

HALL EFFECT EXPERIMENT:

$$R_{xx} = \frac{V_x}{I_x}$$

$$\rho_{xx} = \frac{E_x}{j_x} = \text{Resistivity}$$

$$\rho_{xy} = \frac{E_y}{j_x}$$

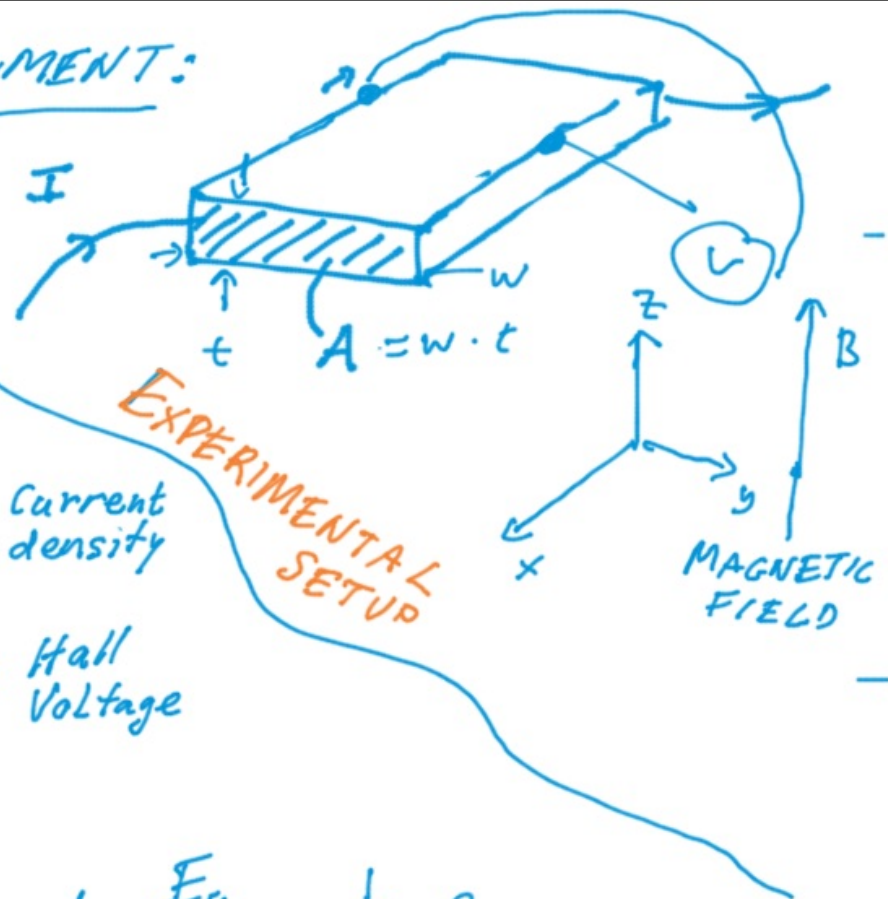
$$R_{xy} = \frac{V_y}{I_x}$$

$$j_x = \frac{I_x}{w \cdot t} = \text{Current density}$$

$$V_y = w E_y = \text{Hall Voltage}$$

$$R_{xy} = \frac{V_y}{I_x} = \frac{w E_y}{j_x \cdot w t} = \frac{1}{t} \frac{E_y}{j_x} = \frac{1}{t} \cdot \rho_{xy}$$

GEOMETRY FACTOR



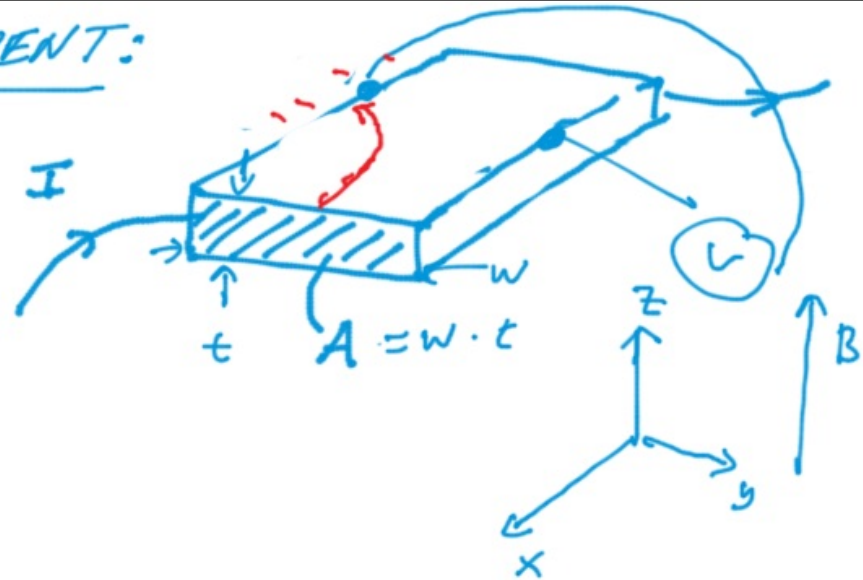
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HALL EFFECT EXPERIMENT:

$$F = -e(\vec{E} + \vec{v} \times \vec{B})$$

= LORENTZ FORCE



$$E_y = -v_x \cdot B_z$$

$$j_x = -en v_x$$

$$V_y = -E_y \cdot w = +v_x \cdot B_z \cdot w = \frac{-j_x}{en} \cdot B_z \cdot w = \frac{-I_x}{en w \cdot t} B_z w$$

$$R_{xy} = \frac{V_y}{I_x} = \frac{-1}{en} \frac{1}{t} \cdot B_z$$

$$S_{xy} = t \cdot R_{xy} = \frac{-1}{en} B_z$$

$$S_{xy} = R_H \cdot B_z = \text{HALL RESISTANCE}$$

$$R_H = \frac{-1}{ne} = \text{HALL COEFFICIENT}$$

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CHARGED PARTICLE IN MAGNETIC FIELD

$\hbar \frac{dk}{dt} = -e \vec{v} \times \vec{B}$

$= -e \frac{dr}{dt} B_z$

\Downarrow
 $dk = \frac{-e B_z}{\hbar} dr$

CIRCUMFERENCE OF ORBIT

$l_S = 2\pi k_F$
 $l_A = 2\pi \frac{e B_z}{\hbar} k_F$

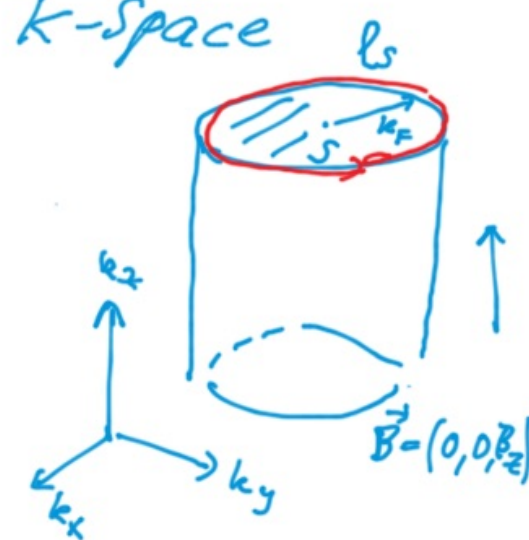
AREA OF ORBIT

$S = \pi k_F^2$
 $A = \left(\frac{\hbar}{e B_z}\right)^2 S$

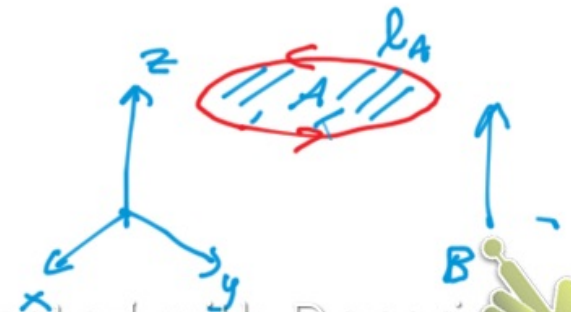
Flux:


$\Phi = B_z A$
 $= \left(\frac{\hbar}{e}\right)^2 \frac{S}{B_z}$

k-space



REAL SPACE



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Flux: →
$$\begin{aligned} \Phi &= B_z \cdot A \\ &= \left(\frac{\hbar}{e}\right)^2 \bar{B}_z \end{aligned}$$

Flux quantization

$$\Phi = (n + \gamma) \frac{\hbar}{e} \quad ; \quad \gamma = \frac{1}{2} ; n = 0, 1, 2, 3 \dots$$

$$\begin{aligned} S &= \left(\frac{e}{\hbar}\right)^2 \cdot B_z \cdot \Phi = \left(\frac{e}{\hbar}\right)^2 \cdot B \cdot (n + \gamma) \frac{2\pi \hbar}{e} \\ &= \frac{2\pi e}{\hbar} B (n + \gamma) \end{aligned}$$

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Flux quantization

$$\Phi = (n + \gamma) \frac{h}{e} \quad ; \quad \gamma = \frac{1}{2}; n = 0, 1, 2, 3 \dots$$

$$S = \left(\frac{e}{h}\right)^2 \cdot B_z \cdot \Phi = \left(\frac{e}{h}\right)^2 \cdot B \cdot (n + \gamma) \frac{2\pi h}{e} = \frac{e}{h} 2\pi B (n + \gamma)$$

Define: $\Delta B = B_{n+1} - B_n$

$$S_{n+1} = \frac{e}{h} 2\pi B_{n+1} (n+1 + \gamma) = S_n = \frac{e}{h} 2\pi B_n (n + \gamma)$$

$$\Downarrow B_{n+1} (n+1 + \gamma) = (B_{n+1} - \Delta B) (n + \gamma)$$

$$\Downarrow -\Delta B (n + \gamma) = B_{n+1}$$

$$\Downarrow n + \gamma = \frac{-B_{n+1}}{\Delta B}$$

$$S_n = \frac{e}{h} 2\pi \frac{B_n B_{n+1}}{\Delta B} \Rightarrow S_n \left(\frac{1}{B_{n+1}} - \frac{1}{B_n} \right) = \frac{2\pi e}{h}$$

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ϵ vs s graph showing a linear relationship.
 s quantized $\Rightarrow \epsilon_k$ quantized \Rightarrow DOS PEAK = LANDAU LEVELS

ϵ_k vs k graph showing a parabolic energy band.

ϵ vs DOS graph showing discrete peaks. The spacing between peaks is $\hbar\omega_c$.

LANDAU LEVELS
 $E_n = (n - \frac{1}{2})\hbar\omega_c$

Centripetal Force = $\frac{mv^2}{r} = eBv$
 ORBIT PERIOD = $T = \frac{2\pi r}{v}$
 FREQUENCY = $f = 1/T = \frac{v}{2\pi r}$

CYCLOTRON FREQUENCY
 $\omega_c = 2\pi f = \frac{eB}{m}$
 $\hbar\omega_c (1T) \approx 10^{-4} eV$

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