4.1. Introduction
4.2. Seebeck Coefficient
4.3. Heat Current
4.4. One-level Device
4.5. Second Law
4.6. Entropy
4.7. Law of Equilibrium
4.8. Shannon Entropy
4.9. Fuel Value of Information
4.10. Summing up ..
4.10a Summing up

4.2, 4.3, 4.4 Thermoelectricity

➢ Obtain standard results for thermoelectric coefficients

\[ I = G_0 \Delta V + G_s \Delta T \]

\[ I_Q = G_P \Delta V + G_Q \Delta T \]
4.10b Summing up

\[
\frac{E_1 - \mu_1 N_1}{T_1} + \frac{E_2 - \mu_2 N_2}{T_1} + \frac{E_0}{T_0} \leq 0
\]
4.5 Second Law

\[
\frac{E_1 - \mu_1 N_1}{T_1} + \frac{E_2 - \mu_2 N_2}{T_1} + \frac{E_0}{T_0} \leq 0
\]

4.6 Entropy

\[
E - \mu N \rightarrow E, N
\]

\[
\mu N \rightarrow \text{Contact} \quad T, \mu
\]

\[
\frac{P(E, N)}{P_r(E, N)} = \exp \left( - \frac{E - \mu N}{kT} \right)
\]

4.7 Law of Equilibrium

\[
p_i = \frac{1}{Z} e^{-\frac{(E_i - \mu N_i)}{kT}}
\]
4.10d Summing up

4.6 Entropy

\[ \frac{S}{k} = \ln W \]

4.8 Shannon Entropy

\[ \frac{S}{k} = - \sum_i \tilde{p}_i \ln \tilde{p}_i \]

Why is it harder to take than to give

\[ \frac{P(E)}{P_r(E)} = \exp \left( - \frac{E}{kT} \right) \]
4.10e Summing up

Information Content

4.8 Shannon Entropy

\[ S = - k \sum_i \tilde{p}_i \ln \tilde{p}_i \]

\[ H = - \sum \tilde{p}_i \ln \tilde{p}_i \]
4.10f Summing up

“Info-battery”

Maxwell’s Demon

\[ S = 0 \]

\[ S = nk \ln n2 \]

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Basic Concepts: Semiclassical Models

1. The New Perspective
2. Energy Band Model
3. What and Where is the Voltage?
4. Heat & Electricity: Second Law & Information

Entropy driven

Force driven

Entropy driven

“Epilogue”

Quantum Models

5. Schrodinger Equation
6. Contact-ing Schrodinger
7. NEGF Method
8. Spin Transport

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