AST 300B – Spring 2017

In-class/take-home Problems Due: Friday April 7th

39. Neutral Carbon (CI) has 3 fine structure levels in the ground electronic state that result in 2 transitions at 370 and 609 μm. See back for energy level diagram of CI.

a. 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} $ster^{-1}$. What is the column density of CI (cm^{-2}) in the 1st excited energy level (N_1)? Assume optically thin emission.

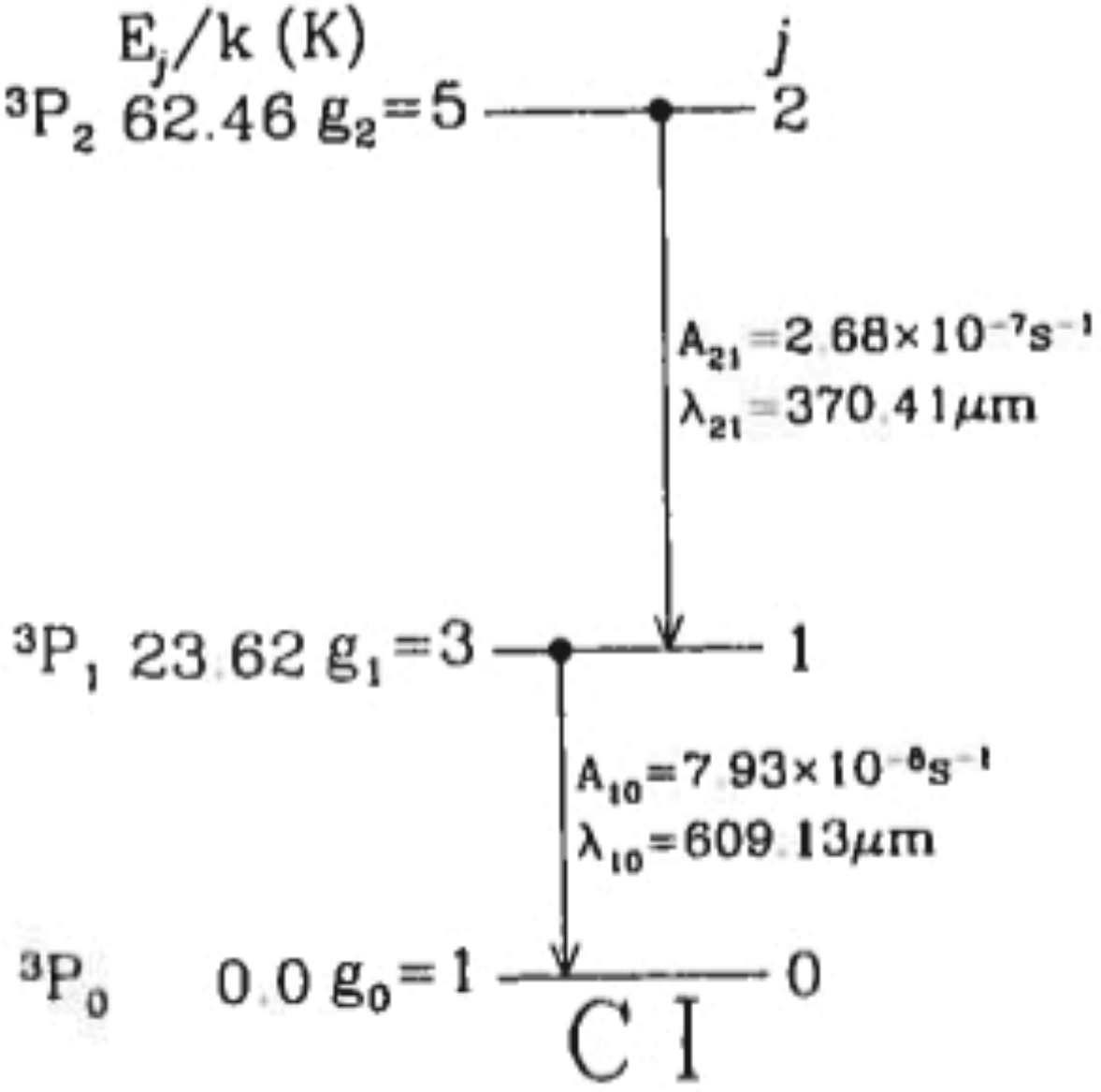
b. Using Boltzmann's Equation, now calculate the total column density of CI (cm^{-2}) assuming that only the 3 fine structure levels are populated. [Hint: you need to calculate the partition function.]

c. Calculate the abundance of C/H = N(CI)/N(HI) if the cloud has $A_V \sim 1$ mag.

d. Up to this point, we've assumed that the emission was optically thin. Let's check that assumption. Calculate the column density for which the optical depth at the peak of the spectral line (v = 0 km/s) is equal to 1 for a CI line with a velocity dispersion σ_v = 1 km/s and T_{ex} = 25 K. Was optically thin a good assumption in parts a-c?

Assume the line profile function is given by a Gaussian:

$$\phi_v = 1/\mathrm{sqrt}(2\pi) * c/\nu * 1/\sigma_v * \exp(- v^2/2\sigma_v^2)$$


E_j/k (K)
j
$^3P_2$ 62.46 $g_2=5$
2
$A_{21}=2.68\times10^{-7}s^{-1}$
$\lambda_{21}=370.41\mu m$
$^3P_1$ 23.62 $g_1=3$
1
$A_{10}=7.93\times10^{-8}s^{-1}$
$\lambda_{10}=609.13\mu m$
$^3P_0$ 0.0 $g_0=1$
0
C I