Ep09 Newton's rings

OBJECTIVE

1. To understand the interference of light.
2. To learn how to measure the curvature radius of a convex lens using Newton'rings.

THEORY

Interference is a phenomenon common to all wave motion, whether mechanical, electrical, optical, acoustical or electromagnetic. A useful principle in analyzing wave motion is the principle of superposition: Two or more waves can be in the same space independently of one another, and their combined effect at any point is the sum of the individual effects. The 'combined effect' is actually the interference of the waves; it is constructive when the waves differ by a multiple of 2Pi, and it is destructive when the waves differ by an odd multiple of Pi.

If the convex surface of a lens is placed in contact with a plane glass plate, as in Fig 1, a thin film of air is formed between the two surfaces (the glass-air and the air-glass interfaces). The thickness of this film is very small at the point of contact, gradually increasing as one proceeds outward. The loci of points of equal thickness are circles concentric with the point of contact.

We consider monochromatic light incident along the normal on the plane surface of the lens. We view the reflected light from the glass-air and the air-glass interfaces, and observed a dark spot at the point of contact. At the point of contact, the rays reflected from the glass-air and the air-glass interfaces have zero path difference. The interference nonetheless is seen to be destructive. Since the path difference is zero, the two waves are out of phase because one reflected wave experienced no phase change upon reflection (the wave from the glass-to air reflection) while the other reflected wave had a phase change of π rad (the one from the air-to-glass reflection).

Note that the pattern of the constructive and destructive interference in the reflected light consists of a series of concentric circles, called **Newton's rings**, as shown in Fig 2 which trace out contours of constant thickness of the air gap between the surfaces.

If we view the transmitted light, the central spot is bright. There is no path difference between the transmitted waves, and no phase difference from reflection since the transmitted light is not reflected. The transmitted light also consists of a series of concentric bright and dark rings.

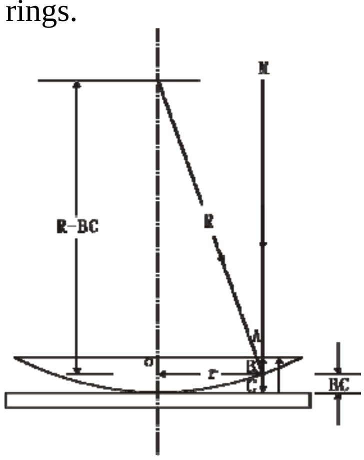

Fig1 Newton's rings device sketch map

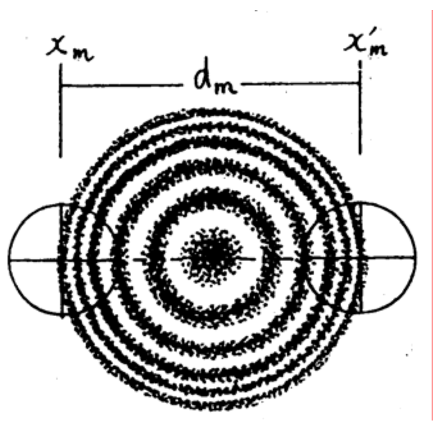

Fig2 Newton's rings in reflected light produce a dark spot at the point of contact.

In this lab, we will calculate curvature radius of lens using Newton'rings seen through microscope. Assume that the diameter of the mth Newton's ring and the nth Newton's ring are respective d_m and d_n, then we can calculate the curvature radius of lens using the following equation:

$$R = \frac{d_m^2 - d_n^2}{4(m-n)\lambda} \qquad (1)$$

The accurate value of n and m is not very important, but the difference between m and n must be known, and the difference value can't be too small, otherwise, the significant figures of d_m-d_n can't meet the requirement, which will increase the measurement error.

PROCEDURE

A. Adjust the device

(1) Adjust the ocular of the microscope until the cross hair "+" is clearest.

(2) Turn on the natrium light and make rays straight incident on the glass P, as shown in Fig 3. Put the Newton's rings device under the objective of the microscope; adjust the angle of glass P until the reflected yellow light can be seen.

(3) Rotate the hand wheel of the microscope to ascend or descent the objective drawtube until the Newton's rings can be seen clearly.

(4) Adjust the "+" in ocular until the "|" line is vertical to the transverse ruler.

B. Measuring the curvature radius of lens R

(1) Measuring the diameter of the Newton's rings

Measure the diameters of the Newton's rings from the 20th dark ring to the 6th dark ring (suppose that the first dark ring around the center is the 1st). Firstly, rotate the reading hand wheel until the cross hair is on the center of the Newton's rings. Count the ring series when you rotate the hand wheel continuously until the cross hair is on the middle of the 22th dark ring in left of the center, then rotate the hand wheel in the opposite direction and record the readings from the 20th in left to the 20th in right.

CAUTION

In order to eliminate the error from pitch difference, you must not rotate the hand wheel in the opposite direction when you record the readings.

DATA RECORDING AND PROCESSING

Ring series(m)	Position of the dark rings(mm)		Diameter of the dark rings(d_m)	Ring series(n)	Position of the dark rings(mm)		Diameter of the dark rings(d_n)	$d_m^2 - d_n^2$
	x_1(left)	x_2(right)			x_1(left)	x_2(right)		
20				10				
19				9				
18				8				
17				7				
16				6				

(2) Calculate the average of the diameter squared difference Δd^2 using the successive difference method ,and the curvature radius of lens R can be obtained from equation (1).

QUESTIONS

1 Why must the "|" line of the "+" in ocular be vertical to the transverse ruler? How to meet the requirement?

2 How to eliminate the error from pitch difference when you measure the diameter of the Newton's rings?