* Perturbation Theory handout - Start on Step 4

Final Pert Theory note:

$$U_{kk'} = \int \psi_k^{0*} \, U(\vec{r}) \, \psi_{k'}^{0} \, dV$$

$$= \frac{1}{V} \int U(\vec{r}) \, e^{i(\vec{k}'-\vec{k})\cdot\vec{r}} \, dV \quad \text{(as discussed)}$$

Also as discussed, $\vec{k}' - \vec{k} = \vec{G}$ to give a nonzero integral

So $U_{kk'}$ really $= \frac{1}{V} \int U(\vec{r}) \, e^{i\vec{G}\cdot\vec{r}} \, dV$

compare to $\frac{2}{L} \int f(x) \cos \frac{2\pi n x}{L} \, dx$

or $\frac{1}{L} \int f(x) \, e^{i 2\pi n x / L} \, dx$

fourier coefficient of n^{th} term

$U_{kk'}$ = Fourier coeff associated w/ G!

$= U_{\vec{G}}$ in Kittel's notation from Central Equation. :)

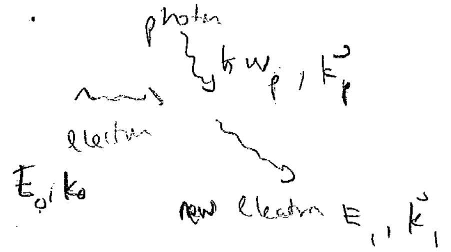
Things fit together!

Another fit: both Central Eqn approach & Pert Theory approach predicted that only states related to $\vec{k}$ via RLV will couple together.

TOPS 35500

Photon Absorption

(Not really in Ch 7, but seems to fit here)



Cons. energy: $E_0 + \hbar\omega_p = E_1$

cons. momentum: $\vec{k}_0 + \vec{k}_p = \vec{k}_1 \pm \vec{G}_{RLV}$

used reduced zone scheme

$\vec{k}_0 + \vec{k}_p = \vec{k}_1$ ↳ can be in different band

Consider magnitude of numbers

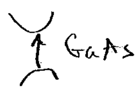
visible light $\lambda \approx 500\,nm \rightarrow k = \frac{2\pi}{\lambda} = \frac{2\pi}{(500\cdot10^{-9})} \approx \underline{10^7\,m^{-1}}$

size of BZ: $\frac{2\pi}{a} \approx \frac{2\pi}{5\cdot10^{-10}\,m} \approx \underline{10^{10}\,m^{-1}}$

Also: $E_{photon} \approx 1\text{-}3\,eV$

Conclusion: **optical transitions look vertical**

only go over $\approx .1\%$ of BZ



Indirect transitions:

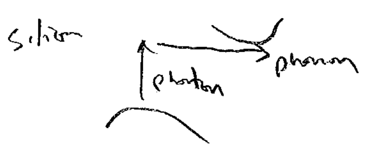
recall phonon energy scales: $f \approx 5\cdot10^{12}\,Hz$ (fig 8, pg 96)

$E = hf \Rightarrow \underline{E = .021\,eV}$

and yet phonon k values include whole BZ

⟹ **phonon transitions look horizontal**

combo transitions called "indirect"



optical absorption at E_g less likely because need to absorb a phonon as well!

(Si can't emit light easily also, for same reason)

but GaAs = great!