Name:	
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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

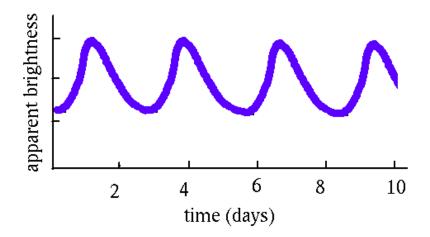


Figure 1: How a Cepheid star changes brightness with time.

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:

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

$$d = 10^{(m-M+5)/5} (2)$$

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]

G 1 11		G 1 11	
Cepheid number		Cepheid number	
Max apparent	Α .	Max apparent	Α
magnitude	 A	magnitude	 A
Min apparent	D	Min apparent	D
magnitude	 В	magnitude	 В
Avg apparent	C = (A + D)/2	Avg apparent	C = (A + D)/2
magnitude	 C=(A+B)/2	magnitude	 C=(A+B)/2
Number of	D	Number of	D
cycles	 D	cycles	 D
Total time	Б	Total time	D
(days)	 E	(days)	E
Period (days)	 F=E/D	Period (days)	 F=E/D
Absolute	, _	Absolute	/_
magnitude	 G; eq. (1)		 G; eq. (1)
Apparent	c, eq. (1)	Apparent	c, eq. (1)
mag. –		mag. –	
Absolute mag.	C-G	Absolute mag.	C-G
Distance		Distance	
(parsecs)	eq. (2)	(parsecs)	eq. (2)
,	 cq. (2)	,	 cq. (2)
Cepheid	 cq. (2)	Cepheid	cq. (2)
Cepheid number	eq. (2)	Cepheid number	Cq. (2)
Cepheid number Max apparent		Cepheid number Max apparent	
Cepheid number Max apparent magnitude	A	Cepheid number Max apparent magnitude	A
Cepheid number Max apparent magnitude Min apparent	A	Cepheid number Max apparent magnitude Min apparent	A
Cepheid number Max apparent magnitude Min apparent magnitude		Cepheid number Max apparent magnitude Min apparent magnitude	
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Cepheid		Cepheid	
number		number	
Max apparent		Max apparent	
magnitude	 A	magnitude	 A
Min apparent		Min apparent	
magnitude	 В	magnitude	 В
Avg apparent		Avg apparent	
magnitude	 C=(A+B)/2	magnitude	 C=(A+B)/2
Number of		Number of	
cycles	 D	cycles	 D
Total time		Total time	
(days)	 E	(days)	 E
Period (days)	 F=E/D	Period (days)	 F=E/D
Absolute		Absolute	
magnitude	 G; eq. (1)	magnitude	 G; eq. (1)
Apparent		Apparent	
mag. –		mag. –	
Absolute mag.	 C-G	Absolute mag.	 C-G
Distance		Distance	
(parsecs)	 eq. (2)	(parsecs)	 eq. (2)