

1. (Computer programming problem)

(a) Write a computer program to plot the Maxwell-Boltzmann velocity distribution for a gas with input particle mass and temperature (ala Fig 8.6).

The plot must have:

- Labeled x and y axes
- Title
- A cross-hatched or shaded region under the Ndv curve that shows the region between v and $v+dv$
- Annotation regarding the type of particle (or its mass)
- Annotation regarding the input temperature

(b) The program must also print out a summary of calculated information:

- Particle type (or mass)
- Temperature
- $v_{\text{most probable}}$
- v_{RMS}
- the fraction of particles between v and $v+dv$
- the fraction of particles with velocity between v and $v+dv$

(c) Run your program for the following cases:

- (a) H atoms at 8000K, $v=5000 \text{ cm s}^{-1}$, $dv=2000 \text{ cm s}^{-1}$
- (b) He atoms at 6000K, $v=5000 \text{ cm s}^{-1}$, $dv=2000 \text{ cm s}^{-1}$
- (c) Make up your own case

(d) In addition to plots and the information summary for all three cases, attach the IDL program that you wrote.

2. (Computer programming problem). Write a program to calculate and plot

(a) the Saha equation for Hydrogen gas, assuming a pressure of 20N. Show the ionization distribution, $N_{\text{II}}/N_{\text{total}}$ for temperatures between 0 and 25000K. Indicate the temperature where there is 50% ionization (ala Fig 8.8).

(b) Boltzman equations for that same gas, showing the fraction of H atoms in the $n=2$ state, N_2/N_{total} as a function of the same temperature range, accounting for the fraction of electrons lost to ionization. Indicate the peak value, N_2/N_{total} .

Partition functions are included on a handout, photocopied from "Observational Astrophysics" by David Gray; code in these partition functions instead of trying to calculate your own.

The two plots must have:

- Labeled x and y axes
- Title
- Annotation regarding the particle species (e.g., Hydrogen)

- (c) Run your program for (b) again, this time including 10% He atoms. Overplot N_2/N_{total} for hydrogen on the plot (b) with 100% hydrogen.
- (d) Interpret your plots for (b) and (c) in terms of the strength of H absorption in stars of different spectral types.

3. Problem 8.13 in your text: Use the information in Example 8.1.5 to calculate the ratio of doubly to singly ionized calcium atoms (Ca III / Ca II) in the Sun's photosphere. The ionization energy of Ca II is 11.9 eV. Use $Z = 1$ for the partition function of Ca III. Is your result consistent with the statement in example 8.1.5 that in the solar photosphere, "nearly all of the calcium atoms are available for forming the H and K lines of calcium?" Use your program (from problem 2) to make a plot illustrating the science in this problem.

4. Problem 8.16 in your text: The blue-white star Fomalhaut ("the fish's mouth" in Arabic) is in the southern constellation of Pisces Austrinus. Fomalhaut has an apparent visual magnitude of $V = 1.19$. Use the H-R diagram in Figure 8.16 to determine the distance to this star.

5. Restore the Hipparcos catalog at <http://www.physics.sfsu.edu/~fischer/data/hip.dat> and make an H-R diagram of all stars closer than 200 pc. Compare this to an H-R diagram of all stars brighter than $V=9$. How do these two diagrams differ and why?