ECE 659 Quantum Transport: Atom to Transistor

Lecture 4: Landauer Model

Supriyo Datta

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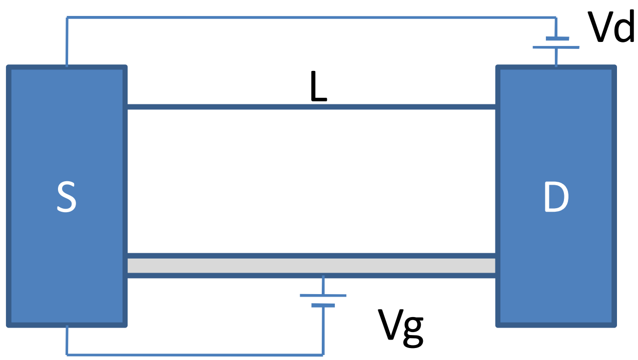
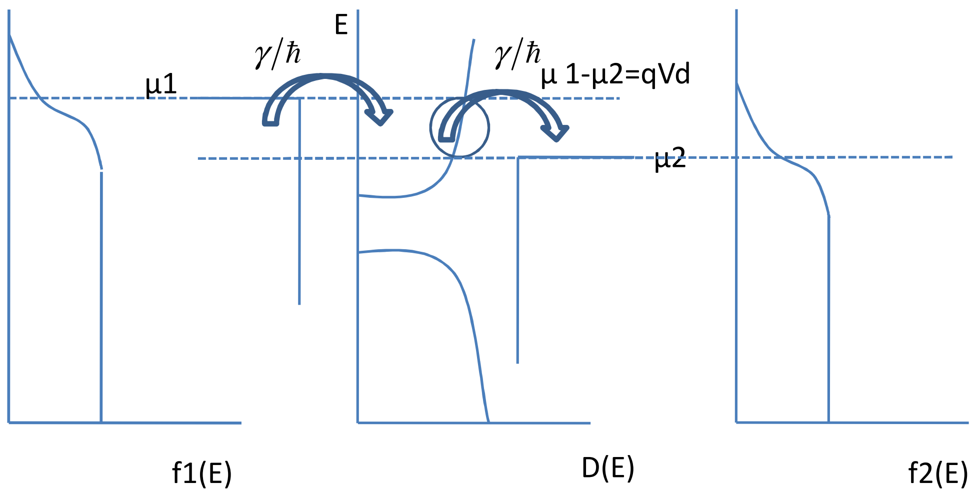
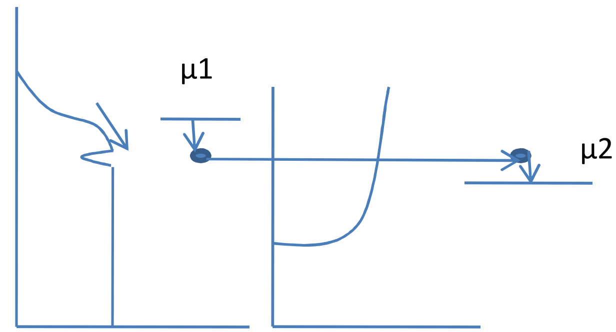
Notes prepared by Samiran Ganguly



$$I = \frac{q}{h}\int dE\,\bar{T}(E)\left(f_1 - f_2\right)$$





Energy lost = μ1-μ2=qVd

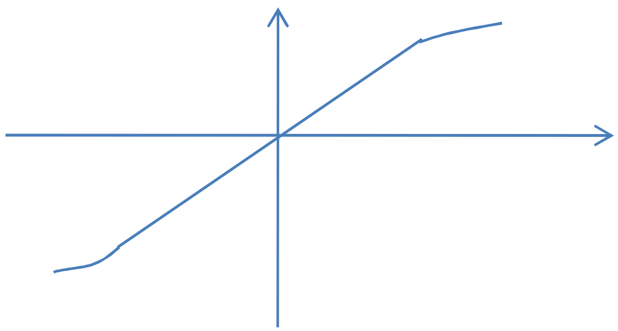
$$G = \frac{q^2}{h}\int dE\left(-\frac{\partial f}{\partial E}\right)\bar{T}(E)$$

Usual expression $G = \frac{\sigma A}{L}, \quad \sigma = qn\overbrace{\frac{q\tau}{m}}^{\mu_n}$

gives the idea that all electrons conduct

$$T = \underbrace{M}_{Dv_z}\frac{\overbrace{\lambda}^{2v_z\tau}}{\lambda + L}$$

Limits of linearity of I-V characteristics

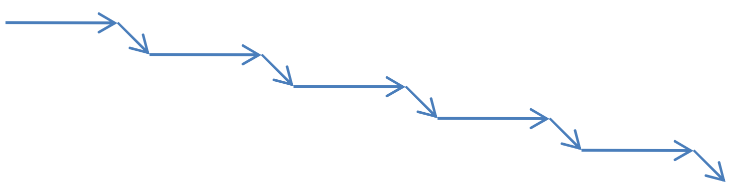


Limit of non linearity:

E-μ<kT $\qquad \frac{25mV}{0.1\mu m} = 2.5KV/cm$

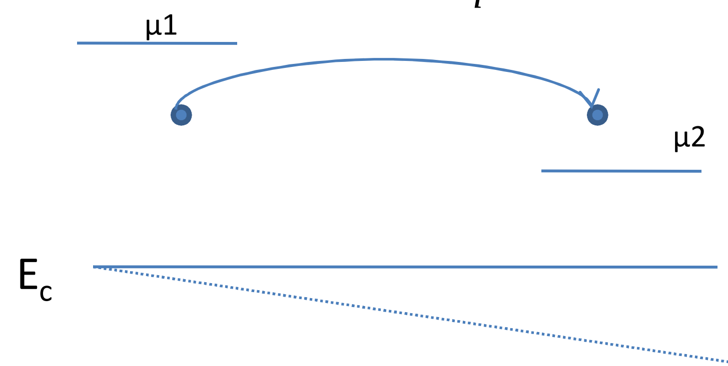
Breakdown fields: $\frac{1V}{0.1\mu m} = 10^5 V/cm$

Series of Landauer devices:



Instead of $J = \sigma E$

we should use $J = \sigma \nabla \frac{\mu}{q}$



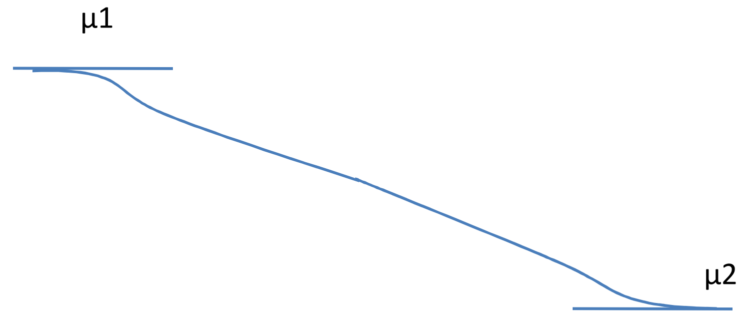
In presence of electric field

Poisson's Equation:

$$\nabla^2 U = \frac{q}{\varepsilon}(n - n_0)$$

$$\nabla^2 U = \frac{q^2}{\varepsilon}(\mu - U)D$$

$$\left[\nabla^2 + \frac{1}{\lambda_D^2}\right]U = \frac{q^2 \mu D}{\varepsilon}$$



Two resistances in series

$$G = \sigma \frac{A}{L + \lambda}$$

$$R = \frac{\rho}{A}(L + \lambda)$$

$$R = \frac{\rho}{A}2(L + \lambda) \quad ?$$

or

$$R = \frac{\rho}{A}(2L + \lambda) \quad ?$$