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BIOMEDICAL OPTICS AND SPECTROSCOPY

Biomedical Optics and Spectroscopy

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This issue of *Optika i Spektroskopiya* (Optics and Spectroscopy) contains papers that reflect the current state of optical technologies that are applied and are promising for application in biomedical research. The current rapid development of optical biomedical diagnostics and therapy is due to many factors. First, new results of basic research of interaction of optical radiation with biological tissues and cells, including polarized radiation, fluorescence in multiple scattering media, and speckle-interference phenomena, have been obtained. Second, considerable progress has been achieved in the development of systems for the delivery, detection, and visualization of optical radiation. Third, new computer and nanotechnologies have been created. All of this yields an opportunity to obtain new, previously unavailable information on living objects by spectroscopy methods and to ensure the more efficient photoaction on individual biological structures.

Optics of nanoparticles and its applications in biomedicine comprise a new field of nanobiotechnology. A challenging field of application of luminescent semiconductor nanoparticles that possess a broad absorption spectrum and a clearly pronounced narrow luminescence peak in the visible spectral range is medical diagnostics. Because the wavelength of fluorescence of nanocrystals of the same composition depends on their size, by varying the size and composition of semiconductor nanocrystals, one can vary the wavelength of their fluorescence from the blue to the IR spectral range. Remarkably, the luminescence of all colors of nanocrystals can be excited with only one radiation source. These unique properties make nanocrystals ideal fluorophores for ultrasensitive polychromatic detection of biological objects, as well as for medical diagnostics, which requires measuring many parameters simultaneously. In particular, one of the papers of this issue describes the synthesis of nanoparticles of cadmium sulfide.

The possibility of generating narrowband highly coherent radiation, as well as broadband radiation with a small coherence length, underlies methods of correlation and Doppler spectroscopy, laser interferometry, optical coherence tomography, and numerous methods of laser diagnostics and therapy of many diseases. These methods are efficiently used to study the dynamic and structural peculiarities of normal and pathological changes in biological objects. The detection and correlation processing of speckle structures also make it possible to obtain diagnostic information on spatial and temporal organization of biological objects. An example of the most important medical problems, which can be prospectively solved by coherence optical methods, is the measurement of the diffusion rate of water and pharmaceuticals in tissues of the human organism. Studies in recent years have shown that optical coherence tomography is a promising method for solving these problems. One work in this issue is devoted to measuring the diffusion rate of water in human dentin and another work analyzes spatial and temporal scales of coherence of biospeckles forming in biotissues.

Optical methods that combine the spectral and polarization analyses of the interaction of light with biological tissues are of considerable interest as tools for diagnostics in vivo. These techniques are constantly developing and are finding increasing application in biology and medicine. Two papers in this issue are devoted to the development of basic principles of polarization methods of investigation. Fluorescence microscopy is one of the most promising methods for studying the structure and state of proteins of biological tissues. Two papers in this issue are devoted to studying the possibility of applying luminescence-probing method to investigating structural changes of bovine serum albumin upon nonenzymatic thermal glycation and to the study of interactions of polar and nonpolar luminescent probes with human blood-serum albumins.

Important information on the structure and functions of various tissues of the human organism can be obtained by spectroscopic methods of resonance Raman scattering. The content of carotenoids in human skin is noninvasively studied by this method in one of the papers of the issue. The knowledge of optical characteristics of biotissues is a key moment in constructing mathematical models that can adequately describe the propagation of light in biotissues,

which is principally important for the development of new optical methods used in various fields of biology and medicine, including photodynamic and photothermal destruction of cells and tissues, as well as for the development of new approaches in optical tomography, optical biopsy, etc. Integrating sphere spectrophotometry is one of the most frequently used methods of determining the optical parameters of biotissues in the visible and near-IR ranges. One of the works in this issue is devoted to measuring the optical parameters of human sclera in a wide wavelength range.

Photothermally induced variation of the optical parameters of biotissues under the action of laser radiation is a powerful tool of modern laser medicine, which makes it possible to quite efficiently fight against many diseases. One of the papers in this issue investigates the absorption spectra of intact human tooth enamel and dentin in the range 0.26–10 μm. The effect of water irrigation on the mechanism of laser ablation, as well as on the IR absorption spectra, is discussed and transformations observed in the wavelength range 2.5–3.5 μm of the absorption spectrum of enamel upon its heating to +700°C are reported. Another paper deals with experimental in vitro investigation of adipose tissue upon its sensitization with dyes such as Indocyanine Green and Brilliant Green.

Interest in the use of optical methods for diagnostics and therapy of various diseases constantly increases because they are relatively simple, rather inexpensive, and patient friendly. However, the transport of probing radiation through surface layers of biotissue still remains a significant problem in modern laser medicine. In particular, upon the diagnostics of subcutaneous and intracutaneous diseases of optical methods, the considerable scattering of radiation in the visible and near-IR spectral ranges by skin tissues restricts the spatial resolution and probing depth. Reducing light scattering by immersion clearing of biotissues is a possible way of solving this problem. One of the works in this issue considers how the action of an aqueous solution of glycerol on skin affects the optical parameters of this tissue.

The reliable layer-by-layer dosimetry of probing radiation requires the development of new, efficient methods of computer analysis of experimental data. In addition, by no means can all the parameters that determine the properties of biological objects and character of propagation of probing laser radiation in them be directly measured. In this relation, methods of numerical simulation of propagation of laser radiation in biological tissues assume ever greater importance. One of the papers in this issue is devoted to applying numerical methods to the solution of the radiation transfer equation in scattering media. A three-dimensional mathematical model of interaction of optical radiation with plant tissue is constructed. The model takes into account the structural inhomogeneity of the tissue, its spectral properties, and fluorescence effects.

The problem of the efficient elimination of the poisonous effect of carbon monoxide is very important and socially significant. Up to date, the possibilities of modern medicine still remain very restricted, and, therefore, losses due to consequences of gas poisoning are considerable. In connection with this, one of the papers of the issue proposes and studies an optical method of elimination of the poisonous effect of carbon monoxide, which is based on laser-induced photodestruction of carboxyhemoglobin in blood vessels and capillaries.

Optical methods based on measurement and analysis of scattering properties of dispersive media find wide application in studies of blood and its components. Erythrocytes, as well as their shape and rheological properties, such as deformability, aggregability, and tolerance to varying external factors, play an important role in intratissular exchange processes of oxygen, carbon dioxide, and metabolic products. The violation of the osmotic equilibrium initiates the transmembrane material transport in the system cell–surrounding medium. This transport affects the functional properties of cells and rheological properties of blood, which are determined not only by changing the chemical composition of the intracellular material, but also by changing the shape and size of erythrocytes. One of the works in this issue is aimed at clarifying how changes in the shape and size of erythrocytes under hypotonic conditions affect the spectral characteristics of radiation scattered by samples of diluted blood. Using the results of these investigations, the authors analyzed the possibility of developing the optical method of determining the osmotic resistance of erythrocytes based on measuring the scattered radiation and eliminating the force action on cells.

The agglutination of cells in vitro is used in many medical diagnostic methods and medicobiological research tests. In particular, the widely used method of research, the determination of the human blood type, is based precisely on this approach. However, unfortunately, this method suffers from certain drawbacks and complications. Therefore, two papers of the special issue are devoted to the experimental and theoretical investigation of the possibility of increasing the resolving power of this method.

The works presented in this special issue were reported on the 13th Annual International Interdisciplinary School for Young Scientists and Students on Optics, Laser Physics and Biophotonics, which was held in Saratov, Russia, September 21–24, 2009. Nearly 500 undergraduates, postgraduates, young researchers, as well as lecturers from 35 countries

attended the school. Some works reported on the school were published in the collection of papers *Problems of Optical Physics and Biophotonics*, Ed. by V.V. Tuchin and G.V. Simonenko (Novyi Veter, Saratov, 2009), as well as in Proceedings of SPIE **7547** (Ed. by E.A. Genina and V.V. Tuchin), Journal of Innovative Optical Health Sciences **3**, 2010 (Ed. by E.A.Genina, K.V. Larin, and V.V. Tuchin), and Journal of Biophotonics. **3**, 2010 (Ed. by E.A. Genina and V.V. Tuchin).

We are deeply grateful to all of the authors and hope that all papers in this issue will be interesting for the readers of the journal.

The 14th Annual International Interdisciplinary School for Young Scientists and Students on Optics, Laser Physics and Biophotonics will be held in Saratov, October 5–8, 2010. On behalf of the organizing committee of the conference, we invite all comers to participate in the school.

Translated by V. Rogovoi