Column density for 0 km/s cloud AF01n1 from Dickey et al. 21 cm paper

$T_B := 15 \cdot K$ Brightness T of cloud

$$B_\lambda(\lambda, T) := 2 \cdot h \cdot \frac{c^2}{\lambda^5 \cdot \left[\exp\left[h \cdot \frac{c}{[\lambda \cdot (k \cdot T)]}\right] - 1\right]}$$

Planck function. At low frequencies (1420 MHz, and high T (> 3 K) this reduces to

$$B_\lambda(\lambda, T) := 2 \cdot \frac{c}{\lambda^4} \cdot k \cdot T$$

i.e. linearly proportional to T. This is the **Rayleigh-Jeans** tail of the Planck function, correct far beyond the peak wavelength λ_{max}

Setting observed intensity **I** equal to the Planck function **B** defines the brightness **T**emperature, so the intensity of cloud AF01n1 is:

$$I_{21cm} := B_\lambda(21 \cdot cm, T_B) \qquad I_{21cm} = 6.386 \times 10^{-13} \frac{W}{m^2 \cdot cm \cdot ster}$$

To find the H column density, we need the integrated line strength: $I = I_\lambda \cdot \Delta\lambda = I_\nu \cdot \Delta\nu$

The width of the line is given by the Doppler shift: $\Delta\lambda := 21 \cdot cm \cdot \frac{5 \cdot \frac{km}{sec}}{c}$ $\qquad I := I_{21cm} \cdot \Delta\lambda$

From Lecture 21, the integrated line strength is given by: $I = \frac{A \cdot h \cdot \nu}{4 \cdot \pi} \cdot N_u$

where $A := \left(3 \cdot 10^6 \cdot yr\right)^{-1}$ is the spontaneous decay rate (Einstein A) of the upper level

and $h\nu := h \cdot \frac{c}{21 \cdot cm}$ $\qquad h\nu = 5.912 \times 10^{-6} eV$ $\qquad$ so

$$N_u := \frac{I \cdot 4 \cdot \pi}{A \cdot h\nu} \qquad N_u = 2.808 \times 10^{19} cm^{-2}$$

We showed in class that 3/4 of the H atoms will be in the excited state, so the atomic H column density is merely:

$$N_H := \frac{4}{3} \cdot N_u \qquad N_H = 3.743 \times 10^{19} cm^{-2}$$

Our result on dust extinction in the Milky Way, i.e. the "visibility" is about 500 pc at visible wavelengths implies:

$$A_{V\_N.H} := \frac{1.1}{500 \cdot pc \cdot 1 \cdot cm^{-3}} \qquad A_{V\_N.H} = 0.711 \frac{1}{10^{21} \cdot cm^{-2}}$$

So this cloud has a visual extinction of $A_{V\_N.H} \cdot N_H = 0.027$ magnitudes

The cloud is translucent. This is typical of HI "cirrus" clouds detected by IRAS from their infrared emission. Since A.V is less than one magnitude, molecular H will not form here!