Experiment 9: Diffraction Grating Phys 431

A diffraction grating produces periodic alterations in the phase and/or amplitude of an emergent wave. In this lab, we will study three gratings: a steel ruler, and two multiple-slit gratings. For the case of shining light through the multiple-slit system, it is clear how this can act like a diffraction grating: light emerging from the slits will have a periodic modulation in amplitude. In contrast, you may be surprised that a steel ruler can act as a diffraction grating. Of course, you can't shine light through the ruler. But in reflection mode, the tick marks on the ruler can modulate the emergent wave. By treating these spots as point sources, we can find the condition for constructive interference, as shown in the appendix.

You are required to photograph the diffraction patterns for parts A and B (not C), and you may also need to make marks on the paper screen to achieve the best accuracy. As always, your write-up should contain reasonable estimates for the uncertainties.

Procedure:

A. Use the tick marks on a steel ruler as a diffraction grating, in reflection mode. Knowing the spacing of the marks, compute as accurately as possible the wavelength of the He-Ne laser. (The accepted value is 6328 Å.)

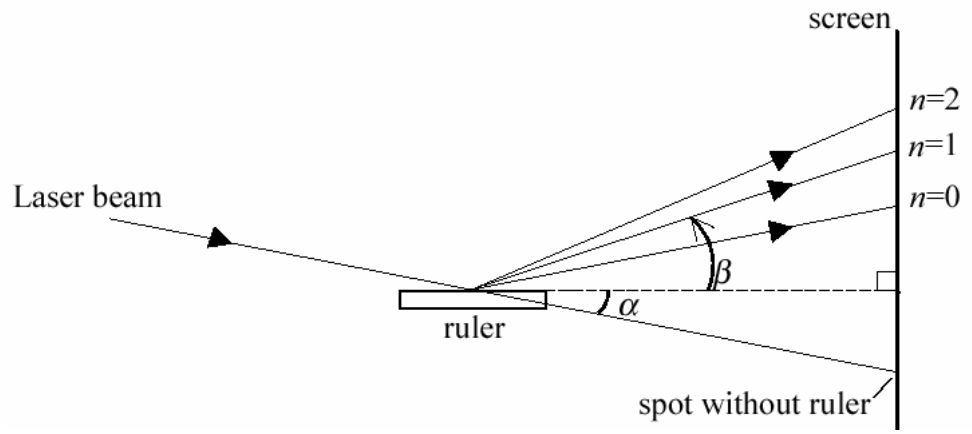
B. In part A you knew the spacing of the grating and determined the wavelength of the light. In this part, please assume that you accurately know the He-Ne wavelength. Now, design and perform an experiment to determine the spacing of the multiple-slit gratings, by shining the laser light through the grating (i.e., transmission mode). First use the permanently mounted grating (nominally 80 lines/mm), then use the card grating (nominally 500 lines/mm). To see several spots, you may need to bring the screen much closer. How do your measurements compare to the nominal values? **Q1** Does the pattern on the screen look qualitatively similar to last week's multiple-slit experiment (an equally spaced pattern of maxima and minima)? What is going on here? Try performing the measurements in reflection mode for the card grating (use the same geometry as for the steel ruler). **Q2** Do maxima and minima appear? Why or why not?

C. Replace the laser with the white light of a halogen lamp. Shine the white light through the card grating and photograph the diffraction pattern. In this case, a single maximum can form a "spectrum" showing a rainbow of colors, as light of different wavelengths will have maxima and minima at different angles. Calculate the angular positions of the blue and red light within a single maximum and estimate the ratio of red to blue light.

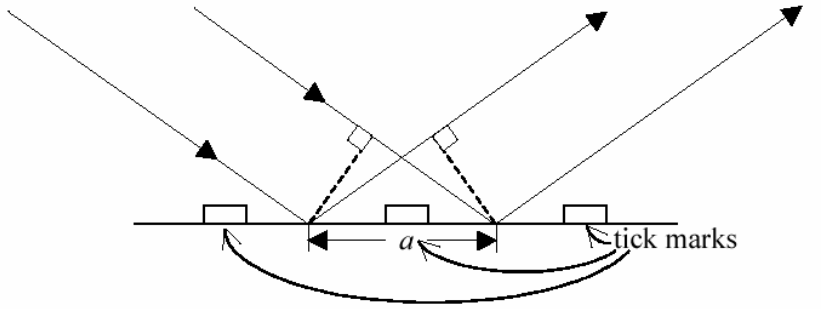
Appendix

Steel Ruler Diffraction Grating: Reflection Grating

Lets call the angle of the incident beam α and the outgoing beam β:



Note: n=0 corresponds to specular reflection, $\alpha=\beta$.



The condition for constructive interference: $a\ (\cos\beta - \cos\alpha) = 0, \lambda, 2\lambda, \ldots = n\lambda$

Multiple-Slit Grating: Transmission Grating

The diffraction pattern for multiple slits can be calculated in a similar way as the double slit system. Consider light incident from the left on any two adjacent slits: