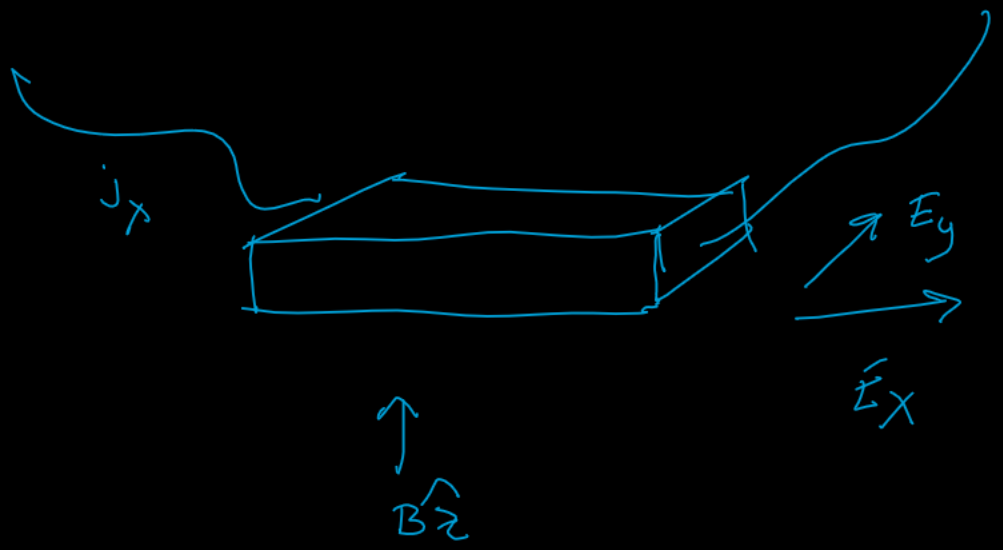
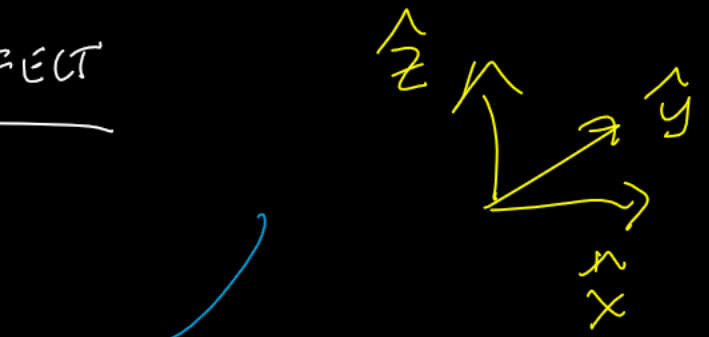
Lecture 5

Monday, January 25, 2021

HALL EFFECT





HALL FIELD IS E_y (COMES FROM $\vec{B}$)

STEADY STATE:

$$V_x = -\frac{e E_x}{m}\tau - \omega_c \tau V_y \qquad \omega_c = \frac{eB}{mc}$$ CYCLOTRON FREQ.

$$V_y = -\frac{eE_y\tau}{m} + \omega_c\tau V_x$$

$V_y = 0$ (NO CURRENT)

$$+\frac{eE_y\tau}{m} = \omega_c\tau V_x = -\frac{eE_x\tau(\omega_c\tau)}{m}$$

HALL COEFFICIENT

$$R_H \equiv \frac{E_y}{j_x B} = -\frac{e\tau}{mc}\frac{E_x}{j_x} = -\frac{e\tau}{mc\sigma} = -\frac{e\tau}{mc}\left(\frac{m}{ne^2\tau}\right)$$

$$\boxed{R_H = -\frac{1}{nec}}$$

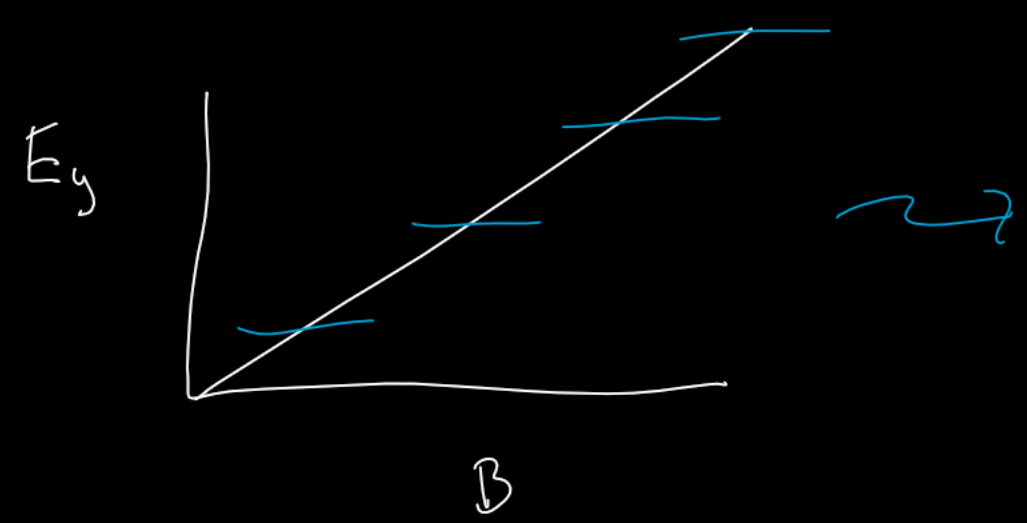
① MEASURES "SIGN" OF CHARGE CARRIER

$\left(\frac{1}{n(-e)c}\right)$

$\left(\frac{1}{n(-e)c}\right)$

(2) DOES NOT DEPEND ON τ, m

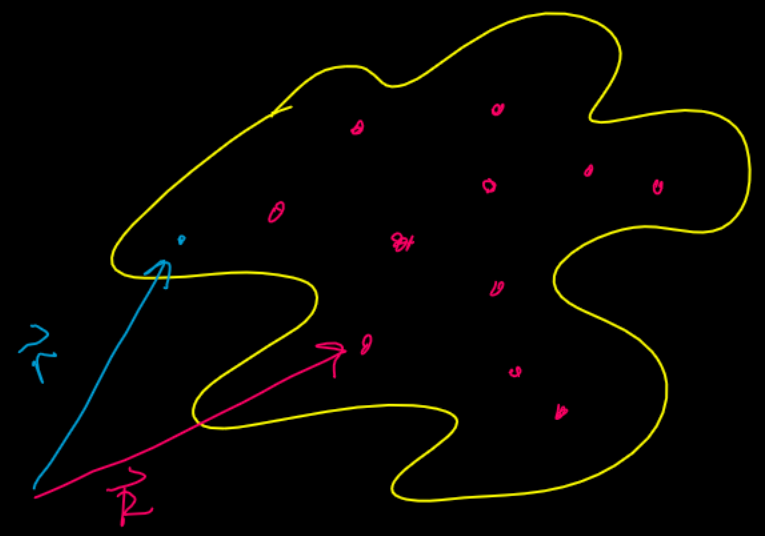
(3) R_H MEASURES n WHICH COULD DEPEND ON T



LOW T, PURE MATERIALS

"QUANTUM HALL EFFECT"

CHAP. 1



• NUCLEI + CORE ELECTRONS

$$U(\vec{r}) = \sum_{\{\vec{R}\}} v(\vec{r}-\vec{R})$$

$$H = \sum_i H_i \qquad H_i = -\frac{\hbar^2 \nabla_i^2}{2m} + U(\vec{r}_i)$$

H_i : 1-PARTICLE

$U(\vec{r})$: e^- – ION POTENTIAL

$U(\vec{r})$ ① LIQUID (1 – CONFIGURATION)

② GLASSY (AMORPHOUS)

③ ION ARE IN CRYSTAL (HIGH SYMMETRY)

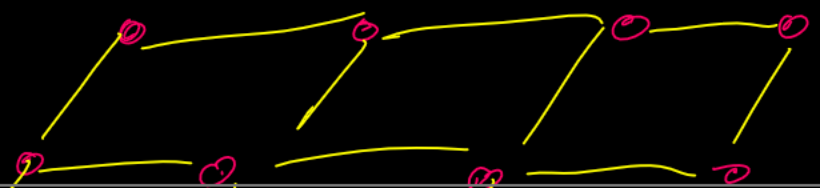
$$H(\vec{p}, \vec{r}+\vec{R}) = H(\vec{p}, \vec{r}) \quad \forall \vec{R} \ni \vec{R} = n_1\vec{a}_1 + n_2\vec{a}_2 + n_3\vec{a}_3$$

$$n_1, n_2, n_3 \in \mathbb{Z}$$

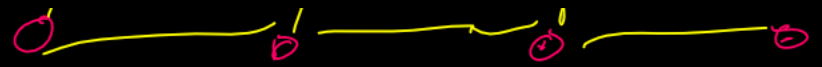
$\vec{a}_1, \vec{a}_2, \vec{a}_3$ ARE LINEAR IND. VECTORS

$$\{\vec{R} : \vec{R} = n_1\vec{a}_1 + n_2\vec{a}_2 + n_3\vec{a}_3,\ n_1, n_2, n_3 \in \mathbb{Z}\}$$

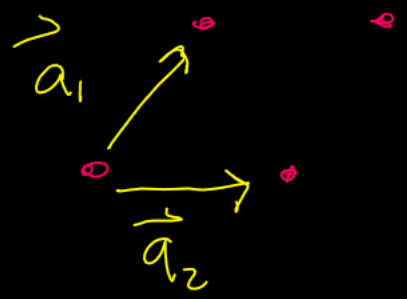
"LATTICE" (BRAVAIS LATTICE)

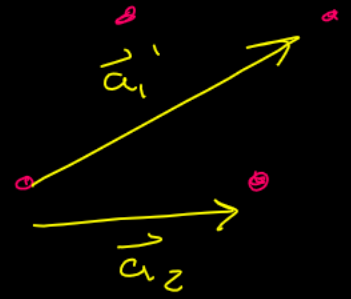


PERIODIC ARRAY OF POINTS IN SPACE

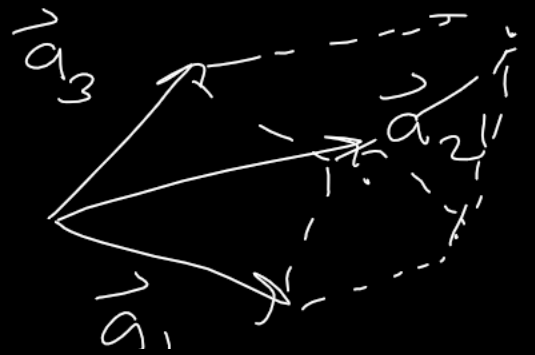


$\{\vec{a}_i\}$ ARE NOT UNIQUE (PRIMITIVE VECTORS)





FILL ALL SPACE BY TRANSLATING A "PRIMITIVE" CELL



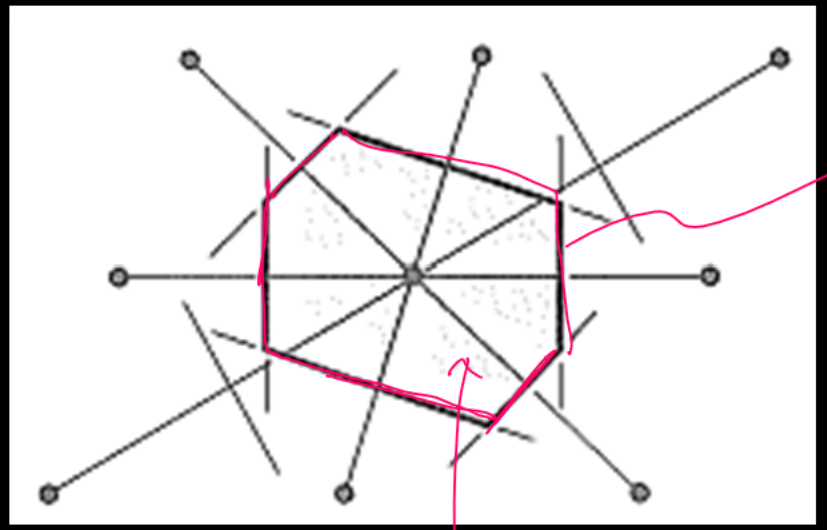
$$V_{11} = \vec{a}_1 \cdot \vec{a}_2 \times \vec{a}_3$$

$\vec{a}_j$ -

PARALLELIPIPED

"SPECIAL UNIT CELL"

WIGNER-SEITZ CELL



CRYSTAL = LATTICE + "BASIS"
STRUCTURE

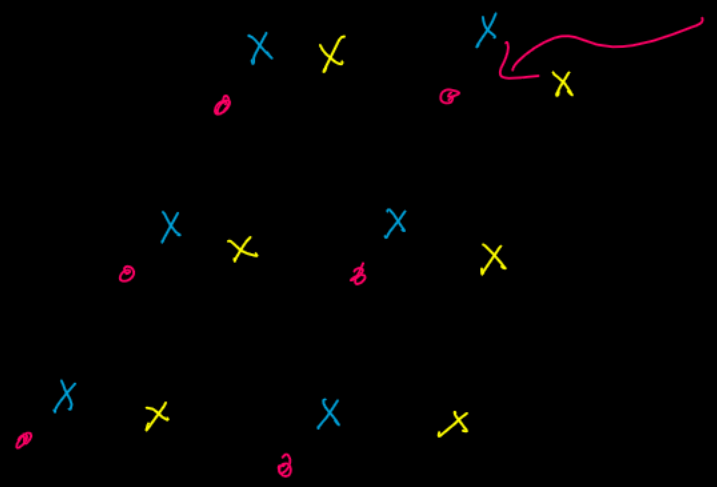
BASIS = $\{ r_i \}$ $\quad r_j = x_j \vec{a}_1 + y_j \vec{a}_2 + z_j \vec{a}_3$

BASIS $\simeq \{ r_i \}$

"ATOMS"

$$r_j = x_j \vec{a}_1 + y_j \vec{a}_2 + z_j \vec{a}_3$$

$$0 \leq x_i, y_i, z_i < 1$$



LATTICE POINTS

$\{ \times, \times \}$

2-D $\Rightarrow$ 5 LATTICE TYPES

3-D $\Rightarrow$ 14 LATTICE TYPES

CRYSTALS MORE COMPLICATED.