Far-Field Propagation Through a Round Aperture

MIDN 4/C Carpenter, MIDN 4/C Vasconez

Professor Reza Malek-Madani, Mathematics Department

Background

Intensity of Light:

The far-field intensity of light passed through a ***one-dimensional slit*** can be modeled by…

$$I(L,a) = \left| \int_{-D}^{D} \frac{e^{ik\sqrt{L^2+(a-y)^2}}}{\sqrt{L^2+(a-y)^2}} \right|^2$$

Integrated with respect to "a"

L = distance from the aperture
a = vertical distance from individual photon's origin
D = half-span of the slit
k = spatial frequency ($2\pi/L$)

The far-field intensity of light passed through a ***round aperture*** can be modeled by…

$$I(L,r,\Theta) = \left| \int_0^{2\pi} \int_0^{R} \frac{e^{ik\sqrt{L^2+r-(r\cos\Theta)^2}}}{\sqrt{L^2+r-(r\cos\Theta)^2}} r \right|^2$$

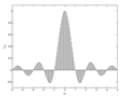
Integrated with respect to "r" then "Θ"

L = distance from the aperture
r,Θ = photon's polar coordinates at aperture
k = wave number ($2\pi/L$)

Phenomenon of the Airy Disk:

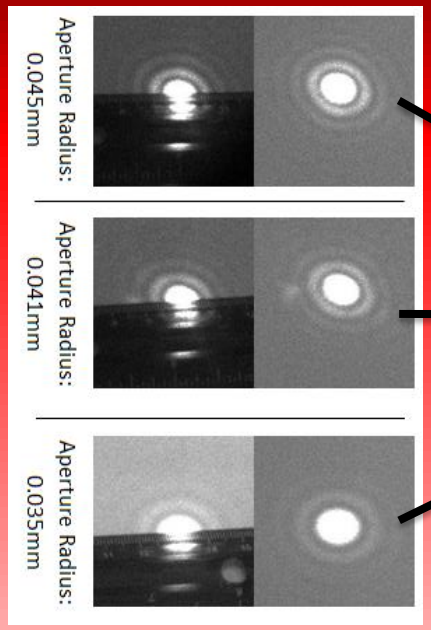
- This ideal, computer-generated image is the observed result when passing a laser through a round aperture

- To the left is a 3D representation of the intensity of light passed through a round aperture at any point in its propagation

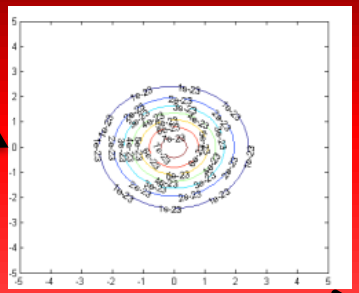


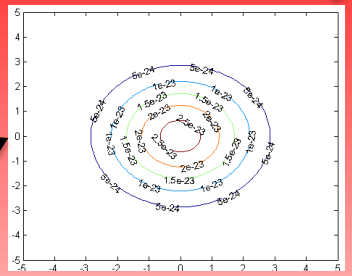
- Mathematically, the graph of the intensity function can be described using Fourier transforms, also commonly used in radio communications

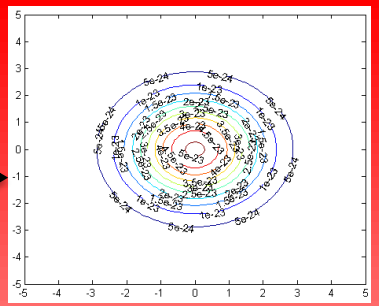
Experiment



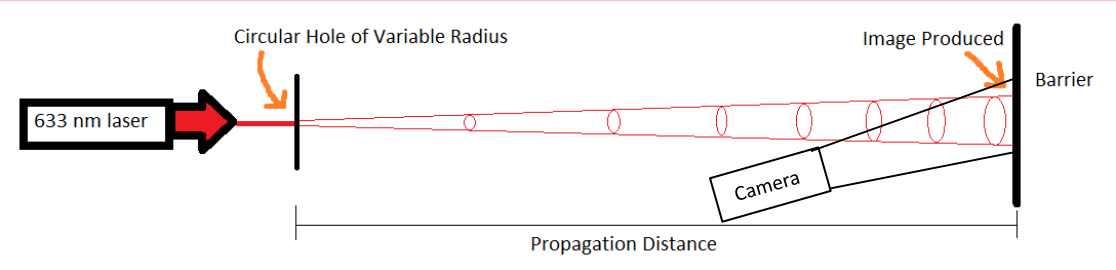
MATLAB Models:







Experimental Set-Up



Acknowledgements: Dr. Svetlana Avramov-Zamurovic, Stephen Guth

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MIDN 4/C CARPENTER

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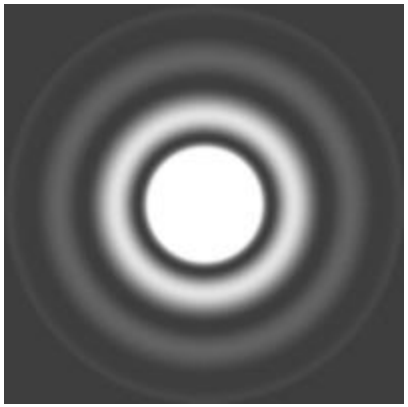
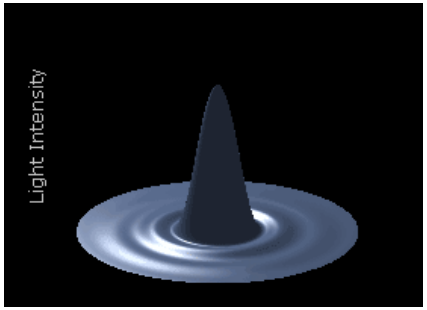
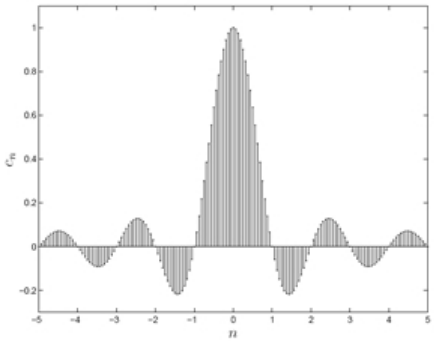
Phenomenon of the Airy Disk







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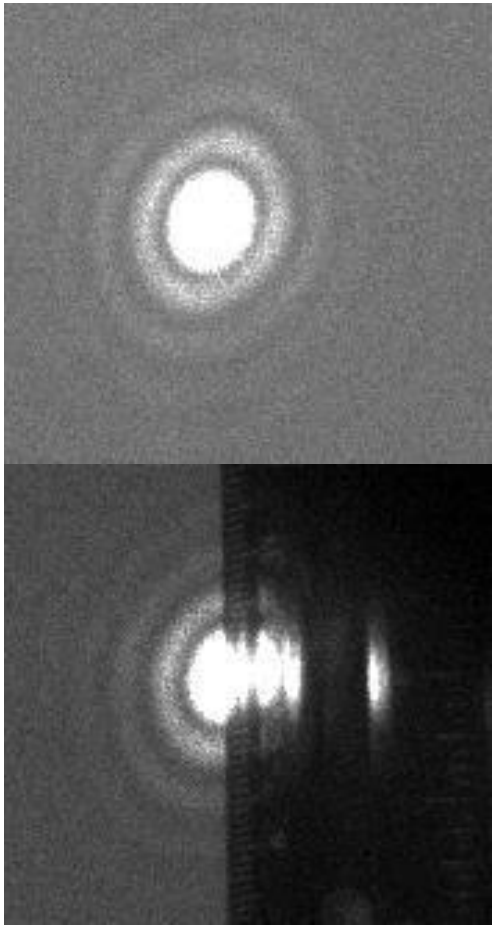
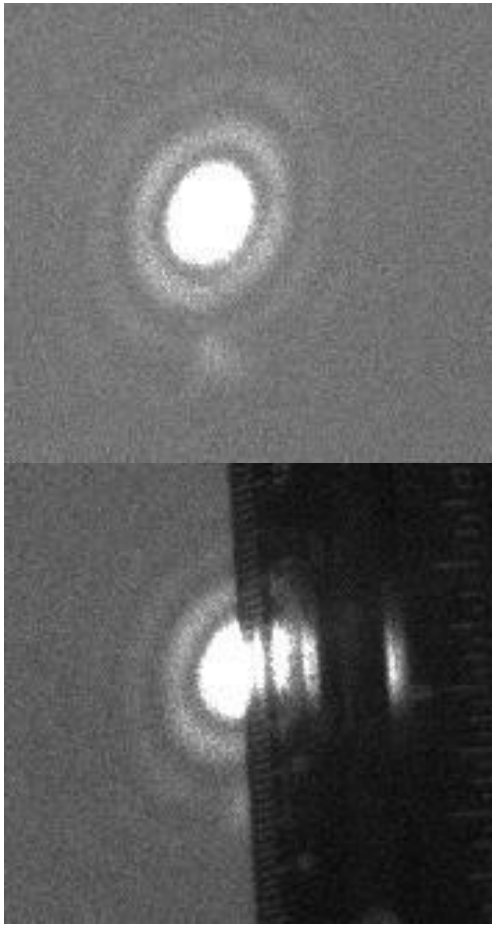
Experimental Results



Aperture Radius: 0.045mm



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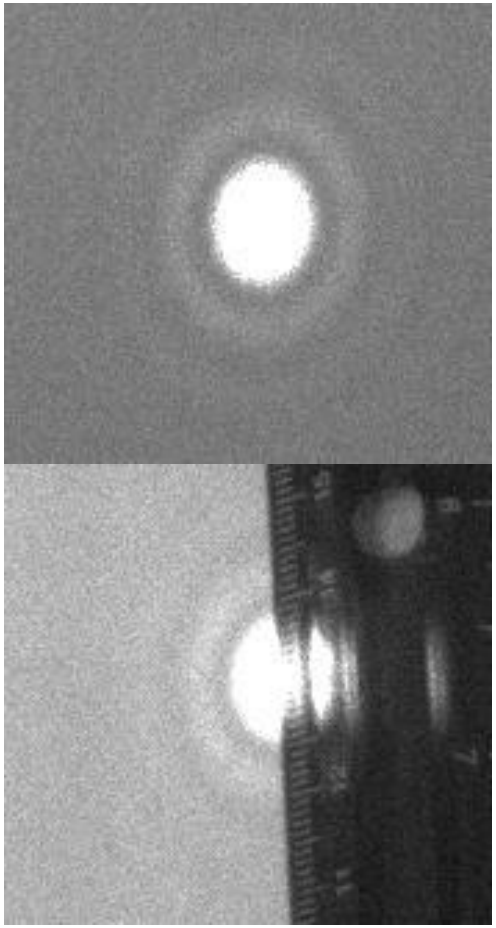

Aperture Radius: 0.035mm

http://www.cambridgeincolour.com/tutorials/diffraction-photography.htm
http://see.stanford.edu/see/courseinfo.aspx?coll=84d174c2-d74f-493d-92ae-c3f45c0ee091