Front Matter: Volume 6535
Saratov Fall Meeting 2006

Optical Technologies in Biophysics and Medicine VIII

Valery V. Tuchin
Editor

26–29 September 2006
Saratov, Russia

Organized by
Saratov State University (Russia) • Research-Educational Institute of Optics & Biophotonics at SSU (Russia) Institute of Precision Mechanics & Control, Russian Academy of Sciences (Russia) • Research-Educational Center on Nonlinear Dynamics and Biophysics of CRDF and Ministry of Education and Science RF (REC-006) (Russia) • Volga Region Center of New Information Technologies (Russia) • Saratov Railway Clinic Hospital (Russia)

In Cooperation with
Russian Academy of Natural Sciences, Saratov Regional Division • Russian Society for Photobiology Saratov Science Center of the Russian Academy of Sciences

Sponsored by
Russian Foundation for Basic Research • U.S. Civilian Research & Development Foundation for the Independent States of the Former Soviet Union (CRDF) (Russia) • SPIE Russia Chapter • Saratov State University SPIE Student Chapter (Russia) • Russian Academy of Science • British Council, Program British Degrees in Russia (Russia) • Almus Ltd. (Russia)

Published by
SPIE—The International Society for Optical Engineering

Proceedings of SPIE—The International Society for Optical Engineering, 9780819466563, v. 6535

SPIE is an international technical society dedicated to advancing engineering and scientific applications of optical, photonic, imaging, electronic, and optoelectronic technologies.
Contents

xi  Conference Committees

xv  Introduction

xix  Plenary Presentation: High-resolution Photoacoustic Tomography [6535-02]
L. V. Wang, G. K. Beare, Washington Univ. in St. Louis (USA)

PLENARY LECTURE

653502  Non-invasive in-vivo Raman spectroscopic measurement of the dynamics of the antioxidant substance lycopene in the human skin after a dietary supplementation [6535-01]
M. E. Darvin, Charité Universitätsmedizin Berlin (Germany); I. Gersonde, H. Albrecht, Laser and Medical Technology GmbH (Germany); W. Sterry, J. Lademann, Charité Universitätsmedizin Berlin (Germany)

SELECTED INVITED LECTURES

653503  Diffuse reflection imaging of sub-epidermal tissue haematocrit using a simple RGB camera [6535-03]
M. J. Leahy, J. O’Doherty, P. McNamara, Univ. of Limerick (Ireland); J. Henrikson, Linköping Univ. Hospital (Sweden); G. E. Nilsson, Linköping Univ. (Sweden) and WheelsBridge AB (Sweden); C. Anderson, F. Sjöberg, Linköping Univ. Hospital (Sweden)

653504  On the way to subcellular imaging of mechanotransduction in the developing vasculature [6535-04]
I. V. Larina, Baylor College of Medicine (USA); Y. Wang, Univ. of California, San Diego (USA) and Univ. of Illinois at Urbana-Champaign (USA); S. Chien, Univ. of California, San Diego (USA); M. E. Lane, Rice Univ. (USA); M. E. Dickinson, Baylor College of Medicine (USA)

653505  Femtosecond pulse propagation in biotissue-like scattering medium: theoretical analysis versus Monte Carlo simulations [6535-05]
E. A. Sergeeva, Institute of Applied Physics (Russia); M. Yu. Kirillin, Univ. of Oulu (Finland) and M.V. Lomonosov Moscow State Univ. (Russia); A. V. Priezzhev, M.V. Lomonosov Moscow State Univ. (Russia)

Pagination: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon they are published online, and connects the same identifier to all online, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

• The first four digits correspond to the SPIE volume number.
• The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B ... 0Z, followed by 10-1Z, 20-2Z, etc. The CID number appears on each page of the manuscript. The complete citation is used on the first page, and an abbreviated version on subsequent pages.
The influence of human eye aberrations on the resolution and field of view of fundus-cameras [6535-06]
A. Dubinin, T. Cherezova, A. Belyakov, Moscow Lomonosov State Univ. (Russia); A. Kudryashov, Moscow State Open Univ. (Russia)

Non-invasive diagnostics of several structural and biophysical parameters of skin cover by spectral light reflectance [6535-07]
A. P. Ivanov, V. V. Barun, B.I. Stepanov Institute of Physics (Belarus)

Frequency-domain photon density wave setup with multicolor illumination at 684, 794, and 1060 nm [6535-08]
V. I. Plehanov, I. V. Turchin, E. A. Sergeeva, V. A. Kamensky, Institute of Applied Physics (Russia)

Fluorescence diffuse tomography for tumor detection and monitoring [6535-09]
I. V. Balalaeva, Institute of Applied Physics (Russia) and Nizhny Novgorod State Univ. (Russia); A. G. Orlova, Institute of Applied Physics (Russia); M. V. Shirmanova, E. A. Kibraeva, Nizhny Novgorod State Univ. (Russia); E. V. Zagainova, Institute of Fundamental and Applied Medicine (Russia); I. V. Turchin, Institute of Applied Physics (Russia)

Light diffuse reflectance for detection and differentiation of teeth caries lesions [6535-10]
E. Borisova, Institute of Electronics (Bulgaria); Tz. Uzunov, Medical Univ. Sofia (Bulgaria); S. Valkanov, Institute of Metal Science (Bulgaria); L. Avramov, Institute of Electronics (Bulgaria)

Monitoring changes in the scattering properties of mouse skin with optical coherence tomography during an in vivo glucose tolerance test [6535-11]
M. Kinnunen, S. Tausta, R. Mylylä, S. Vainio, Univ. of Oulu (Finland)

Optical coherence tomography among medical imaging modalities: potential and limitations [6535-12]
N. Gladkova, E. Zagaynova, Nizhny Novgorod State Medical Academy (Russia) and Institute of Applied Physics (Russia); N. Shakhova, A. M. Sergeev, V. Gelikonov, Institute of Applied Physics (Russia); F. Feldchtein, Institute of Applied Physics (Russia) and Imalux Corp. (USA); G. Gelikonov, Institute of Applied Physics (Russia) and BioMedTech (Russia); E. Balandina, Nizhny Novgorod State Medical Academy (Russia)

Effect of the width of the scattering indicatrix on the dispersion of the photon density waves in a strongly scattering medium [6535-13]
V. V. Lyubimov, A. V. Chemezov, Vavilov State Optical Institute (Russia)

Image transfer through the complex scattering turbid media [6535-14]
I. V. Meglinski, E. Berrocal, Cranfield Univ. (United Kingdom); M. A. Linne, Lund Institute of Technology (Sweden); D. A. Greenhalgh, Cranfield Univ. (United Kingdom)

Concurrent NIRS-fMRI activation studies by using a new method for BOLD signal analysis [6535-15]
A. Sassaroli, Tufts Univ. (USA); B. deB. Frederick, McLean Hospital (USA); Y. Tong, Tufts Univ. (USA); P. F. Renshaw, McLean Hospital (USA); S. Fantini, Tufts Univ. (USA)
65350G Effects of apertures on scattered light: a Monte Carlo study of confocal imaging [6535-18]  
C. Tjokro, Singapore-Massachusetts Institute of Technology Alliance (Singapore);  
C. J. R. Sheppard, National Univ. of Singapore (Singapore)

65350H Polarization sensitive optical coherence tomography for application conditions with external perturbations [6535-19]  
V. Tougbaev, T.-J. Eom, C.-S. Kee, D.-K. Ko, J. Lee, Gwangju Institute of Science and Technology (South Korea)

65350I Measuring of optical properties of biological samples by low cost goniometrical equipment [6535-20]  
M. Hoffmann, O. Schewtschenko, Forschungszentrum für Medizintechnik und Biotechnologie e.V. (Germany); O. Minet, Charité Berlin (Germany)

65350J Quantitative tissue polarimetry using polar decomposition of 3 × 3 Mueller matrix [6535-21]  

65350K In vivo flow cytometry and time-resolved near-IR angiography and lymphography [6535-84]  
E. I. Galanzha, Saratov State Univ. (Russia) and Univ. of Arkansas for Medical Sciences;  
V. V. Tuchin, Saratov State Univ. (Russia); R. W. Brock, V. P. Zharov, Univ. of Arkansas for Medical Sciences (USA)

65350L Perturbation model for photon migration imaging in the low scattering regime [6535-22]  
V. Toronov, Ryerson Univ. (Canada)

65350M Changes in capillary filling do not influence inspiratory-induced vasoconstrictive episodes [6535-23]  
R. Rauh, E. Ochsmann, M. Kessler, Univ. of Erlangen-Nuremberg (Germany);  
M. Mueck-Weymann, Univ. of Erlangen-Nuremberg (Germany) and Univ. for Health Sciences, Medical Informatics and Technology (Austria)

65350N Uptake of photosensitizers by bacteria is influenced by the presence of cations [6535-24]  
A. Kishen, S. George, National Univ. of Singapore (Singapore)

65350O Internal temperature distribution in blood vessel under the action pulse laser radiation [6535-25]  
L. G. Astafyeva, G. I. Zheltov, B.I. Stepanov Institute of Physics (Belarus)

65350P Monitor glucose induced changes in optical properties of rat skin in vitro [6535-26]  
D. Zhu, W. Lu, Q. Li, H. Gong, Q. Luo, Huazhong Univ. of Science and Technology (China)

65350Q Changes in visible light transmission across the corneal stroma [6535-27]  
J. Doutch, A. J. Quantock, K. M. Meek, Cardiff Univ. (United Kingdom)

65350R Elasticity mapping of tissue mimicking phantoms by remote palpation with a focused ultrasound beam and intensity autocorrelation measurements [6535-28]  
C. Usha Devi, R. S. Bharat Chandran, R. M. Vasu, A. K. Sood, Indian Institute of Science, Bangalore (India)
<table>
<thead>
<tr>
<th>Page</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>65350S</td>
<td>Optical fluorescence biosensor for plant water stress detection</td>
<td>J. P. C. Chong, O. W. Liew, Singapore Polytechnic (Singapore); B. Q. Li, A. K. Asundi, Nanyang Technological Univ. (Singapore)</td>
</tr>
<tr>
<td>65350T</td>
<td>Toward a methodology for studying the application of open source innovation practices in non-software domains</td>
<td>S. Tanev, Carleton Univ. (Canada)</td>
</tr>
<tr>
<td>65350U</td>
<td>Hemispherical imaging of skin with polarized light</td>
<td>J. C. Ramella-Roman, The Catholic Univ. of America (USA) and National Institute of Standards and Technology (USA); B. Boulbry, T. A. Germer, National Institute of Standards and Technology (USA)</td>
</tr>
<tr>
<td>65350V</td>
<td>Propagation of infrared wavelengths through the corneal stroma with reference to hydration changes</td>
<td>J. Doutch, C. Tucker, A. J. Quantock, P. A., R. Ade, K. M. Meek, Cardiv Univ., (United Kingdom)</td>
</tr>
<tr>
<td>65350W</td>
<td>Optical trapping near a charged surface: three-dimensional optical binding of colloids</td>
<td>S. Ahlawat, R. Dasgupta, P. K. Gupta, Raja Ramanna Ctr. for Advanced Technology (India)</td>
</tr>
<tr>
<td>65350X</td>
<td>Ultrasound assisted optical elastography for measurement of tissue stiffness: contribution to the measurement from scattering coefficient variation</td>
<td>R. S. Bharat Chandran, C. Usha Devi, R. M. Vasu, A. K. Sood, Indian Institute of Science, Bangalore (India)</td>
</tr>
<tr>
<td>65350Y</td>
<td>Efficient noise tolerant reconstructions in diffuse optical tomography through computation of Jacobian in wavelet domain</td>
<td>B. Kanmani, B.M.S. College of Engineering (India); R. M. Vasu, Indian Institute of Science, Bangalore (India)</td>
</tr>
<tr>
<td>65350Z</td>
<td>A high-resolution optical imaging system for obtaining the serial transverse section images of biologic tissue</td>
<td>L. Wu, B. Zhang, P. Wu, Q. Liu, H. Gong, Huazhong Univ. of Science and Technology (China)</td>
</tr>
<tr>
<td>653510</td>
<td>Stratum corneum: a barrier of skin resistsants light</td>
<td>D. Zhu, Y. Hu, Z. Mao, Y. Zheng, W. Lu, Q. Luo, Huazhong Univ. of Science and Technology (China)</td>
</tr>
<tr>
<td>653511</td>
<td>Concentration dependence of the optical clearing effect created in muscle immersed in glycerol and ethylene glycol</td>
<td>L. Oliveira, Ctr. de Ciências e Tecnologias Ópticas (Portugal); A. Lage, Porto Univ. (Portugal); M. Pais Clemente, Ctr. de Ciências e Tecnologias Ópticas (Portugal); V. Tuchin, Saratov State Univ. (Russia)</td>
</tr>
<tr>
<td>653512</td>
<td>Oxygenation of biological tissue in vivo by laser irradiation</td>
<td>A. N. Korolevich, M. M. Asimov, B.I. Stepanov Institute of Physics (Belarus); E. E. Konstantinova, Republican Ctr. of Research and Service on Cardiology (Belarus)</td>
</tr>
</tbody>
</table>
Optical properties of human stomach mucosa in the spectral range from 400 to 2000 nm

Monte Carlo study of skin optical clearing to enhance light penetration in the tissue

Optical clearing of human eye sclera under the action of glucose solution

Laser microinterferometer for estimation of red blood cell volume

Signal propagation in nerve fiber

Competitive intelligence information management and innovation in small technology-based companies

Endoscopic laser Doppler flowmetry in the experiment and in the bleeding gastric and duodenal ulcer clinic

Photonic crystal fiber with hollow-core for biosensing application

Application of LASCA for study of blood microcirculation in brain: testing of new prophylactic preparations

Investigation of glucose-hemoglobin interaction by optical coherence tomography
65351D Investigation of formalin influence over hard and soft biological tissues fluorescent spectra in vitro [6535-49]
E. Borisova, Institute of Electronics (Bulgaria); Tz. Uzunov, Medical Univ. Sofia (Bulgaria); B. Vladimirov, Univ. Hospital Queen Jovanna (Bulgaria); L. Avramov, Institute of Electronics (Bulgaria)

65351E Influence of multiple light-scattering on TiO2 nanoparticles imbedded into stratum corneum on light transmittance in UV and visible wavelength regions [6535-50]
A. P. Popov, Univ. of Oulu (Finland) and M.V. Lomonosov Moscow State Univ. (Russia); A. V. Priezzhev, M.V. Lomonosov Moscow State Univ. (Russia); J. Lademann, Humboldt Univ. (Germany); R. Myllylä, Univ. of Oulu (Finland)

65351F Optical model of thermo-sensitive heterophase medium (adipose tissue) [6535-52]
A. V. Belikov, O. A. Smolyanskaya, Saint-Petersburg State Univ. of Information Technologies, Mechanics and Optics (Russia)

65351G Investigation of skin water loss and glycerol delivery through stratum corneum [6535-53]
E. A. Genina, A. A. Korobko, A. N. Bashkatov, V. V. Tuchin, Saratov State Univ. (Russia); I. V. Yaroslavsky, G. B. Altshuler, Palomar Medical Products (USA)

65351H In vitro study of indocyanine green solution interaction with skin [6535-54]
E. A. Genina, M. Yu. Kuzmina, S. S. Pankov, A. N. Bashkatov, V. V. Tuchin, Saratov State Univ. (Russia)

65351I Estimations of complex refractive index of hemoglobin at its incubation with glucose [6535-55]
E. N. Lazareva, V. V. Tuchin, Saratov State Univ. (Russia)

65351J Modification of terahertz pulsed spectrometer to study biological samples [6535-56]
M. M. Nazarov, A. P. Shkurinov, M.V. Lomonosov Moscow State Univ. (Russia); V. V. Tuchin, O. S. Zhernovaya, Saratov State Univ. (Russia)

65351K Dependence of optic disc parameters on disc area according to Heidelberg Retina Tomograph: Part II. [6535-57]
V. Machekhin, G. Manaenkova, O. Bondarenko, S.N. Fyodorov Eye Microsurgery Complex (Russia)

65351L 3D simulation of tissue pathological changes localization [6535-58]
A. R. Sindyaeva, V. P. Zakharov, Samara State Aerospace Univ. (Russia)

65351M Definition of contribution of the endogen fluorophors in the fluorescence spectrum of the attacked cervical tissue [6535-59]
E. P. Konkova, R. Sh. Zatrudina, Volgograd State Univ. (Russia)

65351N Spectral kinetics of plant tissue [6535-60]
I. A. Bratchenko, Samara State Aerospace Univ. (Russia); E. V. Vorobjova, P.N. Lebedev Physical Institute (Russia); V. P. Zakharov, Samara State Aerospace Univ. (Russia); S. P. Kotova, P.N. Lebedev Physical Institute (Russia); P. E. Timchenko, Samara State Aerospace Univ. (Russia)
<table>
<thead>
<tr>
<th>Paper ID</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>65351O</td>
<td>Ultra-violet laser microbeam and optical trapping for cell micromanipulation [6535-76]</td>
<td>D. Kotsifaki, M. Makropoulou, A. A. Serafetinides, National Technical Univ. of Athens (Greece)</td>
</tr>
<tr>
<td>65351P</td>
<td>Superresolution in optical diffuse tomography [6535-77]</td>
<td>A. G. Kalintsev, N. A. Kalintseva, Vavilov State Optical Institute (Russia); O. V. Kravtsenyuk, Foundation for Research and Technology-Hellas (Greece); V. V. Lyubimov, Vavilov State Optical Institute (Russia)</td>
</tr>
<tr>
<td>65351Q</td>
<td>Photooxygenation of singlet oxygen traps upon excitation of molecular oxygen by dark red laser radiation in air-saturated solutions [6535-62]</td>
<td>A. A. Krasnovsky, A.N. Bach Institute of Biochemistry (Russia) and M.V. Lomonosov State Univ. (Russia); I. V. Kryukov, A. V. Sharkov, P.N. Lebedev Physical Institute (Russia)</td>
</tr>
<tr>
<td>65351R</td>
<td>The role of Ca²⁺-related signaling in photodynamic injury of nerve and glial cells [6535-63]</td>
<td>A. V. Lobanov, Y. O. Petin, A. B. Uzdensky, Rostov State Univ. (Russia)</td>
</tr>
<tr>
<td>65351S</td>
<td>The involvement of MAP kinases JNK and p38 in photodynamic injury of crayfish neurons and glial cells [6535-64]</td>
<td>Y. O. Petin, M. Y. Bibov, A. B. Uzdensky, Rostov State Univ. (Russia)</td>
</tr>
<tr>
<td>65351T</td>
<td>The study of liquid water structure and transfer properties by molecular dynamics [6535-65]</td>
<td>V. Vl. Mitrofanov, Moscow State Univ. (Russia)</td>
</tr>
<tr>
<td>65351V</td>
<td>Blood flow structure in patients with coronary heart disease [6535-67]</td>
<td>L. I. Malinova, Saratov Scientific Research Institute of Cardiology (Russia) and Saratov State Medical Univ. (Russia); G. V. Simonenko, Saratov State Univ. (Russia); T. P. Denisova, Saratov State Medical Univ. (Russia); V. V. Tuchin, Saratov State Univ. (Russia)</td>
</tr>
<tr>
<td>65351W</td>
<td>Gross protein influence upon blood plasma and serum self organization processes in patients with coronary heart disease [6535-68]</td>
<td>L. I. Malinova, Saratov Scientific Research Institute of Cardiology (Russia) and Saratov State Medical Univ. (Russia); U. V. Sergeeva, Saratov State Medical Univ. (Russia); G. V. Simonenko, Saratov State Univ. (Russia); T. P. Denisova, Saratov State Medical Univ. (Russia); V. V. Tuchin, Saratov State Univ. (Russia)</td>
</tr>
<tr>
<td>65351X</td>
<td>The effect of LED-light action on microbial colony forming ability of several species of staphylococcus [6535-69]</td>
<td>E. S. Tuchina, N. F. Permyakova, V. V. Tuchin, Saratov State Univ. (Russia)</td>
</tr>
<tr>
<td>65351Y</td>
<td>Diffusion of Cortexin and Retinalamin in eye sclera [6535-79]</td>
<td>E. A. Genina, E. A. Zubkova, A. A. Korobko, I. Yu. Yanina, A. N. Bashkatov, Saratov State Univ. (Russia); T. G. Kamenskikh, V. A. Galanzha, Saratov State Medical Univ. (Russia); V. V. Tuchin, Saratov State Univ. (Russia)</td>
</tr>
</tbody>
</table>
Mathematical modeling of clearing liquid drop diffusion after intradermal injection
M. M. Stolnitz, A. N. Bashkatov, E. A. Genina, V. V. Tuchin, Saratov State Univ. (Russia)

Mathematical modeling of clearing liquid penetration into the skin [6535-82]
M. M. Stolnitz, A. N. Bashkatov, E. A. Genina, V. V. Tuchin, Saratov State Univ. (Russia)

Monte Carlo modeling of eye iris color [6535-83]
E. V. Koblova, Saratov State Medical Univ. (Russia); A. N. Bashkatov, L. E. Dolotov, Y. P. Sinichkin, Saratov State Univ. (Russia); T. G. Kamenskikh, Saratov State Medical Univ. (Russia); E. A. Genina, V. V. Tuchin, Saratov State Univ. (Russia)

Algorithm of the automated choice of points of the acupuncture for EHF-therapy [6535-71]
E. P. Lyapina, I. A. Chesnokov, Ya. E. Anisimov, N. A. Bushuev, E. P. Murashov, Federal State Unitary Enterprise SPE Almaz (Russia); Yu. Yu. Eliseev, Saratov State Medical Univ. (Russia); H. Syuzanna, Univ. of Applied Science (Russia)

Analysis of thermal damage in vocal cords for the prevention of collateral laser treatment effects [6535-75]
F. Fanjul Vélez, J. L. Arce-Diego, Á. del Barrio Fernández, Univ. de Cantabria (Spain); A. Borragán Torre, Ctr. de Foniatría y Logopedia (Spain)

Mid-infrared laser ablation of intraocular acrylic lenses [6535-78]
E. Spyratou, M. Makropoulou, C. Bacharis, A. A. Serafetinides, National Technical Univ. of Athens (Greece)

MANAGEMENT IN BIOPHOTONICS RESEARCH AND EDUCATION

Self-management for physics department graduates [6535-72]
B. A. Medvedev, Saratov State Univ. (Russia); K. R. Babayan, Saratov Juridical Institute (Russia)

Symbiosis of a telemedicine and neural net's project as a new way of the decision of medical problems [6535-73]
O. V. Kasimov, E. V. Karchenova, Saratov Railroad Clinical Hospital (Russia); I. L. Maximova, Saratov State Univ. (Russia)

Author Index
Conference Committees

Annual International Multidisciplinary School for Young Scientists and Students on Optics, Laser Physics & Biophysics X

Chair
Valery V. Tuchin, Saratov State University (Russia)

Secretary
Elina A. Genina, Saratov State University (Russia)

General Program Committee
Lev M. Babkov, Saratov State University (Russia)
Valentin I. Berezin, Saratov State University (Russia)
Michael V. Davidovich, Saratov State University (Russia)
Vladimir L. Derbov, Saratov State University (Russia)
Nikolai G. Khlebtsov, Institute of Biochemistry and Physiology of Plants and Microorganisms RAS (Russia)
Vyacheslav I. Kochubey, Saratov State University (Russia)
Leonid A. Melnikov, Saratov State University (Russia)
Alexander B. Pravdin, Saratov State University (Russia)
Alexander M. Sergeev, Institute of Applied Physics RAS (Russia)
Sergey N. Shtykov, Saratov State University (Russia)
Svetlana V. Eremina, Saratov State University (Russia)
Valery V. Tuchin, Saratov State University (Russia)
Dmitry A. Zimnyakov, Saratov State University (Russia)

General Organizing Committee

Chair
Dmitry A. Zimnyakov

Members
Garif G. Akchurin, Saratov State University (Russia)
Edmund I. Akopov, SPIE Russia Chapter
Alexey N. Bashkatov, Saratov State University (Russia)
Kirill V. Berezin, Saratov State University (Russia)
Elina A. Genina, Saratov State University (Russia)
Andrey I. Konyukhov, Saratov State University (Russia)
Nina A. Lakodina, Saratov State University (Russia)
Vladislav V. Lychagov, Saratov State University (Russia)
Igor V. Meglinsky, Cranfield University (United Kingdom) and Saratov State University (Russia)
Olga A. Perepelitsina, Saratov State University (Russia)
Georgy V. Simonenko, Saratov State University (Russia)
Maxim A. Vilenko, Saratov State University (Russia)
Maria V. storozheno, Saratov State University (Russia)
Internet Group

Chairs

Dmitry A. Agafonov, Saratov State University (Russia)
Ivan V. Fedosov, Saratov State University (Russia)

Members

Georgy V. Simonenko, Saratov State University (Russia)
Mikhail M. Stolnitz, Saratov State University (Russia)
Igor V. Krutikhin, Saratov State University (Russia)

Workshop on Optical Technologies in Biophysics & Medicine VIII

Workshop Chair

Valery V. Tuchin, Saratov State University (Russia)

Secretary

Elina A. Genina, Saratov State University (Russia)

International Program Committee

Victor N. Bagratashvili, Institute of Laser and Information Technologies RAN (Russia)
Gregory E. Brill, Saratov State Medical University (Russia)
Britton Chance, University of Pennsylvania (USA)
Wei Chen, University of Central Oklahoma (USA)
Paul M. W. French, Imperial College of Science, Technology and Medicine (United Kingdom)
James G. Fujimoto, MIT (USA)
Christoph K. Hitzenberger, University of Vienna (Austria)
Joseph A. Izatt, Case Western Reserve University (USA)
Steven L. Jacques, Oregon Health and Sciences University (USA)
Sean J. Kirkpatrick, Oregon Health and Sciences University (USA)
Juergen M. Lademann, Humboldt University (Germany)
Igor V. Meglinsky, Cranfield University (United Kingdom) and Saratov State University (Russia)
Qingming Luo, Huazhong University of Science and Technology (China)
Risto Myllylä, University of Oulu (Finland)
Theodore G. Papazoglou, FORTH—IESL (Greece)
Alexander V. Priezzhev, Moscow State University (Russia)
Valery V. Tuchin, Saratov State University (Russia)
Lihong Wang, Texas A&M University (USA)
Ruikang K. Wang, Oregon Health and Sciences University (USA)
Dmitry A. Zimnyakov, Saratov State University (Russia)
Session Chairs

Plenary Session I
Valery V. Tuchin, Saratov State University (Russia)

Plenary Session II
Sergey A. Piletsky, Cranfield University (United Kingdom)

Plenary Session III
Kirill Larin, University of Houston (USA)

Plenary Session IV
Vladimir L. Derbov, Saratov State University (Russia)

Lecture Session I
Juergen M. Lademann, Humboldt University (Germany)

Lecture Session II
Kirill Larin, University of Houston (USA)

Lecture Session III
Natalia D. Gladkova, Institute of Applied Physics of RAS (Russia) and Nizhny Novgorod State Medical Academy (Russia)

Lecture Session IV
Sergey S. Ulianov, Saratov State University (Russia)

Oral Session I: Tissue Optics and Spectroscopy
Alexander B. Pravdin, Saratov State University (Russia)

Oral Session II: Biophotonics and Imaging I
Alexander A. Stratonnikov, General Physics Institute, Moscow (Russia)

Oral Session III: Biophotonics and Imaging II
Sergey S. Ulianov, Saratov State University (Russia)

Oral Session IV: Workshop on Management of High Technologies Commercialization III
Valery V. Tuchin, Saratov State University (Russia)

Oral Session V: Seminar on Telemedicine - Opportunities, Applications, Prospects
Irina L. Maksimova, Saratov State University (Russia)
Alexander B. Pravdin, Saratov State University (Russia)

Poster Session
Alexander G. Akchurin, Saratov State University (Russia)
Dmitry Lyakin, Saratov State University (Russia)

Internet Plenary Session
Alexander V. Priezzhev, Moscow State University (Russia)
Valery V. Tuchin, Saratov State University (Russia)
Discussion via Internet

Alexander V. Priezzhev, Moscow State University (Russia)
Introduction

The Annual International Multidisciplinary School for Young Scientists and Students on Optics, Laser Physics and Biophysics X, Saratov Fall Meeting (SFM-06) was held in Saratov, Russia, 26–29 September 2006, with about 600 participants from Russia, FSU countries, USA, Canada, Europe, and Asia. It included the wide range of the modern problems of fundamental and applied optics, laser physics, photonics, and biomedical optics.

SFM-06 also contained ten international workshops and seminars:

- **Optical Technologies in Biophysics and Medicine VIII** (Valery V. Tuchin, Chair), SPIE Proc. 6535
- **Coherent Optics of Ordered and Random Media VII** (Dmitry A. Zimnykov, Chair), SPIE Proc. 6536
- **Laser Physics and Photonics VIII** (Leonid A. Melnikov and Vladimir L. Derbov, Chairs), SPIE Proc. 6537
- **Spectroscopy and Molecular Modeling VII** (Valentin I. Berezin, Lev M. Babkov, and Michael D. Elkin, Chairs), SPIE Proc. 6537
- **Electromagnetics of Microwaves, Submillimeter and Optical Waves IV** (Michael V. Davidovich, Chair), SPIE Proc. 6537
- **English as a Communicative Tool in the Scientific Community V** (Vladimir L. Derbov, Svetlana V. Eremina, and Alexander B. Pravdin, Chairs), SPIE Proc. 6537
- **Management of High Technologies Commercialization III** (Valery V. Tuchin, Chair), SPIE Proc. 6535
- **Luminescence II** (Vyacheslav I. Kochubey and Sergey N. Shtykov, Chairs), SPIE Proc. 6537
- **Nanostructures and Nanoparticles: Fabrication, Properties, and Applications II** (Nikolai G. Khlebtsov, Chair), SPIE Proc. 6536
- **Telemedicine: Opportunities, Applications, Prospects** (Irina L. Maksimova, Alexander B. Pravdin, Chairs), SPIE Proc. 6535

The main organizers of the Saratov Fall Meeting are Saratov State University (SSU), Research-Educational Institute of Optics & Biophotonics at SSU, and Research-Educational Center on Nonlinear Dynamics and Biophysics of CRDF and Ministry of Education and Science RF (REC-006).

The main goal of the school, workshops, and seminars is to inform young researchers and students in the field of recent developments and applications of laser and optical technologies in medicine and biology, coherent optics of random and ordered media, material and environmental sciences, nonlinear dynamics of laser systems, laser spectroscopy, and molecular modeling. The
primary focus was the discussion of fundamentals and general approaches of description of coherent, low-coherent, polarized, spatially and temporally modulated light interactions with inhomogeneous absorbing media, photonic crystals, tissue phantoms, and various types of tissues in vitro and in vivo. Such effects as static and dynamic light scattering, Doppler effect, optoacoustic and optothermal interactions, mechanical stress, photodynamic effect, etc., were also considered. On this basis the variety of laser and optical technologies for medical diagnostics, therapy, surgery, and light dosimetry, as well as for spectroscopy of random and ordered media, were presented.

SFM-06 was organized as morning plenary sessions, afternoon lecture and oral sessions, and evening poster presentations. The original oral reports and posters were presented by the junior scientists and students. Plenary lectures were listened to with great interest and were discussed by the audience.

Plenary and invited lectures and oral and poster presentations covered a wide area of topics including tissue optics, spectroscopy and imaging, controlling of optical properties of tissues, as well as biophysical and photo-chemical aspects of photo and laser therapy.

One main aspect of Saratov Fall Meetings is the one-day Internet session. In 2006 this session included the plenary lecture “High-resolution photoacoustic tomography” by Lihong V. Wang from the Washington University in St. Louis (USA).

Participants from USA, Russia, Austria, Australia, Bulgaria, Canada, Finland, Germany, Ireland, UK, Slovakia, Canada, China, Portugal, Italy, Japan, Ukraine, Belarus, Switzerland, Denmark, Spain, Singapore, the Netherlands, Poland, India, and other countries have placed their papers on the meeting website: http://optics.sgu.ru/SFM/, which was available during the meeting and will be available for a whole year up to the next meeting. Among the invited Internet lecturers were well-recognized experts in the fields of biomedical optics and light scattering: Steven L. Jacques (USA), S. Fantini (USA), Sean J. Kirkpatrick (USA), R. K. Wang (USA), Hong Liu (USA), Wei Chen (USA), Omar S. Khalil (USA), K. M. Meek (UK), J. Lademann (Germany), M. Hoffmann (Germany), O. Minet (Germany), Colin J. R. Sheppard (Singapore), A. K. Asundi (Singapore), A. Kishen (Singapore), Qingming Luo (China), P. K. Gupta (India), Christoph K. Hitzenberger (Austria), A. Kowalczyk (Poland), Vitali A. Tougbaev (South Korea), and O. V. Angelsky (Ukraine). A three-hour on-line Internet discussion was held on papers presented in the Internet session via a chat moderated by Alexander Priezzhev. Many of the presented Internet papers are published in this conference volume.

SFM-06 has gathered about 600 participants; a great number of presented materials are the result of collaboration between research groups from different countries supported by international scientific programs such as CRDF, INTAS, Royal Society and others.
The major portion of this volume includes papers presented in the workshop on Optical Technologies in Biophysics and Medicine VIII. However, a few of the most interesting papers (paper numbers 30, 44, 72, and 73) presented in the workshops on Management of High Technologies Commercialization III and Telemedicine: Opportunities, Applications, Prospects also are published in the volume.

This year SFM was held a few months after the XII Conference on Laser Optics in St. Petersburg (26–30 June 2006) with the Workshop on Lasers in Biomedical Diagnostics and Laser Tomography of Biomedical Objects (co-chairs, V. V. Lubimov, A. M. Sergeev, and V. V. Tuchin), with topics related to SFM-06. This opportunity allowed us to invite a few papers presented in the St. Petersburg Workshop to be published in this volume. These papers are numbers 75, 76, 77, and 78.

This year is also very important for organizers of the meeting, because 60 years ago the Chair of Optics of Saratov State University was organized by our teacher, Professor Mark L. Katz. We have dedicated SFM-06 to the memory of Professor Mark L. Katz on the 100th anniversary of his birth and the 60th anniversary of the Chair of Optics, founded by him in 1946. We are very proud that our Chair is recognized as a host of many international conferences and schools including SFM. We are very thankful to our numerous friends all over the world who sent us their congratulations and best wishes.

It is a great pleasure and privilege for the chair of SFM to thank all of the authors for their contributions to SFM-06, especially to the Internet lecturers for their exciting presentations, and to Alexander Priezzhev, a moderator of the Internet sessions for the last nine years, for his talent and impressive moderation.

The organizers of SFM are grateful to all of the sponsoring organizations and programs that supported this meeting very effectively: SPIE Russia Chapter, Executive Director Edmund Akopov; Russian Foundation for Basic Research; U.S. Civilian Research & Development Foundation for the Independent States of the Former Soviet Union (CRDF), grant REC-006 and mini-grant on the conference support; and Volga Region Center of New Information Technologies.

I would like to thank Elina Genina and Ivan Fedosov for their help with the preparation of this volume.

Valery V. Tuchin
High-resolution Photoacoustic Tomography

Lihong V. Wang, Gene K. Beare

Dept. of Biomedical Engineering Washington University in St. Louis

ABSTRACT

Novel photoacoustic tomography techniques, including, orthogonal-mode photoacoustic tomography, reflection-mode photoacoustic microscopy and deeply penetrating RF-based thermoacoustic tomography are presented.

Keywords: photoacoustic tomography, photoacoustic microscopy
Credits to Lab Members

CURRENT LAB MEMBERS
- A. Garcia-Uribe
- S. Hu
- X. Jin
- R. Kothapalli
- C. Kim
- G. Ku
- C. Li
- L. Li
- Y. Li
- K. Maslov
- E. Smith
- K. Song
- L. Song
- M. Todorovic
- X. Xu
- X. Yang
- R. Zemp
- H. Zhang
- S. Zhou

SELECTED FORMER LAB MEMBERS
- J. Ai, PhD
- D. Feng, MS
- J. Hollmann
- S. Jiao, PhD
- J. Li, PhD
- M. Li, PhD
- G. Marquez, PhD
- M. Mehrubeoglu, PhD
- J. Oh, PhD
- H. Sun, PhD
- Y. Pang, MS
- S. Sakadzic, PhD
- M. Sivaramakrishnan, MS
- X. Wang, PhD
- Y. Wang, MS
- X. Xie, MS
- M. Xu, PhD
- Y. Xu, PhD
- G. Yao, PhD
- W. Yu, MS
- X. Zhao, MS

Credits to Collaborators

- Texas A&M University (Animal study):
  - G. Stoica, DVM
- UT MD Anderson Cancer Center (Clinical study & molecular contrast agents):
  - M. Duvic, MD
  - B. Fornage, MD
  - K. Hunt, MD
  - C. Li, PhD
  - V. Prieto, MD
- Nanospectra (Nanoshells):
  - P. O’Neal, PhD
  - J. Schwartz, PhD
Motivation for Optical Imaging

- Safety — Non-ionizing radiation: photon energy is ~2 eV.
- Physics — Related to the molecular conformation of tissue.
- Optics — High intrinsic contrast:
  - Optical absorption: Angiogenesis, hyper-metabolism, apoptosis, necrosis, and exogenous contrast agents.
  - Optical scattering: Size of cell nuclei.
  - Optical polarization: Collagen, muscle fibers.
  - Spectroscopy: Wavelength multiplexing
- Physiology — Functional imaging of physiological parameters:
  - Oxygen saturation of hemoglobin
  - Total hemoglobin concentration (related to blood volume)
  - Enlargement of cell nuclei
  - Denaturation of collagen
  - Blood flow (Doppler)
- Physiology — Molecular imaging (exogenous contrast agents).
- ....
Challenges in Optical Imaging

- SNOM: Scanning near-field optical microscopy
- CFM: Confocal microscopy
- 2PM: Two-photon microscopy
- SHM: Second harmonic microscopy
- OCT: Optical coherence tomography
- DOT: Diffuse optical tomography
- UOT: Ultrasound-modulated optical tomography
- PAT: Photoacoustic tomography

Outline

- Motivation
- Orthogonal-mode photoacoustic tomography
- Reflection-mode photoacoustic microscopy
- Deeply penetrating RF-based thermoacoustic tomography
- Summary

Simulation software available from http://oilab.tamu.edu
Orthogonal-mode Photoacoustic Tomography

(1) Laser pulse (<ANSI limit: e.g., 20 mJ/cm²)
(2) Local heating (~ mK)
(3) Ultrasonic emission (~ mbar)
(4) Ultrasonic detection (scattering/100)


http://oilab.tamu.edu

Functional Photoacoustic Imaging of Rat Cortex in response to Whisker Stimulation In Vivo

PAT image (left stimulation)  PAT image (right stimulation)


http://oilab.tamu.edu
Deeply Penetrating Photoacoustic Tomography with NIR Excitation & ICG Contrast

5 mm

5.2 cm deep


Outline

- Motivation
- Orthogonal-mode photoacoustic tomography
- Reflection-mode photoacoustic microscopy
- Deeply penetrating RF-based thermoacoustic tomography
- Summary
Reflection-mode Confocal Photoacoustic Microscopy: Illustration

Reflection-mode Dark-field Confocal Photoacoustic Microscopy: System

**System Parameters**

- **Laser**
  - Tunability: 570-770 nm
  - Repetition rate: 10 Hz
  - Pulse width: 6.5 ns
  - Optical fiber: 0.6 mm diameter
  - Energy per pulse: 0.2 mJ
  - Energy density at focus: $\sim 6 \text{ mJ/cm}^2 < 20 \text{ mJ/cm}^2$ (ANSI safety limit)

- **High-frequency ultrasound transducer**
  - Center frequency: 50 MHz
  - Nominal bandwidth: 70% of 50 MHz
  - NA: 0.44

---

**Imaging Depth and Resolution**

- Imaging depth: $\sim 3$ mm
- Axial resolution: $\sim 15$ microns
- Depth/resolution: $\sim 200$ pixels
- Lateral resolution: $\sim 45$ microns
- Acquisition time: $2 \mu s/A$-scan
- No signal averaging

Volumetric Imaging of Microvasculature In Vivo

Maximum amplitude projection onto the skin

- 1 mm

Volume: 10 mm x 8 mm x 3 mm

http://oilab.tamu.edu -

Imaging of Skin Burn in Pigs

Acute thermal (175 °C, 20 s) burn in pig skin in vivo. Postmortem imaging at 584-nm optical wavelength.

Photograph

Healthy tissue

Coagulated tissue

Hyperemic ring 1 mm

Histology

Hyperemic bowl

Photoacoustic image

B-scan image

Hyperemic bowl

Hyperemic bowl

Burn depth ~1.7 mm

Skin surface

PA amplitude [a.u.]

Distance [mm]

5.5 6 6.5 7 7.5 8

0 0.1 0.2
Imaging of Skin Burns of Various Depths

Acute thermal (150 °C, various times) burn in pig skin in vivo. Postmortem imaging at 584-nm optical wavelength.

Imaging of Hemoglobin Oxygen Saturation (SO₂) In Vivo

Total hemoglobin concentration and SO₂ in segmented venules and arterioles

Histology

Arterial microsphere perfusion

**Hemodynamics In Vivo**

578, 584, 590, and 596 nm

Change in oxygenation

- Artery
- Vein

Hypoxia Normoxia Hyperoxia

Physiological states

Total hemoglobin

Oxygen saturation

**Imaging of Melanoma In Vivo**

Composite photoacoustic image acquired at 584 and 764 nm

B-scan image at 764 nm

**Contrasts:**
- Vessel: 13
- Melanoma: 69

**Surface rendering**

Skin surface

**Nature Biotech.**
24, 848 (2006).

http://oilab.tamu.edu --*0
**Imaging of Human Palm In Vivo**

![Image of human palm](image_url)

*Photo: Maximum amplitude projection onto the skin.*

Skin surface:
- 0.3 mm
- 0.13 mm

**B-scan image**

- Stratum corneum

**Optical absorption**

**Modern High-resolution Optical Microscopy**

<table>
<thead>
<tr>
<th>Modality</th>
<th>Year</th>
<th>Depth</th>
<th>Depth / Resolution</th>
<th>Contrast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confocal microscopy</td>
<td>1970s</td>
<td>~0.5 mm</td>
<td>&gt; 100</td>
<td>Scattering, fluorescence</td>
</tr>
<tr>
<td>Two-photon microscopy</td>
<td>1990s</td>
<td>~0.5 mm</td>
<td>&gt; 100</td>
<td>Fluorescence</td>
</tr>
<tr>
<td>Optical coherence tomography</td>
<td>1990s</td>
<td>~1 mm</td>
<td>&gt; 100</td>
<td>Scattering, polarization</td>
</tr>
<tr>
<td>Dark-field confocal photoacoustic imaging</td>
<td>2005*</td>
<td>~3 mm, scalable</td>
<td>&gt; 100</td>
<td>Absorption</td>
</tr>
</tbody>
</table>

*Optics Letters 30, 625 (2005).*
Outline

• Motivation
• Orthogonal-mode photoacoustic tomography
• Reflection-mode photoacoustic microscopy
• Deeply penetrating RF-based thermoacoustic tomography
• Summary

Experimental System for Thermo-acoustic Tomography

[Diagram of experimental system with labels:
- Water tank
- Stepper motor
- Ultrasonic transducers
- Waveguide
- Microwave generator
- Amplifiers and scope]
Summary

- Physically combining ultrasonic and electromagnetic waves (light & RF) provides
  - improved spatial resolution compared with optical/RF imaging,
  - new contrast mechanisms compared with ultrasound imaging.
- Spatial resolution is determined by the ultrasonic parameters.
- Spatial resolution is scalable with the ultrasonic parameters.
- Contrast is provided by the electromagnetic properties.
- Deep (~cm) tissue imaging can be achieved.
- Speckle artifacts do not exist.
- Functional imaging can be accomplished with endogenous contrast.
- Molecular imaging can be accomplished with exogenous contrast agents.
- Non-ionizing radiation is used.
- Costs are comparable with those of ultrasound systems.

http://oilab.tamu.edu -- 48
Funding Sources

ACTIVE
• NIH
  • R01 CA106728
  • R01 NS46214 (BRP)
  • R33 CA094267
  • R01 CA092415
  • R01 EB000712
• NIST

RECENTLY COMPLETED
• NIH
  • CA83760
  • CA71980
  • CA68562
  • EB000319
• NSF
• US Army
• Whitaker Foundation

http://oilab.tamu.edu -- 43

Visit Our Web Site:
http://oilab.tamu.edu

Welcome to the Optical Imaging Laboratory, a research laboratory dedicated to the developments of novel non-ionizing tomography and spectroscopy for the early detection of various cancers.