26PB2

THE DESIGN OF EYE SAFETY YAG:TmCrHo PULSED LASER AND STUDY THE ENERGY LOSSES OF ITS RADIATION IN AIR AND GAS-AEROSOL MEDIA

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The purpose of this paper is to discuss the pulsed YAG: TmCrHo–laser design and application to remote sensing of aerosol and gaseous components of the atmosphere and to present the results of measurement of energy losses of its radiation in molecular gases and air.

The characteristics of pulsed radiations of the YAG:TmCrHo–laser with the laser rod of 5 mm in diameter and 80 mm in length with a flash lamp in quartz monoblock cavity were investigated. The regime of the short intense pulse was obtained with use of the electrooptical Q–switch cell. The study of YAG:TmCrHo–laser selfmodulation in unstable resonator with spherical mirror was also performed following the ideas of Ref.1.

The optimal parameters of laser resonator were chosen to get the minimal duration of a pulse. The spectral characteristics of monopulse laser radiation like the spectral line width and frequency tuning interval were also optimized.

We measured the absorption coefficient of air in transparency microwindows inside the range of laser frequency tuning in order to applicate the designed laser to aerosol lidar. Spectral interval from 4905 to 4925 cm^{-1} is characterized by low absorption coefficient value. Estimation made with use of HITRAN database (see Ref.2) and a calculating procedure described in Ref.3 give the average value of absorption coefficient about 10^{-6} cm^{-1} for standard temperature and pressure.

We use two type of laser spectrometers with tunable YAG:TmCrHo–laser for measurement of absorption spectra of CO_2, H_2O and air.

The multipass spectrophotometric cell with geometrical length of 110 meters was used by us to investigate transparency spectra and determine the absolute value of absorption coefficient of pure molecular gases (CO_2 and H_2O) and air. Using the White optical system, we can realize the optical length from 400 m to 500 m and measure the absorption coefficient with limit sensitivity about 10^{-6} - 10^{-7} cm^{-1} (Ref.4).

The photo-acoustic cell was used to investigate the dependence of absorption coefficient on partial and total pressure of gases under study. The limit of sensitivity of photo–acoustic cell allows us to measure of absorption coefficient of $\sim 10^{-7}$ cm^{-1} with laser pulse energy of ~ 0.05 J.

A numerical simulation of absorption and transmission spectra of CO_2, H_2O and air with the spectral resolution equal to the laser line half–width was performed using a line-by-line calculating procedure. The parameters of individual H_2O and CO_2 spectra lines inside spectral interval

1.9–2.1 mkm were borrowed from HITRAN database.

A comparison of calculated and experimental absorption spectra for air and pure H_2O and CO_2 was performed.

The measurements of H_2O and CO_2 absorption coefficients dependence upon the laser pulse intensity were made and the results were compared with numerical estimation of nonlinear spectroscopical effects which could took place when propagating YAG:TmCrHo–laser radiation through the resonantly absorption gases like H_2O or CO_2.

We focused the laser beam by long focus lens in order to obtain the intensity of laser radiation more then $10^7 W/cm^2$ inside the photo-acoustic cell. The neutral light attenuators were used to vary the intensity on the photo-acoustic cell input. The instrumentation procedure of measurement of nonlinear absorption of molecular gases using the photo–acoustic technique was described in details in Ref.4.

The obtained results are discussed from the point of view of perspective applications of YAG:TmCrHo–laser to both aerosol lidar and trace gas analyzer.

In particularly, requirements to the main parts of the YAG:TmCrHo-laser lidar for investigation of natural and industrial aerosols for the distance about some kilometers were determined. Signal-to-noise ratio equaled to 1 as criterion of the lidar potential was used. Then the lidar returns are detected by InGaAs p-i-n photodiode the noise models are served the shot noise, caused by signal and background, and heat noise of loading resistors. As showed with our estimates, made applicationly for creating of a compact lidar with pulse energy 20 mJ and receiving telescope diameter 0.3 m, the main noise source is the heat noise of the loading resistor.

Sounding range of lidar with a such parameters in conditions of clear atmosphere (backscattering coefficient $\sim 10^{-6}\ m^{-1}$) for horizontal and low-elevations directions may be reach about 10 km.

A such lidar will be applied for remote control of industrial centers atmosphere.

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