Project 2

Remember to number your answers 1a. 1b., etc. so I know which questions you're answering. Be sure to show your work and reasoning for full credit.

1. *You observe a star you identify to be a cepheid to have the light curve shown in Figure 1*
.

   (a) *List the period in days and the average, maximum, and minimum apparent magnitudes. Double-check these, since your work in the next questions will depend on them!*

   (b) *By what factor does the brightness change from minimum to maximum brightness? Show your work.*

   (c) *Suppose the period-luminosity relation is given by*

   $$M_v = A\,(\log(P) - 1) - B,$$

   where M_v is the absolute magnitude, P is the period in days, and the constants are given by $A = -2.43$ and $B = -4.05$. Using the period you found from analyzing the graph, what is the absolute magnitude of this cepheid star? (Pay attention to significant figures).

   (d) *Using the distance modulus equation and the value you found for the average apparent magnitude, find the distance to the cepheid, in AU; show all work and remember significant figures.*

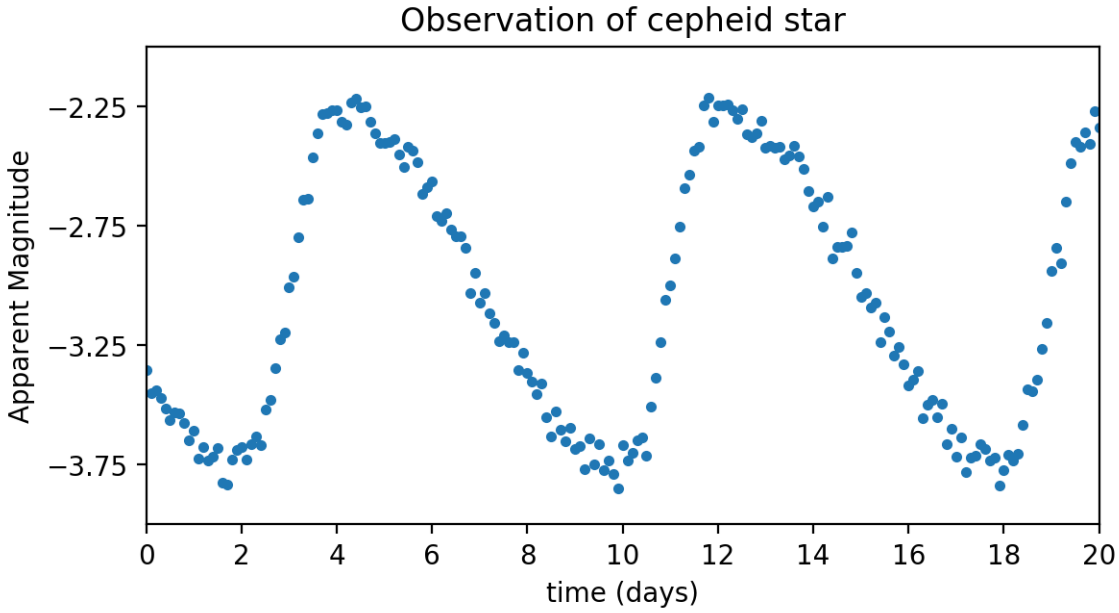

Figure 1: Apparent magnitude of a cepheid star.

2. *Now we'll verify this distance calculation by comparing the star to the Sun in the equation*

$$m_1 - m_2 = 2.5 \log\left(\frac{b_2}{b_1}\right) \tag{1}$$

to find its luminosity and flux, then find its distance using the relation,

$$F = \frac{L}{4\pi d^2}. \tag{2}$$

(a) *Showing your work, use the distance modulus equation to calculate the absolute magnitude of the Sun from its apparent magnitude given by* $m_\odot = -26.7$.

(b) *Use this absolute magnitude and the absolute magnitude for the cepheid that you found in the previous problem in Equation 1 to find the luminosity of the cepheid, in units of* $L_\odot$*, keeping significant figures in mind and showing all work.*

(c) *Showing your work and without plugging in for the luminosity of the Sun* $L_\odot$*, find its flux on Earth in units of* $L_\odot/AU^2$

(d) *Repeat the same process as (b), but comparing apparent magnitudes, to find the flux of the cepheid in units of* $L_\odot/AU^2$.

(e) *You now have* $L_{cepheid}$ *in units of* $L_\odot$ *and* $F_{cepheid}$ *in units of* $L_\odot/AU^2$*. Plug them in to Equation 2 to find the distance* $d_{cepheid}$*. Do your results match those of Problem 1?*

3. *To find out more about this cepheid, you take measurements of the cepheid's light and find that with an ultraviolet filter, you obtain a magnitude of 1.2, with a blue filter, you obtain a magnitude of 2.1, and with a yellow filter, a magnitude of 1.1. Looking at Figure 2,*

   (a) *What is the star's B-V color index?*

   (b) *What is the star's spectral class?*

   (c) *What is the star's approximate temperature?*

   (d) *What is the star's peak wavelength in nm (remember Wien's Law)?*

   (e) *What is the cepheid's luminosity class?*

   (f) *What is the luminosity of the cepheid (in units of $L_\odot$)? Does this approximately match your results in the previous section?*

   (g) *A planet is observed (through eclipsing and spectral methods) to orbit the cepheid with a semimajor axis of 10 AU and a period of 5 years. How many solar masses is our cepheid? Show your work, and keep in mind that Newton's reformulation of Kepler's third law requires certain units to work.*

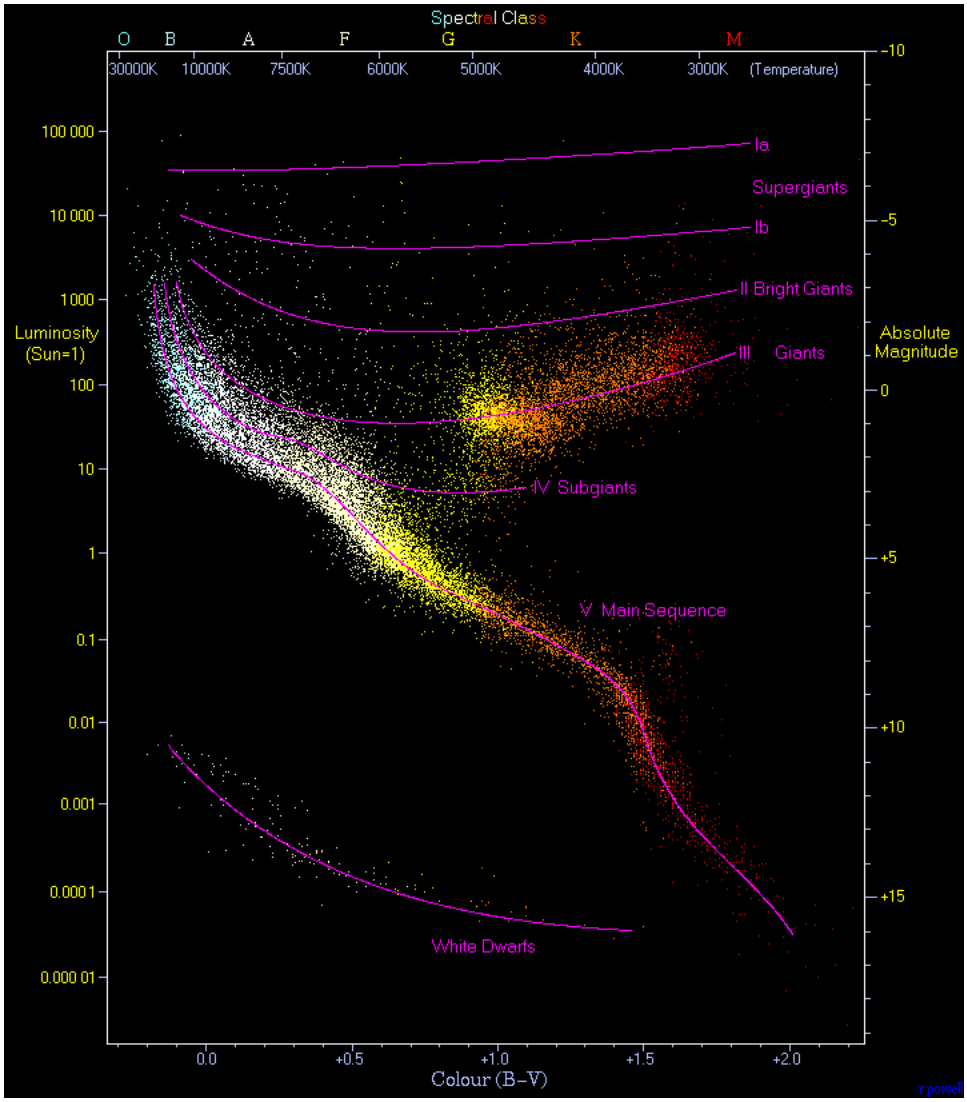

Figure 2: H-R diagram with several stars plotted. By Richard Powell - The Hertzsprung Russell Diagram, CC BY-SA 2.5, https://commons.wikimedia.org/w/index.php?curid=1736396