

ECE 495N

Fundamentals of Nanoelectronics

Fall 2008

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**Lecture: 2
Title: Quantum of Conductance
Date: August 27, 2008**

**Video Lectures posted at:
<https://www.nanohub.org/resources/5346/>**

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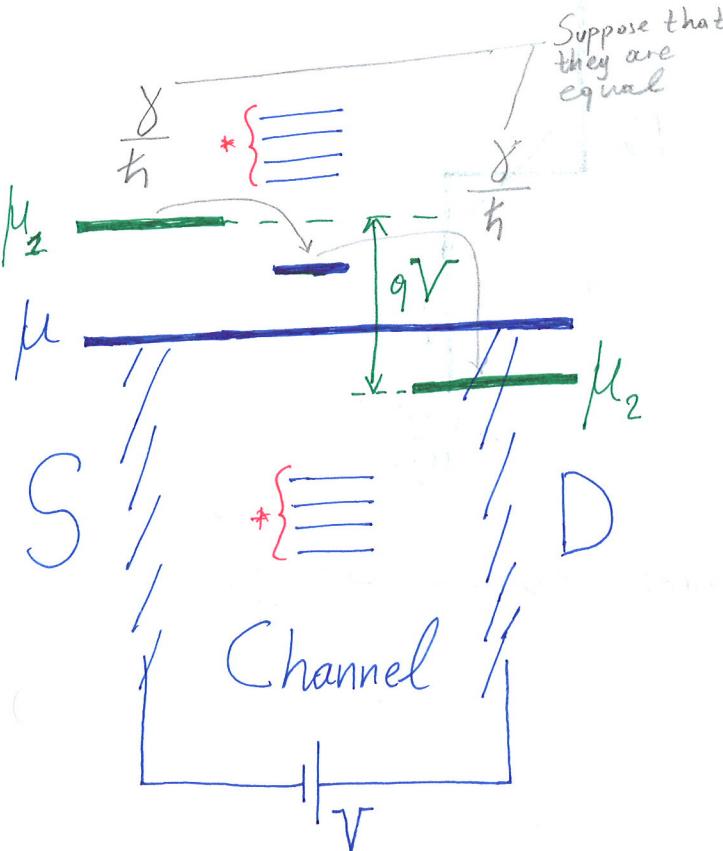


Quantum of Conductance

Lecture 2

Aug. 27 2008

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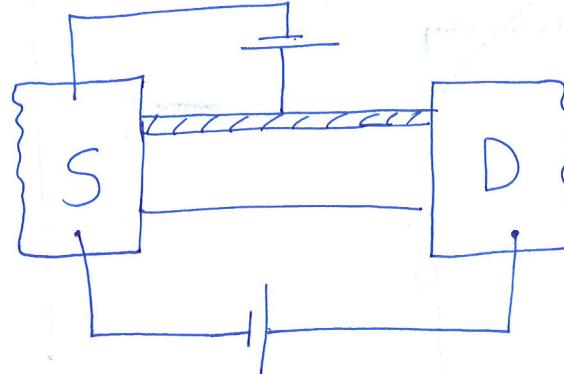


* We can ignore these levels because what matters is the number of levels in the window. Then the question is what the current vs voltage looks like

$$G = \frac{q^2}{h} \left(\frac{1}{2\pi D\gamma} \right)$$

how much voltage we need to go from no current to full current.

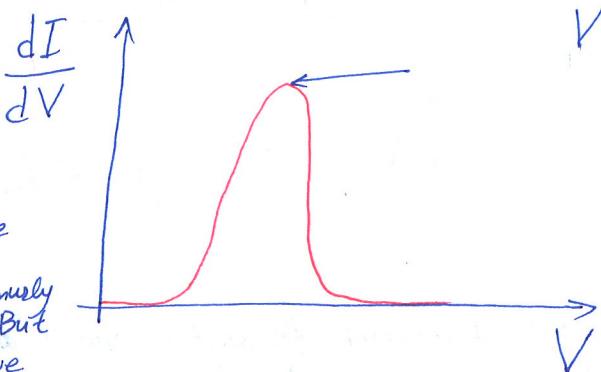
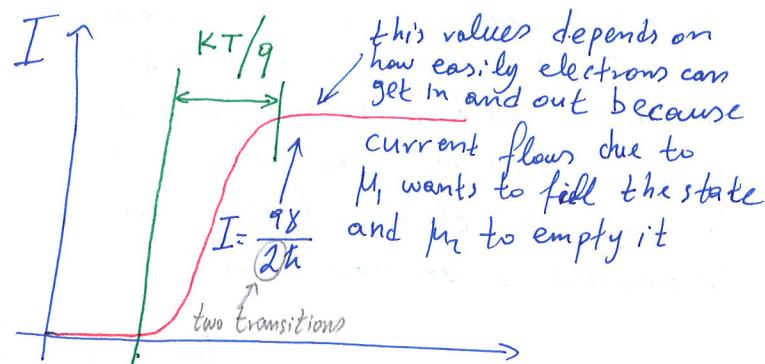
I ideally from the picture above we see that this transition happens instantaneously that is $\Delta V = 0$ and $G \rightarrow \infty$. But in non-zero temperature we define the Fermi function.

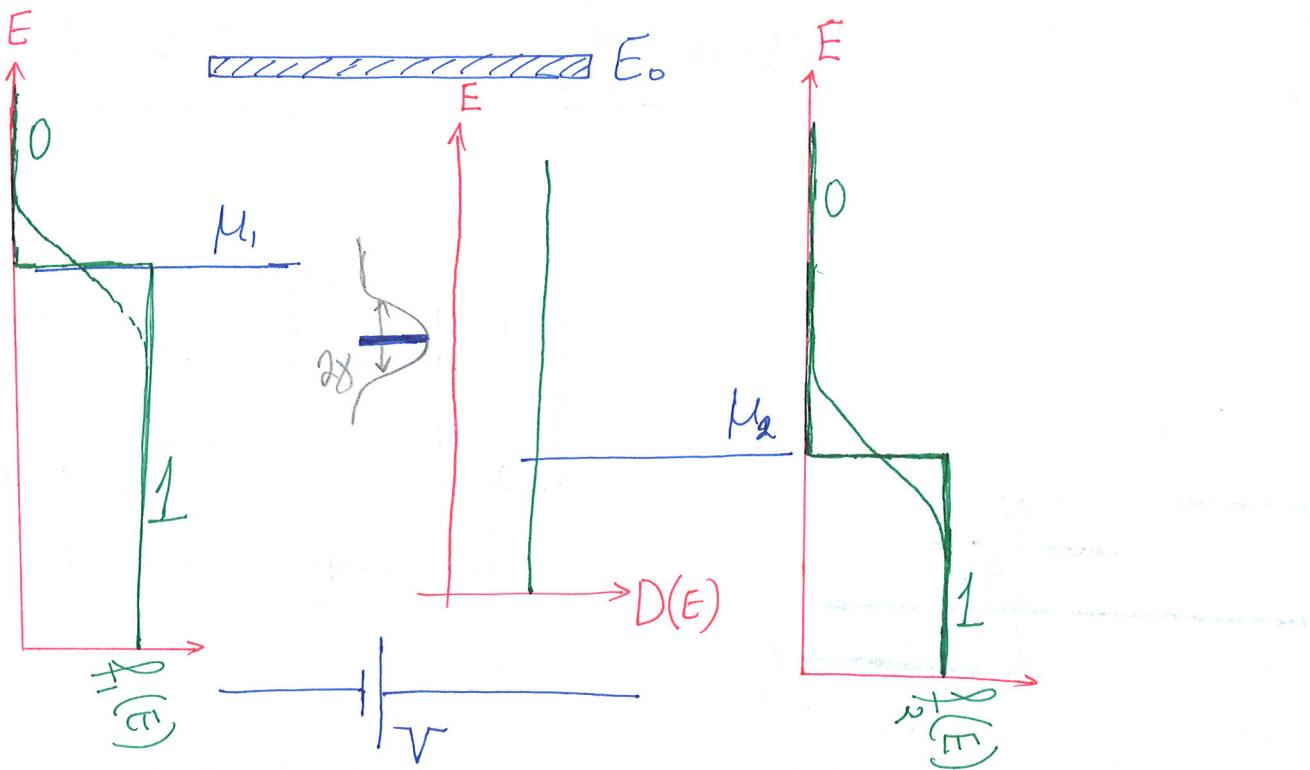


$$G = \frac{q^2}{h} (\pi D\gamma)$$

$$\begin{aligned} q &= 1.6 \times 10^{-19} \text{ Coul} & h &= h/2\pi \\ h &= 6.63 \times 10^{-34} \text{ J-sec} & kT &= 25 \text{ meV} \\ 1 \text{ eV} &= 1.6 \times 10^{-19} \text{ J} & q^2/h &= 1/25 \text{ K} \\ && &= 1/12.5 \text{ K} \end{aligned}$$

↑ up-spin and down-spin





$$G = \frac{98/2\pi}{4KT + 2\gamma + \dots}$$

for low temperatures $T \rightarrow 0$ and $G = \frac{q^2}{4\pi}$

In this relationship also something missing because if $T \rightarrow 0$ then $G \rightarrow \infty$ which is not correct. The quantum-mechanics say that the wave function of an electron then the energy level broaden when electrons trying to get in and out by an amount of γ

Fermi Function

$$f(E) = \frac{1}{e^{(E-\mu)/kT} + 1}$$

This is the fermi function for a given fermi level μ

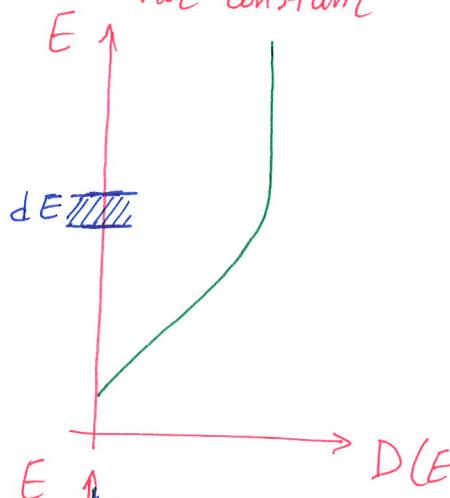
We have two different fermi functions in the two contacts because there are two different ~~different~~ fermi levels

If I have only a level then $I = \frac{g\gamma}{2\hbar}$

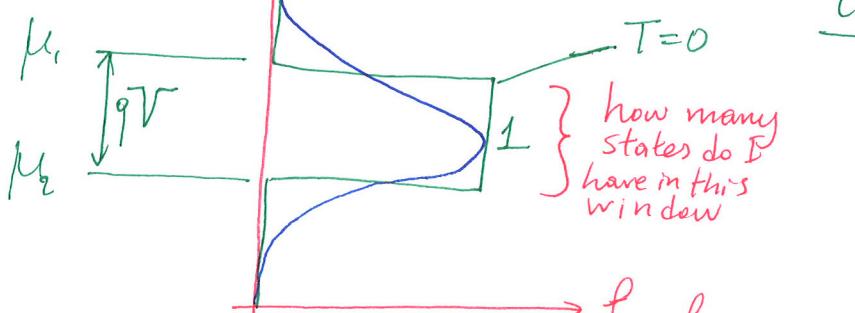
If I have $D(E)$ density of states per energy then in the window that we are interesting in there are $D(E) \cdot gV$ energy states. Hence

$$I = \frac{g\gamma}{2\hbar} D \cdot g \cdot V \Rightarrow \frac{I}{V} = \frac{g^2}{2\hbar} D\gamma = \frac{g^2}{\hbar} \underbrace{(\pi D\gamma)}_{\text{maximum value is approximately one}} = G$$

in general it is not constant



$$I = \frac{g\gamma}{2\hbar} \int E \cdot D(E) \cdot [f_1(E) - f_2(E)] dE$$



Voltage Difference and Temperature Difference in the contacts

