Physics 371: Astrophysics
chapter 3

$\sigma := 5.670 \cdot 10^{-5} \cdot \frac{erg}{s \cdot cm^2 \cdot K^4}$ $\quad nm := 1 \cdot 10^{-9} m$

$AU := 1.496 \cdot 10^{13} cm$ $\quad pc := 3.086 \cdot 10^{18} cm$

3.7 a)

$A := 1.4 m^2$ $\quad T := 306K$ $\quad T_e := 293K$

$L := A \cdot \sigma \cdot T^4$ $\quad L = 695.98\,W$ $\quad L = 6.9598 \times 10^9 \frac{erg}{s}$

b) $\lambda_{max} := \frac{0.290 cm \cdot K}{T}$ $\quad \lambda_{max} = 9477.1\,nm$ This is in the infrared region (much longer than 700 nm)

c) $L_e := A \cdot \sigma \cdot T_e^{\ 4}$ $\quad L_e = 585.035\,W$ $\quad L_e = 5.85035 \times 10^9 \frac{erg}{s}$

d) $L - L_e = 110.945\,W$ $\quad L - L_e = 1.10945 \times 10^9 \frac{erg}{s}$

3.8 $R := 5.16 \cdot 10^{11} cm$ $\quad T := 28000K$ $\quad d := 180pc$

$M_{Sun} := 4.76$ $\quad L_{Sun} := 3.826 \cdot 10^{33} \frac{erg}{s}$

a) $L := \sigma \cdot \left(4 \cdot \pi \cdot R^2 \cdot T^4\right)$ $\quad L = 1.166 \times 10^{31}\,W$ $\quad \frac{L}{L_{Sun}} = 30477.5$

b) Use eq 3.6 and consider all wavelengths, which is L above.

$M := M_{Sun} - 2.5 \cdot \log\left(\frac{L}{L_{Sun}}\right)$ $\quad M = -6.45$

c) $F_{Sun} := \frac{L_{Sun}}{4 \cdot \pi \cdot AU^2}$ $\quad F_{Sun} = 1.36 \times 10^6 \frac{erg}{cm^2 \cdot s}$ The solar constant

$F_{Sun.10} := F_{Sun} \cdot \left(\frac{AU}{10 \cdot pc}\right)^2$ $\quad F_{Sun.10} = 3.197 \times 10^{-7} \frac{erg}{cm^2 \cdot s}$

$F := \frac{L}{4 \cdot \pi \cdot d^2}$ $\quad F = 3.007 \times 10^{-5} \frac{erg}{cm^2 \cdot sec}$

equation 3.9: $\quad m := M_{Sun} - 2.5 \log\left(\frac{F}{F_{Sun.10}}\right)$ $\quad m = -0.174$

alternatively...eq 3.6: $\quad m := M + 5 \log\left(\frac{d}{10pc}\right)$ $\quad m = -0.174$

d) $m - M = 6.276$

e) $F := \frac{L}{4 \cdot \pi \cdot R^2}$ $\quad F = 3.485 \times 10^{13} \frac{erg}{cm^2 \cdot s}$

f) $F := \frac{L}{4 \cdot \pi \cdot d^2}$ $\quad F = 3.007 \times 10^{-5} \frac{erg}{cm^2 \cdot sec}$ $\quad \frac{F}{F_{Sun}} = 2.211 \times 10^{-11}$

g) $\lambda_{max} := \frac{0.290 cm \cdot K}{T}$ $\quad \lambda_{max} = 103.6\,nm$ This is in the ultraviolet region (shorter than 400 nm)

3.8

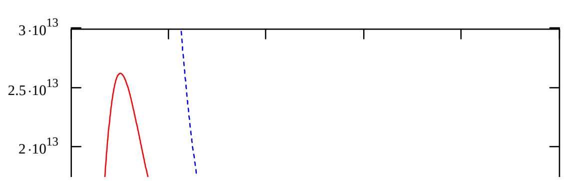
$$B_l(T) = \frac{2hc^2 / l^5}{e^{hc/lkT} - 1} = \frac{2hc^2 / l^5}{e^{(hc/kT)/l} - 1} = \frac{2hc^2 / l^5}{\left(1 + (hc/kT)/l + \cdots\right) - 1}$$

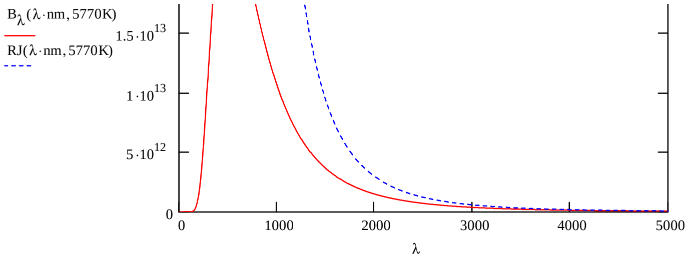
$$\approx \frac{2hc^2 / l^5}{1 + (hc/kT)/l - 1} = \frac{2hc^2 / l^5}{hc/kT\,l} = \frac{2ckT}{l^4}$$

$$B_l(T) \approx \frac{2ckT}{l^4}$$

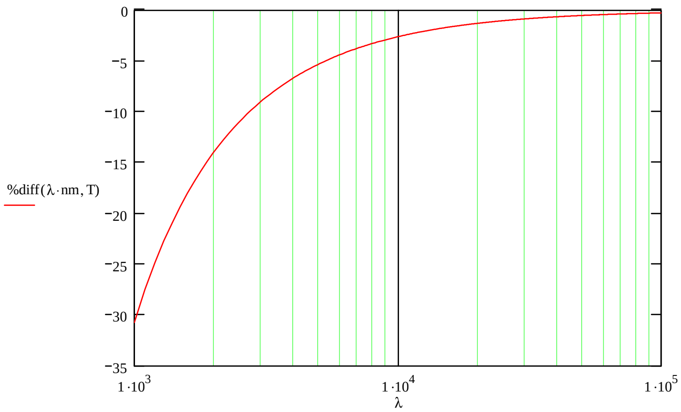
$h := 6.626 \cdot 10^{-27} erg \cdot s$ $\quad c := 2.99792458 \cdot 10^{10} \frac{cm}{s}$ $\quad k := 1.381 \cdot 10^{-16} \frac{erg}{K}$

$B_\lambda(\lambda, T) := \frac{2 \cdot h \cdot c^2 \cdot \lambda^{-5}}{e^{\frac{h \cdot c}{\lambda \cdot k \cdot T}} - 1}$ $\quad RJ(\lambda, T) := \frac{2 \cdot c \cdot k \cdot T}{\lambda^4}$





$$\%diff(\lambda,T) := \frac{B_\lambda(\lambda,T) - RJ(\lambda,T)}{B_\lambda(\lambda,T)}100$$



3.14 $T := 9500K$

$$U = -2.5\log\left(\int_0^\infty F_l S_U\, dl\right) = -2.5\log\left(\int_0^\infty \left(\frac{R}{d}\right)^2 B_l\, S_U\, dl\right)$$
$$= -2.5\log\left(\int_{331nm}^{399nm} \left(\frac{R}{d}\right)^2 B_l\, dl\right) = -2.5\log\left(\left(\frac{R}{d}\right)^2 \int_{331nm}^{399nm} B_l\, dl\right)$$

Similar expressions exist for B and V with the limits of integral being different.

In each case, it will come down to looking at the integral of Planck's Blackbody curve over different limits. The largest number will be the brightest, so let's evaluate the integral over the defined bandwidths.

$$mU := \int_{331nm}^{399nm} B_\lambda(\lambda,T)\, d\lambda \qquad mB := \int_{391nm}^{489nm} B_\lambda(\lambda,T)\, d\lambda \qquad mV := \int_{505.5nm}^{594.5nm} B_\lambda(\lambda,T)\, d\lambda$$

$$mU = 1.999\times10^{7}\,\frac{kg}{s^3} \qquad mB = 2.343\times10^{7}\,\frac{kg}{s^3} \qquad mV = 1.44\times10^{7}\,\frac{kg}{s^3}$$

So from brightest to faintest: B, U, V.