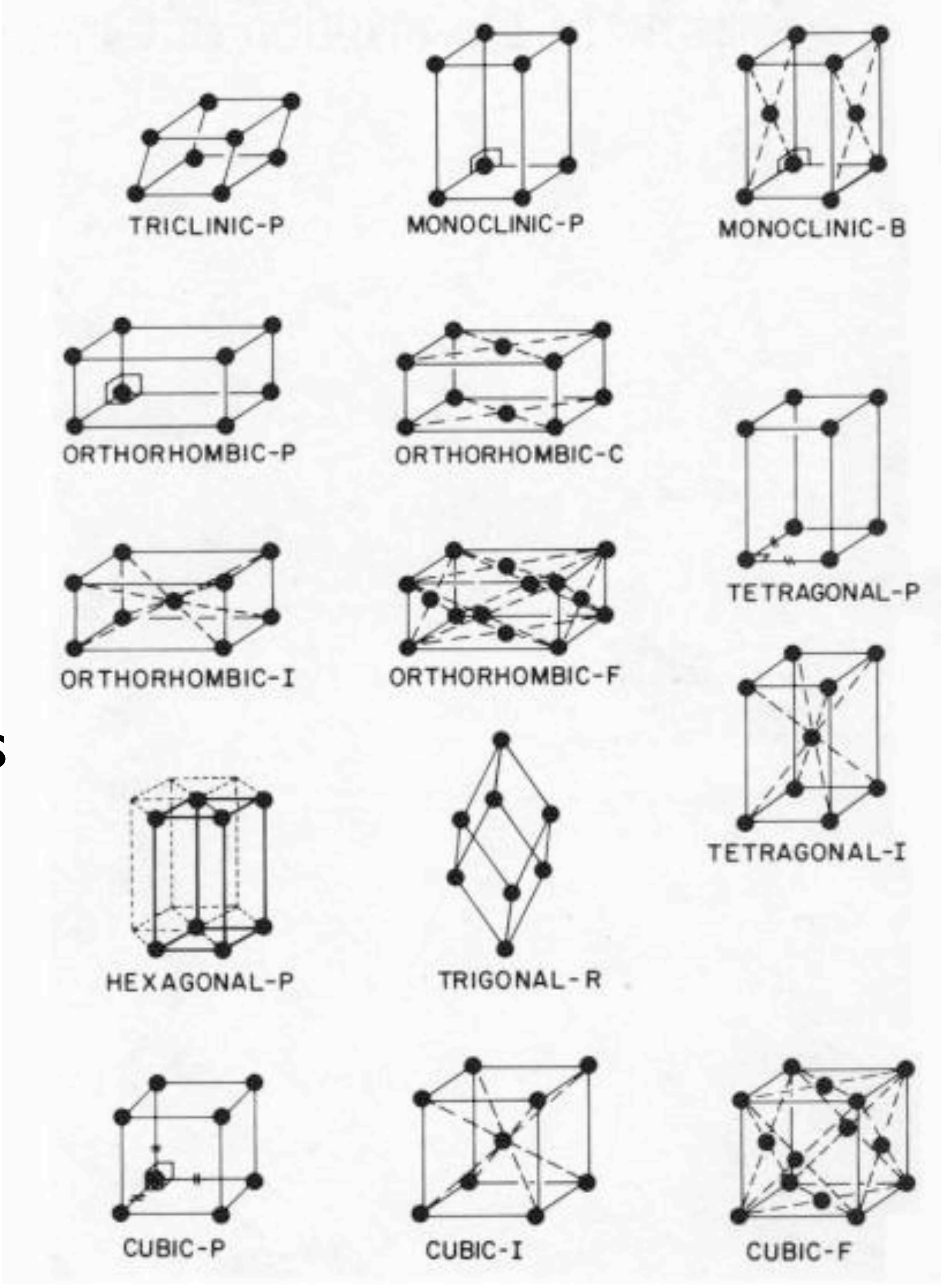
Bravais lattices

(few notes/ pictures complementary to the A&M book)

The 14 Bravais lattices in 3D

the dashed lines in this figure indicate the nearest neighbour distances =>



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see also this figure that specifies the cell parameters (distances and angles):

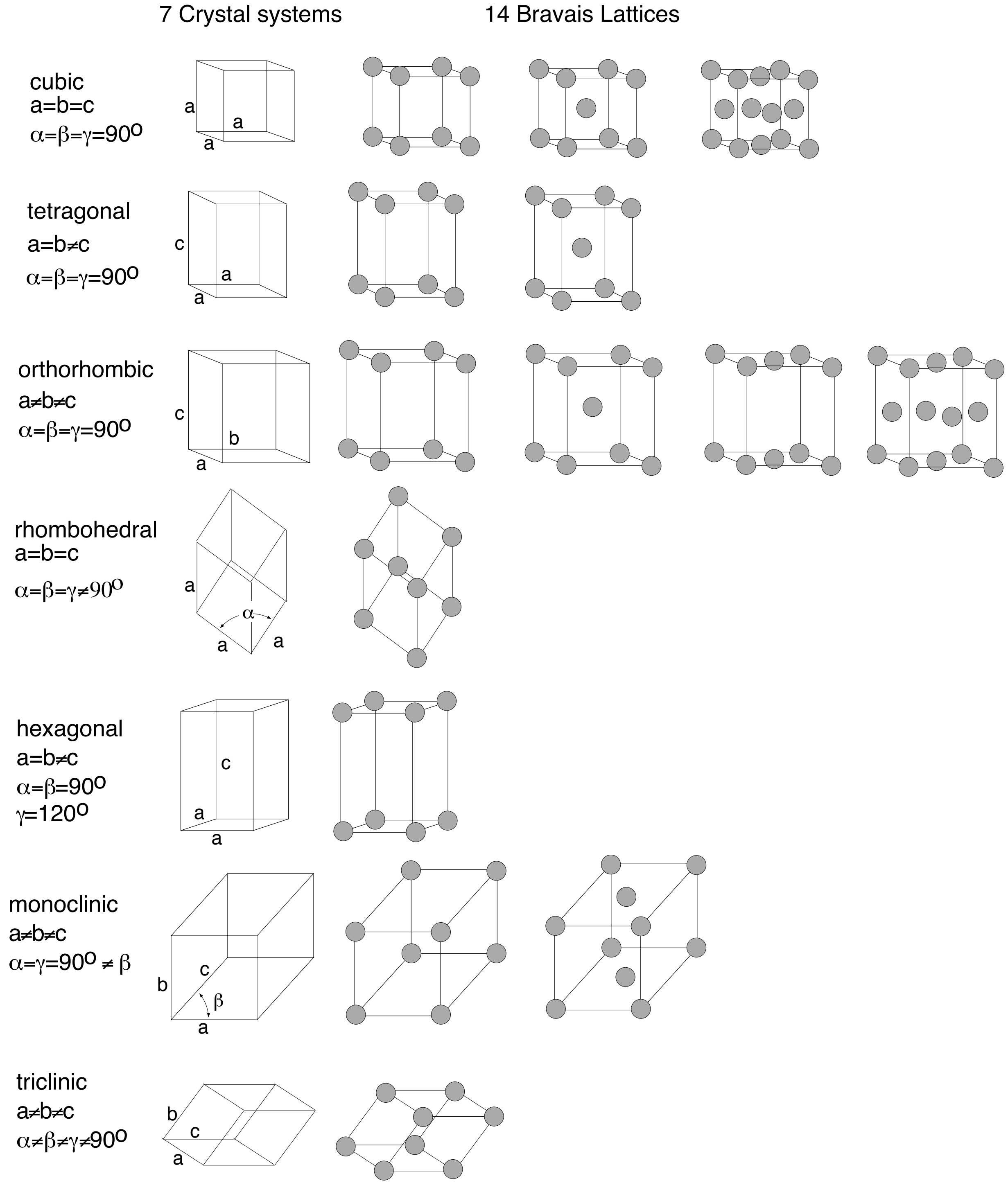
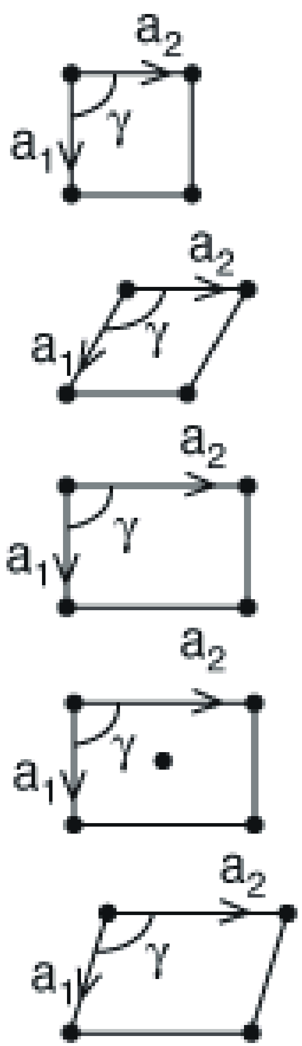


Figure 4 The 7 crystal systems and the 14 Bravais lattices

The 5 Bravais lattices in 2D



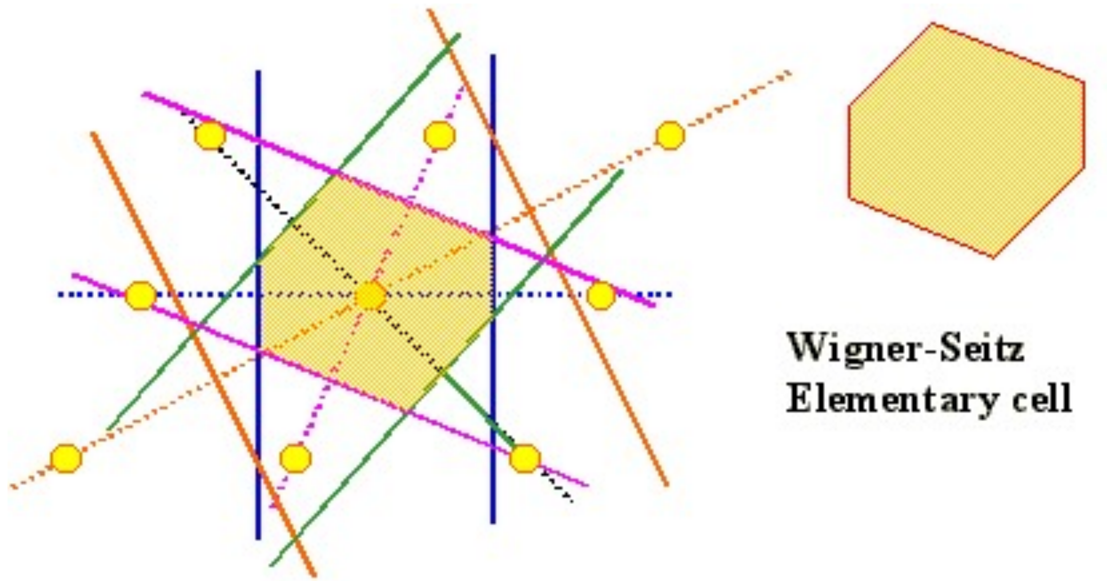
square	$a_1 = a_2$	$\gamma = 90°$
hexagonal	$a_1 = a_2$	$\gamma = 120°$
rectangular	$a_1 \neq a_2$	$\gamma = 90°$
centered rectangular	$a_1 \neq a_2$	$\gamma = 90°$
oblique	$a_1 \neq a_2$	γ π $90°, 120°$

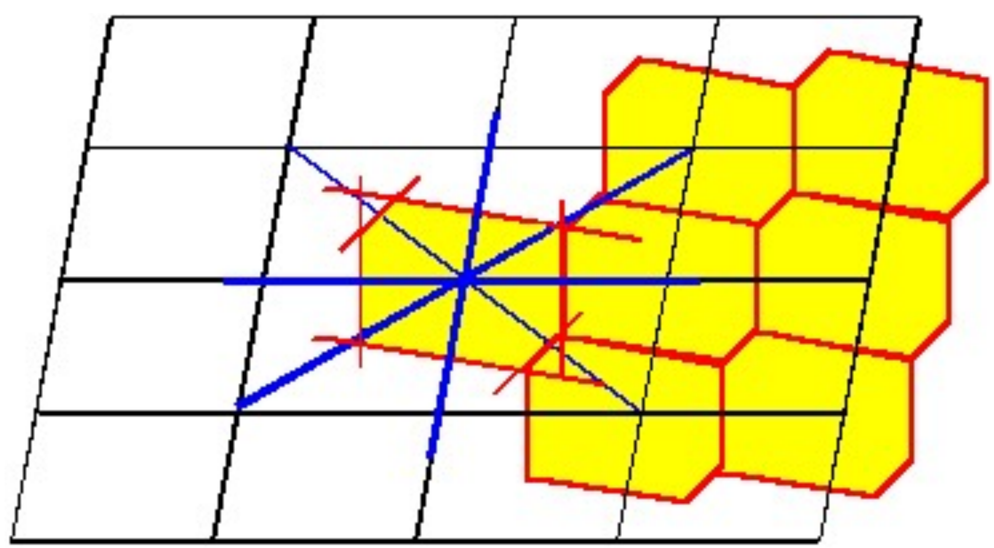
Wigner-Seitz cell

around a lattice point

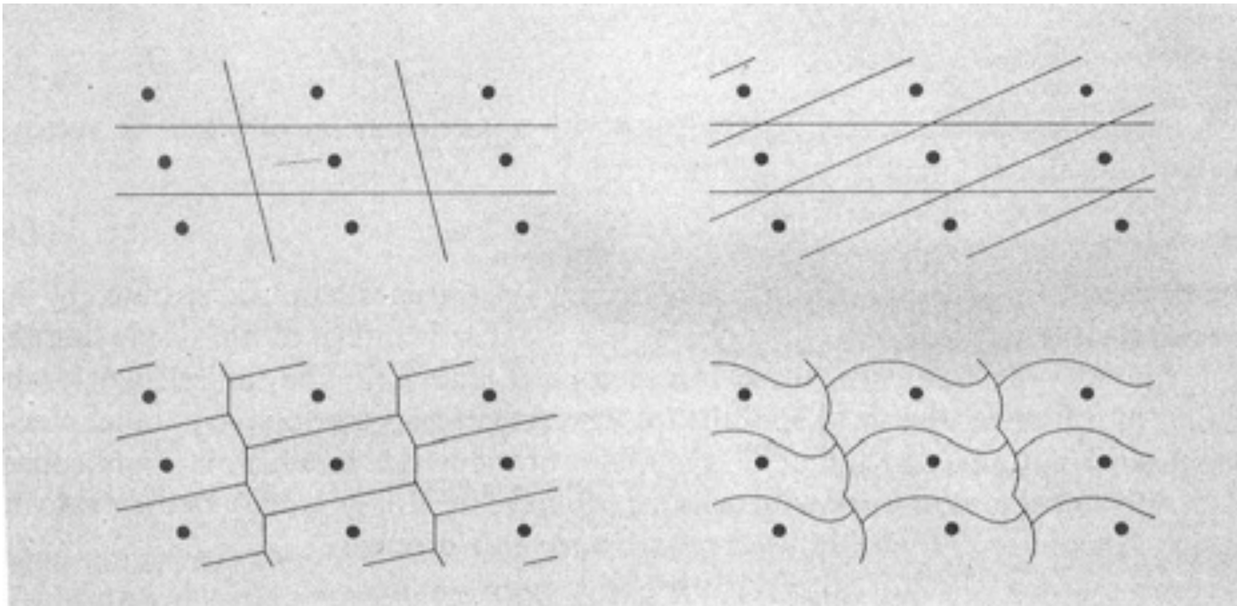
- region of space that is closer to that point than to any other lattice point (topological def.)
- each point pertains to 1 WS cell
- translation => covers the whole space
- no reference to a particular choice of the primitive vectors: same symmetry of the lattice!

a Wigner-Seitz cell: construction and properties

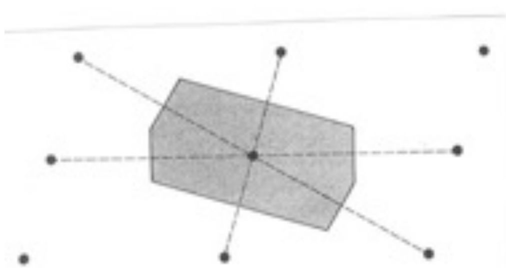


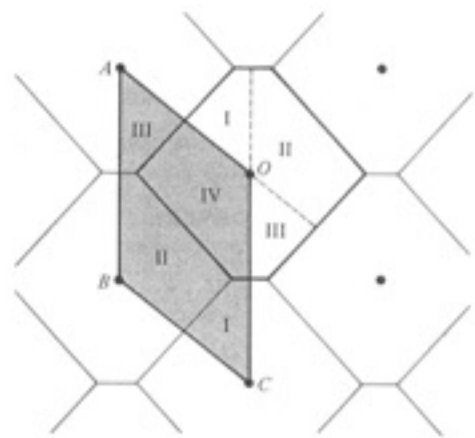


2D examples



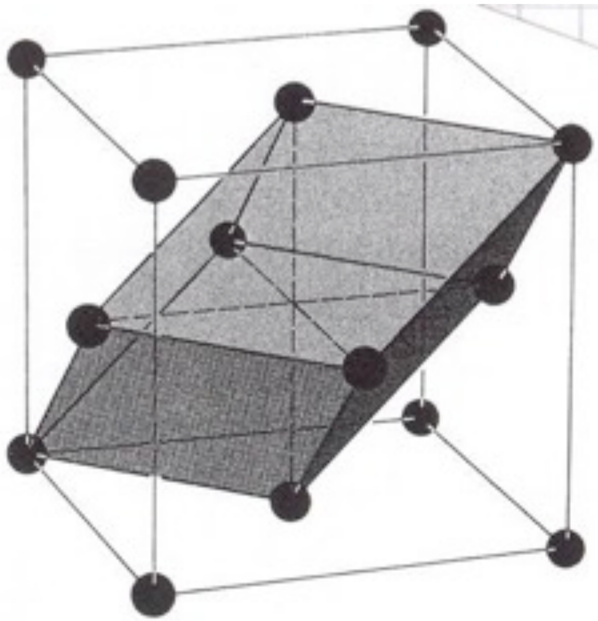
some possible choices of **primitive unit cells** for oblique lattice





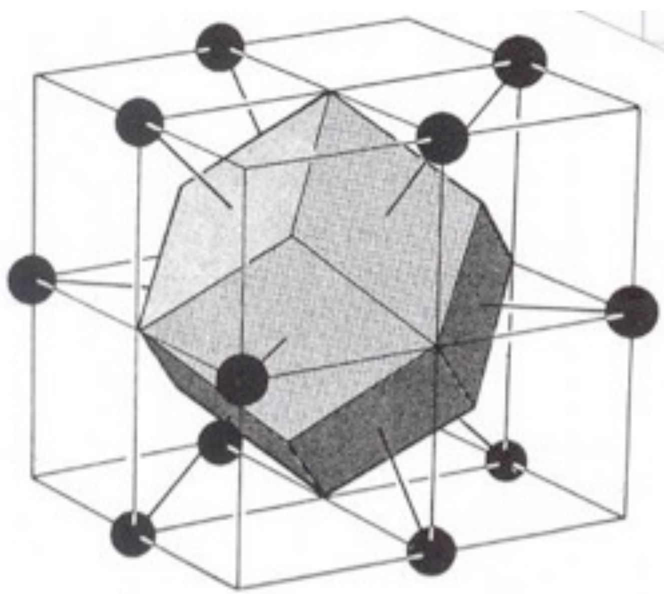
Wigner-Seitz cell for oblique lattice

3D - cubic lattices : example of FCC



Primitive and conventional unit cells for the face-centered cubic Bravais lattice. The conventional cell is the large cube. The primitive cell is the figure with six parallelogram faces. It has one quarter the volume of the cube, and rather less symmetry.

unit primitive ; conventional

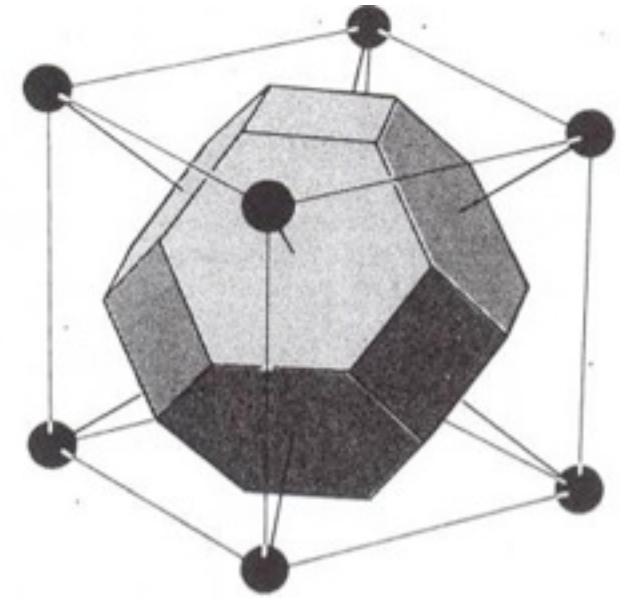


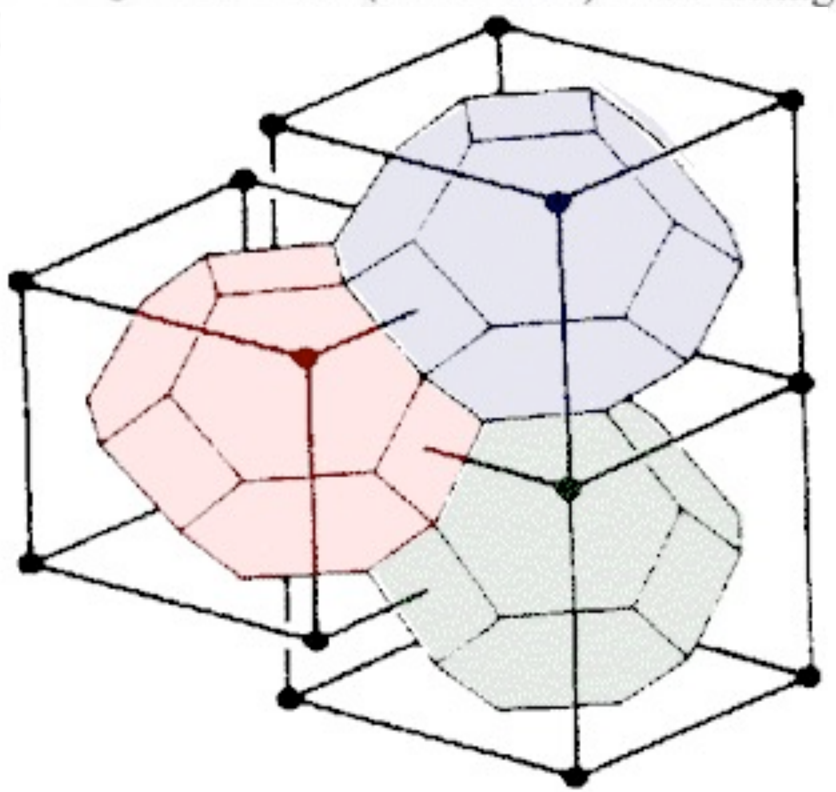
Wigner-Seitz cell for the face-centered cubic Bravais lattice (a "rhombic dodecahedron"). The surrounding cube is *not* the conventional cubic cell of Figure 4.12, but one in which lattice points are at the center of the cube and at the center of the 12 edges. Each of the 12 (congruent) faces is perpendicular to a line joining the central point to a point on the center of an edge.

Wigner-Seitz

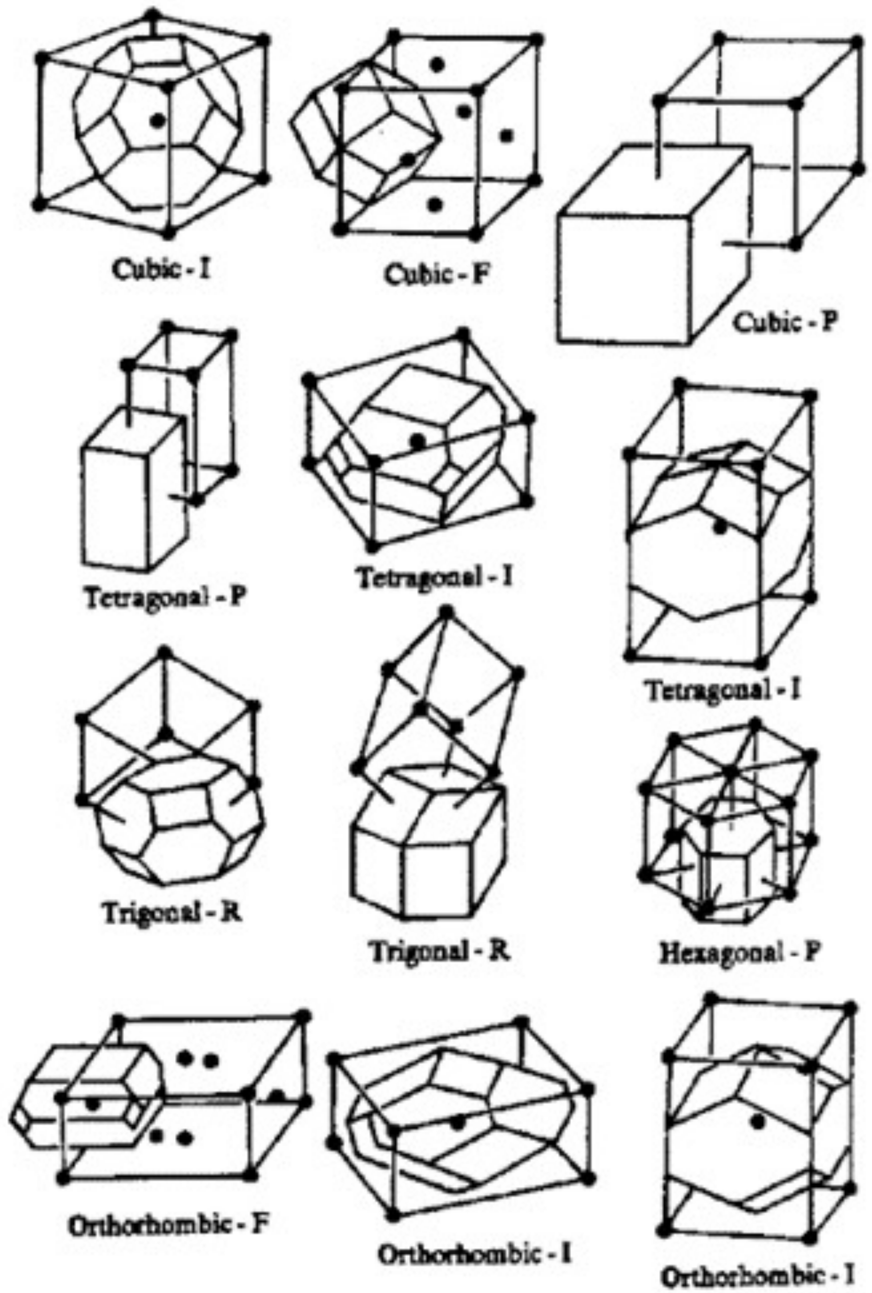
3D examples: Wigner - Seitz cell for BCC

The Wigner-Seitz cell for the body-centered cubic Bravais lattice (a "truncated octahedron"). The surrounding cube is a conventional body-centered cubic cell with a lattice point at its center and on each vertex. The hexagonal faces bisect the lines joining the central point to the points on the vertices (drawn as solid lines). The square faces bisect the lines joining the central point to the central points in each of the six neighboring cubic cells (not drawn). The hexagons are regular (see





Wigner - Seitz for all Bravais Lattices

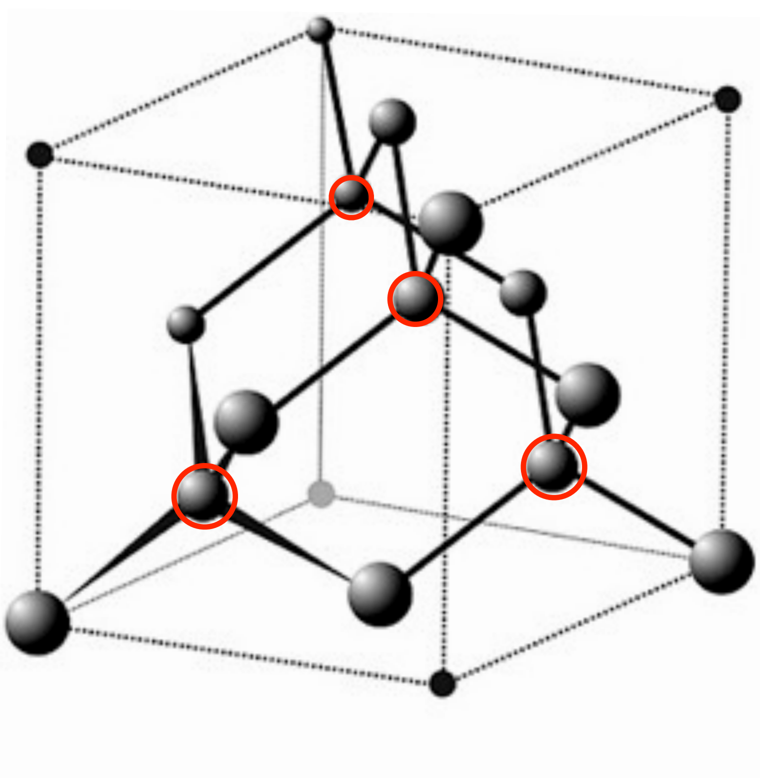


Crystalline lattices with basis

Crystalline lattices with basis

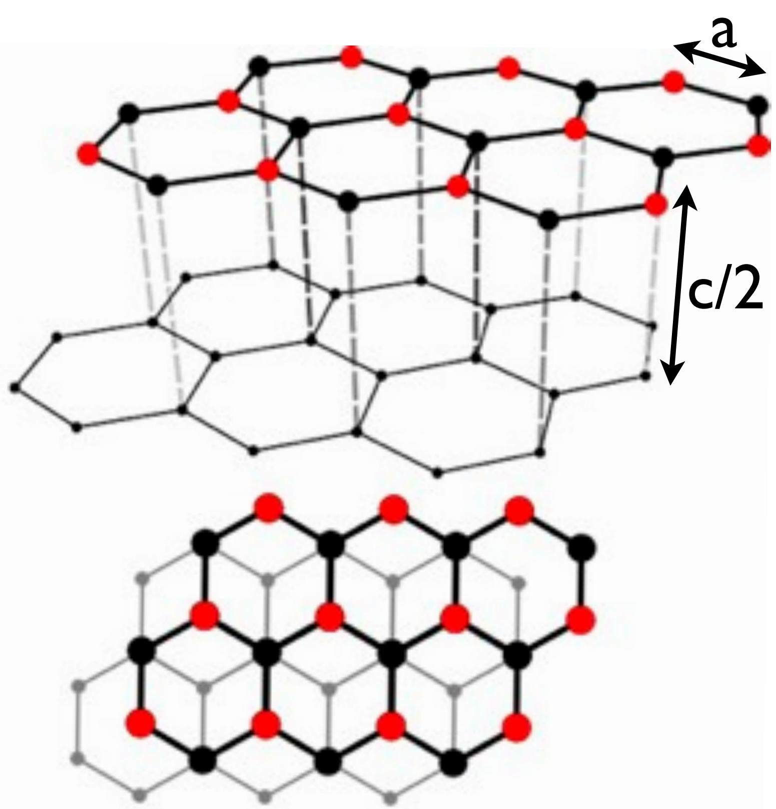
example: two allotropic forms of Carbon

(elemental solid - only **one** atomic type)



diamond

(FCC+basis)



graphite

(HEX+basis)

primitive vectors
and
vectors of the basis:

$$a_1 = a\left(\frac{1}{2}, \frac{\sqrt{3}}{2}, 0\right)$$

$$a_2 = a\left(-\frac{1}{2}, \frac{\sqrt{3}}{2}, 0\right)$$

$$a_3 = c\,(0, 0, 1)$$

$$d_1 = (0, 0, 0)$$

$$d_2 = \left(0, \frac{a}{\sqrt{3}}, 0\right)$$

$$d_3 = \left(0, 0, \frac{c}{2}\right)$$

$$d_4 = \left(0, \frac{2a}{\sqrt{3}}, \frac{c}{2}\right)$$

Hexagonal closed packed

(NOT a Bravais lattice: HEX+basis)

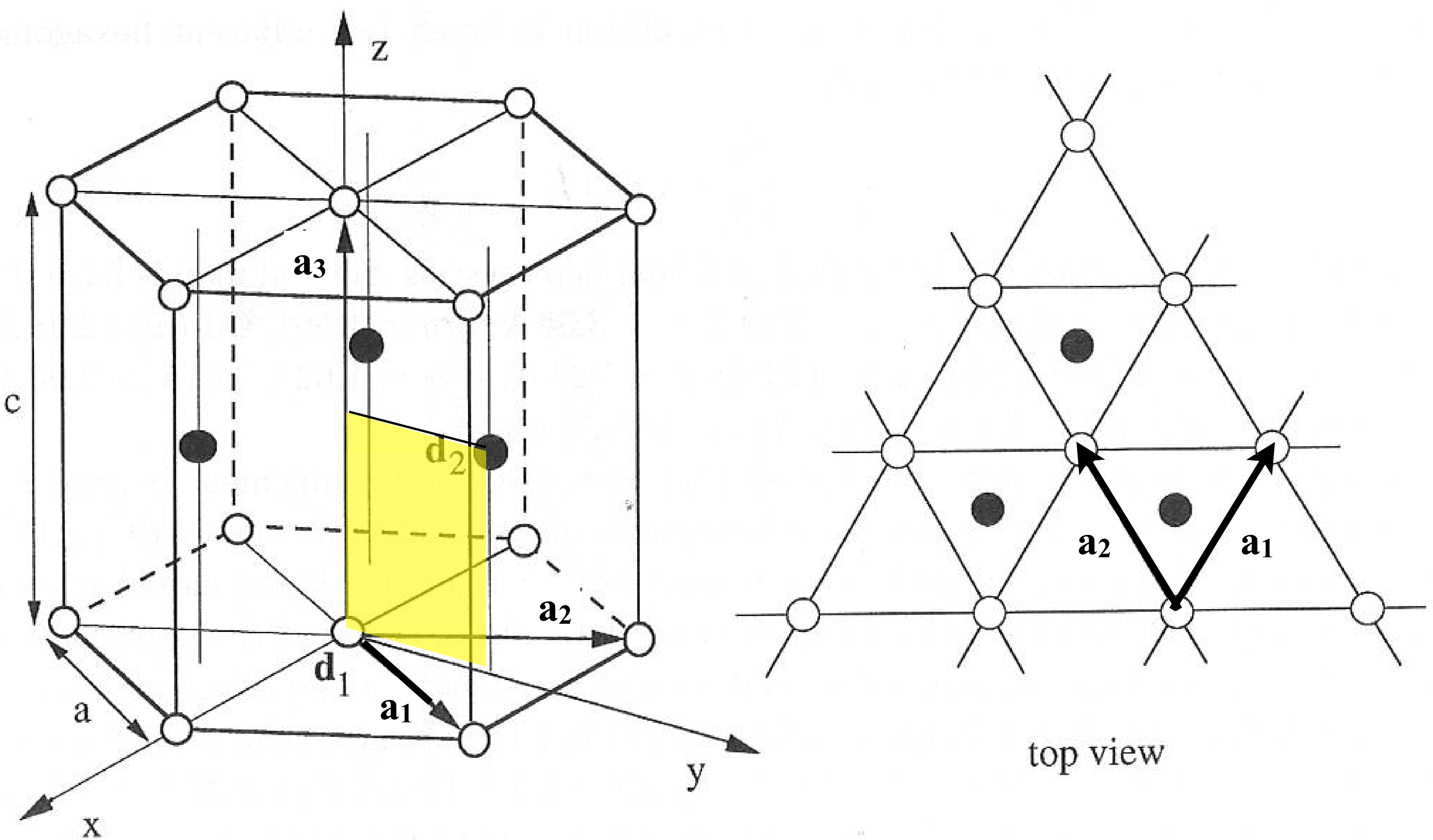
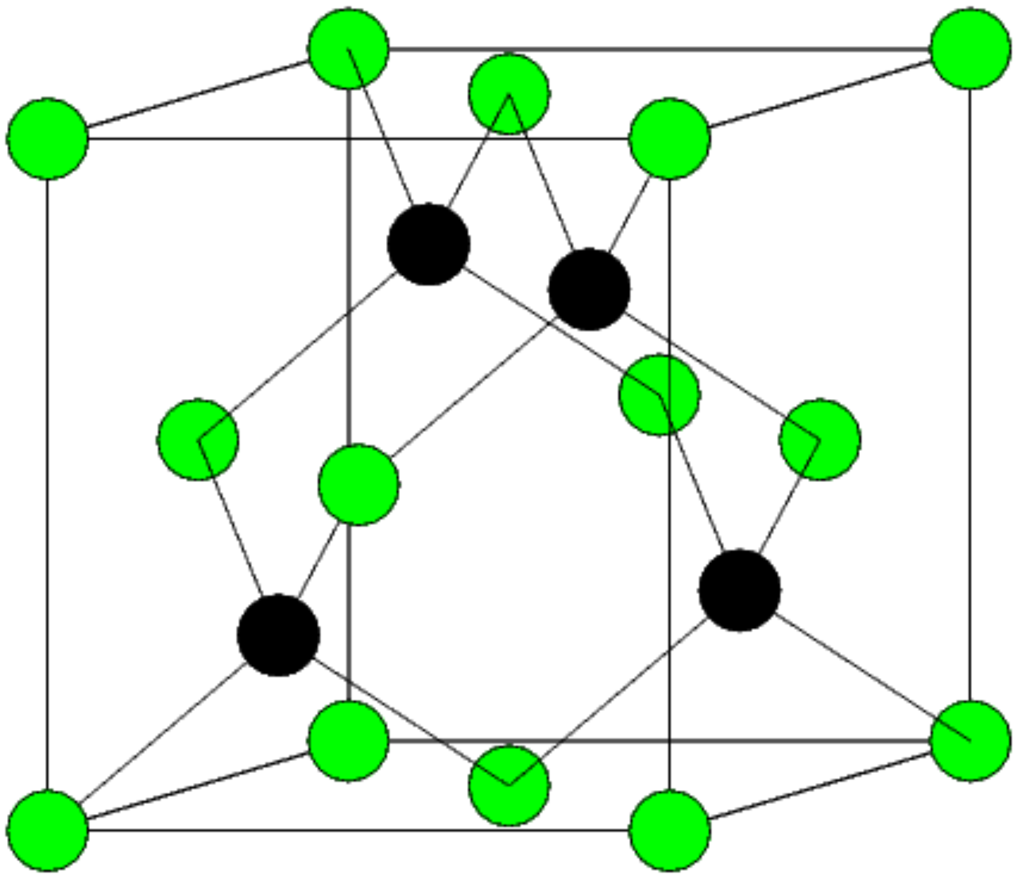


Fig. 13 Hexagonal closed-packed structure. The primitive translation vectors $\mathbf{t}_1, \mathbf{t}_2, \mathbf{t}_3$ and the end points of the basis vectors $\mathbf{d}_1$ and $\mathbf{d}_2$, given in Eqs. (15) of the text, are also indicated. The top view of the structure is also shown for convenience.

zincblende

(NOT a Bravais lattice: FCC+basis with 2 different atoms)

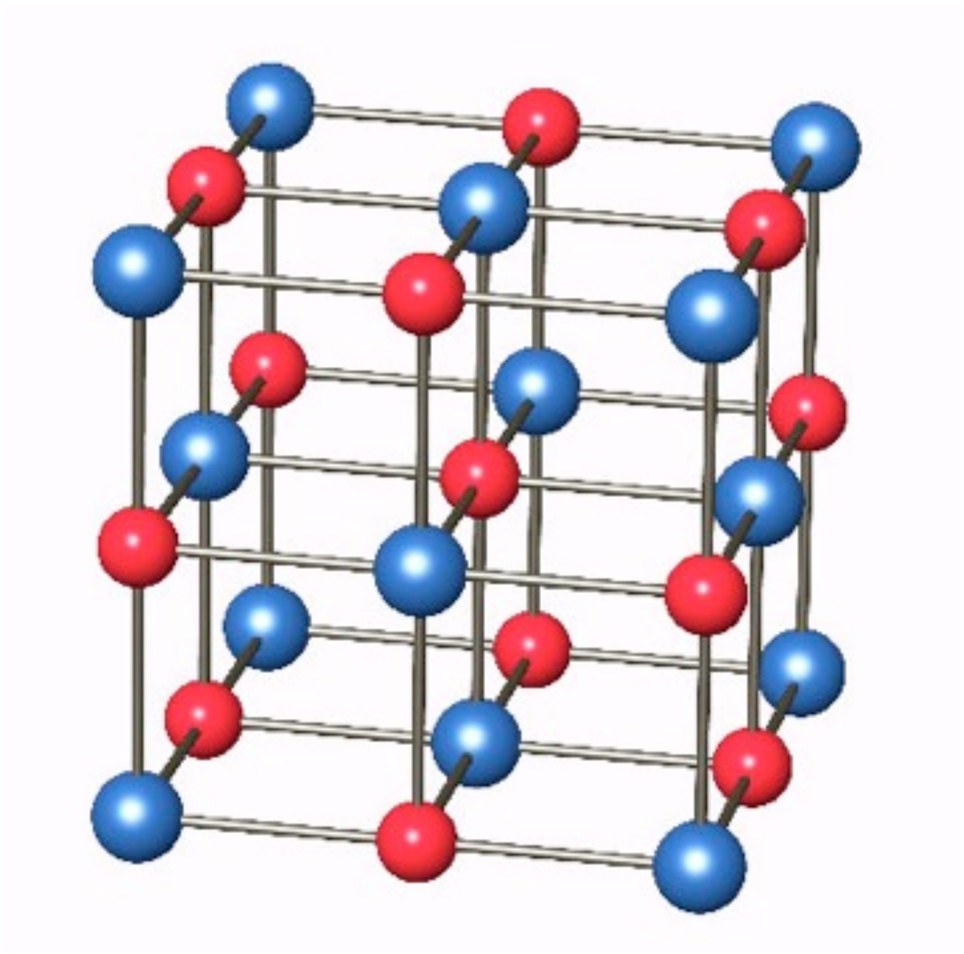
reduces to diamond
in case of one atomic type



rocksalt

(NOT a Bravais lattice: FCC+basis with 2 different atoms)

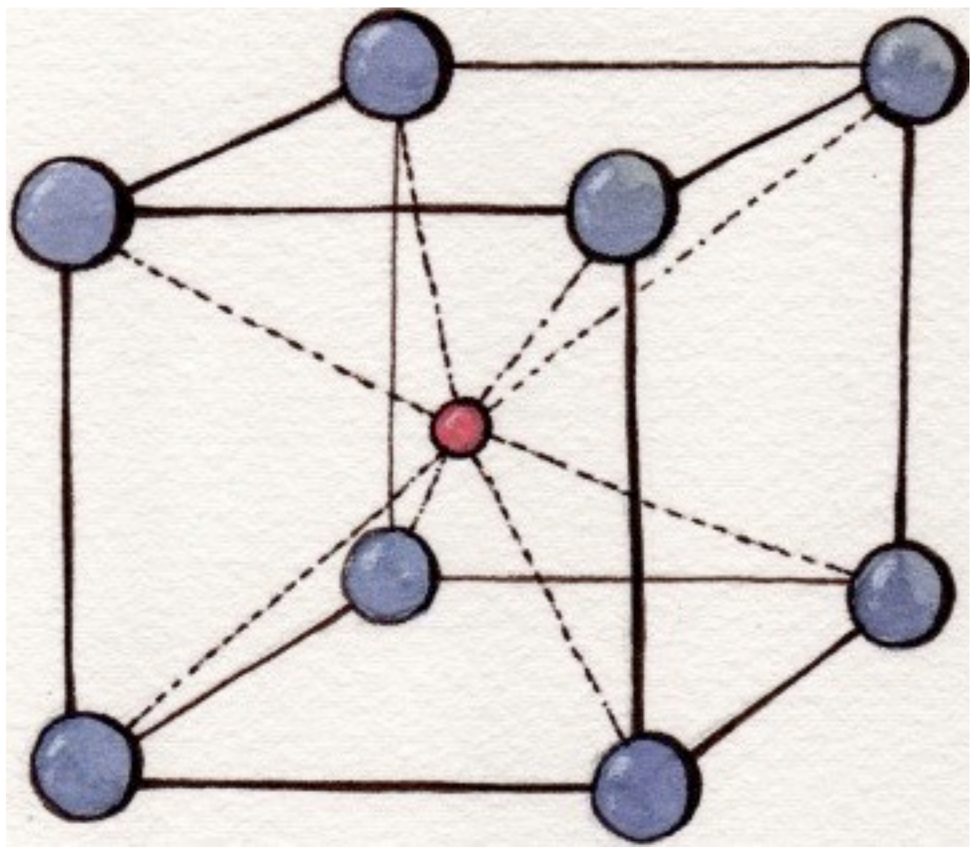
(basis with different positions w.r.t. the zincblende)



CsCl

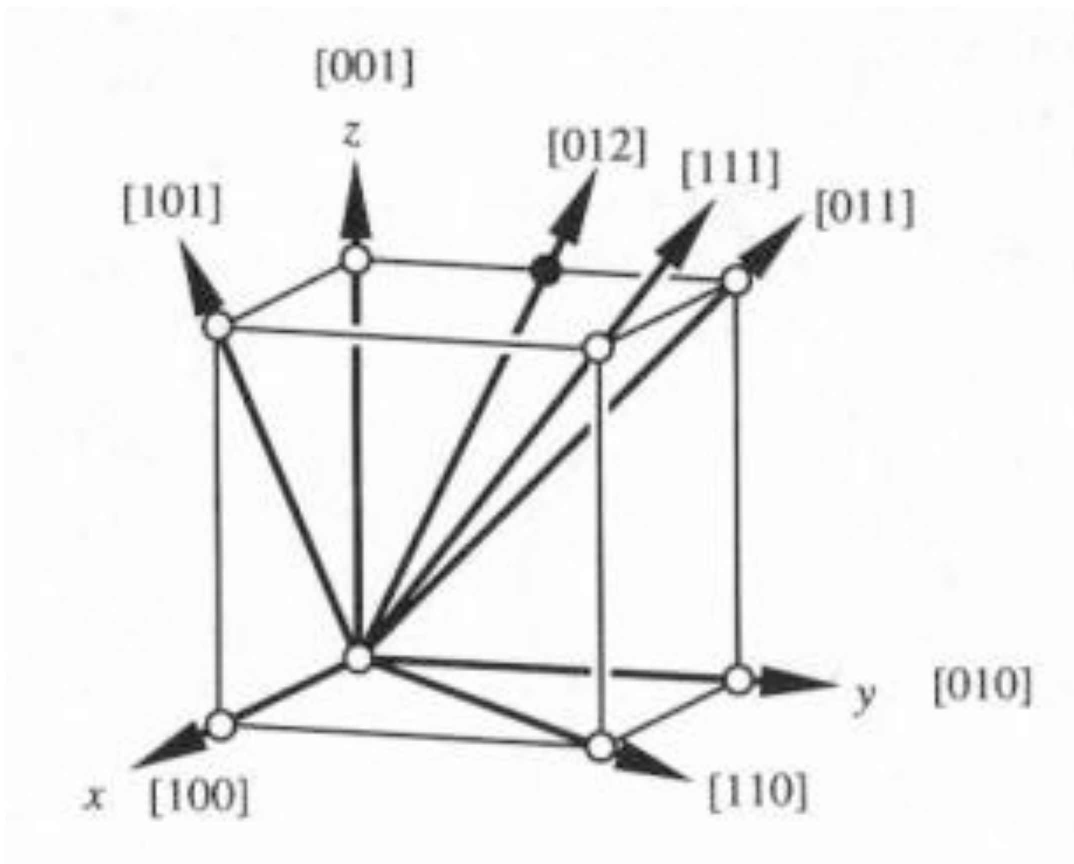
(NOT a Bravais lattice: SC+basis with 2 different atoms)

reduces to the BCC Bravais lattice
in case of one atomic type



Crystalline directions and planes

Crystallographic directions



Crystallographic planes and Miller indexes