Exercise 2.1-1

Quick Questions to:

2.1 Basic Band Theory

Here are a few quick questions to 2.1.1: Essentials of the Free Electron Gas

- What happens, if you do not choose $U = U_0 = 0$ but $U = U_1$?
- What does the sentence "...a plane wave with amplitude $(1/L)^{3/2}$ moving in the direction of the **wave vector** $\underline{k}$" mean"? Wave vectors, after all, are defined in *reciprocal* space with a dimension **1/cm**. What, exactly, is their direction in *real* space?
- Recount what you know bout the *spin* of an electron.
- Where does the $(1/L)^{3/2}$ in the solution of the Schrödinger equation come from? What would one expect for a crystal with the dimension L_x, L_y, L_z?
- What kind of information is contained in the wave vector $\underline{k}$?
- Consider a system with some given energy levels (including possibly energy continua). Distribute a number N of classical particles, of Fermions and of Bosons, respectively, on these levels. Describe the basic principles employed..
- How does one *always* derive the density of states $D(E)$?

Here are a few quick questions to 2.1.2: Diffraction of Electron Waves

- Consider a **fcc** and **bcc** lattice with lattice constant $a = 0.3$ **nm**. Give the distance between **{100}** planes and the distance between the corresponding atomic planes. Do the same thing for the **{111}** plane of a **fcc** lattice with just one atom in the base, and for a diamond structure.
- Remember the Ewald construction? Describe and explain for what kind of situations it is particularly useful.
- Compare the free electron gas model with and without diffraction.

Here are a few quick questions to 2.1.3: Energy Gaps and General Band Structure

- Draw a one-dimensional *realistic* periodic potential Now draw in the first Fourier component. Add the probability densities for finding electrons with $k = k_{BZ}$. Explain the energy splitting and why ΔE is approximately given by the first Fourier component of the potential.

Solution