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Power tuning for 632.8nm wavelength He-Ne lasers with various frequency spacing by mode-split

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Abstract: The laser longitudinal mode-split technology provides a powerful tool to study the power tuning property for a laser with various frequency spacing form a few tens of megahertz to half of the longitudinal mode spacing. A serious of experiments have been done. The experimental results show that the power varying trend of o-light and e-light are opposite to each other, no matter what kind of Ne(Ne^{20} or the mixture of $Ne^{20}$and Ne^{22}) is used and how much the mode split is.

Key words: laser longitudinal mode-split technology power tuning curve

波长 632.8nm 的 He-Ne 激光器在不同频差下的功率调谐曲线

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摘要: 激光纵模分裂技术能使双频激光器的频差从几十兆赫到几百兆赫,我们进行了一系列的实验来研究不同频差下激光器的光输出功率特性,实验结果表明,不论激光器充 Ne^{20}还是 Ne^{22},也不管输出光的频差多大,随着腔长的调谐, o 光和 e 光的功率变化方向是相反的。

关键词: 激光纵模分裂技术 功率调谐曲线

ⅳ. Introduction

Because of the academic value and good applied prospects, the dual-frequncy lasers have been studied and applied widely for a long time[1~5].

In ref. [1], some properties of the two-frequency gas laser in mutually orthogonal transverse magnetic fields were studied, such as the output power profiles for the light waves whose electrical vectors were parallel to the directions of the crossed transverse magnetic fields versus cavity tuning for different values of the magnetic fields strength.

Ref. [2] gave out the experimental output power profiles for the extraodinary eigenstate and the ordinary eigenstate versus cavity tuning for three values of beat frequency, but the value of beat frequency is small(only tens of megahertz) and the discharge tube filled with Ne^{20} was only used.

In ref. [3], the lasing transition is homogeneously or quasihomogeneously broadened, the mode intensities vary linearly with the detuning in the two-mode lasing range.

Katuo Seta and etc. have investigated the intermode competition effect on power tuning curves for the He-Ne lasers by using 15~ 30cm cavity length lasers of which the mode spacing is 500MHz~ 1000MHz[6].

But untill now, no literature has reported the followings: for a He-Ne laser with inhomogeneously broadened lasing transition, the output power profiles for the exteaodinary and ordinary light verus cavity tuning for different values of the frequency split(tens of maghertz to hundreds of maghertz) and the discharged tube filled with different kinds of Ne. But in all applied fields, these are important factors. In this paper, we will report the expriments and results of power tuning in various values of mode split and for both single isotope Ne^{20} and the mixture of Ne^{20} and Ne^{22}.

㈢. Experimental setup

The setup is shown in Fig. 1, where M_1 is a concave high reflective mirror, T is a discharge tube, Q is a quartz crystal plate that can be rotated around its diameter to make the laser longitudinal mode split[5], M_2 is an output mirror. PZT is a piece of pizo-electric ceramic, G is a dc voltage supply, P is a polarizer which can be rotated around its center to be as a gate which let o-light to pass through or e-light pass through. PM is a power metrer. D is a scanning interferometer connected with the oscilloscope O.

In order to compare the experimental results, two He-Ne laser discharge tubes haven been made, one is filled with the isotope Ne^{20} and the other is filled with an equal mixture of Ne^{20} and Ne^{22}, and used in the experimental setup. The other parameters of the discharge tubes are conventional.

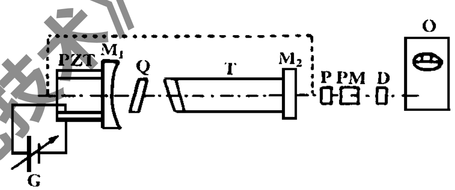

Fig. 1 The experimental setup

㈣. Experimental process and results

1. Experiment 1(for the tube filled with Ne^{20})

The laser cavity length is 177mm. 60minutes after the laser is turned on, before placing P and PM in the beam path, let the output beam be incident into D to obersve the magnitude of longitudinal mode split on O. Rotate Q to get the demanding frequency difference to be experimented on. In the experiments the frequency difference chosen are 424MHz, 93MHz and 53MHz. Under the frequence difference the relationship between the power and cavity tuning , for both o-light and e-light, can be obtained respectively. Then put P in the beam path and rotate it, at the same time we observe the intensity of o-light and e-light. Finally, we find out the extinguishing positions of o-light compenent and e-light compenent respectively. At one of the two positions, only one polarization compenent, say o-light, can pass through P, while at the other position, only e-light pass through P. We call these two positions o-light passing position and e-light passing position respectively. A dc voltage supply V_1 is applied on the PZT, then PM is set into the beam path to detect the power of o-light and e-light respectively by rotating P to o-light passing position and e-light passing position. Continue to increase the voltage on PZT to voltage V_2 and write down the values of the power of the o-light and e-light again. Next, the power of the o-light and e-light are measured at voltage V_3 …

a) The power tuning curves of o-light and e-light are shown in Fig. 2 for 424MHz mode-spit($\Delta\nu$) which is half of the longitudinal mode spacing.

Because the cavity length is little longer than the length which ensures the laser have single mode working within the lasing bandwidth when no mode split occurs. The "single" mode region is about 430MHz corresponding the voltage 36V to 60.5V. Single mode working means that there are only two frequenxcies splitted from a single mode. At 36V, the power of o-light and e-light are 0.147mW and 0.105mW respeectively. With increasing the voltage, the power of o-light(P_o) is decreasing and that of e-light(P_e) is increasing. At 44V, they are almost equal to each other. When V gets up to 60.5V, the other mode comes to appear at the left side of the lasing bandwidth and we stop the measurement.

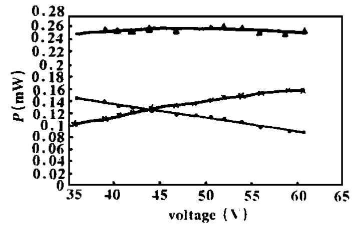

Fig. 2　The power tuning curves of o-light and e-light in the case of $\Delta\nu$= 424MHz for the laser tube filled with Ne^{20}　• – for o-light　× – for e-light　▲ – for the total power

b) In the case of $\Delta\nu$= 93MHz, the curves are shown in Fig. 3. The "single" mode region is between 50V and 83V corresponding 500MHz lasing bandwidth. At 50V, P_o and P_e are 0.105mW and 0.045mW respectively. With increasing the voltage, P_o decreases and P_e increases. At 60V, they are equal to each other. When V gets up to 66V, P_o is 0.076mW and P_e is 0.093mW, they are the lowest point and the highest point respectively. After 66V, P_o increases and P_e decreases, when V is 76V, the highest point for P_o and the lowest point for P_e are got again, then P_o decreases and P_e increases, when V gets up to 83V, the other mode comes to appear at the left side of the lasing bandwidth, we stop the measurement.

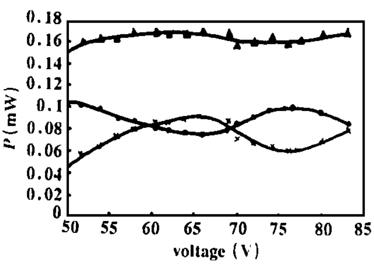

Fig. 3　The curves in the case of $\Delta\nu$= 93MHz for the laser tube filled with Ne^{20}　• – for o-light　× – for e-light　▲ – for the total power

c) In the case of $\Delta\nu$= 53MHz, the curves are shown in Fig. 4. The "single" mode region is between 48.5V and 88V. At 48.5V, P_o is zero and P_e is 0.172mW. With increasing the voltage, P_e gets up to 0.189mW and varies little, till 60V, it begins to decrease and at 70V, it is 0.160mW and P_o is 0.05mW, then P_e decreases quickly and P_o increases quickly, at 72V, P_e is zero and P_o is 0.150mW. The bandwidth within which the o-light and e-light exist together is very small, corresponding the voltage variation of 4V and the bandwidth of 66MHz.

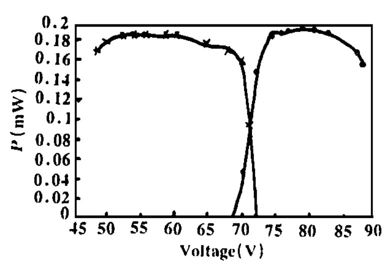

Fig. 4　The curves in the case of $\Delta\nu$= 53MHz for the laser tube filled with Ne^{20}　• – for o-light　× – for e-light

2. Experiment 2(for the tube filled with Ne^{20}: Ne^{22}= 1∶1)

The laser cavity length is 160mm.

Do the same as experiment 1, the power tuning curves corresponding to 470MHz, 108MHz and 45MHz mode split are shown in Fig. 5, Fig. 6 and Fig. 7 respectively.

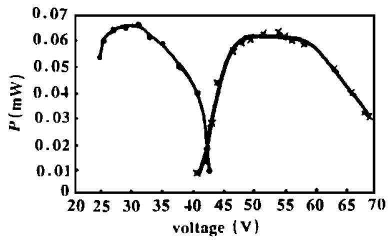

Fig. 5 The curves in the case of $\Delta\nu$ = 470MHz for the laser tube filled with Ne^{22}: Ne^{22}= 1∶1
$\bar{5}$– for o-light × – for e-light

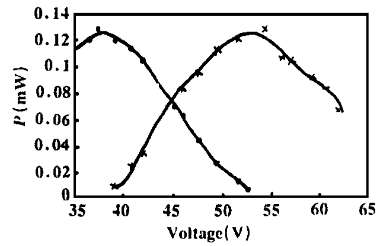

Fig. 6 The curves in the case of $\Delta\nu$ = 108MHz for the laser tube filled with Ne^{20}: Ne^{22}= 1∶1
$\bar{5}$– for o-light × – for e-light

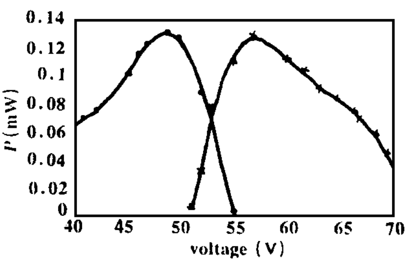

Fig. 7 The curves in the case of $\Delta\nu$ = 45MHz for the laser tube filled with Ne^{20}: Ne^{22}= 1∶1
$\bar{5}$– for o-light × – for e-light

From Fig. 4 and Fig. 7, we find that the bandwidth within which the o-light and e-light exist together for the laser filed with Ne^{20}: Ne^{22}= 1∶1 is larger than that for the former when the beat frequency is about 50MHz.

㈤. Conclusion

By the experimental research we get the following conclusion: The power varing trend of o-light and e-light are opposite to each other, no matter what kind of Ne (Ne^{20} or the mixture of Ne^{20} and Ne^{22}) is used and how much the mode split is.

㈨. Acknowledgement

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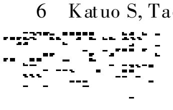

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