AST 300B – Spring 2018

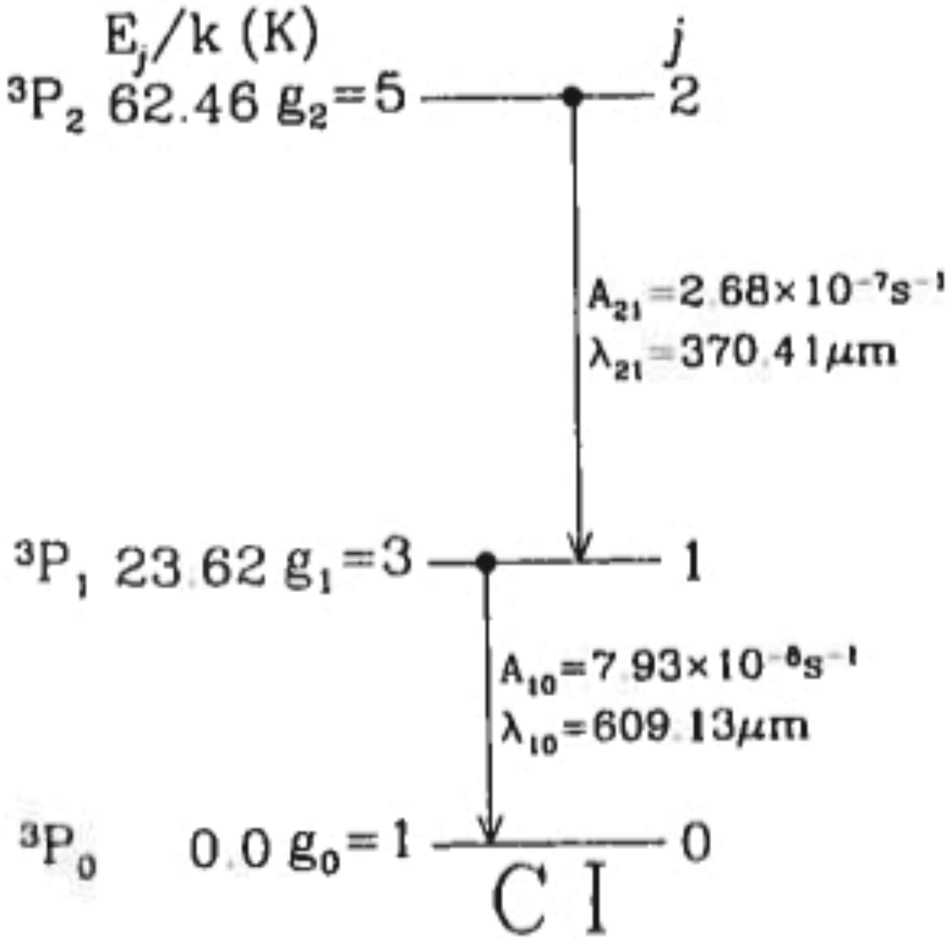
<u>In-class/take-home Problems Due: Friday April 6</u>

37. Neutral Carbon (CI) has 3 fine structure levels in the ground electronic state that result in 2 transitions at 370 μm (809 GHz) and 609 μm (492 GHz) which can be observed with submillimeter telescopes from the ground. See the back for the energy level diagram of CI.

a. The "integrated intensity", I, is defined as the integral over frequency of the monochromatic specific intensity of the spectral line (units of I = erg s^{-1} cm^{-2} $ster^{-1}$; notice the Hz^{-1} has been integrated out). Solve the radiative transfer equation in the optically thin limit and derive how the integrated intensity, I, depends on the frequency of the transition, the Einstein A, and the column density in the upper state of the transition, and some constants. Assume that the level populations of the CI atoms do NOT vary along the line of sight. NOTE: you actually have two integrals in this problem – an integral over frequency and an integral over line of sight. Both integrals are easy (don't make them hard).

b. Observations of the 370 μm and 609 μm lines indicate that they have integrated intensities of 2×10^{-6} and 1×10^{-6} erg s^{-1} cm^{-2} $ster^{-1}$. First derive a general expression for the excitation temperature in the optically thin limit that depends on the observed ratio of the integrated intensities of the two CI fine structure lines (I_{21}/I_{10}). Solve this expression to find T_{ex}.

c. Now calculate the total column density of CI (cm^{-2}) assuming that only the 3 fine structure levels are populated, that they have the same T_{ex} (called the "CTEX" or constant Tex approximation), and that you are in the optically thin limit. Boltzmann is your buddy.



It may be a little hard to read some of the numbers, so I also copied the part of the entry from the Leiden database. Note, the numbers for Einstein A's are slightly different - but really close:

EINSTEINA(s^-1) +	FREQ(GHz) +	E_u(K)
7.880E-08	492.160651	23.620
2.650E-07	809.34197	62.462

In the atomic spectroscopy part of the class coming up soon, we will explain what $^3P_0$, $^3P_1$, $^3P_2$ mean and how to calculate the statistical weights. Exciting!