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暨南大学本科实验报告专用纸

课程名称 Physics Experiment 成绩评定 ____

实验项目名称 Newton's rings 指导教师 Zhang

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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 individuals effects. The 'combined effect' is actually the interference of the waves; it is constructive when the waves differ by a multiple of 2π, and it is destructive when the waves differ by an odd multiple of π.

If the convex surface of a ~~len~~ 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 ~~two paths~~ zero path difference. The interference nontheless is seen to be destructive. Since the path difference is zero, the ~~zero~~ 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~~ 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 ~~the~~ 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.

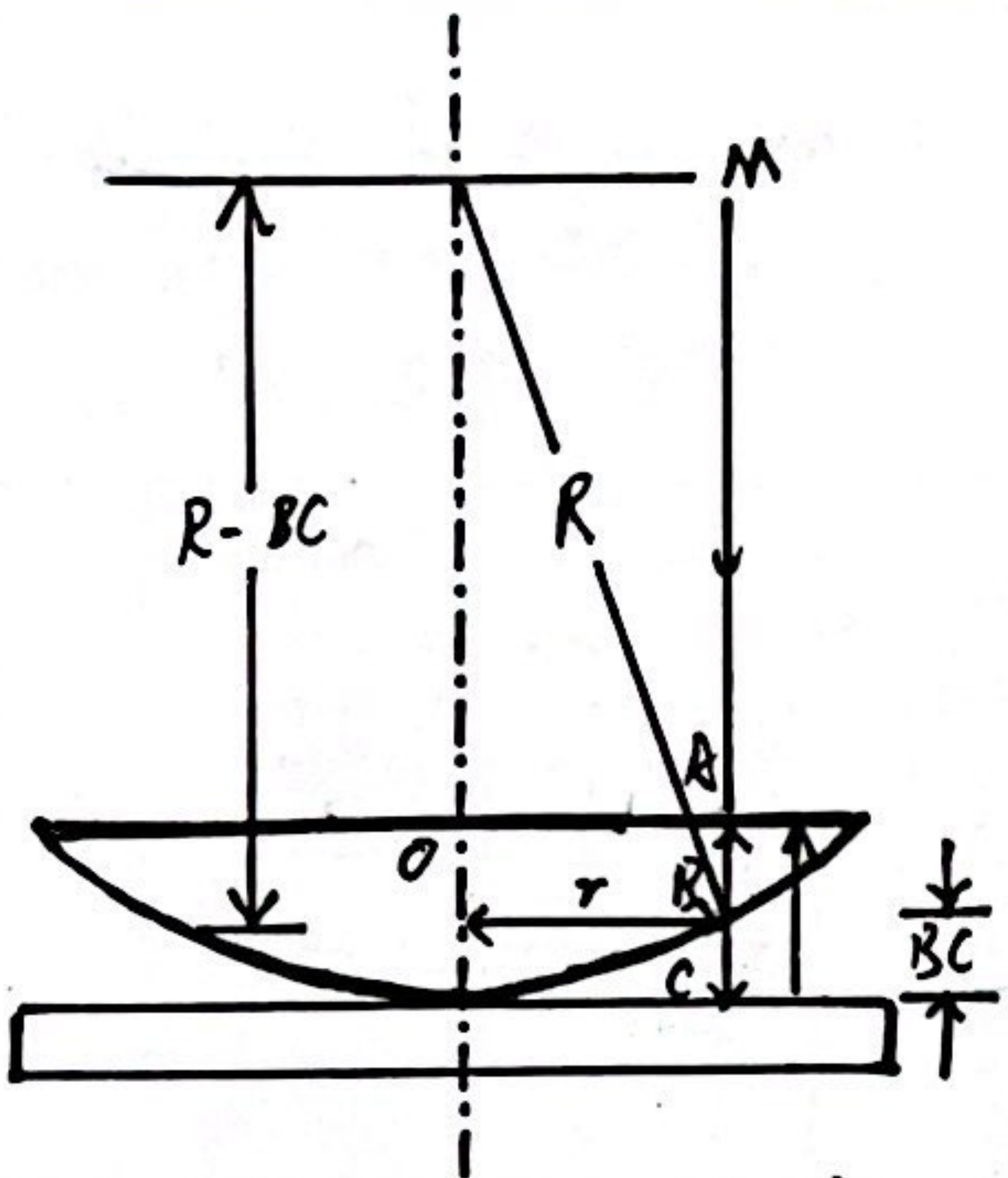

Fig 1. Newton's rings device sketch map

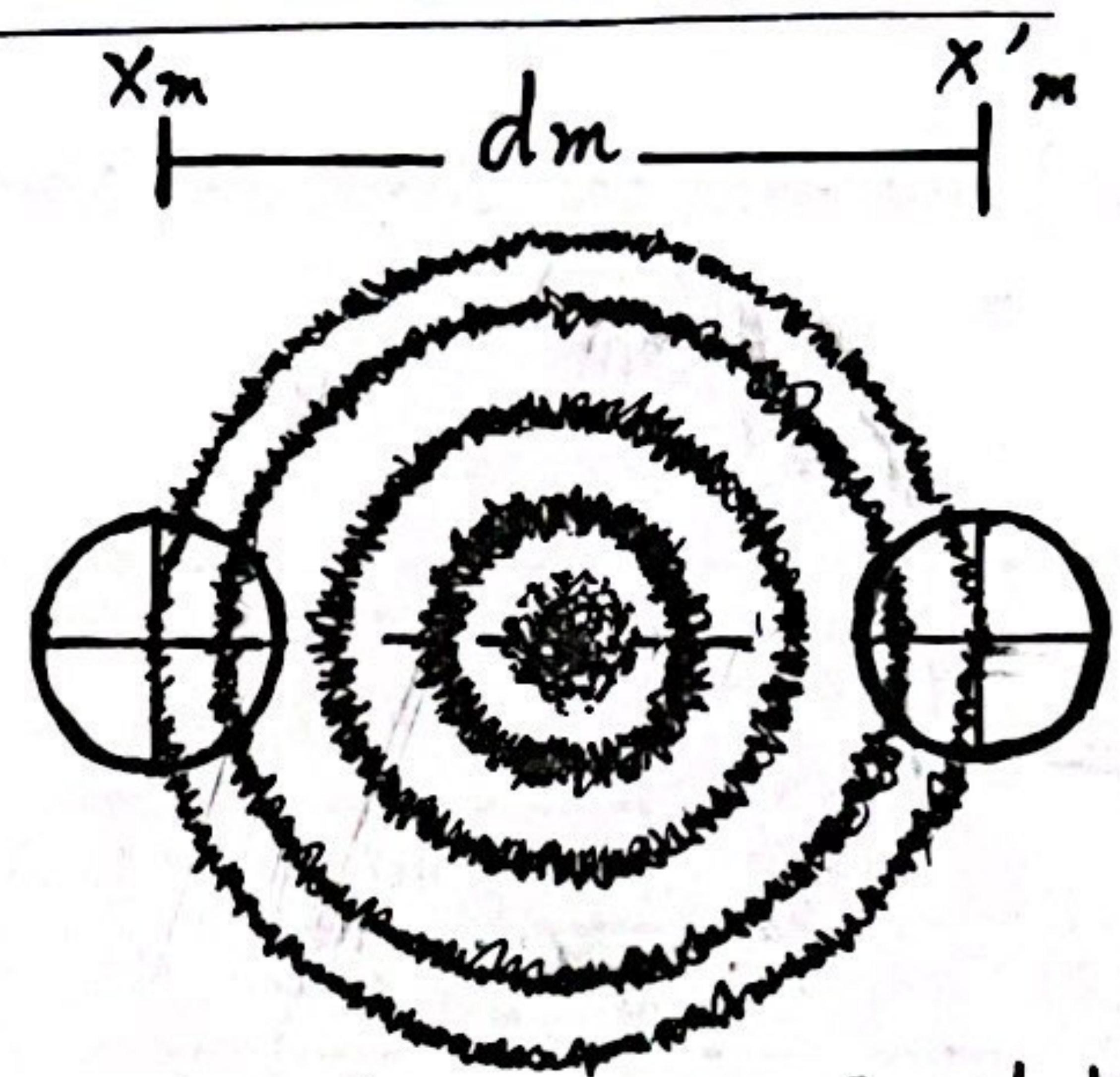

Fig 2 Newton's rings in reflected light produce a dark spot at the point of contact.

In this lab, we will calculate curvature radius of lens using Newton's rings seen through ~~mic~~ microscope. Assume that the ~~diamer~~ diameter of the m_{th} Newton's ring and the n_{th} 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 the clearest.

(2). Turn on the natrium light and make ~~a~~ 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 ~~been~~ be seen.

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

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

B. Measuring the diameter of the Newton's rings

(1) 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 ~~ha~~ 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 22nd dark ring in left of the center, then rotate the hand wheel in the opposite direction and record the readings ~~fo~~ from the 20th in left to the 20th in right.

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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 reading.

DATA RECORDING AND PROCESSING

Ring series (m)	Position of the dark rings (mm)		Diameter of the dark rings (d_m)	Ring series (m)	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	29.200	21.419	7.781	10	28.349	22.265	6.084	23.528905
19	29.120	21.488	7.632	9	28.245	22.368	5.877	23.708295
18	29.045	21.568	7.477	8	28.135	22.475	5.660	23.869929
17	28.954	21.659	7.295	7	28.030	22.581	5.449	23.525424
16	28.870	21.731	7.139	6	27.912	22.691	5.221	23.70648

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

Since the wave length of sodium light is $\lambda = 589.3\,nm = 5.893 \times 10^{-4}\,mm$. By using the successive ~~$d_{20}^2 - d$~~ difference method, I calculate the data as follows.

$d_{20}^2 - d_{10}^2 = 7.781^2 - 6.084^2 = 23.528905$, $d_{19}^2 - d_9^2 = 7.632^2 - 5.877^2 = 23.708295$,

$d_{18}^2 - d_8^2 = 7.477^2 - 5.660^2 = 23.869929$, $d_{17}^2 - d_7^2 = 7.295^2 - 5.449^2 = 23.525424$,

$d_{16}^2 - d_6^2 = 7.139^2 - 5.221^2 = 23.70648$

Hence, $\Delta d^2 = \frac{1}{5}(d_{20}^2 - d_{10}^2 + d_{19}^2 - d_9^2 + d_{18}^2 - d_8^2 + d_{17}^2 - d_7^2 + d_{16}^2 - d_6^2)$

$= \frac{1}{5} \times (23.528905 + 23.708295 + 23.869929 + 23.525424 + 23.70648)$

$= 23.6678066$

Using the formula $R = \frac{d_m^2 - d_n^2}{4(m-n)\lambda} = \frac{\Delta d^2}{4(m-n)\lambda}$, and $m-n = 10$, $R = \frac{\Delta d^2}{4(m-n)\lambda}$

$= \frac{23.6678066}{4 \times 10 \times 5.893 \times 10^{-4}} = 1004.66\,mm \approx 1.004\,m$

ERROR ANALYSIS

1. If there is dust at the contact point ~~when~~ between the lens and the flat glass, there will be additional optical path difference.
2. It is difficult to observe ~~the whether~~ whether the cross hair is aligned with the center of the dark spot, and there will be errors.
3. The image of the measured object is not in the same plane as the measuring ruler, which is prone to error.