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Homework 1

All calculations can be found in the notebook
`https://github.com/meredith-durbin/ASTR531/blob/master/HW1/HW1.ipynb`.

2.3 (a) A distance of 470 ly gives τ Sco a distance modulus of 5.79 mag, which means that its M_V is -2.99 mag.

(b) With a bolometric correction of -3.16 mag, the bolometric magnitude is $M_{\rm bol} = -6.15$ mag, giving a luminosity of 2.28×10^4 $L_\odot$.

(c) From the Stefan-Boltzmann equation, the radius of the star is 5.59 $R_\odot$.

(d) Using the relation $L/L_\odot = 1.5(M/M_\odot)^{3.5}$, we find a mass of 15.65 $M_\odot$.

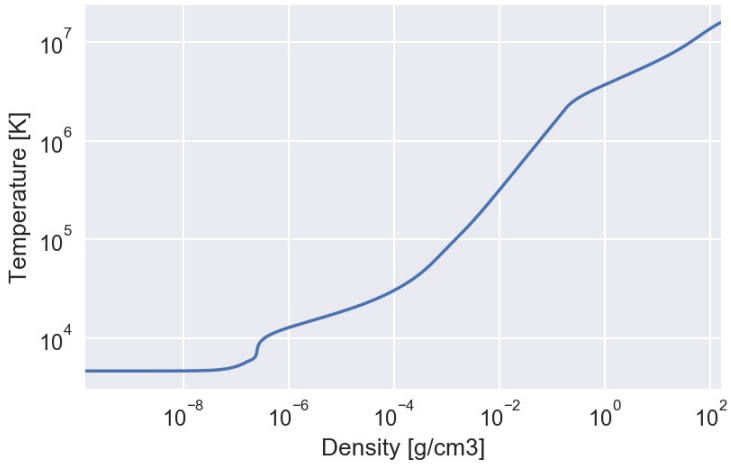
(e) The surface gravity of the star is 1.37×10^4 cm s^{-2} ($\log g = 4.13$), and the escape velocity is 1.03×10^8 cm s^{-1}.

(f) The mean density is $\rho = 0.12$ g cm^{-3}.

(g) The surface gravity of τ Sco is about half that of the sun, whereas the escape velocity is about 1.67 times solar. τ Sco's mean density is only 0.09 of solar.

3.4

4.3 Based on the plot of solar temperature vs. density, it looks as though the sun is mostly in the ideal gas regime, and becomes degenerate at the highest densities.



5.2 (a) For a mean free path of $\ell = 1$ cm, it will take a photon about 5×10^{21} scatterings to travel 1 $R_\odot$.

(b) The total path length ℓN is 5×10^{21} cm, or 6.9×10^{10} $R_\odot$. It will take a photon traveling this path 1.6×10^{11} s to exit the sun, or a little over 5000 years.

(c) This is almost certainly not the same photon.

6.2 (a)

7.3 (a) The main sequence lifetime can be estimate by comparing the stellar luminosity to the total amount of energy that core fusion can produce. Assuming that all of the hydrogen in the convective core is converted to helium over the MS lifetime, and assuming a hydrogen fusion efficiency factor of 0.007, we can estimate the MS lifetime as $t_{\rm ms} = 0.007 M_{\rm core} c^2 / L_\star$. Assuming a convective core mass fraction of 0.25 for 4 $M_\odot$ and 0.5 for 20 $M_\odot$, we find MS lifetimes of 1.4×10^{16} s and 8×10^{14} s respectively, or 4.4×10^8 and 2.5×10^7 years.

(b) According to Appendix D, the MS lifetimes of 4 and 20 $M_\odot$ stars are 1.5×10^8 and 7.8×10^6 years respectively. Our derived lifetimes are slight overestimates.