12/1

Review of last lecture

* Single particle

Solut. of Maxwell equat.

→ ○

cross-section / efficiency $\begin{cases} \text{absorpt.} \\ \text{scatte.} \\ \text{extinct.} \end{cases}$

albedo

phase function $\phi(\Omega' \to \Omega)$

* spherical particle : Mie theory – general $x = \frac{2\pi r}{\lambda_0}$, $m = \frac{N_2}{N_1}$

$\begin{cases} \text{Rayleigh} \quad x \ll 1 \\ \text{Geometric} \quad x \gg 1 \end{cases}$; $\begin{cases} Q_s \sim x^4 \\ Q_a \sim x. \end{cases}$

└ ray tracing.

* there is also Mie theory for infinitely long cylinder.

Today : a. finish particle clouds.

b. Drude model.

~~from~~ N (table), we can calculate

R, T, A, ϕ

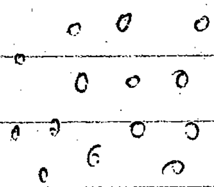
but N depends on λ.

We do not quite understand this dependence ~~yet~~.

FORM 7527

Made in U.S.A.

Particle Clouds:



uniform size

N_T — # of particle per unit volume

scattering coefficient

$$\sigma_{s\lambda} = N_T C_s \qquad \left[\frac{1}{m}\right]$$

absorpt. coeffic.

$$\kappa_\lambda = N_T C_a$$

extinct.:

$$\beta_\lambda = \kappa_\lambda + \sigma_{s\lambda} = N_T C_e$$

non-uniform size: particle distribut. funct. $n(r)$ ↑ $\frac{\#\text{particles}}{m^3}\frac{1}{m}$ ↑ per unit radi.

volume fract.

$$f_v = \int_0^\infty \frac{4}{3}\pi r^2\, n(r)\, dr$$

$$\sigma_{s\lambda} = \int_0^\infty n(r)\, C_s\, dr$$

$$\kappa_\lambda = \int_0^{\infty} n(r)\, C_a\, dr$$

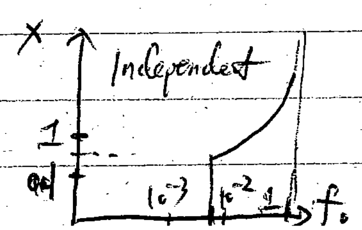
$$\beta_\lambda = \int_0^{\infty} n(r)\, C_e\, dr$$

phase funct.

$$\Phi(\Omega' \to \Omega) = \frac{1}{\sigma_{s\lambda}} \int_0^\infty C_s\, \phi(r, \Omega' \to \Omega)\, n(r)\, dr$$

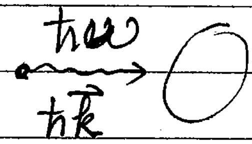
* Dependent vs. Independent scattering

~~size parameter~~



Next ~3 lectures, understand ~~[illegible]~~ spectral properties of matters

fundamental requirement



absorption

$E_f - E_i = \hbar\omega$

↑ final state of matter ↑ initial state of matter

— energy conservation

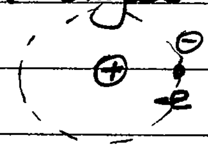
$\hbar\vec{k} = \vec{P}_f - \vec{P}_i \pm \vec{G}$.

↑ due to geometry
↑ reciprocal lattice vector.

— momentum conservation.

Energy states in Matters

- A single atom

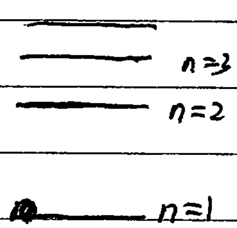


translation

$E = \frac{mv^2}{2}$

∟ pretty much continuous.

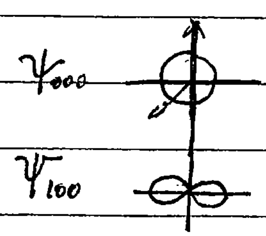
electronic



$E_n = -\frac{13.6\,eV}{n^2}$ (hydrogen atom)

↑ quantum number. (l, m), $l \le n$, $|m| \le l$.

Comment on periodic table.



$E_2 - E_1 = h\nu$

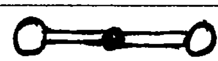
- diatomic molecule.

~~rigid~~ rotation : $E_l = \frac{\hbar^2}{2I} l(l+1)$  I – moment of inertia

vibration: $E_n = h\nu(n+\frac{1}{2})$  $\nu = \frac{1}{2\pi}\sqrt{\frac{K}{m^*}}$

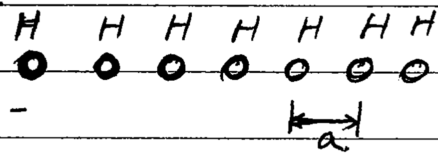
↑ zero point energy ↑ reduced mass.

- 3 atoms per molecule CO_2



fundamental modes { symmetric stretch, asymmetric stretch, out of ~~plane~~ line.

- Solid



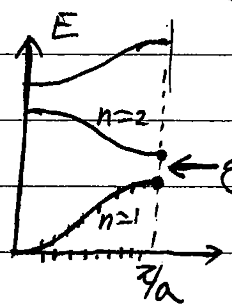
When you put 2 atoms close

ψ cannot be same

ψ_{000} – split.

electron has now more space

travel as a wave.



$k_i = \frac{n\pi}{Na}$ $(n = 0, \pm 1, \ldots, \pm\frac{N}{2})$

↳ momentum of electrons

$e^{ikL} = 1$

$kL = 2\pi n$

$k = \frac{2\pi n}{Na}$

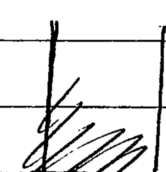
$\psi_i(\vec{k}_x, ~~k_y, k_z~~, \text{spin})$

— one-D 2N ~~for~~ states ~~for~~

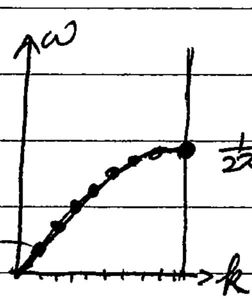
H cold ⇒ metalic

He ⇒ insulator

We are typically interested in band gap reg.



Atomic vibrat. ⇒



heavier. ⇐ all atoms in one period

$E = \hbar\omega(n+\frac{1}{2})$

↑

$\omega = \omega(\vec{k})$

└ dispersion.