FUNDAMENTALS OF NANOELECTRONICS

Basic Concepts

1. The New Perspective
2. Energy Band Model
3. What & Where is the "Voltage"?
4. Heat & Electricity: Second Law & Information

3.1. Introduction

3.2. A New Boundary Condition

3.3. Quasi-Fermi Levels (QFL's)

3.4. Current from QFL's

3.5. Landauer Formulas

3.6. What a Probe Measures

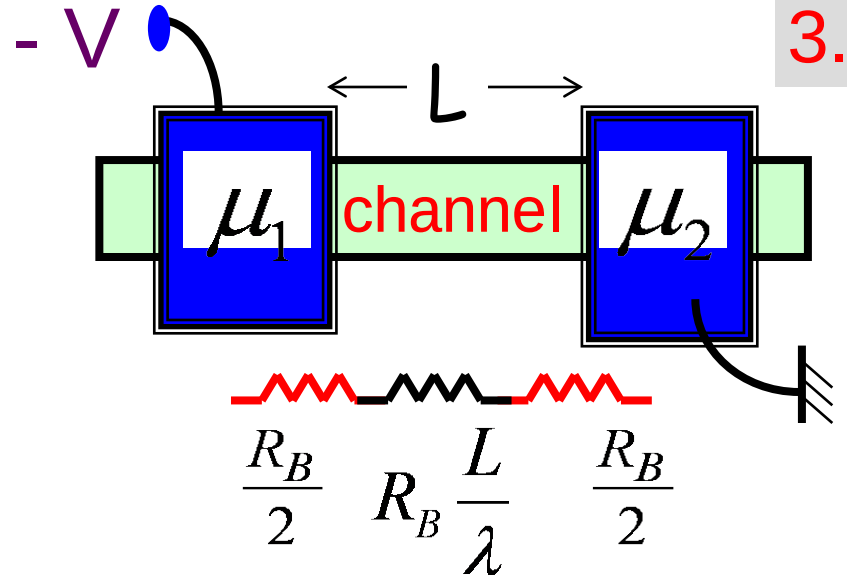
3.7. Electrostatic Potential

3.8. Boltzmann Equation

3.9. Spin voltages

3.10. Summing up ..

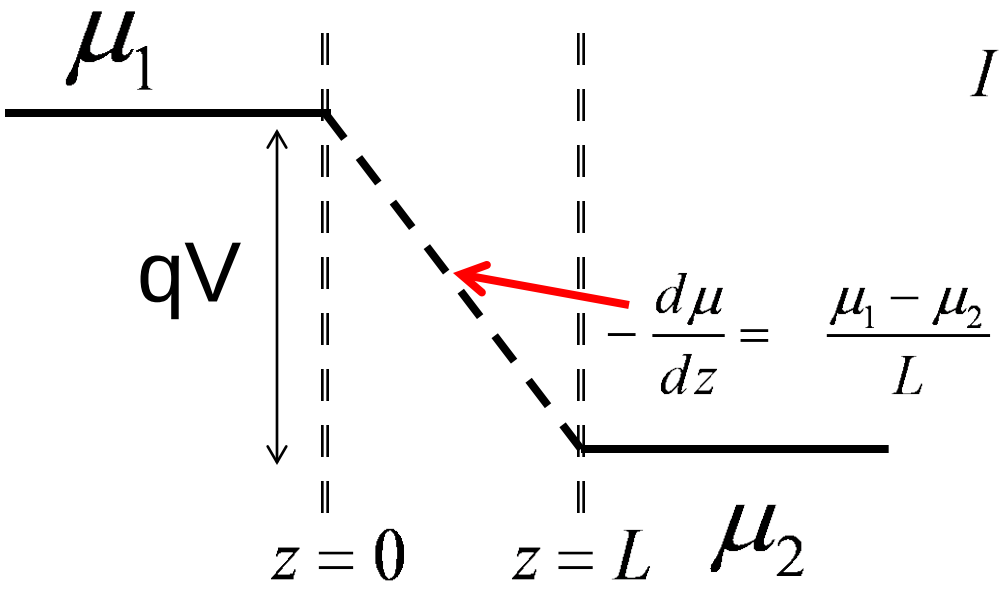
3.2a A New Boundary Condition



$$R_0 = R_B + R_B \frac{L}{\lambda}$$

Resistance is associated with

- Voltage drop: IR

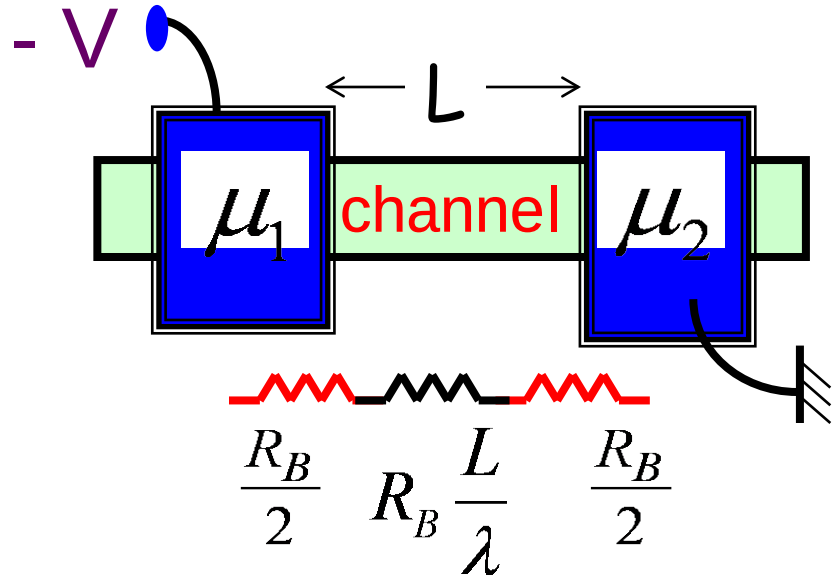


$$I = -\frac{\sigma_0 A}{q}\frac{d\mu}{dz}, \quad \frac{dI}{dz} = 0$$

$$= \frac{1}{q}\frac{\sigma_0 A}{L}(\mu_1 - \mu_2)$$

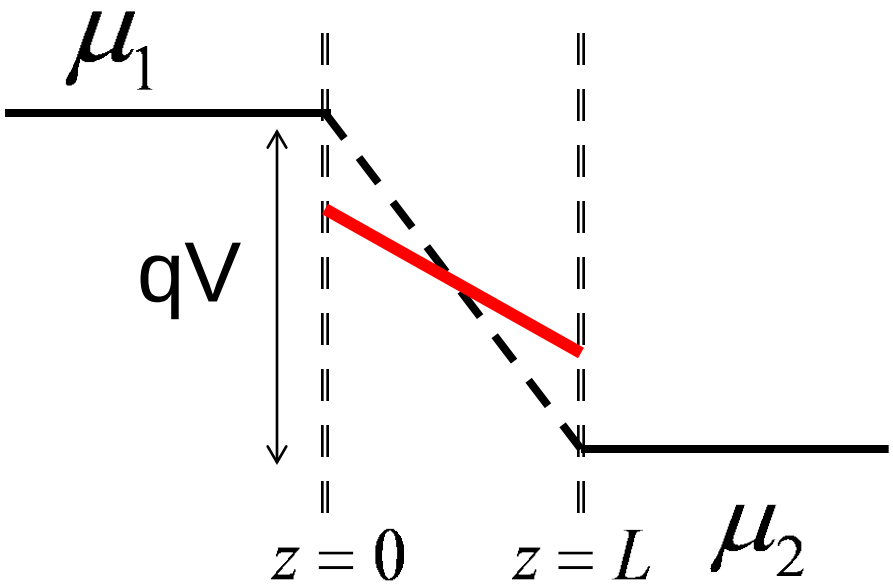
Instead of

$$I = \frac{1}{q}\frac{\sigma_0 A}{L+\lambda}(\mu_1 - \mu_2)$$



Equation is fine !

$$I = -\frac{\sigma_0 A}{q}\frac{d\mu}{dz}, \quad \frac{dI}{dz} = 0$$

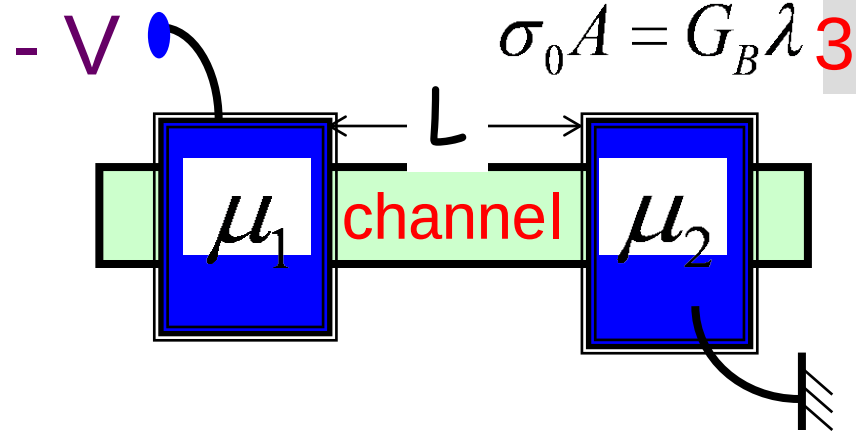


Boundary condition is wrong !!

$$\mu(z = 0) = \mu_1$$

$$\mu(z = L) = \mu_2$$

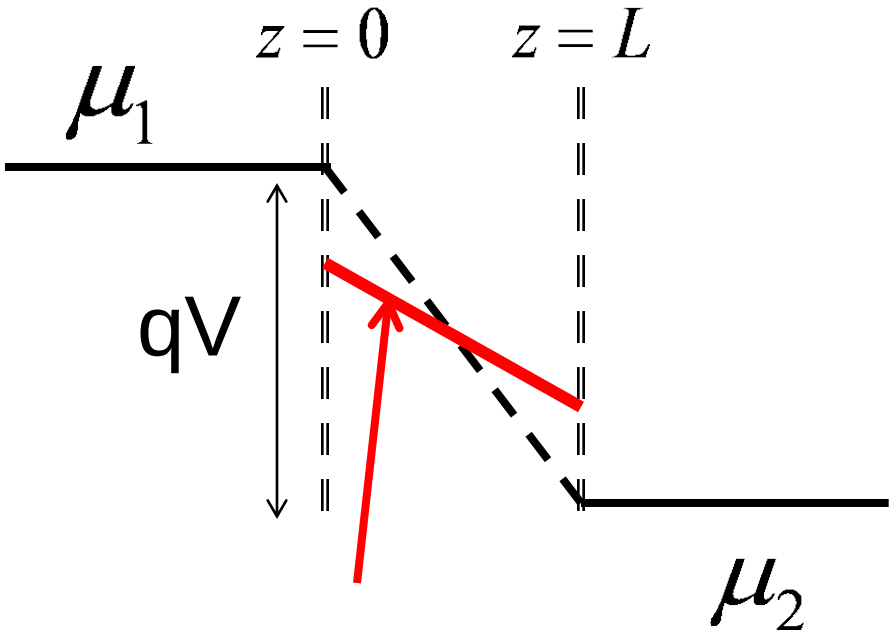
3.2c A New Boundary Condition



$$\sigma_0 A = G_B \lambda$$

$$I = -\frac{\sigma_0 A}{q}\frac{d\mu}{dz}$$

$$= \frac{1}{q}\frac{\sigma_0 A}{L}\left(\mu_1 - \mu_2 - qIR_B\right)$$



$$-\frac{d\mu}{dz} = \frac{\mu_1 - \mu_2}{L} - qIR_B$$

$$I\left(1 + \frac{\sigma_0 A R_B}{L}\right) = \frac{1}{q}\frac{\sigma_0 A}{L}\left(\mu_1 - \mu_2\right)$$

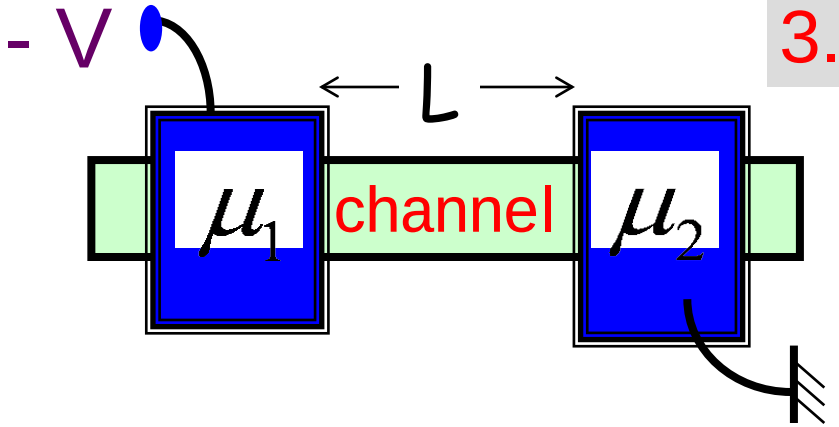
λ

$$\rightarrow \quad I = \frac{1}{q}\frac{\sigma_0 A}{L+\lambda}\left(\mu_1 - \mu_2\right)$$

$$\mu(z=0) = \mu_1 - \frac{qIR_B}{2}$$

$$\mu(z=L) = \mu_2 + \frac{qIR_B}{2}$$

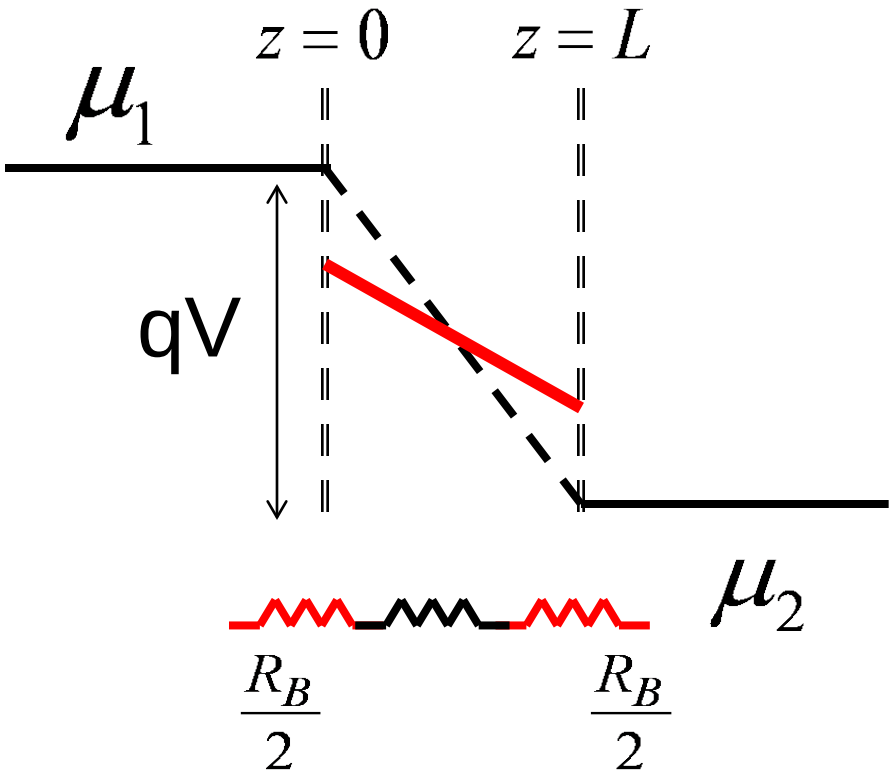
3.2d A New Boundary Condition



$$I = -\frac{\sigma_0 A}{q}\frac{d\mu}{dz}$$

Same equation !

New boundary condition !!

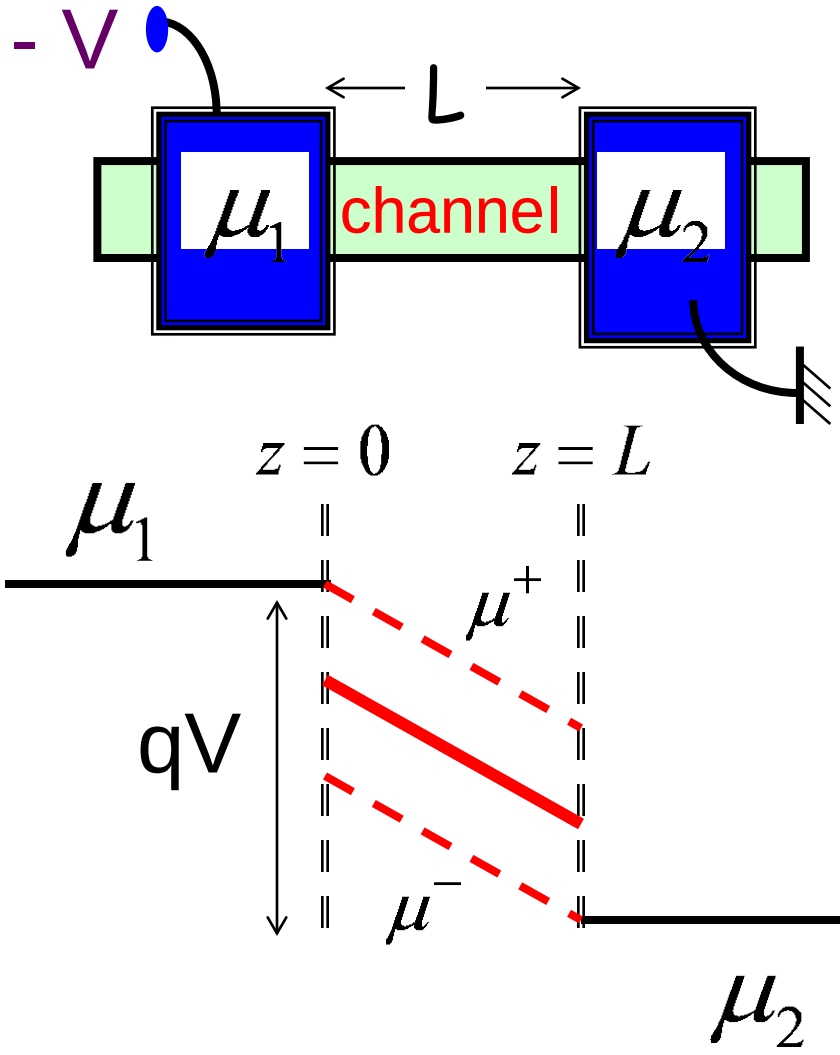


$$\rightarrow \quad I = \frac{1}{q}\frac{\sigma_0 A}{L+\lambda}(\mu_1 - \mu_2)$$

$$\mu(z=0) = \mu_1 - \frac{qIR_B}{2}$$

$$\mu(z=L) = \mu_2 + \frac{qIR_B}{2}$$

Coming up next ..



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