Experimental Physics - II
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Lecture – 30
Determination of the dispersive power, Cauchy constant and resolving power of a given prism

in last class, we have demonstrated a how we can measure the unknown wavelength of a light using the prism spectrometer, today, we will do the similar experiment, but aim of the experiment is different. in last experiment, we have we have first we have found out the deviation versus wavelength curve, so that is called the calibration curve

And then for any unknown light, any unknown wavelength of that light if we measure the deviation, then from the deviation corresponding wavelength we can find out the on that curve, so that is how that curve is called the calibration curve now today the experiment will do that dispersive curve, dispersion curve of the prism ok; prism has dispersion power.

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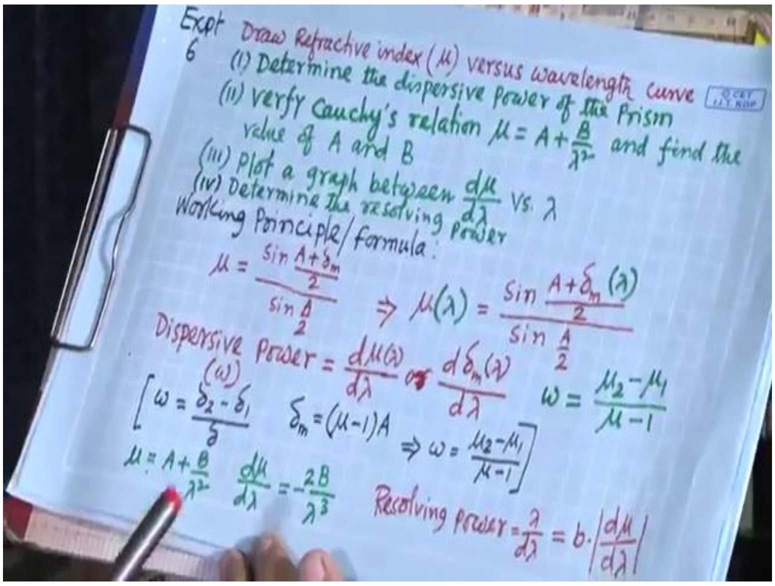

our aim of the experiment which will demonstrate now is draw refractive index versus wavelength curve, so that is called the dispersive curve, Now, after drawing this curve dispersive curve, determine the dispersive power of the prism. Then second, verify

Cauchy's relation mu equal to A plus B by lambda square, and find the value of the of A and B, this is the constant, it depends on the prism materials,

Third plot a graph between d mu by d lambda that dispersion d mu by d lambda versus the lambda ok; not dispersion, this is the dispersive power d mu by d lambda dispersive power versus the lambda. Then determine the resolving power of the prism, dispersive power and resolving power of the prism as I discussed earlier. aim of this experiment is to find out of this parameter,

working principle or formula for this experiment is you know this refractive index is equal to sin A plus delta m; angle of prism plus angle of deviation minimum deviation divide by 2 divide by sin A by 2, this is the relation so that means, to draw refractive index versus wave length. for different wavelength we have to find out, we have to calculate the refractive index to calculate the refractive index I have to know, I have to measure two parameters; one is angle of the prism, another is minimum deviation.

Angle of the prism does not depend on the wavelength ok, so for any wavelength you can measure the angle of prism and, but minimum deviation it depends on the wavelength. For each wavelength known wavelength, we have to measure the angle of minimum deviation Then you can find out the refractive index for different wavelength. this is the experiment we have to do and then draw a curve of that. And now, actually yes this I had mentioned here. this mu is a function of lambda wavelength ok, because this deviation minimum deviation is a function of lambda.

how this dispersive power this refractive index, it depends on the wavelength so that is the basically, so I think here I have not that the Cauchy relation, that the Cauchy relation ok; mu it depends on the wavelength following this relation, so this is the Cauchy's law. when will we know the refractive index as a function of wavelength from that data one, we can verify whether this relation is valid or not; of course, it is valid and also you can find out this constant A and B,

And, then here find out the dispersive power of the prism. from this curve we can find out the dispersive power, so that is mean dispersive power is d mu by d lambda, so with change of lambda how refractive index changes. this or since is a function of minimum deviation is a function of lambda. one can also tell the dispersive power is d delta lambda by d lambda, And, one can find out; one can find out that mu this dispersive power, it is a omega equal to mu 2 minus mu 1 divided by mu minus 1.

what is mu 2 and mu 1 you have refractive index as a function of wavelength. at two wavelength at on the curve, you can choose two refractive index ok; obviously at two wavelength one is mu 2, another is mu 1 and then mu is average of mu 2 and mu 1; so middle one from the curve if you find out so from this one can find out, from this definition of the dispersive power the relation comes like this, how you can determine the dispersive power of the prism from this curve, using this relation we can easily find out the dispersive power of the prism,

now this dispersive power whether, its independent of wavelength or it depends on wavelength; if it depends on the wavelength, how it depends on the wavelength this dispersive power so how it comes here, just I try to show ok, so anyway. dispersive power how it depends on the wavelength, so this is the Cauchy's relation formula. from here if you find out d mu by d lambda, so it is a equal to minus 2B by lambda cube ok, so that means the dispersive power depends on the lambda ok, it depends on the 1 by lambda cube

here plot a graph between d mu by d lambda versus lambda here if you plot see you can see the dependents of the dispersive power on the wavelength and it will depend on the wavelength, it is not independent as you can see from the Cauchy's formula, Now, resolving power; resolving power is defined by lambda by d lambda or del lambda And for prism, it is a one can find out that it is a equal to B, B means base this length of the base B d mu improve dispersive power of the prism,

dispersive power of the prism will find out from this curve itself ok, and it is measuring the base of the wavelength prism is not difficult, it is around I think 10, 15, 20, 30 centimetre, so that is also known to us. one can find out the resolving power of the of the prism and from the value of the resolving power one can estimate, whether this prism will be able to resolve to separate the wavelength of del lambda, wavelength of del lambda,

about a about if it is a mean wavelength say lambda 1 and lambda 2, so lambda 1 minus lambda 2 is del lambda; now lambda 1 and lambda 2 whether it will the prism can resolve or not ok, so that we can find out. taking this lambda is equal to lambda 1 plus lambda 2 divided by two average one, And if it is known and this part from find out from here, so del lambda you can find out that means, what will be the what should be the separation of the wavelength, which we can resolve using this prism ok, so one can estimate basically.

so for knowing this all this information first we have to do this experiment, Now, what is the experiment we have to we have in the experiment we have to measure the we have to measure the angle of prism ok; and we have to measure the minimum deviation as a function of wavelength means for different colour, we have to measure the wave length ok, minimum deviation. Then rest of the thing just we have to calculate, and we have to draw the curve, and then rest of the part is analysis

the experiment is exactly similar, the experiment we have demonstrated in last class at deviation versus the wave length measurement, in that case also we required the measurement of the angular prism ok, also we are measuring; we are measuring the just deviation fixing the prism fixing, the prism at minimum deviation of sodium light And for that position of the prism, what was the deviation for different wavelength so that deviation you can measure, so that was not the minimum deviation.

Only difference between this two experiment, experiment what about we discussed in last class del lambda and here new lambda or l lambda, refractive index versus wavelength. Here will not measure the deviation as a function of wavelength, each time we have to measure the minimum deviation for each wavelength ok, so that is the difference

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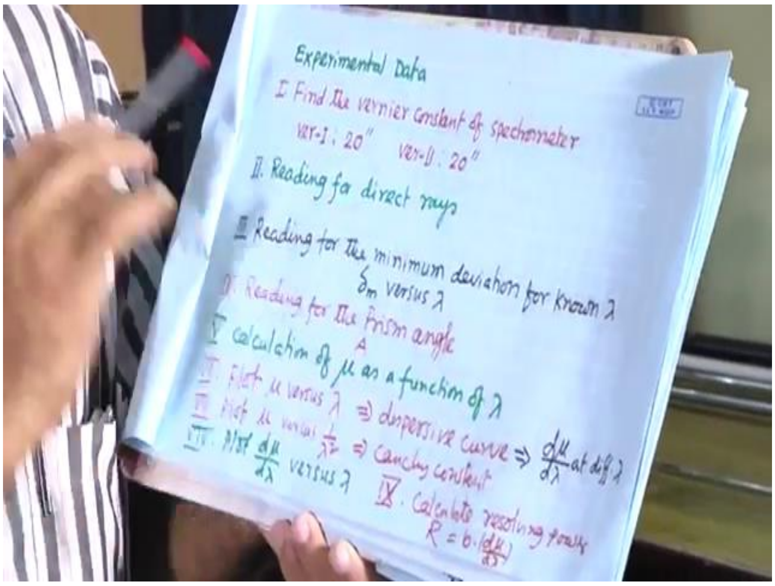

what is the step we will follow; I think I will not show everything in detail?

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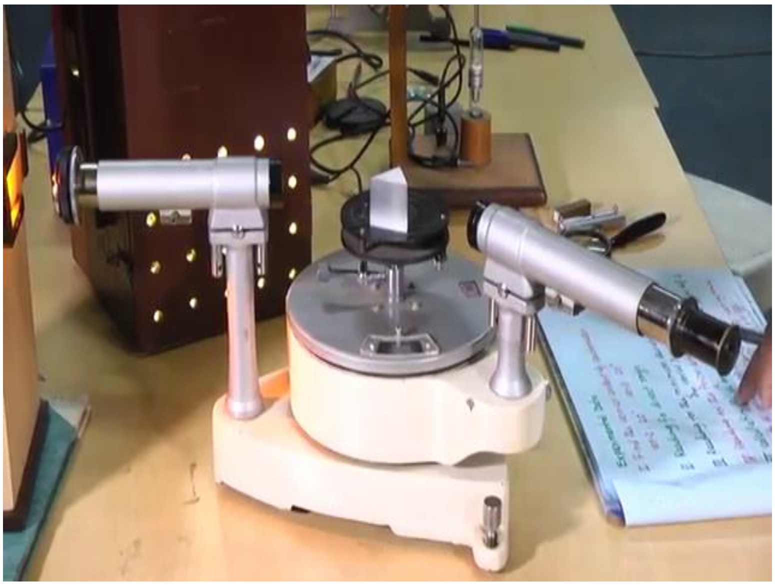

first this is the let us this is the of this our spectrometer. we are quite familiar with this spectrometer. lot of experiment we have done using the spectrometer, say again let me repeat that you have to you have to do first of this mechanical levelling using the spirit level, using the spirit level,

putting on this on the telescope and taking this one just directly this way, then you adjust this two screw to make it horizontal ok, and then you take this other direction and put it here ok, put here and check ok; not this direction I think it is the 180 degree, it should be at 180 degree ok, so almost as much as possible put here. then again you adjust the this two again adjust, so this way you do it few times ok, you do it few times. And so, this base is keeping this one is horizontal, keeping this one a horizontal. just repeat this process few times and then you put it here, and you adjust this hard screw here we cannot adjust, because this fixed.

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And also, you can adjust here this, this levelling screw of their these two. this also you can adjust and make it parallel, here also you adjust this two one to make it finally parallel. initially this you should use this three, but not this one in this case fixed; so, this two use and also you use this two screw make it parallel,

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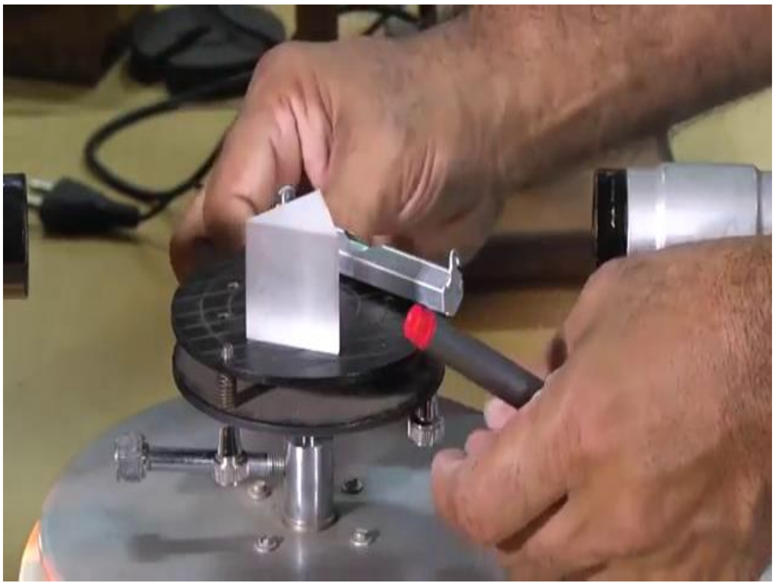

Similarly, prism table you will make it parallel ok, putting the this one parallel to the two screw adjust and then put it perpendicular, third one you adjust this one makes it parallel ok; so, these are the mechanical levelling you have to do. And, then next you have to put the prism ok, and then take the reflection from the prism on both side and you take the telescope, this side and see this whether this image in both side your getting at the centre of the filled up the view.

Other side also check it; if not, then you should you should use this three screw to make it to get the image at the centre of the filled, this is the this called optical levelling and that optical levelling we required, because some times in case of prism this is the does not matter, but when you will use getting generally what happen this getting this surface in it may not be perfectly horizontal. there may be some change or in prism also may be some up down may be there ok, so that is why this optical levelling is required.

next Vernier 2 Vernier 1, Vernier 2, find out the Vernier constant, note down then important thing is that important thing is that if you rotate this one telescope, then what happens your reading will change, because this circular scale is rotating. And if you rotate this one, is the Vernier attached with this, so prism table as well as the Vernier both will rotate, both will rotate and your reading will change without changing Vernier without changing rotating Vernier, also one can change the only prism or only prism table,

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rotating that I have already showed you ok, just you can rotate it in this way you will not change the you will not change the reading, You will not change the reading because of the rotation of the prism, so that is that is very important when you are going to take most of us do this mistake, we rotate this one reading is changed find that you are interested to take that change of reading, but are knowingly we rotate the prism using this, using this I think it is the, yeah.

Using this one, so unknowingly you are changing the reading ok; so, this will give you error, so that we do not want, we want to change the incident angle, etcetera. So, we will rotate this one only ok, so that means I am not changing because of the rotation of this one prism, I am not changing the reading. this is very important when you are going to do this experiment using the spectrometer. I repeat it, earlier I will all I told and now also I repeat it.

Another important thing this for prism experiment, for getting experiment, theory demand that whatever theory will use, it demand that this parallel rays will fall on the prism or getting And after refection or reflection or deflection ok, so whatever the ray we will get so that also will be set of parallel rays will get. Set a parallel rays means, it can be that is set can be because of different colour, the set can be because of different diffractive angle, now we have to see the image, we have to see the image; so parallel rays are coming after, after afters deflection or reflection now we have to we have to see the image, because parallel rays it will found the image at infinity but to form in our laboratory space, so use telescope what the things are in telescope I told, one lens is there, at focal length we put the screen; in this case screen is the cross-wire, is the cross-wire. here whatever will move, so that cross-wire will move.

Now, to see the cross-wire we are using IPs. IPs here without changing cross-wire, individually IPs we can change the position. initially IPs we have to that that cross-wire, I have to put at the focal point of this IPs Now, this IPs and the cross-wire together, we can move; we can move to place the focal point of these of these telescope lens, then image you will form at the cross-wire and we will be able to see that one,

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And here also lens is there, and this is source.

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But for our experiment we take a sleeve source that sleeve source position we can change using this one and here the sleeve source, we have to put at the focal point of this lens ok, then we will get the parallel rays. using the Schuster's method, you can do that is compulsory one should do before starting experiment. And another way I told that let us this one just focus at the distant object, make it distance object in sharp, so that means that from distance object as a parallel rays are coming, parallel rays are coming and meeting at the focal point means at the cross-wire.

And we can see that one, so that way we put this cross-wire at the focal point of this lens. Now, you look at the look at the source slit, when you look at the source slit, you will see that image your seeing of the source slit at the cross-wire, it is not it is defocused that we parallel rays are not coming because this is set for parallel rays. now, you change this one makes it sharp image, so that means, your placing this slit at the focal point of this lens one can follow this method also

now, for this experiment for this experiment using the sodium light first you measure the measure the first you measure the direct rays, first you measure the direct rays. these are the step one has to follow. after reading the, after reading the Vernier constant, after reading the Vernier's constant, noting down these Vernier constant, take reading for the direct rays, take reading for the direct rays

how to take from Vernier 1, Vernier 2; I have shown already the table just here I am mentioning, so reading for the direct rays fine. Now, reading for the minimum deviation for known wavelength means delta lambda versus lambda I think before doing this experiment, so let us do this one reading for the prism table prism angle

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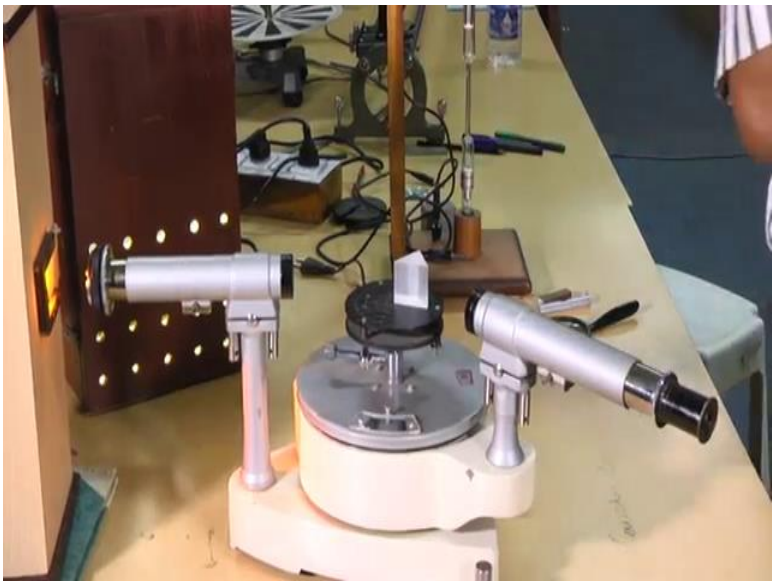

using this sodium light itself you measure the prism angle prism angle; how to measure already we have described taking the reflection from this surface; taking the reflection from this surface you take reading you take reading in both Vernier and difference of this two reading will give the two way, this is the affix. double of this prism angle so; half of it will give you the angle of the prism that that one has to do. Then let us come for the minimum deviation for different one.

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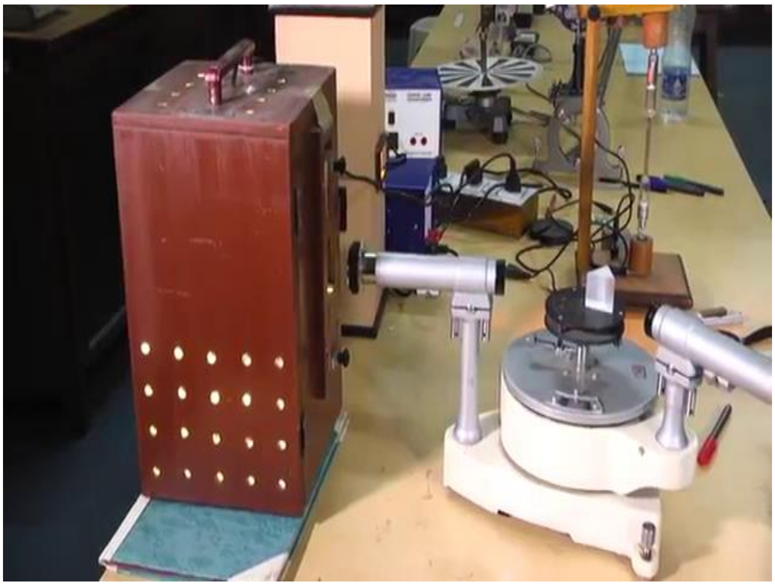

here I have source I just replace the sodium source. I will replace the sodium source. I think we have to take it here, yes and place this, I think this is the mercury source in last, yes, mercury source Now, this source we are used for delta lambda experiment. here also I have to see, I have to see I will take prism out, I have to see the ok, it is placed at right way or not, I think I will just, yes, I can see that one. yes, nice, I describe about this method, but this adjustment for parallel rays is done. now, I can see this white light I can see this white light.

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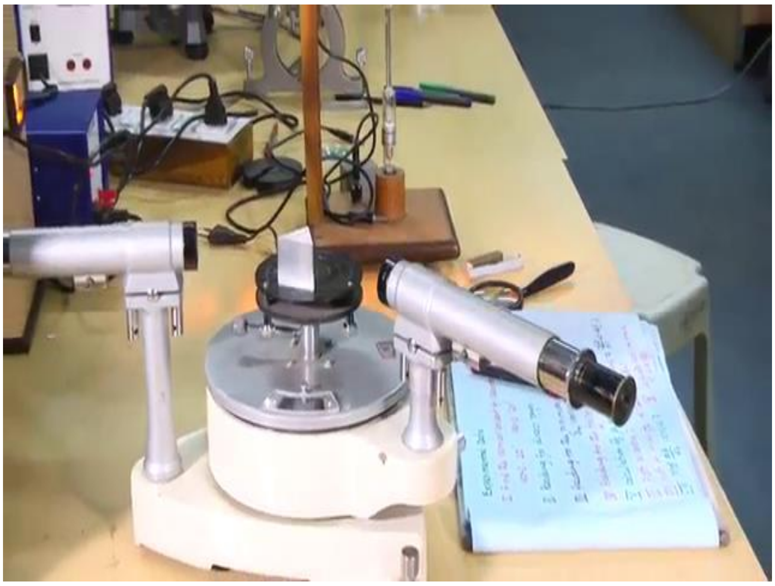

now if you put the prism for minimum deviation how to put you know, so this base we will keep almost parallel to the base almost parallel to the coli meter since see direct reading we have taken for this position of the Vernier Now, for minimum deviation, I will take reading Now, from direct reading and this reading at the minimum deviation position, so this will give me the deviations here. important is that this Vernier I should not rotate ok; Vernier I should not rotate. What I should do only I should rotate the prism without rotating the Vernier and find out the minimum deviation position for a particular light colour, yes, I got it yes, but this not the minimum position.

Yes, here it is the minimum position I can see this is the minimum deviation position. then I will place it, then I will place it, yes, I got it I am getting green, then yellow, then orange, yes, and then also violet these are two far ok, also I am getting violet now I set a violet colour ok, it is a quite away. earlier minimum deviation whatever I have seen that is for green the they are very closed. green light and this yellow light ok so now, this deviation it depends on the wavelength

I have to set, I have to go close to the to a, I have to set this telescope or cross-wire close to the close to a colour, and then I have to rotate the prism only prism not Vernier, and then find out the minimum deviation position for that colour Now, let me see whether this one is at minimum position, no, it is not at the minimum position. It is the, this is the minimum position of violet colour you know, this is which is difference. I have to rotate this one to set the minimum deviation position yes.

Now, this is the minimum deviation position for the violet colour. I have to note down, I have to note down the reading for this for this minimum deviation position for violet colour take reading. As I told every time we take three reading and then average, I have shown you table. this sent table you will use only earlier we wrote that minimum deviation position, not minimum deviation position.

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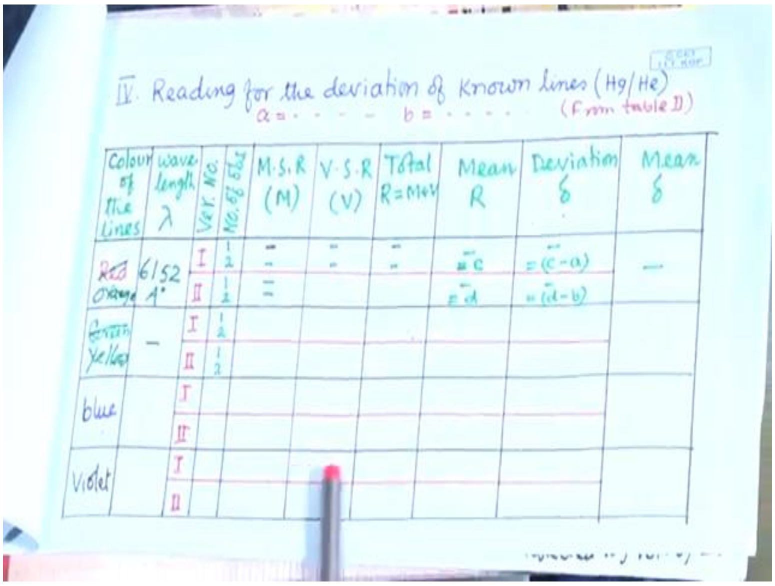

reading for the deviation of known lights. Now, here you have to right reading for the minimum deviation position, reading for the minimum deviation position of known lines that is the difference ok, same table you will use. you will this is the violate colour, I have said Now, for Vernier 1, Vernier 2 what is the wavelength that from chart one has to find out. take reading and find out the deviation here written that delta m it will be delta m. minimum deviation you will find out for different colour; you have to find out.

next minimum deviation position I have to, so this is set at the violet colour. Now, I will go for the I think green colour. yes, so green colour ok, this is the minimum deviation position looks me. I have to rotate this one. You see the minimum deviation position is not same for violet colour and the green colour. I have to rotate this one, I have to rotate this one set to the green Now, I have to adjust slightly to make it yes. yes, so this is the position for the minimum deviation for green colours now, take the reading, so that you note down.

Similarly, for other three colours at there, here I can see yellow and this other orange colour. I will go to the next one, yes, but they are very close. one has to there will not be much difference, but slight difference will be there, slight difference will be. we have to we have to use this one ok, fine one to adjust yes. I think, it is not, yes. slight change of the minimum deviation, so that way for different colours of known wavelength, we will find out we will find out the minimum deviation for this minimum deviation for this minimum deviation for this. this similar table we are going to use.

now, you know the delta m Now, in this case it will be delta m right delta m this I am showing this same table as I used in last experiment. what is the difference I told. I know the delta m versus wavelength right and also, I know the what I know the angle of prism I think ok, so that table is not here. angle of prism also I know. Now, for each deviation, for each deviation, for each minimum deviation for each wavelength will calculate mean ok, will calculate mean as a function of wavelength Now, you plot now you have to plot I think I have not plotted. calculate mu as a function of delta.

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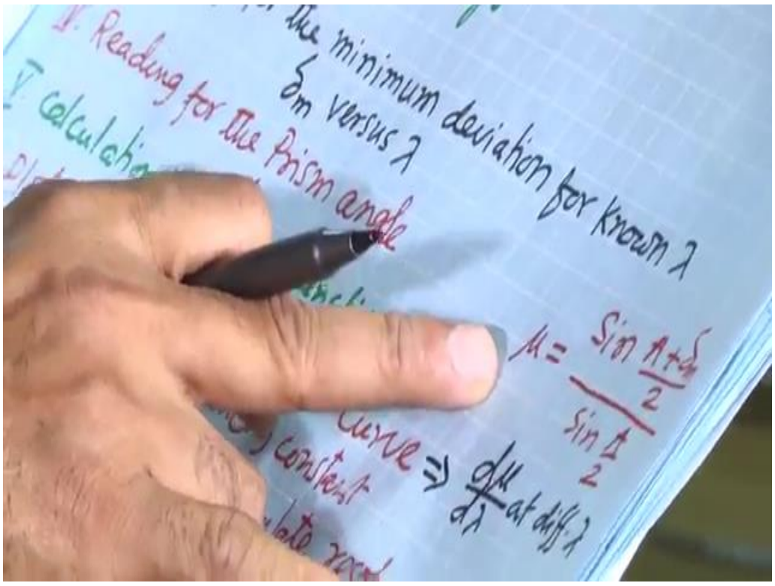

from that using that formula wants to do which formula that formula is mu equal to sin A plus delta m divide by 2 divide by sin A by 2 for different wavelength you calculate Now, you plot, you plot mu versus wavelength you will get this type of whether I should right I can.

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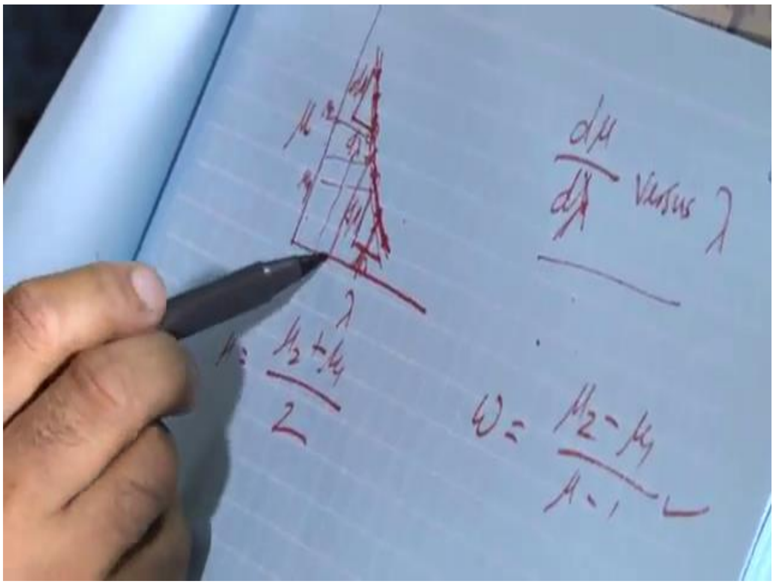

then you plot mu as a function of wavelength you will get this type of curve, you will get this type of curve plot the data, plot the data these dispersion curve So now, from the dispersion curve, this dispersive curve, find out the, you find out the d mu by d lambda that is dispersive power, you calculate dispersive power at different at different wavelength. dispersive power at different wavelength you can calculate.

d mu by d lambda how to calculate, how to calculate, so we have to take a tangent we have to take a tangent at a at a particular wavelength al this will be d mu, and this will be d lambda right, del mu by del lambda for this wavelength. for different point for different point, you can find out the d mu by d lambda d lambda for versus lambda right that you can find out from this curve itself at this lambda, so just draw a draw a tangent here at this lambda draw a tangent here. this, this will be just keeping at in middle. you take this del mu and del lambda

this way you can find out this another just for an for an average wavelength a dispersive power omega as a as I told mu 2 minus mu 1 divided by mu minus 2 this formula also can be used just take this two point; two point one can take. this one is mu 2, this one is mu 1 average mu is mu 2 plus mu 1 divided by 2 ok, using this formula also you can find out dispersive power And this generally this dispersive power of generally you see what about mu value here what is the corresponding wavelength, so this dispersive power is at this wavelength now, d mu by d lambda versus lambda you have, now you can now you can ok, before plotting that one another thing you can serve.

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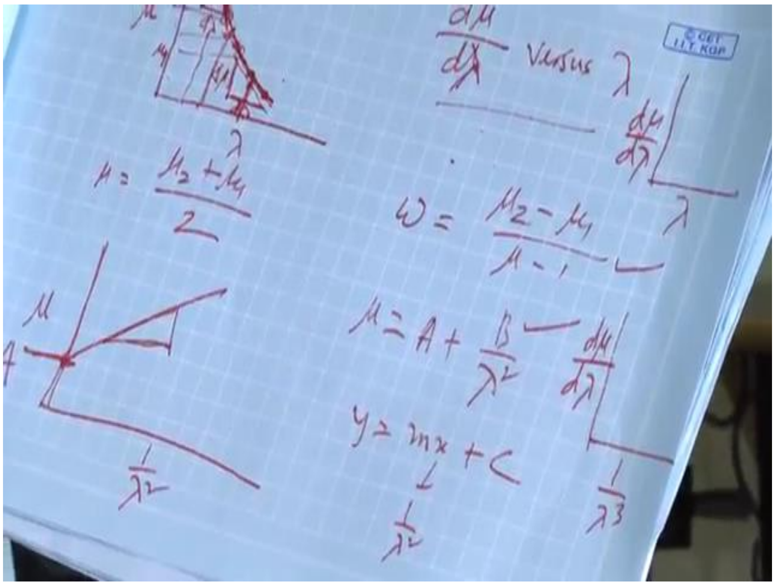

I plotted I plotted mu versus lambda. Also, I should plot I should plot mu versus 1 by lambda square ok, mu versus 1 by lambda square to verify the Cauchy's law. that is a plus b by lambda square right mu equal to. 1 by lambda square, so it is a y equal to m x plus c this kind of relation x is 1 by lambda square here, y is mu you will get you will get a straight line like this or whatever you will get

Now, this C here, it is A basically, you will get what are from the intersection from the intersection you will get value A And from slope, you will get B. From slope of this curve, so how to find out the slope you know from the slope of this curve you will get the wavelength And if it is straight line mu versus 1 by lambdas, if it is straight line this Cauchy's relation is verified And from here from this easily you can find out the value A and value B

next you can you can plot d mu by d lambda versus lambda ok, d mu by d lambda versus lambda if you so then you can find out, so that is as I told that you can find out this one. Now, you plot it d mu by d lambda divide by lambda you plotted then you will see it is a curve I think it is not straight line ok, but as I mentioned here. d mu by d lambda equal to minus 2B by lambda cube. if you plot d mu by d lambda as a function of 1 by lambda cube as a function of 1 by lambda cube ok, instead of that if you plot 1 by lambda cube d mu by d lambda ok, then you will see this is a straight line ok, y equal to m x, m, m is C 0 and m is minus 2 B you will see a, you will see you find a get a straight line here your showing that dispersive power also depends on the wavelength and how it depends. this this is the dependence and then resolving power, so d mu by d lambda is at a particular wavelength lambda, you can find out from this curve Now, you multiply with the base length, then you will get the resolving power of the prism

And if lambda is known to you, then you can find out d lambda or del lambda. And then you can conclude that this if del lambda is a 20 Angstrom, that means, this prism it, it can resolve only 20 Angstrom only two wave two wavelength or two light having wavelength greater than the 20 Angstrom ok, greater or equal to the 20 Angstrom like sodium d lines, it has two lines d 1 and d 2, the wavelength difference is the 6 Angstrom. if resolving power is here, if you get this del lambda 20 Angstrom. using this prism, you cannot resolve sodium d lines one can estimate the resolving power of the prism.

these are also very nice experiment, actually similar to the last experiment slightly difference is there as I mentioned. Also, mainly one has to analyze and find out the very, very interesting parameters of the prism I think I will stop here.

Thank you for your attention.