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# ***Dynamics and Fluctuations in Biomedical Photonics X***

**Valery V. Tuchin**  
**Donald D. Duncan**  
**Kirill V. Larin**  
**Martin J. Leahy**  
**Ruikang K. Wang**  
*Editors*

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## Introduction

This proceedings volume is from the Dynamics and Fluctuations in Biomedical Photonics VIII conference, held on February 2 through 4, 2013 at the SPIE Photonics West Conference in San Francisco, California. It was a three-day meeting featuring 45 oral and joint one-day poster session with 13 poster presentations from leading international research groups.

The goal of the conference was to gather essentially different groups of leading researchers along with students, such as biophysicists, medical doctors and physicians, mathematicians, optical and laser engineers, to report the current state of the art and to facilitate future progress in the development of optical and laser technologies based on dynamics and fluctuations approaches (such as laser-speckle, speckle-based coherence imaging, microcirculation analysis using various optical techniques and methods, dynamics of molecular diffusion, including nanoparticles, etc.) towards biomedical science and clinical applications. These approaches should be useful for diagnosis and therapy of devastating life-threatening diseases such as those of the heart, cancer, vascular, mental illness, and many others that manifest as a breach of the living organism's immune systems at the level of molecule, cell, organ, or organism as a whole. We hope that proceedings of this conference will contribute to the development of such interdisciplinary fields of science and applications as dynamics and structures of living systems, biomedical optics and laser medicine, and that it will be useful to scientists, medical doctors, engineers and students.

The conference was organized into several sessions: Speckle Technologies (co-chaired by Profs. Wang and Yaroslavsky); Tissue and Cell Dynamics (co-chaired by Profs. Larin and Chen); Clinical Imaging and Evaluation (co-chaired by Profs. Leahy and Lademann); Optical Clearing and Biomechanics (co-chaired by Profs. Duncan and Meglinski); Functional Imaging and Spectroscopy (co-chaired by Profs. Wang and Zharov); and Cerebral Hemodynamics (co-chaired by Profs. Tuchin and Yaroslavsky). Most of the sessions featured invited talks. The special features of this year conference were keynote lecture by Prof. A. Claude Boccara from Sylvain Gigan, Institute Langevin (France) entitled "Randomness in OCT and diffuse tomography" and special panel discussion on optical methods in tissue elastography (described in detail below). Both of these sessions drew significant attention from the audience and resulted in wide discussions of these topics.

The keynote lecture delivered by Prof. Boccara described recent advances in development and application of optical low coherence methods for real-time imaging and diagnostics of tissue pathology both *in vitro* and *in vivo*. Prof. Boccara has contributed to the advance of optical sciences as Director of the Optics Laboratory (now part of the Langevin Institute), then Dean of Research with Pierre-Gilles de Gennes (Nobel Laureate in Physics) and Jacques Prost. His pioneering work on understanding the physics of small objects has led to extremely sophisticated technologies in microscopy and spectroscopy. Based on

his work, a new kind of microscope has been developed to increase depth and lateral resolution much below sub-wavelength limits (picometers in depth and nanometers in lateral). Professor Boccara is the recipient of ten scientific awards, including in 2009 the prestigious Leon Brillouin Prize, a major honor of the French Optical Society, and in 2011 the NIH Bench to Bedside Pioneer Award.

The oral sessions and corresponding poster session of the conference featured many presentations which described different methods and techniques developed and applied to study complex problems of dynamics and fluctuations in biological systems on the scale ranging from cell to the whole body. The reader is encouraged to browse the table of contents for this issue to learn about the conference.

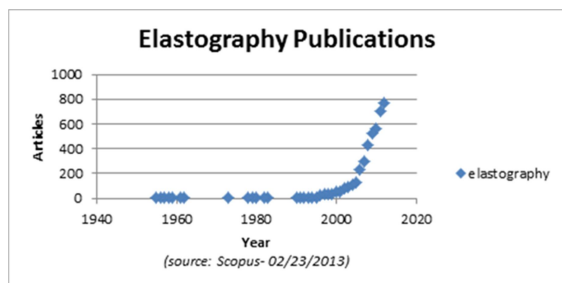
The conference chairs would like to thank the members of the technical program committee for their help in organizing the conference. We sincerely appreciate the support of the SPIE and the conference staff. Finally, we would like to thank all of the conference attendees and manuscript authors for their contributions and participation, especially invited speakers, who helped to make this meeting a success.

**Valery V. Tuchin**  
**Donald D. Duncan**  
**Kirill V. Larin**  
**Martin J. Leahy**  
**Ruikang K. Wang**

## Panel discussion: Biophotonics to study Tissue Biomechanics

*Martin J. Leahy, National Univ. of Ireland, Galway (Ireland) and National Biophotonics and Imaging Platform (Ireland); Royal College of Surgeons (Ireland); Ruikang Wang, Univ. of Washington (USA); Kirill Larin, Univ. of Houston (USA); Donald Duncan, Portland State Univ. (USA); Valery Tuchin, N.G. Chernyshevsky Saratov State Univ. (Russian Federation) and Univ. of Oulu (Finland); Claude Boccara, Institute Langevin (France), Brendan Kennedy, David Sampson, The Univ. of Western Australia (Australia); Sean Kirkpatrick, Michigan Technological Univ. (United States); Sergey Alexandrov, National Univ. of Ireland, Galway (Ireland)*

A special panel was assembled with leading biophotonics researchers involved in the study of tissue



**Fig 1:** Number of papers devoted to elastography per year

biomechanics. Elastography is a method to measure and display the elastic (or shear) modulus of materials (especially tissue) either for direct use of the mechanical properties or to improve contrast. Ultrasound mediated elastography has been in development for more than 20 years and is well-established [1-3]. The discussion explored known methods and developments, focusing ultimately on how to harness biophotonics for discoveries, which cannot be achieved with other means such as ultrasound.

The discussion was opened by Martin Leahy (NUI Galway) with a general introduction and overview. The number of papers concerning elastography in general published each year has grown from 129 in 2005 to 768 in 2012 (source Scopus, Fig 1). The vast majority of these papers are based on ultrasound. A smaller, but growing number of papers have investigated optics-based elastography measurements.

Sergey Alexandrov (NUI Galway) in his presentation discussed specific requirements (hardware and software) for instrumentation to study tissue biomechanics. Could we specify what the best approach for structural imaging and characterization is? What is the suitable contrast mechanism, resolution, sensitivity (at micro or/and nanoscale)? How existing techniques (for example, OCT) meet these requirements? What parameters of the instrumentation must be improved for effective solution of this problem? Can we establish some classification of the optical technique for specific problems?

David Sampson and Brendan Kennedy (UWA, Australia) presented complex approach to optical coherence elastography (OCE), from phantom development-mechanical modeling - development of the probe (including needle probes) and to applications, specifically for breast cancer diagnostics.

Sean Kirkpatrick (Michigan Technological Univ. (US) discussed application of polarization sensitive optical elastography for determination of skin pathologies, including melanoma *in situ*, intra-epidermal squamous cell carcinoma, granuloma annulare, plaque psoriasis and solar lentigo. He stressed some key issues in optical elastography for both clinical and laboratory applications. It is still not clear which component of the 3-D deformation (or strain) tensor is of interest and what component(s) of the 3-D deformation (or strain) tensor is being 'imaged'.

Valery Tuchin (Saratov State University, Russia, and Univ. of Oulu, Finland) discussed an interesting possibility to enhance OCT image contrast via tissue compression [4-7]. This effect is based on different mechanical properties and water content of epithelial and stromal layers. As a result, the compression-induced changes in scattering properties of these two layers are different and so the contrast of the OCT image can be improved. Furthermore, pushing out the "fast water", that which is not bound to hyaluronic acid, permits deeper images since scattering is reduced. He also mentioned that another promising application of tissue compression is to see hidden bands of

important tissue chromophores (water, carotenoids, and etc) on the background of tissue scattering [4, 8].

Kirill Larin (Univ. of Houston, USA) presented localized OCE of soft and ocular tissues based on phase sensitive stabilized swept light source OCT (PhS-SSOCT). Results of assessing biomechanics of the eye and biomechanics of the cancer tissues were discussed and appreciated.

Martin Leahy (NUI Galway) presented some results from Susana Marcos (Spain) who could not come to the meeting. He discussed measurements and experiments on eye, funded by ERC Advanced Grant, which were done in Marcos group for better understanding of accommodation and presbyopia.

There was some debate on different specific aspects of presented techniques, including accuracy, limitations, further development, etc. There were significant contributions from the audience, in particular Steve Jacques and Michael Kolios including highlighting the need for a rationale for using biophotonics instead of ultrasound. In conclusion, if biophotonics is to be successfully harnessed for tissue biomechanics, we must identify a niche, which requires the enhanced resolution and contrast, but does not require large penetration.

In particular:

- 1 Need to learn from ultrasound.
- 2 Need to enlist ultrasound people in the field.
- 3 Need to show a distinct need for a biophotonics approach.
- 4 Need to improve instrumentation and adapt it to study tissue biomechanics.

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