ECE 659 Quantum Transport: Atom to Transistor

Lecture 23: Transverse Modes

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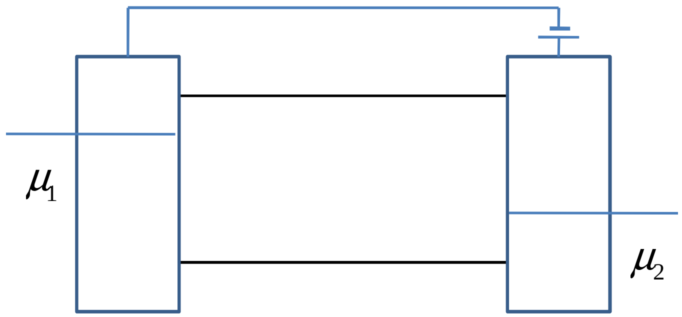
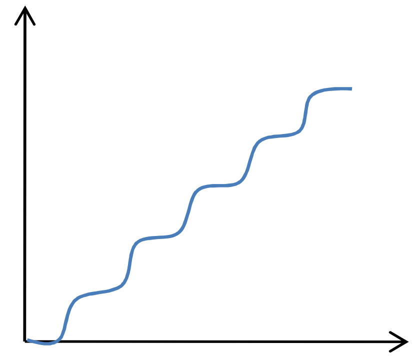
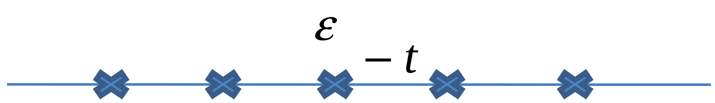
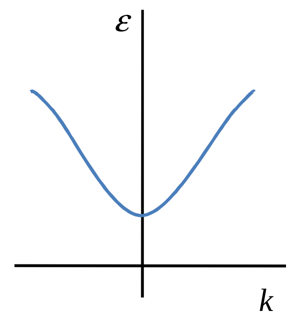
Spring 2009

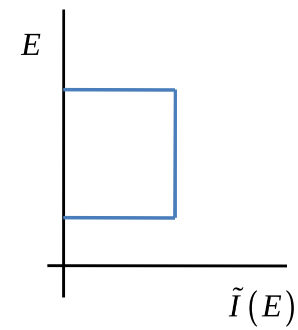
Notes prepared by Samiran Ganguly

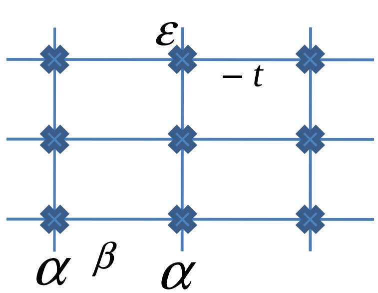


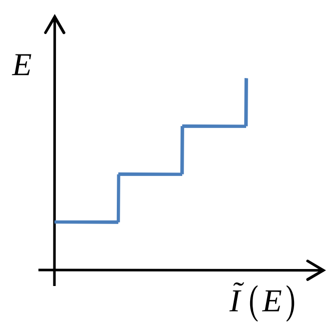












$$\alpha = \begin{bmatrix} 4t & -t & \\ -t & 4t & \ddots \\ & \ddots & \ddots \end{bmatrix} \quad \beta = \begin{bmatrix} -t & & \\ & -t & \\ & & \ddots \end{bmatrix}$$

$$H = \begin{bmatrix} \alpha & \beta & & \\ \beta^* & \alpha & \beta & \\ & \beta^* & \alpha & \ddots \\ & & \ddots & \ddots \end{bmatrix}$$

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[V,D]=eig(alpha)
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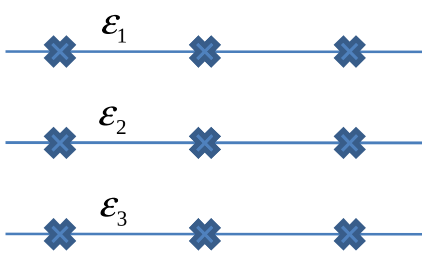
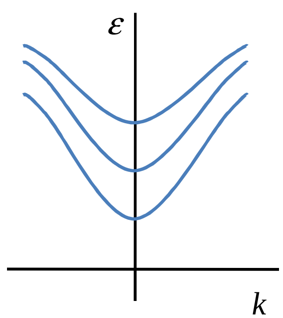
$$V^{+} = V^{-1}$$

$$V^{+}\alpha V = D$$

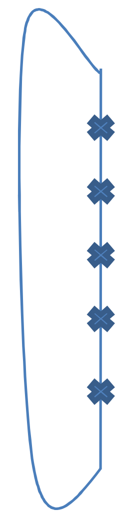
$$\alpha = VDV^{+}$$





$$E_\nu(k) = \alpha_\nu - 2t\cos ka$$

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



$$\alpha_\nu = 4t - 2t\cos \underbrace{ka}_{\frac{2\pi\nu}{N}}$$

$$E\psi_n = \varepsilon\psi_n - t\psi_{n-1} - t\psi_{n+1}$$

$$\psi_n = \psi_0 e^{ikna}$$

$$= \psi_0 e^{ik(n+N)a}$$

$$kNa = 2\pi\nu$$

For box boundary condition:

$$\psi_n = \psi_0 \sin kna$$

$$(E-\varepsilon)\sin kna = -t\underbrace{\left[\sin k(n-1)a + \sin k(n+1)a\right]}_{2\sin kna\cos ka}$$

$$k_\nu (N+1)a = \pi\nu$$

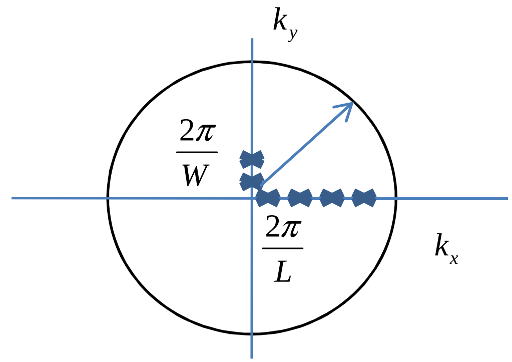
For periodic boundary:

$$k_\nu a = \frac{2\pi\nu}{N}$$

For box boundary:

$$k_\nu a = \frac{\pi\nu}{N+1}$$

$$\begin{aligned} E_\nu(0) &= \alpha_\nu - 2t \\ &= 4t - 2t\cos \underbrace{k_\nu a}_{\frac{2\pi\nu}{N},\frac{\pi\nu}{N+1}} - 2t \\ &= 2t(1-\cos k_\nu a) \\ &\simeq ta^2 k_\nu^2 \end{aligned}$$



$$N = \frac{\pi k_f^2}{\frac{2\pi}{L}\frac{2\pi}{W}} = \frac{k_f^2}{2\pi} LW$$

$$n_s = \frac{k_f^2}{2\pi} \qquad 10^{12}/cm^2$$

$$\frac{2\pi}{\lambda_f}$$

$$k_f\omega = \pi\nu$$