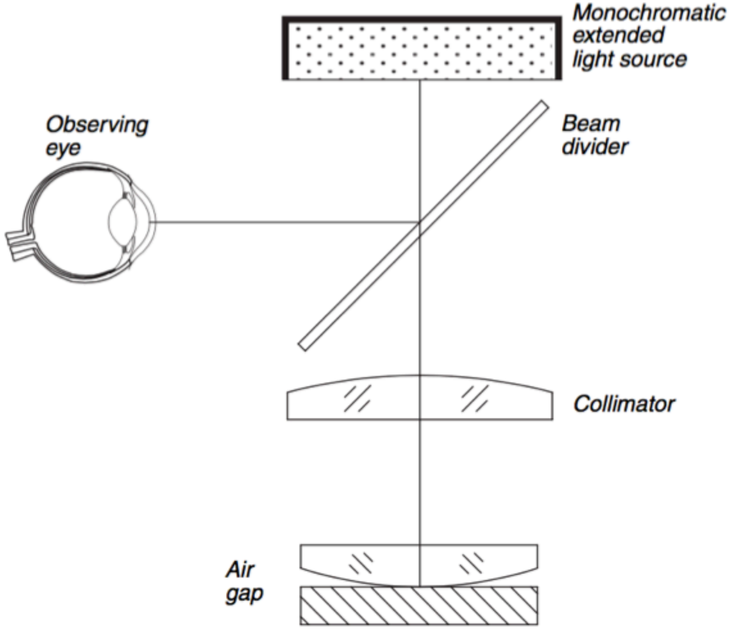
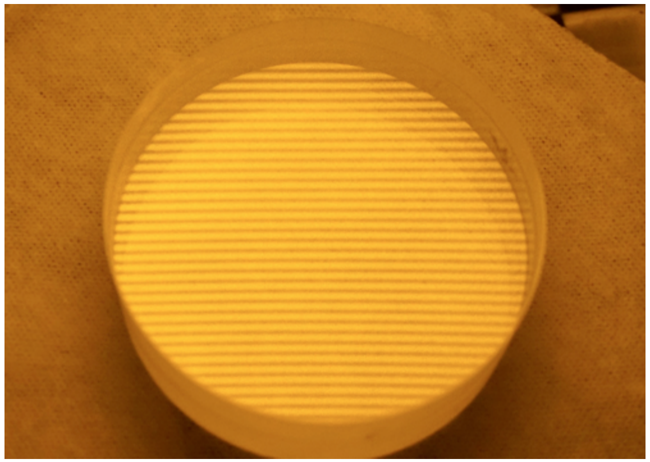


FIGURE 1.2. A simple arrangement to observe the Newton fringes in the optical workshop. With this arrangement plane and long radius spherical surfaces can be tested.

Controllo delle ottiche
"Optical Shop Testing" (Malacara)

$L_{coh}=c*T_{coh}=c/\Delta\nu$



integer multiple of the wavelength. We may easily conclude that if the separation x is zero, there is a dark fringe.

Hence the dark fringes may be represented by

$$2\alpha x = n\lambda, \tag{1.1}$$

where n is an integer, and the bright fringes may be represented by

$$2\alpha x + \frac{\lambda}{2} = n\lambda. \tag{1.2}$$

Each of these equations represents a system of equally spaced straight fringes, and the distance d between two consecutive bright or dark fringes is

$$d = \frac{\lambda}{2\alpha}. \tag{1.3}$$

Thus the appearance of the fringes is as shown in Figure 1.3, when two good optical flats are put in contact with each other, forming a small air wedge, and are viewed in monochromatic light.

ascertain its deviation from flatness. Let us consider a spherical surface of large radius of curvature R in contact with the optical flat.

Then the sag of the surface is given by $x^2/2R$, where x is the distance measured from the center of symmetry. Hence the OPD is given by $x^2/R + \lambda/2$, and the positions of the dark fringes are expressed by

$$\frac{x^2}{R} = n\lambda. \tag{1.4}$$

Hence the distance of the nth dark fringe from the center is given by

$$x_n = \sqrt{nR\lambda}. \tag{1.5}$$

From this, it is easy to show that the distance between the $(n+1)$th and the nth fringe is given by

$$x_{n+1} - x_n = \sqrt{R\lambda}(\sqrt{n+1} - \sqrt{n}), \tag{1.6}$$

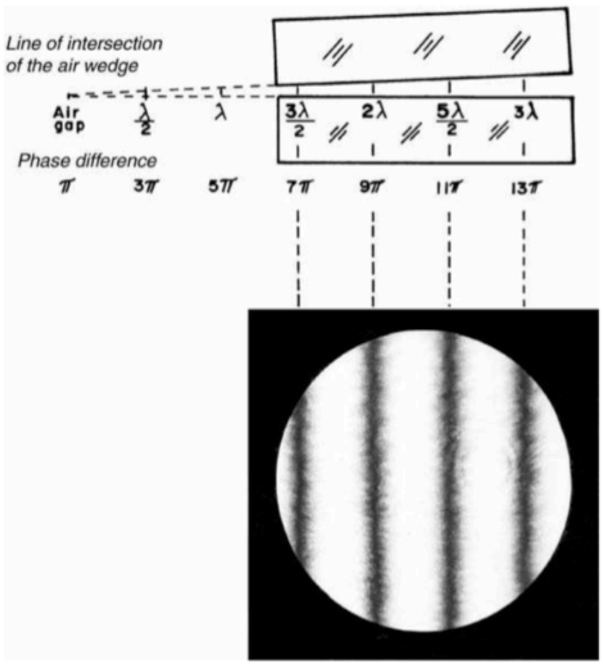
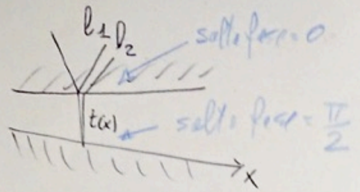


FIGURE 1.3. The principle of the formation of straight, equally spaced fringes between two optically plane surfaces when the air gap is in the form of a wedge. The fringes are parallel to the line of intersection of the two plane surfaces.



salto di fase se $n_{2\,mat} > n_{inc}$

$\frac{\lambda}{2} = \pi$

[illegible]

$\Delta l_{geom.} = 2t$

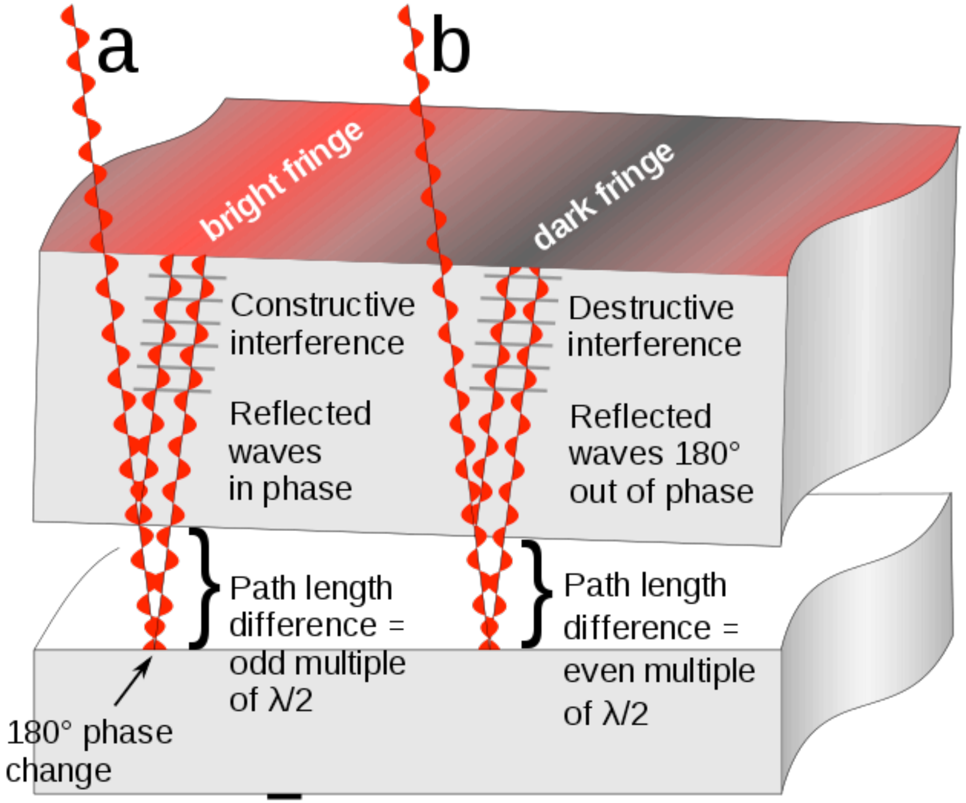
phase shift: $180° = \pi = \lambda/2$

$$\Delta l_{OPD} = 2t + \frac{\lambda}{2}$$

$$\alpha = n^{\circ} \cdot \frac{\lambda}{2} \cdot \frac{1}{D} \quad \text{rad}$$

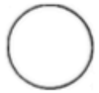
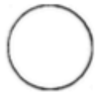
$$D = \frac{\lambda}{2\alpha} \cdot n^{\circ}$$

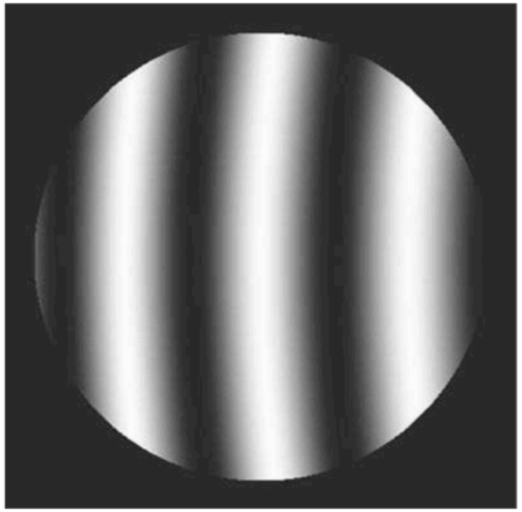
t air gap	Δl_{OPD}		$2t$ BLACK	$2t$ WHITE	AIR GAP	φ
0	$\lambda/2$	Black	0		0	π
$\frac{1\lambda}{4}$	λ	White		$\frac{1}{2}\lambda$	$\lambda/4$	2π
$\frac{\lambda}{2}$	$\frac{3}{2}\lambda$	B	$2\frac{\lambda}{2}$		$\lambda/2$	3π
$\frac{3}{4}\lambda$	2λ	W		$\frac{3}{2}\lambda$	$\frac{3}{4}\lambda$	4π
λ	$\frac{5}{2}\lambda$	B	$4\frac{\lambda}{2}$		λ	5π
$\frac{5}{4}\lambda$	3λ	W		$\frac{5}{2}\lambda$	$\frac{5}{4}\lambda$	6π
$\frac{3}{2}\lambda$	$\frac{7}{2}\lambda$	B	$6\frac{\lambda}{2}$		$\frac{3}{2}\lambda$	7π



Creation of interference fringes by an optical flat on a reflective surface. Light rays from a monochromatic source pass through the glass and reflect off both the bottom surface of the flat and the supporting surface. The tiny gap between the surfaces means the two reflected rays have different path lengths. In addition the ray reflected from the bottom plate undergoes a 180° phase reversal. As a result, at locations ***(a)*** where the path difference is an odd multiple of λ/2, the waves reinforce. At locations ***(b)*** where the path difference is an even multiple of λ/2 the waves cancel. Since the gap between the surfaces varies slightly in width at different points, a series of alternating bright and dark bands, *interference fringes*, are seen.

TABLE 1.1. Nature of Newton fringes for different surfaces with reference to a standard flat.

		Appearance of the Newton fringes	
S. No.	Surface type	Without tilt	With tilt
1	Plane		
2	Almost plane		
3	Spherical		
4	Conical		
5	Cylindrical		
6	Astigmatic (curvatures of same sign)		
7	Astigmatic (curvatures of opposite sign)		
8	Highly irregular		



GURE 1.11. Newton fringes for an optical flat showing peak error of $\lambda/20$.

Newton interferometer to estimate peak errors up to about $\lambda/10$ by visual observation alone. Beyond that, it is advisable to obtain a photograph of the fringe system and to make measurements on this photograph. Figure 1.11 shows a typical interferogram as viewed in a Newton interferometer. Here, we have a peak error much less than $\lambda/4$. Consequently, the top plate is tilted slightly to obtain the almost straight fringes. The central diametral fringe is observed against a straight reference line such as the reference grid kept in the Newton interferometer in Figure 1.2. By means of this grid of straight lines, it is possible to estimate the deviation of the fringe from its straightness and also from the fringe spacing. The optical path difference is $2t$, so the separation between two consecutive fringes implies a change in the value of t equal to $\lambda/2$. Thus, if the maximum fringe deviation from the straightness of the fringes is d/k with d being the fringe separation, the peak error is given by

$$Peak\ error = \left(\frac{k}{d}\right)\left(\frac{\lambda}{2}\right) \tag{1.14}$$

In Figure 1.11 $k = 2.5$ mm and $d = 25$ mm; hence, we can say that the peak error is $\lambda/20$. Even in this case, it is desirable to know whether the surface is convex or concave, and for this purpose we can use the procedure described earlier. The only difference is that we have to imagine the center of the fringe system to be outside the aperture of the two flats in contact.

1.3.7. Testing Nearly Parallel Plates

In many applications, glass plates having surfaces that are both plane and parallel are required. In such cases, the small wedge angle of the plate can be determined by the Fizeau interferometer, and the reference flat of the interferometer need not be used since the fringes are formed between the surfaces of the plate being tested. If α is the angle of the wedge and N is the refractive index of the glass, the angle between the front- and back-reflected wavefronts is given by $2n\alpha$, and hence the fringes can be expressed as

$$2N\alpha = \frac{\lambda}{d}, \tag{1.23}$$

where d is the distance between two consecutive bright or dark fringes. Hence the angle α is given by

$$\alpha = \frac{\lambda}{2nd}. \tag{1.24}$$

To determine the thinner side of the wedge, a simple method is to touch the plate with a hot rod or even with a finger. Because of the slight local expansion, the thickness of the plate increases slightly. Hence a straight fringe passing through the region will form a kink pointing toward the thin side, as shown in Figure 1.22. For instance, if we take $N = 1.5$, $\lambda = 5 \times 10^{-4}$ mm, and $\alpha = 5 \times 10^{-6}$ (1 s of arc), we get for d a value of about 33 mm. Hence a plate of 33 mm diameter, showing one fringe, has a wedge angle of 1 s of arc. If the plate also has some surface errors, we

FIGURE 1.22. Kink formation in the straight Fizeau fringes of a slightly wedged plate, obtained by locally heating the plate. The kink is pointing toward the thin side of the wedge.

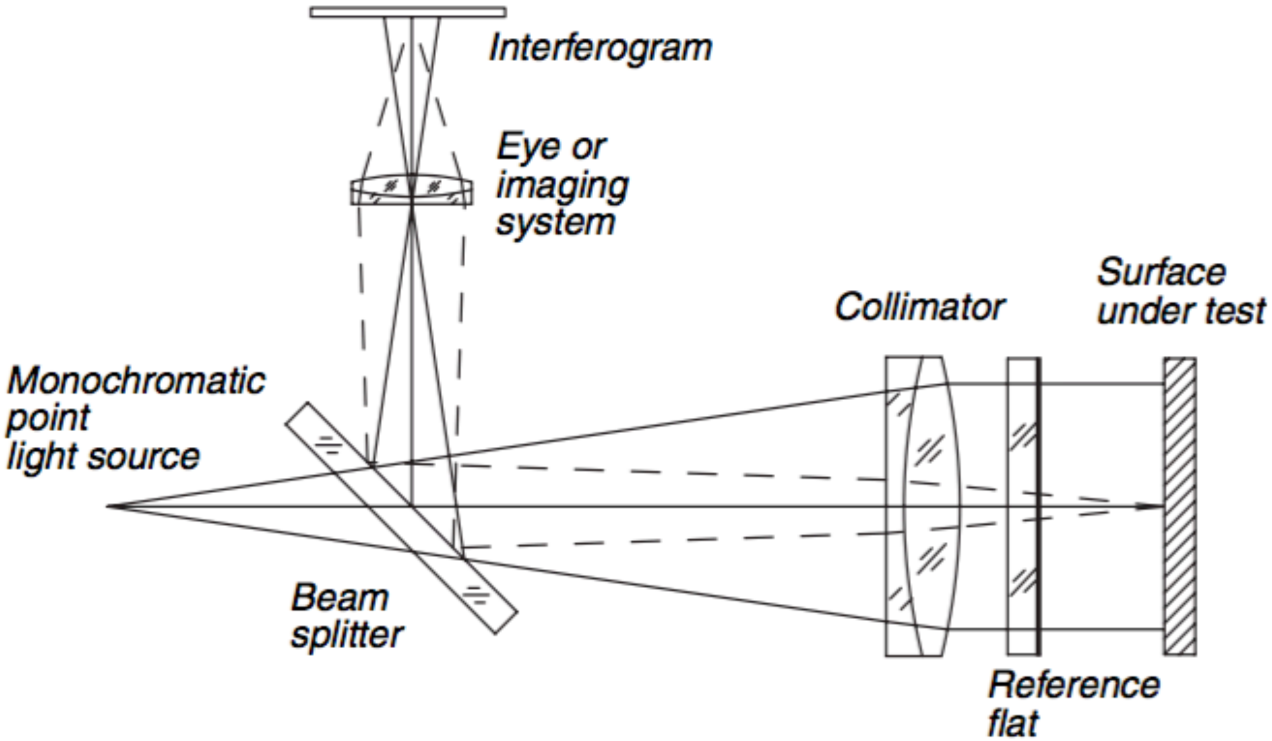


FIGURE 1.16. Schematic arrangement of a Fizeau interferometer using a lens for collimation of light.