CONFOCAL MUELLER MATRIX POLARIMETRY OF BIOLOGICAL MEDIA

Jessica C. RAMELLA-ROMAN,[1,2,*]

[1]*Department of Biomedical Engineering, Florida International University, 11110 SW 11th St Miami, FL 33174, USA*
[2]*Herbert Wertheim College of Medicine, Florida International University, 11110 SW 11th St Miami, FL 33174, USA*
**jramella@fiu.edu*

Keywords: Mueller matrix polarimetry, confocal microscopy, imaging of biological tissues

Mueller Matrix (MM) polarimetry offers micrometer-scale depth resolution for assessing the polarization properties of biological tissues, enabling the extraction of structural and functional information with medical relevance. However, when applied to thick, highly scattering media, interpreting MM data becomes difficult due to overlapping polarization effects caused by optical complexity and heterogeneity. To address this, we have previously introduced a multimodal system—SAMMM—that integrates MM microscopy with nonlinear imaging via second-harmonic generation (SHG) [1]. This approach allows for MM characterization of bulk tissues while SHG imaging provides a complementary, independent probe of tissue anisotropy.

In this study, we demonstrate the use of confocal MM microscopy for depth-resolved polarimetric analysis in both microsphere-based optical phantoms and fibrous biological tissues. This enables us to investigate how polarized light propagates through scattering media and to quantify the resulting depolarization across depth. We further examine how the spatial arrangement of anisotropic elements within the sample influences local retardance and depolarization signals. To support and validate these experimental findings, we employ a polarization-sensitive Monte Carlo simulation that models light interaction within the phantom, simulating both backscattered MM signals and confocal MM detection.

[1]. I. Saytashev, S. Saha, J. Chue-Sang, P. Lopez, M. Laughrey, J. C. Ramella-Roman, "Self validating Mueller matrix Micro–Mesoscope (SAMMM) for the characterization of biological media," Opt. Lett. **45**, 2168-2171 (2020)