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

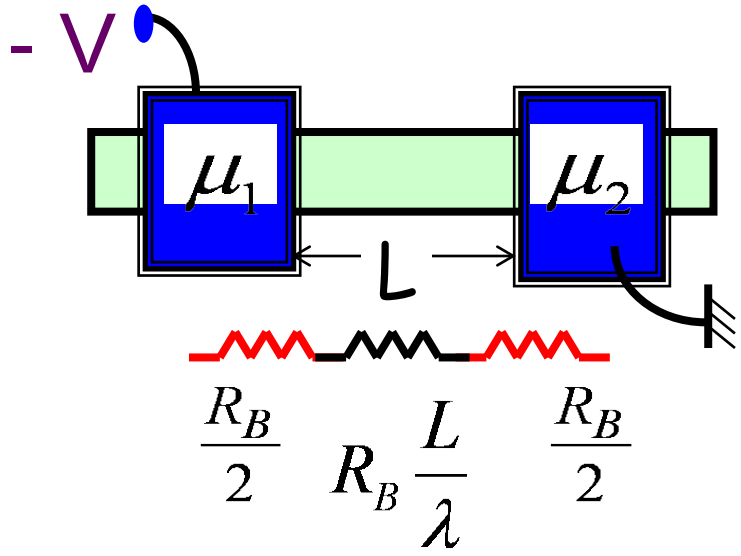
3.7. Electrostatic Potential

3.8. Boltzmann Equation

3.9. Spin voltages

3.10. Summing up ..

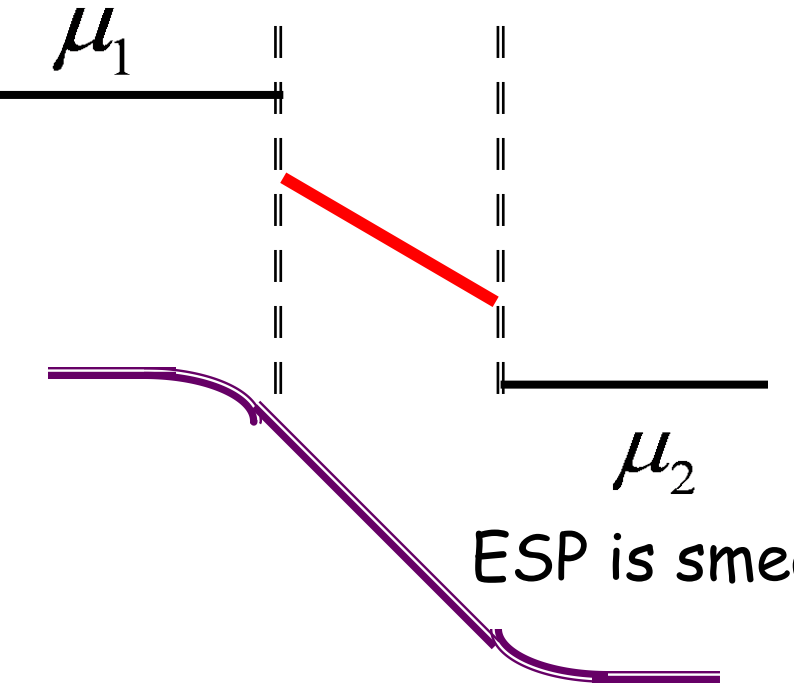
3.10a Summing Up …



- Follow the voltage IR
  NOT the heat I^2R

Voltage drop corresponds to intuition even on atomic scale

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

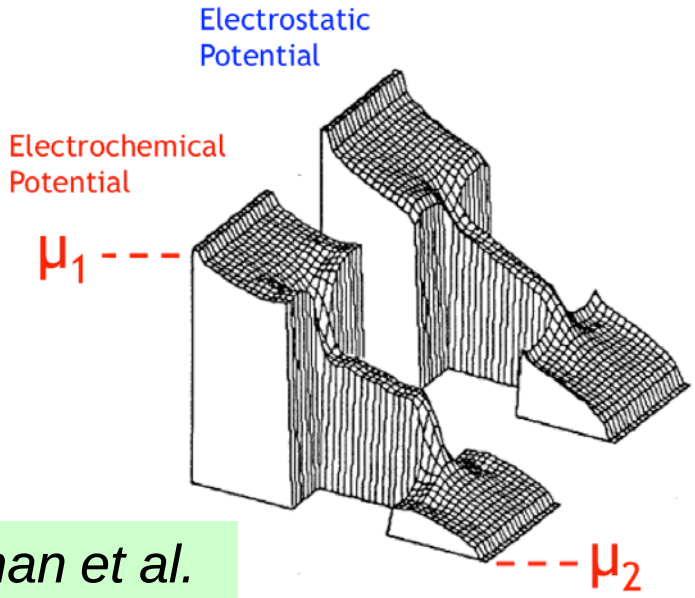


ESP is smeared out

- Electrochemical NOT Electrostatic Potential

ESP is NOT constant even in equilibrium

3.10b Summing Up …



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

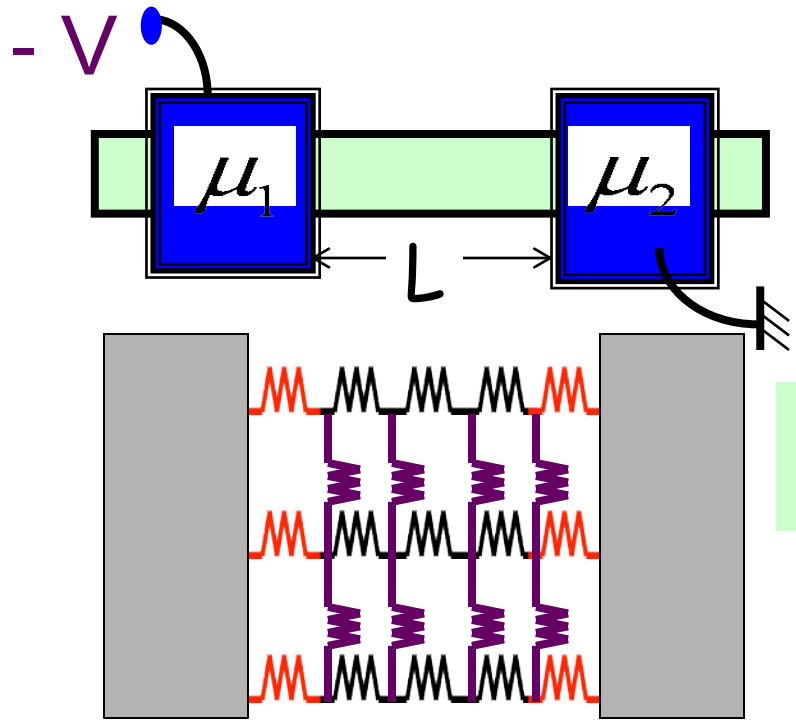
- Follow the voltage IR NOT the heat I^2R
- Electrochemical NOT Electrostatic Potential

Benchmark:

- Boltzmann equation

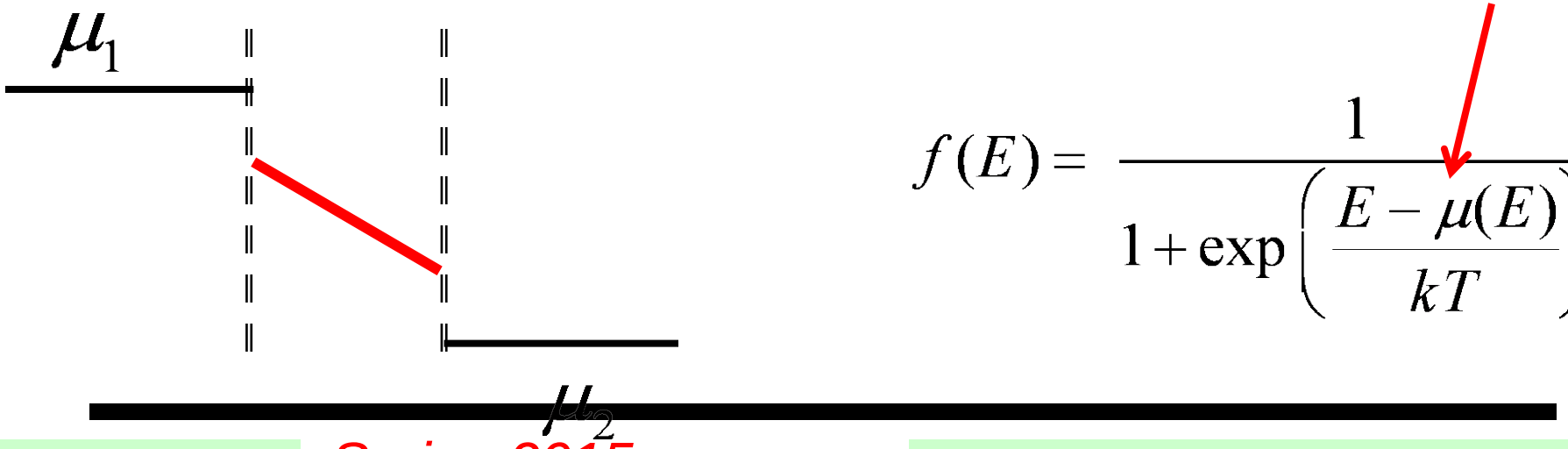
NEGF: Quantum Transport

3.10c Summing Up …



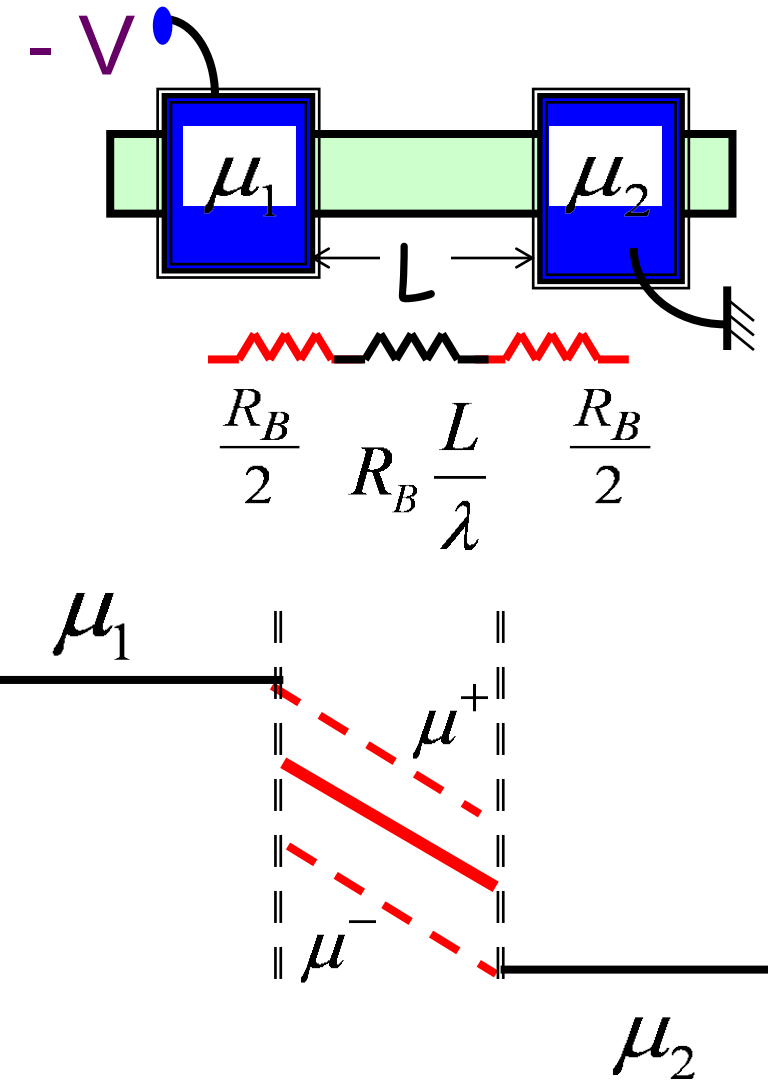
Inelastic processes

- Follow the voltage IR NOT the heat I^2R
- Electrochemical NOT Electrostatic Potential



$$f(E) = \frac{1}{1+\exp\left(\frac{E-\mu(E)}{kT}\right)}$$

3.10d Summing Up …

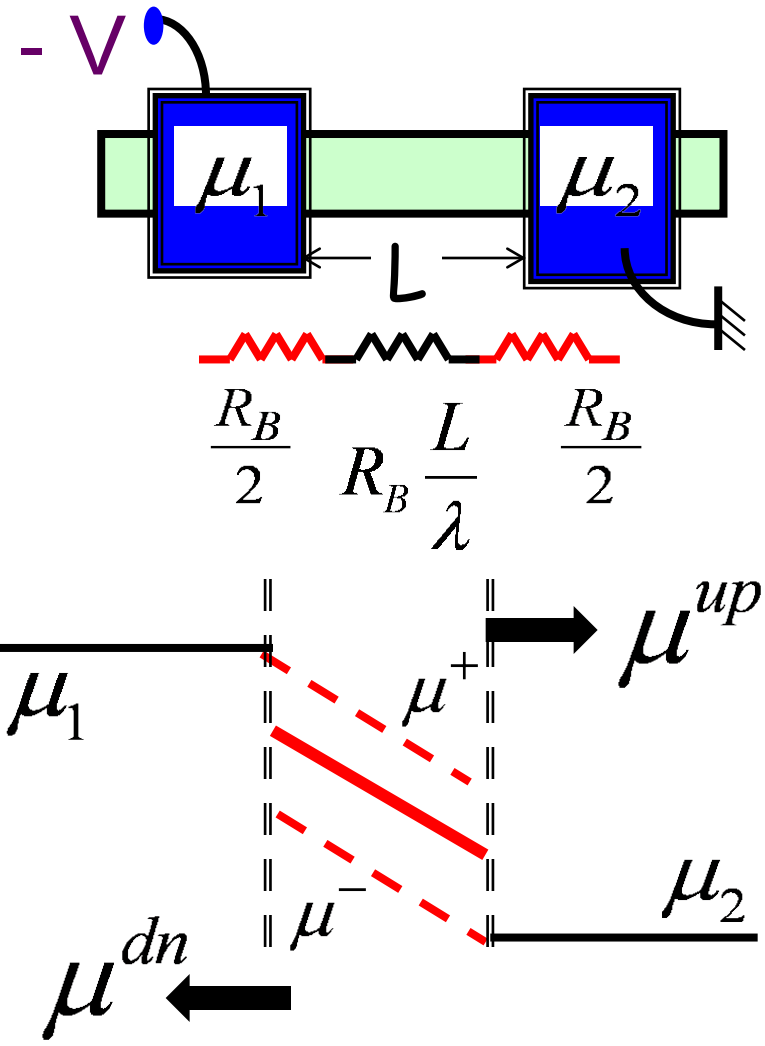


$\mu(E)$

- Follow the voltage IR NOT the heat I^2R
- Electrochemical NOT Electrostatic Potential
- Boltzmann equation

  NEGF: Quantum Transport
- Quasi-Fermi Levels (QFL's)

3.10e Summing Up …



$\mu(E)$

$\mu(z, p_z, s)$

- Follow the voltage IR NOT the heat I^2R
- Electrochemical NOT Electrostatic Potential
- Boltzmann equation
  NEGF: Quantum Transport
- Quasi-Fermi Levels (QFL's)
- Spin Potentials

$$J = \sigma F \sim -d\phi/dx$$ ✗

FUNDAMENTALS OF NANOELECTRONICS

Basic Concepts

Coming up next ..

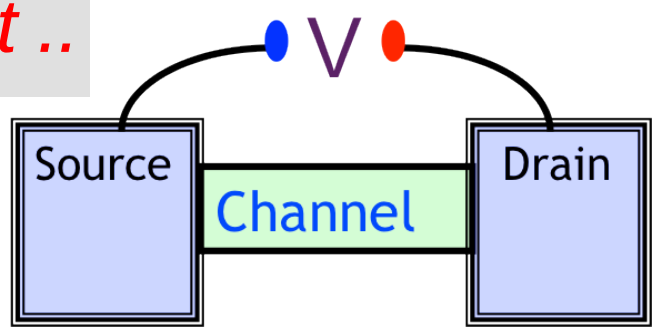
1. The New Ohm's Law

2. Quantum of Resistance

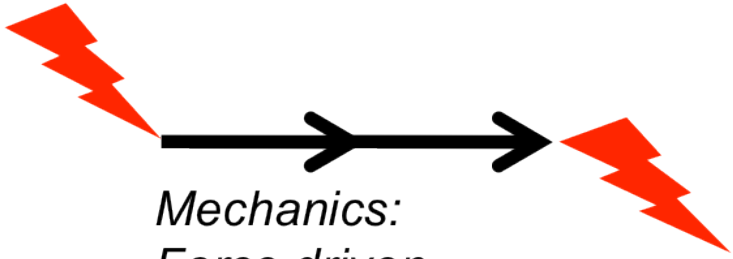
3. What & Where is the "Voltage"?

4. Heat & Electricity:

Second Law & Information



Thermodynamics:
Entropy driven



Mechanics:
Force driven

Usually all mixed up !!