918.

Problem 56.25 (RHK)

We have to find the observed wavelength of the 656.3-nm H_α *line of hydrogen emitted by a galaxy at a distance of* 2.4×10^8 pc.

Solution:

We assume that the Hubble's law is applicable in calculating the receding speed of the galaxy, which is at a distance of 2.4×10^8 pc.

Hubble's law is

$v = Hd$,

$H = 67\,\dfrac{\text{km/s}}{\text{Mpc}}$,

$1\ \text{Mpc} = 3.26\times10^6$ light-years

$= 3.084\times10^{19}$ km.

Therefore, the recessional speed of the galaxy at a distance of 2.4×10^8 pc will be

$v = 67\times2.4\times10^2\ \text{km s}^{-1} = 160.8\times10^5\ \text{m s}^{-1}$.

For relativistic speeds the Doppler shift can be obtained from the formula

$$\lambda = \lambda_0 \sqrt{\frac{(1+v/c)}{(1-v/c)}}\,.$$

The wavelength of the H_α line of hydrogen, $\lambda_0 = 656.3$ nm, emitted by a galaxy at a distance of 2.4×10^8 pc when observed from the Earth will be

$$\lambda = 656.3\sqrt{\frac{1+160.8\times10^5/3\times10^8}{1-160.8\times10^5/3\times10^8}}\ \text{nm}$$

$$= 656.3\sqrt{\frac{1+0.0536}{1-0.0536}}\ \text{nm} = 692.5\ \text{nm}.$$