ASTRONOMY 8300 – Fall 2024
Homework Set 2 Answers

1.a. $\tau_V = n_D \pi a^2 s Q_E = \left(10^{-12}\,\mathrm{cm}^{-3}\right)(\pi)\left(10^{-5}\,\mathrm{cm}\right)^2\left(3.1\times10^{21}\,\mathrm{cm}\right)(0.5) = 0.485$

1.b. $A_V = -2.5\log\left(\frac{F_\lambda}{F_0}\right) = (2.5)(0.434)\ln\left(\frac{F_0}{F_\lambda}\right) = 1.086\tau_V = 0.53$ mag

$\frac{F_0}{F_V} = 10^{0.4A_V} = 10^{0.4(0.53)} = 1.63$ times brighter (0.53 mag)

1.c. $A_{\lambda1200} = R_{\lambda1200}E(B-V) = R_{\lambda1200}\frac{A_V}{3.1} = 9.9\frac{0.53}{3.1} = 1.69$

$\frac{F_0}{F_{\lambda1200}} = 10^{0.4A_{\lambda1200}} = 10^{0.4(1.69)} = 4.74$ times brighter (1.69 mag)

2.a. $\int \frac{L_\lambda}{4\pi d^2}\,\pi a^2 Q_A(a,\lambda)\,d\lambda = \int 4\pi a^2 Q_{Em}(a,\lambda)\,\pi B(\lambda,T_D)\,d\lambda$

$\frac{Q_A}{4\pi d^2}\int L_\lambda d\lambda = 4Q_{Em}\int \pi B(\lambda,T_D)\,d\lambda \quad (F_\lambda = \pi B_\lambda)$

$\frac{Q_A L_*}{4\pi d^2} = 4Q_{Em}\sigma T_D^4$

$T_D = \left(\frac{Q_A}{Q_{Em}}\right)^{1/4}\left(\frac{L_*}{16\pi\sigma d^2}\right)^{1/4}$

$T_D = \left(\frac{Q_A}{Q_{Em}}\right)^{1/4}\left(\frac{4\pi R_*^2\sigma T_*^4}{16\pi\sigma d^2}\right)^{1/4}$

$T_D = \left(\frac{Q_A}{Q_{Em}}\right)^{1/4}\left(\frac{R_*}{2d}\right)^{1/2} T_*$

2.b. $T_D = \left(\frac{R_*}{2d}\right)^{1/2} T_*$

$d = 1/2\left(\frac{T_*}{T_D}\right)^2 R_*$

For $T_D = 1500\mathrm{K},\ T_* = 50{,}000\mathrm{K},\ R_* = 12R_\odot$:

$d = 6666R_\odot = 4.64\times10^{14}\,\mathrm{cm} = 31\ \mathrm{AU}$

For $T_D = 20\mathrm{K}$:

$d = 3.75\times10^7 R_\odot = 2.61\times10^{18}\,\mathrm{cm} = 0.85\mathrm{pc}$

3.a. $E(B-V) = 2.5(\log X_B - \log X_V) = 2.5(\log\frac{0.689}{0.401} - \log\frac{0.524}{0.348}) = 0.14$

b. $N_{HI} = 5.2\times10^{21}\,\text{cm}^{-2}\ E(B-V) = 7.4\times10^{20}\,\text{cm}^{-2}$

c $$A_V = 2.5\log\left(\frac{F_V}{F_0}\right) = 2.5\log\left(\frac{0.524}{0.348}\right) = 0.44\ \text{mag}$$

$$R_V = \frac{A_V}{E(B-V)} = \frac{0.44}{0.12} = 3.1$$

d. $$R_\lambda = \frac{E(\lambda - V)}{E(B - V)} + R_V \quad \text{where} \quad \frac{E(\lambda - V)}{E(B - V)} = \frac{\log X_\lambda - \log X_V}{\log X_B - \log X_V} \quad \text{and } X_\lambda = \frac{F_0}{F_\lambda}$$

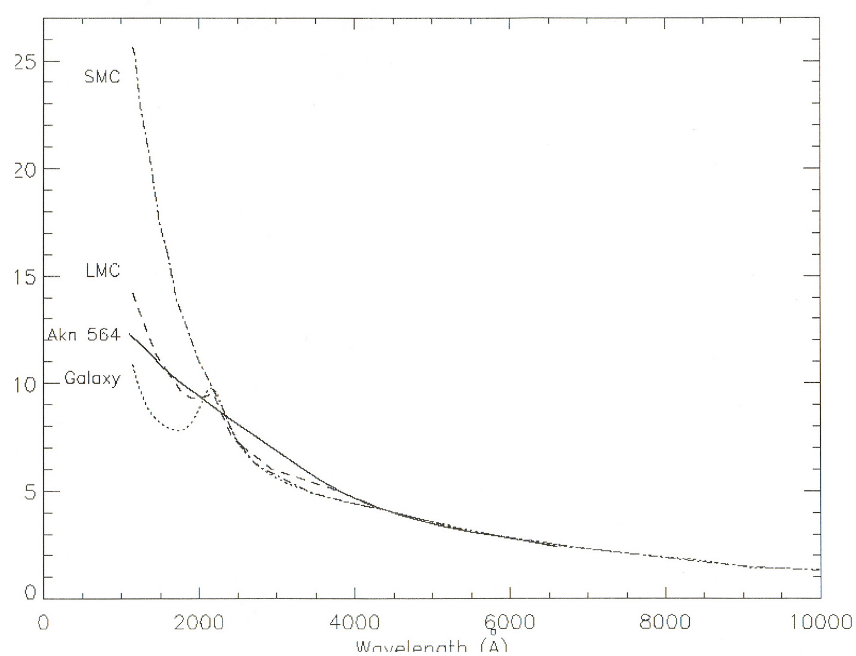
The IDL procedure "unred" corrects an observed spectrum with your choice of reddening curve (Galactic, SMC, LMC).

$$\frac{F_0}{F_\lambda} = 10^{0.4A_\lambda} = 10^{0.4R_\lambda E(B-V)}$$

So if we generate a wavelength vector, and run unred with $F_\lambda = 1$ and E(B-V) = 1, we get F_0

Then $R_\lambda = 2.5\log(F_0)$ gives us the reddening curve.

Reddening Curve for Akn 564



e. Reddening curve for Akn 564 has no 2200 Å bump. Similar to standard reddening curve of LMC, but turns up at slightly longer wavelengths – slightly more small dust grains?