Name: _____

Date: _____

Section: _____

Astron 104 Laboratory #11
Cepheid Variable Stars
Section 14.2

To determine the distances to most stars, we often use the relationship among the following three quantities:

- The **apparent magnitude** of the star, which is a measure of how much light we receive on Earth (i.e., how bright do we measure the star to be).
- The **absolute magnitude** of the star, which is a measure of how much light it is actually radiating into space (i.e, how bright it actually is).
- The star's **distance** from us.

In principle, if we know the first two of these quantities, we can calculate the distance. The **apparent magnitude** is usually easy to measure because all we need to do is use a telescope that has a calibrated light detector (i.e., a good camera). The **absolute magnitude** is harder to obtain, since we cannot travel to the star to figure it out. Instead, we must rely on other measureable properties to estimate the **absolute magnitude**. Here we will see a technique that can be used to measure the **absolute magnitude** of the star, which we can then combine with the **apparent magnitude** to get the true **distance**.

Cepheid Variable Stars as Distance Markers

Although the light output from most stars is essentially constant with time, the light from intrinsically **variable** stars changes with time in a predictable manner (Figure 1). The variation in the light output is related to the properties of the star itself, and is driven by regular pulsations in the size of the star. In the case of Cepheid variable stars, the period of the variation is related to the absolute magnitude.

Select *Cepheid Variable Stars* from the *Start Lab* menu. The field of view shows a section of sky, which contains 10 Cepheid stars along with a number of ordinary ones. You can identify which of the stars are the Cepheid variables by placing the cursor over a star. If the star is a Cepheid star, then an identification number for that star will appear at the bottom of the window. If you click on the star, you will be shows a plot of the brightness of the star as a

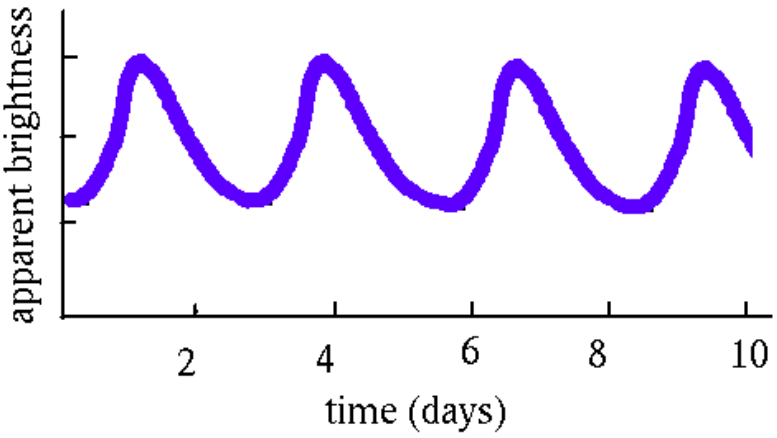

Figure 1: How a Cepheid star changes brightness with time.

function of time. Note that the vertical axis represents the **apparent magnitude**, which can be easily measured, not the **absolute magnitude**.

Click anywhere on the plot to return to the view of the sky.

To assist you in making accurate readings, the time and apparent magnitude corresponding to the cursor's current location are shown at the bottom of the screen. Make sure that you also make a note of the star's identification number on the table.

For each star, you will need to make the following measurements and calculations:

- **The average apparent magnitude**
  From the apparent magnitude vs. time plot, measure the maximum and minimum apparent magnitude of the star for at least one full cycle, and then compute the average. Record these values.

- **The period over which the star changes**
  If the period is short, an accurate result can be obtained by making measurements over more than one cycle and then dividing the total time by the number of cycles. Record the number of cycles, the total time for *all complete cycles*, and the period in the table.

- **The absolute magnitude**
  From the following equation, you can calculate the absolute magnitude from the period you just measured:

$$\text{Absolute Magnitude} = -3.52 \log_{10}(\text{Period}) - 0.60 \qquad (1)$$

  The absolute magnitude is in magnitudes, and the period is in days. When you have finished, select *Check Your Answers* on the left-hand side of the overhead menu and enter your results. Correct results will be indicated with a check mark to the right of the boxed value. When you are satisfied that your answer is correct, record it in the table.

- **The distance**
  Now that you have measured the apparent magnitude m and calculated the absolute magnitude M, you can determine the distance d (in parsecs) for each of the Cepheid stars:
  $$d = 10^{(m-M+5)/5} \tag{2}$$
  After you check your results, record the distance in the table, and start measurements on a new Cepheid.

Note: you are advised to complete all the measurements and calculations for a given star before you start on the next star. **15 points per star**.

Using Equations 1 and 2 above along with the following, answer the questions below. Show your work for full credit.

$$m - M = -5 + 5\log_{10}(d) \tag{3}$$

1. If Cepheid Variable Omicron Persei has an apparent magnitude m of 7.3 and an absolute magnitude M of -3.1, what is the distance in parsecs? [**10 points**]

2. The star XYZ has an apparent magnitude $m = 6.9$ and is at a distance of $d = 90$ parsecs. What is XYZ's absolute magnitude M? [**10 points**]

Cepheid number	______	
Max apparent magnitude	______	A
Min apparent magnitude	______	B
Avg apparent magnitude	______	C=(A+B)/2
Number of cycles	______	D
Total time (days)	______	E
Period (days)	______	F=E/D
Absolute magnitude	______	G; eq. (1)
Apparent mag. – Absolute mag.	______	C-G
Distance (parsecs)	______	eq. (2)

Cepheid number	______	
Max apparent magnitude	______	A
Min apparent magnitude	______	B
Avg apparent magnitude	______	C=(A+B)/2
Number of cycles	______	D
Total time (days)	______	E
Period (days)	______	F=E/D
Absolute magnitude	______	G; eq. (1)
Apparent mag. – Absolute mag.	______	C-G
Distance (parsecs)	______	eq. (2)

Cepheid number	______	
Max apparent magnitude	______	A
Min apparent magnitude	______	B
Avg apparent magnitude	______	C=(A+B)/2
Number of cycles	______	D
Total time (days)	______	E
Period (days)	______	F=E/D
Absolute magnitude	______	G; eq. (1)
Apparent mag. – Absolute mag.	______	C-G
Distance (parsecs)	______	eq. (2)

Cepheid number	______	
Max apparent magnitude	______	A
Min apparent magnitude	______	B
Avg apparent magnitude	______	C=(A+B)/2
Number of cycles	______	D
Total time (days)	______	E
Period (days)	______	F=E/D
Absolute magnitude	______	G; eq. (1)
Apparent mag. – Absolute mag.	______	C-G
Distance (parsecs)	______	eq. (2)

Cepheid number	_____	
Max apparent magnitude	_____	A
Min apparent magnitude	_____	B
Avg apparent magnitude	_____	C=(A+B)/2
Number of cycles	_____	D
Total time (days)	_____	E
Period (days)	_____	F=E/D
Absolute magnitude	_____	G; eq. (1)
Apparent mag. – Absolute mag.	_____	C-G
Distance (parsecs)	_____	eq. (2)

Cepheid number	_____	
Max apparent magnitude	_____	A
Min apparent magnitude	_____	B
Avg apparent magnitude	_____	C=(A+B)/2
Number of cycles	_____	D
Total time (days)	_____	E
Period (days)	_____	F=E/D
Absolute magnitude	_____	G; eq. (1)
Apparent mag. – Absolute mag.	_____	C-G
Distance (parsecs)	_____	eq. (2)