CHAPTER 26

Variable and binary stars

Answers to revision questions

1. With the observation of a binary star system's period of revolution, T, and information about the separation of the two stars, r, the combined mass of the two stars can be calculated. If the mass of one star can be estimated, the mass of the other star may then be found. The application of the equation $m_1 + m_2 = \frac{4\pi^2 r^3}{GT^2}$ is used for the calculations.

2. A spectroscopic binary system is found from analysis of the spectrum: periodic splitting of the spectral lines indicating simultaneous red and blue shift must be caused by two separate sources (the two stars). Astrometric binary systems are detected from the movement of the visible star as it revolves around the other star.

3. As the name implies, visible binaries are detected through visual means – using binoculars or telescopes.

4. This could be caused by a smaller, dimmer star passing in front of the brighter star, blocking (occulting) some of its light each time it passes. For example, a white star with a companion red dwarf star (not a red giant but a main sequence red star) may cause this if the plane of revolution of the two stars is aligned with our viewing angle.

5. Extrinsically variable stars do not vary their actual luminosity (light output), whereas intrinsically variable stars do.

6. There exists a relationship between the period and the luminosity of a Cepheid variable. The longer the period, the more luminous (as the star is larger). See Figure 26.7.

7. Using Figure 26.7, a Type I Cepheid with a period of 10 days has an absolute magnitude of –7.0. The equation $M = m - 5\log(\frac{d}{10})$ is then applied where $m = 21$,

$$M = m - 5\log\left(\frac{d}{10}\right)$$
$$-7.0 = 21 - 5\log\left(\frac{d}{10}\right)$$
$$28 = 5\log\left(\frac{d}{10}\right)$$
$$\log\left(\frac{d}{10}\right) = 5.6$$
$$\frac{d}{10} = 10^{5.6}$$
$$= 398000 \text{ pc}$$
$$= 4.0 \times 10^5 \text{ pc}$$

8. Use:

$$m_1 + m_2 = \frac{4\pi^2 r^3}{GT^2}$$

$$= \frac{4\pi^2 \times \left(3.0 \times 10^{12}\right)^3}{6.67 \times 10^{-11} \times \left(6 \times 365 \times 24 \times 60 \times 60\right)^2}$$

$$= 4.5 \times 10^{32} \text{ kg}$$

9. Analysis of the equation used in question 8 shows that a halving of r requires the factor T^2 to be reduced to 1/8th. Given that $\sqrt{\frac{1}{8}} = \frac{1}{2\sqrt{2}}$, the period T of revolution will be reduced by this factor.

10. The mass luminosity relationship for main sequence stars is important. It enables the determination of the distance to binary star systems, as the mass of the system can be found and then the mass of the individual stars. Once the mass is found, the stars' absolute magnitudes can be inferred. With the stars' apparent magnitudes found by photometry, their distances can be calculated.