AST 300B – Spring 2018
In-class Problems Due: Wednesday Apr. 4

36. Singly ionized C (CII or C^+) may be found in neutral atomic H environments because the ionization potential of C is 11.4 eV, less than the 13.6 eV ionization potential of H. One of the strongest spectral lines in star-forming galaxies is the 157.7 μm far-infrared transition of CII (see spectrum below of the Circinus Galaxy). CII has 2 fine structure levels in the ground electronic state which can be well approximated as a 2 level system. Assume you have a HI cloud with a density of $n = 10^2$ cm^{-3} and a gas kinetic temperature of 100 K. Assume the CMB is the dominant radiation background. The statistical weights of the upper and lower levels are $g_u = 4$ and $g_l = 2$ and $A_{ul} = 2.4 \times 10^{-6}$ s^{-1}.

(a) Calculate the excitation temperature of the 157.7 μm transition of CII in this cloud. Is this transition "thermalized" in this cloud? [Hint: what can you assume about the stimulated emission rates in this problem?]

(b) Calculate the HI density for which T_{ex} is 90% thermalized. How does that density compare to the critical density? [Note: a common mistake is that people assume n_{crit} also implies thermalized.]

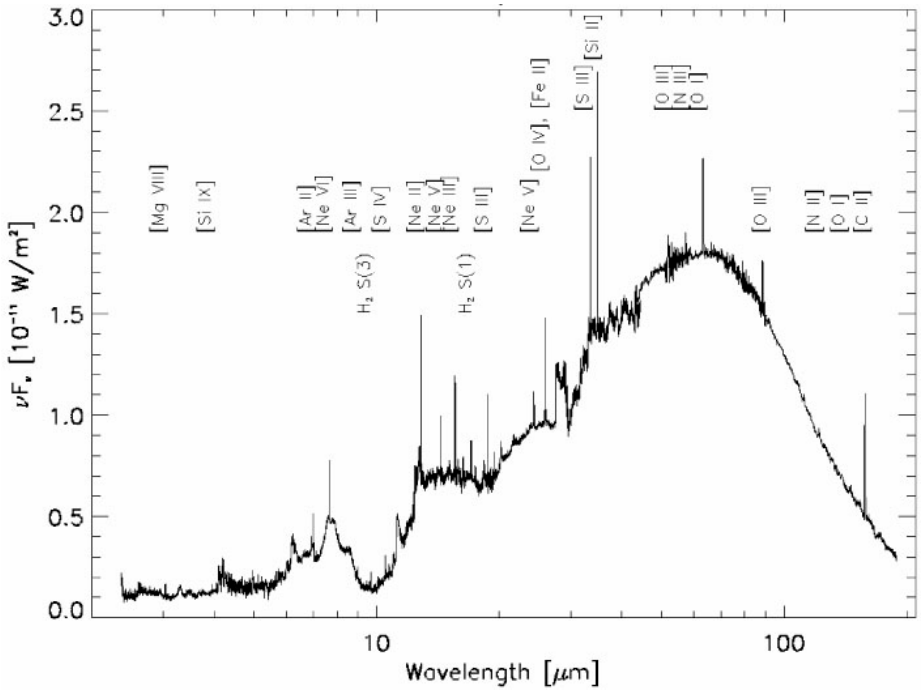

Figure: The infrared spectrum of the Circinus Galaxy showing thermal dust emission and atomic spectral lines.