Quadrant II – Transcript and Related Materials

Programme: Bachelor of Science (Third Year)
Subject: Physics

Paper Code: PYD103

Paper Title: Solid State Physics

Unit-1: Crystal Structure

Module Name: Unit cell and Basis

Module No: 02

Name of the Presenter: Dr. Ananya Das, Associate Professor

Parvatibai Chowgule College of Arts and Science, Margao.

Notes

Space Lattice and Lattice Points:

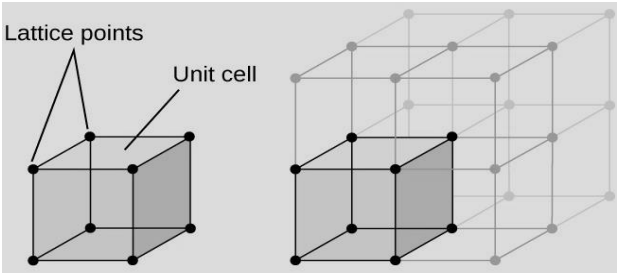
Bravais was the first one to introduce the concept of three-dimensional lattice.

A **Space Lattice** represents an infinite array of points, each of which has identical surroundings.

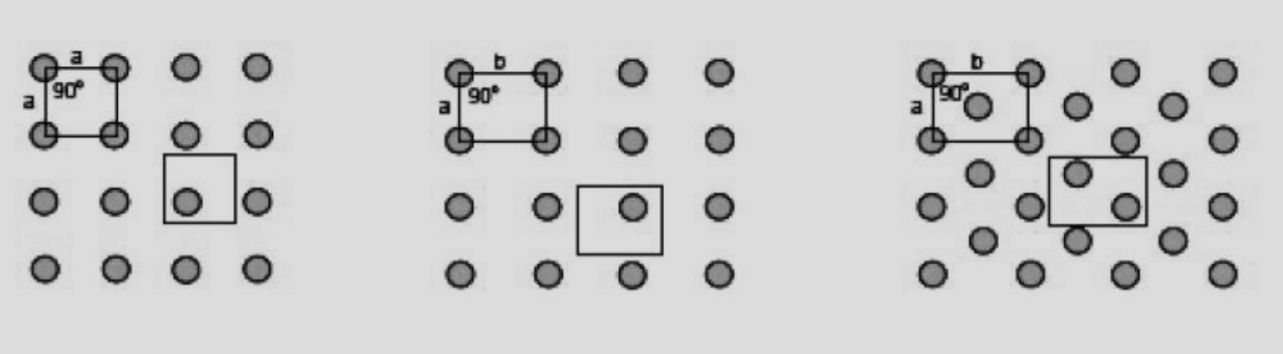
These points in space about which the atoms are located in a crystal are called **lattice points** and the totality of such points forms a space lattice.

Space Lattice, Lattice Points and Unit Cell (3-Dimensional):

- ✓ A network of straight lines constructed in such a way that it divides space into identical volumes with no space excluded.
- ✓ The lattice points are at the intersections of these lines.
- ✓ The smallest unit of a space lattice is called unit cell. Repeated unit cells form space lattice.



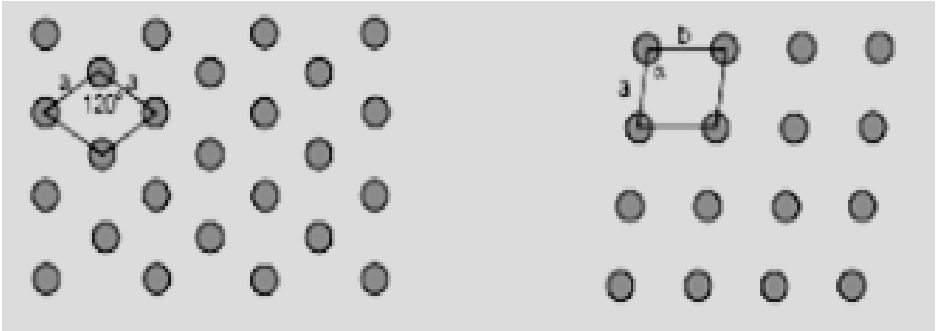
Space Lattice and Unit Cells (2-Dimensional):



Square lattice,
Square Unit Cell

Rectangular lattice,
Rectangular Unit Cell

Rectangular lattice,
Centred Rectangular Unit Cell

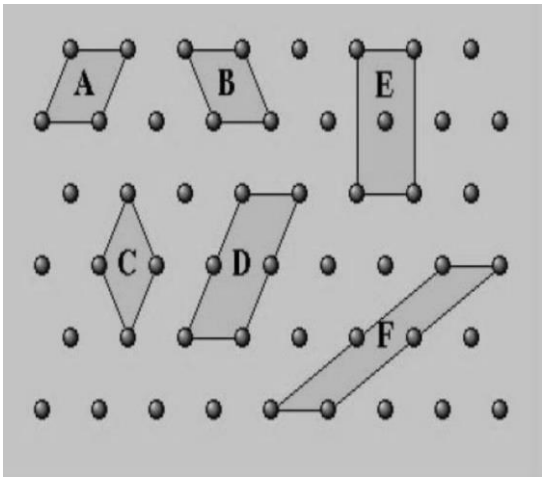


Hexagonal lattice, Unit Cell

Parallelogram lattice, Unit Cell

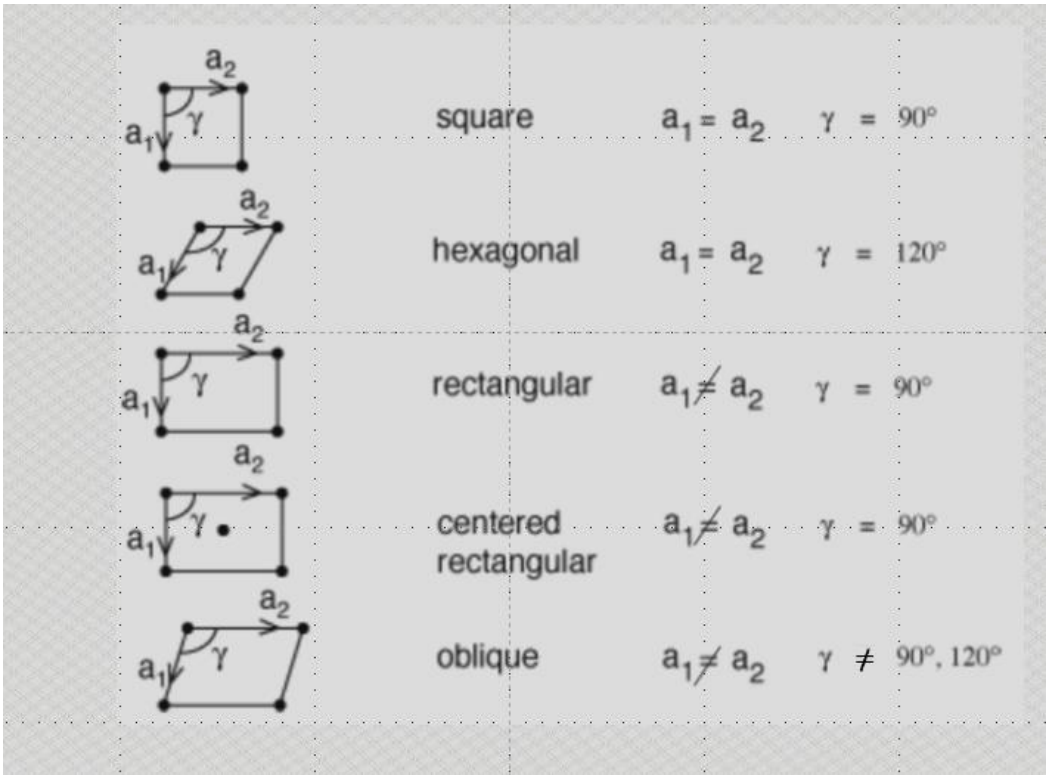
Unit Cell and Primitive Cell (2-Dimensional):

- ✓ Unit cell having only one lattice point is called primitive cell.
- ✓ All unit cells may not be primitive cells.
- ✓ A lattice can be characterized by the geometry of its primitive cell.

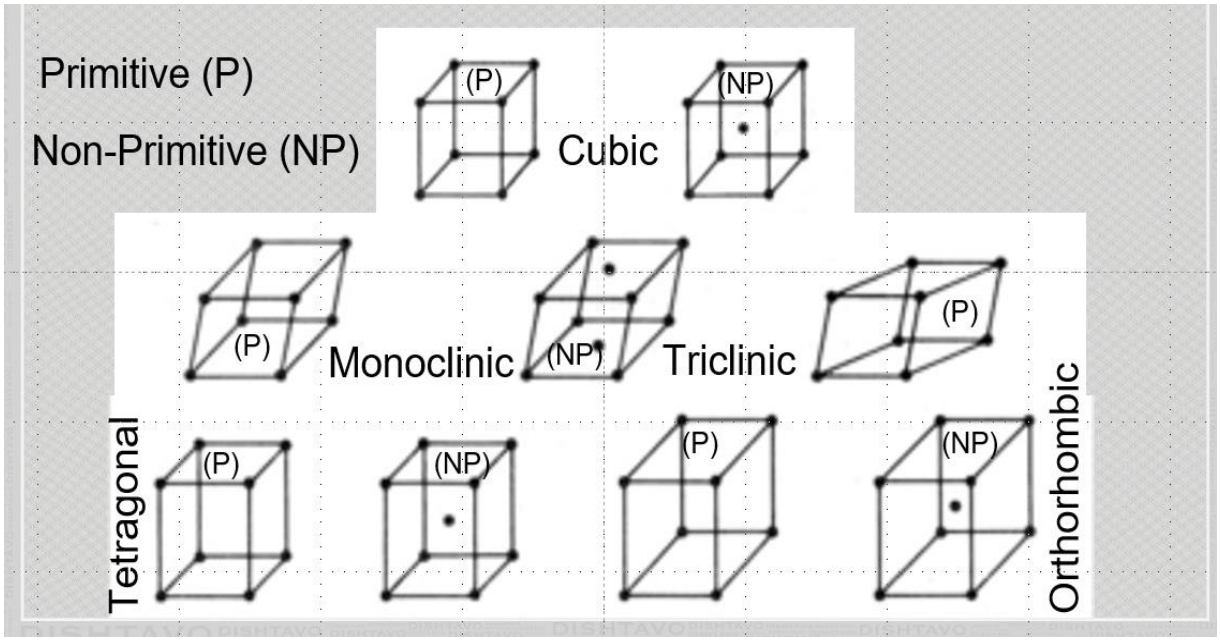


Ex: Primitive: A, B, C and Non-Primitive: D, E, F (with reference to above figure)

Crystal Systems (2-Dimensional):

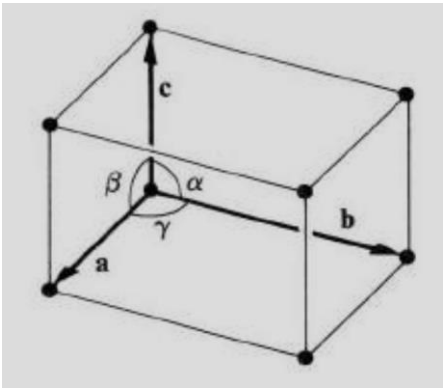


Unit Cell and Primitive Cell (3-Dimensional):



Lattice Parameters (3-Dimensional):

A unit cell can be completely described by the shortest vectors: **a**, **b** and **c** along the three crystallographic axes, and the angles: $\boldsymbol{\alpha}$, $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ between them. These three vectors and three interfacial angles constitute the **lattice parameters** of the unit cell



3-Dimensional unit cell

Crystal Systems (3-Dimensional):

There are s**even basic crystal systems** based on the geometrical consideration (symmetry and internal structures).
Most of the common **metals** and some important alkali halides have cubic structures.

7 Crystal Systems:

- Cubic
- Tetragonal
- Orthorhombic
- Monoclinic
- Triclinic
- Trigonal
- Hexagonal

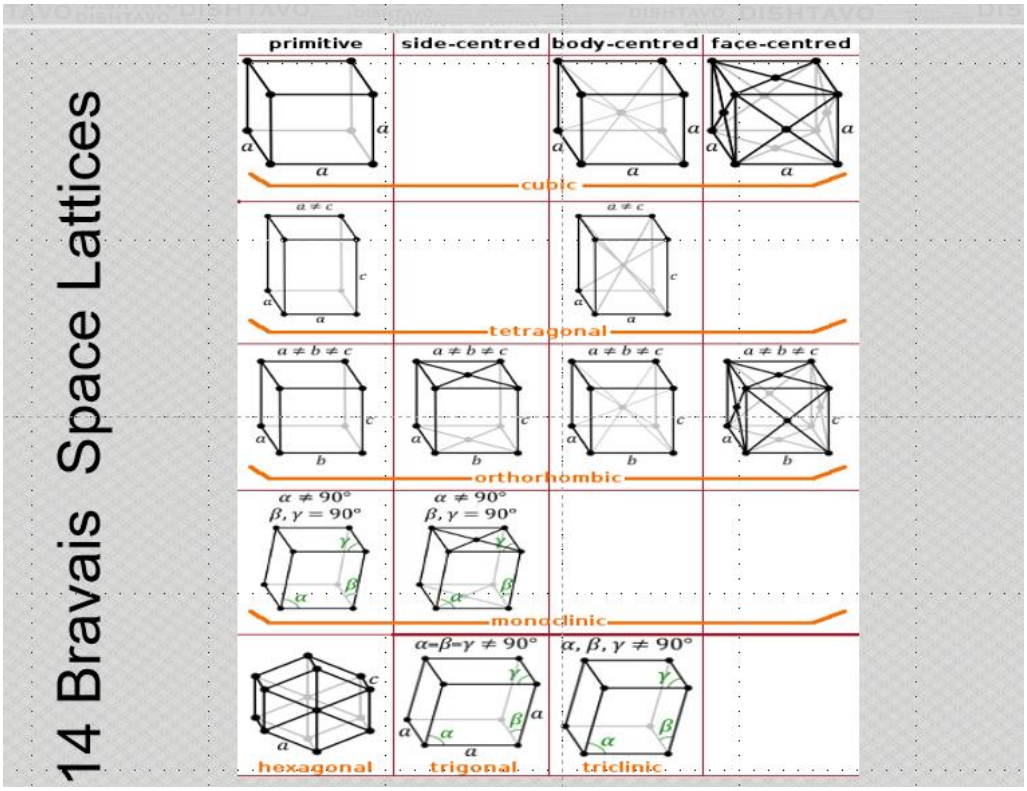
Bravais Space Lattices (3-Dimensional):

It was shown by **Bravais in 1848** that there are only **14 different lattices** in which atoms are arranged in space such a way that each atom has identical surroundings.

In each crystal system, atoms are packed in the respective pattern with four different types of repetitions: **Simple** structure/Primitive (**P**), **Side centred/Base centred** (**C**) structure, **Body centred** (**I**) structure, and **Face centred** (**F**) structure.

14 Bravais Space Lattices

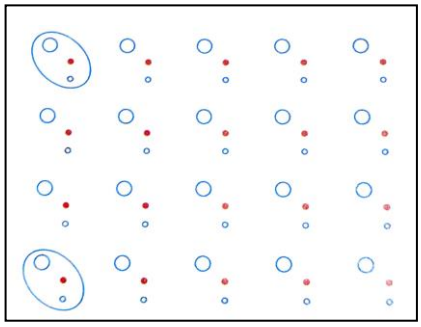
Sr. No.	System	Nature of the lattice, unit cell axes and angles	Symbols	Total
1	Cubic	$a = b = c$, & $\alpha = \beta = \gamma = 90°$	P, I & F	3
2	Tetragonal	$a = b \neq c$, & $\alpha = \beta = \gamma = 90°$	P & I	2
3	Orthorhombic	$a \neq b \neq c$, & $\alpha = \beta = \gamma = 90°$	P, C, I, F	4
4	Monoclinic	$a \neq b \neq c$, & $\alpha = \gamma = 90° \neq \beta$	P & C	2
5	Triclinic	$a \neq b \neq c$, & $\alpha \neq \beta \neq \gamma \neq 90°$	P	1
6	Trigonal	$a = b = c$, & $\alpha = \beta = \gamma \neq 90° < 120°$	P	1
7	Hexagonal	$a = b \neq c$, & $\alpha = \beta = 90°, \gamma = 120°$	P	1



Basis of Crystalline Structure:

For a lattice to represent a crystal, every lattice point is associated with one or more atoms. This is called **Basis**.

When the Basis is repeated with correct periodicity in all directions it gives a crystal structure.

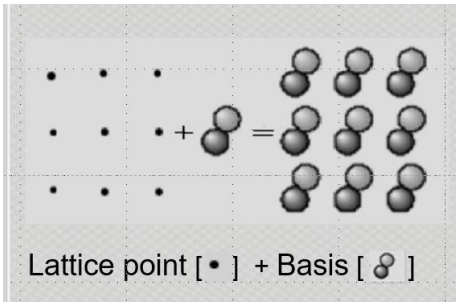


[Basis associated with a lattice point in 2-Dimensional Square Space Lattice]

Crystal Structure (2-Dimensional):

If there are more than two atoms at a lattice point. We need to define:

- ✓ Number of atoms and its kind.
- ✓ Interatomic spacing
- ✓ Orientation in space



[All atoms are arranged periodically.]

Space Lattice + Basis = Crystal Structure

Ex: 3-Dimensional Crystal Structure: