The information system in investigations of the laser signature phenomenon

E. F. Plinski*, D. A. Wojaczek*, J. S. Witkowski*, A. Izworski**

*Institute of Tecommunications and Acoustics; **Institute of Engineering Cybernetics, Wroclaw University of Technology, Wybrzeze Wyspianskiego 27, 50-370 Wroclaw

mailto: edward.plinski@pwr.wroc.pl

The laser signature phenomenon in an RF transversely excited slab-waveguide CO_2 laser is investigated. In the experiment, the laser mirrors are separated by a heated aluminum rod. In that way a laser histogram – series of signatures - is obtained when the laser is tuned by temperature changing of the optical path – the length of the rod - between mirrors of the optical resonator. Collected data can be used for searching and stabilization of the suitable signature for different purposes. Some applications are suggested.

1 Introduction

A CO_2 laser exhibits a known phenomenon called a signature [1]. It is a specific picture of the changes of the laser output power when a laser is tuned. The signature is observed as a result of “jumping” of the laser operation from one to another emission line during the laser tuning. It is a consequence of a rich CO_2 molecule spectrum, and another effect – a high competition between rotational levels from a laser action goes [2]. Fig. 1 shows a mechanism of the laser signature creation. Possible frequencies of the laser resonator can be in coincidence with some emission lines. In that way, at least theoretically, the laser can operates even on many emission lines. In the case of the CO_2 laser it operates only on one chosen line due to a competition between lines (rotational levels) [3].

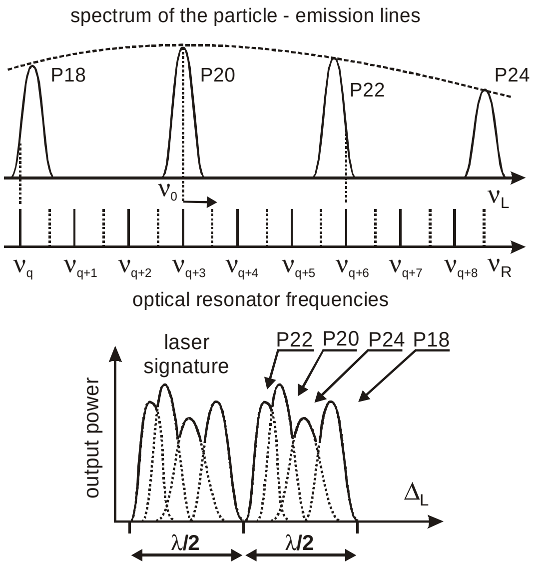

Fig. 1 *The model for demonstration how the laser signature appears when the laser is tuned (see the next figure). Names of possible lines taking part in a laser action are indicated. a) coincidence of emission lines and resonant frequencies of the laser optical resonator, b) possible picture of the laser output power when the laser is tuned of half-lengthwave [4].*

As seen, the picture of the signature repeats with each half-wavelength tuning. It is obvious. Each half-wavelength tuning means the laser mirror translation from one node of the standing wave to another one. In that way the effect repeats.

2 Experiment

The experimental results are shown in Fig. 2. The laser consisted two mirrors - total reflecting MR, and output one M0, and piezoceramic transducer PZT. The laser mirror MR was translated with a piezoceramic transducer PZT of ΔL (ΔL can be equal to a half-lengthwave λ/2 or more).

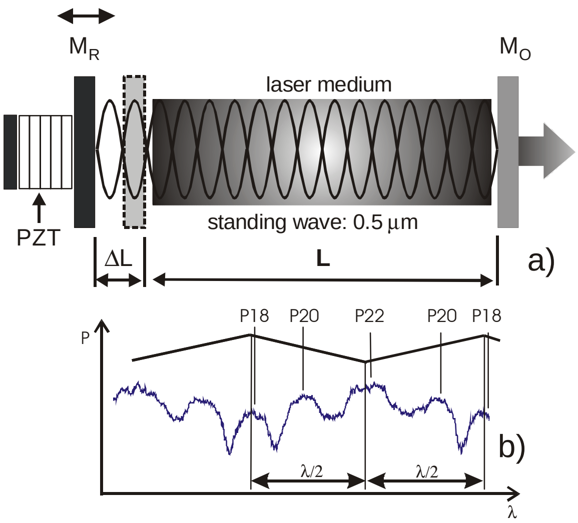

Fig. 2 *a) Tuning of the laser from one to the next node of the standing wave in an optical resonator. b) An experimental result from a slab-waveguide RF excited CO_2 laser used in the experiment.*

In our experiment we used an RF excited CO_2 slab-waveguide laser structure. It consisted of two plane aluminum electrodes of dimensions: 380 mm long and 20 mm wide – top electrode and 400 mm long - bottom electrode. A distance between electrodes was 2 mm. We applied two mirrors in an unstable positive branch confocal configuration. A total reflecting mirror curvature was 5800 mm, and the output mirror - 5000 mm. A continuous-wave operation was used in experiment.

We used a total reflecting diffraction grating to recognize a spectral contents of the output radiation. We registered the changes of the laser power – a laser histogram (a series of signatures) in two points: at the 0-order of the grating and 1-order. In that way we could register a total signature and chosen emission line as a marker for our histogram.

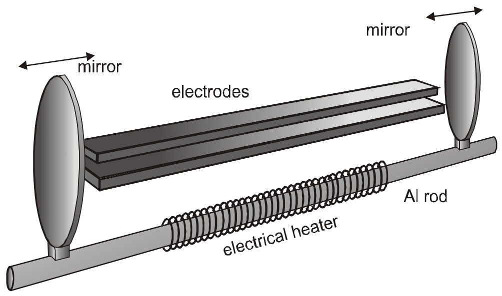

Fig. 3 *A simple mechanism for laser tuning in the wide range of the laser mirror distance L: an electrical heater wound around the aluminum rod.*

We applied a simple device to obtain a high distance tuning (Fig. 3). The mirrors were fixed to aluminum rod. The rod was wound with a coil, which worked as an electrical heater. We delivered about 20 W to the aluminum rod. In that way the distance between mirrors could be changed of about 25 µm during heating, it was 5 half-wavelengths.

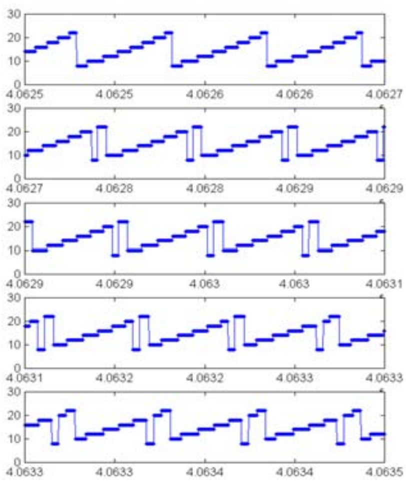

Fig. 4 *The laser histogram (series of laser signatures) starting from 406.25 mm resonator length (theor. result)*

Detailed investigations in a higher range of the translation showed that the signature does not change with tuning of a few half-wavelengths but after that slowly change its picture. Fig. 4 shows a typical example how so called Well-Ordered Laser Signature (WOLS effect [5]) slowly looses a perfect order (according to the order of the CO_2 molecule spectrum) with the laser tuning.

3 Conlucions

The signature can be used as a standard for calibration of the servomechanism. The self-calibrating system can be applied for continuous investigations of the laser signatures. Our investigations show, that it is possible to find a suitable laser signature for many applications. One of them is a single frequency operation of the laser. To avoid as much as possible temperature drifts of the laser mirrors we should choose the length of the resonator, where the signature is very poor. It means, the laser operates on one chosen line in a wide range of the resonator tuning. Another application is a trace gas analyzer. Some gases show quite narrow dips in the absorption spectrum. Choosing a suitable signature we can tune the laser very easy to desired emission lines, which are absorbed by the investigated gas medium.

Reassuming, a carbon dioxide laser can be designed as a chip spectral device, where choosing a suitable operation frequency can be very easy realized (comparing to expensive, and complicated devices, where one of the laser mirrors is replaced by a diffraction grating, which stimulates the laser operation on one chosen line).

It is necessary to remark, that the results of the investigations above are possible to obtain rather on the laser in a single-mode operation regime, where only longitudinal modes are excited in the laser cavity. It is why an unstable resonator is used, which stimulates a single-frequency operation of the laser used. In that way, high-order transverse modes (disturbing the picture of the signature) are suppressed by definition.

References

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