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

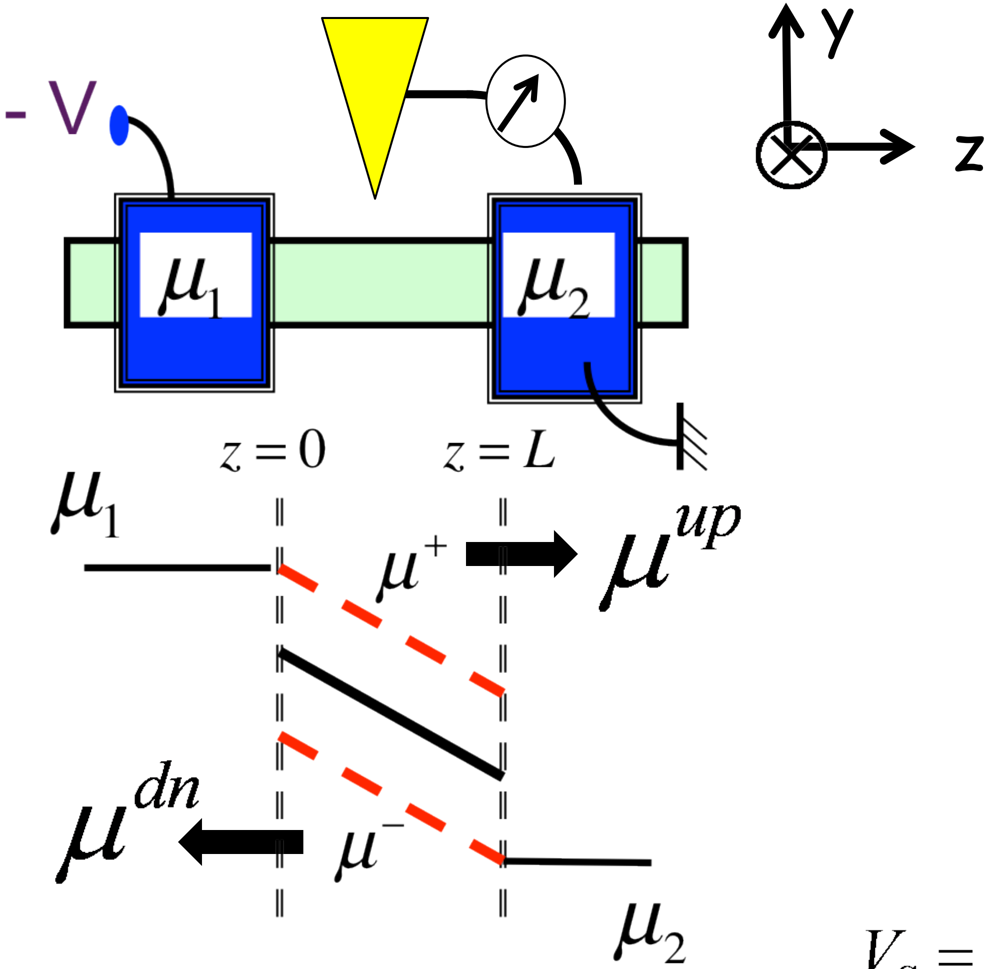
3.10. Summing up ..

Supriyo Datta

Spring 2015

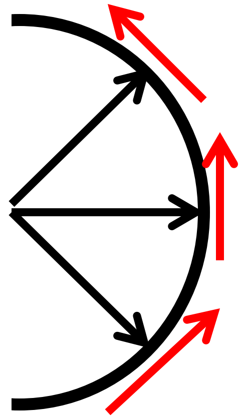
http://nanohub.org/groups/lnebook

3.9a Spin Voltages



Topological Insulators

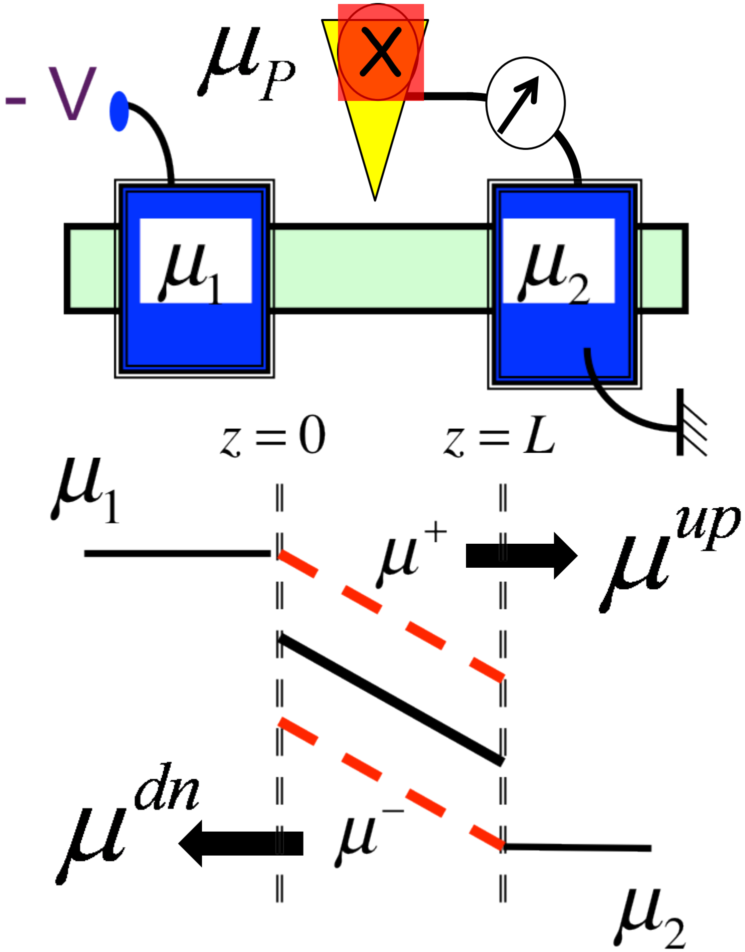
$$H = \hbar v_0 \, \hat{n} . \vec{\sigma} \times \vec{k}$$

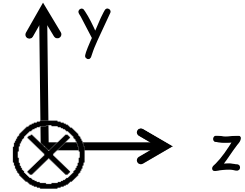


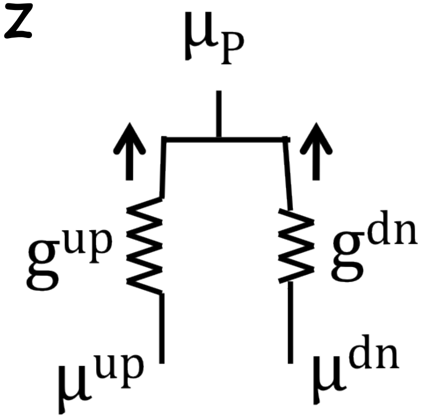
$$V_S = \frac{I}{2G_B} \times \frac{2}{\pi}$$

$$I = \frac{G_B}{q}\left(\mu^+ - \mu^-\right) = \frac{G_B}{q}\left(\mu^{up} - \mu^{dn}\right) = 2G_B V_S$$

3.9b Spin Voltages







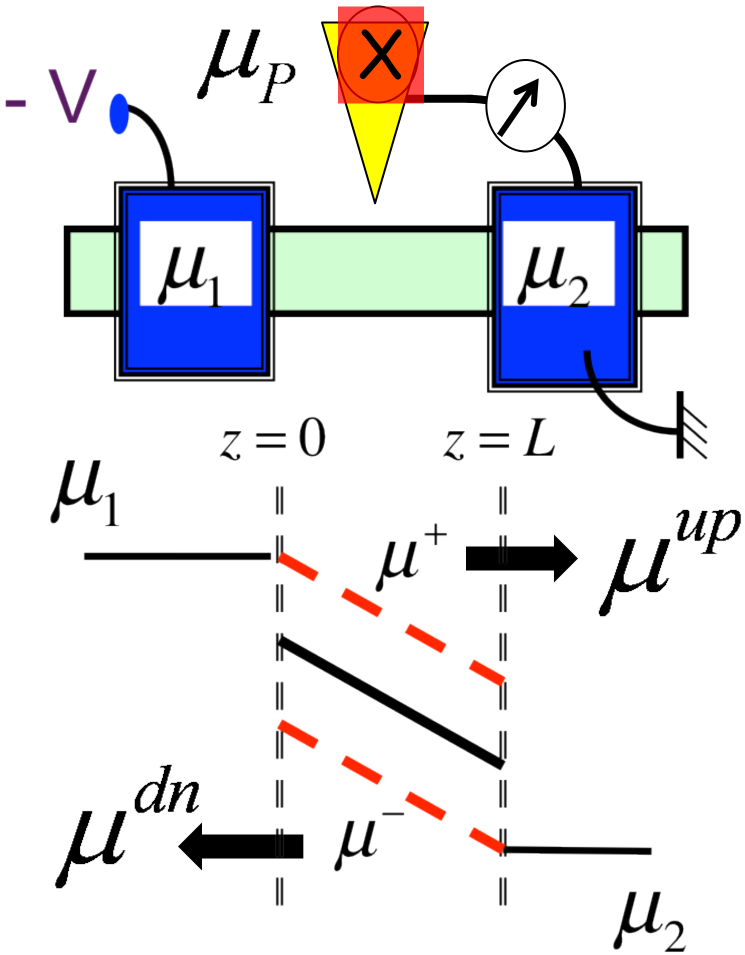
$$\mu_P = \frac{g^{up}}{g^{up}+g^{dn}}\mu^{up} + \frac{g^{dn}}{g^{up}+g^{dn}}\mu^{dn}$$

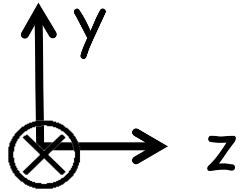
$$\mu_P(+\hat{M}) - \mu_P(-\hat{M})$$

$$= \underbrace{\frac{g^{up}-g^{dn}}{g^{up}+g^{dn}}}_{P}\left(\mu^{up} - \mu^{dn}\right)$$

$$V_S = \frac{I}{2G_B} \times \frac{2}{\pi} \times \hat{p}.\vec{P}$$

3.9c Spin Voltages

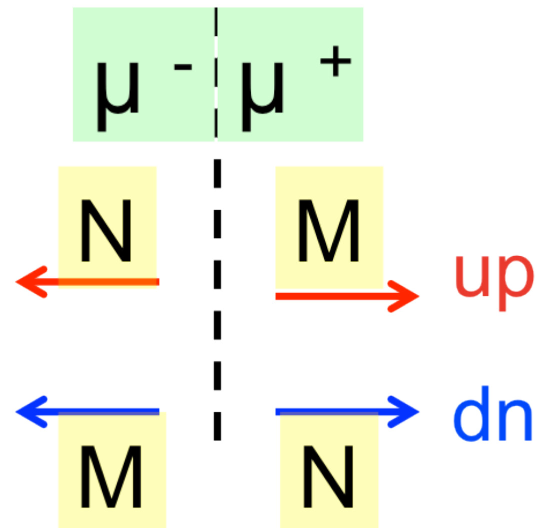




Rashba Spin – Orbit Coupling

$$H = \frac{\hbar^2 k^2}{2m} + \hbar v_0 \; \hat{n}.\vec{\sigma} \times \vec{k}$$

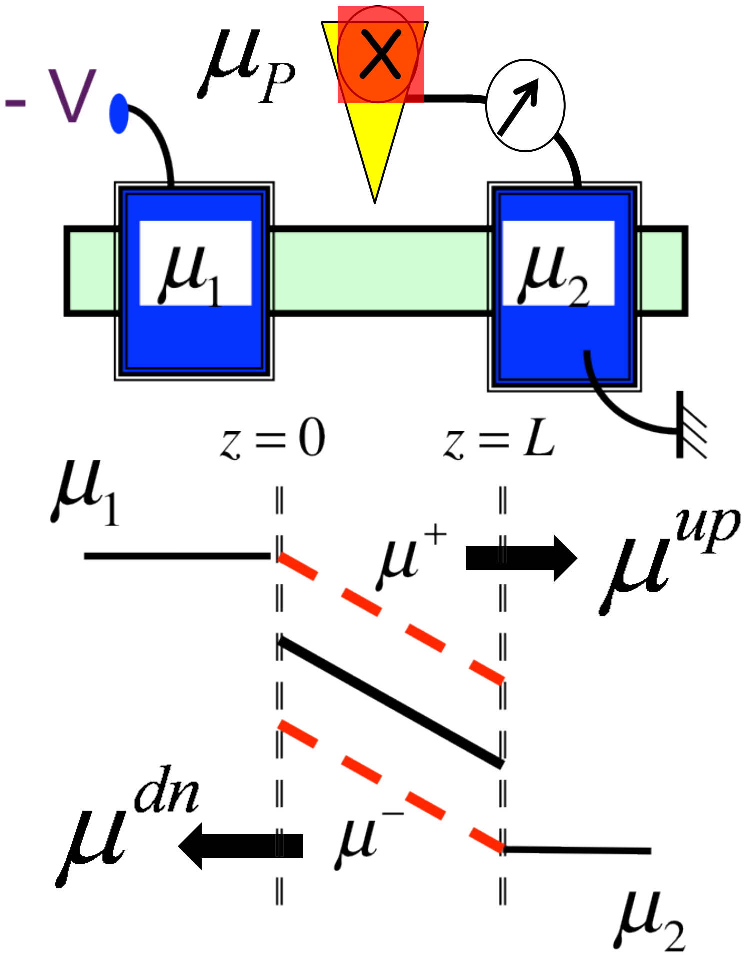
$$p = \frac{M - N}{M + N}$$

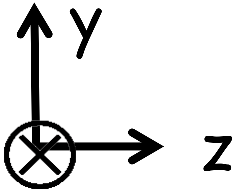


$$V_S = \frac{I}{2G_B} \times \frac{2}{\pi} \times \hat{p}.\vec{P}$$

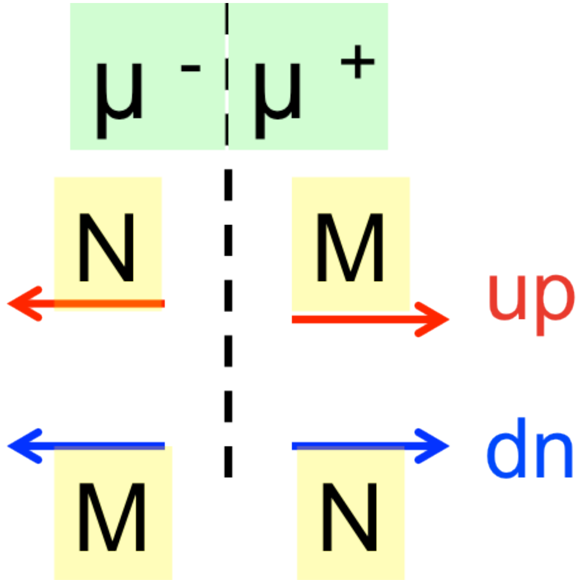
Topological Insulators : $N = 0$

3.9d Spin Voltages





Quasi-Fermi Levels (QFL's)

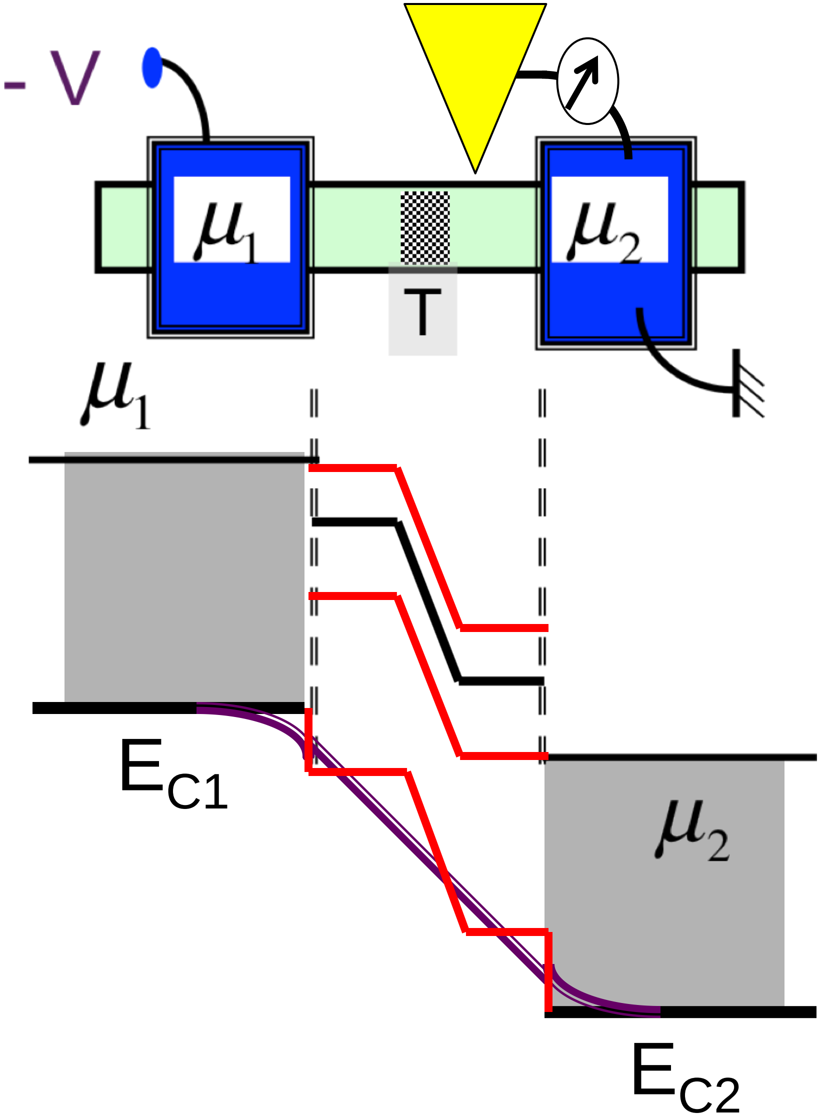


$$p = \frac{M - N}{M + N}$$

$$V_S = \frac{I}{2G_B} \times \frac{2}{\pi} \times \hat{p}.\vec{P}$$

$$Topological\ Insulators: \quad N = 0$$

Coming up next ..



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