Experimental Physics - III
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Lecture – 47
Determination of Wavelength of Spectral Line Using Constant Deviation Spectrometer

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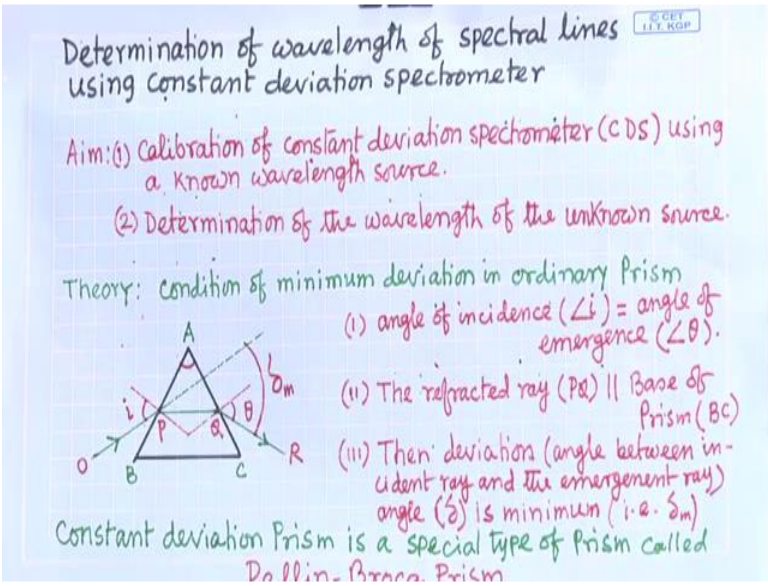

Today I will demonstrate how to determine the Wavelength of Spectral Lines Using Constant Deviation Spectrometer. Far we have used grating; grating spectrometer for measuring the wavelength of different source. This is another new method; it is very convenient method to determine the wavelength of unknown source. Generally, this technique is used in industry it is a; it is a very convenient, this experiment we will demonstrate in our optics laboratory of Department of Physics IIT, Kharagpur.

Before demonstrating the experiment, let me discuss the theory of that experiment. Aim of this experiment is calibration of constant deviation spectrometer CDS, Constant Deviation Spectrometer using a known wavelength source. First, we have to calibrate the spectrometer, constant deviation spectrometer and then we will determine the wavelength of the unknown source. You know we have seen that minimum deviation in a prism; this is very essential condition for many experiments.

If you change the incident angle of light on a prism. this the light will be refracted and then it will emerge from the prism. Deviation is this is the incident direction of the light and this is the emerging direction of the light. this is called deviation delta ok. These delta become minimum for a particular value of incident angle. See if you vary incident angle then this deviation will vary, for decreasing or increasing the incident angle from a particular angle. Deviation will be higher than a particular deviation that, we tell this del delta m. this minimum deviation.

When we get this minimum deviation or when we get minimum deviation during that time the angle of incidence will be angle of emergence. angle of incidence i will be equal to the angle of emergence theta. In addition, the refracted ray PQ, refracted ray inside the prism the PQ that will be parallel to the base of the prism. If A is, the prism angle opposite side is the base of the prism. This PQ will be parallel to the base of the prism then, deviation means angle between the incident ray and the emergent ray will be minimum del m ok.

Constant deviation prism is a special type of prism is called Pellin Broca prism ok. For constant deviation spectrometer there, we will use a prism, but that prism is a special type of prism and it is called who discovered this prism. According to their name, it is called Pellin Broca prism. We should know about this prism Pellin Broca prism. let me tell about this prism.

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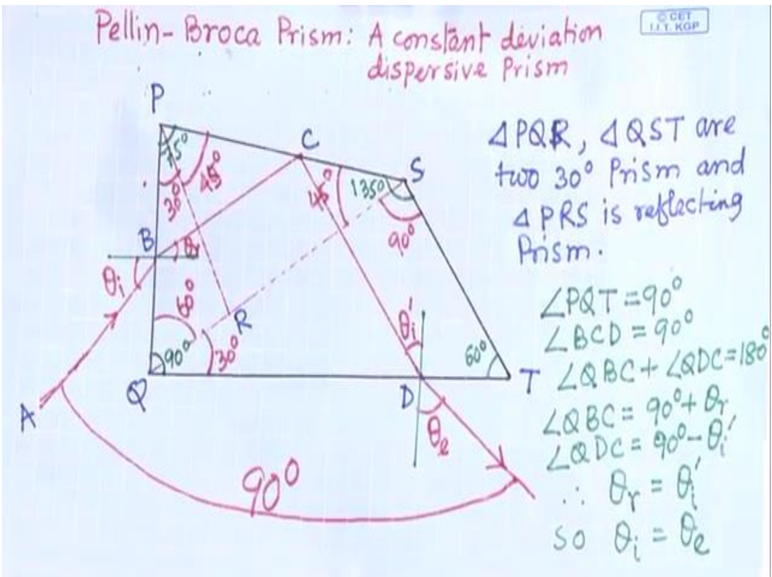

Pellin Broca prism a constant deviation dispersive prism ok. this is the shape of the prism this is the shape of the prism P Q T S, this is a single piece; this is a single piece of prism and this prism have defined angle. This one angle is 90 degree, this angle Q this is a 90 degree, another angle is 60 degree, angle T is 60 degree, and angle S is 135 degree and angle P that is 75 degrees. I have written with green colour.

This is the specification of the prism; the prism is made in such a way that it is angle have to be this, whatever I mentioned ok. now, this prism we can think that is consist of three prism; it consists of three prism. One is P Q R; P Q R, another is, another is Q S T; Q S T ok. These two prism as if this are this 30 degree prism, you can see their angle here their angle is 30 degree of this prism and this prism also, angle is 30 degree. Whatever the prism I have shown ordinary prism angel A. that here you can think that the prism angle prism angle.

This will be the base of this prism; this will be the base of this prism ok. P Q R and Q S T are 230 degree prism and another prism is Q R S Q R S or sorry P R S, P R S is a reflecting prism, you can say this is reflecting prism, why we are calling as a reflecting prism that we will understand. Now, actually, this is a single prism, but you can think it consists of these kind three prisms.

Now, light is falling like this ok. incident angle is theta i this is the normal, now it will be refracted, refraction angle of refraction is theta R ok. BC is the refracted angle. Now, here it will be reflected, total internal reflection here this angle will be such that it will be total internal reflection. It will be reflected this way ok.

Then at this surface, this will be the emergent light, emergent ray. here at this surface you can think these are again refraction from prism material to the environment ok. These will be the angle will be incident angle and this will be the emergent angle or refracted angel ok. now, here you can see that for a, if you change; if you change this angle theta i. you will get a particular angle; you will get a particular angle where this ray, this refracted ray will be parallel to these to these QS Q, QR or QS ok.

As if as I told this is a prism, this is a prism. when it will be parallel to this base; when it will be it is a incident angle is for minimum deviation ok. As if that condition is followed and it is going and falling on the surface and then from the surface it is again, it is reflected and it is reflected in such a way as if this is parallel to these to this base, it is parallel to this base. As I told this is another prism of 30 degree if this is the angle of prism, opposite one is base. As if this one is parallel to this, parallel to this.

Now, it is refracted outside emergent one. light always it follows the reversibility principle you know. If you, if you consider that this is the incident ray, then it will be refracted from this inside this prism following this path. as if this path is parallel to this base ok. These construction of the prism is such that. Here whatever the deviation of light we are getting the minimum deviation condition and a deviation this is the incident light. this is the incident direction and this is the emergent light, emergent direction ok.

Angle between these two is the angle of deviation and in this prism, this angle of deviation is 90 degree that you can easily show. Here you can see that you can see that that angle PQT; angle PQT that is 90 degree, angle BCD; angle B C D that is al90 degree. Why it is 90 degree? This line is parallel to this, this line is parallel to this this angle; this angle is 75 and how to show it is a 90 degree.

Why BCD sorry BCD, BCD is 90 degree. From the geometry itself, you should find out if you if you connect this Q S. it was total is 35; total is 35 at this P Q S T it is a 90 degree. This angle will be 45, if this is 45 and this is normal to this, this is normal to this because this is parallel to this is parallel to this ok.

If this is, 90 degree this also will be 90 degree. it is 45 and then this is 90, then this one will be 45; this one will be 45. Similarly, is as since it is reflected one, this one also will be 45. These two are 45, 45, 90 degree, this BCD; will be BCD will be 90 degree ok. Then QBC plus QDC, QBC; QBC this angle QBC plus QDC; QDC is QDC ok.

This angle and this angle is equal to 180 degree. Why? Because, you know this is the trapezium ok. This angle is 90, this angle is 90 180. Other two angle has to be 180 this is 180. Now, Q B C is Q B C is 90 degree plus theta r; plus theta r and QDC, QDC that will be 90 degree minus theta i dash minus theta i dash. Now, if we put these this here from there you can easily find out that theta r equal to theta i dash. theta R is equal to theta i dash. Obviously, theta i will be equal to theta e; theta i will be equal to theta e ok.

Here, this you can see these under the constant deviation in that condition. incident angle from this prism whatever the incident angle and the emergent angle, it will be same and this angle of deviation it will be all the time it will be 90 degree. Now, you think that for a particular wavelength; for a particular wavelength, the angle of deviation; angle of deviation whatever you will get for other wavelength angle of deviation will be different. Here say light of different wave colour is coming incident angle is same.

Because of dispersive power of the prism. Here this angle of refraction; angle of refraction theta r will be different; theta r will be different now, that theta r will be different. it will fall here that refracted one will fall at different position and they will be reflected; they will be reflected at a different angle. Out of them you can set, you can orient the prism you can set the angle, incident angle orienting rotating the prism to select a particular wavelength; to select a particular wavelength for which the deviation will be 90 degree ok. Deviation will be 90 degree how you will make sure.

We have to design the experiment in that way. Collimator of the spectrometer and the telescope of the spectrometer if we keep if we keep at 90 degree. Through the eyepiece of the telescope, you will see; you will see the light, which is coming at 90 degree deviation ok. That way we keep the constant, we keep the deviation constant and for that we can rotate the prism and select a different light; light of different wavelength at these 90 degree deviation ok.

Therefore, this is the principle of Pellin Broca prism and using this prism the constant deviation spectrometer is spectrometer will work. I will show the experimental geometry for the experiment ok.

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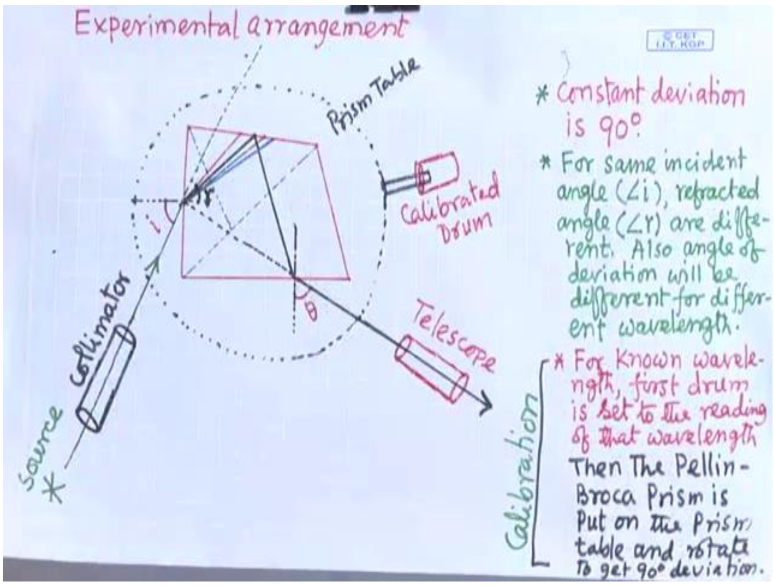

Experimental arrangement. you know this spectrometer means, it will have the collimator, it will have the telescope and it will have the prism table ok. We will have a source. Now, this collimator is one has to set for the parallel rays or parallel rays; for any spectrometer experiment one has to do Schuster's method to get the parallel rays. That one has to set for parallel rays. these rays will come and on the prism table, this is the prism table or prism table, this is Pellin Broca prism is a put.

Now, then this is the Pellin Broca prism and there is a manually, you can rotate the prism table; you can rotate the prism table or prism itself; prism itself to get a particular light it is a particular colour of a light means particular wavelength of a light. That you can choose with the changing of the angle of the prism or rotating the prism.

There is another option with the prism table that prism table you can rotate with some arrangement is there it is called drum. there is a scale with this drum. How much you are; how much you are rotating; how much you are rotating this prism with that. When you will rotate; when you will rotate the prism; when you will rotate the prism, what will happen? Initially if you set this prism for a particular wavelength when you will, change this angle of the prism, the second light will appear will come; will come means it will have that 90 degree deviation ok.

Second wavelength will come that way if you change these drum, you can rotate this drum, then you will get light at this constant deviation of different wavelength. This drum have a scale of wavelength. You see the reading of the drum that is wavelength of light. That reading will be wavelength of light, which is, we are seeing through the telescope; that means, it is having the constant deviation of 90 degree.

To use this drum, to use this reading of the drum as a wavelength. we have to calibrate first with the known wavelength. For that, what we have to do? say you are using the sodium light for calibration. You know the sodium light wavelength is 5890, average wavelength 5890 or 9 3 angstrom or 589 nanometer.

A drum that reading of this drum first we have to keep, we have to keep at 589 keeping this scale of this drum at this at the 589 nanometer. Now, manually without disturbing rotating the prism, what we have to do? We have to rotate; we have to rotate the prism manually with hand, hand rotation I have written here by hand rotation ok.

With the hand rotation, we will change the angle of the incident and set the angle of incidence for the sodium light. That means; sodium light is at constant deviation of 90 degree and this drum is exactly this drum reading is at wavelength of this sodium light 589 that way this drum is calibrated ok. After that, we cannot disturb this prism position ok. Manually, we will not disturb this prism position ok.

Now what we will do? We will just change the source; we will replace the sodium source or the any other known source by unknown source. Now, from unknown source light will come up different wavelength. Now, here through the telescope we will see the light ok.

we will rotate this drum; we will rotate this drum and being different colour one by one after another, one after another will being the drum; will being the; will being the light of different colour in this telescope where we are seeing this light ok. when we will sees say blue colour through this telescope, then that blue colour is at constant deviation of 90 degree. Now, for that what is the reading of the drum? that is the direct wavelength of this blue colour and then again I will change the drum reading ok.

That means, this drum when you are changing the drum reading actually this incident angle is change, incident angle is change and then again I am seeing the red colour ok. that means, whatever the reading of this drum that will be the wavelength of that red colour ok. We will note down this reading of the drum that is nothing but the major wavelength of the light of different colours for the source ok. here different source you can use and just very easily you can find out the wavelength of different colour of the of the light.

This is very convenient and different way to measure the; measure the wavelength of light. And as I told this it is a very it is a very simple compared to the grating spectrometer, that is why this technique is used in industry. I think what we have to do that I have explained. Now, data recording also very simple.

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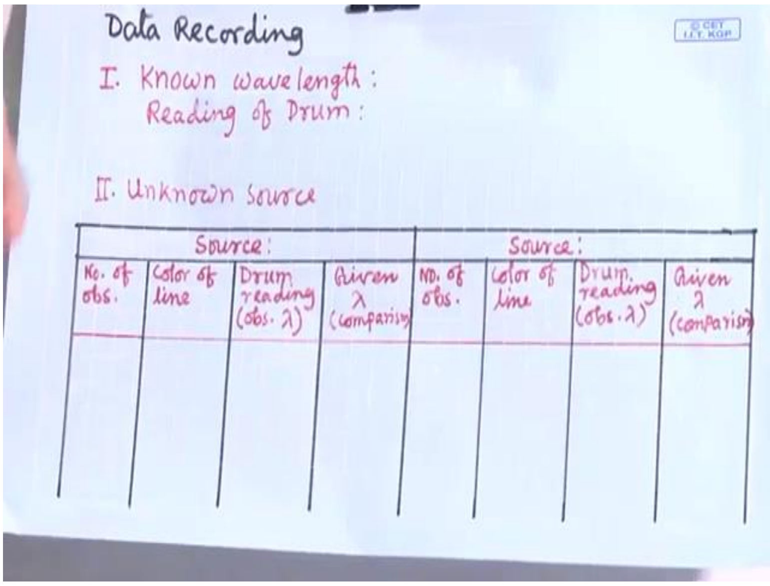

For data recording, we have to; we have to; we have to note down known wavelength note down the wavelength of known source say sodium or is the wavelength and then you set the reading of the drum at that at that wavelength and see the light through the telescope. That is why it is the calibrated.

Now, just put unknown source and different colour. number of observation then, colour of the line you note down and then you just rotate the drum and see the light of different colour through the telescope and corresponding drum reading you note down, that is the observed wavelength. Then given wavelengths of for what source you have used and for that source this wavelength of different colours are available ok.

That data from that data you can compare your measured wavelength and the standard wavelength ok. this is say source 1 and this is a another source 2. Just you continue the experiment for difference source and you can find out the wavelength ok. I think I will stop here and next class I will demonstrate the experiment.

Thank you.