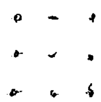
Lattice always has at least as much (if not more) symm. than crystal

Focus now on <u>lattices</u>

Group lattices by symmetry properties

= same class as

but different than



this one more symmetric

Consider <u>all</u> possible lattices, turns out only so many distinct classes.

→ called the "Bravais lattices"

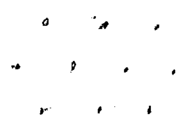
<u>2D</u> - 5 Bravais lattices

1) Oblique — $a_1 \neq a_2$, ϕ = no special angle

2) rectangular — $a_1 \neq a_2$ $\phi = 90°$

3) square — $a_1 = a_2$, $\phi = 90°$

4) hexagonal



$a_1 = a_2$, $\phi = 120°$

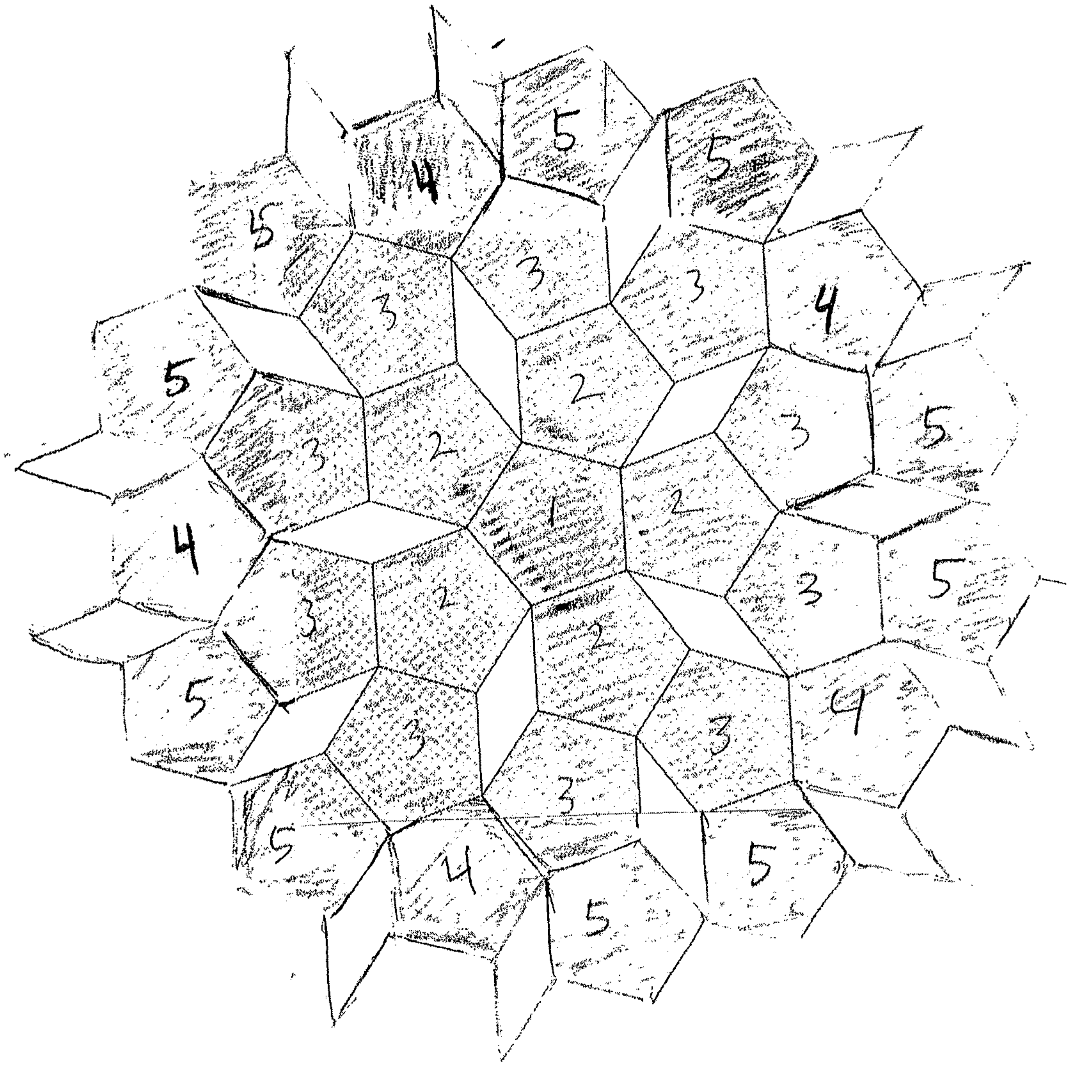
why not 60°? → arbitrary

Harald: obtuse angles generally used when given a choice

Why not pentagonal?

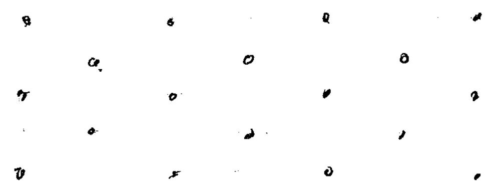
Pentagonal Tiling of 2D Plane
Physics 581 Colton, Winter 2011

From Kittel Figure 1.5, pg 7



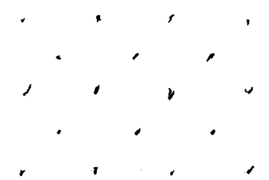
2D cont

5) centered rectangular



rectangular, but with extra dot in middle of rectangles.

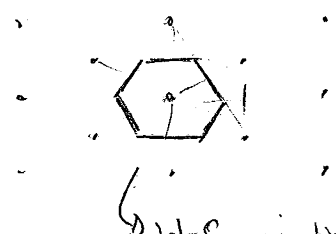
[why not "centered square" type?



hey, it's just square! (rotated)]

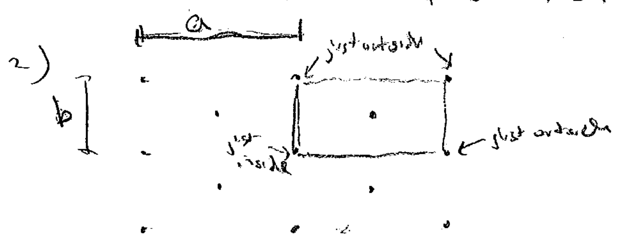
Two ways of looking at centered rectangular w/ 1 atom/cell

1)



W-S primitive unit cell + 1 atom/cell

2)



rectangular unit cell (<u>not</u> primitive) + 2 atoms/cell

$\underset{\sim}{r}_1 = (0,0)$

$\underset{\sim}{r}_2 = (a/2, b/2)$

in this example.

Which is easier?

rev

3D lattices

14 Bravais lattices! (I expected more)

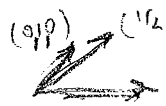
→ handout from Stokes' book

Note on bcc and fcc : like 2D "centered rectangular" have a choice

→ Mostly use the "conventional cell", cubic and not the primitive cell

(bcc) : How many pts in conventional cell ?

one choice of lattice vectors



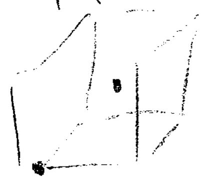
(units of a)

another choice, Kittel Fig 1.10 pg 10

$\frac{1}{2}, \frac{1}{2}, -\frac{1}{2}$

$-\frac{1}{2}, \frac{1}{2}, \frac{1}{2}$

$\frac{1}{2}, -\frac{1}{2}, \frac{1}{2}$

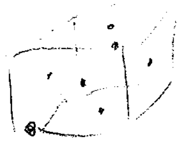


two

$\frac{1}{8} \times 8 + 1 = 2$

volume of primitive cell $= \frac{a^3}{2}$

(fcc)



four

corner : 8, each shared by 8

face : 6, each shared by 2

$\frac{1}{8} \times 8 + \frac{1}{2} \times 6 = 4$

volume of primitive cell $\frac{a^3}{4}$

primitive basis vectors

$\frac{1}{2}, \frac{1}{2}, 0$

$0, \frac{1}{2}, \frac{1}{2}$

$\frac{1}{2}, 0, \frac{1}{2}$

Fig 11 pg 11

This class :

I think all materials we will study are lattice types

1) cubic (sc)
2) bcc
3) fcc
4) hexagonal (?)

One more notation note: [ ] vs ( ) vs { }

[ ] a direction. Eg [100] = $\hat{x}$

[110] = $\frac{\hat{x}+\hat{y}}{\sqrt{2}}$

( ) a single plane or set of parallel planes "Miller indices"

Defined by intercepts on primitive l.v. lines

If plane intersects lines at $A_1 \vec{a}_1$, $A_2 \vec{a}_2$, $A_3 \vec{a}_3$

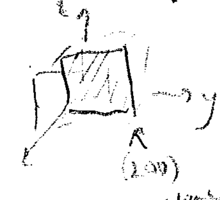
take inverse $\left(\frac{1}{A_1}, \frac{1}{A_2}, \frac{1}{A_3}\right)$

multiply by LCD $\rightarrow (h, k, l)$

careful: for (simple) cubic the planes are exactly what you'd expect: (100) = ⊥ to [100] direction

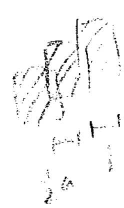
but not necessarily for other systems

(200) = ⊥, and passes through e.g.



convention (I think) in bcc and fcc use cubic planes

If representing a set of planes, (200) =



{ } Planes equivalent by symmetry

Ex. in s.c. {100} = (100), (010), and (001) planes