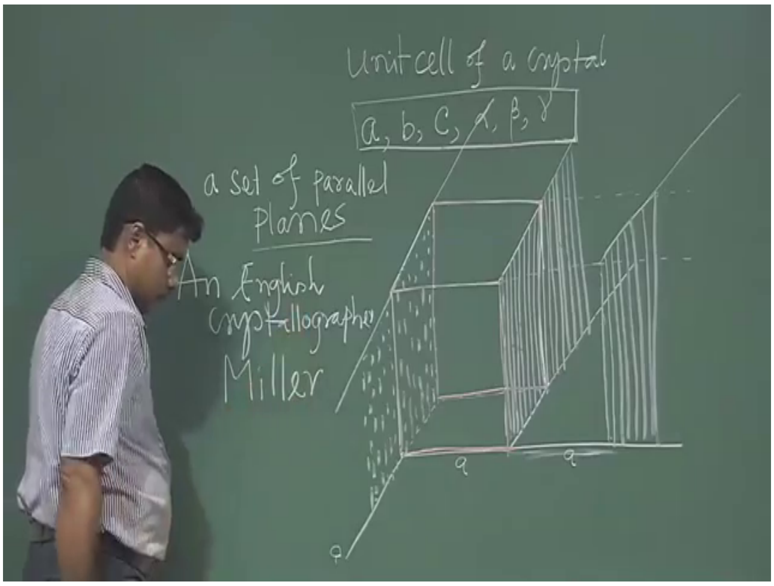
Solid State Physics
Prof. Amal Kumar Das
Department of Physics
Indian Institute of Technology, Kharagpur

Lecture - 09
Crystal Structure (Contd.)

We will study today the crystal indices; Crystal Planes and Miller indices.

(Refer Slide Time: 00:37)



So, this we have seen the unit cell of the crystal and this that lattice parameters, we have used that a, b, c alpha beta gamma. So, this unit cell of a crystal can be expressed with this lattice parameter and you know that repetition of that unit cell is nothing but the crystal structure.

So, now apart from the unit cell we need some other parameters for study the crystal structure. So, that is basically there are different planes of the crystal and how the planes are defined how planes are given name. So, that will see now. So, if we take a unit cell say cubic unit cell cubic unit cell. So, these are the faces of unit cell. So, face means these are these are plane. So, here I can see this is the one plane and this is another plane and this third plane.

So, other this is planes are there backside of this of these and. So, just if I see if I take this one. So, this one is a one face. So, these the face of unit cell we tell this is a plane of the crystal when you consider that that this unit cell or is in a in a crystal structure where many unit cell are placed together. So, if I go towards the next unit cell, if I go towards the next unit cell.

So, then these will be continued unit cell, right and similarly if I consider the opposite faces. So, this is the opposite face of this; this one and this; this 2 are parallel. So, this will be another plane this will be another plane and it extended. So, this planes this crystal planes is not unit cell planes. So, in crystal this plane will be extended throughout the throughout the crystal this plane will be extended throughout the crystal. So, then we tell this the; this is a crystal planes. So, these 2 planes are parallel these 2 planes are parallel and if I go, if I can get see if I draw next unit cell, if I draw next unit cell.

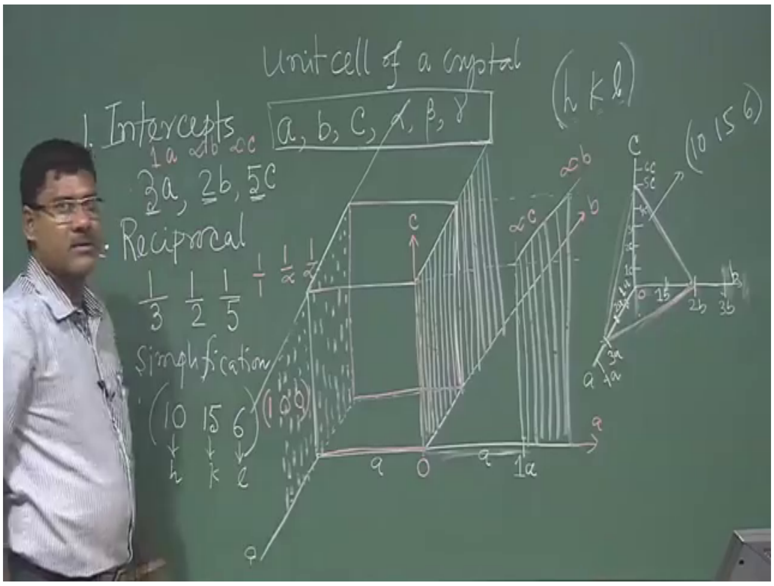
So, this is parallel face. So, you can extend you can extend, right. So, these planes are parallel planes and I can continue from just redraw the unit cell, if I draw the unit cell and just from opposite face if I draw the planes. So, all of them are parallel. So, these are crystal planes here whatever the planes; I have drawn I am showing. So, this planes are basically yes this is nothing but a set of parallel planes a set of parallel planes a set of parallel planes which at equidistant which at equidistance; in this case, say if it is; this thus the distance as a the distance at a, ok.

So, this equidistance parallel planes is basically its we tell this the this a this is one plane this is one plane we give one name of this planes if I give one name of this planes say; these set of parallel planes which are equidistant from each other the inter planar distance are same. So, this is one set of parallel planes, there are other sets of parallel planes there are other sets of parallel planes. So, this and this face opposite faces. So, this also can be one plane we extend throughout the crystal.

So, this can be another set of parallel planes and other 2 faces, this is one face and back side these are another face these one is another face yes these and these they are opposite face. So, this can be another planes another set of parallel planes as similar to this we can get another sets of parallel planes; so here itself that; unit cell have 6 phases. So, basically 2 opposite phases 2 opposite parallel phases. So, 3 pair of oppositely parallel phases. So, this each pair is basically represent a planes each pair represents a plane. So, here itself from 6 phases we can we can get 3; 3 planes 3 planes of the crystal from the face itself.

So, what are those 6 3 planes how I can differentiate those planes. So, we have to give name; so for giving name of the of the planes crystal planes. So, basically and an English crystallographers an English crystallographer; his name is Miller. So, he introduced a process procedure to designate this crystal planes. So, we will discuss this procedures basically in 3 steps we can we can achieve the planes name.

(Refer Slide Time: 13:52)



So, that is expressed by 3 expressed by 3 diameter hkl and we put in bracket first bracket. So, then this is call hkl planes. So, how this hkl has come; so, that we will discuss say if I if I take a axis crystal axis a b; ab. So, this a b and say this c axis right now a plane if I draw a plane which intersect this 3 axis. So, this is a plane this a plane or I can use. So, this a plane say it; it intersect at a axis b axis and c axis. So, if I scaled this axis say.

So, this one a distance is 1 a say 2 a 2 a. So, it has to be equal distance. So, this 3 a this 4 a like this and this one say 1 b, 2 b, 3 b, a simply axis b axis and this ones. So, this 1 c 2 c c c 4 c 5 c 6 c right. So, this planes intersect a axis at intersect at intersect at 3 a 2 b and 5 c 5 c. So, first step to find out the Miller; so these indices which represent the planes. So, first we have to find at inter intercepts; so these are the now intercepts for this planes second step is reciprocal of this reciprocal of this coefficient of this coefficient. So, this 3 times of a 2 times of b 5 times of c. So, these are the. So, we have to take reciprocal of this.

So, this is the second step reciprocal of this coefficient and third step is simplification. So, we have to simplify this all. So, just this obtained 30. So, I can simplify this 10, 15 and 6, 10, 15 and 6 and there should not be any common factors. So, here there is no common factor. So, this is the simplest that the simplification of this one. So, this basically this are called Miller indices this is h this is k this is l; so for this plane. So, this planes is called then 10, 15, 6 planes 10, 15, 6 planes. So, this plane is called the 10, 15, 6. So, this is a hkl planes where the value of h is 10, k is 15 and l is 6.

So, this way to find out the Miller indices and this Miller indices putting in the first bracket is the designation of those planes. So, if this is the procedures to find out the Miller indices which represent the crystal planes. So, let us do exercise what is this plane what is this? This is the one set of planes as I told it represent a single plane it is it will carry one name one Miller indices one set of Miller indices. So, what will be the Miller indices for these planes? So, for that we have to consider we have to consider the axis we have to consider the axis. So, say here let us take the origin o this origin o. So, then this is one axis say; this is a this will be another axis its b and this will be the c axis, right.

So, if I consider this one this plane which cuts intersects the axis. So, where it intersects that we have to find out. So, here I can see this; this planes this planes intersects this planes intersects along the a axis here. So, this is basically 1 a and it is parallel to it is parallel to b axis as well as c axis it will not intersect. So, it will intersect at infinity it will intersect at infinity. So, I can I can I can write that intersect at infinity; so infinity; infinity b and infinity c infinity c along the c infinity c infinity c. So, in this case in this case what I am getting I am getting intersecting intercepts at 1 a infinity b infinity c, then next step one by one reciprocal you have to take 1 by infinity 1 by infinity and simplification that is basically that is given 1 0 0 putting in bracket.

So, this is the planes this named as if 1 0 0 planes; 1 0 0 planes. So, see if we consider this next one. So, it will cut at 2 a next planes it will cut at 2 a and parallel to b and c; so 2 a say 1 by 2 1 by infinity 1 by infinity; so, basically if we simplify. So, again it will be 1 0 0, next parallel planes it is it will cut at say 3 a infinity b infinity c. So, again if you proceed to 1 by 3; so 1 by infinity 1 by infinity; so, they can for simply after simplification it will be 1 0 0.

So, all planes all planes is basically from this procedure we are getting 1 0 0 that is why I told it the set of parallel planes represents a represents a basically one plane one crystal planes and that is 1 0 0. So, so that unit cell it has 3 sets of parallel planes one is this is another is this. So, it cuts at c axis it cuts at c axis at one c, but parallel to a and b right parallel to a and b. So, this sets of parallel planes, it will be cutting at c axis it will be 0 0 1.

If you just follow same procedure for this plane and. So, this and this is sets of plane this sets of plane this one and this other faces this one. So, this is another set of parallel planes. So, it cuts at it cuts at b axis you see it cuts at b axis at 1 b at 1 b and parallel to a and c. So, this will give you this will give you this planes. So, this is this planes and this planes will be will be cut at b means 0 1 0. So, so here itself this considering the faces of this crystal of this unit cell we are getting this planes crystal planes one is 1 0 0, 0 1 0 and 0 0 1. So, this way we can find out Miller indices which represent the when this Miller indices put in a first bracket. So, it represents the crystal planes.

So, we will continue in the next class. So, let me stop here.

Thank you very much.