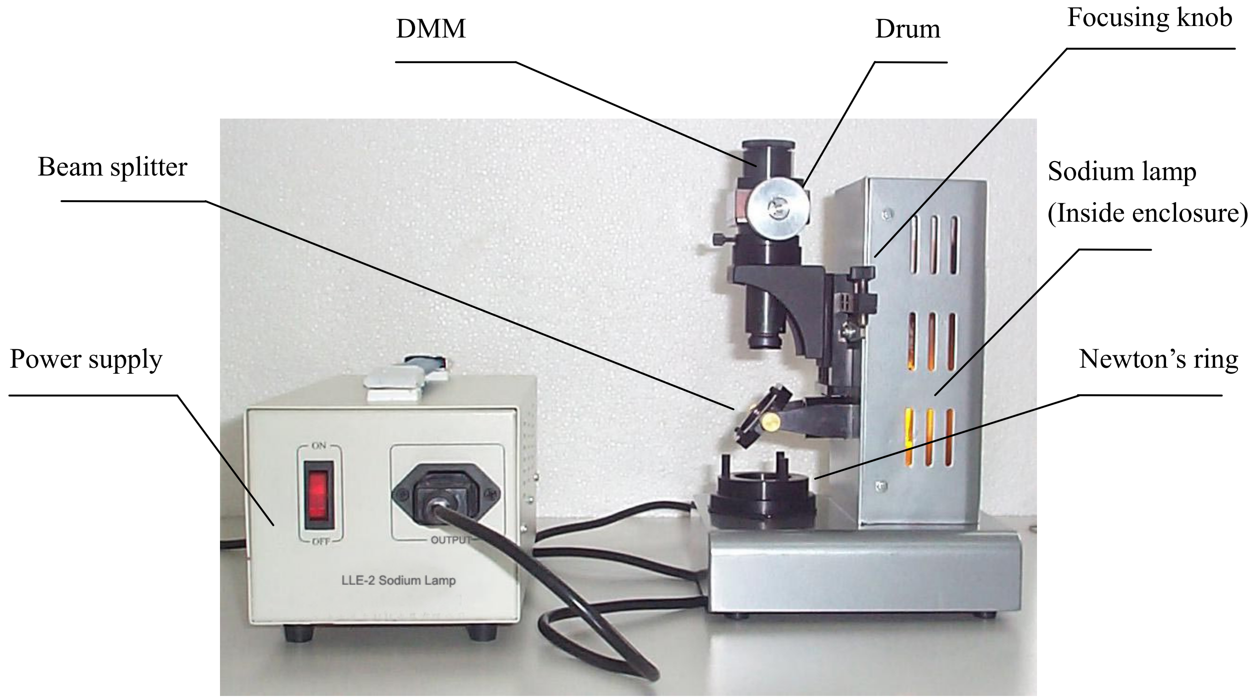
3. Description of Equipment



The LEOK-30 Newton’s Ring Apparatus includes the following equipment:

Reading microscope
Sodium lamp with power supply
Newton’s Ring
Beam splitter

4. Principle

The convex surface of a long focal length lens (large radius of curvature) is placed in contact with a plane glass and the two surfaces are clamped together with a thin film of air formed in between. If a ray of parallel light strikes to them as shown in Figure 1, there will be a light path difference between the light beams reflected by the upper- and lower-surfaces of the air film. Thus, interference phenomenon occurs. The interference pattern is a series alternately dark and bright rings centered at the contact point of the lens and the plane glass. This is the phenomenon of Newton’s rings.

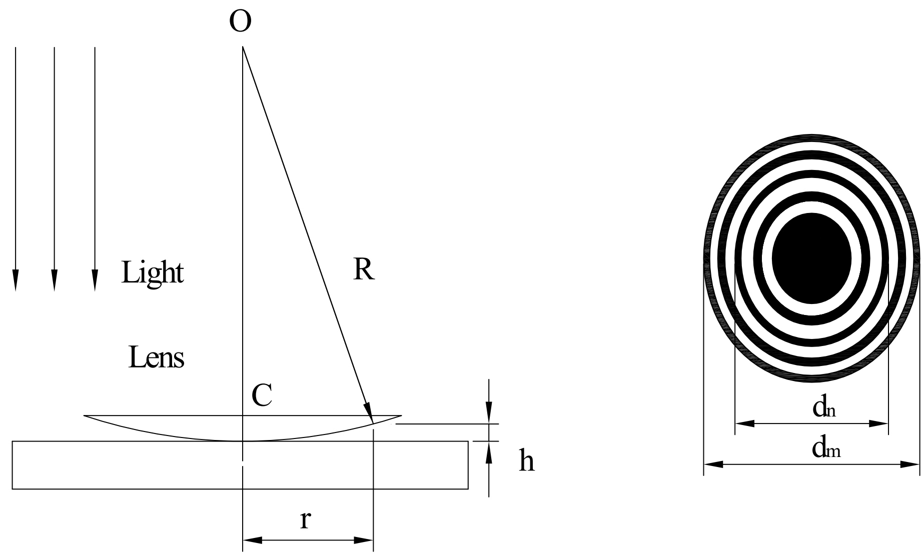


Figure 1 Schematic diagram showing a lens and flat plate used to form Newton's Rings

where R is the radius of curvature of the convex lens, h is the thickness of the thin "air-film", and r is the radius of an interference ring with respect to the point of contact C. With these parameters, there exists an equation as:

$$h = R - \sqrt{R^2 - r^2} \approx \frac{r^2}{2R} \tag{1}$$

There is no phase change at the glass-air surface of the convex lens (because the wave is going from a higher to a lower refractive index medium) whereas the reflection at the air-glass surface of the plane disk suffers a half-cycle phase shift. So the light path difference is:

$$\delta = 2h + \lambda / 2 \tag{2}$$

The light path difference of the k^{th} order dark fringe is:

$$\delta = (2k+1)\frac{\lambda}{2}, \text{ where } k=0, 1, 2\ldots$$

So the radius of the k^{th} dark ring is given by

$$r_k = \sqrt{kR\lambda} \qquad k= 0, 1, 2\ldots \tag{3}$$

It provides a method to measure the radius of curvature of the convex surface. However, very small dust particles may lift the contact point slightly above the surface of the optical flat, so the center of the rings is irregular and r_k cannot be measured precisely. To address this uncertainty, the radii of two rings (the m^{th} and the n^{th}, m>n) should be measured to calculate R as follows

$$R=\frac{r_m^2-r_n^2}{(m-n)\lambda}=\frac{d_m^2-d_n^2}{4\lambda(m-n)} \tag{4}$$

where d_{m} and d_{n} are the diameters of dark rings of the m^{th} and n^{th} orders, respectively.

5 Experimental Procedure

5.1 Observation of Newton's Rings

Step 1: Open the metal cover and install the Sodium lamp bulb to the lamp housing.

Step 2: Turn on the Sodium lamp and warm up for about 5 minutes.

Step 3: Insert the Newton's ring in the holder on the base with three screws up. Secure the Direct Measurement Microscope in focusing device.

> **Notice**
> Before inserting the Newton's ring in the holder on the lamp base, carefully adjust the three screws on Newton's ring until several small rings move to the center of the lens.
>
> Do not over-tighten the screws on Newton's ring assembly to avoid damage to the device.

Step 4: Rotate beam splitter to let Sodium light illuminate the Newton's Ring. When the beam splitter is oriented 45° to the optical axis of the DMM, fine rings can be seen through the eyepiece. Lock the beam splitter. If the interference pattern is not clear, rotate the focusing knob to focus the microscope.

Step 5: Carefully turn eyepiece until cross hair is seen clearly.
Carefully adjust the focusing knob until a clear image of the equal- thickness rings is observed.

Step 6: Adjust the three screws on frame of Newton's ring to let center ring move to the center of the viewing field. Tighten any two of the three crews on Newton's ring, distorted rings should be observed.

> **Notice**
> Do not over-tighten the screws on frame of Newton's ring to avoid damage of the lens.

5.2 Determination of Radius of Curvature of Lens

Step 1: Turn on the sodium lamp and get Newton's rings. For details, please refer to 5.1.

Step 2: Rotate the drum and set the cross hairs on the 5^{th} ring on the left hand side of the interference pattern and record the reading of the drum. Similarly, go to the 14^{th} ring on the same side of the pattern and record the drum reading. Repeat these steps for several rings and record the data in the following table. Repeat these steps on the right hand side of the interference pattern.

Notice
To minimize reading error due to backlash while turning the micrometer knob, first begin with a full counterclockwise turn, and then turn the knob only counterclockwise when counting fringes, this will eliminate reading errors caused by backlash.

Ring #	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14
Position										
Ring #	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14
Position										
Diameter										

Step 3:

Determine d_5, d_6, …, d_{14} from measured data and calculate $(d_{14})^2$-$(d_9)^2$, $(d_{13})^2$-$(d_8)^2$, $(d_{12})^2$-$(d_7)^2$, $(d_{11})^2$-$(d_6)^2$, $(d_{10})^2$-$(d_5)^2$ and their average (m-n=5). Then calculate the radius of curvature of the lens by using the mean wavelength, 589.3 nm, of Sodium D-lines in equation (4).