Crystals, Symmetry and Tensor
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Chirality

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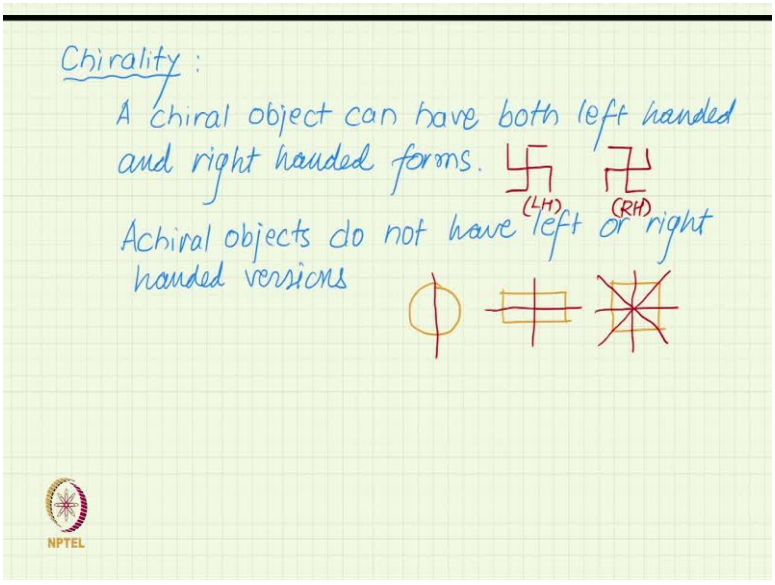

Welcome everybody. The question is whether left handed and right handed and chirality is the same? So, I will think that chirality is the property of being in two states left handed and right handed. So, a chiral object can have forms. Achiral or non-chiral, so a two-dimensional example, suppose the swastika, our popular swastika you can draw it like this or you can draw it like this.

And there is no way by rotation in playing you can super impose, although both of them look like very similar, but one can be called left handed; that is your choice really left handed right handed is from human hand because human hand also have two versions. So, our left hand and right hand both appear very similar, but they cannot be superimposed, superimposed in three dimensions.

You can say that I am super imposing like this, but that is a two dimensional super imposition and is not really a super imposition, because top of the left hand is pointing top, whereas top of the right hand is pointing down. So, even if I am able to, if I am some sort of a super natural ability and I superimpose on them in the same space, still they will not coincide because the top surface of the hand on the top surface of the hand will not match.

So, we have a left hand and right hand looking very identical, very similar, but still not superimposable by rotation. So, that is the criterion. So, by rotate in this 2d example you cannot, again by rotation in 2d you cannot superimposed. But circle has no such problem. There is no left handed or right handed version of circle in 2d or a rectangle, does not have this problem or a square does not have this problem.

So, why is it that swastika has this problem, but these are not having or you could call it problem or property, why does swastika has this property of being in two versions, but there are no two versions of a square? Why do not we have a left handed and right handed square? But rectangle also does not have left handed and right handed. So, that only has two fold. So, four fold or two fold is not really the distinguishing thing.

And if you look if I draw swastika I have not drawn it very nicely, but if I draw a swastika properly it also has four-fold symmetry. So, square has four-fold symmetry, swastika has four-fold symmetry, but swastika is chiral, square is not chiral due to reflection. So, if any object possesses a reflection symmetry, if it possesses a mirror plane, so all these objects which I drew as achiral have some mirror plane.

Circle has infinitely many mirror planes, I have drawn one of them. Rectangle will have two mirror planes, vertical and horizontal. Square has four mirror planes, so that is what distinguishes. If an object has a mirror plane, then if you reflect it, the reflected version will be identical or it will be super imposable by rotation to the original version. Whichever mirror you are reflecting that does not matter.

One mirror is sufficient and if it has a mirror, you do not have to reflect it in the symmetry mirror plane. But any other mirror plane also if you reflect it will move; that will not be a symmetry operation, because it will not be self-coincidence. But still it will not change its chirality because you can bring the moved object to the original object by translation or rotation. I think this is the distinction between chiral and achiral object.

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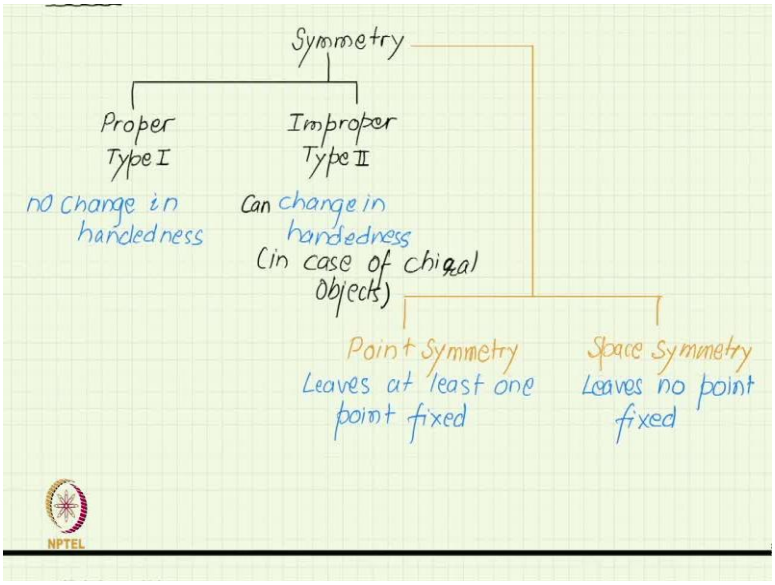

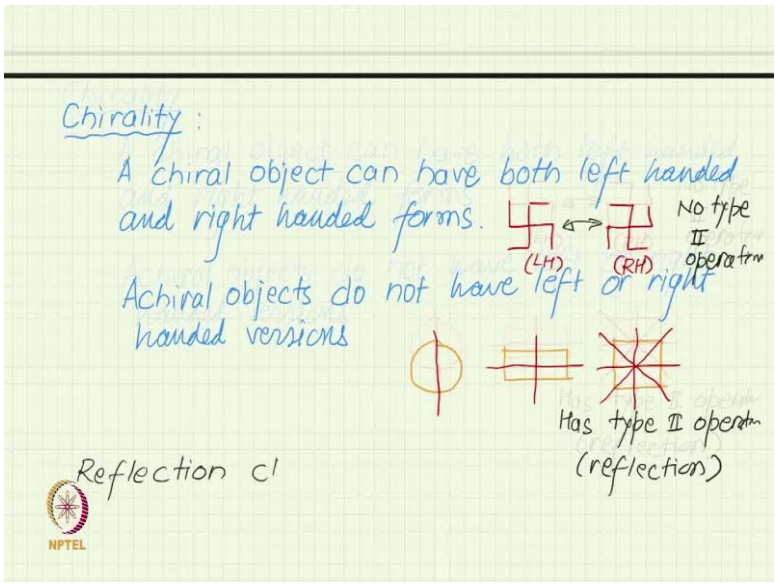

So, here we have seen some we are seeing some examples. I think we have, I had given you this classification that proper or type one where there is no change in handedness. So, that we will see that is why if it possesses only, so from here also you can see. If the object possesses only type one symmetry operations, then if you apply a type two it will become a different

handed object. But if it already possesses an improper type two, then it will not change because it has to have.

If it is having a reflection or a mirror plane, this one has not type two, it means if it is indistinguishable, then it is really not a left hand because then what is the distinction between left handed and right handed. So, then you will define, maybe you will define your left handed and right handed that if I apply an improper operation we get from left handed or right handed, we have to say that as your definition of left handed and right handed.

And if on application of such operation the left handed and right handed versions are not distinguishable, then it is achiral. You can say that but in the difficulty or the only slight objection to that is that if the two versions are not distinguishable, then how do you say that one is left handed and one is right handed. Means you can say that circles left handed and right handed versions are the same.

But then how do you say that which circle is left handed. Whereas in the case of swastika you can clearly identify two things, which are not superimposable. We may still disagree which one is left and which one is right but we have to agree that there are two types. So, what I said here change in handedness maybe needs to be a little bit modified, it will change the handedness if the object itself is chiral.

Because we have seen that it is not able to change the handedness here, if it the object was achiral. So, can change in handedness so a direct claim as I was making previously that improper will change handedness was not perfectly right, because it cannot change handedness if the object is chiral because he does not have hand so how can you change the handedness?

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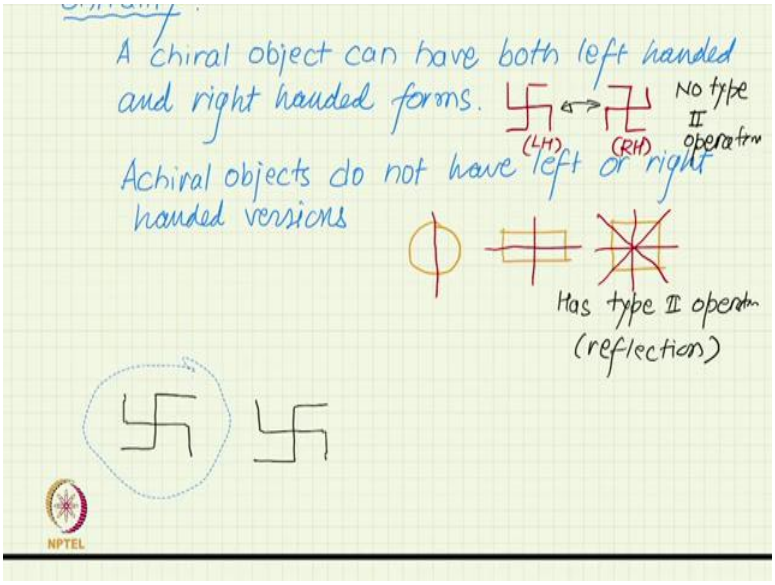

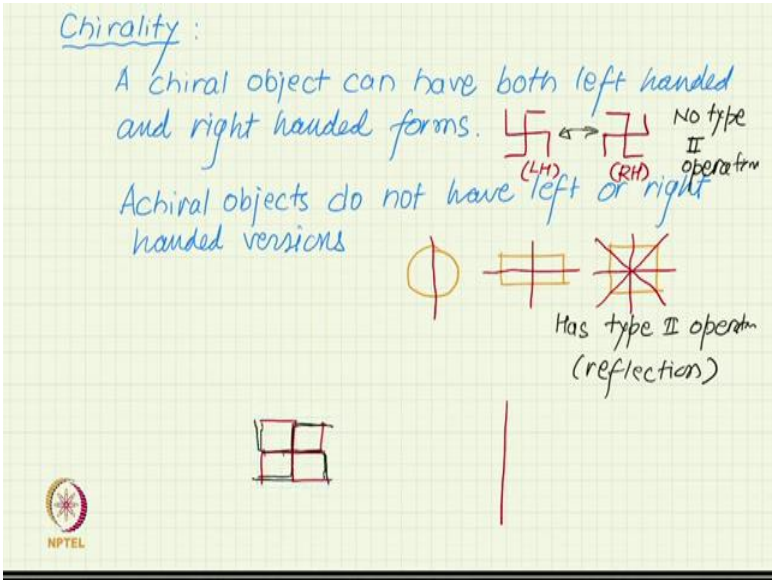

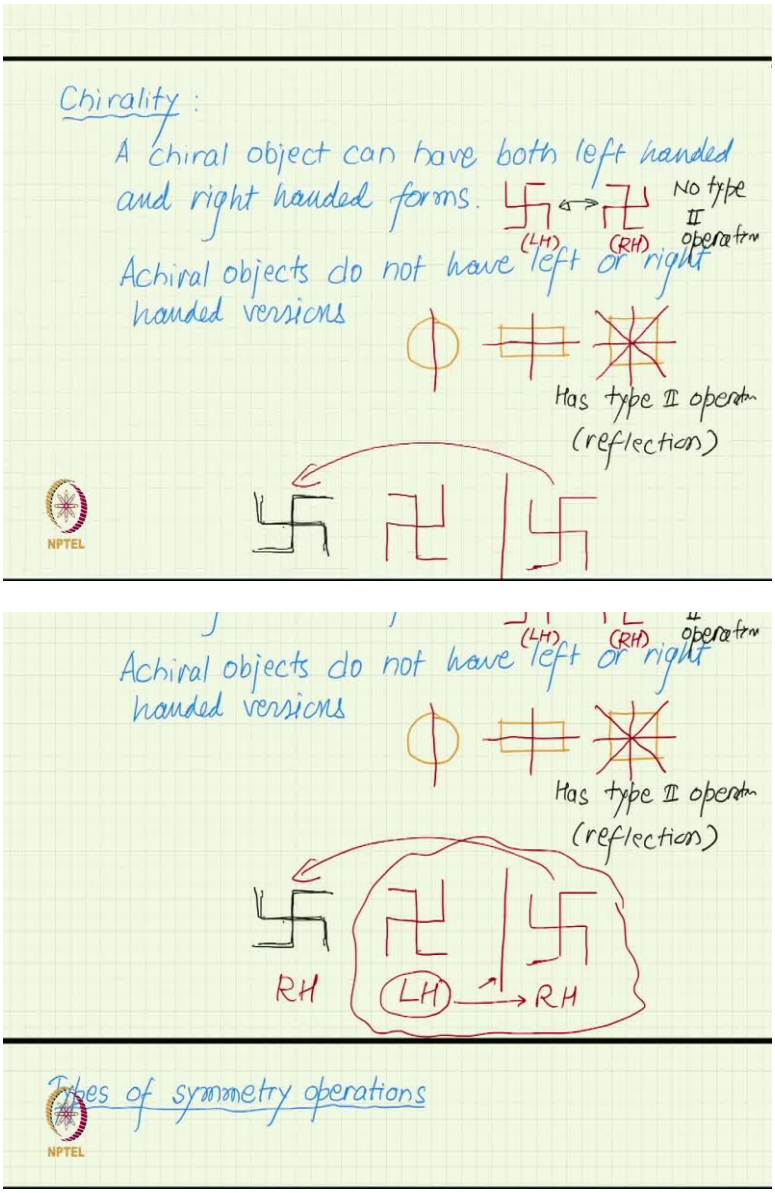

So, whereas in the swastika case, you see if I have now I copy and paste it. So, it is identical swastik and if I rotate this like this I have not changed the handedness it is just a rotation because I can rotate this also. So, if I try to rotate this I can rotate and bring it in similar position. And I think it got a little bit changed in size also in my operation otherwise I could have totally bring it into self-coincidence, self-coincidence.

That flip horizontal or flip vertical they say that is a reflection operation. So, I draw like this here, if I now try to reflect it suppose is the mirror plane. Now, there is no way there is no way I can coincide it, is not coinciding, is not coinciding. If you think that by rotation it should be possible that is also not true. There is no way you can rotate it and make it coincide. However much I rotate I cannot coincide, but if I reflect it, I can coincide it.

So, you can imagine reflecting it then it will reflect like this and then you can see that this and this are translatable. So, reflection is changing handedness. So, this is if you call it left handed this is right handed and this is right handed. So, rotation did not change the handedness, but reflection changed.

Student: Is reflection the symmetry of pressure in this case?

Professor: No.

Student: So, when you change the definition that a symmetry operation that change handiness, I mean, anything that can handle handedness, can it be a symmetry operation?

Professor: That is a good question. So, the definition of symmetry definition of symmetry is little a little bit extended to include that by seeing that if so I cannot coincide left handed and right handed by translation or rotation, but I can coincide them. So, this left handed object will coincide with this right handed object by the reflection in this plane.

So, if I have both the swastika, so the pair of swastika, which now becomes again achiral because you have both left handed and right handed part. So, for that pair of swastika this will be a mirror plane and will be symmetry operation. But, so for the whole object you can say that if I consider the pair, the pair does not have handedness, because it has a mirror, but part of it which is reflected changes handedness.

So, maybe to there is a issue, there I can see your problem. You can say that it is a symmetry operation. It is a symmetry operation of the object. But when applied to a chiral object, it will its handedness. The same operation when applied to a chiral object can chain the handedness. But the object for which this is a symmetry operation will not have the handedness because it will create the left handed and right handed part.

So, for chiral it cannot be a symmetry operation. And for achiral it can be a symmetry operation but that achiral object will have, internally will have a left handed and right handed part which will be being entertained by this symmetry operation. So little bit care is required.