1. Nov/2022/Paper_41/No.9

(a) State what is meant by the luminosity of a star.

total power of radition emitted by a star. [1]

(b) A star in the constellation Canis Major is a distance of 8.14×10^{16} m from the Earth and has a luminosity of 9.86×10^{27} W. The surface temperature of the star is 9830 K.

(i) Calculate the radiant flux intensity of the radiation from the star observed from the Earth. Give a unit with your answer.

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

$$= \frac{9.86 \times 10^{27}}{4\pi \times (8.14 \times 10^{16})^2}$$

$$= 1.18 \times 10^{-7}\ \mathrm{W\,m^{-2}}$$

radiant flux intensity = 1.18×10^{-7} unit $\mathrm{W\,m^{-2}}$ [2]

(ii) Determine the radius of the star.

$$L = 4\pi\sigma r^2 T^4$$

$$r^2 = \frac{L}{4\pi\sigma T^4}$$

$$r = \sqrt{\frac{9.86 \times 10^{27}}{4\pi \times 5.67 \times 9830^4}}$$

$r = 1.22 \times 10^9$ m

radius = 1.22×10^9 m [2]

(c) Explain how the surface temperature of a distant star may be determined from the wavelength spectrum of the light from the star.

- Determine wavelength of peak intensity from spectrum of star.
- Determine wavelength of peak intensity from object whose temperature is known [3]
- Then apply Wien's displacement law. [Total: 8]

$$\lambda_{max} \propto \frac{1}{T}.$$

$$T \lambda_{max} = \text{constant}$$

$$T_x \lambda_{max_x} = T_y \lambda_{max_y}$$

where T_x – is unknown
T_y – is known
both λ_{max_x} and λ_{max_y} have been determined.

$$\therefore \quad T_x = \frac{T_y \lambda_{max_y}}{\lambda_{max_x}}.$$

2. Nov/2022/Paper_42/No.9(b)

(b) The same part of the emission spectrum from hydrogen as in **(a)**, observed in light from stars in a distant galaxy, is shown in Fig. 9.3. The numbers indicate the wavelengths in nm.

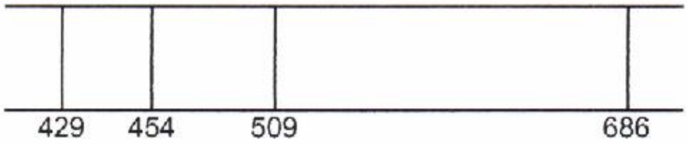

Fig. 9.3

The spectrum shows the same pattern as Fig. 9.1 but with different wavelengths.

(i) State the name of the phenomenon that gives rise to the change in the wavelengths.

Redshift [1]

(ii) State what this phenomenon shows about the motion of the galaxy.

Galaxy is moving away from observer since wavelength is increasing. [1]

(iii) Use one of the lines in Fig. 9.1, and the corresponding line in Fig. 9.3, to determine the speed of the distant galaxy relative to the observer.

$\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$

$v = \frac{\Delta\lambda}{\lambda} \times c$

$\Delta\lambda = 686 - 658$
$= 28\,nm$

$\lambda = 658\,nm$

$c = 3.0 \times 10^8\,ms^{-1}$

$v = \frac{28}{658} \times 3.0 \times 10^8$

$= 1.3 \times 10^7\,ms^{-1}$

speed = 1.3×10^7 $m s^{-1}$ [3]

3. June/2022/Paper_41/No.10

(a) State Wien's displacement law.

The black body radiation curve for different temperatures peak at a wavelength which is inversely proportional to the temperature in Kelvin [1]

(b) Fig. 10.1 shows the wavelength distributions of electromagnetic radiation emitted by two stars A and B.

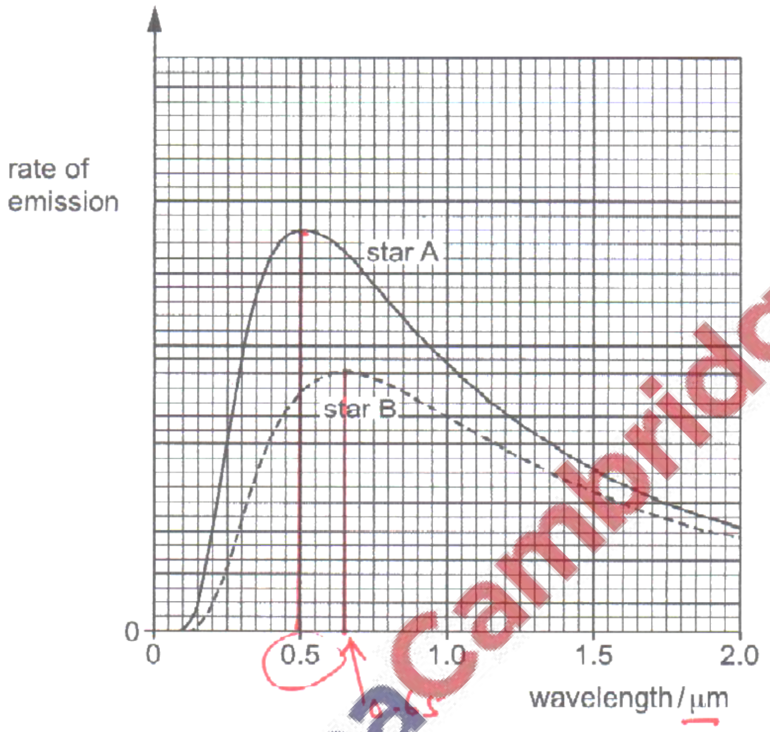

Fig. 10.1

The surface temperature of star A is known to be 5800 K.

(i) Determine the surface temperature of star B.

λ_{max} of A = 0.5 μm

λ_{max} of B = 0.65 μm

$\lambda_{max} \propto \frac{1}{T}$

$\lambda_{max} T = k$.

$T \times 0.65 = 5800 \times 0.5$

$T = \frac{5800 \times 0.5}{0.65}$

$= 4500\text{K}$

surface temperature = 4500 K [2]

(ii) Star B appears less bright than star A when viewed from the Earth.

Use Fig. 10.1 to suggest, with a reason, how else the physical appearance of star B compares with that of star A.

Star B peak at a greater wavelength

So it look more red

.... [2]

(c) The lines in Fig. 10.1 have been corrected for redshift.

(i) State what is meant by redshift.

increase in wavelength.

The apparent change in wavelength due to the movement of star away from the observer. [2]

(ii) Explain how cosmologists are able to determine that light from a distant star has undergone redshift.

By comparing the line spectrum of light from a distant star to light with known spectrum. [2]

[Total: 9]

4. June/2022/Paper_42/No.9

(a) (i) State Hubble's law. $v = H_0 d$ $v \propto d$ since H_0 = constant.

- The recession speed of galaxies moving away from Earth is proportional to their distance from the Earth. [2]

(ii) Explain how cosmologists use observations of emission spectra from stars in distant galaxies to determine that the Universe is expanding.

- The wavelengths of spectral lines are greater than their known values on Earth
- This show redshift indicating the stars are moving away from Earth [2]

(b) Explain how Hubble's law and the idea of the expanding Universe lead to the Big Bang theory of the origin of the Universe.

- Matter must have been close together originally, since all parts of the Universe is moving away from each other.
- The more distant objects are moving away faster. [3]

[Total: 7]

5. March/2022/Paper_42/No.12

(a) State what is meant by luminosity of a star.

is total power of radiation emitted by star. [1]

(b) The luminosity of the Sun is 3.83×10^{26} W. The distance between the Earth and the Sun is 1.51×10^{11} m.

Calculate the radiant flux intensity F of the Sun at the Earth. Give a unit with your answer.

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

$$= \frac{3.83 \times 10^{26}}{4\pi \times (1.51 \times 10^{11})^2}$$

$$= 1340\ \text{W m}^{-2}$$

F = 1340 unit W m⁻² [2]

(c) Use data from **(b)** to calculate the mass that is converted into energy every second in the Sun.

$$m = \frac{E}{c^2}$$

$$= \frac{3.83 \times 10^{26}}{(3.0 \times 10^8)^2}$$

$$= 4.26 \times 10^9\ \text{kg}$$

mass = 4.26×10^9 kg [1]

(d) The radius of the Sun is 6.96×10^8 m.

Show that the temperature T of the surface of the Sun is 5770 K.

$$L = 4\pi\sigma r^2 T^4$$

$$3.83 \times 10^{26} = 4\pi \times 5.67 \times 10^{-8} \times (6.96 \times 10^8)^2 \times T^4$$

[1]

$$T^4 = \frac{3.83 \times 10^{26}}{4\pi \times 5.67 \times 10^{-8} \times (6.96 \times 10^8)^2} = 1.11 \times 10^{15}$$

$$T = \sqrt[4]{1.11 \times 10^{15}}$$

$$T = 5770\ \text{K}$$