

FUNDAMENTALS OF NANOELECTRONICS

B. Quantum Transport

1 Schrodinger Equation →

2. Contact-ing Schrodinger

3. Advanced Examples

4. Spin Transport

1.1. Introduction

1.2. Wave Equation

1.3. Differential to Matrix Equation

1.4. Dispersion Relation

1.5. Counting States

1.6. Beyond 1-D

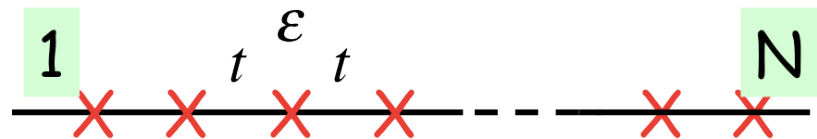
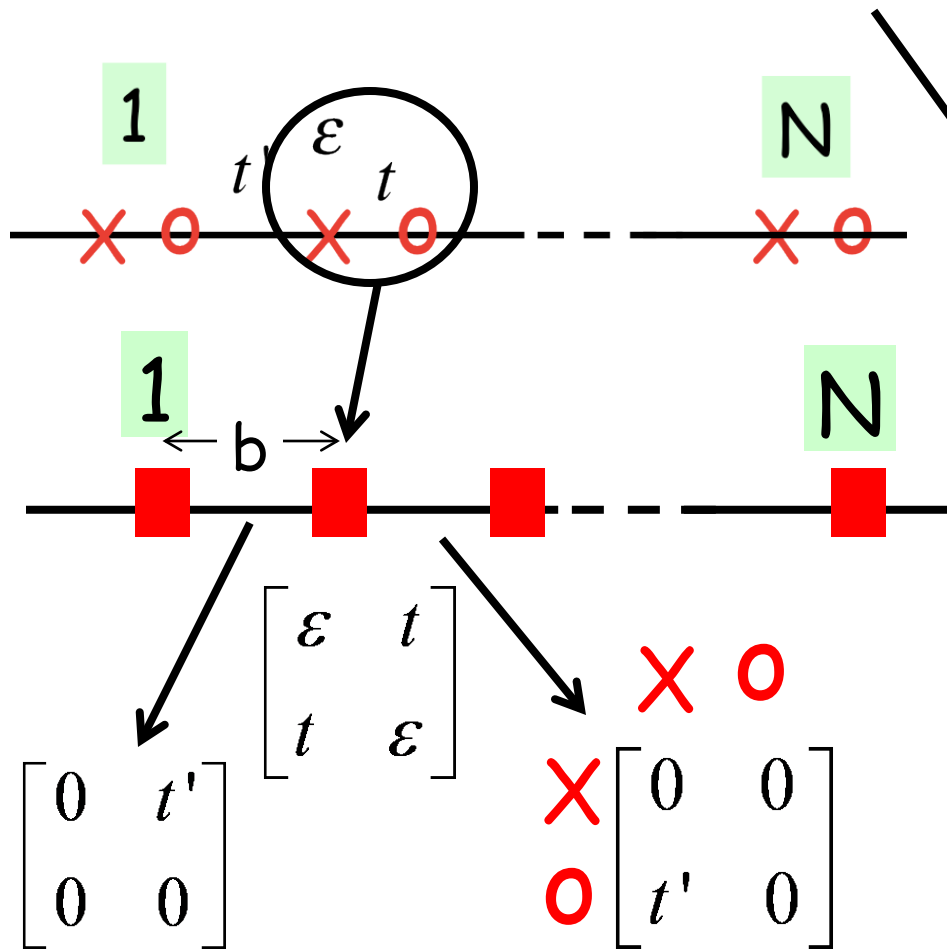
1.7. Lattice with a Basis

1.8. Graphene

1.9. Reciprocal Lattice / Valleys

1.10. Summing up ..

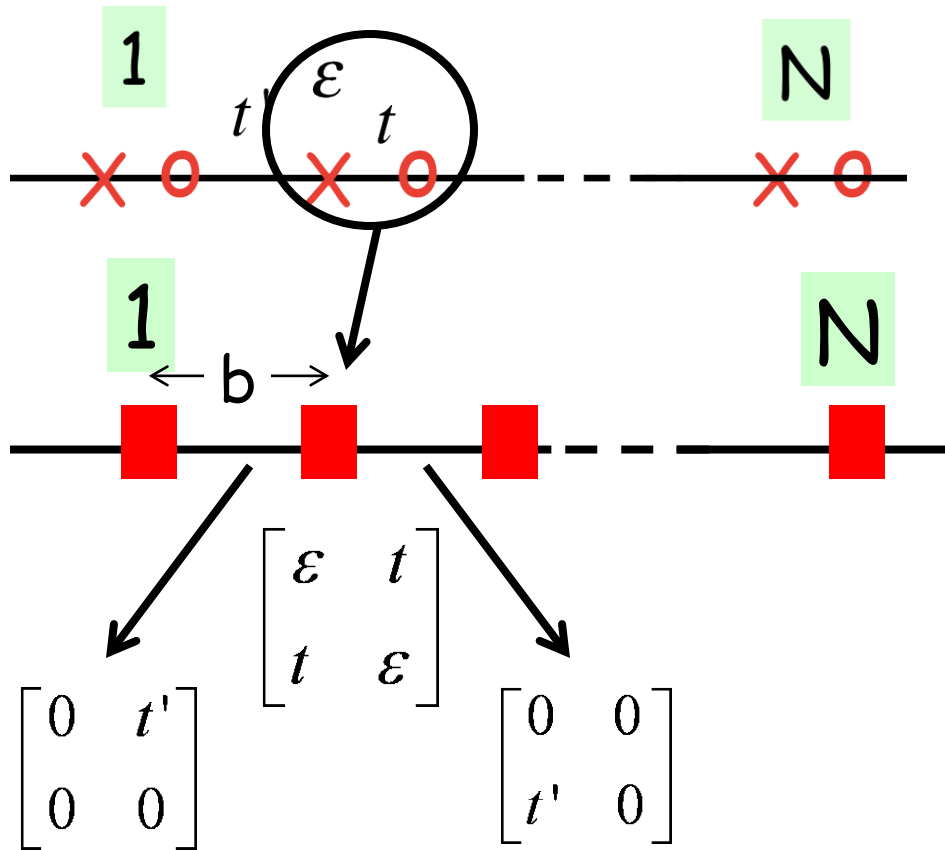
1.7a Lattice with a basis



$$\psi_n = \psi_0 e^{+i\vec{k} \cdot \vec{r}_n}$$

$$\{\psi_n\} = \{\psi_0\} e^{+i\vec{k} \cdot \vec{r}_n}$$

1.7b Lattice with a basis



$$E\{\psi_n\} = \sum_m [H]_{nm} \{\psi_m\}$$

$$E\{\psi_0\} e^{i\vec{k} \cdot \vec{r}_n} = \sum_m [H_{nm}] e^{i\vec{k} \cdot \vec{r}_m} \{\psi_0\}$$

$$\{\psi_n\} = \{\psi_0\} e^{+i\vec{k} \cdot \vec{r}_n}$$

$$E\{\psi_0\} = [h(\vec{k})] \{\psi_0\}$$

$$[h(\vec{k})] = \sum_m [H_{nm}] e^{i\vec{k} \cdot (\vec{r}_m - \vec{r}_n)}$$

1.7c Lattice with a basis

$$[h(k)] = \begin{bmatrix} 0 & t' \\ 0 & 0 \end{bmatrix} e^{-ikb} + \begin{bmatrix} \varepsilon & t \\ t & \varepsilon \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ t' & 0 \end{bmatrix} e^{+ikb}$$

$$= \begin{bmatrix} \varepsilon & t + t' e^{-ikb} \\ t + t' e^{+ikb} & \varepsilon \end{bmatrix}$$

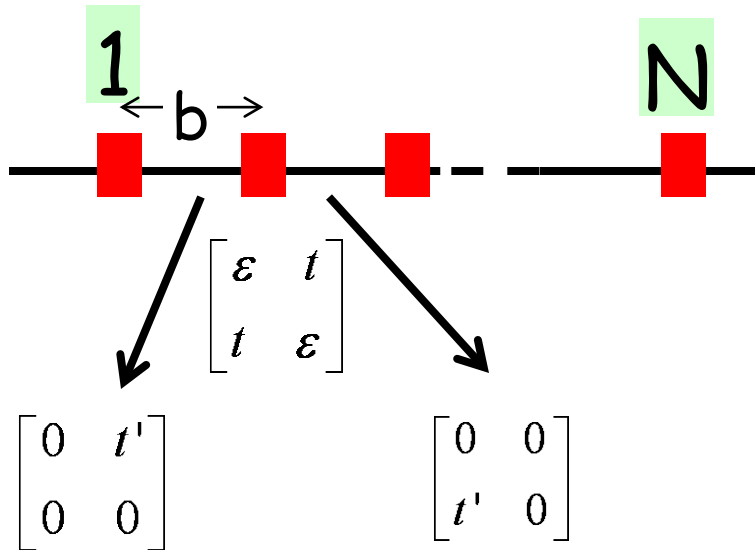
$$h(k) = \begin{bmatrix} \varepsilon & h_0^* \\ h_0 & \varepsilon \end{bmatrix},$$

$$h_0 \equiv t + t' e^{+ikb}$$

$$E = \varepsilon \pm |h_0|$$

$$|h_0| = \sqrt{(t + t' e^{ikb})(t + t' e^{-ikb})}$$

$$= \sqrt{t^2 + t'^2 + 2tt' \cos kb}$$



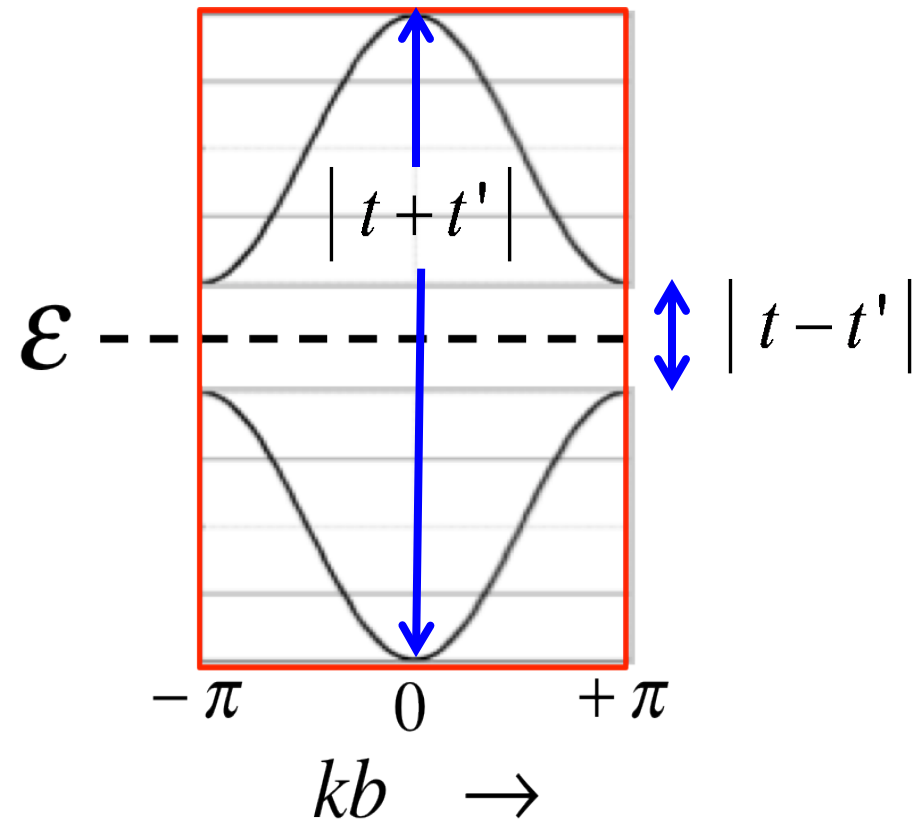
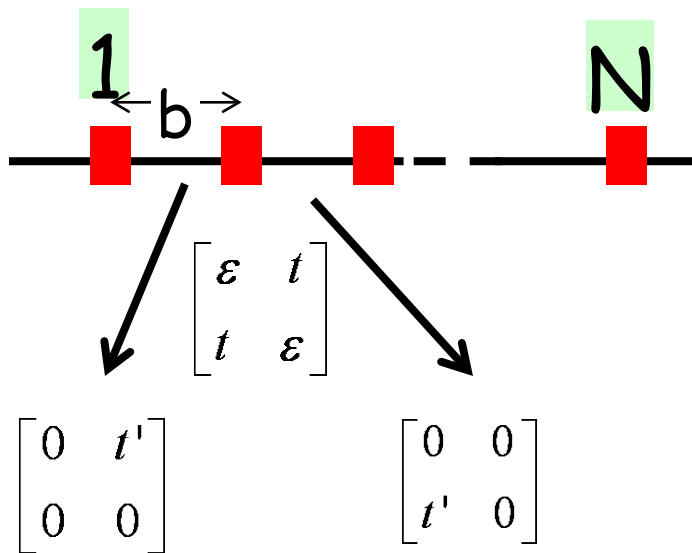
$$[h(\vec{k})] = \sum_m [H_{nm}] e^{i\vec{k} \cdot (\vec{r}_m - \vec{r}_n)}$$

1.7d Lattice with a basis

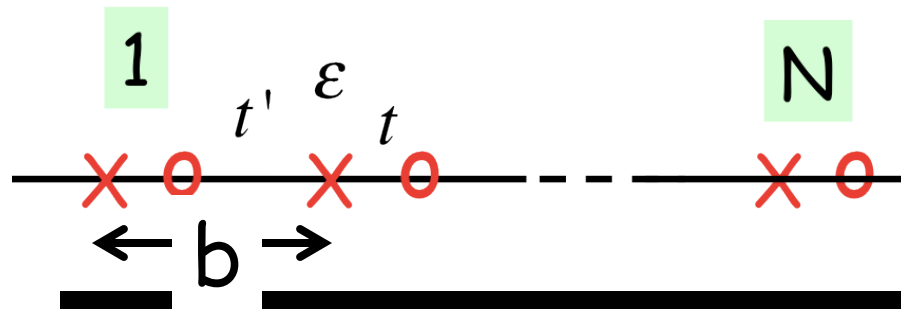
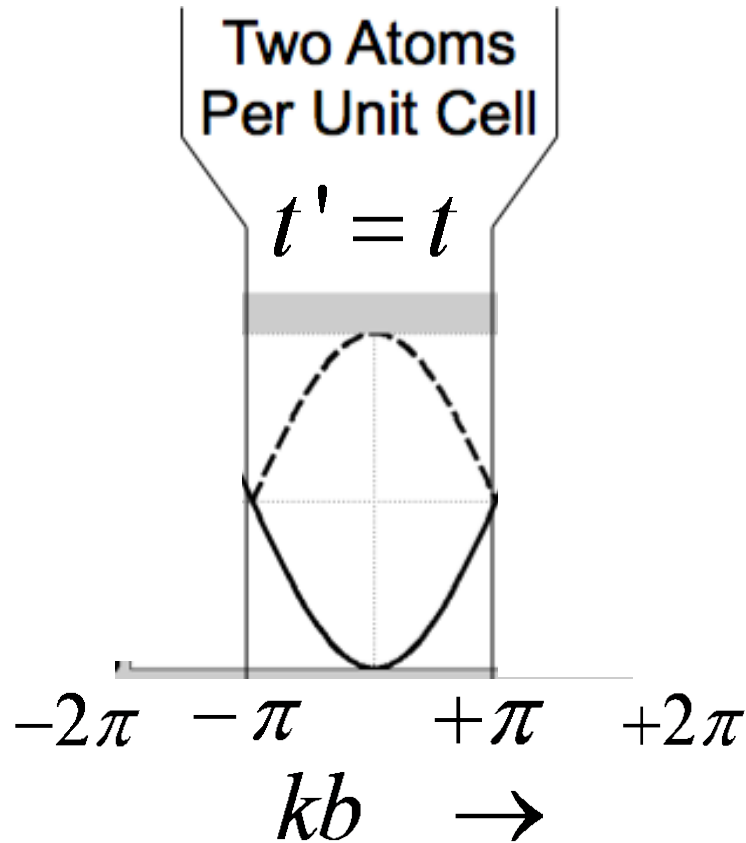
$$h(k) = \begin{bmatrix} \varepsilon & h_0^* \\ h_0 & \varepsilon \end{bmatrix}$$

$$E = \varepsilon \pm |h_0|$$

$$|h_0| = \sqrt{t^2 + t'^2 + 2tt' \cos kb}$$

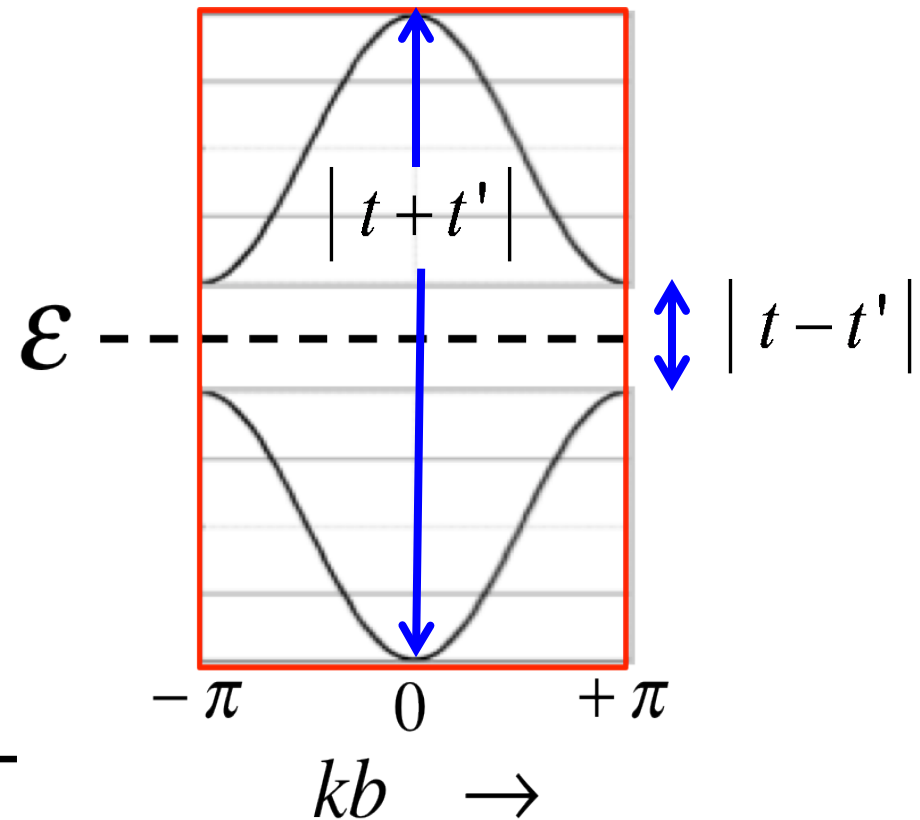


1.7e Lattice with a basis



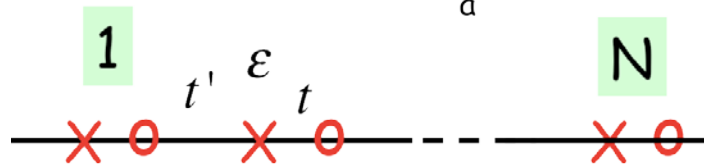
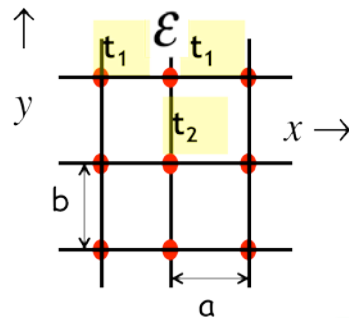
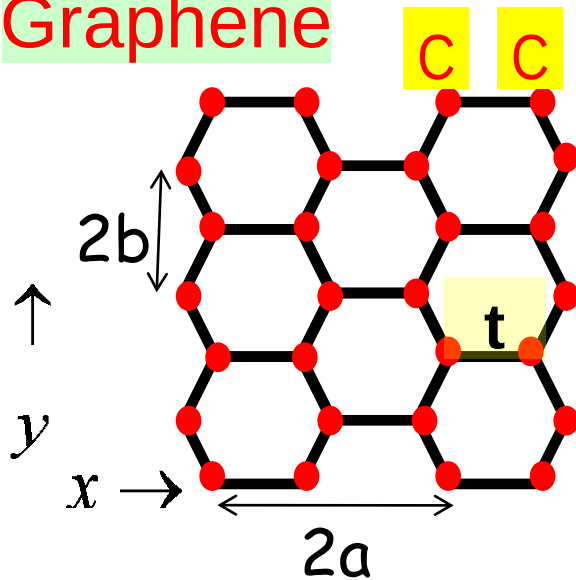
$$E = \epsilon \pm |h_0|$$

$$|h_0| = \sqrt{t^2 + t'^2 + 2tt' \cos kb}$$



Coming up next ..

Graphene



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