PHY 392K (551900) Solid State Physics I, spring 2020

Homework #2

Due February 27, 2020

Problem 1

Describe the crystal structure of graphene; make a drawing, choose the primitive unit cell and provide lattice vectors and atomic basis (I suggest using Cartesian coordinates). This cell is known as a 1×1 cell. (Hint: use a right hand system, and make sure the angle between ***a*** and ***b*** is 120 degrees, not 60.)

Determine the reciprocal lattice vectors.

One can also describe graphene with the so-called $\sqrt{3}\times\sqrt{3}R30$ cell that has six atoms. As the name suggests the lattice vectors are $\sqrt{3}$ times longer and the cell is rotated by 30° with respect to the primitive cell. Find the cell vectors and basis and make a drawing of this cell (use Cartesian coordinates).

Problem 2

What is the bond angle between the tetrahedral bonds in a diamond structure (C, Si or Ge)?

Problem 3

Consider the ***fcc*** lattice, take planes with indices (100) and (001) with respect to the conventional cubic cell.

Find the indices with respect to the primitive ***fcc*** cell.

Problem 4

Find reciprocal lattice vectors for the simple cubic, ***fcc*** and ***bcc*** lattices.

Problem 5

Consider a conventional cell of diamond (eight atoms in the basis). (i) Compute the structure factor of this basis. (ii) Find the zeros of the structure factor, and shoe that allowed reflections satisfy $\nu_1+\nu_2+\nu_3=4n$, where all indices are even and n is any integer, or else all indices are odd.

Problem 6

One way to define the primitive cell is to build a so called Wigner-Seitz cell. It is constructed by choosing a lattice point (arbitrary), connecting it to all its neighbors, and then drawing perpendicular bisectors of all lines connecting the chosen point to its neighbors (in 2D these are lines, in 3D these are planes). The space inside is the Wigner-Seitz cell.

Draw Wigner-Seitz cells in 2D for square, rectangular and hexagonal lattices.