1.1 GENERAL:

The refractive index is an optical parameter for various kinds of liquids, glasses and transparent materials etc., which is responsible for the internal properties of optical materials, like reproducibility and purity of materials. Actually the refractive index plays a great role for identification of the optical materials. It is an important characteristic constant of materials which has the universal appeal in different fields of science and technology. Certain liquid are required in our daily use and it is very important to know the quality of these optical materials. The determination of the refractive index continues to pay the ways to scientists for searching out the physical and chemical properties of materials. Most of the liquids are colorless and hence it becomes too difficult to recognize the particular liquid. But the variation in refractive index with concentration of solution leads to find out the liquid in chemical processing, therefore, its quick and precise measurement is an important aspect of the research.

The term light is commonly used to denote that aspect of radiant energy by which object are made visible, due to stimulation of the retina of the eye. Now days it has become customary to include in this term certain other kind of radiation called ultraviolet and infrared which, although incapable of exciting the sense of sight, nevertheless show other effects similar to those of visible light.

The study of nature and properties of light from a subject itself in physics called optics, which studies the behavior and properties of light, including its interactions with matter and construction of instruments that use or detect it. The optics can be conveniently divided in three distinct branches.

(a) **Geometrical Optics:** In which many facts concerning light can be investigated from the stand point of ray theory that is on the supposition that light travels in straight lines or rays, while no assumption are made in it regarding the nature of light.

(b) **Physical Optics:** It is a more comprehensive model of light, which includes wave effects such as propagation, reflection, refraction, interference, diffraction, interference and polarization.

(c) **Quantum Optics:** In which one studies the interaction of light with atomic entities of matter.

1.2 REFRACTIVE INDEX:

When light rays travel from one medium to another, they usually deviated from their straight line path at the surface separating the two media. This bending is due to the change in the speed of light in passing from one medium to another. This phenomenon of the bending of light rays at the surface separating two media is known as the refraction of light. The ratio of the speed of light in vacuum to that in a medium is known as the refractive index of the medium. The two laws of refraction of light are as follows,

1. The incident ray, the refracted ray and the normal of the refracting surface at the point of incidence, all lies in the same plane.
2. The ratio of the sine of the angle of incidence to the sine of the angle or refraction is a constant, which is equal to the refractive index of second medium with respect to the first.

This law is known as Snell's law. These laws are valid for refraction from plane as well as spherical surfaces.

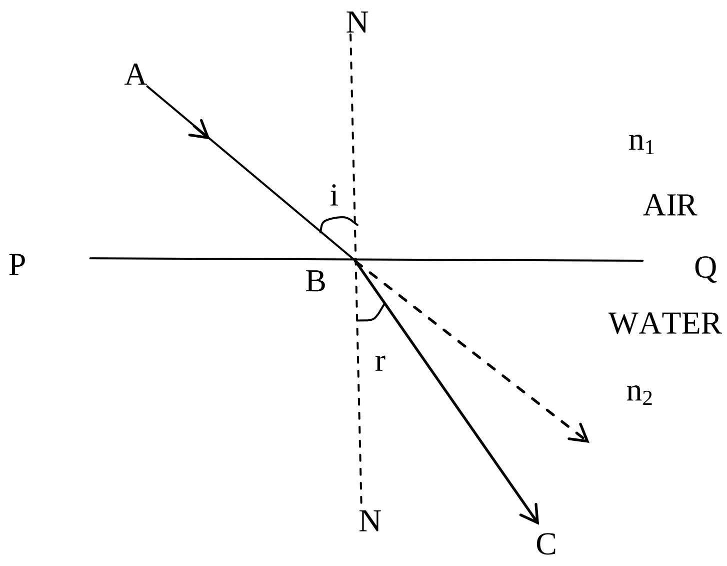

Figure 1.1: Law of Refraction

Suppose a ray of light starting from a point A in the first medium arrives at a point C in the second medium after suffering refraction at the plane surface of separation PQ, In Figure 1.1 if the first medium be a air n_1=1 then the Snell's Law given by

$$n = \frac{\text{Sin i}}{\text{Sin r}} \quad \text{... [1]}$$

Where, n refers to the refractive index of the second medium with respect to air.

It has been experimentally observed that when light passes from a rarer to a denser medium, for example from air to water, the refracted ray bends towards the normal or the angle of refraction 'r' is less then the angle of incidence 'i' and hence, ‘n’ is greater than unity. It has been also proved that the refractive index n is the ratio of velocity of light in two media. When light propagates inside the material, the reduction in speed of light wave is given by the refractive index of the medium (n),

$$n = \frac{\text{Speed of light in vacuum (medium first)}}{\text{Speed of light in medium (medium second)}} \quad \text{... [2]}$$

If instead of vacuum the first medium be air and second medium is water than the relation (2) becomes as,

$$n = \frac{\text{Speed of light in air}}{\text{Speed of light in water}} \quad \text{... [3]}$$

Where, n is the absolute refractive index of water. In general, for more than two media the relation becomes as,

$$n_{1\times2} \times n_{2\times3} \times n_{3\times4} \times n_{4\times1} = 1 \qquad \text{... [4]}$$

According to Maxwell's theory (5) the light wave is characterized by two mutually perpendicular vector's E and H, than the velocity of light in vacuum is given by,

$$C = \frac{E}{H} \approx 3 \times 10^{8} \text{ meter/sec}$$

Where, E = Electric field vector and H = Magnetic field vector, Perpendicular to each other and perpendicular to direction of the propagation of light wave in vacuum. The retardation of light waves inside the medium is defines by refractive index 'n' or optical density of the medium.

$$n = \frac{C}{V}$$

Where, C = Velocity of light in vacuum and V = Velocity of light in medium.

The pair of transparent media, the one which has higher refractive index is called the optically denser or simply denser medium of the two, and the one which has the lower refractive index is called the optically rarer or simply rarer medium. When light travels from a denser to a rarer medium, it bends away from the normal. The angle of incidence in the denser medium, for which the angle of refraction in the rarer medium becomes 90°, is called the critical angle of the media point. When the angle of incidence in the denser medium exceeds the critical angle, the light ray is totally reflected back in same medium and no part of it is refracted in the rarer medium. This phenomenon is known as total internal reflection. The density of air varies at different heights in the atmosphere and hence its refractive index is not uniform throughout. As a result, a ray of light traveling over a considerable distance in the atmosphere has to pass through regions of different refractive indices, and hence, gets refracted continuously. This is known atmospheric refraction.

Many optical phenomena such as mirages, looming, twinkling of stars, etc. are due to atmospheric refraction. When a light ray passes through a transparent glass slab with parallel faces, it is displaced parallel to itself.

1.3 PARAMETERS AFFECTING THE REFRACTIVE INDEX OF MATERIAL:

The optical science is relevant to and studied in several disciplines including astronomical interferometry, various field of Science, Engineering and Technology, Photography and Medicine, Ophthalmology, Optometry and Practical applications of optics like mirrors, lenses, telescopes, microscopes, laser, fiber optics and every day objects optical memory etc.

For many purposes, light can be treated as an electromagnetic wave which does not require any medium for its propagation. The speed of light in vacuum is 3×10^8 m/s. This is the maximum speed of light that can be achieved by any material particle. The relation between velocity (ν), frequency (m) and wavelength (λ) is given by

$$\nu = m \times \lambda$$

These refractive indices of liquids, glass, and transparent material have been measured by using various techniques. In general, the measured refractive index of an optical material is a function of its temperature T, Concentration C, and Wavelength of light λ, then.

$$n = n\,(T, C, \lambda) \qquad \ldots [5]$$

The change in refractive index is Δn of material or multi - component mixture then equation (5) becomes as (By using Taylor's series for several variables)

$$\Delta n \approx (\delta n/\delta T)\,\Delta T + (\delta n/\delta c)\,\Delta C + (\delta n/\delta\lambda)\,\Delta\lambda \qquad \ldots [6]$$

For laser light source the change in λ is minimum or $\lambda\Delta \approx 0$ Thus, the change in refractive index due to medium temperature and concentration can be expressed as follows-

$$\Delta n \approx (\delta n / \delta T)\,\Delta T + (\delta n / \delta c)\,\Delta C \qquad \ldots [7]$$

For the measurement of Δn, Snell's Law employed the relation between incident beam angle and exit beam angle, with respect to medium a and be having refractive index n_1 and n_2 is takes the form

$$n_1 \sin \theta_1 = n_2 \sin \theta_2 \qquad \dots [8]$$

1.4 REFRACTOMETER:

A refractometer is a laboratory or field device for the measurement of refractive index of a medium. There are four main types of refractometers. The existing refractometers make the estimation by measuring the optical path length variation for light beam due to presence of medium in their path. The Rayleigh Refractometer is used for measuring the refractive index of gases. In the field of veterinary medicine, a refractometer is used to measure plasma protein in a blood sample and urine specific gravity.

1.4.1 TRADITIONAL HANDHELD REFRACTOMETER

These types of refractometer's are generally used for measuring the refractive index of liquid's. The traditional handheld refractometer works on the critical angle principle by which lenses and prisms project a shadow line into a small glass reticule inside the instrument, which is viewed by magnifying eyepiece.

Figure 1.2: Handheld Refractometer

1.4.2 DIGITAL HANDHELD REFRACTOMETER

A digital handheld refractometer is an instrument for measuring the refractive index of materials. Most operate on the same general critical angle principle as a traditional refractometer.

Figure 1.3: A Modern Digital Handheld Refractometer

1.4.3 ABBE REFRACTOMETER

Ernst Abbe (1840-1905) was the first to develop a laboratory refractometer called the Abbe Refractometer. An Abbe refractometer is a bench-top refractometer for the high-precision measurement of refractive index. These first instruments had built in thermometers and required circulating water to control instrument and fluid temperatures.

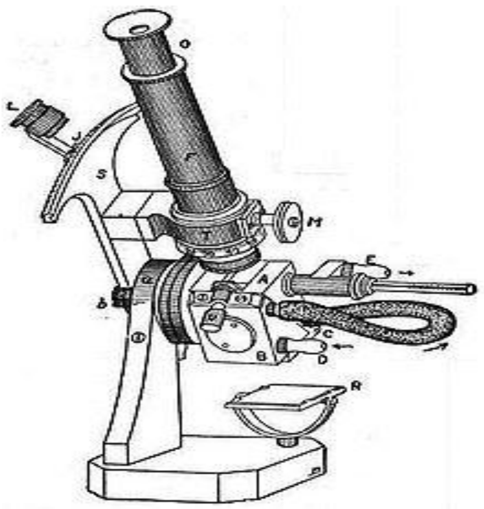

Figure 1.4: Abbe Refractometer with temperature controlled prism

1.4.4 INLINE PROCESS REFRACTOMETER

These types of refractometer are generally designed for the continuous measurement of a fluid flowing through a pipe or inside a tank. The inline process refractometers typically consist by sensors, placed inline with the fluid flow, and coupled to the control box. The control box usually provides a digital readout 4 to 20 mH analog output. This type of measurement has been an important element in the process control of refining and chemical, pulp and paper, food, sugar and pharmaceutical industries.

1.5 INTERFEROMETRY:

The development of optical interferometry extends over more than three hundred years and is closely linked with the history of wave optics. The interferometry is a technique diagnosing the properties of two or more waves by studying the pattern of interference created by their superposition. The instrument is called the interferometer that used to interfere the waves together. Interferometry is an important investigation technique in the field of fiber optics, optical metrology, astronomy, engineering, metrology, seismology, oceanography, quantum mechanics, nuclear and particle physics, plasma physics and remote sensing.

1.5.1 APPLICATIONS OF OPTICAL INTERFEROMETRY

Optical interferometry is used in a vast range of applications, including metrology, microfluidics, velocimetry, mechanical stress or strain measurement and surface profiling. Some applications of optical interferometry are listed below.

- Holographic Interferometry
- Electronic speckle pattern Interferometry

- Low - Coherence Interferometry
- Angle - Resolved Low -Coherence Interfereometry
- Optical Coherence Tomography
- Astronomical Optical Interferometry
- Interferometry with Laser
- Multiple Beam Interference (plane parallel plate)
- Two or Three Beam Interference
- Stellar Interferometry
- Interference Spectroscopy

1.5.2 TYPES OF INTERFEROMETERS

1. Field and Linear Interferometers

- Astronomical Interfereometer/Michelson Stellar Interferometer
- Classical Interference Microscopy
- Cyclic Interferometer
- Diffraction Grating Interferometer (white light)
- Double-slit Interferometer
- Dual Polarisation Interferometry
- Fabry-Perot Interferometer
- Fizeau Interferometer

- Fourier-Transform Interferometer
- Fresnel Interferometer (e.g. Fresnel biprism, Fresnel mirror or Lloyd's mirror)
- Fringes of Equal Chromatic Order interferometer (FECO)
- Gabor Hologram
- Gires-Tournois Etalon
- Heterodyne Interferometer
- Holographic Interferometer
- Jamin Interferometer
- Linnik Interferometer
- Lummer -Gehrcke Interferometer
- Mach-Zehnder Interferometer
- Michelson Interferometer
- Mirau Interferometer also known as a Mirau Objective
- Moire Interferometer
- Multi-Beam Interferometer
- Near-Field Interferometer
- Newton interferometer
- Nonlinear Michelson Interferometer/Step-Phase Michelson Interferometer

- N-Slit Interferometer
- Phase-Shifting Interferometer
- Planar Light wave Circuit (PLC) Interferometer
- Photon Doppler Velocimeter (PDV) Interferometer
- Polarization Interferometer
- Point Diffraction Interferometer
- Rayleigh Interferometer
- Sagnac Interferometer
- Schlieren Interferometer (Phase-shifting)
- Shearing Interferometer (Lateral and Radial)
- Twyman-Green Interferometer
- Talbot Lau Interferometer
- Watson Interferometer (Microscopy)
- White-light Interferometer
- White-light Scatterplate Interferometer (White-light microscopy)
- Wedge Interferometer
- Young's Double-slit Interferometer
- Zernike Three Beam Interferometer

2. Intensity and Nonlinear Interferometers

- Intensity Interferometer
- Intensity Optical Correlator
- Frequency-resolved Optical Gating (FROG)
- Spectral Phase Interferometry for Direct Electric-field Reconstruction (SPIDER)

3. Quantum Optics Interferometers

- Hong-Ou-Mandel Interferometer (HOM)
- Franson Interferometer
- Hanbury-Brown Twiss Interferometer

4. Interferometers outside the Optics

- Atom Interferometer
- Ramsey Interferometer
- Mini Grail Interferometer
- Aharonov-Bohm Effect
- Interferometric Synthetic Aperture Radar (Radar-based 3-d surface mapping)

1.6 LIQUID IMMERSION TECHNIQUES:

The liquid immersion technique is generally used to determine the refractive index of lens materials. For this purpose glass cell filled with liquid and lens is immersed in a liquid. Actual lens arrangement used for experimental investigation and ray-tracing scheme for single curved surface are shown in figure 1.5 and 1.6 respectively.

The liquid immersion technique was modified by G. Smith (6) in the year 1982 and has been used as the collimation method for measuring the refractive index of lens. Keeping in view all such effects, the author have put forward a simple and easy interferometric approach for measuring the index of lens, liquid and air etc.

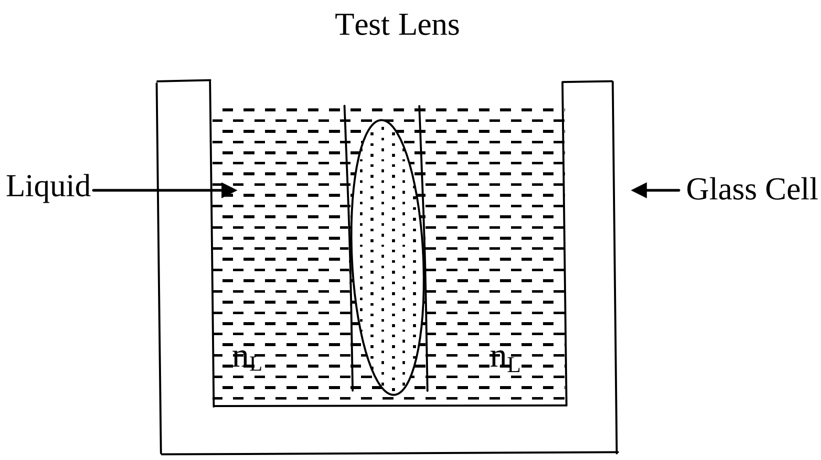

Figure 1.5: Actual lens arrangement used for experimental investigation

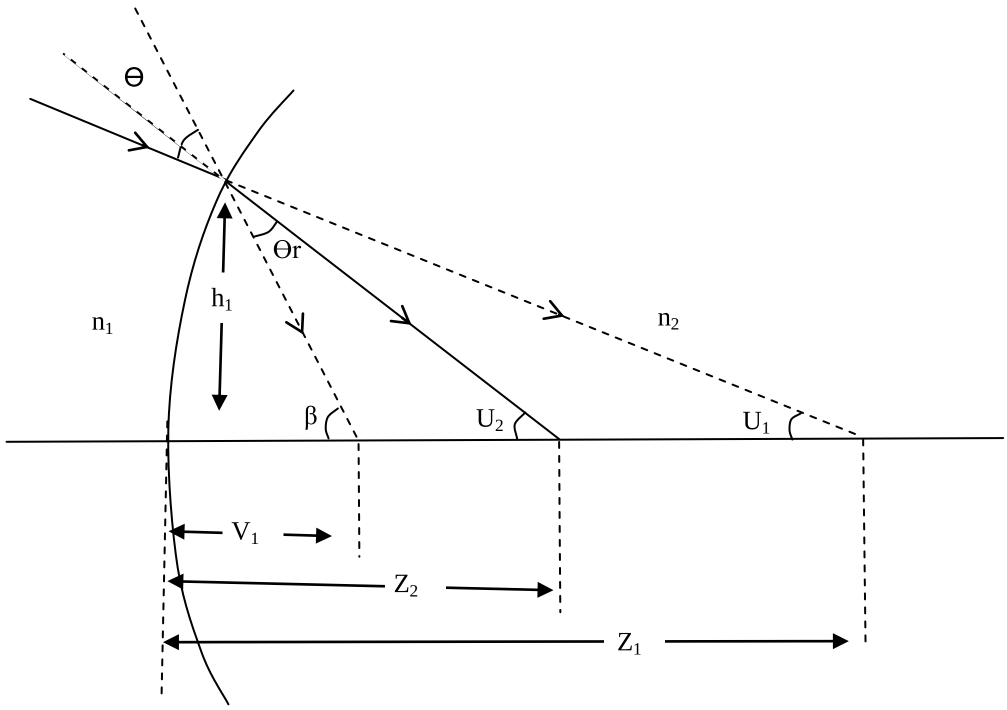

Figure 1.6 Ray-Tracing Scheme for a single curved surface

The power of lens can be denoted as

$$\frac{1}{f} = (n - n_L)(1/r_1 - 1/r_2) + (n - n_L)^2 .t / r_1 r_2 n \qquad \dots [9]$$

In case of thin lenses and Plano convex lens the equation [9] becomes as

$$\frac{1}{f} = (n - n_L)(1/r_1 - 1/r_2) \qquad \dots [10]$$

For Plano convex lens

$$\frac{1}{f} = (n - n_L) 1/r \qquad \dots [11]$$

Where,

f = Focal length of lens

n= Refractive index of lens immersed in liquid

n_L= Refractive index of liquid filled in glass cell

r_1 and r_2 = Radius of curvature of front and back side of the lens.

t = Thickness of the lens

Ray tracing is a method for calculating the path of waves or particles through a system. About the use of ray tracing in optics (7-8) under these circumstances, wave fronts may bend, change direction or reflect of surfaces, complicating analysis.

1.7 LUMMER-GEHRCKE INTERFEROMETER:

A high resolution interferometer commonly known as the Lummer-Gehrcke plate is an extremely ingenious optical device to produce sharp narrow high order bright fringes on wide practically dark back ground by the multiple wave interference. Lummer in 1901 and subsequently developed by him in collaboration with E. Gehrcke in 1903, this interferometer is merely a long plate of very perfect optical glass or quarts with parallel optically flat surfaces, from 10 to 20 cm. long, 1 to 2 cm. wide and few millimeters thick. A small right angled prim of suitable angle is cemented at one end of the plat. This auxiliary prism, as shown in figure 1.7, directs the incoming beam of parallel light into the interferometer so that the angle of incidence at the inner surface of the plate is slightly less than the critical angle of total reflection. Light therefore, undergoes multiple internal reflections at angles near to the critical angle. The reflectivity of glass to air surface is close to unity near to total reflectivity. At each reflection, therefore, a small fraction of the incident light emerges into the air, nearly grazing the plate surface by a process which combines diffraction with refraction. Thus a series of beam of slowly diminishing intensity and with successive optical path retardation leaves each side of the plate. A telescope objective causes these beams to converge to the focal plane below and above the axis of the plate where they mutually interfere and form interference patterns.

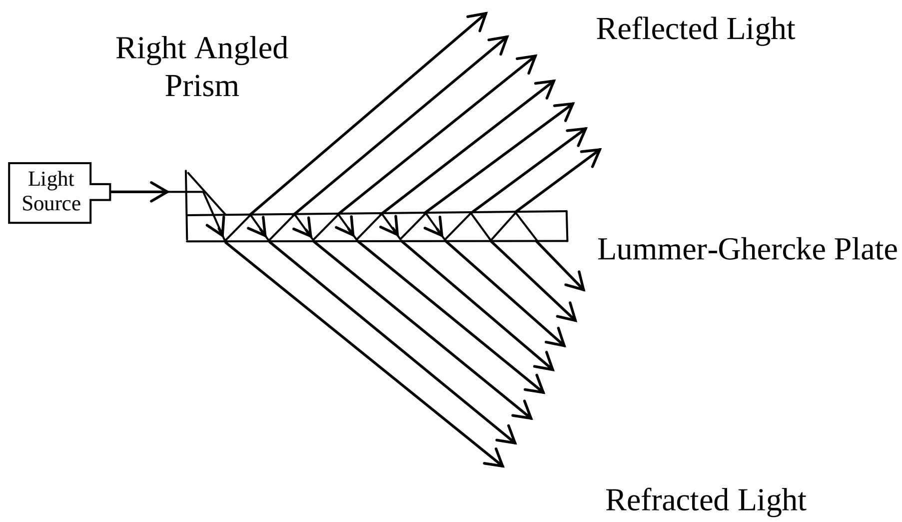

Figure 1.7: Lummer-Ghercke Plate Interferometer

Lummer plate is always, employed with a monochromator, If e is the thickness of the plate and μ its refractive index for a wavelength of λ, the optical path difference between successive emergent beams is 2μe Cos θ. Therefore, the fundamental condition for their reinforcement is given by.

$$2\mu e \cos\theta = n\lambda \quad \dots [12]$$

Where, n is an integer called order of interference or the order of fringe. Since sin i = μ sin θ, then equation [12] can be rewrite in the form of

$$2e\sqrt{(\mu^2 - \sin^2 i)} = n\lambda$$

$$4e^2 (\mu^2 - \sin^2 i) = n^2\lambda^2 \quad \dots [13]$$

Equation [13] is called the fundamental equation of the Lummer plate.

1.8 THREE BEAM FRINGES INTERFEROMETER:

With two beam interference, it is difficult to measure the position of a fringe by visual estimation to better than 1/20 of the inter-fringe distance. However visual intensity matching of two uniform interference fields, one of which contain a small phase step, makes it possible to detect a change in the optical path of λ/1000 given by Kennedy and Hariharan (1-2). Zernike (3) therefore proposed the following simple technique, which permits a photometric setting on a system of interference fringes.

As shown schematically in figure 1.8 the two plane waves of equal amplitude a_0 are used as reference waterfronts: These makes angle $\pm\theta$ with the plane of observation and intersect at a point 0 in this plane. The complex amplitude due to these waterfronts at a point P in the plane of observation at a distance x from 0 are then,

$$a_1 = a_0 \exp(-ik\,\theta_x) \qquad \dots [14]$$

and $$a_2 = a_0 \exp(ik\,\theta_x) \qquad \dots [15]$$

And they produce an interference pattern consisting of equal-spaced, parallel, straight fringes.

A third wave front which is parallel to the plane of observation is now superposed on the first two. We assume that this wave has amplitude $2a_0$, and that its optical path differs by an amount Δz from that to the point 0. The resultant complex amplitude at P can then be written as.

$$A = a_0 \exp(-ik\,\theta_x) + a_0 \exp(ik\theta_x) + 2a_0 \exp(-ik\Delta z) \qquad \dots [16]$$

And the resultant intensity is

$$I = I_0\,[3+2\cos 2\psi + 4\cos\phi\cos\psi] \qquad \dots [17]$$

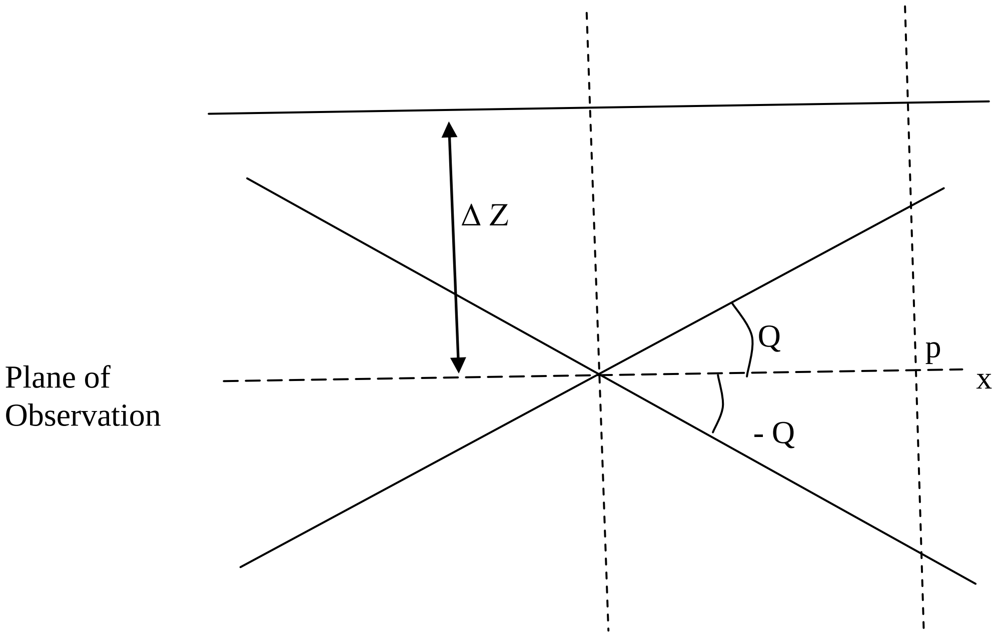

Figure 1.8: Formation of three beam fringes

Where,

$I_0 = a_0^2$

$\psi = k\theta x$

$\phi = k\Delta z.$

Curves of the intensity distribution in fingers when $\phi = 2m\pi$, $2m\pi + \pi/2$ and $(2m+1)\pi$ are presented in figure 1.9 these show that the introduction of third wave-front results in a modulation of the intensity of the fringes. While the minima always of the fringes. While the minima always have zero intensity, the intensities of adjacent maxima are, in general, unequal except when ϕ are an odd multiple of $\pi/2$.

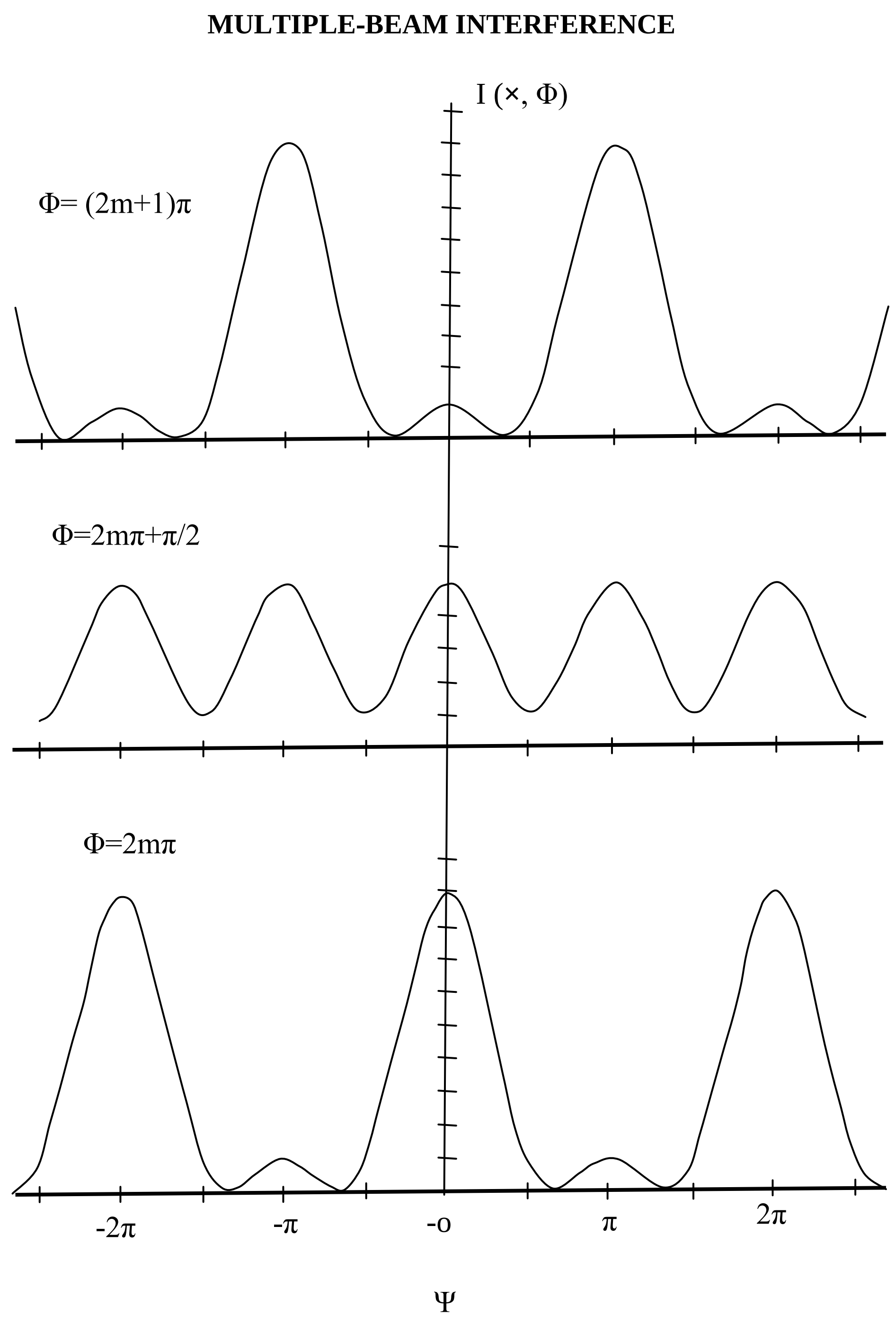

Figure 1.9: Intensity distribution in three beam fringes for different value of ϕ, the phase difference between the third beam and the other two beams.

We can therefore devise a photometric setting criterion which involves adjusting the phase of the third wave-front by means of compensator until the fringes all have the same intensity. To evaluate the precision with which this setting can be made, consider the situation when

$$\phi = (2m+1)\ \pi/2 + \Delta\phi$$

Where,

$$\Delta\phi << \pi/2.$$

The intensities at adjacent maxima are then given by the relation.

$$I_m = I_0\ (5 - 4\Delta\phi) \qquad \text{... [18]}$$

and $$I_{m+1} = I_0\ (5 + 4\Delta\phi) \qquad \text{... [19]}$$

Accordingly, the relative difference in their intensities is

$$\Delta I/I = (8/5)\ \Delta\phi \qquad \text{... [20]}$$

If we assume that a difference of 5% in the intensities of adjacent fringes can just be seen, the setting error is

$$\Delta\phi \approx 2\pi/200 \qquad \text{... [21]}$$

And measurements of the optical path can be made with a precision

$$\Delta p \approx 2\ \lambda/200 \qquad \text{... [22]}$$

In the optical arrangement used by Zernike (1950), which is shown in figure 1.10, the three waves are produced by division of a plane wave-front at a screen containing three equidistant parallel slit. The two outer slits, whose centre lines are separated by a distance 2d, serve to provide the reference beam, while the beam from the middle slit, which is twice as broad, is used for measurements. In this arrangement, the optical paths of the entire three beams are equal at a point on the axis in the back focal plane of the lens L_2. However, at a plane located at a distance *z* from L_2, the optical path of the middle beam will be longer by an amount.

$$\Delta p = (d^2/2)\ [(1/f)-(1/z)] \qquad \text{... [23]}$$

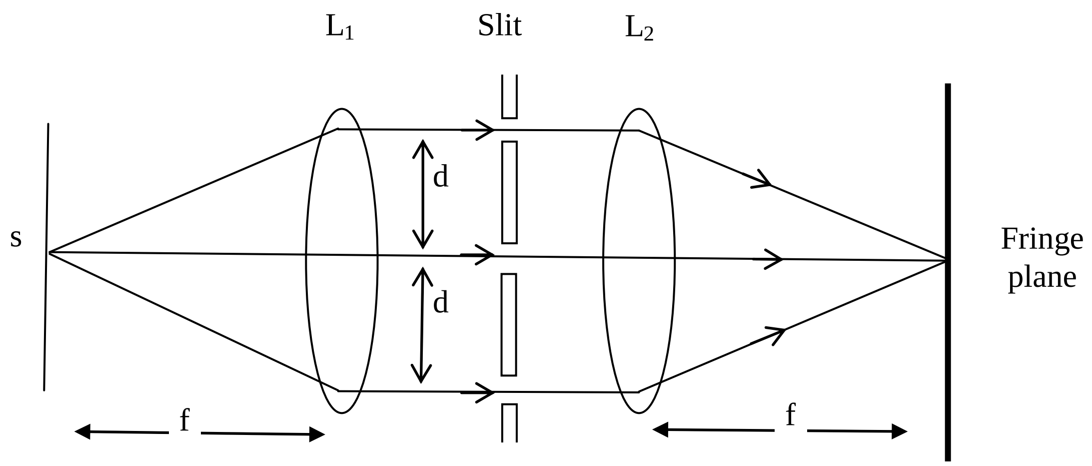

Figure 1.10: Zernike's Three Beam Interferometer

This type of interferometer is easy to setup and very stable. It has been used to calibrate phase - retardation plates as well as to measure very small changes in the optical thickness of a specimen. However because the beams are obtained by wave-front division, the amplitudes of the individual beams are not uniform over the field. As a result, the photometric setting has to be made using only the fringes on either side of the central fringe. The problems are eliminated if the three beams are produced by amplitude division using an optical system similar to that in Jamin Interferometer (4) by Hariharan and Sen.

1.9 OPTICAL SOURCE:

The optical source form's an important part of the optical communication system. It converts electrical energy (current) into optical energy (light). Broadly, there are three types of sources available to us. These are

(i) Incandescent lamps with wide band continuous spectral light output.

(ii) Monochromatic but incoherent light sources such as light emitting diodes LED's.

(iii) Monochromatic and coherent light source such as Lasers.

The LED's and Laser's are widely used as optical sources for communication systems.

LASER is a short form of Light amplification by stimulated emission of radiation. The Laser is a mechanism for emitting the electromagnetic radiation via the process of stimulated emission of radiation. In 1917 Einstein predicted two types of emissions, namely the stimulated and spontaneous emission and explained these on the basis of quantum theory. Townes 1954 used first time the phenomena of stimulated emission for the construction of MASER. Schawlow and Townes further extended the MASER principle to the optical region 1958, resulting in light amplified device commonly known as Laser. The different properties of laser are following:

- Coherent light source
- Monochromatic
- Very intense
- Travel as a highly concentrated and parallel beam.

There are many other applications of laser namely, industrial uses, Surgical uses application in radio communication, Laser cooling, Astronomical application, Non-liner optics.

Types of Laser and operating principles:

- **Gas Laser -** Gas lasers using many gases have been built and used for many purpose. The helium - neon laser wavelength 633 nm are very common in education because of its low cast. The other gas lasers are Carbon dioxide laser, Argon-Ion Laser etc.
- **Chemical Laser-** Hydrogen fluoride laser (2700-2900 nm), Deuterium fluoride laser (3800 nm) etc.

- **Excimer Lasers -** Commonly used excimer molecules include F_2 (fluorine, emitting at 1.57 nm) and noble gas compounds ArF (193 nm), KrCl (222nm), XeCl (308 nm), and XeF (351 nm).
- **Solid State Laser's** - Ruby laser made from ruby chromium - doped corundum.
- **Fiber - Hosted Laser**
- **Photonic Crystal Lasers -** are based on nanostructures.
- **Semiconductor Laser -** Semiconductor laser are also solid-state laser but have a different mode of laser operation for example - Commercial laser diodes (375 nm to 1800 nm) and Low power laser diodes are used in laser printers and CD/DVD players.
- **Dye Lasers -** Use an organic dye as a gain medium.
- **Free Electron Lasers -** FEL,s generate coherent, high power radiation, that is widely tunable. They have the widest frequency range of any laser type.

1.10 OPTICAL FIBER:

In the present day communication technology, the optical communication system involving optical fibers as guiding medium have become very popular. The major advantage is that the light signals can be modulated too much higher frequencies as compared to either radio or microwaves thereby making available very wide frequency bandwidths for the use in different applications. An optical communication system has major components such as light source Laser or LED, photo-detector and optical fiber wave-guides for signal transmission.

The light signal can be transported over large distances using optical fiber with remarkably distances using optical fiber with remarkably little alteration. The propagation of light signal based on the phenomenon of total internal reflection.

1.10.1 FIBER GEOMETRY

The optical fiber consists of a dielectric material of refractive index n_1, sandwiched between dielectric material of refractive index n_2, where $n_1 > n_2$. The central part (refractive index n_1) is called the core and outer part (refractive index n_2) is called as cladding figure 1.11. The core region is typically made of silica glass, and typically has a diameter between 5µm to 100 µm. A small core (diameter < 10 µm) fiber (called a single mode fiber) propagates light in a somewhat different fashion than a large core (diameter ~20 to 50 µ) fiber (called a multimode fiber). A silica glass cladding having a slightly lower optical density (lower refractive index), typically between a fraction of 1% and few percent lower surrounds the core of the fiber. The diameter of cladding is typically 125 µm. The cladding of fiber is surrounded by a protective jacket. The jacket consists of one or more layers of plastic material.

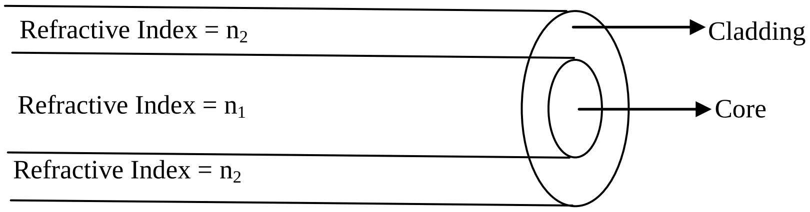

Figure 1.11 Typical Optical Fiber Geometry

1.10.2 TOTAL INTERNAL REFLECTION

The propagation of light through an optical fiber can be explained on the basis of ray theory utilizing the concept of refractive index of the optical medium. The refractive index is related to the electric and magnetic propagation of the material through the equation.

$$v = \frac{1}{\sqrt{k}}\frac{1}{\sqrt{\varepsilon_0\mu_0}} = \frac{c}{\sqrt{k}} = \frac{c}{v} \cong \sqrt{k} = n$$

Where, ε_0 and μ_0 defines the electric permittivity and magnetic permeability of the vacuum. K is known as the dielectric constant for the medium.

The reflection of light at the interface follows the Snell's Law figure 1.12 that is

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}$$

Where, θ_1 and θ_2 are the incidence and refraction angles in the two media having refractive indices n_1 and n_2, respectively.

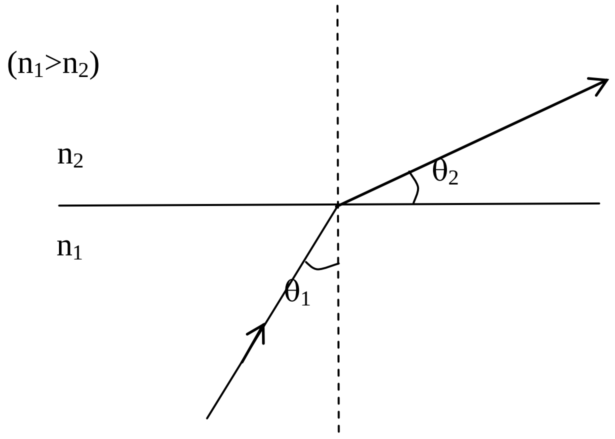

Figure 1.12: Refraction of light at an interface of two media

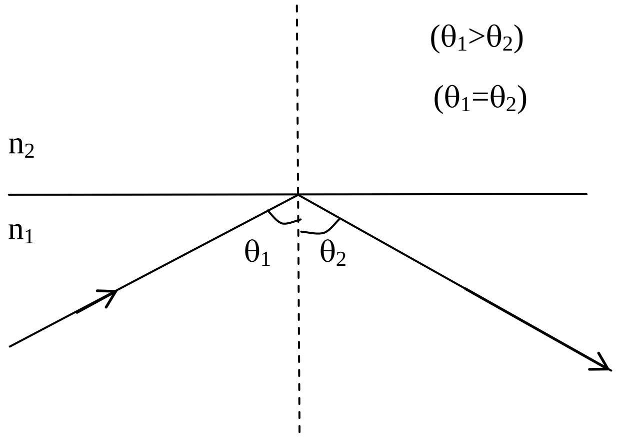

Figure 1.13: Total internal reflection of light

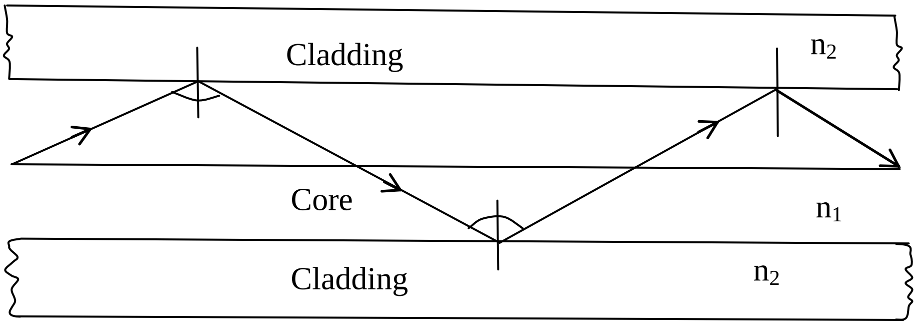

Figure 1.14: Transmission of an optical ray through an optical fiber

Assuming that $n_1>n_2$, the angle of refraction θ_2 is always greater than θ_1. Thus, when the angle of refraction is 90^0, the refracted (transmitted) ray emerges out parallel to the interface between the dielectrics and the θ_1 must be < 90^0. This is the limiting case of the refraction and the corresponding angle of incidence is known as critical angle (θ_c).

$$\frac{n_2}{n_1} = \sin \theta c$$

For $\theta_1 > \theta_c$, the light is totally reflected back at interface into the same medium. This phenomenon is known as the total internal reflection shown in figure 1.13.

Figure 1.14 shows the transmission of light ray in an optical fiber via a series of total internal reflections at the interface of the core and cladding. The ray incident on the interface at an angle θ greater than the critical angle gets reflected at the same angle to the normal.

1.11 Y-GUIDE APPLICATIONS:

The simplest form of branched light guide is one in which the guide has two branches, and for obvious reasons this has become known as Y-Guide or fiber optic probe. This can be used to combine two beams of light. However, the most common use of this type of guide has been sensing applications, and normal mode of operation is illustrated in figure 1.15. Where it will be seen that one branch is used to illuminate the area of interest, and the other to guide the reflected light to photo detector. Any change in the amount of reflected light will result in a change of signal level from the detector.

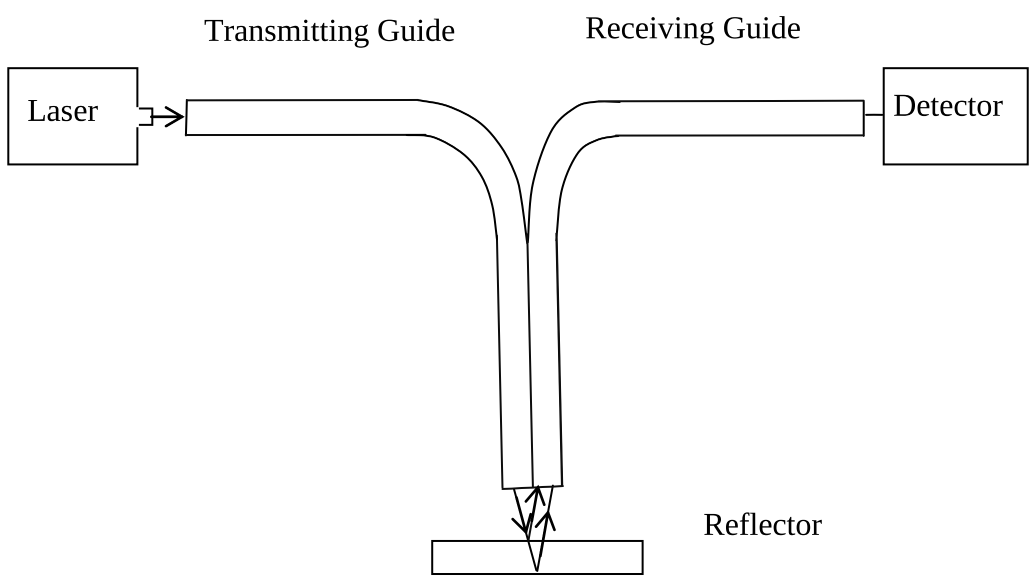

Figure 1.15: Basic diagram of a Y-Guide

1.12 REVIEW OF THE EARLIER WORK:

The refractive index is an important optical parameter for various types of liquid, transparent materials, glasses and gases etc. Actually it plays a great role for the identification of the materials. It is an important characteristic constant of optical material which has the universal appeal in different field of Science, Engineering and technology namely- glass industries, instrumentation, refractometry etc.

The laser has made a tremendous impact on science and Technology. At present time, laser based research has undergone rapid development and has seen wide use due to its unique properties, such as fast response, noninvasiveness and sensitivity of laser-based tool.

Because of the utmost of importance of refractive index, many workers have centered their attention to discover the experimental techniques for determining the refractive index of different type of material. They have designed and developed some new optical systems depending upon physical states of samples like solid, liquid and gas. Recently the refractive index determination by using different interferometric techniques has been proposed (9-11) in literature. Murty *et al.* (12-14) have used a wedge form between two plates which acts as liquid container. The different aspects of (15-17) estimating the value of refractive index of pure liquids. In general, the refractive index of liquid is measured by spectroscopic method (18-21). This technique has certain limitation because of several instrumental components. Similar problem were faced in case of Abbe's Refractometor (22). E. Moreels *et al.* (1984) and S. Sainov *et al.* (1990) have used the total internal reflection phenomenon for finding the refractive index of liquid (23 to 24).

Owing to such important properties the laser has been preferred as light source for optical purposes. Keeping in view the above narration the author has made up his mind to take up laser refractometry for his research studies. Several workers have appreciable contributions regarding the determination of refractive index. Chhrnov *et al.* and Danish *et al.* (25-26) have reported the use of continuous liquid level sensor to measure the wide range of refractive indices. Defranzo *et al.* (27) have measured the refractive index at low temperature. Kasana *et al.* have reported a new liquid immersion technique (28-32) by using only a single liquid at a time. They have replaced the telescope by Murty Shearing plate and low frequency rulings. This optical configuration acts as a refractometer. With the help of this refractometer they have measured the refractive index of liquids and lenses up to accuracy of forth place of decimal.

The refractive index of some molten ionic salts was investigated by J. Marcoux (33). Measurements of refractive index with temperature and concentration variation have been undertaken by M. H. McCay *et al.* (34) for propylene glycol. The dependence of refractive index on concentration of several aqueous solutions was reported as tabular values have been undertaken by J.A. Dean and D. R. Lide (35-36). The change of refractive index with temperature was determined by Lusty and Dunn (37).

This work presents a high-precise real-time, noninvasive, Laser-based technique to measure the refractive index of a liquid mixture or an aqueous solution. Recently several workers have put the efforts to study the refractive index of liquid crystals (38-42). Transparent material by Efimor (43), solid state polymer by Ford *et al.* (44), holographic material by Ikeda *et al.* (45), Light dispersion by Zwiller (46), liquid benzene by R.H.C. Janssen *et al.* (47), liquid sulpher dioxide by Musso *et al.* (48), Multiple reflection and interference processes by Nose and Nerkar Aryan K.H.V. *et al.* (49, 50), Crude Oil with capillary tube by Ghandoor *et al.* (51), multiple beam interferometric technique for measuring the refractive index of lenses by Kasana *et al.* (52), refractometry of liquids by acousto-optic diffraction technique (53) by R.S. Kasana and K. Soni.

Accurate measurement of the refractive indices of solid and liquids using double layer interferometer is proposed by M.A. Khashan *et al.* (54). The two beam method to determine the refractive index of liquids and translucent solids and Refractive index measurement by using Laser has been reported by S. Singh (55,56), He-Ne laser and a thin cell, and diffraction method (57-60) by S. Singh and Palchikova *et al.* (61). Recently some laser based optical facility for determination of refractive index of optical material has been discussed in literature (62-65).

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