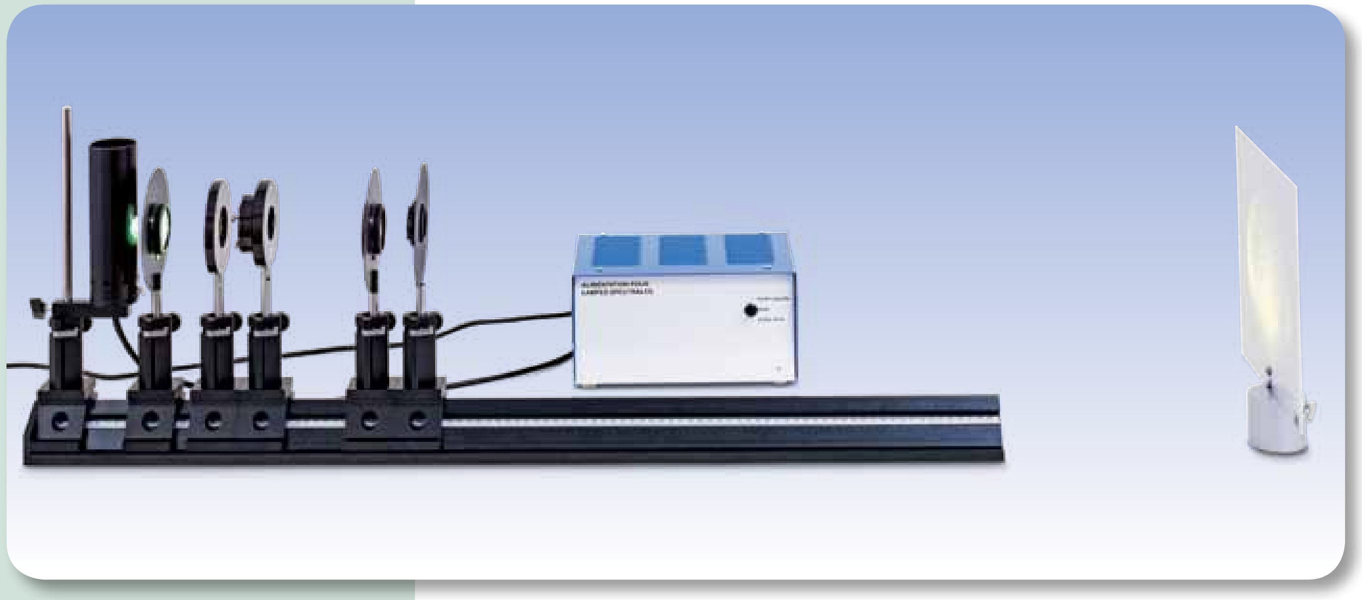
NEWTON'S RINGS



EXPERIMENT PROCEDURE

- **Observe Newton's rings with monochromatic light transmitted through the apparatus.**
- **Measure the radius of the rings and determine the radius of curvature of the spherical body.**
- **Determine by how much the set up is deformed by the sphere pressing down on the plate.**

OBJECTIVE

Observe Newton's rings in monochromatic light.

SUMMARY

Newton's rings are generated by a set-up involving a flat glass plate and a spherical body with a large radius of curvature. If parallel monochromatic light is incident on the set-up from an angle normal to the apparatus, alternating light and dark concentric rings are generated, centred on the point where the surfaces meet. In this experiment Newton's rings are investigated using monochromatic light transmitted through the apparatus. The radius of curvature R of the spherical body can be determined from the radii r of the interference rings as long as the wavelength λ is known.

REQUIRED APPARATUS

Quantity	Description	Number
1	Optical Precision Bench D, 100 cm	**1002628**
6	Optical Rider D, 90/50	**1002635**
1	Control Unit for Spectrum Lamps (230 V, 50/60 Hz)	**1003196 or**
	Control Unit for Spectrum Lamps (115 V, 50/60 Hz)	**1003195**
1	Spectral Lamp Hg 100	**1003545**
1	Convex Lens on Stem f =+50 mm	**1003022**
1	Convex Lens on Stem f =+100 mm	**1003023**
1	Iris on Stem	**1003017**
1	Glass Inset for Newton's Rings Experiments	**1008669**
1	Component Holder	**1003203**
1	Interference Filter 578 nm	**1008672**
1	Interference Filter 546 nm	**1008670**
1	Projection Screen	**1000608**
1	Barrel Foot, 1000 g	**1002834**
1	Pocket Measuring Tape, 2 m	**1002603**

BASIC PRINCIPLES

Newton's rings are a phenomenon which can be viewed on a daily basis. They arise due to interference in light reflecting from the upper and lower boundaries of an air gap between two very nearly parallel surfaces. In white light, this produces colourful interference, since the condition for a maximum in the interference is dependent on the wavelength.

In order to deliberately generate Newton's rings, a set-up is used which involves a flat glass plate and a spherical body with a large radius of curvature. The spherical body touches the flat glass plate in such a way that an air gap results. If parallel monochromatic light is incident on the set-up from an angle normal to the apparatus, alternating light and dark concentric rings are generated, centred on the point where the surfaces meet. The darker rings are caused by destructive interference while the light ones result from constructive interference. The light waves reflected from the boundary between the spherical body and the air interfere with ones reflected from the boundary between the flat plate and the air. The interference rings can be viewed in both reflected and transmitted light. With transmission, though, the interference is always constructive at the centre, regardless of the wavelength of the incident light.
The separation between the interference rings is not constant. The thickness d of the air gap varies in proportion to the distance r from the point of contact between body and plate. The following can be seen from Fig. 1:

(1) $$R^2 = r^2 + (R - d)^2$$

R: radius of curvature

This means that when the thickness d is small, the following applies for the bright interference rings:

(2) $$d = \frac{r^2}{2 \cdot R} = (n-1) \cdot \frac{\lambda}{2}\ ,$$

Therefore the radii of the bright rings are given by

(3) $$r^2 = (n-1) \cdot R \cdot \lambda\ .$$

It may be seen that the spherical body is slightly deformed at the point of contact. By rearranging equation (2) an approximation of this can be derived from the following expression:

(4) $$d = \frac{r^2}{2 \cdot R} - d_0 \quad \text{for} \quad r^2 \geq 2 \cdot R \cdot d_0$$

Therefore the radii of the bright rings are now given by:

(5) $$r_i^2 = (n-1) \cdot R \cdot \lambda + 2 \cdot R \cdot d_0$$

This experiment investigates Newton's rings using transmitted light from a mercury lamp which has been rendered monochromatic with the aid of interference filters. The interference pattern is focussed onto the screen with the help of an objective lens.

EVALUATION

To determine the radius r, an average is taken of the measured radius values for the crossover point to the left and right. The magnification due to the lens is also taken into account.
Values for r^2 are then plotted as a function of n-1, whereby the measurements lie on straight lines of gradients $a = R \cdot \lambda$ which cross the axes at $b = 2 \cdot R \cdot d_0$. Since the wavelengths are known, it is possible to calculate the radius of curvature R. This is approximately 45 m. The flattening d_0 of the sphere due to it pressing down on the plate is less than one micrometer.

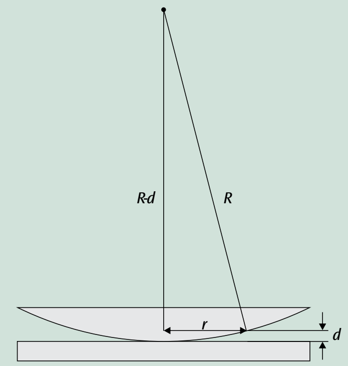


Fig. 1: Schematic illustration of the air gap between the convex lens and the flat plate

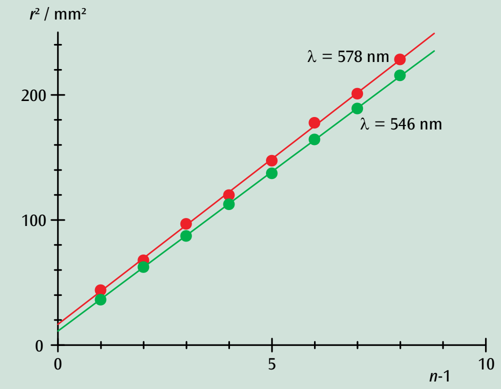


Fig. 2: Relationship between radii r^2 of bright interference rings and their number in sequence n

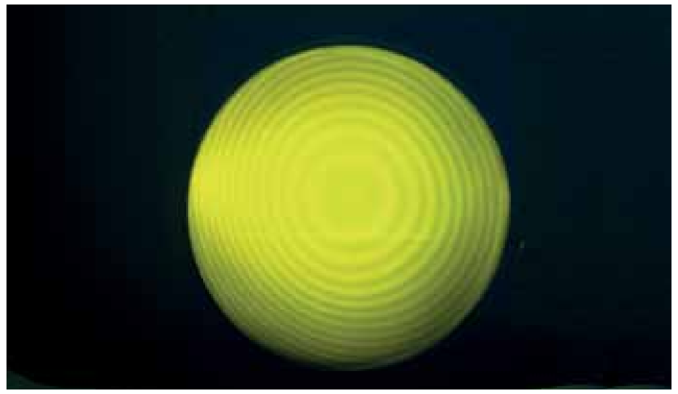


Fig. 3: Newton's rings in yellow light