Introduction to Solid State Physics   2:10 - 4:10 (11/19/2006)
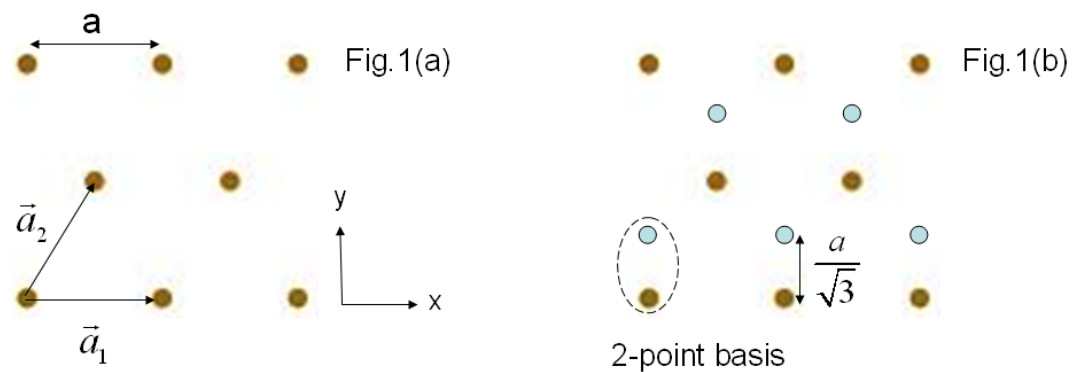
1. (30%) (a) There is a triangular lattice in Fig.1(a). Find out the primitive vectors $\vec{b}_1, \vec{b}_2$ of its reciprocal lattice. Also, plot this reciprocal lattice.

(b) Plot the first Brillouin zone (BZ) of the lattice above.

(c) If each of the lattice point in Fig. 1(a) is replaced by a 2-point basis (see Fig.1(b)), then we have a honeycomb lattice. Find out the structure factor S(h,k) of the 2-point basis.

2. (20%) Answer the following questions briefly. Use formulas and figures if that helps your explanation.

(a) For a 1-dim vibrating lattice, the phonon dispersion relation is plotted in the first BZ only. Why there is no need to plot the curve outside of the first BZ?

(b) Near $k=0$, the pattern of atom vibration for optical branch is very different from that of the acoustic branch. Plot the patterns of vibration and point out the major difference.

3. (20%) (a) For a 1-dim vibrating lattice, the dispersion relation is $\omega(k) = \omega_M |\sin ka/2|$. Find out the phonon density of states $D(\omega)$, then plot it.

(b) What is a van Hove singularity? Where is the van Hove singularity in the $D(\omega)$ of (a)?

4. (30%) Answer the following questions briefly. Use formulas and figures if that helps your explanation.

(a) What is the Ewald construction?

(b) What is the umklapp process of phonon scattering?

(c) Why the thermal conductivity K is proportional to T^3 at low temperature?