DIFFRACTION EXPERIMENTS : DIFFRACTION GRATING AND CIRCULAR APERTURE

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1. Aim

We try to find the wavelength of the Laser using the diffraction pattern of Diffraction Grating. And using this we find the radius of a Circular Aperture.

2. Theory

2.1. **Diffraction Grating:** The equipment consists of a laser, A diffraction grating with holder and a screen with Graph sheet attached. The whole setup is on an Optical breadboard to reduce noise in the experiment. The theory is similar to Double slit case, except here, instead of just using two slits, the light beam will pass through the multiple slits of the diffraction grating. By measuring the angles at which the interference peaks or maxima occur, we can determine the wavelength of the laser light by knowing the spacing of the grating (grating constant). We can geometrically construct the case of light diffraction from a diffraction grating, this gives the condition for nth maxima to be

$$n\lambda = d \sin\theta_n$$

where $\theta_n = \arctan(x/L)$, n is the order number ($n = 0, 1, 2...$), x is the distance of the nth maxima from the central maxima ($n = 0$), D is the grating constant ,which is the distance between two consecutive lines in the grating, and L is the distance between the grating and the screen.

2.2. **Circular Aperture:** For a circular hole of diameter a the diffraction pattern consists of concentric rings, which are analogous to the bands which we obtained for the grating. The pattern for this intensity distribution can be calculated in the same way as for the single slit , but because the aperture here is circular, hence, it is more convenient to use cylindrical coordinates (z, s, ϕ). The superposition principle requires us to integrate over a disk, and the result is a Bessel function.

The condition for observing a minimum of intensity is found from the zeroes of the Bessel function:

$$a = \frac{k_m l \lambda}{x}$$

where x is the radius of Airy's Disc. For the first order ($m = 1$) minimum $k_1 = 1.22$. Higher order minima will have different k_m coefficients.

3. Procedure

3.1. **Diffraction Grating:** First mount the grating in the holder. Measure the distance between the grating and the Screen. Now, using the lateral and vertical adjustment screws on the Laser, the light beam has to be directed such that the beam falls on the center of the grating and distinct pattern is observed on the screen. After this is adjusted, we can using a pencil and mark the position of the diffraction patter on the graph paper. Now, unmount the graph sheet and measure the distance between the central maximum (brightest of all lines in the pattern) and the next maxima on either side of the central maxima. This can be used to calculate the Wavelength of the light given out by the laser.

3.2. **Circular Aperture.** This also has a similar arrangement as above with the grating replaced with a circular aperture.The diffraction pattern observed consists of concentric rings with the central one, being a disc called the Airy's Disc which has much higher intensity compared to the remaining rings. When the screen is moved closer to the Circular Aperture, the Intensity Measurement using a sensor gives the radius of the Airy's disc, which otherwise is calculated from the graph sheet.We find the radius of the Airy's disc from both the methods and use it calculate the diameter of the pinhole.

In the Intensity Profile method, if we have a detector with a sufficiently small aperture, the profile would have been better. In this we notice that this falls off continuously like a Gaussian as more than one ring is present on the detector's aperture at one position.

4. Observations and Results

4.1. **Diffraction Grating:**

- Distance from the Diffraction Grating to the Screen $l = 161.3cm$
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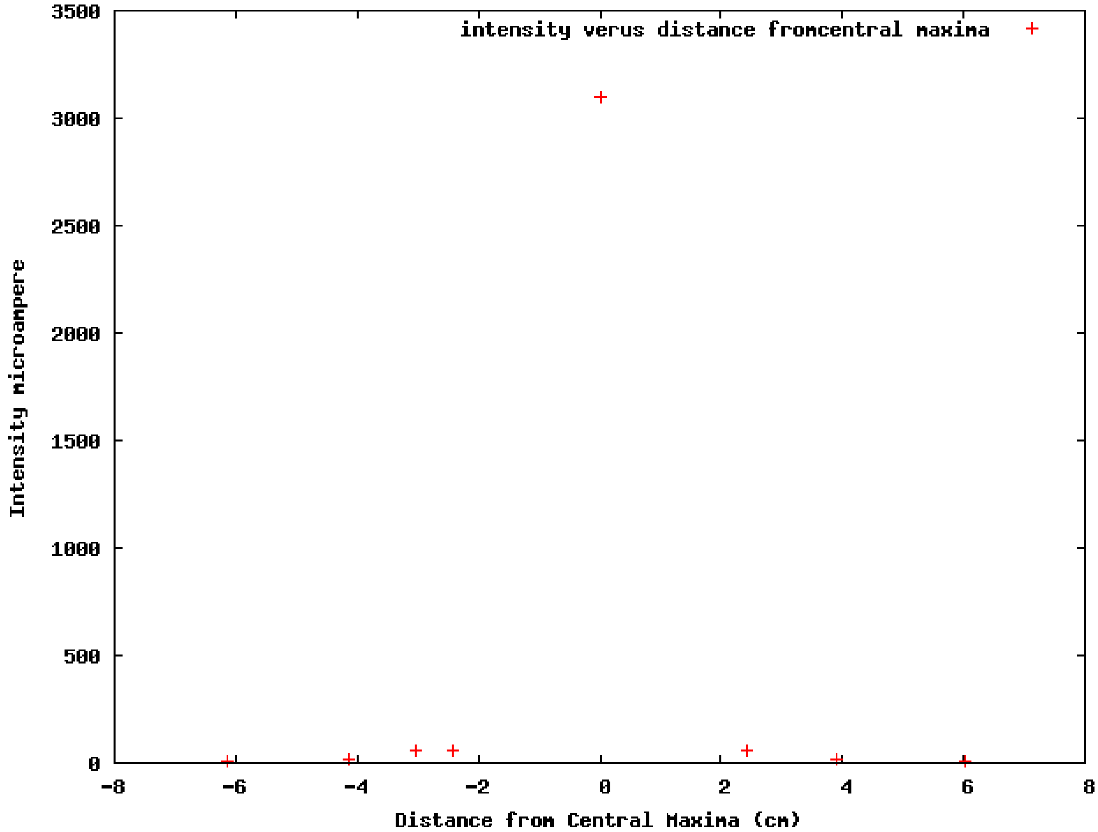
S.No	m	distance(to right from central maxima)	λ	distance to left	λ
1	1	5 mm	619.9 nm	5 mm	619.9 nm
2	2	10 mm	619.9 nm	10 mm	619.9 nm
3	3	15.5 mm	635.2 nm	15 mm	619.9 nm
4	4	20 mm	619.9 nm	20.5 mm	635.4 nm
5	5	25 mm	620 nm	25 mm	620 nm
6	6	30.5 mm	630.2 nm	30 mm	620 nm
7	7	36 mm	637.5 nm	35 mm	619.8 nm

- We can calculate the wavelength of light emitted from laser and is found to be $\lambda = 620nm$.

4.2. **Circular Aperture.**

- Distance from the Circular Aperture to the Screen $l = 168.8cm$
- Radius of the Airy's Disc $x = 0.3cm$
- Calculated Diameter of the pinhole is $d = 425.601\mu m$
- Distance between Aperture and Screen in the method using the Intensity sensor $l = 78.7$
- Airy's Disc radius using the intensity Measurement method is $x = 0.135cm$.
- Calculated Diameter of the pinhole is $d = 440.953\mu m$.

The intensity plot of the Circular Aperture Diffraction pattern looks like this



This is with $l = 78.75cm$