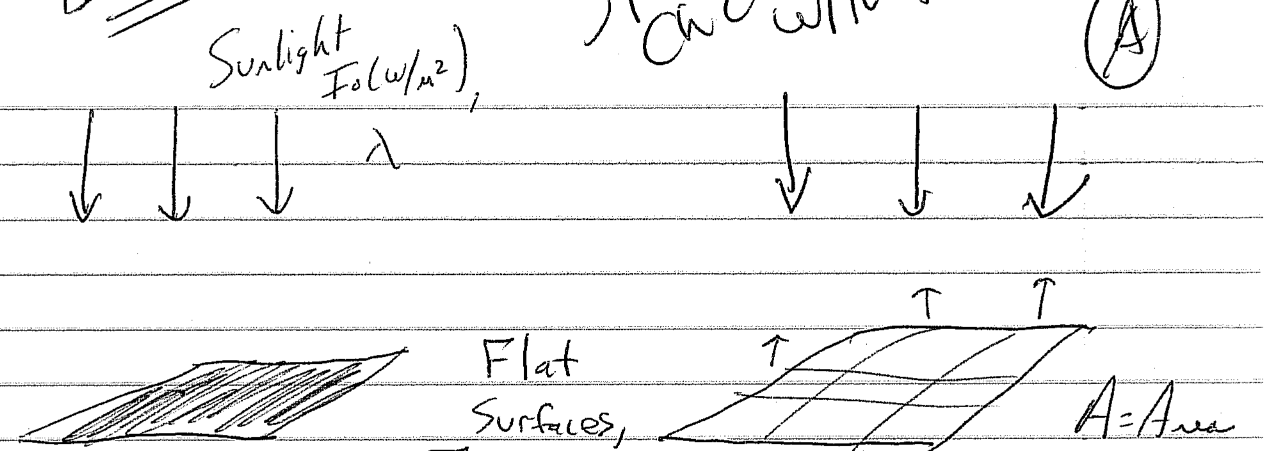
Cross Section Definitions

For 9/26/06

Start Ch 2 w/ this Class

(A)



Black Surface,
Area A, (m^2)

a = albedo
Absorptance $= (1-a)$

Power Absorbed

$I_0 A$

$\sigma_{abs} = A$

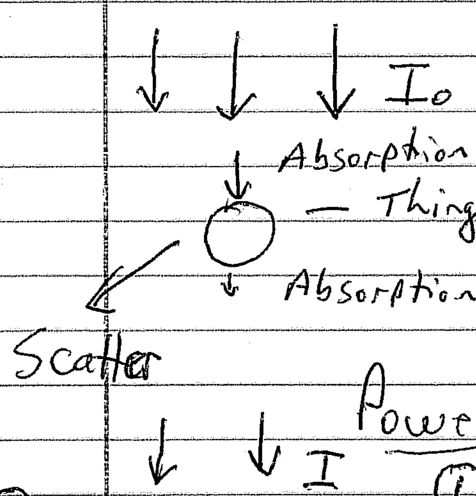
Absorption Cross Section

Power Absorbed

$I_0 A (1-a)$

$\sigma_{abs} = A(1-a)$

✓✓



— Thing (Particle, molecule, flea, etc)

Absorption indicated by less light thru thing.

Power Removed From beam:

(1)

$P_{ext} = I_0 \sigma_{ext} = I_0 (\sigma_{abs} + \sigma_{sca})$

$P_{abs} = I_0 \sigma_{abs}$

$P_{sca} = I_0 \sigma_{sca}$

(2) Let $\omega \equiv \dfrac{\sigma_{sca}}{\sigma_{ext}}$

(3) $\omega \equiv$ Single Scatter Albedo (Compare: Albedo from multiple Scatter by many things)

✓✓

$P_{abs} = (1-\omega) \sigma_{ext} I_0$

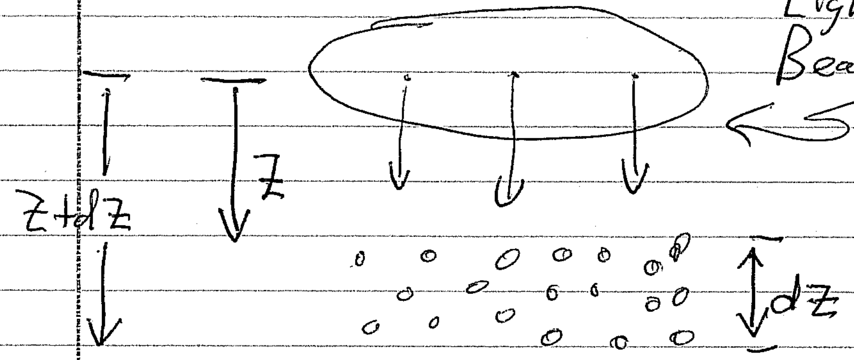
$P_{sca} = \omega \sigma_{ext} I_0$

9/26/06
Class notes
(B)

Particles ⇌ "Things"

Single Scatter Optics of Many Things

Light Beam Area = A



(identical)

n = # Particles in thickness dZ

$N \equiv \dfrac{\#\ \text{Particles}}{\text{Volume}}$

$n = N\,A\,dZ$

Power Removed in dZ $= I(Z)\, n\, \sigma_{ext}$

or

$$\big(I(Z) - I(Z+dZ)\big)A = I(Z)\, N\, A\, dZ\, \sigma_{ext}$$

or

$$-dI = I(Z)\, N\, \sigma_{ext}\, dZ$$

$$\int_{I_0}^{I(Z)} \frac{dI}{I} = -\int_0^Z N\,\sigma_{ext}\, dZ'$$

$\kappa_{ext} = \beta_{ext} =$ Extinction coefficient

$$\ln \frac{I}{I_0} = -\underbrace{N\sigma_{ext}}\, Z$$

Students Like This

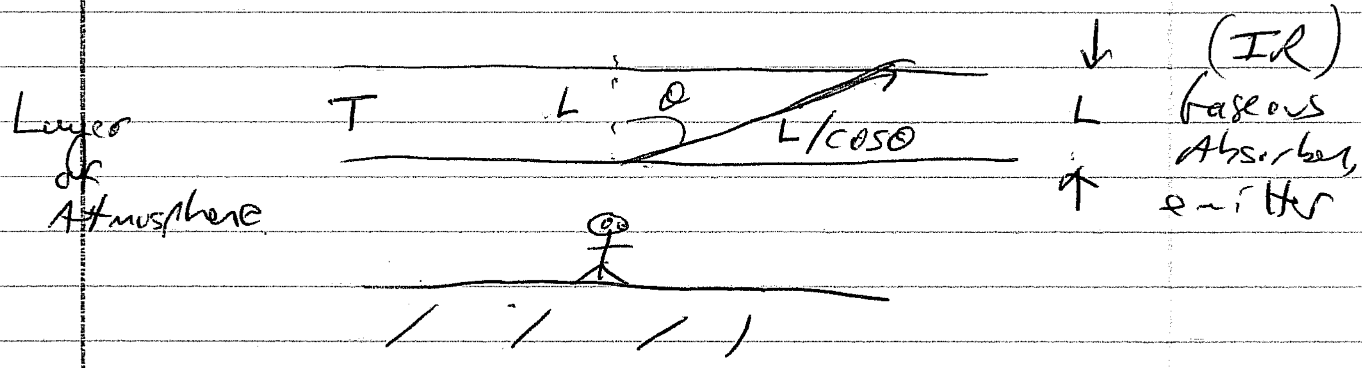
Bouger Beer.

$$I(Z) = I_0\, e^{-N\sigma_{ext} Z}$$

Generally describes ONLY the direct beam attenuation. If $N\sigma_{sca}Z \geq 0.5$, multiple scattering can be very important.

CH2 Outline:

1) Exponential Attenuation, Skin Depth
woodsmoke [From the Power Point Presentation]
2) Directional Emissivity



$$\text{Transmissivity}(\theta) = e^{-\frac{kL}{\cos\theta}}$$

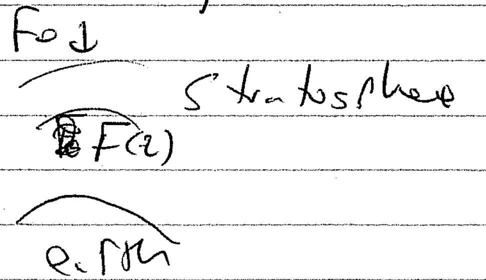
$$\epsilon(\theta) = 1 - e^{-kL/\cos\theta}$$

$\theta\uparrow$ $\cos\theta\downarrow$, see more atmosphere at temperature T,

$\epsilon(\theta)\uparrow$

3) Flux Divergence, Largest?

Heating Rate: $\frac{\partial T}{\partial t} = -\frac{1}{\rho_0 c_p}\frac{\partial F}{\partial z}$



$$F(z) = F_0 e^{-kz}$$

$$-\frac{\partial F}{\partial z} = +k F_0 e^{-kz}$$

What value of k gives greatest heating rate?

$$\frac{\partial}{\partial \kappa}\left(\frac{\partial F}{\partial z}\right) = 0 = F_0\left[e^{-\kappa z} - \kappa z e^{-\kappa z}\right) = 0$$

$\Rightarrow \quad \kappa z = 1$, after factoring out $e^{-\kappa z}$.

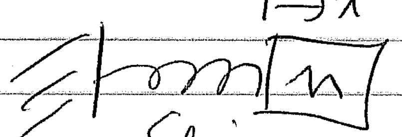
Absorption optical depth $\Rightarrow 1$, max heating rate, true in Stratosphere.

How do we talk about the death of photons?

$\boxed{\text{Goto Pg 2.2A, 2.2B}}$

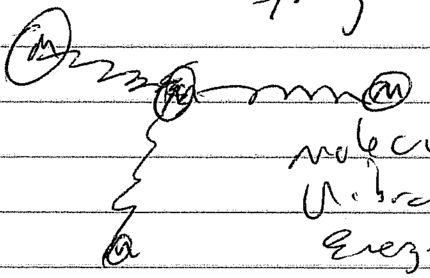
Harmonic Oscillators

All the world is a mass model



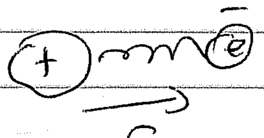
$F = -kx$

$V = \frac{1}{2}kx^2$ Potential Energy



molecule, Vibration

Energy levels "Resonance" Associated with Energy levels -



Charge drive be external Electric field

$\vec{E}$

Nature does All it can to get things to share their energy

4,65

Ch2

Tropopause

Absorbs + Emits IR
Little SLAB of Atm

T

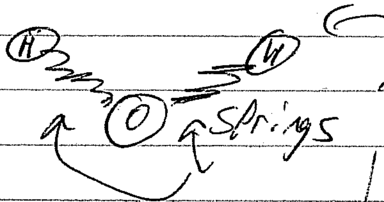
Slab Emission $= \epsilon(\lambda)\ P_e(\lambda, T)$ — Planck Electromagnetic (Power) energy function

$P_e(\omega, T)$

Ground T_G

(1) Molecules have kinetic energy associated with translation - moving around. They move around!

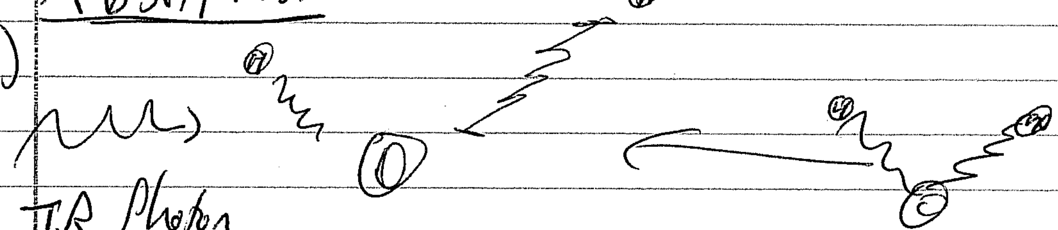
(2) Molecules have "modes" $\Rightarrow$ Ways they can dance



Rotations Moments of Inertia

Absorption

(3)



IR Photon

2nd Showing Collision

λ just right to "tickle" a mode

Photon energy $\Rightarrow$ "tickle"

tickle shared with others during collision.

Result: heat How Shared?

Heat Capacity: $C_p = R + \frac{3}{2}R + \frac{2R}{2} + \frac{?R}{2}$

Translation, Rotation, Vibration

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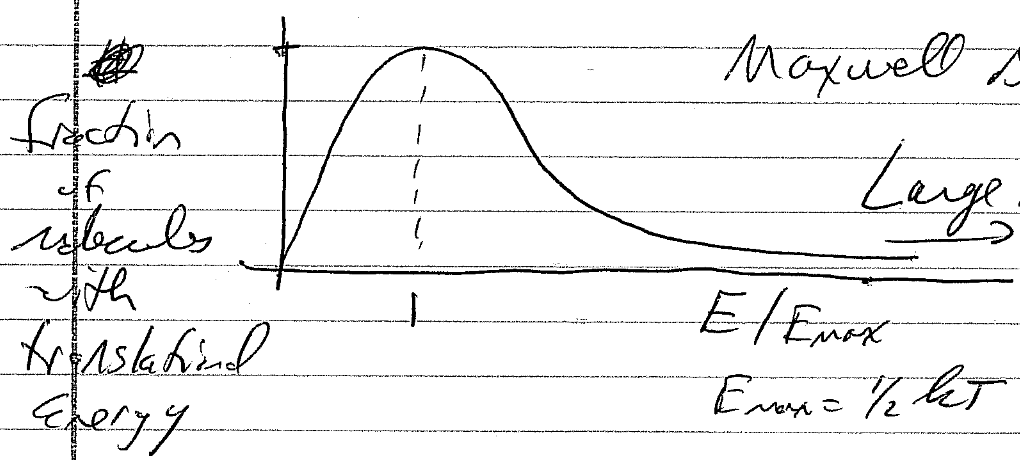
KE

(4) Is the translational energy enough to excite all modes?

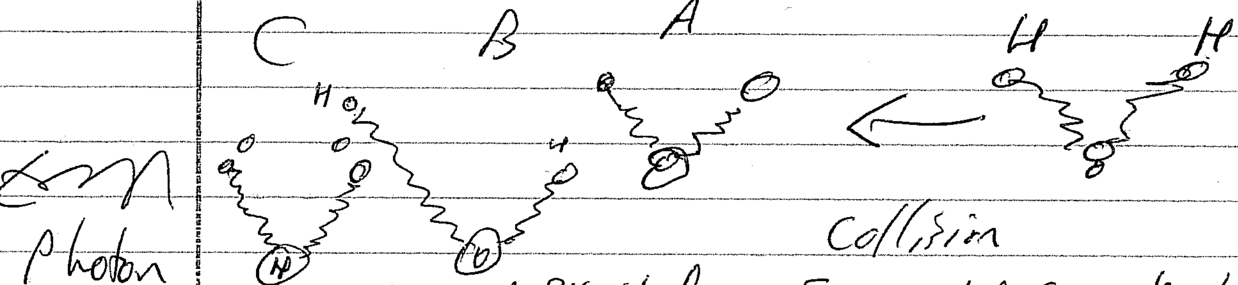
Is the tickle strong enough to excite the modes?

translation ✓
rotation ✓
Vibration not so much



$E_{max} = \frac{1}{2} kT$

(5) Run the film in Reverse:



tickled, excited molecule

Frames A, B, C, molecule gives up the tickle to photon emission. If it is long enough until the next collision, otherwise energy is lost back as heat.

Emission