Lecture 1, 2

e, ph, atoms → waves / particles → photoelectric effect
↳ Conduction in metals

Drude's conductivity:

$$\sigma = \frac{ne^2\tau}{m} = \underbrace{(N_e e)}_{\text{no. of carrier charge}} \cdot \underbrace{\left(\frac{e\tau}{m}\right)}_{\text{mobility}}$$

τ → relaxation time

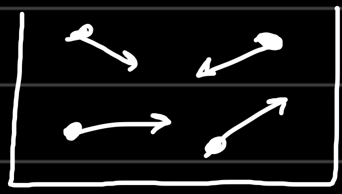
$v_d = \mu E$
↳ mobility {scaling factor / proportionality const}

τ ⇒ statistical thermodynamic variable
τ ⇒ mean time to scatter
μ ⇒ also mean value
V_d ⇒ mean drift velocity

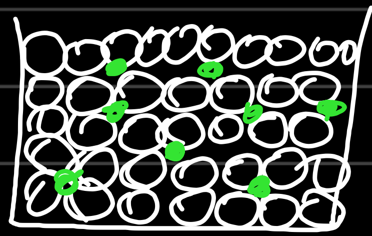
$$R_H = \frac{1}{N_e e} \quad \{\text{Hall coefficient}\}$$

$$\boxed{E_y = R_H J_x B}$$ transverse potential

$$\sigma(\omega) = \frac{\sigma_0}{1 - i\omega\tau}$$



electron



hole

vacancy movement can be tracked.

ω_p = plasma frequency

$$\omega_p = \frac{ne^2}{m\varepsilon}$$ {intrinsic material property}

$\downarrow$

$\omega < \omega_p \Rightarrow$ decay

$\omega > \omega_p \Rightarrow$ transmits.

} describes transparency of materials to EM radiation.

The time-independent SE eqn:

Free particle: energy is continuous

Particle in a box: energy is quantized:

$$E = \frac{\hbar^2 k^2}{2m} \qquad k = \frac{2\pi n}{a}$$

$$= \frac{h^2}{4\pi^2} \times \frac{4\pi^2 n^2}{2ma^2} = \frac{h^2 n^2}{2ma^2}$$

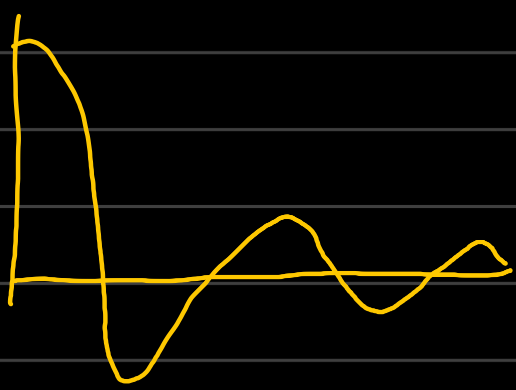
Hydrogen atom: $V = \frac{-kZe^2}{r} = -\frac{Ze^2}{4\pi\varepsilon_0 r}$

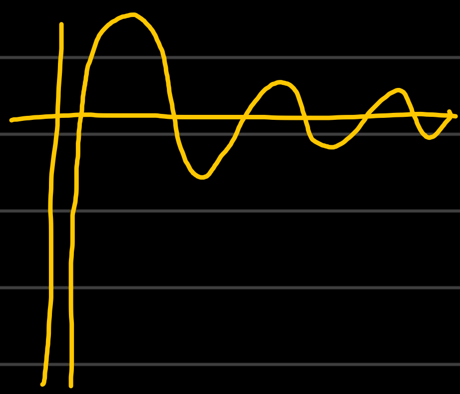
$$\psi(r,\theta,\phi) = R(r)\,\Theta(\theta)\,\Phi(\phi)$$

$$\frac{\partial^2 \Phi}{\partial \phi^2} = -m^2 \phi$$

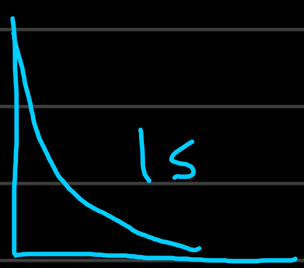
$$\Phi(\phi) = e^{im\phi}$$

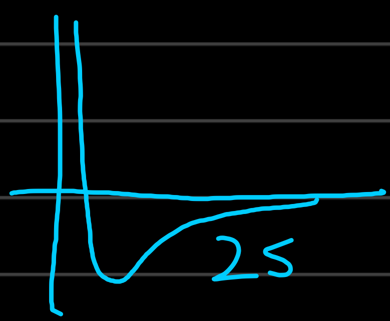
$$u(r) = A r \underbrace{j_\ell}_{\text{Bessel's fnc}}(kr) + B r \underbrace{n_\ell}_{\text{Neumann fnc.}}(kr)$$

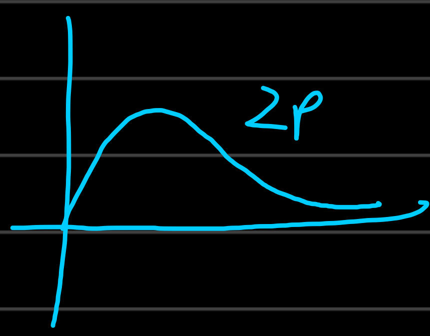




Radial wavefunctions:







$$E(3p) > E(3s)$$

due to Orbital Angular momentum.

contributes an additional energy.

Angular momentum:

$$\mathcal{L}\psi = L\psi$$

angular momentum operator.

$$L = \hbar\sqrt{l(l+1)}$$

$$L_z = m_l \hbar$$

→ Selection rules:

↳ Electronic transition. $\Delta l = \pm 1$

{angular momentum is conserved}

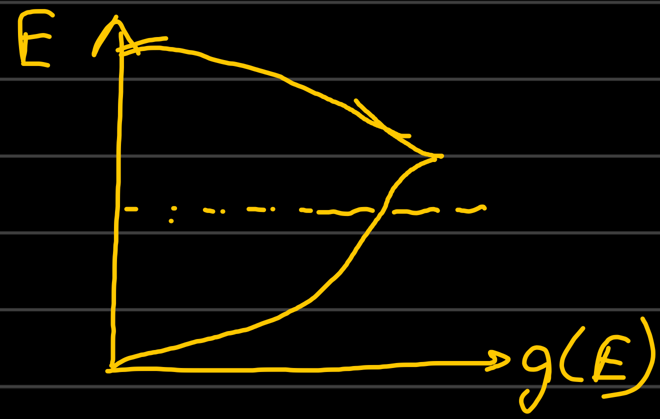
$s \not\to d$

$s \to p$

Density of States:

$$\boxed{D = \frac{1}{V}\frac{dN}{dE}}$$

$\frac{\text{no.}}{\text{energy} \times \text{vol}}$ $\left(\frac{1}{eV\,cm^{-3}}\right)$

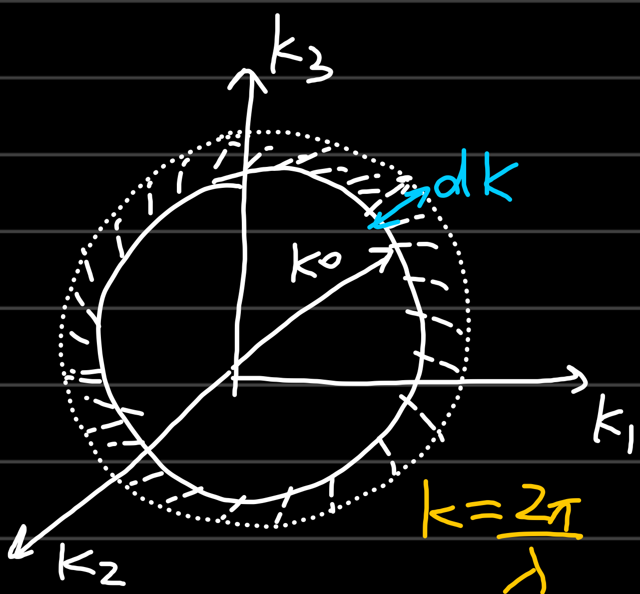


→ Anti-symmetric energy addition has higher no. of configurations, hence accounts for higher density of states.

$\rightarrow \quad E = \frac{\hbar^2 k^2}{2m} \qquad p = \hbar k \; ; \; E = \frac{1}{2}\frac{p^2}{2m}$

$dE = \frac{\hbar k}{m} dk$

$E_0 = \frac{\hbar^2 k_0^2}{2m}$



$k = \frac{2\pi}{\lambda}$

$E_0 \rightarrow E_0 + dE$

$k_0 \rightarrow k_0 + dk$

$N = ?$ {How many electrons are added}

$k = \frac{n\pi}{a}$; $\Delta k = \frac{\pi}{a}$, $\Delta V_k = \left(\frac{\pi}{a}\right)^3$

smallest possible

No. of states added: $E_0 \rightarrow E_0 + dE \rightarrow k_0 + dk$

$$dN = \frac{\text{vol. increment}}{\text{vol. discreteness}}$$

$$= \frac{4\pi k_0^2 dk}{\left(\frac{\pi}{a}\right)^3} = a^3 \times \frac{4}{\pi^2} k_0^2 dk$$

$$dN = V \times \frac{4}{\pi^2} \times k_0^2 \times \frac{dE\, m}{\hbar^2 k_0}$$

$$\frac{dN}{V dE} = \frac{4 k_0 m}{\pi^2 \hbar^2} = \text{Density of states (D)}$$