

Physics 8510

Problem Set 1

1) In the Drude model, the energy electron gains between collisions from the electric field is lost to the background fixed ions since the electron gas remains at equilibrium with the material temperature. This energy loss is the heat generated during the electron motion.

(a) Show that the average energy loss to the ions in the second of two collisions separated by time t is $(eEt)^2/2m$, where E is the uniform electric field applied.

(b) If the probability that an electron picked at time 0, will on average have no collision during the next time t is given by $P = \exp\{-t/\tau\}$, show that the average energy loss per electron per collision is $(eE\tau)^2/m$, and hence the average loss per cubic centimeter per second is $(ne^2\tau/m)E^2 = \sigma E^2$. (Problem 2 from Chap 1 Ashcroft)

2) In the Drude model, the probability of an electron suffering a collision in any infinitesimal interval dt is just dt/τ . (τ is the mean time between successive collisions)

(a) Show that an electron picked at random at a given moment had no collision during the proceeding t seconds with probability $P = \exp\{-t/\tau\}$.

(b) Show that the mean time between successive collisions of an electron is τ . (Parts of problem 1 from Chap. 1 Ashcroft)

(c) What is the mobility (in $\text{cm}^2 \text{V}^{-1} \text{s}^{-1}$) of electrons in GaAs where τ is calculated to be 1 ps according to Drude model. Compare the values for effective mass and free electron mass of the electrons in GaAs. (In Drude model $\mu = e\tau/m$, $m^* = 0.067 m_0$.)

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