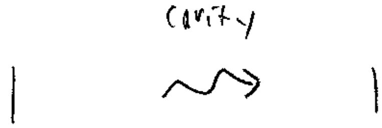
267 Problem # 12 Solution



$\lambda = 632.8$ nm

$L = 30$ cm

(1.) $N = \dfrac{L}{\lambda} = \dfrac{0.3\ \text{m}}{632.8 \times 10^{-9}\,\text{m}} = 4.7 \times 10^5$

(2.) Doppler shift $f = f_0 \left(\dfrac{1 + v/c}{1 - v/c} \right)^{1/2}$

$$\frac{1}{\lambda} = \frac{1}{\lambda_0} \left(\frac{1 + v/c}{1 - v/c} \right)^{1/2}$$

using small v/c approximation

$$\lambda = \lambda_0 \left(1 - \tfrac{1}{2} v/c\right)\left(1 - \tfrac{1}{2} v/c\right) \approx \lambda_0 \left(1 - \frac{v}{c}\right)$$

$\Delta\lambda = \lambda - \lambda_0 = \lambda_0 \dfrac{v}{c}$

thermal motion $\tfrac{1}{2} m v^2 = \tfrac{3}{2} kT$

$v = \sqrt{\dfrac{3kT}{m}}$

for He
A = 20

$$\Delta\lambda = \lambda_0 \sqrt{\frac{3kT}{mc^2}} \approx \left[\frac{3\left(\frac{1}{40}\,\text{eV}\right)}{20 \cdot \left(10^9\,\text{eV}\right)} \right]^{1/2} (632.8\ \text{nm})$$

each nucleon has $mc^2 \approx 1$ GeV

$= 1 \times 10^{-3}$ nm

(3.) $\lambda N = L$

$d\lambda = \dfrac{dL}{N}$ use $\Delta\lambda$ for $d\lambda$

$$\Delta L = N \Delta\lambda = \left(4.7 \times 10^5\right)\left(1 \times 10^{-3}\,\text{nm}\right) = 500\ \text{nm}$$