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Physics 731 **HOMEWORK ASSIGNMENT #2** **Due: Sept. 13, 2001**
(Deadline: next lecture*)

**No class on Tuesday, Sept. 18; make-up class time to be determined.*

Read Ashcroft & Mermin (A&M), chaps. 5-6.

1. A&M 5-3
2. A&M 6-2

3a) Show as a corollary to problem 2 [A&M 6-2] that the {111} planes of a simple cubic crystal are triangular lattices. (So are the {111} planes of the bcc crystal.) What is the interplanar spacing? [Hint: problem 1, A&M 5-3, may be helpful.]
b) For an fcc crystal, viewed from the [111] direction as a sequence of stacked close-packed planes, write down a third primitive vector $\mathbf{a_3}$, given that the first two are in a close-packed plane [e.g. $\mathbf{a_1} = a\,\mathbf{x}$; $\mathbf{a_2} = (a/2)\,(\mathbf{x} + \mathbf{y}\sqrt{3})$]. (I.e., find the components of $\mathbf{a_3}$ along $\mathbf{x}$, $\mathbf{y}$, and $\mathbf{z}$.) Then show explicitly how the ABCABC stacking sequence is realized, i.e. that after 3 translations by $\mathbf{a_3}$ the lattice points coincide with those in the original plane, translated perpendicular to this plane by 3 times the interplanar spacing d. This problem provides details of assertions made in class.

4. A&M 6-3
5. A&M 6-5
6. Consider the reciprocal lattice of a two-dimensional (2D) lattice. Write $\mathbf{k} = \mathbf{k}_{\parallel} + k_Z$.

a) Show that $\mathbf{K}_{3D} = \mathbf{K}_{2D} + K_Z$, K_Z arbitrary, so that the reciprocal lattice can be represented by a net of rods. For elastic scattering, $\mathbf{k} \rightarrow \mathbf{k}'$, write the relation between $\mathbf{k}_{\parallel}$ and $\mathbf{k}_{\parallel}'$.
(Hint: Consider a 2D lattice as the limit of a (3D) family of planes with interplanar spacing d going to infinity.) What added constraint comes from energy conservation?
b) Generalize Fig. 6.7 to show the Ewald construction for diffraction from a 2D lattice. Note that one observes a diffraction pattern of electrons from a surface for all values and orientations of the incident wavevector $\mathbf{k}$ above a critical value.
c) Show that for electrons incident perpendicularly on a {100} surface of a copper crystal, the critical *energy* at which the first diffracted beam appears (as incident energy is raised) is about 22 eV. (Use the handy relationship $\lambda(\text{Å}) \approx 12/[E(\text{eV})]^{1/2}$. Note that the periodic table inside the front cover of A&M provides lattice constants of the elements, as well as lots of other information; alternatively, use table 2.1 of Marder.)

Read and think about (but do not turn in) A&M 5-4, A&M 6-4.