Method of creation of coherent waves

Previously, we discussed that coherent waves overlapping together form interference pattern. Now let's answer to the following question:

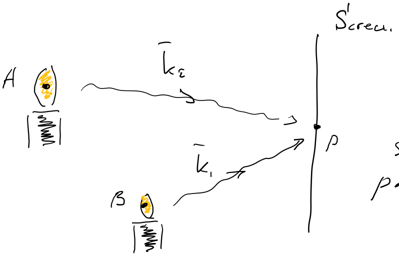
How we can create coherent waves?

1) What is actually the problem?

2) Why we cannot take two independent sources that are not coherent?

3) What is the physical meaning the sources are not coherent?

Two sources:



Why we will not see interference pattern?

Two reasons!

① $\Delta\varphi = (\bar{k}_2 - \bar{k}_1)\bar{r} - (\delta_1 - \delta_2)$

$\delta_{1,2}$ - initial phase

This initial phase is exactly the reason.

Let's take one atom in candle A and one in candle B.

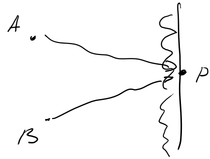
$\tau = 10^{-8} s$

δ_1 and δ_2 are random

$\Downarrow$

$\Delta\varphi$ is random

That means on screen we will have random interference picture, but will exist only for $10^{-8}s$.



Next interference picture will be in another $10^{-8}s$, assuming only natural broadening.

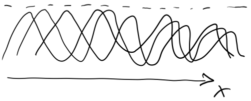
Of course, we cannot detect it by eye.

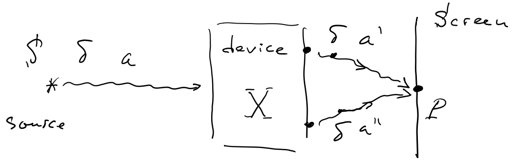
What about by fast detector?

We still will not be able to detect it, because of reason 2.

② Too many pairs of individual random sources.

$6 \cdot 10^{23}$ =>





$\bar{X}$ devides light train by 2.

$a \rightsquigarrow a'$ and a'' with $\delta = \delta' = \delta''$

Since for such case $\delta_1 - \delta_2 = 0$, hence $\Delta\varphi = (\bar{k}_2 - \bar{k}_1)\bar{r}$ and will be solely function of coordinate, not time.

The device $\bar{X}$ should have the following properties:

1) Creates light train with $I_1 = I_2$ to increase V
2) small $\theta \Rightarrow \Delta x = \dfrac{\lambda}{\theta}$

The device $\bar{X}$ is method to create coherent waves:

① Method of wave front division.
② Method of amplitude division.

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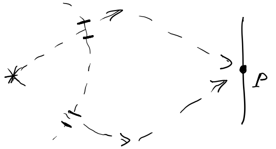
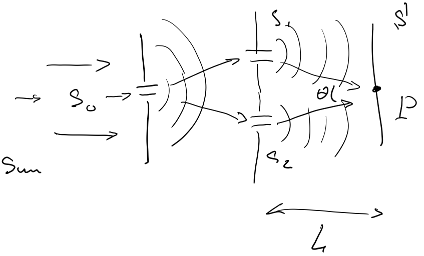
① Wave front division.



different parts of wave front.

a) Young interferometer (beginning of $\overline{XIX}$ century)



$\Delta X = \frac{\lambda}{\theta}$ – width of interference pattern

$S_1S_2 = 1$ mm
$L = 1$ m
$\lambda = 600$ nm

$\Delta X \approx 0.6$ mm

Young experimentally proofed that light is wave and measured its wavelength λ.

b) Fresnel's bi-mirrors

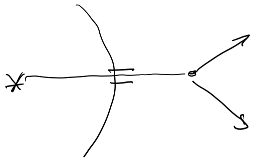
c) Fresnel's bi-prism

d) Billet's bi-lenses

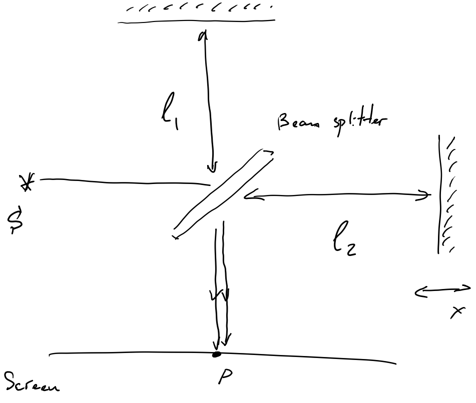
Please notice, in all schemes $\begin{cases} I_1 = I_2 \\ \theta \text{ is small} \end{cases}$

② Amplitude division.

When one part of wave front is divided into two parts.

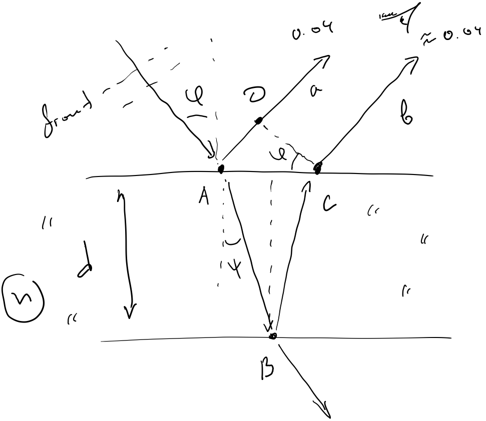


a) Michelson's interferometer



$\Delta = 2l_1 - 2l_2 \Rightarrow$ we can control if they interfere to maximum or two minimum.

b) Thin film interference



What will be the intensities?

$I_a \approx I_b$ (Please, check this numbers for actual air-glass interface)

This beams a and b are coherent. The interference pattern will solely depend on optical path difference.

Optical path difference - phase difference that will build up in points D and C due to difference in beam propagation.

$$\Delta = (AB + BC)n - HD = 2n\frac{d}{\cos\psi} - 2d\,tg\,\psi \sin\varphi$$

$$\Delta = 2dn\cos\psi$$

Please, solve

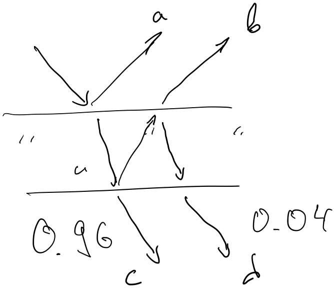
It is important to remember here, that a is reflected from more dense medium, hence the phase shift π.

Thus, $\Delta_{full} = 2dn\cos\psi \pm \frac{\lambda_0}{2}$

Now we can see, that Δ depends on:

- λ_0 (coloration)
- d and ψ (φ)

Very important question. Why we do not observe interference in transmission?



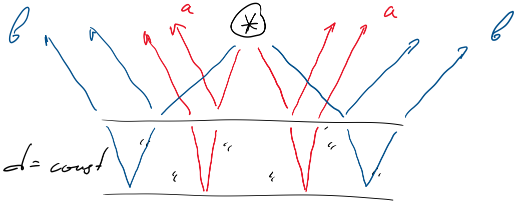
Now let's see demonstration.

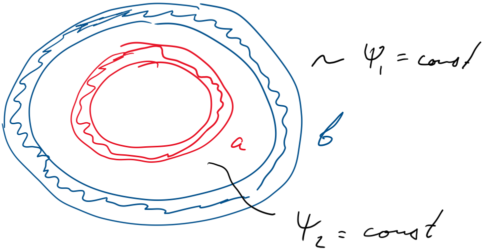
We need to try to answer following questions:

1) Why at the beginning the film is colorless?
2) Why later the stripes are colorful?
3) Why are they parallel?
4) Why are they moving?
5) Origins of dark film appearance prior to the break.

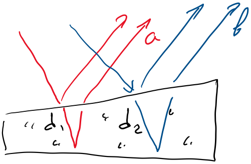
The dependence on d or φ is quite interesting.

1) If $d = \text{const}$, then it will result in interference pattern of strips of equal tilt.

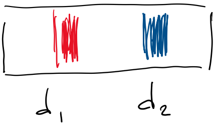




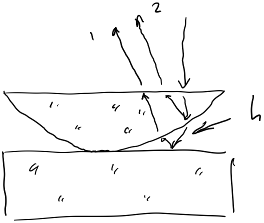
2) d is random, but $\varphi = \text{const}$



Strips of equal thickness.



b) Newton's rings (91)



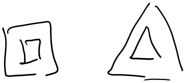
1) Show that these are stripes of equal thickness.

2) Why they have ring form?

3) What is the ring radius and what it depends on?

4) Why beams 1 and 2?

5) Please, offer the optical layout of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Demonstration

1) Why the rings are colorful?

2) Why in monochromatic light the amount of rings increases?