

Group Members:

Photoelectric Photometry of the Pleiades

This lab makes use of software from CLEA (Contemporary Laboratory Exercises in Astronomy), which was developed by Gettysburg College in PA. The purpose of the activity is to simulate the observation of stars using the technique of photoelectric photometry. This technique is widely used to determine the magnitude (both apparent and absolute) of stars and to study variable stars.

INTRODUCTION

From the roots of the words, photoelectric photometry is a technique that receives light (photons in) and converts them into an electric current (electrons out) whose magnitude is then measured (photometry). Since the device measures all the light falling in an area inside the telescope there will be two sources of light being measured. First, the light from the star under observation and second, the **background light** from the sky. From a light polluted area such as downtown the background light is quite obvious as a bright glow throughout the sky. Even from a very dark site, though, there is still a slight background glow that must be accounted for. Once the background light is subtracted the only thing that is left is a number that is proportional to the **apparent magnitude** of the star. It is then a matter of calibrating the instrument to convert the measured number to an apparent magnitude value.

To determine the **absolute magnitude** of a star you must know both the apparent magnitude and the distance to the star. Conversely, if the apparent magnitude and the absolute magnitude of a star are known then the distance to the star can be found using the formula

$$(1) \quad d = 10^{\frac{(m-M+5)}{5}}$$

m = apparent magnitude of the star

M = absolute magnitude of the star

d = distance to the star in parsec

When observing stars, astronomers often measure the stars apparent magnitude at several different wavelength ranges. If a complete spectrum of the light from the star was obtained the **spectral classification** of the star could be determined. Taking a complete spectrum is very time consuming though and requires specialized instruments. By measuring the magnitude of the star at several colors a **color index** can be found. While not as precise as the spectral classification, the color index is a good indication of the surface temperature and luminosity class of the star. The standard colors we will use are called V & B for **Blue** and **Visible** (actually yellow). The color index is just the difference in the B magnitude and the V magnitude.

Since the color index is not as precise as the spectral classification, using it to determine the absolute magnitude of a star introduces a large error in the value. Fortunately, there is a better way. If the apparent magnitudes of a large number of stars that are all at the same distance away are known and their color indices are also known then an H–R diagram can be constructed. Since most of the stars will lie on the main sequence it is possible to determine the difference between the apparent magnitude (m) and the absolute magnitude (M) of a group of stars by plotting their apparent magnitude on an H-R diagram that has a plot of the absolute magnitude of a group of main sequence stars. This method is more accurate since a large number of stars are used. There is also the added advantage that nature provides groups of stars all located at roughly the same distance from Earth: clusters. In this lab you will observe a variety of stars in the Pleiades, an open cluster easily visible to the naked eye in the constellation Taurus. After obtaining the apparent magnitudes and color indices of a large number of the cluster members you will make an H-R diagram and determine the difference between their apparent magnitude and absolute magnitude ($m-M$). From the $m-M$ value you will be able to determine the distance to the Pleiades.

PROCEDURE

1. You will find the program by going to **Start**, then **Programs**, then **CLEA Labs** and finally **Pleiades**. Choose **login** from the *File* menu, enter your names and then click **OK**. You are now on the main page. When you click on **Start** the view is of the inside of the dome of a virtual telescope and the controls for it. Open the dome by clicking on the **Dome** button and then lock the **Tracking**. You now see the Pleiades star cluster.
2. The telescope can be moved by clicking on the **N**, **W**, **E** and **S** buttons. You can change the rate the telescope moves by clicking on the **Slew Rate** button. Notice how the **Right Ascension** and **Declination** change as you slew the telescope around. Finally, to zoom in on the area of the red square click on the **Change View** button. You are now looking through the virtual telescope. The red circle is the detector area of the photometer.

3. The first thing you must do is measure the background brightness of the sky. Slew the telescope so that the red circle is in an area with no stars inside it. The **Filter** button selects the U, B or V filter, the **Seconds** sets how long the measurement will be for and the **Integrations** determines how many times the measurement is repeated. Select the V **Filter**, set the **Seconds** to 10.0 and **Integrations** to 5. Click **Take Reading** and the photometer starts collecting photons. After the five integrations are completed the computer calculates the average number of counts from the five measurements and then the mean count per second. Record the Mean Sky Counts/Sec in the space below. Repeat the measurement for the B filter and record the results. You can ignore the U filter.

Filter	Mean Sky Counts/Sec
B	_____
V	_____

4. Now move the telescope so that a star lies completely inside the red circle. If it is a bright star a collection time of 1.0 second is sufficient. If the star is dim set the **Seconds** to 10.0. Leave the **Integration** at 5, select the V **Filter** and take a reading. After the measurements are completed the computer subtracts the background and calculates the apparent magnitude of the star. Record the U magnitude along with the Right Ascension and Declination of the star in the space below. Repeat the measurement for the B and V filters and record the results.

Right Ascension _____ Declination _____
 B Mag = _____ V Mag = _____

5. Now that you know the technique, you are ready to measure the rest of the stars of the cluster. Using the RA and Dec values for the stars in the table on the next page carefully center the red circle over each star and measure the B and V magnitudes of each star. The star you have already measured is probably on the list so you don't have to re-measure it. Record the B and V values and calculate the B – V value for each star.
6. After you have completed all the measurements and calculated the color indices, plot the points on the H-R diagram at the end of this lab.

Photoelectric Photometry of the Pleiades Data Sheet

Star	RA			Dec			B	V	B-V
	hr	min	sec	deg	min	sec			
1	3	41	05	24	05	11			
2	3	42	15	24	19	57			
3	3	42	33	24	18	55			
4	3	42	41	24	28	22			
5	3	43	08	24	42	47			
6	3	43	08	25	00	46			
7	3	43	39	23	28	58			
8	3	43	42	23	20	34			
9	3	43	56	23	25	46			
10	3	44	03	24	25	54			
11	3	44	11	24	07	23			
12	3	44	19	24	14	16			
13	3	44	27	23	57	57			
14	3	44	39	23	27	17			
15	3	44	39	24	34	47			
16	3	44	45	23	24	52			
17	3	45	09	24	50	59			
18	3	45	27	23	17	57			
19	3	45	28	23	53	41			
20	3	45	33	24	12	59			
21	3	46	26	23	41	11			
22	3	46	26	23	49	58			
23	3	46	57	24	04	51			
24	3	47	29	24	20	34			

7. When you have all the points plotted use a dark marker like a Marks-a-lot or Sharpie pen to highlight the main sequence on the pre-plotted stars and on your observed stars. Recall that the main sequence is not a straight line but a curving diagonal. After you have highlighted the two main sequences you should have two roughly parallel curves. Using a metric ruler, measure the vertical height of one square of the graph. Record that number here:

Graph Square Height = _____

Now measure the vertical separation between the two main sequence curves. Record that number here:

Main-Sequence Separation = _____

To determine the difference between the apparent magnitude and the absolute magnitude, simply divide the vertical separation between the two main sequence curves by the height of one square

$$m-M = \frac{\text{Main Sequence Separation}}{\text{Graph Square Height}} = \underline{\hspace{2cm}}$$

8. Now that you have the $m-M$ value of the Pleiades you can calculate the distance to the cluster. Use equation 1 to calculate the distance to the Pleiades in parsec. Record your answer below. Use the information in Appendix 6 of your textbook to calculate the distance to the cluster in lightyears and record the results.

Distance to Pleiades in parsec = _____

Distance to Pleiades in lightyears = _____

9. Modern estimates of the distance to the Pleiades calculated by professional astronomers give a distance of 410 light-years. As a percentage how does your value for the distance to the Pleiades compare to the accepted value?

$$\text{Percentage} = \frac{\text{accepted value} - \text{experimental value}}{\text{accepted value}} \times 100 = \underline{\hspace{2cm}}$$

H-R Diagram of the Pleiades

