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LIDAR FOR SOUNDING OF TROPOSPHERIC OZONE USING A COPPER - VAPOR LASER AND AN EXCIMER LASER

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At present for purposes of laser sounding of ozone in the UV spectral range the excimer lasers and the fourth harmonic of the Nd:YAG laser are mainly used coupled with the stimulated Raman-scattering techniques. Based on the obtained at the Institute of Atmospheric Optics results of investigation of harmonics generation of copper-vapor laser radiation in nonlinear crystals [1], we have developed the lidar for sounding of tropospheric ozone with the use of nontraditional pairs of laser spectral lines.

As such lines for ozone sounding using the differential absorption method the two pairs of lines are selected: the line of 289 nm (second harmonic of yellow line of the copper-vapor laser radiation) and the line of 308 nm of the excimer XeCl laser; and 271 nm (sum frequency of green and yellow lines of the copper-vapor laser radiation) and 289 nm.

In the nonlinear β-BBO crystals the efficiency ~ 25% was obtained when transforming the green and yellow radiation lines of the copper-vapor laser into second harmonics, and the efficiency ~14% when transforming the both radiation lines into the sum frequency (λ=271 nm). This has made it possible to obtain the generation energy parameters acceptable for sounding of the troposphere (see Table 1.) High pulse repetition rate of the copper-vapor laser generation with low energy per pulse make this laser most convenient for sounding in the photon counting regime under conditions are just the ones characteristic for ozone tropospheric sounding at λ<300 nm.

A sounding channel of tropospheric ozone has been developed on the basis of the 0.3 m diameter receiving mirror. The above channel is supplemented by the stratospheric ozone sounding channel at the complex lidar station with the 2,2 m diameter receiving mirror. A simplified block-diagram of the tropospheric channel is given in Fig. 1 and basic parameters are presented in Table 1.

Table 1.

Emitting system

Laser	λ, nm	E, mJ	$P_{av.}$, W	f, Hz
Cu,doubled yellow	289		~0.2	5 10^3
Cu, sum frequency	271		~0.2	5 10^3
XeCl	308	50		50-100
**Beam divergence		~0.2 mrad		

Receiver system

Telescope diameter, m	0.3
Telescope focal length, m	1
Field of view , mrad	0.5
Photomultiplier	PMT-130, PMT - 142
Temporal resolution, m	100
Spatial resolution, min	~10

The lines of 308 and 353 nm are used for sounding stratospheric ozone with recording by the mirror being 2,2 m in diameter. The lidar returns from the troposphere at the wavelengths of 289 and 308 nm or 271 and 289 nm are recorded with the small mirror receiving system. The signals were recorded in the photon counting regime by the multifrequency counter with the 512 strobes storage of 100 m length.

For selected line pairs the ozone numerical simulation was carried out using the differential absorption method.

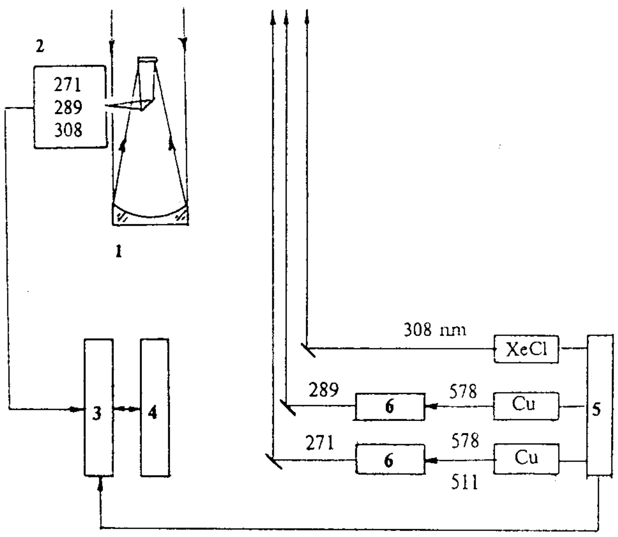

Fig. 1. Block diagram of the ozone lidar.
1- receiver mirror; 2- cell of spectral selection with PMT;
3- photon counter; 4-computer;
5-synchronizer;
6- nonlinear β-BBO crystal

To calculate lidar returns we used the following values of the parameters entering into the lidar equation: pulse energy is 0.04 mJ for sounding on 271, 289 nm and 50 mJ for sounding on 308 nm; system constant is 0.394; photodetector sensitivity is 0.15; height resolution is 100 m; pulse repetition rate is 5000 Hz at wavelength 271 and 289 nm and 50 Hz at 308 nm; time of signal accumulation is 10 min. To estimate the possibility of sounding O_3 we took into account the current hours: day and night

The simulated error of ozone sounding are given in Fig. 2. It is clear that the tropospheric ozone sounding can be made in the day time and night-time at the wavelengths 271 - 289 nm preferably.

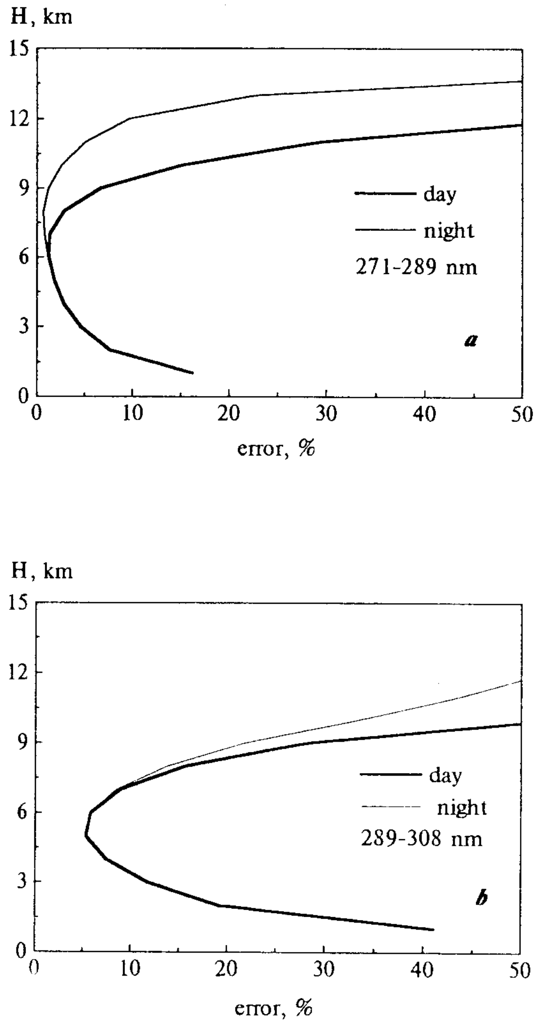

Fig. 2. The result of modeling the errors in sounding ozone at the wavelengths 271 with 289 (a) and 289 with 308 nm (b)

REFERENCES

1. V.O. Troitskii "Features of the Copper Vapor Laser Radiation Harmonics Generation in Nonlinear Crystals" . Atmospheric and Oceanic Optics, v. 6, No.6, 1993.