(PO2-4)Newton's Rings

Aim of experiment

Determination of the wavelength of monochromatic light.

Apparatus

Long-Focus Lens of Known Radius of Curvature, Glass Block G, Thin Glass Sheet S, Traveling Microscope M, Sodium Lamp F.

Theory of experiment

"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 flat surface. 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.

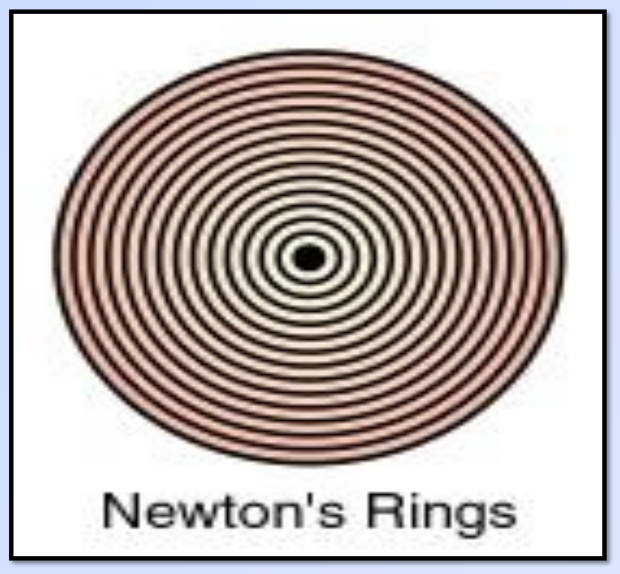

Figure 1. An image of Newton's Rings

The light rings, *figure 1,* are caused by constructive interference between the light rays reflected from both surfaces, while the dark rings are caused by destructive interference. Also, the outer rings are spaced more closely than the inner ones.

Moving outwards from one dark ring to the next, for example, increases the path difference by the same amount, λ, corresponding to the same increase of thickness of the air layer, $\lambda/2$. Since the slope of the convex lens surface increases outwards, separation of the rings gets smaller for the outer rings. For surfaces that are not convex, the fringes will not be rings but will have other shapes.

When a plano-convex lens of long focal length is placed with its curved surface in contact with a glass plate, there is an air film between the surfaces. The faces of the film may be supposed approximately parallel and separated by a distance *t.* consequently interference fringes will be produced.

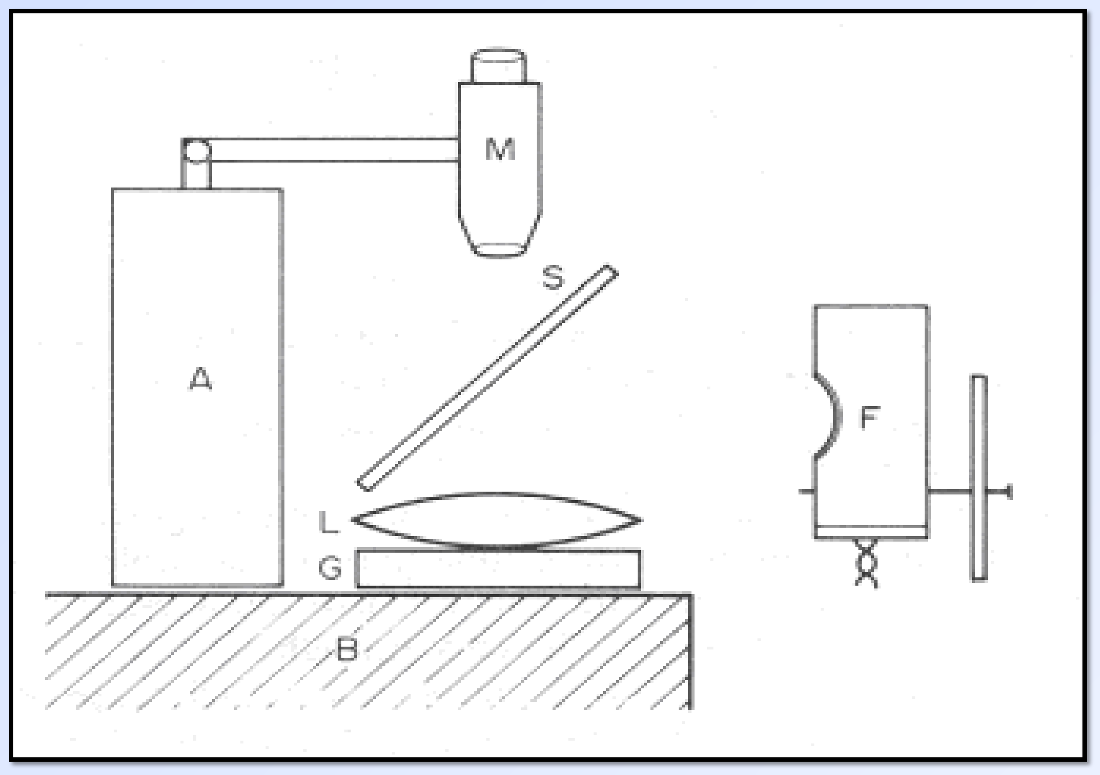

Figure 2. A schematic diagrams of Newton's ring apparatus

The condition of producing bright fringes is:

$$2\mu t\cos\theta = (n+\frac{1}{2})\lambda$$

Where the condition of producing dark fringes is:

$$2\mu t\cos\theta = n\lambda$$

n =1, 2, 3, ….is the order of interference, μ, the refractive index equals 1 for air, t thickness of the air film, θ the refracting angle in the air film and λ the wavelength of the light used.

From the geometry of figure 3, one gets;

$$t(2a-t)=r^2$$
$$2at-t^2=r^2$$

Where a is the radius of curvature of the lens

Since t^2 is very small, then

$$2at=r^2$$

Since the path difference between the two rays in air, where μ=1 and θ is approximately equal to zero, is:

$$2t=(r^2/a)=(n+0.5)\lambda \quad \textit{for bright rings}$$
$$2t=(r^2/a)=n\lambda \quad \textit{for dark ring}$$

and. If $d=2r$, is the fring diameter of order n, then

$$d^2=4\lambda an$$

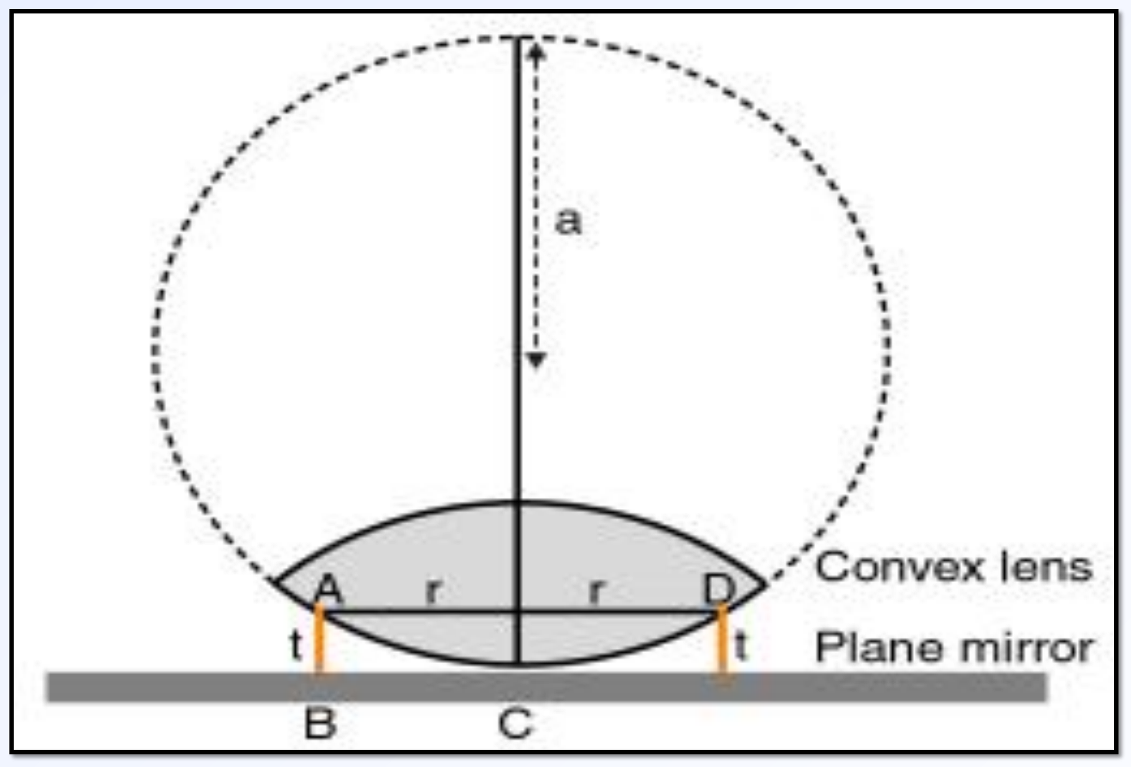

Figure 3. Geometry of convex lens

If the square of the diameter of dark ring is drawn as a function of the ring order n, a straight line of slope equals $4\lambda a$ is obtained. So, if a is known, the incident light wavelength can be obtained from the relation:

$$\lambda=slope/4a$$

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Procedure

1. Thoroughly clean the lens L and glass block G, both of which should be free from scratches, and of good optical quality.
2. Place L on top of G near the edge of the bench B, and fix a sodium lamp near L, as shown in the *figure 2.*
3. Arrange the base A of the traveling microscope M so that the microscope is vertically above the centre of the lens, and focus the microscope onto the upper surface of G (slip of paper inserted between L and G will assist in this).
4. Fix the sheet of glass S in a clamp at about 45° , and insert the sheet between L and M. Looking into the microscope, vary the position and angle of S until the field of view is as bright as possible. If rings are not now visible, slightly raise or lower M until they appear, and focus as sharply as possible on them. Move microscope sideways until the rings are central in the field of view.
5. Set the crosswire on the centre of the rings, and use the vernier screw to move the crosswire out to, say, the 10^{th} dark ring. Read the vernier with the crosswire set on the 10^{th} dak ring, and then bring the microscope back, stopping on each ring and reading the vernier. Continue past the center, and take readings on the opposite side until the 10^{th} dark ring is again reached.
6. Subtract the micrometer readings corresponding to each ring to obtain the diameters d_1 of the rings, and record these in the table of measurements, together with d_1^2
7. Repeat the previous step two more times.
8. Draw a graph of d_{av}^2 v. n, the graph is a straight line, passing through the origin, of slope $4\lambda a$.
   Calculate from the slope the value of λ, using the measured value of a.

Results

$a=$ cm

n	d_1	d_1^2	d_2	d_2^2	d_3	d_3^2	$d_{av}^2 \pm \Delta d_{av}^2$

$\lambda=$ cm

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