Modeling Laser Propagation Through A Double Slit

Midshipmen 4/C Emma Carlson, Sean O'Bryant, and Sara Peeleman

UNITED STATES NAVAL ACADEMY

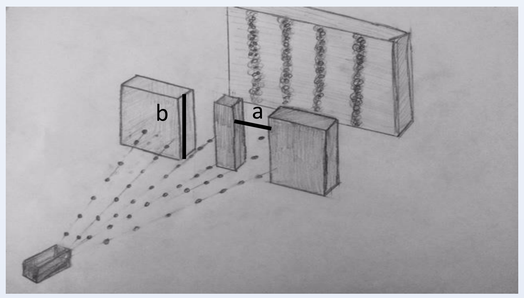
Motivation/Math Background

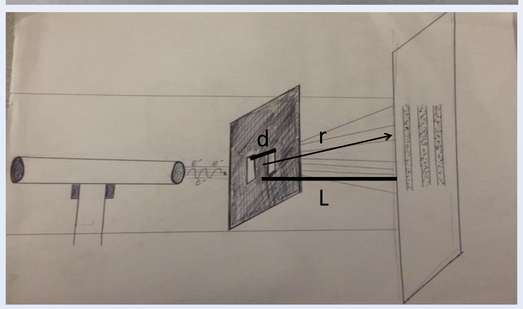
Purpose
-To mathematically model the effect of laser propagation through two slits by calculating intensity in a region of definite dimensions.

Background:
A practical experiment where a laser was shown through two slits produced a series of bright and dark bands on a screen.
Our objective was to mathematically model this effect.
Wave-Particle Duality
This result demonstrates that light has the properties of both a particle and a wave.
Light is always found to be absorbed at the screen at discrete points; the wave is being affected before it hits the screen, affecting the behavior of the particles and disrupting the diffraction pattern of a typical single-slit experiment.

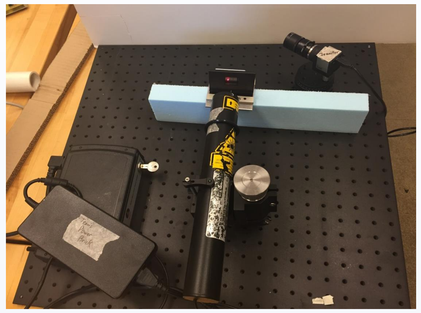
Experiment Plan

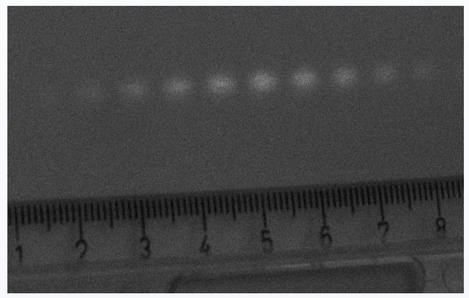
-A laser beam will be projected through an expander and two slits. The pattern projected onto a surface of known distance from the laser will be observed,.
-We will then construct a mathematical model and compare its accuracy to our results.

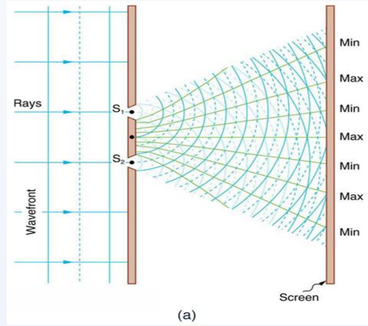


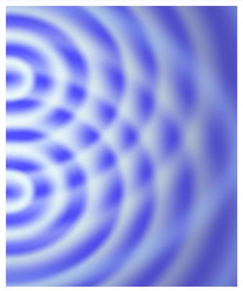


Experiment









Simulation

-The code represents the calculation for the intensity of the laser beam every 0.0001m after passing through slit A on the screen it was projected on. The matrix containing the values of the intensity at different points is represented by the figures under Results.

```
function z = integrand(x,y,X,Y)
lambda = 633*10^-9;
k = 2*pi/lambda;
L = 10^7*lambda;
r = sqrt((x-X).^2+(y-Y).^2+L^2);
z = exp(1i*k*r)./r;
```

```
lambda=633*10^-9;
a=63.1912*lambda;
b=3949.45*lambda;
d=394.945*lambda;

X=-4.7393e+04*lambda:0.0001:4.7393e+04*lambda;
Y=X;
mat=[];

for i=1:length(X)
    for j=1:length(Y)
        terml(i,j)=quad2d(@(x,y)
integrand(x,y,X(i),Y(j)),-b/2,b/2,d,d+a);
        term2(i,j)=quad2d(@(x,y)
integrand(x,y,X(i),Y(j)),-b/2,b/2,-d-a,-d);

intensity(i,j)=abs(terml(i,j)+term2(i,j))^2;
        mat = [mat intensity(i,j)];
    end
end
```

Results

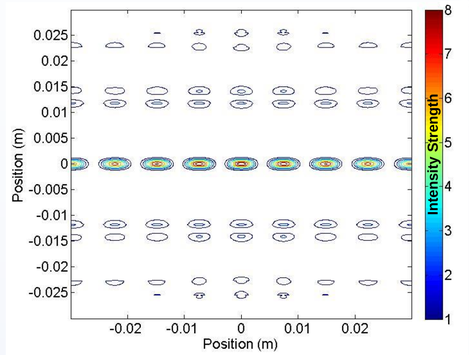


Figure 1: Mathematical model of the intensity of the laser's projection on the screen using contour lines

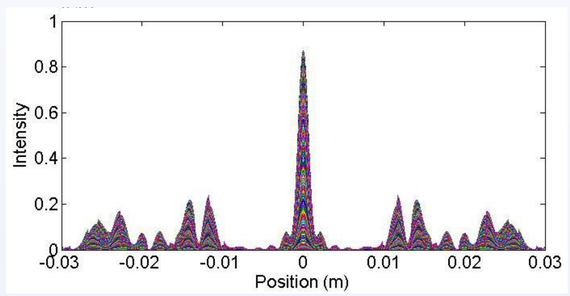


Figure 2: Graphical representation of the intensity of the laser's projection on the screen with respect to position in the horizontal direction.

Conclusion

-Our model accurately reflects the pattern we observed in our experiment. During the experiment, the blocks of light were 0.004 m long and had a space of 0.003 m between them. Figure 1 displays similar values for the width of and distance between the blocks of light.
-The blocks of light diminish in intensity as they radiate out from the central axis. With the greatest intensity for each individual block at its center. These observations are displayed in Figure 2.
-We can therefore conclude our model has represented laser propagation through a double slit to an acceptable degree of accuracy.

Acknowledgements

Dr. Reza Malek-Madani, Professor, Dept. of Mathematics, USNA
Dr. Svetlana Avramov-Zamurovic, Professor, Weapons and Systems Department, USNA
Stephen Guth, Research Assistant, USNA