LECTURE #21

Note Title 3/2/2009

MIDTERM:

Chapt 1-6 + 8-10

SEMICLASSICAL MODEL Chap 12 A & M

DESCRIBE DYNAMICS OF A BLOCH ELECTRON WITH EQUATION OF MOTIONS

DRUDE / SOMMERFELD ELECTRONS	BLOCH ELECTRONS
$\hat{p} = \hbar k$	$\hbar \hat{k}$ CRYSTAL MOMENTUM $\neq \hat{p}$
$\Delta k = \frac{(2\pi)^3}{V}$ K SPACE INFINITE	$\Delta k = \frac{(2\pi)^3}{V}$ $K \in 1^{o}$ BZ

$$\varepsilon(k) = \frac{\hbar^2 k^2}{2m}$$

$$\varepsilon_m(k) = \varepsilon_m(k+G)$$

$\forall G \in$ RECIPROCAL LATTICE VECTOR

$$\psi_k = \frac{1}{\sqrt{V}} e^{i\vec{k}\cdot\vec{r}}$$

$$\psi_{mk}(\vec{r})$$

$$\psi_k(r + r') = e^{ik\cdot r'} \psi_k(r)$$

CONTINUOUS TRANSLATIONAL SYMMETRY $\forall r'$

$$\psi_{mk}(\vec{r} + \vec{R}) = e^{i\vec{k}\cdot\vec{R}} \psi_{mk}(\vec{r})$$

$\forall R \in$ BRAVAIS LATTICE

$\vec{V}$ RESET AFTER EACH COLLISION WITH ION

COLLISIONS WITH IONS DO NOT AFFECT DYNAMICS OF BLOCH ELECTRONS

$$\dot{p} = -e\left(\vec{E} + \frac{v}{c} \times \vec{H}\right)$$

ψ_{nk} STEADY STATE

$$v_n(k) = \frac{1}{\hbar}\frac{\partial \mathcal{E}(k)}{\partial \vec{k}}$$

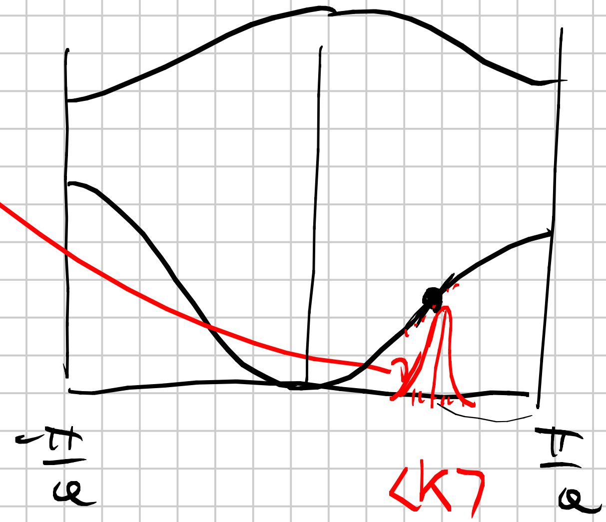
$\tau = \infty$ $\sigma = \infty$

BLOCH ELECTRON τ IS FINITE BECAUSE OF:

1. IMPURITIES AND DEFECTS
2. LATTICE VIBRATIONS

DESCRIBE DYNAMICS BETWEEN COLLISIONS (1 OR 2)

$$\psi_n(\vec{r}) = \sum_k g(k)\, \psi_{nk}(\vec{r})$$



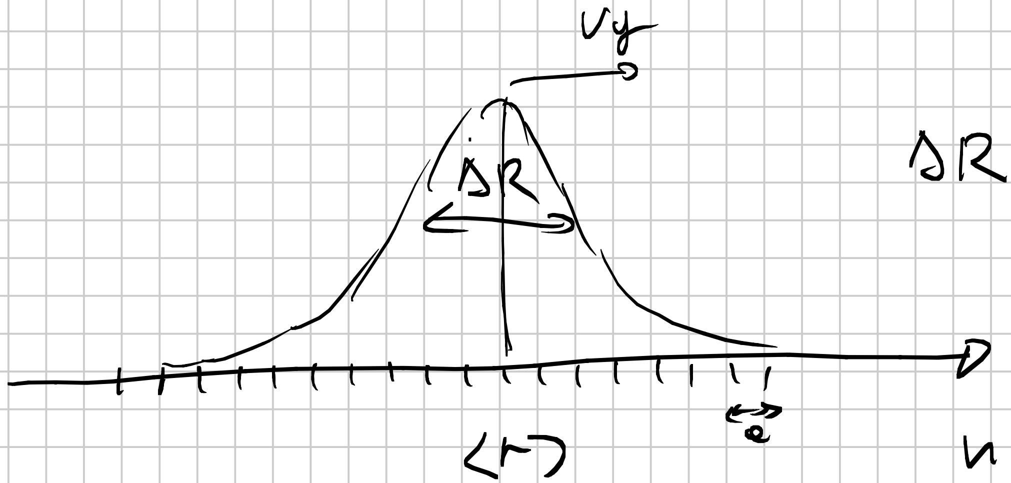
$$\psi_n(\vec{r},t) = \sum_k g(k)\, e^{-\frac{i\varepsilon_n(k)}{\hbar}t}\, \psi_{nk}(\vec{r})$$

$$V_g = \frac{1}{\hbar}\frac{\partial \varepsilon_n(k)}{\partial \vec{k}}\bigg|_{k=\langle K \rangle}$$

ΔK OF WAVE PACKET $\ll \frac{2\pi}{a}$

$\Delta R \, \Delta K \sim 1$

"SIZE" OF e WAVEPACKET $\Rightarrow$ $\Delta R \gg \frac{a}{2\pi}$



$\Delta R \gg a$

$\Rightarrow$ "SIZE" OF ELECTRON $\gg$ UNIT CELL

SEMICLASSICAL EQUATIONS OF MOTION

① FIX THE BAND

② $$\frac{d\langle r \rangle}{dt} = \dot{r} = \frac{1}{\hbar} \left. \frac{\partial \varepsilon_m(k)}{\partial k} \right|_{k = \langle k \rangle}$$

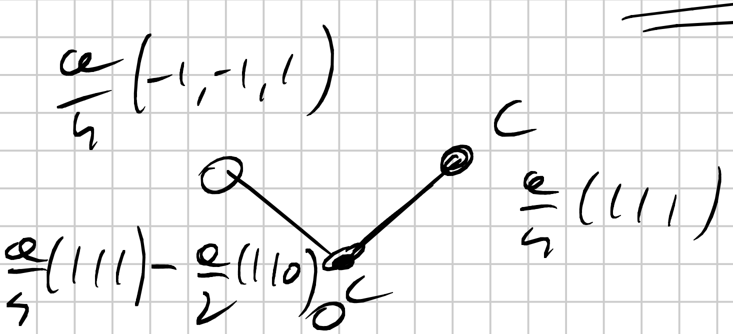
③ $\hbar\langle \dot{k}\rangle = -e\left(\vec{E} + \frac{\vec{v}(k)}{c}\times\vec{H}\right)$

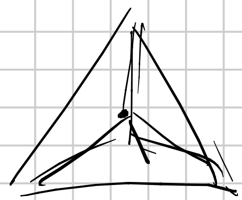
$\langle k+G\rangle = \langle k\rangle$

③ CAN BE DERIVED FROM ENERGY CONSERVATION.

$\boxed{\text{FCC}}$ $\quad 0 \quad \frac{a}{4}(1,1,1)$

$\frac{a}{2}(110) \quad \frac{a}{2}(101) \quad \frac{a}{2}(011)$





$$\varepsilon(k_x, k_y) = \hbar v_F \sqrt{k_x^2 + k_y^2}$$

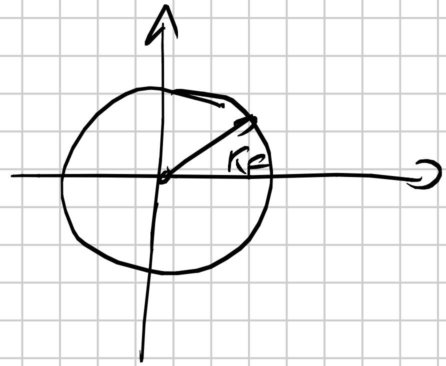
$$g(\varepsilon) = 2 \int \frac{d^2 k}{(2\pi)^2} \delta(\varepsilon - \hbar v |k|) =$$

$$\hbar v_F k = \cancel{x}$$

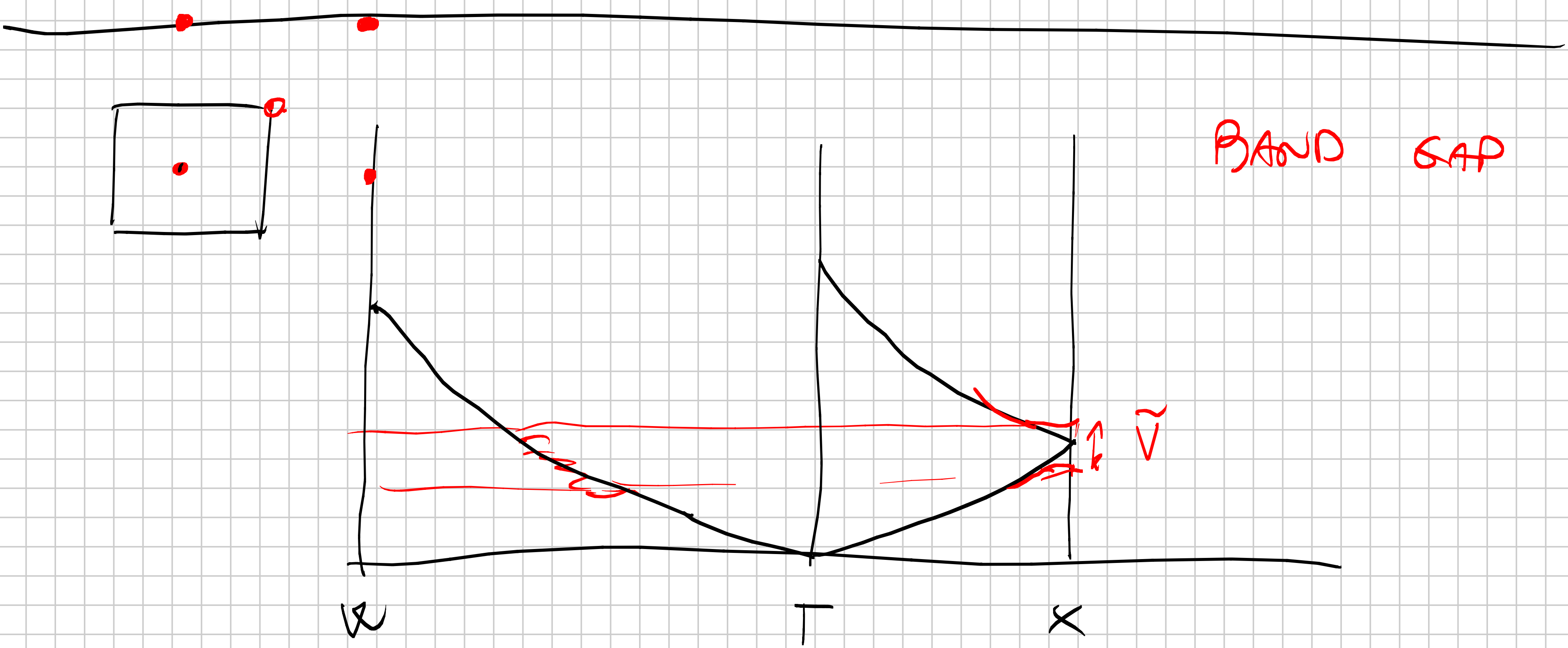
$$= 2 \frac{\cdot 2\pi}{(2\pi)^2} \int_0^\infty k \, dk \, \delta(\varepsilon - \hbar v k) \qquad \hbar v_F dk = dx$$

$$= \ldots \frac{1}{(\hbar v_F)^2} \int_0^\infty x \, dx \, \delta(\varepsilon - x) = \frac{1}{(\hbar v_F)^2} \varepsilon$$

$K_F \Rightarrow$



$$\frac{2\pi k_F^2}{\frac{(2\pi)^2}{A}} = N. \quad = \quad n = \frac{k_F^2}{2\pi}$$



$$V(x,y)$$

$$\frac{1}{A}\int dx\,dy \; \underbrace{V(x,y)} \; \underbrace{e^{i\frac{2\pi}{a}x}\, e^{i\frac{2\pi}{a}y}}$$