Experimental Physics - II
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Lecture – 52
Expt. on e-ray and o-ray

In last class we have discuss about the double refraction in calcite crystal as well as quartz crystal. there we have seen that there are when this light passes through the calcite crystal or quartz crystal. there will be 2 image there must be double refraction. there is one is for O - ray and another is for E - ray that image will see today I will demonstrate the experiment based on this double refraction.

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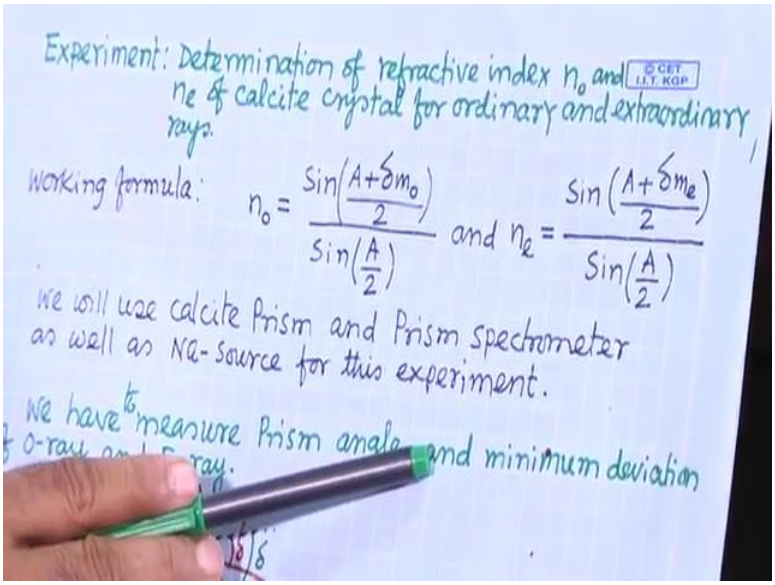

that experiment will do today that is determination of refractive index n o and n e of calcite crystal or ordinary and ex ordinary rays. refractive index we have earlier for glass prism we have found the refractive index. how to find it that we have we have done the experiment using the prism spectrometer.

there is what we have done we have measured the prism angle a as well as we have measured the minimum deviation of the light. this monochromatic light refracted through the prism. here also same thing we have to do. instead of glass prism we will take calcite prism and now the same light monochromatic light sodium light we will fall on the calcite prism and then if we see the refraction then we will see this 2 image.

we have to measure the minimum deviation of this two image; one is for O - ray another is for E - ray, as well as we have to measure the deviation minimum deviation sorry the angle of prism calcite prism. what will formula is refractive index equal to sin A plus delta m minimum deviation divided by 2 divided by sin A by 2, A is the angle of prism and delta m is the minimum deviation

now, here 2 this 2 refractive index, one is n o or O - ray. here we have written this minimum deviation for O - ray and here we have written the minimum deviation for E - ray.

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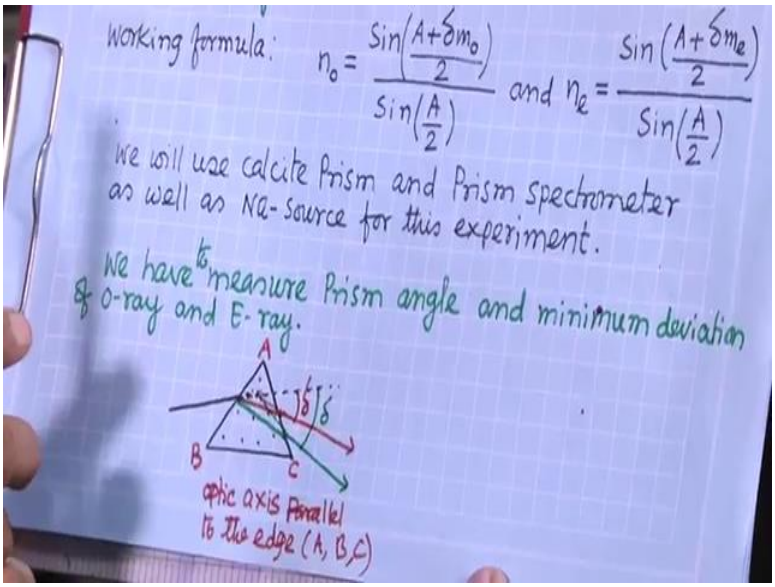

angle of prism same for both cases, only the derivation minimum deviation will be different for 2 rays, we will use calcite prism and prism spectrometer as well as sodium source for this experiment as we used for glass prism where we measure the refractive index single refractive index for that glass prism. we have to major prism angle and minimum deviation of O - ray and E - ray. if this is the calcite prism.

now, in case of calcite crystal or quartz crystal double refraction crystal. there is optic axis of the crystal along the optics axis the refractive index is same for O - ray E - ray, theirs velocity of O - ray and E - ray are same along the optic axis. that we have discussed, when it; well, like pass to the prism the direction of light is perpendicular to the optic axis then there is velocity their difference of the velocity are maximum, one is for E - ray if it is higher than for O - ray it will be lower velocity. reflective index just

will be opposite. will be lowers for one ray and higher for another ray. in details we have discuss in previous class.

this crystal that calcite prism that is taken that is cut in such a way that optics axis is perpendicular to the, it is parallel to the edge of the prism is parallel to the edge of the prism. dotted line I have put. that dotted line is the direction of the optics axis. direction of the optics axis here is a perpendicular to the plane parallel to the edge of the prism. when light falling this is the incident light. when it will pass through this prism. it is direction of light is all the time it is perpendicular to the optics axis.

in this case this refractive index will be reflectively is difference for O - ray and E - ray for this material calcite material the difference will be maximum. that is what we will measure. when it is passing through the calcite prism. we will see 2 image; that means, there will be 2 refracted rays. one is for O - ray and another is for E - ray. this minimum deviation for O - ray and E - ray is delta that; there will be it is not only for minimum deviation we will see always 2 image and then we have to find out the minimum deviation position and at that position we have to measure the angle minimum deviation angle for O - ray and E – ray,

And also, this angle prism this A we have to measures. how to measure the angle of prism that, same method same process we will use and how to measure the minimum deviation. same method we will use. here only we have to major for 2 days we will see 2 image for that we have to major minimum deviation for each case.

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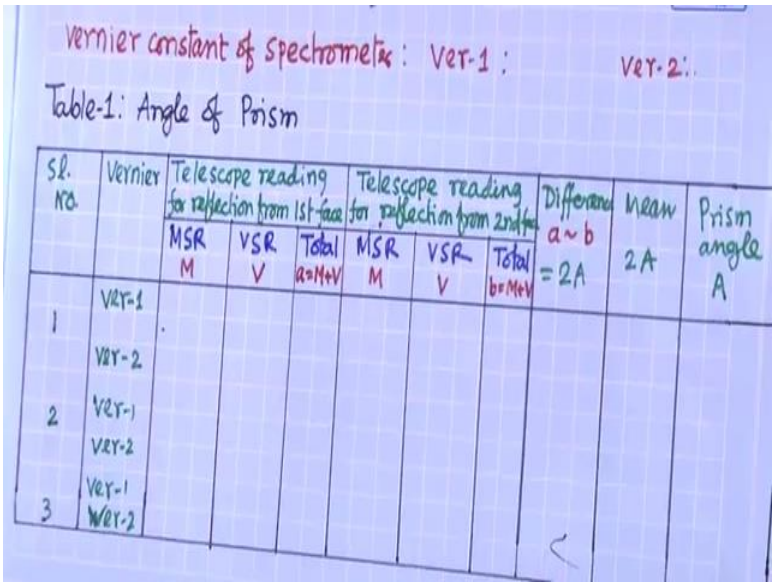

what data explain; in the data we have to record. prism spectrometer we will use Vernier constant of the spectrometer Vernier 1, Vernier 2 many times we have discuss. then we will measure angle of prism serial number Vernier for Vernier 1, 2

angle of prism we know this how to measure this apex edge of the prism we will put towards the telescopes sorry, towards the collimator and then this light will fall on both refracting surface and then from refracting surface this there will be reflection of light. that reflection of light will measure. then that will the difference of these 2 reading will give us 2 A we will give us 2 A. we will find out we will take few reading observation, we will find out mean of lay from theirs half will be the prism angle.

then next we will measure the minimum deviation angle of minimum deviation.

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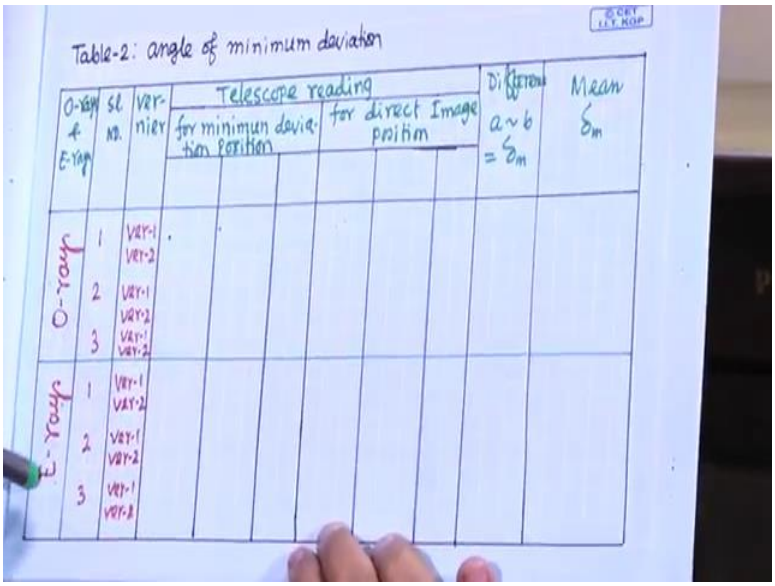

we will see this two rays; O - rays and E - rays. for O rays we have to take telescope reading. telescope reading for minimum deviation position and telescope reading for direct image measurement from direct image from the collimator direct reading and this is the minimum deviation reading for O - ray then we will find out take few gradient find out the mean delta m o delta m o for O – ray.

Similarly, for E - ray set at the minimum deviation position for E - ray and take the reading, few observation and take direct reading and then find out the mean of minimum deviation delta n e, there is the task we have to do.

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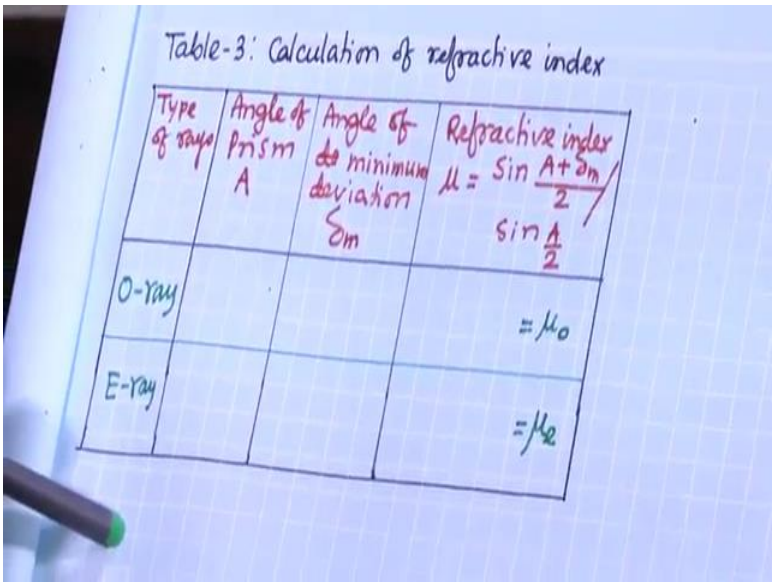

And then of course, we can calculate the refractive index for O - ray and E - ray angle of prism from table 1, angle of minimum deviation from table 2 and then refractive index we can calculate mean o and mean e,

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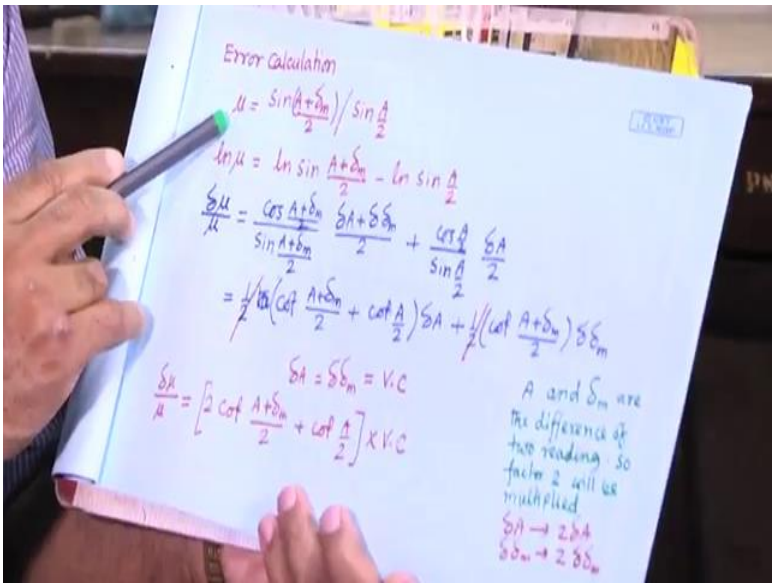

error calculation also wants to do in the measurement of refractive index. this is the formula. take log and then differentiate that one. finally, you are getting del mu by mu equal to 2 cot A plus del m by 2 plus cot A by 2 into Vernier constant minimum deviation.

from here as I wrote that angle of prism and delta m all the time this, we are they are is not direct one reading. we are taking difference of two reading. that is why in error 2 times of that 2 times of Vernier constant for least count that will be the error. that that 2 if we multiply that 2 if we multiply. this half is going and delta A equal to delta del m equal to Vernier constant. that is why this formula I have written this way one can calculate the error percentage error for this measurement. now, I will demonstrate the experiment.

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we have set the experiment; here, we have set the experiment these the prism table prism spectrometer. this is calcite that calcite prism, we have set at minimum at deviation position refractive position and here you can see in our mobile camera.

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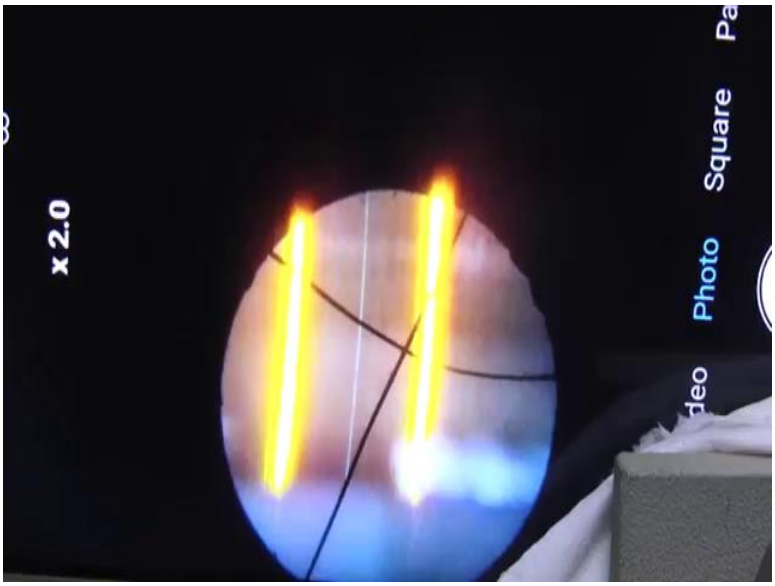

We can see that there are two image. see it is an refractive position I can make it slightly bigger; you are seeing the cross wire and that 2 image you are seeing 2 image So from collimator this we have used sodium light. there is a slit one image one image one source slit source.

for ordinary prism you will see one image, but here we have used calcite prism and how that prism is made as I told this it is axis optics axis are parallel to the edge of the prism. in we have set at refracting position and we are getting the we are getting the double refraction and thus there are two image and that search in mobile camera I showed you. I will just I will disturb it and then again, I will show you.

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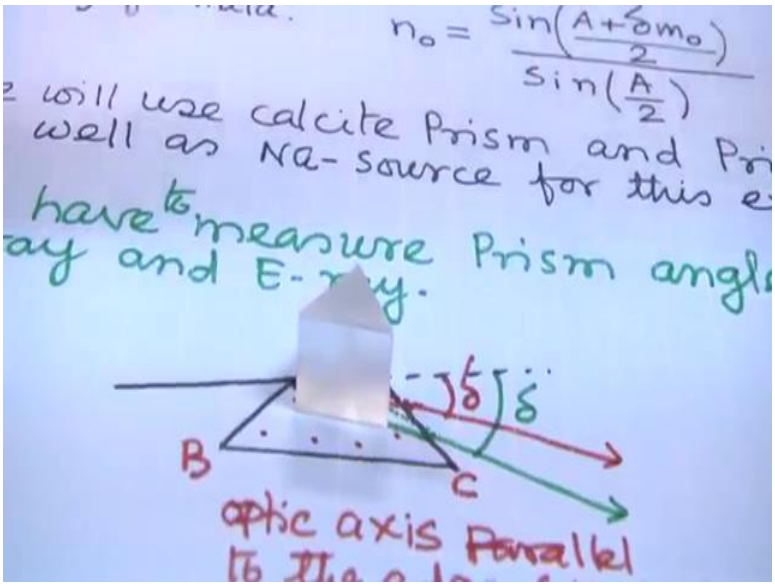

this is the prism, this is the calcite prism very small prism, it is similar to the glass prism it is similar to the glass prism. I can just put here I can just put here as I have drawn this is the epics edge. these are refracting surface; this is the refracting surface and other side also refracting surface ok and this is the base back side this is the base these are nonreflecting surface

it is optics axis is parallel to the edge parallel to the edge it is a perpendicular to the surface of the plane of the paper plane of the paper exactly I have put whatever picture I have done. I put this one is same way. it is this way ok, it is this way. Now let me let us see the direct image of the object without prism table.

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direct image of the is; it is not focused well I think yes. direct image I will show you in camera you see this one image you can see hopefully I will be able to show you. Yes, I got it,

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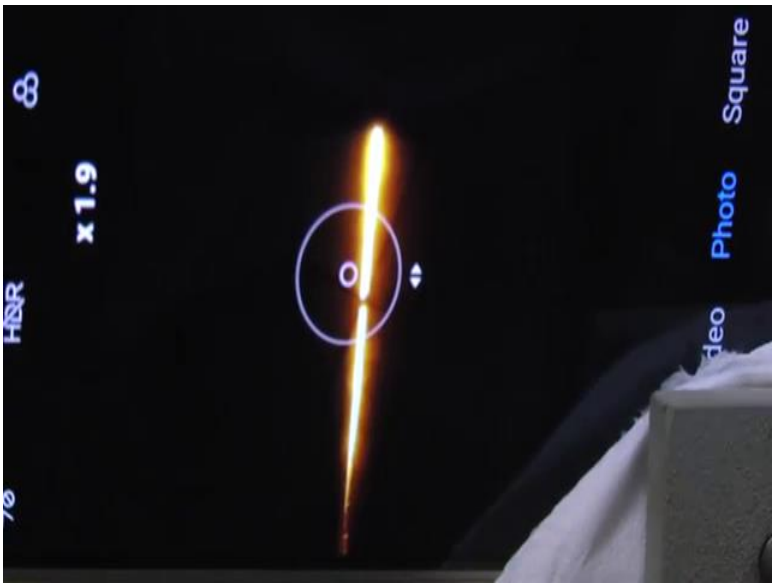

See if I just you see just one image, just one image you can see these the direct image of the slit, now we can take direct reading as we need for measurement of minimum division. you have Vernier I am not going to take reading. we have Vernier constant 1 and Vernier constant 2.

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you should note down this two reading; you should note down this reading for this direct position of the image and yeah cross wire should concede at the, this cross point should be at the middle of this image should be at the middle of this cross wire, now; this is the single image direct image you are seeing, now what I will do. I have to actually if this direct reading may not be useful, but we will see.

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Now, I will put this I think I will put this prism it is epics edge it should be at the center of the prism table at the center of the prism table. now, here you can see that this very

small prism because this is made of calcite quite costly. now, what will see the reflection? I have put prism. how to put prism it is a very important, because this you see edge this epics edge should be at the center of the prism table.

now, if I see the reflecting rays yes, here I can see reflecting yes. somehow is the, I am not one should not change the focusing. parallel rays one should set for parallel rays, but I have not done properly, but you should do it. here I am seeing the image reflecting due to reflection.

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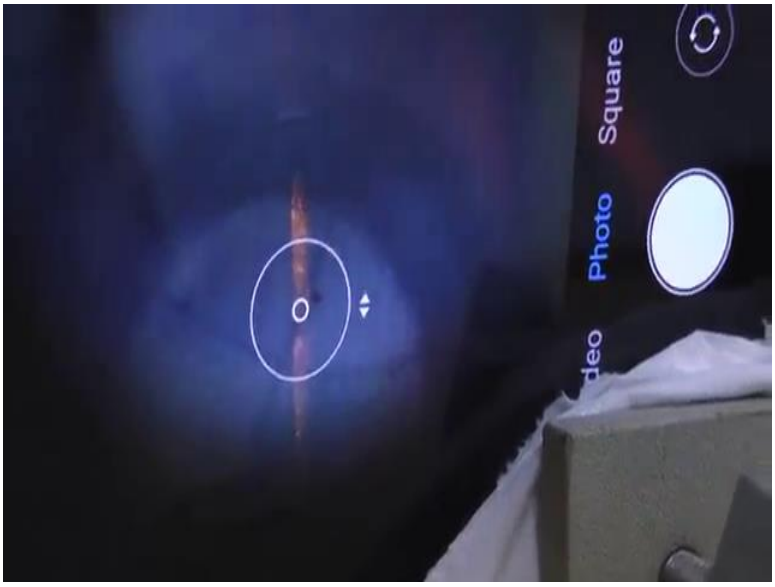

I will show you this image I will show you this image. Yes, I think I am getting yeah, I think if I yes you can see the image, but one can take in middle yes, we are seeing this single image due to the reflection. we have to note down the reading for from Vernier 1 and Vernier 2 this is for the reflection from one phase.

similarly, we have to just see the reflection from the other side I think I will. after taking reading you have to set the see the refracting is, I can see here; yes, I am able to see. I am able to see it. this is another reflection from another phase; reflection from another phase image I can show you.

let us let me try, I do not have to take in this position; yes, it is there yes, it is there. you can see another reflection image, now, for this position you take the reading from Vernier 1 and Vernier 2 few times 3 observation you should take and take the difference

of this 2. that will give you 2 A. find out the mean 2 A and half of it will be the angle of prism this is done.

Now, I will go for the minimum deviation position for that what you have to do? The prism I am rotating the prism table to keep this non refracting surface parallel to the collimator So; that means, this is the refracting surface light will enter into this and this other refracting surface. it will be refracted towards the; it will bend towards the base. I will expect the deviated refracted light along this direction. let me see.

let me see where I can see the no. I have to rotate; I have to rotate this way and find out the deviated rays you know I think I will put it this way. yes, I got the deviated light, but this is not at the minimum deviation position it is not at the minimum deviation position, no, as you cannot getting reflection it is not refection, it is not reflection. you put light this as I should able to see. this normal position and then I can keep this way.

light is falling. normally is this this. it is a through go that way, but I want to show you. I would like to get this light will fall this way this is the normal. it is bend this way. I would expect when I will rotate this way, I would expect the minimum deviation among this is I think this maybe the let me check yes, I got it, but it is defocused somehow, I have to focused. I got it is the minimum deviation position it is not minimum deviation position, but it is just deviation. I am getting 2 image I will show you that is very interesting that is very interesting while I am getting 2 image; I am getting 2 image,

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if I extend it you see I am getting 2 image this sorry also you can see, but somehow, but through telescope I can see very sharp image, but here on camera it is we coming slightly diffused 2 image you are seeing; that means, there are E - ray and O - ray 2 image. now, I have to find out the minimum deviation position. if I rotate the crystal, I change the angle. it is moving this side.

I will move the telescope and this one it is same side, but I missed it seems no. It is, it will more I have to go off, yes, it is here. Now, let me find out the minimum deviation position. I have to rotate, fine. this is the minimum deviation position; this is the minimum deviation position I will show you now. That if I rotate the prism either side it will move it same direction; it will move in same direction, yes, I got it,

It is the minimum deviation position, because you see I am now rotating the prism table on in one side. it is going this that side; Now I am rotating the other side it is coming back to the minimum deviation; I will continuing the rotation same way it is the again going back. I am rotating other way. it is at minimum deviation position and if I continue the rotation in same direction it is going back ok, now other way,

this is the minimum deviation position. you are in just set your cross wire with one cross wire with one and for this particular this one we find out the minimum deviation position I am rotating the this, yes. this is the minimum deviation position for this ray, you note down the reading from Vernier 1 and Vernier 2.

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few times you do it; few times you do it at least 2, 3 times you just try to find out the just you change it and try to find out the best place and take reading.

Now, after that you take the, then you should take the minimum deviation position for the second one. cross wire should you should put with the second one sorry, this first one and then second one. I think I have to adjust it is at adjust the camera, yes.

Now, it is coincide with the second one coincides with the second one, now for the second one there is the minimum deviation for second one. you take the reading first Vernier 1 and Vernier 2. few times reading for that you should take and then already you have taken the direct reading, or you should take now or for each case you should take.

you have to make sure that when you are after fixing the prism table at minimum deviation position at minimum deviation position you should not disturb the prism Vernier only secular scale that reading from secular scale for 2 Vernier, after taking the reading you have to rotate the secular scale to take the direct reading ok, just take out the prism table prism from the prism table and take the direct reading,

initially we took, but that will not work because I have change the prism table. it will not work. what we have to do after taking this two reading for the same this minimum deviation we have. both rays or at minimum deviation position minimum deviation position, but they are at different angle. that 2 angle we have measured. this prism table we should not disturb ok, ones we set for the minimum deviation position then you should take out this prism table take out the prism table and take the direct reading. only I am rotating this one telescope.

you set cross wire at the cross wire at the direct image; cross wire at the direct image direct image I have shown you. I am not showing again. set the cross wire at the direct image. now, you take the reading for Vernier 1 and Vernier 2 this you have 2 reading for minimum deviation for O - ray and E - ray now you have direct reading for both the same. take the difference of this reading so direct reading, if you take difference between direct reading and this for O - ray minimum deviation. you will get the minimum deviation for O - ray and reading for E - ray and this direct reading. you will get the minimum deviation for E - ray and prism angle already you have measured.

you will be able to find out the two different refractive index, because delta m are different because delta m are minimum deviation, this minimum deviation we are different, delta m 0 is different than delta m e. that's why you will get the refractive index 2 different reflected index this is very nice experiment to demonstrate the E - ray and O - ray, and how to measure the reflective index of a calcite crystal using the just monochromatic light like sodium I will stop here.

Thank you for your attention.