ECE 659 Quantum Transport: Atom to Transistor

Lecture 20: Summary

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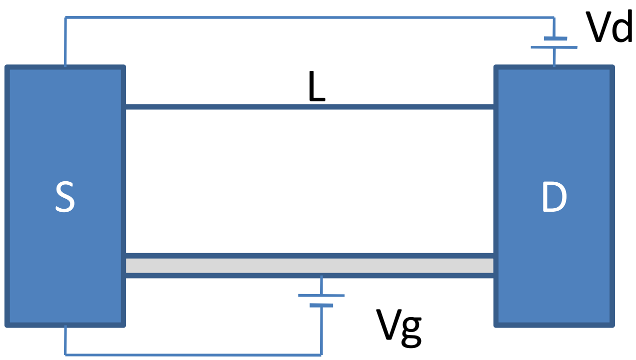
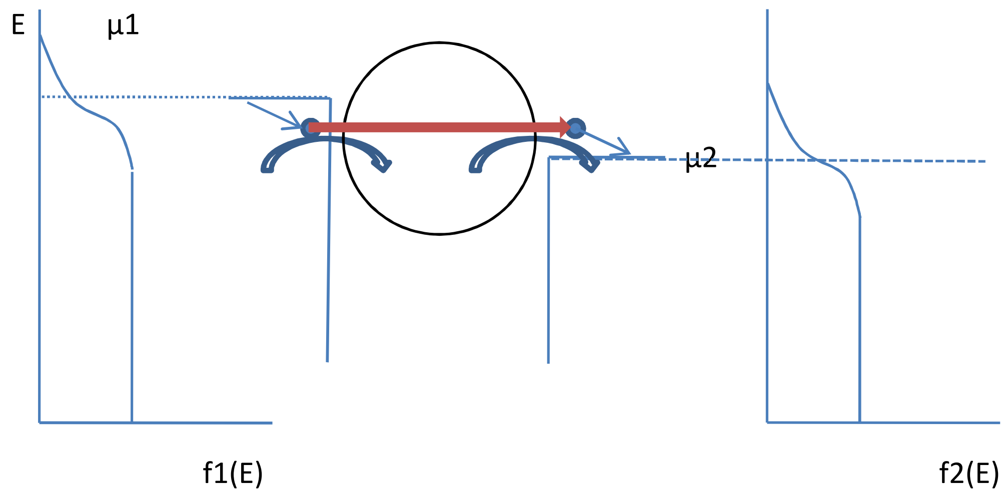
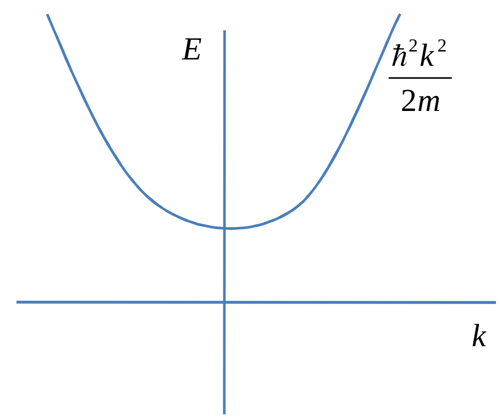
Spring 2009

Notes prepared by Samiran Ganguly



1 mm	Drift diffusion
1 µm	Boltzmann Equation
1 nm	NEGF





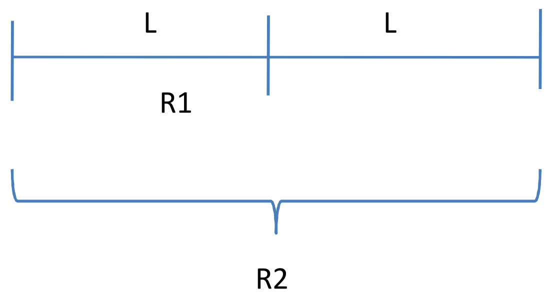
$$G = \frac{\sigma A}{L}$$

$$\sigma = qn\frac{q\tau}{m}$$

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

$$\sigma = q^2 \int dE \left(-\frac{\partial f}{\partial E} \right) \frac{D(E)}{AL} \frac{v^2 \tau}{d}$$

$$f = f_0 + \left(-\frac{\partial f}{\partial E} \right) \mu$$



$$R_2 = 2R_1$$ Drift diffusion

$$R_2 > R_1$$ Boltzmann Equation

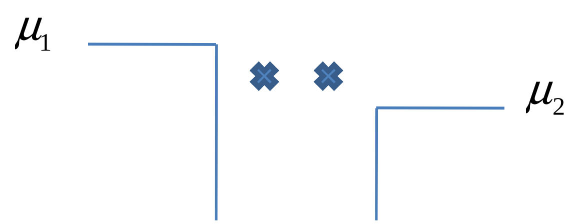
$$\frac{d\vec{x}}{dt} = \frac{1}{\hbar}\nabla_k E$$

$$\hbar\frac{d\vec{k}}{dt} = \nabla E$$

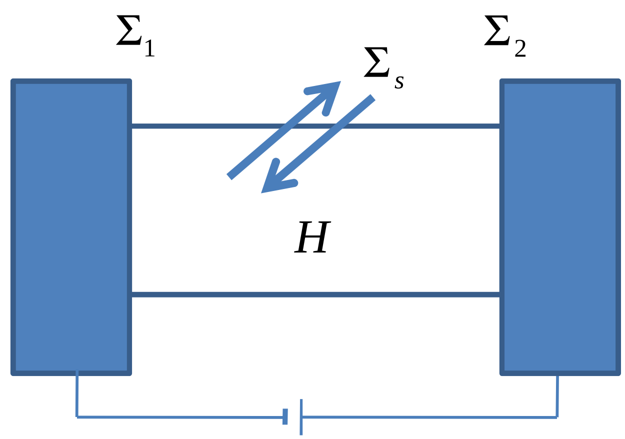
$$i\hbar\frac{d\psi}{dt} = H\psi$$

$$i\hbar\frac{d\{\psi\}}{dt} = [H]\{\psi\}$$

$$\sin ka \approx ka \quad \cos ka \approx 1 - \frac{k^2a^2}{2}$$



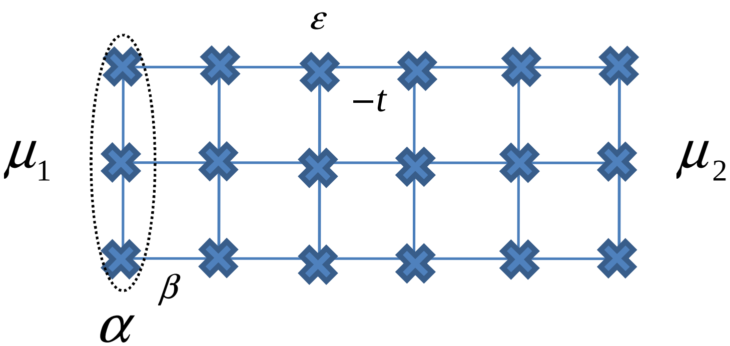
$$\Rightarrow \begin{bmatrix} \varepsilon & t \\ t & \varepsilon \end{bmatrix}$$



$$i\hbar\frac{d\psi}{dt} = \underbrace{H}_{H+U}\psi + \Sigma\psi + s$$

$$\Sigma_s = DG$$

$$G = \left[EI - H - \Sigma - DG\right]^{-1}$$



$$E = \varepsilon - 2t \underbrace{\cos ka}_{1-\frac{k^2a^2}{2}}$$

$$E = \left(\varepsilon - 2t\right) + ta^2k^2$$

In 2-D

$$E = \varepsilon - 2t\cos k_x a - 2t\cos k_y a$$

$$= \left(\varepsilon - 4t\right) - ta^2\left(k_x^2 + k_y^2\right)$$

$$\Sigma = \tau g \tau^+$$

$$\begin{bmatrix} EI-\alpha & -\beta & & \\ -\beta^+ & EI-\alpha & -\beta & \\ & -\beta^+ & EI-\alpha & \ddots \\ & & \ddots & \ddots \end{bmatrix}$$

$$\alpha = \begin{bmatrix} 4t & -t & \\ -t & 4t & \ddots \\ & \ddots & \ddots \end{bmatrix}$$

$$\beta = \begin{bmatrix} -t & & \\ & -t & \\ & & \ddots \end{bmatrix}$$

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[V,D]=eig(alpha)
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$$D = V^+ \alpha V$$

$$\begin{bmatrix} -te^{ik_1a} & & \\ & -te^{ik_2a} & \\ & & \ddots \end{bmatrix}$$