Experimental Physics - III
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Lecture – 52
Faraday Effect

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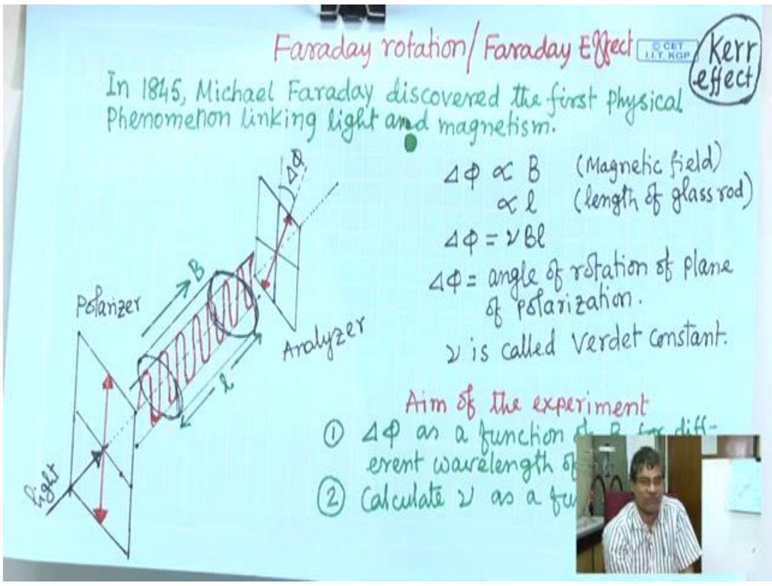

Faraday rotation/ Faraday Effect

Kerr effect

In 1845, Michael Faraday discovered the first physical Phenomenon linking light and magnetism.

$\Delta\phi \propto B$ (Magnetic field)
$\propto l$ (length of glass rod)

$\Delta\phi = \nu B l$

$\Delta\phi$ = angle of rotation of plane of polarization.

ν is called Verdet constant.

Aim of the experiment

① $\Delta\phi$ as a function
erent wavelength

② Calculate ν as a

Today I will discuss about Faraday Effect or Faraday rotation. Actually, in 1845 Michael Faraday discovered the first physical phenomenon linking light and magnetism. What does it mean? If light passes through a magnetic material and transmit through this material then, if light is polarized light the angular polarization is changed due to the interaction of light with the magnetic material. That is called its Faraday Effect or Faraday rotation.

There is another effect its called Kerr effect; it is called Kerr effect, it is a similar effect. The effects we have seen Verdet we have seen when light passes, when light transmit through the material then we tell the Faraday Effect. In addition, it will be called Kerr effect when, light reflects from the magnetic material. In reflection magnetism that is the Kerr, effect in transmission mode, the light with the magnetic material or magnetic field that is called the Faraday Effect

I will demonstrate one experiment in our laboratory is Faraday Effect, Kerr effect separately I will not demonstrate, but there is a research in prepared it is called MOKE:

Magneto Optical Kerr Effect. that it that then the instrument we tell MOKE instrument and that is very useful for research purpose. that experiment separately sometimes probably not in this experiment III, Experimental Physics III course, but in that will be the advance course maybe later on I can demonstrate that MOKE that is based on the Kerr effect.

However, today I will just describe the Faraday Effect and demonstrate the experiment. Light interact with the magnetism, magnetic material or magnetic field due to interaction that interaction, we observed through the rotation of the angular polarization of incident light. That rotation of the polarization, if it is del phi. That del phi is proportional to B it's the, it is proportional to the strength of the magnetic field also it is proportional to the length of the material through which the light is passing del phi is proportional to the B and l.

That is equal to del phi equal to here I have written nu nu B l. nu is proportionality constant. That constant it is called Verdet constant a working formula is very simple. we have to aim of this experiment is we will see the del phi as a function of magnetic field called different wave length here these two component; one is light another is magnetic field. Light have different wavelength.

We will choose a particular wavelength and for that wavelength, we will measure the del phi as a function of magnetic field. And, then we will calculate nu this Verdet constant as a function of lambda for that means, for different wavelength we have to measure, for different wavelength we have to measure del phi as a function of B. And from there of l is constant, l is constant

del phi by B. del phi as a function of B means del phi by B. if you draw a graph; if we draw a graph del phi versus B; then we will get slope that slope will be del phi by B. from the graph we will get this del phi by B divided by l, l is known the length of the sample. We can calculate the Verdet, Verdet constant nu we will calculate nu for different wavelength. In addition, we will see whether that Verdet constant depends on the wavelength

That is the aim of this experiment. In addition, theory is very simple and this experimental set up for this will take a light white source light it will have all source of wavelength. Then we will use filter to choose a particular wavelength. Now, that light of particular wavelength will fall on a polarizer. It will polarize the light. we will it will be linearly polarized light. Now, that light will pass this is the sample; this is the sample and we need arrangement the length of the sample is l and we need arrangement to apply magnetic field in this direction along the length magnetic field.

We have to apply along the length that is B. Now beside the there is an analyser. Initially if both are parallel. we will get we will get maximum intensity; because whatever the linearly polarized light is passing. That will fall on the analyzer if there is no rotation, then that light will pass through it because we have kept this analyser as a parallel to the polarizer

That is an axis analyser polarizer it has uh optic axis. That optics axis we will keep parallel for both cases. Now, what we will do we will rotate this one by 90 degree analyzer so; that means, it is in cross position now. There should not be any light pass through it we will keep in dark condition and now if we apply magnetic field then what is happening then we will see there is that whatever dark spot we are we are getting, now it will be slightly b

Now then that is because this l polarization this uh this light polarized light now its rotated a small component is passing through these through these analyzer. now we will rotate this analyzer ok, by a certain angle we have to find out that angle for which this again we will get the dark spot means light will not pass through

That is the; that means, the all of these polarized light it is rotated by this angle. That is we are telling del phi, that del phi will measure through the rotation of the analyzer and there is a scale on the analyser from that scale, we will find out the angle of rotation of the polarizer polarized light linearly polarized light.

This experiment now I will show I will demonstrate in our laboratory. I think before that what are the data we have to take that I can tell you or what we have to do. I think I have discussed this how to do experiment.

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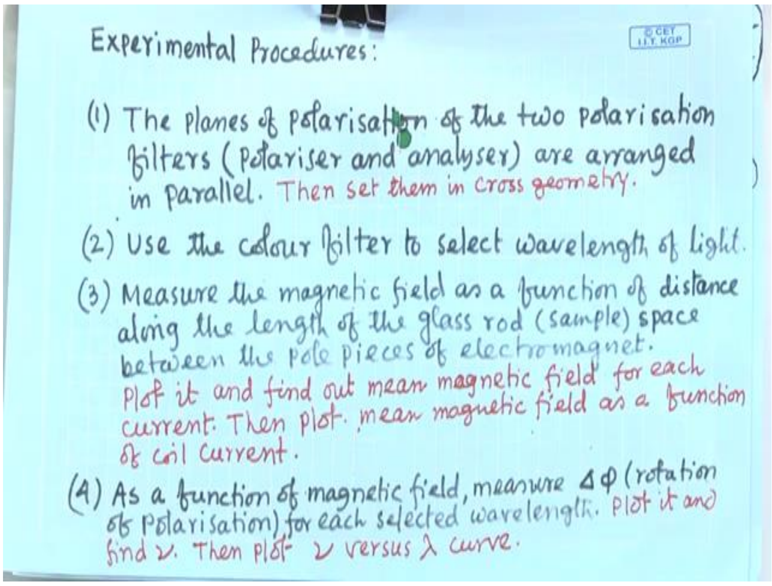

Experimental Procedures:

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(1) The planes of polarisation of the two polarisation filters (Polariser and analyser) are arranged in parallel. Then set them in cross geometry.

(2) Use the colour filter to select wavelength of light.

(3) Measure the magnetic field as a function of distance along the length of the glass rod (sample) space between the pole pieces of electromagnet. Plot it and find out mean magnetic field for each current. Then plot mean magnetic field as a function of coil current.

(4) As a function of magnetic field, measure $\Delta \phi$ (rotation of Polarisation) for each selected wavelength. Plot it and find ν. Then plot ν versus λ curve.

the plane of polarization of the two polarization filters that is polarizer and analyser are arranged in parallel As I told you then we will see the spot because light will plane polarized light will pass through both the polarizer and analyser then set them in cross geometry as I mentioned. After that, we will use the colour filter to select wavelength of light the second step.

Third step measure the magnetic field as a function of distance along the length of the glass rod or sample, the space between the pole pieces of the electromagnet. As I told that, we have to apply magnetic field. How to generate magnetic field in laboratory that I will discuss in separate lecture. between two pole pieces we will get the magnetic field and that that rod we will place along the along the pole pieces.

Magnetic field will not be same at different position of the sample length it will be it will vary. At between the pole pieces. We will measure the first we have to measure the magnetic field as a function of distance of the of the sample Distance of the sample means, if you start from the one end of the sample. at different position of the sample will what is the magnetic field that we have to calibrate first and up to the end other end of the sample. Then we will take the average magnetic field on the sample

See that we have to do because; it is very difficult to get uniform magnetic field over an in few centimetre length. For that is why we have to take average magnetic field. that is what here I have I have written. I will show you how to do that then plot it and find out mean magnetic field for each current. Means for each current means an electromagnet we will pass electric we will pass current, through the through the coil of the electromagnet. For a particular current what is that magnetic field?

Now, magnetic field will vary along the length of the sample. for a particular current we will find out the average magnetic field on the sample for that we have to measure the magnetic field at different position of the on the sample then from plot one can find out the mean magnetic field for each current. for different current we will measure that one or if we decide that we will do the experiment for two current or three current Means for two magnetic field or three magnetic field of different magnitude. Then that one has to decide and do the step mean magnetic field one has to find out for each coil current.

After that yeah, we will do the measurement of del phi as a function of magnetic field for each selected wavelength. As I told that for wavelength, whether for different wavelength, whether Verdet constant varies or it constant it is independent of wavelength of the light. It depends on the wavelength of the light. that one can show plotting a nu versus lambda curve

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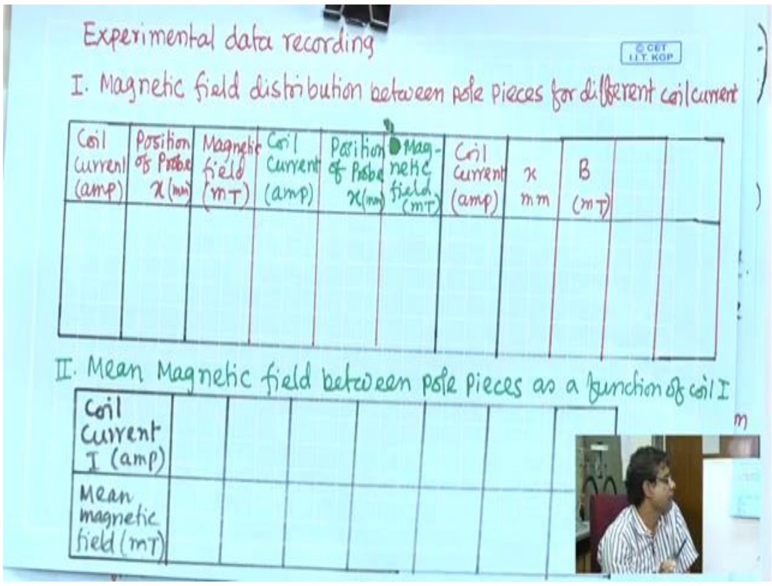

Experimental data recording

I. Magnetic field distribution between pole pieces for different coil current

Coil current (amp)	Position of Probe x (mm)	Magnetic field (mT)	Coil Current (amp)	Position of Probe x (mm)	Magnetic field (mT)	Coil Current (amp)	x mm	B (mT)		

II. Mean Magnetic field between pole pieces as a function of coil I

Coil Current I (amp)							
Mean magnetic field (mT)							

Next we will I will show you it is how to record the data ok, experimental data recording. First magnetic field distribution between pole pieces for different coil current a coil current say 1 ampere and for 1 ampere we have to use probe Hall probe we use for measuring the magnetic field. Now, Hall probe generally we use in laboratory that is we use in transverse mode

This is the normal Hall probe, transverse pole means you have pole pieces we have pole pieces. probe we will put this way in transverse in transverse direction. This probe when magnetic field falls perpendicular to this this then this we are telling transverse mode. then we get the correct magnetic field for a particular coil current Now, in this experiment we have to measure the magnetic field variation along the length along the axis of the pole pieces of the magnet

That is why we need separate Hall probe separate probe that is called axial probe ok that is called axial probe. that probe we have to use for this for measuring the magnetic field in this case. This is the special case generally we do not use the axial probe what is the different I will tell you wait I will show you uh.

for different position we have to we have to note down this position of the of the of the probe and corresponding magnetic field for magnetic from gauss meter or tesla meter for a coil current we are getting for different position x; we are getting the magnetic field. Here just for many positions if you want to take. here this is one I think this magnetic field coil current then I am just continuing this this table, along the along the along these direction not this way. Because this for probe two here top probe to for second this column is this is the same as this one then this is same as the this one

So; that means, we are continuing the reading we are continuing the taking reading Then we will find out the mean magnetic field between pole pieces as a function of coil current ok for different coil current. What is the mean magnetic field, that we can write here as a function of coil current. We will apply different coil current different coil current and what is the mean magnetic field from this table whatever the mean magnetic field we will find out.

That we will write. here what we know for different coil current what is the mean magnetic field over the length of the sample that we know

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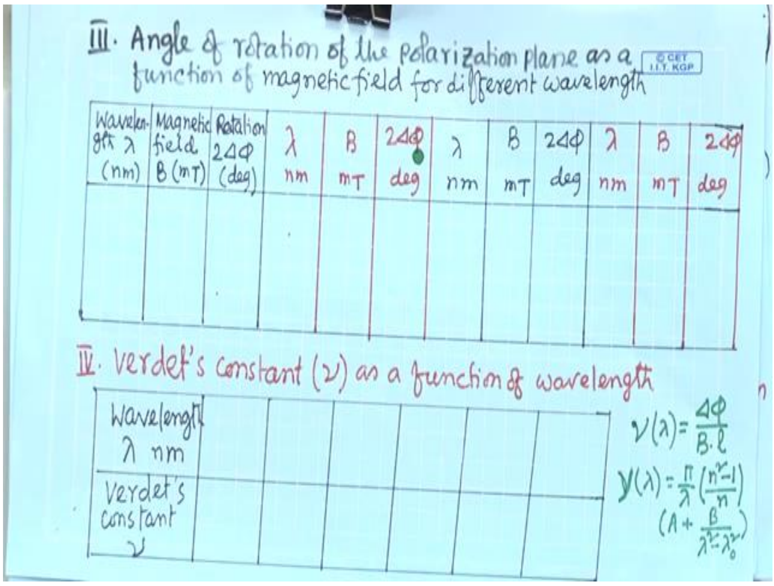

III. Angle of rotation of the polarization plane as a function of magnetic field for different wavelength

Wavelength λ (nm)	Magnetic field B (mT)	Rotation $2\Delta\phi$ (deg)	λ nm	B mT	$2\Delta\phi$ deg	λ nm	B mT	$2\Delta\phi$ deg	λ nm	B mT	$2\Delta\phi$ deg

IV. Verdet's constant (ν) as a function of wavelength

Wavelength λ nm						
Verdet's constant ν						

$$\nu(\lambda) = \frac{\Delta\phi}{B \cdot l}$$

$$\nu(\lambda) = \frac{\pi}{\lambda}\left(\frac{n^2-1}{n}\right)\left(A + \frac{B}{\lambda^2-\lambda_0^2}\right)$$

Second table we have to next table we will we use, that is the measurement of the angle of rotation of polarize light or angle of rotation of the polarization plane as a function of magnetic field for different wavelength as I told you. for this is the table. Lambda as corresponding magnetic field, we will select lambda corresponding we will apply magnetic field. for different magnetic field we will measure the del phi.

Here I have written 2 del phi here I have written 2 del phi in we will take in degree. Why 2 is taken, that I will tell you. Corresponding this is the three column is continuing. Corresponding lambda beta 2 phi. you can take because for each wavelength we will have some few data for different magnetic field For second wavelength we will continue the we will continue the same way for different magnetic field what is the rotation

After that, you can find out the Verdet constant nu as a function of wavelength. for that you just note down the data from this table, wavelength corresponding Verdet constant calculate from that formula This nu as a function of lambda equal to del phi by B l as I told. In addition, if we of this if you take just write data here and then you can plot nu versus lambda. And, then one can find out whether that curve we are getting, whether that curve can be treated with this with this A plus B by lambda square minus lambda 0 square or B by lambda square this kind of expression

Generally, theoretically it is found that this it depends this nu it depends on wavelength like this A plus B by lambda square this kind of expression if you use you can feed the experimental data. How Verdet constant depends on other whether it is linearly dependent or it depends on in complicated form? It depends on in this form generally that one can check this is the theoretical part of this experiment before starting explained one has to understand what I told you. Then, one should go to the lab and do the experiment.

In next lecture, I will demonstrate the experiment.

Thank you.