QUANTITATIVE BIOMEDICAL DIAGNOSTICS USING POLARIZED LIGHT AND ORBITAL ANGULAR MOMENTUM: FROM AMYLOID DETECTION TO MACULAR HEALTH ASSESSMENT

Dmitry Pushin, *,[1,2,3,4] David G CORY, [1,5] Benjamin THOMPSON, [6,3] Dusan SARENAC, [7,3,4] Jelena MIRKOVIC, [8,5]

[1]*Institute for Quantum Computing, University of Waterloo, Waterloo, Canada;*
[2]*Department of Physics and Astronomy, University of Waterloo, Waterloo, Canada;*
[3]*Centre for Eye and Vision Research, 17W Hong Kong Science Park, Hong Kong;*
[4]*Incoherent Vision Inc., Wellesly, Canada;*
[5]*Department of Chemistry, University of Waterloo, Waterloo, Canada;*
[6]*School of Optometry and Vision Science, University of Waterloo, Waterloo, Canada;*
[7]*Department of Physics, University at Buffalo, State University of New York, Buffalo, USA;*
[8]*Department of Laboratory Medicine and Molecular Diagnostics, Sunnybrook Health Sciences Centre, Toronto, Canada;*
**dmitry.pushin@uwaterloo.ca*

Keywords: optics, polarization, optical orbital momentum

Polarized light and optical angular momentum (OAM) offer powerful tools for non-invasive, quantitative biomedical diagnostics by probing the intrinsic optical properties of biological tissues. This talk will present two groundbreaking applications of these techniques, leveraging advanced polarized light microscopy (PLM) and structured light-induced entoptic phenomena. First, we demonstrate a novel PLM methodology that quantitatively detects amyloid fibrils—pathological protein aggregates associated with diseases like Alzheimer's and amyloidosis—without the need for Congo red staining [1]. By analyzing birefringence, dichroism, and optical activity in hematoxylin and eosin (H&E)-stained tissue samples, our approach achieves robust amyloid identification across diverse tissues (e.g., duodenal, thyroid, and breast), offering a simpler, more objective alternative to traditional methods. Second, we introduce a psychophysical approach to characterize the circularly oriented macular pigment (coMP) optical density in the human retina, a biomarker for macular health linked to conditions such as age-related macular degeneration (AMD). Using structured light with tailored OAM and spatiotemporal frequencies, we map coMP profiles with high sensitivity, validated through a model with a Pearson χ^2 fit statistic of 0.06 [2]. These techniques highlight the potential of polarized light and OAM to transform clinical diagnostics by enabling rapid, accurate, and stain-free assessments of tissue pathology and retinal health, paving the way for early detection and improved patient outcomes.

[1]. Lailey, Owen, et al., *Biomedical Optics Express* **16**(6), 2283, (2025)

[2]. Pushin, D.A., et al., *Journal of Vision*, **25**(6), 11, (2025)