

Drude and Tompson proposed the classical free-electron model of metals to calculate the electrical and thermal conductivities.

According to their model, the electrical conductivity σ is given by

$$\sigma = \frac{\overset{\substack{\text{\# of free} \\ \text{electrons/cm}^3}}{n} e^2 L}{(3 k_B T m_e)^{1/2}}$$

← mean free path

↑ temperature (K)

and the resistivity ρ is given by

$$\rho = \frac{1}{\sigma} = \frac{\sqrt{3 k_B m_e}}{n e^2 L} \sqrt{T} \propto \sqrt{T}$$

However experimental measurements show that

$$\rho \propto T!$$

Furthermore σ calculated is different from σ measured by one order of magnitude!

If L is replaced by the quantum mean free path and v_{rms} is replaced by the Fermi velocity $\Rightarrow \sigma_{measured} = \sigma_{calculated}!$