MLL 100

Introduction to Materials Science and Engineering

Lecture-2

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Department of Materials Science and Engineering

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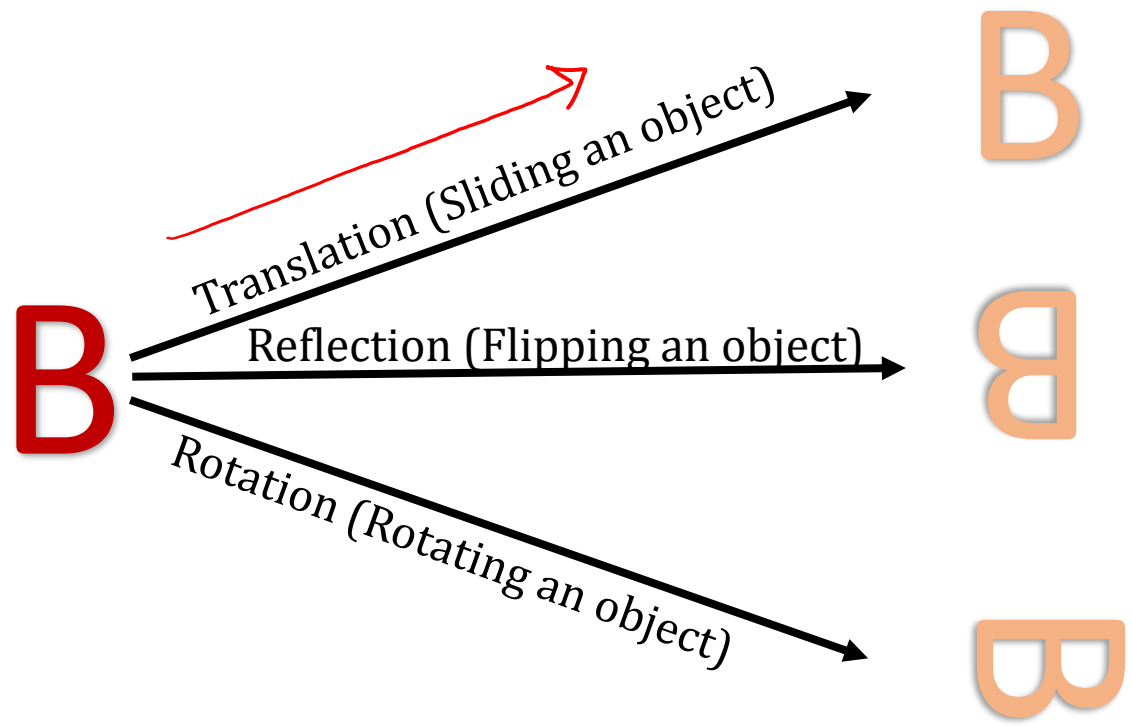
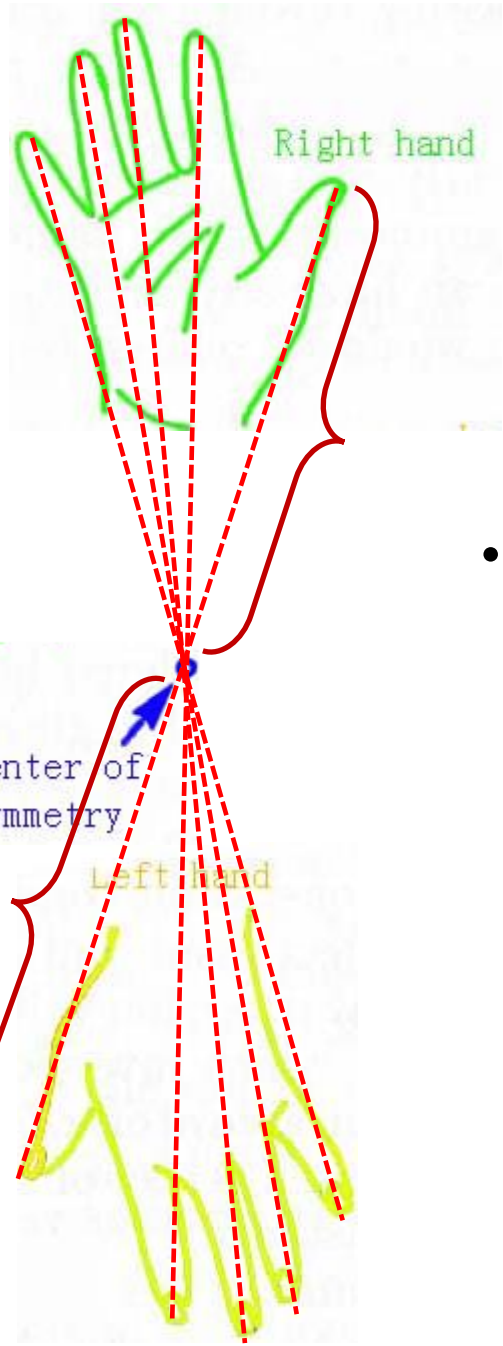
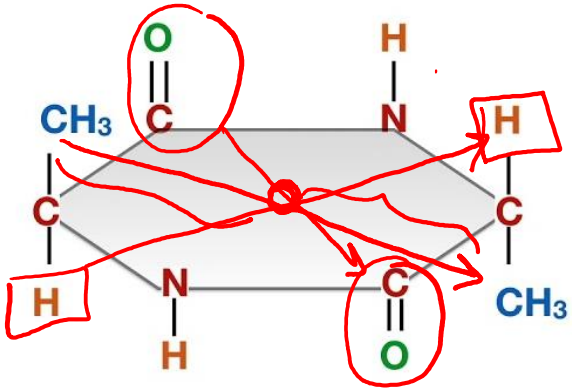
What we learnt in Lecture-1?

- Course Policy
- Structure of materials: Different length scales
- Symmetricity and periodicity

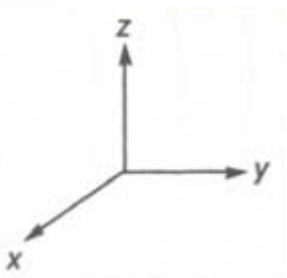


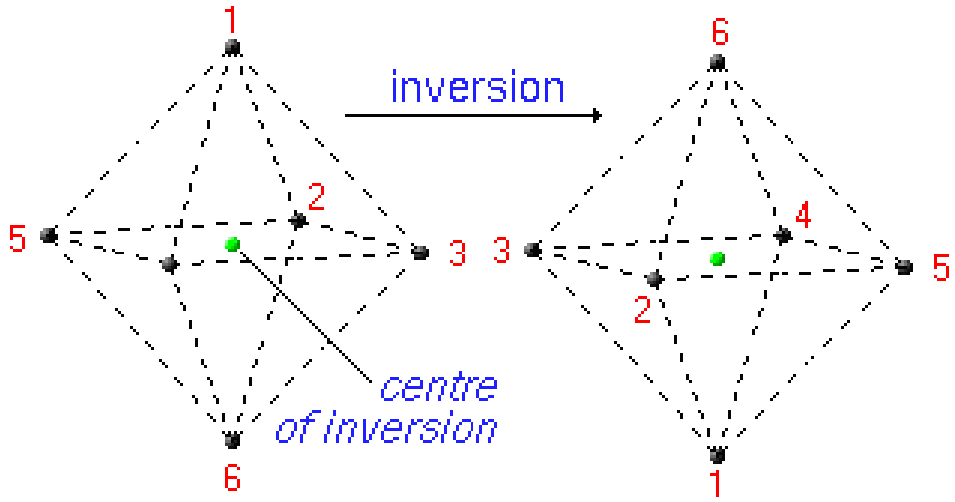
Inversion





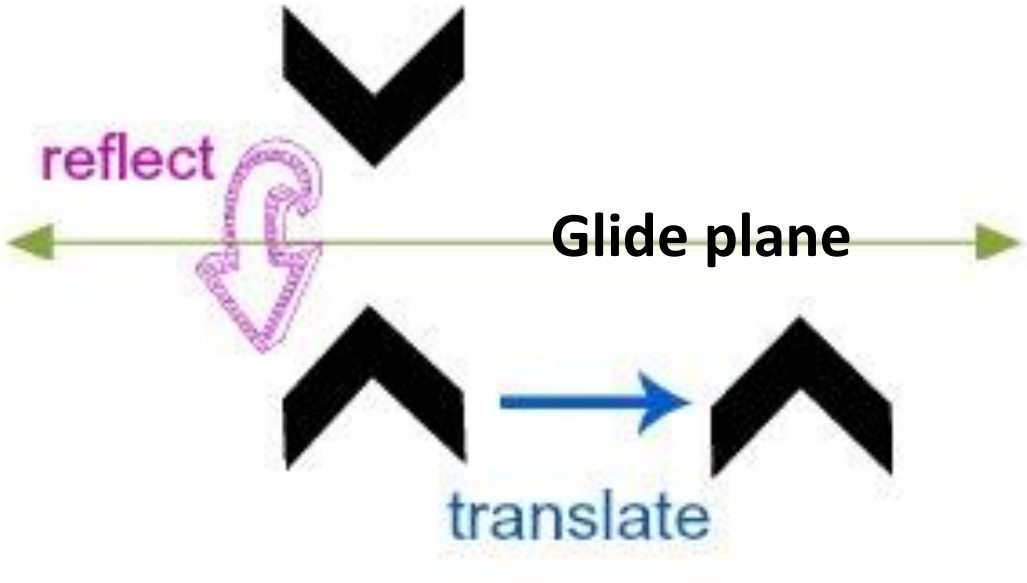
- An object at an equal and opposite distance through a single point ‘i’ after an inversion operation.

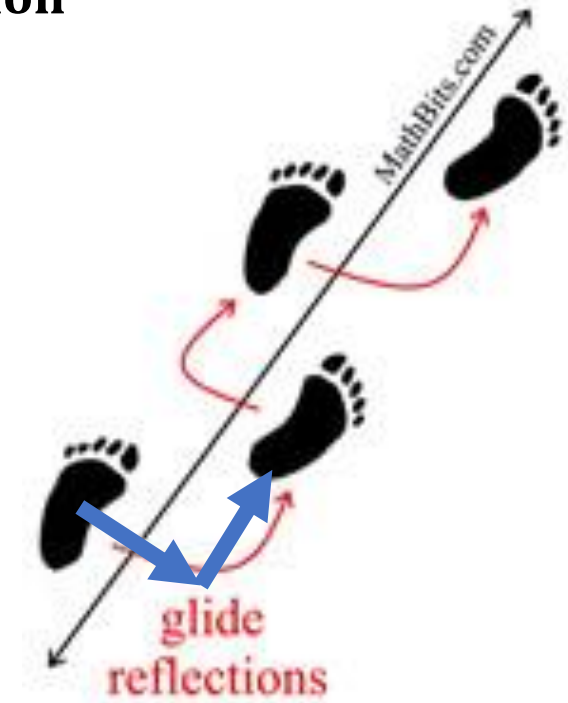


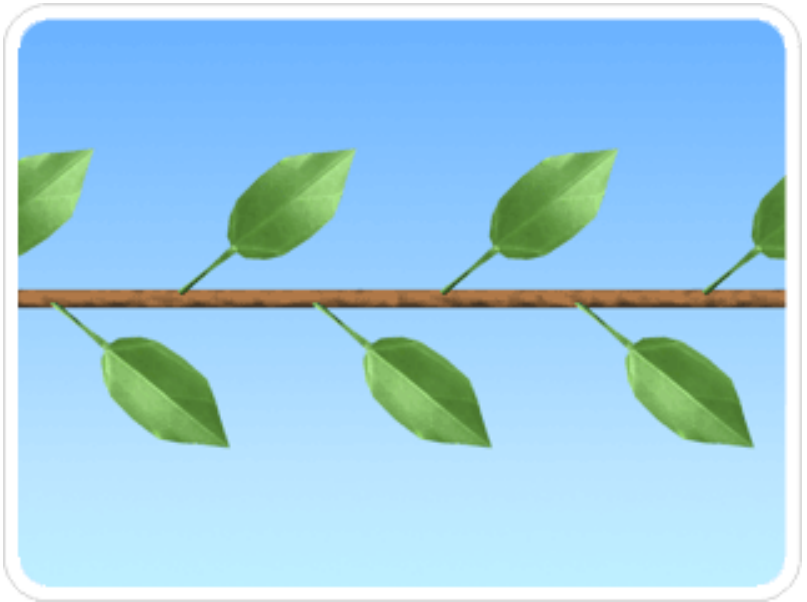


Glide

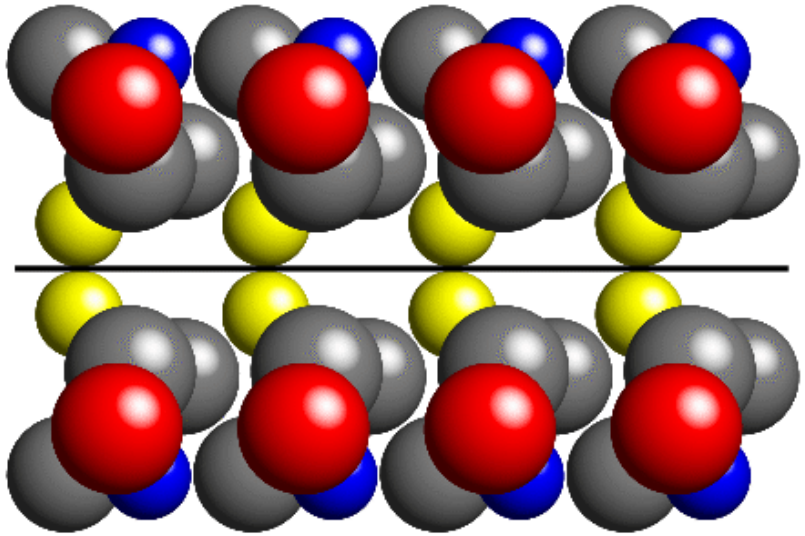
Glide = Reflection + Translation



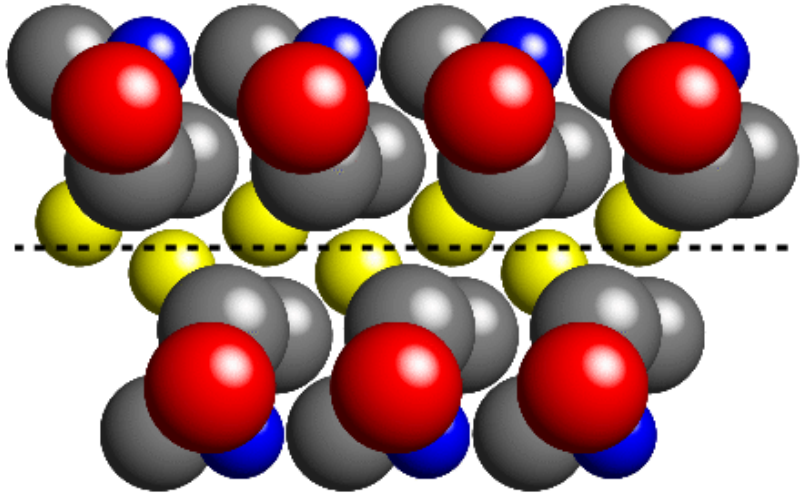




Mirror operation



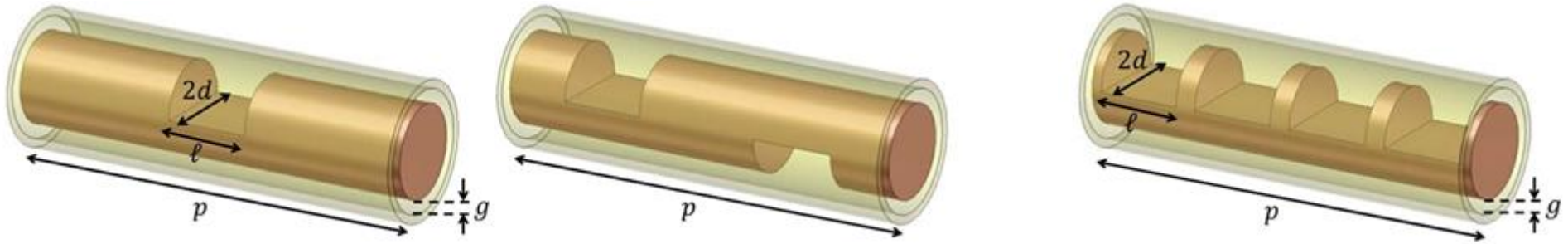
Glide operation



Makes the molecular packing compact

[Glide Symmetries: an Additional Degree of Freedom to Control the Propagation Characteristics of Periodic Structures]

Glide symmetry offers a compact, flexible solution for suppression of channel crosstalk in SSPP transmission lines



Twist and Polar Glide Symmetries: an Additional Degree of Freedom to Control the Propagation Characteristics of Periodic Structures

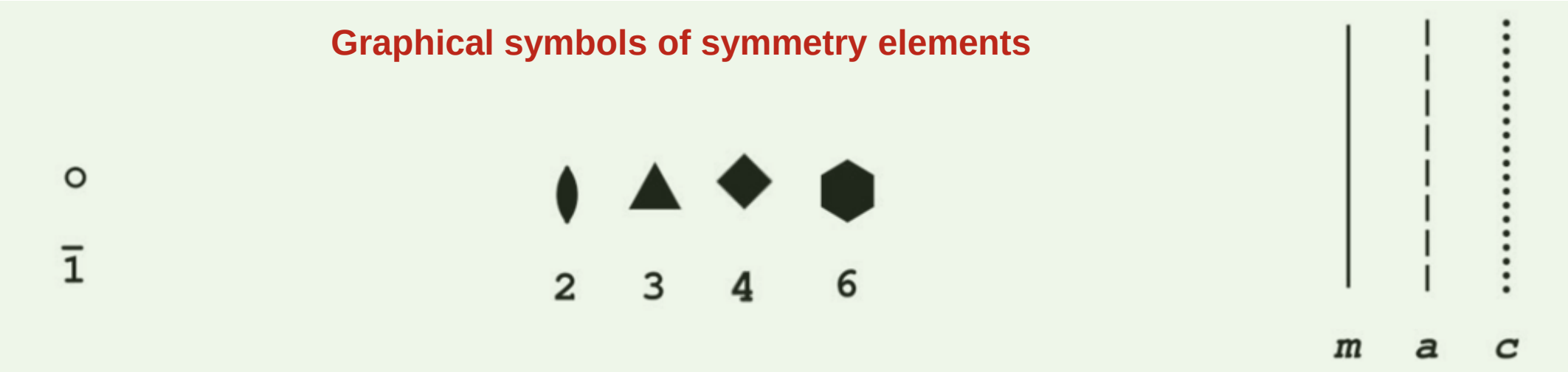
Fatemeh Ghasemifard, Martin Norgren & Oscar Quevedo-Teruel

Scientific Reports 8, Article number: 11266 (2018) | Cite this article

Graphical symbol of symmetry elements

*An object has **symmetry** if there is an operation, such as translation, rotation or reflection which maps the object onto itself, i.e., the object remains invariant after the transformation.*

- Symmetry:
  - Translational symmetry
  - Non-translational Symmetry (Inversion, Rotational and Reflectional)
  - Non-translational + Translational symmetry (Glide)



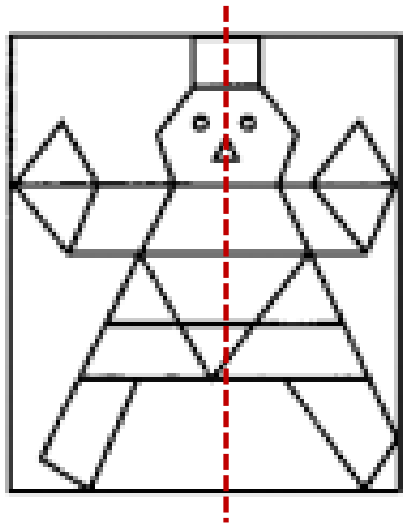
How many alphabets do you think has mirror symmetry?

A, B, C, D, E, H, I, K, M,
O, T, U, V, W, X, Y

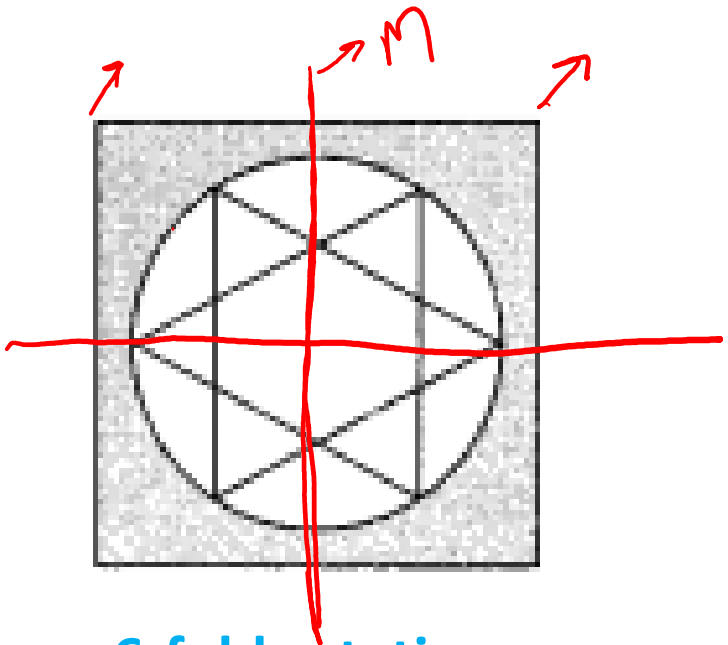
How many alphabets do you think has mirror symmetry along two planes?

H, I, O, X

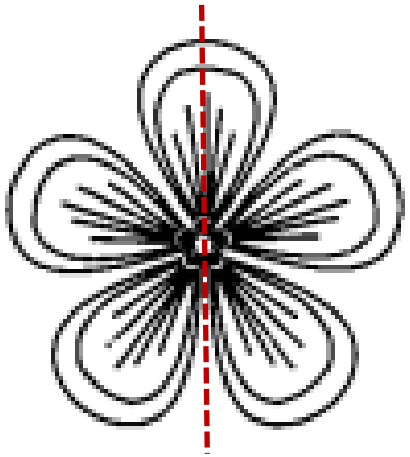
What are the symmetry elements present in these objects?



Mirror?

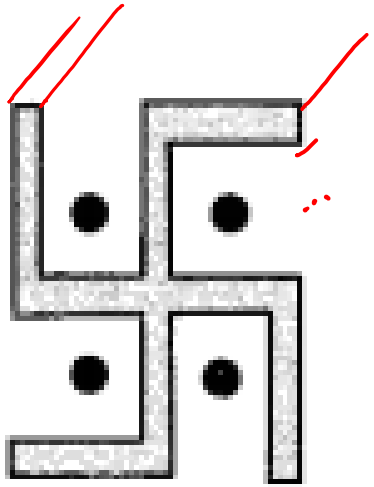


6-fold rotation



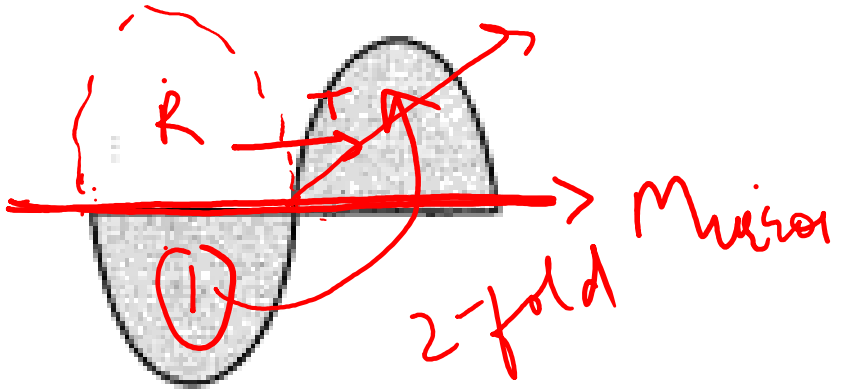
Mirror

5-fold rotation

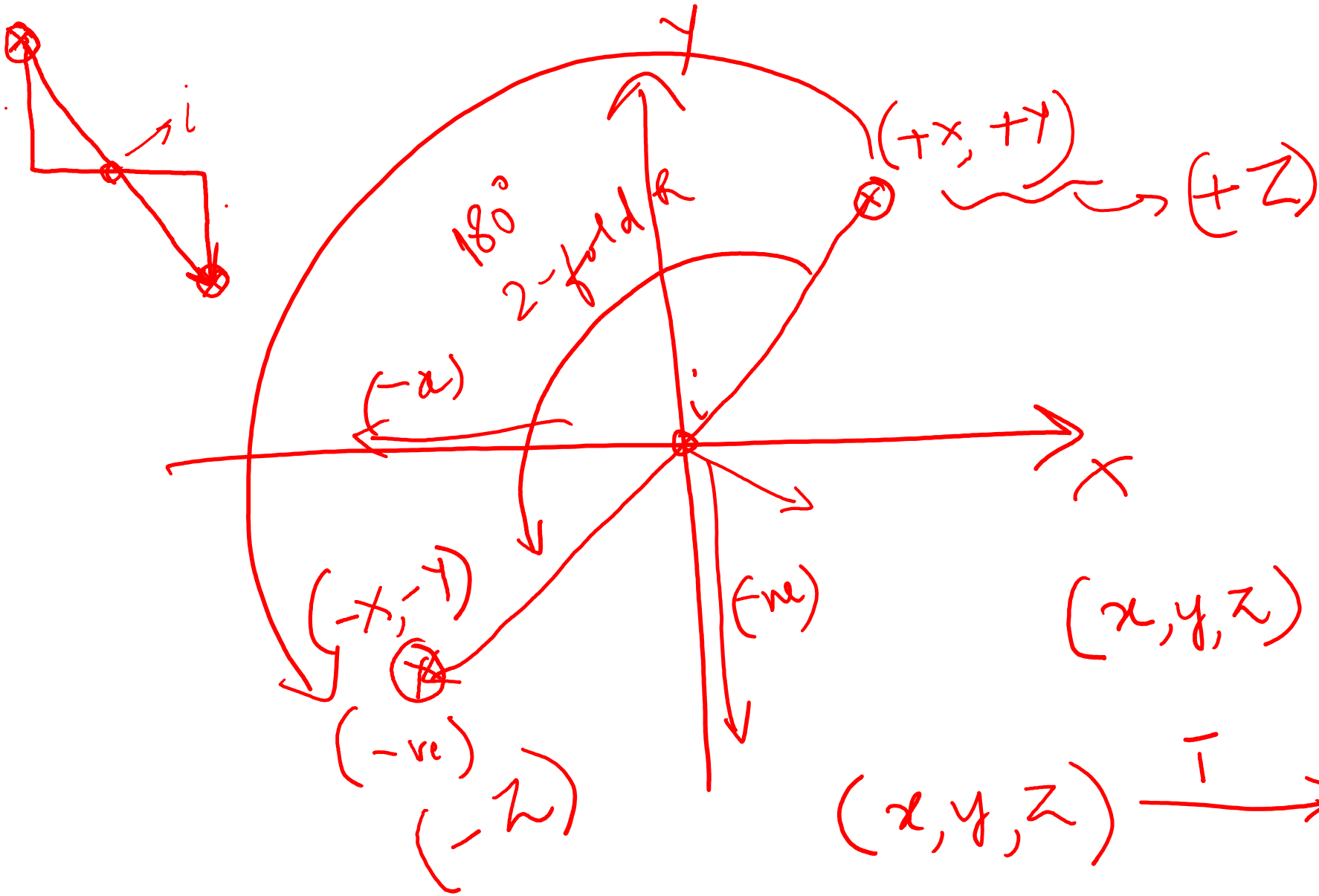


4-fold rotation

Centre of inversion?



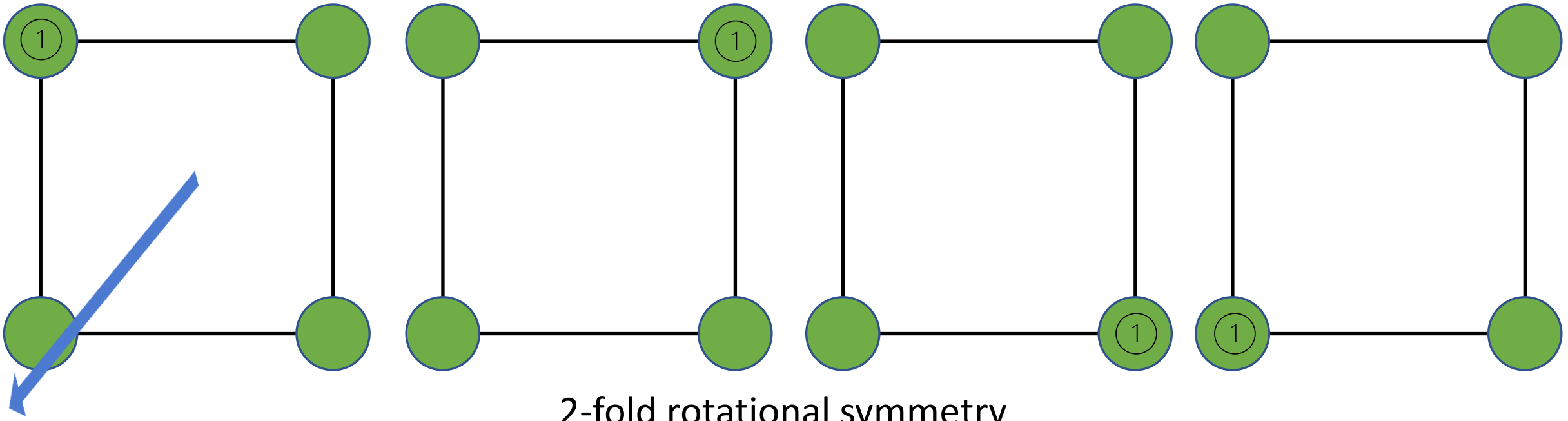
Glide plane



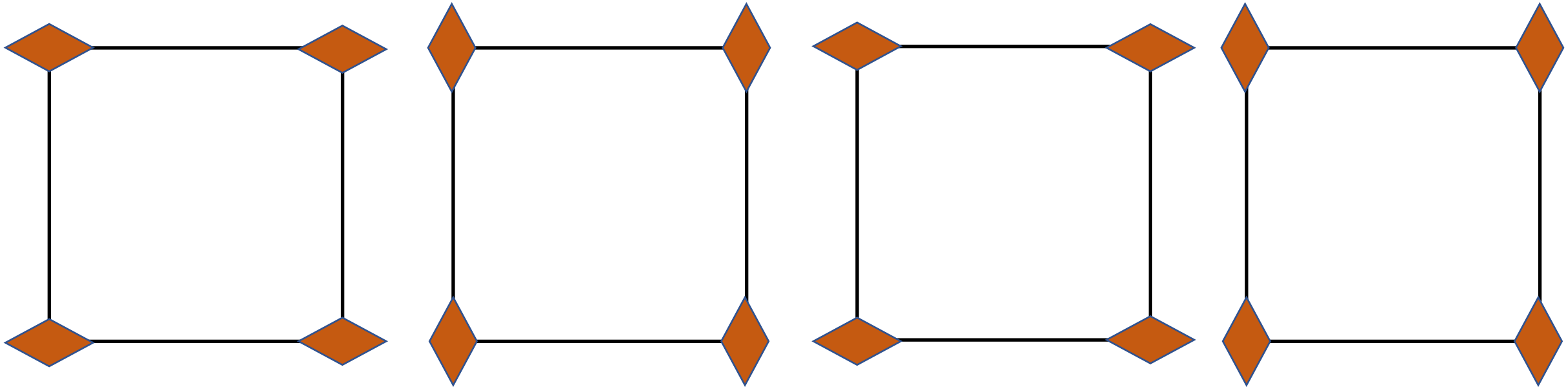
$(x, y, z) \xrightarrow{2\,||\,z} (x, -y, z)$

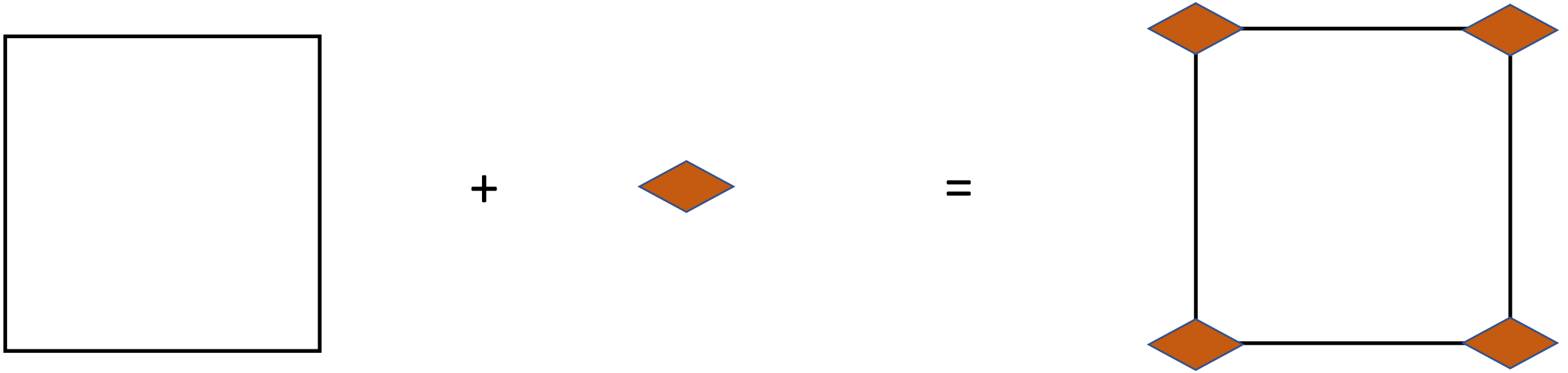
$(x, y, z) \xrightarrow{\bar{1}} (-x, -y, -z)$

4-fold rotational symmetry



2-fold rotational symmetry

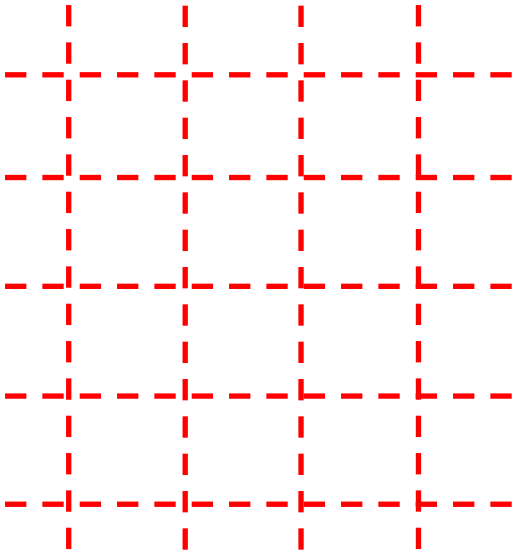




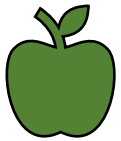
- What factor is likely to govern the symmetry of the crystal?
- Symmetry of a crystal will have either equivalent or lower order than that of the symmetry of a lattice.

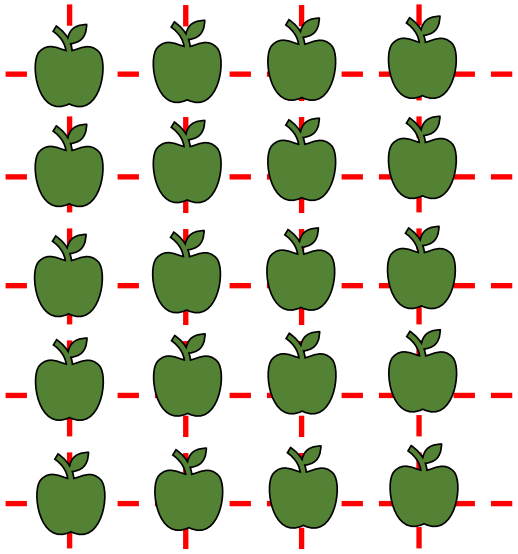
2-D crystal

Lattice + **Motif** = **Crystal**



+





Lattice points: How to repeat?

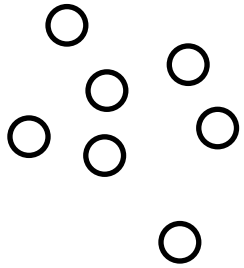
Translationally periodic arrangement of points

Entity associated with lattice points: What to repeat?

Translationally periodic arrangement of motifs

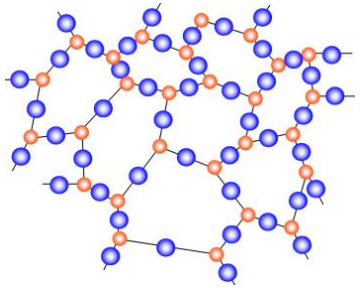
Atomic order of materials

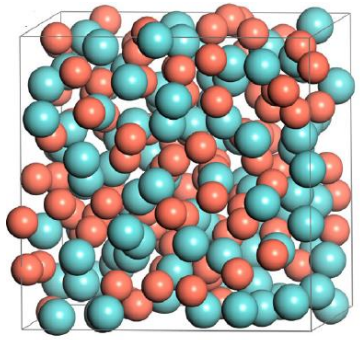
Inert gases (He, Ar)



No regular atomic order

Amorphous (silicate, metallic glasses)

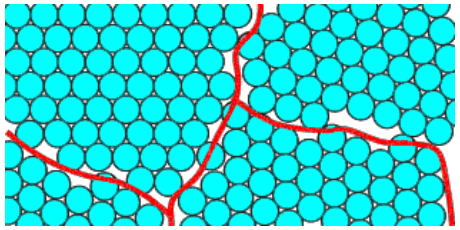




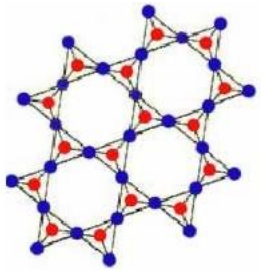
Short-range order; Lack periodicity in atomic arrangement

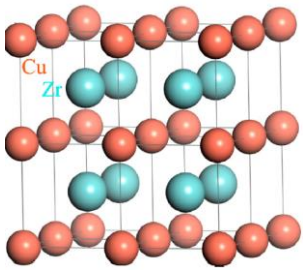
Polycrystal

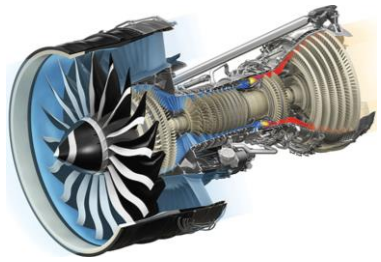
Periodic across each grain



Crystal (Metals, Ceramics, such as MgO, Al_2O_3; Conductive polymers)







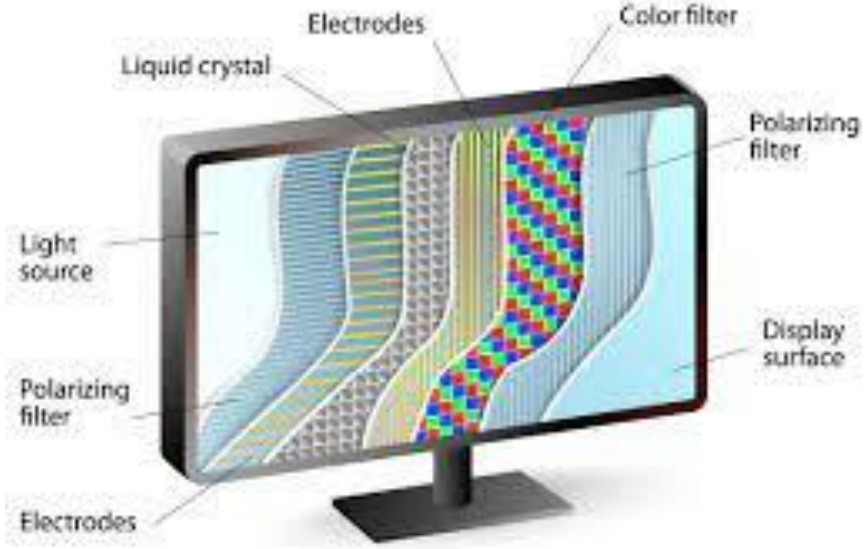
Regular atomic order extending over a large length scale > 100 nm

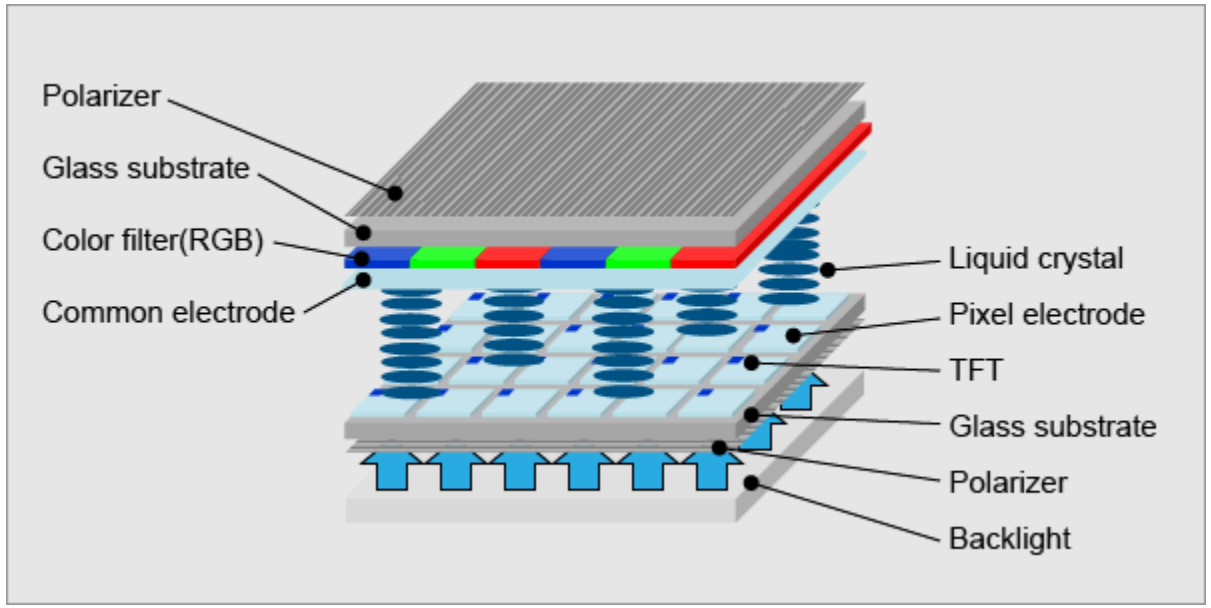
Increase in atomic order

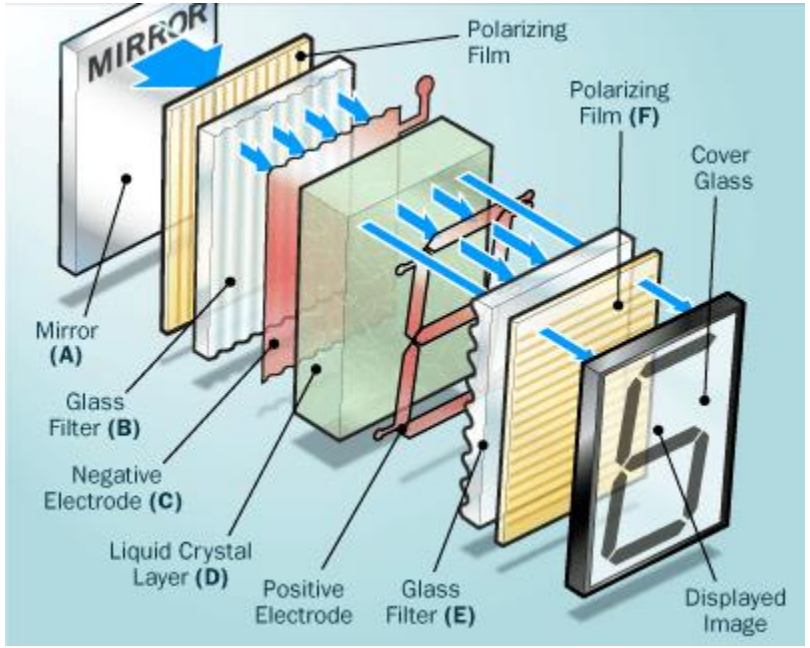
Andrienko J. Molecular Liq. 267 (2018)

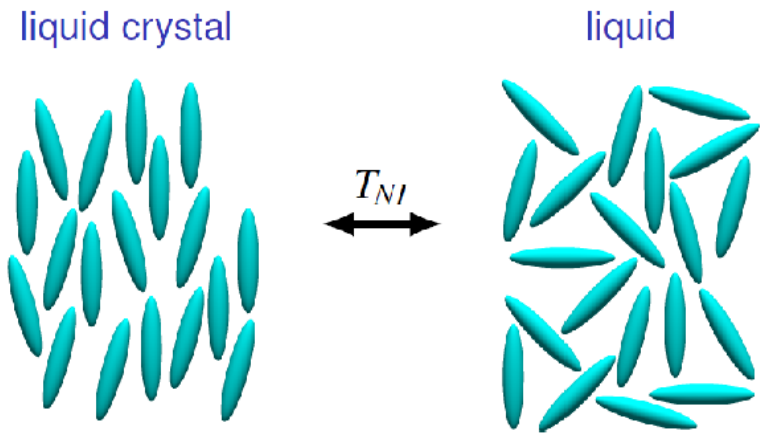
Qiao et al. Mater. Sci. Engg. R 100 (2016)

Liquid crystal



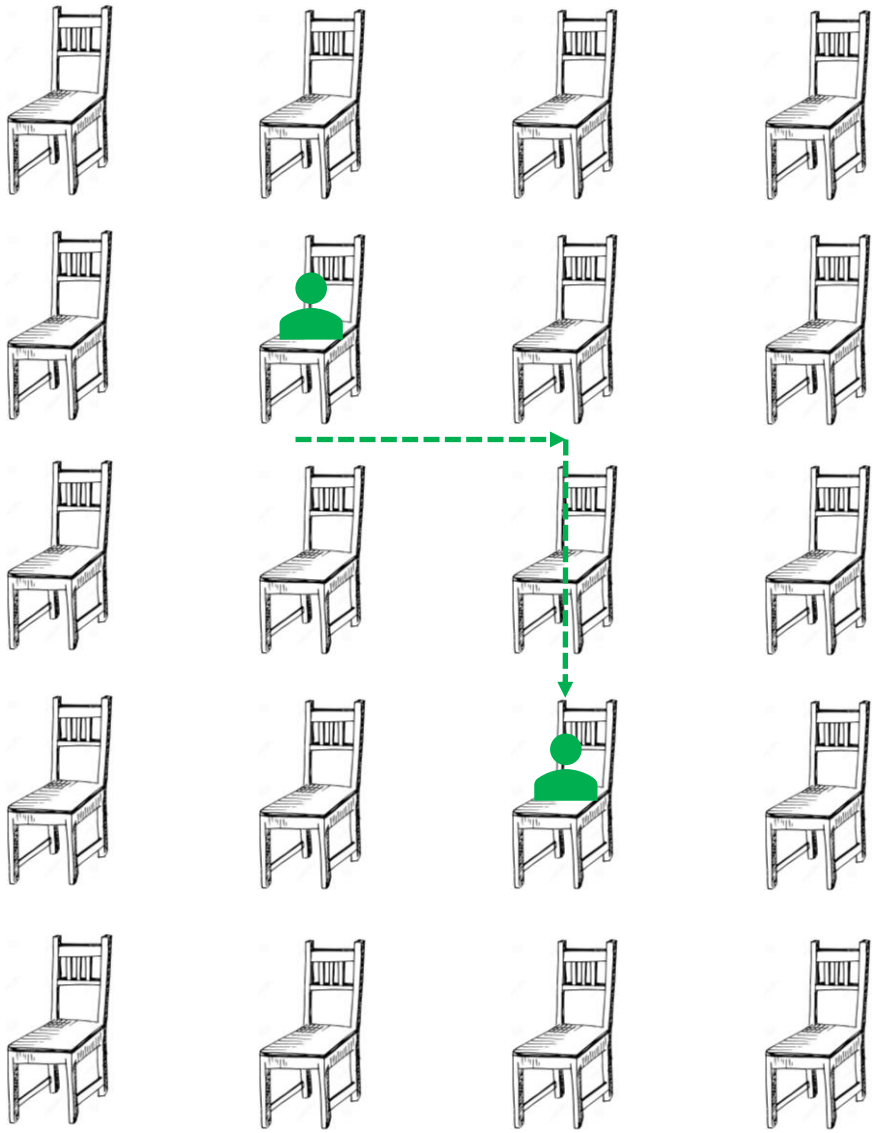






https://www.xenarc.com/lcd-technology.html

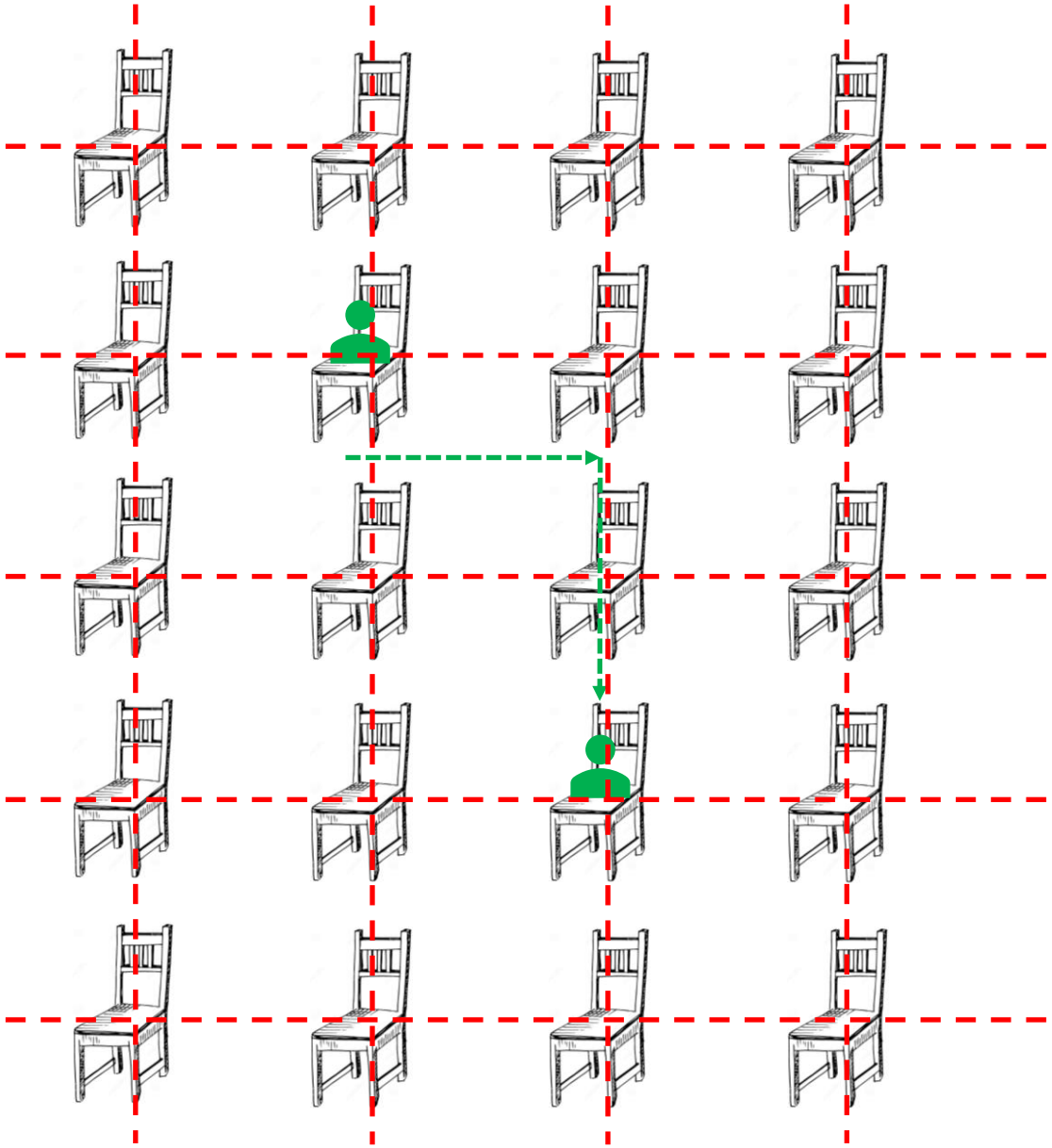
2-D lattice



- Would you be able to make out the difference between your first and second positions looking at its environment?

NO ! ----------→ Both look identical

2-D lattice



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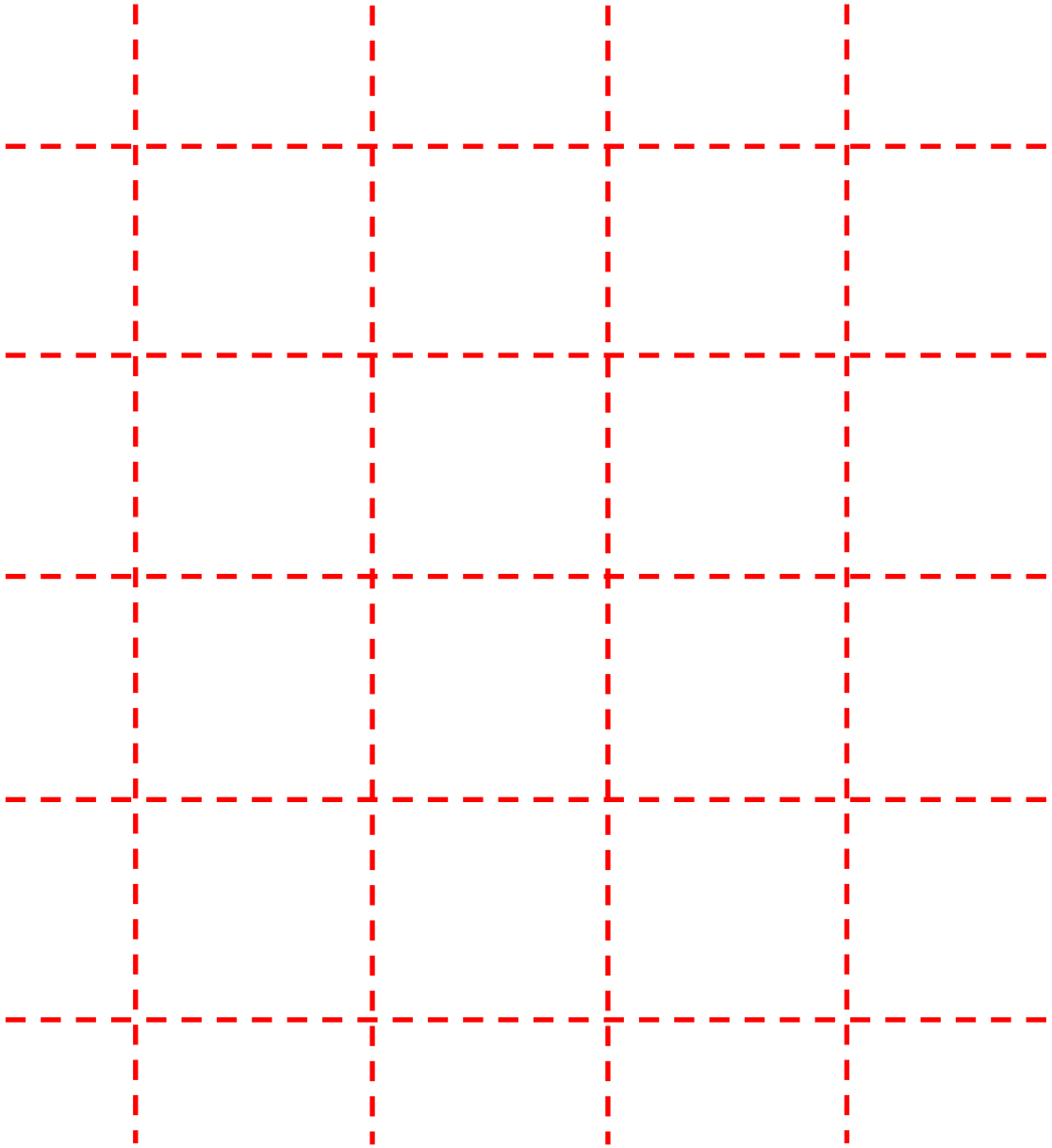
- Translational periodicity

2-D lattice



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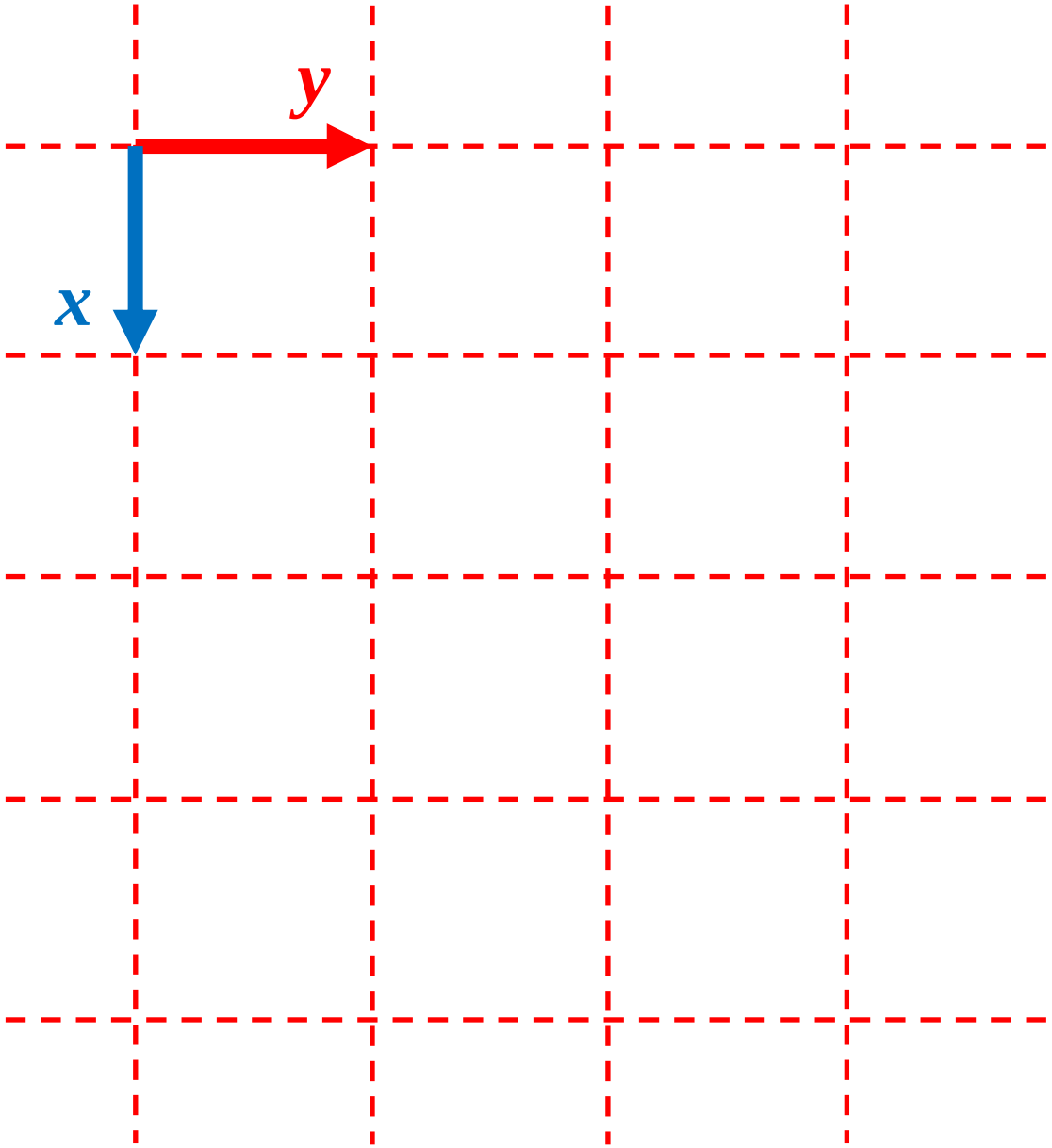
- Translational periodicity

Lattice: Translationally periodic arrangement of points in space such that every point has identical surroundings

- **Dotted grid is a 2-D Square lattice and the intersection points are called the lattice points**

2-D square lattice



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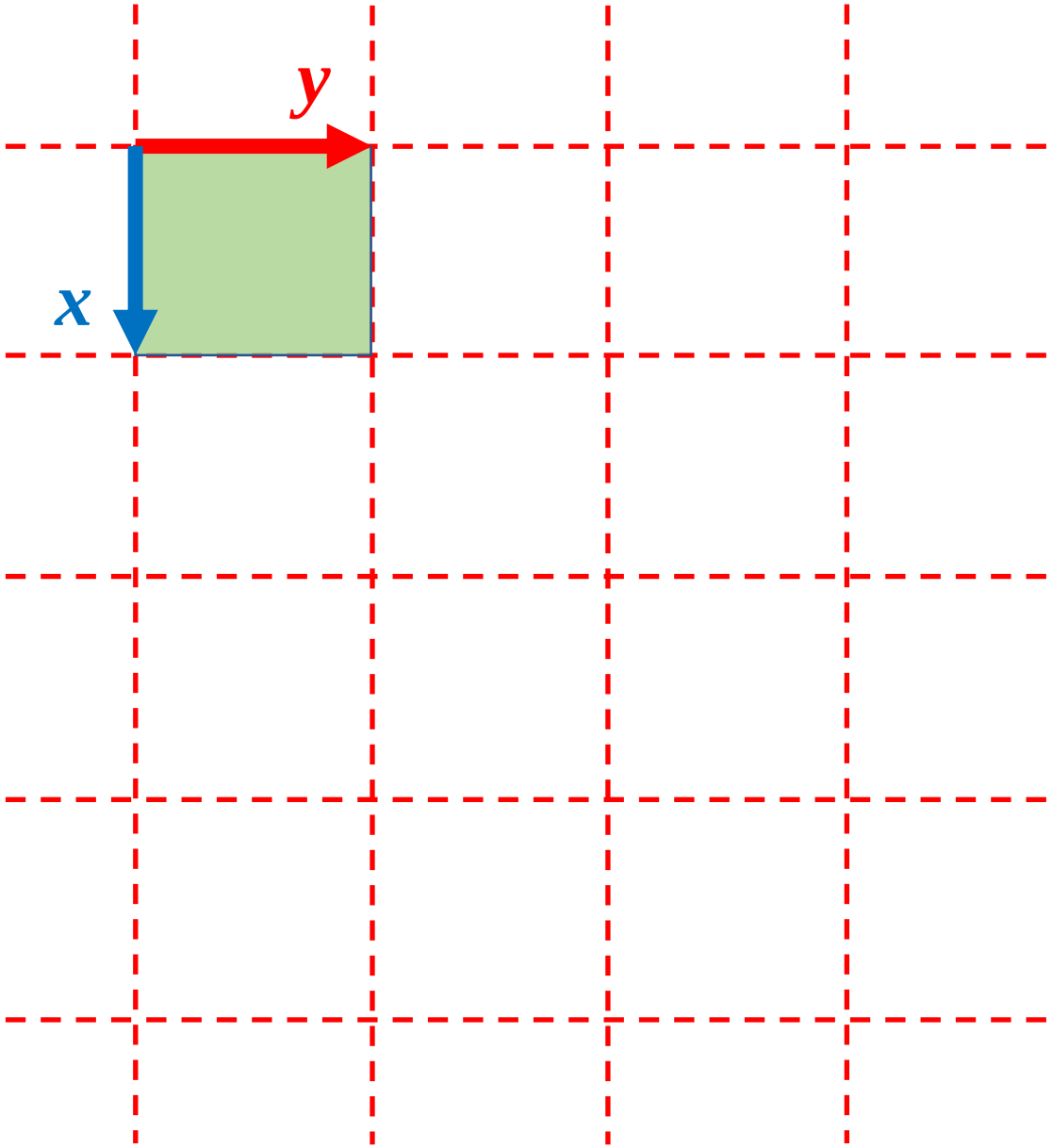
- Translational lattice/basis vectors

2-D square lattice



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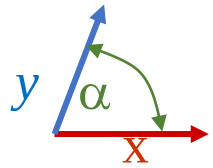
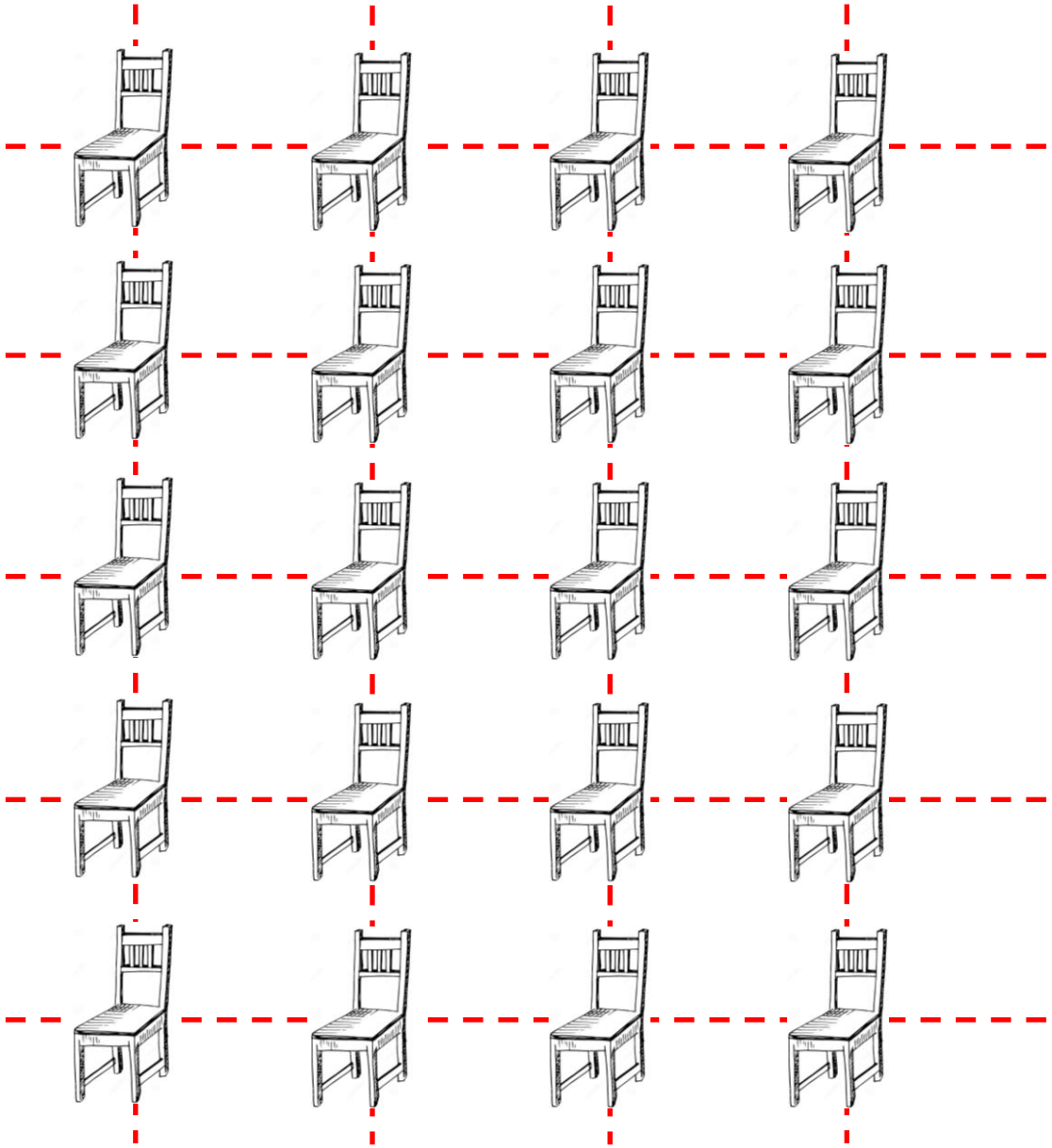


- Translational lattice/basis vectors
- **Unit cell** : Smallest area enclosed by the lattice vectors

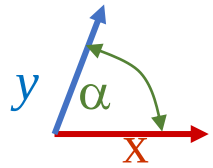
Motif



Lattice: Translationally periodic arrangement of points in space such that every point has identical surroundings

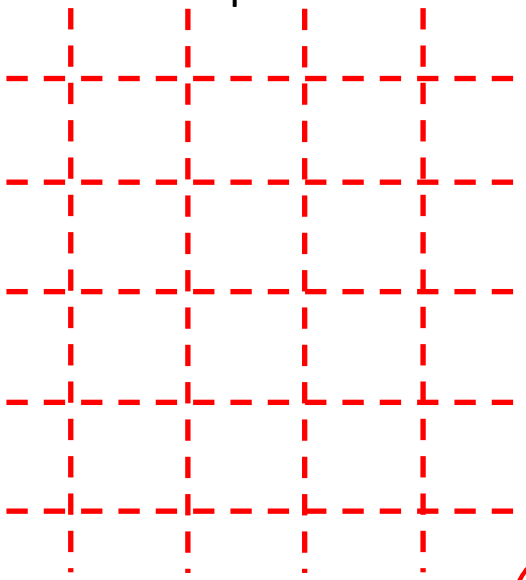
- **Dotted grid is a 2-D Square lattice and the intersection points are called the lattice points**

Entity associated with the lattice point is called a **motif**

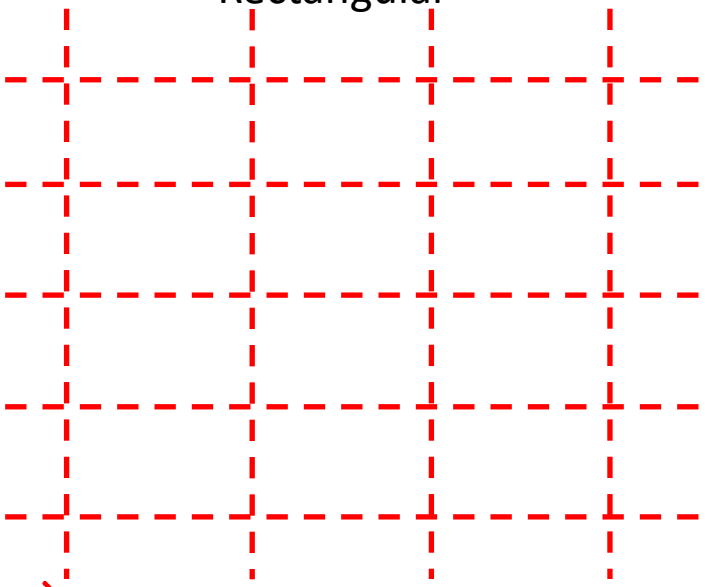


2-D lattice

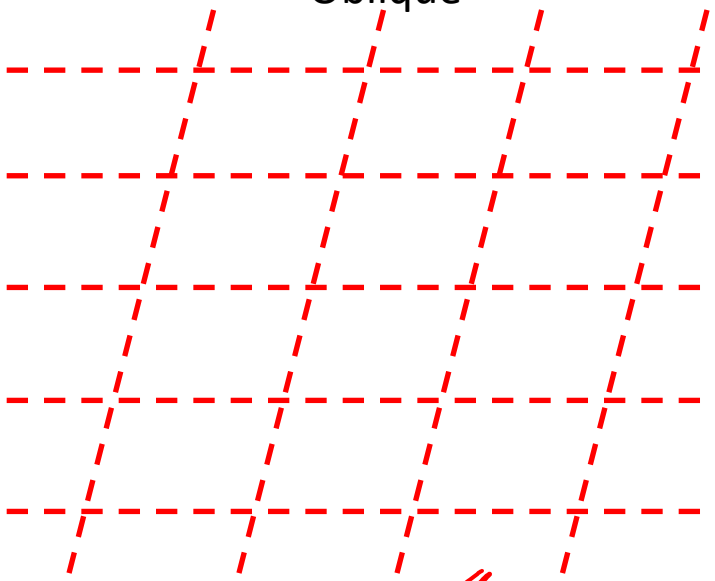
Square



Rectangular



Oblique



Hexagonal → Square Oblique.