格拉斯哥学院
UoG-UESTC Joint School

Physical Experiments I

Experiment Title- Newton's rings

Your Chinese Name-张立澄
(Student Number-2017200602011)

Instructor: Jing Wu

Teaching Assistant: Hao Wen

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Score

Abstract (About 50 words, 10 points)

The purpose of the Newton's rings experiment is to observe the phenomenon of Newton's rings formed by thin film interference, demonstrate the wave-like properties of the light, and get the radius of curvature of lens by measuring and calculating the experiment data after interference takes place with producing dark and bright circular fringes. Since errors must be reduced, I have to do above steps successively. Although the process is a little bit inconvenient, I have learn a lot from observing images, calculating, and analyzing reasons for different patterns by myself.

Score

Calculations and Results (Calculations, data tables and figures, more than 150 words, 20 points)

On the whole, configure the experimental setup, finish the experimental procedure step by step, and then analyze data combined physical experiments with the mathematical method to compute the radius of curvature, $\bar{R}$ of the lens, and the uncertainty of R.

(1) After measuring and calculating the experiment data successively, I get a table as following:

The order of the dark rings		30th	25th	20th	15th	10th	5th
readings (mm)	Left, D_L	37.270	36.789	36.241	35.653	34.946	34.010
	Right, D_R	25.701	26.178	26.701	27.303	27.995	28.910
Diameter(mm) $D=\lvert D_L - D_R\rvert$		11.569	10.611	9.540	8.350	6.951	5.100
D^2 (mm^2)		133.865	112.572	91.012	69.723	48.303	26.010
$\lvert D_m^2 - D_n^2\rvert(\text{mm})^2$ (m-n=15)		$D_{30}^2 - D_{15}^2$=64.142		$D_{25}^2 - D_{10}^2$=64.269		$D_{20}^2 - D_5^2$=65.002	
$\overline{D_m^2 - D_n^2}$ (mm)^2		64.471					
$\bar{R}$ (mm)		1823.398					

(2) The calculation process is shown as following:

(I)

30th: $D=\lvert D_L - D_R\rvert=\lvert 37.270-25.701\rvert=11.569(mm)$

25th: $D=\lvert D_L - D_R\rvert=\lvert 36.789-26.178\rvert=10.611(mm)$

20th: $D=\lvert D_L - D_R\rvert=\lvert 36.241-26.701\rvert=9.540\ (mm)$

15th: $D=\lvert D_L - D_R\rvert=\lvert 35.653-27.303\rvert=8.350(mm)$

10th: $D=\lvert D_L - D_R\rvert=\lvert 34.946-27.995\rvert=6.951(mm)$

5th: $D=\lvert D_L - D_R\rvert=\lvert 34.010-28.910\rvert=5.100\ (mm)$

(II)
30th: $D^2 = |D_L - D_R|^2 = 133.865(mm^2)$
25th: $D^2 = |D_L - D_R|^2 = 112.572\ (mm^2)$
20th: $D^2 = |D_L - D_R|^2 = 91.012(mm^2)$
15th: $D^2 = |D_L - D_R|^2 = 69.723\ (mm^2)$
10th: $D^2 = |D_L - D_R|^2 = 48.303(mm^2)$
5th: $D^2 = |D_L - D_R|^2 = 26.010(mm^2)$

(III)
$D_{30}^2 - D_{15}^2 = 64.142(mm^2)$
$D_{25}^2 - D_{10}^2 = 64.269(mm^2)$
$D_{20}^2 - D_5^2 = 65.002(mm^2)$

(IV) $\overline{D_m^2 - D_n^2} = \frac{64.142+64.269+65.002}{3} = 64.471(mm^2)$

(IV) $\bar{R} = \frac{\overline{D_m^2 - D_n^2}}{4(m-n)\lambda} = \frac{64.471}{4\times15\times588.9950\times10^{-6}} = 1823.398$ (λ=588.9950 nm)

(3) The uncertainty of R and some steps are shown as following:

(I) $S_{(D_m^2-D_n^2)} = \sqrt{\frac{\sum[(D_m^2-D_n^2)_i - \overline{(D_m^2-D_n^2)}]^2}{3\times(3-1)}} = \sqrt{\frac{(64.142-64.471)^2+(64.269-64.471)^2+(65.002-64.471)^2}{3\times(3-1)}} = \sqrt{\frac{0.108241+0.040804+0.281961}{3\times(3-1)}} = \sqrt{\frac{0.431006}{3\times(3-1)}} = 0.268(mm)$

(II) $\mu_{(D_m^2-D_n^2)-Read.} = \frac{\Delta_{Read.}}{\sqrt{3}} = \frac{0.002}{\sqrt{3}} = 0.00115(mm)$

(III) $\mu_{(D_m^2-D_n^2)-Instr.} = \frac{\Delta_{Instr.}}{\sqrt{3}} = \frac{0.005}{\sqrt{3}} = 0.00289(mm)$

(IV) $\sigma_{(D_m^2-D_n^2)} = \sqrt{S_{(D_m^2-D_n^2)}^2 + \mu_{(D_m^2-D_n^2)-Read.}^2 + \mu_{(D_m^2-D_n^2)-Instr.}^2} = \sqrt{(0.268)^2 + (0.00115)^2 + (0.00289)^2} = 0.268(mm)$

(V) $\sigma_{\bar{R}} = \frac{\sigma_{(D_m^2-D_n^2)}}{4(m-n)\lambda} = \frac{0.268}{4\times15\times588.9950\times10^{-6}} = 7.991(mm)$

(4) After comprehensive analysis and calculation repeatedly by myself. Ultimately, I get $R = \bar{R} + \sigma_{\bar{R}} = 1823.398 \pm 7.991 = 1823 \pm 8(mm)$

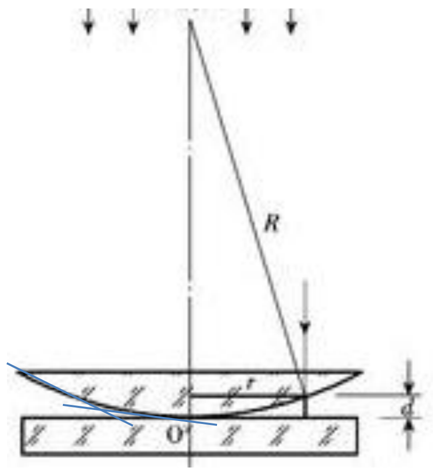
Score

Answers to Questions (10 points)

（1） At the center, the central connection point of the lens and the glass plate, a dark circle is formed. The rings alternate colorful（like rainbow colors） concentric rings around the center, and the distance of fringes is sparse inside and dense outside with color changed periodically.

（2） There is interspace between the lens and the glass plate (the contact is dusty, or damaged), causing optical path difference increased. It will not affect the measurement results if we keep the bright circle in the center.

（3） No, it isn't. The distance of fringes is sparse inside and dense outside, because the center slopes gently and the slope changes more dramatically when close to the convex of lens (as can be seen from the following picture).



Appendix

(Scanned data sheets)

3.6.5 Experiment Data

Data Table 3.6-1 ***Purpose*: To measure the radius of curvature of a lens**

wavelength $\bar{\lambda} = \frac{1}{2}(\lambda_1 + \lambda_2) = \frac{1}{2}$(588.9950 589.5924) 589.2937 nm

The order of the dark rings		30th	25th	20th	15th	10th	5th
Readings /mm	Left, D_L	37.270	36.789	36.244	35.653	34.945	34.010
	Right, D_R	25.701	26.178	26.704	27.303	27.995	28.910
Diameter /mm $D = \lvert D_L - D_R \rvert$		11.569	10.611	9.540	8.350	6.950	5.100
D^2 /mm^2		133.865	112.572	91.012	69.723	48.303	26.010
$\lvert D_m^2 - D_n^2 \rvert$ / mm^2 ($m-n = 15$)		$\lvert D_{30}^2 - D_{15}^2 \rvert =$ 64.142		$\lvert D_{25}^2 - D_{10}^2 \rvert =$ 64.269		$\lvert D_{20}^2 - D_5^2 \rvert =$ 65.002	
$\overline{\lvert D_m^2 - D_n^2 \rvert}$ /mm^2		64.471					
$\bar{R} = \frac{D_m^2 - D_n^2}{4(m-n)\lambda}$ /mm		$\frac{64.471}{4 \times 15 \times 589.2937 \times 10^{-6}} = 1823.398$					

Your name and student number: 张立滢 2017200602011 Instructor's initial: Jing Wu.