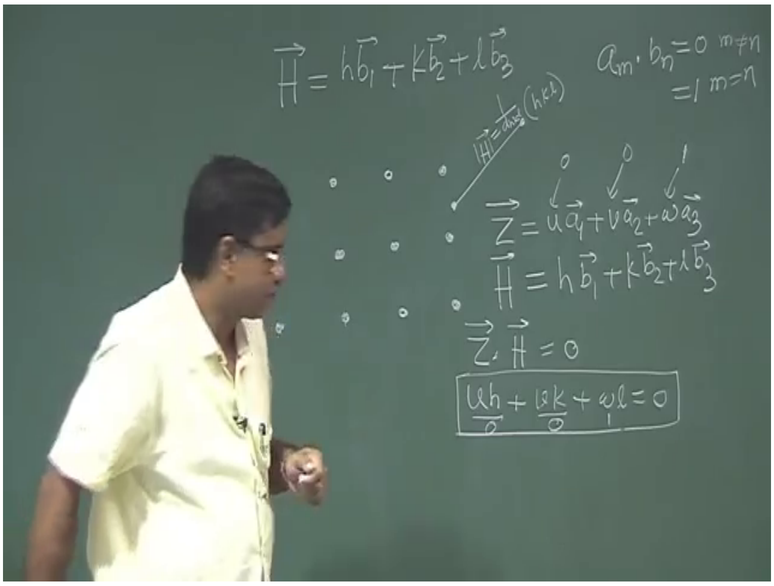
Solid State Physics
Prof. Amal Kumar Das
Department of Physics
Indian Institute of Technology, Kharagpur

Lecture - 27
Reciprocal Lattice (Contd.)

(Refer Slide Time: 00:28)



So far we are discussing reciprocal lattice and we have formulated, it is reciprocal vector these very important is that one can write h b1 plus K b 2 plus l b 3 right and this the end of this vector, is basically in reciprocal lattice it will be represented by this h k l coordinate right and that magnitude of vector is just inverse of the planar distance of this plane h k l plane right and of course, this vector will be perpendicular to this h k l plane. So, that is what we have seen.

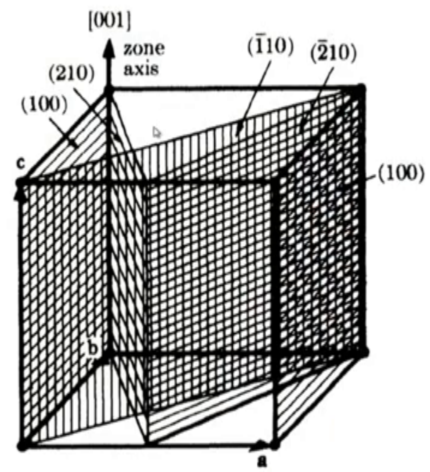
So, now you have axis system b1 b 2 b 3, you have vector reciprocal vector equivalent to translation vector. So, using this one I can generate all sorts of I can generate the points right, as we generate in direct lattice right. So, now using this translational vector, I can generate the points and that points are basically will form the lattice because it has symmetry so just it will have.

So, in reciprocal lattice it will have unit cell and that repetition of this unit cell will the form the lattice right. So, whatever when we are telling that it is lattice, so it will satisfy all sorts of properties of lattice; means each points will have the it will call lattice point.

But reciprocal lattice point, it will satisfy that the surrounding of this lattice point will be same as the surrounding of the other points ok.

So, lattice means in case of direct lattice, crystal lattice or space lattice, whatever the things are applied. So, all applied for this case is also right. So, here what is the use of this so there are many it is very useful, I will just discuss what to aspect of this from simple case I will discuss. So, I have just here see I have shown that is this zone planes and zone axis right.

(Refer Slide Time: 04:44)



So some planes which are parallel to a line to a single line. So, those planes are called zone planes and that axis is called zone axis right. So, now here if I just draw normal on each plane, so all normals on each plane will be normal to the zone axis because zone axis the planes are parallel to the zone axis and so normal to the plane will be the normal to the zone axis.

So, planes of all normal of all planes or normal to the normal of zone axis and all planes will be coplanar. So, they will be always same plane, all normals of all zone planes will be coplanar means will be on the same plane ok.

So, now again here why I am discussing that normal to any plane that is represent by the reciprocal lattice right, we can represent normal to the any plane, we can represent by the reciprocal lattice, reciprocal vector right. So, zone axis it is along the see it is whatever in general zone axis, I can write zone axis say what notation I should use. So, a zone axis vector say what I should write, say let me write z zone axis vector z. So, it is in real crystal system space lattice, so it is in terms of u a1 plus v a 2 plus w a 3 right

So, this u v w is the basically co ordinate and it represent the direction of this of the z zone axis right. So, these the vector zone axis, vector along the zone axis and normal to the planes or normal to the zone axis. So, this is basically I can represent with this or that; I already I know that this represent the normal to the plane h k l plane, so h b1 plus k b 2 plus l b 3 right. Now if there they are perpendicular to each other. So, z dot h if they are perpendicular to each other so it should be 0, rights.

So, if you take dot product of this following that rules a m following that rule. So, it is equally important as this relation is very important b n is equal to 0, when m is not equal to n and equal to1 when m equal to n; so this is very important ok.

So, here only you see a1 dot b1 a 2 dot b 2 a 3 dot b 3 this will be 1 and other a1 dot b 2 etcetera it will be 0. So, this I can get that u h plus v k plus w l equal to 0 right. So, here I will getting the relation between the coordinate you know in this in space lattice a1 a 2 a 3 axis in that lattice and is coordinate of this reciprocal lattice. So, they follow this relation ok. This relation is very useful for indexing the planes, you know for identifying the planes indexing the plane whether what are the miller indices of a particular plane, there are many planes right. What are the indices of those planes right? One we have to identify we have to give them value of miller indices, so this relation helps how just see in this particular.

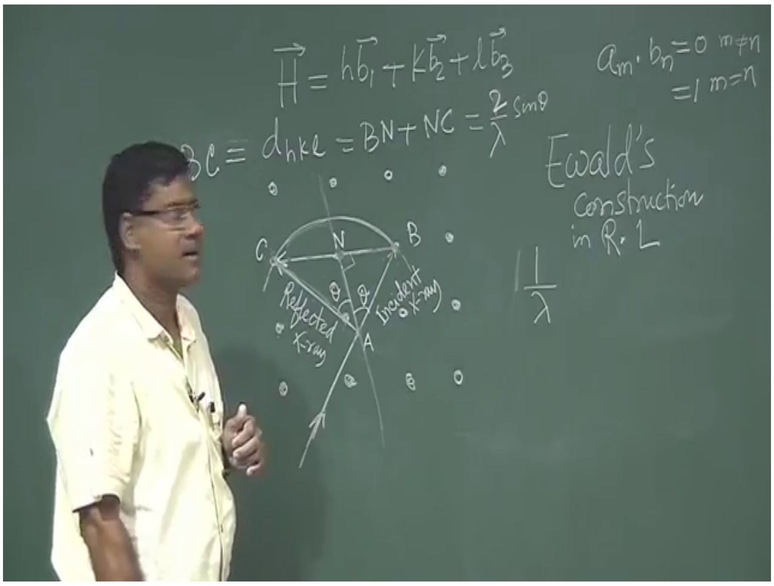
In this example so these are general derivation and in this example you see what is this z axis, what is the direction of the z axis. So, this is 001 so that means our u v w So u will be 0 v will be 0 and one right because this zone axis is a 3 right. So, if I put this value here, so this will be 0, this part will be 0 this part will be 0 right, but this w is one then l has to be 0, this relation is telling that one has to be 0 then it will be equal to 0 right.

So, you have zone axis and there are many planes parallel to the zone axis, but they are miller indices will be different right. Now from this relation it is helping me how that l has to be 0, means which are all the planes in zone which are parallel to this a 3 axis ok. So, all the planes miller indices, whatever the indices but out of h k l; l has to be all the time 0 and that is what happened you see this is our right side, all this planes you see l value 0, ok.

So h k l are different value but l is all the time, so taking help of this reciprocal vector and for many planes you see here I can see this 5 planes and for 2 in I have to index this find out the miller indices of this 5 plane and I can immediately identify 1 indices that is l that is 0. I will put first that l 0 then; I will look for the other h k l, what will be the h k l value for different planes, ok.

So, this way it is reciprocal lattice helps to analyse the crystal structure. So, this is 1 example I showed you and second I will show you that reciprocal lattice. So, I will show that what will be the Bragg law in case of reciprocal lattice right. What will be the form of Bragg law in reciprocal lattice?

(Refer Slide Time: 14:58)



For this I have to consider Ewalds construction in reciprocal lattice. So, I am writing r l reciprocal lattice Ewlads construction reciprocal lattice. So, what is that so 1 has to remember that reciprocal lattice it is nothing but the diffraction spot, it is collection of the diffraction spot, right

So, it is related with the wavelength, it is related to the incident x ray and it is direction and it is magnitude is wavelength right. So, it is there so what Ewlads did, so this just taking the magnitude of 1 by lambda x ray wavelength is a lambda. So, taking the amplitude inverse of wavelength, if you draw with this magnitude if you draw a line in the direction of incident x ray if you draw a if you say, so just if you incident of x ray it can be any direction. So, this is the incident of x ray say these the direction of incident of x ray and take a point end point a.

So, in the direction of the x ray incident, x ray from a point a if you if you take a length 1 by lambda. So, this the1 by lambda so this is the incident direction of x ray and this on this direction, this is the magnitude1 by lambda and then that is a Ewlads construction, then it is telling that if you take a sphere of radius a b whatever that is1 by lambda, if you draw a take a sphere cantering at this a. So, just if I draw a so, if this radius I have to draw. So, if I can draw a sphere, now these sphere it will intersect the point, reciprocal lattice point.

So, that now if you add this 2, so from centre if you I have to draw properly from the centre; if you draw a line adding this 2 from centre. So, it is scaling this will be the direction of the reflection of x ray. So, this the direction incident x ray, if this is the incident x ray direction, then this will be the reflected x ray direction.

So, this is basically is called Ewlads constructions in reciprocal lattice. So, now if you just join this 2, so it is telling that these will be the normal to the crystal planes from which reflection occurred, from which this ray this reflected ray this these the reflection occurred ok.

So, this will be the normal of the planes h k l planes so from where this incident x ray is reflected in this direction towards AC. So, for just whatever Ewlad told following this his construction, following whatever I am telling just this is the statement there is the proof now ok.

So, just we have taking this magnitude in are magnitude, this length1 by lambda in the direction of the incident ray with this radius if I draw a sphere. So, it will intersect the lattice point so from centre if I just connect them, so they are the so it is not the only point right so it is the sphere you have reciprocal lattice. So, it will intersect few more points. So, for this incident x ray it will be reflected in this direction this other direction curves, if intersect other point; So, will how many points it will this x ray will reflected right.

So, that will depend on this satisfying the Bragg condition right. If Bragg condition satisfied then we will get reflection right in the direction, means he will get the lattice we will get the diffraction spot, that is what we know and here this same things; similar things we are getting right and in which direction it is going where this lattice point this a point in reciprocal lattice is there.

So, it is just you can connect with the diffraction spot right, whatever now we have seen with this lattice point right. So this way then curves that will be the reflected ray and then if you connect this 2 just end of this reflected incident x ray and if you connected at this 2 end; then that will be here BC that will be the perpendicular now are normal to the to the planes.

So, that plane we can so these definitely if I draw a normal on this, so this can be normal to this. So, here this point is there but the point may not be here, what it may be here? it is no problem, but we have not taken because after this is cut here so we have taken this. So, these will be the crystal plane and from this crystal plane, so x ray is coming incident here and it is reflected right. So, with this crystal plane so angle will be theta right this angle. So drawing is not proper but so this angle will be theta grazing incidence right this.

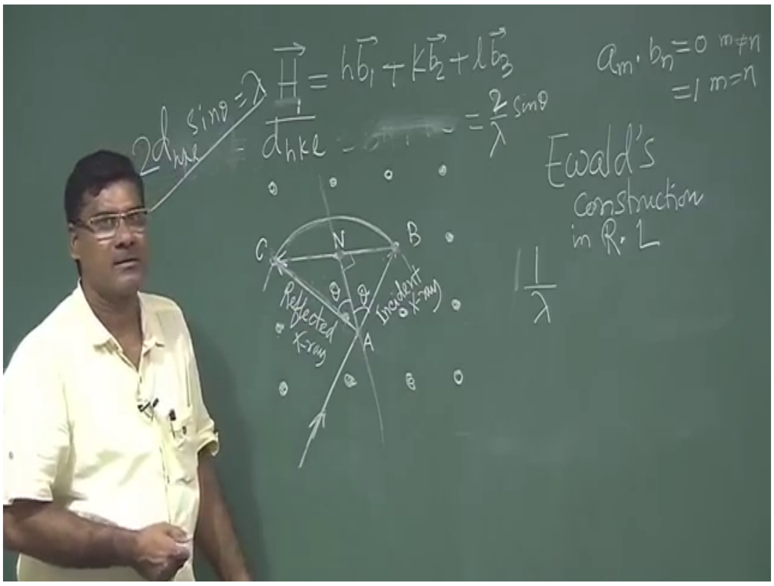
So, with this will be theta right grazing incidence right, this we can take theta. Now so this is telling this is the normal to this planes h k l. So whatever planes h k l planes so this is the n normal from AN is normal ok. So, this is definitely what is this normal? Sorry; I did mistake. So, these plane this that not normal this plane and is not the normal, so these intense; so this is normal. So, here normal this BC normal, it will be d h k l right. Normal to any plane right that magnitude, we take that magnitude we take d h k l right.

So, BC will be d h k l now BC you see this AB this is 90 degree, this is 90 degree right this is theta. So, projection of this1 on this so here we can take AB. So BN this BC will be d h k l and this is basically BN plus NC BN plus NC. So, BN will be you see if I take cos theta. So, it will represent if I take with respect to this. So, cos theta is 90 minus theta so it will be sin theta. So, what is this is b n will be1 by lambda. So, this magnitude is1 by lambda and then this is sin theta and this also be NC will be this sin theta1 by lambda, this also1 by lambda right because this magnitude will be same and it is also1 by lambda.

So, it is basically we can write 2 by lambda sin theta, so from here d h k l equal to 2 lambda sin theta. So, I did mistake sorry. So, it is in reciprocal lattice right. So normal to the plane that is basically reciprocal vector.

So, magnitude of the reciprocal vector is inverse of planar distance. So, that will be basically1 by d h k l right, since it is in reciprocal distance so 1 by this.

(Refer Slide Time: 30:10)



So, basically will get this; so this is giving 2 d sin theta equal to lambda, it will give 2 d h k l sin theta equal to lambda so this is nothing but the Bragg law. So, here we have consider the reciprocal lattice and just following some Ewalds construction, we have drawn the incident ray, reflected ray and this normal distance etc; from they are basically from these geometry we are getting this Bragg law, ok.

So, it is exactly whatever I always told this statements are all are correct right, following that just is model kind of things or statement we are getting back our this Bragg law, which is the base of all diffraction of all this point in reciprocal lattice. So, we see here is one can simple way, one can also show that this reciprocal lattice we have formed following some this and from there itself we can get back our original this Braggs law.

So, I will stop here.

Thank you for your attention.