

Laboratory 3: Photometry of the Pleiades (VIREO)

Experiments are to be completed on the provided laboratory sheets below; any supporting material (eg. graphs) should be attached. Make sure your name and your partners name(s) are clearly indicated on the front page of your lab. **Neatness and clarity count!** Use complete sentences in answering all questions, explain your answers when asked clearly, and if you use an equation to do a calculation, *write the equation down* first, then put in numbers and solve. **Show all your work!**

Labs are due on VIULearn one week after the lab; please use the provided lab pages and submit your lab (in the correct order) as a single, reasonably sized PDF file.

APPARATUS

Starry Night, *SkySafari* or equivalent planetarium software, CLEA's VIREO software (Photoelectric Photometry of the Pleiades), provided graph paper & ZAMS handout.

OBJECTIVE

1. To simulate photometric data collection and plot a colour-magnitude diagram for the Pleiades
2. To determine the distance to the Pleiades using main sequence fitting

THEORY

1). The *apparent magnitude* of a star, m , is the brightness of a star as seen from the Earth. The *absolute magnitude* of a star, M , is the brightness of a star at a standard distance of 10 parsecs from the observer. Given m and M , the distance d in parsecs to the star is found using:

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

Measuring the rate of emission of photons ("brightness") at certain wavelengths is called *UBV photometry*, and utilizes filters which isolate certain wavelengths (UBV stands for Ultraviolet, Blue and Visual). Comparing photon emission rates in these three bands identifies a star's *spectral class*.

2). To compare a measurement with an expected value, use *percent deviation*:

$$\text{Percent Deviation} = \frac{(\text{experimental} - \text{expected})}{\text{expected}} \times 100$$

(Example) We measure a value to be 9.0 units and compare to a known, expected value of 10.0:

$$\text{Percent Deviation} = \frac{(\text{experimental} - \text{expected})}{\text{expected}} \times 100 = \frac{(9.0 - 10.0)}{10.0} \times 100 = -10\%$$

The measured value is ten percent below the expected value.

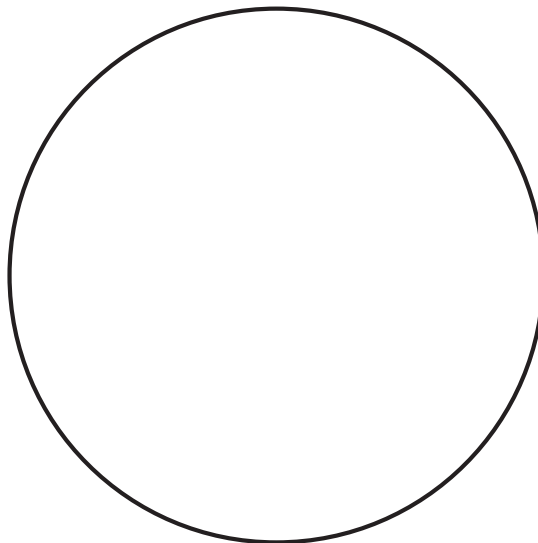
Mark this lab: individually
 as a group

NAME:
PARTNER:

Laboratory 3: Photometry of the Pleiades (VIREO)

1. Print off the lab, graph paper & Zero Age Main Sequence (ZAMS) HR graph from the website.
2. [1 mark] What is *photometry*? What is 'UBV' as it pertains to *photometry*?

3. [3 marks] Our UBV photometry 'targets' will be various members of the *Pleiades* star cluster. **Find & center the Pleiades in a planetarium program of your choice - set it for Nanaimo at 8pm PST on February 15, 2024.** In *Starry Night* use the FOV Indicators submenu item to display a red, circular 2° field-of-view on the sky; in *SkySafari* use **Observe** → **Scope Display** and enable both the 2° Custom Field of View and Show Even if Not Connected to Telescope settings. Zoom in so the 2° field-of-view circle fills the screen. **In the circular FOV below draw (by hand) a COLOUR view of the Pleiades as observed; label its seven (7) primary stars.**



Pleiades (2° FOV)

Using your class notes or the program, **list other common name(s) for this cluster.**

4. Form groups of two (2). The strategy for the photometry portion of the lab is:
 - Use the VIREO software to simulate photometric measurements of the Pleiades
 - Record photon counts with B & V filters for a number of specified stars
 - Plot apparent brightness V vs. B-V & compare with a standard main sequence (ZAMS)
 - Determine the overall difference in brightness & calculate the distance to the Pleiades

5. Each group member will perform simulated photometry on a number of stars in the Pleiades. Start the VIREO software. Select the **Log In** menu item and press return (don't bother entering names). Select **Run Exercise...** from the File menu, and choose **Photoelectric Photometry of the Pleiades**. **** IGNORE ANY ERROR MESSAGES/POP-UPS. ****

6. The Main Control window should appear, simulating the 'warm room' of a real observatory. Select the **Telescope** menu and choose the 0.4 m telescope. Click on the **Dome Open** switch (top right) to open the observatory dome, then turn ON the **Telescope Control Panel** button (lower right). This will open the Telescope Control Panel window. Turn ON the **Tracking** (middle left) to get the scope to follow (track) stars as the Earth rotates.

7. We will record the brightness of various stars (*photometry*) in the Pleiades cluster by counting *photons* (particles of light) coming from the stars and passing through Blue (B) and Visual (V) band filters. First, we must do a *dark sky calibration*. This measures photon counts coming from a patch of 'dark' sky which are then used by the program to correct for 'light contamination' in the star measurements we will make. To perform the calibration, **take a reading through each filter (U, B, V) while pointed at a dark (starless) patch of sky**. Do the following:
 - In the Telescope Control Panel window, click **View** (top right) to Telescope
 - You are now in *photometer view*; the red circle indicates *where* the photometer is aimed
 - Use the 'slewing' buttons (N, E, S, W) to point the telescope at *empty* (black) sky
 - Click on **Access** (bottom right) to change to the Photometer Control window
 - Set **Filter** (top left) to U (ultraviolet)
 - Set **Integration Seconds** (mid left) to a measurement duration of 10 s
 - Set **Integrations** (bottom left) to 5 measurements
 - Set **Reading** (mid left) to Sky to measure sky background/calibrate
 - Click on **Start** (top right) & sit back and wait :-)
 - When it finishes, **record Mean Sky (counts/sec) for U in the table below**
 - Repeat above and record for B & V filters, **i.e. calibrate all of the U, B, & V filters**
 - Close the Photometer Control window using **x** (top right)

Photometer Dark Sky Calibration			
Filter	U	B	V
Mean Sky (counts/sec)			

[1 mark] Which 'band' shows the greatest background 'contamination'? Why?

8. You are now ready to perform some photometry! In the Telescope Control Panel window, select the **Slew** menu and then choose **Enter Coordinates**. In the resulting pop up window *carefully* enter the right ascension (RA) and declination (Dec) coordinates for the first star in the Photoelectric Photometry Data Sheet table found at the end of the lab and then press OK. The scope should 'slew' or move to view that location. Once the scope has finished moving, *the star should be in the center of the red circle and will be the target for our photometric measurements*. Verify the coordinates shown below the scope starfield view with those given in the data table.

9. Click on **Access** (bottom right) to change to the Photometer Control window. Set **Reading** to Object (NOT Sky). Set **Filter** to B, **Integration Seconds** to 1, and **Integrations** to 5. *These are your default settings. Depending on the target star's brightness, you may need to adjust these settings*. Select **Start** and wait for a value to appear under **Magnitude** (lower right). BEFORE recording this value, check the **S/N Ratio** ('Signal to Noise Ratio') (mid right); if SN is *greater than or equal to 50, the data is of acceptable quality*. If it is *lower than 50, increase Integration Seconds* by one step & measure again. Repeat until the **S/N Ratio** is acceptable and then **record the resulting Magnitude in the data table** (included at the end of the lab) under 'B (mag)'. Set **Filter** to V (leaving other settings) and repeat to measure 'V (mag)'. **Record the lower of your S/N ratios in the table**. Close the window.

Calculate B - V (watch the *sign*; B-V may be *negative!*) **and record it in the table**.

[2 marks] Repeat for all 24 stars in the Photometry Data Sheet table.

10. [4 marks] Graph your visual magnitudes V vs. B-V on the blank graph paper provided on the website. Your 'y' values (vertical axis) are V and your 'x' values (horizontal axis) are B-V (which may be *positive* or *negative*). **Graph carefully and number each point** indicating the star it corresponds to.

11. [2 marks] Identify stars on your graph which deviate from the trend representing the main sequence. **What type(s) of stars are these outliers, based on their HR position? Explain.**

12. [**1 mark**] You now have two graphs showing the brightness of main sequence stars: one is your graph of *apparent magnitudes* of the Pleiades while the other is the (downloaded) graph of the *absolute magnitude* of a standard main sequence. **Since both represent the same range of main sequence stars the graphs should be identical.** However, the two groups of stars are at different distances, so while the shapes of the two graphs are the same the vertical positions (brightness) are *offset* from each other. *The amount of vertical offset represents the decrease in brightness due to the distance of the Pleiades cluster*, e.g. apparent vs absolute magnitude.

**** Please view the video on the class website demonstrating this part of the lab. ****

Place your graph on top of the standard main sequence, aligning the vertical axes, and hold them up to a bright light. Keeping the vertical axes aligned, slide your graph *vertically* to achieve the best alignment with the *overall trend* of the standard main sequence. The graphs won't *perfectly* overlap; you must judge the position at which the best *overall* alignment occurs. **To one decimal place, what value of V (or apparent magnitude m) on the vertical axis of your graph aligns with the absolute magnitude $M = 0$ on the ZAMS graph?** $m =$ _____.

13. [**3 marks**] From your m (above), $M = 0.0$, and equation (1), **find the distance in parsecs to the Pleiades star cluster. Convert to lightyears (1 pc = 3.26 ly).** Show all work.

14. [**3 marks**] **Compare your calculated distance to the expected value of 440 ly using % deviation. Comment on the agreement & identify potential sources of significant error.**

Photoelectric photometry data sheet

Star	RA (hr min sec)	Dec (deg min sec)	B (mag)	V (mag)	B - V	Integs	Secs	Lowest S/N ratio
1	3 41 18.00	23 58 00.0	10.5	8.8	1.7	3	1	85
2	3 42 55.09	24 29 35.7						
3	3 44 06.55	24 20 11.8						
4	3 45 06.53	24 15 49.5						
5	3 45 12.51	24 28 01.9						
6	3 45 40.16	24 37 38.8						
7	3 45 42.44	25 03 26.2						
8	3 45 43.24	24 16 12.7						
9	3 45 48.42	24 52 42.6						
10	3 46 27.26	24 15 18.1	7.5	7.4	0.1	5	0.1	141
11	3 46 27.77	23 35 34.6						
12	3 46 34.18	23 37 27.2						
13	3 46 50.51	23 14 21.8						
14	3 46 59.35	24 31 12.2						
15	3 47 01.43	24 22 23.7						
16	3 47 29.07	24 06 18.5						
17	3 47 36.89	23 36 33.9						
18	3 47 50.79	24 40 44.9						
19	3 48 13.41	25 05 55.7						
20	3 48 20.78	23 25 16.1						
21	3 48 30.06	24 20 44.3						
22	3 49 07.51	24 00 40.0						
23	3 49 25.14	23 47 42.0						
24	3 49 56.56	24 20 56.5						