Monday, October 26, 2020

Example 1: How much power is emitted by the Sun?

watts

Energy per second

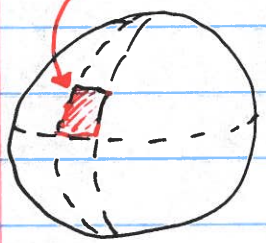
Joules

$T_{Sun,\,surface} = 5800\ K$

Stefan-Boltzmann Law: $\text{Intensity}\big|_{surface} = \sigma T^4$

power per unit area (Watts/m^2)

outgoing Joules per second in 1 m^2



$$= \left(5.67\times10^{-8}\ \frac{W}{m^2\cdot K^4}\right)(5800\ K)^4$$

$5800^4 = 1.132\times10^{15}$

$$= 6.416\times10^{7}\ W/m^2$$

Total surface of Sun $= \text{Area}\big|_{Sun} = 4\pi R_{Sun}^2$

$$= 4\pi\left(\frac{1.39\times10^{6}\ km}{2}\right)^2$$

$$= 4\pi\left(\frac{1.39\times10^{9}\ m}{2}\right)^2 = 6.07\times10^{18}\ m^2$$

Total power = total energy output per second

$$= \text{Intensity}\big|_{surface} \times \text{Area}\big|_{Sun}$$

$$= \left(6.416\times10^{7}\ W/m^2\right)\left(6.07\times10^{18}\ m^2\right)$$

$$= 3.895\times10^{26}\ W$$

Luminosity of Sun

Joules per second

Solar output power is thus $\boxed{P_{Sun} = 3.89\times10^{26}\ W}$

Example 2: How much brighter is Sirius than Betelgeuse?

magnitude $= m_1 = -1.5$

magnitude $= m_2 = +0.5$

$$\frac{b_1}{b_2} = \frac{\text{brightness Sirius}}{\text{brightness Betelgeuse}} = 2.512^{(m_2 - m_1)}$$

$$m_2 - m_1 = 0.5 - (-1.5) = 2.0$$

$$\Rightarrow \frac{b_1}{b_2} = (2.512)^{2.0} = 6.31$$

$\Rightarrow$ Sirius is 6.31 times brighter than Betelgeuse

i.e. your eye receives 6.31 more photons/second from Sirius than from Betelgeuse.