MEASUREMENTS OF THE IR–LASER EMISSION SPECTRAL COMPOSITION DYNAMICS BY THERMAL VISION TECHNIQUES

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A technique of using an automated thermal vision system for measuring the dynamics of spectral composition of CO–laser radiation is described. Some measurement results and their comparison with literature data are discussed. Complex and variable behavior of the laser emission spectrum is clearly demonstrated.

Determination of emission spectral composition and its dynamics is necessary for investigations of generation processes in IR–lasers and for estimates of atmospheric influence on laser radiation.

Use of an automated thermal vision system for measuring the dynamics of spectral composition of a cw CO–laser emission is described in this paper. The measuring technique is as follows. A portion of the laser output radiation reflected from a wedge of CaF_2 was directed into a grating panoramic spectrum analyzer. A 10–mm horizontal slit, cutting out only the spectrum image, was placed in the spectrum image plane. The slit was covered with a matt lavsan film used as a screen with the transmission coefficient about 0.5 in the range of 5 μm.

The spectrum recording was performed with a TV–0.3 thermovisor (the operating range of wavelengths is 3–5.5 μm) connected via an interface to an IBM PC. The recording block includes an analog–to–digital converter (ADC), programed control system for signal transformation, and buffer memory, where the information from the thermovisor is recorded. The spectrum image of 50 by 50 elements size formed on the lavsan film was then transformed into the electrical signal by the thermovisor with the frame frequency of 16 Hz. To make the wavelength scaling we used two reference points arranged using two small lamps placed behind the lavsan screen at the positions of He–Ne laser emission at $\lambda = 0.63$ μm, in the 16th and 17th orders of its diffraction. A He–Ne laser was used in our system for the alignment of the whole system. The reference points corresponded to the wavelengths 5.0624 and 5.3788 μm. Between reference points we could resolve 33 elements, that corresponded to 0.0096 μm between two readings in the spectrum image. At this stage we solved the problem on developing measurement technique, therefore nonlinearity of the image along the string (spatial resolution and sensitivity) was not studied.

The results of two measurements of dynamics of CO–laser spectrum composition are presented in Fig. 1. At the top of this figure we have placed several scales: 1 is the wavelengths 5.1488–5.3792 μm, corresponding to the position of elements in a line; 2, 3, 4, and 5 is the scale of possible transitions in a CO–laser taken from Ref. 1.

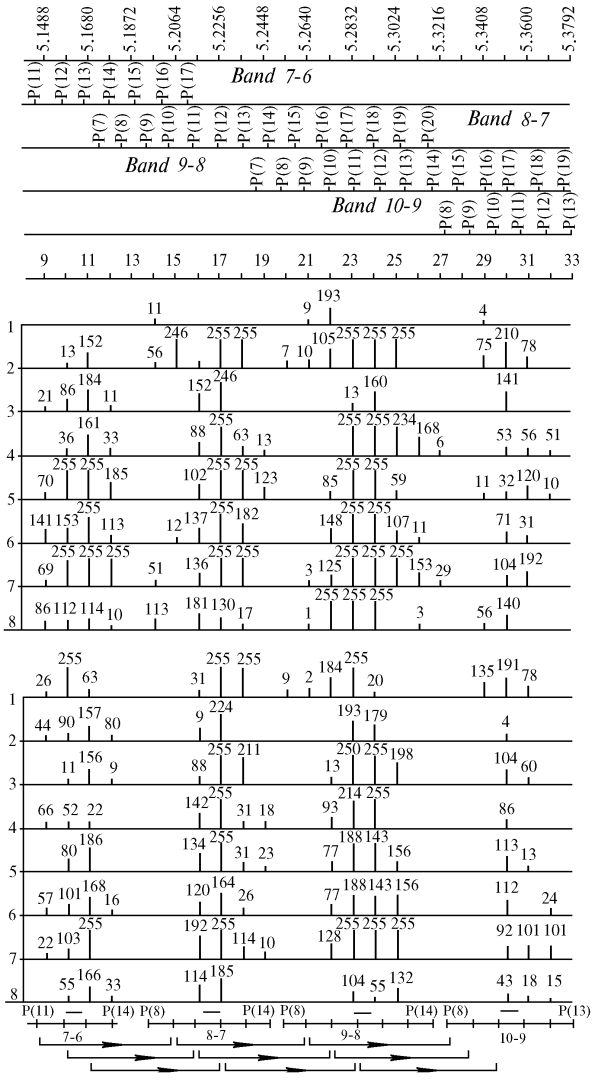

FIG. 1. The dynamics of spectral composition of CO–laser radiation.

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The transitions are shown on the scale in accordance with their wavelengths, where 6 is the number of a recorded point (element) in the image referred to the reference point of 5.0624 μm.

The emission lines and their amplitudes in relative units are shown by vertical lines. The amplitude value 255 corresponds to a limit of the ADC measurement range that means that intensity of individual lines exceeds this range. The reading time for one spectrum is $0.6 \cdot 10^{-3}$ s, time interval between spectra is $\Delta t = N \cdot 0.0625$ s, where N is the spectrum (frame) number indicated on the left side of the figure.

The positions of known emission lines $P(K)$, in the bands 7–6, 8–7, 9–8, and 10–9, similar to our CO–laser were taken from Ref. 1, and are presented at the bottom of the figure. Known CO–laser transitions at the cascade emission are shown with arrowed lines.

Analysis of the obtained data allows the following conclusions to be drawn.

1. A CO–laser emission spectrum contains a lot of emission lines and it is rapidly varying with time at the establishment of the emission. Some lines appear and disappear during the generation as, for example, the line $P(11)$ of the band 7–6; $P(9)$, P(10), and $P(14)$ of the band 8–7; $P(8)$, $P(9)$, $P(10)$, and $P(13)$ of the band 9–8 and others.

2. The main fraction of the total output energy is concentrated in 7–10 basic lines. In these experiments they were:

band 7–6	band 8–7	band 9–8	band 10–9
$P(12)$–5.1969	$P(11)$–5.2141	$P(10)$–5.2738	–
$P(13)$–5.1666	$P(12)$–5.2250	$P(11)$–5.2847	$P(10)$–5.3459
–	$P(13)$–5.2360	$P(12)$–5.2937	$P(11)$–5.3969
–	–	$P(13)$–5.3069	–

These laser emission bands and lines coincide or are close to known from Ref. 1 and completely coincide with the cascade transitions for CO–lasers.

Thus, the measurement results clearly demonstrate the possibilities of using such an automated thermal vision system for investigation of the dynamics of spectral composition of cw CO–laser radiation. Moreover, this automated system enables one to achieve sufficiently high spectral resolution, fast response, and to simplify data calculation and processing. If necessary, the response time can be essentially reduced to provide 1600 measurements per second, by using a single line mode of recording instead of a frame recording, though this would require certain modifications of the thermovisor.

In addition, this technique can be used for investigations of CO–laser radiation dynamics with the use of a thermovisor and a spectrum analyzer operating in the range 8–12 μm. The developed automated system allows one to record from 104 to 208 spectra in the frame recording mode of operation and up to 10,000 –– in the single line mode. Moreover, using a programable mode of ADC conversion one can vary the interval between measurements of two successive spectra from 0.06 to several seconds.

REFERENCES

1. R.J. Pressly, Ed. *Handbook of Lasers with Selected Data on Optical Technology*, Vol. 1 (Chemical Rubber Co, Cleveland, 1971).