Dipartimento di Fisica
Università degli Studi di Genova

ISTITUTO ITALIANO
DI TECNOLOGIA

PhD program in Physics and Bio-Nanoscience

Cycle: XXXV

PhD Student: Ali Mohebi
Nanoscopy & NIC@ IIT
Tutors: Prof. Alberto Diaspro
Dr. Aymeric Le Gratiet

Second year PhD Annual Report

The idea is to exploit the possibility to tune the microscope across a large, almost unlimited, range of spatial and temporal resolution ranges by integrating different light-matter interactions. The main subject of my research line is label-free nanoscopy based on polarized light scattering integrated with fluorescence imaging of biological macromolecules. Polarized light scanning microscopy is a non-invasive and contrast-enhancing technique to investigate anisotropic specimens and chiral organizations. However, this approach suffers from averaged signal of the mixture of structures in the illumination volume. We show that a phasor map analysis combined with polarization resolved microscopy has provided an intuitive view of the sample organization to recognize the presence of different molecular species. This would offer a distinctly sensitive fast and easy representation of the polarimetric contrast that can pave the way for remote discrimination of pathological tissues or even virus phenotypes in real-time.

My work consists in firstly validating this method by numerical simulations and comparing results with that of experimental data of reference optical devices and secondly showing that the conversion of the polarization-resolved images into the phasor map could further utilized for segmenting specific structures to confer various optical properties under the polarized light.

The perception of chromatin compartments as chiral-group structures inside cell nuclei is crucial to identify enriched expressed genes regions based on different compaction levels of chromatin. In our work, we present employment of the image phasor approach of polarimetric images to follow different stages of isolated Hutchinson-Gilford progeria syndrome caused by a mutation in the lamin-A (LMNA) gene that is responsible to make a defective protein that holds the nucleus of the cell together and gives rise to the nuclei to be unstable. The phenomenological polarization response changes induced by deformation of the nucleus in presence of the pathology compared to normal cell is then shown by phasor map approach as an easy, robust and intuitive graphical analysis. We also applied the polarimetric imaging method on starch granules that are complex crystals, analyze them by segmentation of disparate optical active regions and represent graphically employing the corresponding image phasor map as baseline.

The outcome of my work is published in Applied Optics entitled "*Combined Approach using Circular Intensity Differential Scattering Microscopy under Phasor Map Data Analysis"* 60(6):1558-1565; and we have another manuscript under review.

The list of attended courses and exams given

During the second year, I have passed four courses and two remaining ones are to be done by October 2021:

- ✓ Surface Microscopy and Spectroscopy (Prof. Buzio, Prof. Gerbi, Prof. Savio)
- ✓ Optical microscopy at the nanoscale (Prof. Alberto Diaspro)
- ✓ Nanophotonic devices: from fabrication to application (Prof. Andrea Toma)
- ✓ Biosensing (Prof. Elena Angeli and Prof. Ornella Cavalleri)

Schools and conferences attended:

BPS 2021, 65th Biophysical Society Annual Meeting, 22-26 February 2021; online

Resolution improvement in CIDS super-resolution microscopy using a phasor plot approach

ECBO 2021, European Conferences on Biomedical Optics (ECBO), 20 - 24 June 2021; online

Multimodal polarization-resolved/fluorescence optical scanning microscopy for chromatin organization imaging

EBSA 2021, 13th European Biophysics Conference, 24-28 July 2021; on-site in Austria

Oral presentation; "Phasor analysis in circular polarization-resolved optical scanning microscopy for biological organization imaging"

SIF 107 Congress, Congresso della Società Italiana di Fisica, 13-17 September 2021; online

Phasor analysis in polarization-resolved optical scanning microscopy for progeria organization imaging.