Formulae Used :

(μ, num-lvls, E, g, ν, A, B, C, num-partners, temps)
→ read from the LAMDA file.

→ ni → level populations
→ ~~#~~ for i → 0 to num_lvls :

$$\frac{g[i] \times \exp\left(\frac{-E[i]}{K_b\ T}\right)}{Z}$$

→ Z → partition function
→ for i → 0 to num-lvls :

$$Z = Z + g[i] \times \exp\left(\frac{-E[i]}{K_b T}\right)$$

→ for u ~~in range~~ → 0 to num_lvls :
for l → 0 to u :
if u-l == 1 :
phi → line profile (ϕ)
→ used Tine's code
→ an array of size (41,41) with every element = 1.0 when u-l = 1 otherwise = 0

$$j_0[u][l] = \text{emissivity} = \frac{h \cdot \nu[u][l] \cdot n_i[u] \cdot A[u][l] \cdot \phi}{4\pi}$$

$$\alpha_0[u][l] = \text{extinction} = \frac{h}{4\pi}\nu[u][l] \cdot \phi \cdot \left[n_i[l] \cdot B[l][u] - n_i[u] \cdot B[u][l] \right]$$

$$S_0[u][l] = \text{source function} = \frac{j_0[u][l]}{\alpha_0[u][l]}$$

→ n_H, n_{H2}, X_{H2}, λ_J → from previous code

→ for $u = 2$ & $l = 1$, & $m \to 0$ to 1000

luminosity, $L[2][1][m] \mathrel{+}= 4\pi \cdot (\lambda_J[m])^2 \cdot j_\nu[2][1]$

$d\lambda$?

→ radiation_field $= B_\nu(\nu, T)$

$$= \frac{2h\nu^3}{c^2} \cdot \frac{1}{\exp\left(\frac{h\nu}{k_B T}\right) - 1}$$

at $T = T_{CMB}$ & $\nu = \nu[u][l]$

then J_ν = radiation_field

→ Now, matrix can be solved using A, B, C, J_ν

→ τ & β

↳ need velocity gradient

Units used :

→ A = $[s^{-1}]$

→ B = $[cm^2\, eV^{-1}\, s^{-1}]$

→ C = $[cm^3\, s^{-1}]$

→ ν = $[Hz]$

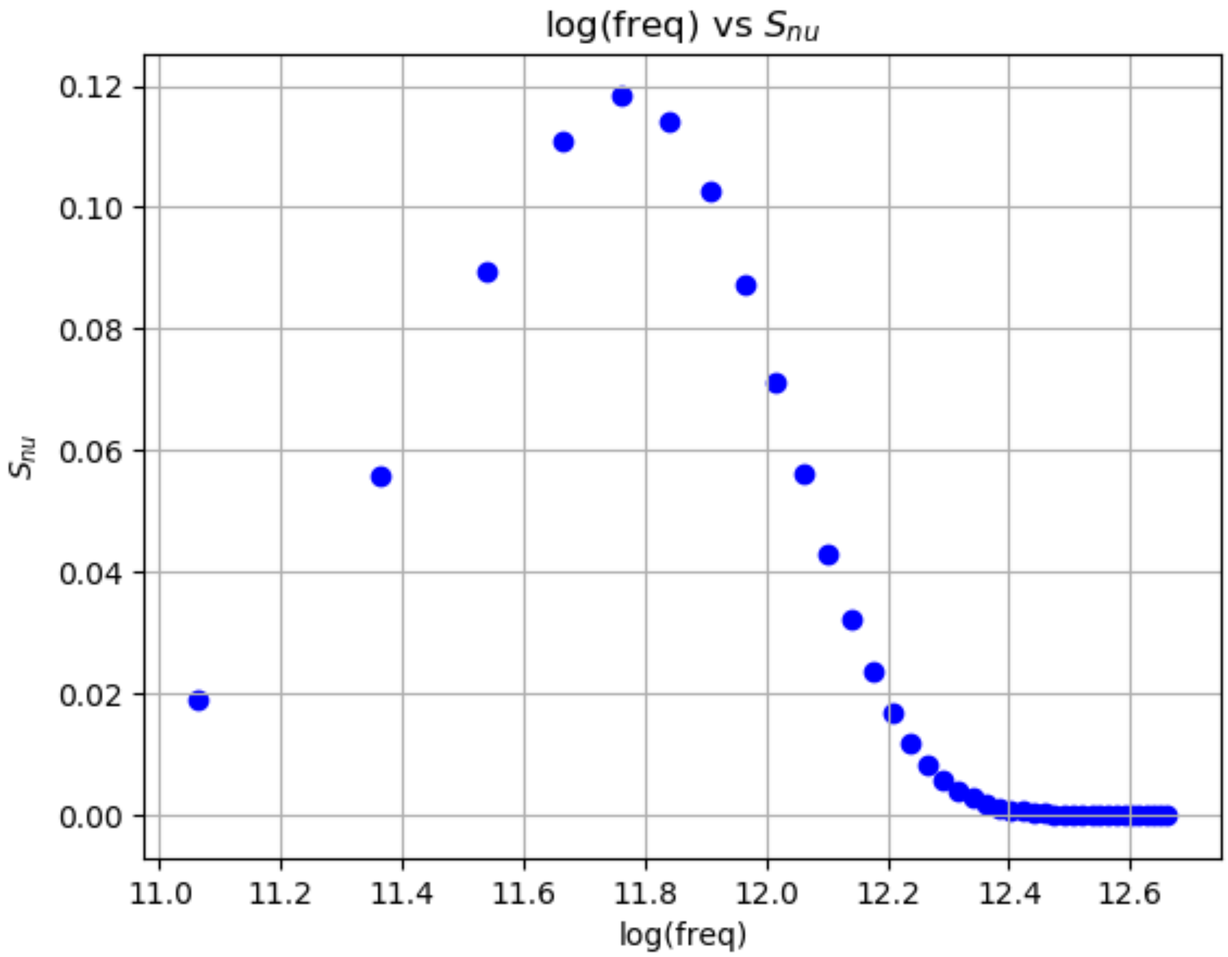
→ j_ν = $[eV\, s^{-1}]$

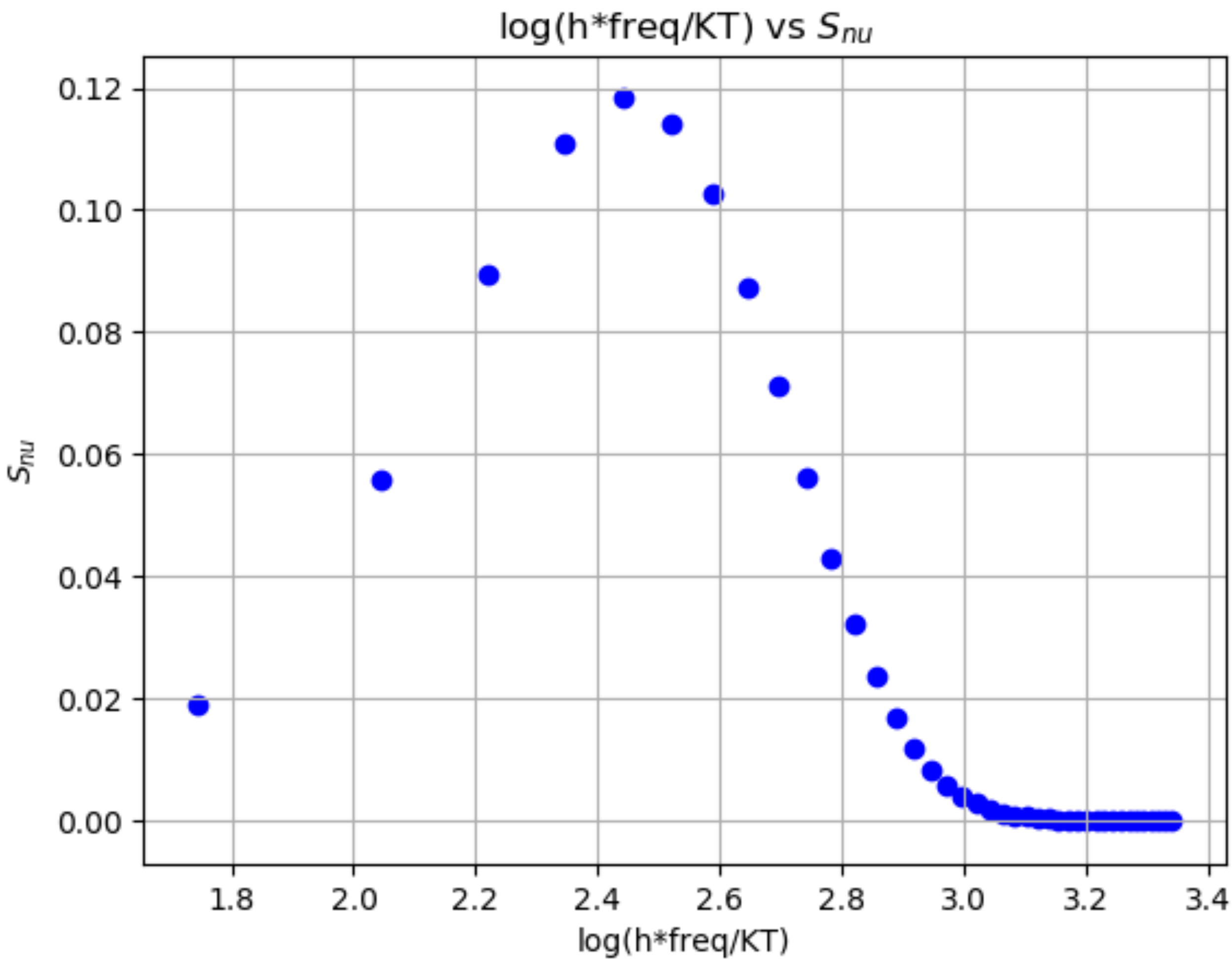
→ α_ν = $[cm^2\, s^{-1}]$

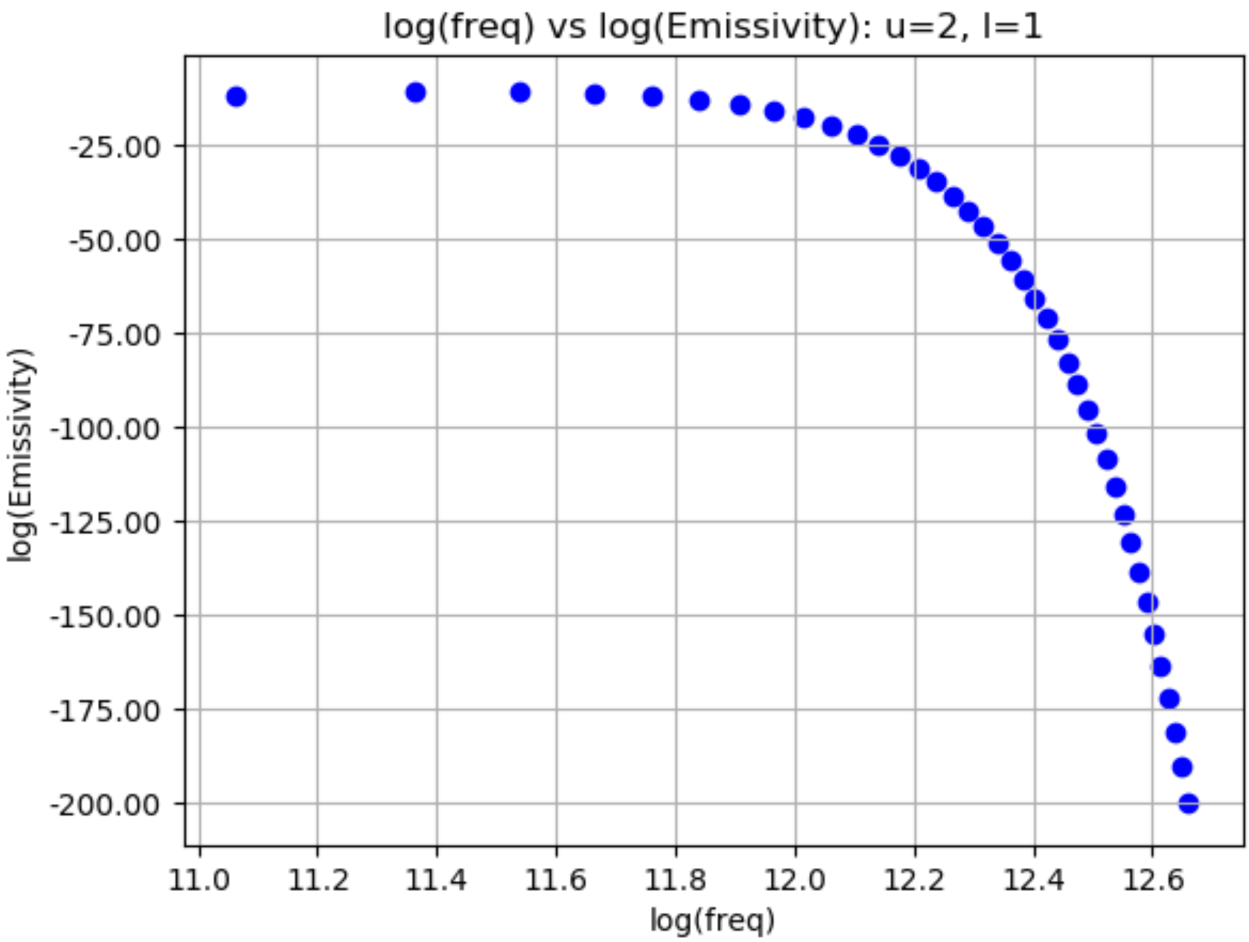
→ S_ν = $[eV\, cm^{-2}]$

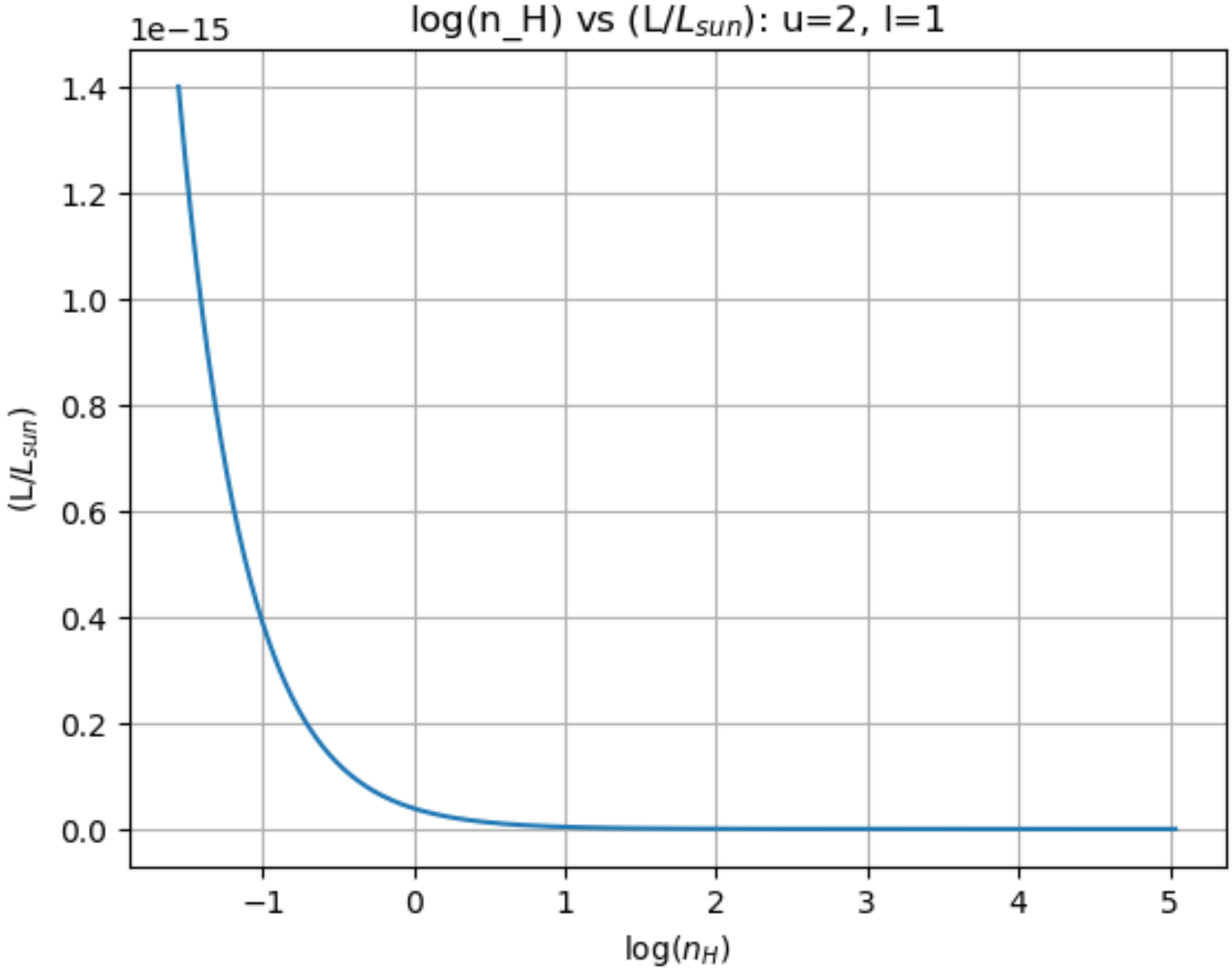
→ λ_J = $[cm]$

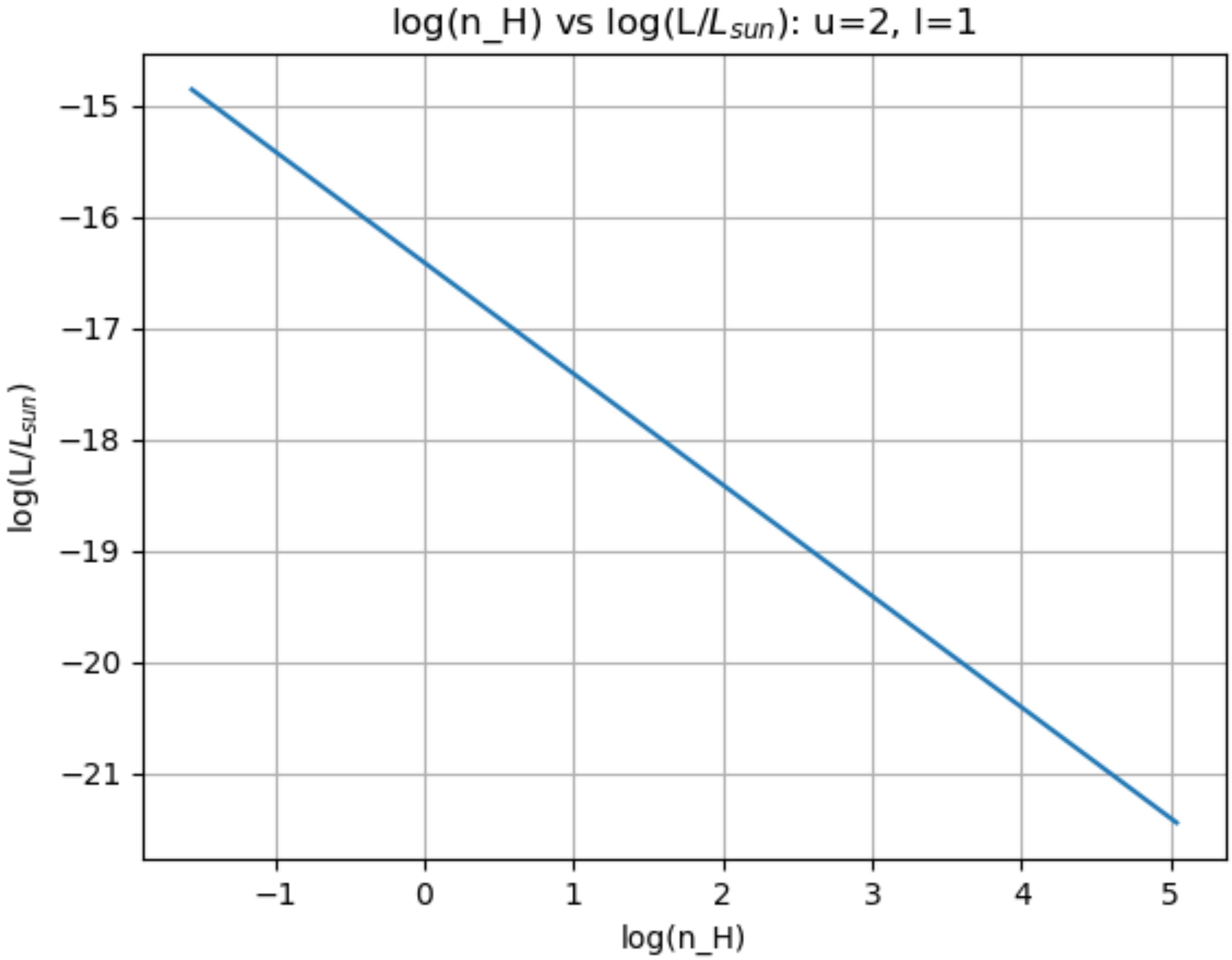
→ L_ν = $[cm^2\, eV\, s^{-1}]$


log(freq) vs S_{nu}
0.12
0.10
0.08
0.06
0.04
0.02
0.00
S_{nu}
11.0
11.2
11.4
11.6
11.8
12.0
12.2
12.4
12.6
log(freq)


log(h*freq/KT) vs S_{nu}
0.12
0.10
0.08
0.06
0.04
0.02
0.00
S_{nu}
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
log(h*freq/KT)


log(freq) vs log(Emissivity): u=2, l=1
-25.00
-50.00
-75.00
-100.00
-125.00
-150.00
-175.00
-200.00
log(Emissivity)
11.0
11.2
11.4
11.6
11.8
12.0
12.2
12.4
12.6
log(freq)


log(n_H) vs (L/L_{sun}): u=2, l=1
1e−15
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
(L/L_{sun})
−1
0
1
2
3
4
5
log(n_H)


log(n_H) vs log(L/L_{sun}): u=2, l=1
−15
−16
−17
−18
−19
−20
−21
log(L/L_{sun})
−1
0
1
2
3
4
5
log(n_H)