بسم الله الرحمن الرحيم

A comparative study of intra-cavity photoacoustic resonances in a conventional and waveguide CO_2 lasers

By

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Thesis submitted in partial fulfillment of the requirements for the degree of Master of Physics

Physics Department, Al-Quds University

December 2001

Physics Master/Physics Department
Deanship of Graduate Studies

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Declaration

I certify that this thesis submitted for the degree of Master of physics, is the result of my own research, except where otherwise acknowledged, and that this thesis (or any part of the same) has not been submitted for a higher degree to any other university or institution.

Signed..........................

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Acknowledgements

It is great pleasure to acknowledge the contribution of people in the preparation of this thesis. My deepest thanks go to my supervisors Dr. M. Abu-Taha and Dr. A. Leghrouz for their interest, guidance, encouragement and .valuable suggestions through the period of study.

I would also thanks my friend Dr. M. Abu-Sammrha for his help through numerous discussions.

Thanks also to Ahmad Amro (Abu Anass), Mr. Asad and Ahlam Amro for photographing and typing this thesis.

Finally I offer special thanks to my father, mother and to my Fiancee Areej Amro for their encouragement, forbearance during the preparation of this thesis.

Abstract

Carbon dioxide laser is famous by the large number of spot frequency lines it generates. Therefore this laser system has many applications, scientific, industrial, agricultural and medical. The laser is most useful when operated in a stabilized mode. The objective of this study is to compare PA signals detected in two types of the CO_2 laser carriedout by Abu-Taha, 1987 and Parslow, 1993. Data were derived from an experimental curves obtained by both researchers. Trials were also carriedout to calculate the theoretical resonances assuming the different formula for PA cell designs. A difficulty was encountered in deciding the exact volume of the cavity involved in the cell action. Similarity of curves shapes and approximate resonance values confirmed the PA signals were generated in the vicinity of the laser beam in the cavity and expanded into the rest of all parts connected to it. The PA signals are found to be a good indicator of the physical processes that takes place in the laser cavity. It seems that the PA signals are also generated in the discharge region of the laser. In general it can be said that the study showed an agreement between theoretical and experimental measured frequencies for both conventional and waveguide laser, although discrepancies exist within experimental errors and satisfaction of the acoustic cell conditions.

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Chapter 1.

Introduction

1-1 Historical background

The word laser is an acronym for light amplification by stimulated emission of radiation. That radiation is in the form of photons of light, which is the end product of light amplification that is produced, in turn, by stimulated emission (Ratz, 1995). Several lasers were proposed from 1958 through 1960, however the first laser to emit coherent light was the ruby laser invented in 1960 by Maiman. The helium- neon- gas laser was developed by Javan, 1961, later a wide variety of lasers have been developed, and it can now be said that the era of the laser has come at last. Patel, 1964 developed the carbon dioxide laser. The 1980 began with a new surge in laser use and new functions were found for the available lasers. Technologic advances brought new laser systems and upgrades of older lasers and ancillary equipment that fostered an almost exponential growth of laser use in dermatology in the mid- to late 1980s and into the 1990s (Apfelberg, 1992). Lasers are designed in different types and shapes depending on the used active material. In the following a brief a count is given:

A- Gas lasers for example: Neutral atom lasers (He-Ne copper and gold vapor lasers), Ion lasers (Argon laser, He-Cd laser), molecular lasers (CO_2, CO, N_2 lasers).

B- Solid state lasers, for example: Ruby laser and, Neodymium lasers.

C- Liquid lasers, for example: (Dye laser).

D- Chemical lasers, for example: (The HF laser).

E- Semiconductor lasers, for example: (GaAs laser).

F- Color –center lasers, for example: (F_2^+center laser).

G- X–rays lasers.

H- The free- electron laser.

Lasers have found many applications, such as:

1- Industrial application in material processing, for example:

Welding, hole drilling, and cutting.

2- Laser in medicine: For example in surgery.

3- Laser in science: For example, harmonic Generation, self- focusing, and applications in chemistry and biology and many other scientific branches.

4- Lasers in communication. For example: Large information- carrying capacity of light waves, (Thyagarajan and Ghatak, 1981).

Laser system is mostly useful when operated in a stabilized mode. This can be a cheived using many techniques; for example the Photoacoustic (PA) and the optogalvanic (Abu-Taha, 1987) effects. Both effects depend on the process being going on in the laser cavity. The Photoacoustic effect is the process of acoustic wave generation in a sample resulting from the absorption of photons. This Process was first discovered by Alexander Braham Bell in 1880, and before that Tyndall and Rontegen (1980) who had heard of Bell's discovery. Tyndall and Roentgen then work together on the same experirnents, in which optical radiation was chopped by passing it through a rotating slotted disk and then directing it into a closed chamber containing the sample. Before that nearly 50 years the photoacoustic effect revived again by development in microphone technology. This development encouraged Viengrov (1938) to use the phenomenon to study infrared light absorption in gaseous species in gas mixtures. A year later (Pfund, 1939) described a gas analyzer system for measuring the concentration of CO and CO_2. Significant step forward was achieved by (Luft, 1943). When he used gas analyses that employed two-photoacoustic cells. In 1946, Gorelik, first proposed a method of measuring the phase of the transfer between the vibrational and the transnational degrees of freedom of gas molecules using this technique. The next important step forward in the development of the photoacoustic effect was the first use of a laser as a radiation source by Kerr and Atwood (1968). They successfully in that year managed to measure the absorption spectrum of water vapor, and also the absorption spectrum of CO_2 and N_2. Since the 1970s, with the presence of the laser and the progress of highly sensitive pressure detectors, the PA technique flourished and used in many applications. This thesis is concerned with a comparison study between results obtained for PA signals from both conventional and waveguide CO_2 laser cavities. Understanding of PA signals generated in the CO_2 laser cavity will result in good understanding of sustained stabilization and enhancement of laser power.

1-2 Thesis Plan

This thesis contains the following chapters:

a- Chapter one: This chapter introduces the CO_2 laser and brief study of the general types and applications of laser and the historical background to the photoacoustic technique.

b- Chapter two: Explains the properties of the CO_2 laser and brief description of excitation methods.

c- In chapter three a brief review of the photoacoustic technique is given.

d- Chapter four deals with the derived PA experimental results, accompanied by experimental description of the measurement techniques.

e- In chapter five results are analyzed and their indications of what is going on in the cavity is discussed.

f- The last chapter deals with conclusions and further suggested work.