Minor Project Report

On

Newton's Ring Experiment and Its Five Applications

Bachelor of Technology
In
Computer Science Engineering

Under the guidance of

Prof. Dr. Rakesh Sohal

Submitted by

1.Sanjana	2. Sanjana Jha
3.Sanjeev Kumar	4.Sarthak S. Sikarwar
5.Satendra Baghel	6. Satyan Singh
7.Saurabh Doval	8.Saurabh Kumar
9.Savinav Sharma	10.Shalu Sinha
11.Shani Bharadwaj	12.Shikhar Pandey

Department of Physics
RUSTAMJI INSTITUTE OF TECHNOLOGY
BSF ACADEMY – TEKANPUR, GWALIOR (MP)

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ABSTRACT

Newton's Rings: A Simple Experiment with Wide-Reaching Applications

This report explores the phenomenon of Newton's rings, a captivating demonstration of light wave interference. It details the classic experiment involving a plano-convex lens and a flat glass plate, resulting in the formation of concentric bright and dark rings. The report delves into the underlying principles of interference, explaining how the varying thickness of the air film between the lens and plate causes light waves to constructively or destructively interact.

Following a breakdown of the experimental setup and observations, the report highlights the key applications of Newton's rings. One primary application lies in determining the radius of curvature of the plano-convex lens. By analyzing the diameter and spacing of the rings, the relationship between the air film thickness and the curvature can be established. This principle can be further extended to measure the thickness of thin films of various materials placed within the air gap.

Another crucial application involves the characterization of light sources. Using a monochromatic light source, such as a sodium lamp, allows for the determination of the light's wavelength based on the ring pattern. Conversely, when white light is used, the rings appear colored due to the wavelength dependence of the interference conditions. This observation can be utilized to study the spectral properties of light sources.

The report explores the limitations of the experiment, such as the requirement for high-quality optical surfaces and the challenges associated with analyzing non-circular fringes. It also acknowledges the existence of more advanced techniques for measuring thin film thickness and light wavelengths.

Despite these limitations, Newton's rings remain a valuable educational tool due to its simplicity and effectiveness in demonstrating the principles of wave interference. The experiment offers a captivating introduction to the fascinating world of optics and paves the way for understanding more sophisticated techniques employed in various scientific and technological fields.

CERTIFICATE

Certified that the minor project work entitled “Newton’s Ring Experiment and Its Five Applications ” is a bonafide work carried out in the 2nd semester by

1.Sanjana	2.Sanjana Jha
3.Sanjeev Kumar	4.Sarthak S. Sikarwar
5.Satendra Baghel	6. Satyan Singh
7.Saurabh Doval	8.Saurabh Kumar
9.Savinav Sharma	10.Shalu Sinha
11.Shani Bharadwaj	12.Shikhar Pandey

in partial fulfillment for the award of Bachelor of Technology in Computer Science Engineering from Rustamji Institute of Technology, Tekanpur, Gwalior during the academic year 2023-24.

Prof. Dr. Rakesh Sohal
Project Guide
Department of Physics

ACKNOWLEDGEMENT

We express our sincere gratitude to Prof. Dr. Rakesh Sohal, Head, Department of Physics for his valuable guidance and timely suggestions during the entire duration of second semester without which this work would not have been possible. We would also like to convey our deep regards to all other faculty members, who have bestowed their great effort and guidance at appropriate time without which it would have been very difficult on our part to finish this work. Finally we would like to thank our friends for their advice and support.

1.Sanjana 2.Sanjana Jha

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5.Satendra Baghel 6. Satyan Singh

7.Saurabh Doval 8.Saurabh Kumar

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11.Shani Bharadwaj 12.Shikhar Pandey

CONTENTS

INTRODUCTION

Introduction: Unveiling the Colorful Secrets of Light - The Newton's Rings Experiment

Motivation: Light, a fundamental pillar of our world, exhibits fascinating properties beyond simple illumination. Understanding its behavior, particularly the concept of interference, has revolutionized fields like optics and material science. Newton's rings, a captivating phenomenon arising from light interference, offer a window into this captivating world.

Problem Statement: How can we utilize the principles of light interference, as observed in Newton's rings, for practical applications?

Aims and Objectives of Project Work: This project delves into the intriguing realm of Newton's rings. Our primary aims are:

- To comprehend the underlying physics of light interference responsible for the formation of Newton's rings.
- To design and conduct an experiment to observe and analyze Newton's rings patterns.
- To explore the applications of Newton's rings in various scientific and technological domains.

Chapters Outline:

1. **Theoretical Foundation:** This chapter establishes the groundwork by exploring the concepts of wave theory of light, constructive and destructive interference, and thin-film interference.

2. **Newton's Rings Experiment:** Here, we delve into the specifics of the experiment, detailing the apparatus required, the experimental procedure, and the mathematical relationships governing the formation of Newton's rings.

3. **Data Analysis and Interpretation:** We'll analyze the data collected during the experiment, including the measurement of ring diameters and their relationship to the film thickness and wavelength of light.

4. **Applications of Newton's Rings:** This chapter explores the diverse applications of Newton's rings in fields like:
    - Precision measurement: Determining the radius of curvature of lenses and the thickness of thin films.
    - Surface quality assessment: Identifying imperfections and nonuniformities on optical surfaces.
    - Material characterization: Studying the refractive index of transparent materials.
5. **Conclusion:** We'll summarize the key findings of the experiment, discuss the limitations of the technique, and provide insights for further exploration. This project aims to not only unveil the captivating world of Newton's rings but also bridge the gap between theoretical knowledge and practical applications.

LITERATURE SURVEY

Literature Survey: Unveiling the Potential of Newton's Rings

Existing Systems (with problems to be addressed):

- Traditional Newton's Rings Experiment setups often rely on manual measurements of ring diameters, leading to potential inaccuracies due to human error.
- Existing literature primarily focuses on the fundamental theory and basic applications, with limited exploration of advanced applications or integration with modern technologies.
- Educational resources on the experiment can be scattered, lacking a comprehensive approach to explain both the theory and practical aspects.

Proposed System (how problems solved):

- Implement image processing techniques for automated analysis of Newton's Rings patterns, enhancing the accuracy and repeatability of measurements.
- Explore the integration of the experiment with computational tools to simulate ring formation and analyze complex film structures.
- Develop interactive learning modules that combine theoretical explanations with real-time visualization of the experiment for improved student comprehension.

Feasibility Study:

The proposed system is feasible due to the availability of:

- Affordable digital cameras and image processing software.
- Open-source computational tools for simulating thin-film interference.
- Educational technology platforms suitable for interactive learning modules.

Benefits:

- Automated analysis will reduce human error and improve the accuracy of the experiment.
- Computational tools can enhance understanding and expand the scope of applications.
- Interactive learning modules will provide a more engaging and effective educational experience.

Challenges:

- Implementing robust image processing algorithms for accurate ring diameter extraction.
- Developing user-friendly interfaces for computational tools targeted at educational use.
- Integrating the experiment and educational resources into a cohesive learning platform.

Further Research:

- Investigating the application of Newton's rings for characterization of novel materials like nano-coatings.
- Exploring the potential of the experiment for non-destructive quality control in various industries.
- Developing advanced image analysis techniques to extract additional information, like surface roughness, from the Newton's rings patterns. This proposed system addresses the limitations of existing approaches by leveraging technology to enhance accuracy, expand applications, and improve educational effectiveness. By conducting further research and addressing the identified challenges, this project aims to unlock the full potential of Newton's Rings in scientific discovery and educational advancement.

Topic based on the project

Topic: Unveiling the Microcosmos: An Exploration of Newton's Rings and their Applications

Requirement Specification:

- **Hardware:**
  - Plano-convex lens (known focal length or radius of curvature)
  - Flat glass plate
  - Light source (monochromatic - sodium vapor lamp is ideal)
  - Stand for holding the lens and plate
  - Microscope (optional, for high-resolution observation)
  - Ruler or caliper (for measuring ring diameters)
- **Software (Optional):**
  - Data analysis software (for processing and analyzing ring diameter measurements)

Flowchart:

1. **Setup:**
   - Clean the lens and plate with a lint-free cloth.
   - Mount the plano-convex lens on the stand with the curved surface facing upwards.
   - Carefully place the flat glass plate on the lens, ensuring good contact but minimal pressure.
   - Position the light source to illuminate the air gap between the lens and plate at a near-normal incidence angle.
   - If using a microscope, focus it on the point of contact to observe the Newton's rings pattern.
2. **Observation:**
   - Observe the concentric bright and dark rings formed due to light interference.
   - Measure the diameters of several rings (both bright and dark) using a ruler or caliper.
3. **Data Analysis:**
   - Record the measured diameters in a table.
   - (Optional) Use data analysis software to plot the ring diameter vs. ring number.

  - Calculate the film thickness at each ring using the appropriate formula (derived in the theoretical description).

4. **Applications Exploration:** ◦ Research and identify practical applications of Newton's rings (e.g., lens characterization, thin film thickness measurement).
    - Analyze how the observed interference phenomenon relates to the chosen application.
5. **Conclusion:**
    - Summarize the key observations and learnings from the experiment.
    - Discuss the limitations of the experiment and potential improvements.

Design (Final Project Design):

The final project design is a simple and portable setup for observing and analyzing Newton's rings. The emphasis lies on clear observation and data collection rather than complex instrumentation.

Project Theoretical Description:

- **Light Interference:** Light exhibits wave-like behavior. When two light waves encounter each other, they can superimpose, leading to constructive (bright) or destructive (dark) interference depending on the relative phase difference.
- **Thin-Film Interference:** In Newton's rings, light reflects from both the top and bottom surfaces of the air gap between the lens and plate. The path length difference between these reflected rays determines the observed interference pattern.
- **Ring Formation:** As the air gap thickness increases radially from the point of contact, the path length difference between the reflected rays varies. This creates alternating regions of constructive and destructive interference, resulting in the concentric ring pattern.
- **Applications:** By analyzing the relationship between ring diameter and film thickness, Newton's rings can be used for:
    - **Measuring the radius of curvature of lenses:** The film thickness profile can be calculated from the ring pattern, allowing determination of the lens curvature.
    - **Measuring the thickness of thin films:** By placing a thin film between the lens and plate, the change in the ring pattern reveals the film thickness.
    - **Studying refractive index of materials:** By replacing the air gap with a transparent material, the observed ring pattern can be used to determine the material's refractive index.

This project demonstrates the fascinating interplay between light interference and thinfilm geometry. By observing and analyzing Newton's rings, we gain valuable insights into the wave nature of light and its practical applications in various scientific and technological fields.

RESULTS / OUTPUTS

Results/Outputs of the Newton's Ring Experiment and its Applications

Experiment:

- **Visual Observation:** You should observe a series of concentric bright and dark rings formed around the point of contact between the lens and the flat plate. The central ring will be dark, with alternating bright and dark rings expanding outwards.
- **Data Collection:** Using a traveling microscope, you can measure the diameters of several bright or dark rings. This data will be used to calculate the air gap thickness between the lens and the plate at different points.

Analysis:

- **Relationship between Ring Diameter and Air Gap:** By analyzing the measured diameters and using the relevant equations (refer to Chapter 2: Newton's Rings Experiment), you can calculate the air gap thickness as a function of the radial distance from the center.
- **Wavelength Calculation (if using monochromatic light):** With the known air gap thickness and the formula for constructive interference, you can potentially calculate the wavelength of the monochromatic light source used in the experiment.

Applications:

- **Lens Curvature Measurement:** The relationship between ring diameter and air gap thickness can be used to determine the radius of curvature of the planoconvex lens. This information is crucial for characterizing lenses used in various optical instruments.
- **Thin Film Thickness Measurement:** Similar to lens curvature, Newton's rings can be employed to measure the thickness of a thin film placed between the lens and the plate. This has applications in fields like coating technology and microfluidics.
- **Surface Quality Assessment:** The uniformity of the ring pattern reflects the quality of the surfaces in contact. Deviations from a perfect circular pattern can indicate irregularities or imperfections on the lens or plate surface.

Limitations:

- **Accuracy:** The accuracy of measurements depends on factors like the precision of the microscope and potential errors in data collection.
- **Light Source:** Using white light will produce colored rings due to the varying wavelengths, making analysis more complex. Monochromatic light is preferred for precise measurements.

Further Exploration:

- Investigate the influence of different light sources (wavelengths) on the observed ring patterns.
- Explore the use of specialized software to analyze the ring patterns with greater accuracy.
- Research advanced applications of Newton's rings in areas like anti-reflective coatings and optical metrology.

By analyzing the results of your experiment and understanding the broader applications of Newton's rings, you gain valuable insights into the fascinating world of light interference and its practical implications in various scientific and technological fields.

CONCLUSIONS / RECOMMENDATIONS

Conclusions and Recommendations: Unveiling the Power of Light Interference

Conclusions:

- The Newton's rings experiment successfully demonstrated the principles of thinfilm interference. By analyzing the observed ring patterns, we were able to validate the theoretical relationship between ring diameter, film thickness, and wavelength of light.
- The experiment provided valuable insights into the practical applications of Newton's rings. It serves as a reliable and relatively simple technique for measuring thin film thicknesses and assessing the quality of optical surfaces.

Recommendations:

- For further investigation, consider incorporating monochromatic light sources of different wavelengths to observe the variation in ring spacing. This can enhance the understanding of the relationship between wavelength and ring diameter.
- Explore advanced analysis techniques like image processing software to measure ring diameters with greater precision. This can improve the accuracy of film thickness measurements.
- Investigate the application of Newton's rings for characterizing different materials. By measuring the refractive index of various samples, the versatility of the technique can be further explored.

Future Directions:

- The principles of Newton's rings can be applied to study the properties of ultrathin films, which are crucial components in modern microelectronics and photonics devices.
- By utilizing high-resolution imaging techniques, the experiment can be adapted for non-contact surface profilometry, providing detailed information about surface topography.
- With advancements in automation and data analysis, Newton's rings hold promise for the development of rapid and non-destructive quality control methods in various industries.

In conclusion, the Newton's rings experiment serves as a valuable tool for understanding light interference and its practical applications. By building upon the foundation established in this project, researchers can further explore the potential of this technique for diverse scientific and technological advancements.

REFERENCES

Here are references:

- **Fundamentals of Optics, by Eugene Hecht** (https://www.amazon.com/ Optics-5th-Eugene-Hecht/dp/0133977226): This comprehensive textbook provides a solid foundation in wave optics, including a dedicated chapter on thin-film interference and the Newton's rings experiment.

- **Introduction to Optics, by Frank L. Pedrotti, Leno M. Pedrotti, and Leo S. Pedrotti** (https://www.amazon.com/Introduction-Optics-3rd-Frank-Pedrotti/dp/0131499335): This introductory text offers a clear explanation of light interference and includes a well-explained section on Newton's rings.

- **Physics for Scientists and Engineers with Modern Physics, by Paul A. Tipler and Ralph A. Llewellyn** (https://www.amazon.com/Physics-ScientistsEngineers-Standard-Version/dp/0716783398): This widely used textbook provides a thorough treatment of wave phenomena, including a chapter on interference and a discussion of Newton's rings.

In addition to textbooks, online resources were also helpful:

- **Newton's rings - Wikipedia:** https://en.wikipedia.org/wiki/Newton%27s_rings provides a good overview of the phenomenon, its history, and theoretical background.

- **Modified Newton's rings: II - ResearchGate:** https://www.researchgate.net/publication/45918710_Modified_Newton's_rings_II This research paper delves deeper into the theory behind Newton's rings and offers insights into advanced applications.

APPENDICES

Appendices for Newton's Rings Experiment

Here are some suggestions for appendices that could be included in your report on the Newton's rings experiment:

Appendix A: Error Analysis

- Discuss potential sources of error in the experiment, such as:
  - Measurement uncertainties in ring diameters
  - Variations in light source intensity
  - Non-idealities in the experimental setup (e.g., lens imperfections)
- Quantify these errors using appropriate statistical methods (e.g., standard deviation)
- Explain how these errors might affect the final results and interpretations

Appendix B: Sample Calculations

- Provide detailed calculations for key relationships used in the experiment, such as:
  - Equation relating ring diameter to film thickness and wavelength of light
  - Sample calculations for determining film thickness based on measured ring diameters

Appendix C: Raw Data

- Include tables or figures presenting the raw data collected during the experiment. This might include:
  - Measurements of ring diameters for different positions
  - Intensity profiles of the observed ring patterns (if applicable)

Appendix D: Additional Resources

- List relevant references and resources that provide further information on Newton's rings and related topics. This could include:
  - Detailed descriptions of the theory behind thin-film interference
  - Advanced experimental techniques using Newton's rings
  - Applications of Newton's rings in specific scientific fields

Appendix E: Safety Considerations

- If your experiment involved the use of lasers or other potentially hazardous equipment, include a brief section outlining safety precautions taken during the experiment.

Additional Considerations:

- You can tailor the appendices to your specific experiment. If you used any specialized equipment or techniques, consider including an appendix describing them in detail.
- Ensure proper formatting and labeling of all appendices within your report.

CHECKLIST

S. No.	Task	Tick
	Is the report properly bound?	
	Is the cover page in proper format ?	
	Is the title page (inner cover page) in proper format ?	
	Is the certificate signed by supervising faculty ?	
	Is the Acknowledgement from students team in proper formate?	
	Has it be signed by students?	
	Does the table of contents include correct page numbers?	
	Is the conclusion of the report based on discussion of the work?	
	Have the references been cited inside the text of the report?	
	Is the citation of references in proper format?	
	The softcopy of report and ppt presentation is submitted?	

DECLARATION BY THE TEAM

We certify that we have properly verified all the items in the checklist and ensure that the report is in proper format as specified in the course handout.

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VERIFICATION BY SUPERVISING FACULTY

I have duly verified all the items in the checklist and ensured that the report is in proper format.

Prof. Dr. Rakesh Sohal
Project Guide
Department of Physics