HW2_2

1. **Nickel** (**Ni**) has a **FCC** lattice with a cube edge **a = 3.25 Å.** In the following, consider a powder sample of **Ni.**
   - **a.** A beam of electrons of energy **150 eV** falls on the sample. **Calculate** the two smallest Bragg angles at which reflection takes place.
   - **b.** If, instead of electrons, a beam of neutrons of energy **0.08 eV** falls on the sample, repeat the calculations of part **a** for this case.

2. Work the following problem (**#14**, from Ch. 1 of the book **"Solid State Physics"** by J.S. Blakemore, 1st Edition. W.B, Saunders Co., Philadelphia, 1969).

1.14 Figure 1-58 shows two parallel planes of atoms (with spacing d) in a crystal. Each plane consists of lines of atoms in the direction perpendicular to the paper, with a spacing of c between the lines. X-rays of wavelength λ have an angle of incidence θ with respect to the planes. The rays leaving at an angle ϕ_m are those of diffraction order m for the first plane considered as a plane grating. You are told that these rays are reinforced in phase by components diffracted from lower planes. Show that

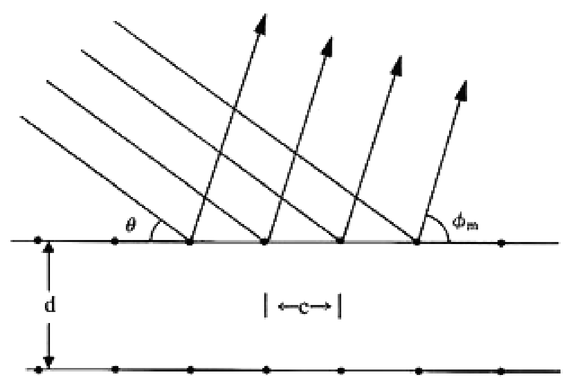
$$m\lambda = c[\cos\phi_m - \cos\theta]$$

and

$$n\lambda = d[\sin\phi_m + \sin\theta]$$

where m and n are integers. Show that a crystal plane exists making an angle $\frac{1}{2}(\phi_m - \theta)$ with the original set of planes, for which the diffracted rays shown in Figure 1-58 are the result of specular reflection satisfying the Bragg condition.

Figure 1-58 Construction for Problem 1.14.



3. The electron density for the 2P state of the hydrogen atom is given by:

$$n(\bar{\mathbf{r}}) = \frac{r^2}{64\pi a_0^5} e^{-r/a_0} \sin^2\theta$$

Where r and θ refer to a spherical coordinate system. Determine the atomic form factor for this state. In your determination, you may assume that the z-axis is defined by the reciprocal lattice vector.

(4) Simple example of 3-D Fourier transform: A tetragonal lattice has cell dimensions $a \times a \times c$, with c corresponding to $\vec{a}_3$ according to standard convention (same as problem 1). The periodic potential consists of two Dirac delta functions in each cell:

$$V(\vec{r}) = V_o \sum_j \left[\delta(\vec{r} - \vec{r}_1 - \vec{R}_j) - \delta(\vec{r} - \vec{r}_2 - \vec{R}_j) \right],$$

with $\vec{r}_1 = (0,0,0)$ and $\vec{r}_2 = \left(1/2, 1/2, 1/\sqrt{3}\right)$.

[a] What is the general form for the reciprocal lattice vectors, $\vec{G}$?

[b] Find a general form for V_G, the Fourier coefficients of the potential. Do this by directly computing the Fourier transform.

[c] Show that the $\vec{G} = (0,0,0)$ coefficient is zero. Explain why one can expect this result for this case without calculating the Fourier transform.