Studybeesofficial

Where Minds Pollinate

Class 12
Physics

Chapter 23

Exercise Solution

1) What is meant by blackbody radiation?

Blackbody radiation is the radiation emitted by an ideal body called a blackbody. A blackbody absorbs all the radiation falling on it and does not reflect any radiation. The radiation emitted by a blackbody depends only on its temperature and not on its material. As the temperature increases, the energy of emitted radiation also increases.

2) What is the relationship between luminosity and radiant flux intensity?

Luminosity is the total amount of energy emitted by a source in one second. Radiant flux intensity is the energy received per unit area per second at a certain distance.

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

Radiant flux intensity depends on both the luminosity of the source and its distance from the observer. As the distance increases, the intensity decreases.

3) What is the inverse square law for radiant flux intensity?

The inverse square law states that radiant flux intensity decreases as the square of the distance from the source increases.

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

This means that when the distance becomes double, the intensity becomes one-fourth. This law explains why stars appear dimmer when they are very far from Earth.

5) What is Wien's displacement law?

Wien's displacement law states that the wavelength at which a body emits maximum radiation is inversely proportional to its temperature.

$$\lambda_{max} T = 2.9 \times 10^{-3}\, mK$$

Hotter objects emit radiation at shorter wavelengths, while cooler objects emit at longer wavelengths. This law is useful in determining the temperature of stars.

6) Define Stefan–Boltzmann law.

The Stefan–Boltzmann law states that the total energy radiated per second by a blackbody is proportional to the fourth power of its absolute temperature.

$$L = \sigma A T^4$$

This means a small increase in temperature causes a large increase in radiation. This law helps in understanding why hotter stars are brighter.

7) How can we estimate the radius of a star by applying Wien's displacement law and the Stefan–Boltzmann law?

First, Wien's displacement law is used to find the surface temperature of the star from its peak wavelength.

$$\lambda_{max} T = 2.9 \times 10^{-3}$$

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

Then Stefan–Boltzmann law is applied using the known luminosity of the star. By rearranging the formula, the radius of the star can be calculated. In this way, both laws help in estimating stellar radius.

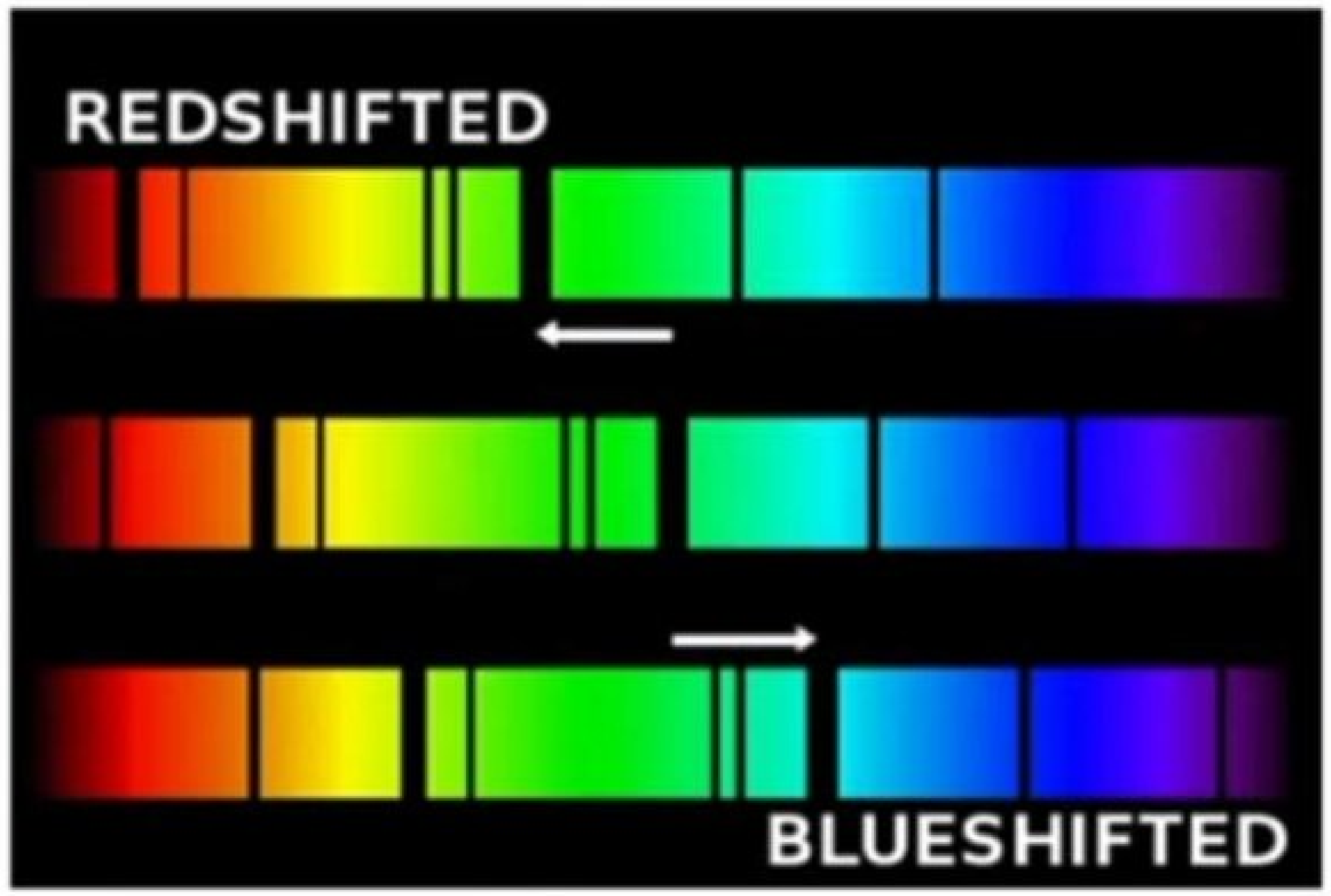
8) How does redshift lead to the idea that the Universe is expanding?

Redshift occurs when the light from distant galaxies shifts towards the red end of the spectrum.

This shift shows that galaxies are moving away from the Earth.

The greater the redshift, the faster the galaxy is moving away.

This observation leads to the idea that the Universe is expanding.



10) How do different types of spectra (emission, absorption, continuous) provide insights into the composition and properties of celestial objects?

Emission spectra show bright lines and help identify elements in hot gases. Absorption spectra show dark lines and indicate elements present in cooler gases in front of stars. Continuous spectra give information about temperature and brightness. By studying spectra, astronomers learn about the composition and physical properties of celestial objects.

Statement

There are two stars A and B. Both stars have the same luminosity of 10^4 J s^{-1}. The radius of star A is 10^4 m and the radius of star B is 10^5 m. Determine which star has the greater surface temperature.

Given Data

$$L_A = L_B = 10^4\,J/s$$

$$R_A = 10^4\,m$$

$$R_B = 10^5\,m$$

To Find

Which star has **greater temperature**

Formula

$$L_A = 4\pi R_A^2 \sigma T_A^4$$

$$L_B = 4\pi R_B^2 \sigma T_B^4$$

Solution Since $L_A = L_B$,

$$4\pi R_A^2 \sigma T_A^4 = 4\pi R_B^2 \sigma T_B^4$$

$$R_A^2 T_A^4 = R_B^2 T_B^4$$

$$\frac{T_A^4}{T_B^4} = \frac{R_B^2}{R_A^2}$$

$$\frac{T_A}{T_B} = \sqrt{\frac{R_B}{R_A}}$$

$$\frac{T_A}{T_B} = \sqrt{\frac{10^5}{10^4}} = \sqrt{10} > 1$$

Since: $\boxed{\text{Star A has greater temperature}}$

Statement

The Sun has a surface temperature of 6000 K and produces peak radiation at 420 nm. The peak wavelength of radiation from Sirius is 72 nm. Find the surface temperature of Sirius.

Given Data

$$\lambda_S = 72\,nm = 72 \times 10^{-9} m$$

To Find

$$T_{Sirius}$$

Formula

$$\lambda_{max} T = 2.9 \times 10^{-3}$$

Solution

$$T = \frac{2.9 \times 10^{-3}}{72 \times 10^{-9}}$$

$$T \approx 3.5 \times 10^4\,K$$

$$\boxed{35000\,K}$$

Statement

A source has a luminosity of 3.826×10^{26} W and is at a distance of 3 light years from the Earth. Calculate the radiant flux intensity at the Earth.

Given Data

$$L = 3.826 \times 10^{26}\, W$$

$$1\, ly = 9.46 \times 10^{15} m$$

$$d = 3 \times 9.46 \times 10^{15} = 2.84 \times 10^{16} m$$

To Find

Radiant flux intensity

Formula

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

Solution

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

$$F = \frac{3.826 \times 10^{26}}{4\pi(2.84 \times 10^{16})^2}$$

$$F \approx 3.78 \times 10^{-8}\, W/m^2$$