B. Quantum Transport

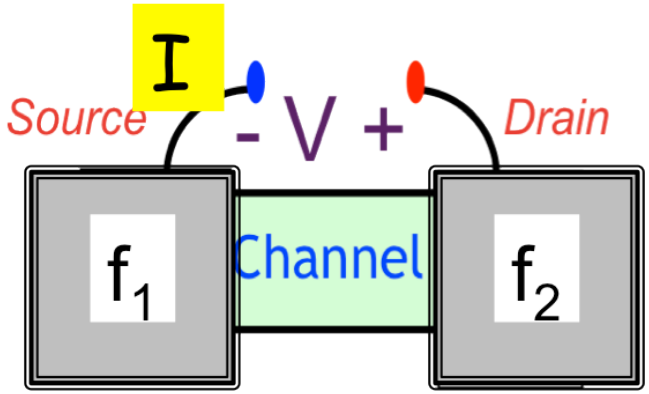
1. Schrodinger Equation

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 ..

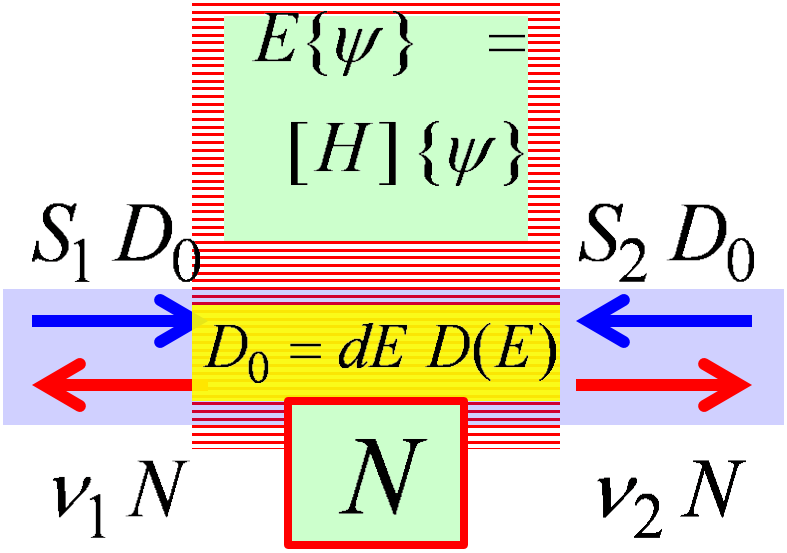


$$E\{\psi\} = [H]\{\psi\}$$

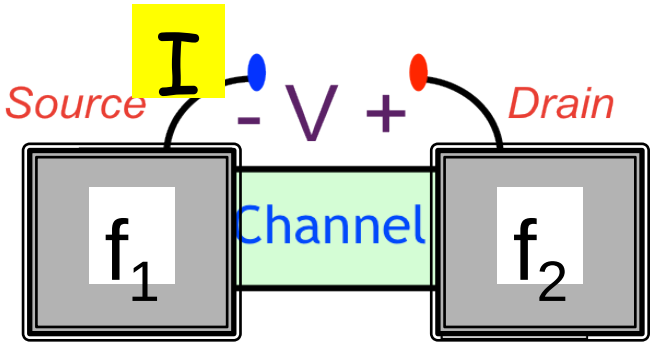
Schrodinger + ⚡ = NEGF

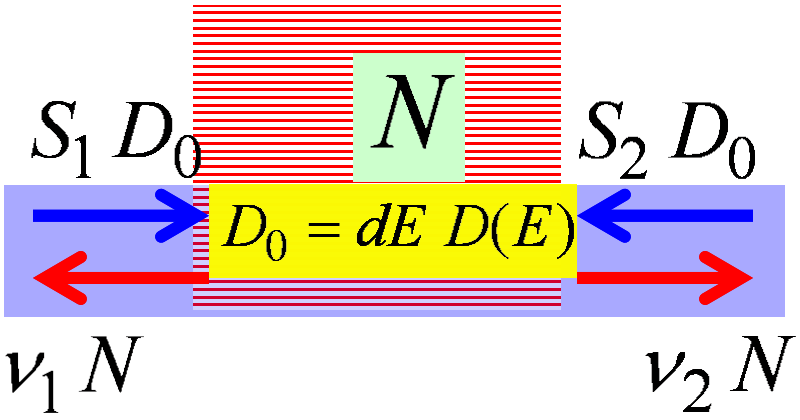
Quantum Transport

Part B



2.10b Summing up ..

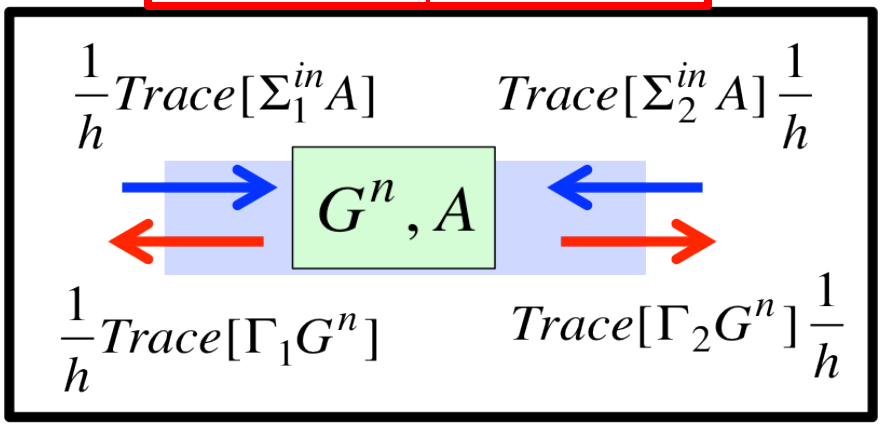




$$E\psi = s_1 + \Sigma_1\psi + H\psi + \Sigma_2\psi + s_2$$

$$\Gamma \equiv i(\Sigma - \Sigma^+) \quad A = i[G^R - G^A]$$

$\frac{A}{2\pi} \leftrightarrow D$	$\frac{G^n}{2\pi} \leftrightarrow N$
$\frac{\Sigma^{in}}{\hbar} \leftrightarrow S$	$\frac{\Gamma}{\hbar} \leftrightarrow \nu$



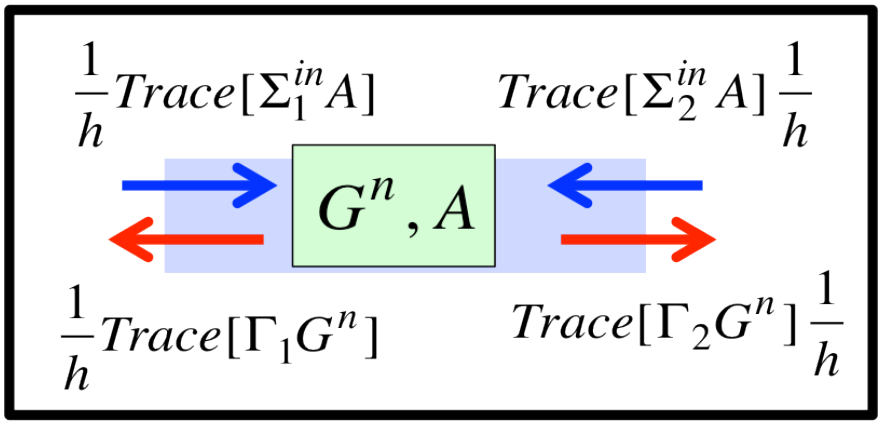
$$\psi\psi^+ = \frac{[G^n]}{2\pi}$$

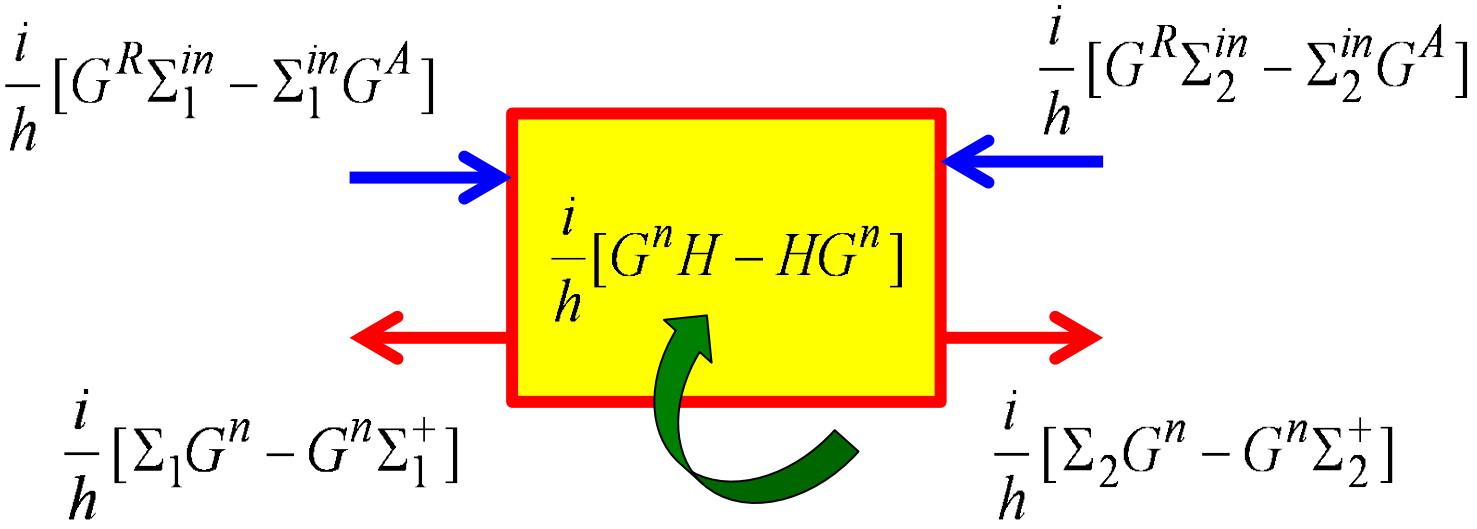
$$ss^+ = \frac{[\Sigma^{in}]}{2\pi}$$

Current Operator

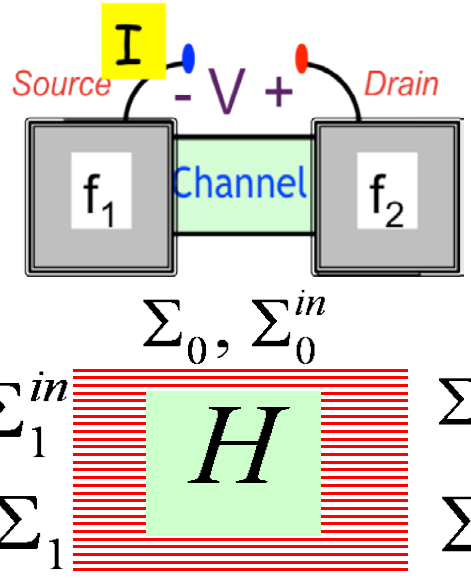
$$I_Y = Trace\, Y\, I_{op}$$

$$\rightarrow \quad Y\, Trace\, I_{op}$$





2.10d Summing up ..



$$\Gamma \equiv i(\Sigma - \Sigma^{+})$$

$$A = i[G^{R} - G^{A}]$$

$$\frac{1}{h} Trace[\Sigma_1^{in} A] \qquad Trace[\Sigma_2^{in} A] \frac{1}{h}$$

$$G^{n}, A$$

$$\frac{1}{h} Trace[\Gamma_1 G^{n}] \qquad Trace[\Gamma_2 G^{n}] \frac{1}{h}$$

$$G^{R} = [EI - H - \Sigma]^{-1}$$

$$G^{n} = G^{R} \Sigma^{in} G^{A}$$

$$\Sigma = \Sigma_1 + \Sigma_2 + \Sigma_0$$

$$\Sigma^{in} = \Sigma_1^{in} + \Sigma_2^{in} + \Sigma_0^{in}$$

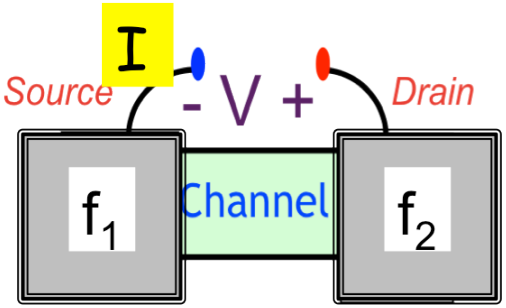
$$\Sigma_1^{in} = \Gamma_1 f_1(E)$$

$$\Sigma_2^{in} = \Gamma_2 f_2(E)$$

For the dephasing contact

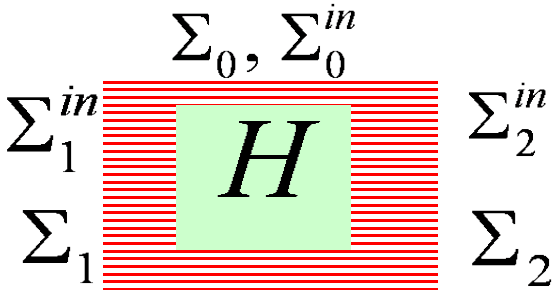
$$Trace[\Sigma_0^{in} A] = Trace[\Gamma_0 G^{n}]$$

2.10e Summing up ..

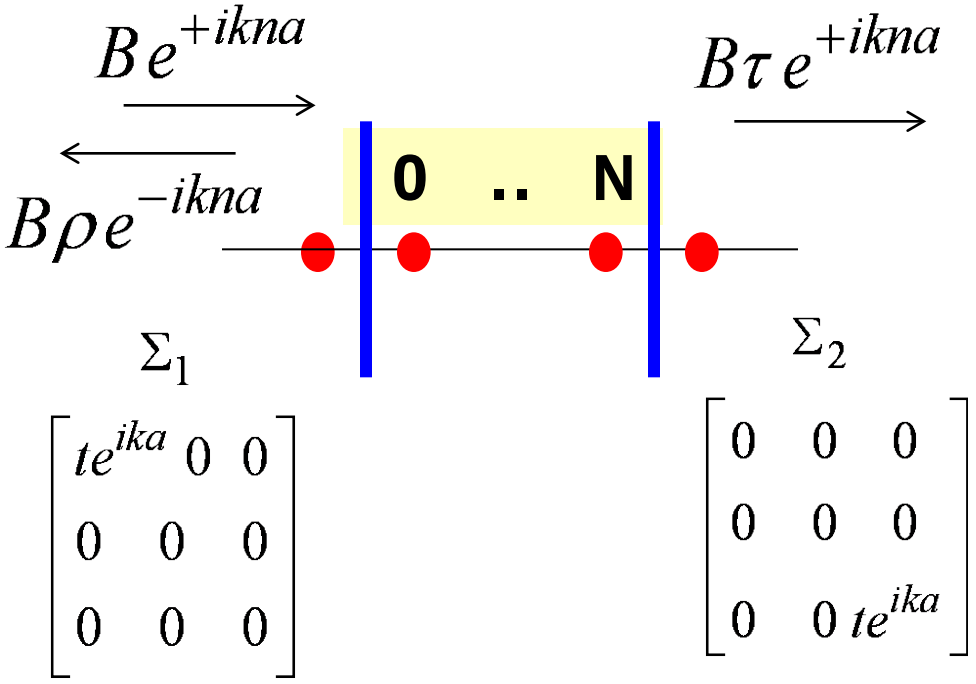


$$\Gamma \equiv i(\Sigma - \Sigma^{+})$$

$$A = i[G^{R} - G^{A}]$$



1D



$$G^{R} = [EI - H - \Sigma]^{-1}$$

$$G^{n} = G^{R}\,\Sigma^{in}\,G^{A}$$

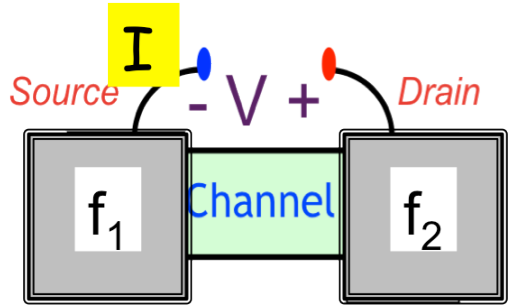
$$\Sigma = \Sigma_1 + \Sigma_2 + \Sigma_0$$

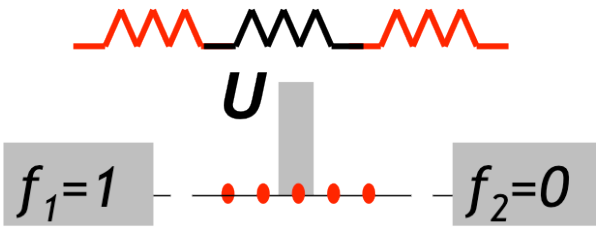
$$\Sigma^{in} = \Sigma_1^{in} + \Sigma_2^{in} + \Sigma_0^{in}$$

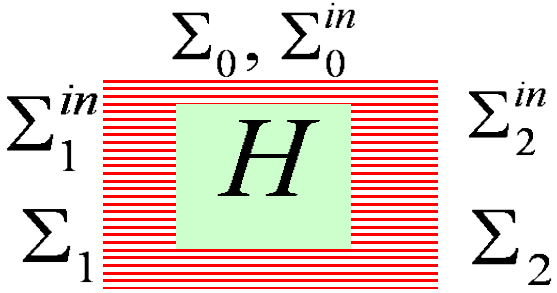
$$\Sigma_1 = \begin{bmatrix} te^{ika} & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

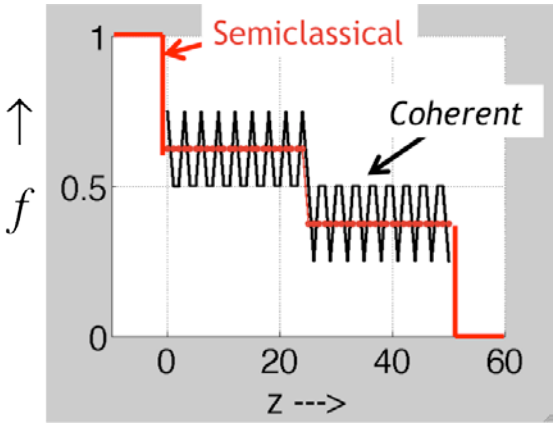
$$\Sigma_2 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & te^{ika} \end{bmatrix}$$

2.10f Summing up ..









$$[\Sigma_0]_{ij} = D_{ij}\,[G^R]_{ij}$$

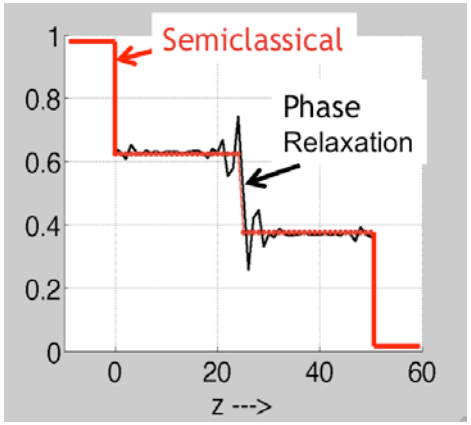
$$[\Sigma_0^{in}]_{ij} = D_{ij}\,[G^n]_{ij}$$

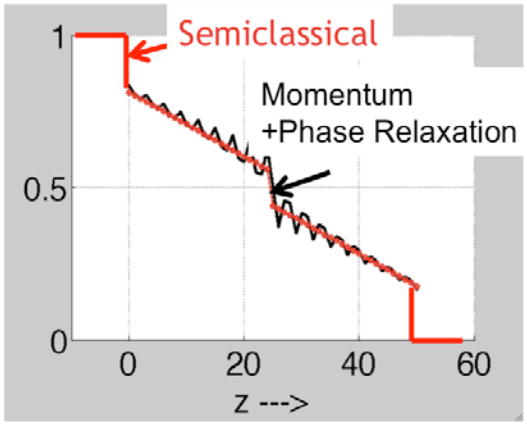
$$G^R = [EI - H - \Sigma]^{-1}$$

$$G^n = G^R\,\Sigma^{in}\,G^A$$

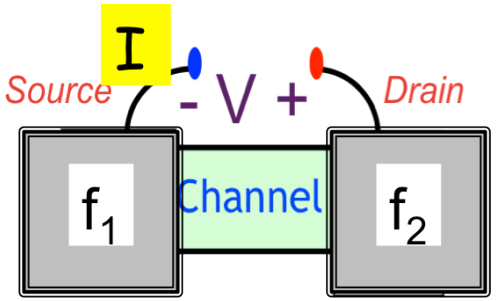
$$\Sigma = \Sigma_1 + \Sigma_2 + \Sigma_0$$

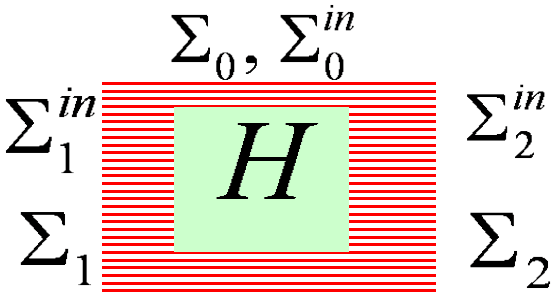
$$\Sigma^{in} = \Sigma_1^{in} + \Sigma_2^{in} + \Sigma_0^{in}$$





$$\Gamma \equiv i(\Sigma - \Sigma^+) \qquad A = i\,[G^R - G^A]$$





$$G^R = [EI - H - \Sigma]^{-1}$$

$$G^n = G^R \Sigma^{in} G^A$$

$$\Sigma = \Sigma_1 + \Sigma_2 + \Sigma_0$$

$$\Sigma^{in} = \Sigma_1^{in} + \Sigma_2^{in} + \Sigma_0^{in}$$

$$\Gamma \equiv i(\Sigma - \Sigma^+) \quad A = i[G^R - G^A]$$

Coming up next ..

B. Quantum Transport

1. Schrodinger Equation
2. Contact-ing Schrodinger

3. Advanced Examples

4. Spin Transport

UNIT 3

More advanced examples