ASTR 400/700: Stellar Astrophysics

Stephen Kane

San Francisco State University

A700 Oral Exam

- **Dec 6:**
  - Archana Dobaria
  "Stellar Formation in Different Galaxies"
  - Yuzo Ishikawa
  "Understanding the Properties and Formation of Black Holes"

- **Dec 8:**
  - Daniel McKeown
  "Stellar Content in the Illustris Simulation"
  - Heechan Yuk
  "Structures and Mechanisms of Supernovae"

Upcoming schedule

- Oct 18: Stellar atmospheres (Chapter 9)
- Oct 20: Stellar atmospheres (Chapter 9)
- Oct 25: Stellar Atmospheres (Chapter 9)
- Oct 27: Stellar interiors (Chapter 10)
- Nov 1: Stellar interiors (Chapter 10)
- Nov 3: Stellar evolution (Chapter 13)

Stellar Atmospheres

Chapter 9.1, 9.2

Stellar Atmosphere

- Light comes from the Star's Atmosphere
  - Atmosphere is the layers of gas overlaying opaque interior of star
- Flood of photons pour from these layers releasing energy produced by the thermonuclear reactions, gravitational contraction and cooling in the star's center
- The temperature, density and composition of the atmospheric layers determine the features of the star's spectrum
  - No solid surface…

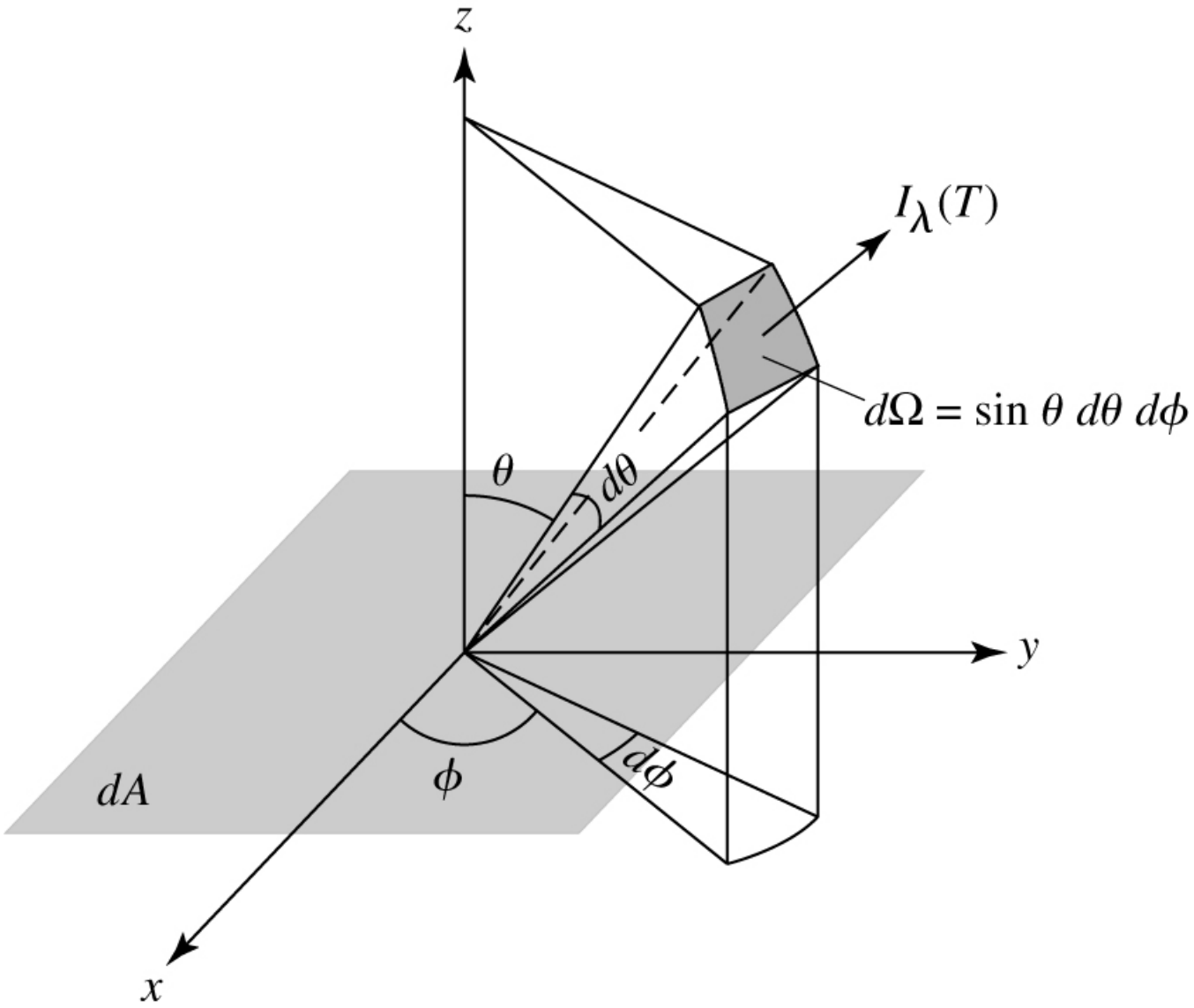
Photosphere: Segment of star that emits light. Typically defined to be the region down to an **optical depth** of 2/3.

Chromosphere: In the Sun, a thin layer just above the photosphere that is visually more transparent than the photosphere. The spectrum of the light generated here is dominated by Hα wavelength. Temperature of Chromosphere is up to 20,000K.

Transition Region: In the Sun, a region between the Chromosphere and Corona.

Corona: In the Sun, a type of plasma atmosphere that extends millions of kilometers into space. High temperature.

Description of the Radiation Field
Specific and Mean Intensity



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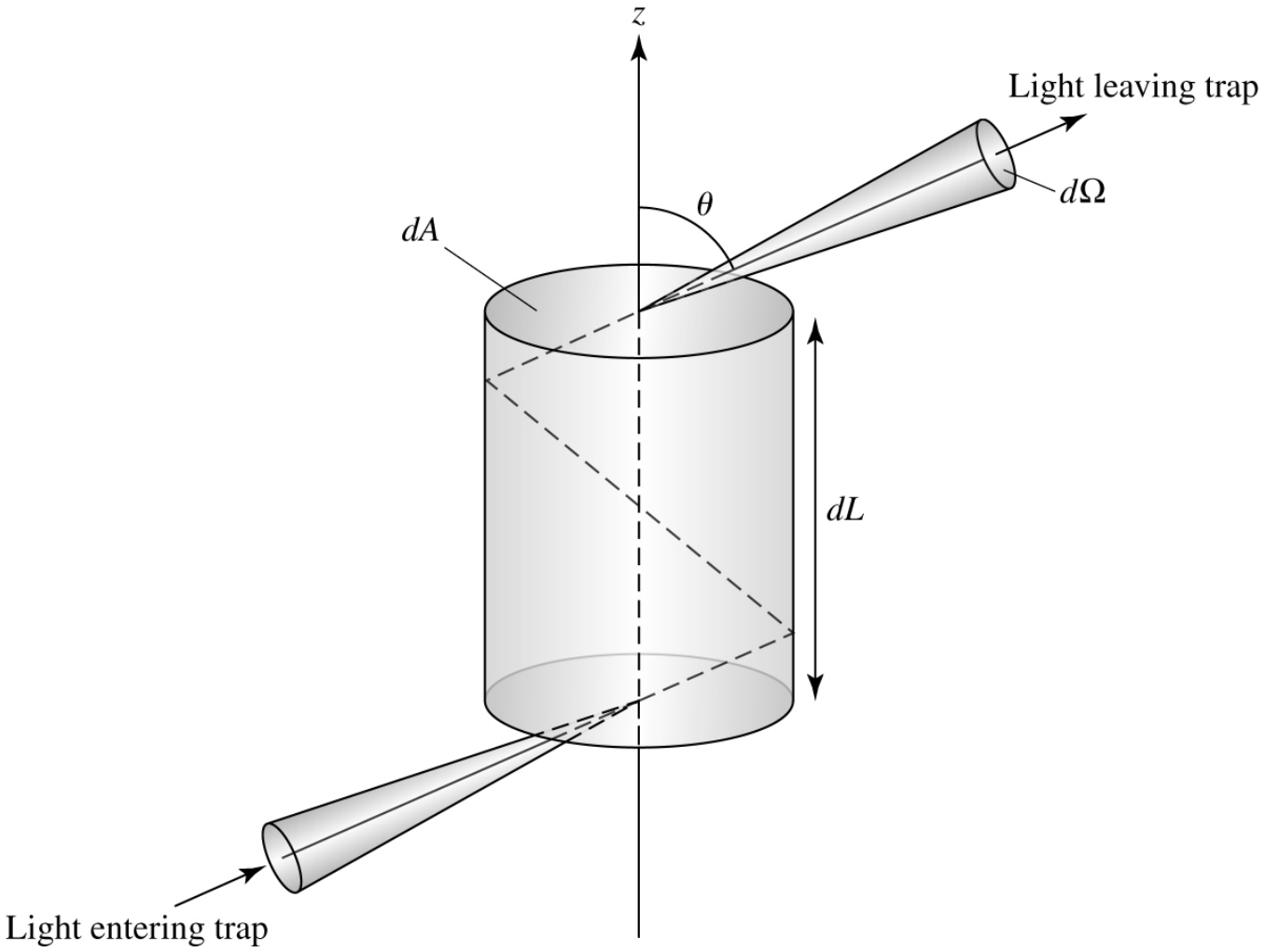
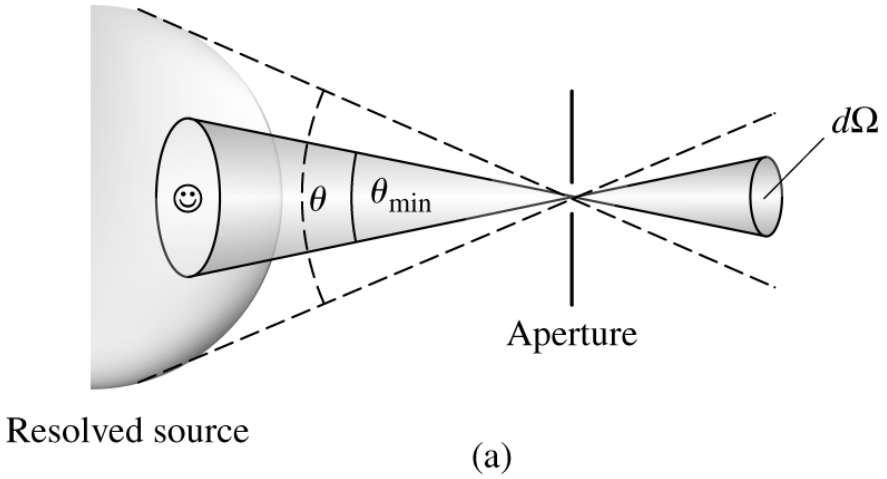


Specific Radiative Flux

- Net Energy having a wavelength between λ and λ+dλ that passes each second through unit area in the direction of the +z axis

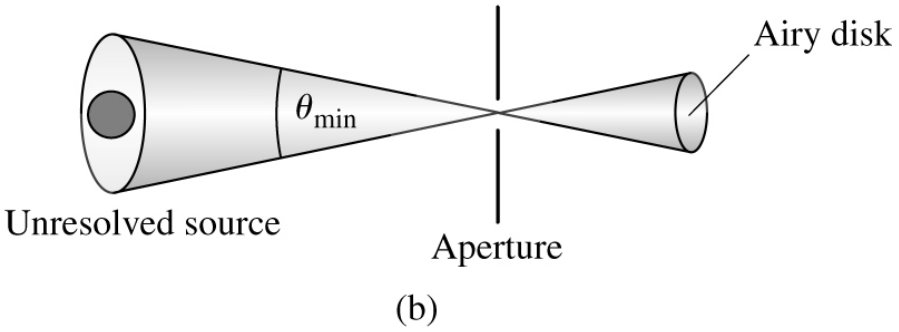
Resolved Source

Flux independent of r

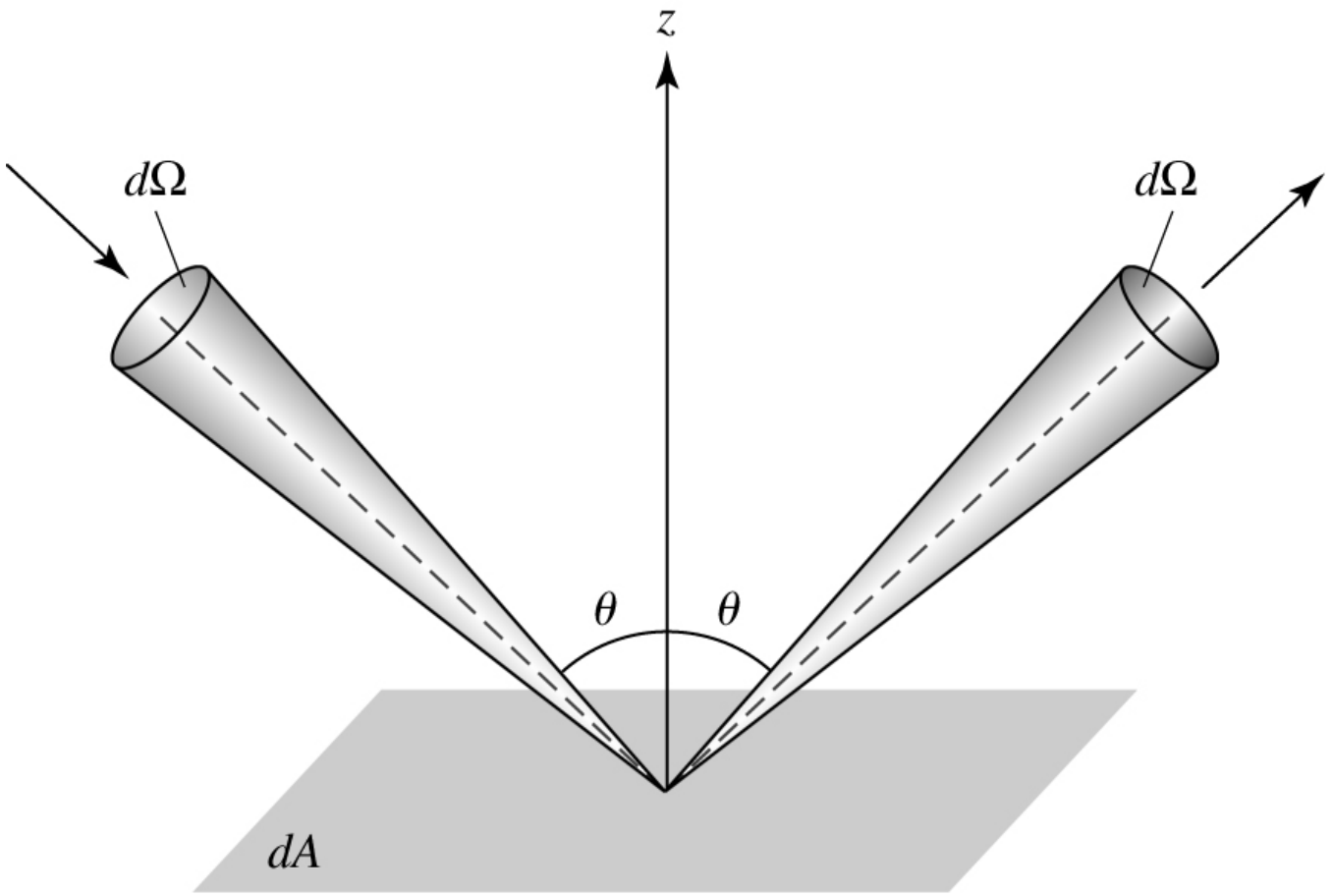


Unresolved Source

Flux decreases as $1/r^2$



Radiation Pressure

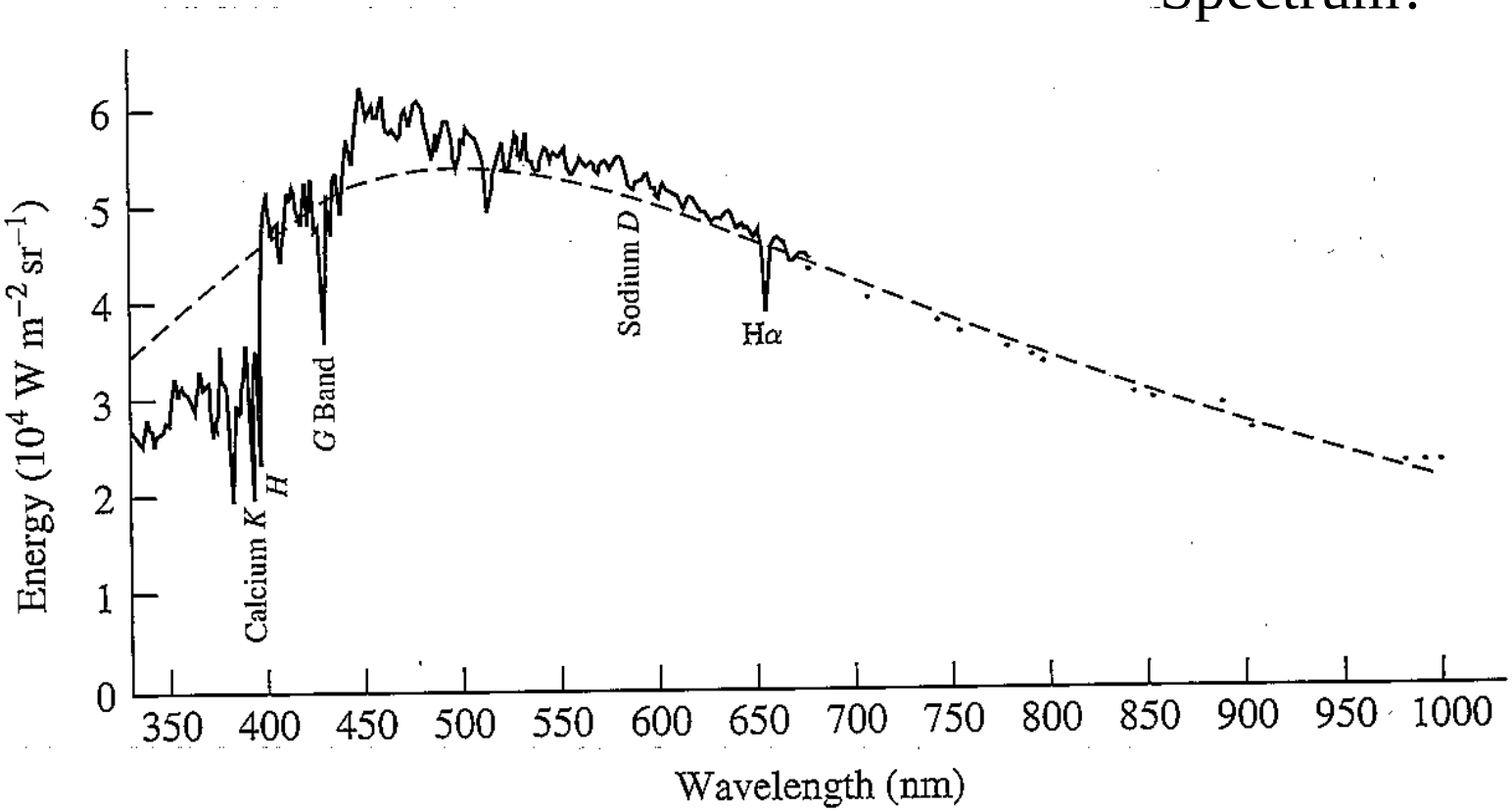


Radiation Pressure is 1/3 of
the Energy Density for
Blackbody Radiation

Stellar Opacity

- Solar Spectrum

What determines features of Spectrum?

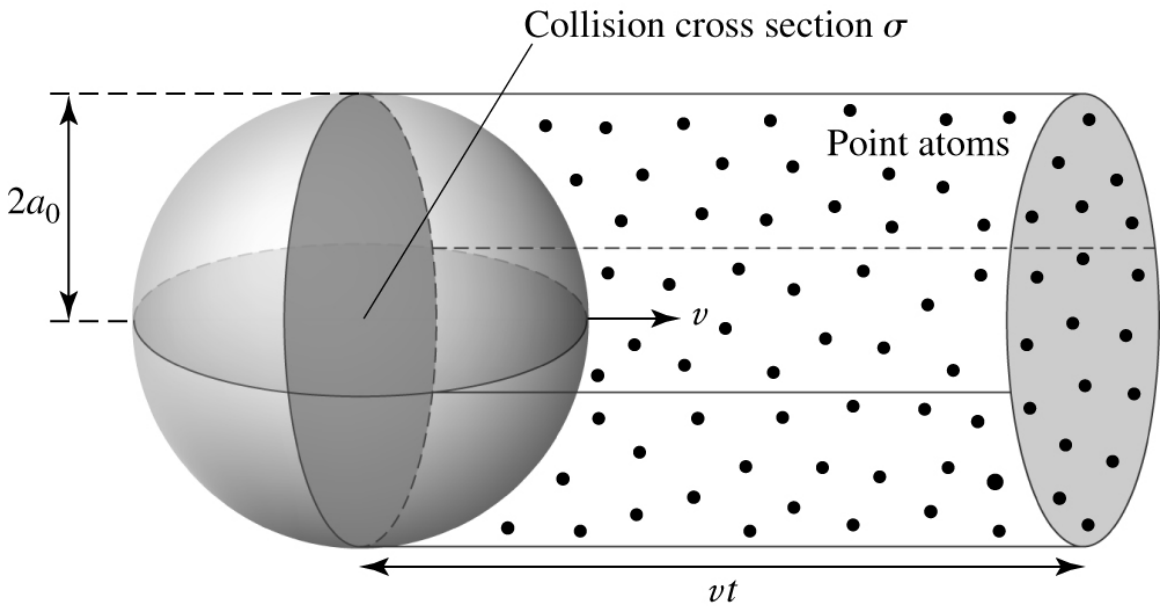


Stellar Opacity

Temperature and Local Thermodynamic Equilibrium

- The **effective temperature**, which is obtained from the Stefan–Boltzmann law (Eq. 3.17), is uniquely defined for a specific level within a star and is an important global descriptor of that star.
- The **excitation temperature** is defined by the Boltzmann equation (8.6).
- The **ionization temperature** is defined by the Saha equation (8.8).
- The **kinetic temperature** is contained in the Maxwell–Boltzmann distribution, Eq. (8.1).
- The **color temperature** is obtained by fitting the shape of a star's continuous spectrum to the Planck function, Eq. (3.22).

Stellar Opacity



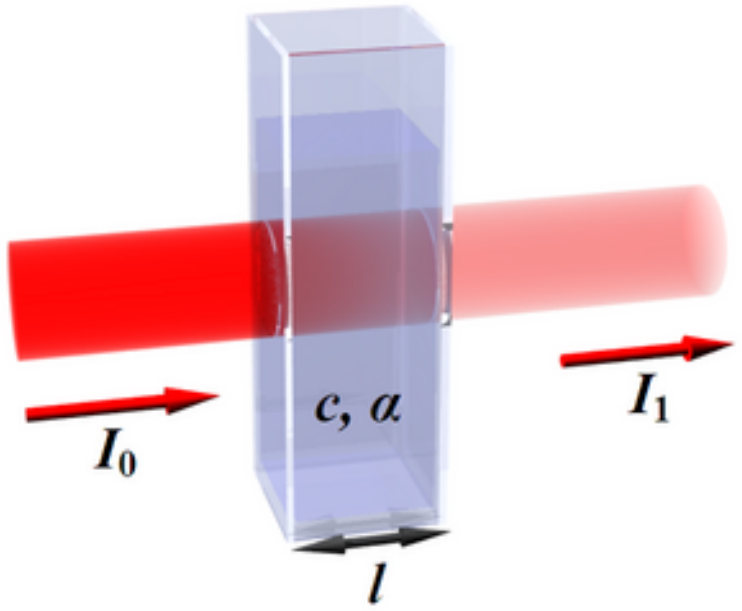
Mean free path

$$\ell = \frac{vt}{n\sigma vt} = \frac{1}{n\sigma}.$$

Definition of Opacity

- Consider a beam of parallel light rays traveling through a gas.
- Any process that removes photons from this beam of light is called absorption
- Absorption includes Scattering!!
- True absorption is by electronic transitions in atoms (and sometimes molecules)
- Change in Intensity is

$$dI_\lambda = -\kappa_\lambda \rho I_\lambda \, ds.$$



Proportional to:

distance traveled

density of gas

absorption coefficient