Unraveling Cellular Complexity with Polarized Light and Orbital Angular Momentum

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Oral contribution

Polarized light and orbital angular momentum (OAM) are new and important approaches implemented to the cells studies. In this presentation, we propose a novel methodology based on the structured light, i.e., conventional spin angular momentum and OAM carrying beams that are highly resistant to scattering in turbid tissue-like scattering medium [1]. We have been able to achieve spatial and dynamic sensitivity with resolution 1000 times better than conventional techniques by using the preserved photonic vortices within the biological samples including cells cultures. Through precise measurement of refractive index utilizing OAM, we develop an electrodynamic model of blood cells that quantifies dielectric properties, particularly relative permittivity. This approach reveals distinctive spatial permittivity patterns between healthy and pathological samples, enabling the calculation of contrast parameters that significantly enhance diagnostic capabilities (Fig.1-a). In addition, we present the application of spin angular momentum (SAM)-based approach through a polarization based image reconstruction that reveals polycrystalline structure in dried blood cells [2]. By combining polarization-holographic reconstruction with differential 3D Mueller-matrix (MM) imaging methodologies, our system performs layer-by-layer characterization of blood samples' polycrystalline structure (see Fig.1-b). By leveraging alterations in the proteins' tertiary structure (their unique 3D shape) and quaternary structure (how multiple proteins join together), the approach is able successfully detect and classify the cells. The technique exploits changes in blood proteins' optical anisotropy properties during early disease stages, analyzing linear and circular birefringence and dichroism distributions through phase scanning and digital holographic reconstruction.

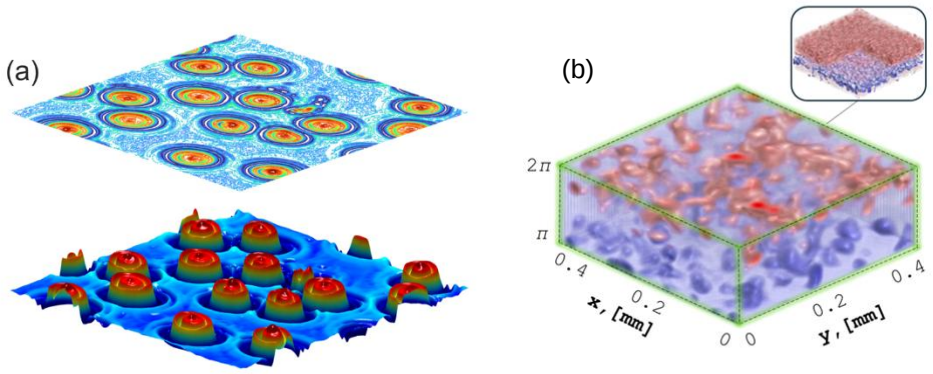

Fig. 1 Examples of spatial permittivity pattern obtained for the healthy blood sample (a) and (b) – the results of typical polarization-interference measurement through digital holographic reconstruction for a dehydrated blood film [2].

References

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[2] A.G. Ushenko, A. Sdobnov, I.V. Soltys, Yu.A. Ushenko, A.V. Dubolazov, V.M. Sklyarchuk, A.V. Olar, L. Trifonyuk, A. Doronin, W. Yan, A. Bykov, and I. Meglinski, "Insights into polycrystalline microstructure of blood films with 3D Mueller matrix imaging approach", Sci. Rep. **14**, 13679 (2024).