Monday, September 7, 2020

Example #1: Blackbody radiation from a hot star

The surface of a hot star has a temperature of 10,000 K. Calculate its peak emission wavelength λ_{max} and luminosity

Wien's law: $\lambda_{max} = \frac{2.9 \times 10^6}{T} = \frac{2.9 \times 10^6}{10,000} = \frac{2.9 \times 10^6}{10^4} = 2.9 \times 10^2 = 290$ nm

(λ_{max} in nm)

$\Rightarrow \boxed{\lambda_{max} = 290 \text{ nm}}$ (ultraviolet)

Stefan-Boltzman law:

$$\text{Luminosity} = L = \sigma T^4$$

$$= (5.67 \times 10^{-8})(10^4)^4$$

$$= 5.67 \times 10^{-8} \times 10^{16}$$

$$= 5.67 \times 10^8$$

$\Rightarrow$ The Luminosity is $\boxed{L = 5.67 \times 10^8 \text{ W/m}^2}$

Example 2: Force on a Solar Sail

Consider a $1m \times 1m$ solar sail

→ Calculate the force of the Sun's light on it

Intensity of sunlight near Earth: $I = 1000\ W/m^2$

$= 1\ kW/m^2$

$$P = \text{light pressure} = \frac{\text{Intensity}}{c} = \frac{I}{c} = \frac{1000}{3\times10^8} = 3.3\times10^{-6}\ \frac{N}{m^2}$$

Force on $1m \times 1m = 1m^2$ solar sail is

$$\text{Force} = \text{Pressure} \times \text{Area} = 3.3\times10^{-6}\ \frac{N}{m^2} \times 1\ m^2$$

$$\Rightarrow \boxed{F_0 = 3.3\times10^{-6}\ N}$$

If the sail is very reflective, then $F = 2 \times F_0$

$= 6.6\times10^{-6}\ N$