Exercise 6: Spectral Line Intensities

Reproduce the plot (figure 8-13) on page 166 of Introductory Astronomy & Astrophysics, 4th ed. Use Excel or the spreadsheet/plotting program of your choice to produce the $log(N_2/N)$ curve shown at the bottom of fig. 8-13.

$$\frac{N_2}{N_1} = \frac{g_2}{g_1} e^{\left(\frac{E_1 - E_2}{kT}\right)}$$ Boltzmann's Eqn. set for H energy states 1 & 2

$$\frac{N_+}{N_0} = \frac{A(kT)^{\frac{3}{2}}}{N_e} e^{\left(-\frac{\chi_0}{kT}\right)}$$ Saha's Eqn. set for H ionization states

Balmer line strengths related to:

$$\frac{N_2}{N} = \frac{N_2}{N_0 + N_+} \cong \frac{\left[N_2/N_1\right]}{\left[1 + N_+/N_0\right]}$$ where: $N = N_0 + N_+$ and $N_0 \cong N_1$

$$E_n = (13.6\ eV)\left[1 - \frac{1}{n^2}\right] \qquad g_n = 2n^2 \qquad \chi_0 = 13.6\ eV$$

$$k = 8.617\ x\ 10^{-5} eV \qquad \frac{A}{N_e} = 3.5\ x\ 10^{7} eV^{-\frac{3}{2}}$$

(Note: for the temperature range considered, the electron number density can be considered constant as it is mostly determined by heavy element ionization. Its value is set for this exercise such that figure 8-13 plot values will be approximately recreated using the value of A/N_e above.)

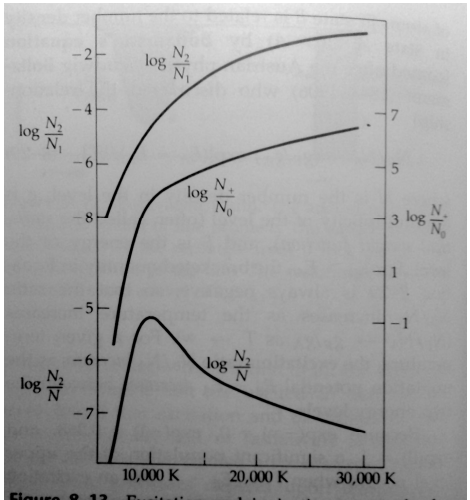

Figure 8–13 Excitation and ionization curves for hydrogen Balmer lines. The relative populations of the energy levels (N_2/N_1) from the Boltzmann equation and the ionization stages (N_+/N_0) from the Saha equation are calculated for equilibrium at the indicated temperatures. The lower curve shows the combination of the upper two with $N = N_0 + N_+$.