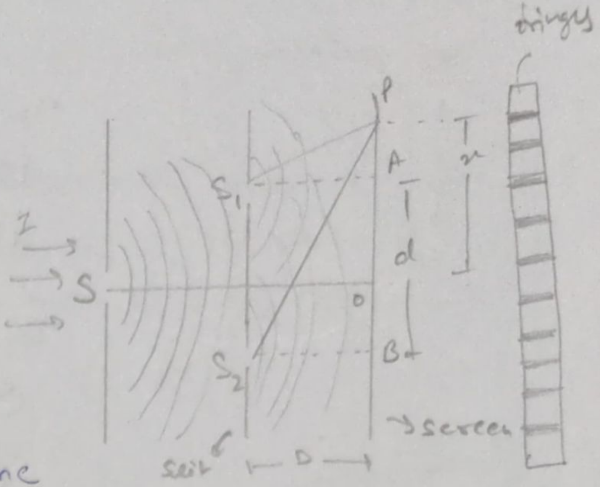
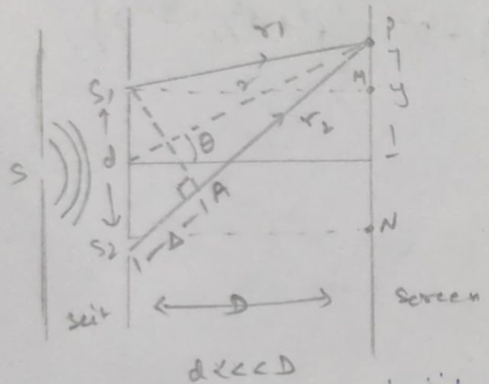
* Young's Double Slit exp :-

- Monochromatic light used mtlb same wavelength ho wagera.
- Fir yeh light wave 2 slits se guzarti hai.
- Two waves interfere and equally spaced bright & dark bands are formed on screen.



Note :- centre mein hamesh bright fringe banegi kyunki Slit 1 and Slit 2 jo rays travell krengi unko centre mein jane ke liye same dist. travel krna padega jiska mtlb path diff. is 0 ∴ centre mein hamesh bright fringe hoti hai.



- let humne 'p' par fringe nikalna hai ki Bright banega ya dark banega, to yeh Brigh aur dark depend krega path diff. pr.
- Because S_1 se P aur pt. A to P tk dono ka dist. same hai pr dusre wale ko 'Δ' dist. jyada chalna pada.

to jitna extra chala wohi uska path diff. hai.

remember always :- Agar path diff. → $\Delta = n\lambda$ ($n = 0, 1, 2, 3$) hua to P point pe bright banega

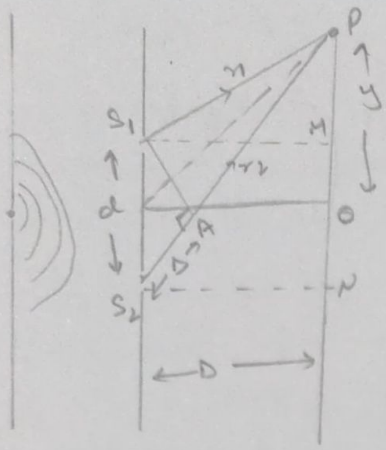
aur path diff → $\Delta = (2n-1)\lambda/2$ hua to pt. P pe dark banega.

* Derivation :-

- Humko ab path diff. nikalna so, step are :- (diagram upar wala refer karo.)

1. Hum 2 triangles lenge one for S_1P (i.e. S_1MP) and another for S_2P (i.e. S_2NP).
2. Fir dono triangles mein pythagora theorem lga denge.
3. Jo 2 eqns banengi dono ko subtract krenge.
4. final step. $d <<< D$ so, $S_1P \approx S_2P \approx D$ last mein D likh denge.

Note :- * fringe width (β) - the dist. b/w two consecutive dark or bright fringes.



Here path diff. $= S_2A$ → chota – Bada

So, $\Delta = S_2P - S_1P$ —①

In ΔS_1PM :- → triangle find kiya

$(S_1P)^2 = (S_1M)^2 + (PM)^2$ → Pythagoras lagaya.

$(S_1P)^2 = D^2 + (y - d/2)^2$ —②

In ΔS_2PN :- → Δ find kiya

$(S_2P)^2 = (S_2N)^2 + (PN)^2$ → Pythagoras lagaya.

$(S_2P)^2 = D^2 + (y + d/2)^2$ →③

Subtracting eqn ③ & eqn ②

$(S_2P)^2 - (S_1P)^2 = D^2 + (y + d/2)^2 - \{D^2 + (y - d/2)^2\}$

$\underbrace{(S_2P - S_1P)}_{\text{upar padha tha yeh path diff. hai}}(S_2P + S_1P) = \cancel{D^2} + (y^2 + d^2/4 + \cancel{2}yd/\cancel{2}) - \cancel{D^2} - (y^2 + d^2/4 - \cancel{2}yd/\cancel{2})$

$= yd + yd$

Since $d << D$ i.e. $S_2P \approx S_1P \approx D$

So, $\Delta(D + D) = [yd + yd]$ → y ki value aa path diff. ke terms mein

$\Delta 2D = 2yd \Rightarrow \boxed{y = \frac{\Delta D}{d}}$

Linear position of Bright fringe toh $\Delta = n\lambda$ put kardo

So, $\boxed{y_n = \frac{n\lambda D}{d}}$ → Bright fringe ki position $\forall n = 0, 1, 2 \ldots$

Linear position of Dark fringe toh $\Delta = (n-1)\lambda/2$ put kardo.

$\boxed{y_n = (2n-1)\lambda D/2d}$ $\forall n = 0, 1, 2 \ldots$

- Bright fringe width

$\beta = y_n - y_{n-1}$

$\beta = \frac{n\lambda D}{d} - \frac{(n-1)\lambda d}{d}$

$\boxed{\beta = \frac{\lambda D}{d}}$

Bright fringe ki fringe width.

- Dark fringe width

$\beta = y_n - y_{n-1}$

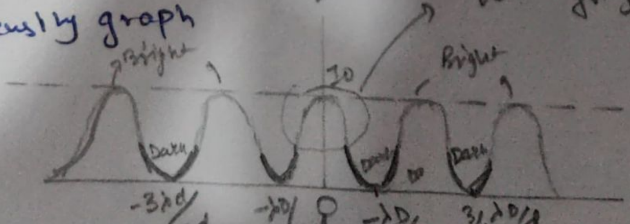
$= (2n-1)\frac{\lambda D}{2d} - [2(n-1)-1]\frac{\lambda D}{2d}$

$= \frac{\lambda D}{2d}[(2n-1) - (2n-2-1)]$

$= \frac{\lambda D}{2d}[-1+3]$

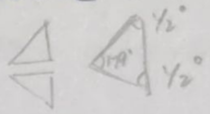
$\boxed{\beta = \lambda D/d}$ → Bright aur dark fringe width same aa rhi hai iska matlb dono ke beech ka dist. same hi hoga.

* Intensity graph

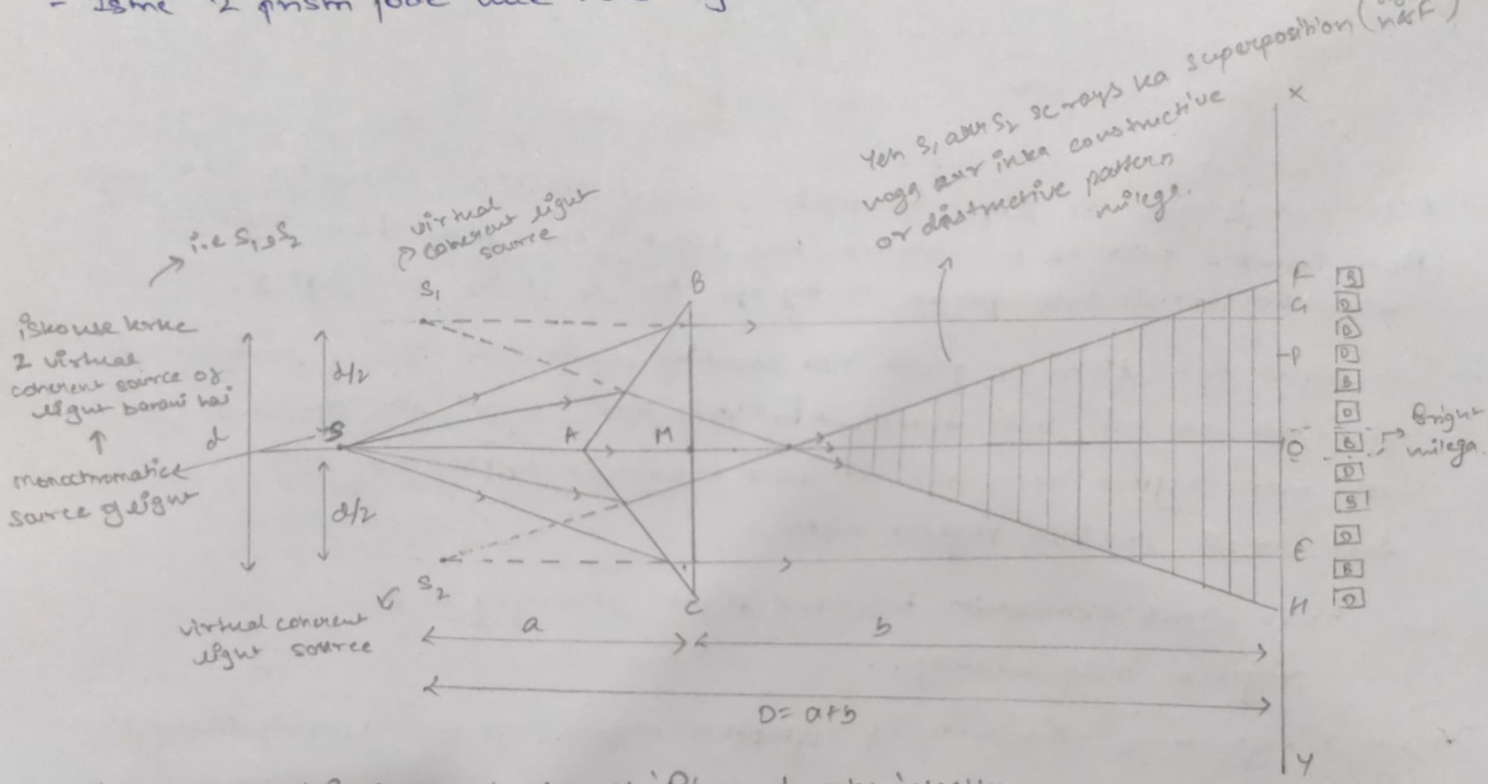


* Fresnal Biprism:-

- Agar 'interference phenomena ko study krna hai toh uski pehli requirement hoti hai 'coherent sources', isko banane ke alag alag methods hai unn mein se ek 'Fresnal Biprism' hai.
- It is an optical device which is used to produce two coherent sources of light by phenomenon of refraction of light. In this we use division of wavefront method to produce two coherent sources of light.



- Isme 2 prism jode hue hote by their base.



→ Ab dekhenge ki ek particular pt. 'P' pe humhe intesity max. milegi ya min. milegi.

for Bright fringe

path diff. $= S_2P - S_1P = n\lambda$ $(n = 0, 1, 2 \ldots)$

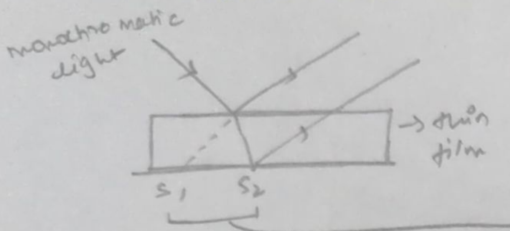
for dark fringe

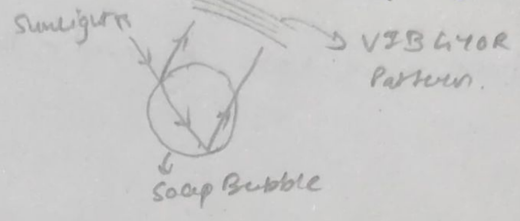
path diff. $= S_2P - S_1P = (2n+1)\lambda/2$ $(n = 0, 1, 2 \ldots)$

* Interference in thin films :-

- Thin film interference is natural phenomenon in which light waves reflected by upper and lower boundaryies of thin film interference with one another, giving interferen pattern. (fringes)

- But in soap bubble humhe VIBGYOR patter milta not dark/Bright fringes because soap bubble bubble jo light padti hai woh sunlight hoti hai i.e polychromatic aur hum jo labs mein use krte hai woh monochromatic hota hai so humhe tab Dark/bright fringes milte hai.





- Also, interference ke liye humko 2 light sources chahiye hote hai But hamare pass ek hi source hai light therefore hum reflected wale ko dotted krke piche le ayenge to S_1 & S_2 mil jayenge.

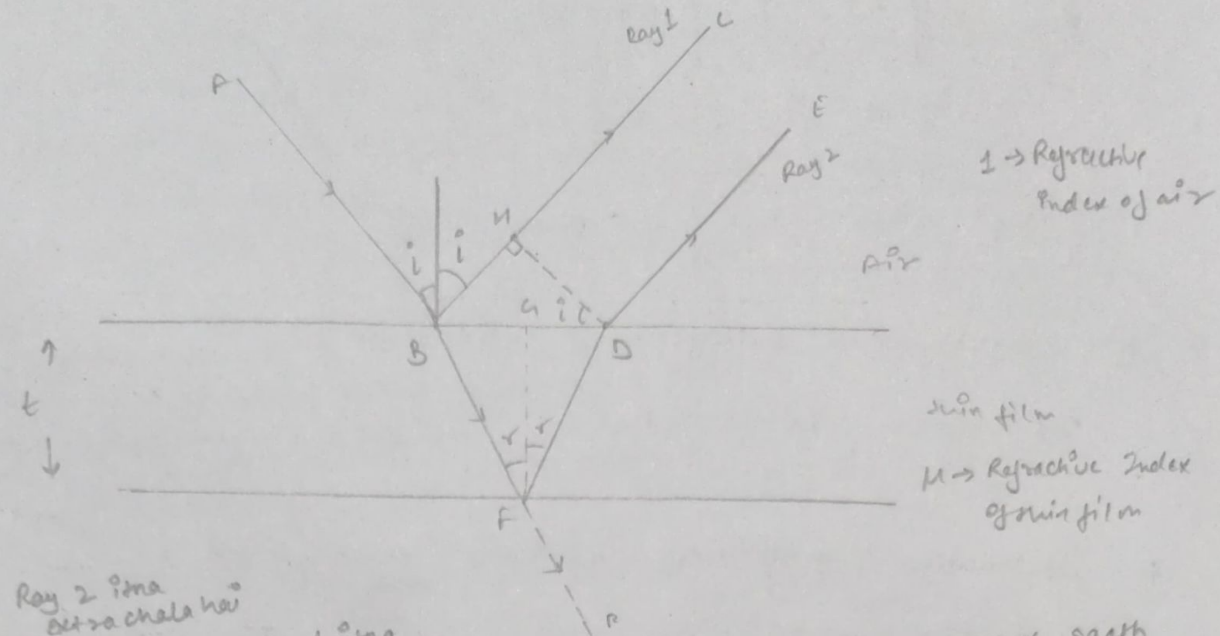
- Jab light thin film pe padti hai starting mein toh small portion hi reflected hota hai max. transmit ho jata hai aur fir andar dusri baari mein reflect hota hai to max. transmit hojata hai aur ~~that~~ small portion reflect hota.

so, i.e. Thin films transmit incident light strongly and reflect only weakly.] Imp

After 2 reflections intensity of reflected rays drop to negligible strength, so we consider first 2 reflected rays only.

- These 2 rays are derived from same incident ray but appear to come from two source located below the film. i.e S_1 & S_2
- The sources are virtual coherent sources. The reflected waves 1 & 2 travel along parallel paths and interfere.

- Condition for maxima and minima can be deduced once we have calculated optical path difference b/w 2 rays at point of their meeting.



Ray 2 itna extra chala hai

Path difference :- ↑ Ray 1 itna extra chala hai → Pt. H & D se dono rays saath chalna shuru ki hai

$$\Delta = \mu(BF + FD) - 1(BH) \quad — ①$$

In $\triangle BFD$ → $BF = FD$ → ∵ angle equal hai toh sides bhi equal hongi.

$\cos r = FG/BF$ → $BF = FG/\cos r = t/\cos r$

since $BF = FD$ toh $FD = t/\cos r$

so, $\boxed{BF + FD = \frac{2t}{\cos r}}$ — ②

Now, $BG = GD$ → $BD = 2BG$

$\tan r = BF/FG$ ⇒ $BG = FG \tan r$ ⇒ $BG = t \tan r$

$BG = 2t \tan r$

In $\triangle BHD$

$\angle HBD = 90 - i$, $\angle BHD = 90$, $\angle BDH = i$

$\sin i = BH/BD$ → $BH = BD \sin i$

$BH = 2t \tan r \sin i$ — ③

from snell's law

$\sin i/\sin r = \mu$ → $\sin i = \mu \sin r$

$BH = 2t \tan r (\mu \sin r)$

$B = \frac{2\mu t \sin^2 r}{\cos r}$ — ④

using eqn (2) & (4) in (1)

$$\Delta_a = \mu\left[\frac{2t}{\cos r}\right] - \left[\frac{2\mu t \sin^2 r}{\cos r}\right]$$

$$= \frac{2\mu t}{\cos r}[1-\sin^2 r] = \frac{2\mu t}{\cos r}[\cos^2 r]$$

$$\boxed{\Delta_a = 2\mu t \cos r}$$ → path diff.

so, for constructive Interference (Maxima) Bright fringes

$2\mu t \cos r = (2m+1)\lambda/2$ ∀ $m = 0,1,2,3 \ldots$

aisa YDSE mein Dark ke liye hota that

for destructive interference (minima) Dark fringes.

$2\mu t \cos r = m\lambda$ ∀ $m = 0,1,2,\ldots$

aisa YDSE mein hota that for Bright.

YDSE ka ulta ho gya

- YDSE ka ulta ho gya aise isliye hua kyunki air ka refractive Index '1' hota hai aur thin film ka refractive index 'μ' air wale se zyada hai i.e. $\mu > 1$ isliye jab bhi jyada Refractive index wale se hamari light reflect hoti hai toh woh hamesh π shift i.e. 180° shift ho jaati hai.

* working dekhlo ab iski :-

- let us consider a transparent film of unifor thickness 't' bounded by 2 parallel surfaces. let refractive index of film be 'μ' & air be '1'

let us consider plane waves from a monochromatic source falling on thin film at an angle of incidence 'i'.

Part of ray such 'AB' is reflected along 'BC', and part of it is transmitted into film along 'BF'.

Transmitted ray 'BF' makes an angle 'r' with normal to surface at pt. 'G'.

Ray 'BF' is in turn partly reflected back in to film along 'FD'

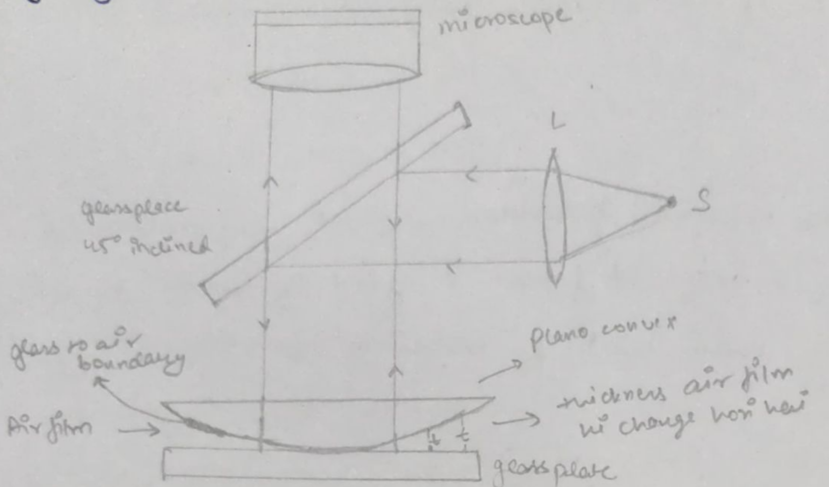
The ray 'FD' is transmitted at upper surface & travels along 'DE'.

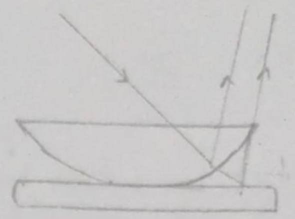
Since film boundaries are parallel. the reflected rays 'BC' & 'DE' will be parallel to each other.

waves travelling along paths 'BC' and 'BF DE' are derived from a single incident wave AB. ∴ they are coherent & can produce interference.

* Newton's Ring :-

- Newton's ring is a phenomenon in which interference pattern is created by reflection of light b/w 2 surfaces, typically a spherical surface and an adjacent touching flat surface.
- Isme fringes circular hoti hai.





- Monochromatic light from an extended source S is rendered parallel by a lens 'L'. It is incident on glass plate inclined at 45° to horizontal, and is reflected normally down to plano convex lens placed on flat glass plate.
- Part of light incident on system is reflected from glass to air boundary. The ~~ae~~ remaining light is transmitted through air film.
- Then it again reflect from air to glass boundary
- The two rays reflected from top and bottom of air film interfere to produce darkness and brightness.
- Condition of Brightness or darkness depends on path difference b/w 2 reflected rays, which in turn depends on thickness of film.

⇒ remember agar centre pr light incident hoti hai toh isme hamesh dark fringe milega centre mein. kyunki centre pr thickness 0 hoti hai.

We know that optical path diff. b/w rays is (refractive index of air film)

$$\Delta_a = 2\mu t \cos r \quad (t \to \text{thickness}) \to \text{reflection angle.}$$

for normal incidence of light → Yaha optics mein normal ka mtlb 0° hota hai

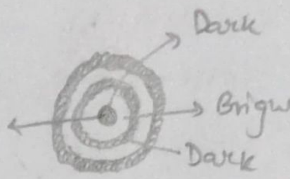
$$\Delta_a = 2\mu t \cos r \quad (\mu = 1 \to \text{i.e. R.I of air} = 1)$$

$$= 2(1)t(\cos 0°) \quad (\cos 0° = 1)$$

$$\Delta_a = 2t$$ → Yeh hamara 2 rays ke beech ka path diff. hai

for constructive interference / Maxima / Bright fringes :-

$2t = (2m+1)\lambda/2$ $m = 0, 1, 2, 3 \ldots$



for destructive interference / Minima / Dark fringes :-

$2t = m\lambda$ $m = 0, 1, 2, 3 \ldots$

Yeh YDSE ka ulta ho gya because ~~[illegible]~~ light waves changes phase by 180° when reflect from surface of medium with higher refractive index than that of medium in which they are travelling.

- Why newton's rings are circular?

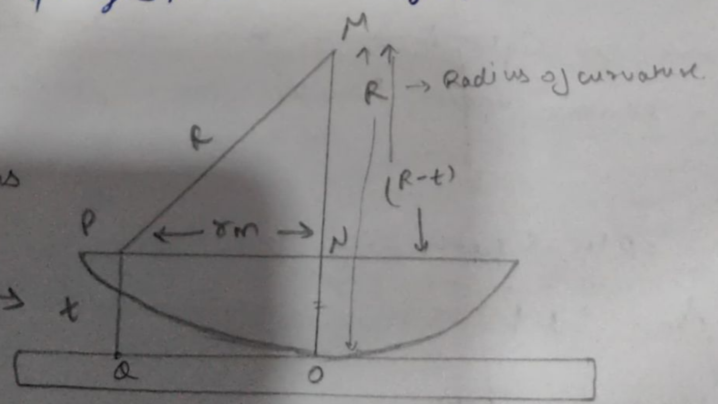
Ans. The thickness of air film at point of contact is zero and gradually increases as we move ~~outside~~ outward.

- The locus of points where air film has same thickness then fall on a circle whose centre is point of contact.

Generally circular isliye hoti hai kyunki hamara lense circular hota hai (i.e plano convex) aur due to ~~air~~ varying thickness of air gap b/w surfaces.

*** Radii of Dark fringes / Newton Rings :-**

maan lete hai 't' thickness pr humne dark fringe mil rhe hai matlb at pt 'Q'



In ΔPNM using pythagoras.

$$PM^2 = PN^2 + MN^2$$

$$R^2 = (r_m)^2 + (R-t)^2$$

$$R^2 = r_m^2 + R^2 + t^2 - 2Rt$$

$$r_m^2 = 2Rt - t^2$$

As $R >> t$, $2Rt >> t^2$

↳ lens ke radius se thickness bohot kam hai almost negligible.

so, $r_m^2 \simeq 2Rt \longrightarrow r_m = \sqrt{2Rt}$

w.r.t condition for darkness at Q is

$$2t = m\lambda \rightarrow t = m\lambda/2$$

$$r_m^2 = 2R\,m\lambda/2 \rightarrow r_m^2 = m\lambda R$$

$$r_m = \sqrt{m\lambda R} \qquad * \; m = 1,2,3,4 \ldots$$

the radii of dark fringes can be found by using

$m = 1, 2, 3 \ldots$

$r_1 = \sqrt{1\lambda R}$ $\qquad r_3 = \sqrt{3\lambda R}$

$r_2 = \sqrt{2\lambda R}$

so, we can see that $\boxed{r_m \propto \sqrt{\lambda}}$ → mtlb wavelength badhega toh fringes ka radius badhega.

thus radius of m^{th} dark ring is proportion to underroot of wavelength.

* Ring ~~for~~ Diameter.
- Yeh radius ka double ho jayega.

so, $D_m = 2r_m$

$D_m = 2\sqrt{2Rt}$

or $D_m = 2\sqrt{m\lambda R}$

- Spacing b/w fringes :-

$D_m = 2\sqrt{m\lambda R} \qquad m = 1,2,3,4 \ldots$

$D_1 = 2\sqrt{\lambda R}$

$D_2 = 2\sqrt{2\lambda R} = 2(1.4)\sqrt{\lambda R} = 2.8$

$D_3 = 2\sqrt{3\lambda R} = 2(1.7)\sqrt{\lambda R} = 3.4$ $\quad$ +6

$D_4 = 2\sqrt{4\lambda R} = 2(2)\sqrt{\lambda R} = 4$ $\quad$ +6

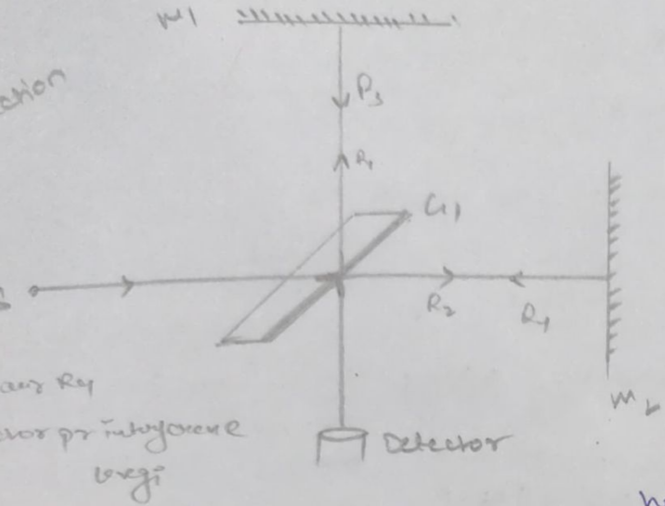
→ Abhi yeh gap normal aur equal hai but dheere dheere yeh gap kam hota jayega. jaise hi hum 'm' ki value badha denge.

- Rings get closer and closer, as 'm' increases. this is why rings are not evenly spaced.

* Michelson Interferometer :-

- It is an instrument in which phenomenon of interference is used to make precise measurements of wave ~~wa~~lengths, refractive index and distance.

Basic construction



R_3 aur R_4 Detector pr interference krgi

M_1, M_2 → 2 mirrors perpendicular mein lge hote hai

G_1 → partially silver glass place

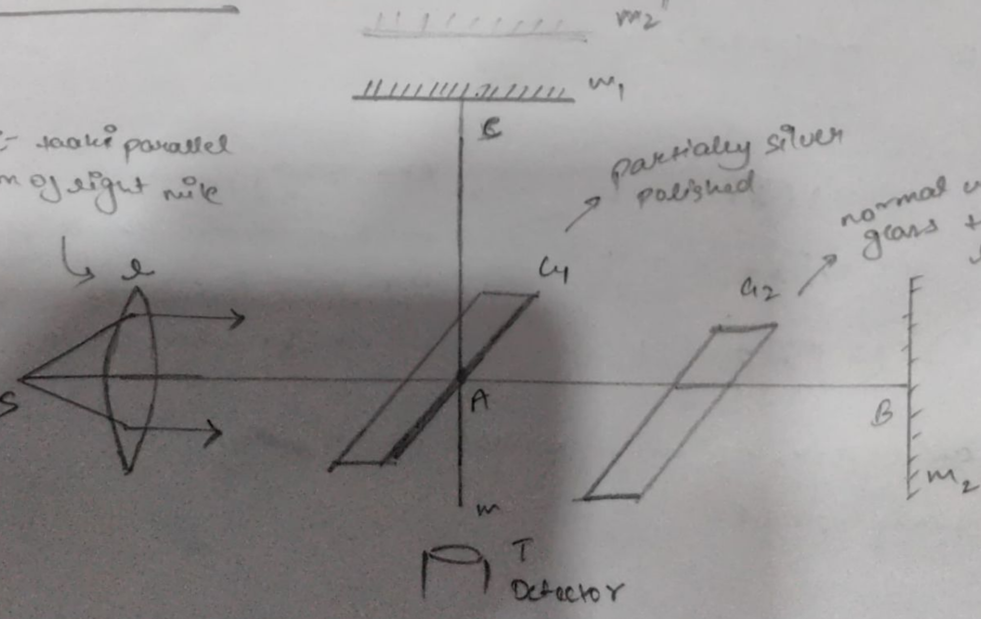
Detector → Jaha fringes milenge.

- light source se nikal ke G_1 se reflect hoke M_1 jaati hai aur transmit hoke M_2 jaati fir waha se woh wapas reflect hote hai aur dono rays detector ke pass jaake interference krti hai.

* Principle :-

- In michelson inferometer, a beam of light from an extended source is divided into 2 parts of equal intensities by partial reflection and refraction.
- These beams travel in two mutually perpendicular direction and come together after reflection from plane mirror.
- The beams overlap on each other and produce interference fringes.

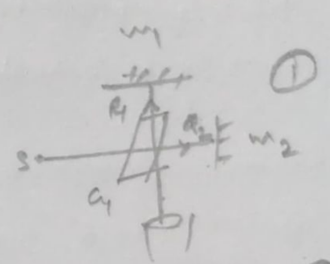
* Construction :-



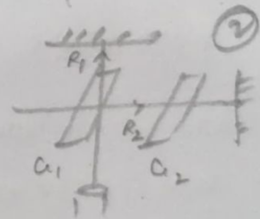
- It consist of beam splitter 'G_1', a compensating plate 'G_2', and two plane mirrors m_1 & m_2. The beam splitter G_1 is partially silvered plane parallel glass plate.
  Compensating plate G_2 is simple plane parallel glass plate having same thickness as G_1.
- 2 plates G_1 & G_2 are held parallel to each other and are inclined at angle of 45° with respect of mirror m_2.
- mirror m_1 is mounted on carriage and can be moved with help of micrometer screw.
- plane mirrors m_1 and m_2 can be made perfectly perpendicular with help of fixed screw attached to them.
- Interference bands are observed in field of view of detector.

~~* Working :-~~

Compensating plate samjho pehle :-



- Compensation basically hamare dono rays ke path difference ko same banata hai.
- Diagram ① mein Ray 1, teen baar silver glass plate se guzarti hai i.e. G_1



(i) Source se silver glass plate mein enter
(ii) silver glass plate se mirror m_1
(iii) mirror m_1 se reflect hoke silver glass plate tak gya.

~~Aur~~ But jo Ray 2 hai woh bas ek baar guzarti hai i.e. glass plate se mirror glass plate.

isliye hum compensating plate use karte hai jies.

- Daigram ② mein Ray 1 3 baar guzar rhi hai But ab ray 2 bhi 3 baar guzar rhi hai i.e.
(i) G_1 se G_2
(ii) G_2 se mirror
(iii) mirror 'm_2' se G_2

ab inka path diff. match ho gya hai. isse humhe fringes ache milte hai.

*** Working :-**

- monochromatic light from extended source S is rendered parallel by means of lens L ~~an~~ and is made incident on beam splitter G_1. It is partly reflected at back surface of G_1 along AC and partly transmitted along AB.
- Beam AC travels normally toward plane mirror ~~M~~ M_1 and is reflected back along same path and comes out along AT.
- Transmitted beam travel toward mirror M_2 and is reflected along same path. It is reflected at back surface of G_1 and proceeds along AT.
- The two beams ~~as~~ received along AT are produced from single source through division of amplitude and are hence coherent.
- The superposition of these beams leads to interference and produce interference fringes.

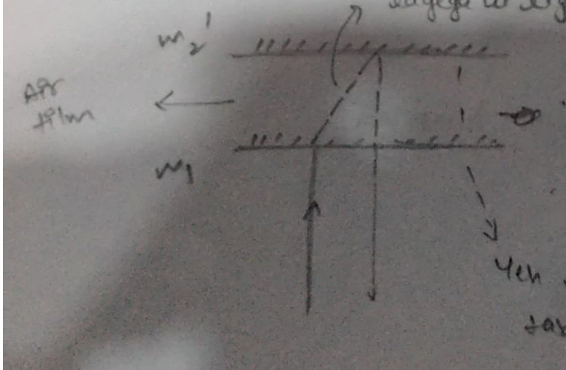
Interference ke liye coherent source zaruri honda si.

- From construction, it is clearly seen that light ray starting from source S and undergoing reflection at mirror M_1 passes through glass plate G_1 three times.
- On other hand, in absence of plate G_2, the ray reflected at M_2 travels through glass plate G_1 only once.
- For compensating this path difference, a compensating plate G_2 of same thickness is inserted to path AB and held exactly parallel to G_1.
- If we look into intrument from T, we see mirror M_1 and in addition we see virtual image, M_2' of mirror M_2. Depending on position of mirror, image M_2' may be in front of, or behind, or exactly coincide with mirror M_1.

m1 ke pass m_2 ka image dikhta hai

iska mtlb dekhlo ab.

source ko extend karenge toh aisa lagega ki light m_2' pr bhi jaa rhi



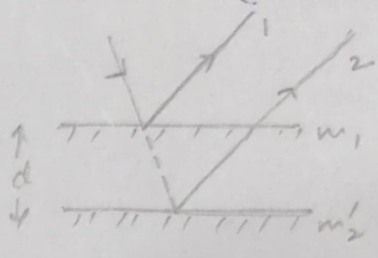
→ yeh hai tarah se interference inside film jaisa lagega.

Yeh virtually bani hai i.e jab m1 and m_2 ⊥r honge tabhi yeh m_2' banega

* Circular fringes :-

- Circular fringes are produced with monochromatic light when mirrors m_1 and m_2 are exactly perpendicular to each other.

- Situation is similar to an air film enclose b/w mirror m_1 and m_2', but diff. is that in case of real film b/w 2 surfaces, multiple reflection take place, whereas in this case only two reflection takes place.



$$m_2' m_1 = d.$$

total path diff. b/w 2 beams given by

$$\Delta_a = 2d\cos\theta$$ → θ is angle of observation i.e. w/s ∠ se observe kr rhe ho.

- for constructive interference (maxima)

$$2d\cos\theta = (2m+1)\lambda/2 \quad \forall\ m = 0, 1, 2, 3 \ldots$$

- for destructive ~~infer~~ interference (minima)

$$2d\cos\theta = m\lambda \quad \forall\ m = 0, 1, 2, 3 \ldots$$

- agar m_1 aur m_2' dono coincide krenge toh dark fringe milega bss