# AST 300B – Spring 2016
# Exam #2 (6 pages)

No calculators or notes.  Work out and write answers directly on exam.

1. Write down the equations ***and*** give the cgs units for:

(A) The emission coefficient ($j_\nu$) and absorption coefficient ($\alpha_\nu$) for a 2 level system with bound states labeled "1" and "2".
[4 points]

(B) What is the Source function for spectral line emission from a 2 level system equal to? [2 points]

(C) Write down the equation that ***defines*** excitation temperature?
[2 points]

2. Consider a 2 level system with levels labeled 1 and 2 ($E_2 > E_1$). Write down the equations for the rates of the following processes:

    a. The rate of spontaneous emission from level 2 [2 points]

    b. The rate of stimulated emission [2 points]

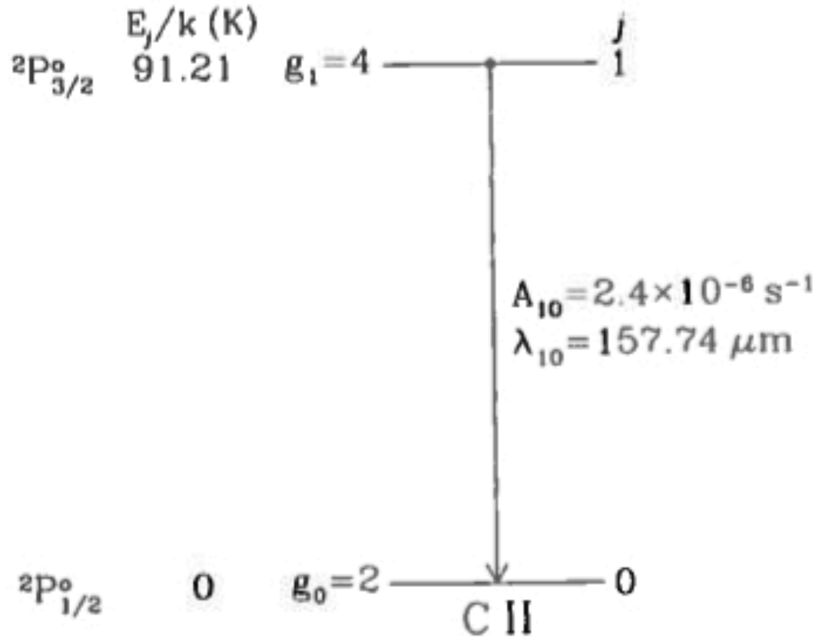
    c. The rate of absorption [2 points]

    d. The rate of collisional excitation to level 2 [2 points]

    e. The rate of collisional de-excitation from level 2 [2 points]

3. For a 2 level system, sketch the curve of how the excitation temperature varies with the density of colliding particles $n_c$. Indicate the appropriate limits in $T_{ex}$. [4 points]

4. The ground state fine structure splitting of CII is a 2 level system:




(A) Derive an expression for the TOTAL CII column density ($cm^{-2}$) for ***optically thin*** emission of the 158 micron line as a function of $T_{ex}$ and the integrated intensity of the spectral line (units of Jy * Hz). You may assume that backgrounds are negligible. [4 points]

(B) If we also assume we are in the low density limit such that every collision from level 0 to level 1 results in spontaneous emission, show how to calculate $T_{ex}$ as a function of the density of colliding particles $n_c$ and the gas kinetic temperature $T_k$.
[2 points]

(C) If the CII emission originates ***in front*** of an optically thick dust cloud with an average dust temperature of $T_d$ = 50 K, what condition on $T_{ex}$ is necessary to see the CII 158 micron line in emission? Write down the formal solution to the radiative transfer equation for this case ($I_\nu$ = ...). [4 points]

(D) If the collision rate of CII with H is $\gamma_{10} \sim 8 \times 10^{-10}$ $cm^3$ $s^{-1}$ and the emission is very optically thick with $\tau \sim 10$, what is approximately the critical density of this transition? Also explain what the critical density means in terms of rates in a 2 level system. [4 points]