

FUNDAMENTALS OF NANOELECTRONICS

Basic Concepts

The New Perspective



2. Energy Band Model

3. What and Where

is the Voltage?

4. Heat & Electricity:

Second Law & Information

1.1. Introduction

1.2. Two Key Concepts

1.3. Why Electrons Flow

1.4. Conductance Formula

1.5. Ballistic(B) Conductance

1.6. Diffusive(D) Conductance

1.7. Connecting B to D

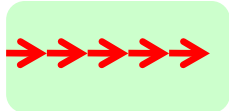
1.8. Angular Averaging

1.9. Drude Formula

1.10. Summing up ..

$$G_B = q^2 \frac{D \bar{v}}{2L}, \quad \sigma = q^2 \frac{\bar{D}}{AL} D$$

Ballistic



$$G = \frac{q^2 D}{2t}$$

Diffusive



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

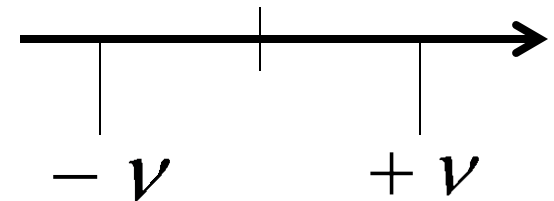
General

$$\sigma = G_B \lambda, \quad \lambda \equiv \frac{2\bar{D}}{\bar{v}}$$

1.8a Angular Averaging

$$\bar{v}: \langle |v_z| \rangle, \quad \bar{D}: \langle v_z^2 \tau \rangle$$

1-D



$$\bar{v} = v, \quad \bar{D} = v^2 \tau$$

$$\lambda = 2v\tau$$



mfp for backscattering

2-D

$$\bar{v} = \frac{\int_{-\pi}^{+\pi} d\theta \, |v \cos \theta|}{\int_{-\pi}^{+\pi} d\theta}$$

$$= v \frac{\int_{-\pi/2}^{+\pi/2} d\theta \cos \theta}{\int_{-\pi/2}^{+\pi/2} d\theta} = \frac{2v}{\pi}$$

$$\bar{D} = v^2 \tau \frac{\int_0^{2\pi} d\theta \cos^2 \theta}{\int_0^{2\pi} d\theta} = \frac{v^2 \tau}{2}$$

1.8b Angular Averaging

$$\bar{v}: \langle |v_z| \rangle \quad , \quad \bar{D}: \langle v_z^2 \tau \rangle$$

1-D

$$\bar{v} = v \quad , \quad \bar{D} = v^2 \tau$$

$$\lambda = 2v\tau$$

mfp for backscattering

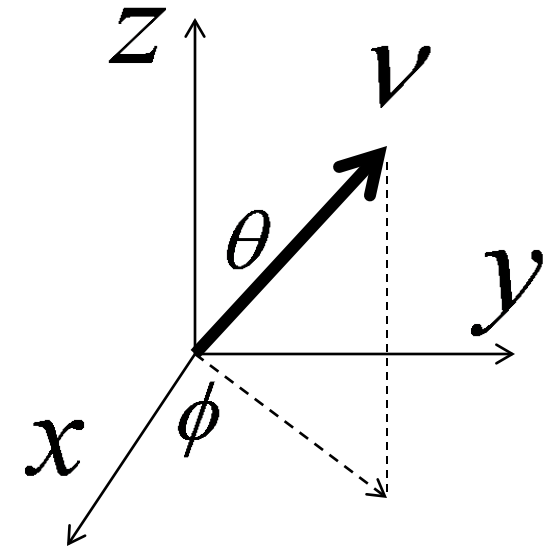
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<http://nanohub.org/groups/Inebook>

1.8c Angular Averaging

3-D



$$r^2 \int_0^{2\pi} d\phi \int_0^{\pi} d\theta \sin \theta$$

$$= 4\pi r^2$$

$$\bar{V} = \frac{\int_0^{2\pi} d\phi \int_0^{\pi} d\theta \sin \theta |v \cos \theta|}{\int_0^{2\pi} d\phi \int_0^{\pi} d\theta \sin \theta}$$

$$= v \frac{\int_0^{2\pi} d\phi \int_0^{\pi/2} d\theta \sin \theta \cos \theta}{\int_0^{2\pi} d\phi \int_0^{\pi/2} d\theta \sin \theta} = \frac{v}{2}$$

$$\bar{D} = v^2 \tau \frac{\int_0^{2\pi} d\phi \int_0^{\pi/2} d\theta \sin \theta \cos^2 \theta}{\int_0^{2\pi} d\phi \int_0^{\pi/2} d\theta \sin \theta} = \frac{v^2 \tau}{3}$$

Ballistic

$$G_B = q^2 \frac{D\bar{v}}{2L}$$

$$G = \frac{G_B \lambda}{L + \lambda}, \quad \lambda \equiv \frac{2\bar{D}}{\bar{v}}$$

$$\bar{v}: \langle |v_z| \rangle = v \begin{cases} 1 & 2D & 3D \\ 1D & 2D & 3D \end{cases}$$

$$\bar{D}: \langle v_z^2 \tau \rangle = v^2 \tau \begin{cases} 1 & 1/2 & 1/3 \\ 1D & 2D & 3D \end{cases}$$

$$\lambda \equiv \frac{2\bar{D}}{\bar{v}} = v\tau \begin{cases} 2 & \pi/2 & 4/3 \\ 1D & 2D & 3D \end{cases}$$

Coming up next ..

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