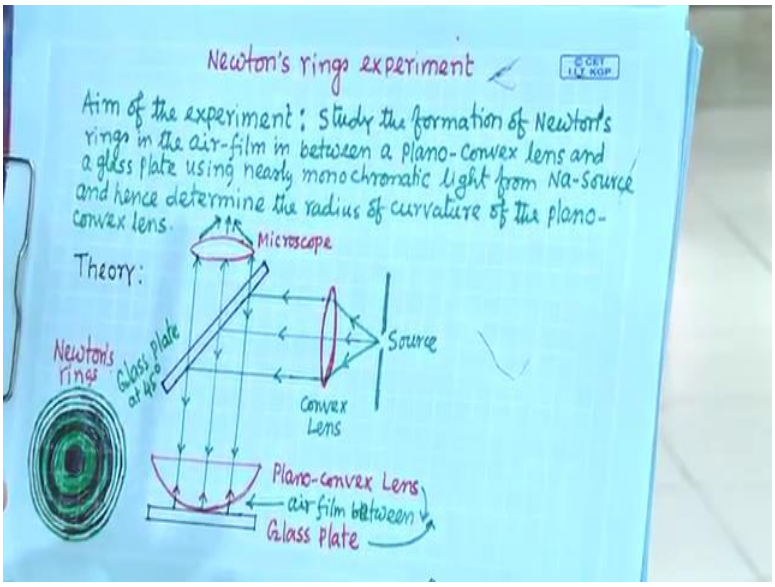
Experimental Physics - II
Prof. Amal Kumar Das
Department of Physics
Indian Institute of Technology, Kharagpur

Lecture - 36
Interference phenomena by Newton Ring (Theory)

we are in the first year lab of IIT Kharagpur, today we will demonstrate Newton Rings Experiment.

(Refer Slide Time: 00:39)



Newton's rings experiment came up this experiment is study the formation of Newton rings in the air film, in between a Plano-convex lens and a glass plate, using nearly monochromatic light from sodium source. And, hence determine the radius of curvature of the Plano-convex lens. that is the purpose of this experiment.

here this sketch, this diagram or experimental set up. this is the Plano-convex lens, Plano-convex lens this, this one is double convex by convex lens or double convex lens. this half of it is the Plano-convex lens and this is a glass plate, this is a glass plate. this you know this a small portion of a sphere, small portion of a spheres this one it has sphere means it has a centre from this centre. this is a small part of that sphere.

this is the cross section through the diameters if you just cut it. that section we have cross, section we have shown here. it has radius of curvatures. that radius of the, radius

of the sphere that radius of sphere we want to find out experimentally Now, when you put this Plano-convex lens on a glass plate on a glass plate what will what we will see? You will see that the Plano-convex lens, this curved surface it will touch the plate.

as if this plate is the tangent, is the tangent at that touching point between the curved surface and this plane, you will see this space, this we are telling there is a air film between Plano convex lens and glass plate. this is air film it can be put if put water If, you put this system in water, then it will be air film now, here important is that film from this is the say centre not centre of a sphere, it is the contact point if we take a centre, now if you move along this direction then thickness of this air film are changing.

that is important that, that is what very important for interference effect that path difference will come from this change of thickness Generally, the path difference comes or it varies, because of two reasons; one is variation of angle of incidence ok, or is called inclination Either that inclination angle will vary thickness remain constant; this is one type of experiment. Another type of experiment is that inclination angle of inclination is constant ok, but thickness varies

in this case angle of inclination is constant, it is a normal incidence, normal incidence. angle of inclination this is 0. now, interference pattern we will see, because of variation of the thickness of the air film That will introduce the variation of path difference point to point. Now, here you know that, we get b fringe and dark fringe that fringe will be straight line fringe or the concentric circle fringe or ring that is the rings ring types

It depends on the variation of path difference ok; for a particular fringe, whether dark fringe or b fringe, for a particular fringe, if the path difference is constant now that fringe will be straight line or it will be, it will be circular or elliptical or whatever. it decides the path difference for a particular path difference in path difference that particular path difference is constant over a straight line. we will get straight line fringe, if that is constant over a circle. then this fringe will be circle.

in this case as I told this is just 2 dimension diagram, in 3 dimension this one is placed on a on a on a plate ok, this one is placed on a plate now, you can see, you can see that for a particular for a particular thickness. that this that thickness is constant over a circle Now, thickness is varying that thickness is varying, thickness is varying, along this direction; that means, this contact point taking as a centre, will get concentric circle will get

concentric circle for each thickness; that means, for each thickness the path difference is constant over the circle

that is why here for this shape of the film, we will get fringe that is concentric circle. this type of fringe you will see this is the dark and then b green one is the b one, then dark b, dark b, dark b this type of concentric circle will see of as a fringe pattern. in this set up this is the is the forming the air film. Now, we will use source monochromatic source, we have to use monochromatic source we have to use this will use sodium source. from sodium source light will come and we will use lens to get the parallel rays convex lens to get the parallel rays.

we will put this source at the focal point of this lens. it is a just like coli meter you know. now, this parallel rays are coming and here, we have we will put a glass plate at 45 degree, at 45 degree. that it will be reflected, it will be reflected, and it will be reflected at 90 degree with the incident angle yes. not incident angle incident rays. reflected rays will form that 90 degree, if this glass plate is 45 degree what happens?

this when incident rays will fall here. one part of this rays will be reflected, and another part of the light will be refracted ok, will be refracted and it will go this way. Now, sorry I think that is not the case this is the glass plate at 45. it is reflected and coming back, it is reflected and coming this in this direction. now, this ray is coming and then passing through the air film and fall on the glass plate.

Now, from the glass plate it will be reflected and come back Now, this is the incident rays and another reflected rays will get these two will interfere. These two will interfere and form the form the fringe, depending on the path difference between this incident and the reflected. for this one same way it will this is the incident, and this is the reflected. they will interfere. there are many rays will fall on it, but all of them will fall on this system this at perpendicularly.

So; that means, incidence angle of inclination that is 0 ok, that is constant for all range, only path difference will depend on the on the where it is falling on the on the air film and interference will never happen between these rays and these rays Because, they may not be the they may not be the coherent interference will happen between the incident and corresponding reflection rays and where it is falling.

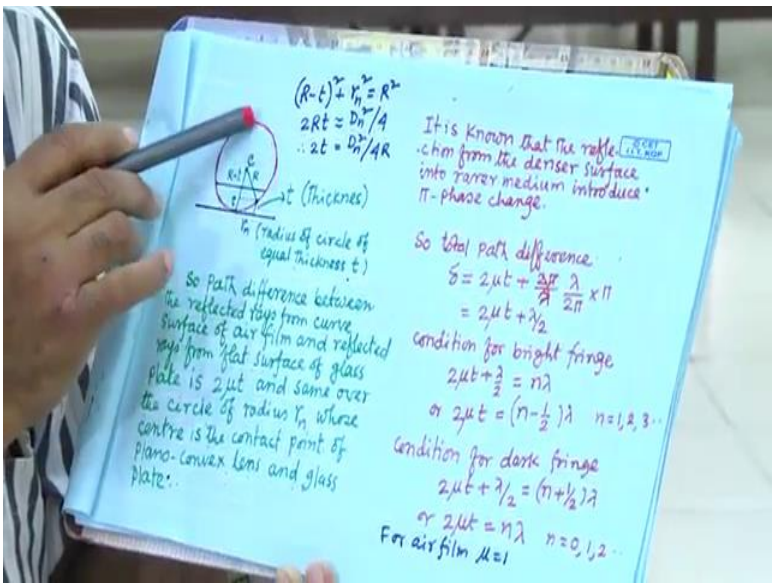
it will be decided by the thickness of the air film and that, because of the thickness of the air film the path difference, path difference will be different for this interference fringe, for this interference fringe, for this interference fringe that is why, we will get the fringe if say this is for the this thickness of this rays if we get that fringe. next this side thickness is decreasing, or other side thickness is increasing. path difference is changing. it will satisfy the for b fringe.

dark b dark b that type of variation will get and that variation dark b dark that is what I am telling and it will go over a circle over a circle, because thickness is constant over a circle And, that that fringe pattern will form, fringe pattern will form here And, that will object the microscope that will object to the microscope

as if this light is coming from here and through the microscope, we will be able to see this image ok, fringe pattern. you want to this is the formation of the formation of the Newton's ring in air film. that is one aspect this is one very important aspect, how it is forming and then using that fringe pattern, how we can measure the measure the curvature of the of the of the Plano convex lens or there is other way.

In this case if we know the wavelength, if wavelength is known other way if this radius of curvature is known, then one can use this experiment for measuring the wavelength if wavelength is known, we can find out the radius of curvature, if radius of curvature is known we can find out the unknown wavelength

(Refer Slide Time: 15:56)



next for measuring the radius of curvatures what is the working formula we will use. working formula is you see as I told that this Plano-convex lens this part curved surface is a part of a circle part of a sphere basically. in 2 dimension it is a circle this is the centre of the sphere this distance is radius. this is R And, now we see from this centre this from this point contact point, if we look at this point where you want to find out the path difference. this distance if it is r n

as I told there will be circle circular path for the constant thickness. this r n is radius of that circle of constant thickness, constant thickness t, this is t, t so; that means, this is the normal at the contact point. here that dotted line if you draw. this is thickness t, then this rest of the part from this sphere centre. that will be R minus t, and this is R this is this triangle angle triangle R minus t square plus r n. this dotted line that this is a r n square equal to R square

From here we can find out that 2 t equal to D n square divided by 4 R. What is D n? D n diameter of the ring 2 r n D n is 2 r n. I have replaced this r n by D n by 2. that is why it is the D n square by 4 R that 2 t now, at this point when light is falling. as I told interference between the incident light and the reflected light; from the curved surface from the curved surface. this incident actually it is a it is not incident light, incident light is coming, and it is falling say at this point is the at this curved surface.

Now, reflected from this curved surface means, the interface of denser medium and rear medium, rear medium is here denser medium is this lens material it is the reflected from this curved surface and another part of the incident ray will be refracted. Through the through the air film and it will fall on the it will fall on the glass plate. from the glass plate that refracted one will be reflected again this here it is reflected from the from the from the denser, from the denser medium, from the from the surface from the interface of the here means rarer medium and this glass plate. That is denser medium.

these two reflected rays one is from the glass plate, another is from the curved surface, these two reflected rays will interfere. these two reflected rays are generated from the same incident rays. they are coherent, they are coherent. we will get the interference between these two rays and these two rays, what will be the path difference? this reflected from the curved surface, after that reflected from the glass surface.

that rays will travel this thickness twice, will travel this thickness twice path difference is 2 t between these 2 reflected rays path difference will be 2 t Additionally, additionally there will be there will be phase pi phase change in one of this reflected rays. actually, it is known that the reflection from the denser surface into the rarer medium introduce pi phase change. reflected rays reflected from this glass plate.

That rays will have the additional phase change of pi means additional path difference that will be corresponding phase change pi that will be lambda by 2. the reflected rays from the glass plate, that has additional path 2 t plus lambda by 2 compared to, compared to the reflected rays from the curved surface that is why this path difference 2 mu t here since it is air medium if it is other medium in general we have written mu, refractive index of this film in this case it is air film.

2 mu t plus lambda by 2 pi into pi that is a lambda by 2. that is the path difference between the 2 reflected rays and this path difference is decided by the thickness of the of the air film now, thickness will vary, and we will get the b and dark fringe.

condition of b fringe is equal to lambda path difference is equal to lambda. in this case this lambda by 2 in this side it is there. 2 mu t it is a n minus half 1 can write plus half also lambda originally this is the condition for dark ok, in plus half into lambda. that is the condition for dark fringe ok, but in this case, it is the condition for b fringe, that is because the additional phase change is introduced by the by the reflection from this glass surface

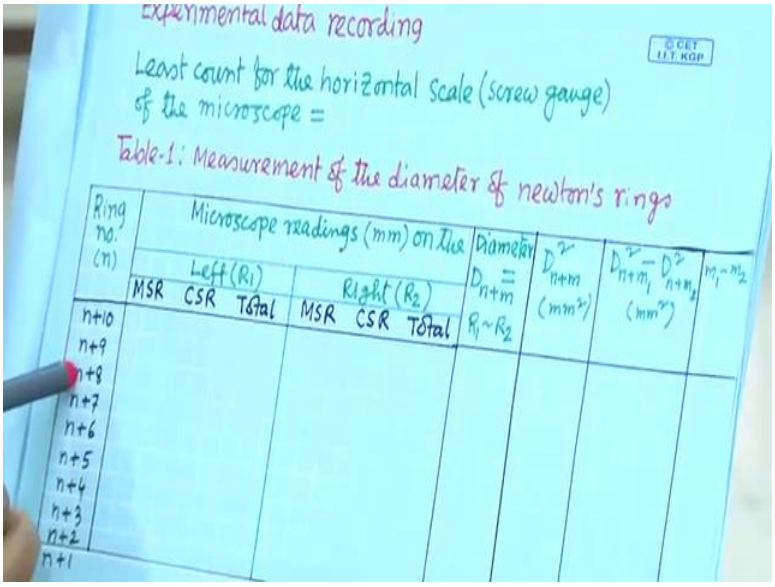
in young's double slit experiment there the condition for b fringe is in lambda and condition for the dark fringe is n plus half lambda in this case it is just change that is because of the additional phase change here whatever you are getting this condition for the b fringe and dark fringe. you can see this n equal to 0 2 mu t equal to n lambda n equal to 0.

that will be the condition for the dark fringe And, this part will be 0 when it will be 0 when t will be 0. when t will be 0 that will be at the contact point So; that means, that the contact point means at the centre of the concentric circle ok, we will get the dark fringe all the time we will get the dark fringe, then additional path difference 0.

now additional lambda by 2 will be introduced for the next thickness. we will get the b fringe, then additional lambda by 2 again means lambda path difference will be introduced. we will get the again dark fringe. central one concentric that circle centre one will be the dark fringe, then b dark b dark we will get the concentric fringe pattern, that is all the Newton's ring.

And, Newton's discovered analysed by the Newton's past why after his name. this experiment of this what I was discussing today this is called Newton's ring experiment

(Refer Slide Time: 26:06)



Now, the least count of that microscope ok that is it is a similar to the screw gauge. we have to we can treat scale as screw gauge scale. least count we have to note down. Then, measurement of the diameter of the Newton's ring concentric circles we will see concentric circles we will see centre one it is a centre one is dark one and it is we are telling that is the 0th ring that was next first b ring. now, it will be difficult to because this central one this is a quite broad one and this is difficult to define the it is of first fringe, second fringe, third fringe, it is a difficult to be find.

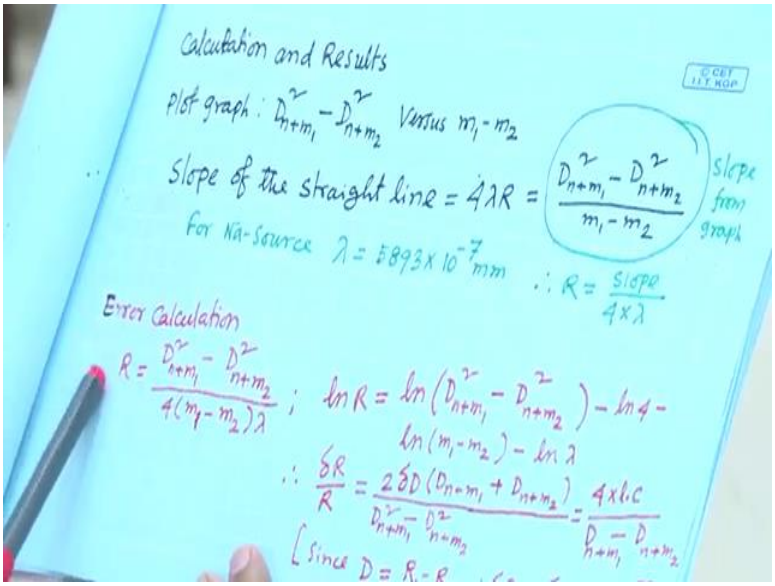
what we will do from the centre from the dark fringe. we will go towards the left, we will go towards the left, and we will sit there we will sit there, we will we will just define that is the nth one that is the nth fringe, then what we will do? further we will go sorry. concentric circle as I mentioned from there, we will go to towards the left

that will take as I say n plus n plus n that is a here n, we have taken this 10 10th fringe will come from the centre of 1 2 3 4 5 6 7 8 9 10. here it is n plus exactly you do not know, what is the order of that one? we will take that as the n plus 10 now, we will go towards the what is the reading of that one. that we will note down that is the left we are telling left side, left side of the ring, that is the reading, main scale reading circular reading then total, then we will go next 1 n plus 9 we will take reading.

that way we will we will proceed and take n plus 10 n plus 9 this way n plus 1 Then, we will move towards and take the reading for other side, because this is a ring, we will get n plus 1. that reading we will note down, then n plus 2 n plus 3 n plus 4 n plus 5 that way we will go to the up to 10 order n plus 10 order for each case the difference of these 2 reading is the diameter. And, that cross wire will set as a will set tangentially to the ring to the circle ok, for each position lefts left and or same circle.

that difference of this reading is the diameter here square of the diameter then, you can calculate this n plus 10 what is the diameter at n plus 1, what is the diameter take the difference of these 2 this we are at the n plus m 1 minus D n plus m 2 m 1 minus m 2 10 minus 1, 9, then 9 minus 1, 8 minus 1 this will vary 9 8 7 this for that what is that diameter difference?

(Refer Slide Time: 30:52)

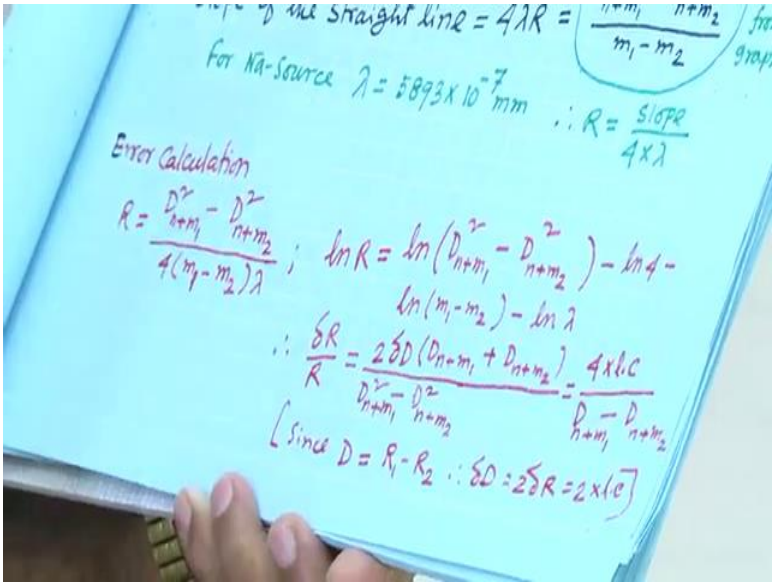


that we will note down and if you look at the if you look at the working formula. that is, it is this type of formula if we plot, if we plot D n plus m 1 square minus D n plus m 2

square versus m 1 minus m 2. you will get a straight line and the slope of the straight line will be 4 lambda R. R equal to this divided by m 4 m lambda was there from this plot this will be the slope and that slope will be equal to 4 lambda R, 4 lambda R and 4 lambda R.

R equal to slope whatever you will calculate from the graph divided by 4 into lambda. that will give you the, if lambda if lambda is applied. slope is given by the graph. you can calculate R and error calculation; this is the formula take log as I taught you earlier.

(Refer Slide Time: 32:13)



And, then del R by R equal to you can proceed. here this D we have measured D we have measured taking the difference of 2 reading. del D is 2 del R that is that is a that is equal to 2 into least count for del D 2 del D 2 del D so; that means, del D is 2 least count. that is the 4 into the least count divided by D n plus m 1 minus D n plus n 2. this is the final formula for the error del R by R.

one can calculate the error for this experiment this is the details discussion about the experiment and now I will I will demonstrate the experiment just in next class so.

Thank you for your attention.