

Indoor Laboratory: Cepheid Variables and Extra-Galactic Distance

Introduction

In this laboratory, you'll be calculating the distance to the Small Magellanic Cloud (SMC), which is one of the Milky Way's nearby neighbors. Due to its declination, we cannot observe the SMC from most of the norther hemisphere.

Like other variable stars, the magnitude of cepheids change with time. However, cepheids all share one characteristic: a period related to its luminosity. All cepheids with the same period have the same brightness and the longer the period, the brighter the cepheid. Cepheids pulsate due to an imbalance between their inward gravitational pull and outward pressure over periods from 1 to 70 days.

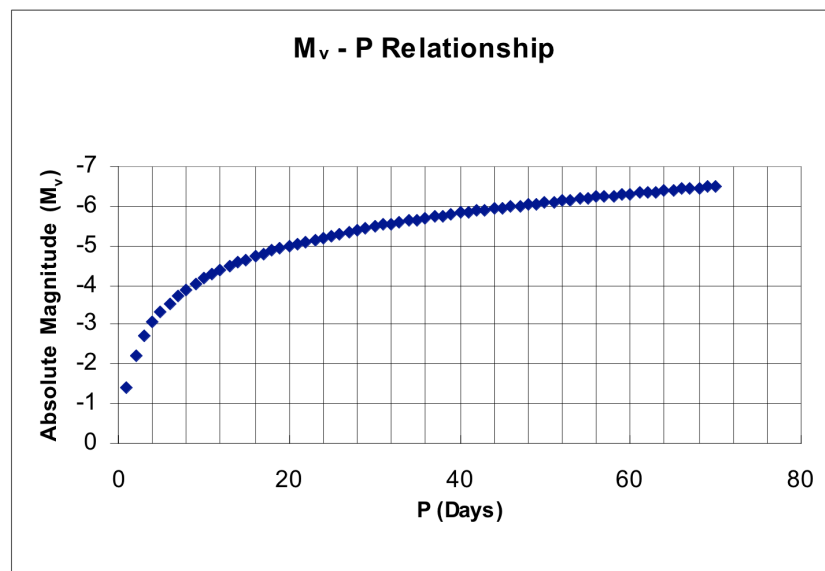
If a cepheid is found in another galaxy and its period is determined, the distance to the cepheid can be derived from its *apparent magnitude* (m_v). Apparent magnitude is the brightness of an object as viewed from Earth and is dependent on the object's intrinsic brightness, distance from Earth and extinction (interstellar dust) along the line-of-sight.

To find the distance, the object's *absolute magnitude* (M_v), which is the intrinsic brightness as if it were ten parsecs (32.6 ly) from Earth, must be known. The formula for calculating absolute magnitude is:

Formula 1: $M_v = (m_v + 5) - (5 * \text{Log}_{10}(d))$ Where “d” is the distance.

If the distance is not known, the absolute magnitude can be derived from the period of the cepheid.

Formula 2: $M_v = - (2.76 (\text{Log}_{10}(P) - 1.0)) - 4.16$ Where “P” is the period.



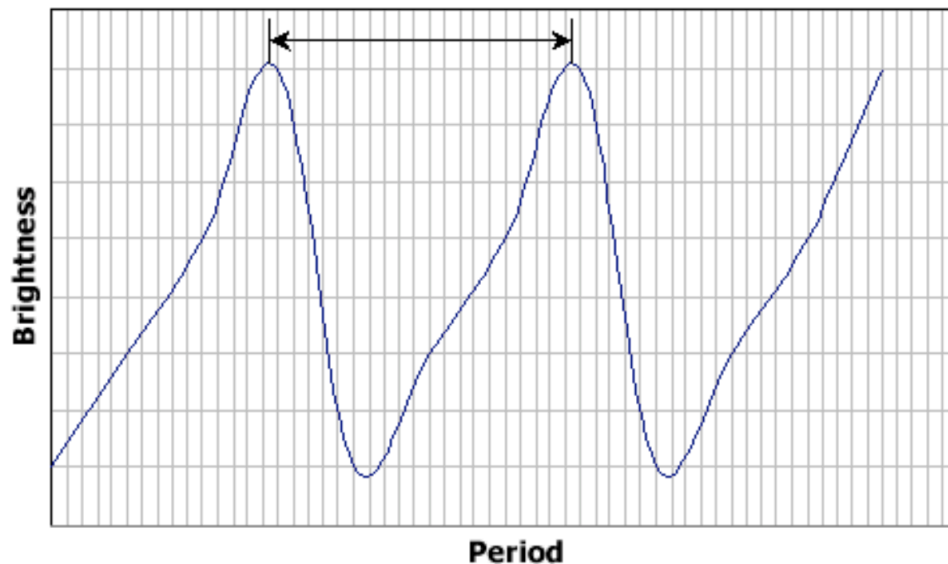
Establishing the Distance to the SMC

Finding the distance of a single Cepheid in a galaxy is not enough to establish the distance to the galaxy. The periods, apparent magnitudes and absolute magnitudes of several cepheids within the same galaxy are needed to establish the distance.

Cepheid	P (days)	m_v
HV1871	1.2413	17.21
HV1907	1.6433	16.96
HV11114	2.7120	16.54
HV2015	2.8742	16.47
HV1906	3.0655	16.31
HV11216	3.1148	16.31
HV11113	3.2139	16.56
HV212	3.9014	15.89
HV11112	6.6931	15.69

Table 1

The period of a variable star is determined by noting the number of days to complete each cycle, or *pulsation*.



Name: _____

Date: _____

Cepheid Variables Worksheet

Use any six of the cepheids from *Table 1* to determine the distance the SMC.

Cepheid ID	P (Days)	m_v	M_v	$(m_v - M_v)$
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

1. Average the $(m_v - M_v)$ results

$$X_{\text{avg}} = \underline{\hspace{2cm}}$$

2. Divide the X_{avg} result by 5.

$$\Delta m = X_{\text{avg}} \div 5 = \underline{\hspace{2cm}}$$

3. Calculate the distance to the SMC in parsecs.

$$d_{\text{pc}} = 10 * 10^{\Delta m} = \underline{\hspace{2cm}}$$

4. What is the distance in light years? _____ ly