PHYSICS 160: Stellar Structure

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Office Hours: Fri. 10-12
Texts: Carrol & Ostlie "An Introduction to Modern Astrophysics",
Homework no. 1
Due: Tues. Oct. 23

1

(a) Work out the density ratios H^0/H and H^+/H as a function of temperature in the case of thermodynamic equilibrium. Do your calculation for electron densities $n_e = 10^{10}$, 10^{15}, and 10^{20} cm^{-3}. Plot your results for $T = 10^3$ - 10^5 K.

(b) The critical temperature, T_{crit}, is the temperature at which H is 50 % ionized. Compute T_{crit} for the above densities. Compare your results with χ_H/k, i.e., the ionization potential of H in temperature units. Explain why T_{crit} is smaller, larger, or the same as χ_H/k.

2

Paschen α is the transition between the n=3 to n=4 states in hydrogen.

(a) Compute an expression for the density ratio of H^0 in the n=3 state to the total density of neutral hydrogen.

(b) Combine this result with the ratio of neutral to total hydrogen you worked out in problem 1 to determine the ratio of H in the n=3 state to the total density of hydrogen.

(c) Estimate the spectral type of the star in which Paschen α will be strongest.

3

Show that if hydrogen gas is in thermodynamic equilibrium, the ratio of the number of H atoms in energy level n to the number of ionized H ions is given by:

$$\frac{N_n(H)}{N(H^+)} = \frac{n_e h^3 n^2}{(2\pi m_e kT)^{3/2}} \exp \frac{\chi_H}{n^2 kT}$$

4

What is the spectral type of a normal star having a maximum in its continuum spectrum at the wavelength of H_α?

5

Consider a giant star and a main sequence star of the same spectral type. The giant star, which has a lower electron density, has a slightly lower temperature than the main sequence star. Use the Saha equation to explain this result.