Quiz 4

Thursday, February 16, 2012

Your Name:

[15 points; 10 minutes] A one dimensional crystal with lattice constant a and two atoms per unit cell are characterized by alternating spring constants C_1 and C_2. The two atoms are of the same atomic number, and so their masses are the same. For this problem the phonon dispersion can be shown to be

$$\omega_k = \sqrt{\frac{C_1 + C_2}{M} \pm \frac{\sqrt{C_1^2 + C_2^2 + 2C_1C_2 \cos ka}}{M}}$$

Sketch the phonon dispersions of the following two cases *in a single plot*.

a. $C_1 = C - \delta C$ and $C_2 = C + \delta C$ where δC is a small but finite number.
b. $C_1 = C_2 = C$. Note that in *this* case the distance between the two atoms must be uniform and equal to $a/2$ [whereas, in case a, the distance between the two atoms must be alternating].

It is important to consider the following points. (1) To make the sketch of the dispersions, it is *probably* enough to inspect the values of ω for $k = 0$ and $k = \pm\pi/a$. (2) In case a, there are two phonon branches. How about case b? (3) In case a, the k space periodicity is $2\pi/a$. How about case b? (4) [Something to think about later:] some material go from case b to case a, as the temperature decreases. If you are doing a neutron scattering experiment to measure phonons, what would you see as the temperature goes down so that the transition from b to a occurs?