J.Basrah Researches (Sciences) Vol.32. Part.2. 50 - 52 (2006)

Dynamic Polarized Output from a He-Ne Visible Laser

S. S. Najem
College of Teachers, Babylon University, Babylon, Iraq

ISSN –1817 –2695

Received 11/7/2006, Accepted 30/8/2006

Abstract
We have experimentally observed the emission of polarized light from a visible He-Ne laser with no intracavity polarization-selecting element (s).

Key words: polarized light, Doppler broadening, He-Ne laser

Introduction
In this paper, we investigate the behavior of He-Ne laser that has no interactivity polarization-selective element for the polarization of the electromagnetic field vector. The laser operates on a single transverse mode of the cavity. It was shown in a recent paper [1] that this laser is able to operate in pulsating fashion during the variation of gain of the medium then in a quasipulsating and finally in the well continuous wave (cw) conventional method of operation. Since the single-pass gain obtainable from He-Ne laser is small, one is forced to use a Fabry-Perot cavity with an enormously high quality factor (Q) in order to exceed the threshold requirement for oscillation. In practice this implies a cavity width $\Delta\upsilon_{\frac{1}{2}} (= \frac{\upsilon}{Q} = \frac{1}{2\pi t_c}$, where υ is light frequency and t_c is cavity or photon life time) which is much narrower than the Doppler width $\Delta\upsilon_D (= 7.162*10^{-7} \frac{c}{\lambda}\sqrt{\frac{T}{M}}$ where c is the free space velocity of light, λ is the wave length, T is the absolute temperature, and M is the atomic weight) for one transition and that the frequencies of oscillation will be primarily determined by the cavity resonance. The dominant cavity resonance frequencies are determined by requiring that the cavity length (L) be a half-integer multiple of the wavelength. These resonance frequencies differ in frequency by ($\frac{c}{2L}$). Since the frequency separation (=$3*10^8$ Hz, L=50 cm) is small compared to the Doppler width (=$1.5*10^9$ Hz, for T $\approx 400^\circ$K , C=$3*10^8$ m/sec, M_{Ne}=20, $\lambda = 6328\ A^\circ$) The laser may oscillate on several of these frequencies simultaneously.

What actually involved in the helium-neon laser is a Gaussian distribution of the Lorentzian lines resulting from the thermal motion of the excited neon atoms and the corresponding Doppler shift of the atoms center frequencies. Hence, in limit that the natural line width (=0.6 MHz [2]) is small compared to the Doppler width, the line much more closely resembles a Gaussian than Lorentzian.

Experimentals
To study the polarization phenomena in this laser we have connected the laser input to variac so that the input voltage to the laser tube can be varied from (0 V) to (10 kV). As was mentioned previously [1] the laser action started when (V_{input}=4.55 k V) with output have a pulsating profile i.e. pulses are emitted. By increasing the input voltage to (10 kV), cw output

was established. Between (4.55 k V) and (10 kV) the gain increases monotonically and the power out too. Physically and since the losses were constant in the laser, the number of oscillating axial modes increases since the gain available to these modes is greater than the loss line (see fig.1). A conventional polarizer with accurate readings in degrees for the axis of transmission is used to study the state of polarization of the laser output.

Results and Discussion

Fig.(2) is an example result obtained were the continuous curve is the output calculated using Malus law ($I=I_o \cos^2\theta$, where I is the transmitted light intensity from the polarizer, I_o is the incident intensity and θ is the angle between the axis of transmission of the polarizer and the direction of oscillation (or vibration) of the light electric field) while the dotted one is the output of the polarizer with variable θ between (-90^o) obtained experimentally. As can be seen, the peak output is shifted from the theoretical one, the full width at half maximum is only 70^o experimentally compared to the theoretical one, and the difference between maximum and minimum transmission positions (i.e. $\theta_{max} - \theta_{min}$) is 75^o experimentally while it is 90^o theoretically. By reducing the input voltage we decrease the number of oscillating axial modes. The difference became 90^o experimentally i.e. one axial polarized mode is available for oscillation. If there are anisotropies, in the resonator, two orthogonally polarized components of the electromagnetic field experience different losses and therefore may “split” any axial mode of the cavity into two modes distinct in frequency and intensity and the mirror reflectance coefficient may vary with polarization.

Interpretation

Besides the different losses introduced by the quartz windows that close the laser tube, which presumably the main source of asymmetry in the laser system, there may be other effects such as mirror or active medium birefringence, and Faraday effects in the lasing material-dependent on the excitation current that favor one polarization over the other.

Therefore, one (or each) axial mode is split into two different modes having slightly different loss for the two polarization components of the electromagnetic field. In fact two orthogonally polarized components do not interfere. More over two modes, resulting from the interaction between the cavity and the electromagnetic field might not be completely orthogonal.

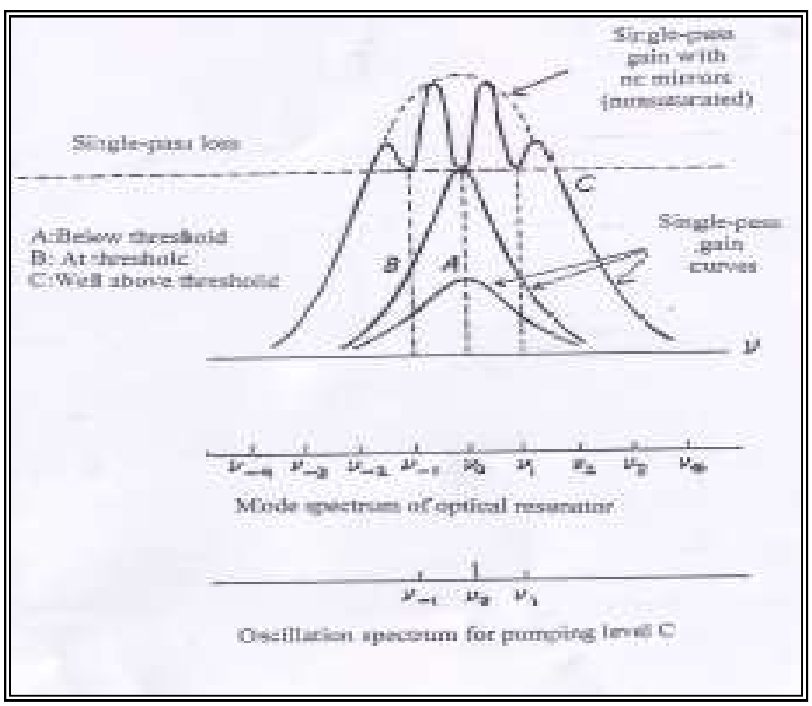

Fig.(1): Effect of pumping level on the gain height hence the number of oscillating axial modes.

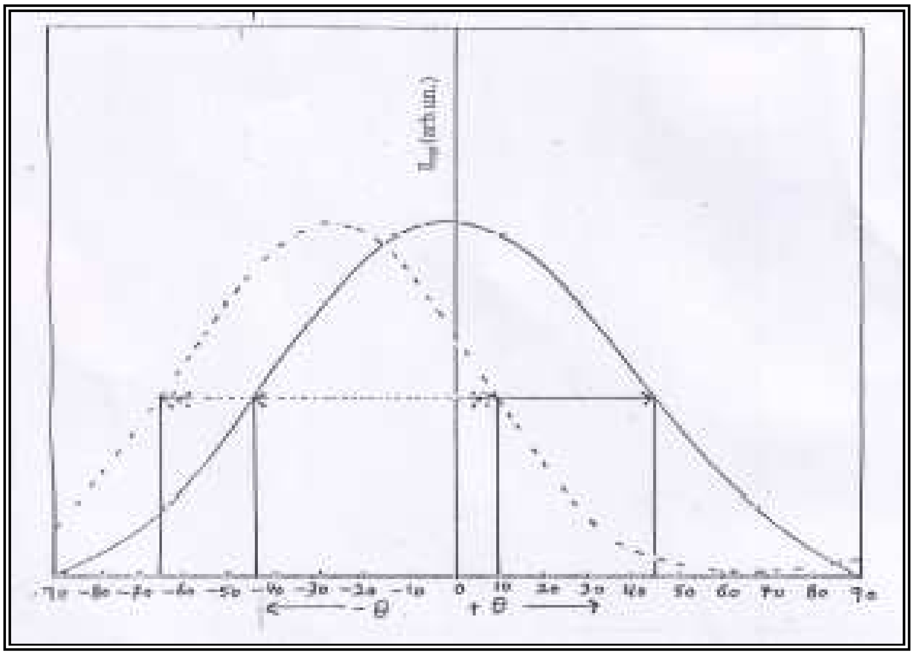

Fig.(2): Distribution of light intensity transmitted from the polarizer as a function of polarizer angles, continuous curve calculated theoretically white dotted one produced experimentally.

Conclusion

In an experiment conducted on a He-Ne laser with no intracavity polarization selective device we have observed a polarized output. The state of polarization was found to be a function of gain i.e. of the number of axial modes oscillating in the laser cavity.

The auther wishes to thank prof. Dr. C. A. Emshary for his invaluable support during the course of this work.

References

1. C. A. Emshary, Nonlinearities in He-Ne laser, J. Bas. Res., V. 24, 37-45 (2000)
2. O. Svelto "Principles of lasers", Plenum (1976).

حركيات الخرج المستقطب من ليزر هيليوم- نيون المرئي

سناء سالم نجم

كلية المعلمين/جامعة بابل/العراق

الخلاصة

لاحظنا عمليا انبعاث ضوء مرئي مستقطب من ليزر هيليوم – نيون من دون استعمال أي وسيلة استقطاب داخل تجويف الليزر.