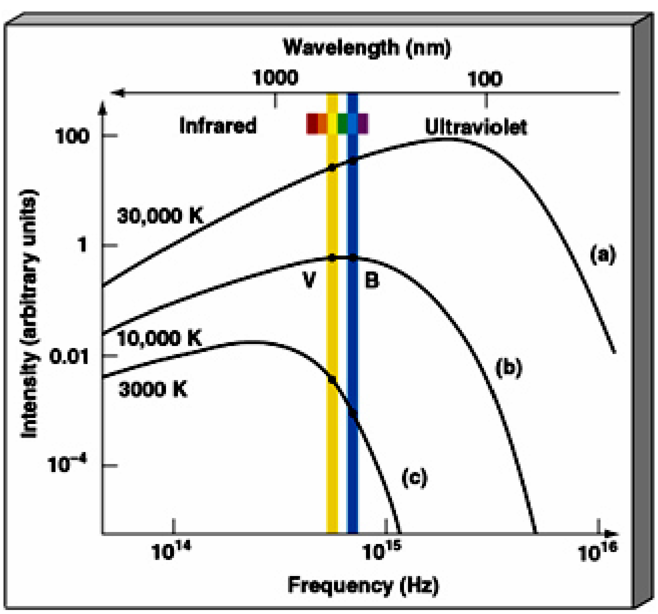
# Lab 08: CLEA Color-Magnitude Diagram of the Pleiades

## Purpose
To use a photometer to determine the apparent magnitude of blue (B) and yellow (V) light for stars in the Pleiades cluster and to construct a Color-Magnitude diagram from the data.

## Introduction
Two of the most easily measured properties of any star are its apparent magnitude and its temperature. These two stellar properties can be plotted to form a color-magnitude diagram (similar to the HR diagram) and the age of a star cluster can be determined.

Because the basic shape of the blackbody curve is so well understood, astronomers can estimate a star's temperature using as few as *two* measurements at selected wavelengths. This is accomplished through the use of telescope filters that block out all radiation except that within specific wavelength ranges. For example, a B (blue) filter rejects all radiation except for a certain range of violet to blue light. Similarly, a V (visual) filter passes only radiation in the green to yellow range (the part of the spectrum to which human eyes happen to be particularly sensitive).

The figure below shows how these filters admit different amounts of light for objects of different temperatures. In curve (a), corresponding to a very hot 30,000-K emitter, considerably more radiation is received through the B filter than through the V filter. In curve (b) the temperature is 10,000 K and the B and V intensities are about the same. In the cool 3000-K curve (c) far more energy is received in the V range than in the B range. In each case, it is possible to reconstruct the entire blackbody curve on the basis of only those two measurements because no other blackbody curve can be drawn through both measured points.



To the extent that a star's spectrum is well approximated as a blackbody, measurements of the B and V intensities are enough to specify the star's blackbody curve and thus yield its surface temperature. Astronomers often refer to the difference of a star's B to V intensities as the star's *color index*.

The color index (B-V) is equal to the apparent magnitude of blue light minus the apparent magnitude of yellow (visual) light

$$B\text{-}V = m_b - m_v$$

Because a star's apparent magnitude depends on its distance as well as its intrinsic brightness, we really would not expect a correlation between apparent magnitude and temperature (or color index) for most stars in the sky. However, it might seem reasonable for the temperature of a star to be related to the total amount of energy it radiates, or its absolute magnitude. Unfortunately, absolute magnitudes are hard to determine directly because of the difficulty in determining reliable distances for more than a few hundred stars in the sky.

One way to avoid this difficulty is to study the magnitudes and colors of stars in a cluster. All stars in the cluster are at approximately the same distance, so the apparent magnitude of each differs from its absolute magnitude by the same factor. By comparing color index and apparent magnitude we are also relating temperature and absolute magnitude. The most famous cluster is the Pleiades, a prominent clump of stars in the constellation Taurus. The Pleiades are often called the Seven Sisters, although only six of the cluster's several thousand stars are easily visible to the naked eye.

**Equipment**
You will need a pencil, computer and a calculator.

**Procedure**
The computer program you will use is a realistic simulation of a B-V photometer attached to a moderate sized research telescope. A B-V photometer is an instrument that counts the number of photons of blue and yellow (visual) light over a given period of time. When a blue filter is inserted in front of the lens only blue light can enter the photometer. Likewise, when a yellow (visual) filter is inserted in front of the lens only yellow light can enter the photometer. The number of photons per second of blue and yellow light is counted and the apparent magnitude of blue and yellow light is calculated.

You will use this instrument to collect data on 24 stars in the region of the Pleiades star cluster and plot the apparent magnitude of the stars vs. their color index. The apparent magnitudes will be determined by measuring the amount of yellow light passing through the V filter and the color index will be determined by taking the difference in the amount of blue and yellow light that has passed through the B and V filters. Your diagram should show the apparent magnitude on the y-axis and the color index on the x-axis. Use the graph paper provided.

**Set up and Take SKY Readings**
Since the aperture is much larger than the star under study, and the sky is not perfectly dark, the sky within the aperture contributes a certain number of photons. These unwanted photons are counted by taking a *sky readin*g. The star to be measured is then centered in the aperture and a *star reading* is taken. It is important that both the sky and the star reading be taken through the same color filter. Then the star reading minus the sky reading approximates the true photon count for the star by itself.

1. Make sure the **Tracking** is on, and click on the **Change view** button to turn on the **Photometer** mode. Move the telescope until the aperture (red circle) is free of any star.

2. Click on **Take Reading**, then select filter B by clicking on the **Filter** button until filter B appears. Set **Seconds** to 10 seconds, and **Integrations** to 5.

3. Click on **Start count** and wait for the readings to appear. When the measurement is completed, the mean sky count will appear in the box labeled **Mean Sky.**

4. Repeat the measurement for filters V. Record your results below.

**Sky Readings**

| Filter | Mean Sky (Counts/sec) |
|---|---|
| B | ____________________ |
| V | ____________________ |

5**.** Click on **Record Reading** and OK. Click on **Return** to go back to the telescope control window.

**Take a Star Reading and Record the Results**

1. Click on the **Set Coordinate** button and enter the coordinates of the first star.

2. Click on the **Take reading** button.

3. Select a filter (B or V) by pressing on the **Filter** button.

4. Record the magnitude measurements of the star on the **Photoelectric Photometry Data Sheet** for both the B and V filters before choosing another star.

5. Take star readings for each star listed on the **Photoelectric Photometry Data Sheet.** Measure the B and V apparent magnitudes. Record all magnitudes to the nearest 0.001 magnitudes on the data sheet.

**Data Analysis**
1. Calculate the color index B-V for each star to the nearest 0.01 magnitudes and record it on the data sheet.

2. Create a Color-Magnitude diagram of your data by plotting V (the apparent magnitude) vs. B-V (the color-index) and then answer the following questions:

a. Do you see a pattern to the data? Describe the pattern if there is one.

b. Are there stars that do not fit into this pattern?

c. What portion of the graph displays the largest stars?

Upper right, upper left, lower right or lower left?

d. What portion of the graph displays the smallest stars?

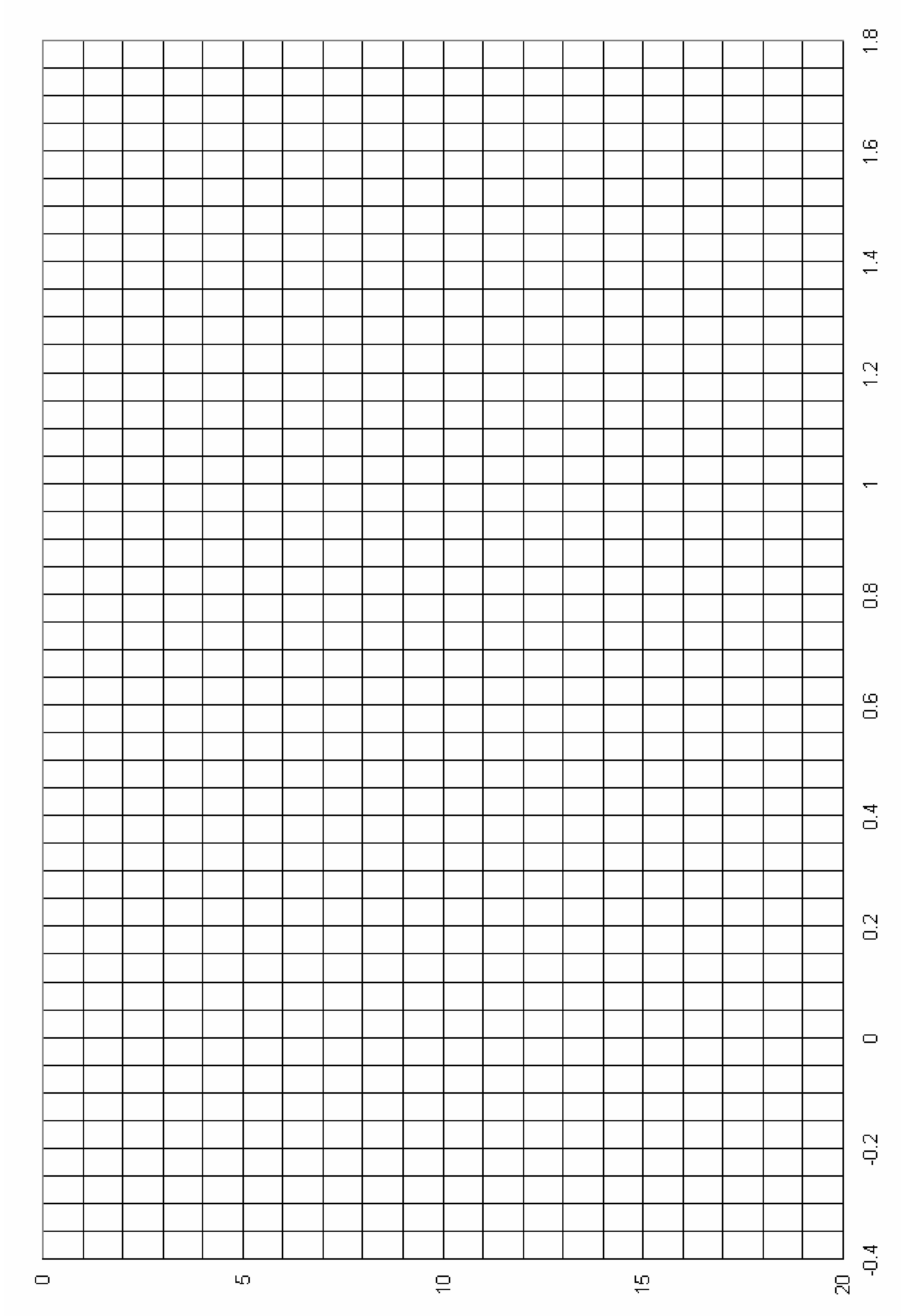
Upper right, upper left, lower right or lower left?

3. Using the Main-Sequence coordinates (M, B-V) = (2, 0.08) and (7, 1.04), determine the distance D (in parsec) of the Pleiades by Spectroscopic Parallax method (measure the magnitude gap between the Pleiades and the Main Sequence and solve for D).

$$D = 10 \text{ pc} \times 10^{(m - M)/5} = \_\_\_\_\_\_\_\_\_\_\_\_\_\_$$

## Photoelectric Photometry Data Sheet

| star | RA<br>hr: min: sec | Dec<br>Dec: min: sec | 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 | 3:43:39 | 25:00:46 | | | |
| 7 | 3:43:42 | 23:28:58 | | | |
| 8 | 3:43:56 | 23:20:34 | | | |
| 9 | 3:44:03 | 23:25:46 | | | |
| 10 | 3:44:11 | 24:25:54 | | | |
| 11 | 3:44:19 | 24:07:23 | | | |
| 12 | 3:44:27 | 24:14:16 | | | |
| 13 | 3:44:39 | 23:57:57 | | | |
| 14 | 3:44:39 | 23:27:17 | | | |
| 15 | 3:44:45 | 24:34:47 | | | |
| 16 | 3:45:09 | 23:24:52 | | | |
| 17 | 3:45:27 | 24:50:59 | | | |
| 18 | 3:45:28 | 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 | | | |


0
5
10
15
20
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8