WAVES AND OPTICS

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Atul Singh Arora: *Waves and Optics*, Physics Lab III, *Every honest researcher I know admits he's just a professional amateur. He's doing whatever he's doing for the first time. That makes him an amateur. He has sense enough to know that he's going to have a lot of trouble, so that makes him a professional.*

— Charles F. Kettering (1876-1958) (Holder of 186 patents)

ACKNOWLEDGEMENTS

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I also thank Vivek Sagar (MS11017) for his contribution to this report as my lab-partner, who made the task of performing experiments immensely comfortable and productive at the same time.

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NEWTON'S RING

August 14 and 21, 2012

1.1 AIM

To study the fringes of equal thickness in the Newton's ring setup and hence determine the wave-length of sodium light.

1.2 APPARATUS

Sodium vapour lamp, travelling microscope, lens assembly consisting of a plane glass plate and a planoconvex lens, spherometer, magnifying glass, vernier callipers and a tiltable glass plate assembly.

1.3 THEORY

Light when shone on a plano-convex lens in contact with a flat glass plate, produces circular successive dark and bright interference fringes, called Newton's rings. The radius of these fringes depends on both the wavelength and the radius of curvature of the lens. The objective of the experiment is to determine the wavelength of light, by experimentally determining the radius of curvature and analysing the fringes.
To derive the basic relationship, let's first consider the geometry of the problem (refer to Figure 2). For a spherical lens of radius of curvature R, consider a circle at a distance d from the bottom plane, with radius r. Invoking Pythagoras Theorem, we have

$$d = R - (R^2 - r^2)^{1/2} \tag{1}$$

Now let's consider a thin film problem (refer to Figure 3). Optical path distance can be evaluated as $n_2(AB + BC) - n_1(AD)$. Also, from geometry, we have $AB = BC = \frac{d}{\cos\theta_2}$. Plus, $AD = 2d(\tan\theta_2 \sin\theta_1)$. Therefore from Snell's Law, we can further simplify the optical path difference to $2n_2 d(\frac{1-\sin^2\theta_2}{\cos\theta_2})$ which can be rewritten as:

$$2n_2 d\cos\theta_2 = m\lambda \tag{2}$$

for constructive interference.

For newton's ring, we can approximate $\cos\theta_2$ to be 1. Thus we have $2nt = (m + \frac{1}{2})\lambda$ where $n = 1$ for air. We therefore get

$$2nt = (m + \frac{1}{2})\lambda \tag{3}$$

for the bright interference, m=0,1, etc.
We also have $r_m = (R\lambda m)^{1/2}$ from which we obtain directly a linear relation

$$(D_m)^2 = 4R\lambda m \tag{4}$$

Further, we can use the difference to evaluation λ as follows:

$$\frac{(D_{m+n})^2 - (D_m)^2}{4Rn} = \lambda \tag{5}$$

1.4 OBSERVATIONS AND CALCULATIONS

h was found out to be 0.25 mm = 0.025 cm.
l was found out to be $\frac{4.668+3.874}{2} = 4.271$ cm. (For details, refer to Table 2)
Using these, $R = \frac{l^2}{6h} + \frac{h}{2}$ turns out to be 121.6211 cm.

Observations for diameter of the ring are given in Table 1.
Slope of the graph of Diameter Squared, D_m^2 vs Order of Ring, m was found to be 0.0291 cm. (Figure 1)
Using the relation

$$(D_m)^2 = 4R\lambda m \tag{6}$$

$\lambda = 598.16 \pm 3.25\%$ nm (where the error is calculated from the standard deviation of the slope).

1.5 RESULT

The expected wavelength of sodium vapour lamp is 589.5 nm.
Experimentally, the wavelength, λ was found to be
$598.16 \pm 3.25\%$ nm (standard deviation of the slope).
Accuracy error is 1.5%, within the precision.

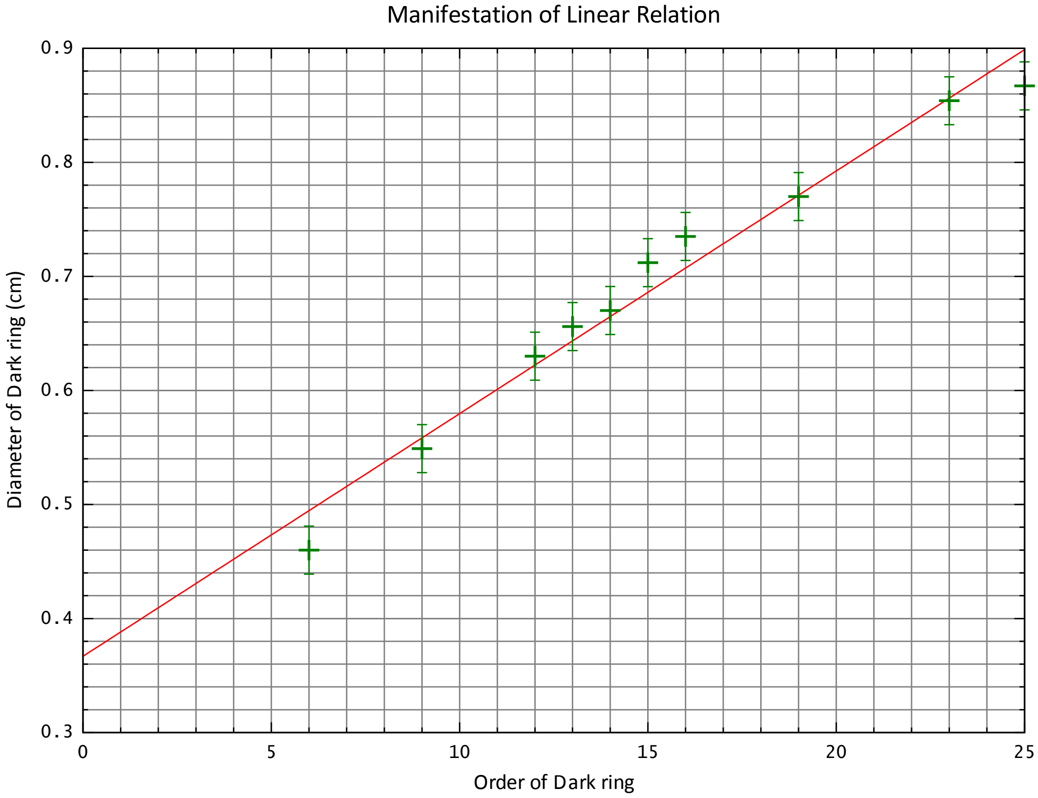
ORDER OF DARK RING m	LEFT (CM)	RIGHT (CM)
6	5.800	6.260
9	5.755	6.304
12	5.720	6.350
13	5.704	6.360
14	5.700	6.370
15	5.670	6.382
16	5.665	6.400
19	5.650	6.420
23	5.605	6.459
25	5.600	6.467

Table 1: Diameter of Newton's Ring

MAIN SCALE (CM)	VERNIER SCALE DIVISION	READING (CM)
OUTER l		
4.6	34	4.668
4.6	35	4.670
4.6	34	4.668
INNER l		
3.8	37	3.874
3.8	38	3.876
3.8	37	3.874

Table 2: Measurement of l of spherometer

Experiment: Newton's Rings




```
Slope of Best Fit Line          : +0.0213
Intercept of Best Fit Line      : +0.3669
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Performed on: August 14, 2012
Performed by: Vivek Sagar and Atul Singh Arora
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Figure 1: Least Square Fit of Diameter Squared vs Order of Ring

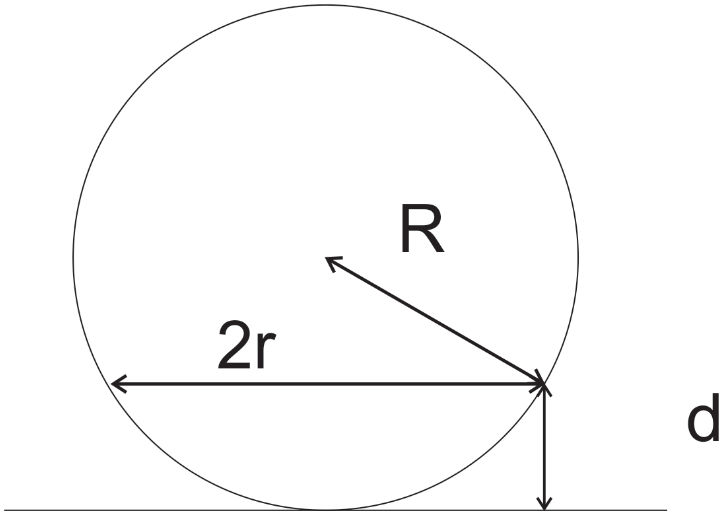

Figure 2: Spherical Lens

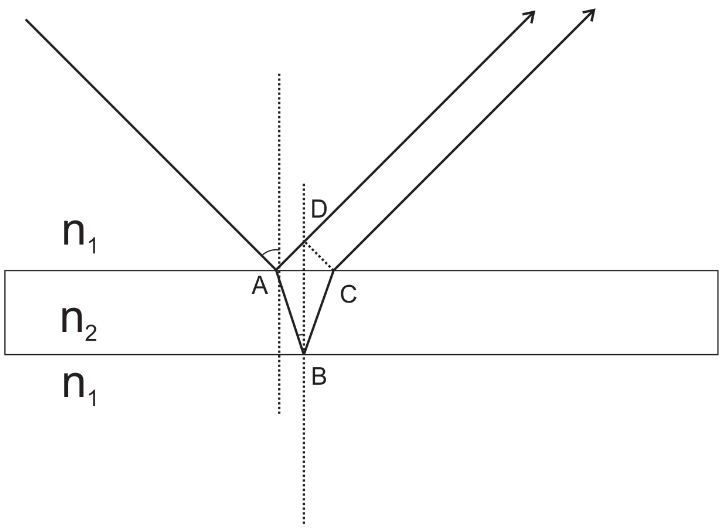

Figure 3: Thin Film Interference

Part II

THE SHOWCASE

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COLOPHON

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https://github.com/toAtulArora/IISER_repo