Problem 3: Diffraction

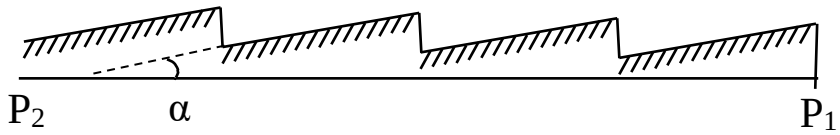
a.	Determine the ratio between the intensities of the central maxima in the diffraction patterns for two slits of width a and b respectively if they are illuminated with the same beam of coherent monochromatic light.	**1 point**

Consider a diffraction grating made up of a sequence of identical equidistant slits.

b.	What relationship exists between the intensities of the main maxima of the 1st order obtained with the help of two complementary diffraction gratings (both having the same constant l, the distance between the center of one slit and the center of the adjacent slit), and slit widths a and respectively l-a)? It is considered that the diffraction gratings are illuminated with the same beam of coherent monochromatic light.	**1 point**

c.	Prove that in the case of a diffraction grating made up of a sequence of identical and equidistant slits, the intensity of the diffracted light, I_{dif}, is not more than a quarter of the intensity of the light incident on the grating. What is the condition for $I_{dif}=I_{inc}/4$, such that the brightness of the grating is maximized? (where I_{dif} is the intensity of the diffracted light in all maxima, except the maximum of order zero).	**2.5 points**

The gratings with a better brightness, *i.e.* $I_{dif} > I_{inc}/4$, are the blazed (reflection) gratings, in which the plane of the individual grooves makes an angle α with the grating plane P_1P_2. (see figure).



d.	Determine this angle for a grating with $n = 2000$ grooves/mm which forms the 1st order maximum in the direction of the incident beam for the wavelength $\lambda_0 = 500$ nm and this maximum is the brightest from the diffraction pattern.	**1 point**

The grating from *(d)* is used in a monochromator in which the diffraction spectrum is projected onto the exit slit with a concave mirror having the radius of curvature $R = 1$ m.

e.	Determine the spectral width $\Delta\lambda$ and the coherence length of the beam that comes out of the monochromator if it is illuminated with white light, the slit has the width $d = 20$ μm, and the central wavelength is $\lambda_0 = 500$ nm. Calculate their numerical values.	**3 points**

f.	What is the minimum spectral range between two monochromatic radiations that can still be resolved using the grating from *(d)*. The grating is 10 cm long and the spectrum is projected with the mirror from point *(e)*. onto a CCD detector having 200 pixels/mm.	**1.5 points**

Note. The normal incidence on the slits and gratings is considered only for a., b., c. Diffraction in parallel light is considered.

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