HOMEWORK #2 SOLUTIONS

ASTR 250
Spring 2010

1. (a) $\lambda_{yellow} \sim 550\,nm = 5.5 \times 10^{-5}\,cm$

$$\nu_{yellow} = \frac{c}{\lambda_{yellow}} = \frac{3 \times 10^{10}\,cm/s}{5.5 \times 10^{-5}\,cm} \approx 5.45 \times 10^{14}\,Hz$$

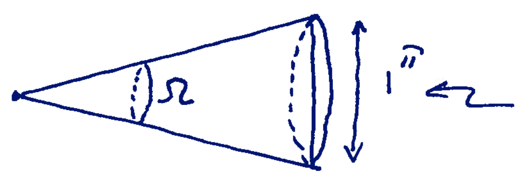
$$E = h \cdot \nu = 6.626 \times 10^{-27}\,erg \cdot s \cdot 5.45 \times 10^{14}\,s^{-1} \cdot \frac{1\,eV}{1.602 \times 10^{-12}\,erg} = 2.26\,eV$$

(b) $$\lambda_{HI} = \frac{c}{\nu_{HI}} = \frac{3 \times 10^{10}\,cm/s}{1.42 \times 10^{9}\,s^{-1}} = 21.1\,cm$$

2. (a) $$1\text{ radian} = 1\,rad \cdot \left(\frac{180^\circ}{\pi\,rad}\right) = 57.29^\circ$$

so $$1\,rad^2 = 1\text{ ster} = \left(\frac{180^\circ}{\pi\,rad}\right)^2 \cdot 1\,rad^2 = 3282.8\,deg^2$$

(b)



$$\text{Area} = \pi \cdot \left(\frac{1''}{2}\right)^2$$

$$\Omega = \pi \cdot \left(\frac{1''}{2}\right)^2 = 7.85 \times 10^{-1}\,arcsec^2 \cdot \left(\frac{1\,rad}{206265\,arcsec}\right)^2 = 1.85 \times 10^{-11}\text{ ster}$$

3. (a) $D_{♂} = 1.524\,AU$

so $$F_{♂} = F_{\oplus} \cdot \left(\frac{D_{\oplus}}{D_{♂}}\right)^2 = 1370\,W \cdot m^{-2} \cdot \left(\frac{1\,AU}{1.524\,AU}\right)^2 = 590\,W \cdot m^{-2}$$

(b) $\text{Power} = P = \text{Flux} \cdot \text{efficiency} = 0.2 \cdot \mathcal{F}$

$$\mathcal{F} = F_{♂} \cdot \text{area of solar panels} = 590\,W \cdot m^{-2} \cdot 1.3\,m^2 = 767\,W$$

$$P = 767\,W \cdot 0.2 = 153\text{ Watts}$$

⇒ Could power 2½ 60W lightbulbs!

(4.) $D = 4.2\ \text{ly} \cdot \dfrac{1\ \text{pc}}{3.26\ \text{ly}} = 1.29\ \text{pc}$

$m_V - M_V = 5 \log_{10}\left(\dfrac{D}{10\text{pc}}\right)$ $M_{V,\odot} = +4.8\ \text{mag}$

$m_V = M_V + 5\log_{10}\left(\dfrac{D}{10\text{pc}}\right) = 4.8\ \text{mag} + 5\log_{10}\left(\dfrac{1.29\ \text{pc}}{10\ \text{pc}}\right) = +0.35\ \text{mag}$

It wouldn't be the brightest star in the sky, but it will still appear to be very bright (and in the direction of the constellation Cassiopeia)

(5.) (a) $m_V - M_V = 5\log_{10}\left(\dfrac{D}{10\text{pc}}\right) \Rightarrow M_V = m_V - 5\log_{10}\left(\dfrac{D}{10\text{pc}}\right)$

$M_V = +5.49\ \text{mag} - 5\log_{10}\left(\dfrac{15.61\ \text{pc}}{10\ \text{pc}}\right) = +4.52\ \text{mag}$

(b) $M_V^{51\,Peg} - M_V^{\odot} = -2.5\log_{10}\left(\dfrac{L_{51\,Peg}}{L_\odot}\right) \Rightarrow \dfrac{L_{51\,Peg}}{L_\odot} = 10^{-0.4(M_V^{51\,Peg} - M_V^{\odot})}$

$\dfrac{L_{51\,Peg}}{L_\odot} = 1.3 \Rightarrow L_{51\,Peg} = 1.3\,L_\odot$

(c) $\dfrac{L_{51\,Peg}}{L_\odot} = \dfrac{4\pi R_{51\,Peg}^2\,\sigma\,T_{51\,Peg}^4}{4\pi R_\odot^2\,\sigma\,T_\odot^4} \Rightarrow \left(\dfrac{R_{51\,Peg}}{R_\odot}\right)^2 = \dfrac{L_{51\,Peg}/L_\odot}{\left(\dfrac{T_{51\,Peg}}{T_\odot}\right)^4}$

$\dfrac{R_{51\,Peg}}{R_\odot} = \left(\dfrac{1.3}{\left(\dfrac{5570\ \text{K}}{5780\ \text{K}}\right)^4}\right)^{1/2} = 1.22 \Rightarrow R_{51\,Peg} = 1.22\,R_\odot$

(d) $F_{planet} = F_{51\,Peg}\cdot\left(\dfrac{R_{51\,Peg}}{D_{planet}}\right)^2$ and $F_{51\,Peg} = \sigma T_{51\,Peg}^4$

so $\dfrac{F_{planet}}{F_\oplus} = \dfrac{F_{51\,Peg}}{F_\odot}\cdot\left[\dfrac{(R_{51\,Peg}/R_\odot)}{(D_{planet}/D_\oplus)}\right]^2 = \left(\dfrac{T_{51\,Peg}}{T_\odot}\right)^4\cdot\left[\dfrac{R_{51\,Peg}/R_\odot}{D_{planet}/D_\oplus}\right]^2$

$= \left(\dfrac{5570\ \text{K}}{5780\ \text{K}}\right)^4\cdot\left[\dfrac{1.22}{0.053}\right]^2 = 460 \times$ larger!

This planet is cooking! ↓