Problem 1: Solar Photosphere

In[1558]:=

```
R = 8.314 × 10^7; (* erg/(mol K) *)
M_H = 1.00784;(* g/mol Molar mass of hydrogen *)
N_A = 6.02214076 × 10^23;(* (#H/mol) Avagadro constant *)
m_H = M_H/N_A;(* g/#H molecular weight of hydrogen *)
R_H = R/M_H; (* erg/(g K) *)
T = 6 × 10^3; (* K *)
ρ = 3 × 10^-7; (* g/cm^3 *)
γ = 5/3; (* Monotonic ideal gas *)
v_th = Sqrt[γ R_H T];(* cm/s These units worked out great without changing anything! *)
n_H = ρ/m_H;(* #H/cm^3 Number of particles per unit volume *)
λ = (3/(4 π n_H))^(1/3);(* cm using a Wigner-Seitz radius *)
ν = v_th λ; (* cm^2/s *)

Echo[λ, "λ in cm:"];
Echo[v_th, "v_th in cm/s:"];
Echo[ν, "(nu) ν in cm^2/s:"];
```

» λ in cm: 1.10021×10^{-6}

» v_{th} in $\frac{cm}{s}$: 908 258.

» (nu) ν in $\frac{cm^2}{s}$: 0.999278

Problem 2: Solar Convection Zone

In[1483]:=

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R = 8.314 × 10^7; (* erg/(mol K) *)
M_H = 1.00784;(* g/mol Molar mass of hydrogen *)
N_A = 6.02214076 × 10^23;(* (#H/mol) Avagadro constant *)
m_H = M_H/N_A;(* g/#H molecular weight of hydrogen *)
R_H = R/M_H; (* erg/(g K) *)
T = 2 × 10^6; (* K *)
ρ = 0.2; (* g/cm^3 *)
γ = 5/3; (* Monotonic ideal gas *)
v_th = Sqrt[γ R_H T];(* cm/s These units worked out great without changing anything! *)
n_H = ρ/m_H;(* #H/cm^3 Number of particles per unit volume *)
λ = (3/(4 π n_H))^(1/3);(* cm using a Wigner-Seitz radius *)
ν = v_th λ; (* cm^2/s *)

Echo[λ, "λ in cm:"];
Echo[v_th, "v_th in cm/s:"];
Echo[ν, "(nu) ν in cm^2/s:"];
```

» λ in cm: 1.25943×10^{-8}

» v_{th} in $\frac{cm}{s}$: 1.65824×10^{7}

» (nu) ν in $\frac{cm^{2}}{s}$: 0.208844

Problem 3: Earth’s Atmosphere

In[1573]:=

$$R = 8.314\times 10^{7}; (* \frac{\text{erg}}{\text{mol K}} *)$$

$$M_{N_2} = 28.0134; (* \frac{\text{g}}{\text{mol}} \text{ Molar mass of nitrogen gas } *)$$

$$N_A = 6.02214076\times 10^{23}; (* \left(\frac{\#\text{H}}{\text{mol}}\right) \text{ Avagadro constant } *)$$

$$m_{N_2} = \frac{M_{N_2}}{N_A}; (* \frac{\text{g}}{\#\text{H}} \text{ molecular weight of hydrogen } *)$$

$$R_{N_2} = \frac{R}{M_{N_2}}; (* \frac{\text{erg}}{\text{g K}} *)$$

$$T = 290; (* \text{ K } *)$$

$$\rho = 1\times 10^{-3}; (* \frac{\text{g}}{\text{cm}^3} *)$$

$$\gamma = \frac{7}{5}; (* \text{ Diatomic ideal gas } *)$$

$$v_{th} = \sqrt{\gamma R_{N_2} T}; (* \frac{\text{cm}}{\text{s}} \text{ These units worked out great without changing anything! } *)$$

$$n_{N_2} = \frac{\rho}{m_{N_2}}; (* \frac{\#\text{H}}{\text{cm}^3} \text{ Number of particles per unit volume } *)$$

$$\lambda = \left(\frac{3}{4\pi n_{N_2}}\right)^{1/3}; (* \text{ cm using a Wigner-Seitz radius } *)$$

$$\nu = v_{th}\,\lambda; (* \frac{\text{cm}^2}{\text{s}} *)$$

$$\text{Echo}\left[\lambda, \text{"}\lambda \text{ in cm:"}\right];$$

$$\text{Echo}\left[v_{th}, \text{"}v_{th} \text{ in } \frac{\text{cm}}{\text{s}}\text{:"}\right];$$

$$\text{Echo}\left[\nu, \text{"(nu) } \nu \text{ in } \frac{\text{cm}^2}{\text{s}}\text{:"}\right];$$

» λ in cm: 2.23105×10^{-7}

» v_{th} in $\frac{\text{cm}}{\text{s}}$: 34 712.4

» (nu) ν in $\frac{\text{cm}^2}{\text{s}}$: 0.00774451

Problem 4: Thoughts

These values do seem reasonable (although the value for Earth’s atmosphere seems a bit a small). I think the majority of my error will be in the mean-free path length. My calculation for a mean free path is purely based on packing particles into a box and estimating the average distance between the center of each particle. All of the sound speed values seem spot on on though!