Lab #1: Variable Star Photometry

Due: Friday, October 4, 2024 by 5pm to Dickinson 104

Part II: Data Analysis

Goals

- Create a plot of brightness vs. time for two variable stars
- Determine the period of variability
- Use the period (and some other information) to determine:
    - Algol: temperature of eclipsed star
    - δ Cepheus: Distance, color change

Part A – Brightness vs. Time

The goal of this part is to create a plot of the brightness of the star vs. time. Because this project is only based on *relative photometry*, we will be plotting the *magnitude difference* between the target star and the comparison star as a function of time. Because both stars are periodic variables, we will be "folding" the light curve so that we actually plot *magnitude difference* vs. *variability phase*. You are welcome to use whatever software package you like but below are instructions for plotting in Google Sheets.

The first thing to do is to copy each of the (read-only) data sheets over into your own sheets that you can edit. Click File -> Make a copy… in Google Sheets.

The **Magnitude Difference** can be computed for each observation of a target star.

1. For those counts not already averaged (i.e. the Delta Ceph data), calculate the average count rate for each measurement. This is the **average** of the counts divided by the integration time (5 seconds). Do this for all of the star measurements along with the sky measurements.
2. Next, we need to figure out the count rate for the target star. To do this, we simply subtract the sky count rate (for the target star) from the target star count rate.
3. Next, we need to figure out the counts from the comparison star. To do this, subtract the sky count rate (for the comparison star) from the comparison star count rate.
4. The count rates that we've measure are **fluxes**, so to calculate the magnitude difference between the target star and the comparison star, we use the magnitude equation:

$$m_{target} - m_{comp} = \Delta m = -2.5 \log \frac{F_{target}}{F_{comp}}$$

The **Phase** of the observation can be found by taking the Julian Date dividing it by the period of the variable star, and discarding the number to the left of the decimal. The *approximate* period of Delta Ceph is 5.3 days and the approximate period of Algol is 2.8 days. Note that these *approximate* periods are in the data sheet; you will need to adjust the entries in the data sheet to find the actual period (more on that later). So:

1. Calculate the UT Julian Day by calculating the number of days since Noon on January 1, 4713 BCE (*Hint: The Sheets DATEDIF function is your friend here*).

2. Calculate the decimal Julian Date from the UT Julian Day and the UT hour and minute. Note that an hour divided by 24 is the fraction of a day that the hour contributes and a minute divided by (24*60) is the fraction of a day that the minute contributes.
3. Create a column that divides the Julian Date by the period of the star of interest. Top do this, create a column with the equation =CELL_WITH_JD/CELL_WITH_PERIOD
4. Discard the integer part of the phase. For this, the MOD function in Google Sheets is useful. Setting one column equal to =MOD(CELL_WITH_JD_DIVIDED_BY_PHASE, 1) will give you the decimal date.
5. Create a plot of the decimal phase vs. magnitude difference. If you haven't get found the precise period, adjust the cell with the period in it until the light curve looks like one coherent curve. Note that this is a "trial and error" process; you will probably need to adjust the period parameter several times before you get a light curve that looks reasonable.

For this part of the lab, you should turn in a spreadsheet of the data (a link to a Google Sheet is fine) and your plots (hard copies, please!).

Part B – Data Analysis

Using the periods given to you in part A and whatever resources you can find, answer the following questions. As always, **show** and **explain** your work and state any assumptions that you may make.

1. Using the Cepheid Period-Luminosity relationship, determine the absolute magnitude of δ Cep.
2. Using the apparent magnitude from Simbad, determine the distance to δ Cep. Compare this distance to the distance you would infer from the parallax listed on δ Cep's Simbad page.
3. Choose five points during the observations of δ Cep that have both a B and a V observation. Compute a "pseudo B-V color" by subtracting the V value for Δ Mag from the B value for Δ Mag. Note that this will **not** be a true B-V color because you don't know the intrinsic color of the comparison star. Compare the "pseudo B-V color" you determined for each of the five observation times. Does the color change appreciably?

Algol is an eclipsing binary system composed of a B8 Dwarf and a K0 subgiant.

4. Using the "pseudo B-V color" of Algol (see #3 above for how to calculate this), determine whether the light coming from Algol is bluer or redder when it is in eclipse than when it is not in eclipse. What does that tell you about which star is being blocked during that time?
5. The *difference* between the "pseudo B-V color" in eclipse and the "pseudo B-V color" out of eclipse is the (true) B-V color of the star that was eclipsed. Using these data and the "Blackbody Curves and Filters Explorer" (Google it!), determine the temperature of the eclipsed star.