

Diffraction (6.161 Lab3)

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10/21/2008

Topics to be discussed

1. Introduction

1. Diffraction theory
2. Fraunhofer diffraction integral

2. Experimental setup

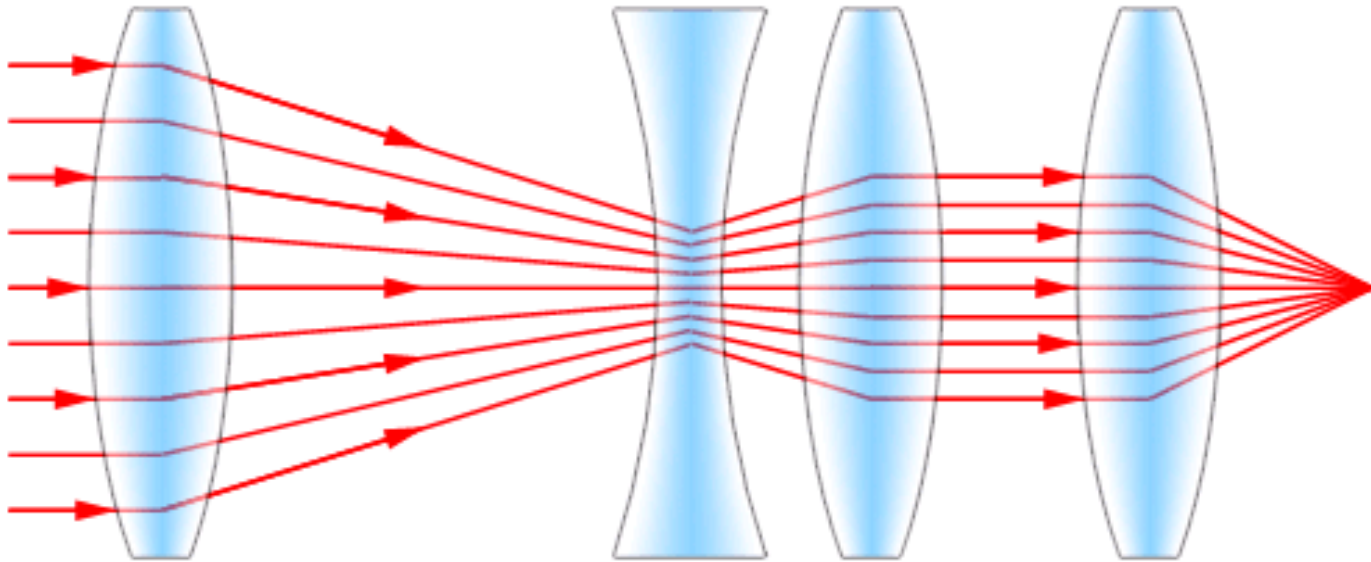
3. Patterns from apertures

1. Single-slit
2. Double-slit
3. Rectangular aperture
4. Rectangular grid

4. Conclusions

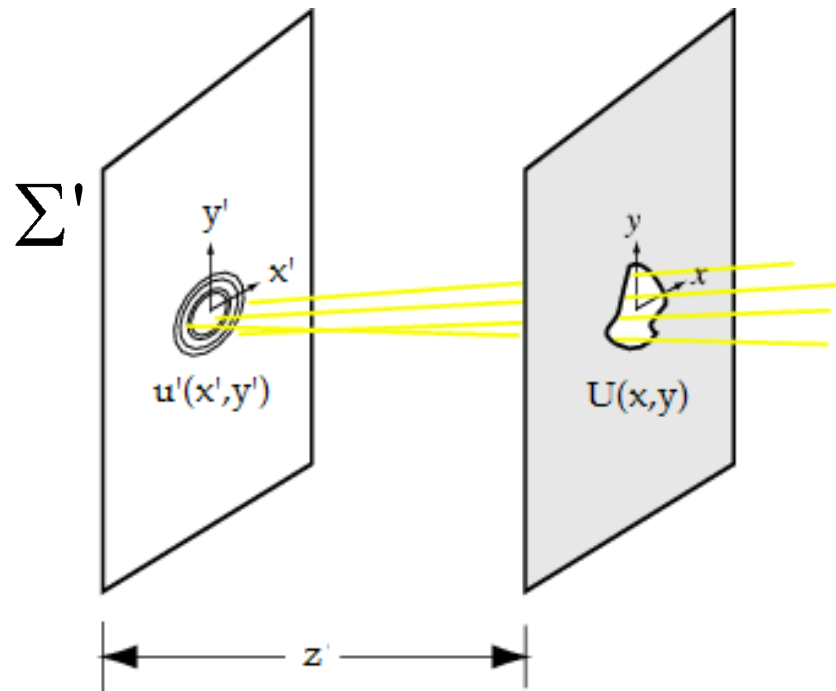
Diffraction = Wave - Ray

- Although *ray optics* is intuitive...



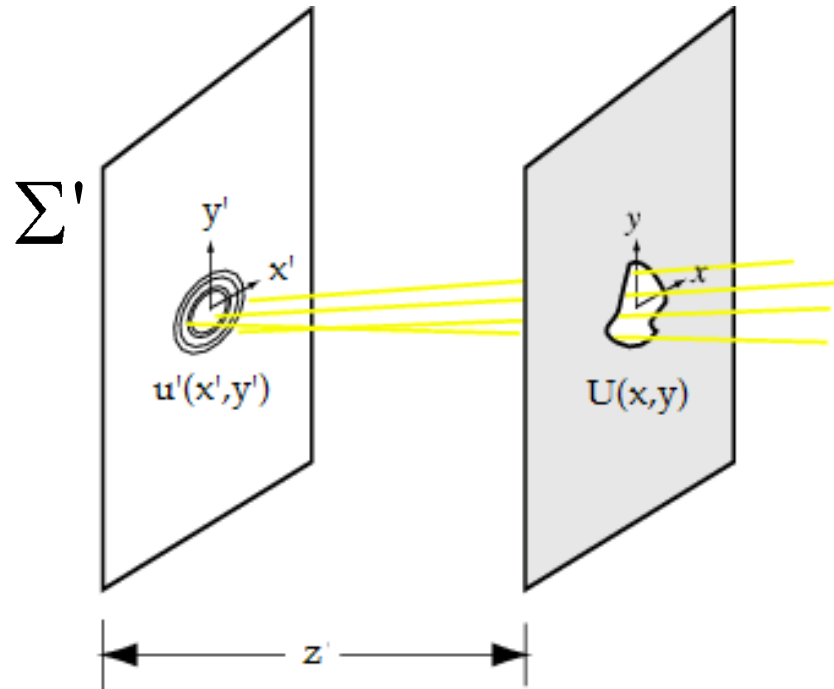
- Light is a *wave* phenomenon

Fraunhofer diffraction integral



$$U(x, y) = \frac{e^{ikz} e^{\frac{ik}{2z}(x^2 + y^2)}}{i\lambda z} \iint_{\Sigma'} u'(x', y') \cdot e^{-i\frac{2\pi}{\lambda z}(x'x + y'y)} dx' dy'$$

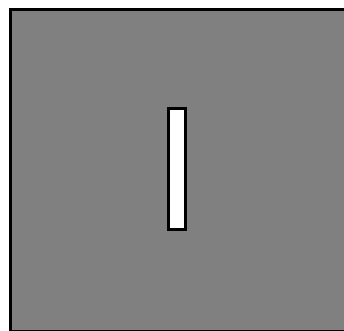
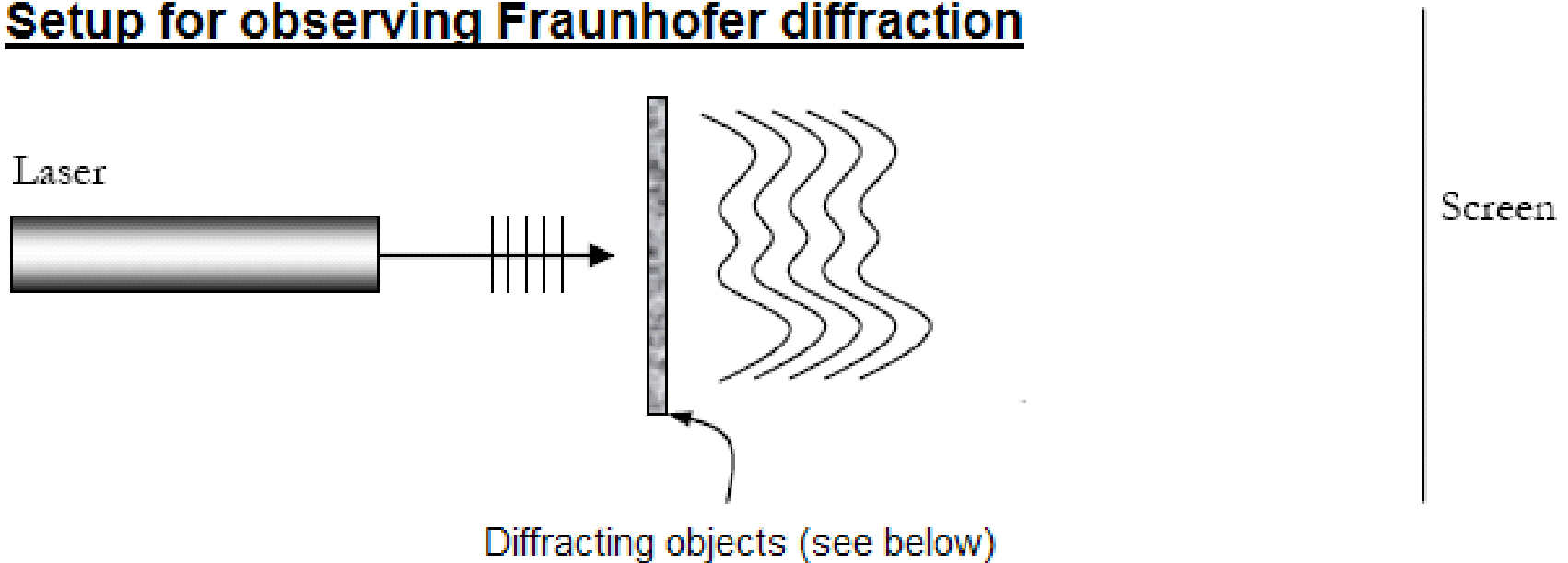
Fraunhofer intensity pattern



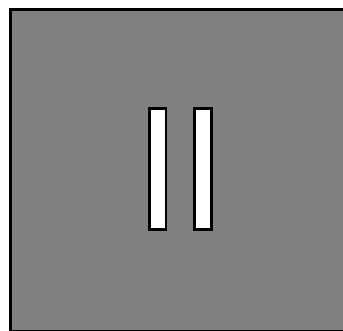
$$I \propto |U(x, y)|^2 \propto |F(u'(x', y'))|^2$$

Setup to observe diffraction

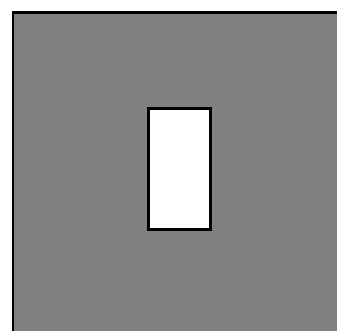
Setup for observing Fraunhofer diffraction



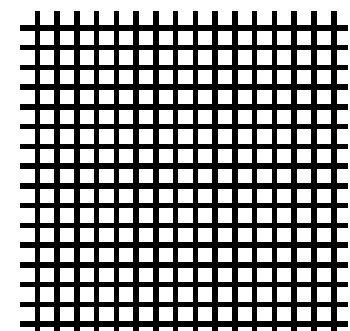
Single slit



Double slit



Rectangular aperture

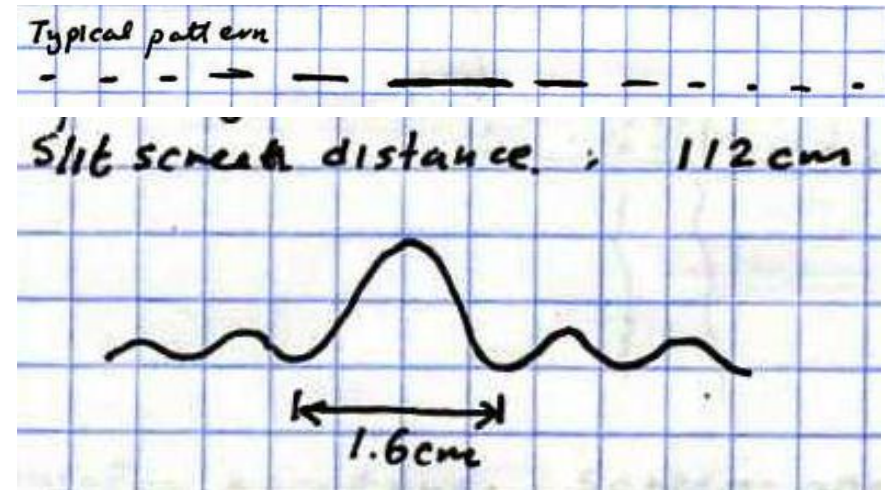
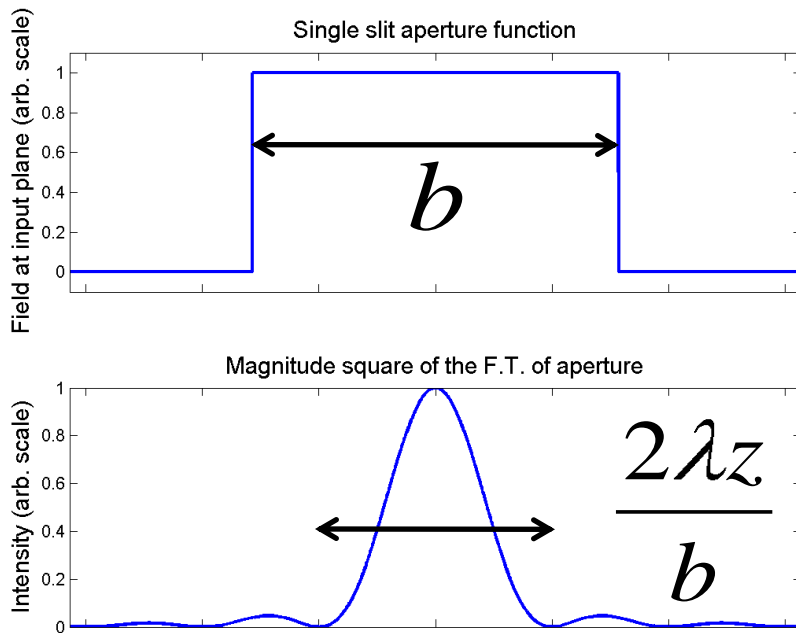
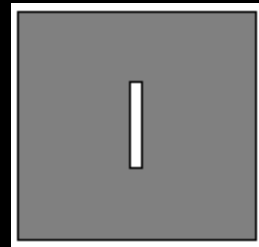


Rectangular grid

Patterns from apertures

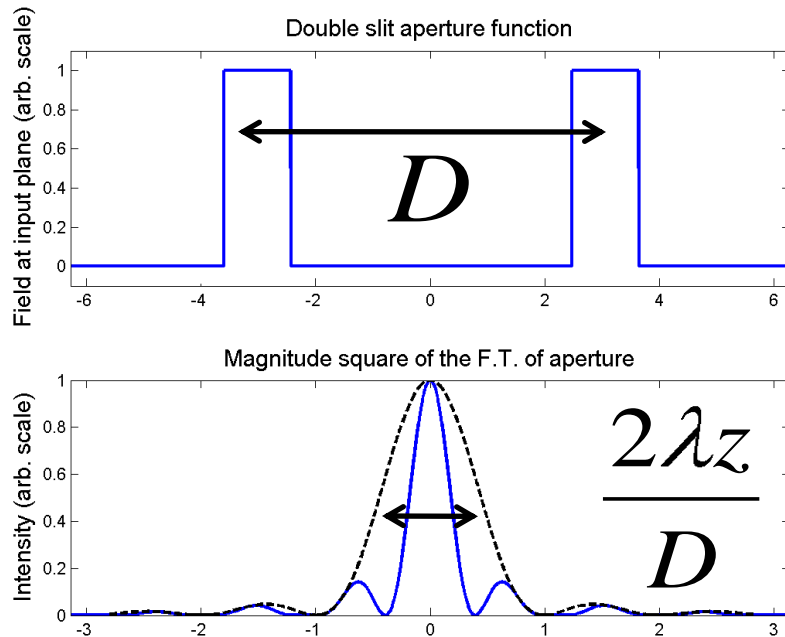
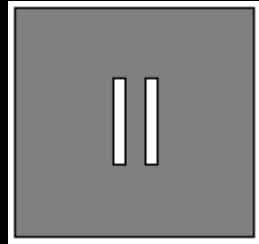
- We'll present and analyze (Topic set 1):
 1. Single-slit
 2. Double-slit
 3. Rectangular aperture
 4. Rectangular grid

Single slit

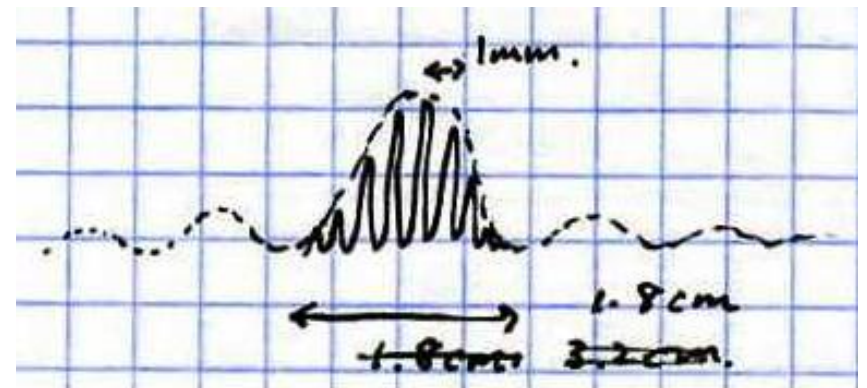


- Note *Fourier reciprocity* in characteristic lengths
- Calculate slit width from pattern: **b = 89 microns**

Double slit

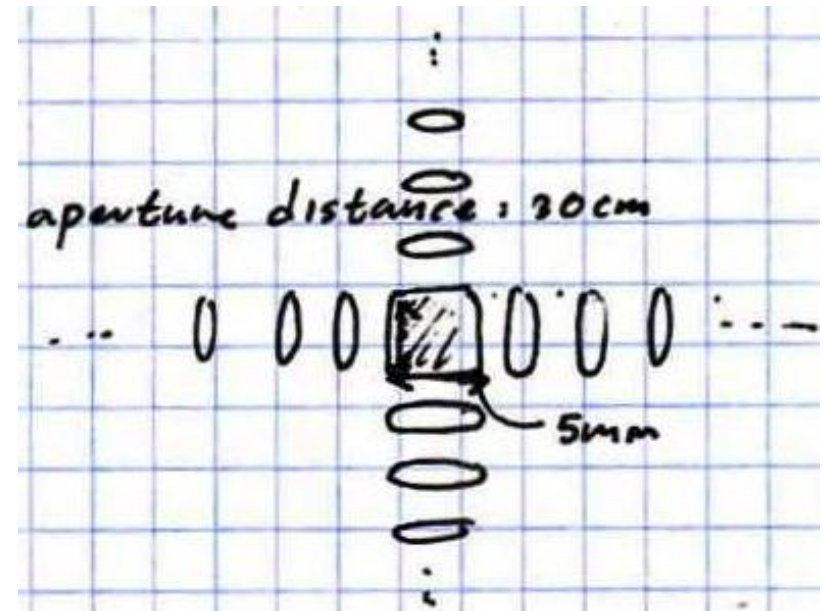
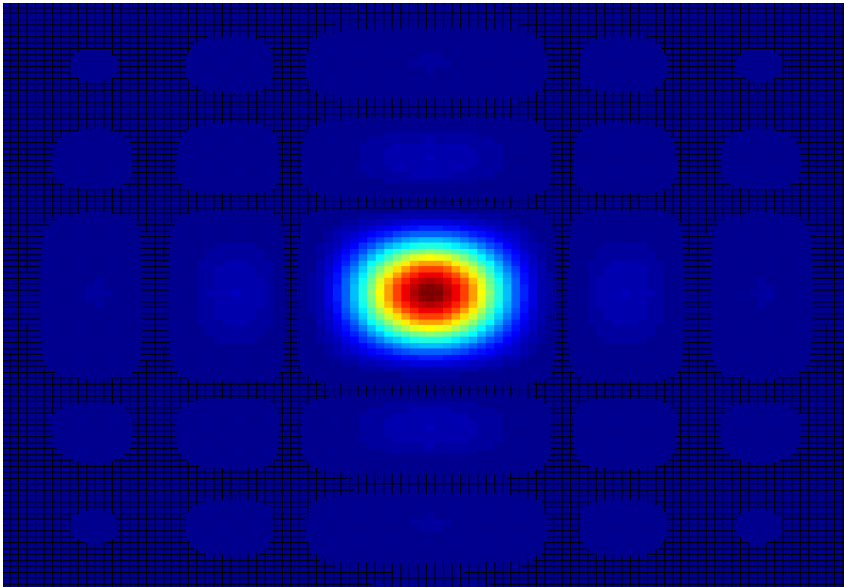
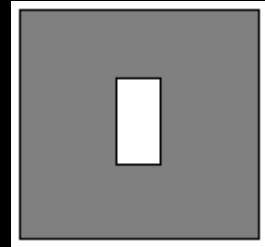


slit-screen distance : 104 cm



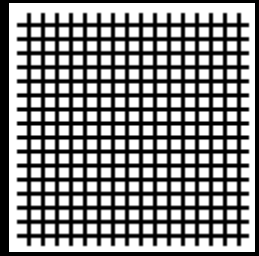
- *Periodicity in aperture produces localization in pattern*
- Calculate inter-slit distance: $D = 6.5$ mm

Rectangular aperture

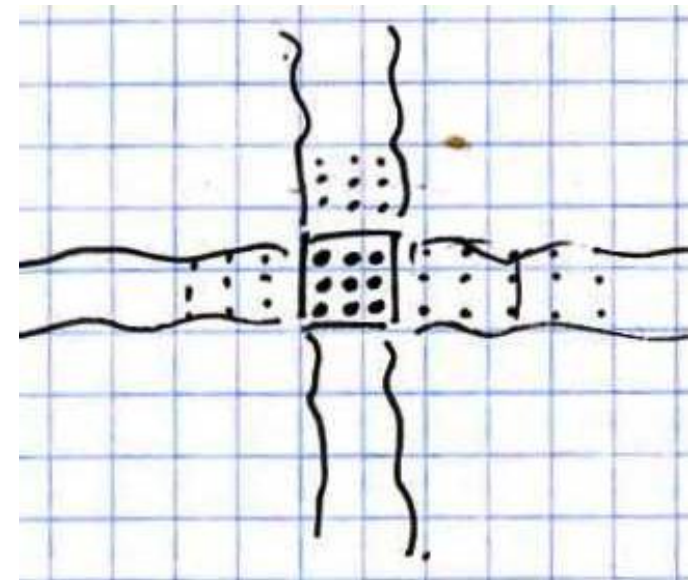
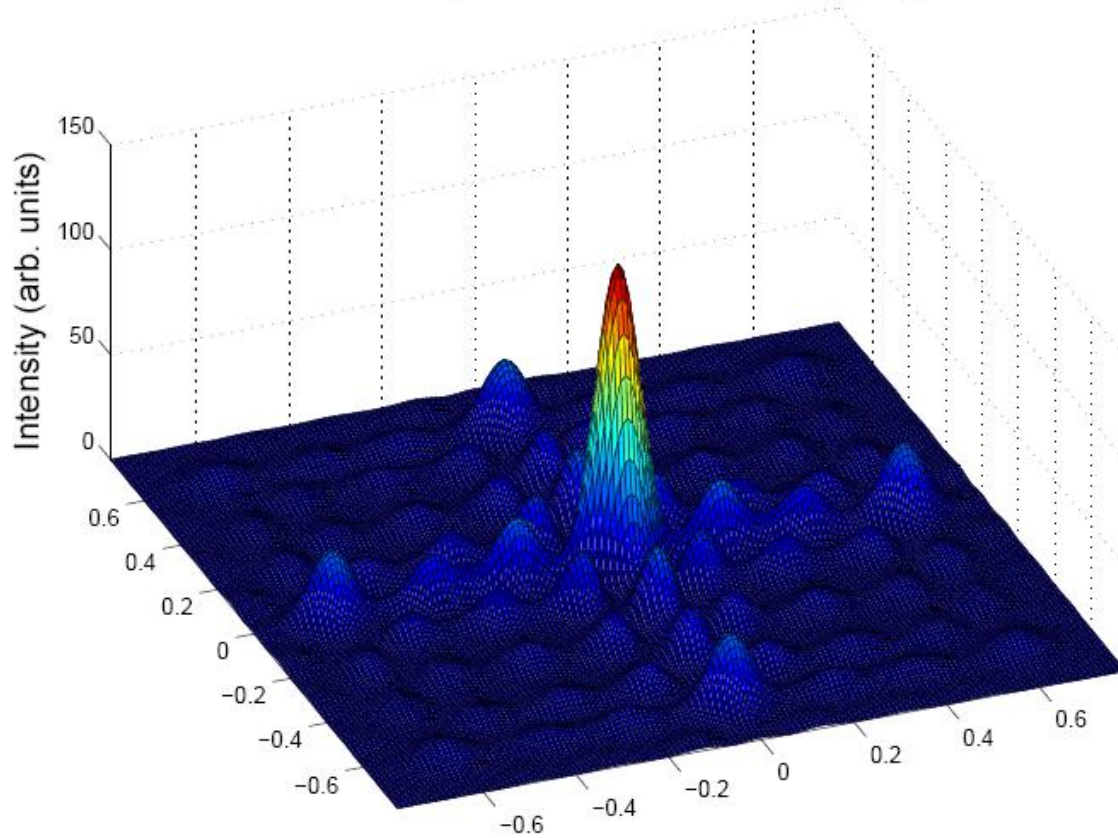


- Just a slit in two dimensions
- Calculate aperture dimensions: $b = 76$ microns

Rectangular grid



Fraunhofer pattern of a small rectangular grid



- Again, periodicity \rightarrow localization

Concluding remarks

- Verified Fraunhofer diffraction in lab
- General lessons:
 - “Fourier pairing” between aperture and pattern
 - Reciprocity in characteristic lengths.
 - Periodicity of aperture → Localization of pattern
- Possibilities for metrology

Sources of images

- Lens system: <http://www.trustedreviews.com/images/article/inline/4778-ZoomOut500.gif>
- Fraunhofer planes: <http://scienceworld.wolfram.com/physics/FraunhoferDiffraction.html>
- Experimental setup: 6.161 Lab guide