Optics 554 — Homework 3

Gratings and Fraunhofer diffraction problem.

Due Wednesday, February 17, 2021

1) Resolution of a Grating

Consider a square grating of 600 lines/mm, 5 cm $\times$ 5 cm.

Questions:

(a) What is the blaze angle in Littrow configuration *in third order* at a wavelength of 500 nm?

(b) Assuming the grating is curved with a focal distance of 2 meter. What is the maximum resolution $\Delta\lambda$ that can be achieved in third order? You will assume that the beam is Gaussian, with a "diameter" $2w$ covering the dimension of the grating, and that the angle of incidence on the grating is 30 degrees. Explain/justify your approximation(s), if any.

(c) Keeping the angle of incidence of (b): At which wavelength will the first order diffraction angle coincide with the third order? What is the resolution $\Delta\lambda$ at that wavelength?

2) Diffraction orders

Let us consider a transmission grating made of successive identical triangular transmission functions. The transmission function of one element of this one dimensional aperture is shown in Fig. 1.

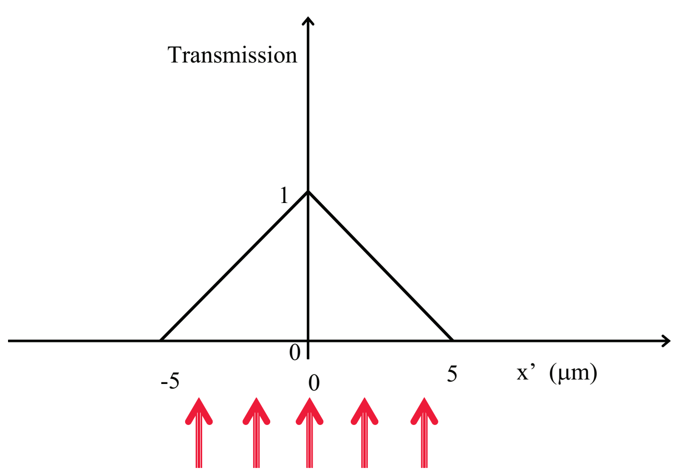

Figure 1: Triangular transmission function, with a peak transmission of 1 at $x' = 0$, and total opacity at $x' = \pm 5\mu$m. The axis x' is labeled in μm.

(a) Find the diffraction pattern — in intensity — for a uniform plane wave incident (normal incidence) on one element of this slide (as represented in Fig. 1), as it will appear on a screen situated at a distance of 1 meter from the slide. The wavelength is 1 μm. What is the full with at half maximum (FWHM) of the intensity pattern in the diffraction plane. (Hint: use the convolution theorem: the triangle is the autoconvolution of ??))

(b) What diffraction orders can be mainly observed with this grating? Find the diffraction efficiency in the orders +1 and -1 (Assuming the grating to be perfect, calculate the diffraction intensity in first order, and divide by the incident intensity)

3) Aperture diffraction

An aperture is made of an open rectangle of dimensions $h_1 \times W_1$. The central part of that rectangle has a rectangular obstruction of dimensions $h_2 \times W_2$. Find an expression for the far field diffraction pattern (intensity distribution). Sketch.