Mean free path and cross section

$\lambda \sim \frac{1}{\sigma n}$ with the number density n and the cross section σ

- Cross section for atoms / molecules (no electrostatic interactions)

$\sigma = \sqrt{2}\,\pi\, d^2$, with d the diameter of the atom / molecule

For example water: $r \approx 1.4\,\text{Å} \Rightarrow d \approx 2.8 \cdot 10^{-8}\,\text{cm}$

$\Rightarrow \sigma \approx 3.5 \cdot 10^{-15}\,\text{cm}^2$, $\rho \approx 1\,\text{g cm}^{-3}$

$\Rightarrow \lambda \approx \frac{1}{\sigma n} \approx 8.6 \cdot 10^{-9}\,\text{cm}$ $\Rightarrow n \approx 1\,\frac{\text{g}}{\text{cm}^3} / 18\,m_H \approx 3 \cdot 10^{22}\,\text{cm}^{-3}$

- Coulomb scattering cross section (charges):

$$\sigma \simeq 10^{-4}\,\text{cm}^2 \left(\frac{T}{\text{K}}\right)^{-2}$$

For example: solar core: $T \approx 15 \cdot 10^6\,\text{K}$

$n \approx 150\,\text{g/cm}^3 / 0.6\,m_H \approx 1.5 \cdot 10^{26}\,\text{cm}^{-3}$

$\Rightarrow \sigma \approx 4 \cdot 10^{-19}\,\text{cm}^2 \Rightarrow \lambda \approx 10^{-8}\,\text{cm}$

Solar wind: (at a distance of ≈ 1 AU)

$T \approx 10^5 K$; $n \approx 10 cm^{-3}$

$\Rightarrow \sigma \approx 10^{-14} cm^2 \Rightarrow \lambda = 10^{13} cm$

(≈ 1 AU)

↳ More examples on slides and in the assignment.