LECTURE # 9

Note Title 10/8/2007

Solid State Physics

Chapter 4
Ashcroft-Mermin

POLY-CRYSTALLINE

1915 BRAGG

distance between atoms $\sim$ $1\,\text{Å} \sim 10^{-8}$ cm

need probe system with $\lambda \sim 1\,\text{Å}$

Photons $\hbar\omega_{photon}\,[eV] = \dfrac{12400}{\lambda\,[\text{Å}]} \sim 10^4\,eV$

10 keV

⇓

X RAY

MATHEMATICAL DESCRIPTION OF LATTICE

1) BRAVAIS LATTICE

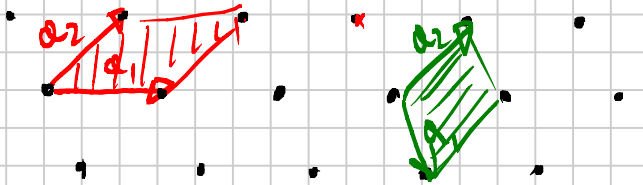
3D
3 vectors
2D
2 vectors

(A) SAME "VIEW"

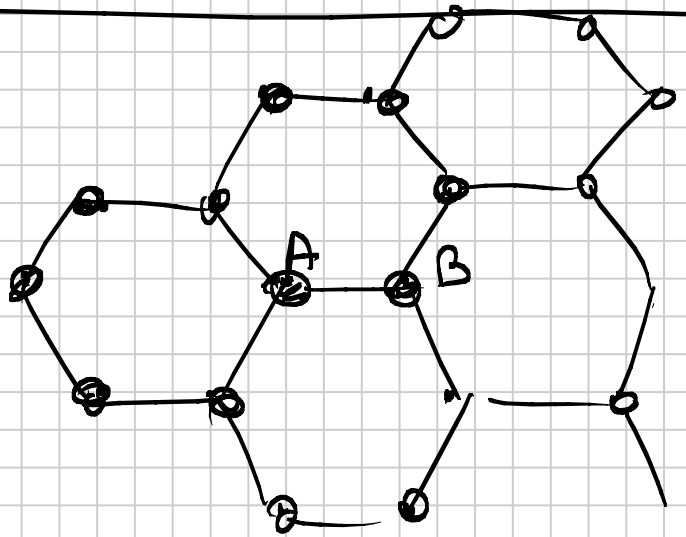
(B) $\vec{R} = n_1 \vec{a}_1 + n_2 \vec{a}_2 + n_3 \vec{a}_3$

$\vec{a}_1, \vec{a}_2, \vec{a}_3$
PRIMITIVE VECTORS

$n_1, n_2, n_3 \in \mathbb{Z}$



choice of primitive vectors is not unique



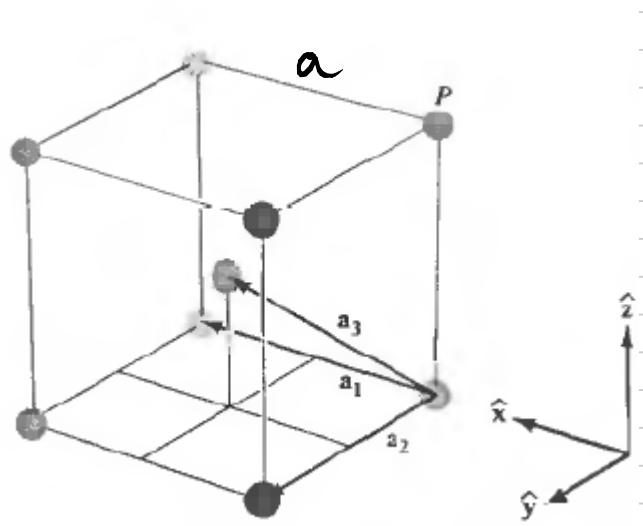
HONEYCOMB LATTICE

NOT A BRAVAIS LATTICE

3D BRAVAIS LATTICES (CUBIC not very common)

BODY CENTERED CUBIC (BCC)

a LATTICE CONSTANT

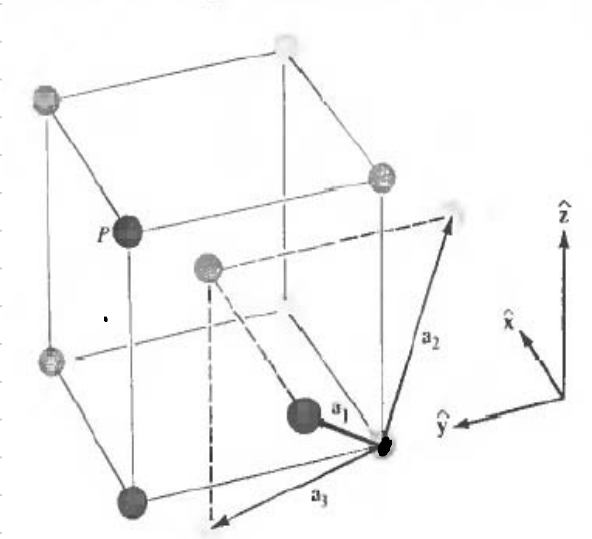


$\vec{a}_1 = a(100)$

$\vec{a}_2 = a(010)$

$\vec{a}_3 = \frac{a}{2}(111)$

Fe
Li
Na
K
W



BCC

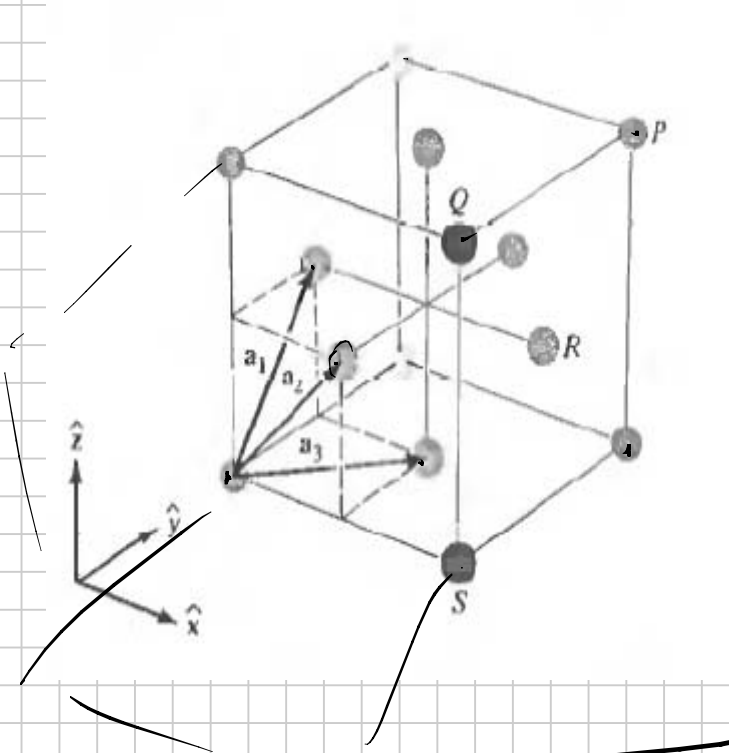
$\bar{1} = -1$

$\vec{a}_1 = \frac{a}{2}(11\bar{1})$

$\vec{a}_2 = \frac{a}{2}(1\bar{1}1)$

$\vec{a}_3 = \frac{a}{2}(\bar{1}11)$

FACE CENTERED CUBIC (FCC)



$$\vec{a}_1 = \frac{a}{2}(0\,1\,1)$$

$$\vec{a}_2 = \frac{a}{2}(1\,0\,1)$$

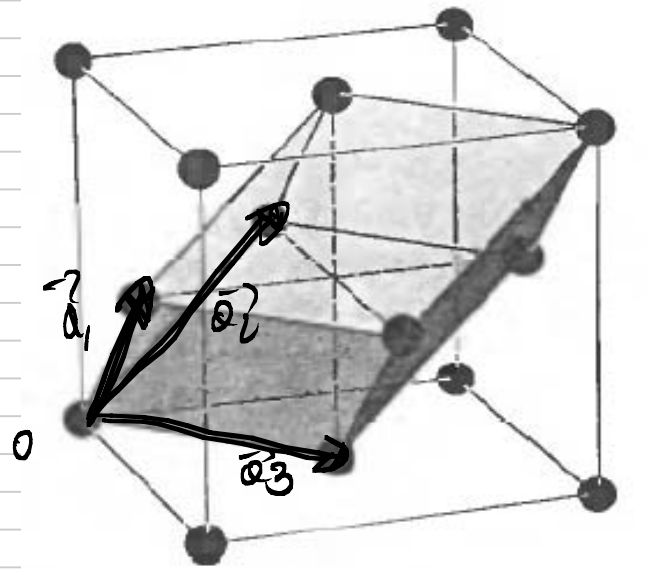
$$\vec{a}_3 = \frac{a}{2}(1\,1\,0)$$

Ag
Au
Cu

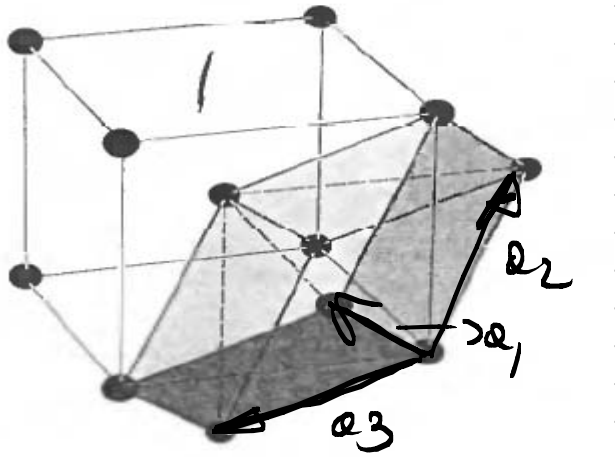
PRIMTIVE UNIT CELL

= SOLID (AREA IN 2D) GENERATED BY PRIMITIVE VECTORS

FCC

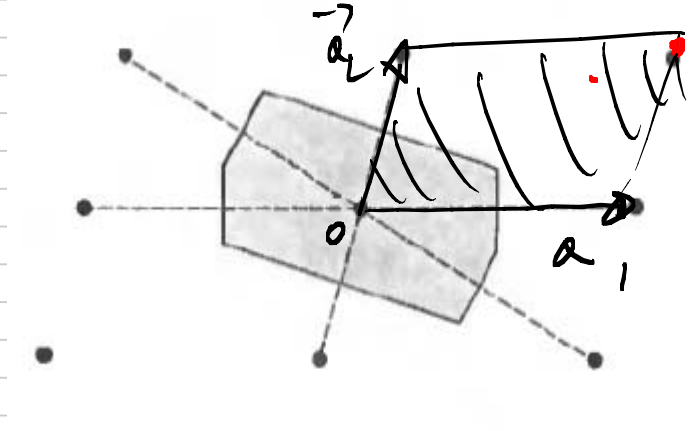


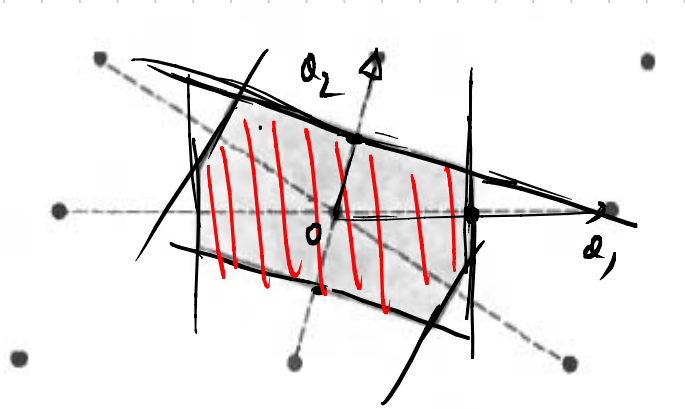
BCC

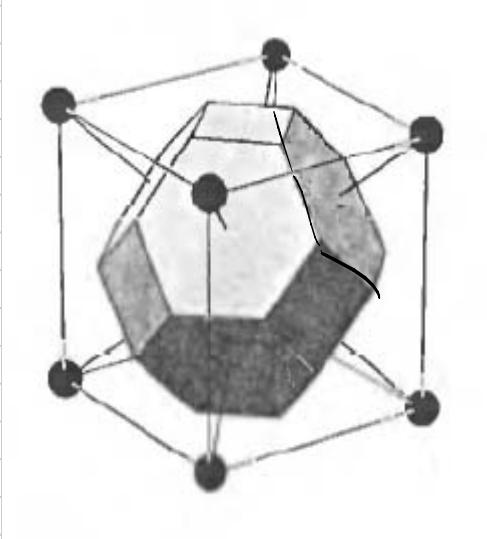


WIGNER - SEITZ CELLS

2D





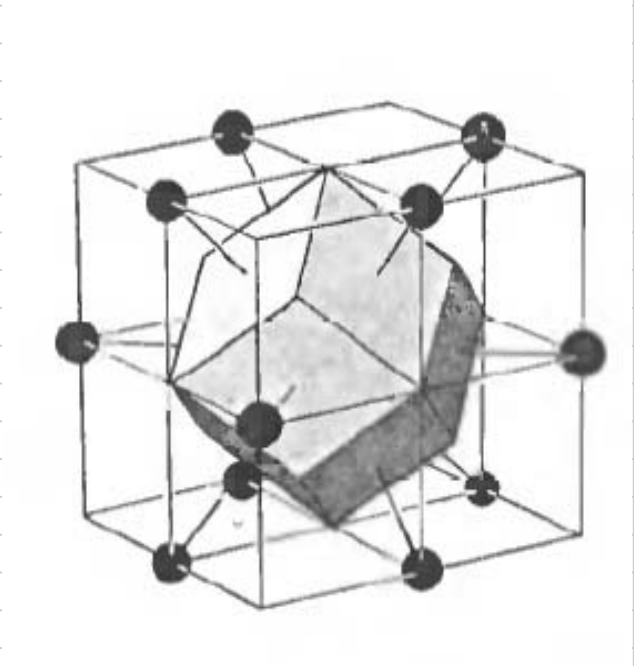


WIGNER SEITZ FOR BCC

TRUNCATED OCTAHEDRON

8 ATOMS ARE FIRST NEIGHBURS → CALLED COORDINATION NUMBER

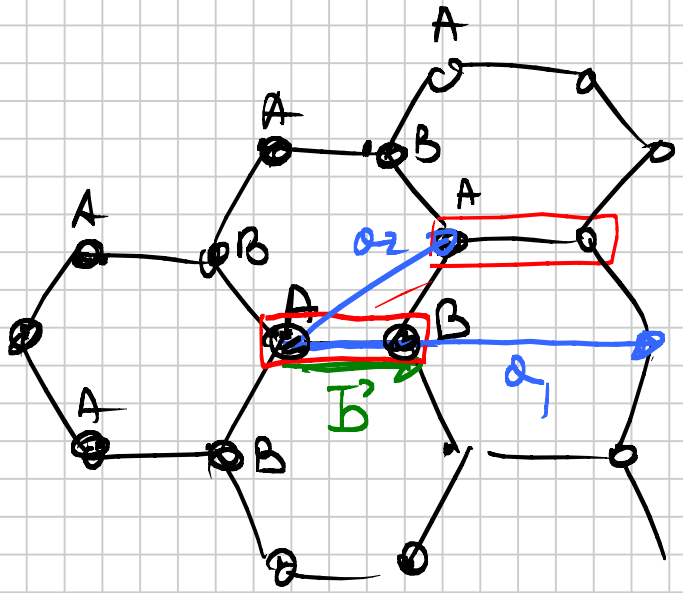
FCC → COORDINATION NUMBER 12



TRUNCATED DODECAHEDRON

CRYSTAL STRUCTURES

BRAVAIS LATTICE WITH BASIS



CONSIDER A AND B TOGETHER

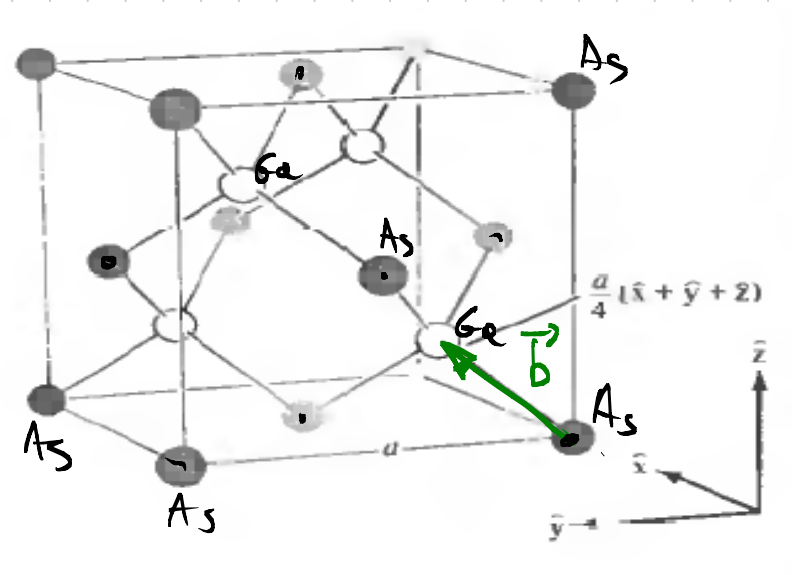
$\vec{a}_1$ $\vec{a}_2$ PRIMITIVE VECTORS

$\vec{b}$ BASIS VECTOR

2D

3D LATTICE WITH BASIS : DIAMOND

C , Si , Ge



FCC

$$\vec{b} = \frac{a}{4}(1\,1\,1)$$

$$\vec{a}_1 = \frac{a}{2}(1\,1\,0)$$

$$\vec{a}_2 = \frac{a}{2}(1\,0\,1)$$

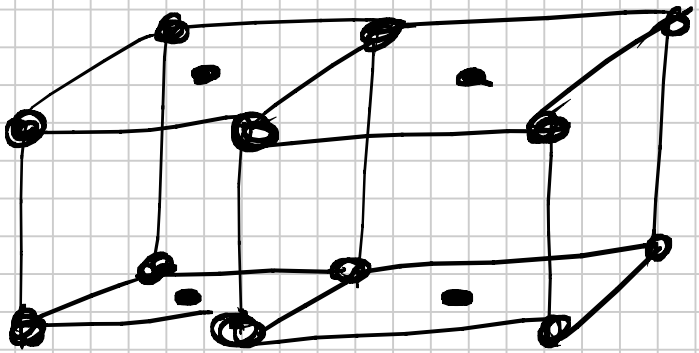
$$\vec{a}_3 = \frac{a}{2}(0\,1\,1)$$

ATOM AT $\vec{b}$ IS DIFFERENT : ZINC BLEND LATTICE

GaAs, CdTe

---

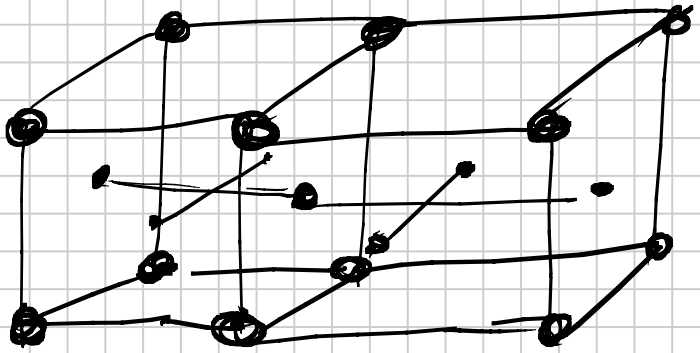
(1) BASE CENTERED CUBIC



BRAVAIS LATTICE?

$\vec{b}$?

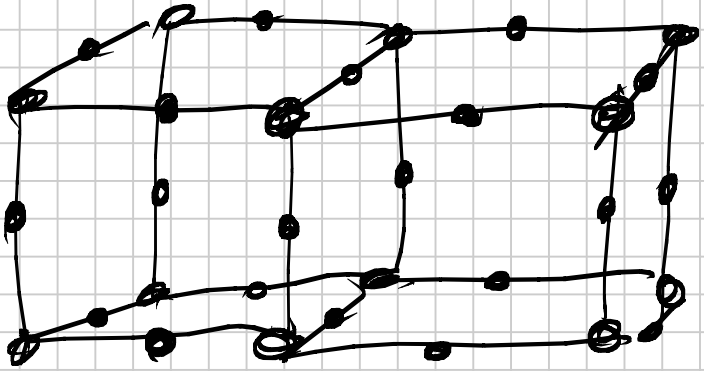
(2)



BRAVAIS LATTICE?

$\vec{b}$?

(3)



BRAVAIS LATTICE?

$\vec{b}$?