Lec #17: 30 September 2011 Chapters 1 & 3

Part 1. Basic Astronomy and Measuring Properties

TODAY: Internal Processes in Gasses. II.

- Collisions
- Thermal Equilibrium
- The 4 TE Distributions

NEXT Week: Atomic Physics & Spectroscopy

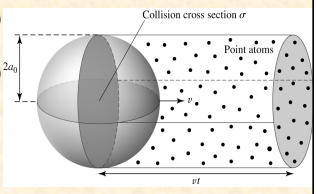
- The Bohr Atom
- Bound-Bound and Bound-Free Processes
- What we can learn from spectral lines

Things that go Bump in a Box of Gas

- Particles (mostly electrons, protons, H atoms in stars)
  - Elastic collisions: KE before = KE after
  - Inelastic collisions: KE lost or gained in collision
    - where does it go?
- Photons
  - Emission: creation of photons (where is E from?)
  - Absorption: destruction of photons (where does E go?)
  - Scattering: no net change in photon number, just a change in direction
    - but these processes are extremely important
    - can lead to *apparent* emission or *apparent* absorption

Collisions

- Number density, n (cm^{-3})
- Column density, N (cm^{-2})
- Cross Section, σ (cm^2)
- Mean free path, l (cm)
  - $l = 1/n\sigma$
- Collision time, t_c (s)
  - $t_c = l/v_t = 1/n\sigma v_t$



Examples:

- $\sigma_H = \pi a_o^2 = 8.75E\text{-}15\ cm^2$
- $\sigma_{HH} = 3.5E\text{-}16\ cm^2$
- $\sigma_T = (2/3)E\text{-}26\ cm^2$

Air in room:	ISM:
• $n \sim 10^{19}\ cm^{-3}$	• $n \sim 10^{-3}\ cm^{-3}$
• $\sigma \sim 10^{-15}\ cm^2$	• $l \sim 10^{14}$ cm
• $l \sim 10^{-4}$ cm	~ 5 AU
• $t_c \sim 10^{-9}$ sec	• but $L \sim 10^{19}$ cm

TE Distribution Functions

- *Maxwell-Boltzmann Distribution:*

$$N_v/N\ (T_k)\ dv = [m/2\pi kT_K]^{3/2}\ e^{-mv^2/2kTK}\ 4\pi v^2\ dv$$

- *Boltzmann Distribution:*

$$N_b/N_a\ (T_x) = (g_b/g_a)\ e^{-(E_b-E_a)/kT_x}$$

- *Saha Equation:*

$$N_{i+1}/N_i\ (T_i) = (2/n_e)\ (Z_{i+1}/Z_i)\ (2\pi m_e kT_i/h^2)^{3/2}\ e^{-\chi_i/kT_i}$$

- *Planck Function:*

$$B_\nu(T_r) = 2h\nu^3/c^2\ [e^{h\nu/KT_r} - 1]^{-1}$$

- **Where does this $e^{-\Delta E/kT}$ come from?**