

IYPT #14 –CIRCLE OF LIGHT

Contributors:

Karl Sewick

David Nascari

Mike Shaw

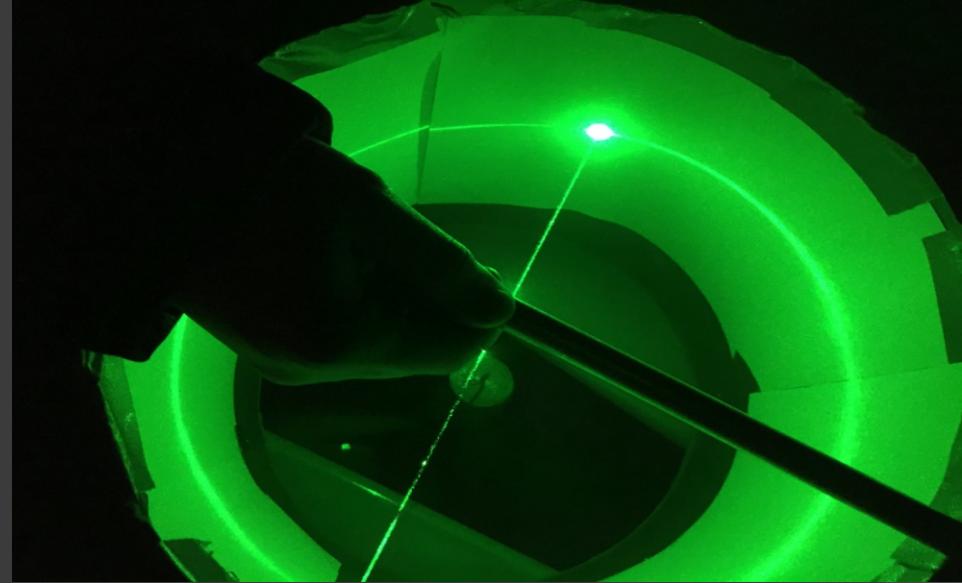
Mentors:

Darryll Barkhouse

Gerard Jennings

Circle of Light

- When a laser beam is aimed at a wire, a circle of light can be observed on a screen *perpendicular* to the wire. Explain this phenomenon and investigate how it depends on the relevant parameters.



Intro

Circle

Wire

Single Slit

Conclusion

Overview

- Understand the aspects of the Circle of Light
 - Diffraction
 - Reflection
- Wire parameters
 - Wire material/reflectivity
 - Wire diameter
 - Imperfections
- Single-Slit diffraction approximation

Intro

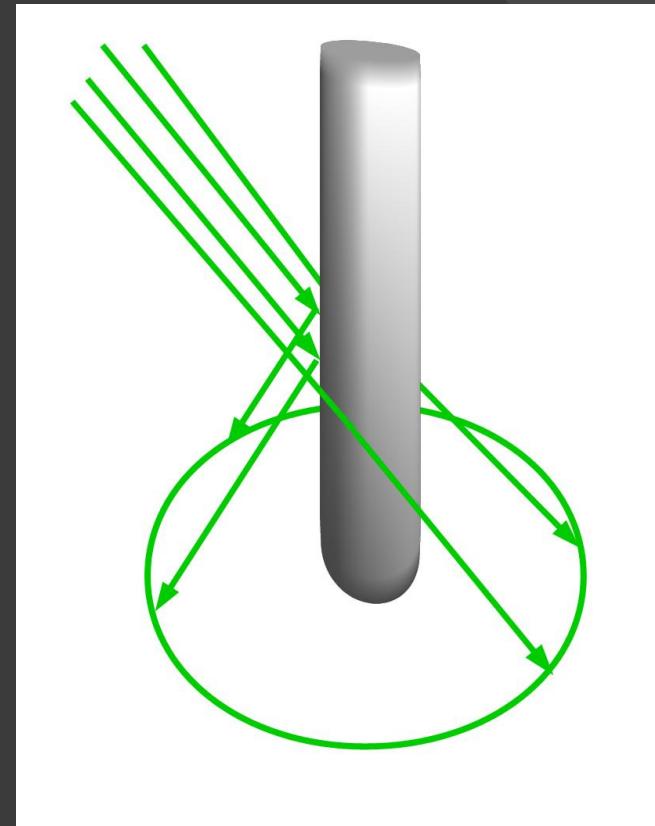
Circle

Wire

Single Slit

Conclusion

Experimental Setup



Intro

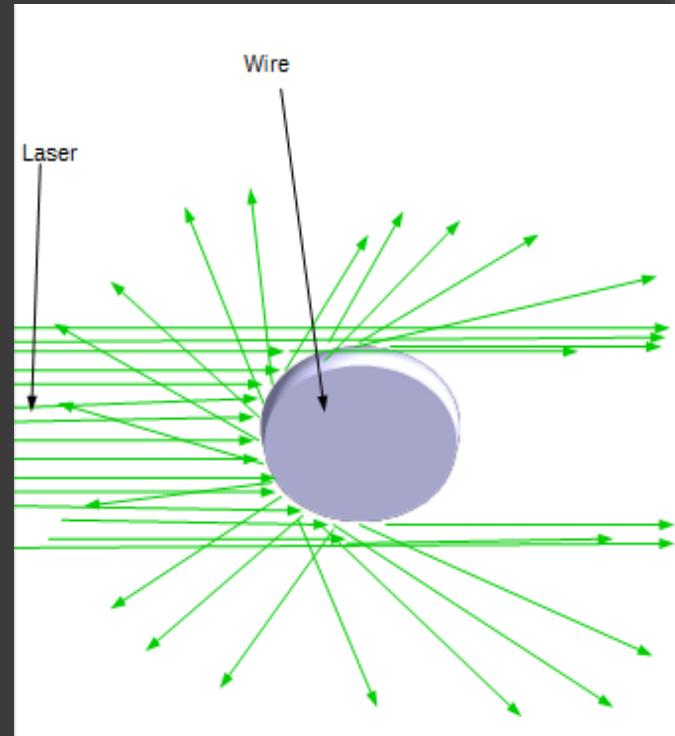
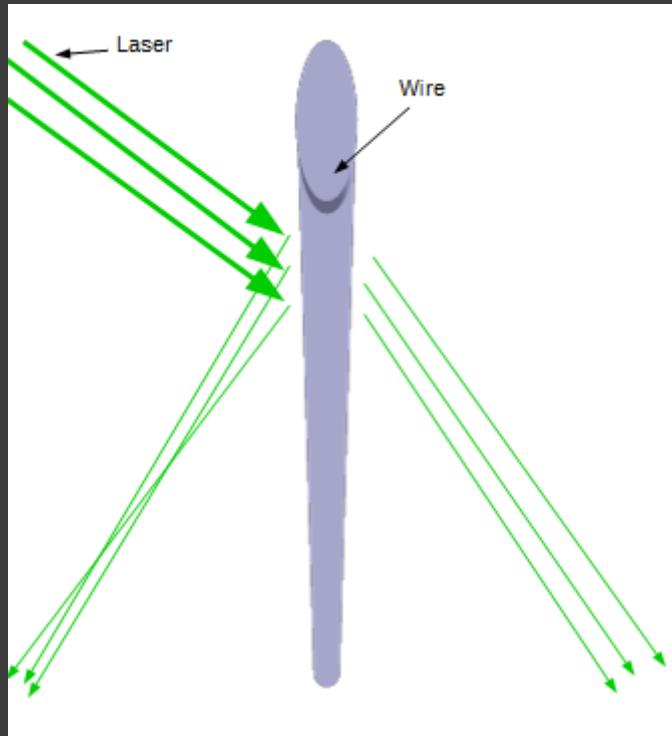
Circle

Wire

Single Slit

Conclusion

Diagram of the Setup



Intro

Circle

Wire

Single Slit

Conclusion

Hypothesis

- Diffraction and reflection are what makes up the circle of light.
- Imperfections on the surface of the wire will affect the image displayed.

Intro

Circle

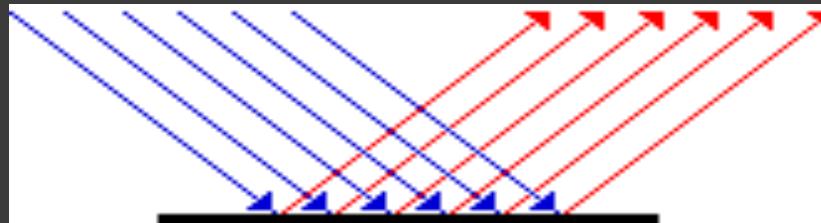
Wire

Single Slit

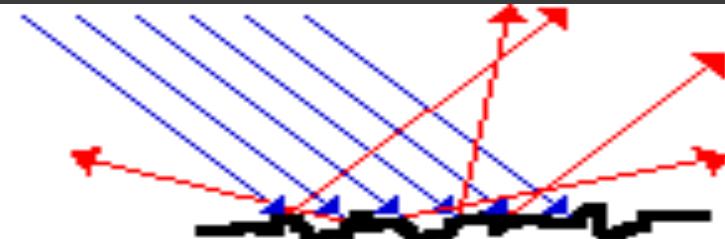
Conclusion

Reflection

- Caused from imperfect surfaces



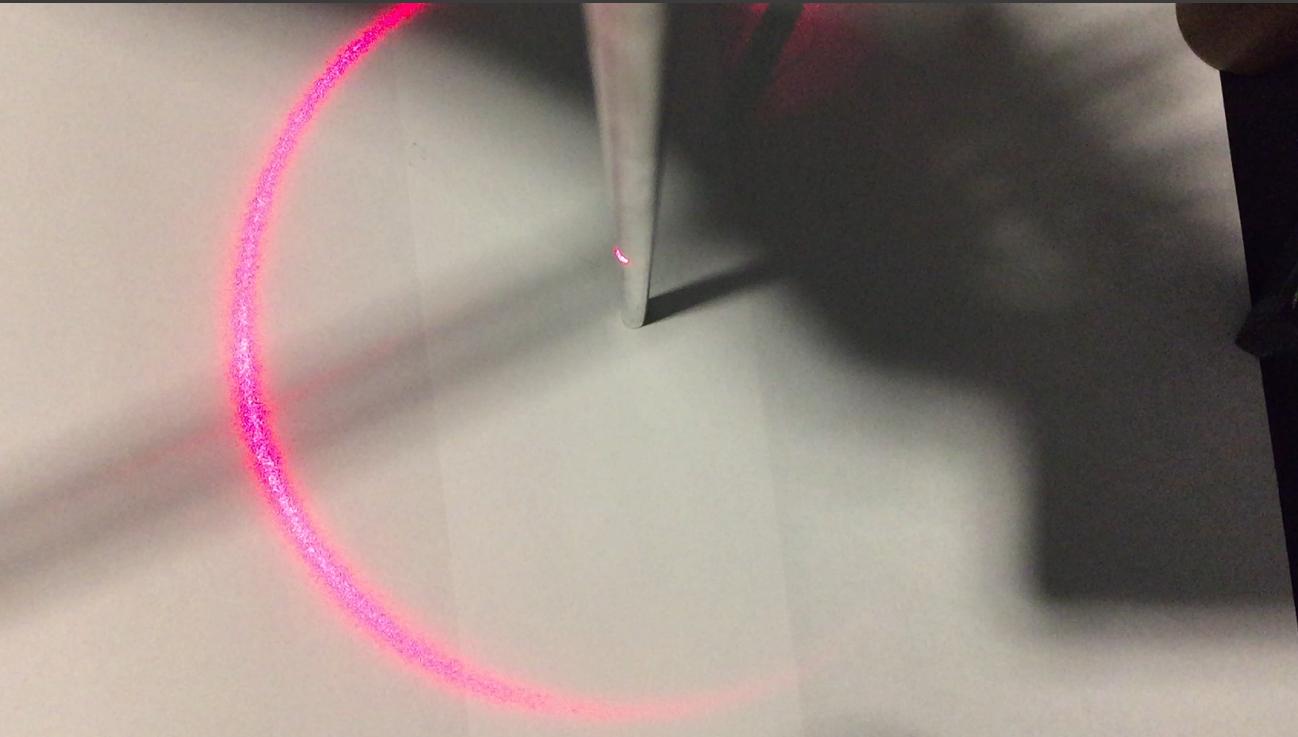
Specular Reflection
(smooth surfaces)



Diffuse Reflection
(rough surfaces)

Henderson, Tom. "Specular vs. Diffuse Reflection." *Specular vs. Diffuse Reflection*. N.p., 2015. Web. 14 Mar. 2015.

Video of Reflection



Intro

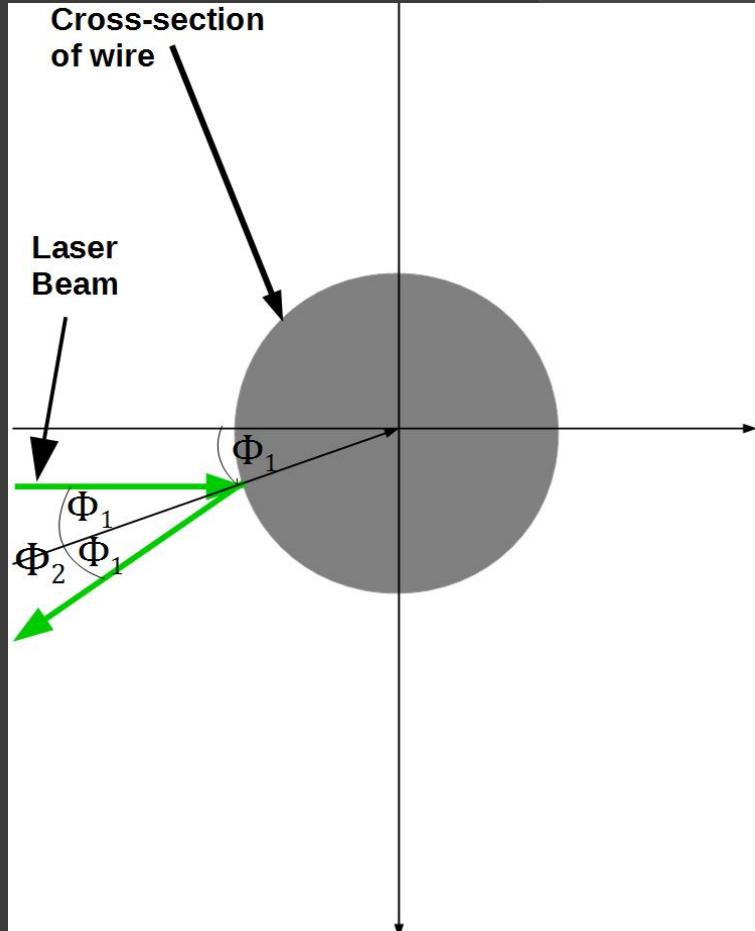
Circle

Wire

Single Slit

Conclusion

Reflection Angles



Intro

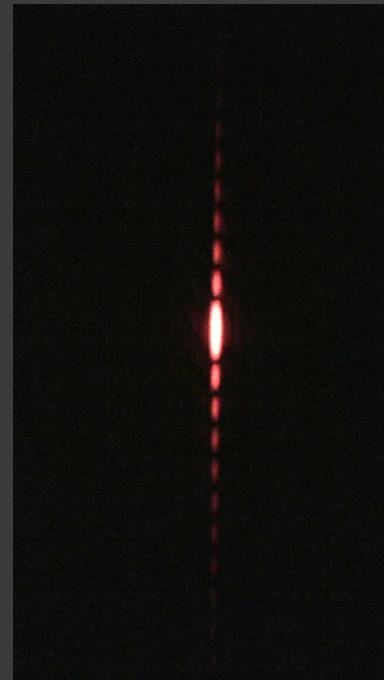
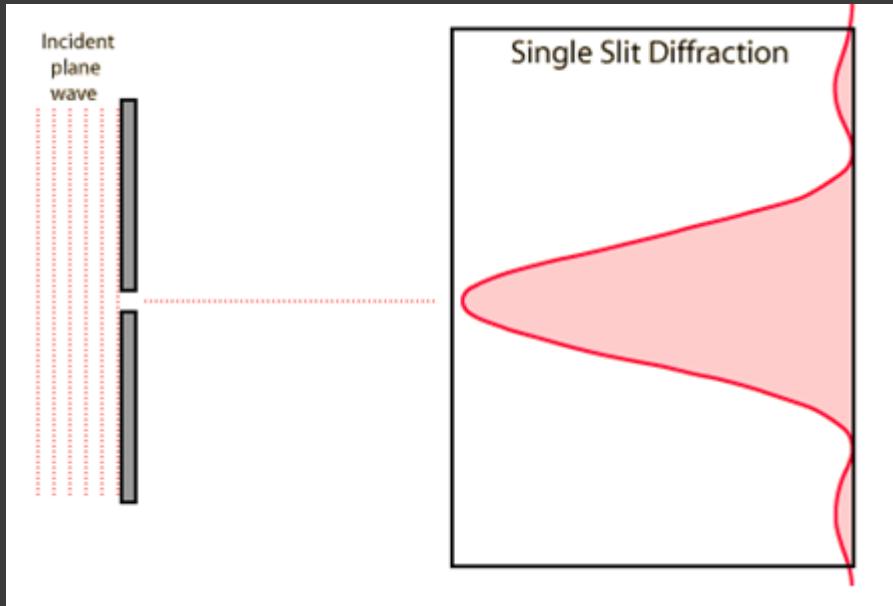
Circle

Wire

Single Slit

Conclusion

Diffraction



Intro

Circle

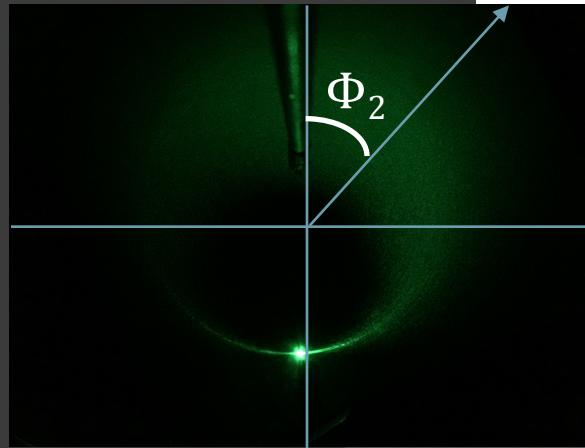
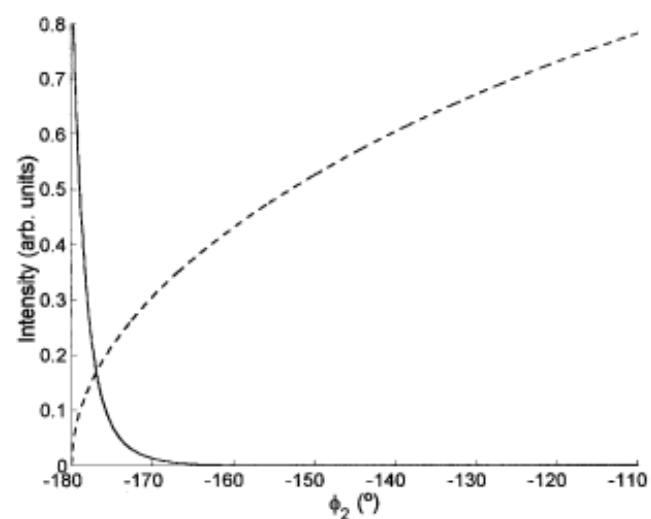
Wire

Single Slit

Conclusion

Past Research

- Conducted using thin wire ($300\mu\text{m}$)
- Found that diffraction dominates for about five degrees to each side of the circle



Intro

Circle

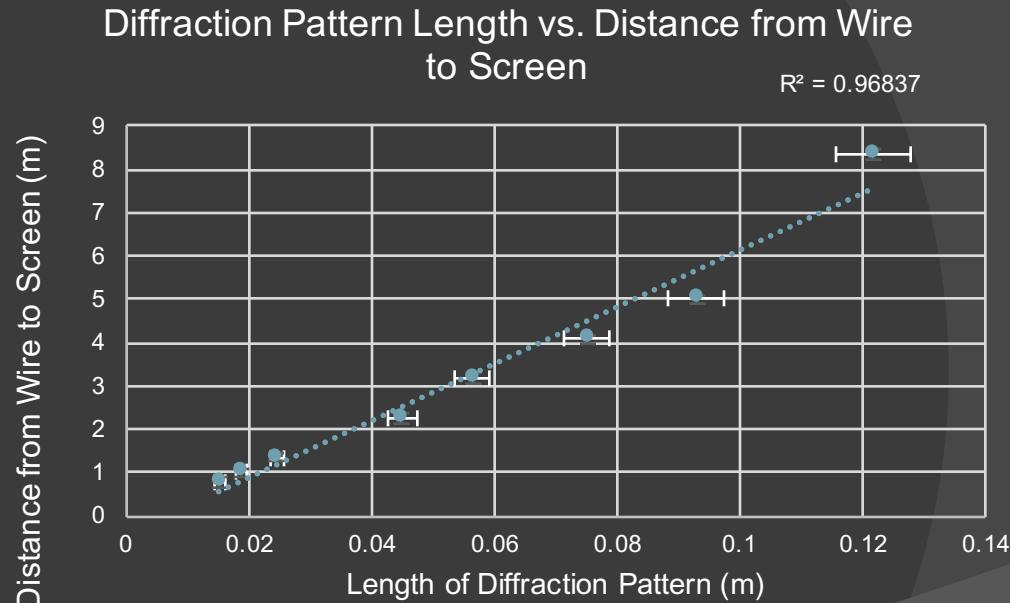
Wire

Single Slit

Conclusion

Comparison to Past Research

- 500 μm wire
- Measured Diffraction pattern and then calculated angle using arc length
- Past Research: ~ 10 degrees for total pattern
- We obtained a value of 10.4 ± 0.7 degrees



Intro

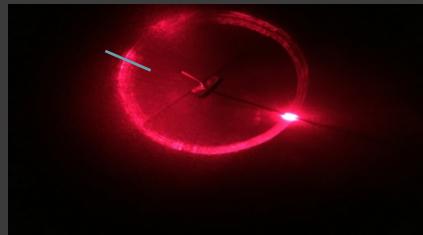
Circle

Wire

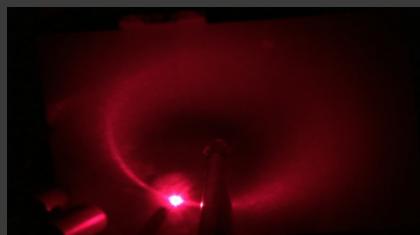
Single Slit

Conclusion

Wire Material/Reflectivity Effects



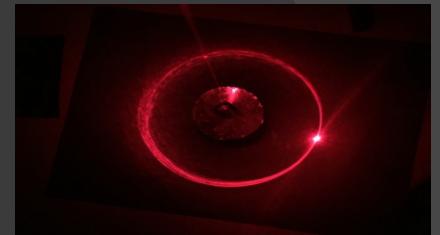
Paperclip



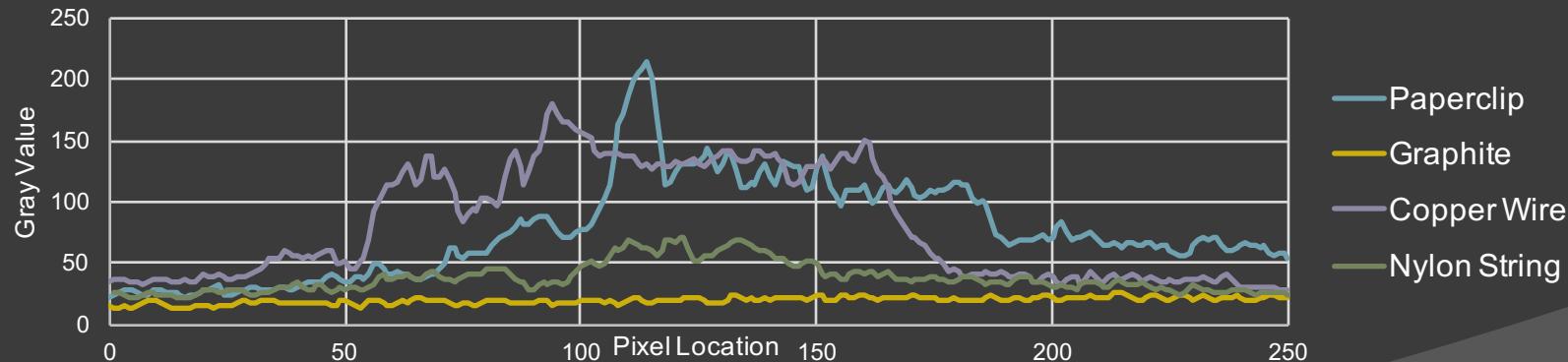
Graphite



Copper Wire



Nylon String



Intro

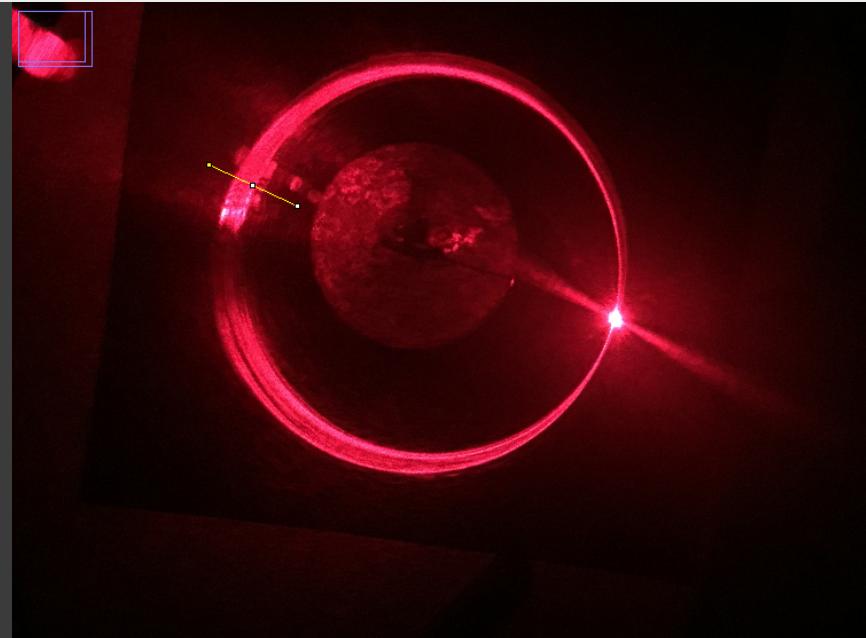
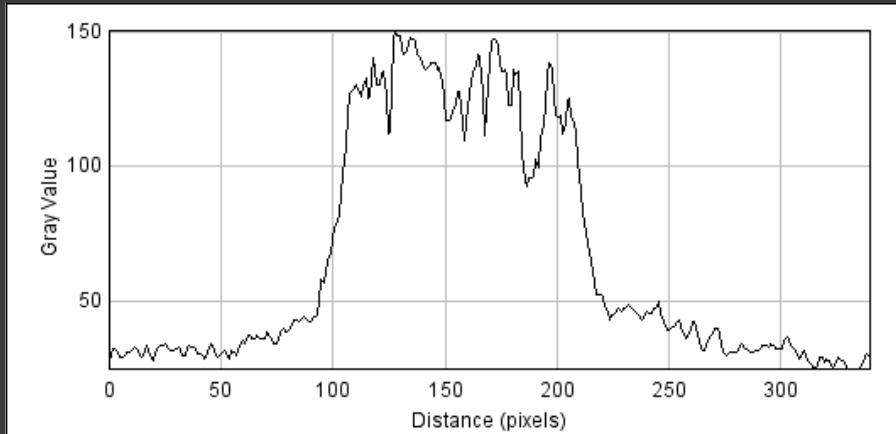
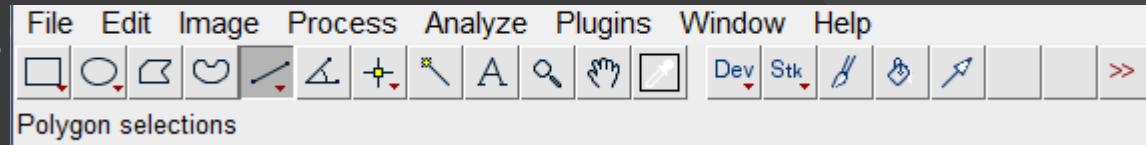
Circle

Wire

Single Slit

Conclusion

Image J Analysis



Intro

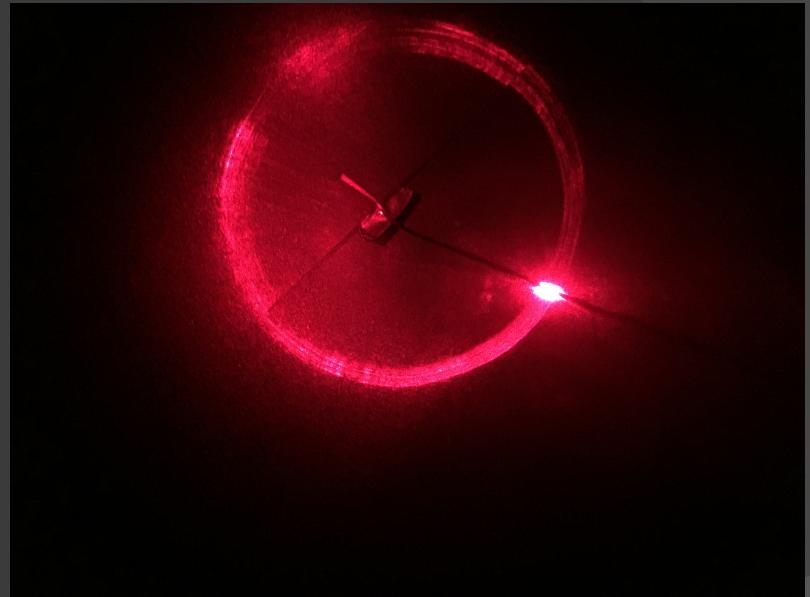
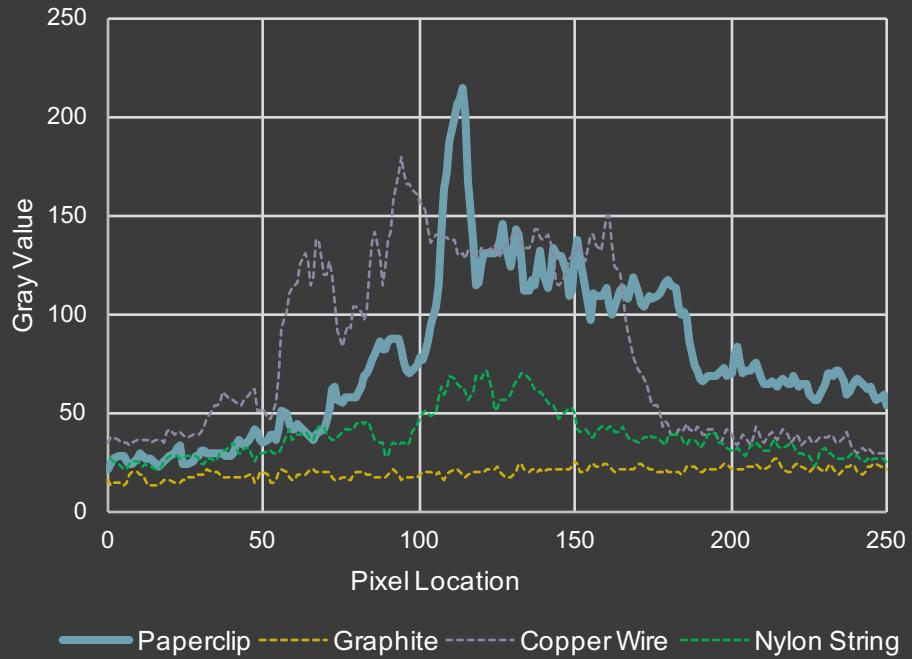
Circle

Wire

Single Slit

Conclusion

Paperclip Reflectivity



Intro

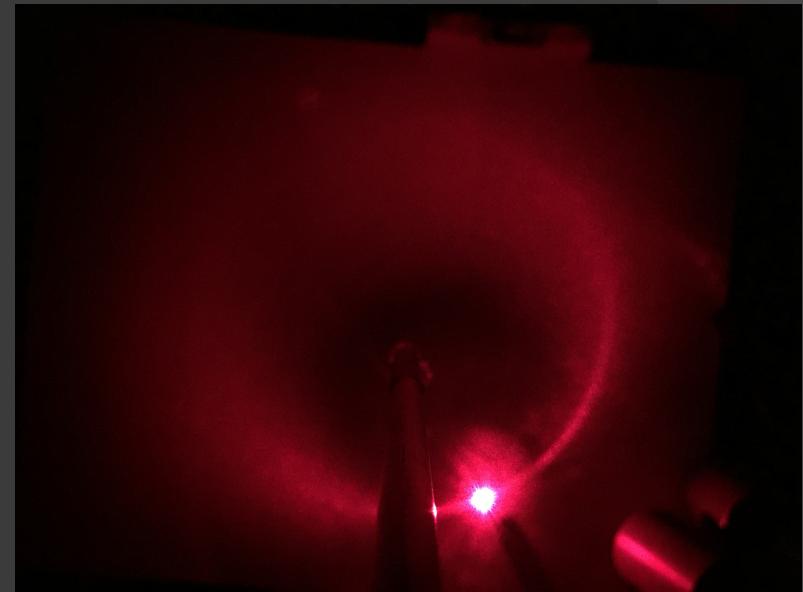
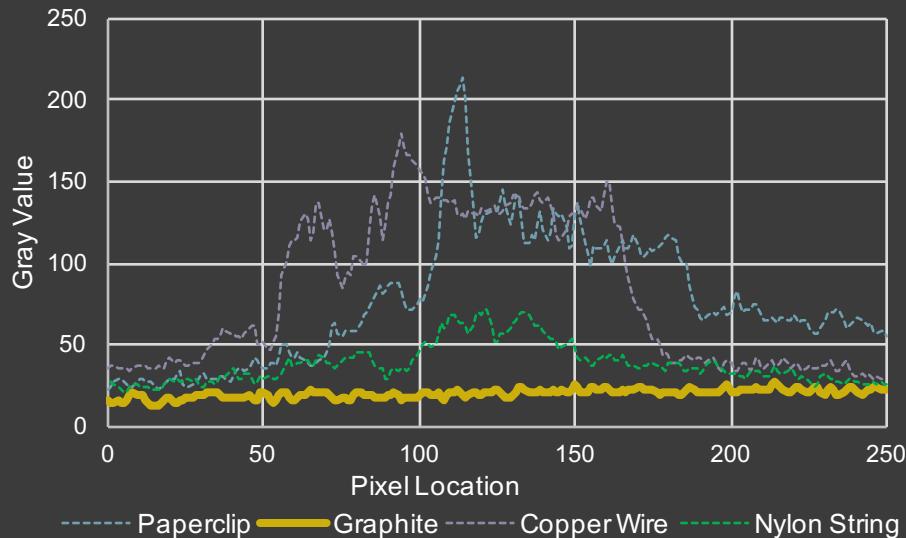
Circle

Wire

Single Slit

Conclusion

Graphite Reflectivity



Intro

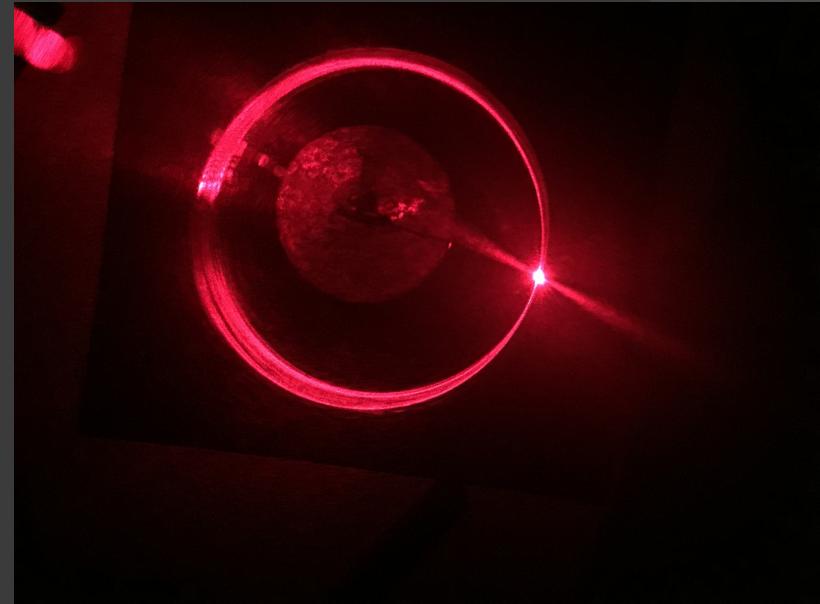
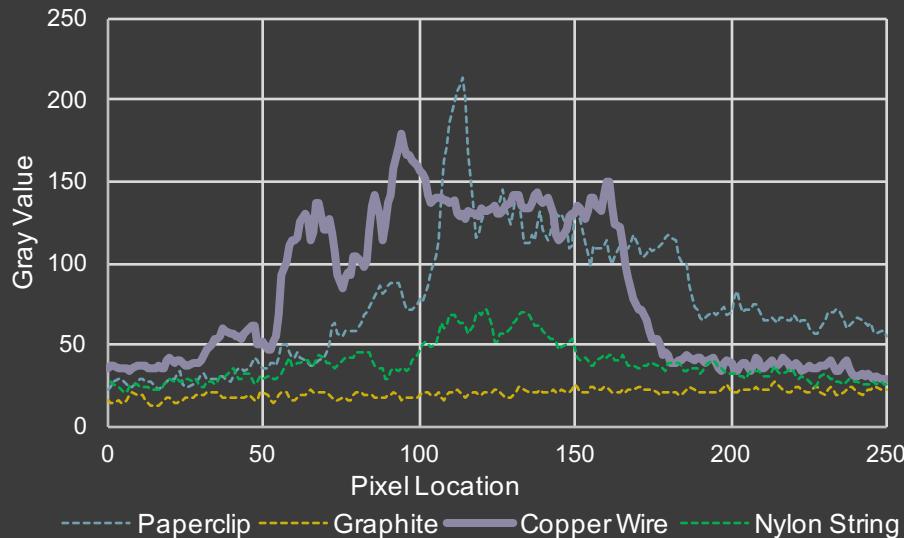
Circle

Wire

Single Slit

Conclusion

Copper Wire Reflectivity



Intro

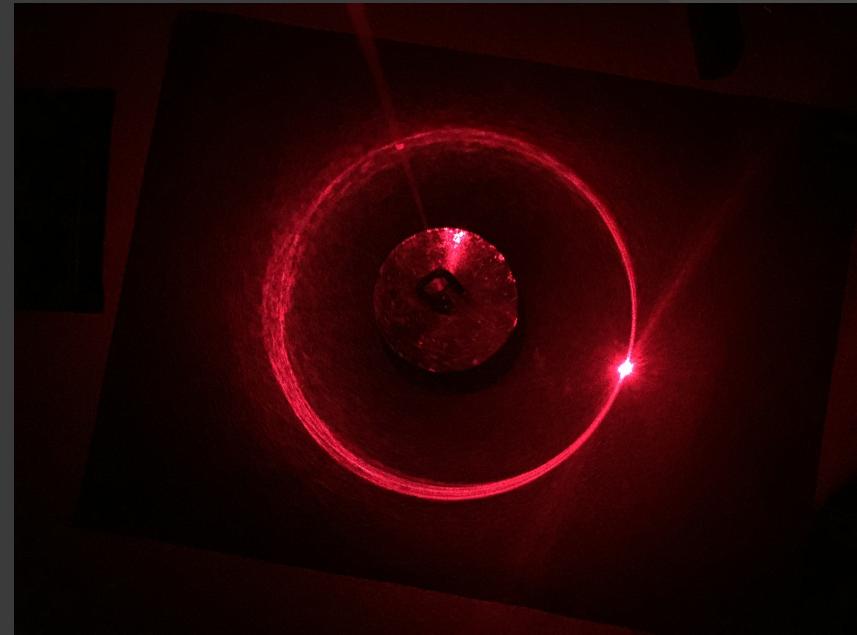
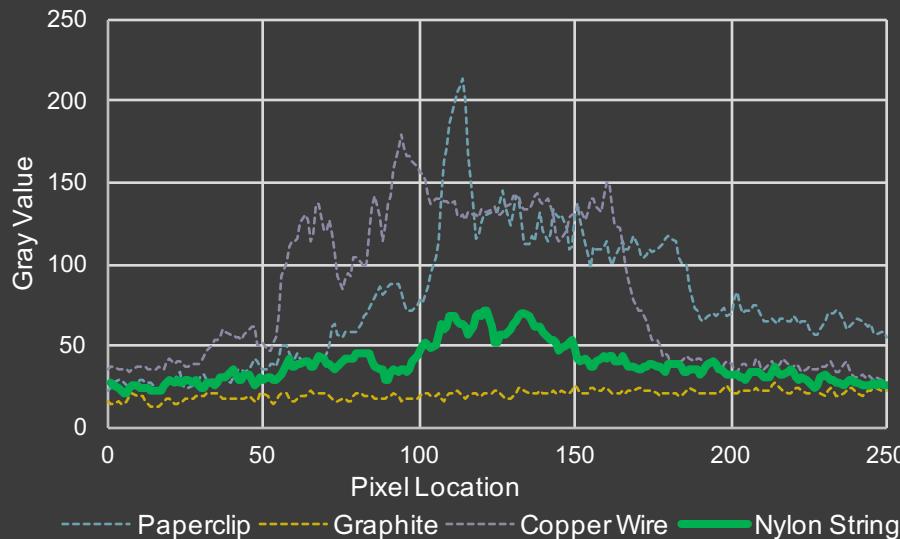
Circle

Wire

Single Slit

Conclusion

Nylon String Reflectivity



Intro

Circle

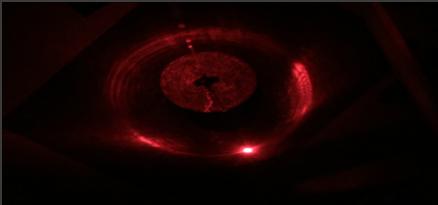
Wire

Single Slit

Conclusion

Imperfections in material

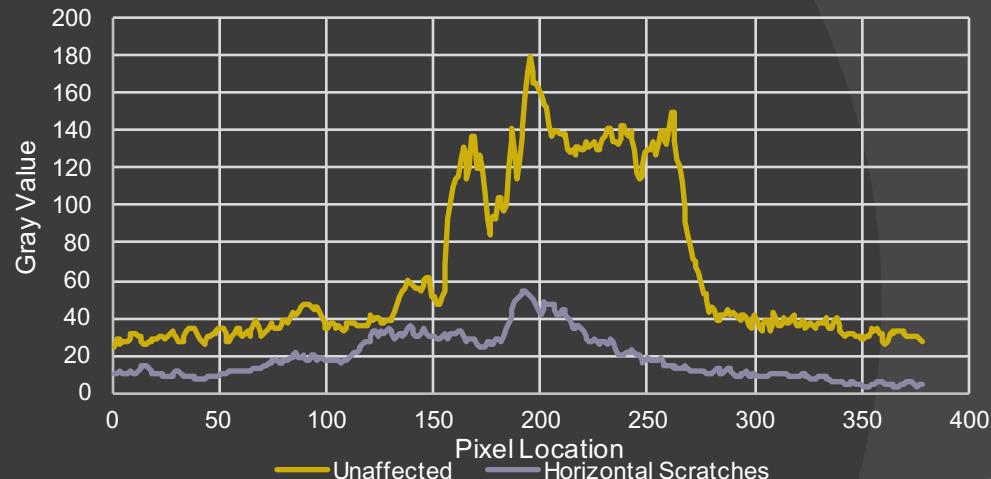
- Horizontal Scratches



- Unaffected



Vertical Scratches vs. Unaffected vs. Horizontal Scratches



Intro

Circle

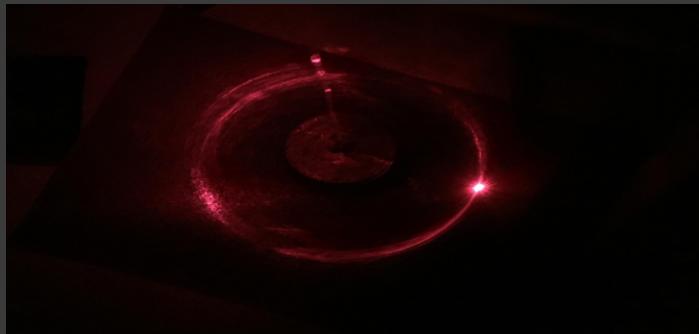
Wire

Single Slit

Conclusion

Imperfections Cont'd

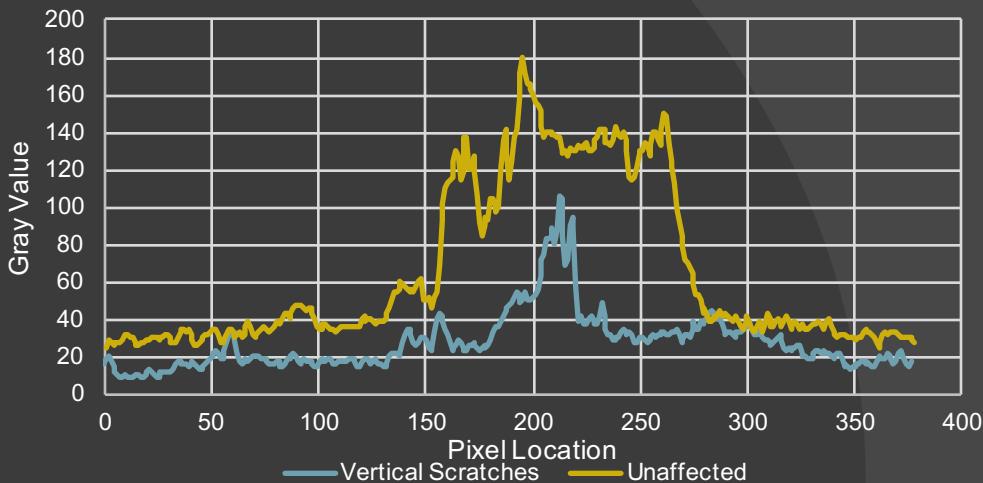
- Vertical Scratches



- Unaffected



Vertical Scratches vs. Unaffected vs. Horizontal Scratches



Intro

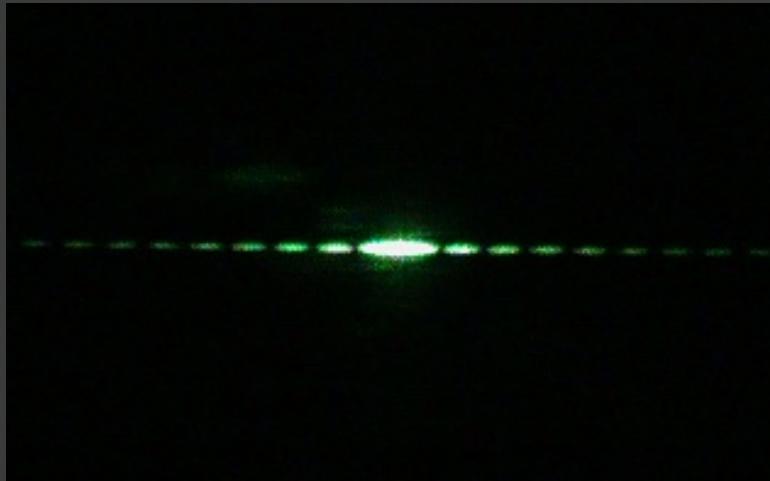
Circle

Wire

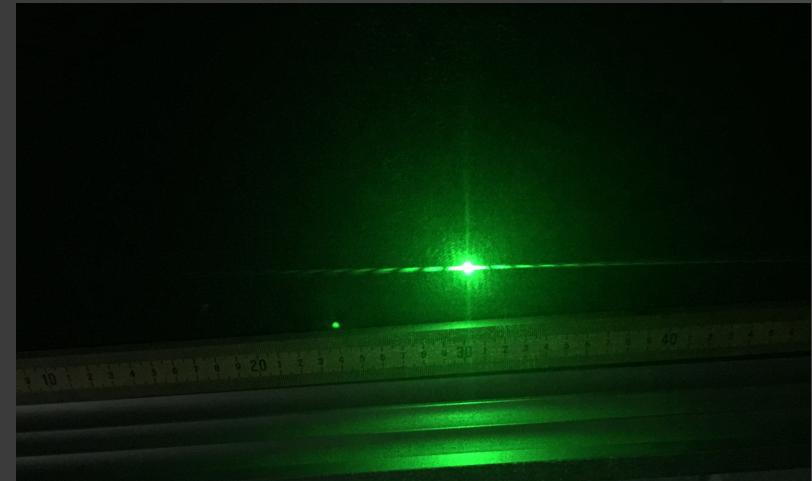
Single Slit

Conclusion

Slit Diffraction vs. Wire Diffraction



Slit



Wire

Intro

Circle

Wire

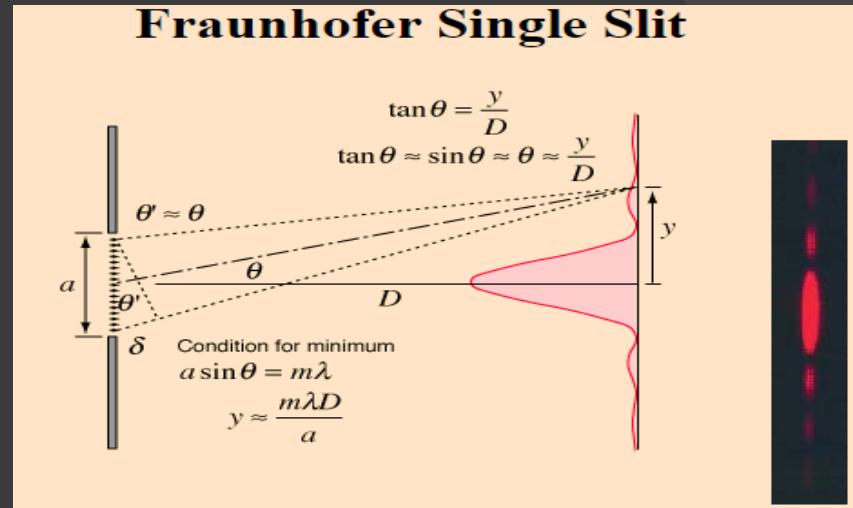
Single Slit

Conclusion

Single Slit Diffraction

- Babinet's principle from Huygen-Fresnel
- Fraunhofer Single Slit Diffraction Approximation

$$Y = \frac{m\lambda d}{a}$$



<http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/sinslit.html>

Intro

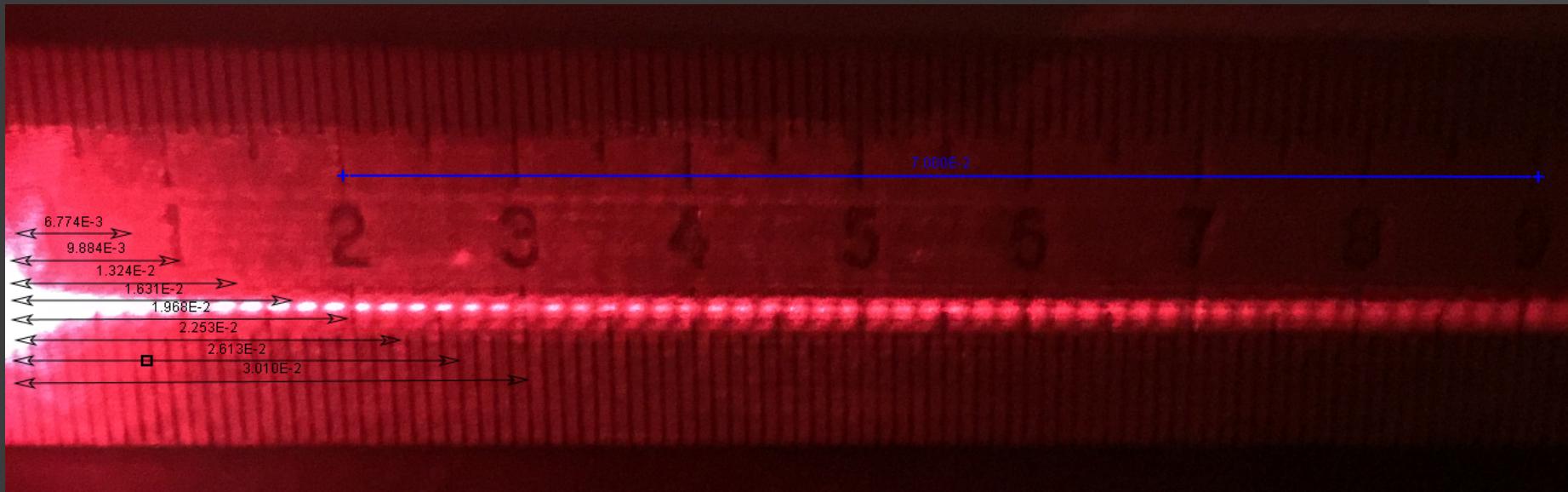
Circle

Wire

Single Slit

Conclusion

Experimental Method



Intro

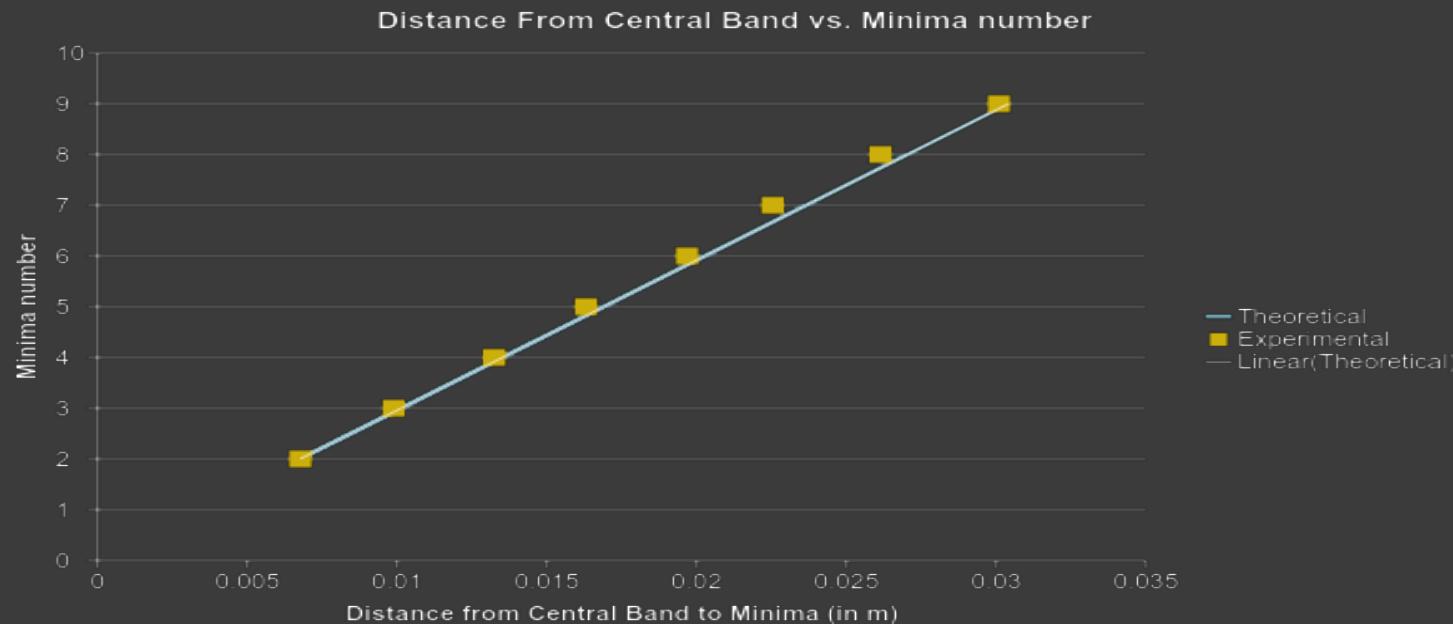
Circle

Wire

Single Slit

Conclusion

Theoretical vs. Experimental



Intro

Circle

Wire

Single Slit

Conclusion

Conclusions

- Diffraction and Reflection are present
- The reflection is impacted by the surface of the wire
- Diffraction can be approximated using Single Slit Approximation

Intro

Circle

Wire

Single Slit

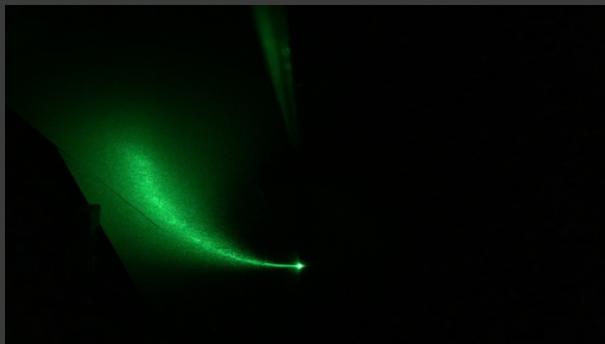
Conclusion

References

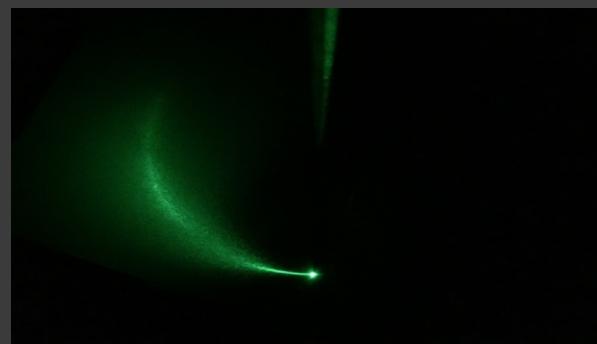
- "Images." *Diffraction with Hair or Wire*. N.p., n.d. Web. 14 Mar. 2015.
- "Fraunhofer Diffraction -- Thin Wires | MIT Video." *MIT Video*. N.p., n.d. Web. 14 Mar. 2015.
- "SINGLE SLIT DIFFRACTION PATTERN OF LIGHT." *SINGLE SLIT DIFFRACTION PATTERN OF LIGHT*. University of British Columbia, n.d. Web. 14 Mar. 2015.
- "How a Laser Works." *How a Laser Works*. Oregon State University, 2015. Web. 14 Mar. 2015.
- "Who Is Using HyperPhysics?" *HyperPhysics Concepts*. Georgia State University, n.d. Web. 11 Mar. 2015.
- Henderson, Tom. "Specular vs. Diffuse Reflection." *Specular vs. Diffuse Reflection*. N.p., 2015. Web. 14 Mar. 2015.
- Hollis, Benjamin. "Physics of Sound." *The*. N.p., n.d. Web. 12 Mar. 2015.
- Walker, Jearl, David Halliday, and Robert Resnick. *Fundamentals of Physics*. Hoboken, NJ: Wiley, 2011. Print.
- Sanchez-Brea, Luis Miguel, Philip Siegmann, Maria Aurora Rebollo, and Eusebio Bernabeu. "Optical Technique for the Automatic Detection and Measurement of Surface Defects on Thin Metallic Wires." *Applied Optics Appl. Opt.* 39.4 (2000): 539. Web.
- Keller, Joseph B. "Geometrical Theory of Diffraction." *J. Opt. Soc. Am. Journal of the Optical Society of America* 52.2 (1962): 116. Web.
- Sanchez-Brea, Luis Miguel, Philip Siegmann, Maria Aurora Rebollo, and Eusebio Bernabeu. "Optical Technique for the Automatic Detection and Measurement of Surface Defects on Thin Metallic Wires." *Applied Optics Appl. Opt.* 39.4 (2000): 539. Web.

Radius of Wire Effect

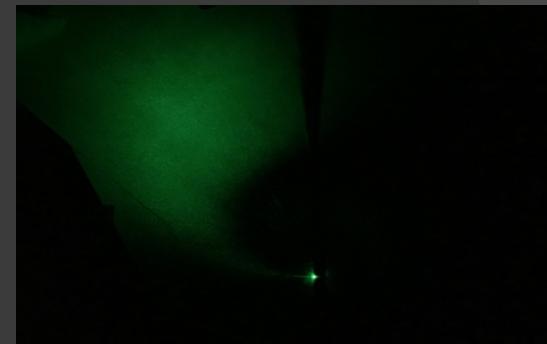
- Zinc rod with varying thickness (4.85, 6.4, 7.9mm, respectively).



4.85mm Zinc



6.4mm Zinc



7.9mm Zinc

Intro

Circle

Wire

Single Slit

Conclusion