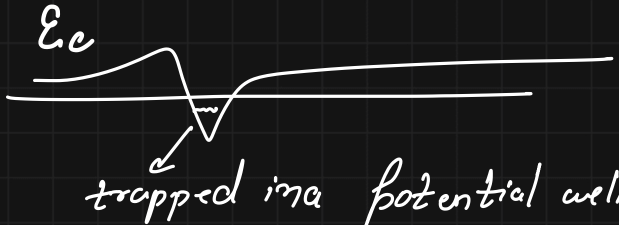
Recap

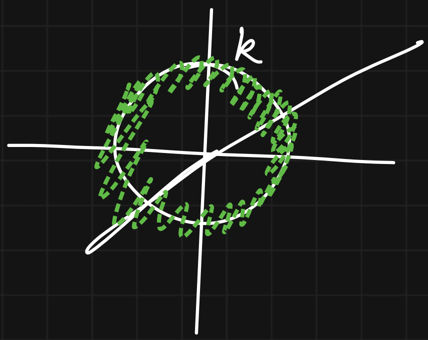
\# 2D system → not only where topo is relevant



metal-semiconductor junction

\# drift → drude picture → elastic collisions, momentum gets scrambled

\#



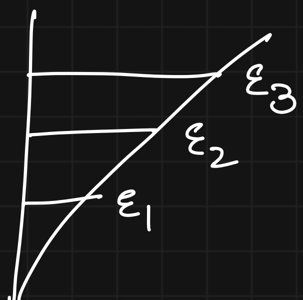
steady state

$$\left(\frac{dp}{dt}\right)_{scattering} = \left(\frac{dp}{dt}\right)_{field}$$

$$v_d = \frac{e\tau_m}{m} E \quad \text{or} \quad \mu = \frac{e\tau_m}{m}$$

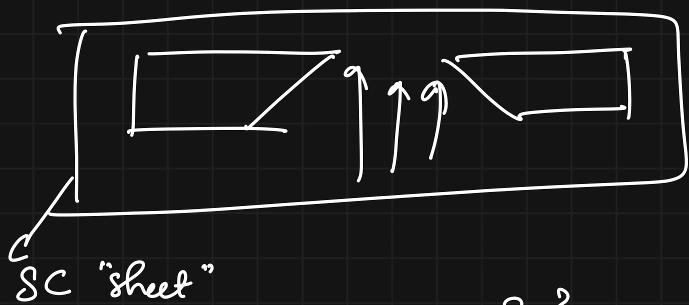
\# Concept of subbands → for confinement along z-direction

$$\psi(z) = \phi_n(z)\, e^{ik_x x}\, e^{ik_y y}$$



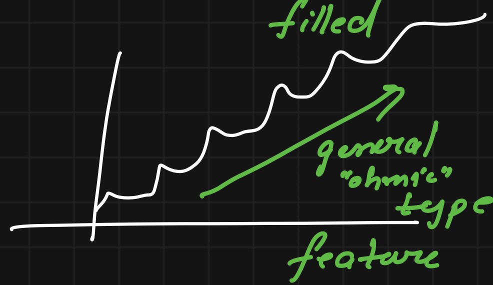
$$\mathcal{E} = \mathcal{E}_c + \mathcal{E}_n + \frac{\hbar^2}{2m}(k_x^2 + k_y^2)$$

\# PRL paper → quantized conductance



Gate voltage
↳ # of states that are filled

$$\sigma = \frac{2e^2}{h} n$$



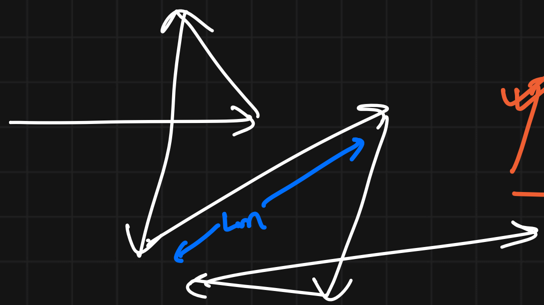
Question 2

diffusive model works? or do we need something extra?

remark

Length scales

momentum scattering length.



$$\boxed{l_m \sim v_f \tau_m}$$

"This is due to ELASTIC scattering" & not INELASTIC scattering

Problem:-

states $\rightarrow \frac{1}{4\pi^2} \times 2 \times d^2k$ $\qquad \mathcal{E} = \frac{\hbar^2 k^2}{2m}$

$$= \frac{1}{2\pi^2} \cdot k\,dk\,(2\pi)$$

$$d\mathcal{E} = \frac{\hbar^2}{m} k\,dk$$

$$= \frac{1}{\pi} k\,dk$$

$$= \frac{1}{\pi} d\mathcal{E} \frac{m}{\hbar^2} \Rightarrow \underbrace{\frac{m}{\pi\hbar^2}}_{\text{indpt of energy}} = g(\mathcal{E})$$

$$\int \frac{1}{\pi} \times (1) \times d\mathcal{E} = \frac{m\,\mathcal{E}_F}{\hbar^2 \pi} = n$$

$$\frac{m}{\hbar^2} \times \frac{1}{\pi} \frac{\hbar^2 k_F^2}{2m} = n$$

$$k_F = \sqrt{2\pi n}$$

periodic BCs

$$\boxed{\frac{dn}{d\mathcal{E}} = \frac{m}{\pi\hbar^2}}$$

$$m v_F = \hbar k_F \quad \Rightarrow v_F = \frac{\hbar k_F}{m} = \frac{\hbar}{m}\sqrt{2\pi n}$$

$$\boxed{L_m = v_f \tau_m \longrightarrow \text{momentum scattering}}$$

1 more length scale

$$\lambda_f = \frac{1}{k_F} \longrightarrow \lambda_f = \text{de-broglie wavelength of electrons}$$

$$\lambda_f \sim (n^{-1/2})$$

$$k_f \sim (n)^{1/d}$$

$$\lambda_f \sim (n)^{-1/d}$$

Problem

What is the typical λ_f for electrons in typical metals?

Ans:- $\lambda_f \sim \text{Å}$ (for typical metals) $n \sim 10^{22}\ cm^{-3}$

atomic spacing

$$\lambda_f \sim (n)^{-1/d}$$

$\lambda_{f\,semicond} \sim$ larger than metals

↳ essentially a small n

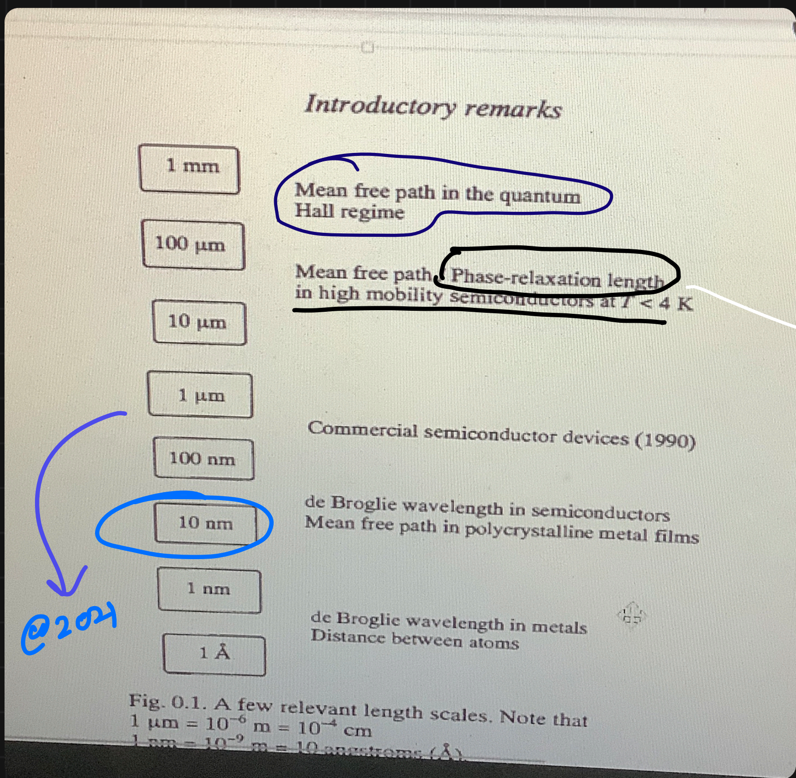


Fig. 0.1. A few relevant length scales. Note that 1 µm = 10^{-6} m = 10^{-4} cm

→ S.datta

gives diff regimes of transport

Phase relaxatn

If source of collision is inelastic ⟶ "phase" of e gets scrambled

Phase coherence time scale:-

drop an e^- into a solid → gets scattered due to "Inelastic collisions"
(e^-'s, phonons, magnetic)

↓

Quantum coherence of phase is lost.
(decoherence/dephasing)

elastic scattering → no decoherence
↳ might add a const. phase

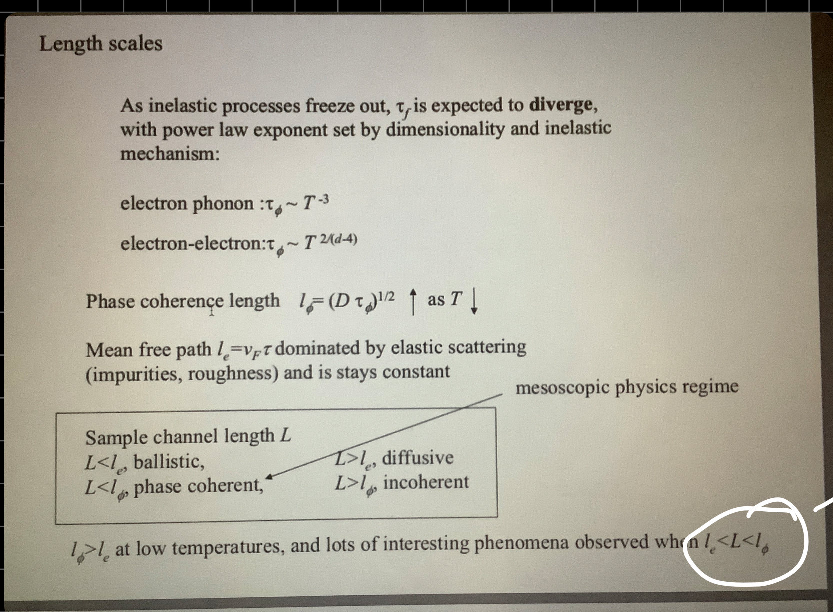
on some timescale τ_ϕ → e^- becomes uncorrelated from its initial phase.

↓

interference effects wash out.

Dist e^- moves in this time in a diffusive system

$$l_\phi = (D\tau_\phi)^{1/2} = \text{"Coherence length"}$$

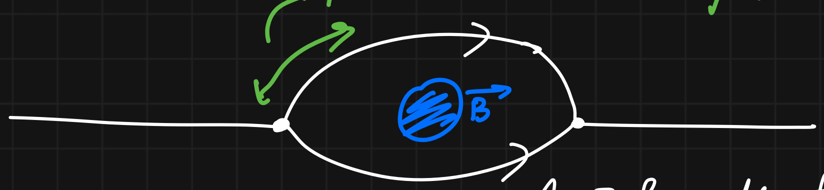


weak localization / weak-anti localization expt → double slit

phase coherence length → energy rel. mech

↓

phase gets scrambled



A-Bohm effect

kind of ✓

collisions

BIG picture

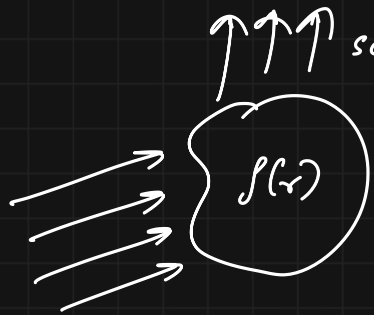
All collisions that have fixed target, then the phase is same in & out.

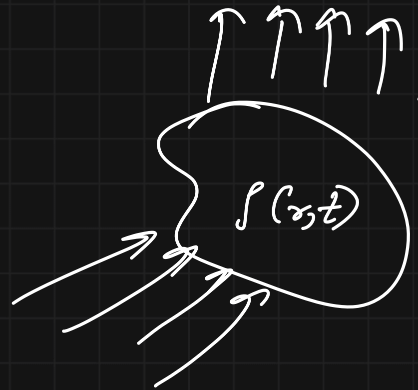
↳ "no time dependence"

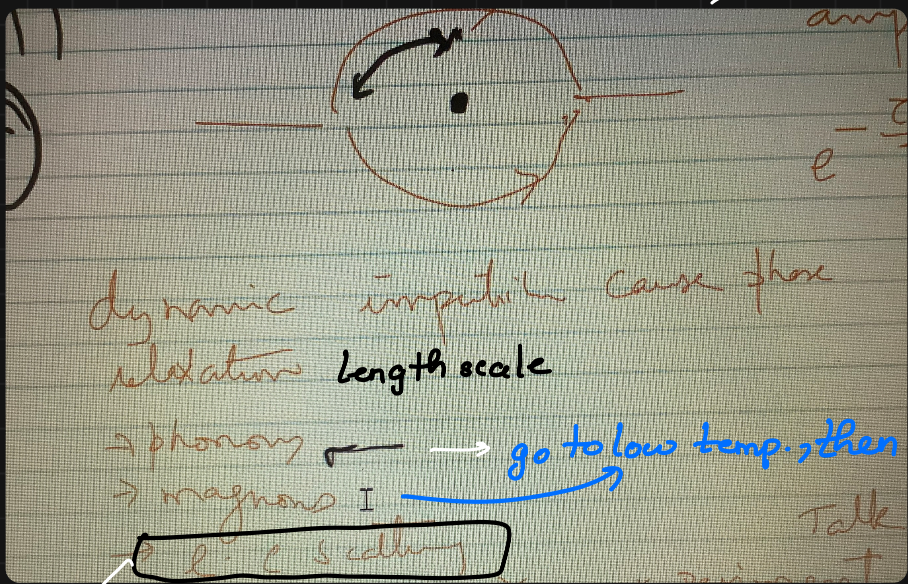
↳ t dependence ⇒

same phase

phase info is destroyed







go to low temp., then they'll just condense

↳ at low temp, it's still there.

↳ even in non-correlated system, it's there.

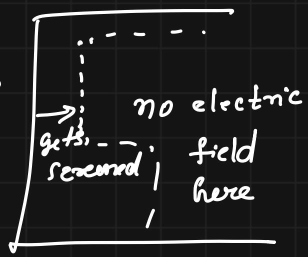
↓

"metals"

1 more lengthscale

Screening length λ_s

$\vec{E}$



diff models

↳ Thomas-Fermi model

$\lambda_{TF} \sim (\lambda_F)^{power} \times const.$

$\sim$ few Å in metals

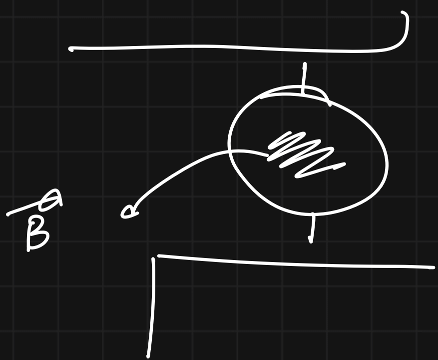
in SC the lengthscale can be large

e.g. for transistors → have a large screening "length"

$\lambda_f <$ atomic spacing → Particle in a box

Paper measuring phase coherence length

Mesoscopic "physics"



G vs B_{ext}

faster beating oscillations

↳ a resetting of phase & oscillation

dia < coh. rel. length $\not\Rightarrow$ oscillations wash away

$\Downarrow$

E_0 component → T = knob for phonons

amplitude of oscillations washes away

control inelastic collisions

Datta's Book → phase coherence length

AZM

⇒ L.levels → not observed for short magnetic field.

always about the numbers