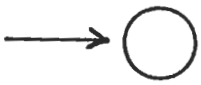
2.58 3/24/06

LAST TIME



absorption
scattering
extinction
} CROSS-SECTION
EFFICIENCY

- ALBEDO
- PHASE FUNCTION

MIE SCATTERING

... FOR SPHERICAL PARTICLE

SIZE PARAMETER, $X = \frac{2\pi r}{\lambda_0}$, $m = \frac{N_2}{N_1}$

.. SPECIAL SOLUTIONS

RAYLEIGH SCATTERING $X \ll 1 \Longrightarrow$ $Q_s \sim X^4$, $Q_a \sim X$ (AT NANOSCALE ABSORPTION IS MORE IMPORTANT)

GEOMETRIC OPTICS $X \gg 1$
(RAY TRACING)

GROUP OF IDENTICAL PARTICLES

$N_T \equiv$ PARTICLES PER UNIT VOL.

SCATTERING COEFFICIENT: $\sigma_{s\lambda} = \underbrace{N_T}_{\frac{1}{m^3}} \underbrace{C_s}_{m^2} \left[\frac{1}{m}\right]$

ABSORPTION COEFF: $\kappa_\lambda = N_T C_a$

EXTINCTION COEFF: $\beta_\lambda = \kappa_\lambda + \sigma_{s\lambda}$

2.58 3/21/06

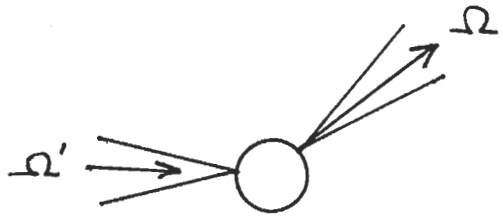
PARTICLE DISTRIBUTION FUNCTION

$$n(r) = \left[\frac{1}{m^3} \cdot \frac{1}{m}\right]$$

$$\underbrace{\sigma_{s\lambda}}_{\beta_\lambda - \chi_\lambda} = \int_0^\infty n(r) \underbrace{C_s}_{C_a \cdot C_e} dr$$

"A WEIGHTED AVERAGE"

VOLUME FRACTION: $f_v = \int_0^\infty \frac{4}{3}\pi r^3 n(r) dr$

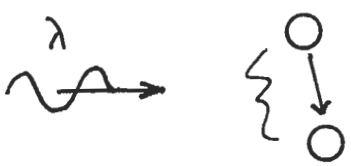


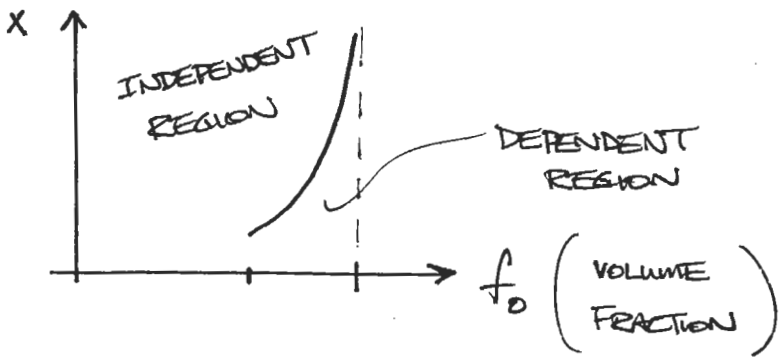
PHASE FUNCTION:

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

INDEPENDENT VS. DEPENDENT SCATTERING

- PARTICLES CAN SCATTER WAVES FROM TO NEIGHBORING PARTICLES
- THE CLOSER PARTICLES ARE, THE STRONGER THEY INTERFERE WITH ONE ANOTER





2.58 3/21/06

SPECTRAL PROPERTIES OF MATERIALS

ENERGY STATES IN A MATERIAL ; GOVERNED BY QUANTUM MECHANICS

ENERGY CONSERVATION $E_{FINAL} = E_{INITIAL} + \hbar\omega_{PHOTON}$

OR $E_f - E_i = \hbar\omega_p$

MOMENTUM CONSERVATION $\hbar\vec{k} = \vec{P}_f - \vec{P}_i + \vec{G}$

MATERIAL ENERGY STATES

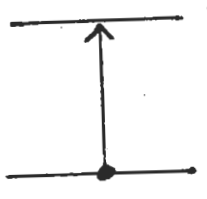
... A SINGLE ATOM ⊕ NUCLEUS e^-

TRANSLATIONAL ENERGY OF THE ATOM $E = \frac{mv^2}{2}$

de BROGLIE WAVE $\lambda = \frac{h}{p}$

HYDROGEN ATOM : $E_n = \frac{-13.6\,eV}{n^2}$, $n = 1, 2, 3, \ldots$

$n \equiv$ PRINCIPLE QUANTUM #



$\hbar\omega_{photon} = -13.6\,eV\left(\frac{1}{2^2} - 1\right) = \frac{3}{4} \times 13.6\,eV$

2.58 3/21/06

NEED PRINCIPLE QUANTUM #s FOR EACH DIMENSION (D.O.F.)

THUS, FOR 3-D OUR WAVE FUNCTION TAKES THE FORM

WAVEFUNCTION $\psi_{n\ell m_s}$ (each n,ℓ,m,s combo DEFINES 1 QUANTUM STATE)

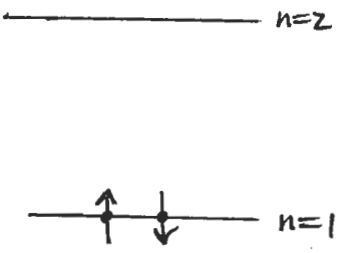
CONSTRAINTS $\ell < n$

$|m| \leq \ell$

ELECTRONS

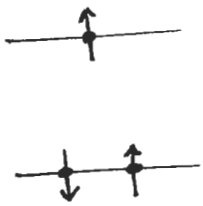
$\psi_{100s} \Rightarrow \psi_{100(\frac{1}{2})}, \psi_{100(-\frac{1}{2})}$

$s = \pm\frac{1}{2}$



$n=1$ HAS 2 STATES

$n=2$ HAS 8 STATES



LITHIUM, NOT SO STABLE

DIATOMIC MOLECULES

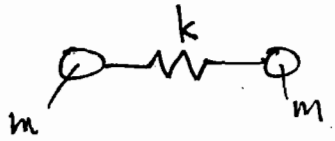
CAN HAVE ROTATION

$$E_\ell = \frac{\hbar^2}{2I}\ell(\ell+1) \quad ; \quad I \equiv \text{MOMENT OF INERTIA } mr^2$$

$$E_{\ell+1} - E_\ell = \hbar\omega_p$$

2.58 3/21/06

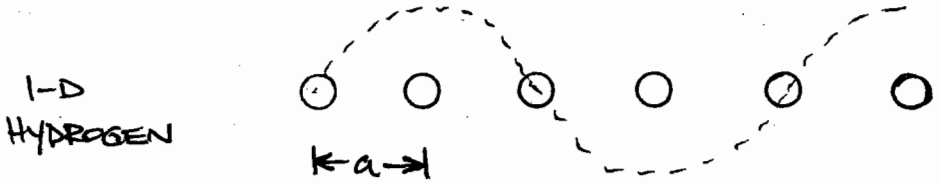
VIBRATION

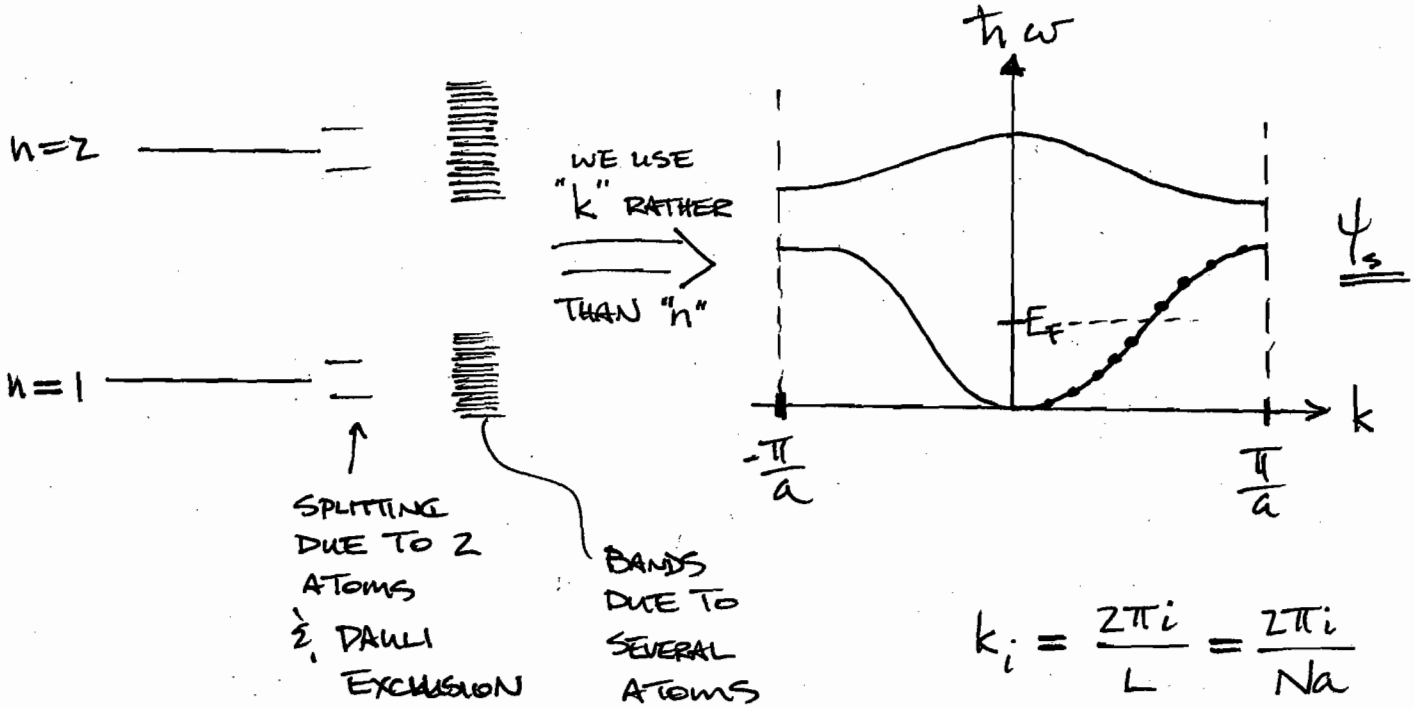


$$E_n = \hbar\omega\left(n+\frac{1}{2}\right)$$

$$\omega = \sqrt{\frac{k}{m_{eff}}}$$

SOLIDS





$$k_i = \frac{2\pi i}{L} = \frac{2\pi i}{Na}$$