

LECTURE 4

Newton's rings

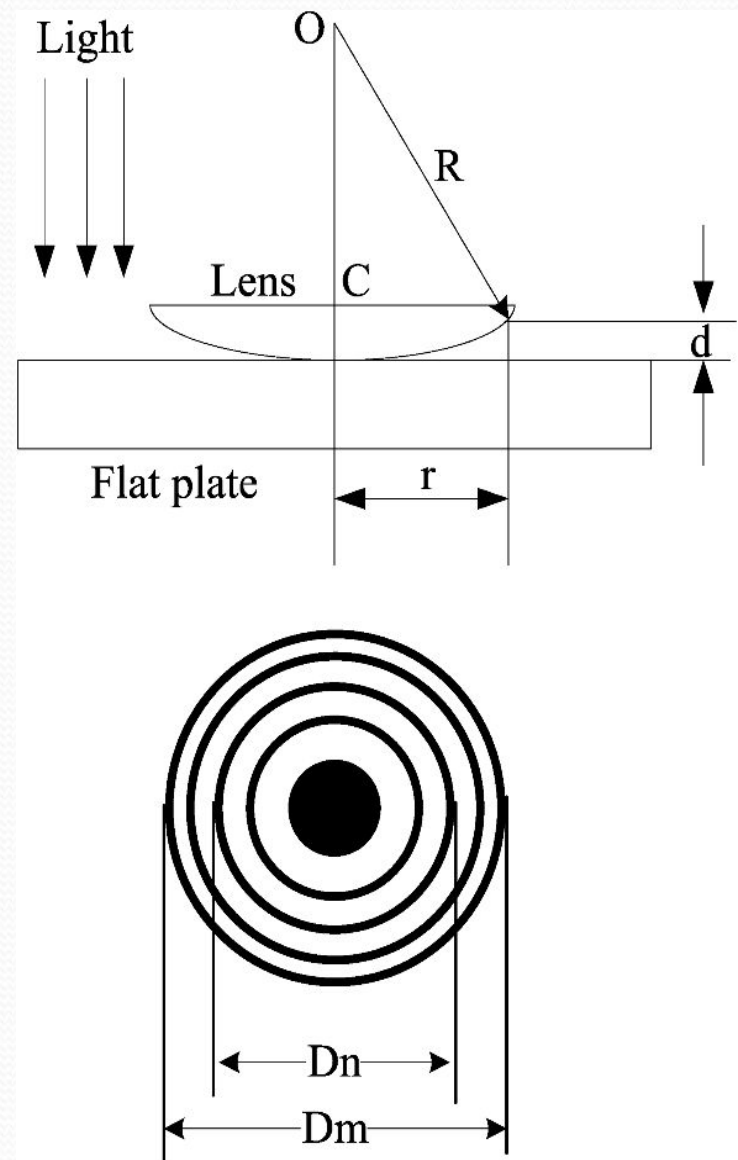
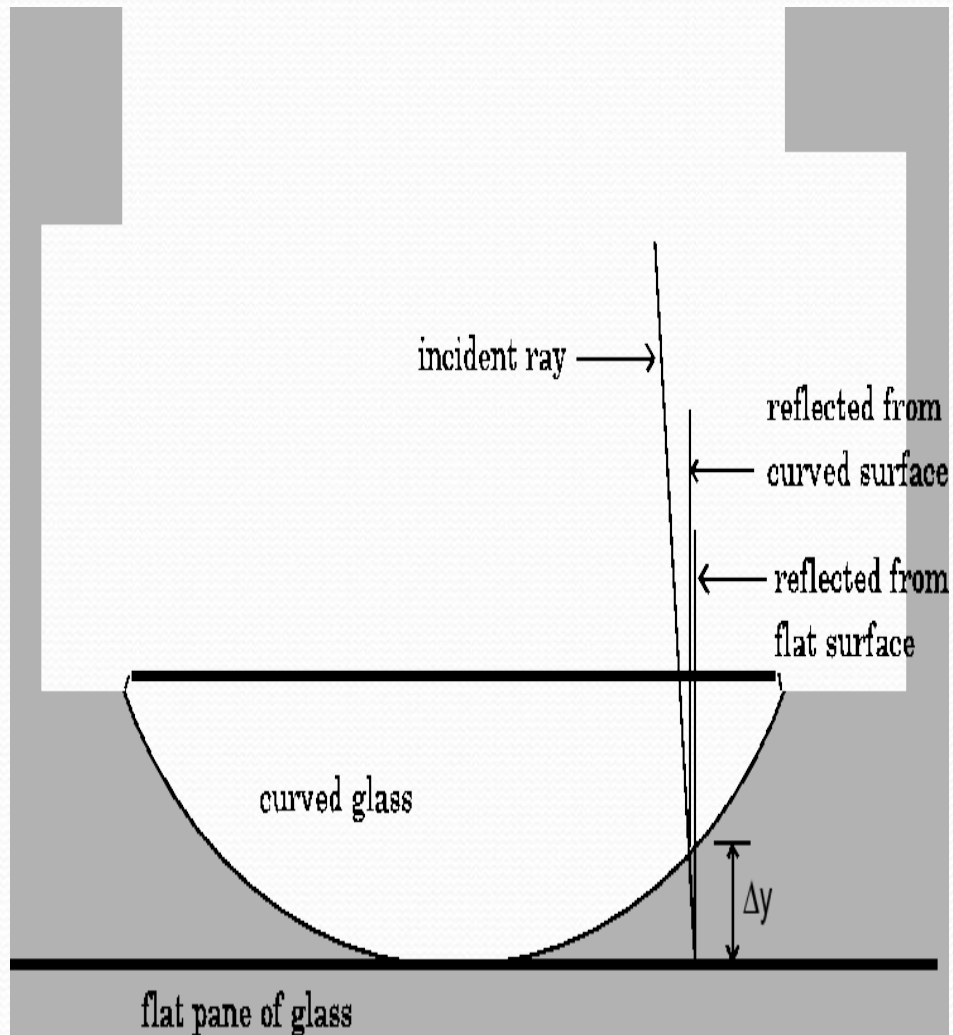
- **Newton's rings** is a phenomenon in which an interference pattern is created by the reflection of light between two surfaces—a spherical surface and an adjacent touching flat surface. It is named for Isaac Newton, who first studied the effect in 1717. When viewed with monochromatic light, Newton's rings appear as a series of concentric, alternating bright and dark rings centered at the point of contact between the two surfaces. When viewed with white light, it forms a concentric ring pattern of rainbow colors, because the different wavelengths of light interfere at different thicknesses of the air layer between the surfaces.
- The phenomenon was first described by Robert Hooke in his 1664 book *Micrographia*, although its name derives from the physicist Isaac Newton, who was the first to analyze it.

- The bright rings are caused by constructive interference between the light rays reflected from both surfaces, while the dark rings are caused by destructive interference. Moving outwards from one bright ring to the next, the path difference of interfering rays at the given radius is one wavelength, λ , corresponding to an increase of thickness of the air layer between the glass surfaces by $\lambda/2$. For glass surfaces that are not spherical, the fringes will not be rings but will have other shapes.
- For illumination from above, with a dark center, the radius of the N^{th} bright ring is given by

$$r_n = \sqrt{(2k - 1)R \frac{\lambda}{2}}$$

where k is the bright-ring number, R is the radius of curvature of the glass lens the light is passing through, and λ is the wavelength of the light.

The above formula is also applicable for dark rings for the ring pattern obtained by transmitted light.



- **Optical interferometer,** instrument for making precise measurements for beams of light of such factors as length, surface irregularities, and index of refraction. It divides a beam of light into a number of beams that travel unequal paths and whose intensities, when reunited, add or subtract (interfere with each other). This interference appears as a pattern of light and dark bands called interference fringes. Information derived from fringe measurements is used for precise wavelength determinations, measurement of very small distances and thicknesses, the study of spectrum lines, and determination of refractive indices of transparent materials. In astronomy, interferometers are used to measure the distances between stars and the diameters of stars.

● **Types of interferometers:**

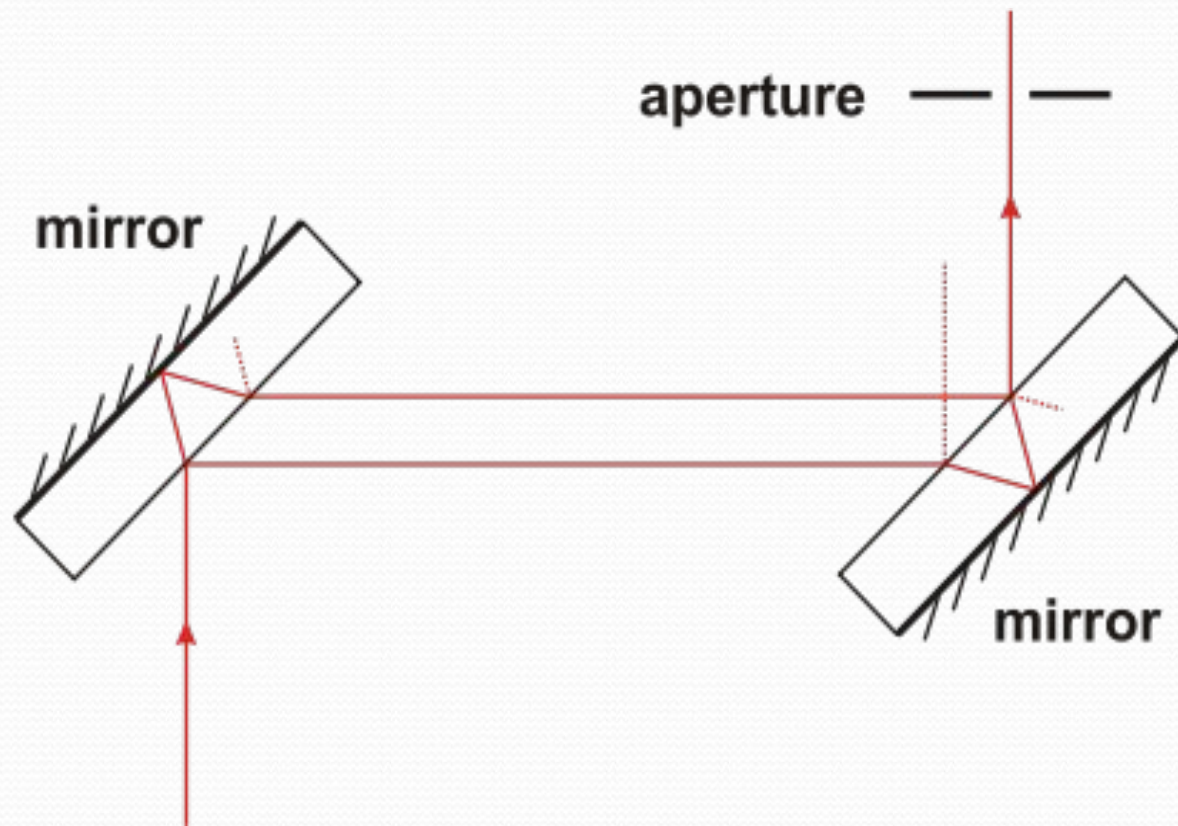
1) Jamin interferometer

The **Jamin interferometer** is a type of interferometer, related to the Mach-Zehnder interferometer. It was developed in 1856 by the French physicist Jules Jamin.

The interferometer is made up of two mirrors, made of the thickest glass possible. The Fresnel reflection from the first surface of the mirror acts as a beam splitter. The incident light is split into two rays, parallel to each other and displaced by an amount depending on the thickness of the mirror. The rays are recombined at the second mirror, and ultimately imaged onto a screen.

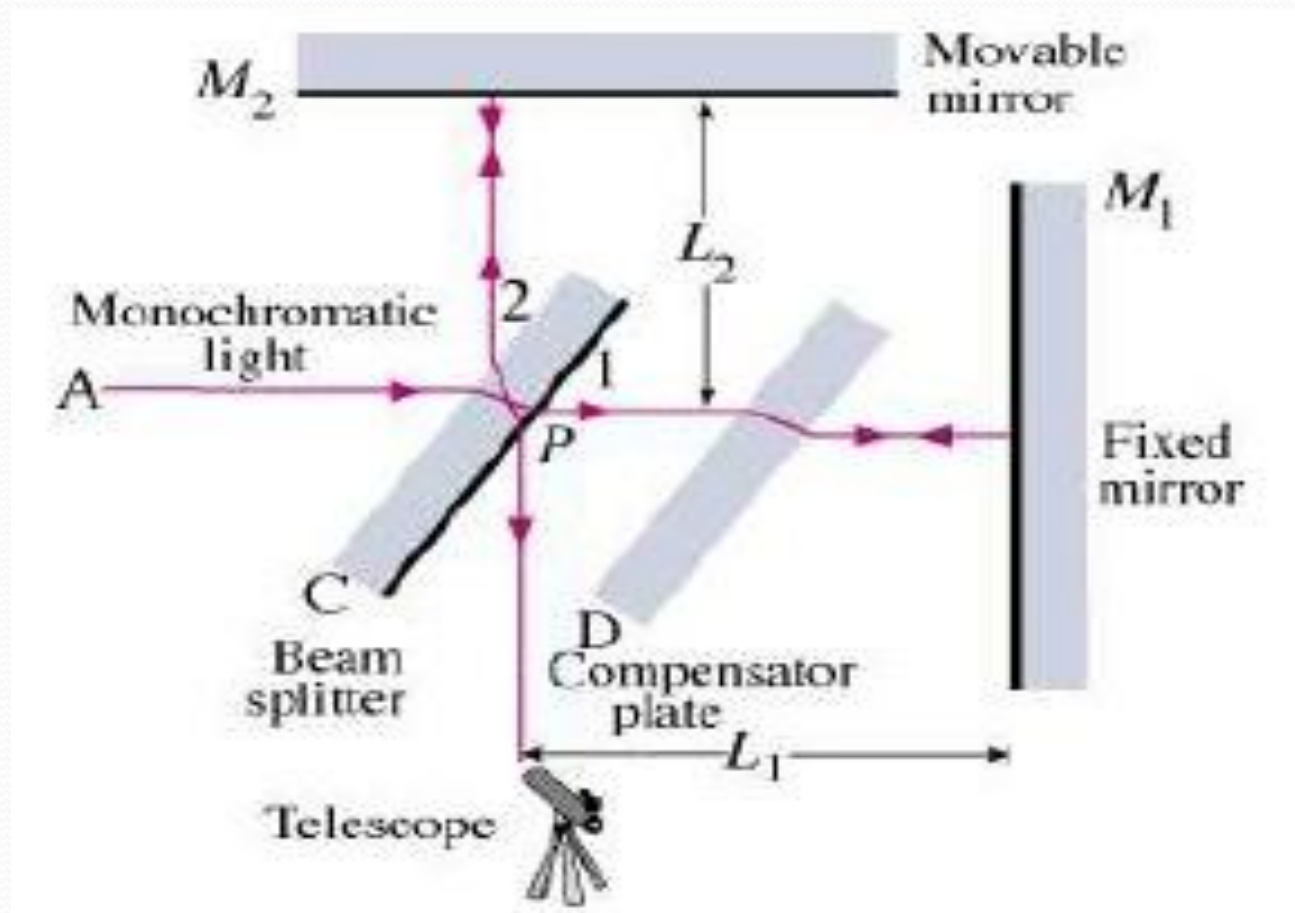
If a phase-shifting element is added to one arm of the interferometer, then the displacement it causes can be determined by simply counting the interference fringes, *i.e.*, the minima.

The Jamin interferometer allows very exact measurements of the refractive index and dispersion of gases; a transparent pressure chamber can be positioned in the instrument. The phase shift due to changes in pressure is quite easy to measure.



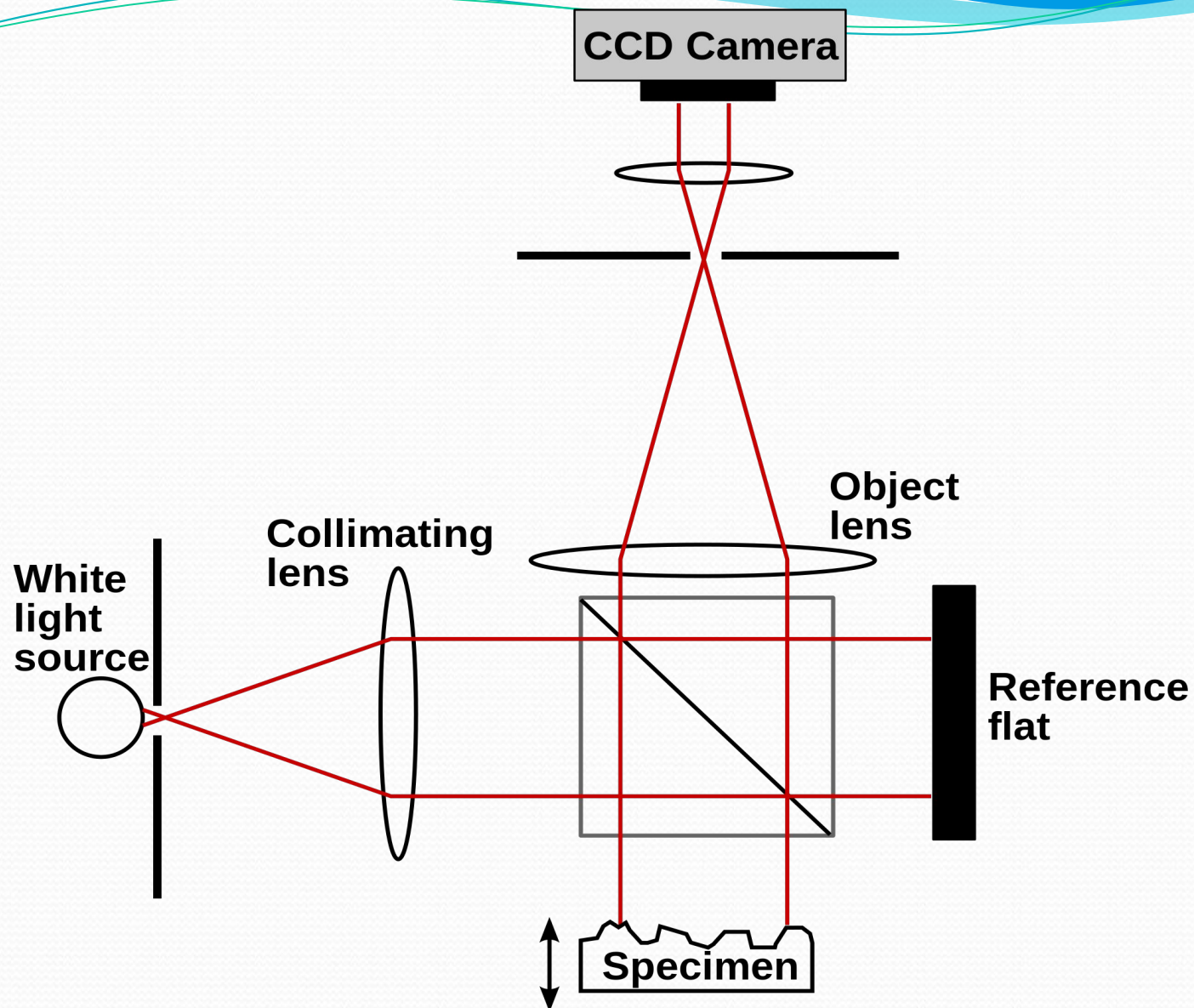
2) *Michelson interferometer*

- The **Michelson interferometer** is a common configuration for optical interferometry and was invented by Albert Abraham Michelson. Using a beamsplitter, a light source is split into two arms. Each of those is reflected back toward the beamsplitter which then combines their amplitudes interferometrically. The resulting interference pattern that is not directed back toward the source is typically directed to some type of photoelectric detector or camera. Depending on the interferometer's particular application, the two paths may be of different lengths or include optical materials or components under test.
- The Michelson interferometer is especially known for its use by Albert Michelson and Edward Morley in the famous Michelson-Morley experiment (1887) in a configuration which would have detected the earth's motion through the supposed luminiferous aether that most physicists at the time believed was the medium in which light waves propagated. The null result of that experiment essentially disproved the existence of such an aether, leading eventually to the special theory of relativity and the revolution in physics at the beginning of the twentieth century.



- **3) Linnik interferometer**

- A **Linnik interferometer** is a two-beam interferometer used in microscopy and surface contour measurements or topography. The basic configuration is the same as a Michelson interferometer. What distinguishes the Linnik configuration is the use of measurement optics in the reference arm, which essentially duplicate the objective measurement optics in the measurement arm. The advantage of this design is its ability to compensate for chromatic dispersion and other optical aberrations.
- In the image of a Linnik interferometer at right, 110 is the light source, 164 the detector. The beamsplitter 120 produces the two arms of the interferometer. The measurement arm 140 contains an objective lens 141 for imaging the surface to be studied 152. The reference arm 130 contains complementary optics to compensate for aberrations produced in the measurement arm.



4) **Fabry–Perot interferometer**

In optics, a **Fabry–Perot interferometer** or **etalon** is typically made of a transparent plate with two reflecting surfaces, or two parallel highly reflecting mirrors. (Precisely, the former is an etalon and the latter is an interferometer, but the terminology is often used inconsistently.) Its transmission spectrum as a function of wavelength exhibits peaks of large transmission corresponding to resonances of the etalon. It is named after Charles Fabry and Alfred Perot. "Etalon" is from the French *etalon*, meaning "measuring gauge" or "standard".

Etalons are widely used in telecommunications, lasers and spectroscopy to control and measure the wavelengths of light. Recent advances in fabrication technique allow the creation of very precise tunable Fabry–Pérot interferometers.

