Experimental Physics - III
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Lecture – 53
Topic – Faraday Effect (Contd.)

I am in the 3rd year laboratory of a department of physics this optics and modern physics laboratory. In this laboratory, we have the setup for observing the Faraday Effect.

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This is the experimental set up here, we have arranged this experiment. As I told this there are two components main components in this experiment; one is light, another is magnetic field.

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Light this is the light source, this is the light source. White light it has all source of wavelength it is coming; it is coming ok.

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Now, here we have used a filter, one filter I have put this looks color it looks green ok, looks color green. This light will, this light this filter will select a particular wavelength so that, what is the wavelength it will select that that is there written on this filter. It is an interference filter very good one need very good filter. In filter, main problem is the absorption of light.

See, filter quality is good then you can get absorption will be less. intense light we can get for a particular wave length as well as quality of filter decide the bandwidth of this of this of the wave length now, this from the filter light of a particular wave length will come and this is the polarizer. It will fall on this polarizer. Light will be polarized light plane polarized light. That light will.

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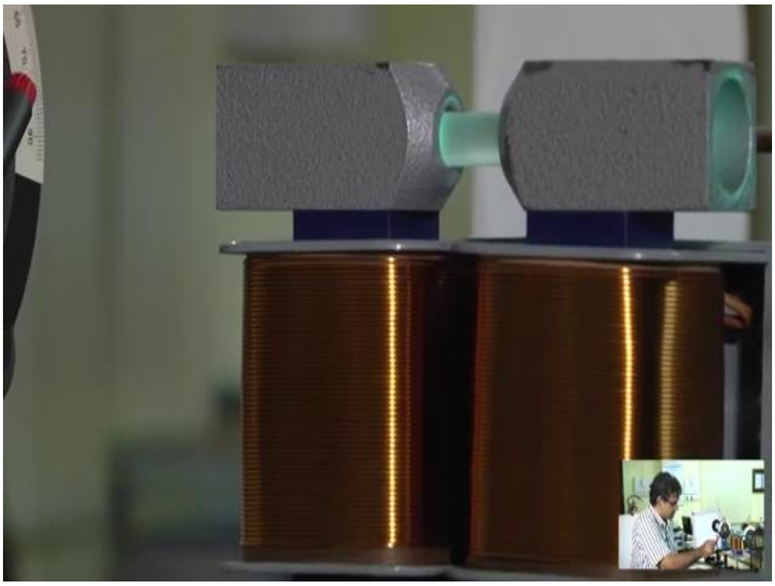

Here will fall on the sample, this is the sample here this is the sample between two pole pieces of bar magnet because we have to apply magnetic field. for the magnetic field what is the arrangement that I will tell you, but before that let me finish that light will fall on the sample and pass through the sample and that light then it will fall on the another polarizer. We tell this is the analyzer polarizer and analyzer are same. It will fall on this analyzer ok.

If both initially, if both polarizer and analyzer will keep they are axis, optics axis keep the parallel and for that we will get intense light.

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Here we have used one lens and this is the screen. One can use also photo detector to see the intensity of light. We have to measure the intensity of light. Here we have used one lens and then this is the screen on the screen you will see the spot of the light coming.

Now actually we have kept this polarizer and analyzer in cross position. In parallel position; we do not keep because, it is difficult to it is difficult to see the change of intensity; from b, it will be less bit will not be this measurement will not be sensitive, but initially if it is dark then from there it is becoming slightly band to make it dark how much we have to rotate the optics axis means this analyzer from the cross position; how much we have to rotate.

That much this that is the will be the angle of polarization that we have to we have to measure for different magnetic field and for different wavelength. Now, you see this different wavelength how will select. We will use different filter. I have different filter ok.

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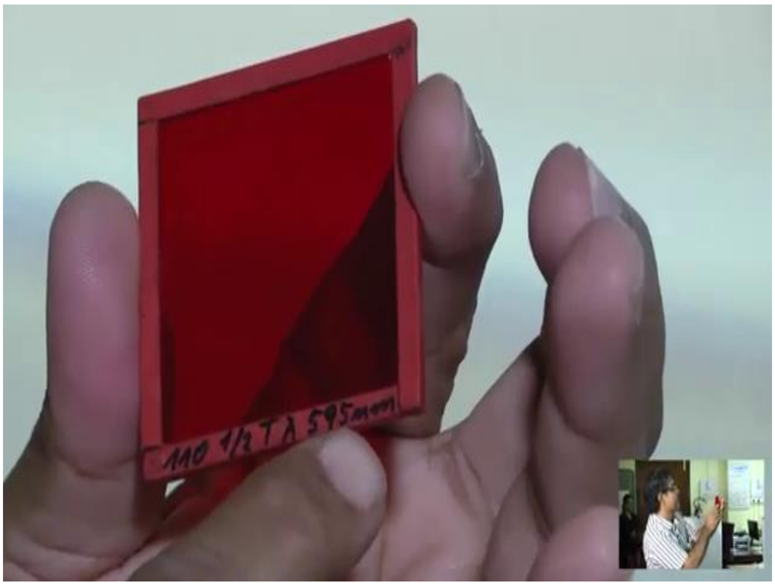

I have different filter and wavelength is written this is red color means; this wavelength will be I think here it is.

Student: 5 wave length.

565; 565ah angstrom or 5; 595 sorry.

Student: 5 9.

It is a written this way it is written this way it is a 595 595 angstrom or 5 sorry, 595 nano meter or 5950 angstrom this is a red one. Then I have other this it is the blue one, it is the blue a violet one ok.

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What is the wavelength that also it is a written here; say anyway it is a written. For different I have, I can select 5 wavelength. I have here I have 5 filter, I can choose 5 wavelength ok.

For each wavelength then, what we have to do? We will apply magnetic field for zero magnetic field first we have to set for a particular wavelength and then we will change the, we will apply the magnetic field. How you are applying? You can say this is the electromagnet. This is the electromagnet and these two are called pole pieces magnetic field will produce between these pole pieces where we have kept a sample. Now we have to if we pass current through this coil so that; that means, we need the power supply for constant current.

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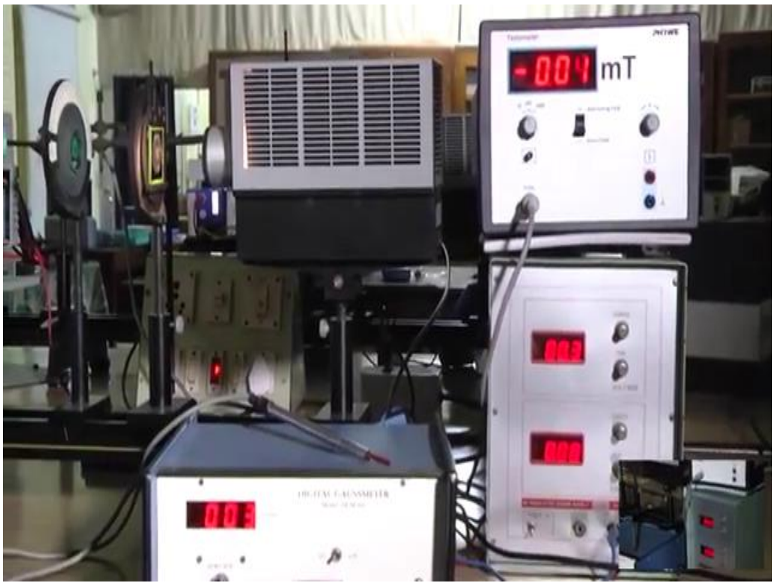

This is the power supply; this is the power supply for constant current power supply. Here you can see is the, here we can change the voltage and here we can get the current. If we change the voltage then current will vary. We will set at a particular current and for that current what is the magnetic field between these two pole pieces, where we have kept the sample or we will keep the sample that we have to note down.

Now, as I mentioned that magnetic field along the axis of the pole pieces, it will vary. If generally it varies like this it is a like Gaussian cone at different position, we have to put the probe hall probe that from hall probe is part of the gaussmeter or Tesla meter. This Tesla meter or gauss meter will give the reading of the magnetic field we will apply from the power supply, we apply a particular current. For that; what is the field between these two pole pieces, mean field between the two pole pieces that we have to measure for that current and to get the mean magnetic field.

at different position on the sample, in absence of the sample at different position between the pole pieces, we will measure the magnetic field then, we can plot it and then from that plot one can find out the mean magnetic field that we have to do for that for that we will use probe as I told, I will show you probe on an gaussmeter.

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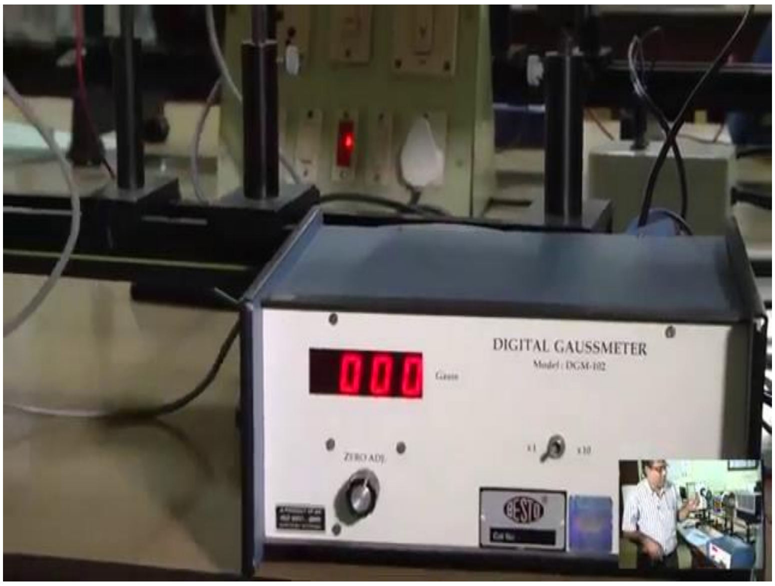

This is the gaussmeter, it has a probe. It will give me reading initially, now, it is reading is 0 Because, I have not applied any current or it is away from that magnet ok.

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Now here this is it is the hall probe; I will in separate class, I will when I will discuss basic tools and instrument in a laboratory during that time I will discuss about the principle of this hall probe. Here this probe a transverse probe here magnetic field if we want to measure between two pole pieces I have to apply like this.

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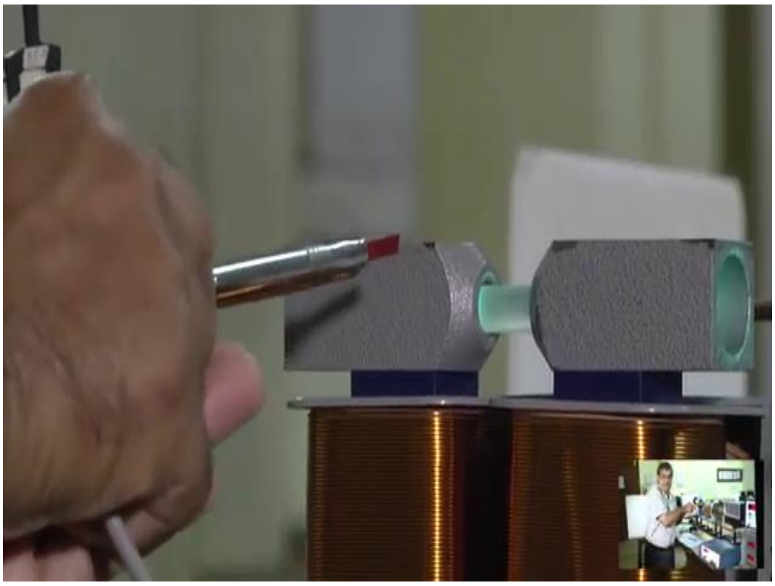

Perpendicular to the axis of the pole piece, I have to apply this this way. That is why it is a called transverse mode ok, transverse probe. In addition, but here we want to magnetic field along the axis and inside the you see sample also it is inside the pole I cannot put here inside this way. I have to put this one like this along the axis I have to measure the magnetic field for that this is the special type of pole pieces there is a hole between that inside these pole pieces.

Through hole, I have to put the probe. this probe then it cannot measure Condition for this probe the magnetic field has to fall on this perpendicularly if I put this way magnetic field will fall like this, like along the axis ok; along the length so that is why we have to use special type of probe; it is called axial probe it is this, this one the axial probe I will not use that one. That axial I have to for measuring that one this should be I have to remove that one and then I have to put this probe through this hole and for different position I have to note down the magnetic field.

Instead of that just I will just to demonstrate I will show that this can be used for measuring the how magnetic field, we are noting down for a particular current of the of the pole pieces current passing through the coils of the of the electromagnet and magnetic field produced because of that between the pole pieces. that I will tell you later on after disturbing these arrangement because if I disturbed now, then it will take time to align it.

Let me demonstrate the experiment first. What we have to do the experiment?

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First experiment as I if you see the data this is the here we have put this type of rod, glass rod it is transparent, it is transparent ok, this is the length l, small l in formula you have seen. that is given or one can measure ok, it is looks to me around 2 centimetre, 2 or 2, 2 2 to 3 centimetre That one has to measure or it will be supplied ok.

Now already this same sample we have put there. I am not going to disturb that is that one that why that is why I showed you another piece. Now here we have used this as I told this one filter we have used there, this is the I think it is a looks green colour some wavelength is there, it is written on this filter. That one has to note down. Now what I will do? I will I know first starting the before starting the experiment as I told either before starting the experiment or after the experiment one can calibrate the magnetic field, one can calibrate the magnetic field means magnetic field versus current, mean magnetic field for different current ok.

That one has to find out. how to find out the mean magnetic field for that at different position along the pole piece we have to measure from that we have to find out the mean magnetic field Now if I have not applied any magnetic field here, you can see this 0 reading of the power supply Now in this condition here you can see.

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Now it is in cross-position, here you can see there is an I have put here a scale is there Here top here it is 0, this side 90 degree, other side minus 90 degree. You can rotate it by 180 degree.

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Now, it is at 90 degree and it is at you see, it is 0 degree. Exactly it is not at 0 degree, but more or less, it is in 0 degree, because it is because these two we have put here it is not perfectly align. It may be slightly rotated during the aligning the things. If you do the perfectly alignment, then this also will be at 0, but not necessary. Say I just disturbed it ok, I just disturb it. What you will see, here you can see green light green spot you are seeing ok.

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If I maximize this green this intensity of the green speed spot I will rotate it I have to make it if both are aligned so intensity. It should be also near the 90 degree what is the value now? It is at 90 degree it is at 90 degree, you see this is at 90 degree that is also at 90 degree intensity here spot you are seeing this is spot as I told polarize light. Now without changing the angle of polarization it is falling on the analyser; all light passing through it ok.

Now from this condition, I will go to the dark position. As I told dark position will take the initial condition now, I am changing this one and I want to see that at which position I am getting the dark one, you see becoming dark, dark, dark, yes, I think this is the dark spot more or less. one has to adjust here yeah more or less I have come to the same position as I or slightly more one can go or I have done more. One has to adjust as I am showing you one has to adjust yeah. I think I this is the dark condition on the.

That way one has to perfectly try to find out the dark wave there should not be any light pass through this, and then they are in cross-position. This is my initial position without magnetic field. Now I am applying current here I can apply maximum 0 to 4 current, 4 ampere current of let me vary let me go to the maximum current we will see the maximum effect ok, maximum magnetic field, but you have to do for 1 ampere, 2 ampere, 3 ampere, 4 ampere ok.

Therefore; that means, for four different current what is the magnetic field that you are find finding out because you want to do the experiment for this four current four magnetic field. Alternatively, if you want to take more data, then 0.5, you can take the step of 0.5 ampere 0.5, 1, 1.5 etcetera. 8 set of data for different magnetic field you can do the experiment. One has to decide.

Now, let me apply this is the darkest condition in cross position whatever the polarize light is coming. Here it is falling at 90 degree, if that is that we tell this this polarize light it is the here we kept in this. Light polarize that it is if it is say in this direction. here optics axis this direction it is in cross position Now if I apply magnetic field; this polarized one, if it is just slightly rotate either this direction the other direction. There will be component along this direction ok.

That component will pass and we will get the sub intensity. Let me apply the magnetic field and see the one has to see there. Let me apply magnetic field say here I am changing the voltage and corresponding current is I am setting at say setting at 4 ampere. 5 known I can just ok, exactly a 4 ampere I am interest about the current not about the voltage.

For getting 4 ampere current, what is the voltage I need? Yes, I can you can switch off this light then. I have applied 4 ampere is slightly changing more or less is 4. Now it is 3.97 ampere. Here I think you can see this dot of light ok.

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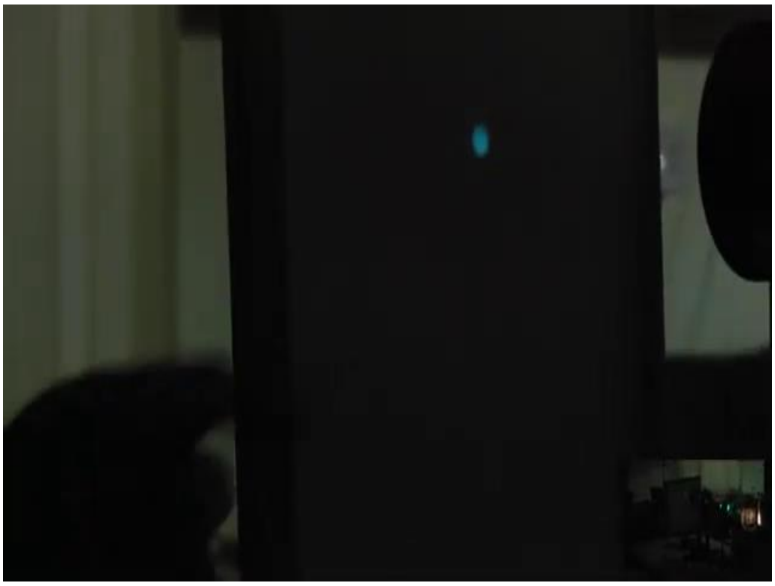

If that light I think it will just yeah I think you can see now what I have to do. Now here I have to take reading ok, in a condition what is the reading of these of these analyser ok.

Here it has the scale, vernier scale also that I will show you later on one has to note down this reading and now I will rotate that one to make it dark. How much I have to rotate that. I will one have to rotate it, but it becoming darker. slightly I have to slightly very slowly I have to rotate and make it perfectly dark It is more or less dark slightly more I can rotate, but still let me check it (Refer Time: 22:37) light dark yeah.

One has to do carefully ok, more or less is intensity decreased. One has to tuned properly, but since I am trying to show you the in the video it is yeah. It is a, you can use the light seeing same condition, they can see. Now we cannot see, you cannot see this because, in that condition I have. These more or less one has to very precisely one has to rotate and find out the dark condition.

It may not be perfectly dark, but one has to find out. Now, I have to take reading of this one. Here for taking reading, you can see here this is the one scale main scale and here it is an if the scale is there another scale is there that is the vernier. Here ten divisions are there and we have seen that this ten division coincide with the nine division of the main scale. Each division then vernier constant is 0.01 ok; 0.01 degree because; this is the is the in degree ok.

1 by 10, 1 it is the 1 degree 1 by 10 0.1 degree sorry, not 0.01. 0.1 degree is the vernier constant that means, here from here directly you can find out the rotation angle of rotation from initial reading and this now second position reading and reading you will get like 10.1 or 2 or 0.3, 0.5 etcetera. Accuracy here we will get 0.1 degree ok.

For these two position; you note down the reading and find out the difference of that, that will give you del phi. That will give you whatever we are telling the del phi that you will get that you have to note down. I have to reduce the current because, they have a highest current I have given if you keep it for more time, then it will be hot ok, then magnetic field acquire magnetic field you will not get it will fluctuate because of the temperature.

I will reduce this one for yeah I have to just reduce the I have reduce the voltage, current is more or less 0 so let me show you the let me show you the this is the for magnetic measurement that I will come later.

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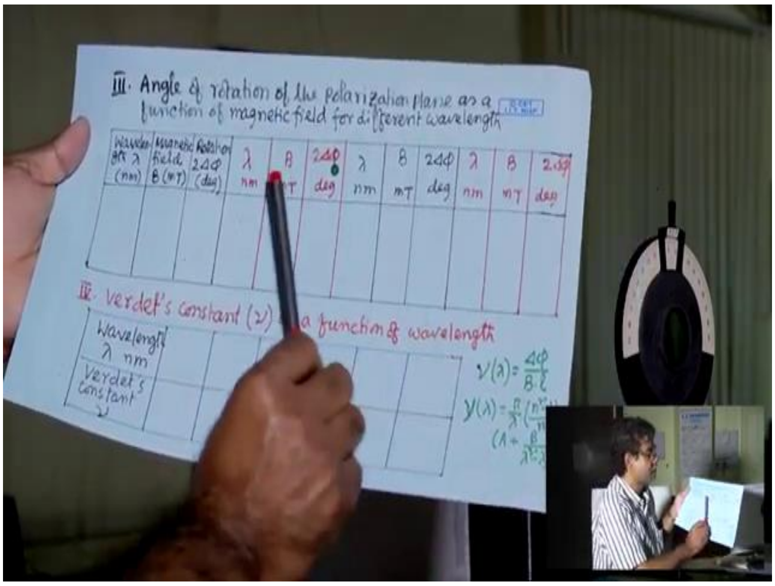

angle just I showed you the angle of rotation of the polarization plane as a function of magnetic field ok as a function of magnetic field for different wavelength. We have chosen a particular wavelength, so that we have to note down here it is written on that filter now magnetic field, magnetic field here this what is the current you are you are applying. 4 ampere I applied. For that what is the mean magnetic field that from calibration we know. That magnetic field and corresponding rotation here we have to note down and yes; for a particular wavelength.

Now for second wavelength for different magnetic field, only one magnetic field I have showed you for 1 lambda I showed you. For second wavelength for different magnetic field, you have to do that, but that is the mean magnetic field. Mean magnetic field how to find out I have described. These are you will find out the angle of rotation now, from here you will you know the is the wavelength and for that what is the Verdet’s constant.

Because for that wavelength this from these magnetic field and this del phi from that either plotting graph or plotting graph you can find out the slope from del phi by b In that formula, you have seen this Verdet’s constant is del phi by B l del phi by B from this a del phi by b this one now only I have to see this actually I forgot these two rotation 2 del phi why we are taking not taking del phi.

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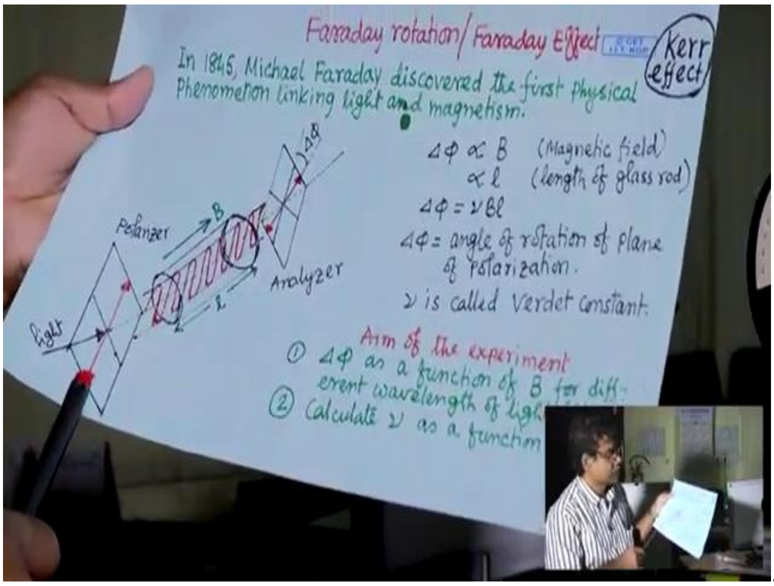

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We are taking two del phi that I forgot to what is the reason that let me 2 del phi. We are taking double rotation, but in formula it is not coming double rotation, it is del phi angle of rotation of plane of polarization nu is called Verdets constant.

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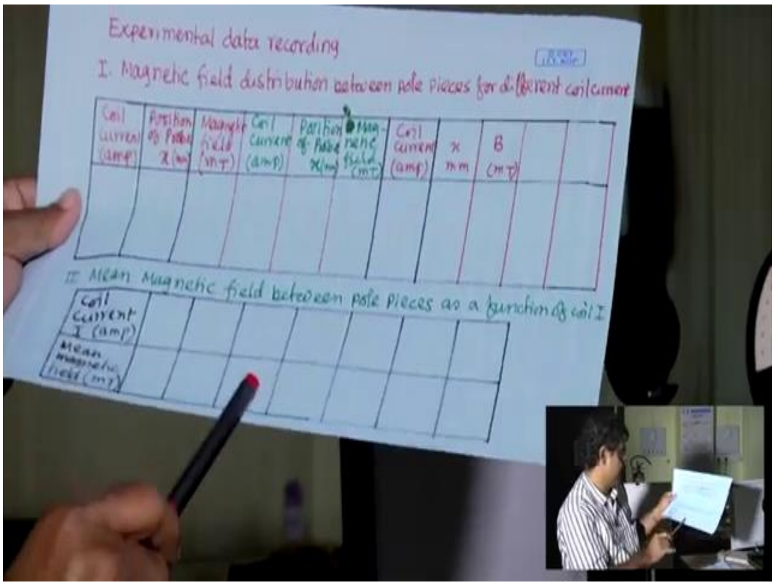

That what is the reason exactly I forgot, but I can tell you B I p, you will find out from their mean magnetic field for different coil current. I think nothing to do with the 2 del phi to experimental formula.

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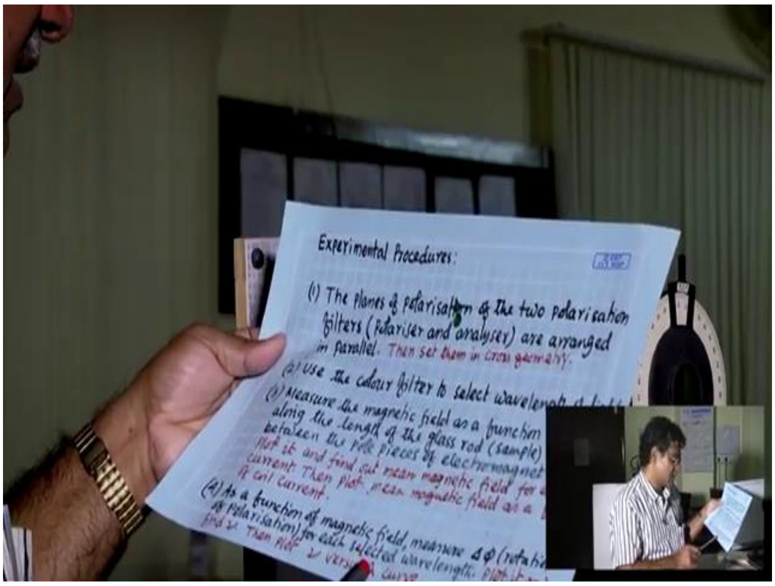

I think there is a function of magnetic field measure del phi rotation of polarization for each selected wavelength plot it and find nu then plot nu versus lambda curve I. I do not know, but I do not see any reason for written 2 here actually, in my opinion it should be del phi it should be del phi, but why I have written 2 del phi particular reason I cannot tell you now. Anyway, but it is a whether it is it is a rotation say light is coming and then, I it is not reflections. Alternatively, something we are not rotating.

Anyway, if I think it should be del phi, not 2 del phi or if it is 2 del phi, there should be some reason the now I cannot tell you later on I will see it. Anyway will find out del phi. del phi by B that from the graph will get the that is the slope of the graph B versus del phi. That slope we can use for calculating the del nu for a particular wavelength.

Now you repeat for the second wave length, third wavelength, fourth, fifth, we have 5 filter and corresponding Verdet's constant you can calculate and you plot it and you see how it how it depends nu, how it depends on the wavelength whether it depends on the if it depends linearly.

We will get a straight line it depends some other form like A plus B by lambda square. It will not be straight line, there it should be some curve, that curve can be fitted with the some expression, and that expression generally comes like this. nu depends on lambda following this form. That one can one can find out from this experiment now, here as I told you, I will show you the let me disturb it. No magnetic field.

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Now, you see I will take out the how to change the filter, I will show you there is a. I will take out this filter ok.

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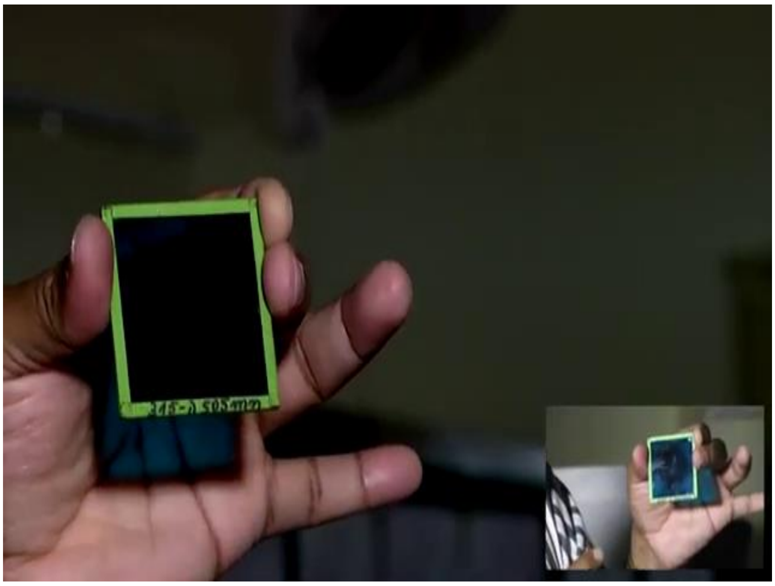

A filter it is a wavelength one has to note down 505 nanometre, 505 nanometre a wavelength one has to note down and then you can use another filter; repeat the experiment I am not going to do. For 5 filter, 5 set of data you can get.

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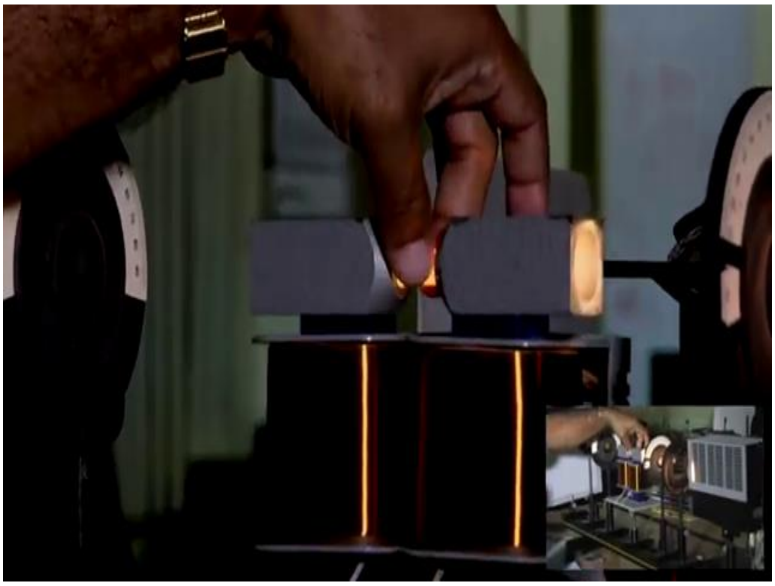

Now this is the polarizer, and this is the analyser I have to I have to disturb this one for if I want to measure the this I will take out this one this sample.

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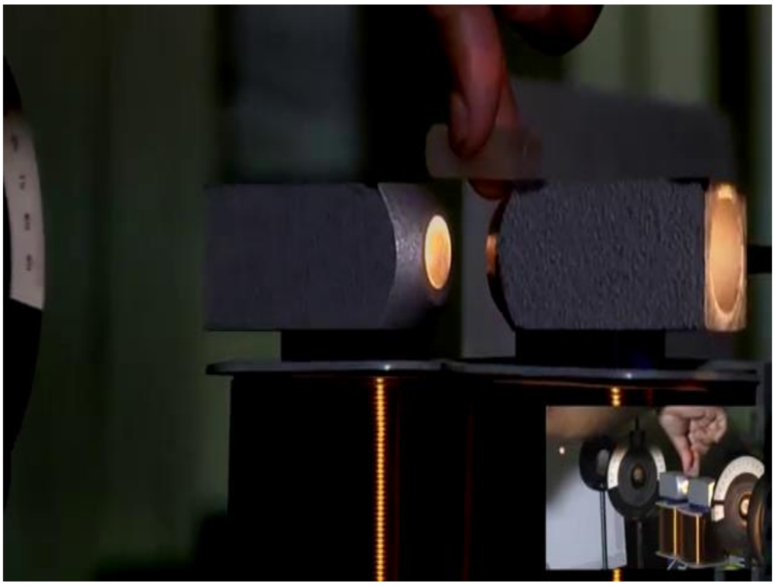

I think one has to yes this you see. this is the pole piece, this is the gap between this, but it is the length is more than that I cannot put this way ok, I cannot put this way; that means, it is also inside this pole ok, some portion. I have to measure the measure the magnetic field inside the pole also that there is a hole and through hole. I am not going to disturb this one because, now then I have to remove all things. I will, what I will do, I will just one has to disturb the setup for measuring these.

Just I have to and let me check whether I can put a one I have to let me think I have to take more distance, but still I do not think. I can remove this I can remove this, I can take out them I can take out them ok.

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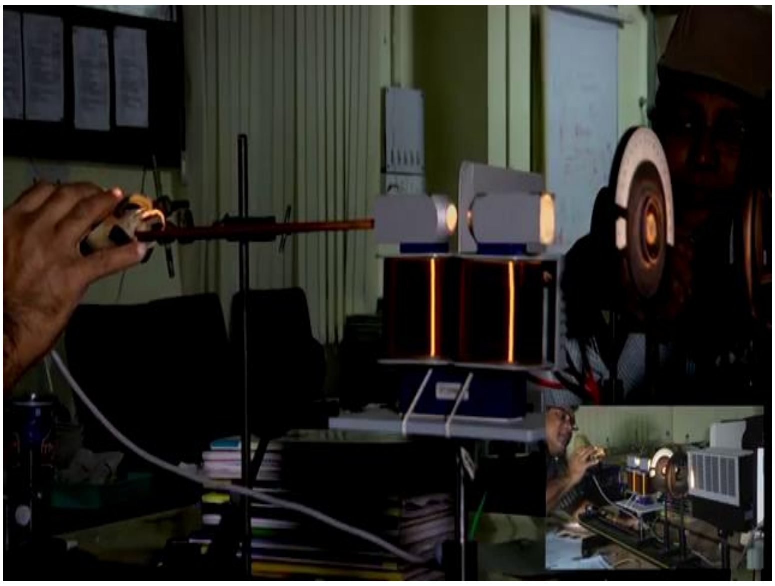

Then actually, I have to use the spoke and put this is see, but one has to make it length more. Let me make the length more, this you have to make it proper alignment slightly height I have to. Yes, slightly height I have to decrease, yes.

I have to put along the axis. One has to align it you know. Then I think I have aligned is not is not lightly more I have to go yes. More or less, it is along the axis. You have to go you see I can go, I can show you the end this is the I see I am in at the middle position between the gap, and you have to start from the inside you have to start from inside ok.

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Then for this position what is the you see if I apply current here you will see the reading Here you can see the changing I am applying current, I am applying current how much current here I have put say let me put this 4 ok.

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Earlier whatever I have done one for one current I am showing you for one current I am showing you more or less it is 4 For that you see for this position it is I have to note down 6.21 milli tesla. Now I have to change the position at this position it is going out of the scale. Let me go there still it is out of the because maximum current I have taken 204, 204 milli tesla at the middle you will get maximum current middle you have will get maximum current 214. Now, it will start to decrease 180, I am going in this say.

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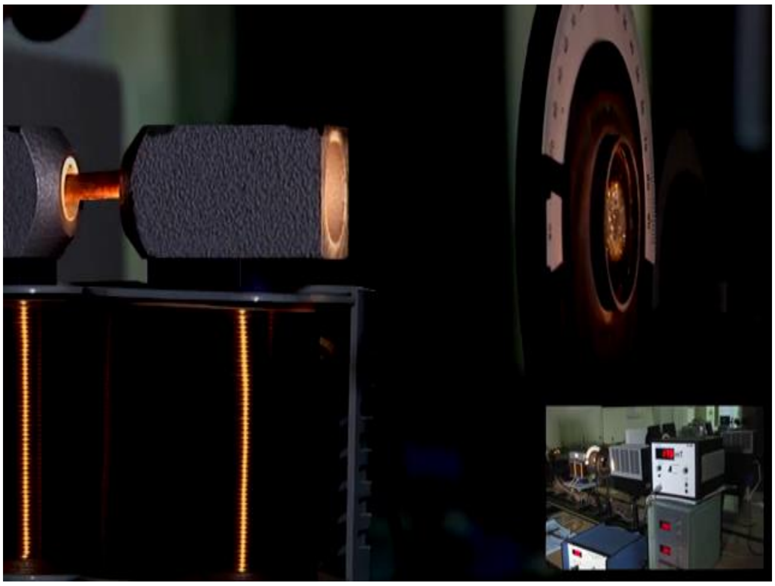

For different position you have to measure the magnetic field using the axial probe and other probe we use this way you know, this way here also you seen current put this way. If I put this way, we will not you should not see any perfectly if you see we will say there should not be any, but some reading is showing anyway. It is an it will not give the accurate magnetic field if I try to and it is difficult to do that because condition of this one is one has to put this way ok.

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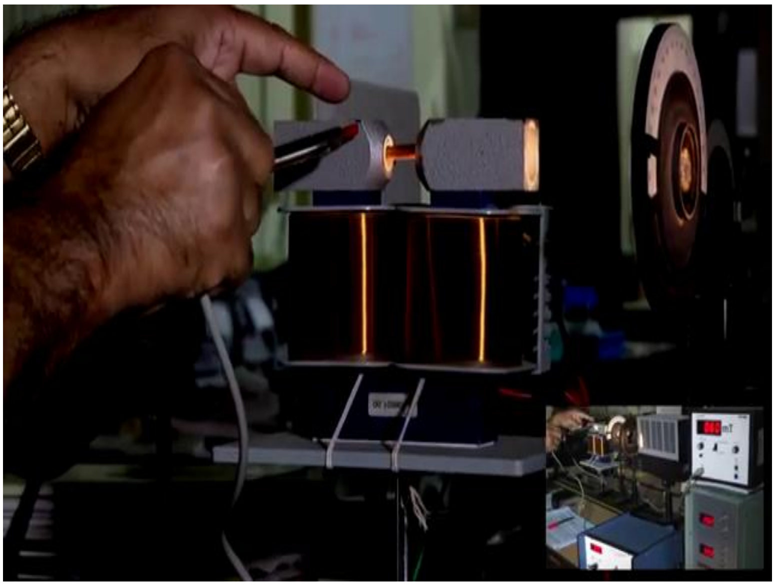

Then you will get. This also one could use be because outside if you we could use at different position you could measure, but since sample is inside also. That is why we cannot put this one inside of this pole pieces. Inside of the pole pieces, you cannot measure the magnetic field you need this one. that is why we have to use this axial probe In axial probe condition magnetic field will fall on this because this here I will explain you later in different class.

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Here whatever the sample for hall probe there we use a small size of a material, semiconductor material. condition is here current magnetic field and we are measuring hall voltage these three has to be mutually perpendicular to each other to fulfil this condition here magnetic field has to fall on this. In addition, to fulfil that condition here the magnetic field has to fall in this direction, because they are probe is that material is put like this ok.

Here material is put like this. magnetic field from perpendicularly and in that here magnetic field at this material hall sensor it is put like this that means, field has to put like this. that is the difference between axial probe and this transverse probe and that is important to know for this experiment this is the experiment I will I should make it current 0 because I should not apply current more time then, this will be hot I can see this become already hot.

I showed you the setup and then what are the individual component, how it works that I explained and one of the steps for the experiment and how to take the data that I explained you showed you. One set of data I showed you, but for this experiment as you know that for one data is not enough for getting the better results.

A set of data one has to take and there for that you have to plot graph from that graph we find out the either the mean value or the we use the gradient. That gives the average effect thus reduce the error in the measurement. I think I will stop here.

Thank you.