OPTICAL MODELS OF THE MOLECULAR ATMOSPHERE

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U S S R

The use of optical and laser methods for carrying out the atmospheric investigations has stimulated the development of the optical models of the atmosphere. The optical (laser) radiation absorption by molecular gases of the atmosphere is one of steady factors affecting the laser beams propagation along the atmospheric paths. A great bulk of stored information on absorption spectra of atmospheric gases and parameters of individual spectral lines, peculiarities of spectral characteristics dependence on variations of meteorological parameters, gas composition, and laser radiation characteristics [1-5] are the basis for developing the molecular atmosphere optical models.

The optical model of an absorbing molecular atmosphere is assumed to be the complex of information (in the form of plots, tables, analytical formulas, and computer programs) on molecular absorption characteristics along the path of light beam propagation taking into account the dependence on the path coordinate of meteorological parameters (temperature and pressure) and concentrations of the absorbing air components for given initial information on the light beam characteristics.

The paper considers the principles of constructing the optical models of molecular atmosphere for radiation with different spectral composition (wide-band, narrow-band, and monochromatic) in the case of linear and nonlinear absorptions.

The optical model of molecular atmosphere, in the case of linear interaction of monochromatic radiation with individual gas components, includes a quantitative information on vertical profiles of the volume coefficient of air absorption, optical depth and transmittance of the atmospheric vertical column, as well as the root-mean-square deviations of these values caused by variations of temperature, humidity and small gas-component concentrations. The analysis of the basic factors determining the value of the r.m.s. deviations of the optical-model parameters has been made for different spectral ranges.

The optical models for a narrow-band radiation have been developed for the case where the laser-radiation spectrum width is comparable with the resonance-absorption line width, and the form of spectral distribution is rectangular or Gaussian. The approximated analytical expressions [6] were suggested to simplify the procedure for calculating the energy absorbed from a laser beam with the Gaussian spectrum when

it propagates along the inhomogeneous vertical path.

The possibilities of increasing the accuracy of optical models of an absorbing atmosphere due to the use of additional information on altitude correlations of absorption characteristics [7] have been considered. The problems of calculating the atmospheric transmittance for the case of wide band ($\Delta\nu \gg \gamma$) optical radiation are discussed. The comparative analysis of approximated calculational methods possibilities, in which the transmittance functions are calculated using the parametric formulas, has been made. The paper considers in detail the approach where the models parameters are calculated based on the data on a vibration-rotation structure of the spectrum obtained with the use of modern spectrometers with high spectral resolution. It was shown that in the framework of such an approach the model of an isolated spectral line is sufficiently simple and reliable for some individual spectral intervals of the IR range.

When constructing an optical model of the nonlinearly absorbing atmosphere for the wavelength range of CO_2 laser generation the nonlinear spectroscopic effects have been taken into account including the effects of absorption saturation in atmospheric CO_2 spectral lines and the new effect (theoretically and experimentally observed and studied at present at the Institute of Atmospheric Optics) of "blaching" of a line wing [8,9]. Both effects are characterized by a less intensive threshold than that of an air optical breakdown, and their actions result in significant increase of the atmosphere transmittance at easily attainable intensity levels of pulsed CO_2 lasers. Due to insufficient study of the considered nonlinear spectroscopic effects the suggested model can be considered as an evaluating one. The prospects for further development of a nonlinearly absorbing atmosphere model are discussed in the paper.

The solution of the problems on numerical simulation of the total sum of phenomena of optical radiation transformation in the atmosphere, even in the visible and IR, requires consideration of the order of 10^6 units of spectral information just as input data. Moreover, the variety of meteorological considerations and types of paths assumes a great number of calculations. Due to this fact an actual problem in developing numerical methods of atmospheric optics and spectroscopy is the problem of automated computation of absorption characteristics.

The paper presents the example of the development of such a system which provides for the modeling of the processes of optical-wave energy transfer in the atmosphere [10]. Its physical foundations, structure, programming software and functioning have been considered.

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