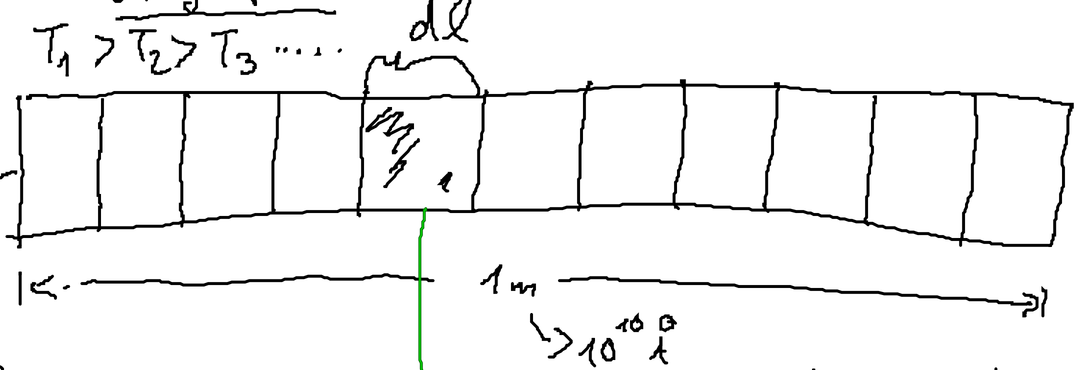
→ Chap 9: TRANSPORT

↳ Non-Equilibrium Thermodyn. & Statistical Mechanics

Onsager picture




$\Delta U \approx 220V$

$\Delta T \approx 300K$

dl : → Large enough, so that equil. thermo. holds

↳ individual segments are in non-equ. with respect to each other

$\vec{j}_e = -\sigma \nabla U$ … Ohm's law

$\vec{j}_h = -\kappa \nabla T$ … Fourier's law

} linear response

⇒ Lasers: ⇒ non-linear optics

⇒ $\sigma$ … elec. conductivity, $\kappa$ … thermal conductivity } = f(T, p, crystal structure, compo.)

→ Macroscopic Effects: $\nabla U$, $\nabla T$

→ Microscopic Response: $\kappa$, $\sigma$

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<u>Definition of transport coefficients:</u> Onsager Coefficients

⇒ electrons
- charge → $j_e$
- Energy → $j_h$ ← phonons

$$\vec{j}_c = L^{11}\left(-\nabla U - \frac{\nabla\mu}{e}\right) + L^{12}\left(-\nabla T\right)$$

$$\vec{j}_h = L^{21}\left(-\nabla U - \frac{\nabla\mu}{e}\right) + L^{22}\left(-\nabla T\right)$$

↳ $L^{21} = T \cdot L^{12}$

$$\sigma = L^{11} \quad \dots \quad \nabla T = 0$$ ↗ closed thermal circuit

$$\kappa = L^{22} - \frac{L^{21} L^{12}}{L^{11}} = L^{22} - T\frac{\left(L^{12}\right)^2}{L^{11}}$$

↳ open electrical circuit.

$$\left(-\nabla U - \frac{\nabla\mu}{e}\right) = \frac{L^{12}}{L^{11}}\nabla T = S\,\nabla T$$

↳ Seebeck coefficient:

„Temperature is converted into voltage"

⇒ convert unused heat into useful voltage

$\eta$ ... efficiency

$$\rightarrow \quad \eta = \eta_{CARNOT}\left( zT \right)$$

$$zT = \frac{S^2 \sigma}{\kappa_{el} + \kappa_{ph}}$$