



Labs 07 and 08: The Photoelectric Photometry of the Pleiades

Introduction

Professional astronomy can be surprisingly competitive. There are not many large telescopes, and telescope time is limited by daylight and cloudy conditions. When an astronomer applies for observing time, he is not guaranteed that it will be granted—there are a large number of astronomers applying for a small amount of time. And even if telescope time is awarded, that's no guarantee of observing time: weather conditions may prevent observations, and once your time is up, it's up and the next guy in line gets his turn!

Lucky for us, we can simulate the observing experience with astonishing realism. We will not be able to get observing time on a real telescope, but the VIREO (The VIRtual Education Observatory) program we will use has been designed by astrophysicists to reproduce an accurate observing experience. The Student Manual for this exercise is freely available online at:

ftp://io.cc.gettysburg.edu/pub/clea_products/manuals/Photo_sm.pdf

The advantage of this manual is that it provides additional detail describing the program features, but you may not need to print the entire document. A clickable link is provided on the course web, and remember that you can run these programs any time the lab LSC 174 is open.

Objectives

The Pleiades are a cluster of stars that not only appear close together to us here on Earth, but are actually located close to each other in space. Our goal is to determine how far this cluster is, relative to the Earth.

You have been granted unlimited observing time on a 0.4 meter optical telescope and permission to request time on a 1.0 meter and/or 4.0 meter optical telescopes. The telescopes will be equipped with filter wheels and photoelectric photometers. Your project mission is to

- Obtain multi-color (B (for short- λ blue) and V (for visible, peak λ in the green)) photometry of a sample of 24 stars in the Pleiades star cluster
- Compare the main sequence of the cluster to a calibrated absolute magnitude main sequence
- Graphically determine the distance to this cluster

Procedures

This lab will take two sessions to complete. You should spend the first lab period using the computer to collect observational data. If you need additional time, you may use the computer lab the following day when it is not reserved for another class.

We will spend the second lab period performing the analysis of the photometric data. We will meet in the lab classroom, and you must be prepared with your complete set of observational data.

Monday: Observation and Data Collection

1. **Start VIREO:** Double click on the icon for the VIREO program found on the desktop.

2. **File \rightarrow Login:** Enter your name and the number of the computer and click OK.
3. **File \rightarrow Run Exercise \rightarrow Photoelectric Photometry of the Pleiades.**
4. **Telescopes \rightarrow Access 0.4 Meter:** Choose a telescope, or *Request Time* \rightarrow on either the 1.0 Meter or 4.0 Meter. If you are granted time on either of the larger telescopes, then you will have to access them from the menu in order to use them. (Hint: Bigger telescope means more light-gathering power means shorter exposures required!)
5. **Control the scope:** Once you have selected one of the telescopes you will need to open the dome, and once the dome is open you will need to turn on the *Telescope Control Panel*.
6. **Tracking:** Turn on the telescope *Tracking* on from the control panel.
7. **Field of view:** Toggle from *Finder* view to *Telescope* view. This switch occasionally sticks, and you might have to toggle a second time to change to the *Telescope* view.

Sky Calibration

The sky is never perfectly dark. You will need to teach the instrument computer what the sky brightness level is for your observing session by observing blank region of sky.

8. **Clear the field of view:** Make sure there are no objects in the circular aperture of the photometer. If there are, use the *N-S-E-W* buttons to move the telescope aperture to a part of the sky free from any apparent objects.
9. **Access the Photometer Control Panel.**
10. **Calibrate the B:** Set *Filter \rightarrow B*, *Reading \rightarrow Sky*, *Integration Seconds \rightarrow 10*, and *# of Integrations \rightarrow 3*. Click *Start* to take a sky reading with the B filter.
11. **Calibrate the V:** Repeat step 10, but with the *Filter \rightarrow V*.
12. **Re-calibrate:** If at any time you switch to a different telescope, you must calibrate the sky for that telescope (because it is a different size and has different light gathering power).

Targeting Stars

13. **Slew \rightarrow Observation Hot List \rightarrow Object View/Select from List:** Double click on the star you want to observe. Click *OK* to slew the telescope to those coordinates. Once the telescope has completed its slew, there should be a star centered in the aperture.

B and V Photometry

14. **Set exposure time:** Total exposure time is Integration Seconds multiplied by the # of Integrations. You cannot set the exposure time to any arbitrary value, but you should be able to find a combination to get you close to the exposure time you may desire.
15. **Watch your S/N:** A bigger number is better (more signal, less noise), and we want values of at least **S/N = 100**. Very bright objects will reach this level with shorter total exposure times, but dimmer objects are going to require either an increased number of Integration Seconds, or more # of Integrations.
16. **Reading \rightarrow Object:** *Make absolutely certain that you do not miss this step!* If you leave your setting on *Sky*, you are not collecting data properly, and you will have to recalibrate your sky a second time.

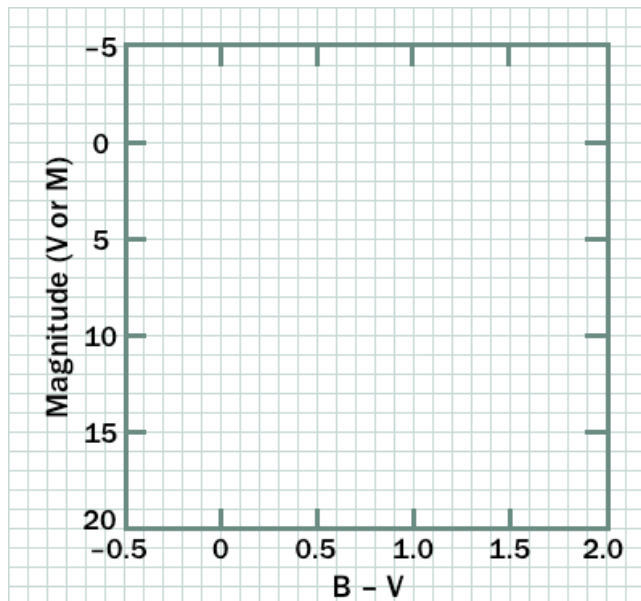
17. **Select a filter:** Choose **B** or **V**. You will want both **B** and **V** magnitudes for each star from the *Hot List*. **You will perform an exposure for each star using each filter.**
18. **Start:** Once you have the exposure time and filter set, start the exposure (Integration) by clicking on the *Start* button.
19. **File → Data → Record/Review:** Once the exposure is complete, the sky-subtracted magnitude and S/N ratio will be displayed. Record in your notebook the stellar magnitude and also save the results on the computer.
20. **Complete your data table:** Obtain a **B** magnitude and **V** magnitude for each star in the *Hot List*. Write down the values in your notebook as well as saving them on the computer.

STAR	B	V	B - V
N2230-01442	10.508	8.797	1.711
etc...			

Notice as you collect and record data that the **brighter** a star appears, the **lower** its B or V brightness number is! A dim star has a high B or V magnitude, a bright star has a low or even a negative value.

Wednesday: Data Reduction and Analysis

1. **You must have a complete data set to proceed.** Please do not skip the Week 1 data collection and then expect someone else in lab to hand over their painstakingly collected data for you to use.
2. **Compute:** Calculate the **B-V** color index for each of the stars by taking the B-magnitude and subtracting the V-magnitude from it.
3. **Graph:** Using most of a lab notebook page, create a graph like the one shown below. The larger you make your graph, the more accurate your results will be.



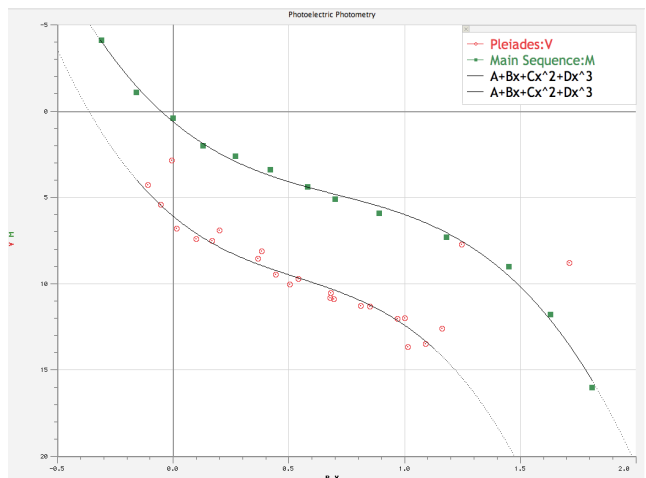
4. **Plot your data:** For each of the 24 stars, plot **B-V** on the **x-axis** and **V** on the **y-axis**. Do not label each star but use the same plot symbol (or color) for each of the Pleiades stars.
5. **Plot the reference stars:** On the same graph, plot a calibrated set of main sequence stars. From the table below, plot **B-V** as the **x-coordinate** and **M** (absolute magnitude) for

the **y-coordinate** using a different plot symbol (or color) than the one used for the Pleiades.

ABSOLUTE MAGNITUDES OF MAIN-SEQUENCE STARS

B-V	M (ABSOLUTE MAGNITUDE)	B-V	M (ABSOLUTE MAGNITUDE)
-0.31	-4.1	0.7	5.1
-0.16	-1.1	0.89	5.9
0	0.4	1.18	7.3
0.13	2	1.45	9
0.27	2.6	1.63	11.8
0.42	3.4	1.81	16
0.58	4.4		

6. **Fit both curves:** Draw a smooth curve through the main-sequence for the Pleiades and for the calibrated stars. Your graph should look similar to the one below.



7. **Skip the outliers:** If there are any Pleiades stars that are not main-sequence stars, indicate them and do not draw your curve through them.
8. **Compare the curves:** Is your Pleiades curve brighter or dimmer than the 10 pc curve? The calibrated main-sequence represents the magnitudes that a cluster of main-sequence stars would have if they were 10 pc from the Earth. Keeping that in mind, are the Pleiades further or closer than 10 pc?
9. **Find (V-M):** To determine how many parsecs (pc) the Pleiades cluster is from us, you need to measure how many magnitudes separate the Pleiades main-sequence and the standard main-sequence (V-M). We will discuss exactly how to do this during the second lab session.
10. **Calculate:** Use the equation below to find the distance to the Pleiades in parsecs.

$$d = 10^{\left[\frac{(V-M)+5}{5} \right]} \text{pc}$$

11. **Compare:** If the accepted value for the distance to the Pleiades is 135 pc, what is your percent error?

$$\%error = \left(\frac{d - 135}{135} \right) \times 100$$

12. **Convert:** What is the distance in light years given 1 pc=3.26 ly?