Solid State Physics: Problem Set #8

The Free Electron Model: Transport and Optical Properties of Metals

Due: Friday Mar. 7 by 6 pm

Note: Write-up for experiment #3 (Bragg X-ray) is now due on Friday Mar. 7.

Reading assignment: for Monday, 6.4, 6.7 (Drude model for electrical and thermal transport)
for Wednesday, 6.5 (optical properties of metals)
for Friday, 7.1-7.2 (the periodic potential and energy gaps)

Problem assignment:

Chapter 6 Problems:

6.11 Wavelength at which Al becomes transparent

6.15 Plasma frequency and "optical mass" for Al from $\varepsilon(\omega)$ data

*6.16 Loss of reflectivity for Hg **[Melissa]**

*6.20 Total internal reflection of X-rays in Si **[Peter]**

A1. *Static magnetoconductivity tensor*. As shown in the text (pg. 164), the steady state solution to the Drude model for the free electron gas in an external magnetic field is given by

$$\vec{v} = -\frac{e\tau}{m}(\vec{E} + \vec{v} \times \vec{B}).$$

a) Show that for $\vec{B} = B\hat{z}$, the static current density $\vec{j} = -ne\vec{v}$ can be written in the form $\vec{j} = \sigma\vec{E}$, where σ is the conductivity tensor, as follows

$$\begin{pmatrix} j_x \\ j_y \\ j_z \end{pmatrix} = \frac{\sigma_0}{1+\omega_c^2\tau^2} \begin{pmatrix} 1 & -\omega_c\tau & 0 \\ \omega_c\tau & 1 & 0 \\ 0 & 0 & 1+\omega_c^2\tau^2 \end{pmatrix} \begin{pmatrix} E_x \\ E_y \\ E_z \end{pmatrix}$$

where $\omega_c = eB/m$ is called the cyclotron frequency.

b) In the high field limit of $\omega_c\tau >> 1$, show that $\sigma_{yx} = -\sigma_{xy} = nec/B$. These off-diagonal elements are known as the Hall conductivity.

*To be presented in class on Friday.