Name: ______________________
Partner: ______________________
Partner: ______________________
Partner: ______________________

Diffraction Grating and Spectrometer

EQUIPMENT: Spectrometer; High Intensity Lamp; Black Cloth; Mercury spectrum tube; Grating

PURPOSE: To become familiar with the spectrometer and its use with a diffraction grating, to measure the wavelengths of light given off from the hydrogen atom and to correlate these wavelengths with the energy level diagram for hydrogen.

Diffraction Grating

You will use the diffraction grating relation, which may be written as

$$sin\theta_m = Nm\lambda \qquad (1)$$

θ_m is the angle at which the m^{th} order maximum occurs for light of wavelength λ. N represents the number of lines per unit distance on the diffraction grating. Equation 1 was derived using the assumption that parallel rays from the collimator are incident exactly perpendicular to the grating. Refer to fig 1. If the incident rays make an angle θ_i with the normal to the grating face, then the rays from two adjacent slits for the m^{th} order maximum on the same side of the normal have a path difference (see figure 1a) of λ. For the m^{th} order maximum on the other side of the normal the path difference (see figure 1b) is

$$d\sin\theta_{m\,right} - d\sin\theta_i = m\lambda \qquad (2)$$

$$d\sin\theta_i - d\sin\theta_{m\,left} = m\lambda \qquad (3)$$

d is the distance between adjacent lines & $N \times d = 1$. Combining this with (2) & (3) yields

$$\frac{sin\theta_{m,left} + sin\theta_{m,right}}{2} = Nm\lambda \qquad (4)$$

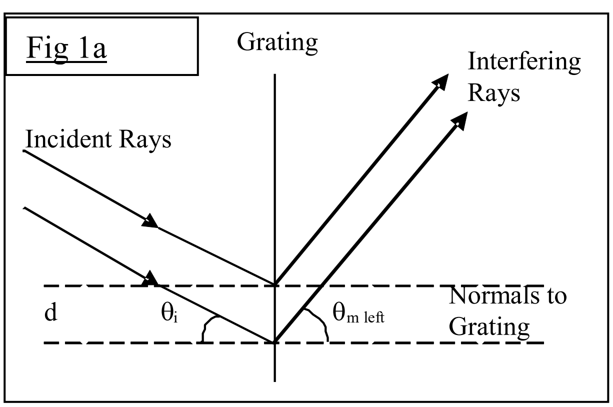


Fig 1a

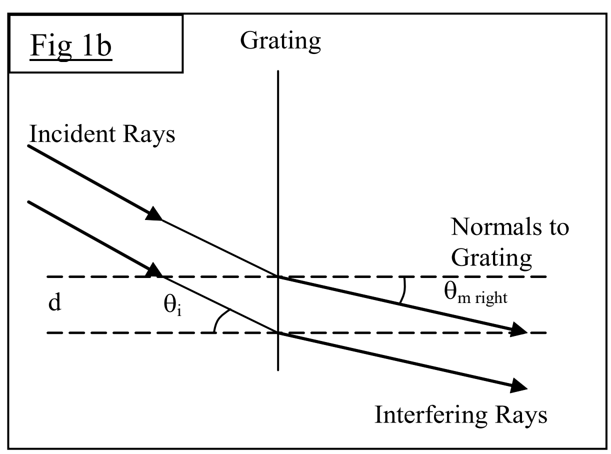


Fig 1b

The intense green line of the mercury spectrum has wavelength 546 nm. You will measure angles, and count orders for this line, then solve for the grating spacing d.

Part 1 PROCEDURE.

1. Adjust spectrometer for parallel light (see Addendum).

2. Set the grating at the center of the prism table and clamp it so that its surface is perpendicular to the light from the collimator (make sure the film side faces the telescope), and so the prism holder post is to one side of the grating. Tighten the locking screw for the prism table. Do not replace the sliding shield or light shield. Use the black cloth to block out external light.

3. Loosen the telescope locking screw and rotate the telescope to one side so that it is out of the way. Look straight into the grating and collimator (not through the telescope) and locate the slit image having the same color as the mercury lamp. Then, moving your head to your left while looking through the center of the grating, find the images of the slit in the various spectral colors of mercury. Repeat moving the head to the right. In the following steps you will use the telescope to look at these spectral lines. Record the colors you see.

4. With the central image in view, rotate the telescope in front of your eye, find the central image through the telescope, get the cross hairs as nearly centered on it as possible, and tighten the telescope locking screw. The tangent screw may now be used as a fine adjustment to center the cross hairs.

5. Tighten the locking screw for the rotating dial, and read the innermost or degree scale with the aid of the vernier. Record this angle. It is the angle for constructive interference of light coming straight through the diffraction grating ($m = 0$). Only the telescope is to be unlocked and rotated hereafter.

6. Loosen the locking screw for the telescope arm and rotate the telescope to the left to the first order ($m=1$) bright green line. Record this angle. Calculate the angle through which you have rotated the telescope arm from the straight through $m=0$ position

7. Repeat 6 for the first order ($m=1$) image on the right.

8. Repeat 6 and 7 for higher orders of this color line.

Part 1 CALCULATIONS: Show all of your calculations in a clear, well organized fashion.

1. Record the position of the $m=0$ order of the slit (light shining straight through the telescope & collimator).

2. Use Eq. (4) and $\lambda = 546$ nm for the green line to find N. Calculate N for each order, then average the values (see next page).

	m	Angular position	θ_m
	0		0
left	1		
	2		
right	1		
	2		

m	$\theta_{m, left}$	$\theta_{m, right}$	N
1			
2			
		AVERAGE =	

Q. How does your value compare to the manufacturers claim? Your grating has ~6,000 lines per cm. Calculate the percent difference.

HOMEWORK

H1. What is the function of the collimator in this experiment?

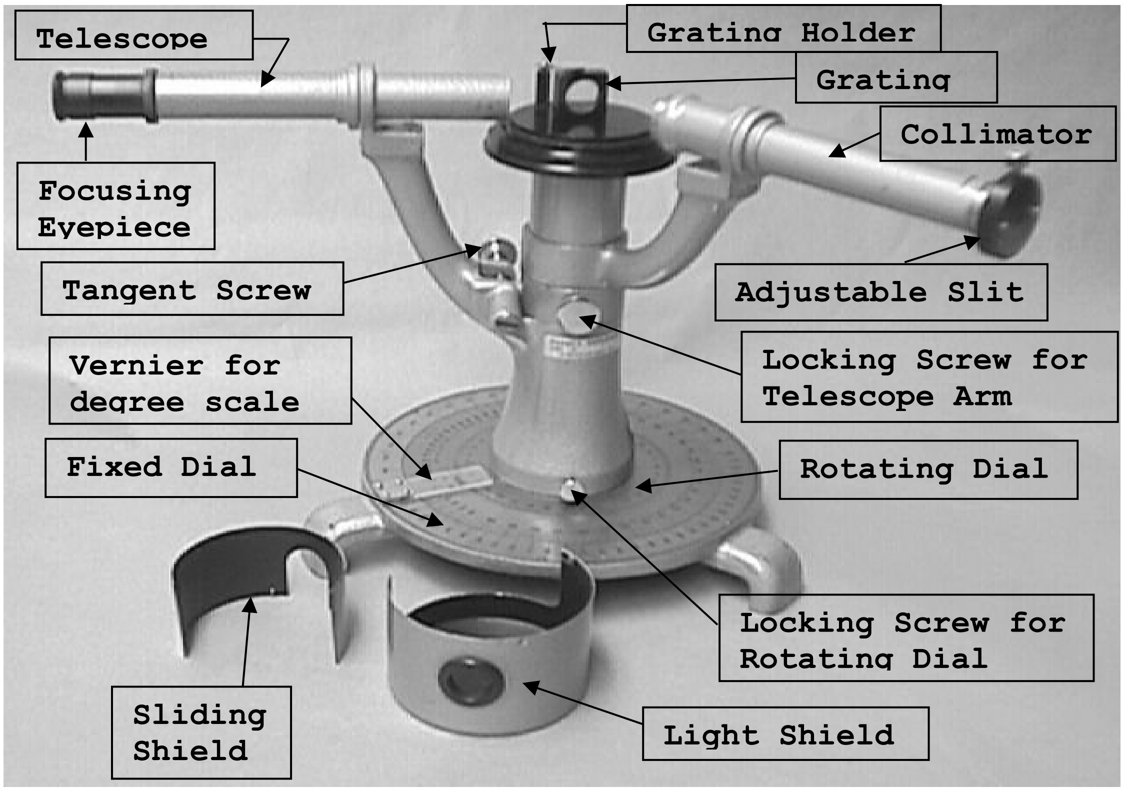
H2. In this experiment you used a diffraction grating of ~6000 lines/cm. What would happen to your measured values of the angles if you were to use a diffraction grating of (you should actually provide evidence of you claim by calculating angles for m=1) –

- ~3000 lines/cm

- ~12000 lines/cm

H3. As a follow-up to H2, if you want to detect more orders in the diffraction pattern would you choose a grating with more or less lines/cm?

Addendum: The Spectrometer.



The various parts of the spectrometer are labeled in the photograph above. There is a locking screw for the grating/prism table on the other side of the pedestal that is not shown in the photograph.

Always avoid touching optical surfaces (i.e., those surfaces through which light passes) of lenses, prisms, and gratings.

Remove the light shield (retract the sliding tube on the collimator), and the sliding shield, noting into which grooves on the prism table each fits. Loosen the locking screw for the telescope arm and rotate the telescope. <u>When rotating the telescope always grasp the arm near the tangent screw</u>. Failure to follow this advice later will probably defocus the telescope.

Look into the telescope and bring the cross hairs into sharp focus by sliding the focusing eyepiece in or out. Aim the telescope at some distant object such as a brick wall on another building seen through the laboratory window. Focus the telescope on this distant object by sliding the telescope tube in or out. (Note that this sliding part contains the focusing eyepiece and hairlines so that the previous focus need not be disturbed.) Rotate the telescope arm until it is opposite the collimator and open the adjustable slit so that it can be seen through the telescope. Slide the adjustable slit in or out until it is in sharp focus and parallax is eliminated between it and the cross hairs.

The spectrometer is now in adjustment for parallel light and should remain so throughout the experiment.