

OPTI 380A Intermediate Optics Lab 13: Gratings

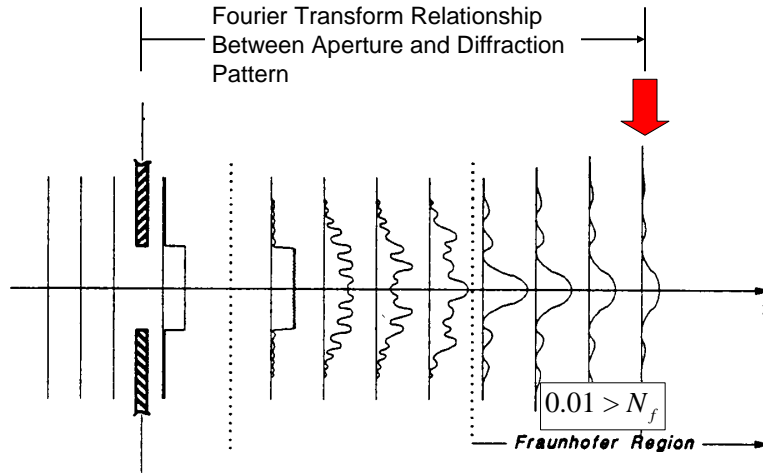
*Tom Milster
Professor, College of Optical Sciences,
University of Arizona
milster@arizona.edu*

Experiments

- A: Multiple-slit diffraction
 - Finesse
- B: Fourier transform relationships for various grating types
 - Changes in duty cycle
 - Phase gratings
- C: Spectral properties of gratings
 - Free spectral range
 - Grating spectrometer

Fraunhofer Diffraction

Fraunhofer: far field, wave pattern far from the obstruction



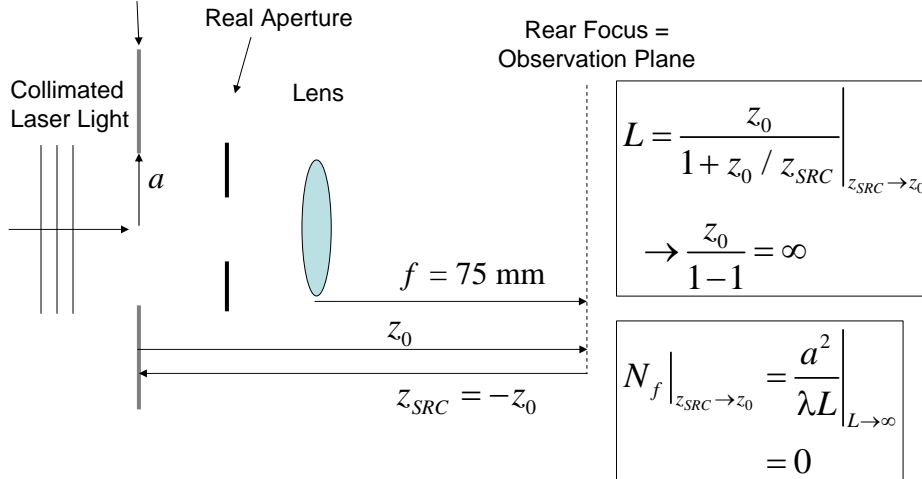
11/29/2009

OPTI380A - Lab 13: Gratings

3

Experiment

Magnified image of Real Aperture
Seen Through the Lens

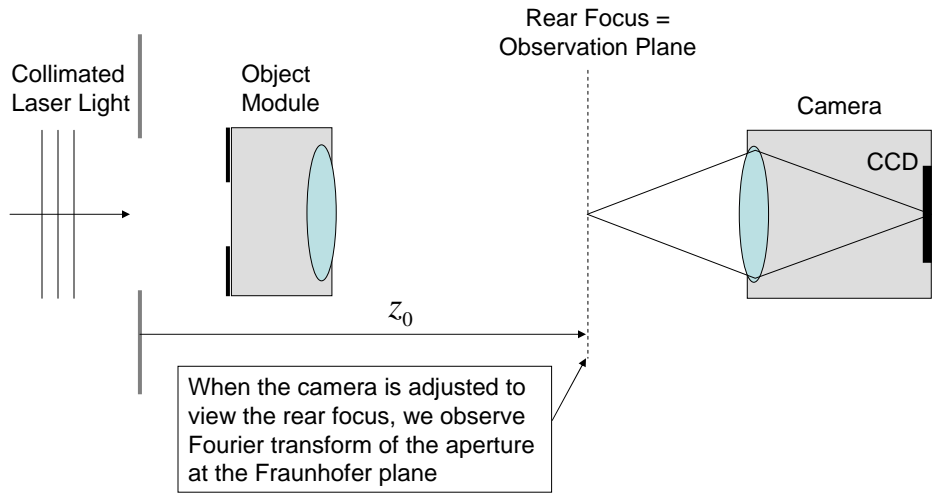


11/29/2009

OPTI380A - Lab 13: Gratings

4

Experiment

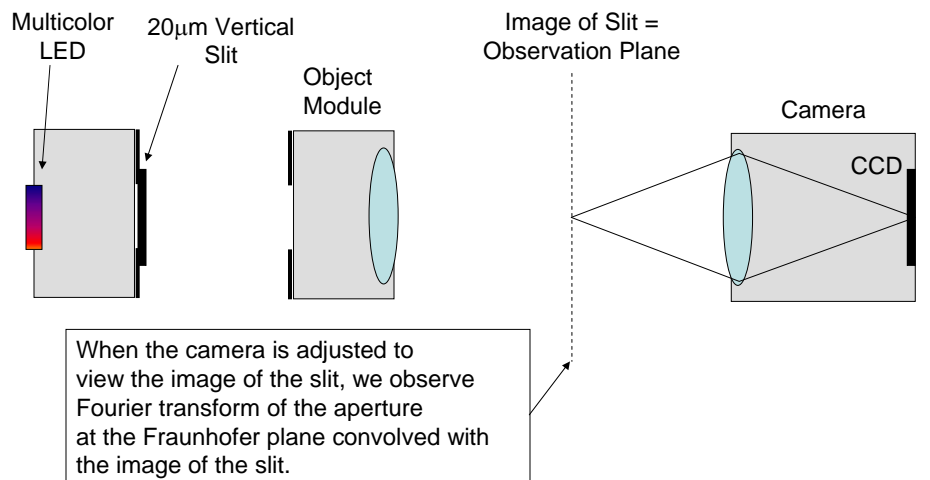


11/29/2009

OPTI380A - Lab 13: Gratings

5

Experiment: Spectral Properties

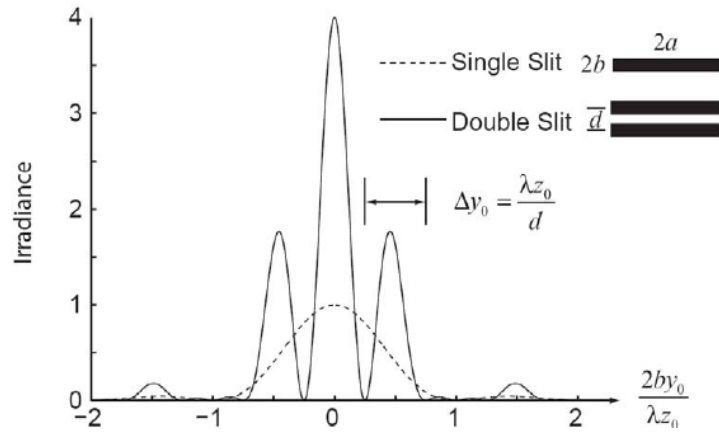


11/29/2009

OPTI380A - Lab 13: Gratings

6

Multiple-Slit Diffraction



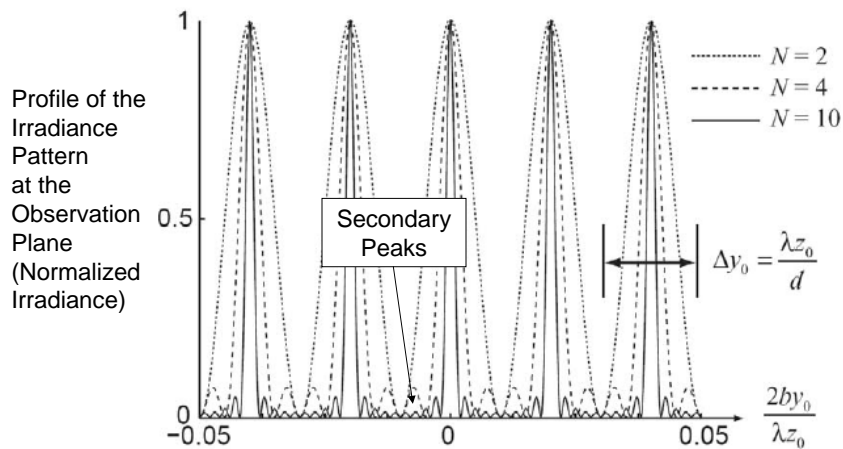
Fraunhofer diffraction of a single and double slit. The double slit has superimposed cosine fringes on top of the single-slit pattern. The double slit exhibits higher irradiance, because twice as much energy passes through the two slits.

11/29/2009

OPTI380A - Lab 13: Gratings

7

Multiple-Slit Diffraction



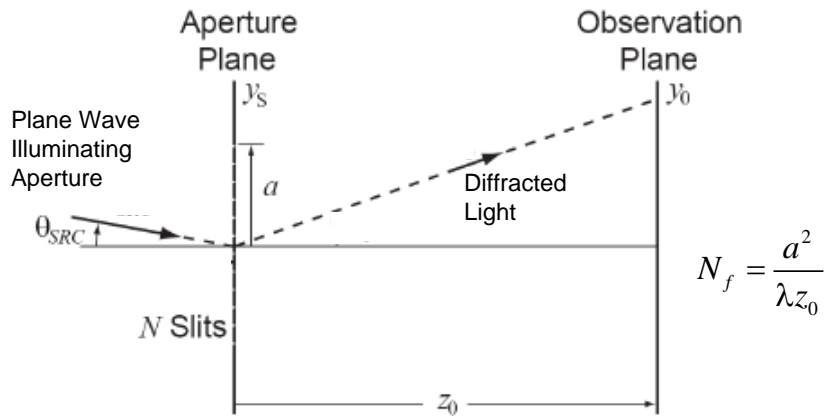
As more slits are added to the aperture, the peaks of the diffraction pattern narrow. The number of secondary peaks between the primary peaks equals $N - 2$, where N is the number of illuminated slits.

11/29/2009

OPTI380A - Lab 13: Gratings

8

Gratings



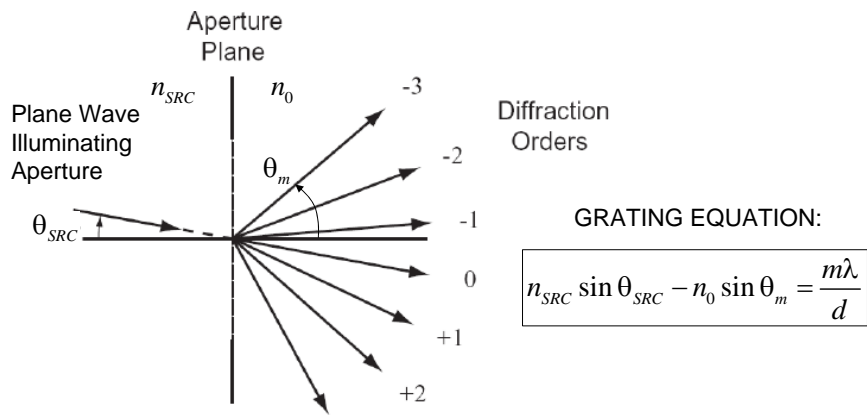
- A *grating* is a large collection of regularly spaced structures, like slits.
- The Fraunhofer diffraction pattern of the slits occurs at the observation plane for $N_f < 0.01$.

11/29/2009

OPTI380A - Lab 13: Gratings

9

Gratings



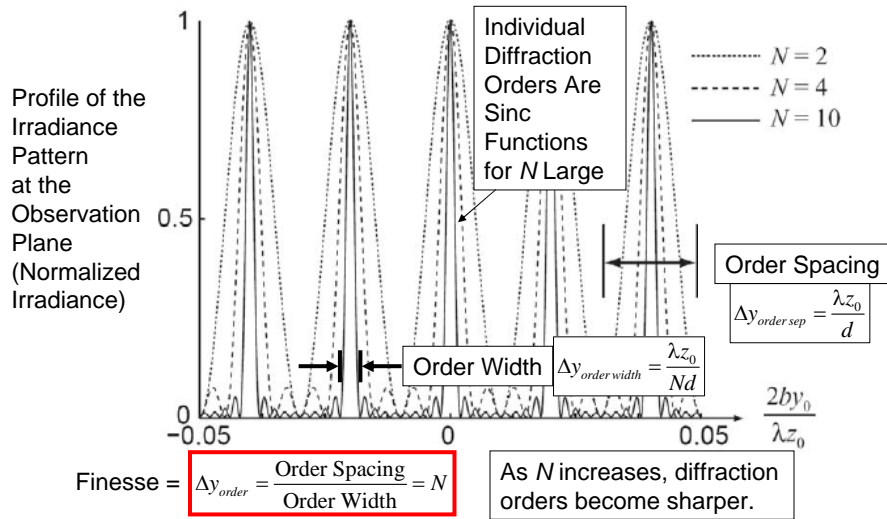
- *Diffracted orders* occur at peaks of the diffraction pattern.
- Peaks of the orders occur at angles according to the *grating equation*.
- m corresponds to the number of waves of OPD between adjacent pairs of slits.

11/29/2009

OPTI380A - Lab 13: Gratings

10

Finesse

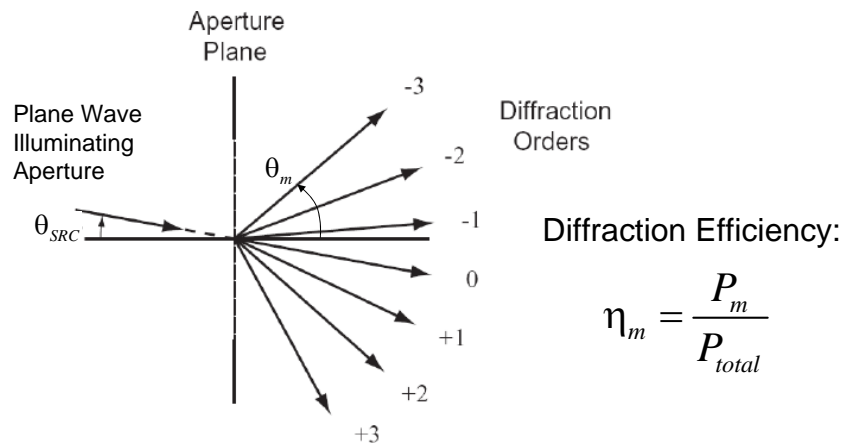


11/29/2009

OPTI380A - Lab 13: Gratings

11

Diffraction Efficiency



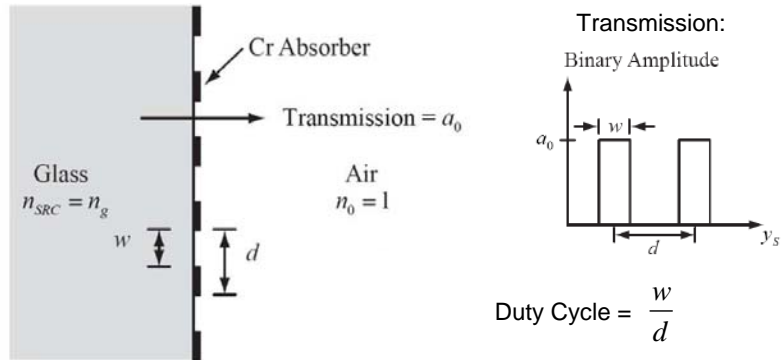
- *Diffraction efficiency is the ratio of power in order m to the total power illuminating the grating*

11/29/2009

OPTI380A - Lab 13: Gratings

12

Fourier Transform Relationship Rectangular Amplitude Grating and Duty Cycle



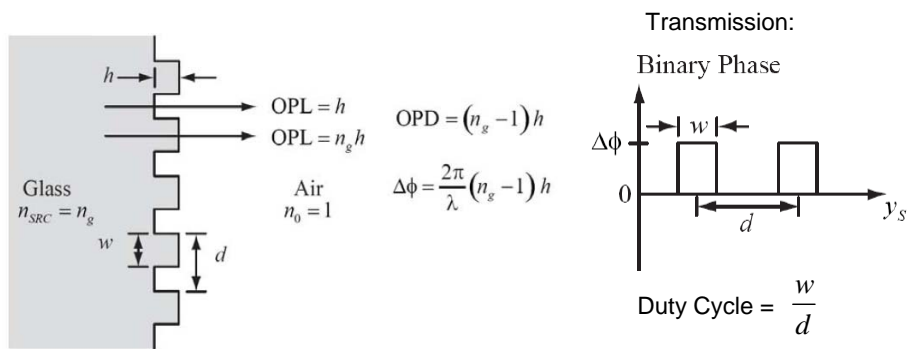
- Binary amplitude gratings have various diffraction efficiencies, depending on the duty cycle.
- Maximum diffraction efficiency into the +/- 1 order is about 10%

11/29/2009

OPTI380A - Lab 13: Gratings

13

Fourier Transform Relationship Binary Phase Grating



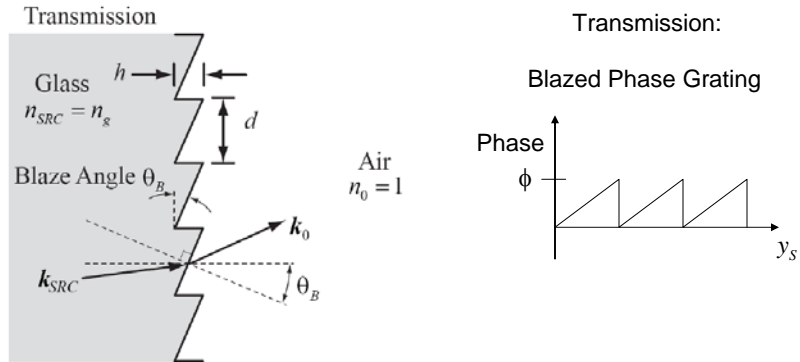
- Binary phase gratings have various diffraction efficiencies, depending on the duty cycle and depth of the grooves.
- Maximum diffraction efficiency into the +/- 1 order is about 40%

11/29/2009

OPTI380A - Lab 13: Gratings

14

Fourier Transform Relationship Blazed Phase Grating



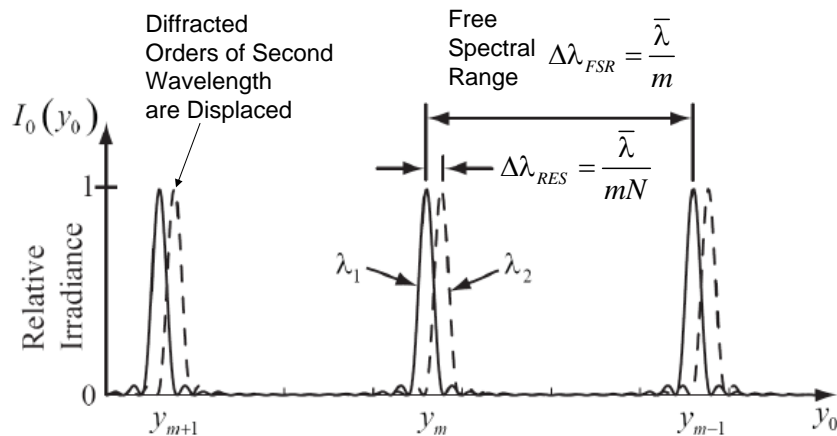
- Blazed phase gratings are designed to have 100% diffraction efficiency into one order.
- Facets of the grating act like individual prisms to direct the light.

11/29/2009

OPTI380A - Lab 13: Gratings

15

Spectral Properties of Gratings



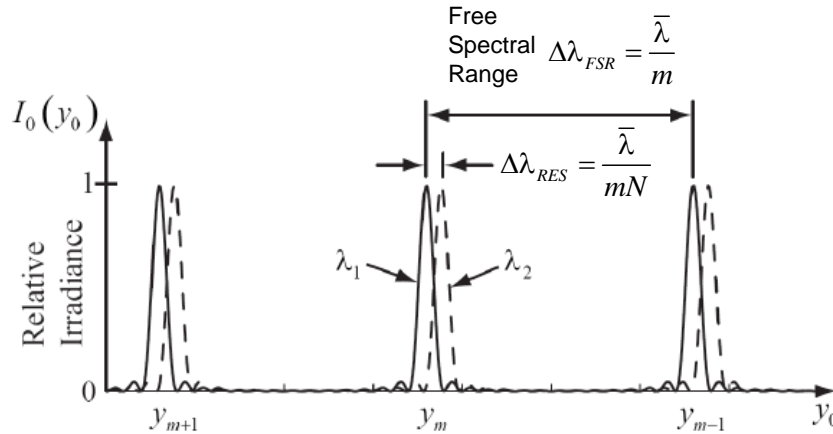
- Assume second wavelength in source.
- Minimum detectable wavelength difference depends on width of order.
- Maximum unambiguous wavelength spread depends on order spacing.

11/29/2009

OPTI380A - Lab 13: Gratings

16

Spectral Properties of Gratings



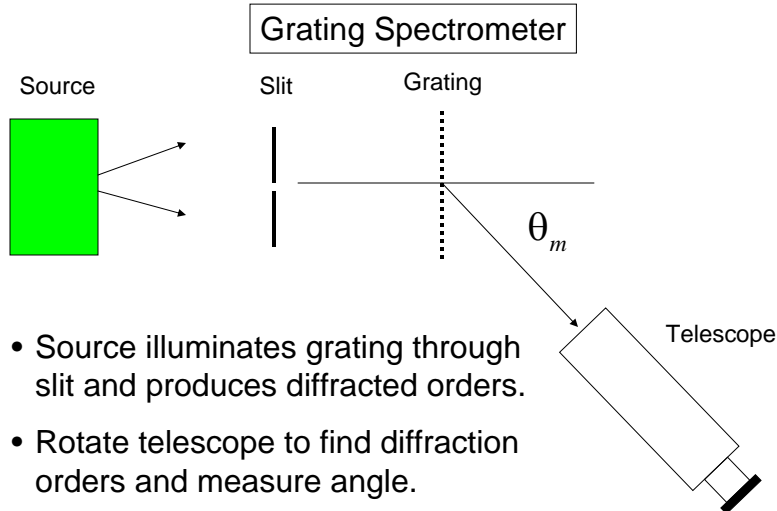
Ratio of Free Spectral Range to Minimum Detectable Wavelength Difference:

$$\frac{\Delta\lambda_{FSR}}{\Delta\lambda_{RES}} = N = \text{Finesse}$$

Chromatic Resolving Power:

$$R_\lambda = \frac{\bar{\lambda}}{\Delta\lambda_{RES}} = mN$$

Spectral Properties of Gratings



Lab 13 Preparation (Same as Lab 12)

- We will be using some features of the camera that allows us to save data onto a hard drive.
- We will be using Matlab to process the data.
- Although lab computers are available, you can bring your own laptop, if you prefer. The lab computers tend to be slow.
- If you use your own laptop, have Matlab loaded and download the camera driver (Logitech Quickcam) from <http://www.logitech.com/index.cfm/435/254&hub=1&cl=us,en>