Introduction to Materials Science and Engineering
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Lecture - 08
Classification of lattice on the basis of symmetry

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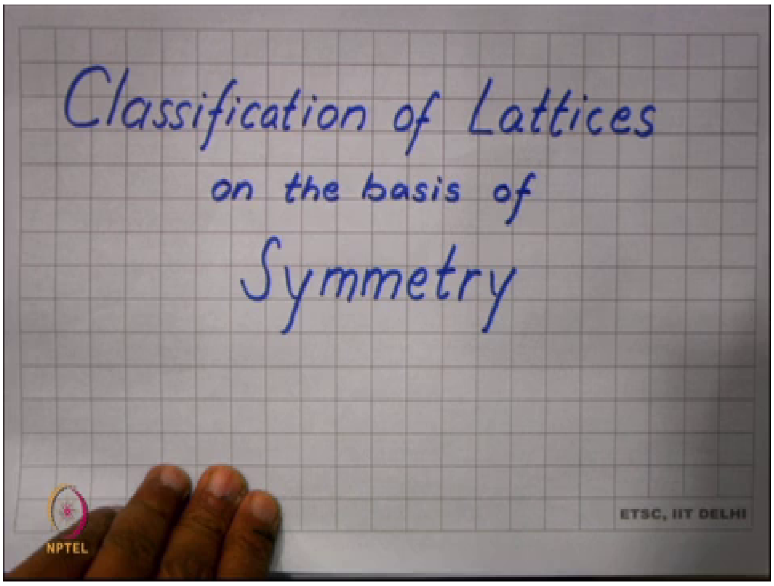

So, we looked at the basic definition of symmetry in the last video, and we now continue that definition use that definition for the classification of lattices.

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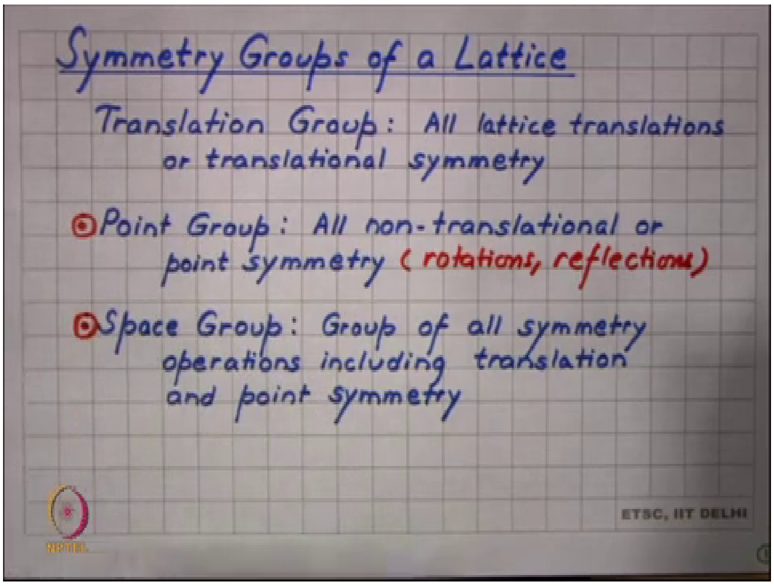

So, let us recap we said that all lattice translations or translational symmetry form a group called Translational Group. All non-translational or point symmetry like rotations and reflections rotations reflections form a group called Point Group and finally, we define group of all symmetry operations including translational endpoint symmetry which was called a Space Group.

Now, lattices are classified on the basis of the point group and the space group. So, let us look at that classification.

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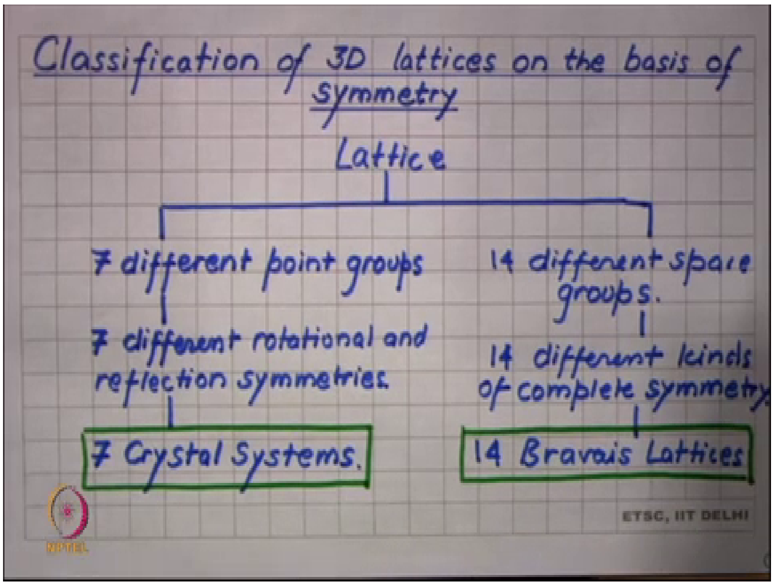

So, let us begin with lattice and let us try to look at what kind of point symmetry the lattice is having. So, if we look at the point symmetry of the lattice we will find that lattices although they can have different a b c alpha beta gamma finally, they can have only one of the 7 different kinds of point group or 7 different kinds of rotational and reflection symmetry. 7 different point groups or in other words 7 different rotational reflection symmetry these are what we call add 7 crystal systems.

So, 7 crystal systems are nothing but 7 different point symmetry which a lattice can have a very important statement we are making here similarly if you look at this space symmetry the complete symmetry of the lattice including the translations then you will find that there are 14 different space groups. Space groups which means 14 different kinds of complete symmetry by complete symmetry we have already defined this including translations and rotations point symmetry as well as translations. So, these 14 different is space groups or what are called 14 Bravais Lattices

So, 14 Bravais Lattices are nothing but 14 different is space groups in which a lattice can be classified. So, this is our symmetry definition of these 2 important concepts. So, they do not we have made all this effort for defining symmetry probably to present this slide that 7 crystal systems and 14 Bravais Lattices are not different kinds of unit cells which a lattice can have, but different kinds of point symmetry and space symmetry which a lattice can have.

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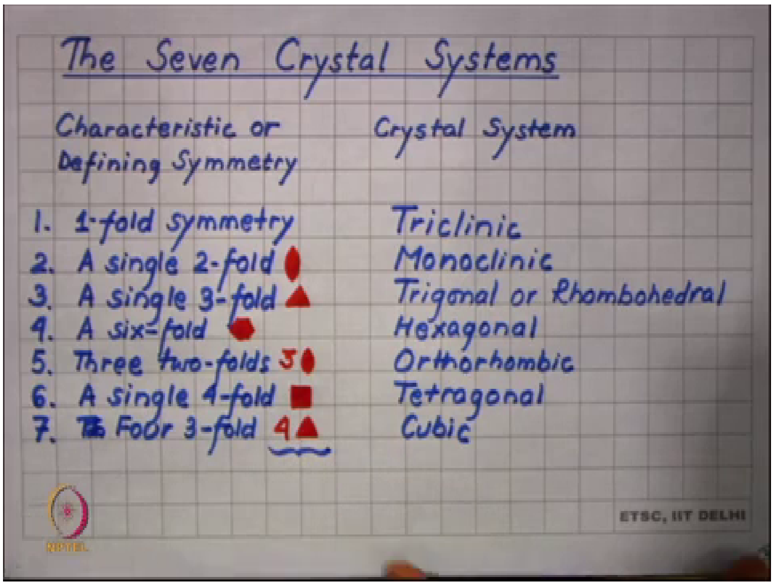

So, let us look at the 7-crystal system further in terms of symmetry we have already met this 7-crystal system and that time we had not developed the concept of symmetry. So, we only talked about the unit cell shape, but now we will look at the symmetry. So, let us let us write one by one. So, if it has a one-fold axes which no special symmetry one-fold symmetry no is special symmetry. Then the crystal system that is the least symmetric crystal system and that is what is called Triclinic if it has a single a single 2-fold single; 2-fold axes then the crystal system is called Monoclinic. If it had a single 3-fold then the system is called Trigonal or Rhombohedral if it has a 6-fold access shown by local Hexagon. Then this will be called a Hexagonal crystal system. If we have 3, 2-fold axes 3 mutually orthogonal 2-fold axes then it is called Orthorhombic belongs to the Orthorhombic class. If it has a single 4-fold then we call it Tetragonal, Tetragonal crystal system and finally, the most symmetric one is a cubic one and cubic is characterized by a symmetry sorry 4, 3-fold 4 3-fold axes.

Now, cubic one usually thinks in terms of 4-fold axes, but cu cubic crystal also have 3-fold axes and it is the 3-fold which has been taken as the characteristic symmetry this may surprise some of you. So, we will look at the 4 3-fold or the cubic symmetry and little bit more detail.

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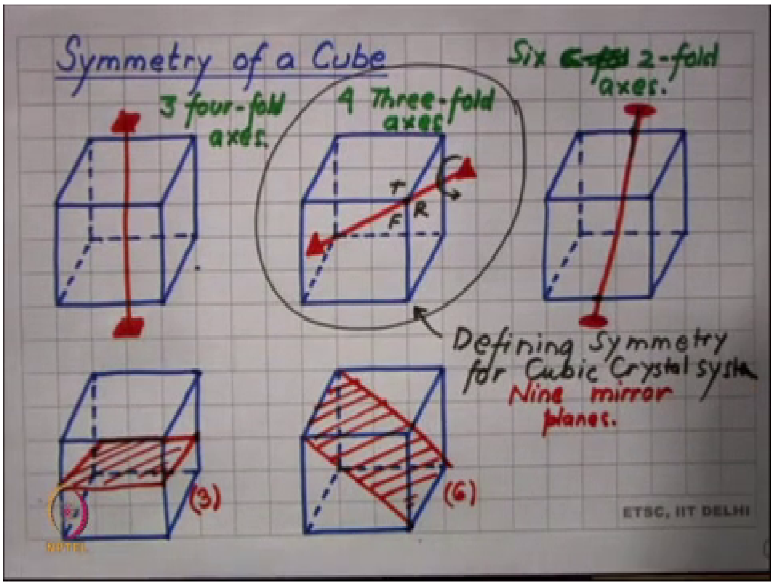

So, let us look at the symmetry of the cube. So, cube or one very obvious symmetry of the cube is of course, the 4-fold axes passing through the centre and normal to it is faces there will be 3 such 4-fold4-fold axes. Then if you look at the body diagonal of the cube so, let me try to draw the body diagonal and think of a rotation about the body diagonal and this is where a model will help if you have a model of a cube it will be nice to stand it on the body diagonal and try to rotate it. If you do not have you can always make a simple paper model of the cube not very difficult to make. So, this axes this body diagonal is a 3-fold axes of the cube you can appreciate that 3-fold by looking at this corner where this body diagonal is a merging and if you see at that corner 3 faces are meeting. These 3 faces are the top face the front face and the right face, and if I rotate about this axes if I rotate about this axes I will interchange the top face to the front face the front face to the right face and right face back to the top face.

So, the cube will come into self-coincidence by rotation about this axes and; obviously, since there are 3 faces in one complete rotation the self-coincidence will come 3 times. So, this is a 3-fold axes of the cube and since there are 4 body diagonals I am not drawing all of them here also I had not drawn the other. So, as not to clutter my diagram, but you can draw it in your notebook. So, there are 4 such three-fold axes, 4 three-fold axes. The cube also has 2-fold axes these are if you take any edge, if you take any edge and the center of that edge and you take an opposite edge and let an axes let an axes pass through I am drawing the axes in red. So, let me use the red. So, this will be you can rotate a cube by 180 degree to bring into self-coincidenceand we are used to parallel faces for defining this 2-fold there are 12 edges in the cube. So, that will give you 6 such 2-fold axes. You can see cube is highly symmetric sorry 6 2-fold axes. Then cube has mirrors some of them not very difficult to see

So,for example, we see that we have a horizontal mirror if I draw this plane the top and bottom half will reflect into each other you will have a mirror plane also. So, there will be 3 such mirror plane and you can of course, draw another diagonal mirror if I look at this plane. So, this is also a mirror you will have 6 such mirrors. So, nine mirror planes. So, you can see the cube has a lot of symmetry 3-fold, 4-fold, 2-fold and these mirror planes and a cubic crystal system will have many of these symmetry, but it is the it is the 4 three-fold axes is what is has been taken as a defining symmetry of cubic crystal system.

So, we will continue our discussion on the classification of the lattices we have already shown in this video that it is the symmetry and not the unit cell shape and how different symmetry define different crystal system. We have mainly focused on the crystal system classification here which is based on the point group symmetry in the next video we will take up the classification of bravais lattices and some of our earlier problems that why cubic c was absent, but face centred cubic was present. So, we will look in that up in the next video.