Experimental Physics – II
Prof. Amal Kumar Das
Department of Physics
Indian Institute of Technology, Kharagpur

Lecture – 45
Plane Transmission Grating

Today, I will discuss about the Grating diffraction experiment and also, I will demonstrate the grating diffraction experiment.

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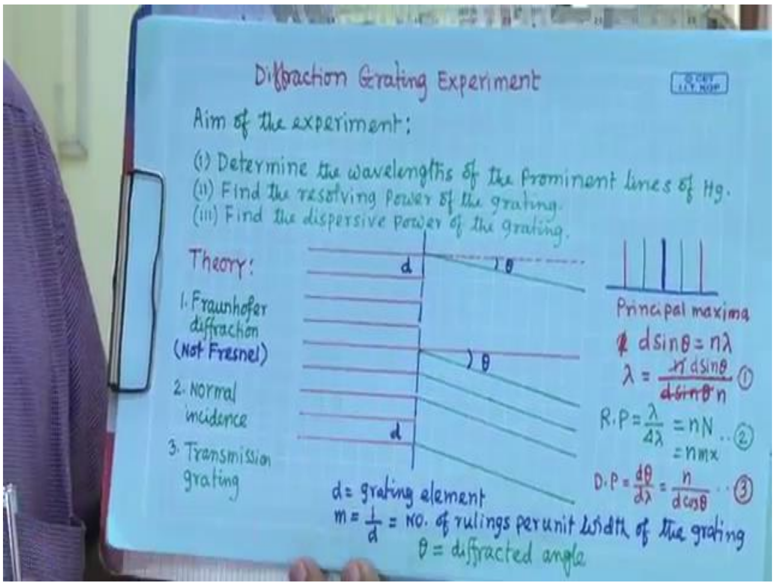

let us see the working formula for this experiment. aim of this experiment is to determine the wavelength of the prominent lines of mercury ok, it can be other any other source. in our lab we will use mercury source. it has it has many of spectral lines, but there are few are prominent intensity high. we will determine the wavelength of those mercury lines and then we will find the resolving power of the grating as well as we will find the dispersive power of the grating.

this is the diffraction grating experiment. From this experiment we can measure the wavelength of resource it can be mercury, it can be hydrogen, it can be cadmium then we can find out the resolving power as well as dispersive power of the grating. you know this grating is a is n slit device single slit, double slit and this is n slit device. that is gratings.

the grating element d is. slit it has a opaque part. If you consider a slit, it has an open part say that is a and the for double slit this two open part and this in between there is an opaque part. distance between the middle of this two slit that is distance of the middle point of the two slits; that means, half from here half from here. this is the a by 2 a by 2, so that is a slit with pass this separation of these two slit if it is b a plus b, so that is the d that is called grating element.

now, these grating experiment diffraction of grating is the Fraunhofer type of diffraction. You know this there are two types of diffraction one is Fresnel's diffraction, and another is Fraunhofer diffractions. Fresnel's diffraction one of the source or the not one of the source or screen one of them will be at finite distance. If both are at infinite distance, then that is Fraunhofer type if one of them or both are at finite distance then the diffraction will see that is a Fresnel type diffraction

in these experiment this is the Fraunhofer type experiment; that means, object will be at infinity and image also will format infinity, but in laboratory in finite distance will do the experiment for that; infinite distance means object is that infinite distance means light will fall on the grating. those lights are parallel light image will format infinity means the diffracted light they will meet at infinity. that means, the diffracted rays also parallel they will form image at infinity

to do this in finite distance we have to make the setup equivalent to that infinite distance. how we can do? we use convex lens. if you use convex lens and source as a finite distance at focal point of this convex lens. other side of the lens the light will get parallel lens. it is an equivalent to that object is at infinite distance.

Similarly, the diffractive ray's parallel rays are coming to put them at a screen we have to put the focal skin at the focal point of a lay of that lens. here also we have to use convex lens to form the image at finite distance. that is why; that means, if we use collimator if you use PGM spectrometer they are collimator is there. these collimator it will produce a parallel rays. that will fall on the grating and then diffracted rays is it different sets of parallel rays we will get. each set will give the image for a particular order it depends on the diffracted angle.

we will use telescope have convex lens. and it has IPs we will see the image two IPs. The image will format the at the focal point of the telescope lens and that at that focal point is this crosswire are put there. on crosswire this image will formed and through IPs we will see that one this is first condition to see this diffraction Fraunhofer type diffraction.

Second condition is that light will fall parallel light will fall on the grating perpendicularly normal incidence of light that means, incidents angle is 0 we have to make sure we have to save the grating in such a way that from collimator whatever lights are coming. they will fall on the grating perpendicularly you have to set grating at that that should be perpendicular to the to the normal life to the to the light parallel light from the collimator

because the working formula we will use that formula is only valid for perpendicular incidents or normal incidents. this second condition has to be fulfilled and in (Refer Time: 09:00) there are two types of grating your reflection grating and transmission grating here we will use transmission grating. we will see the diffracted ray in other side If it is reflecting grating one will see the images in the same site here, we will use transmission grating

if this light is monochromatic light other side, we will see the fringe; we will see the fringe of different order these type of fringe we will see they are of different order. from central order to in both side we will get this order first order second order or third order other side also we will see the a symmetrically we will see.

difference this can be one another is if we use not monochromatic light it has light of different wavelength like mercury. different color of light they will fall on this grating and other side for each color; for each color we will get the we will get the fringe pattern that is first order, second order, third order. Similarly, it is another side also first order, second order, third order and if you look at the only first order fringe there you will see the lines of different colors.

say this is of different colors. this is the first order ok, again it will come symmetrically from left side and side. you will get the second order again at higher distance higher angle. you will see the second order, third order etcetera that will be the that are we tell the principal maxima. condition for principal maxima is d sin theta equal to n lambda. d is the grating element, sin theta this theta is this diffracted angle ok, n is the order of the order of the fringe and lambda is the wavelength then we want to find out the lambda wavelength; wavelength is equal to d sin theta by n d sin theta by n uh. we have to we have to know the grating element. generally, this is supplied actually it is supplied is the number of lines per unit or length per unit width. generally, company supplied this per inch number of lines per inch. which refer in centimeter, so whatever number of lines per inch number of lines divided by 2.54 that will be the number of lines per centimeter

, if you know the number of lines per centimeter then one by that number of lines per centimeter that will be d; that will be d. d is we can calculate from the supply data and only we have to measure this theta for different lambda we will get in first order n equal to 1 in first order. what is the theta for different color if we can measure this angle of diffraction theta for different lambda, we can calculate lambda using this formula measuring the diffraction angle for different order, for different color we can calculate the wavelength?

Now, this grating like it is a prism like prism this getting have again resolving power and dispersive power resolving power means this two close wavelength whether grating can resolve or not means whether these two close wavelength we can we can see in spectra. that is the resolving power. that is a lambda by del lambda. that is equal to n small n this is small n that is order as I told first order, second order, third order of diffraction and here capital N that is number of lines; number of lines on the grating it is not per centimeter it is it is the number of lines exposed by the light.

here you have grating it is the say it is to which is 1 inch, but your light is not falling on this 1 inch means 2.5 percent if it is falling on the one centimeter this one in 1 centimeter how many lines are there? that is capital N this I have written equal to nmx; n is order small n, m is mx m is number of lines per inch into x is the width of the source; width of the source or the width of the width of the source slit we can see tell that width of the source slit. that this uh width of the source slit that the exposed width we can exposed width of that grating we can tell; so that is x. number of lines will be m into x

here you will get from this what is the resolving power of this getting. all data available with us. here generally what we do? We do not we here our exposures that exposure of the light on this slit is around 1 centimeter. that is why x we take 1 that n into m. here for different order we will we can calculate the resolving power. resolving power mainly will depend on the m involve number of lines per centimeter number of lines per centimeter. it will depend on that factor.

And, dispersive power is d theta by d lambda if you find out from here d theta by d lambda. these are n by d cos theta n small n is order and d you know there is a uh. that 1 by m these d and theta will measure this theta for different order we will measure this theta we can calculate the dispersive power of the grating

so, these three are the working formula lambda equal to d sin theta by m or sin theta by m n small m n ok; m will be calculated from the given data, only we have to measure theta. we can for different wavelength and for different order and then we can from that same data we can calculate the resolving power, from same data we can calculate the dispersive power of the grating

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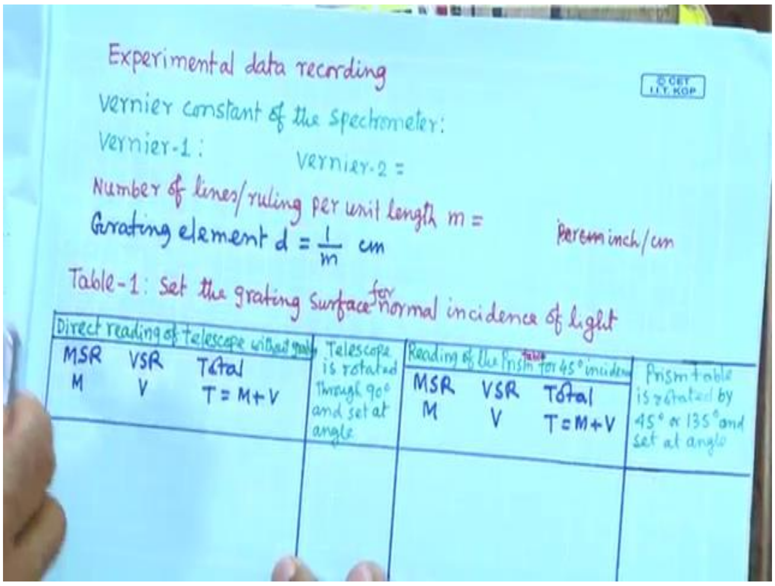

what is the measurement? We have to do is at the following. experimental data prism spectrometer we will use. you are quite familiar you are quite familiar with the prism spectrometer because lot of experiment already we have done using the prism, but this is the first time I am demonstrating using the prism table where we will use the grating instead of prism

Vernier constants of the spectrometer Vernier 1, Vernier 2 you have to note down then number of lines per ruling number of lines or rulings per unit length that m small m is it is the per centimeter we have to say if it is given per inch we have to convert it per centimeter in our case we will see how what is the value, then you have to find out the grating element d equal to 1 by m in centimeter.

Then, a table 1 set the grating surface for normal incidence of light as I told this uh actually first spectrometer you have to level and then say for the parallel rays used to stress method. everything the spectrometer is ready for the experiment using the grating. here the table I am showing after that what you have to do with the grating. we have to set the grating surfaced normal to the incident light how to do that?

we have to take direct reading of the telescope without grating, then telescope is rotated through 90 degree and set at some angle we will note down that angle. here this is the direct reading and here this is the at 90 degree what is the reading this difference should be the 90 and then reading of the prism table for 45 degree incidents we will put the then we will put the we will put the grating on the prism table and prism table will rotate; will rotate in such a way that the in telescope at 90 degree we should get the reflected light from the prism surface

when we will get the prism reflected light from the prism surface then this prism that grating is the grating surface is a 45 degree with the with the light incident light. Now, from that position prism table is rotated by 45 degree more or it depends on or 135 degree. if you rotate in opposite direction it should be 135 and set at angle means that reading will take this is the first table we have to do.

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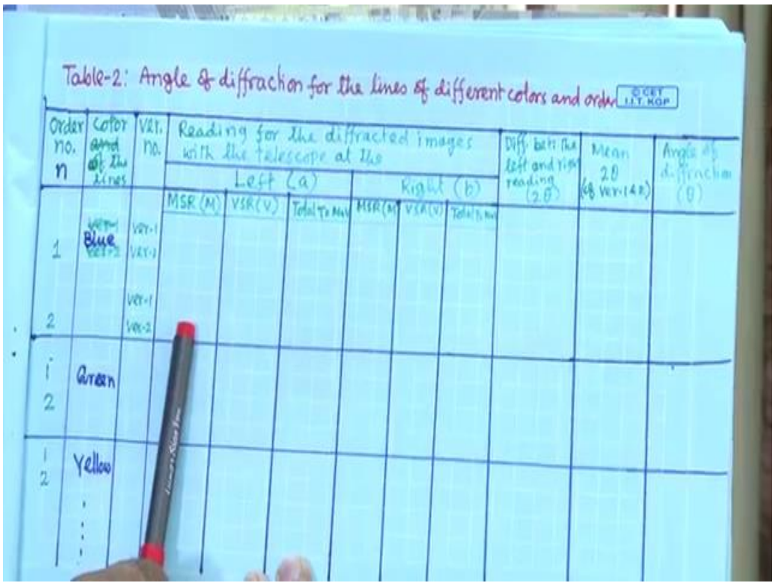

And, then we will go for the second table. the second table is data for this angle of diffraction for the lines of different colors and orders we will note down the angle for different diffracted lines of different order and colors order number we are writing here actually we will take only first order and second order higher order this intensity generally is decreased it is difficult to take

first order second order for one color say his color is blue. for blue color for first order we will take reading from Vernier 1 and Vernier 2 for second order we will take Vernier 1 reading for Vernier 1 and Vernier 2. then for Vernier 1, Vernier 2s main scale reading for the diffracted image with the telescope at the left. we will start from the from one side

we will say that second order and then as I told symmetrically, we will see this symmetrically we will see this from central fringe central order. left side and side we will see first order second order third order etcetera this other side also we will see first order second order third order. that is a we are written left order, and this is the order side order

we will take for first order and second order for a particular color. these this card is extremely left for second order. we will start from there. second order of that color, then first order of that color or what we will do from extreme left we will move. we will get this second order. for second order first we will take reading from Vernier 1 and Vernier

2 for blue color, then green color, then yellow color then other colors, then we will move still in same direction, then we will get the first order.

first order for blue color, green color, yellow color we will note down then in same direction we will move same direction we will move and we will go to the other side of the center fringe There we will get first order first and then there we will get this color . we will note down for the first order for different color and continue to move in the same direction and we will get the second order for second order for different color you note down the angle note down the reading

now difference of these two reading will give 2 theta then we will find out the mean 2 theta from order 1 and order 2 and half of that will be angle of diffraction for different color and for different order we will get angle of diffraction theta for first order second order, this angle of diffraction are same . we will note down the average value of this angle of diffraction for different color

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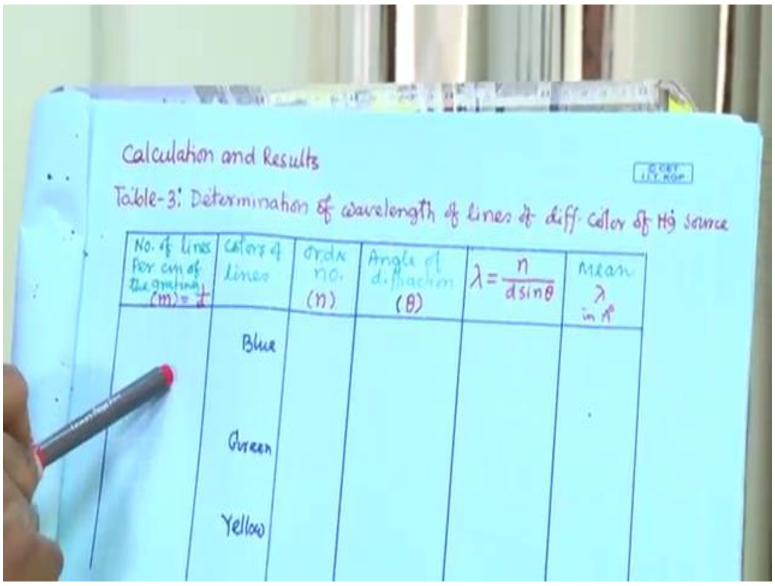

after that calculation, determination of wavelength of lines from color of different colors of mercury source. here this it is a m equal to 1 by d. this is the same value supplied value or calculated value, then for different color for different order for different order angle of diffraction will note down. from there we can calculate this lambda then we will take the mean lambda; so, this is one way.

Another way also plotting graph one can find out if we plot order versus, I think what is that formula? This is the formula if you plot if you plot order versus sin theta sin theta versus order. in that case you have to you have to yes you have to you have to at least you have to take 3 – 4 order, but it is difficult to get if grating is not very good ok, quality is not very good beyond second order it is difficult to get. plotting graph also one can find out.

sin theta versus n and then from the slope one can find out that slope will lambda into d. d is those lambda can would be find out. we are not going to use that method because in our setup only we get up to second order other higher order is very weak. we will calculate mean wavelength from 2 order

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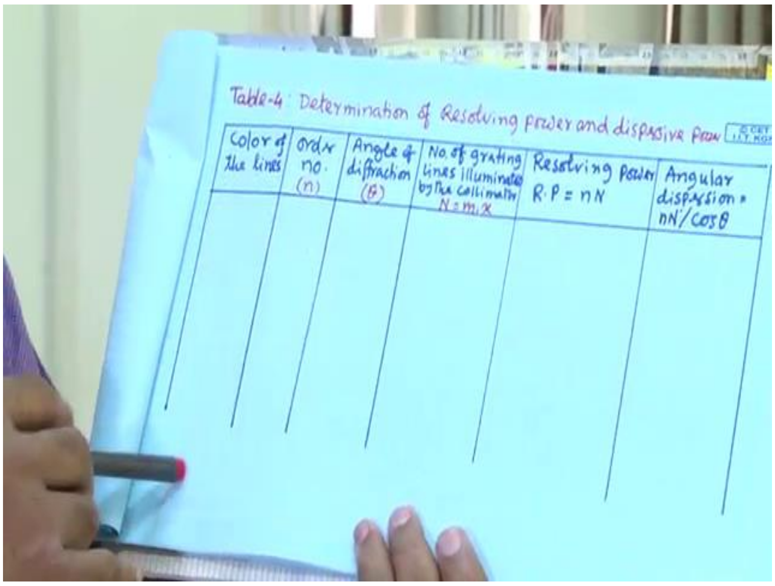

then you can calculate the dispersive power or resolving power for that for different color, different order angle we know already. number of grating lines illuminated by the collimator. this capital N equal to small m into x here we will we will take the m value as I told that we will not measure this x we will saw our approximately our exposure is one centimeter and resolving power you can calculate.

here also this capital N we will take equal to m lines per centimeter, and then using this formula angular dispersion you can find out this is the experimental data we can analyze and get different parameter and then you can calculate the error.

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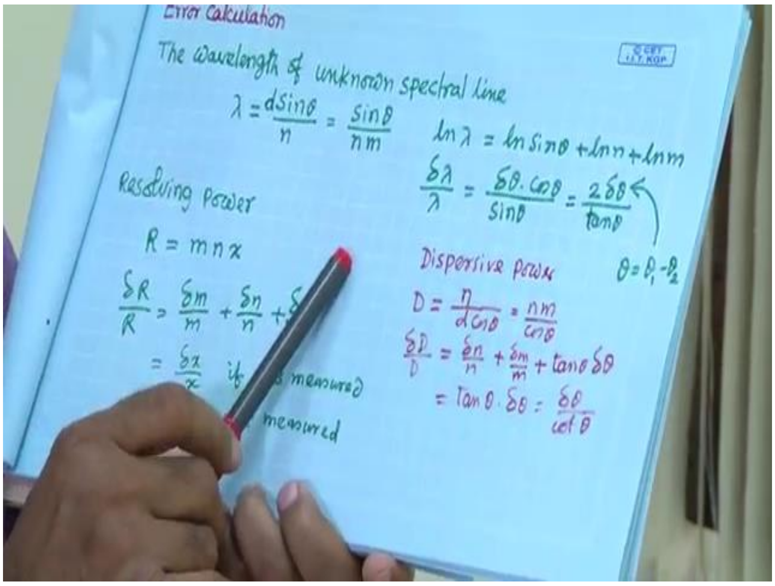

for wavelength lambda equal to d sin theta by n; that is sin theta by n m take log and find out these delta lambda by lambda equal to actually this term will contribute other term this is the number of order counting. no error and this are lnm this we are calculating from supplied data, no error from here. only this part will contribute to the error. this will be delta theta by tan theta

Here I have written 2 delta theta because theta equal to theta 1 minus theta 2 which is difference of two reading that is why we have been in 2 delta theta whereas, delta theta is the list count or Vernier constant.

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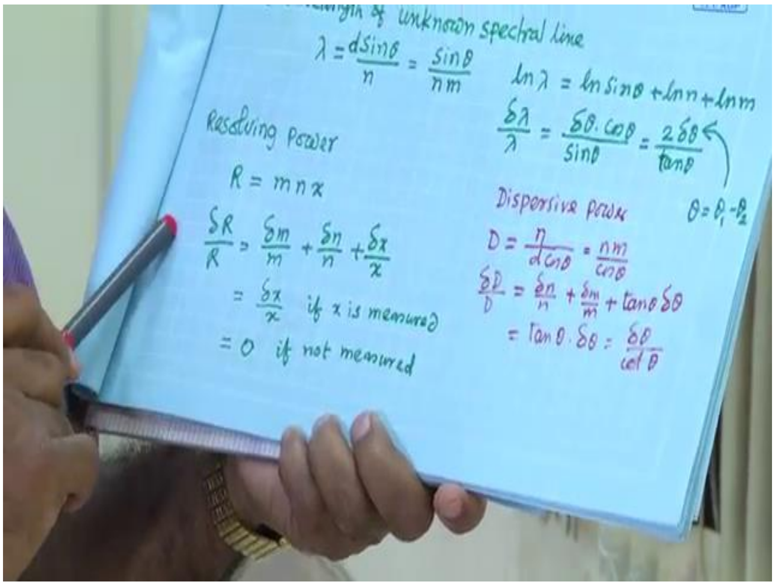

Similarly, for resolving power are equal to m n x. here if we measure this x with using the slit micrometer slit. then there will be error, but in our case, we will not measure ok, we will only consider x is 1 then for this case there is no probable error Similarly, for dispersive power these the formula take log and differentiate you will get this. again, this delta n by n it is a 0 delta m by m also we are calculating it is a 0. only this part will continue.

this del theta by cot theta or tan theta into del theta. that will be the error. this theta we are measuring. there will be error; one can calculate the error in dispersive power this is the before doing experiment this all these things we have to understand, and we have to keep ready this your table. I will stop here.

Thank you for your attention.