Study of some electrical characteristics of axial flow CO_2 laser spectra modeling

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Abstract

This work is aimed to characterize axial flow carbon dioxide (CO_2) laser and study the some electric properties of discharge medium using USB 2000spectrometer. The light intensity emitted from discharge tube shows variation of intensities due to current, voltage and pressure values. The mechanical alignment of the cavity and optical attachment of mirrors in the cavity it is difficult task to obtained optimum pressure. The electrical discharge for CO_2laser is depending on discharge voltage and the plasma tube length and pressure. The intensities variation due to current values shows the lasing lines obtained in the CO_2 laser medium spectrums.

المستخلص

تهدف هذه الدراسه الي تصميم ليزر ثاني اوكسيد الكربون ذو الانسياب الطولي لدراسة بعض الخصائص الكهربائيه للوسط الليزري الفعال باستخدام المطياف USB 2000.تظهر قيم التيار والجهد والضغط تغيرا مع شدة الضوء المنبعثه من المرنان .التصميم الميكانيكي لوزن المراة والحصول علي التفريغ المناسب من العمليات بالغة الصعوبه. التفريغ الكهربي لليزر ثاني اوكسيد الكربون يعتمد علي قيم الجهد وطول المرنان والضغط .تغير الشدات وفق قيم التيار يظهر الخطوط الليزريه لوسط طيف ليزر ثاني اوكسيد الكربون.

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Research problem

The research problem is related to the fact that the effect of vacuum on atomic electrons is not widely studied. The behavior of bulk matter on atomic electrons does not studied within the frame work of fluid mechanics by treating bulk matter as a viscous fluid.

The aim of work

The aim of the present study is to modify energy of some quantum particles in Hydrogen atom, rigid body, free particle and harmonic oscillator using Stock's force to drive an expression for energy lost by the particles due to viscosity. This expression of energy is used to derive quantum equation that accounts for the effect of viscosity.

1.Introduction

The acronym LASER, means, light amplification by stimulated emission of radiation. The terms ‘‘gas,’’ ‘‘liquid,’’ and ‘‘solid state’’ give the most general description of lasers. Gas lasers can be divided into atomic or molecular lasers, for example gold vapor is the atomic gas laser and He Ne and CO_2 are molecular gas lasers. CO_2 Laser operates inmidd infrared in rotational vibrational transitions, at 10.6 and 9.6 μm regions of wavelengths. Both CW and pulsed output is available in different configurations with range of power outputs (10 to 100 kW) possible and typical efficiencies of industrial lasers being over 10%. The active medium in CO_2 laser is really a combination of specific concentrations of CO_2, nitrogen, and helium gases designed to increase efficiency of the output. This active medium is excited by electrical currents to generate the production of laser photons. Its beam readily absorbed by most materials and readily converted into heat. Today, CO_2

lasers are applied in industries for cutting, welding, Drilling and also in medicine for surgery[1].

Method

2. Mechanical Design

Figure (1) shows the mechanical design at ends of the two tubes.

Mechanical design at reflected mirror consists of five items.

First item: Is aluminum part which consist from two concentric cylinders of different inner diameter (34 mm and 21 mm) , the small cylinder diameter be opened in both side and a tiny hole punched in cover to insert tungsten wire, this wire curled in a ring form to work as electrode and the same shape in other side to be work another electrode. Also we made a hole of 4 mm diameter on a cover to pass gas tap through it. But the cylinder of a diameter 34mm sealed in one side, at this side three screw holes placed at 120° are made, to fix this part with the second item. Using araldite substance to fuse the small cylinder with discharge tube and fuse water jacket tube with the cylinder of a diameter 34 mm, this item is the same at both sides in a tube.

O-Ring of 30 mm in diameter was putted between the first and second items to isolate the high voltage from other items and provide high vacuum seal. Another O-Ring of diameter 22 mm in front of gold mirror was used to safety mirror from broken.Also all O-Rings keep evacuation of tube and prevent the gas dissipate to surround.

The second item: Consist of two copper plates with holes of 19mm in diameter, this holes are surrounding by spring and its core cladded by araldite substance, the tow plates and all mechanical parts are concentric, oriented and parallel with

each other. The plate faced to first item has three holes screws placed 120° to connect the tow items, and also we made three punch flanges of holes diameter 2 mm to connect with the second plate.The second plate has six holes screw placed by 60°, three screws insert into flange to connected the tow plates.

The third item: Is made from PVC, had central hole of diameter 19 mm, we made six screw holes by 60° three screws hitched with second plate in the second item.

The fourth item: Also from PVC and mark circle of diameter 24 mm in one side to made fit position for placed gold mirror and three screws will made for connected with third item.

The fifth item: Is the piece of aluminum in U letter form, it was connected from point between the second plate of brass with the third term and we made screw of diameter 4 mm at the center of aluminum attach the fourth item at the sealed side to push gold mirror back and forward.

Mechanical design at output coupler itconsists of three items

The first item: Is aluminum part exactly similar to the first item at high reflected mirror. O-Ring of diameter 30 mm to isolated this item from the second one. But the other O-Ring placed in front of mirror to keeps it.

The second item: Is the PVC of hole diameter 19mm, we mark circle of diameter 24 mm and 1.5 mm in deep at one side of this item to hold ZnSe mirror. It has six holes placed by 60° three holes screws connected with the first item and the other three are connected to third item.

The third item: Is also PVC of hole diameter 19mm and it has flange of length 2 mm and three hole screws. The reflectivity of output mirror (ZnSe) 60% and radius of curvature 2 meter,

there reflectivity of high reflected mirror (gold) is 98% and its radius of curvature infinity. All parts in mechanical designs are orient and parallel to each other.

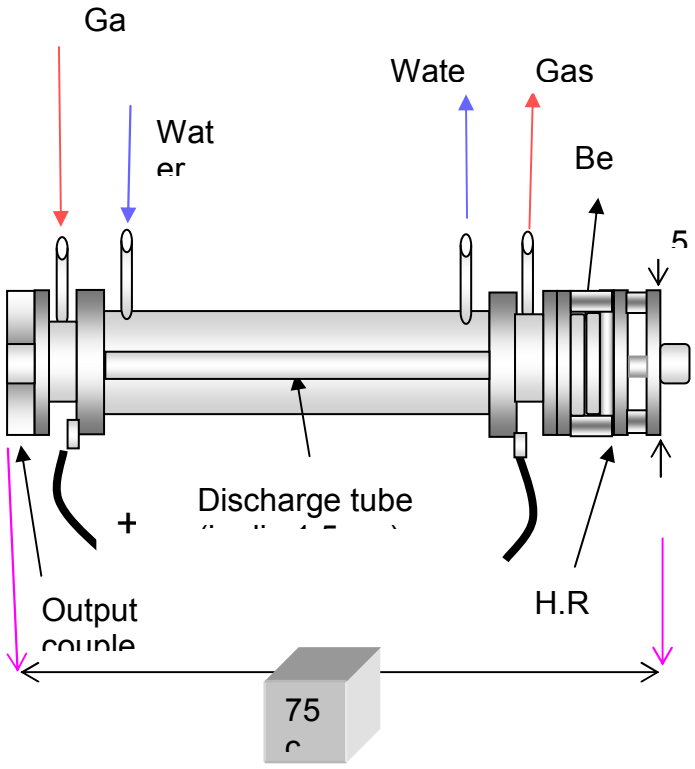


Figure (1): Sketch systematic of design.

(2.1) The Double Jacket Tubes

Pyrex glass double jacket consist of discharge tube with a length of 736 mm and 19mm for inner diameter, the second tube is water jacket, it concentric with discharge tube and it have inner diameter of 32mm and the same length of discharge tube. Discharge tube has two taps at the ends of tube, one tap used as inlet gas and the other used as outlet gas.Also we made tow taps at the end of water jacket tube to inlet and out water.

(2.2) Cooling System

The cooling system simply flow the water from container to water jacket and return to container through water pump. The circular cooling contains tow participants each one have three taps and the water pump also has three taps.The circular cooling begins to connect one tap of water pump to first tap in participant and from second tap of participant to water jacket tube. The other tap on water pump will connected to first tap in second participant and from second tap of participant to the outlet tap in water jacket. The third tap of two participants is connected to other but third tap of water pump was connecting with a water container. Using fitting rubber to connected the taps of tube.

(2.3) Gas Mixture and Vacuum System

We have been used container to mixed gas as ratio of (10%CO_2: 10%N_2: 80% He).Sealed mechanical pumps has been used in which the gas is trapped, the gas passed from mixture to input tap in discharge tube, and removed to the surrounding by Rotary pump.The Rotary pump of type B.S 2412 have speed (50 Litter/minute), we had been used absolute gage of maximum range 0.001torr to measure pressure.

(2.4) The Power Supply of a System

The DC digital power supply (of maximum voltage 5kw and 20 mA as the maximum current) are used, its positive electrode connected with electrode at the output coupler mirror to work as anode and the negative electrode of supply is connected to Ballast resistor of 5kΩ it will change to (10,15 and 100kΩ) . The ammeter connected in series between Ballast resistor and the tube electrode at high reflected mirror to work as cathode.

(2.5) He – Ne Laser

We had been using helium – neon laser of 632 nm wavelength and power 1mw to align mirrors.

(2.6) The USB 2000 Spectrometer

This device can be detect wavelength from 400 to 1150 nm against output intensity corresponding to software (Ocean OOI Base 32) and its reading appear in computer automatically.USB 2000 spectrometer consisted of USB and serial fiber optic of tow meter in length and its core made from silica, the light enter to USB through the optical fiber. The USB2000 was supplied from ocean company module USB 2E7524.

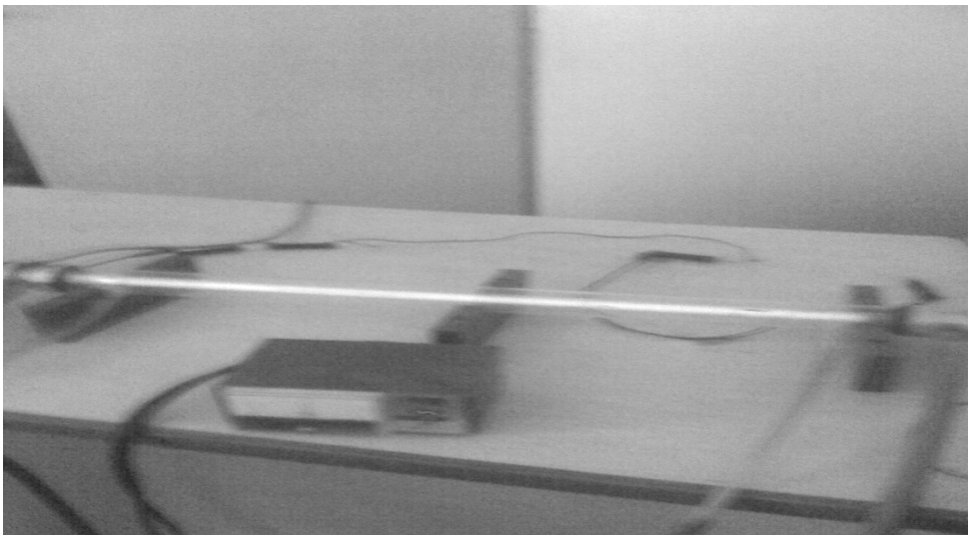
3. Experimental set-up

At the beginnings witching the rotary pump until the pressure in tube reach 0.5 torr as the maximum evacuation in this system, gas mixture flow from the mixture container to tube by a rate 50Litter/ minute, and the gas out from the tube to surround through a rotary pump. Switching DC digital power supply, at specific value of voltage and current, the tube will bright by pink light color. Gas pressure is fixed in specific value reading from gage, and change the current by changing

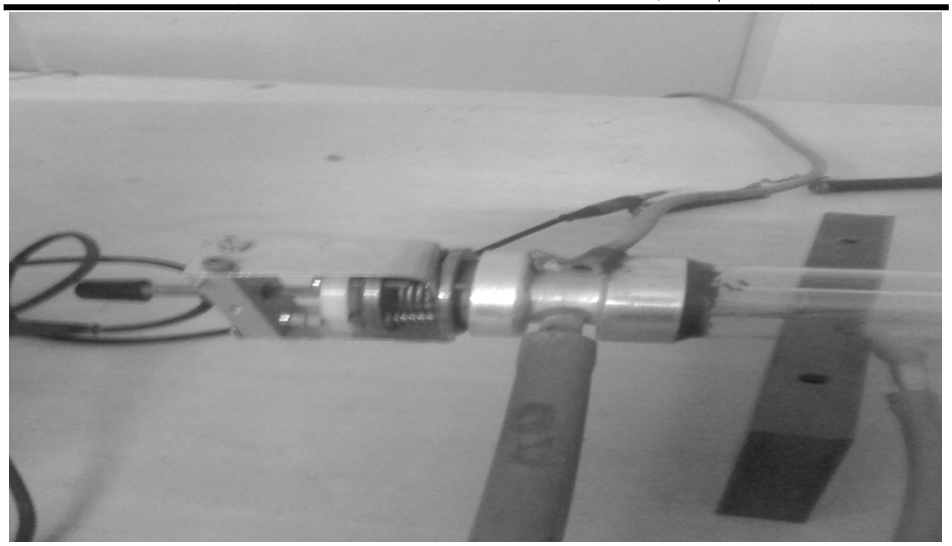
resistance 5, 10, 15 and 100 kΩ in each value of current, we take six values and record the intensity of the bright tube by using USB 2000 spectrometer.Attached optical fiber probe at the center outside the tube and also record voltage directly from the DC digital power supply.

(3.1) Alignment

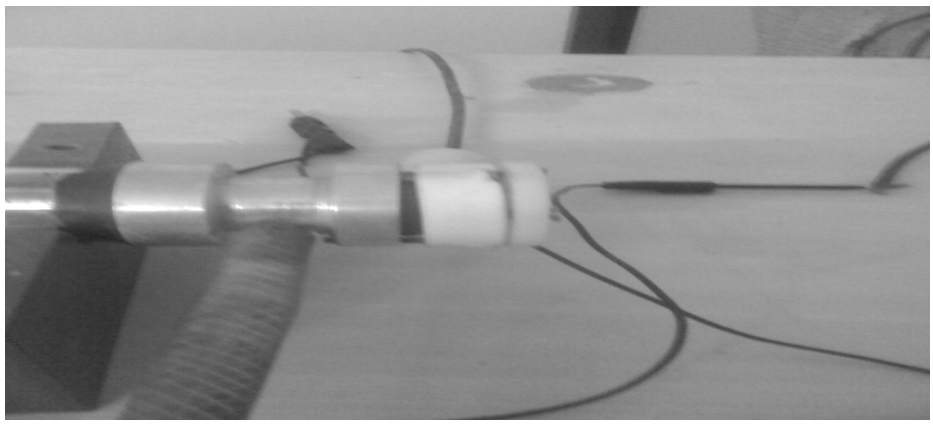
He – Ne laser was putted to incident perpendicular on gold mirror through ZnSe mirror and we used the three adjusting screws on the brass and the central screw until the reflected light is centered on the emitted hole of He – Ne laser.Initially, turn the required screws clockwise until the beam is reflected near center. After that we can turn any of the screws either direction to achieve perfect alignment.Using a central screw until the reflected light is centered on the emitted hole of He – Ne laser.



Picture (1): is the fold of a system.



Picture (2): Mechanical design at high reflected mirror.



Picture (3): Mechanical design at output coupler.

4. Result and discussion

Behavior ofVoltage and Current in Discharge Tube

The practical results of current voltagedischarge frompresent design of tube length 736 mm andfixed pressureat 0.5 torrare recorded in table (1).

Table (1): The practical results of voltage and current.

Point	Current mA	Voltage kV
A	1.8	1.61
B	2.1	1.7
C	2.12	1.72
D	2.14	1.67
E	2.23	1.67
F	2.6	1.67

Table (1) is represented by Figure (2) for all points.

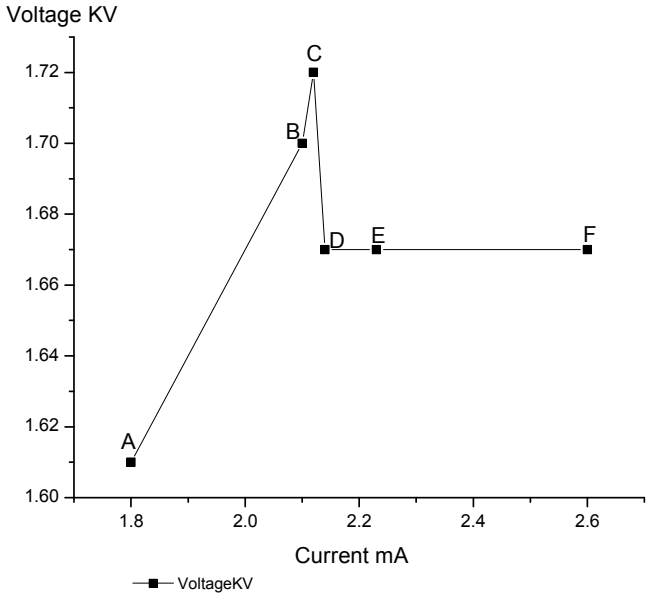


Figure (2):The relation between voltage and current discharge.

From figure (2), the saturation current is 2.08 mA and the break down voltage occur at 1.72 k volt, but at 1.67 k volt

normal discharge begin to operate and the voltage still constant with increasing current.

(4.1) Effects of Changes Current Voltage on Intensity of a Light Emitted From Discharge Tube

The intensity of emitted wavelength is proportional to concentration of atoms or molecules and the number of charges and also the energy was spending to these charges (electric field or voltage).

The higher peaks intensities of dominate electronic transition of CO_2 , He andN_2at 602.59, 663.35 and 746.03 nm respectively, are recorded in table (1).

Table (2): The higher peak intensities of CO_2 , He and N_2 and its wavelengths according to the points in figure (3).

Point	A	B	C	D	E	F
$I_{CO_2}(\lambda =$ 602.59nm)	884	916	904	1132	1060	990
I_{He} (λ = 663.35 nm)	1155	1186	1233	1775	1542	1254
$I_{N_2}(\lambda$ = 746.03 nm)	893	910	942	1314	1175	953

Many wavelengths with low intensities than that in table (1) was recorded as, 774.385, 867.133 and 885.847 nm forN_2, and 581.57 nm for CO_2. Also this figures contain transition with very lower intensities, at 377.83, 399.499, 421.0, 452.5, 706.716, 758.643 and 847.82 nm for oxygen ion O^{-2} , nitrogen ion N^1, CO, nitrogen atom, helium, N_2 and oxygen atom respectively, oxygen and carbon dioxide produced from dissociate CO_2molecule, nitrogen atoms are produced from dissociated of nitrogen molecules.

Table (3): The lowest peak intensities of carbon monoxide, oxygen and nitrogen atom, and its wavelengths according to the points in figure(2).

Point	A	B	C	D	E	F
$I_{CO}(\lambda$ = 421.0 nm)	181	169	169	214	193	177
$I_{O}(\lambda$ = 847.82 nm)	280	293	286	306	301	304
$I_{N}(\lambda$ = 452.5 nm)	172	174	172	208	194	177

The intensity ofCO_2, He and N_2at A was the lowest value of intensity in table (2), as shown in figure (3). That is because the voltage and current discharge was lowest at A and the charges loses by a recombination and drift toward the electrodes.

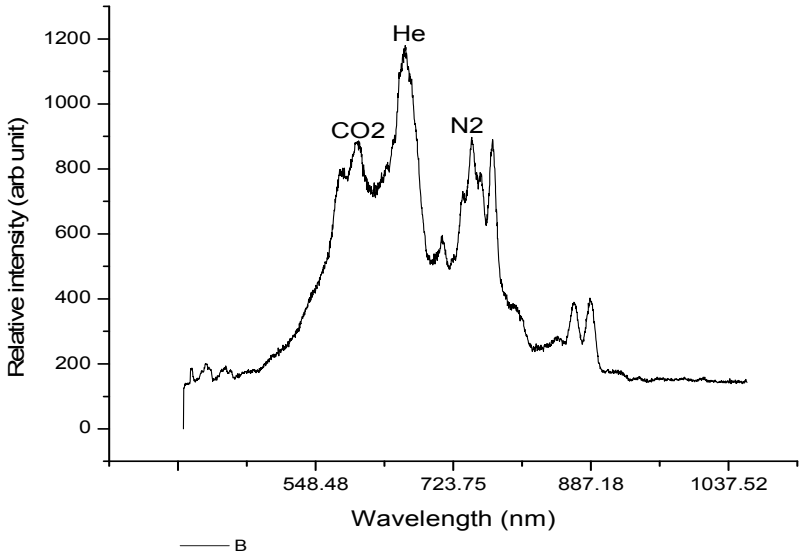


Figure (3): The intensity at point A from figure (2).

The discharge voltage increased at B with increased current and the charges begin to losses only by drift charges toward the electrodes. This lead to intensity at B could be increased as in figure (4).

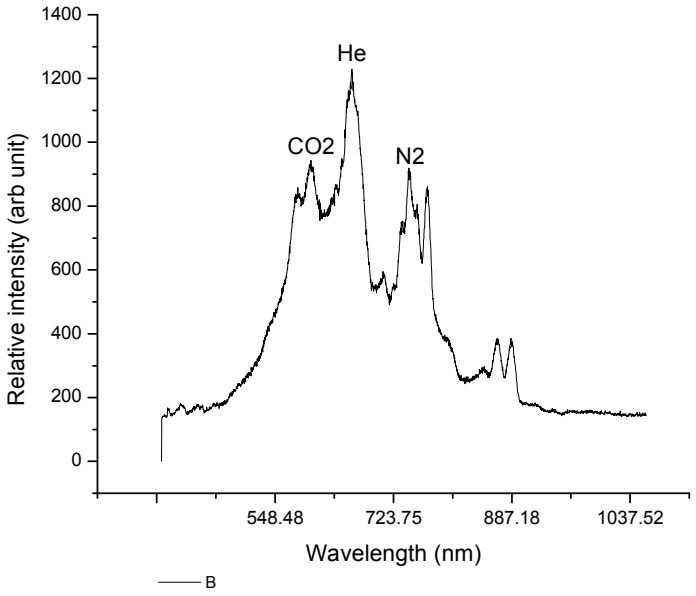


Figure (4): The intensity at point B from figure (2).

At C in figure 4.1 the intensity still increases with increased voltage as in figure (5). While the intensity of CO_2 molecule was decreased, that is because the effect of dissociate of CO_2 molecule could appear.

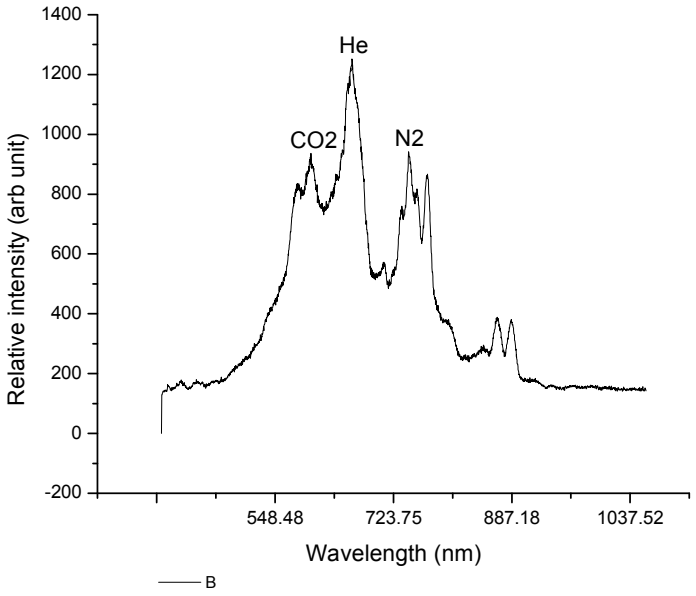


Figure (5): The intensity at point C from figure (2).

The higher intensity recorded at D as in figure (6).

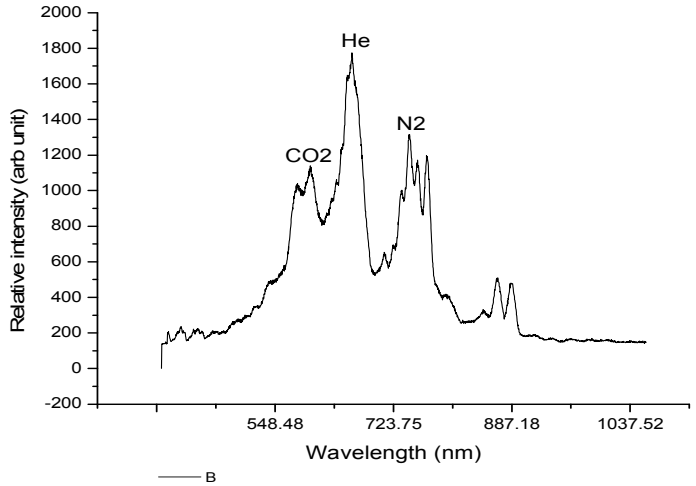


Figure (6): The intensity at point A from figure (2).

This is due to high electric field build at the cathode which responsible for generation a new current by α and γ processes. In this region the electrons were loses by diffused through the walls of tube, this is lead to decrease intensities at E and F as in figure (7) and figure (8) respectively.

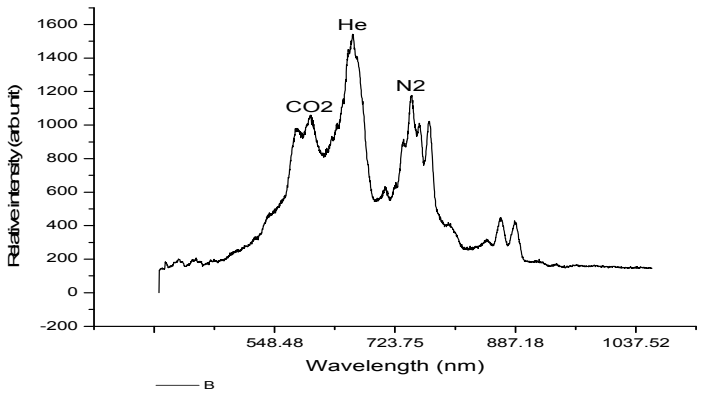


Figure (7): The intensity at point E from figure (2).

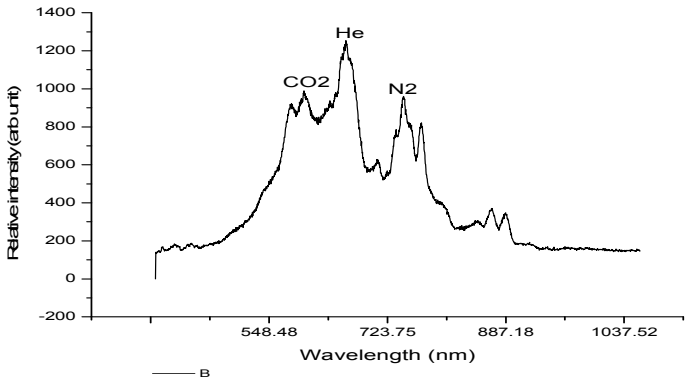


Figure (8): The intensity at point F from figure (2).

All intensities are interface as in figure (9).

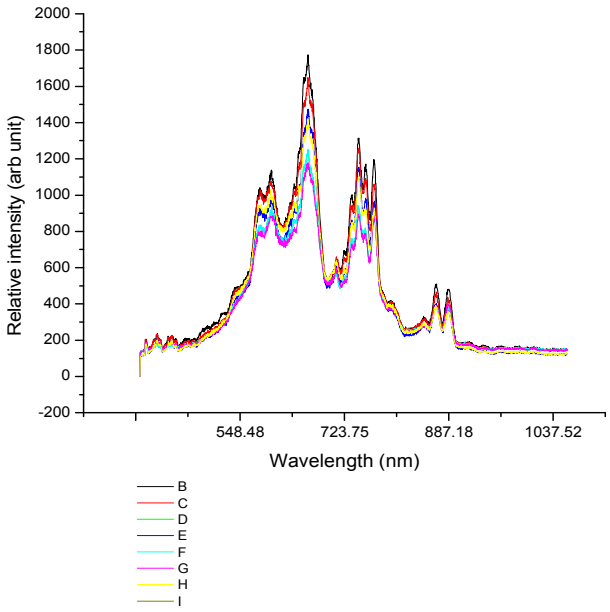


Figure (9): The intensities super position.

5. Conclusion

In this article, construct CO_2 axial flow laser and determine the intensities of visible light emitted from CO_2 discharge tube for different discharge region, one can note the intensity of normal discharge is the higher intensity for the other region of discharge.Thus this region of discharge is the best one to detect the spectroscopic of matter and evaluate the process of evacuation.

6. Reference

1-Brian J. Thompson "Gas Lasers"London, Taylor & Francis Group, 2007.

2-J.Beránek, M. Hugenschmidt "Laser Physics and Application"Vol.1, New York, Springer-Verlag Berlin Heidelberg, 2007.

3-ZainabKasim "Design and Construction of Axial Slow Flow CW CO_2Lasers" University of Baghdad, Institute of laser, July 2003.

4- Paul L.Kelly "Tunable Lasers Handbook " London, Academic press ,INC, 1995,

5-Csele, Mark"Fundamentals of Light Sources and Lasers"New Jersey, John Wiley & Sons, 2004.

6-David W. Ball," The Basics of Spectroscopy"Washington, The International Society for Optical Engineering, 2001.

7-Paul Harteck"Laser Interaction and related plasma Phenomena" New York, Rensselaer polytechnic institute, 1971.