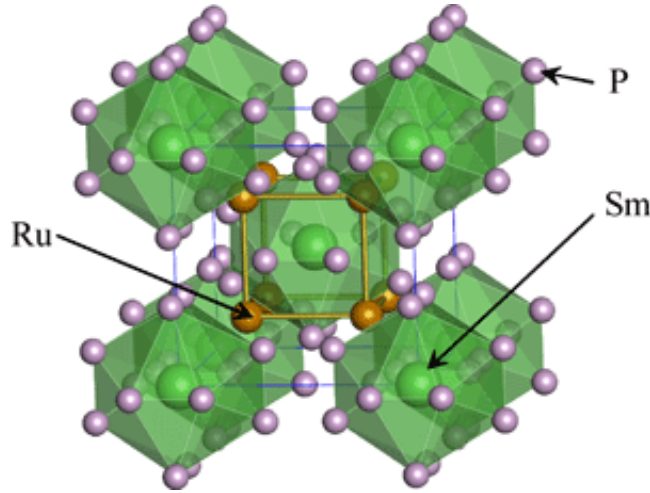
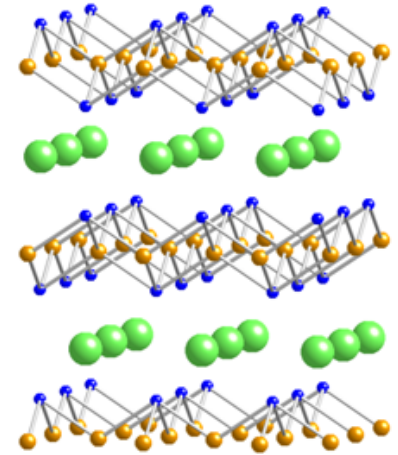


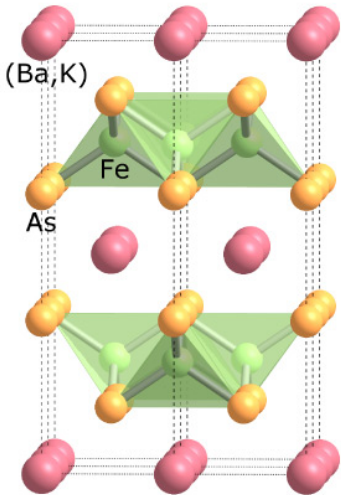
NaCl



$\text{SmRu}_{14}\text{P}_{12}$



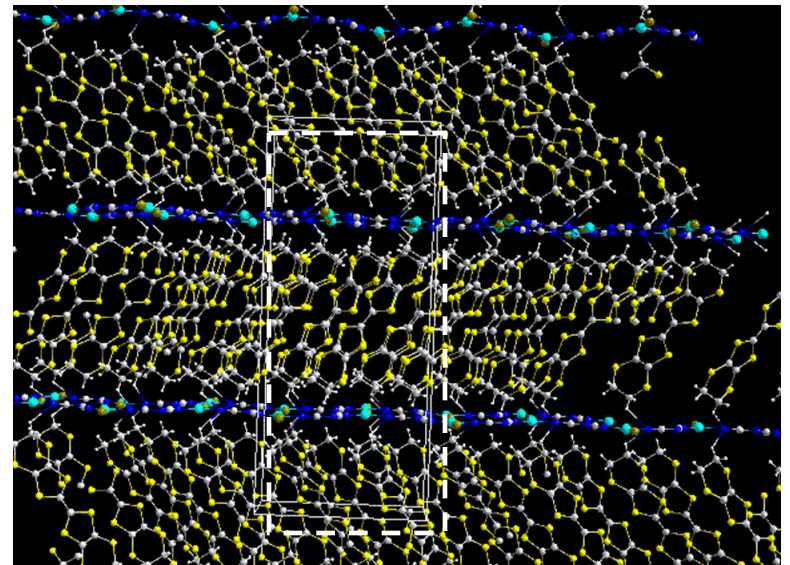
CeCu_2Si_2



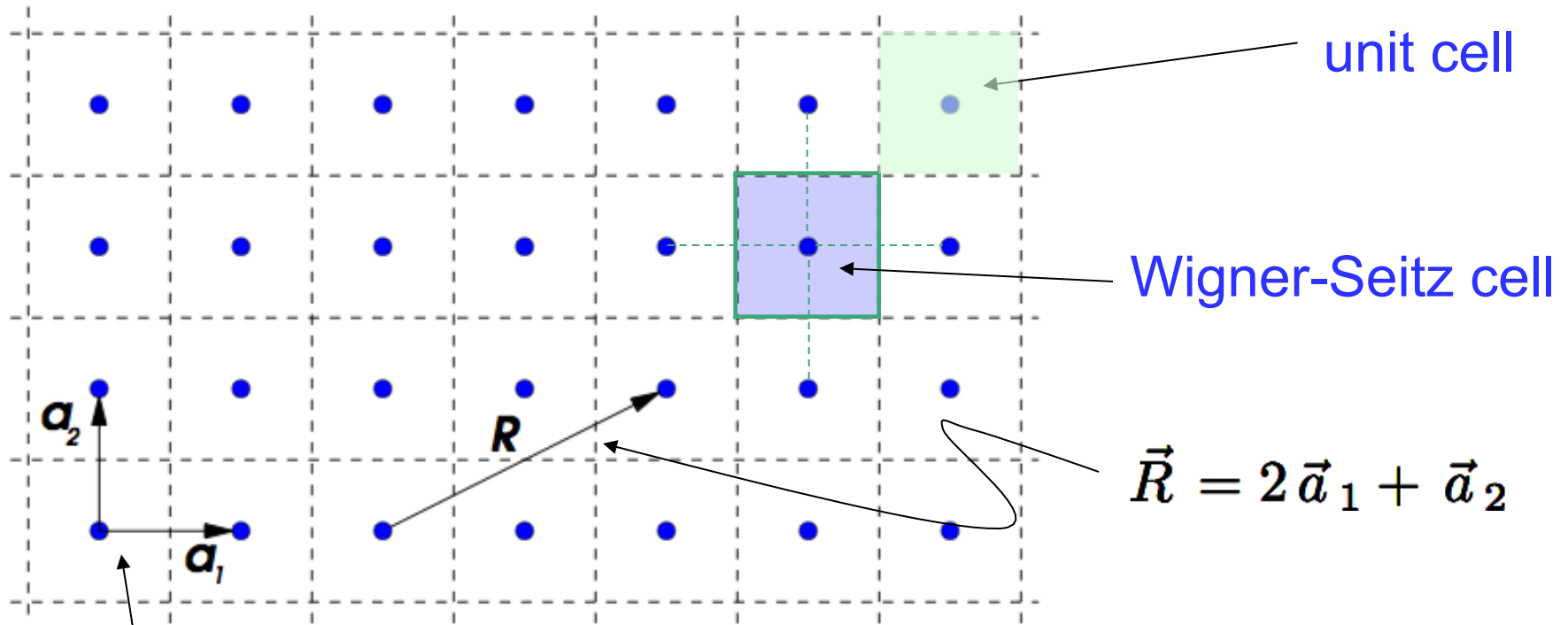
$(\text{Ba},\text{K})\text{FeAs}$

periodic array
of atoms

complex
sub-structures



$\text{K}-(\text{BEDT-TTF})_2\text{Cu}[\text{N}(\text{CN})_2]\text{Br}_x\text{Cl}_{1-x}$



primitive
lattice vectors
basis set

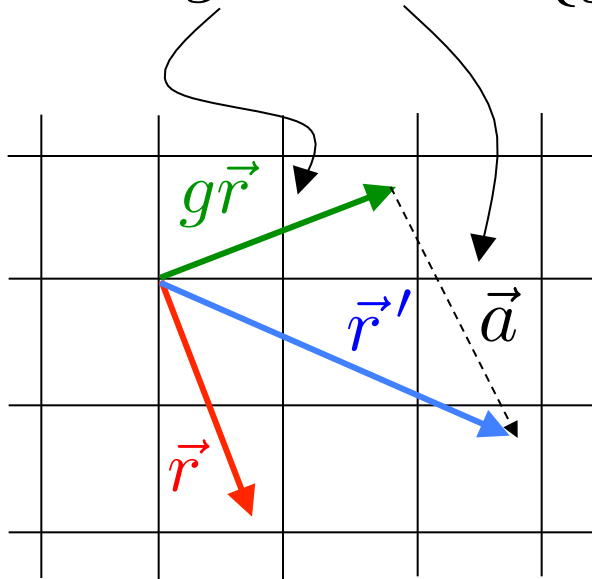
lattice vectors

$$\vec{R}_n = n_1 \vec{a}_1 + n_2 \vec{a}_2$$

general symmetry operations in a crystal lattice

$$\vec{r}' = g\vec{r} + \vec{a} = \{g|\vec{a}\}\vec{r}$$

$\{g|\vec{a}\}$ space group element



basic elements

$\{E|\vec{a}\}$ basic translations

$\{g|0\}$ rotations, reflections, inversions

$\{g'|\vec{a}'\}$ screw axis, glide plane

$g \in \mathcal{P}$ point group element

\vec{a} lattice vector

screw axis

\vec{a}' + g'

not a lattice vector + 60° rotation around z-axis
 not a basic point group element

space group \mathcal{R} is a group

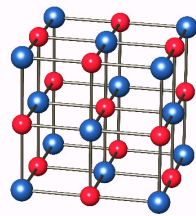
- multiplication $\{g|\vec{a}\}\{g'|\vec{a}'\} = \{gg' | g\vec{a}' + \vec{a}\}$ associative
- unit element $\{E|\vec{0}\}$ $\{E|\vec{0}\}\{g|\vec{a}\} = \{Eg | E\vec{a} + \vec{0}\} = \{g|\vec{a}\}$
- inverse $\{g|\vec{a}\}^{-1} = \{g^{-1} | -g^{-1}\vec{a}\}$
 $\{g|\vec{a}\}^{-1}\{g|\vec{a}\} = \{g^{-1} | -g^{-1}\vec{a}\}\{g|\vec{a}\} = \{g^{-1}g | g^{-1}\vec{a} - g^{-1}\vec{a}\} = \{E|\vec{0}\}$

space groups with
screw axes and
glide planes

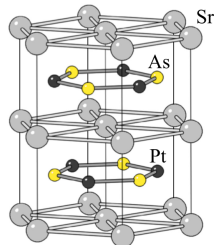


non-symmorphic

symmorphic



non-symmorphic



230 space groups =
73 symmorphic + 157 non-symmorphic

crystal system (# point groups, # space groups)	point groups Schönflies symbols	space group numbers international tables
triclinic (2,2)	C_1, C_1	1-2
monoclinic (3,13)	C_2, C_s, C_{2h}	3-15
orthorhombic (3,59)	D_2, C_{2v}, D_{2h}	16-74
tetragonal (7,68)	$C_4, S_4, C_{4h}, D_4, C_{4v}, D_{2d}, D_{4h}$	75-142
trigonal (5,25)	$C_3, S_6, D_3, C_{3v}, D_{3d}$	143-167
hexagonal (7,27)	$C_6, C_{3h}, C_{6h}, D_6, C_{6v}, D_{3h}, D_{6h}$	168-194
cubic (5, 36)	T, T_h, O, T_d, O_h	195-230