back in the spirit realm. The configuration of Cygnus in the Milky Way coincides with their belief about the route of spirits. **(Source 14)**

Draco

For the Chinese, Draco is considered part of a larger region of the sky which is the Celestial Dragon, which stands for wealth and good fortune. In Chinese culture dragons are important animals and for ancient astronomers and astrologers, the position of Draco around the north pole would have had significance. **(Source 15)**

Ursa Major

In many of the Native American stories, including those of the Mi'kmaq and Iroquois, Bear is also related to Ursa Major. Micmac natives narrate a tale in which the four stars in the bowl of the Big Dipper are the bear that these four hunters (the three stars of the handle) chase after the bear. With the running of the bear, the passing of the visits or the seasons is dramatised on the earth’s surface. During fall, when the bear is killed, its blood turns the foliage bright red.

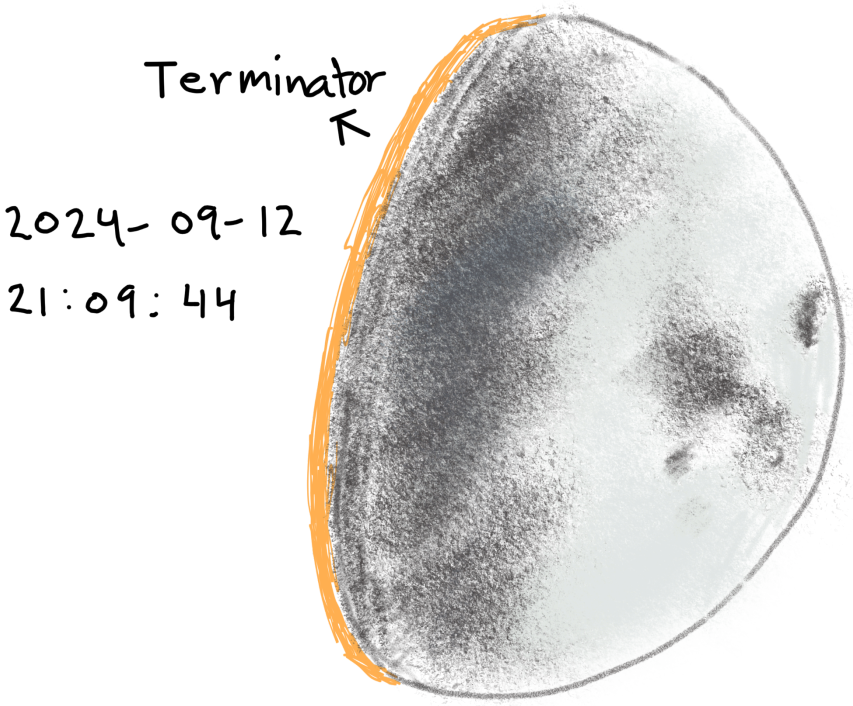
In Hindu mythology, the Ursa Major, is referred to as the Saptarishi and denotes the seven active sages considered as the original seers of the Vedic religion. Every star is dedicated to a particular sage who appears in numerous stories and is a paragon of reason in all of them. **(Source 16 & 17)**

PART III: STARS AND SOLAR SYSTEM OBJECTS

Objective Statement: Observing and understanding the moon and planet phases alongside stars and binary stars.

THE MOON

10. **Sketch and describe the Waxing Gibbous Moon as it would look through a small telescope similar to the Celestron telescope.**



(Source 18)

11. **In a sentence or two, explain what the terminator is?**

    The moon's terminator is the line separating the illuminated and dark sections when observed from Earth. It could also be considered as the line that shows the separation of night and day on the Moon.

12. **Indicate the terminator on your sketch.**

    Shown above in the sketch. (orange line)

THE PLANETS

13. **Describe how Jupiter and Venus would look through a small telescope similar to the Celestron telescope (particularly note the phase of Venus). Note also the time and date that Stellarium is set to.**

    Stellarium Settings:

    Jupiter: 2024/09/12 at 21:09:47
    Venus: 2024/09/16 at 20:05:32
    (Venus was not above horizon during the night with enough visibility prior to this)

    a. **What colour is the planet?**

    Jupiter: The planet is a mixture of colours in the following layer order (top to bottom): faded brown, white, deep brown, white (hints of blue), faded brown, white, faded brown.

    Venus: The planet looks like a gradient of brown that fades as it reaches the edges of the planet. There are two gradients that start both from the centre and span till the top and bottom, respectively, giving the planet its colours.

    b. **Can you see markings on its surface?**

    Jupiter: The great red spot was visible, along with some other smaller storms.

    Venus: No obvious markings visible apart from the typical streaks.

    c. **Can you see its moons?**

    Jupiter: There were 4 moons visible: Callisto, Io, Europa, Ganymede

    Venus: No, as Venus doesn't have any moons.

    d. **Is the planet crescent-shape, round, or gibbous (nearly full)?**

    Jupiter: The planet is nearly fully visible or gibbous.

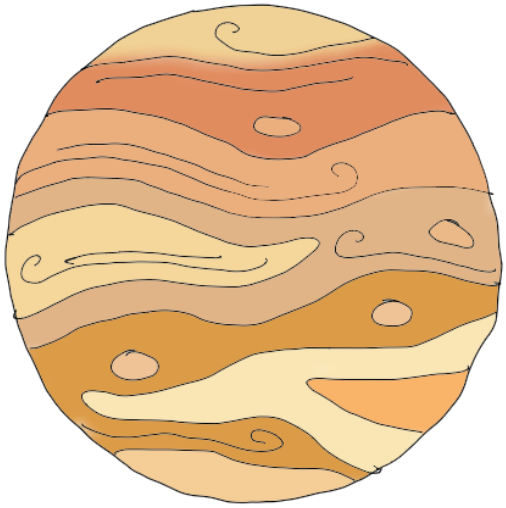
    Venus: The planet is gibbous/nearly fully visible.

14. **Sketch each planet (and its moons, if any) as seen through the telescope.**

15. **If the moons of any planet would be visible, label them on your sketch.**

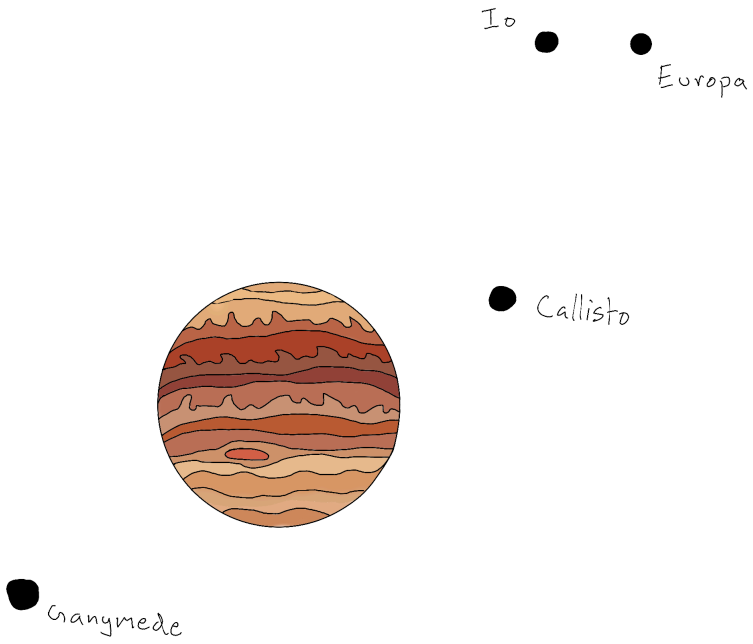
Question 14 and 15 are on the next page.

Venus:



(Source 20)

Jupiter:

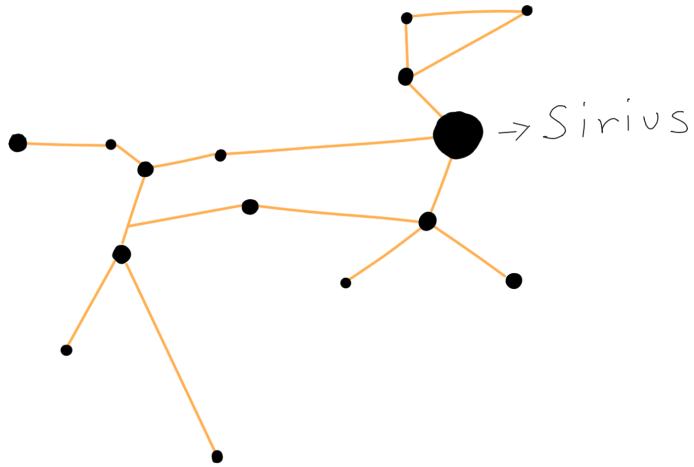


(Source 20)

(Note: Ganymede is significantly further away in terms of distance from Jupiter; however, for it to fit here I had to draw it closer.)

THE STARS

16. **Sketch and describe the bright star, Sirius, in the constellation Canis Major. Note the colour and brightness of the star.**



(Source 20)

17.

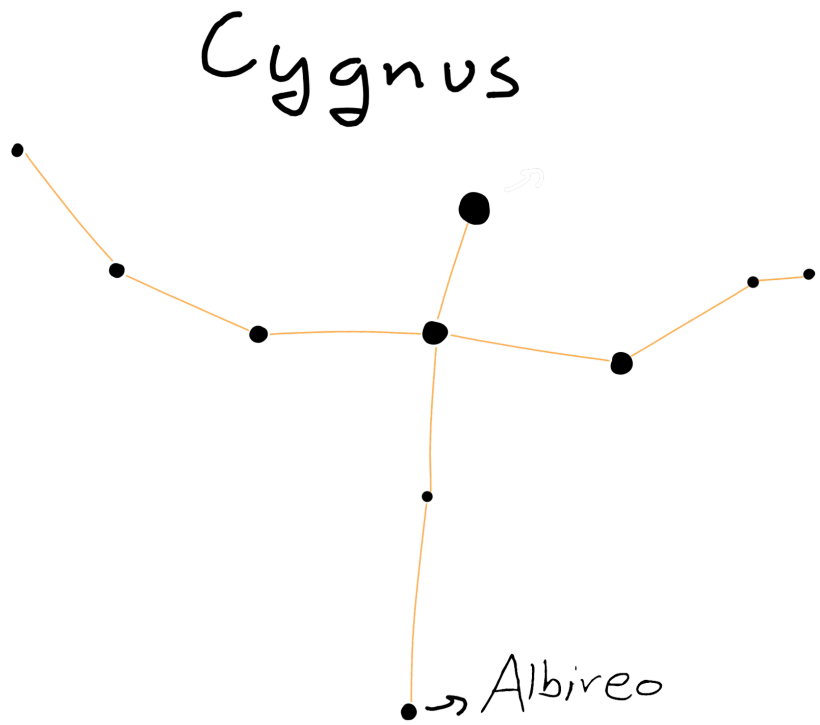
BINARY STARS

18. **Write a brief description of the Albireo binary star system (type of stars, location in the sky, distance from Earth, etc).**
Albireo is located in the Swan constellation and is indisputably one of its brightest components. It is a two-star system approximately 430 light years from planet Earth. Without any telescopic help, Albireo looks as a single active star. Nevertheless, orbital telescopes show it emits and resolves two distinct stars with diverse hues.
The system consists of:

    Albireo A which is a golden yellow giant star of type K3-II located within the star type classification within the subdivision II of the third. It is cooler and comes from a civilising nation that has evolved from the main sequence.

    Albireo B is a star much more white and bluer than that of moderate evolution. It is hotter and has more energy emitting at shorter wavelengths. It is classified as a main-sequence star of the spectral type B8 which is only 1 category short of the highest O type stars. **(Sources 11 & 12)**

19. Sketch the constellation in which Albireo lies, and locate Alberio on it.



20. What is the colour of each star in the binary system?

Albireo A (Primary Star): Golden-yellow or orange in colour.

Albireo B (Secondary Star): Blue in colour.

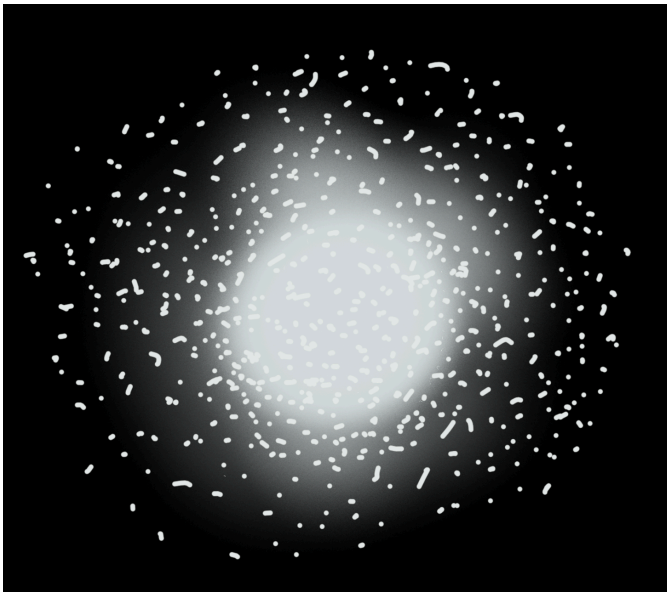
21. Which star is the hotter of the two? Explain how we may determine this by only using their colours.

Between the two, blue star Albireo B is hotter than the rest. The audio-visual relation between the hotness of a star and its colour is due to blackbody radiation. Hotter stars emit energy at a shorter blue wavelength due to high surface temperature. On the other hand Yellow or Orange Stars emit energy at longer red wavelengths, because they are relatively cooler. From the fact that Albireo B is blue while Albireo A is yellow orange, it can therefore be concluded that Albireo B has a higher surface temperature than that of Albireo A.

PART IV: DEEP SKY OBJECTS

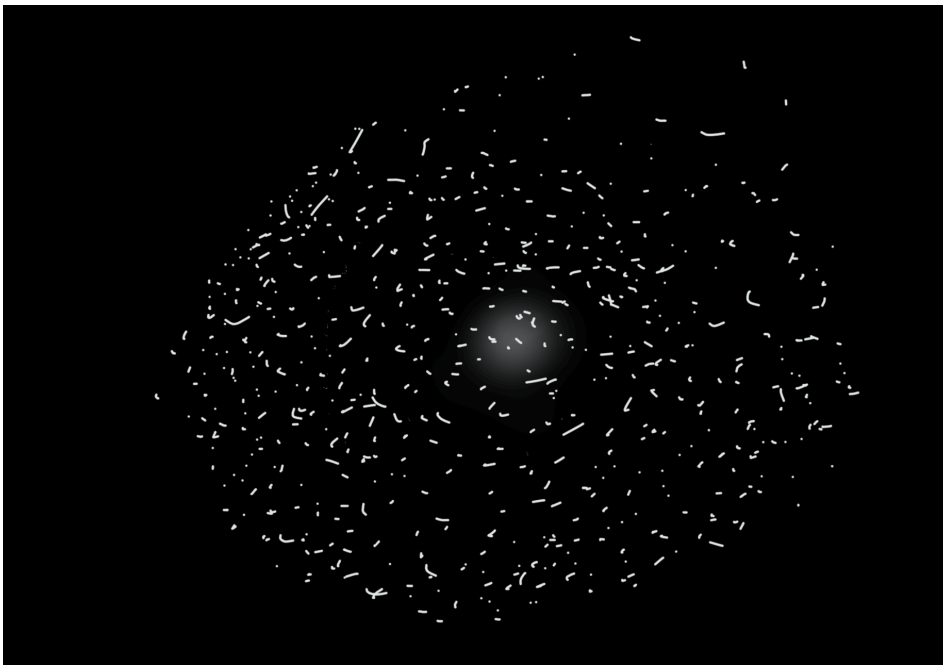
Objective Statement: Exploring Deep Sky Objects such as clusters, galaxies, nebulae and understanding them in detail regarding their lifetimes and contents.

22. **Sketch how each of these four types of objects would look through a moderate-sized (32") telescope (use online research for this). The sketch should be your own, not copied and pasted from the web. Cite your source.**
    a. **Globular Cluster - M13**



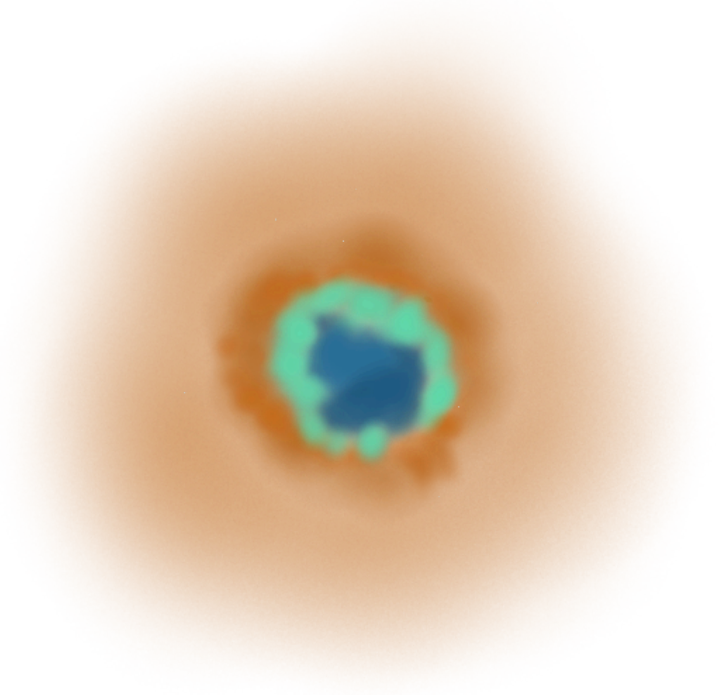
(Sources 3 & 21)

    b. **Open Cluster - M11**



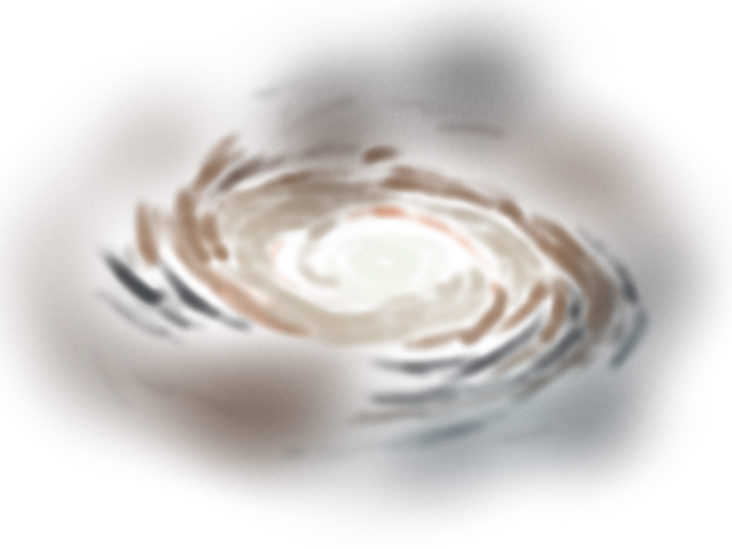
(Sources 4 & 21)

c. Planetary Nebula - M57 (Ring Nebula)



(Sources 8 & 19)

d. Galaxy - M31 (Andromeda Galaxy)



(Sources 10 & 23)

23. **Describe each of the four objects given above. Explain the class of object, e.g., globular cluster, and then include pertinent details about the particular object, eg., distance, size, number of stars, age, etc. Refer to sources such as Wikipedia to obtain relevant information about each of them. The descriptions should be written in your own words, no copying and pasting. Remember to cite all your sources in your References.**

1. M13 - The Hercules Cluster

Class of Object: Globular Cluster

M13, or Messier 13, is a spherical region of stars that are grouped together and are bonded by gravity. Also in this region, and in the constellation Hercules, some 22 200 light years from the terrestrial globe, M13 features around three hundred thousand stars. M13 is among the most prominent and extensive clusters of stars that are routinely referred to as globular attacking the planet's view. The stars that live inside M13 can be dated back about 11.65 billion years, bringing out the great abundance of variable stars in particular RR Lyrae variables. They are similar to Cepheid variables in that they are used to judge distance based on their luminosity; but they are not that bright, have shorter cycles, are mostly found in globular clusters and are therefore not very bright as cepheids. **(Sources 1,2,3)**

2. M11 (Wild Duck Cluster)

Class of Object: Open Cluster

Messier 11 also called NGC 6705, the Wild Duck Cluster is one of the most distinguished open clusters located in the skies. Situated in the constellation Scutum, M11 lies 6200 light-years from our galaxy, the Milky Way. It contains roughly 2900 stars that are held together by their gravitational pull but are less tightly packed in comparison to stars in a Globular Cluster. M11 is a relatively young open cluster aged only about 220 million years. Its popularity comes from its optically distinct V-shape when viewed up close, this being the key reason for its name "Wild Duck cluster." **(Sources 4,5,6)**

3. M57 (Ring Nebula)

Class of Object: Planetary Nebula

Among the famous celestial objects is M57, popularly called the Ring Nebula, which is a prominent planetary nebula located in the constellation Lyra which is nearly 2300 light years from Earth. It takes its form by the ejected outer layers of gas released by a dying star with the core still barred as a hot white dwarf. When viewing the Ring Nebula, a bright and colourful set of rings is visible. Its composition of ionised gases which emit light albeit at different wavelengths is what causes the colourful and eye-catching view. The nebula spans about 1 light-year across and provides a lot of information regarding the last phases of a star's life cycle. **(Sources 7,8)**

4. M31 - Andromeda Galaxy

Class of Object: Spiral Galaxy

Messier 31 (M31), or the Andromeda Galaxy, is perhaps one of the most well known spiral galaxies in the vicinity of all known galaxies having pronounced and clearly visible spiral arms located 2.5 million light years in the Andromeda constellation. This galaxy spans about 220,000 light-years in diameter, making it significantly larger than our Milky Way galaxy. Each of the well-defined arms of the Andromeda Galaxy contains billions of stars, with numerous star-forming regions. M31 is a member of the Local Group, which includes other nearby galaxies such as the Milky Way, and it is extensively studied due to its proximity and brightness, offering valuable insights into galactic structure and evolution. **(Sources 9,10)**

CONCLUSION

This lab provided me with a comprehensive exploration of astronomical observation and deepened my appreciation for the universe. By studying the components of telescopes, I learned how these instruments gather and focus light, enhancing our ability to see distant celestial objects. Exploring constellations and their diverse mythologies across different cultures enriched my understanding of humanity's connection to the stars. Observing the Moon, planets like Jupiter and Venus, and stars such as Sirius and the Albireo binary system allowed me to witness firsthand the variety and beauty of our solar system and beyond. Finally, delving into deep-sky objects like globular clusters, open clusters, planetary nebulae, and galaxies expanded my knowledge of the vast structures that make up the cosmos. This lab not only reinforced key astronomical concepts but also reignited my passion for stargazing and astrophotography.

REFERENCES

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18. https://www.youtube.com/watch?v=j7IKX5NJ7Nk
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20. https://stellarium-web.org/
21. https://www.reddit.com/r/telescopes/comments/1bpa8w7/the_hercules_globular_cluster_m13/
22. https://www.reddit.com/r/telescopes/comments/oa1b1v/messier_11_the_wild_ducks_cluster/
23. https://science.nasa.gov/image-detail/m31-2/