L.10: Deciphering patterns in depolarization maps from turbid medium and tissue

Polarization characterization of tissue is being widely explored for imaging and diagnosis of biological tissue. For turbid medium like tissue the polarization change can occur due to multiple effects (Diattenuation, birefringence and depolarization). Muller matrix measurement along with its polar decomposition is widely used for quantification of these three polarization effects which can provide useful diagnostic information.

While anisotropic tissue constituents predominantly determine the retardance and diattenuation characteristics of tissue, the depolarization is influenced by a large number of parameters like the size of the scatterers, refractive index, absorption in the medium, and the heterogeneity in the arrangement and distribution of polarization altering tissue constituents. Extracting information about these factors from the measured depolarization is difficult because depolarization is a single valued metric. Spatial backscattering patterns of Mueller matrix elements have been used to address this issue. However, the approach used assumes the sample to have a homogeneous spatial distribution of optical properties which is not true for tissues. Recent studies carried out at LBAID have shown that measurement of depolarization as a function of input polarization state (ellipticity δ, orientation θ) using a point Mueller matrix measurement can provide information about scatterer size (Fig. L.10.1) and also the presence of retardance and its order viz a viz depolarizer in a layered system. Further, the results show that while the value of depolarization is affected by absorption its polar map (with $\sin\delta\sin\theta$ and $\sin\delta\cos\theta$ as axis) is not affected by the presence of absorption.

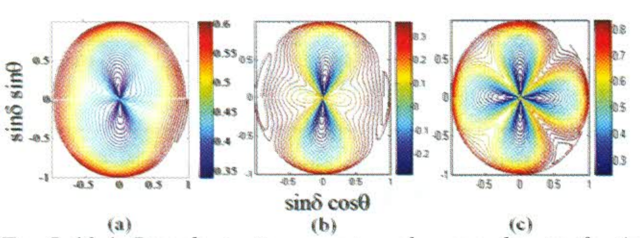

Fig. L.10.1: Depolarization map in polar-coordinates for (a) Intralipid, (b) 2 μm, and (c) 6 μm Polystyrene microspheres. Color-bar shows the depolarization.

Fig. L.10.2(a) shows depolarization spectra from mice liver tissue. The spectral variation of depolarization shows the characteristic dip in the wavelength region with strong blood absorption and gradually increases with wavelength. The pattern in depolarization map is same for both low and high absorption region and is similar to a Rayleigh scatterer dominated depolarization map pattern (Fig. L.10. 2b & 2c).

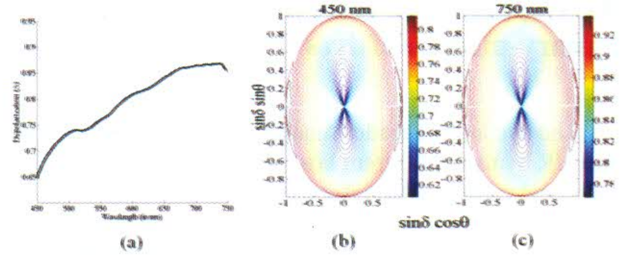

Fig L.10.2: Spectral variation of depolarization from mice liver tissue (a). The depolarization map at 450 nm and 750 nm are shown in (b) and (c).

For mice tail tissue having highly oriented collagen fibrils the pattern (Fig. L.10.3) was found to be similar to that for the large size scatterers. Further the whole pattern was also observed to rotate with the rotation of the sample about the direction of incidence, indicating the role of birefringence from collagen fibrils.

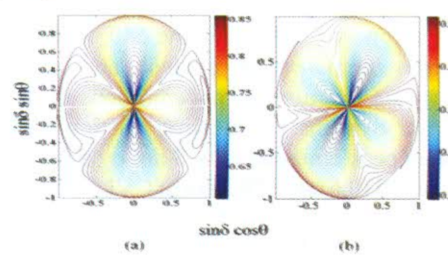

Fig. L.10.3: Depolarization map from mice tail tissue (a) oriented vertically and (b) oriented 45° to vertical.

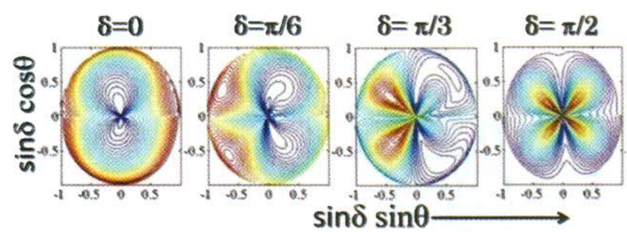

Fig. L.10.4: Depolarization map for turbid medium with a retarding layer in front.

Apart from adding to depolarization, retardance will also change the polarization state as seen by the depolarizing layer if retarder precedes the depolarizer (Fig. L.10.4) whereas the polarization of light seen by the depolarizing layer remains unchanged when the retarder is behind. (For more details, please refer to M. K. Swami et al., Applied Optics, 2014, http://dx.doi/org/10.1364/AO.99.099999)

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