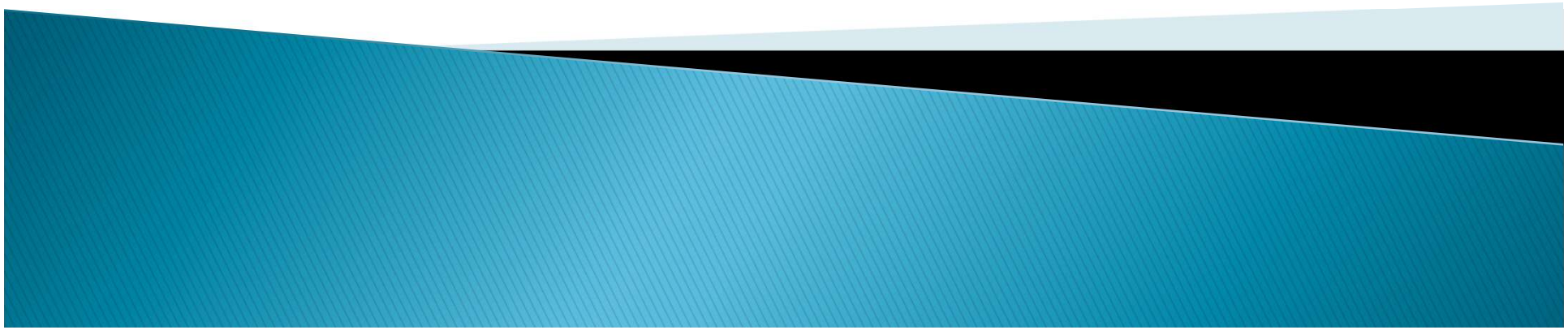
UNIT–II

Interference of Light

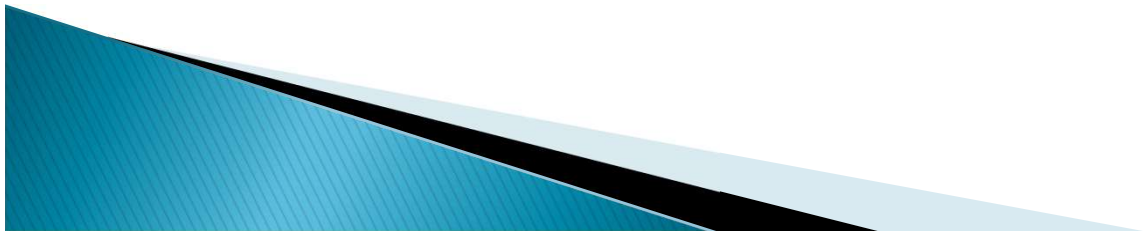


OPTICS

Optics is the branch of Physics that studies the behaviour and properties of light and the construction of instruments that use or detect it.

Optics usually describes the behaviour of visible, ultraviolet, and infrared light.

Light is an electromagnetic wave, other forms of electromagnetic radiation such as X-rays, microwaves, and radio waves exhibit similar properties.

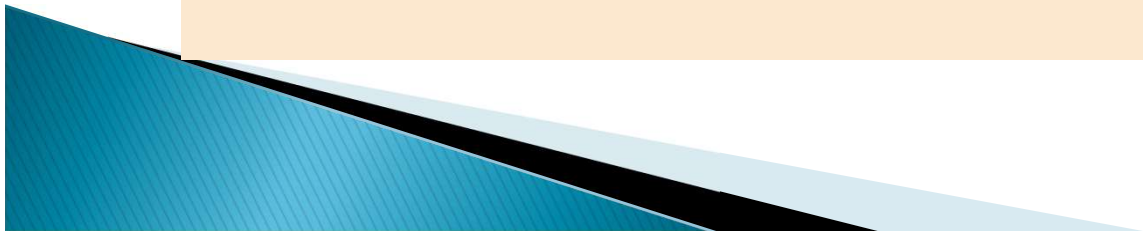


Three broad subfields of optics

1) *Geometrical optics*, the study of light as rays

2) *Physical optics*, the study of light as waves

3) *Quantum optics*, the study of light as particles



LIGHT

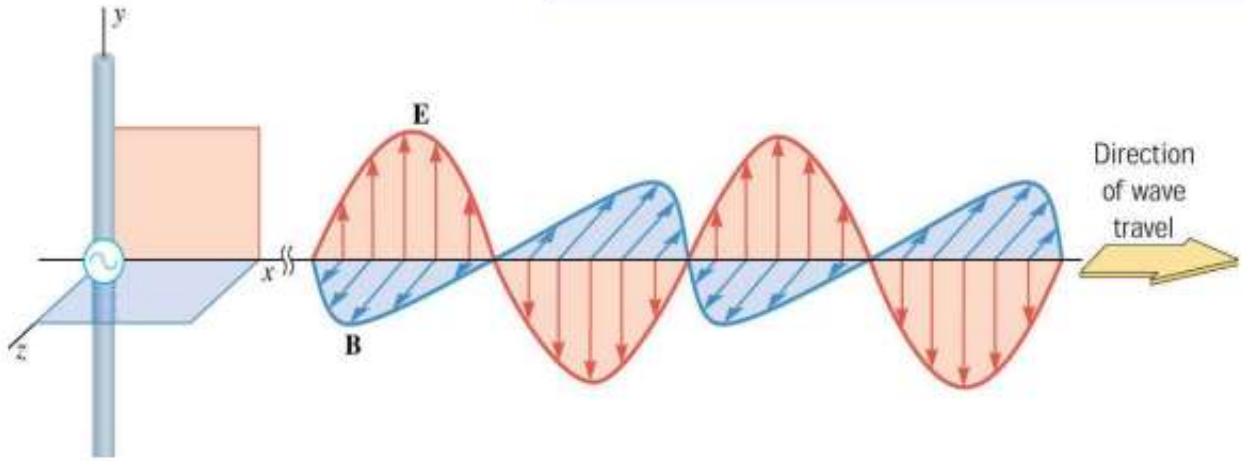
- Light is an electromagnetic wave, namely the wave the vibration of which is electric field and magnetic field.
- Light is included into transversal wave.
- Light can spread without medium, so light can spread in vacuum.

James Clerk Maxwell
1860s

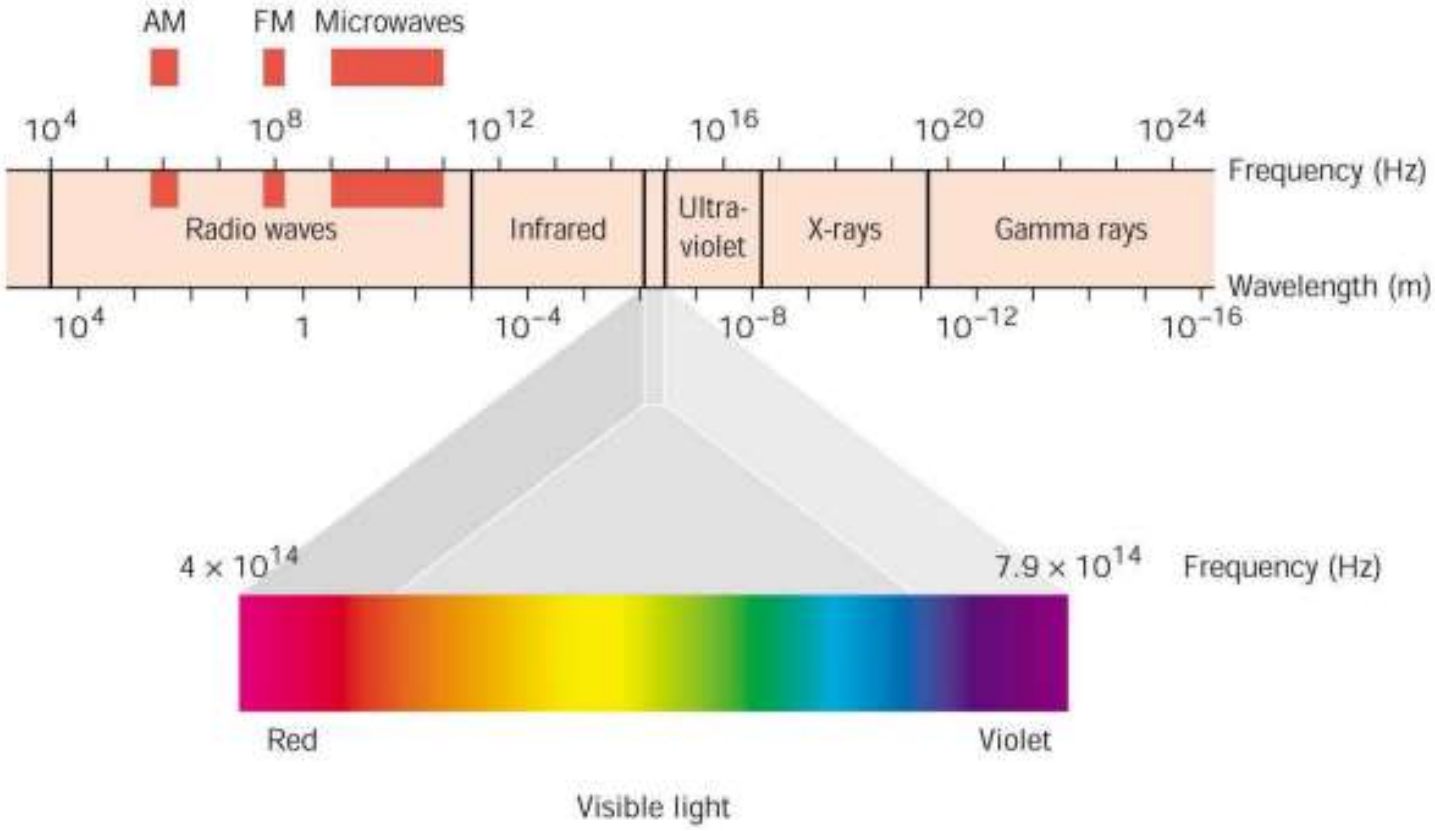
Light is wave.

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_o}} = 3.0x10^8 m/s$$

Speed of Light in a vacuum:
186,000 miles per second
300,000 kilometers per second
3 x 10^8 m/s



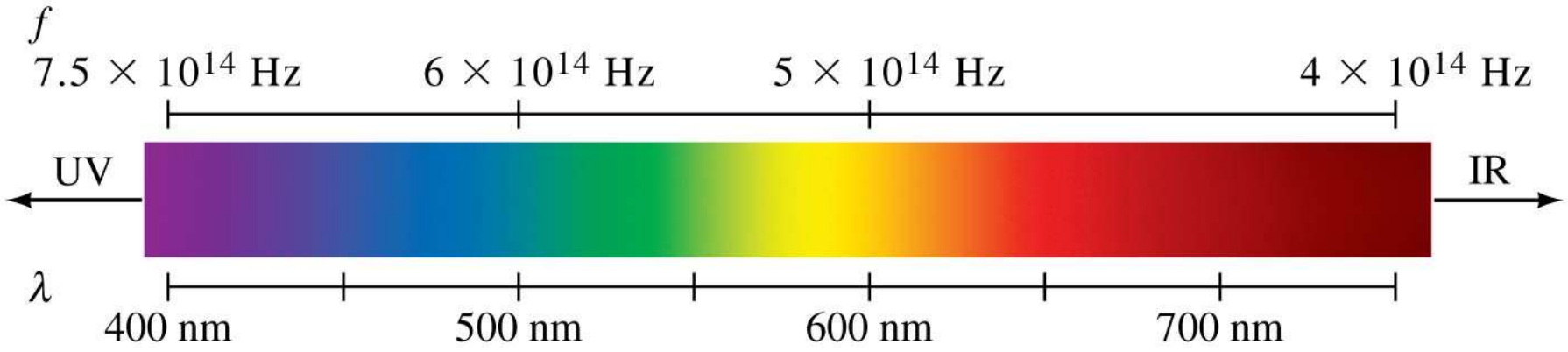
The Electromagnetic Spectrum



The Visible Spectrum and Dispersion

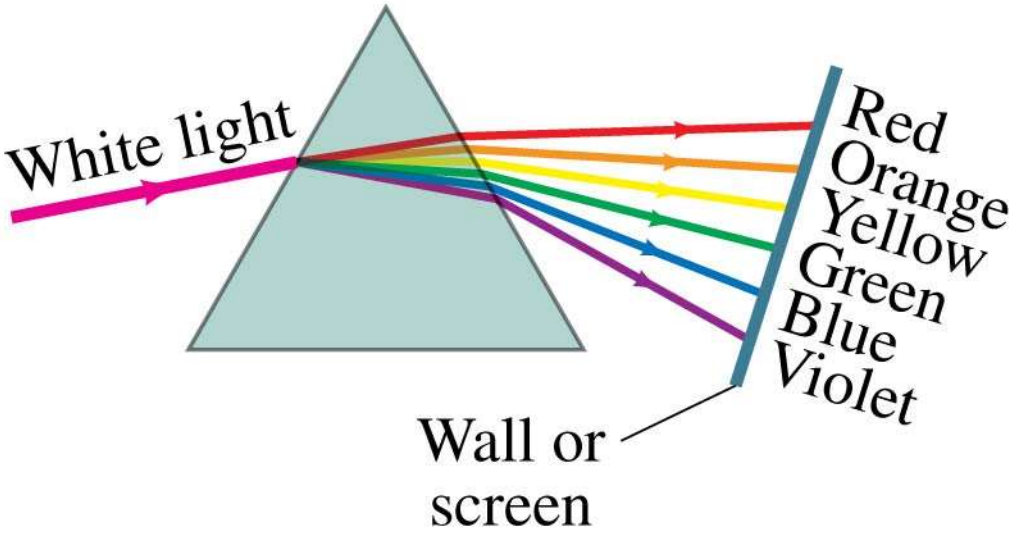
Wavelengths of visible light: 400 nm to 750 nm

Shorter wavelengths are ultraviolet; longer are infrared



The Visible Spectrum and Dispersion

This variation in refractive index is why a prism will split visible light into a rainbow of colors.



The Wave Nature of Light

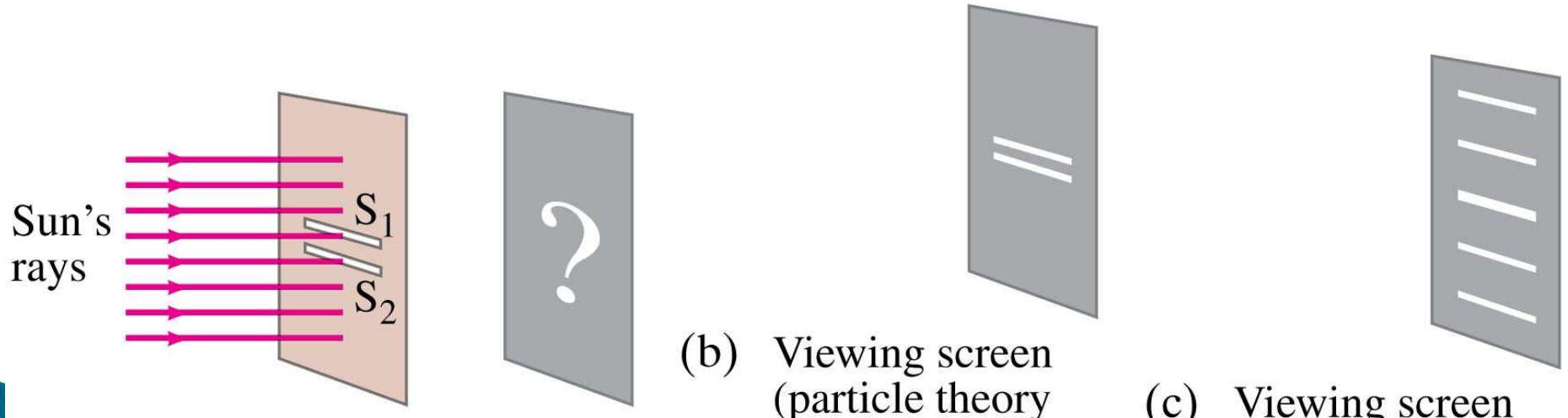
Interference

- *Interference* is the ability of a wave to interfere with itself, creating localized regions where the field is alternately extremely bright and extremely dark.

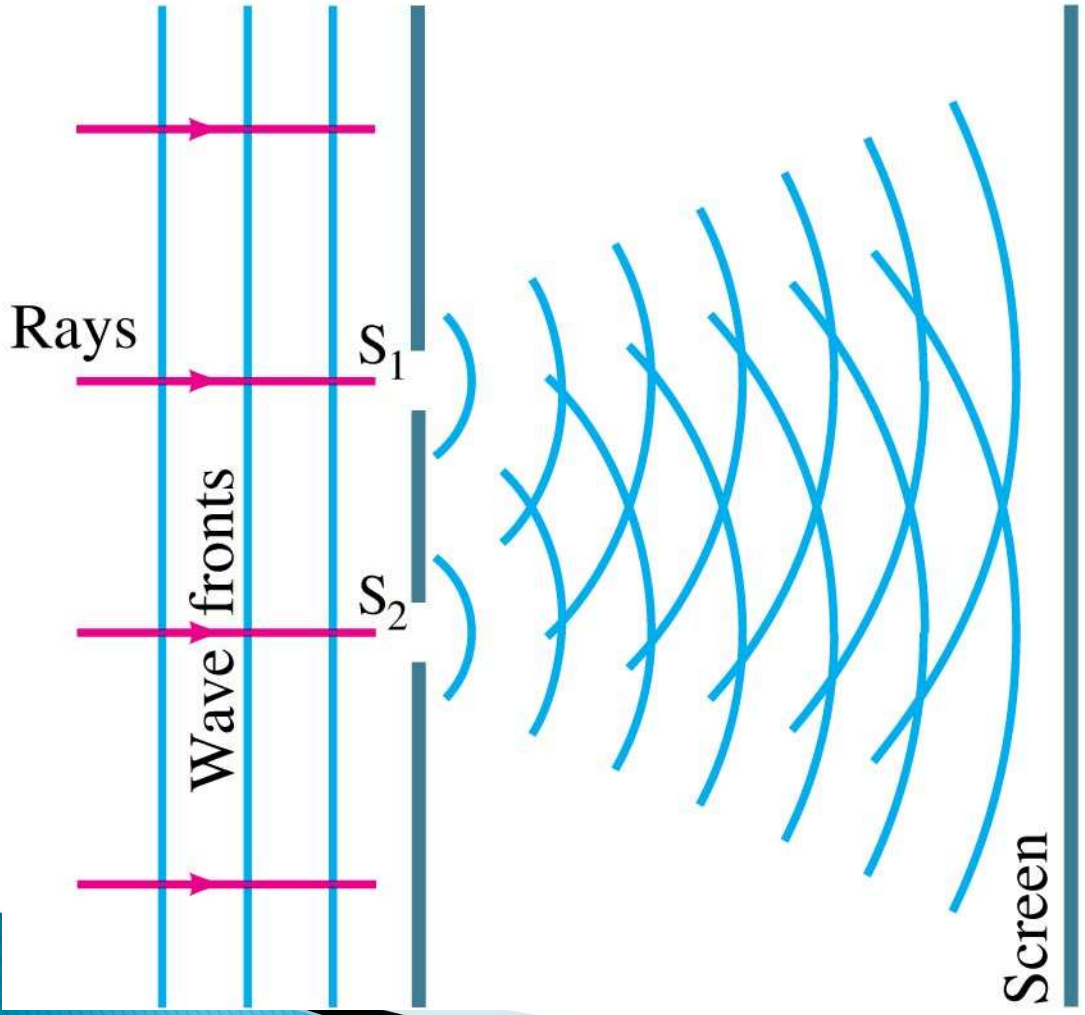
Interference—Young's Double-Slit Experiment

If light is a wave, interference effects will be seen, where one part of wavefront can interact with another part.

One way to study this is to do a double-slit experiment:

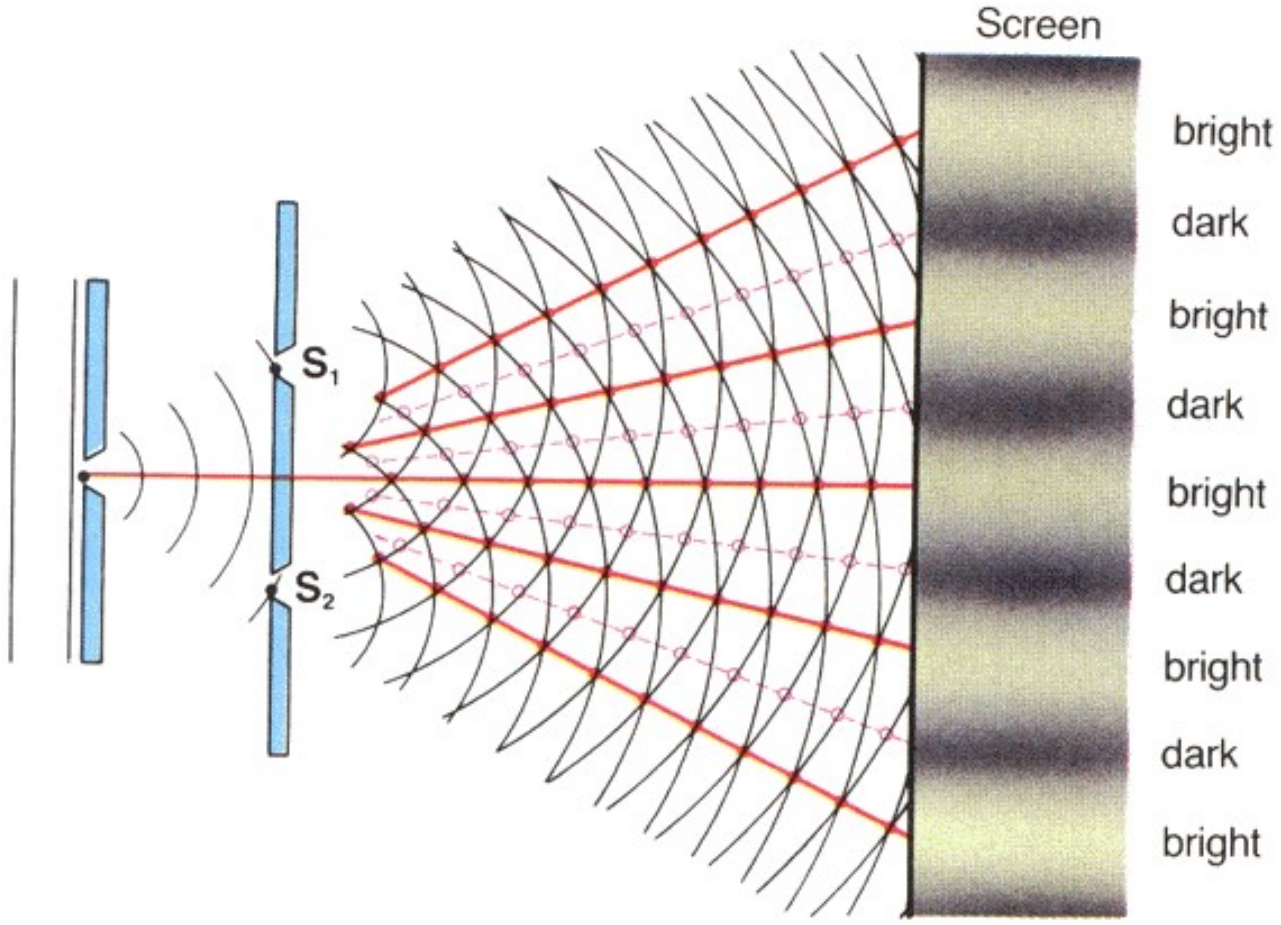


Interference—Young's Double-Slit Experiment



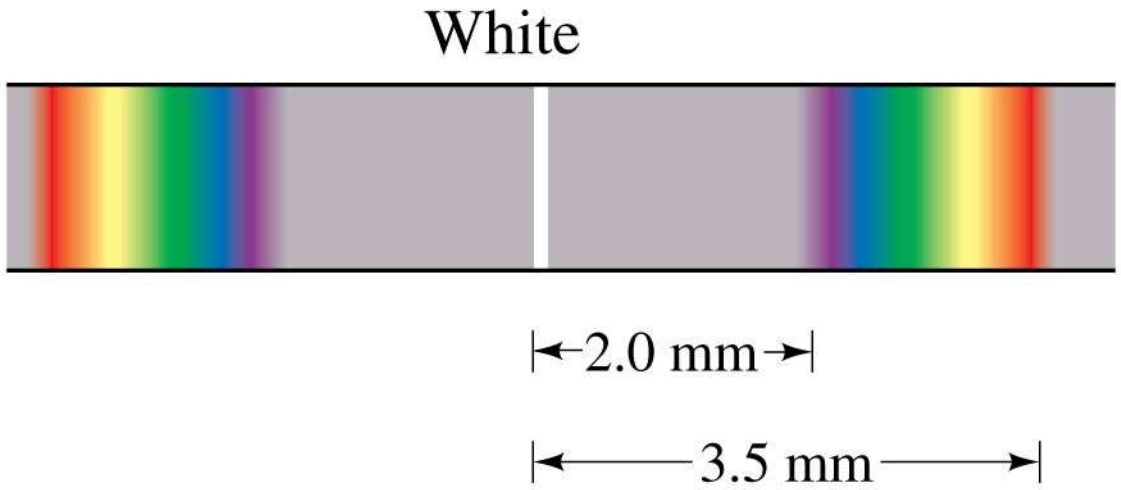
If light is a wave, there should be an interference pattern.

Interference Patterns



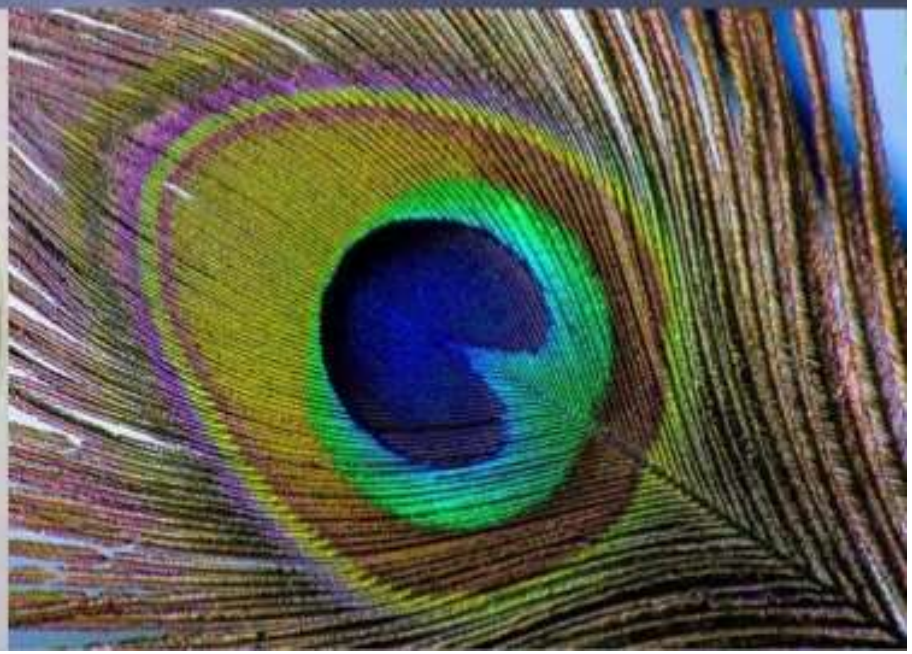
Interference—Young's Double-Slit Experiment

Since the position of the maxima (except the central one) depends on wavelength, the first- and higher-order fringes contain a spectrum of colors.



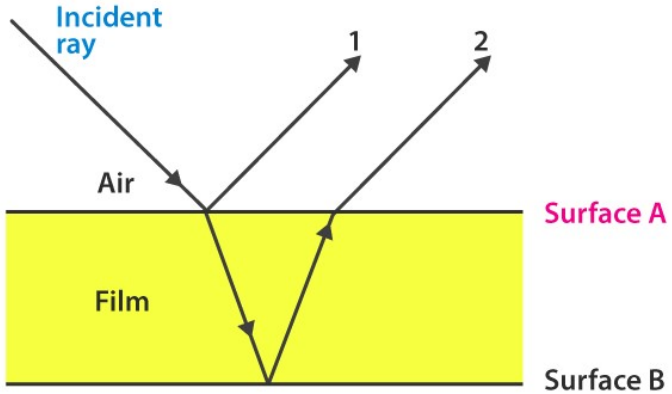
What is it?

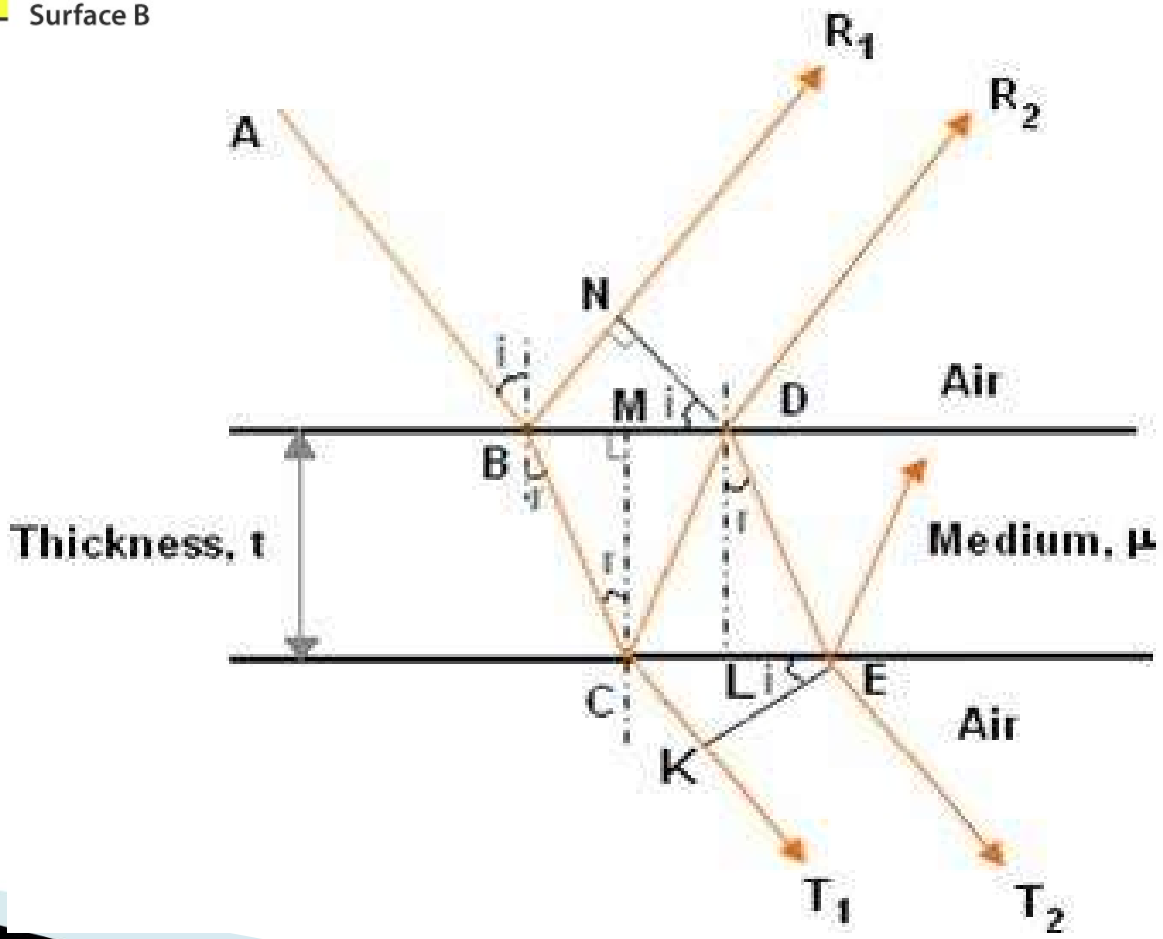
A substance that is normally clear and colorless can appear to give off an array of colors when it is found in a very thin layer

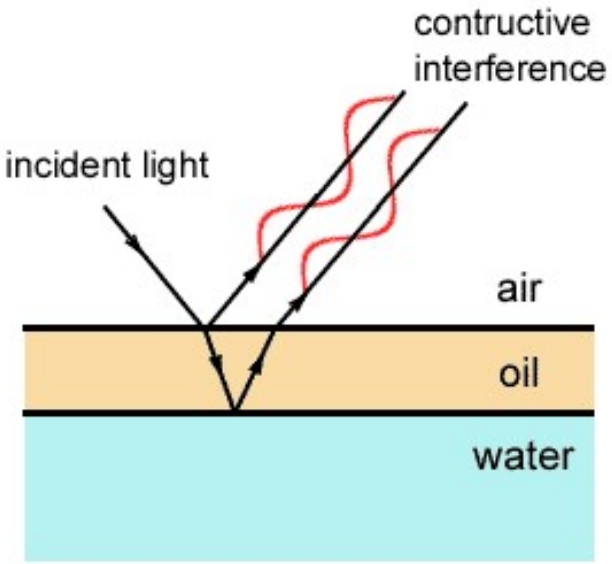


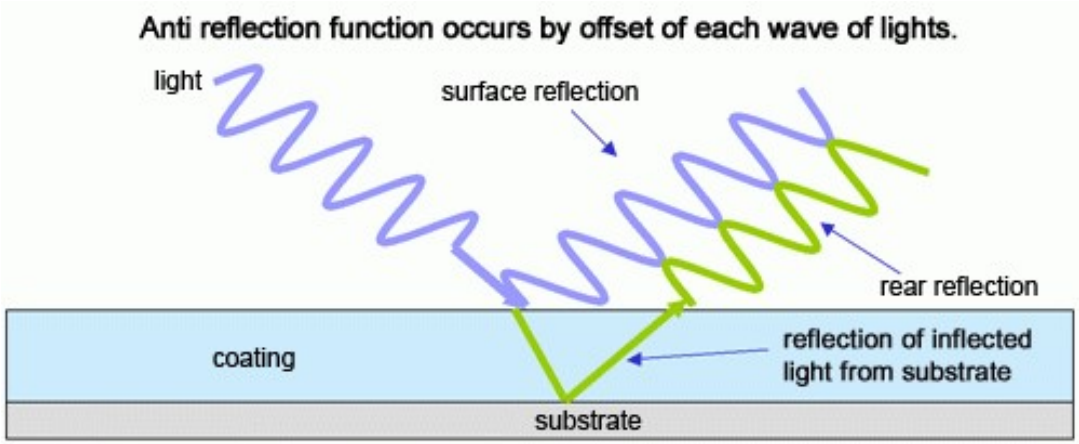
Observation of interference effects in thin films

- Examples of thin films in everyday life: thin layers of oil on water or the thin surface of a soap bubble.
- **Observation**: varied colors are observed when white light is incident on such thin films.
- **Explanation for the observation**: The varied colors result from the interference of waves reflected from the two surfaces of the film.


Incident ray
1
2
Air
Surface A
Film
Surface B

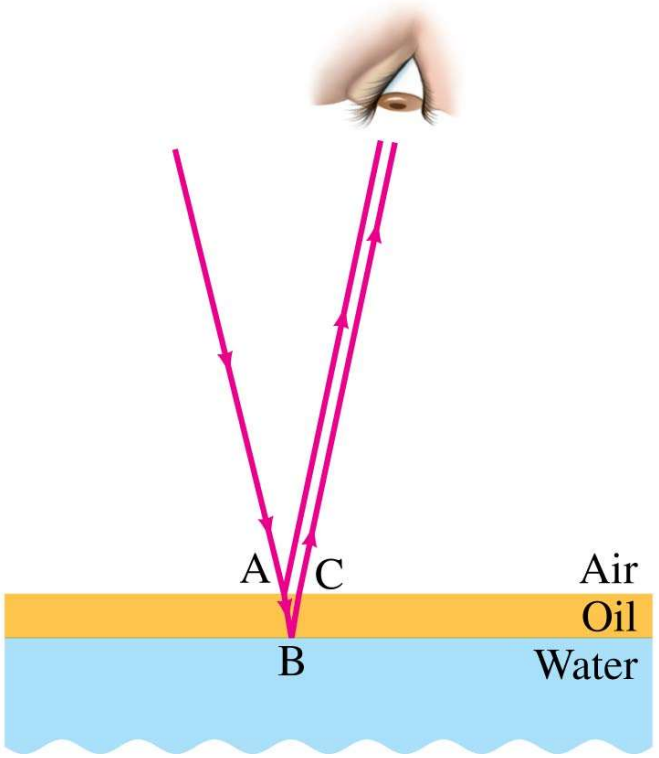

R1
R2
A
N
i
M
D
Air
B
r
Thickness, t
Medium, μ
C
L
E
Air
K
T1
T2


contructive
interference
incident light
air
oil
water


Anti reflection function occurs by offset of each wave of lights.
light
surface reflection
rear reflection
coating
reflection of inflected
light from substrate
substrate

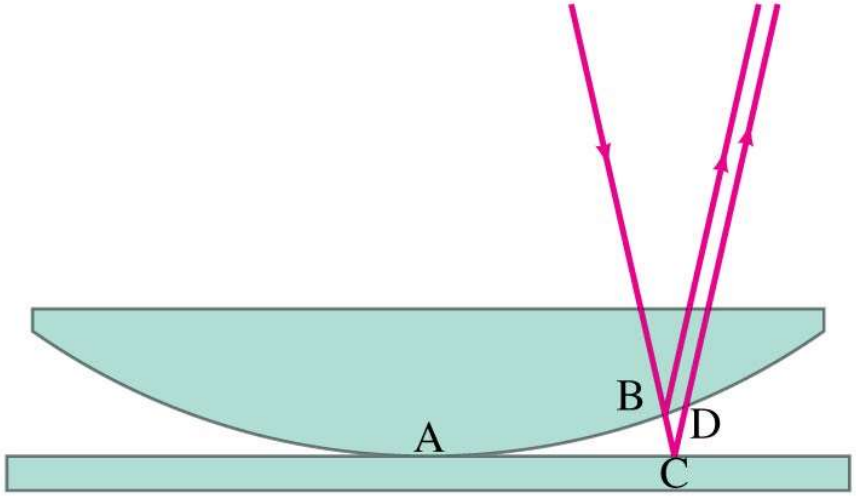
Interference in Thin Films

The wavelength of the light will be different in the oil and the air, and the reflections at points A and B may or may not involve reflection.



Interference in Thin Films

A similar effect takes place when a shallowly curved piece of glass is placed on a flat one. When viewed from above, concentric circles appear that are called Newton's rings.

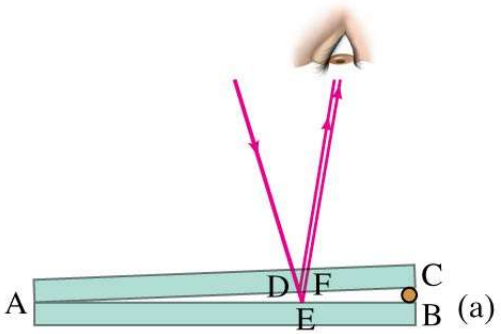


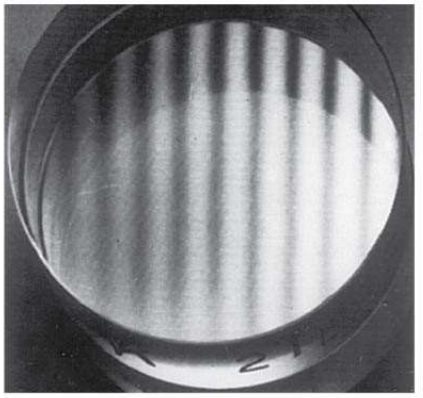
(a)

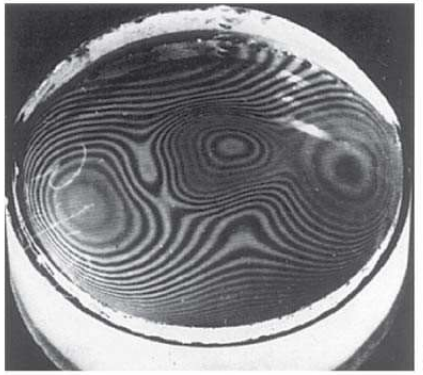
(b)

Interference in Thin Films

One can also create a thin film of air by creating a wedge-shaped gap between two pieces of glass.




(b)

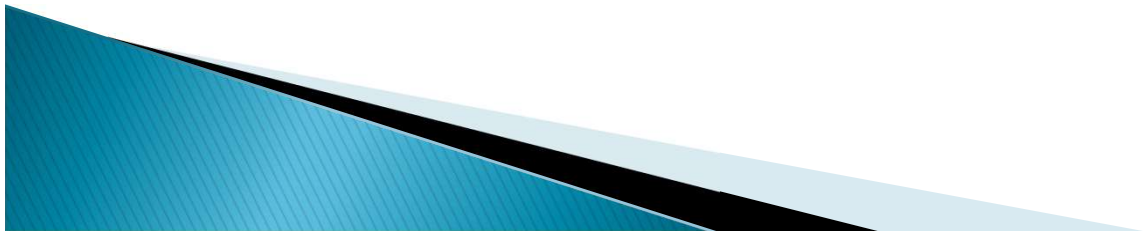

(c)

Interference in Thin Films

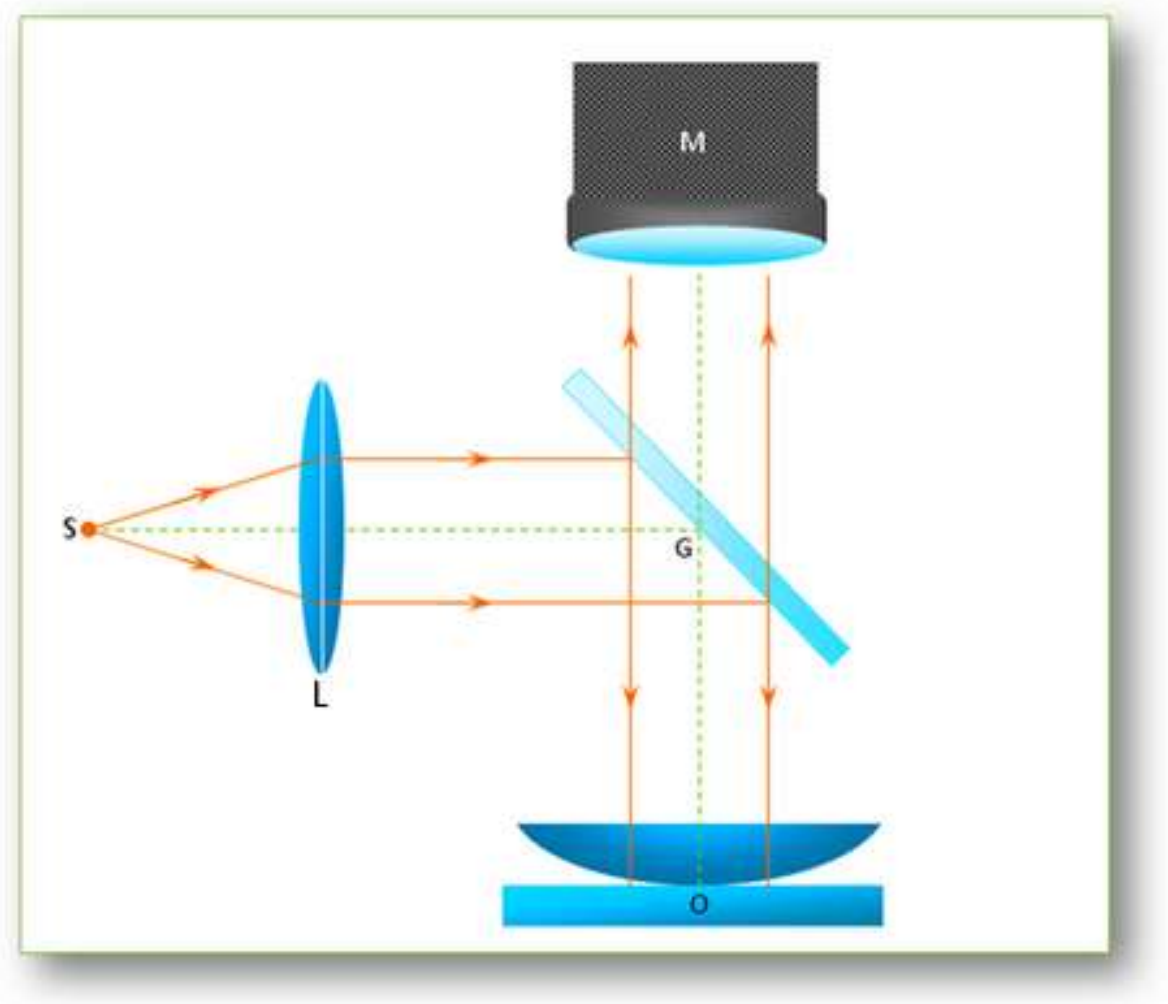
Another way path lengths can differ, and waves interfere, is if the travel through different media.

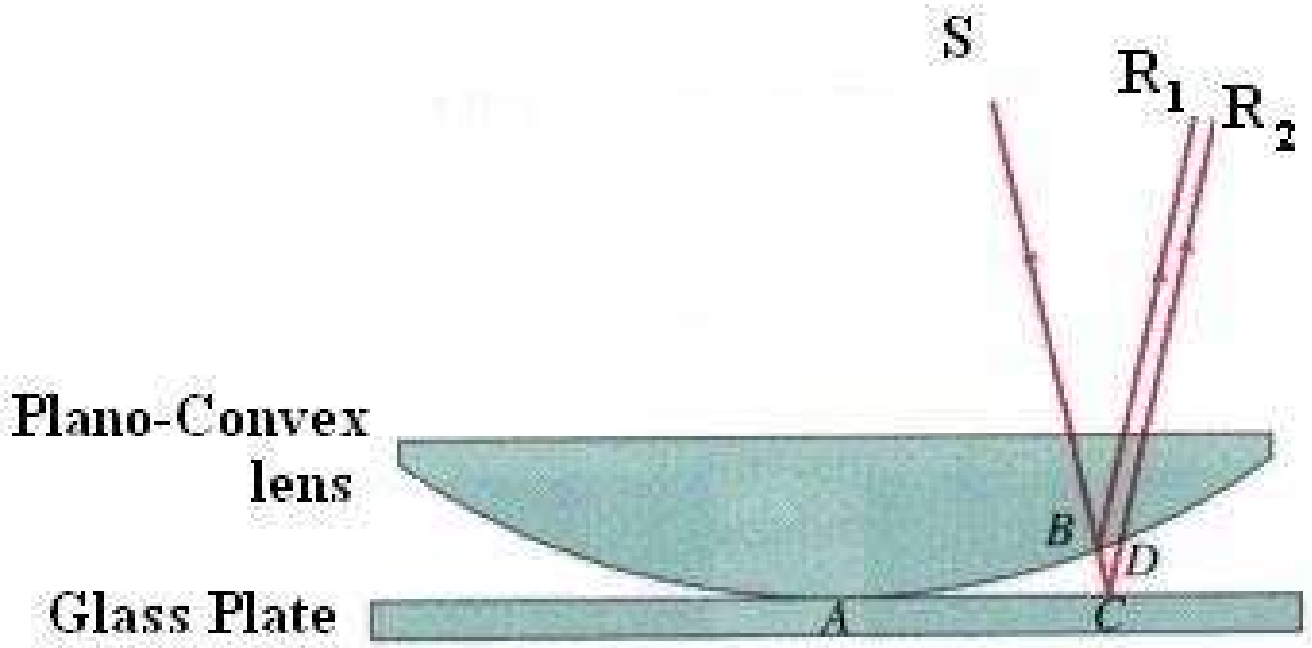
If there is a very thin film of material—a few wavelengths thick—light will reflect from both the bottom and the top of the layer, causing interference.

This can be seen in soap bubbles and oil slicks, for example.



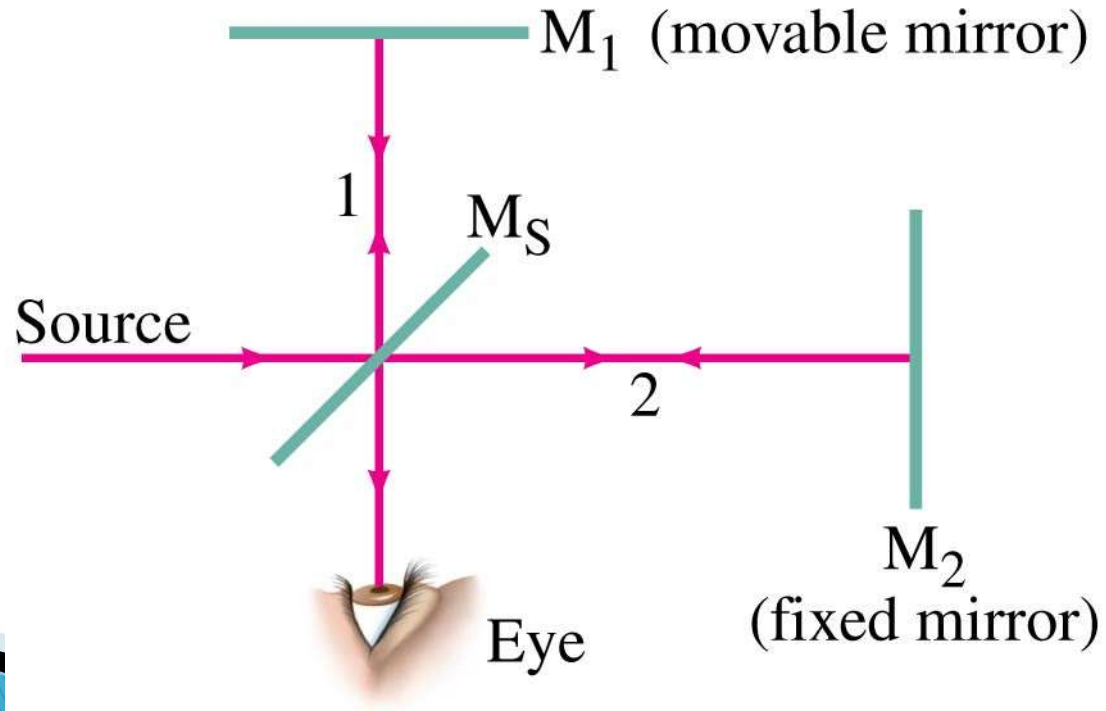
Newton's Rings Experiment




S
R1
R2
Plano-Convex
lens
B
D
Glass Plate
A
C

Michelson Interferometer

The Michelson interferometer is centered around a beam splitter, which transmits about half the light hitting it and reflects the rest. It can be a very sensitive measure of length.



Michelson interferometer :

The Michelson interferometer is a common configuration for optica interferometry and was invented by Albert Abraham Michelson. Using a beam splitter, a light source is split into two arms. Each of those light beams is reflected back toward the beamsplitter which then combines their amplitudes using the superposition principle.