AST 300B – Spring 2019

In-class/take-home Problems Due: Monday April 8th

32. The Figure below shows a spectrum of molecular absorptions in diffuse gas observed towards the high mass star forming region W51 taken with the *Herschel Space Observatory*. It is due to absorption in diffuse molecular clouds from the ground rotational state of the molecule CH^+ to the first excited rotational state (J = 0 – 1) from multiple clouds along the LOS. The y-axis is normalized flux.
CH^+ 1-0 : $\nu = 835.137504$ GHz, $A_{10} \sim 6.4 \times 10^{-3}\ s^{-1}$, $g_1 = 3$, $g_0 = 1$.

(a) Assuming $T_{ex} = 3$ K, what fraction of CH^+ is in the ground state J=0?

(b) A Gaussian line profile can be fit to the component centered at 24 km/s with a minimum normalized flux of 0.7 and a FWHM line width of 10 km/s. Calculate the column density of CH^+ (cm^{-2}) in this velocity component assuming the absorption line is optically thin and T_{ex} = 3K. Hints: You will need to calculate the integral of τ_ν over velocity (use the differential Doppler formula to convert from an integral over frequency to an integral over velocity: $d\nu = dv\ \nu / c$ on one side of the equation). It is easier to pull $n_0\ g_1/g_0$ out front in the expression for α_ν instead of n_1 for this problem – this is a good strategy because of the result you got from part (a) and because we are analyzing an absorption line. A good/quick approximation of the area under a Gaussian function is ~ peak of Gaussian * FWHM of Gaussian (accurate to ~94%).