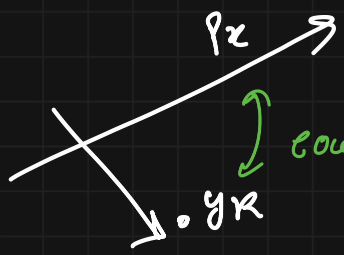
Recap

Q Hall system → Datta's book
↓
Q Hall & Landauer Buttiker approach

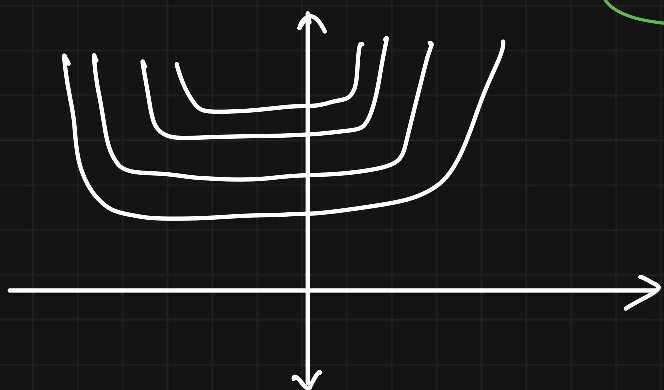


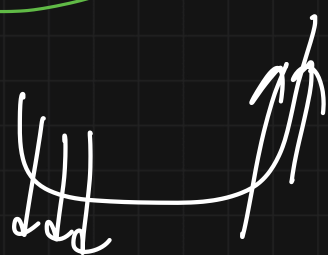
① 2DEG + magnetic field
② 2DEG + " "
+ confining potential
↓
not a realistic potential

2 en scales → ω_c & ω_0

$$\omega_{c0}^2 = \omega_c^2 + \omega_0^2$$

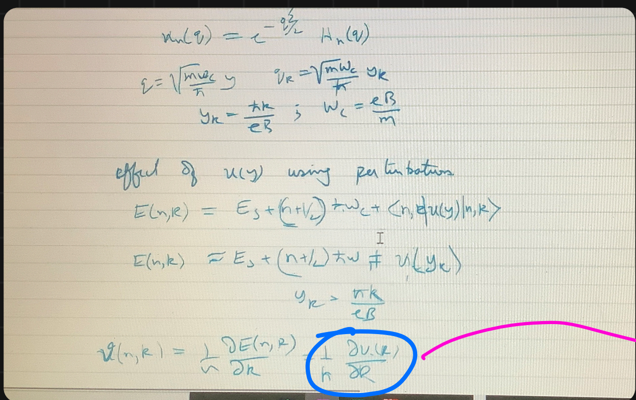
$$\mathcal{E} = \mathcal{E} + \left(n+\frac{1}{2}\right)\hbar\omega + \frac{\hbar^2 k^2}{2m}\frac{\omega_0^2}{\omega_{c0}^2} \sim \frac{1}{2M^*}$$





State on a side move one direction

Choice of arbitrary potential



$$u_n(q) = e^{-q^2/2} H_n(q)$$

$$q = \sqrt{\frac{m\omega_c}{\hbar}}\, y \qquad q_k = \sqrt{\frac{m\omega_c}{\hbar}}\, y_k$$

$$y_k = \frac{\hbar k}{eB} \; ; \; \omega_c = \frac{eB}{m}$$

effect of $u(y)$ using perturbation

$$E(n,k) = E_s + (n+1/2)\hbar\omega_c + \langle n,k|u(y)|n,k\rangle$$

$$E(n,k) \approx E_s + (n+1/2)\hbar\omega + u(y_k)$$

$$y_k = \frac{\hbar k}{eB}$$

$$v(n,k) = \frac{1}{\hbar}\frac{\partial E(n,k)}{\partial k} = \frac{1}{\hbar}\frac{\partial u(k)}{\partial k}$$

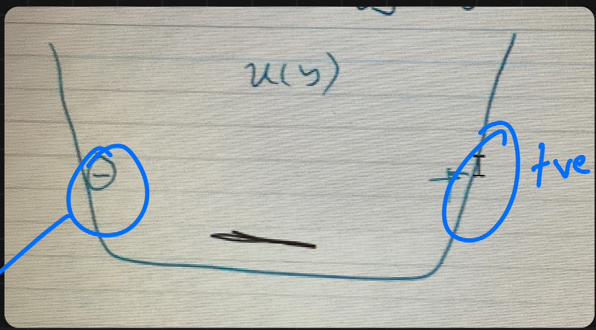
→ group velocity

$$\langle n,k|U(y)|n,k\rangle = U(y_k)$$

How??

$$v(n,k) = \frac{1}{\hbar}\frac{\partial \varepsilon(n,k)}{\partial k} = \frac{1}{\hbar}\frac{\partial u(y_k)}{\partial y_k}\cdot\frac{\partial y_k}{\partial k}$$

$$= \frac{1}{eB}\frac{\partial u(y_k)}{\partial y_k}$$



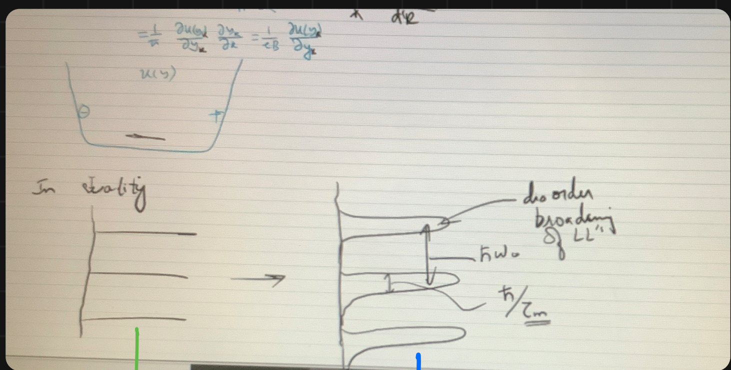
+ve Group velocity

-ve sign of Gp velocity

∴ a similar argument works for our case too.

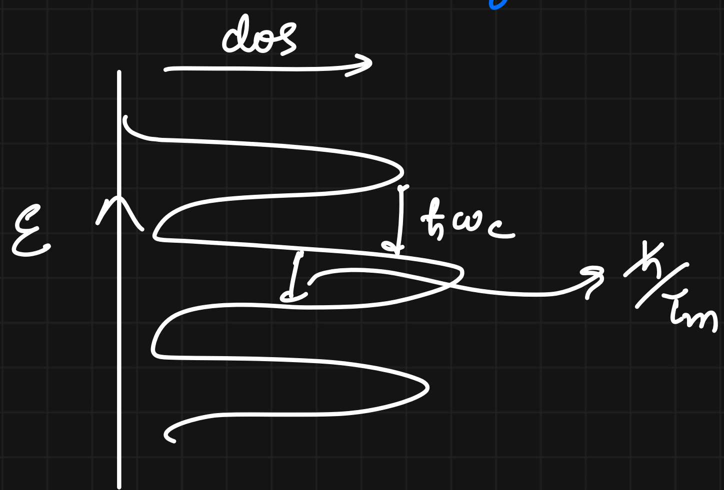
→ Away from edges its an insulator but at boundaries it's <u>conductor</u>.

⇒ In reality there are some disorder:-



ideal

reality (due to disorder)



$$\therefore \quad \omega_c > \frac{1}{\tau_m} \Rightarrow B > \frac{m}{e\tau_m} = \frac{1}{\left(\frac{e\tau_m}{m}\right)} = \frac{1}{\mu}$$

intrinsic mobility of the system

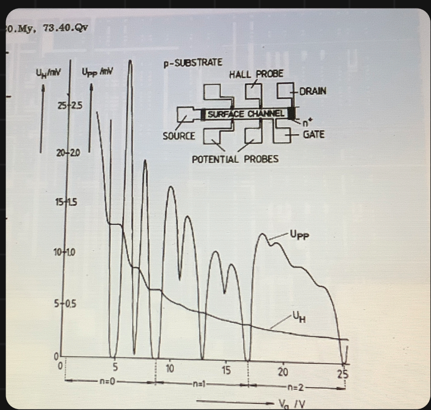
If it's extremely disordered system, with $\tau_m <<< 1$, then we'd have to go extremely large $\vec{B}$.

Klitzing' paper $\longrightarrow$ developed a high mobility 2DEG.

#

Gate voltage $\propto$ density of charge carriers

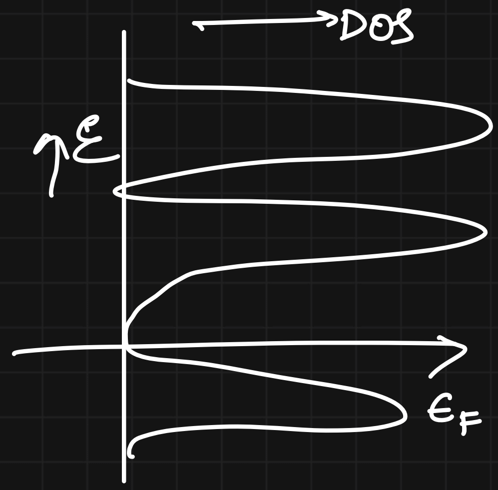
$\rightarrow$ Hall voltage doesn't drop smoothly.

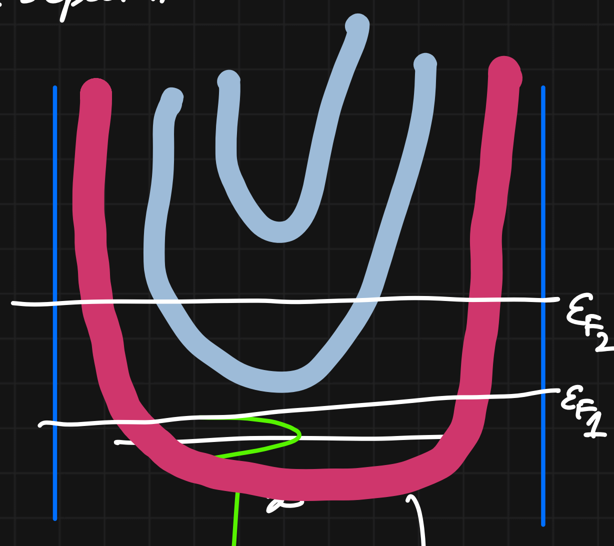


at plateaus, the longitudinal <u>resistance</u> <u>drops</u>.

$\sim 18\,T \rightarrow$ LL well separated

#

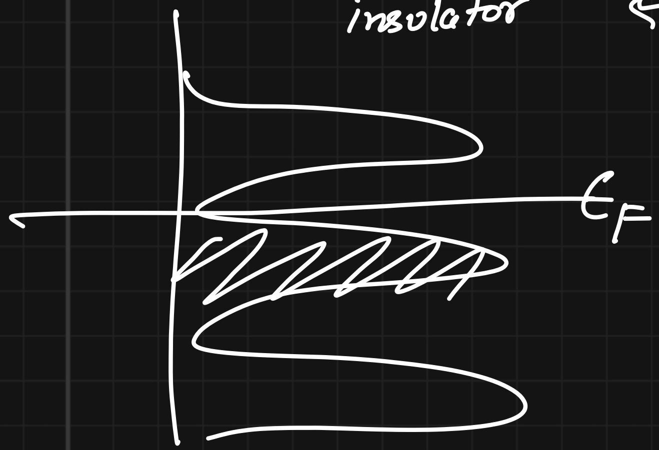


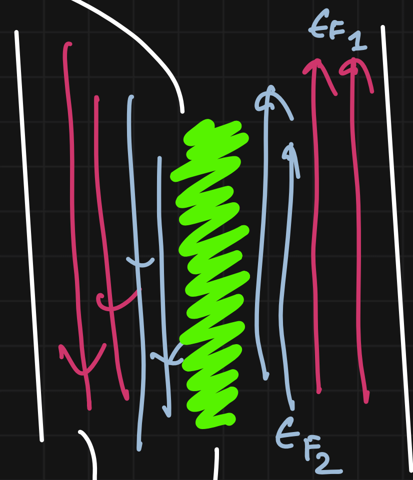


at middle.

fatter/ broadened L.L

insulator





∴ more the ϵ_F, more the edge states involved.

→ no states available for insulator

free electron like,

& plane wave like → 1D

Peculiarity

In 1D, if we have to backscatter, i'll have to invert my $\vec{k}$

↓

have to go the other edge.

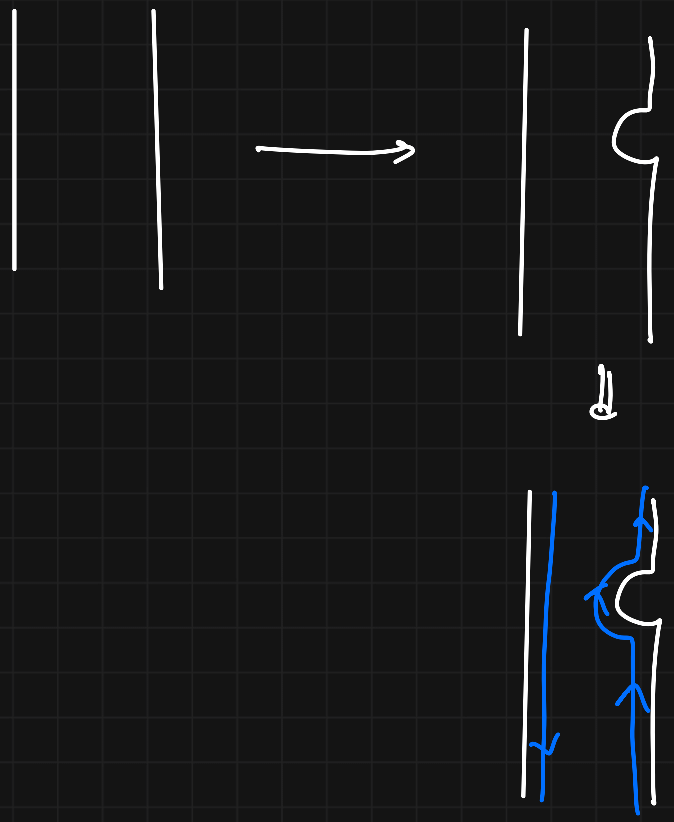
Selection Rule

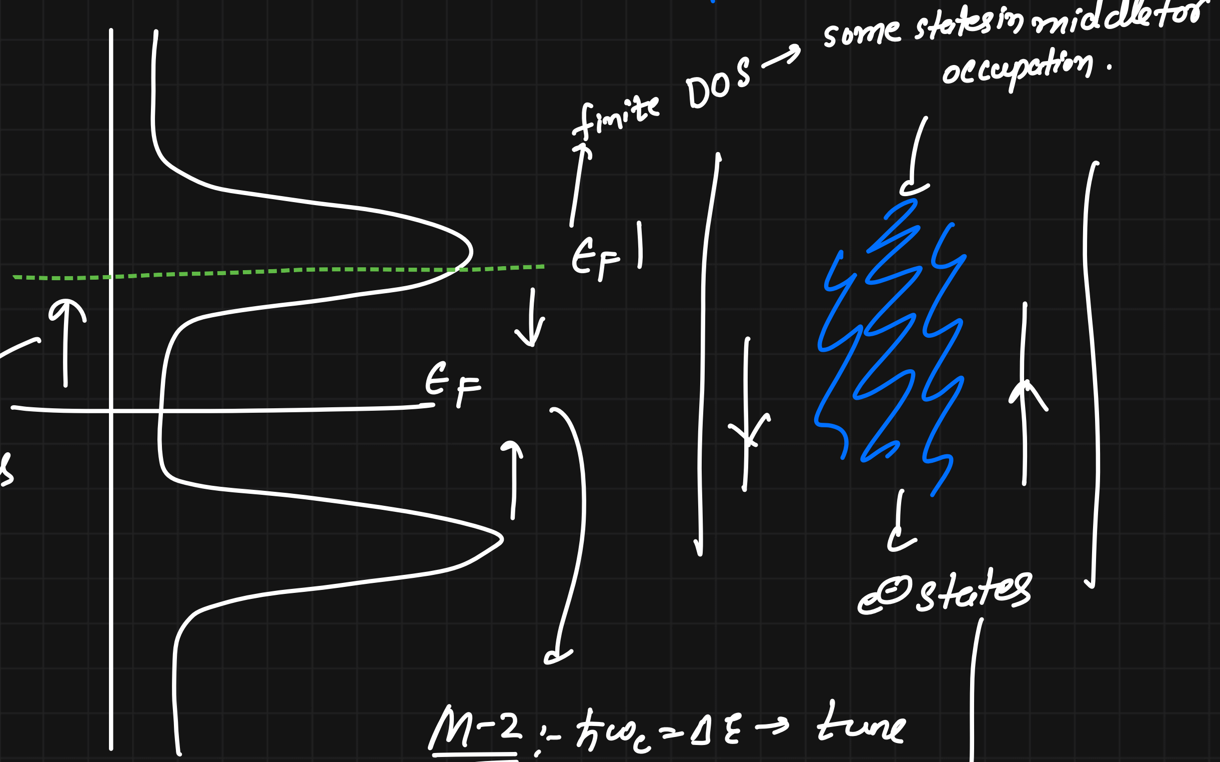
∴ Backscattering is highly suppressed in Q Hall system.

⇒ not 0 (like a SC) but supremely small.

⇒ seem to have a protection.

Protection:-



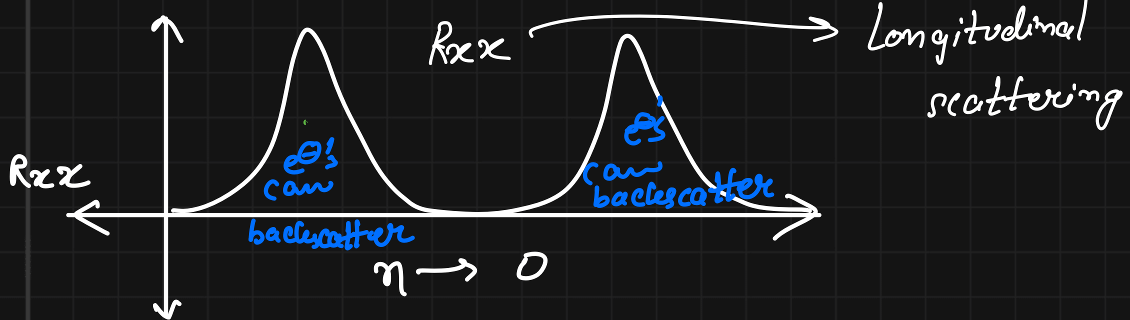


M-1 add extra electrons "doping"

M-2 :- $\hbar\omega_c = \Delta E \rightarrow$ tune B

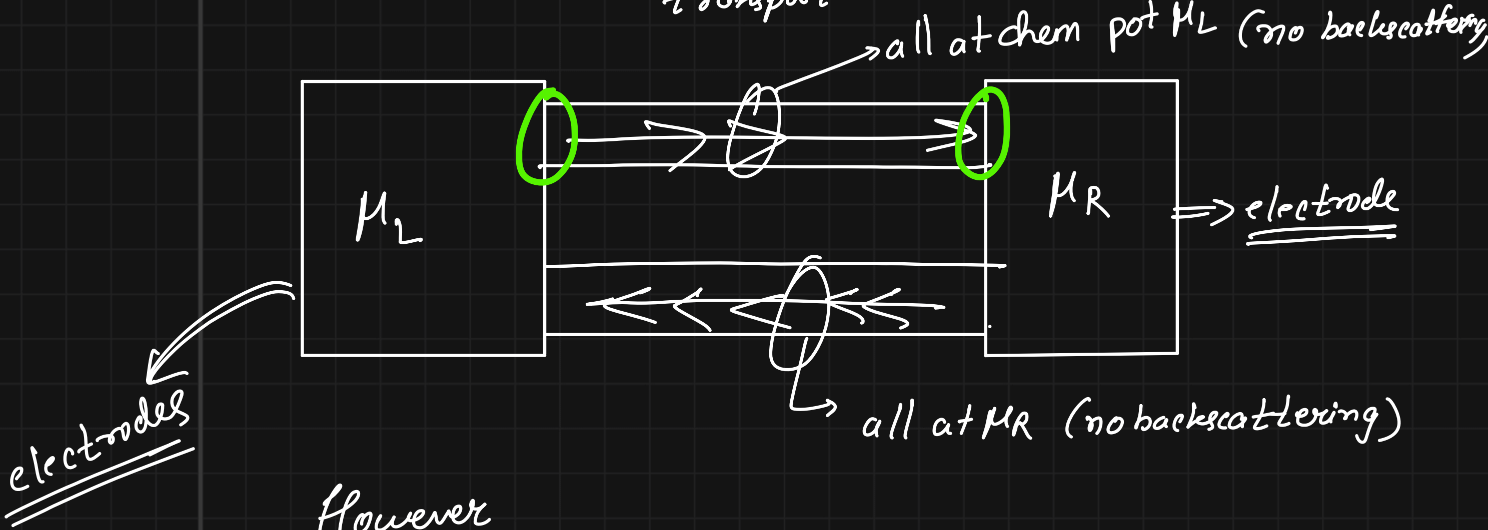
↓ now electrons can backscatter

$\therefore$ ϵ_F is middle of Landau level, Longitudinal resistance shoots up.

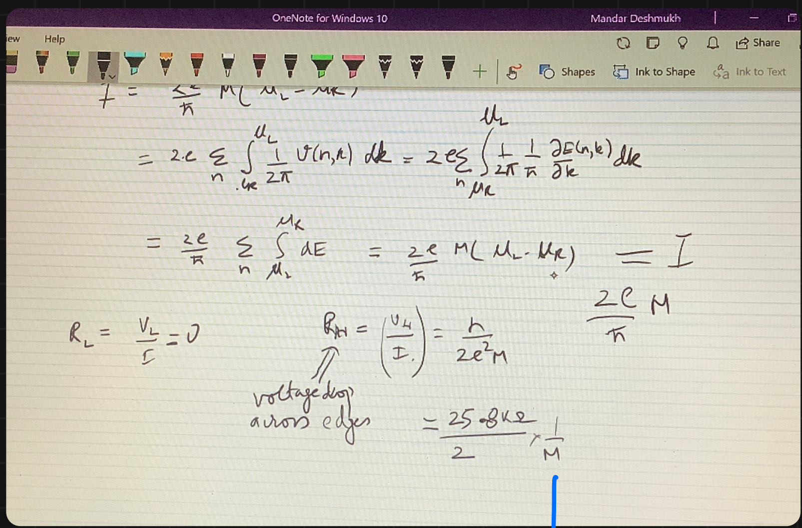


R_{xy}

$R_{xy} \rightarrow$ set by how many channels are present for transport



However



$$I = \frac{2e}{h} M(\mu_L - \mu_R)$$

$$= 2e \sum_n \int_{\mu_R}^{\mu_L} \frac{1}{2\pi} v(n,k)\, dk = 2e \sum_n \int_{\mu_R}^{\mu_L} \frac{1}{2\pi} \frac{1}{\hbar} \frac{\partial E(n,k)}{\partial k} dk$$

$$= \frac{2e}{h} \sum_n \int_{\mu_L}^{\mu_R} dE = \frac{2e}{h} M(\mu_L - \mu_R) = I$$

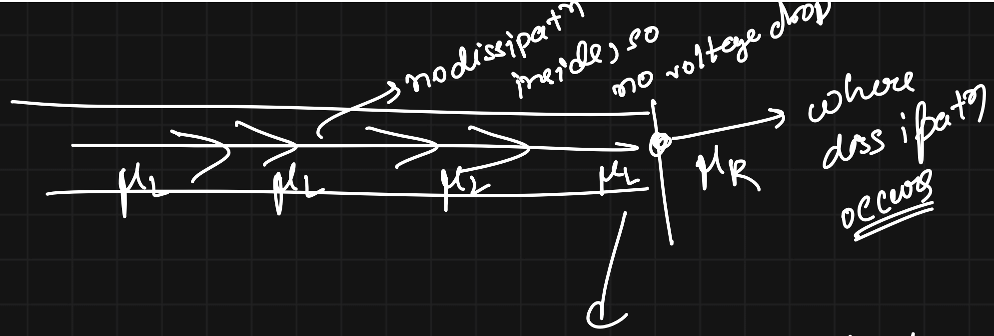
$$\frac{2e}{h} M$$

$$R_L = \frac{V_L}{I} = 0 \qquad R_H = \left(\frac{V_H}{I}\right) = \frac{h}{2e^2 M}$$

voltage drop across edges

$$= \frac{25.8\,k\Omega}{2} \times \frac{1}{M}$$

M = # of modes involved.



no dissipation inside but at ends only.