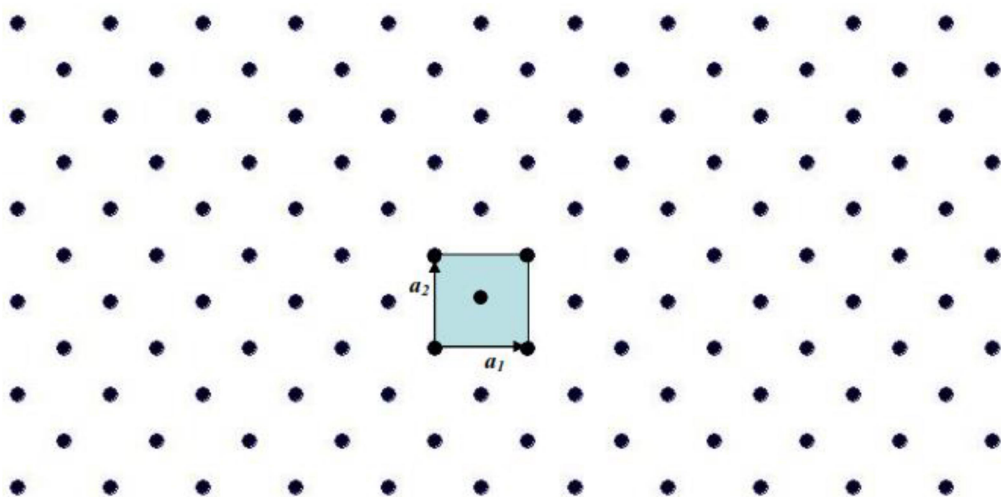
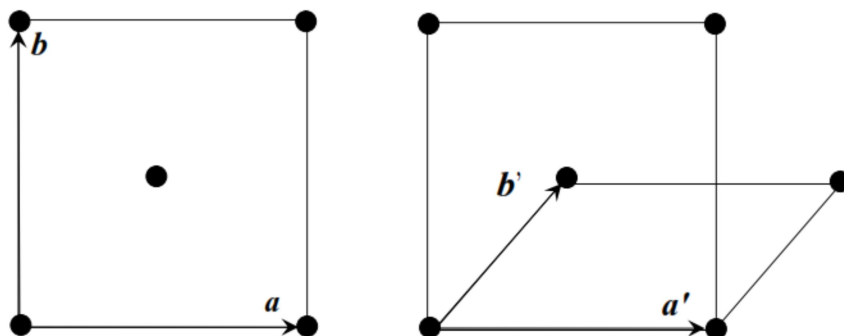


6. Homework “Symmetry of crystal lattice, 2D crystal system, 2D Bravais lattice”

1. 2D lattice has two basis vectors \mathbf{a}_1 and \mathbf{a}_2 (see figure below). These vectors have the same size and the angle of 90° in between. The unit cell is non-primitive and contains an additional lattice point at the $[1/2 \ 1/2]$ position. Which type of a lattice is depicted in the figure, explain why this lattice cannot be a new type of Bravais lattice (No. 6) ?



2. The 2D Bravais lattice (*the centered-rectangular lattice*) can be constructed using the basis vectors of the primitive and non-primitive unit cell accordingly. The basis vector of the primitive unit cell is $\mathbf{a}' = \mathbf{a}$, $\mathbf{b}' = 1/2\mathbf{a} + 1/2\mathbf{b}$ (see figure below). Find the relation between their reciprocal vectors \mathbf{a}^* , \mathbf{b}^* and \mathbf{a}'^* , \mathbf{b}'^* .



3. Find a type of Bravais lattice using the *Minkowski algorithm* to reduce lattice vectors. The initial vectors \mathbf{A}_1 , \mathbf{A}_2 and α angle have the following values:

a) $|\mathbf{A}_1|=1$, $|\mathbf{A}_2|=1.6125$, $\alpha = 7.125^\circ$

b) $|\mathbf{A}_1|=1$, $|\mathbf{A}_2|=2.0276$, $\alpha = 170.53^\circ$

c) $|\mathbf{A}_1|=1$, $|\mathbf{A}_2|=1.5275$, $\alpha = 169.100^\circ$

4. A crystal has the following symmetry elements:

a) a 2-fold axis $\parallel \mathbf{e}_1$ and a 4-fold rotoinversion axis $\parallel \mathbf{e}_3$

b) a 2-fold axis $\parallel \mathbf{e}_1$ and a 2-fold axis $\parallel \mathbf{e}_3$

Find the **complete** symmetry group (all possible symmetry elements) of this crystal.