Experimental Physics - II
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Lecture - 47
Theory of polarization

today I will discuss about the Polarization by Double Refraction.

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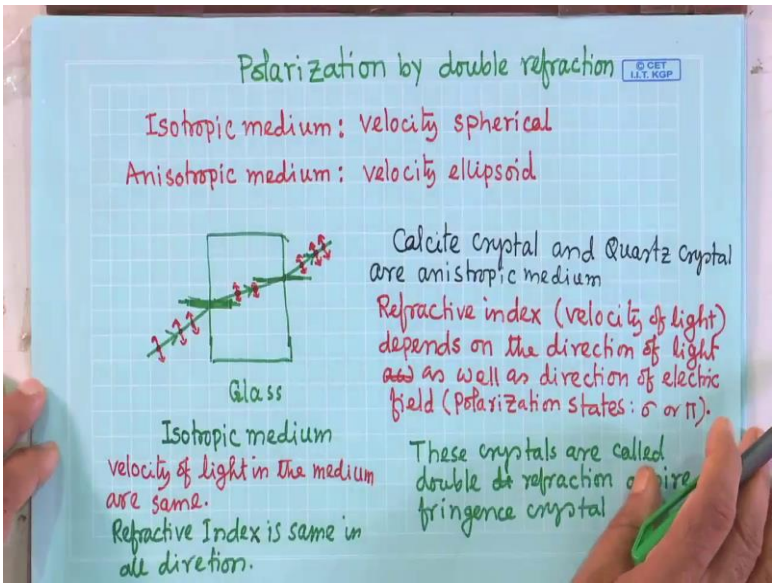

what is that of polarization by refraction? medium we can divide into two types, one is called isotropic medium and another is called anisotropic medium, these are general term isotropic and anisotropic general term. for any property, the medium can show the isotropic property or anisotropic property. in this case about the velocity of light through the medium whether in all direction the velocity of light is same in the medium or not. If velocity is same in all directions, so then it is called the isotropic medium, if velocity is not same in all direction then it is called anisotropic medium,

velocity same means all direction is called the velocity spherical and velocity is not same in all directions is called velocity ellipsoid, common material for refraction or refraction is the glass material, this material is isotropic material, its velocity is same, velocity of light is same in all directions, But there are some transparent crystal. It is calcite crystals and quartz crystals; it is they are like glass. Glass is not crystal, but this calcite and quartz they are crystal, but they are transparent like glass.

in this crystal also we see the refraction, but the refraction that is or the velocity of light in this crystal are not same in all direction. it is the anisotropic medium, velocity depends on the refractive index or refractive index is defined by the velocity of light in the medium with respect to the velocity of light in vacuum. refractive index velocity of light depends on the direction of light as well as direction of electric field.

that is polarization state. Polarization states are two types either sigma polarized state or phi polarized state, these crystals are called double refraction or birefringence crystal, ok; calcite crystal and quartz crystal. There are other crystals also; they are called double refraction crystal or birefringence crystal,

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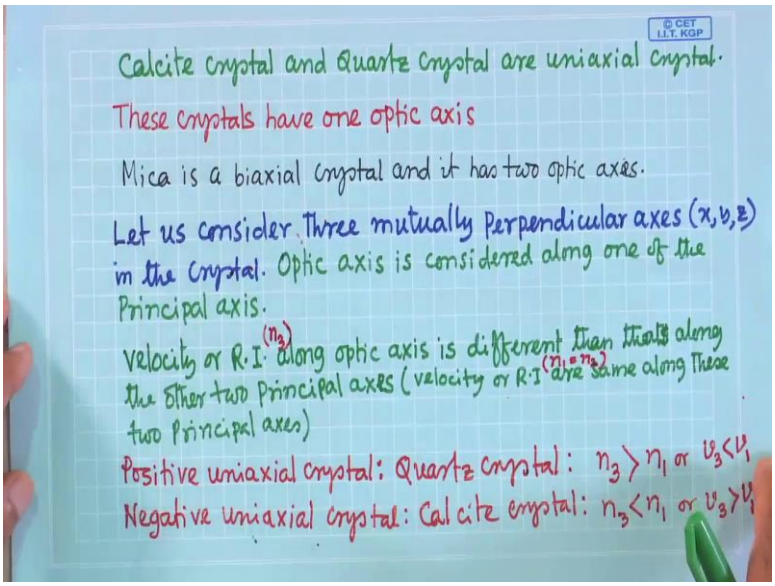

we will discuss about just keep we keep our discussion with these calcite crystal and quartz crystal. these two are again, it is the uniaxial crystal means, uniaxial crystal means that in one direction there is a, in one directions the velocity or refractive index or whatever the that is different than the other directions. that is called uniaxial crystal.

in one direction it is different, but other directions; if you consider these mutually perpendicular 3 coordinate x, y, z Cartesian coordinates. in one directions these property is different than the other two directions. See, in other two directions property are same, refractive index of velocity they are same, that is special direction that is called optics axis. In this crystal, so there is uniaxial crystal there is a special direction, axis, that direction is called optics axis. these crystals have only one optics axis,

but there is some other crystal like mica; mica is a biaxial crystal means it has to optics axis, will not discuss about the biaxial crystal; will limit within these uniaxial crystal and that is quartz crystal and uniaxial crystal. let us consider 3 mutually perpendicular axis x, y, z in the crystal. optics axis is considered along one of one of the principal axis x, y, z is principal axis. one of the axis is considered as a optics axis.

velocity or refractive index say along the z axis, so is a refractive index is say n 2 or n z. that is along the optics axis. z axis if you consider that is the axis optics axis. velocity or a refractive index along the optics axis means along the z axis is different than that along the other two principal axis. that is the velocity or refractive index, so are same along these two principal axis,

z axis is the optics axis. See, its refractive index if it is n 3 or velocity v 3 other two axis x and y in these to axis the velocity and refractive index are same; so that means, refractive index is one along the x axis and refractive index in two along the y axis. they are equal or velocity v 1 equal to v 2, now, these this calcite crystal and quartz crystal there is a difference both are uniaxial crystal, but there is a difference. quartz crystal is called the positive uniaxial crystal and calcite crystal is called the negative uniaxial crystal,

these in case of quartz crystal refractive index along the x axis along the z axis that is n 3 is greater than refractive index along the x or y axis. it is say n 1 or n 2, they are equal. they are equal, n 3 is greater than n 1 means v 3 is less than velocity is less than v 1. in case of quartz crystal, velocity along the optics axis is less than the velocity along the x axis or y axis. And in case of calcite crystal that is called negative uniaxial crystal it just reversed, Refractive index along the optics axis n 3 is less than n 1 or n 2 or velocity is along the optics axis is greater than the velocity along the other two directions that is v 1 or v 2,

that way we differentiate the uniaxial crystal. quartz crystal is example of positive uniaxial crystal and calcite crystal is example of positive uniaxial crystal and calcite crystal is example of negative uniaxial crystal. that is defined this way.

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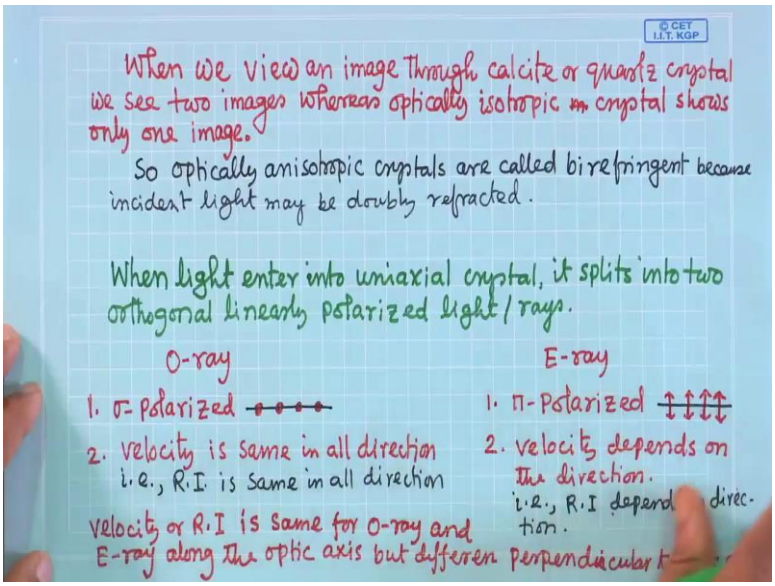

when we view the image due to refraction through the glass. we say we see one image for a particular one object, In case of double crystal when we when we view an image through calcite or quartz crystal, we see two image, two images, whereas optically isotropic crystal isotropic crystals shows only one image as I mentioned about the if you see through the glass, so generally we are familiar with this type of refraction. that is isotropic medium. one object you see one image, but in calcite crystal or quartz crystal we see two images for a particular one object.

so that means, these crystals are an isotropic crystal and these anisotropic crystal that is why we call them birefringent because incident light may be doubly refracted, when light enters into uniaxial crystal it splits in to two orthogonally orthogonal linearly polarized light or rays, when light enters into the uniaxial crystal, so it splits into two orthogonal linearly polarized light or rays. one of them is called this O-ray and another is called E-ray. O-ray is ordinary ray and E-ray is extra ordinary ray.

if you compute this two ray their characteristics are, so O-ray is, O-ray is sigma polarized light. sigma polarized light you know this this dot is the electric field direction, it is a perpendicular to this paper plane of paper, and this is the direction of light. now, these plane of polarization plane of polarization means the plane contains the direction of light and the and the electric field vectors, in this case this is this plane perpendicular to the plane perpendicular to the to the plane of this paper,

if it is if this plane of polarization is perpendicular to the plane of incidence plane of incidence means which contain the reflected which contain the incident ray refracted ray or reflected ray and the normal to the to the crystal, ok, crystal surface where this polarization this refraction is happening. that is the plane of incidence. that plane of incidence in this case say it is this plane of paper, plane of this paper. now plane of polarization is perpendicular to the plane of incidence. there is the sigma polarization, and O-ray is all the time is sigma polarized light,

E-ray is the phi polarized light, plane of polarization this direction of light and the electric component, so that is parallel to the plane of plane of incidence, in this case this is plane of paper is the plane of incidence as well as plane of polarization because this electric component is as well as this direction of light is on the plane parallel to these paper, these type. E-ray is sigma polarized light.

Velocity is same in case of O-ray ordinary ray velocity same in all directions, means refractive index is same in all direction, Whereas, in case of E-ray velocity depends on the direction that is refractive index depends on the direction, Now, for E-ray and O-ray velocity or refractive index same, for E-ray and O-ray along the optics axis, but velocity of refractive index are different for O-ray and E-ray perpendicular to the optics axis,

these so this we can differentiate the O-ray and E-ray following this characteristics. one thing common for both the velocity or refractive index for O-ray and E-ray are same along the optics axis. then we can define the optics axis which what is optics axis. optics axis in the crystal is the axis in that direction the velocity or refractive index for E-ray and O-ray are same, that way we define the optics axis.

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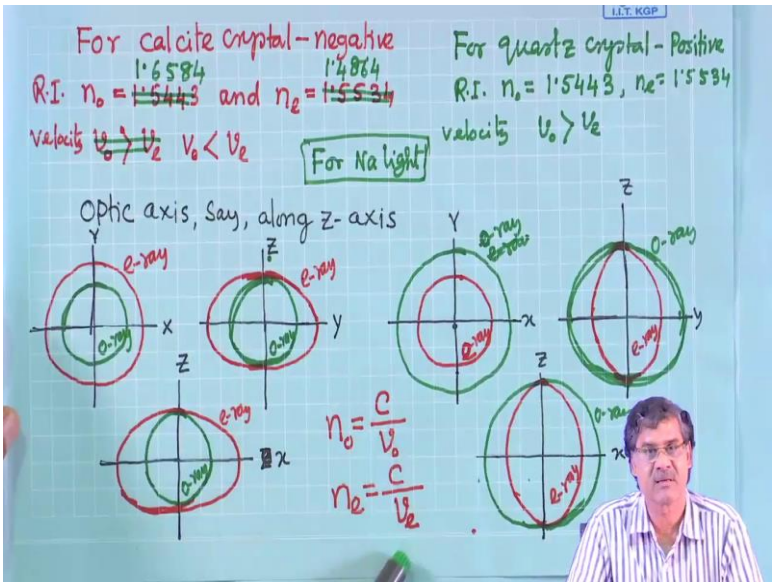

these two crystal for these calcite crystal and the quartz crystal. The refractive index if you use the sodium light means this it is a nearly monochromatic light sodium the lines wavelength is 5893 angstrom for this wavelength because refractive index depends on wavelength it varies dispersion.

for this wavelength refractive index for O-ray and E-ray in calcite crystal is 1.6584 and 1.4864 respectively, refractive index for O-ray is greater than the refractive index of O-ray sorry, E-ray. refractive index for O-ray is greater than the refractive index of E-ray, in case of calcite crystal or else for quartz crystal refractive index for O-ray is less than the refractive index of E-ray and this for sodium light this the value 1.5443 and 1.5534.

for quartz crystal the velocity of O-ray is greater than the velocity of E-ray, whereas for calcite crystal velocity of O-ray is less than the velocity of E-ray, and another things that velocity or refractive index are same for O-ray and E-ray along the optics axis. these value are not along the optics axis, See, other direction all,

if you consider the velocity in the calcite crystal for calcite crystal, velocity of O-ray is less than velocity of E-ray, And x axis and y axis they are in that two directions the is the isotropic, isotropic means velocity will be same in this two direction, but they will be different for O-ray and E-ray, in x y plane, in x along x and y direction in x y plane if I consider the velocity draw the velocity; there will be circle, there will be circle. But

velocity of, so this will be bigger circle then the circle for O-ray because velocity for O-ray is less than velocity of E-ray,

if you consider the z axis and y axis, so in this case for O-ray again now the refractive index of velocity of same in all directions, x, y, z directions, all the time it is spherical, this we showed these velocity spherical, here also for O-ray, so we will just draw the will just draw the circle the velocity same in all direction x y z direction, it will be circle now velocity is same for O-ray and E-ray along the optics axis. optics axis we have considered along the z axis,

velocity of E-ray is same as the velocity of O-ray. immediately we can we can consider the same velocity of O-ray at this direction, but other direction x and y direction velocity of E-ray is greater than they will be greater than the velocity of O-ray. you can draw these it will be ellipsoid, here also the same if you instead of y axis if we consider x axis it will be same, we can draw the velocity; we can map the velocity of O-ray and E-ray through the calcite crystal uniaxial crystal that is the calcite crystal. that is the picture, if you consider the quartz crystal. it will be just reverse,

again in case of quartz crystal, so only these you are seeing the change, this one is now velocity of E-ray is less than the velocity of O-ray, Now, this red one is inside, red one was outside that is for E-ray, so now, for E-ray these the this sphere of the circle is inside and for O-ray v 1 this is the outside bigger circle bigger sphere,. z axis velocity will be same, in other direction x or y direction velocity are different and velocity will be just reverse of that.

Velocity of E-ray is less than the velocity of O-ray, velocity of O-ray, here also velocity we have to keep here, this velocity higher one because the velocity of O-ray is same in all directions. that condition we have to fulfill. then this velocity of E-ray is along the x and y direction is less than the O-ray. you will see the ellipsoid, ellipse like these, ok, this. If you change x or y, so it will remain same, ok; for quartz crystal and the calcite crystal these are the map for the velocity distribution inside the crystal,

it is just, it is nothing but the velocity its nothing, but the similar mapping of the refractive index, ok; just whatever velocity of higher. refractive index will be lower, just opposite wise you have to draw. since these c is constant, so they are reverse, they

are inverse; c is velocity in vacuum, whatever here we have drawn, so this is nothing but the either its velocity or opposite way it is refractive index distribution in the crystal,

I will continue this discussion. In the next class there are lot of things to tell you. I will stop the discussion here.

Thank you for your attention.