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

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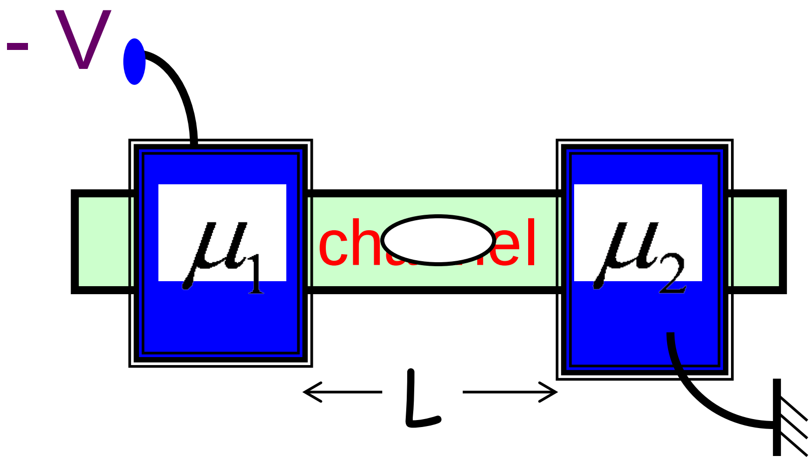
http://nanohub.org/groups/lnebook



Resistance is associated with

- ~~Joule Heating: I^2R~~

- Voltage drop: IR

$$\frac{R_B}{2} \qquad R_B \frac{L}{\lambda} \qquad \frac{R_B}{2}$$

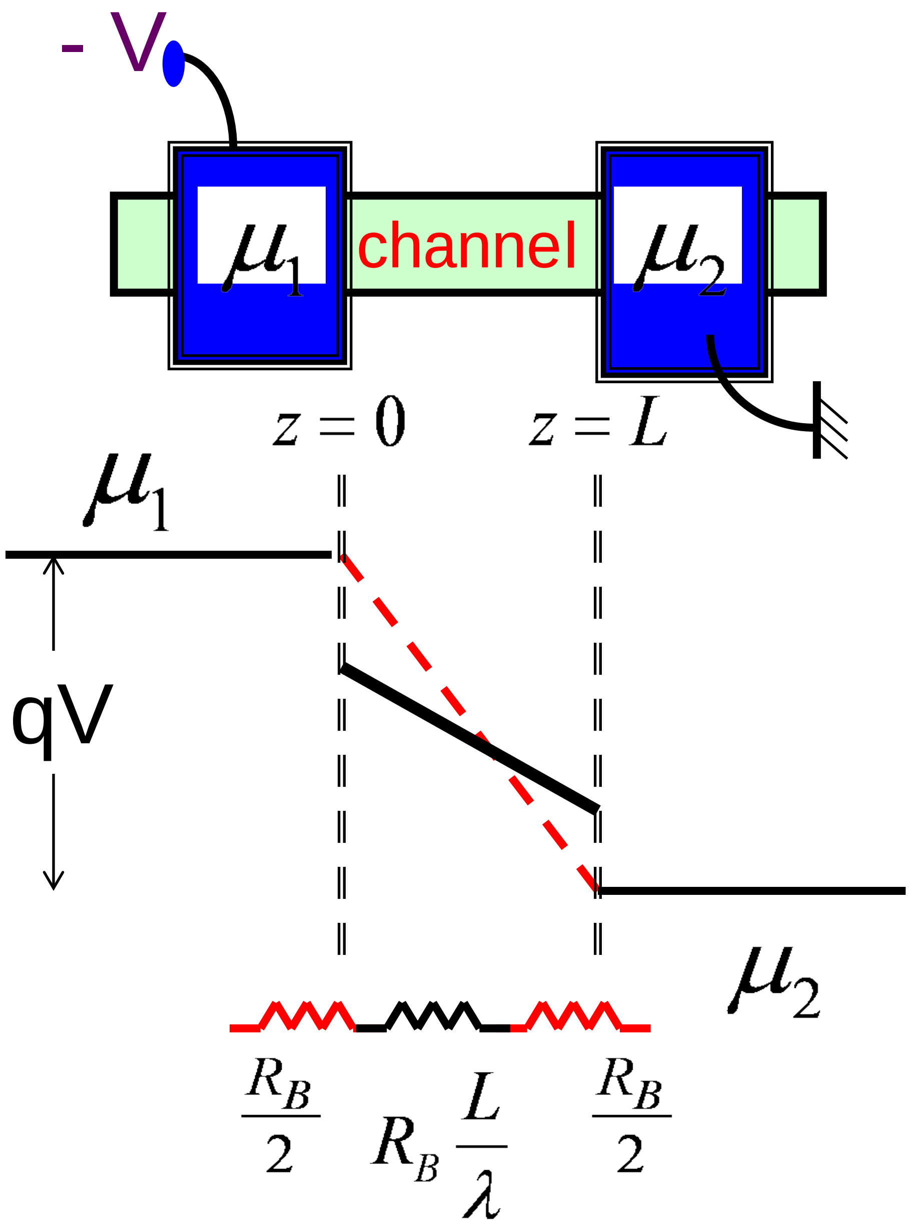
$$I = G_0 V$$

$$R_0 = \frac{1}{G_0} = R_B + R_B \frac{L}{\lambda}$$

$$G_0 = G_B \frac{\lambda}{L+\lambda}$$

$$R_B \equiv \frac{1}{G_B}$$

3.1b Introduction



Where is the voltage drop?

What is Voltage ?

Common answer

Electrostatic Potential

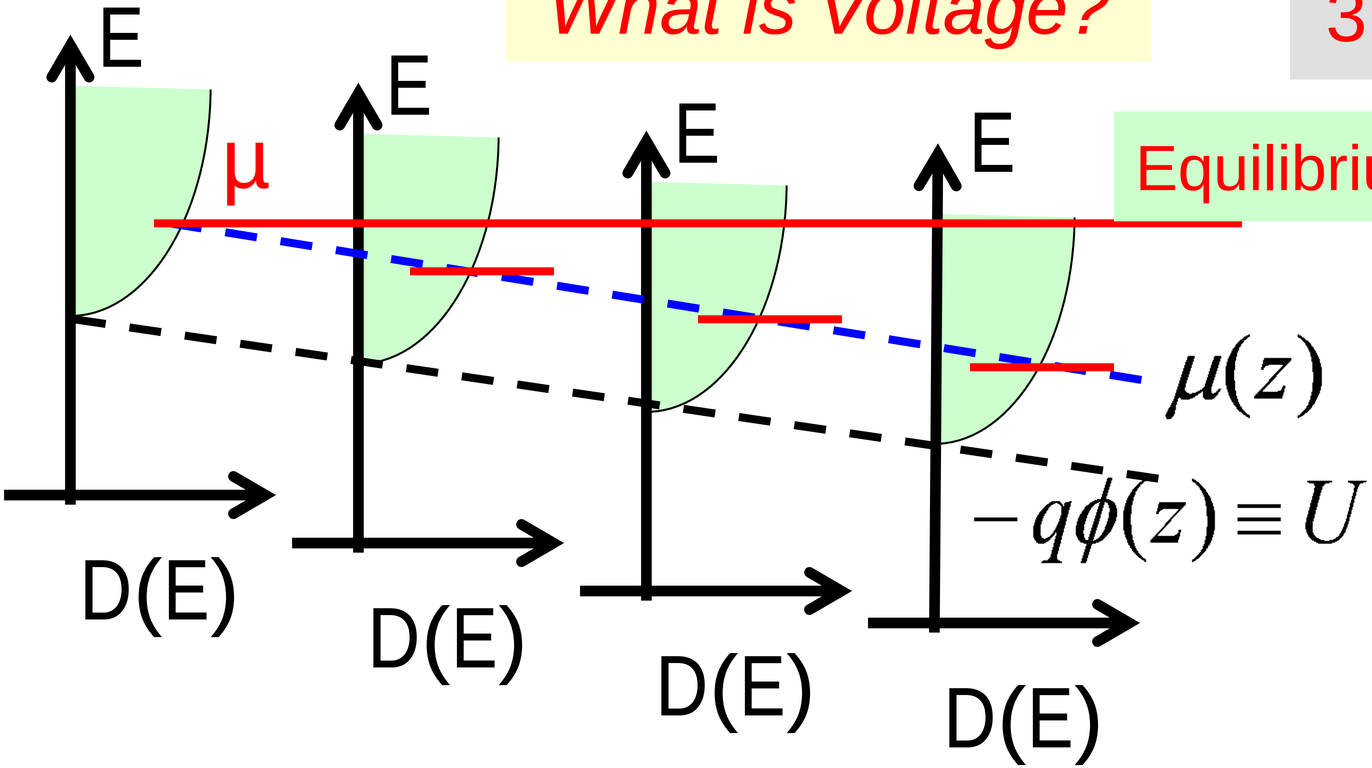
X $J \sim \sigma_0 F \sim \frac{\sigma_0}{q} \frac{dU}{dz}$

Correct answer

Electrochemical Potential

$$J \sim \frac{\sigma_0}{q} \frac{d\mu}{dz}$$

What is Voltage?



μ is difficult to define under non-equilibrium conditions

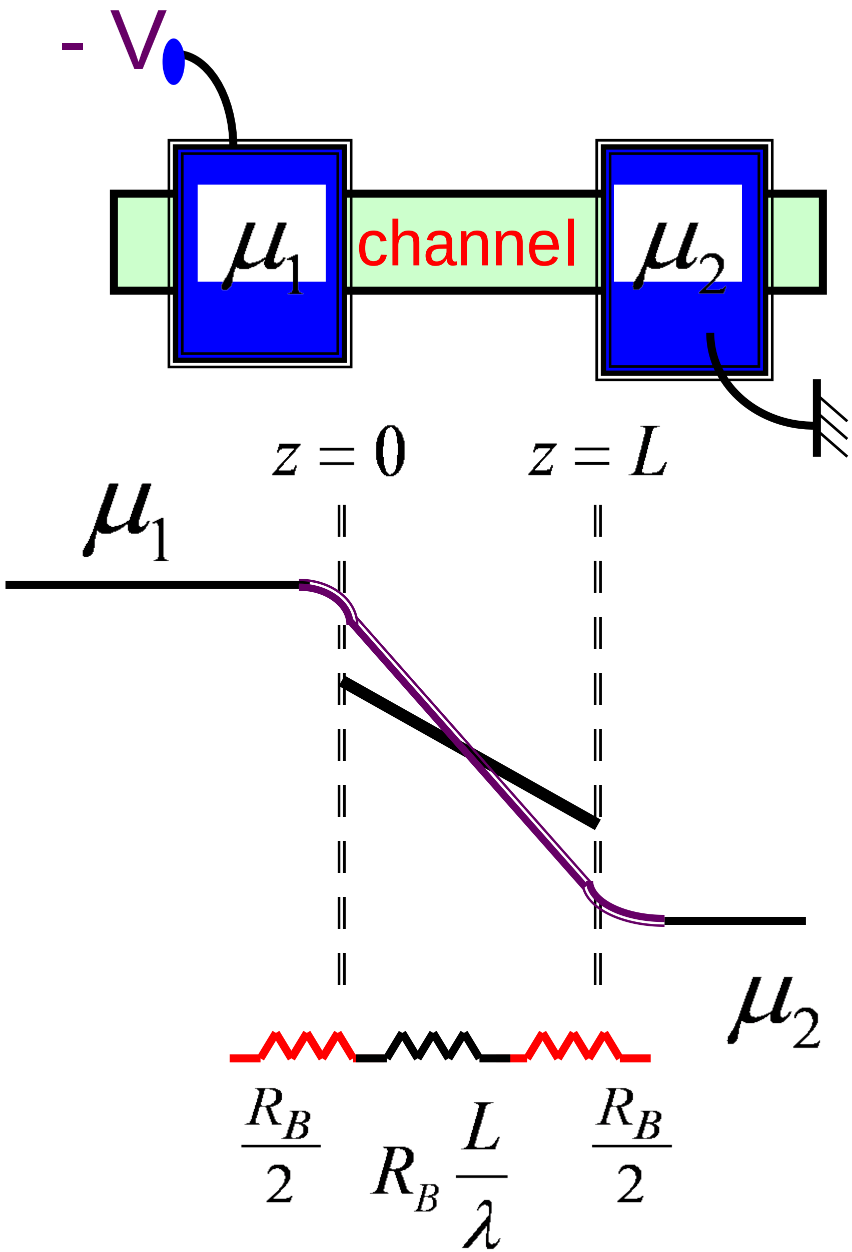
$$-\frac{\sigma_0}{q}\frac{d}{dz}(\mu - U)$$

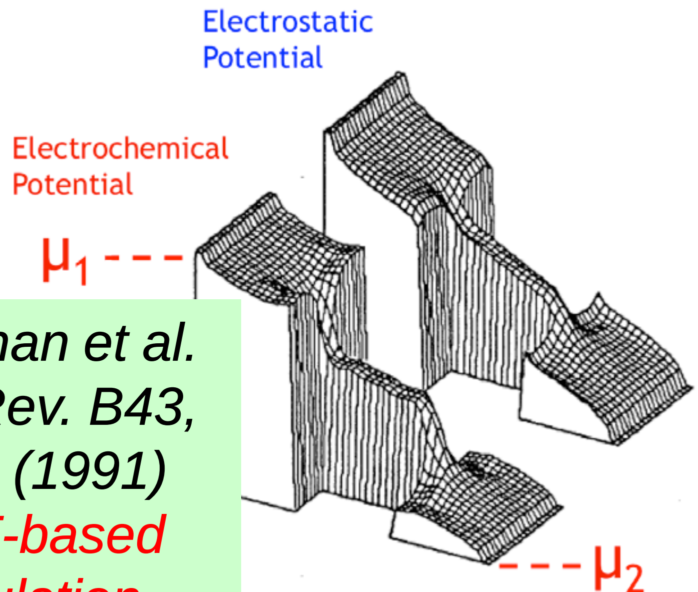
Electron Current

$$J = -\frac{\sigma_0}{q}\frac{dU}{dz} - q\frac{dn}{dz}$$

DRIFT *DIFFUSION*

$$\rightarrow \quad J = -\frac{\sigma_0}{q}\frac{d\mu}{dz}$$



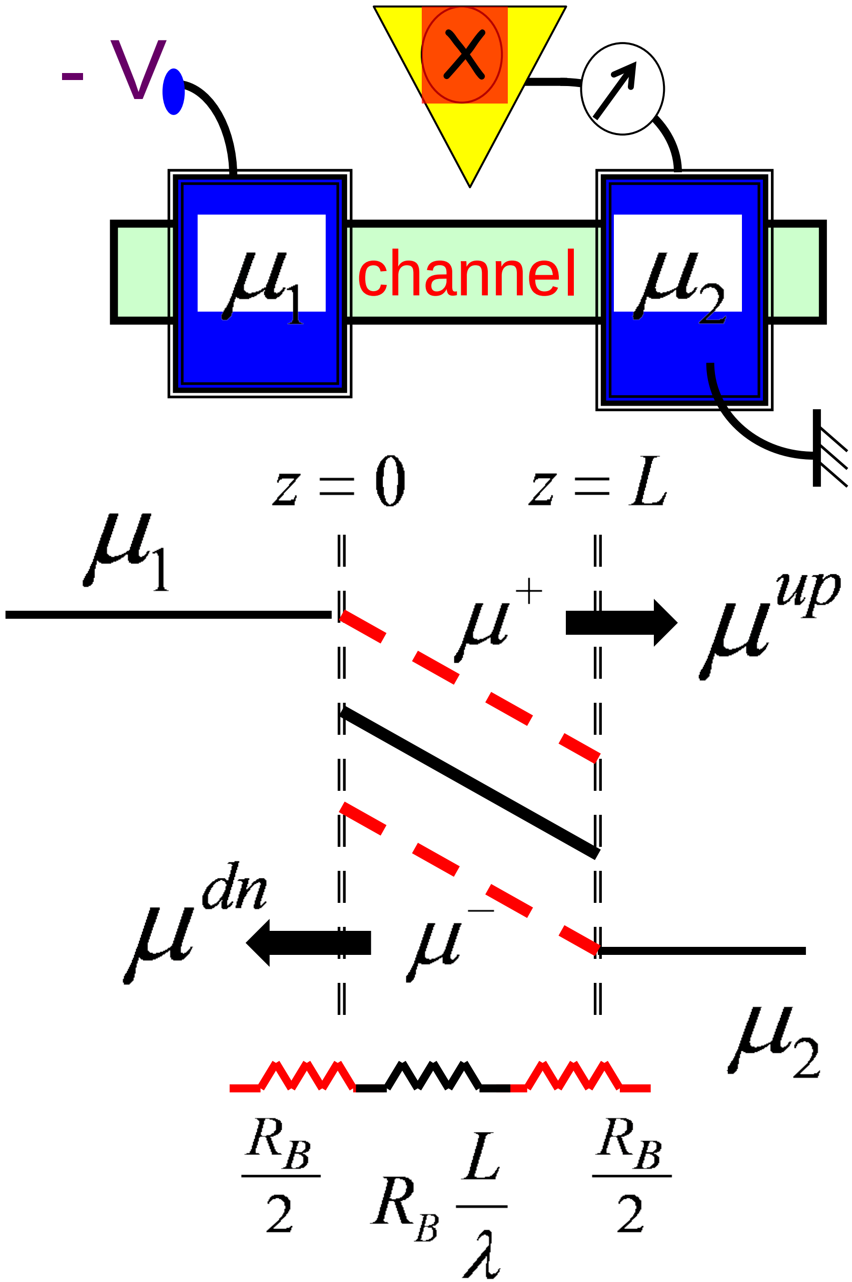


McLennan et al. Phys. Rev. B43, 13846 (1991)
NEGF-based Calculation

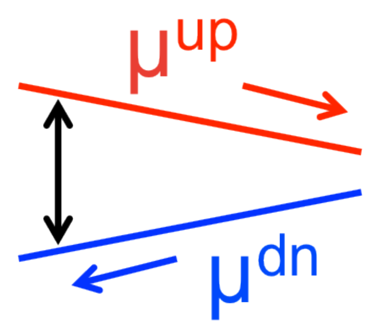
μ is difficult to define under non-equilibrium conditions

Boltzmann Equation

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



Spin Potential



Topological Insulators

Spin-momentum locking

Quasi-Fermi Levels (QFL's)

Boltzmann Equation

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

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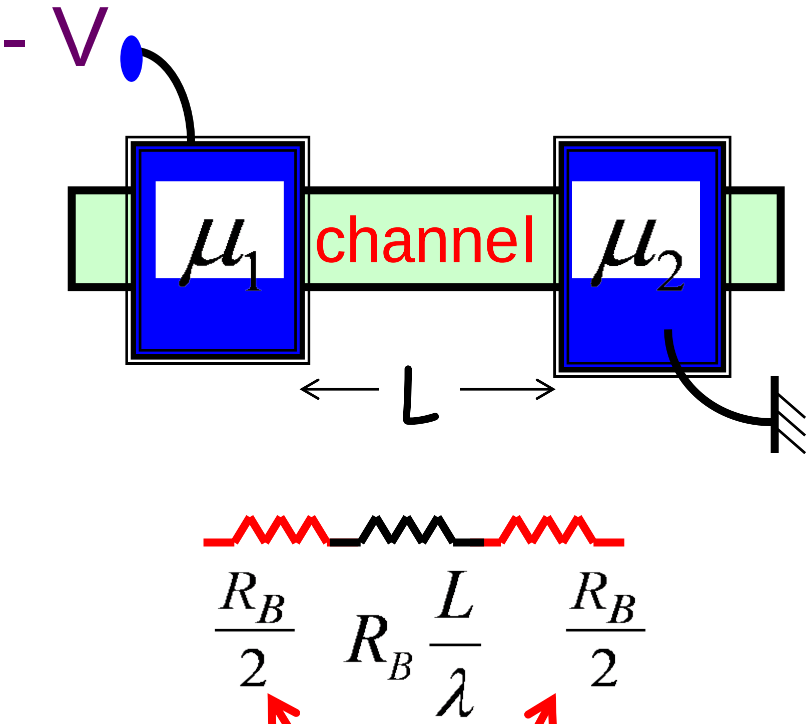
Coming up next ..



$$R_0 = \frac{1}{G_0} = R_B + R_B \frac{L}{\lambda}$$