THE EQUATION OF STATE

Assuming, a gas composed of three different kind of particles each with its own m_i and density n_i

$$\bar{m} = \frac{n_1 m_1 + n_2 m_2 + n_3 m_3}{n_1 + n_2 + n_3} = \frac{\rho}{n}$$

And gas pressure,

$$P_g = nKT \quad \left\{ \text{and} \quad n = \frac{\rho}{\bar{m}} \right\}$$

$$\downarrow$$

$$P_g = \frac{\rho}{\bar{m}} KT$$

The mean mass will depend on the chemical abundance and ionization state of the gas. And for completely ionised pure hydrogen,

$$\bar{m} = \frac{m_H}{2}$$

$$n = \underline{2n_H} + 3n_{He} + \sum \frac{A}{2} n_A = \frac{\rho}{m_H}\left(2X + \frac{3}{4}Y + \frac{1}{2}Z\right)$$

complete ionization of Hydrogen results in this case (electron + proton)

in this case three particles 2 electrons and a nucleus.

$$\left[\; n_H = \frac{X\rho}{m_H} \qquad n_{He} = \frac{Y\rho}{4m_H} \;\middle|\; n_A = \frac{Z_A \rho}{A\, m_H} \;\right]$$

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$$= \frac{\rho}{2m_H}\left(3x + \frac{Y}{2} + 1\right) \quad \left\{ \text{where} \quad x + Y + Z = 1 \right\}$$

$$\Rightarrow \frac{\bar{m}}{m_H} = \frac{\rho}{n m_H} = \frac{2}{1 + 3x + 0.5Y}$$

RADIATION PRESSURE

$$P = \frac{F}{A} = \frac{dP/dt}{A} = \frac{2}{c}\int_{\pi/2}^{\pi} B\cos^2\theta \sin\theta \, d\theta \, d\phi$$

$$= \frac{4\pi}{3c} B = \frac{1}{3} u$$

Energy density

or,

$$P_{rad} = \frac{1}{3}u = \frac{1}{3}aT^4$$

{ rewriting upon case of pressure due to thermal photon inside a star

$$P = P_g + P_{rad}$$

$$\boxed{P = \frac{\rho k T}{\bar{m}} + \frac{1}{3}aT^4}$$