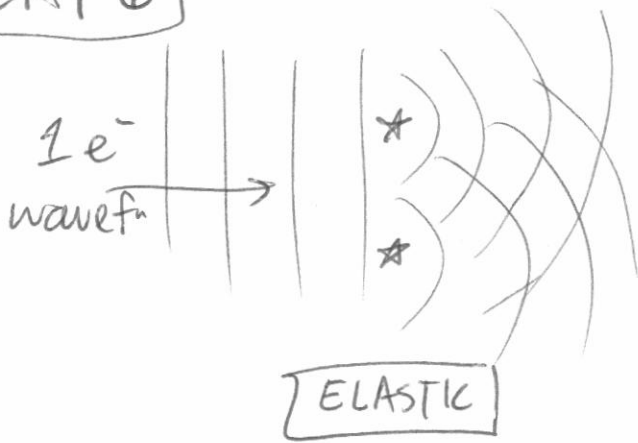


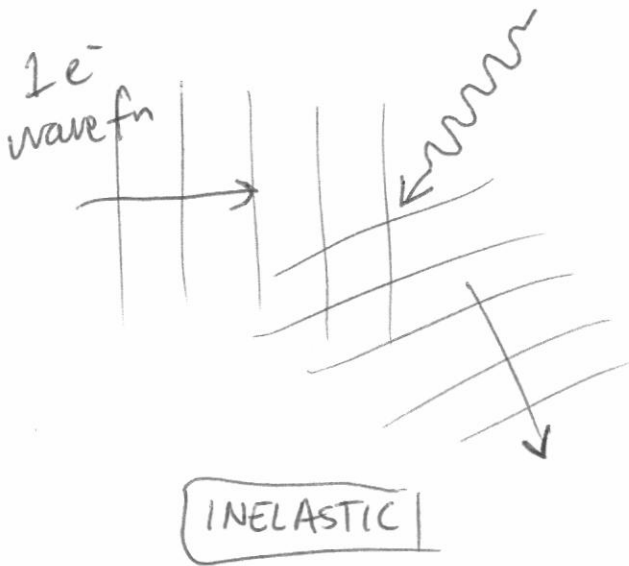
DAY 6

~~PH671~~ ①

PH671



$1e^-$
Simultaneously
going on different paths,
interference patterns
like a 2-slit expt.



The e^- transitions from
one state to another.

New state has a new phase.

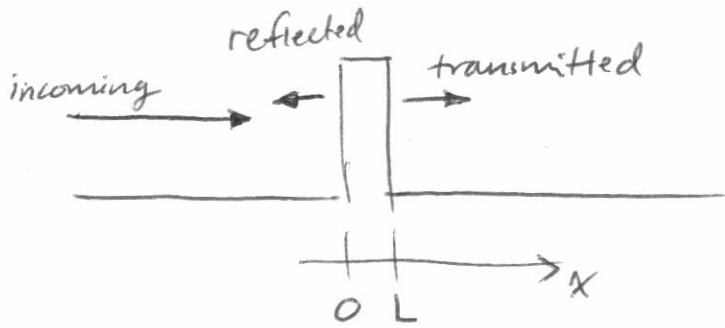
No memory of the old state.

We want to add 1 or 2 scattering events
to a ballistic system.

Start with a single elastic scattering
site in a single 1d channel.

(This is a QM problem you've seen before)

(2)



Tunnel barrier
in a 1d system.

$$\psi_{\text{left}} = Ae^{ikx} + Be^{-ikx}$$

(don't need to keep
track of time dependence)

$$\psi_{\text{barrier}} = \text{?}$$

$$(De^{ik'x} + \bar{E}e^{-ik'x})$$

$$\psi_{\text{right}} = Ce^{ikx}$$

The WKB Approximation assumes $E \rightarrow 0$

So that the transmission probability is given by

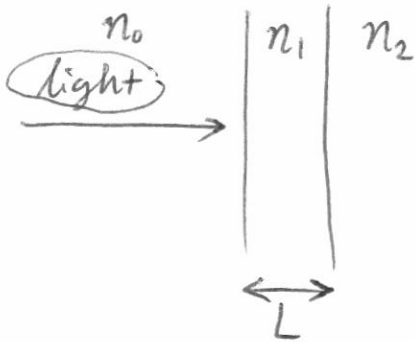
$$T = \left| \frac{\psi_{\text{barrier}}(L)}{\psi_{\text{barrier}}(0)} \right|^2$$

$$= \exp(-2k'L)$$

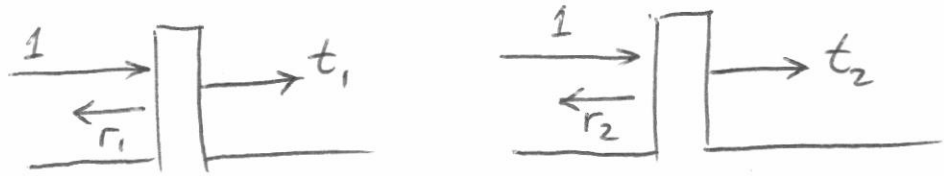
$$\text{where } k' = \frac{1}{\hbar} \sqrt{2m(V_{\text{barrier}} - E)}$$

(4)

Very similar to solving the problem of anti-reflective coatings in optics



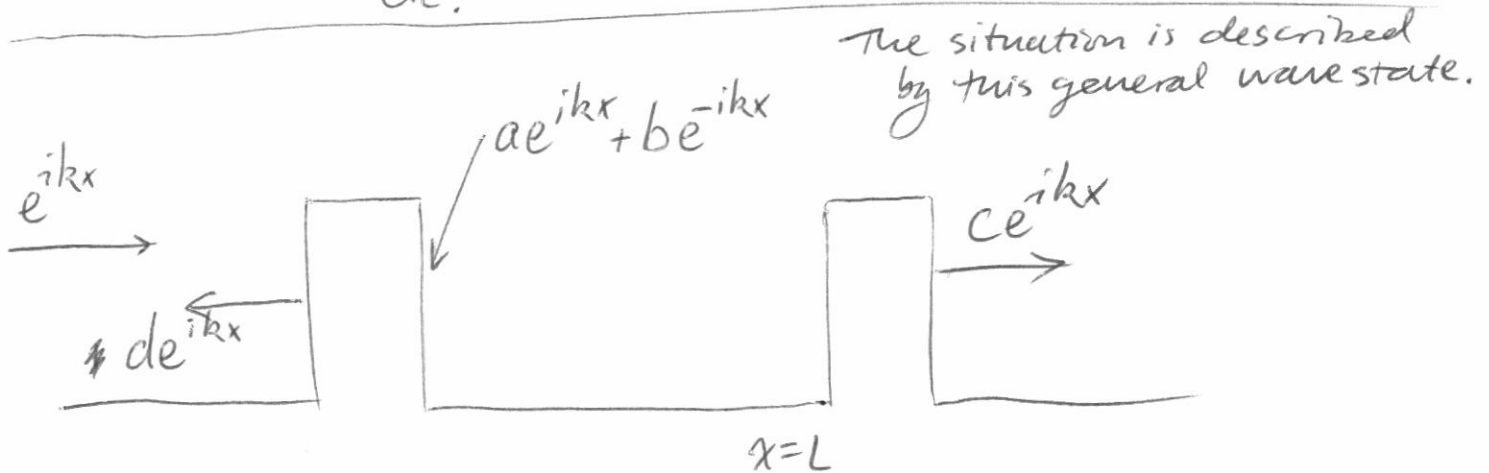
Derive the transmission probability for arbitrary pair of tunnel barriers



r_1 describes the phase & amplitude of reflections from barrier 1

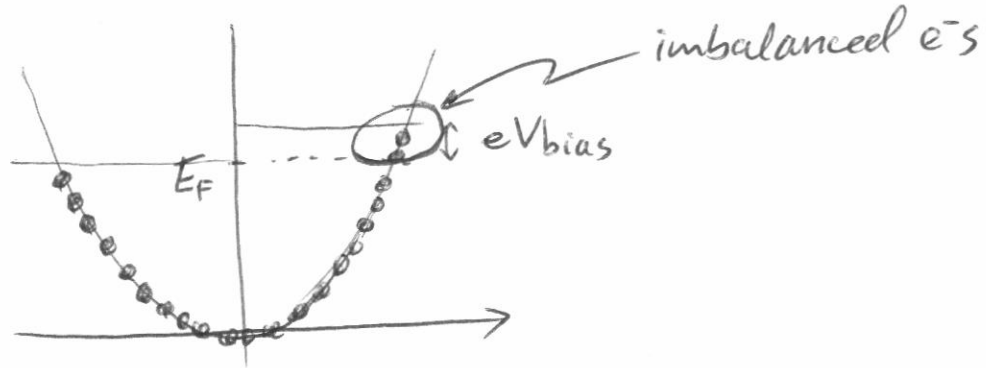
t_1 describes " " " of transmitted wave after barrier 1

etc.

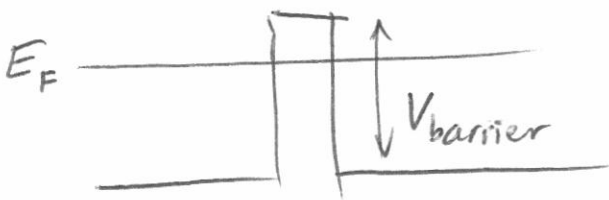


(3)

If V_{bias} is small, the imbalanced e^- s have $E \approx E_F$



$\Rightarrow T$ depends on E_F and the height of the barrier



Conclusion $I = T(E_F) \frac{2e^2}{h} V_{bias}$

when $eV_{bias} \ll E_F$

ie. Current is reduced by factor $T(E_F)$.

What about 2 identical ^{elastic} scattering sites?



$I \stackrel{?}{=} T(E_F)^2 \frac{2e^2}{h} V_{bias} ?$

No!

(5)

$$a = t_1 + r_1 b$$

————— ①

$$b = a r_2 e^{i2k_F L}$$

————— ②

$$c = a e^{ik_F L} t_2$$

————— ③

$$d = r_1 + t_1 b$$

————— ④

Combine ① & ②

$$a = t_1 + r_1 a r_2 e^{i2k_F L}$$

$$a = \frac{t_1}{1 - r_1 r_2 e^{i2k_F L}}$$

Plug into ③

$$c = \frac{e^{ik_F L} t_1 t_2}{1 - r_1 r_2 e^{i2k_F L}}$$

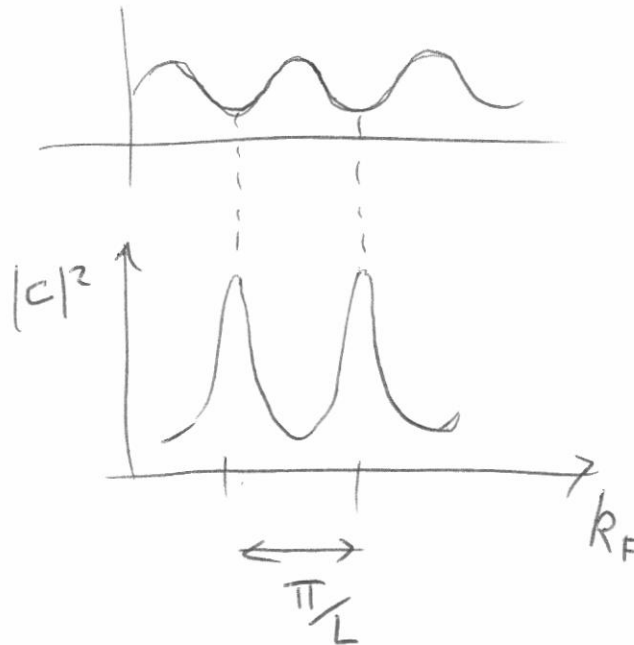
Note, you could also derive this from a superposition of multiple reflections

$$c = e^{ik_F L} t_1 t_2 \left[1 + r_1 r_2 e^{i2k_F L} + r_1^2 r_2^2 e^{i4k_F L} + \dots \right]$$

$$T = |c|^2 = \frac{|t_1|^2 / |t_2|^2}{1 + |r_1|^2 / |r_2|^2 - 2 |r_1| / |r_2| \cos(2k_F L + \phi_{r_1} + \phi_{r_2})}$$

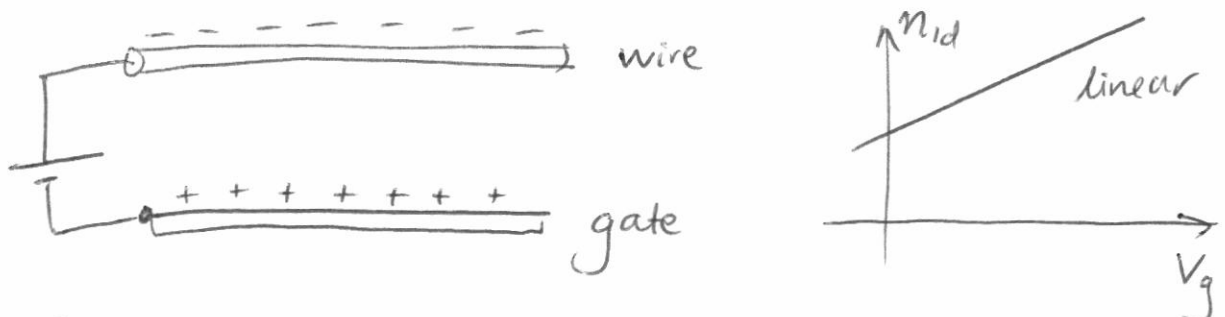
Eq 29. Ch 6 Kittel.

Denominator



Recall HW #1 $k_F = \frac{\pi}{2} n_{1d}$ for an ~~free~~ e^- gas in one-dimension.

n_{1d} can be tuned by adding more charge to the wire



Therefore k_F can be tuned by V_g .