Physical Experiment I

Experimental Title

Newton's rings

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Date Performed:

Overall

Score

Abstract (About 100 words, 10 points)

When we detect the curvature of the glass lens, we based on the following equations:

$$D_m^2 = 4mR\lambda \qquad D_n^2 = 4nR\lambda$$

$$R = \frac{D_m^2 - D_n^2}{4(m-n)\lambda}$$

We use the successive minus method to measure the result in order to avoid some errors like the dirt on the lens and the errors generated when we operate these precise equipment which influence the result of the radius.

This experiment like many other classic experiments which demonstrate the wave-like properties of the light. When those two branch of waves with equal intensity come across, the intensity of the resulting wave can happened at anywhere between zero and four times the intensity of their individual waves, which depend upon the length of the phase difference between them.

What we do next is to follow the experiment trace and get the final result.

Score

Calculations and Results (Calculations, data tables and figures; Use about 100 words to describe your results, 20 points)

1. First of all, in order to measure the Newton's Rings, we operate the equipments and find the rings. After we could see the rings, we make sure the 'cross hairs' is clear for us to observe. Then, we suppose that the first dark ring in the left that close to the center is the 5^{th} ring. From this ring, counting the rings one by one until finding the 35^{th} ring(we need it to rote farer than 35^{th} ring). Then

rotate the wheel reversely and count the rings, and read the scale on the traveling microscope every five rings.

2. Keep rotating the wheel and make the cross hairs cross the center. When finding the 30th ring in the right side, We read its position, and read the scale on the traveling microscope every five rings from 30th to 5th and from 5th to 30th(vise versa)

Calculation

For the constructive interference, we can get the follow equations.

$$d=(m-\frac{1}{2})\times\frac{\lambda}{2}$$

$$d=\frac{m\lambda}{2}$$

Because of d is extremely small when it compared to R and we can assume that $d^2 \ll Rd$, therefore, we can just neglect the d^2. So, se can get.

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

$$r^2=2Rd-d^2=2Rd=mR\lambda$$

Suppose that D_m and D_n are the diameters of two dark rings and we define that (m-n=15).

$$D_m^2=4mR\lambda \qquad D_n^2=4nR\lambda$$

$$R=\frac{D_m^2-D_n^2}{4(m-n)\lambda}$$

$$R=1245\pm 40(mm)$$

The next is the data and the calculation of the result and the uncertainty.

$$D_{10}=\left|D_L-D_R\right|=5.892(mm)$$

$$D_{10}^2=\left|D_L-D_R\right|^2=34.71(mm^2)$$

$$D_5=\left|D_L-D_R\right|=4.350(mm)$$

$$D_5^2=\left|D_L-D_R\right|^2=18.92(mm^2)$$

$$\left|D_{20}^2-D_5^2\right|=44.60(mm^2)$$

$$D_{30} = \left|D_L - D_R\right| = 9.636(mm)$$

$$D_{30}^2 = \left|D_L - D_R\right|^2 = 92.85(mm)$$

$$D_{25} = \left|D_L - D_R\right| = 8.820(mm)$$

$$D_{25}^2 = \left|D_L - D_R\right|^2 = 77.79(mm)$$

$$\left|D_{30}^2 - D_{15}^2\right| = 44.33(mm^2)$$

$$D_{20} = \left|D_L - D_R\right| = 7.970(mm)$$

$$D_{20}^2 = \left|D_L - D_R\right|^2 = 63.52(mm^2)$$

$$D_{15} = \left|D_L - D_R\right| = 6.965(mm)$$

$$D_{15}^2 = \left|D_L - D_R\right|^2 = 48.51(mm^2)$$

$$\left|D_{25}^2 - D_{10}^2\right| = 43.08(mm^2)$$

$$\left|\overline{D_m^2 - D_n^2}\right| = 44.00(mm^2) \quad (m - n = 15)$$

$$\overline{R} = \frac{\left|\overline{D_m^2 - D_n^2}\right|}{4\left|m-n\right|\lambda} = 1245(mm)$$

$$\mu_{A-(D_m^2-D_n^2)} = \sqrt{\frac{\sum\left[(\left|D_L - D_R\right|)_i - \left|\overline{D_m^2 - D_n^2}\right|\right]^2}{3\times(3-1)}} = \sqrt{\frac{0.1089+0.8464+0.3600}{6}} = 0.4682(mm)$$

$$\mu_{read-(D_m^2-D_n^2)} = \frac{\Delta_{read}}{\sqrt{3}} = 0.0012(mm)$$

$$\mu_{Instr.-(D_m^2-D_n^2)} = \frac{\Delta_{Instr.}}{\sqrt{3}} = 0.0029(mm)$$

$$\mu_{B-D} = \sqrt{\mu_{read-(D_m^2-D_n^2)} + \mu_{Instr.-(D_m^2-D_n^2)}} = 0.0632(mm)$$

$$\mu_{B-(D_m^2-D_n^2)} = 2\mu_{B-D}\sqrt{D_m^2 + D_n^2} = 1.503(mm)$$

$$\sigma_{(D_m^2-D_n^2)} = \sqrt{\mu^2_{A-(D_m^2-D_n^2)} + \mu^2_{B-(D_m^2-D_n^2)}} = 1.404(mm)$$

$$\sigma_{(\overline{R})} = \frac{\sigma_{\left|D_m^2-D_n^2\right|}}{4\left|m-n\right|\lambda} = 39.71(mm)$$

Finally I get the final result:

$$R = 1245 \pm 40(mm)$$

Score

Answers to Questions (10 points)

(1)We use sodium light lamp in this experiment. It can be treated as monochromatic light because the double line are very close. If we use polychromatic light, what will happen?

Because if we use the sodium lamp to be the light source, we can see the limpid Newton's rings as it can be treated as monochromatic light after it go through the close double line. Only using the monochromatic light can display the Newton's ring clearly. However, if we use polychromatic light as the source of the light, what we can see will be similar to be many rings with the colors of the rainbow but the center of that circle will be dark.

(2)If there is a bright circle in the center for the Newton's rings, not a dark circle, that would be the reasons? Will it affect the measurement results if we keep the bright circle in the center?

The reason why the center of the rings appears a bright spot but not the dark one is because the contact between spherical and plane glass may be not so tight (may be there are some dust, or any breakage or abrasive wear between the contact of spherical and plane glass). This would generate the difference on the additional optical path,and this difference have no effect on the final results(if the rings are still in a shape of circle).

(3)Is the distance between two adjacent bright ring and dark ring equal for the newton's rings, Why?

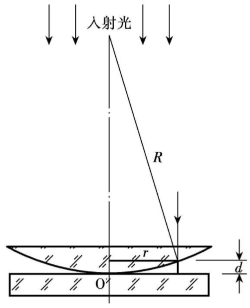
It is not equal. It will be more and more close as the distance between the adjacent bright ring and dark ring with increasing of the diameter. We can get this solution by constructing a right triangle.

$$d = k^2 + \lambda^2$$

$$r^2 = R^2 - (R - k\lambda)^2 \quad (R \gg d)$$

$$r = \sqrt{2Rk\lambda}$$

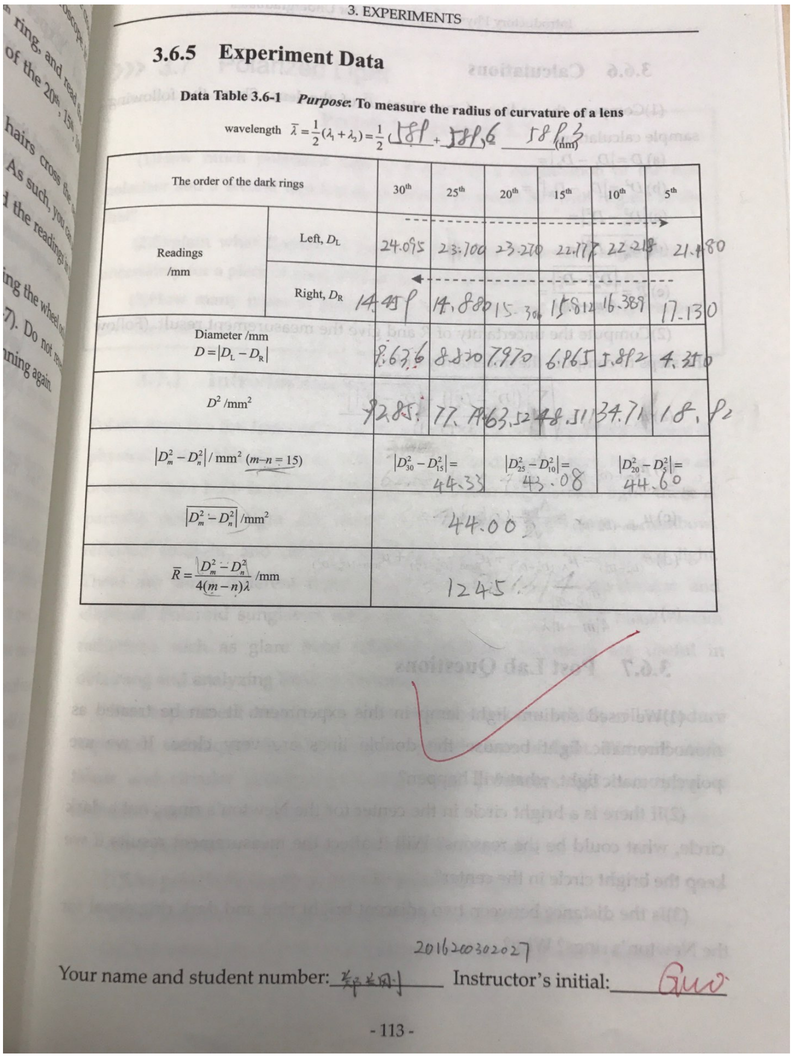
$$\frac{dr}{dk} = \frac{2}{\sqrt{\frac{2k}{R\lambda}}}$$



We can know that the optical path difference increase faster and the dense of the rings will increase when the diameter rise.

Appendix

(Scanned data sheets)



3. EXPERIMENTS

3.6.5 Experiment Data

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

wavelength $\bar{\lambda} = \frac{1}{2}(\lambda_1 + \lambda_2) = \frac{1}{2}$ (581 + 581.6) = 581.3 (nm)

The order of the dark rings		30th	25th	20th	15th	10th	5th
Readings /mm	Left, D_L	24.095	23.700	23.270	22.777	22.218	21.480
	Right, D_R	14.458	14.880	15.300	15.812	16.389	17.130
Diameter /mm $D = \lvert D_L - D_R \rvert$		9.637	8.820	7.970	6.965	5.892	4.350
D^2 /mm^2		92.85	77.79	63.52	48.51	34.71	18.92
$\lvert D_m^2 - D_n^2 \rvert$ / mm^2 ($m-n = 15$)		$\lvert D_{30}^2 - D_{15}^2 \rvert$ = 44.33		$\lvert D_{25}^2 - D_{10}^2 \rvert$ = 43.08		$\lvert D_{20}^2 - D_5^2 \rvert$ = 44.60	
$\overline{\lvert D_m^2 - D_n^2 \rvert}$ /mm^2		44.00					
$\bar{R} = \frac{\overline{\lvert D_m^2 - D_n^2 \rvert}}{4(m-n)\lambda}$ /mm		1245					

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