last Wednesday:

\[ \frac{dI}{dT} = I(\varepsilon) - (1 - \varepsilon) B = \varepsilon - B \]

\[ \to I = I_0 e^{-\varepsilon} + \int B e^{-\varepsilon} d\varepsilon \]

absorption \( \varepsilon \) = \( \frac{dI}{dT} = \omega_0 \) assuming no scattering.
\[ \frac{d\omega}{dT} = 0 \] peak absorption/emission
assuming a well-mixed gas and density profile that is exponentially decreasing, find this maximum at \( \frac{\lambda_0}{\lambda} \approx 1 \).

absorption by atmospheric gas / methods of calculating IR. sec 4.43

it's all in fact

Fig. 4.7 will

broadening: fig. 4.21

natural: & \text{uncertainty}

Doppler: shifting of frequencies
Pressure: collisional broadening.

\[ k = \frac{1}{\sigma_0 \tilde{\nu} \gamma} \exp \left[ -\left( \frac{\tilde{\nu} - \nu_0}{\sigma_0} \right)^2 \right] \]

line shape factor
or intensity

Doppler \( \alpha_0 \) half width = \( \frac{\nu_0}{c} \left( \frac{2kT}{m} \right)^{1/2} \) pressure \( \tilde{\nu} \)
Doppler: \( f = \frac{1}{\alpha_0 \pi} \exp \left[ - \left( \frac{v - v_0}{\alpha_0} \right)^2 \right] \) \( \omega_1 \) \( \alpha_0 = \frac{v_0}{c} \left( \frac{2 E}{m} \right)^{\frac{1}{2}} \) half width

Pressure (Lorentz):

\[ f = \frac{\alpha}{\pi \left[ (v - v_0)^2 + \alpha^2 \right]} \] \( \omega \) \( \alpha < \frac{P}{T^2} \)

So Doppler \( \propto T^{-\frac{1}{2}} \)
pressure \( \propto \frac{P}{T^2} \)

\[ \uparrow \] \[ \text{strahlung} \]
\[ \uparrow \]
\[ \text{local thermodynamic} \]

Typically these are combined, one \( \alpha + s \) are specified at a given \( T_p \), \( \alpha_p = \alpha_0 \left( \frac{P}{P_0} \right) \left( \frac{T_p}{T} \right)^n \)

can maybe appreciate how difficult it is to formulate a continuum from this...

Lo k-surf

how to get broadband fluxes & heating rates from this?

\[ \Phi_{abs} = \sum_{i} \rho_i k_i (v) = \sum_{i} \rho_i (v) \left[ k_{\text{cont}} (\tilde{v}_i, v) + \sum_{j} \tilde{S}_j (v) \tilde{f}_j (\tilde{v} - \tilde{v}_j, v) \right] \]

\( N \) constituents
\( M \) absorption lines

HITRAN 1992 model have 709,308 lines. accurate to 5-10%

climate models need something less computationally expensive.

"collided k-distribution"

basic idea shown in fig 4.27:

\[ \text{eq 4.49: } \overline{T_v} = \frac{1}{\Delta v} \int e^{-k_{\text{cont}} v} dv = \int e^{-k_{\text{cont}} g} dg. \]

new variable \( g \): prob. distribution of \( \Delta v \)
ordered in increasing \( g \):
\[ g = 0 \] for smallest \( k \)
\[ g \] for largest

data compression scheme
Reading rates within atmosphere: \[ \frac{dF}{dt} = \frac{dE}{dz} \] \[ \text{eq. 4.52} \]

A: radiative exchange w/ surface.

B: "cooling by space

C: exchange w/ neighboring layers, note that if

\[ B(z) = B(z', \text{isothermal}), \text{then } C = D = 0 \]

in real atmosphere, \( C + D \) is a maximum where \( T \) is a min/max.

( stratosphere can only warm)

\[ \left( \frac{dT}{dt} = \frac{SN}{C_0} \right) \left| k \cdot r \left( I_r \cdot B_r \right) d\mu \right. \quad \text{eq 4.54} \]

now backtrack to: RT w/ scattering,

\[ \frac{\omega}{4\pi} \left[ \mathbf{P}(\alpha, \alpha') \right] I(\alpha') d\alpha' \]

1. properties of various constituents \[ \text{sec 4.4.1, fig 4.11} \]
2. multiple scattering
3. formulation in radiative models (2-stream approx.) (multiple

3) satellite remote sensing, \[ \text{radiol} \]

1) when \( \frac{\lambda}{\alpha} \) small \( \Rightarrow \) Mie-like scattering, if \( \alpha^2 \) to absorption complete

air molecule