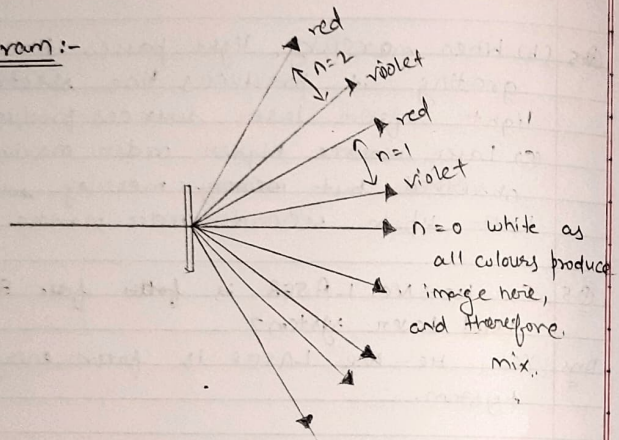
Diagram:-



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Experiment No. 8

Object :- To determine the coherent length and coherent time of laser using He-Ne laser.

Apparatus :- Spectrometer, laser source, optical screen, double convex lens, optical slit, diffraction grating & one convex lens with lens holder.

Theory & Formula :- Coherence is an important property of light it means that the co-ordinate motion of several waves maintaining a fixed and predictable phase relationship with each other, it is of two types.

(a) Temporal coherence
(b) Spatial coherence

If the phase difference ($\Delta\phi$) is measured in single point in the space at the beginning & end of a fixed time interval $(\Delta t)_c$ doesn't change with time then waves are said to possess temporal coherence.

Coherence time & Coherence length L_c.

$$L_c = C\tau_c = C/\Delta\nu = \lambda^2/\Delta\lambda$$

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Calculation:-

The wavelength λ of any line is given by

$$\lambda_1 = \frac{(a+b)\sin\theta_1}{n} \text{ cm}$$

$n = 1$

$$\lambda_1 = (a+b)\sin\theta_1 = 1.693\times10^{-4}\times\sin(123.88) \text{ cm}$$

$$= 14055 \text{ Å}$$

Now $\lambda_2 = \frac{(a+b)\sin\theta_2}{2} = \frac{1.693\times10^{-4}\times\sin(205.66)}{2}$ cm

$n = 2$

$$= -3665 \text{ Å}$$

Hence

$$\lambda_{ave} = \frac{\lambda_1+\lambda_2}{2} = \frac{14055-3665}{2} = 5195 \text{ Å}$$

&

$$\Delta\lambda = 14055 + 3665 = 17720 \text{ Å}$$

here $a+b = 2.54/N$ (grating element)

N = No. of lines per inch.

θ = angle of diffraction

n = order of spectrum

&.

$\because L_c = \frac{\lambda^2}{\Delta\lambda}$

$$L_c = \frac{(5195)^2}{17720} = 1523.02 \text{ Å}$$

By this $\because L_c = c\cdot\tau_c$

$$\tau_c = \frac{L_c}{c} = \frac{1523.02\times10^{-10}}{3\times10^8} = 507.67\times10^{-18} \text{ Sec}$$

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Where,

c = velocity of light

$\Delta\lambda$ = band width of the wave packet.

Observation table

	M.S.	V.S	T.R.(A)
V_1	165	1	165.016
V_2	345	8	345.133

Order of Spectrum	Vernier	Central max (A)	Spectrum on the left of the direct image M.S	V.S	T.R (B)	Spectrum on the Right of the direct image M.S	V.S	T.R. C	θ_1 = A-B	θ_2 = A-C
1.	V_1	A, 165.016	141.5	1	141.516	321.5	19	321.816	23.5	208.2
	V_2	345.133	189	1	189.016	9	6	9.2666	203.883	335.86
									∨	∨
									①	113.69	269.53
2.	V_1	A, 165.016	126.15	15	126.75	293	5	293.083	38.266	231.93
	V_2	345.133	215	1	215.016	35	12	35.20	299.883	50.06
									∨	∨
									②	134.07	141.00

$\theta_1 = 123.88$

$\theta_2 = 205.66$

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Observation

1. Least count of the spectrometer = $1/60$

2. Grating element (a+b) = $1''/N = 1.693 \times 10^{-4}$

Result:-

The wavelength of the He-Ne LASER is
= 5195 Å

Coherence length is = 1523.02 Å

& Coherence time is = 507.67×10^{-18} sec

Precautions:-

(1) Height of all the riders must be same & they are aligned on the same common axis.
(2) Do not see laser directly.
(3) Reading of both verniers scales at both windows is essential.

Industrial Application:- He-Ne laser is used widely in commercial and industrial applications and commonly used in laboratory demonstration of optics. It is the most common laser used in holography. Other major applications of He-Ne laser include.

- Barcode scanners
- Tool alignment

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- Non-contact measuring & monitoring
- Blood analysis
- particle counting & food sorting
- Alignment of high power CO_2 & YAlr treatment lasers & printing beams.

Viva Questions:-

Q1 What is LASER?

Ans It is a device to produce a strong monochromatic, Collimated & highly coherent beam of light.

Q2 What is meaning of LASER?

Ans The LASER word is an acronym for "Light Amplification by Stimulated emmision Radiation."

Q3 What is the principle of LASER?

Ans The LASER works on the principle of Stimulated emission or induced emission. It emits coherent light by population inversion.

Q4 What is the difference between mercury source & Laser source?

Ans Comparison between mercury source & Laser source.

(a) Light emitted from mercury light source is all direction while laser source produce light emitting in only one direction.

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(b) When mercury light passes through the grating it produces lines spectrum while light from laser sources produces spots.

(c) Laser source higher order maxima can observed but mercury source have limit up to second order maxima.

Q5 Is He-Ne laser four energy level laser system?

Ans Yes, He-Ne laser is four energy level laser.

Q6 Give an example of three level laser.

Ans Ruby laser.

Q7 Define the coherence time.

The average time interval for which the field remains sinusodial (means definite phase relationship exists) is known as "Coherence time" or temporal coherence" of the light beam.

Q8 Define the Coherence length.

The average length of wave trains for which the field in sinusodial is known as "Coherent length" or longitudinal coherent length".

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Q9 Mention the basic characteristics of laser light source?

Ans LASER light is monochromatic, high intense, directional & coherent.

Q10 What is wavelength of light emitted from He-Ne laser?

Ans The wavelength of light emitted by He-Ne laser is 6328 Å.

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