1 Problem – Cooper White

Suppose you're an upcoming hobby astronomer and have set up a telescope in your backyard (hopefully not in Rochester due to our amazing cloud cover). Over the course of a few months you've taken pictures of the sky each night and notice something, strange? Some of the stars seem to change magnitude every so often. You go back to your notes from your favorite undergrad class PHYS 371, Galactic Astrophysics. Inside Week 5 Day B, you find it, Pulsating Stars! You notice two distinct stars in your scene, one that pulses every day, and one that pulses about once a month. Ah yes! RR Lyrae, and Cepheids! RR Lyrae pulse shorter, and have a constant absolute magnitude. Whereas Cepheids have a longer period and a variable absolute magnitude. You decide to try and find the distance that each of these stars are from your cozy home on Earth.

- What is the average absolute magnitude of an RR Lyrae?
- Given that the Cepheid pulses once a month (30 days) what is it's absolute magnitude?
- If you identify each variable star, and look up their light curves, what is the apparent magnitude of each star?
- If you now have their apparent magnitudes, which star is further, and by how much?

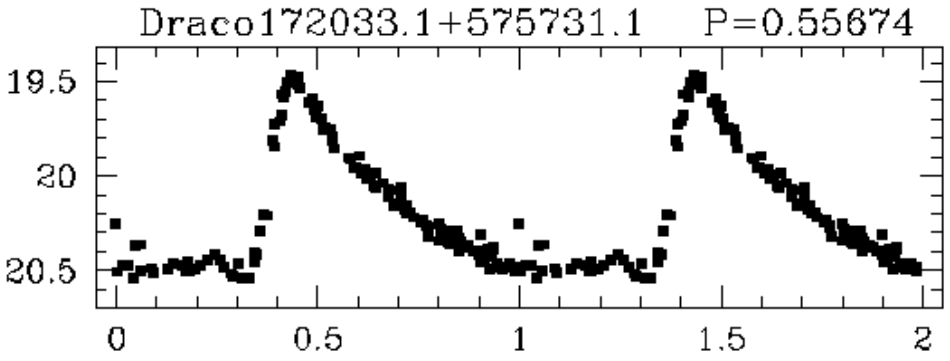

Figure 1: RR Lyrae

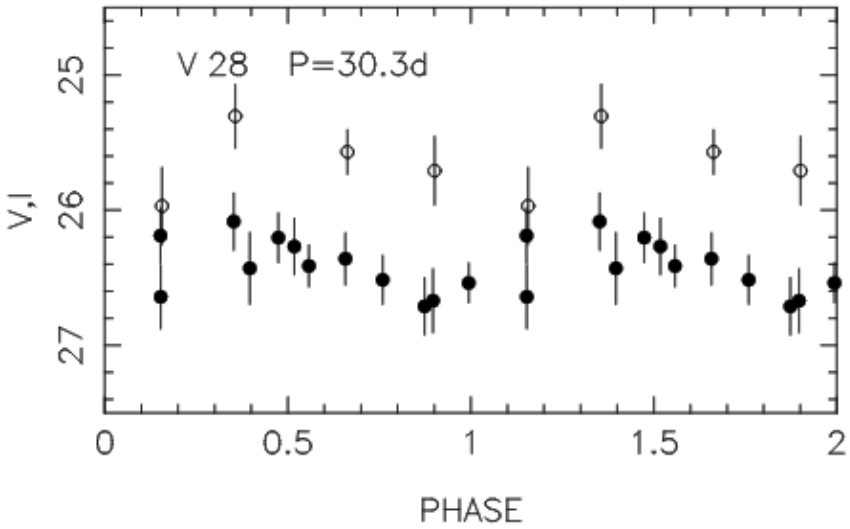

Figure 2: Cepheid

2 Answers

a) What is the average absolute magnitude of an RR Lyrae?
Answer: $M_{V,RR}$ is Roughly +0.6 to +0.7 magnitudes. For this example I chose +0.6

b) Given that the Cepheid pulses once a month (30 days) what is its absolute magnitude?
Answer: Using the period-luminosity relationship

$$M_{V,C} = -2.678 Log(P) - 1.00 \tag{1}$$

where P is the period of the Cepheid star, in days, and the log is base 10. We find that the absolute magnitude, M_V, is:

$$M_{V,C} = -2.678 \log(30) - 1.00$$
$$M_{V,C} = -4.9557$$

c) If you identify each variable star, and look up their light curves, what is the apparent magnitude of each star?
Answer: Rough estimation of graphs. I chose:

RR Lyrae, $m_{V,RR} = 20$.

Cepheid, $m_{V,C} = 26.5$

d) If you now have their apparent magnitudes, which star is further, and by how much?
Answer: Starting with the distance modulus equation :

$$m_V - M_V = 5Log(d) - 5 \tag{2}$$

where m_V is the apparent magnitude, M_V is the absolute magnitude, and d is the distance in parsecs.
We want distance so we solve for d:

$$m_V - M_V = 5Log(d) - 5$$
$$(m_V - M_V + 5)/5 = log(d)$$
$$10^{(m_V - M_V + 5)/5} = 10^{log(d)}$$
$$d = 10^{0.2(m_V - M_V + 5)}$$

Plug in our values for RR Lyrae:

$$d = 10^{0.2(20 - 0.6 + 5)}$$
$$d = 75.85 \text{ kpc}$$

Plug in our values for Cepheid:

$$d = 10^{0.2(26.5 - (-4.9557) + 5)}$$
$$d = 19.55 \text{ Mpc}$$

So the Cepheid is **much** further, by about

$$\Delta d = 19.55 * 10^3 \text{ kpc} - 75.85 \text{ kpc}$$
$$\Delta d = 19.474 \text{ Mpc}$$