PHYS4450 Solid State Physics

SAMPLE QUESTION FOR DISCUSSION IN WEEK 8 EXERCISE CLASSES (13 March 2013))

You may want to think about it before attending exercise class.

(SQ15) **(An extension of the Drude model. This is Kittel's Chapter 6 Problem 9.)** We discussed the Drude model of conductivity, i.e., electrons in the presence of a static electric field. What if we include a magnetic field into the consideration?

Intuitively, one may predict that the conductivity may become magnetic-field dependent. Yes, it is true, the phenomenon is called mangetoconductivity. However, there is another effect more apparent than magnetoconductivity. It is the Hall effect. These two effects come out from the equations of motion when both electric and magnetic fields are included.

Students and TA should study Kittel's pages 152-156 on motion of electron in electric and magnetic fields, with collision term. Formally, one can write $\mathbf{J} = \sigma\mathbf{E}$, where σ in general is a 3x3 matrix representing a conductivity tensor. However, the matrix elements are related to the magnetic field and thus it is called the static (meaning: static fields, no frequency involved) magnetoconductivity tensor. Work out Eq.(64) in Problem 9 of Kittel's Chapter 6. Introduce the Hall conductivity, which is related to the off-diagonal term. In addition, introduce the idea of magnetoconductance, which is related to the diagonal term.

SQ16 **(Think about band structures in terms of the Empty Lattice Approximation - 2D square lattice.**

We discussed how one can get at the phonon dispersion relation of a diatomic chain by folding the dispersion relation of a monoatomic chain into the 1st BZ.

A similar method works for the understanding of electronic energy bands. A key difference is that we expect to get **infinitely many** electronic bands in a solid. One **starts with the free electron** $E(\mathbf{k})$ relation (that has no restriction on the k value), and then **imagine that there is a very weak periodic potential imposed**. This immediately leads to the idea of a 1st BZ. Folding the free electron relation into the 1st BZ gives infinitely many bands. This is called the *empty lattice approximation*. Easy!

TA: Sometimes the empty lattice approximation is not too easy to visualize in 2D and 3D cases. TA will start with free electron relation in 2D, fold the band into the 1st BZ corresponding to a 2D square lattice (show at least 3 bands). It will be good if there is a computer animation showing how to move the parts into the 1st BZ by an appropriate reciprocal lattice $\mathbf{G}$. Also point out the important features in higher dimensions (2D here), e.g., the top of the first band is lower than the bottom of the second band, etc.

These Sample Questions are related to questions in Problem Set 4 (to be distributed).

Mid-Term Exam Announcement
Date: 21 March 2013 (Thursday)
Time/Venue: 2:30PM - 4:15PM (Class time) at LSB C2 (classroom)
Be There!