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# Polarized Light for Biomedical Applications

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Polarization is one of the most salient features of light, even more so than its spectral or coherence properties. Imaging and diagnostics modalities that utilize light polarization could translate into fast, accurate, and highly sensitive techniques for probing structures of living cells, for the purpose of cancer detection and stage identification. It has been roughly ten years since a publication of papers on tissue polarimetry[1] has been edited and a number of new research groups from around the world have entered this research field. The aim of this special section is to present the current state-of-the-art in this fast-growing research field. Focus area are advances in polarized light diagnostics and imaging, physical, mathematical and computational foundations, innovative optical instrument designs, as well as clinical, preclinical, and laboratory applications.

This special section was prepared *in memoriam* of Dr. Antonello De Martino – one of the pioneers of the tissue polarimetry in France and in the world.[2]

The special section includes a tutorial on polarimetry (by V. Tuchin) covering the fundamentals of polarized light and tissue interaction, recent advances in the theoretical aspects of polarization transfer in scattering media, the development of polarimetric optical diagnostic techniques, and examples of numerous biomedical applications of these techniques. Many modeling results of tissue polarization properties discussed in this tutorial were authored by Prof. Irina L. Maksimova, who passed away in 2013. Irina was one of the pioneers of modeling polarization properties of eye tissues and designing precise algorithms for their measurements. She was a talented person and a great worker, a brilliant representative of women in optics.

The obvious complexity of polarized light interaction with biological samples is reflected in a significant number of papers dealing with the measurements of the test samples' complete Mueller matrix. Despite more complex polarimetric instrument design and calibration, the use of Mueller matrix algebra for data analysis allows straightforward phenomenological interpretation of basic optical properties of the tissue, such as depolarization, dichroism, and birefringence. For many decades the depolarization of light due to scattering was used for tissue diagnosis. The above-mentioned studies clearly demonstrate that tissue scalar retardance developing due to the presence of aligned collagen fibers is extremely sensitive to the small pathological alterations of tissue. Consequently, the tissue scalar retardance, as well as the azimuth of optical axis could also be used as the optical markers of different diseases which break or modify the fine-ordered fabric of healthy tissue (e.g. cancer, cirrhosis, and different types of fibrosis) and for the studies of mechanical properties of connective tissues (D. Yakovlev et al.).

A new instrument combining two different optical techniques: (i) surface imaging with Mueller matrix polarimetry (MMP) and (ii) cross-sectional imaging with polarization-sensitive optical coherence tomography (PS-OCT) is discussed by J. Chue-Sang et al. The co-registration of two systems provides both bulk and local polarization properties of thick tissue, which could be used for both lesion boundary detection and optical biopsy of tissue. An interesting extension of conventional MMP is proposed by A. G. Ushenko et al. The authors study the application of laser-induced autofluorescence of dried peritoneal liquid for endometriosis diagnostics using Mueller matrix formalism which relates the distinct excitation and detection wavelengths of light. The use of angle-resolved Mueller polarimetry as a dosimetric technique for emergency reconstruction of the exposure dose of unpredictable ionizing radiation in large population is discussed in the paper of Savenkov et al. The use of multi-spectral Mueller polarimetric imaging technique for cervical cancer detection is discussed by J. Rehbinder et al.

Many papers of this special section are dedicated to the design and fabrication of new polarimetric instruments. The development of a miniaturized, noise-immune optical rotation polarimeter (Z. Weissman and D. Goldberg), Mueller matrix microscope (Y. Wang et al.), and polarimetric endoscopic imaging systems (J. Vizet et al. and K. Kanamori), all reflect a growing trend towards clinical applications.

In-depth experimental and numerical studies of anisotropy of light scattering in tissue (S. L. Jacques et al.), scattering of polarized light on rough surfaces (A. Doronin et al.), polarization gating technique, combining co-elliptical and counter-elliptical measurements for image contrast enhancement (S. Sridhar and A. Da Silva), statistical analysis of polarization-inhomogeneous images of skin taken in Fourier plane (A. G. Ushenko et al.), comparative studies of confocal imaging technique and polarization diffraction imaging flow cytometry for the classification of cancerous and healthy prostate epithelial cells (W. Jiang et al.), and polarized laser speckle imaging for the medical diagnosis of dental erosion (C. Abou Nader et al.) explore new ideas in the domain of polarized light scattering and pave the way for the development of new unconventional polarimetric techniques for various biomedical applications.

## *References*


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