Preface

Application of high-power lasers in environmental research

Obvious progress achieved recently in development of new laser technologies stimulates their active use in optics of natural media. Unique properties of laser radiation allow new information on the objects under study to be obtained. A prominent example is the application of femtosecond lasers to atmospheric sensing, clearly demonstrating the increase in accuracy, sensitivity, and range of sensing. The use of broadband femtosecond radiation, as well as initiated by the radiation "white" supercontinuum, significantly extend the list of measured parameters of the environment and allow sensing of ecologically dangerous gaseous and aerosol substances.

For efficient application of high-power lasers in the environmental research, it is important to know how the high-power laser radiation propagates in the atmosphere and how one can improve properties of the radiation as a research instrument. This knowledge is also important for many other practical applications (laser power supply of the satellite-borne solar batteries, removal of thunderstorm electricity from clouds by a laser ray, laser removal of space refuse, etc.).

The use of high-power lasers in environmental research is a complex problem including both basic and applied aspects. To be noted among them are nonlinear optics of the atmosphere, problems of linear and nonlinear propagation of optical radiation in the atmosphere, adaptive optics, and laser technologies of diagnostics of natural media.

This issue begins with articles devoted to nonlinear optics of the atmosphere. In the first article (I.S. Golubtsov, V.P. Kandidov, and O.G. Kosareva), an important problem of atmospheric optics – the formation and evolution of "white" supercontinuum at self-focusing of terrawatt titanium-sapphire laser – is studied numerically. It is shown that the supercontinuum is generated as a result of self-modulation of a pulse phase in space and time under conditions of strong optical nonlinearity of a highly localized light field. The article by A.A. Zemlyanov and Yu.E. Geints is devoted to theoretical study of peculiarities of nonlinear optical interactions initiated by a high-power femtosecond pulse in weakly absorbing liquid-droplet aerosols. The article also describes the numerical experiment on formation of resonance structures of fields in droplets-microresonators. The obtained results are used for construction of some physical model describing the processes of generation of stimulated radiation in microparticles in various spectral regions. The article by V.P. Drachev, S.V. Perminov, S.G. Rautian, et al. discusses their results in nonlinear optics of clusters as applied to polarization effects in the aggregated colloid silver solution. The experimental results demonstrate high values of the inverse Faraday effect and the Kerr optical effect. The papers by T.N. Kopylova, R.T. Kuznetsova, and G.V. Maier with co-authors present the review and results of their research in photonics of complex molecules exposed to high-power optical fields. Peculiarities of spontaneous and stimulated emission of molecules and their phototransformation at high-power laser excitation are studied in detail. The paper by S.E. Skipetrov and M.A. Kazaryan considers dynamic multiple scattering of laser radiation in dense scattering media (concentrated suspension of particles) with allowance made for acceleration of particles in the field of a laser beam. It is shown that, using the methods of diffusion-wave spectroscopy, it is possible to determine characteristic rates of light-induced flows of microparticles.

Several papers are devoted to the problem of optical discharge in the atmosphere. V.I. Bukatyi and O.V. Gas'kova in their work present the results of experimental study of optical-discharge plasma in air in the presence of particles exposed to the Nd laser radiation. The paper by A.M. Skripkin systematizes the experimental data on the phenomenon of optical discharge in weakly focused laser beams. The dependence of optical discharge and its transfer characteristics (for propagating in it optical radiation) on radiation parameters and medium properties is thoroughly analyzed.

A series of papers are devoted to propagation of laser radiation (including high-power laser radiation) through the atmosphere.

In the paper by R.Kh. Almaev and A.G. Slesarev, the propagation of intense laser beam in the liquid-droplet aerosol under the effect of power stochastization is studied theoretically. The paper by A.V. Kashevarov, A.N. Kucherov, and G.V. Molleson considers optical characteristics of the condensation contrail of air-engines in the atmosphere depending on the distribution law of parameters of nonisobaric exhaust jet at exhaust nozzle exit. The peculiarities of propagation of high-power radiation of CO and oxygen-iodine lasers along the paths lying above the height of 10 km in the upper hemisphere under the effect of stimulated Raman scattering are discussed in the paper by A.B. Ignat'ev and V.V. Morozov. O.G. Buzykin, S.V. Ivanov, A.A. Ionin, and others study in their paper experimentally and theoretically the linear and nonlinear atmospheric absorption of the overtone CO laser radiation. The paper provides practically important data on frequencies of most and least strongly absorbed radiation of the laser in the atmosphere. The spectra of nonlinear atmospheric absorption of the multifrequency overtone CO laser radiation are modeled to demonstrate its capabilities for new promising schemes of diagnostics.

The study of the laser radiation propagation in the atmosphere is closely related to optical control and adaptive optics. V.A. Banakh and A.V. Falits in their paper consider the problem of influence of optical wave strong

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fluctuations in the turbulent medium on the efficiency of reconstruction of its phase. N.G. Ivanov, V.F. Losev, and Yu.I. Panchenko study experimentally the capability of using SRS to form diffraction divergence and to increase the radiation contrast in the laser system based on electric-discharge XeCl amplifiers. V.P. Lukin examines the schemes of formation of a laser reference star for adaptive optical systems providing for wavefront tilt correction. The paper by T.A. Sheremet'eva and A.A. Fillipov presents theoretical results on reconstruction of the spectra of refractive index fluctuations in a turbulent medium from optical measurements.

The issue also includes some articles considering application of high-power lasers to diagnostics of the atmosphere. The paper by N.I. Popov and V.V. Samartsev discusses capabilities of the technique of photon echo in laser sensing of the atmosphere. The paper by S.E. Kunts, S.V. Mel'chenko, A.N. Panchenko, and V.F. Tarasenko is devoted to prospects of using high-power exciplex lasers for sensing the gaseous atmosphere. The paper by L.K. Chistyakova analyzes capabilities of remote diagnostics of radioactive pollutants in the atmosphere with application of passive (UHF) and active optical methods, including methods using sources of high-power laser radiation.

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