LECTURE #1

DRUDE MODEL

METAL = \[ \text{positive ions fixed} \]

\[ e + \] \[ e - \]

COLLISIONS BETWEEN \( e \) AND FIXED IONS

CLASSICAL GAS OF FREE ELECTRONS

\[ \frac{1}{m} = \frac{4}{3} \pi n_s^2 \]

\[ v_s \approx \frac{1}{a_B} \sim 2 - 3 \]

\[ \frac{v_s^2}{a_B} = \frac{\hbar^2}{m e^2} \sim 0.5 \text{ Å} \]

\[ M = 2 \text{ mass} \]
ASSUMPTIONS

DRUDE MODEL:

1. NO E-E INTERACTION (INDEPENDENT E APPROX)
2. NO E-ION INTERACTION (FREE E APPROX)
3. RELAXATION TIME \( Z \)

TIME INTERVAL

\[ \Delta t \longrightarrow \frac{\Delta t}{Z} \]

PROBABILITY TO HAVE E-ION COLLISION DURING \( \Delta t \)

IN THE CORRECT PICTURE

\( Z \) HAS TO DO WITH E-PHONON SCATTERING
\( \frac{1}{2} \) SCATTERING RATE

\( \sqrt{\frac{1}{2}} \)

MARKOV APPROXIMATION

THERMAL EQUILIBRIUM

DRUDE MODEL GOOD FOR

1. DC conductivity
2. Hall effect
3. AC conductivity

\( \mathbf{E} \rightarrow \)
\[
\vec{V}(t) = -\frac{e}{m} \vec{E} t \\
\vec{V}_{\text{AVERAGE}} = -\frac{e}{m} \vec{E} t \\
\vec{J} = \frac{e m \vec{E}}{m} = J_0 = \frac{e}{m} \frac{e m^2}{m} \vec{E} \\
J_0 = \frac{m e^2}{m} \Rightarrow \rho_0 = \frac{m e^2}{m} \\
\sigma_0 = \rho_0 \quad \text{(Drude conductivity)} \\
\sigma_0 = \rho_0 \quad \text{(Resistivity)}
\]
$Z$ can be estimated from $T$.

$Z \sim 1 - 10$ femto - seconds

Femto $s$  \hspace{1cm} $10^{-15}$ sec
Picosecond \hspace{1cm} $10^{-12}$ sec
Nanosecond \hspace{1cm} $10^{-9}$ sec

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