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U6048 - P3

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Pledge

I solemnly affirm that I am presenting this journal based on my own experimental work. I have neither copied the observations, calculations, graphs and results from others nor given it to others for copying.

Signature of the student

Experiment 04: Laser based experiment I: Beam divergence

Aim: To measure the peak power and beam divergence of a given laser beam

Apparatus: He-Ne laser, Optical bench, Laser Beam Analyzer with sensor and micrometer screw arrangement.

Significance of the experiment: *One of the characteristics of laser is high directionality/parallelness. Thus the diameter of the laser at any position should be same. However, laser has a small divergence due to diffraction effects. This experiment provides an easy and accurate method to measure the divergence of a laser*

Theory: Laser is an extremely coherent, monochromatic, directional, focusable, polarized and powerful light. These extraordinary features make it greatly applicable in day-to-day life, science and technology. A few notable applications of laser include medical diagnosis and treatments, fiber optic communications, CD-ROMS, CD players, laser printers, defense, cutting, welding, drilling, surveying, aligning etc.

Laser is produced due to stimulated radiation; a process where a resonating photon stimulates the de-excitation of an excited atom. This results in to emission of two coherent photons, which are identical in all respects. These photons further stimulate the de-excitation of other excited atoms and this continues to generate an avalanche of coherent photons. For stimulated emission to take over spontaneous emission and stimulated absorption, a few conditions are necessary. These are availability of metastable state (life time $\approx 10^{-3}$ sec), population inversion (greater number of atoms in metastable state than in lower energy state) and enough number of photons in the cavity (mirrors).

He-Ne laser

He-Ne laser is a low power, continuous gas laser, which is used in supermarket scanners, student laboratories and holography. The active system is neon, which is pumped electronically via helium in a resonant cavity made of discharge tube (Fig. 5.1) . The main lasing occurs in neon between the levels E_6 (metastable) and E_3 which produces an intense coherent beam of red color (wavelength 6328^o). (refer Fig 5.2). The population of photons necessary for stimulated emission is maintained by mirrors (one is semitransparent) on both sides. Brewseter windows are used to polarize the laser light.

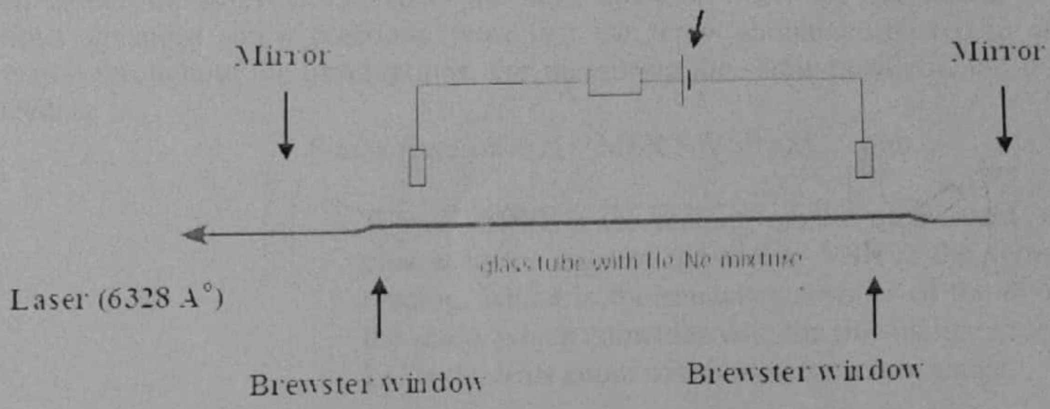

Fig. 4.1: Schematic diagram of He-Ne laser

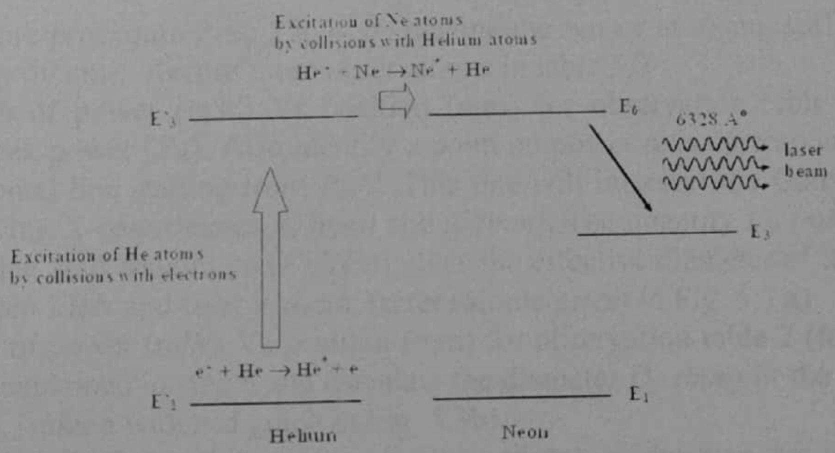

Fig. 4.2. The simplified energy level diagram of He-Ne laser

Procedure:

Make the laser beam ON. **Avoid eye contact**

1. The power in laser beam follows Gaussian distribution with peak value at center.
2. Mount the sensor of LBA on optical bench at a distance relatively closer to laser beam, say 10 cm. Let this distance be d_1. Adjust sensor so that laser is incident exactly on the centre of the window of the sensor. Align the sensor, till LBA reads power closest to 2.0 mW.
3. Now move the sensor laterally so that the beam falls on the edge of the window of the sensor. LBA will now read zero.
4. Using micrometer screw, move the sensor-window gradually across the laser beam. Note the increasing powers in the beam (mW) at various screw positions (mm) as per table

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ROUGH WORK

Observation table 4.1

Powers at different positions at a distance d_1 = ..10... cm

Sr. No.	Power in LBA, P (mW)	Position of micrometer X (mm)
1	0	2.2
2	0.25	3.2
3	0.5	4.3
4	0.75	4.4
5	1.00	4.5
6	1.25	4.5
7	1.5	4.7
8	1.75	4.8
9	2.1	5.7
10	1.75	6.2
11	1.5	6.3
12	1.25	6.5
13	1.0	6.6
14	0.75	6.8
15	0.5	7.7
16	0.25	8.5

Observation table 4.2

Powers at different positions at a distance d_2 = ..80... cm

Sr. No.	Power in LBA, P (mW)	Position of micrometer X (mm)
1	0	1.4
2	0.25	2.5
3	0.5	2.8
4	0.75	3.2
5	1.00	3.5
6	1.25	3.7
7	1.36	4.0
8	1.25	4.6
9	1.0	5.0
10	0.75	5.4
11	0.5	5.7
12	0.25	6.5
13	0	7.8
14		
15		
16		

Calculations:

$$Divergence = \frac{(D_2 - D_1)\, mm}{(d_2 - d_1)\, cm}$$

$$= \frac{(D_2 - D_1)\, cm}{(d_2 - d_1)\, cm} \times 10^{-1}$$

$$= \frac{(2.3 - 2.0)}{(80 - 10)} \times 10^{-1}$$

$$= 0.00042\, rad$$

$$= 0.00042\, rad \times \frac{180\ deg}{3.14\ rad}$$

$$= 0.024\, deg$$

$$= 0.024\, deg \times 60\ \frac{min}{deg}$$

$$= 1.44\, min$$

Table 4.3 Results

Sr. No.	Physical quantity	Value	Unit
1	Peak power the laser beam (at d_1 10 cm)	2.1	mW
2	Divergence of laser beam	1.44	Min

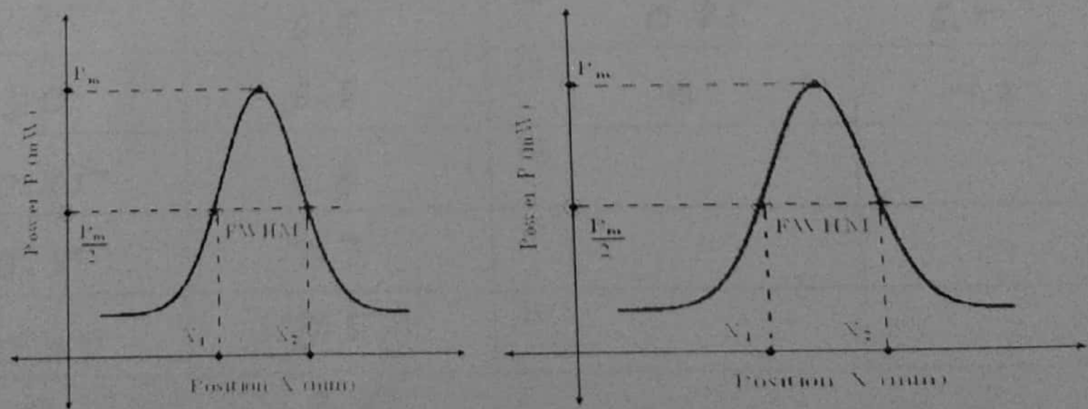

Figure 4.3 Calculation of (a) diameter *D1* at position *d1* (b) diameter *D2* at position *d2*

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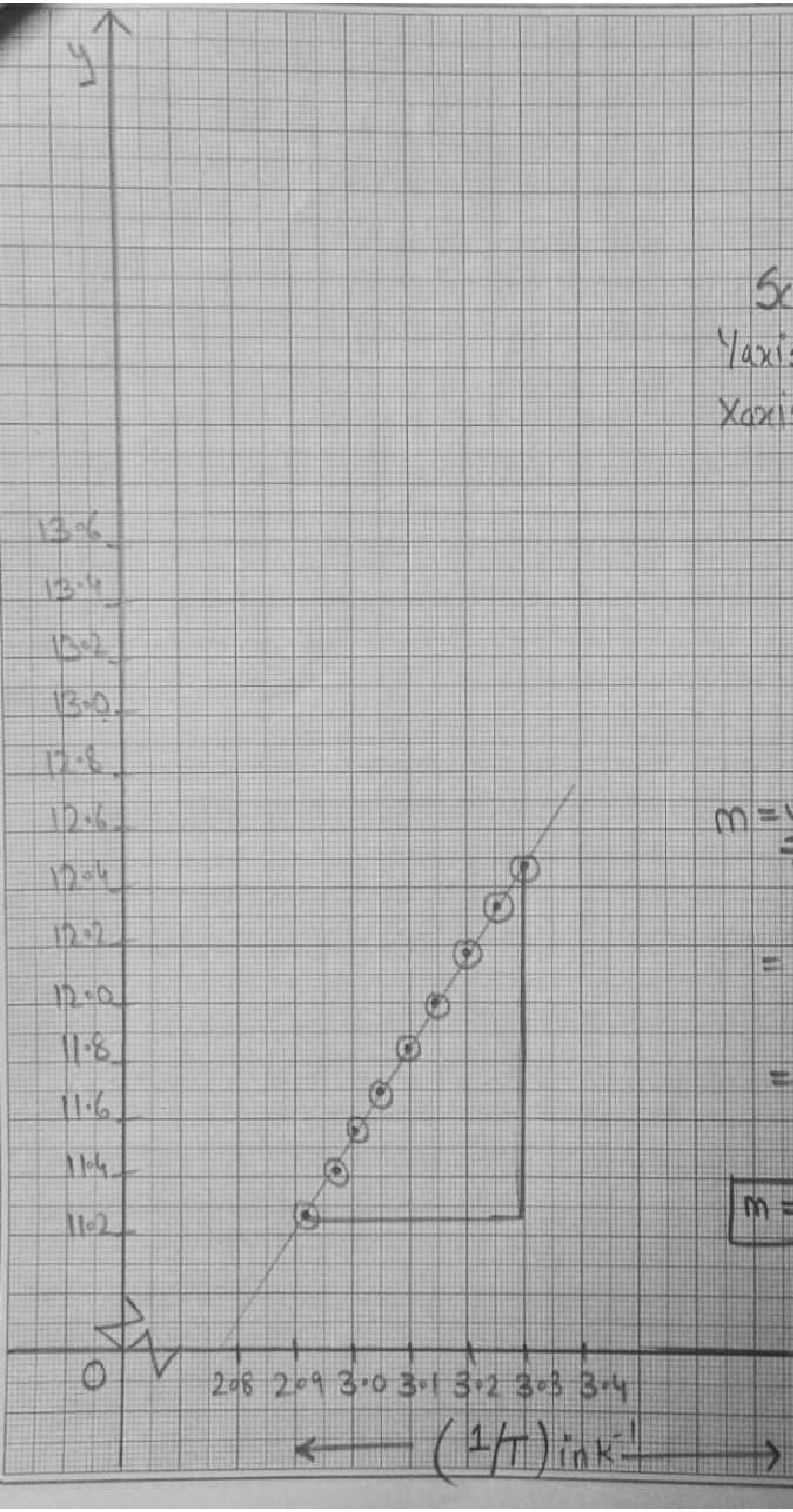
FAIR WORK

Observation table 4.1 Powers at different positions at a distance d_1= ...10.. cm			Observation table 4.2 Powers at different positions at a distance d_2= ..80... cm		
Sr. No.	Power in LBA, P (mW)	Position of micrometer X (mm)	Sr. No.	Power in LBA, P (mW)	Position of micrometer X (mm)
1	0	2.2	1	0	1.4
2	0.25	3.2	2	0.25	2.5
3	0.5	4.3	3	0.5	2.8
4	0.75	4.4	4	0.75	3.2
5	1.00	4.5	5	1.00	3.5
6	1.25	4.5	6	1.25	3.7
7	1.5	4.7	7	1.36	4.0
8	1.75	4.8	8	1.25	4.6
9	2.1	5.7	9	1.0	5.0
10	1.75	6.2	10	0.75	5.4
11	1.5	6.3	11	0.5	5.7
12	1.25	6.5	12	0.25	6.5
13	1.0	6.6	13	0	7.8
14	0.75	6.8	14		
15	0.5	7.7	15		
16	0.25	8.5	16		
	0	9.5			



Scale :-

Y axis : 1 unit = 0·2 Ω

X axis : 1 unit = $0·1 \times 10^{-3}\ K^{-1}$

$$m = \frac{y_2 - y_1}{x_2 - x_1} =$$

$$= \frac{12·484 - 11·297}{3·800 - 2·915}$$

$$= \frac{1·187}{0·3848}$$

$$\boxed{m = 3084·09}$$