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Effect of Light Intensity on Newton's Rings Diameter

Research question: How does the variation in the intensity of incident light influence the radius of Newton's rings formed in the interference pattern between a plano-convex lens and a flat glass surface?

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Introduction

The study of the behaviour of light rays and fluids has always been intriguing, the contrast of fluid viscosity and the concept of light have very few physical and experimental connections to research and develop on real-world issues. This paper addresses these issues with a tested and elegant method of forming Newton's rings in a controlled environment to observe the viscosity and elementary properties of the plano-convex lens using the mean of n diameters produced by the light that is reflected on a droplet of fluid.

This phenomenon occurs because of the intricate reflective and diffractive properties of a fluid that has a certain viscosity. The light ray produced by the flashlight* diffracts and passes through the plano-convex lens and a minuscule air film and reflects towards the second mirror that changes its angle by theta towards the observer, allowing us to observe and measure the rings produced.

The phenomenon covered in this paper explores the intricacies of the experiment and the data needed to calculate and get results for observing and determining the properties of both the plano-convex lens and the viscosity of the fluid used. The experiment here can also be used to determine specific wavelengths of monochromatic light that can have a positive impact on health-related problems such as spring asthenia, circadian rhythm disruption, and even bipolar disorders and Alzheimer's.

Background information

Newton's rings were discovered in 1666, they are generated because of interaction betweenlight waves and a fluid droplet, cast back from the top and bottom surfaces of the air filmformed between the lens and glass sheet, they have had been and are currently being used tocheck the quality of optical surfaces and to find the wavelength of monochromatic light.Newton's rings were used for the filming, display of blueprints, movies and also in the making
of film.

These rings pertain to a phenomenon of diffraction and interference of light-carrying particlesand fluids of varying viscosity. This paper explores the Effect of Light Intensity on Newton's Ring diameters. The experiment under controlled environments can help determine theviscosity of a fluid and the properties of a plano-convex lens.

<u>Importance</u>

Plano-convex lenses are used in magnifiers, telescopes, collimators, condensers, and imaging instruments, they are extensively used in quantum mechanical and laser setups and an extremely small difference in properties can affect the results, this method in a controlled setup can yield precise results with close to zero error.

By varying the intensity of light we can measure and determine the change in the diameterand in turn, the radius of the rings formed, which would give us an insight on the viscosity of
the fluid and the properties of the plano-convex lens.

Thus the diameter of the n^{th} bright ring is:

$$\left(\frac{D_n}{2}\right)^2 = (2n-1)\frac{\lambda R}{2\mu}$$

$$D_n^2 = 2(2n-1)\frac{\lambda R}{\mu}$$

$$D_n = \sqrt{2(2n-1)\frac{\lambda R}{\mu}}$$

The radius of the n^{th} bright ring becomes:

$$r_n = \sqrt{\frac{(2n-1)}{2}\lambda R}$$

Apparatus

Table 1: shows the complete list of apparatus used

Apparatus	Quantity/Amount
Flat Glass surface	1
Plano-convex lens	1
Intensity controllable Flashlight	1
Digital Vernier Caliper	1

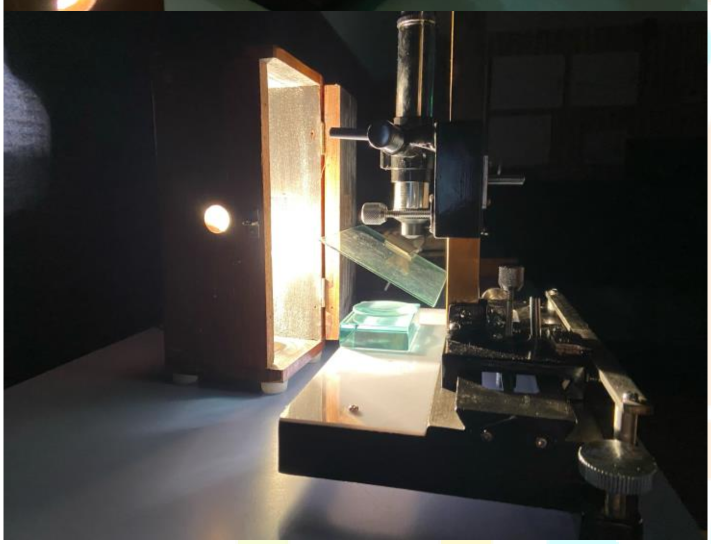
Retort stand	2
Water	__ml
Rheostat	1
Switch	1
Copper wires	
Sodium Vapor lamp	1
Droplet fitting(3D printed)	1
Wire clips	3
dropper	1
Leveling tool	1
Power supply	1
Set Square	1
Micrometer	1

1.1

Methodology

1. Sterilize the apparatus, including the retort stand.
2. Ensure that the room is significantly dark for better observation.
3. Distill the fluid if possible, if water on 110 degrees for 2 minutes.
4. Prepare a towel and the necessary fluids that will be used for the experiment.
5. Using a levelling tool, find a level surface.
6. Set the retort stand on the level surface.
7. Set up the experimental apparatus by placing the glass surface on the retort stand.
8. Place the sodium vapour lamp on an adjustable stand to control the distance and angle of the lamp in front of the travelling microscope.
9. After ensuring that the Plano-convex lens and the flat glass surface are free of debris and clean.
10. Place the glass surface on the base of the travelling microscope.
11. With a focal length of 20cm, place the second lens in front of the microscope.
12. For the parallel beam of light, the distance from the lens to the source should be 20cm.
13. The glass being held by the retort stand must be placed at a 45-degree angle.
14. Carefully place the plano-convex lens on the glass surface, creating a thin air gap between them.
15. Turn on the sodium vapour lamp and adjust its height and angle to illuminate the glass and lens setup.
16. Use a micrometre to control the thickness of the air gap between the glass and lens.
17. Gradually adjust the air gap until Newton rings can be observed.
18. Observe the Newton rings.
19. Adjust the lamp's intensity and use the vernier caliper to measure the thickness of one of the rings.

20. Analyze the data to observe any patterns or relationships between the intensity of the light and Newton's ring diameter.
21. Document the setup, observations, and measurements clearly.
22. Draw conclusions based on observations and measurements.



The environment for this experiment has to be sterilized and has to be performed in a setting with no vibrations or in an extremely bright environment with strobing of moving lights, which could affect the results produced by this experiment by either human error or disturbances in the carefully curated setup.

Hypothesis

<u>Null hypothesis(H_0):</u>

There is no significant relationship between the intensity of the incident light and the diameter of the newton rings formed in the interference pattern between the flat glass surface and the plano-convex lens on top.

<u>Alternative hypothesis(H_1):</u>

There is a significant relationship between the intensity of the incident light and the diameter of the Newton rings formed in the interference pattern between the flat glass surface and the plano-convex lens. As the intensity of the incident light increases, the diameter of the rings present also increases, an enhanced contrast between the rings is observed and there may be changes in the interference patterns themselves in accordance with the arrangement and spacing.

Variables

Table 2: shows the independent variable, how it was varied and why it was varied.

Independent Variable	How it was varied	Why it was varied
The intensity of the incident light	The intensity of the flashlight using a variable resistor/rheostat	The different intensities of light produced different diameters in the Newton's rings that are produced.

1.2

Table 3: shows the dependent variable, how it was measured and why it was measured.

Dependant variable	How it was measured	Why it was measured
The diameter of the Newton rings produced	Digital Vernier Calliper and a microscope	To quantity how changes in intensity impact the interference patterns

1.3

Table 4: Shows the controlled variables, how it was controlled, why they were controlled and the uncontrolled variables with the significance.

Controlled variable	How it was controlled	Why it was controlled
Water film thickness	Using a 3D printed droplet fitting and using a pipette to drop exactly __ml of water	To make sure that the rings formed were roughly the same size and number.
Temperature and environmental conditions	By performing the experiment in a sterilized and slightly dark environment	To make sure that the temperature of the fluid did not affect the results on the newton's rings.
Position of the flashlight	Using a clamp and screw retort stand	Different positions of the flashlight could vary the intensity of light reflected by the lens.
Calibration of the Vernier Calliper	By noting down the start readings and calibrating it to the initial calibration	Deferred readings could affect the error rate and the results of the wavelength calculated.
The plano-convex lens and the flat glass surface	By using the same lens-glass combination	Different lenses have different properties that could affect the result of the results.

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Risk assessment

Table 5: Shows the risk assessment for this particular experiment

Risk	Material/ Procedure	Hazard	Safety precaution	Level of risk
Wavelength and reflection of monochromatic light	Lasers and certain flashlights produce monochromatic light, whose wavelengths need to be determined.	Wavelength of monochromatic light may cause damage to the eyes and brain	Safety goggles and general head covering	Low
Voltage of battery used.	High voltage batteries and altered circuits to add a variable resistor to change the wavelength of light	Electricity and voltage	Rubber gloves and shoes	Medium
Glass Breakage	Use of fragile glass materials	May break during handling or adjustments	Handle glassware with care. If breakage occurs,	Low

			safely clean up the glass and dispose of it properly.	
Heat Hazard	The sodium vapour lamp may produce heat.	May lead to burns or a fire.	Allow the lamp to cool before handling. Keep flammable materials away from the lamp. Use appropriate heat-resistant materials.	Medium
Micrometer	Adjusting the air gap using the micrometre.	Pinching fingers of hands when adjusting.	Use tools carefully, and be mindful of hand placement.	Low

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Environmental and Ethical Considerations

Careful attention must be paid to the environmental considerations to minimize the ecological footprint associated with this research. Utilizing an energy-efficient lighting source and equipment will reduce the overall energy consumption of the experiment hence contributing to a more sustainable approach. Additionally, prioritising the safe disposal of material after use and ensuring that any chemical components are discarded in accordance with regulations and choosing materials that create minimal environmental impact. Ensuring the research is done on ethical grounds is of paramount importance, it adheres to all safety precautions and does not compromise the safety of the experimenter or the surroundings.

Results

Raw data

Quantitative data

The wavelength of the light can be calculated using:

The intensity (I) of light can be related to the number of photons per unit time and area. The energy (E) of a photon is directly related to its wavelength (λ) through the equation:

$E= hc/\lambda$

Where:

- E is the energy of the photon
- H is Planck's constant (6.62607015×10^{-34} joule-hertz^{-1})
- C is the speed of light (299 792 458 m / s/ $3.0*10^{8}$m/s)

- λ is the wavelength of light.

The intensity (I) of light can be related to the energy (E) of photons per unit time and area using the formula:
I = P/A
Where:
- I is the intensity of light,
- P is the power of the light source (energy per unit time)
- A is the area over which the light is distributed.

Now, we can connect this intensity equation to the equation for the energy of a photon.
The power, P can be expressed as the product of the energy of each photon and the number of photons per unit time:
P = nE
Where:
- n is the number of photons per unit time.

Hence,
I = nE/A
I = n*hc/A

1. Focal length: 20cm same
2. The curvature of the lens: 20cm
3. λ was taken as 600* 10^{-2}

	Intensity	**Intensity**	**Intensity**	**Intensity**	**Intensity**
Intensities Taken (_W/m^2)	0.359	0.331	0.326	0.32	0.276
Trial 1: radius(mm)	0.015	0.018	0.06	0.14	0.25
Trial 2: radius (mm)	0.017	0.021	0.07	0.17	0.26
Trial 3: radius (mm)	0.015	0.019	0.06	0.15	0.24
Trial 4: radius (mm)	0.016	0.018	0.05	0.14	0.25
Trial 5: radius (mm)	0.014	0.015	0.04	0.13	0.023

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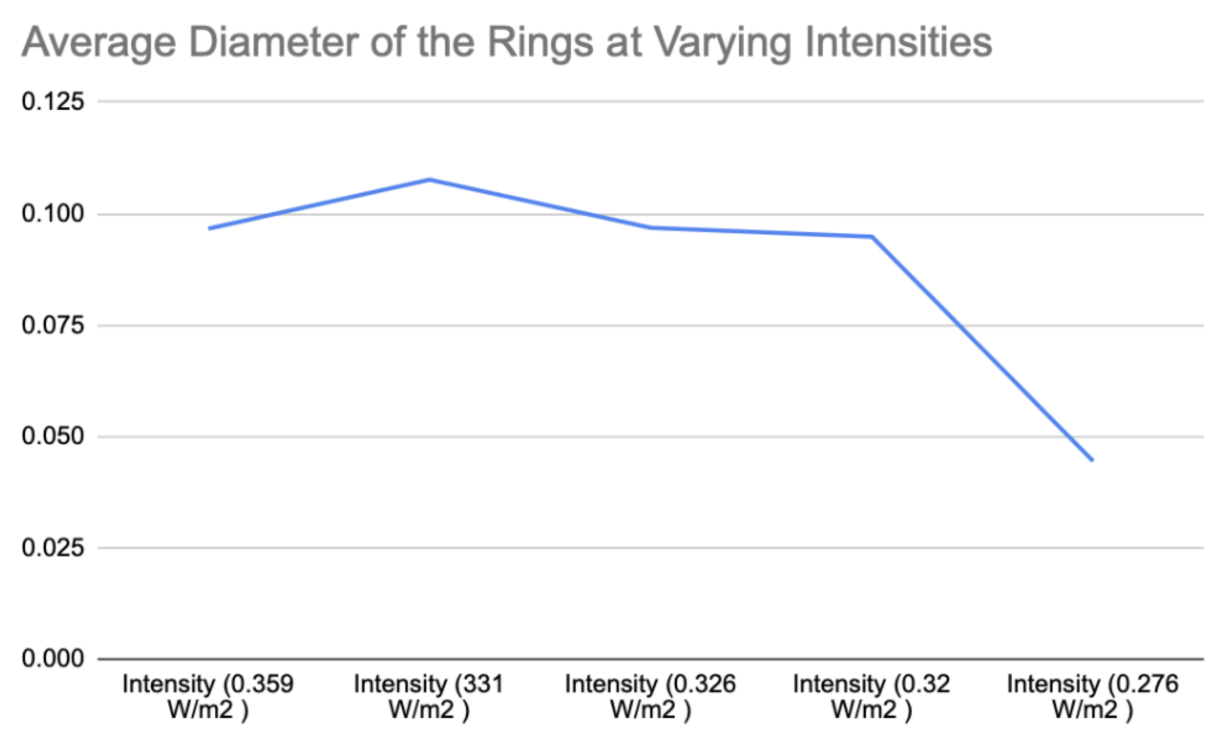
Processed data

	Average radius (mm) Calculation: [Total of all Diameters/5]	**Standard deviation:** $\sigma = \sqrt{\frac{\sum(x_i - \mu)^2}{N}}$
Intensity (0.359 W/m²)	0.0966	0.09948768768
Intensity (331 W/m²)	0.1076	0.1051679609
Intensity (0.326 W/m²)	0.0968	0.0967403742
Intensity (0.32 W/m²)	0.0948	0.1003055332
Intensity (0.276 W/m²)	0.0444	0.04897244123

1.7



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Evaluation and analysis

The results of the paper clearly show that the radii of the Newton's rings is a function of intensity and resolves the initial Research question of How the variation in the intensity of incident light influence the radius of newton's rings formed, it clearly shows the change in the radii as the intensity is increased.

The research on Newton rings has been closely examined since the 1800s and the results in this paper are intensities varied from an average of 0.326 to the peak of 0.359 where the radius of the Newton ring peaks at 0.33 and is reduced on a steady incline at 0.362 and stabilizes till an intensity of 0.32 and shows a contrast to 0.331 at 0.276 as shown by graph 1.8, the experiment build a establishes a relationship between the wavelength of the photons released by a sodium lamp at a steady wattage and the radii of the Newton's rings formed on the water droplet taken, the experiments includes custom made circuity and a 3D printed mold for the droplet of water which shows the neutrons rings formed by the reflection of light through the plano-convex lens.

The setup itself could have had slight variation due to human error and the change in temperature of the water droplet could have affected the intensity of the photons being reflected off of the plano-convex lens apart from which there were limited errors in the physical setup for this examination of the radii of the Newton's rings.

The experiment itself has a magnitude of variables that are functions of intensity that affect the final product, which signifies that the variables that are fragmented in the final equation are equal functions of intensity of light.

Improvements

In the relentless pursuit of scientific excellence, continual improvements and refinements are always necessary for experimental techniques. Improvements that can be made include making sure there is a controlled temperature throughout the course of the experiment to ensure not adding another variable affects the outcome of the experiment; performing the experiment in a darker environment for better measurement of the Newton rings; performing the experiment with a glass adhesive bed instead of using a 3D printed drop mold for more precise measurement and lastly the use of distilled water to reduce the chance of error in the reflection of the light.

Conclusion

The study of Rings or ring theory is a well-nigh 600-year-old yearning to understand rings, their functions and behaviours, and “Newton’s rings” is an experiment that exhibits an interference pattern used for the quantity control for lenses used in jets and medical instruments, it uses a Plano-convex lens and a drop of water to form rings and patterns on the droplet and proves that certain monochromatic light behaves in peculiar ways creating dark rings. This paper emphasizes and explores the behaviour of Newton rings with varying intensities and radii of instruments used, it proves how the change of radii and intensities and vary the radii of the Newton rings and how this behaviour can be used in determining the wavelengths of monochromatic light that have been seen to show a positive effect on problems such as spring asthenia, circadian rhythm disruption, and even bipolar disorders and Alzheimer's.

The paper also gives an in-depth analysis of the experimental setup required for recreating the fortunate results achieved by the author and the required equipment to perform the experiment.

This paper modernizes the ideas of ring theory and the ideas of Newton while focusing on the ethical and anthropological implications of a system of equipment that can correct errors in jets and provide relief for millions of people from disease.

Experimental Errors

Type of Error	Error
Random Error	Variations in ambient temperature may affect experimental outcomes

Random Error	Imprecisions in measuring the air gap thickness with the micrometre and vernier calliper
Systematic Error	Fluctuations in the sodium vapour lamp's intensity can introduce uncertainties
Systematic Error	Deviations from the ideal 45-degree angle when placing the glass surface may introduce systematic errors

1.9

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