Experimental Physics - III
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Lecture - 05
Electro Magnet and Constant Power Supply

we are in solid state physics laboratory of Department of Physics IIT Kharagpur, I will show you the Electro Magnet in our laboratory. In last class I discussed about the different components of the electromagnet and purpose of each component.

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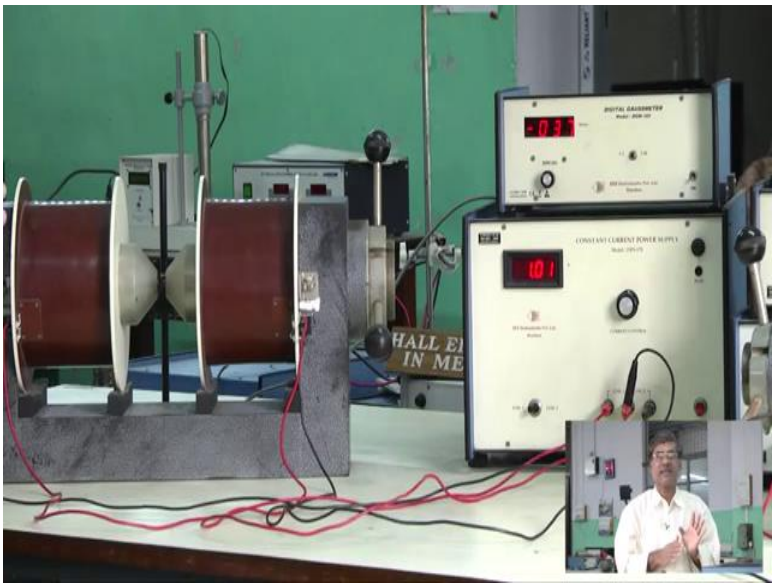

here you see this is electromagnet as I told, it has 2 coils this is one coils and this is another coil. 2 coils and it has 2 pole pieces, this 2 pole pieces is a tapered pole piece it is the tapered pole piece there is a gap between this 2 pole piece and that these pole piece it is the I can change the position of these pole

that I will show you it is a heavy it is a one need to apply just this is for changing the pole gap I think I will show in other one. there variation is smooth and this heavy one, this heavy one it is the heavy this at least it is weight will be 1 quintal know 1 quintal. let me show this smaller electromagnet there I can easily rotate and show you how you can change the gap.

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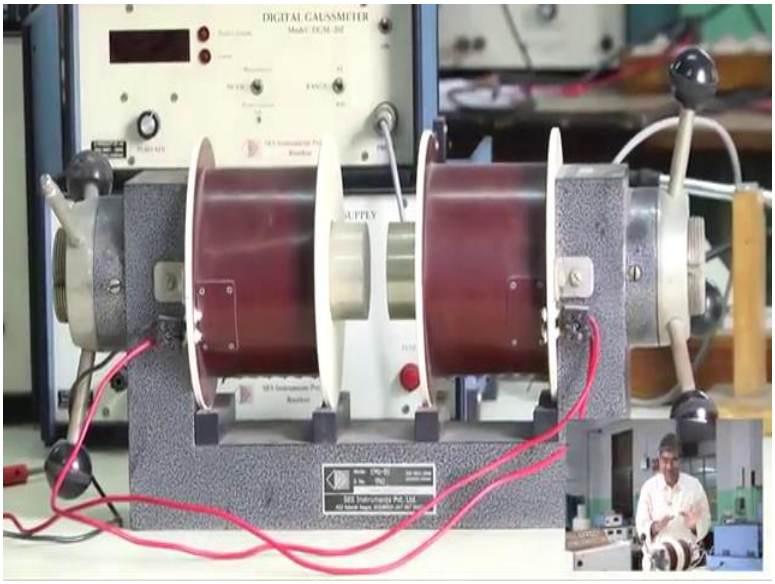

here this is another electromagnet same similar, but in this as I told flat pole and this flat pole and the tapered pole. in this case this is the flat pole, this is the flat pole for in this case flat pole will give you the lace negative field then the tapered pole, but sometimes we need flat pole also. Because, uniform field depending on the size of the uniform field you one between the pole piece that will decide, that will decide the that will decide the size of the pole.

flat pole where you need the uniform magnetic field over a higher area. there you have to use flat pole, it will need the uniform field in a small area means your sample is very small in millimeter size then one can easily use the tapered pole or if your sample size in centimeter range or in inch 5 centimeter, 10 centimeter or 20 centimeter then you have to use the flat pole. there are some rules, but I am not going to discuss about that.

flat pole electromagnet and tapered pole electromagnet and same magnet also use can be used for flat pole as well as tapered pole in that case separate tapered piece is just there will be option to just attach on this flat pole then you can attach and you can detach this tapered part then you can use as a flat pole as well as tapered pole. that option alone can keep.

now here what we have seen as I told you this there will 2 coils, now 2 pole pieces 2 pole pieces are made of iron or some alloy magnetic alloy iron alloy this rod kind of pole circular pole in each coil it is inside passing through this inside the coil and it is attached

to this, it is attached to this. you can rotate and adjust the gap of this pole pieces, magnetic field is very sensitive to this gap of this pole pieces.

depending on the size of the sample or depending on the geometry of the experiment we keep the pole piece separation accordingly because if you can keep the separation smaller you will for same current you will get higher magnetic field. for same current you will get lower magnetic field if this pole pieces pole gap is higher, pole gap is higher.

another as I told this stand to hold this one; it is not act as a stand it is it mainly it also works like a magnetic conductive magnet magnetic conductive part for magnetic line support this is also made of some alloy magnetic alloy. Now, as I told this you can rotate and you can rotate and you change the pole gap, you can change the pole gap yes easily pole gap is changing now you see gap is almost I think this is slightly harder.

I have to it is yeah I think generally ok, but this is very smooth increase or decrease now it is 2 to 3 millimeter depending on your requirement of the gap you can adjust the gap. And, now for same current magnetic field will be different for different gap. it is important to note that before starting experiment. with current how magnetic field varies for a particular varies with current for a particular gap that you have to calibrate

After calibration you should not this should be locked, you should not change the gap If you change the gap then that magnetic field versus current that will not, that will not work that will not be valid. for doing experiment in laboratory if it is teaching laboratory different students in different days they are doing. it is you cannot expect that pole gap will remain same, somebody can change it.

when you are going to do experiment before starting the experiment always we calibrate the magnet first means current versus magnetic field that calibration we have to do now, this is the magnet. it has coils each coil have 2 ends, each coil has 2 ends here you can see, here you can see this two end you can see, this two end this two end of this coil, these two ends of this coil now, these two end here there is option to keep just fixed it and from outside we can just we have taken connection from this 2 wire.

this is this whatever I am showing you this and this, this is the end of this coil 2 ends of this coil and here this end I think this and this the 2 end of the other coil. Now, as I told

that generally company just connect like this company connected like this and given us to do the experiment, to do the experiment now this these two end is connected of this 2 coil and other two end, other two end is used for applying is used for applying current these two will be connected to the power supply right.

Now, let me just let me use this two I think I will go to the other one. this same thing is here, same thing is here ok, but here I have slightly advantage here since it connected I will not open that one, let it be there. same instrument, same electromagnet everything is same, but here you can get higher magnetic field because coils are bigger, coils are bigger number of turns is higher as well as tapered pole is there.

If coil size bigger that is different turn, it has also different meaning. now here you see here actually I have option, here I have option you see I will just show you I will just detach and show you. this two ends of the coil and this two are other end these two are other end, these two are other end this is one coil, this is one coil you can see this is one coil, this is another coil this is another coil ok.

this you can take the two ends of the coil two ends of coil number 1 and this is two end of coil number 2 this 2. Now what I want to do? I want to do connection in series, connection is in series I want connect in series, then how to connect that is very important as I told you that current should flow in this two coil in same direction. Then only you will get magnetic field here, if the current in opposite direction then you will not get magnetic field here ok.

for whether current is flowing in same direction or in opposite direction how I will check it. I will check it this just using this concept that when current will be in same direction then it is in, it is I will get magnetic field here maximum magnetic field here. And, if current in opposite direction I will get here minimum magnetic field for the same current I do not need to bother how I am connecting just I will decide just seeing the magnetic field.

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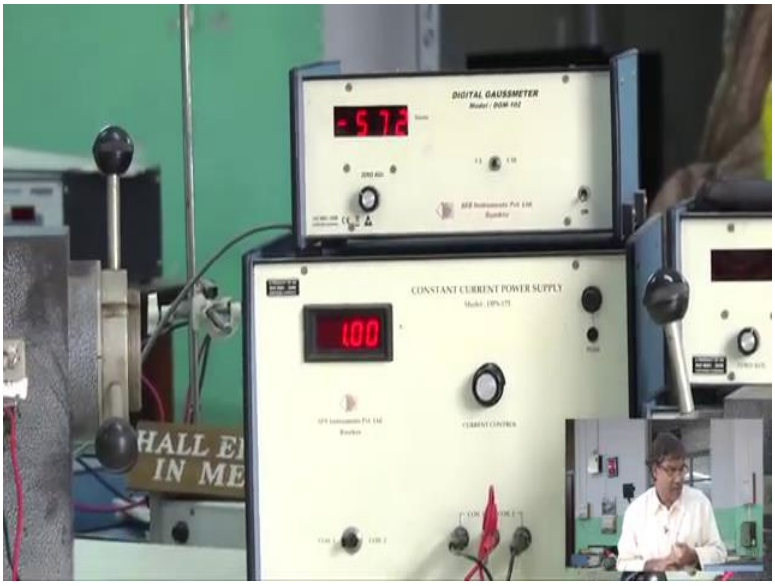

let me how I will do that, let me use this one. here picture is here this coil 1 and coil 2 and this middle one I can interconnect them. let me take this red one, this red one I will put some yes; I think let me take this two red wire; these two red wires connect together I am instead of connecting here there is an option here to make them like this I will use this one here and I put here means earth these two coils are connected ok.

Now, these two ends are for applying the I have to connect to the power supply this is the power supply, this is the constant current power supply. in this power supply here this two knobs are connected with the power supply, power supply has cathode ion positive and negative pole this two are connected with positive and negative ok.

now what I will do? I will this is the, it is telling connect the coil one end. one can be taken anyone I think and the other one is connected here. this two are end of the power supply ok, internally that is connected with for coil 1 and this the other one the for coil 2 end this free end which I have not interconnect interconnected one is this red part

now what I will do whether I am getting magnetic field here or not just I will check it. I will switch on the power supply, here there is option coil 1 or coil 2, I do not probably it will not, it does not need probably right.

Power (Refer Time: 16:30).

I think we have to check the; I will I have switch on this power supply and I have option to vary the current here now at present the current is 0. here let me apply current, apply current say it is the in ampere; it is in the ampere. let me apply 1 ampere current. 1 ampere current ok, 1 ampere current is flowing to the coil. here for individual coil alone can do, but here it does not matter because here interconnected this one here ok.

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 teslameter I will discuss about the gaussmeter, teslameter in next class, but let me just use this some this probe ok, it is called hall probe and corresponding meter that is called gaussmeter ok.

is the gaussmeter it is together this hall probe and this some meter together is called gaussmeter. meter is here it is a some that meter has some option for 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 ok.

Now, if I think it is the 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 to do; if I just exchange this instead of this you see if I interconnect. 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 ok.

now these two I interconnected to (Refer Time: 20:26) 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 if now this I will I input ok, now you will see that earlier whatever the interconnection was there ok, now in this connection current will be in independent way.

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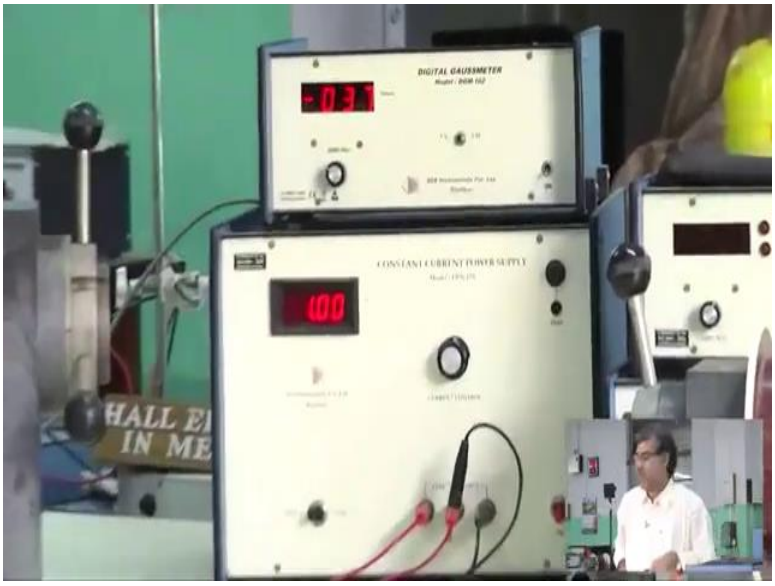

in that case let met check, it should be in anti-clock in opposite direction that I can verify. I will apply again I will apply again this 1 ampere current, I will apply 1 ampere current yes, I applied 1 ampere current. There is no change of this magnetic field; that means, no magnetic field between these two 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 are current flowing in the same direction or in opposite direction. I we want current should be flow should flow in same direction whether this two coils are connected in series or it is in parallel that way we can check.

now, I will switch off, but before that I should reduce the I should reduce the current, I have 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 here I make sure that this I got the interconnection of this two in such a way current will flow in the same direction in both coils ok.

Now, here if that is magnetic field will vary with the current it is obvious, it varies with the pole gaps that is you can just check for a particular current you can just check you can. for a particular gap you have 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 right.

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. 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 turns, 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 it contain the all constant of the element of electromagnet like number of turns and then what is the mu value etcetera without knowing them what I will do? If I have instrument that it will tell, 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 up to certain current ok, beyond that current there are some non- linearity. 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 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 the 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 ok.

that is why this that this sometimes this gaussmeter is that type instrument is very important when the geometry of the Biot Savart Law it is difficult to fulfill in the real instrument There are some instrument where this geometry of that formula can be can be fulfill easily. there just without any additional instrument we can just calculate from that by using that formula ok.

Thank you.