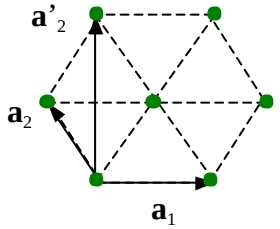
Solid State Physics – Midterm Exam

Time: 9:10 AM -- 11:10 AM (12/2) (10 points for every single question)

1. Draw the reciprocal lattice of the triangular lattice given blow



(a) First by using primitive vectors $\mathbf{a}_1$ and $\mathbf{a}_2$. (The length of $\mathbf{a}_{1,2}$ is a)

(b) If we choose non-primitive vectors $\mathbf{a}_1$ and $\mathbf{a'}_2$, what will be the structure factor?

(c) Based on the result of (b), draw the reciprocal lattice by eliminating the reciprocal lattice points where the value of the structure factor is zero.

(d) Draw the first Brillouin zone.

2. Answer the following questions briefly. You can use equations or figures to clarify your answers.

(a) Explain the Ewald construction.

(b) When one measures the dispersion relation of the crystal vibration of NaCl, how many phonon *branches* will you expect to observe, and with what types?

(c) The specific heat calculated by the Einstein model drops exponentially, instead of T^3 as $T\rightarrow 0$ K. Explain why there is such a rapid decrease in Einstein's theory.

(d) Give two examples of thermal property of crystal that requires anharmonic interactions between ions.

3. Assume there is a 2-dimensional crystalline sample, in which the ions can vibrate within the crystal plane (but not out of plane). It is a square lattice with lattice constant a. The sample itself is a square with side length L. There are $N=L^2/a^2$ atoms in the sample.

(a) Derive the form of the density of states $D(\omega)$. (The answer can be expressed in terms of $d\omega/dk$.)

(b) Assume the phonon dispersion relation is $\omega=\upsilon k$, calculate the density of states explicitly based on the result of (a).