# Electron Diffraction and Imaging

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## Lecture - 11
## Diffraction - 02

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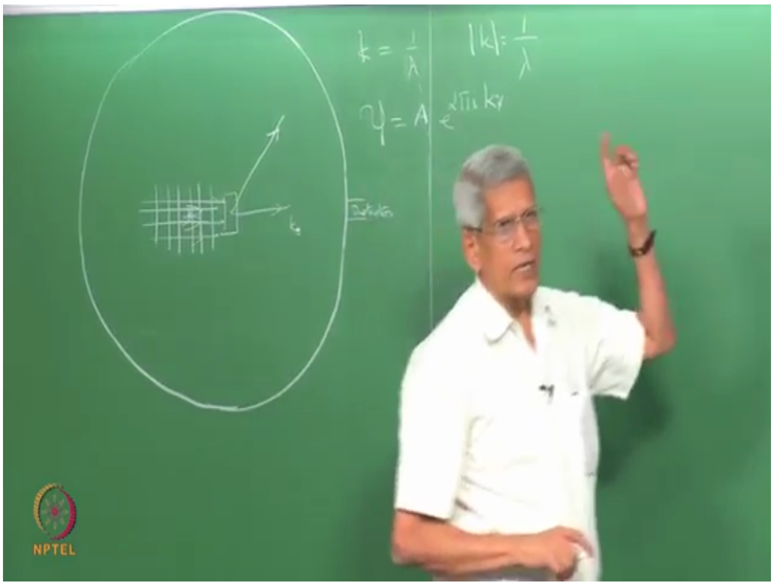


Welcome you all to this course on a diffraction and imaging. So, what did we essentially start we is if we have a sample and if we a beam of any radiation an wave you considered electromagnetic wave is falling onto the sample. Yes we are with the sample at the center if you take it, and keep a detector and if we move the detector around on all points in this sphere at some points we get high intensity at some point there is reduction in intensity; when such a phenomena occurs then we say that a diffraction is taking place in that sample right that is essentially what we have seen.

So, the next that question which comes is that, if the beam can be consider supply in wave if we consider the supply in wave traveling in this direction k, how do you define the wave vector of the wave plane wave the incident beam? It is represented as;

Student: (Refer Time: 01:49).

Equal it will 1 by lambda and when we represent it is vector it will have a direction also associated with it.

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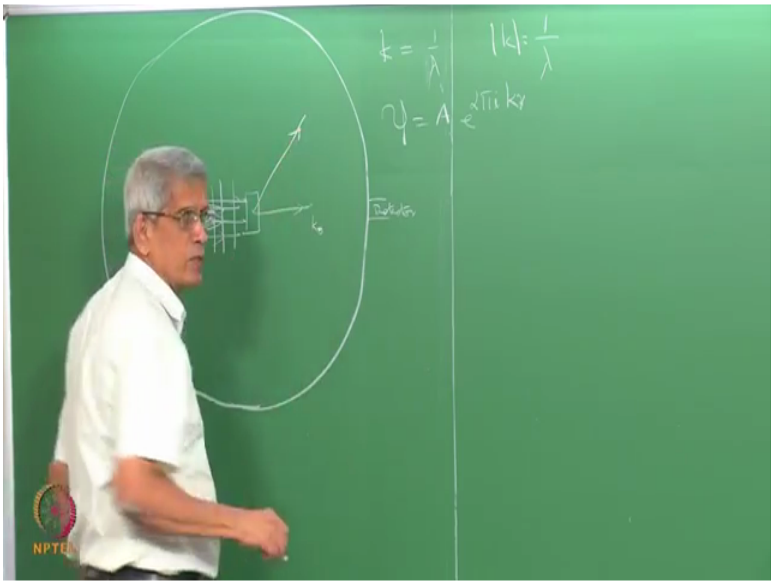


So, this is essentially going to be the magnitude of k, because the wave we represent it as psi equals some constant A e to the power of 2 pi i k dot.

Student: (Refer Time: 02:22).

Or k r we can write it. So, this k is what we call it as. So, if we fix a coordinate system and you assume that this is what in the; this is k 0; signal which comes out is also the same radiation without no change in wave length correct. Incident beam that is; that means, that is scattering is an elastic scattering which we are considering it.

So, what will be the wave vector corresponding to that that should also we corresponding to k, suppose equals 1 by lambda correct. So, how will you represent this when in a vectorial form? So, once you fix a coordinate and if you assume this to be k 0, all other vectors since the magnitude remains the same the end of the vector is going to lie on this sphere and we can represent with respect to what is the angle which it is submits with respect to that is how we define.

Once we have fix the wave length of the radiation, we know what the value of magnitude of k is going to beam. So, irrespective of whatever be the direction in which the scattering is taking place, the magnitude of each of the scatter vector is always going to be 1 by lambda. So, if you take a locals of all the vectors which are there with respect to the origin, all these reciprocal lattice vectors not reciprocal all these a scatter the beam vectors is going to lie on a.

Student: Sphere.

Sphere on the surface of the sphere it will come correct. So, this is what is the basis of Ewald sphere construction; you understand that that is if this is the incident beam and this is the vector k.

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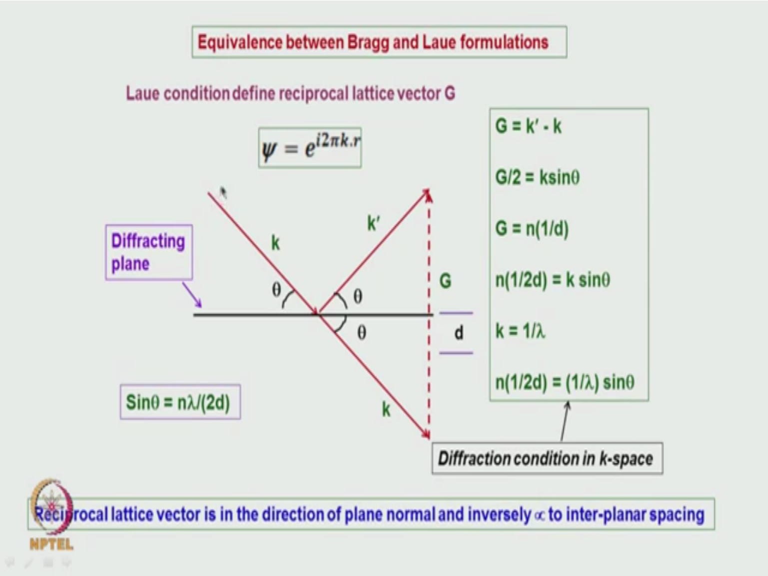


And this is k dash is the scatter vector and does not the magnitude remains the same for both of them with respect to this point as the center if you try to draw, in this particular case it will be a circle in three dimension it is going to be a sphere that is sphere we call it as the Ewald sphere. What is the relationship between this because this relationship between all the points; that means, that the scatter vector will be lying on the surface of this sphere correct. The primary beam is also lying on the primary beam vector is also lying on the surface of this sphere, and the scatter beam vector when it lies on the surface of this sphere, then the diffraction condition is satisfy. So, this will be the vector G which is going to be. How to draw a Ewald sphere is that you choose any point as the origin in the Ewald sphere.

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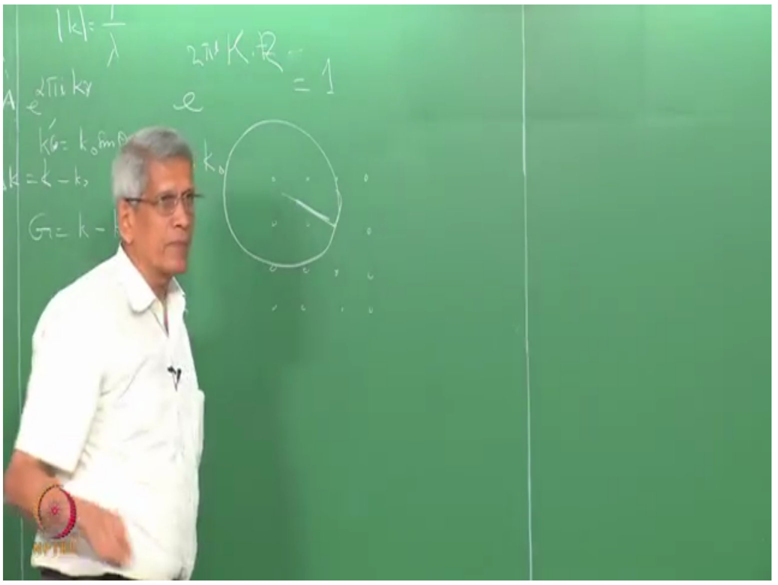

From that suppose we have suppose we choose this is the point, from this point you choose.

The direction we know in which the beam is coming the k we know that. So, the vector k you try to measurer from this point in this direction the direction of the beam which is coming; and this point as the center now you draw a sphere. So, if you draw as a sphere then try to look for what are points are going to lying reciprocal lattice points are lying on the surface of this sphere, all this points are the once which will give raise to diffraction for the specific direction in which the beam is falling on to the sample. So, only those points will gives rise to diffraction; though reciprocal lattice has got lot of points are there on the reciprocal lattice now the incident beam direction for a specific value of the wave length of the incident radiation, and for the particular direction in which the beam is centering what are the directions or what are the reciprocal lattice parts which will give you raise to diffraction is defined, and from this construction the reciprocal Ewald sphere construction one can understand it.

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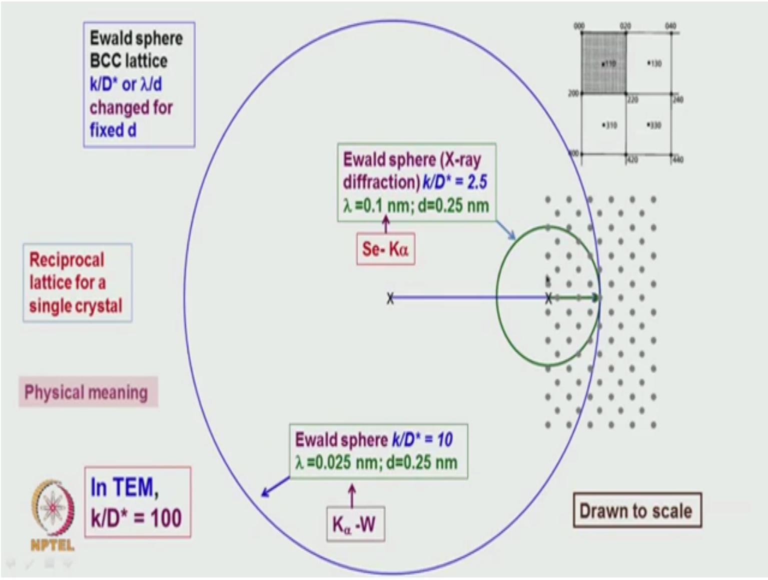


So, what I have done here is that. If you look for an a x ray on a wave length of the radiation almost of the same order as the lattice parameter; where as in the case of electrons if you take it the wave length of the radiation is 100 times smaller than that of the lattice parameter spacing. In fact, if you use k alpha of tungsten then the wave length of the k alpha of tungsten is 10 time smaller than that of the normally the lattice parameter spacing.

So, what I have done it is, with respect to a origin in the reciprocal lattice of a crystal has been constructed this what the reciprocal lattices. Taken at this point as a the origin these are direction in which the beam is coming, so I can mark know what the value of k is that. So, I can mark this point correct. So, with this as the center this is for wavelength equals 0.01, I have just drawn the because this is also taken reciprocal lattice are drawn with respective some lattice parameter look at drawn to scale. You can draw the sphere and the sphere cuts here as a circle. Now you can find out what all points reciprocal lattice points which are touching the surface of this sphere; only for this particular beam direction all of them will give raised to a diffraction spot, which in the last class I have shown you that for a particular beam direction more than in one direction in which we will be getting the Bragg diffraction correct.

So, now when the radius of the sphere as become very large are the wave length as become very small, now you can see that the points which are touching are essentially points almost lying on a plane itself correct and this is for the ratio of a lattice parameter to the wavelength it is going to be 10. When it become 100 you can imagine where exactly it is going to be there then almost a reciprocal lattice plane is what is cutting the Ewald's sphere. So, all the spots which are there on those on that is surface will give raise to diffraction and another point becomes obvious is that, in such a case here only very few spots are touching so, the number of diffraction which you get for a particular beam direction is going to be small for x ray diffraction, conventional x ray diffraction with copper k alpha are molybdenum k alpha if you see.

And for electron beam you can understand that the more number of spots will be coming correct, but what is going to be the consequence of it is that the Bragg angle will becomes smaller and smaller. So, essentially the physical meaning of a this Ewald's sphere is that using this Ewald's sphere construction looking at the reciprocal lattice, we can immediately if we can define what is the direction in which beam is falling, we can immediately tell that these are all the diffraction spots which will appear in the diffraction pattern, for that particular orientation in which the incident beam is falling on the sample.

This; whatever we have done so for the last slide is solve with respect in a reciprocal space we have considered correct. But when we do a experiment when we are collecting an information and diffraction pattern it is done in a real distance correct.

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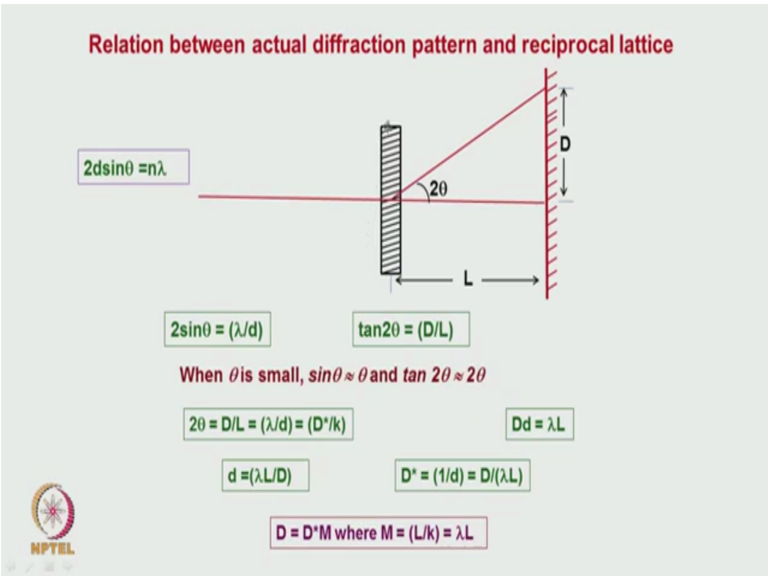

That is what we do; that means, that this is a sample, these the incident beam which is falling at just shown lattice plane which is implant for this particular plane it gives raised to a diffraction, and the screen is kept it is some particular distance l.

Then you get at a particular point from the center you will be getting the diffraction spot correct. So, the relationships are this D divided by L will be tan 2 theta t 2 theta and 2 d sin theta will be lambda by d, and when theta is small we will get 2 theta equals D by L equals lambda by d this is gives raise to some relationship, the distance in reciprocal space multiplied by the distance in d L space equals wavelength of the radiation times the distance at which the screen is kept from the sample. So, this distance in a electron microscope is normally called as the camera constant. L is called as camera constant camera length and lambda L is called as camera constant. This constant is the one which will tell us how much time this D is magnified otherwise how do we define d star d star equals 1 by d?. So, this D here equals lambda l into 1 by d, correct.

So, this is the sort of a magnification factor which is use to define the distance in to measure the distance in actual diffraction pattern.

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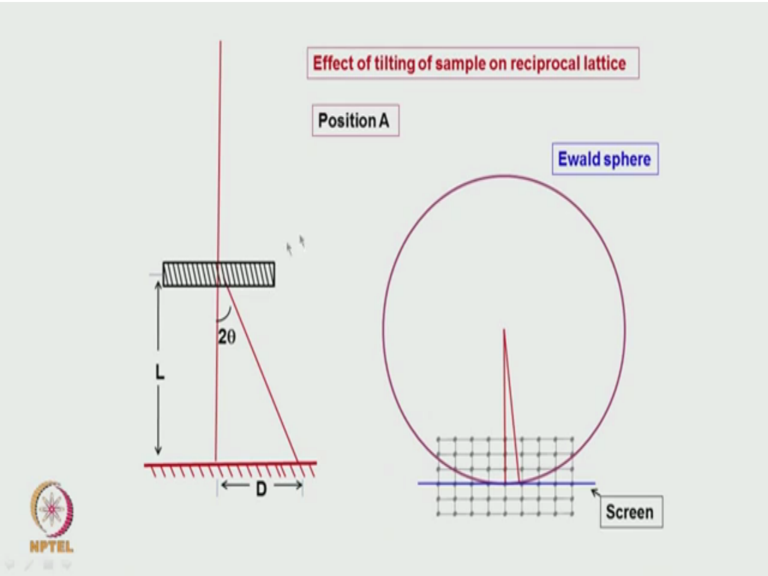


I am just showing the sample you look at the these are all the planes which is going give raise to diffraction correct. This is where I am measure we are measure the screen at this particular distance we are capturing this diffraction pattern. The reciprocal lattice is shown here with the origin at this point and this is what the Ewald sphere is, this is the way it looks like. If I till the sample what will happen because this is related to a sample the Ewald sphere remain is the same because it is fix by the wavelength of the radiation correct what is going to happen is that the reciprocal lattice will tilled correct.

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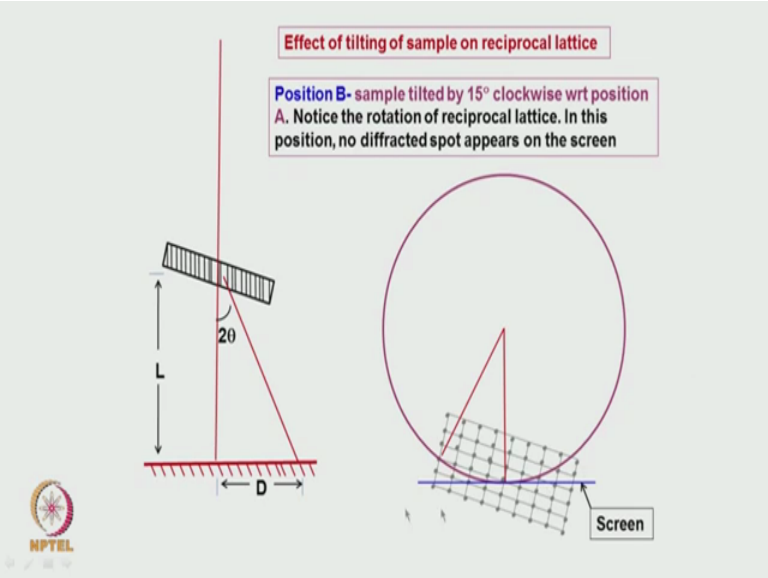


Now, when the reciprocal lattice has tilted, now you see that what are spots which are touching the surface of that sphere, those are all the only ones which are going to appears diffraction pattern on the screen correct. Now from this you can understand that these to are related to each other one is tied with the other.

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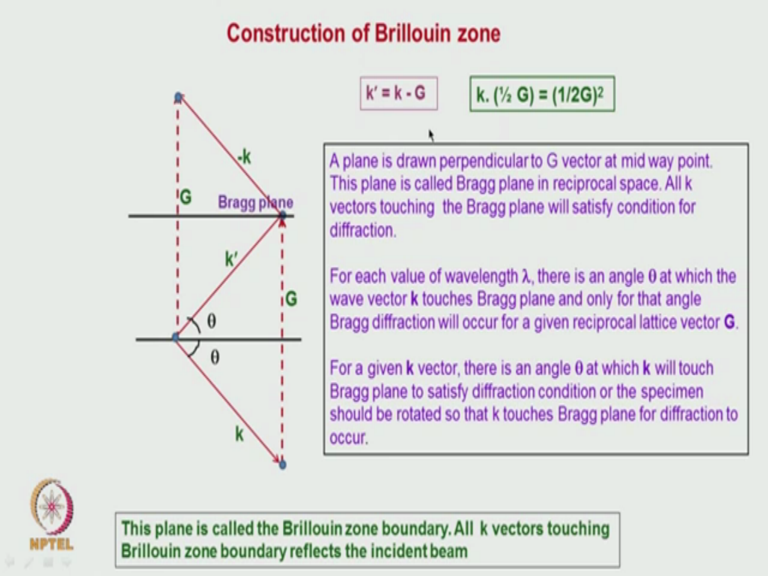

Then from the same relationship another interesting information comes because this delta k equals G is the cracks of the whole diffraction when we look at, what essentially is that from this we can get the concept of Brillouin zone. What is the Brillouin zone concept which you have studied you have an idea.

Student: (Refer Time: 14:50).

Primitive lattice, other than that with respect to distribution of electron in a sample then have you have studied.

Student: (Refer Time: 15:05).

No free electron concept you have studied nah free electron concept what it means.

Student: (Refer Time: 15:12).not related to any particular atoms (Refer Time: 15:16).but.

Yeah, but an all these electrons can they have any energy if it is a free electron module they can have an energy which is continues energy can be there with the electrons, and the relationship is e equals k squared it will come.

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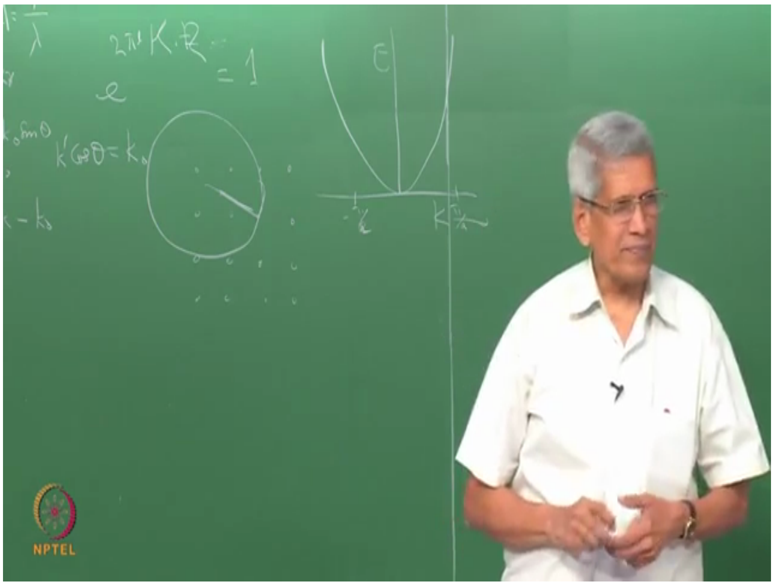

So, what we essentially try to plot is that energy versus K if you try to plot it this is respect to the some pi by a and all these things will come. Essentially this is the wave the distribution will be going correct what it happens when the there is the potential pass you potential is also associated the periodic potential is there or when we consider that it is essentially atoms are there with positive nucleus which as some potential associated with it.

Student: (Refer Time: 16:10).

And only if you then some gaps come, so this is where some gaps will be coming in this energy which is come in this will come corresponding to this various values of K by a it will come. This gap which is they are in a this boundary of this values of k which corresponds to that that energy this is called as a Brillouin zone boundary. What it means is that if I put an electron in that particular k direction, within energy which is there in the which is not corresponding to what is detected by the which the electron can have in that sample, all those will be just thrown out. How will it be thrown out there will be a scatter back.

Student: This electronic (Refer Time: 17:04).means they cannot be a (Refer Time: 17:06).that particular (Refer Time: 17:07).

That in that energy level that energy level if we try to put an electron with that energy, it cannot remain with that energy in that sample that is what the band gap means. That is electrons occupy some specific levels and some energy values are not permitted ok.

So, if you put any radiation with an energy which is different from this. Suppose I try to push into that sample electron with an energy which is much different from that either that electron as to loose energy base some pollution with it or it has to be reflected out of that samples scatter out of that sample if the full energy has to be there the same is true for also. So, the boundary at which this happen that k values this we call it as the.

Student: Brillouin.

Brillouin zone boundary; essentially what happens is that if a look at this is k minus k 0 equals G, this we can write it an another form k equals k 0 plus G also we can write it, if we take the dot product and all finally, what it will happen is that this sort of a relationship will come, G the whole square. This you can just for called this is see this will turn out to be k square.

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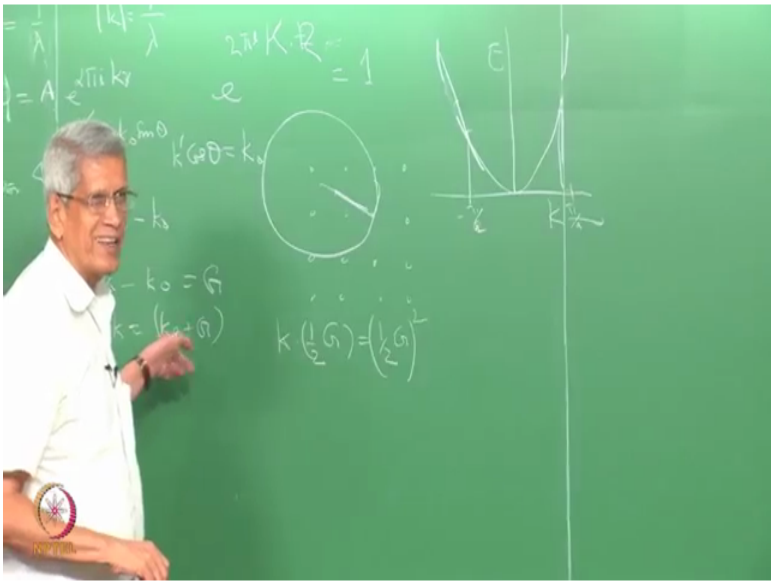


This will be k 0 square plus G squared plus 2 k 0 dot G will come here in this picture.

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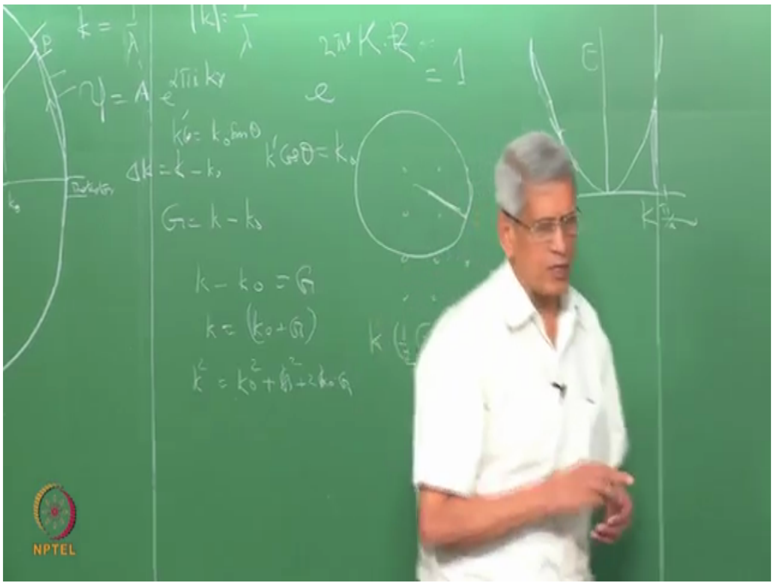


These values are the same they will go. So, G squared plus 2 k 0 into G will come from this sort of an expression will come. What does this expression essentially mean?

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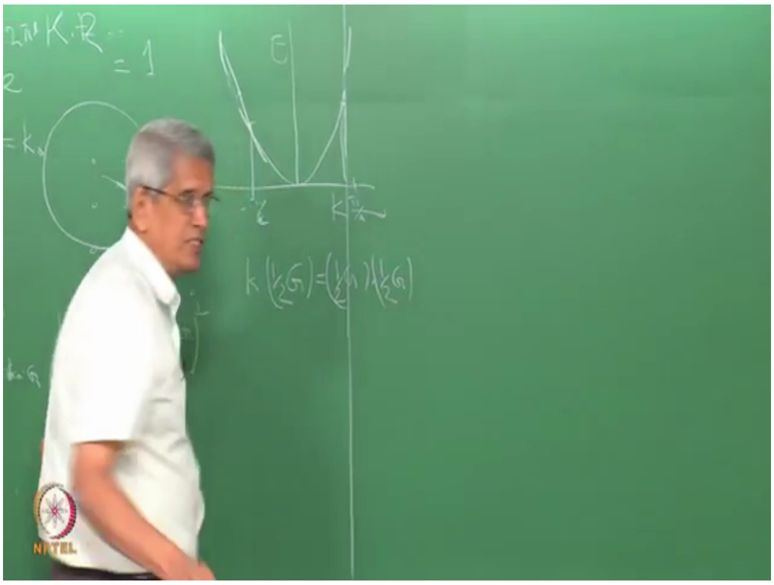

This is nothing, but k dot half G equals half G dot half G nah. This how we can look at it is that when a Bragg diffraction is taking place. These just a mathematical derivation to try to make a sense out of it is that this is the reciprocal lattice vector from here to here, this is the incident beam direction and this is the direction in which scattering is taking place. So, the delta k has to be equal to G. So, G means that this is one reciprocal lattice vector this is another reciprocal lattice vector similarly here this is one and this is another one right. So, these vectors can be written as this we also; this is k dash and this direction is from here to here this is that minus k, correct.

And if you look at the mid plane of this what does this half G means vector? Is from the origin half of this distance correct this is the vector. If you draw a plane perpendicular to this vector the scattering vectors touch that plane correct. This is k and k dash of the scatter vector incident beam direction and the scatter beam direction both of them are touching this surface is it not.

Student: Yes sir.

Is it clear?

Student: (Refer Time: 20:44).

All touch.

Student: If you consider a k (Refer Time: 20:53).

See vector you can tying where the vector is a from the origin be normally define all the vectors, but if you see this from this reciprocal lattice point if you see this vector touch as this, are from here from the origin if you say this k vector touch as it.

Suppose I have a beam with a particular energy which is not equal to lambda it is some other value, then what it should be done is that that vector if it has to touch here the angle which it is satisfies with the sample surface will be different or it essentially means that for a specific value of k, there is a particular value of theta at which only the Bragg diffraction will take place. You understand that is what essentially means; in reciprocal space if you try to look at it with respect to this vector, a plane which is perpendicular to their half position is the one which this scatter vector has to touch. Only and that happens for some particular a value of the angle.

So, whatever be the vector which we have a does not matter unless this condition is satisfied we will not get a Bragg diffraction or to satisfy the Bragg diffraction if the beam energy is fix either you rotate the beam, so that with respect to a samples surface the angle theta is satisfy, so that the vector the scatter vector touches the Bragg plane. So, this plane is called as a Bragg plane.

So, this we have drawn with respect to origin for one vector correct. So, this is a another way of looking at the diffraction.

Student: So, the Bragg plane will be only wherever else will be the (Refer Time: 22:53).

Now you consider as a 2 dimensional lattice, I can have a reciprocal lattice point somewhere here I will have a Bragg plane.

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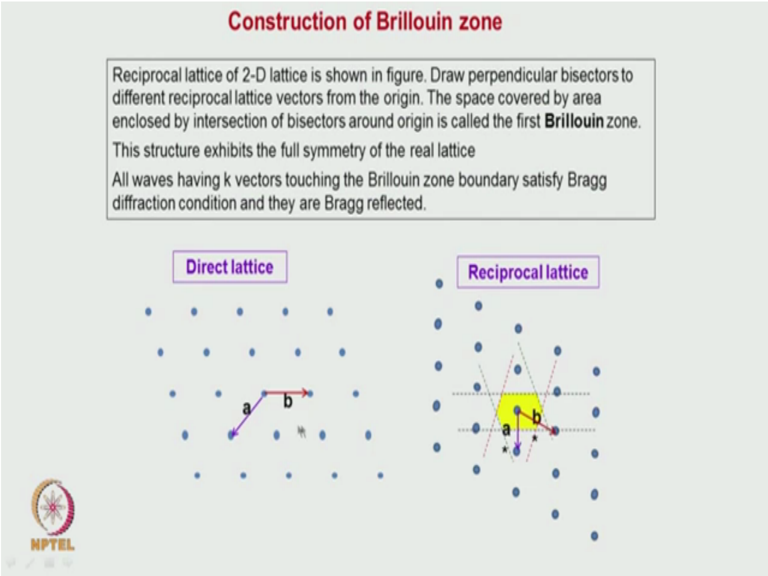


Now, that is precisely what it is being done; now this is a lattice with respect to from the origin, I can take all the reciprocal lattice vectors, draw the plane which is perpendicular to it that is the Bragg plane correct all the scattering vectors to satisfy the Bragg condition has to touch this Bragg plane.

So, this defines an area correct. So, this boundary this called as a Brillouin zone boundary. All the once a wavelength is fixed of the radiation when we have a reciprocal lattice which is their, then we know these are all the k vectors which will be touching the Brillouin zone boundary only those vectors will give raise to a diffraction peak.

So, if the wavelength is fixed you know what the value of k for the incident beam is going to be. So, that will tell you how the beam should be oriented so that we get a diffraction peak that becomes clear from its. So, this is nothing, but in reciprocal space as in which are in Fourier space equivalent to a unit cell like Wigner Seitz cell. Exactly the same way it is being constructed right how is a Wigner Seitz cell is constructed? Wigner Seitz cell is a primitive cell in real lattice which exhibits all the symmetry of the lattice. Similarly in reciprocal lattice Brillouin zone this is called as the first Brillouin zone then you have second third like that, this is for a 2 dimensional lattice we can constructed we can construct it for 3 dimensional lattice also.

So, this concept of Brillouin zone also can be use to explain diffraction right. Ewald's sphere construction can be use to explain a concern diffraction. So, the there are so many ways we can look at the diffraction that is what I wanted to tell you, that is the message which I wanted to tell convey to you. You have any doubt and whatever has been told so far.

Student: Getting Brillouin.

Brillouin zone see this is the incident beam direction k vector the direction that beam is coming. This is the scatter vector correct this is the points from which it is getting scatter correct and this difference between k dash minus k has to be equal to G that is the condition for Bragg condition. So, this is nothing, but from here to here is a essentially a reciprocal lattice vector. So, that is precisely what I had shown here also the same vectors can be shown like this also and the plane if you considered this surface here this surface is nothing, but we call that this is the plane which is diffractive nah; what does this plane is it with respect to the reciprocal lattice this plane is perpendicular to that? This is exactly what we call in the Bragglana if you look at it is a Braggla, the behave at some diffraction planes the reciprocal lattice vector is always normal to the diffraction plane correct.

And the distance at which the Bragg plane comes in reciprocal space is at mid way between the reciprocal lattice vector.

Student: So, Bragg plane corresponds to the lattice plane.

It is similar to a lattice plane because when we draw the; this one we can draw it in any way.

Student: So, the (Refer Time: 27:03).where is the k 1 half G half G square.

No this is if this is G this will be half G correct this will be half G, k dot half G if you take it that is k dash sin theta cos theta.

Student: (Refer Time: 27:20).

The projection which is what it we have to take it with respect to this, that has to be half G squared it will be turning out to be correct. So, this vector has to always touch this plane that is the scattering vector if you touch as this plane only this condition will be satisfied because this is the condition for Braggla that is essentially what we are looking at it. So, like this, this is with respect to from the origin one G vector we have considered with all the vectors which are reciprocal lattice which are closed by reciprocal lattice vectors, we can drop line perpendicular to this and generate a cell and this cell is called as the Brillouin zone first Brillouin zone; similarly second Brillouin zone, third Brillouin zone like that it comes. Essentially this concept of Ewald sphere is the one and Ewald sphere construction is the one which is used to develop different type of X-ray diffractometers.

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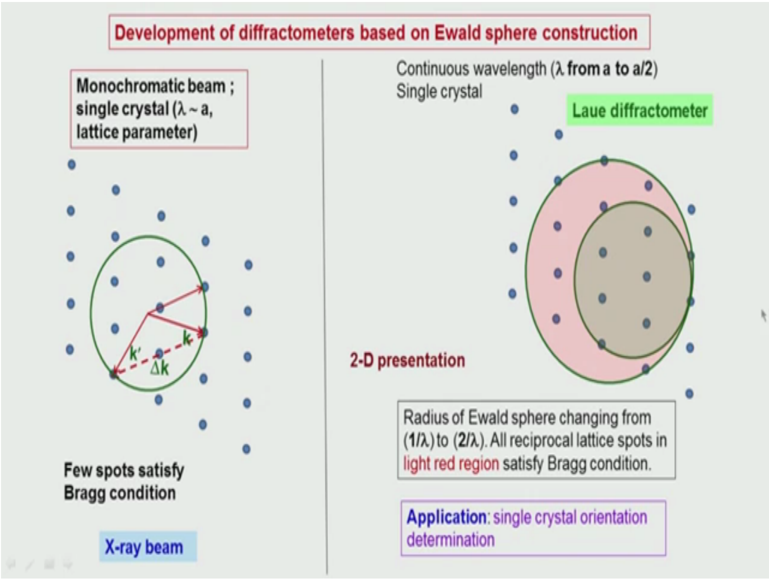


We will just have a look at it, you assume that a monochromatic beam is falling on the sample in some particular direction in the crystal with respect we have define that k dash vector. Then we are drawing a Ewald sphere construction; when you have drawn this Ewald sphere construction what are the reciprocal lattice spots which touch the Ewald sphere for the particular direction in which the beam is centering, will only will give raise to the diffraction spots.

When wavelength of the radiation and the lattice parameter of the sample is closed by, then only very few spots will satisfy Bragg condition some condition the none of the spots be satisfying the Bragg condition that can also happen for some direction of the beam. So, we have to essentially why we are rotating the beam is to make it is satisfy the Bragg condition, this is precisely what is being done. So, in such a case what is going to happen is that in this type of a if you make a diffractometer like this, hardly very few spots will come. If you want more spots what we have to do it is this is one technique called as a Laued diffractometer.

This is the one which is used to find out orientation of single crystals especially if the sample is a single crystal will not be getting many spots what do we do? We change the wavelength of the radiation it is a continuous x ray if you take it wavelength varies from one value to another. But it is coming in the same direction if the continuous X-ray falls on this what is essentially going with respect to a reciprocal lattice point if we consider the wave vector is going to be in the same direction, but the magnitude is going to be different. So, with this is the point in this particular direction if we draw we will be finding out the centers a different point, you draw the Ewald spheres corresponding to it.

Now, what is going to happen is that if you look at it between this circle and this circle this are the 2 extreme values of lambda, you have so many circles are there so one or the other is going to satisfy the touch the reciprocal lattice. So, now, we have more spots are going (Refer Time: 31:03) especially in single crystal when you wanted to find out the orientation, otherwise you put a beam on a particular direction no diffractions spots will come. So, if you put a continuous radiation where the wave length is being varied continuously, then we will getting a lot of the diffraction spots because the Ewald sphere when you look at it, Ewald sphere is continuously radius is changing because of it many reciprocal lattice spots will be touching; this is the basic principal on which this laue diffractometer is constructed.

You might a heard of a this oscillation method for single crystals, what is normally being done is that you take the single crystal x ray beam is coming then around an axis which is perpendicular the single crystal will be rotated around it so that more spots come.

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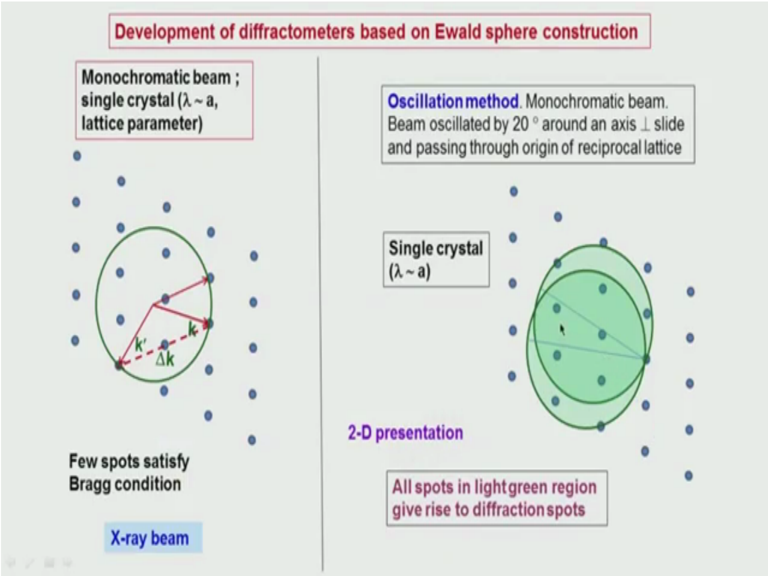


When we do a rotation like this, when the wavelength of the radiation is kept the same monochromatic radiation, once the sample is fixed we know the Ewald sphere is already and now what we are trying to do is around this axis here, only trying to rotate the Ewald sphere. So, when we rotate the Ewald I have just shown the 2 extremities, now if you see is that all those spots which are lying on this light green color between these 2 where there intersecting, all of them will be appearing on the diffraction pattern; this is precisely what it happens for an a oscillating crystal method.

Student: (Refer Time: 32:36).

This type of crystal diffractometers are there for finding out the lattice parameters and a symmetry of this a single crystals.

Student: (Refer Time: 32:50).same part will be give.

Which one?

Student: Same part (Refer Time: 32:54).oscillator.

No here what we are doing it is wavelength is not being changed.

Student: (Refer Time: 32:56).

Monochromatic wavelength is there only the sample is being rotated. When we rotate the sample what are we essentially rotating? We are rotating the Ewald sphere in such a way that for some particular angle the reciprocal lattice spots will be the touching the Ewald sphere right, so.

Student: (Refer Time: 33:13).

We are making.

Student: (Refer Time: 33:15).get all (Refer Time: 33:16).

Yeah. So, more spots are touching. So, we get more diffraction spots correct. So, that is what is being done.

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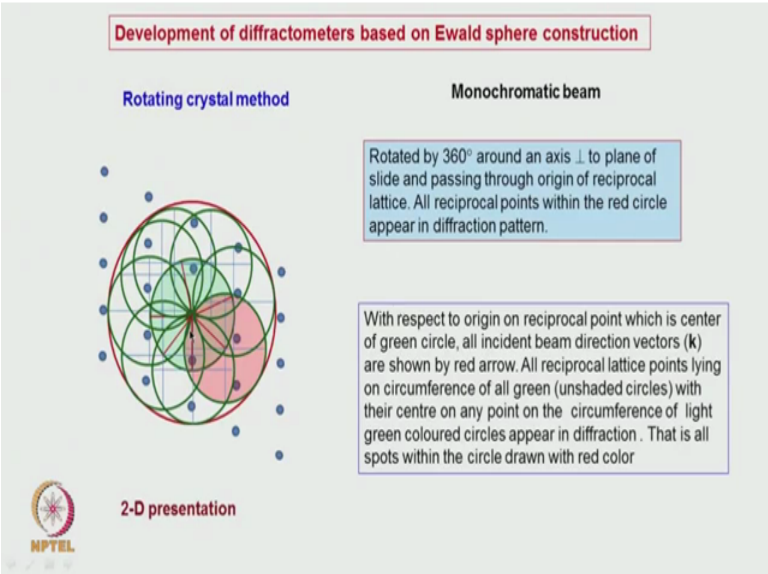


The another method of it is that the whole that sample itself can be done it is around 360 degree around on axis you can rotate it, that is even if the sample is a single crystal by rotating it that sample continuously, we will be able to get at different positions at the different directions of the beam, we will be able to get diffraction spots. It is nothing, but what is being done here is that, these are all the red line shows these are all the with respect to a origin which are the vectors which has to be taken with respect to this vector now I have constructed a reciprocal lattice constructed an Ewald sphere like this all these Ewald sphere have been constructed.

Now, we see that around this red circle which is there, all the reciprocal lattice point which are going to be there in this reciprocal, all of them will give raise to a diffraction spot. This is a geometric construction which shows that what are reciprocal spots which are going to appear in the diffractions spot; because the beam direction when we rotate the sample keeping like this the beam direction is going to change with respect to a sample correct. This is the rotating crystal method the same method, an another form of it is what we call it is the Debye Scherer powder pattern.

In powder pattern what we do? We take the sample and powder return put it so that means, that the beam is remaining that same, but the powder is taking all orientations it is exactly equivalent it you understand that. So, this is also base done the same principal of the Ewald sphere.

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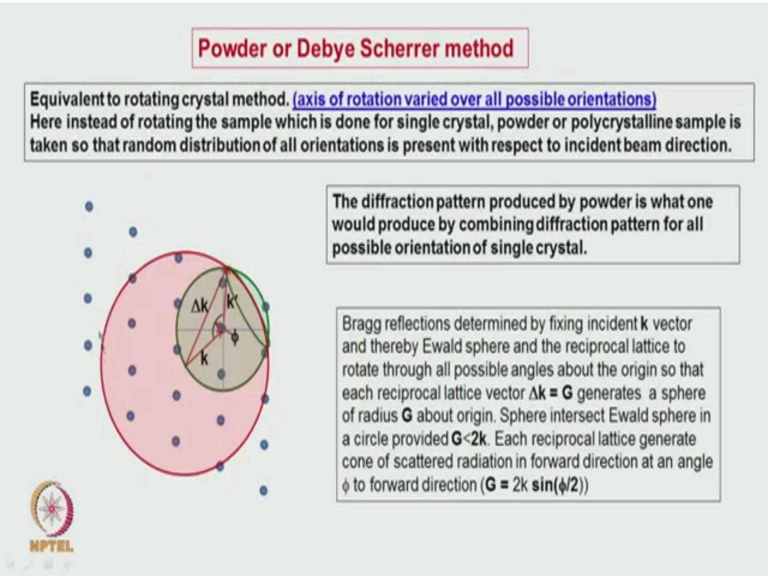


So, that is exactly what is being shown here, but in a single crystal the rotation method around the particular direction the single crystal is being rotated. Now here the crystal itself is a safe the single crystal can be rotated not only around this or various orientations of the axis we can rotate it nah that is what is going to happen in the case of a powder diffraction. In that case what will happen is that instead of getting all the reciprocal lattice spots. So, around any direction if a point here is satisfying, it around this direction if I rotate it all other because there we have some orientation of the crystal will be there which satisfy. So, it will be getting a continuous ring pattern. That is why if you look at the Debye Scherrer this diffractometer, essentially you might have notice it that there will be a center spot you will be getting this is on the film you will be getting a continuous lines like this which will be coming.

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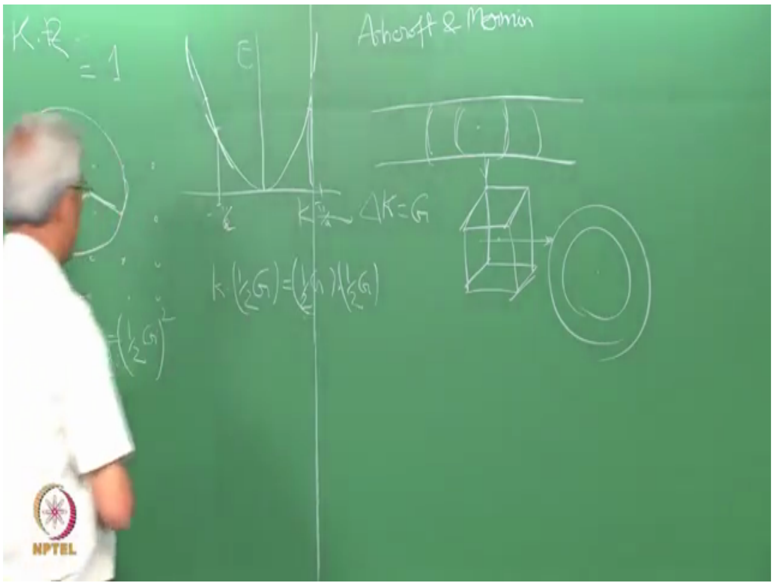


So, that is also base done the same Ewald sphere construction. So, the equipments are constructed in such way that more reciprocal lattice spots appear there, so that the analysis is simple. Most of this things if you see the solid state physics book by Ashcroft and Mermin there also here explain I have taken it is from there only. Here explained very nicely how using this; the Ewald sphere construction forms the basis of various diffractometers which we use for x ray analysis because this is very yes.

Ashcroft and Merman; actually the first class when I had given mention that I had given all these books name is there solid state physics. Now why you wanted you to know is that diffraction is a general one suppose you are working with a single crystal example that you wanted to study deformation behavior in a material crystalline material, how the deformation be a depends upon orientation of the sample, then you have to take only a single crystal.

Then the single crystal has to be the loading direction has to be fixed in the single crystal. To do that first thing which you require is that the crystal which you have got what is the loading axis you have to find out; nah. So, with respect to a external shape first thing which want should do is to find out how surfaces surface normals, what are the directions that you have to find out nah that can be done using Laue diffraction. This Laue diffraction could be used to find out even on a optical microscope, on single crystals you can mark all the directions of planes and everything it is very powerful.

So, just do not think that it is a, but depending upon the (Refer Time: 38:42) when you do research you find that for some particular result which you are looking for you have to use a particular type of a diffraction setup, that is why I am telling you about it. Like why do we go for a powder crystal diffraction tell me what is an advantage of powder crystal diffraction?

Student: If we are doing an single crystal you are fixing an axis (Refer Time: 39:09).

Actually the information about the single crystal that is true even from a powder if you take it and if it is orientated in all directions the crystal structure determination could be done from even a powder sample. It is like a powder sample is nothing, but a polycrystalline material, but with the all the random direction still we can get all the point group symmetry space everything could be determined from that pattern itself that has the advantage.

Student: Then why do we have single crystal (Refer Time: 39:41).

Student: When why do we use single crystal if like what else can we a only from single crystal (Refer Time: 39:46).

All material you cannot powder it and use it correct different setup for an different purpose when you wanted to use.

Student: (Refer Time: 39:58).

Student: (Refer Time: 40:00).

No, no one is an isotropy property you want it otherwise suppose you have made a sample; because when you do in a powder form it is an nondestructive technique correct; You cannot go back to the original sample you cannot bring back right for many application we do require single crystals of finite size, but then we require information about the single crystal as we have grown, then this is one technique which is very powerful. Like in some samples we can make them into powders, but not all many of them are grown into a powder form many of the metallic samples when you try to do anything you get deform the sample, it is not that easy to get powder crystals powder. Generally for metallic sample what you do it is you some take some turning, and then what you do it is try to because when you make it any that will be heavily deform, then you have to annelid because there are lot of changes will happen it is not that.

Student: (Refer Time: 41:24).

That is in a powder form when it is available you can use it in many of the ceramic samples, but it is not that you can replace it with that there are many cases it is not possible.

Student: Why do you have this line (Refer Time: 41:40).

Which one?

Student: (Refer Time: 41:43).

This is a which one these lines.

Student: (Refer Time: 41:46).yeah.

That is what I said that this circle is essentially is that if I take a any one particular direction one orientation sample is there I get a peak, if all other orientations will be there around this if I rotate it there will be many peaks will be there. A simple example which I will tell you suppose I take a cube like this, this is the direction in which the beam is coming; you assume that these planes are the once which you raise to diffraction. So, which is the direction in which the diffraction spot will come which will be perpendicular to this correct in this direction is where the diffraction spot will come may be with respect to a center somewhere it is coming. With respect to this direction if I rotate the sample what will happen? Because if it is a powder it can have so many orientation then what it will happen to this spot?

Student: (Refer Time: 42:54).

So, you get in a diffraction spot you get a circle like this will be getting in a this is exactly on a 3 dimension you consider it now, it is essentially a spheres spherical surface on which it will be cutting and this is what an arc of that circle is what we are going to get it there. So, this with respect to a thin strip if you put a film around that sample then you will be getting arcs like this.

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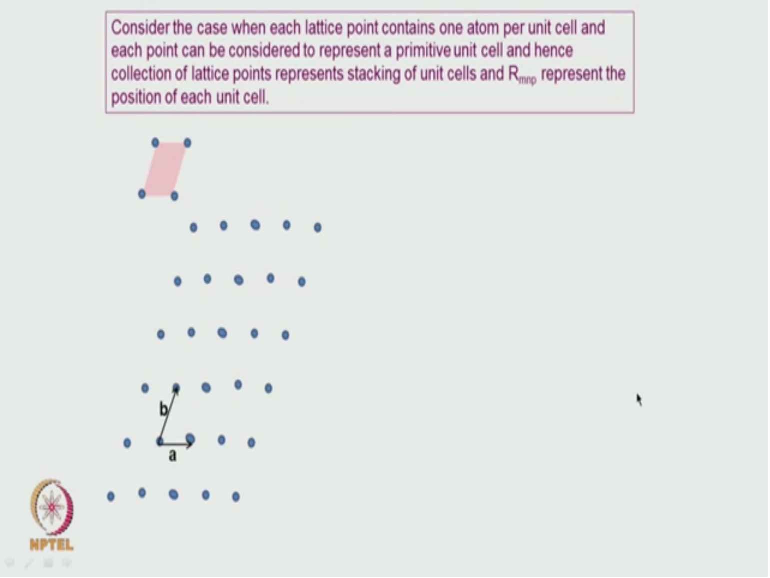



So, for what we have considered what are the things we have consider today? One looking at the basic condition delta K equals G, the Ewald sphere construction right.

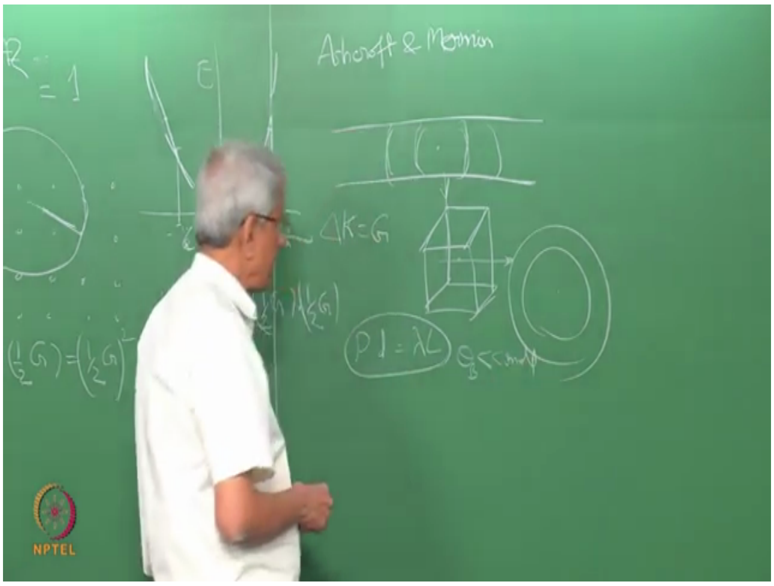
Student: (Refer Time: 43:55).

Right and then?

Student: Brillouin.

Brillouin zone concept; how this Ewald sphere construction gives raise to diffraction pattern and how the diffraction pattern appear on the screen that we have looked at it.

(Refer Slide Time: 44:19)




In that only thing which you have not considered that expression which we have written d into d equals lambda into L, this is for the condition when theta Braggan theta is very small. But when theta is large for x ray diffraction, you try to find out what will be the relationship because what we do essentially is the sample is kept at some distance or we are trying to the radius of the like here the radius of the circle or which the detector is being move it. So, then you can find out what is the angle at which what is the distance at which you have to move it to get the diffraction spots you can find out that relationship.

I will stop here.