MUELLER-MATRIX OPTICAL SCANNING MICROSCOPY: FROM MICRO- TO MACROSCOPIC BIOLOGICAL ORGANIZATION

Aymeric Le Gratiet[1], Ali Mohebi[1,2], Fabio Callegari[1,2], Alberto Diaspro[1,2]

[1] Nanoscopy, CHT Erzelli, Istituto Italiano di Tecnologia, 16152 Genova, Italy
[2] DIFILAB, Department of Physics, University of Genoa, Via Dodecaneso 33, 16146 Genova, Italy
E-mail: aymeric.legratiet@iit.it

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Microscopy techniques based on the measurements of polarimetric contrasts has proven to be an interesting tool for extracting additional information about the organization and orientation of any anisotropic sample [1]. Among these techniques, we have implemented two polarimetric multimodal optical scanning microscopy methods allowing the acquisition of all the physical effects induced by the interaction of the polarized light with a medium at different biological level of organization. This interaction can be summarizes in a single 4x4 elements Mueller-matrix by comparing the independent coding and decoding polarization states, giving access simultaneously to physical parameters such as dichroism, birefringence and scattering.

First, we proposed to image sub-microscopic structures based on the measurement of the scattering differential signal from the circular left and right polarization states excitation, named Circular Intensity Differential Scattering (CIDS) [2]. Here, coupled with fluorescence imaging, we demonstrate our capability to distinguish the different chiral order conformation in chromatin-DNA from fixed isolated cell nuclei, i.e. the more compacted heterochromatin from the euchromatin areas [3].

Second, using Stokes-Mueller formalism, we demonstrate the potentiality to characterize the polarimetric transformation of non-labeled small animal. As a proof of principle, we have imaged particular biological structures of interests (collagen fibers and muscles). Then, we study the polarimetric transformation of zebrafish preserved at different embryonic developmental stages [4]. By combining the full polarimetric measurements with statistical analysis, it is possible to quantify the localized structural changes. We show that this easy and convenient method can pave the way for a better understanding of developmental biology, in which label-free techniques become a standard tool to study organisms.

References

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