

# Solid State Theory, Exercises I

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Prof. Hans Peter Büchler SS 2012, 17th of April 2012

## Exercise 1 - Crystal Structure

(a) The primitive vectors for a *body center cubic* (bcc) lattice are

$$\begin{aligned}\vec{a}_1 &= a\vec{x}, \\ \vec{a}_2 &= a\vec{y}, \\ \vec{a}_3 &= \frac{a}{2}(\vec{x} + \vec{y} + \vec{z}).\end{aligned}$$

or, in a more symmetric set

$$\begin{aligned}\vec{a}_1 &= \frac{a}{2}(-\vec{x} + \vec{y} + \vec{z}), \\ \vec{a}_2 &= \frac{a}{2}(\vec{x} - \vec{y} + \vec{z}), \\ \vec{a}_3 &= \frac{a}{2}(\vec{x} + \vec{y} - \vec{z}).\end{aligned}$$

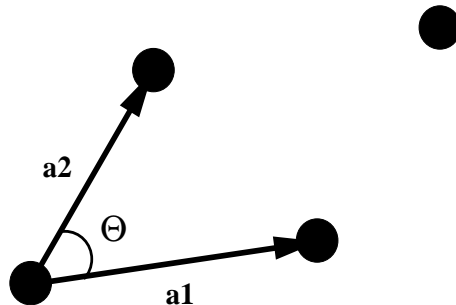
1. Make a drawing of this lattice,
2. Find the reciprocal lattice vectors and make a drawing of the reciprocal lattice.

(b) The primitive vectors for a *face center cubic* (fcc) lattice are

$$\begin{aligned}\vec{a}_1 &= \frac{a}{2}(\vec{y} + \vec{z}), \\ \vec{a}_2 &= \frac{a}{2}(\vec{x} + \vec{z}), \\ \vec{a}_3 &= \frac{a}{2}(\vec{x} + \vec{y}).\end{aligned}$$

1. Make a drawing of this lattice,
2. Find the reciprocal lattice vectors and make a drawing of the reciprocal lattice.

(c) Graphically construct the Wigner-Seitz cell and the reciprocal lattice of the two dimensional oblique lattice with basis vectors  $\vec{a}_1$  and  $\vec{a}_2$  shown in the following sketch :



### Exercise 2 - The Brillouin Zone

Show that the volume of the elementary cell  $\Omega$  and the volume of the Brillouin Zone  $\Omega_B$  are connected by the following relation :

$$\Omega_B = \frac{(2\pi)^3}{\Omega} \quad (1)$$

### Exercise 3 - Tetragonal symmetry

Show that if one stretches a fcc lattice along one of its lattice vectors, the resulting lattice is equivalent to a tetragonal body centered lattice. So the point group with the tetragonal symmetry has two Bravais lattices : simple tetragonal and body centered tetragonal, whereas the point group with cubic symmetry has three Bravais lattices : sc, bcc and fcc.

### Exercise 4 - Fourier transformations

1. Calculate the Fourier coefficients for a function  $f(x) = c$ ,  $c$  some number,  $x$  defined in some one-dimensional interval.
2. Calculate explicitly the Fourier coefficients for a function  $f(x) = \exp(ip\frac{2\pi}{a}x)$ , with  $p$  some integer.

Solutions due on : 20th pf April, 2012