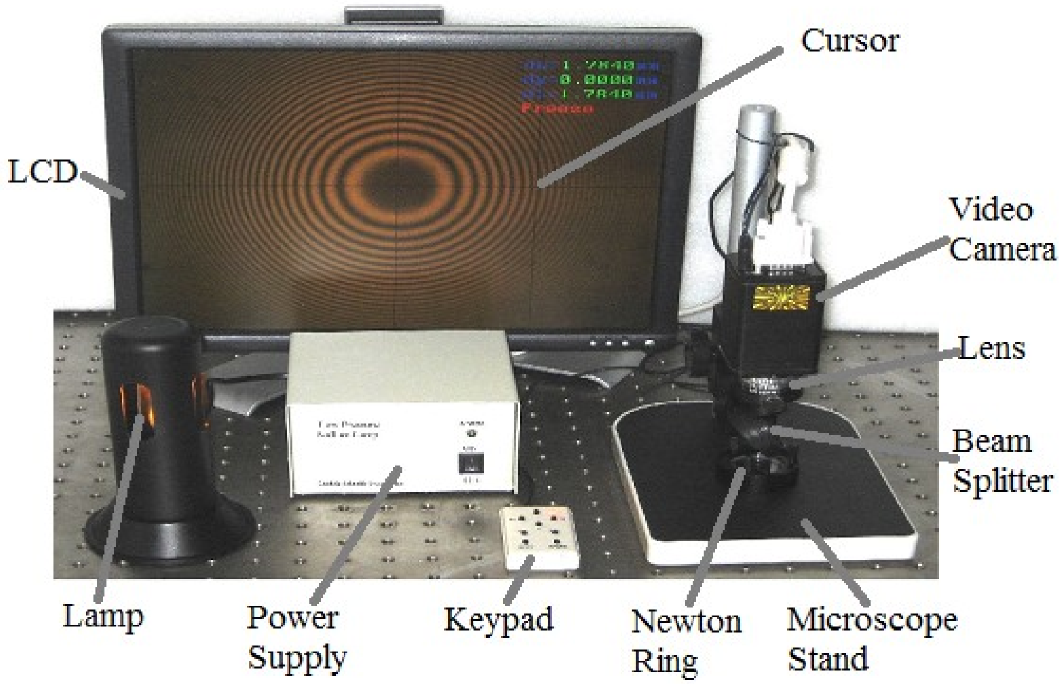
3. Description of Equipment



The LEOK-31 Newton's Ring Apparatus includes the following items:

VGA output color camera with lens and keypad (1 set)
Microscope stand with focusing knob (1 set)
Sodium lamp with power supply (1 set)
Note: the actual housing and power supply may differ from those shown in the photo above.
Newton's ring assembly (1)
Pre-installed beam splitter (1)
Note: LCD needs to be prepared by user.

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 point of contact between the lens and the flat glass. This is the phenomenon of Newton's rings.

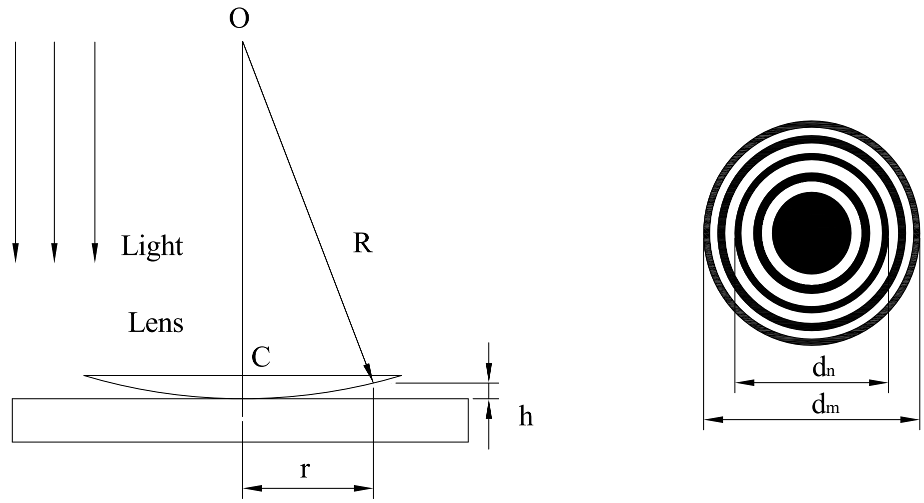


Figure 1 Schematic diagram showing a lens and flat plate used to form Newton's Rings

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 Procedures

Please read Section 7 to know how to use the video camera. This camera was pre-calibrated for length measurement at factory. In case a recalibration is needed, please read the instruction shown in Section 7.

5.1 Observation of Newton's Rings

Step 1: Open the lamp housing and install the Sodium lamp bulb into the lamp housing.

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

Step 3: Mount the camera with lens onto the ring holder of the microscope stand by locking the screw on the ring to fix the lens.

Step 4: Connect the keypad, LCD and ac adapter to the camera. Turn on camera power.

Step 5: Place the Newton's ring device on the stand base under the beam splitter.

Note

Before placing the Newton's ring device on the 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 6: Carefully rotate the beam splitter and move the location of the lamp housing to let Sodium light illuminate onto the Newton's Ring. When the beam splitter is oriented properly, fine rings can be seen on the LCD screen. If the interference pattern is not clear, rotate the focusing knob of the microscope stand to focus the camera.

Step 7: Carefully adjust the focusing knob, beam splitter orientation and lamp location until a clear image of the equal- thickness rings is observed at the central region of the LCD screen.

5.2 Determination of the radius of curvature of a lens

Step 1: Follow the above steps to get Newton's rings on the LCD.

Step 2: There are two vertical cursors on the screen. Let one vertical cursor stay at any position. Move the other vertical cursor to the center of the 14^{th} ring on the left hand side of the interference pattern and record the x- reading on the screen. Similarly, go to the 13^{th} ring on the same side of the pattern and record the x-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.

Ring #	L14	L13	L12	L11	L10	L9	L8	L7	L6	L5
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).