Diffraction: Lab 4

6.2370 Modern Optics Project Laboratory

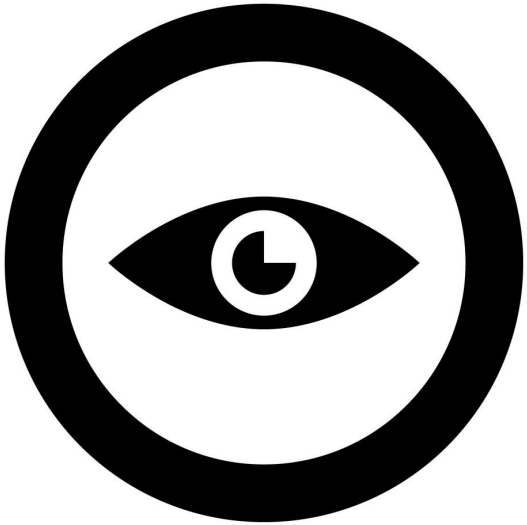
Daniel Sanango

Overview

Essentials

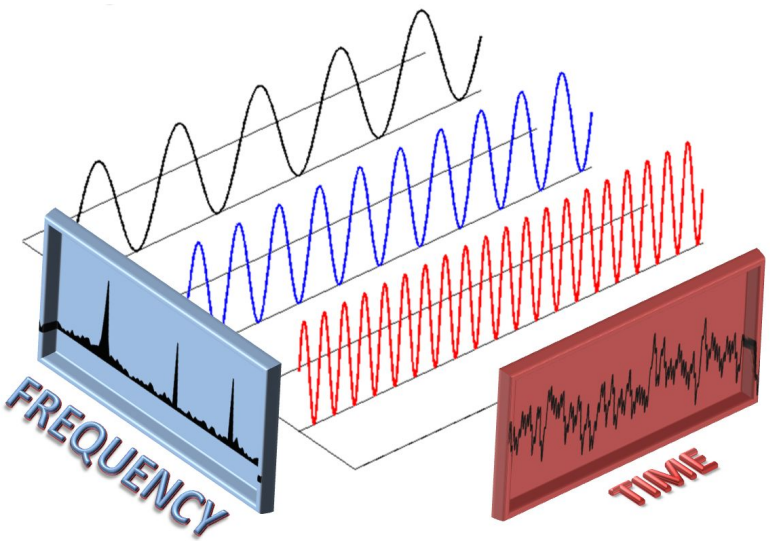
Experiment

Observations



Diffraction Essentials

1) Fourier Transform
    - Spatial Domain
    - Spatial Frequency Domain
    - NOT Time



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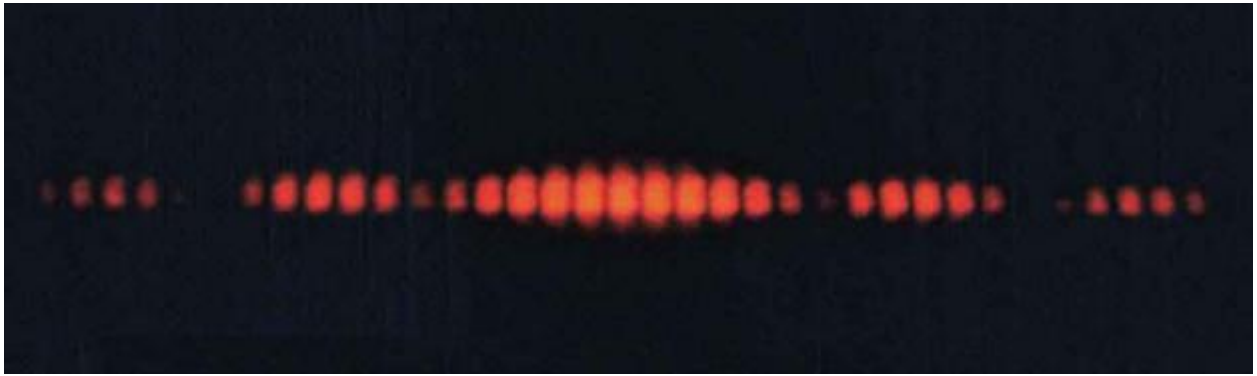
Diffraction Essentials

2) Intensity
- What we visibly see
- $I \propto E^2$

3) Interference
- Causes “nulls”
- Related to phase
- Path length differences



Fraunhofer Far Field - Fourier Transform

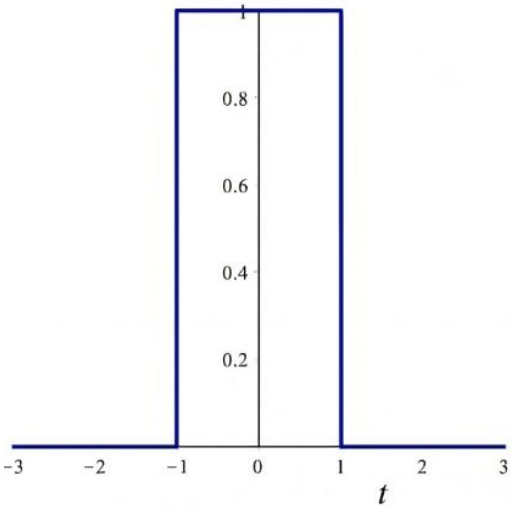
$$\underline{U_2}(x_2, y_2) = \frac{1}{j\lambda z} e^{jkz} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \underline{U_1}(x_1, y_1) e^{-j2\pi(f_x x_1 + f_y y_1)} dx_1 dy_1$$

Where,...

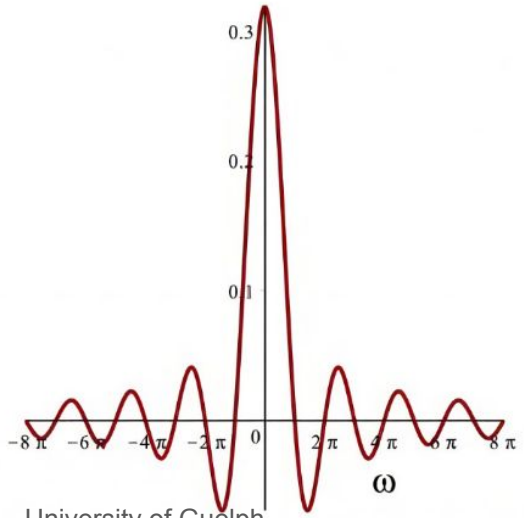
- $\underline{U_2}(x_2, y_2) \rightarrow$ Diffracted Electric Field
- $\frac{1}{j\lambda z} \rightarrow$ Scaling Factor
- $e^{jkz} \rightarrow (+\hat{z})$ Wave Propagation
- $\underline{U_1}(x_1, y_1) \rightarrow$ Input Electric Field
- $e^{-j2\pi(f_x x_1 + f_y y_1)} \rightarrow (+\hat{x_1})$ and $(+\hat{y_1})$

Most Common Transform Pair in this Lab:

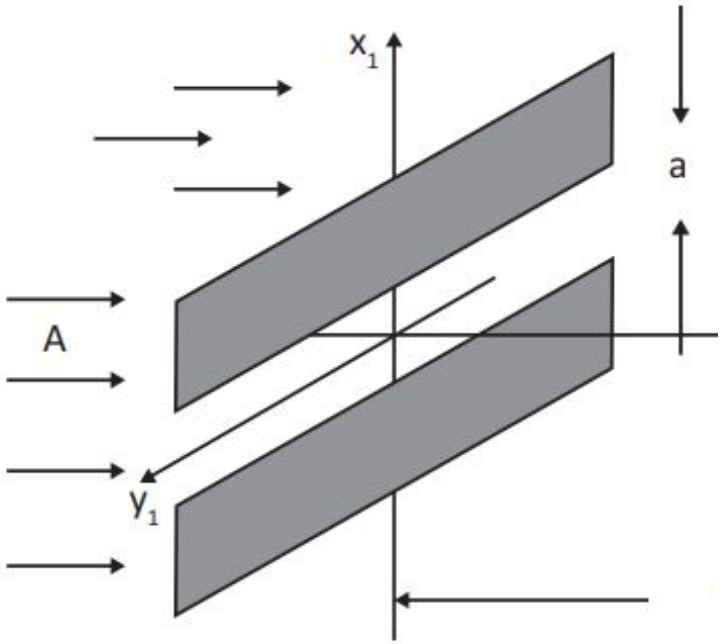
Rect Function



Sinc Function



Single Slit - Experiment



Objective:

- Find slit width relation to diffraction pattern

Setup:

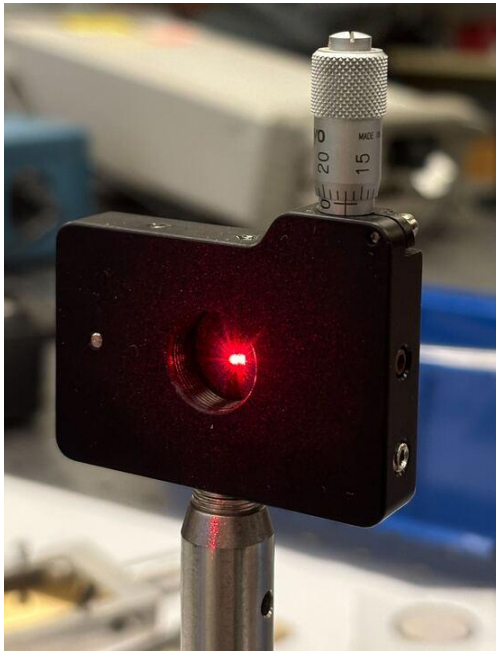
- Variable slit device
- Red light

Approach:

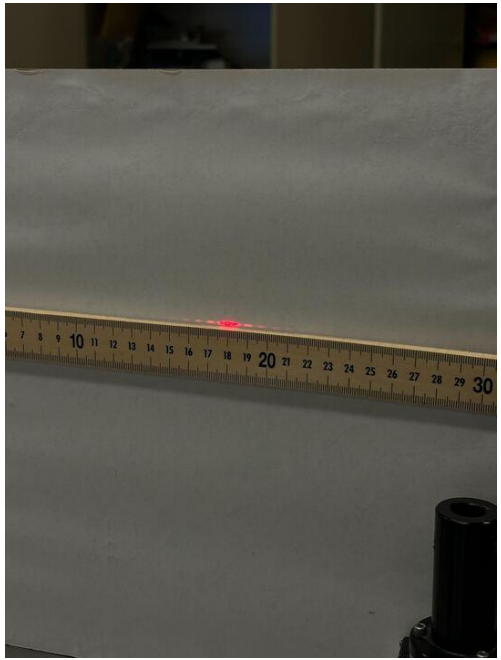
- Make note of relation

Single Slit - Lab Experiment

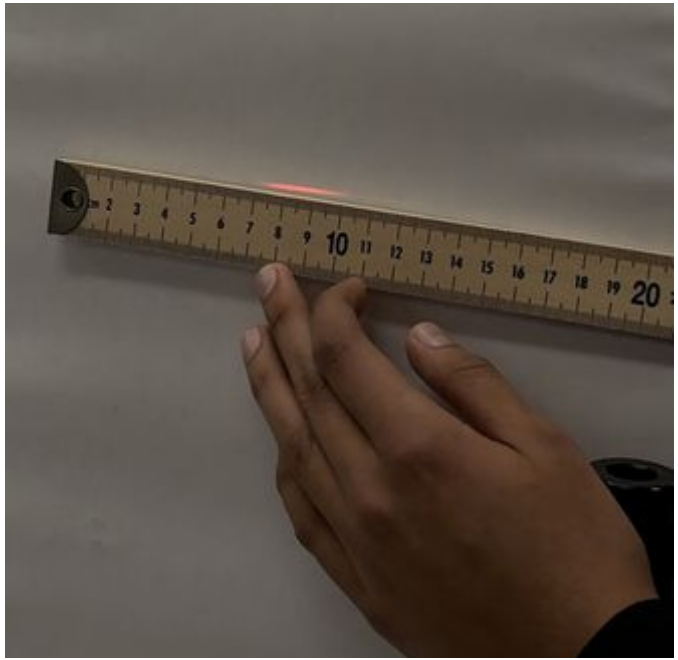
Setup:



Results:



Large slit width



Small slit width

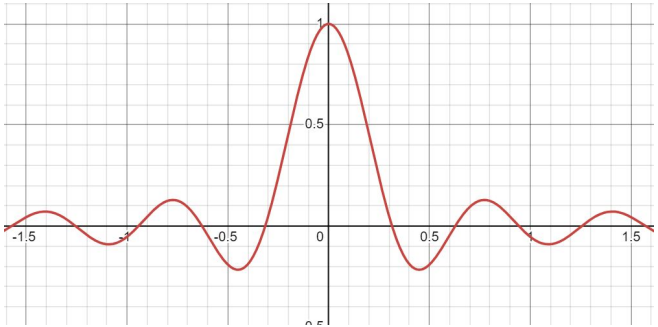
Single Slit - Observations

Observations:

- Matches theory

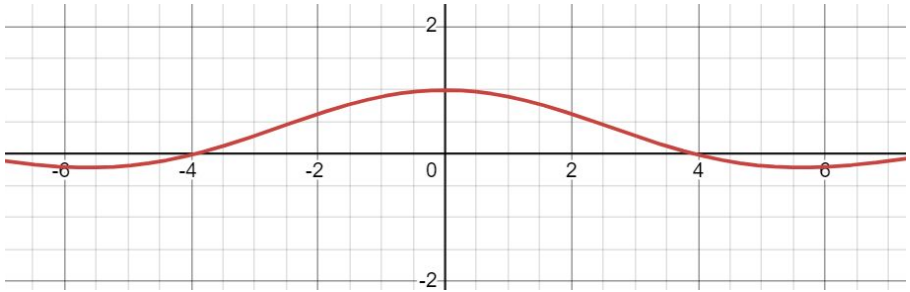
$$I(f_x) = KA^2a^2 \left| \frac{\sin(\pi f_x a)}{\pi f_x a} \right|^2 |\delta(f_y)|^2$$

$$I(x_2) = I_0 \ \operatorname{sinc}^2(x_2 a/\lambda L)$$



Desmos

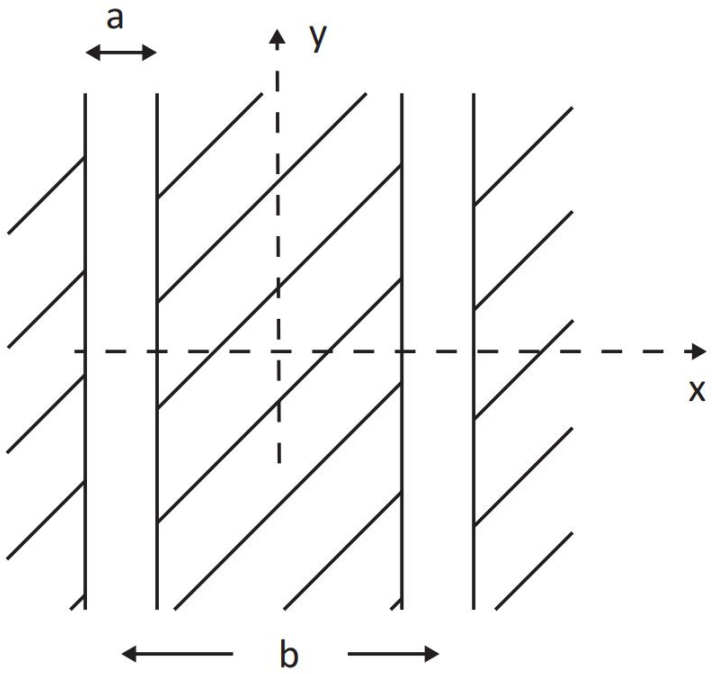
sinc(ax), a small



Desmos

sinc(ax), a large

Double Slit - Experiment



6.2370 Lecture Notes

Objective:

- Find slit width relation to diffraction pattern

Setup:

- Double slit grating with fixed grating distances (a,b)

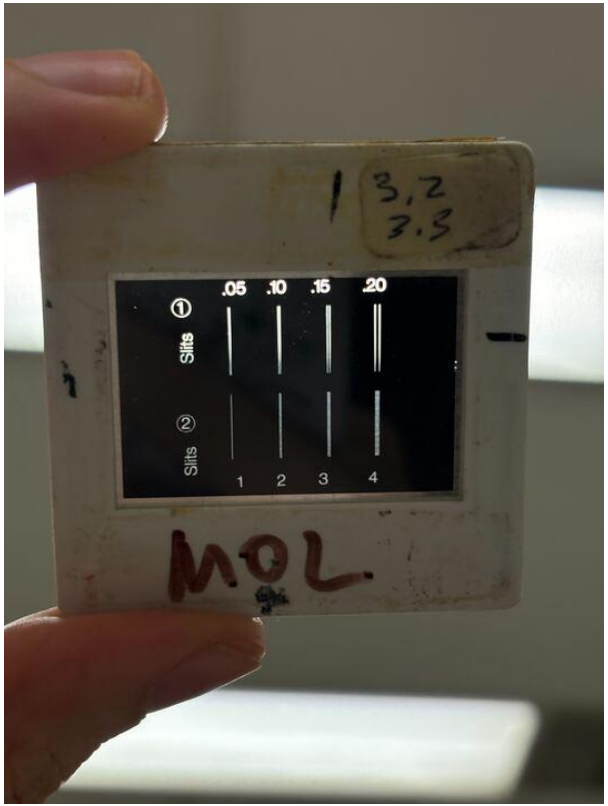
Approach:

- Make note of relation

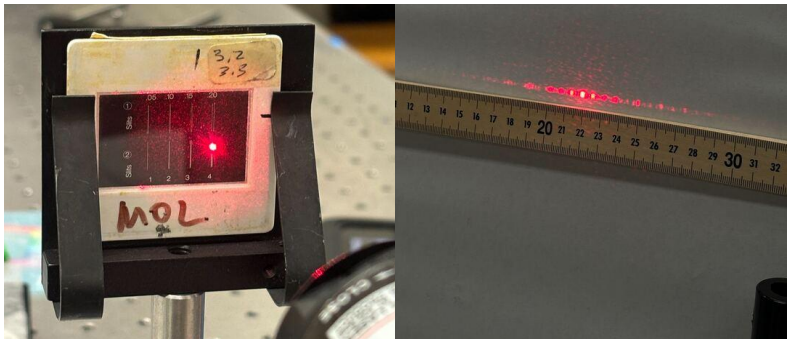
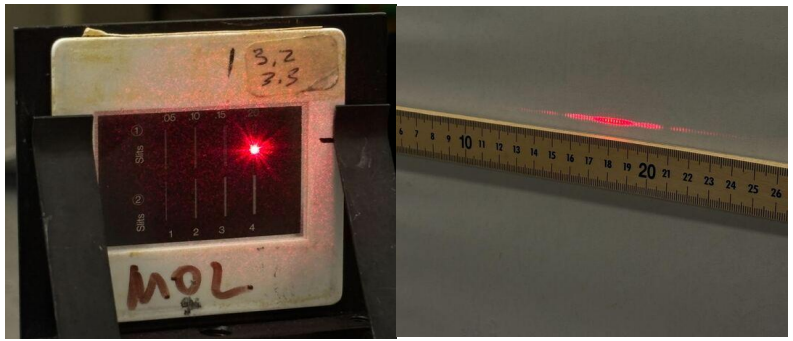
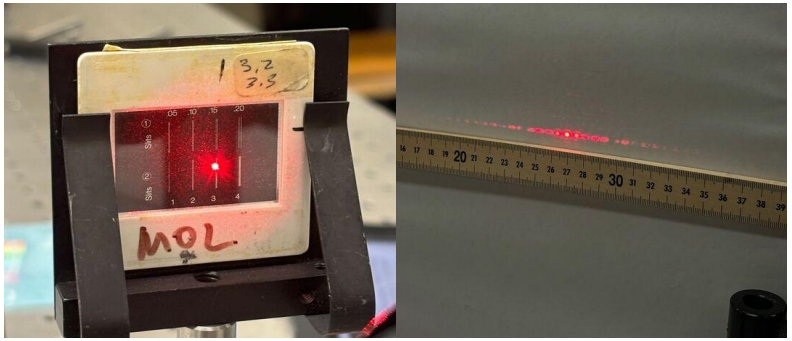
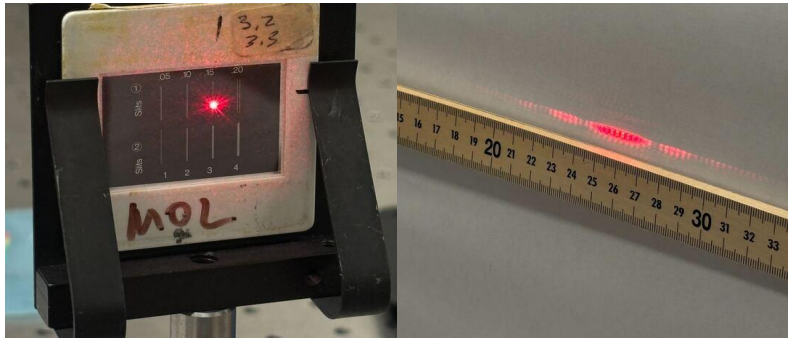
Double Slit - Lab Experiment

Notes about Slit

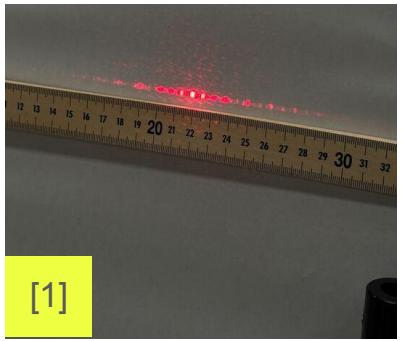
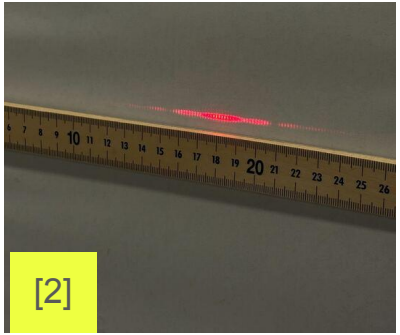
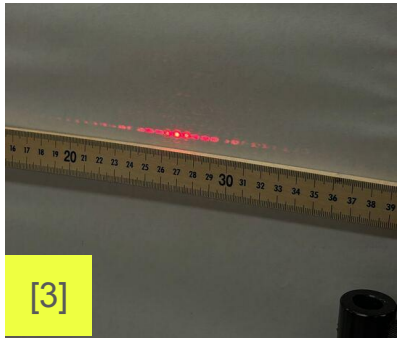
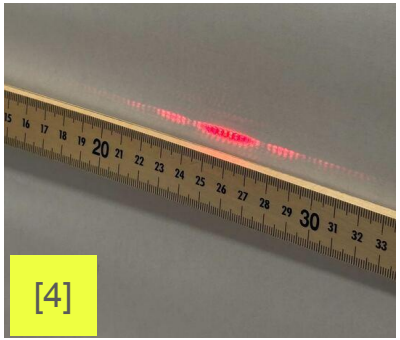
- Top numbers: “b” for top row
- Top Row: Huge “b”, Small “a”
- Bottom Row: Small “b”, Big “a”

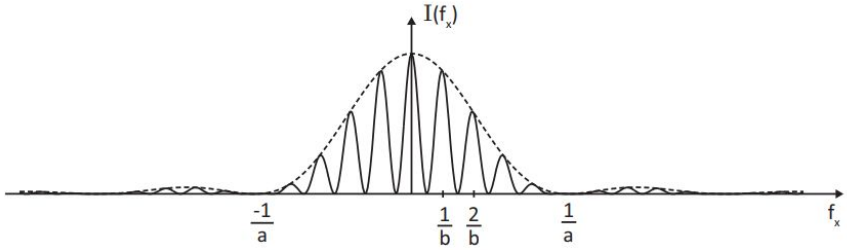


Double Slit - Lab Experiment

	↑a, ↓b (bottom)	↓a, ↑b (top)
↑b (right)		
↓b (left)		

Double Slit - Observations

	↑a, ↓b (bottom)	↓a, ↑b (top)
↑b (right)	 [1]	 [2]
↓b (left)	 [3]	 [4]



6.2370 Lecture Notes

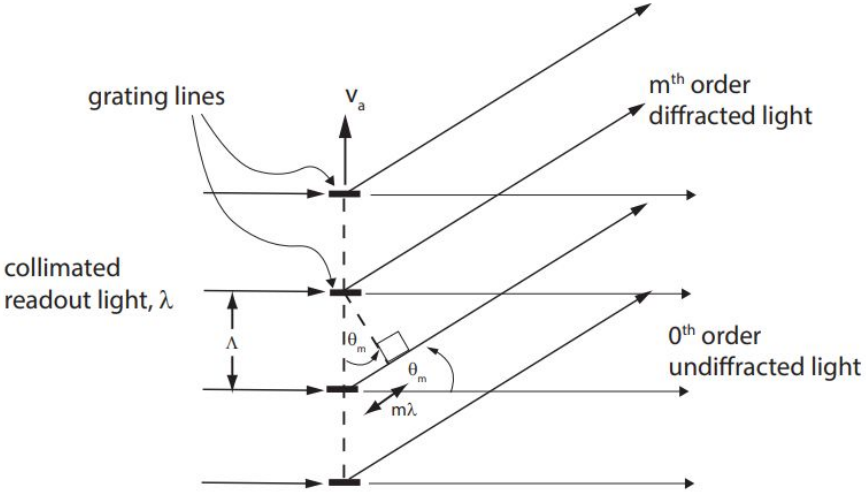
Observations:

[3] → Largest a, Smallest b
greatest space range

[2] → Smallest a, Largest b
greatest pattern density

[1] → Similar to ([3]), b Larger
[4] → Similar to ([2]), b Smaller

Numerous Slits - Experiment



6.2370 Lecture Notes

Objective:

Find slit width relation to diffraction pattern

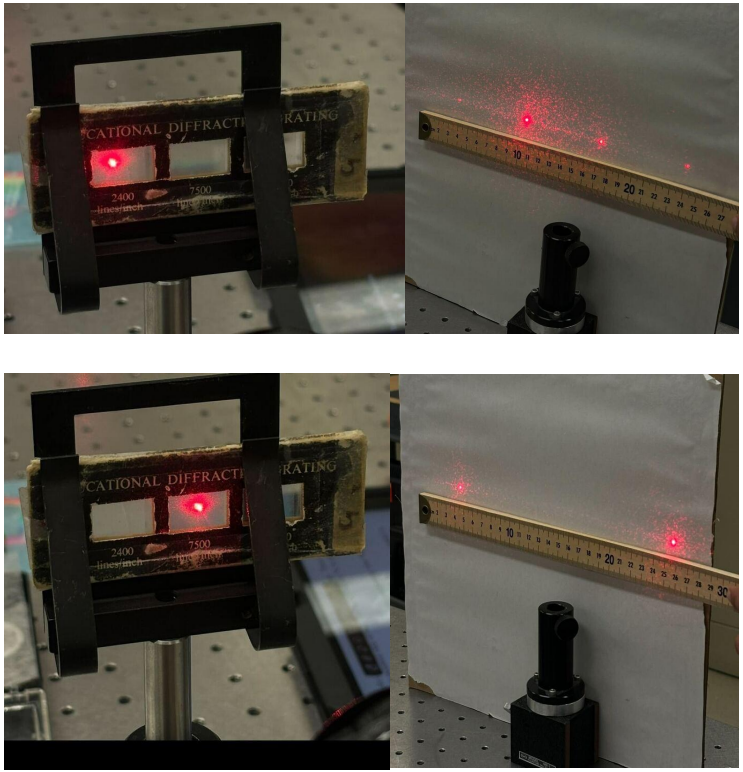
Setup:

- Set slit mask
- Red light

Approach:

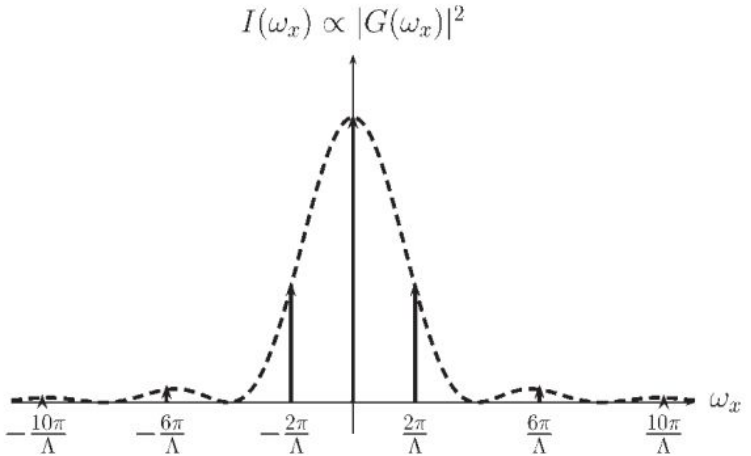
- Make note of relation

Numerous Slits - Lab Experiment

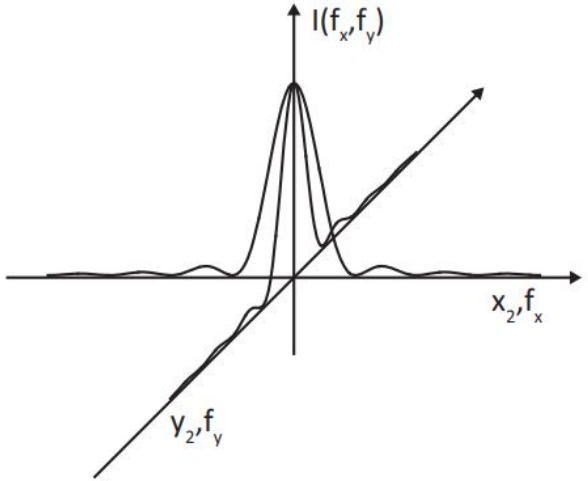


Observations:

- Have speckles
  - Implies aging
- More Lines → More Spread



Rectangular Slit - Experiment



6.2370 Lecture Notes

Objective:

- Find slit width relation to diffraction pattern

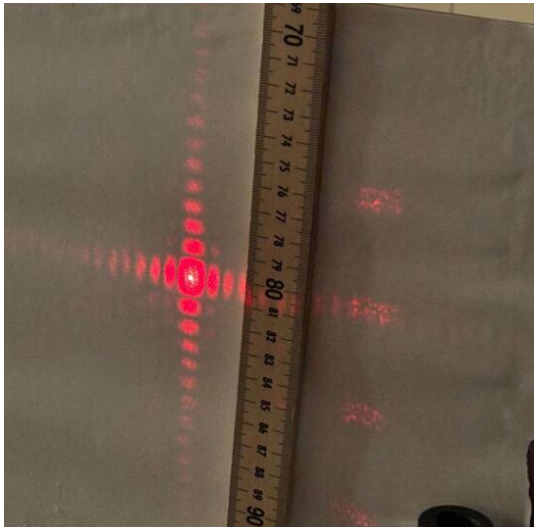
Setup:

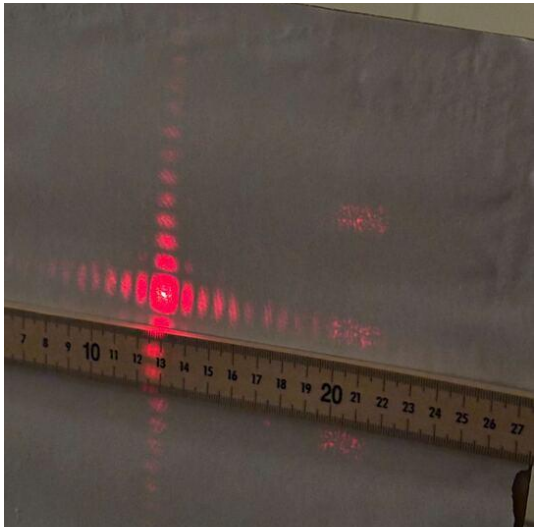
- Set slit grating
- Red light

Approach:

- Make note of relation

Rectangular Slit - Results





Observations:

1) Matches Theory
   - Basically a vertical and horizontal slit
   - With single slit, had ignored y-dimension

2) Similarities to slit
   - Rectangular center