

FUNDAMENTALS OF NANOELECTRONICS

B. Quantum Transport

1. Schrodinger Equation

Contact-ing Schrodinger →

3. Advanced Examples

4. Spin Transport

2.1. Introduction

2.2. Semiclassical Model

2.3. Quantum Model

2.4. NEGF Equations

2.5. Current Operator

2.6. Scattering Theory

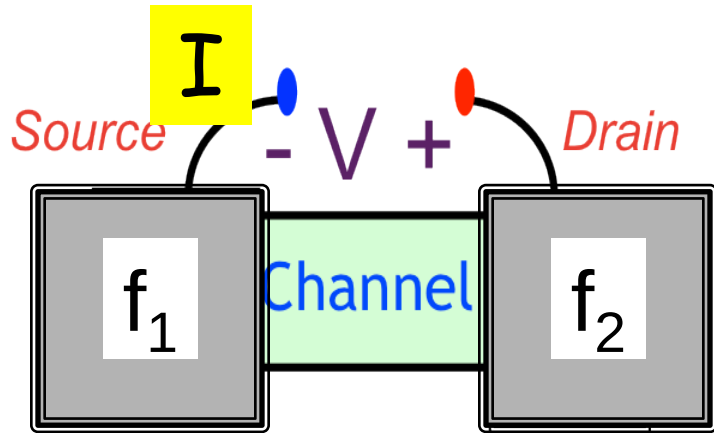
2.7. Transmission

2.8. Resonant Tunneling

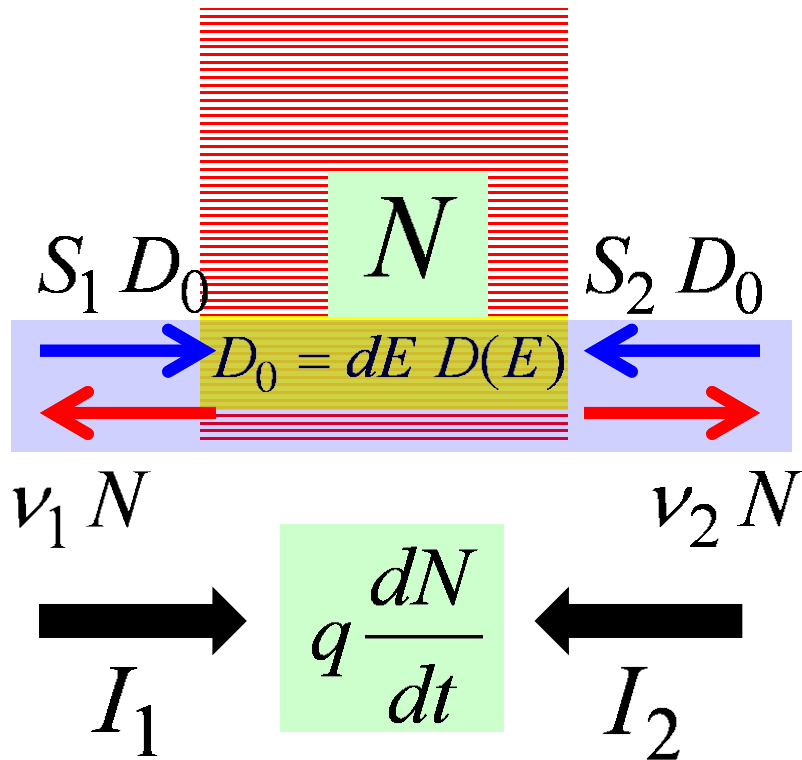
2.9. Dephasing

2.10. Summing up ..

2.2a Semiclassical Model

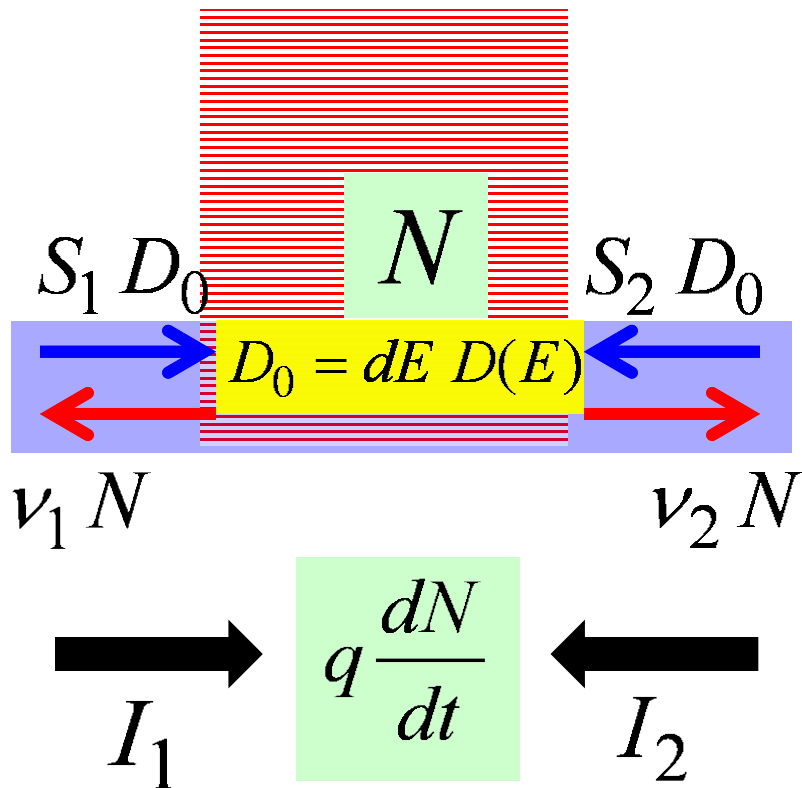
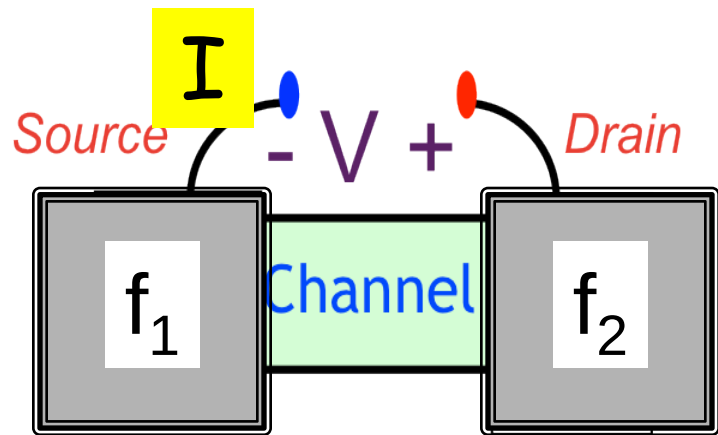


$$\frac{N}{D_0} = \frac{S_1 + S_2}{\nu_1 + \nu_2} \quad \text{Steady-state}$$



$$\frac{dN}{dt} = \overbrace{S_1 D_0 - \nu_1 N}^{\sim I_1} + \overbrace{S_2 D_0 - \nu_2 N}^{\sim I_2}$$

2.2b Semiclassical Model



$$\frac{N}{D_0} = \frac{S_1 + S_2}{\nu_1 + \nu_2} \quad \text{Steady-state}$$

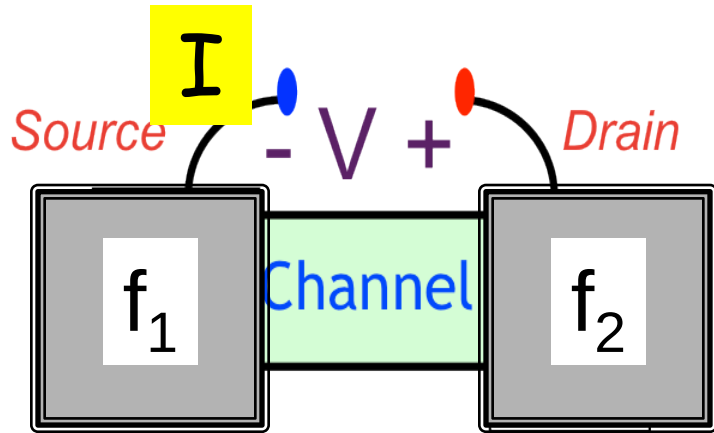
$$I_1 = D_0 \left(S_1 - \nu_1 \frac{N}{D_0} \right) \quad \times q$$

$$S_1 - \nu_1 \frac{S_1 + S_2}{\nu_1 + \nu_2} = \frac{\nu_2 S_1 - \nu_1 S_2}{\nu_1 + \nu_2}$$

$$I_1 = D_0 \frac{\nu_2 S_1 - \nu_1 S_2}{\nu_1 + \nu_2} \quad \times q$$

$$= -I_2$$

2.2c Semiclassical Model



$$\frac{N}{D_0} = \frac{S_1 + S_2}{\nu_1 + \nu_2}$$

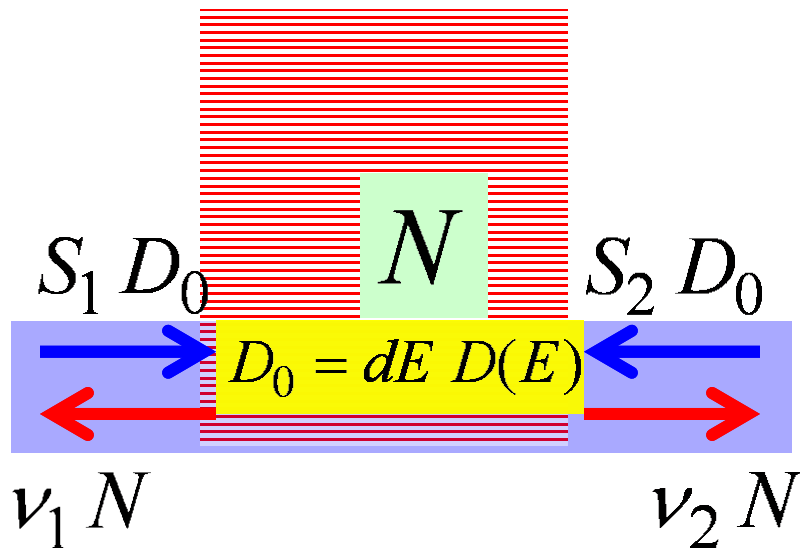
Steady-state

If only contact 1 were connected

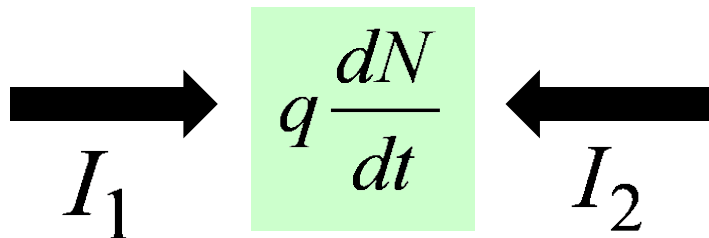
$$\frac{N}{D_0} = \frac{S_1}{\nu_1} = f_1(E)$$

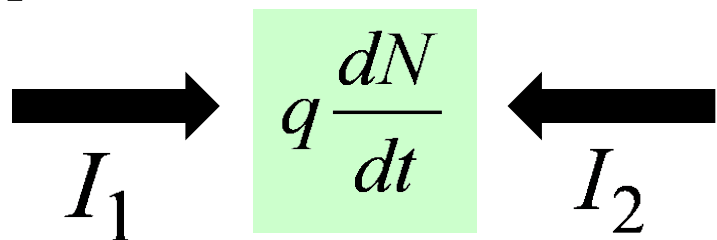
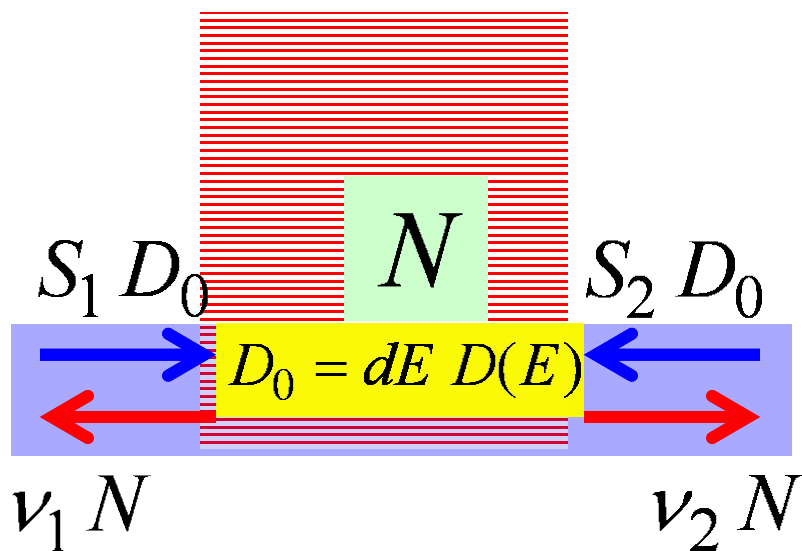
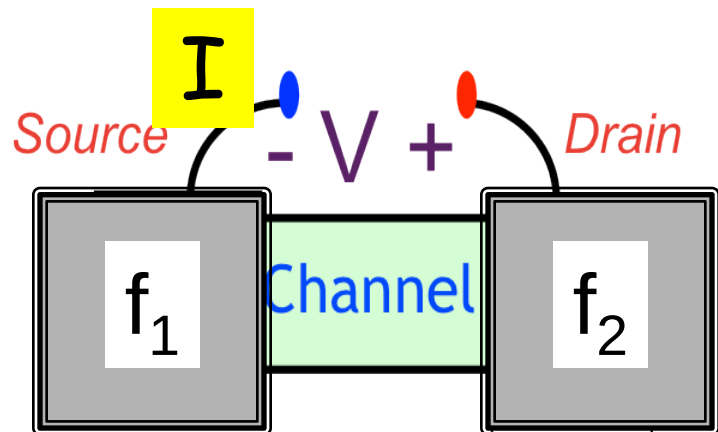
$$S_1 = \nu_1 f_1(E)$$

$$S_2 = \nu_2 f_2(E)$$



$$\begin{aligned} I_1 = -I_2 &= qD_0 \frac{\nu_2 S_1 - \nu_1 S_2}{\nu_1 + \nu_2} \\ &= qD_0 \frac{\nu_2 \nu_1 f_1 - \nu_1 \nu_2 f_2}{\nu_1 + \nu_2} \end{aligned}$$





2.2d Semiclassical Model

$$\frac{N}{D_0} = \frac{S_1 + S_2}{v_1 + v_2}$$

Steady-state

$$S_1 = v_1 f_1(E) \quad , \quad S_2 = v_2 f_2(E)$$

$$\frac{1}{\frac{1}{v_1} + \frac{1}{v_2}}$$

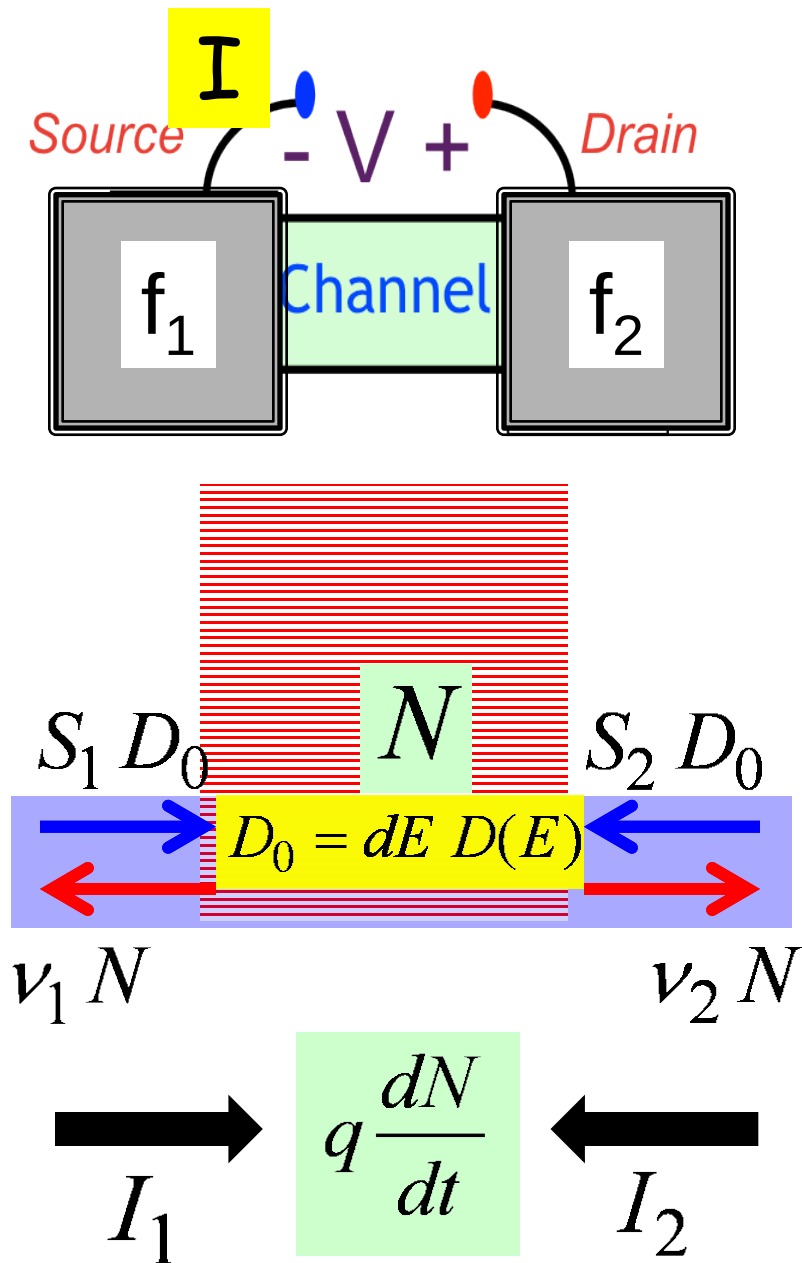
Recall from Part A

$$\frac{q^2 D_0}{2t}$$

$$I_1 = -I_2 = qD_0 \left[\frac{v_1 v_2}{v_1 + v_2} (f_1 - f_2) \right]$$

$$= qD_0 \frac{v_2 v_1 f_1 - v_1 v_2 f_2}{v_1 + v_2}$$

2.2e Semiclassical Model



$$\frac{N}{D_0} = \frac{S_1 + S_2}{v_1 + v_2} \quad \text{Steady-state}$$

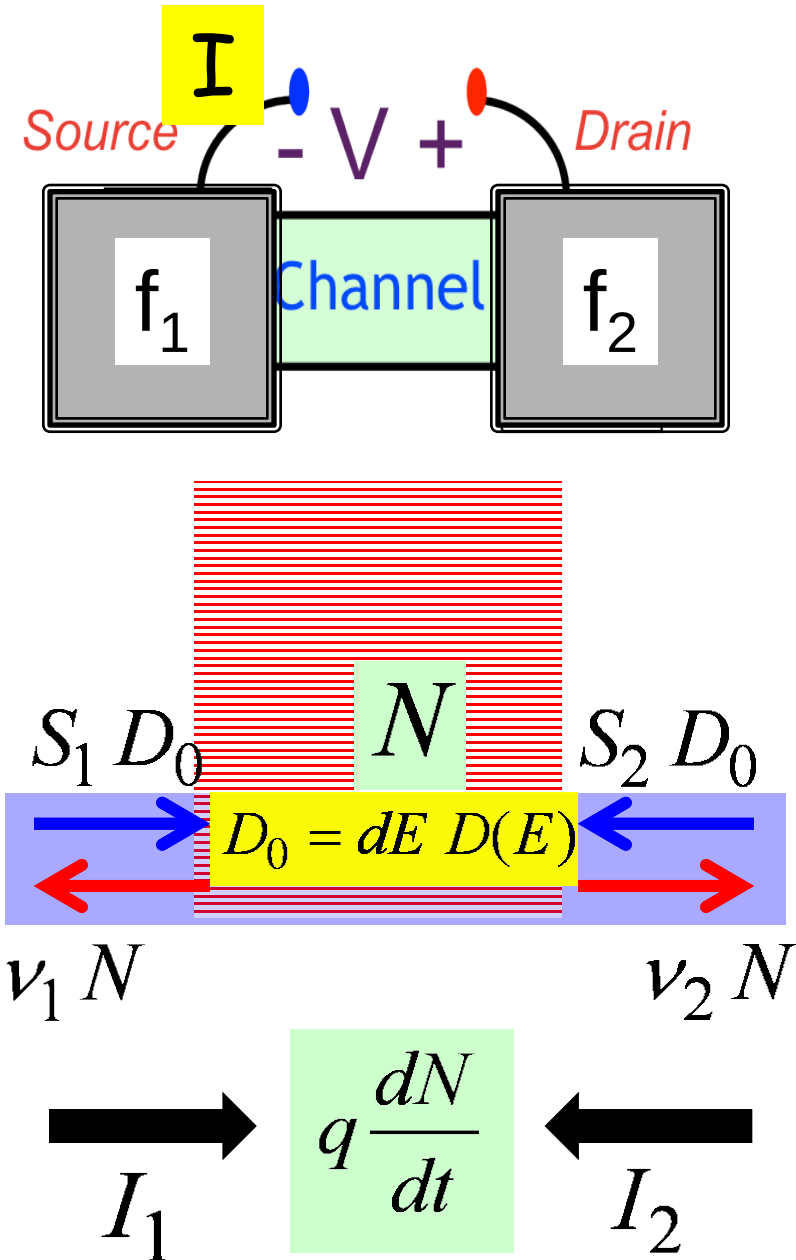
$$N = \int_{-\infty}^{+\infty} dE D(E) \frac{v_1 f_1 + v_2 f_2}{v_1 + v_2}$$

$$S_1 = v_1 f_1(E) \quad , \quad S_2 = v_2 f_2(E)$$

$$I_1 = -I_2 = q \int_{-\infty}^{+\infty} dE D(E) \frac{v_1 v_2}{v_1 + v_2} (f_1 - f_2)$$

$$I_1 = -I_2 = q D_0 \frac{v_1 v_2}{v_1 + v_2} (f_1 - f_2)$$

Coming up next ..



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