Statistical Mechanics

Equilibrium Problems

Non-equilibrium Problems

Boltzmann Equation

\[ f \left( \vec{r}, \vec{k}, t \right) \rightarrow \text{Newton's Law + scattering (Entropic forces)} \]
Quantum Mechanics

\[ \psi(r) \rightarrow \text{Schrodinger Equation} \]

NEG F \rightarrow \text{Quantum Boltzman Equation (Schrodinger Equation + scattering)}

Landauer Model

Channel \rightarrow \text{dynamics}

Contact \rightarrow \text{thermodynamics}

Applications: small devices, large device in low bias

Multi-particle Schrodinger Equation

\[ \Psi(r_1, r_2, \ldots) \]

\[ i\hbar \frac{d\Psi}{dt} = H\Psi \]

\[ \rho = \frac{1}{Z} \exp \left( -\frac{H - \mu N}{k_B T} \right) \]

Works well when coupling of levels is low

Photons

\[ E^2 = m^2 c^4 + p^2 c^2 \]

Maxwell's Equation \rightarrow \text{Schrodinger Equation for photons}

\[ \vec{E}(\vec{r}) \Rightarrow \Psi(r) \]

Applications: small devices, large device in low bias

Air Glass

1 photon/s

? \rightarrow ?
Multi-electron Schrodinger Equation

\[ \Psi(r_1, r_2, ...) \]

This becomes an operator in second quantization

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

\[ G^n = G \Sigma^{in} G^+ \]

\[ G^n = \langle \psi \psi^+ \rangle \]

\[ i\hbar \frac{\partial}{\partial t} \begin{pmatrix} \uparrow \downarrow \\ \downarrow \uparrow \end{pmatrix} = \begin{bmatrix} * & \ast \\ \ast & * \end{bmatrix} \begin{pmatrix} \uparrow \downarrow \\ \downarrow \uparrow \end{pmatrix} \]

\[ \psi = a(r_1)b(r_2) - a(r_2)b(r_1) \]

if \( r_1 = r_2 \)

\[ \psi = 0 \]

\( \psi \) cannot be measured

\( \psi^* \psi \) can be measured

In case of photons, the ‘-’ sign is replaced by a ‘+’ sign so many photons can be in a single state, which gives a big magnitude for electric field, that can be measured