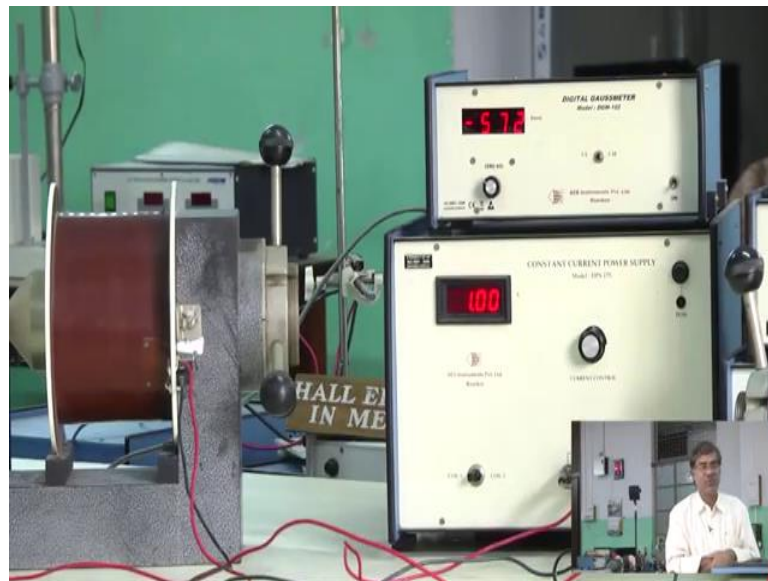**Experimental Physics - III**
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Lecture - 07
Electro Magnet and Constant Current Power Supply (Continued)

we are in solid state physics laboratory of Department of Physics IIT Kharagpur.

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I will switch on this power supply. I have option to vary the current here now we are at present the current to 0. here let me apply current; apply current say it is an in ampere, it is in the ampere. let me apply 1 ampere current 1 ampere current

1 ampere current is flowing through the coil. here for individual coil also one can do, but here it does not matter, because we are interconnected this one here

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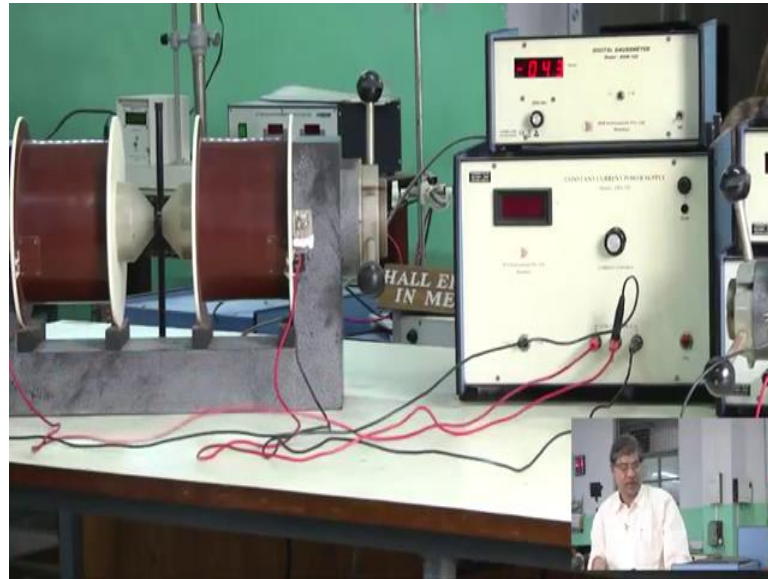
what is the magnetic field between this pole gap that we can find out for that we need some? we have to measure the; we have to measure the magnetic field, we have to measure the magnetic field how we can measure? for that there is a gaussmeter or tesla meter

I will discuss about the gaussmeter teslameter in next class, but let me just use this some this probe is called hall probe and corresponding meter that is called gaussmeter is the gaussmeter it is together this hall probe and this some meter together is called gaussmeter. meter is here it is a sum that meter has some option power supply, for passing current and measuring the voltage

that I will discuss later on, but now let me use this meter will give me the magnetic field. I am putting something here in middle. it will give me; it is giving me you see some value here 572 gauss 572 gauss. some negative minus value is there, but does not matter forget it. 572 it is giving

Now, if I so I think it is a minimum current or maximum current that I have to check, hopefully it is maximum current, because sorry not current this magnetic field. I have to check whether it is giving maximum field or minimum field that will tell me whether current in both coil is flowing in same direction or in opposite direction.

for that what I have do. if I just exchange this instead of this you see, if I inter connect. I should not do that way, I should reduce this one, I should not do that way I should reduce and switch off this one and then I should check

now this two I interconnected to instead of that I am doing this one, I think it has some problem, this I will interconnect now red and this black interconnected other one kept now this I will put Now, you will see that earlier whatever the interconnection was there Now, in this connection current will be in different way.

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in that case let me check it should be in anti-clock wise in opposite direction that I can verify. I will apply again; I will apply again this 1 ampere current, I will apply 1 ampere current yes, I apply 1 ampere current; there is no change of this magnetic field; that means, no magnetic field between these 2 pole piece. it is because this, it is because this the current is flowing in opposite direction in the 2 coils

this way we check whether it is this current or current flowing in the same direction or in opposite direction. I we want current should be flow should flow in same direction, whether these 2 coils are connected in series or it is in parallel that way we can check. now, I switch off, but before that I should reduce the; I should reduce the current and I had made it a switch off and then I will go back to the previous connection. red with red, red with red and then red with red and then yes I make sure that, this I got the

interconnection of this 2 in such a way current will flow in the same direction in both coils

Now, here you it varies magnetic field will vary with the current it is obvious it varies with the pole gaps that you can just check for a particular current you can just check you can. for a particular gap you have to do calibration Calibration now here important thing is that, following the Biot-Savart law, I can get the formula h equal to something

it is proportional to the current as well as proportional to the other factors they are they depends on the coils number of turns of the coils, then permeability of the material of the probe etcetera for a particular gap of a coil if I maintain that one using that formula Biot-Savart law, using that formula I can come to know what is the magnetic field for a particular current

why do I need any instrument to measure the magnetic field? Using this formula itself I could tell, what should be the magnetic field? Now, problem is when this formula is derived it is derived on some boundary condition or assumption this formula is we tell this an it is in ideal condition.

instrument generally when it is made tactical instrument, it is very difficult to fabricate following those ideal condition, ideal condition. for that in reality it will be very difficult to get the accurate magnetic field calculating from the calculation that is why if we have some instrument, then we will not bother the other parameters of the electromagnet, what is the number of tons, what is the etcetera ok, what is the mu I will not bother what I will do?

in that case h is equal to some constant K into I this constant will if contain the all constant of the element of the electromagnet like, number of tons and then what is the mu value etcetera so without knowing them what I will do for if I have instrument that it will tell me the magnetic field I will vary the current and instrument is telling me, what is the magnetic field between the pole piece, I will note down

H versus I this data I will get I will collect and then I will plot it. generally it become the linear for up to certain current ok, beyond that current there are some non lean linearity. so then what you are getting you are getting a straight line and from the slope you will

get that constant value K. Now, that K is will be used for calculating the unknown magnetic field

using that magnet, if I apply different current ok; the corresponding what will be the magnetic field during the experiment because during the experiment it may not be possible to put that probe near the sample. I do not need to use that probe hall probe or gauss hall probe or gaussmeter, during some other experiment where I will use the electromagnet

there just if I know the current then corresponding magnetic field from that curve or from that constant you can calculate that is way this that this sometimes this gaussmeter is that type of instrument is very important when the when the geometry of the Biot-Savart Law It is difficult to fulfill in the real instrument ok, there are some instrument where this geometry of that formula can be arrived can be can be fulfill easily.

there just without any additional instrument we can just calculate from that by using that formula in case of electric field this is this concept we use, because they are geometry and the experimental set up experimental set up for electric field this both are in same condition here this is the important step for calibration of the instrument ok, means this electromagnet.

Now, another things as I told this, I do not know how much, what is the maximum I have to switch on what is the maximum current, what is the maximum current I can get in this instrument let me check it?
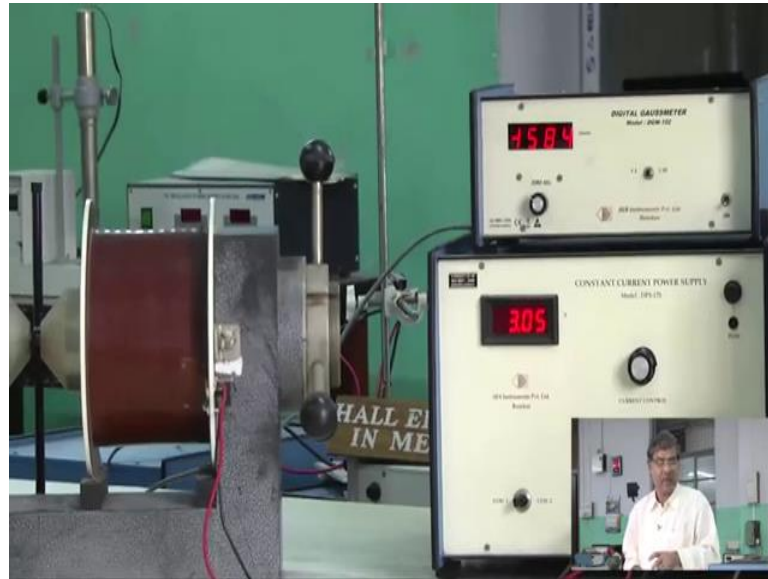
in this here put this one I can get 3 3 amperes current ok, 3 ampere current and 3 ampere is very high for this, because if you keep this 3 ampere current for longer time then there will be lot of heat generation for short time you can apply and corresponding magnetic field, you can see I think I multiplied with 10 whatever he here reading you are seeing it is multiplied with 10

here instead of two type of scale is given. this I can see 4 5 8 4 into 10 this means; that means, I am getting 15 000 gauss, 15 000 gauss means, 10 to the 4 10 000 gauss means one tesla here I am getting 1.5 tesla it seems ok, 4.5 tesla 440 not 15 it should be it is it looks to be 45 83 4,000, 40,583, but is a very high filed, that is because this pole gap I have kept very small.

Now, if you change this pole gap, but this had to change here, if I change this it is increasing, but other direction if I change other direction, but it is hard it is hard to change it is decreasing for a pole gap and increasing it is decreasing for same current you see it is decreasing, the value is decreasing for same current, this value is decreasing you can see

this gap for same current magnetic field is changing. it is your that Cali earlier calibration will not be valid for that. that is there this pole gap once, it once it is calibrated you have to keep fixed, you should not nobody should not if any change is

there then you have to do calibration again. this current I should not apply for longer time let me decrease it

this is in series condition you can check it for parallel condition in parallel condition and then from this power supply I can show you, that you can apply you can apply maximum 6 ampere current, more or less let me check it how to do that? then here what is the connection let me switch off this one. here it is sure that. current far parallel connection what have I to do? I have to for parallel connection. this two ends of the coil I have to take, I think yeah it is in sketch it is easy to show, but in reality one has to think.

I will not change this two end this two end we have kept in a such a way that current in both cases will be in same direction. now, what I will do? I will not disturb that one, what I have to do this. this two will be in this may the supply this may the supply now using this one probably I will face problem to do that, this end and this is ok, but that option probably here I will face problem, because here other one I can use, but here this problem is this connection.

for parallel what I have to do let me take out this one this two end positive to positive, this 2 end and this one is say here it is a with battery now other end also should be with battery I think this way I could connect it now this 2, this 2 or this one should be same wire. this should be I think there I will not put here, I can put no this the problem is here what I am facing problem, this end and putting here, but the already polarity I have check whether it will be in same direction or not that I have to I have to check yes.

Now, in middle I do not know this two or connect it or this two are not connected, this two I have not connected yes. this should work in principle this way I am expecting that this there is no internally there is no interconnection of this two externally we have to connect if. let me check it should be it should work in principle; no it is not working ok, it is not working. let me just this way ok, I think there something here coil say current is coming this way passing and going back going back to it should go back to this other one, other one is then there oh it is going there, but it should then it is going or coming back no.

that is to work I think this is something wrong that is why it looks short circuit yeah why. that I was trying to oh I think it is the here is it is the short circuit. for this is coming yes it is short circuit. because this coil itself here is a connected like this. this coil here it is

coming then going this way then coming back coming back this is a short circuit. there should not be short circuit. for same that is true it is become short circuit.

I this two let me just follow the; I have to this two end is the for this two end is for. that is the I shift drawing the sketch is very easy. I and then follow the drawing and then do the things otherwise it becomes slightly as a I think this I will follow this one whatever I drawn.

one end of this one end of this is this coil, coil this end will go to the power supply say, it is going to the power supply this is the power supply one end and then the this one will be connected to the it will be connected to the end of this other coil, end of this other coil and, then other end no other end, I think this coil have two end, one end is connected to the one end is connected to the, one end is connected to the, one end is connected to the power supply

And, other end of the coil is connected to the another coil, other end also connected to the not another coil, it should be connected to the it is other end of the coil should be connected as per my diagram, it should be connected to the another powers another this one this is fine.

Now, let me check it whether this way current is going for this 2 coils this coils I have connected. Now, I understand the problem, this 1 coil I am using if this 2 ends are the connected with the battery. then it should work it is not working; that means, I think here this 2 coil this I do not know here if I use this is for coil 1, this is for coil 1 this connection this is for coil 1 fine. And, this 2 connection is for coil 2. maybe this two are for coil 2

Now, this coil 2, this is the 2 end of coil 2. I would like to take this other end has done here. And, for coil 2 also 1 will go to this way, yes, I understand the problem it should go to the it is a power supply 1. And, I think this I should put this way Now, this should work as per my diagram I have done.
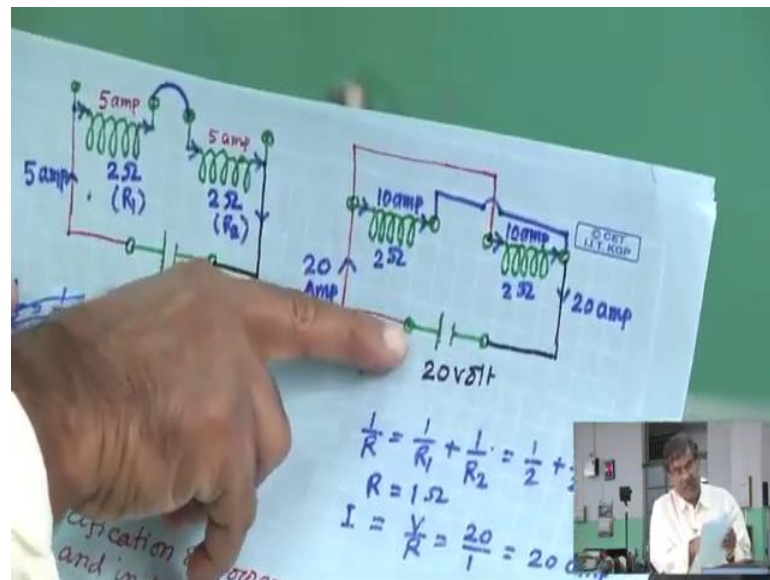
here one end will go to the to the power supply, other end will also go to the power supply for this also one end will go to the power supply other end also go to the power supply earlier why I did not get because I assuming this two end this end and here you see, here this coil 1 this connection I am taking this way that is why I was not getting.

And, now I should get, now I should get, yes now I am getting, now I am getting in parallel condition I am getting current let me check how much I can get. If I get 3 then the connection was earlier being in parallel ok, if I get more than 3 then So; that means, earlier the individual I am using ok, it should be 20 ampere no. Now, here earlier if this power supply we are using in parallel condition not in series condition; now, 3 and earlier also 3.

now let me do the series condition and then you will see this current will be half. Just, I want to check show you know; this is the very important concept I. now, I will I want series connection so; that means, earlier it was when now, this two, this two, end and this two end. this is for series condition I will follow this diagram.

it is easy to always in laboratory you should check the diagram and connect it otherwise you will face problem as I was facing this two end here one end of this one end of this will of this coil will go to the battery. let me check this put this one will go to the battery say it is going to the battery and, second one second one will connect with the end with this end of this with this one ok, I think this is the things

Second one is connected with the one end of this second coil. this I am interconnected ok, then this 2 connected and this one, this one we will go to the battery this one we will go to the battery I am putting here no yes. E I have put in this as if only coil 1 I am this battery between these 2 I am using earlier this two I think inside some something different way it is connected.

Now, just I was using. previous to this two now also I am this two. earlier one is parallel now it should be in series let me see maximum current I should get 1.5 not more than that. Let me check it no It should be half, but it is not half I was trying to demonstrate it, but I do not know if I could battery, I do not know inside in which way the problem is inside in which way they are if power supply is connected with this diagram that, I do not know I think this power supply it is easy to take it I think I will take it this one.

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I will take this power supply nothing to do with coil I think I should, I will switch off this one let me use because this concept should work you know. Now, it is in parallel condition. now, is if this two for power supply 1 is positive 1 is negative. I will use them. this ok, but here this confuse I am confused with the inside how they are connected I do not know.

now, if I put this way then it should be in principle it should be in series. this current is coming this way it is going through this, this, and here then coming to the next coil, and passing this way yeah, it could be in series let me check switch on this one and check it,

how much current I can apply. This is current control I am changing current. here I am getting 1.5 yes, maximum current no more I can get I am getting 1.5

Now, this is in series condition. Now, in parallel condition this current I should get more, I should get more, I will switch off, I will switch off 0, I have made 0, I think this way probably can be shown better. now, I will go for parallel connection. what I have to do I will follow this one, this one. this is let me because always things are confusing I will follow this one. one end of this one end of this one will one end will go to the battery and other end also will go to the battery

and here also same thing I have do it is. one end will go to the I do not know. here only that current direction I have to check, but I am not going to check the magnetic field, but here. let me put it here ok, one end will go to here and other end will be connected I think this way I should connect because here there is an option to put it

Then, I have connected following this one. Now, let me check let me check current should be double, hopefully yes just check it 3.92 ok; it is current is 3.92. earlier 1 it was 1.5, 1.5 now it is 3.4; it is a more than double. reason is in here just resistance is not only this coil resistance, there are some it is you know this it is called it is coil there are induction ok, there are some inductive resistance inductive resistance also.

although it is a DC current it is not induction also induction of the coil is also important but more or less these together are of the coil as well as the induction this L of the coil for this circuit you will get the 1 point you will get the total impedance ok, kind of things. what here exact value I cannot tell it is difficult to tell because I was assuming that that only resist pure resistance, but there are inductances also that is why, but once it is clear in one case you are getting 1.5 and other case you are getting 3, more than 3

for pure resistance this could be 3, but since some inductance is there. that is why this it. if there are condition you are getting current is double. magnetic field I can show you magnetic field, here I do not know whether you have checked or not here magnetic field should be the for T, current T here we are not getting magnetic field the reason is that I have to exchange it is a current it flowing in opposite direction. to nullify it, I have to I have to change this end this end instead of this for same direction of the current, I will I will change this one just, I will put is yes

For same direction of current I have to red with red yes that is the real combination for same direction of current. Now, you see there should be yes you can check and check this field you can check this field you see, you can check this field is increasing earlier for that connection field was not changing. this again just I think I have I should not do this way, I should not do this way I should switch off and do this 10 minutes' past

if I do in series means red with red outside. I could do here, but it is difficult, it has some no I think it was now yes red with red and this I will give this way now it is in series, now it is in series. Let me if current yes maximum 1.5 current and here, it is corresponding field is small (Refer Time: 40:53) it is in 10 ok, it was in 10. that is why it was not showing small current

this way you can check. One thing is clear that voltage for this power supply is maximum voltage is there, but using this same power supply of this voltage we can get current in the coil double, when they are connected in series parallel and we can get the current half, when this 2 coils are connected in series that is the anomaly in using the using the specification of the power supply having some voltage having some voltage fixed voltage.

in some extent we can resolve this problem, if voltage is smaller for getting the higher current we can this way, we can just double the magnetic field of current in our electromagnet, if we have a power supply having lower voltage I showed you, I showed you I to long time because of connection, but it is not bad that you see always confusion comes. And, then I think this diagram helps to do that one has to do I have to do you have to do also you have resolve the problem and get the things done

I think I told lot of things and showed lot of things about the electromagnet and now hopefully you will be able to use this electromagnet very confidently. I will stop here and next I will tell about the gaussmeter How to measure magnetic field, what is the principle of this gaussmeter? That I will tell in next class.

Thank you.