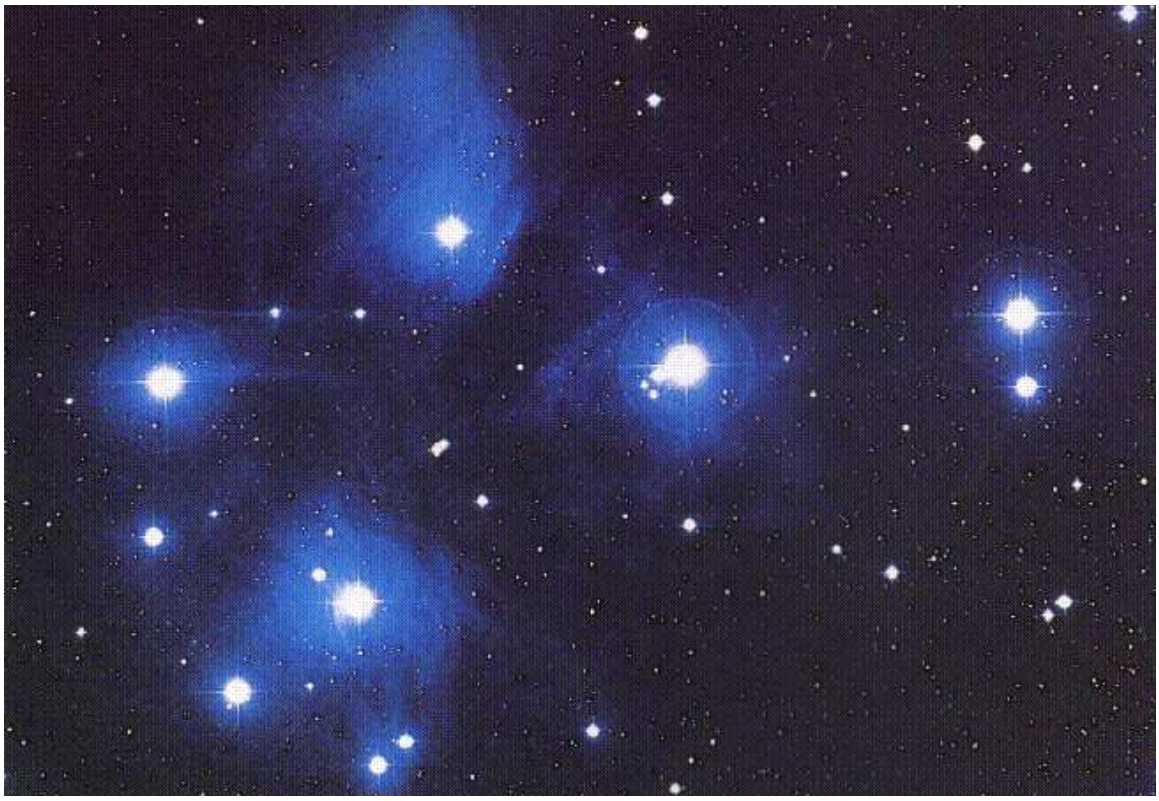
LAB: Photometry of the Pleiades Cluster

ASTR 203 - Instructors Olszewski & Rigby
Due IN CLASS on Oct. 30



You may work with 1 partner. If you do, only turn in 1 assignment with both your names on it!

You will turn in 3 products from this lab:

a) the attached data sheet, filled out

b) an H-R diagram you made from the data, on graph paper

c) answers to this lab's posed questions , typed. As always, math can be neatly hand-written.

Please staple all of these together.

In this lab, you will create an H-R diagram by measuring the brightnesses and colors of the stars in the Pleiades Cluster. (This is an easily-spotted cluster of stars near the constellation Orion.) This will help you understand H-R diagrams, and how astronomers measure the basic properties of stars. The data you'll take make it possible to estimate the age of the cluster (what's are the brightest stars on the main sequence?) and the distance (how bright do stars of known brightness appear?)

Equipment

You will need a calculator, graph paper, and ruler. You'll also need the CLEA lab "Pleiades Photometry", which is installed in the ILC's Information Commons. (On the PCs, it's in the "Courses" folder.)

Introduction

In this lab, you' ll use a computer simulation to take photometric data (photometry = "measuring apparent brightness) Your targets are 24 stars in the Pleiades (a nearby, young open cluster.) You' ll measure the apparent brightness of each star, in 2 colors (B=blue, V=green). *We will assume all of these stars are approximately the same distance awa*y. Since all these stars are members of the same cluster, and the distance to the cluster is much larger than the cluster diameter, this is a reasonable assumption. Without this assumption, you couldn' t make an H-R diagram without knowing the distance to each star. With the assumption, the only unknown is the distance to the cluster (something you could estimate from the data you' ll take.)

From your measurements of apparent brightness, you' ll make a Hertzsprung-Russell (H-R) diagram. By now, you' re used to the axes being luminosity and temperature. We' ll plot these axes as apparent magnitude (which if the distance were known, could be converted to luminosity) and color (the quantity B-V, the B magnitude minus the V magnitude, is the ratio of blue to green photons, which is related to the star' s color, which by the Wein law, is related to a temperature. Don' t sweat it, just call the quantity B-V the "color").

For your H-R diagram, you should plot the B-V you measure on the horizontal *x* axis, and apparent V magnitude on the vertical *y* axis *using graph paper*. Remember that dim stars have high magnitude numbers. Your Y axis should have V=0 on the top, and V=25 on the bottom (a very dim star).
Your X axis should range from -0.4 at left to 1.8 at right.

Using the Photometry Program

Go to the ILC' s Information Commons. On a PC, open the **Courses** folder and double-click on the **Pleiades Photometry**.

Select **Login** from the menu bar. You do not need to enter your name. Just click **OK** to continue, ignore the error message, and click **YES** when you are asked if you are finished logging in.

To begin, choose **Start**. The screen shows the control panel and view from the telescope.
The **dome** is closed and **tracking** is off. Controls and readouts for the telescope are to the left of the dome and the controls and readouts for the photometer are to the right of the dome.

Click **Dome**. The telescope dome will open, and the stars appear. Click **Tracking** so the telescope will compensate for the Earth' s rotation, and track the stars.

You can control where the telescope is pointed by using the **N, S, E, W** buttons (click **Slew rate** to change the speed at which the telescope moves.) You can also use **set coordinates** to type in a star' s position.

Get Started and Take Sky Readings

Since the sky isn' t completely dark, you' ll detect photons from the sky as well as from the star. That would mess up your measurements unless you measure the sky brightness and compensate. If you don't do this part correctly, the rest of the lab won't work.

1. Click **Monitor** button to turn on the Photometer mode.
2. Move the telescope until the aperture (red circle) *has **no** star in it*.

3. Click on the **Filter** button until the filter "V" appears.
4. Set **Seconds** to 10 seconds, and **Integrations** to 5.
5. Click **Take Reading** and wait for readings to appear. When the measurement is completed, the mean sky count will appear in the box labeled **Mean Sky.**
6. ***Repeat the measurement for the B filter***. Don't forget this!
7. Write down the mean sky level (counts/sec) in B and in V. Include this with your type-written writeup.

Take a Star Reading and Record the Results

1. Click on **Monitor** to activate **Finder** mode. Move the telescope to center a star in the red square.

2. Click on **Monitor** to activate the **Photometer** mode. Center the star in the red aperture circle.

3. Select a filter (B or V) by pressing **Filter**. Ignore the U filter.

4. Select an appropriate integration time by clicking on the **Seconds** button. Use short integration times for bright stars to save time/boredom, and long integrations for faint stars. Integration times are in seconds.

5. Select the number of integrations by clicking on the **Integrations** button. The computer will take a series of integrations depending upon this setting, and display the individual and average photon counts in the raw count box. After the integrations are done, the computer subtracts out the sky background you measured before, and displays the star's apparent magnitude in the lower left corner of the photometer window.

6. Record the magnitude measurements (B and V) of the star on the attached **Photometry Data Sheet.**

The program displays the signal-to-noise ratio or **SN Ratio** of the reading. High ratios mean lots of photons, and little noise. For good results, strive for SNs of ~100 or more. You can increase SN by *increasing* the integration time.

Take star readings for each star listed on the attached Photometry Data Sheet.
Use the coordinates ("right ascension" and "declination") to find the stars. Measure the B and V apparent magnitudes. Record all magnitudes to the nearest 0.001 magnitude on the data sheet.

Calculate the color index B-V for each star to the nearest 0.01 magnitude and record it on the data sheet. Nothing tricky – B-V is just the B-magnitude minus the B-magnitude. Hot blue stars have low, and even negative B-V. Cooler red stars have B-V values somewhat over 1.

Create an H-R diagram of your data, as explained in the Introduction section. Use regular graph paper.

After you're done using the CLEA program, complete the following items:

1. On your H-R diagram, identify the main sequence. Sketch a line through it, and label it clearly.

2. What are the coordinates (RA and Dec) of three possible red giant stars?

3. Consider the star near RA 3 h 44 m and Dec 24 d 35". It seems curiously out of place with respect to the main sequence. What type of star might this be? Why do you think so?

Distance to the Cluster

You have enough information to figure out the distance to the cluster now. We didn't talk about this in class, so we're not going to ask you to do it. But since color doesn't change with distance but brightness does, the x-axis stays the same as the cluster gets farther away, while the y-axis changes. Think about this – for a MS star, you've measured the apparent brightness, and from the color you know what the true brightness should be. So you can estimate the distance.

The distance to the Pleiades has been measured by this technique, and even better by the technique of stellar parallax. These techniques give a distance of about 420 $\pm$ 20 light-years.

What fraction of the Milky Way diameter is this? (Milky Way = 100,000 light years across.) Show your work. **Is the Pleiades near or far?**

What is the approximate spectral type of the bluest star on the Pleiades' Main Sequence?
Hint: *Use the information in the table below to help.*

Explain how you could use the this information to estimate the age of the Pleiades.

Calculate the age of the Pleiades using your answer to the question above. (This is similar to a problem in HW#3. The table below, the table in the Stellar Spectroscopy lab, and the H-R diagram with masses labelled (figure in Sept 11 lecture notes) will all help you. Show your work and thinking!

How uncertain do you estimate you answer for the Pleiades age to be?

Extra credit: What could mess up the main-sequence matching distance-estimating technique?

(V) Absolute Magnitude	B-V	Spectral Type
-5.8	-0.35	O5
-4.1	-0.31	BO
-1.1	-0.16	B5
-0.7	00.0	AO
2.0	0.13	A5
2.6	0.27	F0
3.4	0.42	F5
4.4	0.58	GO
5.1	0.70	G5
5.9	0.89	KO
7.3	1.18	K5
9.0	1.45	MO
11.8	1.63	M5
16.0	1.80	M8

Photometry Data Sheet

Star	RA hr min sec	Dec deg min sec	U	B	V	B-V
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				