**Introduction to Materials Science and Engineering**
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**Lecture - 13**
**Weiss Zone law and it is applications**

Hello we will discuss today a very important law called the Weiss zone law, it is a very simple law and gives you the condition.

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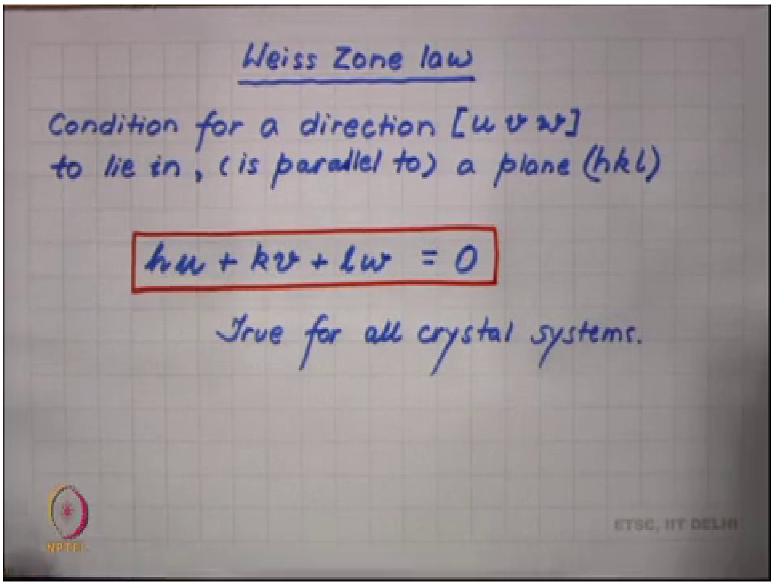


So, the Weiss zone law is condition for a direction uvw for a direction uvw to lie to lie in or which is the same thing in crystallography at least is parallel to condition for the direction uvw to lie in or is parallel to parallel to a plane hkl, notice the direction in dc is uvw is put in the square bracket and the plane in dcs hkl is put in round bracket you will recall this convention from our previous discussion on miller in dc.

Now, why Weiss zone law simply stating what is the condition that these 2 miller indices satisfy if the direction is lying in the plane or is parallel to the plane and the condition itself is quite simple all you have to do is to multiply the corresponding indices the first 1 with first one; hu then kv and then lw and add them. And this sum of the products hu plus kv plus lw should be 0. So, the law itself is quite simple, but it is very useful and powerful law as we will see, as we go along in our crystallographic discussions. And 1 important thing to keep in mind is that this law is true for all crystal systems.

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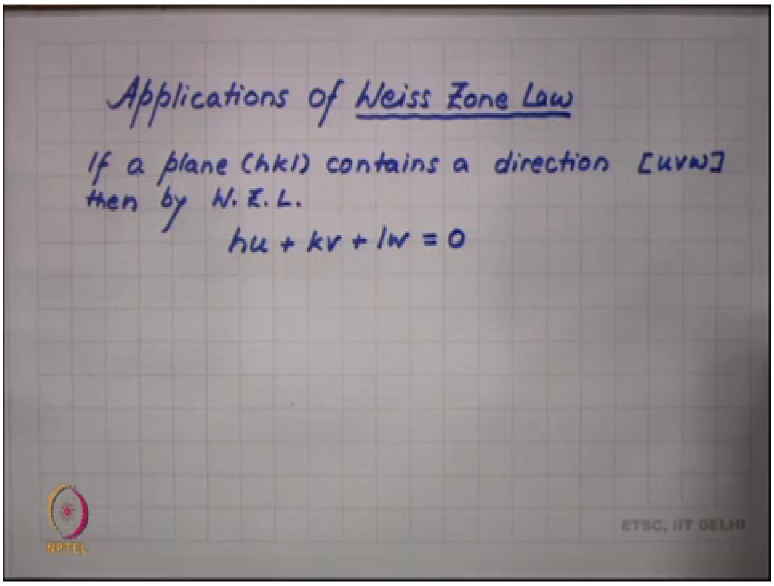


We will see some of the applications of Weiss zone law. So, just recall Weiss zone law it states the condition that if a plane hkl contains a direction uvw, I will again remind you round brackets for the plain square brackets for direction. So, if a plane hkl contains a direction uvw, then the Weiss zone law then by Weiss zone law I am writing it in acronym we have hu plus kv plus lw is equal to 0. This law is very useful in solving certain crystallographic problems and we will try to do that now.

We will take as an example let us take as an example problem of trying to find a common direction.

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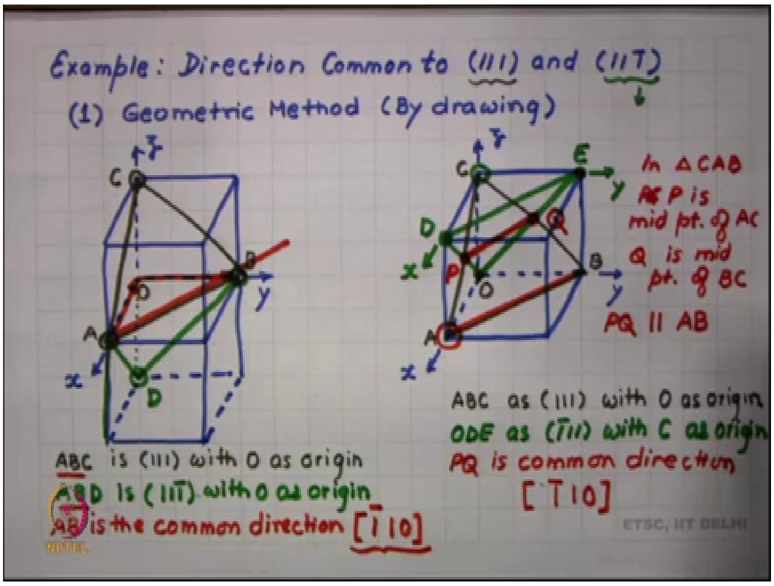


So, direction common to 111 plane. So, let me you 1 1 1 and 1 1 bar 1 plane. So, I have been given 2 planes and I want to find a common direction. So, let me I will do it 2 ways the first will be the geometric method that is by actual drawing the second will be the algebraic method by use of Weiss zone law. So, let me draw a unit cell. So, this is my unit cell let us choose our access convention. So, I am calling this x this y and this z with this.

I am now ready to draw my first plane the 1 1 1 plane, recall that the 1 1 1 plane the miller indices of any given plane is reciprocal of the intercepts in case of 1 1 1 that is not a problem the reciprocal is also 1 1 1. So, this plane intersects the x axis at 1 and 1 means equal to the unit cell edge length. So, at x axis it intersects here at, y axis intersects there let the z axis it intersects there. So, we get these 3 points 1 1 1 and if I join these 3 points I get my plane. So, if I call this a call this b and call this point c then I can write that A B C is 1 1 1 with let me take that origin O with O origin.

Now, I want to draw the second plane 1 1 bar 1 with the same axis and same origin if I want to draw it with the same origin I see that now the intercepts are 1 along x. So, I will get the same point 1 along y I get the same point, but 1 along minus 1 along the z axis. So, I really have to go in the negative direction of the z axis to find the intercept of this new plane on the z axis. So, the third point is here. So, let me for reference let me draw a unit cell which is a unit cell lying below this unit cell let me draw it in draw it in blue only. So, I have a unit cell now and I put my plane let me call this point D. So, A B D A B D becomes 1 1 bar 1 again with O as origin I have not changed the origin, and since I did not change the origin I have to take an another unit cell and I had to go in the lower even itself to draw the second plane.

Now, what is the common direction just by inspection I am seeing that a b direction a b is common to both the planes. So, the A B becomes my common direction. So, by observation I find that A B is the common direction. And how do I find it is miller indices well I can now choose a as my origin and try to move in the direction A B to do this I take a negative 1 step along x and an positive 1 step along y and I do not have to go along z. So, positive negative step along the x axis a positive step along y and not moving along the z. So, just by observation and drawing I can find the common direction as bar 1 1 O. So, I have solved the problem of finding the common direction to these 2 planes by actually drawing.

Let me try to draw the same thing in a different way suppose; suppose I am fond of my unit cell and I do not want to change in the first case I was fond of my origin and I did not want to change the origin. Now I like my unit cell and I do not want to go outside this unit cell if I insist that then also it is possible to draw these 2 planes in the same unit cell. So, let me try to draw these 2 planes in the same unit cell. So, the first plane is as useful as in the previous drawing it will intersect the unit cell axes at A B and C and I draw these lines and I get again ABC as 1 1 1 with O as origin.

But now if I want to draw 1 1 bar 1 in the same unit cell I will have to shift my origin this was the O origin, because if I keep the origin fixed then the bar 1 will take me outside the unit cell. So, if I want to keep myself within this unit cell and still be able to draw 1 1 bar 1 what shall I do. So, since I have to take a negative step I have to shift the origin to the top face of the cube. So, that I can go in the negative direction and still remain within the unit cell and I still have to take positive steps along x and y. So, if you think about it you can convince yourself that C now is the correct choice of origin.

So, I shift the origin at C my new x and y axis are now passing through the new origin and from here I take 1 step along the x that brings me here 1 step along y that brings me there and 1 step along negative z that will take me there.

So, now the new representation of the same 1 1 bar 1 plane in my drawing will be like this. So, let me call this now D and E. So, O D E I have drawn as bar 1 1 1 now the origin is shifted with C as origin, but what about the line of intersection well this requires little bit of seeing they observe that I have drawn 1 of the plane in black the other in green and on the left face of the cube 1 of the black line is intersecting with the green line.

So, 1 of the intersection point of these 2 planes is flying on the left face and I call that P. Another intersection point is on the back face of the cube again O E is laying on the green plane BC is lying on the black plane. So, the common point to the 2 planes are this point Q. So, center of the left face and center of the back face now are common to both the planes so; obviously, this entire line if I have found 2 common points the entire line will be the common direction. So, now, P Q becomes common direction, but how do I find the indices of P Q note that in the triangle C A B in triangle C A B P Q P is midpoint; midpoint of A C and Q is midpoint of B C enemy in any triangle if you join the midpoints of 2 sides it is parallel to the third side. So, P Q is parallel to A B and we know that parallel directions all have the same miller indices. So, P Q will have the same miller indices as A B.

So, we can now index A B by taking origin A and exactly like we had done for the A B in this figure on the left figure we go 1 step minus 1 step along x 1 step along y to come to B. So, the miller indices of the common direction turns out again to be minus 1 1 0 as it should be. So, there are 2 different ways of drawing in the first case in the left case I have drawn the 2 planes in different unit cells with a common direction. Now I have drawn both the planes in the same unit cell and I have drawn the common direction the miller indices come out to be the same.

Now, to demonstrate the application of Weiss zone law we will do the same problem by Weiss zone law so direction common to 1 1 1 and 1 1 bar 1. So, now, the second method algebraic method I will call that by the use of Weiss zone law.

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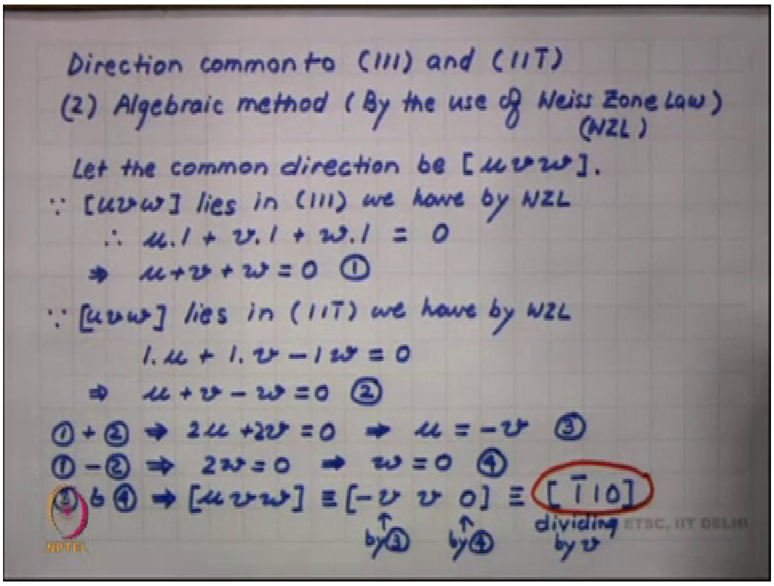


In this I do not have to make any drawing if you want to avoid drawing this is a good method. So, you can do algebraically or you can write a computer program to do it and do this in a much more easy way. So, here we will assume let us assume let the common direction this is what we want to find out. So, let the common direction let the common direction be uvw. Now since uvw since it is a common direction it lies in both the plane. So, it lies in the first plane. So, since uvw lies in 1 1 1 we have by the application of Weiss zone law u into 1 plus v into 1 w into 1 is equal to 0, u plus v plus w is equal to 0 let this be the first equation. Again since uvw also lies in the second plane we get another relation 1 1 bar 1 we have again applying Weiss zone law we have 1 times u plus 1 times v - minus 1 times w is equal to 0 which means u plus v minus w is equal to 0 this is our second relation.

Now, just by taking these 2 relations together and manipulating them we can find the direction uvw of course, we have only 2 equations and 3 unknowns, but really there are not 3 unknowns, but 2 unknowns because remember that we only need to find the ratios of uvw and not uvw independently.

So, these 2 equations are sufficient to solve our problem. So, we do that now algebraically we can see that if I add 1 and 2 then we can get rid of w. So, I do that. So, 1 plus 2 gives me 2 u plus 2 v is equal to 0 which in then gives me u is equal to minus. So, I have established a relation between u and v let me call this relation 3 and if I subtract 2 from 1. So, 1 minus 2 gives me 2 w is equal to 0 which means w is equal to 0 and if I take the relationship 3 and 4 together. So, this will tell me that you v w the miller indices uvw can be written as minus v v 0. So, instead of you I have writ10 minus v by 3 and I have left and instead of w I have written 0 by 4 this is by 3 by 4 3 and 4 gives me this.

But now I know that I can divide by a common factor in case of miller indices. So, by dividing by v I get bar 1 1 0 dividing by 3. So, you can see that you have got now the same miller indices bar 1 1 0 as you had got in the method by the method of drawing by the geometrical method, but here you did not have to draw just use algebra and the Weiss zone law and you will be able to find the answer and of course, the 2 answer should match if you have done both the methods correctly if you applied the methods correctly you will get the same answer.

So, beginning students should actually use both methods for the Weiss zone law and the drawing to become familiar with both the methods because drawing is also important it gives you the perspective view and it helps you in imagination whereas, in the Weiss zone law you only do an algebra and get the answer, but you should be familiar with both the methods and that is why I have solved 1 problem by both these methods.

So, we will take up some more example and other problems in future videos.