Metrology
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Lecture – 30
Basics Of Interferometry

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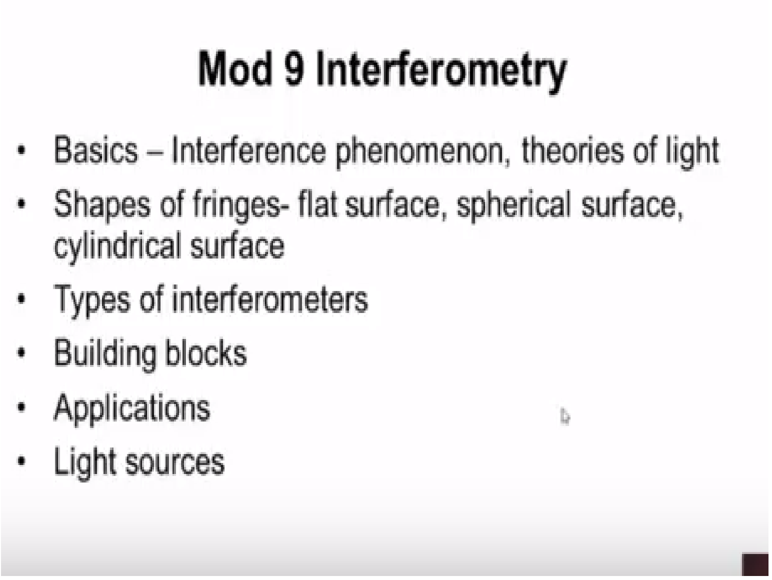

Mod 9 Interferometry

- Basics – Interference phenomenon, theories of light
- Shapes of fringes- flat surface, spherical surface, cylindrical surface
- Types of interferometers
- Building blocks
- Applications
- Light sources

I welcome you all for series of lecture. We will start module 9 on interferometry. In this module, we will be running about basics of interferometry that is what is the interference phenomenon how it happens, what are the theories of light how do we obtain the fringes, what are the different types of fringes, depending upon the type of the work piece and then we will be studying about different types of interferometer and what are the building blocks away in the parameters.

What are the different elements by which interferometers are made and what are the various application offer interferometers and what are the various light sources used in the interferometers.

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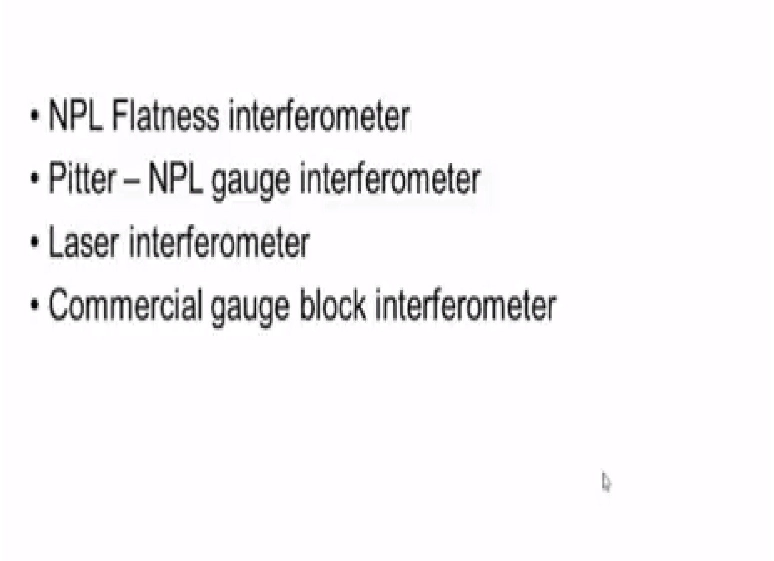

- NPL Flatness interferometer
- Pitter – NPL gauge interferometer
- Laser interferometer
- Commercial gauge block interferometer

And then we will move on to the different types of different types of interferometers like NPL flatness interferometer, NPL gauge interferometer, laser interferometer and then we will discuss about the commercial gauge interferometer.

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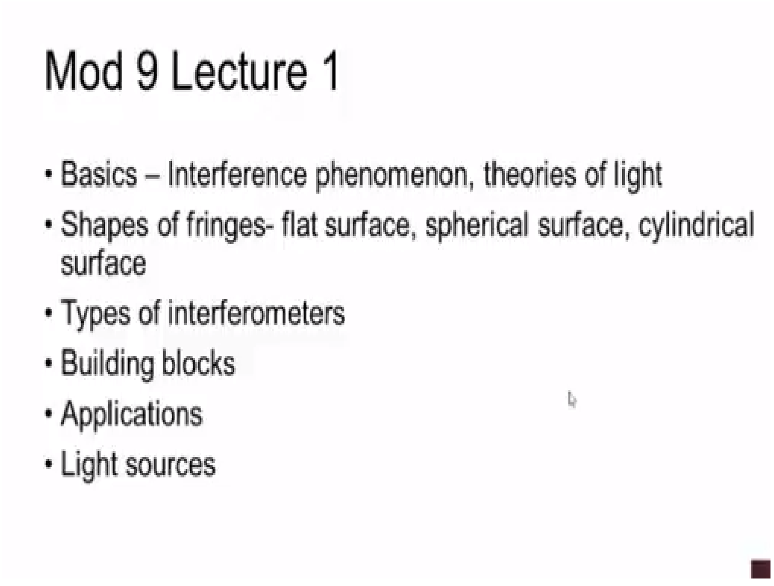

Mod 9 Lecture 1

- Basics – Interference phenomenon, theories of light
- Shapes of fringes- flat surface, spherical surface, cylindrical surface
- Types of interferometers
- Building blocks
- Applications
- Light sources

Now let us start module number 9, lecture 1.In this lecture 1, our discussion will be focused on the basics of interferometry. We will study about theories of light and then how the interference phenomenon occurs, what are the conditions suitable for the occurrence of interference types of fringes the obtained depending upon whether the work piece is flat or cylindrical spherical.

Then we will list some of the available interferometers and then we will study on construction of interferometer, what are the various elements used to build interferometer and what are the applications also we will see and what are the sources light sources used interferometer. These things we will discuss in this first lecture.

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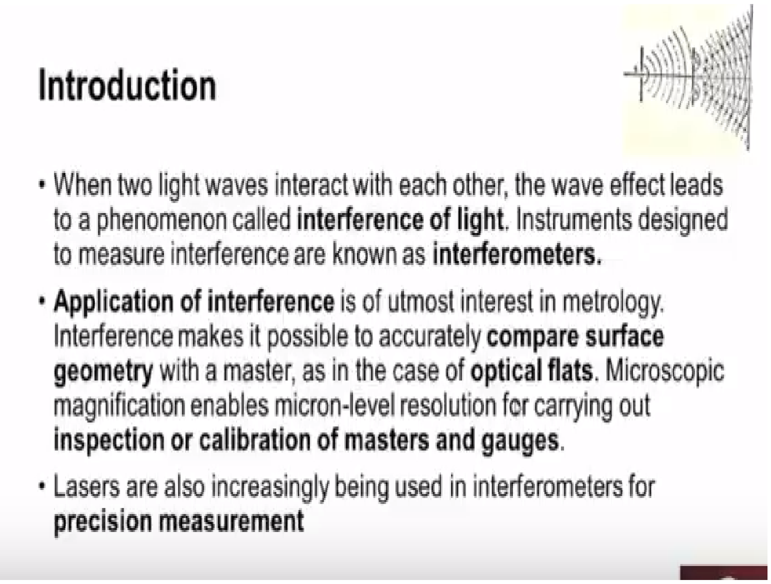

Introduction

- When two light waves interact with each other, the wave effect leads to a phenomenon called **interference of light**. Instruments designed to measure interference are known as **interferometers.**
- **Application of interference** is of utmost interest in metrology. Interference makes it possible to accurately **compare surface geometry** with a master, as in the case of **optical flats**. Microscopic magnification enables micron-level resolution for carrying out **inspection or calibration of masters and gauges**.
- Lasers are also increasingly being used in interferometers for **precision measurement**

Now let us start the introduction on the interferometry. Now we will study what is interference phenomenon and how it occurs, when 2 light waves interact with each other that means we have to consider 2 light waves and when they interact with each other the wave effect leads to a phenomenon called interference of light. Instruments designed to measure interference are known as interferometers. Now what are the applications of the interferometry.

Application of interference is of utmost interest in metrology. Interference makes it possible to accurately compare surface geometry with the master, so they are used to compare the surface geometry with the reference surface, which is an optical flats is normally used as a reference surface. Microscopic magnification enables micron level resolution and for carrying out inspection or calibration of masters and gauges.

Using the interference phenomenon, we can calibrate the masters and gauges. Lasers are also increasingly being used in interferometers for precision measurement that means nowadays laser based interferometers are available commercially, which are used for metallurgical purposes.

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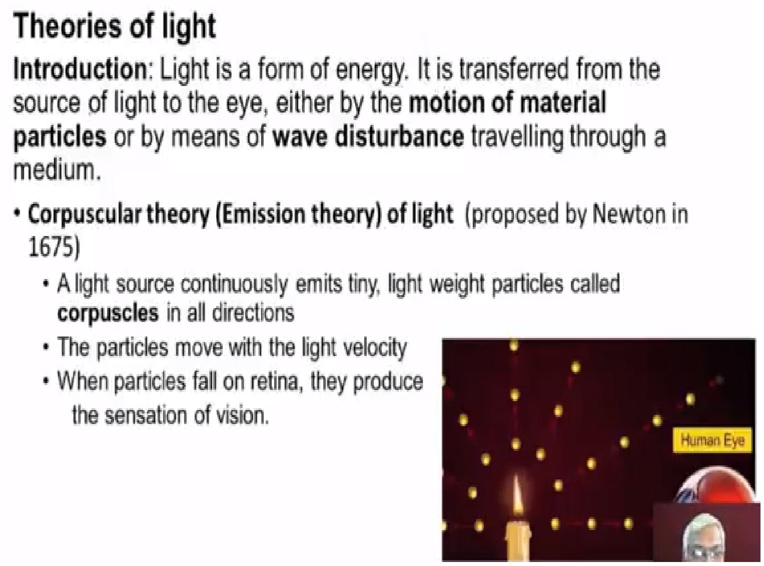

Theories of light

Introduction: Light is a form of energy. It is transferred from the source of light to the eye, either by the **motion of material particles** or by means of **wave disturbance** travelling through a medium.

- **Corpuscular theory (Emission theory) of light** (proposed by Newton in 1675)
  - A light source continuously emits tiny, light weight particles called **corpuscles** in all directions
  - The particles move with the light velocity
  - When particles fall on retina, they produce the sensation of vision.

Now what are the theories of light. Now light is a form of energy, it is transferred from the source of light to the eye either by the motion of material particles are by means of wave disturbance travelling through a medium. Now we have 2 theories of light, one is emission theory of light proposed by Newton in the year 1675. According to the emission theory, a light source continuously ms tiny lightweight particles called corpuscles in all directions.

You can see here in this diagram we have a light source here, which is emitting tiny lightweight particles in all directions. These tiny particles move with the light velocity. When these particles fall on the retina, they produce the sensation of vision. You can see here, we have t eye on which these tiny particles fall and then we get the sensation of light.

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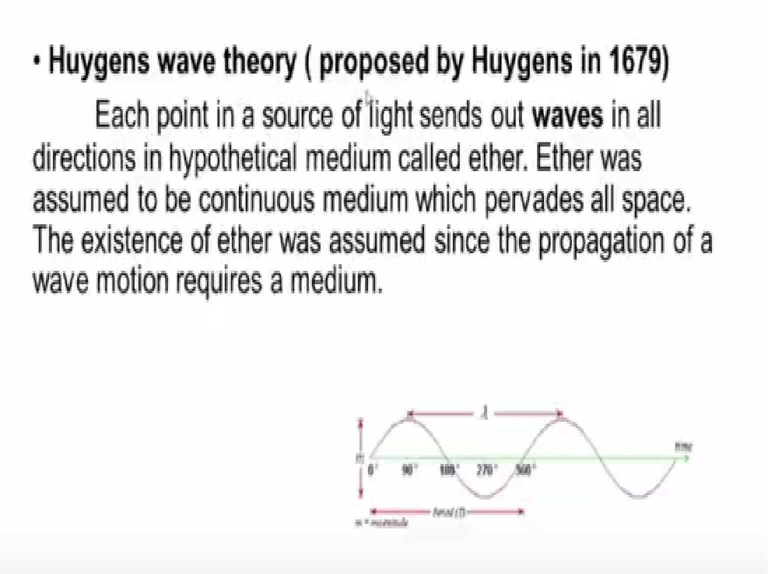

- **Huygens wave theory (proposed by Huygens in 1679)**

Each point in a source of light sends out **waves** in all directions in hypothetical medium called ether. Ether was assumed to be continuous medium which pervades all space. The existence of ether was assumed since the propagation of a wave motion requires a medium.

Now there is another theory called Huygens wave theory proposed by Huygens in 1679. According to this theory, each point in a source of light and sound waves, you can see here light moves in the form of a sinusoidal wave like this, sends out waves in all directions in hypothetical medium called ether, so for the moment of these waves, some medium is called an ether is assumed to be the medium.

Either was assume to be continuous medium, which pervades all space. The existence of ether was assumed since the propagation of a wave motion requires some sort of medium.

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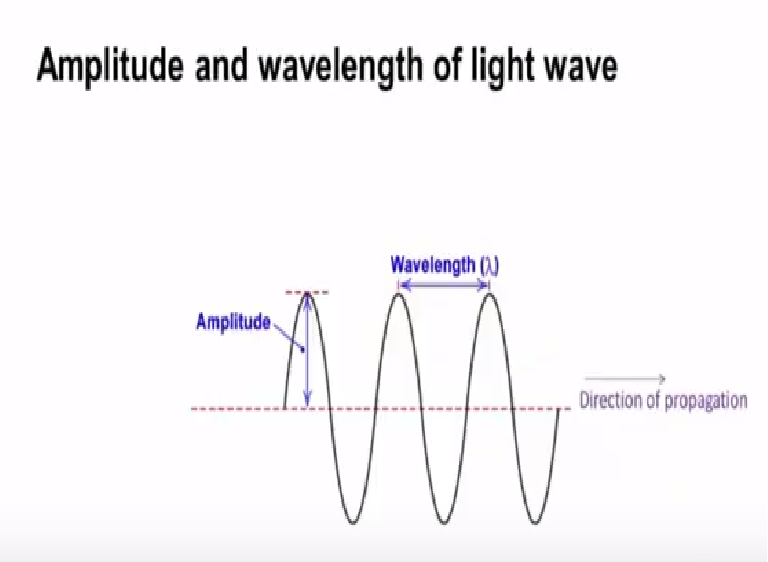

Amplitude and wavelength of light wave

Now we can see a light wave here, which is moving in this direction, so the distance between any 2 consecutive points of this wave is termed as wavelength and it is denoted as lambda and this height is the amplitude of light.

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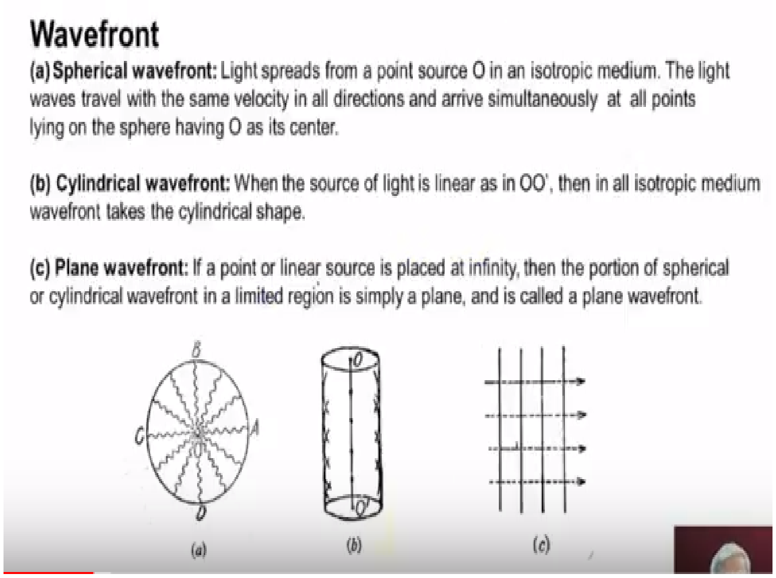

Wavefront

(a) Spherical wavefront: Light spreads from a point source O in an isotropic medium. The light waves travel with the same velocity in all directions and arrive simultaneously at all points lying on the sphere having O as its center.

(b) Cylindrical wavefront: When the source of light is linear as in OO', then in all isotropic medium wavefront takes the cylindrical shape.

(c) Plane wavefront: If a point or linear source is placed at infinity, then the portion of spherical or cylindrical wavefront in a limited region is simply a plane, and is called a plane wavefront.

Now very commonly we use the term called wavefront in the interference phenomenon, so let us understand what is the wavefront, so there are different kinds of wave fronts, spherical wave fronts, cylindrical wave fronts, plane wave fronts depending upon the shape, now when the light spreads from a point source. Today, we can see here we have a point source O here and light is spread the waveform in all directions.

The light waves travel with the same velocity in all directions, all the waves they move at the same speed in all directions and they arrive simultaneously at al points lying on the sphere having O as centre. If you assume a sphere here with center O with diameter CA, then all these waves arrive at this circumference of the same point, so then this front is known as spherical wave front.

Now let us assume that the source of light in the form of linear shape OO dash if this is the case, then in all isotropic medium, wavefront is the cylindrical shape, so we get the waves from the source, we get the wave from this source and they will be moving in all directions then this front of waves is known as cylindrical wavefront. Similarly, we can assume a point source at infinite distance.

If a point linear source is based at infinity, then the portion of the spherical or cylindrical wavefront in a limited region is simply a plane and is termed as plane wavefront.

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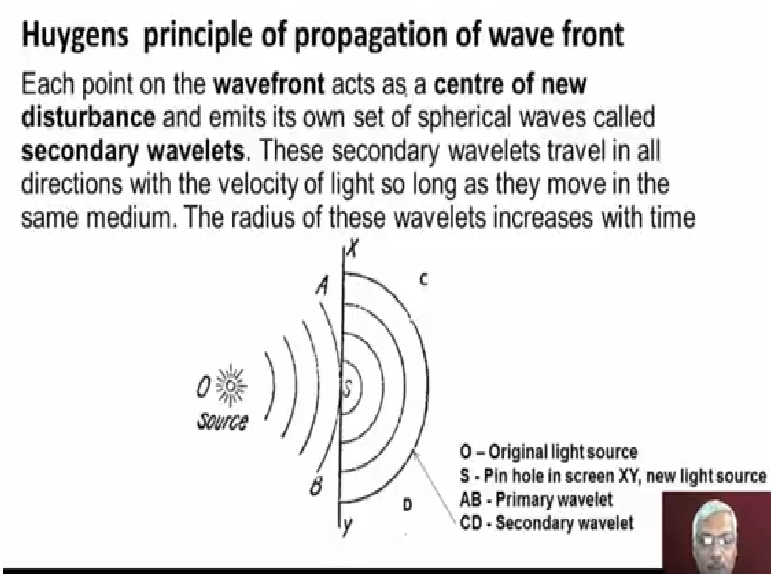

Huygens principle of propagation of wave front

Each point on the **wavefront** acts as a **centre of new disturbance** and emits its own set of spherical waves called **secondary wavelets**. These secondary wavelets travel in all directions with the velocity of light so long as they move in the same medium. The radius of these wavelets increases with time

O – Original light source
S - Pin hole in screen XY, new light source
AB - Primary wavelet
CD - Secondary wavelet

Now let us try to understand Huygens principle of propagation of wavefront. Now each point on the wavefront, you can see here we have a point source O and we are getting the waves, they move like this, in all direction with the same velocity, this is one wavefront, another wavefront radius of the wavefront is getting changed did you change the time here, we have wavefront AB. Each point in the wavefront acts as a center of new disturbance.

Now I keep a screen XY in this path of light with a small hole S is the pinhole okay, so now the light will pass through this pin hole, so this pin hole becomes another source of light and again we get light from this point S and again we get the spherical wavefront, each point on the wavefront. Now, we consider S on this A wavefront AB, each point on the wavefront acts as a center of new disturbance and emits its own set of spherical waves.

We can see here S is the new source of light and we get spherical wavefront with this as center Emits its own center of spherical waves called secondary wavelets, so this AB is the primary wavelet and this CD is secondary wavelet. The secondary wavelets travel in all directions with the velocity of light.

So long as they move in the same medium, as long as the medium here and here remain same, these light waves move with the same velocity. The radius of these wavelets increases with time, which we can observe here. The radius is changing with time.

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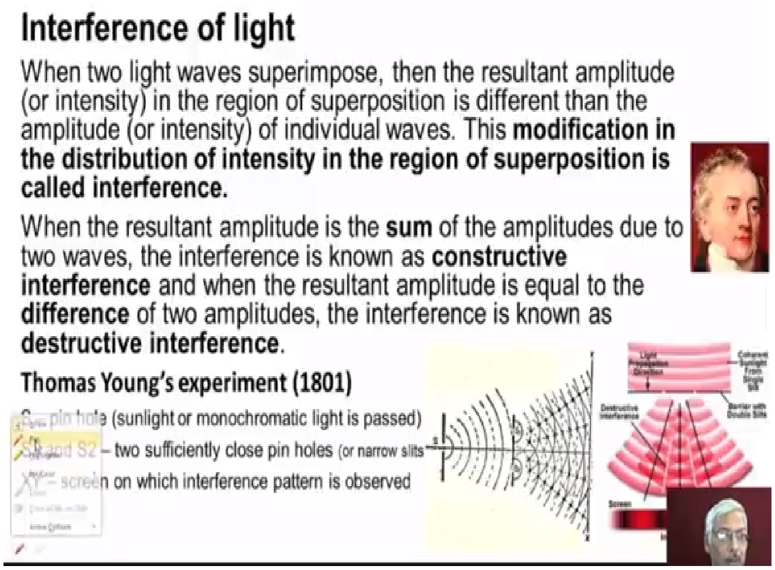

Interference of light

When two light waves superimpose, then the resultant amplitude (or intensity) in the region of superposition is different than the amplitude (or intensity) of individual waves. This **modification in the distribution of intensity in the region of superposition is called interference.**

When the resultant amplitude is the **sum** of the amplitudes due to two waves, the interference is known as **constructive interference** and when the resultant amplitude is equal to the **difference** of two amplitudes, the interference is known as **destructive interference**.

Thomas Young's experiment (1801)

S – pin hole (sunlight or monochromatic light is passed)

S1 and S2 – two sufficiently close pin holes (or narrow slits

XY – screen on which interference pattern is observed

Now let us try to understand the interference phenomenon of light, now when 2 light waves superimpose, now we can see here this diagram, we have a source of light S is the source of light and we are getting the primary spherical waves and at this point, we have a screen say this is AB. AB is the screen, which is having 2 pinholes S1 and S2, S is the pinhole and this is the source of light.

S1, S2, 2 sufficiently closed pinholes or narrow silts, S1 and S2 they can be pinholes or they can be narrow silts, so here from S1 we get secondary wavelets and from S2 also we get secondary wavelets and they are getting superimposed in this region. When 2 light waves superimpose, then the resultant amplitude or intensity in the region of super position, this is the region of super position.

The intensity of resultant wave is different than the amplitude or intensity of individual waves. This modification in the distribution of intensity in the region of superposition is called interference. Now the primary wavelet from S1 will have some intensity and the secondary wavelet from S1 and secondary wavelet from S2, they will have certain intensity. Wen they get superposition, the intensity level changes, so this phenomenon is known as interference.

When the resultant amplitude is the sum of amplitudes due to the 2 waves, the interference is known as constructive interference when the resultant amplitude is equal to the difference of 2 amplitudes, then the interference is known as destructive interference. Now in this diagram, we can observe here the light intensity is increasing, we can see here, we have placed a screen XX here in the path of light.

So this is screen XX and we can observe intensity distribution of the resultant wave, so when the intensity of 2 waves get added, we get constructive interference and we get a bright region here. When the intensity of 2 waves they get subtracted, we get destructive interference and we get dark band, so like this we get fringe pattern, we get bright area followed by dark area, followed by bright like this, so we will get a pattern of fringes.

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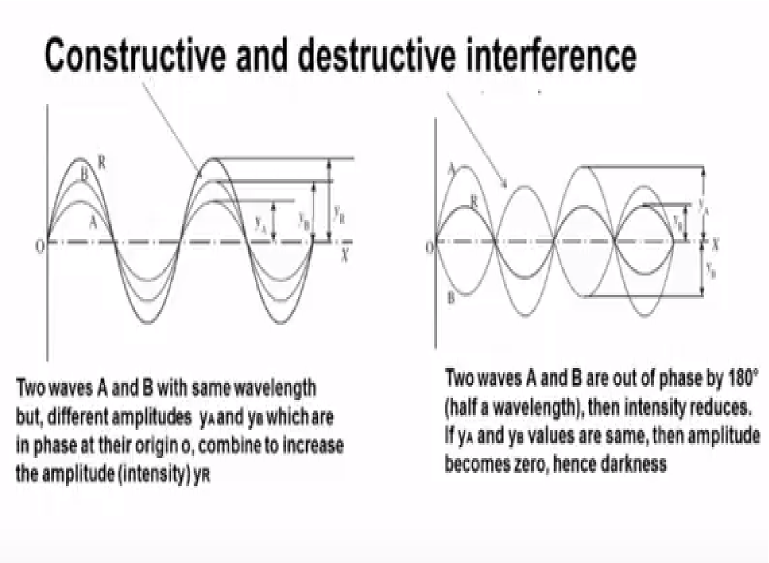

Constructive and destructive interference

Two waves A and B with same wavelength but, different amplitudes y_A and y_B which are in phase at their origin o, combine to increase the amplitude (intensity) y_R

Two waves A and B are out of phase by 180° (half a wavelength), then intensity reduces. If y_A and y_B values are same, then amplitude becomes zero, hence darkness

Now, the constructive interference and destructive interference are detailed here, so we have a source of light O this is the origin O, from where we are getting the 2 waves A is one light wave, B is another light wave, since the source is same, they have same wavelength, but amplitudes are different. YA is having an amplitude of A, where A is having an amplitude of YA and wave B is having an amplitude of YB.

When they combine to increase, if they are phase that means we can see here, the starting point is same and they are in phase, they are moving on the same side of this reference line, we say these 2 waves A and B are in phase, then the resultant wave R will have an amplitude of YR, so this is constructive interference. Now we will see the another case wherein the 2 waves A and B are out of phase by 180 degree, even though they start at the same point.

They are out of phase by 180 degree, which is nothing but half of wavelength so we have the wave A with amplitude YA and we have wave B which is out of phase with respect to wave A by 180 degree and B is having intensity YB. Now when they are out of phase, then the intensity of the resultant wave R reduces and the intensity of resultant wave is YR if YA and YB values are same.

Then amplitude becomes 0 that means complete interference occurs and hence we get darkness that is what we observe here, so this is the constructive interference wherein we get bright area and this is the destructive interference where we get dark area because of complete interference.

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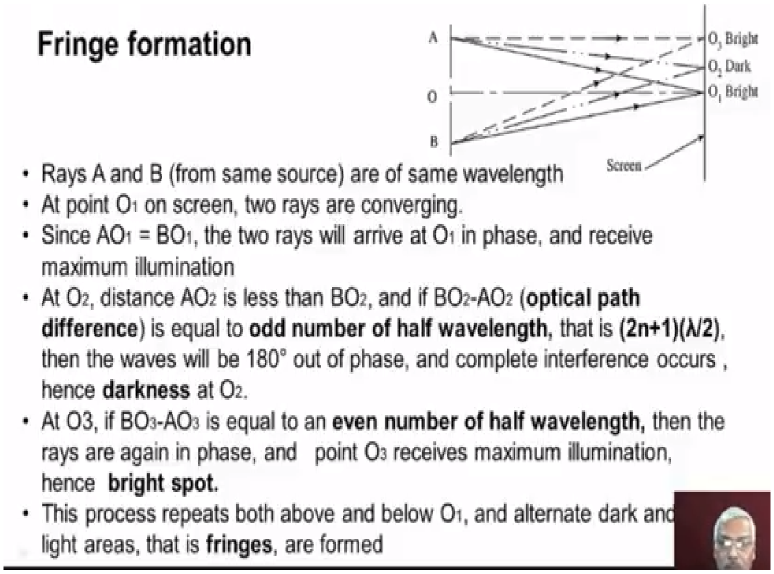

Fringe formation

- Rays A and B (from same source) are of same wavelength
- At point O_1 on screen, two rays are converging.
- Since $AO_1 = BO_1$, the two rays will arrive at O_1 in phase, and receive maximum illumination
- At O_2, distance AO_2 is less than BO_2, and if BO_2-AO_2 (**optical path difference**) is equal to **odd number of half wavelength**, that is **(2n+1)(λ/2)**, then the waves will be 180° out of phase, and complete interference occurs , hence **darkness** at O_2.
- At O3, if BO_3-AO_3 is equal to an **even number of half wavelength,** then the rays are again in phase, and point O_3 receives maximum illumination, hence **bright spot.**
- This process repeats both above and below O_1, and alternate dark and light areas, that is **fringes**, are formed

Now let us learn some more things about the fringe formation, now we can see here, we have screen AB and this is the light source and from here, we are getting the light waves, so these are primary wavelets from light source L, so here we have a pin hole A and pin hole B, so from A we are getting secondary wavelets from B also we are getting secondary wavelets. At some distance, there is a screen, which is placed parallel to the screen AB.

Now rays A but B from the same source, they have the same wavelength, at point O1 on the screen, the 2 rays are converging that means the ray from A and ray from B they travel in this medium and they are getting combined at point O1. Since AO1 = BO1, the distance AO1 = BO1, the rays will arrive at O1 in phase and this point, we receive the highest illumination and hence we get a bright spot here.

Now let us consider what happens at point O2. At O2, distance AO2 is less than distance BO2 and if BO2 – AO2, which is nothing but the optical path difference. If the optical path difference is equal to odd number of wavelength that means (2n+1) (lambda/2), then the waves will be 180 degree out of phase and the complete interference occurs and hence we get a dark spot at O2, here complete interference occurs and we get dark spot.

Now let us study what happens at O3, if BO3 this distance BO3 – AO3 is equal to even number of half wavelength then the rays are again in phase and point O3 receives a maximum illumination, hence we get bright spot at point O3, so like this we are getting alternate bright dark bright spot, dark spot like this, so this happens on both sides of O1. The process repeats both above and below O1 and alternate dark and bright light areas that is fringes are formed on this screen.

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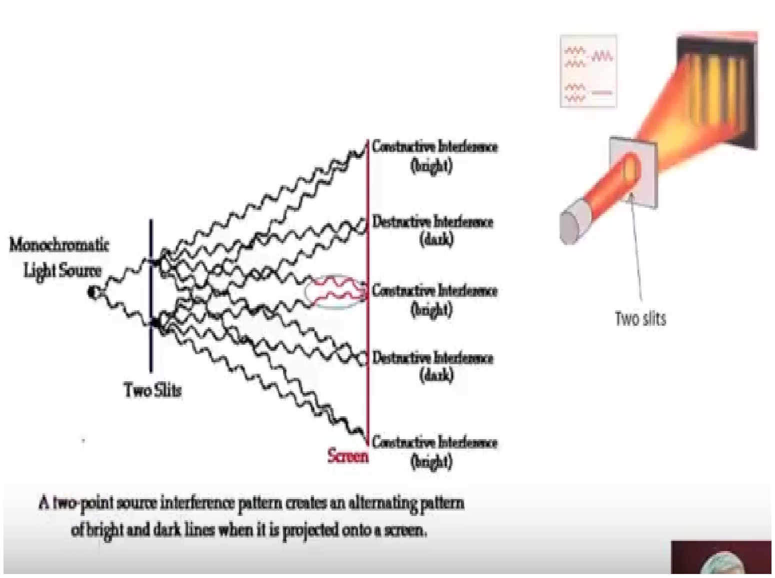

A two-point source interference pattern creates an alternating pattern of bright and dark lines when it is projected onto a screen.

Again the fringe formation is shown systematically here, we have a monochromatic light source and then we have a screen with 2 silts, say this is silt S1 and this is silt S2, and at some distance, screen is placed here, and we are getting light waves from secondary wavelets from S1, as well as from S2, now we can observe here in this region, the 2 secondary wavelets from S2 or S1, they are constructive in nature and hence we are getting a bright spot here.

Whereas in this area, the 2 wavelets from S1 and S2 they are out of phase by 180 degree, so destructive interference happens and get dark band here, so like this alternate dark band and light band we are getting and hence we get fringe pattern as shown here. This is the light source and the screen with 2 silts, S1 and S2 and on the screen we are getting the fringe pattern.

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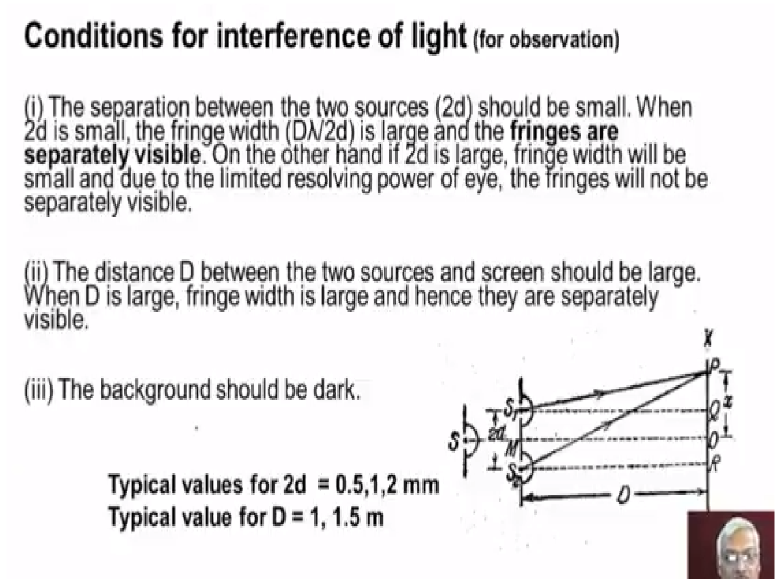

Conditions for interference of light (for observation)

(i) The separation between the two sources (2d) should be small. When 2d is small, the fringe width (Dλ/2d) is large and the **fringes are separately visible**. On the other hand if 2d is large, fringe width will be small and due to the limited resolving power of eye, the fringes will not be separately visible.

(ii) The distance D between the two sources and screen should be large. When D is large, fringe width is large and hence they are separately visible.

(iii) The background should be dark.

Typical values for 2d = 0.5,1,2 mm
Typical value for D = 1, 1.5 m

Now let us study about the conditions, which are suitable for the interference of light, so when do we get the fringe pattern, what are the conditions suitable for getting the fringes so that we will study now. Now the separation between the 2 sources should be small. Now from this diagram, we can understand that we have a light source S from which we are getting wavelets and in the screen AB, we have 2 pin holes S1 and S2 separated by distance 2d, this 2d should be very small.

When 2d is small, the fringe width that is D x lambda/2d, where D is the distance between screen AB and screen XY and 2d is the distance between S1 and S2. So when 2d is small, the fringe width D x lambda/2d is large and the fringes are separately visible. On the other hand, if 2d is large, fringe width will be small and due to the limited resolving power of human eye, the fringes will not be separately visible.

They will be very close and will not be able to identify or will not be able to count the fringes. Second condition is the distance D between the 2 sources and screen should be large that means the distance between the screen AB, which contains 2 silts and the screen XY on which we get the fringe pattern should be large. When D is large, fringe width is large and hence they are separately and clearly visible.

Third condition of the observation of interference is the background should be dark, so that we can clearly observe the fringes. The typical values for small D and capital d are shown here. For 2d should be 0.5 mm or 1 mm or 2 mm, so like this, the 2d should be very small, whereas the D should of the order of 1 m or 1.5 m, so that we can clearly observe the fringes.

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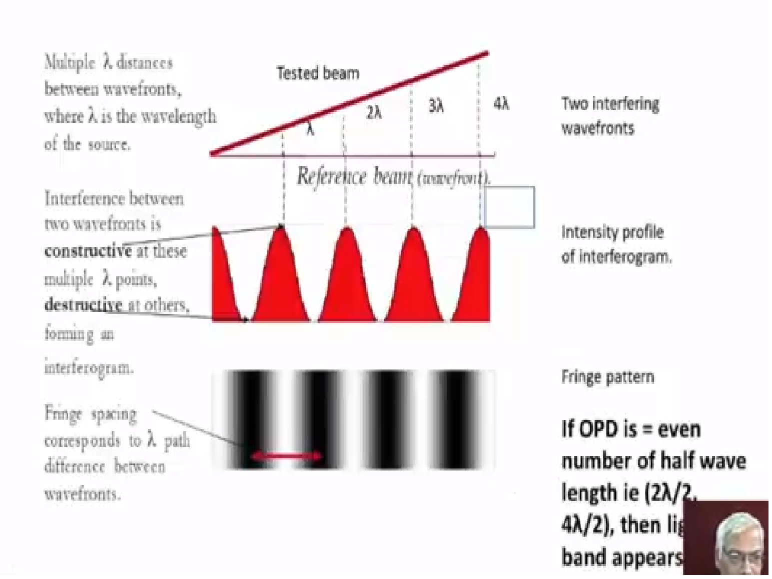

Multiple λ distances between wavefronts, where λ is the wavelength of the source.

Interference between two wavefronts is **constructive** at these multiple λ points, **destructive** at others, forming an interferogram.

Fringe spacing corresponds to λ path difference between wavefronts.

If OPD is = even number of half wave length ie (2λ/2, 4λ/2), then li band appears

Now, we can see here the fringe pattern, now we get the light from the monochromatic source, so part of the light will be reflected from the surface and part of light is passed through the medium and then again it is reflected from this surface, now we can have an optical flat for this reference surface and this can be the surface, the work piece whose surface is to be inspected.

Now we have to combine these 2 waves and then when we combine, we get the interference pattern subjected to this condition that means the reflected light say this is reflected light L1 and this is reflected light L2. There is a path difference between the path length of L1 and L2. The L1 distance is this much whereas the reflected light, we will have one additional length of this.

So this is the path difference. If the optical path difference is equal to even number of wavelength that is 2 x lambda/2 or 4 x lambda/2 or 6 x lambda/2 like this then we get a bright band, so this is the constructive interference between the 2 wave fronts of 2 waves constructive in nature and the amplitude will be maximum and we get a bright spot as shown here. Now at this place, again so we will consider at this point.

This is the light from the source and then we get reflected light, the light is reflected from the surface and then this is the transmitted light and then the light is exited, so we get 2 lights here, one L1 and L2. If the optical path difference between these 2 waves is equal to odd number of wavelength that is destructive interference happens.

Then the amplitudes of the 2 waves they get subtracted and we get very minimum light intensity at this point and then we get a dark band here, so in between we have monochromatic light source and reflected lights, if the path difference between the 2 wave fronts is equal to even number of wavelength then we get bright spot, maximum intensity and bright spot.

If the optical path difference is equal to odd number of wavelength then we get a minimum intensity and dark band appears, so like this we get fringe pattern, so this type of fringe pattern we obtain if the surface to be inspected is flat.

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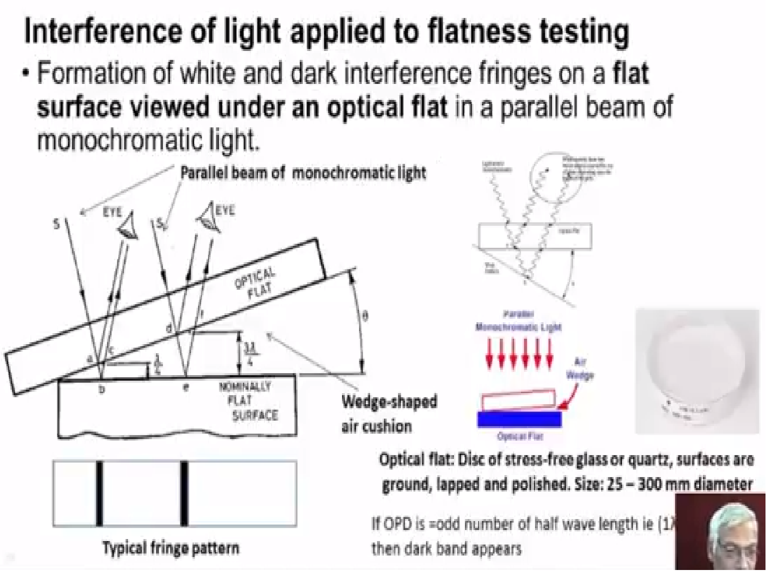

Interference of light applied to flatness testing

- Formation of white and dark interference fringes on a **flat surface viewed under an optical flat** in a parallel beam of monochromatic light.

Optical flat: Disc of stress-free glass or quartz, surfaces are ground, lapped and polished. Size: 25 – 300 mm diameter

If OPD is =odd number of half wave length ie (1
then dark band appears

Now how we can use this phenomena for metrological application, so the interference of light using the interference of light with an obvious test, the surfaces for flatness, now we can see here this is the nominally flat surface and this surface we need to inspect whether it is flat or not. For this, this is the arrangement we use an optical flat.

So the bottom surface of this optical flat is the reference, so this optical flats, they are disc of stress free glass or quartz and sometimes both the surfaces are only one surface, which is indicated by the arrow, so this surface are ground lapped and polished and they are available in different sizes from 25 mm diameter up to 300 mm diameter.

Now using this optical flat and monochromatic light source, we can get the fringe pattern and the fringe pattern will tell us about the flatness of the surface, which is under test. Now what we have to do is, we have to keep the surface, which is to be inspected and on the surface plate, and then we have to keep an optical flat of suitable diameter over the surface to be inspected.

Normally, there will be a small gap between the optical flat and the work piece under test, at one point, there will be a contact and another point, there will not be a contact because of maybe the flatness variation. There will be a small angle between these 2 surfaces, which is indicated by theta. Now we can see here we have a light source monochromatic light source and we get the light wave, so which is shown here, this is the light source.

So it will be in the waveform. Now this light will fall on the bottom surface of the optical flat and part of the light is reflected back as shown here and part of the light will be transmitted, so this is the transmitted light, so this light transmitted will fall on the surface to be inspected and then again it is reflected back and it takes this path.

Now we have 2 light waves, these 2 are combined at the i. Now if the optical path difference, we can see here, this light incident light ray, it is falling at point a and from a, we have a reflected light and we have another light, which is part of the light is transmitted and it takes this path a, b, c and then it will combine at the I. Now between these 2 light waves, there is an optical difference of a, b, c okay.

Now if this optical path difference is equal to odd number of wavelength that is 1 x lambda/2 or 3 x lambda/2 or 5 x lambda/2 like that then the complete interference occurs and then a dark band will appear, which we can observe here, a dark band appears here. Now you will consider another point wherein again we have light from monochromatic source and the light is passed through the optical flat it is reflected from the point b and the reflected light will move in this direction and particle light is transmitted.

It will take this part d, e and from you it is reflected and it will take this path and these 2 base are combined here and again if the optical path is different is equal to odd number of wavelength again dark band will appear. Now in between there will be a light source and light is reflected from this point and light is reflected from this point.

Now let us assume that the optical path difference here is equal to even number of wavelength that is lambda. 2 lambda / 2 or 4 lambda / 2 or 6 lambda / 2 like that then the intensity of the resultant wave to the maximum then we get a bright band here, so like this the get here a fringe pattern so this shows an optical flat and these optical flat are commercially available in different sizes.

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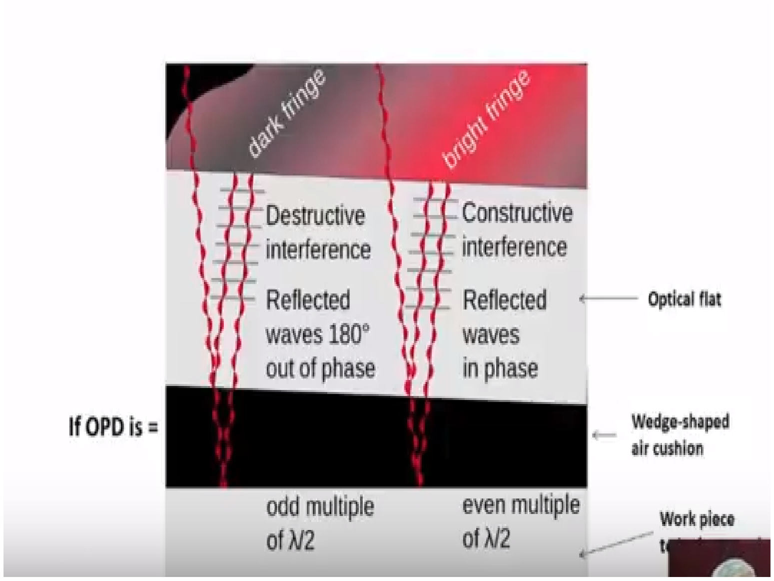

Now this shows the formation of dark fringe and bright fringe so this is the work piece to be inspected this is the surface to be inspected for flatness and this is optical flat and there is a wedge shaped air cushion between the optical flat and work to be inspected.

Now you can see here monochromatic light source by getting the incident light and it is getting reflected from this point and it is transmitted and then again reflected so here we can observe the optical path difference between these 2, in these 2 waves if it is equal to odd number of wavelength then the dark complete interference happens and the dark fringe appears.

You can observe in this region 2 waves their out of phase and hence destructive interference happens and at this point again we have the light source reflected light second reflected light and in this region you can see the 2 waves constructive interference the interference is constructive in nature and we get bright fringe the reason is the optical path difference here is equal to even number of wavelength.

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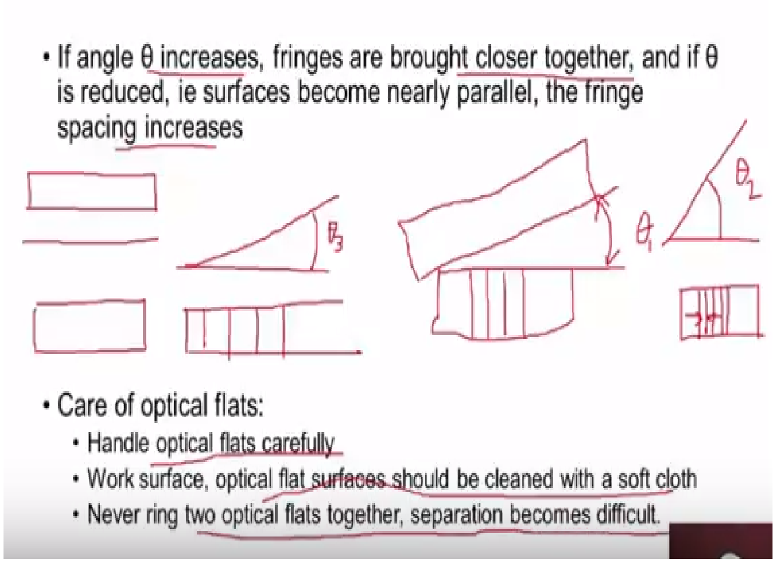

- If angle θ increases, fringes are brought closer together, and if θ is reduced, ie surfaces become nearly parallel, the fringe spacing increases

- Care of optical flats:
  - Handle optical flats carefully
  - Work surface, optical flat surfaces should be cleaned with a soft cloth
  - Never ring two optical flats together, separation becomes difficult.

Now we can now we must understand that if angle theta increases that means, we have the work piece to be inspected and then we have optical flat placed on the surface to be inspected and this is the angle theta if the angle theta increases fringes are brought closer together say we have for this particular value of theta.

So we get the fringes like this. So this is the fringe pattern if this theta increases say, so this is theta 1 and now it is theta to which is > theta 1 then the fringes will move closer together like this, so you can see here the distance between the 2 fringes more for this theta 1 and theta is increased beyond theta 2 > theta 1 the distance between the fringe is reduced but if theta is reduced surfaces become nearly parallel and fringe spacing increases.

Now let us consider another phase where in we have theta r3 which is <theta 1 that means almost parallel then the fringe distance will be large like this fringes move away, now what happens if the surface to be inspected and the optical flat surface if the parallel and the surface to be inspector is almost flat then we do not get any fringes.

So this is the ideal case, now these optical flats are manufactured with great care so that we get a very fine and flat surface these optical flats should be handled with care the work surface and optical flat surface should be cleaned with soft cloth before used and never ring to optical flats together,

If, we ring them together then the separation becomes very, very difficult and the flatness of optical flats will be fraction of millimeter, no micrometer.

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Now let us see how we can check the slip gauge surface of flatness you can see the slip gauge is placed on the flat surface and an optical flat is placed for the surface of the slip gauge which is used to be inspector and the complete set that is slip gauge and optical flat is placed in a chamber where we get monochromatic light source.

Now we can see the set of slip gauge and optical flat from the top surface from the top we can see how when we rotate the optical flat how the fringes pattern see changes by rotating the optical flat always make the fringes to be parallel to one edge and the angle between the surface for surface in optical flat surface changes you can see how the number of fringes changes the pitch of fringes changes.

Now we can see how flatness of the angle surface of a micrometer can be tested by using interferometer. The micrometer his held vertically and on the anvil the optical flat is placed and when the complete set is placed under a source of monochromatic light we can observe the fringe pattern now you can see the fringes are almost parallel and straight which indicates that the surface of the anvil is flat.

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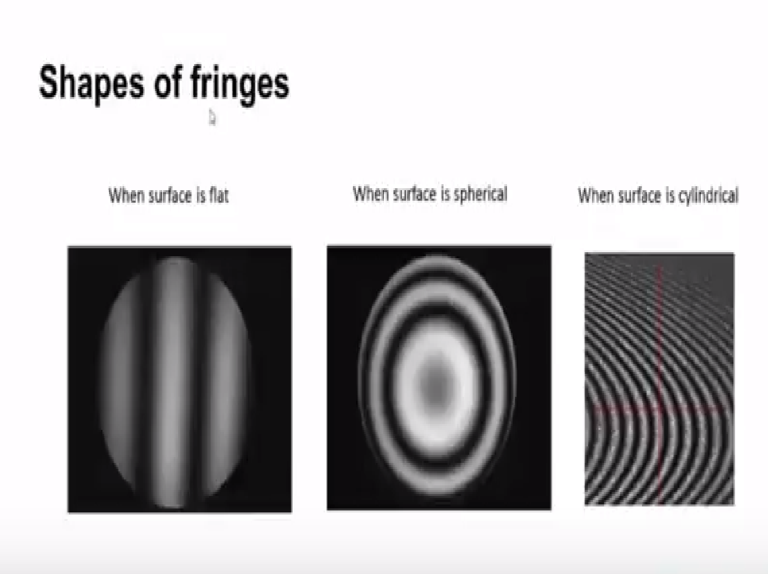

Shapes of fringes

When surface is flat

When surface is spherical

When surface is cylindrical

Now depending upon the work piece surface we get different shape of fringes so let us assume that when the work surface is flat for example flat surface of the slip gauge when we get print pattern like this the dark band and white band parallel to each other side fringes.

We get when the surface is spherical, when the surface is spherical like this then we get fringe pattern like this concentric circles we get when the surface of the work piece is cylindrical in nature then we get the fringe pattern like this.

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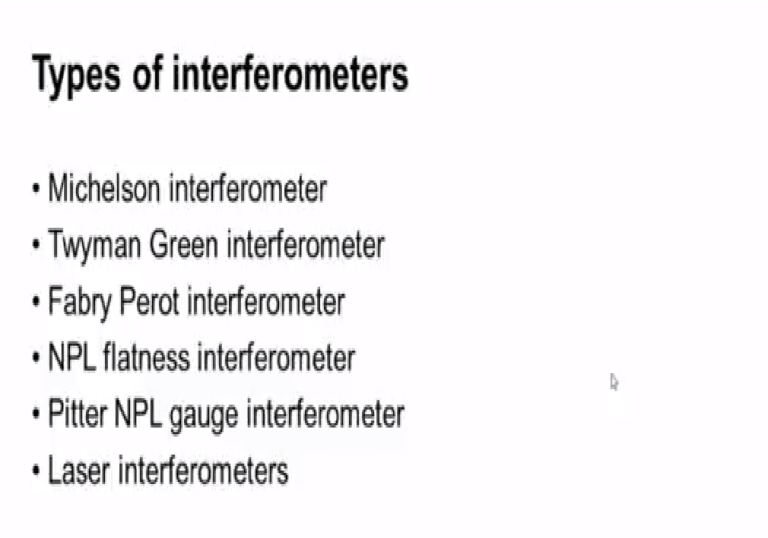

Types of interferometers

- Michelson interferometer
- Twyman Green interferometer
- Fabry Perot interferometer
- NPL flatness interferometer
- Pitter NPL gauge interferometer
- Laser interferometers

Let us start the discussion on various types of interferometers so commercially the following types of interferometer are available Michelson interferometer, Twyman green interferometer, Fabry Perot interferometer and the interferometers are developed by National physical laboratory that is NPL flatness interferometer which is used to check the flatness of the clocks.

Pitter NPL gauge interferometer are available and recently laser based interferometers are also available some of these types we will discuss in the next lecture.

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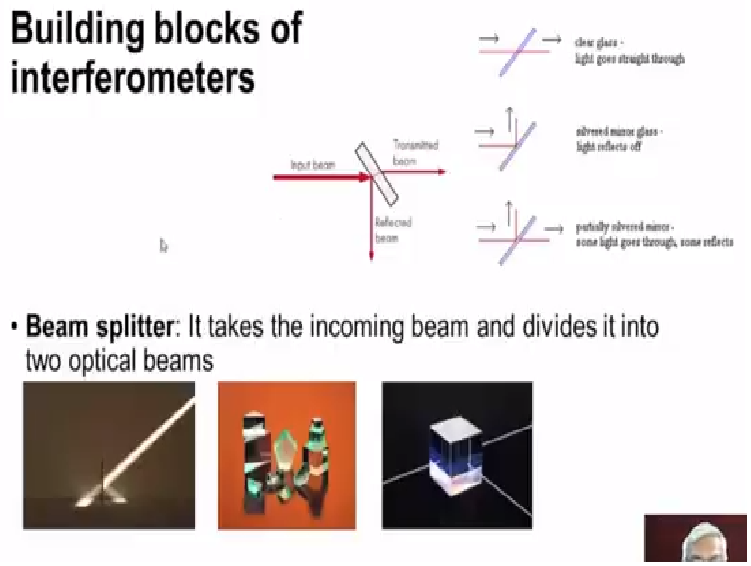

Building blocks of interferometers

- **Beam splitter**: It takes the incoming beam and divides it into two optical beams

Now let us study what are the various elements used in interferometer now we can see here a beam splitter which splits the beam into 2 parts you can see here we have beam splitter here incident beam and then incident made to fall on the splitter part of the incident light is reflected and part of the incident ray light is passed through the beam splitter.

Now here we can see your clear glass and the light will easily pass through that and this clear glass plate will not act as a beam splitter and here when the glass plate is coated with silver part of the light is or full light is reflected now when the glass plate is partially silvered part of the incident ray is reflected and part of the light pass through the glass plate.

Now you can see some of the commercially available beam splitter glass plate which is partially silvered and glass cubes are also available so incident light is also partly allowed to pass and partly reflected.

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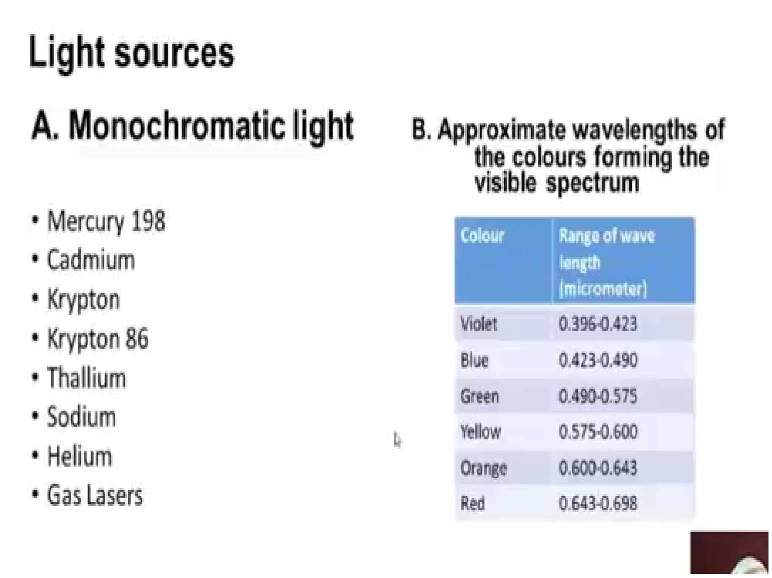

Light sources

A. Monochromatic light

- Mercury 198
- Cadmium
- Krypton
- Krypton 86
- Thallium
- Sodium
- Helium
- Gas Lasers

B. Approximate wavelengths of the colours forming the visible spectrum

Colour	Range of wave length (micrometer)
Violet	0.396-0.423
Blue	0.423-0.490
Green	0.490-0.575
Yellow	0.575-0.600
Orange	0.600-0.643
Red	0.643-0.698

Now different light sources are used see what happens if we use daylight which is consist of the different colors you can see each color will have different range of wavelength so we will not be able to get a clear fringe.

So monochromatic light source or developed which will have sharp wavelength mercury 198, cadmium, krypton, sodium, helium, gas lasers these are developed and these monochromatic light sources are used in making of interferometers.

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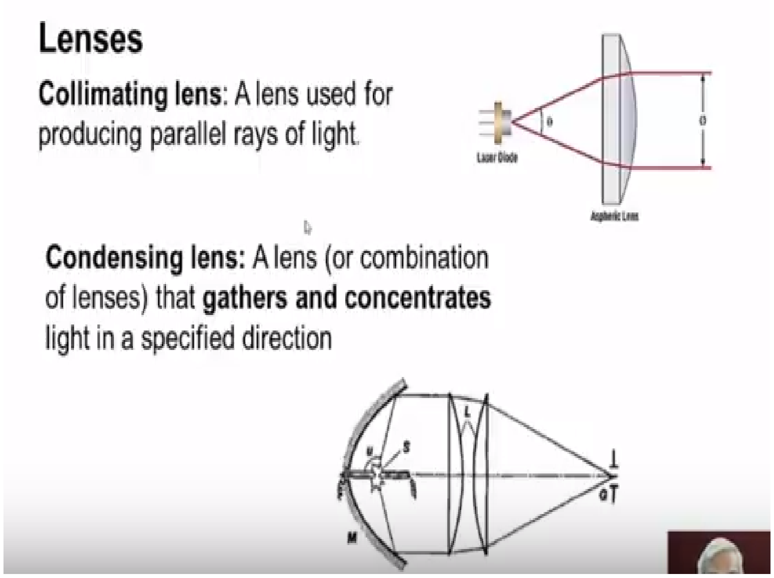

Lenses

Collimating lens: A lens used for producing parallel rays of light.

Condensing lens: A lens (or combination of lenses) that **gathers and concentrates** light in a specified direction

Under different optical lenses are used to manipulate the path of the light collimating lenses are used and these lenses are used to produce parallel ray of light, you can see here we have a light source we get light in this fashion we want to make them parallel we want to get a parallel beam of light.

In such cases we use collimating lens and sometimes we have to make parallel beam of light to fall on particular point, in such cases we go for condensing lens these lenses gather and concentrates the light in a specified direction.

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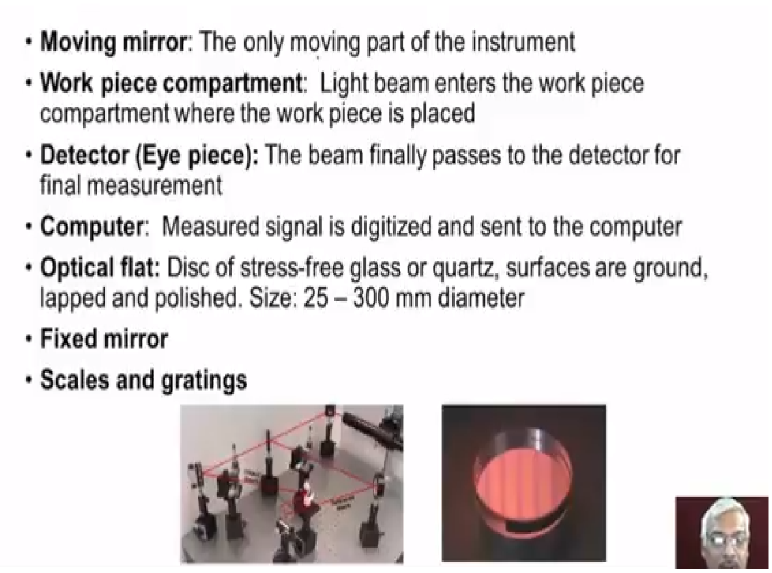

- **Moving mirror**: The only moving part of the instrument
- **Work piece compartment**: Light beam enters the work piece compartment where the work piece is placed
- **Detector (Eye piece):** The beam finally passes to the detector for final measurement
- **Computer**: Measured signal is digitized and sent to the computer
- **Optical flat:** Disc of stress-free glass or quartz, surfaces are ground, lapped and polished. Size: 25 – 300 mm diameter
- **Fixed mirror**
- **Scales and gratings**

Moving mirror is sometimes used in fabrication of interferometers and work piece compartment is very essential where in we get monochromatic light source and there is a arrangement to keep the work pieces optical flats, so we can observe the friendship patterns and a detector is mounted on the appropriate place of interferometers.

So that we can observe the fringe pattern and count the number of fringes computers are used to measure the signal and measure signal is digitalized and send to the computer for processing of the information optical flats are used to have interference phenomenon and fixed mirrors are also used to deviate the light, scales and gratings are also used for measurement purpose we can see here.

Optical flat made out of class or chords so here we can see an optical bench and we can see stands for keeping various elements like mirror and then light sources beam deflectors, detectors etc, you can see here lot of arrangement is provided to adjust the orientation of light source or the mirror or lenses screws are provided by operating this process.

We can tilt the mirrors or light sources and, we can also adjust the height of mirrors are the adjust the height of light sources etc.

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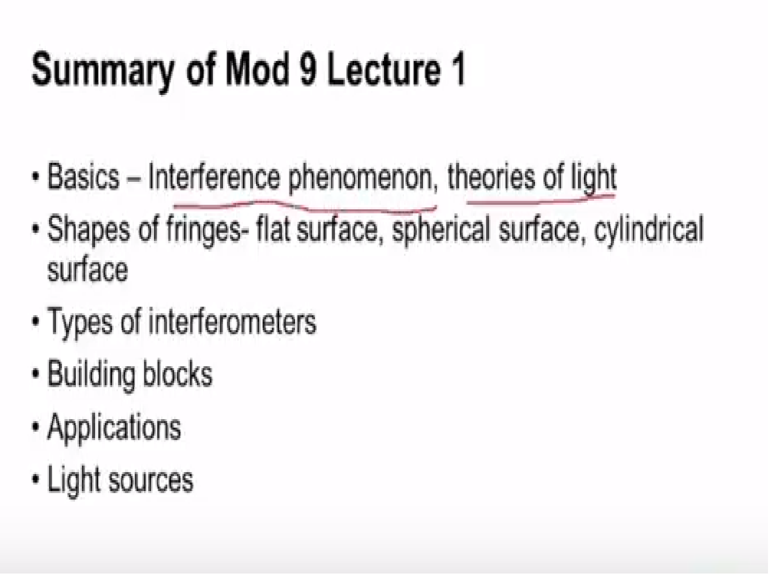

Summary of Mod 9 Lecture 1

- Basics – Interference phenomenon, theories of light
- Shapes of fringes- flat surface, spherical surface, cylindrical surface
- Types of interferometers
- Building blocks
- Applications
- Light sources

Now let us conclude the lecture 1 in this lecture we discussed about different theories of light and phenomenon of interference of light and how do we get the fringe pattern and what is the shape of fringe pattern we get depending upon the type of work piece and then different interferometers like NPL interferometer, laser interferometer etc and we also discussed about the various building blocks like mirror, light sources, lenses etc.

Fringes which are used to build the interferometers and we also discussed about the application of interferometer for flatness testing and what are the light sources in interferometers, so with this we will conclude this lecture we will continue the discussion on interferometer on the next lecture. Thank you.