Solid State Physics
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Lecture - 19
X-ray Diffraction from Crystal (Contd.)

So, we will discuss about the crystal diffraction using X-ray.

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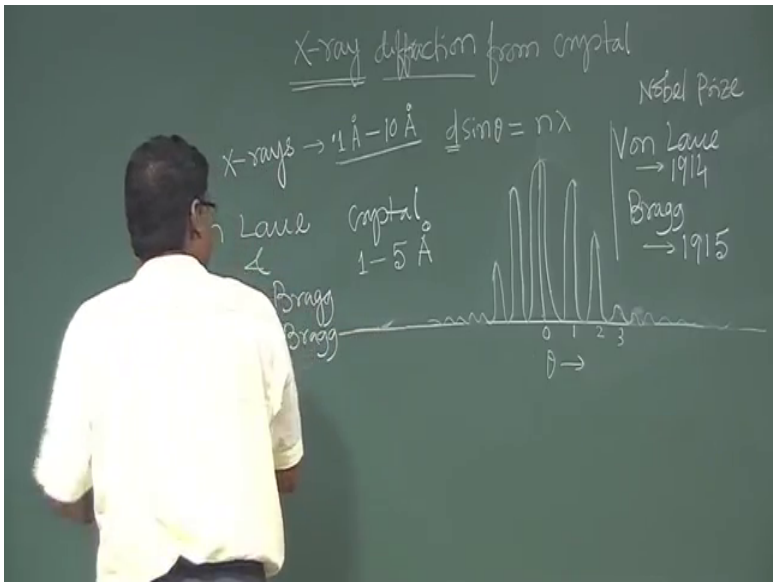

So, basically X-ray diffraction this from crystal. So, I have discussed about the source of X-ray how X-ray is generated using X-ray tube and also I have discussed about the diffraction of visible light from grating. So, from grating if you take diffraction, this is a grating and set of parallel rays of visible light falling on this grating its perpendicular this says a perpendicular to the grating, so then its diffracted in different direction with say angle theta.

So, this angle made with the normal to this grating. So, then we are seen that d sin theta equal to n lambda, that is the condition for principal maxima means we have for this grating basically we have the diffraction pattern like this. So, this the aggressive distribution of due to single slit effect and here then we get principle maxima that is due to basically interference, this equi spaced. So, equi spaced maximum we get this is basically interference maxima and this if I just remove this one which is basically

modulating the amplitude or intensity of this principal maxima, all are not having same intensity. So, it is it varies.

So, this the zeroth order, this is the first order second order third order. So, these are the value of n. So, we get basically if I just we get just equi spaced constructive interference having basically these are different peaks. So, these are due to interference of secondary wavelengths. So, this is angle and this is the intensity. So, this is the grating element. So, this it is middle of this and next one. So, this this distance is d is called grating element. So, if we know lambda then experimentally one can find out theta of different order angle and then we can find out the or if we if we know the d, then we can find out the lambda of unknown wavelength of light ok.

So, one has to measure this angle experimentally, then one can find out either getting element or the wavelength of light; so this in case of X-ray as I mentioned in case of X-ray. So, wavelength is the generally in the range of say point 1 angstrom to say a 10 angstrom. So, this using this X-ray von lave and Bragg W. L W H Bragg and his son w l Bragg. So, they mentioned that X-ray diffraction also we can see if we get grating having this getting element of this dimension. So, in angstrom order getting element if we get then we can see the diffraction effect of X-ray, but practically it is not possible to fabricates such type of grating. So, they actually mentioned that this is the good opportunity to study the crystal a slime materials using X-ray diffraction.

So, in crystal as I mentioned that this lattice spacing d value lattice spacing for crystal that lattice spacing, it is in the range of say 1 to 5 angstrom. So, it is in the same range. So, one can choose appropriate wavelength of X-ray and then that crystal planes is set of planes parallel planes of crystal it can behave like a grating having the spacing that is equivalent to the grating element and we can see the diffraction of X-ray from the crystal. So, they propose that one and also they have demonstrate the same and they found the way to get the lattice structure crystal structure analyzing the X-ray diffraction from the crystal right. So, for their contribution, they are they were awarded Nobel prize. So, von lave he received Nobel Prize in 1914 he received.

So, he received Nobel Prize 1914 and that Bragg W, L Bragg and W.H Bragg. So, they are basically father and son. So, Bragg received the Nobel prize in next year 1915 for their. So, independently they demonstrated the X-ray diffraction from the crystal and

using that X-ray diffraction from crystal they have demonstrated how to calculate the lattice parameters from this X-ray diffraction; so because of their, this great contribution in crystallography. So, they are they are awarded Nobel Prize. So, now, we will see this whether similar type of relation in case of X-ray diffraction whether that relation we can find out whether that type of relation there or it is a different kind of formulation is required for X-ray diffraction.

So, this, there are basically as I told this this von lave and this Bragg independently they found the way to study the X-ray diffraction and determination of the lattice constant of the crystal. So, they have given different mechanism treatment to for this X-ray diffraction; so this Bragg.

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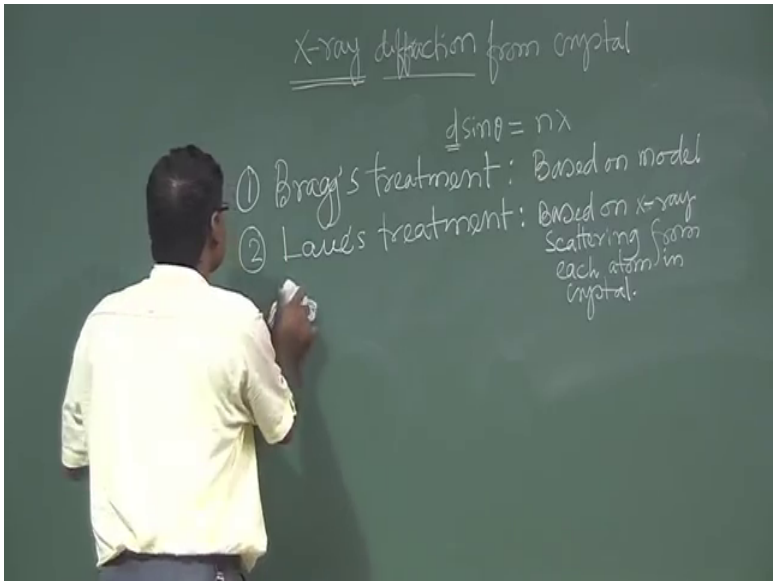

So, one is basically for X-ray diffraction and we tell this Braggs treatment and another is laves treatment. So, basically this in different way they have a they have shown the X-ray diffraction and they have studied that that X-ray diffraction for determination of the crystal structure.

So, this Bragg treatment it is basically it is based on based on model, but this lave consideration laves treatment is based on the X-ray scattering from each lattice point from each atom in the crystal. So, these a more general treatment and more realistic treatment, but fortunately the result of this from this 2 both treatment if results are same, for that one has to one has to correlate both of the relation, but ultimately they are same

they are. So, they give the same physics or same structure of the crystal. So, this based on basically based on X-ray scattering from each atom in crystal.

So, we will discuss both treatment, but let me discuss first is Bragg treatment and this later on we will discuss about the lave treatment, but from Bragg treatment itself whatever relation we will get that is sufficient to study the crystal structure using the X-ray diffraction and from lave treatment it is general and more realistic and from lave relation whatever we will get from there we can show that this from lave relation one can derive the Bragg relation.

So, let us discuss about the Bragg treatment. So, this Bragg treatment as I mention that is it is a based on the model; so this is what is a model. So, basically this they have considered or it is true that these crystals have a set of planes set of planes and they have many orientations, ok.

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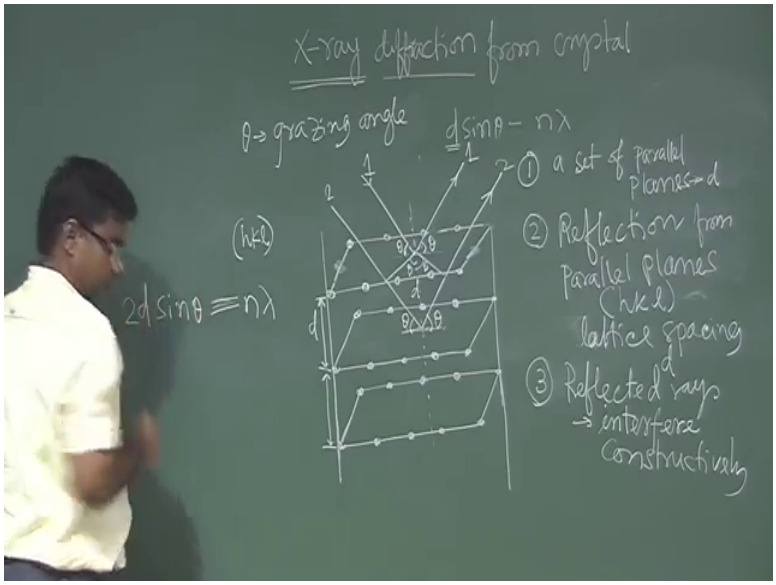

So, there are many planes having different orientation, but as I mentioned that one crystal plane describe by h k l it is not a single plane it is a set of parallel planes having the equal equidistance spacing. So, that is the basically lattice spacing crystal lattice spacing d right. So, they considered that this in crystal let us take a set of parallel planes. So, this just we have considered set of parallel planes. So, one planes means there is a this lattice point atoms on this plane right. So, this one of the arrangement I am taking. So, all are same plane h k l plane say ok.

So, they are I think just you can take arrangement of the let us take the simple one (Refer Time: 21:49) I think I draw this one. So, this is a set of parallel planes h k l planes right h k l planes. So, it is nothing, but a set of parallel planes having the distance spacing. So, this is d lattice spacing. So, infinite numbers of these planes are there. So, now, if you. So, Bragg consider basically as I told that he assumed say he assumed that is crystal have a set of parallel planes with lattice spacing d right with lattice spacing d now second assumption that they are telling that X-ray when X-ray falls on the this crystal.

So, this X-ray reflected from each plane X-ray reflected from each plane and for a. So, if you take a X-ray is falling say one ray is falling here, it is reflected right; so this perpendicular to the to this plane perpendicular to this plane. So, this is another beam is falling. So, beam of X-ray is coming. So, it has many rays. So, is falling on all crystal planes. So, if I consider this second way. So, this is parallel rays say its looks parallel. So, this I have to make it parallel looks parallel; so this normal to this planes because they are parallel. So, is they are is, they have same normal ok.

So, this X-ray they are telling that X-ray beam will fall on this crystal planes on crystal means it will fall on this plane. So, set of parallel planes and they will reflect from these planes. So, this ray is reflected following the reflection rule. So, what is the rule? So, incident angle will be equal to reflection angle. Generally it is that angle is taken with respect to the normal. So, that is fine. So, one can take with the surface also with the plane also. So, then we will tell this the theta is a grazing angle, theta is the grazing angle theta is a grazing angle with the plane. So, this here this is they are parallel. So, here also this this angle is theta this angle is theta ok.

So, from third fourth fifth layers planes this reflected ray will come following the reflection and now they telling that this reflected rays will interfere will interfere that means interference among these reflected rays and it will give resultant will be the constructive interference from this reflected rays. So, when X-ray are falling. So, they will be reflected from these set of parallel planes having the same index means lattice constant, same lattice constant. So, then this reflected rays will interfere constructively. So, there is a guarantee that this ray when ray will interfere and you will get constructive interference there may be destructive, it depends on what it depends on path difference of phase difference.

So, here it is fixed that the difference is that here it is fixed is it will reflect in such a way these reflected rays will interfere constructively. So, that is the assumption that is the main assumption. So, it is the that is a I told this is a model. So, if they consider this. So, then what is the condition we will get? This interference construct. So, reflected reflection. So, they consider the reflection from parallel planes say h k l plane h k l plane. So, they are lattice spacing is. So, d lattice spacing is d, lattice spacing lattice spacing d right. Now, this reflected rays will interfere constructively, reflected rays reflected rays will interfere will interfere constructively that is the main assumption interfere constructively, ok.

So, now when they will interfere this 2 ray will interfere; so this interfere that path difference has to be for constructive interference what will be the path difference either path difference has to be equal to the lambda n lambda like this, lambda integral multiple of that lambda or this 2 phi integral multiple of 2 phi. So, then only they will interfere constructively. So, that is the. So, they assume they from this model itself. So, this it is clear that this path difference has to be n lambda; lambda 2 lambda 3 lambda 4 lambda etcetera. So, now, what is the path difference we have to calculate from here? So, this is the d, this is the d now how to calculate. So, just these are parallel. So, just draw a normal from here, path difference between ray 1 and ray 2. So, this path ray same this path ray are same for both rays and only this ray 2 or travelling the additional path this and this right.

So, if this is the angle theta. So, you can show that this angle this will be the this angle theta. So, this will be yours theta this 90 degree. So, it will be theta and this one will be also theta. So, this is d, if this is d and this is theta. So, this will be d sin theta and this other one also will be d sin theta. So, these d sin theta plus these d d sin theta. So, it will be 2 d sin theta. So, this is the relation they established based on the model of reflection. So, this and it has a it is difficult to tell why they consider the reflected rays and they will interfere constructively, but that was the assumption that was the model and got this relation and this relation satisfy all experiment result; that means, they are assumption are correct ok.

So, their model is correct; later on we will find out that is from lave treatment from lave treatment that is the rigorous treatment, general treatment, realistic treatment from there we will get some relation and from that relation one can derive this relation. So, this is

the simplest way Braggs way is very famous because of its simplicity. And using this relation we can study the crystal, we can find out the crystal structure, so that we will discuss in next class.

Thank you. I will stop here.